DRAFT: Study of Brackish Aquifers in Texas – Project #1 – Gulf Coast Aquifer

TWDB Contract Number 1600011947

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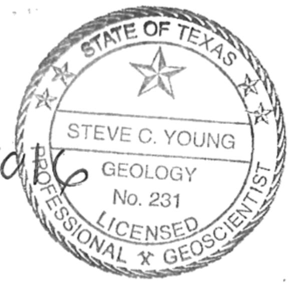

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1 Executive Summary

To better formulate groundwater management strategies, planners and decision makers need reliable estimates of the available fresh, brackish, and saline groundwater in Texas. House Bill 30, passed by the 84th Texas Legislative Session, requires the Texas Water Development Board (TWDB) to identify and designate brackish groundwater production zones in the aquifers of Texas. Specifically, the legislation directed the TWDB to conduct studies on four aquifers and report results to the legislature. This report documents the study of brackish water resources in the Gulf Coast Aquifer, one of the aquifers selected for study in House Bill 30.

The purpose of this study is to provide the information necessary for the TWDB to designate brackish groundwater production zones for the Gulf Coast Aquifer, a major aquifer that underlies all or parts of 51 counties along the Texas Gulf Coast. To meet this goal, we collected and analyzed data to define geologic structure, sand intervals, and water quality in the geological formations of the Gulf Coast Aquifer in order to propose potential brackish production areas.

The project developed and implemented a methodology for delineating salinity zones across the Gulf Coast Aquifer. The salinity zones cover five water quality categories: fresh water, slightly saline, moderately saline, very saline, and brine. Our methodology involved using both empirically-derived and theoretical-based approaches for calculating the total dissolved solids concentration in groundwater from the formation resistivity of sands. Formation resistivity is a parameter that can be easily obtained from most geophysical logs. In order to have a consistent and reliable set of formation resistivity values from which to quantify and map estimated total dissolved solids across the Gulf Coast, we digitized 600 geophysical logs and calculated the formation resistivity for approximately 30,000 sand beds.

We used our mapped three-dimensional salinity zones with hydrogeologic data and criteria set forth by House Bill 30 to identify six Potential Production Areas. The Potential Production Areas are large areas that encompasses several geological formations and span multiple counties. To evaluate the capacity of the Potential Production Areas to produce groundwater, we developed five regional groundwater models and used them to simulate pumping from the 15 candidate well fields. Each well field was pumped at 3,000, 10,000, and 20,000 acre-feet per year for 50 years. Drawdown values at the well field and at monitoring locations were recorded after 30 years and after 50 years of pumping.

The groundwater models were based on the regional groundwater models developed by TWDB to support the joint planning in Groundwater Management Areas 14, 15, and 16. As part of our model development process, we incorporated approaches for accounting for how temperature and porosity differences with depth affect aquifer properties. Because aquifer hydraulic properties were based on limited field data in the deeper portions of the Gulf Coast Aquifer, a sensitivity analysis of aquifer properties was performed. Sixteen different sensitivity simulations for each well field provide a range of drawdown results based on the specified variation in the aquifer hydraulic properties.

Groundwater volumes were estimated for the Gulf Coast Aquifer for different classifications of groundwater quality including fresh, slightly saline, moderately saline, very saline, and brine.

Water levels, aquifer structure and thickness, and sand intervals from geophysical logs were used to calculate the groundwater volumes by formation. The calculated groundwater volumes are tabulated by the volume contained in sands and by the total volume which includes the volume of groundwater contained in both sands and clays. The calculated groundwater volumes are listed by groundwater management area, groundwater conservation district, and county.

2 Introduction

Groundwater is a major source of water in Texas, providing about 60 percent of the water used in the state. To better formulate water management strategies, planners and decision makers need reliable estimates of the available fresh, brackish, and saline groundwater. House Bill 30, passed by the 84th Texas Legislative Session, requires the Texas Water Development Board (TWDB) to identify and designate brackish groundwater production zones in the aquifers within the state. Specifically, the legislation directed the TWDB to conduct studies on four aquifers and report results to the legislature by December 1, 2016. Studies and reports on the remaining aquifers are to be completed by December 1, 2022. To meet these requirements, the TWDB let contracts to conduct studies of brackish groundwater in six Texas aquifers. The Gulf Coast Aquifer was one of the aquifers selected for study in House Bill 30. This report documents the study of brackish water resources in the Gulf Coast Aquifer.

The Gulf Coast Aquifer is a TWDB-designated major aquifer in the state of Texas and underlies all or parts of 51 counties along the Texas Gulf Coast (George and others, 2011) (Figure 2-1). It extends from the Louisiana border to the Mexico-United States border. The Gulf Coast Aquifer is designated as a major aquifer because it provides large quantities of water in large areas of the state. The Gulf Coast Aquifer is not a single aquifer, but rather consists of several aquifers (the Chicot, Evangeline, and Jasper aquifers) and confining units (the Burkeville and Catahoula), as shown in Figure 2-2. The entire extent of the Gulf Coast Aquifer exists in outcrop.

The objective of this study is to characterize the quantity and quality of groundwater within the Gulf Coast Aquifer and to propose potential brackish production areas that can be used by the TWDB to make recommendations to the legislature on designation of brackish production zones. House Bill 30 provides direction to the TWDB to identify and designate local or regional brackish groundwater production zones in areas of the state with moderate to high availability and productivity of brackish groundwater that can be utilized to reduce the use of fresh groundwater. The production of brackish groundwater from the Gulf Coast Aquifer is excluded in the Fort Bend and Harris-Galveston Coastal Subsidence Districts. Table 2-1 defines the criteria set forth in House Bill 30 to be used for designation of brackish groundwater production zones.

The purpose of this study is to provide the information necessary for the TWDB to designate brackish groundwater production zones for the Gulf Coast Aquifer. To meet this goal, we collected and analyzed data to better define structure, sand intervals, and water quality in the geological formations of the Gulf Coast Aquifer.

This study relied on the Gulf Coast stratigraphy developed by the TWDB (Young and others, 2010, 2012). The primary analysis performed on the geophysical logs was identification of sand intervals along with their thickness and formation resistivity. An approach was developed to estimate total dissolved solids concentrations using formation resistivity from geophysical logs, which is based on pairing water wells and total dissolved solids concentration measurements with geophysical logs in the same geological formation. The developed relationship provides the necessary information to identify salinity zones within the Gulf Coast Aquifer from the resisitivity data in the geophysical logs.

Besides salinity zones, the Gulf Coast Aquifer was characterized using maps of the distribution of sands and interpretation of about 200 geophysical logs distributed on nine vertical cross-sections. For these vertical cross-sections, maps of the geological formations, salinity zones, sand intervals, and fault zones were created. Based on consideration of differences in regional hydrogeology and criteria in Table 2-1, we proposed six Potential Production Areas. Portions of the lower Evangeline Aquifer, the Burkeville Confining Unit, the Jasper Aquifer, and the Catahoula Formation are included in the six Potential Production Areas.

To evaluate the capability of producing groundwater over a 30-year period and a 50-year period without causing significant impacts to water availability, we created five three-dimensional models of groundwater flow and simulated pumping from 15 well fields. The aquifer properties used in the groundwater flow models are based on the aquifer hydraulic properties in the regional groundwater flow models developed by the TWDB to support joint planning in Groundwater Management Areas 14, 15, and 16. Major features of the modeling approach include simulation of three different pumping rates at each well field and an analysis that determined the sensitivity of simulated drawdown to aquifer hydraulic properties specified as inputs to the groundwater model. Because aquifer hydraulic properties were based on limited field data in the deeper portions of the Gulf Coast Aquifer, a sensitivity analysis of the aquifer hydraulic properties was conducted.

To help characterize the groundwater resources in the Gulf Coast Aquifer, groundwater volumes were estimated for different classifications of groundwater quality including fresh, slightly saline, moderately saline, very saline, and brine. Water levels, aquifer structure and thickness, and sand intervals from geophysical logs were used to calculate the groundwater volumes by geological formation. The calculated groundwater volumes are tabulated by the volume contained in sands intervals and by the total volume, which includes the volume of groundwater contained in both sands and clays. The groundwater volumes are tabulated for groundwater management areas, groundwater conservation districts, and counties per geological formation.

Table 2-1. House Bill 30 criteria for designation of Brackish Production Zones.

Criteria Type	Criteria for Designation of a Brackish Groundwater Production Zone
Water Quality	Has an average total dissolved solids level of more than 1,000 milligrams per liter.
Hydraulic Isolation	Separated by hydrogeologic barriers sufficient to prevent significant impacts to water availability or water quality in the area of the same or other aquifers, subdivisions of aquifers, or geologic strata that have an average total dissolved solids level of 1,000 milligrams per liter or less at the time of designation of the zone.
Aquifer Use	Is not serving as a significant source of water supply for municipal, domestic, or agricultural purposes at the time of designation of the zone.
Aquifer Use	Is not in an area or geologic stratum that is designated or used for wastewater injection through the use of injection wells or disposal wells permitted under Chapter 27 of Texas Water Code.
Regulatory Jurisdiction	Is not located in: an area of the Edwards Aquifer subject to the jurisdiction of the Edwards Aquifer Authority; the boundaries of the: (a) Barton Springs-Edwards Aquifer Conservation District; (b) Harris-Galveston Subsidence District; or (c) Fort Bend Subsidence District.

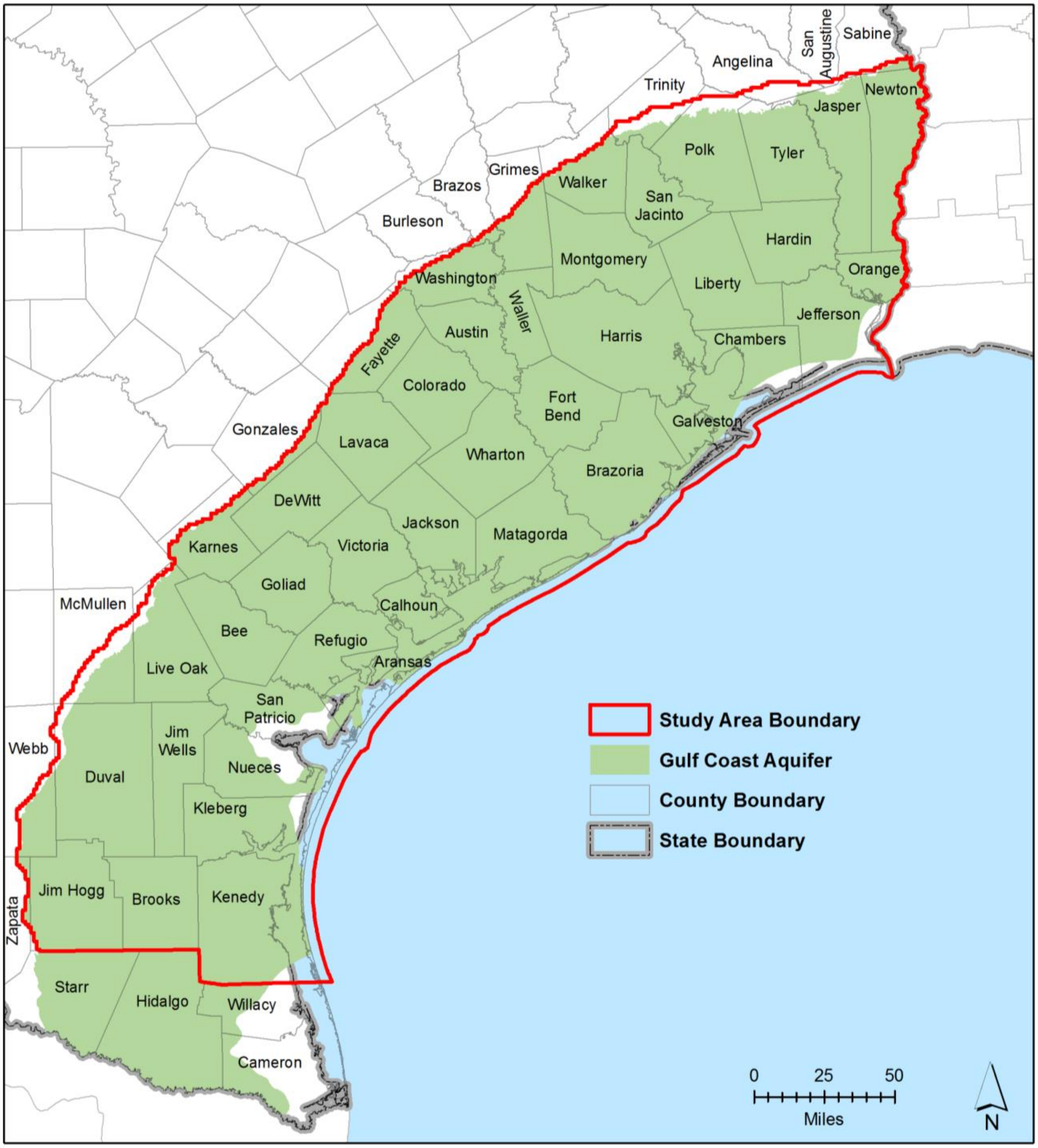
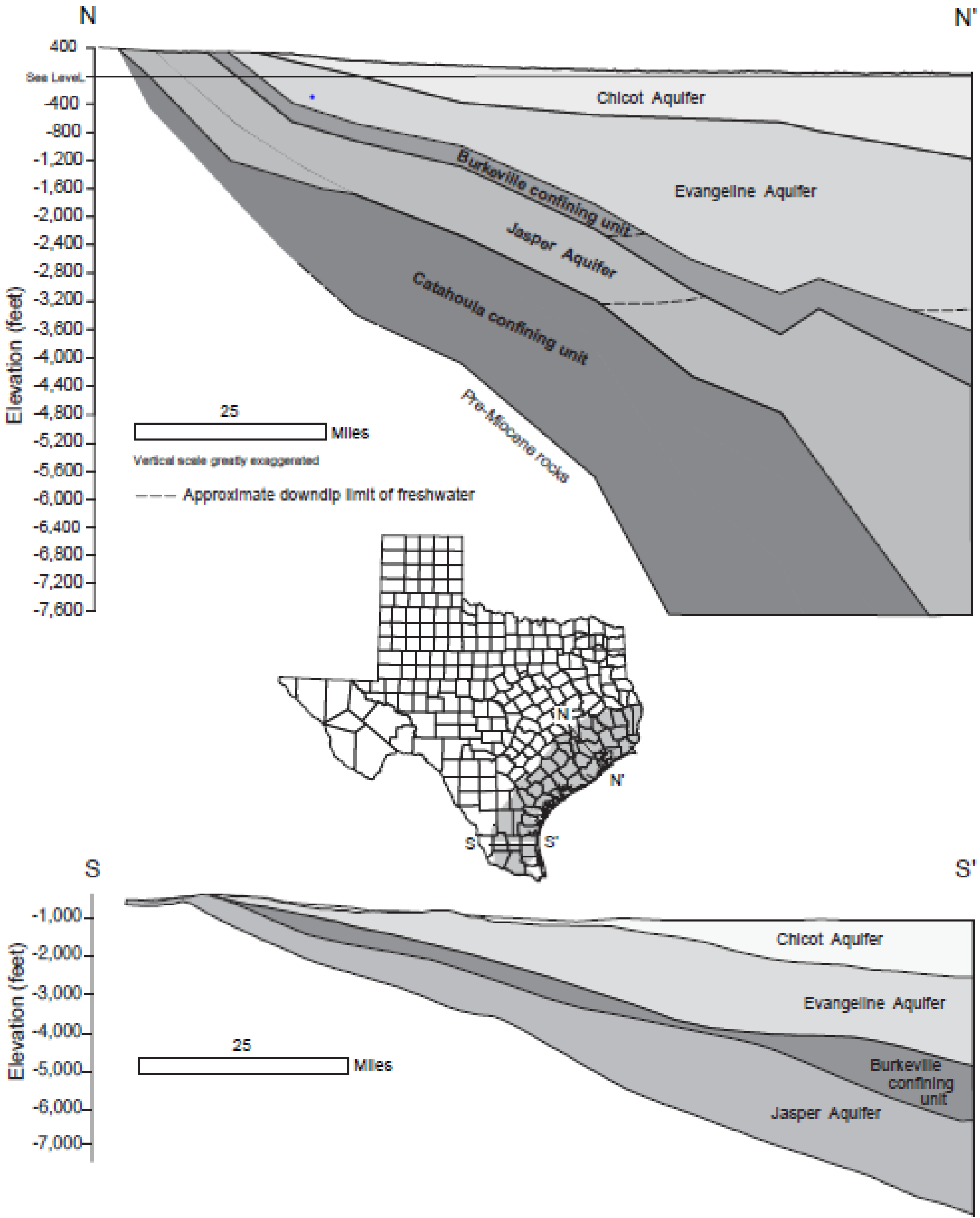


Figure 2-1. **Study area.**



Cross sections across the Gulf Coast Aquifer (modified from Baker, 1979, 1986; Chowdhury and Mace, 2003; Kasmarek and Robinson, 2004).

Figure 2-2. Cross-sections of the Gulf Coast Aquifer (from George and others, 2011).

3 Project Deliverables

Project deliverables for this study include this report and associated ArcGIS files, as well as geophysical logs, data, and study results for inclusion in the Brackish Resources Aquifers Characterization System database. Information contained in this report includes a discussion of the project study area, hydrogeologic setting, groundwater salinity zones, previous investigations, hydraulic properties, and water quality data investigated and analyzed for this study. In addition, it includes discussions of the methodologies used for calculating groundwater volumes, analyzing geophysical logs, and identifying potential brackish groundwater production areas. Based on the study results, our suggestions for future improvements are discussed. The report ends with conclusions. ArcGIS files (shapefiles and rasters) developed for this study are provided, along with metadata, in an ArcGIS file database. The information provided to the Brackish Resources Aquifers Characterization System Group for inclusion in the Brackish Resources Aquifers Characterization System database is summarized in Table 3-1 and the contents of the geodatabases are provided in Section 19.

Table 3-1. Information for inclusion in the Brackish Resources Aquifers Characterization System Database.

Information	Information Type
Digital Images of Geophysical Logs	Obtained Data
Locations of Logged Wells and Water Wells	Obtained Data
Total Dissolved Solids from Water Wells	Obtained Data
Well Identification Information	Obtained Data
Well Construction Information	Obtained Data
Calculated Total Dissolved Solids from Geophysical Log Analysis	Study Results
Sand Picks from Geophysical Log Analysis	Study Results
Stratigraphy Picks from Geophysical Log Analysis	Study Results
Hydrochemical Zone Picks from Geophysical Log Analysis	Study Results

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4 Project Area

The project area encompasses all counties along the Texas Gulf Coast coincident with the Gulf Coast Aquifer, with the exception of Cameron, Hidalgo, Starr, and Willacy counties located at the southern end and previously studied by Meyer and others (2014) (Figure 2-1). The project area is located within eight regional water planning groups (Table 4-1, Figure 4-1) and Groundwater Management Areas 14, 15 and 16 (Figure 4-2). Contained in the area are two subsidence districts, one aquifer storage and recovery conservation district, and all or part of 24 groundwater conservation districts (Table 4-1, Figure 4-2). The study area is located in 19 river basins and 12 river authorities (Table 4-2, Figures 4-3 and 4-4, respectively).

Table 4-1. Regional water planning groups, subsidence districts, aquifer storage and recovery conservation district, and groundwater conservation districts in the study area.

Regional Water Planning Groups	
Coastal Bend	Region G
East Texas	Region H
Lavaca	Rio Grande
Lower Colorado	South Central Texas
Subsidence Districts	
Fort Bend	Harris-Galveston Coastal
Aquifer Storage and Recovery Conservation District	
Corpus Christi	
Groundwater Conservation Districts	
Aransas County GCD	Goliad County GCD
Bee GCD	Kenedy County GCD
Bluebonnet GCD	Live Oak UWCD
Brazoria County GCD	Lone Star GCD
Brush Country GCD	Lower Trinity GCD
Calhoun County GCD	McMullen GCD
Coastal Bend GCD	Pecan Valley GCD
Coastal Plains GCD	Refugio GCD
Colorado County GCD	San Patricio County GCD
Duval County GCD	Southeast Texas GCD
Evergreen UWCD	Texana GCD
Fayette County GCD	Victoria County

Note: GCD = groundwater conservation district
UWCD = underground water conservation district

Table 4-2. River basins and river authorities in the study area.

River Basins	
Brazos River Basin	Nueces-Rio Grande Coastal Basin
Brazos-Colorado Coastal Basin	Rio Grande River basin
Colorado River Basin	Sabine River Basin
Colorado-Lavaca Coastal Basin	San Antonio River Basin
Guadalupe River Basin	San Antonio-Nueces Coastal Basin
Lavaca River Basin	San Jacinto River Basin
Lavaca-Guadalupe Coastal Basin	San Jacinto-Brazos Coastal Basin
Neches River Basin	Trinity River Basin
Neches-Trinity Coastal Basin	Trinity-San Jacinto Coastal Basin
Nueces River Basin	
River Authorities	
Angelina-Neches River Authority	Lower Neches Valley Authority
Brazos River Authority	Nueces River Authority
Guadalupe-Blanco River Authority	Sabine River Authority
Gulf Coast WA	San Antonio River Authority
Lavaca-Navidad River Authority	San Jacinto River Authority
Lower Colorado River Authority	Trinity River Authority

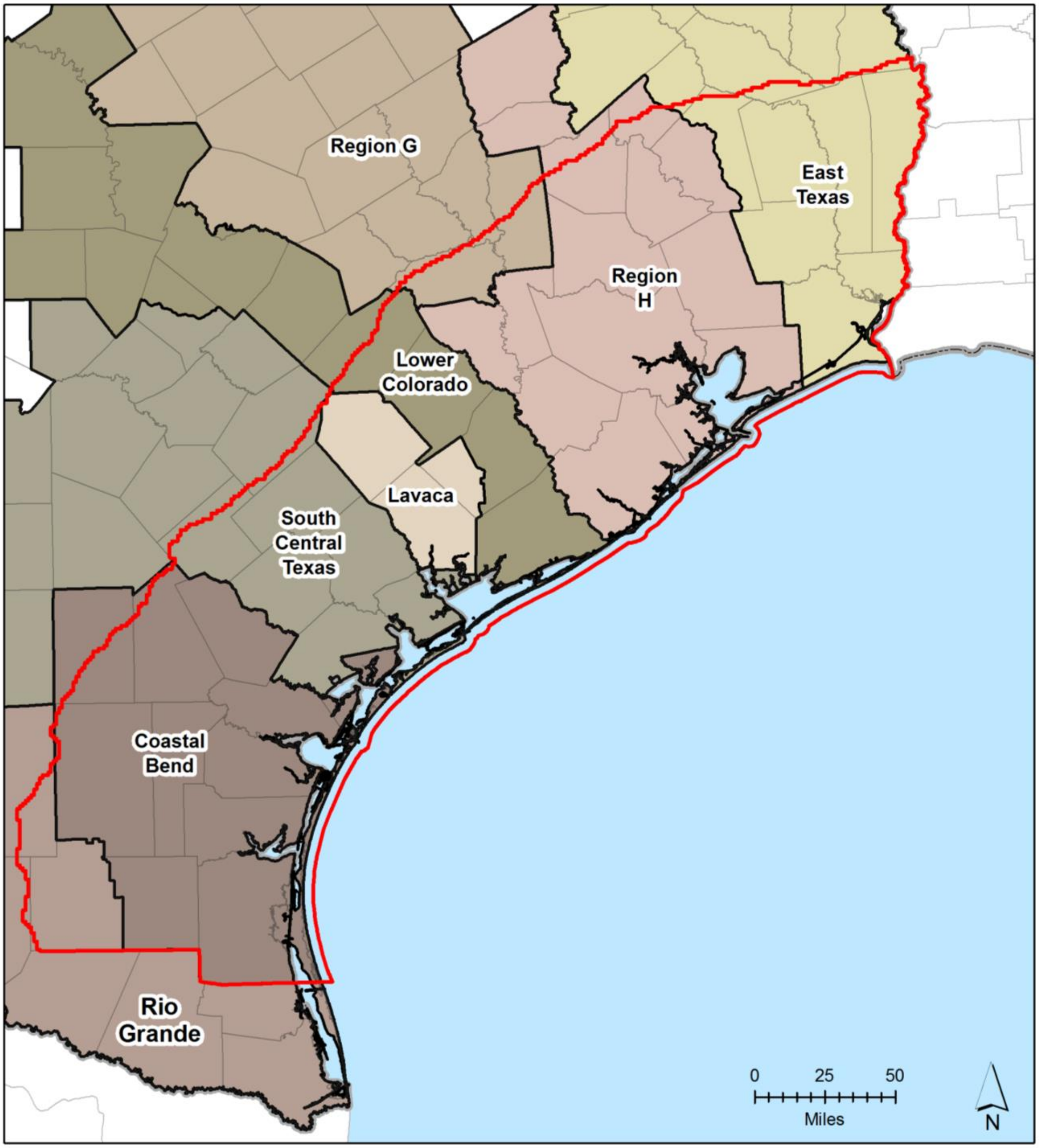

Figure 4-1. Regional water planning groups in the study area.

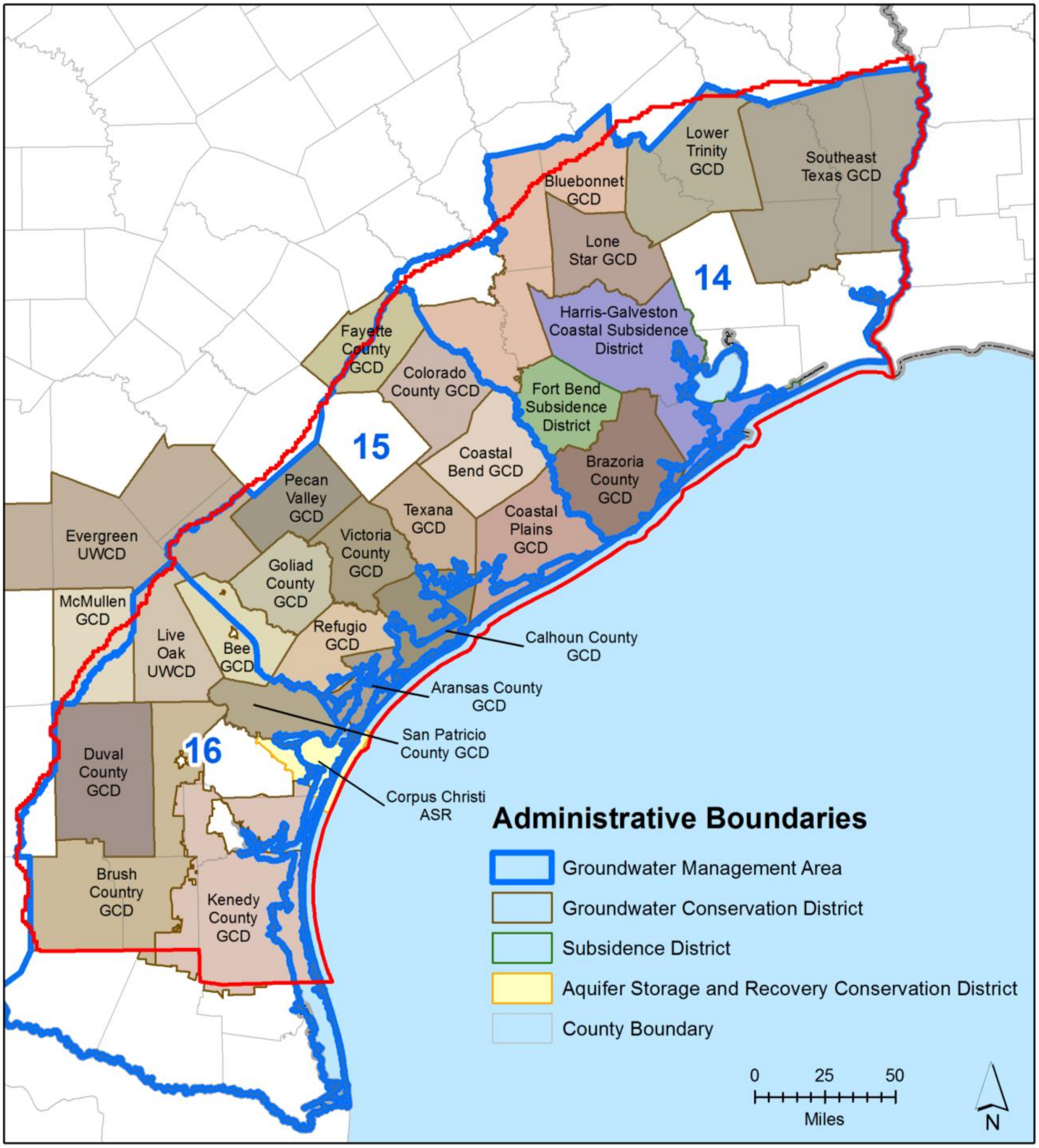

Figure 4-2. Groundwater management areas, subsidence districts, aquifer storage and recovery district, and groundwater conservation districts in the study area.

Note: GCD=Groundwater Conservation District; UWCD=Underground Water Conservation District; ASR=Aquifer Storage Recovery

Figure 4-3. **River basins in the study area.**

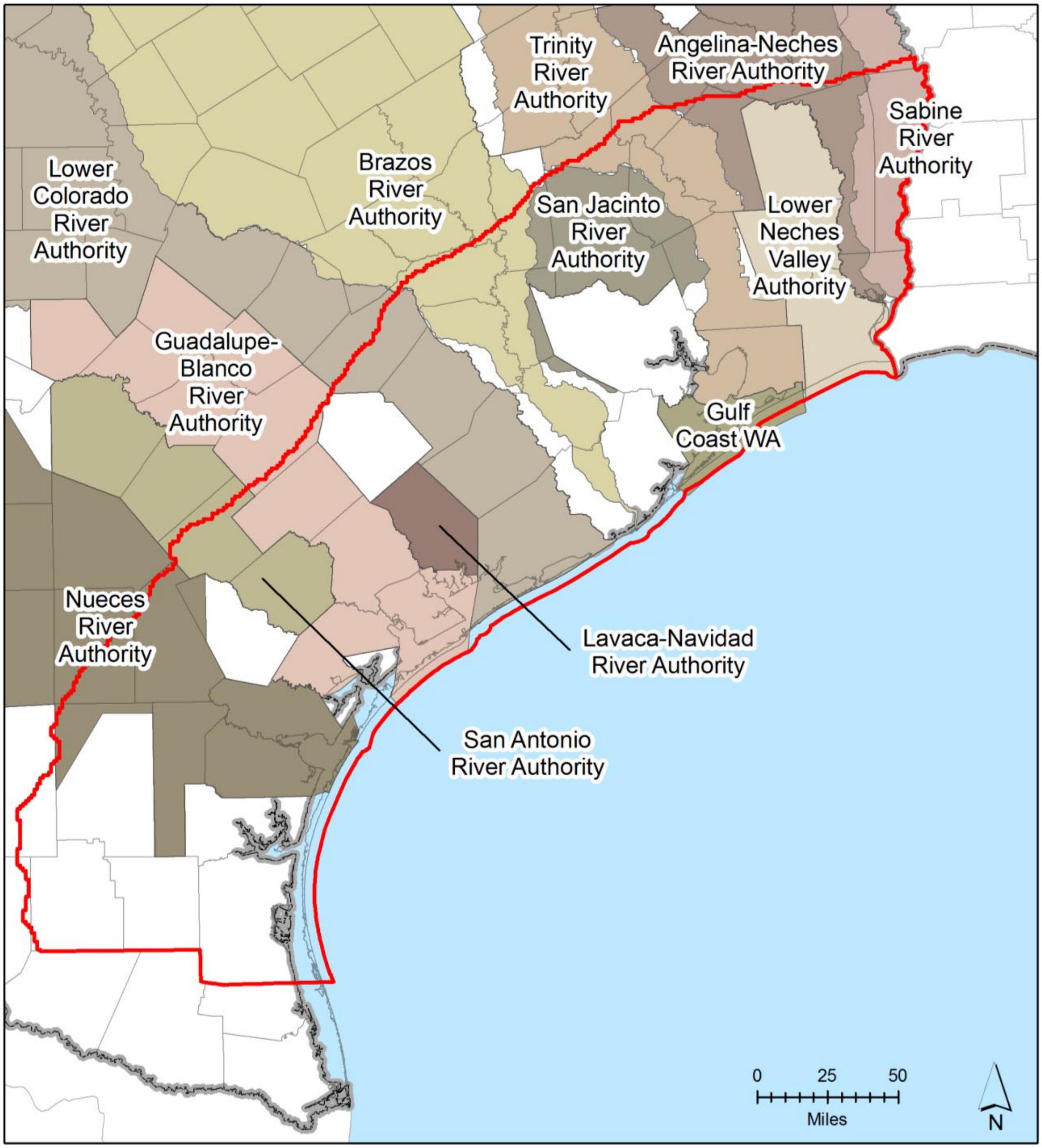

Figure 4-4. **River authorities in the study area.**

Note: WA=water authority

5 Hydrogeologic Setting

5.1 Texas Gulf Coast

The Texas Gulf Coast is a part of the Gulf of Mexico, which is a small, semi-enclosed ocean basin surrounded by continental shelves and coastal plains (Bryant and others, 1991). The northwest portion of the Gulf of Mexico includes the major sand and sandstone aquifer systems that include the Texas Gulf Coast Aquifer System (Williamson and Grubb, 2001; Chowdhury and Turco, 2006). Figure 5-1 provides a simplified stratigraphic and hydrogeologic chart of the Texas Gulf Coast Aquifer System. As shown in Figure 5-1, the Gulf Coast Aquifer System consists of the Catahoula Formation and younger formations. Underlying the Catahoula Formation is the Yegua-Jackson Aquifer.

5.2 Stratigraphy

The study will use the Gulf Coast stratigraphy developed recently by the TWDB (Young and others, 2010, 2012), which differs slightly from the hydrogeologic units shown in Figure 5-1. Young and others (2010, 2012) base their technical approach on the correlation and sequence stratigraphic concepts used by the Gulf Basin Depositional Synthesis Project and the Lower Colorado River Authority-San Antonio Water System Water Project. The common thread among these studies is that chronostratigraphic correlations are used to identify clay-dominated flooding surfaces of the same age to represent the boundaries of episodes that deposit the coarse sediment of an aquifer.

Young and others (2010, 2012) defined 10 geological units in the Gulf Coast Aquifer System. The Chicot Aquifer includes, from the shallowest to deepest, the Beaumont and Lissie formations of Pleistocene age and the Pliocene-age Willis Formation. The Evangeline Aquifer includes the upper Goliad Formation of earliest Pliocene and late Miocene age, the lower Goliad Formation of late Miocene age, and the upper unit of the Lagarto Formation (a member of the Fleming Group) of late and middle Miocene age. The Jasper Aquifer includes the lower Lagarto unit of early Miocene age, the early Miocene Oakville sandstone member of the Fleming Group, and the portions of the Oligocene-age Catahoula Formation. The Catahoula Formation is underlain by the Yegua-Jackson aquifer and is overlain by the Brazos River Alluvium Aquifer. Figure 5-2 shows the outcrops of the 10 geological units in the Texas Gulf Coast, the Yegua-Jackson Aquifer, and the Brazos Alluvium Aquifer.

Young and others (2010, 2012) did not define the Catahoula Formation for their study. In order to define their base of the Jasper Aquifer, they used the lower of the following two surfaces. One of these surfaces was the base of the Jasper Aquifer, defined by the Source Water Assessment Program (Strom and others, 2003a,b,c), and the other surface was the base of the Oakville Formation. In addition, Young and others (2010, 2012) did not explicitly define a Burkeville Confining Unit. As defined by Baker (1979) and the Source Water Assessment Program database (Strom and others, 2003a,b,c), the Burkeville Confining Unit is a lithostratigraphic unit delineated by correlating clay units from formations of different geological ages. Young and others (2010, 2012) selected the middle Lagarto Formation as the geologic unit that best represented the properties of a Burkeville Confining Unit for the entire Texas Gulf Coast. A review of the lithologic profiles of the middle Lagarto Formation reveals large areas, particularly in up-dip areas of the Gulf Coast, where sands are prevalent.

To help illustrate the varied stratigraphy across the Gulf Coast Aquifer System, Figure 5-3 shows vertical cross-sections along the two cross-sections in Figure 5-2. In Cross-section 1, the Chicot Aquifer is significantly thicker and wider than the Chicot Aquifer in Cross-section 2. In Cross-section 2, the Evangeline Aquifer is significantly thicker than in Cross-section 1. In addition, whereas the Evangeline Aquifer outcrops in Cross-section 2, the Evangeline Aquifer subcrops in Cross-section 1 and comes no closer than 500 feet from ground surface.

5.3 Geologic Faults

Growth faults are one of the most prevalent fault types in the Gulf Coast Aquifer System. Growth faults are syndepositional normal faults that form mainly by gravitational failure during rapid sediment loading along an unstable shelf margin and upper slope (Winker and Edwards, 1983). Syndepositional means that sedimentation (deposition) is occurring at the same time as faulting. Growth faults are not isolated surfaces but instead are zones of sediment deformation that commonly enhance vertical flow and impede horizontal groundwater flow. It is believed that growth faults propagate upward through thin sedimentary cover as a series of minor, en echelon, faults that constitute a single mapped fault (Crans and others, 1980; Durham, 1971; Roland and others, 1981).

Figure 5-4 shows the major faults mapped in the Gulf Coast Aquifer System by the Bureau of Economic Geology. As shown in Figure 5-4, the fault zones are generally parallel to the Gulf Coast basin and are grouped according to the shelf-margin positions of major Cenozoic depositional episodes that they mark. As expected, the age of the faults become progressively younger basinward. Maximum displacement (several thousand feet) on growth faults occurs in deep formations, such as the Wilcox and Frio, and decreases upward. In the Gulf Coast Aquifer System, maximum fault displacements are a few hundred feet, and surface expressions of active faults are generally only a few feet (Verbeek, 1979). Faults in the Gulf Coast Aquifer System have the potential to impact groundwater flow in several ways. As discussed by Young and others (2013), faults can hinder horizontal flow by offsetting sand units and restricting the continuity of sands across the fault zone, and by enhancing vertical flow by causing localized breaches in confining units.

5.4 Salt Domes

Salt domes have the potential to affect the salinity of groundwater as a result of dissolution and introduction of sodium chloride salt into the groundwater system. Figure 5-4 shows a map of 64 salt domes in the Gulf Coast Aquifer System that are within 15,000 feet of ground surface. Table 5-1 provides the names, depths, and aquifers in which the salt domes terminate.

Wesselman (1971 and 1972) and Hamlin and others (1988) have used geophysical logs to identify high-salinity plumes within otherwise fresh water sands near several Gulf Coast Aquifer System salt domes and map actual sand-dome contacts. Shallow salt domes have the greatest potential to affect groundwater quality. There are 38 shallow salt domes in the Gulf Coast Aquifer System in Texas that range in depth from 0 to 1,500 feet (Figure 5-4, Table 5-1).

Salt domes typically include three elements: salt stock, cap rock, and surrounding uplifted sediments. The core of a salt dome forms a vertically elongate, cylindrical stock, consisting of 90 to 99 percent crystalline rock salt (halite). Salt-dome crests are generally one to three miles in diameter. Cap rock composed of sulfate and carbonate minerals commonly overlies the crest of the salt stock and drapes down the uppermost flanks (Figure 5-5). Cap-rock formation results from salt dissolution. Anhydrite (calcium sulfate), the main impurity in the salt stock, forms a residual accumulation at the dome crest after the salt has dissolved.

Several researchers have documented the dissolution of salt domes by groundwater and the resulting increase in the salinity of nearby groundwater (Seni and Jackson, 1984; Bruno and Hanor, 2003; Wesselman, 1971 and 1972; Hamlin and others (1988). As shown in Figure 5-5, Hamlin and others (1988) used geophysical logs to map the complicated pattern of vertical and lateral salinity variation near the Barbers Hill salt dome in Chambers County.

Table 5-1. Salt domes located within 15,000 feet of land surface in the Texas Gulf Coast (data from Ewing, 1990).

Salt Dome Name	Land Surface (ft, msl)	Depth (ft) to Cap	Depth (ft) to Salt	Aquifer at Dome Top	Salt Dome Name	Land Surface (ft, msl)	Depth (ft) to Cap	Depth (ft) to Salt	Aquifer at Dome Top
Allen	5	760	1,380	Chicot	Long Point	75	550	930	Chicot
Arriola	40	3,930	3,930	Deep	Lost lake	5	3,275	5,430	Evangeline
Barbers hill	75	350	1,000	Chicot	Manvel	55	11,400	11,400	Deep
Batson	80	1080	1,400	Evangeline	Markham	55	1,350	1,420	Chicot
Big creek	80	450	600	Chicot	Mcfaddin beach	0	1,410	2,600	Chicot
Big hill	30	200	1,300	Chicot	Millican	300	4,890	5,170	Deep
Blue ridge	85	143	230	Chicot	Moca	500	6,365	6,365	Deep
Boling	75	380	975	Chicot	Moss Bluff	35	625	1,100	Chicot
Brenham	300	700	1,834	Jasper	Mykawa	50	7,100	7,100	Deep
Bryan mound	10	680	1,067	Chicot	Nash	55	620	950	Chicot
Cedar point	0	10,300	10,300	Deep	North Dayton	85	580	800	Chicot
Clam lake	0	8,200	8,200	Deep	Orange	10	7,120	7,120	Deep
Clay creek	250	1,400	2,400	Deep	Orchard	110	285	369	Chicot
Clemens	13	600	1,400	Chicot	Palangana	430	120	420	Evangeline
Damon mound	110	0	530	Chicot	Pescadito	680	14,500	14,500	Deep

Salt Dome Name	Land Surface (ft, msl)	Depth (ft) to Cap	Depth (ft) to Salt	Aquifer at Dome Top	Salt Dome Name	Land Surface (ft, msl)	Depth (ft) to Cap	Depth (ft) to Salt	Aquifer at Dome Top
Danbury	20	5,000	5,000	Jasper	Piedras Pintas	375	830	830	Evangeline
Davis hill	100	800	1,200	Evangeline	Pierce junction	60	730	950	Chicot
Day	250	2,710	3,200	Deep	Port Neches	5	6,950	6,950	Deep
Dilworth ranch	290	7,650	7,650	Deep	Raccoon bend	150	11,000	11,000	Deep
Esperson	55	6,000	6,000	Deep	Red fish reef	0	15,200	15,200	Deep
Fannett	15	740	2,000	Chicot	San Felipe	120	3,160	4,200	Deep
Ferguson xing	220	3,820	4,040	Deep	San Luis Pass	0	193	400	Chicot
Gulf	20	825	1,100	Chicot	Saratoga	90	1,500	1,900	Evangeline
Gyp hill	130	0	986	Chicot	Sour lake	50	500	720	Chicot
Hankamer	35	7,535	7,580	Deep	South Houston	35	4,406	4,406	Jasper
Hawkinsville	10	95	600	Chicot	South Liberty	20	320	480	Chicot
High island	20	150	1,100	Chicot	Spindletop	20	700	1,200	Chicot
Hockley	170	76	1,000	Chicot	Stratton ridge	10	850	1,308	Chicot
Hoskins mound	20	574	1,070	Chicot	Sugarland	65	3,450	4,280	Jasper
Hull	75	260	600	Chicot	Thompson	55	9,315	9,315	Deep
Humble	75	700	1,200	Chicot	Webster	30	10,500	10,500	Deep
Kittrell	300	2,990	3,855	Deep	West Columbia	30	740	790	Chicot

Note: ft=feet; msl=mean sea level

ERA	Epoch		Est. Age (M.Y)	Geologic Unit	Hydrogeologic Unit
Cenozoic	Pleistocene		0.7	Beaumont	CHICOT AQUIFER
			1.6	Lissie	
	Pliocene		3.8	Willis	
	Miocene	Late	11.2	Upper Goliad	EVANGELINE AQUIFER
			14.5	Lower Goliad	
		Middle	17.8	Upper Lagarto	
				Middle Lagarto	BURKEVILLE
		Early		Lower Lagarto	JASPER AQUIFER
			24.2	Oakville	
	Oligocene		32	Frio	CATAHOULA
			34	Vicksburg	

Figure 5-1. Geologic and hydrologic units of the Gulf Coast Aquifer.

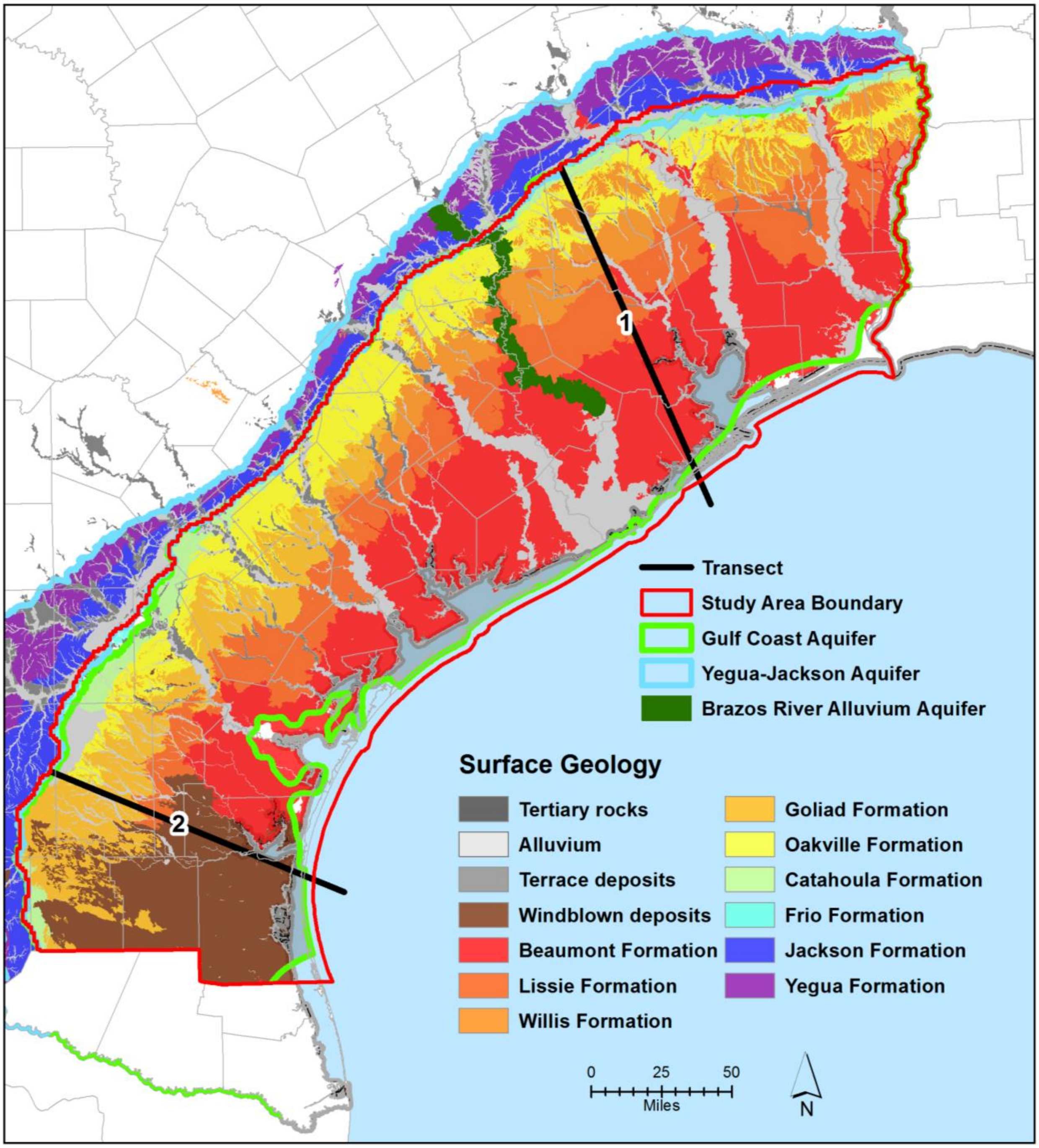

Figure 5-2. **Map of the Texas Gulf Coast showing the surface geology and the outcrops of the Gulf Coast, Yegua-Jackson and Brazos River Alluvium aquifers.**

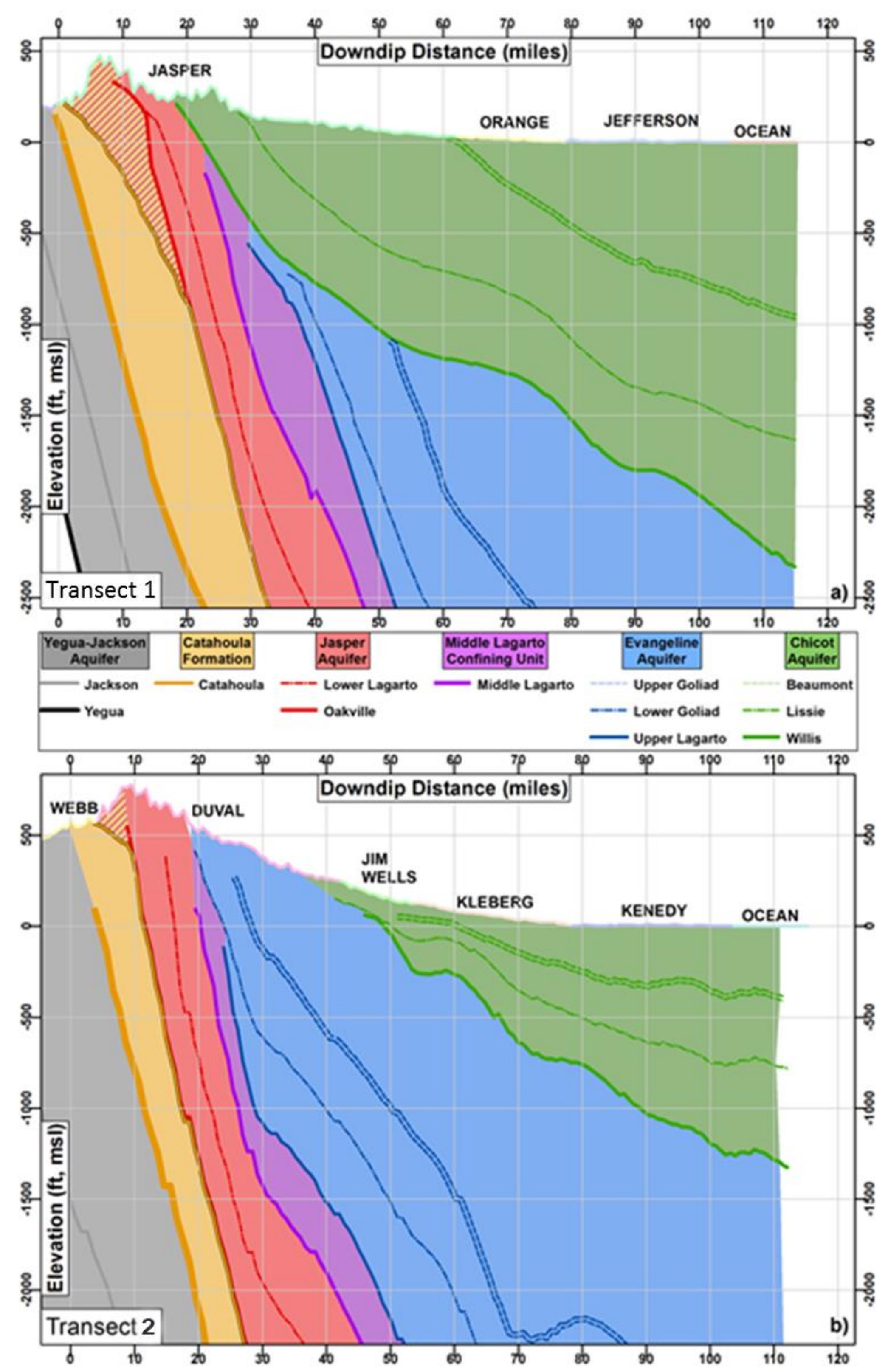

Figure 5-3. **Geologic cross-sections through Transects 1 and 2 (note: surfaces represent the bottom of each geological formation).**

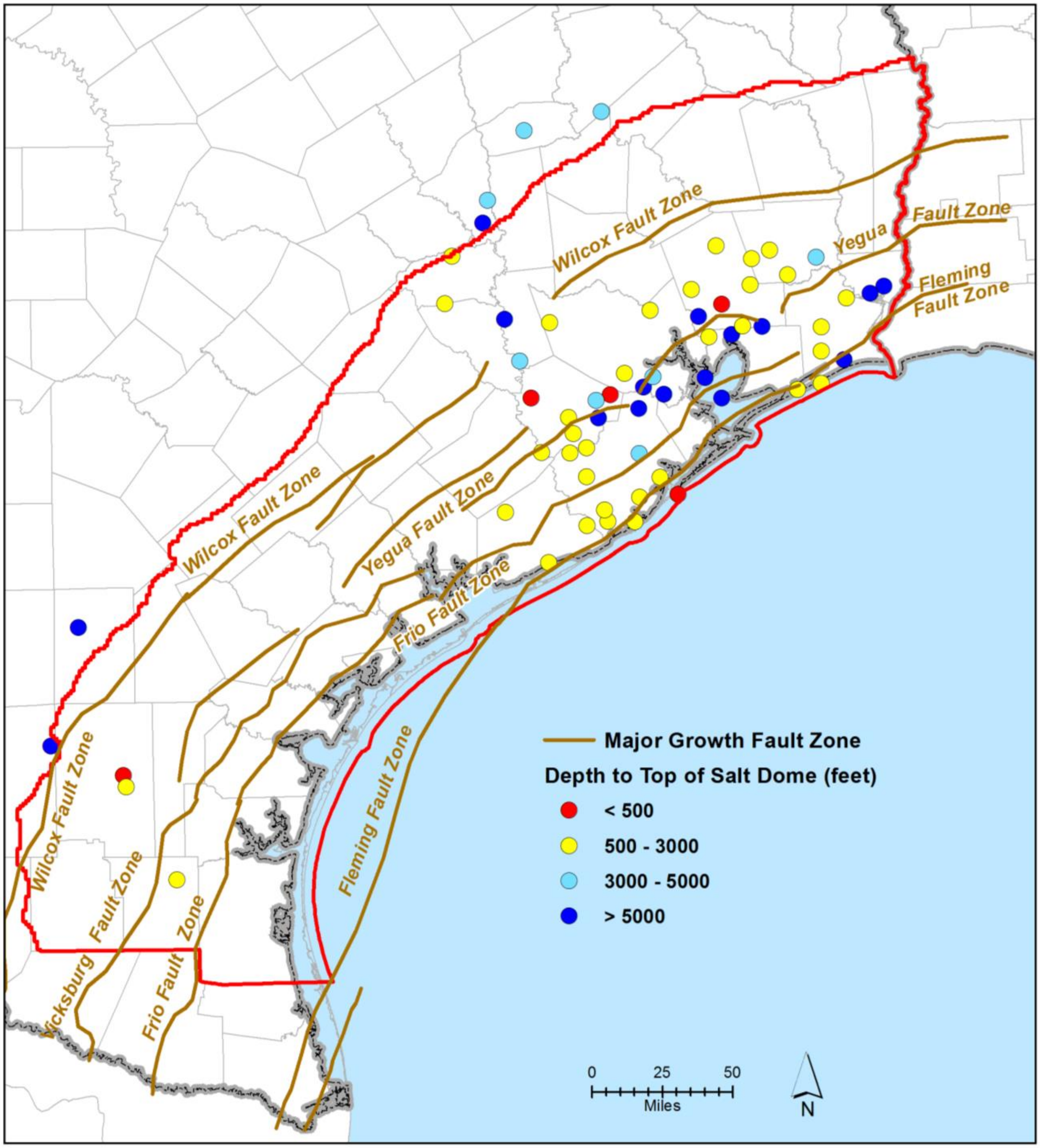

Figure 5-4. **Map showing major growth fault zones and shallow salt domes in the onshore part of the Texas coastal zone (fault locations from Ewing, 1990).**

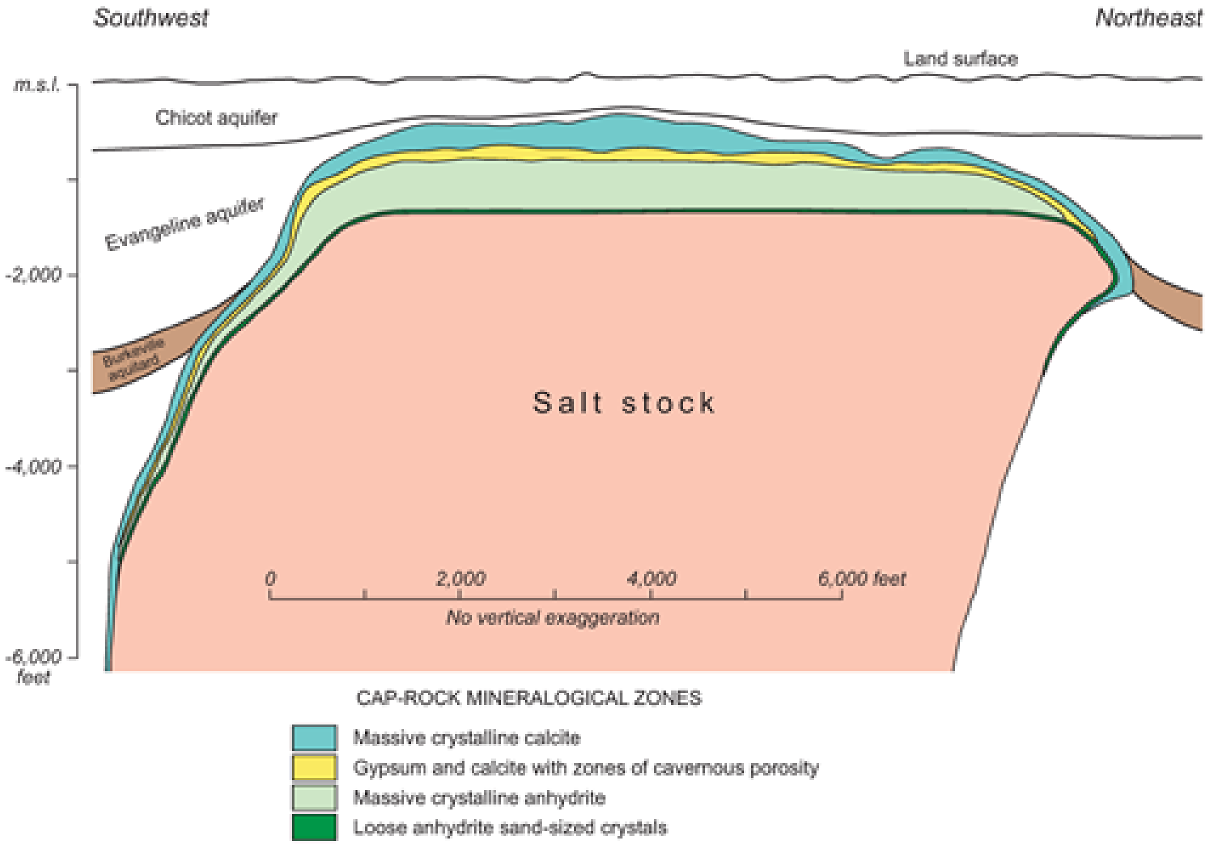

Figure 5-5. Cross section of Barbers Hill salt dome in Chambers County showing the salt stock, cap rock mineralogical zones, and enclosing hydrostratigraphic intervals (modified from Hamlin and others, 1988).

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6 Groundwater Salinity Zones

The salinity zones were developed primarily based on the interpretation of geophysical logs used to estimate the concentration of total dissolved solids across the entire study area. Geophysical well logs were used because total dissolved solids concentrations are limited both laterally and especially vertically across the Gulf Coast Aquifer. In areas where the geophysical logs did not provide sufficient coverage to define the base of the fresh water zone, we augmented our interpretation with nearby water quality measurements.

The groundwater was classified using the criteria presented in Table 6-1. The first four criteria were developed by the United States Geological Survey (Winslow and Kister, 1956). Our salinity zones were developed by interpolation of total dissolved solids concentrations picked at sand beds using two different analysis methods. For total dissolved solids concentrations at 1,000 and 3,000 milligrams per liter, we used the Mean R_o Method (mean resistivity of the formation). For total dissolved solids concentrations of 10,000 and 35,000 milligrams per liter, we used the R_{wa} Minimum Method (minimum apparent resistivity of formation water). The development and methodology associated with these methods is provided in Section 13.

Table 6-1. Groundwater classification based on the criteria established by Winslow and Kister (1956).

Water Classification Description	TDS Range
Fresh	Less than 1,000 mg/L
Slightly Saline	1,000 to 3,000 mg/L
Moderately Saline	3,000 to 10,000 mg/L
Very Saline	10,000 to 35,000 mg/L
Brine	>35,000 mg/L

Note: TDS=total dissolved solids; mg/L=milligrams per liter

Our study was completed at a regional scale and was not designed to characterize the variations that may occur at the local scale, or those needed to design and operate a well field that provides source water to a desalination plant. Figure 6-1 shows the location of the 600 logs used to estimate total dissolved solids concentrations. The average spacing between the logs is about 5 miles. The cross-sections in Figure 6-1 were used to visualize the variation in the predicted salinity values along vertical cross-sections with a higher density of logs relative to most of the study areas.

The salinity zones surfaces were initially developed using a computer program and then manual review. The computer program analyzed each well independently and picked the bottom of a salinity zone based on instructions related to the vertical variation observed in the salinity values at the sand pick locations identified on the geophysical logs. The initial picks made by the computer program were then visualized using another software program that plotted vertical profiles of salinity picks along cross-sections developed by a hydrogeologist. The hydrogeologist then approved, moved, or deleted the initial computer-generated pick.

The salinity zones for fresh, slightly saline, moderately saline, and very saline water were generated by interpolating the salinity picks at each log using the topo-to-raster tool, an interpolation method provided in ArcGIS. In the subsequent subsections of this section, we present a short discussion of the calculated base elevation and thickness for each salinity zone. Then we show the salinity picks used to mark the base of each salinity zone on the geophysical logs that comprise the nine cross-sections shown on Figure 6-1.

6.1 Fresh Water Zone

Figure 6-2 shows the base of the fresh water zone. Appendix 19.1 lists the 344 picks on geophysical logs that were used to create the 1,000 milligrams per liter surface. The pattern shows a deepening of the fresh water zones to depths greater than 1,500 feet toward the middle vicinity of Groundwater Management Areas 14 and 15. In the vicinity of San Patricio, Nueces, Bee, Aransas and Calhoun counties, the fresh water zone thins to between 250 and 500 feet. In the vicinity of Kenedy County and near the coast line, there is a thin fresh water zone that has a base at a depth of about 1,000 feet. Above this fresh water zone there is about 1,000 feet of saline water. This feature is discussed further later in this section.

6.2 Slightly Saline Zone

Figure 6-3 shows the base of the slightly saline zone. Appendix 19.1 lists the 451 picks on geophysical logs that were used create the 3,000 milligrams per liter surface. The depth pattern mimics the large-scale relief pattern evident in the fresh water zone. Figure 6-3 shows a deepening of the slightly saline zones to depths greater than 2,500 feet in Groundwater Management Areas 14 and 15, as well as in Brooks and Jim Hog counties. Along the coastline near San Patricio, Nueces, Refugio, and Chambers counties, the depth to the base of the 3,000 milligrams per liter surface is less than 500 feet. Figure 6-4 shows a thickness map of the slightly saline zone. Across much the study area, the slightly saline zone is between 500 and 1,000 feet thick. In the southern portion of the study area in Brooks and Jim Hogg counties, the zone thickens to 2,000 feet. Likewise, the slightly saline zone thickens to 1,500 to 2,000 feet in the vicinity of Colorado, Wharton, Austin, Waller, and Harris counties. Along most of the coastline, the zone is less than 500 feet thick.

6.3 Moderately Saline Zone

Figure 6-5 shows the base of the moderately saline zone. Appendix 19.1 lists the 434 picks on geophysical logs that were used to create the 10,000 milligrams per liter surface. Toward the western edge of the study area, the surface is coincident with the bottom of the Catahoula Formation, because we used the Catahoula Formation as the lower boundary for any of the salinity zones. Included in the figure is the down dip extent of where the base of the Catahoula Formation is above the base of the moderately saline zone. East of the "base of Catahoula" line, the depth to base of the moderately saline zone is typically greater than 3,000 feet. The greatest depth of the moderately saline zone is about 4,000 feet and occurs in Brooks and Jim Hogg counties. Figure 6-6 shows a thickness map of the moderately saline zone and, across much the study area, it is between 500 and 1,000 feet thick. The thickest portion of the moderately saline zone occurs in southern Duval County, where thicknesses greater than 2,500 feet are prevalent. In the southern portion of the study area near Brooks County, the moderately saline zone thickens to 2,500 feet. Along most of the coastline, the moderately saline zone is less than 500 feet thick.

6.4 Very Saline Zone

Figure 6-7 shows the base of the very saline zone. Appendix 19.1 lists the 147 picks on geophysical logs that were used to create the 35,000 milligrams per liter surface. Approximately half of the base of the very saline zone is coincident with the bottom of the Catahoula Formation, because we used the Catahoula Formation as the lower boundary for any of the salinity zones. Included in the figure is the down dip extent of where the base of the Catahoula is above the base of the very saline zone. East of the "base of Catahoula" line, the depth to the base of the very saline zone typically ranges between 3,500 and 4,000 feet. Along the coastline, the depth typically ranges between 1,500 to 2,500 feet. Figure 6-8 shows a thickness map of the very saline zone, which is between 500 and 1,000 feet thick across much of the study area. The thickest portion of the zone is about 4,000 feet and is located in San Patricio County. Near the coastline, much of the very saline zone is between 400 and 1,000 feet thick.

6.5 General Evaluation the Bottom Surfaces of the Salinity Zones

As part of this project, we generated two surfaces that can be used to help evaluate the reasonableness of the base of the fresh water zone shown in Figure 6-2. One of the maps was generated using groundwater well data from the TWDB, and the other map was generated by the base of fresh water picks made by the Texas Railroad Commission.

Figure 6-9 shows the depth to fresh water based on an interpolation of the water quality data from the TWDB groundwater database. To generate the map, we extracted all the wells with an average measured total dissolved solids concentration less than 1,000 milligrams per liter from the database and portioned them into 5-mile by 5-mile grid cells located within the study area. For each group of water wells in a grid cell, we mapped the maximum well depth where the measured average total dissolved solids concentration is less than 1,000 milligrams per liter. If there were no wells in the grid cell with a total dissolved solids concentration less than 1,000 milligrams per liter, the grid cell was left blank, indicating no concentration was determined for the grid cell.

Figure 6-10 shows the depth to fresh water based on an interpretation of geophysical logs and other data made by the Groundwater Advisory Unit at the Texas Railroad Commission and its predecessor agencies. The map was recreated from an analysis of approximately 23,000 picks to the depth of fresh water that the Texas Railroad Commission has in databases at the Division of Subsurface Casing. We divided the picks into the same 5-mile by 5-mile grid cells used in Figure 6-9 and calculated the average of the total dissolved solids values in each grid cell.

Our base of fresh water salinity zone in Figure 6-2 shows good agreement with the base of fresh water values in Figure 6-10, except for several small regions in the southern end of the study area. In this area, we have the base of fresh water a couple of hundred feet lower than those on the map based on the Texas Railroad Commission picks. A possible explanation of the difference is the approach for handling scenarios where a zone of slightly saline groundwater is above a zone of fresh water. Based on our data, this occurs in Kenedy, Kleberg, and Nueces counties. In addition to Figure 6-10, our results in Figure 6-2 also compare favorably with results in Figure 6-9, if the difference in our deeper base of fresh water in Jackson and Wharton counties is attributed to the lack of wells in the deeper part of the aquifer.

Comparison of our base of the slightly saline zone in Figure 6-3 shows good agreement with the base of useable or fresh quality water in Figure 6-11. Figure 6-11 shows the depth to useable water quality based on an interpretation of geophysical logs and other data made by the Groundwater Advisory Group at the Texas Railroad Commission and its predecessor agencies. The agency defines useable water quality in the Gulf Coast as groundwater with total dissolved solids of 3,000 milligrams per liter or less. The depth contours were recreated from our analysis of approximately 53,000 picks to the depth of useable water that the Texas Railroad Commission has it in databases at the Division of Subsurface Casing. The similarity between Figure 6-11 and 6-3 is quite remarkable across much of the study area.

With regard to checking our base maps for the moderately saline and very saline zones, we compare our results to maps of average salinity concentrations generated by the Core Laboratories (1972) and provided in a publication titled: "A Survey of the Subsurface Saline Waters of Texas." Their map for depths of 4,000 to 6,000 feet show that, across much of the study area, the average total dissolved solids concentrations north of Victoria County are typically greater than 60,000 milligrams per liter, but in the vicinity of Jim Wells, Duval, and a small portion of Nueces County, are less than 10,000 milligrams per liter. This same map shows the average total dissolved solids concentrations of about 30,000 milligrams per liter in the vicinity of Brooks and Kleberg counties. These total dissolved solids concentration levels mapped by Core Laboratories (1972) are consistent with our depth to the base the brine salinity zone of 4,000 to 5,500 feet shown in Figure 6-7. The Core Laboratories (1972) map shows total dissolved solids concentration values of 60,000 milligrams per liter and greater for much of the coastline, which is a result consistent with the base of the brine salinity zone of less than a depth of 3,000 feet along the coastline in Figure 6-7.

6.6 Cross-sectional View of the Salinity Zones

Figures 6-12 through 6-29 show the calculated salinity zones for sand beds identified on geophysical logs associated with the nine cross-sections shown in Figure 6-1. For each cross-section, two figures are presented. One figure shows markers that identify the base of the different salinity zones. The other figure shows markers that identify the base of the different formations. Listed below are general observations relevant to the difficulty inherent in developing mapping salinity zones without a high density of control points.

- At many log locations, there is an oscillatory behavior in the salinity zones that can occur over relatively short vertical distances. This behavior complicates the process of establishing simple rules to picking the base of a salinity zone at a single well.
- Where oscillatory behavior does occur and thick sands are adjacent to thin sands, the thin sand will tend to indicate a higher total dissolved solids salinity zone than indicated by

the thicker sand. This difference is attributed to the different properties, such as porosity, and clay content, between the two sand beds. In this situation, we have presumed that the more reliable estimate of water quality is associated with the thicker sand bed.

- There are several logs that have such drastic differences in predicted salinity profiles compared to their neighboring wells, it would seem logical that there is a problem with the log. Examples of such wells are American Petroleum Institute (API) log 4215731983 on cross-section #8 (Figures 6-16 and 6-17) and American Petroleum Institute (API) log 4223901556 on cross-section #13 (Figures 6-20 and 6-21). Possible reasons for these situations, other than the natural variability of the aquifer system, are incorrect spatial coordinates for the well, an improper logging of the well, or errors or shifts in the digitized curve.
- Highly localized spikes in the resistivity values that cause apparent anomalous shifts in salinity may reflect potentially important water quality zones, but we are unsure whether the cause for the relatively high resistivity is the groundwater quality or changes in lithology types. We know that in several formations, small amounts of limestone are present, and these could be contributing to the spike in resistivity values. Also, at depth, there is evidence to suggest gases, such as methane and hydrogen sulfide, may be affecting the formation resistivity.
- A disadvantage of plotting total dissolved solids concentration by salinity zone is that the magnitude of difference within each range of total dissolved solids concentration for two sands with different salinity zone classification is not known. However, an advantage of the plotting approach of classifying total dissolved solid concentrations into a few ranges as salinity zones helps a user to quickly assess the water quality trends along a cross-section.

The above observations are among the reasons why we relied heavily on manually performing salinity picks using groups of wells along cross-sections. Despite some of the difficulty with resolving the boundary between salinity zones at a single log, we often found strong lines of evidence to determine where to mark boundaries between the salinity zones at the regional scale.

Perhaps the most difficult salinity zone to create was the fresh water salinity zone. In most of the study area, the water well and geophysical log data indicated that fresh water could be found at or near land surface. Some geophysical logs indicated that slightly or moderately saline water could be at the surface, but the inconsistency of these trends, along with adjacent fresh water well total dissolved solids measurements, resulted in us keeping the shallow water classified as fresh. An exception to this occurred in the southeast portion of the study area, predominantly in Nueces, Kleberg, and Kenedy counties. Geophysical log data indicated that, while some fresh water was present mostly in the Evangeline Aquifer, the fresh water was overlain by water with higher total dissolved solids. This trend can be seen in cross-sections #22 and #25 (Figures 6-26 through 6-29), and was found in other geophysical logs near those cross-sections. Consistent with this, the water well water quality measurements in Section 10 (Figures 10-1 through 10-4) indicate that the Chicot Aquifer in this area has very little fresh water, while the deeper Evangeline contains a higher frequency of water wells with fresh measurements.

The extent of the area where this condition (slightly saline on top of fresh) occurs was estimated based on both the water well data and geophysical logs and is shown in Figure 6-30. The elevation of the top of the subsurface fresh water wedge was estimated based on the geophysical logs. This elevation is show in Figure 6-31. A comparison between Figure 6-31 and Figure 6-2 shows that the deep fresh water shown in Kenedy County is not indicative of a large thickness of fresh water, but rather a small wedge of fresh water that lies below slightly saline water. We consider all of the water above the surface shown in Figure 6-31 to be slightly saline, although there is some indication in the geophysical logs that portions of the water may be higher in total dissolved solids (see American Petroleum Institute [API] logs 4226100353 and 4226100201 located in Kenedy County in Figure 6-28). Given that the majority of total dissolved solids measurements in Chicot water wells are less than 3,000 milligrams per liter, and the lack of consistent correlation of higher total dissolved solids markers in the geophysical logs, we consider slightly saline to be the best estimate for the entire volume from ground surface down the depth shown in Figure 6-31.

6.7 Potential Production Areas

House Bill 30 provides direction to TWDB to identify and designate local or regional brackish groundwater production zones in areas of the state with moderate to high availability and productivity of brackish groundwater that can be used to reduce the use of fresh groundwater. Table 6-2 defines the criteria set forth in House Bill 30 to be used for designation of brackish groundwater production zones. It is important to note that the TWDB designates brackish groundwater production zones. Table 6-3 lists the approach this study has taken to address each of the criteria in Table 6-2. This report uses the information presented here and the criteria defined below to define Potential Production Areas that will be considered for designation as brackish groundwater production zones by the TWDB.

Table 6-2. House Bill 30 criteria for designation of Potential Production Areas.

Criteria Type	Criteria for Designation of a Brackish Groundwater Production Zone
Water Quality	Has an average total dissolved solids level of more than 1,000 milligrams per liter.
Hydraulic Isolation	Separated by hydrogeologic barriers sufficient to prevent significant impacts to water availability or water quality in the area of the same or other aquifers, subdivisions of aquifers, or geologic strata that have an average total dissolved solids level of 1,000 milligrams per liter or less at the time of designation of the zone.
Aquifer Use	Is not serving as a significant source of water supply for municipal, domestic, or agricultural purposes at the time of designation of the zone.
Aquifer Use	Is not in an area or geologic stratum that is designated or used for wastewater injection through the use of injection wells or disposal wells permitted under Chapter 27 of Texas Water Code.
Regulatory Jurisdiction	Is not located in an area of the Edwards Aquifer subject to the jurisdiction of the Edwards Aquifer Authority; the boundaries of the: (a) Barton Springs-Edwards Aquifer Conservation District; (b) Harris-Galveston Subsidence District; or (c) Fort Bend Subsidence District.

Table 6-3. Approaches for Addressing House Bill 30 Criteria for designation of Potential Production Areas.

Criteria Type	Approach for Addressing Criteria Type
Water Quality	No Potential Production Area nor any subdivision of a Potential Production Area will exist in the Fresh Water Zone defined by this project.
Hydraulic Isolation	Hydraulic isolation will be evaluated by examining the hydrogeologic conditions. Hydrogeological conditions that will consider capable of producing hydrological layering include fault zones, low permeability strata, and sufficient distance from areas sensitive to drawdown impacts
Aquifer Use	Proximity to municipal, domestic, or agricultural wells that are serving as a significant source of water supply
Aquifer Use	No Potential Production Area will include a geologic stratum designated for wastewater injection or a region contained in the Very Saline or Brine Salinity Zones defined by this project. In addition, regions in a Potential Production Area where water quality is found to be at risk of adverse impact from injection wells, operations will be excluded at the time such evidence is discovered.
Regulatory Jurisdiction	No Potential Production Area will include an area subject to the jurisdiction of the Harris-Galveston Subsidence District or the Fort Bend Subsidence District.*

* Our study area does not include the area of the Edwards Aquifer subject to the jurisdiction of the Edwards Aquifer Authority or the Barton Springs-Edwards Aquifer Conservation District. Thus, the Harris-Galveston Subsidence District and the Fort Bend Subsidence District define the regulatory jurisdictions that define the exclusion zones for Potential Production Areas.

The criteria of hydraulic isolation will be discussed in several other sections of the report, including Section 11 (Net Sand Analysis) and Section 14 (Potential Production Area Analysis and Modeling Methodology). One of the concepts explored in the modeling methodology section is that separation distances between exclusion zones and a potential brackish well field can act as a hydraulic barrier between the brackish zone and the excluded area. This type of isolation will be termed a distance isolation boundary, and they are somewhat arbitrary in nature because the definition of "significant impact" to fresh water availability or quality is not determined in this study.

6.7.1 Aquifer Use

Our approach to defining aquifer use involves reviewing the spatial distribution of wells throughout the study area with an emphasis on determining regional differences regarding the pumping from deep formations. To accomplish this task, we obtained well databases from groundwater conservation districts, the TWDB, the Texas Commission on Environmental Quality, and the Texas Railroad Commission. The information we obtained from the groundwater conservation districts did not improve our understanding of aquifer use beyond what was discovered from the other three data sets, so the groundwater conservations districts' data will not be presented in this report.

From the TWDB groundwater dataset, we obtained well depth information for 23,000 wells. From the Texas Commission on Environmental Quality database of Public Water Supply Wells, we obtained well depth information for 7,600 wells. From the TWDB submitted driller log dataset, we obtained well depth information for 3,500 wells. For all three of these databases, we partitioned the well locations among 5-mile by 5-mile grid cells and plotted the maximum depth per well. Figures 6-31, 6-32, and 6-33 show the spatial distribution of the maximum well depth values across the study area.

Figure 6-31 shows maximum well depths greater than 5,000 feet. At these depths, the wells are not likely to be water supply wells and thus were not included in our analysis. The general pattern of well depth is very similar to the pattern of depth to the base of the fresh water zones shown in Figure 6-9. The deepest wells are about 2,000 feet deep and are located in the vicinity of Harris and Montgomery counties. The results in Figure 6-32 suggest that most of the public water supply wells are already in the TWDB's groundwater database. Figure 6-33 shows the wells drilled since 2001. The distribution is similar to that in Figure 6-31, but is missing many of the deeper wells in the area around Jackson County, Jasper and Newton counties, and Kenedy and Kleberg counties.

A potentially useful way to review the well depth data is to assign an aquifer or formation to the deepest well. Figure 6-34 shows aquifers/formations that are associated with the deepest well in each grid cell in Figure 6-33. The resulting pattern of aquifers/formations changes along dip of the Gulf Coast Aquifer. In general, the aquifer associated with the deepest wells gradually shifts to older aquifers as a function of up-dip distance to the outcrop of the Catahoula Formation. In general, the aquifer pattern is similar to the pattern associated with the aquifer outcrop locations.

Figure 6-35 shows the top injection interval of active and permitted injection and disposal wells regulated under Chapter 27 of the Texas Water Code. The total number of well locations is 8,800. Approximately 490 wells have injection intervals at depths of 1,000 feet or less and approximately 950 wells have injection intervals at depths of 1,500 feet or less. Figure 6-36 shows the aquifer or major formation that is associated with the shallowest well depths for each grid cell. As shown in Figure 6-36, the injection wells are permitted in all the major aquifers in Groundwater Management Areas 14, 15, and 16. For each of the groundwater management areas, the general pattern of aquifer placement is similar. Near the coast, most of the injection wells are permitted in the Evangeline Aquifer and the permitting zones move to older aquifers the farther up dip the wells are permitted. Comparison of the aquifers in Figure 6-34 for water supply wells and in Figure 6-36 for injection and disposal wells shows that a few grid cells have the same aquifer/formation.

6.7.2 Potential Production Areas

The Potential Production Areas were developed through a four step process that considers the five criteria for House Bill 30 listed in Table 6-2, as well as the capacity for the brackish region to serve as a viable long-term source of water.

The development of the Potential Production Areas began with developing a three-dimensional volume of the brackish water by joining together the thickness of the slightly saline zone and the moderately saline zone. The very saline zone was then intersected by the volumes of the individual formations to produce maps of the areal extent and thickness of the brackish groundwater (including both the slightly saline and moderately saline water) in each formation. We then modified the map of brackish water in each formation by excluding the groundwater under the jurisdiction of the Harris-Galveston Subsidence District or the Fort Bend Subsidence District. We then partitioned and grouped the brackish volumes in each formation into preliminary Potential Production Areas based on areas where sandy units were prevalent and where clayey deposits were laterally extensive. Our last step was to adjust the surface boundaries of the preliminary Potential Production Areas to avoid overlapping with regions where wells are serving as a significant source of water supply. This sequence of events produced the six Potential Production Areas shown in Figures 6-37 and 6-38.

All six Potential Production Areas are comprised of multiple formations. The three Potential Production Areas (Potential Production Areas #1, #2, and #3) in Figure 6-37 include portions of the Catahoula, Oakville, and lower Lagarto formations. Potential Production Areas # 4, #5, and #6 in Figure 6-38 include the upper Lagarto, the lower Goliad, and the bottom third of the upper Goliad. Besides these three formations, Potential Production Areas #4 and #6 include the middle Lagarto formation. The three-dimensionality of the Potential Production Areas is evident in both figures by the varying configurations associated with the different formations and the varying thickness of brackish water within each formation.

In Figure 6-37, the break between Potential Production Areas #1 and #2 occurs as a result of two criteria in Table 6-2. One criterion is that a Potential Production Area cannot include Harris County because it is under the jurisdiction of the Harris-Galveston Subsidence District. The other criterion is that there are several large municipal well fields in Montgomery County that pump from the Catahoula Formation. Although Potential Production Areas #2 and #3 abut each other, they are identified as separate entities because of notable differences in their regional hydrogeology.

In Figure 6-38, the break between Potential Production Areas #4 and #5 occurs because neither Fort Bend County nor Harris County can be included as part of a Potential Production Area because these counties are under the jurisdiction of the Harris-Galveston Subsidence District. This break identifies the separate entities because of notable differences in their regional hydrogeology.

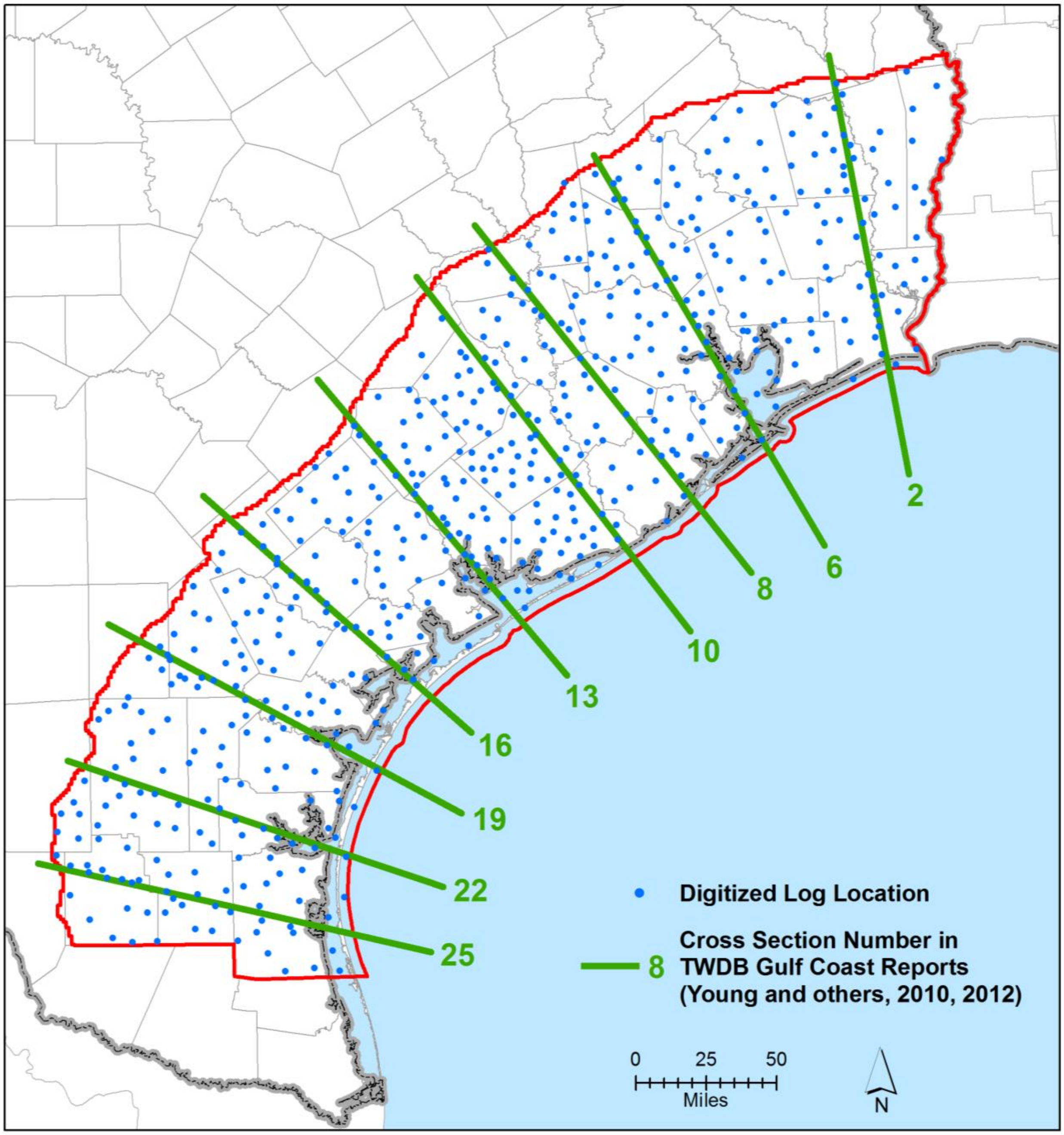

Figure 6-1. Location of the geophysical logs that were interpreted to develop salinity zones and location of nine cross-sections where vertical cross-sections of salinity zones are discussed.

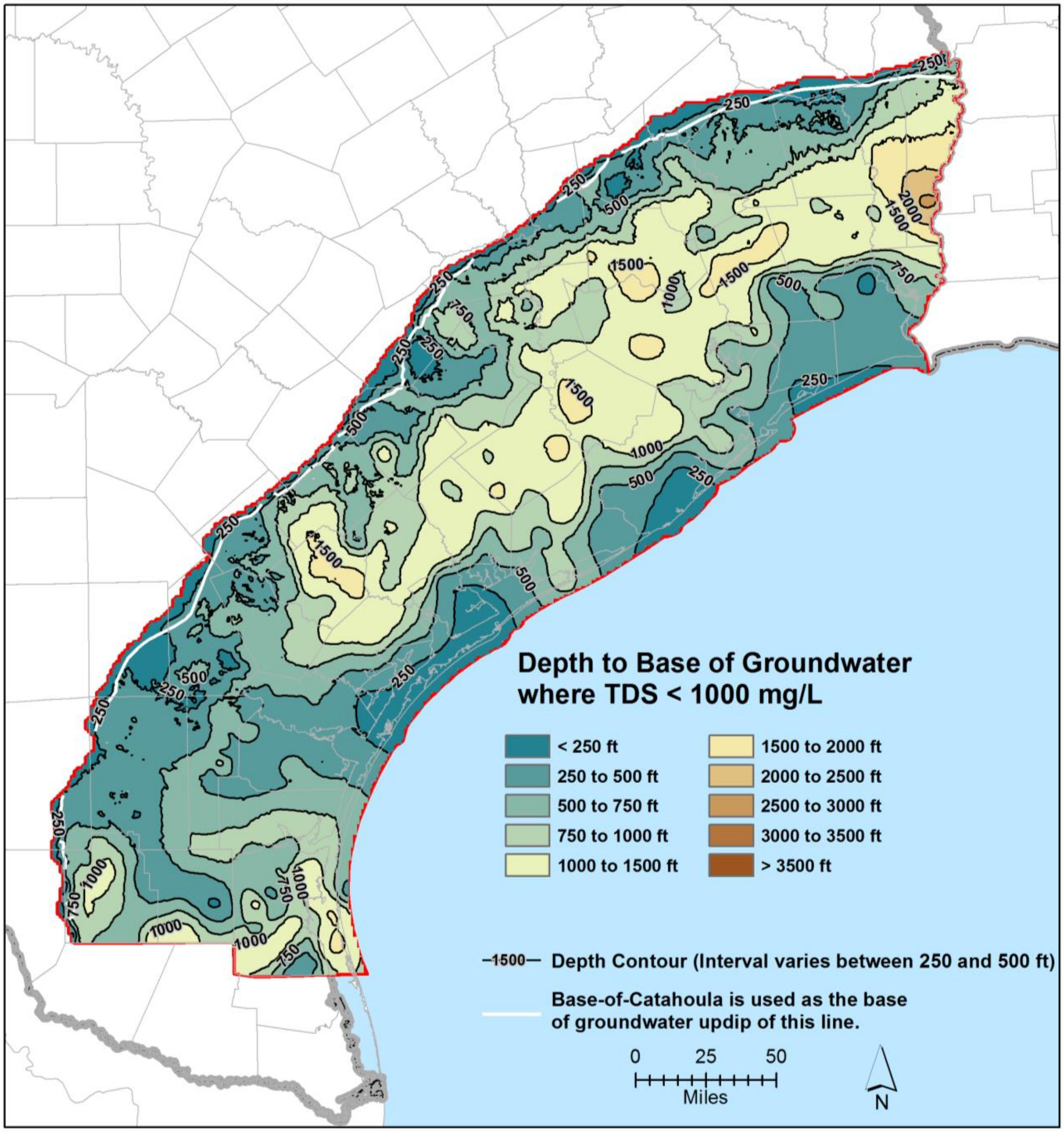

Figure 6-2. Depth to the base of the fresh water zone.

Note: TDS = total dissolved solids; mg/L=milligrams per liter; ft=feet

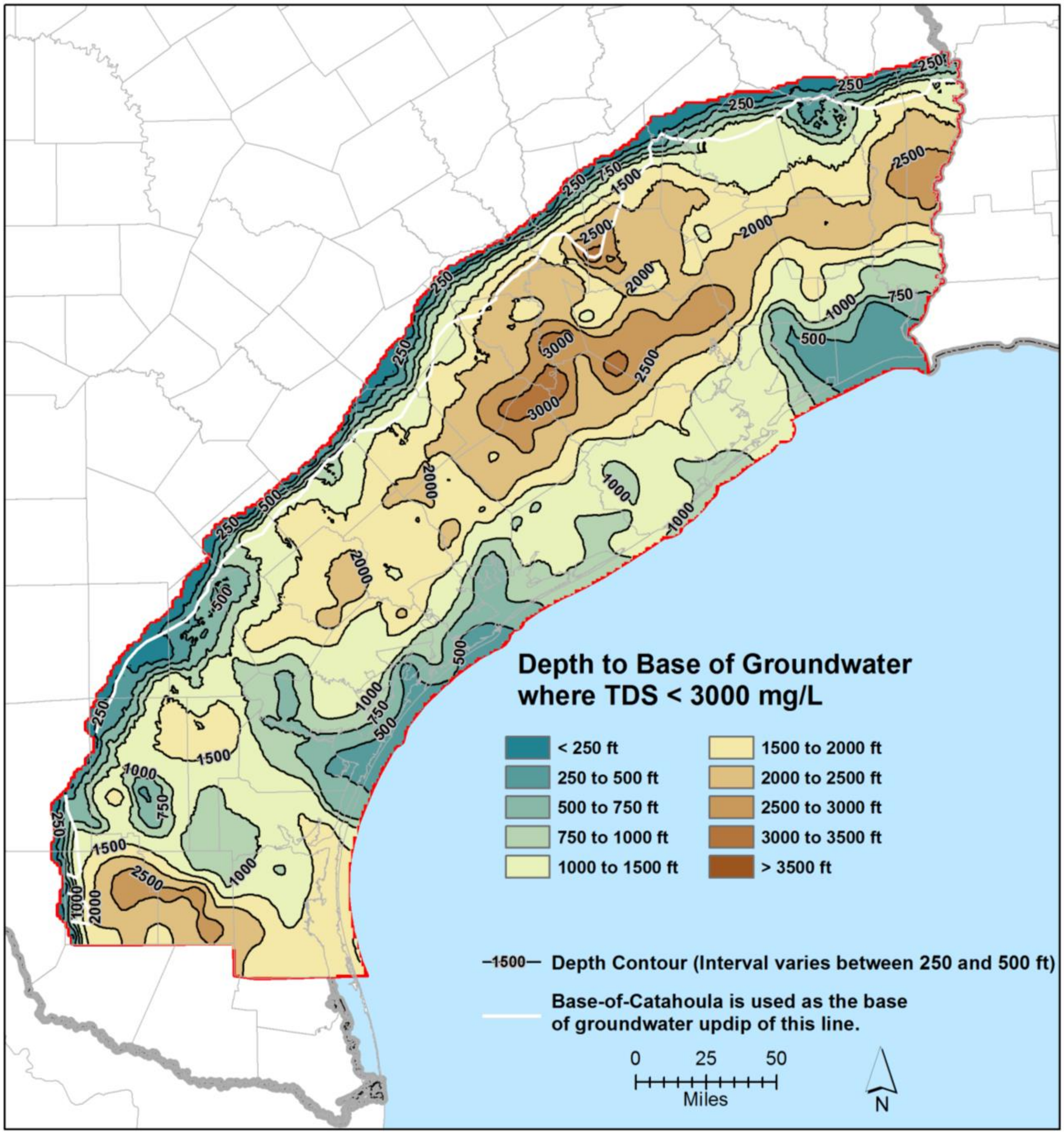

Figure 6-3. Depth to the base of the slightly saline zone.

Note: TDS = total dissolved solids; mg/L=milligrams per liter; ft=feet

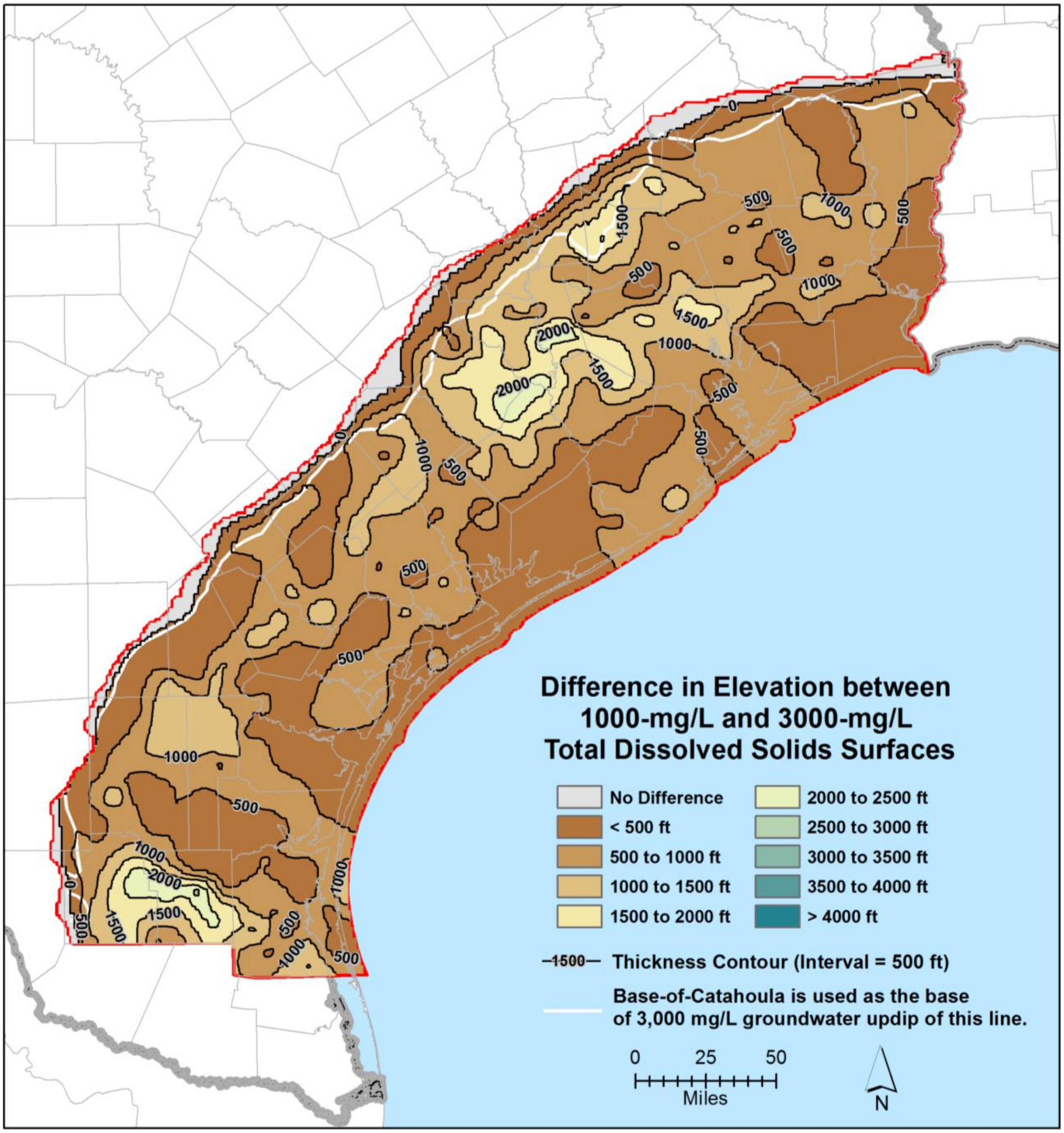

Figure 6-4. Thickness of the slightly saline zone.

Note: mg/L=milligrams per liter; ft=feet

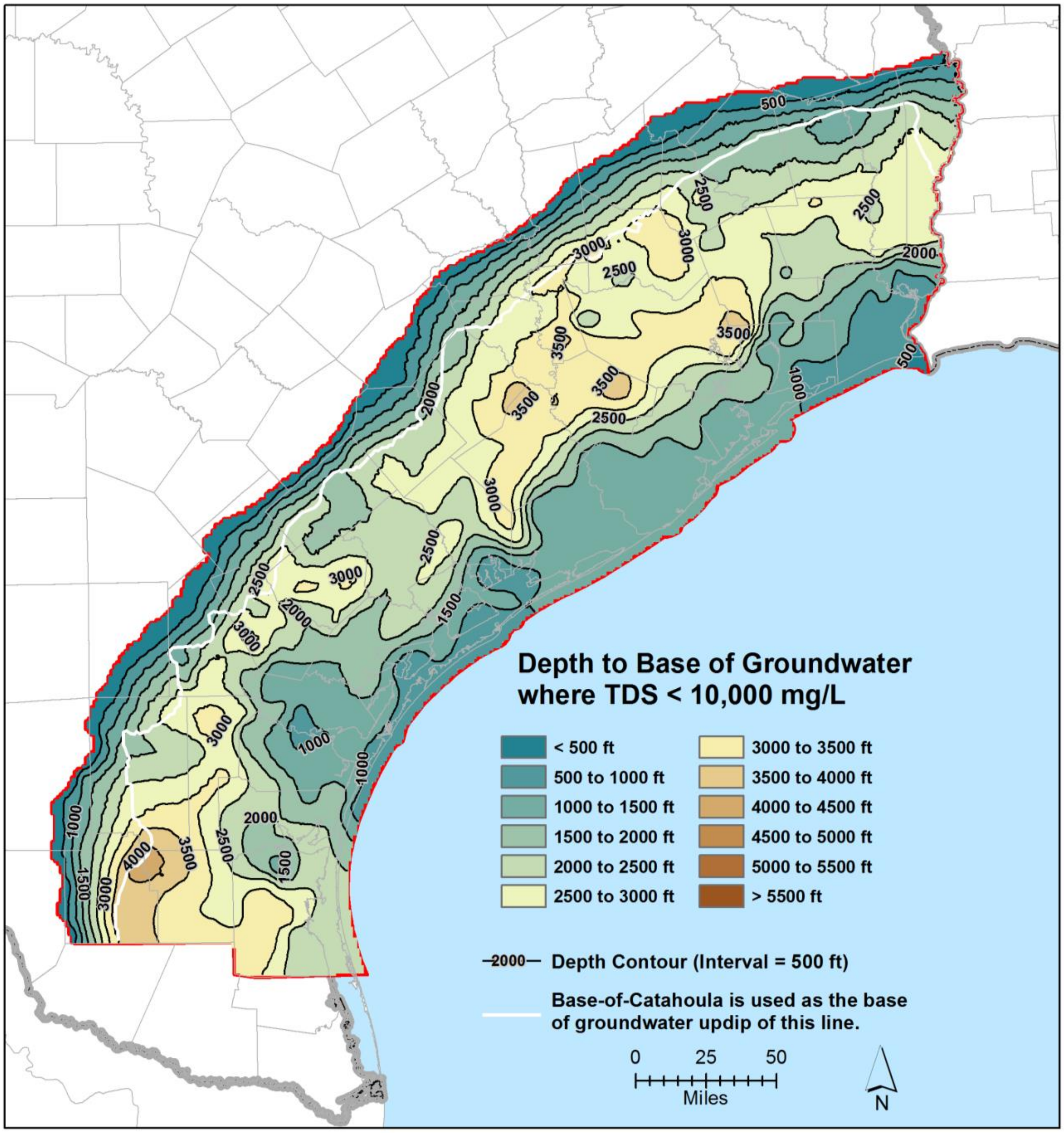

Figure 6-5. **Base of the moderately saline zone.**

Note: TDS = total dissolved solids; mg/L=milligrams per liter; ft=feet

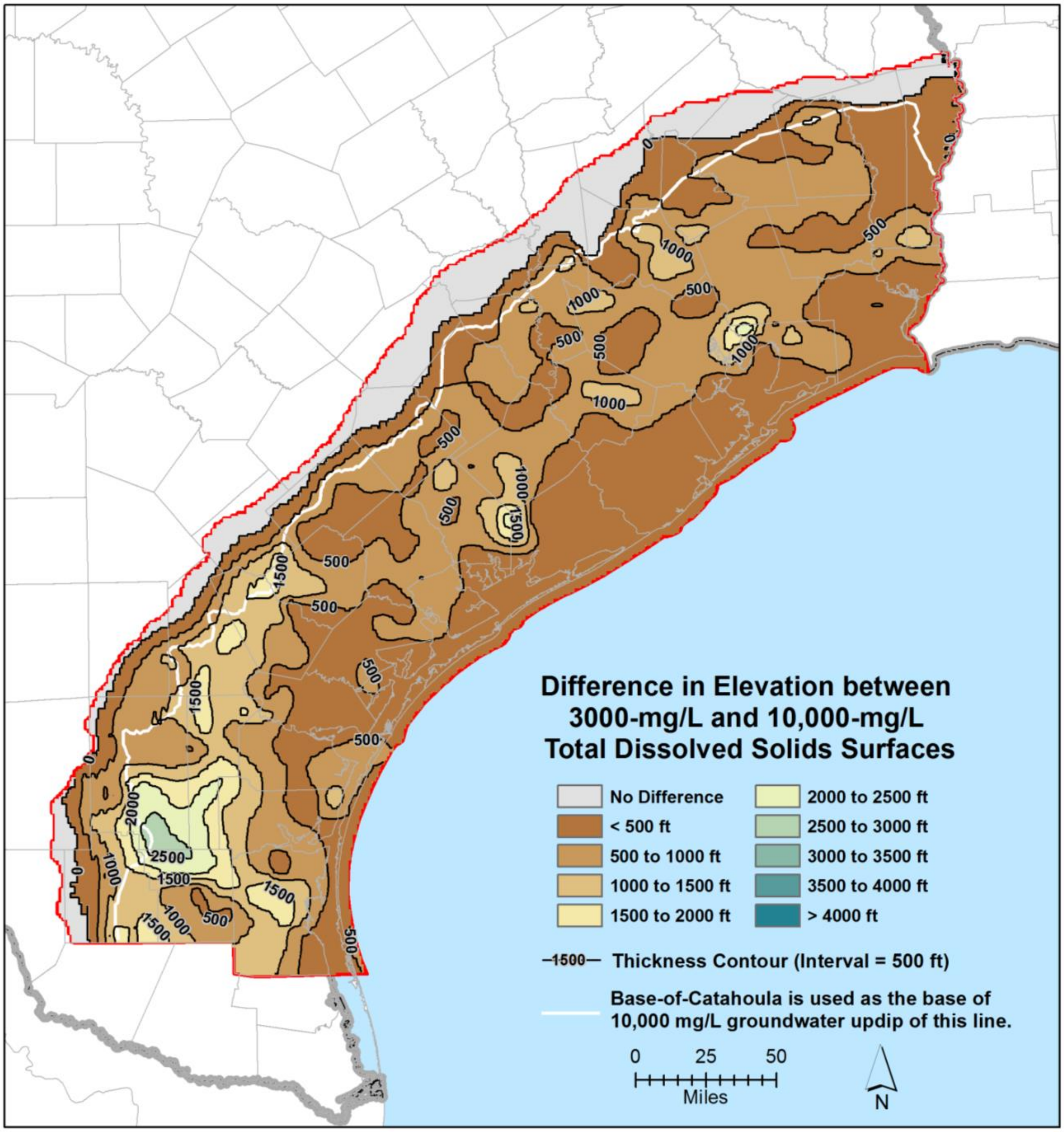

Figure 6-6. Thickness of the moderately saline zone.

Note: mg/L=milligrams per liter; ft=feet

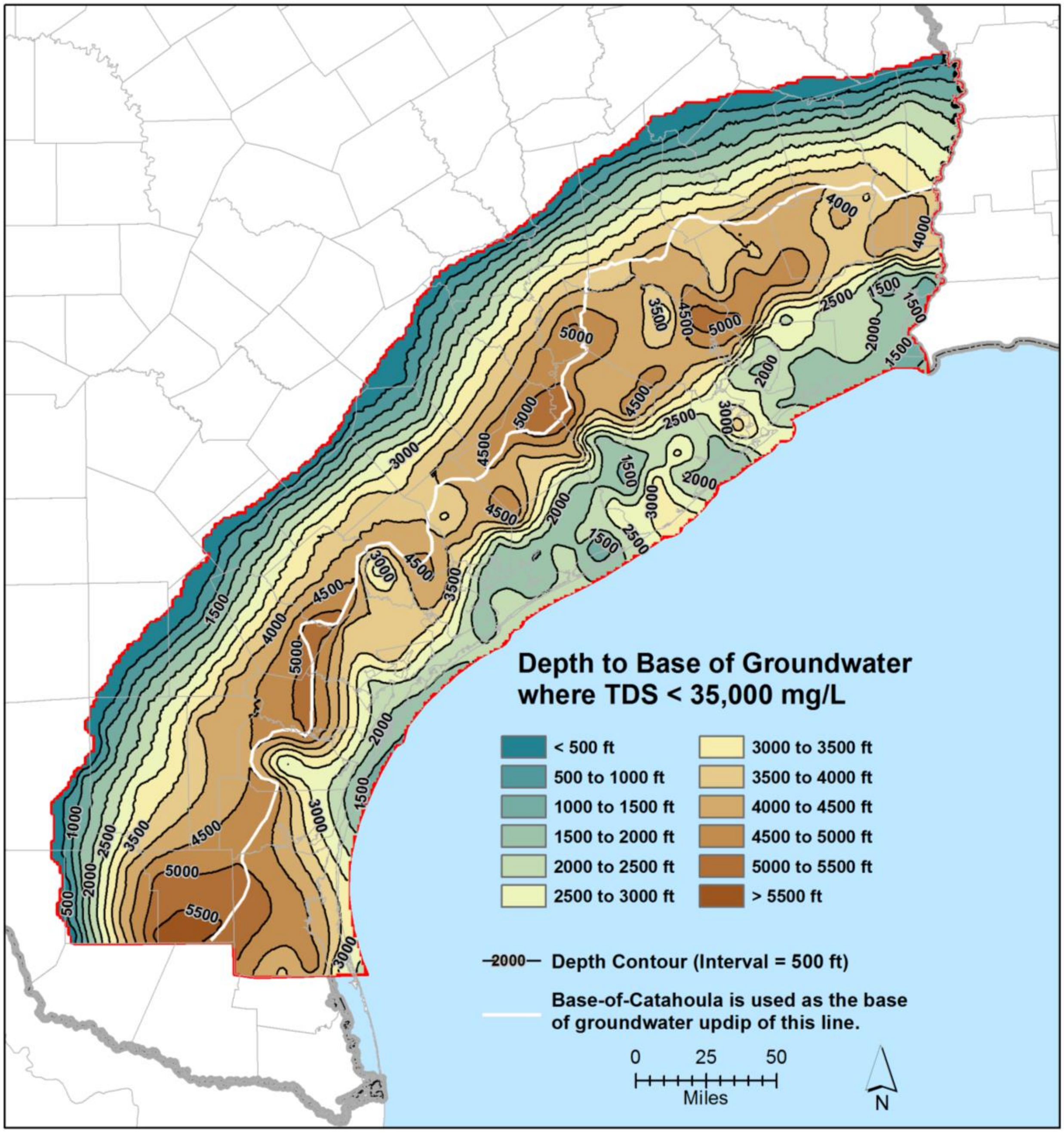

Figure 6-7. **Base of the very saline zone.**

Note: TDS = total dissolved solids; mg/L=milligrams per liter; ft=feet

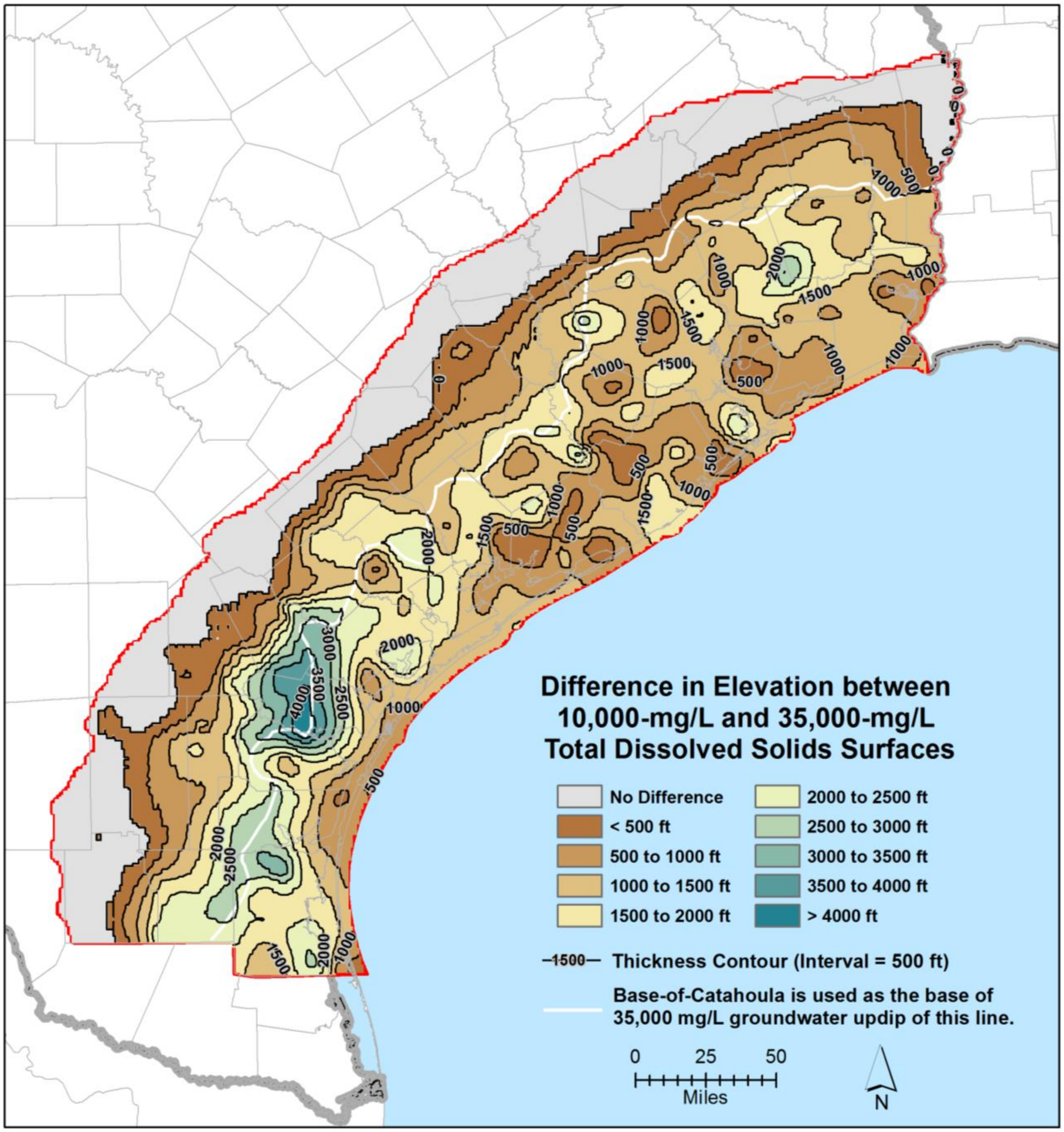

Figure 6-8. Thickness of the very saline zone.

Note: mg/L=milligrams per liter; ft=feet

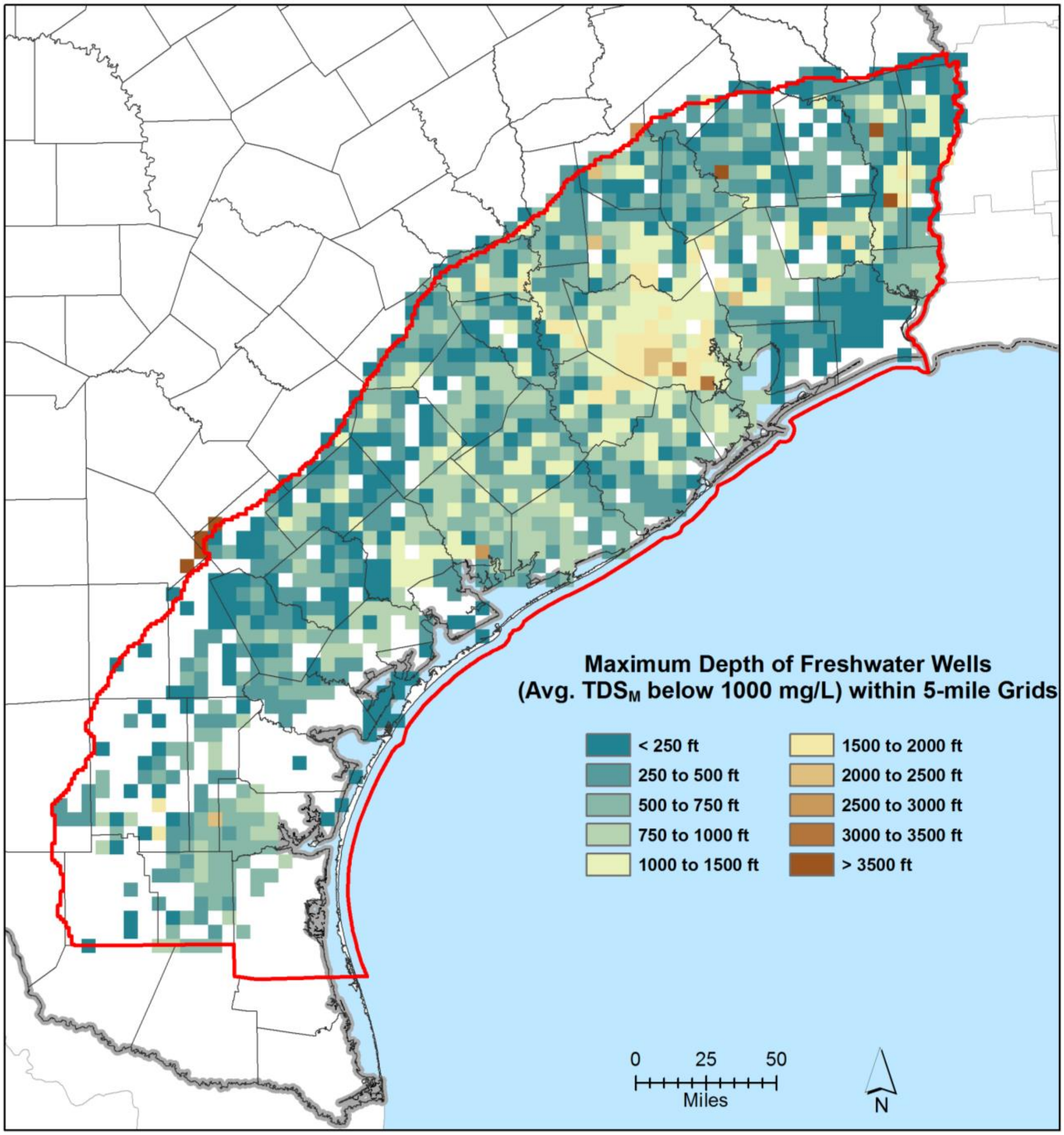

Figure 6-9. Maximum depth of fresh water sampled by wells located in a grid of 5-mile by 5-mile blocks based on information from the TWDB groundwater database.

Note: Avg. TDS_M=average measured total dissolved solids; mg/L=milligrams per liter; ft=feet

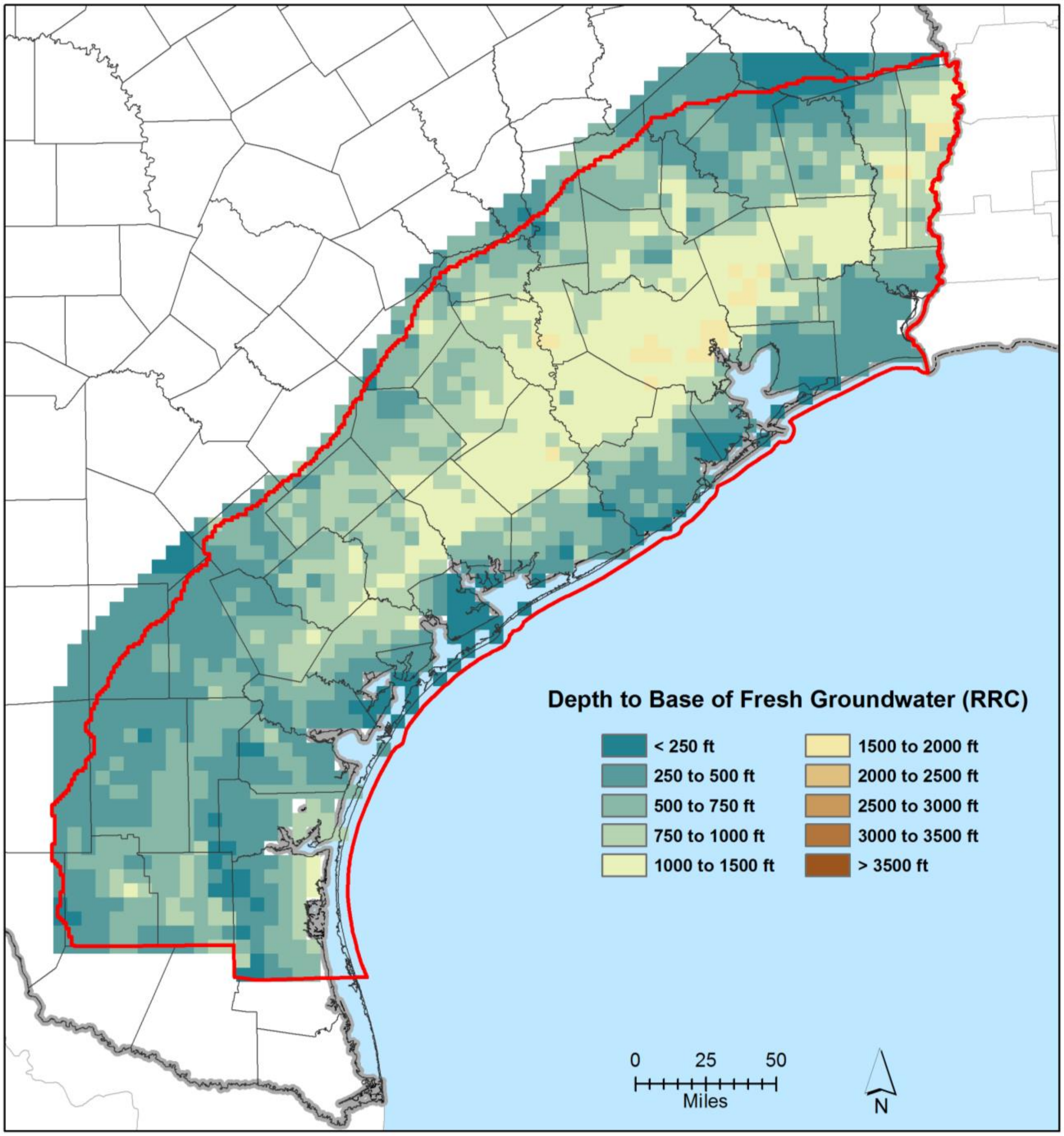

Figure 6-10. Estimated depth to base of fresh water based on 23,000 picks of depth to freshwater from a database maintained by the Groundwater Advisory Unit at the Texas Railroad Commission.

Note: RRC=railroad commission; ft=feet

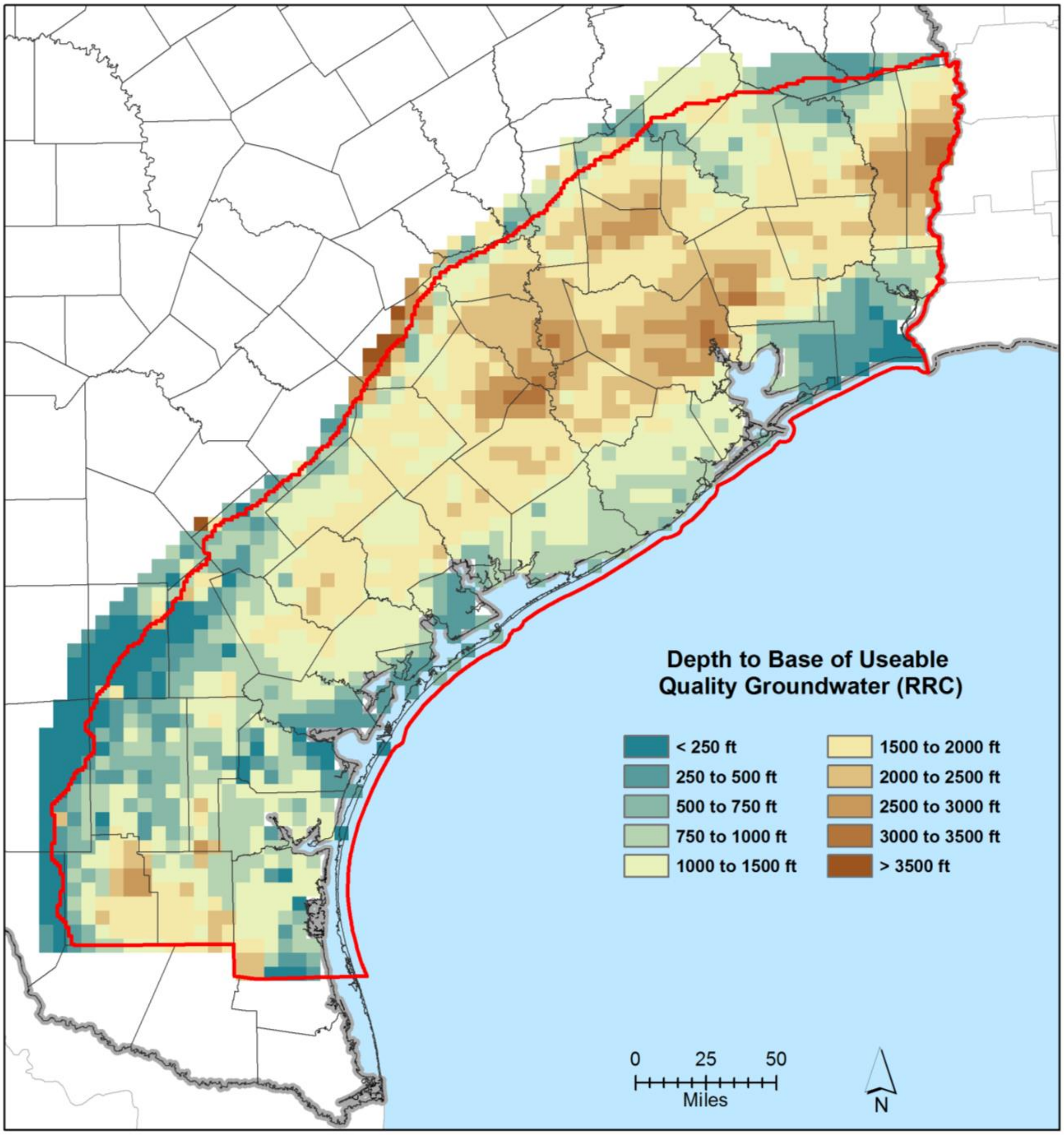

Figure 6-11. Estimated depth to useable water based on 53,000 picks of depth to fresh water from a database maintained by the Groundwater Advisory Unit at the Texas Railroad Commission

Note: RRC=railroad commission; ft=feet

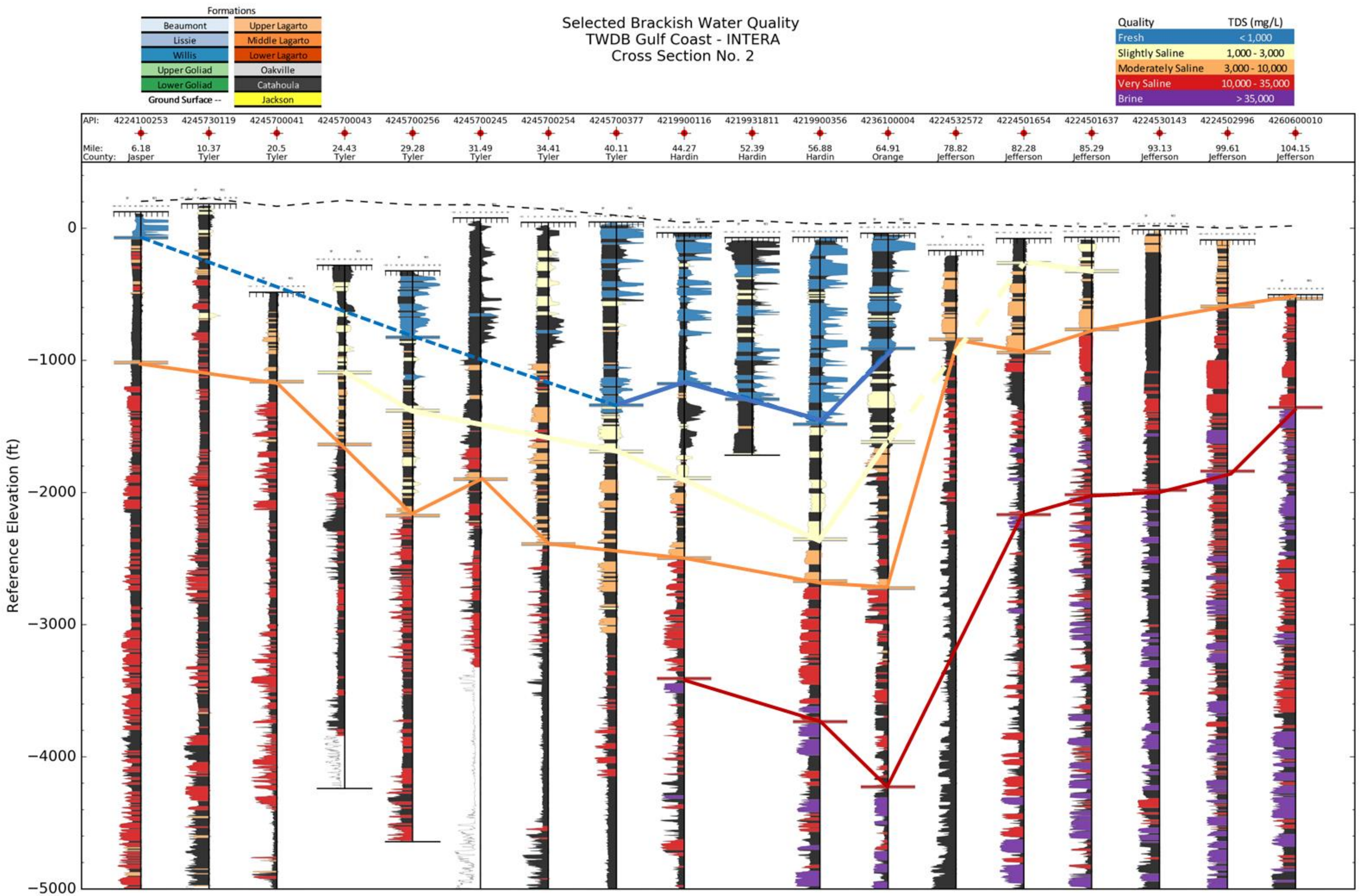

Figure 6-12. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #2 shown in Figure 6-1. Markers represent the base of the salinity zones at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

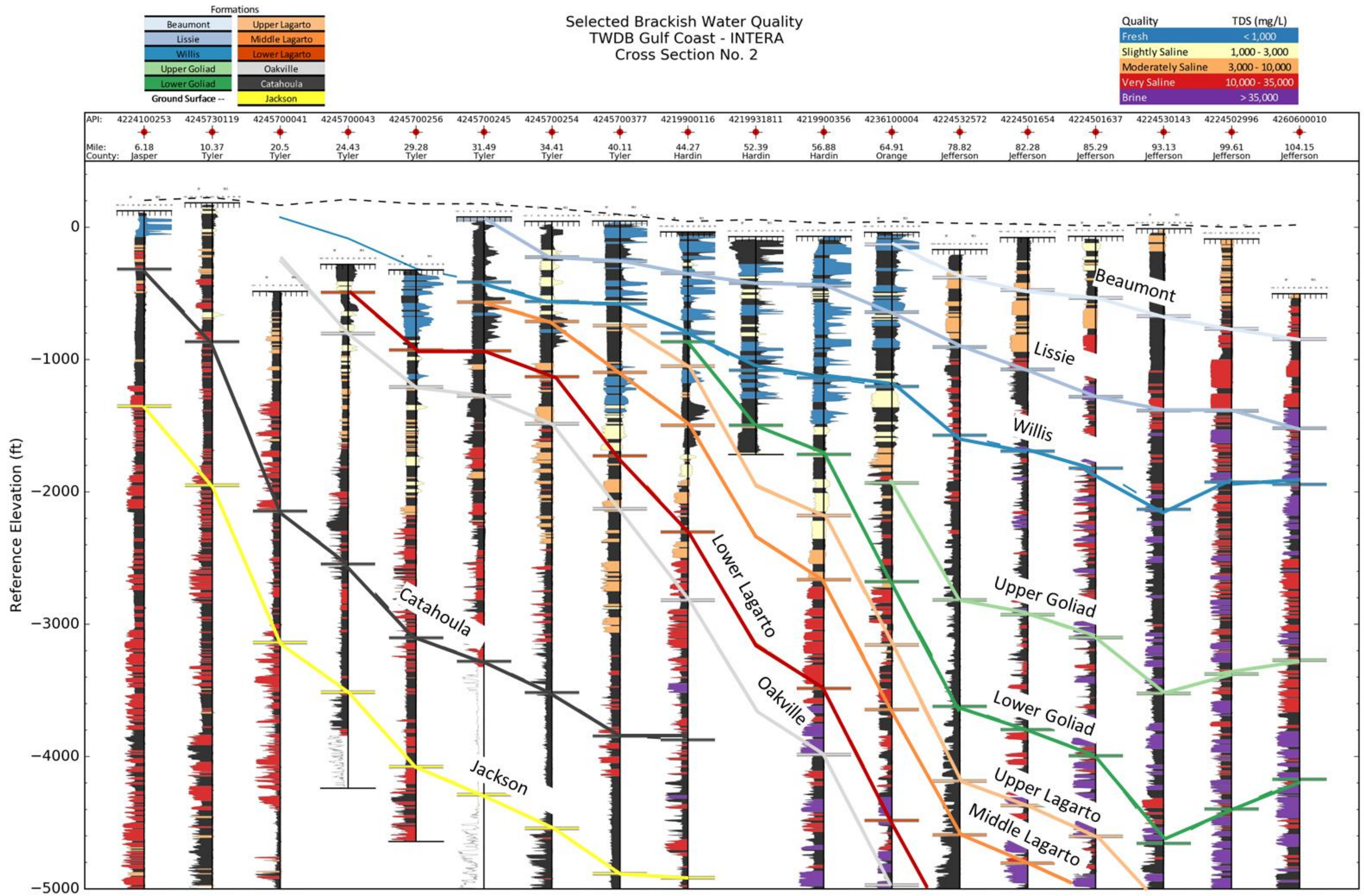

Figure 6-13. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #2 shown in Figure 6-1. Markers represent the base formations at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

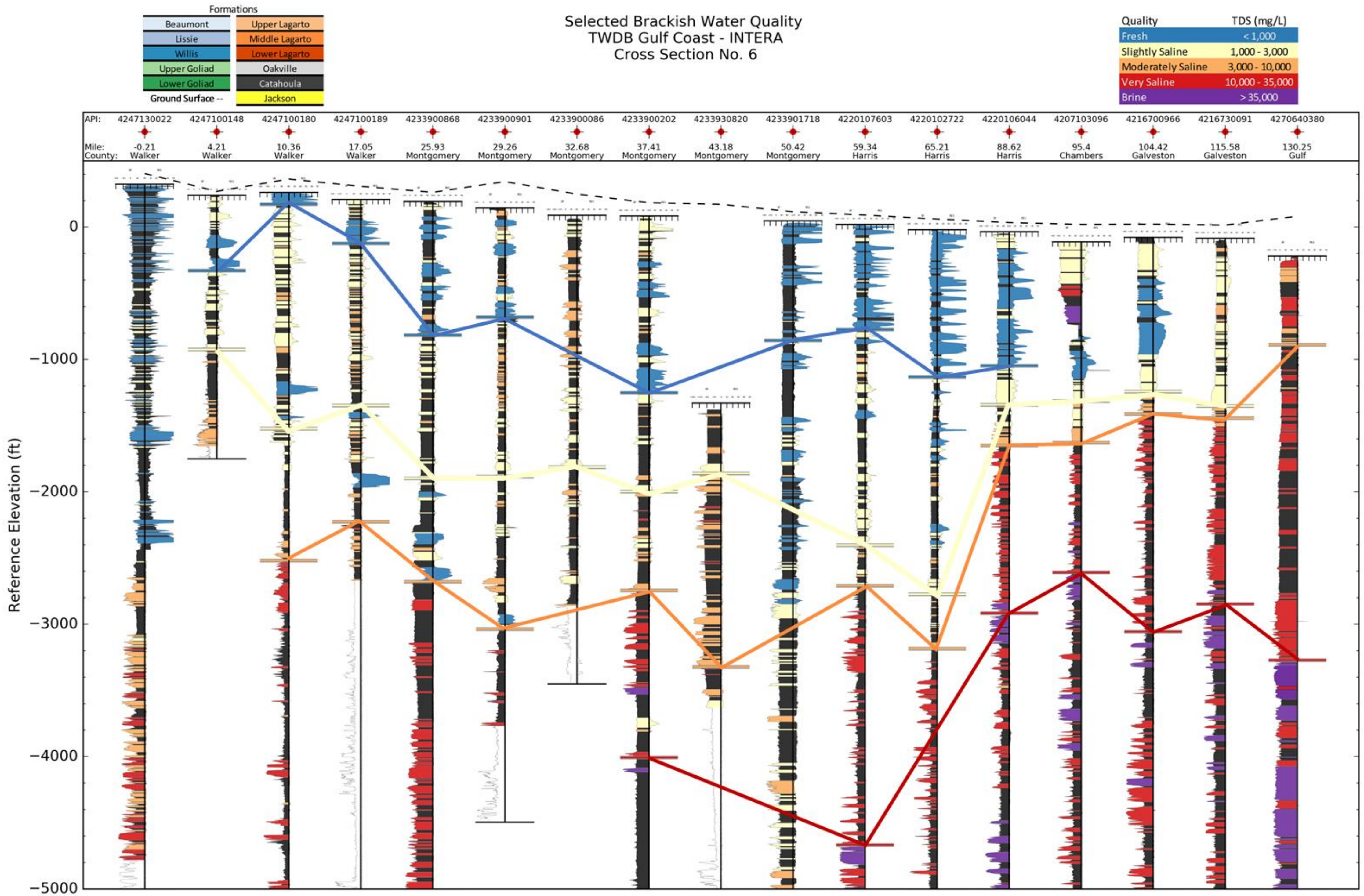

Figure 6-14. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #6 shown in Figure 6-1. Markers represent the base of the salinity zones at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

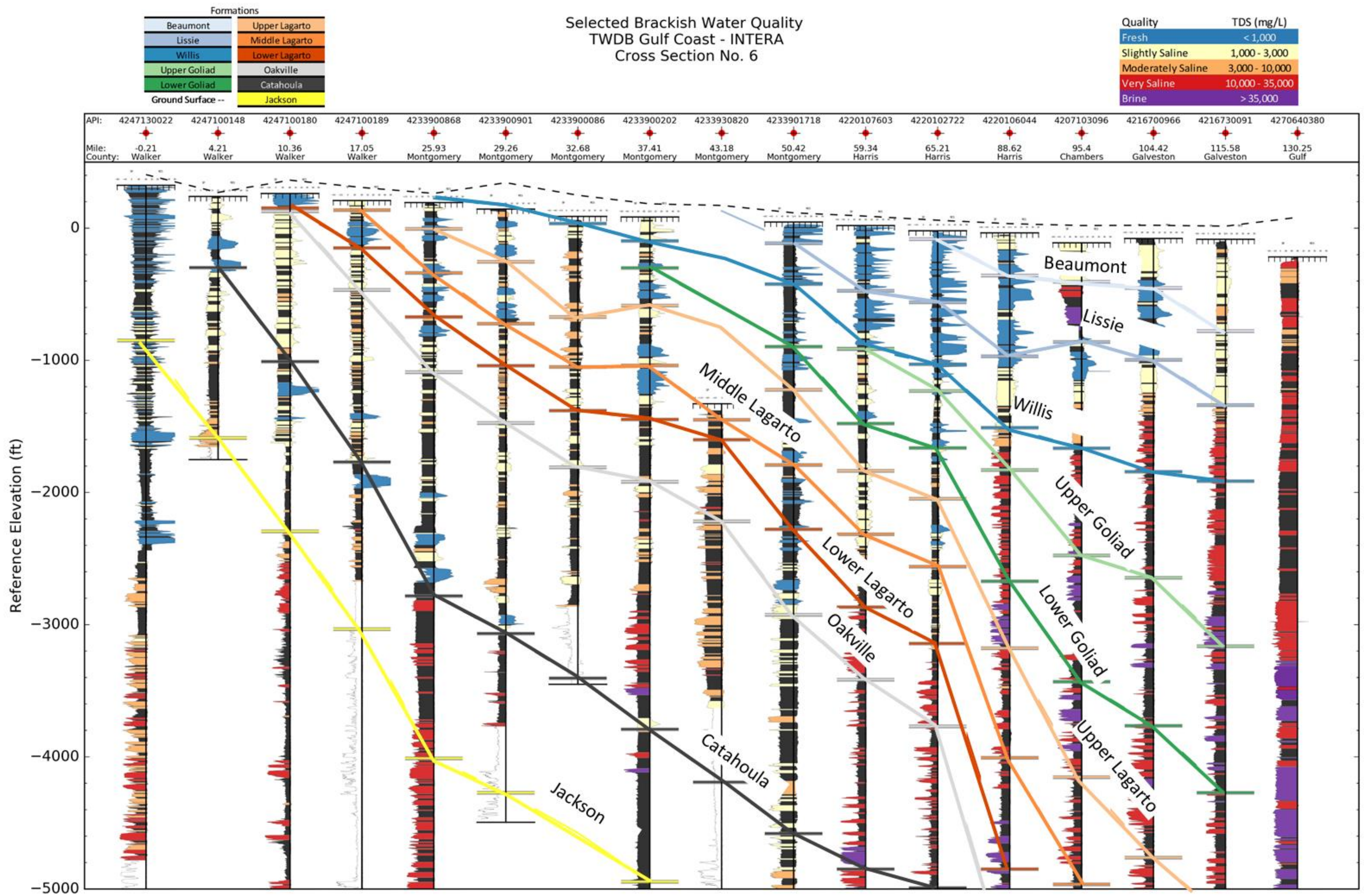

Figure 6-15. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #6 shown in Figure 6-1. Markers represent the base formations at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

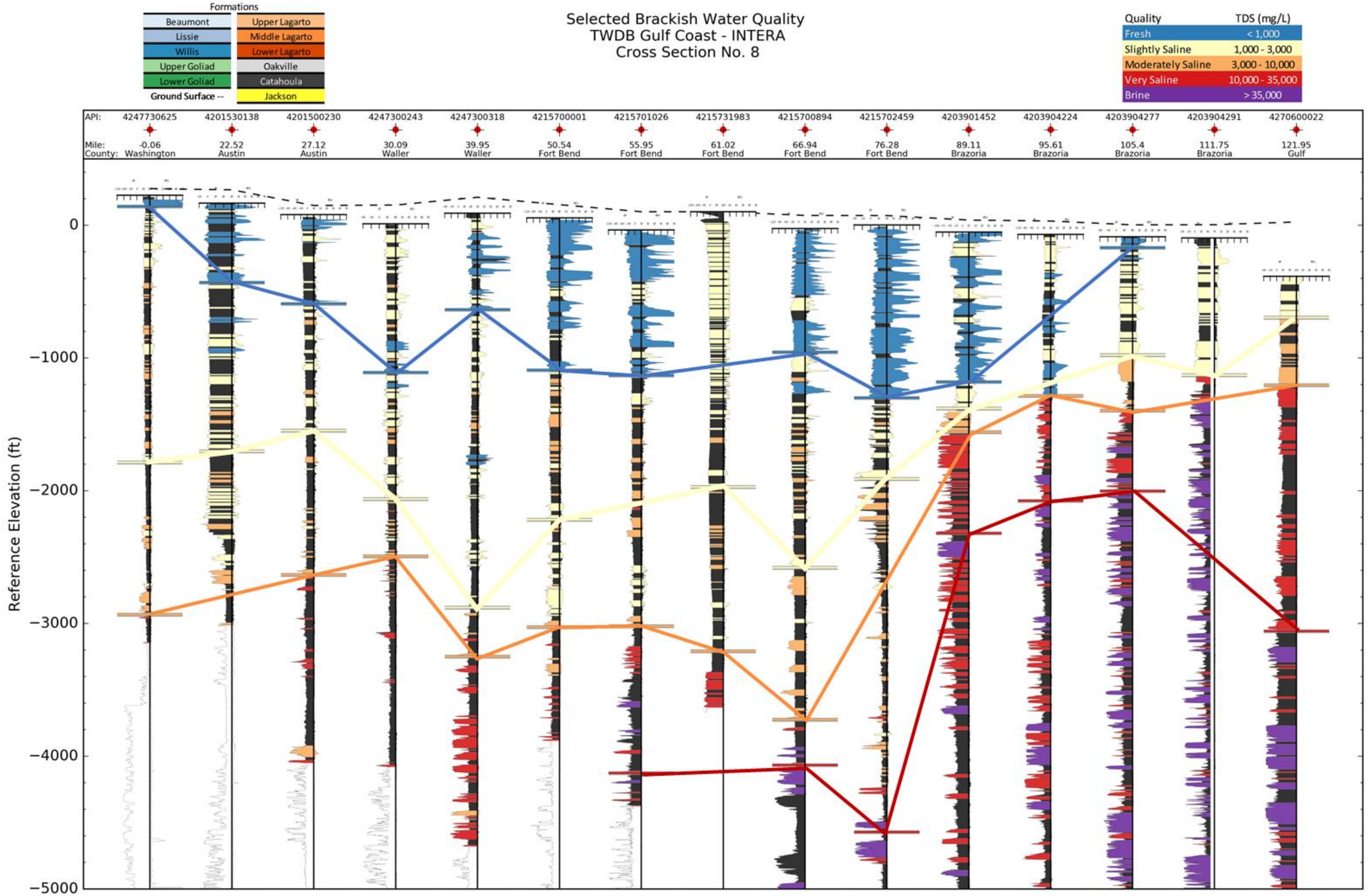

Figure 6-16. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #8 shown in Figure 6-1. Markers represent the base of the salinity zones at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

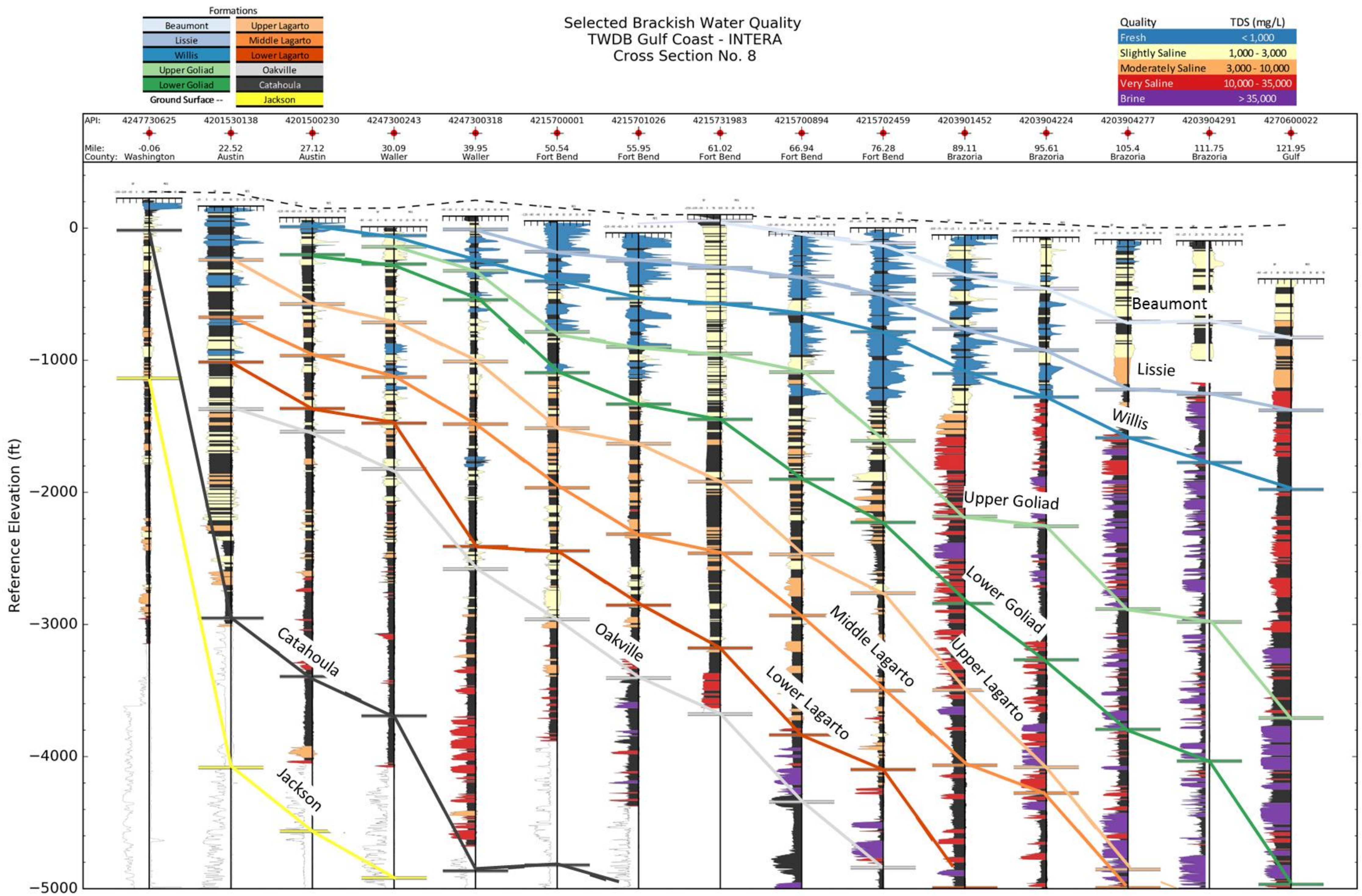

Figure 6-17. **Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #8 shown in Figure 6-1. Markers represent the base formations at each log location. The lines connecting the markers are for illustrative purposes only.**

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

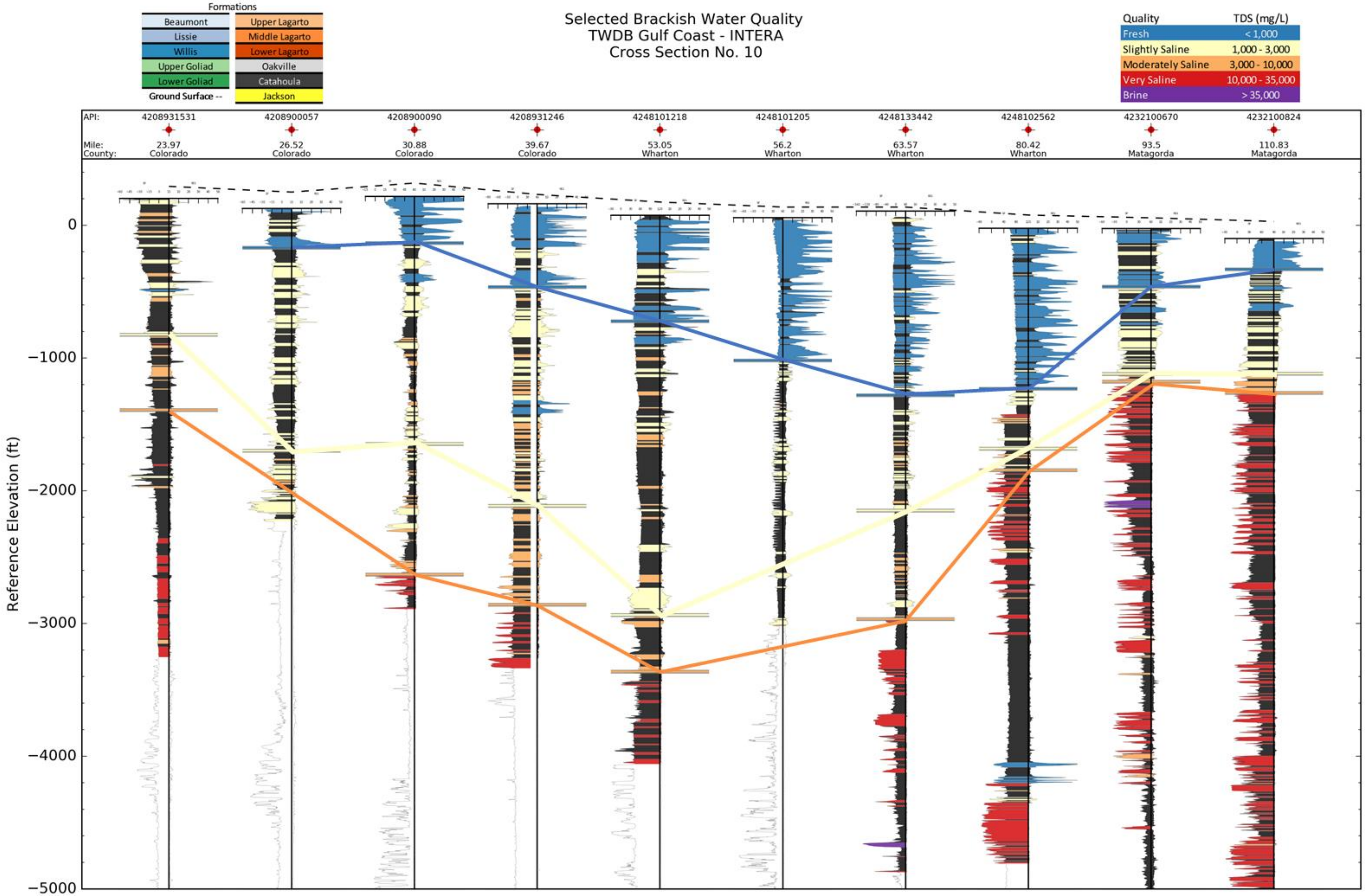

Figure 6-18. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #10 shown in Figure 6-1. Markers represent the base of the salinity zones at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

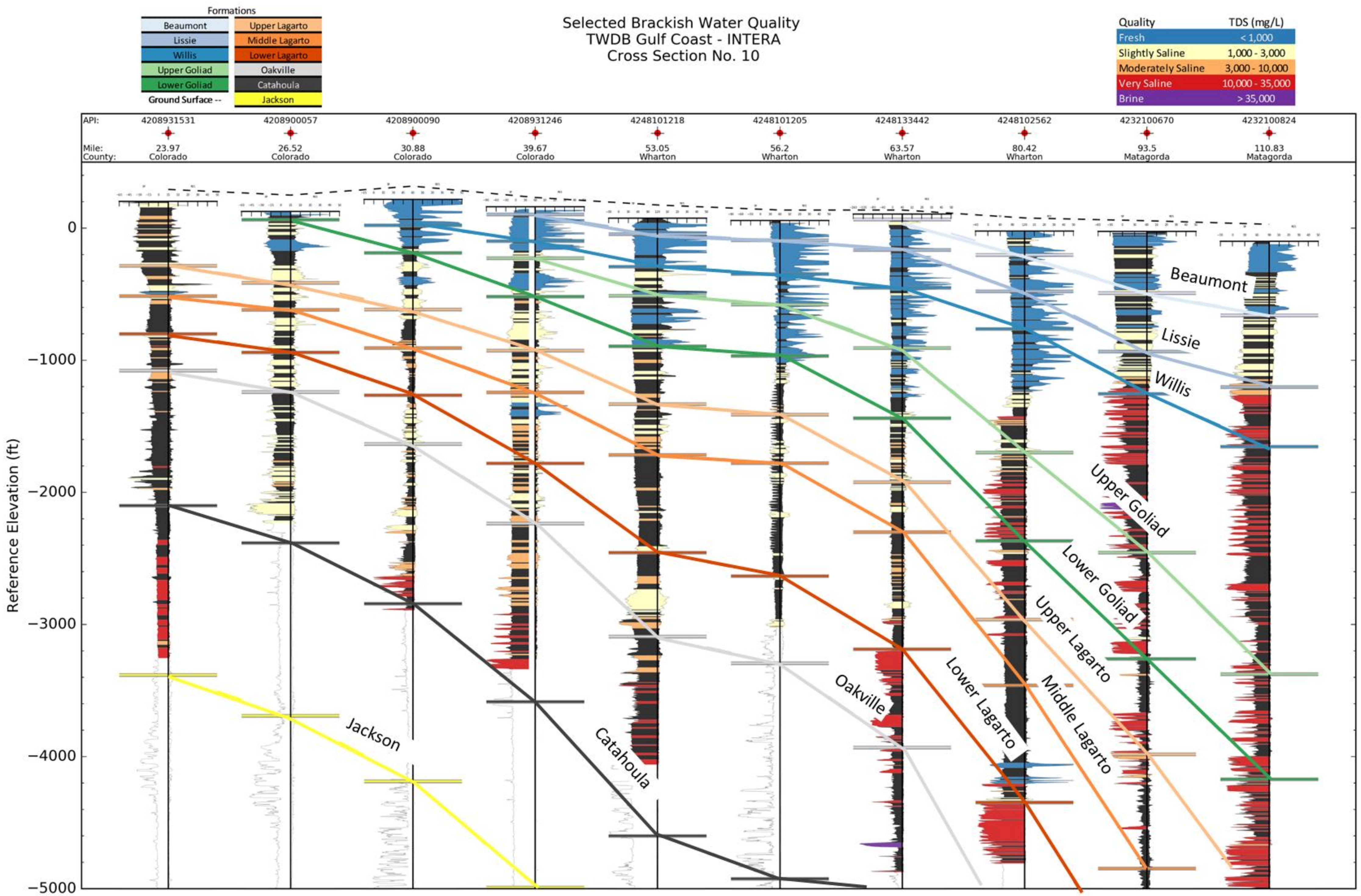

Figure 6-19. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #10 shown in Figure 6-1. Markers represent the base formations at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

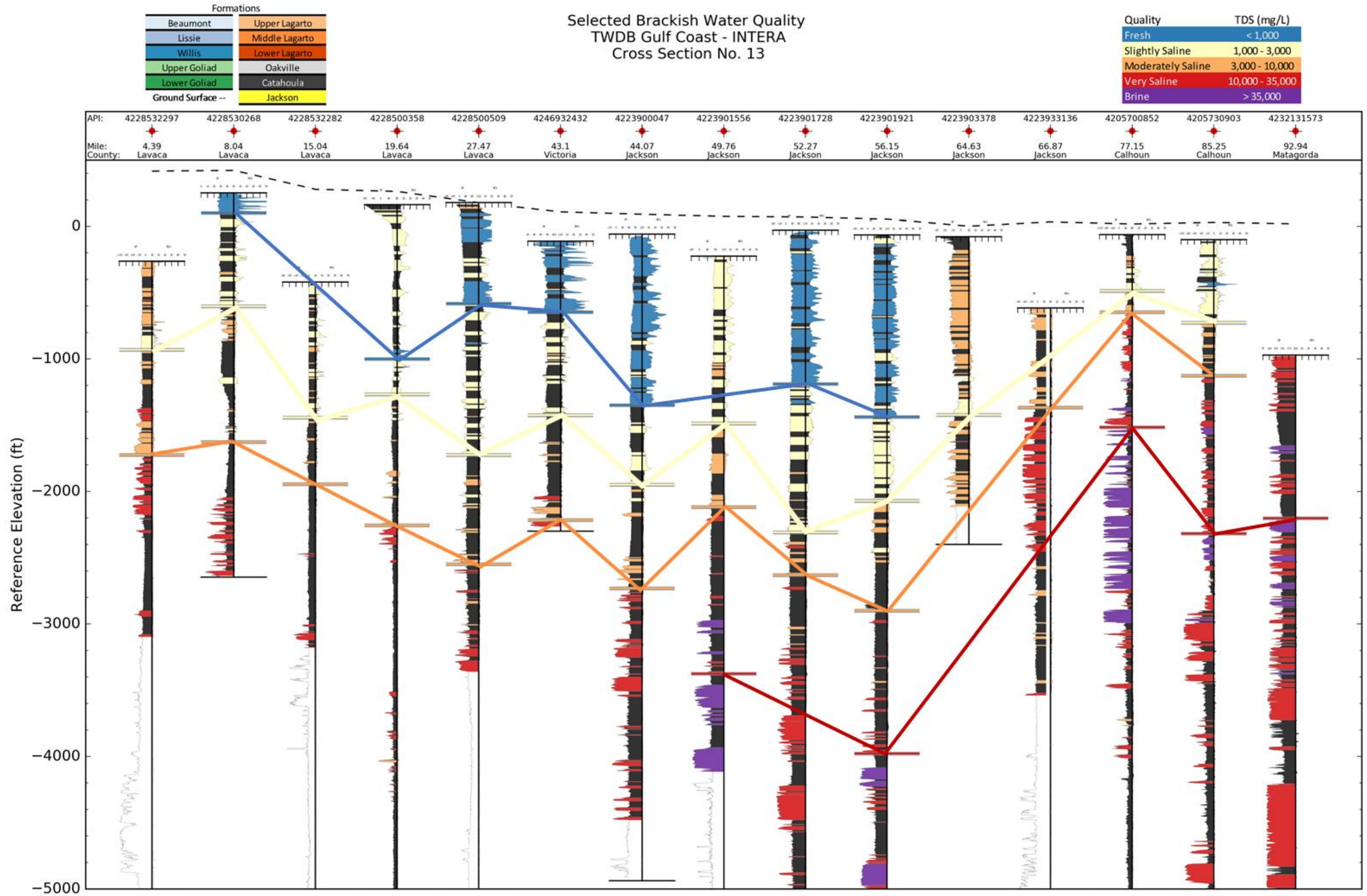

Figure 6-20. **Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #13 shown in Figure 6-1. Markers represent the base of the salinity zones at each log location. The lines connecting the markers are for illustrative purposes only.**

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

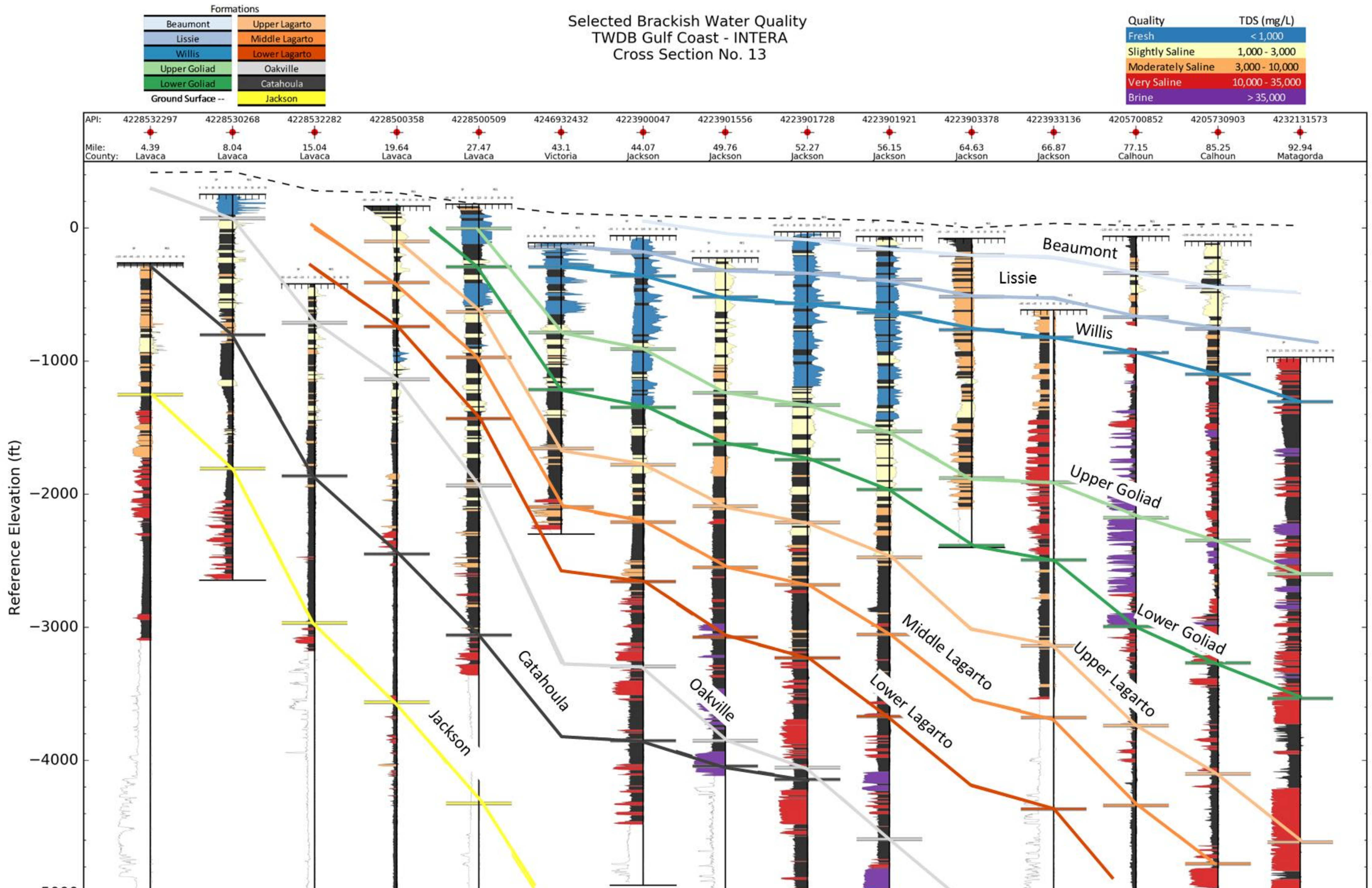

Figure 6-21. **Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #13 shown in Figure 6-1. Markers represent the base formations at each log location. The lines connecting the markers are for illustrative purposes only.**

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

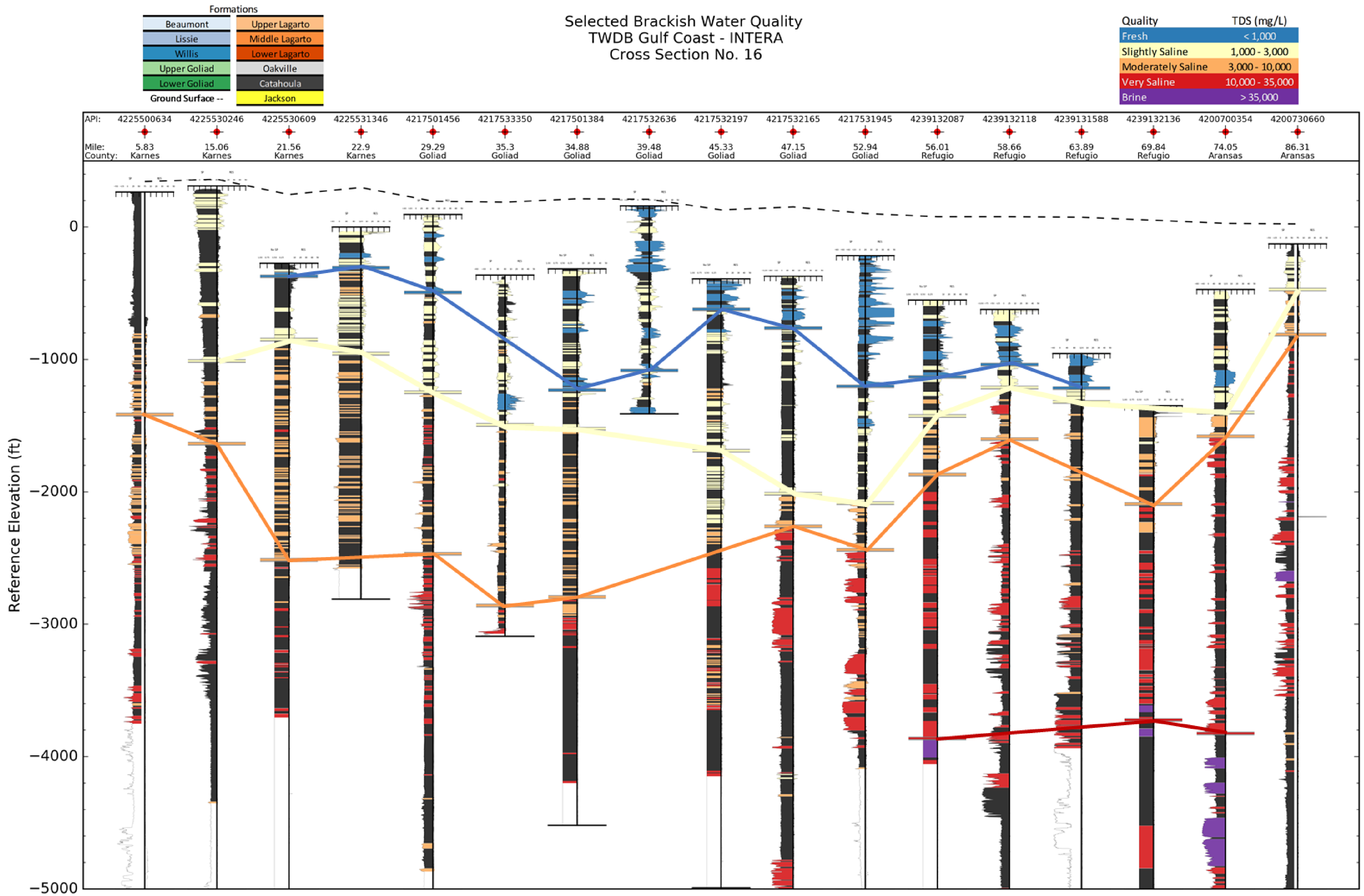

Figure 6-22. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #16 shown in Figure 6-1. Markers represent the base of the salinity zones at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

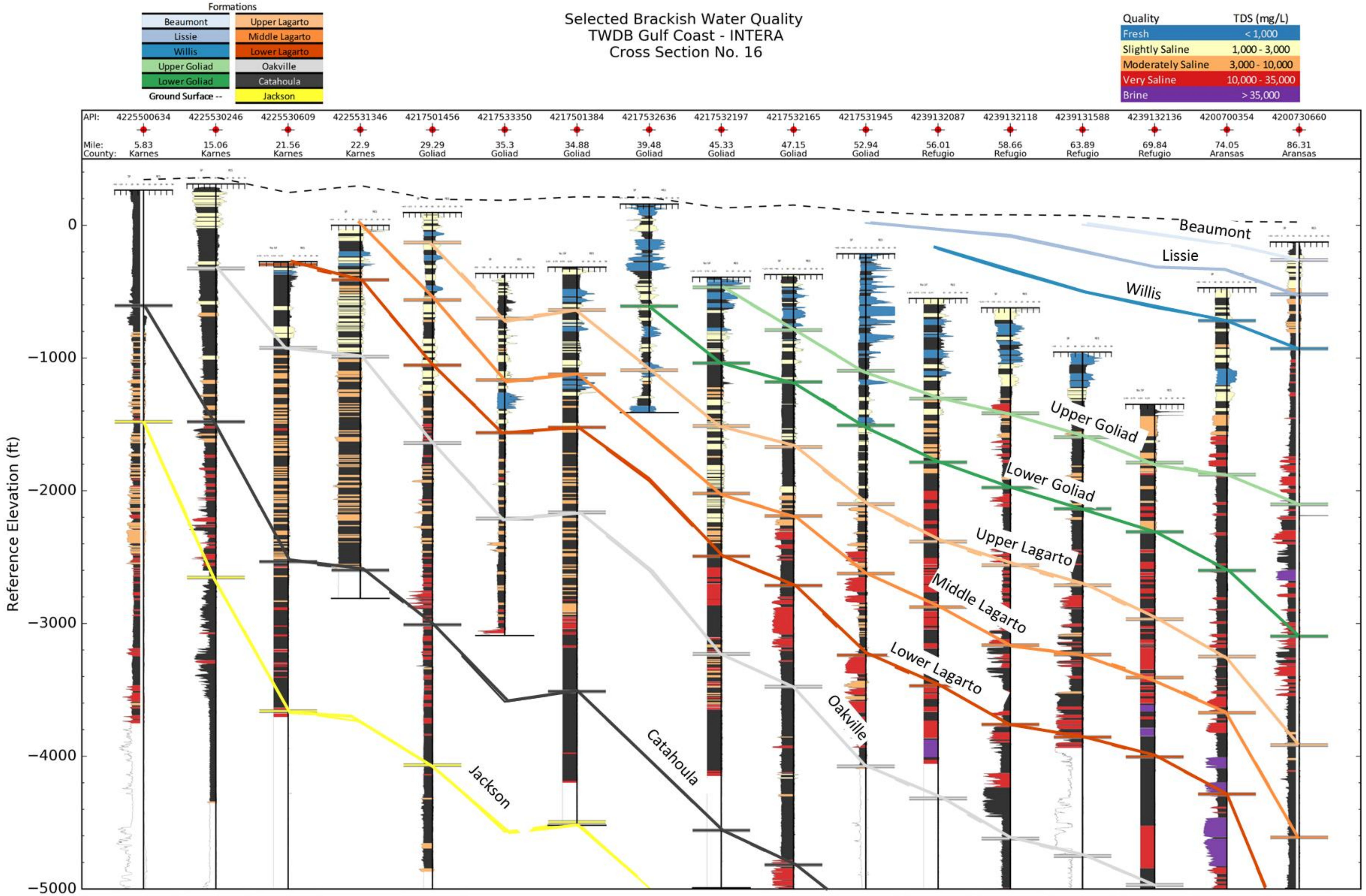

Figure 6-23. **Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #16 shown in Figure 6-1. Markers represent the base formations at each log location. The lines connecting the markers are for illustrative purposes only.**

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

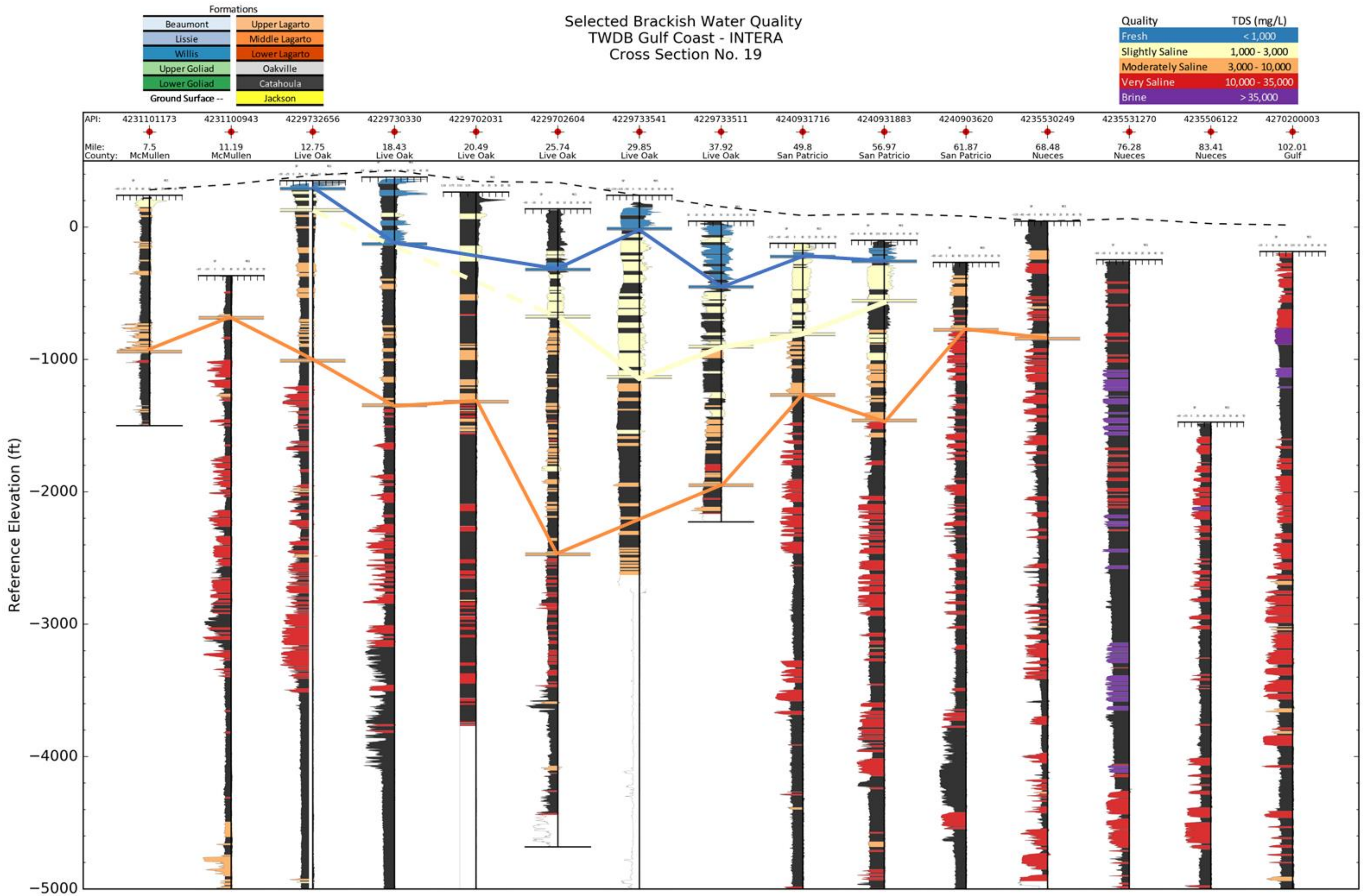

Figure 6-24. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #19 shown in Figure 6-1. Markers represent the base of the salinity zones at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

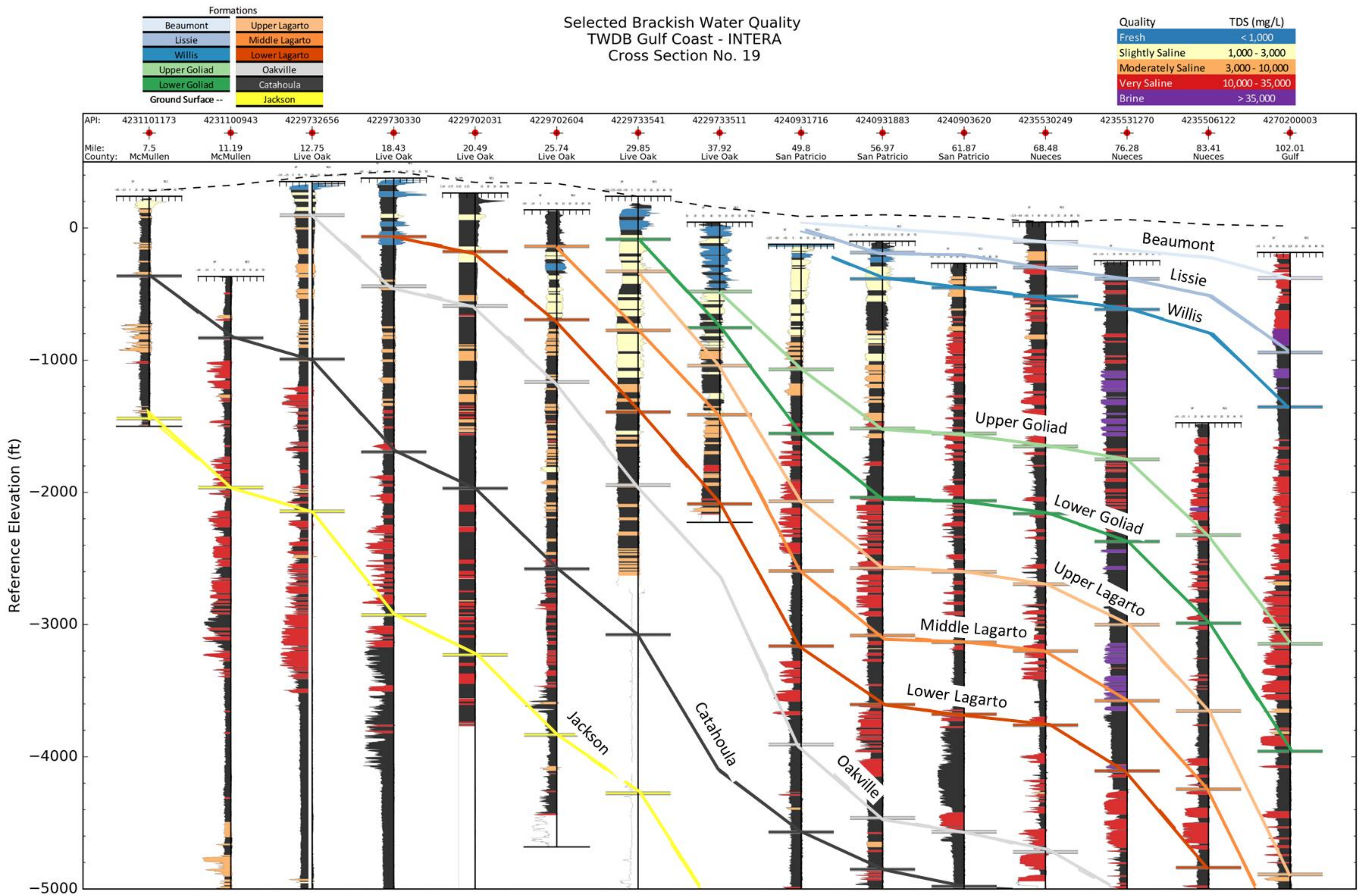

Figure 6-25. **Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #19 shown in Figure 6-1. Markers represent the base formations at each log location. The lines connecting the markers are for illustrative purposes only.**

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

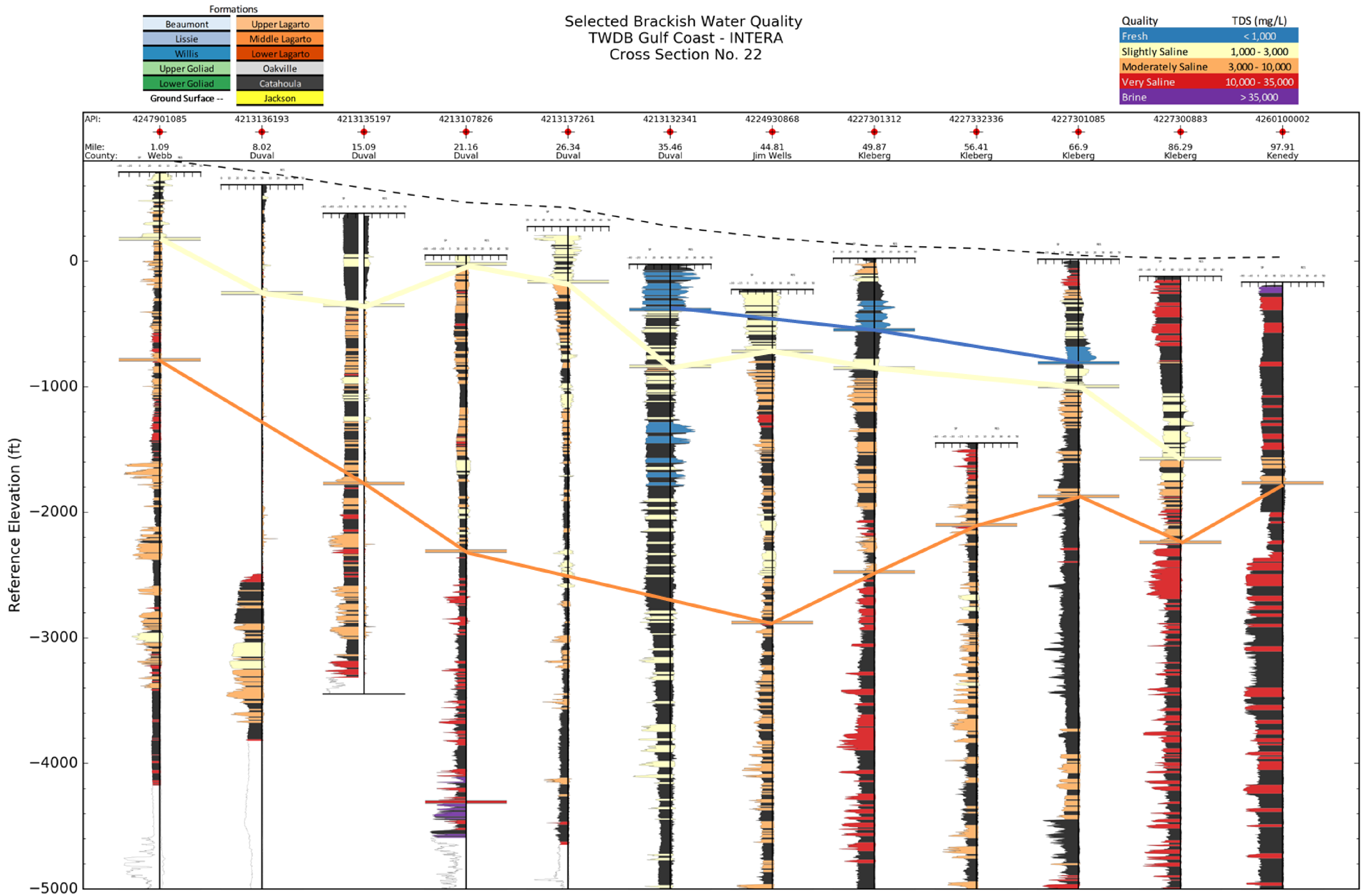

Figure 6-26. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #22 shown in Figure 6-1. Markers represent the base of the salinity zones at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

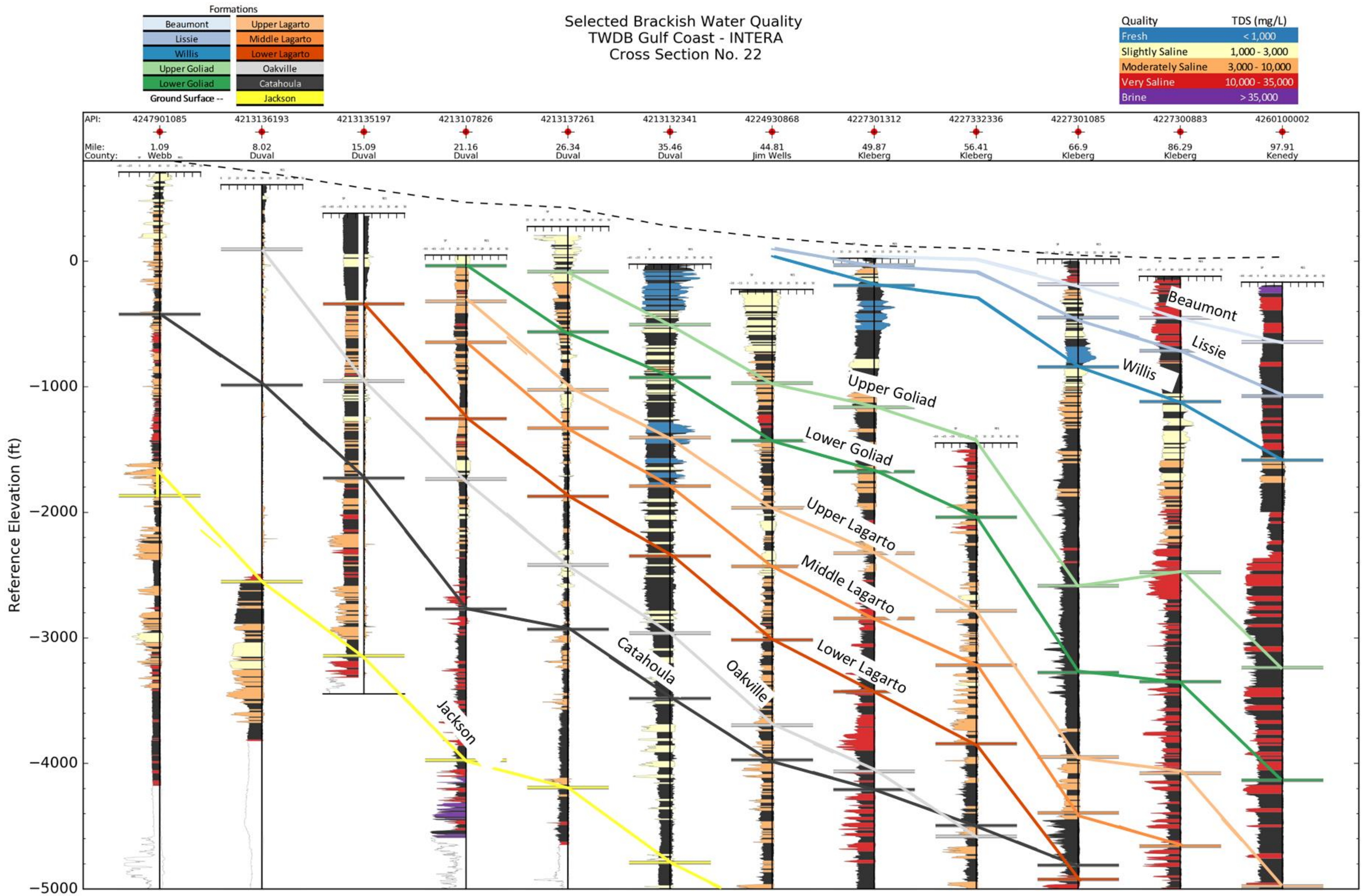

Figure 6-27. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #22 shown in Figure 6-1. Markers represent the base formations at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

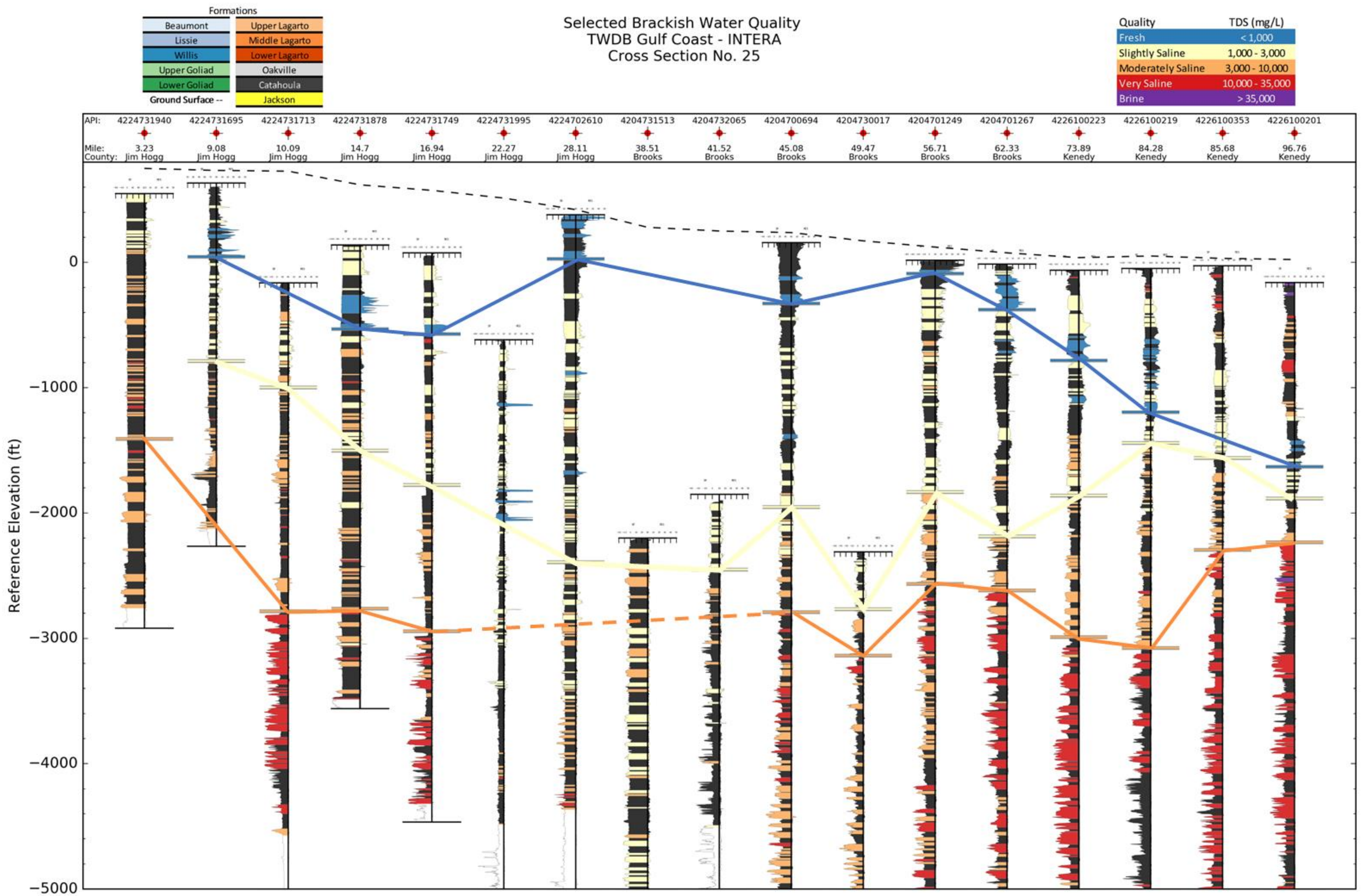

Figure 6-28. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #25 shown in Figure 6-1. Markers represent the base of the salinity zones at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

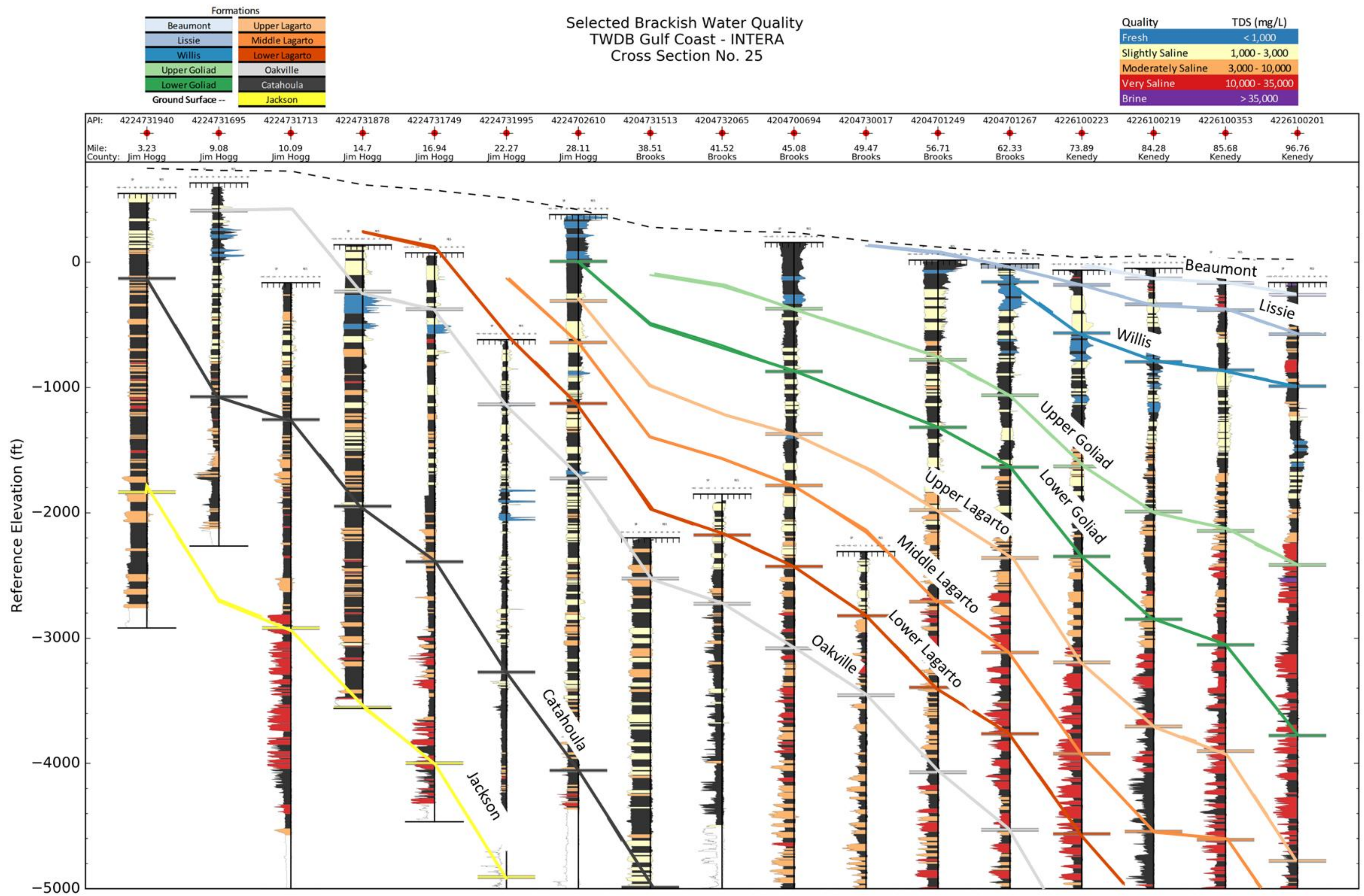

Figure 6-29. Profiles of calculated salinity zones for sand beds identified on geophysical logs aligned on Cross-Section #25 shown in Figure 6-1. Markers represent the base formations at each log location. The lines connecting the markers are for illustrative purposes only.

Note: ft=feet; TDS=total dissolved solids; mg/L=milligrams per liter

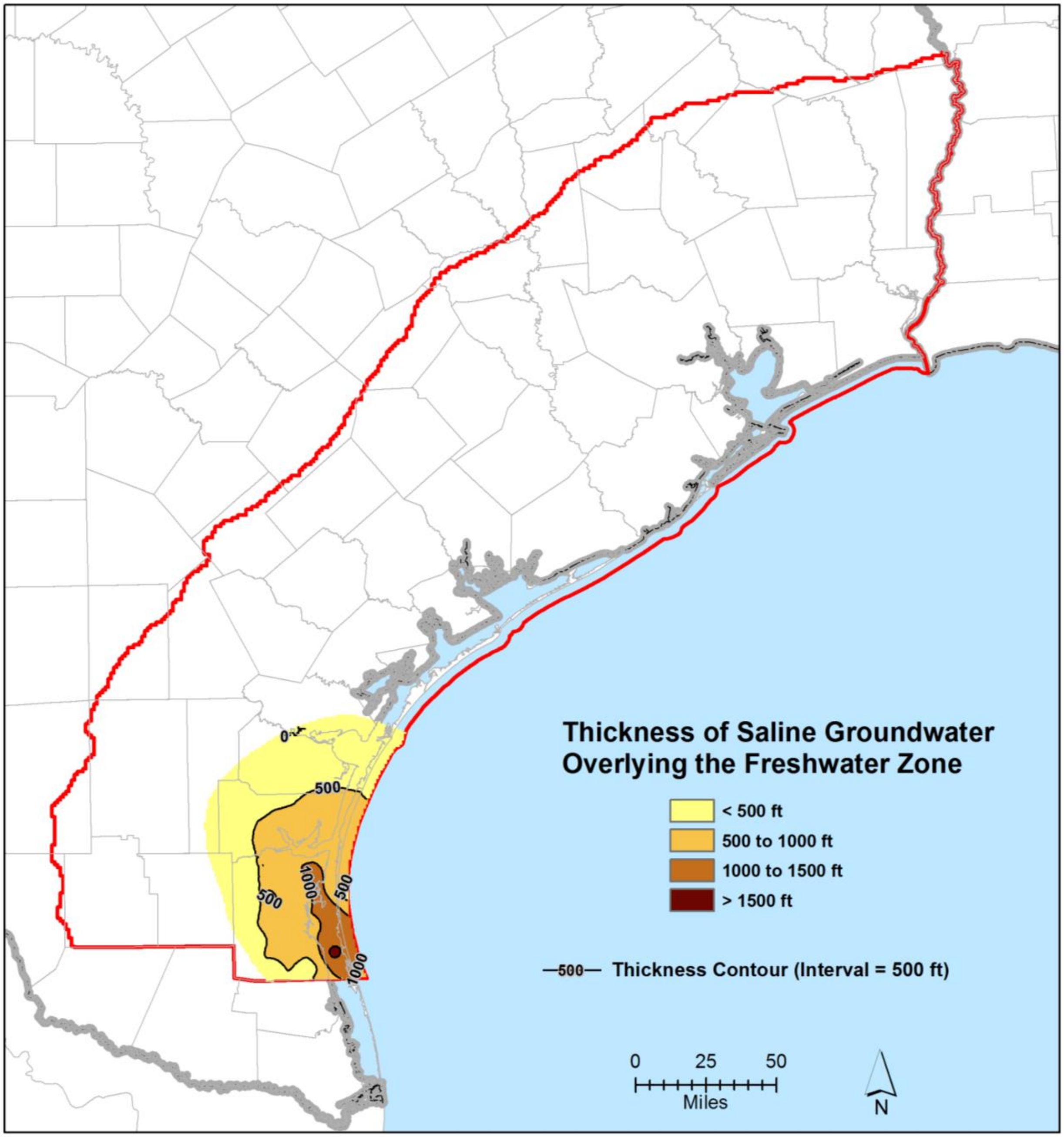

Figure 6-30. **Thickness of saline groundwater overlying the freshwater zone.**

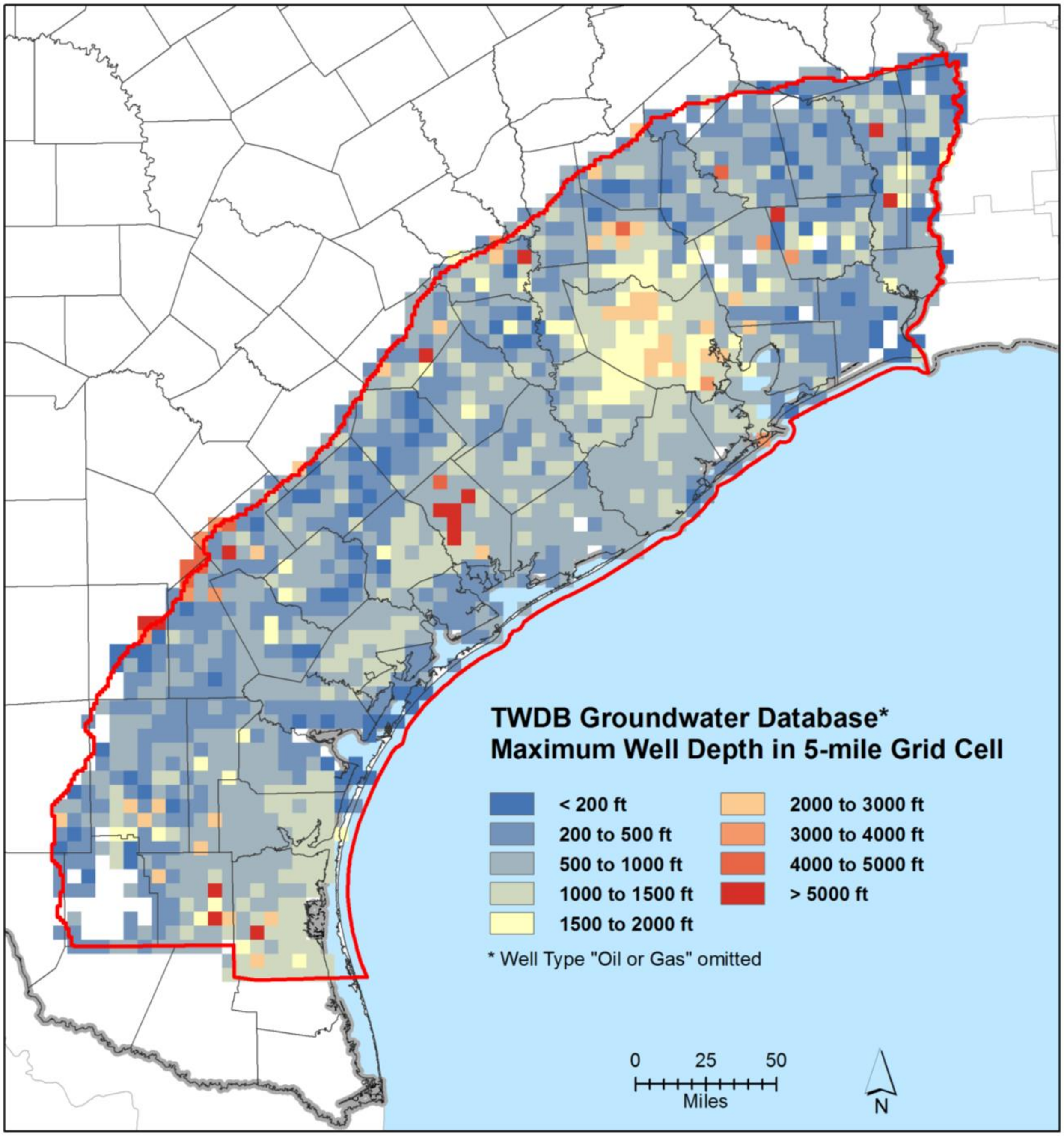

Figure 6-31. Maximum well depth that occurs across 5 mile-by-5-mile grid cells based on well information obtained from the TWDB groundwater database.

Note: ft=feet

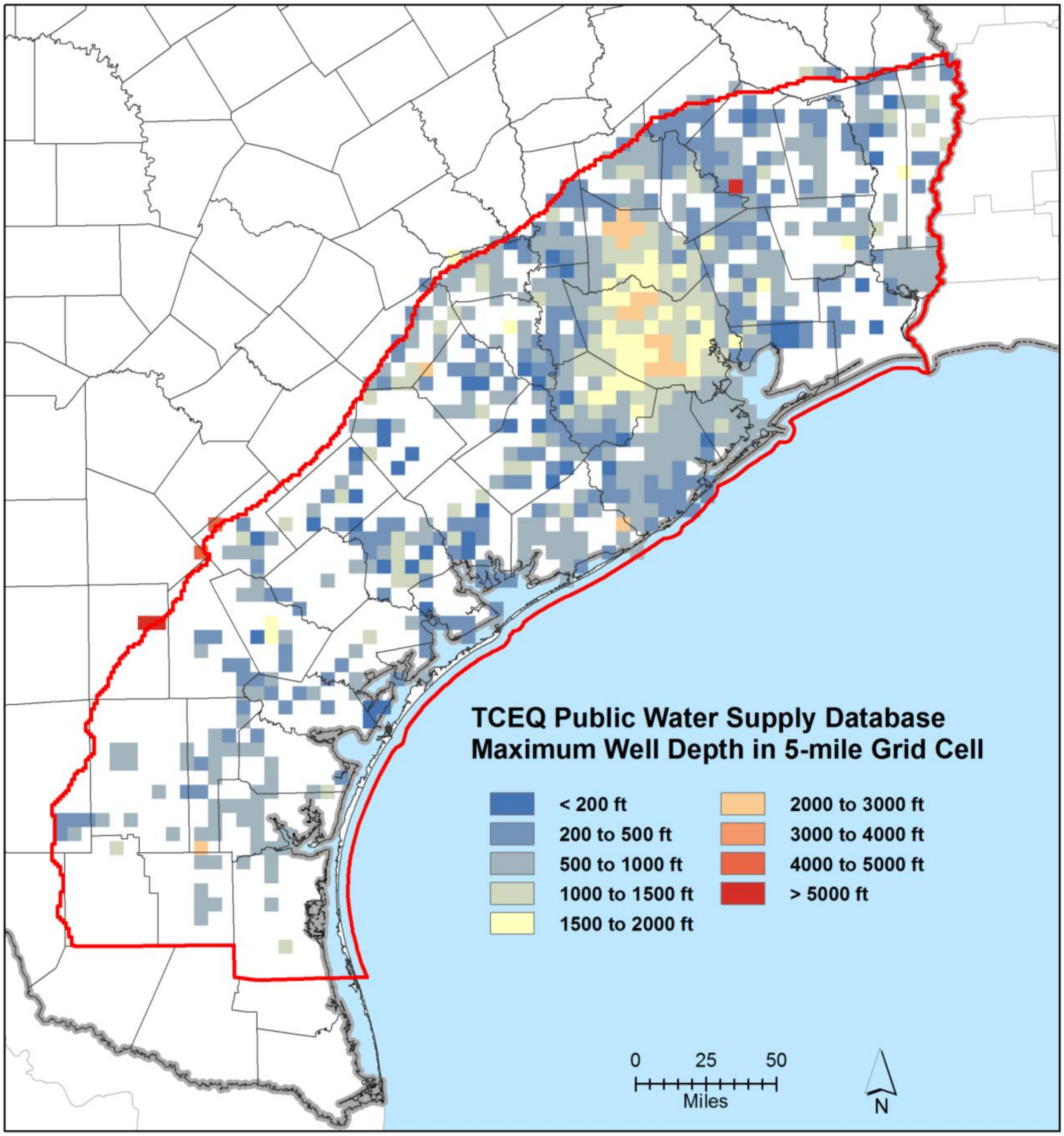

Figure 6-32. Maximum depth of public water supply wells that occur across 5 mile-by-5-mile grid cells based on well information obtained from the Texas Commission on Environmental Quality.

Note: TCEQ=Texas Commission on Environmental Quality; ft=feet

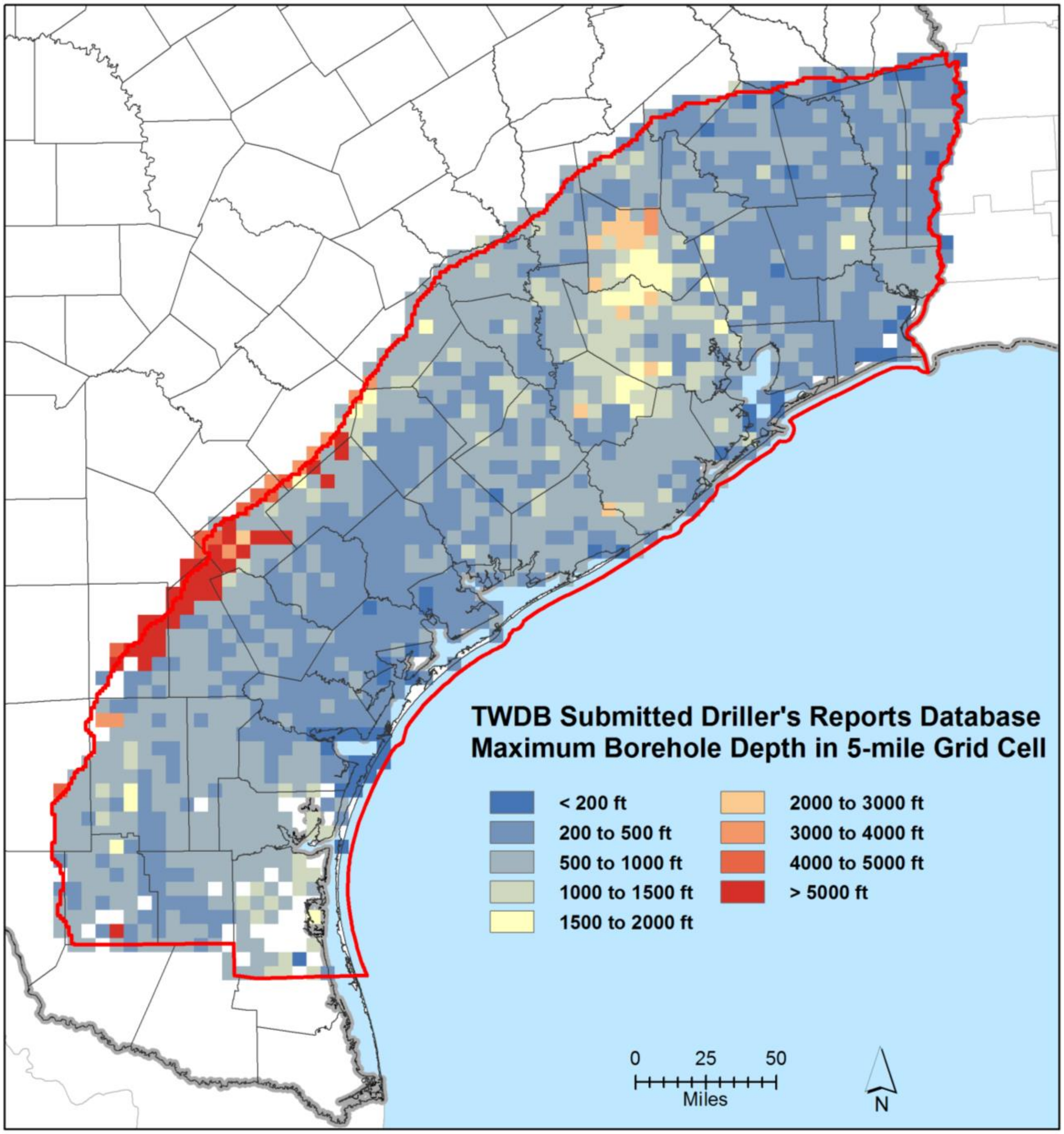

Figure 6-33. Maximum well depth that occurs across 5 mile-by-5-mile grid cells based on well information obtained from the TWDB Submitted Drillers Report.

Note: ft=feet

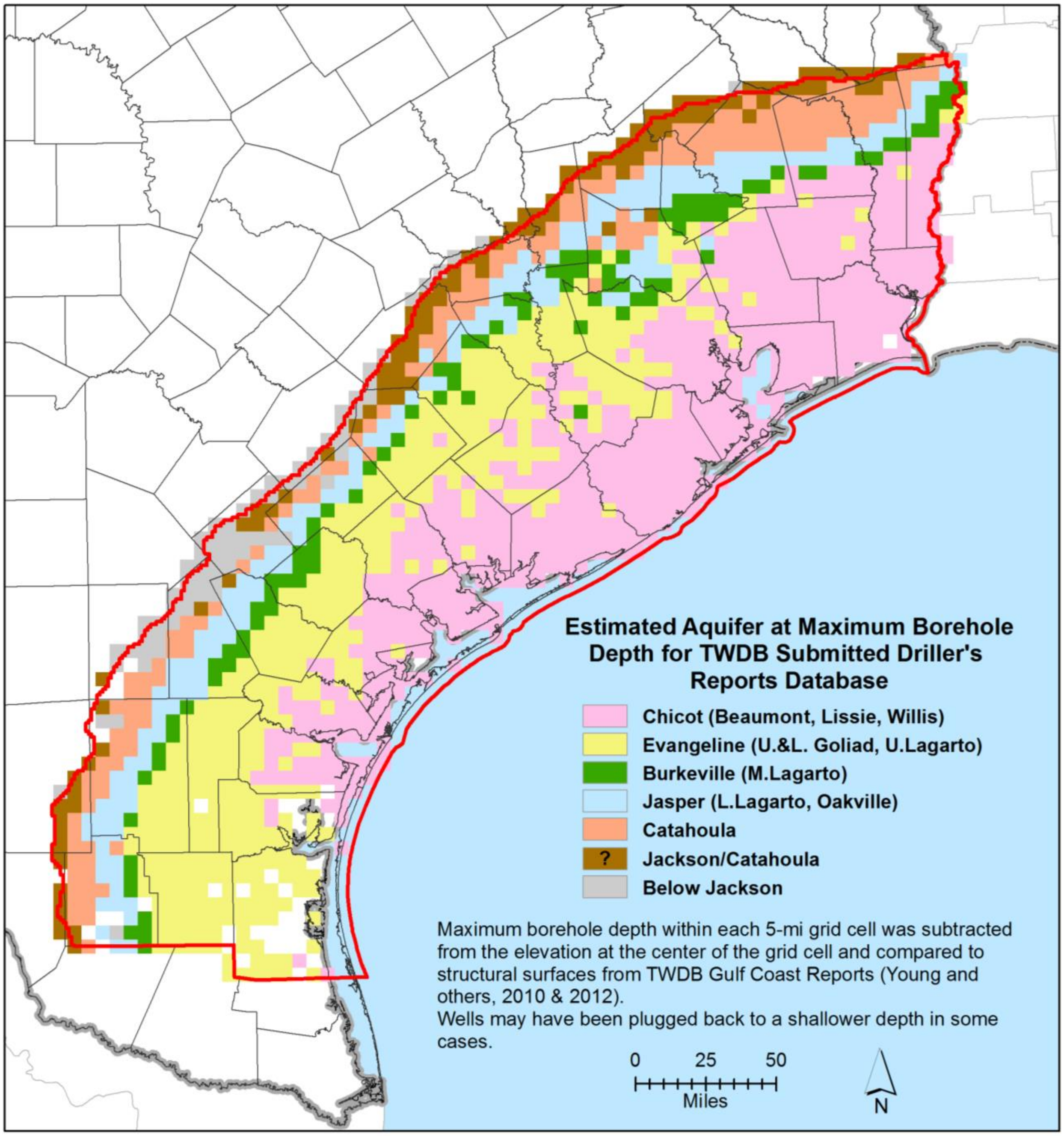

Figure 6-34. The estimated geologic formation in which the deepest well in 5 mile-by-5-mile grid cells terminates. Well information obtained from the TWDB Submitted Drillers Report.

Note: U=upper; L=lower; M=middle

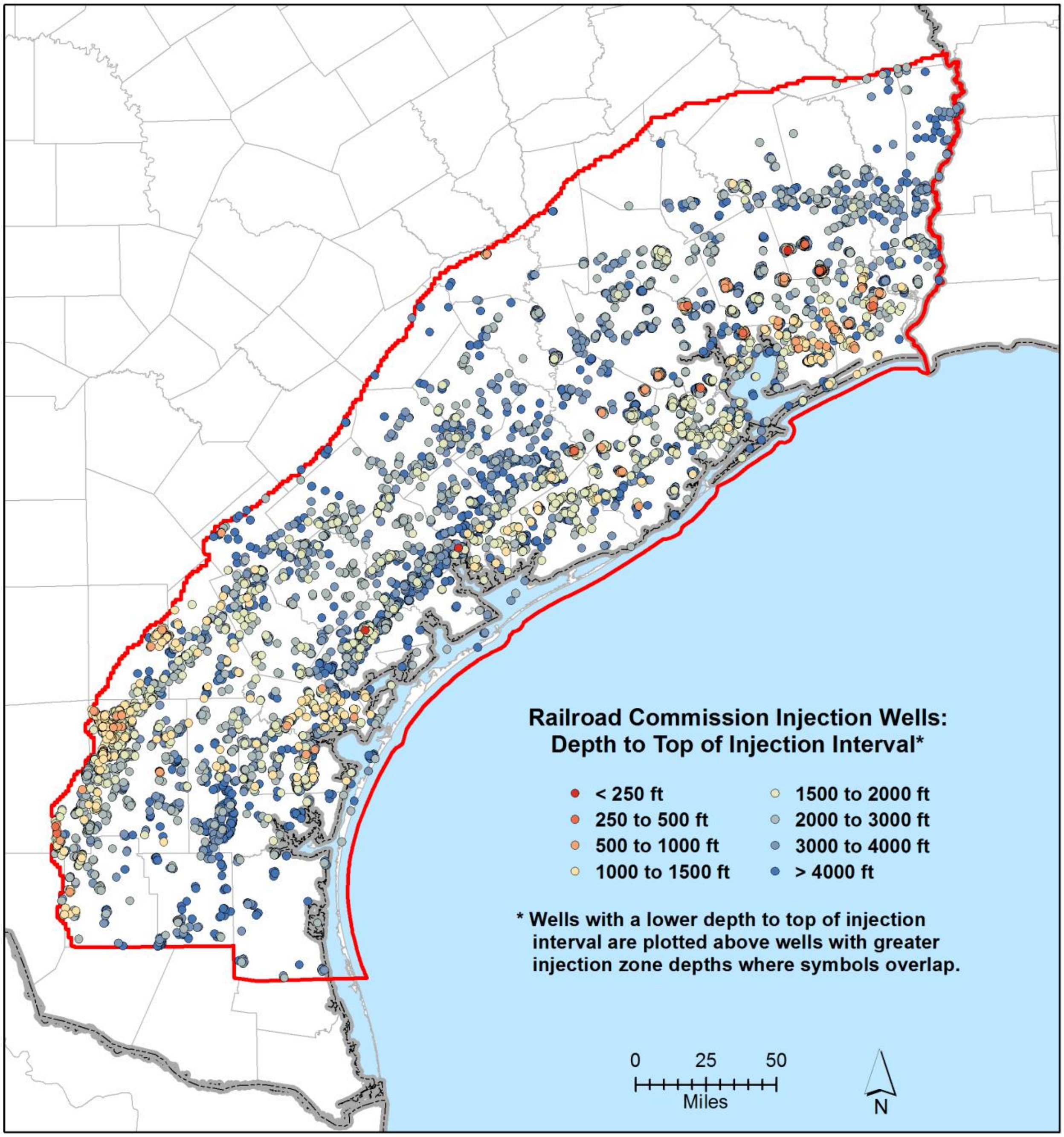

Figure 6-35. Depth to the top injection interval for Texas Railroad Commission active and permitted injection or disposal wells permitted under Chapter 27.

Note: ft=feet

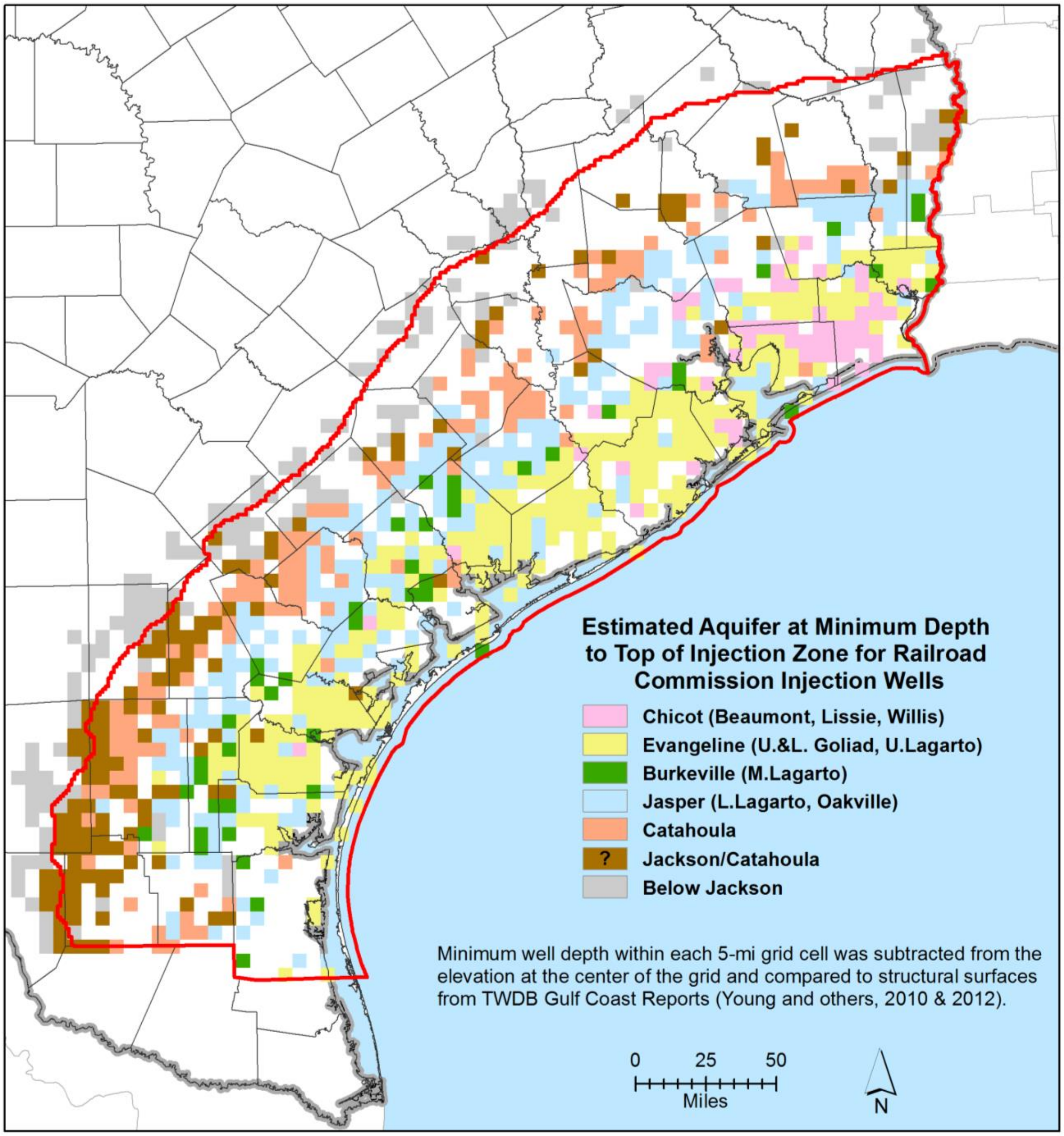

Figure 6-36. The estimated geologic formation at the depth of the top of the minimum injection interval for Railroad Commission injection wells in 5 mile-by-5-mile grid cells.

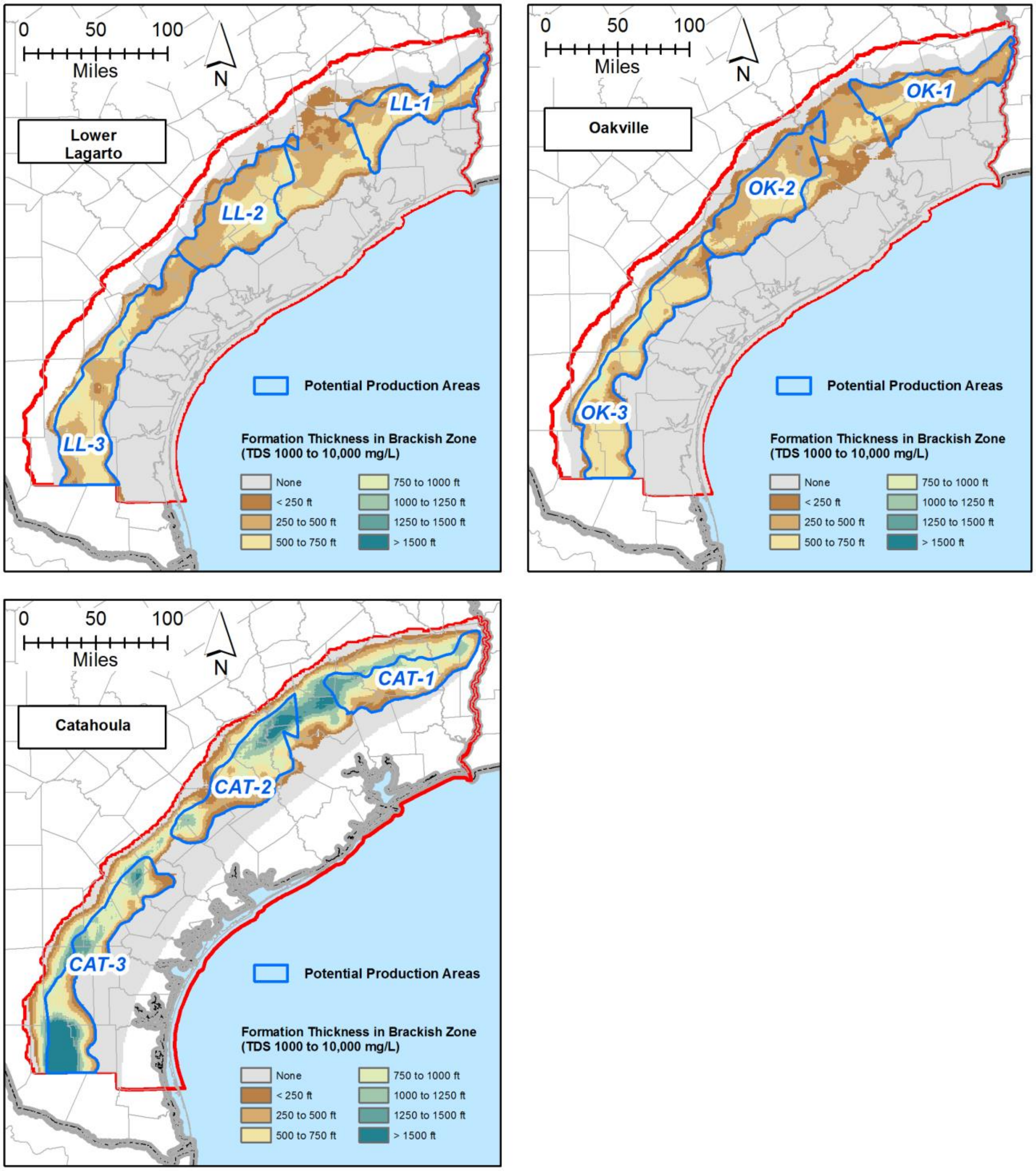

Figure 6-37. **Areal extent of Potential Production Areas #1, #2, and #3 in the lower Lagarto, Oakville, and Catahoula formations.**

Note: TDS=total dissolved solids; mg/L=milligrams per liter

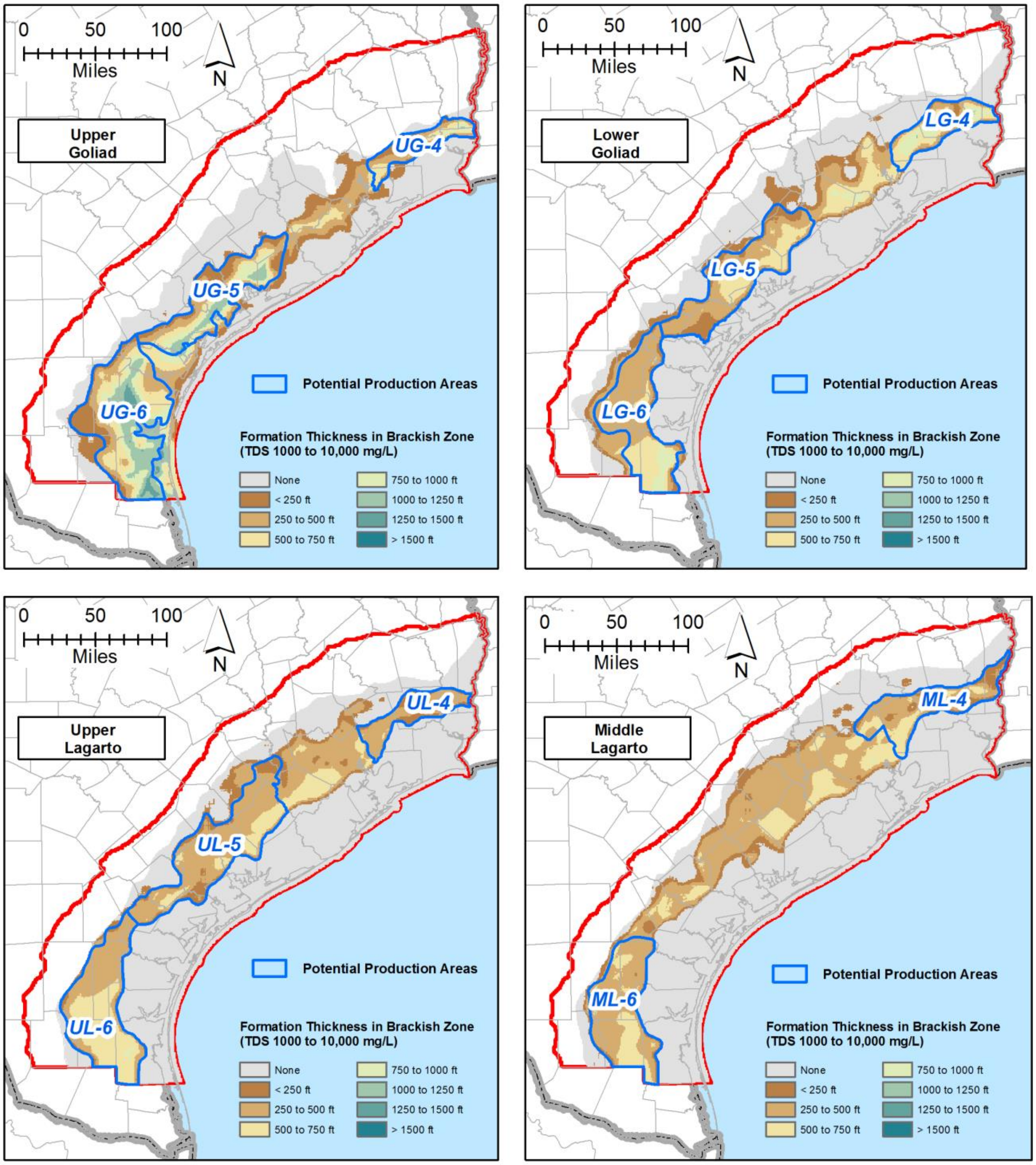

Figure 6-38. **Areal extent of Potential Production Areas #4, #5, and #6 in the upper Goliad (lower portion), lower Goliad, upper Lagarto, and middle Lagarto formations.**

Note: TDS=total dissolved solids; mg/L=milligrams per liter

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7 Previous Investigations

7.1 Hydrogeological Studies

One the most prolific sources of hydrogeological studies in the Texas Gulf Coast are county-wide hydrogeological studies conducted by the TWDB and its predecessor agencies. The reports resulting from the studies describe the geology and hydrogeology of the Gulf Coast Aquifer and summarize water quality and water level data collected over several decades. The county reports are available at URL: (http://www.twdb.texas.gov/groundwater/data/index.asp).

Three major studies have been performed to characterize the stratigraphy and structure of the Texas Gulf Coast Aquifer System. The first major study was part of the United States Geological Society Regional Aquifer-System Analysis Program, which published a series of reports on major aquifer systems across the Gulf Coastal Plain from Texas to Florida (Grubb, 1984, 1987; Ryder, 1988; Weiss, 1992; Hosman, 1996; Williamson and Grubb, 2001; Ryder and Ardis, 2002). These reports assemble hydrogeologic data and interpretations and present the results of numerical simulations. The hydrostratigraphic units developed for the Regional Aquifer-System Analysis Program, however, have generally not been adopted in recent Texas-based studies.

The second major study was also conducted by the United States Geological Society. The Source Water Assessment and Protection Program, a United States Geological Society program, developed a computer-based data set of surfaces (stratigraphic boundaries) for the Chicot and Evangeline aquifers. The primary source data set to generate the Source Water Assessment and Protection surfaces consist of digitized points taken from the surface contours for the Chicot and Evangeline aquifers found in Carr and others (1985). In developing its Source Water Assessment and Protection dataset, the United States Geological Society blended the information from Carr and others (1985) with information from Jorgensen (1975), Baker (1979, 1986), and geologic outcrops mapped on the Bureau of Economic Geology's Geologic Atlas of Texas sheets. The Source Water Assessment and Protection aquifer surfaces were used in developing conceptual models for TWDB groundwater availability models of the Gulf Coast Aquifer (Chowdhury and Mace, 2003; Chowdhury and others, 2004; Kasmarek and Robinson, 2004).

The third major study was funded by the TWDB to characterize the structure and stratigraphy of the geological formation that comprise the Texas Gulf Coast System. The study consisted of two reports; one for the southern Texas Gulf Coast (Young and others, 2010) and another for the northern Texas Gulf Coast (Young and others, 2012). Young and others (2010, 2012) relied on concepts and methods used by the Gulf Basin Depositional Synthesis Project (Galloway,1989; Galloway and others, 2000; Galloway 2005), and the Lower Colorado River Authority-San Antonio Water System Water Project (Young and Kelley, 2006; Young and others, 2009).

Nine of the formation surfaces used in this study were produced by Young and others (2010, 2012). The Chicot Aquifer subaquifer layers include, from the shallowest to deepest, the Beaumont, Lissie, and Willis formations. The Evangeline Aquifer subaquifer layers include the upper Goliad, lower Goliad, and upper Lagarto formations. The Burkeville confining unit is represented as the middle Lagarto Formation. The Jasper Aquifer includes the lower Lagarto and Oakville formations. Figure 7-1 through Figure 7-5 provide the bottom elevations and thicknesses of the 10 formations.

Young and others (2010, 2012) did not map the base of the Catahoula Formation, so for this project, we are using the top of the Yegua-Jackson Aquifer mapped by Knox and others (2007) to represent the base of the Catahoula Formation.

7.2 Geochemical and Salinity Studies

Winslow and Kister (1956) and Core Laboratories (1972) are perhaps the two key studies that provided the first comprehensive investigations for characterizing brackish and saline groundwater in Texas. Both studies make a reconnaissance and inventory of the principal saline aquifers in Texas. The TWDB county-wide reports previously mentioned often discuss water quality data and discuss regions where brackish and saline groundwater exists. A regional assessment of the salinity zones in the Texas Gulf Coast was performed by Young and others (2010, 2012). Young and others (2010, 2012) developed maps of percent fresh water for the Chicot, Evangeline, and Jasper aquifers; however, the results were not validated and, consequently, should be viewed as a high-level assessment of fresh water in the Gulf Coast Aquifer.

To help assess the conceptual flow model of the Texas Gulf Coast Aquifer, the TWDB performed detailed mapping of geochemical data to document evidence of groundwater mixing between aquifers, flow paths, and groundwater ages (Young and others, 2013). These maps included evaluation of total dissolved solids concentration data from over 13,000 water wells. Among the focus of the work was to identify sources of salinity in the groundwater. Potential sources that were reviewed included sea salt spray, saltwater intrusion, connate water, formation of brine upwelling from geopressured zones, bedded halite and evaporates, and salt domes. Young and others (2013) cite previous studies and provide their own analysis to suggest that a potentially significant source of salinity in the Texas Gulf Coast Aquifer is the vertical migration of brines along growth faults that intersect the geopressured zone.

7.3 Geothermal Gradient Studies

For this study, the geothermal gradient studies of interest are those that help define the spatial variability in the geothermal gradient across the study area. Formation temperature affects a wide range of well-log measurements, including resistivity, induction, density, and neutron. Temperature is also important because it affects the electrical conductivity of groundwater. Therefore, there is a need to account for temperature as part of data analysis and interpretation of geophysical log data.

Temperature increases with depth, generally referred to as the geothermal gradient. Much of the heat generated from the interior of the earth is from the decay of naturally radioactive elements. Common units for the geothermal temperature gradient are changes in degrees Fahrenheit per 100 feet or changes in degrees Celsius per kilometer. Although the geothermal gradient varies by location, it averages 25 to 30 degrees Celsius per kilometer (15 degrees Fahrenheit per 1,000 feet). Spatial differences in the geothermal temperature gradient are caused by areal differences in rock thermal conductivities and tectonic activity.

Our review has identified two potentially useful rasters for estimating temperature at the surface. Figure 7-6 shows shallow groundwater temperatures based on a contour map of temperatures in wells with depths ranging from 50 to 150 feet developed by Gass (1982) for the conterminous United States. The raster shown in Figure 7-6 was obtained from Southern Methodist University (http://www.smu.edu/Dedman/Academics/Programs/GeothermalLab/DataMaps/TemperatureMaps). Figure 7-7 shows the mean annual temperature based on a PRISM (Parameter-elevation Regressions on Independent Slopes Model) map for 30-year temperature averages calculated from 1981 to 2010 (PRISM climate group, 2013). The model uses point measurements of climate data and a digital elevation model of terrain to create estimates of monthly climate elements. Estimates are derived for a map with a uniform 4-kilometer grid. Maps were obtained from Oregon State and can be accessed at http://www.prism.oregonstate.edu/.

A comparison of Figures 7-6 and 7-7 shows that both sets of data have similar results that show a 4 to 5 degrees Celsius increase in temperature from the northern to the southern regions of the Gulf Coast Aquifer. The primary difference is that the average temperature data in Figure 7-7 is about 2 degrees Celsius lower than the average groundwater data in Figure 7-6. In general, the two data sets are in good agreement for the needs of this study and the Parameter-elevation Regressions on Independent Slopes Model data will be used for the study because of its better documentation and reproducibility.

Figure 7-8 shows the temperature of the subsurface in the Texas Gulf Coast at a depth of 3,500 meters. The data is extracted from a map of the conterminous United States (Blackwell and others, 2011), prepared as part of the National Geothermal Data System at Southern Methodist University and available at http://www.smu.edu/Dedman/Academics/Programs/GeothermalLab/DataMaps/TemperatureMaps. At a depth of 3,500 meters, the formation temperatures range from approximately 100 to 150 degrees Celsius across the Texas Gulf Coast. There is a pattern of increasing temperatures from the north to the south and from the east to the west. The lowest temperatures occur in Orange and Jefferson counties and the highest temperatures occur in Duval, Jim Hogg, and Webb counties.

Figure 7-9 shows the geothermal temperature gradient calculated using the temperature differences between Figures 7-7 and 7-8. The geothermal gradient varies from about 7 to about 13 degrees Celsius/1,000 feet. The lower geothermal gradients occur near the coastline and the higher geothermal gradients occur near the outcrops of the Oakville and Catahoula formations.

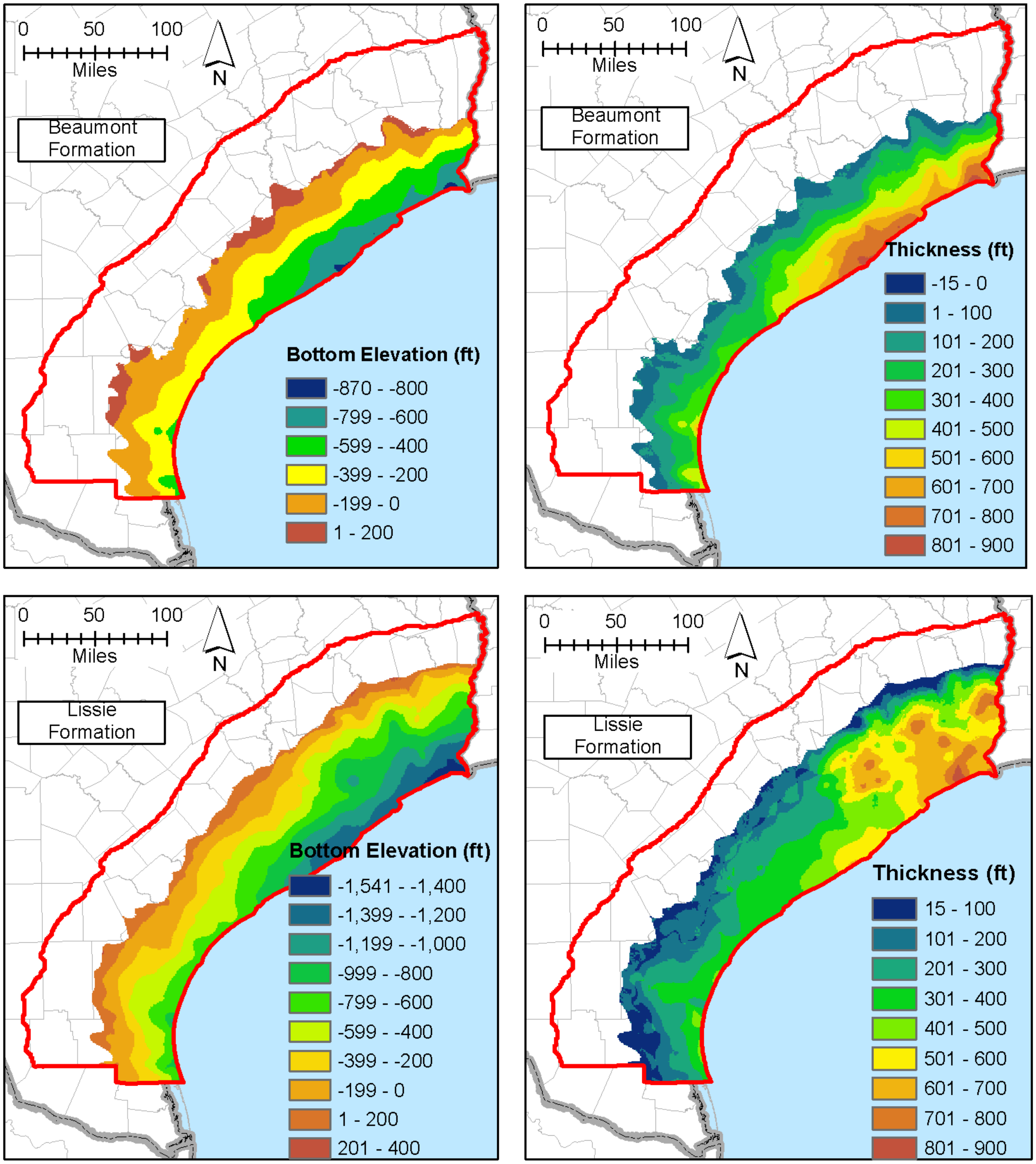

Figure 7-1. **Bottom elevation and thickness for the Beaumont and Lissie formations based on the data from Young and others (2010, 2012).**

Note: ft=feet

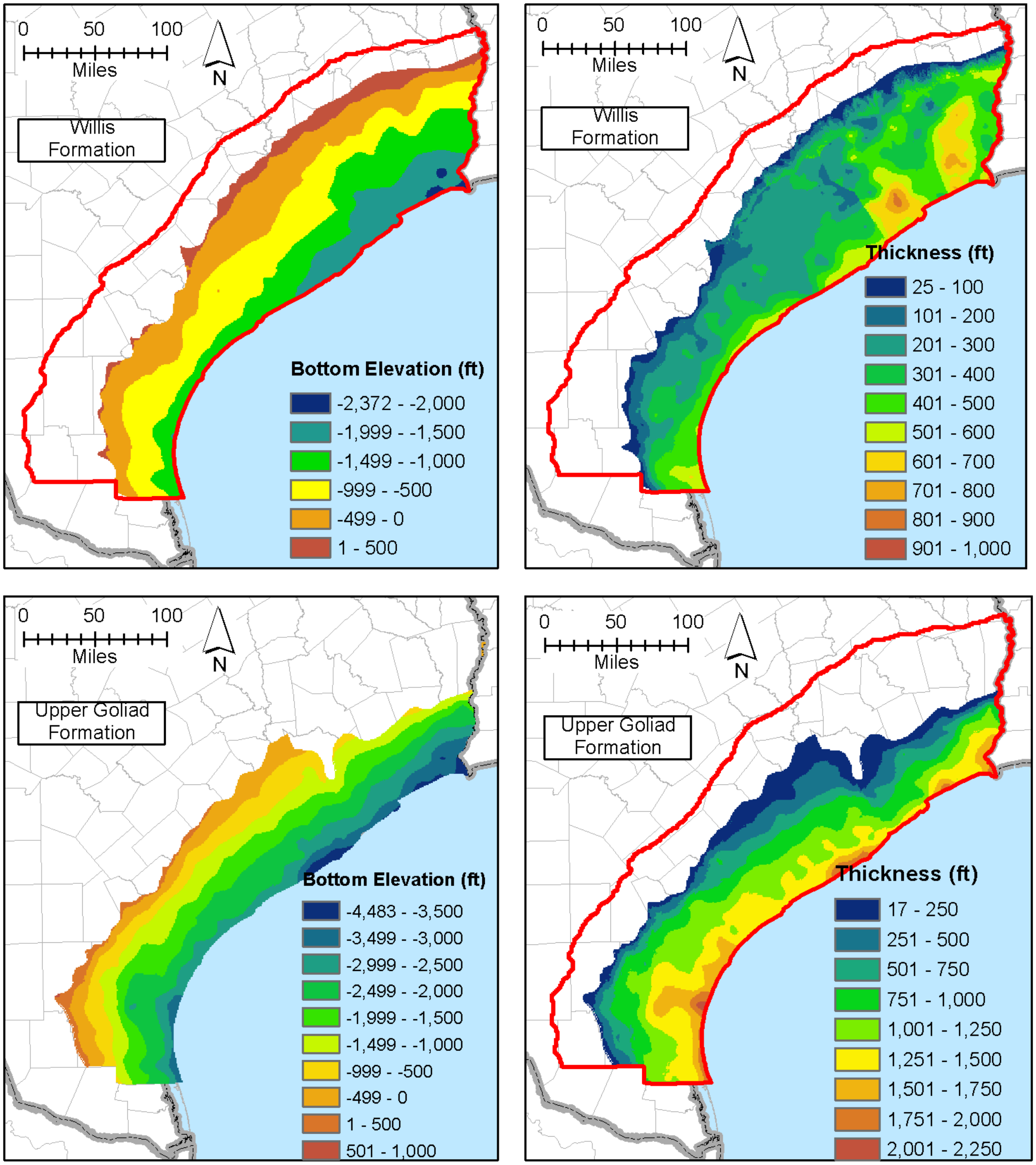

Figure 7-2. Bottom elevation and thickness for the Willis and upper Goliad formations based on the data from Young and others (2010, 2012).

Note: ft=feet

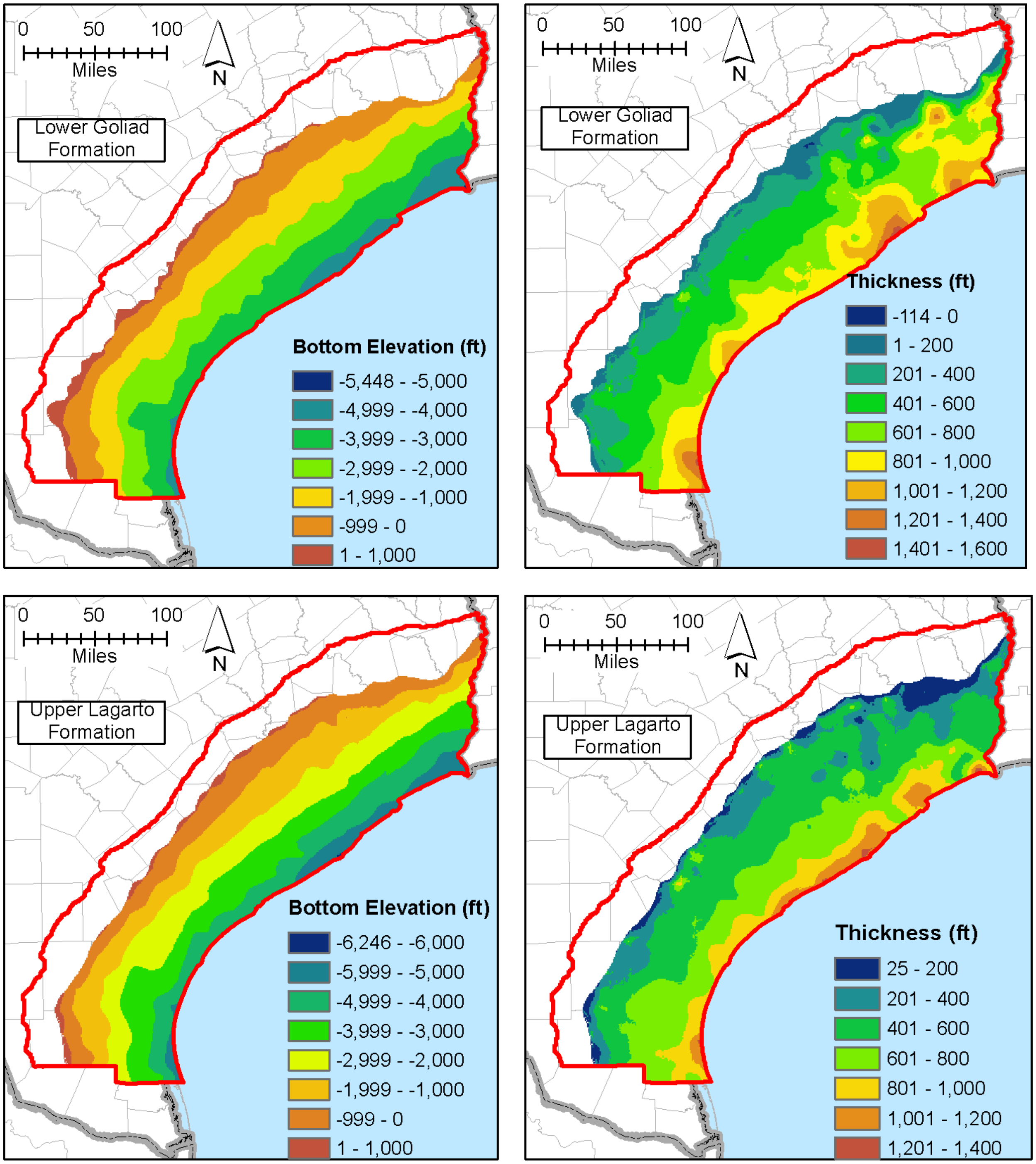

Figure 7-3. Bottom elevation and thickness for the lower Goliad and upper Lagarto formations based on the data from Young and others (2010, 2012).

Note: ft=feet

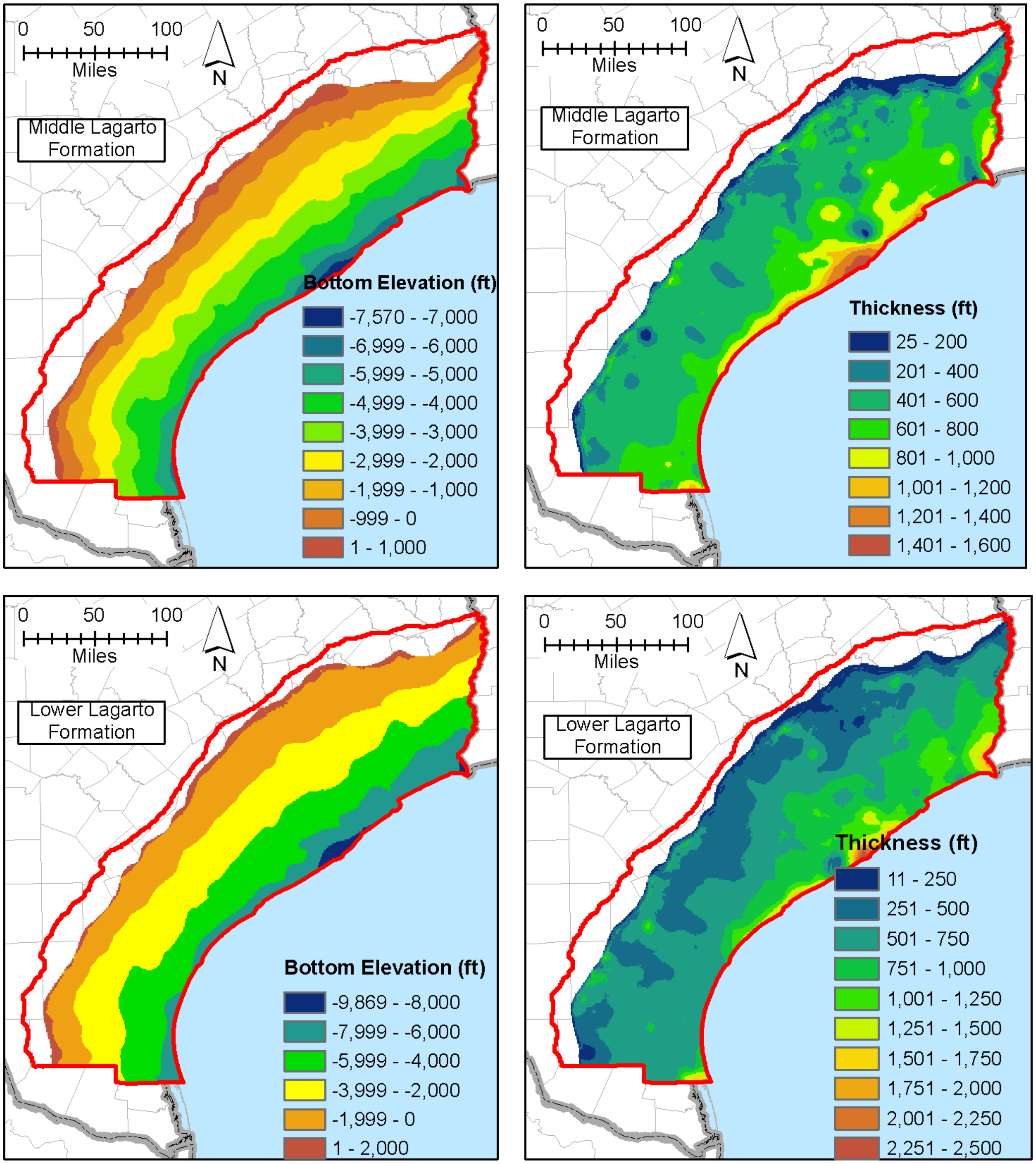

Figure 7-4. Bottom elevation and thickness for the middle Lagarto and lower Lagarto formations based on the data from Young and others (2010, 2012).

Note: ft=feet

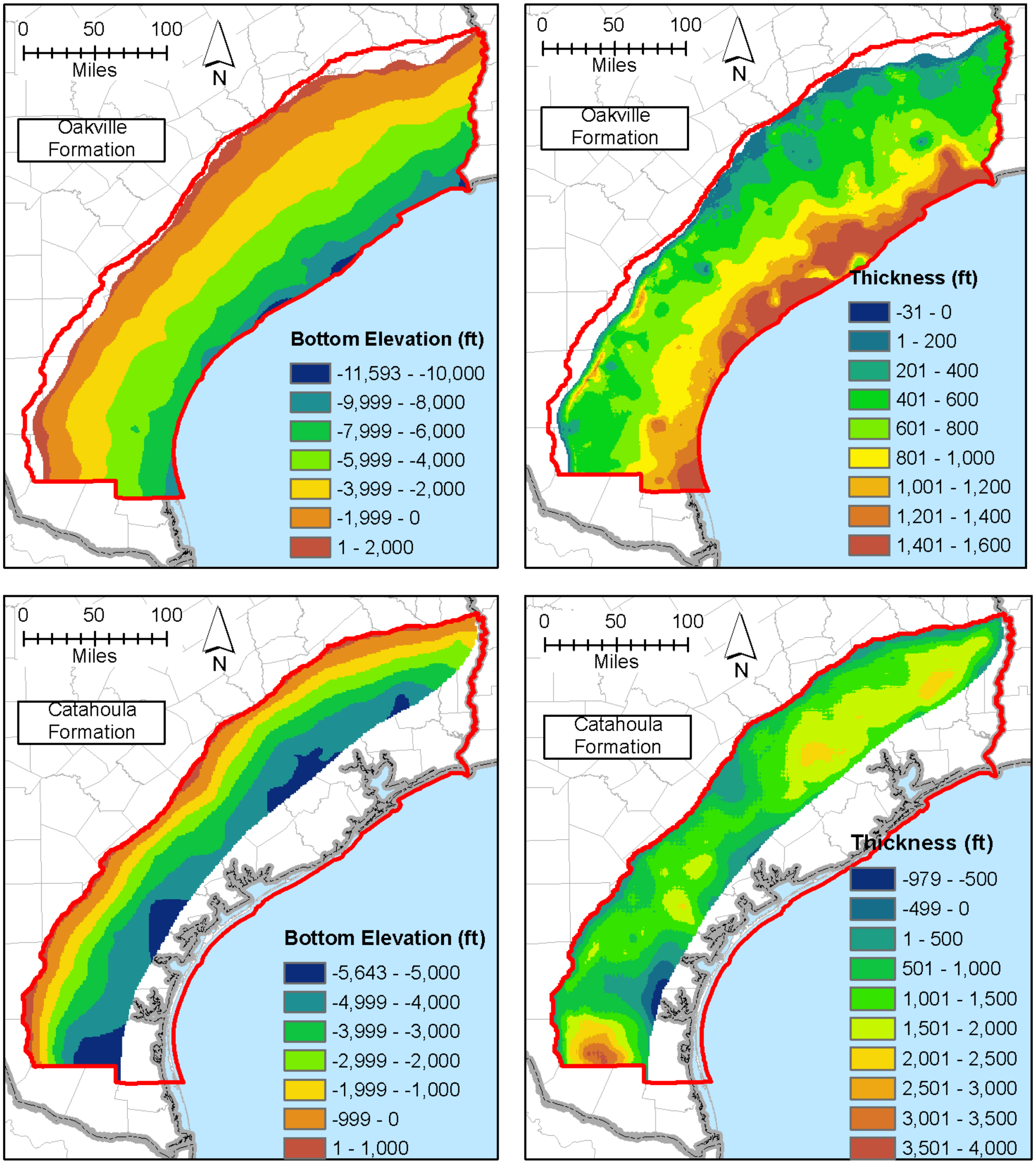

Figure 7-5. **Bottom elevation and thickness for the Oakville and Catahoula formations based on the data from Young and others (2010, 2012) and Knox and others (2007), respectively.**

Note: ft=feet

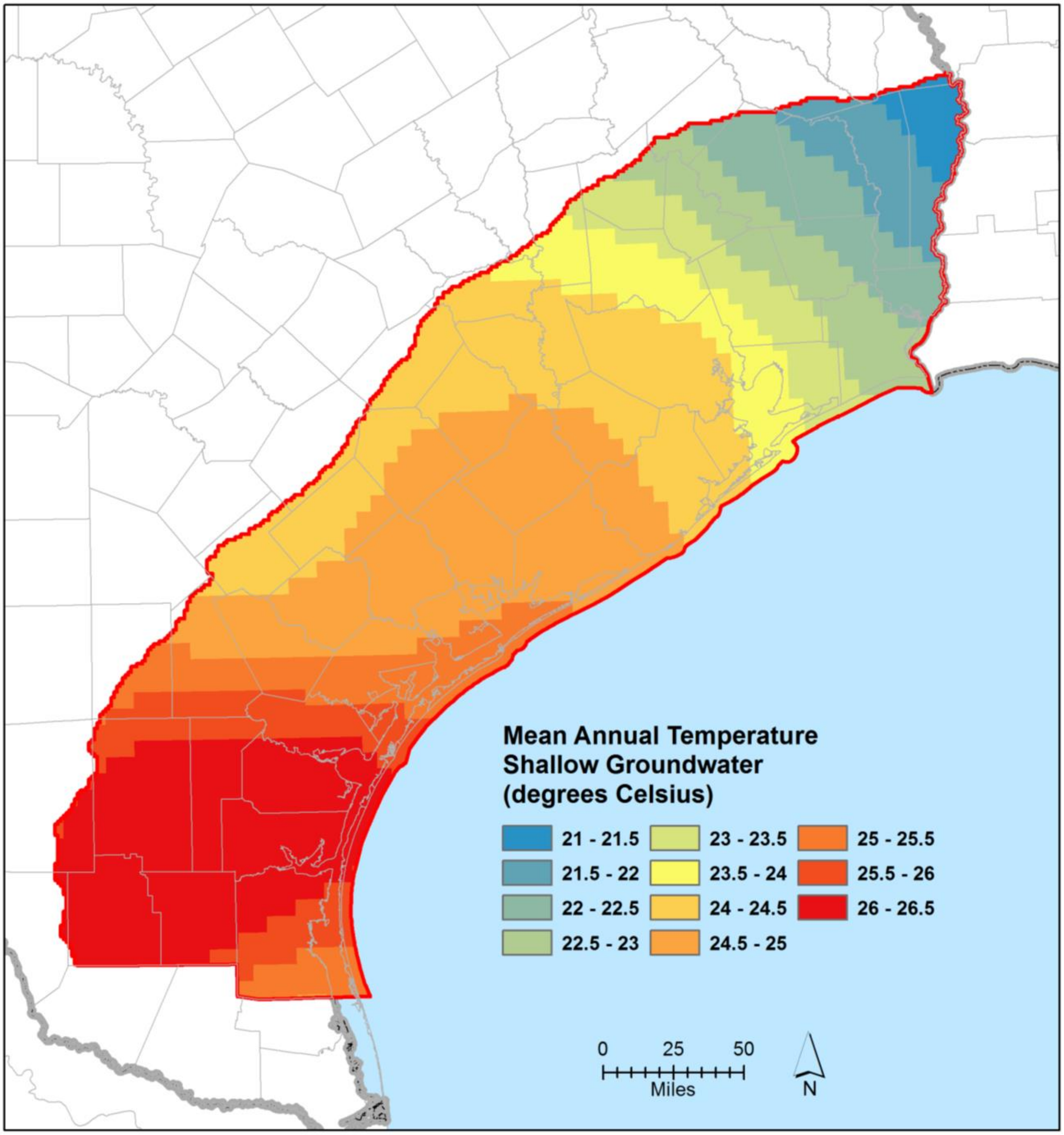

Figure 7-6. Temperature of shallow groundwater based on measurements from wells with depths ranging from 50 to 150 feet (based on Gass, 1982).

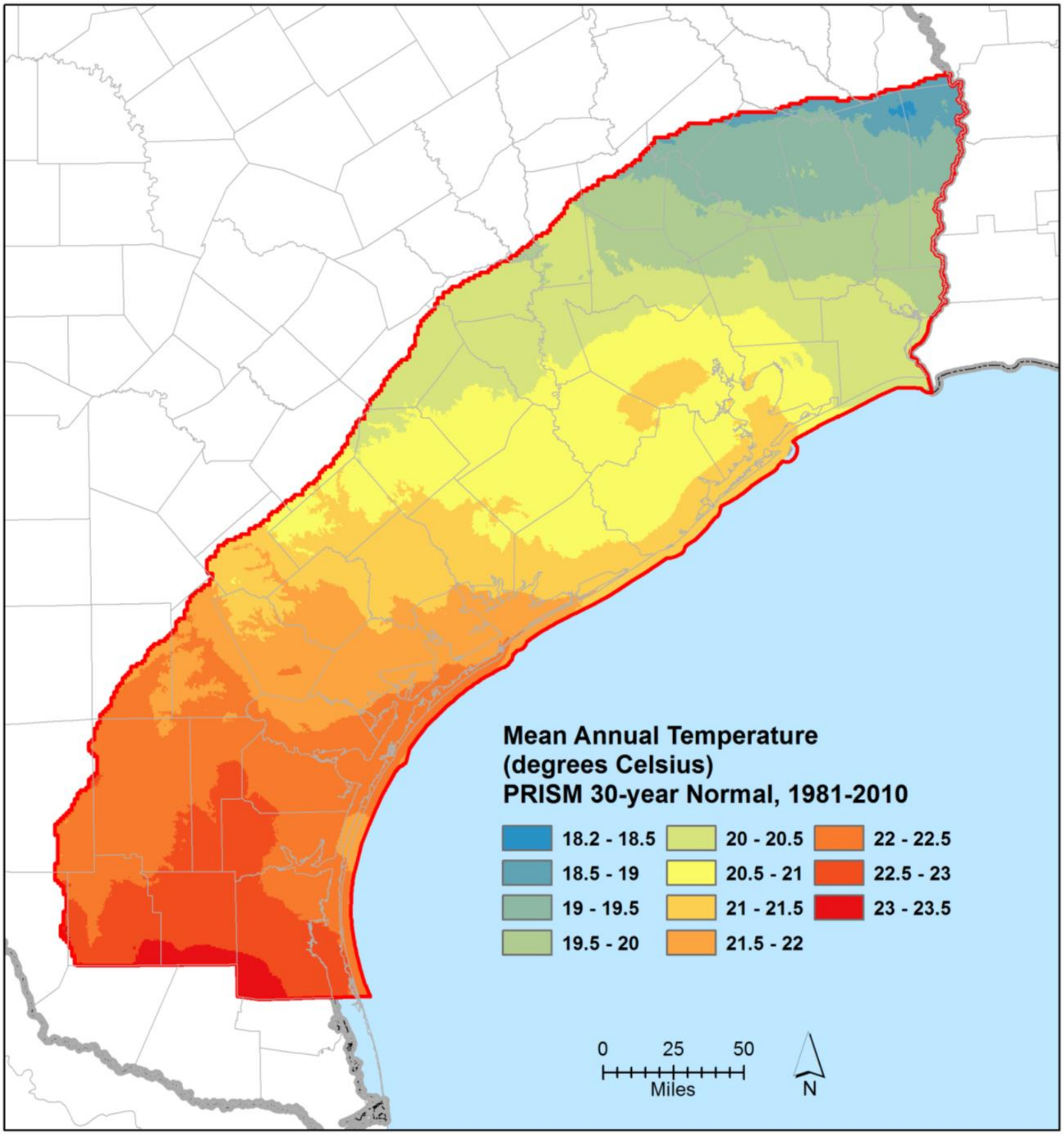

Figure 7-7. **Average annual temperature based on a 30-year period from 1981 to 2010 (PRISM Climate Group, 2013).**

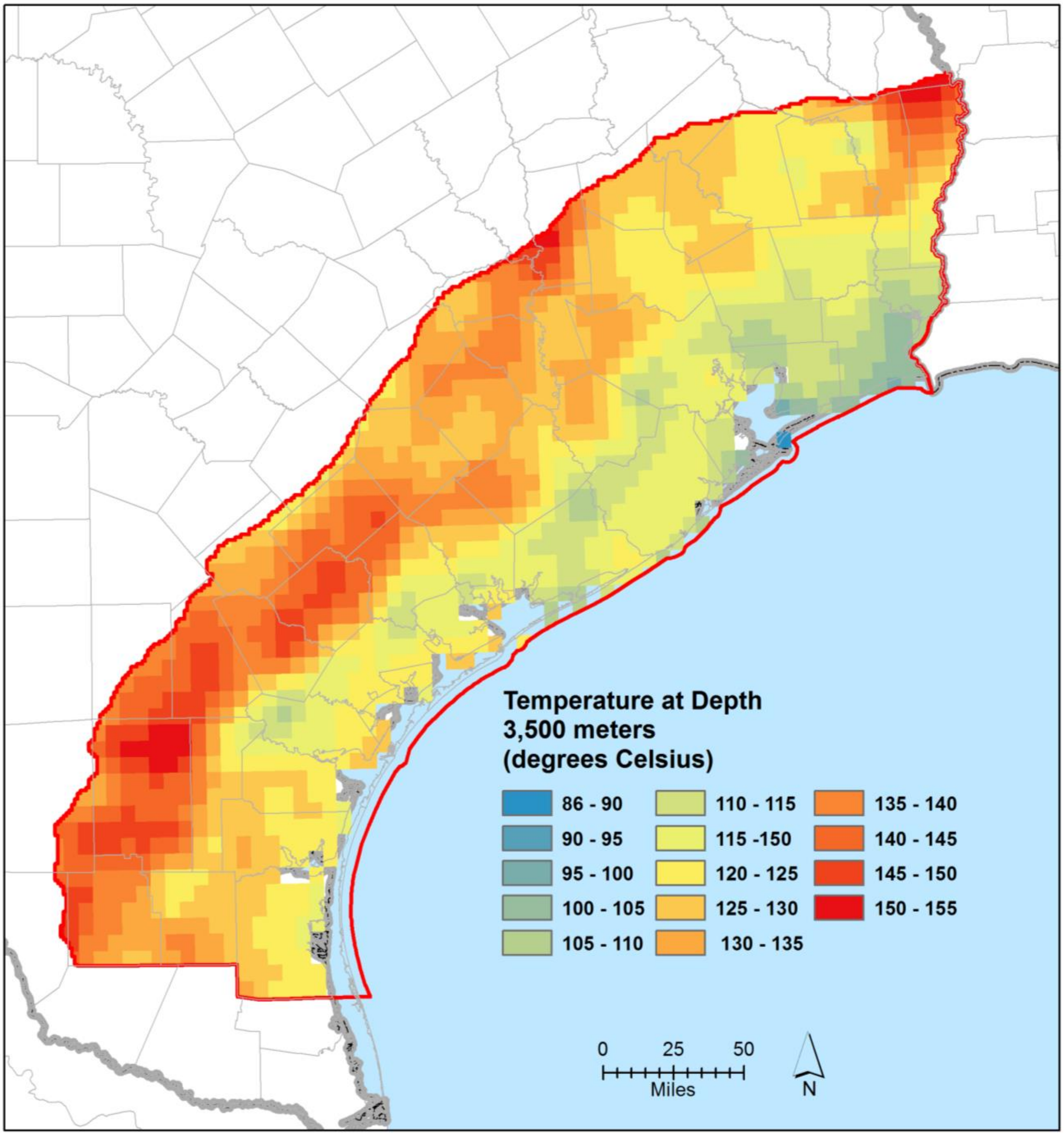

Figure 7-8. Temperature at depth of 3,500 meters based on analysis of bottom hole temperatures (Blackwell and others, 2011).

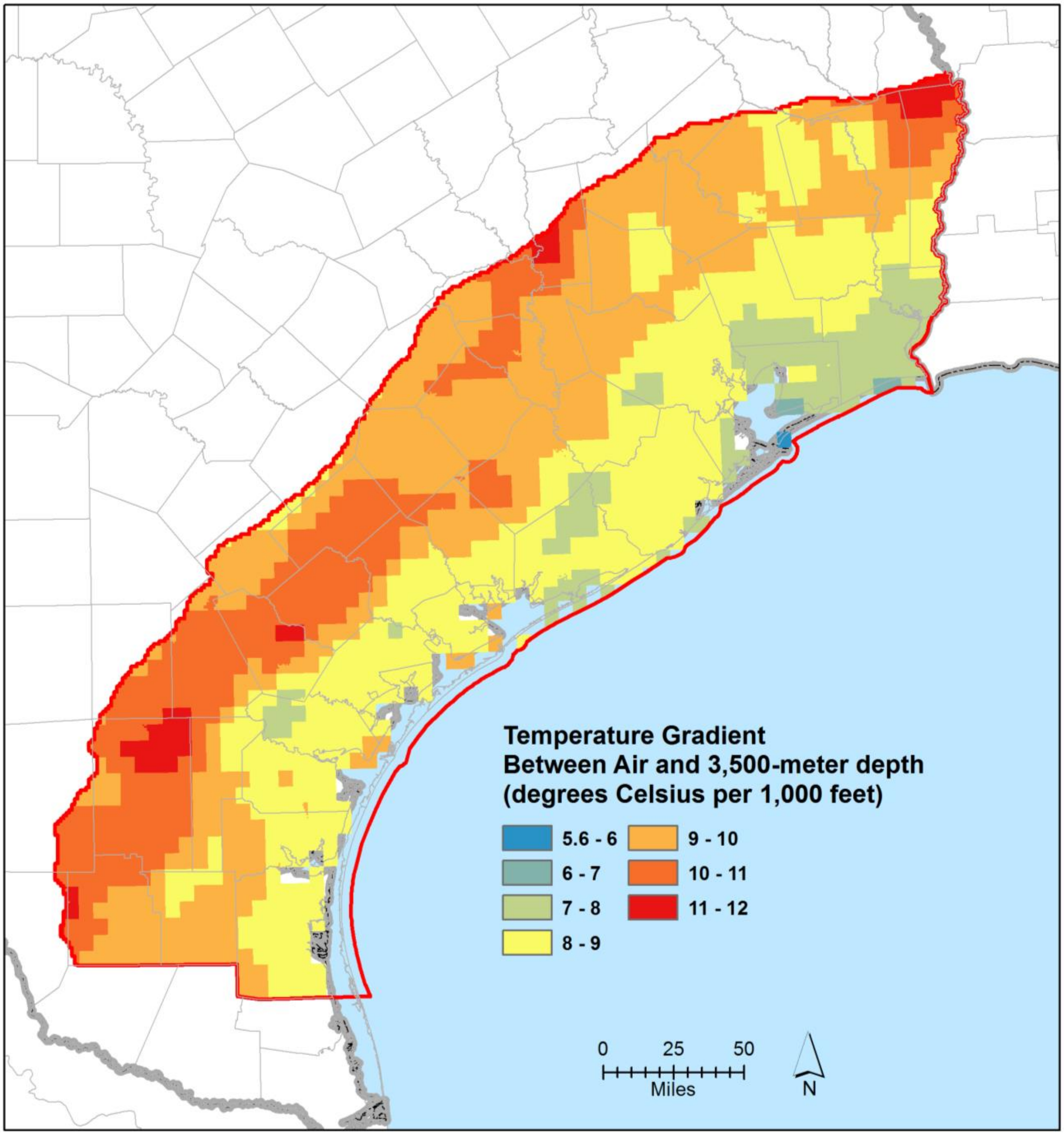

Figure 7-9. **Geothermal gradient calculated using surface temperature values from the PRISM dataset and the subsurface temperature in formations at 3,500-meter depth from Blackwell and others (2011).**

8 Data Collection and Analysis

There were three primary types of data required for this study, including water quality measurements, geophysical logs, and well locations.

The primary source of water quality measurements was the TWDB groundwater database. The groundwater database was used to locate groundwater wells with measured concentrations of total dissolved solids, major cations and ions, radiological compounds, and well construction information. A primary objective of the data collection was to identify geophysical logs within one mile of water wells with both total dissolved solids and well screen information.

The pairing of water wells with geophysical logs was performed in order to investigate and develop approaches for estimating total dissolved solids concentrations using formation resistivity of geophysical logs. The geophysical logs used for the study were obtained from the Brackish Resources Aquifers Characterization System (BRACS) database, the Bureau of Economic Log library, and several commercial vendors. A prerequisite for using a geophysical log as part of the study was that it could be made available to the public. To meet this requirement, we obtained permission from the commercial firms to release their logs to the State of Texas for this project. The commercial firm that provided us with many of the project logs was the Subsurface Library in Austin, Texas. All of the geophysical logs, along with their metadata, are provided as a deliverable for this project. In addition, the metadata have been chronicled in a format consistent with entry into the Brackish Resources Aquifers Characterization System database.

All logs that were obtained from outside sources were received as .tif files. Tagged Imaged File (or TIF) is an efficient file format for storage of high quality raster graphics. TIF files are bitmap-based images comprised of pixels in a grid. TIF files have a fixed resolution and cannot be resized without losing image quality. Figure 8-1 is an example of a TIF image of a geophysical log.

The primary analysis performed on the geophysical logs was to identify sand beds and record their thickness and formation resistivity. The identification of the sand beds was performed manually on the TIF images. The determination of the formation resistivity of the sand was performed using a computer program written to analyzed digitized curves of the deep resistivity curve. The standard file-format common in the oil-and-gas and water well industries to store digital well log information is the Log ASCII Standard (LAS). A LAS file is a structured ASCII file containing log curve data and header information. ASCII is abbreviated from American Standard Code for Information Interchange, and is a character encoding standard that is used for most text files. Figure 8-2 shows the header and several sections from an LAS file. In order to facilitate the calculation of formation resistivity, we digitized over 1,000 tif files to LAS files. All of these logs had their deep resistivity curve digitized. Approximately 200 of the logs also had their spontaneous potential curve digitized.

To help define the exclusion zones for our study, we obtained well information from the following sources:

- Bureau of Economic Geology Geophysical Log Facility;
- Texas Commission on Environmental Quality water well image files and public drinking water files;
- Texas Department of Licensing and Regulation Submitted Driller's Report Database

- Texas Water Development Board Groundwater Database, Brackish Resources Aquifers Characterization System Database, and Submitted Driller Reports database
- Groundwater conservation districts located in the Texas Gulf Coast Aquifer

Beside well construction information, we also obtained well yields and estimates of specific capacity from the TWDB Submitted Drillers Report Database. The details regarding data sources and means of collection and analysis are described in the relevant sections of the report.

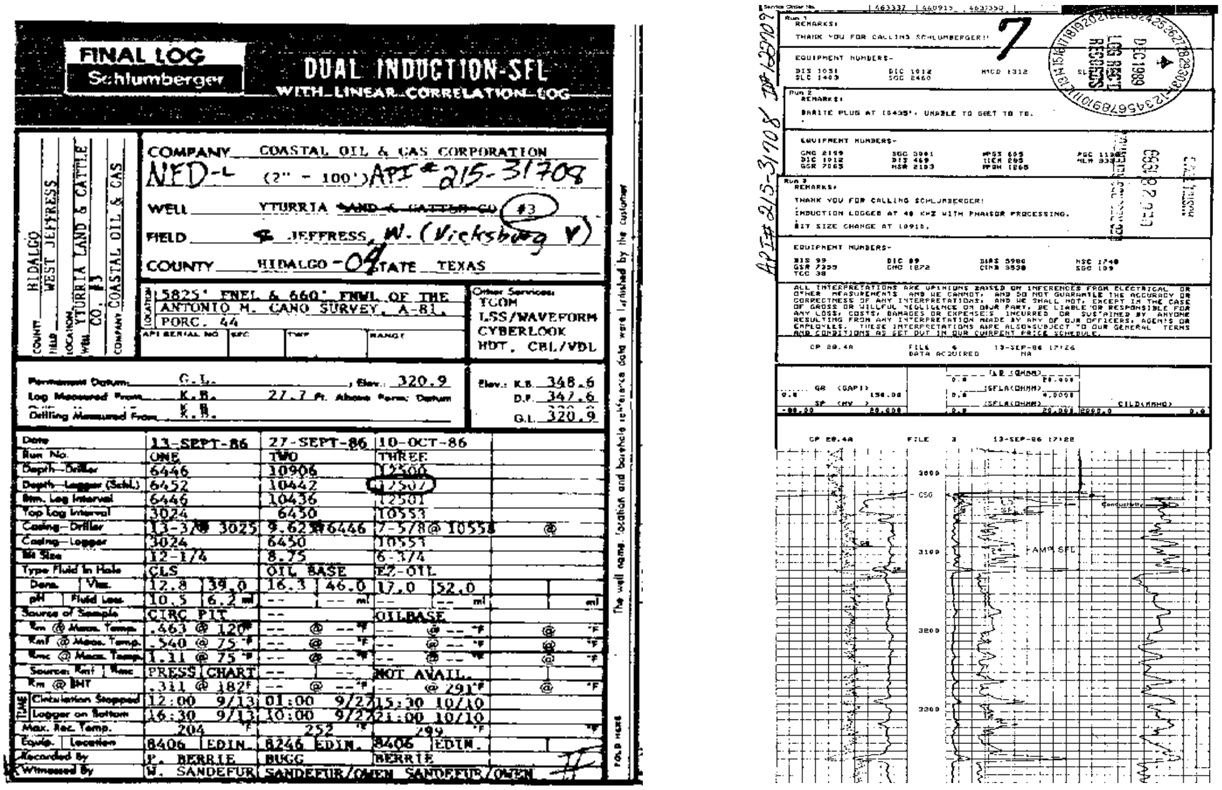

Figure 8-1. **Example of a raster image of a geophysical well log that uses the American Petroleum Institute format.**

```
#    WellGreen Tech Inc.   Digitizing Services
#    www.wellgreentech.com
#    email: sales@wellgreentech.com
#
~Version Information Block
 VERS.                  2.00:    CWLS LOG ASCII STANDARD - VERSION 2.000000
 WRAP.                   NO:     One Line Per Depth Step
#
~Well Information Block
#MNEM.UNIT                    Data                              Information
#----------   ------------------------------------------       ---------------
 STRT.FT                                       40.0000:         START DEPTH
 STOP.FT                                     2010.0000:         STOP DEPTH
 STEP.FT                                        0.5000:         STEP
 NULL.                                       -999.2500:         NULL VALUE
 COMP.                     SUN EXPLORATION & PROD. CO.:           COMPANY
 WELL.                               SANTOS MONTOYA #1:         WELL
 FLD .                                          OILTON:         FIELD
 LOC .                                                :         LOCATION
 CNTY.                                            WEBB:         COUNTY
 STAT.                                           TEXAS:         STATE
 CTRY.                                             USA:         COUNTRY
 SRVC.                                     SCHLUMBERGER:        SERVICE COMPANY
 DATE.                                      01/24/1984:         DATE
 API .                                  42479338120000:         API NUMBER
 UWI .                                  42479338120000:         UWI NUMBER
 TVD .                                              NO:         TVD flag
 WSTA.                                             LOC:         Well status
#
~Curve Information Block
#MNEM.UNIT        API CODE       Curve Description
#----------     ------------     -------------------
 DEPT.FT                     :    Depth in Feet
 SP  .MV        01 010 01 01:    Spontaneous Potential
 RES_SHAL.OHMM 10 220 01 01:    Spherically Focused Laterolog
 RES_DEEP.OHMM 05 120 46 01:    Deep Induction
#
~Parameter Information Block
#MNEM.UNIT              Value                 Description
#----------      --------------------     -------------------
 RUN .                            ONE:     Run Number
 PDAT.                            UNK:     Permanent Datum
 EPD .FT                       0.0000:     Elevation Of Perm. Datum
 WSTA.                            LOC:
 E   .FT                       0.0000:     E (Stretch Coefficient Of The Cable)
 TD  .FT                    2000.0000:     Total Depth
 LMF .                      KELLY BUSHING:     Logging measured from Kelly Bushing
 EKB .FT                               870.0:     Elevation Kelly Bushing
 GL  .FT                                 859.0:     Ground Level
 DF  .FT                                 869.0:     Drill Floor
 CSGL  .FT                             53.0:     Casing Bottom Logger
 CSGD  .FT                            53.0:     Casing Bottom Driller
 MUD   .                               GEL-DRISPAC:     Mud Type
 MUDD  .LB/USG                 9.7:     Mud Weight/Density
 MUDV  .CP                            41.0:     Mud Viscosity
 PH    .                                      9.5:     Mud ph
 FL    .ml/30min                      7.0:     Mud Fluid Loss Rate
 MUDS  .                                    TANK:     Mud Source
 Rm    .OHMM                          2.98:     Mud Resistivity
 RmT   .DEGF                            70.0:     Mud Temperature
 Rmf  .OHMM                           2.59:     Mud Filtrate Resistivity
 RmfT  . DEGF                          74.0:     Mud Filtrate Temperature
 Rmc .OHMM                            4.2:     Mud Cake Resistivity
 RmcT .DEGF                             75.0:     Mud Cake Temperature
 RMB   .OHMM                          2.1:     Mud Resistivity Bottom Hole
 BHT  .DEGF                           102.0:     Bottom Hole Temperature
#
~Other Information Block
<DescLogPlotStart>   NEURALOG PLOT DEFINITION
PLOTDEFVERSION: 3
LASFILE: E:\nds\projects\Intera - Feb 23\las\42479338120000.las
DEPTHSCALE: 240.000000
RESOLUTION: 400
DEPTHLABELFREQ: 100.000000
HEAVYGRIDFREQ: 100.000000
MEDIUMGRIDFREQ: 50.000000
LIGHTGRIDFREQ: 10.000000
#
#   TRACK 1
#
STARTTRACK:
 LEFTX: 0.500000 inch
 RIGHTX: 3.000000 inch
 SCALETYPE: Linear
 NUMCHARTDIVISIONS: 10
CURVE: SP    -80.000000 20.000000  (0,0,255)      Solid              2     N
ENDTRACK:
#
#   TRACK 2
#
STARTTRACK:
 LEFTX: 3.500000 inch
 RIGHTX: 8.500000 inch
 SCALETYPE: Log
 NUMCYCLES: 4
 STARTCYCLE: 2
CURVE: RES_SHAL 0.200000   2000.000000 (0,131,131)    Solid              2     N
CURVE: RES_DEEP 0.200000   2000.000000 (255,0,255)    Dot                2     N
ENDTRACK:
<DescLogPlotEnd>
~A DEPTH       SP             RES_SHAL            RES_DEEP
      40.000 -999.250         0.324            -999.250
      40.500 -999.250         0.322            -999.250
      41.000 -999.250         0.321            -999.250
      41.500 -999.250         0.318            -999.250
      42.000 -999.250         0.315            -999.250
      42.500 -999.250         0.316            -999.250
      43.000 -999.250         0.317            -999.250
      43.500 -999.250         0.318            1888.541
      44.000 -999.250         0.318            1074.619
      44.500 -999.250         0.319            606.204
      45.000 -999.250         0.322            604.297
      45.500 -999.250         0.322            1640.593
      46.000 -999.250         0.320            1963.692
```

Figure 8-2. Example of a .LAS file that was produced from a .tif file.

9 Aquifer Hydraulic Properties

Aquifer hydraulic properties refer to the physical characteristics that govern flow of groundwater through the aquifer. For this study, hydraulic properties are most important in regard to modeling the impacts associated with pumping the well fields in the Potential Production Areas. In this section, we introduce several of the important terms and concepts associated with characterization of aquifer hydraulic properties and we present field data that will help to illustrate some of the important regional differences in the aquifer's ability to transmit water. Simulations of the pumping impacts were performed using regional groundwater models developed by the TWDB and the results are provided in Section 14. Also in Section 14 are detailed discussions and figures that explain how the aquifer properties vary spatially.

There are many factors that impact aquifer hydraulic properties, such as aquifer structure, aquifer lithology, depositional environment, and the presence of fractures and faults. However, the primary hydraulic properties are horizontal and vertical hydraulic conductivity, transmissivity, and specific storage, which are defined below:

Hydraulic Conductivity – The measure of the ease with which groundwater can flow through an aquifer. Higher hydraulic conductivity indicates that the aquifer will allow more water movement under the same hydraulic gradient. Hydraulic conductivity has dimensions of length per unit time and typically is expressed in units of feet per day or gallons per day per square foot.

Transmissivity – This term is closely related to hydraulic conductivity and refers to the product of the hydraulic conductivity multiplied by the effective aquifer thickness. Transmissivity describes the ability of groundwater to flow through the entire thickness of an aquifer. As the thickness of the aquifer increases, the transmissivity increases for a given hydraulic conductivity. Transmissivity has dimensions of length squared per unit time and is typically expressed in units of square feet per day or gallons per day per foot.

Specific Storage – This term describes the volume of water that a unit or portion of a confined aquifer will release when the water level in the aquifer is lowered. Specific storage has units of inverse length.

Storativity – This term is closely related to specific storage and refers to the product of the specific storage times the effective aquifer thickness. Also referred to as the coefficient of storage, this term describes the volume of water a confined aquifer will release when the water level in an aquifer is lowered. Storativity is a dimensionless parameter.

Fault Hydraulic Conductance – This term is a measure of the ability for groundwater to flow across a fault and has dimensions of length squared per unit time. This term is the product of the fault zone hydraulic conductivity times a grid cell area divided by a length over which the fault zone exists.

For every water well drilled in Texas, the driller should submit a drillers report to the TWDB. Since 2001, the TWDB has managed a Submitted Driller Report database that serves as a good source of hydraulic information. Figures 9-1, 9-2, and 9-3 show the reported well yields from the submitted driller reports for the Chicot, Evangeline, and Jasper/Catahoula aquifers, respectively. The well yields are reported in gallons per minute. For all plots, the lowest yields are plotted first and the higher yields are plotted next so that the no well yields are masked by lower well yields in the same locations. The spatial pattern in the well locations reflects where each respective aquifer outcrops, or intersects the ground surface.

A visual inspection of the plotted well yields reveals several of the important trends in the transmissive properties of the aquifers that will become more evident through the simulation of drawdown from candidate well fields. The lowest well yields occur in south Texas in Jasper County and the highest yields occur in all three aquifers in the vicinity of Harris and Montgomery counties. Although useful, the plotting of well yields can be misleading because the spatial pattern may be more representative of the type of well installed rather than the productivity of the aquifer. To help minimize this bias, the well yields that were reported with a drawdown have been converted to specific capacities and plotted in Figures 9-4, 9-5, and 9-6 for the Chicot, Evangeline, and Jasper aquifers, respectively.

Specific capacity is a measure of the productivity of a well and is calculated by dividing the total pumping rate by the drawdown (Equation 9-1). Specific capacity is generally reported as gallons per minute per foot. However, by converting to consistent units, specific capacity can be expressed as feet squared per day. Water well drillers have historically used specific capacity to quantify the productivity of a well.

$$SC = Q/s \qquad \text{(Equation 9-1)}$$

Where:

Q	=	discharge (volume of water per time)
SC	=	specific capacity (volume of water per time per length)
s	=	drawdown (length)

Several researchers have shown that there is a theoretical linear relationship between specific capacity and transmissivity (Mace, 1997, 2001). One approach for developing this relationship is by conversion of units. Equation 9-2 was developed by converting transmissivity in units of square feet per day into specify capacity in units of gallons per minute per foot. Using the relationship from Equation 9-2, Equation 9-3 can be used to estimate drawdown based on a pumping rate, in gallons per minute, and transmissivity (square feet per day).

$$SC = T * 0.0052 \qquad \text{(Equation 9-2)}$$

$$s = Q / (T * 0.0052) \qquad \text{(Equation 9-3)}$$

Where:

SC	=	specific capacity (gallons per minute per foot)
T	=	transmissivity (square feet per day)
S	=	drawdown (feet)
Q	=	pumping rate (gallons per minute)

The spatial trends in specific capacity in Figures 9-4, 9-5, and 9-6 clearly show marked regional differences in the transmissive properties of the Chicot, Evangeline, and Jasper aquifers. Out of the three aquifers, the Jasper is the least transmissive and the lowest specific capacity values within the Jasper Aquifer occur in south Texas.

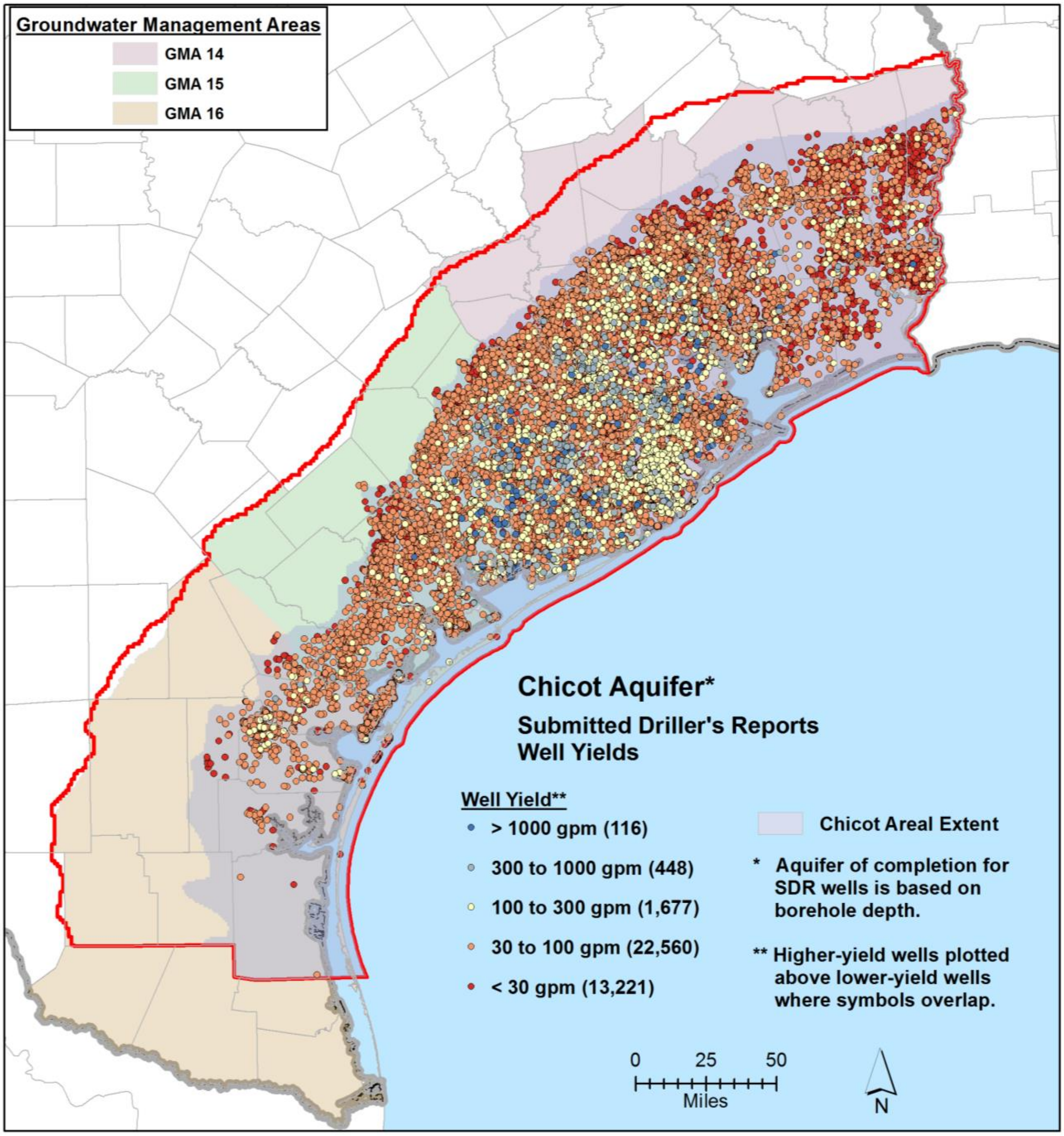

Figure 9-1. Reported well yields for the Chicot Aquifer based on well information obtained from the TWDB Submitted Drillers Reports.

Note: GMA=Groundwater Management Area; gpm=gallons per minute; SDR=Submitted Drillers Report

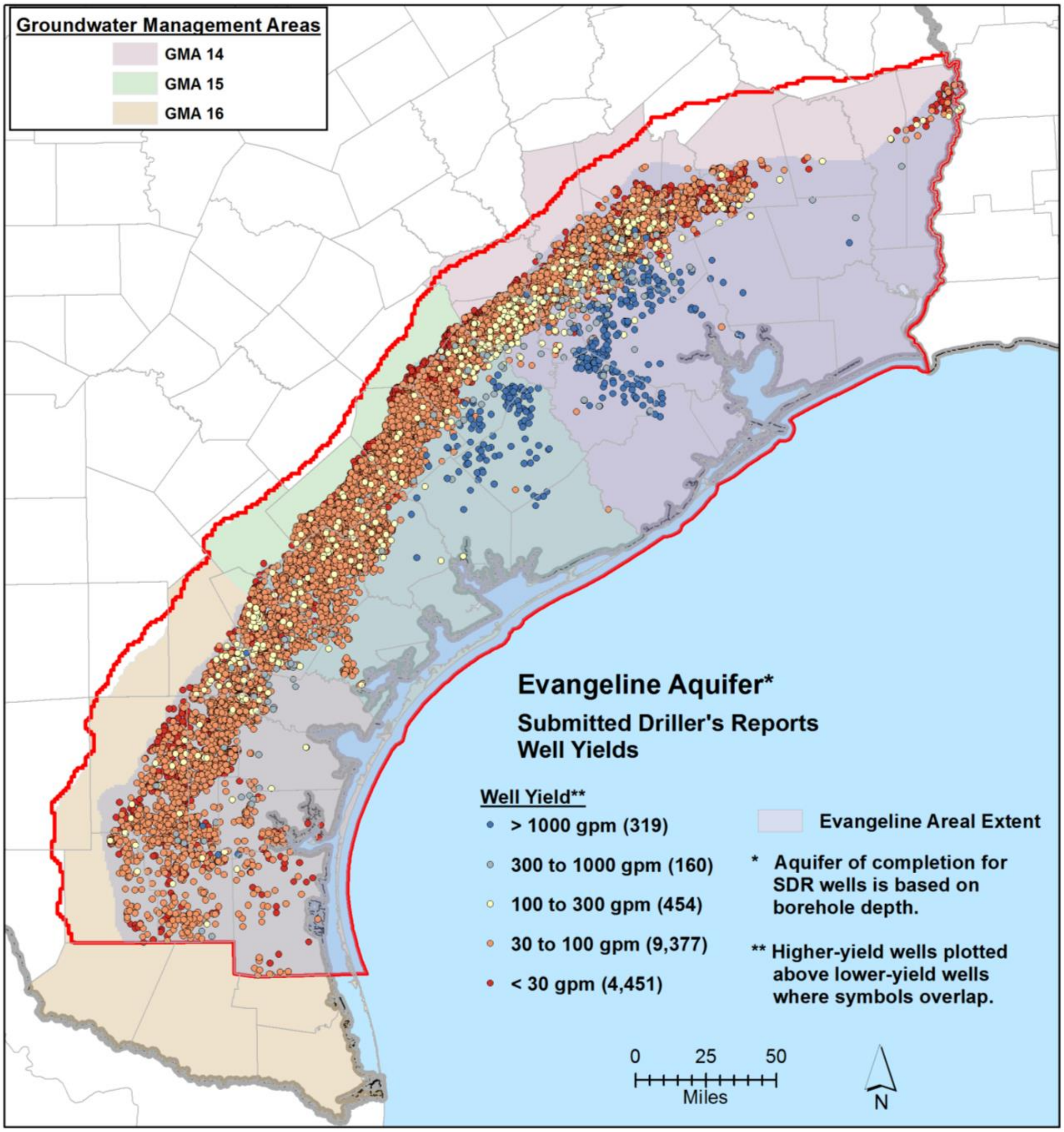

Figure 9-2. Reported well yields for the Evangeline Aquifer based on well information obtained from the TWDB Submitted Drillers Reports.

Note: GMA=Groundwater Management Area; gpm=gallons per minute; SDR=Submitted Drillers Report

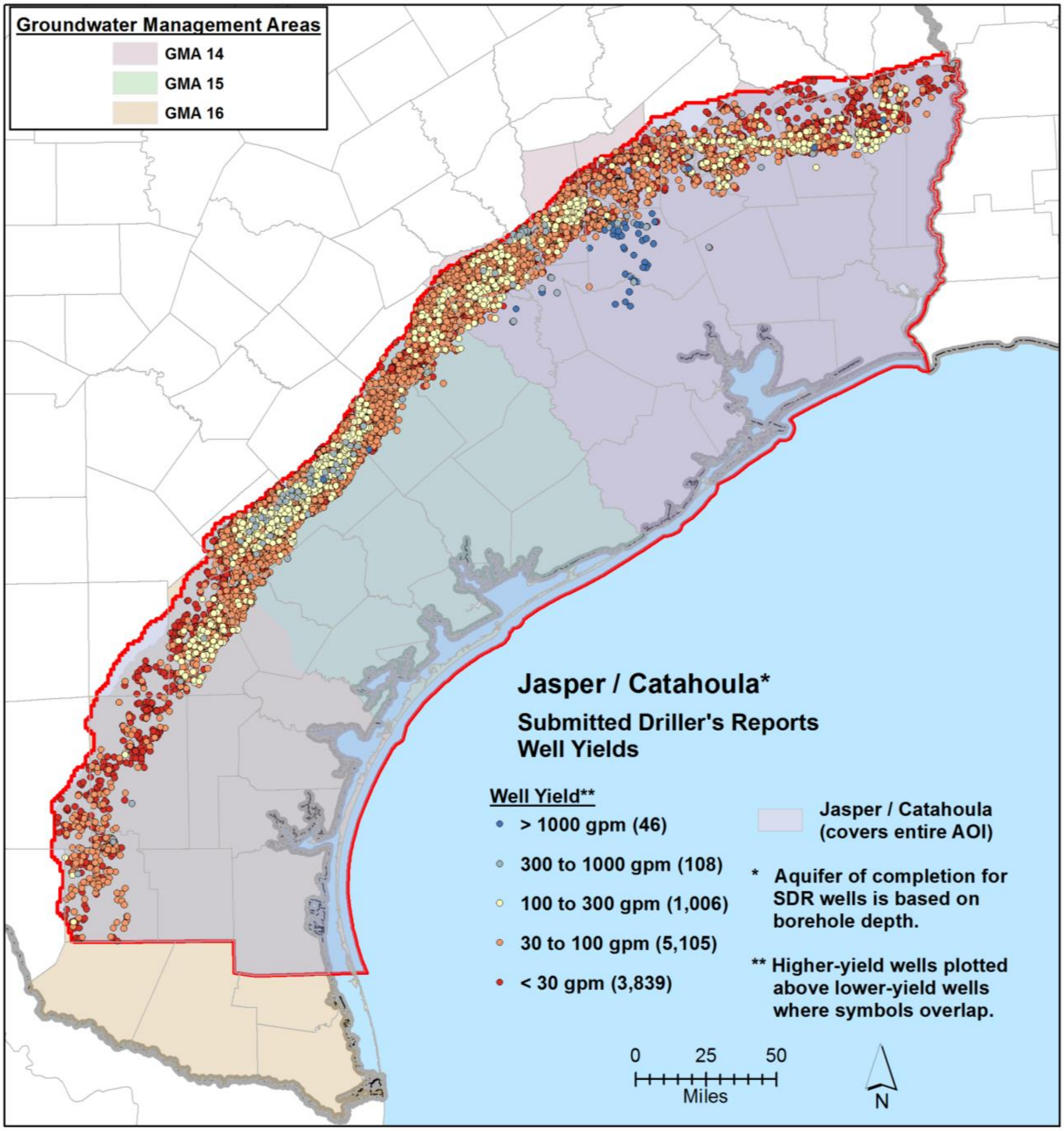

Figure 9-3. Reported well yields for the Jasper Aquifer based on well information obtained from the TWDB Submitted Drillers Reports.

Note: GMA=Groundwater Management Area; gpm=gallons per minute; SDR=Submitted Drillers Report

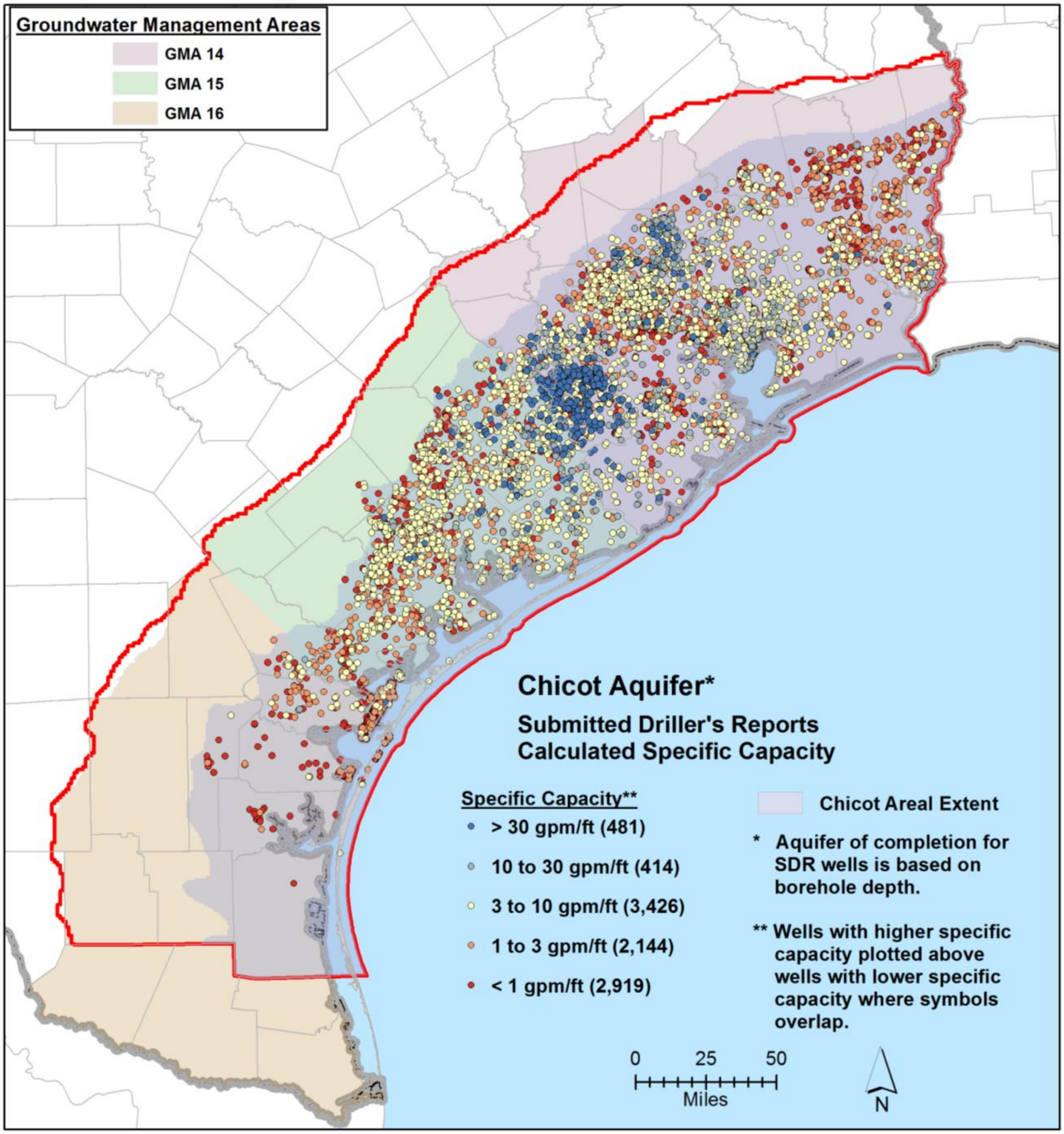

Figure 9-4. Specific capacities for the Chicot Aquifer based on reported well yield and drawdown obtained from the TWDB Submitted Drillers Reports.

Note: GMA=Groundwater Management Area; gpm=gallons per minute; SDR=Submitted Drillers Report

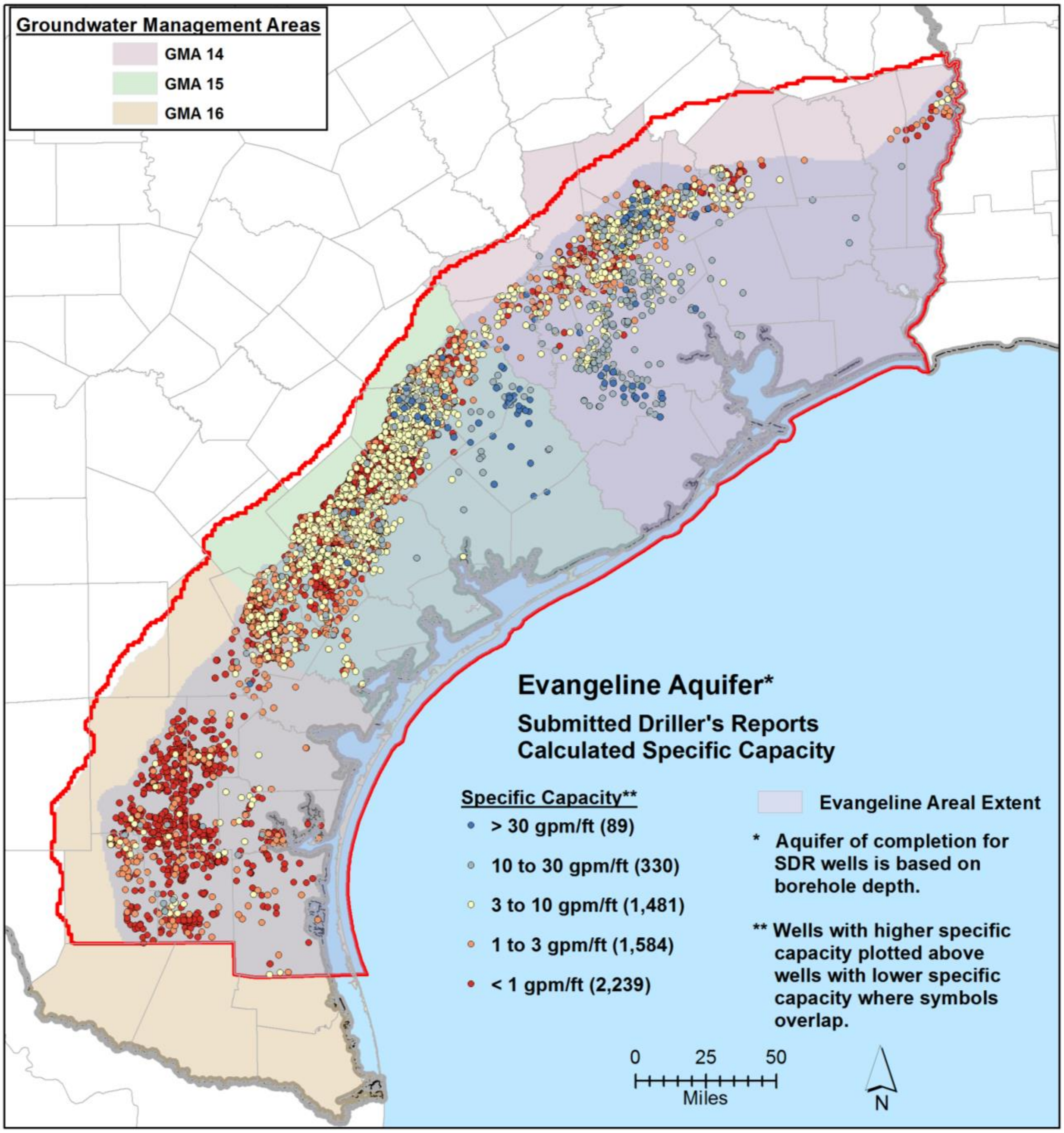

Figure 9-5. Specific capacities for the Evangeline Aquifer based on reported well yield and drawdown obtained from the TWDB Submitted Drillers Reports.

Note: GMA=Groundwater Management Area; gpm=gallons per minute; SDR=Submitted Drillers Report

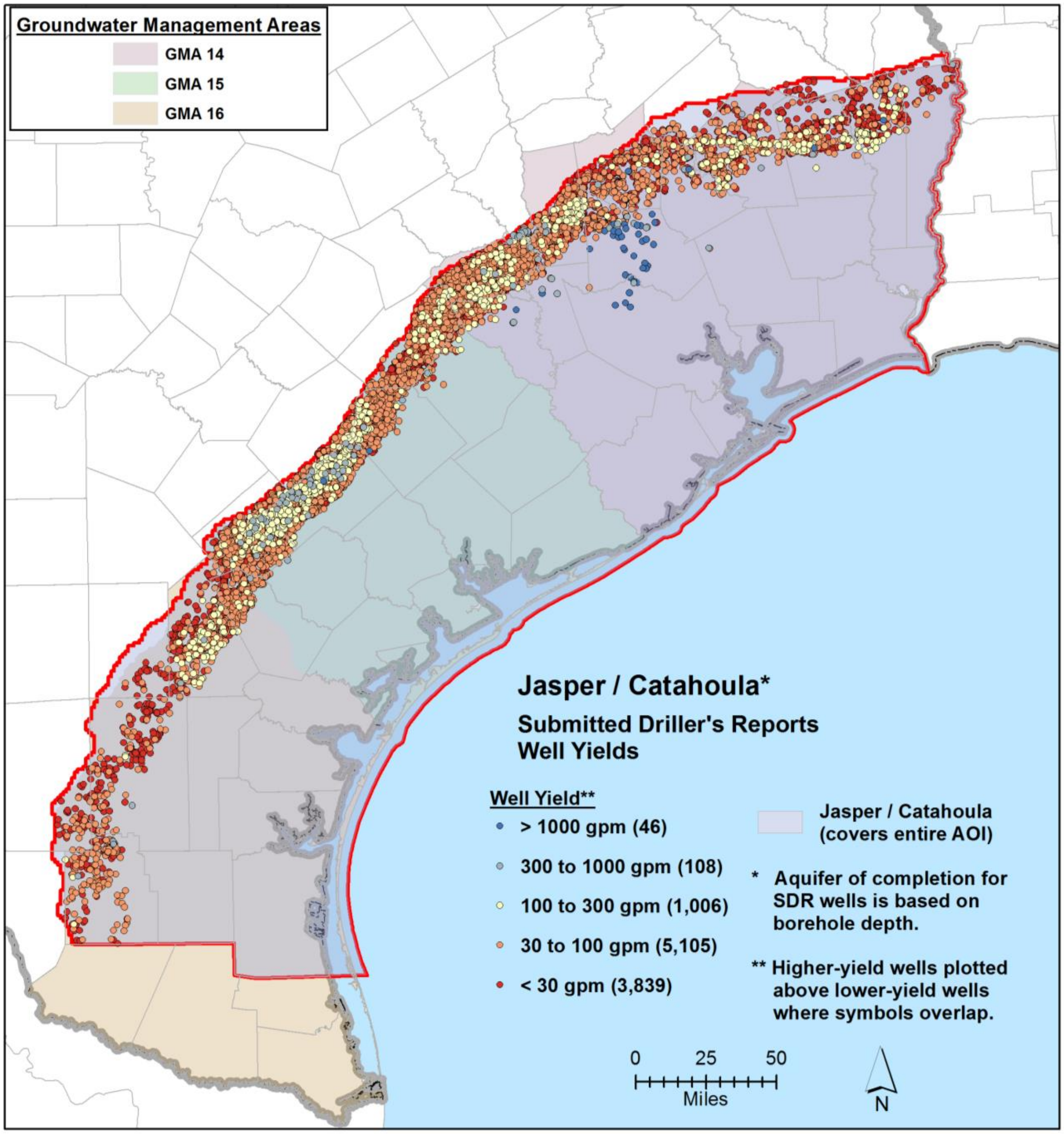

Figure 9-6. **Specific capacities for the Jasper Aquifer based on reported well yield and drawdown obtained from the TWDB Submitted Drillers Reports.**

Note: GMA=Groundwater Management Area; gpm=gallons per minute; SDR=Submitted Drillers Report

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10 Water Quality Data

As part of this study, INTERA reviewed water quality, an important aspect in evaluating groundwater use for all purposes, for the Gulf Coast Aquifer based on data from the TWDB groundwater database (TWDB, 2016). Assignment of these data to the appropriate aquifer was conducted by comparing the well-screen depths, or total depth if screen data were not available, to the structural surfaces of the Chicot, Evangeline, and Jasper aquifers. Water quality for both dissolved minerals and radionuclides was reviewed. For discussion purposes, the average value from all samples for a well was assumed to be representative for dissolved minerals and the maximum value from all samples is presented for radionuclides.

10.1 Dissolved Minerals

A measure of the overall mineral content of groundwater is provided by the concentration of total dissolved solids, typically reported in units of milligrams per liter. Total dissolved solids is also used as a measure of groundwater salinity. The primary sources of groundwater to the Gulf Coast Aquifer consist of relatively fresher meteoric water from precipitation and more saline connate water trapped in the sediments at the time of deposition. Additional sources of increased salinity to the aquifer are considered to include salt domes, the upwelling of brine from geothermal zones along growth faults, natural deposits of evaporate minerals, salt water intrusion, sea salt spray, and oil and gas development (Young and others, 2014). The paleohistory of the Gulf Coast Aquifer is summarized by Young and others (2014) into three 10,000-year periods:

1. 30,000 to 20,000 years ago – Groundwater was part of a larger regional flow system than it is today, because of a lower ocean level and more distant shore line. Also, the base of the meteoric water was deeper than it is currently. Much of the Chicot footprint currently above sea level was being actively recharged and groundwater typically has a large vertical downward flow component.
2. 20,000 to 10,000 years ago – As ocean levels rose 400 feet and the shoreline moved inland from about 40 miles in Groundwater Management Area 16 and about 100 miles in Groundwater Management Area 14, the base of the meteoric water rose. Beneath the Chicot footprint that is above sea level today, the downward hydraulic gradients gradually lessened and even reversed, as movement in the deep Gulf Coast Aquifer System began to slow and as the regional flow system shrunk in response to the transgression of the coastline caused by a rise in sea level.
3. 10,000 years ago to present – The ocean level reached stability about 7,000 years before present, and the Gulf Coast Aquifer regional flow system achieved the current equilibrium with the current shore line, sea level and recharge conditions. Groundwater with an age greater than 10,000 years is a mixture of waters that has been a part of regional flow systems that have been altered with changes in sea levels and recharge conditions.

Both the measured total dissolved solids concentrations from the TWDB groundwater database and total dissolved solids concentrations calculated as the sum of all ions by mass are presented here. The total dissolved solids concentration in the Chicot Aquifer is typically less than 1,000 milligrams per liter in the in the northern and central portions of the aquifer, with the exception of the deep portion of the aquifer near the coast and a few isolated areas further up dip where higher values are observed (Figures 10-1 and 10-2). In the southern portion, the total dissolved solids concentration of the aquifer is significantly higher than that observed in the northern and central portions, suggesting more reducing conditions in this area. A similar pattern of total dissolved solids concentration is observed in the Evangeline (Figures 10-3 and 10-4) and in the Jasper Aquifer/Catahoula Formation (Figures 10-5 and 10-6), with the higher total dissolved solids areas extending further north than in the Chicot Aquifer. Coverage of total dissolved solids data is adequate in the northern and central portions of the Chicot Aquifer, but lacking in the southern portion. Total dissolved solids data coverage in the Evangeline Aquifer is significantly less than that in the Chicot Aquifer and missing in many areas. In the Jasper Aquifer and Catahoula Formation, total dissolved solids data are essentially absent down dip of the outcrop and shallow subcrop areas. For all three aquifers, the calculated total dissolved solids concentration is, in general, higher than the measured concentration.

The percentage of the total dissolved solids concentration by mass comprised of chloride, sulfate, and bicarbonate was determined for each aquifer. For all three, bicarbonate comprised the highest percentage, followed by chloride, and then sulfate in the northern and central portions of the aquifers, with the percentage of chloride increasing and the percentage of bicarbonate decreasing where total dissolved solids values greater than 1,000 milligrams per liter were observed (Figures 10-7 through 10-15). In the southern portion of the aquifers, the percentage of each consistent was more balanced, with the chloride percentage being slightly higher than that for sulfate and bicarbonate (Figures 10-7 through 10-9). These data show that the chemistry of the southern portion of the aquifers differs substantially from that in the northern and central portions.

10.2 Radionuclides

Radionuclides in groundwater are a concern in siting wells and evaluating groundwater resources for development. The TWDB groundwater database provides analytical results for alpha radiation, beta radiation, uranium, radium-226 and radium-228. For discussion and presentation purposes, maximum values for all samples from a well were used, radium-226 and radium-228 were combined, and measurement type (e.g., dissolved or total concentration) is identified.

In general, alpha and beta radiation are higher in the southern portion of the Chicot, Evangeline, and Jasper aquifers than in the northern and central portions, where higher values are only locally observed (Figures 10-16 through 10-21). Overall, alpha radiation is higher than beta radiation in the Chicot Aquifer (Figures 10-16 and 10-17) and they are much more similar in the Evangeline Aquifer (Figures 10-18 and 10-19) and Jasper Aquifer (Figures 10-20 and 10-21).

Natural uranium concentrations are generally below about 15 micrograms per liter in all three aquifers, with a few local exceptions that occur predominately in the southern areas (Figures 10-22 through 10-24). Higher concentrations of combined radium-226 and radium-228 are observed in the northern and central portions of the Chicot Aquifer; however, few data are available in the southern portion (Figure 10-25). Higher combined radium-226 and radium-228 concentrations are observed throughout the Evangeline Aquifer (Figure 10-26) and predominately in the northern portion of the Jasper Aquifer (Figure 10-27).

10.3 Water Quality Parameters of Concern for Desalination

Brackish groundwater is typically defined as water that contains between 1,000 and 10,000 milligrams per liter of total dissolved solids. Significant areas of the Chicot, Evangeline, and Jasper/Catahoula aquifers produce water with total dissolved solids in this range. In addition, water quality from these aquifers may include arsenic, boron, radium, and gross alpha radiation. To be classified as potable water according to Texas Commission on Environmental Quality's primary and secondary drinking water standards, the brackish groundwater will need to be desalinated.

The predominant technology used for desalination of brackish groundwater in Texas is reverse osmosis. Reverse osmosis is a pressure-driven process that relies on semi-permeable membranes to separate dissolved salts from water. These membranes are subject to fouling and scaling depending on the feed water quality and design and operation of the reverse osmosis system. Therefore, understanding the fouling and scaling potentials of a water source are key considerations when developing a brackish groundwater supply.

Fouling is the accumulation of contaminants (particles, bacteria, colloidal material, etc.) on the membrane surface. Turbidity and silt density index values of the membrane feed water are typically used to characterize the water's fouling potential. Silt density index is described in ASTM method D4189, and is based on the plugging rate of a standard 0.45-micrometer membrane filter. Most reverse osmosis membrane manufacturers limit the maximum silt density index value of the feed water to between 1 and 5, depending on the water source. Turbidity can be measured using an in-line continuous or a hand-held nephelometer. The maximum limit for turbidity of the feed water is typically no greater than 0.1 nephelometric turbidity units. Coagulation, filtration, chloramination, and combinations thereof may be used as pretreatment for reverse osmosis systems to minimize fouling of the membranes.

Scaling occurs on the surface of a membrane when the concentration of a salt in the feed water exceeds its solubility limit. Common limiting salts for reverse osmosis systems include:

- Calcium Carbonate
- Calcium Sulfate
- Barium Sulfate
- Strontium Sulfate
- Silica (anionic form)
- Calcium Fluoride
- Calcium Phosphate

Depending on the feed water quality and system recovery, acid, scale inhibitors (sometimes referred to as antiscalants), softening, or appropriate combinations thereof may be used to control scale formation and increase the operating recovery of the reverse osmosis system.

The physical and chemical water quality parameters of concern for reverse osmosis systems and their respective Texas Commission on Environmental Quality primary and secondary standards are presented in Table 10-1. In addition, a summary of potential regulatory- and membrane-related issues for each parameter is presented using the following categories:

Human health - Water quality parameters that present risks to human health are regulated by the Texas Commission on Environmental Quality with Primary Drinking Water Standards. These are enforceable standards with maximum contaminant levels established to protect public health.

Aesthetic - Aesthetic water quality parameters have the potential to cause objectionable taste, odor, and appearance. These parameters are not known to be a risk to human health. Secondary Drinking Water Standards (secondary maximum contaminant levels) were establish by the United States Environmental Protection Agency as guidelines to manage the aesthetic quality of drinking water. In Texas, these standards are enforceable.

Membrane fouling and scaling - Water quality parameters that have potential to cause mechanical damage, fouling, and scaling of membrane-based desalination technologies.

Special concentrate management - In general, management or disposal of reverse osmosis concentrate that contains a majority of the parameters listed in Table 10-1 will be approved by the Texas Commission on Environmental Quality on a case-by-case basis. A major consideration for disposal is whether the reverse osmosis concentrate will deteriorate the water quality of the receiving water body. The presence of constituents like combined radium in high enough concentrations may require special regulatory considerations to manage the radioactive materials in the reverse osmosis concentrate. The need and requirements for special concentrate management should be evaluated in early stages of reverse osmosis project development.

Table 10-1. Summary of physical and chemical water quality parameters of concern for reverse osmosis systems.

Parameter	Potential Issue	TCEQ[a] Primary Drinking Water Standard (mg/L)[b]	TCEQ[a] Secondary Drinking Water Standard (mg/L)[b]
General and Physical Parameters			
Alkalinity	Aesthetic, membrane fouling and scaling	---	---
pH	Aesthetic	---	> 7 standard units
Silt density index	Membrane fouling and scaling	---	---
Temperature[c]	Aesthetic	---	---
Total dissolved solids	Aesthetic	---	1,000
Turbidity	Human health (indicator)[d], aesthetic, membrane fouling and scaling	treatment technique	---
Cations			

Parameter	Potential Issue	TCEQ[a] Primary Drinking Water Standard (mg/L)[b]	TCEQ[a] Secondary Drinking Water Standard (mg/L)[b]
Aluminum	Aesthetic, membrane fouling and scaling	---	0.05 to 0.2
Ammonia	Human health (advisory)[e]	---	---
Arsenic	Human health	0.01	---
Barium	Human health, membrane fouling and scaling	2.0	---
Calcium	Aesthetic, membrane fouling and scaling	---	---
Iron	Aesthetic, membrane fouling and scaling	---	0.03
Magnesium	Aesthetic	---	---
Manganese	Aesthetic, membrane fouling and scaling	---	0.05
Potassium	Aesthetic	---	---
Sodium	Aesthetic	---	---
Strontium	Membrane fouling and scaling	---	---
Anions			
Bromide[f]		---	---
Chloride	Aesthetic	---	300
Fluoride	Human health, membrane fouling and scaling	4.0	2.0
Nitrate	Human health	10	---
Phosphate	Membrane fouling and scaling	---	---
Silica	Membrane fouling and scaling	---	---
Sulfate	Aesthetic, membrane fouling and scaling	---	300
Radionuclides			
Gross Alpha	Human health, special concentrate management	15.0 pCi/L[g]	---

Parameter	Potential Issue	TCEQ[a] Primary Drinking Water Standard (mg/L)[b]	TCEQ[a] Secondary Drinking Water Standard (mg/L)[b]
Radium, Combined (Ra-226 and -228)	Human health, special concentrate management	5.0 pCi/L[g]	---
Other			
Boron	Human health (advisory)[h]	---	---
Hydrogen sulfide	Aesthetic, membrane fouling and scaling	---	0.05

[a] TCEQ stands for Texas Commission on Environmental Quality

[b] mg/L stands for milligrams per liter

[c] Feed water temperatures greater than approximately 110 degrees Fahrenheit may cause failure of reverse osmosis membranes. In such cases, lowering feed water temperatures as part of the design of a reverse osmosis system will need to be addressed.

[d] Turbidity may be used as an indicator parameter for the presence of disease-causing organisms. To control turbidity in public water systems, the Texas Commission on Environmental Quality established a level of treatment process performance that must be followed, known as a treatment technique.

[e] The United States Environmental Protection Agency has established a non-enforceable lifetime health advisory for ammonia of 30 milligrams per liter. This is the concentration of ammonia in drinking water that is not expected to cause any adverse non-carcinogenic effects for a lifetime of exposure.

[f] The concentration of bromide should be considered during development of the groundwater supply. At microgram per liter levels, bromide may react with free chlorine (drinking water disinfectant) and organic carbon to form disinfection by-products, which are regulated by the Texas Commission on Environmental Quality. As an example, this may occur if a groundwater containing bromide is blended with a treated surface water.

[g] pCi/L stands for picoCuries per liter

[h] The United States Environmental Protection Agency has established a non-enforceable lifetime health advisory for boron of 6 milligrams per liter. This is the concentration of boron in drinking water that is not expected to cause any adverse non-carcinogenic effects for a lifetime of exposure.

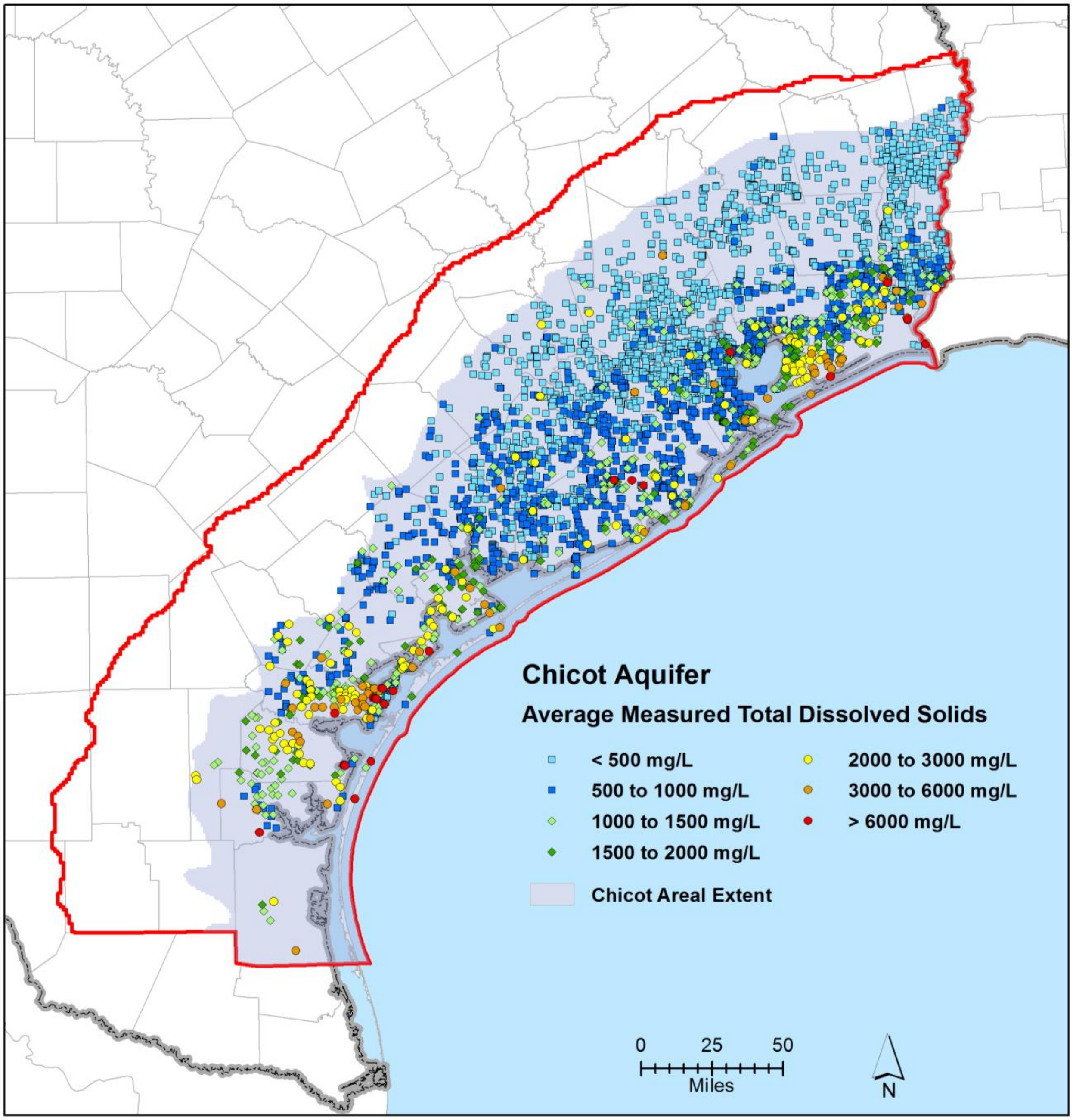

Figure 10-1. Average measured total dissolved solids concentration in the Chicot Aquifer.

Note: mg/L=milligrams per liter

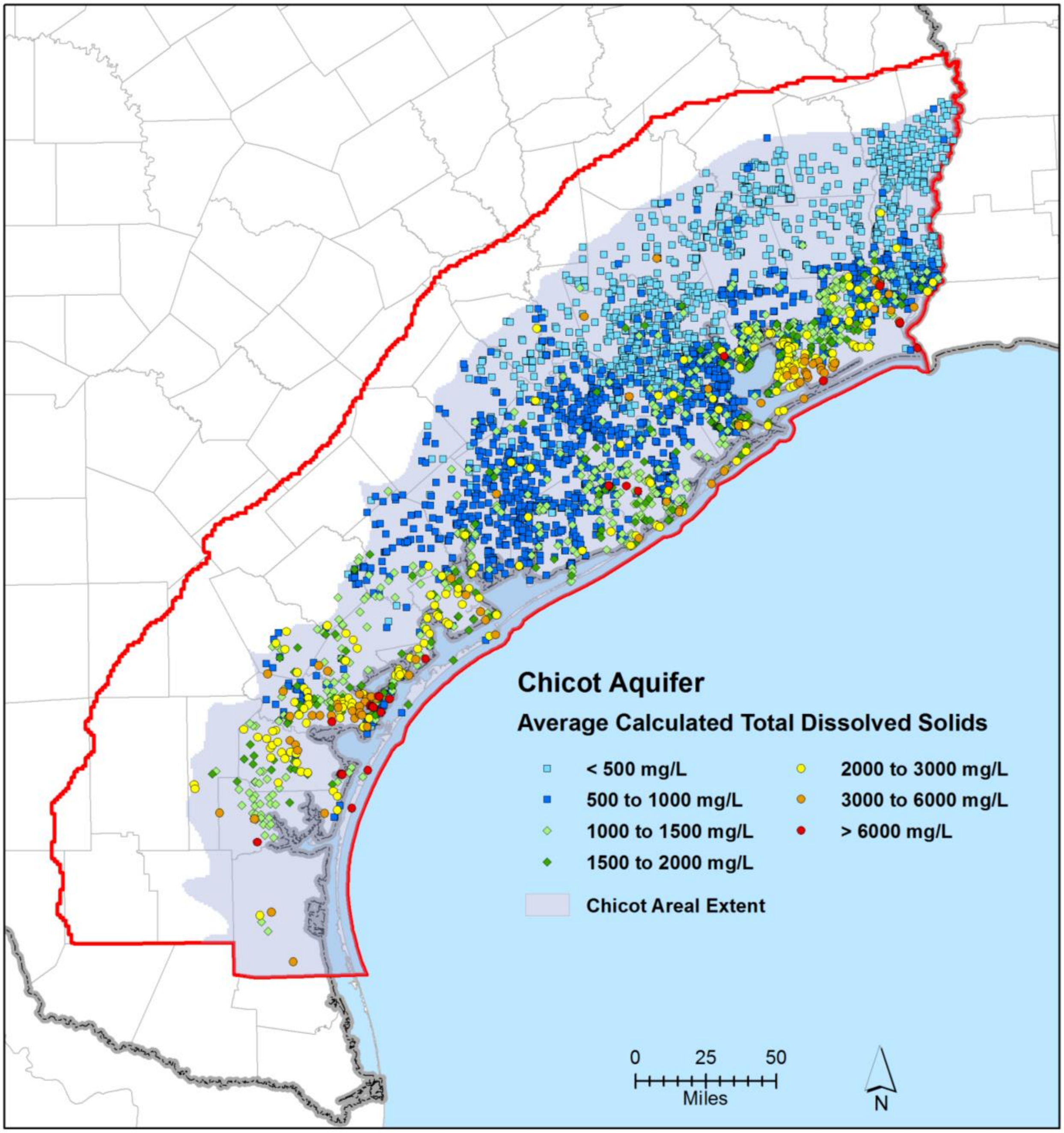

Figure 10-2. Average calculated total dissolved solids concentration in the Chicot Aquifer.

Note: mg/L=milligrams per liter

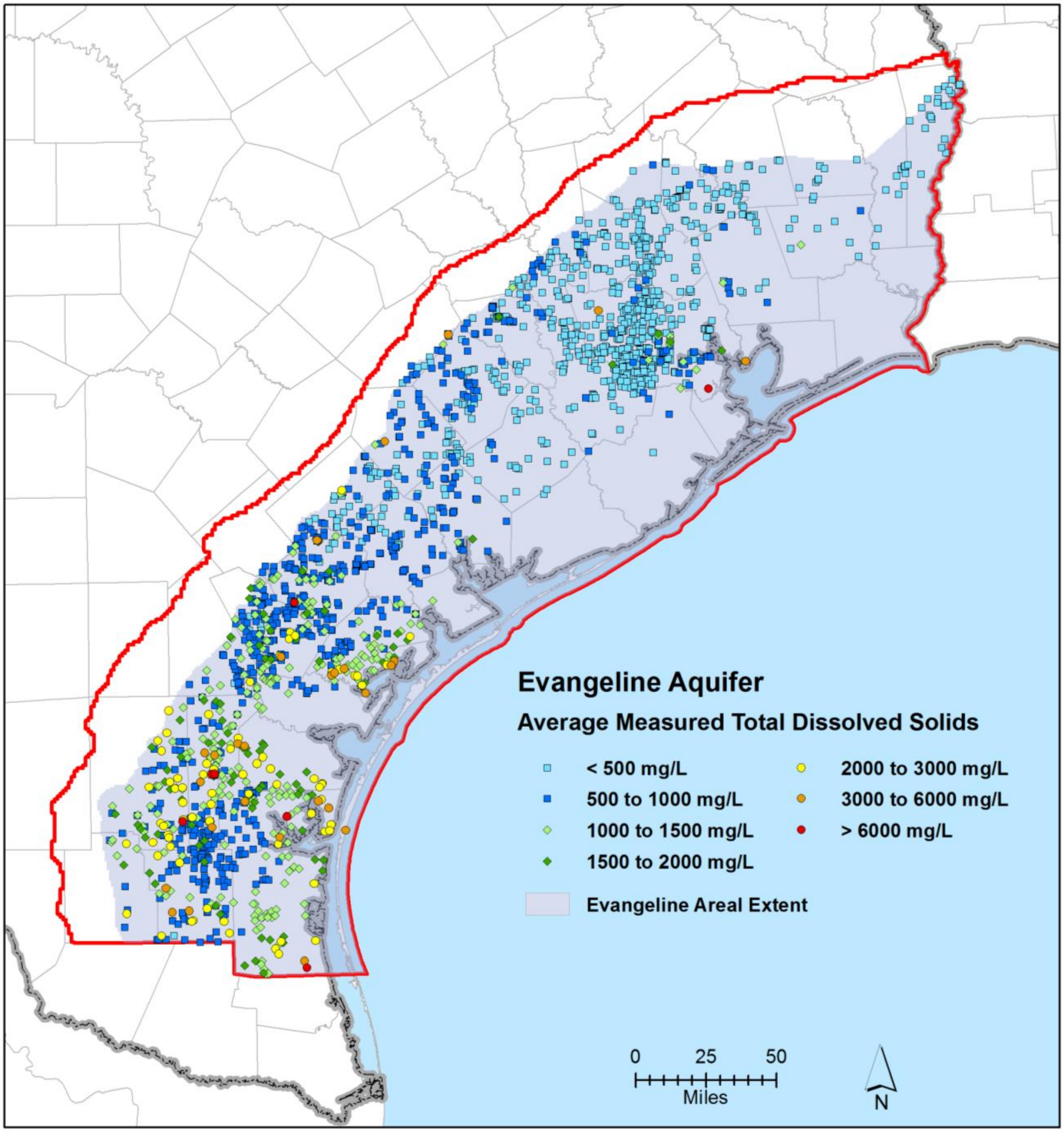

Figure 10-3. Average measured total dissolved solids concentration in the Evangeline Aquifer.

Note: mg/L=milligrams per liter

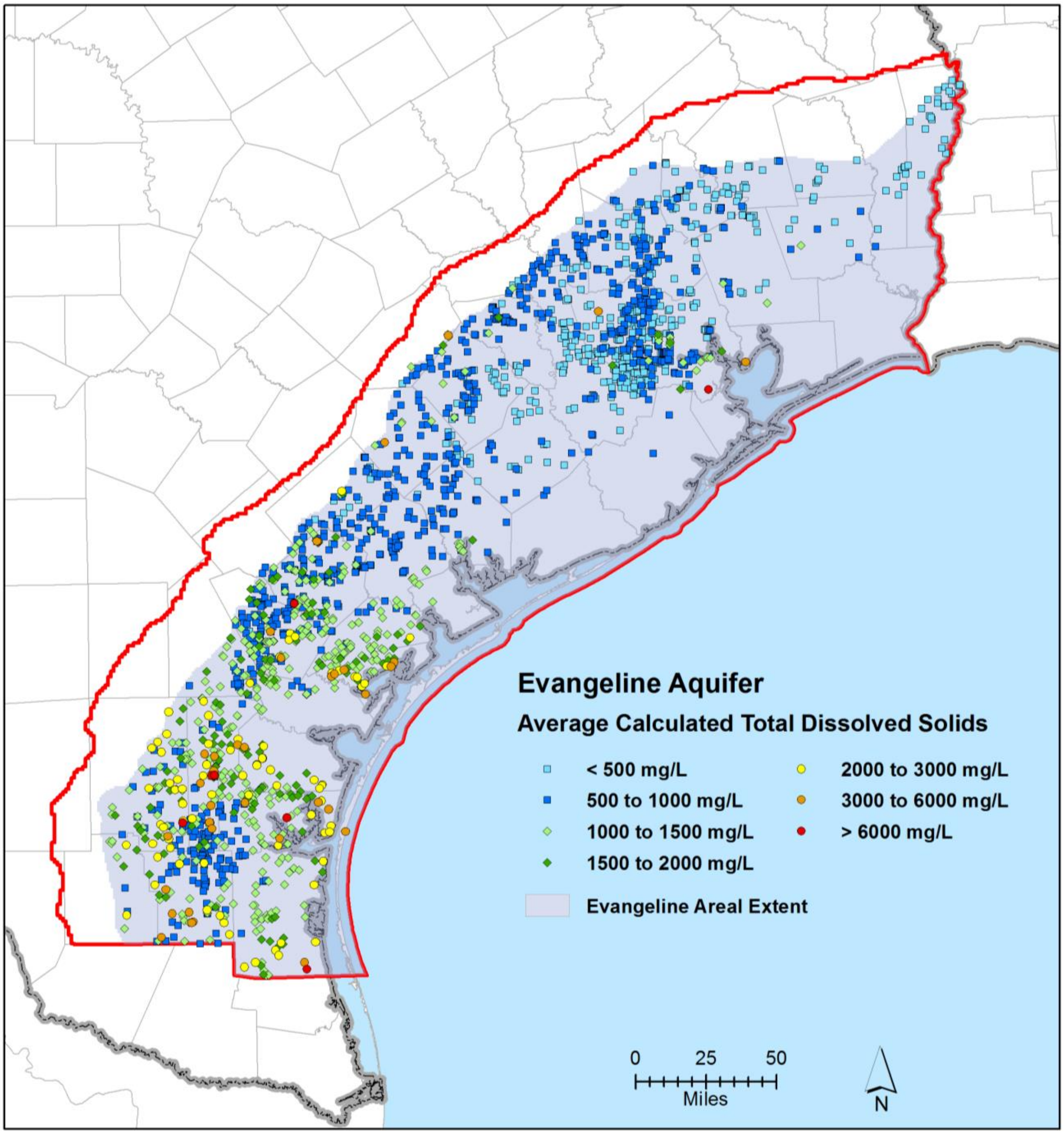

Figure 10-4. Average calculated total dissolved solids concentration in the Evangeline Aquifer.

Note: mg/L=milligrams per liter

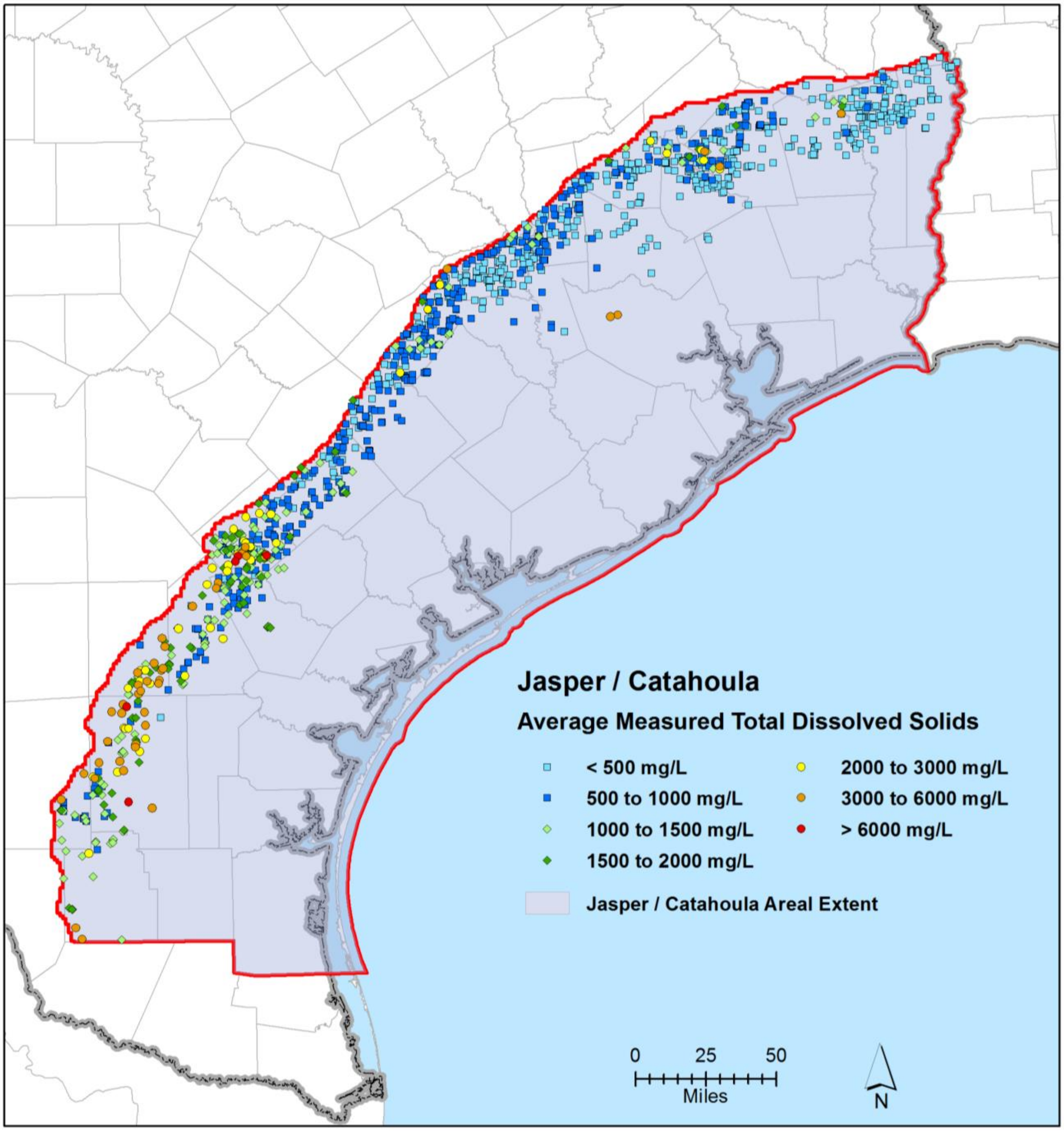

Figure 10-5. Average measured total dissolved solids concentration in the Jasper Aquifer and Catahoula Formation.

Note: mg/L=milligrams per liter

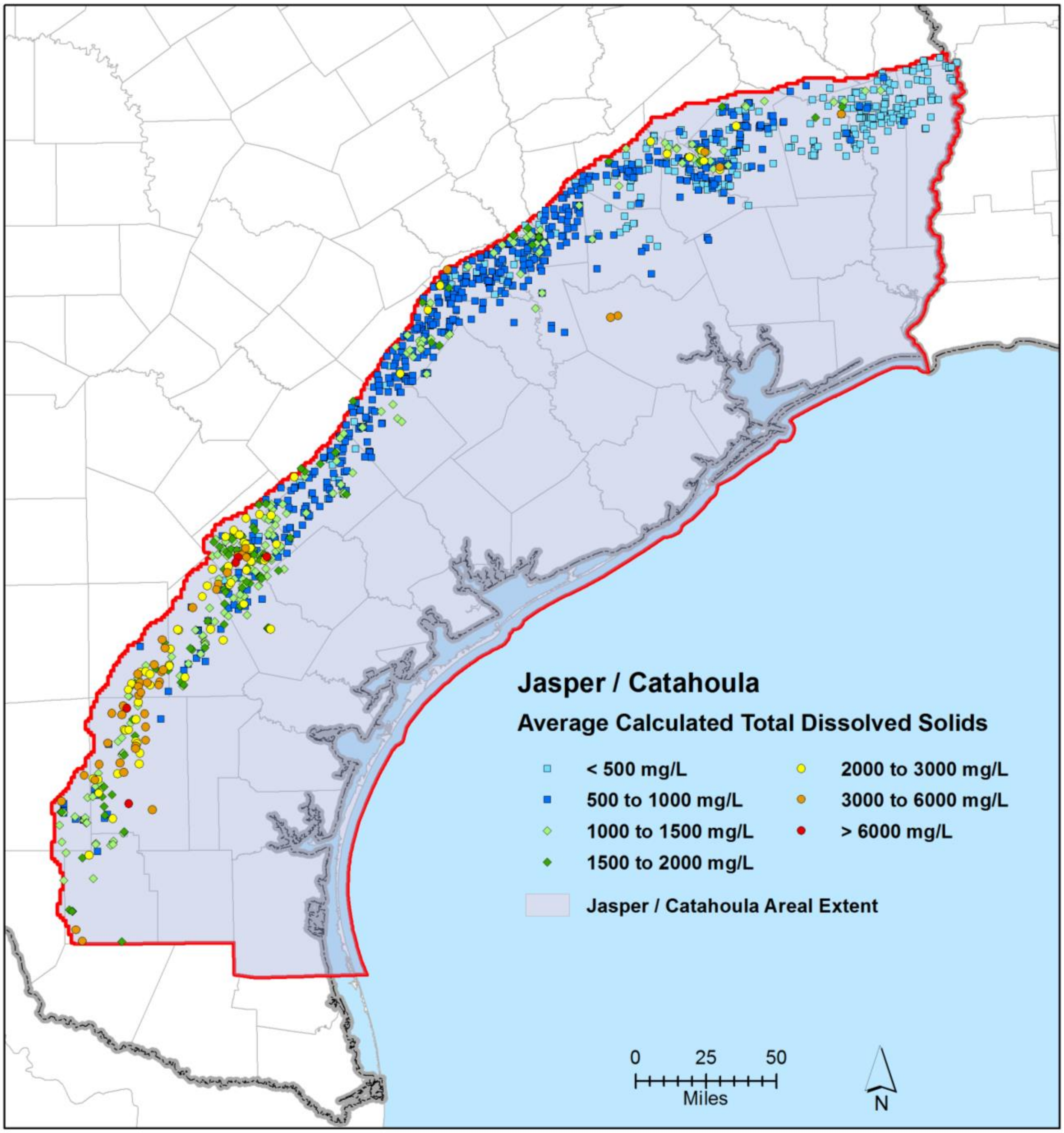

Figure 10-6. Average calculated total dissolved solids concentration in the Jasper Aquifer and Catahoula Formation.

Note: mg/L=milligrams per liter

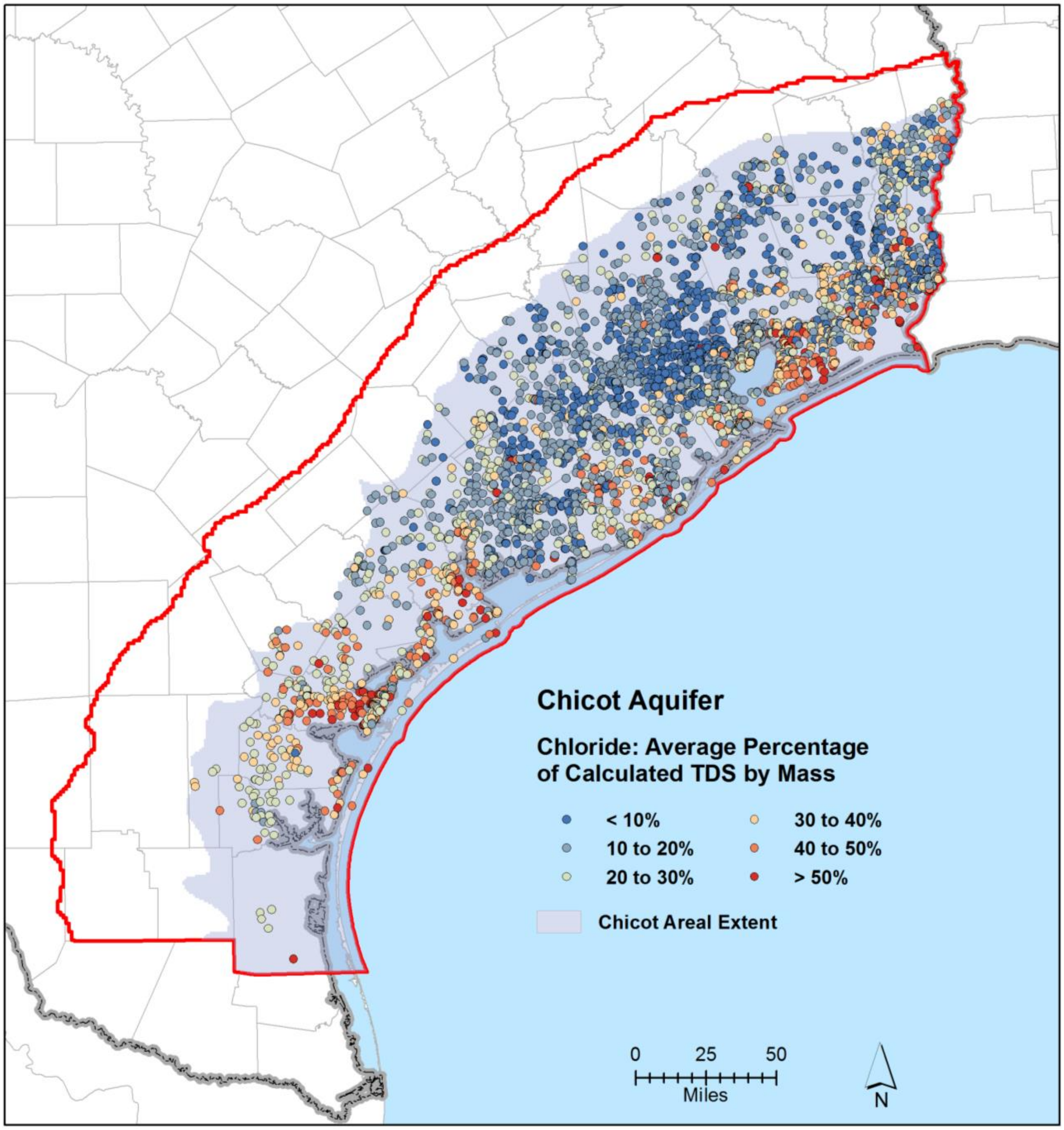

Figure 10-7. **Chloride percentage of average calculated total dissolved solids by mass for the Chicot Aquifer.**

Note: TDS=total dissolved solids

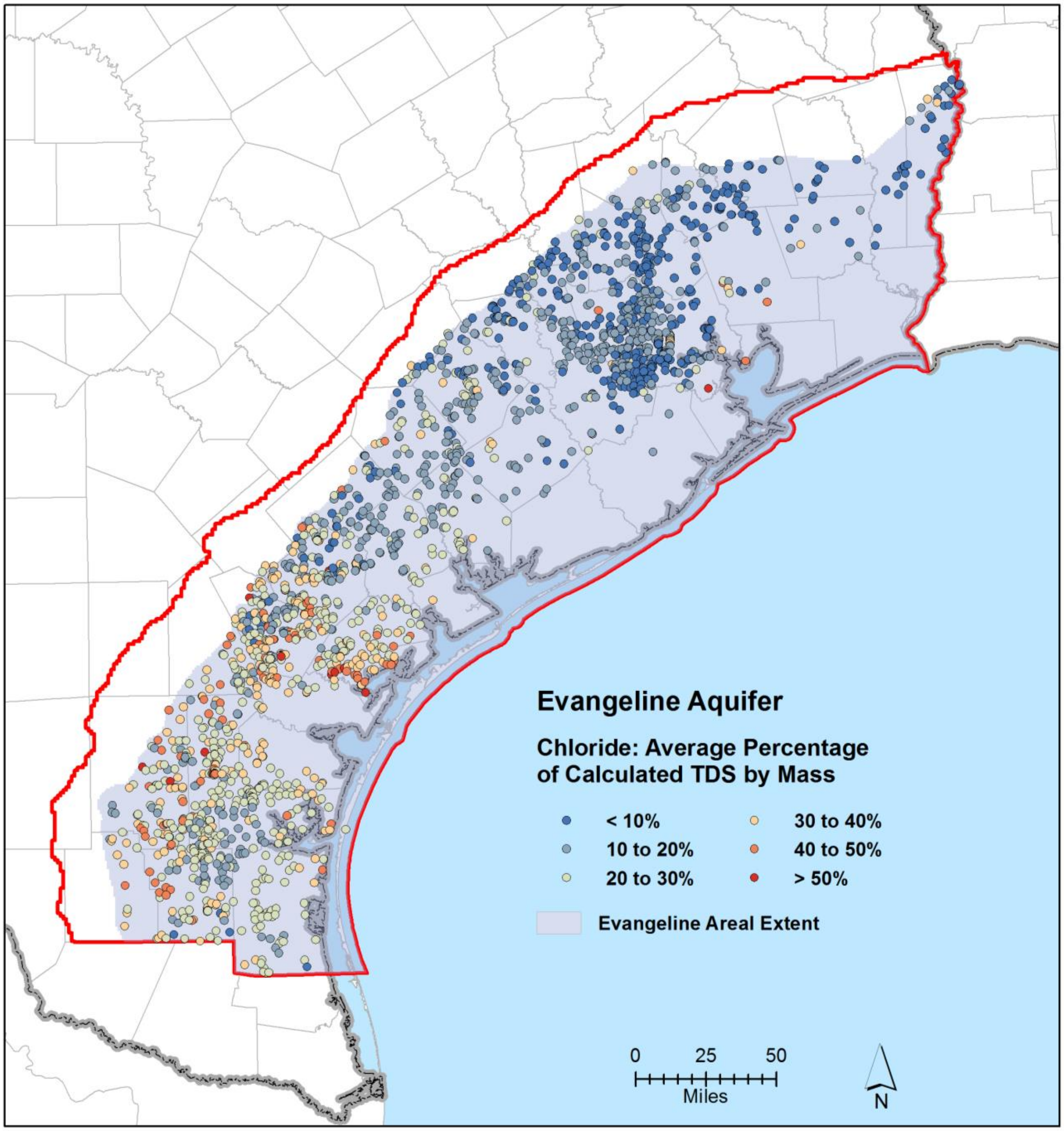

Figure 10-8. Chloride percentage of average calculated total dissolved solids by mass for the Evangeline Aquifer.

Note: TDS=total dissolved solids

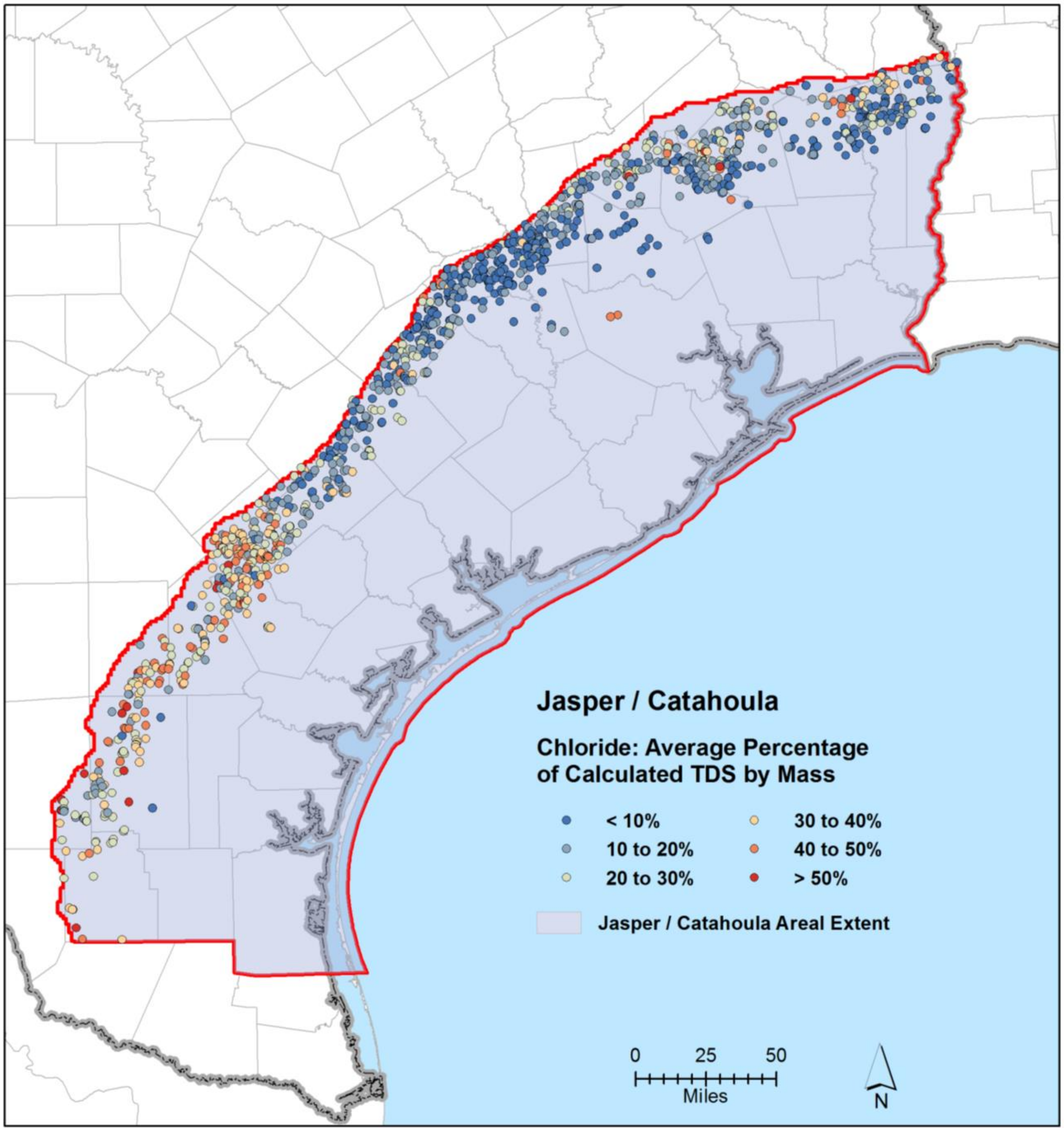

Figure 10-9. **Chloride percentage of average calculated total dissolved solids by mass for the Jasper Aquifer and Catahoula Formation.**

Note: TDS=total dissolved solids

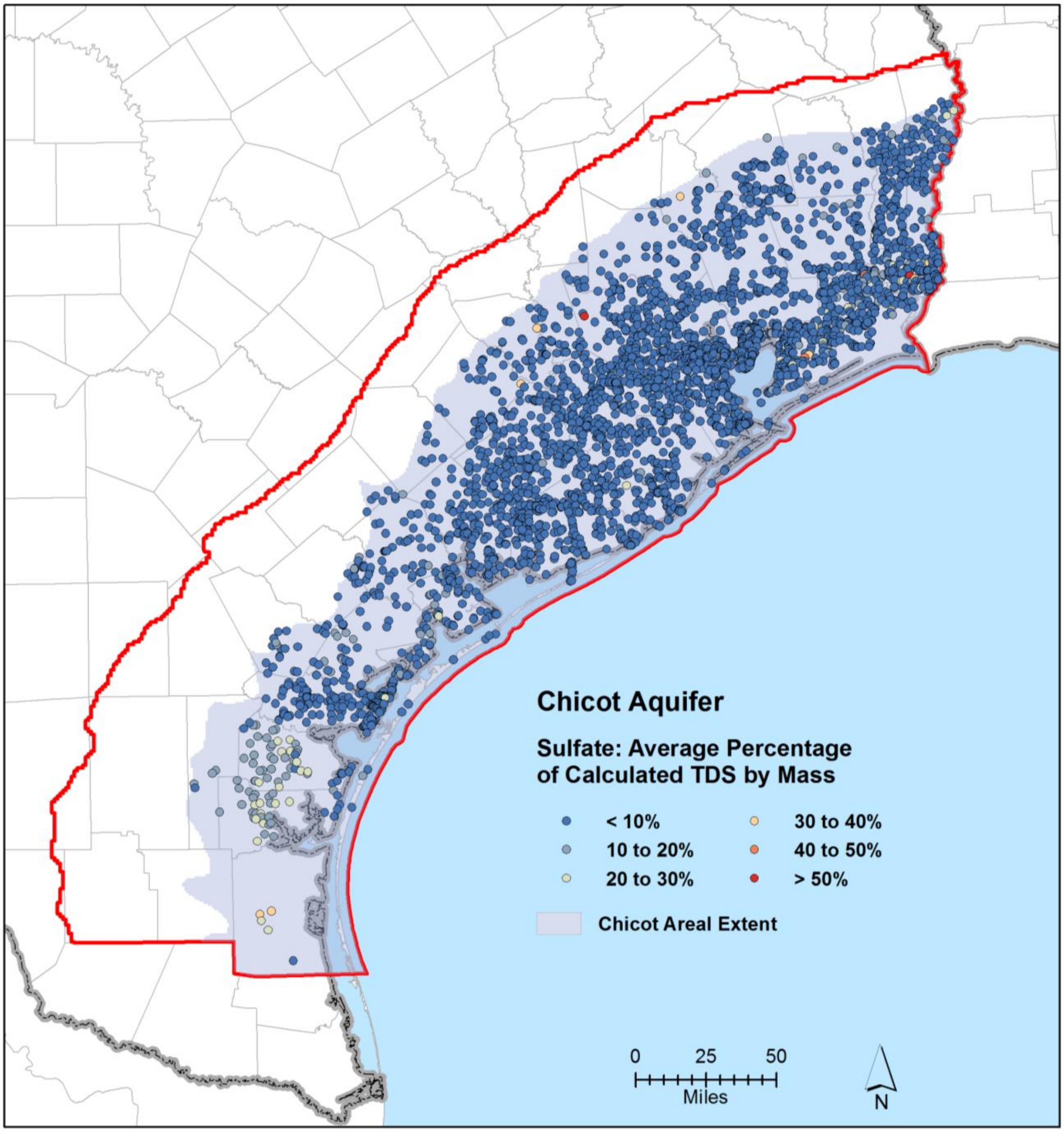

Figure 10-10. Sulfate percentage of average calculated total dissolved solids by mass for the Chicot Aquifer.

Note: TDS=total dissolved solids

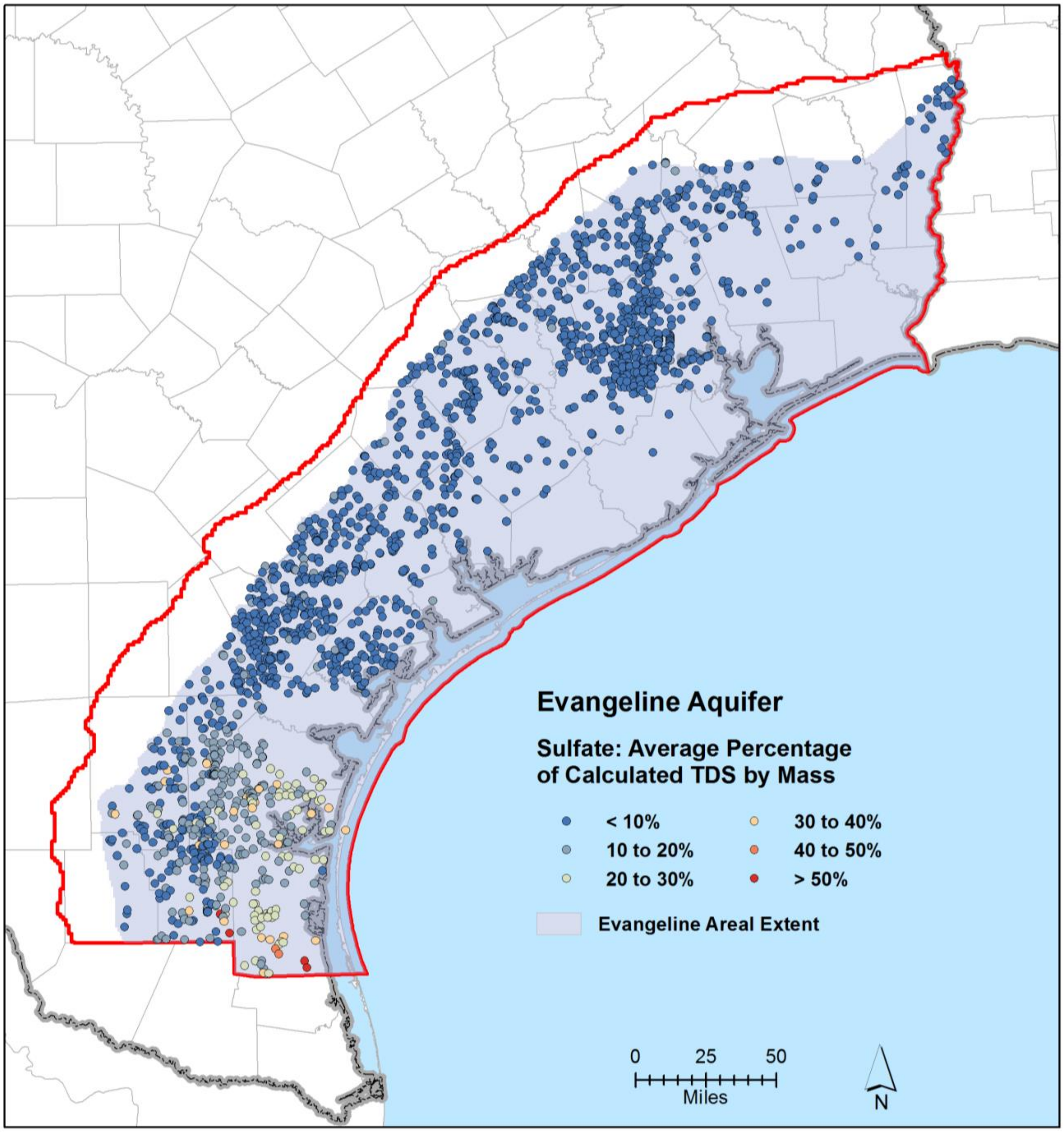

Figure 10-11. Sulfate percentage of average calculated total dissolved solids by mass for the Evangeline Aquifer.

Note: TDS=total dissolved solids

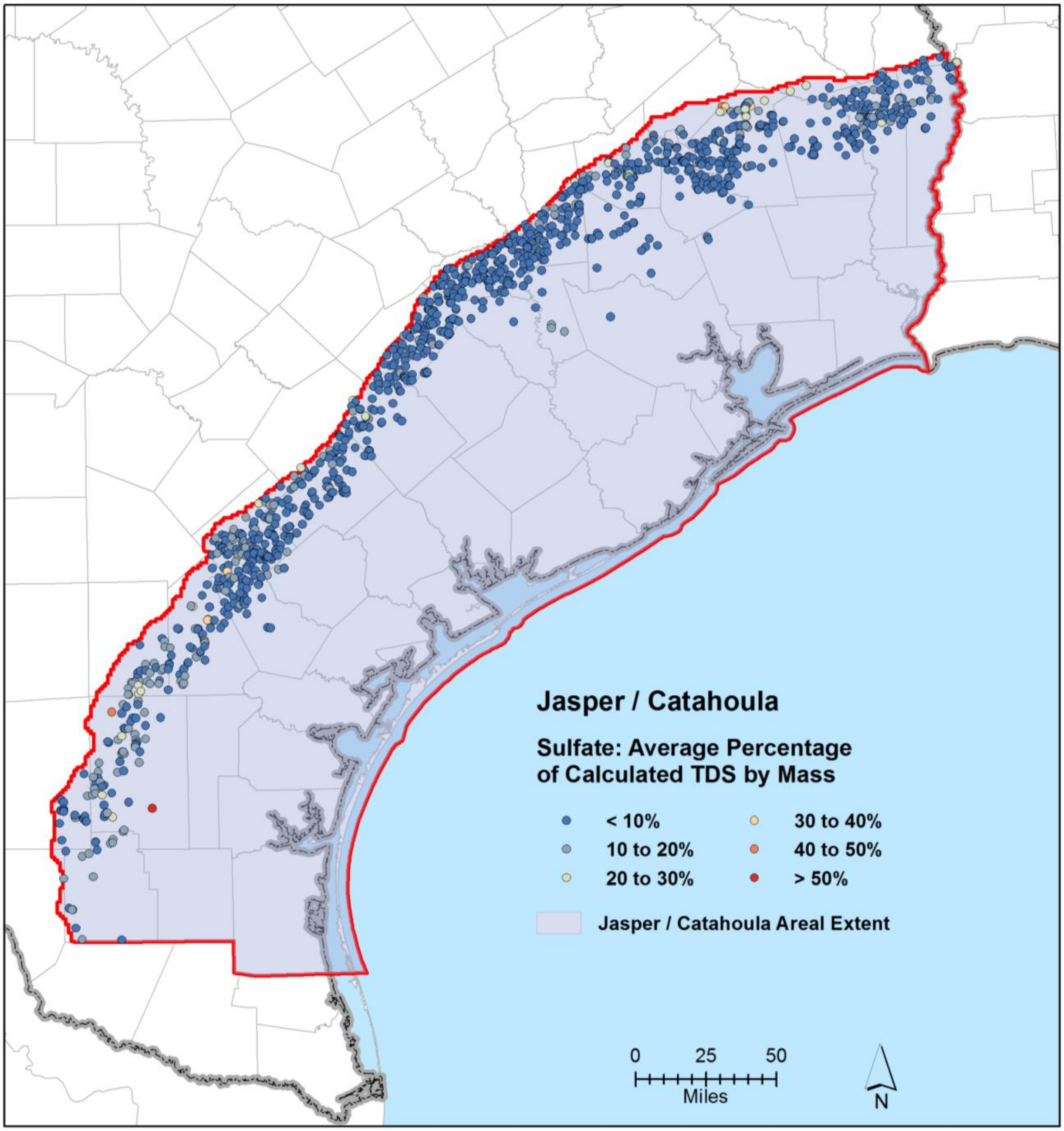

Figure 10-12. Sulfate percentage of average calculated total dissolved solids by mass for the Jasper Aquifer and Catahoula Formation.

Note: TDS=total dissolved solids

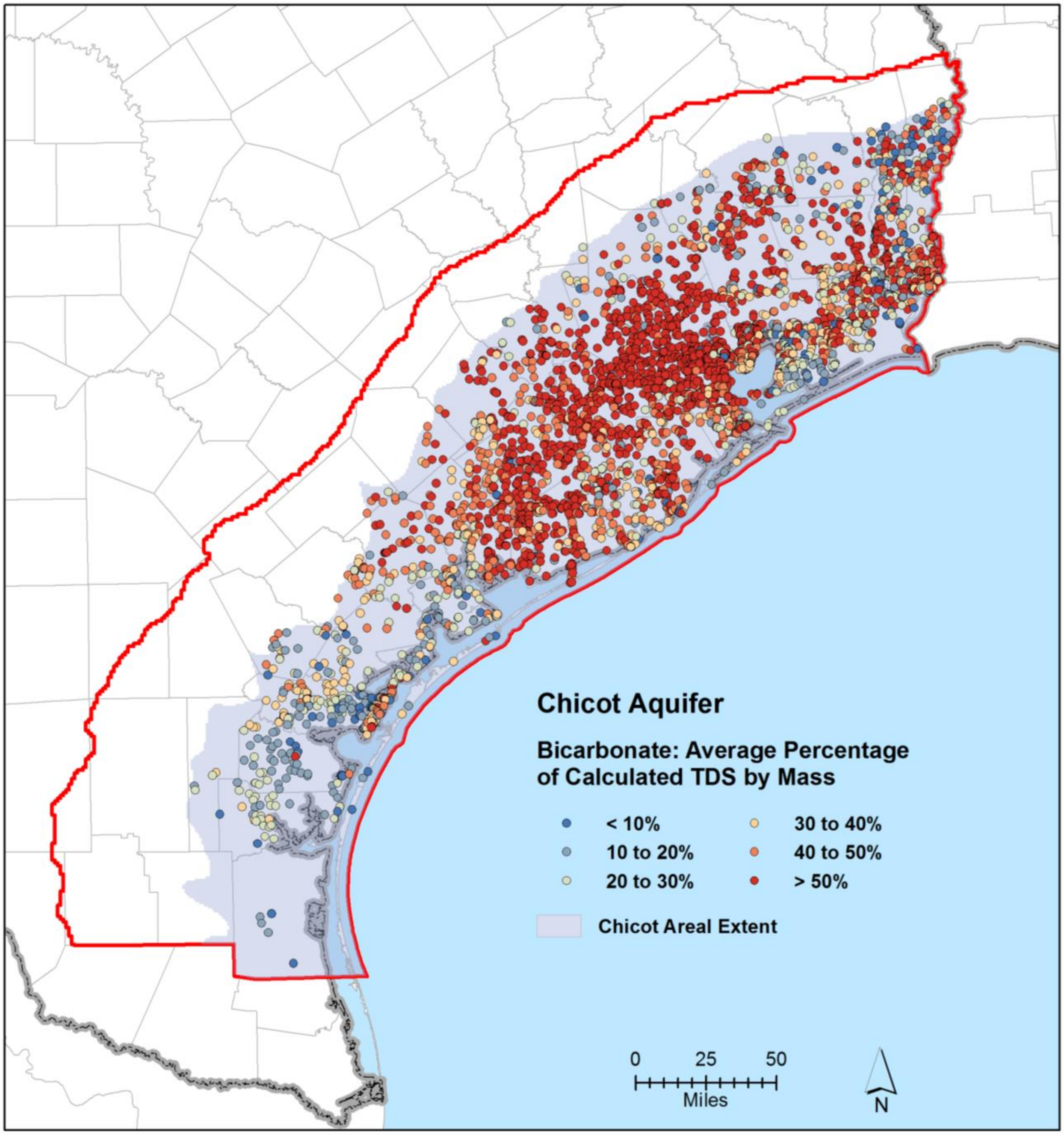

Figure 10-13. Bicarbonate percentage of average calculated total dissolved solids by mass for the Chicot Aquifer.

Note: TDS=total dissolved solids

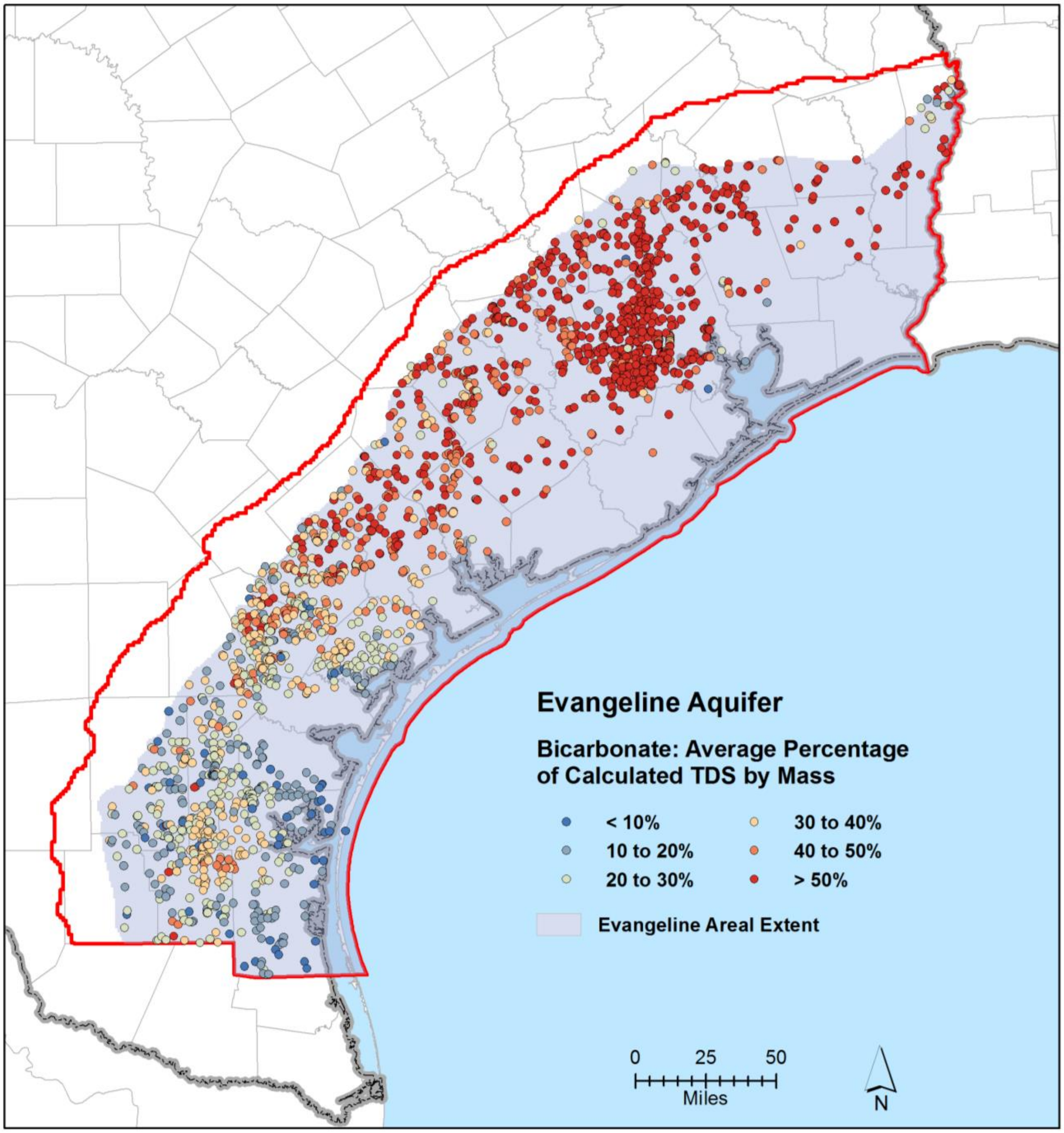

Figure 10-14. Bicarbonate percentage of average calculated total dissolved solids by mass for the Evangeline Aquifer.

Note: TDS=total dissolved solids

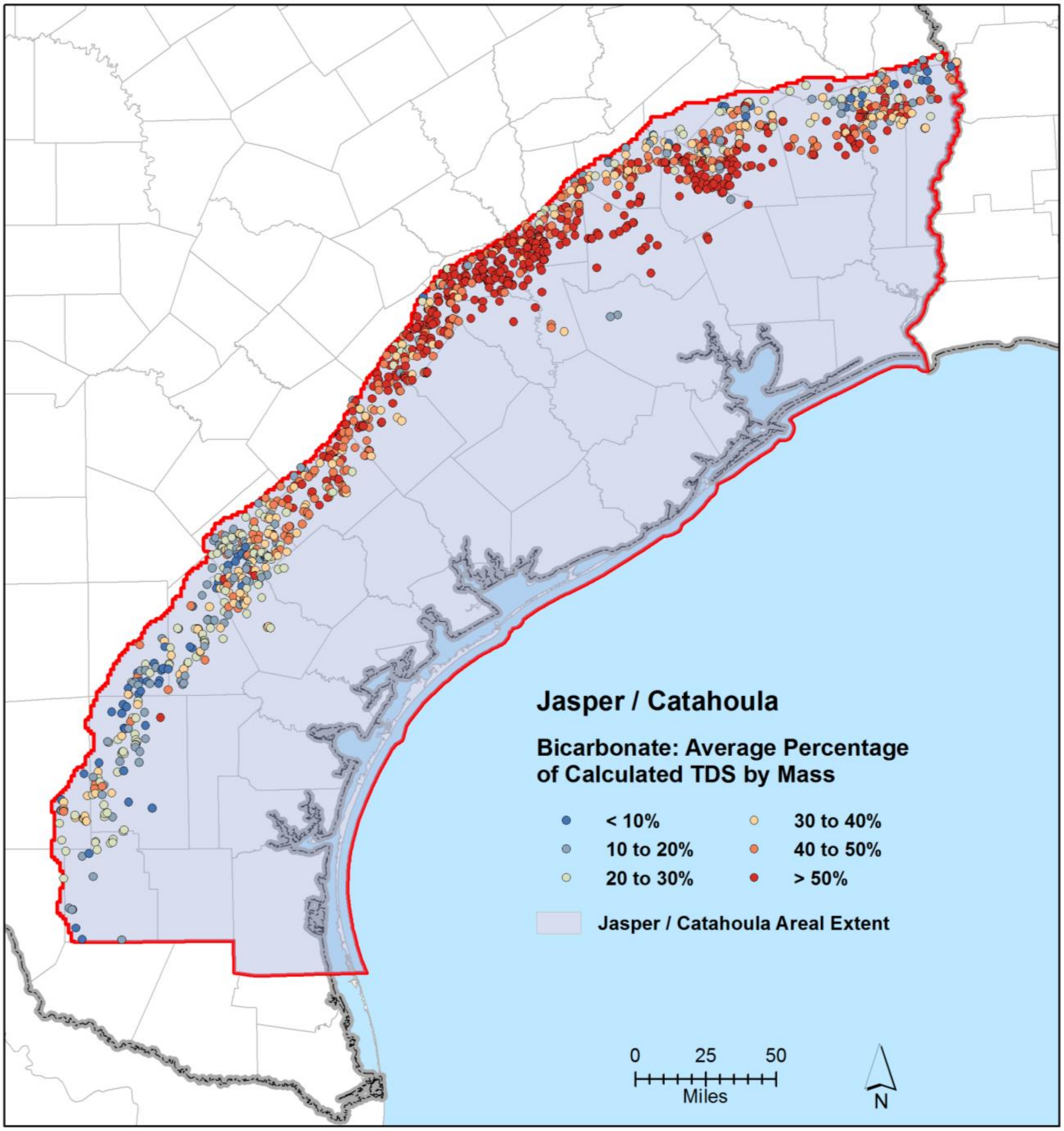

Figure 10-15. Bicarbonate percentage of average calculated total dissolved solids by mass for the Jasper Aquifer and Catahoula Formation.

Note: TDS=total dissolved solids

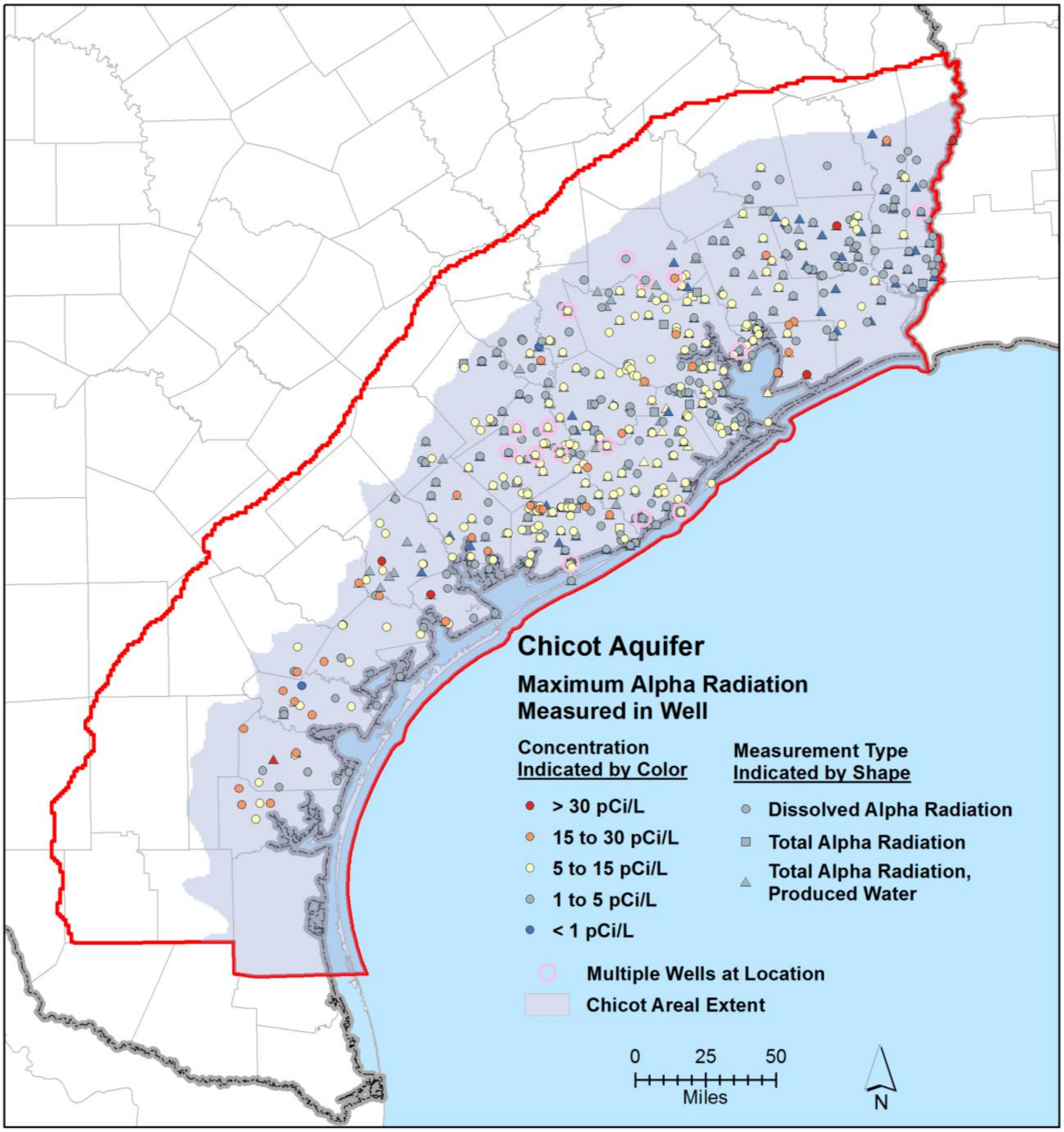

Figure 10-16. Maximum alpha radiation in the Chicot Aquifer.

Note: pCi/L=picoCuries per liter

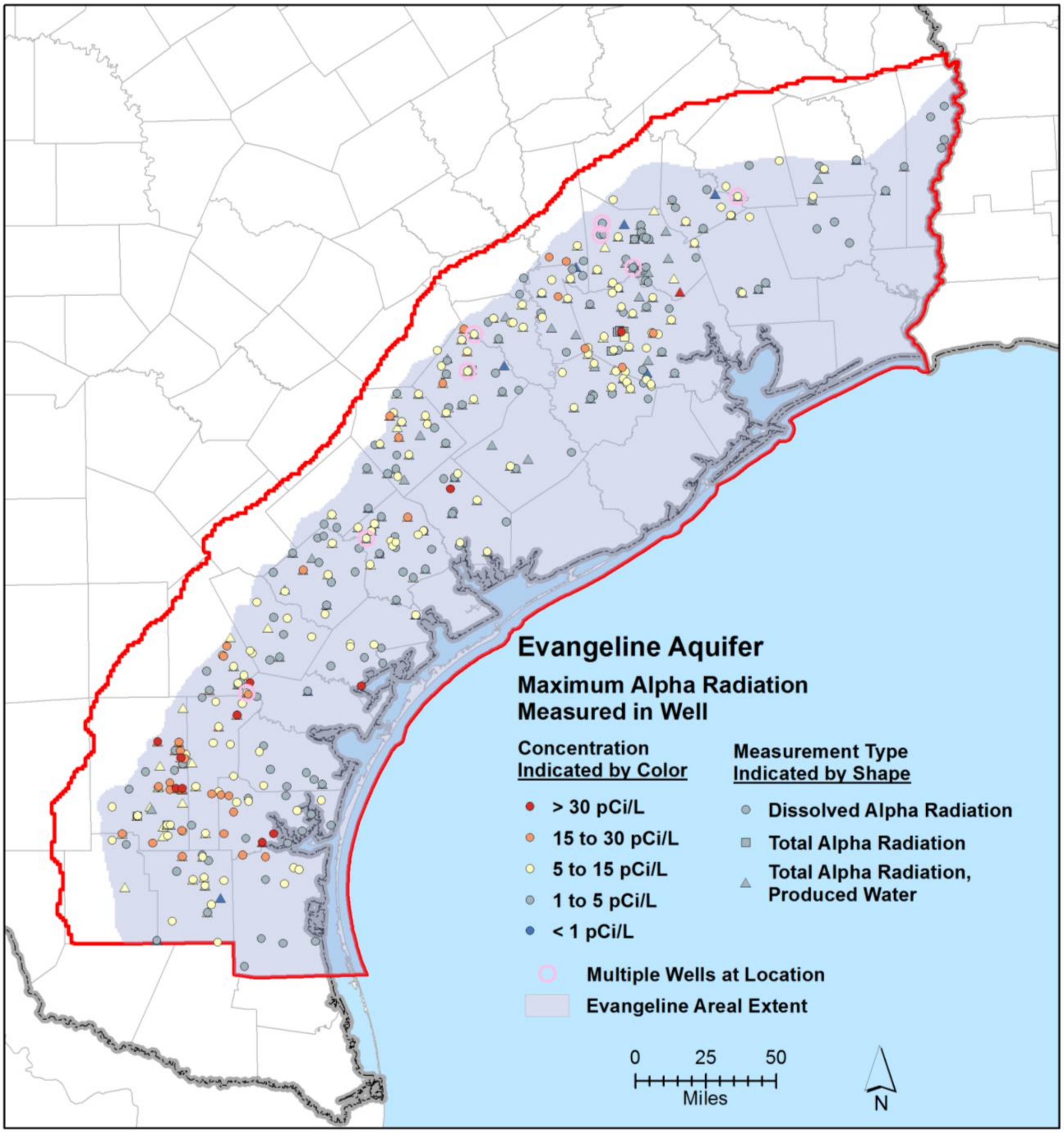

Figure 10-17. Maximum alpha radiation in the Evangeline Aquifer.

Note: pCi/L=picoCuries per liter

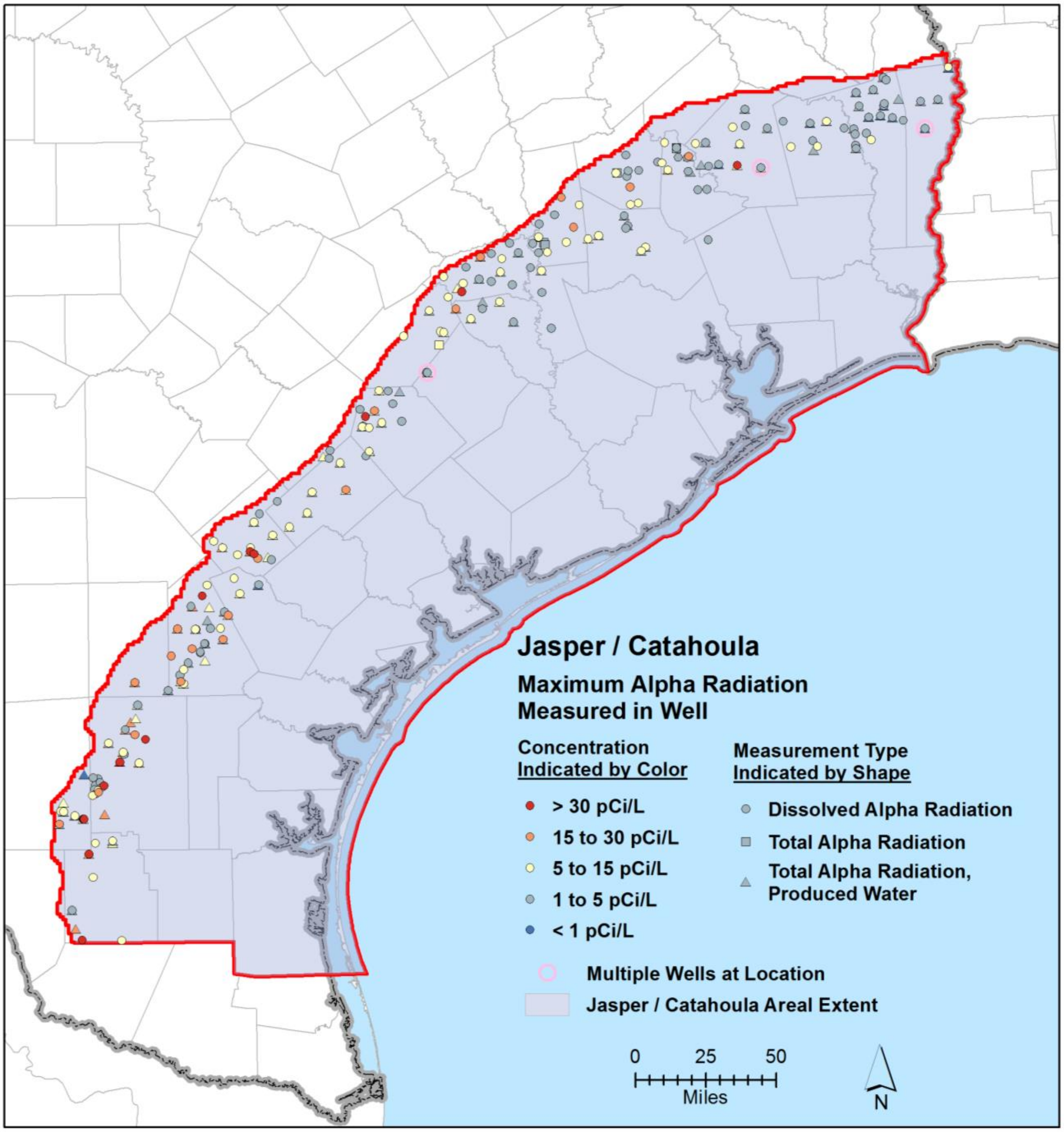

Figure 10-18. Maximum alpha radiation in the Jasper Aquifer and Catahoula Formation.

Note: pCi/L=picoCuries per liter

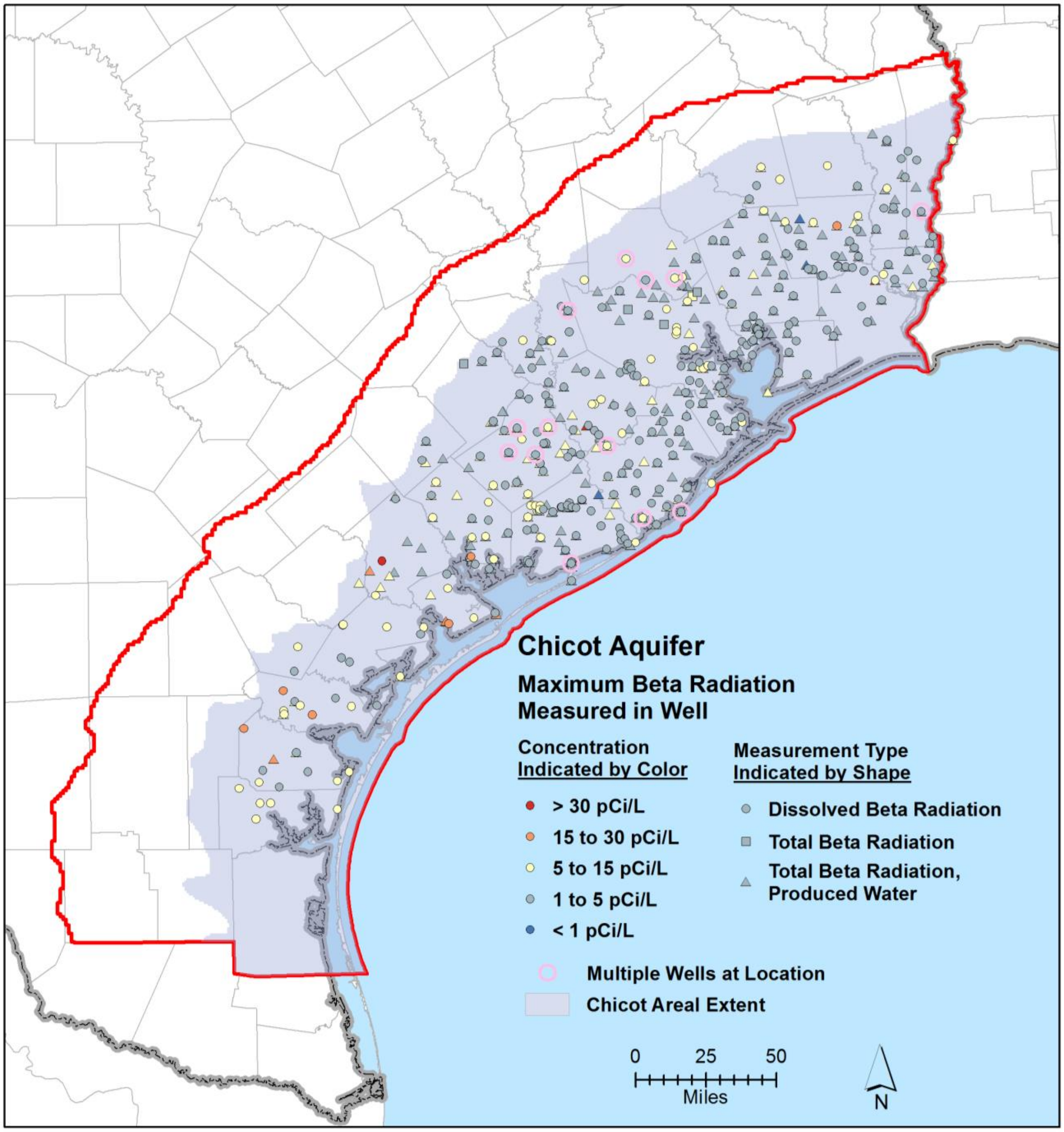

Figure 10-19. Maximum beta radiation in the Chicot Aquifer.

Note: pCi/L=picoCuries per liter

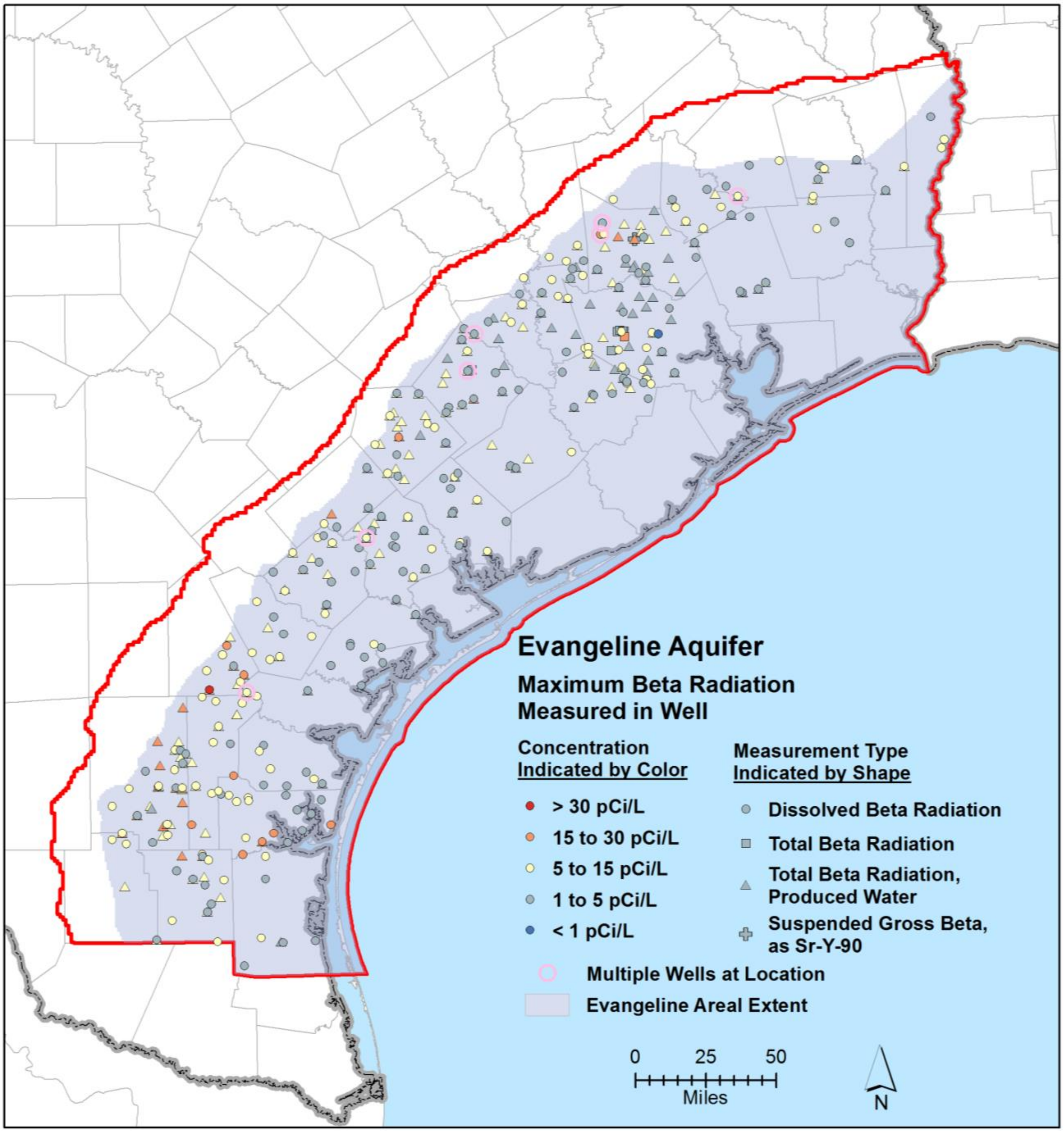

Figure 10-20. Maximum beta radiation in the Evangeline Aquifer.

Note: pCi/L=picoCuries per liter

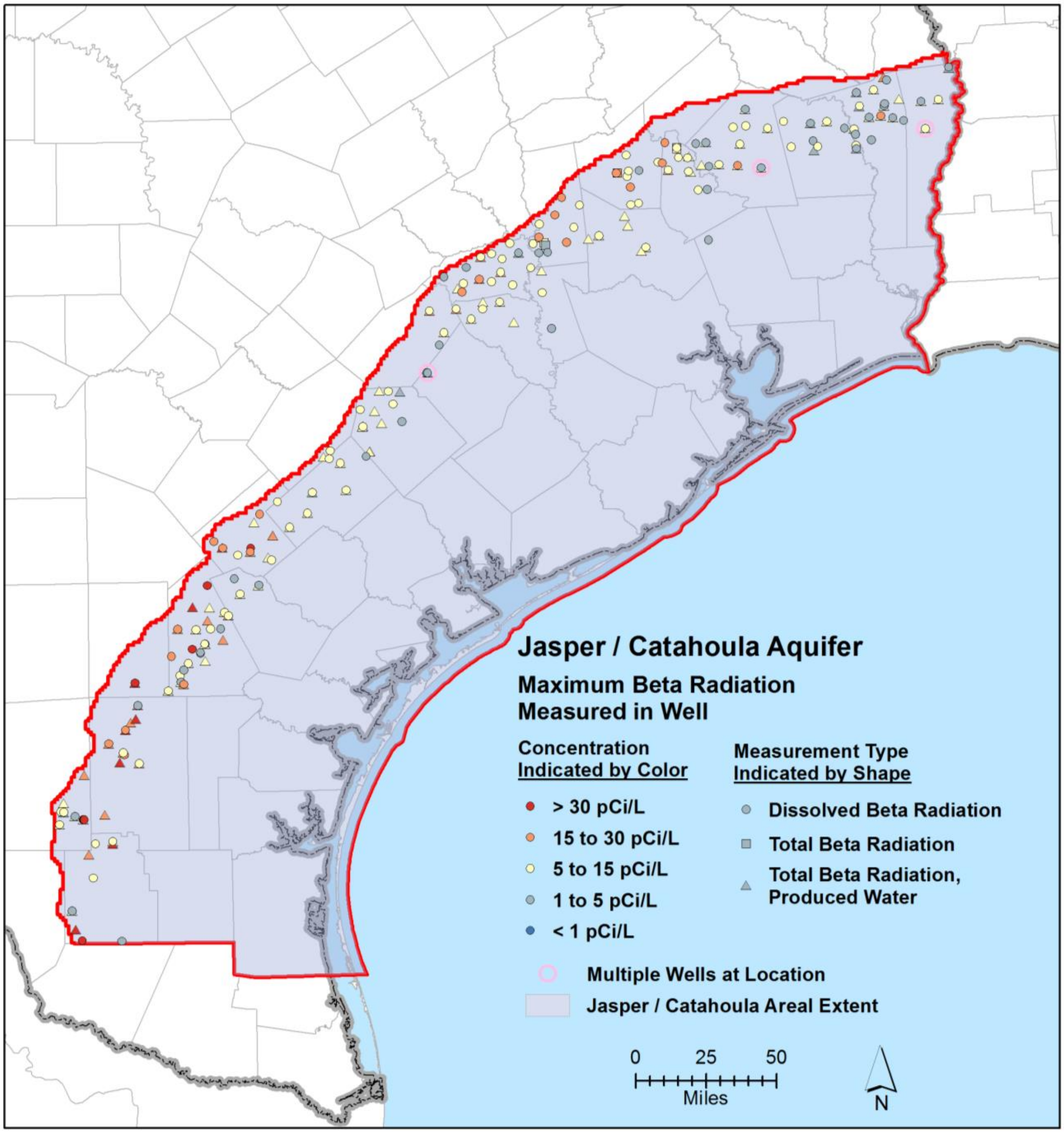

Figure 10-21. Maximum beta radiation in the Jasper Aquifer and Catahoula Formation.

Note: pCi/L=picoCuries per liter

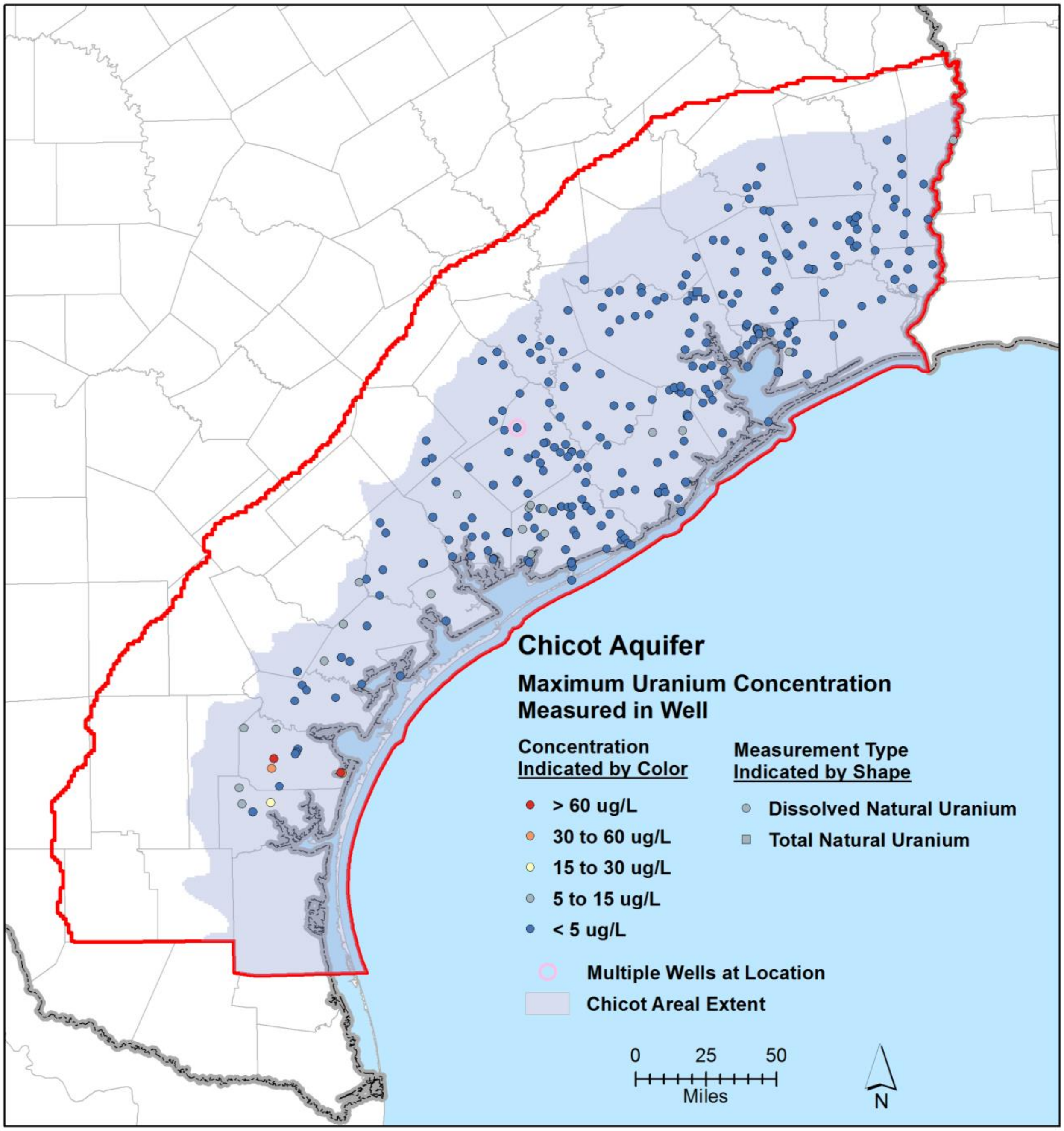

Figure 10-22. Maximum uranium concentration in the Chicot Aquifer.

Note: ug/L=micrograms per liter

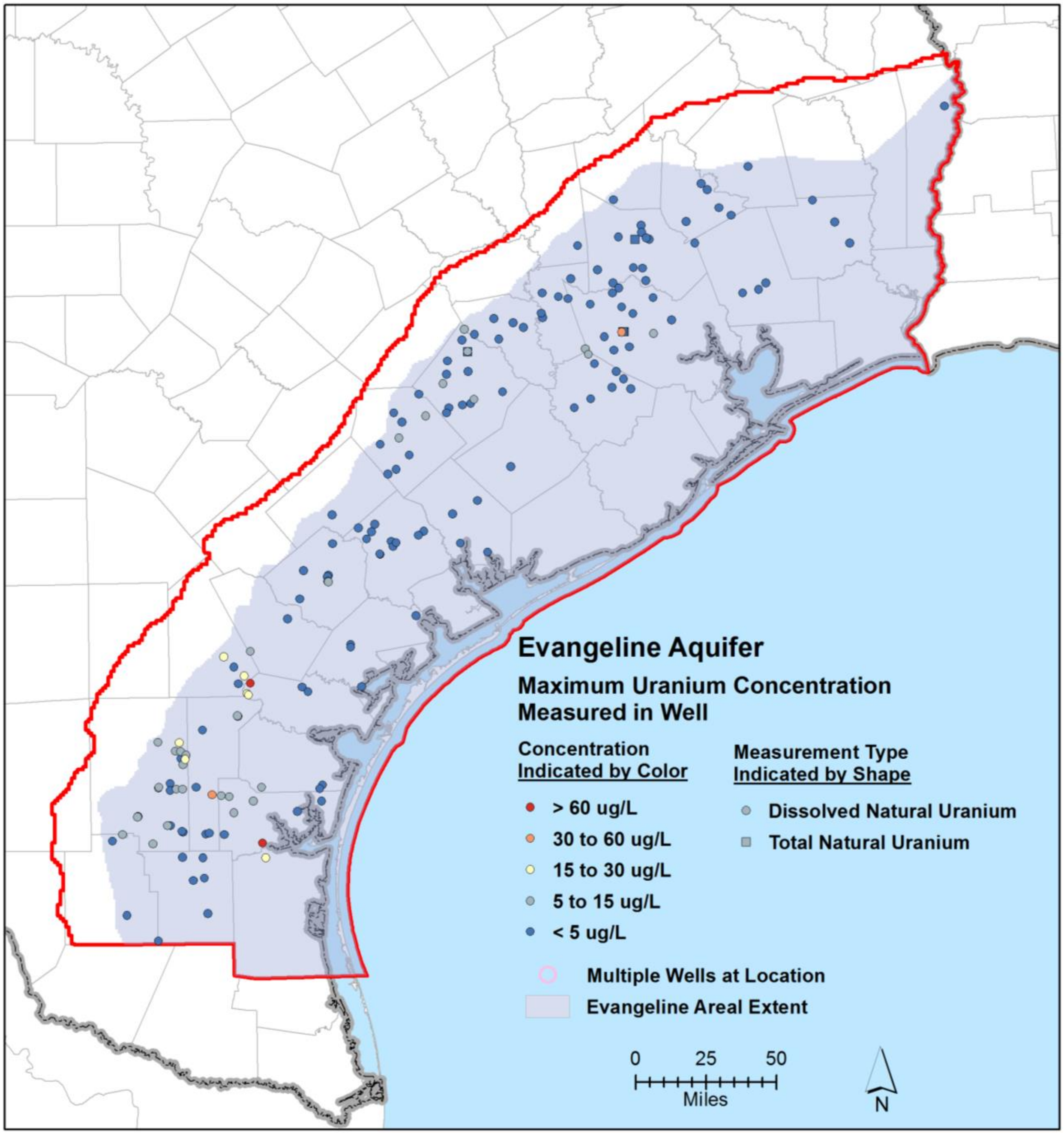

Figure 10-23. Maximum uranium concentration in the Evangeline Aquifer.

Note: ug/L=micrograms per liter

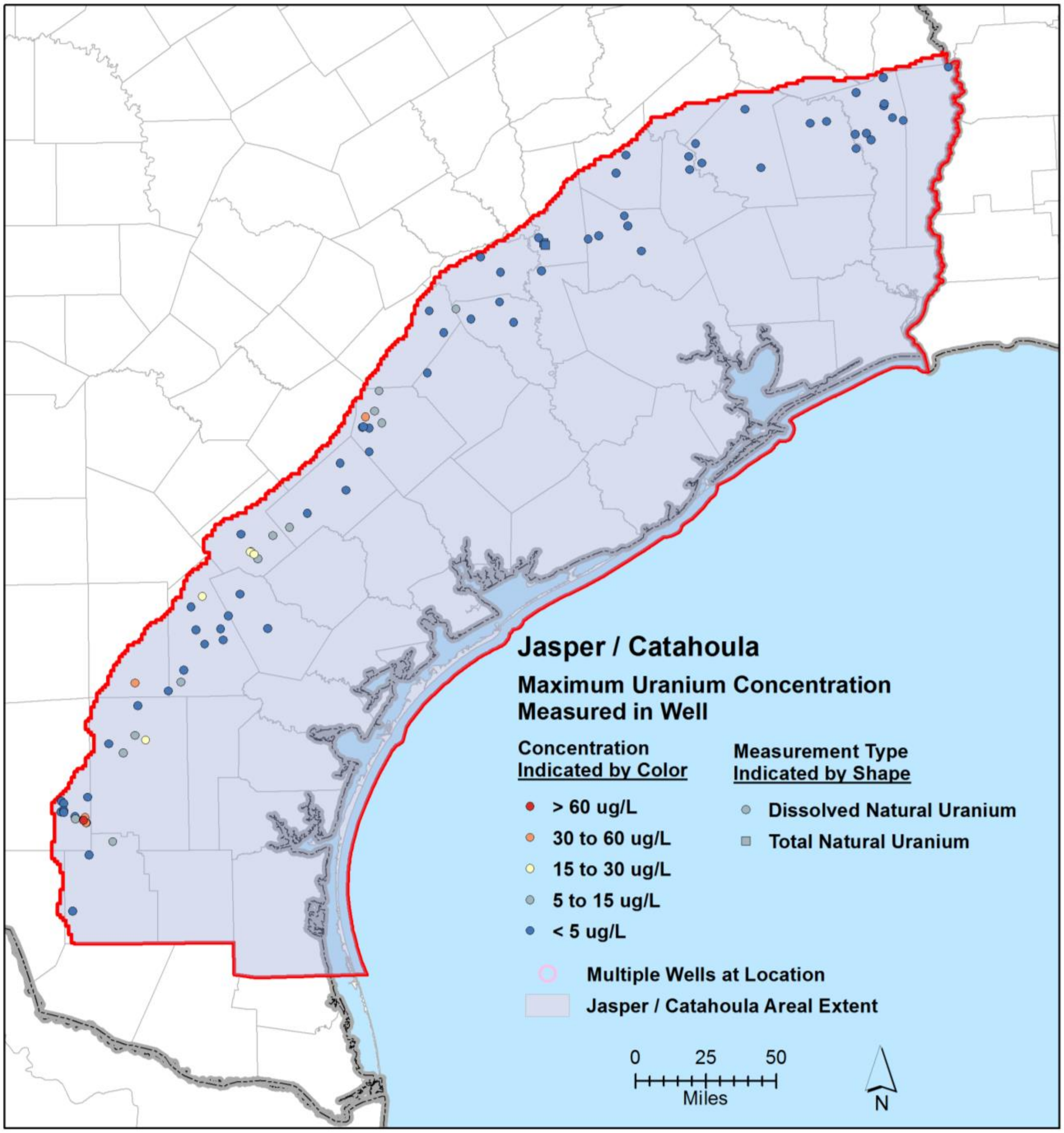

Figure 10-24. Maximum uranium concentration in the Jasper Aquifer and Catahoula Formation.

Note: ug/L=micrograms per liter

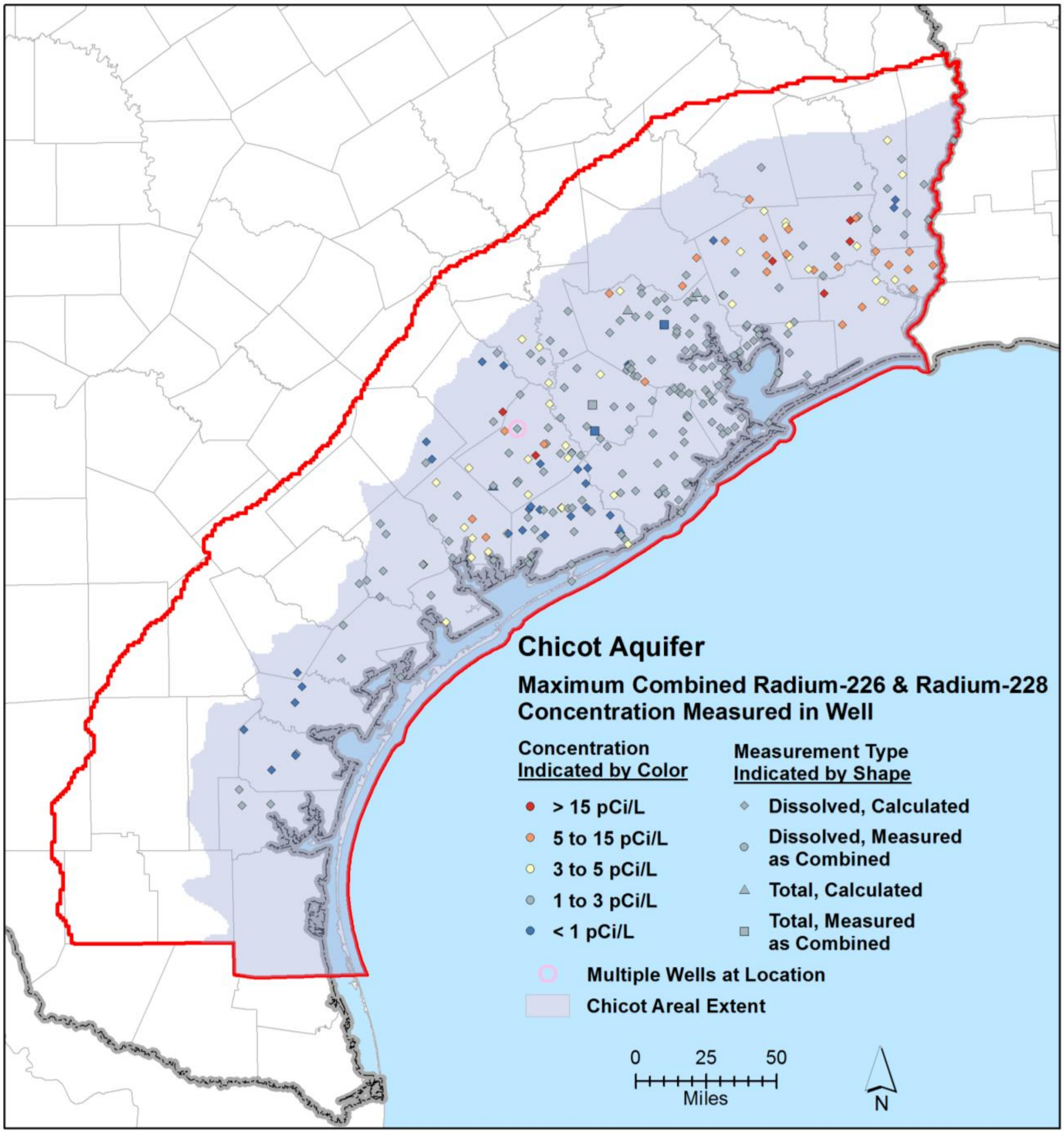

Figure 10-25. Maximum combined radium-226 and radium-228 concentration in the Chicot Aquifer.

Note: pCi/L=picoCuries per liter

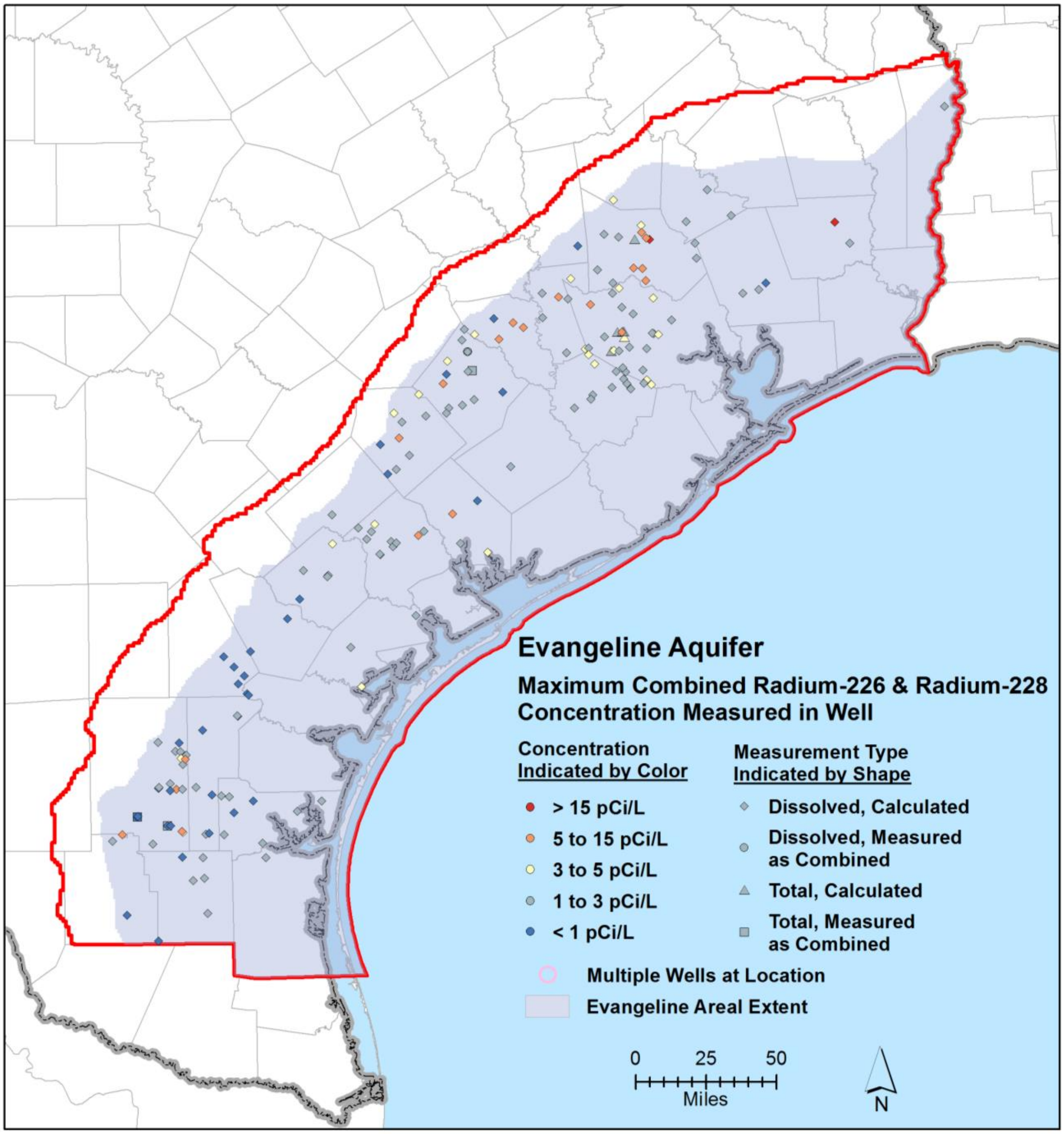

Figure 10-26. Maximum combined radium-226 and radium-228 concentration in the Evangeline Aquifer.

Note: pCi/L=picoCuries per liter

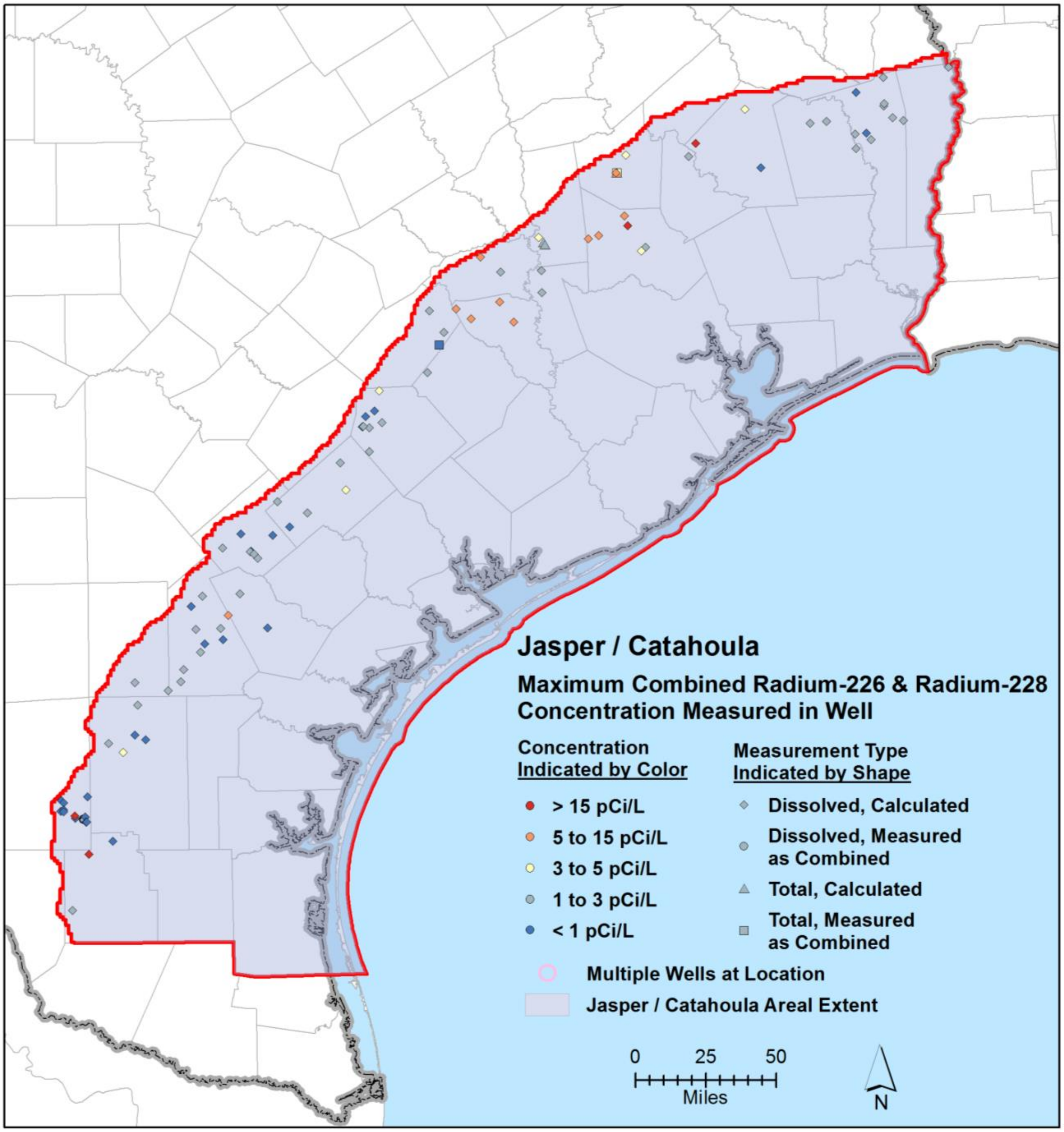

Figure 10-27. Maximum combined radium-226 and radium-228 concentration in the Jasper Aquifer and Catahoula Formation.

Note: pCi/L=picoCuries per liter

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11 Net Sand Analysis

The geophysical analyses included picking sand intervals on approximately 600 individual logs and performing stratigraphic analysis on nine vertical cross-sections. Figures 11-1 through 11-7 provide the maps of log coverage and nine cross-section locations, sand percentage, total sand thickness, and maximum sand interval thickness for the formations that comprise the Evangeline Aquifer, the Burkeville Confining Unit, the Jasper Aquifer, and the Catahoula Formation. The formations that comprise the Chicot Formation are not shown because they are not important to the identification of Potential Production Areas.

The identification of individual sands is important to the project for two reasons. First, our methodology for characterizing the quality of groundwater is only applicable to sands and cannot be applied to clay. Second, sand and clay sequences along vertical cross-sections provide useful information for identifying possible production areas and confinement zones.

11.1 Net Sand Maps

Sands were identified on geophysical logs primarily based on an interpretation of a shallow resistivity curve and a spontaneous potential curve. The geophysical log analyses were performed using PETRA®. PETRA® is a commercial software designed to expedite the selection of sand and clays on a log by allowing the user to identify the tops and bottom of a sand layer with a click of the mouse.

We analyzed the spatial distribution of the sand intervals to produce three types of sand maps for each formation. The sand percentage maps show the percentage of each formation layer that is composed of sand. The total sand thickness map shows the total thickness of sand in a formation. The maximum sand interval shows the thickness of the thickest sand interval in the formation.

11.2 Vertical Cross-sections

We reviewed cross-section lines discussed by Young and others (2010, 2012) and selected nine cross-sections for further analysis. Our analysis included adding and replacing logs to give a more complete cross-section through the Texas Gulf Coast Aquifer. Table 11-1 lists the logs associated with our final cross-sections. Figures 11-8 to 11-17 are the completed annotated cross-sections. The analysis of the cross-sections included a three-step process. The first step was to identify and correlate the marine shale wedges. The second step was to identify major fairways and possible associated confining units consisting of mudstones. The third step was to locate and identify fault zones.

11.2.1 Mapping of Marine Shale Wedges

The methods of Galloway and others (1982, 1986) were followed in connecting marine shale wedges and their contained maximum flooding surface to non-marine formation boundaries. The marine shale wedges were identified by correlating their top and base, as well as a surface of maximum transgression. These three surfaces come to a landward common point in most cases, corresponding to the beginning of the landward unit boundary. The wedge boundaries are approximate in their seaward reaches, as the overlying and underlying sand-bearing units pass into deltaic, shoreline and shelf/slope facies. In these areas, marine shale could be identified through most of the succession; however, as these areas are of limited interest for brackish water resources, we have not tried to identify all of the lesser marine shales in these areas. In the central Gulf Coast, some wedges appear to have broad but thin shales that extend an unusual distance inland. These thin shales are probably the result of extensive lagoons at these times.

Table 11-1. Logs associated with the cross-sections in Figures 11-8 through 11-16.

Well API	Well Plot Number	Well API	Well Plot Number	Well API	Well Plot Number
Cross-Section #2		**Cross-Section #6**		**Cross-Section #8**	
420050019200	1	424713002200	1	424773062500	1
420053011900	2	424710014800	2	424770023900	2
422410025300	3	424710018000	3	424770027200	3
424573011900	4	424710018900	4	424770029400	4
424570004100	5	423390086800	5	420153013800	5
424570004300	6	423390090100	6	420150023000	6
424570025600	7	423390008600	7	424730024300	7
424570025400	8	423390020200	8	424730004900	8
424570037700	9	423393082000	9	424730031800	9
421990011600	10	423390171800	10	424730019900	10
421993181100	11	422010760300	11	424730043000	11
421990035600	12	422010272200	12	421570000100	12
423610000400	13	422010280100	13	421570102600	13
422450016900	14	422013261300	14	421573198300	14
422453257200	15	422010604400	15	421570089400	15
422450165400	16	420710309600	16	421570245900	16
422450163700	17	421670096600	17	420390145200	17
422453014300	18	421673009100	18	420390422400	18
426060001000	19	427064038000	19	420390427700	19
427080001000	20	427060014100	20	420390429100	20
427084004000	21	427064009000	21	427060002200	21
427084007700	22	427064044600	22	427064035500	22
427083004500	23	427084017000	23	427064043400	23
427084016000	24	427084027900	24	427064021200	24
427084046800	25	-	-	-	-
427084030000	26	-	-	-	-
Cross-Section #10		**Cross-Section #13**		**Cross-Section #16**	
421493208800	1	422853229700	1	424930153600	1
421493132900	2	422853026800	2	422550063400	2
420893153100	3	422853228200	3	422553024600	3
420890005700	4	422850035800	4	422553060900	4
420890009000	5	422850050900	5	422553134600	5
420893124600	6	422853176200	6	421750145600	6

Well API	Well Plot Number	Well API	Well Plot Number	Well API	Well Plot Number
420890027000	7	422390001700	7	421750138400	7
424810121800	8	422390004700	8	421753263600	8
424810120500	9	422390155600	9	421753219700	9
424813403300	10	422390172800	10	421753216500	10
424813403300	11	422390192100	11	421753194500	11
424813344200	12	422393313600	12	423913208700	12
424810103800	13	422390319800	13	423913211800	13
424813294400	14	420570085200	14	423913158800	14
424810256200	15	420573090300	15	423913213600	15
423210034100	16	NOAPI_18788	16	420070035400	16
423210067000	17	423213157300	17	NOAPI	17
423210083600	18	427033000600	18	420073066000	18
423210082400	19	427033026700	19	427030000200	19
427043007300	20	427034008400	20	427034013700	20
427040007100	21	427034007400	21	427034026900	21
427043000500	22	427034011000	22	427034044200	22
427040007000	23	427034049000	23	427124002100	23
427044002600	24	427044013100	24	-	-
Cross-Section #19		**Cross-Section #22**		**Cross-Section #25**	
423110117300	1	424793198500	1	425053098400	1
423110094300	2	424790108500	2	425053027100	2
422973265600	3	421313619300	3	422473194000	3
422973033000	4	421313519700	4	422473169500	4
422970203100	5	421310782600	5	422473171300	5
422970260400	6	421313726100	6	422473187800	6
422973354100	7	421310887900	7	422473174900	7
422970232700	8	421313234100	8	422473199500	8
422973198900	9	422493086800	9	422473225400	9
422973351100	10	422730131200	10	422470261000	10
422493198500	11	422733233600	11	no_name_2	11
424093181400	12	422730179500	12	420473151300	12
424093171600	13	422730108500	13	420473206500	13
424093004400	14	422730084500	14	420470069400	14
424093188300	15	422730088100	15	420473001700	15
424090280100	16	422730088300	16	420470124900	16
423553024900	17	422610006000	17	420470126700	17
423553127000	18	426010000200	18	422610022300	18
423550612200	19	427014001100	19	422610021900	19
426020004000	20	427014002600	20	422610035300	20
427020000300	21	427134004200	21	422610020100	21
427024007000	22	427134000700	22	427013000100	22

11.2.2 Mapping of Major Fairways and Major Non-Marine Shales

Once the major geologic units and the marine flooding surfaces were identified, we began the process of identifying major fairways for brackish water production and major shale or mudstone seals for these units. The first step was to identify sandstone-rich packages of possible interest. There are three varieties that were visible on the geophysical logs:

- Thick high net-sandstone aggradational packages (marked in green on the sections) are commonly found above and sometimes below the marine wedges, and also down dip within the units in a marginal-marine environment. These marginal-marine packages are the result of stacked shoreline deposition. They form targets of high continuity in a strike direction and substantial continuity in a dip direction. These units are very pronounced in the interdeltaic areas of the central Texas Gulf Coast and are also present near Beaumont and more sparingly in other areas. These may be optimal targets for sustained high-volume water production; however, many may have salinity values that are too high for presently-contemplated desalination projects.
- Individual channel sandstones that are greater than 50 feet thick are identified (in red) on a few dip sections, mainly in southeast Texas. These channel sandstones are likely to be moderately continuous in a dip direction, and discontinuous in a strike direction. More of them might be found by examination of strike sections with closely-spaced logs. But thick channel sandstones do not appear to be widespread targets.
- Packages of sandstones containing a number of 20-feet or thicker sandstone bodies are the principal fairway type in the non-marine sections, and are present on all sections (marked in violet). In the initial interpretation, all sand-bearing packages with some thicker sands have been labeled; a number of these will probably not meet the criteria for fairway delineation with further study. These zones appear to represent a variety of depositional environments. Most are smaller, complex channel systems and their associated crevasse splays; these are generally dip-elongate but have some strike continuity. Others of undetermined origin appear to be more strike-elongate, perhaps representing sand-poor shoreline or washover systems.

11.2.3 Mapping of Clay-rich Zones

After the major fairways were identified, we identified the units of purer mudstone or shale. We divided the shale into two varieties: thinner units with low resistivity that could form excellent seals even when thin (dark gray); and thicker zones that are free from significant siltstone or thin sandstone (light gray). The remainder of the sections (uncolored) consist of mud-rich sequences with thin siltstone or sandstone beds, which are probably aquitards but do not provide as good a seal as the gray zones.

The mud-rich zones were formed in floodplain environments up dip, and lagoonal environments down dip. Lagoon-formed mudstone may also contain thin carbonate units (oyster reefs). In down dip regions, marine shales are also colored gray where they are interbedded with marginal-marine (deltaic or shoreline) sands. These clay-rich sections form the sealing units between sandstone aquifer fairways. The relationship between seal thickness and seal efficiency is not well determined; even a thin (foot-thick) but plastic, clay-rich shale can form an effective seal for hydrocarbons and water. Leakiness of these units may be governed by the presence of faulting:

either reactivated faults that formed during shelf-margin progradation at earlier times, or faults related to salt domes and other salt-tectonic features. That said, a thicker shale unit may help to limit leakiness on these features.

11.2.4 Mapping of Fault Zones

Within the study area, faulting and related folding are due entirely to loading of sediment and gravity-driven subsidence and seaward movement. In areas with a thick, mobile salt layer, the result is a wide variety of salt-related features, particularly piercement salt domes and areas of enhanced subsidence called salt-withdrawal basins. In all areas, overpressured shales also form mobile substrates that allow fault systems to develop.

Delta systems and related shorelines have prograded the shelf margin throughout the Cenozoic, from a line Freer-Cuero-Sealy-Conroe-Jasper at 55 million years ago, to the present shoreline by 30 million years ago (Frio) to the present shelf margin up to 250 kilometers from shore. As sediments are deposited into deep water at the margin, they are massively unstable and develop large normal faults, often with thousands of feet of displacement. These faults expand the shelf-margin section (sometimes as much as ten-fold) and are, therefore, known as growth faults. The major faults may occur singly, but more often a complex zone of faulting is formed, that takes its name from the shelf-margin unit with which it is associated.

Once the shelf margin has passed a location, and fault activity decreases, that area forms part of the continental shelf. However, some (but not all) faults are reactivated during this time and affect younger units. These reactivated faults may still have displacements up to a few hundred feet and may also generate broad anticlines on their downthrown side. Some faults reach the surface and form gentle fault scarps; others die out somewhere in the subsurface. The shelf-margin section is generally located deeper than 8,000 feet below sea level; shallower units are in the subsiding continental shelf section.

Figure 5-4 shows the major growth fault zones in the Texas coast. These are, from northwest to southeast, the Wilcox fault zone; the Yegua fault zone; the Vicksburg fault zone (one master fault in south and central Texas); the Frio fault zone; and the Fleming fault zone (Lower Miocene). The last continues offshore and is succeeded by a Goliad fault zone (Corsair fault zone, middle Miocene) and faulting related to Plio-Pleistocene progradation and salt movement (High Island, South and East).

The faults zones shown on Figure 5-4 were located on each of the nine cross-sections. In the vicinity of each fault zone, we looked for evidence of offsets in the dip between logs to determine if noticeable offset occurred between the logs. Despite our increasing the number of logs per cross-section, the spacing distance between the logs were not sufficient to pinpoint the fault zone locations. As a result, the location of major faults is largely diagrammatic. The height of the line reflects the upper extent of where there is a likelihood that the fault zone may have been reactivated and affected offsets. Our analyses suggest that, if such reactivation had occurred, the offset along the black lines would be less than 200 feet. The end result of our analysis is that we did not discover any evidence that indicated that that any of the major faults would significant impact groundwater flow. Therefore, no fault zones were included in the groundwater modeling task.

11.3 Porosity

Porosity was measured using the neutron-density combination method, which is the most widely used geophysical log porosity method (Asquith and Krygowski, 2004). Neutron and density curves are displayed in porosity units. Caliper and gamma ray or SP curves are also required for porosity measurement. A resistivity curve is helpful but not essential. NPHI (neutron porosity) and DPHI (density porosity) curves may be recorded as limestone units or sandstone units, depending on the rock density used to convert the raw data to porosity units. Almost all Gulf Coast NPHI (neutron porosity) and DPHI (density porosity) logs are run using a sandstone matrix (density = 2.65 grams per cubic centimeter). Therefore, conversion from limestone to sandstone is not needed, and porosity can be read directly from the log curves. The formation porosity equals the average of the NPHI (neutron porosity) and DPHI (density porosity) readings.

Specific formation and borehole conditions are necessary for accurate porosity log measurements. Gulf Coast porosity must be measured in clean (clay-free) sand or sandstone. The gamma ray and/or spontaneous potential curves are used to identify clean zones. The formation must not contain hydrocarbons, especially natural gas. A resistivity curve can help identify hydrocarbons. Thick sands also help avoid hydrocarbons. The porosity measurement should be taken in the middle or lower part of a thick sand, because hydrocarbons migrate to the upper part. Porosity logging tools are pads that are pressed against the borehole wall and must maintain contact with that wall for accurate readings. The caliper logging tool measures borehole diameter and is used to detect rough or washed out locations, where the porosity pad might lose contact with the borehole wall. Accurate neutron-density porosity measurements are only possible where the borehole wall is smooth and not enlarged by washout or caving.

We measured Gulf Coast porosities on neutron-density logs using the following procedure. First, we scanned hundreds of porosity logs, searching for shallow coverage and suitable conditions as described previously. Most Gulf Coast porosity logs are not usable for the shallow interval, but we found 34 logs scattered across the entire Gulf Coast Aquifer that were usable. Figure 11-17 shows the locations of those logs. We made approximately 10 to 20 porosity measurements per well at depths ranging from the surface to almost 8,000 feet, although most measurements were less than 5,000 feet deep. For each log, we scanned down the log from top to bottom, selecting suitable zones for measurement. Porosity values that were associated with formations below the Catahoula Formation were omitted from analysis.

Our final set of values consisted of 294 porosity measurements. Despite a considerable amount of scatter amount the data points, there is evidence of a gradual decrease in porosity with depth. Figure 11-18 provides our current analysis of porosity. The data show a decrease in porosity with depth that is expressed by Equation 11-1. The equation is similar and agrees with several previous studies. Equation 11-1 indicates that porosity decreases about 1 percent every 1,000 feet of depth. Wallace and others (1972) report a decrease of 0.95 percent and 0.85 percent in porosity every 1,000 feet in the for the Rio Grande embayment and for the Houston embayment, respectively. Loucks and others (1986) report a range of 1.28 percent to 2.05 percent decrease in porosity for every 1,000 feet of depth.

$$\Phi = 36.64 - 0.001 * d \qquad \text{(Equation 11-1)}$$

Where:

Φ = porosity

d = depth (feet)

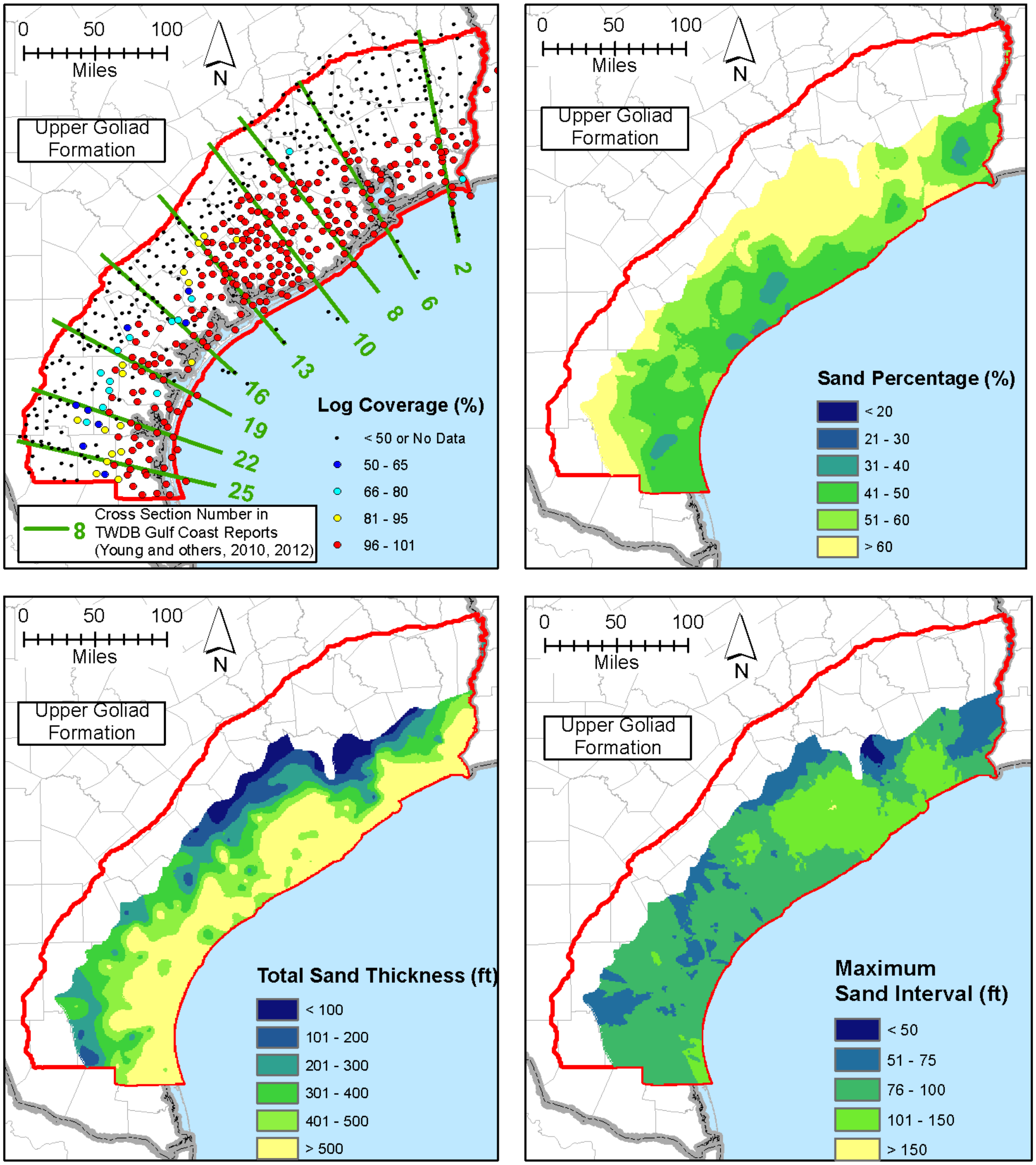


Figure 11-1. **Maps of log coverage, sand percentage, total sand thickness and maximum sand interval for the upper Goliad Formation.**

Note: ft=feet

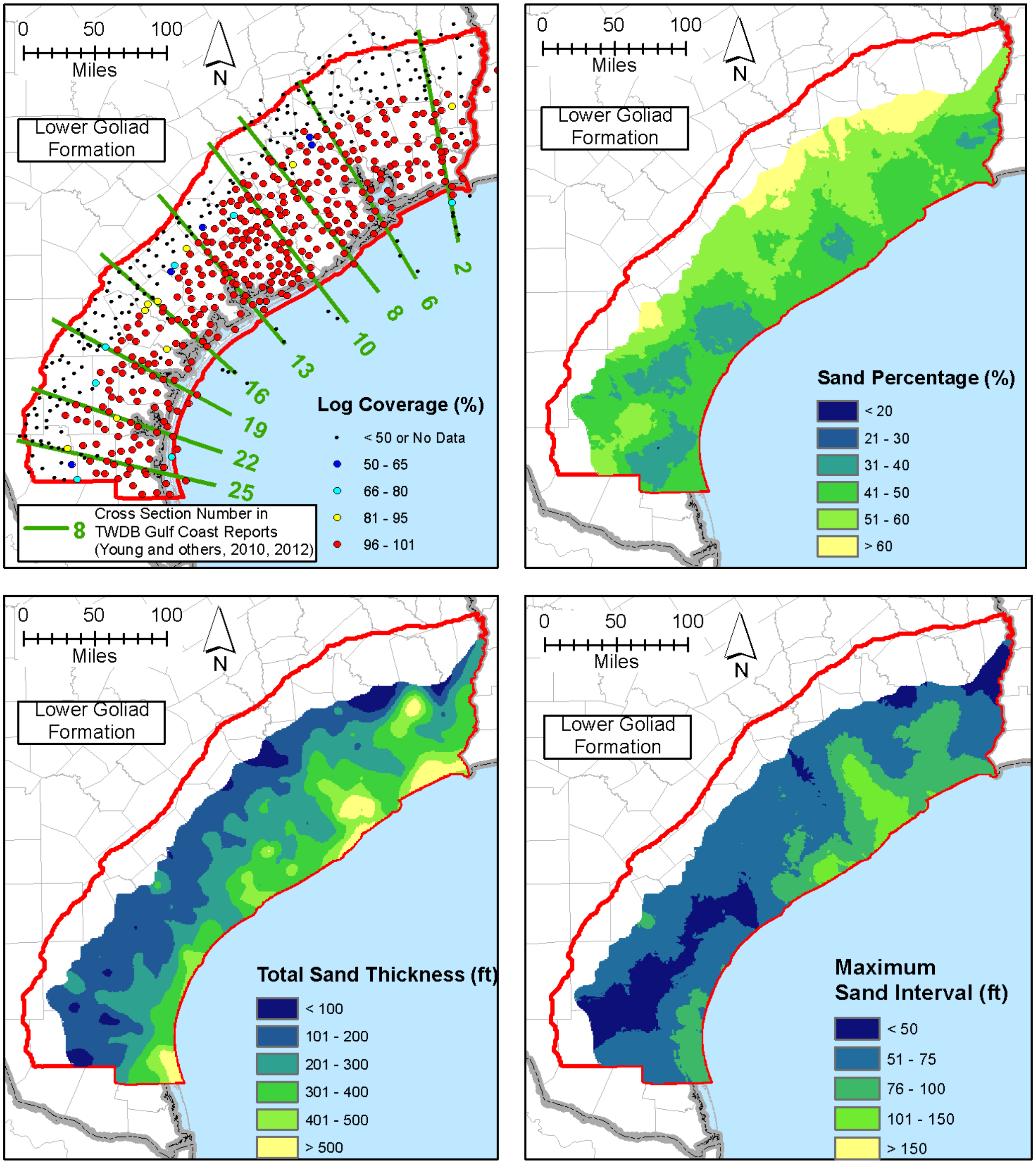


Figure 11-2. **Maps of log coverage, sand percentage, total sand thickness and maximum sand interval for the lower Goliad Formation.**

Note: ft=feet

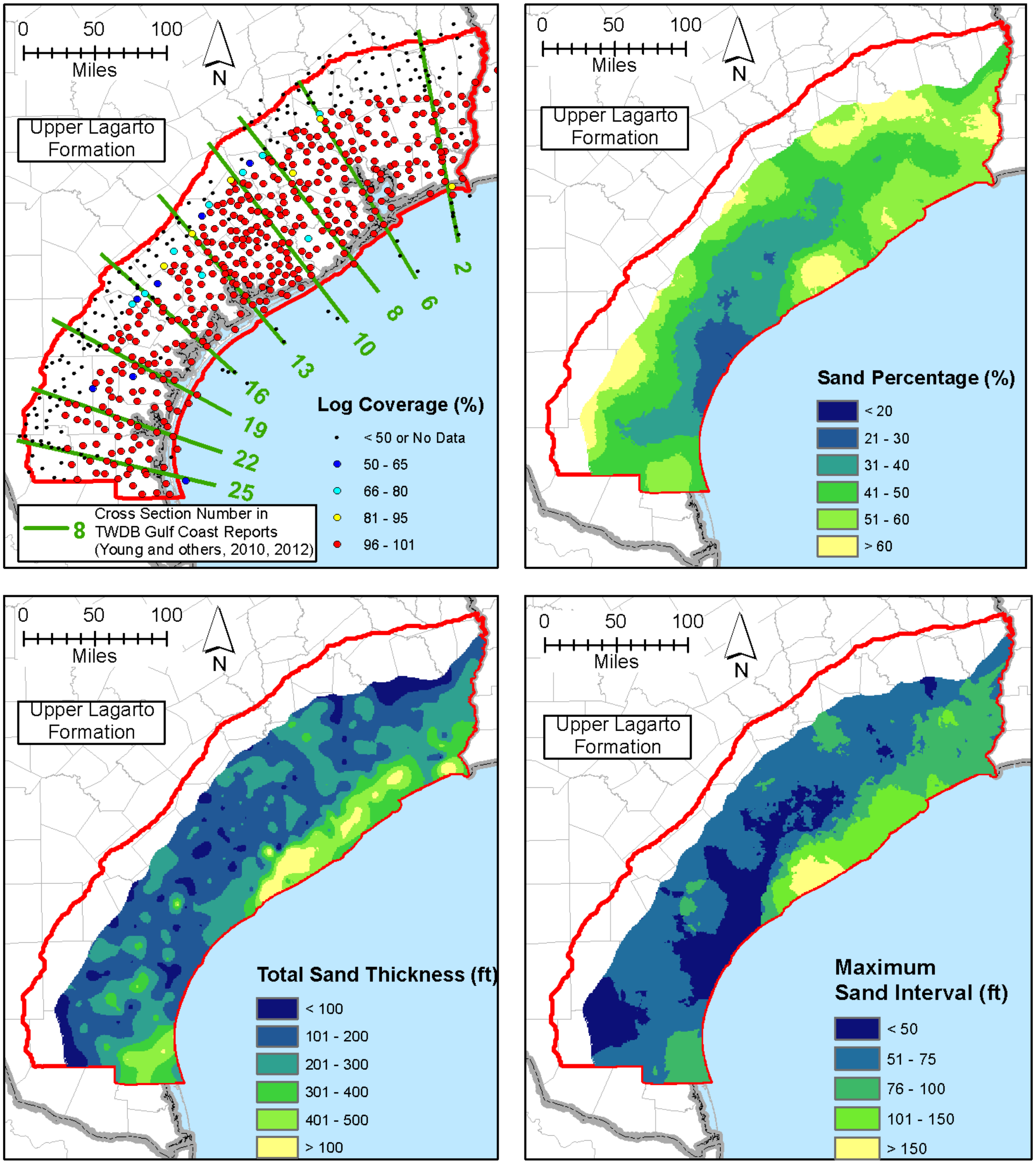


Figure 11-3. **Maps of log coverage, sand percentage, total sand thickness and maximum sand interval for the upper Lagarto Formation.**

Note: ft=feet

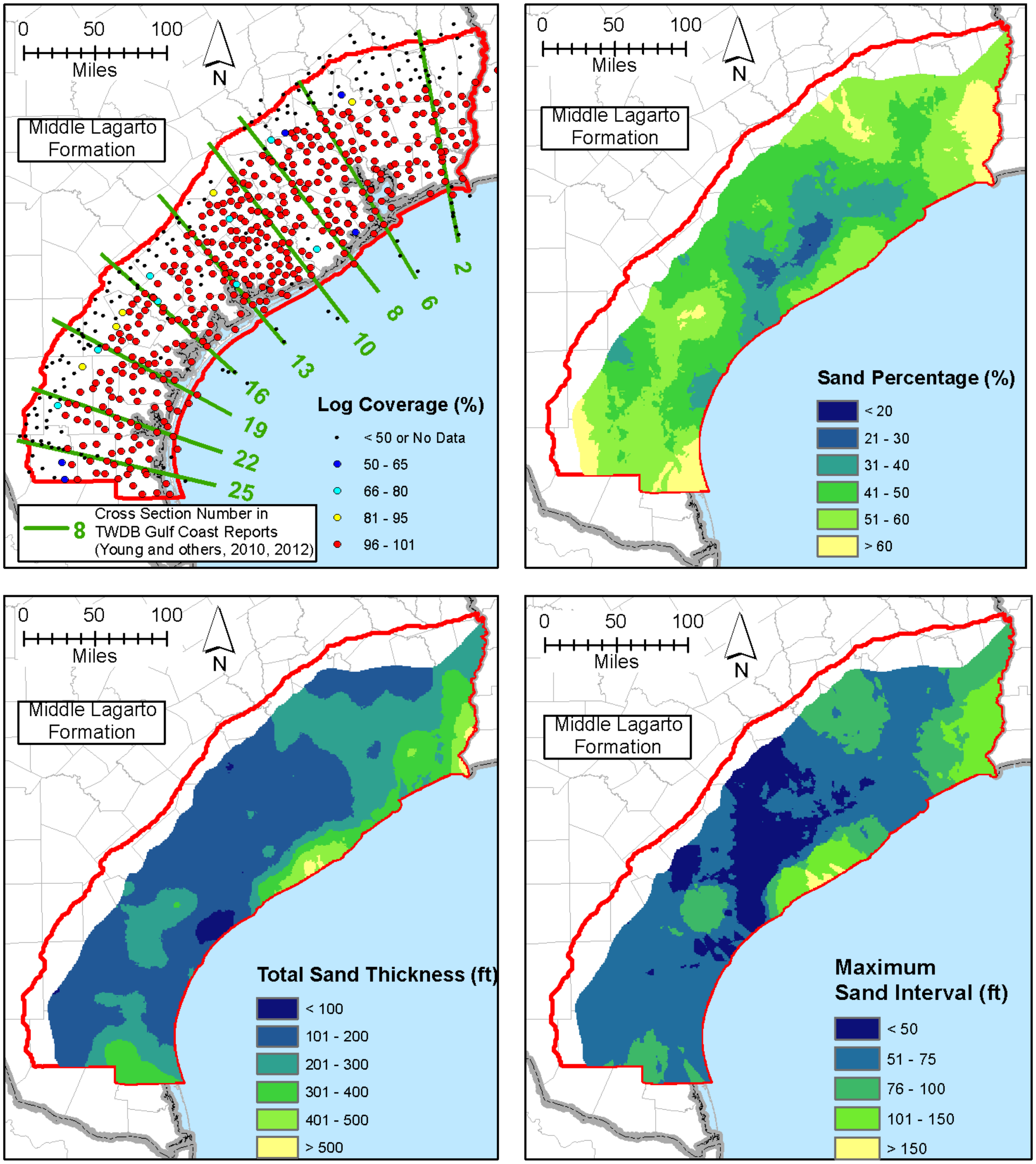


Figure 11-4. Maps of log coverage, sand percentage, total sand thickness and maximum sand interval for the middle Lagarto Formation.

Note: ft=feet

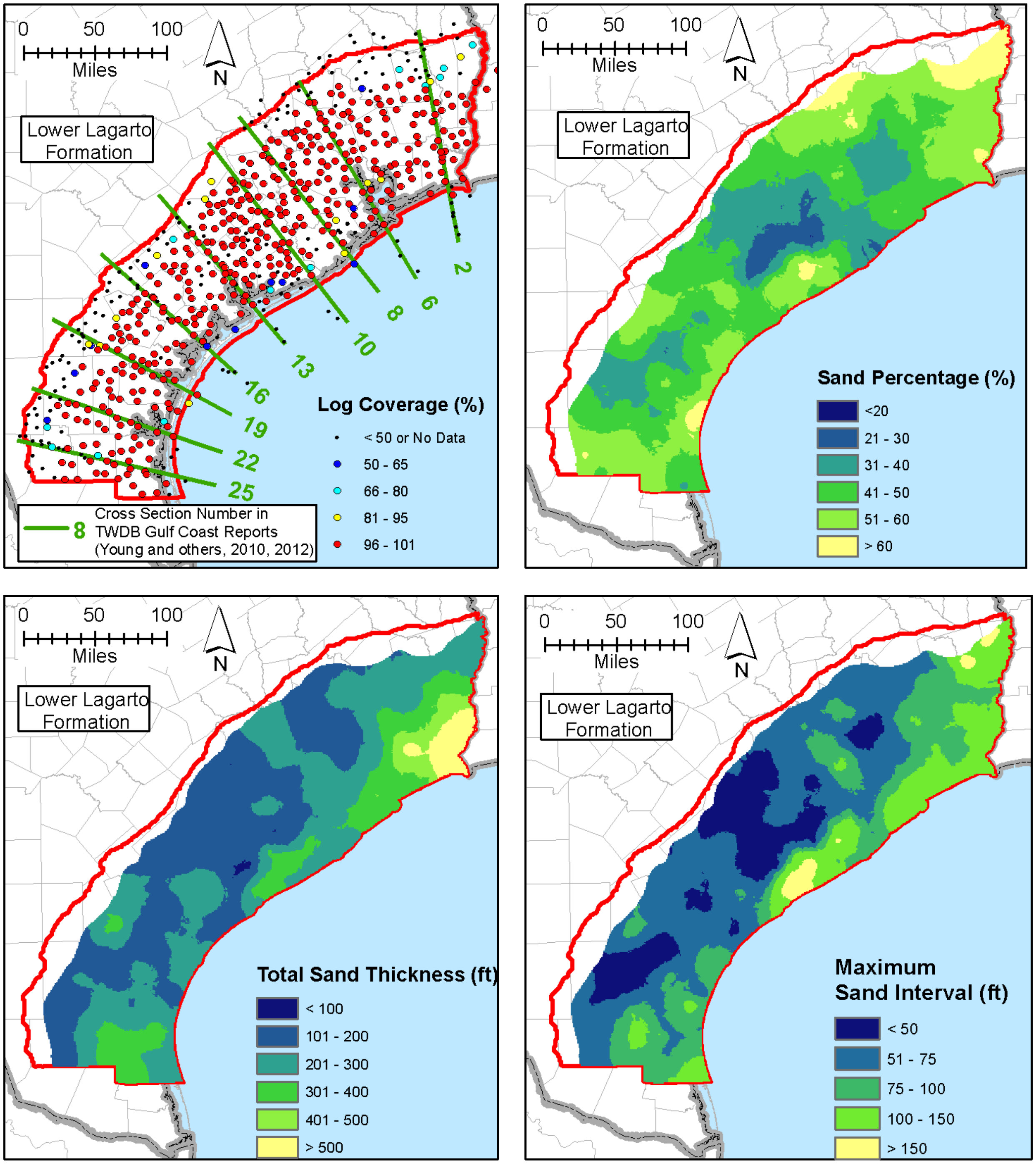


Figure 11-5. **Maps of log coverage, sand percentage, total sand thickness and maximum sand interval for the lower Lagarto Formation.**

Note: ft=feet

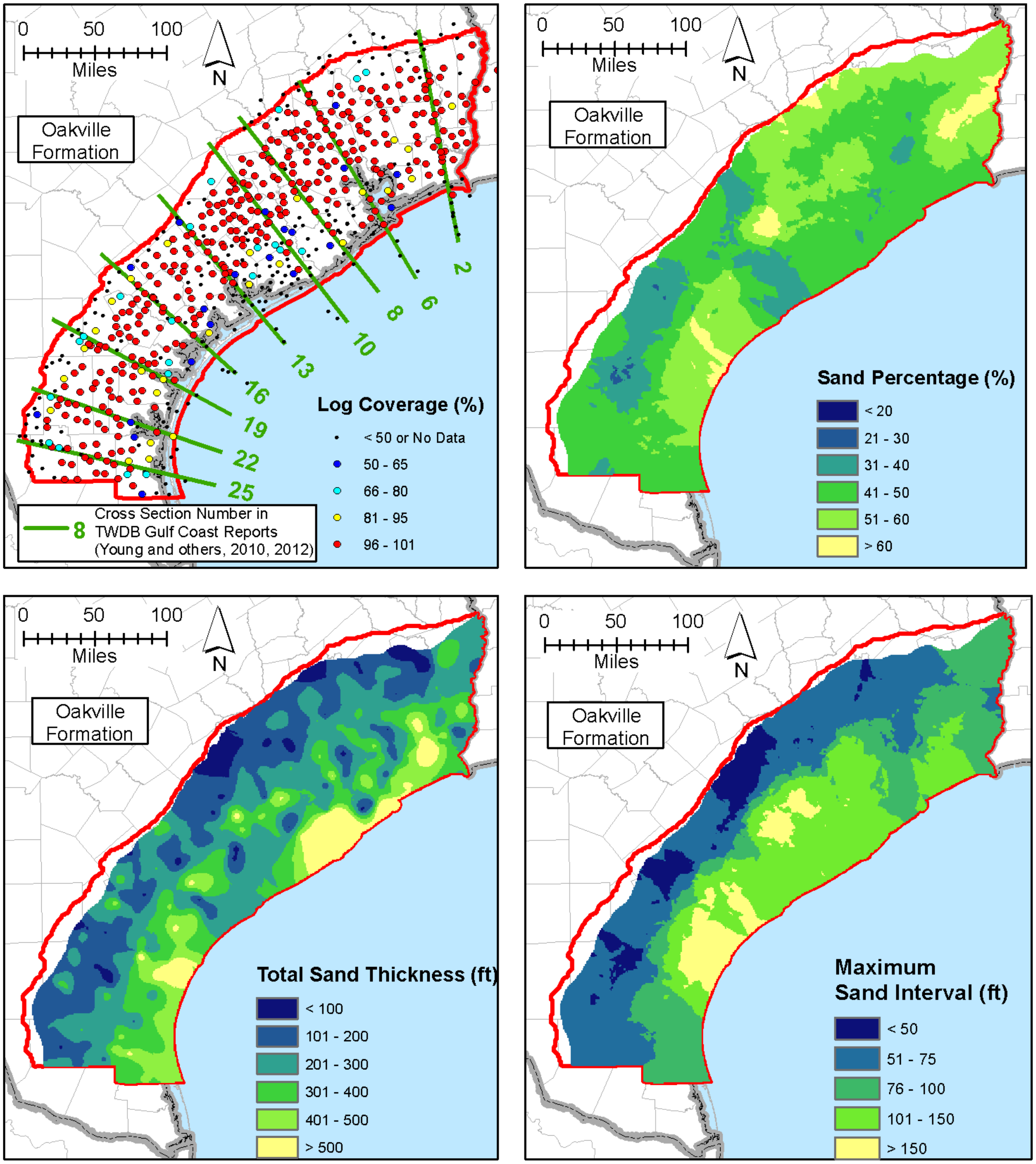


Figure 11-6. Maps of log coverage, sand percentage, total sand thickness and maximum sand interval for the Oakville Formation.

Note: ft=feet

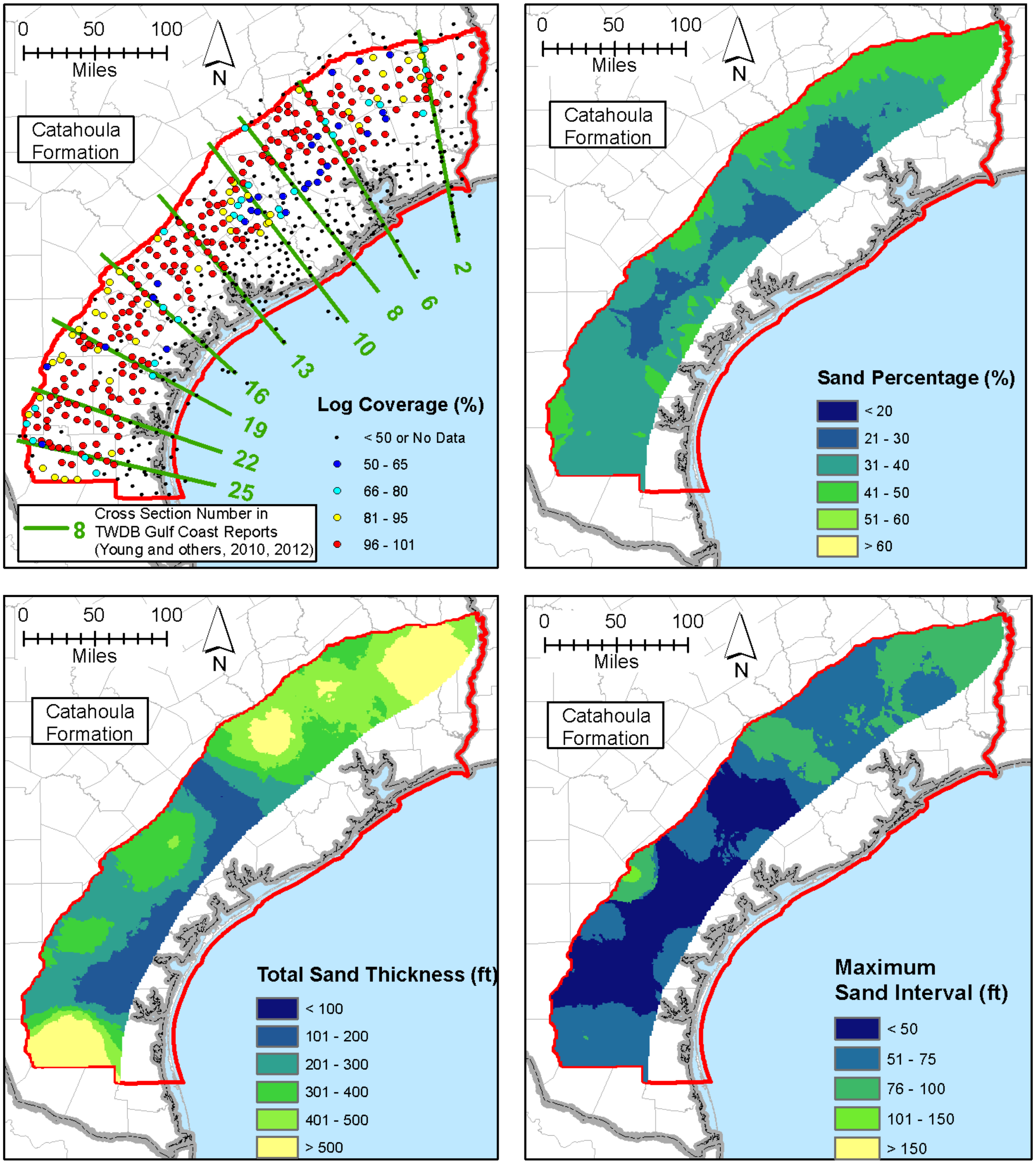


Figure 11-7. **Maps of log coverage, sand percentage, total sand thickness and maximum sand interval for the Catahoula Formation.**

Note: ft=feet

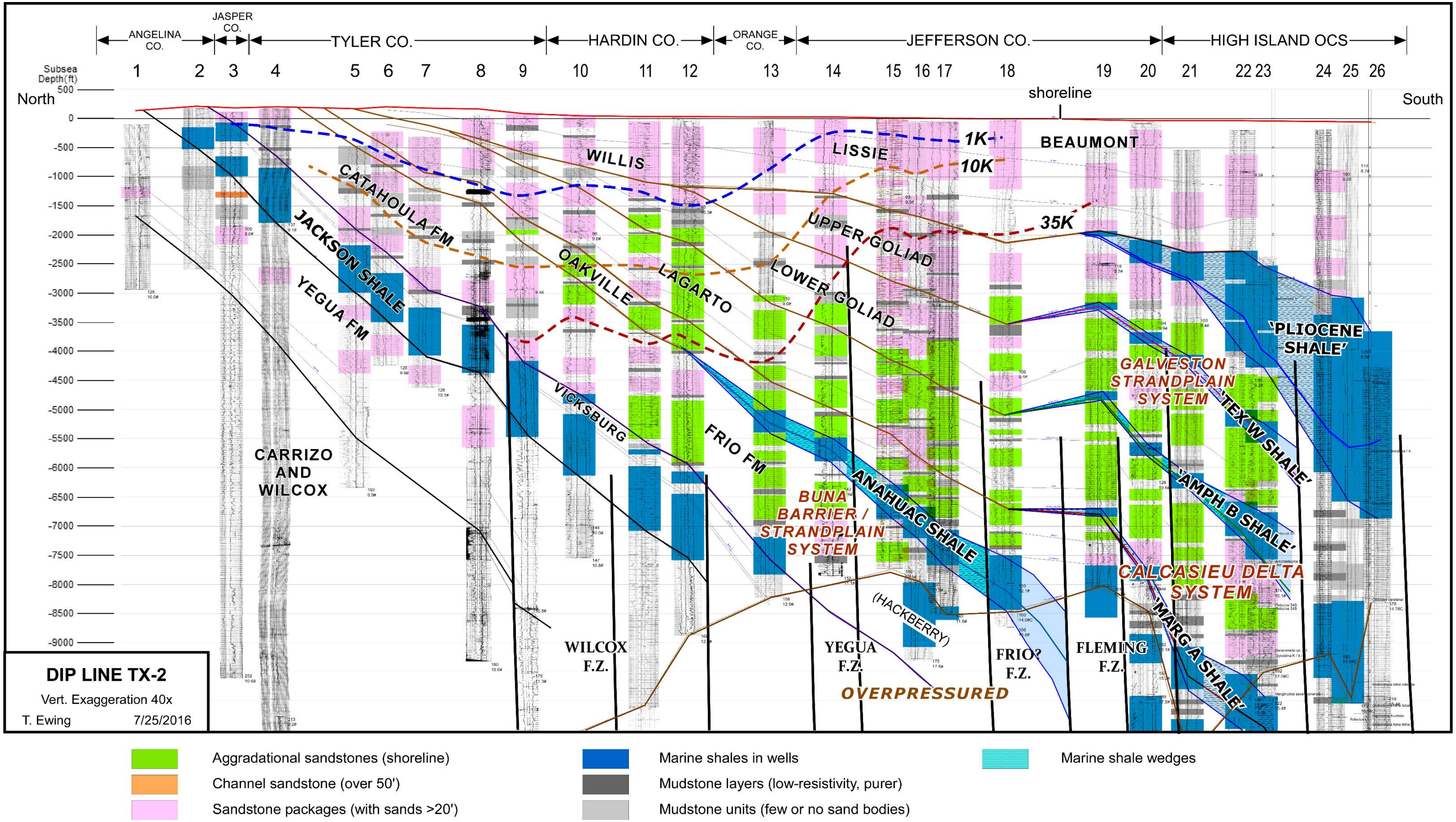


Figure 11-8. **Analysis of sand and clay sequences, fault zones, along cross-section #2 in Figure 6-1.**

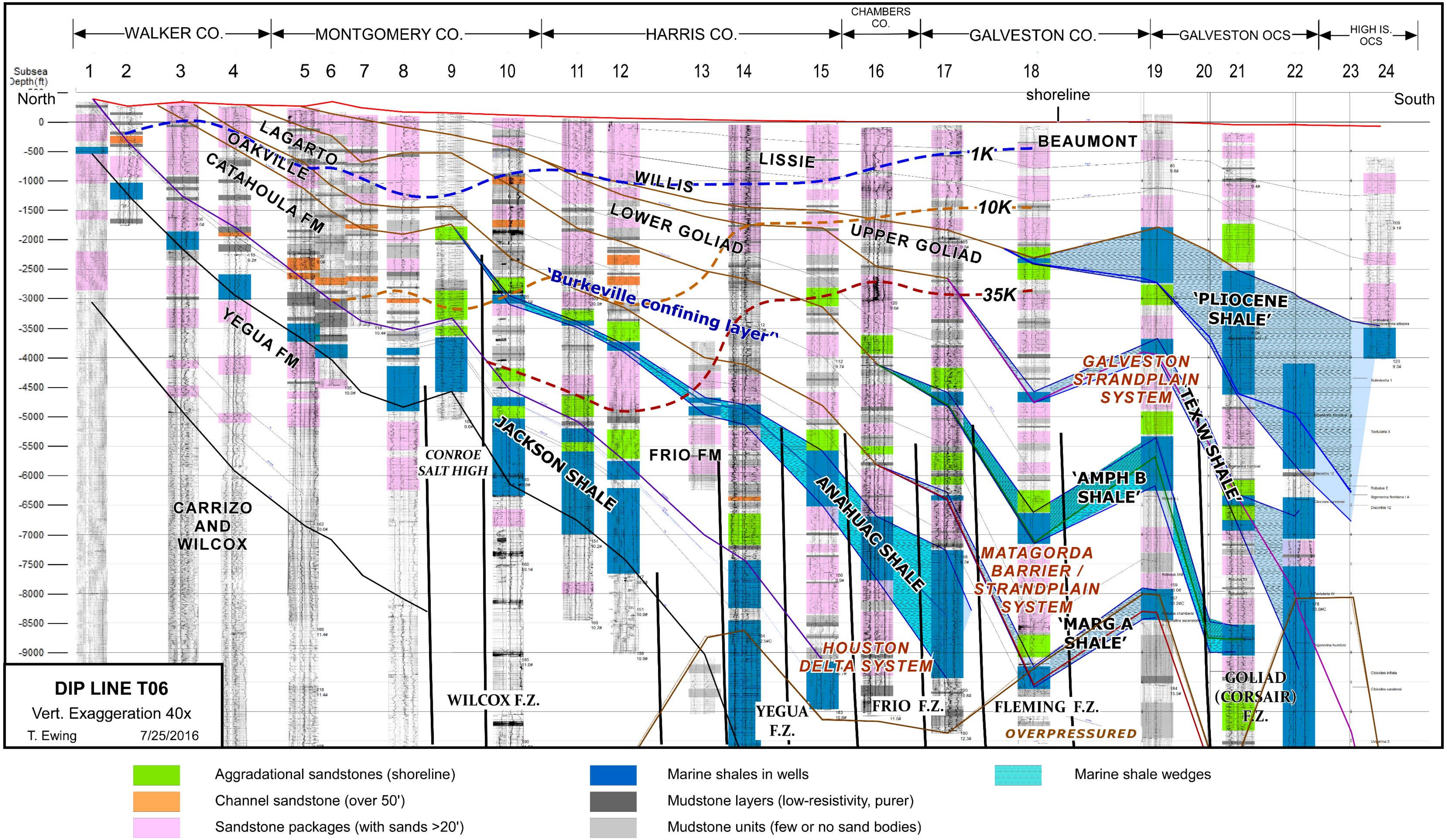


Figure 11-9. Analysis of sand and clay sequences, fault zones, along cross-section #6 in Figure 6-1.

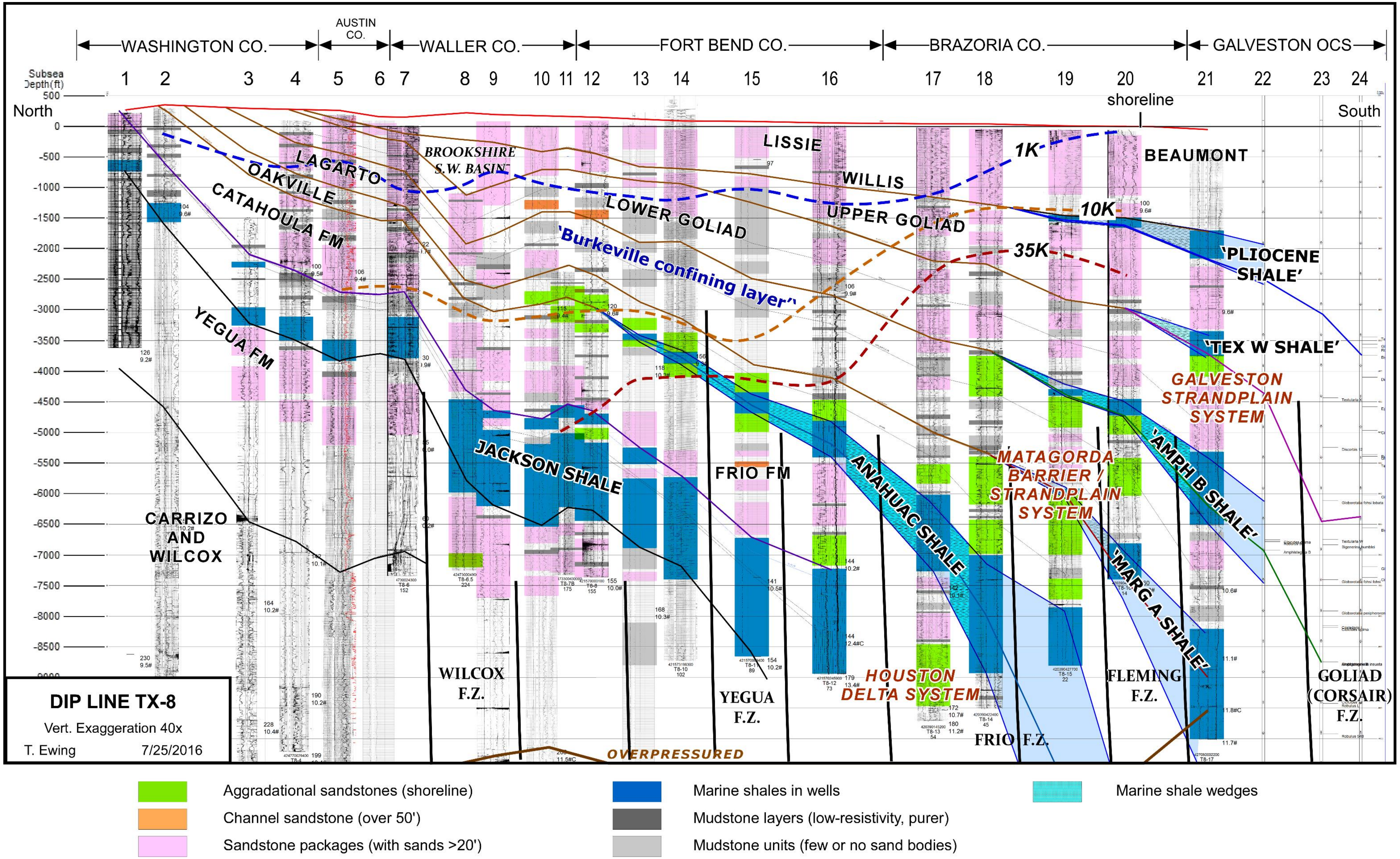


Figure 11-10. **Analysis of sand and clay sequences, fault zones, along cross-section #8 in Figure 6-1.**

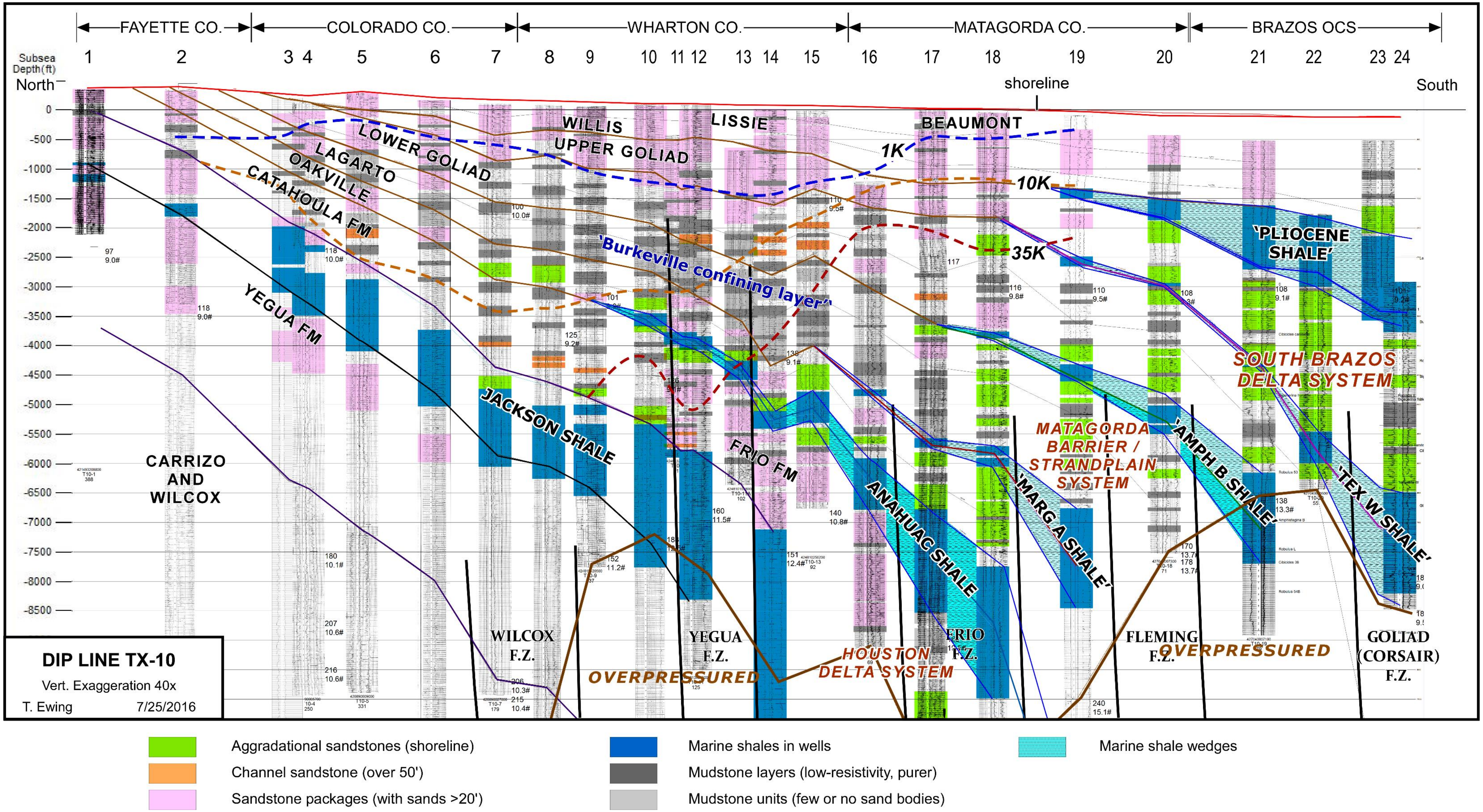


Figure 11-11. **Analysis of sand and clay sequences, fault zones, along cross-section #10 in Figure 6-1.**

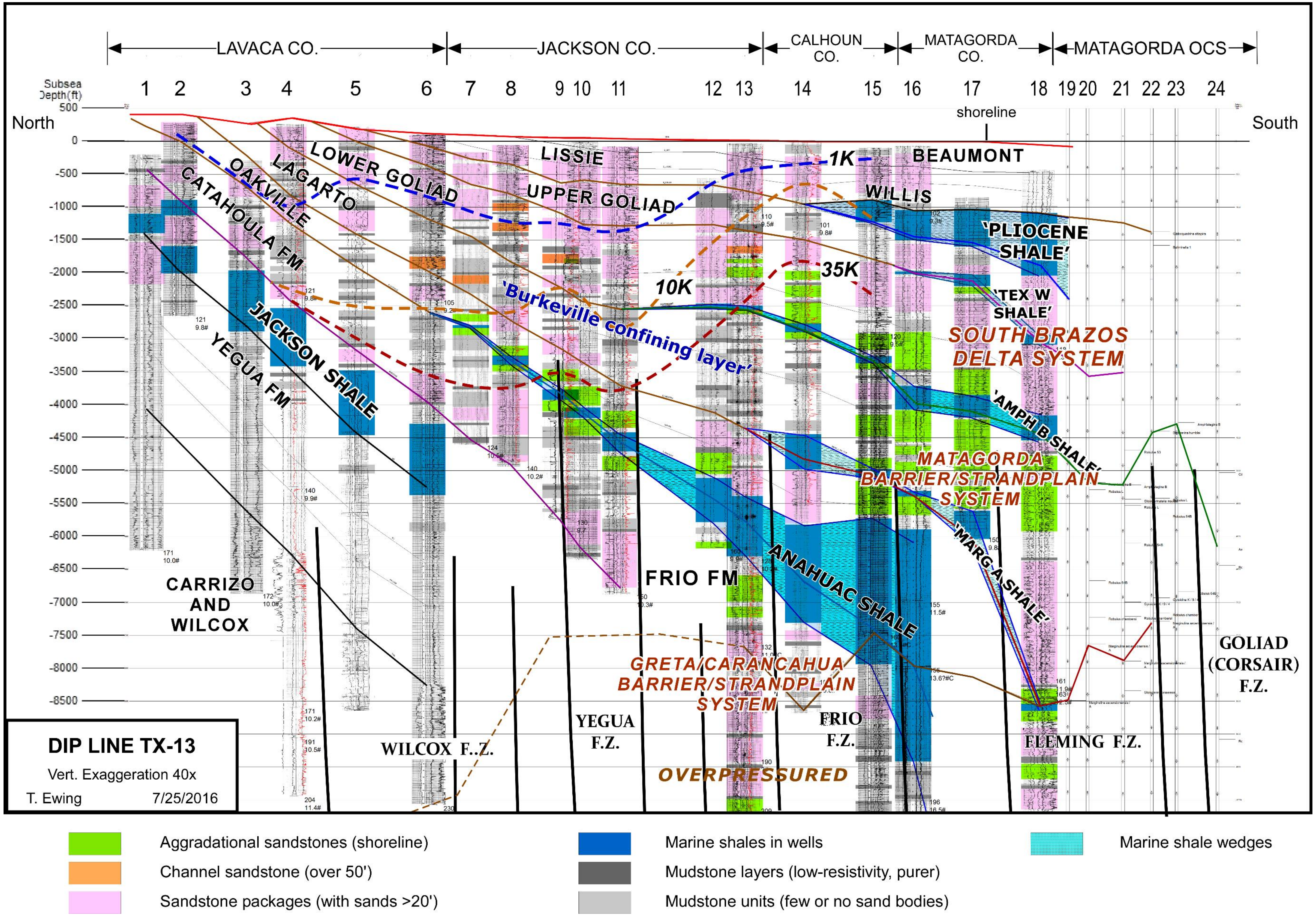
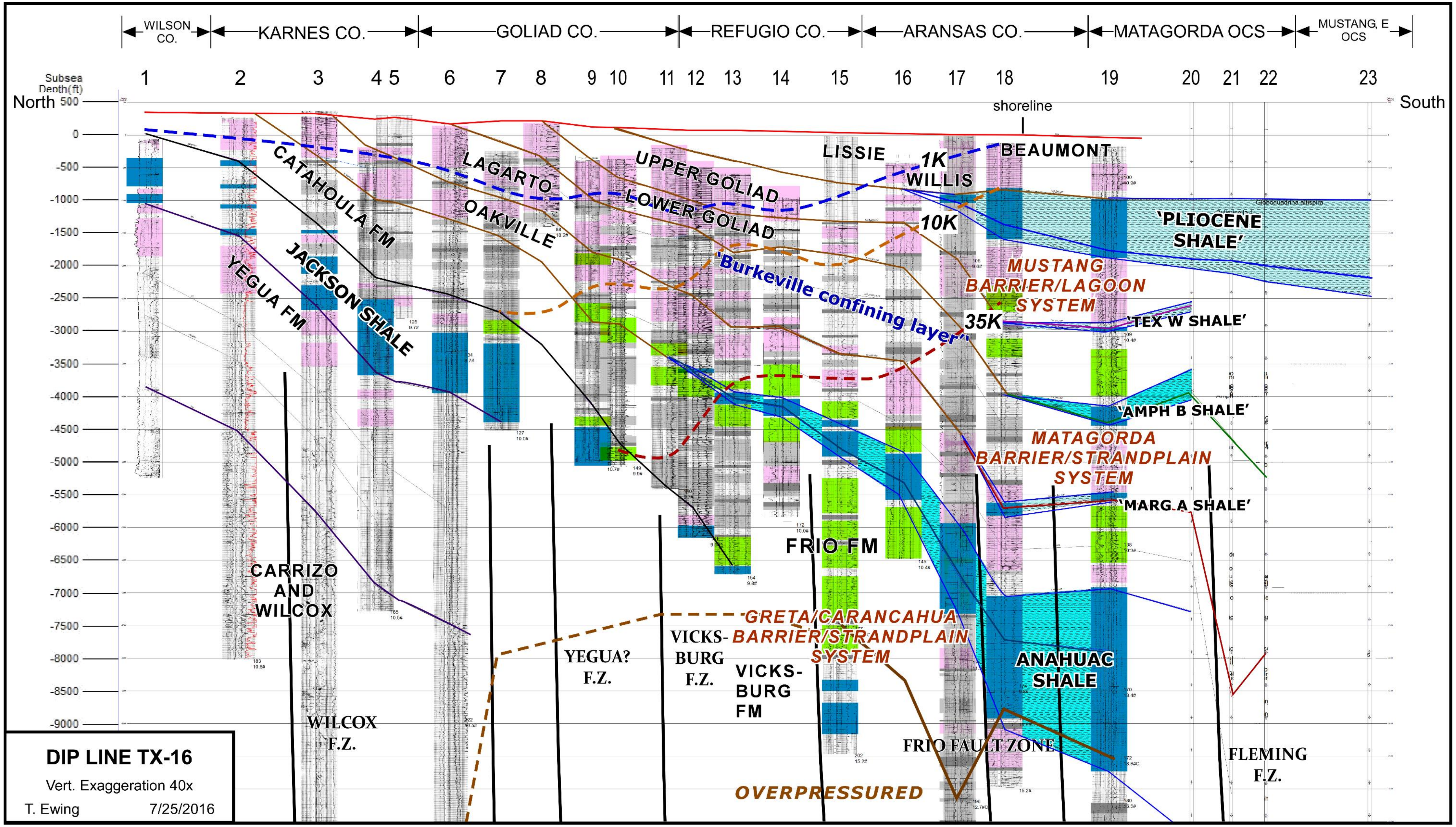


Figure 11-12. Analysis of sand and clay sequences, fault zones, along cross-section #13 in Figure 6-1.



Aggradational sandstones (shoreline)	Marine shales in wells	Marine shale wedges
Channel sandstone (over 50')	Mudstone layers (low-resistivity, purer)	
Sandstone packages (with sands >20')	Mudstone units (few or no sand bodies)	

Figure 11-13. Analysis of sand and clay sequences, fault zones, along cross-section #16 in Figure 6-1.

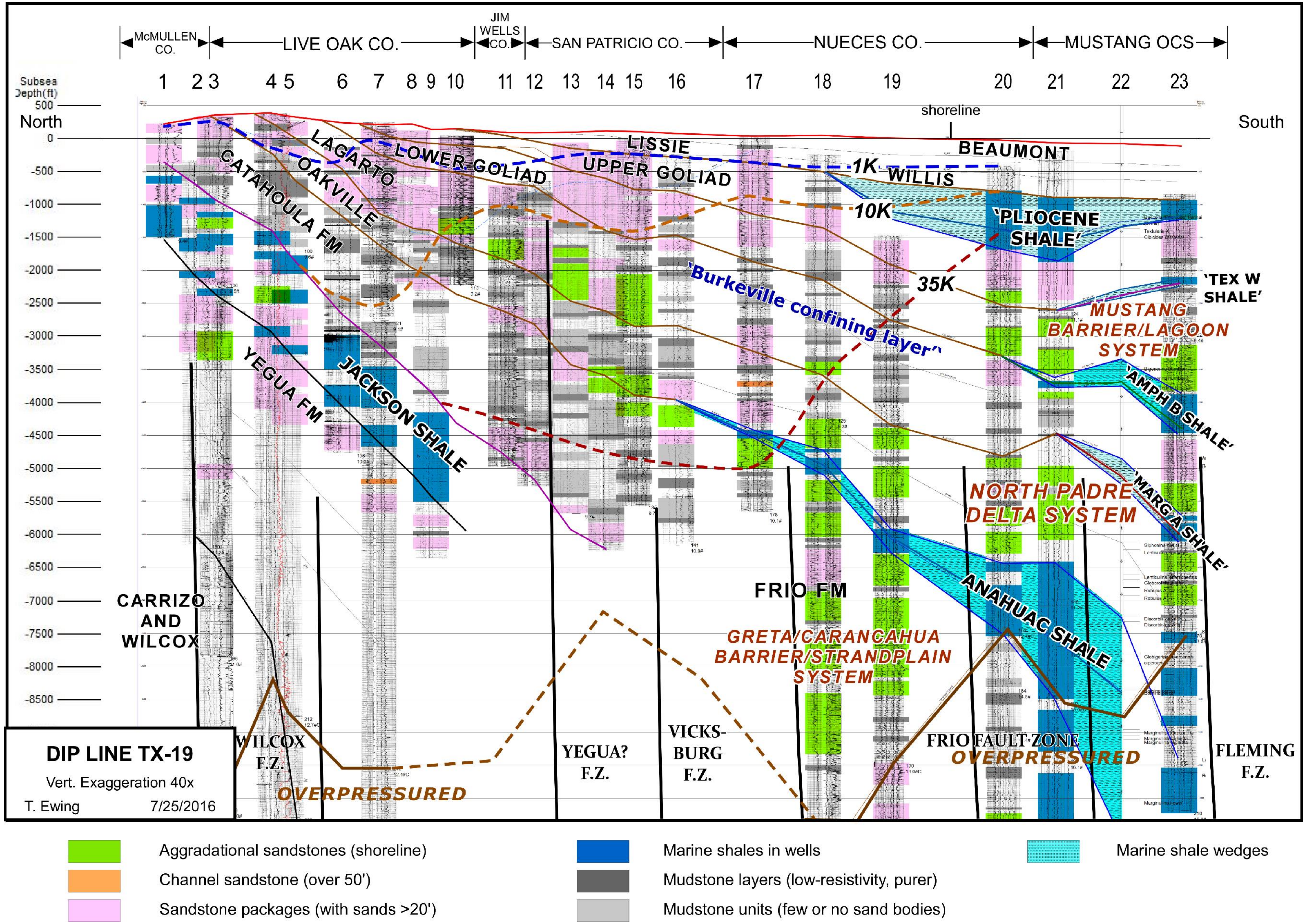


Figure 11-14. Analysis of sand and clay sequences, fault zones, along cross-section #19 in Figure 6-1.

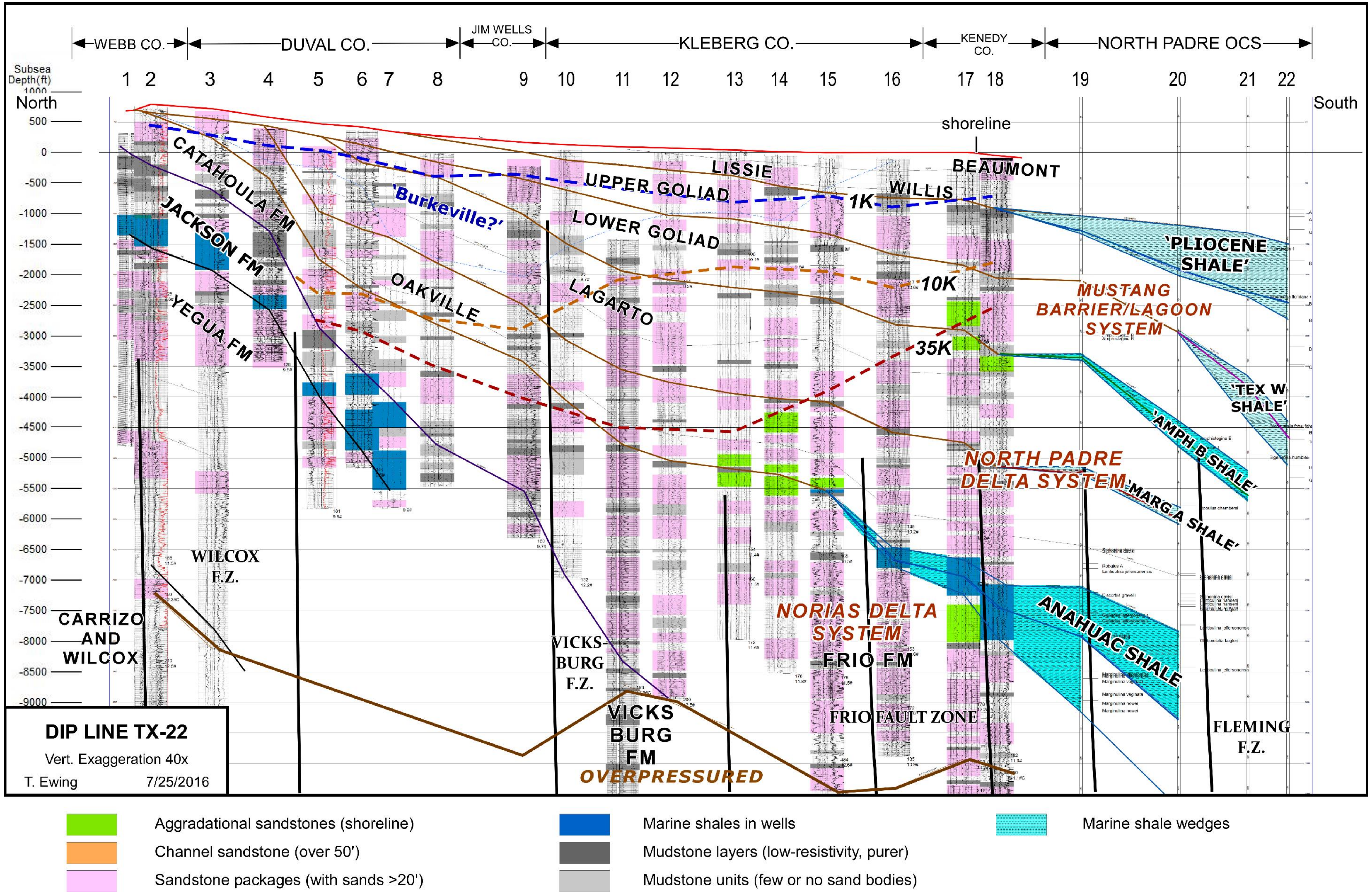


Figure 11-15. Analysis of sand and clay sequences, fault zones, along cross-section #22 in Figure 6-1.

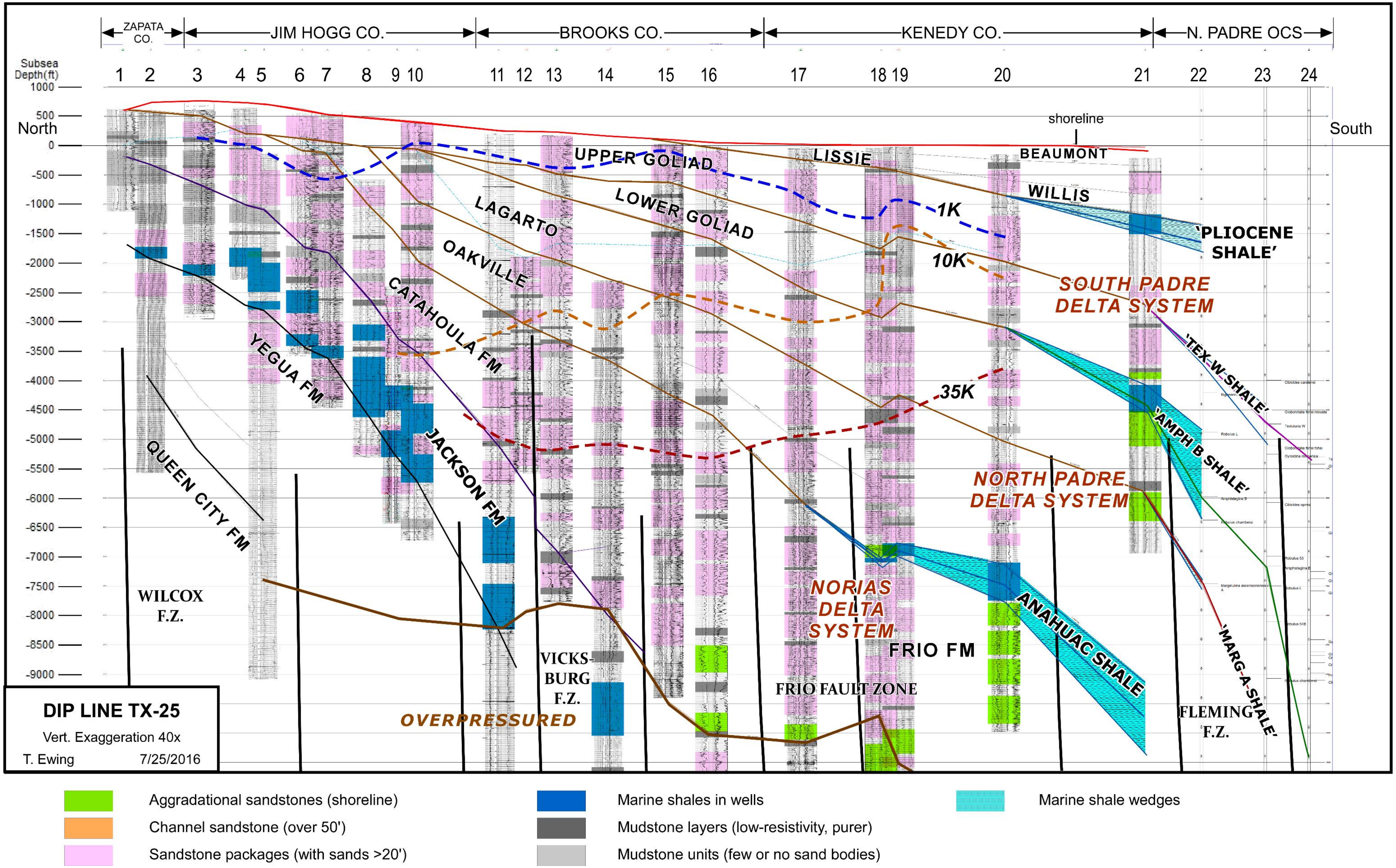


Figure 11-16. **Analysis of sand and clay sequences, fault zones, along cross-section #25 in Figure 6-1.**

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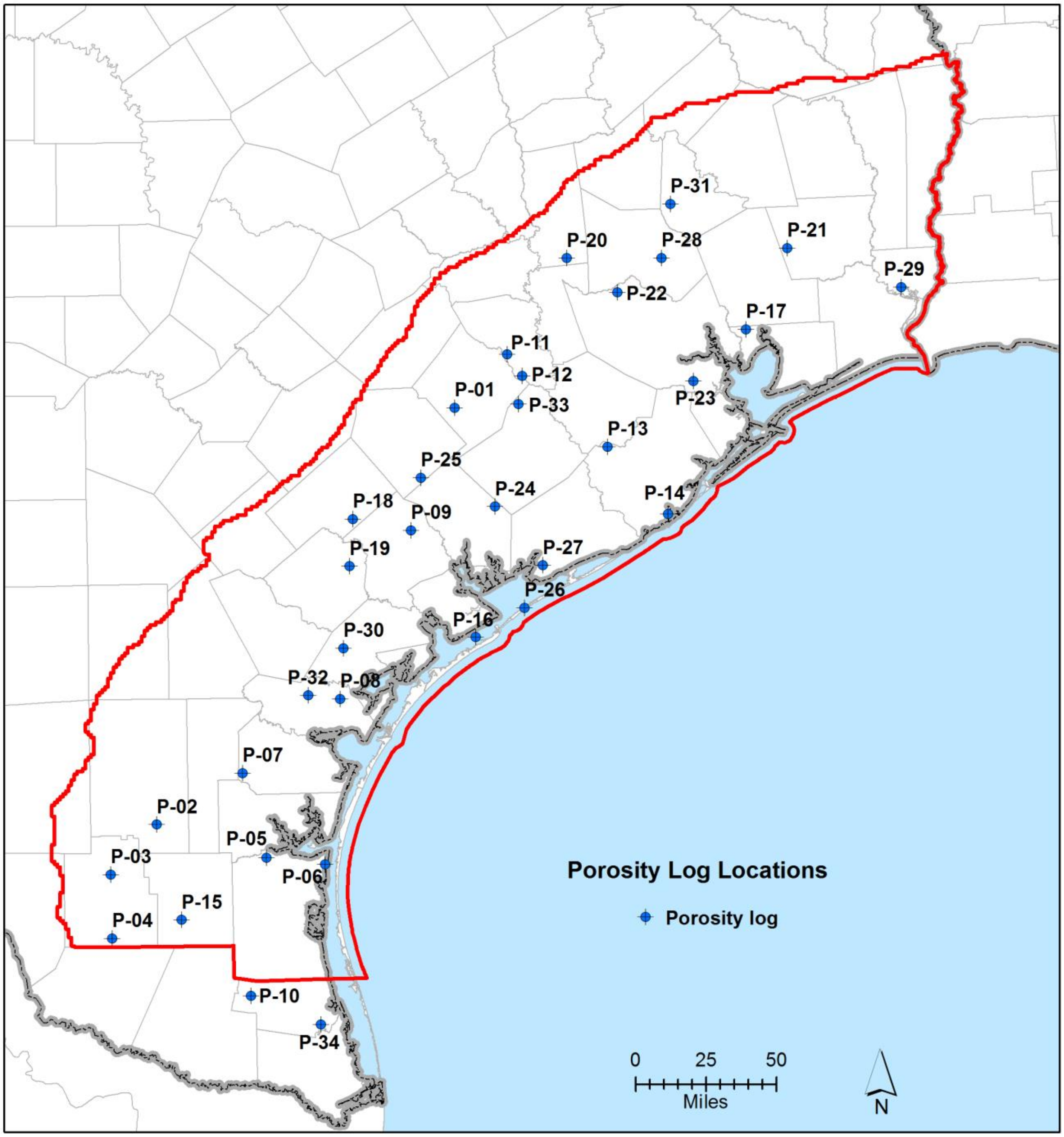

Figure 11-17. Locations of thirty-four logs that were analyzed to determine porosity values.

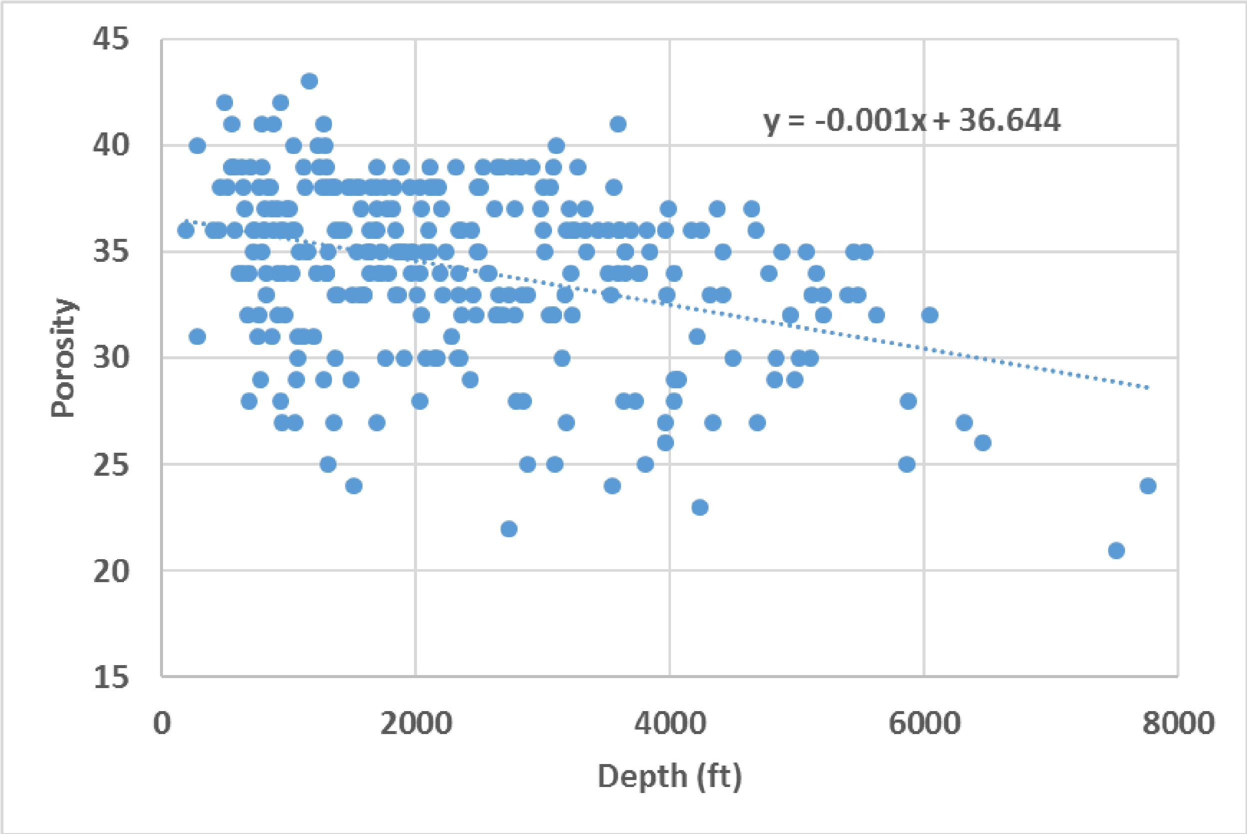

Figure 11-18. Measured porosity versus depth.

Note: ft=feet

12 Groundwater Volume Methodology

In this section, estimates of groundwater volumes are generated for different classifications of groundwater quality for the Gulf Coast Aquifer based on the salinity zones presented in Section 6. The salinity zones have been developed based on observed water quality data and analysis of geophysical logs.

12.1 Approach

Wade and others (2014), Wade and Anaya (2014), and Jigmond and Wade (2013) provide a good overview of an approach for calculating the volume of groundwater in storage as part of their calculation of Total Estimated Recoverable Storage for different aquifers in Groundwater Management Areas 14, 15, and 16, respectively. As part of this study, we performed the same type of calculation to partition the groundwater into the different water quality classifications developed by the United States Geological Survey (Winslow and Kister, 1956) (Table 12-1).

Table 12-1. Groundwater classification based on the criteria established by Winslow and Kister (1956).

Water Classification Description	Total Dissolved Solids (TDS) Range
Fresh	Less than 1,000 mg/L
Slightly Saline	1,000 to 3,000 mg/L
Moderately Saline	3,000 to 10,000 mg/L
Very Saline	10,000 to 35,000 mg/L
Brine	Greater than 35,000 mg/L

Note: TDS=total dissolved solids; mg/L=milligrams per liter

The method used by Wade and others (2014), Wade and Anaya (2014), and Jigmond and Wade (2013) to calculate groundwater volume is dependent on whether or not the aquifer is confined or unconfined. In the Gulf Coast Aquifer system, portions of the aquifers are confined and portions are unconfined. Before describing the mathematical equations used to calculate the groundwater volumes, a general discussion of confined and unconfined aquifers is presented to introduce the terminology used to describe the volume calculations. Because our mathematical calculations are similar to those used to calculate Total Estimated Recoverable Storage, much of the text in Section 12.1.1 mimics the discussions from Wade and others (2014), Wade and Anaya (2014), and Jigmond and Wade (2013).

12.1.1 Confined and Unconfined Aquifer

Figure 12-1 provides a schematic of a confined and unconfined aquifer. Like most dipping aquifers in the eastern part of Texas, the Gulf Coast Aquifer includes both unconfined and confined regions. Figure 12-2 shows a schematic of a dipping aquifer that is unconfined up dip and confined down dip.

For an unconfined aquifer, the total storage is equal to the volume of groundwater removed by pumping that makes the water level fall to the aquifer bottom. For a confined aquifer, the total storage contains two parts. The first part is groundwater released from the aquifer when the water level falls from above the top of the aquifer to the top of the aquifer. The reduction of hydraulic pressure in the aquifer by pumping causes expansion of groundwater and deformation of aquifer solids. The aquifer is still fully saturated to this point. The second part, similar to unconfined aquifers, is the groundwater released from the aquifer when the water level falls from the top to the bottom of the aquifer. Given the same aquifer area and water level decline, the amount of water released in the second part is much greater than the first part. The difference is quantified by two parameters: storativity related to the confined aquifer and specific yield related to the unconfined aquifer. For example, storativity values range from 10^{-5} to 10^{-3} for most confined aquifers, while specific yield values typically range from 0.01 to 0.3 for most unconfined aquifers. The equations for calculating the total groundwater volume are presented below:

For unconfined aquifers:

$$\text{Total Volume} = V_{drainable} = \text{Area} * S_y * (\text{Water Level} - \text{Bottom}) \quad \text{(Equation 12-1a)}$$

$$\text{Total Volume} = V_{in\ place} = \text{Area} * \theta * (\text{Water Level} - \text{Bottom}) \quad \text{(Equation 12-1b)}$$

For confined aquifers:

$$\text{Total Volume} = V_{confined} + V_{drainable} \quad \text{(Equation 12-1c)}$$

- Volume for confined part

$$V_{confined} = \text{Area} * [S * (\text{Water Level} - \text{Top})] \quad \text{(Equation 12-2)}$$

or

$$V_{confined} = \text{Area} * [S_s * (\text{Top} - \text{Bottom}) * (\text{Water level} - \text{Top})] \quad \text{(Equation 12-3)}$$

- Volume for unconfined part

$$V_{drainable} = \text{Area} * [S_y * (\text{Top} - \text{Bottom})] \quad \text{(Equation 12-4a)}$$

$$V_{in\ place} = \text{Area} * [\theta * (\text{Top} - \text{Bottom})] \quad \text{(Equation 12-4b)}$$

where

$V_{drainable}$	=	storage volume due to water draining from the formation (acre-feet)
$V_{confined}$	=	storage volume due to elastic properties of the aquifer and water (acre-feet)
$V_{in\ place}$	=	storage volume due to void spaces in the aquifer occupied by water (acre-feet)
Area	=	area of aquifer (acre)
Water Level	=	groundwater elevation (feet above mean sea level)
Top	=	elevation of aquifer top (feet above mean sea level)
Bottom	=	elevation of aquifer bottom (feet above mean sea level)
Sy	=	specific yield (unitless)
Ss	=	specific storage (1/feet)
S	=	storativity or storage coefficient (unitless)
θ	=	porosity (unitless)

In the above equations, two options are provided to calculate the volume in the unconfined aquifer. Equations 12-1a and 12-4a use specific yield whereas Equations 12-1b and 12-4b use total porosity. Wade and others (2014), Wade and Anaya (2014), and Jigmond and Wade (2013) use Equations 12-1a and 12-4a to calculate Total Estimated Recoverable Storage. The use of specific yield in Equations 12-1a and 12-4a implies that the unconfined aquifer has not fully drained because specific yield is less than the porosity of an unconfined aquifer. The selection of specific yield or porosity is dependent on the purpose of the calculation. If one is interested more in the volume of drainable groundwater than the actual volume of groundwater in place, then the use of specific yield rather than total porosity would be appropriate. If the reverse is desired, and one would therefore be more interested in the total groundwater in place rather than the drainable groundwater, than porosity would be appropriate to use in Equation 12-4.

12.1.2 Hydraulic and Physical Properties for the Gulf Coast Aquifer

The equations for calculating groundwater volumes described above require specification of aquifer properties such as aquifer structure, thickness, water level, and specific yield. These are described below.

Structure and Thickness – Table 12-2 lists the model layers and formations that represent the hydrogeologic units of the Gulf Coast Aquifer obtained from the hydrogeologic framework developed in Young and others (2010, 2012). The top elevation, bottom elevation, and model layer thickness for each model layer was obtained from Young and others (2010, 2012). Each model grid cell is one mile by one mile.

Gulf Coast Aquifer Water Level – The water levels used to calculate the aquifer volumes are based upon the end of the last year of calibration in the groundwater models:

- Corresponding to the end of 2009 for the Houston Area Groundwater Model (Kasmarek, 2013), which applies to the portion of the Gulf Coast Aquifer in Groundwater Management Area 14;
- Corresponding to the end of 1999 for the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004), which applies to the portion of the Gulf Coast Aquifer in Groundwater Management Area 15; and
- Corresponding to the end of 1999 for the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011), which applies to the portion of the Gulf Coast Aquifer in Groundwater Management Area 16.

Specific Yield – Specific yield values were obtained from the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004) because it simulates an unconfined aquifer unlike the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011). The Central Gulf Coast Groundwater Availability Model does not extend below the Jasper and so the specific yield for the Catahoula was set equal to that of the Jasper. The specific yield values vary between 0.005 for the Burkeville confining unit and 0.05 for the Chicot Aquifer as listed in Table 12-2.

Table 12-2. Model layers that comprise the Gulf Coast Aquifer in the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004)

Model Layer	Aquifer or Formation	Hydrogeologic Unit (Baker, 1979)	Specific Yield
1	Beaumont	Chicot aquifer	0.05
2	Lissie		0.05
3	Willis		0.05
4	Upper Goliad	Evangeline aquifer	0.01
5	Lower Goliad		0.01
6	Upper Lagarto		0.01
7	Middle Lagarto	Burkeville confining unit	0.005
8	Lower Lagarto	Jasper aquifer	0.05
9	Oakville		0.05
10	Catahoula	Catahoula	0.05

12.1.3 Process for Calculating Groundwater Volumes Based on Water Quality

The groundwater volume calculations for Total Estimated Recoverable Storage (Wade and others, 2014; Wade and Anaya, 2014; and Jigmond and Wade, 2013) are implemented for each grid cell in the hydrogeologic model of the Gulf Coast Aquifer (Young and others, 2010; 2012) and then summed together. This process was also used for this study with a few modifications. The key modification was to transfer information from the geophysical logs to the grid cell locations prior to calculating the groundwater volumes. The process of transferring the data from the geophysical logs to the grid cells was effected using the following four-step process.

<u>Step 1. Assign sand layers to aquifer units.</u> Intersect the surfaces for the 10 model layers onto every geophysical log within the model domain of the Houston Area Groundwater Model (Kasmarek, 2013), the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004), and the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011). Assign the sand layers and the associated groundwater to an aquifer unit. Geophysical logs were obtained from the Railroad Commission of Texas and TWDB groundwater database.

<u>Step 2. Generate sand percentages for each grid cell.</u> Use kriging to interpolate the point measurements of sand thickness to create a continuous map of sand percentages for each sand unit and assign a sand percent to each grid cell containing the sand units. Where the geophysical logs do not provide adequate coverage to estimate sand percentages in the shallow regions of the aquifer unit, use the lithology profiles from the driller logs shown in Figure 12-3 to complete the data gap.

<u>Step 3. Determine groundwater water classification categories for each grid cell.</u> Create maps for each model layer that distribute the groundwater associated with the sands into fresh, slightly saline, moderately saline, very saline, and brine water for every grid cell based on interpolating data generated from the geophysical well analyses. The geophysical well log analysis converts

the measured resistivity to a total dissolved solids value and assigns a groundwater water classification based on the categories of by Winslow and Kister (1956) as listed in Table 12-1.

Step 4. Add up the groundwater volumes in each grid cell. Assume that the clay layers in a grid cell have the same groundwater classification categories as does the sand. Add up the groundwater volumes in each grid cell. For the unconfined aquifers, use either the specific yield assigned to the grid cell by the Central Gulf Coast Groundwater Availability Model and reported in Table 12-2, or use a porosity value calculated from the porosity versus depth relationship in Equation 11-1, which was developed from porosity measurements generated as part of this study. The porosity measurements were estimated for sand beds identified on neutron and density logs.

12.2 Calculated Groundwater Volumes

Table 12-3 provides the total calculated volume of groundwater in the Gulf Coast Aquifer based on using specific yield for Groundwater Management Areas 14 and 15. Because not all of Groundwater Management Area 16 is included in the study area, no total is given for it. Table 12-4 provides the total calculated volume of groundwater in the Gulf Coast Aquifer based on using porosity for Groundwater Management Areas 14 and 15. The use of porosity in Equation 12-4b leads to a total volume of 75.3 billion acre-feet, which is approximately three times greater than the total volume of 25.0 billion acre-feet that is calculated using specific yield. Table 12-3 also provides the distribution of the groundwater volumes by aquifer unit and by groundwater quality classification. Based on calculations of groundwater volume using specific yield, the total volume of fresh, brackish (including both the slightly saline and moderately saline water), very saline, and brine groundwater is 8.41 billion acre-feet per year (34 percent), 8.81 billion acre-feet per year (35 percent), 5.84 billion acre-feet (23 percent), and 1.97 billion acre-feet (8 percent), respectively. Based on calculations of groundwater volume using porosity, the total volume of fresh, brackish (includes both the slightly saline and moderately saline water), very saline, and brine groundwater is 14.18 billion acre-feet (19 percent), 27.34 billion acre-feet (36 percent), 24.4 billion acre-feet (34 percent), and 8.33 billion acre-feet (11 percent), respectively. The geologic formation with the most groundwater is the Oakville Formation and the hydrogeologic or aquifer unit with the most groundwater is the Jasper Aquifer with 53 percent of the groundwater in the Gulf Coast Aquifer. However, only about 18 percent of groundwater in the Jasper Aquifer is fresh, while the majority of the groundwater is brackish (39 percent) or very saline (32 percent).

Tables 12-5 and Table 12-6 provide the volumes of fresh, slightly saline, moderately saline, very saline, and brine water for the counties within the Gulf Coast Aquifer for volumes calculated by specific yield and porosity, respectively.

Tables 12-7 and Table 12-8 provide the volumes of fresh, slightly saline, moderately saline, very saline, and brine water for groundwater conservation districts in the Gulf Coast Aquifer for volumes calculated by specific yield and porosity, respectively.

Table 12-3. The volume of fresh, slightly saline, moderately saline, very saline, brine, and total groundwater in the Gulf Coast Aquifer calculated using specific yield for Groundwater Management Areas 14 and 15 by formation.

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
GMA 14												
Beaumont	0.0	15.7	9.0	35.6	1.7	61.9	0.0	10.1	5.0	22.4	0.8	38.2
Lissie	1.0	79.8	17.3	41.2	9.9	149.3	0.6	56.1	10.4	26.6	5.2	98.9
Willis	4.6	112.8	15.6	76.2	31.1	240.3	2.5	71.0	9.3	47.7	17.8	148.2
Upper Goliad	9.8	4.0	2.4	3.6	15.2	35.1	4.8	2.4	1.2	2.0	7.7	18.1
Lower Goliad	10.8	18.7	4.8	8.6	14.8	57.8	4.5	7.7	2.0	4.0	6.1	24.3
Upper Lagarto	9.6	21.8	4.4	9.2	14.3	59.3	4.6	10.4	1.8	4.0	6.7	27.5
Middle Lagarto	13.0	6.0	6.2	8.6	22.8	56.7	6.4	3.0	2.3	3.6	9.2	24.5
Lower Lagarto	74.0	39.9	43.2	90.3	124.7	371.9	32.2	21.1	16.3	41.4	49.8	160.8
Oakville	93.6	70.6	45.0	85.9	189.7	484.8	40.7	38.6	19.4	42.9	81.8	223.6
Catahoula	18.2	48.2	148.7	153.5	195.7	564.4	5.5	19.4	54.5	60.5	64.5	204.3
Total	234.5	417.6	296.5	512.9	620.0	2081.5	101.7	239.7	122.2	255.2	249.5	968.3
GMA 15												
Beaumont	0.0	16.0	2.2	16.3	0.3	34.7	0.0	10.2	1.5	11.0	0.2	22.9
Lissie	0.0	27.8	4.7	24.1	1.2	57.9	0.0	18.0	2.5	13.0	0.7	34.2
Willis	0.6	32.8	11.2	22.5	9.8	76.9	0.4	22.7	5.7	11.5	5.1	45.4
Upper Goliad	3.5	12.3	4.4	7.4	15.2	42.7	1.4	6.6	2.1	3.7	6.6	20.4
Lower Goliad	2.8	6.6	4.8	6.8	14.1	35.0	1.2	3.2	2.0	3.1	5.9	15.4
Upper Lagarto	2.6	4.5	10.9	11.4	15.0	44.4	1.2	1.9	3.4	4.3	5.1	15.8
Middle Lagarto	3.8	1.4	12.0	8.0	17.7	42.8	1.8	0.5	3.4	2.5	6.4	14.6
Lower Lagarto	25.9	12.6	53.5	59.0	92.0	243.1	11.7	4.1	14.0	19.2	29.6	78.6
Oakville	65.6	9.5	45.1	40.6	225.9	386.7	29.1	4.2	16.7	17.5	95.6	163.1
Catahoula	7.4	1.0	119.4	47.7	145.3	320.9	2.2	0.4	32.0	15.0	32.0	81.6
Total	112.2	124.4	268.3	243.8	536.3	1284.9	49.1	71.8	83.2	100.8	187.2	492.1

Note: GMA = Groundwater Management Area

Table 12-4. The volume of fresh, slightly saline, moderately saline, very saline, brine, and total groundwater in the Gulf Coast Aquifer calculated using porosity for Groundwater Management Areas 14 and 15 by formation.

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
GMA 14												
Beaumont	0.0	114.3	65.2	258.8	12.1	450.5	0.0	73.3	36.2	163.0	5.5	278.0
Lissie	7.2	574.1	123.9	295.2	70.7	1071.1	4.2	403.4	74.2	190.4	37.1	709.3
Willis	32.2	514.3	104.6	270.7	213.9	1135.7	17.1	332.3	62.5	172.5	122.5	707.0
Upper Goliad	329.6	129.6	80.3	123.3	511.9	1174.8	161.6	81.5	42.4	69.2	258.5	613.2
Lower Goliad	347.4	371.2	130.3	259.4	469.7	1577.9	144.8	178.8	57.2	126.8	195.3	702.9
Upper Lagarto	296.4	251.6	129.4	261.1	384.5	1323.0	141.0	121.5	54.1	112.7	178.0	607.4
Middle Lagarto	265.9	255.2	236.2	398.2	449.5	1605.0	132.5	132.5	93.4	173.8	186.1	718.3
Lower Lagarto	425.6	255.0	275.2	548.5	690.7	2195.0	188.8	132.7	104.4	242.0	284.6	952.5
Oakville	513.2	186.5	280.7	385.7	955.3	2321.4	223.8	98.9	119.4	182.1	408.9	1033.2
Catahoula	116.3	200.3	846.1	766.4	1203.5	3132.7	35.3	81.5	302.3	292.5	392.3	1103.8
Total	2333.9	2852.1	2271.9	3567.3	4961.9	15987.1	1049.2	1636.4	946.2	1724.9	2068.8	7425.7
GMA 15												
Beaumont	0.0	116.3	15.9	118.7	1.9	252.9	0.0	74.3	11.1	79.9	1.4	166.8
Lissie	0.2	186.6	27.9	150.5	7.2	372.3	0.1	122.1	14.6	82.0	4.3	223.2
Willis	2.9	197.4	52.9	124.3	50.3	427.7	1.9	135.1	27.0	63.5	27.0	254.5
Upper Goliad	99.5	425.3	139.0	249.6	458.9	1372.4	41.4	230.7	65.9	124.6	200.8	663.5
Lower Goliad	65.5	191.2	134.0	202.3	368.0	961.1	28.9	95.9	54.3	94.7	152.9	426.7
Upper Lagarto	56.5	109.7	264.1	269.1	367.6	1067.0	25.2	46.6	79.6	103.8	123.6	378.7
Middle Lagarto	57.4	78.2	262.6	273.0	370.9	1042.1	26.4	28.4	78.1	90.7	127.0	350.6
Lower Lagarto	137.8	82.9	288.9	353.8	435.1	1298.5	63.7	27.9	76.9	116.3	138.4	423.2
Oakville	293.9	57.4	253.0	262.6	1041.7	1908.6	130.8	25.6	92.3	112.6	443.8	805.1
Catahoula	30.7	6.2	629.4	260.9	657.0	1584.2	9.5	2.3	178.3	84.5	155.5	430.2
Total	744.5	1451.2	2067.6	2264.8	3758.6	10286.7	328.1	789.0	678.2	952.5	1374.7	4122.5

Note: GMA = Groundwater Management Area

Table 12-5. The volume of fresh, slightly saline, moderately saline, very saline, brine, and total groundwater in the Gulf Coast Aquifer calculated using specific yield by county and formation.

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Aransas												
Beaumont	0.0	0.2	0.1	2.1	0.2	2.6	0.0	0.1	0.1	1.5	0.2	1.9
Lissie	0.0	0.2	0.3	2.7	0.8	4.1	0.0	0.1	0.1	1.0	0.4	1.7
Willis	0.1	0.5	1.9	2.6	1.5	6.6	0.0	0.2	0.6	0.9	0.5	2.2
Upper Goliad	0.2	0.1	0.4	0.4	2.3	3.4	0.1	0.1	0.2	0.2	1.0	1.4
Lower Goliad	0.1	0.0	0.3	0.0	2.0	2.4	0.0	0.0	0.1	0.0	0.7	0.9
Upper Lagarto	0.1	0.0	0.5	0.0	1.7	2.4	0.0	0.0	0.1	0.0	0.4	0.6
Middle Lagarto	0.0	0.0	0.1	0.0	0.8	0.9	0.0	0.0	0.0	0.0	0.2	0.2
Lower Lagarto	1.0	0.0	1.0	0.0	7.4	9.4	0.3	0.0	0.2	0.0	2.2	2.8
Oakville	3.3	0.0	0.8	0.0	13.1	17.1	1.2	0.0	0.2	0.0	4.8	6.1
Total	4.8	1.1	5.5	7.8	29.7	48.9	1.7	0.5	1.7	3.6	10.4	17.8
Austin												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lissie	0.0	0.4	0.0	0.1	0.0	0.5	0.0	0.4	0.0	0.1	0.0	0.4
Willis	0.0	2.5	0.0	0.7	0.0	3.2	0.0	1.9	0.0	0.6	0.0	2.4
Upper Goliad	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.2
Lower Goliad	0.0	0.2	0.0	0.2	0.0	0.5	0.0	0.1	0.0	0.1	0.0	0.2
Upper Lagarto	0.0	0.7	0.0	0.8	0.0	1.5	0.0	0.3	0.0	0.3	0.0	0.7
Middle Lagarto	0.0	0.2	0.1	0.5	0.0	0.9	0.0	0.1	0.0	0.2	0.0	0.3
Lower Lagarto	0.0	2.4	0.9	7.0	0.0	10.3	0.0	0.9	0.3	2.6	0.0	3.8
Oakville	0.0	1.0	2.2	6.5	0.3	10.0	0.0	0.4	0.8	2.5	0.1	3.8
Catahoula	0.0	0.4	8.9	16.6	6.9	32.8	0.0	0.2	3.1	6.1	2.3	11.7
Total	0.0	8.0	12.2	32.4	7.3	59.9	0.0	4.4	4.4	12.4	2.5	23.6
Bee												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lissie	0.0	0.3	0.0	0.4	0.0	0.7	0.0	0.2	0.0	0.3	0.0	0.6
Willis	0.0	0.4	0.0	0.4	0.0	0.8	0.0	0.2	0.0	0.2	0.0	0.4
Upper Goliad	0.0	0.8	0.1	1.2	0.1	2.2	0.0	0.4	0.1	0.6	0.0	1.2
Lower Goliad	0.0	0.5	0.4	0.7	0.1	1.7	0.0	0.3	0.2	0.4	0.1	0.9

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Lagarto	0.0	0.2	0.8	0.9	0.6	2.5	0.0	0.1	0.3	0.3	0.2	0.9
Middle Lagarto	0.0	0.1	0.2	0.4	0.4	1.1	0.0	0.0	0.1	0.2	0.2	0.5
Lower Lagarto	0.0	0.2	2.6	6.8	6.6	16.2	0.0	0.1	1.1	3.0	2.1	6.3
Oakville	0.4	0.1	8.0	2.8	15.9	27.3	0.1	0.0	2.4	0.9	5.3	8.9
Catahoula	0.0	0.0	32.2	0.5	21.1	53.8	0.0	0.0	7.2	0.1	3.6	10.9
Total	0.4	2.6	44.4	14.1	44.9	106.3	0.1	1.4	11.4	6.0	11.6	30.5
Brazoria												
Beaumont	0.0	9.5	0.2	13.2	0.0	22.9	0.0	6.1	0.1	8.4	0.0	14.6
Lissie	0.0	8.5	2.5	10.8	0.5	22.3	0.0	5.5	1.5	6.6	0.3	14.0
Willis	1.5	6.0	3.6	3.2	5.4	19.7	0.8	4.2	2.2	2.1	3.3	12.7
Upper Goliad	2.8	0.7	0.5	1.0	5.3	10.3	1.4	0.4	0.3	0.6	2.8	5.6
Lower Goliad	3.3	0.2	0.3	0.5	4.8	9.2	1.3	0.1	0.1	0.3	1.8	3.6
Upper Lagarto	3.4	0.2	0.2	0.4	4.0	8.2	1.6	0.1	0.1	0.2	1.7	3.6
Middle Lagarto	7.6	0.1	0.9	0.3	15.1	23.9	3.5	0.0	0.2	0.1	5.8	9.7
Lower Lagarto	18.6	1.0	4.2	5.1	48.1	77.1	6.4	0.4	1.1	1.8	14.4	24.0
Oakville	23.7	0.8	1.2	2.2	78.0	105.9	9.6	0.3	0.4	0.8	31.6	42.6
Total	60.9	27.1	13.5	36.9	161.1	299.5	24.6	17.1	6.0	20.9	61.7	130.3
Brazos												
Lower Lagarto	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oakville	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1
Catahoula	0.0	0.7	0.7	2.1	0.0	3.5	0.0	0.3	0.3	0.9	0.0	1.5
Total	0.0	0.8	0.7	2.2	0.0	3.7	0.0	0.3	0.3	1.0	0.0	1.7
Brooks												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Lissie	0.0	0.0	0.1	0.1	0.2	0.4	0.0	0.0	0.1	0.0	0.1	0.2
Willis	0.0	0.1	0.0	0.2	0.0	0.4	0.0	0.1	0.0	0.1	0.0	0.2
Upper Goliad	0.0	1.8	0.2	1.4	0.1	3.5	0.0	1.0	0.1	0.7	0.1	1.8
Lower Goliad	0.0	0.6	0.8	1.8	0.2	3.5	0.0	0.2	0.3	0.6	0.1	1.1
Upper Lagarto	0.0	0.5	1.7	2.8	0.2	5.1	0.0	0.1	0.6	1.0	0.1	1.8
Middle Lagarto	0.0	0.2	0.6	0.9	0.1	1.9	0.0	0.1	0.3	0.4	0.1	0.8
Lower Lagarto	0.0	0.5	5.9	15.0	4.1	25.6	0.0	0.2	3.0	7.5	2.1	12.9

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Oakville	0.0	0.3	17.2	7.1	6.0	30.6	0.0	0.1	6.6	2.8	2.4	11.9
Catahoula	0.0	0.0	46.1	17.3	9.7	73.1	0.0	0.0	15.3	5.6	3.6	24.6
Total	0.0	4.2	72.8	46.6	20.6	144.2	0.0	1.9	26.2	18.8	8.5	55.3
Calhoun												
Beaumont	0.0	0.7	0.8	2.9	0.0	4.4	0.0	0.5	0.5	2.0	0.0	3.0
Lissie	0.0	1.8	1.4	5.2	0.1	8.6	0.0	1.0	0.7	2.5	0.1	4.2
Willis	0.0	0.8	4.0	3.4	3.4	11.6	0.0	0.3	1.6	1.3	1.4	4.6
Upper Goliad	0.9	0.3	0.3	0.7	4.0	6.2	0.4	0.1	0.1	0.3	1.7	2.6
Lower Goliad	0.6	0.0	0.8	0.2	3.5	5.2	0.3	0.0	0.3	0.1	1.4	2.1
Upper Lagarto	0.2	0.0	1.6	0.0	3.6	5.4	0.1	0.0	0.5	0.0	1.1	1.6
Middle Lagarto	0.1	0.0	0.3	0.0	1.4	1.9	0.0	0.0	0.1	0.0	0.3	0.4
Lower Lagarto	5.8	0.0	2.5	0.1	9.0	17.3	1.8	0.0	0.5	0.0	2.5	4.9
Oakville	11.1	0.0	0.4	0.0	19.9	31.5	5.3	0.0	0.2	0.0	9.1	14.6
Total	18.8	3.6	12.1	12.5	45.0	92.1	7.9	1.9	4.5	6.2	17.5	38.0
Chambers												
Beaumont	0.0	0.6	2.7	5.6	0.0	9.0	0.0	0.4	1.8	3.9	0.0	6.1
Lissie	0.0	1.8	5.8	5.1	0.9	13.7	0.0	1.2	3.3	3.0	0.5	8.0
Willis	0.1	0.5	2.8	2.0	4.6	9.9	0.0	0.3	1.8	1.4	2.8	6.3
Upper Goliad	1.6	0.0	0.4	0.1	2.1	4.2	0.9	0.0	0.2	0.1	1.2	2.3
Lower Goliad	1.7	0.0	0.2	0.1	1.5	3.4	0.7	0.0	0.1	0.0	0.7	1.5
Upper Lagarto	2.1	0.0	0.1	0.1	1.2	3.4	0.9	0.0	0.0	0.0	0.5	1.5
Middle Lagarto	1.5	0.0	0.1	0.0	1.1	2.7	0.7	0.0	0.0	0.0	0.5	1.2
Lower Lagarto	13.3	0.0	0.9	0.2	8.1	22.5	5.5	0.0	0.3	0.1	3.2	9.1
Oakville	16.3	0.0	0.1	0.1	7.4	23.8	7.1	0.0	0.1	0.0	3.5	10.6
Total	36.5	3.0	13.0	13.3	26.9	92.7	15.9	1.9	7.5	8.5	12.8	46.6
Colorado												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lissie	0.0	0.8	0.0	0.1	0.0	0.9	0.0	0.8	0.0	0.1	0.0	0.8
Willis	0.0	4.0	0.0	1.0	0.0	5.0	0.0	3.2	0.0	0.8	0.0	3.9
Upper Goliad	0.0	0.4	0.0	0.1	0.0	0.5	0.0	0.3	0.0	0.0	0.0	0.3
Lower Goliad	0.0	0.9	0.0	0.4	0.0	1.3	0.0	0.5	0.0	0.2	0.0	0.7

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Lagarto	0.0	0.8	0.1	1.4	0.0	2.3	0.0	0.4	0.1	0.7	0.0	1.1
Middle Lagarto	0.0	0.3	0.3	0.6	0.0	1.3	0.0	0.1	0.1	0.2	0.0	0.5
Lower Lagarto	0.0	2.6	4.5	8.8	0.1	15.9	0.0	0.8	1.3	2.6	0.0	4.7
Oakville	0.0	0.5	4.6	10.1	0.8	16.0	0.0	0.2	1.7	3.8	0.4	6.1
Catahoula	0.0	0.0	13.1	8.3	11.0	32.4	0.0	0.0	3.5	2.5	2.7	8.7
Total	0.0	10.4	22.6	30.7	11.9	75.6	0.0	6.2	6.8	10.8	3.2	26.9
DeWitt												
Lissie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Willis	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.1
Upper Goliad	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1
Lower Goliad	0.0	0.3	0.0	0.1	0.0	0.4	0.0	0.2	0.0	0.1	0.0	0.3
Upper Lagarto	0.0	0.8	0.2	0.7	0.0	1.7	0.0	0.3	0.1	0.3	0.0	0.7
Middle Lagarto	0.0	0.2	0.1	0.6	0.0	0.8	0.0	0.1	0.0	0.2	0.0	0.3
Lower Lagarto	0.0	4.2	1.2	4.6	0.1	10.1	0.0	1.6	0.4	1.6	0.0	3.6
Oakville	0.0	3.4	3.6	5.9	2.5	15.5	0.0	1.5	1.4	2.7	0.8	6.4
Catahoula	1.7	0.0	16.1	9.5	11.9	39.3	0.8	0.0	5.6	3.6	3.9	13.8
Total	1.7	9.2	21.2	21.4	14.5	68.1	0.8	3.9	7.4	8.4	4.8	25.3
Duval												
Lissie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Goliad	0.0	1.0	0.1	0.7	0.0	1.8	0.0	0.6	0.0	0.5	0.0	1.1
Lower Goliad	0.0	0.2	0.9	1.0	0.1	2.1	0.0	0.1	0.4	0.4	0.0	0.9
Upper Lagarto	0.0	0.4	0.9	1.2	0.0	2.5	0.0	0.1	0.3	0.4	0.0	0.8
Middle Lagarto	0.0	0.1	0.3	0.4	0.0	0.9	0.0	0.1	0.1	0.2	0.0	0.4
Lower Lagarto	0.0	0.3	9.8	10.8	1.3	22.2	0.0	0.1	3.2	3.9	0.4	7.6
Oakville	0.0	0.4	14.1	13.8	1.8	30.2	0.0	0.2	4.8	4.6	0.6	10.1
Catahoula	0.0	0.0	34.2	13.0	5.6	52.8	0.0	0.0	9.7	3.8	1.6	15.1
Total	0.0	2.4	60.4	41.0	8.8	112.5	0.0	1.1	18.5	13.8	2.6	36.0
Fayette												
Middle Lagarto	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Lagarto	0.0	0.5	0.4	0.6	0.0	1.6	0.0	0.2	0.1	0.2	0.0	0.6

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Oakville	0.0	0.1	0.6	1.2	0.0	2.0	0.0	0.0	0.2	0.5	0.0	0.8
Catahoula	0.0	0.4	2.2	5.8	0.4	8.9	0.0	0.2	0.8	2.1	0.1	3.2
Total	0.0	1.0	3.2	7.7	0.4	12.4	0.0	0.4	1.2	2.8	0.2	4.6
Fort Bend												
Beaumont	0.0	0.9	0.0	0.3	0.0	1.3	0.0	0.7	0.0	0.2	0.0	1.0
Lissie	0.0	7.6	0.1	1.5	0.4	9.5	0.0	5.9	0.1	1.1	0.3	7.4
Willis	0.0	7.3	0.3	1.8	0.4	9.6	0.0	5.7	0.2	1.4	0.2	7.5
Upper Goliad	0.0	1.8	0.2	1.0	0.1	3.1	0.0	1.3	0.1	0.7	0.1	2.2
Lower Goliad	0.1	0.9	0.5	1.4	0.2	3.2	0.1	0.4	0.2	0.7	0.1	1.5
Upper Lagarto	0.2	0.4	1.0	1.1	0.5	3.2	0.1	0.1	0.3	0.4	0.2	1.1
Middle Lagarto	0.1	0.1	1.9	1.3	1.0	4.3	0.0	0.0	0.5	0.4	0.2	1.1
Lower Lagarto	1.4	0.7	7.8	9.3	4.8	24.1	0.2	0.2	2.2	2.6	1.1	6.4
Oakville	6.0	0.6	1.6	2.3	14.9	25.4	2.4	0.2	0.7	0.9	6.5	10.8
Catahoula	1.1	0.0	4.0	1.2	14.1	20.5	0.3	0.0	1.7	0.5	5.3	7.8
Total	9.0	20.2	17.4	21.3	36.3	104.2	3.1	14.6	6.0	8.9	14.0	46.7
Galveston												
Beaumont	0.0	0.7	0.6	6.2	0.0	7.5	0.0	0.5	0.4	4.3	0.0	5.1
Lissie	0.2	2.7	0.7	3.6	0.2	7.5	0.1	2.0	0.5	2.5	0.1	5.2
Willis	0.2	0.5	1.8	2.6	4.4	9.6	0.1	0.4	1.2	1.8	2.8	6.2
Upper Goliad	1.0	0.0	0.1	0.0	1.6	2.8	0.5	0.0	0.1	0.0	0.8	1.4
Lower Goliad	1.5	0.0	0.0	0.0	1.7	3.3	0.6	0.0	0.0	0.0	0.8	1.4
Upper Lagarto	1.1	0.0	0.0	0.0	1.4	2.5	0.6	0.0	0.0	0.0	0.7	1.2
Middle Lagarto	0.6	0.0	0.1	0.0	1.6	2.3	0.2	0.0	0.0	0.0	0.6	0.8
Lower Lagarto	6.6	0.1	0.5	0.1	6.2	13.5	2.7	0.0	0.2	0.1	2.6	5.6
Oakville	6.9	0.0	0.1	0.7	10.8	18.6	2.1	0.0	0.0	0.1	3.3	5.5
Total	18.0	4.1	3.9	13.3	28.1	67.4	7.0	2.9	2.3	8.7	11.7	32.6
Goliad												
Lissie	0.0	0.3	0.0	0.2	0.0	0.5	0.0	0.3	0.0	0.1	0.0	0.4
Willis	0.0	0.1	0.0	0.3	0.0	0.4	0.0	0.0	0.0	0.1	0.0	0.2
Upper Goliad	0.0	1.3	0.0	0.2	0.0	1.6	0.0	0.7	0.0	0.1	0.0	0.9
Lower Goliad	0.0	1.4	0.1	1.1	0.0	2.7	0.0	0.6	0.1	0.5	0.0	1.1

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Lagarto	0.0	1.3	0.7	3.5	0.3	5.8	0.0	0.5	0.2	1.4	0.1	2.2
Middle Lagarto	0.0	0.3	0.2	0.9	0.1	1.5	0.0	0.1	0.1	0.3	0.1	0.6
Lower Lagarto	0.0	1.5	3.1	10.0	4.6	19.2	0.0	0.6	1.3	4.3	1.9	8.2
Oakville	2.3	0.7	9.7	2.8	14.2	29.6	0.9	0.3	3.6	1.0	5.8	11.5
Catahoula	0.0	0.0	30.5	6.0	23.5	60.1	0.0	0.0	7.6	1.4	5.3	14.3
Total	2.3	6.9	44.5	25.0	42.8	121.5	1.0	3.1	12.9	9.2	13.2	39.4
Grimes												
Willis	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Upper Lagarto	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Middle Lagarto	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.2
Lower Lagarto	0.0	0.8	0.1	1.3	0.0	2.3	0.0	0.5	0.1	0.9	0.0	1.5
Oakville	0.0	1.1	0.2	3.2	0.0	4.5	0.0	0.6	0.1	1.9	0.0	2.6
Catahoula	0.0	7.7	7.8	12.7	0.3	28.5	0.0	3.5	3.3	5.5	0.1	12.4
Total	0.0	9.9	8.1	17.3	0.3	35.6	0.0	4.9	3.5	8.3	0.1	16.8
Hardin												
Beaumont	0.0	0.1	0.0	0.2	0.0	0.3	0.0	0.1	0.0	0.2	0.0	0.3
Lissie	0.0	9.7	0.2	2.4	0.0	12.4	0.0	7.1	0.1	1.7	0.0	9.0
Willis	0.0	15.9	0.7	3.3	0.3	20.2	0.0	10.3	0.4	2.0	0.2	12.9
Upper Goliad	0.0	0.1	0.1	0.3	0.1	0.7	0.0	0.0	0.1	0.1	0.1	0.3
Lower Goliad	0.1	1.9	0.7	0.9	0.6	4.2	0.0	0.9	0.3	0.4	0.3	2.0
Upper Lagarto	0.0	0.4	0.4	0.6	0.6	2.0	0.0	0.2	0.2	0.3	0.3	0.9
Middle Lagarto	0.1	0.3	0.5	0.5	0.9	2.2	0.0	0.1	0.2	0.2	0.4	1.0
Lower Lagarto	1.4	1.2	3.3	3.1	12.6	21.6	0.7	0.6	1.5	1.3	6.2	10.3
Oakville	3.5	0.0	2.2	1.1	10.8	17.6	2.1	0.0	0.9	0.4	5.7	9.1
Catahoula	2.4	0.0	5.2	0.1	15.8	23.5	0.9	0.0	1.7	0.0	5.6	8.3
Total	7.5	29.7	13.4	12.4	41.6	104.6	3.8	19.3	5.5	6.8	18.7	54.1
Harris												
Beaumont	0.0	1.2	0.3	1.3	0.0	2.8	0.0	0.9	0.2	1.0	0.0	2.1
Lissie	0.1	18.7	1.1	4.1	0.2	24.2	0.1	13.3	0.7	3.0	0.1	17.2
Willis	0.0	16.9	0.9	5.7	0.1	23.6	0.0	12.0	0.6	3.9	0.1	16.6
Upper Goliad	0.0	0.5	0.4	0.4	0.2	1.5	0.0	0.3	0.2	0.2	0.1	0.8

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Lower Goliad	0.1	3.0	0.5	2.0	0.6	6.2	0.0	1.6	0.2	1.0	0.3	3.1
Upper Lagarto	0.3	1.2	0.9	2.6	0.3	5.4	0.1	0.5	0.4	1.2	0.2	2.4
Middle Lagarto	0.0	0.5	0.7	2.1	0.8	4.2	0.0	0.2	0.3	0.8	0.3	1.6
Lower Lagarto	1.9	2.7	8.4	15.7	4.9	33.6	0.6	1.0	2.7	5.5	1.6	11.6
Oakville	6.3	1.5	9.6	3.9	14.0	35.3	2.7	0.7	4.0	1.6	6.0	14.9
Catahoula	7.0	0.0	6.2	2.9	42.9	59.1	1.8	0.0	1.5	0.8	10.8	14.9
Total	15.7	46.2	29.0	40.8	64.1	195.8	5.4	30.6	10.9	19.0	19.5	85.3
Jackson												
Beaumont	0.0	1.5	0.6	2.1	0.0	4.1	0.0	0.9	0.5	1.5	0.0	2.8
Lissie	0.0	4.5	0.7	2.2	0.0	7.5	0.0	2.5	0.4	1.2	0.0	4.1
Willis	0.0	4.9	1.3	2.9	0.2	9.2	0.0	3.5	0.8	1.8	0.1	6.2
Upper Goliad	0.1	1.7	0.6	1.0	1.3	4.7	0.0	0.9	0.3	0.5	0.5	2.2
Lower Goliad	0.2	0.6	0.5	0.8	1.4	3.5	0.1	0.3	0.2	0.4	0.7	1.7
Upper Lagarto	0.1	0.2	2.1	0.8	0.6	3.7	0.0	0.0	0.6	0.2	0.2	1.1
Middle Lagarto	0.0	0.0	2.6	0.9	0.7	4.1	0.0	0.0	0.7	0.2	0.2	1.1
Lower Lagarto	0.8	0.0	12.8	2.9	7.0	23.5	0.2	0.0	2.5	0.7	1.3	4.6
Oakville	6.4	0.0	4.7	0.6	24.8	36.6	2.0	0.0	1.6	0.2	8.0	11.8
Catahoula	1.9	0.0	1.5	0.0	7.2	10.7	0.6	0.0	0.4	0.0	1.7	2.7
Total	9.5	13.2	27.5	14.2	43.1	107.5	2.9	8.1	7.8	6.8	12.5	38.2
Jasper												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lissie	0.0	4.7	0.0	0.9	0.0	5.5	0.0	3.1	0.0	0.6	0.0	3.7
Willis	0.0	12.7	0.2	5.3	0.3	18.5	0.0	6.2	0.1	2.6	0.1	9.1
Upper Goliad	0.0	0.0	0.1	0.1	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.1
Lower Goliad	0.1	0.8	0.2	0.2	0.2	1.5	0.0	0.3	0.1	0.1	0.1	0.5
Upper Lagarto	0.0	0.7	0.1	0.2	0.3	1.2	0.0	0.3	0.0	0.1	0.1	0.6
Middle Lagarto	0.1	0.5	0.2	0.3	0.1	1.2	0.0	0.3	0.1	0.2	0.1	0.7
Lower Lagarto	1.1	4.0	0.7	3.3	5.0	14.0	0.5	2.7	0.4	2.0	2.6	8.2
Oakville	1.7	4.5	1.0	1.5	3.2	11.9	1.1	2.7	0.6	0.8	2.0	7.1
Catahoula	0.1	8.8	7.6	7.4	17.2	41.1	0.0	3.5	3.0	2.9	6.8	16.3
Total	3.0	36.6	10.1	19.1	26.4	95.3	1.7	19.3	4.3	9.3	11.8	46.4

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Jefferson												
Beaumont	0.0	1.0	5.0	5.8	1.6	13.3	0.0	0.5	2.4	2.9	0.7	6.5
Lissie	0.6	2.4	4.4	5.6	7.4	20.5	0.3	1.4	2.3	3.1	3.7	10.8
Willis	2.8	0.5	2.3	2.0	11.4	19.0	1.4	0.2	1.2	1.0	6.0	9.8
Upper Goliad	3.3	0.0	0.2	0.2	4.0	7.6	1.5	0.0	0.1	0.1	1.8	3.4
Lower Goliad	3.1	0.0	0.2	0.1	2.9	6.3	1.4	0.0	0.1	0.0	1.2	2.7
Upper Lagarto	2.0	0.0	0.0	0.0	2.0	4.1	1.0	0.0	0.0	0.0	1.0	2.0
Middle Lagarto	2.1	0.0	0.0	0.0	1.3	3.4	1.2	0.0	0.0	0.0	0.7	1.9
Lower Lagarto	20.5	0.0	0.0	0.0	13.8	34.3	10.8	0.0	0.0	0.0	7.4	18.3
Oakville	18.2	0.0	0.9	0.0	19.5	38.6	8.2	0.0	0.3	0.0	8.4	16.9
Total	52.6	3.9	13.0	13.6	63.8	147.0	25.7	2.2	6.3	7.1	30.9	72.3
Jim Hogg												
Upper Goliad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Goliad	0.0	0.2	0.0	0.1	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.1
Upper Lagarto	0.0	0.2	0.1	0.3	0.0	0.5	0.0	0.0	0.0	0.1	0.0	0.1
Middle Lagarto	0.0	0.2	0.0	0.2	0.0	0.5	0.0	0.1	0.0	0.1	0.0	0.2
Lower Lagarto	0.0	1.6	0.3	4.9	0.1	7.0	0.0	0.7	0.1	2.0	0.0	2.9
Oakville	0.0	1.3	3.0	8.1	0.0	12.5	0.0	0.5	1.2	3.5	0.0	5.2
Catahoula	0.0	2.2	29.4	39.7	0.8	72.2	0.0	0.8	10.4	14.3	0.3	25.8
Total	0.0	5.7	33.0	53.3	1.0	92.9	0.0	2.2	11.8	20.1	0.4	34.4
Jim Wells												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Lissie	0.0	0.1	0.4	0.6	0.1	1.1	0.0	0.0	0.3	0.3	0.0	0.7
Willis	0.0	0.7	0.3	0.8	0.0	1.8	0.0	0.5	0.2	0.4	0.0	1.0
Upper Goliad	0.0	1.4	0.6	2.5	0.1	4.6	0.0	0.7	0.3	1.3	0.0	2.4
Lower Goliad	0.0	0.1	1.5	0.6	0.4	2.6	0.0	0.0	0.5	0.3	0.2	1.0
Upper Lagarto	0.0	0.1	1.4	1.3	0.3	3.1	0.0	0.0	0.6	0.7	0.2	1.4
Middle Lagarto	0.0	0.0	0.6	0.5	0.1	1.3	0.0	0.0	0.2	0.2	0.1	0.5
Lower Lagarto	0.0	0.0	10.4	5.8	3.9	20.1	0.0	0.0	3.7	2.5	1.3	7.5
Oakville	0.0	0.0	16.1	2.7	7.4	26.3	0.0	0.0	4.8	0.9	2.2	7.9
Catahoula	0.0	0.0	21.1	3.3	3.7	28.1	0.0	0.0	6.5	0.9	1.0	8.4

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Total	0.0	2.4	52.4	18.2	16.1	89.1	0.0	1.3	17.0	7.4	5.1	30.8
Karnes												
Middle Lagarto	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Lagarto	0.0	0.3	0.1	0.8	0.0	1.3	0.0	0.2	0.1	0.4	0.0	0.6
Oakville	0.0	0.5	0.6	3.1	0.1	4.3	0.0	0.2	0.2	1.2	0.0	1.7
Catahoula	0.0	0.0	11.2	6.5	1.0	18.8	0.0	0.0	3.6	2.1	0.3	6.1
Total	0.0	0.8	12.0	10.5	1.1	24.4	0.0	0.3	4.0	3.7	0.4	8.4
Kenedy												
Beaumont	0.4	1.5	2.6	0.5	2.7	7.8	0.2	0.9	1.5	0.3	1.5	4.5
Lissie	0.0	1.6	1.0	1.9	6.7	11.3	0.0	0.8	0.4	0.8	2.5	4.5
Willis	0.0	3.2	5.3	12.3	5.6	26.4	0.0	1.6	2.2	5.4	1.8	10.9
Upper Goliad	0.0	2.5	2.5	5.1	2.5	12.7	0.0	1.0	1.1	2.2	1.0	5.3
Lower Goliad	0.4	0.0	2.5	1.1	5.0	9.1	0.2	0.0	0.9	0.4	1.8	3.2
Upper Lagarto	0.0	0.0	2.4	0.6	5.7	8.6	0.0	0.0	1.0	0.3	2.4	3.7
Middle Lagarto	0.3	0.0	0.7	0.1	4.5	5.5	0.1	0.0	0.3	0.0	1.9	2.4
Lower Lagarto	4.6	0.0	5.0	3.4	37.5	50.5	2.2	0.0	2.4	1.7	18.1	24.5
Oakville	4.1	0.0	18.1	1.4	62.9	86.5	2.1	0.0	7.5	0.6	30.4	40.7
Catahoula	0.0	0.0	5.6	1.1	1.1	7.8	0.0	0.0	1.9	0.4	0.4	2.7
Total	9.9	8.9	45.7	27.4	134.3	226.3	4.9	4.4	19.3	12.0	61.8	102.4
Kleberg												
Beaumont	0.1	0.1	0.9	1.5	2.8	5.4	0.0	0.0	0.5	0.9	1.6	3.1
Lissie	0.0	0.0	4.4	2.1	3.1	9.6	0.0	0.0	2.4	1.1	1.6	5.2
Willis	0.1	1.4	6.8	4.4	2.0	14.8	0.0	0.7	2.8	1.9	0.8	6.2
Upper Goliad	0.0	0.9	3.4	1.9	3.4	9.5	0.0	0.3	1.4	0.8	1.4	4.0
Lower Goliad	0.0	0.0	1.3	0.0	3.9	5.2	0.0	0.0	0.5	0.0	1.3	1.8
Upper Lagarto	0.0	0.0	2.3	0.3	3.4	5.9	0.0	0.0	0.9	0.1	1.0	2.0
Middle Lagarto	0.0	0.0	0.8	0.1	1.4	2.3	0.0	0.0	0.4	0.0	0.4	0.8
Lower Lagarto	0.3	0.0	10.2	2.9	14.5	27.9	0.1	0.0	4.0	1.5	5.1	10.7
Oakville	0.6	0.0	22.3	0.3	20.3	43.5	0.3	0.0	9.4	0.1	9.1	19.0
Catahoula	0.0	0.0	1.2	0.1	1.9	3.2	0.0	0.0	0.4	0.0	0.7	1.1
Total	1.2	2.4	53.6	13.7	56.5	127.3	0.6	1.1	22.7	6.6	23.1	53.9
Lavaca												

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Lissie	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.2
Willis	0.0	1.6	0.0	0.2	0.0	1.7	0.0	1.2	0.0	0.1	0.0	1.3
Upper Goliad	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.2
Lower Goliad	0.0	0.7	0.0	0.2	0.0	0.9	0.0	0.4	0.0	0.1	0.0	0.5
Upper Lagarto	0.0	0.8	0.0	0.6	0.0	1.4	0.0	0.3	0.0	0.3	0.0	0.6
Middle Lagarto	0.0	0.3	0.2	0.8	0.0	1.3	0.0	0.1	0.1	0.3	0.0	0.4
Lower Lagarto	0.0	0.7	2.7	7.3	0.0	10.7	0.0	0.2	0.8	2.2	0.0	3.2
Oakville	0.0	1.0	6.4	4.8	1.0	13.2	0.0	0.5	2.3	2.1	0.4	5.3
Catahoula	0.0	0.6	9.9	6.3	8.8	25.6	0.0	0.2	3.0	2.1	1.9	7.3
Total	0.0	6.1	19.2	20.2	9.8	55.3	0.0	3.4	6.2	7.2	2.3	19.1
Liberty												
Beaumont	0.0	0.8	0.1	1.8	0.0	2.7	0.0	0.5	0.0	1.2	0.0	1.8
Lissie	0.0	11.1	2.0	4.5	0.1	17.7	0.0	7.9	1.4	3.0	0.0	12.3
Willis	0.0	11.3	1.6	8.2	1.1	22.3	0.0	7.9	1.1	5.7	0.7	15.4
Upper Goliad	0.0	0.0	0.2	0.2	0.5	1.0	0.0	0.0	0.1	0.1	0.3	0.5
Lower Goliad	0.2	0.8	0.7	1.2	0.9	3.8	0.1	0.4	0.3	0.6	0.4	1.8
Upper Lagarto	0.2	0.8	0.7	0.6	0.9	3.2	0.1	0.4	0.3	0.3	0.4	1.5
Middle Lagarto	0.2	0.5	0.6	0.6	0.8	2.8	0.1	0.2	0.3	0.3	0.4	1.2
Lower Lagarto	3.2	1.4	5.7	6.4	9.8	26.6	1.4	0.6	2.4	2.7	4.3	11.4
Oakville	3.8	0.1	5.0	1.5	14.7	25.1	1.7	0.1	2.0	0.6	6.1	10.5
Catahoula	3.4	0.0	5.1	0.4	20.8	29.8	1.1	0.0	1.6	0.1	6.8	9.7
Total	11.1	26.8	21.7	25.5	49.7	134.8	4.5	17.9	9.5	14.5	19.5	66.0
Live Oak												
Upper Goliad	0.0	0.2	0.0	0.1	0.0	0.3	0.0	0.1	0.0	0.1	0.0	0.2
Lower Goliad	0.0	0.2	0.0	0.5	0.0	0.7	0.0	0.1	0.0	0.2	0.0	0.4
Upper Lagarto	0.0	0.1	0.4	0.7	0.1	1.2	0.0	0.0	0.2	0.4	0.0	0.6
Middle Lagarto	0.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1
Lower Lagarto	0.0	0.4	3.0	5.1	1.0	9.5	0.0	0.2	1.4	2.5	0.5	4.6
Oakville	0.0	2.0	9.4	3.4	4.5	19.2	0.0	0.7	3.0	1.2	1.6	6.4
Catahoula	0.0	0.0	50.5	1.6	15.2	67.3	0.0	0.0	13.9	0.5	4.1	18.4
Total	0.0	2.8	63.4	11.3	20.8	98.4	0.0	1.2	18.6	4.9	6.1	30.7

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Matagorda												
Beaumont	0.0	10.4	0.2	7.3	0.0	17.9	0.0	6.6	0.1	4.7	0.0	11.4
Lissie	0.0	8.6	1.9	7.4	0.1	18.0	0.0	5.3	1.1	4.3	0.0	10.7
Willis	0.5	3.5	3.2	4.7	4.3	16.2	0.3	2.3	2.2	3.3	2.9	11.0
Upper Goliad	2.2	0.5	1.5	0.4	6.3	10.9	0.9	0.3	0.7	0.2	2.9	5.0
Lower Goliad	1.7	0.0	1.0	0.0	5.1	7.9	0.8	0.0	0.4	0.0	2.3	3.5
Upper Lagarto	2.1	0.0	1.3	0.2	5.1	8.8	1.0	0.0	0.5	0.1	2.4	4.0
Middle Lagarto	3.3	0.0	2.7	0.4	11.1	17.5	1.7	0.0	0.8	0.1	4.5	7.0
Lower Lagarto	14.8	0.7	6.8	4.0	17.5	43.9	8.2	0.1	1.7	1.6	5.4	17.0
Oakville	16.3	2.3	1.5	6.0	56.9	83.0	8.1	1.0	0.7	3.7	28.3	41.8
Total	41.0	26.0	20.0	30.5	106.6	224.1	21.0	15.5	8.3	18.0	48.5	111.3
McMullen												
Lower Lagarto	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oakville	0.0	0.1	0.2	0.4	0.0	0.7	0.0	0.0	0.1	0.1	0.0	0.2
Catahoula	0.0	0.0	7.8	1.1	0.9	9.8	0.0	0.0	2.5	0.4	0.3	3.1
Total	0.0	0.1	8.0	1.5	0.9	10.5	0.0	0.0	2.6	0.5	0.3	3.4
Montgomery												
Lissie	0.0	1.6	0.2	0.3	0.0	2.0	0.0	1.3	0.2	0.2	0.0	1.7
Willis	0.0	5.0	0.0	2.5	0.0	7.5	0.0	3.3	0.0	1.6	0.0	4.9
Upper Goliad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Goliad	0.0	0.8	0.1	0.6	0.0	1.4	0.0	0.4	0.0	0.3	0.0	0.7
Upper Lagarto	0.0	1.2	0.3	0.7	0.0	2.2	0.0	0.6	0.1	0.3	0.0	1.1
Middle Lagarto	0.0	0.7	0.3	0.6	0.0	1.6	0.0	0.5	0.1	0.4	0.0	1.0
Lower Lagarto	0.0	3.7	2.4	5.4	0.1	11.5	0.0	1.8	0.9	2.6	0.0	5.3
Oakville	0.1	1.4	5.0	9.5	1.2	17.2	0.0	0.7	2.1	4.6	0.5	8.0
Catahoula	2.0	3.0	20.4	21.3	13.6	60.3	0.5	1.0	6.0	6.6	3.7	17.8
Total	2.1	17.4	28.6	40.9	14.9	103.9	0.6	9.5	9.5	16.6	4.2	40.4
Newton												
Beaumont	0.0	0.1	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1
Lissie	0.0	4.7	0.1	0.5	0.0	5.3	0.0	3.0	0.0	0.3	0.0	3.4
Willis	0.0	9.8	0.2	2.3	0.5	12.7	0.0	3.8	0.1	1.0	0.2	5.0
Upper Goliad	0.1	0.5	0.1	0.1	0.2	0.9	0.0	0.1	0.0	0.0	0.1	0.3

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Lower Goliad	0.0	9.6	1.2	1.3	0.6	12.7	0.0	3.2	0.4	0.4	0.2	4.3
Upper Lagarto	0.0	15.0	0.3	1.0	2.4	18.8	0.0	7.2	0.2	0.5	1.2	9.0
Middle Lagarto	0.2	1.9	0.5	0.8	0.4	3.8	0.1	0.9	0.3	0.4	0.2	1.9
Lower Lagarto	0.6	8.0	1.5	14.5	6.2	30.8	0.3	5.2	0.9	9.5	3.3	19.2
Oakville	3.2	55.1	3.7	32.8	13.9	108.7	1.9	30.9	2.0	18.1	7.7	60.6
Catahoula	0.0	13.9	5.6	6.9	5.9	32.3	0.0	4.8	2.0	2.6	2.1	11.4
Total	4.2	118.5	13.2	60.3	30.1	226.3	2.4	59.1	5.9	32.8	14.9	115.1
Nueces												
Beaumont	0.0	0.1	1.1	1.3	1.3	3.8	0.0	0.0	0.8	1.0	0.9	2.7
Lissie	0.1	0.3	3.0	3.1	1.3	7.8	0.1	0.2	1.8	1.9	0.9	4.9
Willis	0.5	1.0	2.7	3.4	2.1	9.7	0.2	0.5	0.9	1.4	0.7	3.7
Upper Goliad	0.3	0.3	1.5	1.5	4.3	7.8	0.1	0.1	0.7	0.7	2.0	3.6
Lower Goliad	0.3	0.0	0.6	0.0	3.3	4.2	0.1	0.0	0.2	0.0	1.2	1.5
Upper Lagarto	0.4	0.0	0.4	0.1	3.4	4.4	0.1	0.0	0.2	0.0	1.1	1.5
Middle Lagarto	0.2	0.0	0.5	0.0	1.0	1.7	0.1	0.0	0.2	0.0	0.4	0.6
Lower Lagarto	2.7	0.0	6.4	0.2	16.5	25.8	1.2	0.0	2.4	0.1	6.6	10.2
Oakville	2.4	0.0	7.9	0.4	36.4	47.1	1.3	0.0	3.4	0.2	16.5	21.4
Catahoula	0.0	0.0	1.5	0.2	2.5	4.2	0.0	0.0	0.5	0.1	1.0	1.6
Total	6.9	1.6	25.7	10.3	72.2	116.7	3.2	0.8	11.1	5.3	31.2	51.6
Orange												
Beaumont	0.0	1.1	0.1	1.3	0.1	2.6	0.0	0.6	0.1	0.6	0.0	1.2
Lissie	0.0	4.8	0.4	1.2	0.2	6.7	0.0	3.3	0.3	0.8	0.1	4.5
Willis	0.1	0.9	1.0	0.5	2.7	5.3	0.1	0.4	0.5	0.2	1.4	2.6
Upper Goliad	1.1	0.1	0.2	0.2	1.1	2.6	0.5	0.0	0.1	0.1	0.5	1.2
Lower Goliad	0.6	0.1	0.2	0.0	0.9	1.9	0.2	0.0	0.1	0.0	0.4	0.7
Upper Lagarto	0.4	0.0	0.0	0.0	0.8	1.2	0.2	0.0	0.0	0.0	0.5	0.8
Middle Lagarto	0.8	0.0	0.0	0.0	0.6	1.4	0.5	0.0	0.0	0.0	0.3	0.9
Lower Lagarto	6.0	0.0	0.0	0.0	6.6	12.7	3.1	0.0	0.0	0.0	3.6	6.7
Oakville	4.6	0.0	0.1	0.0	3.7	8.4	2.3	0.0	0.0	0.0	1.5	3.7
Total	13.6	7.1	2.0	3.3	16.7	42.8	6.9	4.3	1.0	1.8	8.3	22.3
Polk												

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Lissie	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1
Willis	0.0	2.2	0.3	1.3	0.0	3.8	0.0	1.3	0.2	0.8	0.0	2.3
Lower Goliad	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Upper Lagarto	0.0	0.5	0.1	0.3	0.0	0.9	0.0	0.2	0.1	0.1	0.0	0.4
Middle Lagarto	0.0	0.3	0.1	0.5	0.0	0.8	0.0	0.1	0.0	0.2	0.0	0.4
Lower Lagarto	0.0	1.5	2.5	3.9	0.0	7.9	0.0	0.8	1.3	1.9	0.0	4.0
Oakville	0.0	0.6	5.2	4.4	0.1	10.3	0.0	0.3	2.3	2.0	0.0	4.6
Catahoula	0.5	1.1	25.4	15.6	16.3	58.8	0.2	0.5	10.3	6.6	6.1	23.8
Total	0.5	6.4	33.6	25.9	16.4	82.7	0.2	3.4	14.1	11.8	6.2	35.7
Refugio												
Beaumont	0.0	0.5	0.1	1.0	0.1	1.6	0.0	0.3	0.1	0.6	0.0	1.1
Lissie	0.0	1.4	0.1	3.4	0.1	4.9	0.0	0.8	0.0	1.9	0.0	2.8
Willis	0.0	2.3	0.3	4.9	0.2	7.6	0.0	0.8	0.1	1.8	0.1	2.8
Upper Goliad	0.0	1.4	1.3	2.3	0.8	5.8	0.0	0.7	0.6	1.1	0.4	2.8
Lower Goliad	0.0	0.1	1.0	0.5	1.3	2.9	0.0	0.0	0.3	0.2	0.5	1.0
Upper Lagarto	0.1	0.0	0.8	0.1	2.4	3.4	0.0	0.0	0.2	0.0	0.6	0.9
Middle Lagarto	0.0	0.0	0.1	0.0	1.2	1.3	0.0	0.0	0.0	0.0	0.5	0.5
Lower Lagarto	2.0	0.0	0.6	0.4	18.8	21.9	0.8	0.0	0.2	0.1	7.0	8.2
Oakville	10.8	0.0	0.8	0.0	28.1	39.8	4.7	0.0	0.3	0.0	11.2	16.2
Catahoula	0.0	0.0	7.3	0.6	26.4	34.4	0.0	0.0	1.2	0.1	4.6	5.9
Total	13.0	5.6	12.4	13.1	79.4	123.5	5.5	2.7	3.2	5.9	25.0	42.2
San Jacinto												
Lissie	0.0	0.2	0.0	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.2
Willis	0.0	4.0	0.1	7.6	0.0	11.7	0.0	2.6	0.1	5.0	0.0	7.7
Lower Goliad	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Upper Lagarto	0.0	0.3	0.0	0.2	0.0	0.5	0.0	0.2	0.0	0.1	0.0	0.3
Middle Lagarto	0.0	0.4	0.1	0.4	0.0	0.8	0.0	0.2	0.1	0.2	0.0	0.4
Lower Lagarto	0.0	2.6	1.6	3.7	0.0	8.0	0.0	1.4	0.8	2.0	0.0	4.2
Oakville	0.0	0.8	3.4	3.9	0.3	8.4	0.0	0.4	1.7	2.1	0.1	4.3
Catahoula	0.8	1.3	13.5	12.6	7.1	35.2	0.2	0.5	4.7	4.8	2.1	12.4
Total	0.8	9.7	18.8	28.4	7.3	64.9	0.2	5.5	7.4	14.2	2.3	29.6

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
San Patricio												
Beaumont	0.0	0.1	0.1	0.7	0.3	1.2	0.0	0.1	0.1	0.5	0.2	0.9
Lissie	0.0	1.0	0.4	1.5	0.6	3.5	0.0	0.7	0.2	0.9	0.4	2.3
Willis	0.1	1.4	1.5	1.5	1.3	5.8	0.0	0.6	0.5	0.8	0.5	2.4
Upper Goliad	0.1	0.3	1.2	1.5	1.9	4.9	0.1	0.2	0.6	0.8	0.9	2.5
Lower Goliad	0.0	0.0	0.5	0.1	2.0	2.6	0.0	0.0	0.1	0.0	0.7	0.9
Upper Lagarto	0.1	0.0	0.2	0.1	2.6	3.0	0.0	0.0	0.1	0.0	0.9	1.0
Middle Lagarto	0.1	0.0	0.0	0.0	1.3	1.4	0.0	0.0	0.0	0.0	0.5	0.5
Lower Lagarto	0.5	0.0	1.9	0.1	20.6	23.2	0.2	0.0	0.5	0.0	6.9	7.6
Oakville	5.7	0.0	3.1	0.2	33.8	42.9	2.4	0.0	1.3	0.1	11.8	15.6
Catahoula	0.0	0.0	5.6	0.1	15.5	21.3	0.0	0.0	1.5	0.0	6.0	7.6
Total	6.7	2.8	14.5	5.9	79.9	109.8	2.8	1.6	5.0	3.2	28.8	41.4
Trinity												
Oakville	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Catahoula	0.0	0.0	0.1	0.2	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.1
Total	0.0	0.0	0.1	0.2	0.0	0.3	0.0	0.0	0.0	0.1	0.0	0.1
Tyler												
Lissie	0.0	0.8	0.0	0.6	0.0	1.4	0.0	0.6	0.0	0.4	0.0	1.0
Willis	0.0	14.5	0.0	26.3	0.0	40.9	0.0	8.9	0.0	16.0	0.0	24.9
Lower Goliad	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Upper Lagarto	0.0	0.1	0.0	0.3	0.0	0.4	0.0	0.0	0.0	0.1	0.0	0.1
Middle Lagarto	0.0	0.1	0.1	0.2	0.0	0.4	0.0	0.0	0.0	0.1	0.0	0.1
Lower Lagarto	0.0	4.1	1.2	3.7	0.1	9.0	0.0	2.1	0.6	1.9	0.0	4.6
Oakville	0.0	1.6	2.1	2.8	0.4	7.0	0.0	0.7	0.8	1.2	0.2	2.9
Catahoula	0.8	5.3	17.3	6.7	24.6	54.7	0.3	2.3	6.8	2.8	9.6	21.8
Total	0.8	26.6	20.7	40.5	25.1	113.8	0.3	14.6	8.3	22.4	9.9	55.5
Victoria												
Beaumont	0.0	0.2	0.1	0.2	0.0	0.5	0.0	0.2	0.1	0.1	0.0	0.4
Lissie	0.0	2.7	0.2	1.7	0.0	4.6	0.0	1.9	0.1	1.0	0.0	3.0
Willis	0.0	3.7	0.2	1.6	0.0	5.4	0.0	1.9	0.1	0.7	0.0	2.7
Upper Goliad	0.0	2.6	0.1	1.1	0.1	3.9	0.0	1.2	0.0	0.5	0.1	1.8
Lower Goliad	0.0	1.0	0.5	1.6	0.1	3.2	0.0	0.4	0.2	0.6	0.0	1.3

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Lagarto	0.0	0.3	1.7	1.6	0.5	4.1	0.0	0.1	0.5	0.4	0.1	1.1
Middle Lagarto	0.0	0.1	0.5	0.3	0.5	1.3	0.0	0.0	0.2	0.1	0.2	0.5
Lower Lagarto	0.4	0.0	3.3	1.8	15.7	21.2	0.2	0.0	1.3	0.7	6.4	8.6
Oakville	13.2	0.0	4.0	0.5	20.6	38.3	6.1	0.0	1.5	0.2	8.1	15.8
Catahoula	2.1	0.0	5.2	1.5	21.4	30.2	0.4	0.0	1.1	0.3	4.7	6.5
Total	15.7	10.6	15.7	11.8	58.9	112.6	6.7	5.8	5.0	4.7	19.6	41.8
Walker												
Willis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Lagarto	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Lower Lagarto	0.0	1.8	0.1	1.3	0.0	3.2	0.0	1.1	0.1	0.7	0.0	1.9
Oakville	0.0	0.1	0.2	3.1	0.0	3.5	0.0	0.1	0.1	1.8	0.0	2.0
Catahoula	0.0	2.7	8.8	24.8	0.1	36.4	0.0	1.3	3.9	11.5	0.0	16.8
Total	0.0	4.7	9.2	29.2	0.1	43.2	0.0	2.5	4.1	14.1	0.0	20.7
Waller												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lissie	0.0	0.2	0.0	0.3	0.0	0.5	0.0	0.2	0.0	0.2	0.0	0.4
Willis	0.0	2.6	0.0	1.1	0.0	3.7	0.0	1.8	0.0	0.7	0.0	2.5
Upper Goliad	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.0	0.1
Lower Goliad	0.0	0.2	0.0	0.1	0.0	0.3	0.0	0.1	0.0	0.1	0.0	0.2
Upper Lagarto	0.0	0.4	0.1	0.5	0.0	1.0	0.0	0.2	0.0	0.2	0.0	0.4
Middle Lagarto	0.0	0.2	0.1	0.5	0.0	0.8	0.0	0.1	0.1	0.2	0.0	0.4
Lower Lagarto	0.0	2.6	1.6	4.6	0.1	8.9	0.0	1.2	0.6	2.2	0.0	3.9
Oakville	0.0	1.0	1.1	3.4	0.0	5.4	0.0	0.5	0.5	1.6	0.0	2.6
Catahoula	0.0	0.2	9.1	9.5	10.6	29.5	0.0	0.1	2.9	3.2	3.2	9.4
Total	0.0	7.6	12.0	19.8	10.8	50.3	0.0	4.3	4.1	8.3	3.2	19.9
Washington												
Lower Goliad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Lagarto	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Lagarto	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lower Lagarto	0.0	1.2	0.1	2.2	0.0	3.5	0.0	0.6	0.0	1.2	0.0	1.8
Oakville	0.0	0.4	0.3	3.4	0.0	4.1	0.0	0.2	0.2	1.8	0.0	2.2

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Catahoula	0.0	3.0	3.8	13.4	0.3	20.5	0.0	1.3	1.7	5.8	0.1	9.0
Total	0.0	4.6	4.2	19.1	0.3	28.2	0.0	2.1	1.9	8.9	0.1	13.0
Webb												
Oakville	0.0	0.0	0.1	0.5	0.0	0.6	0.0	0.0	0.0	0.2	0.0	0.3
Catahoula	0.0	0.1	2.0	2.8	0.1	5.0	0.0	0.0	0.6	0.9	0.0	1.6
Total	0.0	0.1	2.1	3.3	0.1	5.6	0.0	0.1	0.6	1.1	0.0	1.9
Wharton												
Beaumont	0.0	2.1	0.2	0.6	0.0	3.0	0.0	1.4	0.2	0.4	0.0	2.0
Lissie	0.0	6.6	0.1	0.8	0.1	7.6	0.0	4.8	0.1	0.5	0.1	5.5
Willis	0.0	10.7	0.2	0.8	0.1	11.9	0.0	8.6	0.2	0.6	0.1	9.5
Upper Goliad	0.0	3.1	0.2	0.6	0.2	4.0	0.0	2.0	0.1	0.3	0.1	2.5
Lower Goliad	0.0	1.2	0.3	1.5	0.5	3.6	0.0	0.7	0.2	0.8	0.2	1.9
Upper Lagarto	0.0	0.2	1.2	1.8	0.5	3.7	0.0	0.1	0.4	0.6	0.2	1.3
Middle Lagarto	0.0	0.1	4.8	3.2	0.9	9.1	0.0	0.0	1.3	1.0	0.2	2.5
Lower Lagarto	0.5	1.8	13.2	13.8	7.0	36.3	0.1	0.3	3.1	3.2	1.4	8.1
Oakville	1.7	1.1	3.8	3.7	32.6	42.9	0.7	0.5	1.7	1.5	14.6	19.0
Catahoula	1.5	0.0	3.8	1.9	21.0	28.2	0.4	0.0	1.0	0.5	4.9	6.8
Total	3.8	27.0	27.8	28.7	63.0	150.3	1.2	18.5	8.1	9.4	21.8	59.0

Table 12-6. **The volume of fresh, slightly saline, moderately saline, very saline, brine, and total groundwater in the Gulf Coast Aquifer calculated using porosity by county and formation.**

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Aransas												
Beaumont	0.0	1.4	1.0	15.2	1.5	19.2	0.0	1.0	0.7	10.8	1.1	13.7
Lissie	0.2	1.4	1.5	15.4	4.6	23.2	0.1	0.6	0.7	5.9	2.6	9.9
Willis	0.5	2.4	8.4	12.0	6.9	30.3	0.2	0.9	2.8	4.1	2.4	10.4
Upper Goliad	4.8	3.7	14.7	12.0	72.4	107.7	2.0	1.7	6.6	5.4	30.1	45.9
Lower Goliad	2.6	0.0	8.0	0.4	53.6	64.6	0.9	0.0	2.8	0.1	19.1	23.0
Upper Lagarto	2.3	0.0	12.8	1.0	43.0	59.1	0.5	0.0	3.0	0.2	9.6	13.3
Middle Lagarto	0.5	0.0	7.0	0.0	33.3	40.8	0.1	0.0	1.1	0.0	7.4	8.6
Lower Lagarto	5.8	0.0	5.7	0.0	43.3	54.7	1.9	0.0	1.3	0.0	13.1	16.2
Oakville	18.2	0.0	4.5	0.0	72.3	95.0	6.5	0.0	1.2	0.0	26.6	34.4
Total	34.9	9.0	63.7	56.1	330.9	494.7	12.4	4.2	20.2	26.6	112.1	175.5
Austin												
Beaumont	0.0	0.2	0.0	0.0	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.3
Lissie	0.0	2.9	0.1	0.4	0.2	3.7	0.0	2.6	0.1	0.4	0.2	3.2
Willis	0.0	13.6	0.1	4.7	0.1	18.6	0.0	10.2	0.1	3.7	0.1	14.1
Upper Goliad	0.0	7.4	0.1	0.5	0.1	8.1	0.0	5.3	0.1	0.3	0.0	5.7
Lower Goliad	0.0	7.8	0.1	8.7	0.1	16.7	0.0	4.2	0.0	4.5	0.0	8.8
Upper Lagarto	0.0	24.6	1.6	26.7	0.2	53.1	0.0	11.2	0.7	11.7	0.1	23.6
Middle Lagarto	0.0	11.9	7.8	33.9	0.5	54.0	0.0	5.1	2.6	13.4	0.1	21.2
Lower Lagarto	0.0	17.0	6.1	49.0	0.2	72.3	0.0	6.5	2.1	17.9	0.1	26.6
Oakville	0.0	6.7	15.4	44.8	1.8	68.7	0.0	2.5	5.7	17.0	0.7	25.9
Catahoula	0.1	2.8	59.5	112.5	45.2	220.2	0.0	1.1	21.1	41.4	15.2	78.8
Total	0.1	95.0	90.8	281.4	48.4	515.7	0.0	48.9	32.4	110.2	16.5	208.1
Bee												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lissie	0.0	2.0	0.0	2.7	0.1	4.8	0.0	1.8	0.0	2.4	0.0	4.2
Willis	0.0	2.7	0.1	2.7	0.0	5.6	0.0	1.2	0.0	1.2	0.0	2.5
Upper Goliad	0.0	29.3	4.9	40.5	1.7	76.4	0.0	15.7	2.6	21.8	0.8	40.9
Lower Goliad	0.0	13.6	10.1	18.3	3.5	45.6	0.0	8.0	4.3	9.9	1.3	23.5

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Lagarto	0.0	3.7	18.3	21.0	13.6	56.6	0.0	1.5	6.7	8.3	4.6	21.1
Middle Lagarto	0.0	4.5	13.0	27.7	26.0	71.2	0.0	2.1	5.8	12.4	13.3	33.6
Lower Lagarto	0.0	1.7	16.4	46.3	29.7	94.1	0.0	0.8	7.0	20.4	9.7	37.8
Oakville	1.1	0.7	52.2	19.9	75.7	149.6	0.4	0.2	15.8	6.5	24.7	47.7
Catahoula	0.0	0.0	169.2	2.0	89.2	260.4	0.0	0.0	40.7	0.5	16.8	58.0
Total	1.2	58.2	284.3	181.0	239.5	764.3	0.4	31.2	83.0	83.4	71.3	269.3
Brazoria												
Beaumont	0.0	69.0	1.3	95.9	0.0	166.2	0.0	44.2	0.9	60.7	0.0	105.8
Lissie	0.0	61.2	17.5	77.3	3.8	159.7	0.0	39.3	11.0	47.3	2.3	99.9
Willis	10.3	42.3	25.2	22.7	37.6	138.1	5.7	29.5	15.6	15.0	23.1	88.9
Upper Goliad	94.1	24.7	15.5	33.9	180.6	348.8	48.5	15.1	9.2	20.6	95.9	189.4
Lower Goliad	105.4	8.0	11.6	18.1	154.8	298.0	40.8	3.7	5.0	8.4	59.4	117.2
Upper Lagarto	106.0	5.3	4.9	14.4	124.1	254.6	48.7	2.0	1.8	6.1	52.1	110.7
Middle Lagarto	68.2	2.4	16.2	11.0	150.1	247.9	30.7	0.6	3.8	2.4	53.8	91.3
Lower Lagarto	85.9	5.9	19.1	28.6	211.1	350.6	30.3	2.4	5.1	10.5	63.4	111.7
Oakville	102.9	4.1	5.3	10.6	320.1	443.0	41.1	1.5	1.7	3.9	128.5	176.5
Total	572.7	222.9	116.7	312.6	1182.1	2407.0	245.8	138.3	54.0	174.8	478.5	1091.4
Brazos												
Lower Lagarto	0.0	0.0	0.0	0.3	0.0	0.3	0.0	0.0	0.0	0.2	0.0	0.3
Oakville	0.0	0.0	0.0	0.7	0.0	0.7	0.0	0.0	0.0	0.4	0.0	0.5
Catahoula	0.0	1.9	1.6	5.1	0.1	8.7	0.0	0.8	0.7	2.2	0.0	3.8
Total	0.0	2.0	1.7	6.0	0.1	9.7	0.0	0.9	0.7	2.9	0.0	4.5
Brooks												
Beaumont	0.0	0.1	0.3	0.1	0.3	0.9	0.0	0.1	0.2	0.0	0.2	0.5
Lissie	0.0	0.3	1.0	0.7	1.2	3.1	0.0	0.1	0.4	0.3	0.5	1.4
Willis	0.0	1.0	0.3	1.2	0.1	2.5	0.0	0.6	0.2	0.7	0.0	1.6
Upper Goliad	0.0	64.9	5.5	48.2	4.1	122.7	0.0	34.3	2.7	24.6	2.0	63.5
Lower Goliad	0.0	19.3	21.0	53.7	4.1	98.1	0.0	6.7	7.1	17.2	1.3	32.2
Upper Lagarto	0.0	12.6	37.9	70.5	5.7	126.7	0.0	3.9	13.0	24.2	1.9	43.0
Middle Lagarto	0.0	13.7	35.7	57.6	7.2	114.1	0.0	5.4	15.3	23.3	3.6	47.5
Lower Lagarto	0.0	3.6	29.8	86.7	17.7	137.8	0.0	1.5	14.9	42.7	9.1	68.3

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Oakville	0.0	2.1	87.7	39.4	23.7	153.0	0.0	0.8	34.0	15.8	9.2	59.8
Catahoula	0.0	0.3	246.7	93.0	49.3	389.3	0.0	0.1	82.0	30.5	18.3	130.9
Total	0.2	117.9	466.0	450.9	113.3	1148.3	0.1	53.6	169.8	179.5	46.0	448.9
Calhoun												
Beaumont	0.0	5.2	5.6	20.9	0.1	31.8	0.0	3.6	3.7	14.4	0.1	21.7
Lissie	0.0	11.5	8.2	30.2	0.6	50.5	0.0	6.0	3.9	14.6	0.3	24.9
Willis	0.0	4.1	18.2	16.4	15.1	53.8	0.0	1.5	7.3	6.3	6.2	21.3
Upper Goliad	25.6	8.1	8.2	22.4	114.2	178.5	10.3	3.8	3.4	10.2	47.5	75.3
Lower Goliad	13.5	0.1	20.5	4.5	76.4	115.1	6.3	0.0	7.5	1.6	30.4	45.8
Upper Lagarto	3.2	0.0	30.6	0.7	68.7	103.2	1.1	0.0	9.0	0.2	20.7	30.9
Middle Lagarto	3.5	0.1	13.6	1.4	55.8	74.4	0.7	0.0	3.3	0.3	13.9	18.3
Lower Lagarto	34.2	0.0	14.4	0.4	53.4	102.3	11.0	0.0	3.2	0.0	14.9	29.1
Oakville	63.7	0.0	2.3	0.1	111.2	177.4	30.4	0.0	0.9	0.1	50.7	82.0
Total	143.8	28.9	121.6	97.1	495.6	887.0	59.8	15.0	42.2	47.8	184.6	349.4
Chambers												
Beaumont	0.0	4.7	19.6	40.9	0.2	65.4	0.0	3.1	12.8	28.2	0.1	44.3
Lissie	0.2	13.1	41.4	36.3	6.7	97.6	0.1	8.3	23.6	21.6	3.5	57.1
Willis	0.4	3.4	19.5	14.3	31.9	69.4	0.3	2.1	12.3	9.5	19.5	43.8
Upper Goliad	53.2	0.1	13.6	4.5	70.7	142.1	28.8	0.0	7.8	2.1	40.2	79.0
Lower Goliad	54.3	0.5	6.3	2.5	49.1	112.6	23.5	0.1	2.2	0.7	21.4	47.8
Upper Lagarto	64.6	0.3	2.6	1.7	38.4	107.7	29.8	0.1	0.7	0.5	15.9	46.9
Middle Lagarto	55.7	0.2	2.3	1.0	40.6	99.9	26.1	0.0	0.9	0.3	17.4	44.7
Lower Lagarto	82.7	0.1	5.6	1.3	51.0	140.7	34.4	0.0	1.8	0.4	20.1	56.8
Oakville	97.8	0.1	0.8	0.3	43.9	143.0	42.4	0.0	0.3	0.1	20.7	63.6
Total	409.0	22.4	111.7	102.7	332.5	978.4	185.4	13.8	62.6	63.5	158.8	484.1
Colorado												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
Lissie	0.0	6.2	0.0	0.5	0.0	6.7	0.0	5.7	0.0	0.4	0.0	6.2
Willis	0.0	24.8	0.0	6.4	0.0	31.2	0.0	19.5	0.0	4.9	0.0	24.5
Upper Goliad	0.0	15.4	0.0	2.5	0.0	17.9	0.0	9.2	0.0	1.5	0.0	10.6
Lower Goliad	0.0	30.9	0.2	13.4	0.0	44.6	0.0	16.8	0.1	7.4	0.0	24.3

	Total Volume (Millions of Acre-Feet)						**Total Volume in Sand (Millions of Acre-Feet)**					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Lagarto	0.0	25.3	4.1	45.4	0.0	74.8	0.0	12.3	1.9	21.7	0.0	35.9
Middle Lagarto	0.0	20.1	19.6	38.4	1.7	80.0	0.0	7.5	6.9	13.5	0.6	28.5
Lower Lagarto	0.0	18.0	31.1	61.1	0.6	110.8	0.0	5.4	9.2	18.0	0.2	32.8
Oakville	0.0	3.3	31.5	69.3	5.6	109.6	0.0	1.4	11.8	26.1	2.5	41.8
Catahoula	0.0	0.1	87.2	56.5	72.1	215.9	0.0	0.0	23.7	16.8	18.1	58.6
Total	0.0	144.2	173.9	293.5	80.1	691.7	0.0	77.8	53.7	110.4	21.4	263.2
DeWitt												
Lissie	0.0	0.3	0.0	0.1	0.0	0.3	0.0	0.2	0.0	0.0	0.0	0.2
Willis	0.0	1.2	0.0	0.1	0.0	1.2	0.0	1.0	0.0	0.0	0.0	1.1
Upper Goliad	0.0	2.6	0.1	0.1	0.0	2.8	0.0	1.9	0.0	0.1	0.0	2.0
Lower Goliad	0.0	9.5	0.0	2.9	0.0	12.5	0.0	5.7	0.0	1.7	0.0	7.4
Upper Lagarto	0.0	16.9	1.5	13.7	0.0	32.1	0.0	7.4	0.6	6.7	0.0	14.7
Middle Lagarto	0.0	11.8	3.3	30.2	0.0	45.3	0.0	3.9	1.1	10.4	0.0	15.4
Lower Lagarto	0.0	29.7	8.3	31.5	0.9	70.4	0.0	11.1	2.8	10.8	0.3	25.0
Oakville	0.0	23.8	24.2	40.8	16.9	105.8	0.0	10.6	9.2	18.5	5.6	43.8
Catahoula	9.8	0.0	97.0	52.2	75.8	234.8	4.2	0.0	33.4	19.5	24.9	82.0
Total	9.8	95.8	134.4	171.7	93.6	505.2	4.2	41.8	47.1	67.7	30.8	191.6
Duval												
Lissie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Goliad	0.0	36.0	2.9	27.1	0.2	66.2	0.0	21.8	1.7	16.7	0.1	40.3
Lower Goliad	0.0	6.3	26.4	30.6	2.2	65.4	0.0	2.3	11.0	13.5	0.9	27.8
Upper Lagarto	0.0	9.8	24.8	31.7	1.2	67.5	0.0	3.1	7.8	10.5	0.4	21.8
Middle Lagarto	0.0	7.8	21.8	30.0	0.9	60.5	0.0	3.5	9.5	12.8	0.4	26.1
Lower Lagarto	0.0	1.7	67.8	74.7	8.7	153.0	0.0	0.6	22.1	27.3	2.8	52.8
Oakville	0.0	2.9	93.6	91.3	11.6	199.3	0.0	1.0	31.7	30.1	3.8	66.6
Catahoula	0.0	0.2	192.1	78.8	30.8	301.8	0.0	0.1	54.7	23.1	8.6	86.5
Total	0.0	64.7	429.4	364.2	55.5	913.8	0.0	32.5	138.4	134.0	16.9	321.8
Fayette												
Middle Lagarto	0.0	0.5	0.1	0.2	0.0	0.8	0.0	0.2	0.0	0.1	0.0	0.3
Lower Lagarto	0.0	3.9	2.7	4.7	0.0	11.3	0.0	1.5	1.0	1.7	0.0	4.1

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Oakville	0.0	0.4	4.5	8.8	0.2	13.9	0.0	0.2	1.7	3.5	0.1	5.5
Catahoula	0.0	2.3	13.4	34.6	2.5	52.8	0.0	0.9	4.8	12.4	0.9	19.0
Total	0.0	7.2	20.7	48.2	2.7	78.8	0.0	2.7	7.5	17.7	1.0	28.9
Fort Bend												
Beaumont	0.0	6.5	0.3	2.4	0.0	9.2	0.0	5.1	0.3	1.7	0.0	7.2
Lissie	0.0	54.7	0.7	10.9	2.5	68.7	0.0	42.2	0.5	8.2	2.0	53.0
Willis	0.0	42.1	1.3	9.5	1.8	54.6	0.0	33.2	0.9	7.5	1.1	42.6
Upper Goliad	0.4	64.9	5.4	33.4	4.5	108.7	0.3	45.4	3.3	23.4	2.9	75.4
Lower Goliad	4.7	31.7	17.1	49.2	7.7	110.3	1.9	15.4	8.0	24.2	3.2	52.6
Upper Lagarto	5.9	11.7	33.2	38.0	16.3	105.1	2.1	4.4	10.9	12.9	5.4	35.7
Middle Lagarto	2.4	3.7	58.9	36.5	16.1	117.6	0.5	1.1	16.8	10.8	3.5	32.6
Lower Lagarto	6.8	4.6	48.7	56.9	26.1	143.1	1.1	1.5	13.9	16.4	6.3	39.2
Oakville	31.9	3.9	10.1	14.5	81.2	141.6	12.9	1.4	4.2	5.9	35.4	59.9
Catahoula	7.2	0.0	24.0	6.8	84.5	122.5	2.2	0.0	10.0	2.7	31.3	46.2
Total	59.4	223.7	199.5	258.1	240.6	981.4	20.9	149.8	68.8	113.7	91.1	444.4
Galveston												
Beaumont	0.0	5.2	4.0	45.1	0.1	54.4	0.0	3.6	2.7	30.9	0.1	37.2
Lissie	1.5	19.5	5.3	25.4	1.7	53.4	1.0	14.0	3.5	17.8	1.0	37.3
Willis	1.2	3.6	12.7	18.2	30.7	66.4	0.7	2.5	8.1	12.3	19.7	43.3
Upper Goliad	32.6	0.3	4.8	1.0	55.3	94.0	16.6	0.2	2.5	0.5	26.9	46.7
Lower Goliad	47.6	0.3	1.1	0.7	56.4	106.1	20.9	0.2	0.4	0.3	24.5	46.3
Upper Lagarto	33.1	0.1	0.1	0.4	43.2	76.9	17.5	0.0	0.0	0.2	21.0	38.8
Middle Lagarto	20.6	0.0	2.3	0.3	55.3	78.6	7.9	0.0	0.7	0.1	19.5	28.3
Lower Lagarto	39.6	0.4	2.9	0.9	37.8	81.6	16.4	0.2	1.1	0.3	15.7	33.6
Oakville	40.6	0.1	0.4	3.9	62.7	107.7	12.2	0.0	0.1	0.6	19.1	32.1
Total	216.8	29.5	33.6	95.9	343.2	719.0	93.2	20.7	19.2	63.2	147.4	343.7
Goliad												
Lissie	0.0	2.4	0.0	1.3	0.0	3.7	0.0	1.9	0.0	1.0	0.0	2.9
Willis	0.0	0.9	0.0	1.9	0.0	2.8	0.0	0.3	0.0	0.7	0.0	1.0
Upper Goliad	0.0	46.6	0.5	8.5	0.5	56.1	0.0	25.6	0.3	4.6	0.3	30.7
Lower Goliad	0.0	31.2	2.8	21.7	1.0	56.7	0.0	13.2	1.1	9.2	0.4	23.8

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Lagarto	0.0	21.3	10.1	52.7	4.3	88.3	0.0	8.5	3.5	22.2	1.2	35.4
Middle Lagarto	0.0	16.6	14.5	56.7	8.6	96.5	0.0	6.2	5.3	21.1	3.2	35.8
Lower Lagarto	0.1	9.6	14.7	54.7	16.7	95.8	0.0	4.2	6.2	23.7	6.9	41.0
Oakville	7.2	4.4	48.4	18.4	56.5	135.0	3.0	1.7	17.1	6.6	22.2	50.5
Catahoula	0.0	0.0	150.2	20.3	103.9	274.5	0.0	0.0	39.4	4.8	24.8	68.9
Total	7.4	133.0	241.3	236.3	191.5	809.5	3.0	61.6	72.9	93.8	58.8	290.2
Grimes												
Willis	0.0	0.5	0.0	0.0	0.0	0.5	0.0	0.3	0.0	0.0	0.0	0.4
Upper Lagarto	0.0	1.5	0.0	0.3	0.0	1.8	0.0	0.8	0.0	0.2	0.0	1.0
Middle Lagarto	0.0	13.6	0.3	1.7	0.0	15.5	0.0	9.6	0.2	1.1	0.0	10.9
Lower Lagarto	0.0	6.0	0.9	9.4	0.0	16.2	0.0	3.7	0.6	6.3	0.0	10.6
Oakville	0.0	7.4	1.0	20.2	0.0	28.6	0.0	4.1	0.6	11.9	0.0	16.6
Catahoula	0.0	30.1	38.9	54.1	2.1	125.2	0.0	13.5	16.5	22.9	0.8	53.7
Total	0.0	59.0	41.1	85.7	2.1	187.9	0.0	32.1	17.8	42.5	0.8	93.2
Hardin												
Beaumont	0.0	0.9	0.0	1.6	0.0	2.5	0.0	0.6	0.0	1.2	0.0	1.9
Lissie	0.0	70.6	1.4	17.5	0.0	89.5	0.0	51.5	1.0	12.4	0.0	64.9
Willis	0.0	80.0	4.4	17.8	2.1	104.3	0.0	52.0	2.5	10.9	1.3	66.7
Upper Goliad	0.3	2.6	4.9	9.6	5.1	22.5	0.1	1.2	2.1	4.2	2.1	9.7
Lower Goliad	2.6	64.5	24.7	30.7	20.1	142.5	1.2	30.1	11.8	15.3	9.2	67.6
Upper Lagarto	0.6	12.2	13.2	19.7	18.2	63.8	0.3	5.6	6.7	8.9	9.1	30.7
Middle Lagarto	2.5	17.5	24.5	24.2	40.1	108.8	1.3	7.1	11.7	11.2	19.2	50.5
Lower Lagarto	9.1	8.2	22.4	21.0	82.7	143.5	4.6	3.9	10.1	9.1	40.4	68.1
Oakville	22.4	0.2	14.9	7.1	69.6	114.0	13.1	0.1	6.0	2.8	37.0	58.9
Catahoula	15.3	0.3	33.1	0.7	100.7	150.1	6.0	0.1	10.9	0.3	35.6	52.8
Total	52.8	256.9	143.5	149.7	338.6	941.4	26.5	152.1	62.9	76.2	154.1	471.8
Harris												
Beaumont	0.0	8.9	2.2	9.4	0.0	20.4	0.0	6.6	1.7	7.1	0.0	15.4
Lissie	0.8	133.7	8.0	29.0	1.5	173.1	0.6	95.6	5.3	21.1	0.9	123.5
Willis	0.0	106.1	5.6	35.9	0.9	148.5	0.0	75.5	3.7	24.6	0.6	104.4
Upper Goliad	0.2	18.4	14.1	13.1	6.8	52.6	0.1	9.4	7.2	6.1	3.5	26.3

Formation	Total Volume (Millions of Acre-Feet) Brine water	Fresh-water	Moderately saline water	Slightly saline water	Very saline water	Total	Total Volume in Sand (Millions of Acre-Feet) Brine water	Fresh-water	Moderately saline water	Slightly saline water	Very saline water	Total
Lower Goliad	2.9	102.6	15.6	69.7	21.3	212.0	1.2	54.5	7.2	35.4	9.7	108.0
Upper Lagarto	8.7	41.5	31.2	88.6	11.2	181.2	4.0	18.2	13.0	39.3	5.1	79.8
Middle Lagarto	0.9	28.6	34.9	109.6	34.0	208.0	0.3	13.4	12.7	43.6	11.2	81.2
Lower Lagarto	12.0	18.1	55.9	105.6	31.9	223.6	4.0	6.9	18.2	37.3	10.6	77.0
Oakville	39.7	10.0	63.6	25.6	91.4	230.3	17.1	4.4	26.2	10.8	38.9	97.5
Catahoula	44.8	0.1	40.3	19.1	275.0	379.2	11.5	0.0	10.0	4.9	69.4	95.8
Total	110.1	468.1	271.3	505.6	474.0	1829.0	38.8	284.6	105.3	230.1	150.0	808.8
Jackson												
Beaumont	0.0	10.6	4.5	15.1	0.0	30.3	0.0	6.3	3.4	11.0	0.0	20.6
Lissie	0.0	29.9	4.4	14.6	0.1	49.0	0.0	16.9	2.1	8.0	0.0	27.2
Willis	0.0	28.7	6.4	15.8	0.8	51.7	0.0	20.5	3.9	10.2	0.3	34.9
Upper Goliad	2.4	60.6	18.8	32.4	37.5	151.7	0.8	31.9	8.4	15.5	15.1	71.7
Lower Goliad	5.0	18.9	16.3	27.8	34.3	102.3	2.5	9.3	7.6	13.2	16.5	49.1
Upper Lagarto	1.0	5.0	56.9	26.6	14.2	103.7	0.3	1.6	15.9	7.5	3.8	29.1
Middle Lagarto	1.1	0.7	57.5	23.3	21.6	104.2	0.2	0.2	15.0	5.5	4.8	25.7
Lower Lagarto	3.5	0.0	65.7	15.9	36.0	121.1	0.6	0.0	12.5	3.9	6.4	23.4
Oakville	28.8	0.0	23.3	3.5	119.8	175.5	8.9	0.0	8.0	1.3	38.6	56.8
Catahoula	7.0	0.0	7.4	0.1	33.2	47.6	2.2	0.0	1.7	0.0	7.6	11.5
Total	48.8	154.4	261.3	175.1	297.4	937.0	15.5	86.7	78.3	76.2	93.3	350.0
Jasper												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lissie	0.0	33.8	0.2	6.3	0.0	40.3	0.0	22.7	0.1	4.2	0.0	27.0
Willis	0.0	42.5	1.2	13.6	1.6	58.9	0.0	20.6	0.5	6.6	0.7	28.5
Upper Goliad	1.0	1.1	2.4	3.1	3.6	11.2	0.3	0.4	0.8	1.1	1.3	3.9
Lower Goliad	2.2	25.6	7.7	5.0	6.0	46.5	0.7	9.7	2.6	1.7	2.1	16.8
Upper Lagarto	0.6	15.8	2.2	3.9	7.7	30.2	0.4	8.3	1.0	1.8	4.5	16.0
Middle Lagarto	3.3	25.5	9.7	12.7	5.7	56.9	1.9	15.6	6.1	7.7	3.3	34.7
Lower Lagarto	6.7	27.5	4.6	22.6	32.5	93.9	3.3	19.1	2.4	13.6	16.6	55.1
Oakville	10.7	26.3	6.6	9.3	20.6	73.6	6.6	15.7	3.6	5.2	12.4	43.6
Catahoula	0.6	42.1	37.0	34.4	86.2	200.3	0.2	17.2	14.8	13.8	34.5	80.6
Total	25.0	240.2	71.5	111.0	164.1	611.8	13.6	129.4	32.0	55.8	75.5	306.2

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Jefferson												
Beaumont	0.0	7.3	36.5	41.9	11.3	96.9	0.0	3.7	17.2	21.1	5.1	47.1
Lissie	4.5	17.2	31.1	40.4	52.8	146.0	2.4	10.0	16.4	22.3	26.2	77.3
Willis	19.5	3.2	16.0	13.5	79.8	132.0	10.0	1.6	8.0	6.8	41.7	68.2
Upper Goliad	108.8	0.4	6.0	7.1	132.3	254.5	48.7	0.1	2.6	3.1	60.1	114.7
Lower Goliad	99.2	1.0	6.2	1.9	90.8	199.2	43.0	0.4	2.4	0.7	38.8	85.3
Upper Lagarto	60.7	0.0	1.3	0.4	61.7	124.1	29.3	0.0	0.6	0.2	29.6	59.8
Middle Lagarto	70.7	0.0	1.0	0.3	44.8	116.8	40.3	0.0	0.6	0.1	24.6	65.6
Lower Lagarto	123.8	0.0	0.1	0.0	84.0	208.0	65.3	0.0	0.1	0.0	45.2	110.7
Oakville	106.8	0.0	5.1	0.0	112.4	224.3	48.1	0.0	1.7	0.0	49.0	98.8
Total	594.0	29.1	103.3	105.5	669.9	1501.8	287.1	15.9	49.6	54.4	320.4	727.4
Jim Hogg												
Upper Goliad	0.0	0.2	0.0	0.1	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.2
Lower Goliad	0.0	6.6	0.7	2.1	0.1	9.5	0.0	3.3	0.3	0.9	0.0	4.5
Upper Lagarto	0.0	5.5	2.0	8.7	0.2	16.3	0.0	1.6	0.5	2.2	0.0	4.3
Middle Lagarto	0.0	16.6	2.8	16.0	0.2	35.7	0.0	8.3	1.2	6.9	0.1	16.5
Lower Lagarto	0.0	11.6	2.5	35.0	0.5	49.6	0.0	4.7	1.0	14.5	0.2	20.4
Oakville	0.0	9.3	21.4	57.3	0.3	88.3	0.0	3.5	8.4	24.7	0.1	36.7
Catahoula	0.0	14.8	198.1	270.7	5.7	489.3	0.0	5.4	70.2	97.9	2.1	175.5
Total	0.0	64.7	227.5	389.9	6.9	689.0	0.0	26.8	81.5	147.1	2.5	258.0
Jim Wells												
Beaumont	0.0	0.0	0.1	0.3	0.2	0.6	0.0	0.0	0.1	0.2	0.1	0.4
Lissie	0.0	0.6	3.0	4.2	0.5	8.2	0.0	0.3	1.9	2.3	0.3	4.9
Willis	0.0	4.4	1.7	4.4	0.2	10.6	0.0	2.8	0.9	2.3	0.1	6.1
Upper Goliad	0.0	48.6	21.8	89.0	3.4	162.8	0.0	24.2	10.8	46.6	1.6	83.2
Lower Goliad	0.1	2.9	44.9	20.2	12.0	80.0	0.0	1.4	16.2	9.0	4.3	31.0
Upper Lagarto	0.0	1.7	38.3	37.2	8.1	85.3	0.0	0.7	15.5	18.9	3.7	38.7
Middle Lagarto	0.0	3.0	38.5	33.5	7.7	82.7	0.0	1.3	13.9	13.1	3.0	31.2
Lower Lagarto	0.0	0.2	54.9	27.6	19.4	102.2	0.0	0.1	19.1	11.4	6.5	37.1
Oakville	0.0	0.2	79.5	13.6	36.5	129.8	0.0	0.0	22.4	4.1	10.5	37.1
Catahoula	0.0	0.0	114.2	15.7	16.0	145.9	0.0	0.0	35.7	4.2	4.5	44.3

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Total	0.1	61.5	396.9	245.6	103.9	808.1	0.0	30.9	136.5	112.1	34.6	314.1
Karnes												
Middle Lagarto	0.0	0.2	0.0	0.5	0.0	0.6	0.0	0.1	0.0	0.2	0.0	0.3
Lower Lagarto	0.0	2.4	1.0	6.1	0.0	9.5	0.0	1.1	0.4	2.8	0.0	4.4
Oakville	0.0	3.4	4.6	22.3	0.5	30.8	0.0	1.3	1.8	8.6	0.2	11.9
Catahoula	0.2	0.0	63.2	35.9	6.0	105.2	0.1	0.0	21.0	12.2	1.9	35.2
Total	0.2	6.0	68.7	64.7	6.5	146.1	0.1	2.4	23.2	23.8	2.1	51.7
Kenedy												
Beaumont	3.1	10.7	19.3	3.8	20.0	57.0	1.6	6.9	11.2	2.2	10.9	32.8
Lissie	0.3	10.3	6.0	11.0	37.9	65.4	0.1	5.2	2.1	4.6	14.1	26.0
Willis	0.0	17.2	27.0	60.9	25.1	130.1	0.0	9.0	11.8	27.9	8.3	57.0
Upper Goliad	1.1	87.2	84.7	172.7	80.6	426.2	0.4	35.9	35.3	73.1	32.5	177.2
Lower Goliad	10.6	0.9	83.1	35.3	145.0	274.9	4.3	0.3	29.1	11.8	50.5	96.0
Upper Lagarto	0.3	0.4	75.5	17.8	151.8	245.8	0.1	0.2	32.1	8.3	64.7	105.4
Middle Lagarto	8.0	0.3	34.1	3.8	152.8	199.2	4.2	0.2	16.7	1.9	65.7	88.7
Lower Lagarto	23.0	0.0	20.2	13.6	179.1	235.9	10.9	0.0	9.9	7.0	86.4	114.2
Oakville	17.4	0.0	72.1	5.2	284.1	378.9	9.1	0.0	30.4	2.1	140.5	182.2
Catahoula	0.0	0.0	17.8	3.5	3.5	24.9	0.0	0.0	6.1	1.2	1.3	8.7
Total	63.8	126.9	440.0	327.6	1079.9	2038.2	30.8	57.5	184.6	140.2	475.0	888.2
Kleberg												
Beaumont	0.5	0.5	6.6	11.1	20.5	39.2	0.3	0.3	3.9	6.9	11.5	23.0
Lissie	0.1	0.1	25.9	13.1	16.2	55.4	0.1	0.0	14.3	7.3	8.5	30.2
Willis	0.5	7.9	30.7	23.0	8.5	70.6	0.2	3.8	12.6	10.2	3.3	30.0
Upper Goliad	0.4	27.9	111.0	64.0	107.2	310.6	0.2	11.4	44.8	26.6	46.3	129.3
Lower Goliad	1.2	0.0	32.3	0.3	106.3	140.2	0.4	0.0	11.1	0.1	35.7	47.3
Upper Lagarto	1.1	0.1	48.9	5.5	86.2	141.8	0.4	0.0	18.0	2.1	26.3	46.8
Middle Lagarto	0.5	0.1	45.4	4.5	57.5	108.0	0.1	0.0	20.1	2.0	18.3	40.6
Lower Lagarto	1.7	0.0	37.3	10.7	75.6	125.2	0.5	0.0	14.6	5.4	27.0	47.5
Oakville	3.7	0.0	89.5	1.1	94.4	188.6	2.0	0.0	39.4	0.4	43.2	84.9
Catahoula	0.0	0.0	3.6	0.4	5.6	9.5	0.0	0.0	1.2	0.1	2.0	3.3
Total	9.7	36.5	431.1	133.8	578.0	1189.1	4.1	15.5	180.0	61.1	222.1	482.9
Lavaca												

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Lissie	0.0	1.2	0.0	0.3	0.0	1.5	0.0	1.1	0.0	0.3	0.0	1.4
Willis	0.0	10.5	0.0	1.0	0.0	11.5	0.0	8.2	0.0	0.7	0.0	8.9
Upper Goliad	0.0	11.7	0.2	0.1	0.0	12.0	0.0	6.1	0.1	0.1	0.0	6.3
Lower Goliad	0.0	23.7	0.6	7.2	0.0	31.6	0.0	11.9	0.3	3.7	0.0	16.0
Upper Lagarto	0.0	23.0	0.7	17.8	0.0	41.5	0.0	10.4	0.3	8.7	0.0	19.4
Middle Lagarto	0.0	17.2	8.5	34.9	0.4	61.0	0.0	5.9	2.7	11.3	0.2	20.1
Lower Lagarto	0.0	4.9	18.5	48.8	0.2	72.3	0.0	1.6	5.6	14.5	0.1	21.8
Oakville	0.0	6.6	41.8	31.7	6.3	86.4	0.0	3.8	15.1	14.0	2.4	35.3
Catahoula	0.2	3.6	59.8	39.1	52.9	155.7	0.1	1.4	18.3	13.0	11.7	44.5
Total	0.3	102.4	130.1	180.9	59.8	473.4	0.1	50.4	42.4	66.4	14.3	173.5
Liberty												
Beaumont	0.0	6.0	0.5	13.1	0.0	19.5	0.0	3.8	0.3	8.7	0.0	12.8
Lissie	0.0	79.3	14.5	32.6	0.4	126.8	0.0	56.6	9.9	21.4	0.3	88.2
Willis	0.0	51.5	11.2	39.3	7.5	109.5	0.0	35.4	7.2	27.4	4.8	74.8
Upper Goliad	0.7	0.3	6.6	8.3	16.6	32.6	0.4	0.1	3.9	4.2	9.7	18.3
Lower Goliad	8.2	26.2	22.0	41.2	30.8	128.4	4.0	13.3	10.5	20.1	14.7	62.6
Upper Lagarto	6.3	27.1	23.9	18.9	30.6	106.8	2.5	13.7	11.1	8.7	13.5	49.5
Middle Lagarto	9.0	25.1	31.4	34.5	35.8	135.7	3.7	11.0	13.6	15.1	16.3	59.6
Lower Lagarto	21.0	9.6	38.8	43.4	64.2	176.9	9.2	3.9	16.2	18.2	28.3	75.8
Oakville	23.9	0.9	33.6	10.3	95.9	164.6	10.8	0.4	13.7	4.0	39.6	68.4
Catahoula	22.0	0.1	33.3	2.7	135.6	193.7	7.2	0.0	10.6	0.8	44.2	62.8
Total	91.2	226.1	215.8	244.2	417.3	1194.6	37.8	138.2	97.1	128.4	171.3	572.7
Live Oak												
Upper Goliad	0.0	6.7	0.2	4.1	0.0	11.1	0.0	4.5	0.1	2.8	0.0	7.4
Lower Goliad	0.0	5.5	1.0	7.5	0.1	14.0	0.0	3.7	0.5	4.1	0.0	8.3
Upper Lagarto	0.0	0.7	4.1	8.3	0.9	14.1	0.0	0.4	2.1	4.8	0.5	7.7
Middle Lagarto	0.0	1.1	2.1	7.5	1.0	11.7	0.0	0.5	0.8	2.6	0.3	4.1
Lower Lagarto	0.0	2.7	20.4	32.4	6.9	62.3	0.0	1.3	9.6	15.9	3.1	29.8
Oakville	0.0	11.0	50.2	19.1	25.1	105.5	0.0	3.8	16.1	6.6	8.7	35.3
Catahoula	0.0	0.0	188.9	5.6	55.3	249.8	0.0	0.0	53.2	1.8	15.0	70.0
Total	0.0	27.7	266.8	84.6	89.4	468.5	0.0	14.2	82.3	38.6	27.6	162.7

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Matagorda												
Beaumont	0.0	75.6	1.5	53.0	0.0	130.0	0.0	47.7	0.9	34.2	0.0	82.9
Lissie	0.0	54.7	11.0	44.5	0.5	110.7	0.0	33.6	6.0	25.3	0.3	65.2
Willis	2.3	23.4	15.0	23.7	25.1	89.5	1.7	15.3	10.5	16.5	16.6	60.5
Upper Goliad	64.1	16.4	43.2	12.4	194.8	330.9	27.0	9.2	20.5	6.9	88.6	152.1
Lower Goliad	41.7	0.2	21.2	0.9	138.5	202.4	18.1	0.1	9.5	0.4	61.2	89.2
Upper Lagarto	45.2	0.0	29.1	5.3	124.8	204.4	21.7	0.0	11.5	1.7	56.7	91.6
Middle Lagarto	49.8	0.0	36.1	8.9	119.6	214.4	24.4	0.0	10.2	1.8	47.7	84.2
Lower Lagarto	75.8	3.4	32.5	20.9	80.2	212.7	43.7	0.6	8.3	9.0	25.0	86.5
Oakville	70.9	10.2	7.0	31.9	248.8	368.8	36.4	4.5	3.5	20.3	131.8	196.6
Total	349.8	183.9	196.4	201.4	932.3	1863.8	173.0	110.8	80.9	116.2	427.9	908.8
McMullen												
Lower Lagarto	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oakville	0.0	0.4	1.7	2.9	0.0	5.0	0.0	0.1	0.5	0.8	0.0	1.5
Catahoula	0.0	0.0	46.2	6.7	4.8	57.7	0.0	0.0	14.6	2.2	1.5	18.4
Total	0.0	0.4	47.8	9.5	4.9	62.7	0.0	0.1	15.2	3.0	1.6	19.9
Montgomery												
Lissie	0.0	11.4	1.3	2.0	0.0	14.7	0.0	9.5	1.1	1.7	0.0	12.3
Willis	0.0	30.1	0.0	14.1	0.0	44.1	0.0	20.4	0.0	8.9	0.0	29.2
Upper Goliad	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Lower Goliad	0.0	27.5	3.6	19.4	0.0	50.5	0.0	14.0	1.7	9.8	0.0	25.4
Upper Lagarto	0.0	39.5	8.8	22.6	0.3	71.2	0.0	20.3	4.3	11.5	0.1	36.2
Middle Lagarto	0.0	47.3	16.2	39.0	0.1	102.7	0.0	29.1	8.6	22.1	0.1	59.9
Lower Lagarto	0.0	26.0	16.4	37.3	0.5	80.2	0.0	12.5	6.3	18.2	0.2	37.2
Oakville	0.4	9.6	34.3	63.0	8.1	115.3	0.2	4.6	14.5	29.9	3.6	52.7
Catahoula	13.1	17.1	129.9	125.8	89.1	375.1	3.5	5.5	37.8	37.8	24.0	108.5
Total	13.5	208.5	210.5	323.2	98.1	853.8	3.7	115.8	74.2	139.9	28.0	361.5
Newton												
Beaumont	0.0	0.6	0.1	0.7	0.0	1.4	0.0	0.1	0.0	0.2	0.0	0.4
Lissie	0.0	34.2	0.4	3.8	0.0	38.3	0.0	21.9	0.2	2.4	0.0	24.6
Willis	0.0	40.0	1.0	8.0	2.4	51.5	0.0	15.3	0.4	3.3	0.8	19.8
Upper Goliad	1.8	3.9	2.3	2.9	6.6	17.5	0.6	1.4	0.9	1.0	2.5	6.4

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Lower Goliad	1.5	62.3	9.3	7.0	7.8	88.0	0.6	26.6	3.6	2.8	3.0	36.6
Upper Lagarto	0.6	46.7	0.9	2.7	12.3	63.2	0.4	25.0	0.5	1.4	7.2	34.4
Middle Lagarto	5.9	32.0	9.4	11.9	10.2	69.4	3.3	16.2	5.2	6.1	5.8	36.5
Lower Lagarto	4.0	35.6	5.2	39.7	34.3	118.7	2.0	22.4	3.0	25.1	17.5	70.0
Oakville	11.2	87.6	6.2	44.7	33.3	183.0	6.8	50.0	3.4	24.9	18.6	103.7
Catahoula	0.1	33.9	17.3	18.8	16.8	86.8	0.0	11.9	6.2	7.0	6.0	31.0
Total	25.0	376.8	52.2	140.2	123.7	717.8	13.8	190.7	23.4	74.1	61.4	363.4
Nueces												
Beaumont	0.2	0.5	8.3	9.9	9.2	28.1	0.2	0.3	5.9	7.0	6.3	19.7
Lissie	0.7	2.0	19.2	21.2	8.3	51.4	0.5	1.2	11.9	13.0	5.3	31.8
Willis	2.4	6.1	14.7	21.1	11.5	55.9	0.8	3.0	5.1	8.7	3.8	21.4
Upper Goliad	10.1	8.5	48.5	49.8	139.8	256.8	4.7	3.7	22.0	21.8	65.5	117.6
Lower Goliad	8.5	0.0	15.4	0.5	91.0	115.4	3.1	0.0	5.0	0.2	32.3	40.5
Upper Lagarto	11.9	0.0	8.9	2.2	88.1	111.1	4.2	0.0	3.5	0.8	29.8	38.3
Middle Lagarto	9.0	0.0	30.5	2.0	54.2	95.7	3.5	0.0	11.2	0.7	19.2	34.6
Lower Lagarto	11.8	0.0	23.8	0.6	73.4	109.6	4.8	0.0	8.9	0.2	28.5	42.4
Oakville	11.2	0.0	26.9	1.2	146.3	185.6	6.3	0.0	11.6	0.5	69.7	88.1
Catahoula	0.0	0.0	6.1	0.9	8.0	15.0	0.0	0.0	1.8	0.3	3.1	5.2
Total	65.9	17.2	202.3	109.4	629.7	1024.5	28.0	8.2	86.9	53.1	263.4	439.6
Orange												
Beaumont	0.0	8.2	0.9	9.5	0.5	19.1	0.0	4.1	0.4	4.3	0.2	8.9
Lissie	0.2	34.5	2.7	8.9	1.3	47.6	0.1	23.2	1.8	5.9	0.8	31.8
Willis	0.8	6.2	6.6	3.4	18.8	35.7	0.4	2.8	3.3	1.6	9.8	17.9
Upper Goliad	37.9	2.4	5.1	5.9	37.0	88.3	17.7	1.0	2.3	2.7	16.9	40.6
Lower Goliad	20.1	3.3	5.4	1.1	30.2	60.2	7.6	1.3	1.9	0.4	11.6	22.8
Upper Lagarto	11.0	1.1	0.6	0.3	25.3	38.3	6.9	0.8	0.3	0.2	16.3	24.4
Middle Lagarto	28.6	0.9	1.7	0.6	21.8	53.7	17.4	0.5	1.0	0.4	13.1	32.3
Lower Lagarto	36.4	0.1	0.2	0.2	40.2	77.1	19.0	0.0	0.1	0.1	21.6	41.0
Oakville	27.3	0.0	0.5	0.1	21.6	49.5	13.4	0.0	0.2	0.0	8.5	22.1
Total	162.3	56.8	23.7	30.1	196.6	469.4	82.4	33.7	11.3	15.5	98.9	241.8
Polk												

	Total Volume (Millions of Acre-Feet)						**Total Volume in Sand (Millions of Acre-Feet)**					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Lissie	0.0	1.0	0.0	0.1	0.0	1.1	0.0	0.8	0.0	0.1	0.0	0.9
Willis	0.0	6.3	0.5	3.4	0.0	10.2	0.0	3.8	0.3	2.0	0.0	6.1
Lower Goliad	0.0	1.7	0.0	0.1	0.0	1.7	0.0	0.9	0.0	0.0	0.0	0.9
Upper Lagarto	0.0	3.3	0.9	2.0	0.0	6.1	0.0	1.4	0.4	0.8	0.0	2.6
Middle Lagarto	0.0	8.2	2.8	16.5	0.0	27.6	0.0	4.1	1.3	8.2	0.0	13.7
Lower Lagarto	0.0	10.8	18.0	27.4	0.1	56.2	0.0	5.4	9.2	13.8	0.0	28.5
Oakville	0.0	3.7	35.9	29.2	0.8	69.6	0.0	1.7	15.8	13.4	0.3	31.2
Catahoula	2.9	6.4	138.5	70.3	99.5	317.6	1.3	2.8	55.5	29.9	36.7	126.2
Total	2.9	41.3	196.7	148.9	100.4	490.2	1.3	20.9	82.6	68.2	37.1	210.1
Refugio												
Beaumont	0.0	3.3	0.9	7.1	0.4	11.9	0.0	2.3	0.6	4.6	0.3	7.8
Lissie	0.0	9.7	0.4	22.9	0.5	33.5	0.0	5.7	0.2	13.1	0.3	19.3
Willis	0.0	14.6	1.9	30.0	1.0	47.6	0.0	5.4	0.7	11.1	0.4	17.5
Upper Goliad	1.0	49.5	44.9	79.6	25.4	200.5	0.5	24.2	21.9	38.5	11.8	96.9
Lower Goliad	0.2	2.2	31.9	15.5	42.1	92.0	0.1	0.8	11.1	5.9	15.0	32.8
Upper Lagarto	2.1	0.8	24.1	2.8	75.8	105.7	0.5	0.2	6.2	0.8	19.9	27.6
Middle Lagarto	0.0	0.3	5.1	0.8	71.5	77.8	0.0	0.1	1.9	0.3	28.4	30.7
Lower Lagarto	12.1	0.0	2.6	1.5	86.0	102.3	4.5	0.0	0.9	0.6	32.2	38.3
Oakville	48.0	0.0	3.1	0.0	122.2	173.2	20.1	0.0	1.1	0.0	46.6	67.8
Catahoula	0.0	0.0	20.2	1.9	74.1	96.1	0.0	0.0	3.3	0.3	13.2	16.8
Total	63.4	80.5	135.2	162.2	499.0	940.4	25.6	38.7	48.0	75.1	168.1	355.5
San Jacinto												
Lissie	0.0	1.7	0.0	0.1	0.0	1.9	0.0	1.4	0.0	0.1	0.0	1.6
Willis	0.0	7.9	0.1	14.5	0.0	22.5	0.0	4.9	0.1	9.3	0.0	14.3
Lower Goliad	0.0	0.5	0.1	1.5	0.0	2.0	0.0	0.2	0.0	0.8	0.0	1.0
Upper Lagarto	0.0	6.0	0.9	3.1	0.0	10.0	0.0	3.7	0.6	1.8	0.0	6.0
Middle Lagarto	0.0	15.4	5.4	19.2	0.1	40.1	0.0	8.3	2.8	10.2	0.0	21.2
Lower Lagarto	0.0	18.5	11.6	26.2	0.1	56.3	0.0	9.8	5.9	13.8	0.0	29.6
Oakville	0.0	5.5	23.2	24.0	1.8	54.5	0.0	3.0	11.4	12.8	0.8	27.9
Catahoula	4.8	5.5	79.5	61.7	46.6	198.1	1.4	2.2	27.1	22.7	14.1	67.4
Total	4.8	61.0	120.8	150.3	48.6	385.5	1.4	33.4	47.9	71.4	14.9	169.0

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
San Patricio												
Beaumont	0.1	0.5	0.8	4.9	2.2	8.5	0.0	0.4	0.6	3.7	1.6	6.3
Lissie	0.1	7.1	2.5	10.3	4.0	24.0	0.1	5.0	1.7	6.5	2.5	15.8
Willis	0.3	9.5	9.1	9.7	6.9	35.5	0.1	4.4	3.4	4.8	2.4	15.1
Upper Goliad	3.5	10.5	41.5	50.1	65.5	171.2	1.8	6.0	21.0	26.7	31.9	87.4
Lower Goliad	0.9	0.2	11.4	3.6	63.9	80.0	0.3	0.0	3.4	1.2	22.2	27.2
Upper Lagarto	3.7	0.0	6.4	1.1	74.5	85.7	0.9	0.0	2.3	0.5	24.8	28.5
Middle Lagarto	4.3	0.0	1.3	0.6	69.5	75.6	1.4	0.0	0.5	0.2	27.9	30.0
Lower Lagarto	2.2	0.0	9.8	0.8	78.8	91.6	0.8	0.0	2.4	0.2	25.9	29.4
Oakville	20.4	0.0	11.5	0.8	119.9	152.6	9.1	0.0	4.6	0.3	43.6	57.5
Catahoula	0.0	0.0	22.0	0.7	46.5	69.2	0.0	0.0	5.3	0.1	16.6	22.1
Total	35.4	27.8	116.2	82.6	531.7	793.9	14.5	15.9	45.2	44.2	199.5	319.3
Trinity												
Oakville	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Catahoula	0.0	0.1	0.6	1.1	0.1	1.9	0.0	0.0	0.2	0.5	0.0	0.8
Total	0.0	0.1	0.6	1.2	0.1	1.9	0.0	0.0	0.2	0.5	0.0	0.8
Tyler												
Lissie	0.0	6.0	0.0	4.3	0.0	10.3	0.0	4.1	0.0	3.3	0.0	7.4
Willis	0.0	23.9	0.1	33.1	0.0	57.0	0.0	14.6	0.0	20.0	0.0	34.6
Lower Goliad	0.0	1.1	0.0	0.1	0.0	1.2	0.0	0.4	0.0	0.0	0.0	0.5
Upper Lagarto	0.0	1.4	0.3	3.8	0.0	5.5	0.0	0.3	0.1	1.0	0.0	1.4
Middle Lagarto	0.0	6.5	4.0	11.5	0.1	22.1	0.0	2.4	1.3	4.5	0.0	8.3
Lower Lagarto	0.0	28.8	8.3	26.1	0.6	63.8	0.0	14.6	4.1	13.5	0.3	32.5
Oakville	0.1	10.5	14.5	19.7	3.1	47.8	0.0	4.5	5.8	8.1	1.4	19.7
Catahoula	5.3	33.5	103.7	38.7	154.3	335.6	1.8	14.3	40.1	16.1	60.0	132.3
Total	5.4	111.8	131.0	137.2	158.1	543.5	1.8	55.4	51.4	66.5	61.7	236.7
Victoria												
Beaumont	0.0	1.5	0.7	1.3	0.0	3.5	0.0	1.1	0.5	1.0	0.0	2.6
Lissie	0.0	19.7	1.2	12.0	0.0	32.9	0.0	13.8	0.7	7.2	0.0	21.8
Willis	0.0	24.0	1.1	10.1	0.1	35.3	0.0	12.6	0.5	4.4	0.0	17.5
Upper Goliad	0.0	88.1	2.1	38.1	3.7	132.0	0.0	41.0	1.0	18.1	1.7	61.8
Lower Goliad	0.0	23.6	17.2	46.8	3.0	90.7	0.0	10.3	6.7	19.0	1.3	37.3

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Lagarto	0.0	5.9	45.7	31.1	14.1	96.9	0.0	1.7	11.9	8.5	3.6	25.8
Middle Lagarto	0.0	4.4	25.9	14.6	31.7	76.6	0.0	1.5	9.8	5.3	10.6	27.2
Lower Lagarto	2.0	0.1	17.5	10.1	65.7	95.4	0.8	0.0	6.9	4.0	27.3	39.0
Oakville	48.0	0.0	18.4	3.3	88.6	158.4	22.0	0.0	6.4	1.0	34.0	63.5
Catahoula	6.8	0.0	19.5	4.2	87.3	117.8	1.4	0.0	4.5	0.9	20.1	26.9
Total	56.9	167.4	149.4	171.5	294.2	839.4	24.2	82.2	49.0	69.4	98.6	323.3
Walker												
Willis	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Middle Lagarto	0.0	1.4	0.4	4.4	0.0	6.2	0.0	0.8	0.2	2.4	0.0	3.5
Lower Lagarto	0.0	11.6	0.9	7.8	0.0	20.3	0.0	6.9	0.5	4.4	0.0	11.8
Oakville	0.0	0.8	1.4	14.3	0.0	16.5	0.0	0.4	0.7	8.2	0.0	9.3
Catahoula	0.1	11.0	32.0	88.5	0.4	131.9	0.0	5.3	14.0	40.9	0.2	60.3
Total	0.1	24.7	34.7	115.0	0.4	174.9	0.0	13.4	15.5	55.9	0.2	84.9
Waller												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lissie	0.0	1.6	0.0	1.8	0.0	3.4	0.0	1.2	0.0	1.4	0.0	2.6
Willis	0.0	13.5	0.0	5.8	0.0	19.3	0.0	9.6	0.0	3.9	0.0	13.5
Upper Goliad	0.0	6.0	0.0	1.2	0.0	7.2	0.0	3.7	0.0	0.7	0.0	4.4
Lower Goliad	0.0	7.7	0.0	4.0	0.0	11.7	0.0	4.6	0.0	2.4	0.0	7.0
Upper Lagarto	0.0	14.6	3.7	15.8	0.0	34.1	0.0	6.2	1.6	6.6	0.0	14.5
Middle Lagarto	0.0	14.6	8.8	28.8	0.5	52.7	0.0	7.3	3.8	13.2	0.2	24.5
Lower Lagarto	0.0	18.2	11.1	32.3	0.4	62.0	0.0	8.5	3.9	15.1	0.1	27.6
Oakville	0.0	6.7	7.2	23.1	0.3	37.3	0.0	3.2	3.3	11.1	0.1	17.7
Catahoula	0.1	1.5	60.7	63.0	69.9	195.3	0.0	0.6	19.5	21.2	21.1	62.4
Total	0.1	84.4	91.6	175.9	71.1	423.2	0.0	45.0	32.2	75.6	21.5	174.3
Washington												
Lower Goliad	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Lagarto	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Middle Lagarto	0.0	0.8	0.0	2.7	0.0	3.6	0.0	0.4	0.0	1.4	0.0	1.8
Lower Lagarto	0.0	8.7	0.5	16.2	0.0	25.4	0.0	4.5	0.2	8.6	0.0	13.3
Oakville	0.0	2.7	2.0	22.7	0.1	27.6	0.0	1.4	1.0	12.1	0.0	14.6

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Catahoula	0.0	13.8	20.3	68.8	1.9	104.7	0.0	6.1	8.8	29.6	0.8	45.2
Total	0.0	26.0	22.8	110.5	1.9	161.2	0.0	12.3	10.1	51.6	0.8	74.9
Webb												
Oakville	0.0	0.2	0.6	3.4	0.0	4.3	0.0	0.1	0.3	1.8	0.0	2.2
Catahoula	0.0	0.8	14.2	20.0	1.0	36.0	0.0	0.3	4.3	6.3	0.3	11.2
Total	0.0	1.0	14.9	23.4	1.0	40.3	0.0	0.4	4.6	8.1	0.3	13.4
Wharton												
Beaumont	0.0	15.6	1.6	4.6	0.0	21.7	0.0	10.3	1.2	3.0	0.0	14.5
Lissie	0.0	46.1	0.7	5.3	0.9	53.0	0.0	33.7	0.6	3.7	0.7	38.6
Willis	0.0	59.1	1.0	5.1	0.7	65.9	0.0	47.4	0.9	3.7	0.6	52.5
Upper Goliad	0.4	109.1	5.7	20.0	6.0	141.1	0.2	68.9	3.3	12.0	3.5	87.9
Lower Goliad	1.3	41.9	10.9	50.2	16.4	120.7	0.6	22.8	5.6	27.0	8.0	64.0
Upper Lagarto	1.2	7.4	37.9	58.6	16.9	122.0	0.4	2.7	12.2	20.4	5.4	41.2
Middle Lagarto	0.5	2.4	64.0	49.5	10.4	126.8	0.1	1.0	17.8	15.3	2.4	36.6
Lower Lagarto	2.1	9.4	66.9	72.2	33.8	184.4	0.4	1.9	15.9	16.8	6.7	41.7
Oakville	7.3	5.0	18.4	20.6	147.4	198.6	3.1	2.2	8.0	8.2	66.3	87.8
Catahoula	6.6	0.0	21.3	9.8	101.2	138.9	1.5	0.0	5.8	2.7	24.0	34.0
Total	19.2	296.1	228.3	295.9	333.5	1173.0	6.4	190.9	71.2	112.7	117.6	498.8

Table 12-7. The volume of fresh, slightly saline, moderately saline, very saline, brine, and total groundwater in the Gulf Coast Aquifer calculated using specific yield by groundwater conservation district and formation.

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water sand**	**Fresh-water sand**	**Moderately saline water sand**	**Slightly saline water sand**	**Very saline water sand**	**Grand Total**
Aransas County GCD												
Beaumont	0.0	0.3	0.2	2.9	0.3	3.6	0.0	0.2	0.1	2.1	0.2	2.6
Lissie	0.1	0.3	0.4	3.3	1.0	5.1	0.0	0.1	0.2	1.4	0.6	2.3
Willis	0.1	0.7	2.4	2.8	1.8	7.8	0.1	0.2	0.8	0.9	0.6	2.6
Upper Goliad	0.2	0.1	0.6	0.5	3.2	4.6	0.1	0.1	0.2	0.2	1.3	1.9
Lower Goliad	0.2	0.0	0.3	0.0	2.9	3.4	0.1	0.0	0.1	0.0	1.0	1.2
Upper Lagarto	0.1	0.0	0.7	0.0	2.5	3.3	0.0	0.0	0.2	0.0	0.6	0.8
Middle Lagarto	0.0	-	0.2	-	1.1	1.3	0.0	-	0.0	-	0.2	0.3
Lower Lagarto	1.1	-	1.2	-	10.4	12.7	0.4	-	0.3	-	3.1	3.7
Oakville	4.1	-	0.9	-	18.3	23.4	1.5	-	0.3	-	6.9	8.6
Total	6.0	1.4	6.8	9.5	41.5	65.3	2.1	0.6	2.2	4.6	14.5	24.1
Bee GCD												
Beaumont	-	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Lissie	-	0.3	0.0	0.3	0.0	0.6	-	0.2	0.0	0.3	0.0	0.5
Willis	-	0.4	0.0	0.4	0.0	0.8	-	0.2	0.0	0.2	0.0	0.3
Upper Goliad	-	0.8	0.1	1.1	0.0	2.1	-	0.4	0.1	0.6	0.0	1.1
Lower Goliad	-	0.5	0.4	0.7	0.1	1.6	-	0.3	0.2	0.3	0.0	0.8
Upper Lagarto	0.0	0.1	0.8	0.8	0.6	2.4	0.0	0.1	0.3	0.3	0.2	0.9
Middle Lagarto	0.0	0.1	0.2	0.4	0.4	1.0	0.0	0.0	0.1	0.2	0.2	0.5
Lower Lagarto	0.0	0.2	2.4	6.5	6.1	15.3	0.0	0.1	1.0	2.8	2.0	5.9
Oakville	0.3	0.1	7.7	2.7	15.0	25.8	0.1	0.0	2.3	0.9	5.0	8.4
Catahoula	-	-	30.5	0.4	19.8	50.8	-	-	6.8	0.1	3.3	10.2
Total	0.3	2.4	42.1	13.3	42.1	100.3	0.1	1.3	10.7	5.7	10.8	28.7
Bluebonnet GCD												
Beaumont	-	0.0	0.0	0.0	-	0.0	-	0.0	0.0	0.0	-	0.0
Lissie	-	0.6	0.0	0.3	0.0	1.0	-	0.5	0.0	0.2	0.0	0.8
Willis	-	5.1	0.0	1.8	0.0	6.9	-	3.7	0.0	1.3	0.0	5.0
Upper Goliad	-	0.4	0.0	0.1	0.0	0.4	-	0.2	0.0	0.0	0.0	0.3
Lower Goliad	-	0.4	0.0	0.3	0.0	0.8	-	0.3	0.0	0.2	0.0	0.4

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water sand**	**Fresh-water sand**	**Moderately saline water sand**	**Slightly saline water sand**	**Very saline water sand**	**Grand Total**
Upper Lagarto	-	1.2	0.2	1.2	0.0	2.6	-	0.5	0.1	0.5	0.0	1.1
Middle Lagarto	-	0.6	0.3	1.1	0.0	2.0	-	0.3	0.1	0.5	0.0	0.9
Lower Lagarto	-	7.6	2.8	14.0	0.1	24.5	-	3.7	1.0	6.2	0.0	11.0
Oakville	0.0	3.2	3.7	16.0	0.3	23.2	0.0	1.5	1.5	7.8	0.1	10.9
Catahoula	0.1	11.0	34.8	63.2	18.1	127.2	0.0	5.1	13.4	26.1	5.7	50.3
Total	0.1	30.2	41.8	98.1	18.6	188.6	0.0	15.9	16.1	42.8	5.9	80.7
Brazoria County GCD												
Beaumont	-	9.2	0.2	13.3	-	22.8	-	5.9	0.1	8.4	-	14.5
Lissie	0.0	8.2	2.5	10.8	0.5	22.0	0.0	5.2	1.6	6.6	0.3	13.8
Willis	1.5	5.8	3.6	3.1	5.4	19.4	0.8	4.1	2.2	2.1	3.3	12.5
Upper Goliad	2.8	0.7	0.4	1.0	5.3	10.2	1.5	0.4	0.3	0.6	2.8	5.5
Lower Goliad	3.3	0.2	0.3	0.5	4.8	9.1	1.3	0.1	0.1	0.2	1.8	3.6
Upper Lagarto	3.4	0.2	0.1	0.4	3.9	8.1	1.6	0.1	0.1	0.2	1.7	3.5
Middle Lagarto	7.3	0.1	0.9	0.3	14.5	23.1	3.4	0.0	0.2	0.1	5.6	9.3
Lower Lagarto	18.5	1.0	4.0	4.9	47.1	75.6	6.4	0.4	1.0	1.7	14.1	23.7
Oakville	23.4	0.8	1.1	2.2	76.7	104.1	9.5	0.3	0.3	0.8	31.1	42.0
Total	60.3	26.2	13.1	36.5	158.2	294.3	24.4	16.5	6.0	20.7	60.7	128.3
Brazos Valley GCD												
Lower Lagarto	-	0.0	0.0	0.0	-	0.0	-	0.0	0.0	0.0	-	0.0
Oakville	-	0.0	0.0	0.1	-	0.1	-	0.0	0.0	0.1	-	0.1
Catahoula	-	0.6	0.5	1.6	0.0	2.7	-	0.3	0.2	0.7	0.0	1.2
Total	-	0.6	0.5	1.7	0.0	2.8	-	0.3	0.2	0.8	0.0	1.3
Brush Country GCD												
Beaumont	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Lissie	0.0	0.1	0.4	0.5	0.1	1.0	0.0	0.0	0.2	0.3	0.1	0.6
Willis	-	0.7	0.2	0.6	0.0	1.5	-	0.4	0.1	0.3	0.0	0.9
Upper Goliad	-	2.4	0.6	3.0	0.1	6.1	-	1.2	0.3	1.6	0.1	3.1
Lower Goliad	0.0	0.8	1.7	1.7	0.4	4.6	0.0	0.3	0.6	0.7	0.1	1.7
Upper Lagarto	0.0	0.6	2.0	3.2	0.4	6.2	0.0	0.2	0.7	1.2	0.2	2.3
Middle Lagarto	-	0.5	0.9	1.4	0.1	2.9	-	0.2	0.3	0.5	0.1	1.1
Lower Lagarto	0.0	2.2	12.0	21.8	3.6	39.6	0.0	0.9	4.6	9.9	1.3	16.8
Oakville	0.0	1.7	27.1	16.4	7.0	52.3	0.0	0.6	9.2	6.6	2.1	18.6

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water sand**	**Fresh-water sand**	**Moderately saline water sand**	**Slightly saline water sand**	**Very saline water sand**	**Grand Total**
Catahoula	-	2.2	83.7	55.3	10.0	151.1	-	0.8	28.0	19.3	3.3	51.4
Total	0.0	11.0	128.6	104.0	21.9	265.4	0.0	4.7	44.1	40.4	7.3	96.5
Calhoun County GCD												
Beaumont	-	1.0	1.1	5.0	0.0	7.2	-	0.7	0.7	3.4	0.0	4.8
Lissie	0.0	2.1	2.1	7.5	0.1	11.8	0.0	1.1	0.9	3.5	0.1	5.6
Willis	0.0	0.9	5.6	4.4	4.5	15.5	0.0	0.3	2.2	1.7	1.8	6.1
Upper Goliad	1.4	0.3	0.5	0.9	6.3	9.4	0.6	0.1	0.2	0.4	2.6	3.9
Lower Goliad	1.1	0.0	1.1	0.2	5.4	7.8	0.5	0.0	0.4	0.1	2.2	3.1
Upper Lagarto	0.2	0.0	2.4	0.1	5.6	8.2	0.1	0.0	0.7	0.0	1.7	2.5
Middle Lagarto	0.2	0.0	0.5	0.0	2.2	2.9	0.0	0.0	0.1	0.0	0.5	0.6
Lower Lagarto	8.4	-	4.4	0.1	13.2	26.1	2.7	-	1.0	0.0	3.7	7.4
Oakville	15.5	-	0.8	0.0	29.9	46.3	7.4	-	0.3	0.0	13.3	21.1
Total	26.8	4.3	18.5	18.2	67.2	135.1	11.3	2.2	6.6	9.2	25.9	55.2
Coastal Bend GCD												
Beaumont	-	2.2	0.2	0.7	-	3.1	-	1.5	0.2	0.4	-	2.1
Lissie	-	6.9	0.1	0.8	0.1	7.9	-	5.0	0.1	0.5	0.1	5.8
Willis	-	11.0	0.2	0.9	0.2	12.4	-	8.9	0.2	0.7	0.1	9.9
Upper Goliad	0.0	3.2	0.2	0.6	0.2	4.2	0.0	2.0	0.1	0.4	0.1	2.6
Lower Goliad	0.0	1.3	0.3	1.5	0.5	3.7	0.0	0.7	0.2	0.8	0.3	2.0
Upper Lagarto	0.0	0.2	1.2	1.8	0.6	3.9	0.0	0.1	0.4	0.6	0.2	1.3
Middle Lagarto	0.1	0.1	5.0	3.3	1.0	9.4	0.0	0.0	1.3	1.0	0.2	2.6
Lower Lagarto	0.5	1.9	13.6	14.2	7.4	37.7	0.1	0.4	3.2	3.3	1.5	8.4
Oakville	1.9	1.2	4.1	3.9	33.6	44.7	0.8	0.5	1.7	1.6	15.1	19.7
Catahoula	1.5	-	4.1	2.1	21.7	29.4	0.4	-	1.1	0.6	5.1	7.1
Total	4.1	28.0	29.0	29.9	65.4	156.4	1.3	19.1	8.5	9.9	22.7	61.4
Coastal Plains GCD												
Beaumont	-	11.1	0.3	9.6	-	21.0	-	7.0	0.2	6.3	-	13.5
Lissie	-	9.0	2.3	9.2	0.1	20.6	-	5.5	1.3	5.3	0.1	12.1
Willis	0.5	3.5	3.9	5.2	5.4	18.5	0.4	2.3	2.6	3.6	3.5	12.4
Upper Goliad	2.7	0.5	1.7	0.4	7.9	13.1	1.1	0.3	0.8	0.2	3.5	5.8
Lower Goliad	2.2	0.0	1.1	0.0	6.3	9.6	1.0	0.0	0.5	0.0	2.8	4.3
Upper Lagarto	2.5	0.0	1.6	0.2	6.6	11.0	1.2	0.0	0.7	0.1	3.0	5.0

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water sand**	**Fresh-water sand**	**Moderately saline water sand**	**Slightly saline water sand**	**Very saline water sand**	**Grand Total**
Middle Lagarto	3.9	-	2.6	0.4	11.7	18.6	2.0	-	0.8	0.1	4.8	7.6
Lower Lagarto	18.6	0.7	7.0	4.1	20.1	50.5	10.1	0.1	1.8	1.6	6.5	20.2
Oakville	18.9	2.3	1.5	6.5	68.1	97.4	10.0	1.0	0.8	4.1	36.8	52.7
Total	49.3	27.1	22.1	35.6	126.3	260.4	25.7	16.2	9.3	21.3	61.0	133.5
Colorado County GCD												
Beaumont	-	0.0	0.0	0.0	-	0.0	-	0.0	0.0	0.0	-	0.0
Lissie	-	0.8	0.0	0.1	0.0	0.9	-	0.8	0.0	0.0	0.0	0.8
Willis	-	3.9	0.0	1.0	0.0	4.9	-	3.1	0.0	0.7	0.0	3.8
Upper Goliad	-	0.4	0.0	0.1	0.0	0.5	-	0.2	0.0	0.0	0.0	0.3
Lower Goliad	-	0.9	0.0	0.4	0.0	1.2	-	0.5	0.0	0.2	0.0	0.7
Upper Lagarto	-	0.8	0.1	1.4	0.0	2.3	-	0.4	0.1	0.7	0.0	1.1
Middle Lagarto	-	0.3	0.3	0.6	0.0	1.3	-	0.1	0.1	0.2	0.0	0.5
Lower Lagarto	-	2.5	4.3	8.6	0.1	15.5	-	0.8	1.3	2.5	0.0	4.6
Oakville	0.0	0.5	4.5	9.9	0.8	15.6	0.0	0.2	1.7	3.7	0.3	6.0
Catahoula	0.0	0.0	13.0	8.3	10.6	31.9	0.0	0.0	3.5	2.5	2.7	8.7
Total	0.0	10.1	22.2	30.3	11.5	74.2	0.0	6.0	6.7	10.7	3.0	26.4
Corpus Christi ASRCD												
Beaumont	0.0	0.1	0.8	1.7	1.4	4.0	0.0	0.0	0.6	1.3	1.0	2.9
Lissie	0.3	0.2	1.7	1.1	2.1	5.4	0.2	0.1	1.1	0.7	1.3	3.5
Willis	1.3	0.2	1.7	0.5	2.9	6.5	0.4	0.1	0.6	0.2	0.9	2.1
Upper Goliad	0.5	0.0	0.5	0.1	4.4	5.5	0.2	0.0	0.3	0.0	2.2	2.8
Lower Goliad	0.2	-	0.1	-	3.1	3.3	0.1	-	0.0	-	1.2	1.3
Upper Lagarto	0.3	-	0.1	0.0	3.3	3.7	0.1	-	0.0	0.0	0.6	0.7
Middle Lagarto	0.2	-	0.1	-	1.2	1.5	0.1	-	0.0	-	0.3	0.4
Lower Lagarto	1.0	-	0.4	-	10.1	11.4	0.3	-	0.1	-	3.9	4.4
Oakville	1.7	-	1.6	0.0	17.3	20.6	0.9	-	0.8	0.0	9.2	11.0
Catahoula	-	-	0.0	0.0	0.4	0.4	-	-	0.0	0.0	0.2	0.3
Total	5.5	0.5	6.9	3.5	46.0	62.4	2.3	0.3	3.6	2.2	21.1	29.4
Duval County GCD												
Lissie	-	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Upper Goliad	-	1.0	0.1	0.7	0.0	1.8	-	0.6	0.0	0.4	0.0	1.1
Lower Goliad	-	0.2	0.8	0.9	0.1	2.0	-	0.1	0.3	0.4	0.0	0.9

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water sand**	**Fresh-water sand**	**Moderately saline water sand**	**Slightly saline water sand**	**Very saline water sand**	**Grand Total**
Upper Lagarto	-	0.4	0.9	1.2	0.0	2.5	-	0.1	0.3	0.4	0.0	0.8
Middle Lagarto	-	0.1	0.3	0.4	0.0	0.9	-	0.1	0.1	0.2	0.0	0.4
Lower Lagarto	-	0.2	9.7	10.7	1.2	21.8	-	0.1	3.2	3.9	0.4	7.5
Oakville	-	0.4	13.8	13.6	1.7	29.5	-	0.1	4.7	4.5	0.6	9.9
Catahoula	-	0.0	33.2	12.7	5.4	51.3	-	0.0	9.3	3.7	1.5	14.6
Total	-	2.3	58.8	40.2	8.4	109.7	-	1.1	18.0	13.5	2.5	35.1
Evergreen UWCD												
Middle Lagarto	-	0.0	0.0	0.0	-	0.0	-	0.0	0.0	0.0	-	0.0
Lower Lagarto	-	0.4	0.1	0.9	0.0	1.5	-	0.2	0.1	0.4	0.0	0.7
Oakville	-	0.5	0.7	3.3	0.1	4.5	-	0.2	0.3	1.3	0.0	1.8
Catahoula	0.0	-	11.7	6.7	1.1	19.5	0.0	-	3.8	2.2	0.3	6.4
Total	0.0	0.9	12.5	10.9	1.2	25.5	0.0	0.4	4.1	3.9	0.4	8.8
Fayette County GCD												
Middle Lagarto	-	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Lower Lagarto	-	0.6	0.4	0.7	0.0	1.6	-	0.2	0.1	0.2	0.0	0.6
Oakville	-	0.1	0.7	1.3	0.0	2.0	-	0.0	0.2	0.5	0.0	0.8
Catahoula	-	0.4	2.3	5.9	0.4	9.0	-	0.2	0.8	2.1	0.1	3.2
Total	-	1.0	3.3	7.8	0.5	12.6	-	0.4	1.2	2.9	0.2	4.6
Fort Bend Subsidence District												
Beaumont	-	0.9	0.0	0.3	-	1.3	-	0.7	0.0	0.2	-	1.0
Lissie	-	7.6	0.1	1.5	0.3	9.6	-	5.9	0.1	1.1	0.3	7.3
Willis	-	7.2	0.2	1.8	0.4	9.6	-	5.7	0.2	1.4	0.2	7.4
Upper Goliad	0.0	1.9	0.2	1.0	0.1	3.1	0.0	1.3	0.1	0.7	0.1	2.2
Lower Goliad	0.2	0.9	0.5	1.4	0.2	3.2	0.1	0.4	0.2	0.7	0.1	1.5
Upper Lagarto	0.2	0.4	1.0	1.1	0.5	3.2	0.1	0.1	0.3	0.4	0.2	1.1
Middle Lagarto	0.1	0.1	1.8	1.3	1.0	4.3	0.0	0.0	0.5	0.4	0.2	1.1
Lower Lagarto	1.5	0.7	7.8	9.3	4.7	24.0	0.2	0.2	2.2	2.6	1.1	6.4
Oakville	5.9	0.6	1.6	2.3	14.9	25.3	2.4	0.2	0.7	0.9	6.5	10.7
Catahoula	1.1	-	3.9	1.1	13.9	20.0	0.3	-	1.7	0.5	5.2	7.7
Total	9.0	20.2	17.2	21.2	36.0	103.6	3.1	14.6	5.9	8.9	13.8	46.4
Goliad County GCD												
Lissie	-	0.3	0.0	0.2	-	0.5	-	0.2	0.0	0.1	-	0.4

	Total Volume (Millions of Acre-Feet)						**Total Volume in Sand (Millions of Acre-Feet)**					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water sand**	**Fresh-water sand**	**Moderately saline water sand**	**Slightly saline water sand**	**Very saline water sand**	**Grand Total**
Willis	-	0.1	0.0	0.3	0.0	0.4	-	0.0	0.0	0.1	0.0	0.1
Upper Goliad	-	1.3	0.0	0.2	0.0	1.6	-	0.7	0.0	0.1	0.0	0.9
Lower Goliad	-	1.4	0.1	1.1	0.0	2.7	-	0.6	0.1	0.5	0.0	1.1
Upper Lagarto	-	1.3	0.7	3.5	0.3	5.8	-	0.5	0.2	1.4	0.1	2.2
Middle Lagarto	-	0.3	0.2	0.9	0.1	1.5	-	0.1	0.1	0.3	0.0	0.6
Lower Lagarto	0.0	1.5	3.1	10.0	4.4	18.9	0.0	0.6	1.3	4.3	1.8	8.0
Oakville	2.0	0.7	9.6	2.8	14.0	29.0	0.8	0.3	3.5	1.0	5.7	11.3
Catahoula	0.0	-	30.7	5.9	23.0	59.6	0.0	-	7.7	1.4	5.2	14.3
Total	2.0	6.9	44.5	24.8	41.8	119.9	0.8	3.1	12.9	9.2	12.8	38.8
Harris-Galveston Coastal Subsidence District												
Beaumont	-	2.1	1.2	10.8	0.0	14.1	-	1.5	0.8	7.5	0.0	9.9
Lissie	0.3	22.6	2.3	10.1	0.5	35.8	0.2	16.2	1.5	7.1	0.3	25.3
Willis	0.2	17.2	3.9	9.3	6.9	37.6	0.1	12.2	2.5	6.3	4.4	25.5
Upper Goliad	1.5	0.5	0.6	0.4	2.7	5.8	0.8	0.3	0.3	0.2	1.3	2.9
Lower Goliad	2.2	3.0	0.5	2.1	3.1	10.8	1.0	1.6	0.2	1.0	1.3	5.1
Upper Lagarto	2.0	1.2	0.9	2.6	2.5	9.3	1.0	0.5	0.4	1.2	1.2	4.2
Middle Lagarto	0.9	0.5	0.8	2.1	3.2	7.5	0.3	0.2	0.3	0.8	1.1	2.8
Lower Lagarto	11.3	2.7	9.3	15.8	14.3	53.4	4.5	1.0	3.1	5.6	5.5	19.7
Oakville	16.9	1.6	9.6	4.7	31.2	63.9	6.1	0.7	3.9	1.7	11.4	23.8
Catahoula	6.8	0.0	5.8	2.8	41.8	57.2	1.7	0.0	1.4	0.7	10.6	14.5
Total	42.3	51.4	34.7	60.7	106.3	295.5	15.8	34.3	14.4	32.1	37.1	133.8
Kenedy County GCD												
Beaumont	1.0	2.1	4.5	1.8	5.4	14.8	0.5	1.3	2.8	1.0	2.9	8.5
Lissie	0.1	2.2	5.4	4.7	10.5	22.9	0.0	1.1	2.7	2.4	4.3	10.4
Willis	0.1	4.3	12.7	18.6	9.4	45.1	0.0	2.1	5.1	8.0	3.2	18.4
Upper Goliad	0.1	4.6	6.0	8.9	6.0	25.6	0.0	2.0	2.5	3.8	2.5	10.9
Lower Goliad	0.9	0.3	4.6	2.3	10.6	18.8	0.4	0.1	1.7	0.8	3.9	6.8
Upper Lagarto	0.1	0.2	5.7	2.3	11.3	19.5	0.0	0.1	2.3	0.9	4.5	7.8
Middle Lagarto	0.4	0.1	1.8	0.5	7.7	10.5	0.2	0.0	0.8	0.2	2.9	4.2
Lower Lagarto	6.1	0.2	17.5	11.7	62.5	98.0	3.0	0.1	8.1	6.0	29.6	46.8
Oakville	6.5	0.0	47.4	4.0	100.9	158.8	3.4	0.0	18.9	1.5	47.8	71.6
Catahoula	-	-	25.6	8.2	7.2	41.0	-	-	8.1	2.6	2.7	13.3

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water sand**	**Fresh-water sand**	**Moderately saline water sand**	**Slightly saline water sand**	**Very saline water sand**	**Grand Total**
Total	15.3	14.0	131.2	62.9	231.6	454.9	7.5	6.8	52.9	27.3	104.3	198.8
Live Oak UWCD												
Upper Goliad	-	0.2	0.0	0.1	0.0	0.3	-	0.1	0.0	0.1	0.0	0.2
Lower Goliad	-	0.2	0.0	0.4	0.0	0.7	-	0.1	0.0	0.2	0.0	0.4
Upper Lagarto	-	0.1	0.4	0.7	0.1	1.2	-	0.0	0.2	0.4	0.0	0.6
Middle Lagarto	-	0.0	0.0	0.1	0.0	0.2	-	0.0	0.0	0.0	0.0	0.1
Lower Lagarto	-	0.4	3.1	5.2	1.0	9.8	-	0.2	1.4	2.6	0.5	4.7
Oakville	-	1.9	9.6	3.4	4.6	19.6	-	0.7	3.1	1.2	1.6	6.6
Catahoula	-	-	51.0	1.6	15.3	67.9	-	-	14.1	0.5	4.1	18.6
Total	-	2.9	64.2	11.6	21.0	99.6	-	1.2	18.8	4.9	6.2	31.2
Lone Star GCD												
Lissie	-	1.6	0.2	0.3	0.0	2.1	-	1.4	0.2	0.3	0.0	1.8
Willis	-	5.2	0.0	2.5	0.0	7.7	-	3.4	0.0	1.6	0.0	5.0
Upper Goliad	-	0.0	0.0	0.0	-	0.0	-	0.0	0.0	0.0	-	0.0
Lower Goliad	-	0.8	0.1	0.6	0.0	1.5	-	0.4	0.1	0.3	0.0	0.7
Upper Lagarto	-	1.2	0.3	0.7	0.0	2.2	-	0.6	0.1	0.4	0.0	1.1
Middle Lagarto	-	0.8	0.3	0.6	0.0	1.7	-	0.5	0.1	0.4	0.0	1.0
Lower Lagarto	-	3.7	2.5	5.4	0.1	11.7	-	1.8	0.9	2.6	0.0	5.4
Oakville	0.1	1.5	5.1	9.5	1.3	17.4	0.0	0.7	2.2	4.6	0.6	8.0
Catahoula	2.2	2.9	20.2	21.3	14.3	60.9	0.6	1.0	5.9	6.6	3.8	17.9
Total	2.2	17.7	28.7	40.9	15.7	105.2	0.6	9.7	9.5	16.6	4.4	40.9
Lower Trinity GCD												
Lissie	-	0.4	0.0	0.0	-	0.5	-	0.4	0.0	0.0	-	0.4
Willis	-	6.6	0.3	9.3	-	16.3	-	4.2	0.2	6.0	-	10.4
Upper Goliad	-	0.1	0.0	0.1	-	0.2	-	0.0	0.0	0.0	-	0.1
Lower Goliad	-	0.8	0.2	0.4	0.0	1.4	-	0.4	0.1	0.2	0.0	0.7
Upper Lagarto	-	0.6	0.2	0.9	0.0	1.7	-	0.3	0.1	0.4	0.0	0.9
Middle Lagarto	-	4.1	4.2	7.7	0.0	16.0	-	2.1	2.1	3.9	0.0	8.2
Lower Lagarto	0.0	1.4	8.8	8.2	0.4	18.9	0.0	0.7	4.0	4.1	0.2	9.0
Oakville	1.3	2.4	38.7	27.7	23.7	93.8	0.5	1.0	14.9	11.3	8.3	35.9
Catahoula	-	0.4	0.0	0.0	-	0.5	-	0.4	0.0	0.0	-	0.4

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water sand**	**Fresh-water sand**	**Moderately saline water sand**	**Slightly saline water sand**	**Very saline water sand**	**Grand Total**
Total	1.3	16.5	52.4	54.3	24.1	148.6	0.5	9.2	21.5	26.0	8.5	65.7
McMullen GCD												
Lower Lagarto	-	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Oakville	-	0.1	0.3	0.5	0.0	0.8	-	0.0	0.1	0.1	0.0	0.3
Catahoula	-	-	8.4	1.2	1.0	10.6	-	-	2.7	0.4	0.3	3.4
Total	-	0.1	8.7	1.7	1.0	11.5	-	0.0	2.8	0.5	0.3	3.7
Pecan Valley GCD												
Lissie	-	0.0	0.0	0.0	-	0.0	-	0.0	0.0	0.0	-	0.0
Willis	-	0.2	-	0.0	-	0.2	-	0.1	-	0.0	-	0.1
Upper Goliad	-	0.1	0.0	0.0	-	0.1	-	0.0	0.0	0.0	-	0.1
Lower Goliad	-	0.3	0.0	0.1	-	0.4	-	0.2	0.0	0.1	-	0.2
Upper Lagarto	-	0.8	0.2	0.7	0.0	1.6	-	0.3	0.1	0.3	0.0	0.7
Middle Lagarto	-	0.2	0.1	0.5	0.0	0.8	-	0.1	0.0	0.2	0.0	0.3
Lower Lagarto	-	4.1	1.2	4.4	0.1	9.8	-	1.5	0.4	1.5	0.0	3.5
Oakville	0.0	3.3	3.5	5.8	2.4	15.0	0.0	1.5	1.3	2.6	0.8	6.2
Catahoula	1.7	0.0	15.6	9.3	11.4	38.1	0.7	0.0	5.4	3.5	3.8	13.4
Total	1.7	9.0	20.5	20.8	13.9	66.0	0.7	3.8	7.2	8.1	4.6	24.5
Refugio GCD												
Beaumont	-	0.5	0.1	1.1	0.1	1.7	-	0.3	0.1	0.7	0.0	1.1
Lissie	-	1.4	0.1	3.5	0.1	5.1	-	0.8	0.0	1.9	0.1	2.8
Willis	-	2.3	0.3	5.0	0.2	7.8	-	0.8	0.1	1.9	0.1	2.9
Upper Goliad	0.0	1.4	1.3	2.3	0.8	6.0	0.0	0.7	0.7	1.1	0.4	2.9
Lower Goliad	0.0	0.1	1.0	0.5	1.4	3.0	0.0	0.0	0.3	0.2	0.5	1.1
Upper Lagarto	0.1	0.0	0.8	0.1	2.5	3.5	0.0	0.0	0.2	0.0	0.7	0.9
Middle Lagarto	0.0	0.0	0.1	0.0	1.2	1.3	0.0	0.0	0.0	0.0	0.5	0.5
Lower Lagarto	2.1	0.0	0.7	0.4	19.0	22.2	0.8	0.0	0.2	0.2	7.0	8.2
Oakville	11.0	-	0.9	0.0	28.5	40.4	4.7	-	0.3	0.0	11.4	16.5
Catahoula	0.0	-	7.5	0.7	26.3	34.5	0.0	-	1.2	0.1	4.5	5.8
Total	13.2	5.7	12.8	13.6	80.1	125.4	5.6	2.7	3.3	6.1	25.1	42.7
San Patricio County GCD												
Beaumont	0.0	0.1	0.1	0.7	0.3	1.2	0.0	0.1	0.1	0.5	0.2	0.9
Lissie	0.0	1.0	0.4	1.6	0.6	3.6	0.0	0.7	0.2	1.0	0.4	2.4
Willis	0.1	1.5	1.5	1.7	1.3	5.9	0.0	0.7	0.5	0.8	0.4	2.5

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water sand**	**Fresh-water sand**	**Moderately saline water sand**	**Slightly saline water sand**	**Very saline water sand**	**Grand Total**
Upper Goliad	0.1	0.3	1.2	1.6	1.9	5.1	0.0	0.2	0.6	0.8	0.9	2.6
Lower Goliad	0.0	0.0	0.5	0.2	2.0	2.7	0.0	0.0	0.1	0.1	0.7	0.9
Upper Lagarto	0.1	0.0	0.3	0.1	2.7	3.2	0.0	0.0	0.1	0.0	0.9	1.1
Middle Lagarto	0.1	0.0	0.0	0.0	1.3	1.4	0.0	0.0	0.0	0.0	0.5	0.6
Lower Lagarto	0.5	0.0	2.2	0.1	21.5	24.3	0.2	0.0	0.6	0.0	7.2	8.0
Oakville	5.9	-	3.5	0.3	35.1	44.8	2.5	-	1.5	0.1	12.3	16.4
Catahoula	-	-	6.1	0.2	17.0	23.2	-	-	1.6	0.0	6.4	8.1
Total	6.8	2.9	15.8	6.3	83.5	115.3	2.9	1.6	5.5	3.4	30.0	43.4
Southeast Texas GCD												
Beaumont	-	0.2	0.0	0.3	0.0	0.5	-	0.1	0.0	0.2	0.0	0.3
Lissie	0.0	19.3	0.2	4.2	0.0	23.7	0.0	13.4	0.2	3.0	0.0	16.5
Willis	0.0	52.1	1.0	36.8	1.0	91.0	0.0	28.9	0.5	21.5	0.4	51.3
Upper Goliad	0.1	0.5	0.3	0.5	0.4	1.8	0.0	0.1	0.1	0.2	0.2	0.6
Lower Goliad	0.2	12.2	2.1	2.3	1.3	18.1	0.1	4.4	0.8	0.9	0.5	6.7
Upper Lagarto	0.0	16.0	0.9	2.1	3.2	22.1	0.0	7.6	0.4	0.9	1.6	10.6
Middle Lagarto	0.3	2.7	1.2	1.6	1.3	7.2	0.2	1.3	0.6	0.8	0.7	3.5
Lower Lagarto	2.8	16.3	6.4	21.7	22.8	69.9	1.4	9.9	3.2	12.9	11.5	38.8
Oakville	7.8	52.5	8.3	32.8	26.1	127.5	4.6	29.5	4.0	17.6	14.3	70.0
Catahoula	3.3	27.9	35.7	21.2	63.2	151.3	1.2	10.6	13.6	8.4	24.1	57.9
Total	14.5	199.7	56.2	123.5	119.3	513.1	7.6	105.9	23.3	66.2	53.2	256.2
Texana GCD												
Beaumont	-	1.4	0.6	2.0	-	4.1	-	0.8	0.5	1.5	-	2.8
Lissie	-	4.3	0.7	2.2	0.0	7.3	-	2.4	0.4	1.2	0.0	4.0
Willis	-	4.7	1.3	2.8	0.2	8.9	-	3.4	0.8	1.8	0.1	6.0
Upper Goliad	0.1	1.7	0.6	0.9	1.3	4.5	0.0	0.9	0.3	0.4	0.5	2.1
Lower Goliad	0.2	0.5	0.5	0.8	1.3	3.4	0.1	0.3	0.2	0.4	0.7	1.6
Upper Lagarto	0.1	0.1	2.1	0.8	0.6	3.6	0.0	0.0	0.6	0.2	0.2	1.1
Middle Lagarto	0.0	0.0	2.5	0.8	0.6	4.0	0.0	0.0	0.7	0.2	0.2	1.1
Lower Lagarto	0.8	0.0	12.5	2.7	6.7	22.7	0.1	0.0	2.4	0.7	1.2	4.4
Oakville	6.1	0.0	4.6	0.6	24.1	35.4	1.9	0.0	1.5	0.2	7.7	11.3
Catahoula	1.9	-	1.5	0.0	6.8	10.2	0.6	-	0.3	0.0	1.6	2.5
Total	9.2	12.7	26.9	13.7	41.7	104.1	2.8	7.8	7.6	6.6	12.0	36.9

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water sand**	**Fresh-water sand**	**Moderately saline water sand**	**Slightly saline water sand**	**Very saline water sand**	**Grand Total**
Victoria County GCD												
Beaumont	-	0.2	0.1	0.2	-	0.5	-	0.2	0.1	0.1	-	0.4
Lissie	-	2.8	0.2	1.8	0.0	4.8	-	2.0	0.1	1.1	0.0	3.2
Willis	-	3.8	0.2	1.7	0.0	5.7	-	2.0	0.1	0.7	0.0	2.8
Upper Goliad	0.0	2.7	0.1	1.2	0.1	4.1	0.0	1.3	0.0	0.6	0.1	1.9
Lower Goliad	0.0	1.1	0.6	1.6	0.1	3.4	0.0	0.5	0.2	0.7	0.1	1.4
Upper Lagarto	-	0.3	1.9	1.7	0.5	4.3	-	0.1	0.5	0.5	0.1	1.2
Middle Lagarto	-	0.1	0.5	0.3	0.6	1.4	-	0.0	0.2	0.1	0.2	0.5
Lower Lagarto	0.5	0.0	3.4	2.0	16.4	22.3	0.2	0.0	1.3	0.8	6.7	9.1
Oakville	13.8	0.0	4.3	0.6	21.5	40.1	6.3	0.0	1.6	0.2	8.4	16.5
Catahoula	2.2	-	5.5	1.6	22.5	31.8	0.4	-	1.2	0.3	5.0	6.9
Total	16.4	11.1	16.7	12.6	61.6	118.5	7.0	6.0	5.3	5.1	20.5	43.9

Note: GCD = Groundwater Conservation District; UWCD = Underground Water Conservation District; ASRCD = Aquifer Storage and Recovery Conservation District.

Table 12-8. **The volume of fresh, slightly saline, moderately saline, very saline, brine, and total groundwater in the Gulf Coast Aquifer calculated using porosity by groundwater conservation district and formation.**

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	Brine water	Fresh-water	Moderately saline water	Slightly saline water	Very saline water	Grand Total	Brine water	Fresh-water	Moderately saline water	Slightly saline water	Very saline water	Total
Aransas County GCD												
Beaumont	0.0	1.9	1.4	21.0	2.2	26.6	0.0	1.4	1.0	15.3	1.6	19.3
Lissie	0.4	1.9	2.2	20.0	6.5	30.9	0.2	0.9	1.1	8.2	3.6	14.0
Willis	0.7	3.7	11.9	13.4	9.4	39.1	0.3	1.3	4.0	4.5	3.3	13.4
Upper Goliad	7.2	4.7	18.0	16.5	98.8	145.2	3.0	2.1	8.0	7.2	40.6	60.9
Lower Goliad	4.2	0.0	9.3	0.5	75.6	89.5	1.5	0.0	3.3	0.2	26.7	31.6
Upper Lagarto	3.3	0.0	16.0	1.0	58.7	79.0	0.7	0.0	3.6	0.2	13.1	17.7
Middle Lagarto	0.7	-	8.3	-	46.3	55.3	0.2	-	1.3	-	9.8	11.3
Lower Lagarto	6.6	-	7.0	-	60.3	74.0	2.1	-	1.5	-	17.9	21.6
Oakville	22.9	-	5.0	-	101.3	129.1	8.2	-	1.4	-	38.3	48.0
Total	46.0	12.2	79.2	72.4	459.0	668.7	16.2	5.6	25.2	35.7	155.0	237.6
Bee GCD												
Beaumont	-	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0
Lissie	-	1.9	0.0	2.5	0.1	4.5	-	1.7	0.0	2.2	0.0	4.0
Willis	-	2.6	0.1	2.5	0.0	5.2	-	1.2	0.0	1.1	0.0	2.4
Upper Goliad	-	27.9	4.6	38.3	1.6	72.3	-	14.9	2.4	20.5	0.8	38.6
Lower Goliad	-	12.8	9.6	17.3	3.2	43.0	-	7.5	4.1	9.4	1.2	22.2
Upper Lagarto	0.0	3.5	17.6	19.8	12.7	53.5	0.0	1.4	6.4	7.8	4.3	20.0
Middle Lagarto	0.0	4.2	12.5	26.4	24.6	67.8	0.0	2.0	5.6	11.9	12.6	32.0
Lower Lagarto	0.0	1.6	15.3	44.3	27.9	89.0	0.0	0.7	6.5	19.5	9.1	35.8
Oakville	1.0	0.6	50.0	18.9	71.7	142.3	0.4	0.2	15.1	6.1	23.4	45.2
Catahoula	-	-	160.5	1.7	84.4	246.6	-	-	38.2	0.4	15.8	54.4
Total	1.0	55.1	270.3	171.7	226.2	724.2	0.4	29.5	78.5	79.0	67.2	254.6
Bluebonnet GCD												
Beaumont	-	0.3	0.0	0.0	-	0.3	-	0.2	0.0	0.0	-	0.3
Lissie	-	4.3	0.1	2.3	0.2	6.9	-	3.6	0.1	1.7	0.2	5.6
Willis	-	27.6	0.1	10.7	0.1	38.4	-	20.1	0.1	7.7	0.1	27.9
Upper Goliad	-	13.2	0.1	1.8	0.0	15.2	-	8.8	0.1	1.0	0.0	10.0
Lower Goliad	-	15.6	0.1	12.3	0.0	28.1	-	8.9	0.1	6.6	0.0	15.6

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Lagarto	-	40.6	5.5	42.5	0.1	88.8	-	18.2	2.4	18.3	0.1	39.0
Middle Lagarto	-	41.3	17.4	68.3	1.0	128.0	-	22.7	6.9	30.1	0.3	60.0
Lower Lagarto	-	52.2	19.3	97.1	0.6	169.2	-	25.4	7.2	43.3	0.2	76.1
Oakville	0.0	21.2	25.2	101.1	2.0	149.4	0.0	10.2	10.3	47.6	0.7	68.9
Catahoula	0.3	45.4	191.7	314.5	118.7	670.7	0.1	20.5	71.0	124.8	37.3	253.7
Total	0.3	261.7	259.5	650.7	122.8	1,295.0	0.1	138.6	98.1	281.4	38.8	557.0
Brazoria County GCD												
Beaumont	-	67.2	1.4	96.9	-	165.5	0.0	43.1	0.9	61.2	0.0	105.2
Lissie	0.0	58.6	17.7	76.8	3.8	156.9	0.0	37.6	11.2	47.1	2.3	98.3
Willis	10.4	41.0	25.5	21.8	37.8	136.6	5.8	28.6	15.7	14.4	23.2	87.7
Upper Goliad	95.6	23.3	15.0	32.7	178.0	344.5	49.3	14.2	8.9	19.8	94.6	186.8
Lower Goliad	105.7	7.6	10.9	17.1	154.0	295.2	40.9	3.4	4.7	7.9	59.0	115.9
Upper Lagarto	105.9	4.9	4.5	13.6	122.7	251.6	48.7	1.8	1.6	5.8	51.7	109.7
Middle Lagarto	67.8	2.2	15.0	10.3	146.9	242.3	30.6	0.5	3.5	2.3	52.9	89.8
Lower Lagarto	86.8	6.0	17.9	27.7	207.9	346.2	30.7	2.5	4.8	10.2	62.6	110.7
Oakville	102.1	3.7	4.9	10.5	316.6	437.8	40.8	1.3	1.6	3.9	127.1	174.7
Total	574.2	214.6	112.7	307.5	1,167.6	2,376.7	246.8	133.1	52.9	172.4	473.5	1078.8
Brazos County GCD												
Lower Lagarto	-	0.0	0.0	0.1	-	0.1	0.0	0.0	0.0	0.1	0.0	0.1
Oakville	-	0.0	0.0	0.5	-	0.5	0.0	0.0	0.0	0.3	0.0	0.3
Catahoula	-	1.5	1.2	3.8	0.1	6.6	0.0	0.7	0.5	1.7	0.0	2.9
Total	-	1.5	1.3	4.4	0.1	7.2	0.0	0.7	0.6	2.1	0.0	3.3
Brush Country GCD												
Beaumont	0.0	0.0	0.1	0.2	0.1	0.4	0.0	0.0	0.0	0.1	0.1	0.3
Lissie	0.0	0.5	2.6	3.5	0.7	7.3	0.0	0.3	1.5	2.0	0.4	4.2
Willis	-	4.0	1.2	3.5	0.1	8.9	0.0	2.7	0.7	1.9	0.1	5.3
Upper Goliad	-	86.6	20.1	106.3	4.1	217.1	0.0	44.0	10.1	55.8	2.0	112.0
Lower Goliad	0.0	25.3	52.4	56.4	11.4	145.6	0.0	10.4	18.7	21.0	4.0	54.0
Upper Lagarto	0.0	17.9	57.2	93.3	11.3	179.8	0.0	5.4	20.9	36.3	4.5	67.1
Middle Lagarto	-	32.0	56.9	91.6	7.9	188.4	0.0	14.2	20.7	36.0	3.0	74.0
Lower Lagarto	0.0	15.5	68.4	131.9	20.4	236.1	0.0	6.3	26.0	59.3	7.4	99.0
Oakville	0.0	11.7	152.7	104.5	38.0	306.9	0.0	4.4	52.0	42.6	11.1	110.0

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Catahoula	-	15.0	509.5	360.1	56.4	941.0	0.0	5.5	172.5	126.5	19.2	323.7
Total	0.1	208.5	921.1	951.4	150.6	2,231.6	0.0	93.2	323.0	381.4	51.8	849.5
Calhoun County GCD												
Beaumont	-	7.4	8.3	36.5	0.1	52.2	0.0	5.0	5.3	24.8	0.1	35.3
Lissie	0.0	13.5	12.6	46.3	0.9	73.2	0.0	6.8	5.8	21.7	0.4	34.8
Willis	0.0	4.5	29.1	23.5	22.4	79.5	0.0	1.7	11.5	9.1	9.1	31.4
Upper Goliad	39.2	9.0	12.9	26.7	178.0	265.8	15.6	4.2	5.4	11.9	73.0	110.1
Lower Goliad	22.5	0.1	25.5	5.0	116.8	169.8	10.2	0.0	9.4	1.8	46.4	67.9
Upper Lagarto	4.5	0.0	43.5	1.2	105.0	154.2	1.5	0.0	12.9	0.4	31.6	46.3
Middle Lagarto	7.0	0.0	21.6	1.7	82.2	112.6	1.5	0.0	5.0	0.3	18.4	25.3
Lower Lagarto	49.5	-	25.2	0.4	77.5	152.7	15.8	0.0	5.8	0.1	22.0	43.6
Oakville	87.6	-	4.4	0.2	166.0	258.2	42.0	0.0	1.7	0.1	74.1	117.9
Total	210.3	34.6	183.1	141.4	748.9	1,318.3	86.7	17.8	62.8	70.2	275.0	512.5
Coastal Bend GCD												
Beaumont	-	16.3	1.6	5.0	-	22.9	0.0	10.8	1.2	3.2	0.0	15.3
Lissie	-	47.8	0.7	5.6	1.0	55.1	0.0	34.9	0.6	3.8	0.8	40.2
Willis	-	61.3	1.2	5.5	0.7	68.7	0.0	49.0	1.0	4.0	0.6	54.6
Upper Goliad	0.4	112.2	6.4	21.1	6.8	146.9	0.2	70.8	3.7	12.7	3.9	91.3
Lower Goliad	1.4	43.5	11.3	51.4	18.0	125.6	0.7	23.6	5.8	27.5	8.7	66.4
Upper Lagarto	1.4	8.0	39.0	60.4	18.3	127.1	0.5	2.9	12.5	21.1	5.9	43.0
Middle Lagarto	0.6	2.7	66.5	50.8	11.7	132.2	0.1	1.1	18.5	15.7	2.7	38.1
Lower Lagarto	2.4	10.0	68.7	74.6	36.0	191.8	0.5	2.0	16.3	17.4	7.2	43.4
Oakville	8.2	5.3	19.4	22.1	152.1	207.0	3.4	2.3	8.4	8.8	68.4	91.4
Catahoula	6.6	-	23.2	10.8	104.8	145.4	1.5	0.0	6.4	3.0	25.0	35.9
Total	20.9	307.1	238.0	307.2	349.5	1,222.8	7.0	197.5	74.4	117.3	123.3	519.5
Coastal Plains GCD												
Beaumont	-	80.9	1.9	69.7	-	152.5	0.0	51.3	1.2	45.8	0.0	98.2
Lissie	-	57.2	14.1	56.6	0.6	128.4	0.0	35.0	7.7	32.4	0.3	75.5
Willis	2.6	23.5	19.8	27.1	32.6	105.5	1.9	15.2	13.2	18.5	20.8	69.6
Upper Goliad	76.8	15.9	47.3	12.5	237.1	389.6	31.8	8.9	22.1	6.9	105.7	175.3
Lower Goliad	52.0	0.1	24.2	0.8	162.1	239.2	22.6	0.1	10.9	0.4	71.3	105.2
Upper Lagarto	52.5	0.0	34.1	5.4	151.9	243.9	24.8	0.0	13.6	1.8	69.3	109.5

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Middle Lagarto	69.3	-	36.6	9.0	133.7	248.7	34.3	0.0	10.5	1.9	55.9	102.5
Lower Lagarto	97.3	3.3	33.8	21.0	94.8	250.2	54.9	0.5	8.8	9.1	31.5	104.8
Oakville	84.3	10.5	7.3	34.8	308.5	445.4	46.6	4.7	3.8	22.3	177.9	255.3
Total	434.7	191.4	218.9	237.0	1,121.3	2,203.3	216.8	115.7	91.7	139.0	532.8	1095.9
Colorado County GCD												
Beaumont	-	0.0	0.0	0.0	-	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Lissie	-	5.9	0.0	0.4	0.0	6.4	0.0	5.5	0.0	0.4	0.0	5.9
Willis	-	24.2	0.0	6.3	0.0	30.5	0.0	19.1	0.0	4.9	0.0	24.0
Upper Goliad	-	14.5	0.0	2.4	0.0	16.9	0.0	8.6	0.0	1.4	0.0	10.1
Lower Goliad	-	29.7	0.2	13.2	0.0	43.2	0.0	16.2	0.1	7.3	0.0	23.6
Upper Lagarto	-	24.9	4.0	44.8	0.0	73.8	0.0	12.2	1.8	21.5	0.0	35.5
Middle Lagarto	-	19.6	19.1	37.9	1.7	78.4	0.0	7.3	6.7	13.3	0.6	27.9
Lower Lagarto	-	17.5	30.2	60.1	0.6	108.4	0.0	5.3	9.0	17.8	0.2	32.2
Oakville	0.0	3.1	30.9	68.1	5.2	107.2	0.0	1.3	11.5	25.7	2.3	40.7
Catahoula	0.0	0.1	86.7	56.7	70.1	213.6	0.0	0.0	23.6	16.9	17.6	58.2
Total	0.0	139.7	171.2	290.1	77.6	678.6	0.0	75.5	52.8	109.1	20.7	258.1
Corpus Christi ASRCD												
Beaumont	0.2	0.4	6.0	12.7	9.9	29.2	0.2	0.3	4.5	9.4	7.2	21.5
Lissie	2.0	1.5	10.9	7.7	13.7	35.9	1.3	1.0	7.0	4.9	9.0	23.3
Willis	7.6	1.4	10.1	2.9	17.3	39.3	2.5	0.5	3.4	1.0	5.6	12.9
Upper Goliad	15.1	0.1	15.5	2.7	129.5	162.9	7.3	0.1	7.6	1.3	65.4	81.7
Lower Goliad	4.2	-	1.2	-	71.5	76.9	1.5	0.0	0.5	0.0	28.0	30.0
Upper Lagarto	8.1	-	1.2	0.0	68.7	78.0	1.4	0.0	0.2	0.0	13.4	15.1
Middle Lagarto	12.8	-	3.4	-	50.4	66.6	4.6	0.0	0.9	0.0	14.5	20.1
Lower Lagarto	6.0	-	1.8	-	57.7	65.5	1.9	0.0	0.7	0.0	22.3	25.0
Oakville	9.7	-	8.1	0.1	95.1	113.1	5.3	0.0	4.1	0.0	51.2	60.7
Catahoula	-	-	0.0	0.0	0.9	1.0	0.0	0.0	0.0	0.0	0.6	0.6
Total	65.7	3.4	58.3	26.0	514.8	668.3	26.1	1.8	29.1	16.6	217.1	290.8
Duval County GCD												
Lissie	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Upper Goliad	-	35.2	2.7	26.2	0.1	64.2	0.0	21.4	1.5	16.2	0.1	39.3
Lower Goliad	-	6.2	25.7	30.1	2.1	64.0	0.0	2.3	10.7	13.3	0.9	27.2

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Lagarto	-	9.7	24.3	31.1	1.1	66.2	0.0	3.1	7.6	10.2	0.4	21.2
Middle Lagarto	-	7.6	21.0	29.5	0.8	58.9	0.0	3.4	9.2	12.6	0.3	25.5
Lower Lagarto	-	1.6	66.9	73.5	8.3	150.3	0.0	0.6	21.8	26.8	2.7	51.8
Oakville	-	2.7	91.9	89.6	11.1	195.4	0.0	1.0	31.1	29.5	3.6	65.3
Catahoula	-	0.2	186.6	77.1	29.9	293.8	0.0	0.1	53.0	22.6	8.3	83.9
Total	-	63.1	419.1	357.1	53.4	892.8	0.0	31.8	134.9	131.3	16.3	314.2
Evergreen UWCD												
Middle Lagarto	-	0.2	0.0	0.7	-	0.9	0.0	0.1	0.0	0.3	0.0	0.4
Lower Lagarto	-	2.7	1.1	6.8	0.0	10.5	0.0	1.2	0.5	3.1	0.0	4.8
Oakville	-	3.6	5.0	23.3	0.6	32.5	0.0	1.4	1.9	9.0	0.2	12.5
Catahoula	0.2	-	65.7	36.9	6.4	109.3	0.1	0.0	21.8	12.6	2.1	36.5
Total	0.2	6.5	71.8	67.7	7.0	153.2	0.1	2.7	24.2	25.0	2.3	54.3
Fayette County GCD												
Middle Lagarto	-	0.6	0.1	0.2	0.0	0.9	0.0	0.2	0.0	0.1	0.0	0.4
Lower Lagarto	-	4.1	2.8	5.1	0.0	11.9	0.0	1.5	1.0	1.8	0.0	4.4
Oakville	-	0.4	4.7	9.0	0.2	14.3	0.0	0.2	1.8	3.6	0.1	5.6
Catahoula	-	2.3	13.7	35.0	2.5	53.6	0.0	0.9	4.9	12.6	0.9	19.2
Total	-	7.3	21.2	49.4	2.8	80.7	0.0	2.8	7.7	18.1	1.0	29.6
Fort Bend Subsidence District												
Beaumont	-	6.6	0.3	2.4	-	9.3	0.0	5.3	0.2	1.8	0.0	7.3
Lissie	-	54.8	0.6	11.0	2.4	68.8	0.0	42.2	0.5	8.3	2.0	53.0
Willis	-	42.1	1.2	9.5	1.7	54.5	0.0	33.1	0.8	7.5	1.0	42.5
Upper Goliad	0.5	64.9	5.4	33.7	4.7	109.3	0.3	45.5	3.3	23.6	3.1	75.9
Lower Goliad	5.1	31.0	17.2	49.2	7.7	110.3	2.1	15.1	8.0	24.2	3.1	52.5
Upper Lagarto	6.1	11.9	32.9	37.5	16.5	104.9	2.1	4.5	10.8	12.7	5.5	35.6
Middle Lagarto	2.6	3.9	58.6	36.2	16.4	117.7	0.5	1.1	16.7	10.7	3.5	32.5
Lower Lagarto	6.9	4.5	48.6	56.6	25.8	142.5	1.1	1.5	13.9	16.3	6.2	39.0
Oakville	31.8	4.0	9.9	14.8	80.9	141.5	12.8	1.4	4.1	6.0	35.0	59.3
Catahoula	7.2	-	23.2	6.3	83.3	120.0	2.1	0.0	9.8	2.5	31.0	45.5
Total	60.3	223.8	197.9	257.3	239.4	978.7	21.1	149.7	68.1	113.5	90.4	442.9
Goliad County GCD												
Lissie	-	2.2	0.0	1.2	-	3.5	0.0	1.8	0.0	1.0	0.0	2.8

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Willis	-	0.8	0.0	1.7	0.0	2.5	0.0	0.3	0.0	0.6	0.0	0.9
Upper Goliad	-	45.0	0.5	8.5	0.4	54.5	0.0	24.8	0.3	4.6	0.2	29.9
Lower Goliad	-	30.9	2.7	21.5	0.9	56.0	0.0	13.2	1.0	9.1	0.3	23.7
Upper Lagarto	-	21.5	9.7	52.9	4.0	88.1	0.0	8.7	3.4	22.3	1.1	35.5
Middle Lagarto	-	16.9	14.0	57.3	8.3	96.5	0.0	6.3	5.2	21.3	3.1	35.8
Lower Lagarto	0.1	9.7	14.6	54.8	16.0	95.2	0.0	4.2	6.2	23.7	6.6	40.7
Oakville	6.5	4.6	48.6	18.5	56.3	134.4	2.6	1.7	17.0	6.6	22.0	50.0
Catahoula	0.0	-	151.9	20.0	102.5	274.4	0.0	0.0	40.0	4.7	24.5	69.2
Total	6.6	131.6	242.1	236.4	188.4	805.2	2.7	61.0	73.1	93.9	57.9	288.5
Harris-Galveston Coastal Subsidence District												
Beaumont	-	15.3	8.4	78.7	0.1	102.6	0.0	11.1	5.9	54.7	0.1	71.8
Lissie	2.4	161.7	16.3	71.7	3.7	255.8	1.7	115.7	10.6	50.4	2.2	180.7
Willis	1.7	108.7	26.3	60.6	48.1	245.5	1.0	77.2	16.8	41.0	30.5	166.5
Upper Goliad	51.4	19.0	20.2	14.9	90.8	196.3	26.7	9.8	10.4	7.1	45.4	99.4
Lower Goliad	72.0	102.2	17.5	70.6	101.3	363.5	30.9	54.1	8.0	35.7	43.8	172.5
Upper Lagarto	62.9	40.7	31.4	88.6	77.4	301.0	31.1	17.8	13.0	39.2	36.2	137.5
Middle Lagarto	30.3	27.4	37.6	108.5	117.1	320.9	11.7	12.8	13.3	42.8	41.2	121.8
Lower Lagarto	69.0	18.3	61.4	105.8	88.7	343.2	27.4	6.9	20.4	37.4	34.1	126.2
Oakville	102.1	10.2	63.0	30.0	191.0	396.3	37.0	4.5	25.9	11.3	70.3	149.0
Catahoula	43.5	0.1	37.5	17.9	268.3	367.3	11.2	0.0	9.3	4.5	67.7	92.8
Total	435.4	503.6	319.5	647.4	986.4	2,892.3	178.6	310.0	133.8	324.2	371.4	1318.0
Kenedy County GCD												
Beaumont	7.5	15.2	33.1	13.0	39.1	107.8	3.6	9.5	20.2	7.5	21.4	62.2
Lissie	0.7	13.7	31.6	27.4	59.0	132.5	0.2	6.6	15.8	13.9	23.8	60.3
Willis	0.2	23.5	60.7	92.5	42.2	219.1	0.1	12.0	25.1	41.5	14.5	93.2
Upper Goliad	2.0	156.4	195.6	293.8	190.2	838.0	0.8	69.1	81.9	127.1	79.7	358.6
Lower Goliad	20.8	8.5	132.8	69.1	286.5	517.6	8.6	2.7	47.3	22.6	102.3	183.5
Upper Lagarto	1.5	5.1	141.6	53.7	277.9	479.9	0.5	1.9	58.2	22.3	111.5	194.5
Middle Lagarto	11.3	4.6	94.0	28.2	249.6	387.5	5.5	2.2	43.5	13.3	98.9	163.3
Lower Lagarto	31.1	0.8	68.1	48.9	307.7	456.7	14.8	0.4	31.6	25.3	146.0	218.2
Oakville	29.1	0.2	190.0	15.5	464.1	698.9	15.5	0.1	77.6	5.8	225.5	324.4
Catahoula	-	-	92.5	30.2	24.0	146.7	0.0	0.0	28.6	9.2	9.0	46.8

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Total	104.2	227.9	1,040.0	672.4	1,940.4	3,984.8	49.7	104.5	429.8	288.4	832.5	1705.0
Live Oak UWCD												
Upper Goliad	-	6.9	0.2	4.3	0.1	11.4	0.0	4.6	0.1	2.9	0.0	7.6
Lower Goliad	-	5.7	1.1	7.7	0.1	14.6	0.0	3.8	0.5	4.3	0.0	8.6
Upper Lagarto	-	0.8	4.2	8.8	1.0	14.9	0.0	0.4	2.1	5.1	0.5	8.2
Middle Lagarto	-	1.2	2.3	7.9	1.1	12.4	0.0	0.5	0.8	2.7	0.3	4.4
Lower Lagarto	-	2.7	20.9	33.3	7.1	64.0	0.0	1.3	9.8	16.3	3.2	30.6
Oakville	-	11.0	51.5	19.4	25.8	107.7	0.0	3.8	16.5	6.7	9.0	36.1
Catahoula	-	-	191.8	5.7	55.6	253.1	0.0	0.0	54.3	1.8	15.1	71.1
Total	-	28.3	271.9	87.0	90.8	478.1	0.0	14.5	84.2	39.8	28.1	166.6
Lone Star GCD												
Lissie	-	11.9	1.4	2.2	0.0	15.5	0.0	9.9	1.2	1.8	0.0	12.9
Willis	-	31.1	0.0	14.1	0.0	45.2	0.0	21.1	0.0	8.9	0.0	30.0
Upper Goliad	-	0.1	0.0	0.0	-	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Lower Goliad	-	28.3	3.8	20.0	0.0	52.2	0.0	14.4	1.8	10.1	0.0	26.3
Upper Lagarto	-	39.9	9.2	23.4	0.3	72.7	0.0	20.5	4.4	11.9	0.1	37.0
Middle Lagarto	-	47.9	16.3	39.5	0.1	103.8	0.0	29.4	8.7	22.4	0.1	60.5
Lower Lagarto	-	25.9	17.0	37.6	0.6	81.1	0.0	12.4	6.5	18.3	0.2	37.4
Oakville	0.4	9.8	35.1	62.7	8.8	116.8	0.2	4.6	14.8	29.7	3.9	53.3
Catahoula	14.1	17.1	129.0	125.3	93.4	379.0	3.8	5.4	37.4	37.6	25.0	109.2
Total	14.5	212.0	211.8	325.0	103.2	866.4	4.0	117.9	74.7	140.7	29.3	366.7
Lower Trinity GCD												
Lissie	-	3.2	0.1	0.2	-	3.5	0.0	2.6	0.0	0.2	0.0	2.9
Willis	-	15.3	0.7	18.8	-	34.8	0.0	9.4	0.4	11.8	0.0	21.6
Upper Goliad							0.0	1.2	0.1	1.0	0.0	2.3
Lower Goliad	-	2.5	0.1	1.9	-	4.5	0.0	5.5	1.1	2.7	0.0	9.3
Upper Lagarto	-	9.9	2.0	5.3	0.0	17.3	0.0	12.7	4.3	18.8	0.1	35.9
Middle Lagarto	-	24.4	8.6	36.6	0.2	69.7	0.0	15.2	15.2	27.8	0.1	58.3
Lower Lagarto	-	29.2	29.9	54.1	0.2	113.3	0.0	4.7	27.5	26.2	1.2	59.6
Oakville	0.0	9.2	60.2	53.4	2.9	125.6	2.8	4.9	82.2	51.8	51.3	193.0
Catahoula	8.1	11.7	217.9	130.3	148.5	516.4	0.0	2.6	0.0	0.2	0.0	2.9

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Total	8.1	105.3	319.3	300.6	151.7	885.1	2.8	56.2	130.8	140.3	52.7	382.9
McMullen GCD												
Lower Lagarto	-	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Oakville	-	0.5	2.0	3.3	0.0	5.8	0.0	0.2	0.6	1.0	0.0	1.8
Catahoula	-	-	49.1	7.2	5.4	61.8	0.0	0.0	15.6	2.4	1.7	19.7
Total	-	0.5	51.1	10.6	5.5	67.6	0.0	0.2	16.2	3.4	1.7	21.5
Pecan Valley GCD												
Lissie	-	0.2	0.0	0.0	-	0.3	0.0	0.2	0.0	0.0	0.0	0.2
Willis	-	1.1	-	0.1	-	1.2	0.0	1.0	0.0	0.0	0.0	1.1
Upper Goliad	-	2.3	0.0	0.1	-	2.5	0.0	1.6	0.0	0.1	0.0	1.8
Lower Goliad	-	9.0	0.0	2.7	-	11.8	0.0	5.4	0.0	1.6	0.0	7.0
Upper Lagarto	-	16.2	1.4	12.8	0.0	30.4	0.0	7.1	0.5	6.3	0.0	13.9
Middle Lagarto	-	11.4	3.1	28.8	0.0	43.3	0.0	3.8	1.0	9.8	0.0	14.7
Lower Lagarto	-	29.2	8.0	30.3	0.8	68.2	0.0	10.9	2.7	10.4	0.3	24.2
Oakville	0.0	23.2	23.5	40.0	16.2	102.8	0.0	10.3	8.9	18.1	5.4	42.7
Catahoula	9.7	0.0	94.1	50.7	72.7	227.3	4.2	0.0	32.5	18.9	24.0	79.6
Total	9.7	92.6	130.0	165.5	89.8	487.7	4.2	40.3	45.7	65.3	29.7	185.1
Refugio GCD												
Beaumont	-	3.4	1.0	7.8	0.5	12.7	0.0	2.3	0.7	5.0	0.4	8.4
Lissie	-	9.7	0.4	23.8	0.6	34.5	0.0	5.7	0.2	13.4	0.4	19.7
Willis	-	14.8	2.0	30.6	1.1	48.6	0.0	5.4	0.7	11.3	0.4	17.8
Upper Goliad	1.1	50.2	46.5	81.6	27.1	206.5	0.5	24.6	22.6	39.5	12.7	99.9
Lower Goliad	0.2	2.3	32.7	15.6	44.7	95.5	0.1	0.9	11.3	5.9	15.7	33.9
Upper Lagarto	2.6	0.9	24.4	3.1	77.7	108.6	0.6	0.2	6.3	0.9	20.2	28.2
Middle Lagarto	0.0	0.3	5.4	0.8	72.9	79.4	0.0	0.1	2.0	0.3	28.8	31.3
Lower Lagarto	12.7	0.0	2.8	1.6	87.6	104.7	4.7	0.0	1.0	0.6	32.4	38.8
Oakville	48.8	-	3.3	0.0	125.2	177.4	20.5	0.0	1.2	0.0	48.0	69.7
Catahoula	0.0	-	20.6	2.0	73.5	96.2	0.0	0.0	3.3	0.3	12.8	16.4
Total	65.4	81.6	139.1	166.9	511.1	964.1	26.4	39.2	49.4	77.3	171.7	363.9
San Patricio County GCD												
Beaumont	0.0	0.6	0.8	4.9	2.1	8.4	0.0	0.4	0.6	3.7	1.6	6.3
Lissie	0.1	7.2	2.5	10.8	3.9	24.5	0.1	5.1	1.6	6.9	2.4	16.1
Willis	0.3	10.0	9.0	10.4	6.7	36.3	0.1	4.6	3.4	5.2	2.3	15.6

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Upper Goliad	3.3	11.6	42.7	54.4	65.5	177.5	1.6	6.7	21.6	28.8	31.8	90.5
Lower Goliad	0.8	0.2	12.3	4.1	65.3	82.7	0.2	0.1	3.7	1.4	22.8	28.2
Upper Lagarto	3.5	0.0	7.1	1.2	76.9	88.8	0.9	0.0	2.6	0.5	25.9	29.9
Middle Lagarto	3.9	0.0	1.5	0.7	71.9	77.9	1.3	0.0	0.6	0.2	29.0	31.2
Lower Lagarto	2.1	0.0	11.0	0.9	81.4	95.5	0.8	0.0	2.8	0.2	27.0	30.8
Oakville	20.8	-	13.1	0.9	123.7	158.5	9.2	0.0	5.3	0.4	44.8	59.6
Catahoula	-	-	24.2	0.8	50.7	75.7	0.0	0.0	5.8	0.2	17.7	23.6
Total	34.9	29.6	124.1	89.2	548.1	825.8	14.3	16.8	48.0	47.5	205.2	331.8
Southeast Texas GCD												
Beaumont	-	1.3	0.1	1.9	0.0	3.4	0.0	0.6	0.1	1.2	0.0	1.9
Lissie	0.0	139.8	1.7	30.5	0.1	172.1	0.0	96.9	1.2	21.5	0.0	119.7
Willis	0.1	182.5	6.0	71.0	5.5	265.1	0.0	100.6	3.1	40.1	2.6	146.4
Upper Goliad	2.6	7.2	8.7	14.4	13.9	46.8	1.0	2.7	3.4	5.8	5.3	18.1
Lower Goliad	5.7	149.9	40.0	41.9	31.4	268.9	2.3	65.4	17.3	19.5	13.4	117.8
Upper Lagarto	1.6	74.3	16.3	29.9	35.8	157.9	0.9	38.2	8.1	13.0	19.5	79.8
Middle Lagarto	10.7	79.6	46.7	59.5	53.4	249.9	6.0	40.5	23.9	29.2	27.0	126.5
Lower Lagarto	18.0	98.5	39.8	104.9	144.9	406.0	9.0	59.1	19.2	58.6	72.3	218.1
Oakville	41.6	115.0	41.0	75.0	121.8	394.4	25.0	65.0	18.3	37.8	66.7	212.9
Catahoula	21.2	109.8	191.5	93.1	357.0	772.6	8.0	43.6	72.3	37.4	135.9	297.2
Total	101.5	957.8	391.9	522.1	763.8	2,737.0	52.2	512.7	166.9	263.9	342.7	1338.4
Texana GCD												
Beaumont	-	10.2	4.5	14.9	-	29.6	0.0	6.0	3.4	10.8	0.0	20.2
Lissie	-	28.9	4.4	14.2	0.1	47.7	0.0	16.3	2.2	7.8	0.1	26.4
Willis	-	27.5	6.4	15.3	1.0	50.2	0.0	19.8	3.9	9.9	0.4	34.0
Upper Goliad	2.5	58.1	18.2	31.6	37.3	147.8	0.9	30.6	8.1	15.1	15.0	69.7
Lower Goliad	5.1	17.9	15.9	26.5	33.8	99.3	2.5	8.8	7.4	12.5	16.3	47.6
Upper Lagarto	0.9	4.6	55.5	25.6	14.0	100.5	0.3	1.4	15.5	7.2	3.8	28.2
Middle Lagarto	1.1	0.6	55.8	22.6	20.7	100.9	0.2	0.2	14.5	5.3	4.6	24.8
Lower Lagarto	3.5	0.0	64.5	15.1	34.5	117.5	0.6	0.0	12.1	3.6	6.0	22.4
Oakville	27.5	0.0	22.6	3.2	116.9	170.3	8.4	0.0	7.7	1.2	37.3	54.6
Catahoula	6.8	-	7.1	0.1	31.2	45.2	2.1	0.0	1.6	0.0	7.2	11.0
Total	47.4	147.9	255.0	169.1	289.5	909.0	15.0	83.1	76.4	73.6	90.7	338.8

	Total Volume (Millions of Acre-Feet)						Total Volume in Sand (Millions of Acre-Feet)					
Formation	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Grand Total**	**Brine water**	**Fresh-water**	**Moderately saline water**	**Slightly saline water**	**Very saline water**	**Total**
Victoria County GCD												
Beaumont	-	1.7	0.8	1.4	-	3.9	0.0	1.3	0.6	1.1	0.0	3.0
Lissie	-	20.5	1.3	12.6	0.0	34.5	0.0	14.4	0.8	7.6	0.0	22.8
Willis	-	24.9	1.3	10.8	0.1	37.1	0.0	13.1	0.6	4.7	0.0	18.3
Upper Goliad	0.0	92.4	2.5	39.9	4.2	139.0	0.0	43.2	1.1	19.1	1.9	65.4
Lower Goliad	0.0	24.9	18.3	48.8	3.4	95.4	0.0	10.9	7.2	19.9	1.4	39.4
Upper Lagarto	-	6.7	48.2	32.5	15.0	102.5	0.0	2.0	12.6	9.0	3.9	27.5
Middle Lagarto	-	4.6	27.0	15.9	33.8	81.2	0.0	1.6	10.2	5.8	11.2	28.7
Lower Lagarto	2.3	0.2	18.4	11.3	68.8	100.9	0.9	0.1	7.3	4.4	28.5	41.1
Oakville	50.8	0.0	19.4	3.5	92.6	166.3	23.1	0.0	6.7	1.1	35.5	66.6
Catahoula	7.0	-	20.8	4.6	92.4	124.8	1.5	0.0	4.8	1.0	21.4	28.6
Total	60.1	175.8	158.0	181.4	310.3	885.7	25.5	86.5	51.9	73.6	103.9	341.5

Note: GCD = Groundwater Conservation District; UWCD = Underground Water Conservation District; ASRCD = Aquifer Storage and Recovery Conservation District.

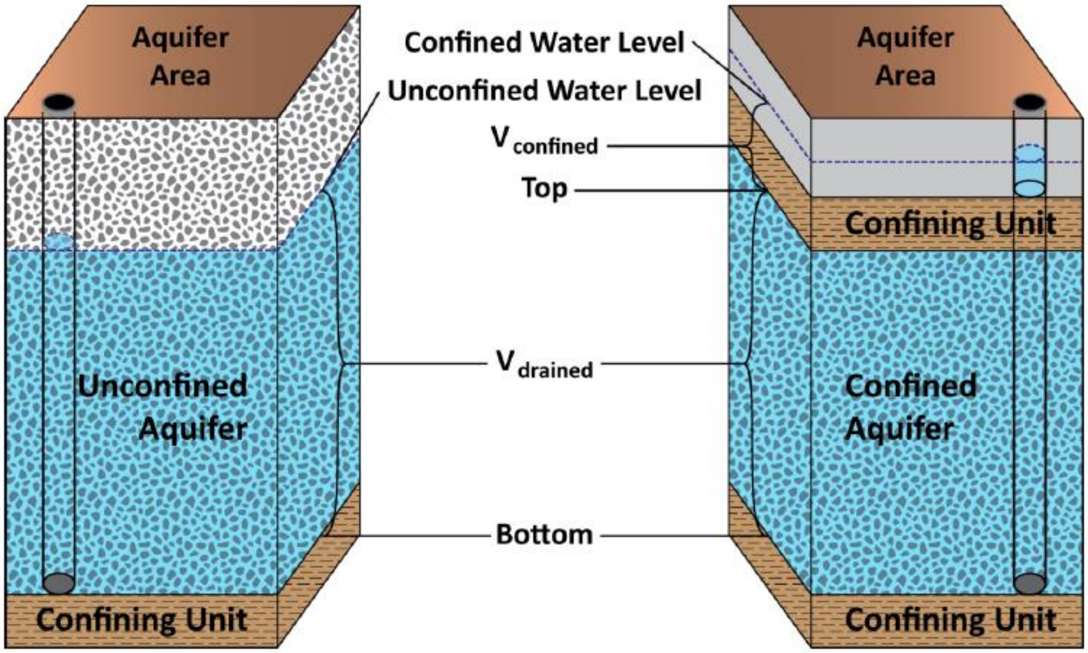

Figure 12-1. Schematic graph showing the difference between unconfined and confined aquifers (from Jigmond and Wade, 2013).

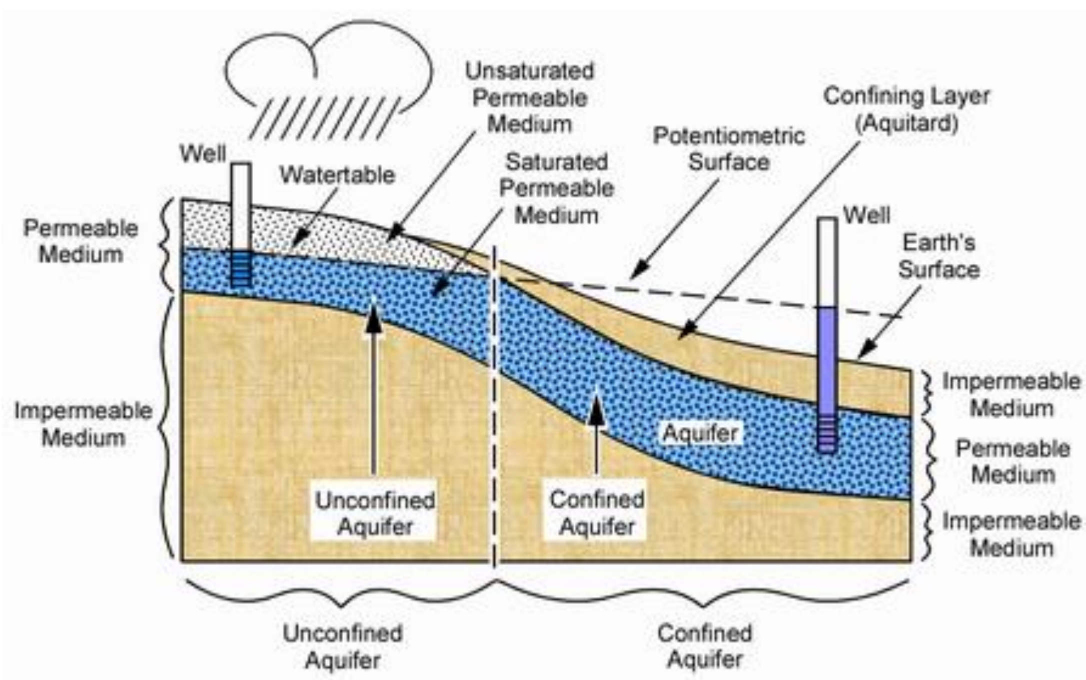

Figure 12-2. Schematic of aquifer transitioning from unconfined in outcrop region, where recharge from precipitation occurs, to confined conditions in the down dip regions of the aquifer (from http://www.geo.brown.edu/research/Hydrology/ge58_IntrodHydrology/ge58_index.htm).

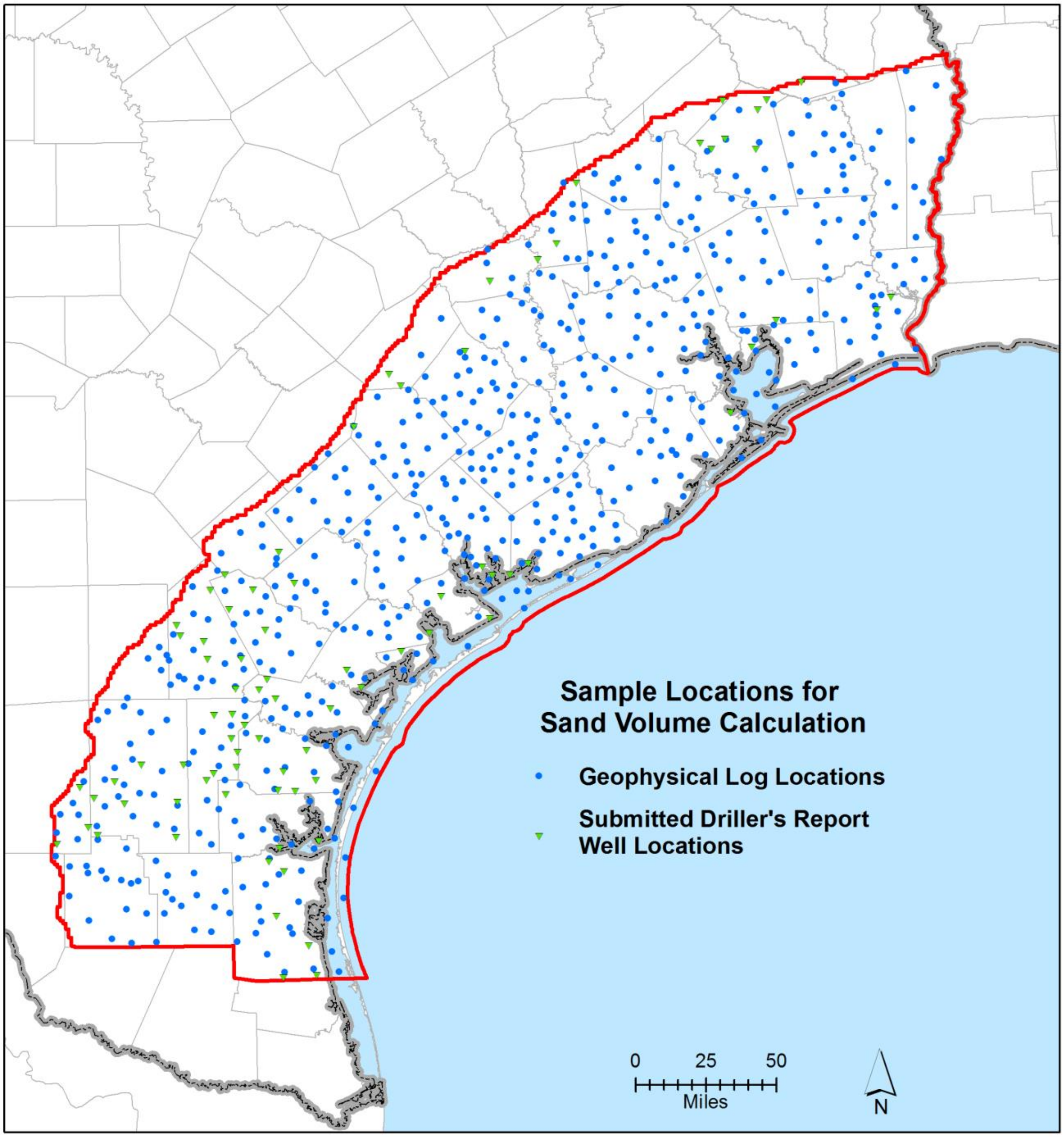

Figure 12-3. **Location of the 880 drillers and 600 geophysical logs used to construct continuous profiles of sand and clay sequences that support calculations of volumes.**

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13 Geophysical Well Log Analysis and Methodology

13.1 Introduction to Total Dissolved solids

13.1.1 Terms

Electrical Conductivity

Electrical conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkalis, chlorides, sulfides and carbonate compounds. Compounds that dissolve into ions are also known as electrolytes. The more ions that are present, the higher the conductivity of water. Likewise, if fewer ions are present in the water, the conductivity of the water will be lower. Distilled or deionized water can act as an insulator due to its very low (if not negligible) conductivity value. Sea water, on the other hand, has a very high conductivity. Ions conduct electricity due to their positive and negative charges. When electrolytes dissolve in water, they split into positively charged (cation) and negatively charged (anion) particles. As the dissolved substances split in water, the concentrations of each positive and negative charge remain equal. This means that even though the conductivity of water increases with added ions, it remains electrically neutral.

Electrical conductivity is usually measured in micro- or millisiemens per centimeter. It can also be reported in micromhos or millimhos/centimeter, though these units are less common. One siemen is equal to one mho. Microsiemens per centimeter is the standard unit for fresh water measurements. Reports on seawater conductivity use micro-, milli- and sometimes even just siemen/mho per centimeter, depending on the publication.

Specific Conductance

Specific conductance is an electrical conductivity measurement made at or corrected to 25 degrees Celsius (77 degrees Fahrenheit). As the temperature of water will affect conductivity readings, reporting conductivity at 25 degrees Celsius allows data to be compared easily. If a conductivity measurement is made at 25 degrees Celsius, it can simply be reported as the specific conductance. If a measurement is made at a different temperature and corrected to 25 degrees Celsius, then the temperature coefficient must be considered. The specific conductance temperature coefficient can range depending on the measured temperature and ionic composition of the water. A coefficient of 0.0191-0.02 is commonly used based on potassium chloride standards. Sodium chloride-based solutions should have a temperature coefficient of 0.02-0.0214.

In an evaluation of specific conductance data obtained from the TWDB groundwater database, Collier (1993) identified several sources of error with reported measured values. As a result of Collier's (1993) findings and in-house reviews conducted by the TWDB, the following caveat is provided by the TWBD regarding specific conductance (TWDB 2016):

> "Analyses run by the Texas Department of Health (TDH) for the TWDB may be inaccurate. (This lab was used by the TWDB in the 1980s and early 1990s.) When

the analytical results were returned from the TDH lab, in many instances the specific conductance values were less than TDS, which is incorrect. Instead, the diluted conductance, as eventually corroborated by the TDH, was the more accurate value. TWDB attempted to switch all the conductivity values in the database, but was not entirely successful, and a few incorrect values still exist.

TDS (mg/L) approximately equals (conductivity x A), where A = 0.46 to 0.76. Waters high in sulfate can be as high as 0.96. The value of A can be determined simply by dividing TDS by conductivity for sampled sites in the surrounding area that have similar hydrologic attributes."

Electrical Resistivity

Electrical resistivity is a measurement of water's opposition to the flow of a current over distance. Electrical resistivity is the reciprocal of conductivity. The standard international unit of electrical resistivity is the ohm-meter. Equation 13-1 provides an equation to calculate electrical resistivity from specific conductance and Equation 13-2 provides the reverse. These equations are from Estepp (1998, pg 9-2) with the slight modification of changing the reference temperature from 75 degrees Fahrenheit to 77 degrees Fahrenheit. This temperature shift is made in this report because the standard temperature for reporting specific conductance is 77 degrees Fahrenheit (or 25 degrees Celsius). Table 13-1 provides a perspective for the relationship between electrical conductivity, resistivity and electrical concentrations of sodium chloride and calcium carbonate in solution.

$$R_{w25°C} = 10,000/ SCw25°C \qquad \text{(Equation 13-1)}$$

$$SC_{w25°C} = \frac{10,000}{R_{w25°C}} \qquad \text{(Equation 13-2)}$$

Where:

$SC_{w25°C}$ = Specific Conductance (micromhos per centimeter at 25 degrees Celsius or 77 degrees Fahrenheit)

R_{w75} = water resistivity (Ohm-meter at 25 degrees Celsius or 77 degrees Fahrenheit)

Table 13-1. Electrical conductivity and electrical resistivity of sodium chloride and calcium carbonate solutions at different concentrations. (from http://www.calservice.net/refrencematerials/conductivity/conductivityresistivity.pdf).

Dissolved Solids (ppm)		Conductivity (µmhos-cm)	Resistivity (Ohm-m)
$CaCO_3$	NaCl		
1,700	2,000	3,860	2.6
1,275	1,500	2,930	3.4
850	1,000	1,990	5
425	500	1,020	9.9
170	200	415	24
127.5	150	315	32

Dissolved Solids (ppm)		Conductivity (µmhos-cm)	Resistivity (Ohm-m)
$CaCO_3$	NaCl		
85	100	210	48
42.5	50	105	95
17	20	42.7	230
12.7	15	32.1	310
8.5	10	21.4	470
4.25	5	10.8	930
1.7	2	4.35	2,300
1.27	1.5	3.28	3,000
0.85	1	2.21	4,500

Note: ppm = parts per million; µmhos-cm=micromhos per centimeter; ohm-m=ohm meters; $CaCO_3$=calcium carbonate; NaCl=sodium chloride

Temperature Adjustments to Conductivity and Resistivity

The electrical conductivity and electrical resistivity of water changes with temperature. This dependency exists because elevating temperature increases the kinetic energy of ions and decreases water viscosity, which increases ionic movement. The effect of temperature on electrical conductivity varies according to ionic species and ionic strength (Collier, 1993; Hayashi, 2003).

For some applications, the assumption that changes in conductivity due to temperature are linear is adequate. One of the commonly used linear adjustments is a 2 percent increase in electrical conductivity per one degree Celsius (Hem, 1985; Matthess, 1982). Because the electrical conductivity-temperature is only slightly non-linear in the temperature range of 0 to 30 degrees Celsius (Sorensen and Glass, 1987), a linear correction factor is typically adequate.

In the geophysical logging literature, the temperature ranges exceed 30 degrees Celsius, and the temperature adjustments to electrical conductivity are non-linear. Among the first equations to account for non-linear changes is the Arp equation (Arps, 1953), which can be found in most logging manuals such as Schlumberger (2009). The Arp equation will be used to correct for temperature changes. Equations 13-3 and 13-4 provide the corrections for temperature measured in Fahrenheit and Celsius, respectively.

For Fahrenheit $$R_{W^2} = R_{W^1}\frac{(T_1+6.77)}{(T_2+6.77)}$$ (Equation 13-3)

For Celsius $$R_{W^2} = R_{W^1}\frac{(T_1+21.5)}{(T_2+21.5)}$$ (Equation 13-4)

Where:

Rw2 = resistivity at temperature T2
Rw1 = resistivity at temperature T1
T1 = temperature, T1
T2 = temperature T2

Definition of Total Dissolved Solids

The definition of total dissolved solids is important to this project. Listed below are a few definitions that can be found on the internet and in reports.

The World Health Organization states that "Total dissolved solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The principal constituents are usually calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen, carbonate, chloride, sulfate, and nitrate anions" (World Health Organization, 2016).

The Government of Canada defines total dissolved solids as "Total dissolved solids (TDS) comprise inorganic salts and small amounts of organic matter that are dissolved in water. The principal constituents are usually the cations calcium, magnesium, sodium and potassium and the anions carbonate, bicarbonate, chloride, sulfate and, particularly in groundwater, nitrate (from agricultural use)" (Government of Canada, 2016).

The United States Environmental Protection Agency defines total dissolved solids as "the total dissolved (filterable) solids present in a fluid as determined by use of the method specified in Title 40 of the Code of Federal Regulations (40 CFR) Part 136." The method specified in Title 40 of the Code of Federal Regulations (40 CFR) Part 136 subchapter D (Water Programs) and Part 136 (Guidelines Establishing Test Procedures for the Analysis of Pollutants) (United States Environmental Protection Agency, 2016).

The Texas Administration Code Title 30 (Environmental Quality), Part 1 (Texas Commission on Environmental Quality) and Chapter 307 (Texas Surface Water Quality Standards) Rule 307.3 (ii) (C) (74) defines total dissolved solids as "The amount of material (inorganic salts and small amounts of organic material) dissolved in water and commonly expressed as a concentration in terms of milligrams per liter. The term is equivalent to the term filterable residue, as used in 40 Code of Federal Regulations Part 136 and in previous editions of the publication entitled, *Standard Methods for the Examination of Water and Wastewater"* (Texas Administration Code, 2016).

A TWDB report on characterizing the brackish water of Texas (LBG-Guyton and NRS, 2003) states that "Total dissolved solids is the most commonly used parameter to describe overall groundwater quality because it is a measure of all of the dissolved constituents in water."

The TWDB website describing the groundwater database provides the following definition for Dissolved Solids:

> **"Dissolved Solids:** (sum of constituents) This is calculated based on the values, in mg/L, of the major anions and cations, silica, and 0.4917 of the bicarbonate. Nothing is added into the 'TDS' from the infrequent table. However, some high values that might be considered as contributing to the TDS, while not included in the TWDB's formula, are Fe, Br, B, Ba, and Zn. If a sample is missing one or more major anions or cations so that the analysis is unbalanced, a TDS determined by residue can be entered into the dissolved solids field. However, if

all constituents are present, the TDS is calculated and replaces anything else in the field" (TWDB, 2016)

A TWDB report related to using borehole geophysical techniques for determining water quality (Collier, 1993) presents the following three equations below to define total dissolved solids: The rationale for the development of Equations 13-5, 13-6, and 13-7 are discussed in Section 13.1.6.

$$TDS = (0.492 \times HCO_3) + SiO_2 + \text{all other ions} \qquad \text{(Equation 13-5)}$$

$$TDS = \text{all ions} + SiO_2 - (0.508 \times HCO_3) \qquad \text{(Equation 13-6)}$$

$$TDS = \text{total of ions} + SiO_2 \qquad \text{(Equation 13-7)}$$

Where

TDS = total dissolved solid concentrations (milligrams per liter)
HCO_3 = concentration of bicarbonate ions in the groundwater sample (milligrams per liter)
SiO_2 = concentration of Silica oxide in solution (milligrams per liter)

Measurement of Total Dissolved Solids

One of the reasons for the wide range of definitions for total dissolved solids is that there is no laboratory method for measuring all of the dissolved solids in solutions. The lack of such a method leads to the compromise of using a method or methods that comes closest to meeting the objective of the measurement of total dissolved solids. The following three measurement approaches are used to define total dissolved solids:

1. Filter the water sample, and then evaporate it at 180 degrees Celsius in a pre-weighed dish until the weight of the dish no longer changes. The increase in weight of the dish represents the total dissolved solids, and it is reported in milligrams per liter.
2. The electrical conductivity of the water sample is measured, and the total dissolved solids is estimated based on linear correlation equation relating total dissolved solids and specific conductivity.
3. Laboratory measurements are used to measure individual ions and compounds and their masses are summed to represent total dissolved solids.

All three of the methods have problems with measuring total dissolved solids. With respect to the measured total dissolved solids values obtained from the TWDB groundwater database, the problems associated with evaporating a known amount of water and then weighing the residue is of most concern because it is commonly used in Texas. One of the problems with this method is that a mass of bicarbonate is lost during evaporation. Bicarbonate is converted to carbon trioxide, carbon dioxide, and water with 50.8 percent of the bicarbonate driven off as carbon dioxide and water vapor and 49.2 percent remaining as carbon trioxide. (Collier, 1993). The loss of bicarbonate mass during evaporation is the basis for Equations 13-5 and 13-6.

13.1.2 Relationship between Electrical Conductivity and Total Dissolved Solids

Several researchers (Walton, 1989; Hayashi, 2003; Sorensen and Glass, 1987) show that the relationship between electrical conductivity and total dissolved solids of groundwater is dependent on several factors, including ionic composition and ionic strength of the solution and

the method used to calculate total dissolved solids. To investigate the factors that could be potentially important to the study's objective of mapping brackish groundwater estimates of the electrical conductivity and resistivity of the groundwater developed from geophysical logs, the relationship between electrical conductivity and total dissolved solids was investigated using groundwater samples from the TWDB groundwater database, collected from wells located in the Texas Gulf Coast. Figure 13-1 shows the location of the wells in the Texas Gulf Coast.
Table 13-2 shows the distribution of measured total dissolved solids and calculated total dissolved solids with depth. The calculated total dissolved solids was determined using Equation 13-4. Among the notable results for all five depth categories, the number of wells with total dissolved solids values less than 500 milligrams per liter is significantly dependent on the total dissolved solids definition. For all five depth categories, the calculated total dissolved solids is at least 35 percent lower than the measured total dissolved solids. Such a significant change may be important with regard to mapping the boundary between fresh and brackish groundwater.

Table 13-2. Summary of the well and chemical data extracted from the TWDB Groundwater Database for the Texas Gulf Coast to compare measured and calculated total dissolved solids Using Equation 13-5.

Measured TDS	**Depth (ft)**				
TDS Range	**0 to 250 ft**	**250 to 500 ft**	**500 to 1500 ft**	**1500 to 2500 ft**	**>2500 ft**
0 to 500	1,520	724	1,366	130	12
500 to 1000	1,343	632	827	38	28
1000 to 1500	546	209	335	23	10
1500 to 3000	537	288	257	15	9
3000 to 10,000	200	91	89	9	5
>10,000	22	3	7	2	0

Calculated TDS Using Equation 13-4	**Depth (ft)**				
TDS Range	**0 to 250 ft**	**250 to 500 ft**	**500 to 1500 ft**	**1500 to 2500 ft**	**>2500 ft**
0 to 500	984	450	865	72	3
500 to 1000	1,483	708	1,083	88	29
1000 to 1500	772	341	486	19	9
1500 to 3000	692	332	342	25	13
3000 to 10,000	230	113	98	11	8
>10,000	22	3	7	2	2

Note: TDS=total dissolved solids; ft=feet

Out of the 9,227 wells with measured total dissolved solids, there are 6,985 wells with enough data to compare the measured total dissolved solids to a measured specific conductance and a total dissolved solids calculated by summing the measured cations and ions. Out of those 6,985 wells, 9 wells had measured total dissolved solids that is more than the calculated total dissolved solids. In this analysis, 9,339 wells had a charge balance greater than 95 percent. The remaining 50 wells total dissolved solids have a charge balance greater than 85 percent.

13.1.3 Comparison between Measured and Calculated Total Dissolved Solids

Figure 13-2 compares calculated total dissolved solids, per Equation 13-7, to measured total dissolved solids for a total dissolved solids range of 0 to 4,000 milligrams per liter for approximately 9,000 wells in the Gulf Coast. The data points have been color-coded to show the percentage that the bicarbonate ion comprise the total amount of equivalents in the charge balance. This percentage has an upper range of 50 percent because the sum of the anions cannot exceed 50 percent of the total charge balance. Several potentially important relationships that can be extracted from Figure 13-2 are identified:

1. With increasing percentage of bicarbonate, the discrepancy between calculated and measured total dissolved solids concentration increases.
2. For a measured total dissolved solids concentration of 500 milligrams per liter, the range of calculated total dissolved solids concentration ranges between about 500 milligrams per liter and about 625 milligrams per liter.
3. For a measured total dissolved solids concentration of 1,000 milligrams per liter, the range of calculated total dissolved solids concentration ranges between about 1,000 milligrams per liter and about 1,500 milligrams per liter.
4. For a measured total dissolved solids concentration of 1,500 milligrams per liter, the range of calculated total dissolved solids concentration range between about 1,500 milligrams per liter and about 2,100 milligrams per liter.
5. There is an inverse correlation between total dissolved solids concentration and average magnitude of the bicarbonate percentage.

The findings above are complemented by the results in Figure 13-3 and Table 13-3. Figure 13-3 compares the mass associated with the correction fraction for bicarbonate compare to the differences between calculated total dissolved solids and measured total dissolved solids. Table 13-3 shows that, for 98 percent of the samples, the difference between the measured and calculated total dissolved solids masses is within 3 percent of the bicarbonate correction. These results validate that the correction factor of 0.508 in Equation 13-6 to account for loss of bicarbonate through evaporation during the measurement of total dissolved solids in the laboratory.

Table 13-3. Summary of the well and chemical data extracted from the TWDB Groundwater Database for the Texas Gulf Coast Coast to determine the contribution that bicarbonate correction factor accounts for the difference between measured and calculated Total Dissolved Solid Concentrations

(0.508*HCO$_3$)/ (TDScal -TDSmeas)	**Number of Wells**	**Percentage of Total Wells**
< 0	10	0.1
0 to 0.75	16	0.2
0.75 to 0.85	34	0.4
0.85 to 0.90	55	0.6
0.90 to 0.95	146	1.6
0.95 to 0.975	143	1.6
0.975 to 1.0	8586	93.2
> 1.0	223	2.4
TOTAL	**9213**	

Note: HCO_3= Bicarbonate; TDScal = TDS calculated; TDSmeas = TDS measured

Figure 13-4 and 13-5 show calculated total dissolved solids, Equation 13-4, to measured total dissolved solids for a range of 0 to 10,000 milligrams per liter where chloride and sulfate comprise at least 25 percent of the total equivalents. Several potentially important relationships that can be extracted from Figures 13-2 and 13-3 are:

1. There are relatively few data points in Figure 13-3 for the situation where sulfate comprises the majority of the anionic equivalents. Out of 8,952 wells, only 121 wells have groundwater samples where sulfate comprises more than 25 percent of the equivalents.
2. Joint interpretation of Figures 13-2 to 13-5 indicate that the majority of the groundwater samples with total dissolved solids concentrations greater than 1,500 milligrams per liter have their anionic composition dominated by chloride. Out of 1,501 wells with total dissolved solids concentration above 1,500 milligrams per liter, 1,113 have a chloride equivalent percentage greater than 25 percent. Out of 392 wells with total dissolved solids concentration above 3,000, 313 have a chloride equivalent percentage greater than 25 percent.

Figure 13-6 shows the average anionic composition for the groundwater with different total dissolved solids concentrations. For groundwater samples with total dissolved solids concentrations less than 1,000 milligrams per liter, the bicarbonate is the most predominant anion. For groundwater samples with total dissolved solids concentrations greater than 1,000 milligrams per liter, chloride is the predominant ion. The shift in the predominant ion with increase in the total dissolved solids is explained by the chemical evolution that groundwater undergoes as it migrates through the Gulf Coast deposits (Young and others, 2013; Estepp, 1998). Along the down-dip direction that is the general flow direction, the total dissolved solids concentration of groundwater increases and its anionic composition changes with a sample initially high bicarbonate losing bicarbonate with distance travel to increased concentrations of chlorides and some sulfate.

13.1.4 Relationship between Electrical Conductivity and Total Dissolved Solids

The relationship between electrical conductivity and total dissolved solids is constructed by plotting specific conductance as a function of total dissolved solids. This relationship is potentially important because it can be used to calculate the total dissolved solids of a groundwater solution via Equation 13-8 after its electrical conductivity or electrical resistivity has been determined from the analysis of geophysical log curves. Equation 13-8 is modified from Estepp, (1988).

$$TDS = Ct * SC_{77} \qquad \text{(Equation 13-8)}$$

Where:

TDS	=	total dissolved solids concentrations (milligrams per liter)
Ct	=	specific conductivity-total dissolved solids conversion factor
$SC_{w77°F}$	=	specific conductance (micromhos per centimeter at 25 degrees Celsius or 77 degrees Fahrenheit)

Figure 13-7 plots specific conductance versus total dissolved solids for solutions with a high anionic percentage of bicarbonate. Figure 13-8 plots specific conductance versus total dissolved solids for solutions with high anionic percentage of chloride. Figure 13-9 plots specific conductance versus total dissolved solids for all groundwater samples. For each figure, the specific conductance is plotted against measured total dissolved solids on the right and against calculated total dissolved solids on the left. For all six plots, a linear regression produces a Pearson's correlation coefficient (R^2) greater than 0.96 for fitting a linear relationship through the data that intercepts the origin. The slope of the line produced by the linear regression represents an averaged value for the specific conductivity-total dissolved solids conversion factor (Ct) in Equation 13-8 for the groundwater samples used in the regression analysis.

Table 13-4. Values of Ct, the specific conductivity-total dissolved solids conversion factor (see equation 13-8), for different chemistry groupings of the groundwater samples and different methods for determining total dissolved solids.

Chemistry Group	Method for Determining TDS	Slope or Ct in Equation 13-8	R^2	Count
HCO_3 > 35%	Measured	1.70372	0.985	1866
	Calculated	1.1991	0.984	1860
Cl > 35%	Measured	1.75203	0.961	587
	Calculated	1.67555	0.963	587
All Data	Measured	1.70266	0.969	6959
	Calculated	1.55586	0.965	6959

Note: HCO_3=Bicarbonate; Cl=chloride; %=percent; TDS=total dissolved solids; Ct= Specific conductivity- total dissolved solids conversion factor

The results in Table 13-4 show that for the three chemistry groups, the most consistent set of specific conductivity-total dissolved solids conversion factor values for determining total dissolved solids is by measuring. The maximum difference between any two values is 0.051, which is about one-tenth the value of 0.478, which is the maximum difference between any two Specific conductivity-total dissolved solids conversion factor values for the calculated total dissolved solids. For the situation where the chemistry of the groundwater is not known, the information in Table 13-4 indicates that the specific conductivity-total dissolved solids conversion factor of 1.70 is the best single value to use in Equation 13-8.

13.2 Calculation of Total Dissolved Solids Concentration from Geophysical Logs Curves

13.2.1 Methods for Calculating Total Dissolved Solids Concentrations in Groundwater

Table 3-5 shows the six primary methods described by Estepp (1998) to estimate total dissolved solids concentrations from geophysical logs, as well as the range of total dissolved solids concentrations for their application, in addition to the variables used by each method. As shown in Table 3-5, there are up to six different input variables required to apply the methods. These variables are spontaneous potential value, deep resistivity value, shallow resistivity value, porosity, resistivity of the mud filtrate, cementation factor, and Guyod water chemistry factor. The method requiring the least number of parameters is the mean resistivity of the formation (R_o) method, called the "Mean R_o method," which requires only a value for the deep resistivity. The method requiring the most number of parameters is the Guyod method, which requires three additional input variables other than the deep resistivity. Also shown in Table 3-5 is the recommended operating and working range for the six methods. Among the six methods, only the Mean R_o method has a recommended working range that spans the entire total dissolved solids range for this study, which is from about 100 milligrams per liter to 35,000 milligrams per liter. For several of the methods, such as the apparent water resistivity (R_{wa}) method, called the "R_{wa} Method," Estepp (1998) indicates that the method is not well suited for total dissolved solids concentrations less than 3,000 milligrams per liter. Therefore, these methods should be used with an appropriate correction factor when used to estimate total dissolved solids concentrations less than 3,000 milligrams per liter.

Table 13-5. The recommended working range and maximum operating range for methods used for estimating total dissolved solids concentration from geophysical logs (from Estepp, 1998).

Analysis Method	Recommended Working TDS (mg/L) Range	Requires Fresh Water Correction	Maximum Operating TDS (mg/L) Range
R_w from SP	3,000 to 100,000	100 to 3,000	NA
Alger-Harrison	3,000 to 100,000	100 to 3,000	NA
Estepp	100 to 3,000	NA	3,000 to 10,000
Mean R_o	100 to 100,000	NA	NA
Guyod	1,000 to 3,000	NA	3,000 to 10,000
R_{wa}	3,000 to 100,000	1,000 to 3,000	NA

Note: SP=spontaneous potential; R_w=resistivity of the formation water; R_o=resistivity of formation; R_{wa}= apparent water resistivity; TDS=total dissolved solids; mg/L=milligrams per liter; NA=not applicable

13.2.2 Previous Application of Methods in Texas Gulf Coast Aquifer

Based on our review of the literature, the two most commonly used methods for estimating total dissolved solids in the Texas Gulf Coast are the Mean R_o method and the R_{wa} Minimum method. A short review of each method and their application in the Texas Gulf Coast is provided in this section.

The Mean R_o Method

The Mean R_o method involves correlating deep resistivity (long normal or deep induction) with total dissolved solids concentration of groundwater samples from the same zone. The deep resistivity curve is used to minimize the effects of mud filtrate invasion. Deep resistivity is assumed to be approximately equal to true formation resistivity (R_t), where water saturation is 100 percent (no hydrocarbons) (Jones and Buford, 1951; Turcan, 1962; Alger, 1966). Bed thickness also affects the deep resistivity; for beds thinner than about twice the electrode spacing, the deep resistivity does not equal true formation resistivity (Jones and Buford, 1951). Therefore, only sand layers more than 10 feet thick should be included in developing and applying the correlations and calculations.

Among the studies that have used the Mean R_o method in either the Gulf Coast Aquifer System or the Carrizo-Wilcox Aquifer are: Fogg and Blanchard, 1986; Hamlin and others, 1988; Collier, 1993; Estepp, 1998; Hamlin and Luciana de la Rocha, 2015; Ayers and Lewis ,1985; Fogg, 1980, Fogg and Kreitler 1982, and Meyer, 2012.

The Mean R_o method requires plotting measured total dissolved solids from a water well against the resistivity (R_o) of the sands near the upper well screen. Figure 13-10 shows such a graph developed by Meyer (2012) for a groundwater characterization study performed by the TWDB in the vicinity of Corpus Christi in South Texas. The graph includes data assembled by Meyer (2012) and compares it to results from other projects. The graphic shows an inverse relationship between total dissolved solids concentration and resistivity of the formation. However, the relationship between total dissolved solids concentration and resistivity is not unique and, for many of the resistivity values, the data shows a relatively large spread in the measured total dissolved solids concentrations. For instance, in Figure 13-10, a resistivity value of 8 ohm-meters has a total dissolved solids concentration range between 800 milligrams per liter and 4,000 milligrams per liter and a resistivity value of one ohm-meter has a total dissolved solids concentration range between 10,900 milligrams per liter and 100,000 milligrams per liter. Partly because of these wide concentration ranges Meyer (2012) recommends that appropriate error bars accompany such estimates of total dissolved solids concentrations from the Mean R_o method.

Among the six methods discussed by Estepp (1998), the Mean R_o method requires the least input variables and is the only method recommended for use over the study's total dissolved solids concentration range of about 100 milligrams per liter to 35,000 milligrams per liter. Moreover, its successful application has been documented in numerous studies and, furthermore, the Mean R_o method is currently being used as the sole approach for mapping groundwater quality in the Carrizo-Wilcox aquifer in Groundwater Management Area 13 by the Bureau of Economic Geology and INTERA Incorporated. Table 13-6 lists the advantages and weaknesses of the Mean R_o total dissolved solids method provided by Estepp (1998).

Table 13-6. Advantages and weaknesses of the Mean R_o total dissolved solids method provided by Estepp (1998).

Advantages	If the porosity is relatively constant, this method is not dependent of a porosity log A shallow resistivity values is not required to approximate total dissolved solids This is a quick look method that can be used in evaluating large amounts of data
Weaknesses	Variations from the assumptions create a significant error margin in the total dissolved solids approximations Shale causes R_o values to be too low in fresh-water aquifers

Note: $R_{o=}$resistivity of the formation

Collier (1993) states that Mean R_o method is well suited for application in sandstones that have consistent lithology, are unconsolidated to semi-consolidated, Tertiary or younger, which includes the Gulf Coast Aquifer and the Carrizo Wilcox aquifer. To address concerns regarding the possible changes in the aquifer over distances of hundreds of miles or thousands of feet of sediment, Collier (1993) suggests that the Mean resistivity of the formation -total dissolved solids can be normalized or corrected for variations in porosity, aquifer or formation, formation temperature, and difference in water quality. A potential limitation with the Mean resistivity of the formation-total dissolved solids method is for the deeper portions of the aquifers where measured water quality parameters are scarce or not available.

A commonly used variant of the Mean R_o method is using specific resistivity values as a cut-off to assign groundwater to a water quality classification based on total dissolved solids concentrations. Perhaps the largest areal application of the Mean R_o method is by Mr. Ernie Baker, who used the values presented in Table 13-7 to classify groundwater across the entire Gulf Coast System as part of the TWDB project to update the stratigraphy of the Texas Gulf Coast Aquifer System (Young and others, 2010; 2012).

Table 13-7. General criteria used by Mr. Baker to estimate total dissolved solids from the geophysical logs (from Young and others, 2010, 2012).

Classification	Resistivity (ohms-m) of aquifer formation	Assumptions
Fresh water (<1,000 ppm TDS)	> 18-20 ohms-meter	Assume water has major calcium ions
Slightly saline (1,000-3,000 ppm TDS)	8-18 ohms-meter	Calcium ions decreasing, sodium ions gaining
Moderately saline (3,000-10,000 ppm TDS)	< 8 ohms-meter	Sodium and chloride ions predominate

Note: ppm=parts per million; TDS= total dissolved solids; ohms-m=ohms-meter

In lieu of providing his data to support the cutoff values in Table 13-7, Mr. Baker cites several references for justifying the relationships he used, which are provided in Table 13-7. Among the references cited by Mr. Baker are Schlumberger (1972), Keys and McCary (1971), Whitman (1965), and Alger (1966). Table 13-8 provides the cut-off values developed by Malcolm Pirnie (2001) for an area including San Patricio County and surrounding area. Collier Consulting, a consulting firm in Texas, analyzed the resistivity curves from 168 logs to map groundwater quality. A comparison of the values in Table 13-7 and 13-8 show that that the two sets of values provide similar cut-off values for total dissolved solids concentrations for 3,000 and 10,000 milligrams per liter.

Table 13-8. Relationship between resistivity measurement and total dissolved solids concentrations used by Collier Consulting, Inc. (Malcolm Pirnie, 2001).

Resistivity of Aquifer Formation	Approximate Total Dissolved Solids Concentrations (mg/L)
8 Ohms-meter	3,000
4 Ohms-meter	10,000
2 Ohms- meter	20,000
1.5 Ohms-meter	greater than 20,000

Note: mg/L=milligrams per liter

The R_{wa} Minimum Method

The R_{wa} Method uses the Archie (1942) equation to estimate total dissolved solids concentration. For the situation where the aquifer is saturated with water, the Archie Equation can be written as:

$$R_{we} = \Phi^m \times R_o \qquad \text{(Equation 13-9)}$$

Where

R_{we} = resistivity of water equivalent (ohm-meters)
Φ = porosity
m = the cementation exponent
R_o = the resistivity of a 100 percent water saturated formation (ohm-meters)
F = formation factor = Φ^m

As shown in Table 13-5, Estepp (1998) indicates that the R_{wa} method is not well suited for fresh water applications. This observation is supported by the work of Alger (1966) and Meyer (2015). Alger (1966) found that the formation factor is also a function of the resistivity of the formation water in fresh water aquifers and that the formation factor decreases with increased resistivity of the formation water. Data from Alger (1966) also indicates that the customary relation between formation factor and porosity, widely used in oil-well interpretation, does not apply to fresh water sediment because formation factor varies not only with porosity but also with resistivity of the formation water and grain size. Alger (1966) provides data that show the formation factors for fresh water systems were appreciably lower than those applied to petroleum industry log interpretation. Alger concluded that a basic relation exists between geophysical-log data and groundwater parameters, and that collecting and using local empirical data results in the most reliable and accurate interpretations.

In his study near Corpus Christi, Meyer reviewed two other methods in Table 13-5 in comparison to the Mean R_o Method. One of these two methods was the R_{wa} Minimum method. The other method was the Modified Alger-Harrison method. Meyer (2012) suggests that, for his particular area and application, the minimum apparent resistivity of the water (R_{wa}) method, called the "R_{wa} Minimum method" is a more appropriate method than the Modified Alger-Harrison method but that the R_{wa} Minimum method may not be well suited for groundwater with total dissolved solids concentrations less than 2,000 milligrams per liter. Based on a comparison of drill stem data and a geophysical log from a borelog about 600 feet from the tested well, Meyer (2012) observed that the R_{wa} Minimum method overestimated the total dissolved solids concentrations by 500 to 1,400 milligrams per liter for total dissolved solids concentrations less than 2,000 milligrams per liter.

For the same region where Meyers (2012) conducted his study, Young and Lupton (2014) evaluated the R_{wa} Minimum method by using total dissolved solids concentration from water wells and measurements from logs within a mile of the well that provided resistivity data for the depth interval of the well screen. For their study, they had difficulty with identifying which resistivities of the sand beds should be used from the geophysical log to calculate the total dissolved solids concentrations measured in the well screen, due to the relatively short sand bed thickness and the variability among the resistivity values of the sands. For their application of the R_{wa} Minimum method, Young and Lupton (2014) used the resistivity or combination of resistivities from sand beds that would best match the total dissolved solids measured in the water well. Because their application of the R_{wa} Minimum method involved total dissolved solids concentration less than 3,000 milligrams per liter, Young and Lupton (2014) developed a correction factor to help adjust and improve the fit between total dissolved solids measured at the water well and total dissolved solids calculated using the R_{wa} Minimum method. Despite using an empirically derived correction factor for total dissolved solids concentrations less than 3,000 milligrams per liter and using the resistivities that provided total dissolved solids values from the R_{wa} Minimum method that best matched the measured total dissolved solids values measured at the water wells, Young and Lupton (2014) could only calculated a total dissolved solids value within 50 percent of the measured total dissolved solids 70 percent of the time.

To help quantify the uncertainty in the application of the R_{wa} Minimum method, Young and Lupton (2014) performed a sensitivity analysis by calculating the percent change produced in the calculated total dissolved solids concentration over the input range of five input variables. Their results, shown in Figure 13-11, support the conclusion that an uncertainty of 50 percent in the calculated total dissolved solids for application of the R_{wa} Minimum method for a region where the resistivity of the sands are available is not unreasonable.

13.3 Development of Methods for Estimating Total Dissolved Solid Concentrations Gulf Coast Aquifer

13.3.1 Pairing of Water Wells and Geophysical Logs

The data used to develop relationships between total dissolved solids concentrations and resistivity values were measured total dissolved solids concentrations from water wells and resistivity values calculated from geophysical logs. This section discusses the pairings of water wells and geophysical logs that were used to construct resistivity of the formation-total dissolved solids graphs.

Figure 13-12 illustrates the concept of pairing a water well and a geophysical well. The water well provides a value of total dissolved solids concentration for a known vertical interval in a formation. A geophysical log near the water well is used to identify the sands near the well screen. The geophysical log is analyzed to determine the resistivity of the sands, and these resistivities are correlated with the total dissolved solids concentrations of the groundwater in the water well.

At each water well, both well construction and measured water quality data was assembled. Key well construction information includes the well location, the ground surface elevation, and the well screen construction specification. Well screen specification includes the number of well screens, the size of the well screens, and the uppermost and the lowermost screened aquifer interval. Key water quality information includes measured total dissolved solids concentrations and measured concentrations of major anions and cations.

Several water well databases were reviewed for this project, including several from state and county agencies. A major limitation of most of the well datasets was that the measured ion concentration did not provide a charge balance. The water well data set that provided the most complete sets of chemistry and well construction data was the TWDB Groundwater database (GWDB). The vast majority of the water sample data extracted from the TWDB Groundwater base had a charge balance error of less than 5 percent.

In the study area, the TWDB GWDB provided well screen information and measurements of both total dissolved solids and the major ions for approximately 2,500 wells. We entered the location of these water wells into ArcGIS, along with location of geophysical logs. We used an ArcGIS spatial joint tool to fine pairs of water wells and geophysical logs that were less than one mile apart.

Table 13-9 lists several of the conditions that led to the elimination of a well-log pair from consideration in the study. The most prevalent reason for omitting a well-log pair was that the geophysical log started below the bottom of the water well. Another common reason for omitting a well-log pair was that the water well was already paired with at least two other geophysical logs. As a general rule, we tried to limit the pairing of a water well to no more than two geophysical logs. If multiple logs were available for consideration for a specific water well, the primary criteria were used to select the log closest to the water well and/or select the log with the most recent logging date.

Table 13-9. Conditions that prevented a paired geophysical log and water well from being included in the final analyses.

Geophysical Log
1. Inadequate vertical coverage above and below the well screen interval
2. The geophysical log was not legible or of poor quality
3. The geophysical log did not include a deep resistivity curve
4. Other geophysical logs are paired to the same water well
Water Well
1. Well screen over 300 feet
2. Well screen consisting of more than 5 separately screened sections

If several well-log pairs were located closely together, we preferentially omitted well-log pairs with long well screens. A concern with using water wells with long well screens is that the well screens intersect multiple sand beds that could contain groundwater with significantly different total dissolved solids concentrations because of the large vertical distances among the sand intervals. In turn, these sand beds would produce groundwater in the water well with a composite total dissolved solids concentration that may be hard to correlate to the individual sand layers because of the relatively unknown quantities of groundwater that each sand layer contribute to the well. Our cut off length for considering a screen as long was 300 feet. However, in some locations, such as Harris County where wells with large well screens are relatively common, we included well-log pairs with long well screens in our analysis.

Appendix 19.2 lists the 769 well-log pairs that we used in our analysis. Figure 13-13 shows the location of the well-log pairs. The well-log pairs consist of 379 water wells with screen information and 23 water wells without screen information. Screen information is used in our analysis to identify the vertical interval on the geophysical log where the resistivity of the sands will be correlated to the total dissolved solids concentrations calculated from the water well data. However, a limitation of using only wells with screened information was that there were relevantly few water wells with total dissolved solids concentrations greater than 2,500 milligrams per liter. To improve the number of well-pairs with total dissolved solids concentrations greater than 2,500 milligrams per liter, we include 23 well-pairs where water well did not have screen data.

Appendix 19.3 provides the well construction information for the 402 water wells used for this study. This well information includes well location coordinates, screen information, and the formation assigned to the well. The wells without screen information have columns labeled with "ND" to indicate that "no data" is available. Appendix 19.4 provides concentrations for total dissolved solids and major ions for the 402 water wells. For each well, a measured and calculated total dissolved solids is provided. The calculated total dissolved solids value is obtained from summing the mass of the 12 chemical constituents listed in the table. The table also provides a charge balance for the water samples based on milliequivalents calculated from the measured concentrations.

Table 13-10 provides a breakout of the total dissolved solids concentrations for the 769 well-log pairs by groundwater management area and by aquifer. The total dissolved solids concentration used to place a well pair in a group is based on the calculated total dissolved solids value at the water well. Two observations in Table 13-10 that have implications to the analysis of the total dissolved solids data is that there are no water wells with total dissolved solids concentrations less than 500 milligrams per liter in Groundwater Management Area 16 and there are not water wells in Groundwater Management Areas 14 and 15 with total dissolved solids concentrations greater than 3,000 milligrams per liter.

Table 13-10. Distribution of the calculated total dissolved solids concentration among well-log pairs by groundwater management area and aquifer using water well with well screen data.

	GMA				Aquifer				
TDS Range (mg/L)	**13**	**14**	**15**	**16**	**Chicot**	**Evangeline**	**Jasper**	**Catahoula**	**Other**
0 to 500	0	50	93	0	76	59	7	1	0
500 to 1000	0	49	199	108	82	220	43	6	5
1000 to 1500	2	7	53	101	31	72	47	7	8
1500 to 3000	0	3	18	46	6	28	6	13	12
3000 to 1000	0	0	0	10	3	1	6	0	0
>10,000	0	0	0	0	0	0	0	0	0
Total	2	109	363	265	198	380	109	27	25

Note: TDS=total dissolved solids; mg/L=milligrams per liter; GMA=Groundwater Management Area

13.3.2 Development of the Mean R_o Method

There are numerous factors that could potentially affect the correlation between a formation resistivity of a sand and the total dissolved solids concentration of groundwater in that same sand. Among these factors are groundwater temperature, the dip of the formation, the distance and orientation between the log location and the water well location, the chemical composition of the groundwater, and mineralogical and lithological difference among the formation both locally and regionally. To account for some of these factors, we perform the following analysis:

Temperature Correct Formation Resistivity of the Sand Interval: A temperature was assigned to all of the sand intervals based on interpolation of the geothermal gradient at the log location based on the temperatures for groundwater near ground surface shown in Figure 7-7 and for groundwater at a depth of 3,500 feet shown in Figure 7-8. The estimate of the in-situ groundwater temperature was used to adjust the Ro for a sand to a temperature of 77 degrees Fahrenheit using Equation 13-10.

$$R_{W^{77}} = R_{W^{1}} \frac{(T_1+6.77)}{(77+6.77)} \qquad \text{(Equation 13-10)}$$

Where:

$R_{W^{77}}$ = sand bed resistivity adjusted to 77 degrees Fahrenheit
$R_{W^{1}}$ = sand bed resistivity calculated from the geophysical log
T_1 = estimated in-situ temperature of groundwater in the sand bed based on the depth of the sand bed

Calculate Vertical offsets caused by Formation Dip Between a Paired Well and Log: The formations of the Gulf Coast generally dip toward the coast, with dip angle increasing with depth. For example, we would expect the dip angle of the Beaumont Formation to be less than the dip angle of the Willis Formation, and so on as depth increases The dip of a geological formation is often expressed as the feet per mile, where feet represents the vertical decline of the top or bottom elevation of the surface, and the mile represents a distance measured along the direction of greatest vertical change.

As discussed previously, each water well/geophysical log pair is separated by as much as one mile of lateral distance. If the paired well and log are oriented along strike, then we would expect the least amount of relative vertical offset due to that separation, with respect to formation depth from ground surface. If the pair are oriented along dip, then we would expect the maximum vertical offset with respect to depth from ground surface.

For example, consider a well screen in a water well is centered at 450 feet below ground surface. The well screen is coincident with a 100-foot thick sand package. The water quality that is sampled and reported for that water well is representative of that 100-foot thick sand package, centered 450 feet below ground surface. A geophysical log that was run in the water well borehole would reflect this location. The ability to correlate that water quality measurement to the same interval on a geophysical log that is located some distance from the water well requires identification of a sand in the geophysical log that is connected to the sand identified in the water well. If the water well and geophysical log locations are oriented along strike, then our best approach is to assume that the 100-foot sand occurs at the same depth in the geophysical log as in the water well. If the water well and geophysical log locations are oriented along dip, then we can use the formation dip angle to “correct” for an expected vertical offset between the two.

To investigate the relationship between offset and strike/dip orientation, we extracted the formation top and bottom elevations at all of the geophysical log and water well locations, with the formation top and bottom elevations based on Young and others (2010, 2012). Because those formation surfaces are regional, they have a limited ability to show dip angles at small distances. However, we assumed that in aggregate the data may show the proposed trends and provide estimates of dip angles for each of the formations being considered in the study. We also calculated the orientation of each water well and geophysical log pair, as an angle in degrees relative to true north. Because average maximum dip for the Gulf Coast formations occurs at approximately 315 degrees relative to true north, we would expect maximum offsets to occur at pair orientation angles of approximate 315 degrees and 135 degrees.

Figure 13-14 shows a plot of the difference between the bottom of the Willis Formation at the water well location compared to its paired geophysical log location, relative to the horizontal orientation angle between the water well and geophysical log location. The plot includes a spline fit line to demonstrate a smoothed trend in the data. The water well location is considered to be the origin, so an angle of 315 degrees corresponds to the geophysical log located directly down dip of the water well location, an angle of 135 degrees corresponds to the geophysical log located directly up dip of the water well location, and angles of 45 or 225 degrees correspond to the geophysical log located directly along strike compared to the water well location.

The trend in Figure 13-14 generally shows a maximum negative offset occurring between angles of 75 and 150 degrees, while the maximum positive offset occurs between approximately 275 and 360 degrees. The lines cross zero offset at approximately 45 and 225 degrees. So Figure 13-14 supports a relationship between orientation angle and vertical offset, although noise in the data limits precision. In general, the maximum and minimum offsets on a per mile basis appear to be approximately 30 and -30 feet per mile, based on the smoothed line.

Figure 13-15 shows the trend for the bottom of the middle Lagarto Formation, a deeper formation. As with the Willis Formation, the trend supports the general relationship where maximum negative offset (absolute minimum) occurs near the proposed 135 degrees (the smoothed line minimum ranges between about 100 and 175 degrees), while the maximum positive offset occurs near the proposed 315 degrees (the smoothed line maximum ranges between 275 and 350 degrees).

Because the data based on regional surfaces do not offer the kind of precision required to develop a continuous relationship between orientation angle and offset, but do support the proposed trend, we simplified the implementation of "dip correction" when analyzing the water well/geophysical log pairs. For those pairs with an orientation angle in the dip quadrant centered on 315 degrees, we used a positive correction factor (i.e., the geophysical log vertical intervals were shifted up relative to the water well intervals). For those pairs with an orientation angle in the dip quadrant centered on 135 degrees, we used a negative offset. For those pairs with an orientation angle in the strike quadrants centered on either 45 or 225 degrees, no offset was used. Table 13-11 shows the gradient (feet offset per mile) used for each formation. The available data was somewhat limited for the Oakville and Catahoula formations, so the estimated 100-foot offset from the lower Lagarto Formation was also used for these units.

Table 13-11. Dip gradients (feet per mile) by formation used to correct vertical correlations between water well and geophysical log pairs.

Formation	Gradient (feet per mile)
Beaumont	10
Lissie	20

Formation	Gradient (feet per mile)
Willis	30
Upper Goliad	50
Lower Goliad	50
Upper Lagarto	100
Middle Lagarto	100
Lower Lagarto	100
Oakville	100
Catahoula	100

The vertical offset that occurs as a result of the dip of the formation between the log and the well is calculated using Equation 13-11.

$$\text{offset} = \text{dip} * \sin((\text{ang}-45)) * \text{dist} \qquad \text{(Equation 13-11)}$$

where:

offset = vertical offset caused by the formation (dip)
dip = the average dip of the formation
ang = angle of orientation between the location of the log and the water well (degrees)
dist = distance between the log and the well.

The Mean R_o method is not conceptually well suited for accounting for large variations in hydrogeochemical conditions across a study area that impact the relationship between formation resistivity and total dissolved solids concentration in groundwater. Because of a concern with the limitation of the Mean R_o method, we created a series of scatter plots that compared the logarithm of total dissolved solids as a function of the logarithm of resistivity of the formation for different filtering criteria. This process was automated using a computer program so we could generate the plots quickly and with few errors. The filtering criteria included all variables that we assemble including spatial location, geochemical composition of groundwater, formation, sand thickness, and proximity of sand to the water well. These plots range from including of well-log pairs to just small groups of the well-log pairs. Among the key observations from these plots are:

- Evidence of a correlation between resistivity of the formation and total dissolved solids is most evident when total dissolved solids was represented as calculated total dissolved solids.
- Two important factors that affected the magnitude of the regression coefficient R in developing a correlation between Total Dissolved Solids and Formation resisitivity was restriction on selecting sand based on their thickness and on their vertical offset from the mid point of the water well screen.

As part of our initial review and investigation into the resistivity of the formation and total dissolved solids datasets, we also reviewed the sequences of the thicknesses and resistivity of the formation values associated with sands identified from our analysis of the geophysical logs. One of the purposes of this review was to establish guidelines to identify which resistivity of the formation values are the most appropriate for correlating to the total dissolved solids concentrations in the water well. Our general guideline was to give priority to thicker sands and less priority to thinner sands based on both hydrogeological and geochemical reasons. From a hydrogeological perspective, thick sands are more transmissive and have a greater likelihood of being hydraulically connected to a sands in the vicinity of a well screen up to a mile away than thin sands. From a geochemistry perspective, thick sands are associated with depositional environments that produce a sand with less sand percent than thin sands.

Table 13-12 tabulates sand sequences that reflect three relatively common patterns in resistivity of the formation values near relatively thick sands. In Table 13-12, the sand profile for American Petroleum Institute log 4207102957 shows resistivity of the formation adjacent to a 72-foot thick sand ise about 50 percent of the 15.9 ohm-meter resistivity. This profile is a pattern that represents where the resistivity of the formation values decrease significantly with distance from a relatively thick sand. The sand profile for American Petroleum Institute log 4217531044 shows resistivity of the formation values gradually decreasing with distance from a relatively thick sand with resistivity values varying from a high of 18.7 ohm-meter to a low of 6.1 ohm-meter. The sand profile for American Petroleum Institute log 4240900372 shows resistivity of the formation values are very similar for a relatively thick sand and adjacent thinner sands.

Toward the end of our investigations, we used our computer program to investigate the potential importance of sand thickness as a variable in developing correlations between resistivity of the formation and total dissolved solids concentrations. Our analysis showed that better correlations could be achieved with the omission of thinner sands rather than with the omission of the thicker sands. Moreover, we discovered that the inclusion of the thinner sands with the relatively thick sands could significantly degrade the correlation.

Table 13-12. Example of Sand Sequences Showing Different Patterns in the Formation Resistivity.

Log API	Depth to Sand (ft bgs)		Sand Bed Thickness (ft)	Formation Resistivity (ohm-m)
	Top	Bottom		
Ro of Sand Significantly Decreases with Distance from the Thickest Sand				
4207102957	695	714	19	7.6
4207102957	728	800	**72**	**15.9**
4207102957	835	876	41	8.4
Ro of Sands Gradually Decreases with Distance from Thickest Sand				
4217531044	205	216	11	11.9
4217531044	227	245	18	16.7
4217531044	247	301	**54**	**18.7**
4217531044	332	356	24	13.6
4217531044	365	369	4	6.1
Ro Among Sands of Varying Thickness Are Similar Across Four or More Sand Intervals				

Log API	Depth to Sand (ft bgs)		Sand Bed Thickness (ft)	Formation Resistivity (ohm-m)
	Top	Bottom		
4240900372	270	281	11	14.5
4240900372	292	349	**57**	**16**
4240900372	366	383	17	16
4240900372	390	413	23	14.8
4240900372	455	467	12	16.8
4240900372	473	487	14	16.6

Note: API=American Petroleum Institute; ft bgs=feet below ground surface; ft=feet; ohm-m=ohm-meter

Our investigation of groupings primarily focused on different regional locations and different groups of formations. Our analysis discovered some difference between regional locations but none of the differences were statistically significant. Our final groups were based on the formations that comprise the three major aquifers in the Texas Gulf Coast Aquifer System. One group consists of well-log pairs from Beaumont, Lissie, andWillis formation that comprise the Chicot Aquifer. Another group consists of the upper Goliad, lower Goliad, upper Lagarto and middle Lagarto formations that comprise the Evangeline Aquifer and the Burkeville Confining Unit. The third group consists of the lower Lagarto, Oakville, and Catahoula formations, which comprise the Jasper Aquifer and the Catahoula Formation.

Table 13-13 presents data from the well- log pairs data used to construct a Ro-TDS graph for each of the three resistivity of the formation-total dissolved solids groups. These well-log pairs were selected as high quality and reliable because they meet the following conditions:

1. The water well has on a single well screen
2. The well screen has a total length greater than 25 feet but less than 100 feet
3. There is a relatively large sand bed that is identified on the log covers that approximately the same vertical interval as does the well screen.

The data from Table 13-14 was used to develop a R_o-TDS graph for the three groups of formations in order to evaluate the methodology. In addition to the data in Table 13-14, the graph included two resistivity cutoff values for 1,000 milligrams per liter and 3,000 milligrams per liter used by Young and others (2010, 2012)

The result graphs show a good correlation between the logarithm of total dissolved solids and the logarithm of the formation factor. Figure 13-15 shows the results for the group consisting of well pairs located in the Beaumont-Lissie-Willis formations. Figure 13-16 shows the results for the group consisting of well pairs located in the Lower Largarto-Oakville-Catahoula formations. Figure 13-18 shows the results for the group consisting of well pairs located in the Lower Lagarto-Oakville-Catahoula formations. All of the plots have an R-squared, or by another name the coefficient of determination, of 0.9 or greater

To help facilitate the analysis of the data points, we developed procedures that involves using several different pieces of computer code to help picks sands at geophysical logs to complete the analysis of available well-pairs for each group. The final set of rules that were implemented for the final regression analysis is listed in Table 13-13.

Table 13-13. Data from well-log pairs used to construct resistivity of the formation-total dissolved solids graphs for three well-log groups.

				Offset Information				Well Screen Information					Log Information								
Aquifer	**Formation**	**API Number**	**TWDB Well Number**	**Angle (degrees)**	**Distance (miles)**	**dip (ft/mile)**	**offset (ft)**	**Top (ft bgs)**	**Bottom (ft bgs)**	**Length (ft)**	**Midpoint (ft bgs)**	**Calculated TDS**	**Depth to Sand Top (ft bgs)**	**Depth to Sand Bottom (ft bgs)**	**Thickness (ft)**	**Ro Geometric Mean (Ohms)**	**Estimated Temperature (°F)**	**Ro Geometric Mean @ 77°F (Ohms)**	**Distance (ft) between the Well Screen midpoint and the Sand Bed top or bottom**	**Does the Well Screen and Sand overlap?**	**Sand Thickness to Well Screened Interval (as %)**
Beaumont-Lissie-Willis	Lissie	4207102957	6426804	63	0.93	40	12	684	742	58	713	811	728	800	72	15.9	82.7	17.0	3.4	1.0	124%
	Willis	4208900138	6622203	14	0.84	40	-17	180	210	30	195	222	162	218	55	23.7	72.2	22.3	15.8	1.0	183%
	Willis	4240900372	7960212	127	0.21	40	8	300	352	52	326	851	292	349	57	16	76.1	15.8	14.7	1.0	110%
	Lissie	4232130995	8023404	101	0.29	40	10	527	571	44	549	604	528	562	34	17.3	78.7	17.7	3.3	1.0	77%
	Lissie	4205700220	8026501	313	0.82	40	-33	225	267	42	246	1371	192	250	58	13.3	74.1	12.8	21.1	1.0	138%
	Willis	4227330109	8326701	293	0.25	40	-9	576	623	47	600	1125	643	733	90	13.2	83.7	14.3	52.7	0.0	191%
Upper Goliad-Lower Goliad - Upper Lagarto-Middle Lagarto	Middle Lagarto	4233900979	6044114	119	0.28	100	27	658	730	72	694	526	748	802	53	29.3	80.6	30.6	27.4	1.0	74%
	Middle Lagarto	4217500209	7912601	257	0.81	100	-43	581	648	67	614.5	749	577	624	48	17.5	81.8	18.5	5.5	1.0	72%
	Middle Lagarto	4217531857	7912601	74	0.24	100	12	581	648	67	614.5	749	624	647	22	21.9	82.4	23.3	2.0	1.0	33%
	Upper Lagarto	4217531044	7921202	138	0.70	100	69	170	220	50	195	606	247	301	54	18.7	76.1	18.5	17.4	1.0	108%
	Upper Goliad	4217530273	7923408	18	0.80	100	-36	402	472	70	437	868	422	473	51	17.1	78.7	17.5	20.7	1.0	73%
	Lower Goliad	4202501367	7935401	313	0.52	100	-51	250	290	40	270	972	246	298	51	14.8	76.5	14.8	27.5	0.0	128%
	Upper Goliad	4205701358	8026103	112	0.42	100	39	1030	1080	50	1055	1027	1032	1092	60	11.0	86.4	12.2	1.6	1.0	120%
	Upper Goliad	4224931428	8301706	255	0.43	100	-21	283	316	33	299.5	1225	261	298	36	12.1	76.6	12.0	17.2	1.0	109%
	Upper Goliad	4227300582	8346201	185	0.14	100	9	1530	1560	30	1545	5253	1512	1565	53	3.9	96.7	4.8	10.7	1.0	177%

				Offset Information				Well Screen Information					Log Information								
Aquifer	**Formation**	**API Number**	**TWDB Well Number**	**Angle (degrees)**	**Distance (miles)**	**dip (ft/mile)**	**offset (ft)**	**Top (ft bgs)**	**Bottom (ft bgs)**	**Length (ft)**	**Midpoint (ft bgs)**	**Calculated TDS**	**Depth to Sand Top (ft bgs)**	**Depth to Sand Bottom (ft bgs)**	**Thickness (ft)**	**Ro Geometric Mean (Ohms)**	**Estimated Temperature (°F)**	**Ro Geometric Mean @ 77°F (Ohms)**	**Distance (ft) between the Well Screen midpoint and the Sand Bed top or bottom**	**Does the Well Screen and Sand overlap?**	**Sand Thickness to Well Screened Interval (as %)**
	Upper Goliad	4204700179	8455329	58	0.37	100	8	540	580	40	560	770	470	537	67	14.5	80.9	15.2	31.0	0.0	168%
Lower Lagarto-Oakville-Catahoula	Catahoula	4237300037	6117402	NA	NA	NA	NA	NA	NA	NA	NA	4034	NA	NA	NA	3	89.9	3.5	-	-	-
	Lower Lagarto	4213130836	8420403	NA	NA	NA	NA	NA	NA	NA	NA	3626	NA	NA	NA	3	77.4	3.0	-	-	-
	Catahoula	4214900012	5959507	93	0.39	100	29	235	260	25	247.5	621	227	260	32	22.3	72.5	21.1	16.6	0.0	128%
	Oakville	4229701364	7840302	332	0.21	100	-20	105	125	20	115	1089	89	151	62	14.2	73.2	13.6	5.8	1.0	310%
	Lower Lagarto	4229701137	7847903	241	0.13	100	-3	200	240	40	220	1039	238	281	43	14.4	76.8	14.4	21.4	0.0	108%
	Oakville	4202500566	7925602	180	0.54	100	38	730	830	100	780	1458	727	759	32	10	84.3	10.9	59.3	0.0	32%
	Oakville	4213130091	8419303	353	0.14	100	-11	540	560	20	550	5977	535	564	29	2.6	82.3	2.8	4.1	1.0	145%

Note: API=American Petroleum Institute; ft/mile=feet per mile; ft bgs=feet below ground surface TDS= total dissolved solids; R_o=resistivity of the formation; °F=degrees Fahrenheit; ft=feet; %=percent

Table 13-14. Rules that were Implemented During the Construction of the resistivity of the Ro-TDS Graphs.

1	Continue to pick sand until the total length of sand is at least 60 percent of the total length of the slotted area of the screen.
2	If more than one sand interval is picked, the effective resistivity of the sands will be calculated as the geometric mean of their individual resistivity of the formation values.
3	The search for available sands for correlations is a function of the screen length. For a 10-foot screen, the vertical search interval is 30 feet. The vertical search interval is allowed to increase with screen length until it reaches it maximum extend of 250 feet, which occurs when the screen length is 270 feet.
4	Estimates of dip of the formation and distance between the well and the log will be used to determine offsets that will vertically shift the vertical search interval.
5	All resistivity of the formation values will be temperature corrected.
6	For each water well, the final regression analysis will include at least one well-log pair.
7	Where there are multiple well-log pairs at a well, one of the well-pairs is a candidate for expulsion from the final data regression if the quota of no more than 25 percent of the multiple well-log pairs has not already been exceeded.
8	The regression variable for total dissolved solids is calculated total dissolved solids.
9	All well-pairs were equally weighted.
10	Equation 13-13 was used to develop the relation between total dissolved solid concentration and Ro.

$$TDS = e^{(coef2 * \ln(Ro) + coef1)} \quad \text{(Equation 13-12)}$$

Where:

TDS = total dissolved concentration (milligrams per liter)
Ro = formation resistivity (ohm-meters)
Coef1 = a coefficient to be determine by the regression analysis
Ceof2 = a coefficient to be determine by the regression analysis

Figures 13-19, 13-20, and 13-21 present the results from all three regression analysis. Each plot has a blue line that mark the locaton where the resistivity represents a total dissolved solids concentration is 1,000 milligrams per liter and a red line where the resisitivity represents a total dissolved solids concentration of 3,000 milligrams per liter. The results among the different formations are quite similar. The Ro-TDS graph for the Beaumont, Lissie, and Willis formations in Figure 13-19 has a R square of 0.9. The regression contains data from 164 well-log pairs. The location of the well-log pairs are shown on Figure 13-22. The well-log pairs include 115 water wells and 164 geophysical logs. The range of total dissolved solids values is from about 100 to 8,000 milligrams per liter. A total of 29 well-log pairs were not used in the final analysis. They were omitted because another well-log pair involving the same well was used in the regression. Table 13-15 lists the individual well pairs that were used and omitted.

The Ro-TDS graph for the upper Goliad, lower Goliad, upper Lagarto, and middle Lagarto in Figure 13-20 has a R square of 0.67. The regression contains data from 305 well-log pairs. The location of the well-log pairs are shown on Figure 13-23. The well-log pairs include 115 water wells and 192 geophysical logs. The range of total dissolved solids values is from about 250 to 6,000 milligrams per liter. A total of 56 well-log pairs were not used in the final analysis. They were omitted because another well-log pair involving the same well was used in the regression. Table 13-15 lists the individual well pairs that were used and omitted.

The resistivity of the formation-total dissolved solids graph for the lower Lagarto-Oakville-Catahoula formations is shown in Figure 13-21 has a R square of 0.62. The range of total dissolved solids values is from about 600 to 7,000 milligrams per liter. The regression contains data from 117 well-log pairs. The location of the well-log pairs are shown on Figure 13-23. The well-log pairs include 69 water wells and 192 geophysical logs. The range of total dissolved solids values is from about 250 to 6,000 milligrams per liter. A total of 25 well-log pairs were not used in the final analysis. They were omitted because another well-log pair involving the same well was used in the regression. Table 13-17 lists the individual well pairs that were used and omitted.

Table 13-16 lists the coefficient produced for Equation 13-12 from the regression analysis for the three formation groups along with predicts of total dissolved solids concentrations for a range of resistivity of the formation values. Overall, the equations for the different formations is very similar.

Table 3-15. Equation for Predicting total dissolved solids concentrations from Formation Coefficients Produced.

Formation Resistivity	B-L-W	UG-LG-UL-ML	LL-OK-CAT
30	474	477	524
25	564	575	623
20	697	723	770
18	771	806	851
16	862	910	952
14	979	1044	1081
12	1133	1223	1251
10	1348	1475	1488
8	1666	1855	1839
6	2191	2494	2417
4	3222	3785	3553
2	6229	7720	6865
1	12044	15748	13265
0.5	23286	32123	25630
0.25	45021	65525	49521
Formation Group		coef1	coef2
B-L-W		9.40	-0.95

Formation Resistivity	B-L-W	UG-LG-UL-ML	LL-OK-CAT
UG-LG-UL-ML		9.66	-1.03
LL-OK-CAT		9.49	-0.95

Note: B-L-W=Beaumont-Lissie-Willis; UG-LG-UL-ML=upper Goliad-lower Goliad-upper Lagarto-middle Lagarto; LL-OK-CAT=lower Lagarto-Oakville-Catahoula

Table 13-16. The well -log pairs used and omitted to construct a Ro-TDS graph for the Beaumont-Lissie-Willis formations

SWN	TDS	API	R_o	Used
6054805	339.4	4233901718	44.2	Yes
6061307	370.5	4233901737	35.8	Yes
6061307	370.5	4233901738	46.9	Yes
6130405	131.2	4245700143	50.2	Yes
6131302	102.8	4245700366	180.6	Yes
6144967	1177.9	4219932589	12.2	Yes
6144967	1177.9	4219932590	16.1	Yes
6144967	1177.9	4219932603	8.8	Yes
6144967	1177.9	4219933018	10.8	Yes
6146201	305.1	4219900500	31.6	Yes
6146201	305.1	4219900502	30.1	Yes
6147201	246.4	4219903330	51.3	Yes
6153907	974.8	4219902148	13.4	Yes
6153907	974.8	4219902153	15.7	Yes
6153913	1096.6	4219902237	24.0	Yes
6153928	1425.3	4219902268	13.9	Yes
6153928	1425.3	4219902590	14.5	Yes
6153928	1425.3	4219903240	11.3	Yes
6160902	973.4	4229131424	17.6	Yes
6161309	753.4	4219902186	23.1	Yes
6162415	1021.8	4224500123	15.4	Yes
6164513	3814.0	4224500643	3.8	Yes
6242909	270.2	4235100394	68.1	Yes
6242909	270.2	4235100398	72.5	Yes
6408201	1506.6	4224501553	7.5	Yes
6409207	769.7	4207132442	18.9	Yes
6409207	769.7	4207132443	21.0	Yes
6409301	630.3	4207100065	23.0	Yes
6409301	630.3	4207100179	23.4	Yes
6409301	630.3	4207130072	21.6	Yes
6409302	698.2	4207100231	20.2	Yes
6409302	698.2	4207100258	23.0	Yes
6409307	703.4	4207100102	19.2	Yes
6409307	703.4	4207100699	13.9	Yes
6409335	742.0	4207100112	12.7	Yes
6426701	780.5	4207102962	14.6	Yes
6426701	780.5	4207102975	14.4	Yes
6426804	811.2	4207102877	12.3	Yes
6426804	811.2	4207102880	15.2	Yes
6426804	811.2	4207102957	17.0	Yes
6428302	2628.0	4207102365	5.7	Yes
6429502	8075.0	4207102253	2.8	Yes
6433911	1577.6	4216730283	8.1	Yes
6434201	3740.0	4216700961	6.8	Yes
6441114	952.5	4216701097	19.7	Yes
6534718	556.9	4215701698	24.4	Yes
6538124	760.5	4203901326	11.8	Yes
6541804	509.8	4248100824	31.3	Yes
6551803	1036.1	4203902872	15.7	Yes
6551803	1036.1	4203902873	10.7	Yes
6553605	703.9	4203904203	15.7	Yes
6561707	1810.3	4203904477	14.5	Yes
6561707	1810.3	4203904806	9.2	Yes
6561707	1810.3	4203930519	7.7	Yes
6562802	1255.6	4203904519	8.7	Yes
6616810	312.9	4201500530	26.3	Yes

SWN	TDS	API	R_o	Used
6622203	222.0	4208900138	22.4	Yes
6623205	393.5	4201500265	34.2	Yes
6623701	197.6	4208900110	34.7	Yes
6629302	319.4	4208930079	22.4	Yes
6630103	442.6	4208932123	30.4	Yes
6631203	275.8	4208931393	26.9	Yes
6635207	501.5	4208900484	36.7	Yes
6636604	698.6	4208931583	26.2	Yes
6637402	823.1	4208931206	10.5	Yes
6637607	356.8	4208900704	46.0	Yes
6637607	356.8	4208900705	35.1	Yes
6637607	356.8	4208931034	50.1	Yes
6637701	889.9	4208900755	18.6	Yes
6637701	889.9	4208931746	18.3	Yes
6638105	395.5	4208931735	34.6	Yes
6638106	424.1	4208900724	52.0	Yes
6638301	612.4	4248101213	39.7	Yes
6640607	469.3	4215731072	25.2	Yes
6642904	473.1	4228500343	21.8	Yes
6646601	439.9	4248133274	31.9	Yes
6647904	502.7	4248130084	35.1	Yes
6652801	566.7	4223900123	20.7	Yes
6658903	688.9	4223900047	22.3	Yes
6658903	688.9	4223900049	21.4	Yes
6660201	396.2	4223900136	22.2	Yes
6660401	1034.1	4223903549	15.8	Yes
6660703	709.6	4223900462	21.6	Yes
6661702	662.7	4223900651	27.8	Yes
6661702	662.7	4223900652	23.0	Yes
6661806	685.1	4223900667	18.5	Yes
6661806	685.1	4223900668	16.0	Yes
6661806	685.1	4223903321	22.1	Yes
6662313	491.0	4248132241	17.0	Yes
7908503	536.6	4246900800	17.3	Yes
7932602	1237.1	4246901569	11.7	Yes
7932602	1237.1	4246901571	13.3	Yes
7952407	1509.2	4202502633	11.8	Yes

SWN	TDS	API	R_o	Used
7952407	1509.2	4202502640	11.6	Yes
7952407	1509.2	4202502647	8.9	Yes
7952407	1509.2	4202502648	15.6	Yes
7959303	951.4	4240900346	12.5	Yes
7959501	1013.0	4240901049	15.1	Yes
7960106	976.0	4240900898	14.3	Yes
7960106	976.0	4240900907	13.2	Yes
7960212	851.3	4240900372	15.9	Yes
7960401	865.7	4240903989	18.6	Yes
7960503	909.9	4240900525	11.1	Yes
7960503	909.9	4240900616	16.9	Yes
7960616	925.5	4240900531	12.3	Yes
7960616	925.5	4240900615	18.9	Yes
7960801	960.6	4240904015	14.4	Yes
7961605	1227.2	4240901466	12.1	Yes
7961902	1369.6	4240901798	6.9	Yes
7962707	1323.0	4240901988	8.6	Yes
7964307	1432.9	4200700229	6.5	Yes
8004403	797.1	4223901657	16.3	Yes
8004403	797.1	4223933328	17.8	Yes
8004710	937.0	4223901936	17.0	Yes
8004710	937.0	4223901937	14.7	Yes
8005507	610.1	4223903325	20.6	Yes
8006703	533.8	4223901333	21.3	Yes
8006703	533.8	4223901366	17.8	Yes
8006704	726.7	4223901372	22.4	Yes
8007203	659.0	4232101587	27.2	Yes
8007206	783.1	4232101286	13.1	Yes
8007313	546.1	4232101226	23.1	Yes
8007313	546.1	4232101273	27.9	Yes
8007313	546.1	4232101278	21.0	Yes
8009506	637.2	4246900407	18.9	Yes
8011103	785.0	4246900158	10.6	Yes
8012303	1372.5	4223902138	14.7	Yes
8012305	988.6	4223902327	15.9	Yes
8017506	789.0	4246901644	22.1	Yes
8018401	1182.9	4246901887	13.6	Yes

SWN	TDS	API	R_o	Used
8019802	1155.2	4205700442	11.1	Yes
8020803	2088.2	4205701246	8.8	Yes
8021217	921.5	4223903224	15.0	Yes
8021601	660.2	4223903265	20.9	Yes
8023202	636.4	4232131723	13.3	Yes
8023404	603.6	4232130256	31.5	Yes
8023404	603.6	4232130995	17.7	Yes
8026501	1370.8	4205700220	12.8	Yes
8027603	1555.5	4205700540	7.4	Yes
8027603	1555.5	4205700542	9.3	Yes
8042106	1314.1	4239100086	8.3	Yes
8045201	5806.0	4205731113	2.7	Yes
8101101	457.3	4232100945	30.8	Yes
8101101	457.3	4232100946	27.9	Yes
8101101	457.3	4232101011	23.5	Yes
8101201	452.0	4232101019	22.7	Yes
8101201	452.0	4232101022	29.3	Yes
8101201	452.0	4232101025	29.5	Yes
8101201	452.0	4232101026	22.7	Yes
8102901	967.5	4232131364	9.0	Yes
8105320	1006.6	4203930263	19.4	Yes
8109905	902.0	4232131061	16.0	Yes
8301901	2282.2	4235500013	10.6	Yes
8301901	2282.2	4235532446	11.3	Yes
8303607	3719.8	4240903834	2.8	Yes
8305501	3716.9	4240902801	4.8	Yes
8319402	1593.3	4235504659	9.3	Yes
8325501	1238.7	4227300289	12.9	Yes
8325501	1238.7	4227300306	14.1	Yes
8326701	1124.5	4227330109	14.3	Yes
8334501	1180.0	4227301002	16.3	Yes
8334501	1180.0	4227301004	16.9	Yes
8334501	1180.0	4227301076	16.9	Yes
8904625	1649.7	4206100125	13.0	Yes
6130405	131	4245700196	42.8	No
6130405	131	4245700199	37.2	No
6144967	1,178	4219932365	4.7	No

SWN	TDS	API	R_o	Used
6153913	1,097	4219902360	25.9	No
6153928	1,425	4219902479	18.8	No
6409302	698	4207100226	11.8	No
6409302	698	4207100267	6.4	No
6409307	703	4207100071	11.5	No
6409335	742	4207100024	10.2	No
6409335	742	4207100113	9.4	No
6426701	780	4207131322	10.6	No
6426804	811	4207102896	10.2	No
6541804	510	4248132108	10.8	No
6623205	394	4201500280	11.7	No
6623701	198	4208900119	30.5	No
6630103	443	4208900246	70.8	No
6637607	357	4208931788	24.4	No
6660201	396	4223900137	16.0	No
6660703	710	4223900464	39.6	No
6662313	491	4248130006	16.7	No
7908503	537	4246900801	55.4	No
8004710	937	4223930384	9.6	No
8007206	783	4232101285	11.5	No
8007313	546	4232101254	10.2	No
8017506	789	4246902893	7.4	No
8019802	1,155	4205700531	6.6	No
8027603	1,556	4205700541	5.6	No
8319402	1,593	4235506684	5.7	No
8326701	1,125	4227301972	8.2	No

Note: SWN=State Well Number; TDS=total dissolved solids; API=American Petroleum Institute identifier; R_o=resistivity of the formation

Table 13-17. The well-log pairs used and omitted to construct a Ro-TDS graph for the Upper Goliad-Lower Goliad-Upper Largto-Middle Largto Formations (Evangeline)

SWN	TDS	API	R_o	Used
5963801	547.0	4201530138	14.1	Yes
6027602	511.6	4247130016	13.9	Yes
6044114	525.8	4233900979	30.6	Yes
6044318	502.2	4233900910	24.2	Yes
6045207	458.1	4233900926	25.4	Yes
6045402	521.0	4233900104	20.4	Yes
6045507	462.7	4233900139	23.8	Yes
6045507	462.7	4233900141	22.0	Yes
6053406	546.6	4233901879	17.4	Yes
6053709	604.1	4233901425	22.3	Yes
6053709	604.1	4233901779	24.6	Yes
6053821	506.1	4233901416	23.9	Yes
6053821	506.1	4233901420	26.5	Yes
6061408	644.9	4220100996	19.1	Yes
6061410	568.8	4220100911	21.0	Yes
6064305	1095.2	4229132387	21.5	Yes
6217911	255.0	4224100084	49.2	Yes
6217911	255.0	4224100086	38.9	Yes
6511406	470.5	4220104100	18.9	Yes
6606108	1035.1	4201500621	18.4	Yes
6620407	843.4	4208900354	17.3	Yes
6620508	602.4	4208900330	19.4	Yes
6620902	715.4	4208932648	13.7	Yes
6622701	387.6	4208900970	14.9	Yes
6627905	754.2	4208930336	16.1	Yes
6628402	348.3	4208930653	18.7	Yes
6628503	621.4	4208930088	30.8	Yes
6628508	539.4	4208931330	19.9	Yes
6628602	348.1	4208930592	17.6	Yes
6628607	695.9	4208930565	17.4	Yes
6628805	405.6	4208930579	14.5	Yes
6630203	305.5	4208930236	35.1	Yes
6630208	274.9	4208900247	40.1	Yes
6631105	344.2	4208900127	21.0	Yes
6631906	444.5	4248134117	32.8	Yes
6635303	436.9	4208930312	19.6	Yes
6636103	729.8	4208930576	12.9	Yes
6636603	471.8	4208900584	26.5	Yes
6636603	471.8	4208930150	24.7	Yes
6643803	528.5	4228531445	23.7	Yes
6644409	394.1	4208931604	23.6	Yes
6644704	451.7	4208931902	19.4	Yes
6650401	651.8	4228500431	21.6	Yes
6650801	775.1	4223933251	21.6	Yes
6651305	769.5	4223932729	33.1	Yes
6651810	817.9	4223900098	20.1	Yes
6651810	817.9	4223900340	16.3	Yes
6652407	588.5	4223932665	23.7	Yes
6654511	483.0	4248101603	33.3	Yes
6654511	483.0	4248133033	25.4	Yes
6658402	468.3	4223931605	18.3	Yes
6659501	573.8	4223900300	19.1	Yes
6659501	573.8	4223903704	25.0	Yes
6660902	915.5	4223900520	18.7	Yes
6660902	915.5	4223900525	15.2	Yes
6660907	536.2	4223900563	19.9	Yes
7856701	1135.4	4229730552	10.1	Yes
7864102	1300.6	4229702352	10.9	Yes
7864102	1300.6	4229702353	11.8	Yes
7864301	1503.1	4229702327	10.9	Yes
7864301	1503.1	4229702659	13.8	Yes
7864803	1005.9	4224900067	14.1	Yes
7864803	1005.9	4224930011	14.1	Yes
7905605	717.7	4212300545	17.5	Yes
7905605	717.7	4212300548	20.6	Yes
7905605	717.7	4212300802	28.7	Yes
7905901	744.5	4217500586	17.9	Yes
7907903	1052.7	4246900857	16.7	Yes

SWN	TDS	API	R_o	Used
7907903	1052.7	4246930303	15.7	Yes
7907904	606.1	4246900856	21.2	Yes
7912601	748.5	4217500209	18.5	Yes
7912601	748.5	4217531711	16.2	Yes
7912601	748.5	4217531857	20.9	Yes
7912804	755.8	4217500101	16.0	Yes
7912804	755.8	4217500120	27.2	Yes
7912804	755.8	4217500128	23.2	Yes
7912804	755.8	4217500133	17.2	Yes
7912804	755.8	4217500136	21.9	Yes
7912901	836.2	4217502086	16.1	Yes
7912901	836.2	4217531390	17.1	Yes
7913105	895.3	4217500446	11.7	Yes
7913703	925.0	4217501779	16.7	Yes
7913703	925.0	4217501881	13.2	Yes
7913801	779.5	4217502028	16.7	Yes
7913801	779.5	4217531694	14.8	Yes
7914602	1031.1	4217500680	15.9	Yes
7914602	1031.1	4217531042	11.5	Yes
7914602	1031.1	4217531590	15.9	Yes
7914602	1031.1	4217532457	16.1	Yes
7915501	792.2	4217531657	11.2	Yes
7916903	770.2	4246900998	19.9	Yes
7916906	794.4	4246901010	22.3	Yes
7916906	794.4	4246901051	17.6	Yes
7918901	1236.6	4202500145	12.6	Yes
7919101	1080.0	4225530283	17.8	Yes
7919301	903.7	4217501549	12.0	Yes
7919304	933.5	4217530193	20.1	Yes
7919705	1609.6	4217501601	9.1	Yes
7920401	891.0	4217501407	14.2	Yes
7920501	800.0	4217501336	14.8	Yes
7920501	800.0	4217501396	14.9	Yes
7920505	733.4	4217501406	14.1	Yes
7920603	1233.2	4217501900	14.0	Yes
7920603	1233.2	4217501908	13.7	Yes
7920801	1304.6	4217501328	15.4	Yes

SWN	TDS	API	R_o	Used
7920801	1304.6	4217501333	14.4	Yes
7920801	1304.6	4217531272	16.2	Yes
7920901	808.0	4217501394	16.8	Yes
7920901	808.0	4217533344	18.2	Yes
7921202	606.2	4217531044	18.5	Yes
7921502	841.1	4217530365	21.8	Yes
7921701	792.3	4217530082	16.2	Yes
7921701	792.3	4217530217	18.0	Yes
7922404	689.9	4217534159	13.2	Yes
7922502	771.1	4217500948	18.7	Yes
7923103	922.9	4217531549	14.1	Yes
7923408	868.1	4217500751	17.6	Yes
7923408	868.1	4217530273	17.5	Yes
7923408	868.1	4217530344	19.9	Yes
7923408	868.1	4217530415	17.4	Yes
7926102	1806.3	4202500251	6.7	Yes
7926102	1806.3	4202532413	10.3	Yes
7926102	1806.3	4202532857	8.2	Yes
7926204	1289.9	4202500146	14.9	Yes
7926204	1289.9	4202500147	9.7	Yes
7926205	1257.1	4202500130	12.9	Yes
7926801	1557.2	4202530223	14.8	Yes
7926801	1557.2	4202530379	9.9	Yes
7927302	903.3	4217501615	14.0	Yes
7927303	1036.1	4217501616	19.0	Yes
7927303	1036.1	4217501620	13.3	Yes
7928501	1057.2	4217501080	15.3	Yes
7928706	1056.9	4217501163	20.1	Yes
7928706	1056.9	4217501194	15.0	Yes
7928706	1056.9	4217501195	14.3	Yes
7928717	722.0	4217501204	25.4	Yes
7928717	722.0	4217501207	27.8	Yes
7933302	883.9	4202501693	15.0	Yes
7933302	883.9	4202501725	13.8	Yes
7933302	883.9	4202502539	13.7	Yes
7933906	1220.8	4202501712	9.0	Yes
7934405	769.9	4202501636	22.7	Yes

SWN	TDS	API	R_o	Used
7934601	915.2	4202531843	12.8	Yes
7935401	972.0	4202501367	14.8	Yes
7936901	1036.5	4202533418	11.9	Yes
7937204	922.4	4217501723	22.1	Yes
7937402	940.5	4217533228	18.9	Yes
7937906	897.9	4202502437	17.7	Yes
7937906	897.9	4217531496	20.7	Yes
7938406	1149.4	4217531188	15.1	Yes
7938406	1149.4	4217531261	14.5	Yes
7938406	1149.4	4217531668	16.5	Yes
7938406	1149.4	4217531741	14.9	Yes
7938406	1149.4	4217531785	14.6	Yes
7941301	1001.8	4202501758	9.6	Yes
7942103	1096.0	4202530422	8.0	Yes
7943102	765.3	4202501410	13.8	Yes
7943305	815.1	4202532965	19.5	Yes
7943401	1106.4	4202501451	13.7	Yes
7943401	1106.4	4202501454	14.4	Yes
7943401	1106.4	4202501468	13.9	Yes
7943702	977.0	4202502496	15.4	Yes
7943704	1077.1	4202502001	15.6	Yes
7945101	1176.3	4202501259	11.6	Yes
7945203	1057.4	4202501219	10.7	Yes
7945203	1057.4	4202501221	11.3	Yes
7946611	1103.9	4239102342	14.5	Yes
7946611	1103.9	4239102530	11.6	Yes
7946612	1127.4	4239102287	13.5	Yes
7946612	1127.4	4239102346	14.7	Yes
7949803	765.8	4229701819	15.3	Yes
7950304	894.5	4202532161	15.0	Yes
7950503	1592.3	4202532114	11.3	Yes
7950907	1246.6	4240900047	14.9	Yes
7950907	1246.6	4240932081	13.5	Yes
7951105	1078.6	4202532194	13.5	Yes
7951603	1249.4	4202502054	14.0	Yes
7951603	1249.4	4202502063	13.7	Yes
7951603	1249.4	4202502067	14.4	Yes

SWN	TDS	API	R_o	Used
7956203	1494.4	4200700354	11.2	Yes
7959101	1335.6	4240900355	10.2	Yes
7959101	1335.6	4240931657	14.0	Yes
7959101	1335.6	4240931672	13.3	Yes
7959102	1360.0	4240900274	12.4	Yes
7959102	1360.0	4240931671	12.9	Yes
7960604	1196.7	4240900448	17.1	Yes
7960604	1196.7	4240900457	14.1	Yes
7960604	1196.7	4240904196	9.9	Yes
7960614	1152.5	4240900451	10.6	Yes
7960614	1152.5	4240900488	14.2	Yes
7960614	1152.5	4240903997	13.1	Yes
7960614	1152.5	4240904001	14.1	Yes
8003202	740.7	4223930023	24.0	Yes
8003803	825.7	4223901863	14.9	Yes
8003803	825.7	4223901887	19.1	Yes
8009105	682.4	4246932781	21.6	Yes
8009409	720.0	4246900519	20.6	Yes
8017503	937.1	4246901660	18.8	Yes
8017504	915.0	4246901666	10.7	Yes
8017905	1019.2	4246902061	16.7	Yes
8017905	1019.2	4246903066	16.3	Yes
8018501	1102.0	4246901754	15.0	Yes
8018501	1102.0	4246901792	16.5	Yes
8018503	1006.4	4246902560	13.8	Yes
8018503	1006.4	4246930589	12.4	Yes
8025301	1038.5	4205700037	19.3	Yes
8025301	1038.5	4205700043	15.4	Yes
8025301	1038.5	4246902423	14.9	Yes
8025301	1038.5	4246932847	14.8	Yes
8026103	1026.9	4205700039	18.8	Yes
8026103	1026.9	4205700083	11.1	Yes
8026103	1026.9	4205701358	12.9	Yes
8026903	1484.0	4205700238	7.5	Yes
8033610	1083.9	4239130260	12.5	Yes
8033610	1083.9	4239130547	19.7	Yes
8301508	1331.4	4224900422	13.6	Yes

SWN	TDS	API	R_o	Used
8301508	1331.4	4224900461	12.7	Yes
8301509	1066.9	4224900585	14.4	Yes
8301509	1066.9	4224930126	14.3	Yes
8301509	1066.9	4224931327	16.0	Yes
8301514	1115.2	4224900581	13.0	Yes
8301514	1115.2	4224900582	13.6	Yes
8301706	1224.9	4224931428	12.0	Yes
8302306	1342.3	4224900183	12.8	Yes
8310602	2084.8	4235500386	9.4	Yes
8310602	2084.8	4235500417	8.5	Yes
8310602	2084.8	4235500422	11.0	Yes
8310602	2084.8	4235500423	9.5	Yes
8317901	2278.1	4235505978	8.5	Yes
8325101	1766.0	4227300239	10.2	Yes
8325608	2174.6	4227300508	7.0	Yes
8325801	1019.7	4227300504	16.8	Yes
8325801	1019.7	4227300505	14.4	Yes
8325801	1019.7	4227300506	15.3	Yes
8326401	1107.0	4227302022	13.1	Yes
8326404	1093.4	4227301915	16.7	Yes
8326509	1787.7	4235505970	9.2	Yes
8327901	1606.0	4227300537	8.5	Yes
8329201	2863.7	4235503199	5.3	Yes
8329202	2683.0	4235503199	6.8	Yes
8329701	4629.0	4227331873	3.5	Yes
8334101	1195.8	4227301047	14.5	Yes
8337201	3352.3	4227331464	3.0	Yes
8346201	5252.5	4227300582	4.8	Yes
8358703	1490.7	4226130175	12.2	Yes
8407903	891.8	4224931724	11.1	Yes
8408801	992.3	4224901072	11.4	Yes
8408801	992.3	4224901139	17.5	Yes
8415702	936.8	4213100995	14.3	Yes
8416407	2112.3	4224901362	8.3	Yes
8416804	1381.9	4224901547	11.8	Yes
8416804	1381.9	4224901563	13.2	Yes
8416805	1120.8	4224901394	13.5	Yes
8416805	1120.8	4224901475	12.4	Yes
8416807	1326.8	4224903602	13.1	Yes
8416807	1326.8	4224903684	13.6	Yes
8421601	1019.8	4213108481	15.9	Yes
8421601	1019.8	4213131592	17.2	Yes
8422401	1670.2	4213108591	8.7	Yes
8422401	1670.2	4213108592	12.0	Yes
8422401	1670.2	4213108593	10.7	Yes
8423105	1308.5	4213137123	7.4	Yes
8423204	1085.1	4224903587	9.5	Yes
8424101	1423.6	4224901550	11.9	Yes
8424101	1423.6	4224901552	13.1	Yes
8424102	1322.7	4224901660	12.9	Yes
8424204	1311.2	4224930401	12.2	Yes
8424208	1506.2	4224901786	11.8	Yes
8424208	1506.2	4224901787	14.5	Yes
8424208	1506.2	4224901788	9.6	Yes
8424208	1506.2	4224901794	9.4	Yes
8424208	1506.2	4224901797	11.0	Yes
8424401	2154.0	4224901570	7.8	Yes
8424401	2154.0	4224901583	10.6	Yes
8424401	2154.0	4224901586	11.2	Yes
8424513	2947.0	4224903689	9.0	Yes
8429309	1448.7	4213108934	14.3	Yes
8429310	1440.9	4213111054	13.0	Yes
8430404	1642.7	4213108704	13.7	Yes
8432503	1449.8	4227300036	11.0	Yes
8432503	1449.8	4227300037	11.9	Yes
8438902	910.1	4213109664	16.7	Yes
8440206	909.1	4227301304	17.9	Yes
8440206	909.1	4227301312	16.5	Yes
8440703	2496.9	4224902721	8.7	Yes
8440703	2496.9	4224902756	8.8	Yes
8440703	2496.9	4224902815	8.4	Yes
8440703	2496.9	4224902998	9.0	Yes
8443509	1133.1	4224700246	9.0	Yes
8448117	923.4	4224903220	14.0	Yes

SWN	TDS	API	R_o	Used
8448117	923.4	4224903314	19.2	Yes
8455325	767.5	4204700167	14.4	Yes
8455329	770.4	4204700179	15.6	Yes
8456203	770.0	4204730163	15.4	Yes
8460402	973.7	4224700401	10.1	Yes
8463304	915.2	4204730279	12.8	Yes
8707604	1063.2	4204701201	14.3	Yes
8708801	1057.4	4204701304	12.8	Yes
8708801	1057.4	4204701306	12.5	Yes
8713503	1013.7	4204701107	10.9	Yes
8713503	1013.7	4204701140	14.4	Yes
8713601	2840.0	4204701650	6.2	Yes
8802403	1340.2	4226100225	13.0	Yes
8802403	1340.2	4226100226	11.9	Yes
8802403	1340.2	4226100227	11.6	Yes
6045402	521.0	4233900103	13.8	No
6053406	546.6	4233901121	15.7	No
6628402	348.3	4208900449	13.1	No
6628503	621.4	4208900445	13.8	No
6628503	621.4	4208931209	13.5	No
6628508	539.4	4208932613	15.0	No
6628805	405.6	4208931159	11.7	No
6630203	305.5	4208930160	29.5	No
6630203	305.5	4208930284	14.6	No
6631105	344.2	4208900129	15.5	No
6631105	344.2	4208900133	17.8	No
6635304	518.5	4208900500	12.2	No
6643803	528.5	4228500187	16.3	No
6651810	817.9	4223900097	11.3	No
6658402	468.3	4223930650	2.6	No
6659501	573.8	4223900304	15.1	No
6660907	536.2	4223900581	11.4	No
7905901	744.5	4217500582	12.1	No
7912901	836.2	4217500162	11.2	No
7913105	895.3	4217500445	10.6	No
7913105	895.3	4217500453	9.0	No
7913801	779.5	4217500328	12.9	No

SWN	TDS	API	R_o	Used
7913801	779.5	4217533150	8.1	No
7918901	1236.6	4202500129	47.2	No
7920501	800.0	4217501405	13.0	No
7920505	733.4	4217502040	11.3	No
7920505	733.4	4217530341	8.2	No
7920801	1304.6	4217501331	19.1	No
7920901	808.0	4217530090	11.5	No
7921701	792.3	4217530084	11.7	No
7921701	792.3	4217530237	9.7	No
7921701	792.3	4217532847	12.0	No
7922502	771.1	4217500887	12.1	No
7928717	722.0	4217501186	13.1	No
7933302	883.9	4202501692	9.6	No
7936901	1036.5	4202532563	10.7	No
7937402	940.5	4202502414	38.1	No
7943102	765.3	4202530197	11.5	No
7943401	1106.4	4202501459	6.2	No
7950503	1592.3	4202501938	15.9	No
7951105	1078.6	4202532157	23.8	No
8026903	1484.0	4205701231	6.7	No
8033610	1083.9	4239130253	6.8	No
8301509	1066.9	4224930455	9.2	No
8408801	992.3	4224901075	7.8	No
8408801	992.3	4224901138	9.8	No
8408801	992.3	4224901140	10.6	No
8415702	936.8	4213100987	8.7	No
8422401	1670.2	4213108590	18.9	No
8422401	1670.2	4213111077	6.2	No
8423204	1085.1	4224903701	9.2	No
8424401	2154.0	4224901574	4.7	No
8440703	2496.9	4224902825	4.1	No
8460402	973.7	4224700509	8.0	No
8460402	973.7	4224702549	8.7	No

Note: SWN=State Well Number; TDS=total dissolved solids; API=American Petroleum Institute identifier; R_o=resistivity of the formation

Table 13-18. The well-log pairs used and omitted to construct Ro-TDS graphs for the Lower Lagarto-Oakville –Catahoula Formatons (Jasper).

SWN	TDS	API	R_o	Used
5959507	621	4214900012	21.1	Yes
5961402	624	4201530146	29.8	Yes
5961803	636	4201500018	13.9	Yes
5963902	1192	4201500048	9.2	Yes
5963902	1192	4201500051	19.2	Yes
5963902	1192	4201500068	15.0	Yes
5963902	1192	4201500071	14.5	Yes
6016801	3937	4237300032	4.7	Yes
6041107	740	4218500102	10.0	Yes
6045503	513	4233900154	18.4	Yes
6045503	513	4233900155	22.2	Yes
6117402	4034	4237300037	3.5	Yes
6503308	5227	4220103926	4.5	Yes
6503505	5526	4220131206	6.7	Yes
6604302	884	4201530127	16.5	Yes
6609801	766	4214900053	14.8	Yes
6611208	1481	4214900369	9.7	Yes
6618502	886	4214930293	12.0	Yes
6618602	795	4208931622	12.5	Yes
6618604	1209	4208931004	14.4	Yes
6618604	1209	4208931611	8.4	Yes
6618701	743	4214931607	8.6	Yes
6762307	907	4212300290	17.9	Yes
7816201	1894	4225500855	9.6	Yes
7816615	1119	4225500853	8.6	Yes
7832303	782	4202530389	8.5	Yes
7839801	1088	4229701045	17.3	Yes
7840302	1089	4229701364	13.6	Yes
7840302	1089	4229701367	12.8	Yes
7847801	996	4229701222	11.4	Yes
7847801	996	4229701228	15.9	Yes
7847903	1039	4229701137	14.4	Yes
7847903	1039	4229701138	15.2	Yes
7847903	1039	4229701139	14.8	Yes
7855701	2424	4229702031	8.1	Yes
7903707	940	4225531202	13.9	Yes
7905101	782	4212301070	18.9	Yes
7905101	782	4212331729	26.0	Yes
7910408	1434	4225500553	16.5	Yes
7911901	887	4225500339	12.2	Yes
7911901	887	4225500340	11.0	Yes
7911901	887	4225500342	16.2	Yes
7911901	887	4225500350	15.9	Yes
7911902	919	4225500353	17.4	Yes
7911902	919	4225500414	14.0	Yes
7918501	1657	4225501016	10.6	Yes
7918501	1657	4225501034	15.9	Yes
7918501	1657	4225520073	11.1	Yes
7918503	1735	4202500085	6.1	Yes
7918503	1735	4202502587	7.2	Yes
7918604	1735	4202500102	8.5	Yes
7918604	1735	4202500104	9.4	Yes
7919501	1676	4217501550	14.4	Yes
7919501	1676	4217501551	12.2	Yes
7919501	1676	4217531575	10.1	Yes
7919501	1676	4217531696	8.0	Yes
7919602	1465	4217501526	10.8	Yes
7919602	1465	4217501527	6.6	Yes
7919602	1465	4217531006	7.2	Yes
7925602	1458	4202500566	9.6	Yes
7925602	1458	4202530995	17.7	Yes
7926207	1468	4202500216	11.9	Yes
7926207	1468	4202530530	9.2	Yes
7926207	1468	4202532229	6.9	Yes
7934903	1422	4202501578	11.4	Yes
7934903	1422	4202532220	12.2	Yes
7935701	1652	4202530101	10.4	Yes
7935701	1652	4202530201	11.6	Yes
7935702	2108	4202501374	10.8	Yes
7935702	2108	4202501375	8.3	Yes
7935702	2108	4202501376	10.7	Yes
7935702	2108	4202501379	12.5	Yes

SWN	TDS	API	R_o	Used
7935702	2108	4202501841	10.5	Yes
8412301	1633	4213103454	7.6	Yes
8412301	1633	4213103459	6.6	Yes
8412603	3443	4213104040	8.0	Yes
8412605	3078	4213131452	5.7	Yes
8419101	5205	4213137995	6.7	Yes
8419303	5977	4213107018	3.0	Yes
8419303	5977	4213107020	3.4	Yes
8419303	5977	4213107023	3.5	Yes
8419303	5977	4213130091	2.8	Yes
8419303	5977	4213130100	4.0	Yes
8420403	3626	4213130836	3.0	Yes
8427405	1563	4213108259	7.7	Yes
8427405	1563	4213108295	10.5	Yes
8428803	6989	4213107860	4.3	Yes
8433101	1245	4247902608	8.0	Yes
8433101	1245	4247933812	12.0	Yes
8433103	1754	4247902487	8.4	Yes
8433204	675	4247902483	11.6	Yes
8433701	1362	4247902807	7.6	Yes
8434404	1012	4247933395	8.0	Yes
8434405	1049	4247904876	8.4	Yes
8434407	1437	4247904672	9.2	Yes
8434407	1437	4247904846	7.0	Yes
8434502	1108	4247902011	9.2	Yes
8434502	1108	4247904941	8.4	Yes
8434805	1196	4247904905	8.5	Yes
8437203	4485	4213109336	10.4	Yes
8442601	1267	4224700149	13.6	Yes
8442601	1267	4224700162	11.7	Yes
8442601	1267	4224700168	9.8	Yes
8443512	1296	4224700232	14.2	Yes
8443512	1296	4224700233	13.9	Yes
8443512	1296	4224700234	17.5	Yes
8443512	1296	4224700235	12.1	Yes
8443514	1384	4224700261	15.3	Yes
8443514	1384	4224700262	15.8	Yes
8443514	1384	4224731904	13.1	Yes
8450101	1547	4224700724	7.4	Yes
8450101	1547	4224700725	7.8	Yes
8457101	1173	4250500388	6.9	Yes
8701201	1796	4224701875	6.2	Yes
8701601	1888	4224701880	5.2	Yes
8709301	5070	4224702276	4.6	Yes
8710402	5656	4224702242	4.1	Yes
5961402	624.0	4201500782	12.3	No
5961402	624.0	4201500783	13.7	No
5963902	1192.1	4201500049	6.9	No
5963902	1192.1	4201500070	6.6	No
6041107	739.9	4218500099	9.9	No
6609801	765.7	4214900052	7.1	No
6609801	765.7	4214900055	11.1	No
6618701	742.7	4214931555	6.7	No
7839801	1088.3	4229701037	5.2	No
7839801	1088.3	4229701041	2.1	No
7919602	1465.1	4217531185	2.9	No
7925602	1457.6	4202500567	5.8	No
7925602	1457.6	4202530433	4.1	No
8412301	1632.8	4213103458	4.4	No
8427405	1563.0	4213108299	4.5	No
8433204	675.1	4247902657	10.5	No
8434405	1049.1	4247904902	7.9	No
8434805	1195.5	4247902046	3.7	No
8457101	1173.2	4250500395	3.4	No
8701201	1795.7	4224701535	1.9	No
8701201	1795.7	4224701852	2.5	No
8701601	1887.7	4224701877	2.3	No
8701601	1887.7	4224702046	3.8	No
8701601	1887.7	4224702050	2.7	No
8701601	1887.7	4224702143	1.5	No

Note: SWN=State Well Number; TDS=total dissolved solids; API=American Petroleum Institute identifier; R_o=resistivity of the formati

Among the variables that can be important in developing the resistivity of the formation-total dissolved solids graphs is criteria controlling the amount and number of sand picked at a log to establish the resistivity of the formation value to be matched with the total dissolved solids concentration at the well. In developing the relationships resistivity of the formation-graphs in Figures 13-19, 13-20, and 13-21, we required that the total length of the sand picks at a well be at least 60 percent of the screen interval. For the Ro-TDS graphs in Figure 13-19, 13-20, and 13-21 the values are general higher that 60 percent and varies with formation and screen lengh. As shown in Table 13-18, the majority of the well pair meet an 80 percent criteria. As might be expected the results in Table 13-18 show that the sand coverage is a function of both foundation and screen size. The relatively high percentages in Table 13-18 gave us confidence in the relationships reported in Table 13-14.

Table 13-19. The Percentage of well-log Pairs where the Total length of Sand is at least 80% of the Screen Length.

Formation Group	Size of Well Screen			
	200 ft or less	150 ft or less	100 ft or less	50 ft or less
B-W-L	76%	80%	85%	93%
UG-LG-UL-ML	68%	73%	77%	84%
LL-OK-CAT	52%	60%	65%	68%

Note: B-L-W=Beaumont-Lissie-Willis; UG-LG-UL-ML=upper Goliad-lower Goliad-upper Lagarto-middle Lagarto; LL-OK-CAT=lower Lagarto-Oakville-Catahoula; ft=feet; %=percent

13.3.3 Development of the Minimum Rwa Method

The development of the Minimum Rwa Method follows the formulas provided by Estepp (1988) and Meyers and others (21014). For total dissolved solids concentrations above 10,000 milligrams per liter, we used the Rwa method to predict total dissolved solids concentrations. We implemented the Rwa method using Equation 13-9, which is repeated here again as Equation 13-13.

$$R_{we77} = \Phi^{m} \times R_{o77} \qquad \text{(Equation 13-13)}$$

Where

R_{we77} = resistivity of water equivalent (ohm-meters) at 77°F
Φ = porosity
m = the cementation exponent
R_{o77} = the resistivity of a 100 percent water saturated formation (ohm-meters) at 77°F

F = formation factor = Φ^{m}

After applying Equation 13-13 we applied Equation 13-14 and then Equatoin 13-15 to convet resistivity to specific conductance using Equation 13-14

$$C_{w77} = 10{,}000 / R_{we77} \quad \text{(Equation 13-14)}$$

$$TDS = ct * C_{w77} \quad \text{(Equation 13-15)}$$

Where:

C_{w77} = Specific Conductane (umhos/cm at 77°F)
Ct = specific conductivity-total dissolved solids conversion factor
TDS = dissolved solid concentrations (mg/L)

To implement the method above we define porosity using equation 11-1, which is

$$\Phi = 36.64 - 0.001 * d \quad \text{(Equation 13-16)}$$

Where:

Φ = porosity
d = depth (feet)

For a groundwater solution that is fully dominated by sodium chloride the value of ct is 0.56. (Shlumberger, 2009). Our analysis of the high total dissolved solids data and high chloride content, the Ct values ranges from 0.57 to 0.59 depending on the sampling of the available data. For our application we have selected Ct value of 0.58.

Estepp (1998) provides two ranges for the cementation coefficient that are relevant to the Texas Gulf Coast Aquifer. For fine to medium loose sandstone, Estepp (1998) provides a range of 1.3 to 1.4 for the cementation exponent. For slightly cemented sandstone, Estepp (1998) provides a range of 1.4 to 1.5 for the cementation exponent. Because the Gulf Coast Aquifer is largely an unconsolidated deposit the exponent 1.3 was selected.

13.3.4 Conversion from Calculated TDS to Measured TDS

The Mean Ro method was constructed to predicted a calculated TDS from Ro. The predicted TDS for the groundwater concentration needs to be express as a measured TDS. To convert calculated TDS to measured TDS we developed conversion coefficients that are region and concentration specific. The conversion coefficients were determined by extracting the total dissolved solids values form the TWDB groundwater database and calculating for quotient for the measured total dissolved solids divided by the Calculated total dissolved solids. These quotients for calculated for two ranges. One range was for measured total dissolved solids from 900 to 1100 mg/l and the other range was for measured total dissolved solids from 2700 mg/L to 3300 mg/L. These two set of values was then partitioned into the three major aquifers to calculate a conversion factor. Table 3-20 lists the conversion factors that are used to adjust calculated total dissolved solids values to measured dissolved solid values near 1,000 mg/l and 3,000.

Table 13-20. **(Measured total dissolved solids)/(calculated total dissolved solids) values by aquifer and concentration range.**

Aquifer	Region	Concentration Range: 900 to 1,100 mg/L	Concentration Range: 2,700 to 3,000 mg/l
Chicot	North	0.82	0.93
	South	0.84	
Evangeline	All	0.86	0.95
Japer	All	0.82	0.95

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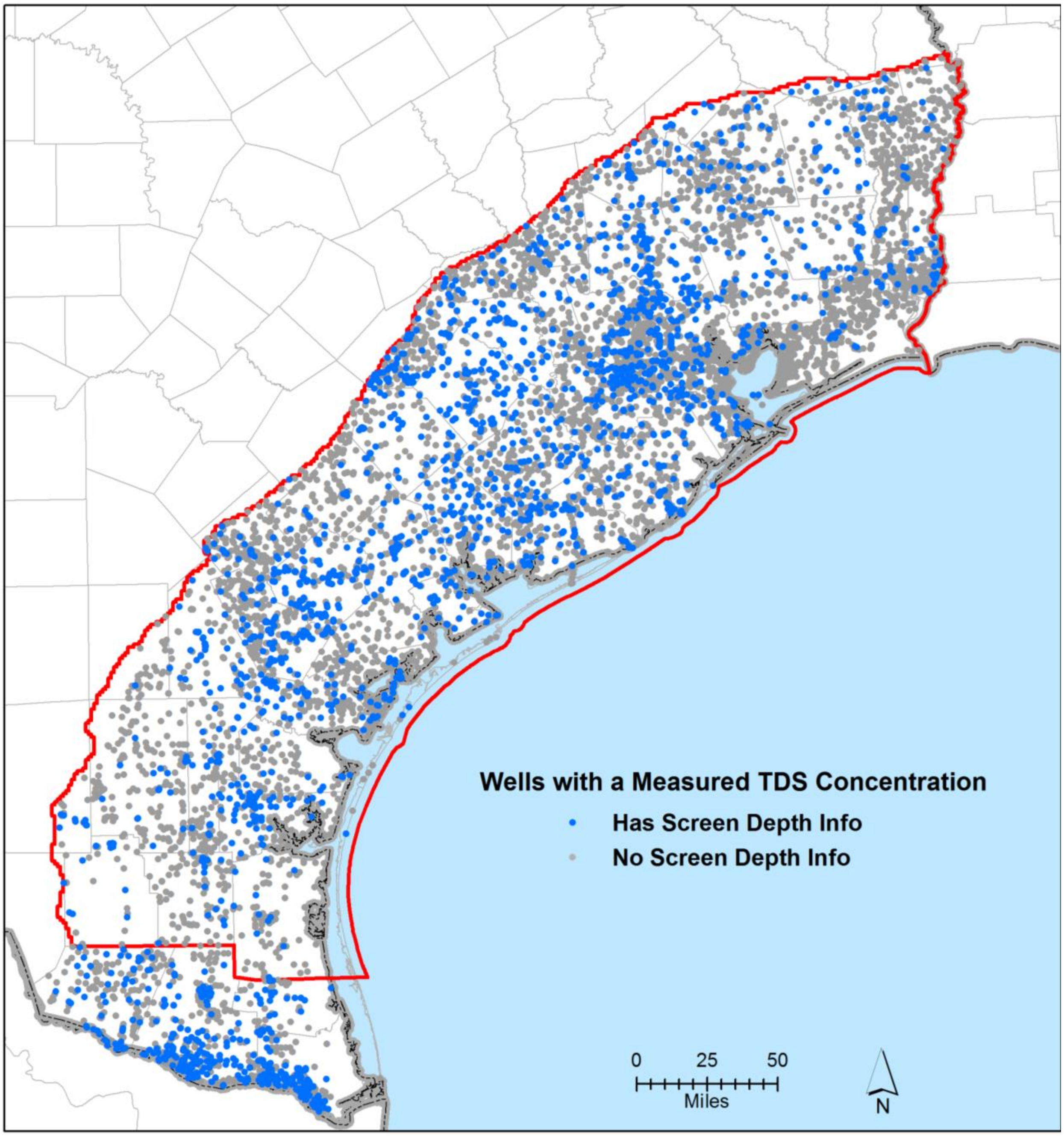


Figure 13-1. Location of wells with measured total dissolved solids concentrations in the Texas Water Development Board groundwater database.

Note: TDS=total dissolved solids

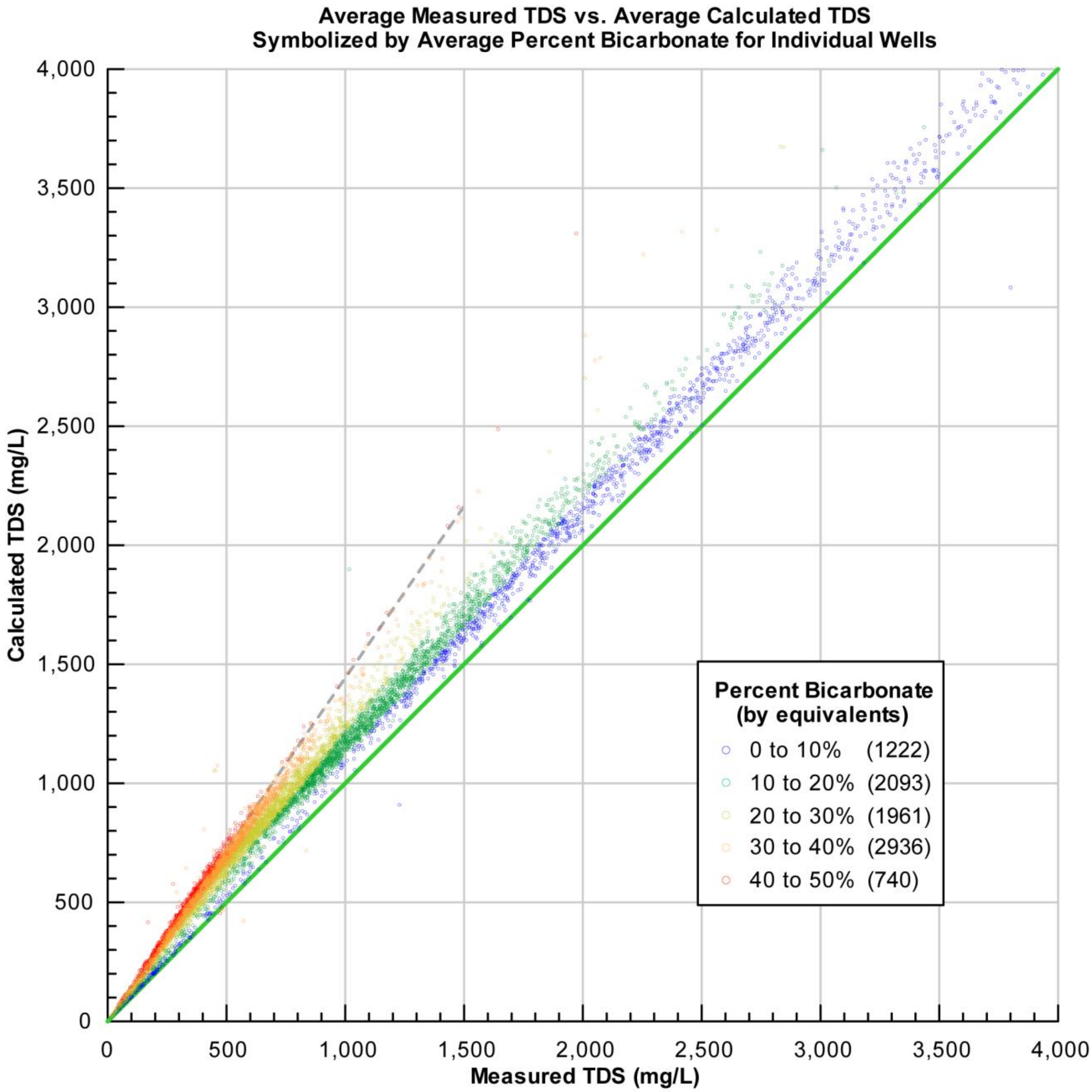


Figure 13-2. Calculated total dissolved solids versus measured total dissolved solids for groundwater samples from the Texas Gulf Coast Aquifer that are grouped into bins based on their equivalents of bicarbonate.

Note: TDS=total dissolved solids; mg/L=milligrams per liter

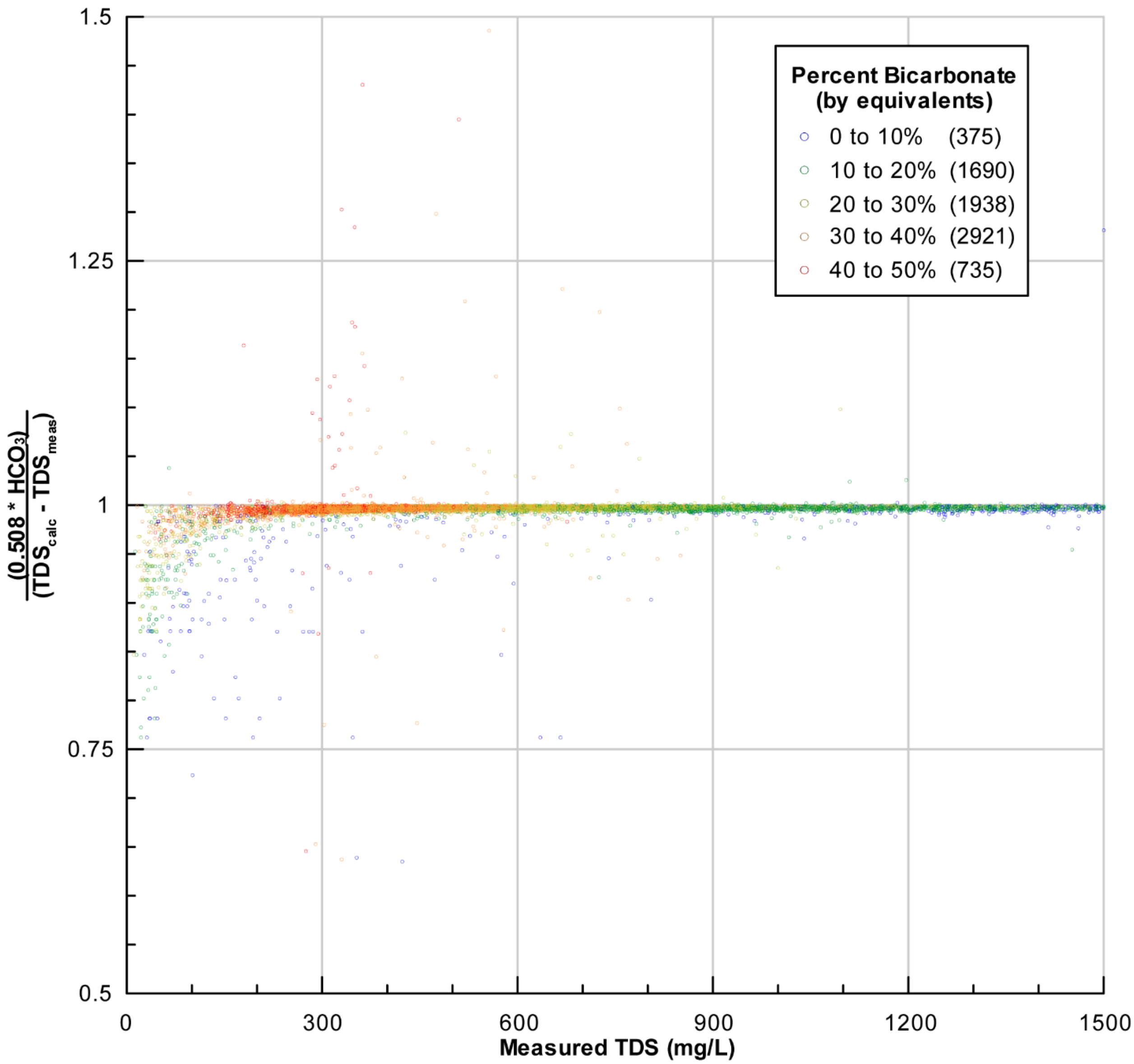


Figure 13-3. **Calculated evaporative bicarbonate loss as a percent of the difference between calculated and measured total dissolved solids plotted as a function of calculated total dissolved solids that includes silicon dioxide mass.**

Note: TDS=total dissolved solids; mg/L=milligrams per liter;HCO_3=bicarbonate; TDS_{calc}=calculated total dissolved solids; TDS_{meas}=measured total dissolved solids

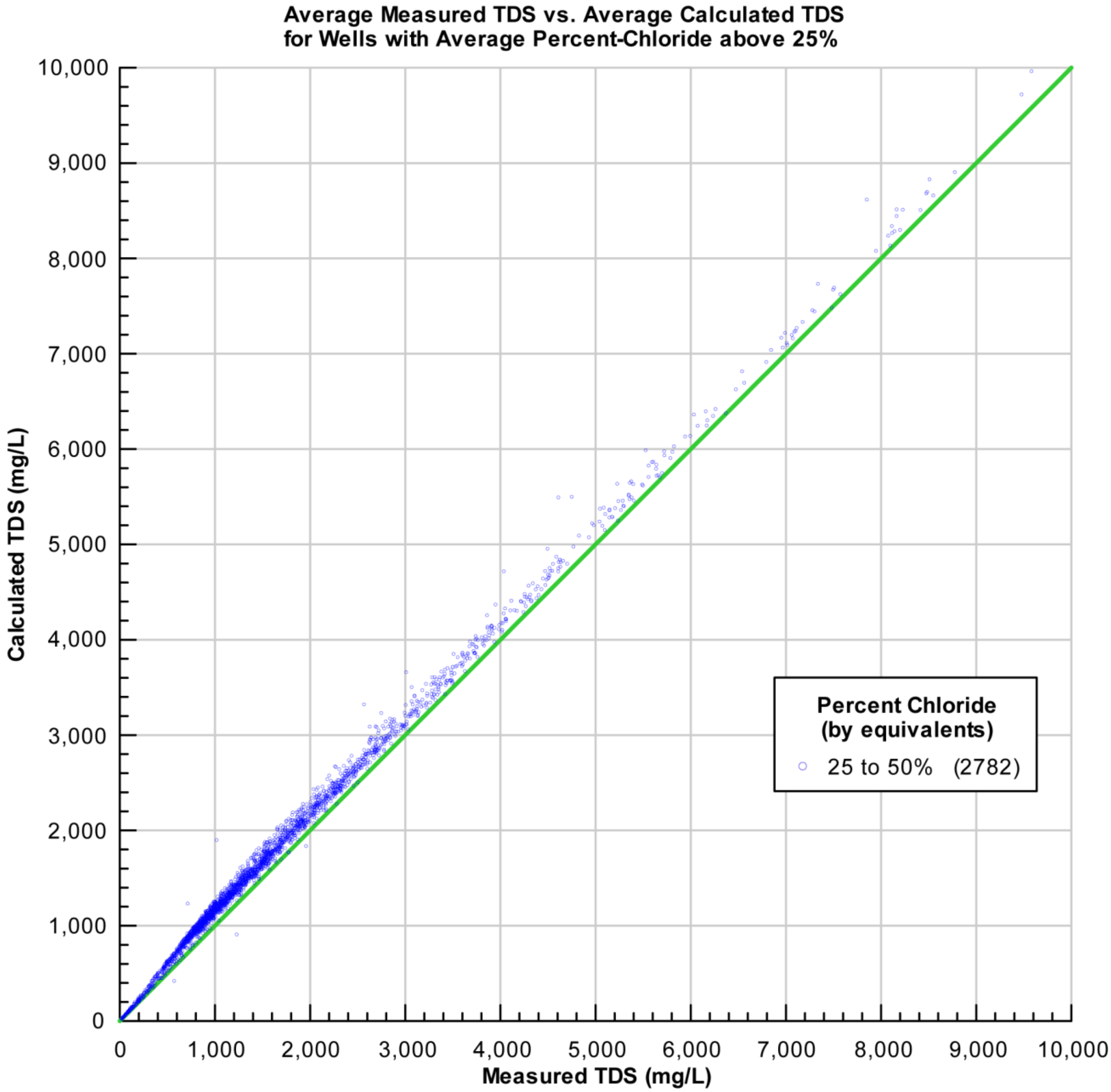


Figure 13-4. Calculated total dissolved solids versus measured total dissolved solids for groundwater samples from the Texas Gulf Coast Aquifer that that have more than 50 percent of their anionic equivalents contributed by chloride.

Note: TDS=total dissolved solids; mg/L=milligrams per liter

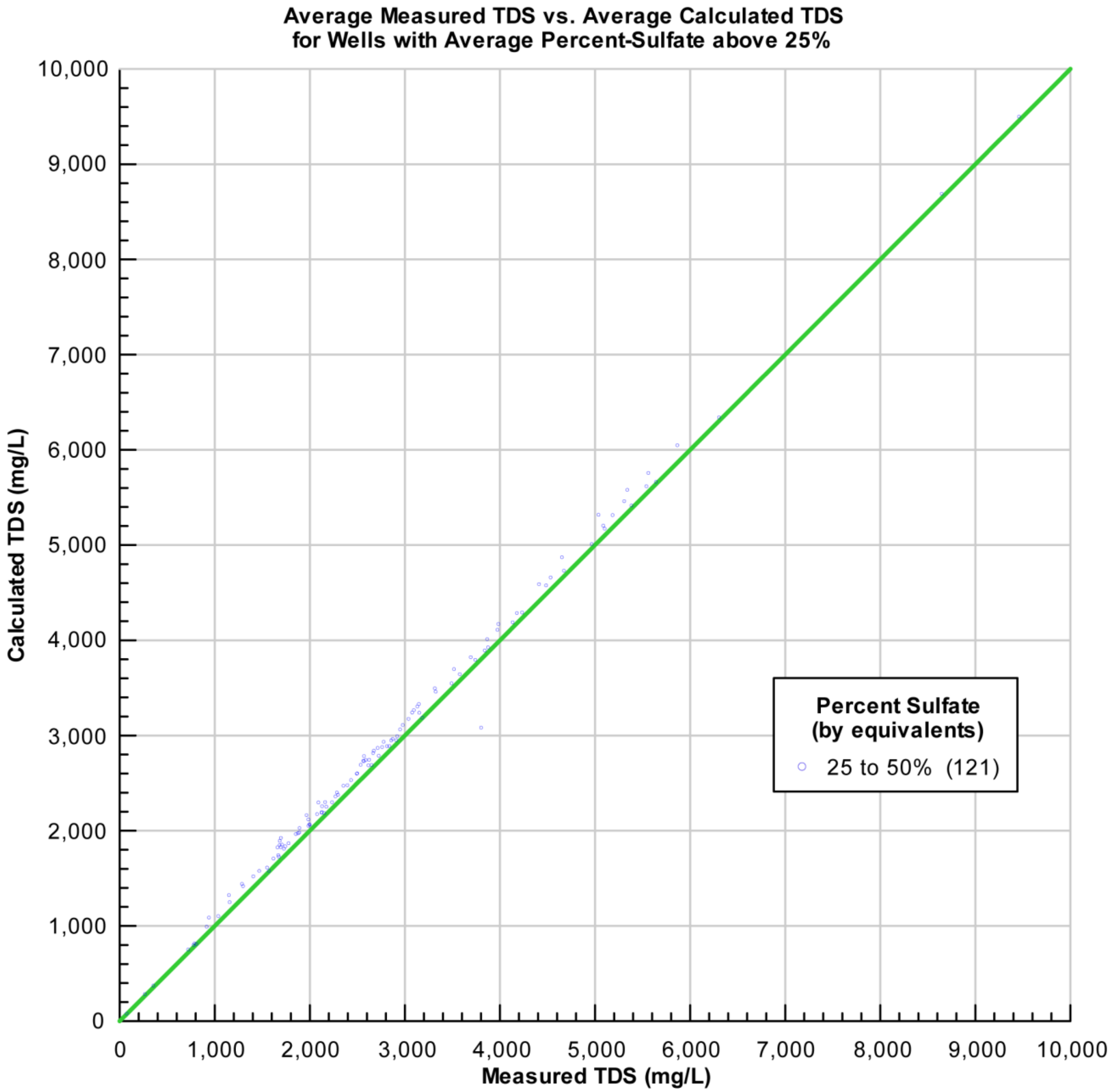


Figure 13-5. Calculated total dissolved solids versus measured total dissolved solids for groundwater samples from the Texas Gulf Coast Aquifer that that have more than 50 percent of their anionic equivalents contributed by sulfate.

Note: TDS=total dissolved solids; mg/L=milligrams per liter; %=percent

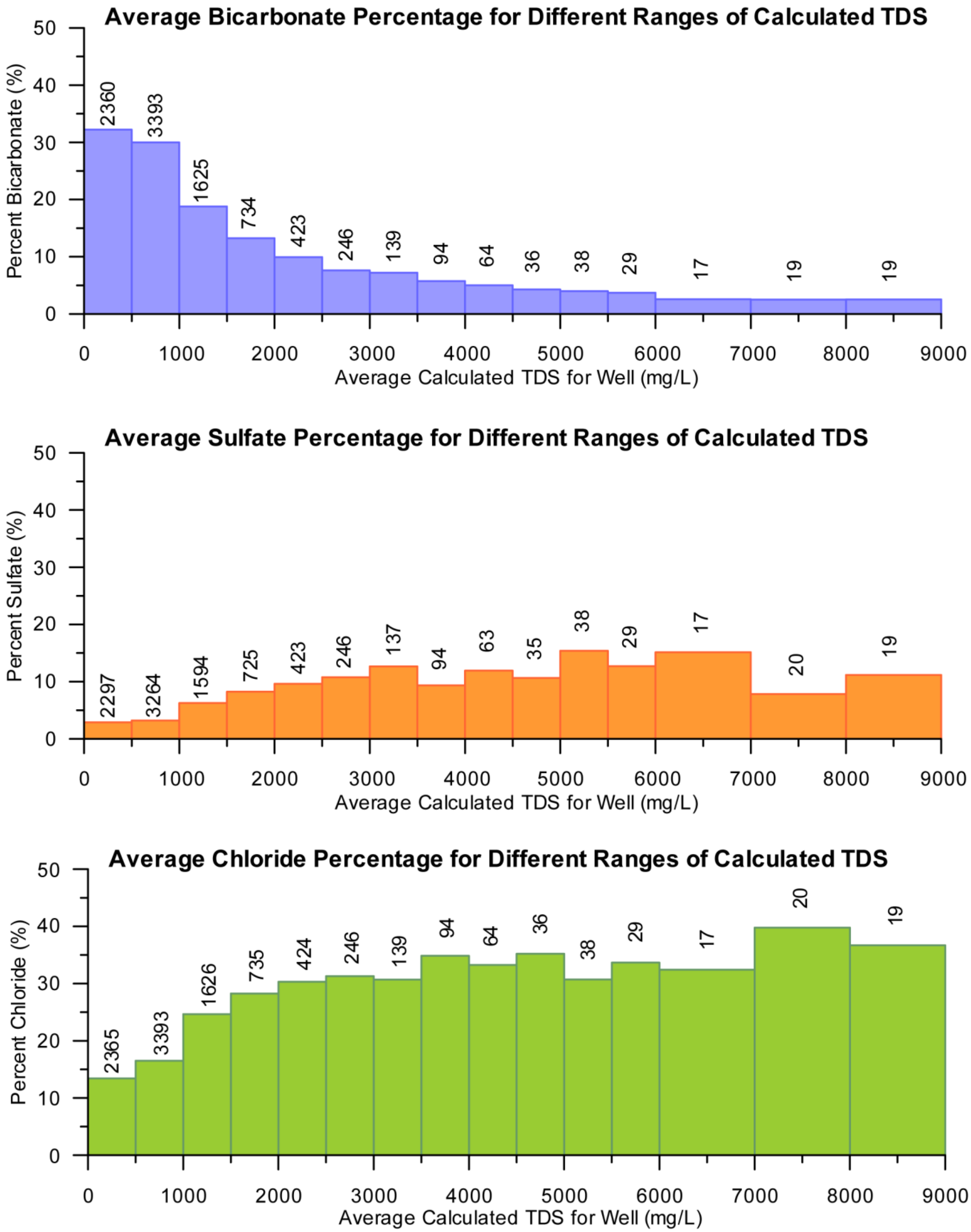


Figure 13-6. **Average percent that a specific anion comprises the total equivalent for different ranges of calculated total dissolved solids for (a) bicarbonate; (b) sulfate; and (c) chloride.**

Note: TDS=total dissolved solids; mg/L=milligrams per liter; %=percent

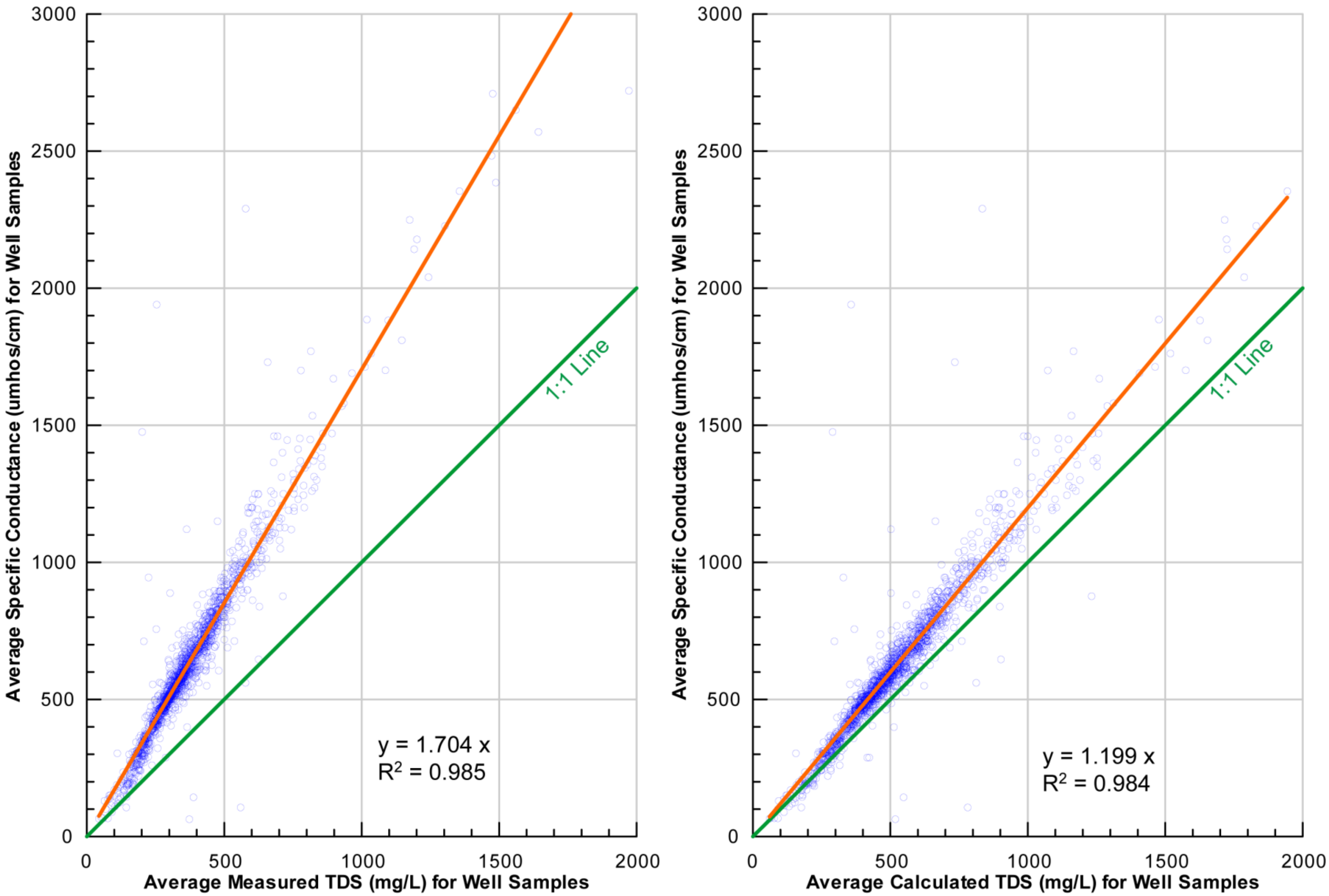


Figure 13-7. Linear regression between specific conductance and total dissolved solids for 1,866 groundwater samples where bicarbonate comprises at least 35 percent of the equivalence in the charge balance where (a) total dissolved solids is measured and (b) total dissolved solids is calculated.

Note: TDS=total dissolved solids; mg/L=milligrams per liter; umhos/cm=micromhos per centimeter

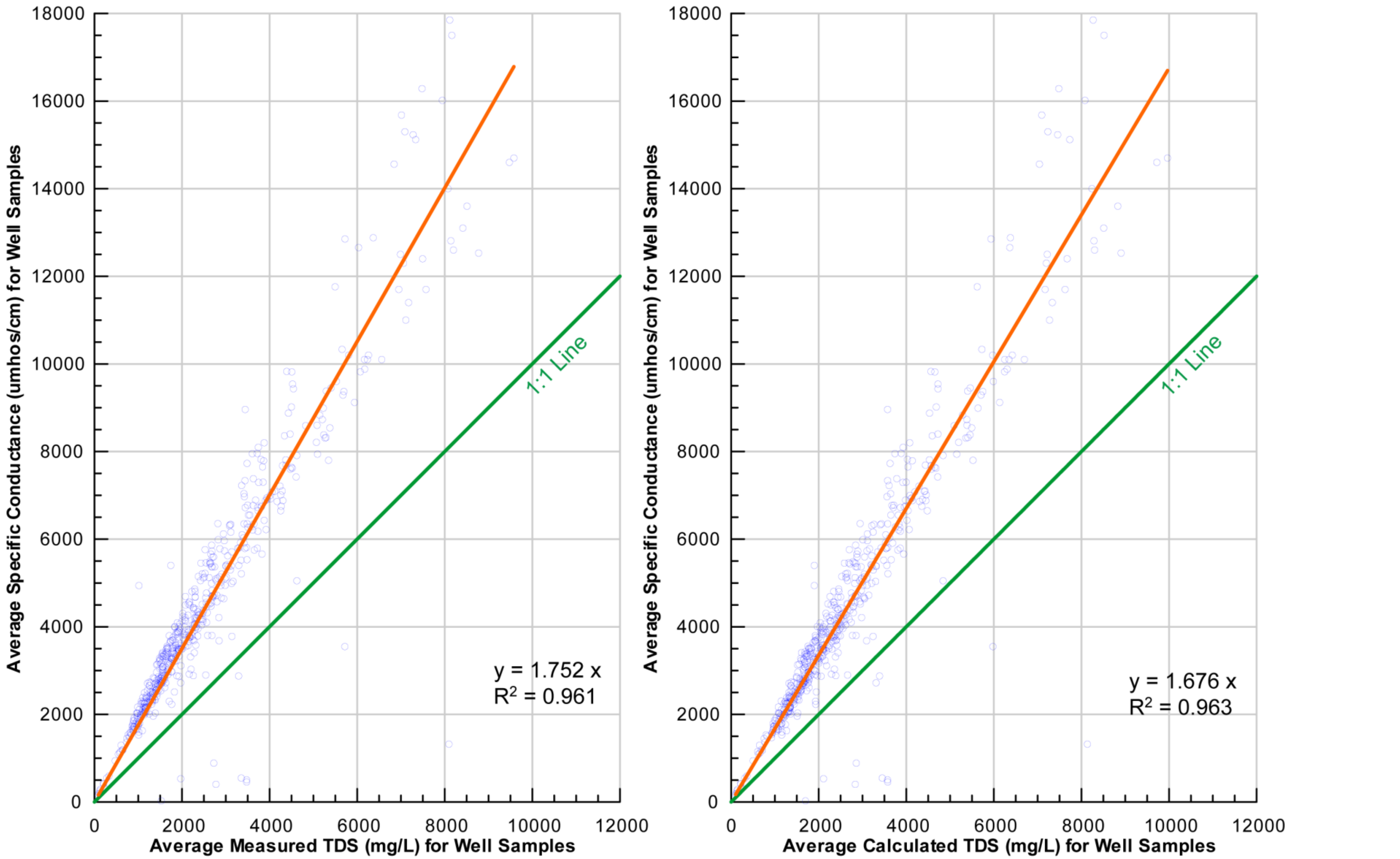


Figure 13-8. **Linear regression between specific conductance and total dissolved solids for 587 groundwater samples where chloride⁻ comprises at least 35 percent of the equivalence in the charge balance where (a) total dissolved solids is measured and (b) total dissolved solids is calculated.**

Note: TDS=total dissolved solids; mg/L=milligrams per liter; umhos/cm=micromhos per centimeter

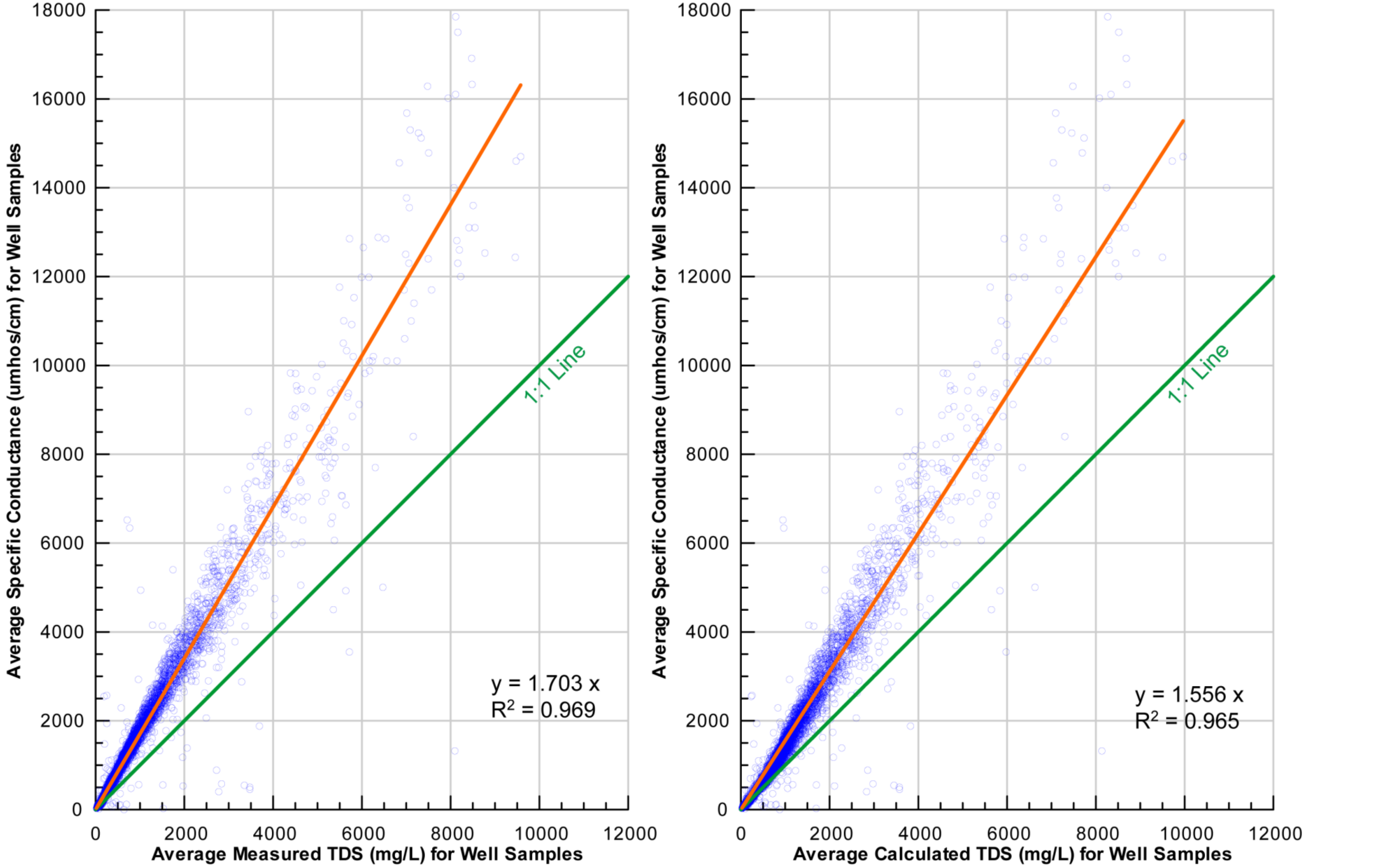


Figure 13-9. Linear regression between specific conductance and total dissolved solids for 16,959 groundwater samples where (a) total dissolved solids is measured and (b) total dissolved solids is calculated.

Note: TDS=total dissolved solids; mg/L=milligrams per liter; umhos/cm=micromhos per centimeter

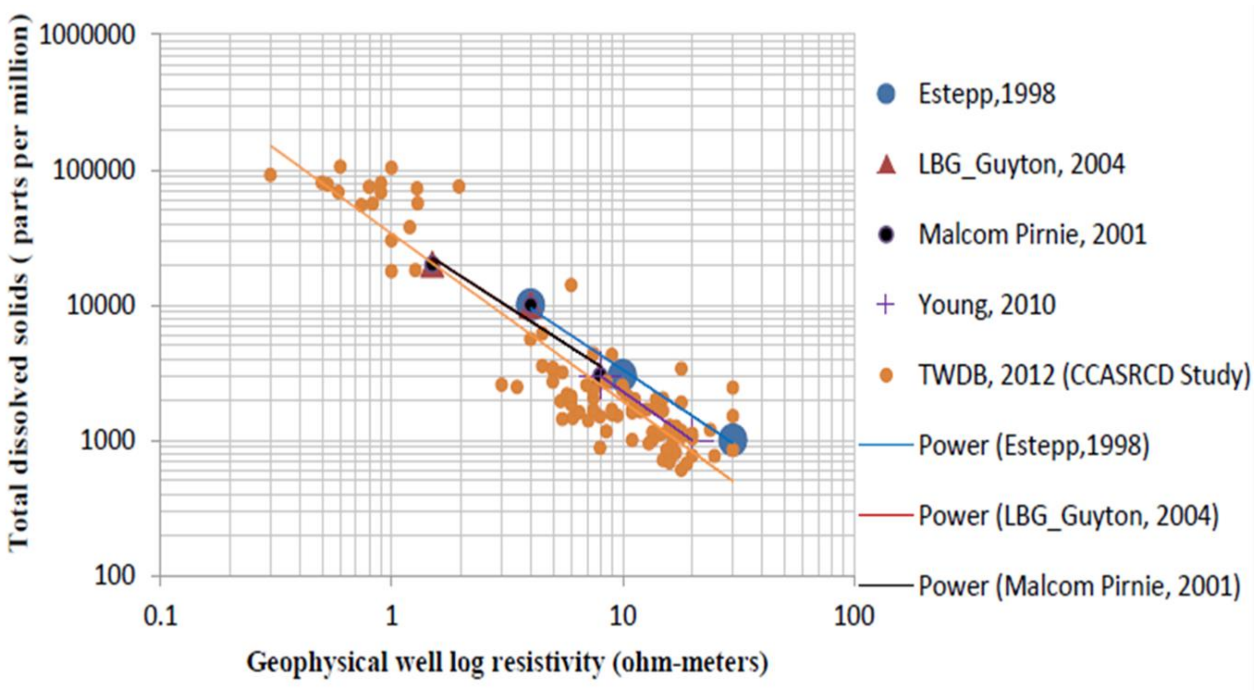


Figure 13-10 Comparison of total dissolved solids concentration of formation water and deep resistivity from geophysical well logs (from Meyer, 2012).

Rwa MinimumTDS Method		
BHT	Bottom Hole Temp	97.00
Ts	Temperature at Surface	72.00
Depth	Depth of Interest	920.00
TD	Total Depth	1240.00
Rs	Rmf @ Ts	1.00
Tf	Temp of Formation	90.55
por	Porosity	0.35
m	cementation exponent	1.50
a	Lithology Parameter	1.00
Rt	True Deep Resistivity	8.00
Rwe	Apparent Formation Water Res	1.66
Predominantly NaCl type water		
Rw75	Rw@Tf to RW@75	2.00
Cw75	Specific Conductivity @75	5,000
TDS	Default Multiplyer 0.6	3,000

Factor	Range in Value	Percent Change
porosity	0.25 to 0.5	-18% to 65%
cementation factor	1.3 to 1.8	-19% to 37%
temperature *	83°F to 112°F	-30 % to 30 %
chemistry	Cl to HCO_3	0 to 25%
dirty sands/mis-pick	?	0 to >50%

*depth dependent

Figure 13-11. Calculations using the R_{wa} method to estimate total dissolved solids concentrations using actual data and estimates of input variability to show the sensitivity of the calculated total dissolved solids concentrations to changes in the input variables.

Note: TDS=total dissolved solids

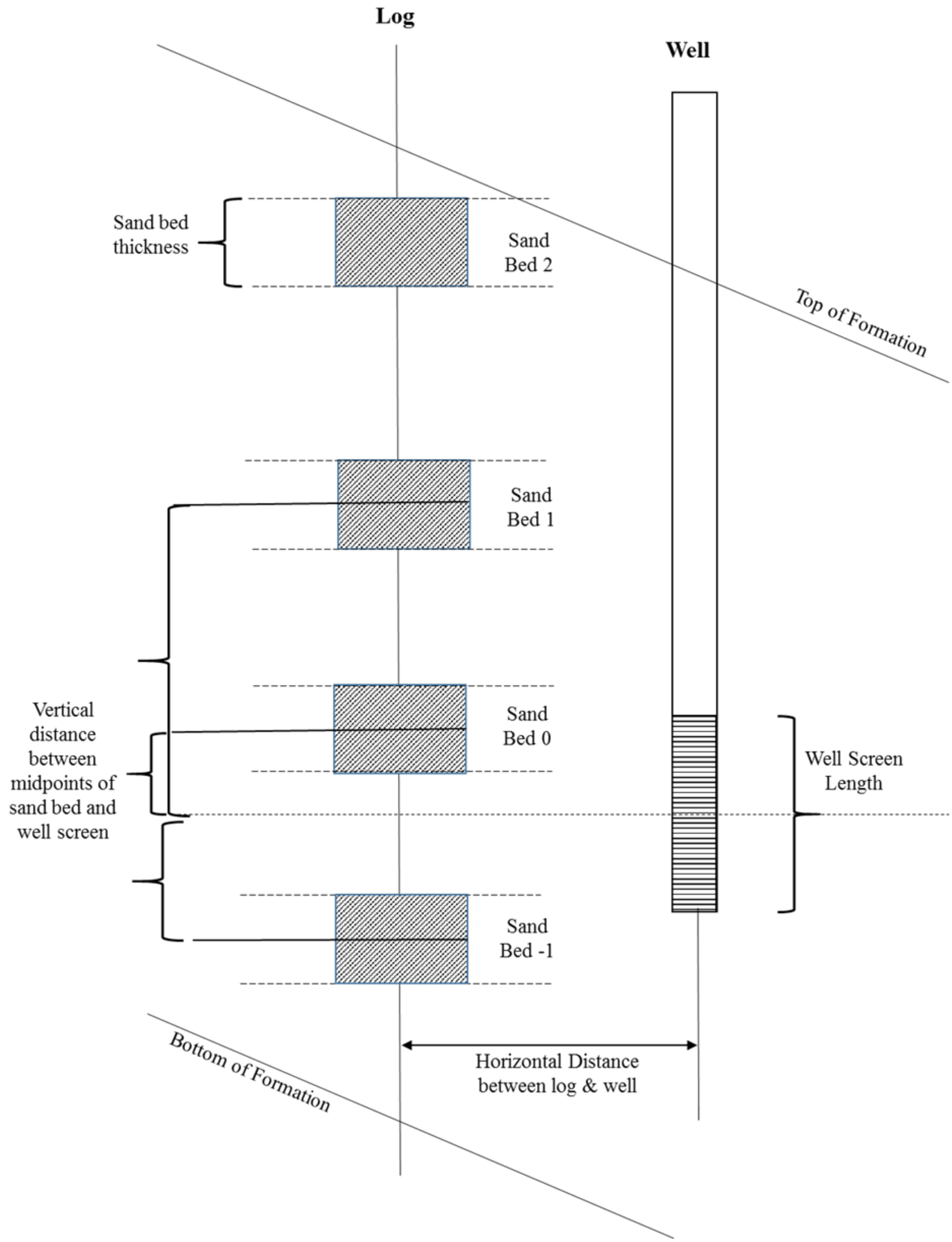


Figure 13-12. Schematic showing the sand beds identified on a geophysical log and a nearby well screen where total dissolved solids concentrations have been measured.

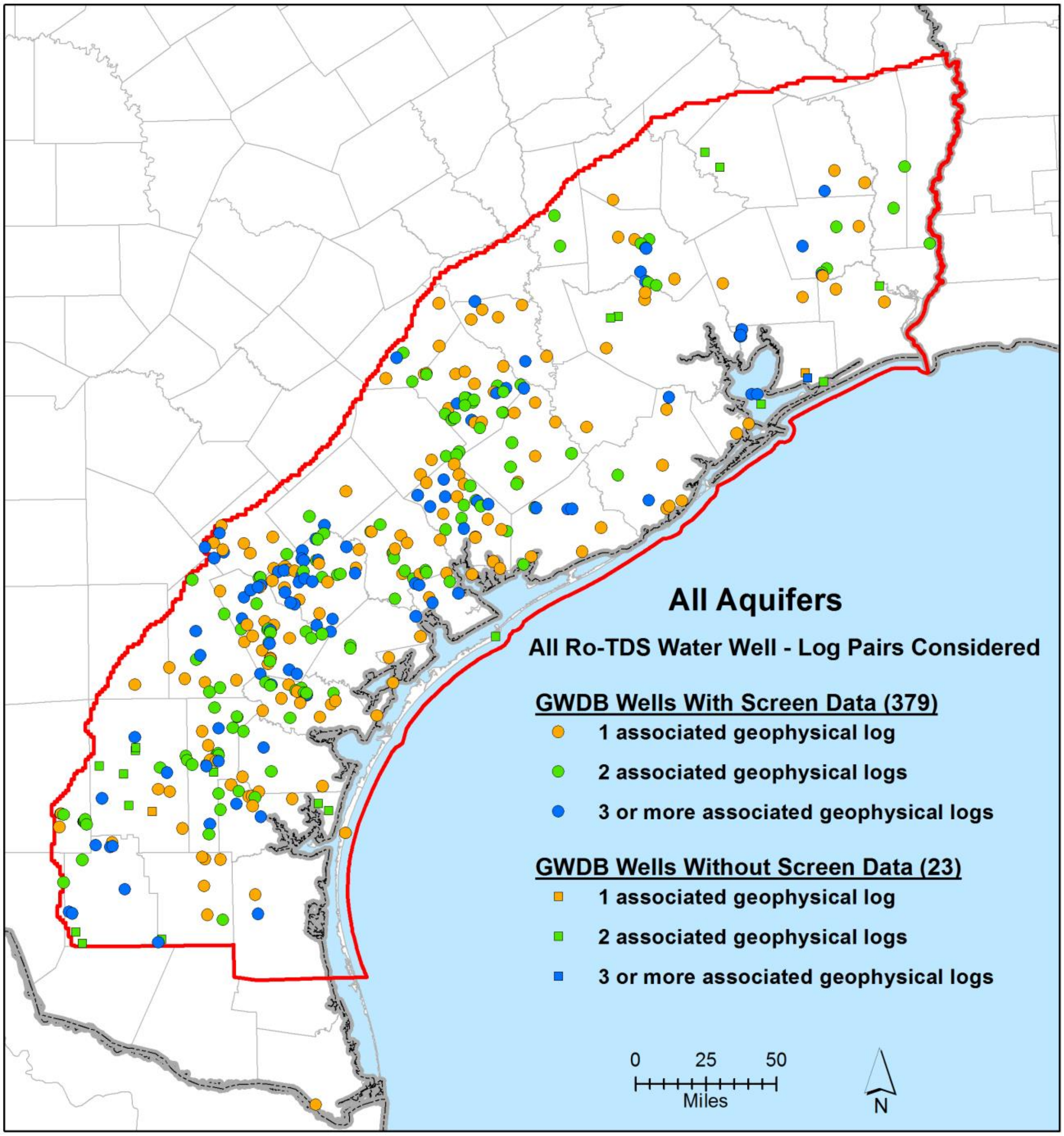


Figure 13-13. Locations of 379 pairs consisting of a geophysical log(s) and a water well with screen data and 23 pairs consisting of a geophysical log(s) and a water well with no screen data.

Note: Ro-TDS=resistivity-total dissolved solids

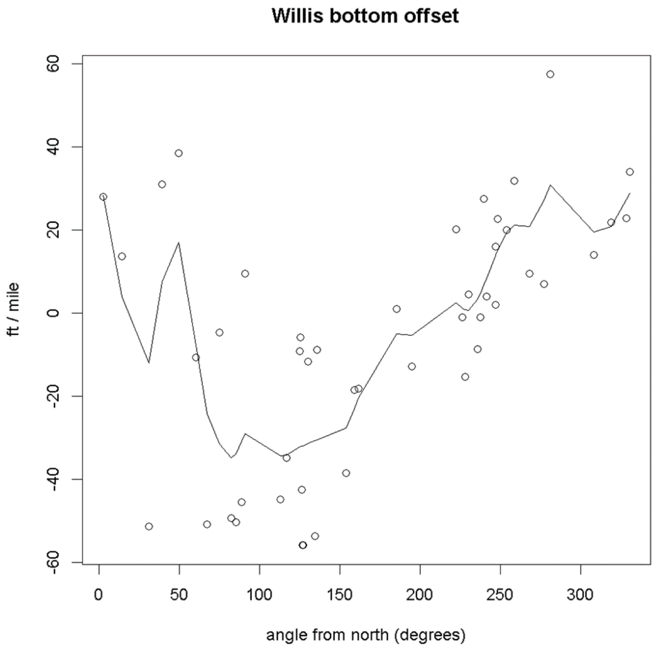


Figure 13-14. Offset of the Willis Formation bottom between paired water well and geophysical log(s) assigned to the Willis Formation calculated as a function of orientation angle.

Note: ft/mile=feet per mile

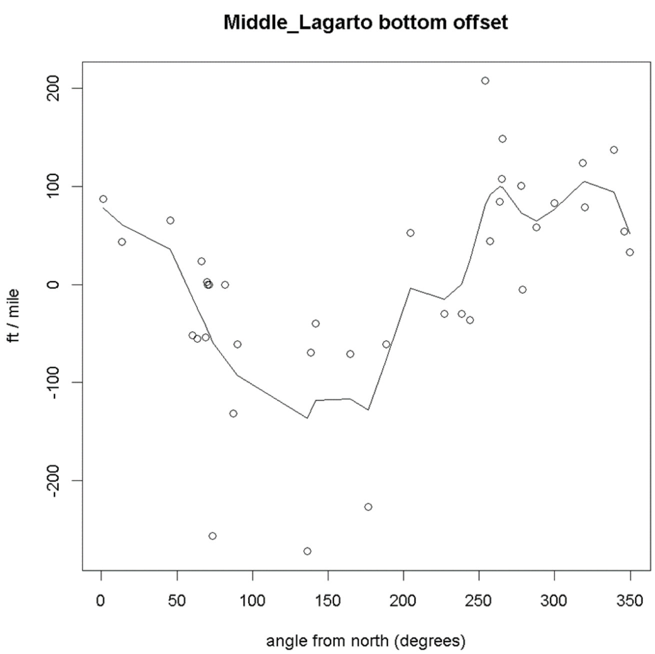
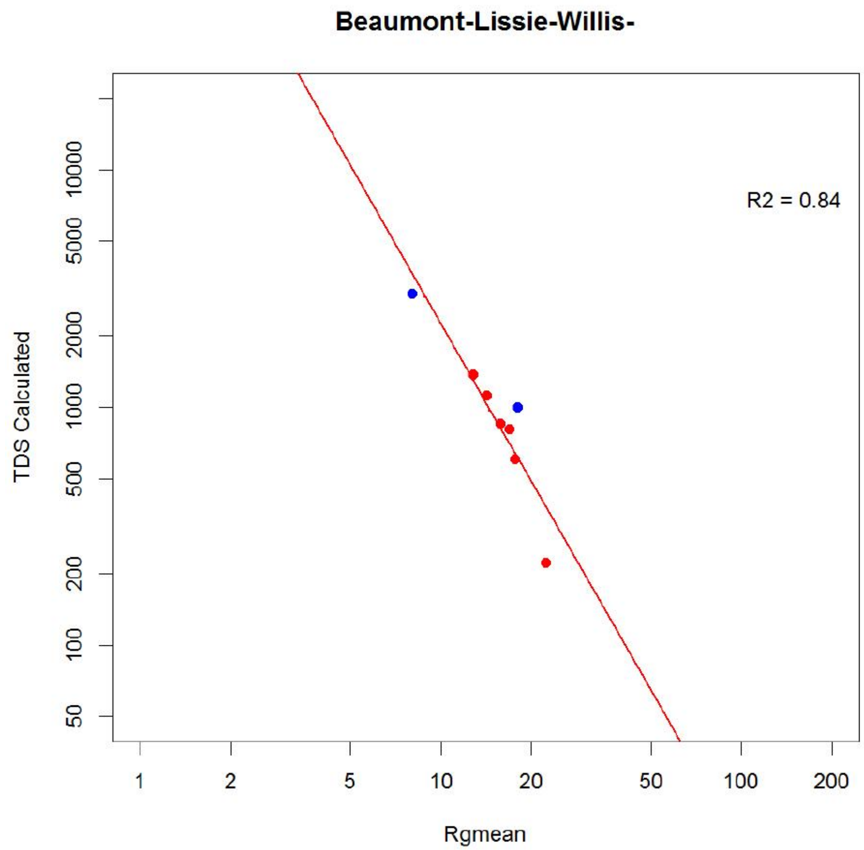


Figure 13-15. Offset of the middle Lagarto Formation bottom between paired water well and geophysical log assigned to the middle Lagarto Formation calculated as a function of orientation angle.

Note: ft/mile=feet per mile



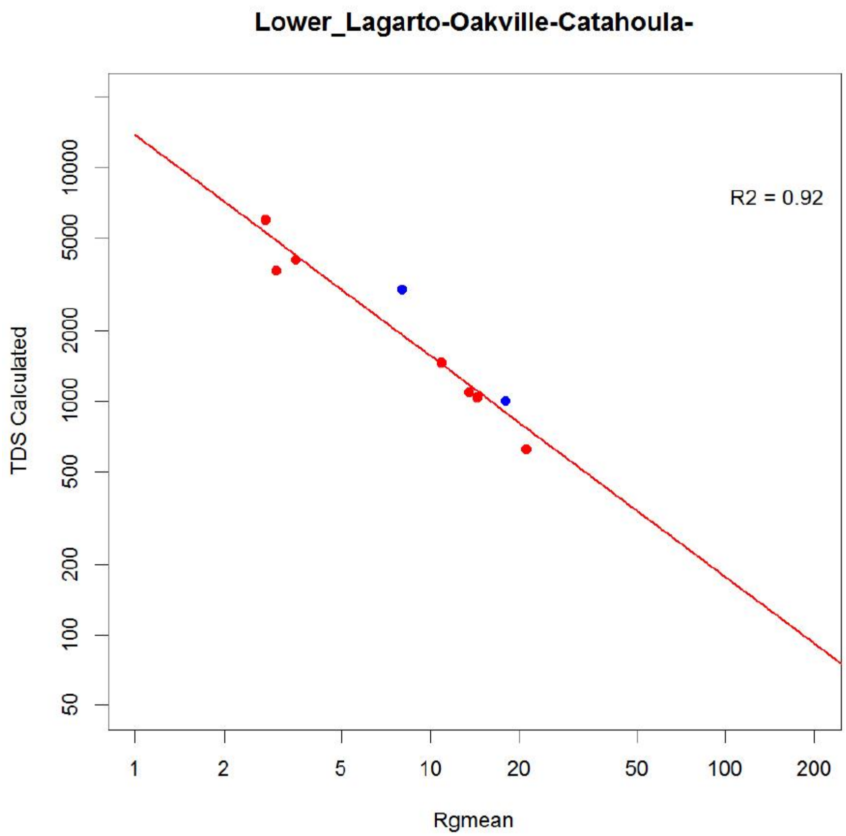
Cut-Off Values from Young and others (2010,2012)

18 ohm-meters for TDS = 1,000 mg/L

8 ohm-meters for TDS = 3,000 mg/L

Figure 13-16. Ro-TDS graph for the Beaumont, Lissie, and Willis formations developed using the Ro-TDS data in Table 13-12 (red dots) and resistivity "cut-off" values used by Young and others (2010, 2012) (blue dots).

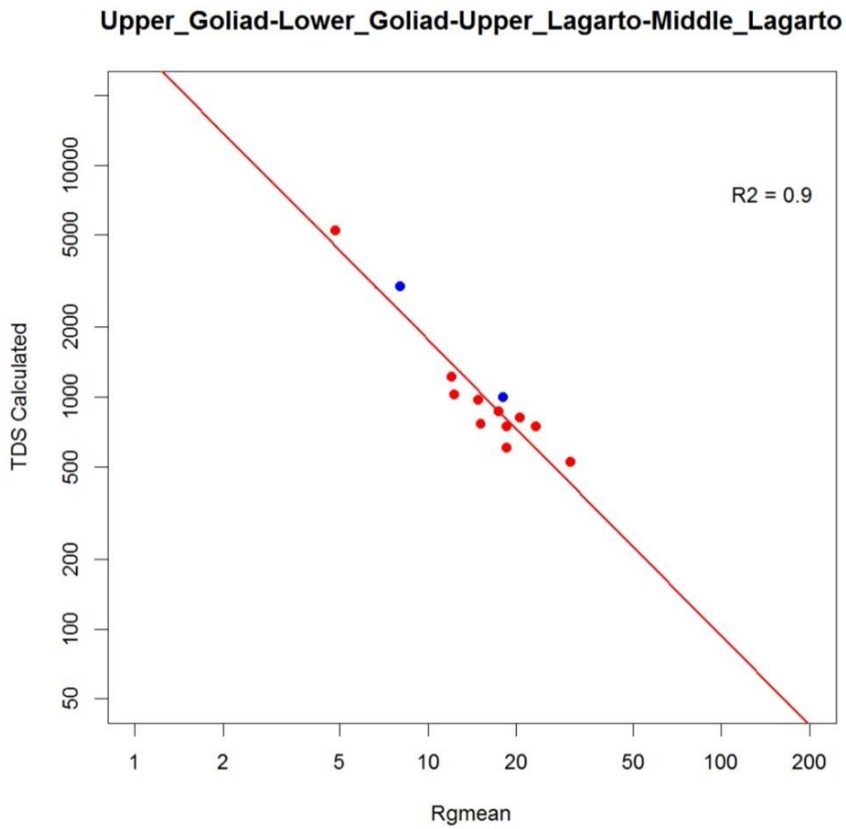
Note: TDS=total dissolved solids; Ro=resistivity; TDS= -total dissolved solids; Rgmean=geometric mean resistivity



Cut-Off Values from Young and others (2010,2012)
18 ohm-meters for TDS = 1,000 mg/L
8 ohm-meters for TDS = 3,000 mg/L

Figure 13-17. Ro-TDS graph for the lower Lagarto, Oakville, and Catahoula formations developed using the Ro-TDS data in Table 13-12 (red dots) and Ro "cut-off" values used by Young and others (2010, 2012) (blue dots).

Note: TDS=total dissolved solids; Ro=resistivity; TDS= -total dissolved solids; Rgmean=geometric mean resistivity



Cut-Off Values from Young and others (2010,2012)

18 ohm-meters for TDS = 1,000 mg/L

8 ohm-meters for TDS = 3,000 mg/L

Figure 13-18. Ro-TDS graph for the upper Goliad, lower Goliad, upper Lagarto, and middle Lagarto formations developed using the Ro-TDS data in Table 13-12 (red dots) and Ro "cut-off" values used by Young and others (2010, 2012).

Note: TDS=total dissolved solids; Ro=resistivity; TDS=total dissolved solids; Rgmean=geometric mean resistivity

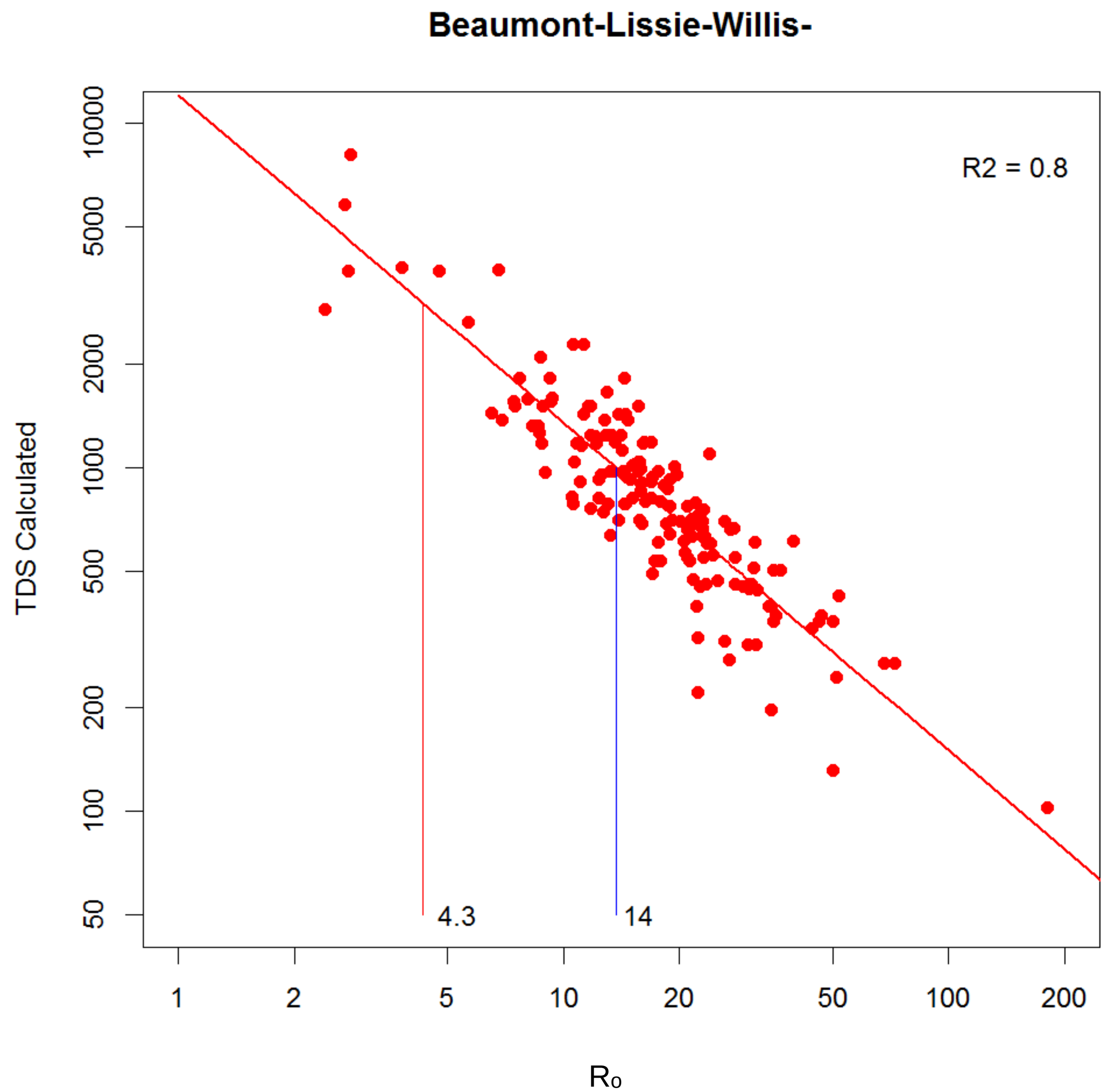


Figure 13-19. **Ro-TDS graph Beaumont-Lissie-Willis Grouping based on 164 well-log pairs. The blue line is the resistivity of the formation value for a 1,000 milligram per liter total dissolved solids and the red line is the resistivity of the formation value for 3,000 milligrams per liter total dissolved solids.**

Note: TDS=total dissolved solids; Ro=resistivity of the formation

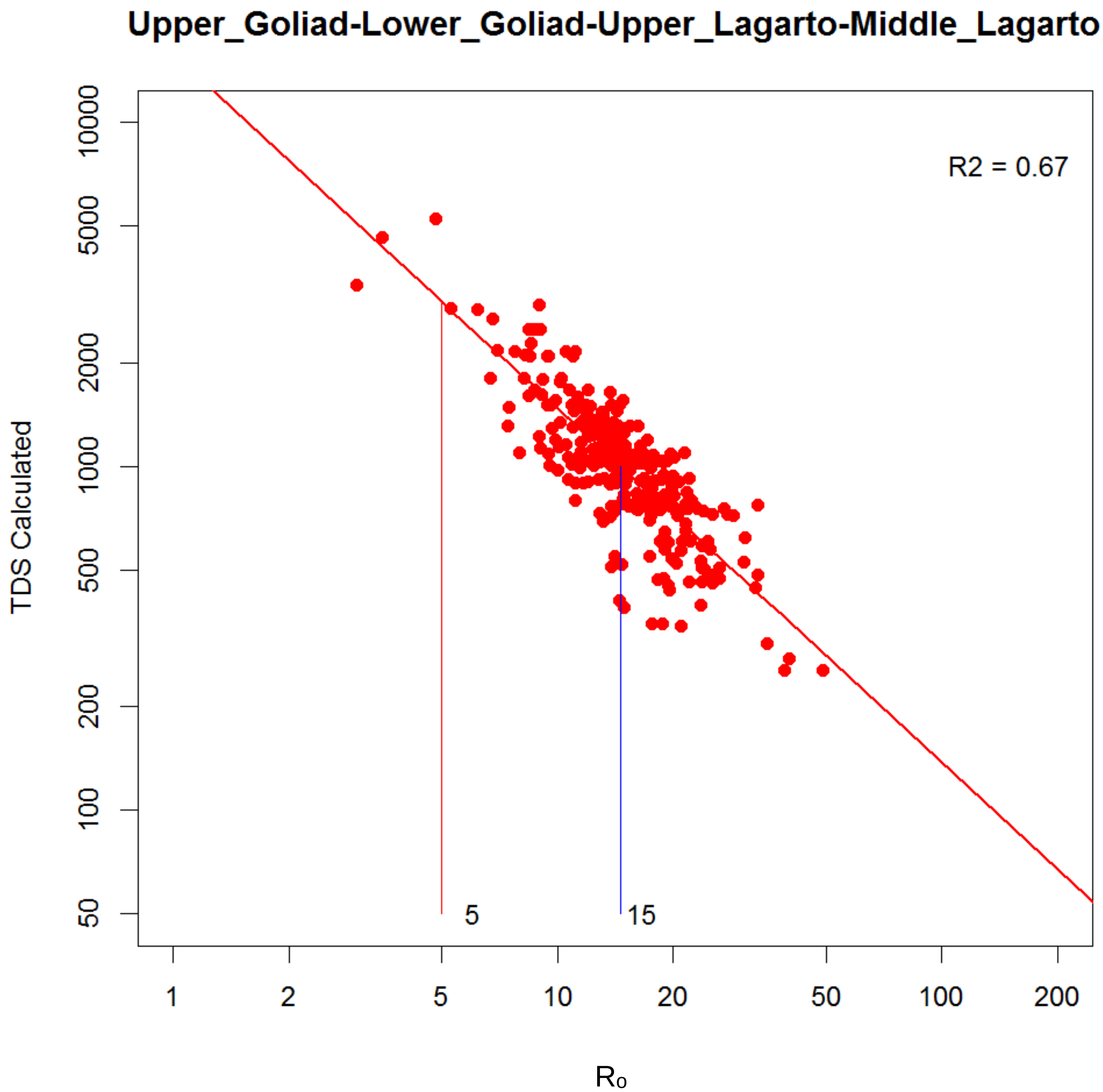


Figure 13-20. Ro-TDS graph Upper Goliad, Lower Goliad, Upper Lagarto, and Middle Lagarto Grouping based on 305 well-log pairs The blue line is the resistivity of the formation value for a 1,000 milligram per liter total dissolved solids and the red line is the resistivity of the formation value for 3,000 milligrams per liter total dissolved solids.

Note: TDS=total dissolved solids; Ro=resistivity of the formation

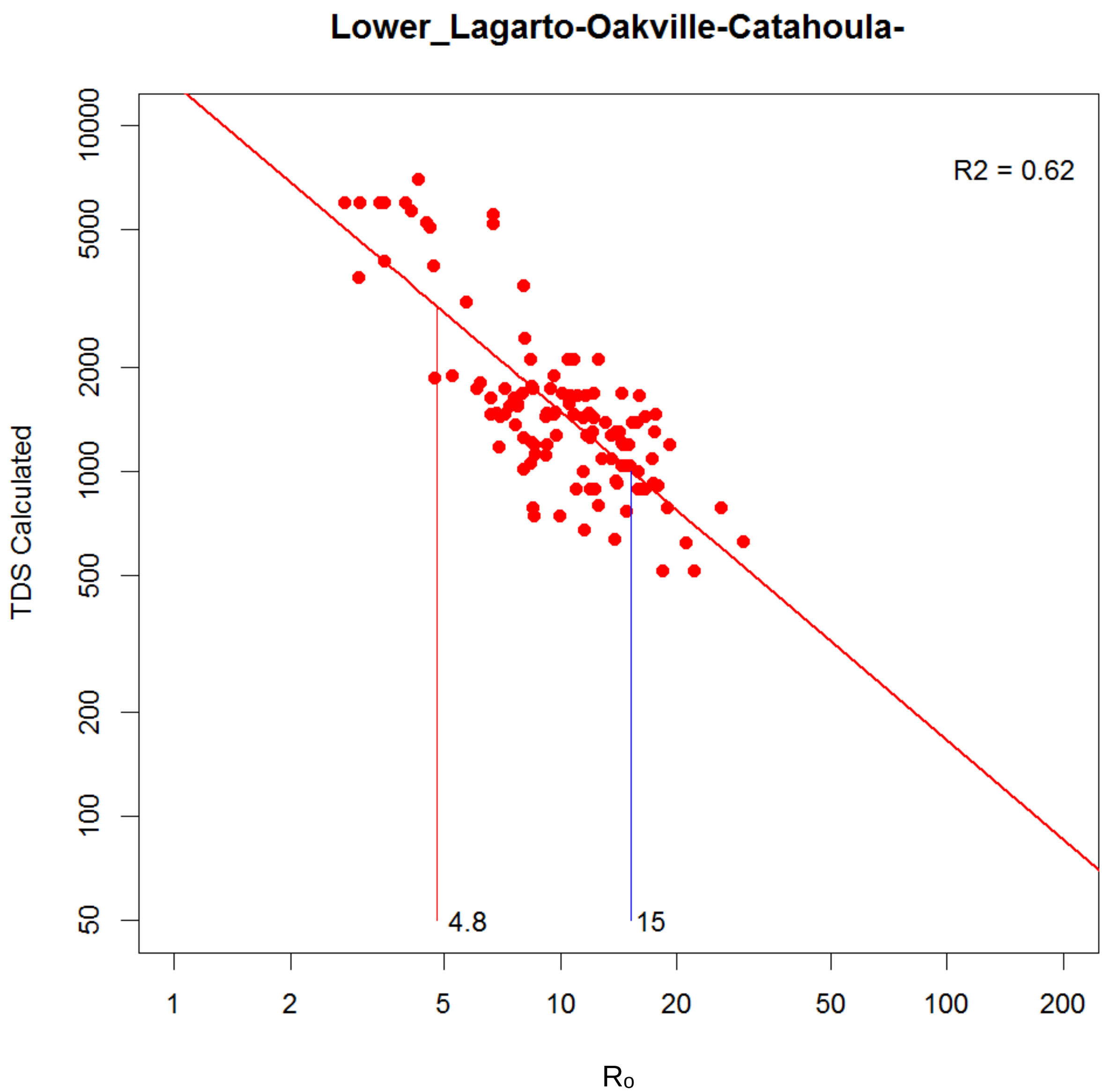


Figure 13-21. Ro-TDS graph Lower Lagarto, Oakville, and Catahoula Group based on 117 well-log pairs. The blue line is the resistivity of the formation value for a 1,000 milligram per liter total dissolved solids and the red line is the resistivity of the formation value for 3,000 milligrams per liter total dissolved solids.

Note: TDS=total dissolved solids; Ro=resistivity of the formation

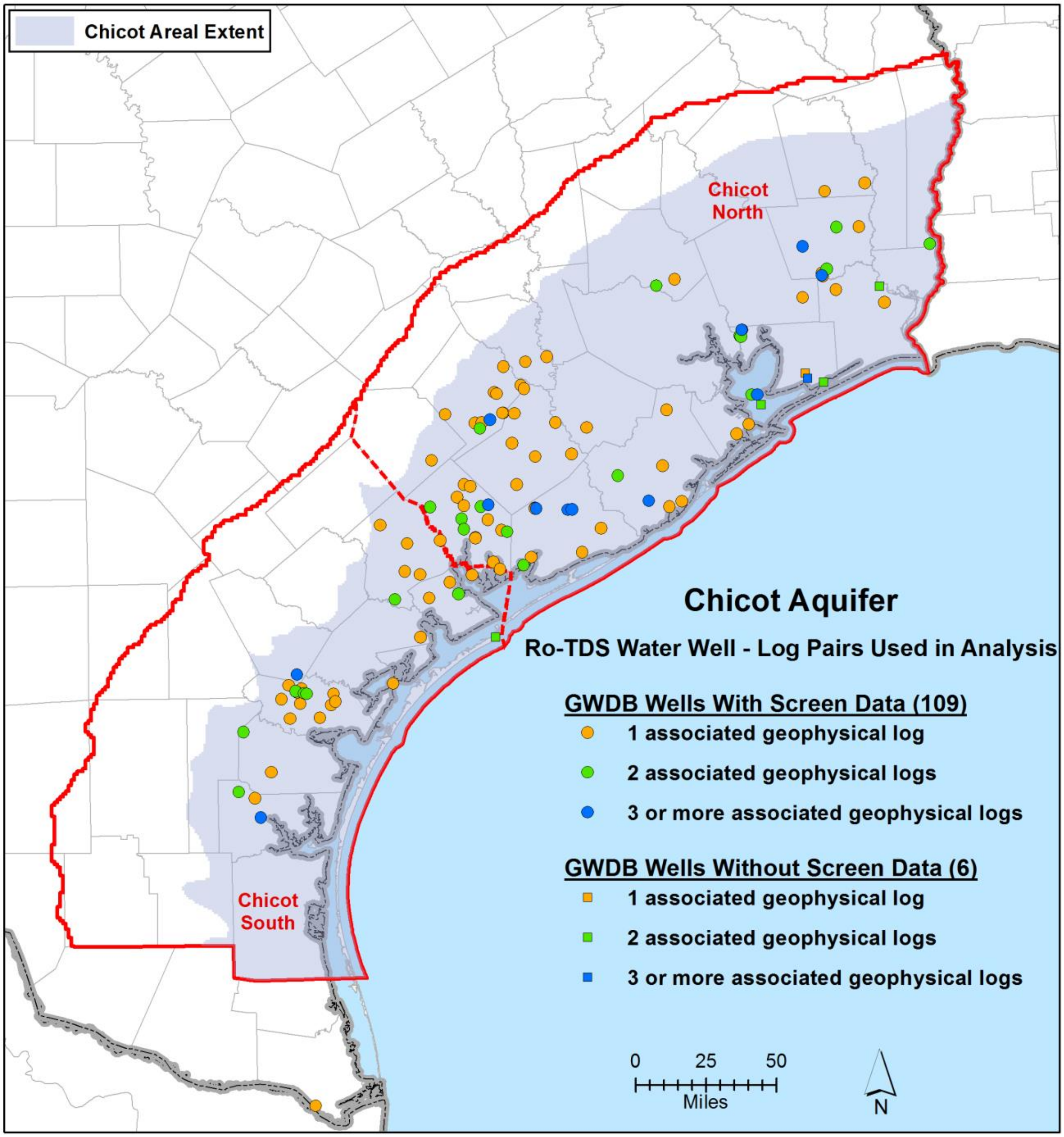


Figure 13-22. Location of the 164 well pairs used to construct the Ro-TDS graph for the Beaumont, Lissie, and Willis Formations

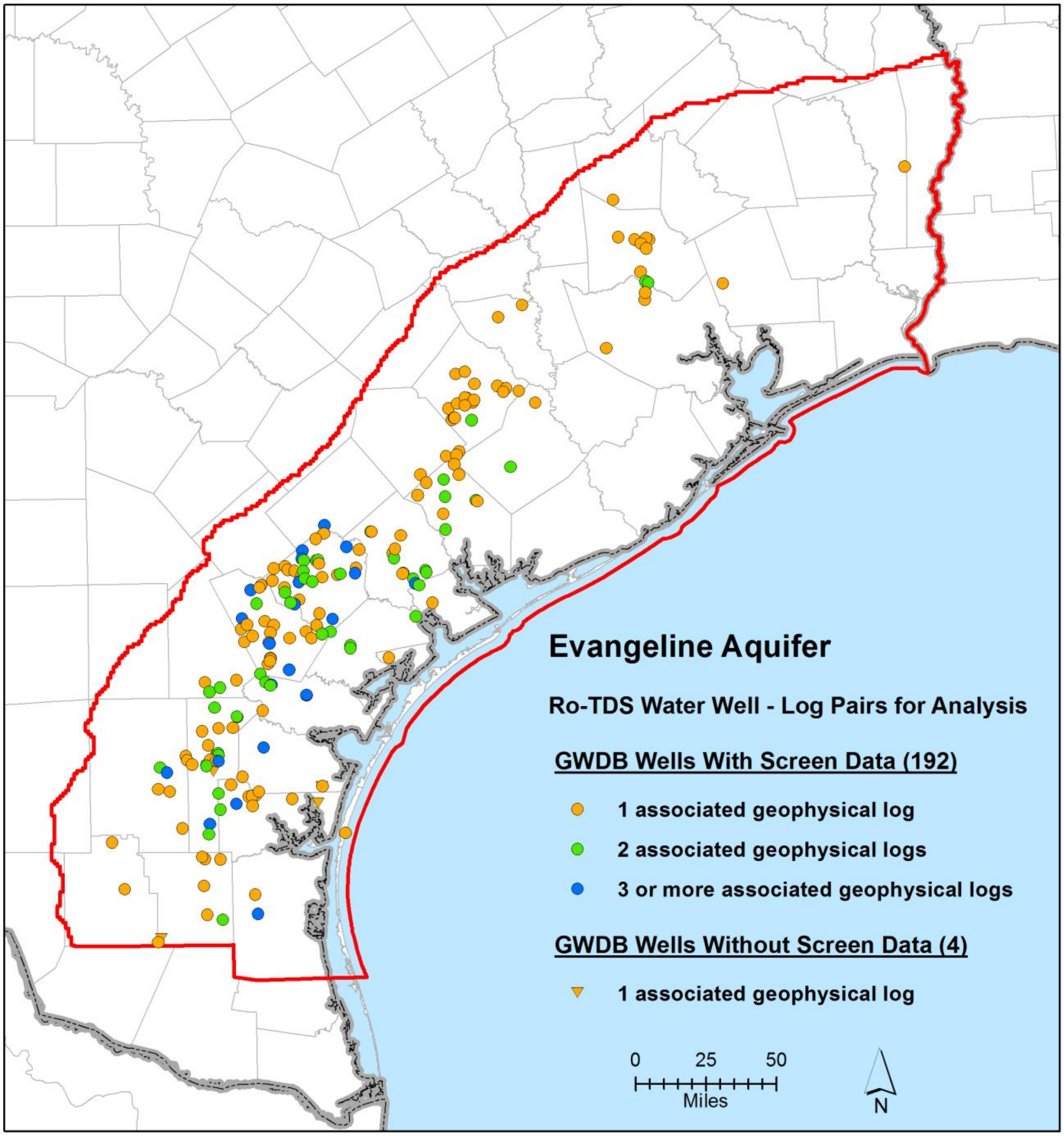


Figure 13-23. Location of the 305 well pairs used to construct Ro-TDS graph for the upper Goliad, lower Goliad, upper Lagarto, and middle Lagarto formations.

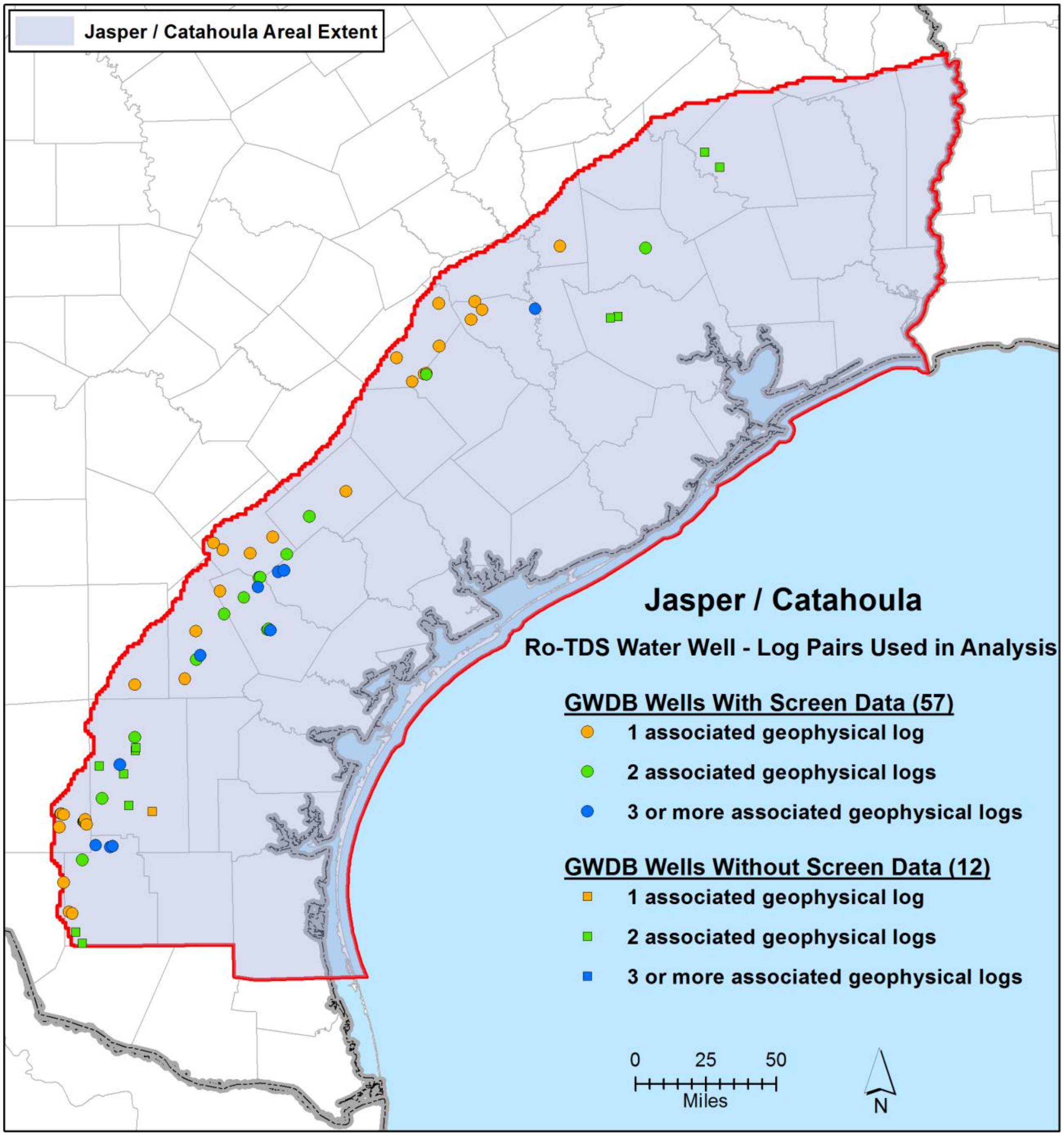


Figure 13-24. Location of the 305 well pairs used to construct the Ro-TDS graph for the lower Lagarto, Oakville, Catahoula formations.

14 Potential Production Area Analysis and Modeling Methodology

This section discusses the development and application of groundwater models to simulate changes in groundwater levels caused by pumping from candidate well fields identified in Section 4. Five groundwater models were developed to simulate pumping from candidate well fields for 50 years at the withdrawal rates of 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year. The models were constructed using hydraulic properties extracted from regional groundwater models used by Groundwater Management Area 14, Groundwater Management Area 15, and Groundwater Management Area 16 for regional water planning. Simulated drawdowns from the five groundwater models were tabulated after 30 years and 50 years of pumping at different distances down dip from the outcrop of the Catahoula Formation. In order to help evaluate the potential for significant drawdown impact in areas of concern, a sensitivity analysis was performed to document the sensitivity of simulated drawdown to changes in aquifer properties in the groundwater models.

14.1 Groundwater Availability Models

In 1999, the 76th Texas legislature approved initial funding for the Groundwater Availability Modeling Program. A primary purpose for creating the Groundwater Availability Modeling program was to provide useful and timely information regarding the availability of groundwater in Texas that would be beneficial to water resource planning. One of the initial goals of the Groundwater Availability Modeling Program is to have Groundwater Availability Models developed for the nine major aquifers and the 21 minor aquifers in Texas. The Gulf Coast Aquifer is one of the nine major aquifers in Texas. The Texas Water Development Board funded the development of regional groundwater flow models for Groundwater Management Area 14, Groundwater Management Area 15, and Groundwater Management Area 16. The aquifer properties from these three regional flow models will be used to help construct the groundwater models that will simulate pumping from the well fields in the Potential Production Areas.

14.1.1 Conceptual Groundwater Flow Model for the Gulf Coast Aquifer System

A consistent tenet for the majority, if not all, of the Gulf Coast Aquifer System groundwater models is that basinal flow can be subdivided into local, intermediate, and regional flow regimes, as described by Toth (1963) and as illustrated in Figure 14-1. The major driver for the local, shallow flow system is the difference in topography between adjacent hills and valleys. Recharge to local flow regimes occurs in topographically high areas, and discharge occurs in nearby low areas, such as stream valleys. The shallow flow system occurs primarily in the outcrop or unconfined portion of the aquifer and is characterized by flow paths on the scale of a few miles, travel depths measured in tens of feet, and travel times that last between a month and several decades. Intermediate flow paths are longer and deeper than local flow paths and underlie several local flow regimes. Regional flow regimes extend from regional recharge areas, such as outcrops, and discharge to near the coastline. The regional system is composed of confined to semi-confined aquifers and is characterized by groundwater flow paths involving travel distances measured on a scale of tens of miles, travel depths in the range of 500 to 3,000 feet, and travel times that range between 50 and 40,000 years. The flow lines in Figure 14-1, and those associated with Toth's (1963) original conceptualization of a hierarchical system of groundwater flows, assume that aquifers are homogenous and isotropic.

14.1.2 Overview of TWDB Regional Groundwater Flow Models for GMA Planning in the Texas Gulf Coast

The most recently developed regional models used for joint planning by Groundwater Management Areas in the Texas Gulf Coast include the Groundwater Management Area 16 Alternative Groundwater Model (Hutchison and others, 2011), the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004), and the Houston Area Groundwater Model (Kasmarek, 2013). Figure 14-2 shows the areal extent of these three models. All three models represent the Texas Gulf Coast Aquifer System as four model layers consisting of the Chicot Aquifer, the Evangeline Aquifer, the Burkeville Confining Unit, and the Jasper Aquifer. The surfaces for the model layers are based on the structural and hydraulic databases developed by the Texas Natural Resource Conservation Commission and the United States Geological Survey (Strom and others, 2003a,b,c) as part of the Source Water Assessment Program.

Figures 14-3 and 14-4 show that the vertical extent varies among the three groundwater models. As a general guideline, Groundwater Availability Models are constructed to include groundwater with a total dissolved solids concentration of 3,000 milligrams per liter and less. Both the Houston Area Groundwater Model for Groundwater Management Area 14 and the Central Gulf Coast Groundwater Availability Model have model layers representing the Burkeville Confining Unit and the Jasper Aquifer truncated before they reach the shoreline and at elevations between -2,500 feet mean sea level and -4,000 feet mean sea level.

14.2 Modeling Objectives and Approach

The primary modeling objective is to provide the TWDB with sufficient modeling results to adequately address House Bill 30 requirements to determine the amount of brackish groundwater that a Potential Production Area is capable of producing over a 30-year period and a 50-year period without causing a significant impact to water availability.

The expedited schedule of the project, as well as the lack of measured water levels and aquifer tests at depth in saline and brackish waters, precluded developing predictions with a high level of accuracy. The model simulations are considered be at a “scooping-level” because the groundwater models have not undergone a high level of model construction and calibration. The inability to associate a high level of accuracy does not mean that the model results are inaccurate or unreliable, but rather that the accuracy of the model predictions have not yet been thoroughly evaluated. One problem associated with evaluating the model’s accuracy near the well fields is that there is a lack of hydrogeological data in the vicinity of the well fields. This issue should not be too surprising because the well fields are located in regions away from existing wells and groundwater use.

The evaluation of the Potential Production Areas will consist of pumping from three different well fields located along five cross-sections. Figure 14-5 shows the location of the five cross-sections and the 15 well fields. Table 14-1 briefly describes each well field. For each of the three well fields, three different model runs were performed to simulate pumping rates at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year. To simulate the effects of pumping, a groundwater flow model was created for each cross-section. The hydraulic properties of the groundwater models are based on the aquifer properties associated with each cross-section.

Table 14-1. Description of the 15 Well Fields and their geological formations and six Potential Production Areas.

Cross-Section Information						
Cross-Section Number	**TWDB Cross-Section Number**	**Well Field ID**	**County**	**Aquifer or Confining Unit**	**Formation**	**Potential Production Area**
1	2	1a	Tyler	Catahoula	Catahoula (CAT)	CAT-1
		1b	Tyler	Jasper	Lower Lagarto (LL)	LL-1
		1c	Hardin	Evangeline	Upper Largarto (UL)	UL-4
2	8	2a	Washington	Catahoula	Catahoula (CAT)	CAT-2
		2b	Waller	Jasper	Oakville (OK)	OK-2
		2c	Waller	Jasper	Lower Lagarto (LL)	LL-2
3	16	3a	Goliad	Jasper	Oakville (OK)	OK-3
		3b	Goliad	Jasper	Lower Lagarto (LL)	LL-3
		3c	Refugio	Evangeline	Lower Goliad (LG)	LG-5
4	19	4a	Live Oak	Jasper	Lower Lagarto (LL)	LL-3
		4b	Live Oak	Evangeline	Upper Lagarto (UL)	UL-6
		4c	San Patricio	Evangeline	Upper Goliad (UG)	UG-6*
5	22	5a	Duval	Jasper	Oakville (OK)	OK-3
		5b	Duval	Burkeville	Middle Lagarto (ML)	ML-6
		5c	Jim Wells	Evangeline	Lower Goliad (LG)	LG-6

Note: * Potential Production Area UG-6 includes the lower 1/3 of the upper Goliad formation; Potential Production Areas are identified using a numeric value from 1 to 6 and a two- to three-character prefix that indicates the geological formation associated with the Potential Production Area.

Because of the uncertainty associated with several of the assumptions related to constructing each groundwater model, sensitivity analyses were conducted. A sensitivity analysis consists of a series of model runs to document how changes in the aquifer hydraulic properties affect the amount of drawdown simulated by the groundwater model. Table 14-2 lists the sixteen model runs that comprise the sensitivity analyses. A sensitivity analysis with 16 runs was performed for each of the three well fields at a pumping rate of 10,000 acre-feet per year for each of the five groundwater models corresponding to the five vertical cross-sections.

Each of the sensitivity analyses involved varying model input parameters. The focus of the sensitivity analysis was on specific storage (Ss), vertical hydraulic conductivity (Kz), and horizontal hydraulic conductivity (Kh) for the Gulf Coast Aquifer. These three parameters were varied as a group for a set of model layers, depending on the model layer that contains the simulated well field and whether it is above or below the Burkeville confining unit (middle Lagarto). Aquifer parameters in the Chicot Aquifer (Beaumont, Lissie, and Willis formations) were not varied during the sensitivity analysis because these hydraulic properties have been adequately defined during previous modeling studies. To illustrate the set of model layers that are varied during sensitivity analysis, consider a well field that simulates pumping from the upper Goliad. The group of model layers with hydraulic properties that were varied during the sensitivity analysis would include the model layers between the Burkeville confining unit (middle Lagarto) and the upper Goliad.

The three model input parameters were increased and decreased by a factor of 3. Sensitivity model runs were performed that involved only one of the parameters (see runs 2 through 8 in Table 14-2). Also, sensitivity model runs were performed that involved varying all three of the hydraulic properties at the same time (see runs 9 through 16 in Table 14-2). In addition, the maximum potential recharge rate (R) was increased and decreased by a factor of 50 percent.

Table 14-2. Description of the changes in model parameters associated with the 16 model runs that comprise the sensitivity analysis for each well field.

Run #	Number of Variables	Variable #1	Multiplier	Variable #2	Multiplier	Variable #3	Multiplier
1	1	Ss	0.33	NA	NA	NA	NA
2	1	Ss	3	NA	NA	NA	NA
3	1	Kz	0.33	NA	NA	NA	NA
4	1	Kz	3	NA	NA	NA	NA
5	1	Kh	0.33	NA	NA	NA	NA
6	1	Kh	3	NA	NA	NA	NA
7	1	R	0.5	NA	NA	NA	NA
8	1	R	1.5	NA	NA	NA	NA
9	3	Ss	3	Kz	3	Kh	3
10	3	Ss	3	Kz	0.33	Kh	3
11	3	Ss	0.33	Kz	3	Kh	3
12	3	Ss	0.33	Kz	0.33	Kh	3
13	3	Ss	3	Kz	3	Kh	0.33
14	3	Ss	3	Kz	0.33	Kh	0.33
15	3	Ss	0.33	Kz	3	Kh	0.33
16	3	Ss	0.33	Kz	0.33	Kh	0.33

Note: Ss = Specific Storage; Kz=vertical hydraulic conductivity; Kh=horizontal hydraulic conductivity, R= Potential Recharge; NA = Not Applicable

To help simplify the interpretation of the modeling results, the pumping that occurs in the groundwater model simulations is only from the well field. Thus, all drawdown simulated by the groundwater model is attributed to the development of the Potential Production Area. There are two main reasons for including no other sources of pumping. One reason is that the Potential Production Areas are located in confined portions of the aquifer and are far away from the unconfined regions of the aquifer. For the case of pumping a confined aquifer, simulated drawdowns from different well fields are additive. That is, the same amount of drawdown will be obtained whether the pumping from the two well fields are simulated together in the same model run or whether the pumping from each well field is simulated in different model runs and then added together. The other main reason is that removing all pumping except that from the Potential Production Area keeps the data analysis simple and the resulting drawdowns simple to interpret. Table 14-3 summarizes the four major features of the modeling approach.

Table 14-3. Overview of the three main features of modeling approach.

Major Feature of the Modeling Approach	Rationale for the Modeling Approach
Three Well Fields Per Cross-section	Because the drawdown impacts are a function of time, distance, and pumping rate, the geologic formation, the groundwater modeling at each vertical cross-section includes simulating drawdown from three well fields located at different distances down dip from the outcrop of the Catahoula Formation.
Three Pumping Rates	Because the drawdown impacts are a function of time, distance, and pumping rate, the drawdown produced by pumping each well field was evaluated at three different withdrawal rates. These three withdrawal rates were 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.
Sensitivity Analysis	Because of the uncertainties associated with defining the aquifer properties based on limited field data, a sensitivity analysis was performed for groundwater models at the pumping rate of 10,000 acre-feet per year. Each sensitivity model simulation involved adjusting between one to three hydraulic properties of the entire Gulf Coast Aquifer at a time.

14.3 Development of Three-Dimensional Groundwater Models

The code selected for the groundwater modeling is MODFLOW-USG (Panday and others, 2013). MODFLOW-USG is a three-dimensional control volume finite difference groundwater flow code that is supported by a suite of MODFLOW packages that simulate recharge, evapotranspiration, streams, springs and reservoirs. MODFLOW-USG is an enhanced version of the MODFLOW family of codes developed and supported by the United States Geological Survey. The benefits of using MODFLOW-USG for the current effort include the following: (1) MODFLOW incorporates the necessary physics of groundwater flow, (2) MODFLOW is the most widely accepted groundwater flow code in use today, (3) MODFLOW was written and is supported by the United States Geological Survey and is in the public domain, (4) MODFLOW is well documented (McDonald and Harbaugh, 1988; Harbaugh and McDonald, 1996; Harbaugh and others, 2000; Harbaugh, 2005; Niswonger and others, 2011; Panday and others, 2013), and (5) MODFLOW has a large user group.

14.3.1 Construction of a Three-dimensional Models for Potential Production Areas

As previously stated, a groundwater model was constructed for each of the five vertical cross-sections for a total of five groundwater models. Each of these models has different numerical grids to reflect the layering of each vertical cross-section and also differs in the aquifer properties used to represent the Gulf Coast Aquifer. The construction of a three-dimensional groundwater flow model from each of the vertical cross-sections can be conceptualized through the following four-step process.

Step 1: Construct a Vertical Cross-Sectional Grid. The top of model layer 1 represents land surface. For all cross-sections, recharge rates were obtained from the groundwater chloride mass balance recharge rates in Scanlon and others (2012, Figure 17) for the Gulf Coast Aquifer as shown in Figure 14-6. At the Gulf of Mexico, a constant-head boundary condition is used to represent the water surface for the last two rows in the Beaumont Formation (layer 1). The lowest and deepest model layer represents the Catahoula Formation (layer 1) as listed in Table 14-4. The base of the Catahoula Formation is considered to be a no-flow boundary. For the grid cells located at the most down-dip extent of each model layer, a no-flow boundary condition is imposed in all model layers below the Beaumont Formation (layer 1). This assumption is the same assumption used in the Central Gulf Coast Groundwater Availability Model. The lateral boundaries are specified as no-flow boundaries.

Table 14-4. Formation or aquifer assigned to the ten to thirteen layers for the five modeled cross-sections.

	Formation or Aquifer by Modeled Cross-Section				
Model Layer	**Cross-Section #1**	**Cross-Section #2**	**Cross-Section #3**	**Cross-Section #4**	**Cross-Section #5**
1	Beaumont	Beaumont	Beaumont	Beaumont	Beaumont
2	Lissie	Lissie	Lissie	Lissie	Lissie
3	Willis	Willis	Willis	Willis	Willis
4	Upper Goliad	Upper Goliad	Upper Goliad	Upper Goliad	Upper Goliad
5	Lower Goliad	Lower Goliad	Lower Goliad	Upper Goliad	Upper Goliad
6	Upper Lagarto	Upper Lagarto	Upper Lagarto	Upper Goliad	Upper Goliad
7	Middle Lagarto	Middle Lagarto	Middle Lagarto	Lower Goliad	Lower Goliad
8	Lower Lagarto	Lower Lagarto	Lower Lagarto	Upper Lagarto	Upper Lagarto
9	Lower Lagarto	Oakville	Oakville	Middle Lagarto	Middle Lagarto
10	Oakville	Catahoula	Catahoula	Lower Lagarto	Lower Lagarto
11	Catahoula	Catahoula	-	Oakville	Oakville
12	Catahoula	Catahoula	-	Catahoula	Catahoula
13	Catahoula	-	-	-	-

Step 2: Assign Aquifer Properties. Two different methods were used to assign hydraulic properties for the formations depending on whether the model grid cells are located above or below the Burkeville confining unit. One method is called the Groundwater Availability Model-based method and the other method is called the adjusted Groundwater Availability Model-based method. For brevity, these methods are referred to as the “GAM-based Method” and the “adjusted GAM-based Method.” For the GAM-based method, hydraulic properties are assigned to the grid cells above the Burkeville confining unit by intersecting cross-section #3, shown in Figure 14-5, with the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004), and using the aquifer hydraulic properties from this model. Cross-sections #1, #2, #4, and #5 are located outside of the model domain of the Central Gulf Coast Groundwater Availability Model. The Houston Area Groundwater Model (Kasmarek, 2013) was used to obtain hydraulic properties for cross-sections #1 and #2, and the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) was used to obtain hydraulic properties for cross-section #4 and #5 using the same approach as was used for cross-section #3. “GAM-based approach” will be used to indicate that hydraulic properties were obtained from the available groundwater models, either the Central Gulf Coast Groundwater Availability Model, the Houston Area Groundwater Model, or Groundwater Management Area 16 Approved Groundwater Model, for cross-sections #1 through #5. Because these groundwater flow models were calibrated to the available water level data (and in some cases calibrated to base flow discharge), the hydraulic properties from these models reflect the best available information on aquifer hydraulic properties in the Gulf Coast Aquifer.

For grid cells at or below the Burkeville confining unit (middle Lagarto), the adjusted GAM-based method developed for this project was used to estimate aquifer hydraulic properties that occur at depths greater than those simulated in the Groundwater Management Area 16 Approved Groundwater Model, the Houston Area Groundwater Model, and the Central Gulf Coast Groundwater Availability Model. Because little information on pumping stresses, water levels, or measured aquifer properties was available to calibrate the Central Gulf Coast Groundwater Availability Model, Groundwater Management Area 16 Approved Groundwater Model, or the Houston Area Groundwater Model groundwater flow models below the Burkeville confining unit (middle Lagarto), scaling relationships developed for this study were used to assign aquifer hydraulic properties as a function of depth below ground surface as discussed in Section 14.5. Three of the key parameters that were used to calculate hydraulic properties for the grid cells using the adjusted GAM-based method are aquifer properties from the Central Gulf Coast Groundwater Availability Model, Groundwater Management Area 16 Approved Groundwater Model, or the Houston Area Groundwater Model groundwater flow models associated with the grid cell; the depth below ground surface associated with the grid cell; and the average sand fraction in the aquifer at the grid cell location.

Step 3. Develop a Three-Dimensional Model. Figure 14-7 shows the process used to construct the three-dimension model grids by replicating the vertical cross-section grids multiple times. With each replication, the width of vertical cross-section is expanded by another grid cell until the total width of the three-dimensional groundwater model is 100 miles wide. This procedure maintains the structure, hydraulic properties, and hydraulic boundaries in the original vertical cross-sectional model throughout the entire model domain. The lateral expansion of 50 miles on both sides of the original vertical cross-section was performed so that the lateral model boundaries were sufficiently far from the pumping at the well fields in the middle of the model, so that no-flow boundary conditions are justified.

Step 4. Refine Grid Spacing for Placement of Wells. The three-dimensional model developed in Step 3 consists of grid cells that are 1-mile by 1-mile. In the vicinity of the wells, grid cells were refined. Figure 14-8 shows examples of grid refinement from a three-dimensional groundwater model developed for cross-section #1. In the vicinity of the wells, the 1-mile by 1-mile grid spacing was replaced with quadtree refinement down to a grid cell size of 1/8-mile by 1/8-mile near the wells.

14.4 Well Fields

Candidate well field locations were identified within Potential Production Areas for brackish groundwater and simulated in the groundwater flow model. The candidate well fields for brackish production were sited based on four criteria. First, the well fields are sited such that are were located outside of the zone of fresh water. Second, the well fields are sited away from existing pumping wells. Third, the well fields are sited away from existing injection wells. Lastly, the well fields are sited away from the exclusion zones corresponding to the Fort Bend and Harris-Galveston Coastal subsidence districts, the two exclusion zones within the study area. Figure 14-9 shows the locations of the well fields in relation to three Potential Production Areas in the lower Lagarto, Oakville, and Catahoula. Figure 14-10 shows the location of the well fields in relation to three Potential Production Areas in the upper Goliad, lower Goliad, upper Lagarto, and Middle Lagarto.

Detailed information regarding the well field locations, the geological formations containing the well fields, and the names of the Potential Production Areas is provided in Table 14-5. Individual well field location information in Table 14-5 includes the groundwater salinity classification, the location of the centroid of the well field, and the location the well fields along the vertical cross section reported as the distance along dip from the outcrop of Catahoula Formation to the centroid of the well field. The geological formation information in Table 14-5 includes the formation name, elevation of the top of the geological formation, and the elevation of the bottom of the geological formation.

Figures 14-11 through 14-15 provide the boundaries for fresh, slightly saline, moderately saline, and very saline groundwater along cross-sections #1 through #5, respectively. Application of the groundwater salinity classification of Winslow and Kister (1956) indicates the well fields are located in slightly saline to moderately saline groundwater. To produce 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year, the well fields are comprised of 9, 12, and 15 wells, respectively. For a given pumping rate, each well within the well field has the same pumping rate and the rate remains constant over time. As shown in Table 14-6, these pumping rates vary between 1,000 gallons per minute to 1,333 gallons per minute. For each well field, the depth of the production zone varied as listed in Table 14-5.

Potential Production Areas 1 through 3 are located in the Jasper and Catahoula while Potential Production Areas 4 through 6 are located in the Evangeline and Burkveville. Potential Production Areas 1, 2, and 3 contain 2, 3, and 4 well fields, respectively. Potential Production Areas 4, 5, and 6 contain 1, 1, and 4 well fields, respectively.

Table 14-5. Detailed description of the 15 Well Fields, their geological formations and groundwater salinity classifications, and six Potential Production Areas.

Cross-Section Information		Well Field Information					Geological Formation Information			
Cross-Section Number	TWDB Cross-Section Number	Well Field ID	Latitude	Longitude	Distance from Catahoula Outcrop (miles)	Groundwater Salinity Classification	Formation	Depth to Top of Formation (feet)	Depth to Bottom of Formation (feet)	Potential Production Area
1	2	1a	30.71320	-94.22213	30	slightly to moderately saline	Catahoula (CAT)	1,357	1,997	CAT-1
		1b	30.59841	-94.20369	38	slightly saline	Lower Lagarto (LL)	1,279	1,588	LL-1
		1c	30.35373	-94.16476	55	slightly saline	Upper Largarto (UL)	1,705	2,175	UL-4
2	8	2a	30.14214	-96.19973	17	slightly saline	Catahoula (CAT)	1,766	2,208	CAT-2
		2b	29.94371	-96.02988	34	slightly saline	Oakville (OK)	2,023	2,316	OK-2
		2c	29.94371	-96.02988	34	slightly saline	Lower Lagarto (LL)	1,436	2,023	LL-2
3	16	3a	28.64814	-97.56147	33	moderately saline	Oakville (OK)	1,582	2,222	OK-3
		3b	28.57916	-97.47776	40	moderately saline	Lower Lagarto (LL)	1,758	2,138	LL-3
		3c	28.43151	-97.29639	55	slightly saline	Lower Goliad (LG)	1,298	1,785	LG-5
4	19	4a	28.16494	-98.11881	27	slightly saline	Lower Lagarto (LL)	633	1,210	LL-3
		4b	28.05846	-97.90337	42	moderately saline	Upper Lagarto (UL)	1,080	1,475	UL-6
		4c	27.98823	-97.76080	52	moderately saline	Upper Goliad (UG)	1,013	1,367	UG-6*
5	22	5a	27.61939	-98.54283	18	moderately saline	Oakville (OK)	1,375	1,992	OK-3
		5b	27.58592	-98.43565	25	moderately saline	Middle Lagarto (ML)	1,181	1,503	ML-6
		5c	27.50912	-98.18896	41	moderately saline	Lower Goliad (LG)	999	1,447	LG-6

Note: * Potential Production Area UG-6 includes the lower 1/3 of the upper Goliad formation; Potential Production Areas are identified using a numeric value from 1 to 6 and a two- to three-character prefix that indicates the geological formation associated with the Potential Production Area.

Table 14-6. Number of wells and average pumping rates for the modeled well fields.

Total Pumping (Acre-Feet per Year)	Number of Wells	Pumping Rate (Gallons Per Minute) Per Well
3,000	3	1,000
10,000	9	1,011
20,000	15	1,333

14.5 Development of Aquifer Properties for the Gulf Coast Aquifer

The continuous profiles of sand and clay sequences were calculated from the geophysical logs presented in Section 11, which provide an excellent basis for developing aquifer properties for the Gulf Coast Aquifer. For this study, the goal of analyzing the available aquifer property data is to provide transmissive and storage properties for the Gulf Coast Aquifer that are reasonable and defensible. The process of data analysis involves developing relationships among the different geologic data sets, such as sand fraction and porosity, that can be used to estimate aquifer properties such as hydraulic conductivity and specific storage.

14.5.1 Spatial Patterns in the Sand Fraction

Figures 14-16 through 14-20 show the sand fraction for the grid cells that represent the Beaumont (model layer 1), the Lissie (model layer 2), the Willis (model layer 3), the upper Goliad (model layers vary between 4 and 6 among the five vertical cross-sections), the lower Goliad (model layers vary between 5 and 7), the upper Lagarto (model layers vary between 6 and 8), the middle Lagarto (model layers vary between 7 and 9), the lower Lagarto (model layers vary between 8 and 10), the Oakville (model layers vary between 9 and 11), and the Catahoula (model layers vary between 10 and 13) for the groundwater models for vertical cross-sections #1 through #5. The up dip regions of the aquifer have higher sand fractions that the down dip portions of the aquifer. For example, sand fractions are greater than 0.8 in the dip portions of the Lissie and are about 0.3 in the down dip portions of the Lissie. The lower Lagarto tends to have a higher sand fraction than the other formations.

Table 14-7 summarizes the average sand fraction by model layer for model layers at and below the Burkeville confining unit. As reported in Table 14-7, the middle Lagarto has an average sand fraction of 0.36 in cross-section #1, the easternmost cross-section, but higher average sand fractions, between 0.57 and 0.65 in cross-sections #4 and #5 in the southern portion of the Gulf Coast Aquifer system.

Table 14-7. Average sand fraction by formation/aquifer for model layers at or below the Burkeville Confining Unit in the five modeled cross-sections.

Model Layer	Sand Fraction by Modeled Cross-Section				
	Cross-Section #1	Cross-Section #2	Cross-Section #3	Cross-Section #4	Cross-Section #5
7	0.36	0.51	0.43	NA	NA
8	0.47	0.51	0.48	NA	NA
9	0.50	0.50	0.40	0.65	0.57
10	0.37	0.47	0.29	0.52	0.33
11	0.41	0.47	NP	0.35	0.44
12	0.44	0.48	NP	0.27	0.37
13	0.43	NP	NP	NP	NP

Note: NP indicates model layer is not present; NA indicates aquifer layer is not applicable because it is above the Burkeville Confining Unit.

14.5.2 Calculation of Horizontal Hydraulic Conductivity for Model Layers

Equation 14-1 is used to assign a horizontal hydraulic conductivity value to a model grid cell based on horizontal hydraulic conductivity values determined from the Central Gulf Coast Groundwater Availability Model, Groundwater Management Area 16 Approved Groundwater Model, or the Houston Area Groundwater Model. In using Equation 14-1, the sands of the shallow regions of the Gulf Coast Aquifer system have similar hydraulic conductivity values, and these values change as a function of depth because of changes in porosity and temperature.

$$K_H = K_{GAM} * A_{sandfrac} * A_{temp} * A_{porosity} \qquad \text{(Equation 14-1)}$$

where

K_H = horizontal hydraulic conductivity of the grid cell

K_{GAM} = average horizontal hydraulic conductivity value determined from the Groundwater Availability Model across the depth of 500 or 1,000 feet

$A_{sandfrac}$ = adjustments to account for the change in the sand fraction

A_{temp} = adjustments to account for the change in the viscosity and density of water with temperature

$A_{porosity}$ = adjustments to account for the relationship between permeability and porosity to account for an estimated 1 percent decrease in porosity per 1,000 feet of depth

The adjustment for sand fraction is based on the concept of effective hydraulic conductivity for one-dimension flow through uniform layered media. For this condition, the equivalent horizontal hydraulic conductivity values can be obtained using Equation 14-2, which is the arithmetic mean of the hydraulic conductivity values (Maliva, 2016; Freeze and Cherry, 1979; Domenico and Schwartz, 1990). A schematic of the equivalent horizontal hydraulic conductivity concept is shown in Figure 14-21. For our application, we assume that the horizontal hydraulic conductivity of the clay layers to be about 100 times less than the sand layers so that the effective horizontal hydraulic conductivity is proportional to the sand fraction and can be calculated using Equation

14-3. Using the relationships in Equation 14-3 and an estimate of an average porosity based on the first 1,000 feet of aquifer thickness, Equation 14-4 is used to calculate $A_{sandfrac}$.

$$K_{Hbinary} = [(K_{HS}*D_s) + [(K_{Hc}*D_c)]/(D_s + D_c) \quad \text{(Equation 14-2)}$$

$$K_{Heff} = [(K_{HS}*D_s)]/(D_s + D_c) \quad \text{(Equation 14-3)}$$

$$A_{sandfrac} = GC_{sandfrac}/AV_{sandfrac} \quad \text{(Equation 14-4)}$$

where:

$K_{Hbinary}$ = effective horizontal hydraulic conductivity for one-dimensional flow in layered media consisting of sand and clays
K_{Heff} = estimate of effective horizontal hydraulic conductivity for one-dimensional flow in layered media consisting of sand and clays where clays are orders of magnitude less permeable than sands
D_s = total thickness of sand
D_c = total thickness of clay
K_{Hc} = hydraulic conductivity of clay
K_{Hs} = hydraulic conductivity of sand
$GC_{sandfrac}$ = sand fraction calculated for the grid cell
$AV_{sandfrac}$ = average sand fraction for first 1,000 feet of the formation along the cross-section

Equation 14-1 includes a temperature adjustment because hydraulic conductivity is a function of the density and viscosity of water, which are temperature dependent. Equation 14-5 (Freeze and Cherry, 1979) shows how hydraulic conductivity is dependent on the density and viscosity of water. Figure 14-22 shows how hydraulic conductivity will increase with increases in temperature from 32 degrees Fahrenheit to 180 degrees Fahrenheit. This increase occurs primarily because the dynamic viscosity of water decreases with increases in temperature. We assumed that shallow groundwater across the Texas Gulf Coast Aquifer is 77 degrees Fahrenheit and a geothermal gradient of about 20 degrees Fahrenheit per 1,000 feet, or about 100 degrees Fahrenheit per 5,000 feet. Based on Figure 14-22, the increase in temperature from about 80 degrees Fahrenheit to about 180 degrees Fahrenheit will cause an increase in the hydraulic conductivity of approximately 140 percent, which translates to approximately 0.03 percent increase per one foot of depth.

$$K = k*\rho*g/\mu \quad \text{(Equation 14-5)}$$

where

K = hydraulic conductivity of media (dimensional analysis is length per time)
k = intrinsic permeability of media (dimensional analysis is length squared)
ρ = density of fluid (dimensional analysis is mass per length cubed)
g = gravitational constant (980.6 square centimeters per second)
μ = dynamic viscosity of fluid (dimensional analysis is mass per length times time)

The adjustment for porosity is based on both theoretical and observational considerations. One of the most widely accepted and simplest models for the permeability-porosity relationship is the Kozeny-Carman model (Kozeny, 1927; Carman, 1937). This model describes intrinsic permeability in terms of porosity starting from first principles. However, because of the complexity and the large number of related parameters, no simple single function exists. When simplified to the form of Equation 14-6 (Domenico and Schwarz, 1990), the Kozeny-Carmen model shows that permeability should decrease with decreases in porosity. Several comprehensive reviews of field measurements (Nelson, 1994; Magara, 1978; Loucks and others, 1986) provide compelling evidence that the permeability of a formation decreases with decreases in the formation porosity.

$$K = [\rho * g/\mu]*[\theta^3/(1-\theta)^2]*[d^2_{50}/180] \qquad \text{(Equation 14-6)}$$

where

K	=	hydraulic conductivity of media (L/T)
θ	=	porosity
d^2_{50}	=	median grain diameter (L)

Loucks and others (1984) provide a comprehensive summary of laboratory tests on cores from 253 wells located in the Gulf Coast to demonstrate a general relationship between a decrease in permeability and porosity with depth. Among their findings is that the sandstone porosity reduction rate remains relatively constant from a depth of a few hundred feet to over 10,000 feet. For different regions of the Catahoula Formation, Loucks and others (1984) calculate an average decrease of porosity of about 1.5 percent per 1,000 feet, which is consistent with the 1 percent determined by this study for all of the Texas Gulf Coast Aquifer System. Figure 14-23 shows data compiled by Loucks from the Catahoula formation (also known as the Frio formation) along the Texas Gulf Coast Aquifer. Figure 14-23 shows that there is a log-linear relationship between the decrease in porosity and decrease in intrinsic permeability. Intrinsic permeability is plotted instead of hydraulic conductivity because intrinsic permeability is invariant with the properties of the liquid, and hydraulic conductivity is not because the density and viscosity of water will vary with depth, as temperature and dissolved solid concentrations vary. The data in Figure 14-23 represents approximately a 1.5-order of magnitude reduction in permeability for a decrease in porosity of about 10 percent. The relationship in Equation 14-7 was developed to adjust the porosity value to reflect a reduction in porosity as a function of depth from groundwater surface for depths up to 10,000 feet.

$$A_{porosity} = 10^{-0.000148*depth} \qquad \text{(Equation 14-7)}$$

Where

$A_{porosity}$	=	adjustments to account for the relationship between permeability and porosity to account for an estimated 1 percent decrease in porosity per 1,000 feet of depth
depth	=	depth in feet

Adjustments to horizontal hydraulic conductivity that combines the adjustment factors for temperature, sand fraction, and porosity from Equation 14-1, are listed in Table 14-8. At 1,000 feet below ground surface, the adjustment factors for temperature, sand fraction, and porosity are small and result in a K_{GAM} of 1 foot per day being adjusted to a K_H of 0.97 foot per day. However, at a depth of 10,000 feet below ground surface, the adjustment factors for temperature, sand fraction, and porosity result in a K_{GAM} of 1 foot per day being adjusted to a K_H of 0.06 foot per day.

Table 14-8. Temperature, sand fraction, and porosity adjustments to horizontal hydraulic conductivity as a function of depth.

	Grid Cell Properties			Adjustment Factors			
K_{GAM} [a] (feet per day)	**AV_{sdfrac} [b]**	**Depth (feet)**	**Sand Fraction**	**Temperature (A_{temp})[c]**	**Sand ($A_{sandfrac}$) [d]**	**Porosity ($A_{porosity}$) [e]**	**K_H [f] (feet per day)**
1	0.5	1,000	0.6	1.28	1.2	0.71	1.09
1	0.5	2,500	0.3	1.7	0.6	0.43	0.44
1	0.5	2,500	0.7	1.7	1.4	0.43	1.02
1	0.5	5,000	0.4	2.4	0.8	0.18	0.35
1	0.5	7,500	0.5	3.1	1	0.08	0.24
1	0.5	10,000	0.8	3.8	1.6	0.03	0.22

[a] K_{GAM} = average horizontal hydraulic conductivity from the Groundwater Availability Model across the depth of 500 or 1,000 feet

[b] AV_{sdfrac} = average sand fraction for first 1,000 feet of the formation along the cross-section

[c] A_{temp}= an adjustment factor for temperature to account for the change in the viscosity and density of water with temperature

[d] $A_{sandfrac}$= an adjustment factor to account for the change in the sand fraction

[e] $A_{porosity}$= an adjustment factor for porosity to account for the relationship between permeability and porosity

[f] K_H=horizontal hydraulic conductivity of the grid cell

Table 14-9 lists the average hydraulic conductivity baseline value, K_H, for model layers below the Burkeville confining unit (or middle Lagarto) in model layers 7 through 9. As previously discussed, the hydraulic conductivity values above the Burkeville confining unit were obtained from the available groundwater flow models and were not adjusted for temperature, sand fraction, or porosity. Table 14-9 lists average horizontal hydraulic conductivity values between for the middle Lagarto, lower Lagarto, Oakville, and Catahoula formations by cross-section using the adjusted-GAM approach to hydraulic properties. These average horizontal hydraulic conductivity values vary between 0.01 and 3.5 feet per day. For formations at and below the lower Lagarto, the average hydraulic conductivity is much lower in cross-sections #4 and #5 compared to the other cross-sections. This trend is consistent with the measured well yields from submitted drillers reports, discussed in Section 9, that document lower well yields near cross-sections #4 and #5 in the Jasper and Catahoula compared to the other cross-sections. An explanation for the noted trends in the well yields from the drillers logs would be that coarser fluvial sands were deposited in the northern portion of the Gulf Coast Aquifer system in the Jasper and Catahoula, while finer sands were deposited in the southern portion of the Gulf Aquifer system in the Jasper and Catahoula.

Table 14-9. Average horizontal hydraulic conductivity in feet per day by formation assigned to model layers in the five modeled cross-sections using the adjusted GAM-based approach.

	Horizontal Hydraulic Conductivity (feet per day)				
Formation	**Cross-Section #1**	**Cross-Section #2**	**Cross-Section #3**	**Cross-Section #4**	**Cross-Section #5**
Middle Lagarto	0.01 (Layer 7)	0.01 (Layer 7)	0.07 (Layer 7)	3.50 (Layer 9)	3.50 (Layer 9)
Lower Lagarto	1.25 (Layer 8 & 9)	1.24 (Layer 8)	0.73 (Layer 8)	0.40 (Layer 10)	0.40 (Layer 10)
Oakville	1.22 (Layer 10)	1.22 (Layer 9)	0.58 (Layer 9)	0.40 (Layer 11)	0.40 (Layer 11)
Catahoula	1.18 (Layer 11) 1.19 (Layer 12) 1.23 (Layer 13)	1.19 (Layer 10) 1.17 (Layer 11) 1.16 (Layer 12)	0.47 (Layer 10)	0.40 (Layer 12)	0.40 (Layer 12)

14.5.3 Calculation of Vertical Hydraulic Conductivity for Model Layers

For the groundwater models corresponding to modeled cross-sections #1, #2, and #3, the vertical hydraulic conductivity was assigned using anisotropy ratios expressed as the ratio of the horizontal hydraulic conductivity to the vertical hydraulic conductivity as listed in Table 14-10. For the groundwater models corresponding to modeled cross-sections #4 and #5, the vertical hydraulic conductivity (Kz) value was set equal to those used in the Groundwater Management Area 16 Approved Groundwater Model. For all five of the groundwater models, vertical hydraulic conductivity values in the model layers at or below the Burkeville confining unit were adjusted based on the sand fraction in the model grid cell using the vertical hydraulic conductivity multipliers listed in Table 14-11.

Table 14-10. Kx/Kz ratios by formation assigned to model layers in the five modeled cross-sections.

	Anisotropy Ratio, Kx/Kz		
Formation	**Cross-Section #1**	**Cross-Section #2**	**Cross-Section #3**
Chicot	100	100	1,200
Evangeline	100	100	1,200
Burkeville	50	50	200
Lower Lagarto Oakville Catahoula	1,000	1,000	600

Note: Kx = horizontal hydraulic conductivity; Kz=vertical hydraulic conductivity

Table 14-11. Adjustment factors for Kz by formation assigned to model layers below the Burkeville confining unit in the five modeled cross-sections and groundwater models.

Sand Fraction	Multiplier for Kz	Description
0.0 to 0.15	0.1	Tighter Clay
0.15 to 0.35	0.3	-
0.35 to 0.65	1	No Adjustment
0.65 to 0.85	3	-
0.85 to 1	10	More Permeable

Note: Kz=vertical hydraulic conductivity

14.5.4 Calculation of Specific Storage for a Model Layer

The model of Shestakov (2002) was used to estimate specific storage values. Shestakov (2002) postulated a relationship based on geomechanical considerations as follows:

$$Ss = A / [D + z0] \qquad \text{(Equation 14-8)}$$

Where:

- Ss = specific storage (dimensional analysis is per length)
- D = depth (dimensional analysis is length)
- z0 = calibrated parameter
- A = calibrated parameter, which is a function of [1/(1+e)]
- e = void ratio, which is defined as e= [θ /(1-θ)], where θ = porosity

Shestakov (2002) showed that “A” in Equation 14-8 varied in the narrow range between 0.00020 per foot to 0.00098 per foot for sandy rocks and between 0.0033 per foot to 0.033 per foot for clayey rocks. Shestakov (2002) also shows that the variable “A” is a function of the void space such that as the porosity becomes smaller, the specific storage value increases with all other factors remaining equal. This relationship is consistent with the Jacob Equation (Jacob, 1940) for calculating the specific storage from porosity and the compressibility of water and the rock matrix. The Shestakov model assumes a power-law relationship between porosity and depth, where the decrease is more pronounced at shallower depth than is allowed by a linear relationship between porosity and depth. The power-law relationship is consistent with the Magara (1978) observation that the rate of porosity decrease is fast at shallow depths and slows down with greater depth of burial.

Previous applications of the Shestakov model for estimating specific storage values include the Northern Trinity and Woodbine Groundwater Availability Model (Kelly and others, 2014), the Yegua-Jackson Groundwater Availability Model (Deeds and others, 2010), and the Lower-Colorado River Basin Model (Young and others, 2009; Young and Kelley, 2006). These applications have involved a modified version of Equation 14-5 that allows accounting for mixed sands and clay layers over thick intervals, a minimal value of specific storage prevent over extrapolation of the data used to develop Equation 14-5, similar to Equation 14-6. Equation 14-9 was used to calculate specific storage. In applying Equation 14-6, all of the variables are fixed, except SF, D, and e. The three unfixed variables are dependent on the grid cell location and vary across the model. The values for the fixed variables are based primarily on previous application of the Shestakov model to the Gulf Coast Aquifer System (Young and others, 2009). The specific storage values as a function of depth calculated using this approach and applied to the five groundwater models are listed in Table 14-12.

$$Ss = Ss_{min} + \{\frac{A1 * [1/(1+e)] * [SF + CM * (1-SF)]}{A2+D}\} \quad \text{(Equation 14-9)}$$

where:

- Ss = specific storage (dimensional analysis is per length)
- Ss_{min} = set to 1.0 E-7 1/feet (ft^{-1})
- A1 = calibrated parameter that is set to 0.0013
- e = void ratio that is calculated based on the porosity, θ, which is depth specific
- SF = sand fraction that is determined by interpolation of measured sand fractions calculated from geophysical logs
- CM = clay multiplier, which is set to 20
- A2 = a calibrated parameter that is set to 5
- D = depth which is determined by the location of the grid cell (dimensional analysis is length)

Table 14-12. Specific storage as a function of depth.

Depth (feet)	Specific Storage (1/feet)
100	8.26E-05
250	3.41E-05
500	1.74E-05
750	1.17E-05
1,000	8.84E-06
1,500	5.98E-06
2,000	4.55E-06
2,500	3.69E-06
3,000	3.11E-06
3,500	2.7E-06
5,000	1.96E-06
7,500	1.38E-06
10,000	1.1E-06

14.6 Simulated Drawdowns from Well Fields in Modeled Cross-Section #1

This section describes the construction and application of a groundwater model to simulate the drawdowns that would be created by pumping at three proposed well fields along cross-section #1.

14.6.1 Construction of Groundwater Models

The three-dimensional groundwater model constructed to simulate pumping from well fields located along modeled cross-section #1 is shown on Figure 14-5. The width of the model along the geologic strike for the Gulf Coast Aquifer is 100 miles and the length of the model along dip is 117 miles. The applied recharge rate derived from Scanlon and others (2012) varies between 0.03 and 1.9 inches per year.

Table 14-13 provides the average values for horizontal hydraulic conductivity (Kx), vertical hydraulic conductivity (Kz), and specific storage (Ss) for 25-mile reaches. The model aquifer hydraulic properties were extracted from the Houston Area Groundwater Model (Kasmarek, 2013) and assigned to model layers 1 to 6 using the GAM-based approach to hydraulic properties. The model aquifer hydraulic properties were extracted from the Houston Area Groundwater Model (Kasmarek, 2013) and assigned to model layers 7 to 13 using the adjusted-GAM-based approach to aquifer hydraulic properties. The values for vertical hydraulic conductivity (Kz) were determined by imposing a ratio of Kx/Kz of 100 for model layers that represent the Chicot and Evangeline aquifers; a ratio of Kx/Kz of 50 for the model layer that represents the Burkeville confining unit (middle Lagarto); and a ratio of Kx/Kz of 1,000 for the model layers that represent the lower Lagarto, Oakville, and Catahoula formations. For model layers at or below the Burkeville confining unit, the vertical hydraulic conductivity was specified as Kz and was adjusted from values in the Houston Area Groundwater Model (Kasmarek, 2013) as a function of the sand fraction in the model grid cell. These adjustments allow the Kx/Kz ratio to vary between 350 and 3,300.

Figure 14-24 illustrates the values of horizontal hydraulic conductivity obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-25 illustrates the values of horizontal hydraulic conductivity that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-25 illustrates the horizontal hydraulic conductivity values summarized in Table 14-13.

Figure 14-26 illustrates the values of vertical hydraulic conductivity obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-27 illustrates the values of vertical hydraulic conductivity that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-27 illustrates the vertical hydraulic conductivity values summarized in Table 14-13.

Figure 14-28 illustrates the values of specific storage obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-29 illustrates the values of specific storage that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-29 illustrates the specific storage values summarized in Table 14-13.

14.6.2 Simulated Drawdown Produced by Pumping in Modeled Cross-Section #1

Groundwater pumping at the rate of 3,000 acre-feet per year, 10,000 acre-feet per year and 20,000 acre-feet per year was simulated at three well fields along cross-section #1 shown in Figure 14-5. The up dip Well Field #1a is located 25 miles down dip from the outcrop in the Catahoula; the middle Well Field #1b is located 38 miles down dip from the Catahoula outcrop in the lower Lagarto; and the down dip Well Field #1c is located 55 miles down dip from the Catahoula outcrop in the upper Lagarto. Figures 14-30 through 14-32 show the simulated drawdown along the center dip line of the groundwater model at 50 years for the three pumping rates at Well Field #1a, Well Field #1b, and Well Field #1c, respectively.

Among the notable results that can be observed in the plotted drawdown in Figures 14-30 through 14-32 are the following:

- The simulated drawdown is greatest at the up-dip well field (#1a) and diminishes with distance down dip such that Well Field #1b has more drawdown than Well Field #1c.
- Well Fields #1a and #1b are located below the Burkeville Confining Unit (layer 7), which provides an effective hydraulic barrier and prevents appreciable drawdowns from migrating from the well fields into the formations overlying the Burkeville Confining Unit.
- Well Field #1c is located above the Burkeville Confining Unit in the upper Lagarto (layer 6), and drawdown is more radially distributed compared to the drawdown in simulated in Well Field #1a or Well Field #1b, where the well fields are located beneath the Burkeville Confining Unit.
- Well Field #1b has appreciable drawdown that extends a greater distance down dip compared to Well Fields #1a and #1c due to lower horizontal hydraulic conductivities near Well Field #1b.

Drawdown values were recorded for all three model simulations at several monitoring locations at 30 and 50 years. The monitoring locations are located at down dip distances of 5, 10, 15, 20, 25, 30, 38, and 55 miles.

Table 14-13. Average values for Kx (feet per day), Kz (feet per day), and Ss (1/feet) by model layer for 25-mile reaches along dip for modeled cross-section #1.

Reach (miles)	Property	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7
0-25	Kx	nan	nan	1.3E+00	nan	nan	nan	nan
	Kz	nan	nan	1.3E-02	nan	nan	nan	nan
	Ss	nan	nan	5.0E-02	nan	nan	nan	nan
25-50	Kx	nan	1.5E+01	1.1E+01	nan	2.6E+00	2.0E+00	6.7E-03
	Kz	nan	1.5E-01	1.1E-01	nan	2.6E-02	2.0E-02	1.1E-04
	Ss	nan	1.2E-02	2.2E-02	nan	7.5E-07	5.3E-06	1.3E-05
50-75	Kx	1.5E+01	1.7E+01	1.7E+01	3.1E+00	3.1E+00	3.1E+00	7.7E-03
	Kz	1.5E-01	1.7E-01	1.7E-01	3.1E-02	3.1E-02	3.1E-02	1.5E-04
	Ss	6.0E-06	1.0E-05	1.0E-05	2.5E-07	2.8E-07	2.8E-07	2.8E-06
75-100	Kx	8.9E+00	8.9E+00	8.9E+00	4.5E+00	4.5E+00	4.5E+00	4.6E-03
	Kz	8.9E-02	8.9E-02	8.9E-02	4.5E-02	4.5E-02	4.5E-02	9.1E-05
	Ss	4.2E-07	4.2E-07	4.2E-07	1.5E-07	1.5E-07	1.5E-07	1.9E-06
100+	Kx	9.6E-01	9.6E-01	9.6E-01	4.9E+00	4.9E+00	4.9E+00	3.8E-03
	Kz	9.6E-03	9.6E-03	9.6E-03	4.9E-02	4.9E-02	4.9E-02	7.5E-05
	Ss	3.6E-07	3.6E-07	3.6E-07	1.4E-07	1.4E-07	1.4E-07	1.5E-06

Reach (miles)	Property	Layer 8	Layer 9	Layer 10	Layer 11	Layer 12	Layer 13
0-25	Kx	1.8E+00	1.7E+00	1.4E+00	1.1E+00	1.1E+00	1.1E+00
	Kz	4.7E-03	4.4E-03	1.3E-03	1.1E-03	1.1E-03	1.1E-03
	Ss	2.3E-05	1.8E-05	5.4E-04	9.5E-05	8.6E-05	1.3E-04
25-50	Kx	1.1E+00	1.0E+00	1.0E+00	9.5E-01	8.1E-01	7.6E-01
	Kz	1.1E-03	9.6E-04	7.6E-04	9.5E-04	8.1E-04	7.6E-04
	Ss	9.8E-06	7.6E-06	7.2E-06	5.1E-06	3.9E-06	3.3E-06
50-75	Kx	9.1E-01	8.0E-01	1.0E+00	nan	nan	nan
	Kz	9.1E-04	8.0E-04	1.0E-03	nan	nan	nan
	Ss	2.6E-06	2.3E-06	1.9E-06	nan	nan	nan
75-100	Kx	6.1E-01	5.0E-01	4.2E-01	nan	nan	nan
	Kz	6.1E-04	5.0E-04	3.9E-04	nan	nan	nan
	Ss	1.6E-06	1.4E-06	1.7E-06	nan	nan	nan
100+	Kx	3.7E-01	3.0E-01	1.5E-01	nan	nan	nan
	Kz	3.7E-04	3.0E-04	4.5E-05	nan	nan	nan
	Ss	1.6E-06	1.5E-06	1.7E-06	nan	nan	nan

Note: Kx=horizontal hydraulic conductivity; Kz=vertical hydraulic conductivity; Ss=specific storage; and nan= model layer is not present for the defined reach

Tables 14-14 through 14-16 provide drawdown at 30 and 50 years at the monitoring locations for pumping Well Field #1a, #1b, and #1c at 3,000, 10,000, and 20,000 acre-feet per year.

Among the notable results that can be gleaned from a review of Tables 14-14 through 14-16 and Figures 14-30 through 14-32 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown
- After 30 years of pumping 10,000 acre-feet per year from Well Field #1a the groundwater model predicts 70 to 370 feet of drawdown in the Catahoula Formation at the 30 mile monitoring point location and 30 to 60 feet in the Catahoula Formation at the 25 mile monitoring point location.
- After 30 years pumping 10,000 acre-feet per year from Well Field #1b the groundwater model predicts 15 to 25 feet of drawdown in the Jasper Aquifer at the 30 mile monitoring point location and 7 to 12 feet in the Jasper Aquifer at the 25 monitoring point location
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 370 feet of drawdown at the Well Field #1a.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 110 feet of drawdown at the Well Field #1b.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 30 feet of drawdown at the Well Field #1c.
- After 30 years of pumping the Catahoula Formation or the Jasper Aquifer for 10,000 acre-feet per year at either Well Field #1a or Well Field #1b, the groundwater model predicts 1 foot or less of drawdown across the entire Chicot and Evangeline aquifers.
- After 30 years of pumping the Evangeline Aquifer for 10,000 acre-feet per year at Well Field #1c, the groundwater model predicts less than 7 feet of drawdown across the entire Chicot Aquifer and less than 3 feet of drawdown across the entire Jasper Aquifer.

Table 14-14. Simulated drawdown in feet at monitoring locations after pumping Well Field #1a in Potential Production Area CAT-1 in cross-section #1 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Lower Lagarto	Oakville	Catahoula		
		Model Layer												
Location (miles)	**Pumping Rate (AFY)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11***	**12**	**13**
		30 Years												
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.3
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	1.2
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	2.3
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	2.1	1.3
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	7.5	4.5
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.8	15.2	8.6
20	3,000	0.2	<0.1	0.2	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	1.8	4.2	5.7	3.6
	10,000	0.6	<0.1	0.6	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	6.0	15.0	19.9	12.6
	20,000	1.2	<0.1	1.2	1.2	<0.1	<0.1	<0.1	<0.1	<0.1	12.4	34.6	39.7	23.9
25	3,000	0.3	<0.1	0.3	0.3	<0.1	<0.1	<0.1	2.2	3.6	9.3	9.3	17.0	14.5
	10,000	1.0	<0.1	1.0	1.0	<0.1	<0.1	<0.1	7.1	11.9	31.4	34.1	60.6	50.1
	20,000	1.9	<0.1	1.9	1.9	<0.1	<0.1	<0.1	13.5	22.6	60.0	78.1	114.5	93.7
30*	3,000	0.3	<0.1	0.3	0.3	<0.1	<0.1	2.8	3.7	6.5	28.0	208.5	39.7	21.6
	10,000	1.0	<0.1	1.0	1.0	<0.1	<0.1	9.2	12.1	21.0	85.4	369.7	131.5	73.5
	20,000	2.0	<0.1	2.0	2.0	<0.1	<0.1	17.3	22.8	39.0	147.8	533.8	231.7	137.1
38	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.4	3.9	4.9	6.4	8.8	10.9	10.6
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.0	13.0	16.4	21.8	30.6	37.6	36.3
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	15.4	25.2	31.9	42.6	60.1	73.3	70.1
55	3,000	<0.1	<0.1	<0.1	<0.1	0.0	0.0	0.5	1.0	1.1	1.3	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	0.0	0.1	1.8	3.4	3.7	4.2	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	0.0	0.1	3.4	6.5	7.2	8.3	<0.1	<0.1	<0.1
		50 Years												
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	2.6
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.8	10.7	8.0
20	10,000	<0.1	<0.1	0.9	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.0	17.9	25.4	18.7
25	10,000	<0.1	<0.1	1.3	<0.1	<0.1	<0.1	<0.1	8.3	13.5	34.5	38.2	68.0	58.9
30*	10,000	<0.1	<0.1	1.3	<0.1	<0.1	<0.1	10.5	13.7	23.1	89.2	375.8	139.5	82.4
38	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10.5	16.2	19.9	26.1	36.6	45.5	45.2
55	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3.0	5.6	6.1	6.9	<0.1	<0.1	<0.1

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Note: AFY=acre-feet per year

Table 14-15. Simulated drawdown in feet at monitoring locations after pumping Well Field #1b in Potential Production Area LL-1 in cross-section #1 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Lower Lagarto	Oakville	Catahoula		
		Model Layer												
Location (miles)	**Pumping Rate (AFY)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8***	**9***	**10**	**11**	**12**	**13**
		30 Years												
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.0	<0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.0	0.2	0.1
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.6	0.4
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	1.2	0.7
	3,000	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.6	0.5	0.5	0.4
20	10,000	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.2	1.7	1.7	1.2
	20,000	<0.1	<0.1	0.7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.3	3.4	3.4	2.4
	3,000	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	2.2	3.3	2.9	1.1	1.6	1.8
25	10,000	<0.1	<0.1	1.0	<0.1	<0.1	<0.1	<0.1	7.3	11.2	9.6	3.7	5.3	5.9
	20,000	<0.1	<0.1	2.1	<0.1	<0.1	<0.1	<0.1	14.7	22.3	19.1	7.4	10.5	11.7
	3,000	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	3.9	4.9	6.6	6.5	4.9	3.6	2.9
30	10,000	<0.1	<0.1	1.4	<0.1	<0.1	<0.1	13.1	16.6	22.2	21.6	16.4	11.8	9.7
	20,000	<0.1	<0.1	2.7	<0.1	<0.1	<0.1	26.1	33.0	44.0	42.7	32.4	23.2	19.1
	3,000	<0.1	0.0	0.0	<0.1	<0.1	<0.1	14.3	22.3	38.9	20.9	15.0	8.6	5.9
38*	10,000	<0.1	0.1	0.1	<0.1	<0.1	<0.1	46.0	71.5	109.8	67.9	49.1	28.3	19.3
	20,000	<0.1	0.2	0.2	<0.1	<0.1	<0.1	88.3	136.8	194.4	129.8	95.0	55.2	37.9
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	2.4	4.4	4.5	4.7	<0.1	<0.1	<0.1
55	10,000	<0.1	0.1	0.1	<0.1	0.1	0.2	7.8	14.6	15.0	15.6	<0.1	<0.1	<0.1
	20,000	<0.1	0.1	0.1	<0.1	0.2	0.5	15.6	29.1	29.9	31.1	<0.1	<0.1	<0.1
		50 Years												
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	2.6
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.8	10.7	8.0
20	10,000	<0.1	<0.1	0.9	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.0	17.9	25.4	18.7
25	10,000	<0.1	<0.1	1.3	<0.1	<0.1	<0.1	<0.1	8.3	13.5	34.5	38.2	68.0	58.9
30	10,000	<0.1	<0.1	1.3	<0.1	<0.1	<0.1	10.5	13.7	23.1	89.2	375.8	139.5	82.4
38*	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10.5	16.2	19.9	26.1	36.6	45.5	45.2
55	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3.0	5.6	6.1	6.9	<0.1	<0.1	<0.1

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.
Note: AFY=acre-feet per year

Table 14-16. Simulated drawdown in feet at monitoring locations after pumping Well Field #1c in Potential Production Area UL-4 in cross-section #1 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Lower Lagarto	Oakville	Catahoula		
		Model Layer												
Location (miles)	**Pumping Rate (AFY)**	**1**	**2**	**3**	**4**	**5**	**6***	**7**	**8**	**9**	**10**	**11**	**12**	**13**
		30 Years												
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
25	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1
30	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
38	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1
	10,000	<0.1	0.1	0.1	<0.1	<0.1	<0.1	0.2	0.3	0.2	0.2	0.2	0.1	0.1
	20,000	<0.1	0.3	0.3	<0.1	<0.1	<0.1	0.4	0.6	0.5	0.4	0.3	0.2	0.2
55*	3,000	<0.1	1.7	2.2	<0.1	5.9	13.6	6.6	0.8	0.5	0.3	<0.1	<0.1	<0.1
	10,000	<0.1	5.2	6.6	<0.1	15.1	32.3	16.4	2.4	1.7	1.1	<0.1	<0.1	<0.1
	20,000	<0.1	9.9	12.1	<0.1	24.9	50.4	26.2	4.6	3.2	2.1	<0.1	<0.1	<0.1
		50 Years												
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
38	10,000	<0.1	0.2	0.2	<0.1	<0.1	<0.1	0.3	0.4	0.3	0.3	0.3	0.2	0.2
55*	10,000	<0.1	5.2	6.6	<0.1	15.1	32.3	16.5	2.6	1.8	1.2	<0.1	<0.1	<0.1

Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.
Note: AFY=acre-feet per year

14.6.3 Sensitivity Analysis on the Simulated Drawdown for Well Fields in Modeled Cross-Section #1

Table 14-2 describes the changes in the model input parameters associated with set of sixteen sensitivity runs performed for the groundwater model corresponding to cross-section #1. In this section, Model Run00 refers to the baseline run of 10,000 acre-feet per year, for which simulated drawdowns are shown in Figures 14-30 to 14-32. Tables 14-17 through 14-19 provide the sensitivity results for drawdown at six of the monitoring locations after 30 and 50 years of pumping at Well Fields #1a, #1b, and #1c, respectively.

Among the notable results that can be gleaned from a review of Tables 14-17 through 14-19 are:

- After 30 years of pumping Well Field #1a at 10,000 acre-feet per year, the drawdown is between 123 and 1,086 feet in the upper Catahoula (layer 11) at the monitoring point located 30 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #1a at 10,000 acre-feet per year, the drawdown is between 12 and 84 feet in the upper Catahoula (layer 11) at the monitoring point located 25 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #1a at 10,000 acre-feet per year, the drawdown is between 3 and 34 feet in the upper Catahoula (layer 11) at the monitoring point located 20 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #1b at 10,000 acre-feet per year, the drawdown is between 37 and 330 feet in the lower Lagarto (layer 9) at the monitoring point located 38 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #1b at 10,000 acre-feet per year, the drawdown is between 8 and 61 feet in the lower Lagarto (layer 9) at the monitoring point located 30 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #1b at 10,000 acre-feet per year, the drawdown is between 1 and 26 feet in the lower Lagarto (layer 9) at the monitoring point located 25 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #1c at 10,000 acre-feet per year, the drawdown is between 14 and 86 feet in the upper Lagarto (layer 6) at the monitoring point located 55 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #1c at 10,000 acre-feet per year, the drawdown is less than 0.5 feet for all monitoring points located 17 miles or more up dip from the well field.

Table 14-17. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #1a in Potential Production Area CAT-1 in cross-section #1 at six monitoring locations.

		30 Years				50 Years			
	Layer	10	11*	12	13	10	11*	12	13
Monitoring Location at 15 Miles	run00		1.5	7.5	4.5		2.8	10.7	7.9
	run01		2.7	12.6	10.9		3.9	13.8	12.3
	run02		0.3	1.4	0.4		1.1	3.9	1.5
	run03		NC	NC	NC		NC	NC	NC
	run04		0.9	4.6	3.5		1.3	5.9	5.0
	run05		0.1	3.2	1.4		0.2	7.3	4.6
	run06		NC	NC	NC		NC	NC	NC
	run07		2.1	7.8	4.5		4.1	11.3	8.1
	run08		1.1	7.5	4.5		1.8	10.4	7.9
	run09		0.9	2.9	1.6		1.5	4.3	2.9
	run10		NC	NC	NC		NC	NC	NC
	run11		1.9	6.0	5.1		2.2	6.2	5.3
	run12		NC	NC	NC		NC	NC	NC
	run13		0.0	0.1	0.0		0.1	0.7	0.2
	run14		0.0	0.1	0.0		0.2	0.6	0.1
	run15		0.5	5.1	4.1		0.7	5.8	4.7
	run16		2.1	17.8	11.5		4.1	24.9	20.0
Monitoring Location at 20 Miles	run00	5.7	15.0	19.9	12.6	7.6	17.8	25.3	18.7
	run01	7.5	19.0	28.7	23.6	9.2	20.7	30.6	25.9
	run02	3.0	7.6	6.7	2.5	4.9	11.5	12.7	6.2
	run03	NC	NC	NC	NC	NC	NC	NC	NC
	run04	4.0	9.6	13.0	11.1	5.2	11.1	15.3	13.9
	run05	4.6	13.9	15.8	9.7	6.2	19.9	26.4	19.9
	run06	NC	NC	NC	NC	NC	NC	NC	NC
	run07	6.6	16.1	20.1	12.6	9.4	20.2	26.0	18.8
	run08	5.2	14.7	19.8	12.5	6.2	17.1	25.0	18.6
	run09	3.5	6.2	7.0	4.3	4.7	7.6	9.2	6.5
	run10	NC	NC	NC	NC	NC	NC	NC	NC
	run11	5.4	9.1	11.7	9.8	6.1	9.4	12.0	10.0
	run12	NC	NC	NC	NC	NC	NC	NC	NC
	run13	0.8	2.6	1.9	0.8	1.7	5.2	5.2	3.0
	run14	1.0	3.9	1.3	0.2	2.6	9.0	5.3	1.3
	run15	3.7	12.8	17.6	16.6	4.5	13.6	18.8	18.0
	run16	7.8	34.3	50.2	32.7	9.2	40.6	63.3	48.3
Monitoring Location at 25 Miles	run00	30.8	34.0	60.6	50.1	33.7	37.9	67.8	58.8
	run01	34.8	40.1	72.5	65.3	36.4	41.9	75.0	68.4
	run02	22.9	22.1	39.3	28.1	27.5	28.5	50.2	38.7
	run03	NC	NC	NC	NC	NC	NC	NC	NC
	run04	21.1	22.1	41.5	48.2	22.6	24.1	44.5	51.9
	run05	47.2	43.3	87.7	102.0	53.5	53.8	106.0	123.4
	run06	NC	NC	NC	NC	NC	NC	NC	NC
	run07	31.1	34.7	60.7	50.1	34.3	39.5	68.3	59.0
	run08	30.3	33.8	60.5	50.0	32.6	37.4	67.6	58.7
	run09	11.3	12.2	20.5	16.8	12.6	13.9	23.2	19.9
	run10	NC	NC	NC	NC	NC	NC	NC	NC
	run11	13.9	15.8	26.5	24.0	14.3	16.2	26.8	24.3
	run12	NC	NC	NC	NC	NC	NC	NC	NC
	run13	18.3	14.6	31.3	51.0	23.7	21.6	44.1	66.9
	run14	27.9	21.4	40.4	23.9	43.3	35.9	66.5	44.1
	run15	32.1	35.2	66.8	94.1	32.9	36.4	68.3	96.0
	run16	75.4	83.5	153.9	131.0	80.2	92.4	171.8	153.5

		30 Years				50 Years			
	Layer	10	11*	12	13	10	11*	12	13
Monitoring Location at 30 Miles*	run00	84.8	369.4	131.4	73.4	88.4	375.2	139.2	82.2
	run01	90.6	379.1	144.6	88.6	92.1	381.3	147.3	91.6
	run02	74.4	351.1	108.6	49.9	80.1	361.0	120.4	61.6
	run03	NC	NC	NC	NC	NC	NC	NC	NC
	run04	69.5	206.0	102.8	74.2	71.3	208.4	105.9	77.6
	run05	188.2	589.9	270.3	182.3	197.0	603.5	288.5	202.5
	run06	NC	NC	NC	NC	NC	NC	NC	NC
	run07	84.9	369.5	131.5	73.5	88.7	375.6	139.5	82.4
	run08	84.7	369.3	131.3	73.4	88.0	375.0	139.0	82.1
	run09	28.9	123.5	44.0	24.6	30.3	125.8	46.9	27.8
	run10	NC	NC	NC	NC	NC	NC	NC	NC
	run11	32.0	128.5	50.5	31.8	32.3	128.8	50.8	32.1
	run12	NC	NC	NC	NC	NC	NC	NC	NC
	run13	119.7	297.7	169.0	130.1	126.6	307.4	182.0	144.1
	run14	162.4	949.5	208.1	67.7	186.2	999.7	247.4	96.6
	run15	137.4	322.3	202.3	166.1	138.6	323.7	203.9	167.9
	run16	233.3	1,086.	346.5	194.9	241.2	1,100.	365.9	217.4
Monitoring Location at 38 Miles	run00	21.5	30.4	37.5	36.2	25.6	36.1	45.3	45.0
	run01	28.9	40.5	51.2	51.7	30.7	42.8	54.1	54.9
	run02	11.7	16.0	18.5	15.8	16.3	22.9	27.4	25.1
	run03	NC	NC	NC	NC	NC	NC	NC	NC
	run04	16.9	20.3	24.6	26.5	19.4	23.1	27.9	30.0
	run05	28.6	34.9	42.5	45.4	38.6	47.1	57.6	61.9
	run06	NC	NC	NC	NC	NC	NC	NC	NC
	run07	21.5	30.4	37.5	36.2	25.7	36.2	45.4	45.1
	run08	21.4	30.4	37.4	36.2	25.5	36.1	45.2	44.9
	run09	7.4	10.3	12.6	12.2	8.9	12.4	15.4	15.2
	run10	NC	NC	NC	NC	NC	NC	NC	NC
	run11	11.3	15.4	19.2	19.5	11.5	15.6	19.4	19.8
	run12	NC	NC	NC	NC	NC	NC	NC	NC
	run13	9.0	10.2	11.5	12.7	14.8	16.7	18.9	20.6
	run14	10.9	12.1	12.8	8.5	19.9	25.4	27.6	20.7
	run15	32.3	35.5	39.4	42.1	34.5	37.8	41.8	44.6
	run16	59.6	85.0	103.7	99.1	70.2	99.9	124.1	122.3
Monitoring Location at 55 Miles	run00	4.2				6.7			
	run01	9.4				11.2			
	run02	0.7				1.9			
	run03	NC				NC			
	run04	3.3				4.8			
	run05	1.9				4.6			
	run06								
	run07								
	run08								
	run09								
	run10								
	run11								
	run12								
	run13								
	run14								
	run15								
	run16								

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Table 14-18. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #1b in Potential Production Area LL-1 in cross-section #1 at six monitoring locations.

		30 Years				50 Years			
	Layer	8*	9*	10	11	8*	9*	10	11
Monitoring Location at 15 Miles	run00				0.1				0.3
	run01				0.4				0.6
	run02				0.0				0.1
	run03				0.1				0.3
	run04				0.1				0.3
	run05				0.0				0.0
	run06				0.4				0.8
	run07				0.2				0.5
	run08				0.1				0.2
	run09				0.1				0.2
	run10				0.0				0.1
	run11				0.5				0.6
	run12				0.3				0.5
	run13				0.0				0.0
	run14				0.0				0.0
	run15				0.1				0.2
	run16				0.2				0.5
Monitoring Location at 20 Miles	run00			1.9	1.6			2.7	2.6
	run01			2.8	3.3			3.4	3.8
	run02			0.8	0.3			1.4	0.8
	run03			2.6	1.0			3.4	1.7
	run04			1.1	1.8			1.7	2.6
	run05			0.8	1.1			1.4	2.4
	run06			3.2	1.3			4.5	1.9
	run07			2.2	1.7			3.4	2.8
	run08			1.8	1.6			2.3	2.4
	run09			1.3	0.8			1.9	1.3
	run10			1.7	0.2			2.6	0.4
	run11			2.4	2.1			2.8	2.3
	run12			3.8	1.0			4.2	1.2
	run13			0.0	0.1			0.1	0.3
	run14			0.1	0.0			0.5	0.2
	run15			0.9	2.9			1.3	3.6
	run16			2.8	3.9			3.5	5.9
Monitoring Location at 25 Miles	run00	5.5	9.7	9.0	3.6	6.1	10.7	10.7	5.1
	run01	6.4	11.3	11.7	6.4	6.7	11.8	12.5	7.2
	run02	3.8	6.7	4.7	1.0	4.7	8.3	7.0	2.1
	run03	11.4	22.9	12.3	2.3	12.4	24.8	14.4	3.5
	run04	3.0	4.7	5.6	4.1	3.5	5.3	6.6	5.4
	run05	3.4	6.9	7.6	3.7	4.3	8.8	11.0	6.8
	run06	5.8	9.8	6.8	2.0	6.2	10.4	7.9	2.7
	run07	5.5	9.7	9.1	3.7	6.1	10.7	10.9	5.3
	run08	5.5	9.6	8.9	3.6	6.0	10.6	10.4	5.0
	run09	2.9	4.1	3.6	1.4	3.3	4.6	4.4	2.1
	run10	8.5	18.9	4.8	0.4	9.8	20.9	6.3	0.7
	run11	3.8	5.3	5.4	3.3	3.9	5.4	5.6	3.5
	run12	11.5	23.8	8.5	1.6	11.9	24.3	9.1	1.8
	run13	0.6	1.2	1.0	0.5	1.1	2.0	2.2	1.4
	run14	3.6	8.3	2.8	0.3	6.0	13.0	6.8	0.9
	run15	2.6	4.8	7.6	7.8	2.8	5.3	8.5	9.0
	run16	12.0	25.6	23.9	9.8	13.2	27.9	27.4	13.6

		30 Years				50 Years			
	Layer	8*	9*	10	11	8*	9*	10	11
Monitoring Location at 30 Miles	run00	15.1	21.0	20.9	16.0	16.4	22.7	23.4	19.4
	run01	17.2	23.9	25.3	22.1	17.8	24.6	26.4	23.6
	run02	11.2	15.8	13.9	8.4	13.3	18.6	17.5	12.0
	run03	23.4	37.4	26.4	13.5	25.4	39.8	29.6	17.0
	run04	9.9	13.2	14.8	14.5	10.9	14.4	16.5	16.7
	run05	19.1	26.5	28.0	24.0	22.8	31.7	35.1	32.8
	run06	10.0	14.8	11.7	7.3	10.5	15.5	12.7	8.4
	run07	15.1	21.0	20.9	16.0	16.4	22.7	23.5	19.4
	run08	15.1	20.9	20.8	16.0	16.3	22.6	23.3	19.3
	run09	5.9	7.7	7.4	5.6	6.5	8.5	8.5	6.9
	run10	11.4	24.8	8.9	2.4	13.1	27.0	10.8	3.5
	run11	7.2	9.5	9.9	8.9	7.4	9.6	10.1	9.1
	run12	15.7	30.1	13.9	6.2	16.2	30.6	14.6	6.7
	run13	6.4	8.4	8.6	7.6	9.1	12.0	13.0	12.5
	run14	16.3	26.1	18.5	7.3	23.9	35.9	28.8	14.3
	run15	16.2	21.6	25.7	28.0	17.3	22.9	27.3	30.0
	run16	42.4	60.5	61.0	47.2	45.6	65.0	67.8	56.5
Monitoring Location at 38 Miles*	run00	71.1	109.3	67.5	48.8	74.8	113.0	71.7	53.6
	run01	77.5	115.8	74.8	57.4	79.0	117.4	76.5	59.4
	run02	59.6	98.1	55.6	35.8	65.7	103.9	61.7	42.2
	run03	65.8	147.4	62.9	35.6	70.3	151.5	67.7	41.1
	run04	68.4	85.0	66.0	54.9	71.5	88.1	69.2	58.4
	run05	176.6	225.9	167.3	131.1	191.8	241.3	183.5	148.6
	run06	25.3	52.1	24.5	15.7	26.2	53.1	25.7	17.1
	run07	71.1	109.3	67.5	48.8	74.8	113.0	71.7	53.7
	run08	71.0	109.3	67.5	48.8	74.7	113.0	71.6	53.6
	run09	24.0	36.7	22.8	16.5	25.4	38.1	24.3	18.2
	run10	17.9	69.1	16.7	5.9	20.3	71.6	19.0	7.8
	run11	27.4	40.2	26.5	20.8	27.6	40.4	26.7	21.0
	run12	24.9	75.5	23.5	12.3	25.7	76.1	24.3	13.0
	run13	126.7	145.5	121.4	101.4	141.9	160.9	137.2	117.9
	run14	134.6	253.0	124.3	65.7	156.9	274.4	145.3	85.3
	run15	180.0	199.5	176.6	159.1	184.4	204.0	181.2	163.8
	run16	214.0	329.8	203.5	146.9	224.6	340.5	215.3	161.0
Monitoring Location at 55 Miles	run00	14.5	15.0	15.5		18.3	18.9	19.7	
	run01	21.6	22.4	23.2		23.5	24.4	25.4	
	run02	6.1	6.1	6.4		9.9	10.1	10.5	
	run03	15.6	15.1	16.3		20.4	20.2	21.4	
	run04	11.3	11.8	12.3		13.8	14.4	15.0	
	run05	14.8	15.4	16.0		23.4	24.5	25.5	
	run06	8.6	8.6	9.1		9.9	10.0	10.4	
	run07	14.5	15.0	15.5		18.3	18.9	19.7	
	run08	14.5	15.0	15.5		18.3	18.9	19.7	
	run09	4.9	5.1	5.3		6.3	6.5	6.7	
	run10	4.6	3.4	4.6		6.6	5.4	6.6	
	run11	8.7	9.0	9.3		8.9	9.2	9.6	
	run12	12.4	11.7	12.2		13.7	13.1	13.4	
	run13	2.2	2.3	2.4		5.1	5.3	5.5	
	run14	3.6	3.3	3.8		8.6	8.3	9.1	
	run15	20.6	21.6	22.5		23.2	24.3	25.4	
	run16								

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Table 14-19. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #1c in Potential Production Area UL-4 in cross-section #1 at six monitoring locations.

		30 Years				50 Years						30 Years				50 Years			
	Layer	**5**	**6***	**7**	**8**	**5**	**6***	**7**	**8**		**Layer**	**5**	**6***	**7**	**8**	**5**	**6***	**7**	**8**
Monitoring Location at 15 Miles	run00									**Monitoring Location at 30 Miles**	run00			0.0	0.1			0.1	0.1
	run01										run01			0.0	0.1			0.1	0.1
	run02										run02			0.0	0.0			0.1	0.1
	run03										run03			0.0	0.0			0.1	0.1
	run04										run04			0.0	0.1			0.1	0.1
	run05										run05			0.0	0.1			0.1	0.1
	run06										run06			0.0	0.0			0.1	0.1
	run07										run07			0.0	0.1			0.1	0.1
	run08										run08			0.0	0.1			0.1	0.1
	run09										run09			0.0	0.0			0.0	0.1
	run10										run10			0.0	0.0			0.0	0.0
	run11										run11			0.0	0.1			0.1	0.1
	run12										run12			0.0	0.0			0.0	0.1
	run13										run13			0.0	0.1			0.1	0.1
	run14										run14			0.0	0.0			0.0	0.1
	run15										run15			0.0	0.1			0.1	0.1
	run16										run16			0.0	0.1			0.1	0.1
Monitoring Location at 20 Miles	run00									**Monitoring Location at 38 Miles**	run00			0.2	0.3			0.3	0.4
	run01										run01			0.2	0.3			0.3	0.4
	run02										run02			0.1	0.2			0.2	0.3
	run03										run03			0.1	0.2			0.2	0.3
	run04										run04			0.3	0.3			0.3	0.4
	run05										run05			0.2	0.3			0.3	0.4
	run06										run06			0.2	0.2			0.3	0.3
	run07										run07			0.2	0.3			0.3	0.4
	run08										run08			0.2	0.3			0.3	0.4
	run09										run09			0.2	0.3			0.3	0.3
	run10										run10			0.1	0.1			0.1	0.2
	run11										run11			0.3	0.3			0.3	0.4
	run12										run12			0.3	0.2			0.4	0.3
	run13										run13			0.2	0.3			0.3	0.4
	run14										run14			0.1	0.2			0.1	0.3
	run15										run15			0.3	0.4			0.3	0.5
	run16										run16			0.2	0.3			0.3	0.4
Monitoring Location at 25 Miles	run00									**Monitoring Location at 55 Miles***	run00	15.1	32.3	16.4	2.4	15.1	32.3	16.5	2.6
	run01										run01	15.1	32.3	16.4	2.5	15.1	32.3	16.5	2.6
	run02										run02	15.1	32.3	16.3	2.3	15.1	32.3	16.4	2.5
	run03										run03	20.0	58.2	24.4	1.7	20.0	58.2	24.5	1.9
	run04										run04	12.1	19.3	12.1	3.2	12.1	19.3	12.2	3.3
	run05										run05	20.3	43.0	23.1	3.0	20.3	43.0	23.2	3.2
	run06										run06	9.6	21.6	10.1	1.8	9.6	21.6	10.2	2.0
	run07										run07	15.1	32.3	16.4	2.4	15.1	32.3	16.5	2.6
	run08										run08	15.1	32.3	16.4	2.4	15.1	32.3	16.5	2.6
	run09										run09	8.8	14.0	8.4	2.5	8.8	14.0	8.5	2.6
	run10										run10	10.5	34.7	12.3	0.9	10.5	34.8	12.6	1.1
	run11										run11	8.8	14.0	8.5	2.6	8.8	14.0	8.6	2.7
	run12										run12	10.5	34.8	13.0	1.2	10.5	34.8	13.1	1.4
	run13										run13	14.5	23.5	15.2	3.7	14.5	23.6	15.3	3.9
	run14										run14	31.9	85.8	39.2	2.1	31.9	85.8	39.6	2.3
	run15										run15	14.5	23.6	15.3	3.9	14.5	23.6	15.4	4.0
	run16										run16	31.9	85.9	39.8	2.4	31.9	85.9	39.9	2.5

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

14.7 Simulated Drawdowns from Well Fields in Modeled Cross-Section #2

This section describes the construction and application of a groundwater model to simulated the drawdowns that would be created by pumping at three proposed well fields along cross-section #2.

14.7.1 Construction of Groundwater Models

The three-dimensional groundwater model constructed to simulate pumping from well fields located along modeled cross-section #2 shown in Figure 14-5. The width of the model is along the geologic strike for the Gulf Coast Aquifer is 100 miles. The length of the model along dip is 129 miles. The applied recharge rate derived from Scanlon and others (2012) varies between 0.6 and 1.9 inches per year.

Table 14-20 provides the average values for horizontal hydraulic conductivity (Kx), vertical hydraulic conductivity (Kz), and specific storage (Ss) for 25-mile reaches. The model aquifer hydraulic properties were extracted from the Houston Area Groundwater Model (Kasmarek, 2013) and assigned to model layers 1 to 6 using the GAM-based approach to hydraulic properties. The model aquifer hydraulic properties were extracted from the Houston Area Groundwater Model (Kasmarek, 2013) and assigned to model layers 7 to 13 using the adjusted-GAM based approach to aquifer hydraulic properties. The values for vertical hydraulic conductivity (Kz) were determined by imposing a ratio of Kx/Kz of 100 for model layers that represent the Chicot and Evangeline aquifers; a ratio of Kx/Kz of 50 for the model layer that represents the Burkeville confining unit (middle Lagarto); and a ratio of Kx/Kz of 1,000 for the model layers that represent the lower Lagarto, Oakville, and Catahoula formations. For model layers at or below the Burkeville confining unit, the vertical hydraulic conductivity was specified as Kz and was adjusted from values in the Houston Area Groundwater Model (Kasmarek, 2013) as a function of the sand fraction in the model grid cell. These adjustments allow the Kx/Kz ratio to vary between 20 and 3,300.

Figure 14-33 illustrates the values of horizontal hydraulic conductivity obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-34 illustrates the values of horizontal hydraulic conductivity that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-34 illustrates the horizontal hydraulic conductivity values summarized in Table 14-20.

Figure 14-35 illustrates the values of vertical hydraulic conductivity obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-36 illustrates the values of vertical hydraulic conductivity that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-36 illustrates the vertical hydraulic conductivity values summarized in Table 4-20.

Figure 14-37 illustrates the values of specific storage obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-38 illustrates the values of specific storage that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-38 illustrates the specific storage values summarized in Table 14-20.

14.7.2 Simulated Drawdown Produced by Pumping in Modeled Cross-Section #2

Groundwater pumping at the rate of 3,000 acre-feet per year, 10,000 acre-feet per year and 20,000 acre-feet per year was simulated at three well fields along cross-section #2 shown in Figure 14-5. The up dip Well Field #2a is located 17 miles down dip from the outcrop in the Catahoula; the middle Well Field #2b is located 34 miles down dip from the Catahoula outcrop in the lower Lagarto; and the down dip Well Field #2c is located 34 miles down dip from the Catahoula outcrop in the Oakville. Figures 14-39 through 14-41 show the simulated drawdown along the center dip line of the groundwater model at 50 years for the three pumping rates at Well Field #2a, Well Field #2b, and Well Field #2c, respectively.

Among the notable results that can be observed in the plotted drawdown in Figures 14-39 to 14-41 is the following:

- For Well Fields #2a, #2b, and #2c, the Burkeville Confining Unit (layer 7) provides an effective hydraulic barrier that prevents appreciable drawdowns from migrating from the well field into the formations overlying the Burkeville Confining Unit.

Drawdown values were recorded for all three model simulations at several monitoring locations at 30 and 50 years. The monitoring locations are located at down dip distances of 5, 10, 15, 17,20, 25, 30, and 34 miles.

Table 14-20. Average values for Kx (feet per day), Kz (feet per day), and Ss (1/feet) by model layer for 25-mile reaches along dip for modeled cross-section #2.

Reach (miles)	Property	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6
0-25	Kx	nan	nan	3.8E+01	nan	2.2E+00	2.2E+00
	Kz	nan	nan	3.8E-01	nan	2.2E-02	2.2E-02
	Ss	nan	nan	1.1E-03	nan	2.0E-04	1.1E-05
25-50	Kx	nan	2.5E+01	2.8E+01	2.0E+00	2.0E+00	2.0E+00
	Kz	nan	2.5E-01	2.8E-01	2.0E-02	2.0E-02	2.0E-02
	Ss	nan	5.5E-04	4.8E-04	3.9E-07	3.9E-07	3.9E-07
50-75	Kx	3.4E+01	3.4E+01	3.4E+01	3.1E+00	3.1E+00	3.1E+00
	Kz	3.4E-01	3.4E-01	3.4E-01	3.1E-02	3.1E-02	3.1E-02
	Ss	1.0E-03	8.8E-05	7.4E-05	2.4E-07	2.4E-07	2.4E-07
75-100	Kx	1.5E+01	1.5E+01	1.5E+01	3.2E+00	3.2E+00	3.2E+00
	Kz	1.5E-01	1.5E-01	1.5E-01	3.2E-02	3.2E-02	3.2E-02
	Ss	2.8E-04	4.6E-07	4.6E-07	1.7E-07	1.7E-07	1.7E-07
100+	Kx	3.4E+00	3.4E+00	3.4E+00	3.4E+00	3.4E+00	3.4E+00
	Kz	3.4E-02	3.4E-02	3.4E-02	3.4E-02	3.4E-02	3.4E-02
	Ss	1.3E-04	1.2E-07	1.2E-07	1.2E-07	1.2E-07	1.2E-07

Reach (miles)	Property	Layer 7	Layer 8	Layer 9	Layer 10	Layer 11	Layer 12
0-25	Kx	1.5E-02	1.2E+00	1.0E+00	9.5E-01	8.7E-01	8.1E-01
	Kz	2.9E-04	1.2E-03	9.2E-04	3.8E-02	3.6E-02	7.7E-04
	Ss	3.7E-04	1.4E-04	7.2E-05	2.8E-05	8.0E-06	6.1E-06
25-50	Kx	1.1E-02	8.4E-01	9.8E-01	4.8E-01	4.1E-01	3.5E-01
	Kz	2.3E-04	6.9E-04	9.8E-04	1.5E-04	1.2E-04	1.1E-04
	Ss	7.3E-06	5.6E-06	3.8E-06	4.7E-06	3.8E-06	3.2E-06
50-75	Kx	6.8E-03	5.0E-01	6.3E-01	3.9E-01	3.4E-01	3.0E-01
	Kz	9.3E-05	1.5E-04	6.3E-04	1.2E-04	1.0E-04	9.1E-05
	Ss	4.7E-06	3.9E-06	2.7E-06	3.4E-06	3.0E-06	2.8E-06
75-100	Kx	5.2E-03	3.3E-01	3.7E-01	nan	nan	nan
	Kz	7.6E-05	1.2E-04	3.1E-04	nan	nan	nan
	Ss	3.2E-06	2.9E-06	2.0E-06	nan	nan	nan
100+	Kx	4.5E-03	1.6E-01	1.8E-01	nan	nan	nan
	Kz	8.1E-05	8.1E-05	1.8E-04	nan	nan	nan
	Ss	1.8E-06	2.1E-06	1.4E-06	nan	nan	nan

Note: Kx=horizontal hydraulic conductivity; Kz=vertical hydraulic conductivity; Ss=specific storage; and nan= model layer is not present for this reach

Tables 14-21 through 14-23 provide drawdown at 30 and 50 years at the monitoring locations for pumping Well Field #2a, #2b, and #1c at 3,000, 10,000, and 20,000 acre-feet per year.

Among the notable results that can be gleaned from a review of Tables 14-21 through 14-23 and Figures 14-39 through 14-41 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown.
- After 30 years of pumping 10,000 acre-feet per year from Well Field #2a, the groundwater model predicts 10 to 30 feet of drawdown in the Catahoula Formation at the 30 mile monitoring point location and 40 to 50 feet in the Catahoula Formation at the 25 mile monitoring point location.
- After 30 years pumping 10,000 acre-feet per year from Well Field #2b, the groundwater model predicts 100 to 180 feet of drawdown in the Jasper Aquifer at the 30 mile monitoring point location and 60 feet in the Jasper Aquifer at the 25 monitoring point location.
- After 30 years pumping 10,000 acre-feet per year from Well Field #2c, the groundwater model predicts 100 to 140 feet of drawdown in the Jasper Aquifer at the 30 mile monitoring point location and 60 feet in the Jasper Aquifer at the 25 monitoring point location.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 220 feet of drawdown at the Well Field #2a.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 390 feet of drawdown at the Well Field #2b.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 210 feet of drawdown at the Well Field #2c.
- After 30 years of pumping the Catahoula Formation or the Jasper Aquifer for 10,000 acre-feet per year at either Well Field #2a, #2b, or #2c, the groundwater model predicts less than 2 feet of drawdown across the entire Chicot Aquifer and less than 3 feet of drawdown across the entire Evangeline Aquifer.

Table 14-21. Simulated drawdown at monitoring locations after pumping Well Field #2a in Potential Production Area CAT-2 in cross-section #2 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula		
		Model Layer											
Location (miles)	Pumping Rate (AFY)	1	2	3	4	5	6	7	8	9	10	11*	12
		30 Years											
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	3.2	5.8	6.8	5.6
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.7	11.1	19.8	23.3	19.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.4	22.1	39.5	46.6	38.3
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.7	5.0	12.9	18.7	15.8
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.3	17.0	43.8	65.3	54.2
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.5	33.2	85.7	129.1	107.6
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.7	5.0	13.8	24.1	42.2	40.5
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.2	16.2	45.6	80.5	153.8	136.2
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.2	31.1	87.4	153.3	280.2	258.6
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.8	6.7	18.1	31.5	82.8	51.0
17*	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	9.1	21.7	58.0	99.2	215.2	157.5
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17.4	41.6	110.0	186.1	367.0	291.1
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	4.6	11.9	26.0	38.0	40.4
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	14.9	38.7	84.4	129.0	131.5
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	28.8	74.3	161.6	251.9	250.3
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.6	2.4	3.9	13.0	15.2	16.7
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.8	7.9	12.7	42.6	51.1	54.8
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.5	15.2	24.6	83.5	104.7	107.8
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	1.5	1.3	5.2	8.2	4.3
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.3	4.9	4.1	17.1	27.5	14.3
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	2.5	9.4	7.9	33.7	56.3	28.7
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.9	0.9	2.4	3.9	2.2
34	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	2.8	3.1	7.9	13.1	7.4
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	1.7	5.5	6.0	15.9	26.8	15.1
		50 Years											
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.4	18.4	29.0	33.5	29.3
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5.4	23.8	53.4	76.1	65.8
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.9	21.9	53.5	90.3	164.9	148.2
17*	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	15.6	27.8	66.0	109.1	226.4	169.6
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	20.3	46.5	94.7	141.1	144.7
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	4.5	12.2	18.4	53.9	63.3	71.2
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	2.9	8.4	7.6	26.6	37.9	26.5
34	10,000	<0.1	<0.1	<0.1	<0.1	0.1	0.1	1.8	5.6	6.2	14.6	21.3	15.6

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Note: AFY=acre-feet per year

Table 14-22. Simulated drawdown at monitoring locations after pumping Well Field #2b in Potential Production Area OK-2 in cross-section #2 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula		
		Model Layer											
Location (miles)	**Pumping Rate (AFY)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9***	**10**	**11**	**12**
		30 Years											
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.4	0.4	0.3
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.4	0.8	0.8	0.6
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.2	0.4	0.4	0.2
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.7	1.4	1.2	0.9
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	1.3	2.9	2.5	1.7
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	1.2	1.1	1.0	0.8	0.7
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	4.1	3.6	3.2	2.6	2.3
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	8.2	7.3	6.5	5.2	4.6
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	2.3	1.8	1.5	1.0	0.8
17	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.6	7.8	6.2	5.0	3.3	2.7
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5.2	15.6	12.4	10.0	6.6	5.4
	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	7.1	4.7	2.0	1.0	0.7
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	23.7	15.8	6.8	3.6	2.6
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.7	47.4	31.8	13.5	7.1	5.1
	3,000	<0.1	<0.1	0.2	<0.1	0.2	0.2	5.5	17.4	17.2	4.6	1.6	0.4
25	10,000	<0.1	<0.1	0.5	<0.1	0.5	0.8	18.4	57.9	57.9	16.4	5.9	1.4
	20,000	<0.1	<0.1	1.0	<0.1	1.0	1.6	36.6	115.8	118.1	32.5	11.5	2.7
	3,000	<0.1	<0.1	0.2	0.2	0.4	0.5	11.5	30.0	49.5	11.3	2.7	0.7
30	10,000	<0.1	<0.1	0.8	0.7	1.1	1.7	38.5	99.9	181.4	41.0	9.8	2.4
	20,000	<0.1	<0.1	1.5	1.4	2.2	3.4	76.6	197.8	354.1	79.4	18.8	4.6
	3,000	<0.1	<0.1	0.4	0.4	0.5	0.8	17.6	53.9	180.4	19.4	3.9	1.4
34*	10,000	<0.1	<0.1	1.2	1.3	1.5	2.6	56.3	172.6	386.2	71.0	14.2	5.0
	20,000	<0.1	<0.1	2.3	2.5	2.9	5.0	106.5	326.8	620.3	133.7	27.2	9.6
		50 Years											
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.7	1.3	1.3	1.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	1.9	3.3	3.0	2.4
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.2	7.3	6.8	6.2	5.4	5.0
17	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	6.0	12.1	10.3	8.9	6.5	5.7
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.9	31.4	22.8	11.5	7.1	5.6
25	10,000	<0.1	<0.1	1.0	<0.1	1.0	1.4	33.5	69.7	70.7	24.9	10.4	3.8
30	10,000	<0.1	<0.1	1.2	1.2	1.7	2.5	48.9	113.3	196.0	52.8	14.9	5.1
34*	10,000	<0.1	<0.1	1.7	1.8	2.0	3.2	61.7	186.9	400.6	83.1	19.8	8.5

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Note: AFY=acre-feet per year

Table 14-23. Simulated drawdown at monitoring locations after pumping Well Field #2c in Potential Production Area LL-2 in cross-section #2 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula		
		Model Layer											
Location (miles)	Pumping Rate (AFY)	1	2	3	4	5	6	7	8*	9	10	11	12
		30 Years											
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.4	0.3	0.3
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.3	0.8	0.7	0.5
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.2	0.4	0.3	0.2
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.7	1.4	1.1	0.8
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.6	1.3	2.7	2.2	1.5
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	1.3	1.1	0.9	0.7	0.6
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	4.3	3.7	3.1	2.4	2.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	8.7	7.4	6.1	4.7	4.1
17	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	2.5	1.9	1.4	0.9	0.7
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.8	8.3	6.3	4.7	2.9	2.4
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5.7	16.6	12.5	9.3	5.9	4.8
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	7.6	4.9	1.8	0.9	0.6
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	25.5	16.3	6.0	2.9	2.2
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	51.1	32.5	11.9	5.9	4.3
25	3,000	<0.1	<0.1	0.2	<0.1	0.2	0.3	6.0	18.7	17.4	3.6	1.1	0.3
	10,000	<0.1	<0.1	0.6	<0.1	0.6	0.9	20.2	62.7	58.3	11.9	3.8	1.0
	20,000	<0.1	<0.1	1.2	<0.1	1.2	1.9	40.4	125.3	116.3	23.6	7.4	1.9
30	3,000	<0.1	<0.1	0.3	0.3	0.4	0.6	12.5	32.5	41.2	7.6	1.7	0.4
	10,000	<0.1	<0.1	0.9	0.9	1.4	2.0	41.9	109.3	137.8	25.4	5.8	1.3
	20,000	<0.1	<0.1	1.8	1.7	2.7	3.9	84.1	216.6	269.8	50.2	11.4	2.6
34*	3,000	<0.1	<0.1	0.5	0.5	0.6	1.0	23.9	70.5	55.2	12.3	2.5	0.9
	10,000	<0.1	<0.1	1.4	1.5	1.8	3.2	70.6	213.7	177.9	41.0	8.3	2.8
	20,000	<0.1	<0.1	2.8	3.0	3.5	6.0	129.9	394.9	340.5	80.5	16.3	5.6
		50 Years											
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.7	1.2	1.1	1.0
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	1.9	3.0	2.7	2.2
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.3	7.6	6.7	5.8	4.8	4.5
17	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	6.4	12.7	10.2	8.2	5.8	5.0
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	33.3	23.2	10.3	6.0	4.8
25	10,000	<0.1	<0.1	1.1	<0.1	1.2	1.6	36.2	74.6	71.2	19.2	7.3	2.9
30	10,000	<0.1	<0.1	1.4	1.4	2.0	2.8	52.7	123.0	152.4	35.4	9.8	3.2
34*	10,000	<0.1	<0.1	1.9	2.1	2.4	3.8	76.0	228.1	192.3	51.4	12.6	5.3

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Note: AFY=acre-feet per year

14.7.3 Sensitivity Analysis on the Simulated Drawdown in Modeled Cross-Section #2

Table 14-2 describes the changes in the model input parameters associated with set of sixteen sensitivity runs performed for the groundwater corresponding to cross-section #22. In this section, Model Run00 refers to the baseline run of 10,000 acre-feet per year for which simulated drawdowns are shown in Figures 14-39 to 14-41. Tables 14-24 through 14-26 provide the sensitivity results for drawdown at six of the monitoring locations after 30 and 50 years at Well Fields #2a, 2b, and 2c, respectively.

Among the notable results that can be gleaned from a review of Tables 14-24 through 14-26 are:

- After 30 years of pumping Well Field #2a at 10,000 acre-feet per year, the drawdown is between 73 and 646 feet in the middle Catahoula (layer 11) at the monitoring point located 17 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #2a at 10,000 acre-feet per year, the drawdown is between 73 and 459 feet in the middle Catahoula (layer 11) at the monitoring point located 15 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #2a at 10,000 acre-feet per year, the drawdown is between 23 and 187 feet in the middle Catahoula (layer 11) at the monitoring point located 10 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #2b at 10,000 acre-feet per year, the drawdown is between 129 and 1,169 feet in the Oakville (layer 9) at the monitoring point located 34 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #2b at 10,000 acre-feet per year, the drawdown is between 61 and 548 feet in the Oakville (layer 9) at the monitoring point located 30 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #2b at 10,000 acre-feet per year, the drawdown is between 12 and 173 feet in the Oakville (layer 9) at the monitoring point located 25 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #2c at 10,000 acre-feet per year, the drawdown is between 72 and 646 feet in the lower Lagarto (layer 8) at the monitoring point located 34 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #2c at 10,000 acre-feet per year, the drawdown is between 37 and 329 feet in the lower Lagarto (layer 8) at the monitoring point located 30 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #2c at 10,000 acre-feet per year, the drawdown is between 15 and 186 feet in the lower Lagarto (layer 8) at the monitoring point located 25 miles down dip of the Catahoula outcrop.

Table 14-24. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #2a in Potential Production Area CAT-2 in cross-section #2 at six monitoring locations.

		30 Years				50 Years			
	Layer	**9**	**10**	**11***	**12**	**9**	**10**	**11***	**12**
Monitoring Location at 10 Miles	run00	17.0	43.8	65.3	54.2	23.8	53.4	76.1	65.8
	run01	26.4	57.6	81.2	71.7	32.5	66.1	90.5	81.3
	run02	6.0	26.0	43.9	27.9	11.0	34.9	54.8	41.4
	run03	11.5	44.6	93.7	63.3	19.3	58.6	110.4	83.1
	run04	15.9	32.5	40.5	35.2	21.4	38.5	46.6	41.3
	run05	23.2	63.5	83.9	65.5	33.8	79.6	102.1	85.4
	run06	10.3	25.8	43.7	35.4	14.3	31.8	50.4	42.5
	run07	17.0	43.8	65.3	54.2	23.8	53.4	76.1	65.8
	run08	17.0	43.8	65.3	54.2	23.8	53.4	76.1	65.8
	run09	7.3	15.9	23.0	19.0	10.9	20.1	27.5	23.8
	run10	1.5	13.3	44.0	16.9	3.3	19.7	52.0	25.3
	run11	16.9	27.8	35.9	32.7	20.7	31.7	39.8	36.7
	run12	12.3	36.1	71.4	49.7	17.0	46.2	82.6	61.0
	run13	9.7	22.7	26.6	18.7	17.5	33.3	38.2	30.3
	run14	2.7	31.9	71.8	19.4	7.0	51.5	98.5	43.3
	run15	34.4	56.1	63.5	56.5	42.4	64.7	72.0	64.7
	run16	41.1	121.5	187.4	155.7	53.4	142.3	211.9	182.6
Monitoring Location at 15 Miles	run00	45.6	80.5	153.8	136.2	53.5	90.3	164.9	148.2
	run01	56.6	95.4	171.3	155.5	63.5	103.5	180.1	164.5
	run02	30.6	59.7	128.3	106.4	38.6	70.3	141.3	121.8
	run03	32.3	73.5	208.2	142.9	40.8	87.1	225.5	163.5
	run04	48.1	69.9	104.7	102.8	55.6	77.1	111.9	110.0
	run05	103.4	167.2	268.8	260.6	122.3	188.1	291.8	285.2
	run06	17.4	34.8	81.9	62.1	21.2	40.4	88.3	69.0
	run07	45.6	80.5	153.8	136.2	53.5	90.3	164.9	148.2
	run08	45.6	80.5	153.8	136.2	53.5	90.3	164.9	148.2
	run09	17.2	28.0	52.2	46.2	20.9	32.2	56.7	50.9
	run10	4.9	18.0	89.5	35.7	7.3	23.8	97.7	44.7
	run11	27.1	40.0	65.4	60.1	30.9	43.7	69.2	63.9
	run12	16.4	40.3	118.5	70.3	21.3	49.7	129.4	81.5
	run13	72.1	102.1	142.9	144.8	89.7	120.2	161.9	164.6
	run14	47.0	114.5	301.8	212.7	65.7	144.5	342.3	264.8
	run15	114.5	149.7	194.0	198.3	129.0	162.9	207.1	211.5
	run16	124.0	234.9	458.7	406.7	139.8	257.3	485.6	436.5
Monitoring Location at 17 Miles*	run00	58.0	99.2	215.2	157.5	66.0	109.1	226.4	169.6
	run01	69.6	114.9	233.5	177.4	76.6	122.8	242.1	186.4
	run02	42.1	77.2	188.6	127.6	50.5	88.4	202.1	142.9
	run03	40.5	86.9	283.0	157.1	49.0	100.4	300.5	177.7
	run04	63.8	91.5	151.8	129.0	71.8	99.1	159.3	136.5
	run05	147.3	228.5	408.0	338.0	168.2	251.4	432.4	363.4
	run06	20.1	39.1	106.8	66.9	23.8	44.5	113.2	73.7
	run07	58.0	99.2	215.2	157.5	66.0	109.1	226.4	169.6
	run08	58.0	99.2	215.2	157.5	66.0	109.1	226.4	169.6
	run09	20.9	34.1	72.5	53.2	24.6	38.3	77.1	58.0
	run10	6.3	20.1	117.7	38.3	8.9	25.6	125.9	47.2
	run11	31.0	46.2	86.0	67.4	34.6	49.9	89.7	71.1
	run12	17.9	42.1	147.3	72.9	22.9	51.2	158.1	84.2
	run13	115.9	161.1	242.2	219.4	136.3	181.5	262.8	240.3
	run14	77.5	162.5	480.1	278.7	99.4	195.1	522.8	329.9
	run15	165.7	214.8	297.9	276.2	182.4	230.1	312.6	290.7
	run16	164.5	292.8	645.7	471.8	181.9	316.4	673.7	502.5

		30 Years				50 Years			
	Layer	**9**	**10**	**11***	**12**	**9**	**10**	**11***	**12**
Monitoring Location at 20 Miles	run00	38.7	84.4	129.0	131.5	46.5	94.7	141.1	144.7
	run01	50.9	101.2	149.4	153.7	57.5	109.1	158.3	163.1
	run02	22.5	61.3	99.5	98.7	30.6	72.9	114.4	115.4
	run03	26.5	75.3	177.0	133.7	34.4	89.0	195.3	155.2
	run04	42.9	74.7	88.8	102.7	50.5	82.4	96.7	110.7
	run05	84.3	174.8	212.2	252.6	105.3	199.2	239.8	281.2
	run06	14.8	35.3	71.9	59.6	18.2	40.7	78.3	66.6
	run07	38.7	84.4	129.0	131.5	46.5	94.7	141.1	144.7
	run08	38.7	84.4	129.0	131.5	46.5	94.7	141.1	144.7
	run09	14.0	29.0	43.6	44.4	17.4	33.2	48.3	49.4
	run10	4.0	17.5	77.1	32.6	6.1	22.8	85.7	41.3
	run11	24.1	41.5	57.9	59.5	27.5	45.1	61.6	63.3
	run12	14.3	39.4	108.1	67.6	18.8	48.5	118.9	78.9
	run13	53.8	103.3	108.3	140.4	73.5	124.5	130.3	163.0
	run14	25.5	113.1	202.1	181.9	42.9	146.0	248.5	237.5
	run15	112.1	164.6	174.8	206.8	127.4	179.5	189.3	221.4
	run16	109.4	249.4	386.2	394.3	127.2	274.6	417.5	428.7
Monitoring Location at 25 Miles	run00	12.7	42.6	51.1	54.8	18.4	53.9	63.3	71.2
	run01	23.0	62.7	73.8	85.3	28.4	71.0	83.3	96.6
	run02	3.6	19.3	24.2	21.0	7.3	29.8	36.7	35.9
	run03	8.2	38.1	73.5	54.6	13.2	51.7	91.7	76.9
	run04	15.0	36.3	33.1	42.0	20.6	44.1	40.8	51.9
	run05	16.1	56.1	48.5	56.7	28.4	81.2	72.3	89.3
	run06	6.7	22.8	37.3	34.2	9.1	28.2	43.7	41.8
	run07	12.7	42.6	51.1	54.8	18.4	53.9	63.3	71.2
	run08	12.7	42.6	51.1	54.8	18.4	53.9	63.3	71.2
	run09	4.7	14.6	17.2	18.4	7.1	18.8	21.7	24.3
	run10	1.2	8.6	33.3	12.7	2.3	13.1	42.0	19.9
	run11	13.3	28.3	32.5	37.3	16.1	31.8	36.2	41.3
	run12	8.1	29.9	66.1	46.9	11.4	38.8	77.0	58.3
	run13	4.1	15.1	8.1	9.5	10.1	28.3	17.1	22.0
	run14	1.0	14.2	17.2	9.3	3.5	29.9	37.6	26.3
	run15	42.3	75.9	59.5	80.8	53.2	89.2	72.3	96.1
	run16	35.5	126.4	153.1	164.8	49.2	156.7	187.1	211.6
Monitoring Location at 30 Miles	run00	4.1	17.1	27.5	14.3	7.6	26.6	37.9	26.5
	run01	11.6	35.9	48.5	41.1	16.0	44.0	58.0	53.3
	run02	0.4	3.1	8.9	1.3	1.5	8.1	16.7	5.0
	run03	2.0	15.1	41.3	12.5	4.4	25.8	57.1	26.0
	run04	5.4	14.3	17.0	12.7	9.0	20.8	23.5	20.9
	run05	2.7	9.6	16.9	4.8	7.3	22.6	31.0	15.4
	run06	2.9	13.5	25.3	15.6	4.6	18.5	31.4	22.8
	run07	4.1	17.1	27.5	14.3	7.6	26.6	37.9	26.5
	run08	4.1	17.1	27.5	14.3	7.6	26.6	37.9	26.5
	run09	1.5	5.8	9.3	4.8	3.0	9.2	13.0	9.0
	run10	0.3	3.3	19.2	2.6	0.7	6.4	26.9	6.1
	run11	8.3	18.8	23.9	22.8	10.7	22.1	27.5	26.9
	run12	4.2	22.1	51.2	29.3	6.7	30.6	62.0	40.7
	run13	0.2	0.5	1.4	0.2	1.0	2.3	4.1	1.0
	run14	0.0	0.3	3.1	0.1	0.2	1.9	9.9	0.5
	run15	13.9	28.7	29.4	27.6	20.0	38.9	39.8	40.4
	run16	11.1	50.9	82.4	43.3	19.9	77.7	112.3	79.1

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Table 14-25. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #2b in Potential Production Area OK-2 in cross-section #2 at six monitoring locations.

		30 Years				50 Years			
	Layer	7	8	9*	10	7	8	9*	10
Monitoring Location at 15 Miles	run00	0.4	4.1	3.6	3.2	1.2	7.3	6.8	6.2
	run01	1.1	8.9	9.4	9.5	2.7	12.7	13.2	13.4
	run02	0.0	0.7	0.4	0.3	0.3	2.0	1.5	1.2
	run03	0.2	6.0	4.5	2.8	0.7	10.9	8.9	6.0
	run04	0.5	2.3	2.6	2.9	1.5	4.4	4.8	5.3
	run05	0.1	0.9	0.9	1.0	0.3	2.6	2.9	3.2
	run06	0.9	6.0	5.1	3.7	2.2	8.7	7.5	5.7
	run07	0.4	4.1	3.6	3.2	1.2	7.3	6.8	6.2
	run08	0.4	4.1	3.6	3.2	1.2	7.3	6.8	6.2
	run09	0.3	2.2	1.6	1.3	0.9	4.1	3.2	2.6
	run10	0.1	2.6	2.1	0.8	0.4	5.5	4.8	1.9
	run11	1.6	8.2	7.6	7.3	3.4	10.7	10.0	9.6
	run12	0.9	13.1	14.3	7.7	2.1	17.4	17.9	10.6
	run13	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
	run14	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.1
	run15	0.5	3.3	4.4	5.3	1.4	5.9	7.5	8.7
	run16	0.4	7.4	8.3	8.5	1.2	12.3	14.6	15.6
Monitoring Location at 17 Miles	run00	2.6	7.8	6.2	5.0	6.0	12.1	10.3	8.9
	run01	6.1	14.9	13.7	12.9	10.9	19.4	18.1	17.4
	run02	0.4	1.7	1.1	0.7	1.7	4.2	3.0	2.1
	run03	1.6	11.1	7.9	4.3	4.2	17.8	13.7	8.3
	run04	2.5	4.4	4.3	4.5	5.4	7.4	7.3	7.6
	run05	0.6	2.6	2.2	2.1	2.4	6.2	5.7	5.8
	run06	3.5	8.8	7.1	4.8	6.4	11.7	9.7	7.0
	run07	2.6	7.8	6.2	5.0	6.0	12.1	10.3	8.9
	run08	2.6	7.8	6.2	5.0	6.0	12.1	10.3	8.9
	run09	1.4	3.4	2.6	1.9	3.3	5.6	4.4	3.5
	run10	0.7	3.9	3.8	1.1	2.1	7.3	7.6	2.5
	run11	5.8	10.4	9.5	8.9	9.0	13.0	12.0	11.3
	run12	4.4	16.4	18.3	9.2	8.1	20.7	22.0	12.2
	run13	0.0	0.1	0.1	0.1	0.2	0.4	0.4	0.4
	run14	0.0	0.2	0.1	0.0	0.2	1.1	0.5	0.3
	run15	3.0	7.0	7.6	8.8	6.7	11.3	12.1	13.6
	run16	3.6	17.9	15.3	13.4	8.7	26.5	24.4	23.0
Monitoring Location at 20 Miles	run00	0.4	23.7	15.8	6.8	0.9	31.4	22.8	11.5
	run01	0.8	37.5	28.7	16.5	1.8	43.4	34.4	21.5
	run02	0.1	8.3	3.4	1.0	0.3	15.2	8.4	2.9
	run03	0.1	29.1	20.2	5.4	0.4	40.5	31.4	10.2
	run04	0.7	14.9	10.7	6.6	1.7	19.8	15.2	10.5
	run05	0.1	17.0	9.1	3.8	0.6	29.0	18.5	9.4
	run06	0.4	17.6	14.3	5.7	0.9	21.1	17.6	8.0
	run07	0.4	23.7	15.8	6.8	0.9	31.4	22.8	11.5
	run08	0.4	23.7	15.8	6.8	0.9	31.4	22.8	11.5
	run09	0.2	8.5	5.7	2.5	0.5	11.7	8.5	4.4
	run10	0.1	8.4	10.9	1.3	0.2	13.3	18.4	2.8
	run11	0.9	18.6	15.2	10.3	1.7	21.2	17.7	12.7
	run12	0.4	26.0	34.2	10.1	0.9	30.4	38.3	13.2
	run13	0.1	1.5	0.5	0.2	0.3	4.2	2.0	1.0
	run14	0.0	2.6	0.3	0.1	0.0	8.9	2.1	0.4
	run15	0.7	24.8	18.3	14.7	1.9	32.2	25.0	21.1
	run16	0.6	66.0	44.5	19.0	1.4	85.1	62.5	31.4

		30 Years				50 Years			
	Layer	7	8	9*	10	7	8	9*	10
Monitoring Location at 25 Miles	run00	18.4	57.9	57.9	16.4	33.5	69.7	70.7	24.9
	run01	54.6	79.6	81.5	33.6	71.2	87.3	89.4	40.6
	run02	3.1	30.1	25.9	3.6	7.7	43.4	41.2	8.3
	run03	7.6	65.7	83.3	12.0	16.0	82.5	104.1	19.8
	run04	26.6	40.5	41.1	18.3	39.1	48.0	48.8	25.1
	run05	19.2	68.1	65.3	15.8	41.3	93.6	93.4	31.9
	run06	11.0	32.9	40.7	10.0	18.0	37.2	45.1	13.1
	run07	18.4	57.9	57.9	16.4	33.5	69.7	70.7	24.9
	run08	18.4	57.9	57.9	16.4	33.5	69.7	70.7	24.9
	run09	6.2	19.7	19.5	5.6	11.4	24.1	24.2	8.6
	run10	0.7	17.9	50.6	2.5	1.6	24.6	64.3	4.6
	run11	29.1	33.3	33.8	17.0	32.0	35.8	36.3	19.6
	run12	13.1	41.1	88.0	14.2	19.9	45.9	92.7	17.8
	run13	3.6	14.7	13.4	2.4	10.1	26.0	25.3	7.0
	run14	0.7	25.4	12.3	0.7	2.6	50.8	34.3	3.0
	run15	64.4	71.5	72.7	45.6	78.7	82.9	84.4	57.6
	run16	55.0	171.8	173.1	49.1	99.3	204.1	209.4	73.4
Monitoring Location at 30 Miles	run00	38.5	99.9	181.4	41.0	48.9	113.3	196.0	52.8
	run01	56.2	125.0	208.6	64.9	60.9	133.4	217.4	73.9
	run02	14.0	66.3	143.0	18.5	24.8	82.7	162.3	28.2
	run03	23.4	107.4	322.2	30.1	38.0	126.6	344.8	40.9
	run04	35.7	74.6	111.1	45.5	40.7	82.8	119.4	55.0
	run05	59.8	160.0	265.1	70.7	82.0	191.7	299.6	101.7
	run06	18.5	48.4	121.2	18.1	22.4	53.0	126.1	22.0
	run07	38.5	99.9	181.4	41.0	48.9	113.3	196.0	52.8
	run08	38.5	99.9	181.4	41.0	48.9	113.3	196.0	52.8
	run09	13.5	33.6	60.7	13.7	17.5	38.4	65.8	17.8
	run10	2.5	28.5	191.8	6.2	4.9	36.1	205.4	9.0
	run11	23.6	48.5	76.4	28.4	25.1	50.9	78.9	31.2
	run12	19.3	54.8	231.0	21.0	22.9	59.7	236.2	25.1
	run13	23.1	64.0	122.6	25.1	36.8	83.6	145.4	45.2
	run14	7.2	100.0	291.4	14.6	17.8	145.0	360.6	29.8
	run15	67.5	137.8	200.6	118.4	74.1	149.5	212.2	135.1
	run16	114.1	300.4	548.3	123.9	143.4	338.8	590.6	159.0
Monitoring Location at 34 Miles*	run00	56.3	172.6	386.2	71.0	61.7	186.9	400.6	83.1
	run01	65.9	199.4	413.4	95.7	69.2	208.2	422.4	105.4
	run02	41.3	136.1	349.6	47.0	49.2	154.2	367.7	57.8
	run03	53.6	170.9	607.5	52.2	62.5	192.0	629.4	63.8
	run04	48.5	143.3	244.3	78.6	51.9	151.3	252.5	87.8
	run05	112.8	365.8	668.9	173.2	124.6	398.5	702.1	203.5
	run06	24.0	70.7	215.8	26.0	25.9	75.7	220.8	30.2
	run07	56.3	172.6	386.2	71.0	61.7	186.9	400.6	83.1
	run08	56.3	172.6	386.2	71.0	61.7	186.9	400.6	83.1
	run09	20.2	57.8	129.0	23.7	22.4	62.8	134.0	27.8
	run10	10.9	43.4	313.4	10.8	15.0	51.8	326.0	13.8
	run11	26.3	73.2	144.7	39.0	27.5	75.6	147.1	41.9
	run12	23.5	72.5	351.4	27.0	25.2	77.5	356.8	31.4
	run13	72.2	228.1	370.5	119.0	80.6	249.1	391.9	141.5
	run14	67.0	290.9	934.4	83.2	93.0	347.9	993.6	108.8
	run15	97.9	299.5	443.6	208.6	102.4	310.5	454.8	224.7
	run16	165.6	521.5	1.2E3	214.9	180.4	563.1	1.2E3	250.8

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Table 14-26. Results from a sensitivity analysis of simulated drawdowns caused by pumping 10,000 acre-feet per year from Well Field #2c in Potential Production Area LL-2 in cross-section #2 at six monitoring locations.

		30 Years				50 Years			
	Layer	**7**	**8***	**9**	**10**	**7**	**8***	**9**	**10**
Monitoring Location at 15 Miles	run00	0.4	4.3	3.7	3.1	1.3	7.6	6.7	5.8
	run01	1.1	9.1	9.1	8.8	2.7	12.9	12.8	12.5
	run02	0.1	0.8	0.5	0.3	0.3	2.3	1.6	1.2
	run03	0.3	7.3	4.8	2.3	0.9	12.6	9.0	4.9
	run04	0.5	2.3	2.5	2.8	1.5	4.4	4.7	5.1
	run05	0.1	0.9	0.9	1.0	0.3	2.6	2.8	3.1
	run06	1.0	6.7	5.1	3.1	2.4	9.5	7.4	4.8
	run07	0.4	4.3	3.7	3.1	1.3	7.6	6.7	5.8
	run08	0.4	4.3	3.7	3.1	1.3	7.6	6.7	5.8
	run09	0.3	2.4	1.7	1.2	1.0	4.3	3.2	2.5
	run10	0.2	4.7	1.7	0.4	0.7	8.5	3.8	0.9
	run11	1.7	8.2	7.4	6.9	3.4	10.8	9.8	9.1
	run12	1.2	16.2	11.2	4.4	2.7	20.8	14.6	6.4
	run13	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
	run14	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.1
	run15	0.4	3.2	4.3	5.1	1.4	5.7	7.2	8.4
	run16	0.4	7.8	8.2	7.8	1.3	12.8	14.2	14.3
Monitoring Location at 17 Miles	run00	2.8	8.3	6.3	4.7	6.4	12.7	10.2	8.2
	run01	6.4	15.4	13.4	11.9	11.2	19.8	17.7	16.1
	run02	0.5	2.0	1.2	0.7	1.9	4.7	3.1	2.0
	run03	2.0	13.4	8.1	3.4	5.0	20.4	13.7	6.6
	run04	2.6	4.5	4.2	4.3	5.4	7.3	7.1	7.3
	run05	0.7	2.8	2.3	2.1	2.5	6.4	5.7	5.6
	run06	3.9	9.7	7.0	3.9	7.1	12.7	9.5	5.8
	run07	2.8	8.3	6.3	4.7	6.4	12.7	10.2	8.2
	run08	2.8	8.3	6.3	4.7	6.4	12.7	10.2	8.2
	run09	1.6	3.6	2.6	1.8	3.5	5.9	4.5	3.4
	run10	1.3	6.9	2.8	0.5	3.5	11.2	5.6	1.2
	run11	5.9	10.6	9.4	8.4	9.1	13.1	11.8	10.7
	run12	5.6	20.3	13.9	5.2	10.0	24.9	17.4	7.3
	run13	0.0	0.1	0.1	0.1	0.2	0.4	0.4	0.4
	run14	0.0	0.3	0.1	0.0	0.3	1.4	0.7	0.3
	run15	3.0	6.9	7.4	8.6	6.5	10.9	11.7	13.1
	run16	3.9	19.0	15.3	12.3	9.3	27.6	23.9	20.9
Monitoring Location at 20 Miles	run00	0.4	25.5	16.3	6.0	1.0	33.3	23.2	10.3
	run01	0.9	39.3	28.9	14.8	1.9	45.2	34.3	19.5
	run02	0.1	9.5	3.8	0.8	0.3	16.7	8.9	2.5
	run03	0.2	35.3	18.3	3.7	0.5	47.1	28.8	7.4
	run04	0.7	15.3	10.8	6.3	1.8	20.2	15.2	10.0
	run05	0.2	17.9	9.6	3.6	0.6	30.2	19.0	8.9
	run06	0.5	19.8	13.3	4.3	1.0	23.4	16.5	6.4
	run07	0.4	25.5	16.3	6.0	1.0	33.3	23.2	10.3
	run08	0.4	25.5	16.3	6.0	1.0	33.3	23.2	10.3
	run09	0.2	9.2	5.9	2.2	0.6	12.4	8.7	4.0
	run10	0.1	14.8	4.8	0.5	0.3	20.6	9.2	1.2
	run11	0.9	19.3	15.2	9.6	1.8	21.7	17.6	11.9
	run12	0.6	33.3	21.3	5.3	1.2	38.0	25.1	7.5
	run13	0.1	1.5	0.6	0.2	0.3	4.3	2.1	1.0
	run14	0.0	3.5	0.5	0.1	0.1	10.9	2.5	0.4
	run15	0.7	24.7	18.0	14.2	1.9	31.8	24.5	20.3
	run16	0.6	71.0	45.7	16.5	1.5	90.2	63.2	27.5
Monitoring Location at 25 Miles	run00	20.2	62.7	58.3	11.9	36.2	74.6	71.2	19.2
	run01	58.3	84.6	81.7	27.0	75.4	92.2	89.5	33.6
	run02	3.6	34.0	25.9	2.1	8.7	47.8	41.5	5.4
	run03	9.8	80.3	60.5	5.3	19.8	97.4	80.3	10.2
	run04	27.7	42.0	42.1	16.3	40.4	49.4	49.8	22.8
	run05	20.4	72.0	68.3	13.3	43.5	98.0	96.6	27.7
	run06	13.1	37.9	32.8	5.9	20.9	42.3	37.2	8.5
	run07	20.2	62.7	58.3	11.9	36.2	74.6	71.2	19.2
	run08	20.2	62.7	58.3	11.9	36.2	74.6	71.2	19.2
	run09	6.8	21.4	19.7	4.1	12.4	25.8	24.4	6.7
	run10	1.3	31.4	14.8	0.5	2.8	38.9	22.3	1.2
	run11	30.6	34.9	33.8	14.5	33.5	37.4	36.3	17.0
	run12	18.5	55.4	40.6	6.0	27.0	60.3	45.2	8.5
	run13	3.8	15.4	14.0	2.3	10.5	27.0	26.1	6.7
	run14	1.0	32.4	12.4	0.3	3.3	60.3	34.2	1.5
	run15	65.0	72.0	72.8	43.4	78.9	83.0	84.1	54.8
	run16	60.3	186.0	174.2	35.3	107.4	218.6	210.3	56.0
Monitoring Location at 30 Miles	run00	41.9	109.3	137.8	25.4	52.7	123.0	152.4	35.4
	run01	60.1	134.6	164.8	46.2	64.7	142.8	173.4	54.6
	run02	16.0	74.9	99.0	9.0	27.6	91.8	118.5	15.6
	run03	30.2	134.2	142.3	10.7	46.9	153.8	164.3	17.1
	run04	37.1	77.9	106.3	37.0	42.0	85.9	114.6	45.9
	run05	62.9	169.2	251.3	52.0	85.6	201.3	285.9	79.1
	run06	22.1	57.4	61.5	8.8	26.2	62.1	66.4	11.9
	run07	41.9	109.3	137.8	25.4	52.7	123.0	152.4	35.4
	run08	41.9	109.3	137.8	25.4	52.7	123.0	152.4	35.4
	run09	14.7	36.8	46.2	8.5	18.9	41.7	51.3	12.0
	run10	4.9	50.9	36.4	1.0	8.8	59.2	45.1	1.8
	run11	25.0	51.6	61.7	21.8	26.5	54.0	64.1	24.5
	run12	28.0	77.8	65.9	7.4	32.1	82.8	70.8	10.1
	run13	24.0	66.8	125.2	20.5	37.9	86.5	147.9	38.5
	run14	9.1	122.7	164.4	4.7	21.3	169.4	228.3	11.8
	run15	68.2	139.8	201.8	106.8	74.6	151.0	212.9	122.7
	run16	124.2	328.8	415.9	76.8	154.4	367.6	458.1	106.2
Monitoring Location at 34 Miles*	run00	70.6	213.7	177.9	41.0	76.0	228.1	192.3	51.4
	run01	80.2	240.5	204.8	62.8	83.5	249.1	213.6	71.8
	run02	55.0	176.7	141.0	22.2	63.3	195.0	159.3	30.3
	run03	80.5	250.5	174.4	17.8	89.7	271.9	195.6	24.9
	run04	56.1	163.5	149.1	58.8	59.4	171.4	157.1	67.4
	run05	134.1	426.8	383.0	118.6	146.0	459.3	415.9	146.0
	run06	33.3	97.2	72.0	11.7	35.2	102.2	76.9	15.0
	run07	70.6	213.7	177.9	41.0	76.0	228.1	192.3	51.4
	run08	70.6	213.7	177.9	41.0	76.0	228.1	192.3	51.4
	run09	25.3	71.5	59.5	13.7	27.6	76.6	64.6	17.3
	run10	25.2	92.0	44.0	1.6	30.7	100.9	52.4	2.5
	run11	31.4	86.9	75.1	27.7	32.6	89.2	77.5	30.4
	run12	39.5	121.3	73.2	8.6	41.3	126.4	78.2	11.6
	run13	83.4	256.2	240.9	90.3	91.8	276.8	261.9	111.0
	run14	101.3	411.4	303.8	28.9	131.0	469.3	361.8	44.4
	run15	108.5	325.6	311.8	173.7	113.0	336.2	322.6	189.0
	run16	207.9	646.0	537.6	124.0	222.8	687.7	579.5	154.7

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

14.8 Simulated Drawdowns from Well Fields in Modeled Cross-Section #3

This section describes the construction and application of a groundwater model to simulated the drawdowns that would be created by pumping at three proposed well fields along cross-section #3.

14.8.1 Construction of Groundwater Models

The three-dimensional groundwater model constructed to simulate pumping from well field located along cross-section #3 shown in Figure 14-5. The width of the model is along the geologic strike for the Gulf Coast Aquifer is 100 miles. The length of the model along dip is 103 miles. The applied recharge rate derived from Scanlon and others (2012) varies between 0.06 and 0.5 inches per year.

Table 14-27 provides the average values for horizontal hydraulic conductivity (Kx), vertical hydraulic conductivity (Kz), and specific storage (Ss) for 25-mile reaches. The model aquifer hydraulic properties were extracted from the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004), and assigned to model layers 1 to 6 using the GAM-based approach to hydraulic properties. The model aquifer hydraulic properties were extracted from the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004) and assigned to model layers 7 to 10 using the adjusted-GAM based approach to aquifer hydraulic properties. The values for vertical hydraulic conductivity (Kz) were determined by imposing a ratio of Kx/Kz of 100 for model layers that represent the Chicot and Evangeline aquifers; a ratio of Kx/Kz of 50 for the model layer that represents the Burkeville confining unit (middle Lagarto); and a ratio of Kx/Kz of 1,000 for the model layers that represent the lower Lagarto, Oakville, and Catahoula formations. For model layers below the Burkeville confining unit, the vertical hydraulic conductivity was specified as Kz and was adjusted from values in the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004) as a function of the sand fraction in the model grid cell. These adjustments allow the Kx/Kz ratio to vary between 600 and 4,700.

Figure 14-42 illustrates the values of horizontal hydraulic conductivity obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-43 illustrates the values of horizontal hydraulic conductivity that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-43 illustrates the horizontal hydraulic conductivity values summarized in Table 14-27.

Figure 14-44 illustrates the values of vertical hydraulic conductivity obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-45 illustrates the values of vertical hydraulic conductivity that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-45 illustrates the vertical hydraulic conductivity values summarized in Table 4-27.

Figure 14-46 illustrates the values of specific storage obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-47 illustrates the values of specific storage that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-47 illustrates the specific storage values summarized in Table 14-27.

14.8.2 Simulated Drawdown Produced by Pumping in Modeled Cross-Section #3

Groundwater pumping at the rate of 3,000 acre-feet per year, 10,000 acre-feet per year and 20,000 acre-feet per year was simulated at three well fields along cross-section #3 shown in Figure 14-5. The up dip Well Field #3a is located 33 miles down dip from the Catahoula outcrop in the Oakville; the middle Well Field #3b is located 40 miles down from the Catahoula outcrop in the lower Lagarto; and the down dip Well Field #3c is located 55 miles down dip from the outcrop in the lower Goliad. Figures 14-48 through 14-50 show the simulated drawdown at 50 years for the three pumping rates at Well Field #3a, Well Field #3b, and Well Field #3c, respectively.

Among the notable results that can be observed in the plotted drawdown in Figures 14-48 to 14-50 are the following:

- Well Fields #3a and #b are located below the Burkeville Confining Unit (layer 7), which provides an effective hydraulic barrier and prevents appreciable drawdowns from migrating from the well fields into the formations overlying the Burkeville Confining Unit.
- Well Field #3c is located above the Burkeville Confining Unit in the upper Lagarto (layer 6) and drawdown is more radially distributed compared to the drawdown in simulated in Well Field #3a or Well Field #3b where the well fields are located beneath the Burkeville Confining Unit.

To help to quantify the drawdown in areas of interest and at time of interest, drawdown values were recorded for all three model simulations at several monitoring locations at 30 and 50 years. The monitoring locations are located at down dip distances 5, 10, 15, 20, 25, 30, 33, 40, and 55 miles.

Table 14-27. Average values for Kx (feet per day), Kz (feet per day), and Ss (1/feet) by model layer for 25-mile reaches along dip for modeled cross-section #3.

Reach (miles)	Property	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
0-25	Kx	nan	nan	nan	nan	nan
	Kz	nan	nan	nan	nan	nan
	Ss	nan	nan	nan	nan	nan
25-50	Kx	nan	1.9E+01	nan	3.5E+00	3.5E+00
	Kz	nan	1.6E-02	nan	2.9E-03	2.9E-03
	Ss	nan	8.6E-04	nan	2.8E-04	9.2E-05
50-75	Kx	1.9E+01	2.1E+01	2.1E+01	3.5E+00	3.5E+00
	Kz	1.6E-02	1.7E-02	1.7E-02	2.9E-03	2.9E-03
	Ss	8.8E-04	4.9E-04	7.4E-06	1.0E-06	6.6E-06
75-100	Kx	1.5E+01	1.5E+01	1.5E+01	3.5E+00	3.5E+00
	Kz	1.2E-02	1.2E-02	1.2E-02	2.9E-03	2.9E-03
	Ss	3.6E-04	8.0E-06	8.0E-06	1.0E-06	1.0E-06
100+	Kx	1.5E+01	1.5E+01	1.5E+01	3.5E+00	3.5E+00
	Kz	1.2E-02	1.2E-02	1.2E-02	2.9E-03	2.9E-03
	Ss	2.8E-04	8.0E-06	8.0E-06	1.0E-06	1.0E-06
Reach (miles)	**Property**	**Layer 6**	**Layer 7**	**Layer 8**	**Layer 9**	**Layer 10**
0-25	Kx	nan	6.6E-02	7.3E-01	5.6E-01	4.4E-01
	Kz	nan	3.3E-04	1.2E-03	8.4E-04	2.6E-04
	Ss	nan	3.1E-04	2.2E-04	1.5E-04	6.9E-05
25-50	Kx	3.5E+00	5.7E-02	5.5E-01	3.5E-01	2.8E-01
	Kz	2.9E-03	2.7E-04	9.2E-04	3.2E-04	1.4E-04
	Ss	6.9E-05	1.5E-05	5.9E-06	5.3E-06	3.9E-06
50-75	Kx	3.5E+00	4.3E-02	3.2E-01	3.5E-01	8.0E-02
	Kz	2.9E-03	2.0E-04	4.0E-04	5.8E-04	1.7E-05
	Ss	1.0E-05	3.7E-06	3.4E-06	2.4E-06	3.4E-06
75-100	Kx	3.5E+00	1.1E-02	1.6E-01	1.3E-01	nan
	Kz	2.9E-03	1.3E-05	1.6E-04	1.5E-04	nan
	Ss	1.0E-05	3.4E-06	2.5E-06	1.9E-06	nan
100+	Kx	3.5E+00	1.5E-02	1.4E-01	1.1E-01	nan
	Kz	2.9E-03	2.2E-05	6.9E-05	1.8E-04	nan
	Ss	1.0E-05	2.5E-06	1.9E-06	1.5E-06	nan

Note: Kx=horizontal hydraulic conductivity; Kz=vertical hydraulic conductivity; Ss=specific storage; and nan=model layer is not present for this reach

Tables 14-28 through 14-30 provide drawdown at 30 and 50 years at the monitoring locations for pumping at 3,000, 10,000, and 20,000 acre-feet per year.

Among the notable results that can be gleaned from a review of Tables 14-28 through 14-30 and Figures 14-48 through 14-50 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown.
- After 30 years of pumping 10,000 acre-feet per year from Well Field #3a, the groundwater model predicts 60 to 230 feet of drawdown in the Jasper Aquifer at the 30 mile monitoring point location and 30 to 40 feet in the Jasper Aquifer at the 25 mile monitoring point location.
- After 30 years pumping 10,000 acre-feet per year from Well Field #3b, the groundwater model predicts 20 to 22 feet of drawdown in the Jasper Aquifer at the 30 mile monitoring point location and five to eight feet in the Jasper Aquifer at the 25 monitoring point location
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 450 feet of drawdown at the Well Field #3a.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 500 feet of drawdown at the Well Field #3b.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 90 feet of drawdown at the Well Field #3c.
- After 30 years of pumping the Jasper Aquifer for 10,000 acre-feet per year at either Well Field #3a or Well Field #3b, the groundwater model predicts less than two feet of drawdown across the entire Chicot Aquifer and less than 3 feet of drawdown across the entire Evangeline Aquifer.
- After 30 years of pumping the Evangeline Aquifer for 10,000 acre-feet per year at Well Field #3c, the groundwater model predicts less than 6 feet of drawdown across the entire Chicot Aquifer.

Table 14-28. Simulated drawdown at monitoring locations after pumping Well Field #3a in Potential Production Area OK-3 in cross-section #3 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula
		Model Layer									
Location (miles)	Pumping Rate (AFY)	1	2	3	4	5	6	7	8	9*	10
		30 Years									
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	0.1
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.3	3.1	0.4
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.5	10.8	1.3
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.7	21.1	2.4
25	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	8.8	12.8	2.5
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	29.2	44.1	8.5
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	56.8	86.0	16.4
30	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	1.2	10.0	19.8	65.4	17.4
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	3.9	32.6	64.8	231.9	58.4
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	7.4	62.3	124.7	431.0	111.2
33*	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	2.0	14.8	29.8	174.8	29.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	6.6	47.7	94.8	447.5	95.7
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	12.6	90.4	178.3	746.9	177.7
40	3,000	<0.1	<0.1	<0.1	<0.1	0.4	1.3	5.3	9.0	20.0	9.6
	10,000	<0.1	<0.1	<0.1	<0.1	1.4	4.4	18.0	30.5	69.3	33.0
	20,000	<0.1	<0.1	<0.1	<0.1	2.6	8.7	35.8	61.3	143.8	65.3
55	3,000	<0.1	<0.1	<0.1	0.1	0.1	0.2	0.5	0.9	1.4	0.2
	10,000	<0.1	<0.1	<0.1	0.2	0.4	0.5	1.5	3.2	4.6	0.6
	20,000	<0.1	<0.1	<0.1	0.4	0.7	1.1	3.2	6.7	9.8	1.3
		50 Years									
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.0	0.3
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10.0	18.9	4.2
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.8	38.5	57.1	18.5
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	7.7	40.5	75.2	248.5	79.7
33*	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	10.4	55.4	105.4	464.4	117.6
40	10,000	<0.1	<0.1	<0.1	<0.1	2.8	6.8	23.3	38.6	85.6	51.7
55	10,000	<0.1	0.1	0.1	0.4	0.9	1.2	3.6	7.1	9.7	2.0

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Note: AFY=acre-feet per year

Table 14-29. Simulated drawdown at monitoring locations after pumping Well Field #3b in Potential Production Area LL-3 in cross-section #3 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula
		Model Layer									
Location (miles)	Pumping Rate (AFY)	1	2	3	4	5	6	7	8*	9	10
		30 Years									
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.3	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.2	1.2	0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.5	2.4	0.2
25	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.3	1.5	0.2
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	8.3	5.3	0.6
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	17.2	10.7	1.2
30	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	1.3	3.9	6.2	5.7	1.6
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	4.3	13.7	22.0	19.7	5.3
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	8.6	28.1	45.4	39.6	10.3
33	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	3.2	7.2	11.4	9.0	3.4
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	10.6	25.5	40.7	31.0	11.3
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	20.8	51.9	83.5	61.4	21.5
40*	3,000	<0.1	<0.1	<0.1	<0.1	4.2	11.7	83.5	207.0	40.2	7.0
	10,000	<0.1	<0.1	<0.1	<0.1	13.4	37.7	237.2	499.4	120.5	21.9
	20,000	<0.1	<0.1	<0.1	<0.1	25.4	70.7	394.3	782.2	211.2	39.8
55	3,000	<0.1	0.1	0.1	0.6	1.1	1.5	2.9	4.7	4.5	0.7
	10,000	<0.1	0.2	0.2	1.9	3.6	5.0	9.7	16.0	14.8	2.3
	20,000	<0.1	0.4	0.5	3.6	7.0	9.9	19.4	32.1	29.2	4.5
		50 Years									
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.0	<0.1
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.0
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.0	3.0	0.5
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	11.9	9.1	2.1
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	9.4	19.0	27.3	26.5	10.3
33	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	16.2	31.6	47.2	38.9	18.2
40*	10,000	<0.1	<0.1	<0.1	<0.1	18.4	42.6	244.4	508.5	132.2	30.5
55	10,000	<0.1	0.4	0.5	2.9	5.3	7.3	14.7	23.7	23.0	5.1

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.
Note: AFY=acre-feet per year

Table 14-30. Simulated drawdown at monitoring locations after pumping Well Field #3c in Potential Production Area LG-5 in cross-section #3 for 30 years and 50 years.

Location (miles)	Pumping Rate (AFY)	Beaumont	Lissie	Willis	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula
		Model Layer									
		1	2	3	4	5*	6	7	8	9	10
		30 Years									
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
25	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.1	<0.1
30	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.3	0.3	0.2	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.7	0.6	0.6	0.4	0.1
33	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.2	0.2	0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	1.2	0.8	0.6	0.4	0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	2.4	1.6	1.3	0.7	0.2
40	3,000	<0.1	<0.1	<0.1	<0.1	1.3	2.1	1.5	1.1	0.4	0.1
	10,000	<0.1	<0.1	<0.1	<0.1	4.4	7.0	5.1	3.8	1.4	0.2
	20,000	<0.1	<0.1	<0.1	<0.1	8.7	14.0	10.2	7.6	2.7	0.4
55*	3,000	<0.1	1.6	1.8	11.3	36.6	15.5	9.2	3.9	2.0	0.3
	10,000	<0.1	5.3	5.8	37.1	94.2	49.6	29.9	12.7	6.6	1.1
	20,000	<0.1	10.4	11.4	71.1	160.8	94.8	58.2	24.9	13.0	2.1
		50 Years									
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.2	<0.1
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	0.8	0.7	0.6	0.1
33	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	2.3	1.6	1.3	0.9	0.3
40	10,000	<0.1	<0.1	<0.1	<0.1	6.6	9.0	7.0	5.6	2.6	0.6
55*	10,000	<0.1	7.0	7.5	39.1	96.7	52.5	33.1	15.8	9.1	2.0

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.
Note: AFY=acre-feet per year

14.8.3 Sensitivity Analysis on the Simulated Drawdown for Modeled Cross-Section #3

Table 14-2 describes the changes in the model input parameters associated with set of sixteen sensitivity runs performed for the groundwater model corresponding to cross-section #3. In this section, Model Run00 refers to the baseline run of 10,000 acre-feet per year for which simulated drawdowns are shown in Figures 14-48 to 14-50. Tables 14-31 through 14-33 provide the sensitivity results for drawdown at six monitoring locations after 30 and 50 years of pumping Well Fields #3a, 3b, and 3c, respectively.

Among the notable results that can be gleaned from a review of Tables 14-31 through 14-33 are:

- After 30 years of pumping Well Field #3a at 10,000 acre-feet per year, the drawdown is between 150 and 1,321 feet in the Oakville (layer 9) at the monitoring point located 33 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #3a at 10,000 acre-feet per year, the drawdown is between 79 and 685 feet in the Oakville (layer 9) at the monitoring point located 30 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #3a at 10,000 acre-feet per year, the drawdown is between 3 and 123 feet in the Oakville (layer 9) at the monitoring point located 25 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #3b at 10,000 acre-feet per year, the drawdown is between 178 and 1,348 feet in the lower Lagarto (layer 8) at the monitoring point located 40 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #3b at 10,000 acre-feet per year, the drawdown is between 9 and 104 feet in the lower Lagarto (layer 8) at the monitoring point located 33 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #3b at 10,000 acre-feet per year, the drawdown is between 2 and 51 feet in the lower Lagarto (layer 8) at the monitoring point located 30 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #3c at 10,000 acre-feet per year, the drawdown is between 33 and 278 feet in the lower Goliad (layer 5) at the monitoring point located 55 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #3c at 10,000 acre-feet per year, the drawdown is between 0.5 and 11 feet in the lower Goliad (layer 5) at the monitoring point located 40 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #3c at 10,000 acre-feet per year the drawdown is less than 3 feet in all model layers at the monitoring point located 33 miles down dip of the Catahoula outcrop.

Table 14-31. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #3a in Potential Production Area OK-3 in cross-section #3 at six monitoring locations.

		30 Years				50 Years			
	Layer	7	8	9*	10	7	8	9*	10
Monitoring Location at 20 Miles	run00		4.5	10.8	1.3		10.0	18.9	4.2
	run01		8.3	24.1	11.9		15.0	30.0	22.7
	run02		1.2	1.1	0.0		4.0	4.1	0.2
	run03		3.1	19.1	0.7		7.7	37.0	2.5
	run04		4.1	5.1	1.7		8.4	8.9	5.1
	run05		0.9	1.9	0.2		3.7	6.1	1.0
	run06		5.7	19.3	2.8		10.0	24.8	6.1
	run07		4.5	10.8	1.3		10.0	18.9	4.2
	run08		4.5	10.8	1.3		10.0	18.9	4.2
	run09		3.2	4.1	0.4		6.9	7.8	1.5
	run10		1.0	8.6	0.1		2.8	18.7	0.4
	run11		8.8	15.2	13.6		13.8	18.9	18.7
	run12		5.3	50.6	6.8		9.5	59.1	11.5
	run13		0.2	0.0	0.0		1.1	0.3	0.0
	run14		0.1	0.0	0.0		0.8	0.4	0.0
	run15		3.4	5.5	4.6		7.0	9.3	10.4
	run16		5.1	29.4	3.6		11.4	47.6	11.9
Monitoring Location at 25Miles	run00	0.3	29.2	44.1	8.5	0.8	38.5	57.1	18.5
	run01	0.5	40.4	64.6	35.0	1.2	47.9	72.5	51.8
	run02	0.1	12.8	15.3	0.7	0.3	21.8	28.6	2.5
	run03	0.1	21.6	77.9	4.4	0.2	31.4	108.2	10.7
	run04	0.8	25.1	22.0	11.5	2.0	31.6	28.5	22.0
	run05	0.3	36.7	26.2	3.5	0.7	53.5	43.8	11.8
	run06	0.3	14.8	45.3	7.8	0.8	19.2	51.8	13.2
	run07	0.3	29.2	44.1	8.5	0.8	38.5	57.1	18.5
	run08	0.3	29.2	44.1	8.5	0.8	38.5	57.1	18.5
	run09	0.1	13.9	16.1	2.9	0.4	19.2	21.9	6.4
	run10	0.0	5.0	34.7	0.6	0.1	8.3	51.9	1.6
	run11	0.4	25.4	31.2	24.9	1.0	29.7	35.3	30.6
	run12	0.1	16.0	93.3	11.7	0.3	20.3	101.7	17.4
	run13	0.1	8.9	3.0	0.2	0.3	16.7	7.9	1.0
	run14	0.0	5.9	4.4	0.0	0.1	14.9	15.6	0.3
	run15	0.6	39.0	28.4	30.6	1.5	46.5	35.6	47.3
	run16	0.5	61.3	123.3	25.2	1.2	75.4	152.6	54.0
Monitoring Location at 30 Miles	run00	32.6	64.8	231.9	58.4	40.5	75.2	248.5	79.7
	run01	42.8	79.7	259.0	103.9	48.6	86.8	268.4	124.1
	run02	14.8	39.4	180.0	22.1	24.1	52.7	208.0	37.2
	run03	14.6	47.2	358.1	31.1	20.9	59.8	397.0	46.3
	run04	45.6	60.5	128.8	76.1	53.9	68.3	138.3	93.8
	run05	78.7	126.0	311.8	109.8	102.2	150.8	348.1	164.4
	run06	9.9	24.8	142.5	22.7	12.6	29.0	149.5	29.9
	run07	32.6	64.8	231.9	58.4	40.5	75.2	248.5	79.7
	run08	32.6	64.8	231.9	58.4	40.5	75.2	248.5	79.7
	run09	13.5	24.3	78.6	19.6	18.1	29.6	85.4	27.0
	run10	1.4	8.5	149.5	4.3	2.5	12.3	172.5	6.7
	run11	23.2	36.8	96.6	49.7	27.2	40.7	100.6	55.4
	run12	6.4	22.0	220.0	21.3	8.4	26.1	228.0	27.9
	run13	48.5	62.6	113.0	40.7	72.4	81.9	138.7	77.4
	run14	8.5	45.9	320.7	12.0	20.1	75.3	432.1	29.8
	run15	111.9	121.2	191.6	193.9	124.4	132.3	204.2	215.6
	run16	84.9	175.7	684.9	173.8	98.5	195.4	723.2	233.9

		30 Years				50 Years			
	Layer	7	8	9*	10	7	8	9*	10
Monitoring Location at 33 Miles*	run00	47.7	94.8	447.5	95.7	55.4	105.4	464.4	117.6
	run01	57.9	110.8	475.7	141.4	63.4	117.6	485.5	160.9
	run02	30.3	67.3	394.9	53.9	39.9	81.8	423.3	72.5
	run03	25.1	67.1	625.8	51.2	32.6	80.7	664.9	68.4
	run04	61.1	97.9	283.3	125.7	68.9	106.2	293.3	141.7
	run05	121.8	231.3	772.5	260.9	139.8	256.7	809.9	317.6
	run06	14.5	31.9	231.8	30.6	17.3	36.1	238.8	38.2
	run07	47.7	94.8	447.5	95.7	55.4	105.4	464.4	117.6
	run08	47.7	94.8	447.5	95.7	55.4	105.4	464.4	117.6
	run09	19.4	33.8	150.4	32.1	23.9	38.9	157.2	39.8
	run10	2.5	11.6	249.2	7.1	4.1	15.5	272.7	10.0
	run11	28.9	46.3	168.9	61.8	32.6	49.9	172.9	67.3
	run12	9.1	26.2	320.8	25.8	11.2	30.2	328.9	32.6
	run13	101.3	166.9	403.6	198.3	119.1	188.9	432.1	245.6
	run14	36.2	113.9	955.8	69.9	58.2	153.5	1,079	108.1
	run15	144.7	226.4	484.3	339.7	157.1	238.9	497.8	356.9
	run16	126.4	269.4	1,321	282.7	139.7	290.7	1,358	343.2
Monitoring Location at 40 Miles	run00	18.0	30.5	69.3	33.0	23.3	38.6	85.6	51.7
	run01	26.3	44.2	99.3	74.8	30.3	49.8	109.9	94.6
	run02	7.4	13.2	30.6	7.5	12.6	21.5	48.9	16.6
	run03	14.6	31.7	120.9	19.3	21.2	43.7	156.4	33.7
	run04	15.5	21.0	35.2	35.7	20.5	26.9	44.4	49.7
	run05	16.3	26.0	47.4	32.5	24.6	38.4	71.3	62.1
	run06	10.6	19.4	62.7	18.5	13.2	23.2	70.1	26.0
	run07	18.0	30.5	69.3	33.0	23.3	38.6	85.6	51.7
	run08	18.0	30.5	69.3	33.0	23.3	38.6	85.6	51.7
	run09	8.1	11.7	23.6	11.1	11.2	15.5	29.7	17.5
	run10	2.0	6.6	53.6	2.8	3.6	10.1	73.3	5.1
	run11	16.0	22.3	42.6	39.6	18.6	25.1	46.3	45.2
	run12	10.1	22.7	121.2	20.6	12.5	26.8	129.7	27.6
	run13	5.2	5.7	6.8	4.7	10.4	11.8	14.8	13.5
	run14	3.0	7.1	15.3	1.6	8.6	17.9	41.3	6.4
	run15	22.4	29.6	47.3	65.2	29.4	37.6	58.0	80.1
	run16	44.6	84.3	203.1	97.8	55.0	102.5	246.0	151.1
Monitoring Location at 55 Miles	run00	1.5	3.2	4.6	0.6	3.6	7.1	9.7	2.0
	run01	6.2	12.2	16.2	5.9	8.9	16.9	21.9	13.0
	run02	0.1	0.1	0.2	0.0	0.5	0.8	1.3	0.1
	run03	1.1	3.9	9.0	0.4	3.4	10.2	20.5	1.5
	run04	1.3	1.8	2.0	0.7	2.8	3.7	4.1	1.9
	run05	0.4	0.4	0.4	0.1	1.2	1.5	1.7	0.4
	run06	2.9	7.2	12.5	1.6	5.0	11.0	17.7	4.0
	run07	1.5	3.2	4.6	0.6	3.6	7.1	9.7	2.0
	run08	1.5	3.2	4.6	0.6	3.6	7.1	9.7	2.0
	run09	0.7	1.1	1.6	0.2	1.7	2.7	3.4	0.7
	run10	0.1	0.9	4.3	0.1	0.5	2.6	10.4	0.2
	run11	5.3	8.5	10.5	9.4	6.9	10.6	12.8	14.6
	run12	5.9	17.3	42.3	6.2	8.5	22.8	50.5	12.1
	run13	0.2	0.1	0.1	0.0	0.5	0.4	0.3	0.1
	run14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run15	1.8	2.1	2.1	1.4	3.5	4.0	4.2	3.4
	run16	3.9	9.1	13.6	1.8	8.8	19.7	27.7	5.7

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Table 14-32. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #3b in Potential Production Area LL-3 in cross-section #3 at six monitoring locations.

		30 Years				50 Years			
	Layer	7	8*	9	10	7	8*	9	10
Monitoring Location at 20 Miles	run00		1.2	1.2	0.1		3.0	3.0	0.5
	run01		2.5	4.6	1.8		4.9	6.7	4.3
	run02		0.2	0.0	0.0		1.0	0.3	0.0
	run03		2.5	1.3	0.0		6.1	3.8	0.2
	run04		0.5	0.6	0.1		1.5	1.5	0.6
	run05		0.0	0.1	0.0		0.3	0.4	0.0
	run06		4.3	3.0	0.3		7.3	5.0	0.9
	run07		1.2	1.2	0.1		3.0	3.0	0.5
	run08		1.2	1.2	0.1		3.0	3.0	0.5
	run09		0.9	0.5	0.0		2.3	1.5	0.2
	run10		2.8	0.3	0.0		6.9	1.1	0.0
	run11		3.4	4.4	3.7		5.8	6.2	5.9
	run12		9.2	6.3	0.7		15.0	9.0	1.5
	run13		0.0	0.0	0.0		0.0	0.0	0.0
	run14		0.0	0.0	0.0		0.1	0.0	0.0
	run15		0.3	0.4	0.3		0.7	1.1	1.0
	run16		1.2	2.7	0.2		3.0	6.2	1.1
Monitoring Location at 25 Miles	run00	0.1	8.3	5.3	0.6	0.2	11.9	9.1	2.1
	run01	0.2	13.0	11.8	5.5	0.4	16.3	15.1	10.3
	run02	0.0	2.8	0.7	0.0	0.1	5.6	2.2	0.1
	run03	0.1	17.3	5.9	0.2	0.2	24.2	11.7	0.8
	run04	0.1	4.0	2.9	1.0	0.3	6.3	5.0	3.0
	run05	0.0	2.8	1.2	0.1	0.1	5.6	3.3	0.5
	run06	0.3	11.1	6.8	0.9	0.9	14.2	9.6	2.0
	run07	0.1	8.3	5.3	0.6	0.2	11.9	9.1	2.1
	run08	0.1	8.3	5.3	0.6	0.2	11.9	9.1	2.1
	run09	0.0	4.5	2.3	0.2	0.2	7.0	4.3	0.8
	run10	0.1	13.2	1.4	0.0	0.2	19.8	3.2	0.1
	run11	0.2	10.4	8.7	6.8	0.4	12.9	10.9	9.6
	run12	0.3	28.0	11.2	1.2	0.7	33.3	14.5	2.3
	run13	0.0	0.1	0.0	0.0	0.0	0.6	0.2	0.0
	run14	0.0	0.6	0.0	0.0	0.0	2.4	0.3	0.0
	run15	0.0	3.9	2.7	2.2	0.1	6.1	4.6	5.2
	run16	0.1	15.6	12.5	1.7	0.3	20.4	19.9	5.3
Monitoring Location at 30 Miles	run00	13.7	22.0	19.7	5.3	19.0	27.3	26.5	10.3
	run01	19.5	29.5	31.1	17.6	23.9	33.5	35.9	25.1
	run02	5.0	11.2	6.6	0.6	9.9	16.8	12.5	1.9
	run03	18.6	45.0	21.3	1.7	26.2	54.6	31.6	3.9
	run04	10.0	11.1	12.3	8.5	14.9	15.1	16.9	14.5
	run05	8.8	12.4	12.1	3.4	15.9	19.1	20.4	9.6
	run06	12.3	22.0	14.8	2.8	15.5	25.3	18.4	4.6
	run07	13.7	22.0	19.7	5.3	19.0	27.3	26.5	10.3
	run08	13.7	22.0	19.7	5.3	19.0	27.3	26.5	10.3
	run09	6.6	9.3	7.7	1.9	10.2	12.4	11.0	3.9
	run10	6.3	25.9	4.6	0.1	11.1	33.5	7.6	0.3
	run11	13.1	16.6	17.0	13.1	16.5	19.3	19.7	16.4
	run12	20.4	44.3	18.9	2.2	24.2	49.2	22.8	3.6
	run13	1.7	1.8	1.5	0.2	5.1	4.4	4.2	1.2
	run14	1.4	8.0	2.1	0.0	4.9	17.0	6.9	0.2
	run15	13.1	12.6	14.8	16.3	19.4	17.7	20.5	24.2
	run16	30.8	53.9	51.3	14.5	38.4	62.8	65.6	27.4

		30 Years				50 Years			
	Layer	7	8*	9	10	7	8*	9	10
Monitoring Location at 33 Miles	run00	25.5	40.7	31.0	11.3	31.6	47.2	38.9	18.2
	run01	31.7	49.8	44.2	26.8	36.8	54.4	49.6	35.1
	run02	14.9	26.1	13.9	2.4	21.9	34.1	22.1	5.6
	run03	38.4	79.4	31.8	3.6	47.6	90.8	43.5	6.7
	run04	17.9	21.9	21.1	18.8	23.5	27.3	26.9	26.7
	run05	22.1	31.8	27.6	15.7	30.9	41.9	39.6	29.7
	run06	20.7	34.8	19.3	4.1	24.1	38.2	23.1	6.3
	run07	25.5	40.7	31.0	11.3	31.6	47.2	38.9	18.2
	run08	25.5	40.7	31.0	11.3	31.6	47.2	38.9	18.2
	run09	12.2	16.3	11.8	4.1	16.1	20.0	15.6	6.9
	run10	13.8	42.1	6.6	0.2	20.3	50.5	10.0	0.5
	run11	18.8	24.5	22.2	17.0	22.5	27.4	25.1	20.4
	run12	31.3	63.1	22.4	2.8	35.0	67.7	26.5	4.3
	run13	8.9	8.6	6.6	3.7	15.3	15.0	12.7	9.9
	run14	11.8	32.4	8.5	0.5	23.3	50.5	19.6	2.0
	run15	22.8	26.6	28.3	38.8	30.4	34.0	35.9	48.4
	run16	57.4	104.4	81.9	30.8	66.3	115.8	98.8	48.4
Monitoring Location at 40 Miles*	run00	237.2	499.4	120.5	21.9	244.4	508.5	132.2	30.5
	run01	245.6	512.2	141.0	41.0	250.6	517.7	148.3	50.7
	run02	218.7	472.7	91.6	9.0	230.9	488.8	106.2	14.1
	run03	284.3	755.1	83.0	5.6	298.4	773.9	98.2	9.1
	run04	178.9	298.7	130.3	49.5	185.0	305.5	138.8	60.3
	run05	403.2	785.5	306.0	77.4	414.5	801.3	330.9	103.8
	run06	112.5	266.3	39.1	5.1	116.3	270.6	43.8	7.5
	run07	237.2	499.4	120.5	21.9	244.4	508.5	132.2	30.5
	run08	237.2	499.4	120.5	21.9	244.4	508.5	132.2	30.5
	run09	97.8	177.8	43.1	7.8	102.5	182.8	48.2	11.1
	run10	86.0	322.4	13.7	0.3	96.9	335.3	17.6	0.6
	run11	106.3	188.3	57.4	23.0	109.5	191.4	60.4	26.7
	run12	114.5	355.8	32.8	3.1	118.1	360.5	37.5	4.7
	run13	248.0	395.1	227.6	75.8	259.3	409.4	248.2	101.7
	run14	497.6	1.2E3	174.3	8.0	543.5	1.3E3	214.9	14.5
	run15	272.5	430.8	289.3	167.9	280.0	439.1	300.1	182.1
	run16	594.9	1.3E3	327.9	60.4	603.0	1.4E3	354.0	82.7
Monitoring Location at 55 Miles	run00	9.7	16.0	14.8	2.3	14.7	23.7	23.0	5.1
	run01	17.9	30.2	30.8	10.4	21.8	35.8	37.2	17.7
	run02	2.9	4.0	2.8	0.2	6.1	8.9	7.2	0.7
	run03	12.2	32.1	15.5	0.8	20.8	47.3	27.2	2.0
	run04	8.1	9.8	10.1	3.9	11.6	14.2	14.7	7.7
	run05	6.0	6.7	6.5	1.1	10.5	13.4	13.8	3.7
	run06	11.8	21.9	14.5	1.7	15.3	26.6	19.2	3.3
	run07	9.7	16.0	14.8	2.3	14.7	23.7	23.0	5.1
	run08	9.7	16.0	14.8	2.3	14.7	23.7	23.0	5.1
	run09	4.8	6.3	5.5	0.8	7.5	9.7	9.0	1.9
	run10	3.9	18.8	3.3	0.1	7.9	29.0	6.4	0.2
	run11	12.3	17.1	17.3	11.1	14.4	19.5	19.9	15.5
	run12	25.2	55.4	22.4	2.0	29.1	60.9	27.7	3.8
	run13	3.5	2.4	2.0	0.4	5.5	4.4	3.9	1.2
	run14	1.0	0.6	0.3	0.0	2.5	2.9	1.6	0.0
	run15	10.2	11.7	12.0	9.0	13.7	15.8	16.4	14.3
	run16	21.3	42.6	40.5	6.3	31.3	60.9	61.0	13.7

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Table 14-33. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #3c in Potential Production Area LG-5 in cross-section #3 at six monitoring locations.

Monitoring Location		30 Years				50 Years			
	Layer	5*	6	7	8	5*	6	7	8
Monitoring Location at 20 Miles	run00				0.0				0.0
	run01				0.0				0.1
	run02				0.0				0.0
	run03				0.0				0.0
	run04				0.0				0.0
	run05				0.0				0.0
	run06				0.0				0.0
	run07				0.0				0.0
	run08				0.0				0.0
	run09				0.0				0.0
	run10				0.0				0.0
	run11				0.0				0.1
	run12				0.0				0.0
	run13				0.0				0.0
	run14				0.0				0.0
	run15				0.0				0.0
	run16				0.0				0.0
Monitoring Location at 25 Miles	run00			0.0	0.1			0.0	0.3
	run01			0.0	0.2			0.0	0.4
	run02			0.0	0.0			0.0	0.1
	run03			0.0	0.0			0.0	0.2
	run04			0.0	0.1			0.0	0.2
	run05			0.0	0.1			0.0	0.2
	run06			0.0	0.1			0.0	0.3
	run07			0.0	0.1			0.0	0.3
	run08			0.0	0.1			0.0	0.3
	run09			0.0	0.1			0.0	0.2
	run10			0.0	0.0			0.0	0.0
	run11			0.0	0.3			0.0	0.5
	run12			0.0	0.1			0.0	0.2
	run13			0.0	0.0			0.0	0.1
	run14			0.0	0.0			0.0	0.0
	run15			0.0	0.1			0.0	0.2
	run16			0.0	0.1			0.0	0.3
Monitoring Location at 30 Miles	run00		0.4	0.3	0.3		1.1	0.8	0.7
	run01		0.7	0.7	0.6		1.6	1.3	1.1
	run02		0.1	0.0	0.1		0.5	0.2	0.3
	run03		0.5	0.2	0.2		1.5	0.6	0.4
	run04		0.2	0.2	0.3		0.6	0.6	0.6
	run05		0.0	0.1	0.2		0.1	0.3	0.5
	run06		1.5	0.6	0.4		2.8	1.3	0.8
	run07		0.4	0.3	0.3		1.1	0.8	0.7
	run08		0.4	0.3	0.3		1.1	0.8	0.7
	run09		0.3	0.2	0.2		0.9	0.7	0.6
	run10		0.2	0.1	0.0		0.9	0.2	0.1
	run11		0.8	0.9	0.7		1.7	1.6	1.2
	run12		1.0	0.7	0.3		2.5	1.3	0.5
	run13		0.0	0.0	0.0		0.1	0.1	0.2
	run14		0.0	0.0	0.0		0.1	0.0	0.1
	run15		0.1	0.2	0.3		0.3	0.5	0.5
	run16		0.4	0.3	0.4		1.2	0.8	0.8
Monitoring Location at 33 Miles	run00		1.2	0.8	0.6		2.3	1.6	1.3
	run01		1.8	1.3	1.1		3.0	2.2	1.8
	run02		0.5	0.2	0.2		1.2	0.7	0.5
	run03		1.6	0.6	0.3		3.3	1.5	0.8
	run04		0.7	0.6	0.6		1.3	1.1	1.1
	run05		0.2	0.3	0.4		0.7	0.7	0.9
	run06		2.2	1.2	0.7		3.5	2.1	1.3
	run07		1.2	0.8	0.6		2.3	1.6	1.3
	run08		1.2	0.8	0.6		2.3	1.6	1.3
	run09		0.9	0.6	0.5		1.8	1.3	1.1
	run10		0.9	0.2	0.1		1.9	0.5	0.2
	run11		1.9	1.5	1.3		2.9	2.3	2.0
	run12		2.7	1.3	0.5		4.4	2.1	0.9
	run13		0.0	0.1	0.1		0.2	0.2	0.3
	run14		0.1	0.0	0.0		0.3	0.1	0.2
	run15		0.3	0.4	0.5		0.7	0.8	0.9
	run16		1.3	0.8	0.7		2.5	1.7	1.4
Monitoring Location at 40 Miles	run00	4.4	7.0	5.1	3.8	6.6	9.0	7.0	5.6
	run01	5.6	8.7	6.8	5.4	7.6	10.2	8.3	6.9
	run02	2.4	3.8	2.3	1.6	4.4	6.0	4.1	3.1
	run03	7.1	9.4	4.6	2.0	10.4	12.5	6.8	3.4
	run04	2.9	4.0	3.6	3.4	4.5	5.4	5.0	4.8
	run05	2.2	5.2	4.0	3.3	4.4	7.6	6.3	5.6
	run06	5.1	5.5	3.8	2.8	6.7	6.9	5.1	3.9
	run07	4.4	7.0	5.1	3.8	6.6	9.0	7.0	5.6
	run08	4.4	7.0	5.1	3.8	6.6	9.0	7.0	5.6
	run09	3.1	3.8	3.1	2.7	4.6	5.1	4.4	3.9
	run10	7.6	3.6	1.1	0.4	10.5	5.5	2.0	0.9
	run11	4.8	5.8	5.2	4.7	6.1	6.8	6.2	5.7
	run12	11.1	8.1	4.1	2.0	13.8	9.9	5.4	2.8
	run13	0.5	1.1	1.0	1.1	1.4	2.3	2.2	2.4
	run14	1.1	2.0	0.7	0.4	2.5	4.8	2.3	1.3
	run15	2.1	3.6	3.5	3.7	3.4	4.8	4.8	5.1
	run16	5.5	14.0	8.4	4.6	8.5	16.8	10.9	6.8
Monitoring Location at 55 Miles*	run00	94.2	49.6	29.9	12.7	96.7	52.5	33.1	15.8
	run01	97.1	53.1	33.6	15.5	98.4	54.5	35.5	17.9
	run02	86.7	41.0	22.2	8.3	91.2	46.0	26.8	11.4
	run03	137.6	46.6	19.8	4.6	141.7	51.7	24.1	6.7
	run04	63.7	44.4	33.1	18.5	65.8	46.5	35.4	21.1
	run05	171.4	112.9	67.0	26.2	177.6	119.5	73.5	31.8
	run06	48.8	19.0	11.0	5.0	49.9	20.3	12.5	6.4
	run07	94.2	49.6	29.9	12.7	96.7	52.5	33.1	15.8
	run08	94.2	49.6	29.9	12.7	96.7	52.5	33.1	15.8
	run09	33.0	18.0	12.8	7.2	34.5	19.5	14.6	8.9
	run10	64.8	11.2	2.9	0.6	67.8	13.8	4.3	1.1
	run11	35.4	20.7	15.9	9.9	36.3	21.6	16.9	11.2
	run12	71.3	18.3	8.1	2.3	72.8	20.0	9.5	3.2
	run13	102.2	81.7	56.7	26.8	108.1	87.9	62.7	32.0
	run14	227.7	87.4	33.0	6.1	243.6	103.9	44.2	9.6
	run15	112.5	92.8	67.4	35.7	115.7	95.9	70.7	39.3
	run16	277.5	142.7	71.2	17.8	282.7	148.6	76.9	22.3

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

14.9 Simulated Drawdowns from Well Fields in Modeled Cross-Section #4

This section describes the construction and application of a groundwater model to simulated the drawdowns that would be created by pumping at three proposed well fields along cross-section #4.

14.9.1 Construction of Groundwater Models

The three-dimensional groundwater model constructed to simulate pumping from well fields located along modeled cross-section #4 shown in Figure 14-5. The width of the model is along the geologic strike of the Gulf Coast Aquifer is 100 miles. The length of the model along dip is 106 miles. The applied recharge rate derived from Scanlon and others (2012) varies between 0.04 and 0.27 inches per year.

Table 14-34 provides the average values for horizontal hydraulic conductivity (Kx), vertical hydraulic conductivity (Kz), and specific storage (Ss) for 25-mile reaches for both models. The model aquifer properties were extracted from the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) and assigned to model layers 1 to 9 using the GAM-based approach to hydraulic properties. The model aquifer hydraulic properties were extracted from the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) and assigned to model layers 10 to 12 using the adjusted-GAM based approach to aquifer hydraulic properties The values for vertical hydraulic conductivity (Kz) were determined by imposing a ratio of Kx/Kz of 100 for model layers that represent the Chicot and Evangeline aquifers; a ratio of Kx/Kz of 50 for the model layer that represents the Burkeville confining unit (middle Lagarto); and a ratio of Kx/Kz of 1,000 for the model layers that represent the lower Lagarto, Oakville, and Catahoula formations. For model layers below the Burkeville confining unit, the vertical hydraulic conductivity was specified as Kz and was adjusted from values in the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) as a function of the sand fraction in the model grid cell. These adjustments allow the Kx/Kz ratio to vary between 1 and 10.

Figure 14-51 illustrates the values of horizontal hydraulic conductivity obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-52 illustrates the values of horizontal hydraulic conductivity that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-52 illustrates the horizontal hydraulic conductivity values summarized in Table 14-34.

Figure 14-53 illustrates the values of vertical hydraulic conductivity obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-54 illustrates the values of vertical hydraulic conductivity that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-54 illustrates the vertical hydraulic conductivity values summarized in Table 14-34.

Figure 14-55 illustrates the values of specific storage obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-56 illustrates the values of specific storage that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-56 illustrates the specific storage values summarized in Table 14-34.

14.9.2 Simulated Drawdown Produced by Pumping from Modeled Cross-Section #4

Groundwater pumping at the rate of 3,000 acre-feet per year, 10,000 acre-feet per year and 20,000 acre-feet per year was simulated at three well fields along cross-section #4 shown in Figure 14-5. The up dip Well Field #4a is located 27 miles down dip from the Catahoula outcrop in the lower Lagarto, the middle Well Field #4b is located 42 miles down dip from the Catahoula outcrop in the upper Lagarto, and the down dip Well Field #4c is located 52 miles down dip from the Catahoula outcrop in the upper Goliad. Figures 14-57 through 14-59 show the simulated drawdown at 50 years for the three pumping rates at Well Field #4a, Well Field #4b, and Well Field #4c, respectively.

Among the notable results that can be observed in the plotted drawdown in Figures 14-57 through 14-59 are the following:

- Appreciable drawdowns extend laterally some distance from Well Field #4b because of higher hydraulic conductivity near Well Field #4b.
- Along cross-section #4, the vertical and horizontal hydraulic conductivities of the Burkeville Confining Unit (layer 9) is similar to the surrounding formations and does not provide an effective hydraulic barrier to prevent appreciable drawdowns from migrating from Well Fields #4a, #4b, or #4c into the formations overlying the Burkeville Confining Unit. Consequently, the greatest drawdowns occur near the well and propagate vertically into all, or nearly all, of the model layers.
- Appreciable drawdowns are confined to a small lateral distance, approximately 20 feet, from Well Field #4c because it is located in an area of higher specific storage.

Drawdown values were recorded for all three model simulations at several monitoring locations at 30 and 50 years. The monitoring locations are located at down dip distances of 5, 10, 15, 20, 25, 30, 38, and 55 miles.

Table 14-34. Average values for Kx (feet per day), Kz (feet per day), and Ss(1/feet) by model layer for 25-mile reaches along dip for modeled cross-section #4.

Reach (miles)	Property	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6
0-25	Kx	nan	nan	nan	nan	nan	nan
	Kz	nan	nan	nan	nan	nan	nan
	Ss	nan	nan	nan	nan	nan	nan
25-50	Kx	5.8E+01	6.3E+01	6.2E+01	6.3E-01	6.4E-01	6.9E-01
	Kz	1.5E+00	1.8E+00	1.7E+00	3.0E-03	3.5E-03	7.1E-03
	Ss	1.5E-03	4.5E-03	9.1E-03	4.5E-03	3.0E-03	4.0E-03
50-75	Kx	3.2E+01	3.2E+01	3.2E+01	5.5E-01	5.5E-01	5.5E-01
	Kz	9.1E-01	9.1E-01	9.1E-01	1.0E-04	1.0E-04	1.0E-04
	Ss	9.9E-04	3.3E-02	3.3E-02	1.1E-03	1.1E-03	1.1E-03
75-100	Kx	2.2E+00	2.2E+00	2.2E+00	5.2E-01	5.2E-01	5.2E-01
	Kz	3.0E-01	3.0E-01	3.0E-01	6.4E-02	6.4E-02	6.4E-02
	Ss	3.8E-04	1.2E-02	1.2E-02	3.6E-03	3.6E-03	3.6E-03
100+	Kx	2.1E+00	2.1E+00	2.1E+00	5.0E-01	5.0E-01	5.0E-01
	Kz	3.9E-01	3.9E-01	3.9E-01	1.0E-01	1.0E-01	1.0E-01
	Ss	2.5E-04	2.2E-03	2.2E-03	5.5E-03	5.5E-03	5.5E-03

Reach (miles)	Property	Layer 7	Layer 8	Layer 9	Layer 10	Layer 11	Layer 12
0-25	Kx	nan	nan	3.5E+00	3.9E-01	3.8E-01	3.6E-01
	Kz	nan	nan	9.2E+00	3.9E-01	2.3E-01	1.2E-01
	Ss	nan	nan	3.1E-04	1.8E-04	1.5E-04	1.1E-04
25-50	Kx	9.5E-01	1.0E+00	3.0E+00	3.2E-01	2.9E-01	2.5E-01
	Kz	2.6E-02	3.0E-02	2.9E+00	2.4E-01	8.7E-02	9.4E-02
	Ss	5.5E-03	5.8E-03	2.7E-05	6.0E-06	5.5E-06	4.1E-06
50-75	Kx	5.5E-01	5.5E-01	2.4E+00	2.4E-01	2.1E-01	1.9E-01
	Kz	1.0E-04	1.0E-04	2.4E+00	8.4E-02	1.6E-01	1.7E-01
	Ss	1.1E-03	1.1E-03	3.3E-06	3.8E-06	2.7E-06	2.6E-06
75-100	Kx	5.2E-01	5.2E-01	1.8E+00	1.8E-01	1.5E-01	nan
	Kz	6.4E-02	6.4E-02	9.3E-01	1.5E-01	1.4E-01	nan
	Ss	3.6E-03	3.6E-03	3.0E-06	2.2E-06	1.7E-06	nan
100+	Kx	5.0E-01	5.0E-01	1.4E+00	1.4E-01	1.1E-01	nan
	Kz	1.0E-01	1.0E-01	1.4E+00	2.5E-01	4.6E-02	nan
	Ss	5.5E-03	5.5E-03	2.0E-06	1.4E-06	1.9E-06	nan

Note: Kx=horizontal hydraulic conductivity; Kz=vertical hydraulic conductivity; Ss=specific storage; and nan= model layer is not present for this reach

Tables 14-35 through 14-37 provide drawdown at 30 and 50 years at the monitoring locations for pumping at 3,000, 10,000, and 20,000 acre-feet per year.

Among the notable results that can be gleaned from a review of Tables 14-35 through 14-37 and Figures 14-57 through 14-59 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown.
- After 30 years of pumping 10,000 acre-feet per year from Well Field #4a, the groundwater model predicts about 15 feet of drawdown in the Jasper Aquifer at the 30 mile monitoring point location and about 40 feet in the Jasper Aquifer at the 25 mile monitoring point location.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 60 feet of drawdown at the Well Field #4a.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 70 feet of drawdown at the Well Field #4b.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 230 feet of drawdown at the Well Field #4c.
- After 30 years of pumping the Jasper Aquifer for 10,000 acre-feet per year at Well Field #4a, the groundwater model predicts less than 0.1 foot of drawdown across the entire Chicot Aquifer and less than 10 feet across the entire Evangeline Aquifer.
- After 30 years of pumping the Evangeline Aquifer for 10,000 acre-feet per year at either Well Field #4b or Well Field #4c the groundwater model predicts less than 0.1 foot of drawdown across the entire Chicot Aquifer.

Table 14-35. Simulated drawdown at monitoring locations after pumping Well Field #4a in Potential Production Area LL-3 in cross-section #4 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Upper Goliad	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula
		Model Layer											
Location (miles)	Pumping Rate (AFY)	1	2	3	4	5	6	7	8	9	10*	11	12
		30 Years											
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.9
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5.1	5.7	3.3
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17.3	19.5	11.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	31.3	35.2	20.5
25	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11.9	11.5	11.5	12.2
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	40.5	39.2	38.8	41.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	71.1	69.2	67.6	71.9
27*	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	22.0	24.4	22.7	21.6
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	58.6	63.1	61.2	60.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	95.5	101.8	99.8	98.3
30	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.5	1.5	3.3	4.1	4.1	6.7
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.9	5.2	11.4	14.4	14.6	24.6
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	16.0	9.3	21.7	26.9	27.3	43.6
42	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1	0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.2	0.2	0.2	0.2
52	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
		50 Years											
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	1.5
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	25.8	28.1	18.0
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	49.3	47.9	47.5	49.7
27*	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	66.0	70.6	68.8	67.6
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	13.9	9.8	16.5	19.6	19.8	30.4
42	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.2	0.3	0.3	0.3	0.3
52	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.
Note: AFY=acre-feet per year

Table 14-36. Simulated drawdown at monitoring locations after pumping Well Field #4b in Potential Production Area UL-6 in cross-section #4 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Upper Goliad	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula
		Model Layer											
Location (miles)	**Pumping Rate (AFY)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8***	**9**	**10**	**11**	**12**
		30 Years											
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
25	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1
27	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1
30	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1	0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.2	0.3	0.3	0.3	0.2
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.4	0.6	0.6	0.6	0.4
42*	3,000	<0.1	<0.1	<0.1	3.7	4.5	8.2	14.6	32.1	15.0	14.6	14.4	13.9
	10,000	<0.1	<0.1	<0.1	12.8	15.5	24.3	39.6	69.2	42.9	41.9	41.4	40.6
	20,000	<0.1	<0.1	<0.1	20.7	24.9	38.0	61.1	103.7	73.7	72.8	72.5	71.3
52	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	2.5	2.5	2.6	2.5
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	8.1	8.2	8.3	8.2
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	15.9	16.1	16.4	16.2
		50 Years											
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1
27	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.2	0.2	0.2
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.5	0.6	0.6	0.6	0.4
42*	10,000	<0.1	<0.1	<0.1	18.2	20.7	29.5	44.7	73.3	46.2	45.2	44.7	43.9
52	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	10.2	10.3	10.5	10.4

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.
Note: AFY=acre-feet per year

Table 14-37. Simulated drawdown at monitoring locations after pumping Well Field #4c in Potential Production Area UG-6 in cross-section #4 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Upper Goliad	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula
		Model Layer											
Location (miles)	Pumping Rate (AFY)	1	2	3	4	5	6*	7	8	9	10	11	12
30 Years													
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
25	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
27	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
30	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
42	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
52*	3,000	<0.1	<0.1	<0.1	0.3	12.7	129.6	3.4	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	0.4	20.2	227.0	6.3	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	0.5	25.2	288.1	8.3	0.1	<0.1	<0.1	<0.1	<0.1
50 Years													
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
27	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
42	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
52*	10,000	<0.1	<0.1	<0.1	0.9	33.7	274.5	10.4	0.1	<0.1	<0.1	<0.1	<0.1

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.
Note: AFY=acre-feet per year

14.9.3 Sensitivity Analysis on the Simulated Drawdown for Potential Production Area #4

Table 14-2 describes the changes in the model input parameter associated with set of sixteen sensitivity runs performed for the groundwater model simulation corresponding to cross-section #4. In this section, Model Run00 refers to the baseline run of 10,000 acre-feet per year for which simulated drawdowns are shown in Figures 14-57 to 14-59. Tables 4-38 through 14-40 provide the sensitivity results for drawdown at the six monitoring locations after 30 and 50 years at Well Fields #4a, #4b, and #4c, respectively.

Among the notable results that can be gleaned from a review of Tables 14-38 through 14-40 are:

- After 30 years of pumping Well Field #4a at 10,000 acre-feet per year, the drawdown is between 35 and 102 feet in the lower Lagarto (layer 10) at the monitoring point located 27 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #4a at 10,000 acre-feet per year, the drawdown is between 23 and 57 feet in the lower Lagarto (layer 10) at the monitoring point located 25 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #4a at 10,000 acre-feet per year, the drawdown is between 10 and 19 feet in the lower Lagarto (layer 10) at the monitoring point located 20 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #4b at 10,000 acre-feet per year, the drawdown is between 26 and 174 feet in the upper Lagarto (layer 8) at the monitoring point located 42 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #4b at 10,000 acre-feet per year, the drawdown is less than 2 feet for all monitoring point located 12 or more miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #4c at 10,000 acre-feet per year, the drawdown is between 76 and 681 feet in the upper Goliad (layer 6) at the monitoring point located 52 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #4c at 10,000 acre-feet per year, the drawdown is less than 0.1 feet at the monitoring points located 10 miles or more up dip of the well field.

Table 14-38. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #4a in Potential Production Area LL-3 in cross-section #4 at six monitoring locations.

		30 Years				50 Years			
	Layer	9	10*	11	12	9	10*	11	12
Monitoring Location at 20 Miles	run00		17.3	19.5	11.1		25.8	28.1	18.0
	run01		19.0	21.2	13.3		27.7	30.0	20.3
	run02		13.8	15.6	6.7		21.5	23.6	12.6
	run03		15.8	20.6	8.0		25.3	30.5	14.2
	run04		16.2	17.2	13.4		23.3	24.3	20.1
	run05		15.3	17.0	11.2		26.6	28.7	20.7
	run06		14.2	16.1	8.9		19.1	21.1	13.1
	run07		17.3	19.5	11.1		25.8	28.1	18.0
	run08		17.3	19.5	11.1		25.8	28.1	18.0
	run09		13.5	14.4	8.7		18.4	19.3	13.1
	run10		12.4	15.6	4.7		19.0	22.4	8.7
	run11		16.8	17.8	12.4		21.9	22.9	17.1
	run12		16.8	20.6	9.8		23.9	27.6	14.4
	run13		9.6	10.3	7.8		16.9	17.9	14.9
	run14		9.5	12.6	2.7		18.1	22.2	7.1
	run15		14.8	15.8	14.2		23.6	24.7	22.7
	run16		15.1	19.6	11.0		26.3	31.5	19.4
Monitoring Location at 25 Miles	run00	40.5	39.2	38.8	41.1	49.3	47.9	47.5	49.7
	run01	42.1	40.9	40.6	42.8	51.0	49.6	49.2	51.4
	run02	36.4	35.1	34.7	36.8	45.1	43.7	43.2	45.4
	run03	47.9	45.9	44.5	50.0	58.7	56.3	54.7	60.1
	run04	34.1	33.7	34.3	34.7	41.2	40.7	41.3	41.7
	run05	58.0	57.3	59.5	60.6	73.0	72.0	73.9	75.0
	run06	26.6	25.6	24.9	26.9	31.3	30.3	29.7	31.5
	run07	40.5	39.2	38.8	41.1	49.3	47.9	47.5	49.7
	run08	40.5	39.2	38.8	41.1	49.3	47.9	47.5	49.7
	run09	23.5	23.1	23.1	24.0	28.2	27.8	27.8	28.7
	run10	33.2	31.9	30.0	34.0	40.1	38.6	36.6	40.5
	run11	26.5	26.1	26.2	27.1	31.3	30.9	30.9	31.8
	run12	37.7	36.5	34.7	38.9	44.5	43.1	41.3	45.1
	run13	40.0	39.6	41.3	40.3	49.6	49.2	50.8	49.8
	run14	50.9	48.3	47.4	51.3	65.3	62.1	60.8	65.2
	run15	46.4	46.1	47.8	46.9	56.2	55.8	57.4	56.4
	run16	60.6	58.1	57.6	62.6	75.2	72.1	71.2	76.2
Monitoring Location at 27 Miles*	run00	58.6	63.1	61.2	60.1	66.0	70.6	68.8	67.6
	run01	59.8	64.3	62.5	61.4	67.2	71.9	70.0	68.9
	run02	55.5	59.9	58.0	56.9	63.0	67.5	65.6	64.5
	run03	66.8	78.8	75.3	73.2	75.5	87.6	84.1	82.1
	run04	49.1	50.8	49.8	49.2	55.2	57.1	56.0	55.4
	run05	96.0	102.4	99.8	97.9	108.1	114.8	112.2	110.1
	run06	33.9	37.4	36.1	35.3	38.2	41.7	40.4	39.6
	run07	58.6	63.1	61.2	60.1	66.0	70.6	68.8	67.6
	run08	58.6	63.1	61.2	60.1	66.0	70.6	68.8	67.6
	run09	33.3	34.8	33.7	33.1	37.6	39.0	38.0	37.3
	run10	44.2	53.4	49.1	46.0	49.7	59.2	54.8	51.7
	run11	35.6	37.1	36.1	35.4	39.9	41.4	40.4	39.7
	run12	47.5	57.0	52.8	49.8	52.9	62.6	58.3	55.3
	run13	61.7	63.8	63.0	62.6	70.2	72.4	71.6	71.1
	run14	81.1	93.8	91.0	89.8	93.2	106.3	103.5	102.2
	run15	66.6	68.8	68.0	67.6	75.0	77.3	76.5	76.0
	run16	88.5	101.8	99.2	98.1	100.3	113.8	111.2	110.0

		30 Years				50 Years			
	Layer	9	10*	11	12	9	10*	11	12
Monitoring Location at 30 Miles	run00	11.4	14.4	14.6	24.6	16.5	19.6	19.8	30.4
	run01	12.0	15.0	15.3	25.4	17.2	20.3	20.5	31.2
	run02	10.0	12.6	12.8	22.5	15.0	17.8	18.0	28.3
	run03	11.2	16.5	17.2	34.3	16.7	22.2	22.9	40.9
	run04	11.4	13.0	13.1	19.3	15.9	17.6	17.7	24.2
	run05	12.3	14.8	15.0	25.4	18.9	21.7	21.8	32.9
	run06	9.6	12.1	12.4	19.8	13.1	15.6	15.9	23.6
	run07	11.4	14.4	14.6	24.6	16.5	19.6	19.8	30.4
	run08	11.4	14.4	14.6	24.6	16.5	19.6	19.8	30.4
	run09	9.0	10.5	10.6	15.7	12.2	13.8	13.9	19.3
	run10	8.9	13.4	14.5	26.2	12.7	17.4	18.5	30.9
	run11	10.2	11.9	12.0	17.3	13.5	15.3	15.4	21.0
	run12	10.4	15.6	16.8	29.4	14.4	19.5	20.8	33.8
	run13	10.6	11.7	11.8	17.6	16.1	17.4	17.5	23.7
	run14	9.2	12.4	12.6	29.1	15.6	19.4	19.7	37.5
	run15	13.0	14.3	14.4	20.3	18.7	20.1	20.2	26.5
	run16	12.1	17.0	17.4	35.1	18.9	23.8	24.2	42.9
Monitoring Location at 42 Miles	run00	0.1	0.1	0.1	0.1	0.3	0.3	0.3	0.3
	run01	0.1	0.1	0.1	0.1	0.3	0.3	0.3	0.3
	run02	0.1	0.1	0.0	0.0	0.2	0.2	0.2	0.2
	run03	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
	run04	0.2	0.2	0.2	0.2	0.4	0.4	0.4	0.4
	run05	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
	run06	0.3	0.4	0.4	0.3	0.7	0.7	0.7	0.7
	run07	0.1	0.1	0.1	0.1	0.3	0.3	0.3	0.3
	run08	0.1	0.1	0.1	0.1	0.3	0.3	0.3	0.3
	run09	0.3	0.3	0.3	0.3	0.7	0.7	0.7	0.7
	run10	0.2	0.2	0.2	0.2	0.4	0.4	0.4	0.4
	run11	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0
	run12	0.4	0.4	0.4	0.5	0.7	0.8	0.8	0.8
	run13	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
	run14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run15	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
	run16	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
Monitoring Location at 52 Miles	run00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run01	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
	run02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run04	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
	run05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run06	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
	run07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run09	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
	run10	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
	run11	0.2	0.2	0.2	0.2	0.4	0.4	0.4	0.4
	run12	0.1	0.1	0.2	0.1	0.3	0.3	0.3	0.3
	run13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Table 14-39. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #4b in Potential Production Area UL-6 in cross-section #4 at six monitoring locations.

		30 Years				50 Years						30 Years				50 Years			
	Layer	8*	9	10	11	8*	9	10	11		Layer	8*	9	10	11	8*	9	10	11
Monitoring Location at 20 Miles	run00			0.0	0.0			0.0	0.0	Monitoring Location at 30 Miles	run00	0.2	0.3	0.3	0.3	0.5	0.6	0.6	0.6
	run01			0.0	0.0			0.1	0.2		run01	0.8	0.8	0.8	0.8	1.4	1.4	1.3	1.3
	run02			0.0	0.0			0.0	0.0		run02	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2
	run03			0.0	0.0			0.1	0.1		run03	0.2	0.8	0.7	0.7	0.5	1.3	1.1	1.1
	run04			0.0	0.0			0.0	0.0		run04	0.1	0.1	0.1	0.1	0.3	0.2	0.3	0.3
	run05			0.0	0.0			0.0	0.0		run05	0.1	0.3	0.3	0.3	0.3	0.5	0.5	0.5
	run06			0.0	0.0			0.1	0.1		run06	0.3	0.4	0.4	0.4	0.6	0.7	0.7	0.7
	run07			0.0	0.0			0.0	0.0		run07	0.2	0.3	0.3	0.3	0.5	0.6	0.6	0.6
	run08			0.0	0.0			0.0	0.0		run08	0.2	0.3	0.3	0.3	0.5	0.6	0.6	0.6
	run09			0.0	0.0			0.0	0.0		run09	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	run10			0.0	0.0			0.0	0.0		run10	0.0	0.4	0.4	0.4	0.1	0.7	0.6	0.6
	run11			0.0	0.0			0.1	0.1		run11	0.6	0.5	0.5	0.5	0.9	0.8	0.8	0.8
	run12			0.1	0.1			0.3	0.3		run12	0.9	1.4	1.3	1.3	1.6	2.1	1.9	1.9
	run13			0.0	0.0			0.0	0.0		run13	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
	run14			0.0	0.0			0.0	0.0		run14	0.0	0.4	0.3	0.3	0.0	0.6	0.5	0.5
	run15			0.0	0.0			0.1	0.1		run15	0.4	0.3	0.3	0.3	0.9	0.6	0.7	0.7
	run16			0.0	0.0			0.2	0.2		run16	0.7	1.6	1.4	1.4	1.7	2.6	2.3	2.3
Monitoring Location at 25 Miles	run00		0.0	0.0	0.0		0.1	0.1	0.1	Monitoring Location at 42 Miles*	run00	69.2	42.9	41.9	41.4	73.3	46.2	45.2	44.7
	run01		0.1	0.1	0.1		0.3	0.3	0.3		run01	75.1	47.7	46.6	46.2	78.1	50.3	49.2	48.8
	run02		0.0	0.0	0.0		0.0	0.0	0.0		run02	57.4	34.3	33.5	33.0	64.4	39.4	38.5	38.0
	run03		0.1	0.1	0.1		0.2	0.2	0.2		run03	114.2	47.2	46.1	45.7	121.2	52.2	51.0	50.6
	run04		0.0	0.0	0.0		0.1	0.1	0.1		run04	44.4	35.5	34.7	34.3	47.5	38.3	37.4	37.0
	run05		0.0	0.0	0.0		0.1	0.1	0.1		run05	90.6	63.2	61.7	60.8	99.2	70.2	68.5	67.6
	run06		0.1	0.1	0.1		0.2	0.2	0.2		run06	45.4	23.5	23.0	22.9	46.8	24.7	24.2	24.0
	run07		0.0	0.0	0.0		0.1	0.1	0.1		run07	69.2	42.9	41.9	41.4	73.3	46.2	45.2	44.7
	run08		0.0	0.0	0.0		0.1	0.1	0.1		run08	69.2	42.9	41.9	41.4	73.3	46.2	45.2	44.7
	run09		0.0	0.0	0.0		0.0	0.0	0.0		run09	26.4	18.3	17.8	17.6	28.2	19.8	19.3	19.1
	run10		0.0	0.0	0.0		0.1	0.1	0.1		run10	61.2	18.6	18.2	18.1	67.0	21.6	21.1	21.0
	run11		0.1	0.1	0.1		0.3	0.3	0.3		run11	31.6	22.8	22.2	22.0	32.9	24.1	23.5	23.3
	run12		0.3	0.3	0.2		0.6	0.6	0.6		run12	74.4	25.5	25.0	24.9	76.4	27.0	26.5	26.4
	run13		0.0	0.0	0.0		0.0	0.0	0.0		run13	46.5	40.0	39.3	38.6	53.7	46.1	45.3	44.5
	run14		0.0	0.0	0.0		0.0	0.0	0.0		run14	106.1	49.2	48.0	47.2	131.8	62.2	60.6	59.7
	run15		0.0	0.0	0.0		0.1	0.1	0.1		run15	67.4	58.2	57.1	56.3	72.4	62.9	61.6	60.9
	run16		0.1	0.1	0.1		0.4	0.4	0.4		run16	173.6	86.9	84.7	83.8	181.9	93.8	91.5	90.6
Monitoring Location at 27 Miles	run00		0.1	0.1	0.1		0.2	0.2	0.2	Monitoring Location at 52 Miles	run00	0.2	8.1	8.2	8.3	0.3	10.2	10.3	10.5
	run01		0.3	0.3	0.3		0.6	0.6	0.6		run01	0.5	10.5	10.6	10.8	0.8	12.4	12.6	12.8
	run02		0.0	0.0	0.0		0.0	0.0	0.0		run02	0.0	4.9	5.0	5.1	0.1	7.1	7.2	7.3
	run03		0.1	0.1	0.1		0.3	0.3	0.3		run03	0.1	11.1	11.2	11.4	0.2	14.9	15.0	15.2
	run04		0.0	0.0	0.0		0.1	0.1	0.1		run04	0.3	4.5	4.6	4.7	0.5	5.7	5.8	5.9
	run05		0.0	0.0	0.0		0.1	0.1	0.1		run05	0.2	8.9	9.0	9.3	0.5	12.3	12.4	12.7
	run06		0.2	0.1	0.1		0.3	0.3	0.3		run06	0.1	6.3	6.4	6.5	0.2	7.2	7.3	7.4
	run07		0.1	0.1	0.1		0.2	0.2	0.2		run07	0.2	8.1	8.2	8.3	0.3	10.2	10.3	10.5
	run08		0.1	0.1	0.1		0.2	0.2	0.2		run08	0.2	8.1	8.2	8.3	0.3	10.2	10.3	10.5
	run09		0.0	0.0	0.0		0.0	0.0	0.0		run09	0.1	2.8	2.9	3.0	0.1	3.6	3.6	3.7
	run10		0.1	0.1	0.1		0.2	0.2	0.2		run10	0.0	5.0	5.1	5.1	0.0	7.0	7.0	7.1
	run11		0.3	0.3	0.2		0.5	0.5	0.5		run11	0.5	4.8	4.9	5.0	0.7	5.5	5.5	5.6
	run12		0.6	0.6	0.6		1.1	1.0	1.0		run12	0.1	9.1	9.1	9.2	0.2	10.3	10.4	10.5
	run13		0.0	0.0	0.0		0.0	0.0	0.0		run13	0.1	2.8	2.9	3.0	0.2	4.0	4.2	4.3
	run14		0.0	0.0	0.0		0.1	0.1	0.1		run14	0.0	6.3	6.4	6.6	0.1	10.9	11.1	11.3
	run15		0.1	0.1	0.1		0.3	0.3	0.3		run15	1.0	7.0	7.2	7.4	1.8	9.0	9.2	9.5
	run16		0.3	0.3	0.3		0.7	0.7	0.7		run16	0.4	18.4	18.7	19.0	0.8	24.6	24.8	25.2

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Table 14-40. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #4c in Potential Production Area UG-6 in cross-section #4 at six monitoring locations.

		30 Years				50 Years						30 Years				50 Years			
	Layer	**4**	**5**	**6***	**7**	**4**	**5**	**6***	**7**		**Layer**	**4**	**5**	**6***	**7**	**4**	**5**	**6***	**7**
Monitoring Location at 20 Miles	run00									**Monitoring Location at 30 Miles**	run00				0.0				0.0
	run01										run01				0.0				0.0
	run02										run02				0.0				0.0
	run03										run03				0.0				0.0
	run04										run04				0.0				0.0
	run05										run05				0.0				0.0
	run06										run06				0.0				0.0
	run07										run07				0.0				0.0
	run08										run08				0.0				0.0
	run09										run09				0.0				0.0
	run10										run10				0.0				0.0
	run11										run11				0.0				0.0
	run12										run12				0.0				0.0
	run13										run13				0.0				0.0
	run14										run14				0.0				0.0
	run15										run15				0.0				0.0
	run16										run16				0.0				0.0
Monitoring Location at 25 Miles	run00									**Monitoring Location at 42 Miles**	run00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run01										run01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run02										run02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run03										run03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run04										run04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run05										run05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run06										run06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run07										run07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run08										run08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run09										run09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run10										run10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run11										run11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run12										run12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run13										run13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run14										run14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run15										run15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	run16										run16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monitoring Location at 27 Miles	run00									**Monitoring Location at 52 Miles***	run00	0.4	20.2	227.0	6.3	0.9	33.7	274.5	10.4
	run01										run01	2.0	54.4	322.2	16.7	3.5	74.7	361.6	23.3
	run02										run02	0.1	5.4	128.6	1.8	0.2	10.3	172.1	3.3
	run03										run03	0.1	7.7	239.4	2.2	0.1	13.5	293.3	3.7
	run04										run04	2.3	41.8	198.7	16.0	4.3	62.5	234.2	24.9
	run05										run05	1.2	40.0	355.2	15.0	2.9	71.4	466.4	26.6
	run06										run06	0.1	7.9	116.2	2.1	0.2	11.8	132.0	3.0
	run07										run07	0.4	20.2	227.0	6.3	0.9	33.7	274.5	10.4
	run08										run08	0.4	20.2	227.0	6.3	0.9	33.7	274.5	10.4
	run09										run09	0.1	6.7	75.7	2.1	0.3	11.2	91.5	3.5
	run10										run10	0.0	0.9	81.3	0.3	0.0	1.6	100.1	0.4
	run11										run11	1.9	32.7	136.7	10.8	2.9	40.0	153.3	14.2
	run12										run12	0.1	6.8	158.7	1.5	0.1	9.3	181.5	2.1
	run13										run13	0.7	21.0	155.5	9.4	2.0	39.9	212.1	18.0
	run14										run14	0.0	3.2	187.5	1.3	0.0	7.0	268.1	2.6
	run15										run15	19.2	174.7	455.6	96.4	29.0	227.2	520.5	135.6
	run16										run16	1.3	61.2	681.4	19.2	2.8	97.5	763.7	30.3

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

14.10 Simulated Drawdowns from Well Fields in Modeled Cross-Section #5

This section describes the construction and application of a groundwater model to simulated the drawdowns that would be created by pumping at three proposed well fields along cross-section #5.

14.10.1Construction of Groundwater Model

The three-dimensional groundwater model constructed to simulate pumping from well fields located along modeled cross-section #5 shown in Figure 14-5. The width of the models along the geologic strike of the Gulf Coast Aquifer is 100 miles, and the length of the two models along dip is 107 miles. The applied recharge rate derived from Scanlon and others (2012) varies between 0.04 and 0.5 inches per year.

Table 14-41 provides the average values for horizontal hydraulic conductivity (Kx), vertical hydraulic conductivity (Kz), and specific storage (Ss) for 25-mile reaches. The model properties extracted from the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) and assigned to model layers 1 to 8 using the GAM-based approach to hydraulic properties. The model aquifer hydraulic properties were extracted from the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) and assigned to model layers 9 to 12 using the adjusted-GAM based approach to aquifer hydraulic properties The values for vertical hydraulic conductivity (Kz) were determined by imposing a ratio of Kx/Kz of 100 for model layers that represent the Chicot and Evangeline aquifers; a ratio of Kx/Kz of 50 for the model layer that represents the Burkeville confining unit (middle Lagarto); and a ratio of Kx/Kz of 1,000 for the model layers that represent the lower Lagarto, Oakville, and Catahoula formations. For model layers below the Burkeville confining unit, the vertical hydraulic conductivity was specified as Kz and was adjusted from values in the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) as a function of the sand fraction in the model grid cell. These adjustments allow the Kx/Kz ratio to vary between 1 and 10.

Figure 14-60 illustrates the values of horizontal hydraulic conductivity obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-61 illustrates the values of horizontal hydraulic conductivity that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-61 illustrates the horizontal hydraulic conductivity values summarized in Table 14-41.

Figure 14-62 illustrates the values of vertical hydraulic conductivity obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-63 illustrates the values of vertical hydraulic conductivity that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-63 illustrates the vertical hydraulic conductivity values summarized in Table 14-41.

Figure 14-64 illustrates the values of specific storage obtained using the GAM-based approach to assigning hydraulic properties. Figure 14-65 illustrates the values of specific storage that were input to the groundwater model that are a combination of the GAM-based and adjusted-GAM based approach. Figure 14-65 illustrates the specific storage values summarized in Table 14-41.

14.10.2Simulated Drawdown Produced by Pumping from Modeled Cross-Section #5

Groundwater pumping at the rate of 3,000 acre-feet per year, 10,000 acre-feet per year and 20,000 acre-feet per year was simulated at three well fields in cross-section #5 shown in Figure 14-5. The up dip Well Field #1 is located 18 miles down dip from the Catahoula outcrop in the Oakville, the middle Well Field #5b is located 25 miles from the Catahoula outcrop in the Middle Lagarto, and the down dip Well Field #5c is located 41 miles down dip from the Catahoula outcrop in the Lower Goliad. Figures 14-66 through 14-68 show the simulated drawdown at 50 years for the three pumping rates at Well Field #5a, Well Field #5b, and Well Field #5c, respectively.

Among the notable results that can be observed in the plotted drawdown in Figures 14-66 to 14-68 are the following:

- Along cross-section #5, the vertical and horizontal hydraulic conductivities of the Burkeville Confining Unit (layer 9) are similar to the surrounding formations and do not provide an effective hydraulic barrier to prevent appreciable drawdowns from migrating from Well Fields #5a, #5b, or #5c into the formations overlying the Burkeville Confining Unit. Consequently, the greatest drawdowns occur near the well and propagate vertically into all, or nearly all, of the model layers.
- Appreciable drawdowns extend laterally some distance from Well Field #5c in the lower layers of the model (layers 9 through 12) because of the lower specific storage values near Well Field #5c.

Drawdown values were recorded for all three model simulations at several monitoring locations at 30 and 50 years. The monitoring locations are located at down dip distances of 5, 10, 15, 20, 25, 30, 38, 41, and 83 miles.

Table 14-41. Average values for Kx (feet per day), Kz (feet per day), and Ss (1/feet) by model layer for 25-mile reaches along dip for modeled cross-section #5.

Reach (miles)	Property	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6
0-25	Kx	nan	nan	nan	nan	nan	1.9E+00
	Kz	nan	nan	nan	nan	nan	9.7E-02
	Ss	nan	nan	nan	nan	nan	3.5E-04
25-50	Kx	6.7E+01	6.7E+01	6.7E+01	9.6E-01	1.1E+00	1.3E+00
	Kz	2.0E+00	2.0E+00	2.0E+00	2.6E-02	4.0E-02	4.8E-02
	Ss	1.1E-03	3.8E-03	1.3E-02	1.5E-03	1.4E-03	1.5E-03
50-75	Kx	3.2E+01	3.2E+01	3.2E+01	5.6E-01	5.6E-01	5.6E-01
	Kz	6.8E-01	6.8E-01	6.8E-01	1.0E-04	1.0E-04	1.0E-04
	Ss	7.8E-04	2.4E-02	2.4E-02	1.8E-03	1.8E-03	1.8E-03
75-100	Kx	2.4E+00	2.4E+00	2.4E+00	5.3E-01	5.3E-01	5.3E-01
	Kz	1.7E-01	1.7E-01	1.7E-01	3.9E-02	3.9E-02	3.9E-02
	Ss	2.4E-04	3.5E-02	3.5E-02	2.4E-03	2.4E-03	2.4E-03
100+	Kx	2.1E+00	2.1E+00	2.1E+00	5.0E-01	5.0E-01	5.0E-01
	Kz	3.9E-01	3.9E-01	3.9E-01	1.0E-01	1.0E-01	1.0E-01
	Ss	1.9E-04	2.2E-03	2.2E-03	5.5E-03	5.5E-03	5.5E-03

Reach (miles)	Property	Layer 7	Layer 8	Layer 9	Layer 10	Layer 11	Layer 12
0-25	Kx	1.9E+00	1.9E+00	3.3E+00	3.5E-01	3.3E-01	3.1E-01
	Kz	9.7E-02	9.7E-02	5.2E+00	1.1E-01	3.0E-01	1.4E-01
	Ss	1.6E-03	2.7E-03	1.1E-04	2.3E-05	2.8E-05	1.7E-05
25-50	Kx	1.3E+00	1.3E+00	2.7E+00	2.9E-01	2.5E-01	2.3E-01
	Kz	4.8E-02	4.8E-02	3.4E+00	1.7E-01	1.4E-01	6.9E-02
	Ss	1.9E-03	1.9E-03	4.2E-06	4.6E-06	3.9E-06	3.6E-06
50-75	Kx	5.6E-01	5.6E-01	2.0E+00	2.1E-01	1.8E-01	1.7E-01
	Kz	1.0E-04	1.0E-04	2.0E+00	1.6E-01	1.9E-01	1.3E-01
	Ss	1.8E-03	1.8E-03	2.6E-06	2.7E-06	2.1E-06	2.4E-06
75-100	Kx	5.3E-01	5.3E-01	1.7E+00	1.7E-01	1.3E-01	nan
	Kz	3.9E-02	3.9E-02	6.6E-01	1.7E-01	1.3E-01	nan
	Ss	2.4E-03	2.4E-03	2.9E-06	2.1E-06	1.8E-06	nan
100+	Kx	5.0E-01	5.0E-01	1.3E+00	1.2E-01	9.6E-02	nan
	Kz	1.0E-01	1.0E-01	3.9E-01	1.2E-01	9.6E-02	nan
	Ss	5.5E-03	5.5E-03	2.5E-06	1.4E-06	1.4E-06	nan

Note: Kx=horizontal hydraulic conductivity; Kz=vertical hydraulic conductivity; Ss=specific storage; nan= model layer is not present for this reach

Tables 14-42 through 14-44 provide drawdown at 30 and 50 years at the monitoring locations listed in Table 14-19 for pumping at 3,000, 10,000, and 20,000 years as determined by the groundwater

Among the notable results that can be gleaned from a review of Tables 14-42 through 4-44 and Figures 14-66 through 14-68 are the following:

- Except for a small area near the model up-dip boundary at the outcrop, the model exhibits a linear response between increase pumping and increase aquifer drawdown.
- After 30 years of pumping 10,000 acre-feet per year from Well Field #5a, the groundwater model predicts 0.1 foot of drawdown in the Jasper Aquifer at the 30 mile monitoring point location and about 1 foot in the Jasper Aquifer at the 25 mile monitoring point location.
- After 30 years pumping 10,000 acre-feet per year from Well Field #5b, the groundwater model predicts 1 foot of drawdown in the middle Lagarto at the 30 mile monitoring point location and 18 feet in the middle Lagarto at the 25 monitoring point location.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 80 feet of drawdown at the Well Field #5a.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 18 feet of drawdown at the Well Field #5b.
- After 30 years of pumping 10,000 acre-feet per year, the groundwater model predicts about 80 feet of drawdown at the Well Field #5c.
- After 30 years of pumping the Jasper Aquifer for 10,000 acre-feet per year at Well Field #5a, the groundwater model predicts less than 0.1 foot of drawdown across the entire Chicot and less than 17 feet of drawdown across the entire Evangeline Aquifer.
- After 30 years of pumping the middle Lagarto for 10,000 acre-feet per year at Well Field #5b, the groundwater model predicts less than 0.1 foot of drawdown across the entire Chicot Aquifer and less than 55 feet of drawdown across the entire Evangeline Aquifer.
- After 30 years of pumping the Evangeline Aquifer for 10,000 acre-feet per year at Well Field #5c, the groundwater model predicts less than 0.1 foot of drawdown across the entire Chicot Aquifer.

Table 14-42. Simulated drawdown at monitoring locations after pumping Well Field #5a in Potential Production Area OK-3 in cross-section #5 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Upper Goliad	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula
		Model Layer											
Location (miles)	**Pumping Rate (AFY)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11***	**12**
		30 Years											
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.4
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.7	1.7
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.2	3.1
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10.5	9.8	11.1	10.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	37.9	36.0	41.9	38.4
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	69.4	65.4	73.6	68.2
18*	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	19.8	<0.1	20.5	26.3	40.7	46.3
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	53.7	<0.1	54.9	64.6	82.4	92.0
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	94.4	<0.1	95.8	108.3	131.1	142.8
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	7.0	<0.1	7.9	8.9	9.9	11.0
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	23.3	<0.1	27.0	31.8	35.9	39.2
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	41.2	<0.1	47.6	54.6	60.3	66.0
25	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.3
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.3	0.7	0.8	0.9	1.1	1.2
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	0.7	0.6	1.3	1.5	1.8	2.0	2.2
30	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1
41	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
83	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
		50 Years											
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.6	4.4
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	48.8	47.0	52.8	48.7
18*	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	61.5	<0.1	62.7	72.3	90.1	99.9
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	28.9	<0.1	32.7	37.5	41.3	44.9
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	1.0	1.6	1.7	1.9	2.1	2.2
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.2	0.2
41	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
83	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.
Note: AFY=acre-feet per year

Table 14-43. Simulated drawdown at monitoring locations after pumping Well Field #5b in Potential Production Area ML-6 in cross-section #5 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Upper Goliad	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula
		Model Layer											
Location (miles)	**Pumping Rate (AFY)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9***	**10**	**11**	**12**
		30 Years											
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.3	0.4	0.4
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.7	0.6	0.7	0.7
18	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	0.3	0.3	0.3	0.3
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.2	<0.1	1.2	1.2	1.2	1.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.1	<0.1	2.2	2.1	2.1	2.1
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	<0.1	0.6	0.6	0.8	0.7
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.4	<0.1	2.4	2.6	3.5	2.9
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.2	<0.1	4.3	4.6	5.9	5.1
25*	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	3.1	3.1	7.0	7.9	5.9	5.6	5.2
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	8.1	7.9	16.6	17.9	16.5	15.9	15.2
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	12.2	11.8	23.5	25.2	24.1	23.6	22.9
30	3,000	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.0	0.1	0.2	0.3	0.6	0.6
	10,000	<0.1	<0.1	<0.1	<0.1	0.2	0.3	0.1	0.2	0.7	1.1	2.4	1.9
	20,000	<0.1	<0.1	<0.1	<0.1	0.3	0.4	0.1	0.4	1.2	1.9	4.1	4.1
41	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
83	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
		50 Years											
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0	0.9	1.0	1.0
18	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.4	<0.1	2.4	2.3	2.3	2.3
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.4	<0.1	4.3	4.5	5.4	4.7
25*	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	12.3	12.2	20.3	21.6	19.9	19.3	18.6
30	10,000	<0.1	<0.1	<0.1	<0.1	0.5	0.6	0.3	0.6	1.2	1.7	3.4	2.9
41	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
83	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.
Note: AFY=acre-feet per year

Table 14-44. Simulated drawdown at monitoring locations after pumping Well Field #5c in Potential Production Area LG-6 in cross-section #5 for 30 years and 50 years.

		Beaumont	Lissie	Willis	Upper Goliad	Upper Goliad	Upper Goliad	Lower Goliad	Upper Lagarto	Middle Lagarto	Lower Lagarto	Oakville	Catahoula
		Model Layer											
Location (miles)	**Pumping Rate (AFY)**	**1**	**2**	**3**	**4**	**5**	**6**	**7***	**8**	**9**	**10**	**11**	**12**
		30 Years											
5	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
18	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
25	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
30	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.3	0.2	0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.7	0.4	0.1
41*	3,000	<0.1	0.2	<0.1	2.5	5.8	15.3	52.0	14.1	5.6	5.5	5.3	5.2
	10,000	<0.1	0.6	<0.1	5.2	11.2	28.5	82.1	34.0	15.8	15.7	15.5	15.1
	20,000	<0.1	1.1	<0.1	8.7	17.4	40.9	109.6	50.8	27.5	27.4	27.1	26.6
83	3,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.1	<0.1
	20,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.2	0.2	<0.1
		50 Years											
5	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
10	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
15	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
18	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
20	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
25	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
30	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	0.6	0.3	0.1
41*	10,000	<0.1	1.1	<0.1	7.1	14.1	32.3	86.7	38.3	19.3	19.1	18.9	18.5
83	10,000	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.3	0.3	<0.1

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.
Note: AFY=acre-feet per year

14.10.3Sensitivity Analysis on the Simulated Drawdown for Potential Production Area #5

Table 14-2 describes the changes in the model input parameter associated with set of sixteen sensitivity runs performed for the groundwater model corresponding to cross-section #5. In this section, Model Run00 refers to the baseline run of 10,000 acre-feet per year for which simulated drawdowns are shown in Figures 14-66 to 14-68. Tables 14-44 through 14-46 provide the sensitivity results for drawdown at six monitoring locations after 30 and 50 years of pumping at Well Fields #5a, #5b, and #5c, respectively.

Among the notable results that can be gleaned from a review of Tables 14-44 through 14-46 are:

- After 30 years of pumping Well Field #5a at 10,000 acre-feet per year, the drawdown is between 42 and 202 feet in the Catahoula (layer 12) at the monitoring point located 18 miles down dip of the Catahoula outcrop and coincident with the center of the well field. The maximum drawdown occurs in the Catahoula, the model layer beneath the layer containing Well Field #5a, because the initial heads are higher in the Catahoula.
- After 30 years of pumping Well Field #5a at 10,000 acre-feet per year, the drawdown is between 23 and 57 feet in the Catahoula (layer 12) at the monitoring point located 15 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #5a at 10,000 acre-feet per year, the drawdown is between 0.2 and 3 feet in the Catahoula (layer 12) at the monitoring point located 10 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #5b at 10,000 acre-feet per year, the drawdown is between 13 and 22 feet in the middle Lagarto (layer 9) at the monitoring point located 25 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #5b at 10,000 acre-feet per year, the drawdown is between 2 and 3 feet in the middle Lagarto (layer 9) at the monitoring point located 20 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #5b at 10,000 acre-feet per year, the drawdown is between 0.6 and 2 feet in the middle Lagarto (layer 9) at the monitoring point located 18 miles down dip of the Catahoula outcrop.
- After 30 years of pumping Well Field #5c at 10,000 acre-feet per year, the drawdown is between 28 and 243 feet in the lower Goliad (layer 7) at the monitoring point located 41 miles down dip of the Catahoula outcrop and coincident with the center of the well field.
- After 30 years of pumping Well Field #5c at 10,000 acre-feet per year, the drawdown is less than 0.8 feet at the monitoring points located 11 miles or more up dip of the well field.

Table 14-45. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #5a in Potential Production Area OK-3 in cross-section #5 at six monitoring locations.

		30 Years				50 Years			
	Layer	9	10	11*	12	9	10	11*	12
Monitoring Location at 10 Miles	run00			1.7	1.7			4.6	4.4
	run01			2.2	2.1			5.4	5.2
	run02			1.0	0.9			2.9	2.6
	run03			1.6	1.3			4.1	3.5
	run04			2.6	2.7			6.3	6.3
	run05			0.6	0.6			2.0	2.0
	run06			3.8	3.3			7.2	6.4
	run07			1.7	1.7			4.6	4.4
	run08			1.7	1.7			4.6	4.4
	run09			1.8	1.8			4.2	4.1
	run10			1.6	1.4			3.9	3.3
	run11			3.2	3.3			6.4	6.4
	run12			3.3	3.1			6.5	5.8
	run13			0.8	0.7			2.6	2.6
	run14			0.4	0.2			1.3	1.0
	run15			1.9	2.0			5.3	5.3
	run16			1.2	1.0			3.3	3.0
Monitoring Location at 15 Miles	run00	37.9	36.0	41.9	38.4	48.8	47.0	52.8	48.7
	run01	40.4	38.6	44.5	40.9	50.9	49.3	55.0	50.9
	run02	31.8	29.8	35.3	32.0	43.0	41.1	46.7	42.7
	run03	39.6	35.4	47.7	47.8	51.9	47.9	59.5	58.6
	run04	35.4	35.0	38.2	35.1	44.6	44.2	47.5	44.0
	run05	43.7	42.6	50.1	45.2	63.9	62.8	70.7	64.1
	run06	25.6	24.1	27.9	27.1	30.5	29.2	32.8	31.9
	run07	37.9	36.0	41.9	38.4	48.8	47.0	52.8	48.7
	run08	37.9	36.0	41.9	38.4	48.8	47.0	52.8	48.7
	run09	22.6	22.4	24.5	22.8	28.2	27.9	30.1	28.1
	run10	24.2	23.6	31.7	32.9	31.5	31.1	38.6	39.2
	run11	26.5	26.3	28.5	26.7	31.5	31.3	33.4	31.5
	run12	29.5	29.5	37.4	38.6	36.1	36.2	43.6	44.1
	run13	37.1	36.6	39.5	36.0	51.5	51.1	54.2	50.1
	run14	38.5	31.5	43.1	38.5	56.8	49.0	61.9	55.6
	run15	48.6	48.3	51.5	47.9	62.6	62.3	65.6	61.4
	run16	53.8	46.9	61.2	56.5	72.0	64.6	78.9	72.5
Monitoring Location at 18 Miles*	run00	54.9	64.6	82.4	92.0	62.7	72.3	90.2	99.9
	run01	56.7	66.4	84.3	93.9	64.2	73.9	91.7	101.5
	run02	50.4	59.9	77.6	87.0	58.6	68.2	85.9	95.5
	run03	53.0	75.5	115.4	127.6	61.4	84.0	123.8	136.2
	run04	53.4	57.2	64.1	68.8	60.2	64.0	70.9	75.7
	run05	87.1	99.4	121.9	136.4	100.1	112.5	134.9	149.7
	run06	30.3	37.4	50.1	53.9	34.2	41.3	54.0	57.8
	run07	54.9	64.6	82.4	92.0	62.7	72.3	90.2	99.9
	run08	54.9	64.6	82.4	92.0	62.7	72.3	90.2	99.9
	run09	30.4	33.4	38.9	42.0	34.4	37.4	43.0	46.1
	run10	27.8	42.7	68.4	66.4	32.6	47.6	73.3	71.4
	run11	33.1	36.1	41.7	44.8	36.7	39.7	45.3	48.5
	run12	31.3	46.5	72.4	70.7	35.6	50.8	76.7	75.1
	run13	71.0	75.2	83.0	88.5	82.3	86.6	94.4	100.1
	run14	70.7	100.7	157.4	186.7	84.9	115.3	172.2	202.0
	run15	80.0	84.4	92.3	97.9	90.5	94.9	102.8	108.5
	run16	83.1	114.1	171.6	202.0	96.0	127.0	184.5	215.0

		30 Years				50 Years			
	Layer	9	10	11*	12	9	10	11*	12
Monitoring Location at 20 Miles	run00	27.0	31.8	35.9	39.2	32.7	37.5	41.3	44.9
	run01	28.1	33.0	37.1	40.5	33.6	38.5	42.4	46.0
	run02	24.3	28.8	32.6	35.6	30.2	34.8	38.4	41.7
	run03	27.2	42.2	53.3	59.8	33.2	48.3	59.2	66.2
	run04	25.5	27.4	27.1	28.2	30.6	32.6	31.9	33.2
	run05	33.8	39.0	43.1	45.5	42.0	47.3	51.1	53.7
	run06	18.2	22.9	25.6	28.4	21.5	26.1	28.7	31.6
	run07	27.0	31.8	35.9	39.2	32.7	37.5	41.3	44.9
	run08	27.0	31.8	35.9	39.2	32.7	37.5	41.3	44.9
	run09	17.3	18.7	19.0	20.4	20.6	22.0	22.2	23.7
	run10	16.6	28.4	35.0	38.2	20.3	32.2	38.8	42.4
	run11	19.1	20.6	21.0	22.5	22.2	23.7	23.9	25.5
	run12	18.9	31.2	38.1	41.9	22.4	34.6	41.4	45.5
	run13	26.4	29.2	28.0	28.5	33.6	36.6	35.0	35.6
	run14	29.1	41.2	56.1	62.0	37.5	50.6	66.4	73.2
	run15	31.0	34.3	33.1	33.7	38.0	41.5	39.7	40.4
	run16	35.5	49.8	67.6	74.9	43.5	58.0	75.6	83.3
Monitoring Location at 25 Miles	run00	0.8	0.9	1.1	1.2	1.7	1.9	2.1	2.2
	run01	0.9	1.0	1.2	1.3	1.8	2.0	2.2	2.4
	run02	0.6	0.7	0.8	0.9	1.4	1.6	1.8	1.9
	run03	0.8	1.2	1.5	1.8	1.7	2.2	2.6	2.9
	run04	0.8	0.9	1.0	1.0	1.8	1.8	2.0	2.0
	run05	0.4	0.5	0.5	0.6	1.1	1.2	1.3	1.4
	run06	1.4	1.6	1.8	1.9	2.5	2.7	2.9	3.1
	run07	0.8	0.9	1.1	1.2	1.7	1.9	2.1	2.2
	run08	0.8	0.9	1.1	1.2	1.7	1.9	2.1	2.2
	run09	1.3	1.3	1.4	1.5	2.4	2.4	2.5	2.6
	run10	1.2	1.7	2.2	2.5	2.3	2.8	3.3	3.7
	run11	1.6	1.6	1.7	1.8	2.8	2.8	2.9	3.0
	run12	1.6	2.2	2.8	3.2	2.8	3.4	4.0	4.4
	run13	0.3	0.3	0.4	0.4	0.9	1.0	1.0	1.0
	run14	0.2	0.3	0.4	0.5	0.8	0.9	1.1	1.2
	run15	0.4	0.5	0.5	0.6	1.2	1.3	1.3	1.3
	run16	0.4	0.7	0.8	1.0	1.1	1.4	1.7	1.8
Monitoring Location at 30 Miles	run00	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
	run01	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
	run02	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
	run03	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.3
	run04	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
	run05	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
	run06	0.1	0.1	0.3	0.3	0.3	0.3	0.5	0.6
	run07	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
	run08	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
	run09	0.1	0.1	0.2	0.2	0.2	0.3	0.4	0.5
	run10	0.1	0.1	0.3	0.4	0.2	0.3	0.6	0.8
	run11	0.1	0.2	0.3	0.3	0.3	0.3	0.6	0.6
	run12	0.2	0.2	0.5	0.7	0.3	0.4	0.8	1.1
	run13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	run14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run15	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
	run16	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Table 14-46. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #5b in Potential Production Area ML-6 in cross-section #5 at six monitoring locations.

		30 Years				50 Years			
	Layer	**9***	**10**	**11**	**12**	**9***	**10**	**11**	**12**
Monitoring Location at 18 Miles	run00	1.2	1.2	1.2	1.1	2.4	2.3	2.3	2.3
	run01	1.3	1.3	1.3	1.2	2.5	2.5	2.5	2.4
	run02	1.0	0.9	0.9	0.9	2.1	2.0	2.0	1.9
	run03	1.2	1.1	1.1	1.1	2.4	2.3	2.3	2.3
	run04	1.2	1.2	1.2	1.2	2.4	2.4	2.4	2.4
	run05	0.8	0.8	0.8	0.7	1.9	1.8	1.8	1.8
	run06	1.7	1.7	1.7	1.7	3.0	2.9	3.0	2.9
	run07	1.2	1.2	1.2	1.1	2.4	2.3	2.3	2.3
	run08	1.2	1.2	1.2	1.1	2.4	2.3	2.3	2.3
	run09	1.6	1.6	1.6	1.6	2.9	2.8	2.8	2.8
	run10	1.6	1.5	1.5	1.4	2.9	2.7	2.7	2.6
	run11	2.0	1.9	1.9	1.9	3.3	3.2	3.2	3.2
	run12	1.9	1.9	1.9	1.9	3.3	3.2	3.2	3.1
	run13	0.6	0.6	0.6	0.6	1.5	1.5	1.5	1.5
	run14	0.6	0.5	0.5	0.4	1.4	1.3	1.3	1.2
	run15	0.9	0.8	0.9	0.8	1.9	1.9	1.9	1.9
	run16	0.8	0.8	0.8	0.8	1.8	1.8	1.8	1.7
Monitoring Location at 20 Miles	run00	2.4	2.6	3.5	2.9	4.3	4.5	5.4	4.7
	run01	2.5	2.7	3.6	3.1	4.4	4.6	5.6	4.9
	run02	2.2	2.3	3.1	2.6	4.0	4.1	5.0	4.3
	run03	2.3	2.7	3.5	2.6	4.2	4.5	5.3	4.3
	run04	2.5	2.6	3.4	3.2	4.4	4.5	5.3	5.0
	run05	2.0	2.1	3.0	2.7	4.0	4.0	5.0	4.7
	run06	2.9	3.1	3.7	3.0	4.6	4.8	5.3	4.5
	run07	2.4	2.6	3.5	2.9	4.3	4.5	5.4	4.7
	run08	2.4	2.6	3.5	2.9	4.3	4.5	5.4	4.7
	run09	2.8	2.9	3.5	3.1	4.4	4.5	5.1	4.6
	run10	2.7	3.0	3.2	2.4	4.4	4.6	4.8	3.8
	run11	3.0	3.2	3.8	3.4	4.7	4.9	5.5	5.0
	run12	3.0	3.4	3.7	2.9	4.8	5.1	5.3	4.4
	run13	1.9	2.0	2.5	2.5	3.8	3.8	4.4	4.3
	run14	1.7	1.7	2.4	1.7	3.5	3.5	4.2	3.4
	run15	2.2	2.3	3.0	2.9	4.2	4.2	5.0	4.9
	run16	2.0	2.3	3.3	2.7	3.9	4.2	5.3	4.5
Monitoring Location at 25 Miles*	run00	17.9	16.5	15.9	15.2	21.6	19.9	19.3	18.6
	run01	17.9	16.5	16.0	15.3	21.6	20.0	19.4	18.6
	run02	17.8	16.3	15.8	15.0	21.4	19.7	19.2	18.4
	run03	18.7	16.2	15.3	14.0	22.5	19.7	18.7	17.3
	run04	17.0	16.1	15.8	15.4	20.4	19.4	19.1	18.7
	run05	20.8	20.3	19.8	19.3	25.3	24.5	24.0	23.5
	run06	14.1	12.0	11.5	10.7	16.8	14.5	13.9	13.1
	run07	17.9	16.5	15.9	15.2	21.6	19.9	19.3	18.6
	run08	17.9	16.5	15.9	15.2	21.6	19.9	19.3	18.6
	run09	13.1	11.8	11.5	11.1	15.6	14.2	13.9	13.4
	run10	14.7	11.5	10.4	9.1	17.5	14.0	12.8	11.4
	run11	13.3	11.9	11.7	11.2	15.8	14.3	14.0	13.6
	run12	14.8	11.7	10.7	9.4	17.6	14.2	13.1	11.7
	run13	20.0	19.7	19.4	19.1	24.2	23.8	23.5	23.2
	run14	21.3	19.9	19.1	18.0	26.0	24.3	23.4	22.3
	run15	20.2	19.9	19.6	19.3	24.4	24.0	23.7	23.4
	run16	21.5	20.4	19.6	18.6	26.1	24.7	23.8	22.7

		30 Years				50 Years			
	Layer	**9***	**10**	**11**	**12**	**9***	**10**	**11**	**12**
Monitoring Location at 30 Miles	run00	0.7	1.1	2.4	1.9	1.2	1.7	3.4	2.9
	run01	0.7	1.1	2.4	2.0	1.2	1.7	3.5	2.9
	run02	0.7	1.0	2.2	1.8	1.1	1.6	3.2	2.7
	run03	0.6	1.1	2.6	2.3	1.1	1.7	3.6	3.3
	run04	0.8	1.2	2.3	2.0	1.3	1.8	3.3	2.9
	run05	0.3	0.8	1.9	1.5	0.6	1.2	2.9	2.5
	run06	1.3	1.5	2.7	2.5	2.0	2.2	3.7	3.5
	run07	0.7	1.1	2.4	1.9	1.2	1.7	3.4	2.9
	run08	0.7	1.1	2.4	1.9	1.2	1.7	3.4	2.9
	run09	1.3	1.4	2.5	2.2	2.0	2.1	3.5	3.2
	run10	1.2	1.4	2.6	2.7	1.8	2.1	3.7	3.8
	run11	1.4	1.5	2.6	2.3	2.1	2.2	3.6	3.3
	run12	1.2	1.6	2.9	3.0	1.9	2.3	3.9	4.1
	run13	0.3	0.8	1.7	1.7	0.6	1.3	2.7	2.8
	run14	0.2	0.6	1.6	1.2	0.5	1.0	2.7	2.1
	run15	0.4	0.9	1.9	1.9	0.7	1.4	2.8	2.9
	run16	0.3	0.8	2.1	1.7	0.5	1.3	3.2	2.6
Monitoring Location at 41 Miles	run00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run06	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
	run07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run09	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	run10	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
	run11	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	run12	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
	run13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Monitoring Location at 83 Miles	run00	0.0	0.0	0.0		0.0	0.0	0.0	
	run01	0.0	0.0	0.0		0.0	0.0	0.0	
	run02	0.0	0.0	0.0		0.0	0.0	0.0	
	run03	0.0	0.0	0.0		0.0	0.0	0.0	
	run04	0.0	0.0	0.0		0.0	0.0	0.0	
	run05	0.0	0.0	0.0		0.0	0.0	0.0	
	run06	0.0	0.0	0.0		0.0	0.0	0.0	
	run07	0.0	0.0	0.0		0.0	0.0	0.0	
	run08	0.0	0.0	0.0		0.0	0.0	0.0	
	run09	0.0	0.0	0.0		0.0	0.0	0.0	
	run10	0.0	0.0	0.0		0.0	0.0	0.0	
	run11	0.0	0.0	0.0		0.0	0.0	0.0	
	run12	0.0	0.0	0.0		0.0	0.0	0.0	
	run13	0.0	0.0	0.0		0.0	0.0	0.0	
	run14	0.0	0.0	0.0		0.0	0.0	0.0	
	run15	0.0	0.0	0.0		0.0	0.0	0.0	
	run16	0.0	0.0	0.0		0.0	0.0	0.0	

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

Table 14-47. Results from a sensitivity analysis of simulated drawdowns in feet caused by pumping 10,000 acre-feet per year from Well Field #5c in Potential Production Area LG-6 in cross-section #5 at six monitoring locations.

		30 Years				50 Years			
	Layer	**6**	**7***	**8**	**9**	**6**	**7***	**8**	**9**
Monitoring Location at 18 Miles	run00		0.0		0.0		0.0		0.0
	run01		0.0		0.0		0.0		0.0
	run02		0.0		0.0		0.0		0.0
	run03		0.0		0.0		0.0		0.0
	run04		0.0		0.0		0.0		0.0
	run05		0.0		0.0		0.0		0.0
	run06		0.0		0.0		0.0		0.0
	run07		0.0		0.0		0.0		0.0
	run08		0.0		0.0		0.0		0.0
	run09		0.0		0.0		0.0		0.0
	run10		0.0		0.0		0.0		0.0
	run11		0.0		0.0		0.0		0.0
	run12		0.0		0.0		0.0		0.0
	run13		0.0		0.0		0.0		0.0
	run14		0.0		0.0		0.0		0.0
	run15		0.0		0.0		0.0		0.0
	run16		0.0		0.0		0.0		0.0
Monitoring Location at 20 Miles	run00		0.0		0.0		0.0		0.0
	run01		0.0		0.0		0.0		0.0
	run02		0.0		0.0		0.0		0.0
	run03		0.0		0.0		0.0		0.0
	run04		0.0		0.0		0.0		0.0
	run05		0.0		0.0		0.0		0.0
	run06		0.0		0.0		0.0		0.0
	run07		0.0		0.0		0.0		0.0
	run08		0.0		0.0		0.0		0.0
	run09		0.0		0.0		0.0		0.0
	run10		0.0		0.0		0.0		0.0
	run11		0.0		0.0		0.0		0.0
	run12		0.0		0.0		0.1		0.1
	run13		0.0		0.0		0.0		0.0
	run14		0.0		0.0		0.0		0.0
	run15		0.0		0.0		0.0		0.0
	run16		0.0		0.0		0.0		0.0
Monitoring Location at 25 Miles	run00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run01	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
	run02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run11	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1
	run12	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
	run13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run16	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1

		30 Years				50 Years			
	Layer	**6**	**7***	**8**	**9**	**6**	**7***	**8**	**9**
Monitoring Location at 30 Miles	run00	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
	run01	0.1	0.1	0.1	0.5	0.3	0.4	0.4	1.0
	run02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	run03	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.4
	run04	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
	run05	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
	run06	0.0	0.0	0.0	0.2	0.1	0.1	0.1	0.3
	run07	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
	run08	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
	run09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run10	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
	run11	0.3	0.4	0.4	0.6	0.8	0.9	0.9	1.2
	run12	0.1	0.4	0.3	0.8	0.5	1.1	0.8	1.4
	run13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	run15	0.1	0.1	0.1	0.2	0.3	0.2	0.2	0.5
	run16	0.0	0.0	0.1	0.7	0.1	0.1	0.2	1.2
Monitoring Location at 41 Miles*	run00	28.5	82.1	34.0	15.8	32.3	86.7	38.3	19.3
	run01	36.0	90.9	42.4	22.7	38.9	94.3	45.8	25.8
	run02	19.0	68.2	22.6	8.9	23.8	75.8	28.6	12.2
	run03	30.0	138.0	35.6	10.3	36.4	148.1	42.7	14.0
	run04	22.3	48.1	26.2	17.5	24.6	50.7	28.8	19.9
	run05	48.6	120.9	52.1	26.2	55.9	129.5	59.9	32.1
	run06	14.4	52.4	17.4	7.6	16.3	54.7	19.5	9.2
	run07	28.5	82.1	34.0	15.8	32.3	86.7	38.3	19.3
	run08	28.5	82.1	34.0	15.8	32.3	86.7	38.3	19.3
	run09	9.7	27.8	12.2	6.6	11.1	29.5	13.8	7.9
	run10	7.4	67.2	8.5	1.8	10.0	74.3	11.5	2.8
	run11	15.0	33.9	18.2	12.0	16.1	35.0	19.4	13.1
	run12	18.8	89.3	20.7	7.5	21.2	92.2	23.0	9.3
	run13	25.7	60.9	26.1	17.7	31.6	67.6	32.0	22.1
	run14	26.6	142.1	26.8	7.3	40.3	173.1	43.8	12.2
	run15	44.3	81.4	45.6	34.5	47.3	84.7	49.1	37.9
	run16	84.3	243.4	93.3	33.9	94.5	255.4	103.8	41.4
Monitoring Location at 83 Miles	run00	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3
	run01	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.6
	run02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	run03	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3
	run04	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
	run05	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
	run06	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3
	run07	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3
	run08	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3
	run09	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	run10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
	run11	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.3
	run12	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.4
	run13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	run15	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.2
	run16	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.6

*Location of the center of the well field by model layer and distance in miles down dip from the Catahoula outcrop.

14.11 Potential for Water Quality Impacts

14.11.1Objective

We performed a screening analysis to evaluate the movement of the fresh water boundary over time in response to pumping at the candidate well fields. The objective of the screening analysis is to determine the impact pumping stresses have on the location of the fresh boundary and on the location of fresh water transition zone.

14.11.2Approach

A particle tracking approach was used to simulated the particle trajectories over a 50-year simulation period for the five groundwater model. Particles were placed along the fresh water boundary at a density of one particle per square mile. Transient particle tracking was implemented using mod-PATH3DU (Muffels and others, 2014). The code mod-PATH3DU is a publicly available code that implements particle tracking using a grid-independent method developed by Tonkin and Larson (2002) and the code can be used to calculate groundwater paths and travel times for unstructured grids.

Particle tracking uses the area of the grid cell faces, the flux across grid cell faces computed by MODFLOW as part of the solution of the groundwater flow equation that is output as the cell-by-cell file, and the porosity of the porous media to compute an average linear velocity of the groundwater. Particles are tracked from their starting location at their average linear velocity for each stress period in the simulation to represent advective transport. We specified the starting location of individual particles at the beginning of the 50-year simulation period and tracked these particles over the 50-year simulation period using the transient fluxes from the MODFLOW solution to the groundwater flow equation. We specified a porosity of 0.2 as an input to the particle tracking code to convert the Darcy flux to an average linear velocity.

14.11.3Results

Particle tracking results are presented as cross-sections along the dip of the groundwater model for each of the five modeled cross-sections. Figures 14-69 through 14-83 show the particle track results for each of the five modeled cross-section for each of the well fields pumping at 10,000 acre-feet per year for a total of 15 particle tracking result figures. The vast majority of the particles being tracked show no visible movement between their starting and ending locations. To describe the particle tracking results, we use three categories to describe the movement of particles at the fresh water boundary. The first category includes particle tracking results with de minimis transport, the second category describes particles tracking results show minor amounts of transport for some particles, and the third category includes particle tracking results with noticeable movement of some particles down dip and/or toward the well field which could indicate potential water quality impacts. Particle tracking results for the simulations of pumping at each the 15 well fields are summarized in Table 14-48. Figure 14-70 shows movement of particles that are captured by Well Field #1b. Particle tracking results that show down dip movement of particles towards the well field indicate a deeper boundary for the fresh water or a larger transition zone between fresh water and more saline groundwater.

Table 14-48. Summary of particle tracking movement by category and by well field.

Modeled Cross-Section Number	Up Dip Well Field	Middle Well Field	Down Dip Well Field
1	de minimis	minor	noticeable
2	de minimis	de minimis	minor
3	minor	noticeable	noticeable
4	noticeable	noticeable	minor
5	noticeable	noticeable	minor

The screening analysis presented in this study for water quality impacts as a results of pumping the candidate well fields is a simplified approach to analyzing water quality. A transport model, which would simulate more than advective transport of groundwater is needed to identify potential for water quality impacts as a result of pumping at the candidate wells fields. Based on the screening approach employed in this study, only local mixing due to pumping at the candidate well fields can be seen. There is no evidence for impacts on water quality as a result of regionally mixing water as a result of pumping the candidate well fields.

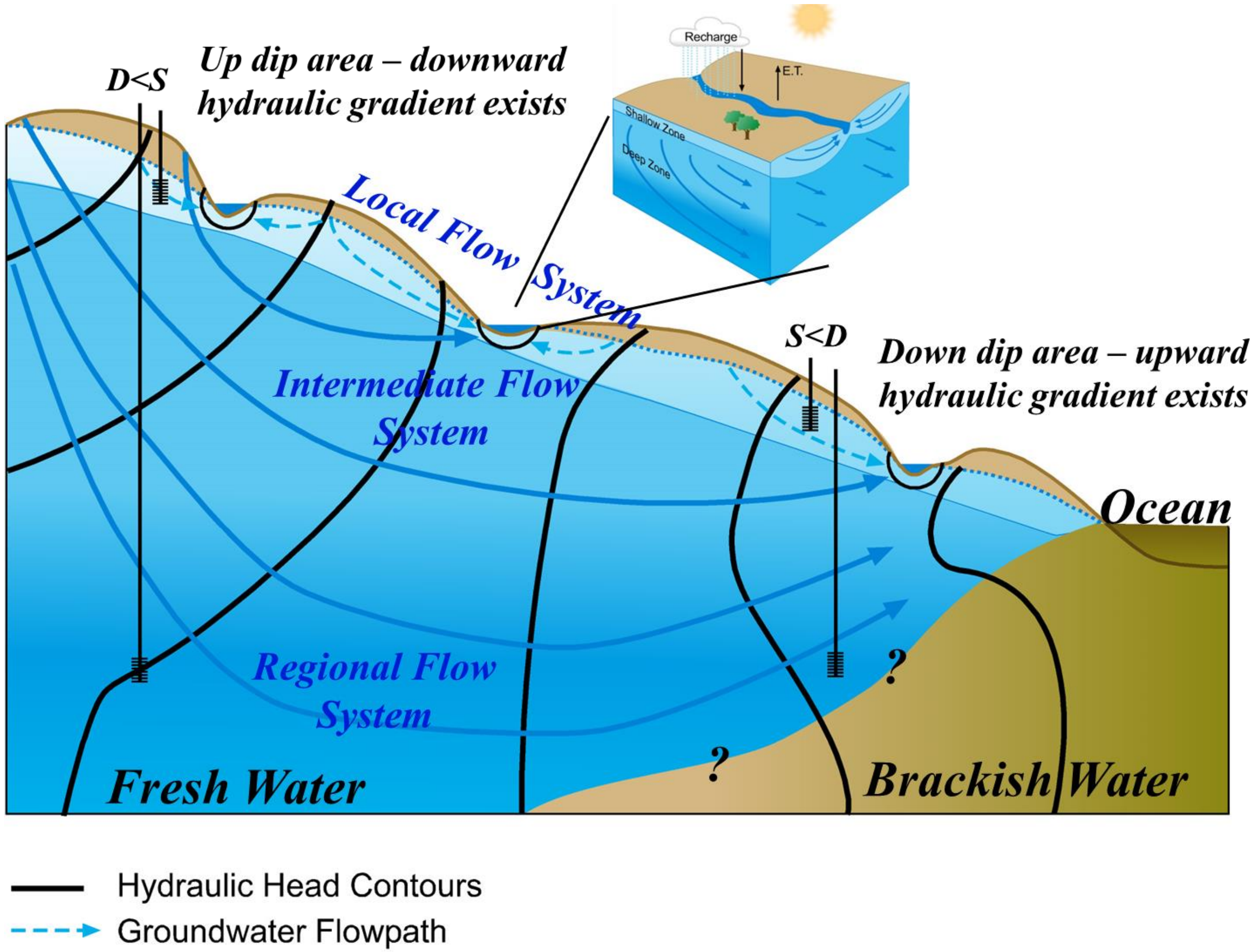


Figure 14-1 **Conceptual flow model of gravity driven groundwater flow in the Texas Gulf Coast Aquifer System based on the local, intermediate, and regional flow systems.**

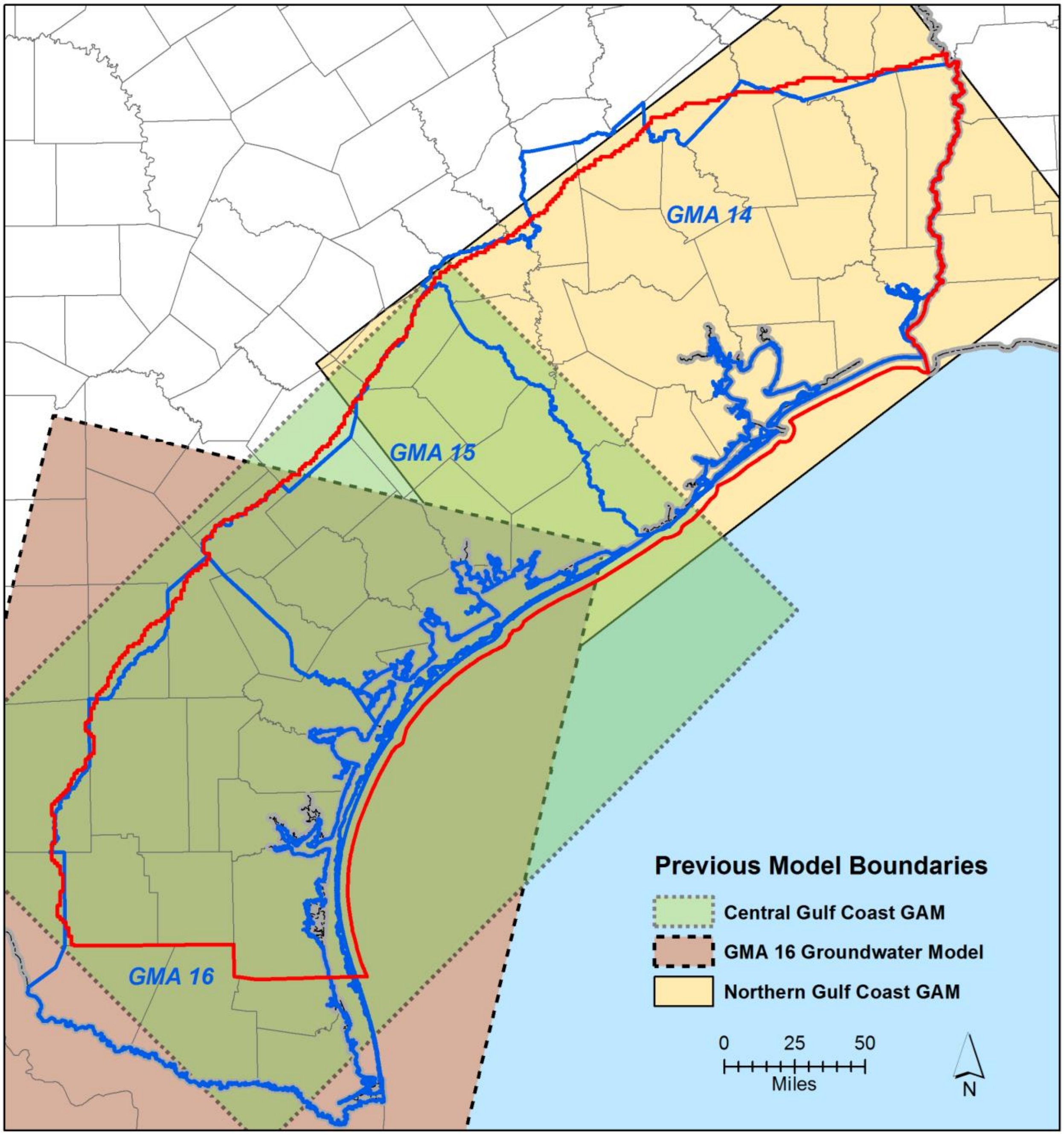


Figure 14-2. Model domains of the groundwater models used for joint planning in Groundwater Management Areas 14, 15, and 16.

Note: GMA=Groundwater Management Area

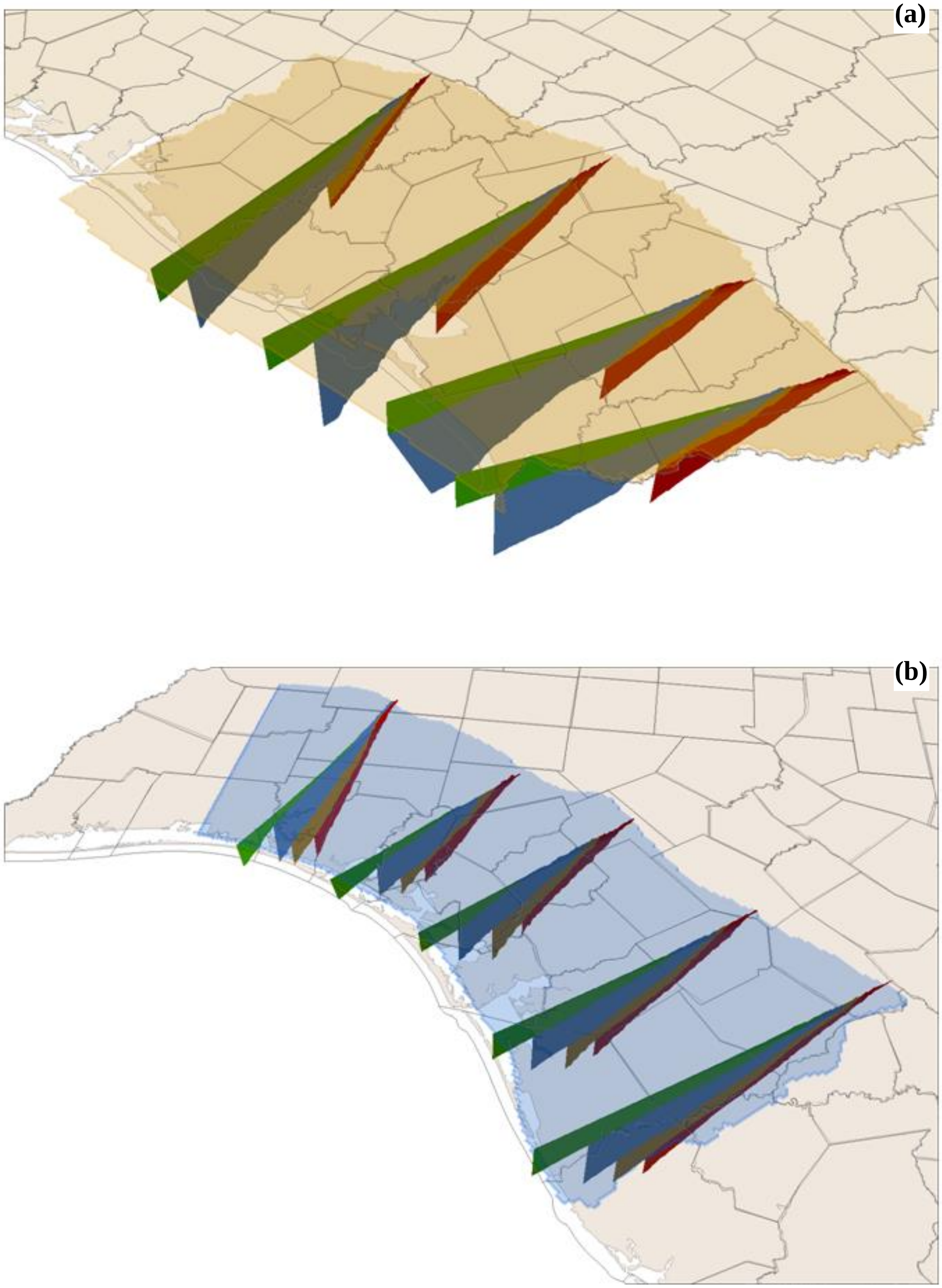


Figure 14-3. Three dimensional view of transects cut through the (a) Northern Gulf Coast Aquifer System Groundwater Availability Model and (b) Central Gulf Coast Aquifer System Groundwater Availability Model. The shaded areas in each view represent the domain of the groundwater model. Three dimensional view of the model layers representing the Chicot Aquifer, the Evangeline Aquifer, the Burkeville confining unit, and the Jasper Aquifer.

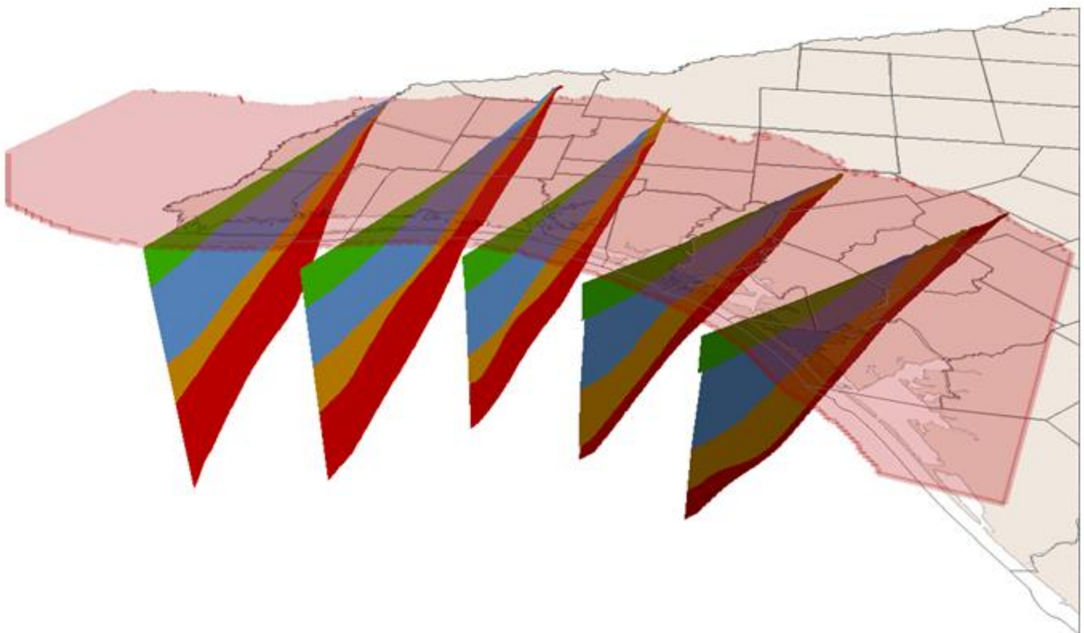


Figure 14-4. Three-dimensional view of transects cut through the Groundwater Management Area 16 Approved Groundwater Model. The shaded area in the view represents the domain of the groundwater model.

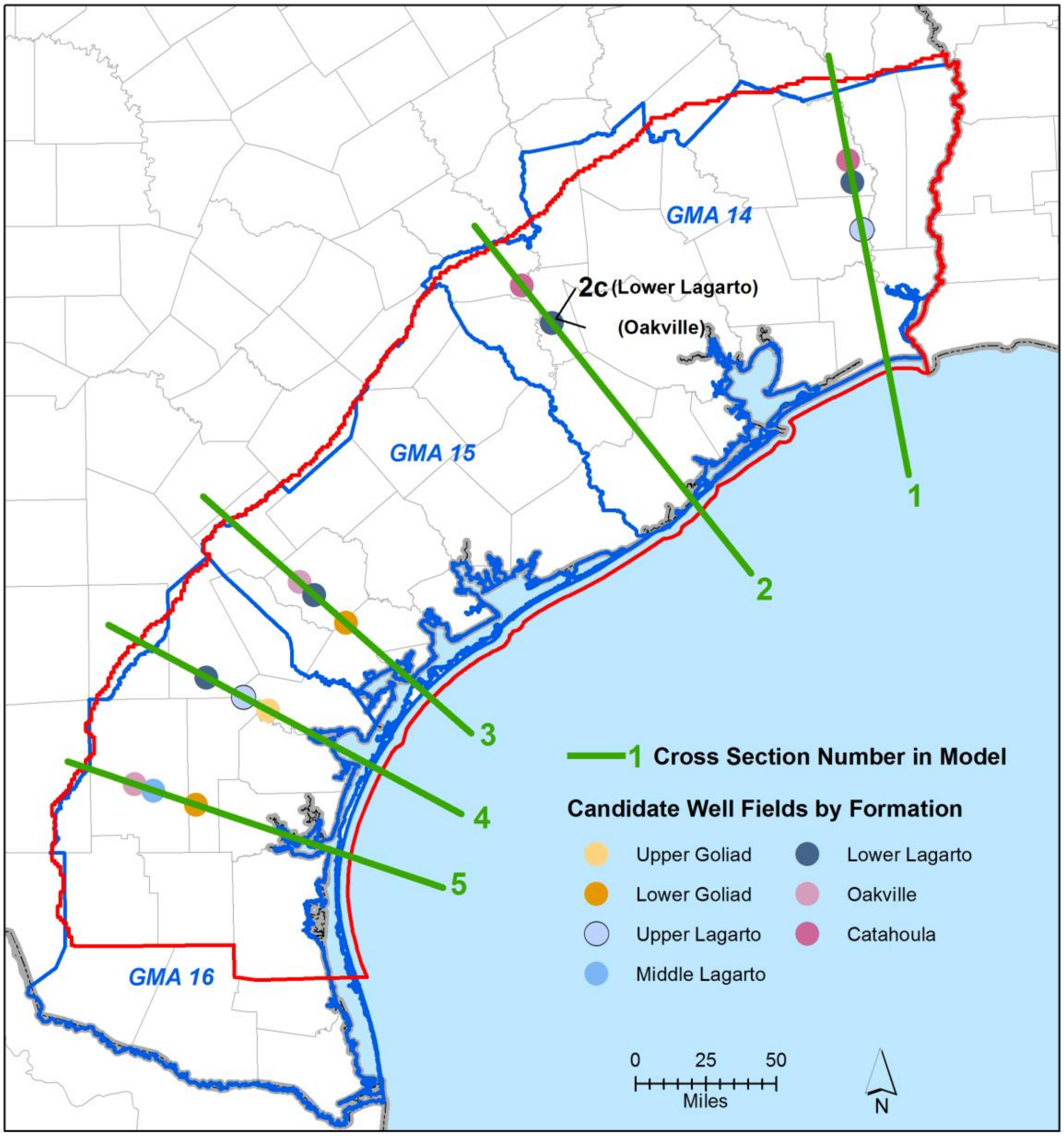


Figure 14-5. Location of five vertical cross-sections used to develop five groundwater models.

Note: GMA=Groundwater Management Area

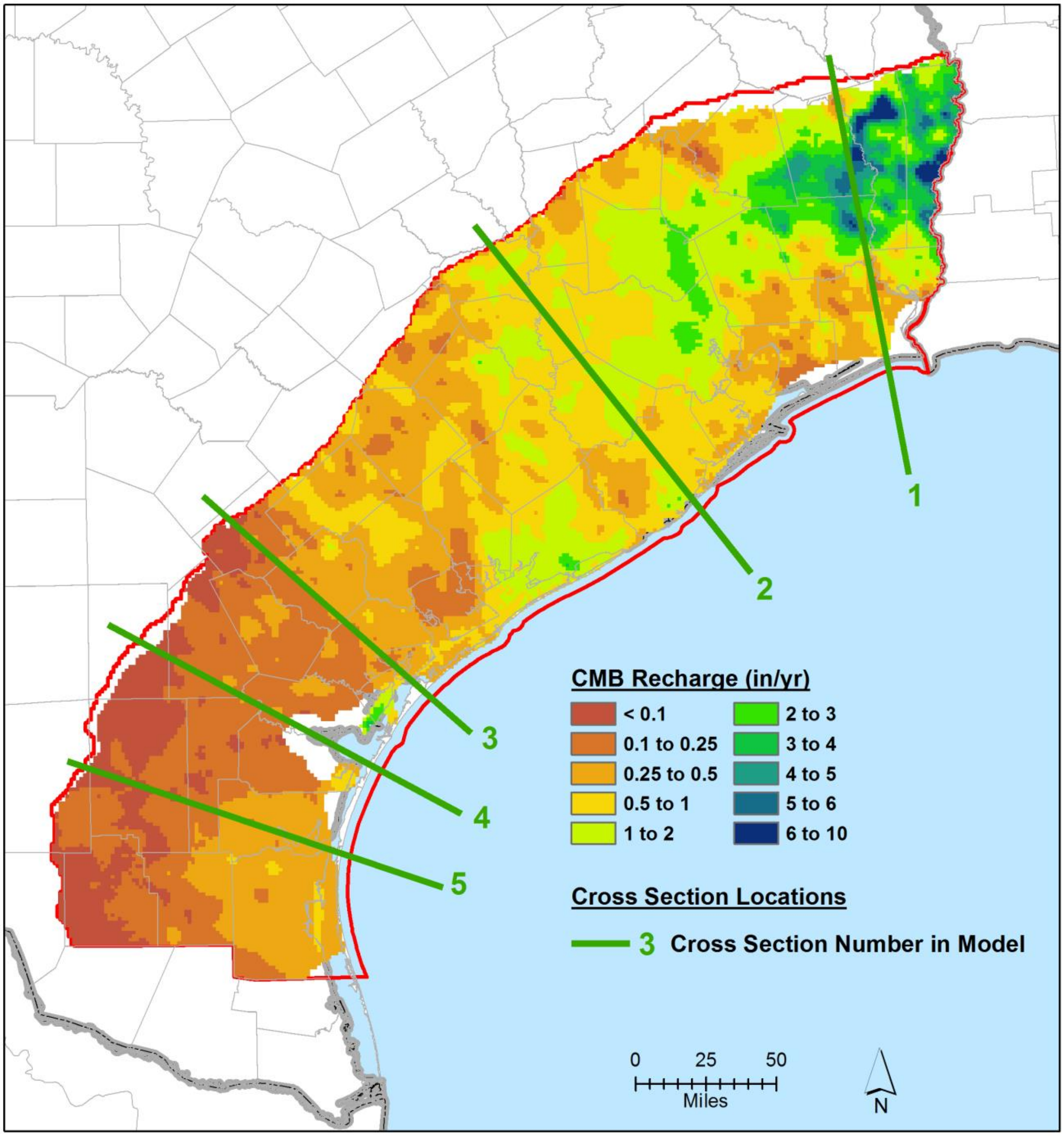


Figure 14-6. Recharge rates used in the groundwater models (from Scanlon and others, 2012).

Note: CMB=Chloride mass balance; in/yr= inches per year

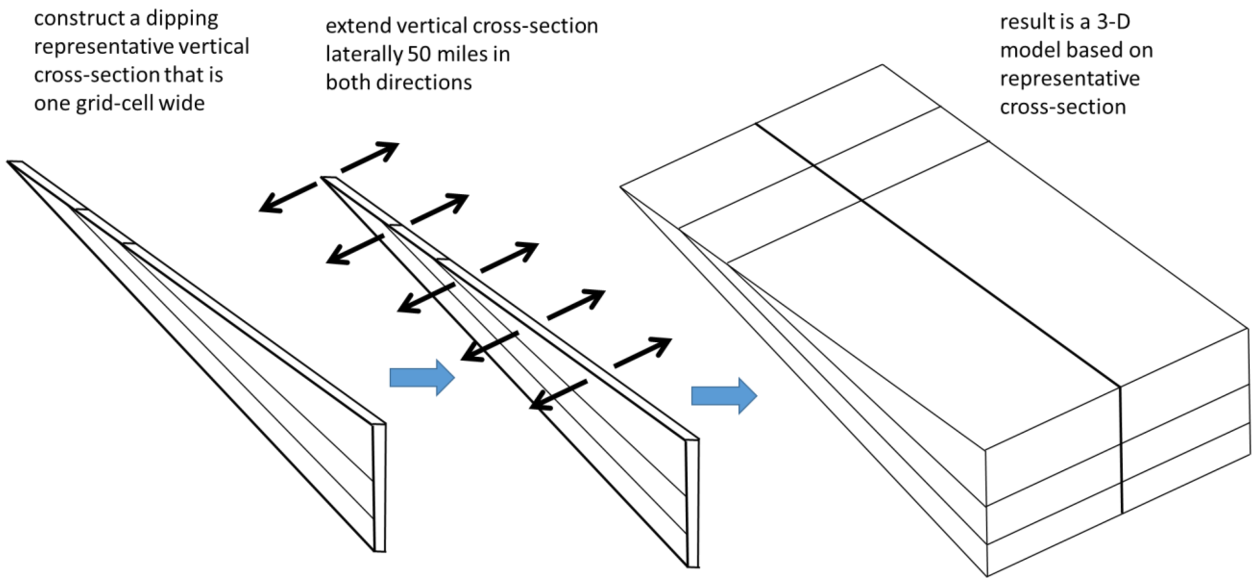


Figure 14-7. Schematic showing the lateral outward replication of a vertical cross-section, which is one grid-cell wide, to construct a three-dimensional model that covers a distance of 50 miles on both sides of the original cross-section.

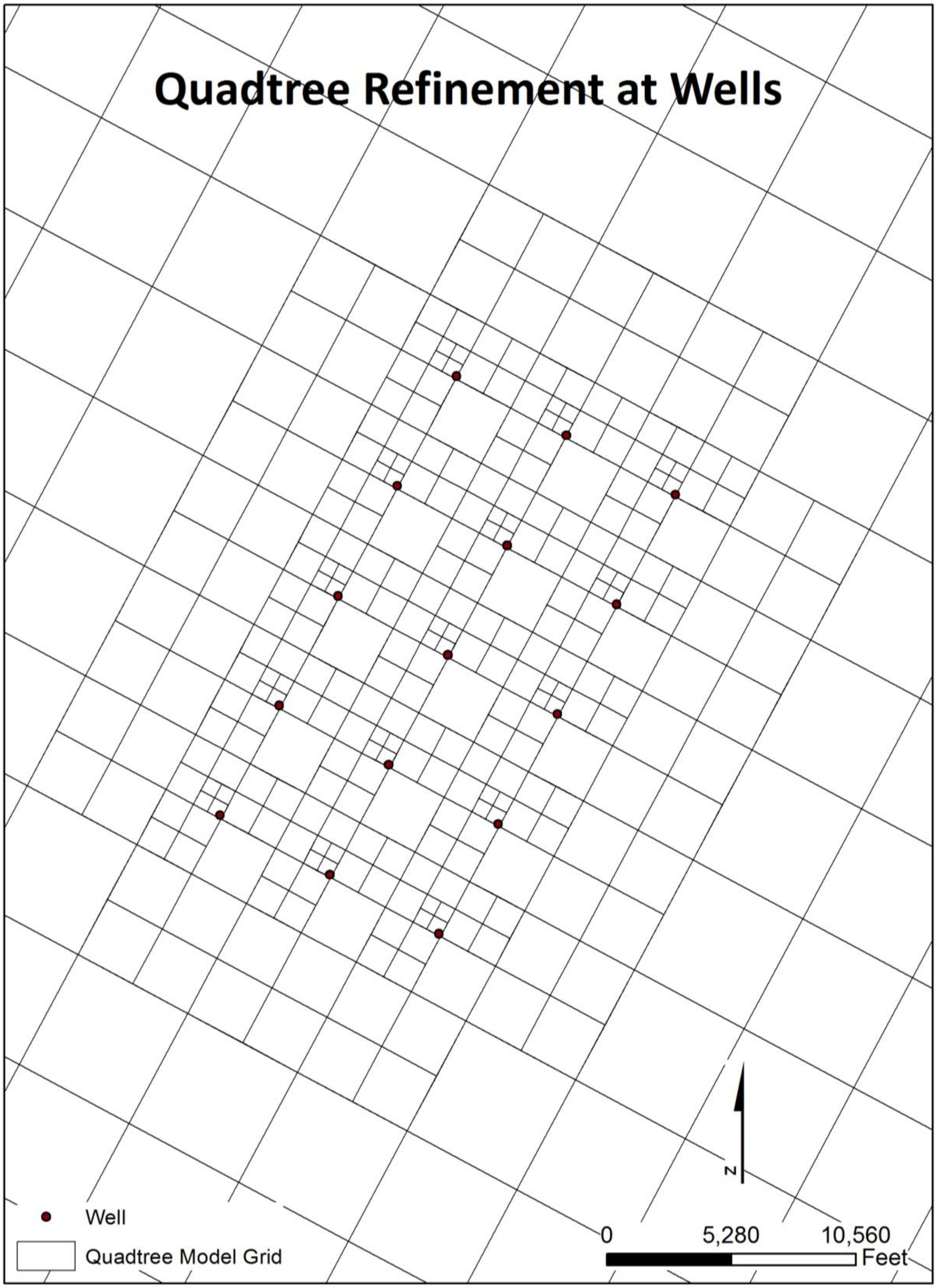


Figure 14-8. Aerial view of the groundwater model for cross-section #1 on Figure 14-5 showing quadtree refinement that occurs in the vicinity of the well fields to reduce from 1-mile by 1-mile grid cells to 1/8-mile by 1/8-mile grid cells.

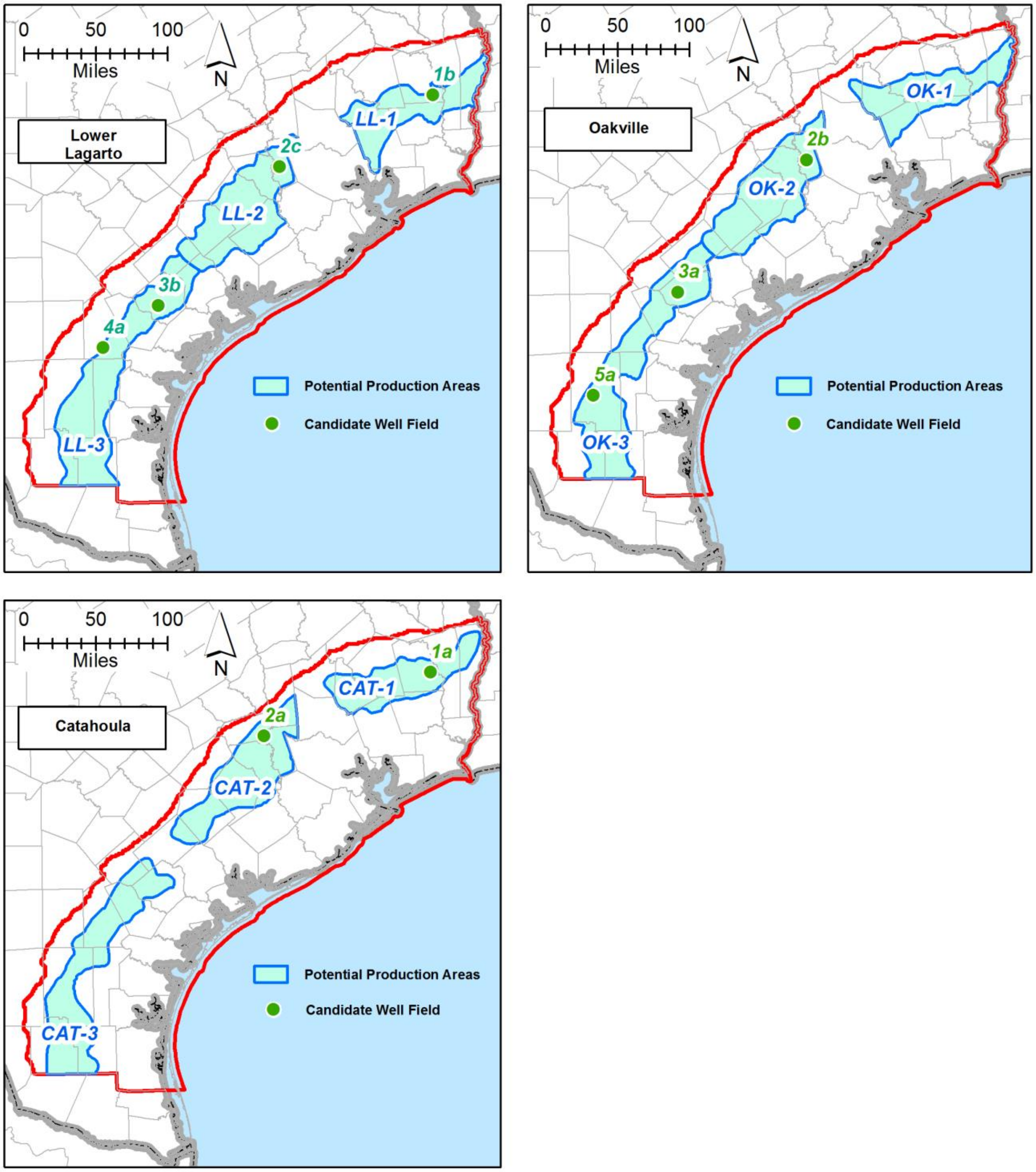


Figure 14-9. Potential Production Areas and well fields in the Jasper and Catahoula formations

Note: LL=Lower Lagarto; OK=Oakville; CAT=Catahoula

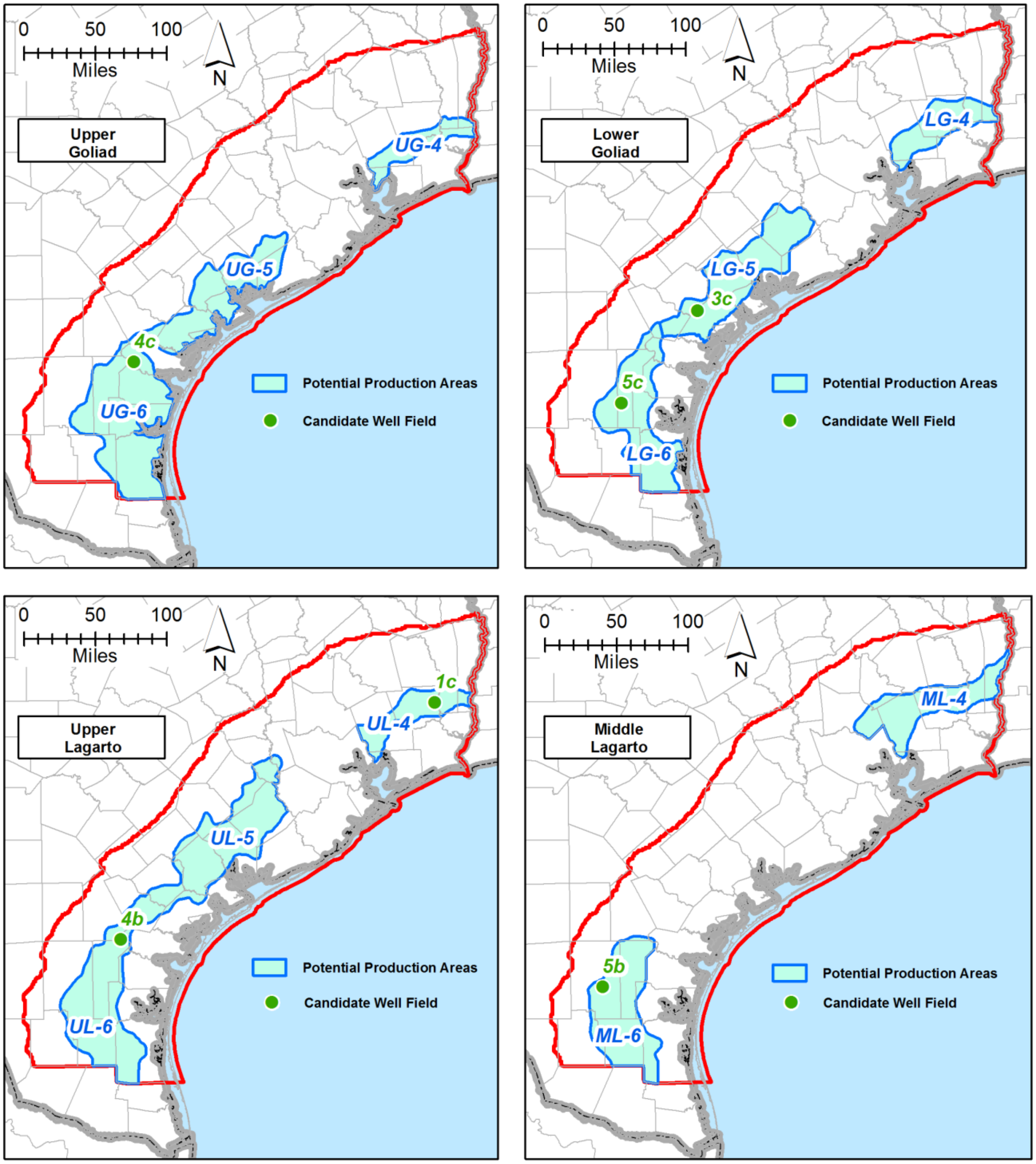


Figure 14-10. **Potential Production Areas and well fields in the Evangeline and Burkeville formations**

Note: UG=Upper Goliad; LG=Lower Goliad; UG=Upper Lagarto; ML=Middle Lagarto

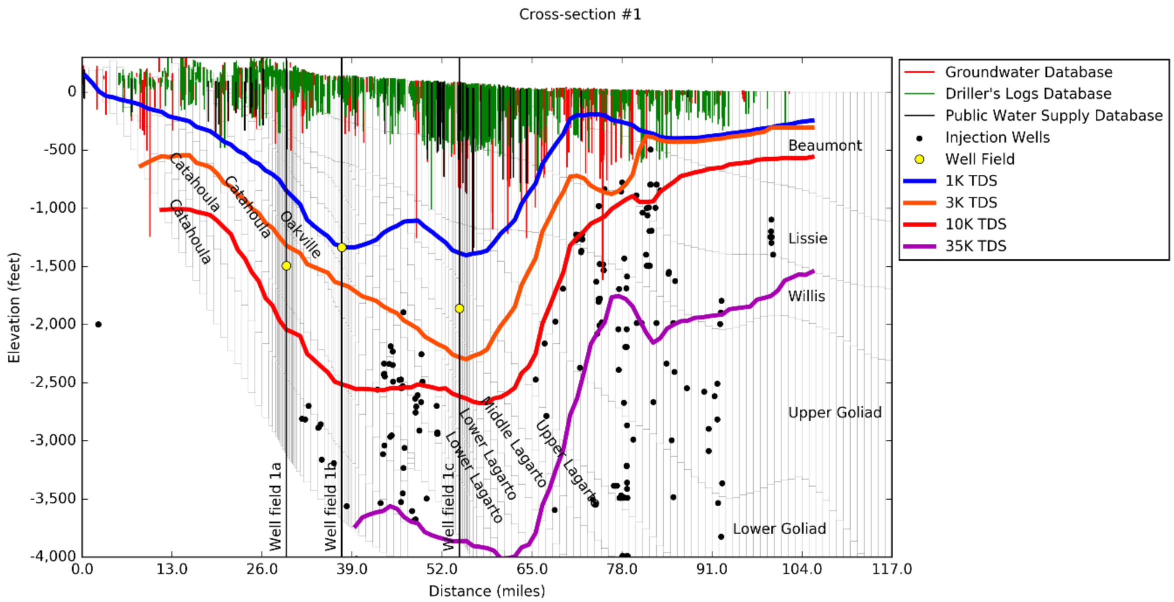


Figure 14-11. Boundaries for fresh water, slightly saline, moderately saline, and very saline groundwater along cross-section #1 on Figure 14-5.

Note: TDS=total dissolved solids reported in milligrams per liter; K= times 1,000

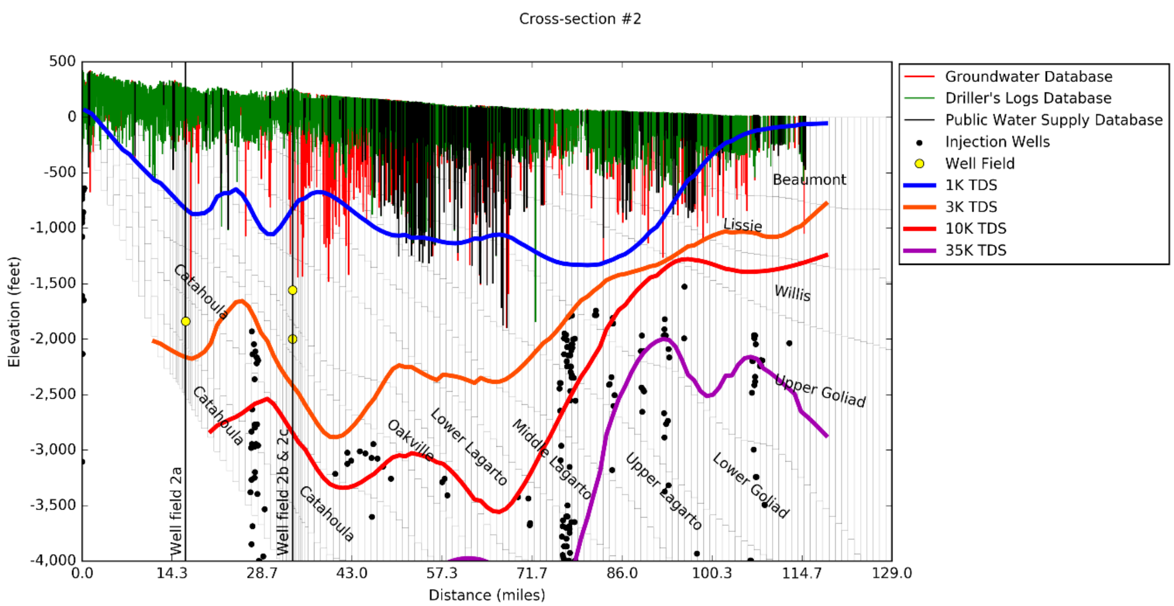


Figure 14-12. Boundaries for fresh water, slightly saline, moderately saline, and very saline groundwater along cross-section #2 on Figure 14-5.

Note: TDS=total dissolved solids reported in milligrams per liter; K= times 1,000

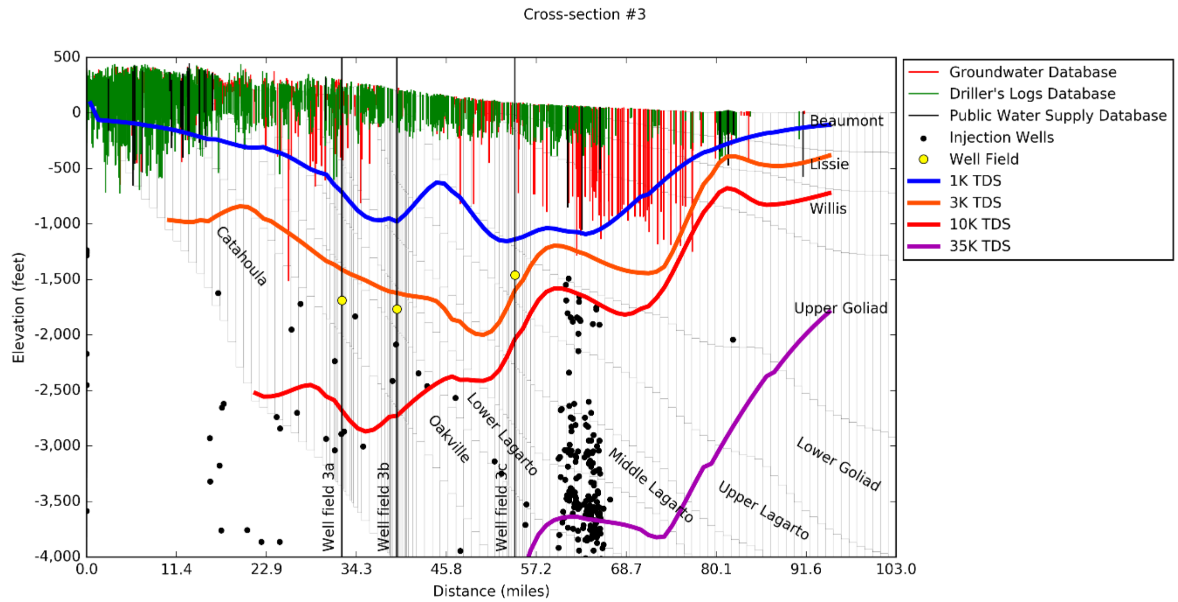


Figure 14-13. **Boundaries for fresh water, slightly saline, moderately saline, and very saline groundwater along cross-section #3 on Figure 14-5.**

Note: TDS=total dissolved solids reported in milligrams per liter; K= times 1,000

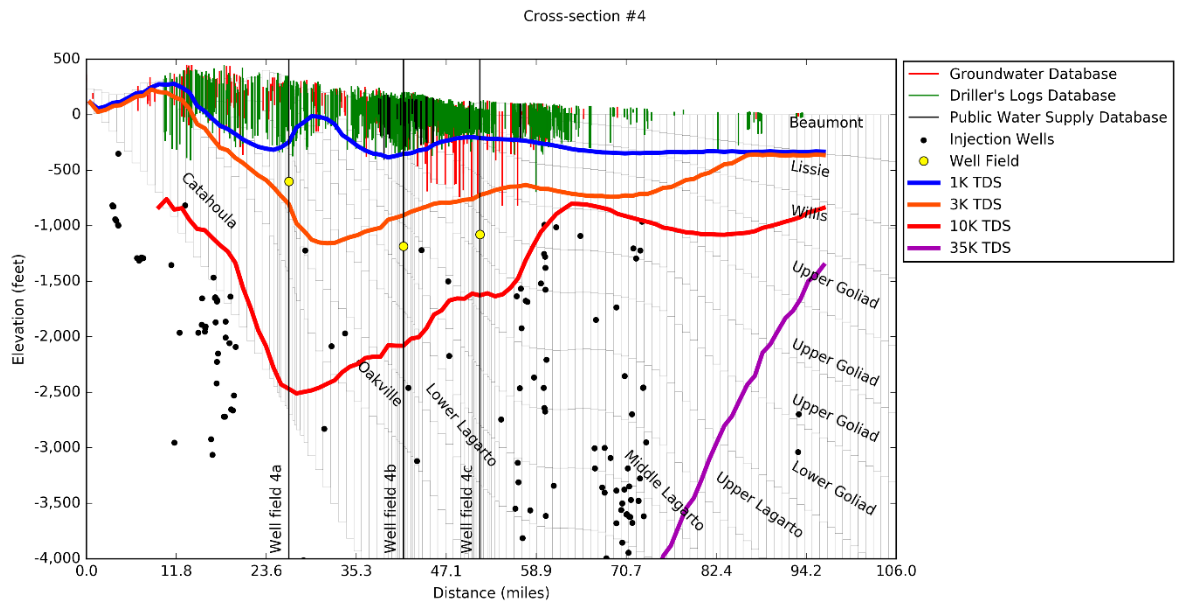


Figure 14-14. **Boundaries for fresh water, slightly saline, moderately saline, and very saline groundwater along cross-section #4 on Figure 14-5.**

Note: TDS=total dissolved solids reported in milligrams per liter; K= times 1,000

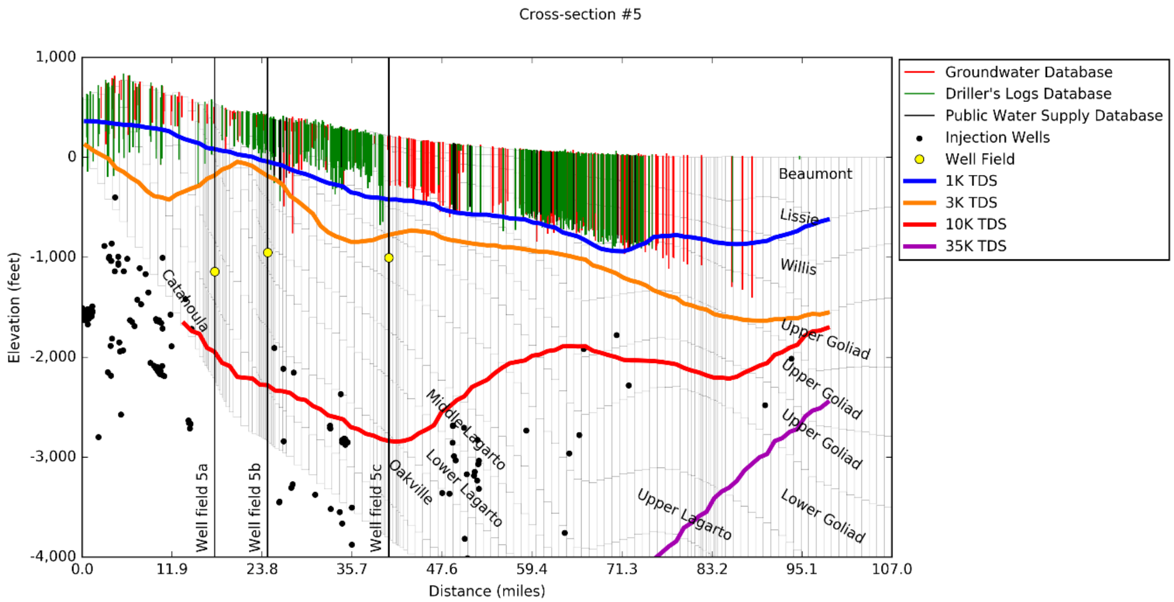


Figure 14-15. Boundaries for fresh water, slightly saline, moderately saline, and very saline groundwater along cross-section #5 on Figure 14-5.

Note: TDS=total dissolved solids reported in milligrams per liter; K= times 1,000

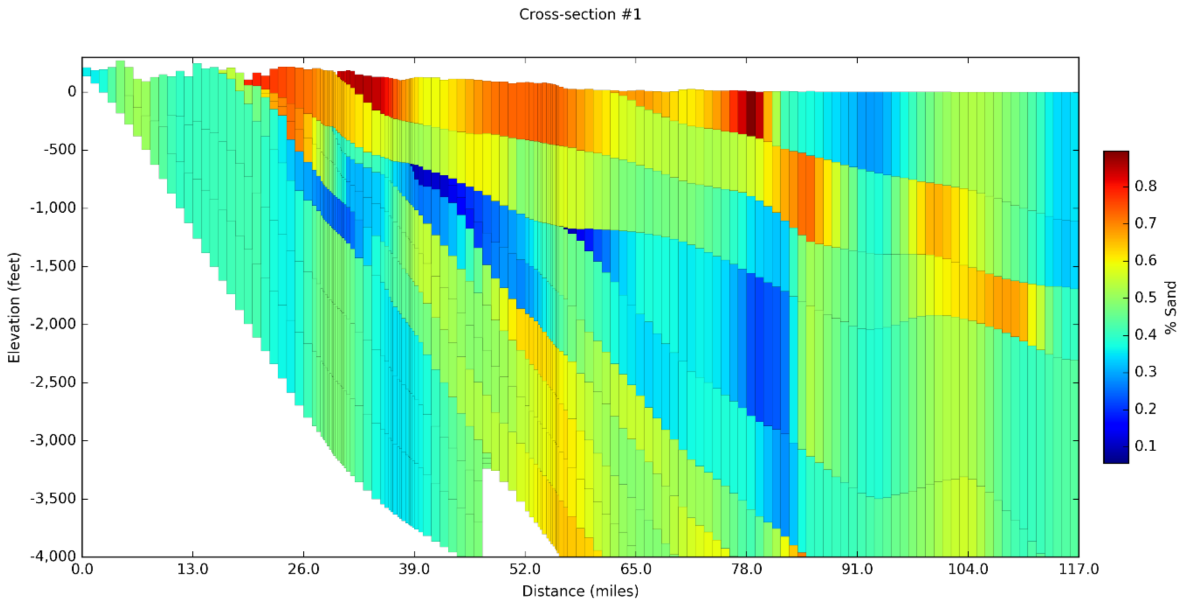


Figure 14-16. **Sand fraction for model layers 1 to 13 for a vertical cross-section cut through the three-dimensional model for cross-section #1 on Figure 14-5.**

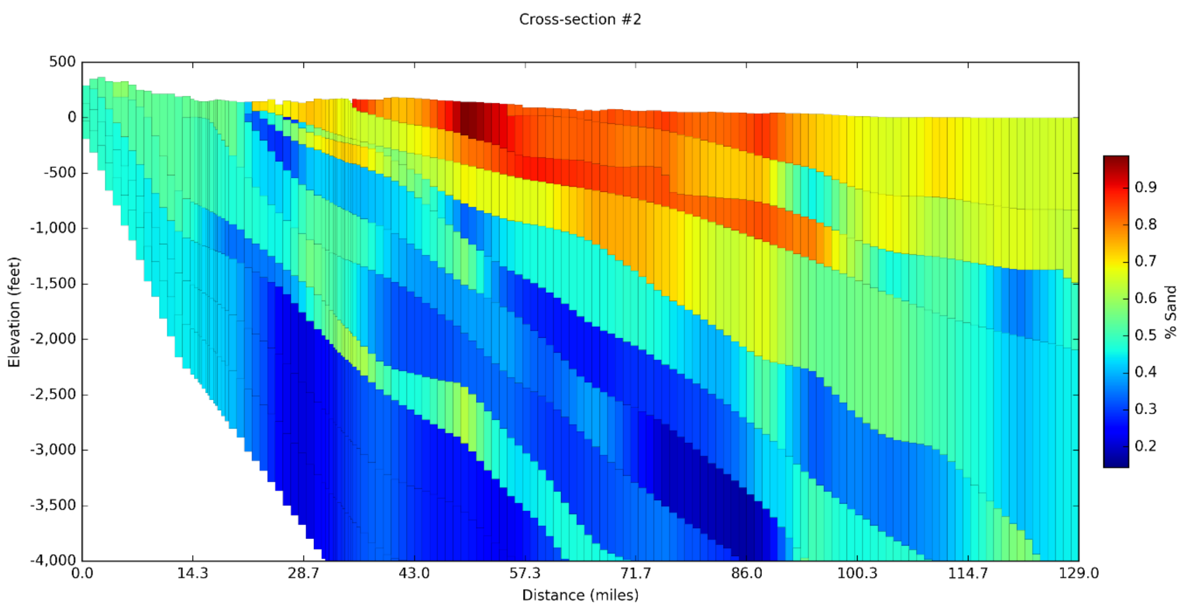


Figure 14-17. **Sand fraction for model layers 1 to 12 for a vertical cross-section cut through the three-dimensional model for cross section #2 on Figure 14-5.**

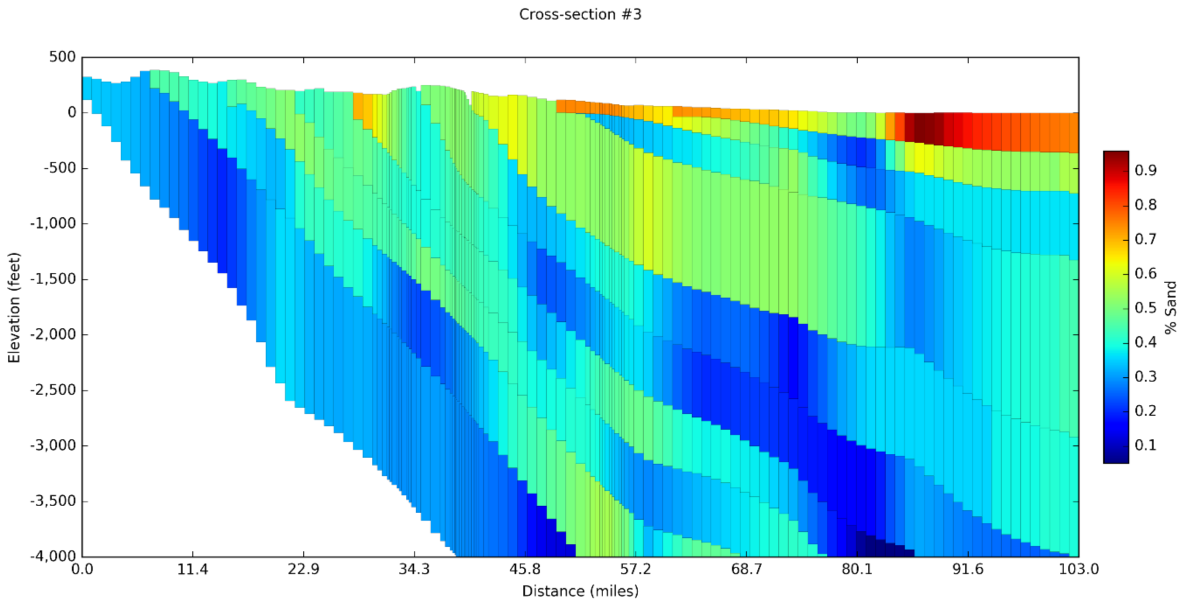


Figure 14-18. Sand fraction for model layers 1 to 10 for a vertical cross-section cut through the three-dimensional model for cross-section #3 on Figure 14-5.

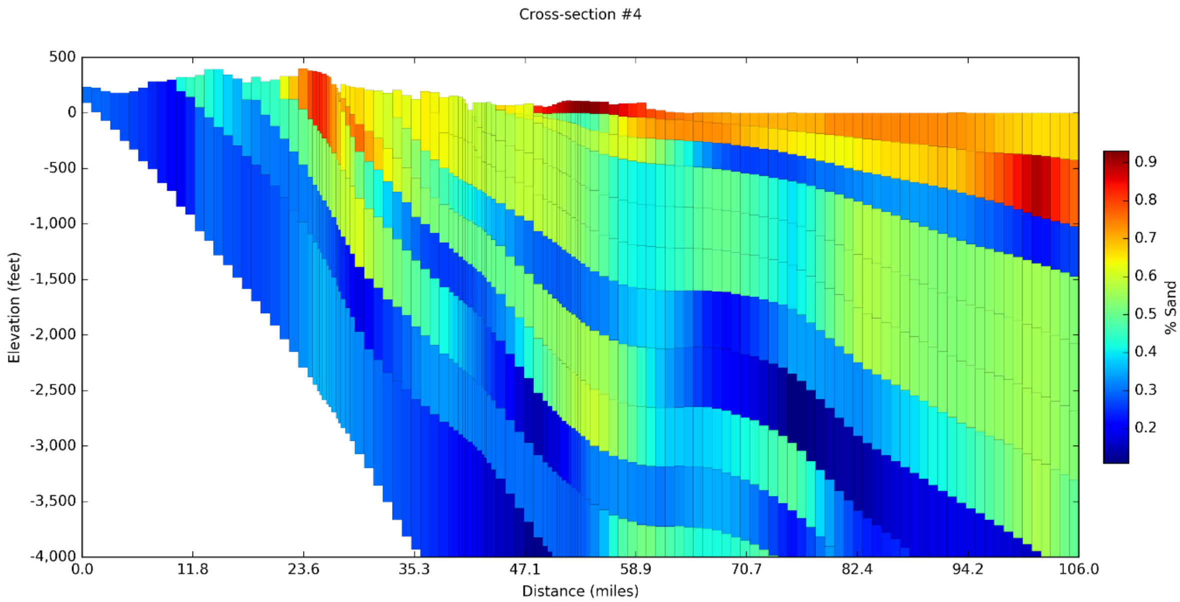


Figure 14-19. Sand fraction for model layers 1 to 12 for a vertical cross-section cut through the three-dimensional model for cross-section #4 on Figure 14-5.

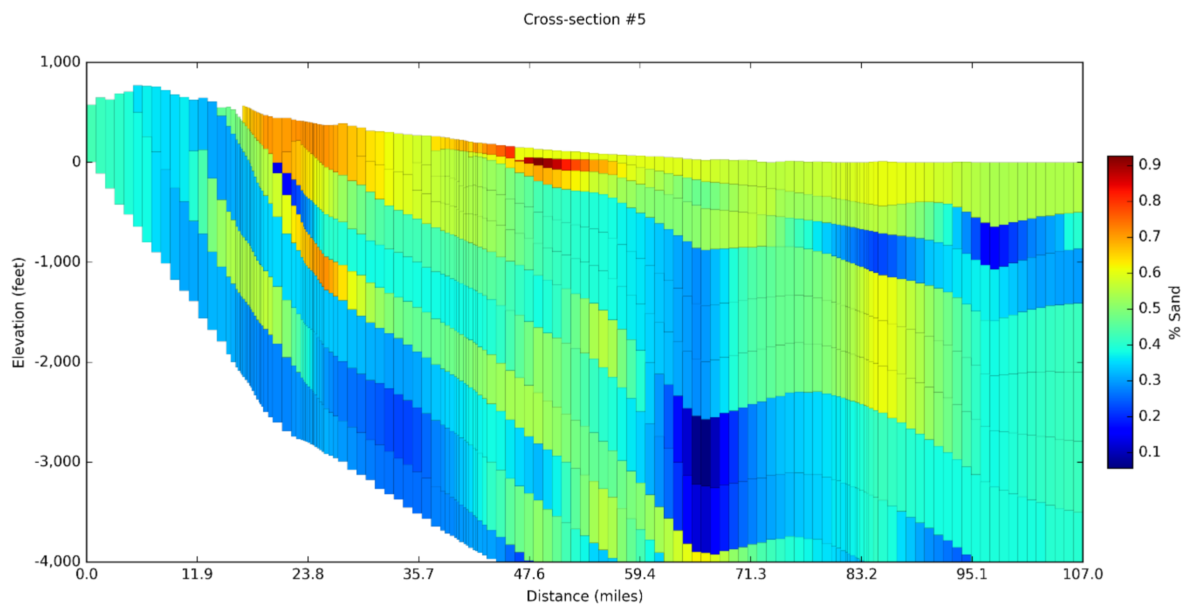


Figure 14-20. **Sand fraction for model layers 1 to 12 for a vertical cross-section cut through the three-dimensional model for cross-section #5 on Figure 14-5.**

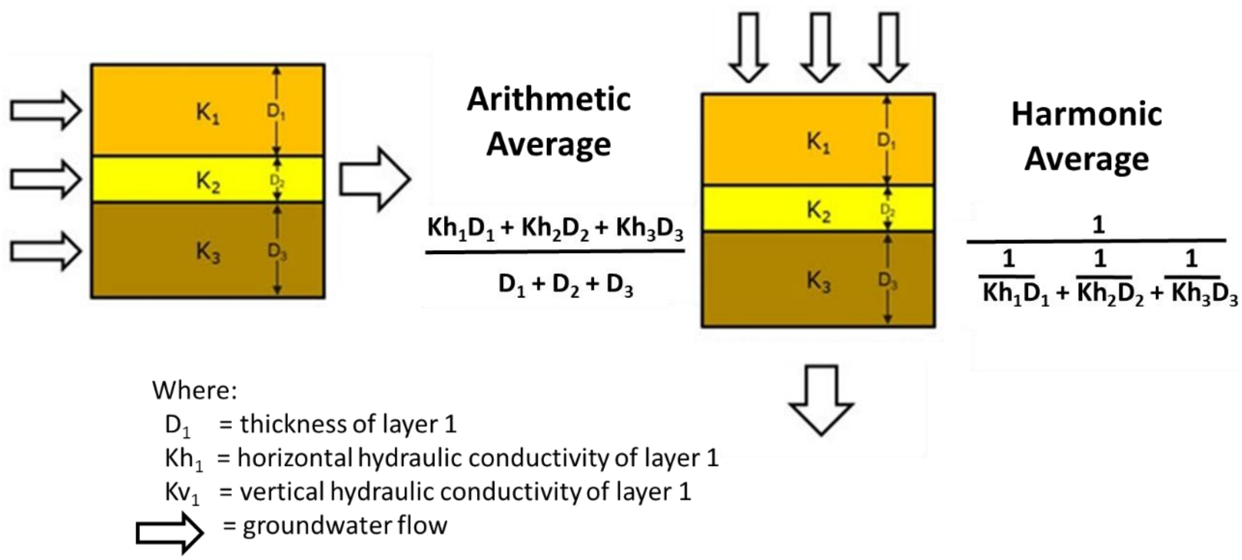


Figure 14-21. **Schematic showing the application of an arithmetic average and a harmonic average to calculate equivalent horizontal and vertical hydraulic conductivities based on the assumption of one-dimension flow through uniform layered media.**

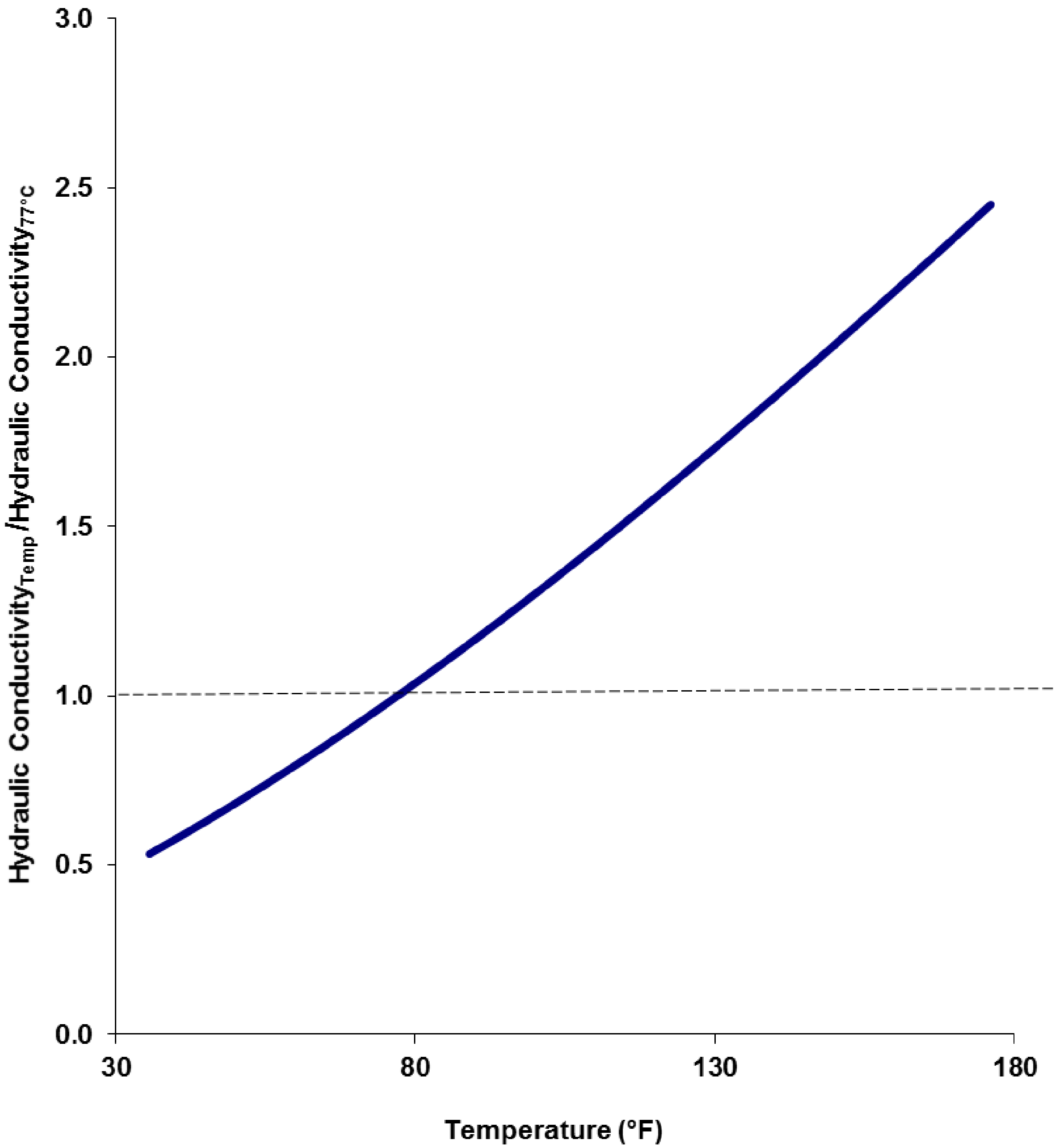


Figure 14-22. **Relative change in hydraulic conductivity values caused by the temperature dependence of the density and viscosity of water.**

Note: °F=degrees Fahrenheit; Hydraulic Conductivity$_{Temp}$=hydraulic conductivity corrected for temperature; Hydraulic Conductivity$_{77°C}$=hydraulic conductivity at 77 degrees Celsius

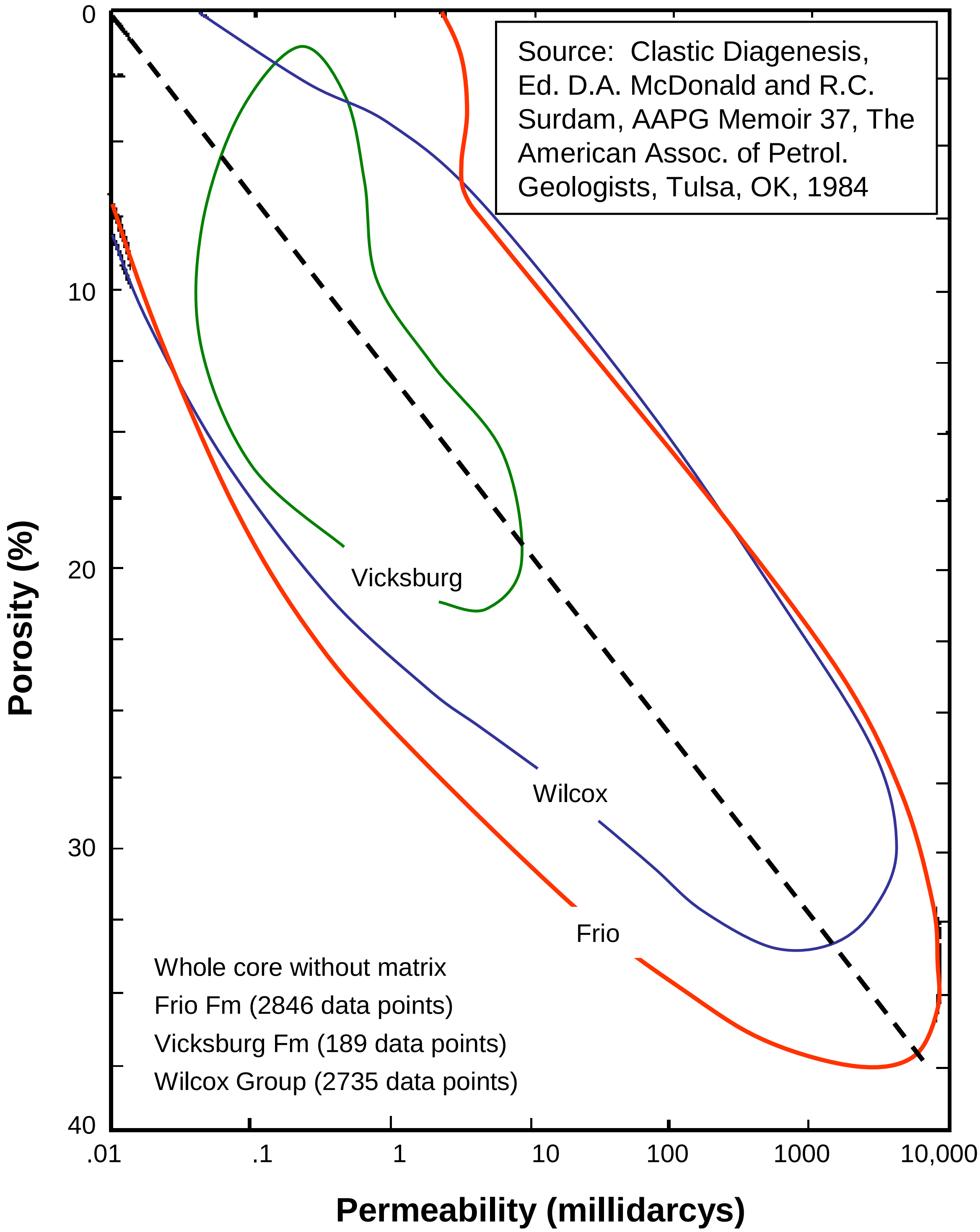


Figure 14-23. **Measured relationship between porosity in percent and permeability in millidarcys measured in laboratory cores for geological formations in Texas (modified from Loucks and others, 1986).**

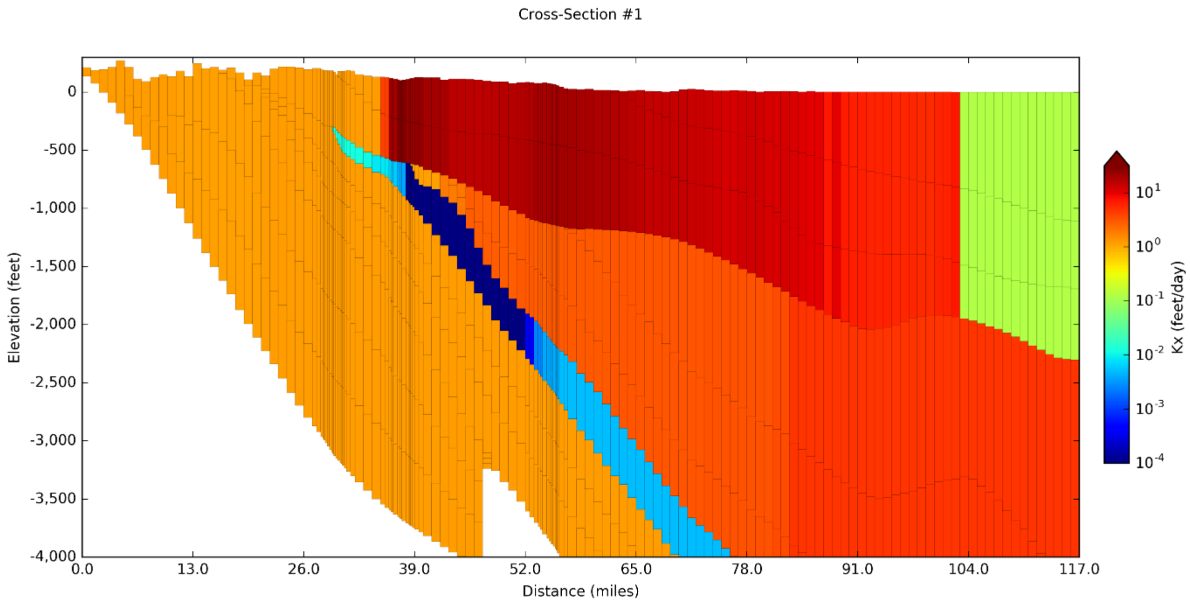


Figure 14-24. **Horizontal hydraulic conductivity (Kx) values for cross-section #1 on Figure 14-5 with aquifer properties from the Houston Area Groundwater Model (Kasmarek, 2012) for model layers 1 to 13.**

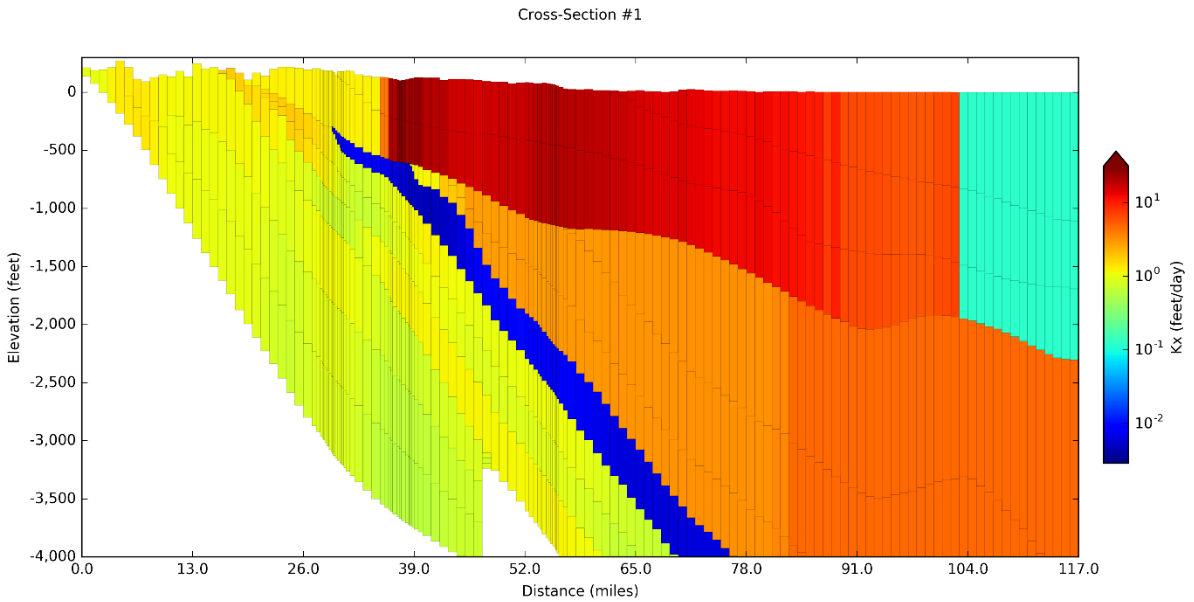


Figure 14-25. **Horizontal hydraulic conductivity (Kx) values in the groundwater model for cross-section #1 on Figure 14-5 for model layers 1 to 13.**

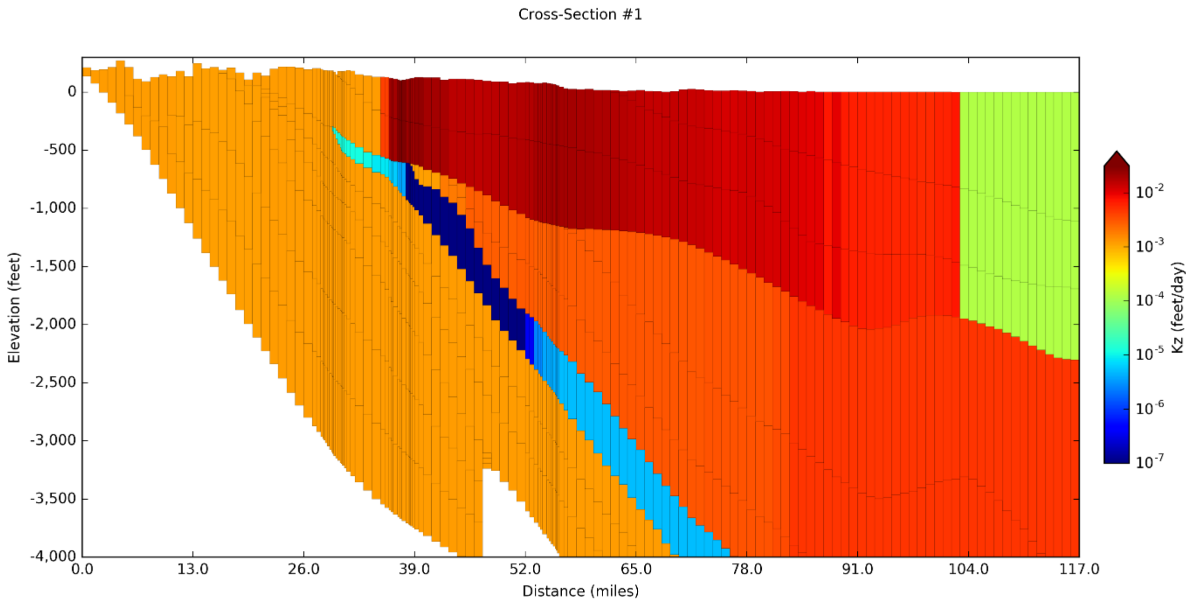


Figure 14-26. Vertical hydraulic conductivity (Kz) values for cross-section #1 on Figure 14-5 with aquifer properties from the Houston Area Groundwater Model (Kasmarek, 2012) for model layers 1 to 13.

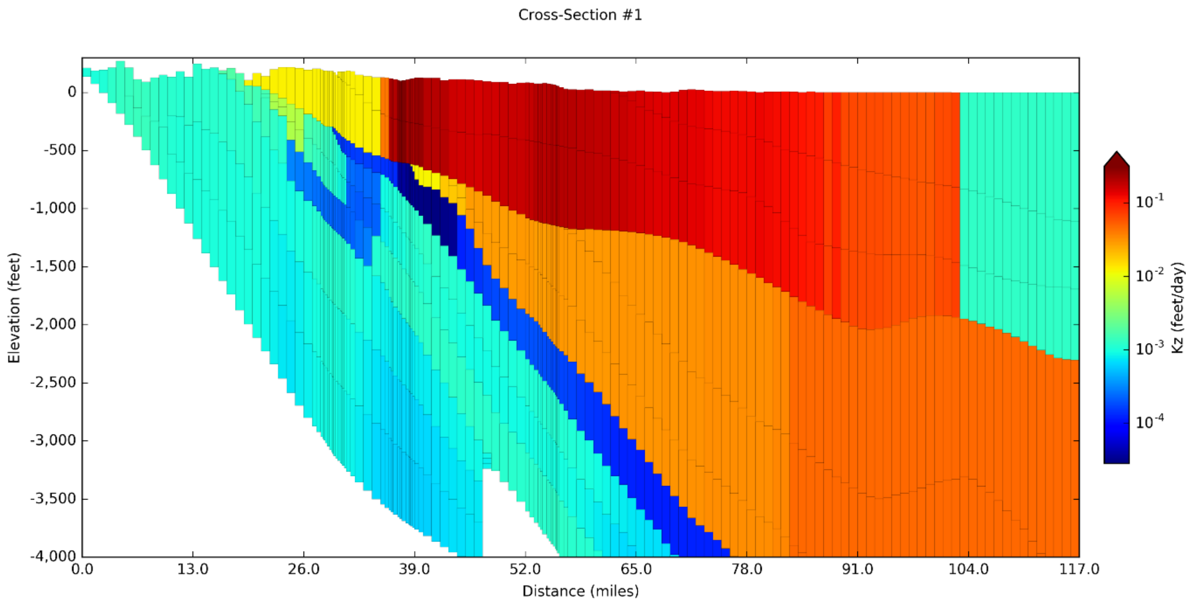


Figure 14-27. Vertical hydraulic conductivity (Kz) values in the groundwater model for cross-section #1 on Figure 14-5 for model layers 1 to 13.

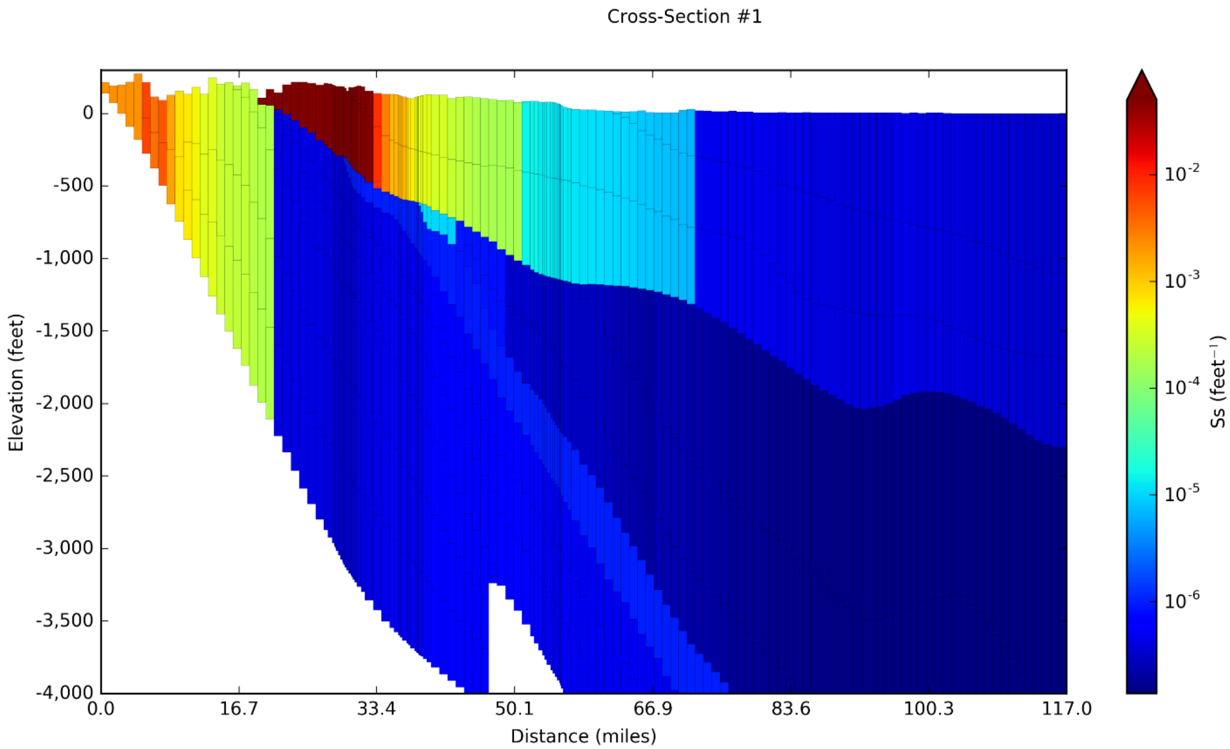


Figure 14-28. **Specific storage (Ss) values for cross-section #1 on Figure 14-5 with aquifer properties from the Houston Area Groundwater Model (Kasmarek, 2012) for model layers 1 to 13.**

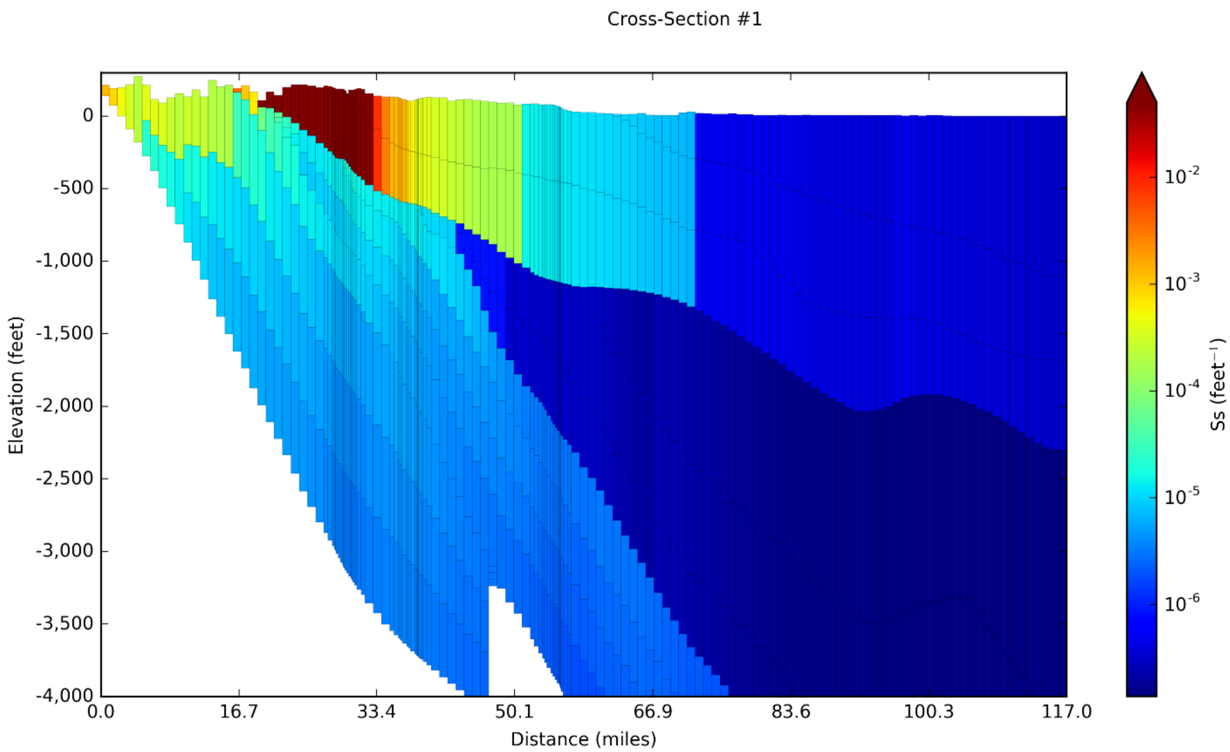


Figure 14-29. **Specific storage (Ss) values in the groundwater model for cross-section #1 on Figure 14-5 for model layers 1 to 13.**

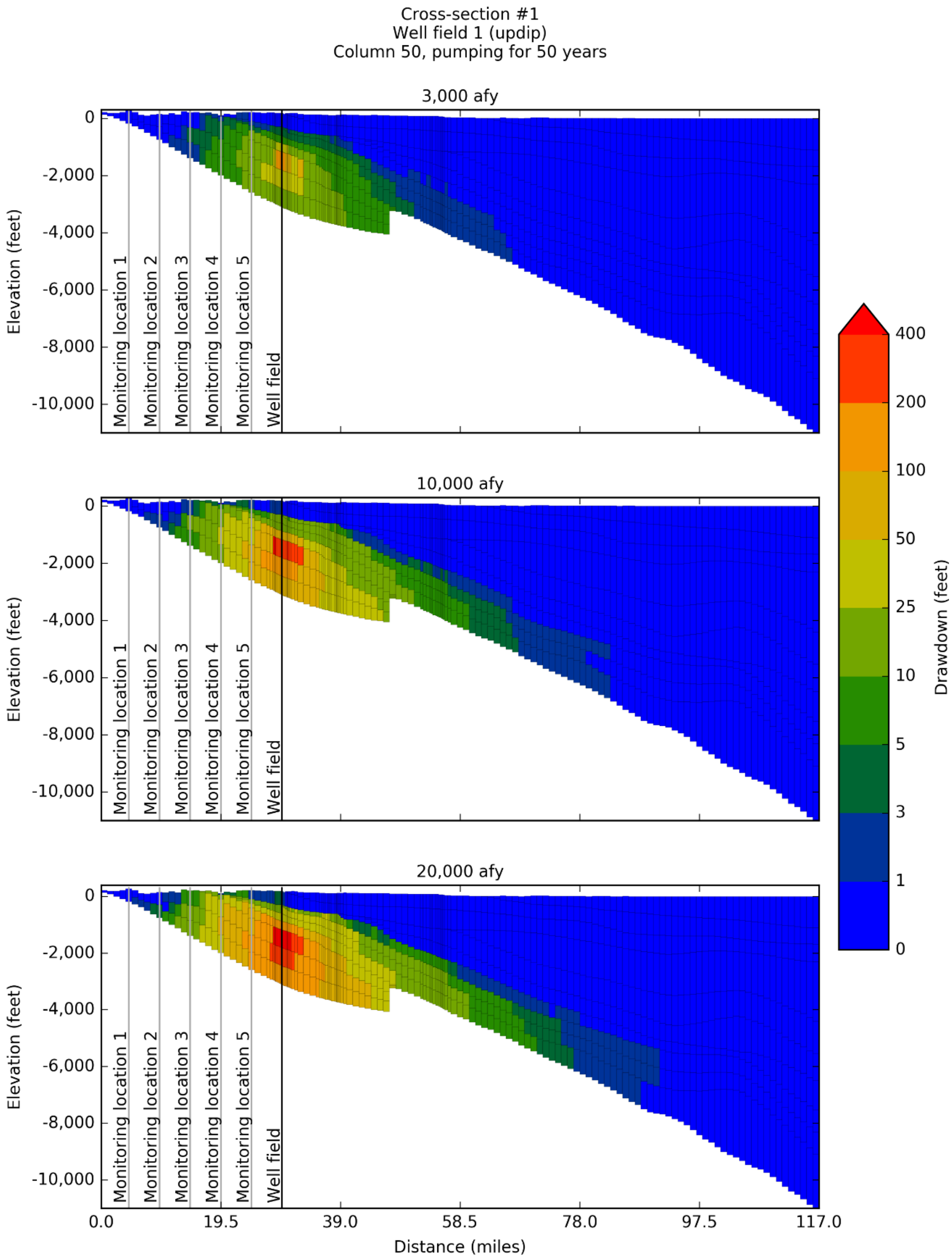


Figure 14-30. Simulated drawdown at 50 years after pumping the up dip Well Field #1a located along cross-section #1 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

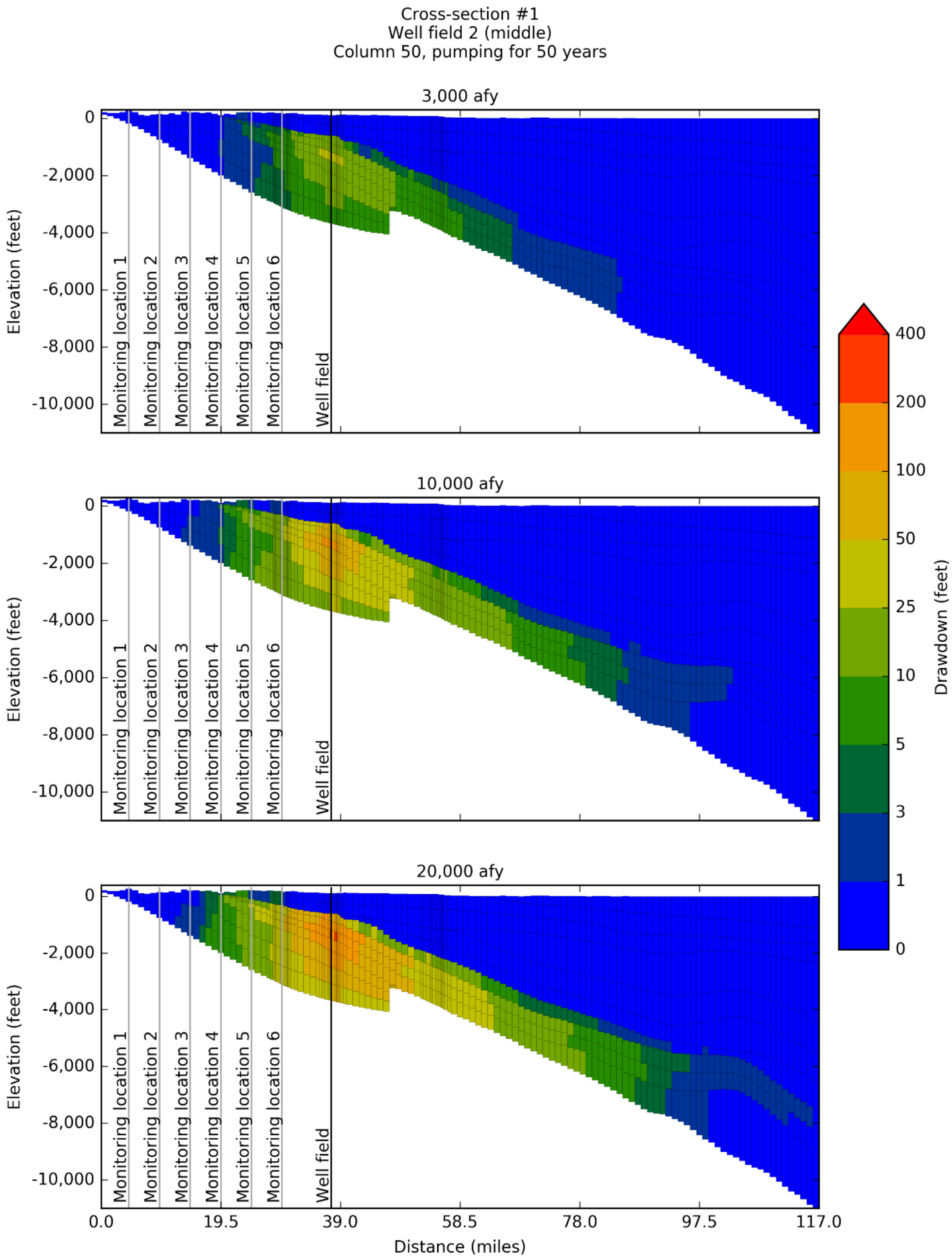


Figure 14-31. **Simulated drawdown at 50 years after pumping the middle Well Field #1b located along cross-section #1 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.**

Note: afy=acre-feet per year

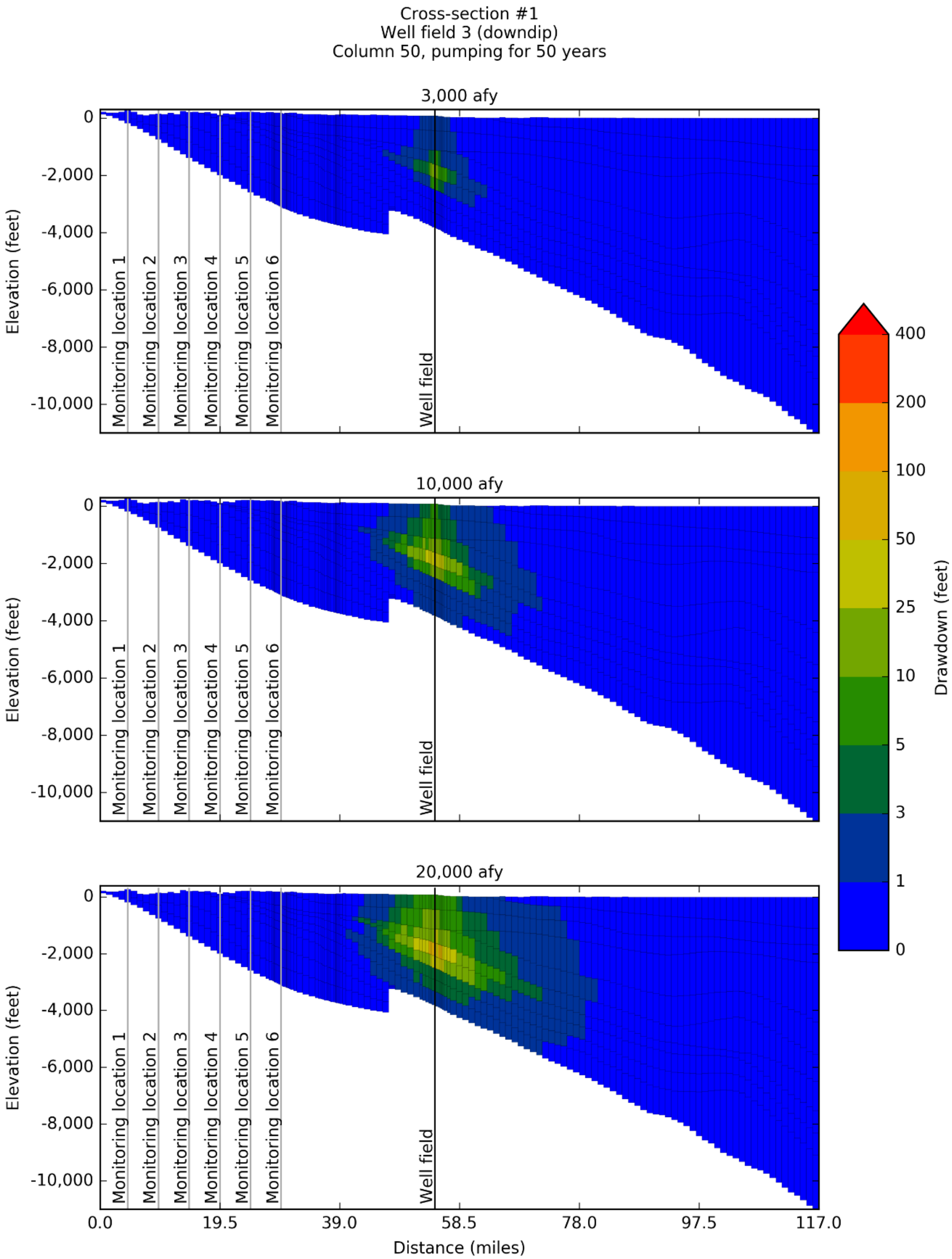


Figure 14-32. Simulated drawdown at 50 years after pumping the down dip Well Field #1c located along cross-section #1 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

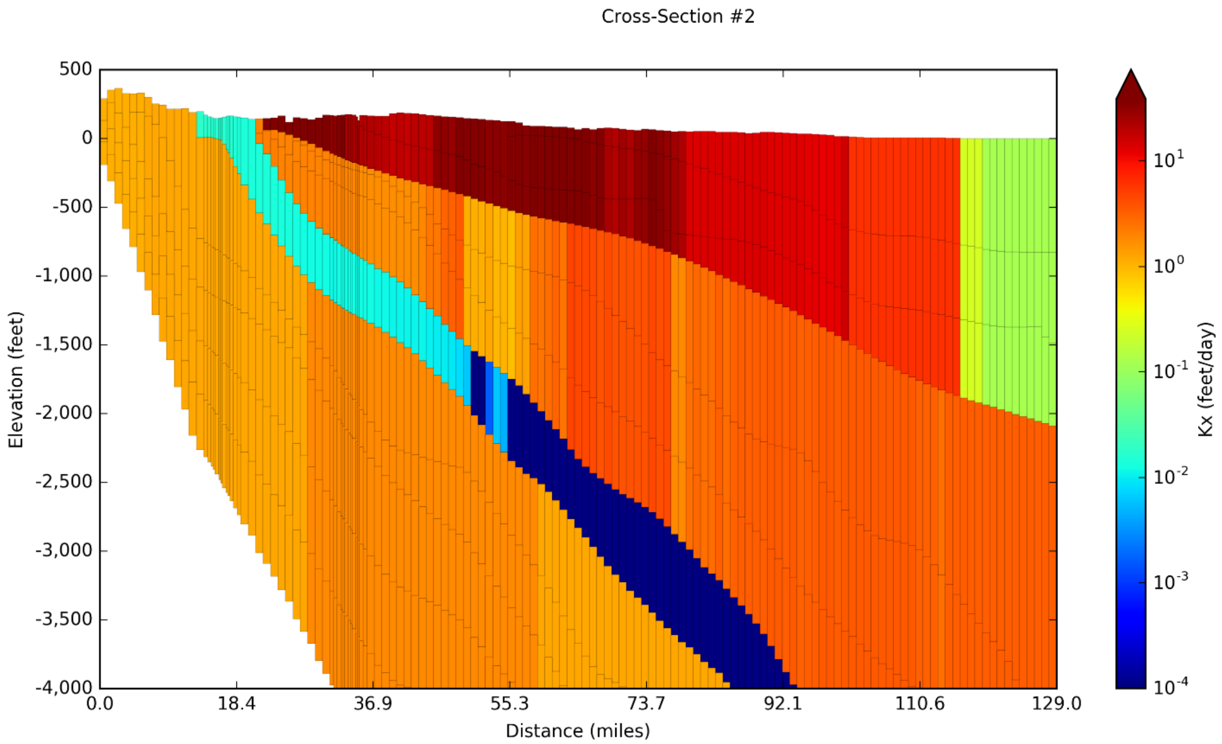


Figure 14-33. **Horizontal hydraulic conductivity (Kx) values for cross-section #2 on Figure 14-5 with aquifer properties from the Houston Area Groundwater Model (Kasmarek, 2012) for model layers 1 to 12.**

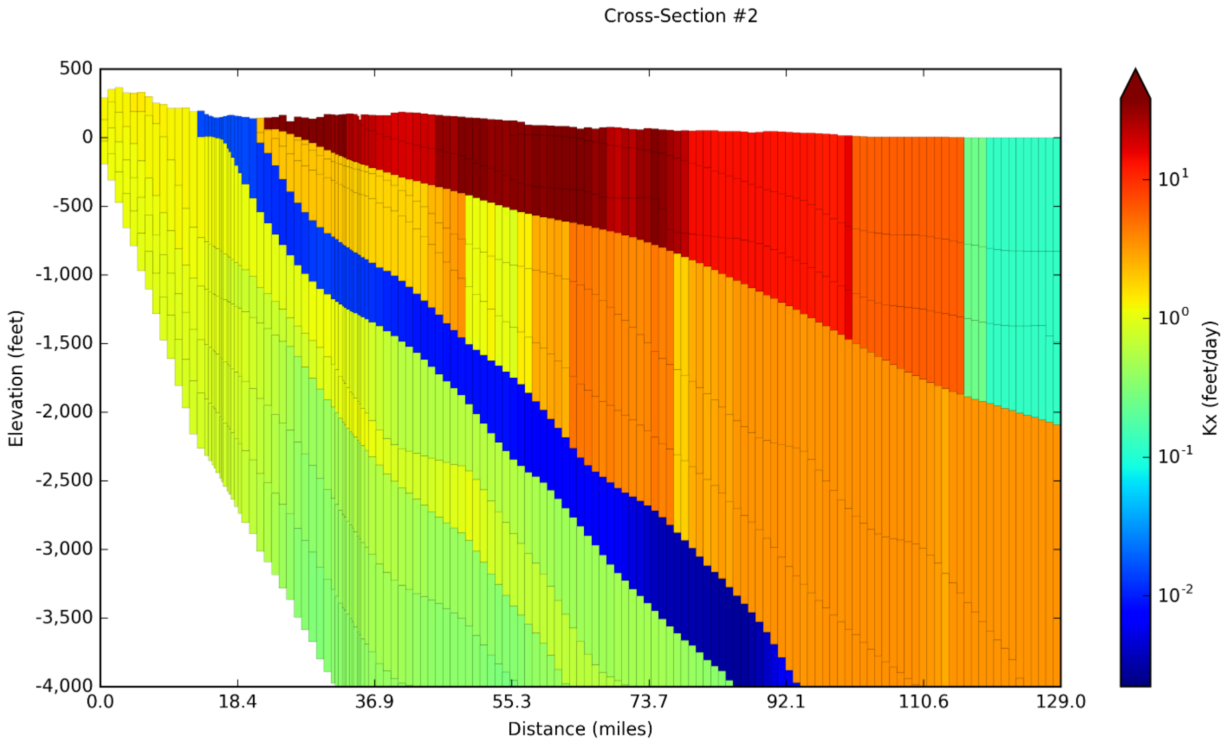


Figure 14-34. **Horizontal hydraulic conductivity (Kx) values in the groundwater model for cross-section #2 on Figure 14-5 for model layers 1 to 12.**

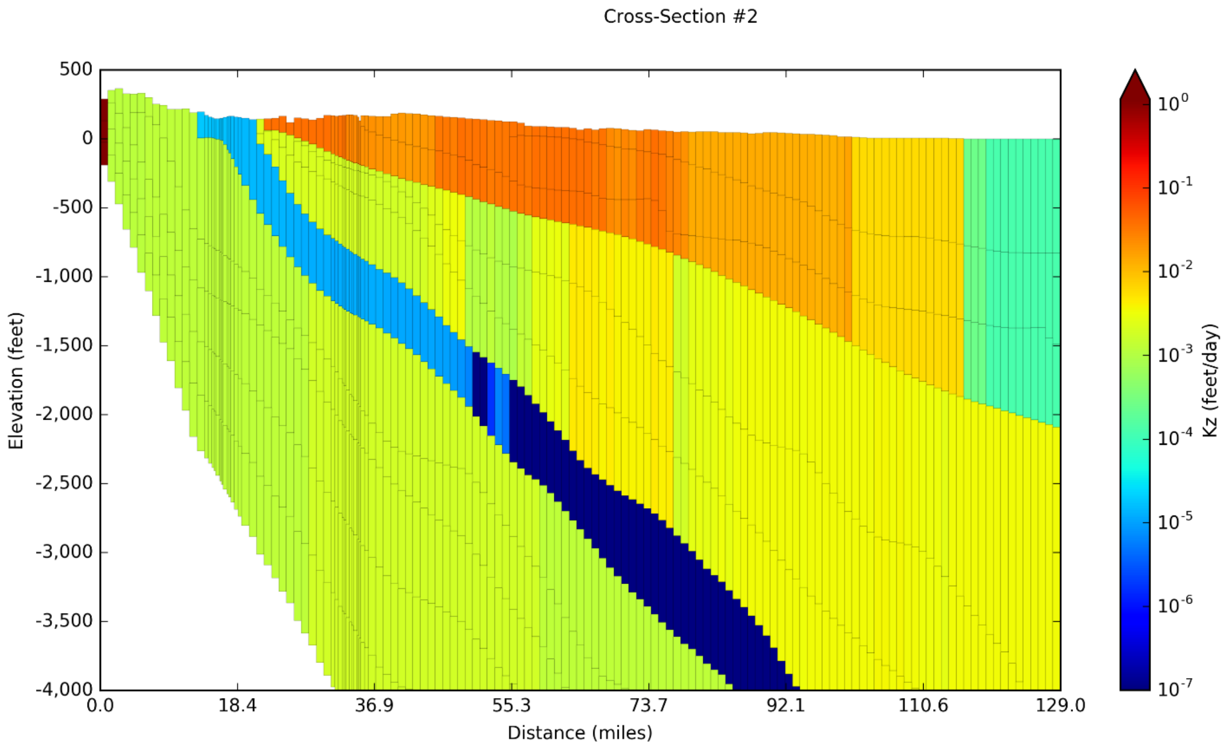


Figure 14-35. Vertical hydraulic conductivity (Kz) values for cross-section #2 on Figure 14-5 with aquifer properties from the Houston Area Groundwater Model (Kasmarek, 2012) for model layers 1 to 12.

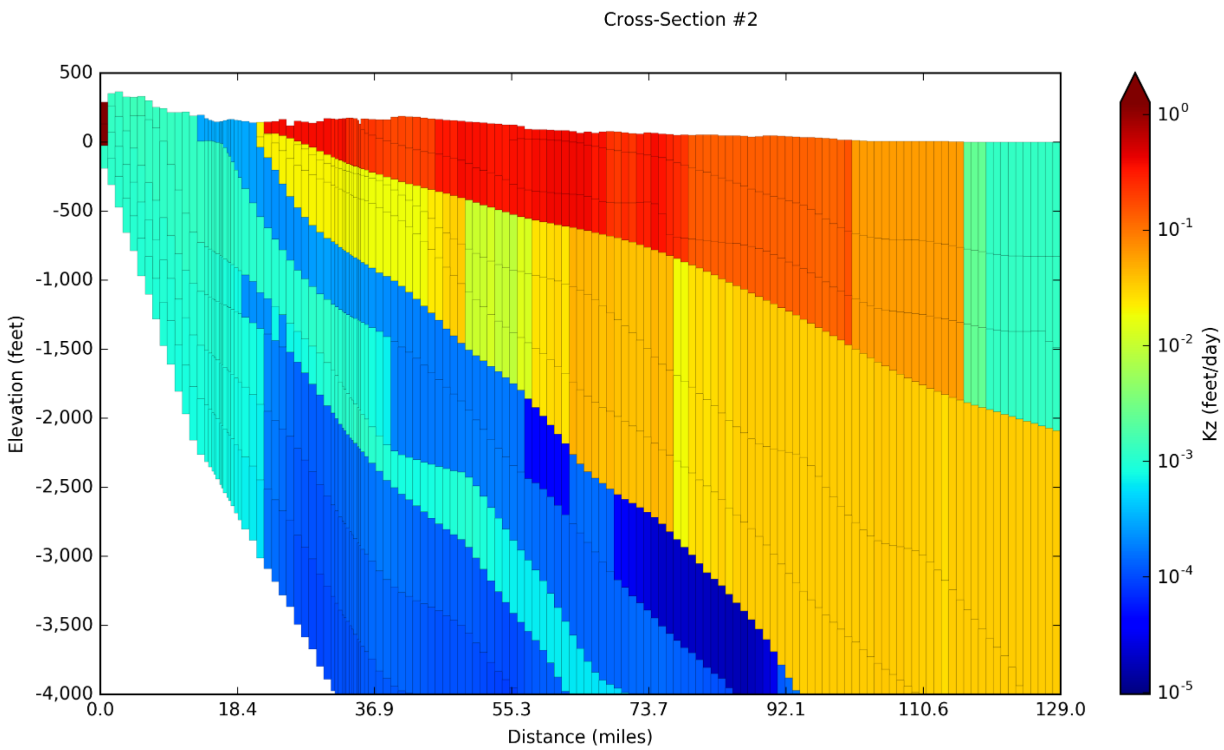


Figure 14-36. **Vertical hydraulic conductivity (Kz) values in the groundwater model for cross-section #2 on Figure 14-5 for model layers 1 to 12.**

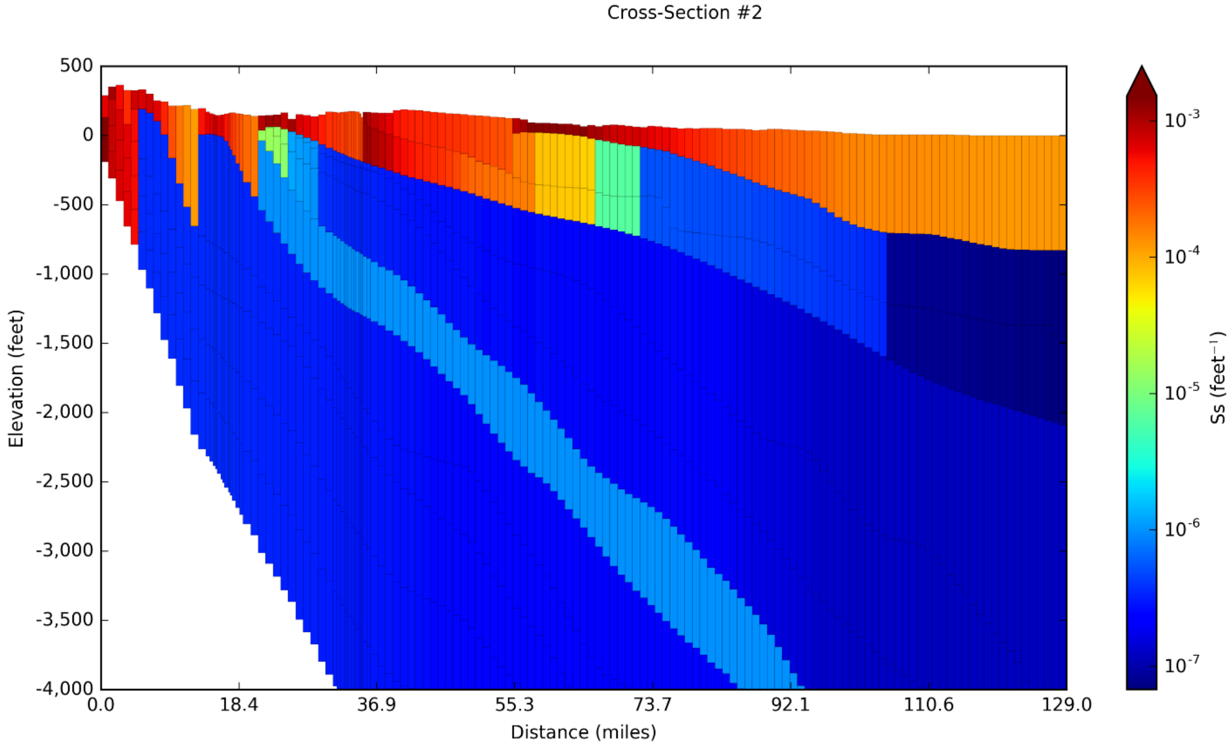


Figure 14-37. **Specific storage (Ss) values for cross-section #2 on Figure 14-5 with aquifer properties from the Houston Area Groundwater Model (Kasmarek, 2012) for model layers 1 to 12.**

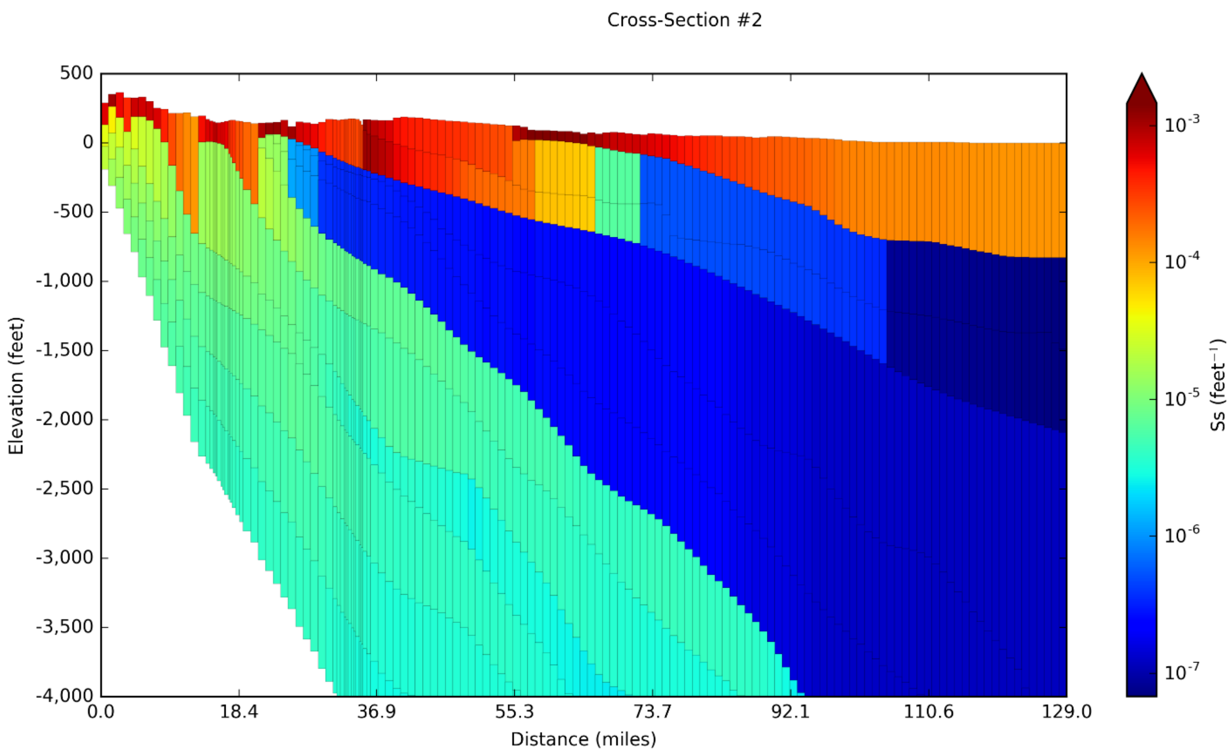


Figure 14-38. Specific storage (Ss) values in the groundwater model for cross-section #2 on Figure 14-5 for model layers 1 to 12.

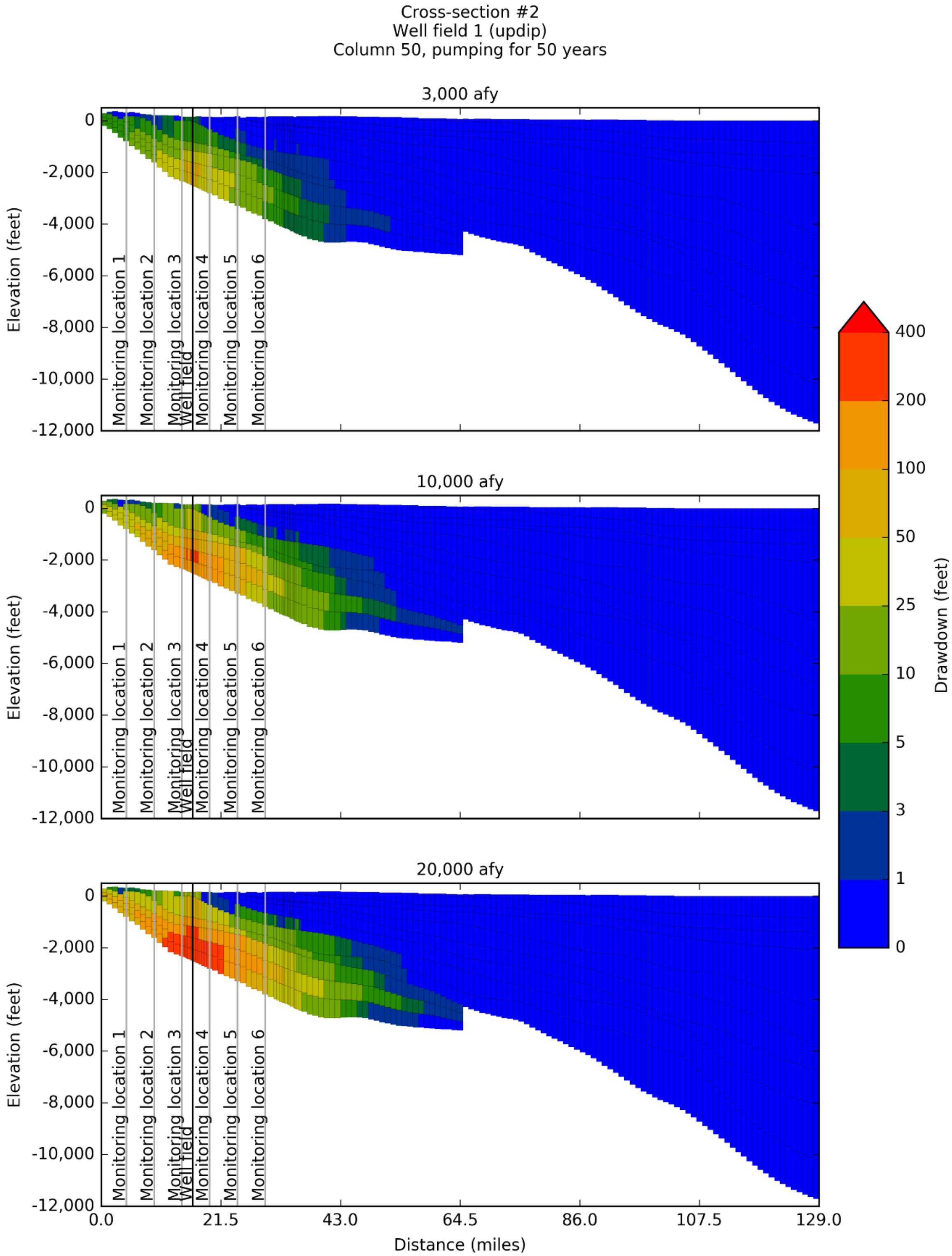


Figure 14-39. Simulated drawdown at 50 years after pumping the up dip Well Field #2a located along cross-section #2 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

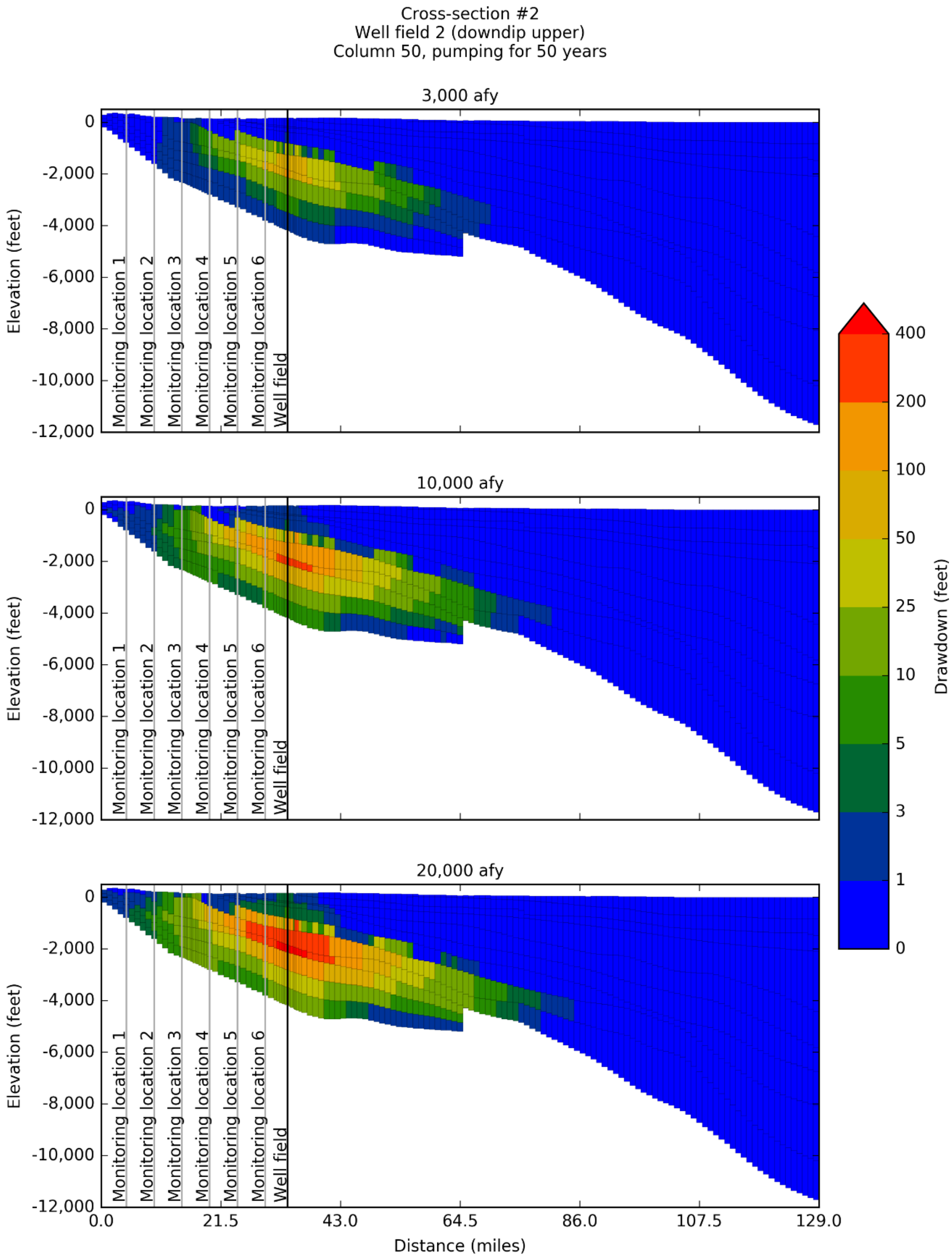


Figure 14-40. Simulated drawdown at 50 years after pumping the Well Field #2b located along cross-section #2 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

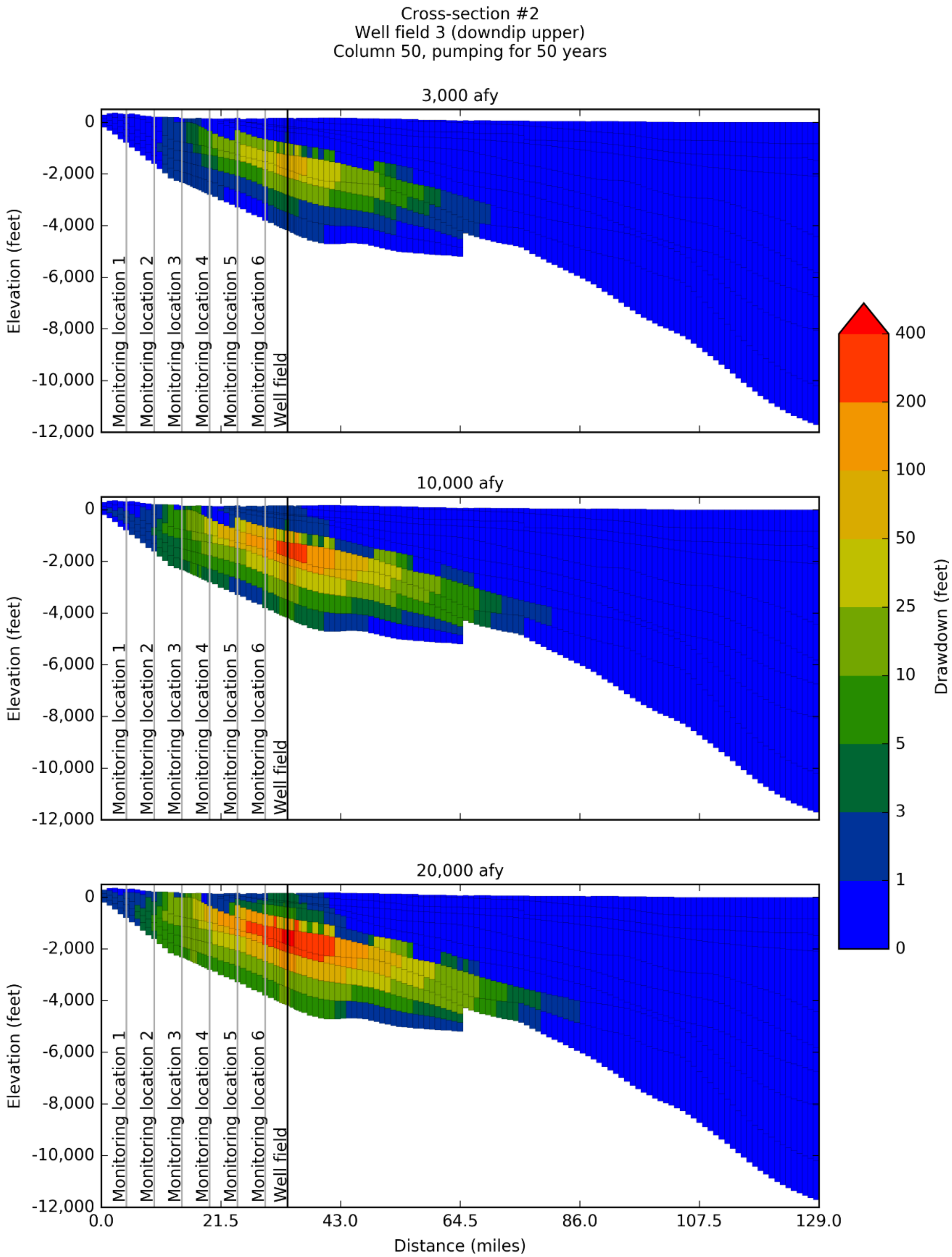


Figure 14-41. **Simulated drawdown at 50 years after pumping the Well Field #2c located along cross-section #2 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.**

Note: afy=acre-feet per year

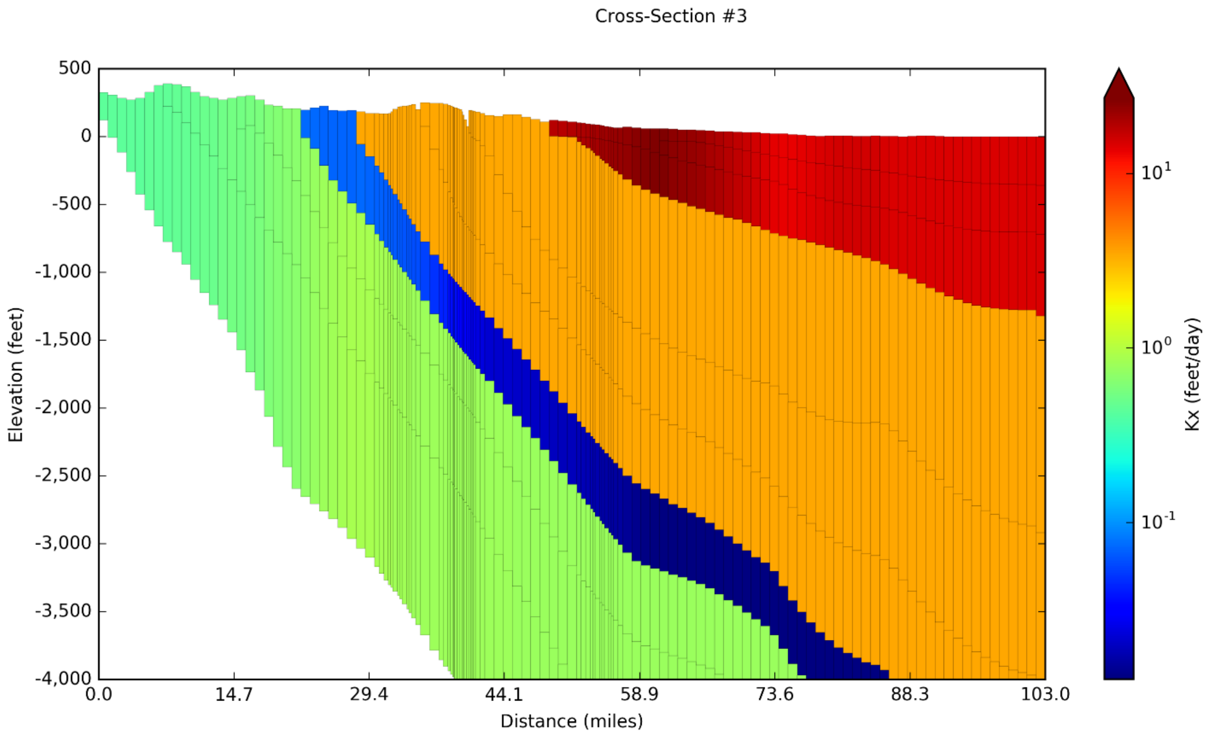


Figure 14-42. **Horizontal hydraulic conductivity (Kx) values for cross-section #3 on Figure 14-5 with aquifer properties from the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004) for model layers 1 to 10.**

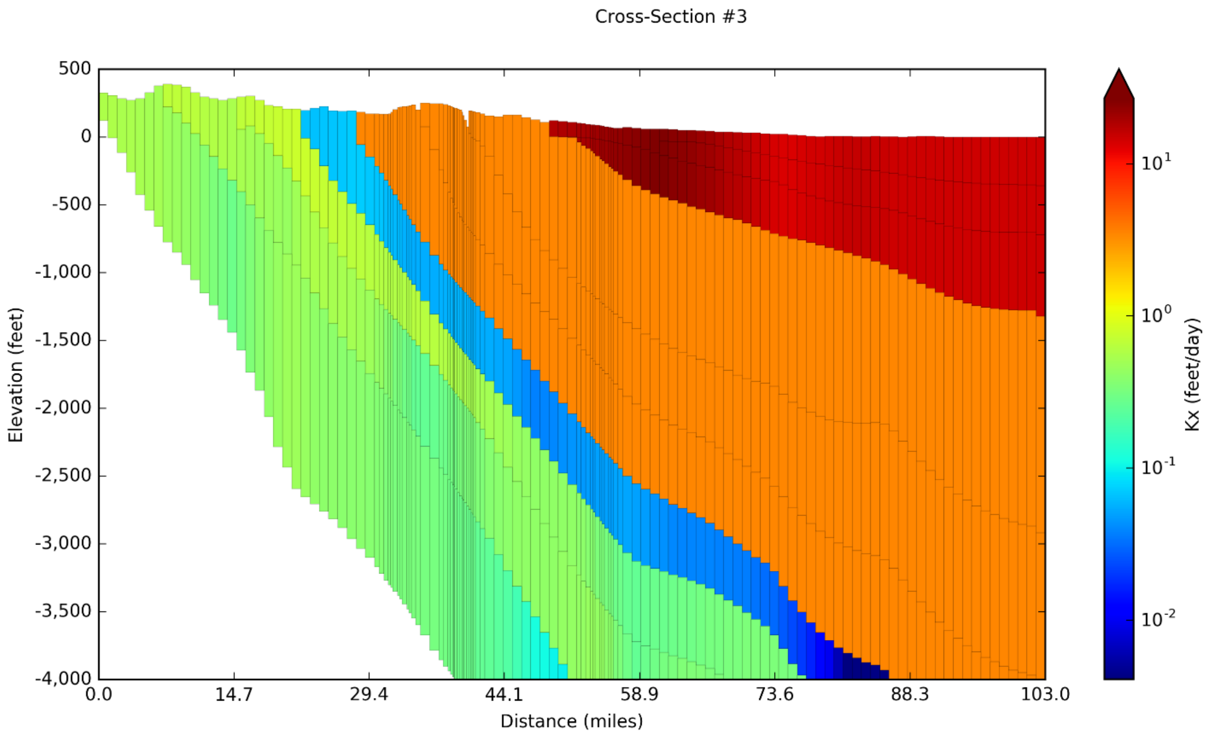


Figure 14-43. **Horizontal hydraulic conductivity (Kx) values in the groundwater model for cross-section #3 on Figure 14-5 for model layers 1 to 10.**

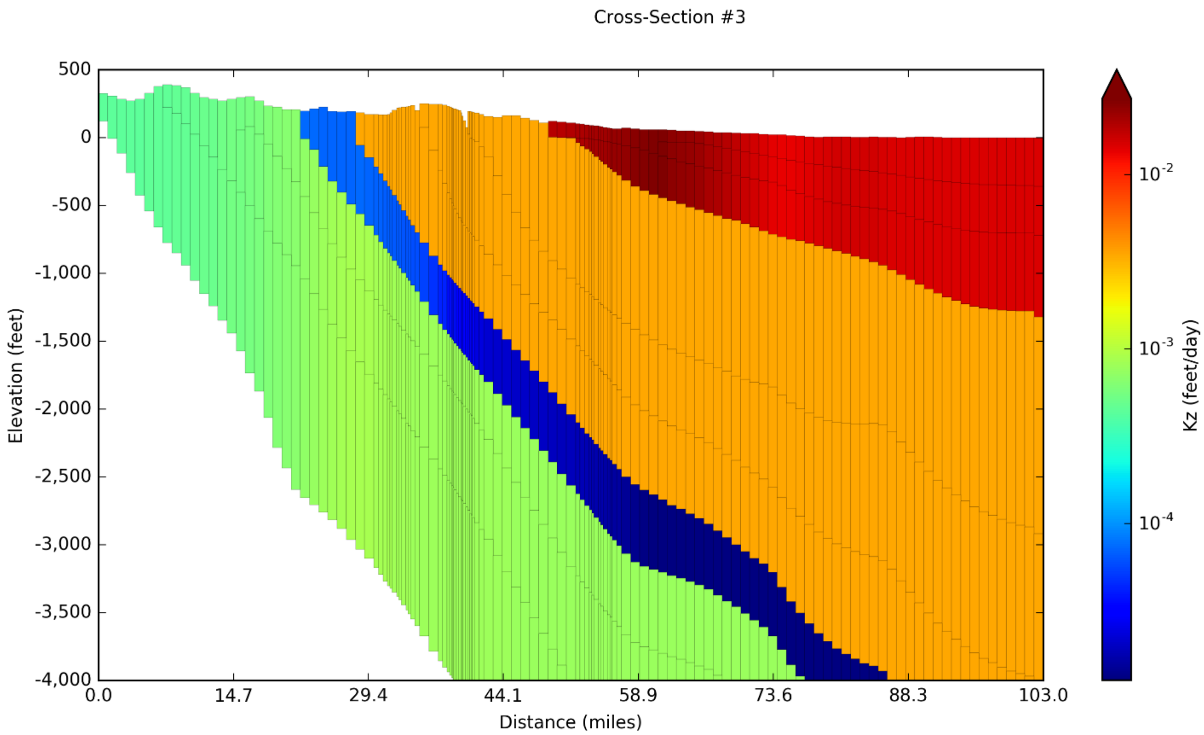


Figure 14-44. **Vertical hydraulic conductivity (Kz) values for cross-section #3 on Figure 14-5 with aquifer properties from the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004) for model layers 1 to 10.**

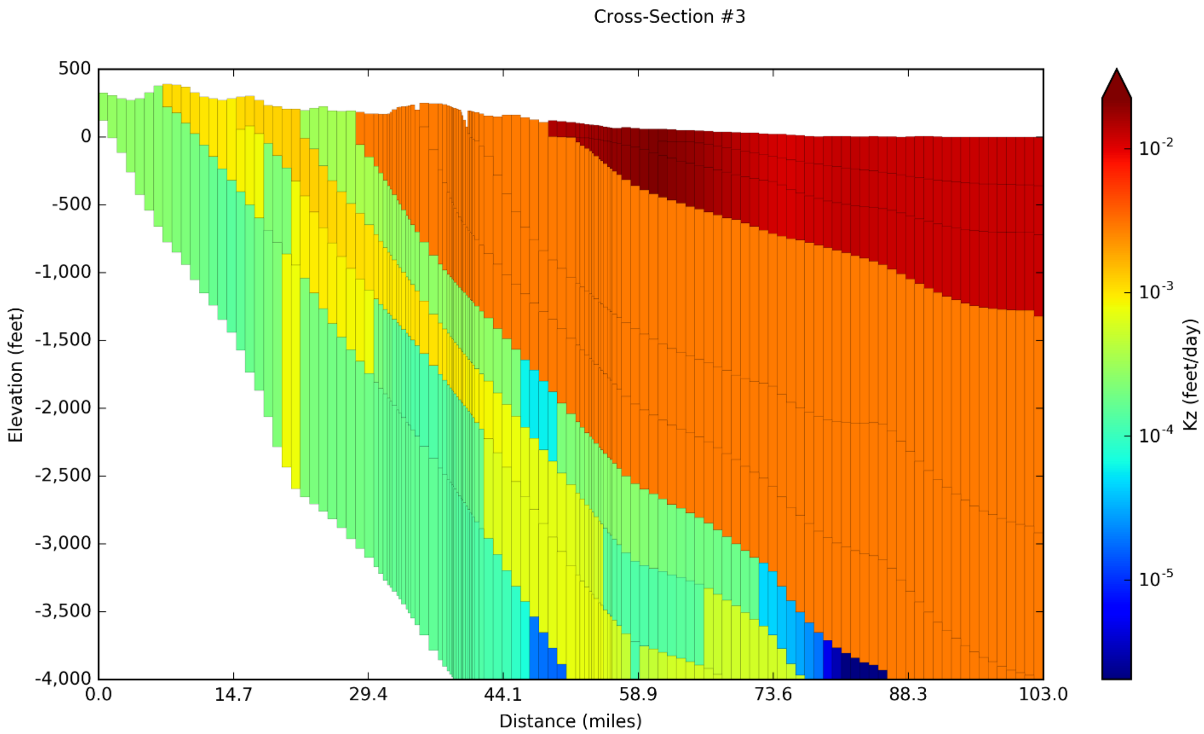


Figure 14-45. Vertical hydraulic (Kz) conductivity values in the groundwater model for cross-section #3 on Figure 14-5 for model layers 1 to 10.

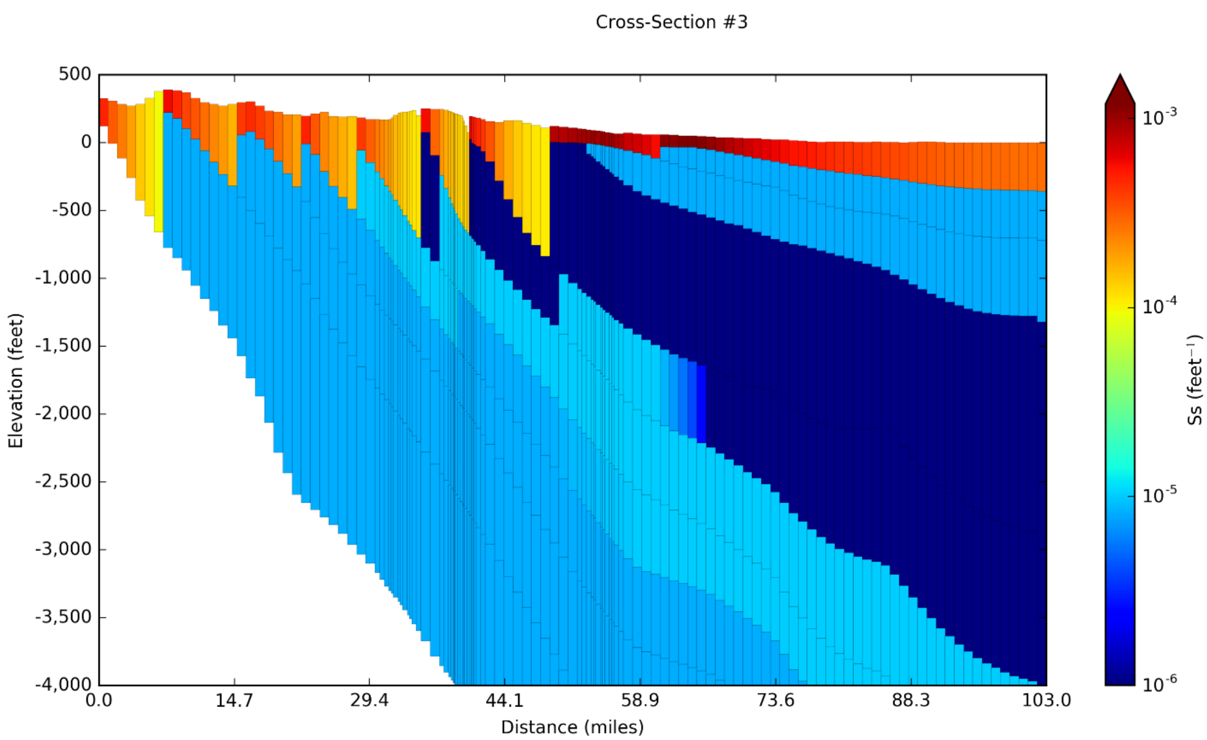


Figure 14-46. Specific storage (Ss) values for cross-section #3 on Figure 14-5 with aquifer properties from the Central Gulf Coast Groundwater Availability Model (Chowdhury and others, 2004) for model layers 1 to 10.

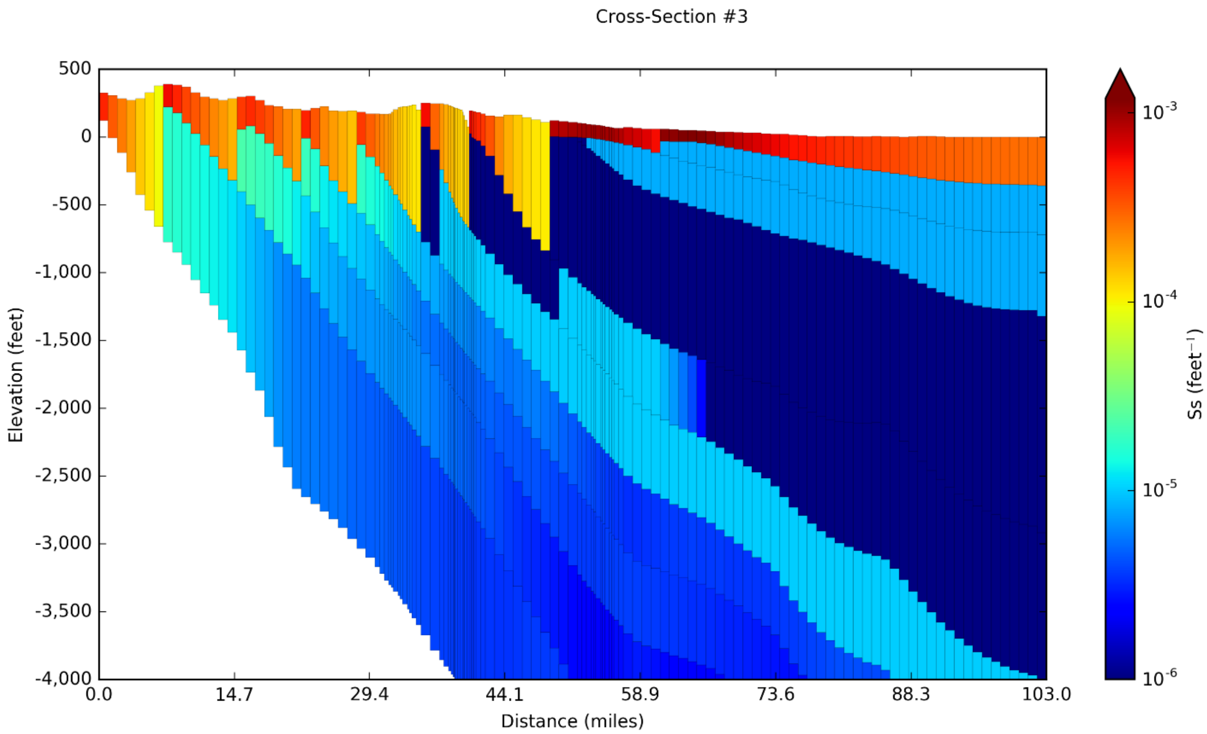


Figure 14-47. Specific storage (Ss) values in the groundwater model for cross-section #3 on Figure 14-5 for model layers 1 to 10.

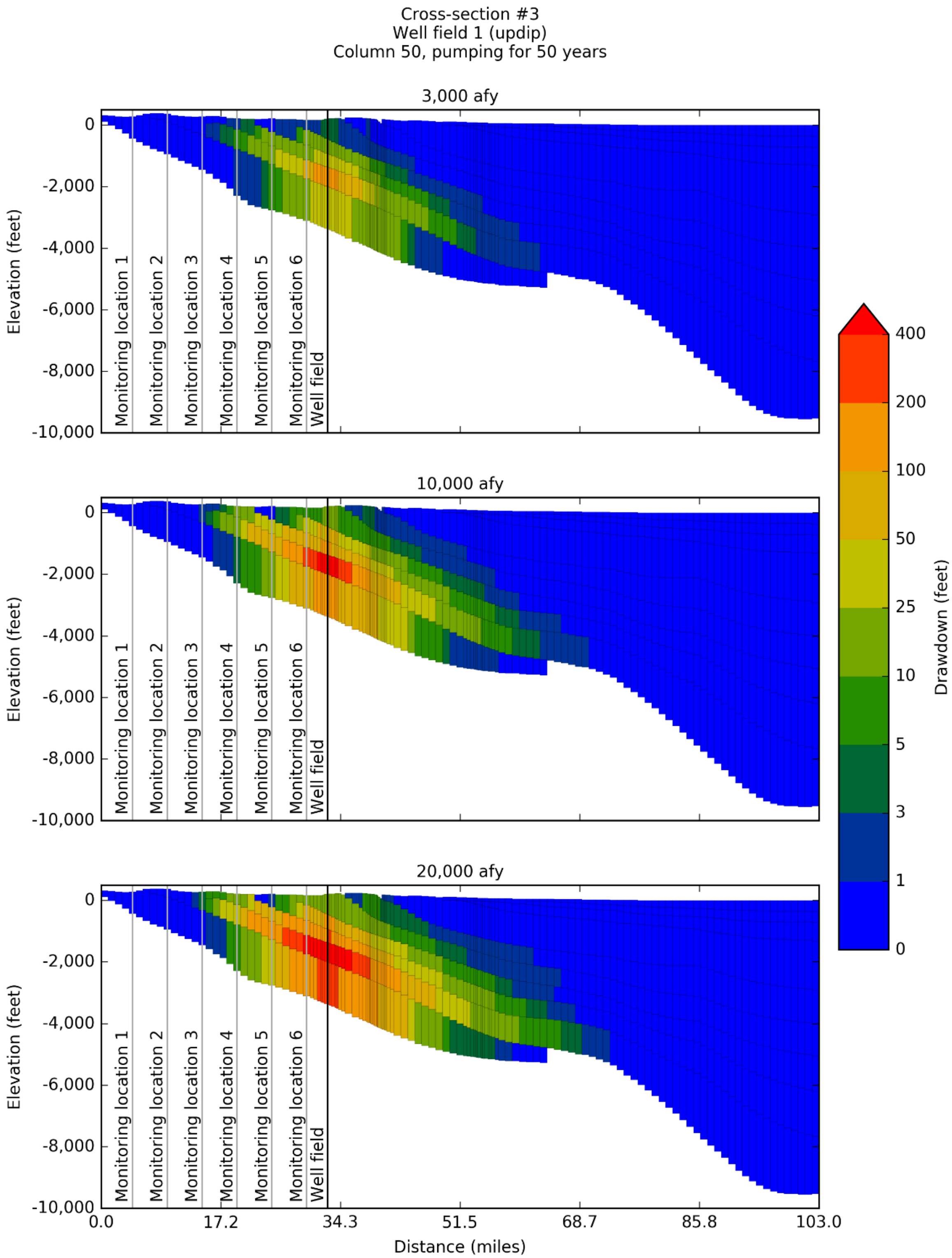


Figure 14-48. **Simulated drawdown at 50 years after pumping the up dip Well Field #3a located along cross-section #3 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.**

Note: afy=acre-feet per year

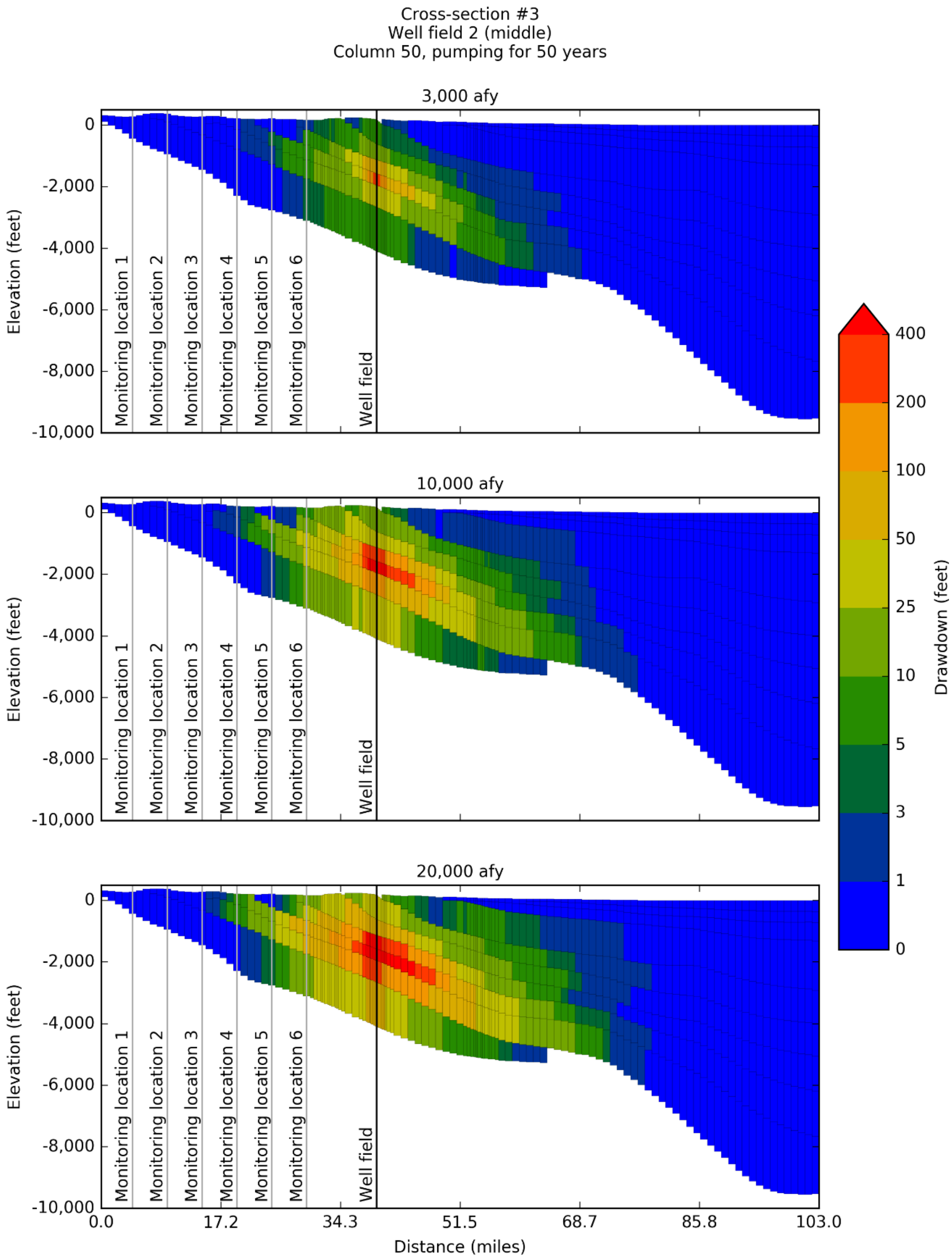


Figure 14-49. Simulated drawdown at 50 years after pumping the central Well Field #3b located along cross-section #3 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

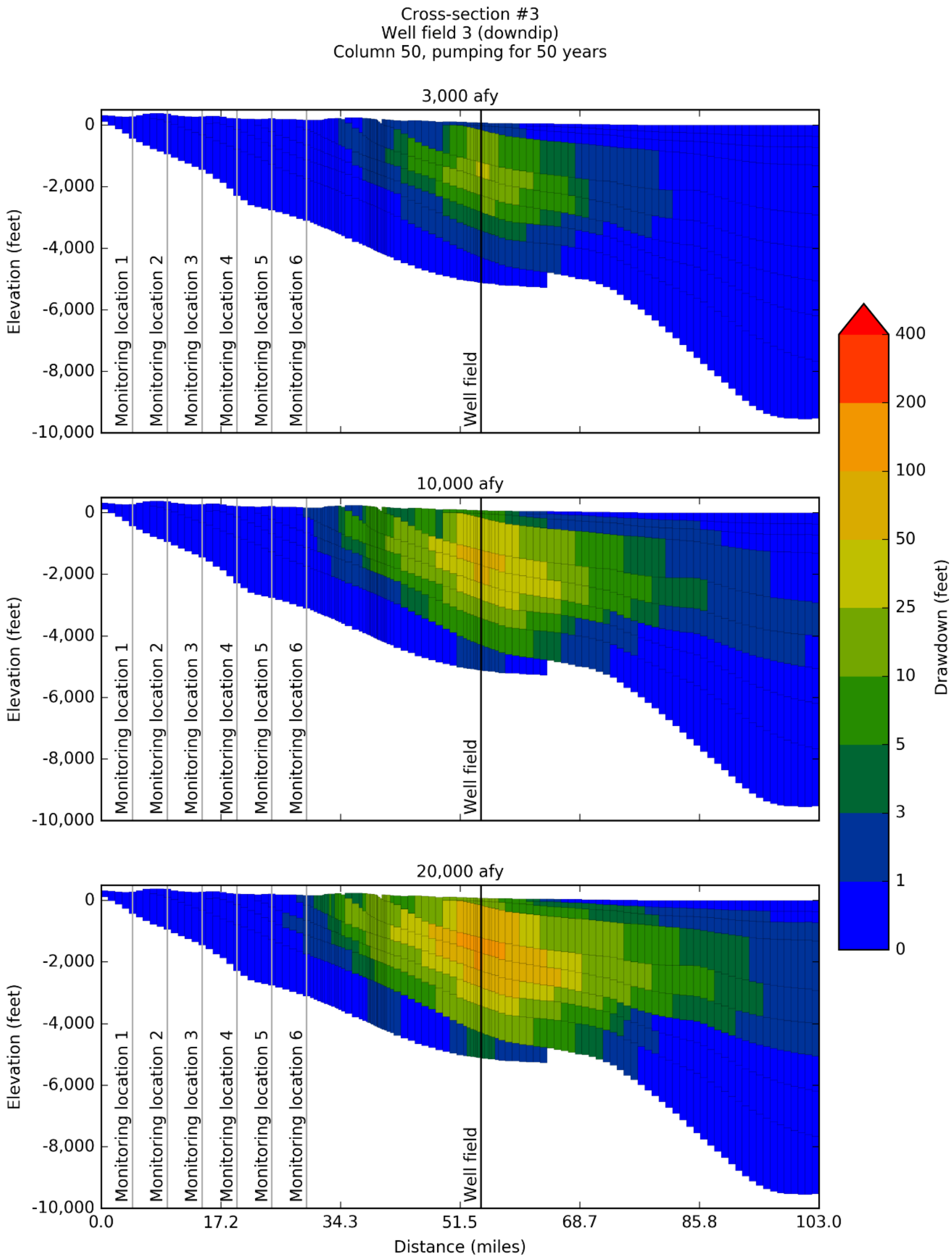


Figure 14-50. Simulated drawdown at 50 years after pumping the down dip Well Field #3c located along cross-section #3 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

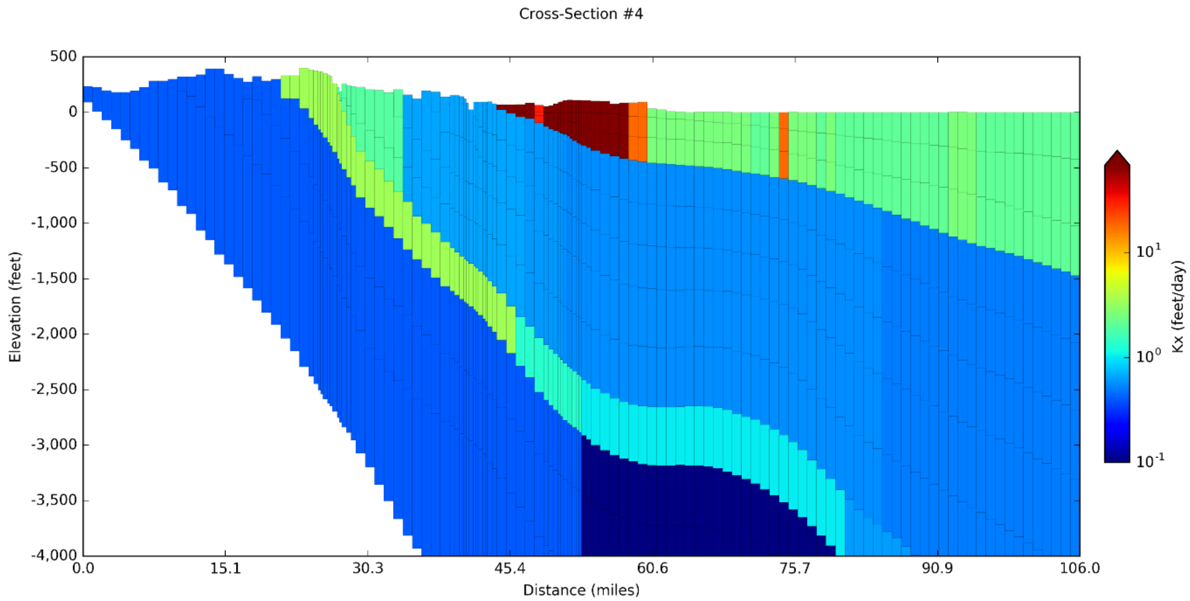


Figure 14-51. Horizontal hydraulic conductivity (Kx) values for cross-section #4 on Figure 14-5 with aquifer properties from the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) for model layers 1 to 12.

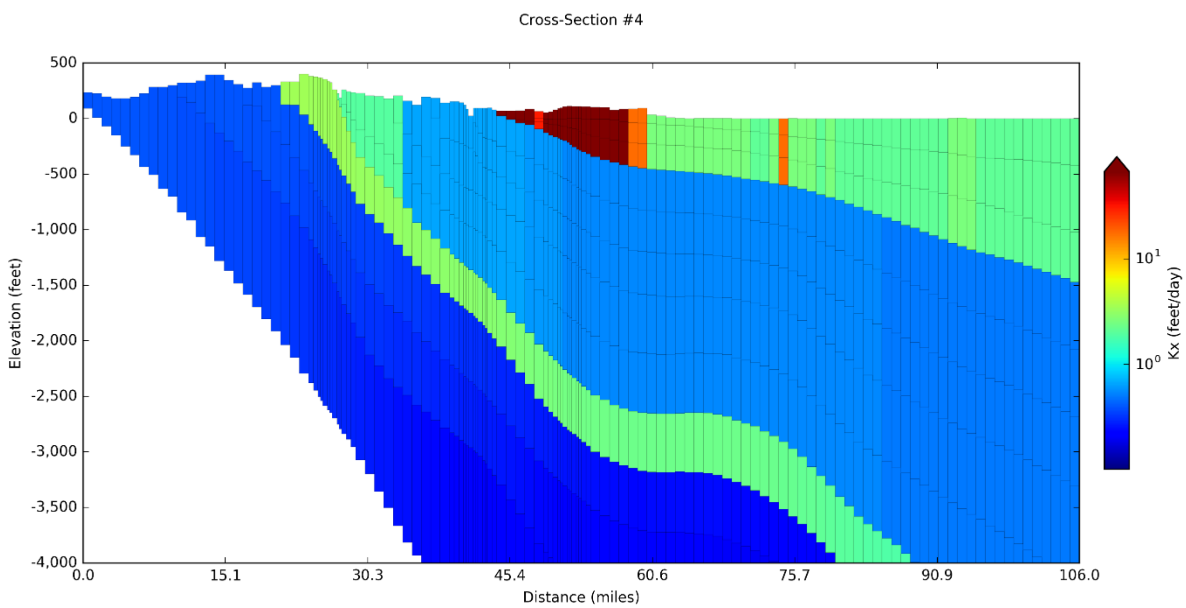


Figure 14-52. Horizontal hydraulic conductivity (Kx) values in the groundwater model for cross-section #4 on Figure 14-5 for model layers 1 to 12.

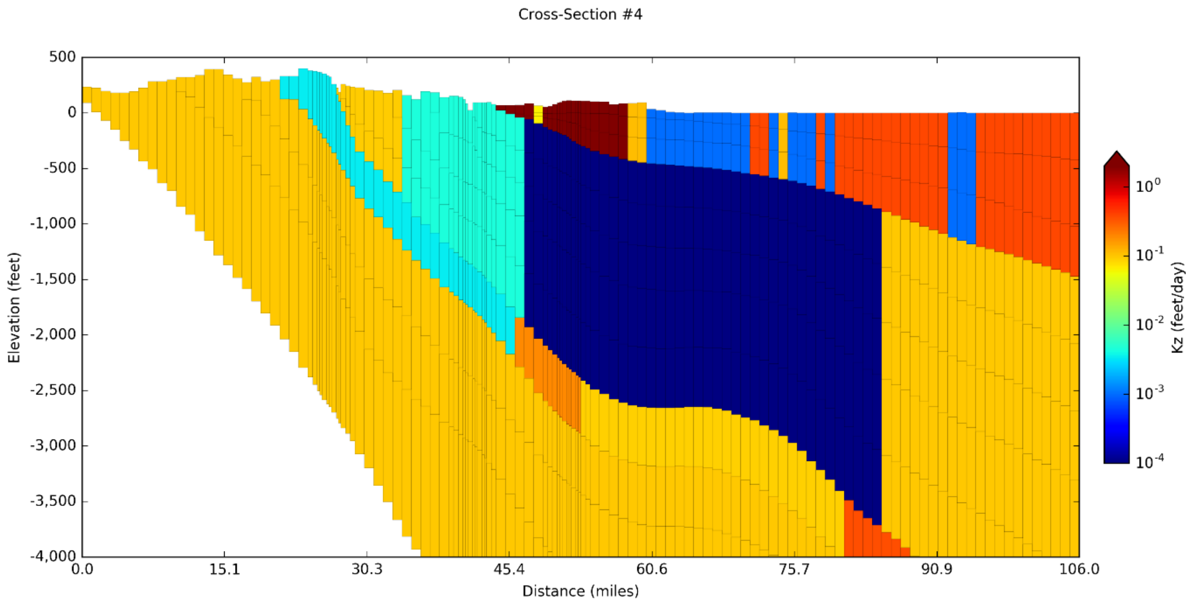


Figure 14-53. Vertical hydraulic conductivity (Kz) values for cross-section #4 on Figure 14-5 with aquifer properties from the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) for model layers 1 to 12.

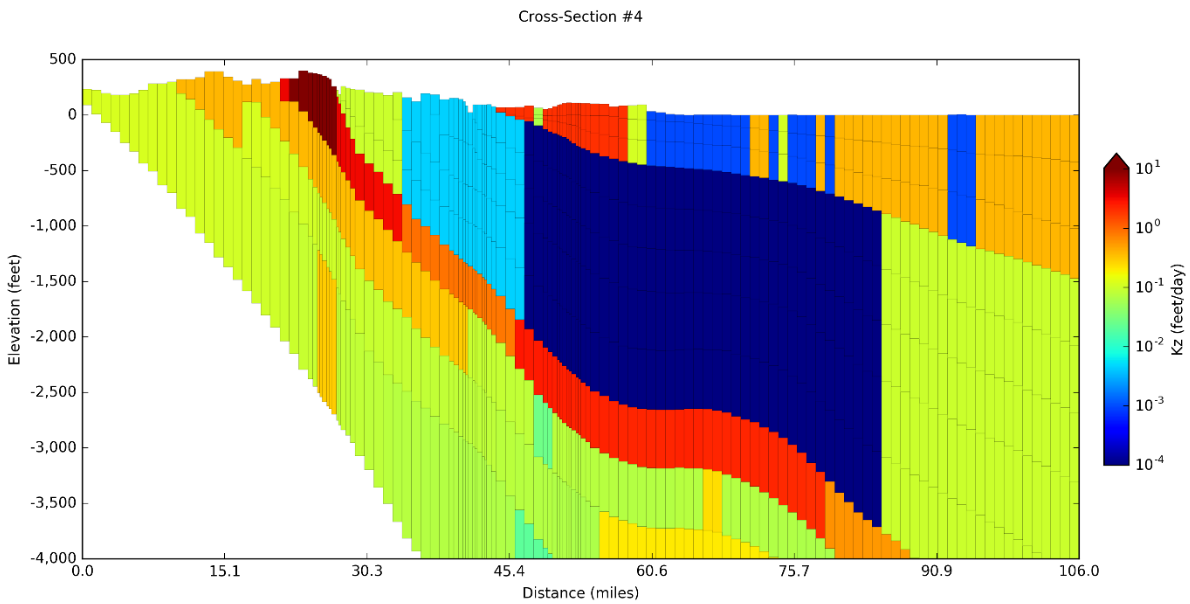


Figure 14-54. Vertical hydraulic conductivity (Kz) values in the groundwater model for cross-section #4 on Figure 14-5 for model layers 1 to 12.

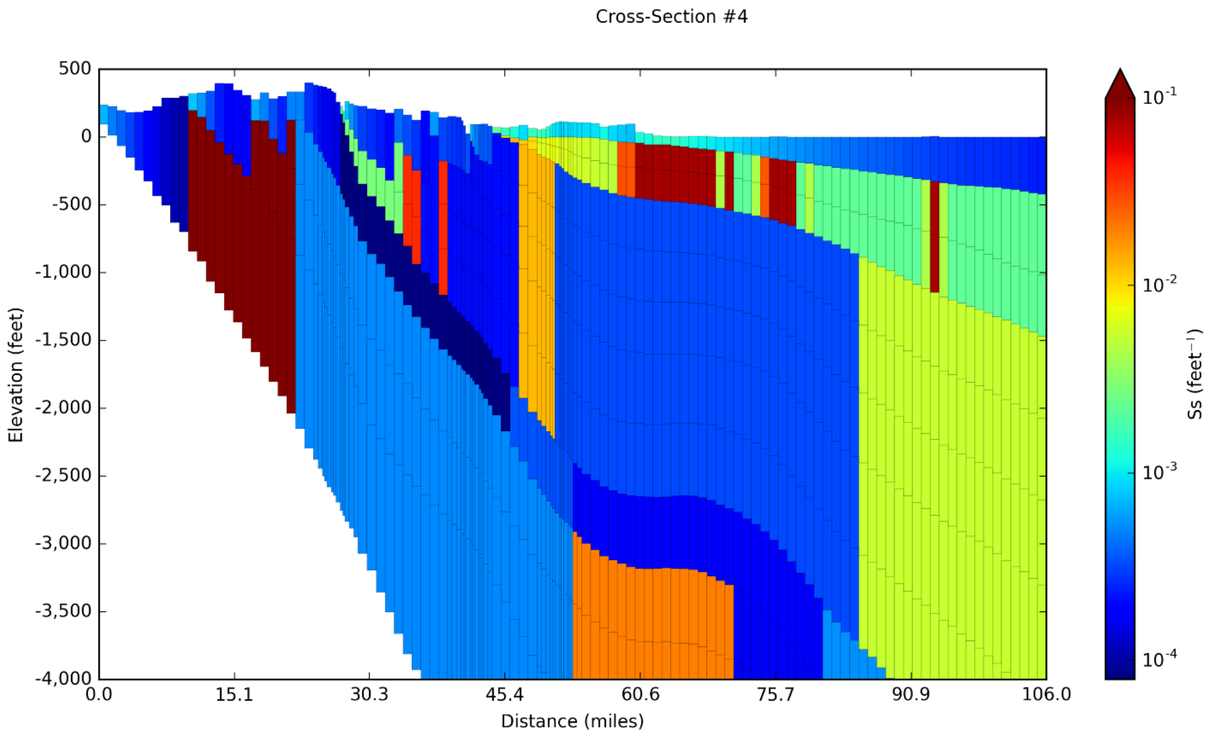


Figure 14-55. **Specific storage (Ss) values for cross-section #4 on Figure 14-5 with aquifer properties from the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) for model layers 1 to 12.**

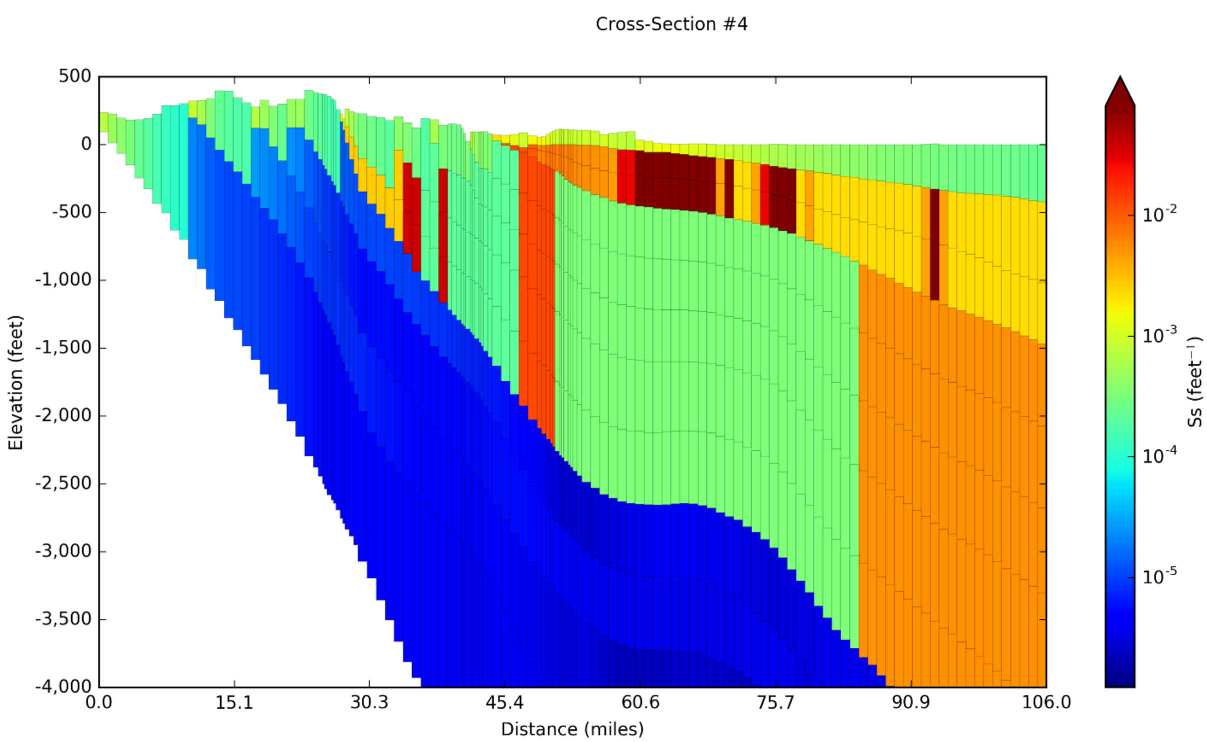


Figure 14-56. **Specific storage (Ss) values in the groundwater model for cross-section #4 on Figure 14-5 for model layers 1 to 12.**

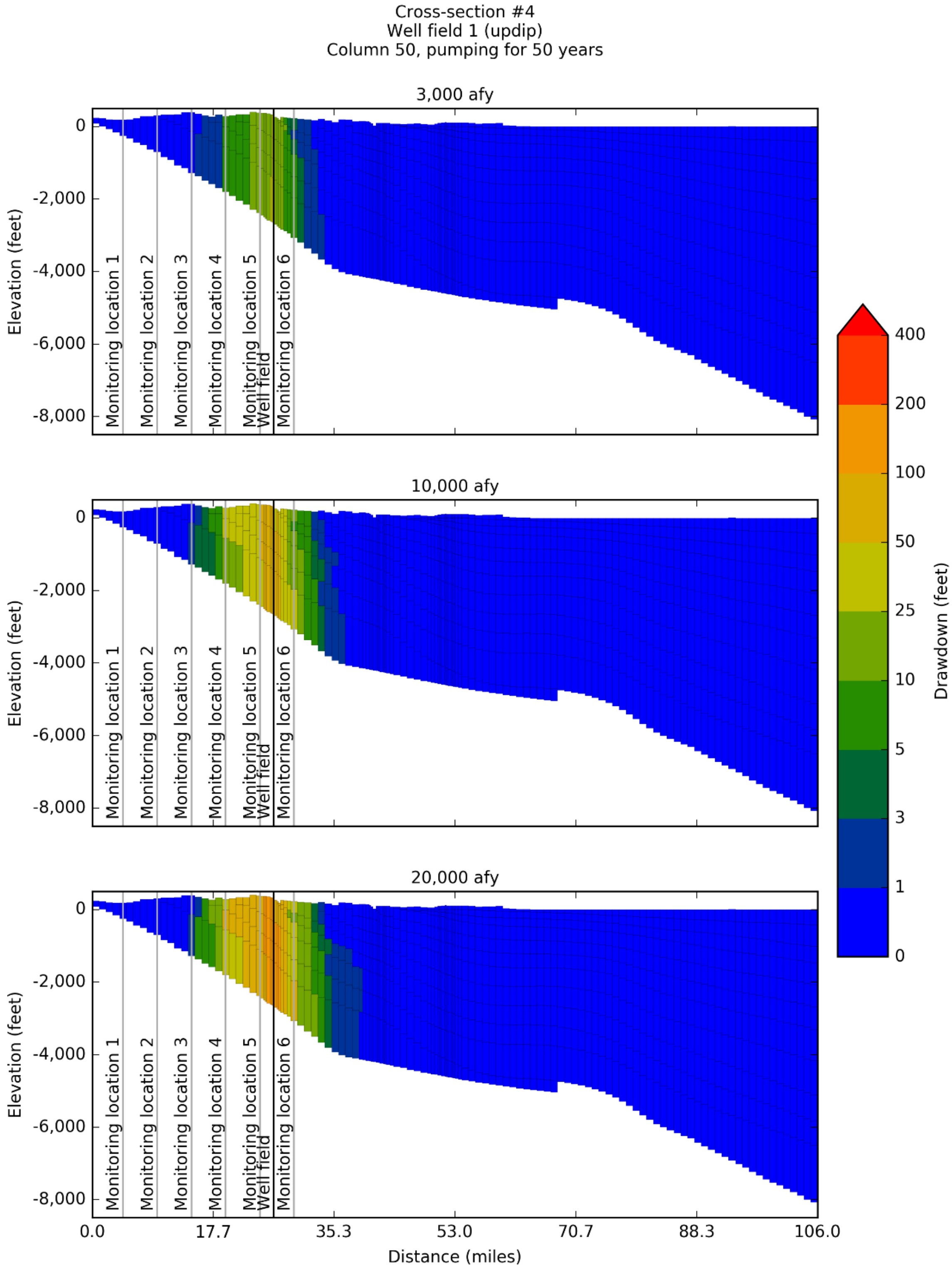


Figure 14-57. Simulated drawdown at 50 years after pumping the up dip Well Field #4a located along cross-section #4 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

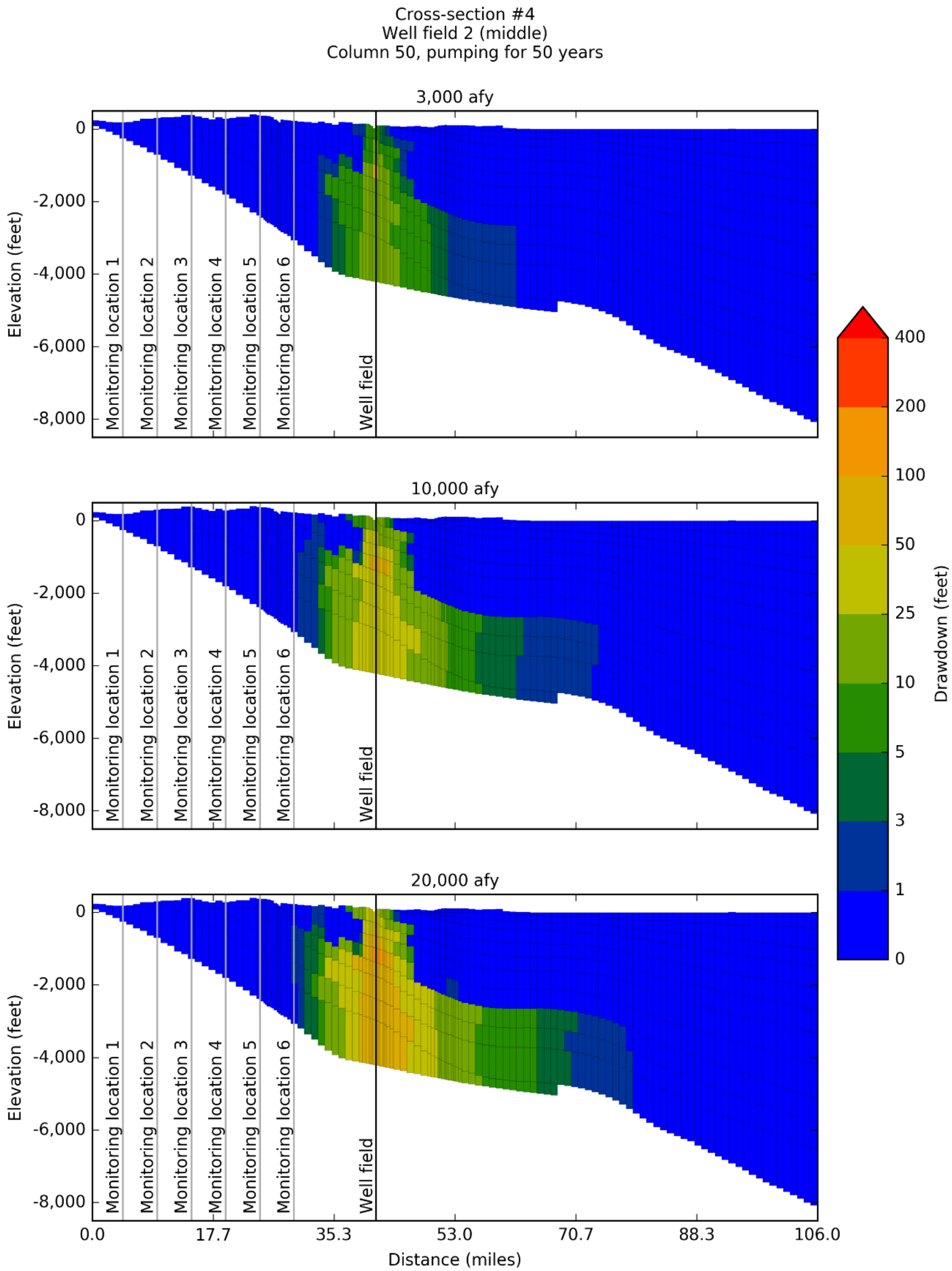


Figure 14-58. Simulated drawdown at 50 years after pumping the middle Well Field #4b located along cross-section #4 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

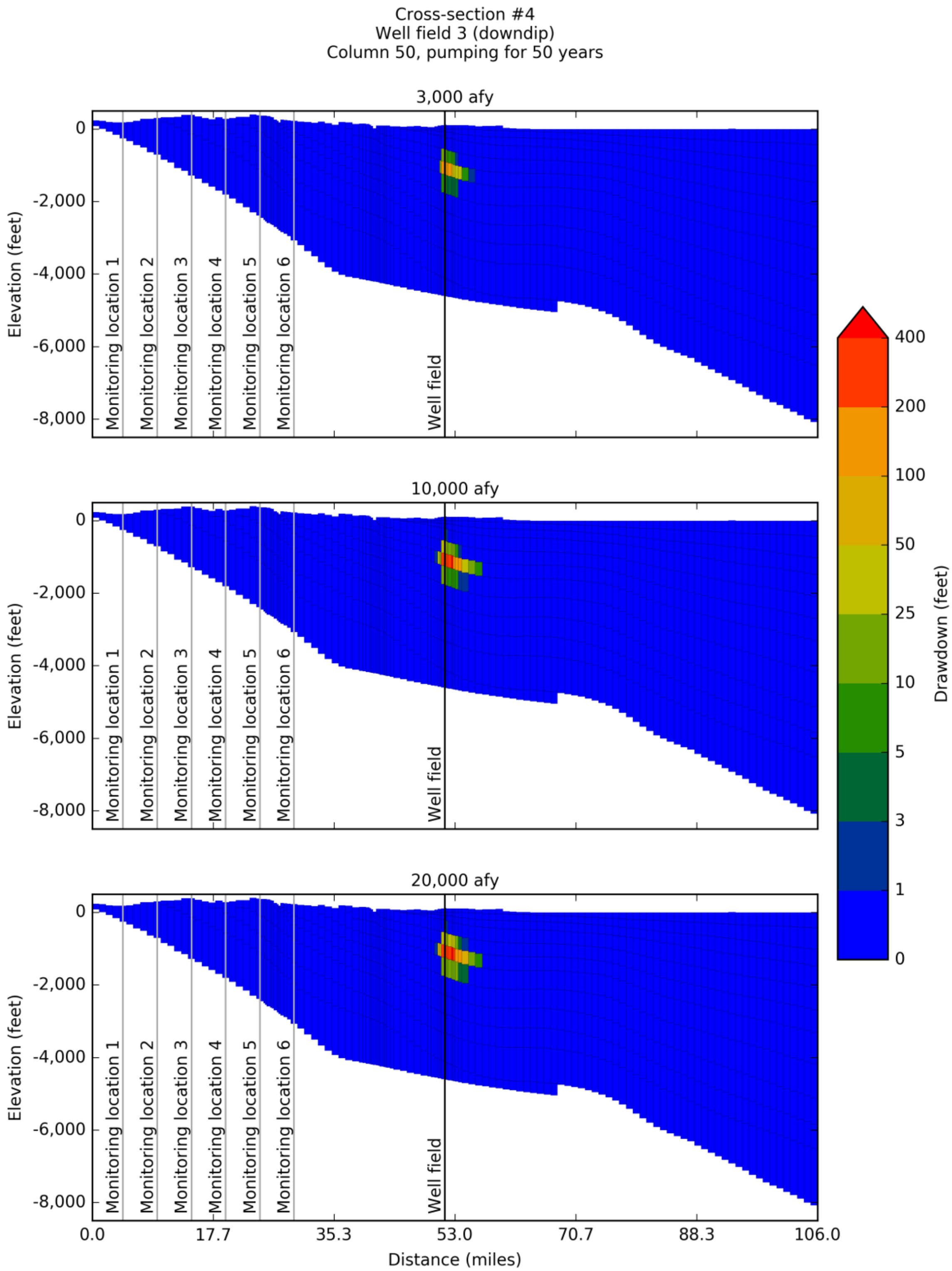


Figure 14-59. Simulated drawdown at 50 years after pumping the down dip Well Field #4c located along cross-section #4 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

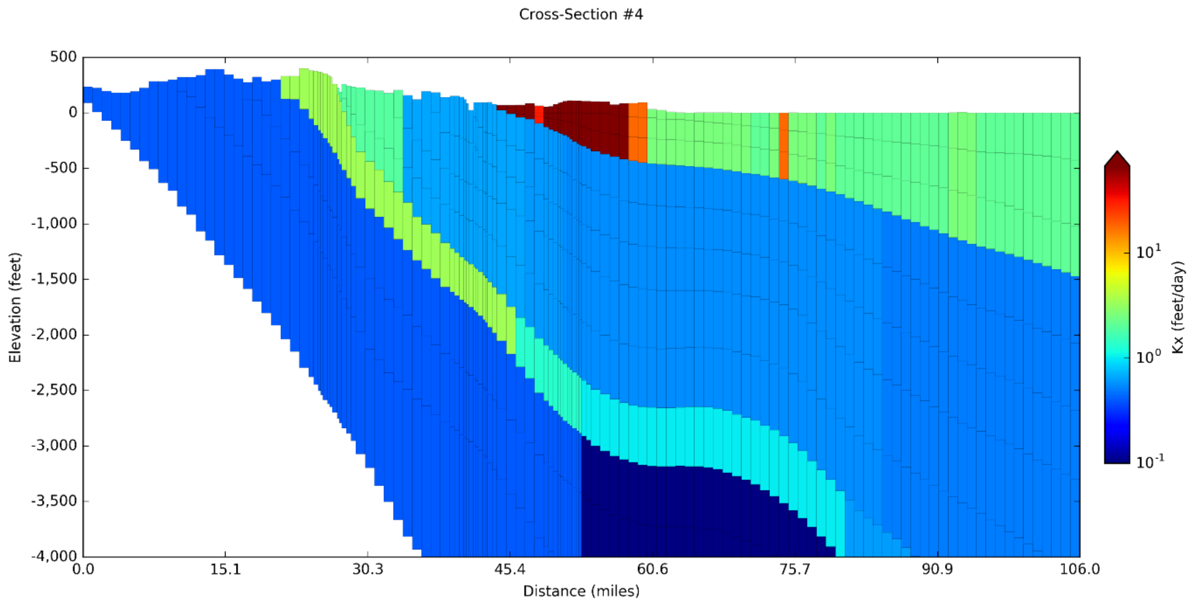


Figure 14-60. **Horizontal hydraulic conductivity (Kx) values for cross-section #5 on Figure 14-5 with aquifer properties from the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) for model layers 1 to 12.**

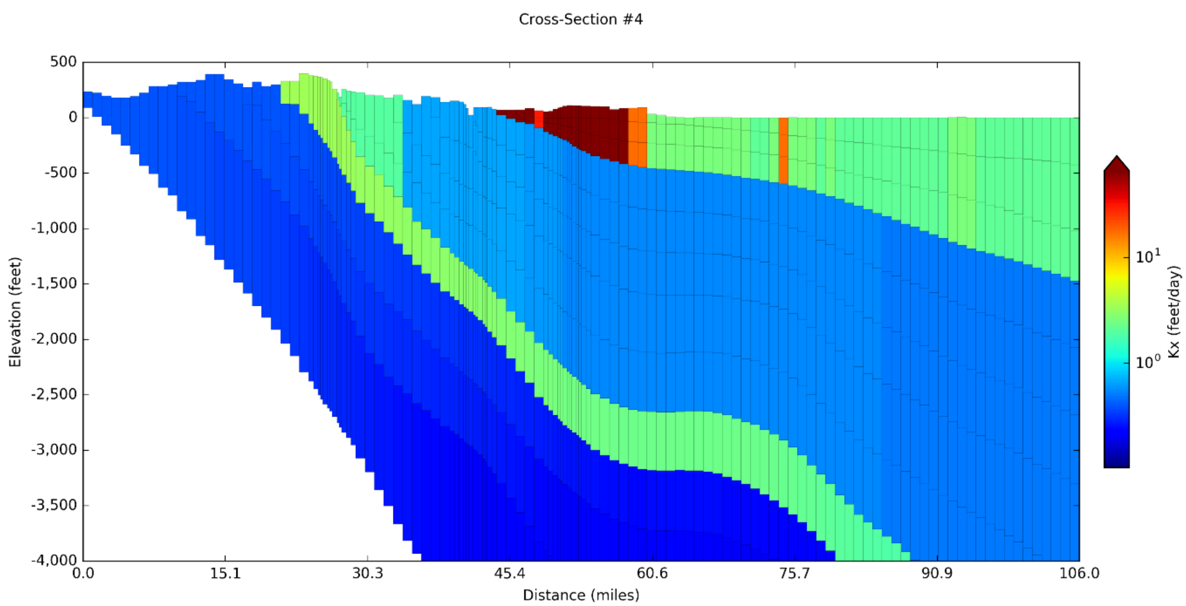


Figure 14-61. **Horizontal hydraulic conductivity (Kx) values in the groundwater model for cross-section #5 on Figure 14-5 for model layers 1 to 12.**

Figure 14-62. Vertical hydraulic conductivity (Kz) values for cross-section #5 on Figure 14-5 with aquifer properties from the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) for model layers 1 to 12.

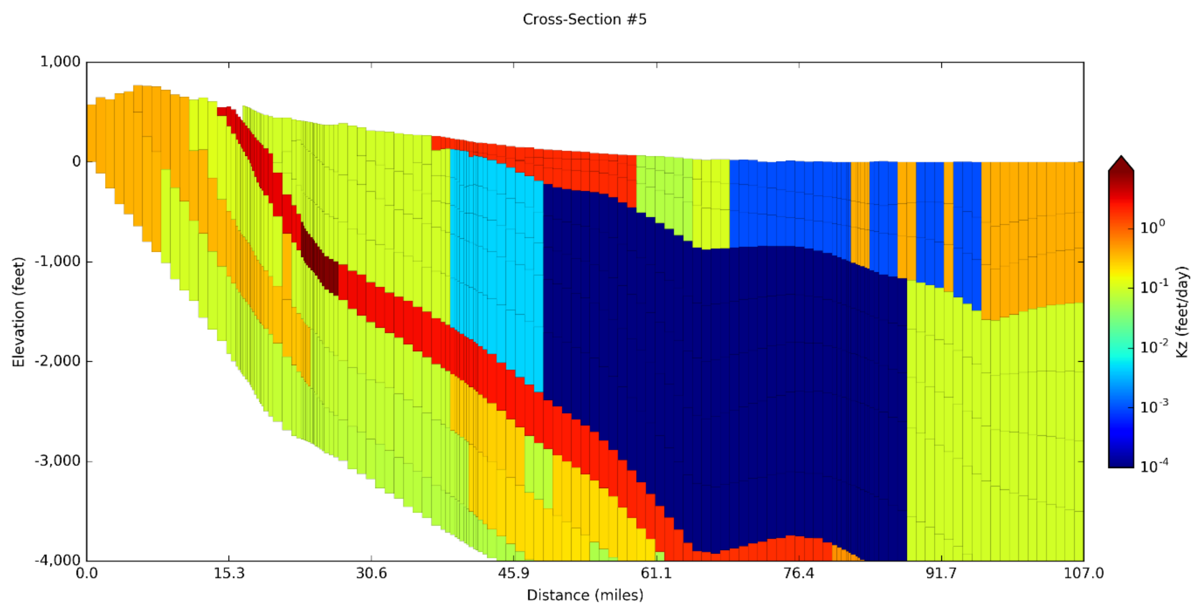


Figure 14-63. Vertical hydraulic conductivity (Kz) values in the groundwater model for cross-section #5 on Figure 14-5 for model layers 1 to 12.

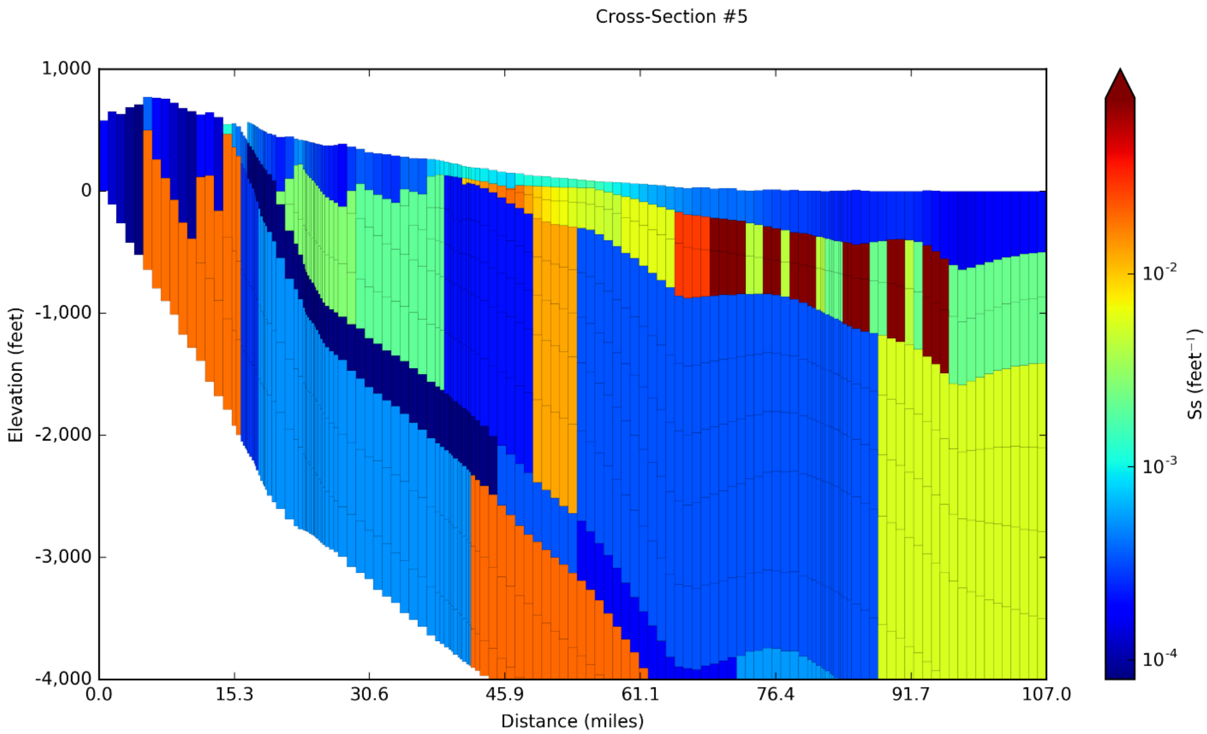


Figure 14-64. Specific storage (Ss) values for cross-section #5 on Figure 14-5 with aquifer properties from the Groundwater Management Area 16 Approved Groundwater Model (Hutchison and others, 2011) for model layers 1 to 12.

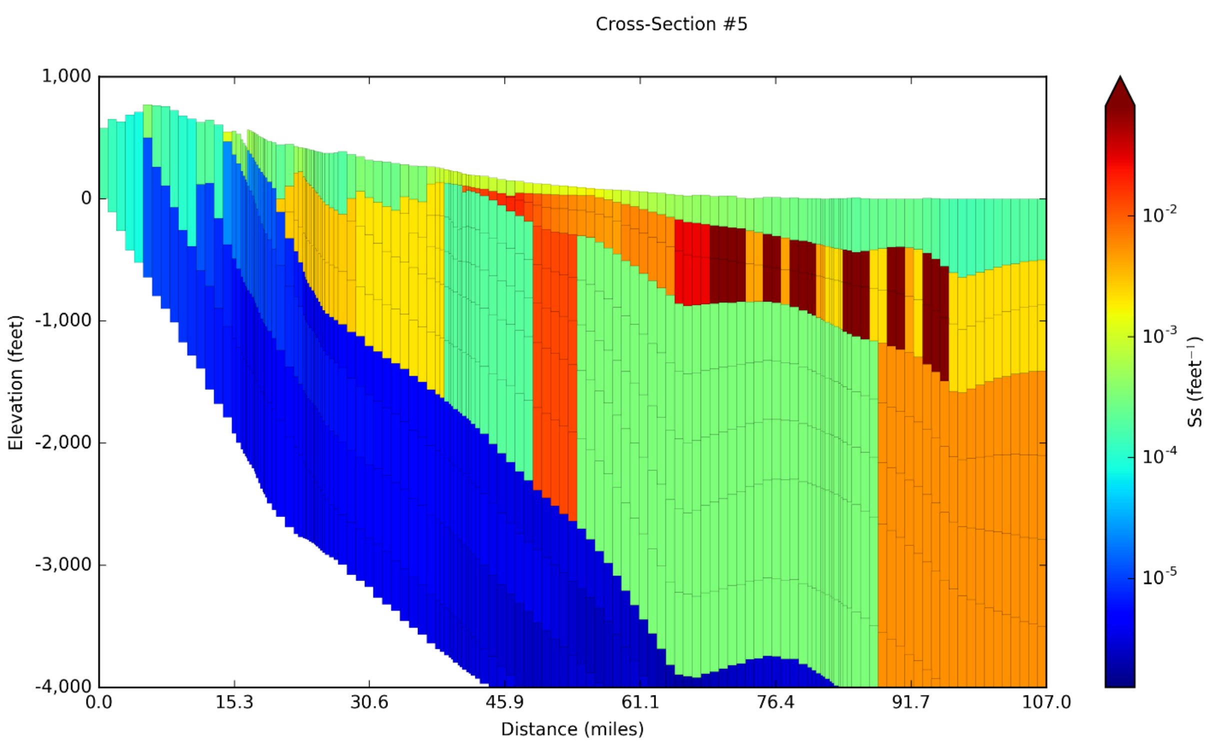


Figure 14-65. Specific storage (Ss) values in the groundwater model for cross-section #5 on Figure 14-5 with for model layers 1 to 12.

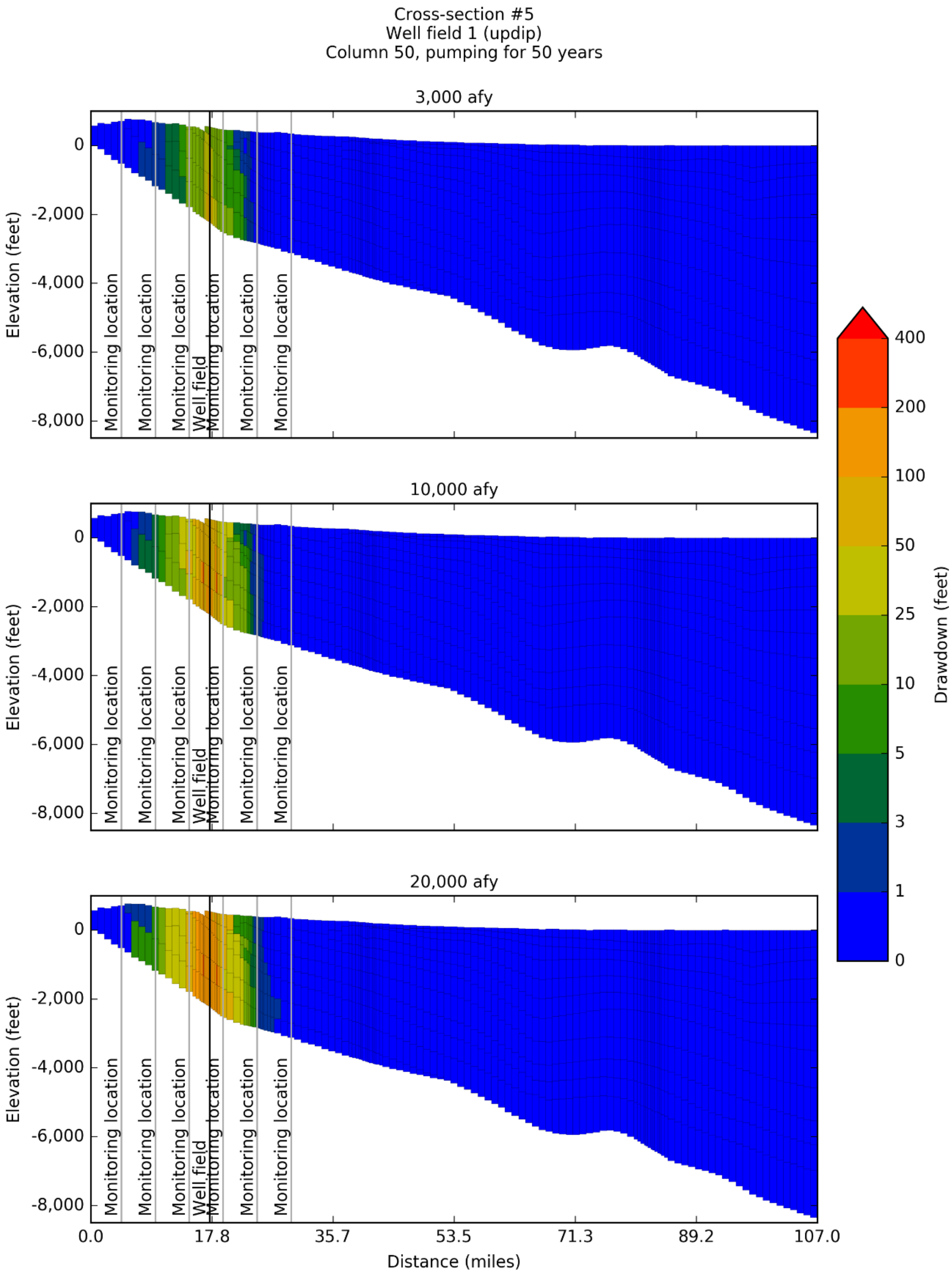


Figure 14-66. Simulated drawdown at 50 years after pumping the up dip Well Field #5a located along cross-section #5 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

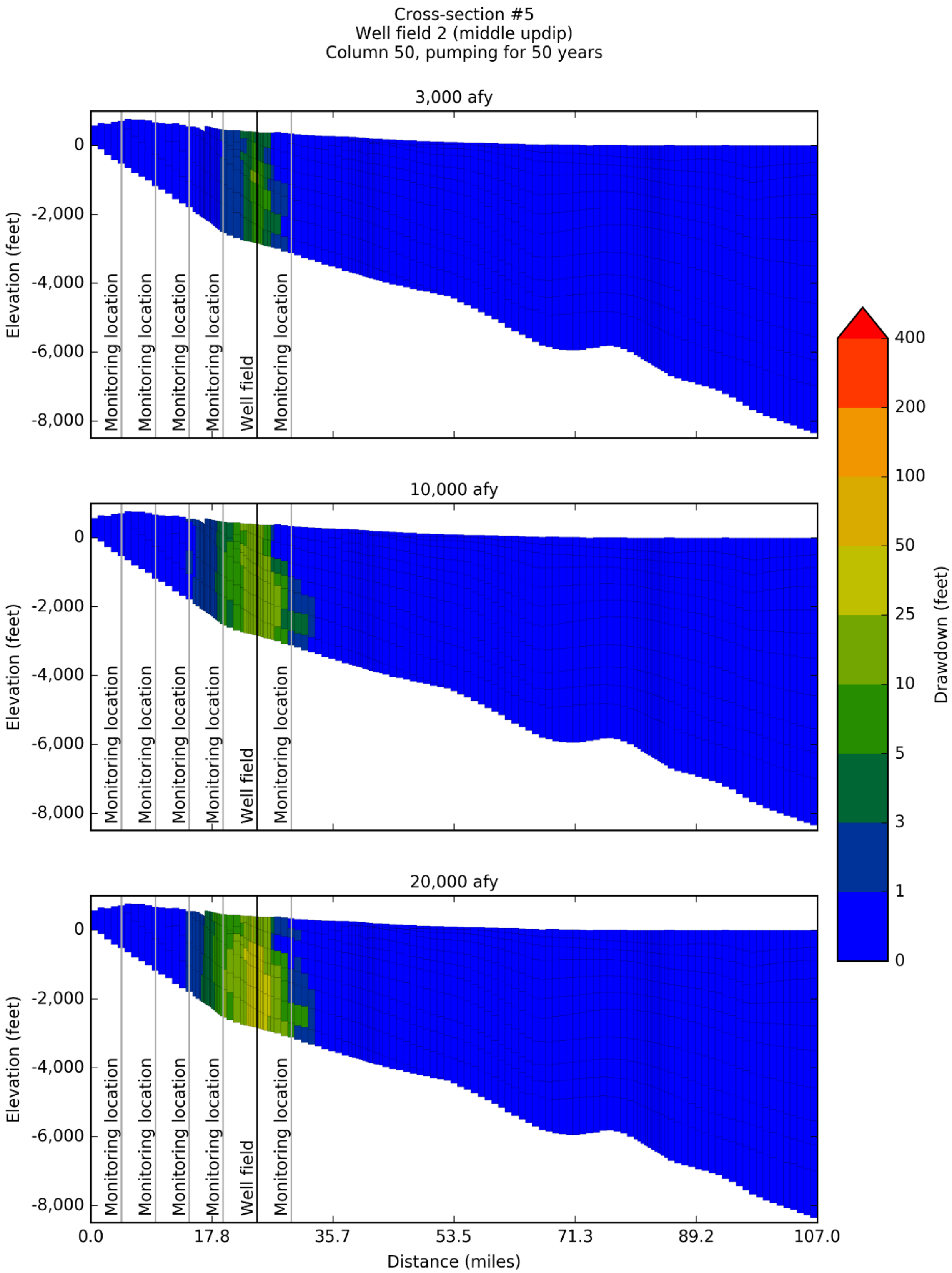


Figure 14-67. Simulated drawdown at 50 years after pumping the middle Well Field #5b located along cross-section #5 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.

Note: afy=acre-feet per year

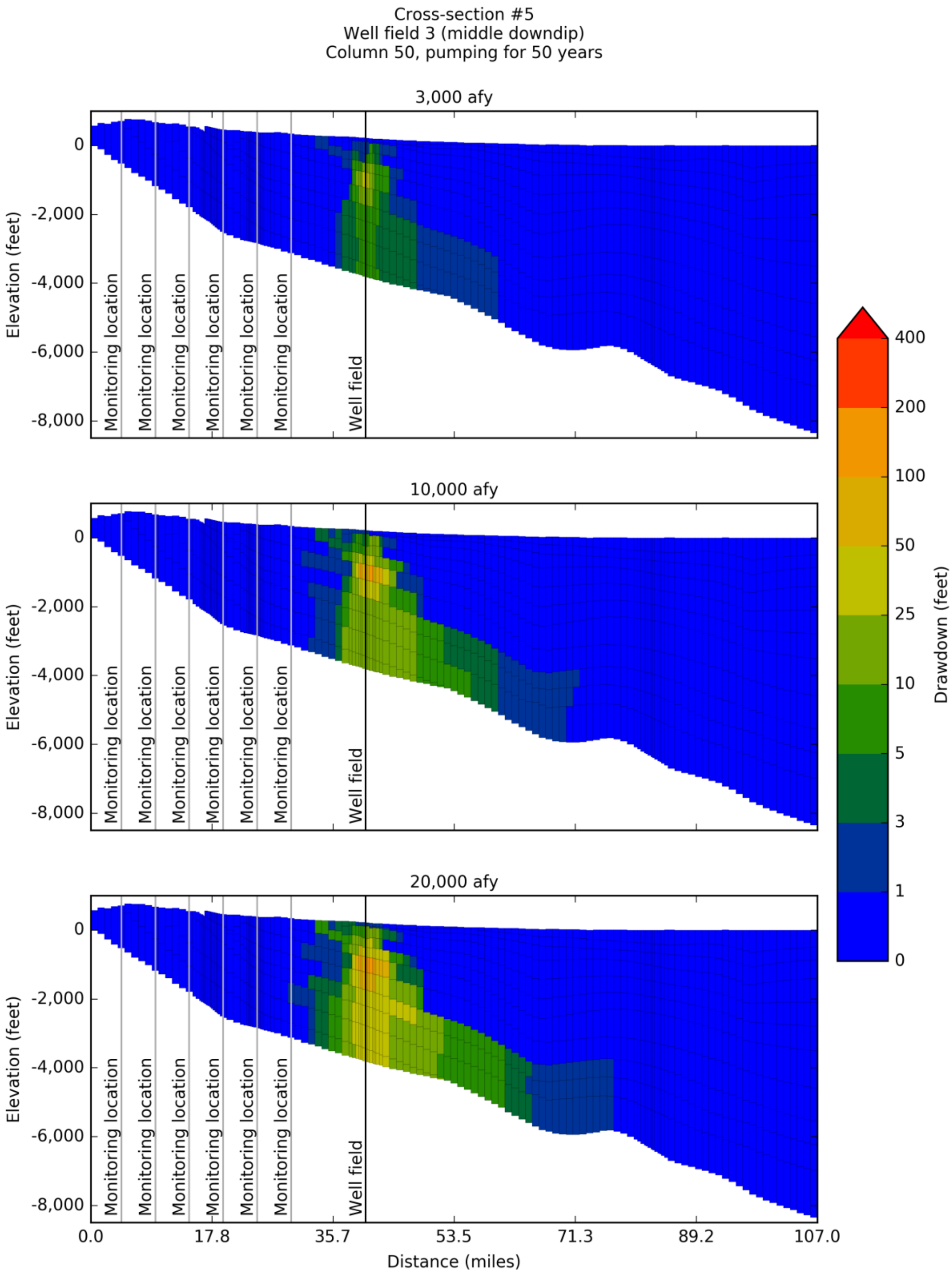


Figure 14-68. **Simulated drawdown at 50 years after pumping the down dip Well Field #5c located along cross-section #5 on Figure 14-5 at 3,000 acre-feet per year, 10,000 acre-feet per year, and 20,000 acre-feet per year.**

Note: afy=acre-feet per year

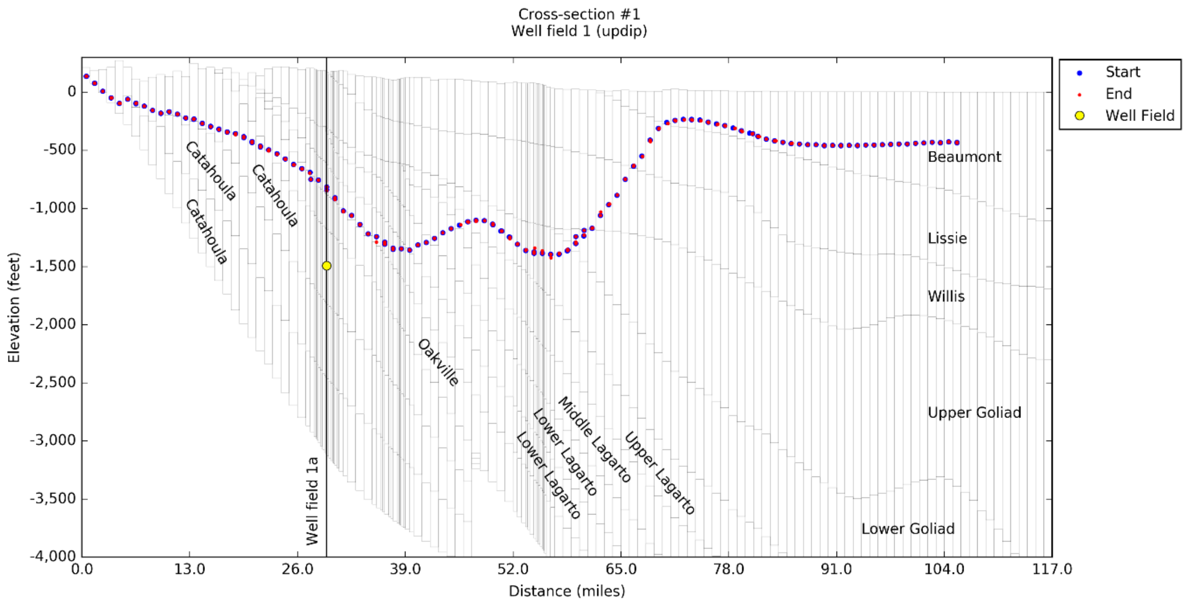


Figure 14-69. Simulated particle tracks 50 years after pumping the up dip Well Field #1a located along cross-section #1 on Figure 14-5 at 10,000 acre-feet per year.

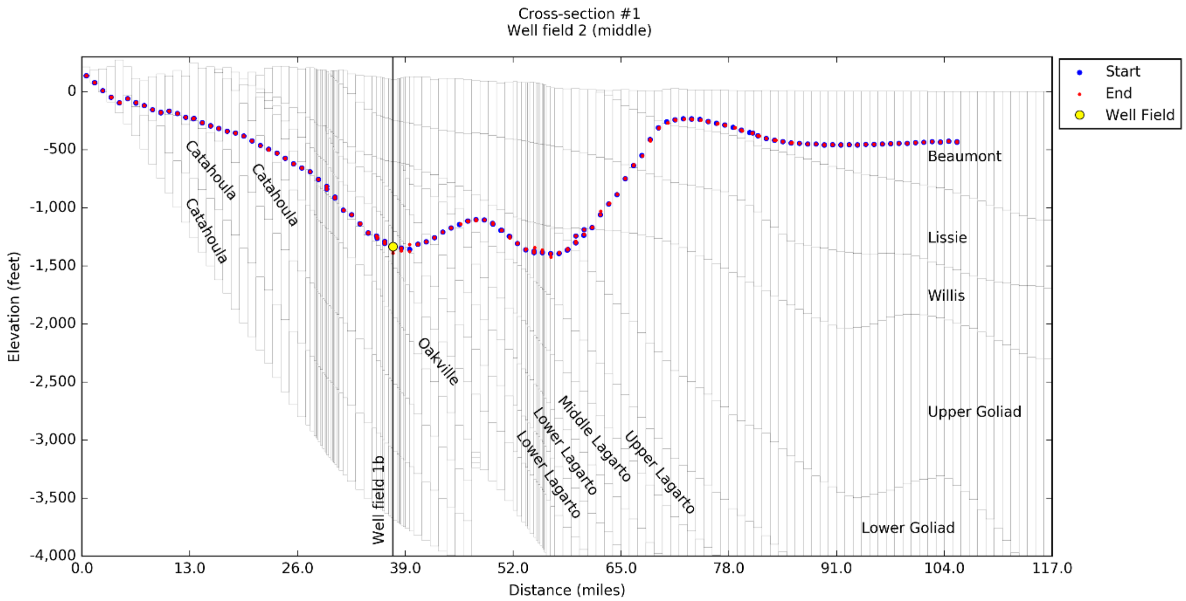


Figure 14-70. Simulated particle tracks 50 years after pumping the middle Well Field #1b located along cross-section #1 on Figure 14-5 at 10,000 acre-feet per year.

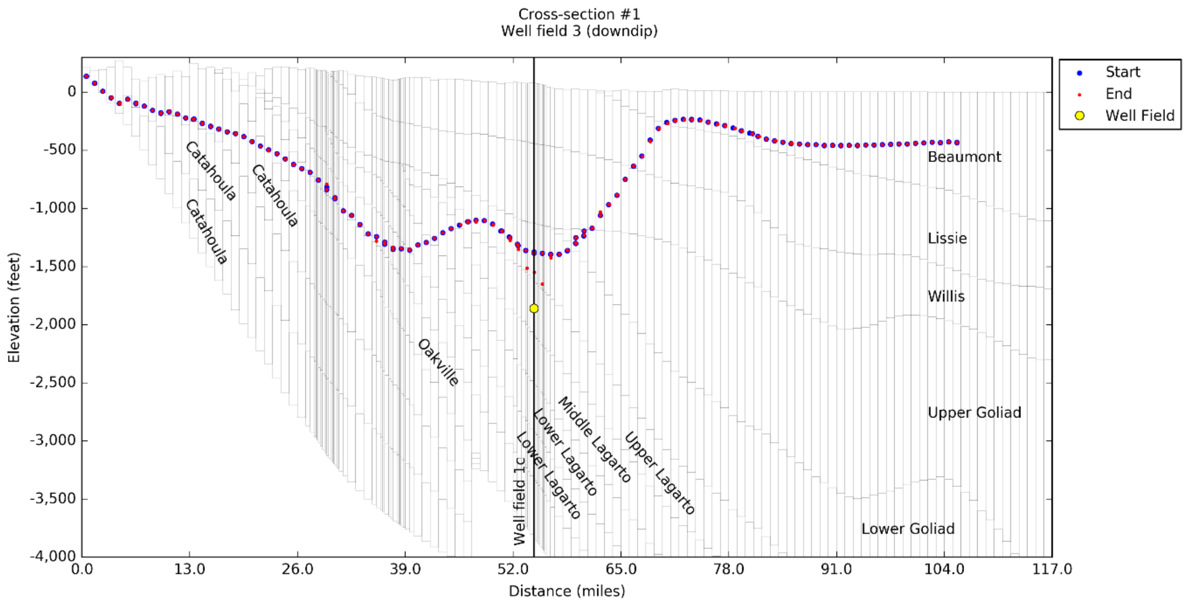


Figure 14-71. **Simulated particle tracks 50 years after pumping the down dip Well Field #1c located along cross-section #1 on Figure 14-5 at 10,000 acre-feet per year.**

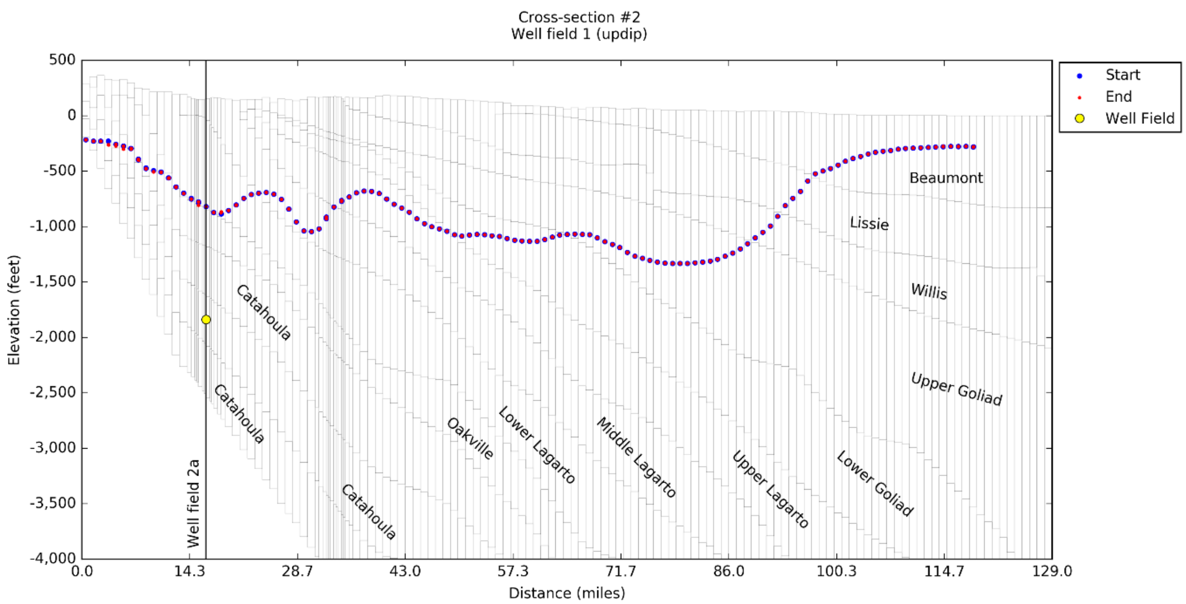


Figure 14-72. **Simulated particle tracks 50 years after pumping the down dip Well Field #2a located along cross-section #2 on Figure 14-5 at 10,000 acre-feet per year.**

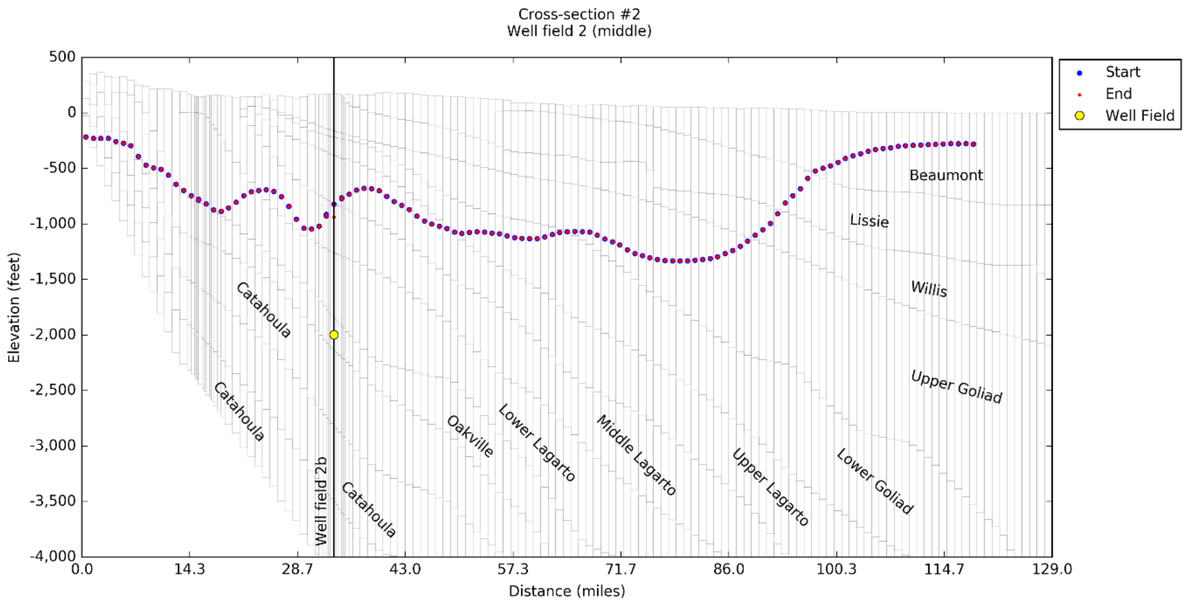


Figure 14-73. Simulated particle tracks 50 years after pumping the middle Well Field #2b located along cross-section #2 on Figure 14-5 at 10,000 acre-feet per year.

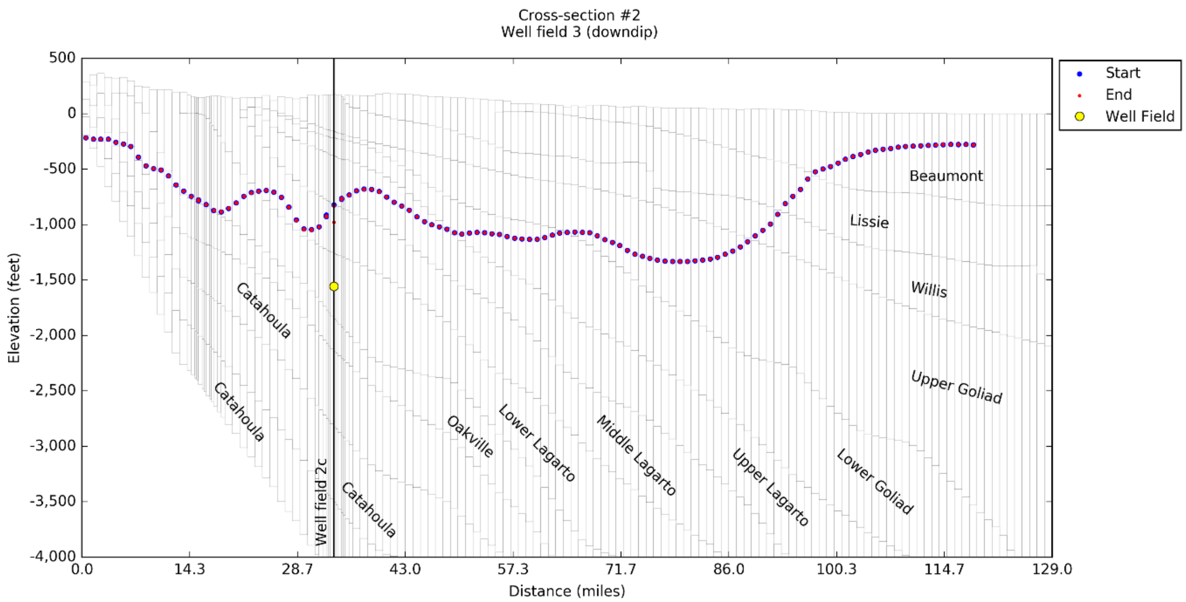


Figure 14-74. Simulated particle tracks 50 years after pumping the down dip Well Field #2c located along cross-section #2 on Figure 14-5 at 10,000 acre-feet per year.

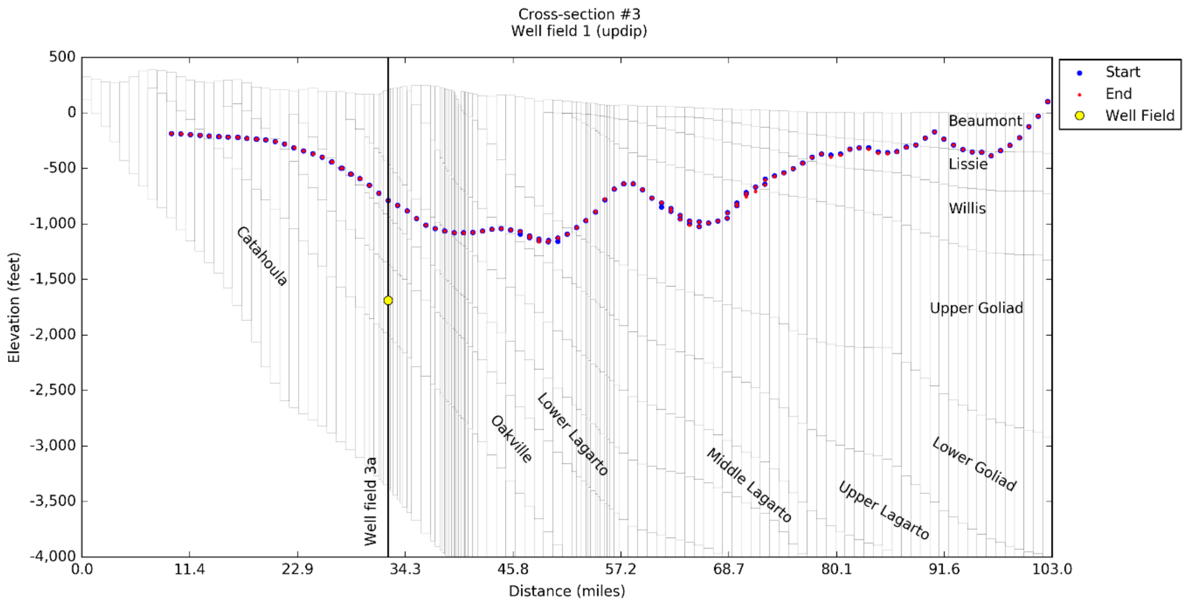


Figure 14-75. **Simulated particle tracks 50 years after pumping the up dip Well Field #3a located along cross-section #3 on Figure 14-5 at 10,000 acre-feet per year.**

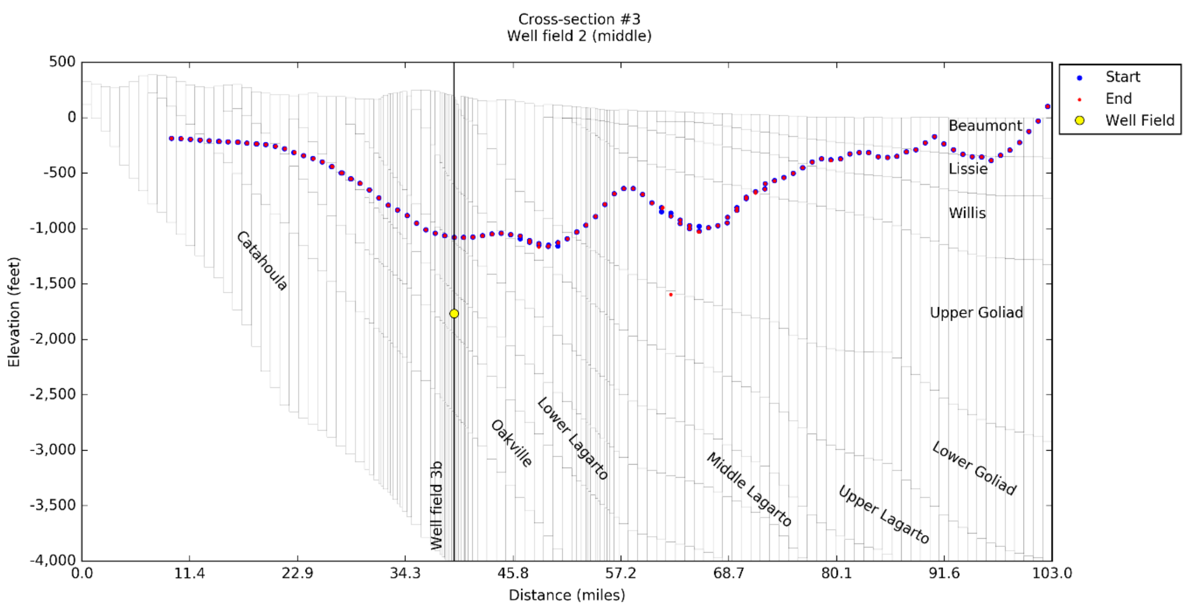


Figure 14-76. **Simulated particle tracks 50 years after pumping the middle Well Field #3b located along cross-section #3 on Figure 14-5 at 10,000 acre-feet per year.**

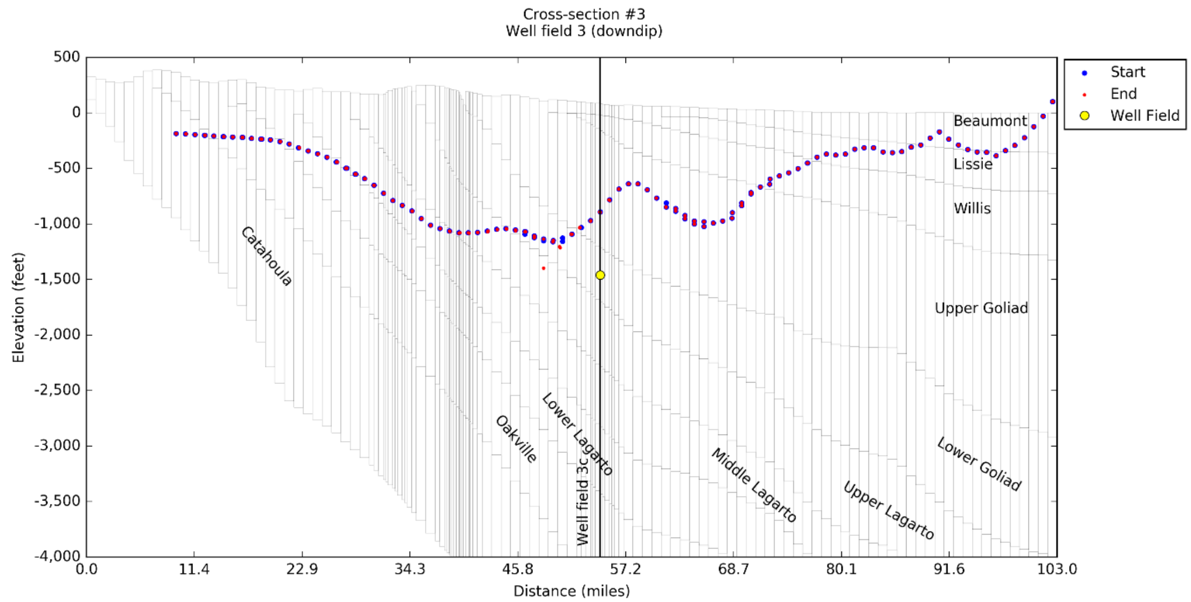


Figure 14-77. **Simulated particle tracks 50 years after pumping the down dip Well Field #3c located along cross-section #3 on Figure 14-5 at 10,000 acre-feet per year.**

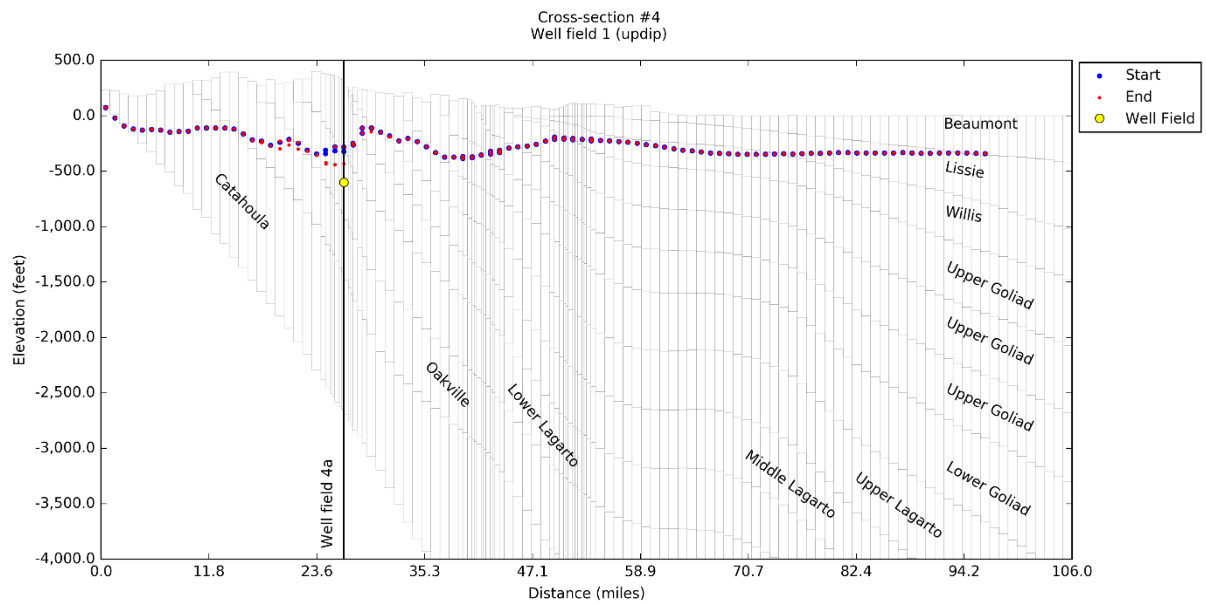


Figure 14-78. **Simulated particle tracks 50 years after pumping the up dip Well Field #4a located along cross-section #4 on Figure 14-5 at 10,000 acre-feet per year.**

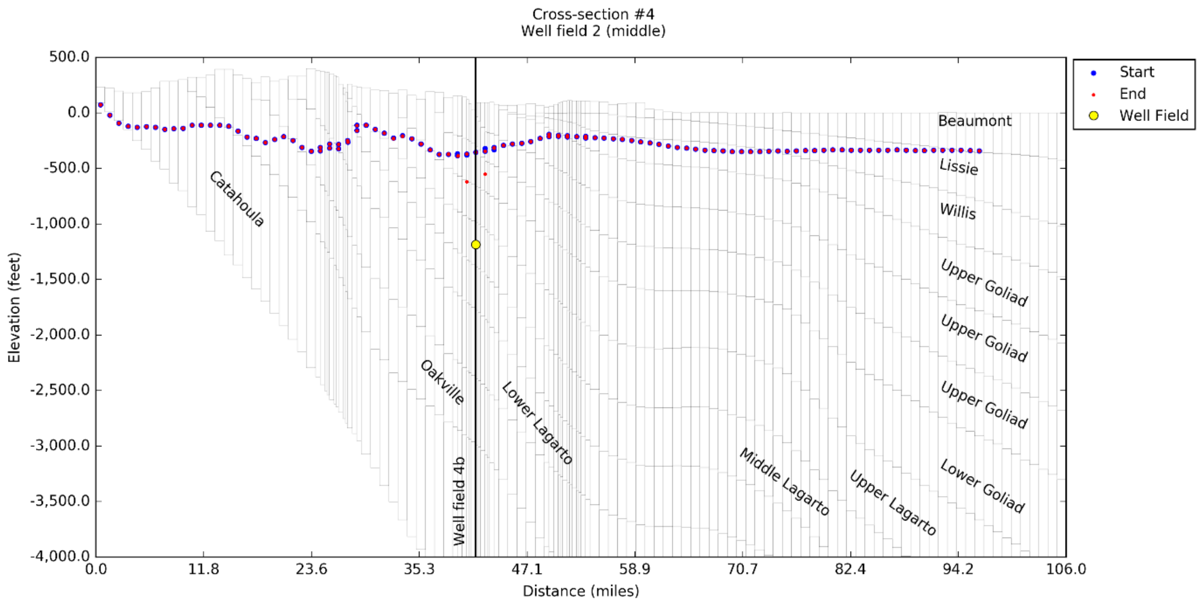


Figure 14-79. Simulated particle tracks 50 years after pumping the middle Well Field #4b located along cross-section #4 on Figure 14-5 at 10,000 acre-feet per year.

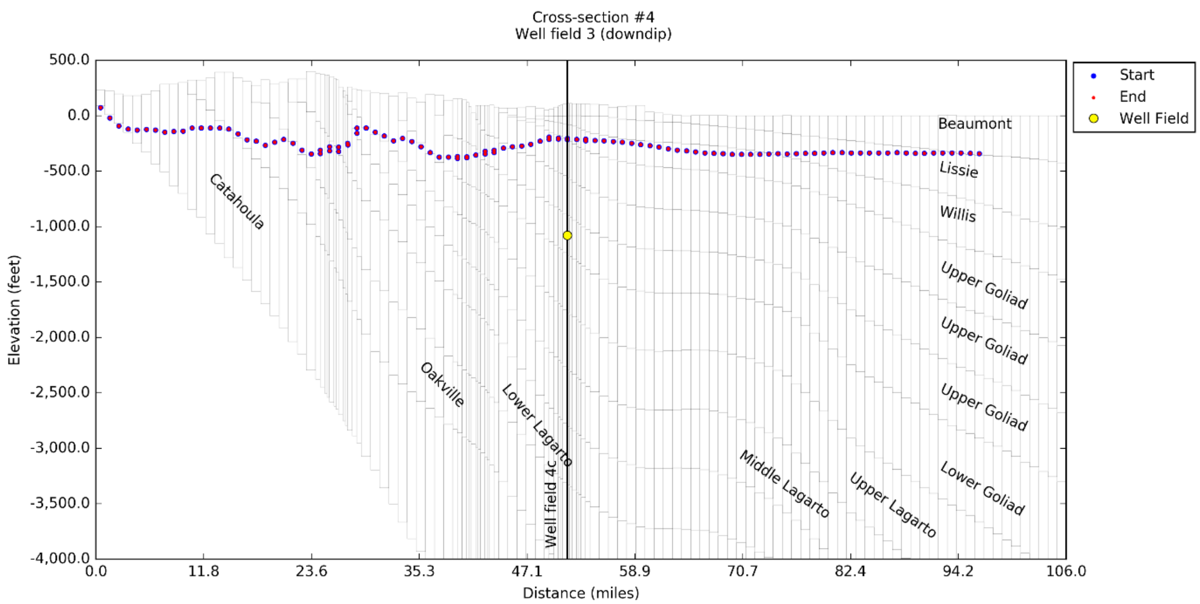


Figure 14-80. Simulated particle tracks 50 years after pumping the down dip Well Field #4c located along cross-section #4 on Figure 14-5 at 10,000 acre-feet per year.

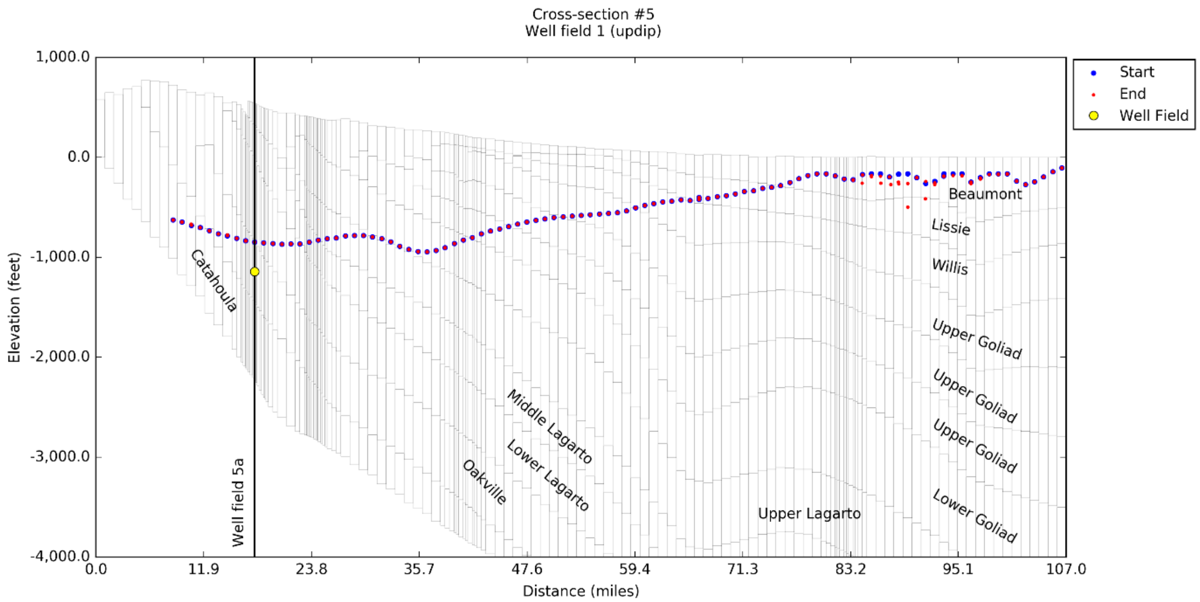


Figure 14-81. Simulated particle tracks 50 years after pumping the up dip Well Field #5a located along cross-section #5 on Figure 14-5 at 10,000 acre-feet per year.

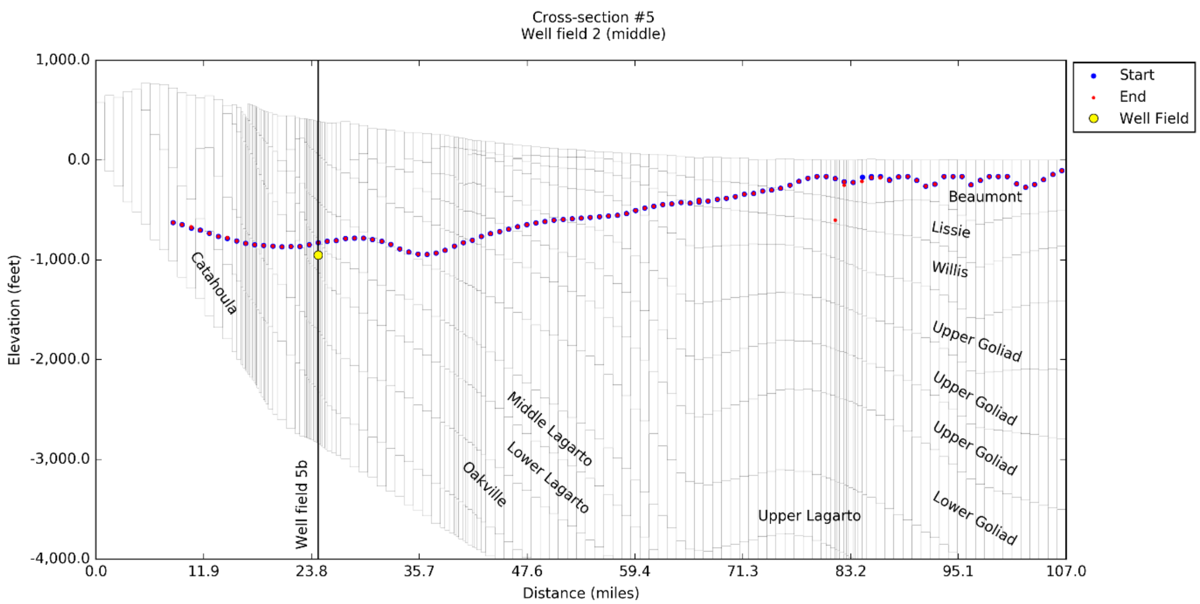


Figure 14-82. Simulated particle tracks 50 years after pumping the middle Well Field #5b located along cross-section #5 on Figure 14-5 at 10,000 acre-feet per year.

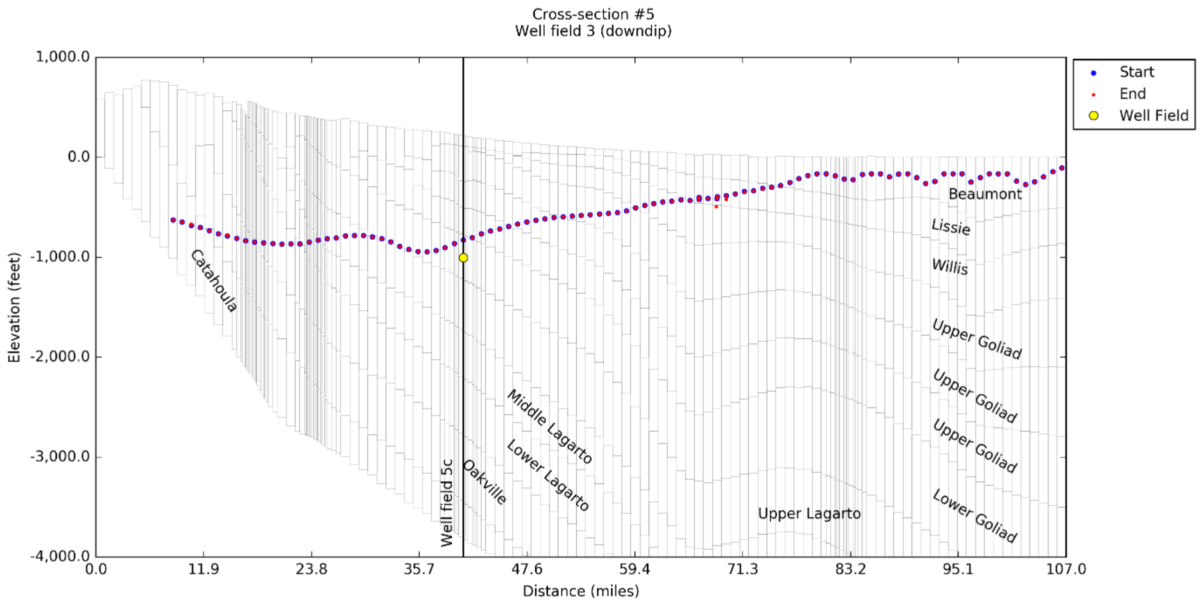


Figure 14-83. Simulated particle tracks 50 years after pumping the down dip Well Field #5c located along cross-section #5 on Figure 14-5 at 10,000 acre-feet per year.

15 Future Improvements

This study has been performed for and funded by the TWDB's Innovative Water Technologies Section to support their Brackish Resources Aquifer Characterization System. Key to their mission is the collection and organization of basic aquifer data to support the understanding and delineation of brackish groundwater resources in Texas. This specific study was work authorized under House Bill 30 passed by the 84th Texas Legislative Session and is specific to the Gulf Coast Aquifer in Texas. Our proposed list of potential future improvements focuses both on the larger mission of the TWDB Innovative Water Technologies Section Brackish Resources Aquifer Characterization System and further study in the Gulf Coast Aquifer specifically.

The following are future improvements that we propose for consideration by the TWDB:

- To evaluate the methods used to estimate groundwater salinity from geophysical log data, we recommend that the TWDB set up a few small scale pilot studies in coordination with drilling and logging companies with the goal of providing data to ground truth the methods used to interpret geophysical logs to estimate total dissolved solid concentrations.
- The evaluation of pumping impacts from potential brackish production zones relied on modeling using the existing groundwater available models. At depths greater than about 1,000 feet, the Gulf Coast Aquifer groundwater availability models, and most other groundwater availability models, are poorly constrained due to a lack of hydraulic property data, site conceptual model, and measured water levels. The Innovative Water Technologies Section of the TWDB could coordinate with the Groundwater Availability Modeling Section to devise methodologies to better characterize, or develop bounding conditions for the models in the deeper portions of the aquifers.
- In the Gulf Coast Aquifer, the development of brackish groundwater will eventually lead to situations where a nearby oil and gas injection or disposal well will be a concern. To prepare for that eventuality, there should be some research to better understand what the possible risks are with nearby injection or disposal wells and how to properly monitor the situation.
- There is a general lack of hydrogeologic data in the brackish aquifers in the Gulf Coast Aquifer. The absence of data is significant in the southern portion of the Chicot Aquifer and in the majority of the deep portions of the Evangeline Aquifer, and is extreme in the portions of the Jasper Aquifer and Catahoula Formation down dip of the outcrop and shallow subcrop. The hydrogeological analysis could be improved in the future with additional aquifer characterization studies, a search for possible existing data not publically available at this time, and/or coordination between the TWDB and entities investigating these portions of the aquifers.
- Future collection of water quality data in the Gulf Coast should look to help improve the number of well-log pairs that would be helpful to future project. Water wells should be targeted for sampling that are close to locations that have been characterized by high quality geophysical logs.
- We would recommend that the Innovative Water Technologies Section Brackish Resources Aquifer Characterization System expand their system to work more closely with modern petrophysics work flows and modern log suites. Large quantities of data will

continue to be generated for these types of brackish resource studies. This data is going to be primarily in the form of geophysical logs (.tif files), digital logs (.LAS files) and their derivatives. Current programs available to the Brackish Resource Aquifer Characterization System Group are limited and will only serve to increase the efforts necessary to process and understand the results of these types of studies. It is recommended that the Brackish Resource Aquifer Characterization System Group further investigate the option of having a petrophysical analysis and log database software built and made publicly available. We would propose that the Brackish Resources Aquifer Characterization System build off of this analysis and develop an improved analysis suite consistent with modern techniques.

16 Conclusions

The Gulf Coast Aquifer is a TWDB designated major aquifer in the state of Texas and underlies all or parts of 51 counties along the Texas Gulf Coast (Figure 2-1). The Gulf Coast Aquifer is designated as a major aquifer because it provides large quantities of water in large areas of the state. The Gulf Coast Aquifer is not a single aquifer, but rather consists of several aquifers (the Chicot, Evangeline, and Jasper aquifers) and confining units (the Burkeville and Catahoula), as shown in Figure 2-2.

This study was performed under contract to the TWDB to support work authorized under House Bill 30, passed by the 84th Texas Legislative Session. This bill requires the TWDB to identify and designate brackish groundwater production zones in four Texas aquifers, and the Gulf Coast Aquifer is one of four aquifers requiring an initial investigation. The objective of this study is to characterize the quantity and quality of groundwater within the Gulf Coast Aquifer and to propose Potential Production Areas that can be used by the TWDB to make recommendations to the legislature on designation of brackish production zones.

The following conclusions can be drawn from this study:

- We developed and implemented a methodology for mapping three-dimensional salinity zones across the Gulf Coast Aquifer using both empirically-derived and theoretical-based approaches for calculating the total dissolved solids concentration in groundwater from the formation resistivity. The salinity zones cover five salinity classes: freshwater, slightly saline, moderately saline, very saline, and brine.
- In order to have a consistent and reliable set of formation resistivity values from which to quantify and map estimated total dissolved solids across the Gulf Coast Aquifer, we digitized 600 geophysical logs; calculated the formation resistivity for approximately 30,000 sand beds; mapped the distribution of sand beds; and completed annotated cross-sections through the Texas Gulf Coast Aquifer.
- We applied our mapped three-dimensional salinity zones and our hydrogeological analysis with the criteria set forth by House Bill 30 to identify six Potential Production Areas which are large areas that encompass several geological formations and span multiple counties. Because much of the Gulf Coast Aquifer is brackish groundwater with total dissolved solids concentrations in excess of 1,000 milligrams per liter, the primary means of excluding regions from Potential Production Zones was protected user class wells. There were two regions, the Fort Bend and Harris-Galveston Coastal subsidence districts, delineated within the Gulf Coast Aquifer but excluded from the Potential Production Areas based on regulatory jurisdiction criteria specified in House Bill 30.
- To simulate the effects of pumping, five regional groundwater flow models were developed through the Potential Production Areas to assess drawdown impacts:
    - During development of the groundwater flow models, which were based on the regional groundwater models developed by the TWDB to support the joint planning in Groundwater Management Areas 14, 15, and 16, we incorporated approaches for accounting for how temperature and porosity differences with depth affect aquifer hydraulic properties.

  - Fifteen well fields each consisting of three to fifteen wells were identified within the Potential Production Areas and drawdown impacts were assessed for three different pumping rates after 30 and 50 years of pumping.
  - There is a general lack of hydrogeologic data in the brackish aquifers in the Gulf Coast Aquifer. The absence of data is significant in the southern portion of the Chicot Aquifer and in the majority of the deep portions of the Evangeline Aquifer, and is extreme in the portions of the Jasper Aquifer and Catahoula Confining Unit down dip of the outcrop and shallow subcrop.
  - Because of the general lack of aquifer data for these formations, sensitivity analyses were performed to understand the impacts of variation in aquifer hydraulic properties on drawdown. Sixteen sensitivity scenarios were developed to evaluate the potential of the Gulf Coast Aquifer to serve as a water source within the potential brackish production zones. This process acknowledges and seeks to account for uncertainty in the aquifer hydraulic properties that most influence the potential for production, including horizontal hydraulic conductivity, vertical hydraulic conductivity, and specific storage.
  - At depths greater than about 1,000 feet, the Gulf Coast Aquifer groundwater availability models, and most other groundwater availability models, are poorly constrained due to a lack of hydraulic property data, site conceptual models; and measured water levels.
  - The presented groundwater modeling provides a good basis for the TWDB to designate brackish Potential Production Areas, however, the model simulations are considered to be at a “scoping level” because the groundwater models have not undergone a high level of model construction or calibration.

- Volumes of in-place groundwater were calculated by salinity class (Winslow and Kister,1956) for ten to thirteen model layers in the Chicot Aquifer, Evangeline Aquifer, Burkeville Confining Unit, the Jasper Aquifer, and the Catahoula Confining Unit. The Gulf Coast Aquifer contains approximately 58,800 million acre feet of groundwater. Of is amount, 13,300 million acre feet is freshwater, 13,700 million acre feet is slightly saline groundwater, 8,700 million acre feet is moderately saline groundwater, 16,600 million acre feet is very saline groundwater, and 5,700 million acre-feet is brine. It is important to note that a large percentage of this in-place groundwater would not be recoverable or economical to produce.

This study provides a good basis for the TWDB to make recommendations to the state legislature regarding brackish resources and brackish groundwater production zones in the Gulf Coast Aquifer.

17 Acknowledgements

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18 References

Alger, R.P., 1966, Interpretation of electric logs in fresh water wells in unconsolidated formations, paper CC, *in* 7th Annual Symposium Transactions: Society of Professional Well Log Analysts, 25 p.

Arps, J.J.: "The Effect of Temperature on the Density and Electrical Resistivity of Sodium Chloride Solutions," Petroleum Transactions, AIME, 1953.

Asquith, G., and Krygowski, D., 2004, Basic well log analysis (second edition): AAPG Methods in Exploration Series 16, 239 p.

Ayers, W.B., Jr., and Lewis, A.H., 1985, The Wilcox Group and Carrizo Sand (Paleogene) in East-Central Texas: depositional systems and deep-basin lignite: The University of Texas at Austin, Bureau of Economic Geology, Geologic Folio No. 1, 19 p., 30 plates.

Baker, E.T., Jr., 1979, Stratigraphic and hydrogeologic framework of part of the coastal plain of Texas: Texas Department of Water Resources Report 236, 43 p.

Baker, E.T., 1986, Hydrology of the Jasper aquifer in the southeast Texas Coastal Plain: Texas Water Development Board Report 295, 64 p.

Blackwell, D.D, Richards, M.C., Frone, F.S., Batir, J.F., Ruzo, A.A., Williams, M.A. and Dingwall, R.K., 2011, SMU Geothermal Laboratory 3.5 km Temperature-at-Depth Map of the United States, Dallas, Texas, 75275-0395.

Bruno, R.S., and Hanor, J.S., 2003, Large-scale fluid migration driven by salt dissolution, Bay Marchand dome, offshore Louisiana. Gulf Coast of Geological Societies Transactions, v. 53, p. 97-107.

Bryant, W.R., Lugo, J., Cordova, C., and Salvador, A., 1991, Physiography and bathymetry: *in* Salvador, A., ed., The geology of North America: the Gulf of Mexico basin, vol. J: Boulder, Colorado, Geological Society of America, p. 13–30.

Carman, P.C., 1937, Fluid flow through granular beds, Transactions – Institution of Chemical Engineers, Vol. 15, pp. 150– 167.

Carr, J.E. Meyer, W.R., Sandeen, W.M., and McLane, I.R., 1985, Digital models for simulation of ground-water hydrology of the Chicot and Evangeline aquifers along the Gulf Coast of Texas: Austin: Texas Department of Water Resources Report No. 289, 101 p.

Chowdhury, A.H., and Mace, R.E., 2003, A groundwater availability model of the Gulf Coast Aquifer in the lower Rio Grande Valley, Texas: Numerical simulations through 2005: Texas Water Development Board.

Chowdhury, A.H., and Turco, M.J., 2006, Geology of the Gulf Coast aquifer, Texas, *in* R.E. Mace and others, eds., Aquifers of the Gulf Coast of Texas: Texas Water Development Board Report 365, p. 23–50.

Chowdhury, A. Wade, S., Mace, R.E., and Ridgeway, C., 2004, Groundwater Availability of the Central Gulf Coast Aquifer System: Numerical Simulations through 1999: Texas Water Development Board, unpublished report.

Collier, H., 1993, Borehole Geophysical Techniques for Determining the Water Quality and Reservoir Parameters of Fresh and Saline Water Aquifers in Texas: Texas Water Development Board, Report 343, vol. I&II.

Core Laboratories, Inc., 1972, A Survery of the Subsurface Saline Water of Texas, Volume IV Geologic Well Data West Texas: Texas Water Development Board Report 157, 150 p.

Crans, W., Mandl, G., and Haremboure, J., 1980, On the theory of growth faulting—A geochemical delta model based on gravity sliding: Journal of Petroleum Geology, 2, p. 265–307.

Deeds, N.E., Yan, T., Singh, A., Jones, T., Kelley, V., Knox, P., and Young, S., 2010, Groundwater Availability Model for the Yegua-Jackson Aquifer, Texas Water Development Board, GAM

Domenico, P.A., and Schwartz, F.W., 1990, Physical and chemical hydrogeology: New York, NY, John Wiley & Sons, Inc., 824 p.

Durham C.O., Jr., 1971, A study of the Scotlandville-Denham Springs faults and their effect on school sites. East Baton Rouge Parish, Louisiana: Etco Engineers and Associates Report.

Estepp, J., 1998, Evaluation of ground-water quality using geophysical logs: Texas Natural Resource Conservation Commission, unpublished Report, 516 p.

Ewing, T.E., 1990, Tectonic map of Texas: University of Texas at Austin, Bureau of Economic Geology, scale 1:750,000, 4 sheets.

Ewing, T.E., 1991, The tectonic framework of Texas; text to accompany the Tectonic Map of Texas: BEG, 36p.

Ewing, T.E., compiler, 1991, Tectonic Map of Texas; BEG, 4 sheets, scale 1:750,000.

Ewing, T.E., 2016, Pliocene sub-Willis unconformity in southeast Texas: forebulge to the Pliocene Mississippi Delta; GCAGS Transactions, v. xx in press

Fogg, G.E., 1980, Geochemistry of ground water in the Wilcox aquifer, *in* Kreitler, C.W., Agagu, O.K., Basciano, J.M., Collins, E.W., Dix, O., Dutton, S.P., Fogg, G.E., Giles, A.B., Guevara, E.H., Harris, D.W., Hobday, D.K., McGowen, M.K., Pass, D. and Wood, D.H., 1979, Geology and Geohydrology of the East Texas Basin A Report on the Progress of Nuclear Waste Isolation Feasibility Studies: The University of Texas at Austin, Bureau of Economic Geology (1979), Geologic Circular No. 80-12, p. 73-78.

Fogg, G.E., and Blanchard, P.E., 1986, Empirical relations between Wilcox groundwater quality and electric log resistivity, Sabine Uplift area, *in* Kaiser, W.R. ed., Geology and Groundwater hydrology of deep-basin lignite in the Wilcox Group of East Texas: The University of Texas at Austin, Bureau of Economic Geology, Special Report No. 10, p. 115-118.

Fogg, G.E., and Kreitler, C.W., 1982, Ground-Water Hydraulics and Hydrochemical Facies in Eocene Aquifers of the East Texas Basin. The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations No. 127, 75 p.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, N.J. Prentice Hall, 604 pp.

Galloway, W.E., 1986, Depositional and structural framework of the distal Frio Formation, Texas coastal zone and shelf; BEG Geological Circular 86-8, 16 p.

Galloway, W.E., 1989, Genetic stratigraphic sequences in basin analysis II: application to northeast Gulf of Mexico Cenozoic basin: American Association of Petroleum Geologists Bulletin, vol. 73, p. 143-154.

Galloway, W.E., 2005, Gulf of Mexico Basin depositional record of Cenozoic North American drainage basin evolution: International Association Sedimentologists Special Publication 35, p. 409–423.

Galloway, W. E., Ganey-Curry, P.E., Li X., and Buffler, R.T., 2000, Cenozoic depositional history of the Gulf of Mexico Basin: American Association of Petroleum Geologists Bulletin, v. 84, p. 1743–1774.

Galloway, W.E., Hobday, D.K., and Magara, K., 1982, Frio Formation of the Texas Gulf Coas Basin - depositional systems, structural framework, and hydrocarbon origin, migration, distribution, and exploration potential: BEG Report of Investigations 122, 78p.

Galloway, W.E. Jirik, L.A., Morton R.A., and DuBar, J.R., 1986, Lower Miocene (Fleming) depositional episode of the Texas coastal plain and continental shelf: structural framework, facies, and hydrocarbon resources: BEG Report of Investigations 150, 50p.

Gass, T.E., Geothermal heat pumps, Geothermal Resources Council Bulletin, 11, 3-8, 1982.

George, P.G., Mace, R E., and Petrossian, R., 2011, Aquifers of Texas: Texas Water Development Board, Report 380.

Government of Canada, 2016, http://healthycanadians.gc.ca/publications/healthy-living-vie-saine/water-dissolved-solids-matieres-dissoutes-eau/index-eng.php

Grubb, H.F., 1984, Planning report for the gulf coast regional aquifer-system analysis in the Gulf of Mexico Coastal Plain, United States: U.S. Geological Survey Water-Resources Investigations Report 84-4219, 30 p.

Grubb, H.F 1987, Overview of the Gulf Coast Regional Aquifer-System Analysis, *in* Vecchioli, J., and Johnson, A.I., eds., Aquifers of the Atlantic and Gulf Coastal Plain: American Water Resources Association Monograph no. 9, p. 101-118.

Hamlin and Luciana de la Rocha, 2015, Using Electric Logs to Estimate Groundwater Salinity and Map Brackish Groundwater Resources in the Carrizo-Wilcox Aquifer in South Texas: GCAGS Journal v.4 (2015), p. 109-131.

Hamlin, H.S., Smith, D.A., and Akhter, M.S., 1988, Hydrogeology of Barbers Hill salt dome, Texas coastal plain: The University of Texas at Austin, Bureau of Economic Geology, Report of Investigations No. 176, 41 p.

Harbaugh, A.W., 2005, MODFLOW-2005. The U.S. Geological Survey Modular Ground-Water Model – the Ground-Water Flow Process, Techniques and Methods 6-A16: United State Geological Survey.

Harbaugh, A.W., and M.G. McDonald, 1996. User’s Documentation for MODFLOW-96, an Update to the U.S. Geological Survey Modular Finite-Difference Ground-Water Flow Model. U.S. Geological Survey, Open-File Report 96-485, 56 p.

Harbaugh, A.W., Banta, E.R., Hill, M.C., and McDonald, M.G., 2000, MODFLOW-2000, the U.S. Geological Survey modular groundwater model—User guide to modularization concepts and the groundwater flow process: U.S. Geological Survey Open-File Report 00–92, 121 p.

Hayashi, 2003. M. Hayashi, “temperature-electrical conductivity relation of water for environmental monitoring and geophysical data inversion,” Environmental Monitoring and Assessment, Kluwer Academic Publishers, Printed in the Netherlands 96: 119–128, 2004.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water: U. S. Geological Survey Water Supply Paper 2254, 249 p.

Hosman, R.L., 1996, Regional stratigraphy and subsurface geology of Cenozoic deposits, Gulf Coastal Plain, South-Central United States—Regional aquifer system analysis—Gulf Coastal Plain: U.S. Geological Survey Professional Paper 1416-G, 35 p.

Hutchison, W.R., Hill, M.E, Anaya, R., Hassan, M., Oliver, W., Jigmond, M., Wade, S, and Aschenbach, E., 2011, Groundwater Management Area 16 Groundwater Flow Model, Unnumbered report: Texas Water Development Board.

Jacob, C.E. 1940. On the Flow of Water in an Elastic Artesian Aquifer. Trans-American Geophysical Union 21: 574-586.

Jigmond, M and Wade, S., 2013, GAM Run 12-025: Total estimated recoverable storage for aquifers in groundwater management area 16.

Jones, P.H. and Buford, T.B., 1951, Electric logging applied to ground-water exploration: Geophysics, vol. 16, no. 1, p. 115–139.

Jorgensen, D.G., 1975, Analog model studies of groundwater hydrology in the Houston district, Texas: Texas Water Development Board Report 190, 84 p.

Kasmarek, M.C., 2013, Hydrogeology and Simulation of Groundwater Flow and Land-Surface Subsidence in the Northern Part of the Gulf Coast Aquifer System, Texas, 1891-2009: U.S. Geological Survey Scientific investigations Report 2012-5154, 55 p.

Kasmarek, M.C., and Robinson, J.L., 2004, Hydrogeology and simulation of ground-water flow and land-surface subsidence in the northern part of the Gulf Coast Aquifer system. Texas: United States Geological Survey, Scientific Investigations Report 2004-2102.

Kelley, V.A., Ewing, J.E., Jones, T.L., Young, S.C., Deeds, N.E., Hamlin, S. (2014) Updated Groundwater Availability Model of the Northern Trinity and Woodbine Aquifers. Prepared for North Texas GCD, Northern Trinity GCD, Prairielands GCD, and Upper Trinity GCD, Final Report: Prepared by INTERA, Austin, TX.

Keys, W.S., and MacCary, L.M., 1971, Application of borehole geophysics to water-resources investigations: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 2, Chapter E1, 126 p.

Knox P.R., Kelley V.A., Vreugdenhil A., Deeds N. and Seni S., 2007, Structure of the Yegua-Jackson Aquifer of the Texas Gulf Coastal Plain: Texas Water Development Board.

Kozeny, J., 1927, About capillaries conducting water in the earth, Sitzber. Akd. Wiss. Wien, Math. Naurv. Kasse 136(Abl. 2a), 271– 306.

LBG-Guyton Associates in association with NRS Consulting Engineers, 2003, Brackish groundwater manual for Texas regional water planning groups: prepared for the Texas Water Development Board, http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/2001483395.pdf.

Loucks, R.G., Dodge, M.M., and Galloway, W.E., 1984, Regional controls on diagenesis and reservoir quality in lower Tertiary sandstones along the Texas Gulf Coast, *in* Clastic Diagenesis, eds McDonald, D.A., and Surdam, R.C.: American Association of Petroleum Geologists Memoir 37.

Loucks, R. G., M. M. Dodge, and W. E. Galloway, 1986, Controls on porosity and permeability of hydrocarbon reservoirs in Lower Tertiary sandstones along the Texas Gulf Coast: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 149, 78 p.

Mace, R.E. 1997. Determination of Transmissivity from Specific Capacity Tests in a Karst Aquifer. Ground Water 35, no. 5: 738-742.

Mace, R. E. 2001. Estimating Transmissivity Using Specific-Capacity Data: The University of Texas at Austin, Bureau of Economic Geology, Geological Circular No. 01-2, 44 p.

Magara, K. 1978. *Compaction and Fluid Migration – Practical Petroleum Geology*. Elsevier Scientific Publishing Company, New York. 350 pages

Malcolm Pirnie, Inc., 2001, Brackish groundwater supply study Phase 1c, San Patricio County and Aransas County Area of Interest: prepared for San Patricio Municipal Water District, Ingleside, Texas, 295.

Maliva, R. G., 2016. Aquifer Characterization Techniques: Schlumberger methods in Water Resources Evaluation Series No. 4, Springer Hydrogeology, Schlumberger Water Services, Fort Myers, FL

Matthess, G., 1982 The Properties of Groundwater. John Wiley & Sons, New York.

McBride, E. F., T. N. Diggs, and J. C. Wilson, 1991, Compaction of Wilcox and Carrizo sandstones (Paleocene-Eocene) to 4420 m, Texas Gulf Coast: Journal of Sedimentary Petrology, v. 61, p. 73–85.

McDonald, M. G., and Harbaugh, A. W., 1988, A modular three-dimensional finite-difference ground-water flow model: U.S. Geological Survey, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 6: Model Techniques, Chapter A1.

Meyer, J.E., 2012, Geologic Characterization of and Data Collection in the Corpus Christi Aquifer Storage and Recovery Conservation District and Surrounding Counties: Texas Water Development Board, Austin, TX, Open File Report 12-01.

Meyer (2015) Brackish Resources Aquifer Characterization System: Texas Water Development Board, Sept. 2015, http://www.twdb.texas.gov/publications/shells/BRACS.pdf

Meyer and others (2014) Brackish Resources Aquifer Characterization System Database Data Dictionary: Texas Water Development Board, Open File Report 12-02, Second Edition, Sept. 2014

Morton, R.A. L.A. Jirik, and W.E. Galloway, 1988, Middle-Upper Miocene depositional sequences of the Texas coastal plain and continental shelf: geologic framework, sedimentary facies, and hydrocarbon plays: BEG Report of Investigations 174, 40p.

Muffels, C., Wang, X., Tonkin, M., and Neville, C., 2014, User's Guide for mod-PATH3DU A groundwater path and travel-time simulator. http://gmsdocs.aquaveo.com/mod-PATH3DU_Manual_v1-0-0.pdf accessed on 7/31/2016.

Nelson, P.H, 1994, Permeability-porosity Relationships In Sedimentary Rocks. Society of Petrophysicists and Well-Log Analysts.

Niswonger, R.G., Panday, Sorab, and Ibaraki, Motomu, 2011, MODFLOW-NWT, A Newton formulation for MODFLOW-2005: U.S. Geological Survey Techniques and Methods 6-A37, 44 p.

Panday, Sorab, Langevin, C.D., Niswonger, R.G., Ibaraki, Motomu, and Hughes, J.D., 2013, MODFLOW-USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation: U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66 p.

PRISM Climate Group, 2013, PRISM-climate data, 30-year normals, –800m precipitation and mean temperature data precipitation dataset: Oregon State University, website http://www.prism.oregonstate.edu.

Roland, H.L., Hill, T.F., Autin, Durham, P., Jr., C.O., and Smith, C.G., 1981, The Baton Rouge and Denham Springs-Scotlandville faults: A report prepared for the Louisiana Department of Natural Resources by the Louisiana Geological Survey and Durham Geological Associates Consultants, Baton Rouge.

Ryder, P. (1988), Hydrogeology and predevelopment flow in the Texas Gulf Coast Aquifer systems, 10. U.S. Geological Survey, Water-Resources Investigations Report 87-4248.

Ryder, P. D., and A. F. Ardis (2002), Hydrology of the Texas Gulf Coast aquifer systems, *U.S. Geological Survey Professional Paper 1416-E, 77 p.*

Scanlon, B.R., Reedy, R., Strassberg, G., Huang, Y, and G. Senay, Y, 2012, Estimation of Groundwater Recharge to the Gulf Coast Aquifer in Texas, USA. Unnumbered Report: Texas Water Development Board.

Schlumberger, 1972, Log Interpretation, Volume 1 – Principles: Schlumberger Limited, 113 p.

Schlumberger, 2009, Log interpretation Charts, Schlumberger, Houston, Texas

Seni, S.J., and Jackson, M.P.A., 1984, Sedimentary record of Cretaceous and Tertiary salt movement, East Texas basin-Times, rates, and volume of salt flow and their implications for nuclear waste isolation and petroleum exploration: The University of Texas at Austin, Bureau of Economic Geology Report of Investigations No. 139, 89 p.

Shestakov, V. 2002. "Development of relationship between specific storage and depth of sandy and clay formations", Environmental Geology, Volume 42, Numbers 2-3 / June, 2002. pp. 127-130.

Sorensen, J. A., & Glass, G. E. 1987, Ion and temperature dependence of electrical conductance for natural waters. *Analytical Chemistry*, *59*, 1594–1597.

Strom E.W., Houston, N.A., and Garcia, C.A., 2003a, "Selected Hydrogeologic datasets for the Chicot aquifer, Texas": USGS Open-File Report 03-297, 1 CD-ROM.

Strom E.W., Houston, N.A. and Garcia, C.A., 2003b, "Selected Hydrogeologic datasets for the Evangeline aquifer, Texas": USGS Open-File Report 03-298, 1 CD-ROM.

Strom E.W., N.A. Houston, and C.A. Garcia, 2003c. "Selected Hydrogeologic datasets for the Jasper aquifer, Texas," USGS Open-File Report 03-299, 1 CD-ROM.

(Texas Administration Code, 2016)

Tonkin, M.J., and Larson, S. P., 2002. Kriging Water Levels with a Regional-linear and Point-logarithmic Drift. Ground Water, vol. 40, no. 2: 185-193.

Toth, J., 1963, "A theoretical analysis of groundwater flow in small drainage basins": *Journal of Geophysical Research*, Vol. 68, No. 16, p. 475-4812.

TWDB, 2016, Explanation of the Groundwater Database (GWDB), http://www.twdb.texas.gov/groundwater/faq/faqgwdb.asp

Turcan, A.N., Jr., 1962, Estimating water quality from electrical logs: U.S. Geological Survey Professional Paper 450-C, p. 135-136.

United States Environmental Protection Agency, 2016. https://www.law.cornell.edu/cfr/text/40/part-136

Verbeek, E.R., 1979, Surface faults in the Gulf Coastal Plain between Victoria and Beaumont, Texas: Tectonophysics, v. 52, p. 373–375.

Wade, S. and Anaya, R., 2014, GAM task 13-038: Total estimated recoverable storage for aquifers in Groundwater Management Area 15.

Wade, S., Thorkildsen, D., Anaya, R., 2014, GAM task 13-037: Total estimated recoverable storage for aquifers in Groundwater Management Area 14.

Wallace, R.H., Kraemeer, T. F., Taylor, R.E, and Wesselman, J B., 1972. Assessment of Geopressured-Geothermal Resources in the Northern Gulf of Mexico Basin,

Walton, N., 1989. Electrical Conductivity and Total Dissolved Solids – What is Their Precise Relationship: Desalination, Vol 72, (3), pg 275-292

Weiss, J., 1992, Geohydrologic Units of the Coastal Lowland Aquifer System South-Central United States, Professional Paer 1416-C: U.S. Geological Survey, Denver, CO., 42 p.

Wesselman, J.B. 1971, Ground-water resources of Chambers and Jefferson Counties, Texas. Texas Water Development Board, Report 133

Wesselman, J.B. 1972, Ground-water resources of Fort Bend County, Texas. Texas Water Development Board, Report 155

Whitman, H.M, 1965, Estimating Water Quality From Electric Logs, Department of Conservation, Louisiana Geological Survey and Louisiana Department of Public Works in cooperation with the United States Geological Survey

Williamson A.K., and Grubb, H.F., 2001, Groundwater Flow in the Gulf Coast Aquifer Systems, South-Central United States, Regional Aquifer System Analyses – Gulf Coast Plains: U.S. Geological Survey Professional Paper 1416-F.

Winker, C.D., and Edwards, M.B., 1983, Unstable progradational clastic shelf margins, *in* Stanley, D.J., and Moore, G.T., eds, The shelfbreak; Critical interface on continental margins: SEPM Special Publication 33, p. 139-157.

World Health Organization, 2016.http://www.who.int/water_sanitation_health/dwq/chemicals/tds.pdf)

Young, S. C. and Kelley, V., editors. 2006. A Site Conceptual Model to Support the Development of a Detailed Groundwater Model for Colorado, Wharton, and Matagorda Counties, prepared for the Lower Colorado River Authority, Austin, TX.

Young, S.C. and Lupton, D., 2014. Gulf Coast Aquifer Groundwater Study for the City of Corpus Christi: Phase 1. Prepared for the City of Corpus Christi, Corpus Christi, TX. April 2014.

Young, S.C., Kelley, V., Budge, T., Deeds, N., and Knox, P., 2009, Development of the LCRB Groundwater Flow Model for the Chicot and Evangeline Aquifers in Colorado, Wharton, and Matagorda Counties: LSWP Report Prepared by the URS Corporation, prepared for the Lower Colorado River Authority, Austin, TX.

Young, S., Budge, T., Knox, P., Kalbouss, R., Baker, E., Hamlin, S., Galloway, B., and Deeds N., 2010, Final hydrostratigraphy of the Gulf Coast Aquifer from the Brazos River to the Rio Grande, (Final Report): Texas Water Development Board, 203p.

Young, S., Ewing, T., Hamlin, S., Baker, E, and Lupton, D., 2012, Final Report Updating the Hydrogeologic Framework for the Northern Portion of the Gulf Coast Aquifer. Prepared for the Texas Water Development Board, June 2012.Young and others (2013)

Young, S.C., Pinkard, J., Bassett, R.L., and Chowdhury, A.H., 2014, Final Hydrogeological Evaluation of the Texas Gulf Coast Aquifer System and Implications for Developing Groundwater Availability Models, prepared for the Texas Water Development Board, April 2014.

19 Appendices

19.1 Tabulated Total Dissolved Solids Picks from Well Logs

The depth at which the total dissolved solids concentration for groundwater was 1,000, 3,000, 10,000, and 35,000 milligrams per liter was picked from geophysical logs conducted in water wells and oil and gas wells. Table 19-1 tabulates the elevations corresponding to these depths. This table includes the 12-digit American Petroleum Institute number for oil and gas wells, the elevation of groundwater with a total dissolved solids concentration of 1,000 milligrams per liter, the elevation of groundwater with a total dissolved solids concentration of 3,000 milligrams per liter, the elevation of groundwater with a total dissolved solids concentration of 10,000 milligrams per liter, and the elevation of groundwater with a total dissolved solids concentration of 35,000 milligrams per liter.

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Table 19-1. **Geophysical log picks of groundwater with a total dissolved solids concentration of 1,000, 3,000, 10,000, and 35,000 milligrams per liter.**

API Number[(a)]	Elevation of TDS Pick[(b)]			
	1,000[(c)]	3,000[(d)]	10,000[(e)]	35,000[(f)]
1701100087	-1,689			
1701100642	-1,702	-2,663	-2,966	-3,682
4200500192		-718		
4200530171		-847		
4200700067		-389	-654	
4200700354		-1,399	-1,579	-3,823
4200700858		-776	-935	
4200730660		-472	-810	
4200730778				-2,212
4201500018	-282	-1,693		
4201500230	-590	-1,546	-2,633	
4201500262	-883	-2,107	-2,934	
4201500591	-290	-1,965		
4201500624	-829	-1,904		
4201500662	-367			
4201500683	-812	-2,973	-3,277	
4201530138	-432	-1,702		
4202500474		-138	-1,286	
4202501511	-676	-913	-1,858	
4202501665		-709	-2,171	
4202502026	-501	-647	-1,064	
4202502430		-1,495	-1,675	
4202530031		-835	-1,958	
4202531493	-125	-999	-2,681	
4202531557		-186	-1,507	
4202531816	-311	-1,570	-2,780	
4202531912	-486		-2,157	
4202532065	-458	-615	-2,116	
4202532278	-275	-1,433	-2,701	
4202532433	-509	-1,509	-2,086	
4202532584	-687	-1,416	-1,563	
4203900965		-1,477	-1,647	
4203901420	-1,276	-1,441	-1,608	-2,274
4203901452	-1,181	-1,381	-1,557	-2,320

API Number[(a)]	Elevation of TDS Pick[(b)]			
	1,000[(c)]	3,000[(d)]	10,000[(e)]	35,000[(f)]
4203901711		-1,209		-2,828
4203901910	-1,094	-1,356	-1,581	
4203902865		-894	-1,120	-1,584
4203903898		-861	-1,042	-1,512
4203904069	-425	-1,184	-1,348	-2,508
4203904224			-1,285	-2,075
4203904263	-450	-1,028	-1,292	-3,058
4203904277	-169	-977	-1,396	-2,002
4203904291		-1,129		
4203904467		-1,207	-1,326	-3,088
4203904481		-1,070	-1,398	-2,101
4203932152	-1,246	-1,459		
4204100012			-830	
4204100068			-1,486	
4204100102		-1,635		
4204700117		-849		
4204700309	-403	-926		
4204700435	-36	-1,481	-3,586	
4204700694	-328	-1,950	-2,790	
4204701249	-87	-1,832	-2,566	
4204701267	-377	-2,185	-2,618	
4204730017		-2,767	-3,138	
4204730662	-572	-2,543	-3,184	
4204731639	-764	-2,303		
4204732065		-2,449		
4205130950		-1,730		
4205700852		-487	-646	-1,515
4205700872		-656	-1,083	
4205701185		-810	-1,010	-2,355
4205701221		-368	-819	-2,154
4205701248	-329	-1,397		-4,264
4205701323				-4,195
4205730876		-585	-705	-1,725
4205730903		-726	-1,127	-2,318

API Number[(a)]	Elevation of TDS Pick[(b)]			
	1,000[(c)]	3,000[(d)]	10,000[(e)]	35,000[(f)]
4207100226	-910	-1,335		
4207100972	-672		-1,423	-2,331
4207101074			-3,884	-4,627
4207101083		-264	-1,152	-2,861
4207101209		-452	-1,645	-2,966
4207102177		-294	-1,232	-1,963
4207102466		-1,141	-1,390	-2,301
4207102513			-919	-1,856
4207102740		-1,166	-1,569	-1,956
4207102880	-665	-1,285	-1,552	-2,517
4207103062	-628	-1,377		-2,167
4207103096		-1,313	-1,626	-2,609
4207131302				-2,526
4207131458	-953	-1,195	-1,713	-2,274
4208900057	-169	-1,698		
4208900090	-134	-1,648	-2,632	
4208900345	-267	-1,812	-2,476	
4208900354	-174	-1,769		
4208900436	-222	-1,645		
4208900484	-724	-1,761		
4208900724	-745	-2,905	-3,328	
4208900755	-838		-2,892	
4208900970	-454	-2,412	-3,060	
4208930229			-2,491	
4208930427	-879			
4208930570	-369	-2,103	-2,399	
4208930592	-770	-2,195	-2,802	
4208931120	-648		-2,625	
4208931221	-122			
4208931246	-465	-2,114	-2,857	
4208931376	-608	-2,536	-3,367	
4208931531		-825	-1,391	
4208931604	-1,271	-1,978	-2,737	
4208931611	159			
4212300276	-483	-853	-1,967	
4212300279		-712	-1,365	

API Number[(a)]	Elevation of TDS Pick[(b)]			
	1,000[(c)]	3,000[(d)]	10,000[(e)]	35,000[(f)]
4212300290	-541	-1,039	-1,349	
4212300337		-896		
4212300661	-381	-1,351	-1,653	
4212300722	-619	-1,394	-1,810	
4212300824	-1,094	-1,274	-1,625	
4212300905	-1,093	-1,276	-1,745	
4212300980		-847	-1,022	
4212300982	-488	-1,389	-2,246	
4212330020	-512	-1,171	-2,089	
4212331022	-509	-1,261	-1,811	
4212331622	-548	-1,758	-2,052	
4213103501		-478	-1,062	
4213107826		-21	-2,307	-4,306
4213108480		-842		
4213109676	-336	-749		
4213109917	228	-405	-2,432	
4213110189		14	-2,090	
4213131667		45	-1,010	
4213131732			-122	
4213132341	-384	-836		
4213133980		-1,062	-2,398	
4213134947		-271	-2,391	
4213135197		-347	-1,769	
4213135869		-740	-2,692	
4213136193		-253		
4213136958			-1,421	
4213137128	-65	-292		
4213137261		-161		
4213137552			-70	
4213137720		-757	-1,336	
4213137895		-864	-1,703	
4213138254		-1,190	-2,232	
4214932049	245			
4215700001	-1,092	-2,217	-3,027	
4215700030	-941	-2,537	-3,265	
4215700894	-956	-2,581	-3,725	-4,067

API Number[(a)]	Elevation of TDS Pick[(b)]			
	1,000[(c)]	3,000[(d)]	10,000[(e)]	35,000[(f)]
4215700940	-1,147	-2,954	-3,158	
4215701026	-1,131		-3,020	-4,126
4215701374	-1,165	-2,350	-3,301	
4215701674	-800	-1,353	-1,694	-2,152
4215701729	-1,308	-2,100	-2,185	
4215702459	-1,301	-1,912		-4,571
4215730949	-1,006	-1,378	-1,519	-1,730
4215731513	-954			
4215731695	-1,427	-3,126	-3,354	
4215731805	-1,583	-2,453	-3,144	
4215731983		-1,972	-3,210	
4216700035	-745	-1,450	-1,950	
4216700956		-1,109	-1,260	-1,985
4216700966		-1,243	-1,412	-3,055
4216701142		-1,197	-1,265	-3,667
4216701276	-940	-1,472	-1,709	
4216701336	-906	-1,072	-1,314	-1,830
4216701876	-711	-1,124	-1,445	-2,305
4216701916		-913	-1,254	-1,790
4216730091		-1,351	-1,443	-2,846
4217500722	-313	-1,734	-2,040	
4217501384	-1,231	-1,523	-2,794	
4217501456	-494	-1,246	-2,466	
4217501928		-994	-2,604	
4217531593		-1,400	-1,732	
4217531719	-1,629	-2,356	-2,915	
4217531945	-1,202	-2,085	-2,439	
4217532165	-762	-2,013	-2,261	
4217532197	-620	-1,689		
4217532584		-1,526	-2,810	
4217532636	-1,082			
4217533350		-1,493	-2,859	
4218500024		-489		
4218500034		-849	-1,100	
4218530009	-765	-1,427	-2,563	
4218530028	5	-1,621	-2,594	
4218530369		-1,287		
4218530399	-720	-1,651	-2,867	
4219900116	-1,176	-1,891	-2,496	-3,406
4219900356	-1,483	-2,353	-2,668	-3,733
4219900618	-770	-2,276	-2,976	
4219900634	-1,164	-1,895	-2,100	-3,774
4219900674	-1,196	-2,089	-2,365	
4219900757	-1,270	-1,858	-2,727	
4219902148	-1,019	-1,401	-2,132	
4219931811	-1,293			
4219931816	-897	-2,033	-2,613	-4,088
4220100104	-972	-1,621	-2,689	
4220102658	-1,080		-3,224	
4220102722	-1,131	-2,774	-3,185	-5,222
4220102972	-919	-2,321		-3,120
4220103343	-1,086	-2,642		
4220103510	-1,627	-2,549	-3,137	-3,912
4220103533	-1,086	-2,619	-2,921	-4,144
4220104395		-3,032		
4220105058	-1,077	-2,007	-2,691	-4,556
4220106044	-1,047	-1,342	-1,649	-2,915
4220106223	-543	-1,619	-3,076	-4,061
4220107603	-773	-2,402	-2,709	-4,666
4220107892	-708	-2,114	-2,723	
4220107904	-1,448	-2,686	-2,889	
4220130958	-1,533	-2,661		
4220131506	-760	-1,802	-3,016	-4,303
4220132062	-1,262			
4220132187	-1,632	-1,744	-2,559	-3,902
4220132368		-1,050	-1,891	
4220132375	-867			
4223900014	-791	-2,054	-2,520	
4223900047	-1,348	-1,949	-2,730	
4223900098	-1,023	-1,380	-2,842	
4223900120	-1,108	-1,528	-2,299	
4223900233	-869	-1,544	-2,032	

API Number[a]	Elevation of TDS Pick[b]			
	1,000[c]	3,000[d]	10,000[e]	35,000[f]
4223900309	-820	-1,450	-2,842	
4223900816		-1,426		
4223901090	-753	-1,564		
4223901427	-784	-959		-2,038
4223901520	-493	-796		
4223901556		-1,487	-2,119	-3,375
4223901728	-1,189	-2,308	-2,632	
4223901917	-1,389	-2,066	-2,710	
4223901921	-1,437	-2,072	-2,900	-3,978
4223901992		-1,332	-1,988	-4,068
4223903228	-597		-954	
4223903329	-1,042	-1,516		
4223903378		-1,423		
4223933136			-1,368	
4224100205	-813	-2,074	-2,355	-3,861
4224100250	-1,424	-1,979	-2,042	
4224100253	-71		-1,016	
4224130308	-856	-1,454	-1,698	
4224130545	-1,718	-2,385		-3,845
4224500169	-204	-719	-1,299	
4224500541		-1,070	-1,296	-2,480
4224501318		-915	-1,085	-1,419
4224501501				-1,744
4224501637		-325	-764	-2,016
4224501654		-262	-940	-2,167
4224502143		-1,047	-1,296	-2,190
4224502265		-768	-1,072	-2,126
4224502689		-498	-971	-2,352
4224502996			-591	-1,838
4224530143				-1,982
4224531562	-266	-1,401	-1,786	-3,522
4224532572			-841	
4224700207	-122	-470	-1,310	
4224702215		-1,340		
4224702371	-271	-2,120		
4224702376	-114	-1,772		

API Number[a]	Elevation of TDS Pick[b]			
	1,000[c]	3,000[d]	10,000[e]	35,000[f]
4224702459	-231	-1,840		
4224702498	-1,050	-1,561		
4224702610	30	-2,393		
4224731484		46		
4224731565			-3,698	-4,244
4224731695	45	-788		
4224731713		-997	-2,782	
4224731749	-570	-1,775	-2,942	
4224731878	-531	-1,502	-2,763	
4224731940			-1,408	
4224732275		-1,298	-2,957	
4224901494			-1,984	
4224901791	-646	-1,079		
4224902710	-613	-693		
4224903514	-740			
4224930868		-716	-2,878	
4224930877		-838	-2,424	
4224931450	-469	-1,721	-2,631	
4224931724	8	-1,231	-2,849	
4224932053		-1,342	-1,817	
4224932086	-536	-1,546	-2,714	
4225500634			-1,415	
4225500642			-1,795	
4225530246		-1,012	-1,635	
4225530609	-371	-849	-2,514	
4225531346	-306	-955		
4226100100	-1,313		-2,087	
4226100135	-780	-1,067	-1,514	
4226100164		-1,157		
4226100179		-1,238	-2,768	
4226100201	-1,631	-1,884	-2,233	
4226100219	-1,194	-1,440	-3,076	
4226100223	-783	-1,859	-2,989	
4226100248	-871	-2,131	-3,069	
4226100250	-654	-2,160	-3,268	
4226100272		-1,647	-2,486	-3,965

API Number[(a)]	Elevation of TDS Pick[(b)]			
	1,000[(c)]	3,000[(d)]	10,000[(e)]	35,000[(f)]
4226100277	-292	-1,831	-2,066	-4,641
4226100291	-1,653	-1,894	-2,126	
4226100294		-1,986	-2,158	-2,891
4226100341	-784	-931	-1,198	
4226100353		-1,560	-2,294	
4226100361	-1,245	-1,709	-3,165	
4226100393	-1,032		-3,382	
4226130174		-1,394	-2,801	-4,581
4227300003		-954	-2,911	
4227300542		-1,297	-1,360	
4227300554		-142	-1,830	
4227300585		-1,553	-1,947	
4227300845	-965	-1,142	-1,988	
4227300883		-1,573	-2,237	
4227301085	-807	-996	-1,873	
4227301312	-545	-850	-2,473	
4227301778			-1,832	
4227301795	-691	-854		
4227302116		-436	-828	
4227332336			-2,099	
4228500007		-832		
4228500191	-259	-1,007	-1,926	
4228500249	-326	-1,301	-2,002	
4228500308	-982	-1,875	-2,244	
4228500326			-2,321	
4228500354	-422	-1,383	-1,975	
4228500358	-1,000	-1,266	-2,256	
4228500431	-931	-2,037	-2,395	
4228500475	-625	-1,736	-2,336	
4228500509	-583	-1,726	-2,549	
4228530268	103	-603	-1,626	
4228531359	-110	-1,220		
4228531464	-340			
4228531777	-346		-1,568	
4228531957	-190			
4228532282		-1,442	-1,944	
4228532297		-932	-1,723	
4229100086	-628	-1,429	-1,975	-3,590
4229100189	-754	-1,805	-2,606	
4229100294	-797	-1,792	-2,552	
4229100302	-1,667	-2,136	-2,404	
4229100333	-467	-1,647	-2,297	-4,108
4229101802	-733	-1,032	-1,868	-4,859
4229102104	-341	-1,548	-2,464	-4,503
4229102169	-1,550	-1,932	-2,759	-3,996
4229102426	-1,216		-2,884	-4,781
4229102431		-1,938	-2,570	
4229103880	-1,414	-2,490		-3,718
4229104384	-1,022	-2,211	-3,373	-4,901
4229104537			-1,349	-2,329
4229104841	-414	-1,126	-1,430	
4229105018	-1,422	-2,115	-2,785	
4229700011			-1,231	
4229700043		-423		
4229701154	-136		-1,510	
4229701533	-516		-2,128	
4229702031			-1,318	
4229702169	32	-979	-2,325	
4229702604	-319	-676	-2,472	
4229730330	-127		-1,344	
4229732519	-197	-675		
4229732656	291	129	-1,008	
4229732681	62	-641		
4229733276	-54	-799	-2,617	
4229733511	-452	-903	-1,949	
4229733541	-11	-1,131		
4229733600	153	-1,017	-2,094	
4229733828			-998	
4229734397			-1,473	
4231100943			-684	
4231101173			-941	
4231131876			-1,637	

API Number[(a)]	Elevation of TDS Pick[(b)]			
	1,000[(c)]	3,000[(d)]	10,000[(e)]	35,000[(f)]
4231132161			-2,613	
4232100003	-737	-913	-1,201	
4232100116	-1,135	-1,301	-1,403	
4232100435	-1,204	-1,264	-1,387	
4232100670	-462	-1,121	-1,177	
4232100824	-331	-1,119	-1,261	
4232101026	-1,152		-1,307	
4232101064	-409	-876		
4232101077	-442	-878	-1,074	-1,195
4232101967	-734	-1,018		-1,494
4232102043		-1,086		
4232102119	-795	-1,095	-1,250	
4232102162		-1,019	-1,191	-2,314
4232102171	-921	-960	-3,182	-4,826
4232102295	-964	-1,026	-2,769	
4232102514	-858	-1,019	-1,146	-2,029
4232102539		-1,059		
4232102576		-800	-1,039	
4232102626	-795	-1,100	-1,184	
4232102721	-723	-1,101	-1,217	-1,525
4232130497	-432	-832	-1,130	-2,559
4232130952	-1,188	-1,389	-1,459	-2,294
4232130961		-793	-955	-1,818
4232130980	-351	-847	-912	
4232130996	-565	-1,013	-1,174	-1,596
4232131159	-1,085	-1,146	-1,259	
4232131273	-611	-960	-1,029	-1,549
4232131324		-902	-1,143	-2,164
4232131558		-974	-1,036	-1,528
4232131573				-2,202
4232131673				-2,441
4233900045	-1,088			
4233900086		-1,813		
4233900202	-1,252	-1,998	-2,745	-4,006
4233900868	-816	-1,899	-2,678	
4233900901	-681	-1,884	-3,036	
4233900994	-618	-2,336	-2,670	
4233900998	-227	-2,114		
4233901014	-595	-1,596	-2,443	
4233901039	-1,438	-2,431		
4233901102	-1,373	-2,109	-2,198	
4233901109	-1,220	-2,180	-2,369	
4233901718	-855			
4233901737	-1,566	-1,803	-2,672	
4233901872	-1,137	-2,170	-3,041	
4233930072	-1,322	-4,165		
4233930478	-999	-2,099	-2,698	
4233930820		-1,859	-3,323	
4233930849	-1,148	-1,906	-2,841	-4,168
4235100048	-698	-1,750	-1,864	
4235100096	-2,079	-2,586		-3,913
4235100213	-2,539		-2,812	
4235100289	-1,426	-1,577	-2,838	-3,993
4235100425		-577	-1,544	
4235130521			-1,456	
4235130726			-2,433	
4235500807		-715	-1,111	
4235500992		-786	-1,259	-2,403
4235503182			-1,634	
4235504082		-1,317	-2,070	
4235506225			-1,289	
4235530009	-634	-1,010	-1,507	
4235530249			-841	
4236100004	-909	-1,619	-2,722	-4,227
4236100328	-700	-832	-902	-1,753
4236100480	-743	-824	-962	-1,455
4236130791	-704	-837	-1,044	-2,208
4236130810				-3,803
4237300003			-1,859	
4237300010			-2,063	
4237300030			-2,143	
4237300037		-1,032	-1,588	

API Number[(a)]	Elevation of TDS Pick[(b)]			
	1,000[(c)]	3,000[(d)]	10,000[(e)]	35,000[(f)]
4237300359	-234	-1,228	-2,157	
4237300423	-1,044	-1,660	-2,259	
4237330091	-298	-979	-1,623	
4237330120		-1,096	-1,683	
4237330154		-877	-1,866	
4237330216		-1,058	-1,313	
4237330484		-786	-1,445	
4237330505	-1,468	-1,554	-2,311	
4237330975			-1,918	
4239100023	-1,257	-1,428	-1,837	
4239100086		-853	-1,555	
4239100205	-1,138	-1,459	-2,098	-3,920
4239103659		-1,093	-1,558	-3,369
4239103722	-431	-1,232	-1,822	-2,591
4239131466		-2,024	-2,301	
4239131588	-1,215	-1,321		
4239132087	-1,131	-1,427	-1,869	-3,863
4239132118	-1,038	-1,212	-1,600	
4239132136			-2,090	-3,723
4240330436			-1,258	
4240700021	-834	-1,737		
4240700127	-578	-1,354	-2,035	
4240700133		-2,091	-2,501	
4240700156	-1,062	-1,658	-2,085	
4240700214	-532	-1,241	-2,522	-3,451
4240730018	-1,110	-1,827	-2,757	
4240730033	-437	-1,687	-2,155	
4240730468	-776	-1,806	-2,275	-4,678
4240902561			-1,178	-4,018
4240903620			-777	
4240903682			-1,742	
4240931716	-222	-810	-1,266	
4240931883	-259	-555	-1,460	
4240931914			-979	
4240932252	-488	-881	-1,063	
4240932438	-457	-1,120	-1,247	
4245530023		-1,319		
4245530401		-1,058		
4245530485	-288	-934		
4245700041			-1,159	
4245700043		-1,090	-1,636	
4245700057	-275	-415	-1,077	
4245700063	-1,153	-1,850	-2,501	
4245700200	-1,347	-1,653	-2,539	-3,858
4245700245			-1,897	
4245700254			-2,388	
4245700256	-824	-1,381	-2,174	
4245700377	-1,337	-1,688		
4245700477	-498	-1,219	-1,850	
4245730101	-289	-864	-1,294	
4245730121		-1,076	-1,468	
4245730130		-82		
4245730426			-1,734	
4246900189	-1,322	-1,991	-2,706	-3,995
4246901497	-845	-1,522	-1,962	-3,224
4246901624	-855	-1,600	-1,990	
4246903149	-1,057	-1,560	-2,098	
4246931553	-590	-1,595	-1,879	
4246931897	-1,232	-1,476	-2,472	
4246932432	-646	-1,424	-2,215	
4246932533	-883	-1,676	-2,125	
4246932685	-976	-1,572	-2,252	
4246932892		-1,489	-2,231	-2,653
4246932912		-1,872		-3,750
4246933114	-780	-1,615		
4246933421	-695	-1,712	-2,047	
4247100014		-252	-1,651	
4247100148	-330	-924		
4247100169		-99	-1,647	
4247100180	174	-1,523	-2,519	
4247100189	-123	-1,346	-2,225	
4247130011	-51	-1,661	-2,712	

API Number[a]	Elevation of TDS Pick[b]			
	1,000[c]	**3,000[d]**	**10,000[e]**	**35,000[f]**
4247130016	10	-2,189		
4247130304		-1,431	-2,340	
4247300003	-894	-2,174		
4247300005	-694	-2,009	-3,071	
4247300049	-636	-2,298	-2,946	
4247300108		-2,773	-3,278	
4247300243	-1,110	-2,063	-2,493	
4247300278	-718	-3,100	-3,243	
4247300288	-1,024	-2,756	-3,376	
4247300318	-636	-2,880	-3,249	
4247330066	-1,124	-1,663	-2,518	-3,278
4247330432	-960	-1,910	-2,790	
4247730625	142	-1,787	-2,934	
4247901085		180	-784	
4247933193		365	-1,296	
4247933812		268	-767	
4247934513		207	-1,026	
4247935268			-255	
4247938683		-358		
4248100671	-991	-1,370	-1,444	-4,081
4248100696	-1,556	-1,867		
4248100943	-1,220	-2,758	-3,165	
4248101140	-1,276	-2,654	-3,227	
4248101205	-1,017			
4248101218	-723	-2,936	-3,361	
4248101288	-894	-2,291	-3,250	-3,901
4248101367	-839			
4248101401	-1,252	-2,405	-2,859	
4248101478	-1,018			
4248101702	-1,094	-2,114	-2,885	
4248101770	-1,581	-2,227		
4248101885	-1,101			

API Number[a]	Elevation of TDS Pick[b]			
	1,000[c]	**3,000[d]**	**10,000[e]**	**35,000[f]**
4248102272	-1,083			
4248102562	-1,232	-1,683	-1,843	
4248102802	-1,314	-1,580		
4248103550	-950	-1,964	-2,781	
4248130581	-1,072	-1,971	-2,837	
4248131273		-2,200		
4248131477	-1,328	-2,085	-3,284	
4248133274	-1,014	-2,349	-2,980	
4248133361	-1,136	-1,907	-2,849	
4248133442	-1,279	-2,148	-2,967	
4250502719			-1,069	
4250530271			-2,557	
4250530984			-908	
4260100002			-1,763	
4260130117	-472	-1,849	-2,117	
4260600010			-533	-1,356
4260600055			-788	
4270100002		-1,758	-2,019	
4270130001	-593	-964		-2,523
4270200015				-1,086
4270340074			-938	-3,008
4270440131				-2,821
4270600022		-695	-1,205	-3,057
4270640090				-1,948
4270640380			-890	-3,271
4270800010				-1,750
4270830045				-4,735
4270840040				-1,831
4270840077				-1,445
4270840160				-1,826
4270840279				-2,185

(a) The 10-digit American Petroleum Institute (API) number

(b) TDS = total dissolved solids

(c) Elevation in feet above mean sea level for groundwater with a total dissolved solids concentration of 1,000 milligrams per liter

(d) Elevation in feet above mean sea level for groundwater with a total dissolved solids concentration of 3,000 milligrams per liter

(e) Elevation in feet above mean sea level for groundwater with a total dissolved solids concentration of 10,000 milligrams per liter

(f) Elevation in feet above mean sea level for groundwater with a total dissolved solids concentration of 35,000 milligrams per liter

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19.2 List of Water Well – Geophysical Log Pairs

<u>Description of Table Attributes</u>

SWN – State well Number for the water well
API – American Petroleum Institute ID for the Geophysical Log
Angle (deg) – The angle (measured in degrees counter-clockwise) that orients the log relative to the well.
Distance (mi) – The distance (in miles) between the log and the well

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Table 19-2. List of water well-geophysical log pairs.

SWN	API	Angle (Deg.)	Distance (mi.)
5959507	4214900012	93	0.39
5961402	4201500762	297	0.52
5961402	4201500782	299	0.67
5961402	4201500783	271	0.48
5961402	4201530146	242	0.33
5961803	4201500018	316	0.04
5963801	4201530138	189	0.65
5963902	4201500048	166	0.43
5963902	4201500049	179	0.23
5963902	4201500051	357	0.05
5963902	4201500068	225	0.55
5963902	4201500070	241	0.20
5963902	4201500071	222	0.87
6016801	4237300032		0.06
6027602	4247130016	227	0.45
6033105	4218500033	162	0.64
6033105	4218500034	161	0.72
6041107	4218500099	237	0.94
6041107	4218500102	240	0.36
6044114	4233900979	119	0.28
6044318	4233900910	87	0.34
6045207	4233900926	51	0.14
6045402	4233900103	89	0.46
6045402	4233900104	69	0.27
6045503	4233900154	68	0.30
6045503	4233900155	74	0.38
6045507	4233900139	2	0.10
6045507	4233900141	350	0.25
6053406	4233901121	76	0.46
6053406	4233901879	46	0.22
6053709	4233901425	71	0.26
6053709	4233901779	318	0.34
6053821	4233901416	267	0.37
6053821	4233901420	332	0.08
6054805	4233901718	184	0.32
6061307	4233901737	100	0.28
6061307	4233901738	113	0.45
6061408	4220100996	18	0.05
6061410	4220100911	18	0.36
6064305	4229132387	124	0.41
6117402	4237300037		1.49
6122802	4245700092	267	0.26
6130405	4245700143	127	0.34
6130405	4245700196	228	0.48
6130405	4245700199	303	0.08
6131302	4245700366	57	0.24
6144967	4219932365	257	0.44
6144967	4219932589	260	0.24
6144967	4219932590	252	0.27
6144967	4219932603	231	0.70
6144967	4219933018	269	0.55
6146201	4219900500	60	0.85
6146201	4219900502	67	0.62
6147201	4219903330	85	0.86
6153907	4219902148	154	0.81
6153907	4219902153	74	0.40
6153913	4219902237	122	0.63
6153913	4219902360	124	0.58
6153928	4219902268	86	0.37
6153928	4219902479	126	0.70
6153928	4219902590	117	0.58
6153928	4219903240	14	0.31
6160902	4229131424	358	0.46
6161309	4219902186	314	0.99
6162415	4224500123	182	0.84
6164513	4224500643		0.80
6217911	4224100084	159	0.88
6217911	4224100086	176	0.82
6233401	4224100300	216	0.69
6242909	4235100394	168	0.10
6242909	4235100398	6	0.21
6408201	4224501553	86	0.89
6409207	4207132442	136	0.95
6409207	4207132443	130	0.72

SWN	API	Angle (Deg.)	Distance (mi.)
6409301	4207100065	343	0.30
6409301	4207100179	21	0.58
6409301	4207130072	54	0.18
6409302	4207100226	307	0.36
6409302	4207100231	289	0.44
6409302	4207100258	290	0.83
6409302	4207100267	298	0.81
6409307	4207100071	267	0.80
6409307	4207100102	223	0.48
6409307	4207100699	270	0.90
6409335	4207100024	258	0.49
6409335	4207100112	228	0.40
6409335	4207100113	244	0.47
6420802	4207102362		0.27
6426701	4207102962	322	0.76
6426701	4207102975	46	0.88
6426701	4207131322	279	0.45
6426804	4207102877	174	0.21
6426804	4207102880	121	0.17
6426804	4207102896	141	0.70
6426804	4207102957	63	0.93
6428302	4207102365		1.10
6428302	4207102365		1.10
6429502	4207102253		0.39
6433911	4216730283	19	0.37
6434201	4216700961		1.31
6441114	4216701097	19	0.07
6503308	4220103926		0.17
6503505	4220131206		0.59
6511406	4220104100	18	0.58
6534718	4215701698	18	0.11
6538124	4203901326	209	0.90
6541804	4248100824	191	0.27
6541804	4248132108	207	0.29
6551803	4203902872	148	0.99
6551803	4203902873	152	0.92
6553605	4203904203	115	0.76
6561707	4203904477	301	0.69
6561707	4203904806	195	0.48

SWN	API	Angle (Deg.)	Distance (mi.)
6561707	4203930519	92	0.91
6562802	4203904519	293	0.60
6604302	4201530127	89	0.52
6606108	4201500621	183	0.16
6609505	4214930089	260	0.41
6609505	4214930914	189	0.49
6609801	4214900052	14	0.67
6609801	4214900053	82	0.67
6609801	4214900055	30	0.37
6611208	4214900369	295	0.83
6616810	4201500530	319	0.96
6618502	4214930293	160	0.84
6618602	4208931622	148	0.83
6618604	4208931004	339	0.38
6618604	4208931611	29	0.67
6618701	4214931555	287	0.60
6618701	4214931607	97	0.27
6620407	4208900354	307	0.84
6620508	4208900330	61	0.37
6620902	4208932648	154	0.41
6622203	4208900138	14	0.84
6622701	4208900970	16	0.98
6623205	4201500265	133	0.49
6623205	4201500280	230	0.35
6623701	4208900110	172	0.62
6623701	4208900119	87	0.48
6627905	4208930336	348	0.60
6628402	4208900449	206	0.87
6628402	4208930653	3	0.74
6628503	4208900445	129	0.14
6628503	4208930088	23	0.82
6628503	4208931209	105	0.33
6628508	4208931330	338	0.53
6628508	4208932613	250	0.17
6628602	4208930592	225	0.53
6628607	4208930565	283	0.50
6628805	4208930579	329	0.98
6628805	4208931159	348	0.87
6629302	4208930079	75	0.92

SWN	API	Angle (Deg.)	Distance (mi.)
6630103	4208900246	226	0.46
6630103	4208932123	237	0.47
6630203	4208930160	269	0.72
6630203	4208930236	286	0.49
6630203	4208930284	236	0.67
6630208	4208900247	173	0.64
6631105	4208900127	32	0.66
6631105	4208900129	63	0.73
6631105	4208900133	186	0.25
6631203	4208931270	134	0.30
6631203	4208931393	186	0.83
6631906	4248134117	279	0.46
6635207	4208900484	89	0.41
6635303	4208930312	9	0.66
6636103	4208930576	252	0.76
6636603	4208900584	2	0.91
6636603	4208930150	222	0.93
6636604	4208931583	126	0.62
6637402	4208931206	228	0.82
6637607	4208900704	247	0.96
6637607	4208900705	195	0.45
6637607	4208931034	50	0.27
6637607	4208931788	86	0.60
6637701	4208900755	141	0.48
6637701	4208931746	101	0.80
6638105	4208931735	247	0.97
6638106	4208900724	125	0.75
6638106	4208932262	240	0.24
6638301	4248101213	285	0.07
6640607	4215731072	241	0.80
6642904	4228500343	73	0.50
6643803	4228500187	199	0.36
6643803	4228531445	345	0.35
6644409	4208931604	245	0.20
6644704	4208931902	231	0.64
6646601	4248133274	26	0.13
6647904	4248130084	153	0.36
6650401	4228500431	256	0.49
6650801	4223933251	204	0.61

SWN	API	Angle (Deg.)	Distance (mi.)
6651305	4223932729	292	0.98
6651810	4223900097	104	0.92
6651810	4223900098	184	0.50
6651810	4223900340	312	0.38
6652407	4223932665	14	0.96
6652801	4223900123	230	0.51
6654511	4248101603	81	0.31
6654511	4248133033	252	0.41
6654906	4248132571	281	0.35
6658402	4223930650	7	0.78
6658402	4223931605	341	0.78
6658903	4223900047	3	0.51
6658903	4223900049	258	0.96
6659501	4223900300	252	0.86
6659501	4223900304	228	0.90
6659501	4223903704	51	0.44
6660201	4223900136	159	0.85
6660201	4223900137	236	0.87
6660401	4223903549	340	0.81
6660703	4223900462	66	0.68
6660703	4223900464	194	0.23
6660902	4223900520	114	0.89
6660902	4223900525	46	0.81
6660907	4223900563	57	0.82
6660907	4223900581	44	0.84
6660907	4223931646	265	0.30
6661702	4223900651	187	0.74
6661702	4223900652	118	0.33
6661806	4223900667	86	0.98
6661806	4223900668	102	0.76
6661806	4223903321	186	0.35
6662313	4248130006	0	0.16
6662313	4248132241	99	0.36
6724602	4214900328	96	0.99
6762307	4212300290	286	0.90
7808603	4225500722	266	0.91
7808903	4225500878	28	0.24
7808903	4225500879	39	0.75
7808903	4225500880	173	0.18

SWN	API	Angle (Deg.)	Distance (mi.)
7808903	4225500882	346	0.07
7808903	4225500885	280	0.86
7816201	4225500855	268	0.16
7816401	4225500811	41	0.55
7816401	4225500819	37	0.62
7816401	4225500832	13	0.38
7816401	4225500833	4	0.39
7816601	4225500842	64	0.75
7816601	4225500848	14	0.80
7816601	4225500850	96	0.44
7816601	4225500851	350	0.03
7816601	4225500852	153	0.41
7816615	4225500853	246	0.22
7816803	4225530597	126	0.61
7816803	4225530603	177	0.82
7816803	4225530730	255	0.33
7823502	4229730597	212	0.48
7823502	4229734339	103	0.26
7827903	4231130061		1.08
7832303	4202530389	15	0.70
7839801	4229701037	186	0.39
7839801	4229701041	183	0.24
7839801	4229701045	85	0.23
7840302	4229701364	332	0.21
7840302	4229701367	102	0.20
7847801	4229701222	58	0.32
7847801	4229701228	311	0.22
7847903	4229701137	241	0.13
7847903	4229701138	232	0.31
7847903	4229701139	220	0.20
7852908	4231101621	216	0.46
7854202	4229702433	190	0.40
7855701	4229702031	92	0.22
7856701	4229730552	331	0.33
7864102	4229702352	346	0.45
7864102	4229702353	16	0.30
7864301	4229702327	267	0.49
7864301	4229702659	119	0.41
7864803	4224900067	156	0.56

SWN	API	Angle (Deg.)	Distance (mi.)
7864803	4224930011	182	0.57
7903707	4225531202	41	0.93
7905101	4212301070	319	0.72
7905101	4212331729	354	0.66
7905605	4212300545	81	0.32
7905605	4212300548	128	0.08
7905605	4212300802	97	0.56
7905901	4217500582	342	0.59
7905901	4217500586	350	0.75
7907903	4246900857	337	0.04
7907903	4246930303	194	0.19
7907904	4246900856	177	0.24
7908503	4246900800	332	0.11
7908503	4246900801	290	0.20
7909304	4225500613	345	0.50
7910408	4225500553	7	0.40
7911901	4225500339	292	0.08
7911901	4225500340	342	0.82
7911901	4225500342	343	0.41
7911901	4225500350	302	0.08
7911902	4225500353	301	0.93
7911902	4225500414	149	0.17
7912601	4217500209	257	0.81
7912601	4217531711	136	0.23
7912601	4217531857	74	0.24
7912804	4217500101	177	0.27
7912804	4217500120	238	0.97
7912804	4217500128	244	0.81
7912804	4217500133	93	0.42
7912804	4217500136	288	0.41
7912901	4217500162	300	0.78
7912901	4217502086	1	0.55
7912901	4217531390	339	0.47
7913105	4217500445	137	0.37
7913105	4217500446	112	0.27
7913105	4217500453	64	0.67
7913105	4217531296	253	0.26
7913202	4217500555	214	0.71
7913202	4217533483	196	0.71

SWN	API	Angle (Deg.)	Distance (mi.)
7913703	4217501779	215	0.28
7913703	4217501881	21	0.62
7913801	4217500324	192	0.84
7913801	4217500328	175	0.58
7913801	4217502028	293	0.40
7913801	4217531694	306	0.50
7913801	4217533150	97	0.22
7914602	4217500680	293	0.40
7914602	4217531042	5	0.64
7914602	4217531590	338	0.21
7914602	4217532457	128	0.93
7915501	4217531657	328	0.68
7916903	4246900998	87	0.49
7916904	4246900521	2	0.19
7916904	4246901059	253	0.24
7916906	4246901010	271	0.22
7916906	4246901051	211	0.45
7918501	4225501016	119	1.00
7918501	4225501034	181	0.77
7918501	4225520073	144	0.47
7918503	4202500085	17	0.87
7918503	4202502587	314	0.36
7918604	4202500102	334	0.99
7918604	4202500104	330	0.65
7918901	4202500125	356	0.09
7918901	4202500129	346	0.87
7918901	4202500145	12	0.33
7919101	4225530283	70	0.78
7919301	4217501549	46	0.79
7919304	4217530193	84	0.16
7919501	4217501550	223	0.97
7919501	4217501551	213	0.53
7919501	4217531575	148	0.21
7919501	4217531696	17	0.13
7919602	4217501526	11	0.61
7919602	4217501527	188	0.24
7919602	4217531006	36	0.49
7919602	4217531185	343	0.48
7919705	4217501601	69	0.95
7920401	4217501407	265	0.37
7920501	4217501336	41	0.78
7920501	4217501396	296	0.49
7920501	4217501405	105	0.11
7920505	4217501406	218	0.06
7920505	4217502040	136	0.62
7920505	4217530341	126	0.79
7920603	4217501900	232	0.85
7920603	4217501908	91	0.44
7920801	4217501328	153	0.60
7920801	4217501331	211	0.84
7920801	4217501333	222	0.50
7920801	4217531272	168	0.28
7920901	4217501394	145	0.37
7920901	4217530090	265	0.37
7920901	4217533344	129	0.34
7921202	4217531044	138	0.70
7921502	4217530365	88	0.71
7921502	4217532523	57	0.12
7921701	4217530082	342	0.45
7921701	4217530084	274	0.18
7921701	4217530217	120	0.66
7921701	4217530237	122	1.00
7921701	4217532847	328	0.25
7921911	4217533739	57	0.95
7922404	4217530593	151	0.91
7922404	4217534159	172	0.94
7922502	4217500887	229	0.95
7922502	4217500948	154	0.65
7923103	4217531549	98	0.92
7923408	4217500751	43	0.77
7923408	4217530273	18	0.80
7923408	4217530344	106	0.14
7923408	4217530415	353	0.28
7925602	4202500566	180	0.54
7925602	4202500567	267	0.61
7925602	4202530433	31	0.18
7925602	4202530995	315	0.48
7926102	4202500251	278	0.65

SWN	API	Angle (Deg.)	Distance (mi.)
7926102	4202532413	279	0.95
7926102	4202532857	230	0.35
7926204	4202500146	220	0.57
7926204	4202500147	211	0.42
7926205	4202500130	320	0.69
7926207	4202500216	29	0.89
7926207	4202530530	15	0.49
7926207	4202532229	37	0.28
7926801	4202530223	13	0.94
7926801	4202530379	29	0.68
7927302	4217501615	25	0.47
7927303	4217501616	151	0.79
7927303	4217501620	198	0.65
7927303	4217531581	70	0.10
7928501	4217501080	196	0.91
7928706	4217501163	144	0.77
7928706	4217501194	110	0.33
7928706	4217501195	108	0.75
7928717	4217501186	17	0.22
7928717	4217501204	331	0.35
7928717	4217501207	339	0.52
7932602	4246901569	76	0.26
7932602	4246901571	195	0.23
7933302	4202501692	71	0.31
7933302	4202501693	71	0.47
7933302	4202501725	82	0.66
7933302	4202502539	60	0.73
7933906	4202501707	335	0.89
7933906	4202501712	114	0.18
7934405	4202501636	141	0.52
7934601	4202531843	35	0.96
7934903	4202501578	358	0.71
7934903	4202532220	10	0.87
7935401	4202501367	313	0.52
7935701	4202530101	231	0.98
7935701	4202530201	237	0.80
7935702	4202501374	219	0.30
7935702	4202501375	221	0.59
7935702	4202501376	252	0.79
7935702	4202501379	321	0.15
7935702	4202501841	29	0.23
7936901	4202532563	252	0.46
7936901	4202533418	176	0.82
7937204	4217501723	197	0.65
7937402	4202502414	356	0.90
7937402	4202531201	352	0.59
7937402	4217533228	231	0.40
7937402	4217533251	234	0.15
7937906	4202502437	191	0.24
7937906	4202530352	242	0.35
7937906	4217531496	202	0.91
7938406	4217531188	255	0.22
7938406	4217531261	344	0.30
7938406	4217531668	198	0.12
7938406	4217531741	239	0.68
7938406	4217531785	203	0.72
7941301	4202501758	146	0.87
7942103	4202530422	45	0.33
7942604	4202530286	347	0.57
7943102	4202501410	91	0.10
7943102	4202530197	97	0.39
7943305	4202532965	110	0.58
7943401	4202501451	336	0.49
7943401	4202501454	272	0.43
7943401	4202501459	355	0.97
7943401	4202501468	5	0.96
7943702	4202502496	105	0.52
7943704	4202502001	73	0.59
7945101	4202501253	280	0.63
7945101	4202501259	3	0.52
7945203	4202501219	77	0.29
7945203	4202501221	71	0.54
7946611	4239102342	122	0.49
7946611	4239102530	330	0.27
7946612	4239102287	24	0.20
7946612	4239102346	24	0.20
7949803	4229701819	86	0.40
7950304	4202532161	308	0.81

SWN	API	Angle (Deg.)	Distance (mi.)
7950503	4202501938	156	0.94
7950503	4202531462	328	0.06
7950503	4202532114	249	0.33
7950907	4240900047	151	0.32
7950907	4240932081	182	0.39
7951105	4202532157	114	0.30
7951105	4202532194	152	0.29
7951603	4202502054	169	0.84
7951603	4202502063	214	0.98
7951603	4202502067	4	0.47
7952407	4202502633	277	0.74
7952407	4202502640	286	0.20
7952407	4202502647	268	0.55
7952407	4202502648	22	0.35
7956203	4200700354	95	0.92
7959101	4240900355	285	0.21
7959101	4240931657	276	0.15
7959101	4240931672	344	0.20
7959102	4240900274	119	0.29
7959102	4240931671	338	0.21
7959303	4240900346	324	0.47
7959501	4240901049	82	0.47
7960106	4240900898	222	0.28
7960106	4240900907	164	0.29
7960212	4240900372	127	0.21
7960212	4240931650	117	0.34
7960401	4240903989	199	0.39
7960503	4240900525	342	0.36
7960503	4240900616	45	0.47
7960604	4240900448	301	0.44
7960604	4240900457	296	0.32
7960604	4240904196	351	0.30
7960614	4240900451	308	0.39
7960614	4240900488	152	0.34
7960614	4240903997	272	0.29
7960614	4240904001	235	0.13
7960616	4240900531	6	0.18
7960616	4240900615	9	0.20
7960801	4240904015	329	0.46
7961605	4240901466	101	0.09
7961605	4240901967	296	0.17
7961902	4240901798	226	0.35
7962707	4240901988	91	0.44
7964307	4200700229	141	0.25
8003202	4223930023	154	0.94
8003803	4223901863	257	0.68
8003803	4223901887	253	0.63
8004403	4223901657	126	0.56
8004403	4223933328	199	0.35
8004710	4223901936	359	0.62
8004710	4223901937	17	0.71
8004710	4223930384	89	0.39
8005507	4223903325	113	0.97
8006703	4223901333	281	0.76
8006703	4223901366	81	0.69
8006704	4223901372	10	0.99
8007203	4232101587	28	0.07
8007206	4232101285	350	0.38
8007206	4232101286	329	0.41
8007313	4232101226	268	0.47
8007313	4232101254	286	0.45
8007313	4232101273	256	0.18
8007313	4232101278	258	0.22
8009105	4246932781	326	0.38
8009409	4246900519	136	0.38
8009506	4246900407	31	0.42
8011103	4246900158	120	0.35
8012303	4223902138	251	0.71
8012305	4223902327	57	0.45
8017503	4246901660	343	0.18
8017504	4246901666	333	0.48
8017506	4246901644	134	0.29
8017506	4246902893	308	0.44
8017905	4246902061	327	0.39
8017905	4246903066	156	0.47
8018401	4246901887	323	0.22
8018501	4246901754	344	0.03
8018501	4246901792	51	0.05

SWN	API	Angle (Deg.)	Distance (mi.)
8018503	4246902560	137	0.09
8018503	4246930589	233	0.07
8019503	4205701305	318	0.90
8019802	4205700442	269	0.24
8019802	4205700531	219	0.74
8020803	4205701246	176	0.70
8021217	4223903224	2	0.57
8021601	4223903265	186	0.64
8023202	4232131723	36	0.37
8023404	4232130256	44	0.45
8023404	4232130995	101	0.29
8025301	4205700037	301	0.57
8025301	4205700043	294	0.76
8025301	4246902423	289	0.38
8025301	4246932847	127	0.40
8026103	4205700039	151	0.87
8026103	4205700083	233	0.41
8026103	4205701358	112	0.42
8026501	4205700220	313	0.82
8026903	4205700238	273	0.21
8026903	4205701231	204	0.49
8026903	4205701232	209	0.72
8026903	4205730066	203	0.73
8027603	4205700540	278	0.26
8027603	4205700541	140	0.51
8027603	4205700542	131	0.88
8033610	4239130253	289	0.49
8033610	4239130260	142	0.09
8033610	4239130547	267	0.47
8042106	4239100086	81	0.30
8045201	4205731113		1.25
8101101	4232100945	319	0.41
8101101	4232100946	324	0.37
8101101	4232101011	343	0.07
8101201	4232101019	122	0.36
8101201	4232101022	39	0.44
8101201	4232101025	228	0.24
8101201	4232101026	217	0.23
8102901	4232131364	32	0.28

SWN	API	Angle (Deg.)	Distance (mi.)
8105302	4203932395	293	0.67
8105320	4203930263	47	0.52
8109905	4232131061	358	0.29
8301508	4224900422	337	0.71
8301508	4224900461	243	0.98
8301509	4224900585	125	0.81
8301509	4224930126	142	0.99
8301509	4224930455	72	0.48
8301509	4224931327	74	0.44
8301514	4224900581	197	0.99
8301514	4224900582	221	0.71
8301706	4224900721	349	0.97
8301706	4224931428	255	0.43
8301901	4235500013	296	0.36
8301901	4235532446	298	0.34
8302306	4224900183	142	0.82
8303607	4240903834	106	0.35
8303607	4240903838	171	0.45
8305501	4240902801	4	0.30
8307617	4200700776	318	0.67
8310602	4235500386	335	0.48
8310602	4235500417	324	0.41
8310602	4235500422	299	0.23
8310602	4235500423	326	0.25
8317901	4235505978	317	0.45
8319402	4235504659	99	0.46
8319402	4235506684	217	0.45
8325101	4227300239	338	0.71
8325501	4227300289	162	0.86
8325501	4227300306	217	0.27
8325608	4227300508	109	0.62
8325801	4227300504	58	0.61
8325801	4227300505	42	0.42
8325801	4227300506	3	0.26
8326401	4227302022	140	0.33
8326404	4227301915	340	0.45
8326509	4235505970	322	0.42
8326701	4227301972	281	0.49
8326701	4227330109	293	0.25

SWN	API	Angle (Deg.)	Distance (mi.)
8327901	4227300537	19	0.84
8329201	4235503199	181	0.25
8329202	4235503199		0.52
8329202	4235503199		0.52
8329701	4227331873		0.66
8334101	4227301047	347	0.57
8334501	4227301002	248	0.80
8334501	4227301004	254	0.91
8334501	4227301076	257	0.14
8337201	4227331464		1.63
8346201	4227300582	185	0.14
8358703	4226130175	17	0.78
8407903	4224931724	321	0.13
8408801	4224901072	180	0.66
8408801	4224901075	243	0.87
8408801	4224901138	11	0.13
8408801	4224901139	349	0.25
8408801	4224901140	26	0.22
8412301	4213103454	212	0.90
8412301	4213103458	195	0.46
8412301	4213103459	191	0.67
8412603	4213104040		0.01
8412605	4213131452		0.22
8415702	4213100987	208	0.82
8415702	4213100995	154	0.85
8416407	4224901362	11	0.08
8416804	4224901547	355	0.58
8416804	4224901563	177	0.82
8416805	4224901394	124	0.92
8416805	4224901475	159	0.97
8416807	4224903602	17	0.87
8416807	4224903684	329	0.97
8419101	4213137995		0.14
8419303	4213100869	51	0.28
8419303	4213107018	127	0.45
8419303	4213107020	8	0.59
8419303	4213107023	8	0.59
8419303	4213130091	353	0.14
8419303	4213130100	247	0.06

SWN	API	Angle (Deg.)	Distance (mi.)
8420403	4213130836		0.71
8421601	4213108481	237	0.82
8421601	4213131592	316	0.93
8422401	4213108590	253	0.10
8422401	4213108591	142	0.81
8422401	4213108592	139	0.46
8422401	4213108593	96	0.24
8422401	4213111077	204	0.98
8423105	4213137123	18	0.27
8423105	4224901494	332	0.97
8423204	4224903587	347	0.91
8423204	4224903701	27	0.70
8424101	4224901550	123	0.73
8424101	4224901552	134	0.90
8424102	4224901660	148	0.94
8424204	4224930401	223	0.71
8424208	4224901786	154	0.23
8424208	4224901787	232	0.66
8424208	4224901788	104	0.07
8424208	4224901794	307	0.84
8424208	4224901797	24	0.15
8424401	4224901570	54	0.81
8424401	4224901574	331	0.43
8424401	4224901583	26	0.68
8424401	4224901586	116	0.15
8424513	4224903689		0.34
8427405	4213108259	291	0.92
8427405	4213108295	334	0.76
8427405	4213108299	314	0.43
8427405	4213108301	302	0.48
8428803	4213107860		0.10
8429309	4213108934	327	0.78
8429310	4213111054	8	0.22
8430404	4213108704	295	0.46
8432503	4227300036	304	0.03
8432503	4227300037	354	0.60
8433101	4247902608	186	0.09
8433101	4247933812	322	0.01
8433103	4247902487	197	0.28

SWN	API	Angle (Deg.)	Distance (mi.)
8433204	4247902483	127	0.23
8433204	4247902657	267	0.11
8433701	4247902807	201	0.25
8434404	4247933395	143	0.28
8434405	4247904876	281	0.49
8434405	4247904902	320	0.22
8434407	4247904672	217	0.11
8434407	4247904846	300	0.09
8434502	4247902011	44	0.17
8434502	4247904941	175	0.36
8434805	4247902046	296	0.19
8434805	4247904905	298	0.21
8438902	4213109664	153	0.99
8440206	4227301304	272	0.37
8440206	4227301312	123	0.47
8440703	4224902721	211	0.07
8440703	4224902756	254	0.31
8440703	4224902815	263	0.76
8440703	4224902825	265	0.60
8440703	4224902998	323	0.17
8442601	4224700149	342	0.73
8442601	4224700162	314	0.41
8442601	4224700168	263	0.21
8443509	4224700246	165	0.88
8443512	4224700232	70	0.66
8443512	4224700233	100	0.35
8443512	4224700234	104	0.58
8443512	4224700235	140	0.34
8443514	4224700261	9	0.30
8443514	4224700262	6	0.77
8443514	4224731904	15	0.90
8448117	4224903220	334	0.34
8448117	4224903314	309	0.82
8450101	4224700724	161	0.78
8450101	4224700725	164	0.90
8455325	4204700167	210	0.73
8455329	4204700179	58	0.37
8456203	4204730163	110	0.42
8457101	4250500388	294	0.21

SWN	API	Angle (Deg.)	Distance (mi.)
8457101	4250500395	111	0.27
8460402	4224700401	278	0.76
8460402	4224700509	70	0.41
8460402	4224702549	67	0.66
8463304	4204730279	263	0.65
8701201	4224701535	173	0.97
8701201	4224701852	151	0.86
8701201	4224701875	92	0.34
8701601	4224701877	80	0.48
8701601	4224701880	332	0.11
8701601	4224702046	317	0.98
8701601	4224702050	312	0.89
8701601	4224702143	265	0.13
8707604	4204701201	79	0.87
8708801	4204701304	85	0.67
8708801	4204701306	250	0.42
8709301	4224702276		0.24
8710402	4224702242		0.65
8713503	4204701107	250	0.65
8713503	4204701140	298	0.71
8713503	4204732274	203	0.47
8713601	4204701650		0.07
8802403	4226100225	27	0.04
8802403	4226100226	336	0.56
8802403	4226100227	203	0.52
8904625	4206100125	18	0.45

19.3 Water Well Construction Information

Description of Table Attributes

SWN	–	State Well Number for the Water Well
County	–	County in which the well is located
Easting (feet)	–	Easting of the well in Groundwater Availability Model coordinates and feet
Northing (feet)	–	Northing of the well in Groundwater Availability Model coordinates and feet
ft	–	feet
GAM	–	Groundwater Availability Model
Ground Surface Elevation	–	elevation of land surface at the well (feet, mean sea level)
Number of Screens	–	Number of individual slotted sections comprising a well screen
Depth to top of Screens	–	Depth (feet) to the shallowest top of the well screen
Depth to bottom of Screen	–	Depth (feet) to the deepest of the bottom of well screen
Actual Screened Interval	–	Total length of the slotted well screen
Top – Bottom of Screen	–	Vertical Distance between the top and bottom of well screen
Primary Formation	–	The formation that has the largest amount of intersection with the well screen
Top of Formation Elevation	–	Elevation (feet) of the top surface of the primary formation at the well
Bottom of Formation Elevation	–	Elevation (feet) of the bottom surface of the primary formation at the well
ND	–	No data

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Table 19-3. Water well construction information.

SWN	County	GMA	Easting (ft-GAM)	Northing (ft-GAM)	Ground Surface Elevation (ft)	Number of Screens	Depth to Top of Screen(s) (ft)	Depth to Bottom of Screen(s) (ft)	Actual Screen Length (ft)	Top - Bottom of Screen (ft)	Primary Formation	Top of Formation Elevation (ft)	Bottom of Formation Elevation (ft)
5959507	Fayette	15	5,963,802	19,267,644	381	1	235	260	25	25	Catahoula	303	-300
5961402	Austin	14	6,031,710	19,270,850	321	1	366	386	20	20	Lower Lagarto	321	-61
5961803	Austin	14	6,045,549	19,255,293	305	1	674	725	51	51	Oakville	-302	-426
5963801	Austin	14	6,120,156	19,263,647	262	3	583	946	343	363	Middle Lagarto	-401	-713
5963902	Austin	14	6,144,811	19,256,501	161	1	1107	1224	117	117	Lower Lagarto	-965	-1,365
6016801	Polk	14	6,462,792	19,550,584	131	ND	ND	ND	ND	ND	Catahoula	ND	ND
6027602	Walker	14	6,291,050	19,460,994	209	1	153	193	40	40	Middle Lagarto	209	17
6033105	Grimes	14	6,180,858	19,432,207	377	4	896	1137	102	241	Jackson	-350	-1,682
6041107	Grimes	14	6,192,135	19,374,572	404	1	662	762	100	100	Oakville	-198	-600
6044114	Montgomery	14	6,300,795	19,391,371	289	1	658	730	72	72	Middle Lagarto	-117	-590
6044318	Montgomery	14	6,331,255	19,386,817	287	6	910	1164	164	254	Middle Lagarto	-419	-836
6045207	Montgomery	14	6,358,723	19,387,129	244	4	830	1090	165	260	Middle Lagarto	-621	-1,037
6045402	Montgomery	14	6,342,873	19,378,778	236	2	930	1140	180	210	Middle Lagarto	-569	-922
6045503	Montgomery	14	6,351,769	19,371,038	214	5	950	1320	115	370	Lower Lagarto	-1,005	-1,404
6045507	Montgomery	14	6,352,598	19,370,058	205	2	1050	1238	152	188	Middle Lagarto	-563	-1,005
6053406	Montgomery	14	6,342,398	19,325,976	149	6	1110	1605	240	495	Middle Lagarto	-1,113	-1,474
6053709	Montgomery	14	6,352,302	19,308,956	129	5	700	934	101	234	Lower Goliad	-499	-792
6053821	Montgomery	14	6,356,909	19,305,701	123	6	620	1012	181	392	Lower Goliad	-510	-806
6054805	Montgomery	14	6,406,081	19,312,926	114	1	145	165	20	20	Lissie	114	-166
6061307	Montgomery	14	6,372,024	19,300,856	105	4	310	506	145	196	Willis	-127	-548
6061408	Harris	14	6,349,859	19,274,312	122	4	890	1130	180	240	Lower Goliad	-607	-962
6061410	Harris	14	6,351,249	19,287,538	136	4	800	992	105	192	Lower Goliad	-551	-926
6064305	Liberty	14	6,496,924	19,304,144	82	6	1159	1489	150	330	Lower Goliad	-884	-1,355

SWN	County	GMA	Easting (ft-GAM)	Northing (ft-GAM)	Ground Surface Elevation (ft)	Number of Screens	Depth to Top of Screen(s) (ft)	Depth to Bottom of Screen(s) (ft)	Actual Screen Length (ft)	Top - Bottom of Screen (ft)	Primary Formation	Top of Formation Elevation (ft)	Bottom of Formation Elevation (ft)
6117402	Polk	14	6,490,913	19,522,253	135	ND	ND	ND	ND	ND	Catahoula	ND	ND
6122802	Tyler	14	6,706,326	19,516,656	157	1	330	350	20	20	Willis	28	-395
6130405	Tyler	14	6,688,486	19,477,930	102	1	396	423	27	27	Willis	-36	-425
6131302	Tyler	14	6,762,455	19,493,535	59	1	370	390	20	20	Willis	-218	-649
6144967	Hardin	14	6,647,022	19,374,993	79	1	185	197	12	12	Lissie	57	-496
6146201	Hardin	14	6,709,740	19,411,202	85	5	220	489	88	269	Willis	-285	-782
6147201	Hardin	14	6,752,422	19,412,003	76	4	404	612	114	208	Willis	-413	-1,093
6153907	Hardin	14	6,691,587	19,332,532	36	2	643	947	304	304	Willis	-417	-1,067
6153913	Hardin	14	6,682,947	19,324,696	50	1	153	176	23	23	Lissie	-45	-515
6153928	Hardin	14	6,683,197	19,319,742	44	1	770	809	39	39	Willis	-549	-1,149
6160902	Liberty	14	6,646,586	19,279,199	53	1	429	492	63	63	Lissie	-218	-871
6161309	Hardin	14	6,684,824	19,318,811	44	2	214	244	16	30	Lissie	-53	-538
6162415	Jefferson	14	6,708,925	19,293,788	41	1	220	241	21	21	Lissie	-100	-678
6164513	Jefferson	14	6,790,302	19,299,774	25	ND	ND	ND	ND	ND	Beaumont	ND	ND
6217911	Jasper	14	6,837,324	19,523,545	104	4	1192	1533	90	341	Upper Lagarto	-1,200	-1,539
6233401	Jasper	14	6,817,724	19,446,019	77	1	280	370	90	90	Lissie	77	-506
6242909	Newton	14	6,884,768	19,378,869	27	1	530	590	60	60	Lissie	-162	-826
6408201	Jefferson	14	6,799,641	19,269,867	15	1	460	580	120	120	Lissie	-462	-1,050
6409207	Chambers	14	6,528,930	19,207,324	29	7	1075	1480	151	405	Willis	-795	-1,177
6409301	Chambers	14	6,532,411	19,217,717	44	2	405	520	100	115	Lissie	-240	-743
6409302	Chambers	14	6,532,757	19,217,834	44	2	418	521	100	103	Lissie	-240	-747
6409307	Chambers	14	6,530,931	19,205,896	24	5	720	910	110	190	Lissie	-251	-795
6409335	Chambers	14	6,529,974	19,207,575	30	7	685	948	120	263	Lissie	-251	-795
6420802	Chambers	14	6,651,139	19,137,060	5	ND	ND	ND	ND	ND	Beaumont	ND	ND
6426701	Chambers	14	6,550,866	19,096,904	0	2	610	671	59	61	Lissie	-444	-964
6426804	Chambers	14	6,561,211	19,096,576	0	1	684	742	58	58	Lissie	-466	-1,012

SWN	County	GMA	Easting (ft-GAM)	Northing (ft-GAM)	Ground Surface Elevation (ft)	Number of Screens	Depth to Top of Screen(s) (ft)	Depth to Bottom of Screen(s) (ft)	Actual Screen Length (ft)	Top - Bottom of Screen (ft)	Primary Formation	Top of Formation Elevation (ft)	Bottom of Formation Elevation (ft)
6428302	Chambers	14	6,655,128	19,127,734	5	ND	ND	ND	ND	ND	Beaumont	ND	ND
6429502	Chambers	14	6,685,063	19,120,311	5	ND	ND	ND	ND	ND	Willis	ND	ND
6433911	Galveston	14	6,545,672	19,041,158	11	3	395	615	90	220	Beaumont	11	-563
6434201	Galveston	14	6,568,603	19,078,284	0	ND	ND	ND	ND	ND	Beaumont	ND	ND
6441114	Galveston	14	6,522,499	19,023,790	6	2	530	622	80	92	Beaumont	6	-617
6503308	Harris	14	6,299,908	19,243,031	132	ND	ND	ND	ND	ND	Oakville	ND	ND
6503505	Harris	14	6,285,794	19,239,945	140	ND	ND	ND	ND	ND	Oakville	ND	ND
6511406	Harris	14	6,277,981	19,183,024	114	8	750	1180	175	430	Lower Goliad	-862	-1,410
6530722	Brazoria	14	6,396,020	19,090,969	56	1	582	1018	436	436	Lissie	-82	-779
6538124	Brazoria	14	6,391,315	19,068,391	53	1	461	481	20	20	Lissie	-182	-750
6541804	Wharton	15	6,212,700	18,985,644	77	2	678	718	40	40	Willis	-434	-719
6551803	Brazoria	14	6,300,129	18,945,325	31	1	740	750	10	10	Lissie	-500	-867
6553605	Brazoria	14	6,383,733	18,963,779	27	5	630	830	80	200	Lissie	-575	-1,017
6561707	Brazoria	14	6,358,176	18,897,431	13	1	290	340	50	50	Beaumont	13	-706
6562802	Brazoria	14	6,419,782	18,897,158	5	1	224	235	11	11	Beaumont	5	-728
6604302	Austin	14	6,024,552	19,236,294	363	4	754	950	64	196	Oakville	-299	-517
6606108	Austin	14	6,075,336	19,241,276	210	1	122	143	21	21	Middle Lagarto	210	-289
6609505	Fayette	15	5,896,642	19,174,377	455	2	362	442	52	80	Jackson	65	-969
6609801	Fayette	15	5,884,481	19,165,536	417	1	190	270	80	80	Catahoula	326	150
6611208	Fayette	15	5,964,451	19,186,962	309	1	660	720	60	60	Oakville	-147	-430
6616810	Austin	14	6,165,857	19,168,327	151	1	247	257	10	10	Willis	-4	-304
6618502	Colorado	15	5,936,412	19,134,706	376	1	399	420	21	21	Lower Lagarto	140	-308
6618602	Colorado	15	5,940,516	19,135,939	414	3	220	591	136	371	Lower Lagarto	125	-324
6618604	Colorado	15	5,940,678	19,133,413	393	1	930	957	27	27	Oakville	-324	-644
6618701	Fayette	15	5,914,701	19,120,722	271	1	274	285	11	11	Lower Lagarto	73	-293
6620407	Colorado	15	5,995,531	19,134,240	321	1	405	430	25	25	Upper Lagarto	321	-202

SWN	County	GMA	Easting (ft-GAM)	Northing (ft-GAM)	Ground Surface Elevation (ft)	Number of Screens	Depth to Top of Screen(s) (ft)	Depth to Bottom of Screen(s) (ft)	Actual Screen Length (ft)	Top - Bottom of Screen (ft)	Primary Formation	Top of Formation Elevation (ft)	Bottom of Formation Elevation (ft)
6620508	Colorado	15	6,013,094	19,138,833	200	5	118	330	126	212	Upper Lagarto	31	-428
6620902	Colorado	15	6,030,294	19,115,783	222	7	293	749	311	456	Upper Lagarto	-287	-673
6622203	Colorado	15	6,085,412	19,149,462	225	1	180	210	30	30	Willis	225	-100
6622701	Colorado	15	6,074,048	19,112,029	203	2	206	947	741	741	Lower Goliad	-291	-596
6623205	Austin	14	6,126,597	19,158,044	202	1	106	116	10	10	Willis	92	-200
6623701	Colorado	15	6,118,143	19,114,215	155	6	100	418	228	318	Willis	4	-253
6627905	Colorado	15	5,982,221	19,070,360	267	1	564	615	51	51	Upper Lagarto	-134	-435
6628402	Colorado	15	5,997,830	19,079,339	274	7	146	600	266	454	Upper Lagarto	-140	-455
6628503	Colorado	15	6,017,618	19,089,872	231	1	240	631	391	391	Lower Goliad	-25	-292
6628508	Colorado	15	6,013,089	19,090,844	241	1	226	769	543	543	Upper Lagarto	-195	-525
6628602	Colorado	15	6,027,433	19,080,664	213	2	170	975	805	805	Upper Lagarto	-458	-816
6628607	Colorado	15	6,029,745	19,085,697	210	1	394	584	190	190	Lower Goliad	-169	-448
6628805	Colorado	15	6,013,214	19,075,460	243	9	290	752	328	462	Lower Goliad	-46	-342
6629302	Colorado	15	6,067,964	19,101,301	175	1	157	399	242	242	Willis	75	-165
6630103	Colorado	15	6,071,756	19,098,590	187	2	190	490	300	300	Willis	60	-172
6630203	Colorado	15	6,090,316	19,108,012	184	1	340	806	466	466	Lower Goliad	-370	-692
6630208	Colorado	15	6,085,700	19,100,974	185	1	455	845	390	390	Lower Goliad	-386	-715
6631105	Colorado	15	6,114,474	19,102,851	160	2	300	900	600	600	Lower Goliad	-487	-832
6631203	Colorado	15	6,124,169	19,108,143	156	1	211	447	236	236	Willis	-19	-280
6631906	Wharton	15	6,145,064	19,080,415	131	3	860	990	87	130	Lower Goliad	-633	-1,032
6635207	Colorado	15	5,976,535	19,059,864	266	1	155	176	21	21	Willis	266	54
6635303	Colorado	15	5,988,344	19,048,883	236	2	101	804	703	703	Lower Goliad	-93	-381
6635304	Colorado	15	5,993,082	19,052,773	230	4	695	820	93	125	Upper Lagarto	-374	-694
6636103	Colorado	15	5,993,718	19,052,184	226	4	695	816	91	121	Upper Lagarto	-403	-727
6636604	Colorado	15	6,031,606	19,043,542	171	1	103	403	300	300	Willis	27	-191
6637402	Colorado	15	6,044,985	19,044,979	168	1	75	297	222	222	Willis	-2	-240

SWN	County	GMA	Easting (ft-GAM)	Northing (ft-GAM)	Ground Surface Elevation (ft)	Number of Screens	Depth to Top of Screen(s) (ft)	Depth to Bottom of Screen(s) (ft)	Actual Screen Length (ft)	Top - Bottom of Screen (ft)	Primary Formation	Top of Formation Elevation (ft)	Bottom of Formation Elevation (ft)
6637607	Colorado	15	6,059,664	19,049,906	163	2	100	318	218	218	Willis	-6	-243
6637701	Colorado	15	6,041,562	19,033,229	161	2	81	194	113	113	Lissie	161	-11
6638105	Colorado	15	6,084,875	19,061,968	148	1	290	320	30	30	Willis	-18	-263
6638106	Colorado	15	6,083,268	19,062,523	156	1	240	250	10	10	Willis	-12	-257
6638301	Wharton	15	6,105,274	19,061,840	155	1	100	288	188	188	Lissie	155	-46
6640607	Wharton	15	6,183,312	19,045,016	100	3	300	426	100	126	Willis	-238	-514
6642904	Lavaca	15	5,950,987	18,973,578	151	1	190	210	20	20	Willis	60	-155
6643803	Lavaca	15	5,978,121	18,980,555	151	2	270	1023	753	753	Lower Goliad	-425	-797
6644409	Colorado	15	6,001,482	18,989,057	146	3	230	900	295	670	Lower Goliad	-471	-906
6644704	Colorado	15	5,996,890	18,983,046	145	6	216	996	385	780	Lower Goliad	-487	-890
6646601	Wharton	15	6,100,968	19,005,916	131	2	77	176	99	99	Lissie	41	-142
6647904	Wharton	15	6,145,183	18,980,499	97	3	300	350	40	50	Lissie	-12	-247
6650401	Lavaca	15	5,929,566	18,946,038	145	10	187	880	512	693	Lower Goliad	-323	-717
6650801	Jackson	15	5,940,899	18,930,779	128	2	229	886	657	657	Upper Goliad	-203	-509
6651305	Jackson	15	5,993,274	18,965,224	131	7	225	1010	530	785	Lower Goliad	-537	-989
6651810	Jackson	15	5,973,148	18,936,685	114	1	403	968	565	565	Upper Goliad	-298	-678
6652407	Jackson	15	6,002,011	18,945,857	111	4	280	960	507	680	Upper Goliad	-321	-691
6652801	Jackson	15	6,011,311	18,928,634	92	1	135	620	485	485	Willis	-164	-385
6654511	Wharton	15	6,098,785	18,960,090	108	6	700	970	215	270	Upper Goliad	-484	-1,096
6654906	Wharton	15	6,112,212	18,932,201	89	1	416	461	45	45	Lissie	-125	-388
6658402	Jackson	15	5,924,293	18,907,231	115	7	160	699	351	539	Upper Goliad	-202	-556
6658903	Jackson	15	5,947,674	18,886,653	86	5	205	694	380	489	Willis	-171	-347
6659501	Jackson	15	5,976,328	18,904,397	90	3	153	666	430	513	Upper Goliad	-387	-924
6660201	Jackson	15	6,023,119	18,925,055	86	8	154	669	332	515	Willis	-194	-440
6660401	Jackson	15	5,998,226	18,904,451	81	4	106	282	117	176	Lissie	-41	-237
6660703	Jackson	15	6,011,390	18,888,765	71	3	132	513	318	381	Lissie	-92	-322

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6660902	Jackson	15	6,033,730	18,897,659	64	3	1185	1291	81	106	Upper Goliad	-562	-1,274
6660907	Jackson	15	6,035,651	18,895,797	66	8	752	1068	166	316	Upper Goliad	-577	-1,306
6661702	Jackson	15	6,043,462	18,887,240	65	1	127	315	188	188	Lissie	-146	-408
6661806	Jackson	15	6,057,194	18,890,613	65	2	218	527	309	309	Lissie	-169	-437
6662313	Wharton	15	6,109,859	18,928,377	85	2	406	480	68	74	Lissie	-138	-404
6724602	Fayette	15	5,864,329	19,126,316	387	1	358	390	32	32	Jackson	171	-899
6762307	De Witt	15	5,789,217	18,914,073	242	14	328	1214	290	886	Lower Lagarto	-405	-934
7808603	Karnes	15	5,556,634	18,850,444	363	1	140	160	20	20	Jackson	363	-355
7808903	Karnes	15	5,553,076	18,836,016	437	1	4036	4039	3	3	Below Jackson	-530	437
7816201	Karnes	15	5,541,683	18,817,405	480	1	200	240	40	40	Catahoula	480	226
7816401	Karnes	15	5,525,295	18,809,536	452	1	305	325	20	20	Jackson	437	-446
7816601	Karnes	15	5,560,457	18,800,949	500	1	5290	5355	65	65	Below Jackson	-1,087	500
7816615	Karnes	15	5,558,600	18,805,366	486	1	290	450	160	160	Catahoula	486	-129
7816803	Karnes	15	5,542,350	18,789,501	368	1	440	500	60	60	Jackson	45	-934
7823502	Live Oak	16	5,501,140	18,749,158	353	1	4689	4789	100	100	Below Jackson	-865	353
7827903	Mcmullen	16	5,349,995	18,685,935	350	ND	ND	ND	ND	ND	Below_Jackson	ND	ND
7832303	Bee	16	5,554,112	18,728,221	358	1	105	127	22	22	Oakville	358	20
7839801	Live Oak	16	5,507,716	18,652,600	258	1	220	230	10	10	Oakville	258	-236
7840302	Live Oak	16	5,562,018	18,684,881	331	1	105	125	20	20	Oakville	331	-604
7847801	Live Oak	16	5,508,857	18,599,746	194	2	400	550	100	150	Oakville	-23	-723
7847903	Live Oak	16	5,517,039	18,607,463	237	1	200	240	40	40	Lower Lagarto	237	-32
7852908	Mcmullen	16	5,393,311	18,551,935	417	1	184	204	20	20	Catahoula	417	-614
7854202	Live Oak	16	5,458,586	18,584,901	437	1	485	525	40	40	Catahoula	-38	-1,208
7855701	Live Oak	16	5,487,626	18,563,517	330	2	318	615	85	297	Oakville	-221	-644
7856701	Live Oak	16	5,525,317	18,556,657	211	1	290	365	75	75	Middle Lagarto	-26	-392
7864102	Live Oak	16	5,533,850	18,539,114	279	1	395	425	30	30	Upper Lagarto	11	-432

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7864301	Live Oak	16	5,553,859	18,546,741	231	1	225	246	21	21	Lower Goliad	22	-349
7864803	Jim Wells	16	5,543,334	18,508,655	315	1	482	501	19	19	Upper Goliad	188	-193
7903707	Karnes	15	5,652,300	18,829,431	310	3	155	210	42	55	Oakville	310	-398
7905101	De Witt	15	5,720,710	18,867,634	296	1	794	991	197	197	Lower Lagarto	82	-621
7905605	De Witt	15	5,749,495	18,850,795	224	1	120	140	20	20	Upper Lagarto	224	-307
7905901	Goliad	15	5,747,826	18,834,873	286	1	300	400	100	100	Upper Lagarto	286	-290
7907903	Victoria	15	5,836,354	18,838,975	105	2	406	660	80	254	Upper Goliad	-2	-475
7907904	Victoria	15	5,837,602	18,838,805	98	4	155	295	101	140	Upper Goliad	-2	-475
7908503	Victoria	15	5,853,958	18,851,677	142	1	80	90	10	10	Lissie	142	24
7909304	Karnes	15	5,598,456	18,816,929	385	1	380	400	20	20	Catahoula	188	-868
7910408	Karnes	15	5,609,930	18,797,933	364	1	478	533	55	55	Oakville	364	-155
7911901	Karnes	15	5,678,671	18,796,504	275	2	510	565	40	55	Lower Lagarto	67	-563
7911902	Karnes	15	5,678,842	18,796,811	277	2	515	590	40	75	Lower Lagarto	67	-563
7912601	Goliad	15	5,707,589	18,803,305	351	1	581	648	67	67	Middle Lagarto	134	-480
7912804	Goliad	15	5,706,488	18,788,816	254	1	627	648	21	21	Middle Lagarto	44	-657
7912901	Goliad	15	5,710,564	18,785,468	263	1	653	674	21	21	Middle Lagarto	-6	-680
7913105	Goliad	15	5,733,294	18,825,736	282	1	574	595	21	21	Middle Lagarto	-191	-695
7913202	Goliad	15	5,737,231	18,824,511	290	1	127	137	10	10	Upper Lagarto	290	-234
7913703	Goliad	15	5,734,501	18,784,796	216	1	222	240	18	18	Upper Lagarto	99	-347
7913801	Goliad	15	5,737,859	18,785,682	230	1	579	600	21	21	Upper Lagarto	75	-362
7914602	Goliad	15	5,790,865	18,810,918	213	1	370	391	21	21	Lower Goliad	-17	-301
7915501	Goliad	15	5,814,281	18,805,735	165	1	125	135	10	10	Upper Goliad	165	-341
7916903	Victoria	15	5,877,942	18,798,597	54	5	420	755	200	335	Upper Goliad	-328	-1,084
7916904	Victoria	15	5,879,625	18,798,845	52	8	420	850	205	430	Upper Goliad	-328	-1,084
7916906	Victoria	15	5,879,877	18,789,545	44	3	360	610	120	250	Upper Goliad	-372	-1,107
7918501	Bee	15	5,627,973	18,753,381	417	1	746	918	172	172	Oakville	-392	-963

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7918503	Bee	15	5,626,947	18,751,237	430	2	727	907	150	180	Lower Lagarto	217	-438
7918604	Bee	15	5,629,483	18,753,513	399	1	761	931	170	170	Oakville	-392	-963
7918901	Bee	15	5,631,467	18,738,888	399	1	146	167	21	21	Middle Lagarto	399	-21
7919101	Karnes	15	5,654,244	18,769,794	307	1	195	210	15	15	Middle Lagarto	307	47
7919301	Goliad	15	5,674,798	18,773,765	191	1	238	280	42	42	Middle Lagarto	191	-242
7919304	Goliad	15	5,680,261	18,767,914	191	1	326	368	42	42	Middle Lagarto	191	-450
7919501	Goliad	15	5,662,825	18,763,600	295	1	560	627	67	67	Lower Lagarto	-175	-627
7919602	Goliad	15	5,673,520	18,766,962	189	1	645	688	43	43	Lower Lagarto	-325	-781
7919705	Goliad	15	5,651,687	18,747,086	360	1	279	300	21	21	Middle Lagarto	360	-192
7920401	Goliad	15	5,693,381	18,765,973	169	1	308	350	42	42	Middle Lagarto	-47	-666
7920501	Goliad	15	5,708,409	18,754,369	154	1	432	476	44	44	Upper Lagarto	154	-396
7920505	Goliad	15	5,706,740	18,757,366	160	2	459	521	39	62	Upper Lagarto	160	-332
7920603	Goliad	15	5,709,867	18,764,819	251	1	120	150	30	30	Upper Lagarto	251	-327
7920801	Goliad	15	5,701,688	18,744,309	231	1	285	318	33	33	Upper Lagarto	231	-511
7920901	Goliad	15	5,711,871	18,750,805	155	1	452	467	15	15	Upper Lagarto	155	-520
7921202	Goliad	15	5,739,356	18,778,636	216	1	170	220	50	50	Upper Lagarto	52	-433
7921502	Goliad	15	5,744,653	18,753,574	210	1	229	249	20	20	Lower Goliad	119	-209
7921701	Goliad	15	5,726,679	18,745,474	141	1	573	593	20	20	Upper Lagarto	-82	-765
7921911	Goliad	15	5,755,270	18,744,921	201	1	237	287	50	50	Lower Goliad	-56	-542
7922404	Goliad	15	5,773,571	18,757,696	146	1	133	145	12	12	Upper Goliad	146	-127
7922502	Goliad	15	5,779,047	18,759,446	160	1	157	178	21	21	Upper Goliad	160	-229
7923103	Goliad	15	5,809,384	18,770,612	121	1	249	264	15	15	Upper Goliad	76	-434
7923408	Goliad	15	5,807,381	18,761,762	139	1	402	472	70	70	Upper Goliad	2	-508
7925602	Bee	16	5,598,962	18,716,004	399	1	730	830	100	100	Oakville	-98	-1,059
7926102	Bee	15	5,611,075	18,729,890	357	1	152	173	21	21	Middle Lagarto	357	-13
7926204	Bee	15	5,627,735	18,734,060	367	1	327	367	40	40	Middle Lagarto	367	-24

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7926205	Bee	15	5,627,737	18,733,959	364	1	360	410	50	50	Middle Lagarto	364	-24
7926207	Bee	15	5,625,220	18,735,123	311	1	441	471	30	30	Lower Lagarto	18	-612
7926801	Bee	15	5,621,996	18,704,519	334	1	124	144	20	20	Middle Lagarto	334	-102
7927302	Goliad	15	5,674,134	18,733,801	332	1	247	268	21	21	Upper Lagarto	332	-147
7927303	Goliad	15	5,674,766	18,725,017	304	1	261	282	21	21	Upper Lagarto	175	-241
7928501	Goliad	15	5,702,511	18,710,953	240	1	143	163	20	20	Lower Goliad	240	-220
7928706	Goliad	15	5,693,582	18,703,577	205	1	150	175	25	25	Lower Goliad	205	-195
7928717	Goliad	15	5,686,042	18,706,043	189	1	299	320	21	21	Upper Lagarto	-97	-610
7932602	Victoria	15	5,881,589	18,713,122	71	1	185	798	613	613	Willis	-208	-492
7933302	Bee	16	5,595,352	18,676,196	374	1	259	280	21	21	Middle Lagarto	196	46
7933906	Bee	16	5,593,145	18,656,134	351	1	208	250	42	42	Lower Goliad	351	67
7934405	Bee	16	5,604,047	18,664,633	354	1	119	140	21	21	Upper Goliad	354	178
7934601	Bee	16	5,637,568	18,670,348	312	3	320	466	98	146	Upper Lagarto	-49	-288
7934903	Bee	16	5,642,614	18,654,677	214	2	1380	1554	146	174	Lower Lagarto	-1,083	-1,618
7935401	Bee	16	5,654,214	18,663,408	210	1	250	290	40	40	Lower Goliad	-19	-311
7935701	Bee	16	5,644,629	18,656,538	222	1	1484	1533	49	49	Lower Lagarto	-1,129	-1,657
7935702	Bee	16	5,648,072	18,653,979	200	2	1428	1590	152	162	Lower Lagarto	-1,174	-1,697
7935706	Bee	16	5,648,165	18,649,431	220	4	1291	1566	185	275	Middle Lagarto	-718	-1,242
7936901	Bee	15	5,714,892	18,651,364	127	1	900	928	28	28	Lower Goliad	-638	-1,022
7937204	Goliad	15	5,740,606	18,685,923	151	1	317	327	10	10	Upper Goliad	151	-559
7937906	Bee	15	5,761,759	18,651,228	83	1	729	750	21	21	Upper Goliad	-53	-1,153
7938406	Goliad	15	5,764,856	18,674,963	110	1	380	390	10	10	Upper Goliad	5	-977
7941301	Bee	16	5,599,138	18,631,983	294	1	458	610	152	152	Upper Lagarto	-215	-283
7942103	Bee	16	5,614,638	18,643,099	281	1	306	327	21	21	Upper Goliad	281	-75
7942604	Bee	16	5,633,210	18,616,169	224	1	200	240	40	40	Upper Goliad	224	-383
7943102	Bee	16	5,645,326	18,631,073	200	1	330	715	385	385	Upper Goliad	200	-340

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7943305	Bee	15	5,683,916	18,638,957	156	1	550	580	30	30	Upper Goliad	89	-457
7943401	Bee	16	5,645,894	18,629,467	209	8	340	835	274	495	Lower Goliad	-356	-660
7943702	Bee	16	5,648,062	18,602,012	180	1	85	100	15	15	Upper Goliad	105	-606
7943704	Bee	16	5,648,006	18,600,394	187	1	85	90	5	5	Upper Goliad	105	-633
7945101	Bee	15	5,725,534	18,638,661	101	1	296	307	11	11	Upper Goliad	-59	-864
7945203	Bee	15	5,745,077	18,646,894	81	1	159	180	21	21	Upper Goliad	-39	-1,009
7946611	Refugio	15	5,798,806	18,625,934	46	7	424	880	145	456	Upper Goliad	-351	-1,465
7946612	Refugio	15	5,798,315	18,620,462	50	7	548	874	104	326	Upper Goliad	-364	-1,482
7949803	Live Oak	16	5,584,921	18,561,052	93	5	60	468	337	408	Upper Goliad	93	-306
7950304	Bee	16	5,643,552	18,590,800	187	1	375	525	150	150	Upper Goliad	61	-671
7950503	Bee	16	5,629,346	18,572,319	186	1	226	247	21	21	Upper Goliad	60	-658
7950907	San Patricio	16	5,639,069	18,555,936	155	5	240	653	323	413	Upper Goliad	11	-903
7951105	Bee	16	5,647,024	18,595,925	188	1	130	150	20	20	Upper Goliad	103	-663
7951603	Bee	16	5,683,475	18,580,310	97	1	254	275	21	21	Upper Goliad	-140	-1,086
7952407	Bee	16	5,698,419	18,571,737	77	1	200	220	20	20	Willis	-70	-228
7956203	Aransas	15	5,870,980	18,603,015	19	1	1175	1201	26	26	Upper Goliad	-730	-1,937
7959101	San Patricio	16	5,649,704	18,552,310	135	6	241	689	358	448	Upper Goliad	-64	-1,049
7959102	San Patricio	16	5,647,787	18,549,745	134	4	250	683	383	433	Upper Goliad	-35	-1,004
7959303	San Patricio	16	5,682,112	18,551,977	105	2	180	290	90	110	Willis	-80	-278
7959501	San Patricio	16	5,669,140	18,526,029	113	4	181	355	119	174	Willis	-120	-301
7960106	San Patricio	16	5,695,494	18,541,651	90	4	225	503	231	278	Willis	-112	-333
7960212	San Patricio	16	5,707,048	18,545,543	79	1	300	352	52	52	Willis	-109	-347
7960401	San Patricio	16	5,698,138	18,539,485	85	1	220	495	275	275	Willis	-120	-351
7960503	San Patricio	16	5,711,444	18,537,048	63	5	182	457	245	275	Willis	-118	-370
7960604	San Patricio	16	5,715,412	18,531,779	55	4	440	750	190	310	Upper Goliad	-382	-1,440
7960614	San Patricio	16	5,715,842	18,532,598	56	8	334	684	130	350	Upper Goliad	-382	-1,440

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7960616	San Patricio	16	5,715,939	18,536,238	62	7	222	582	175	360	Willis	-122	-372
7960801	San Patricio	16	5,704,340	18,517,990	52	4	190	415	140	225	Willis	-165	-413
7961605	San Patricio	16	5,766,897	18,536,197	39	1	371	396	25	25	Willis	-159	-419
7961902	San Patricio	16	5,762,300	18,514,660	49	1	242	260	18	18	Willis	-161	-461
7962707	San Patricio	16	5,770,366	18,522,128	42	1	316	326	10	10	Willis	-163	-431
7964307	Aransas	15	5,878,170	18,554,982	14	1	120	126	6	6	Beaumont	14	-238
8003202	Jackson	15	5,972,406	18,872,304	73	3	194	880	686	686	Upper Goliad	-499	-1,169
8003803	Jackson	15	5,977,449	18,843,110	55	3	0	919	919	919	Upper Goliad	-597	-1,392
8004403	Jackson	15	6,006,900	18,864,544	59	6	222	679	413	457	Lissie	-136	-367
8004710	Jackson	15	6,011,778	18,844,557	50	1	280	300	20	20	Lissie	-183	-400
8005507	Jackson	15	6,055,953	18,862,948	54	2	178	795	617	617	Lissie	-228	-500
8006703	Jackson	15	6,092,579	18,840,059	35	1	154	590	436	436	Lissie	-311	-651
8006704	Jackson	15	6,081,991	18,843,251	35	2	146	430	284	284	Beaumont	35	-289
8007203	Matagorda	15	6,143,993	18,884,505	55	3	221	453	206	232	Lissie	-268	-582
8007206	Matagorda	15	6,144,478	18,883,308	54	3	163	390	174	227	Beaumont	54	-268
8007313	Matagorda	15	6,147,119	18,883,906	50	2	328	362	20	34	Lissie	-268	-586
8009105	Victoria	15	5,892,955	18,831,481	115	1	200	881	681	681	Upper Goliad	-303	-955
8009409	Victoria	15	5,882,074	18,806,904	95	6	550	1016	263	466	Upper Goliad	-329	-1,077
8009506	Victoria	15	5,905,068	18,817,551	94	1	325	525	200	200	Willis	-202	-442
8011103	Victoria	15	5,966,907	18,824,181	41	1	126	136	10	10	Beaumont	41	-111
8012303	Jackson	15	6,032,856	18,829,531	40	1	115	135	20	20	Beaumont	40	-223
8012305	Jackson	15	6,032,447	18,828,405	40	1	118	128	10	10	Beaumont	40	-230
8017503	Victoria	15	5,897,281	18,761,494	68	5	587	1029	289	442	Upper Goliad	-555	-1,296
8017504	Victoria	15	5,895,799	18,760,341	67	6	595	1045	234	450	Upper Goliad	-536	-1,314
8017506	Victoria	15	5,900,727	18,765,636	69	2	329	405	60	76	Willis	-269	-561
8017905	Victoria	15	5,915,918	18,750,784	58	5	784	996	90	212	Upper Goliad	-593	-1,469

SWN	County	GMA	Easting (ft-GAM)	Northing (ft-GAM)	Ground Surface Elevation (ft)	Number of Screens	Depth to Top of Screen(s) (ft)	Depth to Bottom of Screen(s) (ft)	Actual Screen Length (ft)	Top - Bottom of Screen (ft)	Primary Formation	Top of Formation Elevation (ft)	Bottom of Formation Elevation (ft)
8018401	Victoria	15	5,928,574	18,759,740	58	3	202	444	58	242	Lissie	4	-286
8018501	Victoria	15	5,939,151	18,766,516	53	1	960	1100	140	140	Upper Goliad	-546	-1,497
8018503	Victoria	15	5,941,194	18,763,540	50	2	940	1015	65	75	Upper Goliad	-543	-1,520
8019503	Calhoun	15	5,978,917	18,761,206	28	1	255	265	10	10	Lissie	-99	-375
8019802	Calhoun	15	5,985,358	18,745,315	24	1	173	233	60	60	Lissie	-130	-434
8020803	Calhoun	15	6,026,099	18,758,397	1	2	250	359	66	109	Lissie	-243	-564
8021217	Jackson	15	6,065,724	18,783,126	16	1	300	620	320	320	Lissie	-299	-650
8021601	Jackson	15	6,078,795	18,769,791	10	2	317	625	271	308	Lissie	-326	-675
8023202	Matagorda	15	6,137,587	18,791,997	17	1	60	70	10	10	Beaumont	17	-426
8023404	Matagorda	15	6,122,871	18,777,329	10	1	527	571	44	44	Lissie	-376	-736
8025301	Victoria	15	5,920,255	18,742,207	54	1	905	945	40	40	Upper Goliad	-607	-1,542
8026103	Calhoun	15	5,927,142	18,738,052	42	1	1030	1080	50	50	Upper Goliad	-619	-1,620
8026501	Calhoun	15	5,946,667	18,715,853	34	1	225	267	42	42	Lissie	-59	-419
8026903	Calhoun	15	5,952,826	18,706,322	31	1	879	899	20	20	Upper Goliad	-765	-2,009
8027603	Calhoun	15	6,000,815	18,723,225	15	1	244	254	10	10	Lissie	-183	-516
8033610	Refugio	15	5,920,468	18,680,820	30	1	790	840	50	50	Upper Goliad	-710	-1,910
8042106	Refugio	15	5,929,845	18,642,756	15	1	227	247	20	20	Beaumont	15	-229
8045201	Calhoun	15	6,070,530	18,642,677	7	ND	ND	ND	ND	ND	Willis	ND	ND
8101101	Matagorda	15	6,206,237	18,881,149	52	5	565	760	140	195	Lissie	-388	-752
8101201	Matagorda	15	6,213,830	18,882,236	49	5	778	1100	217	322	Willis	-784	-1,097
8102901	Matagorda	15	6,267,893	18,847,111	16	1	278	294	16	16	Beaumont	16	-464
8105302	Brazoria	14	6,391,445	18,882,806	5	1	167	192	25	25	Beaumont	5	-768
8105320	Brazoria	14	6,397,105	18,887,597	5	1	150	180	30	30	Beaumont	5	-761
8109905	Matagorda	15	6,233,329	18,801,588	20	3	364	491	65	127	Beaumont	20	-541
8301508	Jim Wells	16	5,586,221	18,491,238	199	2	630	746	76	116	Upper Goliad	-9	-844
8301509	Jim Wells	16	5,585,584	18,491,731	203	4	550	817	105	267	Upper Goliad	-9	-795

SWN	County	GMA	Easting (ft-GAM)	Northing (ft-GAM)	Ground Surface Elevation (ft)	Number of Screens	Depth to Top of Screen(s) (ft)	Depth to Bottom of Screen(s) (ft)	Actual Screen Length (ft)	Top - Bottom of Screen (ft)	Primary Formation	Top of Formation Elevation (ft)	Bottom of Formation Elevation (ft)
8301514	Jim Wells	16	5,585,674	18,491,733	203	3	520	735	130	215	Upper Goliad	-9	-844
8301706	Jim Wells	16	5,577,178	18,471,061	166	1	283	316	33	33	Upper Goliad	-80	-911
8301901	Nueces	16	5,597,936	18,464,375	122	1	250	290	40	40	Willis	-38	-172
8302306	San Patricio	16	5,633,672	18,503,472	53	1	199	209	10	10	Upper Goliad	-146	-1,179
8303607	San Patricio	16	5,684,883	18,489,371	93	1	248	280	32	32	Lissie	-42	-220
8305501	San Patricio	16	5,741,600	18,491,235	59	1	206	216	10	10	Lissie	-37	-210
8307617	Aransas	15	5,847,270	18,493,415	18	1	42	77	35	35	Beaumont	18	-223
8310602	Nueces	16	5,635,776	18,434,090	81	1	608	623	15	15	Upper Goliad	-430	-1,757
8317901	Nueces	16	5,596,134	18,379,065	103	2	597	738	111	141	Upper Goliad	-434	-1,651
8319402	Nueces	16	5,649,716	18,388,904	61	1	383	405	22	22	Lissie	-76	-359
8325101	Kleberg	16	5,574,193	18,364,112	124	1	480	515	35	35	Upper Goliad	-347	-1,464
8325501	Kleberg	16	5,588,805	18,352,461	104	1	441	485	44	44	Willis	-203	-400
8325608	Kleberg	16	5,607,628	18,342,412	74	2	585	780	180	195	Upper Goliad	-509	-1,810
8325801	Kleberg	16	5,584,757	18,328,043	103	1	555	597	42	42	Upper Goliad	-385	-1,509
8326401	Kleberg	16	5,621,533	18,344,903	53	1	662	750	88	88	Upper Goliad	-625	-1,978
8326404	Kleberg	16	5,613,737	18,343,035	70	1	628	684	56	56	Upper Goliad	-568	-1,923
8326509	Nueces	16	5,626,535	18,351,467	59	3	817	950	103	133	Upper Goliad	-648	-2,057
8326701	Kleberg	16	5,618,922	18,340,307	60	1	576	623	47	47	Willis	-310	-602
8327901	Kleberg	16	5,689,292	18,337,907	35	1	878	915	37	37	Upper Goliad	-843	-2,400
8329201	Nueces	16	5,745,571	18,361,482	27	1	1161	1173	12	12	Upper Goliad	-811	-2,183
8329202	Nueces	16	5,744,612	18,360,146	25	ND	ND	ND	ND	ND	Upper Goliad	ND	ND
8329701	Kleberg	16	5,738,106	18,329,692	25	ND	ND	ND	ND	ND	Upper Goliad	ND	ND
8334101	Kleberg	16	5,614,895	18,325,078	62	3	599	779	150	180	Upper Goliad	-598	-1,995
8334501	Kleberg	16	5,629,983	18,304,465	54	1	610	631	21	21	Willis	-388	-755
8337201	Kleberg	16	5,756,879	18,316,488	18	ND	ND	ND	ND	ND	Upper Goliad	ND	ND
8346201	Kleberg	16	5,788,992	18,274,020	4	1	1530	1560	30	30	Upper Goliad	-1,153	-3,147

SWN	County	GMA	Easting (ft-GAM)	Northing (ft-GAM)	Ground Surface Elevation (ft)	Number of Screens	Depth to Top of Screen(s) (ft)	Depth to Bottom of Screen(s) (ft)	Actual Screen Length (ft)	Top - Bottom of Screen (ft)	Primary Formation	Top of Formation Elevation (ft)	Bottom of Formation Elevation (ft)
8358703	Kenedy	16	5,619,568	18,158,255	53	1	700	860	160	160	Upper Goliad	-384	-1,441
8407903	Jim Wells	16	5,520,591	18,464,914	282	1	500	540	40	40	Upper Goliad	282	-581
8408801	Jim Wells	16	5,551,004	18,469,984	244	1	580	630	50	50	Upper Goliad	58	-802
8412301	Duval	16	5,393,542	18,453,208	600	3	160	503	90	343	Oakville	600	42
8412603	Duval	16	5,395,683	18,433,838	529	ND	ND	ND	ND	ND	Oakville	ND	ND
8412605	Duval	16	5,394,673	18,428,772	587	ND	ND	ND	ND	ND	Oakville	ND	ND
8415702	Duval	16	5,489,851	18,417,833	293	2	402	505	87	103	Upper Goliad	293	-395
8416407	Jim Wells	16	5,531,631	18,438,324	237	1	306	326	20	20	Upper Goliad	148	-805
8416804	Jim Wells	16	5,546,564	18,421,204	199	6	321	841	334	520	Upper Goliad	-24	-1,000
8416805	Jim Wells	16	5,550,299	18,423,391	194	6	395	850	284	455	Upper Goliad	-35	-1,024
8416807	Jim Wells	16	5,551,169	18,419,870	185	7	320	856	269	536	Upper Goliad	-50	-1,057
8419101	Duval	16	5,326,310	18,399,848	651	ND	ND	ND	ND	ND	Catahoula	ND	ND
8419303	Duval	16	5,365,371	18,402,231	590	1	540	560	20	20	Oakville	590	-107
8420403	Duval	16	5,372,151	18,384,738	600	ND	ND	ND	ND	ND	Lower Lagarto	ND	ND
8421601	Duval	16	5,441,118	18,396,381	426	2	255	349	82	94	Lower Goliad	292	14
8422401	Duval	16	5,454,371	18,387,585	400	2	1106	1252	136	146	Middle Lagarto	-658	-1,004
8423105	Duval	16	5,492,044	18,409,886	323	4	305	600	139	295	Upper Goliad	323	-450
8423204	Jim Wells	16	5,500,974	18,402,150	300	1	297	324	27	27	Upper Goliad	181	-617
8424101	Jim Wells	16	5,528,302	18,401,693	233	3	390	790	173	400	Upper Goliad	18	-1,000
8424102	Jim Wells	16	5,535,247	18,410,702	222	5	320	750	223	430	Upper Goliad	27	-1,006
8424204	Jim Wells	16	5,545,616	18,408,659	201	6	400	810	220	410	Upper Goliad	-71	-1,096
8424208	Jim Wells	16	5,551,093	18,408,856	184	8	345	925	300	580	Upper Goliad	-97	-1,152
8424401	Jim Wells	16	5,528,340	18,399,472	227	1	1850	1900	50	50	Upper Lagarto	-1,406	-1,813
8424513	Jim Wells	16	5,541,472	18,388,483	206	ND	ND	ND	ND	ND	Upper Goliad	ND	ND
8427405	Duval	16	5,331,587	18,339,201	689	1	470	540	70	70	Oakville	643	-333
8428803	Duval	16	5,381,714	18,326,074	531	ND	ND	ND	ND	ND	Catahoula	ND	ND

SWN	County	GMA	Easting (ft-GAM)	Northing (ft-GAM)	Ground Surface Elevation (ft)	Number of Screens	Depth to Top of Screen(s) (ft)	Depth to Bottom of Screen(s) (ft)	Actual Screen Length (ft)	Top - Bottom of Screen (ft)	Primary Formation	Top of Formation Elevation (ft)	Bottom of Formation Elevation (ft)
8429309	Duval	16	5,438,025	18,355,324	360	3	332	607	230	275	Lower Goliad	-58	-514
8429310	Duval	16	5,437,482	18,355,518	362	3	322	596	229	274	Lower Goliad	-26	-514
8430404	Duval	16	5,459,861	18,351,302	325	1	180	220	40	40	Upper Goliad	325	-267
8432503	Kleberg	16	5,550,736	18,347,328	139	1	469	534	65	65	Upper Goliad	-145	-1,239
8433101	Webb	16	5,254,898	18,310,027	858	3	178	340	100	162	Catahoula	858	398
8433103	Webb	16	5,255,259	18,310,030	857	2	189	311	87	122	Catahoula	857	398
8433204	Webb	16	5,260,139	18,308,359	848	1	300	352	52	52	Catahoula	848	301
8433701	Webb	16	5,251,527	18,284,851	892	1	180	200	20	20	Catahoula	892	554
8434404	Webb	16	5,297,302	18,295,298	776	1	230	315	85	85	Oakville	776	272
8434405	Webb	16	5,298,475	18,295,209	771	1	236	345	109	109	Oakville	771	272
8434407	Webb	16	5,299,089	18,296,730	764	2	140	210	70	70	Oakville	764	179
8434502	Webb	16	5,300,142	18,299,468	762	1	295	326	31	31	Oakville	762	187
8434805	Webb	16	5,302,590	18,289,598	740	2	320	490	70	170	Oakville	740	176
8438902	Duval	16	5,483,702	18,282,788	251	1	300	310	10	10	Upper Goliad	251	-652
8440206	Kleberg	16	5,554,497	18,317,800	122	3	415	640	185	225	Upper Goliad	-191	-1,199
8440703	Jim Wells	16	5,533,973	18,290,579	147	1	2331	2425	94	94	Middle Lagarto	-2,226	-2,645
8442601	Jim Hogg	16	5,320,236	18,250,813	685	1	160	243	83	83	Lower Lagarto	685	282
8443509	Jim Hogg	16	5,351,123	18,256,218	577	1	305	345	40	40	Middle Lagarto	577	167
8443512	Jim Hogg	16	5,347,524	18,247,693	581	6	827	1383	176	556	Oakville	-205	-563
8443514	Jim Hogg	16	5,352,650	18,249,269	532	9	882	1436	200	554	Oakville	-295	-690
8448117	Jim Wells	16	5,532,947	18,271,374	150	5	410	712	218	302	Upper Goliad	-21	-954
8450101	Jim Hogg	16	5,294,979	18,223,988	804	1	260	300	40	40	Catahoula	605	-789
8455325	Brooks	16	5,525,336	18,225,100	115	1	674	741	67	67	Upper Goliad	115	-745
8455329	Brooks	16	5,520,219	18,228,649	130	1	540	580	40	40	Upper Goliad	130	-719
8456203	Brooks	16	5,554,428	18,224,489	101	1	645	680	35	35	Upper Goliad	-16	-944
8457101	Zapata	13	5,259,435	18,181,843	655	1	233	275	42	42	Catahoula	655	340

SWN	County	GMA	Easting (ft-GAM)	Northing (ft-GAM)	Ground Surface Elevation (ft)	Number of Screens	Depth to Top of Screen(s) (ft)	Depth to Bottom of Screen(s) (ft)	Actual Screen Length (ft)	Top - Bottom of Screen (ft)	Primary Formation	Top of Formation Elevation (ft)	Bottom of Formation Elevation (ft)
8460402	Jim Hogg	16	5,374,695	18,168,272	447	1	428	455	27	27	Middle Lagarto	447	-61
8463304	Brooks	16	5,524,100	18,174,803	119	1	548	598	50	50	Upper Goliad	36	-642
8701201	Jim Hogg	16	5,270,642	18,126,236	540	1	412	548	136	136	Catahoula	540	-102
8701601	Jim Hogg	16	5,276,192	18,123,465	560	1	551	711	160	160	Catahoula	560	-257
8707604	Brooks	16	5,529,813	18,120,291	125	1	305	400	95	95	Upper Goliad	125	-566
8708801	Brooks	16	5,559,060	18,110,603	70	1	639	660	21	21	Upper Goliad	-19	-863
8709301	Jim Hogg	16	5,283,066	18,088,113	545	ND	ND	ND	ND	ND	Catahoula	ND	ND
8710402	Jim Hogg	16	5,295,247	18,067,148	564	ND	ND	ND	ND	ND	Catahoula	ND	ND
8713503	Brooks	16	5,437,532	18,068,699	243	1	226	635	409	409	Upper Lagarto	-19	-386
8713601	Brooks	16	5,443,966	18,075,350	230	ND	ND	ND	ND	ND	Upper Lagarto	ND	ND
8802403	Kenedy	16	5,624,699	18,122,521	29	1	1054	1099	45	45	Upper Goliad	-496	-1,511
8904625	Cameron	16	5,733,689	17,764,322	37	2	172	186	9	14	Beaumont	37	-763

19.4 Water Well Total Dissolved Solids and Chemistry Information

Description of Table Attributes

SWN	–	State well number of the water well
Estimated In Situ Temperature (°F)	–	Estimated temperature of the groundwater (degrees Fahrenheit) in the well screen based on the depth of the well screen and the geothermal gradient at the location of the water well
Specific Conductance (μmho/cm)	–	Average Specific Conductance in micromhos per centimeter
TDS: Meas (#)	–	Number of total dissolved solids measurements
TDS: Meas. (mg/l)	–	Average measured total dissolved solids (milligrams per liter)
TDS: Calc. (mg/L)	–	total dissolved solids calculated by summing up measured water quality constituents (milligrams per liter)
TDS: Meas./Calc.	–	Ratio of total dissolved solids measured divided by total dissolved solids calculated
TDS; as NaCl	–	total dissolved solids, as sodium chloride
Milliequivalence (mEq): Ca	–	percent of charge balance based on milliequivalence comprised of calcium ions
Milliequivalence (mEq): Mg	–	percent of charge balance based on milliequivalence comprised of magnesium ions
Milliequivalence (mEq): Na	–	percent of charge balance based on milliequivalence comprised of sodium ions
Milliequivalence (mEq): K	–	percent of charge balance based on milliequivalence comprised of potassium ions
Milliequivalence (mEq): Sr	–	percent of charge balance based on milliequivalence comprised of strontium ions
Milliequivalence (mEq): CO_3	–	percent of charge balance based on milliequivalence comprised of carbonate ions
Milliequivalence (mEq): HCO_3	–	percent of charge balance based on milliequivalence comprised of bicarbonate ions
Milliequivalence (mEq): SO_4	–	percent of charge balance based on milliequivalence comprised of sulfate ions
Milliequivalence (mEq): Cl	–	percent of charge balance based on milliequivalence comprised of chloride ions
Milliequivalence (mEq): F	–	percent of charge balance based on milliequivalence comprised of fluoride ions
Milliequivalence (mEq): NO_3	–	percent of charge balance based on milliequivalence comprised of nitrate ions

Milliequivalence (mEq): SiO_2	–	percent of charge balance based on milliequivalence comprised of silica
Total	–	summation of the mass fraction of the ions comprising the calculated TDS
%	–	percent

Table 19-4. Water well total dissolved solids and chemistry information.

			TDS					Milliequivalents (mEq)														
SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	Meas. (#)	Meas. (mg/L)	Calc. (mg/L)	Meas. /Calc.	As NACL (mg/L)	Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total	Cation (%)	Anion (%)
5959507	73	780	1	458	621	0.74	281	5.04	0.51	1.74			0.00	5.22	0.33	1.97	0.04	0.01	0.00	14.9	49.0	51.0
5961402	75	693	1	438	624	0.70	253	3.79	0.37	3.18			0.00	5.97	0.31	1.04	0.02	0.00	0.00	14.7	50.0	50.0
5961803	81	747	6	453	636	0.71	277	2.58	0.45	4.31	0.31	0.03	0.00	5.65	0.24	1.87	0.02	0.00	0.00	15.5	49.6	50.4
5963801	82	632	3	381	547	0.70	223	3.43	0.55	2.42	0.12	0.03	0.00	5.33	0.36	0.70	0.01	0.01	0.00	13.0	50.6	49.4
5963902	88	1356	4	802	1192	0.67	449	1.10	0.10	13.11			0.00	12.17	0.20	1.88	0.05	0.00	0.00	28.6	50.0	50.0
6016801	ND	3937	1	3937	4125	0.95	ND	7.73	0.82	60.03			0.00	6.03	0.04	62.34			0.00	137.0	50.1	49.9
6027602	70	606	4	391	512	0.76	258	4.58	0.29	1.56	0.14	0.01	0.00	3.88	0.58	1.77	0.01	0.00	0.00	12.8	51.4	48.6
6033105	88	1034	1	613	745	0.82	413	0.27	0.02	8.92	0.15	0.00	0.00	4.22	2.42	2.85	0.05	0.00	0.00	18.9	49.5	50.5
6041107	81	785	1	528	740	0.71	306	0.90	0.07	7.96	0.21	0.01	0.00	6.80	0.53	1.27	0.04	0.00	0.00	17.8	51.4	48.6
6044114	79	592	1	373	526	0.71	228	3.27	0.77	2.40	0.16	0.03	0.00	4.92	0.42	0.89	0.01	0.01	0.00	12.9	51.5	48.5
6044318	84	584	2	362	502	0.72	218	2.31	0.60	2.99	0.21	0.02	0.00	4.53	0.56	0.85	0.01	0.00	0.00	12.1	50.7	49.3
6045207	83	526	3	324	458	0.71	190	1.77	0.49	2.92	0.13	0.02	0.00	4.34	0.40	0.78	0.01	0.00	0.00	10.9	49.1	50.9
6045402	84	--	1	372	521	0.71	231	2.10	0.58	3.83			0.00	4.80	0.54	1.13			0.00	13.0	50.1	49.9
6045503	86	605	5	370	513	0.72	229	1.79	0.53	3.79	0.19	0.02	0.00	4.58	0.51	1.22	0.01	0.00	0.00	12.6	50.1	49.9
6045507	86	575	2	330	463	0.71	214	1.80	0.66	3.55			0.00	3.86	0.59	1.34	0.02	0.01	0.00	11.8	50.8	49.2
6053406	91	663	1	385	547	0.70	229	0.25	0.08	6.39			0.00	5.18	0.37	1.16	0.02	0.00	0.00	13.5	50.0	50.0
6053709	82	735	3	433	604	0.72	267	0.25	0.11	7.10			0.64	5.51	0.26	1.37	0.04	0.01	0.00	15.3	48.8	51.2
6053821	82	605	1	356	506	0.70	214	0.53	0.21	5.65	0.05	0.01	0.24	4.84	0.27	0.79	0.03	0.01	0.00	12.6	51.1	48.9
6054805	71	389	1	261	339	0.77	179	2.35	0.67	1.70	0.16		0.00	2.52	0.12	1.41	0.01		0.00	8.9	54.5	45.5
6061307	76	464	3	271	371	0.73	175	2.53	0.49	1.58	0.08	0.01	0.00	3.15	0.09	1.33	0.01	0.01	0.00	9.3	50.5	49.5
6061408	86	810	1	469	645	0.73	299	0.75	0.16	7.39			0.00	5.66	0.35	2.26	0.03	0.00	0.00	16.6	50.0	50.0
6061410	84	790	1	413	569	0.73	275	0.75	0.33	6.52			0.00	5.00	0.35	2.17	0.04	0.00	0.00	15.2	50.1	49.9
6064305	89	1880	1	1007	1095	0.92	886	0.10	0.00	17.09			1.44	2.84	0.40	12.52	0.02	0.01	0.00	34.4	50.0	50.0

SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	TDS Meas. (#)	Meas. (mg/L)	Calc. (mg/L)	Meas. /Calc.	As NACL (mg/L)	Milliequivalents (mEq) Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total	Cation (%)	Anion (%)
6117402	ND	4034	1	4034	4277	0.94	ND	12.48	1.48	56.55			0.00	7.84	0.02	62.91	0.00	0.00	0.00	141.3	49.9	50.1
6122802	73	385	1	249	361	0.69	136	2.99	0.33	0.57	0.11		0.00	3.61	0.10	0.31	0.01	0.00	0.00	8.0	49.8	50.2
6130405	74	141	1	103	131	0.79	53	0.80	0.08	0.31	0.12		0.00	0.89	0.00	0.39	0.01	0.00	0.00	2.6	50.1	49.9
6131302	74	93	1	91	103	0.89	40	0.32	0.06	0.37	0.06		0.00	0.36	0.01	0.45	0.01	0.00	0.00	1.6	49.5	50.5
6144967	71	1626	4	967	1178	0.82	740	0.63	0.17	15.88	0.07	0.01	0.00	6.68	0.09	10.23	0.12	0.00	0.00	33.9	49.5	50.5
6146201	73	337	3	214	305	0.70	121	2.59	0.19	0.62	0.07	0.01	0.00	2.87	0.12	0.44	0.01	0.00	0.00	6.9	50.3	49.7
6147201	75	288	1	169	246	0.69	96	1.90	0.35	0.57			0.00	2.48	0.14	0.25	0.01	0.00	0.00	5.7	49.4	50.6
6153907	80	1490	1	816	975	0.84	642	0.80	0.21	13.31	0.05		0.00	5.12	0.00	9.03	0.07	0.00	0.00	28.6	50.3	49.7
6153913	71	2930	5	965	1097	0.88	822	2.85	0.77	13.21			0.00	4.21	0.05	12.43	0.03	0.01	0.00	33.6	50.2	49.8
6153928	80	2463	6	1197	1425	0.84	954	1.28	0.43	19.18	0.07		0.00	7.24	0.26	13.53	0.09	0.01	0.00	42.1	49.8	50.2
6160902	75	--	1	830	973	0.85	685	1.05	0.32	13.40			0.37	4.61	0.04	9.70		0.04	0.00	29.5	50.0	50.0
6161309	72	996	5	630	753	0.84	494	0.99	0.24	9.80	0.07	0.01	0.00	3.93	0.04	6.84	0.02	0.00	0.00	21.9	50.6	49.4
6162415	72	1446	3	830	1022	0.81	625	0.95	0.25	13.27	0.04	0.01	0.00	6.19	0.12	8.23	0.03	0.00	0.00	29.1	49.9	50.1
6164513	ND	3814	1	3814	3956	0.96	ND	4.49	2.30	59.20			0.00	4.56	0.23	61.21			0.00	132.0	50.0	50.0
6217911	90	260	4	181	255	0.71	94	1.34	0.11	1.21	0.08	0.01	0.00	2.34	0.17	0.18	0.01	0.00	0.00	5.4	50.5	49.5
6233401	73	77	6	77	90	0.86	31	0.13	0.10	0.41	0.06	0.00	0.00	0.38	0.02	0.26	0.00	0.01	0.00	1.4	50.8	49.2
6242909	76	280	2	209	270	0.77	110	0.52	0.24	1.99	0.06	0.00	0.00	1.98	0.10	0.77	0.03	0.00	0.00	5.7	49.4	50.6
6408201	75	1960	1	1342	1507	0.89	1138	0.60	0.29	22.14	0.07	0.01	0.00	5.32	0.04	17.60	0.08	0.00	0.00	46.1	50.1	49.9
6409207	87	889	1	529	770	0.69	311	0.12	0.02	9.57			0.47	7.76	0.00	1.30			0.00	19.2	50.5	49.5
6409301	76	725	5	433	630	0.69	250	0.22	0.10	7.44	0.02		0.01	6.33	0.02	1.23	0.09	0.00	0.00	15.5	50.4	49.6
6409302	76	846	8	519	698	0.74	318	0.23	0.14	8.53	0.02		0.02	6.53	0.03	2.14	0.09	0.00	0.00	17.7	50.3	49.7
6409307	81	946	2	508	703	0.72	320	0.34	0.21	8.59	0.05		0.00	6.28	0.24	2.37	0.01	0.00	0.00	18.1	50.8	49.2
6409335	81	927	1	537	742	0.72	342	0.35	0.16	9.13			0.00	6.61	0.31	2.65			0.00	19.2	50.2	49.8
6420802	ND	2883	1	2883	3166	0.91	ND	3.04	3.13	44.80			0.00	9.10	0.04	41.75	0.01		0.00	101.9	50.0	50.0
6426701	80	941	6	552	780	0.71	339	0.26	0.14	9.51	0.03		0.08	7.36	0.00	2.42	0.08	0.00	0.00	19.9	50.0	50.0
6426804	82	985	1	579	811	0.71	360	0.29	0.31	9.53			0.00	7.48	0.42	2.60		0.01	0.00	20.6	49.1	50.9

SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	TDS					Milliequivalents (mEq)														Cation (%)	Anion (%)
			Meas. (#)	Meas. (mg/L)	Calc. (mg/L)	Meas. /Calc.	As NACL (mg/L)	Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total		
6428302	ND	2628	1	2628	2957	0.89	ND	3.09	2.22	40.84			0.00	10.61	0.04	35.54		0.32	0.00	92.7	49.8	50.2
6429502	ND	8075	1	8075	8239	0.98	ND	7.73	7.49	7.73	0.36		0.00	5.26	1.40	5.26			0.00	279.1	50.0	50.0
6433911	78	--	1	1289	1578	0.82	995	0.50	0.36	22.14			0.00	9.30	0.04	13.60		0.05	0.00	46.0	50.0	50.0
6434201	ND	3740	1	3740	4039	0.93	ND	3.29	2.88	59.16	0.20		0.00	9.64	0.33	55.01		0.01	0.00	130.5	50.2	49.8
6441114	77	1287	3	720	953	0.76	493	0.38	0.16	12.35	0.05		0.00	7.42	0.00	5.36	0.07	0.00	0.00	25.8	50.2	49.8
6503308	ND	5227	1	5227	5637	0.93	ND	3.09	0.66	86.99	0.46		0.00	13.22	0.06	76.45	0.04		0.00	181.0	50.4	49.6
6503505	ND	5526	1	5526	5988	0.92	ND	4.84	0.90	89.60			0.00	14.85	0.37	80.11		0.02	0.00	190.7	50.0	50.0
6511406	85	570	1	337	471	0.72	212	1.45	0.41	4.09			0.00	4.30	0.25	1.41	0.02	0.00	0.00	11.9	49.9	50.1
6530722	82	661	1	452	602	0.75	329	4.64	5.92	37.10			0.00	10.76	7.23	28.49		1.19	0.00	95.3	50.0	50.0
6538124	77	1074	2	577	760	0.76	399	4.13	1.23	2.08	0.06	0.02	0.00	4.35	0.35	2.96	0.01	0.00	0.00	15.2	49.5	50.5
6541804	80	627	7	370	510	0.73	252	1.08	0.43	8.72	0.03	0.00	0.00	5.52	0.59	3.99	0.08	0.00	0.00	20.4	50.2	49.8
6551803	81	--	1	874	1036	0.84	717	2.52	1.03	3.17	0.05	0.02	0.00	4.27	0.40	2.00	0.02	0.00	0.00	13.5	50.3	49.7
6553605	80	935	2	531	704	0.75	361	1.35	0.82	13.35			0.00	5.20	0.21	10.30			0.00	31.2	49.7	50.3
6561707	74	2610	1	1545	1810	0.85	1269	0.45	0.18	8.74	0.03		0.00	5.56	0.01	3.88	0.05	0.00	0.00	18.9	49.8	50.2
6562802	74	1750	1	978	1256	0.78	708	2.79	3.62	20.84			0.00	8.56	2.90	15.71	0.04	0.00	0.00	54.5	50.0	50.0
6604302	84	1042	6	636	884	0.72	351	1.25	1.15	15.14	0.07		0.00	8.92	0.02	8.46	0.06	0.08	0.00	35.1	50.1	49.9
6606108	71	1661	1	812	1035	0.78	630	0.68	0.05	9.13	0.20	0.01	0.00	7.97	0.58	1.56	0.02	0.01	0.00	20.2	49.8	50.2
6609505	75	1185	7	694	864	0.80	496	7.34	2.55	5.00			0.00	7.18	0.73	7.14	0.03	0.01	0.00	30.0	49.7	50.3
6609801	72	1085	1	616	766	0.80	425	4.36	0.69	5.83	0.42	0.03	0.00	5.05	0.90	5.44	0.03	0.00	0.00	22.7	49.8	50.2
6611208	81	1886	3	1019	1481	0.69	615	4.59	0.56	4.61			0.00	4.80	0.96	4.17	0.03	0.01	0.00	19.7	49.5	50.5
6616810	73	423	1	236	313	0.75	155	0.67	0.11	17.60	0.31		0.36	14.75	0.26	3.42	0.03	0.08	0.00	37.6	49.7	50.3
6618502	76	1140	1	700	886	0.79	513	2.69	0.22	0.96			0.00	2.48	0.10	1.35	0.01	0.03	0.00	7.8	49.4	50.6
6618602	76	1233	14	599	795	0.75	446	1.30	0.82	10.44			0.00	5.97	0.11	6.21	0.02	0.00	0.00	24.9	50.5	49.5
6618604	86	1604	13	861	1209	0.71	554	4.86	1.14	5.07	0.15		0.04	5.62	0.62	4.77	0.02	0.01	0.00	22.3	50.3	49.7
6618701	74	1000	1	551	743	0.74	359	0.46	0.09	15.00	0.23		0.04	10.95	0.08	4.83	0.02	0.01	0.00	31.7	49.8	50.2
6620407	76	1210	1	640	843	0.76	466	1.35	0.59	7.44			0.00	6.16	0.98	2.57	0.02	0.01	0.00	19.1	49.1	50.9

			TDS					Milliequivalents (mEq)														
SWN	**Estimated In situ Temp. (°F)**	**Specific Conductance (µmho/cm)**	**Meas. (#)**	**Meas. (mg/L)**	**Calc. (mg/L)**	**Meas. /Calc.**	**As NACL (mg/L)**	**Ca (+)**	**Mg (+)**	**Na (+)**	**K (+)**	**Sr (+)**	**CO_3 (-)**	**HCO_3 (-)**	**SO_4 (-)**	**Cl (-)**	**F (-)**	**NO_3 (-)**	**SiO_2**	**Total**	**Cation (%)**	**Anion (%)**
6620508	73	852	1	449	602	0.75	310	2.20	1.40	8.26			0.00	6.56	0.25	5.08	0.02	0.00	0.00	23.8	49.9	50.1
6620902	78	1020	2	547	715	0.76	400	3.64	0.82	3.48			0.00	4.92	0.29	2.85	0.01	0.00	0.00	16.0	49.6	50.4
6622203	72	255	1	161	222	0.73	93	2.77	0.92	6.13	0.06		0.00	5.01	0.29	4.63		0.01	0.00	19.8	49.9	50.1
6622701	79	550	1	301	388	0.78	208	1.83	0.12	0.58	0.03	0.00	0.00	1.96	0.06	0.47	0.01	0.04	0.00	5.1	50.2	49.8
6623205	71	522	1	299	394	0.76	199	2.69	0.35	1.91	0.04		0.00	2.79	0.15	2.14	0.01	0.01	0.00	10.1	49.5	50.5
6623701	73	356	1	161	198	0.81	144	2.54	0.42	2.00	0.02		0.00	3.02	0.14	1.86	0.01	0.02	0.00	10.0	49.7	50.3
6627905	79	898	6	535	754	0.71	338	0.80	0.16	1.57	0.23		1.00	0.00	0.96	0.87	0.01	0.00	0.00	5.6	49.3	50.7
6628402	75	453	1	257	348	0.74	165	1.13	0.59	7.17	0.69	0.02	0.00	6.81	0.24	2.38	0.02	0.00	0.00	19.0	50.4	49.6
6628503	76	981	2	512	621	0.82	404	2.94	0.35	1.09			0.00	2.94	0.17	1.16	0.02	0.01	0.00	8.7	50.5	49.5
6628508	77	--	1	443	539	0.82	344	3.99	1.15	3.74	0.08		0.00	3.51	0.47	4.91	0.02	0.00	0.00	17.9	50.2	49.8
6628602	79	522	1	254	348	0.73	181	4.19	0.82	2.74	0.06		0.00	3.10	0.44	3.95	0.01	0.00	0.00	15.3	51.0	49.0
6628607	77	850	7	511	696	0.73	346	2.35	0.49	1.96			0.00	3.02	0.25	1.52			0.00	9.6	50.0	50.0
6628805	78	504	1	293	406	0.72	181	2.43	1.32	5.37	0.10	0.03	0.00	5.89	0.49	2.79	0.01	0.00	0.00	18.4	50.1	49.9
6629302	74	420	1	237	319	0.74	152	2.15	0.52	2.22	0.06		0.00	3.62	0.20	1.16	0.01	0.01	0.00	9.9	49.7	50.3
6630103	75	619	3	337	443	0.76	235	2.54	0.35	0.96	0.04		0.00	2.64	0.16	1.18	0.01	0.01	0.00	7.9	49.2	50.8
6630203	79	379	1	222	306	0.73	136	3.76	0.49	1.46	0.03		0.00	3.36	0.24	2.23	0.01	0.02	0.00	11.6	49.5	50.5
6630208	80	360	1	191	275	0.69	108	2.25	0.33	1.09	0.04		0.00	2.69	0.15	0.82	0.01	0.01	0.00	7.4	50.2	49.8
6631105	79	500	1	265	344	0.77	181	1.59	0.18	0.98	0.01	0.01	0.00	2.68	0.12	0.63	0.01	0.02	0.00	6.2	44.5	55.5
6631203	75	365	1	210	276	0.76	136	2.94	0.30	1.09	0.04	0.00	0.00	2.54	0.19	1.64	0.01	0.07	0.00	8.8	49.6	50.4
6631906	84	567	3	319	444	0.72	202	2.40	0.20	0.78	0.02		0.00	2.10	0.10	1.18	0.01	0.01	0.00	6.8	50.0	50.0
6635207	72	630	1	360	501	0.72	223	1.26	0.57	3.76	0.05		0.04	4.00	0.35	1.20	0.01	0.00	0.00	11.3	50.1	49.9
6635303	77	567	3	319	437	0.73	210	4.19	0.40	1.48	0.03		0.00	4.56	0.17	1.44	0.01	0.00	0.00	12.3	49.7	50.3
6635304	82	877	2	714	518	1.38	366	0.89	0.35	18.31	0.15		0.01	2.67	7.98	9.24	0.05	0.01	0.00	39.7	49.7	50.3
6636103	82	977	1	547	730	0.75	368	3.03	0.64	1.81	0.05		0.00	3.74	0.23	1.65	0.01	0.00	0.00	11.2	49.5	50.5
6636604	73	995	1	555	699	0.79	406	0.70	0.16	8.83			0.00	5.88	0.02	3.84			0.00	19.4	49.9	50.1
6637402	72	1250	1	681	823	0.83	540	3.54	0.43	2.13	0.03		0.00	3.51	0.25	2.28	0.01	0.01	0.00	12.2	50.3	49.7

			TDS					Milliequivalents (mEq)														
SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	Meas. (#)	Meas. (mg/L)	Calc. (mg/L)	Meas. /Calc.	As NACL (mg/L)	Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total	Cation (%)	Anion (%)
6637607	73	462	1	258	357	0.72	165	5.49	0.70	3.31	0.03		0.00	4.61	0.35	4.51	0.01	0.01	0.00	19.0	50.1	49.9
6637701	72	1380	1	755	890	0.85	623	6.99	0.90	4.13	0.04		0.00	4.57	0.58	6.49	0.01	0.02	0.00	23.7	50.8	49.2
6638105	74	493	1	287	396	0.73	185	3.09	0.26	1.09			0.00	3.18	0.19	1.07	0.01	0.01	0.00	8.9	49.9	50.1
6638106	73	498	3	300	424	0.71	190	7.88	1.07	4.22	0.05		0.00	4.33	0.56	8.18		0.02	0.00	26.3	50.2	49.8
6638301	73	876	1	462	612	0.75	318	2.44	0.59	1.91	0.05	0.01	0.00	3.48	0.29	1.16	0.01	0.03	0.00	10.0	50.1	49.9
6640607	75	659	2	346	469	0.74	238	2.92	0.79	1.64	0.05	0.01	0.00	4.02	0.26	0.95	0.01	0.02	0.00	10.7	50.7	49.3
6642904	73	557	1	345	473	0.73	219	5.09	0.66	2.17			0.00	4.82	0.27	3.02	0.01	0.02	0.00	16.1	49.3	50.7
6643803	81	723	2	397	529	0.75	269	1.97	0.53	3.72			0.02	3.56	0.15	2.44	0.02	0.02	0.00	12.4	50.1	49.9
6644409	79	496	1	290	394	0.74	181	3.28	0.63	1.96	0.04	0.01	0.00	4.12	0.27	1.42	0.02	0.01	0.00	11.8	50.3	49.7
6644704	80	572	1	339	452	0.75	217	2.89	0.69	3.20	0.05		0.00	4.21	0.43	2.30	0.01	0.01	0.00	13.8	49.5	50.5
6646601	72	549	1	307	440	0.70	192	2.50	0.41	1.87	0.03		0.00	3.35	0.21	1.24	0.01	0.01	0.00	9.6	50.0	50.0
6647904	75	584	7	343	503	0.68	212	1.95	0.61	2.96	0.05		0.00	3.62	0.33	1.69	0.02	0.00	0.00	11.2	49.6	50.4
6650401	79	850	1	472	652	0.72	308	3.84	0.55	1.04			0.00	4.26	0.17	1.02	0.02	0.05	0.00	10.9	49.7	50.3
6650801	80	1020	1	587	775	0.76	411	4.03	1.01	1.12	0.07	0.01	0.00	5.00	0.16	1.01	0.01	0.02	0.00	12.4	50.1	49.9
6651305	81	1050	1	622	769	0.81	457	3.04	0.84	4.48			0.00	5.78	0.25	2.43	0.03	0.01	0.00	16.9	49.6	50.4
6651810	82	1099	1	637	818	0.78	467	3.44	0.99	5.87	0.06		0.00	6.04	0.33	4.12	0.03	0.00	0.00	20.9	49.6	50.4
6652407	81	786	5	440	589	0.75	297	2.00	0.64	7.83	0.06		0.00	4.76	1.54	4.29	0.05	0.00	0.00	21.2	49.8	50.2
6652801	77	843	2	453	567	0.80	339	4.74	1.65	4.74	0.11	0.03	0.00	5.82	0.81	4.65	0.02		0.00	22.6	49.9	50.1
6654511	85	626	7	357	483	0.74	239	1.80	0.78	5.09	0.07		0.01	4.71	0.59	2.38	0.02	0.00	0.00	15.4	50.1	49.9
6654906	77	518	2	314	439	0.72	196	3.27	1.07	3.48			0.00	3.65	0.48	3.78	0.01	0.00	0.00	15.7	49.7	50.3
6658402	78	--	1	344	468	0.73	228	2.31	0.93	2.84	0.06	0.01	0.00	4.02	0.27	1.99	0.02	0.04	0.00	12.5	49.2	50.8
6658903	78	978	1	514	689	0.75	354	3.08	0.89	1.37	0.06	0.01	0.00	4.02	0.19	1.11	0.02	0.05	0.00	10.8	50.1	49.9
6659501	77	832	1	425	574	0.74	290	3.49	0.58	2.09			0.00	4.00	0.25	1.69	0.01		0.00	12.1	50.8	49.2
6660201	77	485	2	287	396	0.72	177	2.74	1.32	5.31			0.00	5.64	0.25	3.24	0.02	0.01	0.00	18.5	50.5	49.5
6660401	73	1582	8	861	1034	0.83	704	3.09	1.32	3.13	0.06		0.00	4.79	0.50	2.28	0.02	0.00	0.00	15.2	50.0	50.0
6660703	75	925	1	538	710	0.76	376	2.62	0.49	1.63	0.04		0.00	3.52	0.26	1.07	0.01	0.01	0.00	9.7	49.5	50.5

SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	TDS Meas. (#)	Meas. (mg/L)	Calc. (mg/L)	Meas. /Calc.	As NACL (mg/L)	Milliequivalents (mEq) Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total	Cation (%)	Anion (%)
6660902	91	--	2	727	916	0.79	520	6.88	2.31	5.93	0.07	0.03	0.00	5.54	1.22	8.61	0.02	0.02	0.00	30.6	49.7	50.3
6660907	85	686	5	398	536	0.74	260	2.54	1.23	5.61	0.08		0.00	5.51	0.71	3.39	0.02	0.00	0.00	19.1	49.6	50.4
6661702	74	822	1	492	663	0.74	339	0.72	0.49	11.27			0.00	6.05	1.30	5.12	0.08	0.01	0.00	25.0	49.8	50.2
6661806	76	868	1	514	685	0.75	360	0.52	0.41	5.99	0.05	0.01	0.00	4.45	0.25	2.24	0.03	0.00	0.00	13.9	50.0	50.0
6662313	77	610	3	357	491	0.73	235	4.69	1.48	2.65			0.00	5.48	0.42	2.88	0.02	0.02	0.00	17.6	50.0	50.0
6724602	75	1041	2	627	808	0.78	390	5.14	1.56	2.48	0.09	0.01	0.00	5.50	0.37	3.19	0.02		0.00	18.4	50.6	49.4
6762307	84	1212	6	699	907	0.77	487	3.56	1.01	1.58	0.07	0.01	0.00	4.31	0.27	1.68	0.01	0.03	0.00	12.5	49.7	50.3
7808603	73	2176	2	1178	1333	0.88	960	1.47	0.19	7.76	0.36		0.00	5.60	1.12	2.92	0.02	0.02	0.00	19.5	50.2	49.8
7808903	138	4560	1	2760	4036	0.68	1612	0.66	0.32	11.19	0.07	0.01	0.00	6.57	0.78	4.84	0.05	0.02	0.00	24.5	50.0	50.0
7816201	74	3262	4	1775	1894	0.94	1608	7.41	1.28	9.85	0.55	0.03	0.00	4.96	3.54	10.59	0.04	0.10	0.00	38.4	49.8	50.2
7816401	76	3270	1	2074	2295	0.90	1749	0.11	0.13	50.02	0.31		0.00	41.15	0.00	10.16		0.01	0.00	101.9	49.6	50.4
7816601	162	1810	1	1146	1653	0.69	655	10.87	2.52	14.97	0.72	0.05	0.00	3.57	1.50	24.16	0.08	0.44	0.00	58.9	49.5	50.5
7816615	76	1490	1	957	1119	0.86	687	11.58	1.40	21.44			0.00	7.12	9.23	18.05		0.00	0.00	68.8	50.0	50.0
7816803	79	2230	1	1765	1931	0.91	1536	0.15	0.08	19.75	0.17		0.00	16.35	0.65	3.05	0.13	0.00	0.00	40.3	50.0	50.0
7823502	156	1713	3	1012	1463	0.69	586	2.59	0.20	11.22	0.61		0.00	5.20	2.56	6.52	0.04	0.35	0.00	29.3	49.9	50.1
7827903	ND	4749	5	4749	5499	0.86	ND	1.30	0.03	28.62			0.00	5.36	0.00	24.54		0.03	0.00	59.9	50.0	50.0
7832303	73	1185	1	628	782	0.80	455	0.18	0.12	17.50	0.11		0.16	14.53	0.25	3.09	0.06	0.00	0.00	36.0	49.7	50.3
7839801	76	1575	4	957	1088	0.88	790	0.20	0.15	81.66	0.19	0.02	0.26	24.19	6.04	51.36	0.17	0.01	0.00	164.2	50.1	49.9
7840302	73	1505	2	926	1089	0.85	700	3.49	0.49	6.13	0.38		0.00	4.94	1.17	4.40	0.04	0.01	0.00	21.1	49.9	50.1
7847801	81	1520	1	859	996	0.86	684	7.32	1.50	6.49	0.35	0.03	0.00	4.24	2.40	9.15	0.02	0.15	0.00	31.6	49.6	50.4
7847903	76	1535	1	870	1039	0.84	691	4.84	1.88	8.13	0.15	0.02	0.00	5.28	1.12	7.74	0.03	0.83	0.00	30.0	50.0	50.0
7852908	75	2573	5	1698	1853	0.92	1417	2.54	0.90	10.96			0.00	4.38	2.33	7.56		0.04	0.00	28.7	50.2	49.8
7854202	81	3562	1	1856	2091	0.89	1489	2.30	1.07	11.66	0.21	0.02	0.00	5.44	0.06	9.62	0.05	0.00	0.00	30.4	50.1	49.9
7855701	81	4070	1	2294	2424	0.95	2129	2.51	1.29	22.37	0.81	0.02	0.00	5.01	5.38	16.52	0.06	0.51	0.00	54.5	49.5	50.5
7856701	78	1650	1	948	1135	0.83	730	2.00	0.41	27.40			0.00	7.58	1.35	21.44	0.05	0.26	0.00	60.5	49.3	50.7
7864102	79	1877	3	1151	1301	0.88	974	7.19	4.03	27.66			0.00	4.17	5.60	29.34		0.06	0.00	78.1	49.8	50.2

SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	TDS Meas. (#)	Meas. (mg/L)	Calc. (mg/L)	Meas. /Calc.	As NACL (mg/L)	Milliequivalents (mEq) Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total	Cation (%)	Anion (%)
7864301	76	2835	4	1344	1503	0.89	1211	0.43	0.99	14.70	0.28		0.67	6.02	2.85	6.54		0.05	0.00	32.5	50.4	49.6
7864803	80	1468	1	832	1006	0.83	621	4.02	2.01	13.40	0.27	0.03	0.00	4.82	1.33	13.15	0.07	0.22	0.00	39.3	50.2	49.8
7903707	74	1519	3	792	940	0.84	653	6.47	4.24	12.60	0.40		0.02	4.88	0.98	17.93	0.10	0.09	0.00	47.7	49.7	50.3
7905101	87	1010	1	607	782	0.78	418	2.02	1.20	10.74	0.18	0.02	0.00	5.60	2.27	5.64	0.03	0.19	0.00	27.9	50.8	49.2
7905605	73	815	1	532	718	0.74	351	5.79	2.41	5.71	0.23	0.05	0.00	4.61	0.47	8.56	0.03	0.09	0.00	28.0	50.8	49.2
7905901	77	1050	1	593	745	0.80	443	1.90	0.44	7.66	0.28		0.00	5.61	1.56	3.13	0.01	0.00	0.00	20.6	49.9	50.1
7907903	80	1098	2	873	1053	0.83	690	4.79	0.82	3.83	0.08	0.01	0.00	5.96	0.40	2.54	0.02	0.07	0.00	18.5	51.5	48.5
7907904	75	765	3	434	606	0.72	282	4.79	1.56	4.00			0.00	4.87	0.71	4.74		0.01	0.00	20.7	50.1	49.9
7908503	72	591	2	391	537	0.73	247	3.31	0.41	11.90	0.05	0.02	0.00	5.70	0.49	8.87	0.08	0.01	0.00	30.8	50.9	49.1
7909304	77	3920	1	2382	2571	0.93	2079	2.53	1.06	4.00	0.07	0.02	0.00	5.53	0.16	2.21	0.02	0.00	0.00	15.6	49.2	50.8
7910408	79	1920	4	1223	1434	0.85	940	4.77	0.59	1.23	0.03	0.00	0.00	4.69	0.25	1.60	0.01	0.08	0.00	13.2	49.9	50.1
7911901	81	1200	5	685	887	0.77	477	7.58	1.32	29.62	0.87		0.00	6.08	6.44	26.52	0.04	0.10	0.00	78.6	50.1	49.9
7911902	81	1230	1	732	919	0.80	528	2.83	0.50	16.00	0.57	0.02	0.00	6.78	2.32	10.95	0.07	0.11	0.00	40.2	49.6	50.4
7912601	82	905	1	544	749	0.73	357	1.92	0.89	8.79	0.22	0.03	0.00	6.35	1.71	3.70	0.04	0.02	0.00	23.7	50.0	50.0
7912804	83	994	1	587	756	0.78	403	1.95	1.15	9.13	0.24		0.00	6.02	1.92	4.57	0.03	0.02	0.00	25.0	49.8	50.2
7912901	83	1050	1	632	836	0.76	413	2.05	1.65	6.18			0.00	6.57	0.69	2.43		0.04	0.00	19.6	50.4	49.6
7913105	81	1290	1	736	895	0.82	551	0.85	0.62	8.57			0.00	5.44	1.56	2.99	0.05	0.01	0.00	20.1	50.0	50.0
7913202	73	1068	7	590	767	0.77	419	0.46	0.30	10.05			0.00	6.57	1.85	2.31	0.06	0.00	0.00	21.6	50.0	50.0
7913703	75	1536	2	764	925	0.83	616	0.70	0.50	11.35			0.00	5.13	1.62	5.78		0.00	0.00	25.1	50.0	50.0
7913801	82	974	1	563	780	0.72	360	4.34	1.58	4.30	0.09	0.01	0.00	5.60	0.89	3.74	0.03	0.06	0.00	20.6	50.0	50.0
7914602	77	1537	2	849	1031	0.82	648	5.71	2.76	5.07			0.06	5.17	0.85	7.53	0.03	0.04	0.00	27.2	49.7	50.3
7915501	73	1039	2	606	792	0.76	416	0.75	0.55	8.79			0.00	6.97	0.15	2.96		0.01	0.00	20.2	50.0	50.0
7916903	80	1030	1	581	770	0.75	398	6.59	2.18	5.59			0.00	5.85	1.09	6.67	0.03	0.89	0.00	28.9	49.7	50.3
7916904	81	1120	1	617	809	0.76	427	5.14	1.36	3.87	0.07	0.01	0.00	5.97	0.54	3.75	0.03	0.03	0.00	20.8	50.3	49.7
7916906	78	1060	1	593	794	0.75	400	1.55	0.66	8.13			0.00	6.10	0.29	3.95			0.00	20.7	50.0	50.0
7918501	86	2816	1	1410	1657	0.85	1102	1.10	0.49	9.35			0.00	6.20	0.37	4.34			0.00	21.9	50.0	50.0

			TDS					Milliequivalents (mEq)														
SWN	**Estimated In situ Temp. (°F)**	**Specific Conductance (µmho/cm)**	**Meas. (#)**	**Meas. (mg/L)**	**Calc. (mg/L)**	**Meas. /Calc.**	**As NACL (mg/L)**	**Ca (+)**	**Mg (+)**	**Na (+)**	**K (+)**	**Sr (+)**	**CO_3 (-)**	**HCO_3 (-)**	**SO_4 (-)**	**Cl (-)**	**F (-)**	**NO_3 (-)**	**SiO_2**	**Total**	**Cation (%)**	**Anion (%)**
7918503	85	2530	1	1493	1735	0.86	1172	0.65	0.41	9.57			0.00	6.48	0.00	4.17			0.00	21.3	49.9	50.1
7918604	86	2530	1	1493	1735	0.86	1173	0.65	0.33	22.62			0.00	7.94	3.56	12.61	0.08	0.01	0.00	47.8	49.4	50.6
7918901	73	2277	1	1093	1237	0.88	941	0.75	0.33	23.62	0.23		0.00	7.79	4.56	12.69	0.05	0.00	0.00	50.0	49.8	50.2
7919101	74	1593	2	934	1080	0.86	779	0.75	0.33	24.01			0.00	7.79	4.56	12.69	0.05	0.00	0.00	50.2	50.0	50.0
7919301	76	1210	1	697	904	0.77	486	9.03	2.71	6.83			0.00	4.61	2.23	12.02	0.03	0.03	0.00	37.5	49.6	50.4
7919304	77	1220	1	711	934	0.76	488	5.51	1.62	9.03	0.14	0.02	0.00	4.67	0.84	10.41	0.05	0.07	0.00	32.4	50.4	49.6
7919501	82	2540	1	1489	1676	0.89	1255	2.40	1.23	8.53			0.00	6.66	1.10	4.29	0.04	0.06	0.00	24.3	50.0	50.0
7919602	83	2280	1	1290	1465	0.88	1056	2.30	1.40	8.74			0.00	7.15	1.40	3.86		0.02	0.00	24.9	50.0	50.0
7919705	76	2560	1	1488	1610	0.92	1349	4.49	2.39	18.40			0.00	6.02	4.29	14.95		0.00	0.00	50.5	50.0	50.0
7920401	77	1130	1	669	891	0.75	450	2.00	0.79	18.83			0.00	5.62	2.77	13.20		0.04	0.00	43.3	50.0	50.0
7920501	80	1030	1	598	800	0.75	396	10.83	4.11	10.40			0.00	3.92	4.96	16.42	0.02	0.04	0.00	50.7	50.0	50.0
7920505	80	937	1	542	733	0.74	357	2.05	1.65	8.05			0.00	7.13	1.54	3.05		0.00	0.00	23.5	50.0	50.0
7920603	73	1551	2	1081	1233	0.88	923	1.20	0.99	8.26			0.00	6.51	1.10	2.85		0.00	0.00	20.9	50.0	50.0
7920801	77	2160	1	1172	1305	0.90	1054	0.60	0.82	8.09			0.20	6.16	0.56	2.79		0.01	0.00	19.2	49.4	50.6
7920901	80	1040	1	604	808	0.75	401	9.51	3.24	5.68	0.11	0.03	0.00	4.92	1.73	11.92	0.04	0.05	0.00	37.2	49.9	50.1
7921202	75	619	1	434	606	0.72	258	8.88	4.28	7.39			0.00	4.26	1.60	14.61		0.09	0.00	41.1	50.0	50.0
7921502	76	1310	1	694	841	0.83	566	1.10	0.99	8.48			0.00	6.56	1.17	2.85		0.00	0.00	21.1	50.0	50.0
7921701	82	1000	1	581	792	0.73	371	4.34	1.07	1.87	0.06	0.01	0.00	5.54	0.27	1.18	0.03	0.05	0.00	14.4	50.9	49.1
7921911	76	991	1	728	910	0.80	547	4.89	2.06	5.57			0.00	4.72	0.77	7.00	0.03	0.01	0.00	25.0	50.0	50.0
7922404	74	924	1	506	690	0.73	336	0.60	0.50	9.05			0.00	6.80	1.08	2.28		0.00	0.00	20.3	49.9	50.1
7922502	74	1034	2	593	771	0.77	409	4.63	2.57	5.74	0.10	0.03	0.00	5.88	1.35	5.16	0.03	0.09	0.00	25.6	51.1	48.9
7923103	75	1400	1	741	923	0.80	563	4.44	1.32	3.13			0.00	5.90	0.37	2.68	0.03	0.01	0.00	17.9	49.7	50.3
7923408	79	1071	1	674	868	0.78	490	4.99	1.60	3.55			0.00	5.72	0.58	3.79	0.04	0.02	0.00	20.3	50.0	50.0
7925602	85	2138	2	1169	1458	0.80	859	3.74	2.39	6.87			0.08	5.86	1.62	5.56	0.03	0.01	0.00	26.2	49.7	50.3
7926102	74	3423	3	1658	1806	0.92	1536	3.84	2.14	5.92	0.15	0.04	0.00	6.24	1.27	4.29	0.03	0.00	0.00	23.9	50.5	49.5
7926204	77	1940	1	1114	1290	0.86	946	0.31	0.09	20.10			0.00	9.31	0.49	10.66	0.07	0.00	0.00	41.0	50.0	50.0

SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	TDS Meas. (#)	Meas. (mg/L)	Calc. (mg/L)	Meas. /Calc.	As NACL (mg/L)	Milliequivalents (mEq) Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total	Cation (%)	Anion (%)
7926205	78	2244	1	1090	1257	0.87	910	10.38	3.95	14.35	0.23		0.00	4.58	2.32	22.18	0.04	0.13	0.00	58.2	49.7	50.3
7926207	79	2513	3	1313	1468	0.89	1139	9.08	2.55	7.22	0.59		0.00	5.64	1.69	12.07	0.03	0.02	0.00	38.9	50.0	50.0
7926801	73	3144	2	1437	1557	0.92	1346	1.70	0.90	16.22			0.00	5.38	0.15	13.68	0.03	0.01	0.00	38.1	49.5	50.5
7927302	76	1390	1	764	903	0.85	633	1.62	0.84	19.76	0.13	0.04	0.00	4.98	0.02	18.01	0.08	0.00	0.00	45.5	49.2	50.8
7927303	76	1580	1	873	1036	0.84	728	11.03	4.28	9.66	0.23		0.00	3.73	1.41	19.93	0.03	0.18	0.00	50.5	49.9	50.1
7928501	74	1505	7	859	1057	0.81	626	4.09	2.80	6.66			0.00	4.48	1.17	7.90		0.00	0.00	27.1	50.0	50.0
7928706	74	1760	2	881	1057	0.83	709	7.53	3.13	4.92			0.00	5.23	1.04	9.25	0.05	0.00	0.00	31.2	50.0	50.0
7928717	77	1060	1	635	722	0.88	491	5.84	1.45	6.41	0.40	0.01	0.09	6.05	1.59	6.25	0.04	0.16	0.00	28.3	49.9	50.1
7932602	78	1999	2	1052	1237	0.85	849	7.41	2.47	5.44	0.10		0.00	5.60	1.68	8.07	0.04	0.01	0.00	30.8	50.0	50.0
7933302	76	1356	1	714	884	0.81	520	2.20	2.39	5.39			0.00	2.80	1.58	5.59		0.03	0.00	20.0	49.9	50.1
7933906	75	2277	1	1093	1221	0.90	961	0.58	0.56	17.14	0.07		0.00	5.91	0.18	12.30	0.03	0.02	0.00	36.8	49.9	50.1
7934405	73	1066	2	612	770	0.79	405	4.14	1.89	5.96			0.00	5.46	1.42	5.02	0.05	0.06	0.00	24.0	50.0	50.0
7934601	78	1470	1	747	915	0.82	571	9.08	2.88	6.87			0.00	4.10	1.98	12.58	0.03	0.11	0.00	37.6	50.0	50.0
7934903	100	2037	3	1169	1422	0.82	898	3.72	0.90	4.92			0.00	5.07	0.57	3.67	0.03	0.40	0.00	19.3	49.5	50.5
7935401	76	1584	1	811	972	0.83	622	2.10	1.07	9.83			0.00	5.40	0.96	6.69	0.04	0.01	0.00	26.1	49.8	50.2
7935701	101	2310	1	1346	1652	0.81	1016	1.27	0.39	18.67	0.15	0.01	0.00	8.15	0.46	11.83	0.09	0.00	0.00	41.0	50.0	50.0
7935702	101	3441	1	1795	2108	0.85	1443	5.04	2.55	6.00			0.00	5.16	1.48	6.91	0.05	0.05	0.00	27.2	49.9	50.1
7935706	99	2720	1	1972	1338	1.47	1234	0.80	1.32	20.97			0.00	8.42	6.52	7.70	0.18	0.01	0.00	45.9	50.3	49.7
7936901	87	1720	2	919	1036	0.89	783	0.35	0.11	23.53			0.00	9.86	0.02	13.54	0.09		0.00	47.5	50.5	49.5
7937204	77	1320	1	738	922	0.80	560	0.56	0.20	30.43	0.13		0.64	10.10	0.08	20.56	0.08	0.00	0.00	62.8	49.9	50.1
7937906	83	1110	1	677	898	0.75	458	0.80	0.37	14.77			0.00	3.53	0.80	11.44	0.05	0.01	0.00	31.8	50.2	49.8
7938406	77	1690	1	971	1149	0.84	787	3.14	2.47	7.53			0.00	5.92	0.79	6.32		0.09	0.00	26.3	50.0	50.0
7941301	81	1680	1	853	1002	0.85	675	5.14	2.47	5.26			0.00	6.31	0.62	5.87		0.06	0.00	25.7	50.0	50.0
7942103	77	1936	1	959	1096	0.88	804	1.20	1.15	9.26			0.57	7.10	1.23	3.24	0.02	0.01	0.00	23.8	48.8	51.2
7942604	75	2211	1	1083	1224	0.88	913	5.69	3.29	7.92			0.00	5.74	1.73	9.42		0.01	0.00	33.8	50.0	50.0
7943102	81	1114	5	605	765	0.79	429	6.64	2.14	5.52			0.00	4.79	1.52	7.87	0.04	0.06	0.00	28.6	50.0	50.0

			TDS					Milliequivalents (mEq)														
SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	Meas. (#)	Meas. (mg/L)	Calc. (mg/L)	Meas. /Calc.	As NACL (mg/L)	Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total	Cation (%)	Anion (%)
7943305	82	1260	1	641	815	0.79	469	8.03	2.71	5.31			0.00	4.39	1.58	10.30	0.05	0.11	0.00	32.5	49.4	50.6
7943401	82	2022	2	978	1106	0.88	846	7.34	2.71	8.05			0.00	4.53	1.73	11.96	0.05	0.13	0.00	36.5	49.6	50.4
7943702	73	1422	1	788	977	0.81	548	0.75	0.38	9.15	0.08		0.03	5.11	1.08	4.14	0.02	0.00	0.00	20.7	50.0	50.0
7943704	73	1661	1	880	1077	0.82	639	2.05	1.48	7.74			0.00	5.61	0.85	4.88	0.03	0.01	0.00	22.7	49.8	50.2
7945101	76	1495	1	985	1176	0.84	773	5.59	2.02	9.07	0.15		0.00	4.03	0.95	11.96	0.04	0.05	0.00	33.9	49.7	50.3
7945203	74	1837	1	896	1057	0.85	731	4.24	1.73	6.92			0.00	6.08	0.73	5.50	0.05	0.37	0.00	25.6	50.3	49.7
7946611	81	1624	2	920	1104	0.83	704	5.19	1.40	7.74			0.00	6.34	1.00	6.88	0.06	0.44	0.00	29.1	49.3	50.7
7946612	82	1574	4	930	1127	0.82	705	4.44	2.39	10.61	0.18	0.05	0.00	6.16	2.98	7.11	0.03	0.05	0.00	34.0	52.0	48.0
7949803	76	1190	1	603	766	0.79	420	2.74	2.30	10.74			0.00	5.18	1.44	9.03	0.05	0.01	0.00	31.5	50.1	49.9
7950304	78	1386	1	730	894	0.82	542	0.40	0.34	14.96	0.08	0.02	0.04	5.92	1.68	8.00	0.07	0.00	0.00	31.5	50.1	49.9
7950503	75	3280	1	1487	1592	0.93	1428	0.22	0.18	15.41	0.05	0.01	0.03	6.36	1.14	8.57	0.08	0.00	0.00	32.1	49.5	50.5
7950907	78	--	2	1082	1247	0.87	921	0.55	0.74	8.92			0.03	5.25	0.92	4.03		0.05	0.00	20.5	49.8	50.2
7951105	74	1589	4	904	1079	0.84	686	2.59	0.90	8.96			0.00	5.30	1.40	5.61	0.05	0.01	0.00	24.8	50.2	49.8
7951603	75	2299	1	1109	1249	0.89	958	13.17	5.02	7.92			0.00	3.39	1.92	21.16	0.04	0.01	0.00	52.6	49.6	50.4
7952407	75	2495	2	1382	1509	0.92	1259	5.17	1.90	11.99			0.00	5.28	1.24	12.52			0.00	38.1	50.0	50.0
7956203	90	2170	1	1252	1494	0.84	969	5.46	1.90	7.49	0.14	0.02	0.00	5.60	1.38	7.77	0.06	0.10	0.00	29.9	50.2	49.8
7959101	78	--	2	1165	1336	0.87	1008	7.58	3.70	7.70			0.00	4.53	1.54	13.00	0.05	0.01	0.00	38.1	49.8	50.2
7959102	78	--	1	1193	1360	0.88	1041	8.33	4.49	10.74	0.16	0.06	0.00	4.09	0.85	19.10	0.05	0.03	0.00	47.9	49.7	50.3
7959303	75	1310	1	784	951	0.82	599	0.40	0.21	21.14	0.05		0.00	7.80	1.75	11.71	0.19	0.00	0.00	43.3	50.4	49.6
7959501	75	1450	1	846	1013	0.84	663	5.31	1.99	13.43			0.00	5.50	0.55	14.70			0.00	41.5	50.0	50.0
7960106	77	1360	1	799	976	0.82	607	4.14	1.48	15.66			0.00	5.36	0.62	15.29			0.00	42.6	50.0	50.0
7960212	76	1088	3	651	851	0.76	448	3.79	1.65	8.00			0.00	5.38	1.08	6.91	0.06	0.00	0.00	26.9	50.0	50.0
7960401	77	1305	1	690	866	0.80	508	3.84	1.73	9.00			0.00	5.38	1.23	7.90	0.02	0.02	0.00	29.1	50.0	50.0
7960503	76	1380	1	726	910	0.80	524	3.49	1.81	8.48			0.00	5.71	1.19	6.83	0.04	0.00	0.00	27.5	50.0	50.0
7960604	80	1770	1	990	1197	0.83	756	2.19	1.31	7.76	0.09	0.02	0.00	6.39	1.62	3.22	0.04	0.00	0.00	22.6	50.2	49.8
7960614	79	1674	2	968	1152	0.84	755	2.64	1.56	7.70			0.00	5.66	1.17	5.22	0.05	0.01	0.00	24.0	49.6	50.4

SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	TDS Meas. (#)	TDS Meas. (mg/L)	TDS Calc. (mg/L)	TDS Meas. /Calc.	TDS As NACL (mg/L)	Milliequivalents (mEq) Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total	Cation (%)	Anion (%)
7960616	77	1334	2	755	926	0.82	560	1.45	0.74	10.18	0.08		0.00	5.90	1.71	4.80	0.04	0.00	0.00	24.9	50.0	50.0
7960801	76	1270	1	753	961	0.78	529	0.23	0.05	16.75	0.03		0.00	6.64	0.54	10.01	0.05	0.00	0.00	34.3	49.7	50.3
7961605	78	1850	1	1036	1227	0.84	825	0.93	0.07	15.89	0.03	0.01	0.12	5.94	0.68	9.77	0.06	0.01	0.00	33.5	50.5	49.5
7961902	76	2203	2	1156	1370	0.84	918	0.65	0.51	11.61	0.05	0.02	0.00	5.51	1.41	6.04	0.04	0.00	0.00	25.8	49.7	50.3
7962707	77	2073	4	1168	1323	0.88	986	0.42	0.34	12.31			0.13	6.69	1.25	4.94	0.05	0.00	0.00	26.1	50.0	50.0
7964307	74	2352	1	1269	1433	0.89	1104	0.25	0.17	18.05				6.16	0.00	11.71	0.11	0.00	0.00	36.5	50.7	49.3
8003202	79	978	1	565	741	0.76	400	0.36	0.26	19.51			0.00	6.88	0.17	13.12	0.11	0.01	0.00	40.4	49.8	50.2
8003803	78	1234	2	646	826	0.78	472	0.36	0.20	19.68	0.09	0.01	0.04	5.00	0.03	15.03	0.10	0.00	0.00	40.6	50.2	49.8
8004403	77	1168	2	609	797	0.76	429	2.69	2.88	16.31	0.46		0.00	5.28	0.54	16.36	0.02	0.01	0.00	44.6	50.2	49.8
8004710	75	1348	3	773	937	0.82	608	1.80	1.07	7.09	0.08		0.00	5.64	0.06	4.49	0.02	0.00	0.00	20.2	49.6	50.4
8005507	78	776	1	443	610	0.73	295	0.96	0.94	9.74			0.12	5.77	0.06	5.56	0.03	0.00	0.00	23.2	50.2	49.8
8006703	75	660	2	377	534	0.71	241	1.11	0.73	9.05	0.05		0.00	6.01	0.08	4.77	0.03	0.00	0.00	21.8	50.1	49.9
8006704	74	900	1	543	727	0.75	375	1.34	0.81	11.05	0.05	0.01	0.00	5.18	0.08	8.68	0.03	0.00	0.00	27.2	48.7	51.3
8007203	75	956	3	496	659	0.75	353	2.99	1.56	3.31	0.07		0.00	5.38	0.37	2.26	0.03	0.00	0.00	16.0	49.7	50.3
8007206	74	1170	1	600	783	0.77	437	2.15	1.56	3.18			0.00	5.04	0.37	1.38	0.02	0.00	0.00	13.7	50.2	49.8
8007313	75	702	1	397	546	0.73	263	2.89	2.06	4.78			0.00	5.90	1.06	2.76	0.03	0.00	0.00	19.5	49.9	50.1
8009105	79	849	1	492	682	0.72	321	3.61	1.92	3.35	0.08		0.00	5.18	0.48	3.30	0.02	0.00	0.00	17.9	49.9	50.1
8009409	83	986	1	531	720	0.74	357	4.04	1.89	5.05			0.00	5.90	0.52	4.34	0.03	0.01	0.00	21.8	50.4	49.6
8009506	77	821	1	449	637	0.70	282	3.25	1.46	2.30	0.07	0.01	0.00	4.78	0.30	1.95	0.01	0.00	0.00	14.1	50.1	49.9
8011103	73	1090	1	600	785	0.76	427	2.00	0.99	5.79	0.07		0.00	6.13	0.11	2.68		0.01	0.00	17.8	49.8	50.2
8012303	72	2512	1	1186	1373	0.86	1036	1.05	0.72	7.84			0.00	6.08	0.02	3.50	0.02	0.00	0.00	19.2	50.0	50.0
8012305	72	1595	1	793	989	0.80	619	2.26	1.18	4.35	0.06	0.02	0.00	6.06	0.02	2.15	0.01	0.00	0.00	16.1	48.8	51.2
8017503	83	1265	2	722	937	0.77	519	1.50	0.99	8.35			0.00	5.94	0.00	4.88	0.02	0.01	0.00	21.7	50.0	50.0
8017504	83	--	1	700	915	0.77	497	7.58	5.59	8.00			0.00	6.00	1.67	13.99	0.02	0.00	0.00	42.9	49.4	50.6
8017506	76	1050	1	591	789	0.75	408	5.19	3.37	5.57	0.00		0.00	6.28	1.23	6.94	0.02	0.00	0.00	28.6	49.4	50.6
8017905	84	1418	4	838	1019	0.82	644	1.25	1.19	10.44	0.11	0.04	0.00	6.83	0.36	5.73	0.03		0.00	26.0	50.2	49.8

			TDS					Milliequivalents (mEq)														
SWN	**Estimated In situ Temp. (°F)**	**Specific Conductance (µmho/cm)**	**Meas. (#)**	**Meas. (mg/L)**	**Calc. (mg/L)**	**Meas. /Calc.**	**As NACL (mg/L)**	**Ca (+)**	**Mg (+)**	**Na (+)**	**K (+)**	**Sr (+)**	**CO_3 (-)**	**HCO_3 (-)**	**SO_4 (-)**	**Cl (-)**	**F (-)**	**NO_3 (-)**	**SiO_2**	**Total**	**Cation (%)**	**Anion (%)**
8018401	75	2052	1	999	1183	0.84	832	1.30	1.23	10.13			0.00	6.92	0.48	5.16			0.00	25.2	50.2	49.8
8018501	86	1611	3	909	1102	0.82	709	1.65	0.99	8.05			0.00	6.36	0.02	4.29			0.00	21.4	50.0	50.0
8018503	85	1460	1	804	1006	0.80	596	1.25	1.11	12.20	0.11	0.05	0.06	5.78	1.23	7.40	0.02	0.00	0.00	29.2	50.4	49.6
8019503	75	1294	5	678	884	0.77	480	7.78	2.63	7.31			0.00	5.92	1.17	10.75	0.02	0.01	0.00	35.6	49.8	50.2
8019802	74	1892	4	956	1155	0.83	759	1.08	1.05	13.57	0.08	0.04	0.00	6.21	0.13	9.79	0.02	0.00	0.00	32.0	49.5	50.5
8020803	75	3822	1	1857	2088	0.89	1610	0.80	0.67	12.74			0.00	6.53	0.01	7.67	0.03	0.01	0.00	28.4	49.9	50.1
8021217	77	1206	2	734	922	0.80	536	1.52	0.81	9.72	0.05		0.06	6.61	0.06	5.40	0.05	0.00	0.00	24.3	49.8	50.2
8021601	78	868	4	482	660	0.73	310	2.72	1.44	12.71	0.10		0.06	6.35	0.21	10.35	0.04	0.00	0.00	34.0	49.9	50.1
8023202	71	715	1	453	636	0.71	277	1.75	1.56	29.75	0.08		0.00	7.44	0.06	24.65	0.12	0.00	0.00	65.4	50.7	49.3
8023404	79	--	3	441	604	0.73	277	0.29	0.25	11.96	0.05	0.01	0.08	6.03	0.30	6.63	0.07	0.00	0.00	25.7	48.9	51.1
8025301	84	1500	1	851	1039	0.82	644	0.45	0.31	7.66	0.03		0.05	5.73	0.31	2.48	0.05	0.00	0.00	17.1	49.5	50.5
8026103	86	1570	1	848	1027	0.83	653	0.38	0.26	7.48	0.04	0.00	0.00	5.90	0.48	1.40	0.12	0.01	0.00	16.1	50.8	49.2
8026501	74	2548	1	1213	1371	0.88	1074	0.30	0.27	7.09			0.20	5.24	0.38	1.83	0.02	0.00	0.00	15.3	50.0	50.0
8026903	84	2280	1	1306	1484	0.88	1147	1.05	0.82	12.74	0.09		0.00	6.02	1.54	7.11	0.02	0.01	0.00	29.4	50.0	50.0
8027603	75	2400	1	1347	1556	0.87	1131	0.40	0.30	14.14			0.00	5.74	0.54	8.46	0.06	0.02	0.00	29.7	50.0	50.0
8033610	83	1601	4	875	1084	0.81	655	5.99	2.63	12.88			0.00	5.08	0.21	16.36	0.02	0.01	0.00	43.2	49.8	50.2
8042106	75	1840	1	1102	1314	0.84	856	8.53	4.11	10.48			0.00	5.72	3.35	14.05		0.02	0.00	46.3	50.0	50.0
8045201	ND	5806	1	5806	5972	0.97	ND	2.45	1.97	19.31			0.00	6.71	0.52	16.50		0.01	0.00	47.5	50.0	50.0
8101101	79	570	15	306	457	0.67	190	0.44	0.36	14.20	0.05	0.02	0.00	6.66	0.08	8.79	0.13	0.00	0.00	30.7	49.0	51.0
8101201	83	563	6	322	452	0.71	197	2.25	1.81	14.31	0.23	0.02	0.00	6.82	3.50	8.58	0.06	0.00	0.00	37.6	49.5	50.5
8102901	74	1590	5	818	968	0.85	654	4.04	3.78	92.65			0.00	5.35	0.08	95.06			0.00	201.0	50.0	50.0
8105302	73	1363	4	786	1046	0.75	545	1.73	1.05	2.92	0.05	0.02	0.01	4.39	0.32	0.96	0.02	0.01	0.00	11.5	50.3	49.7
8105320	73	1250	1	715	1007	0.71	465	0.59	0.36	4.62	0.04	0.01	0.00	4.19	0.28	1.18	0.02	0.00	0.00	11.3	49.8	50.2
8109905	76	646	1	625	902	0.69	375	0.74	0.52	13.03	0.06	0.01	0.00	4.78	0.10	9.31	0.07	0.00	0.00	28.6	50.2	49.8
8301508	82	2400	1	1111	1331	0.83	828	2.08	1.67	10.44	0.07	0.01	0.00	8.40	0.37	5.40	0.02	0.00	0.00	28.5	50.1	49.9
8301509	82	1552	7	853	1067	0.80	612	2.94	1.56	8.74			0.00	9.40	0.00	3.84			0.00	26.5	50.0	50.0

			TDS					Milliequivalents (mEq)														
SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	Meas. (#)	Meas. (mg/L)	Calc. (mg/L)	Meas. /Calc.	As NACL (mg/L)	Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total	Cation (%)	Anion (%)
8301514	81	1531	2	908	1115	0.81	663	0.50	0.33	10.22			0.00	8.92	0.10	2.48			0.00	22.6	49.0	51.0
8301706	77	2093	1	1048	1225	0.86	851	1.20	0.79	16.53	0.24	0.03	0.00	7.12	3.96	6.97	0.04	0.18	0.00	37.0	50.7	49.3
8301901	76	3608	9	1965	2282	0.86	1633	1.45	0.91	11.84	0.20	0.02	0.05	6.78	2.16	5.26	0.04	0.25	0.00	29.0	49.8	50.2
8302306	75	2272	2	1166	1342	0.87	944	1.41	0.93	12.33	0.18	0.03	0.00	6.67	2.61	6.05	0.04	0.18	0.00	30.4	48.9	51.1
8303607	76	--	1	3530	3720	0.95	3338	2.94	1.73	13.14	0.20		0.52	5.70	1.35	10.41	0.13	0.11	0.00	36.2	49.7	50.3
8305501	75	6774	2	3501	3717	0.94	3249	3.94	5.65	24.30	0.33	0.08	0.00	9.99	3.72	20.68	0.14	0.13	0.00	69.0	49.7	50.3
8307617	73	1050	1	598	666	0.90	506	1.97	0.86	16.51	0.19		0.12	5.68	2.16	11.82	0.05	0.00	0.00	39.4	49.6	50.4
8310602	82	3495	5	1955	2085	0.94	1703	2.69	1.96	56.79			0.00	6.12	0.05	55.26			0.00	122.9	50.0	50.0
8317901	83	4019	4	2166	2278	0.95	1901	1.72	1.28	57.20			0.00	6.94	0.65	53.03	0.11	0.02	0.00	120.9	49.8	50.2
8319402	79	2320	1	1432	1593	0.90	1169	2.50	1.32	5.74	0.18		0.00	2.16	2.29	5.47	0.01	0.00	0.00	19.7	49.5	50.5
8325101	81	2745	2	1563	1766	0.89	1279	1.22	0.70	29.93	0.17	0.05	0.00	4.03	8.37	19.42	0.08	0.01	0.00	64.0	50.1	49.9
8325501	80	1932	5	1082	1239	0.87	875	1.66	1.06	32.02	0.15		0.00	3.45	10.95	20.74	0.06	0.01	0.00	70.1	49.8	50.2
8325608	84	3900	8	2076	2175	0.95	1746	0.75	0.55	21.92	0.15	0.05	0.00	5.20	6.44	11.65	0.06	0.00	0.00	46.8	50.1	49.9
8325801	82	1235	3	836	1020	0.82	637	2.27	1.93	21.40	0.31		0.00	6.54	5.38	13.82	0.07	0.32	0.00	52.0	49.8	50.2
8326401	84	1690	3	952	1107	0.86	744	1.44	1.17	14.71	0.24	0.05	0.00	4.97	3.09	10.00	0.04	0.27	0.00	36.0	48.9	51.1
8326404	83	1550	1	932	1093	0.85	718	3.64	1.88	26.10	0.33		0.00	3.17	17.08	12.05	0.05	0.11	0.00	64.4	49.6	50.4
8326509	87	3171	1	1676	1788	0.94	1400	1.01	0.63	12.31	0.25	0.03	0.13	5.03	2.92	5.87	0.04	0.31	0.00	28.5	49.9	50.1
8326701	82	1782	1	972	1125	0.86	759	0.86	0.58	14.09	0.18	0.05	0.13	4.87	3.38	7.19	0.04	0.17	0.00	31.5	50.0	50.0
8327901	87	2695	4	1498	1606	0.93	1251	0.95	0.62	13.57	0.19		0.00	5.18	3.33	6.77	0.03	0.23	0.00	30.9	49.7	50.3
8329201	91	4732	8	2728	2864	0.95	2359	2.38	1.20	22.84			0.20	3.60	11.81	10.75	0.04	0.15	0.00	53.0	49.9	50.1
8329202	ND	2683	1	2683	2814	0.95	ND	0.98	0.58	14.05	0.23		0.24	4.90	3.50	7.25	0.03	0.23	0.00	32.0	49.5	50.5
8329701	ND	4629	1	4629	4765	0.97	ND	1.43	0.71	21.35	0.14		0.10	3.40	9.59	10.69	0.06	0.05	0.00	47.5	49.7	50.3
8334101	84	2012	3	1050	1196	0.88	849	1.10	0.43	41.99	0.08	0.05	0.06	4.21	15.37	23.93	0.16	0.00	0.00	87.4	50.0	50.0
8334501	83	1710	1	1035	1180	0.88	810	0.90	0.34	41.89			0.00	4.20	14.91	23.98		0.00	0.00	86.2	50.0	50.0
8337201	ND	3352	3	3352	3443	0.97	ND	2.20	0.90	70.90			0.00	4.40	25.20	44.57		0.05	0.00	148.2	49.9	50.1
8346201	97	8060	1	5233	5253	1.00	4620	1.66	0.93	14.77			0.00	4.70	5.14	7.57	0.04	0.15	0.00	35.0	49.7	50.3

SWN	Estimated In situ Temp. (°F)	Specific Conductance (µmho/cm)	TDS Meas. (#)	Meas. (mg/L)	Calc. (mg/L)	Meas. /Calc.	As NACL (mg/L)	Milliequivalents (mEq) Ca (+)	Mg (+)	Na (+)	K (+)	Sr (+)	CO_3 (-)	HCO_3 (-)	SO_4 (-)	Cl (-)	F (-)	NO_3 (-)	SiO_2	Total	Cation (%)	Anion (%)
8358703	85	2260	1	1377	1491	0.92	1143	1.00	0.56	14.83	0.18		0.00	4.66	5.46	6.63	0.03	0.12	0.00	33.5	49.5	50.5
8407903	81	1300	1	730	892	0.82	552	2.89	0.50	48.35	0.11	0.07	0.00	2.91	24.59	24.84	0.22	0.01	0.00	104.5	49.7	50.3
8408801	82	1363	7	774	992	0.78	541	0.70	0.76	80.47			1.50	0.62	36.66	43.16		0.06	0.00	163.9	50.0	50.0
8412301	79	2553	6	1445	1633	0.89	1143	0.47	0.25	21.14	0.20		0.20	3.64	7.46	10.58	0.05	0.07	0.00	44.1	50.1	49.9
8412603	ND	3443	1	3443	3702	0.93	ND	1.30	0.80	10.57	0.20	0.01	0.00	5.22	0.46	6.66	0.11	0.00	0.00	25.3	50.8	49.2
8412605	ND	3078	1	3078	3321	0.93	ND	0.71	0.55	11.78	0.17	0.02	0.00	6.97	1.27	5.18	0.06	0.01	0.00	26.7	49.5	50.5
8415702	81	1310	1	751	937	0.80	538	3.49	3.80	19.28	0.69	0.02	0.02	6.27	3.90	16.22	0.07	0.54	0.00	54.3	50.2	49.8
8416407	78	3705	2	1910	2112	0.90	1644	3.09	1.15	51.98			0.00	8.36	8.14	39.83	0.07	0.47	0.00	113.1	49.7	50.3
8416804	82	2080	1	1197	1382	0.87	966	0.72	0.13	49.59			0.00	7.82	8.73	34.19	0.14	0.01	0.00	101.3	49.8	50.2
8416805	83	1623	3	960	1121	0.86	777	1.45	0.99	10.05	0.20		0.00	5.97	1.96	4.46	0.04	0.24	0.00	25.4	50.0	50.0
8416807	82	2000	1	1149	1327	0.87	926	3.12	4.28	24.62			0.22	6.52	6.86	19.06	0.06	0.07	0.00	64.8	49.4	50.6
8419101	ND	5205	1	5205	5380	0.97	ND	1.80	1.81	16.18	0.25		0.00	5.94	3.46	10.72	0.05	0.21	0.00	40.4	49.6	50.4
8419303	82	3548	2	5720	5977	0.96	5308	2.69	1.10	12.67	0.24		0.00	4.89	2.88	8.26	0.03	0.12	0.00	32.9	50.8	49.2
8420403	ND	3626	1	3626	3672	0.99	ND	1.80	1.73	15.75	0.25		0.00	5.71	3.42	9.93	0.05	0.23	0.00	38.8	50.3	49.7
8421601	78	1612	4	882	1020	0.86	733	6.69	3.04	76.99			0.00	5.64	13.16	67.98	0.01		0.00	173.5	50.0	50.0
8422401	95	2490	1	1551	1670	0.93	1256	3.45	1.39	89.60	1.74	0.03	0.00	8.30	4.96	82.79	0.21	0.09	0.00	192.6	50.0	50.0
8423105	81	2014	1	1146	1309	0.88	911	29.54	16.87	19.75			0.00	1.44	3.17	61.50	0.03		0.00	132.3	50.0	50.0
8423204	78	1627	6	894	1085	0.82	666	5.78	2.63	6.45	0.24	0.03	0.00	4.35	0.85	9.61	0.04	0.28	0.00	30.2	50.0	50.0
8424101	83	2343	3	1275	1424	0.90	1051	0.50	0.14	23.62			0.00	3.84	11.16	9.17	0.07	0.00	0.00	48.5	50.0	50.0
8424102	82	1970	1	1145	1323	0.87	916	1.45	1.09	16.27			0.00	5.22	4.21	9.17	0.04	0.27	0.00	37.7	49.9	50.1
8424204	83	1970	1	1144	1311	0.87	917	1.45	1.40	11.88	0.21	0.01	0.06	6.07	2.95	5.67	0.06	0.32	0.00	30.1	49.7	50.3
8424208	83	2280	1	1342	1506	0.89	1102	1.13	0.93	18.65	0.23		0.04	4.58	4.98	11.04	0.04	0.35	0.00	42.0	49.9	50.1
8424401	105	3190	1	2021	2154	0.94	1660	1.55	1.32	15.92	0.25		0.00	5.71	3.21	10.10	0.04	0.29	0.00	38.4	49.6	50.4
8424513	ND	2947	1	2947	3113	0.95	ND	1.30	0.99	16.40	0.24		0.00	5.38	3.46	9.93	0.04	0.34	0.00	38.1	49.7	50.3
8427405	82	2066	2	1407	1563	0.90	1135	1.25	0.99	20.01	0.24		0.00	5.28	4.42	11.99	0.05	0.34	0.00	44.6	50.5	49.5
8428803	ND	6989	1	6989	7218	0.97	ND	0.85	0.13	30.62	0.10		0.00	4.26	14.37	12.75	0.18	0.00	0.00	63.3	50.1	49.9

			TDS					Milliequivalents (mEq)														
SWN	**Estimated In situ Temp. (°F)**	**Specific Conductance (µmho/cm)**	**Meas. (#)**	**Meas. (mg/L)**	**Calc. (mg/L)**	**Meas. /Calc.**	**As NACL (mg/L)**	**Ca (+)**	**Mg (+)**	**Na (+)**	**K (+)**	**Sr (+)**	**CO_3 (-)**	**HCO_3 (-)**	**SO_4 (-)**	**Cl (-)**	**F (-)**	**NO_3 (-)**	**SiO_2**	**Total**	**Cation (%)**	**Anion (%)**
8429309	81	2073	4	1278	1449	0.88	1041	10.68	12.42	27.84			0.00	5.32	7.58	38.08	0.11	0.23	0.00	102.3	49.8	50.2
8429310	81	2341	4	1248	1441	0.87	1005	0.77	0.17	22.32	0.27	0.01	0.00	5.01	6.90	10.16	0.05	0.00	0.00	45.7	51.5	48.5
8430404	76	4130	1	1506	1643	0.92	1274	1.50	0.12	118.75			0.00	7.35	0.58	112.27			0.00	240.6	50.0	50.0
8432503	81	2025	2	1262	1450	0.87	1004	2.97	1.87	15.70	0.39	0.03	0.00	5.48	3.94	11.31	0.08	0.50	0.00	42.3	49.6	50.4
8433101	77	2283	6	1158	1245	0.93	1056	1.98	1.15	17.51	0.36	0.03	0.00	5.20	5.31	9.82	0.07	0.33	0.00	41.8	50.4	49.6
8433103	77	3555	2	1660	1754	0.95	1568	7.83	3.26	13.22	0.33	0.03	0.00	4.40	3.31	14.41	0.04	1.90	0.00	48.7	50.6	49.4
8433204	78	847	2	531	675	0.79	364	2.79	1.89	15.70	0.27	0.04	0.00	6.03	4.71	9.82	0.06	0.39	0.00	41.7	49.6	50.4
8433701	75	2077	3	1218	1362	0.89	1002	1.51	0.41	17.54	0.23	0.02	0.01	2.34	0.86	16.63	0.02	0.00	0.00	39.6	49.8	50.2
8434404	77	1450	2	825	1012	0.82	579	4.42	0.49	23.75			0.00	3.03	1.00	24.82	0.03	0.00	0.00	57.5	49.8	50.2
8434405	78	1268	1	840	1049	0.80	576	0.05	0.05	9.11	0.05	0.00	0.75	4.65	1.18	2.23	0.05	0.00	0.00	18.1	51.1	48.9
8434407	76	1516	1	1241	1437	0.86	961	6.04	2.78	10.73	0.31	0.03	0.00	4.62	2.45	12.20	0.05	0.42	0.00	39.6	50.2	49.8
8434502	78	1463	1	929	1108	0.84	680	0.20	0.46	12.74	0.15		0.08	6.01	2.23	4.85	0.04	0.17	0.00	26.9	50.3	49.7
8434805	80	1666	1	993	1196	0.83	742	0.41	0.19	12.74	0.19	0.01	0.00	6.72	2.48	4.65	0.04	0.00	0.00	27.4	49.4	50.6
8438902	78	--	1	768	910	0.84	610	0.80	0.90	18.79	0.36	0.01	0.00	6.32	3.52	9.87	0.02	0.24	0.00	40.8	51.1	48.9
8440206	81	--	1	765	909	0.84	587	0.24	0.18	14.70	0.20	0.01	0.16	5.78	2.29	6.66	0.04	0.07	0.00	30.3	50.5	49.5
8440703	111	3650	1	2327	2497	0.93	1915	0.15	0.07	17.05	0.14	0.01	0.24	6.54	0.10	9.45	0.08	0.00	0.00	33.8	51.5	48.5
8442601	76	2052	2	1085	1267	0.86	861	3.99		8.70			0.00	4.56	2.15	6.46		0.32	0.00	26.2	48.5	51.5
8443509	78	1775	2	1036	1133	0.91	895	1.50	1.23	10.09			0.00	4.64	2.71	5.47			0.00	25.6	50.0	50.0
8443512	93	1936	2	1102	1296	0.85	851	0.70	0.66	35.41	0.07		0.00	5.48	15.46	15.80	0.05		0.00	73.6	50.0	50.0
8443514	94	2030	1	1179	1384	0.85	893	4.67	2.43	10.55	0.33		0.00	5.65	3.06	9.39	0.03	0.09	0.00	36.2	49.6	50.4
8448117	82	1276	1	776	923	0.84	590	5.51	2.63	8.11	0.30	0.03	0.00	3.12	1.81	11.79	0.03	0.58	0.00	33.9	48.9	51.1
8450101	77	2440	1	1423	1547	0.92	1236	0.30	0.09	17.96	0.12	0.01	0.22	5.73	3.90	8.41	0.09	0.02	0.00	36.9	50.2	49.8
8455325	84	1150	4	597	767	0.78	453	0.20	0.03	18.96	0.11	0.01	0.00	6.62	4.21	8.55	0.13	0.06	0.00	38.9	49.7	50.3
8455329	82	1137	1	624	770	0.81	468	2.40	1.40	8.44	0.28	0.02	0.00	4.74	1.94	5.98	0.04	0.36	0.00	25.6	49.0	51.0
8456203	84	1080	2	611	770	0.79	443	5.44	1.53	16.44	0.45	0.05	0.00	4.00	3.40	15.66	0.01	0.10	0.00	47.1	50.8	49.2
8457101	78	1730	1	1004	1173	0.86	768	1.90	1.45	7.32	0.25		0.00	4.68	0.73	5.33	0.03	0.00	0.00	21.7	50.3	49.7

			TDS					Milliequivalents (mEq)														
SWN	**Estimated In situ Temp. (°F)**	**Specific Conductance (µmho/cm)**	**Meas. (#)**	**Meas. (mg/L)**	**Calc. (mg/L)**	**Meas. /Calc.**	**As NACL (mg/L)**	**Ca (+)**	**Mg (+)**	**Na (+)**	**K (+)**	**Sr (+)**	**CO_3 (-)**	**HCO_3 (-)**	**SO_4 (-)**	**Cl (-)**	**F (-)**	**NO_3 (-)**	**SiO_2**	**Total**	**Cation (%)**	**Anion (%)**
8460402	81	1728	4	905	974	0.93	815	1.73	1.32	7.18	0.22	0.03	0.00	4.70	0.89	5.33	0.03	0.00	0.00	21.4	48.9	51.1
8463304	82	1250	1	755	915	0.82	564	1.92	1.07	7.29	0.23		0.00	4.97	1.21	4.26	0.03	0.00	0.00	21.0	50.1	49.9
8701201	83	2950	1	1634	1796	0.91	1403	0.44	0.35	15.75			0.00	5.44	3.37	7.67		0.05	0.00	33.1	50.0	50.0
8701601	85	2288	3	1719	1888	0.91	1482	2.49	1.03	11.17	0.22	0.06	0.00	2.08	1.08	11.70	0.03	0.51	0.00	30.4	49.3	50.7
8707604	79	1538	4	903	1063	0.85	722	1.50	1.07	10.18			0.00	5.15	2.44	5.02	0.03	0.09	0.00	25.5	50.0	50.0
8708801	84	1737	3	923	1057	0.87	774	0.28	0.07	26.49	0.10	0.01	0.46	5.19	3.19	19.01	0.11	0.00	0.00	54.9	49.1	50.9
8709301	ND	5070	2	5070	5195	0.98	ND	0.19	0.05	28.64	0.15	0.01	0.49	5.30	3.67	19.49	0.10	0.00	0.00	58.1	50.0	50.0
8710402	ND	5656	3	5656	5726	0.99	ND	2.98	1.71	10.28	0.29	0.04	0.00	4.69	2.12	7.98	0.02	0.53	0.00	30.6	50.0	50.0
8713503	81	1687	3	899	1014	0.89	749	3.08	2.03	10.51	0.31		0.00	4.05	2.21	9.08	0.01	0.33	0.00	31.6	50.4	49.6
8713601	ND	2840	1	2840	3174	0.89	ND	6.21	1.57	74.29	0.62	0.09	0.22	4.02	8.06	73.58	0.10	0.76	0.00	169.5	48.8	51.2
8802403	90	2244	3	1255	1340	0.94	1054	12.18	1.92	79.30	1.23	0.10	0.00	2.24	13.91	76.25	0.06	1.07	0.00	188.2	50.3	49.7
8904625	77	2573	1	1388	1650	0.84	1031	1.12	0.69	13.09	0.18	0.03	0.07	3.59	2.25	9.06	0.03	0.10	0.00	30.2	50.0	50.0

19.5 Geophysical Logs Paired with Water Wells

<u>Description of Table Attributes</u>

API	– American Petroleum Institute ID for the geophysical log
County	– County in which log is located
GAM	– Groundwater Availability Model
GMA	– Groundwater Management Area in which log is located
Easting	– Easting (feet) in Groundwater Availability coordinate system
Northing	– Northing (feet) in Groundwater Availability coordinate system
Ground Surface Elevation (feet- NAVD88)	– Ground surface elevation in feet using NAV 88
Min Depth	– Minimum depth (feet): start of log coverage measured as depth below ground surface
Max Depth	– Maximum depth (feet): end of log coverage measured as depth below ground surface
ND	– No data

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Table 19-5. Geophysical logs paired with water wells.

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4200700229	Aransas	15	5,877,404	18,555,918	0	128	7,600
4200700354	Aransas	15	5,866,230	18,603,396	20	513	6,550
4200700776	Aransas	15	5,849,754	18,490,685	12	40	8,583
4201500018	Austin	14	6,045,776	19,255,060	290	120	11,020
4201500048	Austin	14	6,144,291	19,258,610	175	191	3,700
4201500049	Austin	14	6,144,794	19,257,617	169	800	6,310
4201500051	Austin	14	6,144,833	19,256,146	162	819	6,650
4201500068	Austin	14	6,146,872	19,258,551	153	803	6,390
4201500070	Austin	14	6,145,738	19,257,009	157	809	6,250
4201500071	Austin	14	6,147,872	19,259,945	150	809	6,450
4201500265	Austin	14	6,124,782	19,159,751	196	100	11,810
4201500280	Austin	14	6,127,999	19,159,218	202	100	10,850
4201500530	Austin	14	6,169,259	19,164,449	150	140	8,150
4201500621	Austin	14	6,075,380	19,242,042	186	70	10,520
4201500762	Austin	14	6,034,248	19,269,579	269	176	6,030
4201500782	Austin	14	6,034,906	19,269,090	277	108	10,530
4201500783	Austin	14	6,034,344	19,270,787	283	121	4,730
4201530127	Austin	14	6,021,876	19,236,236	351	280	2,439
4201530138	Austin	14	6,120,662	19,266,959	252	100	11,013
4201530146	Austin	14	6,033,285	19,271,698	278	70	1,500
4202500085	Bee	15	5,625,624	18,746,781	367	463	7,000
4202500102	Bee	15	5,631,850	18,748,687	389	225	3,953
4202500104	Bee	15	5,631,284	18,750,433	417	278	4,057
4202500125	Bee	15	5,631,509	18,738,299	393	184	3,970
4202500129	Bee	15	5,632,591	18,734,313	401	80	5,000
4202500130	Bee	15	5,630,187	18,731,055	383	100	4,258
4202500145	Bee	15	5,631,089	18,737,091	399	146	3,980
4202500146	Bee	15	5,629,653	18,736,372	364	189	3,966
4202500147	Bee	15	5,628,878	18,735,935	331	193	3,940
4202500216	Bee	15	5,622,926	18,731,008	335	255	4,327
4202500251	Bee	15	5,614,552	18,729,389	304	150	3,608
4202500566	Bee	16	5,598,946	18,718,747	387	109	3,798
4202500567	Bee	16	5,602,272	18,716,183	347	379	3,821
4202501219	Bee	15	5,743,655	18,646,559	72	33	4,970

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4202501221	Bee	15	5,742,420	18,645,993	80	140	5,100
4202501253	Bee	15	5,728,889	18,638,051	97	135	5,400
4202501259	Bee	15	5,725,397	18,635,850	105	117	5,248
4202501367	Bee	16	5,656,309	18,661,471	206	213	3,200
4202501374	Bee	16	5,649,055	18,655,192	214	609	3,700
4202501375	Bee	16	5,650,093	18,656,334	216	376	3,716
4202501376	Bee	16	5,652,079	18,655,259	211	1,000	3,800
4202501379	Bee	16	5,648,659	18,653,264	200	275	3,770
4202501410	Bee	16	5,644,884	18,631,082	194	86	6,012
4202501451	Bee	16	5,646,994	18,627,008	209	255	4,210
4202501454	Bee	16	5,648,240	18,629,397	197	331	4,506
4202501459	Bee	16	5,646,343	18,624,248	190	291	4,280
4202501468	Bee	16	5,645,427	18,624,311	175	331	4,308
4202501578	Bee	16	5,642,757	18,650,843	215	420	4,180
4202501636	Bee	16	5,602,409	18,666,634	361	100	3,732
4202501692	Bee	16	5,593,842	18,675,678	366	93	3,520
4202501693	Bee	16	5,593,087	18,675,396	384	50	7,800
4202501707	Bee	16	5,595,149	18,651,739	357	200	2,165
4202501712	Bee	16	5,592,369	18,656,474	332	207	5,420
4202501725	Bee	16	5,591,989	18,675,707	410	130	3,550
4202501758	Bee	16	5,596,619	18,635,659	323	261	4,221
4202501841	Bee	16	5,647,451	18,652,872	204	306	4,150
4202501938	Bee	16	5,627,396	18,576,714	192	120	3,242
4202502001	Bee	16	5,645,099	18,599,526	179	103	2,264
4202502054	Bee	16	5,682,636	18,584,543	110	200	5,620
4202502063	Bee	16	5,686,383	18,584,560	107	109	5,532
4202502067	Bee	16	5,683,285	18,577,721	95	125	5,629
4202502414	Bee	15	5,735,178	18,658,514	92	320	5,010
4202502437	Bee	15	5,761,991	18,652,375	79	100	5,610
4202502496	Bee	16	5,645,530	18,602,687	157	100	4,220
4202502539	Bee	16	5,592,037	18,674,301	426	53	3,500
4202502587	Bee	15	5,628,404	18,749,854	429	204	3,697
4202502633	Bee	16	5,702,399	18,571,222	74	208	3,460
4202502640	Bee	16	5,699,542	18,571,423	75	130	3,450
4202502647	Bee	16	5,701,423	18,571,843	63	231	3,350

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4202502648	Bee	16	5,697,715	18,569,990	74	100	3,606
4202530101	Bee	16	5,648,656	18,659,775	213	170	4,130
4202530197	Bee	16	5,643,398	18,631,322	210	33	3,987
4202530201	Bee	16	5,648,191	18,658,835	225	204	3,305
4202530223	Bee	15	5,620,823	18,699,597	266	126	2,360
4202530286	Bee	16	5,633,902	18,613,142	205	330	3,550
4202530352	Bee	15	5,763,405	18,652,095	65	111	3,722
4202530379	Bee	15	5,620,221	18,701,371	277	70	10,134
4202530389	Bee	16	5,553,108	18,724,572	331	62	14,128
4202530422	Bee	16	5,613,405	18,641,875	294	231	4,463
4202530433	Bee	16	5,598,459	18,715,168	415	505	7,900
4202530530	Bee	15	5,624,532	18,732,558	308	173	3,034
4202530995	Bee	16	5,600,848	18,714,087	385	155	2,000
4202531201	Bee	15	5,735,355	18,660,149	85	537	4,830
4202531462	Bee	16	5,629,599	18,571,916	186	274	3,360
4202531843	Bee	16	5,634,671	18,666,160	319	213	4,350
4202532114	Bee	16	5,631,014	18,572,972	186	150	4,480
4202532157	Bee	16	5,645,694	18,596,520	188	173	4,750
4202532161	Bee	16	5,647,027	18,588,079	196	340	4,990
4202532194	Bee	16	5,646,354	18,597,161	186	180	4,750
4202532220	Bee	16	5,641,770	18,650,065	237	384	4,640
4202532229	Bee	15	5,624,328	18,733,939	301	409	3,820
4202532413	Bee	15	5,616,127	18,729,130	302	89	1,160
4202532563	Bee	15	5,717,227	18,652,139	124	534	4,850
4202532857	Bee	15	5,612,484	18,731,057	316	40	1,230
4202532965	Bee	15	5,681,151	18,639,964	165	562	4,676
4202533418	Bee	15	5,714,598	18,655,564	133	500	4,850
4203901326	Brazoria	14	6,393,584	19,072,511	54	100	7,730
4203902872	Brazoria	14	6,297,386	18,949,641	35	50	6,500
4203902873	Brazoria	14	6,297,904	18,949,488	34	531	5,512
4203904203	Brazoria	14	6,380,159	18,965,426	30	100	13,120
4203904477	Brazoria	14	6,361,371	18,895,512	15	105	17,600
4203904519	Brazoria	14	6,422,766	18,895,889	5	23	7,528
4203904806	Brazoria	14	6,358,794	18,899,805	11	100	11,320
4203930263	Brazoria	14	6,395,106	18,885,705	8	100	12,270

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4203930519	Brazoria	14	6,353,477	18,897,604	13	102	13,230
4203932395	Brazoria	14	6,394,793	18,881,408	5	293	1,865
4204700167	Brooks	16	5,527,216	18,228,399	116	100	9,205
4204700179	Brooks	16	5,518,592	18,227,615	134	123	9,610
4204701107	Brooks	16	5,440,787	18,069,885	235	89	6,390
4204701140	Brooks	16	5,440,962	18,066,882	233	100	7,800
4204701201	Brooks	16	5,525,397	18,119,446	134	246	8,469
4204701304	Brooks	16	5,555,628	18,110,294	79	90	9,010
4204701306	Brooks	16	5,561,184	18,111,371	63	90	9,010
4204730163	Brooks	16	5,552,476	18,225,193	100	100	7,915
4204730279	Brooks	16	5,527,562	18,175,249	117	529	7,600
4204732274	Brooks	16	5,438,447	18,070,909	236	326	743
4205700037	Calhoun	15	5,922,921	18,740,574	50	117	9,010
4205700039	Calhoun	15	5,924,952	18,741,942	51	1,029	6,220
4205700043	Calhoun	15	5,924,040	18,740,538	55	70	6,360
4205700083	Calhoun	15	5,928,860	18,739,342	52	1,018	5,490
4205700220	Calhoun	15	5,949,951	18,712,806	34	100	9,120
4205700238	Calhoun	15	5,954,044	18,706,268	35	432	6,130
4205700442	Calhoun	15	5,986,684	18,745,340	23	80	9,350
4205700531	Calhoun	15	5,987,776	18,748,345	23	100	8,750
4205700540	Calhoun	15	6,002,245	18,723,029	14	100	5,450
4205700541	Calhoun	15	5,999,185	18,725,189	6	137	8,531
4205700542	Calhoun	15	5,997,409	18,726,173	15	98	8,850
4205701231	Calhoun	15	5,953,835	18,708,619	30	253	5,940
4205701232	Calhoun	15	5,954,667	18,709,626	29	139	6,150
4205701246	Calhoun	15	6,025,847	18,761,990	25	95	12,379
4205701305	Calhoun	15	5,982,186	18,757,566	27	406	6,056
4205701358	Calhoun	15	5,925,199	18,738,836	52	1,008	6,360
4205730066	Calhoun	15	5,954,347	18,709,824	30	538	6,080
4206100125	Cameron	16	5,733,420	17,766,530	33	100	12,050
4207100024	Chambers	14	6,532,532	19,208,124	30	500	6,320
4207100065	Chambers	14	6,532,911	19,216,104	44	91	7,300
4207100071	Chambers	14	6,535,193	19,206,096	33	130	6,162
4207100102	Chambers	14	6,532,653	19,207,768	33	100	7,050
4207100112	Chambers	14	6,531,538	19,208,986	32	512	6,370

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4207100113	Chambers	14	6,532,231	19,208,675	33	570	6,712
4207100179	Chambers	14	6,531,304	19,214,822	41	110	6,480
4207100226	Chambers	14	6,534,355	19,216,612	49	79	7,250
4207100231	Chambers	14	6,535,034	19,217,038	48	60	7,030
4207100258	Chambers	14	6,536,942	19,216,272	51	100	7,110
4207100267	Chambers	14	6,536,616	19,215,761	60	130	6,430
4207100699	Chambers	14	6,535,731	19,205,903	33	501	5,346
4207102877	Chambers	14	6,561,114	19,097,570	0	279	10,640
4207102880	Chambers	14	6,560,519	19,096,999	0	190	9,850
4207102896	Chambers	14	6,558,929	19,099,353	0	220	9,585
4207102957	Chambers	14	6,556,861	19,094,389	0	250	9,600
4207102962	Chambers	14	6,553,433	19,093,655	0	180	9,510
4207102975	Chambers	14	6,547,497	19,093,683	0	281	10,950
4207130072	Chambers	14	6,531,643	19,217,156	41	100	11,350
4207131322	Chambers	14	6,553,305	19,096,511	0	176	13,800
4207132442	Chambers	14	6,525,489	19,210,865	31	151	2,028
4207132443	Chambers	14	6,526,095	19,209,729	29	204	2,014
4208900110	Colorado	15	6,117,719	19,117,389	160	103	7,010
4208900119	Colorado	15	6,115,706	19,114,076	156	100	7,010
4208900127	Colorado	15	6,112,616	19,099,874	158	110	9,506
4208900129	Colorado	15	6,111,054	19,101,159	170	185	9,460
4208900133	Colorado	15	6,114,600	19,104,112	160	407	12,010
4208900138	Colorado	15	6,084,297	19,145,087	202	162	10,516
4208900246	Colorado	15	6,073,520	19,100,279	187	100	11,200
4208900247	Colorado	15	6,085,316	19,104,247	188	124	11,839
4208900330	Colorado	15	6,011,411	19,137,885	221	99	9,816
4208900354	Colorado	15	5,999,162	19,131,456	261	81	10,020
4208900445	Colorado	15	6,017,122	19,090,280	232	90	10,019
4208900449	Colorado	15	5,999,798	19,083,438	275	370	3,510
4208900484	Colorado	15	5,974,472	19,059,825	264	100	9,900
4208900500	Colorado	15	5,995,466	19,054,576	214	92	2,060
4208900584	Colorado	15	6,025,116	19,043,607	181	195	8,985
4208900704	Colorado	15	6,064,358	19,051,906	158	100	10,020
4208900705	Colorado	15	6,060,267	19,052,159	161	120	7,020
4208900724	Colorado	15	6,080,152	19,064,741	150	101	10,704

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4208900755	Colorado	15	6,040,052	19,035,087	160	70	7,000
4208900970	Colorado	15	6,072,597	19,106,978	198	40	9,630
4208930079	Colorado	15	6,063,300	19,100,066	173	50	9,840
4208930088	Colorado	15	6,015,905	19,085,866	230	50	10,830
4208930150	Colorado	15	6,028,542	19,052,126	186	307	2,520
4208930160	Colorado	15	6,094,203	19,108,099	181	350	3,684
4208930236	Colorado	15	6,092,897	19,107,293	180	340	3,250
4208930284	Colorado	15	6,093,260	19,109,993	178	300	3,250
4208930312	Colorado	15	5,987,768	19,045,282	225	52	10,470
4208930336	Colorado	15	5,982,904	19,067,180	274	480	3,020
4208930565	Colorado	15	6,032,415	19,085,087	194	86	10,990
4208930576	Colorado	15	5,997,605	19,053,413	215	410	2,210
4208930579	Colorado	15	6,015,981	19,070,927	231	543	2,680
4208930592	Colorado	15	6,029,413	19,082,666	207	60	11,900
4208930653	Colorado	15	5,997,640	19,075,346	263	461	2,014
4208931004	Colorado	15	5,941,448	19,131,417	412	370	2,800
4208931034	Colorado	15	6,058,566	19,048,973	160	90	9,975
4208931159	Colorado	15	6,014,161	19,070,864	230	435	3,280
4208931206	Colorado	15	6,048,199	19,047,887	166	50	9,410
4208931209	Colorado	15	6,016,041	19,090,305	235	50	12,250
4208931270	Colorado	15	6,123,104	19,109,158	150	511	7,208
4208931330	Colorado	15	6,014,193	19,088,145	237	65	11,885
4208931393	Colorado	15	6,124,585	19,112,430	150	300	4,810
4208931583	Colorado	15	6,029,073	19,045,396	175	50	9,030
4208931604	Colorado	15	6,002,451	18,989,512	146	234	15,912
4208931611	Colorado	15	5,938,918	19,130,282	387	100	1,600
4208931622	Colorado	15	5,938,266	19,139,586	408	95	860
4208931735	Colorado	15	6,089,630	19,064,006	160	263	2,410
4208931746	Colorado	15	6,037,484	19,034,004	157	60	10,560
4208931788	Colorado	15	6,056,604	19,049,671	160	83	12,976
4208931902	Colorado	15	5,999,521	18,985,153	145	440	4,531
4208932123	Colorado	15	6,073,867	19,099,939	186	70	2,850
4208932262	Colorado	15	6,084,393	19,063,181	154	153	2,600
4208932613	Colorado	15	6,013,983	19,091,164	239	87	11,922
4208932648	Colorado	15	6,029,385	19,117,612	226	413	3,500

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4212300290	DeWitt	15	5,793,886	18,912,707	229	100	10,230
4212300545	DeWitt	15	5,747,886	18,850,530	228	116	4,520
4212300548	DeWitt	15	5,749,247	18,850,987	225	80	4,715
4212300802	DeWitt	15	5,746,673	18,851,152	230	106	5,120
4212301070	DeWitt	15	5,723,292	18,864,648	297	500	7,130
4212331729	DeWitt	15	5,721,058	18,864,044	275	70	1,800
4213100869	Duval	16	5,364,247	18,401,329	581	64	3,500
4213100987	Duval	16	5,491,850	18,421,617	305	100	5,050
4213100995	Duval	16	5,487,981	18,421,747	311	238	5,280
4213103454	Duval	16	5,396,018	18,457,216	559	19	2,840
4213103458	Duval	16	5,394,159	18,455,449	600	47	3,020
4213103459	Duval	16	5,394,186	18,456,616	584	80	2,856
4213107018	Duval	16	5,363,588	18,403,577	583	106	2,730
4213107020	Duval	16	5,364,901	18,399,076	588	210	2,244
4213107023	Duval	16	5,364,873	18,399,216	583	106	2,250
4213108259	Duval	16	5,336,222	18,337,428	717	121	3,200
4213108295	Duval	16	5,333,441	18,335,476	674	50	3,210
4213108299	Duval	16	5,333,346	18,337,524	696	30	3,000
4213108301	Duval	16	5,333,883	18,337,791	707	100	2,650
4213108481	Duval	16	5,444,777	18,398,733	418	215	5,550
4213108590	Duval	16	5,454,925	18,387,753	396	762	5,826
4213108591	Duval	16	5,451,811	18,390,861	431	360	6,120
4213108592	Duval	16	5,452,855	18,389,313	433	209	3,820
4213108593	Duval	16	5,453,222	18,387,699	414	495	5,123
4213108704	Duval	16	5,462,182	18,350,202	318	106	6,010
4213108934	Duval	16	5,440,356	18,351,780	387	165	5,909
4213109664	Duval	16	5,481,380	18,287,285	237	152	2,540
4213111054	Duval	16	5,437,313	18,354,270	363	106	6,000
4213111077	Duval	16	5,456,480	18,392,236	388	78	5,184
4213130091	Duval	16	5,365,480	18,401,400	576	94	2,808
4213130100	Duval	16	5,365,671	18,402,358	595	11	2,837
4213131592	Duval	16	5,444,635	18,392,730	430	61	1,998
4213137123	Duval	16	5,491,574	18,408,450	311	165	7,450
4214900012	Fayette	15	5,961,837	19,267,761	346	50	2,568
4214900052	Fayette	15	5,883,588	19,162,057	401	109	4,100

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4214900053	Fayette	15	5,881,026	19,165,049	412	137	5,510
4214900055	Fayette	15	5,883,501	19,163,818	411	190	4,510
4214900328	Fayette	15	5,859,229	19,126,881	448	290	4,230
4214900369	Fayette	15	5,968,494	19,185,038	320	102	2,758
4214930089	Fayette	15	5,898,816	19,174,772	437	267	3,510
4214930293	Fayette	15	5,934,950	19,138,800	367	104	5,850
4214930914	Fayette	15	5,897,049	19,176,845	429	57	11,850
4214931555	Fayette	15	5,917,813	19,119,770	243	8	582
4214931607	Fayette	15	5,913,397	19,120,887	263	129	720
4215701698	Fort Bend	14	6,240,502	19,034,751	90	70	6,300
4215731072	Wharton	15	6,187,049	19,047,070	75	345	5,930
4216701097	Galveston	14	6,522,719	19,023,524	7	160	12,617
4216730283	Galveston	14	6,547,021	19,042,548	0	131	10,777
4217500101	Goliad	15	5,706,408	18,790,145	271	100	7,760
4217500120	Goliad	15	5,710,871	18,791,510	315	520	4,533
4217500128	Goliad	15	5,710,361	18,790,710	303	530	4,514
4217500133	Goliad	15	5,704,351	18,788,920	209	529	4,617
4217500136	Goliad	15	5,708,635	18,788,123	269	521	4,480
4217500162	Goliad	15	5,714,247	18,783,353	328	515	5,360
4217500209	Goliad	15	5,711,822	18,804,276	326	40	7,700
4217500324	Goliad	15	5,738,758	18,789,971	230	205	2,870
4217500328	Goliad	15	5,737,608	18,788,650	229	207	9,320
4217500445	Goliad	15	5,732,051	18,827,047	279	100	8,020
4217500446	Goliad	15	5,732,065	18,826,243	271	317	7,720
4217500453	Goliad	15	5,730,157	18,824,178	268	80	8,000
4217500555	Goliad	15	5,739,341	18,827,604	282	90	7,790
4217500582	Goliad	15	5,748,850	18,831,789	273	41	7,752
4217500586	Goliad	15	5,748,499	18,830,866	260	121	1,997
4217500680	Goliad	15	5,792,936	18,810,056	192	60	10,090
4217500751	Goliad	15	5,804,618	18,758,749	134	420	4,377
4217500887	Goliad	15	5,782,827	18,762,780	160	100	4,060
4217500948	Goliad	15	5,777,594	18,762,423	146	142	4,328
4217501080	Goliad	15	5,703,790	18,715,525	237	148	3,410
4217501163	Goliad	15	5,691,250	18,706,730	213	100	2,280
4217501186	Goliad	15	5,685,678	18,704,885	203	146	2,280

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4217501194	Goliad	15	5,692,051	18,704,121	202	102	3,249
4217501195	Goliad	15	5,689,941	18,704,783	209	102	2,360
4217501204	Goliad	15	5,686,982	18,704,326	198	90	2,189
4217501207	Goliad	15	5,687,048	18,703,364	192	100	2,230
4217501328	Goliad	15	5,700,298	18,747,012	266	281	2,464
4217501331	Goliad	15	5,703,981	18,748,080	202	100	9,460
4217501333	Goliad	15	5,703,448	18,746,242	263	119	9,359
4217501336	Goliad	15	5,705,702	18,751,241	156	101	9,461
4217501394	Goliad	15	5,710,824	18,752,304	155	108	4,881
4217501396	Goliad	15	5,710,855	18,753,177	163	100	4,887
4217501405	Goliad	15	5,707,954	18,754,491	152	101	9,320
4217501406	Goliad	15	5,706,908	18,757,577	160	97	9,300
4217501407	Goliad	15	5,695,405	18,766,135	165	150	9,770
4217501526	Goliad	15	5,672,920	18,763,730	261	98	9,014
4217501527	Goliad	15	5,673,685	18,768,148	180	140	8,000
4217501549	Goliad	15	5,671,803	18,770,827	195	85	4,010
4217501550	Goliad	15	5,666,334	18,767,313	276	149	4,804
4217501551	Goliad	15	5,664,357	18,765,920	245	304	3,930
4217501601	Goliad	15	5,647,042	18,745,288	345	205	4,500
4217501615	Goliad	15	5,673,095	18,731,523	338	162	5,520
4217501616	Goliad	15	5,672,799	18,728,557	307	149	9,574
4217501620	Goliad	15	5,675,784	18,728,216	309	200	3,080
4217501723	Goliad	15	5,741,604	18,689,145	152	153	2,230
4217501779	Goliad	15	5,735,327	18,785,995	199	100	3,490
4217501881	Goliad	15	5,733,331	18,781,669	211	133	3,523
4217501900	Goliad	15	5,713,417	18,767,544	190	100	3,210
4217501908	Goliad	15	5,707,651	18,764,855	206	100	3,436
4217502028	Goliad	15	5,739,894	18,784,815	206	300	3,730
4217502040	Goliad	15	5,704,548	18,759,615	160	261	5,360
4217502086	Goliad	15	5,710,502	18,782,481	312	520	5,429
4217530082	Goliad	15	5,727,443	18,743,082	183	419	3,540
4217530084	Goliad	15	5,727,734	18,745,400	132	441	3,540
4217530090	Goliad	15	5,713,911	18,751,001	166	380	8,436
4217530193	Goliad	15	5,679,503	18,767,841	190	15	10,550
4217530217	Goliad	15	5,723,771	18,747,158	145	484	3,726

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4217530237	Goliad	15	5,722,333	18,748,225	149	481	3,710
4217530273	Goliad	15	5,806,028	18,757,706	130	200	4,250
4217530341	Goliad	15	5,703,452	18,759,754	160	442	5,310
4217530344	Goliad	15	5,806,793	18,761,926	141	263	2,800
4217530365	Goliad	15	5,741,003	18,753,447	172	215	3,411
4217530415	Goliad	15	5,807,584	18,760,165	133	200	4,327
4217530593	Goliad	15	5,771,333	18,761,803	161	431	4,510
4217531006	Goliad	15	5,671,965	18,764,839	207	608	8,014
4217531042	Goliad	15	5,790,548	18,807,450	198	35	10,000
4217531044	Goliad	15	5,736,992	18,781,274	213	176	3,200
4217531185	Goliad	15	5,674,280	18,764,438	189	637	8,040
4217531188	Goliad	15	5,766,032	18,675,268	110	270	5,510
4217531261	Goliad	15	5,765,322	18,673,338	106	346	5,510
4217531272	Goliad	15	5,701,402	18,745,619	230	359	10,240
4217531296	Goliad	15	5,734,656	18,826,143	279	501	7,860
4217531390	Goliad	15	5,711,492	18,783,033	321	590	5,400
4217531496	Goliad	15	5,763,574	18,655,637	90	520	2,720
4217531549	Goliad	15	5,804,674	18,771,239	115	193	4,210
4217531575	Goliad	15	5,662,298	18,764,454	283	485	4,930
4217531581	Goliad	15	5,674,327	18,724,853	297	354	11,150
4217531590	Goliad	15	5,791,317	18,809,797	199	55	9,730
4217531657	Goliad	15	5,816,238	18,802,597	151	70	1,202
4217531668	Goliad	15	5,765,017	18,675,469	110	320	5,180
4217531694	Goliad	15	5,740,077	18,784,046	207	157	3,140
4217531696	Goliad	15	5,662,600	18,762,867	306	526	7,860
4217531711	Goliad	15	5,706,854	18,804,077	330	522	7,778
4217531741	Goliad	15	5,767,947	18,676,829	112	300	5,220
4217531785	Goliad	15	5,766,327	18,678,428	113	319	5,460
4217531857	Goliad	15	5,706,432	18,802,967	329	261	5,110
4217532457	Goliad	15	5,787,070	18,813,836	175	363	3,500
4217532523	Goliad	15	5,744,134	18,753,236	187	317	3,031
4217532847	Goliad	15	5,727,462	18,744,241	186	567	3,400
4217533150	Goliad	15	5,736,832	18,785,808	228	395	3,720
4217533228	Goliad	15	5,736,546	18,664,674	104	449	5,070
4217533251	Goliad	15	5,735,514	18,663,796	93	559	5,120

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4217533344	Goliad	15	5,710,596	18,751,838	153	121	9,511
4217533483	Goliad	15	5,738,245	18,828,045	288	776	5,421
4217533739	Goliad	15	5,751,091	18,742,194	137	600	4,188
4217534159	Goliad	15	5,772,934	18,762,492	132	66	12,642
4218500033	Grimes	14	6,179,833	19,435,308	387	430	4,917
4218500034	Grimes	14	6,179,649	19,435,722	374	100	1,990
4218500099	Grimes	14	6,196,327	19,377,287	346	420	3,822
4218500102	Grimes	14	6,193,813	19,375,526	410	581	3,804
4219900500	Hardin	14	6,705,871	19,409,011	50	100	8,510
4219900502	Hardin	14	6,706,771	19,409,968	58	96	8,520
4219902148	Hardin	14	6,689,726	19,336,306	40	100	10,000
4219902153	Hardin	14	6,689,592	19,331,950	35	40	7,980
4219902186	Hardin	14	6,688,676	19,315,111	40	20	10,630
4219902237	Hardin	14	6,680,226	19,326,414	51	100	3,010
4219902268	Hardin	14	6,681,312	19,319,608	40	646	6,222
4219902360	Hardin	14	6,680,513	19,326,361	51	100	1,620
4219902479	Hardin	14	6,680,281	19,321,887	42	700	5,620
4219902590	Hardin	14	6,680,526	19,321,092	41	628	6,500
4219903240	Hardin	14	6,682,800	19,318,123	44	619	6,950
4219903330	Hardin	14	6,747,928	19,411,641	56	100	12,535
4219932365	Hardin	14	6,649,320	19,375,501	90	80	1,550
4219932589	Hardin	14	6,648,328	19,375,231	70	54	1,137
4219932590	Hardin	14	6,648,387	19,375,444	71	53	1,163
4219932603	Hardin	14	6,649,916	19,377,326	85	52	942
4219933018	Hardin	14	6,649,996	19,375,057	87	40	1,693
4220100911	Harris	14	6,352,912	19,288,502	133	622	6,260
4220100996	Harris	14	6,350,096	19,274,391	121	790	6,510
4220104100	Harris	14	6,280,380	19,184,950	112	740	7,500
4223900047	Jackson	15	5,947,540	18,883,883	85	175	5,015
4223900049	Jackson	15	5,952,724	18,887,687	83	167	4,829
4223900097	Jackson	15	5,968,551	18,937,854	116	80	4,820
4223900098	Jackson	15	5,973,335	18,939,231	117	400	4,790
4223900123	Jackson	15	6,013,383	18,930,349	91	150	3,020
4223900136	Jackson	15	6,021,540	18,929,151	88	324	5,560
4223900137	Jackson	15	6,026,922	18,927,625	85	431	5,800

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4223900300	Jackson	15	5,980,683	18,905,842	67	467	3,250
4223900304	Jackson	15	5,979,869	18,907,556	71	419	3,290
4223900340	Jackson	15	5,974,708	18,935,258	112	423	4,820
4223900462	Jackson	15	6,008,130	18,887,325	67	231	6,323
4223900464	Jackson	15	6,011,659	18,889,860	51	160	6,380
4223900520	Jackson	15	6,029,521	18,899,511	65	90	5,410
4223900525	Jackson	15	6,030,645	18,894,695	63	940	6,460
4223900563	Jackson	15	6,032,040	18,893,495	63	890	4,790
4223900581	Jackson	15	6,032,575	18,892,613	62	941	4,780
4223900651	Jackson	15	6,043,915	18,891,050	68	121	6,850
4223900652	Jackson	15	6,042,032	18,888,002	61	52	6,860
4223900667	Jackson	15	6,052,094	18,890,293	64	160	6,670
4223900668	Jackson	15	6,053,384	18,891,446	65	162	6,680
4223901333	Jackson	15	6,096,610	18,839,279	35	85	10,010
4223901366	Jackson	15	6,089,053	18,839,519	36	100	10,000
4223901372	Jackson	15	6,081,061	18,838,020	31	150	10,010
4223901657	Jackson	15	6,004,599	18,866,226	58	150	6,945
4223901863	Jackson	15	5,980,986	18,843,955	52	314	6,940
4223901887	Jackson	15	5,980,669	18,844,121	53	156	6,632
4223901936	Jackson	15	6,011,829	18,841,174	39	150	7,020
4223901937	Jackson	15	6,010,656	18,840,927	42	190	6,340
4223902138	Jackson	15	6,036,446	18,830,733	42	80	8,030
4223902327	Jackson	15	6,030,474	18,827,134	35	56	1,900
4223903224	Jackson	15	6,065,618	18,780,031	0	150	8,690
4223903265	Jackson	15	6,079,161	18,773,037	10	70	9,760
4223903321	Jackson	15	6,057,395	18,892,383	65	150	6,670
4223903325	Jackson	15	6,051,362	18,864,923	48	148	7,730
4223903549	Jackson	15	5,999,701	18,900,317	77	113	5,766
4223903704	Jackson	15	5,974,530	18,902,944	88	130	2,550
4223930023	Jackson	15	5,970,251	18,876,647	72	255	5,510
4223930384	Jackson	15	6,009,783	18,844,517	47	274	7,430
4223930650	Jackson	15	5,923,789	18,903,059	110	590	4,726
4223931605	Jackson	15	5,925,654	18,903,234	110	400	6,840
4223931646	Jackson	15	6,037,292	18,895,944	63	523	6,620
4223932665	Jackson	15	6,000,785	18,940,869	107	300	2,950

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4223932729	Jackson	15	5,998,205	18,963,278	125	559	4,210
4223933251	Jackson	15	5,942,189	18,933,694	129	176	10,738
4223933328	Jackson	15	6,007,479	18,866,222	60	140	1,302
4224100084	Jasper	14	6,835,663	19,527,781	99	1,018	6,600
4224100086	Jasper	14	6,836,991	19,527,808	103	1,000	6,600
4224100300	Jasper	14	6,819,862	19,448,960	100	1,113	8,334
4224500123	Jefferson	14	6,709,040	19,298,122	40	79	1,940
4224501553	Jefferson	14	6,795,022	19,269,569	13	100	10,015
4224700149	Jim Hogg	16	5,321,450	18,247,030	699	143	3,132
4224700162	Jim Hogg	16	5,321,908	18,249,186	679	136	3,210
4224700168	Jim Hogg	16	5,321,404	18,250,951	676	121	3,640
4224700232	Jim Hogg	16	5,344,326	18,246,499	585	200	3,542
4224700233	Jim Hogg	16	5,345,810	18,247,993	569	202	3,500
4224700234	Jim Hogg	16	5,344,662	18,248,411	572	360	4,113
4224700235	Jim Hogg	16	5,346,455	18,248,953	565	268	4,070
4224700246	Jim Hogg	16	5,349,931	18,260,544	577	137	3,934
4224700261	Jim Hogg	16	5,352,381	18,247,591	536	270	4,214
4224700262	Jim Hogg	16	5,352,204	18,245,133	552	341	4,240
4224700401	Jim Hogg	16	5,378,785	18,167,693	445	175	5,310
4224700509	Jim Hogg	16	5,372,694	18,167,547	454	178	6,302
4224700724	Jim Hogg	16	5,293,693	18,227,731	825	102	1,833
4224700725	Jim Hogg	16	5,293,746	18,228,423	816	112	1,810
4224701535	Jim Hogg	16	5,270,044	18,131,203	522	162	3,512
4224701852	Jim Hogg	16	5,268,506	18,130,062	529	99	3,022
4224701875	Jim Hogg	16	5,268,932	18,126,284	531	150	2,111
4224701877	Jim Hogg	16	5,273,759	18,123,054	554	95	2,580
4224701880	Jim Hogg	16	5,276,529	18,122,840	565	90	2,130
4224702046	Jim Hogg	16	5,279,818	18,119,563	588	150	2,950
4224702050	Jim Hogg	16	5,279,793	18,120,210	585	110	2,927
4224702143	Jim Hogg	16	5,276,972	18,123,529	564	50	2,830
4224702549	Jim Hogg	16	5,371,536	18,166,900	458	355	6,530
4224731904	Jim Hogg	16	5,351,439	18,244,608	558	445	4,340
4224900067	Jim Wells	16	5,542,197	18,511,214	305	116	3,030
4224900183	Jim Wells	16	5,631,129	18,506,779	44	135	3,721
4224900422	Jim Wells	16	5,587,758	18,487,678	180	100	2,310

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4224900461	Jim Wells	16	5,590,873	18,493,614	181	350	5,685
4224900581	Jim Wells	16	5,587,197	18,496,642	188	120	5,330
4224900582	Jim Wells	16	5,588,104	18,494,545	184	117	5,300
4224900585	Jim Wells	16	5,582,188	18,494,092	197	218	2,728
4224900721	Jim Wells	16	5,578,212	18,465,926	170	291	3,612
4224901072	Jim Wells	16	5,551,001	18,473,371	259	102	1,910
4224901075	Jim Wells	16	5,555,129	18,472,104	222	500	5,290
4224901138	Jim Wells	16	5,550,857	18,469,206	244	320	1,960
4224901139	Jim Wells	16	5,551,278	18,468,562	240	100	2,166
4224901140	Jim Wells	16	5,550,490	18,468,916	246	500	5,360
4224901362	Jim Wells	16	5,531,533	18,437,812	235	231	5,193
4224901394	Jim Wells	16	5,546,392	18,426,068	184	199	4,800
4224901475	Jim Wells	16	5,548,553	18,428,040	180	170	5,207
4224901494	Jim Wells	16	5,494,493	18,405,252	302	1,772	7,397
4224901547	Jim Wells	16	5,546,850	18,418,059	198	419	6,028
4224901550	Jim Wells	16	5,525,170	18,403,705	233	225	5,552
4224901552	Jim Wells	16	5,524,971	18,404,874	235	235	5,550
4224901563	Jim Wells	16	5,546,324	18,425,435	195	111	4,630
4224901570	Jim Wells	16	5,524,884	18,396,989	229	325	5,264
4224901574	Jim Wells	16	5,529,517	18,397,380	220	1,400	3,647
4224901583	Jim Wells	16	5,526,717	18,396,201	223	870	5,533
4224901586	Jim Wells	16	5,527,749	18,399,754	226	1,003	9,000
4224901660	Jim Wells	16	5,532,727	18,414,793	229	368	5,630
4224901786	Jim Wells	16	5,550,621	18,409,818	186	115	4,915
4224901787	Jim Wells	16	5,553,824	18,410,984	181	507	3,205
4224901788	Jim Wells	16	5,550,844	18,408,920	185	111	4,936
4224901794	Jim Wells	16	5,554,756	18,406,110	173	340	5,870
4224901797	Jim Wells	16	5,550,746	18,408,076	187	178	4,931
4224902721	Jim Wells	16	5,534,117	18,290,815	145	100	4,450
4224902756	Jim Wells	16	5,535,583	18,291,043	144	1,050	6,050
4224902815	Jim Wells	16	5,538,027	18,291,044	140	1,028	6,210
4224902825	Jim Wells	16	5,537,188	18,290,850	141	97	6,209
4224902998	Jim Wells	16	5,534,592	18,289,742	146	1,049	5,930
4224903220	Jim Wells	16	5,533,776	18,269,651	149	50	7,620
4224903314	Jim Wells	16	5,536,417	18,268,569	140	224	6,230

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4224903587	Jim Wells	16	5,502,082	18,397,337	288	215	5,222
4224903602	Jim Wells	16	5,549,804	18,415,430	193	230	5,870
4224903684	Jim Wells	16	5,553,886	18,415,364	181	228	3,880
4224903701	Jim Wells	16	5,499,286	18,398,813	287	216	4,808
4224930011	Jim Wells	16	5,543,434	18,511,563	303	100	2,640
4224930126	Jim Wells	16	5,582,426	18,495,710	194	196	5,022
4224930401	Jim Wells	16	5,548,145	18,411,380	194	206	2,120
4224930455	Jim Wells	16	5,583,256	18,490,964	204	78	3,494
4224931327	Jim Wells	16	5,583,396	18,491,111	204	209	3,020
4224931428	Jim Wells	16	5,579,419	18,471,672	165	218	5,560
4224931724	Jim Wells	16	5,521,124	18,464,261	277	213	3,432
4225500339	Karnes	15	5,679,144	18,796,311	288	464	4,170
4225500340	Karnes	15	5,680,075	18,792,285	286	450	4,152
4225500342	Karnes	15	5,679,324	18,794,314	279	473	7,638
4225500350	Karnes	15	5,679,146	18,796,211	290	507	4,220
4225500353	Karnes	15	5,683,173	18,794,244	294	182	4,200
4225500414	Karnes	15	5,678,454	18,797,464	263	458	4,140
4225500553	Karnes	15	5,609,654	18,795,781	341	117	7,010
4225500613	Karnes	15	5,599,160	18,814,245	347	50	2,460
4225500722	Karnes	15	5,561,500	18,850,803	334	80	11,430
4225500811	Karnes	15	5,523,375	18,807,359	440	292	4,170
4225500819	Karnes	15	5,523,316	18,806,909	429	170	4,000
4225500832	Karnes	15	5,524,817	18,807,516	427	100	4,060
4225500833	Karnes	15	5,525,150	18,807,421	421	300	3,950
4225500842	Karnes	15	5,556,921	18,799,259	438	40	8,000
4225500848	Karnes	15	5,559,386	18,796,777	477	1,500	7,920
4225500850	Karnes	15	5,558,259	18,801,180	465	1,580	7,870
4225500851	Karnes	15	5,560,497	18,800,714	501	41	8,010
4225500852	Karnes	15	5,559,522	18,802,749	490	1,582	7,870
4225500853	Karnes	15	5,559,692	18,805,858	461	10	8,010
4225500855	Karnes	15	5,542,606	18,817,437	483	108	4,310
4225500878	Karnes	15	5,552,484	18,834,888	444	380	4,300
4225500879	Karnes	15	5,550,570	18,832,926	398	400	4,060
4225500880	Karnes	15	5,552,973	18,836,842	438	378	4,060
4225500882	Karnes	15	5,553,197	18,835,544	430	429	4,035

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4225500885	Karnes	15	5,557,641	18,835,238	362	80	4,203
4225501016	Karnes	15	5,623,453	18,755,852	403	50	8,530
4225501034	Karnes	15	5,628,048	18,757,338	441	150	3,900
4225520073	Karnes	15	5,626,593	18,755,305	436	273	3,725
4225530283	Karnes	15	5,650,421	18,768,402	402	68	15,035
4225530597	Karnes	15	5,539,846	18,791,294	413	0	916
4225530603	Karnes	15	5,542,163	18,793,731	417	24	940
4225530730	Karnes	15	5,544,111	18,789,980	356	70	900
4225531202	Karnes	15	5,649,053	18,825,740	284	80	9,670
4226100225	Kenedy	16	5,624,606	18,122,336	28	120	11,510
4226100226	Kenedy	16	5,625,968	18,119,707	23	97	9,778
4226100227	Kenedy	16	5,625,735	18,124,959	37	100	9,711
4226130175	Kenedy	16	5,618,334	18,154,254	33	39	10,020
4227300036	Kleberg	16	5,550,998	18,347,151	138	80	6,800
4227300037	Kleberg	16	5,551,089	18,344,083	137	44	6,961
4227300239	Kleberg	16	5,575,668	18,360,496	133	37	8,410
4227300289	Kleberg	16	5,587,424	18,356,618	111	104	8,000
4227300306	Kleberg	16	5,589,620	18,353,556	99	99	8,020
4227300504	Kleberg	16	5,582,033	18,326,366	103	100	8,000
4227300505	Kleberg	16	5,583,273	18,326,403	92	120	1,406
4227300506	Kleberg	16	5,584,673	18,326,550	90	98	7,300
4227300508	Kleberg	16	5,604,656	18,343,437	78	100	8,006
4227300537	Kleberg	16	5,687,814	18,333,646	33	80	11,000
4227300582	Kleberg	16	5,789,043	18,274,660	11	151	11,020
4227301002	Kleberg	16	5,633,944	18,306,058	38	321	3,560
4227301004	Kleberg	16	5,634,637	18,305,795	38	330	6,134
4227301047	Kleberg	16	5,615,582	18,322,014	62	190	4,660
4227301076	Kleberg	16	5,630,743	18,304,644	49	190	3,680
4227301304	Kleberg	16	5,556,532	18,317,725	122	90	8,505
4227301312	Kleberg	16	5,552,523	18,319,058	125	101	7,100
4227301915	Kleberg	16	5,614,603	18,340,697	64	100	3,442
4227301972	Kleberg	16	5,621,580	18,339,785	55	390	8,110
4227302022	Kleberg	16	5,620,523	18,346,118	55	320	4,500
4227330109	Kleberg	16	5,620,239	18,339,739	57	519	8,020
4228500187	Lavaca	15	5,978,722	18,982,316	153	90	9,060

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4228500343	Lavaca	15	5,948,523	18,972,812	150	61	9,500
4228500431	Lavaca	15	5,932,131	18,946,694	145	64	16,011
4228531445	Lavaca	15	5,978,614	18,978,665	149	100	747
4229131424	Liberty	14	6,646,664	19,276,693	55	92	3,434
4229132387	Liberty	14	6,495,220	19,305,304	81	80	11,410
4229701037	Live Oak	16	5,507,906	18,654,544	272	106	2,706
4229701041	Live Oak	16	5,507,782	18,653,745	271	230	2,052
4229701045	Live Oak	16	5,506,595	18,652,502	302	101	2,030
4229701137	Live Oak	16	5,517,641	18,607,803	229	240	3,710
4229701138	Live Oak	16	5,518,351	18,608,492	213	232	3,720
4229701139	Live Oak	16	5,517,682	18,608,236	228	228	3,706
4229701222	Live Oak	16	5,507,448	18,598,873	214	46	10,275
4229701228	Live Oak	16	5,509,843	18,598,886	200	90	3,850
4229701364	Live Oak	16	5,562,593	18,683,777	320	88	8,010
4229701367	Live Oak	16	5,561,102	18,685,079	324	99	7,790
4229701819	Live Oak	16	5,582,899	18,560,909	147	164	5,530
4229702031	Live Oak	16	5,486,546	18,563,563	337	80	12,189
4229702327	Live Oak	16	5,556,533	18,546,873	216	120	2,430
4229702352	Live Oak	16	5,534,441	18,536,690	259	80	4,670
4229702353	Live Oak	16	5,533,405	18,537,509	260	200	5,510
4229702433	Live Oak	16	5,458,936	18,586,871	458	34	2,160
4229702659	Live Oak	16	5,552,088	18,547,715	211	120	4,870
4229730552	Live Oak	16	5,526,225	18,555,016	208	210	5,020
4229730597	Live Oak	16	5,502,463	18,751,278	336	270	21,050
4229734339	Live Oak	16	5,499,938	18,749,433	347	650	6,287
4231101621	McMullen	16	5,394,722	18,553,891	441	100	2,616
4232100945	Matagorda	15	6,207,722	18,879,431	51	74	10,650
4232100946	Matagorda	15	6,207,441	18,879,469	51	110	12,590
4232101011	Matagorda	15	6,206,370	18,880,716	53	100	11,520
4232101019	Matagorda	15	6,212,335	18,883,364	60	128	10,291
4232101022	Matagorda	15	6,212,342	18,880,422	48	100	10,300
4232101025	Matagorda	15	6,214,783	18,883,091	49	105	10,470
4232101026	Matagorda	15	6,214,550	18,883,181	49	100	10,444
4232101226	Matagorda	15	6,149,658	18,884,016	58	140	1,610
4232101254	Matagorda	15	6,149,516	18,883,229	56	140	1,920

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4232101273	Matagorda	15	6,148,111	18,884,146	55	331	3,310
4232101278	Matagorda	15	6,148,296	18,884,156	55	316	3,160
4232101285	Matagorda	15	6,144,841	18,881,241	52	30	6,650
4232101286	Matagorda	15	6,145,655	18,881,342	52	164	4,890
4232101587	Matagorda	15	6,143,817	18,884,170	55	180	7,500
4232130256	Matagorda	15	6,121,233	18,775,610	8	320	859
4232130995	Matagorda	15	6,121,441	18,777,602	10	90	9,120
4232131061	Matagorda	15	6,233,387	18,799,955	19	118	16,940
4232131364	Matagorda	15	6,267,091	18,845,831	15	82	14,390
4232131723	Matagorda	15	6,136,403	18,790,394	15	70	10,250
4233900103	Montgomery	14	6,340,497	19,378,744	223	630	5,010
4233900104	Montgomery	14	6,341,599	19,378,289	196	520	5,440
4233900139	Montgomery	14	6,352,572	19,369,463	199	148	5,481
4233900141	Montgomery	14	6,352,855	19,368,662	197	90	5,310
4233900154	Montgomery	14	6,350,344	19,370,459	211	90	5,230
4233900155	Montgomery	14	6,349,889	19,370,485	209	90	5,450
4233900910	Montgomery	14	6,329,510	19,386,739	287	686	4,592
4233900926	Montgomery	14	6,358,150	19,386,669	228	609	5,080
4233900979	Montgomery	14	6,299,602	19,392,029	241	85	4,770
4233901121	Montgomery	14	6,340,074	19,325,396	148	493	5,850
4233901416	Montgomery	14	6,358,943	19,305,792	116	110	6,110
4233901420	Montgomery	14	6,357,150	19,305,245	124	520	6,130
4233901425	Montgomery	14	6,351,057	19,308,535	137	641	7,310
4233901718	Montgomery	14	6,406,187	19,314,551	117	84	11,320
4233901737	Montgomery	14	6,370,658	19,301,101	105	60	7,560
4233901738	Montgomery	14	6,369,943	19,301,736	105	74	6,574
4233901779	Montgomery	14	6,353,558	19,307,550	125	531	6,210
4233901879	Montgomery	14	6,341,561	19,325,180	159	373	5,830
4235100394	Newton	14	6,884,672	19,379,321	25	90	8,560
4235100398	Newton	14	6,884,645	19,377,686	31	80	8,420
4235500013	Nueces	16	5,599,781	18,463,480	114	226	5,847
4235500386	Nueces	16	5,636,896	18,431,659	87	368	7,241
4235500417	Nueces	16	5,637,142	18,432,208	77	369	7,226
4235500422	Nueces	16	5,636,941	18,433,456	71	400	7,513
4235500423	Nueces	16	5,636,611	18,432,868	72	313	7,274

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4235503199	Nueces	16	5,745,598	18,362,688	23	150	5,520
4235504659	Nueces	16	5,647,411	18,389,253	61	182	4,524
4235505970	Nueces	16	5,628,001	18,349,589	56	627	7,397
4235505978	Nueces	16	5,597,865	18,377,207	94	100	2,236
4235506684	Nueces	16	5,651,126	18,390,767	59	330	5,510
4235532446	Nueces	16	5,599,649	18,463,479	114	224	4,430
4239100086	Refugio	15	5,928,337	18,642,510	14	50	10,031
4239102287	Refugio	15	5,797,868	18,619,457	47	427	4,800
4239102342	Refugio	15	5,796,741	18,627,218	49	117	5,385
4239102346	Refugio	15	5,797,868	18,619,457	35	316	8,196
4239102530	Refugio	15	5,799,600	18,624,580	40	470	6,450
4239130253	Refugio	15	5,923,040	18,679,949	4	628	7,800
4239130260	Refugio	15	5,920,244	18,681,104	31	620	7,800
4239130547	Refugio	15	5,923,028	18,680,952	34	451	6,020
4240900047	San Patricio	16	5,638,315	18,557,285	159	200	2,970
4240900274	San Patricio	16	5,646,545	18,550,430	137	85	5,130
4240900346	San Patricio	16	5,683,645	18,549,827	106	120	6,054
4240900355	San Patricio	16	5,650,899	18,551,986	139	169	5,821
4240900372	San Patricio	16	5,706,267	18,546,127	79	205	6,840
4240900448	San Patricio	16	5,717,510	18,530,513	51	200	3,702
4240900451	San Patricio	16	5,717,583	18,531,251	50	244	3,733
4240900457	San Patricio	16	5,717,061	18,530,970	53	135	3,670
4240900488	San Patricio	16	5,715,059	18,534,044	60	318	2,060
4240900525	San Patricio	16	5,712,064	18,535,095	60	100	1,400
4240900531	San Patricio	16	5,715,829	18,535,181	61	80	2,012
4240900615	San Patricio	16	5,715,762	18,535,110	61	90	2,045
4240900616	San Patricio	16	5,709,673	18,535,263	57	90	2,050
4240900898	San Patricio	16	5,696,473	18,542,722	89	343	6,290
4240900907	San Patricio	16	5,695,113	18,542,978	91	218	6,520
4240901049	San Patricio	16	5,666,759	18,525,706	116	224	5,810
4240901466	San Patricio	16	5,766,550	18,536,267	36	100	6,767
4240901798	San Patricio	16	5,763,609	18,515,939	47	269	4,180
4240901967	San Patricio	16	5,767,804	18,535,764	40	463	6,480
4240901988	San Patricio	16	5,768,160	18,522,169	44	25	4,940
4240902801	San Patricio	16	5,741,486	18,489,541	59	160	3,216

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4240903834	San Patricio	16	5,683,232	18,489,849	95	0	7,320
4240903838	San Patricio	16	5,684,519	18,491,584	91	60	5,800
4240903989	San Patricio	16	5,698,772	18,541,350	85	234	3,786
4240903997	San Patricio	16	5,717,464	18,532,535	54	130	2,870
4240904001	San Patricio	16	5,716,414	18,532,996	55	219	4,220
4240904015	San Patricio	16	5,705,675	18,515,809	51	125	5,640
4240904196	San Patricio	16	5,715,686	18,530,095	53	100	2,507
4240931650	San Patricio	16	5,705,576	18,546,284	80	400	6,800
4240931657	San Patricio	16	5,650,608	18,552,219	133	214	5,230
4240931671	San Patricio	16	5,648,258	18,548,590	130	200	5,251
4240931672	San Patricio	16	5,650,019	18,551,179	134	222	5,330
4240932081	San Patricio	16	5,639,154	18,557,914	158	214	3,170
4245700092	Tyler	14	6,707,765	19,516,735	140	450	10,200
4245700143	Tyler	14	6,687,139	19,478,952	101	150	9,500
4245700196	Tyler	14	6,690,352	19,479,633	118	122	8,588
4245700199	Tyler	14	6,688,920	19,477,651	98	109	10,500
4245700366	Tyler	14	6,761,388	19,492,852	60	100	9,650
4246900158	Victoria	15	5,965,405	18,825,047	46	25	7,010
4246900407	Victoria	15	5,903,910	18,815,650	95	299	3,420
4246900519	Victoria	15	5,880,762	18,808,282	97	250	2,720
4246900521	Victoria	15	5,879,593	18,797,761	50	987	3,090
4246900800	Victoria	15	5,854,285	18,851,051	140	25	9,230
4246900801	Victoria	15	5,855,057	18,851,266	147	80	6,020
4246900856	Victoria	15	5,837,548	18,839,975	93	120	3,485
4246900857	Victoria	15	5,836,484	18,838,676	105	128	3,150
4246900998	Victoria	15	5,875,432	18,798,456	57	261	3,250
4246901010	Victoria	15	5,881,119	18,789,514	43	200	4,010
4246901051	Victoria	15	5,881,073	18,791,569	45	244	2,710
4246901059	Victoria	15	5,880,883	18,799,233	49	962	3,340
4246901569	Victoria	15	5,880,346	18,712,807	70	58	6,840
4246901571	Victoria	15	5,881,877	18,714,210	71	81	6,410
4246901644	Victoria	15	5,899,743	18,766,599	70	113	2,060
4246901660	Victoria	15	5,897,580	18,760,488	69	106	4,713
4246901666	Victoria	15	5,897,026	18,757,979	67	100	4,762
4246901754	Victoria	15	5,939,233	18,766,236	53	879	4,748

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4246901792	Victoria	15	5,938,969	18,766,371	54	875	4,760
4246901887	Victoria	15	5,929,338	18,758,716	56	107	6,850
4246902061	Victoria	15	5,917,107	18,748,918	58	276	4,025
4246902423	Victoria	15	5,922,246	18,741,523	50	255	6,198
4246902560	Victoria	15	5,940,958	18,763,792	50	320	4,780
4246902893	Victoria	15	5,902,637	18,764,140	67	326	6,464
4246903066	Victoria	15	5,914,964	18,752,913	59	404	6,820
4246930303	Victoria	15	5,836,579	18,839,864	105	330	3,508
4246930589	Victoria	15	5,941,458	18,763,742	50	523	7,032
4246932781	Victoria	15	5,894,162	18,829,706	114	332	3,130
4246932847	Victoria	15	5,918,698	18,743,398	55	580	5,555
4247130016	Walker	14	6,292,801	19,462,636	212	90	19,450
4247902011	Webb	16	5,299,530	18,298,839	762	61	3,510
4247902046	Webb	16	5,303,611	18,289,105	743	75	3,620
4247902483	Webb	16	5,259,296	18,309,002	850	100	2,520
4247902487	Webb	16	5,255,667	18,311,360	856	71	2,500
4247902608	Webb	16	5,254,933	18,310,371	857	127	1,939
4247902657	Webb	16	5,260,811	18,308,391	846	60	2,080
4247902807	Webb	16	5,251,978	18,286,012	896	33	1,880
4247904672	Webb	16	5,299,398	18,297,137	762	100	3,450
4247904846	Webb	16	5,299,623	18,296,419	760	99	3,436
4247904876	Webb	16	5,301,109	18,294,693	769	97	3,440
4247904902	Webb	16	5,299,296	18,294,214	774	80	3,460
4247904905	Webb	16	5,303,703	18,289,015	744	80	3,457
4247904941	Webb	16	5,299,990	18,301,249	762	101	3,459
4247933395	Webb	16	5,296,491	18,296,359	778	56	1,110
4247933812	Webb	16	5,255,017	18,309,877	858	44	2,006
4248100824	Wharton	15	6,212,944	18,986,959	83	320	2,787
4248101213	Wharton	15	6,105,720	19,061,721	155	80	14,189
4248101603	Wharton	15	6,097,211	18,959,840	109	596	6,210
4248130006	Wharton	15	6,109,855	18,927,455	86	300	7,090
4248130084	Wharton	15	6,144,363	18,982,075	99	339	6,350
4248132108	Wharton	15	6,213,380	18,986,972	82	426	3,010
4248132241	Wharton	15	6,108,056	18,928,662	86	430	5,620
4248132571	Wharton	15	6,114,097	18,931,832	90	530	7,220

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4248133033	Wharton	15	6,100,904	18,960,776	107	618	4,667
4248133274	Wharton	15	6,100,651	19,005,269	129	100	8,100
4248134117	Wharton	15	6,147,540	19,080,019	127	500	5,010
4250500388	Zapata	13	5,260,576	18,181,324	660	108	3,260
4250500395	Zapata	13	5,258,221	18,182,305	642	102	2,000

19.6 Geophysical Logs Used for Predicting the Distribution of Total Dissolved Solids Concentration in Groundwater in the Texas Gulf Coast Aquifer System

Description of Table Attributes

API	– American Petroleum Institute ID for the geophysical log
County	– County in which log is located
GAM	– Groundwater Availability Model
GMA	– Groundwater Management Area in which log is located
Easting	– Easting (feet) in Groundwater Availability coordinate system
Northing	– Northing (feet) in Groundwater Availability coordinate system
Ground Surface Elevation (feet- NAVD88)	– Ground surface elevation in feet using NAV 88
Min Depth	– minimum depth: start of log coverage measured as depth below ground surface
Max Depth	– maximum depth: end of log coverage measured as depth below ground surface

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Table 19-6. Geophysical logs used for predicting the distribution of total dissolved solids concentration in groundwater in the Texas Gulf coast Aquifer System.

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
1701100087	Gulf	NA	6,988,992	19,581,703	180	85	3,480
1701100642	Gulf	NA	6,948,278	19,511,418	135	120	12,644
4200500192	Angelina	11	6,687,428	19,717,326	137	247	3,080
4200530119	Angelina	11	6,708,941	19,679,857	219	59	2,810
4200530171	Angelina	11	6,568,842	19,703,806	200	131	2,140
4200530174	Angelina	11	6,532,502	19,718,559	191	115	8,470
4200700067	Aransas	15	5,898,946	18,580,232	6	101	11,520
4200700354	Aransas	15	5,866,141	18,603,497	28	513	6,550
4200700858	Aransas	15	5,923,622	18,611,208	17	90	9,270
4200730660	Aransas	15	5,915,753	18,561,908	24	157	10,018
4200730778	Aransas	15	5,858,828	18,504,254	19	1,108	8,100
4200730804	Aransas	15	5,845,158	18,479,459	4	481	3,693
4201500018	Austin	14	6,045,696	19,255,138	295	120	11,020
4201500230	Austin	14	6,143,780	19,254,454	149	70	11,372
4201500262	Austin	14	6,124,061	19,162,923	212	107	10,880
4201500591	Austin	14	6,047,805	19,205,127	357	100	10,600
4201500624	Austin	14	6,073,669	19,238,464	259	100	10,510
4201500662	Austin	14	6,090,884	19,190,557	259	210	4,760
4201500683	Austin	14	6,151,902	19,119,351	158	202	12,999
4201530138	Austin	14	6,120,584	19,267,037	267	100	11,013
4202500474	Bee	16	5,563,041	18,728,736	363	58	17,019
4202501511	Bee	16	5,687,263	18,611,556	117	80	5,520
4202501665	Bee	16	5,603,721	18,686,247	381	221	4,325
4202502026	Bee	16	5,653,086	18,579,222	167	109	4,612
4202502430	Bee	15	5,740,688	18,629,408	105	100	5,580
4202530031	Bee	16	5,629,724	18,689,868	375	133	16,020
4202531493	Bee	15	5,640,015	18,718,589	365	54	5,318
4202531557	Bee	15	5,594,472	18,747,470	446	299	4,015
4202531816	Bee	16	5,620,454	18,631,914	225	193	5,813
4202531912	Bee	16	5,628,613	18,595,159	219	217	4,711
4202532065	Bee	16	5,580,200	18,665,895	378	218	3,500
4202532278	Bee	15	5,664,891	18,674,868	257	113	18,522
4202532433	Bee	16	5,662,866	18,644,752	171	100	6,140

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4202532584	Bee	15	5,685,823	18,695,166	223	226	2,621
4203900064	Gulf	NA	6,397,889	19,088,371	58	100	8,613
4203900965	Brazoria	14	6,435,720	19,017,879	36	100	10,000
4203900984	Brazoria	14	6,434,385	19,013,881	45	200	18,000
4203901420	Gulf	NA	6,390,827	19,028,836	38	52	9,950
4203901452	Brazoria	14	6,362,166	19,009,956	39	91	9,765
4203901711	Brazoria	14	6,401,951	18,991,948	23	608	6,112
4203901910	Brazoria	14	6,341,750	18,988,025	36	140	10,210
4203902865	Brazoria	14	6,288,573	18,959,610	41	101	3,470
4203903898	Brazoria	14	6,321,829	18,921,523	48	131	12,267
4203904069	Brazoria	14	6,292,940	18,897,057	26	142	13,988
4203904224	Brazoria	14	6,381,303	18,981,324	32	100	9,550
4203904263	Brazoria	14	6,410,396	18,984,364	19	100	8,580
4203904277	Brazoria	14	6,417,582	18,944,157	3	90	8,840
4203904291	Brazoria	14	6,423,430	18,905,923	4	101	7,425
4203904467	Brazoria	14	6,370,203	18,934,265	35	97	14,033
4203904481	Brazoria	14	6,464,555	18,984,359	28	211	16,073
4203932152	Brazoria	14	6,367,933	19,048,007	89	70	16,600
4204100012	Brazos	12	6,115,595	19,472,499	192	80	6,904
4204100068	Brazos	12	6,110,974	19,419,867	318	60	7,160
4204100102	Brazos	12	6,132,561	19,377,656	148	90	2,110
4204700117	Brooks	16	5,505,081	18,199,927	121	108	7,790
4204700309	Brooks	16	5,564,049	18,165,293	49	65	10,350
4204700435	Brooks	16	5,455,662	18,195,474	307	241	5,517
4204700694	Brooks	16	5,481,872	18,138,352	238	80	8,010
4204701249	Brooks	16	5,544,348	18,136,190	122	104	9,513
4204701267	Brooks	16	5,572,168	18,124,680	76	106	12,006
4204730017	Brooks	16	5,510,195	18,158,624	172	2,481	12,007
4204730662	Brooks	16	5,537,515	18,089,753	107	75	4,606
4204731513	Brooks	16	5,452,143	18,164,208	280	2,490	12,000
4204731639	Brooks	16	5,506,655	18,093,305	192	83	12,440
4204732065	Brooks	16	5,465,290	18,150,271	251	2,150	5,800
4205130950	Burleson	12	6,081,674	19,391,221	200	128	9,930
4205700284	Calhoun	15	6,013,069	18,751,429	24	1,584	6,210
4205700852	Calhoun	15	6,059,172	18,749,685	18	80	5,550

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4205700872	Calhoun	15	6,050,481	18,728,390	3	162	8,701
4205701185	Calhoun	15	5,954,324	18,596,507	20	190	9,475
4205701221	Calhoun	15	6,018,835	18,624,691	19	153	10,208
4205701248	Calhoun	15	5,969,034	18,743,165	31	112	6,289
4205701323	Calhoun	15	5,942,369	18,705,957	20	1,671	9,878
4205730876	Calhoun	15	6,038,752	18,680,192	35	80	12,167
4205730903	Calhoun	15	6,083,437	18,714,222	30	131	15,097
4207100226	Chambers	14	6,534,287	19,216,690	60	79	7,250
4207100972	Chambers	14	6,559,264	19,178,112	3	140	8,311
4207101074	Chambers	14	6,542,873	19,215,250	41	1,173	13,680
4207101083	Chambers	14	6,593,417	19,227,175	35	100	5,800
4207101209	Chambers	14	6,619,221	19,198,187	35	64	7,230
4207102177	Chambers	14	6,672,383	19,180,246	29	101	8,510
4207102466	Chambers	14	6,597,815	19,123,256	4	100	8,860
4207102513	Chambers	14	6,631,878	19,152,688	9	100	9,230
4207102740	Chambers	14	6,584,027	19,137,989	20	97	9,770
4207102880	Chambers	14	6,560,452	19,097,080	0	190	9,850
4207103062	Chambers	14	6,522,786	19,139,619	18	254	8,826
4207103096	Chambers	14	6,517,723	19,104,709	20	130	10,020
4207131302	Chambers	14	6,662,812	19,211,935	49	2,188	9,720
4207131458	Chambers	14	6,557,406	19,199,579	29	81	14,780
4208900057	Colorado	15	6,013,748	19,166,319	250	144	9,090
4208900090	Colorado	15	6,049,923	19,165,151	318	100	10,230
4208900345	Colorado	15	6,021,952	19,141,166	187	63	10,000
4208900354	Gulf	NA	5,999,080	19,131,540	256	81	10,020
4208900436	Colorado	15	6,004,364	19,097,869	297	150	11,000
4208900484	Colorado	15	5,974,389	19,059,910	256	100	9,900
4208900724	Colorado	15	6,080,071	19,064,826	165	101	10,704
4208900755	Colorado	15	6,039,971	19,035,174	148	70	7,000
4208900970	Gulf	NA	6,072,517	19,107,063	198	40	9,630
4208930229	Colorado	15	6,069,166	19,156,881	232	31	11,010
4208930427	Colorado	15	6,055,994	19,023,287	166	71	10,005
4208930570	Colorado	15	6,041,732	19,103,368	213	100	10,510
4208930592	Colorado	15	6,029,331	19,082,751	199	60	11,900
4208931120	Colorado	15	6,014,339	19,045,007	190	531	6,800

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4208931221	Colorado	15	5,975,220	19,090,679	330	50	10,590
4208931246	Colorado	15	6,066,074	19,118,985	232	94	10,880
4208931348	Colorado	15	5,997,202	19,031,715	217	3,000	14,200
4208931376	Colorado	15	6,106,275	19,114,576	173	100	9,500
4208931531	Colorado	15	6,004,002	19,175,772	293	108	15,730
4208931604	Colorado	15	6,002,369	18,989,600	173	234	15,912
4208931611	Gulf	NA	5,938,834	19,130,365	413	100	1,600
4208931932	Colorado	15	5,953,108	19,082,617	313	103	9,855
4212300276	DeWitt	15	5,788,839	18,957,251	297	50	8,020
4212300279	DeWitt	15	5,770,003	18,941,836	280	100	3,529
4212300290	DeWitt	15	5,793,799	18,912,798	224	100	10,230
4212300337	DeWitt	15	5,659,673	18,878,268	494	1,041	9,021
4212300661	DeWitt	15	5,795,953	18,861,944	219	84	8,400
4212300722	DeWitt	15	5,782,801	18,838,952	231	95	8,890
4212300824	DeWitt	15	5,755,375	18,859,107	286	56	12,004
4212300905	DeWitt	15	5,702,984	18,822,026	339	100	13,486
4212300980	DeWitt	15	5,702,216	18,918,182	368	106	5,619
4212300982	DeWitt	15	5,838,404	18,923,475	240	100	8,500
4212330020	DeWitt	15	5,729,656	18,896,869	398	128	17,995
4212331022	DeWitt	15	5,685,004	18,862,434	344	100	15,971
4212331622	DeWitt	15	5,851,428	18,902,936	222	102	15,524
4213103501	Duval	16	5,385,861	18,441,856	632	96	13,820
4213107826	Duval	16	5,402,865	18,349,786	469	420	6,330
4213108480	Duval	16	5,445,869	18,391,207	476	788	7,018
4213109676	Duval	16	5,468,602	18,282,281	304	180	6,520
4213109917	Duval	16	5,391,087	18,306,567	489	140	6,020
4213110189	Duval	16	5,323,513	18,287,856	673	100	3,199
4213131667	Duval	16	5,374,369	18,512,197	485	125	10,240
4213131732	Duval	16	5,343,595	18,502,822	450	50	1,715
4213132341	Duval	16	5,474,605	18,326,340	278	300	5,750
4213133980	Duval	16	5,363,857	18,343,440	540	226	4,005
4213134947	Duval	16	5,404,972	18,500,894	559	80	16,560
4213135197	Duval	16	5,374,230	18,365,330	583	220	4,020
4213135869	Duval	16	5,338,120	18,325,182	683	219	3,615
4213136193	Duval	16	5,338,047	18,374,709	711	107	17,000

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4213136958	Duval	16	5,356,348	18,396,893	641	80	2,751
4213137128	Duval	16	5,434,965	18,290,165	375	60	7,600
4213137261	Duval	16	5,430,694	18,346,851	428	224	5,577
4213137552	Duval	16	5,324,916	18,486,649	422	50	1,650
4213137720	Duval	16	5,390,230	18,413,266	646	271	2,304
4213137895	Duval	16	5,424,837	18,463,913	526	79	10,485
4213138254	Duval	16	5,454,033	18,486,802	525	198	11,900
4214932049	Fayette	15	5,931,064	19,170,367	355	19	891
4215700001	Fort Bend	14	6,228,985	19,164,234	155	115	7,530
4215700030	Fort Bend	14	6,257,485	19,167,712	140	80	7,600
4215700894	Fort Bend	14	6,293,959	19,105,289	74	98	8,748
4215700940	Fort Bend	14	6,276,356	19,145,194	107	180	8,400
4215701026	Fort Bend	14	6,236,799	19,133,919	102	155	12,934
4215701374	Fort Bend	14	6,189,139	19,046,006	85	438	5,800
4215701674	Fort Bend	14	6,241,766	19,006,999	77	121	5,219
4215701729	Fort Bend	14	6,258,446	19,038,088	92	100	5,800
4215702459	Fort Bend	14	6,315,327	19,059,258	73	104	9,040
4215730949	Fort Bend	14	6,271,177	19,010,584	81	90	7,610
4215731152	Fort Bend	14	6,360,197	19,063,986	96	101	22,090
4215731513	Fort Bend	14	6,359,532	19,103,049	84	92	8,039
4215731695	Fort Bend	14	6,196,453	19,117,008	151	63	14,000
4215731732	Fort Bend	14	6,199,874	19,094,154	125	70	4,120
4215731805	Fort Bend	14	6,207,080	19,057,326	120	60	9,220
4215731983	Fort Bend	14	6,247,499	19,108,232	102	75	8,830
4216700035	Galveston	14	6,440,002	19,088,138	49	108	13,030
4216700956	Galveston	14	6,596,086	19,074,104	16	175	7,721
4216700966	Galveston	14	6,537,521	19,061,114	22	100	10,370
4216701142	Galveston	14	6,522,689	19,034,365	19	100	9,850
4216701276	Galveston	14	6,457,544	19,073,262	33	100	9,910
4216701336	Galveston	14	6,490,750	19,010,362	34	122	16,020
4216701876	Galveston	14	6,458,606	19,045,949	54	100	12,610
4216701916	Galveston	14	6,532,163	18,977,654	26	123	19,000
4216730091	Galveston	14	6,569,301	19,011,446	15	109	10,500
4217500722	Goliad	15	5,811,488	18,813,393	137	207	4,110
4217501384	Goliad	15	5,715,265	18,745,080	214	539	4,734

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4217501456	Goliad	15	5,686,208	18,756,813	196	100	11,197
4217501928	Goliad	15	5,658,003	18,737,375	366	99	9,314
4217531593	Goliad	15	5,731,557	18,793,468	269	176	3,015
4217531719	Goliad	15	5,806,596	18,745,139	129	72	4,796
4217531945	Goliad	15	5,771,845	18,665,122	103	319	5,501
4217532165	Goliad	15	5,751,916	18,688,734	152	524	5,228
4217532197	Goliad	15	5,752,865	18,704,331	130	534	5,120
4217532584	Goliad	15	5,695,569	18,716,792	274	61	4,010
4217532636	Goliad	15	5,732,962	18,728,474	210	50	1,620
4217533350	Goliad	15	5,715,972	18,742,556	188	609	3,280
4217700298	Gonzales	13	5,756,760	18,985,441	301	1,834	12,536
4217700424	Gonzales	13	5,731,515	18,960,246	241	102	13,369
4218500024	Grimes	14	6,199,031	19,493,458	379	80	4,810
4218500034	Grimes	14	6,179,574	19,435,793	377	100	1,990
4218530009	Grimes	14	6,226,501	19,351,114	331	113	7,653
4218530028	Grimes	14	6,215,568	19,426,872	375	74	10,830
4218530340	Grimes	14	6,175,798	19,403,302	250	455	1,987
4218530369	Grimes	14	6,215,425	19,452,935	359	101	13,760
4218530399	Grimes	14	6,203,729	19,351,406	338	337	5,520
4219900116	Hardin	14	6,763,200	19,463,425	44	81	7,610
4219900356	Hardin	14	6,746,966	19,392,528	32	100	8,921
4219900618	Hardin	14	6,672,722	19,451,551	84	106	7,602
4219900634	Hardin	14	6,687,623	19,418,502	110	91	11,010
4219900674	Hardin	14	6,677,660	19,382,997	87	807	9,010
4219900757	Hardin	14	6,615,370	19,437,693	135	118	7,360
4219902148	Hardin	14	6,689,663	19,336,380	37	100	10,000
4219931811	Hardin	14	6,759,676	19,419,071	58	153	1,775
4219931816	Hardin	14	6,715,099	19,424,416	80	110	15,400
4220100104	Harris	14	6,285,129	19,280,252	183	129	5,680
4220102658	Harris	14	6,475,025	19,250,819	70	90	9,250
4220102722	Harris	14	6,443,654	19,246,124	60	90	9,070
4220102936	Harris	14	6,424,888	19,182,101	39	202	6,933
4220102972	Harris	14	6,387,726	19,246,088	83	99	8,010
4220103343	Harris	14	6,359,560	19,228,681	76	50	7,610
4220103510	Harris	14	6,361,559	19,181,324	88	89	8,842

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4220103533	Harris	14	6,338,213	19,243,441	124	90	7,520
4220104068	Harris	14	6,322,648	19,168,973	76	120	8,510
4220104395	Harris	14	6,291,077	19,162,276	91	241	8,510
4220105058	Harris	14	6,379,936	19,134,187	58	103	8,630
4220106044	Harris	14	6,491,261	19,130,689	34	91	10,010
4220106223	Harris	14	6,507,505	19,165,621	26	99	8,433
4220107603	Harris	14	6,428,854	19,273,358	91	82	8,550
4220107892	Harris	14	6,220,005	19,282,357	294	370	6,510
4220107904	Harris	14	6,335,044	19,203,526	120	90	17,010
4220130016	Harris	14	6,427,792	19,140,648	48	100	5,003
4220130958	Harris	14	6,456,266	19,286,600	109	532	9,350
4220131506	Harris	14	6,213,142	19,262,377	260	547	5,540
4220132062	Harris	14	6,421,626	19,219,610	65	450	3,703
4220132187	Harris	14	6,335,557	19,289,583	158	97	6,510
4220132368	Harris	14	6,232,694	19,233,428	172	479	3,410
4220132375	Harris	14	6,284,521	19,244,232	148	69	2,896
4221501092	Hidalgo	16	5,587,416	17,920,747	69	139	11,375
4223900014	Jackson	15	5,918,061	18,909,941	125	98	10,010
4223900047	Jackson	15	5,947,455	18,883,975	92	175	5,015
4223900098	Jackson	15	5,973,251	18,939,321	120	400	4,790
4223900120	Jackson	15	6,009,460	18,933,850	92	430	3,320
4223900233	Jackson	15	5,995,476	18,901,283	86	415	2,860
4223900309	Jackson	15	5,977,709	18,928,595	110	445	4,865
4223900816	Jackson	15	6,047,845	18,882,521	69	237	4,250
4223901090	Jackson	15	6,053,940	18,863,374	61	300	8,034
4223901427	Jackson	15	6,084,394	18,823,294	41	70	9,620
4223901520	Jackson	15	6,055,757	18,807,902	38	461	9,226
4223901556	Jackson	15	5,971,405	18,864,872	76	300	5,820
4223901728	Jackson	15	5,978,823	18,853,821	71	107	6,400
4223901917	Jackson	15	6,001,887	18,835,989	16	174	6,095
4223901921	Jackson	15	5,983,759	18,831,167	55	120	6,930
4223901992	Jackson	15	6,018,668	18,828,249	12	166	7,230
4223903228	Jackson	15	6,071,551	18,789,543	26	84	9,290
4223903329	Jackson	15	6,025,578	18,868,340	44	512	7,020
4223903378	Jackson	15	6,012,001	18,796,381	1	89	2,396

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4223933136	Jackson	15	6,024,989	18,791,913	34	660	6,200
4224100205	Jasper	14	6,780,757	19,434,522	36	100	11,060
4224100250	Jasper	14	6,777,522	19,557,270	128	490	5,430
4224100253	Jasper	14	6,720,398	19,659,977	204	94	9,800
4224100300	Gulf	NA	6,819,801	19,449,032	107	1,113	8,334
4224130308	Jasper	14	6,791,020	19,589,139	207	190	14,050
4224130545	Jasper	14	6,806,436	19,493,883	293	71	4,830
4224500169	Jefferson	14	6,769,444	19,321,521	31	75	7,900
4224500541	Jefferson	14	6,753,015	19,298,839	27	97	8,780
4224501318	Jefferson	14	6,794,570	19,283,613	15	150	13,026
4224501501	Jefferson	14	6,825,670	19,251,961	16	1,344	9,270
4224501637	Jefferson	14	6,784,878	19,247,015	11	100	8,530
4224501654	Jefferson	14	6,783,280	19,262,940	23	103	9,310
4224502143	Jefferson	14	6,689,792	19,247,327	33	983	10,030
4224502265	Jefferson	14	6,724,801	19,236,633	32	83	12,900
4224502689	Jefferson	14	6,735,588	19,195,484	9	90	8,550
4224502996	Jefferson	14	6,794,807	19,171,945	1	91	7,350
4224530143	Jefferson	14	6,782,114	19,204,379	19	30	8,750
4224530358	Jefferson	14	6,859,844	19,181,616	2	2,559	8,720
4224531562	Jefferson	14	6,696,107	19,312,140	34	74	13,000
4224532572	Jefferson	14	6,778,915	19,280,661	30	236	7,750
4224700207	Jim Hogg	16	5,324,933	18,262,292	650	161	3,068
4224702215	Jim Hogg	16	5,307,832	18,111,271	690	118	4,011
4224702371	Jim Hogg	16	5,378,968	18,132,414	447	161	5,005
4224702376	Jim Hogg	16	5,388,741	18,068,544	426	242	4,264
4224702459	Jim Hogg	16	5,416,043	18,123,971	328	144	5,510
4224702498	Jim Hogg	16	5,434,724	18,070,481	250	88	7,812
4224702610	Jim Hogg	16	5,400,593	18,185,281	421	41	7,140
4224731484	Jim Hogg	16	5,271,097	18,157,107	536	212	3,121
4224731565	Jim Hogg	16	5,378,680	18,245,469	490	2,685	9,840
4224731695	Jim Hogg	16	5,303,805	18,212,735	734	130	3,000
4224731713	Jim Hogg	16	5,306,476	18,200,317	728	890	9,800
4224731749	Jim Hogg	16	5,341,137	18,189,635	575	500	5,040
4224731878	Jim Hogg	16	5,332,339	18,204,433	619	480	4,180
4224731940	Jim Hogg	16	5,272,088	18,212,584	750	211	3,670

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4224731995	Jim Hogg	16	5,369,289	18,186,672	513	1,141	5,810
4224732254	Jim Hogg	16	5,387,659	18,180,754	451	2,977	6,862
4224732275	Jim Hogg	16	5,351,382	18,076,611	513	1,203	4,670
4224901494	Gulf	NA	5,494,399	18,405,362	311	1,772	7,397
4224901791	Jim Wells	16	5,552,373	18,400,213	1	388	5,260
4224902710	Jim Wells	16	5,515,041	18,275,133	190	534	6,280
4224903514	Jim Wells	16	5,538,209	18,253,970	135	102	7,427
4224930868	Jim Wells	16	5,530,130	18,336,629	185	416	6,507
4224930877	Jim Wells	16	5,601,497	18,493,717	147	215	5,810
4224931450	Jim Wells	16	5,575,171	18,476,315	181	158	3,601
4224931724	Jim Wells	16	5,521,031	18,464,369	272	213	3,432
4224932053	Jim Wells	16	5,504,641	18,426,643	298	879	7,504
4224932086	Jim Wells	16	5,555,991	18,435,070	194	496	4,326
4225500634	Karnes	15	5,592,471	18,837,728	344	1,020	8,350
4225500642	Karnes	15	5,632,543	18,852,750	280	59	2,600
4225500842	Gulf	NA	5,556,829	18,799,351	451	40	8,000
4225530246	Karnes	15	5,633,990	18,811,138	361	77	14,000
4225530609	Karnes	15	5,660,342	18,789,139	246	531	7,520
4225531346	Karnes	15	5,659,660	18,777,658	299	325	3,110
4226100100	Kenedy	16	5,706,935	18,204,530	23	452	10,930
4226100135	Kenedy	16	5,647,381	18,227,088	30	106	8,442
4226100155	Kenedy	16	5,587,803	18,227,321	75	3,553	10,364
4226100164	Kenedy	16	5,596,693	18,173,140	63	1,038	7,010
4226100179	Kenedy	16	5,640,057	18,178,381	36	90	9,900
4226100201	Kenedy	16	5,756,354	18,115,045	23	202	10,012
4226100219	Kenedy	16	5,684,815	18,097,421	51	100	12,120
4226100223	Kenedy	16	5,631,170	18,108,861	38	100	16,000
4226100248	Kenedy	16	5,586,114	18,071,155	39	86	10,000
4226100250	Kenedy	16	5,621,550	18,087,096	42	104	10,600
4226100272	Kenedy	16	5,674,928	18,014,091	18	100	8,522
4226100277	Kenedy	16	5,729,422	18,020,042	36	100	12,006
4226100291	Kenedy	16	5,764,232	18,052,852	23	188	12,998
4226100294	Kenedy	16	5,777,301	18,015,359	0	122	11,964
4226100341	Kenedy	16	5,664,979	18,197,619	47	101	16,044
4226100353	Kenedy	16	5,689,974	18,086,695	32	60	16,350

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4226100361	Kenedy	16	5,642,821	18,047,232	25	100	9,510
4226100393	Kenedy	16	5,626,848	18,136,293	53	60	17,050
4226130174	Kenedy	16	5,701,801	18,146,172	35	65	15,372
4227300003	Kleberg	16	5,563,435	18,374,056	146	152	5,850
4227300542	Kleberg	16	5,722,651	18,334,186	32	90	9,030
4227300554	Kleberg	16	5,776,589	18,333,281	28	100	9,510
4227300585	Kleberg	16	5,756,569	18,282,532	20	100	11,027
4227300845	Kleberg	16	5,659,932	18,263,984	33	100	8,571
4227300883	Kleberg	16	5,730,490	18,245,274	22	140	9,910
4227301085	Kleberg	16	5,634,596	18,281,316	48	42	8,024
4227301312	Kleberg	16	5,552,431	18,319,171	124	101	7,100
4227301778	Kleberg	16	5,769,646	18,264,880	26	197	10,508
4227301795	Kleberg	16	5,594,136	18,269,642	74	100	9,030
4227302116	Kleberg	16	5,804,628	18,321,956	29	267	8,950
4227332090	Kleberg	16	5,591,214	18,365,416	111	1,305	7,983
4227332336	Kleberg	16	5,581,610	18,297,406	103	1,550	12,850
4228500007	Lavaca	15	5,849,719	19,092,098	371	90	8,810
4228500191	Lavaca	15	5,927,620	19,056,845	201	100	9,904
4228500249	Lavaca	15	5,898,933	19,000,805	236	105	10,920
4228500308	Lavaca	15	5,943,939	18,995,673	198	297	12,127
4228500326	Lavaca	15	5,975,175	19,018,304	220	2,495	16,706
4228500354	Lavaca	15	5,841,350	18,970,083	248	163	8,659
4228500358	Lavaca	15	5,860,637	18,979,502	264	100	10,253
4228500431	Lavaca	15	5,932,046	18,946,784	164	64	16,011
4228500475	Lavaca	15	5,914,072	18,947,843	145	102	9,230
4228500509	Lavaca	15	5,882,834	18,944,157	179	18	8,860
4228530268	Lavaca	15	5,813,822	19,020,110	423	170	3,070
4228531359	Lavaca	15	5,897,003	19,044,293	267	56	9,530
4228531464	Lavaca	15	5,905,054	18,970,553	220	61	3,635
4228531777	Lavaca	15	5,923,626	19,084,675	278	90	15,070
4228531957	Lavaca	15	5,907,398	19,105,414	259	80	650
4228532282	Lavaca	15	5,851,203	19,003,313	280	725	7,127
4228532297	Lavaca	15	5,804,706	19,037,656	417	680	6,620
4229100086	Liberty	14	6,476,493	19,375,997	140	82	12,260
4229100189	Liberty	14	6,564,685	19,424,861	71	523	7,220

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4229100294	Liberty	14	6,509,136	19,399,114	150	107	9,500
4229100302	Liberty	14	6,575,902	19,402,275	106	150	7,940
4229100333	Liberty	14	6,660,552	19,291,757	63	100	11,528
4229101802	Liberty	14	6,607,130	19,324,411	68	70	11,700
4229102104	Liberty	14	6,584,260	19,307,680	80	50	9,350
4229102169	Liberty	14	6,572,933	19,346,256	66	164	8,540
4229102426	Liberty	14	6,534,141	19,314,642	92	40	9,010
4229102431	Liberty	14	6,508,166	19,347,797	126	760	8,230
4229103880	Liberty	14	6,490,871	19,294,075	90	40	9,986
4229104384	Liberty	14	6,534,982	19,245,190	49	100	13,284
4229104537	Liberty	14	6,610,490	19,236,054	31	109	17,970
4229104841	Liberty	14	6,661,160	19,237,112	37	30	9,190
4229105018	Liberty	14	6,481,966	19,358,710	144	85	17,000
4229700011	Live Oak	16	5,549,003	18,766,647	382	823	7,713
4229700043	Live Oak	16	5,503,131	18,736,446	267	539	8,028
4229700824	Live Oak	16	5,504,594	18,685,511	159	108	8,030
4229701154	Live Oak	16	5,504,372	18,617,772	289	98	8,010
4229701533	Live Oak	16	5,592,285	18,607,688	224	319	6,330
4229702031	Live Oak	16	5,486,452	18,563,666	345	80	12,189
4229702169	Live Oak	16	5,563,038	18,592,042	162	91	4,081
4229702604	Live Oak	16	5,518,557	18,564,864	337	205	5,020
4229730330	Live Oak	16	5,476,771	18,568,582	428	60	14,860
4229732519	Live Oak	16	5,598,995	18,581,451	13	171	2,055
4229732656	Live Oak	16	5,458,551	18,598,146	391	51	10,550
4229732681	Live Oak	16	5,510,279	18,547,851	299	65	13,324
4229733276	Live Oak	16	5,579,435	18,634,453	217	174	4,581
4229733511	Live Oak	16	5,583,132	18,549,266	154	128	2,380
4229733541	Live Oak	16	5,540,332	18,559,619	239	51	16,500
4229733600	Live Oak	16	5,461,427	18,552,901	315	88	16,018
4229733828	Live Oak	16	5,531,717	18,675,054	162	240	2,870
4229734397	Live Oak	16	5,466,555	18,647,311	211	272	5,708
4231100943	McMullen	16	5,454,682	18,608,413	323	690	6,490
4231101173	McMullen	16	5,440,569	18,623,299	281	51	1,780
4231131779	McMullen	16	5,380,759	18,527,800	393	42	1,324
4231131876	McMullen	16	5,418,936	18,602,332	268	39	2,030

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4231132161	McMullen	16	5,443,365	18,579,768	371	82	9,360
4232100003	Matagorda	15	6,146,464	18,890,919	67	200	9,000
4232100116	Matagorda	15	6,184,472	18,917,289	67	94	7,792
4232100435	Matagorda	15	6,210,454	18,908,774	72	100	11,010
4232100670	Matagorda	15	6,265,866	18,914,215	56	80	11,525
4232100824	Matagorda	15	6,299,219	18,824,318	29	149	16,670
4232101026	Matagorda	15	6,214,471	18,883,272	47	100	10,444
4232101064	Matagorda	15	6,253,233	18,844,867	46	200	14,450
4232101077	Matagorda	15	6,254,154	18,812,053	38	312	17,000
4232101967	Matagorda	15	6,151,148	18,798,540	13	101	9,300
4232102043	Matagorda	15	6,158,792	18,823,939	44	84	10,900
4232102119	Matagorda	15	6,178,152	18,838,401	35	62	11,894
4232102162	Matagorda	15	6,192,611	18,799,259	38	322	16,531
4232102171	Matagorda	15	6,100,947	18,864,979	60	116	8,799
4232102295	Matagorda	15	6,110,848	18,821,106	41	96	12,305
4232102514	Matagorda	15	6,190,426	18,757,672	15	267	6,165
4232102539	Matagorda	15	6,228,864	18,792,842	7	260	4,577
4232102576	Matagorda	15	6,263,463	18,777,585	15	130	7,510
4232102626	Matagorda	15	6,148,193	18,857,338	38	250	9,250
4232102721	Matagorda	15	6,205,601	18,824,400	40	105	11,045
4232130497	Matagorda	15	6,296,726	18,852,028	14	100	12,760
4232130952	Matagorda	15	6,220,402	18,944,885	70	510	6,810
4232130961	Matagorda	15	6,132,926	18,727,914	25	88	17,250
4232130980	Matagorda	15	6,110,506	18,729,062	20	113	7,250
4232130996	Matagorda	15	6,120,875	18,780,505	7	70	9,630
4232131159	Matagorda	15	6,182,858	18,865,814	74	101	13,450
4232131273	Matagorda	15	6,148,609	18,769,452	39	90	6,010
4232131324	Matagorda	15	6,212,392	18,750,387	15	803	6,510
4232131558	Matagorda	15	6,218,572	18,858,805	312	81	10,620
4232131573	Matagorda	15	6,125,134	18,696,316	19	1,001	6,010
4232131673	Matagorda	15	6,234,157	18,829,666	53	2,061	9,310
4233900045	Montgomery	14	6,375,348	19,428,561	355	110	8,250
4233900086	Montgomery	14	6,352,462	19,391,729	249	186	3,700
4233900202	Montgomery	14	6,353,845	19,363,567	184	100	11,310
4233900868	Montgomery	14	6,332,188	19,421,173	263	80	13,060

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4233900901	Montgomery	14	6,334,924	19,402,335	344	215	4,825
4233900994	Montgomery	14	6,286,619	19,384,825	256	580	6,510
4233900998	Montgomery	14	6,242,341	19,422,265	284	216	3,510
4233901014	Montgomery	14	6,261,648	19,303,197	229	110	7,010
4233901039	Montgomery	14	6,296,172	19,334,487	201	600	6,100
4233901102	Montgomery	14	6,302,360	19,307,273	148	453	6,300
4233901109	Montgomery	14	6,324,748	19,338,880	198	258	9,508
4233901718	Montgomery	14	6,406,117	19,314,627	116	84	11,320
4233901737	Montgomery	14	6,370,586	19,301,177	120	60	7,560
4233901872	Montgomery	14	6,401,958	19,376,082	195	100	15,000
4233930072	Montgomery	14	6,248,935	19,360,440	325	100	11,450
4233930478	Montgomery	14	6,274,941	19,356,207	178	80	13,000
4233930820	Montgomery	14	6,379,748	19,343,430	172	1,584	5,230
4233930849	Montgomery	14	6,451,436	19,319,125	112	949	8,220
4235100048	Newton	14	6,852,566	19,632,467	297	80	14,088
4235100096	Newton	14	6,856,854	19,485,834	88	1,525	7,900
4235100167	Newton	14	6,907,607	19,537,207	69	180	9,486
4235100213	Newton	14	6,872,882	19,456,123	61	85	8,055
4235100289	Newton	14	6,860,101	19,391,660	46	95	7,505
4235100425	Newton	14	6,897,682	19,675,772	349	79	15,400
4235130521	Newton	14	6,840,827	19,703,102	294	1,520	8,710
4235130726	Newton	14	6,851,778	19,572,597	247	2,514	8,200
4235500807	Nueces	16	5,671,671	18,469,857	13	119	8,000
4235500992	Nueces	16	5,676,483	18,397,689	71	447	5,900
4235503182	Nueces	16	5,771,950	18,351,861	26	273	9,968
4235504082	Nueces	16	5,656,708	18,357,517	54	249	7,809
4235506112	Nueces	16	5,771,235	18,459,664	0	8,080	12,580
4235506122	Nueces	16	5,794,960	18,436,040	26	1,500	14,523
4235506225	Nueces	16	5,730,558	18,389,370	56	1,220	15,000
4235506517	Nueces	16	5,641,933	18,449,065	100	1,105	8,591
4235530009	Nueces	16	5,603,057	18,462,043	116	310	6,350
4235530249	Nueces	16	5,713,871	18,451,620	45	51	5,730
4235531270	Nueces	16	5,753,415	18,438,186	64	324	15,040
4235531610	Nueces	16	5,642,140	18,391,902	83	2,019	9,260
4236100004	Orange	14	6,790,212	19,357,611	43	93	8,260

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4236100328	Orange	14	6,836,433	19,303,666	18	134	9,078
4236100480	Orange	14	6,875,870	19,313,451	11	117	9,310
4236130791	Orange	14	6,820,145	19,337,657	46	198	9,586
4236130810	Orange	14	6,857,281	19,349,367	45	3,527	14,505
4237300003	Polk	14	6,592,473	19,640,792	180	215	2,520
4237300010	Polk	14	6,528,174	19,629,787	256	38	6,510
4237300030	Polk	14	6,479,081	19,615,519	260	360	3,869
4237300037	Polk	14	6,487,914	19,515,027	143	286	5,011
4237300359	Polk	14	6,543,826	19,478,018	197	100	12,030
4237300423	Polk	14	6,591,140	19,466,623	166	188	10,630
4237330091	Polk	14	6,576,548	19,519,226	345	150	18,386
4237330120	Polk	14	6,502,946	19,574,090	231	104	12,956
4237330154	Polk	14	6,468,403	19,552,134	243	100	13,000
4237330216	Polk	14	6,565,410	19,569,181	345	542	3,520
4237330484	Polk	14	6,577,415	19,667,349	182	80	9,640
4237330505	Polk	14	6,556,117	19,454,324	162	110	12,250
4237330975	Polk	14	6,521,873	19,506,001	313	861	3,295
4239100023	Refugio	15	5,858,705	18,698,269	69	530	6,680
4239100086	Refugio	15	5,928,249	18,642,610	12	50	10,031
4239100205	Refugio	15	5,868,308	18,666,995	59	94	8,560
4239103659	Refugio	15	5,799,997	18,570,995	27	141	5,326
4239103722	Refugio	15	5,825,242	18,564,016	14	80	8,940
4239131466	Refugio	15	5,889,754	18,679,970	61	1,652	8,302
4239131588	Refugio	15	5,835,680	18,650,020	74	1,037	5,928
4239132087	Refugio	15	5,785,721	18,656,311	78	630	6,210
4239132118	Refugio	15	5,807,767	18,660,164	78	700	6,800
4239132136	Refugio	15	5,870,398	18,641,870	52	1,437	9,500
4240330278	Sabine	11	6,828,287	19,752,985	230	48	1,200
4240330436	Sabine	11	6,782,531	19,714,434	243	200	2,250
4240700021	San Jacinto	14	6,514,164	19,463,354	79	102	7,860
4240700127	San Jacinto	14	6,401,299	19,521,559	329	100	10,361
4240700133	San Jacinto	14	6,390,638	19,452,511	389	1,250	12,020
4240700156	San Jacinto	14	6,438,049	19,428,930	253	90	11,100
4240700214	San Jacinto	14	6,448,617	19,406,102	149	131	10,020
4240730018	San Jacinto	14	6,417,923	19,419,616	258	18	10,550

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4240730033	San Jacinto	14	6,410,962	19,490,127	315	70	18,100
4240730468	San Jacinto	14	6,451,408	19,464,140	336	423	6,230
4240902561	San Patricio	16	5,773,504	18,500,746	39	119	6,340
4240903620	San Patricio	16	5,698,800	18,497,475	83	351	6,210
4240903682	San Patricio	16	5,650,346	18,489,058	28	13	6,700
4240931716	San Patricio	16	5,639,414	18,521,567	87	210	5,790
4240931883	San Patricio	16	5,676,093	18,509,858	100	212	5,680
4240931914	San Patricio	16	5,722,950	18,498,611	78	313	5,710
4240932252	San Patricio	16	5,719,354	18,532,229	76	68	8,069
4240932438	San Patricio	16	5,745,412	18,521,252	60	280	2,576
4240932572	San Patricio	16	5,765,317	18,550,041	68	1,529	8,760
4245530023	Trinity	11	6,460,559	19,686,511	356	243	18,800
4245530401	Trinity	11	6,369,903	19,635,761	181	75	11,656
4245530485	Trinity	11	6,445,677	19,712,392	352	50	2,020
4245700041	Tyler	14	6,723,587	19,583,626	166	659	6,510
4245700043	Tyler	14	6,735,244	19,564,690	211	490	4,440
4245700057	Tyler	14	6,688,300	19,585,215	318	96	14,530
4245700063	Tyler	14	6,642,248	19,476,825	135	80	10,510
4245700200	Tyler	14	6,693,275	19,478,257	118	115	9,005
4245700245	Tyler	14	6,722,654	19,524,335	177	143	9,510
4245700254	Tyler	14	6,722,855	19,508,672	144	140	9,490
4245700256	Tyler	14	6,741,483	19,539,828	177	500	4,820
4245700377	Tyler	14	6,727,860	19,479,034	97	68	10,770
4245700477	Tyler	14	6,624,907	19,526,459	291	100	16,010
4245730101	Tyler	14	6,626,215	19,586,189	378	100	13,491
4245730119	Tyler	14	6,705,485	19,634,601	225	55	11,150
4245730121	Tyler	14	6,668,901	19,547,322	306	100	15,217
4245730130	Tyler	14	6,658,485	19,619,475	251	59	11,622
4245730426	Tyler	14	6,653,988	19,647,141	159	478	5,020
4245730630	Tyler	14	6,703,681	19,555,518	281	1,112	11,990
4246900189	Victoria	15	5,976,388	18,803,360	31	89	7,303
4246901497	Victoria	15	5,857,804	18,737,725	86	539	6,520
4246901624	Victoria	15	5,893,999	18,789,801	55	227	2,434
4246903149	Victoria	15	5,935,555	18,829,032	73	252	6,010
4246931553	Victoria	15	5,831,466	18,857,696	151	303	4,077

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4246931897	Victoria	15	5,924,799	18,747,768	58	57	6,499
4246932432	Victoria	15	5,923,434	18,870,411	110	220	2,410
4246932533	Victoria	15	5,884,305	18,847,008	133	440	4,210
4246932685	Victoria	15	5,848,016	18,799,055	127	312	2,900
4246932892	Victoria	15	5,847,824	18,768,641	112	600	5,200
4246932912	Victoria	15	5,904,996	18,699,755	23	14	8,082
4246933114	Victoria	15	5,896,636	18,823,644	106	294	1,989
4246933421	Victoria	15	5,830,275	18,837,420	205	225	11,566
4247100014	Walker	14	6,348,314	19,595,951	135	140	13,500
4247100116	Walker	14	6,293,345	19,571,076	251	20	7,950
4247100148	Walker	14	6,257,136	19,509,990	270	30	2,020
4247100169	Walker	14	6,377,750	19,575,099	176	120	13,820
4247100180	Walker	14	6,290,873	19,492,197	363	100	10,850
4247100189	Walker	14	6,311,091	19,463,128	308	100	11,900
4247100204	Walker	14	6,331,919	19,630,272	289	600	10,750
4247130011	Walker	14	6,373,206	19,496,273	389	180	18,170
4247130016	Walker	14	6,292,728	19,462,705	234	90	19,450
4247130022	Walker	14	6,248,377	19,531,924	405	91	14,500
4247130304	Walker	14	6,300,897	19,501,384	308	909	2,836
4247300003	Waller	14	6,130,269	19,293,261	156	232	4,422
4247300005	Waller	14	6,153,171	19,323,813	254	91	20,800
4247300049	Waller	14	6,193,507	19,230,100	214	129	7,482
4247300108	Waller	14	6,232,634	19,201,114	166	2,519	6,680
4247300243	Waller	14	6,155,692	19,243,865	152	148	7,520
4247300278	Waller	14	6,161,695	19,188,721	137	300	4,020
4247300288	Waller	14	6,176,881	19,178,691	123	100	9,000
4247300318	Waller	14	6,207,679	19,218,710	211	120	13,530
4247330066	Waller	14	6,241,516	19,332,730	292	320	6,130
4247330432	Waller	14	6,177,818	19,317,320	320	118	3,530
4247730625	Washington	14	6,056,285	19,368,217	276	65	10,900
4247901085	Webb	16	5,298,356	18,371,470	810	100	10,512
4247933193	Webb	16	5,278,693	18,331,431	750	114	4,030
4247933812	Webb	16	5,254,917	18,309,987	870	44	2,006
4247934513	Webb	16	5,288,560	18,308,788	807	118	3,727
4247935268	Webb	16	5,247,248	18,275,399	885	67	1,786

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4247938683	Webb	16	5,287,269	18,263,345	874	161	1,499
4248100671	Wharton	15	6,229,224	18,983,481	68	60	9,500
4248100696	Wharton	15	6,201,981	18,995,132	83	370	5,880
4248100943	Wharton	15	6,148,442	19,048,021	102	90	8,003
4248101140	Wharton	15	6,135,642	19,014,603	111	470	6,000
4248101205	Wharton	15	6,130,686	19,058,641	137	97	7,920
4248101218	Wharton	15	6,102,696	19,057,990	175	100	12,850
4248101288	Wharton	15	6,111,728	18,980,292	122	111	5,160
4248101367	Wharton	15	6,061,796	18,980,185	117	146	2,035
4248101401	Wharton	15	6,025,077	18,957,786	105	480	5,222
4248101478	Wharton	15	6,068,163	18,955,949	97	100	3,030
4248101702	Wharton	15	6,048,927	18,934,696	88	334	4,595
4248101770	Wharton	15	6,074,447	18,908,205	85	58	7,227
4248101885	Wharton	15	6,102,382	18,927,127	85	30	7,020
4248102272	Wharton	15	6,135,179	18,939,159	85	90	1,524
4248102562	Wharton	15	6,192,617	18,944,888	77	100	6,860
4248102802	Wharton	15	6,167,169	18,936,833	76	116	7,501
4248103550	Wharton	15	6,046,621	18,957,281	107	260	5,330
4248130581	Wharton	15	6,025,548	18,987,936	148	114	11,300
4248131273	Wharton	15	6,136,479	18,966,266	104	1,826	6,350
4248131477	Wharton	15	6,100,833	18,951,936	121	97	13,454
4248131622	Wharton	15	6,179,912	19,068,542	133	72	16,832
4248133274	Wharton	15	6,100,571	19,005,357	142	100	8,100
4248133361	Wharton	15	6,079,001	18,992,018	151	55	5,570
4248133442	Wharton	15	6,145,003	19,020,532	137	74	12,500
4250502719	Zapata	13	5,258,030	18,097,006	501	117	2,346
4250530271	Zapata	13	5,245,335	18,231,498	736	180	6,320
4250530984	Zapata	13	5,226,227	18,230,528	627	26	1,743
4260100002	Kenedy	16	5,789,776	18,229,029	34	226	16,800
4260130117	Kenedy	16	5,785,803	18,153,669	100	110	4,513
4260600010	Jefferson	14	6,821,329	19,152,612	18	520	8,050
4260600055	Jefferson	14	6,740,591	19,125,550	18	205	6,842
4270100002	Gulf	NA	5,805,598	18,182,115	90	500	17,980
4270130001	Gulf	NA	5,837,906	18,063,645	69	280	7,012
4270200003	Gulf	NA	5,877,820	18,382,765	15	214	12,496

API	County	GMA	Easting (feet-GAM)	Northing (feet-GAM)	Ground Surface Elevation (feet-NAVD88)	Min Depth (feet)	Max Depth (feet)
4270200015	Gulf	NA	5,847,379	18,350,023	15	500	12,500
4270340074	Gulf	NA	6,171,472	18,627,822	80	259	11,495
4270340137	Gulf	NA	5,974,058	18,476,106	96	3,825	7,180
4270340269	Gulf	NA	5,996,812	18,467,918	92	1,004	9,540
4270340442	Gulf	NA	6,017,931	18,467,567	84	2,995	9,800
4270400070	Gulf	NA	6,399,011	18,666,112	77	605	3,100
4270430005	Gulf	NA	6,365,319	18,691,876	55	1,820	6,508
4270440131	Gulf	NA	6,200,835	18,580,142	91	1,187	9,142
4270600022	Gulf	NA	6,459,419	18,865,754	25	410	10,040
4270640090	Gulf	NA	6,631,350	18,897,748	67	272	10,750
4270640380	Gulf	NA	6,621,033	18,952,023	82	334	15,930
4270800010	Gulf	NA	6,823,300	19,122,609	50	150	13,400
4270830045	Gulf	NA	6,827,440	19,043,876	47	2,503	10,094
4270840040	Gulf	NA	6,821,328	19,094,034	78	623	16,030
4270840077	Gulf	NA	6,825,153	19,057,624	96	311	13,032
4270840160	Gulf	NA	6,835,774	19,003,383	103	350	15,710
4270840279	Gulf	NA	6,696,328	18,839,148	81	736	4,100
4270840300	Gulf	NA	6,846,722	18,974,972	100	4,500	12,420
4271240016	Gulf	NA	6,064,948	18,425,661	93	809	9,060
4271530011	Gulf	NA	6,888,709	19,119,000	96	270	10,960

19.7 Geographic Information System (GIS) Geodatabase

During the course of this study, many GIS datasets were created using Environmental Systems Research Institute, Inc.'s ArcGIS® 10.1 and the Spatial Analyst® extension software. Each of the datasets used to create report figures are contained with the file geodatabase Gulf_Coast_Brackish delivered with this report. This geodatabase is available from the TWDB. Dataset types include point data, polylines, polygons, and rasters. Point dataset typically present well locations and associated well information, but also represent other types of data. Polyline datasets typically present section lines, boundary lines, and contour intervals. Polygon datasets typically present administrative boundaries, aquifer boundaries, and data in 5-mile by 5-mile grid cells. Raster datasets include formation structure information, salinity zone information, information related to sand picks from geophysical logs, as well as other types of data. All files are in the Groundwater Availability Model coordinate system.

The contents of the geodatabase are summarized in Table 19-7. A few codes, or abbreviations, were used in naming the raster files (Table 19-8). The dataset names, their type, and a description of each is provided in Tables 19-7 through 19-16 for the Feature Datasets in the geodatabase. Table 19-17 contains a description and name for each raster in the geodatabase by Raster Catalog.

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Table 19-7. Summary of contents for the geodatabase created for the Gulf Coast BRACS study.

Name	Type	General Description
Bottom_Elevation	Raster Catalog	Rasters with elevations of the base of formations
Boundaries	Feature Dataset	Shapefiles with boundaries for various information displayed on figures
Brackish_Thickness	Raster Catalog	Raster with the thickness of brackish zones in the formations
Fishnets	Feature Dataset	Shapefiles with various information within 5-mile by 5-mile grid cells
Formation_Thickness	Raster Catalog	Rasters with formation thickness
Geology	Feature Dataset	Shapefiles with geologic information
Ground_Surface	Raster Catalog	Raster with the ground surface elevation
Hydraulic_Properties	Feature Dataset	Shapefiles with hydraulic property data
Max_Sand_Interval	Raster Catalog	Rasters with the thickness of the maximum sand picked for the formations from the geophysical logs
Points_Log_Coverage	Feature Dataset	Shapefiles with the percent log coverage in the formations
Previous_Investigations	Raster Catalog	Rasters with total dissolved solids and recharge data from previous studies
Salinity_Zones	Feature Dataset	Shapefiles with salinity zone contour lines
Salinity_Zones_Rasters	Raster Catalog	Rasters with salinity zone depth, elevation, and thickness
Sand_Percentage	Raster Catalog	Rasters with thickness of the sand percentage in the formation picked from the geophysical logs
Sand_Thickness	Raster Catalog	Rasters with total sand thickness in the formation picked from the geophysical logs
Thermal Data	Raster Catalog	Rasters with thermal data
Top_Elevation	Raster Catalog	Rasters with elevations of the top of formations
Water_Quality_Data	Feature Dataset	Shapefiles with water quality data
Wells_Lines_Zones	Feature Dataset	Shapefiles with well point locations, section lines, and potential production area zones

Table 19-8. Codes used in GIS raster file naming for the Gulf Coast BRACS study.

Code	Code Type	Code Description	Raster Catalogs Used In
cmb	data method	chloride mass balance	Previous_Investigation
AOI	location	area of interest for this study	Previous_Investigation and Thermal_Data
GC	Location	Gulf Coast	Previous_Investigation
sfc	location	surface	Thermal_Data
gw	object of data	groundwater	Thermal_Data
i	object of data	salinity inversion	Brackish_Thickness,
temp	raster data type	temperature	Thermal_Data
tgrad	raster data type	temperature gradient	Thermal_Data
MaxThickSand	raster value	value for the maximum sand thickness	Max_Sand_Interval
PercentSand	raster value	percent sand value	Sand_Percentages
SandThickness	raster value	sand thickness	Sand_Thickness
1K	salinity value	1,000 mg/L	Brackish_Thickness,
10K	salinity value	10,000 mg/L	Salinity_Zones_Rasters
35K	salinity value	35,000 mg/L	Salinity_Zones_Rasters
TX	state abbreviation	Texas	Thermal_Data
bb or BB	stratigraphy	Beaumont Clay	Bottom_Elevation, Brackish_Thickness, Formation_Thickness, Max_Sand_Interval, Sand_Percentages, and Sand_Thickness
cat or CAT	stratigraphy	Catahoula Formation	Bottom_Elevation, Brackish_Thickness, Formation_Thickness, Max_Sand_Interval, Sand_Percentages, and Sand_Thickness
lg or LG	stratigraphy	Lower Goliad Formation	Bottom_Elevation, Brackish_Thickness, Formation_Thickness, Max_Sand_Interval, Sand_Percentages, and Sand_Thickness
li or LI	stratigraphy	Lissie Formation	Bottom_Elevation, Brackish_Thickness, Formation_Thickness, Max_Sand_Interval, Sand_Percentages, and Sand_Thickness
ll or LL	stratigraphy	Lower Lagarto Formation	Bottom_Elevation, Brackish_Thickness, Formation_Thickness, Max_Sand_Interval, Sand_Percentages, and Sand_Thickness

Code	Code Type	Code Description	Raster Catalogs Used In
cmb	data method	chloride mass balance	Previous_Investigation
ml or ML	stratigraphy	Middle Lagarto Formation	Bottom_Elevation, Brackish_Thickness, Formation_Thickness, Max_Sand_Interval, Sand_Percentages, and Sand_Thickness
ok or OK	stratigraphy	Oakville Formation	Bottom_Elevation, Brackish_Thickness, Formation_Thickness, Max_Sand_Interval, Sand_Percentages, and Sand_Thickness
ug or UG	stratigraphy	Upper Goliad Formation	Bottom_Elevation, Brackish_Thickness, Formation_Thickness, Max_Sand_Interval, Sand_Percentages, and Sand_Thickness
ul or UL	stratigraphy	Upper Lagarto Formation	Bottom_Elevation, Brackish_Thickness, Formation_Thickness, Max_Sand_Interval, Sand_Percentages, and Sand_Thickness
wi or WI	stratigraphy	Willis Formation	Bottom_Elevation, Brackish_Thickness, Formation_Thickness, Max_Sand_Interval, Sand_Percentages, and Sand_Thickness
bot	surface position	bottom elevation	Bottom_Elevation
Diff	surface type	thickness	Salinity_Zones_Rasters
Elev	surface type	elevation	Salinity_Zones_Rasters
c	unit	degrees Celsius	Thermal_Data
ft	unit	feet	Thermal_Data
m	unit	meters	Thermal_Data
TDS	water quality parameter	total dissolved solids	Previous_Investigations and Salinity_Zones_Rasters

Table 19-9. GIS files in the Boundaries Feature Dataset in the geodatabase developed for the Gulf Coast BRACS study.

File Type	Point File Name	Polyline File Name	Polygon File Name
Mask for area outside the study area of interest			blanking_mask_southern_area_062016
Outline of the Brazos River Alluvium Aquifer			BRAA_for_SurfGeo
Boundary line used in plots of the depth and elevation of the base groundwater with a total dissolved solids value of less than 1,000 milligrams per liter		CatBot_Extent_1k_072716	
Boundary line used in plots of the depth and elevation of the base groundwater with a total dissolved solids value of less than 3,000 milligrams per liter		CatBot_Extent_3k_072716	
Boundary line used in plots of the depth and elevation of the base groundwater with a total dissolved solids value of less than 10,000 milligrams per liter		CatBot_Extent_10k_072716	
Boundary line used in plots of the depth and elevation of the base groundwater with a total dissolved solids value of less than 35,000 milligrams per liter		CatBot_Extent_35k_072716	
Boundary of the Central Gulf Coast Aquifer groundwater availability model			Central_GC_GAM_Bndry
Boundary of the Chicot Aquifer		Chicot_formations_Union_GC_AOI_072116	
Boundary of the Evangeline Aquifer		Evangeline_formations_Union_GC_AOI_072116	
River authority boundaries			GC_RiverAuthorities
River basin boundaries			GC_RiverBasins

File Type	Point File Name	Polyline File Name	Polygon File Name
Regional water planning group boundaries			GC_RWPG
Study area boundary			GC_study_area_062116
Groundwater conservation district boundaries			GCDs_AOI
Boundary of the GMA16 model of the central Gulf Coast Aquifer			GMA16_GC_Model_Bndry
Groundwater management area boundaries			GMAs_AOI
Boundary of the Gulf Coast Aquifer			Gulf_Coast_Aquifer
County boundaries in Louisiana			LA_counties
State boundary for Louisiana			LA_State
State boundaries for the country of Mexico			MEX_adm
Boundary for the northern Gulf Coast Aquifer groundwater availability model			Northern_GC_GAM_Bndry
County boundaries in Texas			TWDB_Counties_020211
State boundary for Texas including detail along the Gulf Coast			tx_detailed_coastline
Boundary of the Yegua-Jackson Aquifer			Yegua_Jackson_Aquifer

Table 19-10. GIS files in the Fishnet Feature Dataset in the geodatabase developed for the Gulf Coast BRACS study.

File Type	Point File Name	Polyline File Name	Polygon File Name
The base of fresh groundwater from the Railroad Commission on in a 5-mile by 5-mile grid			Fishnet_BaseOfFresh_fromRaster_061016
The base of usable groundwater from the Railroad Commission on in a 5-mile by 5-mile grid			Fishnet_BaseOfUseable_fromRaster_061016
The maximum and 95th percentile borehole depths for wells from the TWDB groundwater database within 5-mile by 5-mile grids			Fishnet_GWDB_NoPetro_BoreholeDepthStats_063016
The maximum depth of wells with fresh water for wells from the TWDB groundwater database within 5-mile by 5-mile grids			Fishnet_GWDB_TDSdependent_welldepths_v2a_FreshOnly_070616
The maximum and 95th percentile borehole depths for wells from the Texas Commission on Environmental Quality Public Water Supply wells database within 5-mile by 5-mile grids			Fishnet_PWS_BoreholeDepthStats_061516
Estimated aquifer intersected by the shallowest injection interval for injection wells from the Railroad Commission within 5-mile by 5-mile grids			Fishnet_RRC_TIZ_Formation_061416
Estimated aquifer intersected by the deepest borehole from the TWDB submitted driller's reports database within 5-mile by 5-mile grids			Fishnet_SDR_BoreholeDepth_Aquifers_061616

File Type	Point File Name	Polyline File Name	Polygon File Name
The maximum and 95th percentile borehole depths for wells from the TWDB submitted driller's reports database within 5-mile by 5-mile grids			Fishnet_SDR_BoreholeDepthStats_061516
Estimated minimum depth of the shallowest injection interval for injection wells from the Railroad Commission within 5-mile by 5-mile grids			RRCinj_summary_grid_050316

Table 19-11. GIS files in the Geology Feature Dataset in the geodatabase developed for the Gulf Coast BRACS study.

File Type	Point File Name	Polyline File Name	Polygon File Name
Location of major growth fault zones		EwingFaultZonesGen	
Surface geology in the Gulf Coast Aquifer			GulfCoast_Outcrop
Location of salt domes	TxGulfCoast_saltdomes		

Table 19-12. GIS files in the Hydraulic_Properties Feature Dataset in the geodatabase developed for the Gulf Coast BRACS study.

File Type	Point File Name	Polyline File Name	Polygon File Name
Location of wells with a porosity log	porosity_logs_final_072816		
Location of wells with formation yield and specific capacity data	SDR_Yields_FmByBoredepth_072516		

Table 19-13. GIS files in the Points_Log_Coverage Feature Dataset in the geodatabase developed for the Gulf Coast BRACS study.

File Type	Point File Name	Polyline File Name	Polygon File Name
The percentage of the geophysical log that intersects the thickness of the Beaumont Clay	Points_BB_BotEl_FrmtnCvrgVal		
The percentage of the geophysical log that intersects the thickness of the Catahoula Formation	Points_CAT_BotEl_FrmtnCvrgVal		
The percentage of the geophysical log that intersects the thickness of the Lower Goliad Formation	Points_LG_BotEl_FrmtnCvrgVal		

The percentage of the geophysical log that intersects the thickness of the Lissie Formation	Points_LI_BotEl_FrmtnCvrgVal
The percentage of the geophysical log that intersects the thickness of the Lower Lagarto Formation	Points_LL_BotEl_FrmtnCvrgVal
The percentage of the geophysical log that intersects the thickness of the Middle Lagarto Formation	Points_ML_BotEl_FrmtnCvrgVal
The percentage of the geophysical log that intersects the thickness of the Oakville Formation	Points_OK_BotEl_FrmtnCvrgVal
The percentage of the geophysical log that intersects the thickness of the Upper Goliad Formation	Points_UG_BotEl_FrmtnCvrgVal
The percentage of the geophysical log that intersects the thickness of the Upper Lagarto Formation	Points_UL_BotEl_FrmtnCvrgVal
The percentage of the geophysical log that intersects the thickness of the Willis Formation	Points_WI_BotEl_FrmtnCvrgVal

Table 19-14. GIS files in the Salinity_Zones Feature Dataset in the geodatabase developed for the Gulf Coast BRACS study.

File Type	Point File Name	Polyline File Name	Polygon File Name
Depth contour lines for the base of groundwater with a total dissolved solids concentration of less than 1,000 milligrams per liter		depth_1000_tds_altramp_072816	
Thickness contour lines for the saline groundwater that overlies the fresh water zone for several counties along the coast in the southern portion of the study area		depth_1000i_tds_080116	
Depth contour lines for the base of groundwater with a total dissolved solids concentration of less than 10,000 milligrams per liter		depth_10k_tds_072716	
Depth contour lines for the base of groundwater with a total dissolved solids concentration of less than 3,000 milligrams per liter		depth_3000_tds_altramp_072816	
Depth contour lines for the base of groundwater with a total dissolved solids concentration of less than 35,000 milligrams per liter		depth_35k_tds_072716	
Thickness contour lines for the difference between the base of groundwater with a total dissolved concentration of the 3,000 milligrams per liter and the base of groundwater with a total dissolved concentration 1,000 milligrams per liter		diff_1000_3000_tds_elevs_072916	
Thickness contour lines for the difference between the base of groundwater with a total dissolved concentration of the 35,000 milligrams per liter and the base of groundwater with a total dissolved concentration 10,000 milligrams per liter		diff_10000_35000_tds_elevs_072916	

Thickness contour lines for the difference between the base of groundwater with a total dissolved concentration of the 10,000 milligrams per liter and the base of groundwater with a total dissolved concentration 3,000 milligrams per liter	diff_3000_10000_tds_elevs_072916
Elevation contour lines for the base of groundwater with a total dissolved solids concentration of less than 1,000 milligrams per liter	elev_1000_tds_072716
Elevation contour lines for the base of groundwater with a total dissolved solids concentration of less than 10,000 milligrams per liter	elev_10k_tds_072716
Elevation contour lines for the base of groundwater with a total dissolved solids concentration of less than 3,000 milligrams per liter	elev_3000_tds_072716
Elevation contour lines for the base of groundwater with a total dissolved solids concentration of less than 35,000 milligrams per liter	elev_35k_tds_072716

Table 19-15. GIS files in the Water_Quality_Data Feature Dataset in the geodatabase developed for the Gulf Coast BRACS study.

File Type	Point File Name	Polyline File Name	Polygon File Name
Maximum alpha radiation for wells in the TWDB groundwater database	GWDB_AlphaSamples_GC_072116		
Maximum beta radiation for wells in the TWDB groundwater database	GWDB_BetaSamples_GC_072116		
Maximum combined radium-226 and radium-228 concentration for wells in the TWDB groundwater database	GWDB_RadiumSamples_GC_072116		
Group identification for wells with the same coordinates with radionuclide water quality data	GWDB_Rads_GroupedWellLocs_072116		
Average calculated total dissolved solids and percent chloride, sulfate, and bicarbonate for wells in the TWDB groundwater database	GWDB_TDS_pctAnions_072016		
Average measured total dissolved solids and specific conductance for wells in the TWDB groundwater database	GWDB_TDS_SpCond_summary_060916		
Average measured total dissolved solids for wells in the TWDB groundwater database	GWDB_TDSmeas_072116		
Maximum uranium concentration for wells in the TWDB groundwater database	GWDB_UraniumSamples_GC_072116		

Table 19-16. GIS files in the Wells_Lines_Zones Feature Dataset in the geodatabase developed for the Gulf Coast BRACS study.

File Type	Point File Name	Polyline File Name	Polygon File Name
Cross-section locations from Young and others (2010,2012)		GC_xsec_lines_combined_ dip_060116	
Location of digitized geophysical logs used for the study	GulfCoast_LogDatabase_Rev03_062916_used		
Location and formation for potential production areas			GulfCoast_PotentialProduction Areas_Combined
Line dividing the northern and southern Chicot Aquifer		NorthSouth_dividing_line_ 071516	
The wells in the TWDB groundwater database with total dissolved solids concentration data paired with one or more associated geophysical logs for all aquifers	RoTDS_GWDB_Locations_ AllConsidered_072816		
The wells in the TWDB groundwater database with total dissolved solids concentration data paired with one or more associated geophysical logs used in the anlysis	RoTDS_GWDB_Locations_ UsedForAnalysis_072816		
Base of fresh and usable groundwater estimated from surface casing recommendation statements from the Groundwater Advisory Unit of the Railroad Commission for oil and gas wells	RRC_Base_Fresh_Base_ Usable		
Railroad Comission active and permitted injection or disposal wells permitted under Chapter 27 and depth to the top of the injection interval	RRC_InjWells_in_AOI		

Wells from the TWDB submitted driller's reports databased used in the sand volume calculation	SandVolCalc_SDR_locations_072916	
Wells with measured total dissolved solids concentration used in the analysis	TDS_wells	
Geologic cross-section locations		cross-sections
Centroid location for candidate well fields	well_field_location_centroids_072916_v3	

Table 19-17. Raster in all Raster Catalogs in the geodatabase developed for the Gulf Coast BRACS study.

File Type	Raster Name
Bottom_Elevation Raster Catalog	
Beaumont bottom elevation	bb_bot_crop
Catahoula bottom elevation	cat_bot_crop
Lower Goliad bottom elevation	lg_bot_crop
Lissie bottom elevation	li_bot_crop
Lower Lagarto bottom elevation	ll_bot_crop
Middle Lagarto bottom elevation	ml_bot_crop
Oakville bottom elevation	ok_bot_crop
Upper Goliad bottom elevation	ug_bot_crop
Upper Lagarto bottom elevation	ul_bot_crop
Willis bottom elevation	wi_bot_crop
Brackish_Thickness Raster Catalog	
Brackish zone thickness in the Catahoula Formation	CAT_1k_to_10K_thickness.tif
Brackish zone thickness in the lower Goliad Formation	LG_1k_to_10K_thickness.tif
Brackish zone thickness in the lower Lagarto Formation	LL_1k_to_10K_thickness.tif
Brackish zone thickness in the middle Lagarto Formation	ML_1k_to_10K_thickness.tif
Brackish zone thickness in the Oakville Formation	OK_1k_to_10K_thickness.tif
Brackish zone thickness in the upper Goliad Formation	UG_1k_to_10K_thickness.tif
Brackish zone thickness in the upper Lagarto Formation	UL_1k_to_10K_thickness.tif
Formation_Thickness Raster Catalog	
Beaumont thickness	BB_Thickness.tif
Lissie thickness	LI_Thickness.tif
Willis thickness	WI_Thickness.tif
Upper Goliad thickness	UG_Thickness.tif
Lower Goliad thickness	LG_Thickness.tif
Upper Lagarto thickness	UL_Thickness.tif

Middle Lagarto thickness	ML_Thickness.tif
Lower Lagarto thickness	LL_Thickness.tif
Oakville thickness	OK_Thickness.tif
Catahoula thickness	CAT_Thickness.tif
Ground_Surface Raster Catalog	
Ground surface elevation	Ground_Surface_Elevation.tif
Max_Sand_Interval Raster Catalog	
Maximum sand intervals in Beaumont Formation	BB_MaxThickSand
Maximum sand intervals in Catahoula Formation	CAT_MaxThickSand.img
Maximum sand intervals in Lower Goliad Formation	LG_MaxThickSand.img
Maximum sand intervals in Lissie Formation	LI_MaxThickSand.img
Maximum sand intervals in Lower Lagarto Formation	LL_MaxThickSand.img
Maximum sand intervals in Middle Lagarto Formation	ML_MaxThickSand.img
Maximum sand intervals in Oakville Formation	OK_MaxThickSand.img
Maximum sand intervals in Upper Lagarto Formation	UL_MaxThickSand.img
Maximum sand intervals in Willis Formation	WI_MaxThickSand.img
Maximum sand intervals in Upper Goliad Formation	UG_MaxThickSand.img
Previous_Investigations Raster Catalog	
Total dissolved solids concentrations in the upper Gulf Coast Aquifer for the depth interval 0 to 200 feet from Young and others (2013)	TDS_0-200ft.tif
Total dissolved solids concentrations in the upper Gulf Coast Aquifer for the depth interval 500 to 1,000 feet from Young and others (2013)	TDS_500-1000ft.tif
Recharge to the Gulf Coast Aquifer using the chloride mass balance method from Scanlon and others (2011)	cmb_recharge_GC_AOI.tif
Salinity_Zones_Rasters Raster Catalog	
Depth for the base of groundwater with a total dissolved solids concentration of less than 1,000 milligrams per liter	Depth_1000_TDS_072716.tif

Depth for the base of groundwater with a total dissolved solids concentration of less than 3,000 milligrams per liter	Depth_3000_TDS_072716.tif
Depth for the base of groundwater with a total dissolved solids concentration of less than 10,000 milligrams per liter	Depth_10k_TDS_072716.tif
Depth for the base of groundwater with a total dissolved solids concentration of less than 35,000 milligrams per liter	Depth_35k_TDS_072716.tif
Elevation for the base of groundwater with a total dissolved solids concentration of less than 1,000 milligrams per liter	Elevation_1000_TDS_resample_nearest_072816.tif
Elevation for the base of groundwater with a total dissolved solids concentration of less than 10,000 milligrams per liter	Elevation_10000_TDS_resample_nearest_072816.tif
Elevation for the base of groundwater with a total dissolved solids concentration of less than 31,000 milligrams per liter	Elevation_3000_TDS_resample_nearest_072816.tif
Elevation for the base of groundwater with a total dissolved solids concentration of less than 35,000 milligrams per liter	Elevation_35000_TDS_resample_nearest_072816.tif
Thickness difference between the elevation of the base of groundwater with a total dissolved solids concentration of less than 3,000 milligrams per liter and the elevation of the base of groundwater with a total dissolved solids concentration of less than 1,000 milligrams per liter	Diff_1000_to_3000_TDS_surfaces_072916.tif
Thickness difference between the elevation of the base of groundwater with a total dissolved solids concentration of less than 35,000 milligrams per liter and the elevation of the base of groundwater with a total dissolved solids concentration of less than 10,000 milligrams per liter	Diff_10000_to_35000_TDS_surfaces_072916.tif
Thickness difference between the elevation of the base of groundwater with a total dissolved solids concentration of less than 10,000 milligrams per liter and the elevation of the base of groundwater with a total dissolved solids concentration of less than 3,000 milligrams per liter	Diff_3000_to_10000_TDS_surfaces_072916.tif
Thickness of saline groundwater overlying the fresh water zone at the location of an inversion in serval counties located along the coast in the southern portion of the study area	1000.0i_TDSdepth.tif

Sand_Percentage Raster Catalog	
Sand percentage in Beaumont Formation	BB_PercentSand.img
Sand percentage in Catahoula Formation	CAT_PercentSand.img

Sand percentage in Lower Goliad Formation	LG_PercentSand.img
Sand percentage in Lissie Formation	LI_PercentSand
Sand percentage in Lower Lagarto Formation	LL_PercentSand.img
Sand percentage in Middle Lagarto Formation	ML_PercentSand.img
Sand percentage in Oakville Formation	OK_PercentSand.img
Sand percentage in Upper Goliad Formation	UG_PercentSand.img
Sand percentage in Upper Lagarto Formation	UL_PercentSand.img
Sand percentage in Willis Formation	WI_PercentSand.img
Sand_Thickness Raster Catalog	
Sand thickness in Beaumont Formation	BB_SandThickness.img
Sand thickness in Catahoula Formation	CAT_SandThickness.img
Sand thickness in Lower Goliad Formation	LG_SandThickness.img
Sand thickness in Lissie Formation	LI_SandThickness.img
Sand thickness in Lower Lagarto Formation	LL_SandThickness.img
Sand thickness in Middle Lagarto Formation	ML_SandThickness.img
Sand thickness in Oakville Formation	OK_SandThickness.img
Sand thickness in Upper Goliad Formation	UG_SandThickness.img
Sand thickness in Upper Lagarto Formation	UL_SandThickness.img
Sand thickness in Willis Formation	WI_SandThickness.img
Thermal Data Raster Catalog	
Mean annual air temperature	temp_mean_sfc_prism_TX_1981-2010_AOI.tif
Shallow groundwater temperature	temp_mean_annual_shallow_gw_AOI_v2.tif
Deep groundwater temperature	temp_at_3500m_depth_TX_AOI.tif
Temperature gradient between air and deep groundwater	tgrad_c1000ft
Top_Elevation Raster Catalog	
Beaumont top elevation	BB_TopElevation
Catahoula top elevation	CAT_TopElevation

Lower Goliad top elevation	LG_TopElevation
Lissie top elevation	LI_TopElevation
Lower Lagarto top elevation	LL_TopElevation
Middle Lagarto top elevation	ML_TopElevation
Oakville top elevation	OK_TopElevation
Upper Goliad top elevation	UG_TopElevation
Upper Lagarto top elevation	UL_TopElevation
Willis top elevation	WI_TopElevation

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