LAKE JACKSON HYDROGEOLOGIC ASSESSMENT

GEOLOGICAL SURVEY
OF ALABAMA

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By
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Geological Survey of Alabama

Prepared in partial fulfillment of a contract with the
Choctawhatchee, Pea and Yellow Rivers Water Management Authority,
the Alabama Department of Agriculture and Industries, the Covington County Commission,
and the Florala Water and Sewer Board

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INTRODUCTION

Lake Jackson is a 408 acre natural lake, with a drainage basin of 1,134 acres, at Florala, Covington County, Alabama. The lake lies astride the Alabama-Florida state line, providing scenic and recreational opportunities to citizens of both states as well as numerous tourists from around the country. An understanding of the lakes hydrology, its recharge area, formation and structural history, interaction with groundwater, and its water quality, is critical to ensuring the health of this valuable resource.

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Mr. Bill McDaniel, Chairman, Florala Water and Sewer Board

Mayor Danny Franklin, City of Florala

Former Mayor T. C. Boyette

Executive Assistant Hazel Lee, City of Florala

City Clerk Lynn Hughes, City of Florala

Office Assistant Wanda Taylor, City of Florala

Superintendent Mike Holley, Florala Water and Sewer Board

Vicky Nelson, Manager of Florala State Park

Covington County Commissioners: Bragg Carter, Kent Colquett, Harold Elmore, and Carl Turman

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GOALS AND OBJECTIVES

This study of Lake Jackson is intended to document local geology and stratigraphy, determine local groundwater levels and groundwater and surface water interaction, map the bottom of Lake Jackson, determine the primary source of Lake Jackson water, document lake level fluctuations, and determine potential safe water yields.

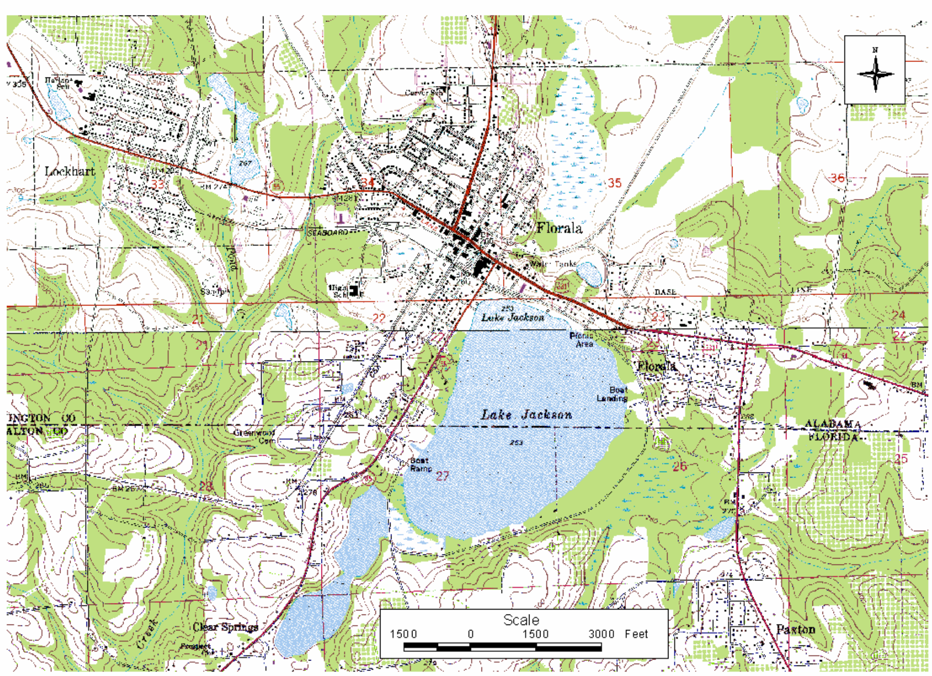
Secondary to the above objectives, this report presents preliminary interpretations of seismic and water-quality data.

STUDY AREA DESCRIPTION

Lake Jackson lies astride the Alabama-Florida state line in southern Covington County, Alabama and Walton County, Florida (figs. 1-3; pl. 1). The city of Florala and surrounding area is home to approximately 4,000 people and serves as the hub for area commerce. The presence of Lake Jackson and Florala State Park attracts local citizens, visitors from other areas of Alabama and Florida, and tourists from all over the United States.

The area included in the study covers approximately 60 square miles surrounding the Lake in Alabama and Florida.

Figure 1 .– Location of study area.



Figure– 2.– Location of Florala and Lake Jackson.

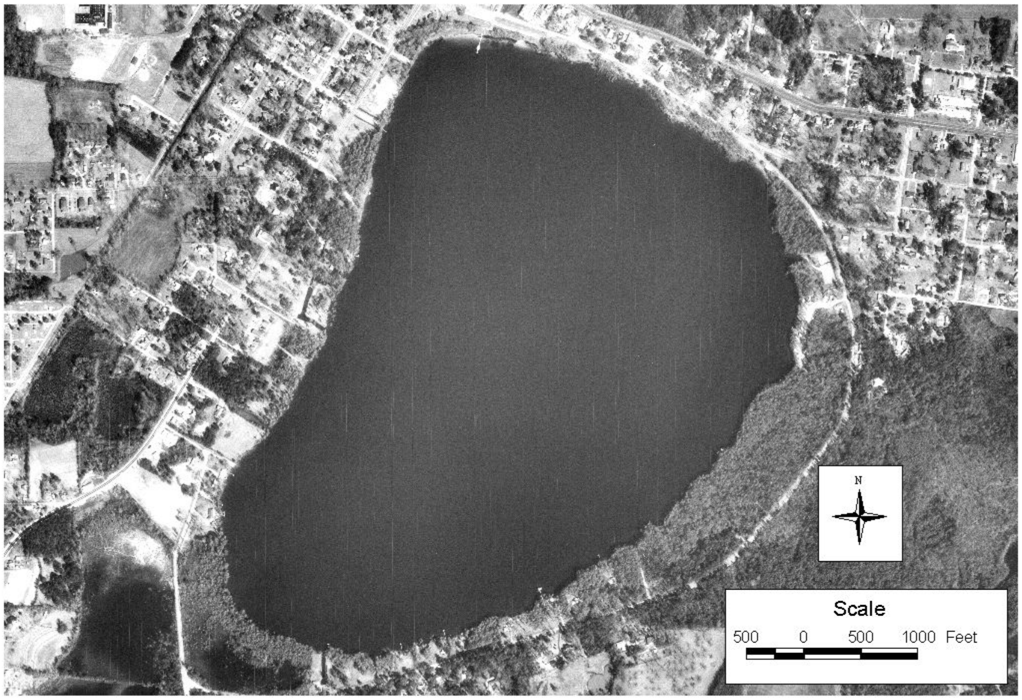


Figure 3.– Aerial photograph of Lake Jackson.

PHYSIOGRAPHIC DISTRICTS

Lake Jackson and Florala lie in the Southern Pine Hills district of the East Gulf Coastal Plain physiographic section. The Dougherty Plain district borders the study area to the north and east of (Sapp and Emplaincourt, 1975).

The Southern Pine Hills district is located in southwest Alabama. Portions of Baldwin, Conecuh, Covington, Escambia, and Monroe Counties are in this district. Topography is low-relief with broad, rounded ridges and V-shaped valleys with sand and clay sediments. This region is not subject to solution like the Dougherty Plain and the boundary between the two districts is sometimes a distinct escarpment. Flat uplands with shallow ponds, bogs, and marshes occur throughout the district and many of the valleys are saucer-like and perpetually wetted by seepage from nearby hills. The abundance of warm summer rains is a major factor in leaching fertility from the soil and favoring the growth of pines in this region. Streams are well sustained by ground-water flows in summer and are commonly called "blackwater" creeks, particularly in reference to those streams originating in the Pine Hills proper, where the term refers to the natural color imparted by dissolved and suspended organic matter.

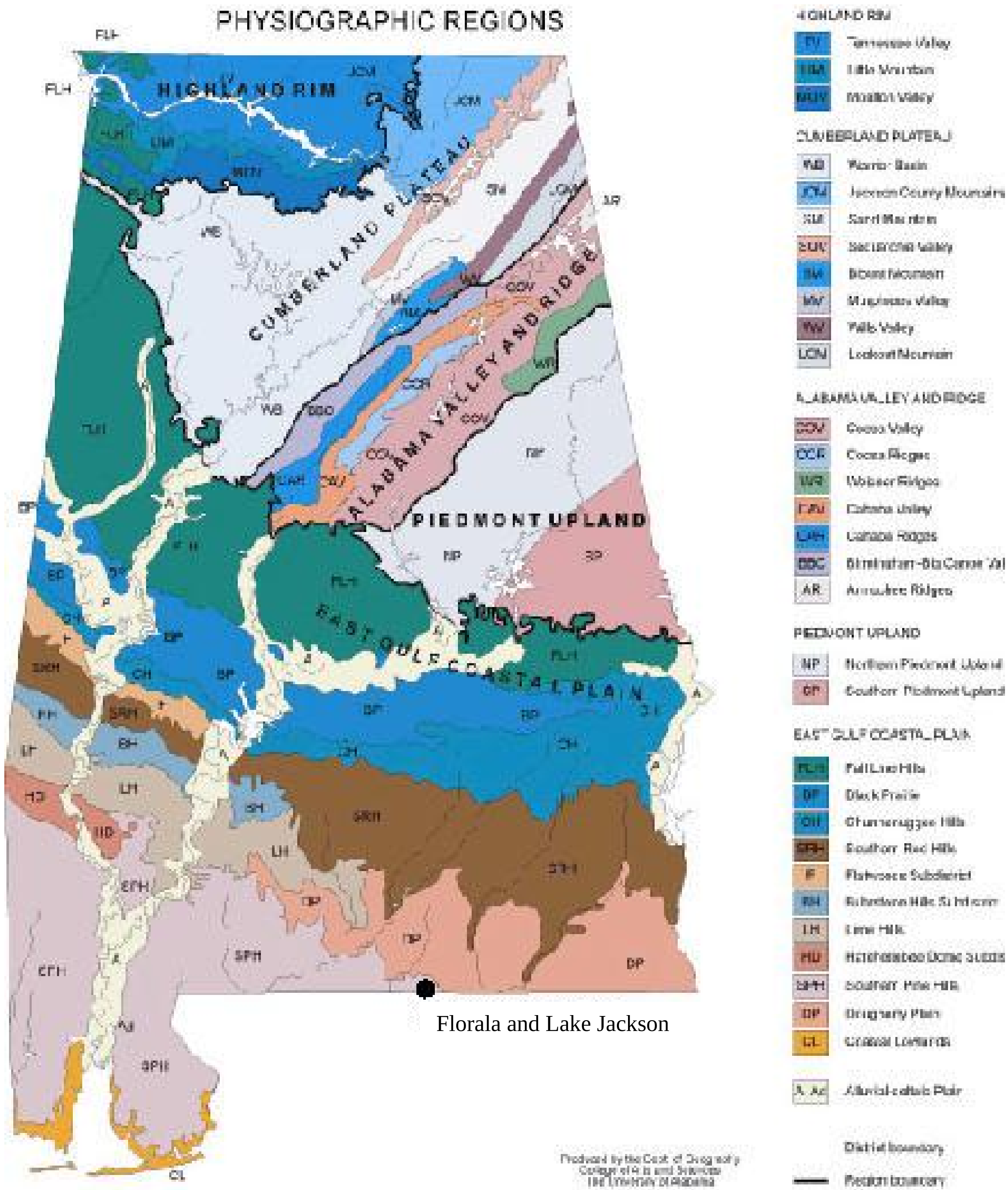


Figure 4.– Alabama physiographic districts and the location of Florala and Lake Jackson.

Major streams draining the Southern Pine Hills include the Conecuh and Perdido Rivers, the lower reaches of the Tombigbee and Alabama Rivers, the Mobile River delta, and the Escatawpa River.

CLIMATE

Alabama, including the Lake Jackson study area, is classified climatically as humid sub-tropical with mild winters and hot summers. Average annual temperature in the area is about 64 degrees Fahrenheit (°F) and annual precipitation is about 60 inches at nearby Kinston in southwest Coffee County, Alabama (Southeastern Regional Climatic Center, 2004). Rainfall in the basin is generally well distributed throughout the year, however, periods of drought and years of excessive precipitation do occur. Lower than normal rainfall occurred in the area during 1954, 66, 67, 84, 86, 87, 90, and 2000. Higher than normal rainfall occurred during 1973, 75, 92, and 94. Table 1 provides a summary of average precipitation and evaporation values for the Lake Jackson area during the period 1965-2004. Annually, about 38 percent of the precipitation in the Lake Jackson area evaporates. During the summer, evaporation is often greater than 75 percent (tbl. 1; fig. 5).

Table 1.– Lake Jackson area average evaporation and precipitation.

MONTH	**EVAP. (mm)**	**EVAP. (in)**	**RAIN (in)**
Jan	10	0.394	5.52
Feb	15	0.591	5.40
Mar	30	1.181	6.59
Apr	50	1.968	4.09
May	75	2.953	4.74
Jun	80	3.150	5.26
Jul	80	3.150	6.46
Aug	80	3.150	4.89
Sept	80	3.150	3.96
Oct	40	1.574	3.35
Nov	20	0.787	4.54
Dec	10	0.394	4.57
TOTALS	**570**	**22.44**	**59.37**

Transpiration from vegetation accounts for additional losses from the hydrologic budget, estimated to be about 4% in the study area. Apart from precipitation, the most significant component of the hydrologic budget is evaporation and transpiration. Evapotranspiration is the water lost to the atmosphere by two processes-evaporation and transpiration. Evaporation is the loss from open bodies of water, such as lakes and

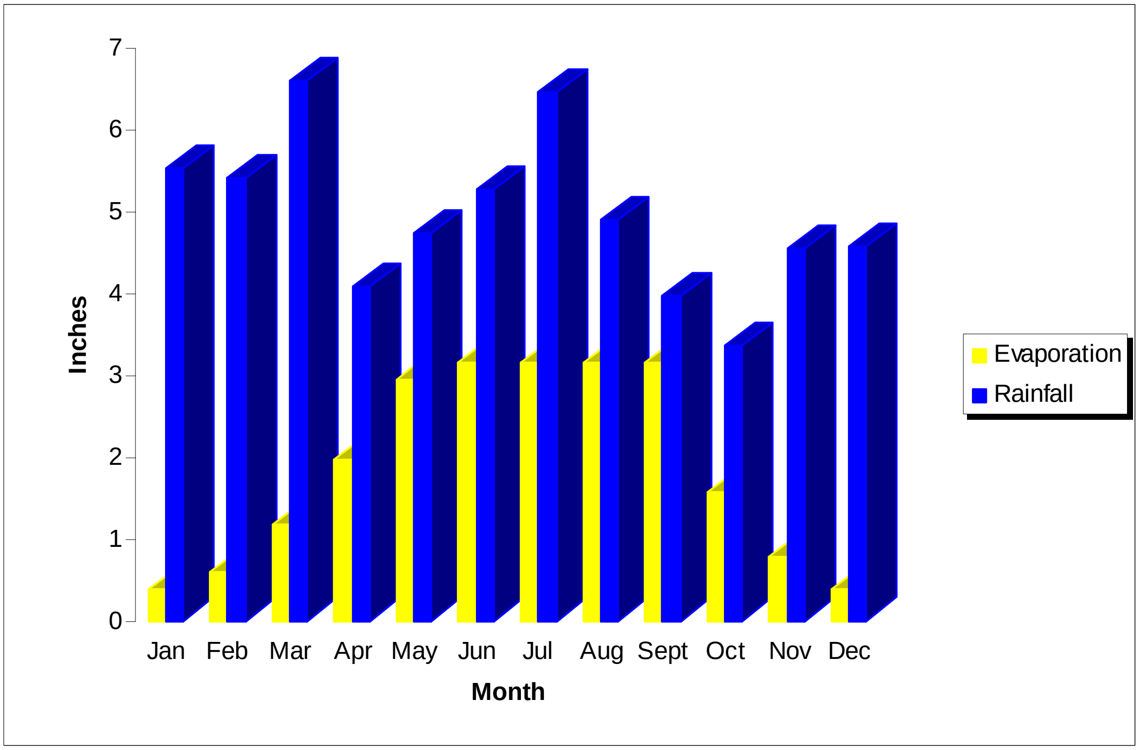


Figure 5.– Lake Jackson area evaporation and precipitation.

reservoirs, wetlands, bare soil, and snow cover; transpiration is the loss from living-plant surfaces. Several factors other than the physical characteristics of the water, soil, snow, and plant surface also affect the evapotranspiration process. The more important factors include net solar radiation, surface area of open bodies of water, wind speed, density and type of vegetative cover, availability of soil moisture, root depth, reflective land-surface characteristics, and season of year. Assuming that moisture is available, evapotranspiration is dependent primarily on the solar energy available to vaporize the water. Because of the importance of solar energy, evapotranspiration also varies with latitude, season of year, time of day, and cloud cover.

Evapotranspiration varies regionally and seasonally; during a drought it varies according to weather and wind conditions. Estimates of average statewide evapotranspiration for the conterminous United States range from about 40 percent (%) of the average annual precipitation in the northwest and northeast to about 100 percent in the Southwest (NOAA, web page). In the Lake Jackson area evapotranspiration is approximately 42% of precipitation (NOAA). During a drought, the significance of evapotranspiration is magnified, because evapotranspiration continues to deplete the limited remaining water supplies in lakes and streams and the soil.

A hydrologic budget for the Lake Jackson area is presented in figure 6. The fate of precipitation in the study area can be summarized as follows: 42% or 25.2 inches is lost to evapotranspiration, 36% or 21.6 inches becomes runoff to streams and rivers, and the remaining 22% or 13.2 inches infiltrates the soil becoming ground water.

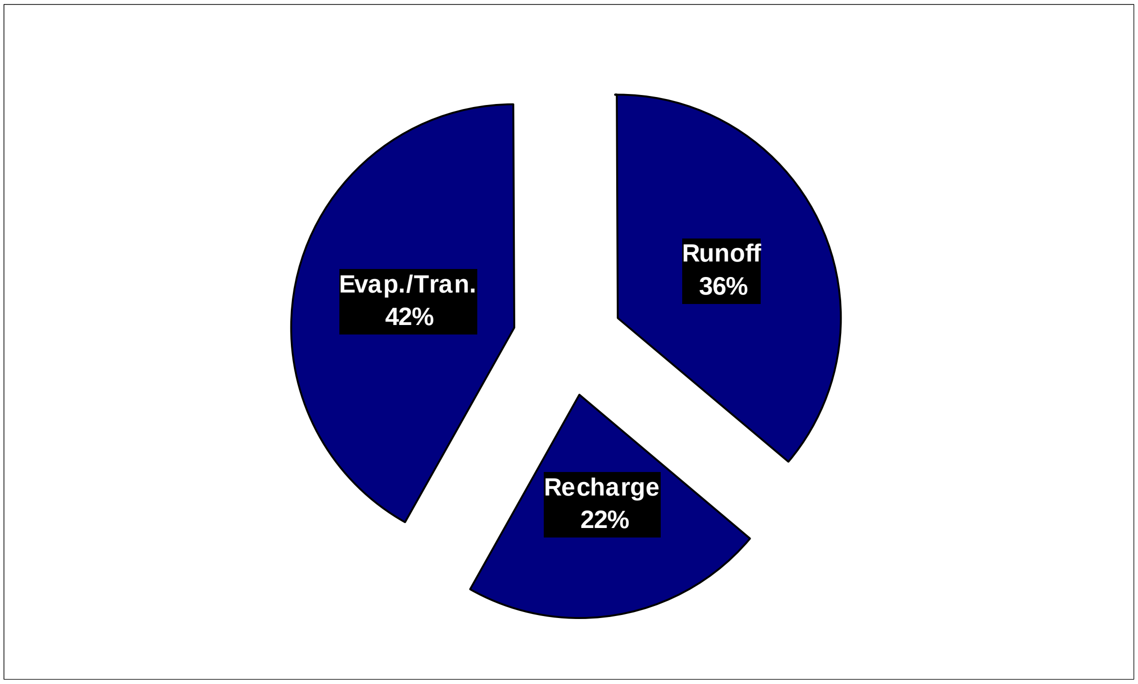


Figure 6.– Hydrologic budget for the Lake Jackson area.

HYDROGEOLOGIC ASSESSMENT

The surface, or exposed, geology of the Florala area consists of deeply weathered Miocene sediments consisting of reddish-brown, highly ferruginous, poorly sorted sand and reddish plastic clays. These Miocene sediments, or the lithologically similar residuum deposits that consist of the soil or weathered accumulation of in-place underlying rock formations, extend from Florala northward throughout the southern two-thirds of Covington County. Eastward, these same sediment types extend throughout the surface of both Geneva and Houston Counties as well as westward throughout Escambia County. These thin Miocene and/or residual sediments overlie all but the most deeply entrenched stream and river beds, or quarry sites, and thus serve to conceal the underlying bedded geology.

In order to understand the “fresh” geology lying beneath the surficial weathered sediments, the subsurface geology is best defined by examining the records of water wells and/or oil and gas test wells. These records are compiled by the various drillers of wells, and usually consist of intervals of drill depth followed by 1- or 2-word adverb-adjective combinations such as “white sand,” “red clay,” or simply “rock.” These are usually the only lithological data which remain in archives after a well has been drilled. These data are often difficult, if not impossible, to interpret and assign to one of the geological formations because most formations contain at least some “white sand,” “red clay,” and “rock.” Fortunately, samples are occasionally caught and retained from one or more of the drilled wells in an area. These samples, with their corresponding depth or depths, are invaluable in deciphering the geology of an area. Fortunately, samples were taken from two wells in the Florala area and later archived by the Geological Survey of Alabama. Samples from two deep wells drilled by the city of Florala, City Well No. 1 drilled in early 1977 near the southwestern margin of the Florala airport (Survey No. CC-01, plates 1-3; appendix) and a deep test well drilled by the city along the northeastern shore of Lake Jackson (Survey No. FF-01, plates 1, 3; appendix), were invaluable in understanding the geological succession of beds beneath the Florala area. Samples from each of these two wells were microscopically examined and described, with the intervals of similar lithology assigned to known geological formations in the southeastern Alabama area. These data were then plotted in lithological “strip logs,” which were used to correlate the individual geological units throughout the area of investigation. Individual “strip logs” (see appendix) were then selected for use in constructing the two geological cross sections which accompany this report (plates 2, 3). The individual “strip logs,” or cross sections, not only show the depths of water production in each well but often indicate underlying formations which might have potential as a future water resource. The cross sections also show the depth and thickness relationships of the formations throughout the study area as well as show the differences in lithology from one area to another. The evaluation of individual wells and the resulting cross sections were critical in the construction of table 1, which shows the name of each formation, its age and generalized thickness, and its predominate lithology in the Florala area.

STRATIGRAPHY

The following sections of this report present lithological descriptions and discussions for each of the geological formations identified to be present beneath the Florala area (table 2). The lithological and thickness data were derived from an evaluation of the enclosed drillers' logs and sample descriptions (see appendix). These data were supplemented by geological information gathered during the hydrogeological evaluation of the area conducted during the geological assessment of the Choctawhatchee, Pea, and Yellow Rivers watershed (Smith, 2001). The discussion of the geologic, or stratigraphic, units in the area will proceed from oldest to youngest so that differing lithologies and depositional processes through time might be more orderly.

TERTIARY SYSTEM
EOCENE SERIES
CLAIBORNE GROUP
TALLAHATTA FORMATION

The Tallahatta Formation takes its name from the Tallahatta Hills which extend in a northwest-southeast band through central Choctaw County, west-central Alabama. In Choctaw County and other areas in west-central Alabama, the Tallahatta Formation is about 125 feet thick and consists predominantly of light-greenish-gray, indurated siliceous claystone with subordinate thin layers of clay, sandy clay, sand, and indurated sandstone. Where weathered, the Tallahatta Formation becomes more indurated and brittle and breaks into sharply angular blocks with pronounced conchoidal fracture. These claystones resist erosion and form prominent northward- or northeastward-facing escarpments or cuestas. These Tallahatta Hills form the steepest and most rugged topography within Alabama's Coastal Plain.

In Covington County, the Tallahatta Formation is exposed at the surface only in the most northern one-third of the county. In this area, the Tallahatta Formation is about 100 to 125 feet in thickness and consists of clay, claystone, and sand. Throughout northern Covington County, these beds are invariably deeply weathered and oxidized and are represented by reddish-orange to reddish-brown sands, clayey sands, and clays. Beds

Table 2.—Stratigraphy of the Lake Jackson area, Covington County, Alabama.

SYSTEM	SERIES	GROUP	GEOLOGIC UNIT	LITHOLOGY AND THICKNESS (feet)
Tertiary	Miocene		Miocene (undiff.)	60-80
	Oligocene		Chickasawhay Ls.	60-80
		Vicksburg	Bucatunna Clay	40-45
			Marianna Ls.	120-135
	Eocene	Jackson	Crystal River Fm.	70-120
			Yazoo Clay	40-70
			Moodys Branch Fm.	90-130
		Claiborne	Lisbon Fm.	>287
			Tallahatta Fm.	? 200

EXPLANATION

Sand, Clay, Sandstone, Dolomitic Ls.

Gravel, Marl, Limestone, Fossils

of typical Tallahatta claystone are rarely present in the outcrop near the top of the formation and just beneath the overlying Lisbon Formation.

During this investigation, the only record of the Tallahatta Formation is that encountered in the test well drilled for the city of Florala (Well FF-01, appendix). In this well, 45 feet of Tallahatta sediments were encountered in the interval between 777 and 822 feet drill depth, or at elevations of -517 to -562 feet sea level. These 45 feet of sediments penetrated just above total depth of the well consists predominantly of sand, silty clay, and limestone similar to that encountered in the overlying Lisbon Formation. However, this interval contains rare to common fragments of greenish-gray claystone and is thus assignable to the Tallahatta Formation.

LISBON FORMATION

The Lisbon Formation, which overlies the Tallahatta Formation, takes its name from exposures at Lisbon Bluff and nearby Lisbon Landing along the eastern bank of the Alabama River in northwestern Monroe County, Alabama. In its type area, the Lisbon Formation consists of about 150 to 175 feet of glauconitic and fossiliferous coarse sand, clayey sand, and sandy clay. The Lisbon Formation becomes thinner in an eastward direction and is only about 50 to 75 feet thick in its outcrop in the northern and north-central portions of Covington County. In most of the outcrop exposures, the Lisbon Formation is deeply weathered and oxidized and consists of reddish-orange medium- and to coarse-grained quartzose sand residuum. In rare unweathered exposures along the Conecuh River and northern tributaries of the Yellow River, the Lisbon Formation consists of light-gray sandy siltstone, sandy limestone, and sand (Turner and Scott, 1968).

In the subsurface beneath the Florala area, the Lisbon Formation has a maximum observed thickness of 287 feet in the test hole drilled for Well FF-01 (plates 1, 3; appendix). In this well, the Lisbon consists predominantly of fossiliferous sand and sandy limestone, very similar to that recorded for the outcrop lithology. Only two other “deep” wells in the study area are known to have penetrated the Lisbon Formation. Known only from drillers’ records, Well CC-4 and the test well for Well CC-01 (pls. 1, 3; appendix) each encountered a Lisbon section consisting predominantly of sandy limestone with subordinate amounts of thin beds of clay. Although sands within the Lisbon Formation currently provide water to only two deep wells in the area, namely Wells CC-04 and FF-01, the deep Lisbon Formation should be a viable aquifer yielding high-quality water throughout the Florala area.

JACKSON GROUP

MOODYS BRANCH FORMATION

The Moodys Branch Formation was named for exposures along Moodys Branch, a tributary of the Pearl River, which flows through the city of Jackson in Hinds County, Mississippi. In its type area, the Moodys Branch consists of about 25 feet of dark-green, very highly glauconitic, calcareous and fossiliferous sandy marl. The Moodys Branch Formation extends from Jackson eastward where it enters Alabama in southwestern Choctaw County.

From its type locality eastward, through west-central Alabama and further eastward across the state to the Chattahoochee River in southeastern Houston County, the Moodys Branch Formation maintains its general thickness and lithology. In Covington County, this formation, like others, is generally deeply weathered and retains none of its original lithological character. According to Turner and Scott (1968), the formation can be distinguished only in the fresh outcrops exposed in the channel of the Conecuh River southwest of Andalusia. These exposures have been described as consisting of glauconitic and calcareous, highly fossiliferous clayey sands containing thin sandy limestones and sandstone ledges.

Toward the south and in the subsurface beneath Florala, the Moodys Branch Formation was observed only in Wells CC-4, CC-01, and FF-01 (pls. 1, 3; appendix). In these wells, and throughout the general study area, the Moodys Branch Formation ranges from about 90 to 130 feet in thickness and consists generally of highly fossiliferous sands and limestones with subordinate beds of highly fossiliferous marls. Although slightly thicker than in the outcrop trend and containing a greater percentage of limestone beds, the Moodys Branch Formation is distinctive and readily mapped throughout the subsurface of the Florala area. The only known water currently produced from this formation in the Florala area is that found in the 15-foot interval between 469 and 484 feet drill depth in Wells CC-4, one of the wells currently supplying water to the town of Florala. Although contained sands might yield water to other wells, the Moodys Branch Formation is not regarded as an aquifer capable of producing large, or even moderate, quantities of water.

YAZOO CLAY

The Yazoo Clay takes its name from exposures in bluffs along the Yazoo River near the town of Yazoo, west-central Mississippi. In Choctaw and western Clarke Counties in west-central Alabama, the Yazoo Clay is about 150-feet thick and is divisible into four lithologically distinctive and mappable members. In outcrop exposures toward the east, the Yazoo Clay becomes progressively thinner and generally more calcareous. Like the underlying Moodys Branch Formation, surface exposures of the Yazoo Clay in Covington County are predominantly deeply weathered and retain none of their distinctive lithological characteristics. A notable exception occurs in exposures along the banks of the Conecuh River southwest of Andalusia. In these exposures, the undivided Yazoo Clay is about 70 feet thick and consists predominantly of highly calcareous sand and sandstone and soft cream-colored limestone.

In the subsurface beneath the study area, the Yazoo Clay was penetrated in part or entirely in five wells, namely Wells CC-4, CC-01, CC-03, DD-07, and FF-01 (pls. 1-3; appendix). In the Florala area, the Yazoo Clay varies from about 40 to 70 feet in thickness with recovered samples indicating it to consist largely of medium to coarse clayey sand with subordinate amounts of soft limestone and light-gray sandy clay. The Yazoo Clay contributes water to three of the wells used in this report: Well CC-03 located along the western margin of the area; Well DD-07 along the eastern margin of the study area; and Well FF-01 located in the southern part of the area along the northeastern shore of Lake Jackson (pl .1). Wells CC-03 and DD-07 individually yield 10 to 20 gallons of water per minute, sufficient volumes for individual home use. Yields in larger quantities are not believed to be possible from the Yazoo Clay in the Florala area.

CRYSTAL RIVER FORMATION

The Crystal River Formation was named for the limestone exposed in the Crystal River Rock Company Quarry near the town of Crystal River, about 70 miles north of Tampa, in Citrus County, Florida. As defined in Florida, and adapted for use in Alabama, the Crystal River Formation is applied to all of the limestone deposits in southeast Alabama that can be shown to be the eastern or southeastern equivalents of the Yazoo Clay toward the west in Choctaw and Clarke Counties (Toulmin, 1977). In the Florala area, as well as throughout Covington County, the Crystal River Formation consists of those limestones lying above the thin beds of Yazoo Clay and beds lying beneath the overlying Marianna Limestone of Oligocene age. Or more simply stated, the name Crystal River Formation is used for all limestone beds in southeastern Alabama of late Eocene age lying above the Moodys Branch Formation (table 1).

In the Florala study area, samples were present from only two wells, Wells CC-01 and FF-01 (pl. 1; appendix). The 120 feet of pale-orange to light-brown limestone within the interval between 240 and 260 feet drill depth in Well CC-01 are herein assigned to the Crystal River Formation, as are the 68 feet of limestones in Well FF-01 within the interval between 240 and 312 feet drill depth. These limestones are fossiliferous, often clayey, and invariably recrystallized, yielding a series of limestones with significantly increased porosity and permeability, resulting in beds generally capable of yielding small to moderate quantities of potable water. Southward from Florala, and throughout much of the panhandle area of Florida, these same beds form part of the Ocala Group of sediments, one of the largest and most significant regional aquifers in northwestern Florida.

In wells lacking sample control, which includes the majority of wells used in this study, this interval cannot be distinguished from the overlying Marianna Limestone. Drillers invariably record rock, limerock, or limestone throughout both formations, thus resulting in a lack of differentiation.

OLIGOCENE SERIES
VICKSBURG GROUP
MARIANNA LIMESTONE

In southwestern and south-central Alabama, the Vicksburg Group consists of, in ascending order, the Red Bluff Clay and its eastern equivalent known as the Bumpnose Limestone, the Forest Hill Sand, Marianna Limestone, and the Byram Formation. These formations and their several members are readily recognized throughout southwestern Alabama in both surface exposures as well as in the shallow subsurface. In southeastern Alabama, including Covington County, the Vicksburg Group in surface exposures is predominantly deeply weathered, its formations and members no longer recognizable, and generally mapped as part of the thick deposits of surface and near-surface residuum.

During the present investigation, a thin series of limestones were identified and mapped lying between the Crystal River Formation and the overlying Bucatunna Clay Member, the upper member of the Byram Formation. Whether these limestones are equivalent in part or in their entirety to the Bumpnose Limestone, the Marianna Limestone, or to the Glendon Limestone Member of the Byram Formation is unknown and well beyond the present investigation. For purposes of this study, the name Marianna Limestone will be used for the subsurface limestones lying above the late Eocene Crystal River Formation and below the uppermost Vicksburg, middle to late Oligocene Bucatunna Clay Member of the Byram Formation.

The Marianna Limestone takes its name from exposures about 30 miles south-southeast of Dothan near Marianna, Jackson County, Florida. In the subsurface of the Florala area, the Marianna Limestone was identified in only two wells, Well CC-01 and FF-01 (pl. 1;

appendix). All other wells used during this investigation had no samples available for study, and thus the Marianna Limestone and Crystal River Formation could not be differentiated. In Well CC-01, the Marianna Limestone was identified within the interval between 120 and 240 feet, and in Well FF-01, correlative limestones were identified between 109 and 244 feet drill depth (see appendix). These limestones are generally coquioidal. That is, they are composed of little other than fossil shells and shell fragments, and thus are readily distinguished from samples assigned to the underlying Crystal River Formation. Where samples are unavailable, and drillers' records record only "lime" or "limestone" or "rock," these two formations cannot be differentiated. Thus, due to the lack of well samples, the Crystal River Formation and overlying Marianna Limestone were mapped as a single unit (pls. 2-3; appendix). As noted previously, the undifferentiated Marianna Limestone and Crystal River Formation constitute one of the most significant aquifers in the Florala area.

BYRAM FORMATION, BUCATUNNA CLAY MEMBER

The Bucatunna Clay was originally described as a unit of formational status, taking its name for exposures of sandy lignitic clay along Bucatunna Creek in southeastern Wayne County, Mississippi. In Alabama, the Bucatunna Clay is regarded as a member of the Byram Formation. In outcrop exposures in Washington and Clarke Counties in southwestern Alabama, the Bucatunna Clay Member is about 20 feet thick and consists predominantly of gray, nonfossiliferous, lignitic clay. Eastward from Clarke County, the Bucatunna is either overlapped (covered) by Miocene and younger sediments, or as in southeastern Alabama, so deeply weathered that it cannot be identified nor mapped in surface exposures.

In the shallow subsurface of southeastern Alabama, the Bucatunna Clay Member has only recently been identified and mapped in southern Covington County (Smith, 2001). During the current study, the Bucatunna was found to vary from about 20 to 80 feet in thickness north, northwest, and northeast of Florala and to thin to only about 40 to 45 feet in thickness in wells in the immediate vicinity of Florala (pls. 1-3; appendix). An examination of archived samples from Wells CC-01 and FF-01 (pl. 1; appendix) indicates that the Bucatunna consists predominantly of clayey fine to coarse sand with only subordinate amounts of non-sand constituents. Drillers, however, generally note clay, limey clay, or chalk when encountering the Bucatunna. This seeming discrepancy in lithology is believed due to excessive "rinsing" of the unconsolidated samples with resulting removal of the soft clay during sample preparation. Other subsurface data for southern Covington County indicates that the Bucatunna Clay Member consists predominantly of light-olive-gray, finely sandy, calcareous clay to very highly clayey fine sand (Smith, 2001).

Although the Bucatunna Clay Member is known to contribute water to Wells CC-04 and DD-06 located northeast of Florala (pl. 1; appendix), its contribution is small (8 to 10 gallons per minute). Rather than serving as a significant aquifer, the Bucatunna has its greatest value in serving as a thin, yet effective, aquitard or confining unit. This unit overlies the Marianna Limestone and Crystal River Formation aquifer and is believed to serve as a retardant to potentially contaminated surface or near-surface water from migrating downward into the underlying limestone.

CHICKASAWHAY LIMESTONE

The Chickasawhay Limestone was named from exposures along U.S. Hwy. 45 and outcrops along Limestone Creek and the Chickasawhay River near Waynesboro in Wayne County, Mississippi. In its type area, the Chickasawhay Limestone consists of about 45 feet of marly and quartzose sandy fossiliferous limestone and highly fossiliferous marl and clay. Southeastward, the unit can be mapped in isolated exposures into southern Choctaw and northern Washington Counties, Alabama. The Chickasawhay Limestone continues to be rarely exposed through central Monroe County into south-central and southeastern Conecuh County. In southwestern and southern Covington County, exposures of fresh Chickasawhay Limestone are rare and occur only in streams and rivers that have cut deeply through the overlying weathered residuum into unweathered Chickasawhay beds. Throughout most of the area of investigation, drill records invariably record “sand,” “clay,” or “marl,” or mixtures of these lithologies. Although these sediments are herein assigned to the Chickasawhay Limestone, they represent deeply weathered beds which are atypical of the Chickasawhay and difficult to distinguish from the overlying sands and clays of Miocene age.

Drill records indicating the presence of fresh and unweathered Chickasawhay Limestone area exceptionally rare in the Florala area. The only record of limestone for this interval is that recorded in the drillers’ log for the production hole for Well FF-01 located along the northeastern shore of Lake Jackson (pl. 1). Two intervals in this production hole, 6 to 15 feet and 52 to 78 feet, were recorded as consisting of “limestone” (see appendix). Unfortunately, samples archived from the test hole from Well FF-01 (see appendix) contain no limestone at all. Thus, the lithological character of the Chickasawhay Limestone in the immediate Florala area remains unknown. Other data from deep wells from southern and south-central Covington County (Smith, 2001), such as a deep oil and gas test well about 7 miles northwest of Florala, indicates the Chickasawhay consists predominantly of white to very light-gray, indurated, quartzose sandy and glauconitic limestone. These beds are dolomitized and highly porous and permeable (vugular) from recrystalization and subsequent solution.

Although there is no known water produced from the Chickasawhay Limestone interval anywhere within the study area, low capacity shallow water production (±3 to 5 gallons per minute) is possible from weathered Chickasawhay sandy residuum. Such shallow wells, however, would be highly susceptible to surface and/or near-surface contamination and any water produced should be closely monitored.

Any role that the Chickasawhay may have played in formation and subsequent evolution of Lake Jackson is currently highly speculative. Hopefully, further study of the lake, its contained sediments, and the sediments bounded and underlying its waters, might resolve many current questions. The lithology within the upper 100 feet of the production hole for Well FF-01 (appendix) certainly suggests the presence of bedded limestone or limestones within the shallow subsurface of the area. The solution and collapse of these shallow Chickasawhay Limestone beds, perhaps hundreds of thousands to a few millions of years ago, may have played an important role in the development of Lake Jackson. Although this preliminary investigation suggests a collapse, or "sink," additional study is necessary to confirm this speculation.

MIOCENE SERIES (UNDIFFERENTIATED)

The Miocene Series (undifferentiated) overlies the Oligocene Chickasawhay Limestone and extends across southern Covington County in a band ranging from about 3 miles in width in the southeastern to about 14 miles in width in the southwestern part of the county (Turner and Scott, 1968). These Miocene beds are only a few feet thick along the northern margin of their zone of outcrop and increase to 100 to 150 feet thick in the subsurface in southwestern Covington County. The maximum observed thickness of the Miocene Series in the Florala area is about 65 feet (Well CC-4; pls. 1, 2; appendix). Throughout southern Covington County, these Miocene beds consist principally of reddish-orange to reddish-brown, ferruginous-stained, poorly sorted sands, sandy clays, and often color-mottled clays with subordinate amounts of gravel. Small dark-reddish-brown limonite (a type of iron oxide) concretions are locally abundant, with thin seams of indurated limonite-cemented sandstone or claystone often occurring in outcrop exposures.

Drillers' logs invariably report "sand," "clay," or "sand and clay," rarely with the addition of a color such as "red" or "white," while drilling through this series of sediments (appendix). Examination of archived samples from Wells CC-01 and FF-01 (pl. 1; appendix) indicates the sands are quartzose, ferruginous-stained shades of pinkish-gray to pale-orange, vary from fine to coarse, with most grains being highly angular. Interbedded clays are generally light-brown to medium-dark-gray and are invariably quartzose silty to fine sandy (appendix).

Although none of the wells that were evaluated during this study are productive of shallow Miocene waters, yields of perhaps 1 to 10 gallons per minute are possible for private supply from shallow dug or drilled wells. As noted for the underlying Chickasawhay Limestone, and its residuum, water produced from these shallow wells are highly susceptible to potential contamination from surface or near-surface pollutants. Thus, appropriate consideration should be given to the possibility of resource contamination prior to exploration drilling and development.

GROUND-WATER RECHARGE, ELEVATIONS, AND QUALITY

Based on the hydrologic budget for the Florala-Lake Jackson area it is estimated that approximately 13 inches for rainfall recharges shallow ground water. A small but unknown quantity of this recharge may reach Lake Jackson.

Plate 4 provides ground-water elevation data for selected wells in the Lake Jackson area. These elevation data represent a mixture of shallow Miocene and deeper formations. As can be seen from the plate, ground-water elevations in the area are considerably less than Lake Jackson's surface elevation of 253 feet above sea level. It appears the lake is perched upon, or in sediments above, the surrounding water table. This is not indicative of a lake fed by a ground-water source. If the lake was in direct communication with area ground water its elevation should closely approximate that of ground water elevations measured in the wells surrounding the lake.

Another indication that Lake Jackson is not sourced primarily by ground water is water quality analysis. An analysis of ground water from Florala City wells CC-01 and CC-4 indicates that it is of good quality and can be classified as calcium- magnesium- bicarbonate type water. When these waters are compared to water from the deepest portion of Lake Jackson it is clear that the waters are not the same type. Lake Jackson water is essentially rainwater, with no dominant water type signature.

ACQUISITION AND INTERPRETATION OF SEISMIC DATA

Seismic data were collected from Lake Jackson during November 17 to 19, 2004, aboard the University of Alabama Department of Geological Sciences research vessel R/V Jenny (fig.7). Acquisition of data was supervised by Dr. Tony Rodriguez with a crew composed of Bob Baker and Marlon Cook of the Geological Survey of Alabama and Robin Metaeus, graduate student in the University of Alabama, Department of Geological Sciences. The purposes of the seismic data were to produce a bathymetric map and provide images of geologic structure below the lake bottom if sub-lake bottom data quality was sufficient for interpretation.

An Edge Tech SB216 full-spectrum “chirp” towfish using a 2-16 killihertz (kHZ) pulse with a theoretical vertical resolution of 6 cm was chosen for the survey (fig. 8 and 9). The system was towed at an average speed of 2.6 knots at a depth of 3 feet below the water surface, and was triggered every 0.25 sec. A CodaOctopus DA50 system was used for digital data acquisition and recorded unprocessed data in SEGY format onto the hard drive and DVD RAM disks. Each trace contains latitude and longitude in the header and approximately 200,000 traces were obtained. The survey was acquired in a grid pattern of 27 eastward trending lines and 24 northward trending lines with an average line spacing of 200 feet.

Due to the expectation that the sub-lake bottom data would be poor, interpretation and presentation of this data was not included in the project scope of work. However, much of the data were excellent. Therefore, the interpretation of a selected group of lines that revealed the probable sequence of events that caused the formation of the lake is included below.

Seismic data are created when an energy pulse is sent downward into the earth. This energy travels as a wave of varying velocities through the subsurface, depending on

Figure 7.– University of Alabama, Department of Geological Sciences research vessel R/V Jenny.

Figure 8.– Edge Tech SB216 full-spectrum "chirp" towfish.

the type of material that is being penetrated. As this energy contacts boundaries of subsurface materials of differing composition, a portion of the energy is reflected back to the earth's surface. There, it is received and converted into an electronic signal that portrays a cross sectional view of the earth's interior. The towfish described above served as energy source and receiver. It emitted a high frequency "chirp" sound wave directed through the lake water column and through the lake bottom (fig. 9). Although a travel time survey was not available for the Lake Jackson area, seismic velocities were obtained from other areas with similar subsurface geology. The velocity of sound through water is approximately 4,800 feet per

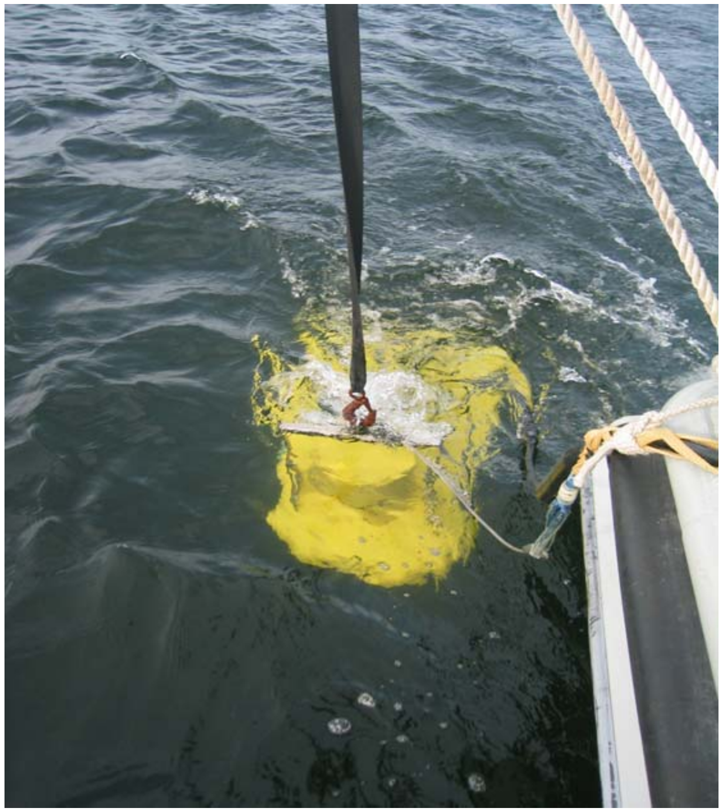


Figure 9.– Edge Tech SB216 full-spectrum "chirp" towfish submerged at tow depth.

second. Using this constant, travel times and distances were calculated for the movement of the energy wave from the lake surface to the bottom of the lake for each of the more than 5,000 data points collected during the survey. Stratigraphic data from water wells constructed near the lake and characteristics of the seismic data indicate that the lake bottom is underlain by layers of sand, silt, and clay. The average velocity of these types of saturated, unconsolidated sediments is approximately 2,500 feet per second. Therefore, unconsolidated sediments may be more than 200 feet thick under portions of the lake. Interpretations of water well data and geologic exposures in the vicinity of the lake by Dr. Charles Smith indicate that the southern Covington County area is underlain by Miocene and Oligocene residuum and by the Chickasawhay and Marianna Limestone. The velocity of limestone is approximately 18,000 feet per second. However, it was expected that the high frequency "chirp" would not penetrate these limestone units. Therefore, the contact between the unconsolidated clastic sediments and the underlying limestone is interpreted as the base of the interpretable seismic signal (base of the clastic sediments) or the top of the zone of no seismic signal (top of limestone).

Results of interpretation of selected seismic data indicate that the center portion of Lake Jackson is underlain by layered clastic sediment varying in thickness from 15 to 80 milliseconds (35 to 200 feet) (fig. 10). The attenuation of seismic signal around the perimeter of the lake indicates that this area is most likely underlain by a thin clastic sediment layer overlying massive limestone (fig. 11). Sediments in the center of the lake are characterized by complex structure related to numerous growth faults caused by differential compaction and subsidence (fig. 12). Localized depressions in the sediment are portrayed on the seismic data during at least three periods of the sediment loading process (fig. 13). The most recent depressions are expressed as holes in the lake bottom that vary in depth from a few feet to more than 20 feet (fig. 14). A relatively large northeastward trending graben is formed by regional normal faulting that probably originates in the deep bedrock. These faults extend into the clastic sediment layers and have throws of approximately 20 feet in the shallow sediment (fig. 15).

The stratigraphic and structural character of the geology underlying Lake Jackson provides clues as to the formation of the lake (fig. 16). Northeastward trending normal faulting of the Chickasawhay and Marianna Limestone created conduits for the infiltration of water which caused solution cavity development (fig. 16 frame 2). Over time a large cavity system developed underneath residuum overburden (fig. 16 frame 3). Eventually, the overburden collapsed into the underlying cavity system, forming a sinkhole at least one mile in diameter (fig. 16 frame 4). As surface water drained into the sinkhole it transported large volumes of sand, silt, and clay. Over a currently undetermined period of time, the sinkhole filled with sediment and eventually held water to form the configuration of Lake Jackson that we see today (fig. 16 frame 5). It is probable that the wetland areas northeast and southwest from the lake were included in the original sinkhole but were filled with sediment so that currently no open water is present.

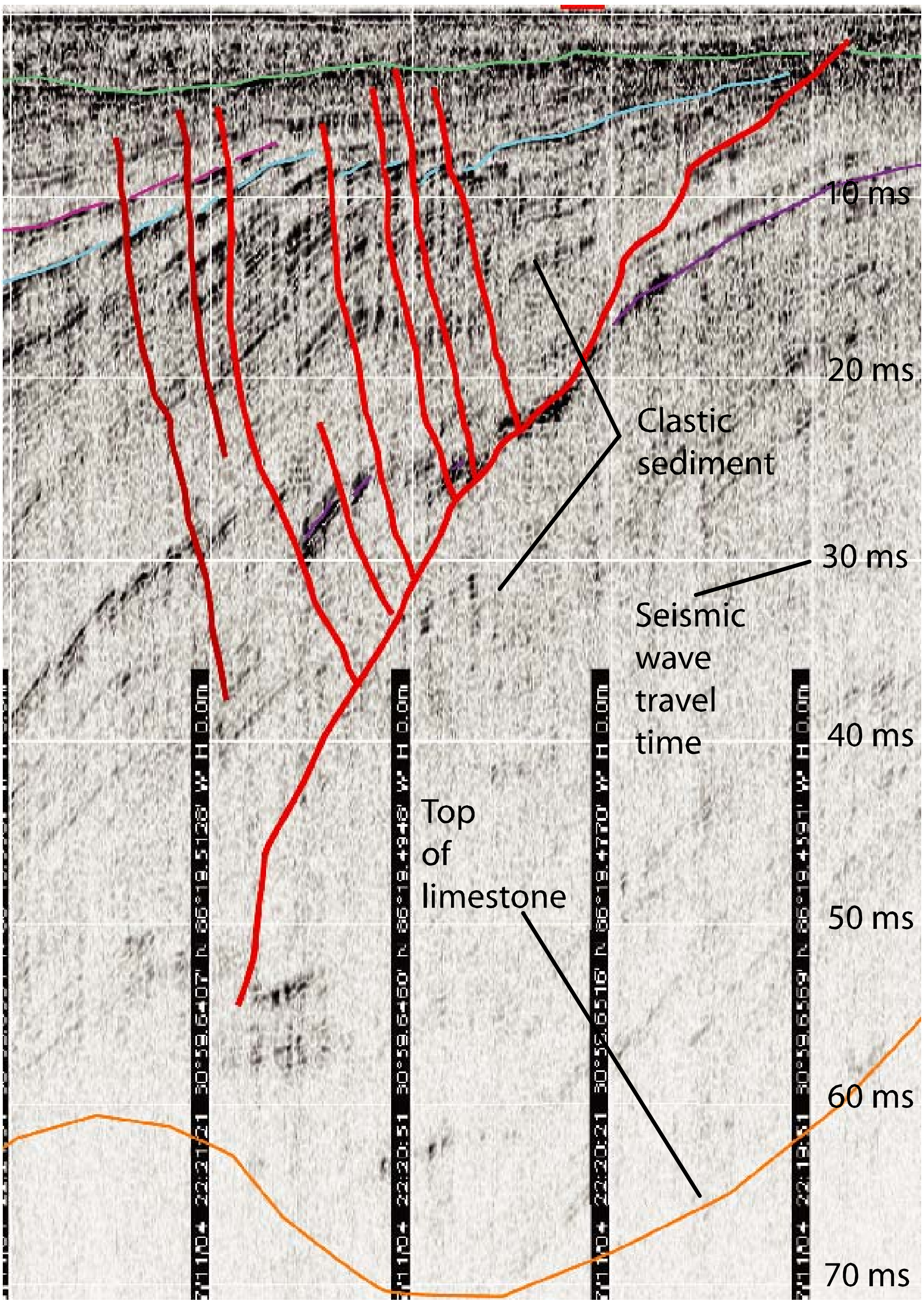


Figure 10.— Interpretation of seismic data from near the center of Lake Jackson.

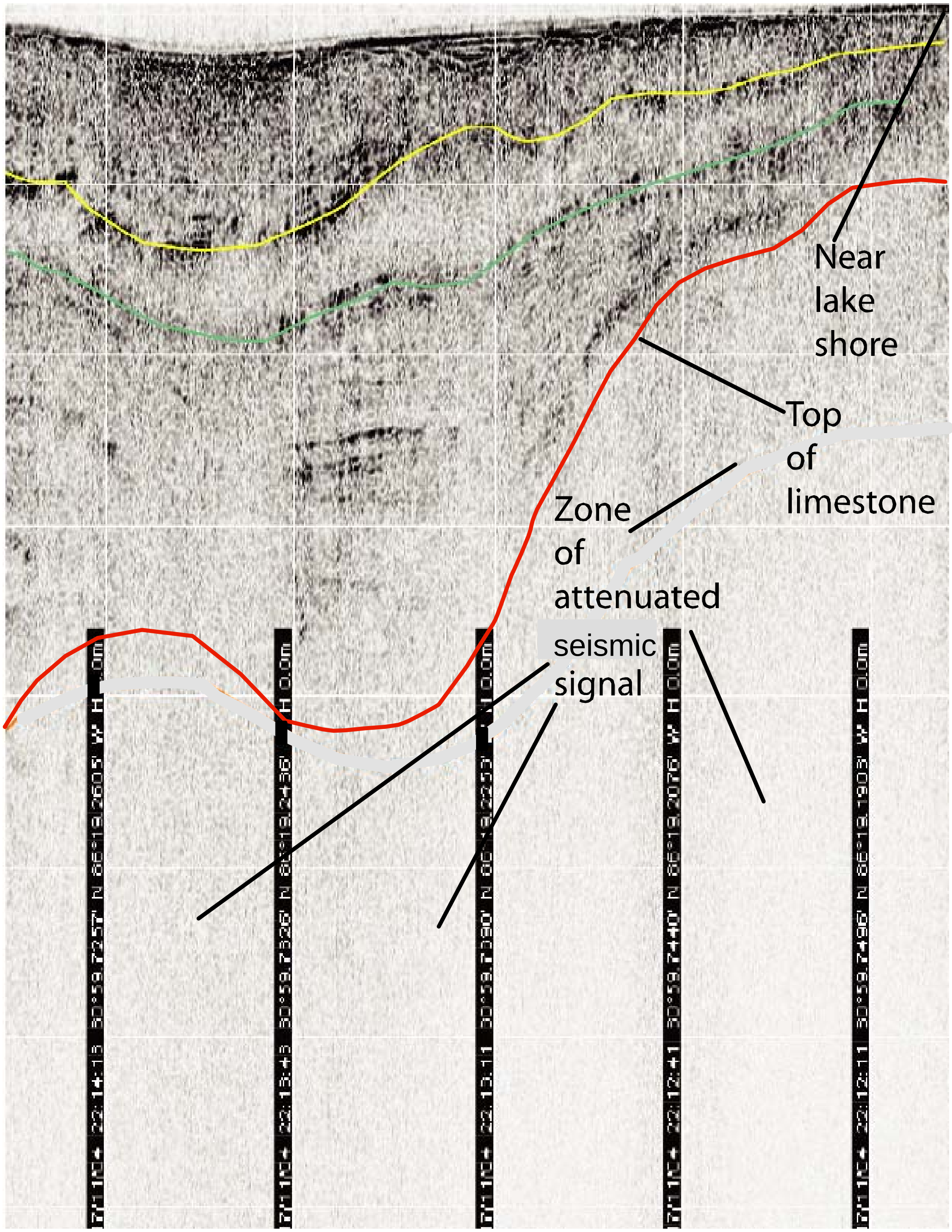


Figure 11.— Interpretation of seismic data from near the perimeter of Lake Jackson.

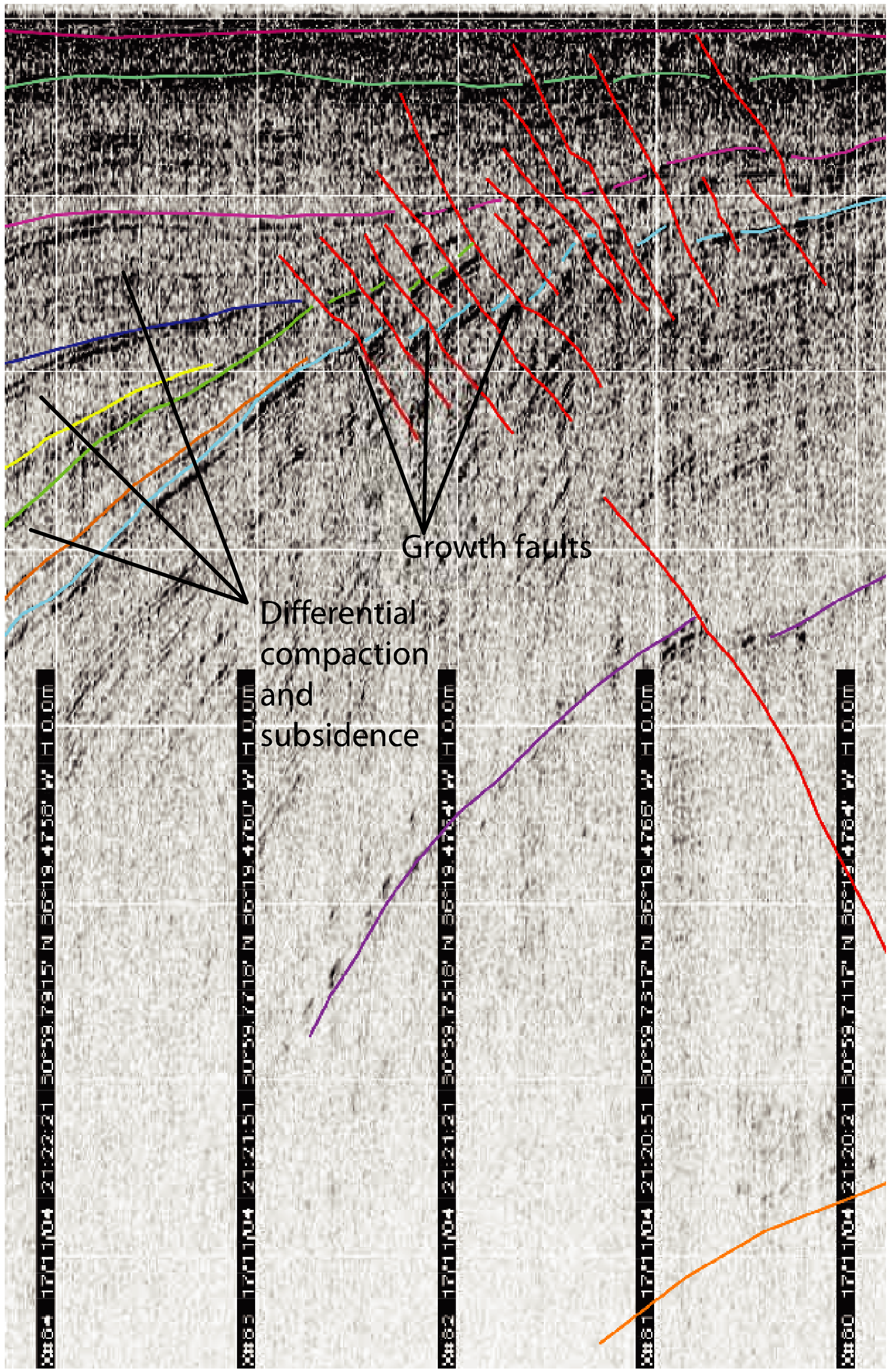


Figure 12.— Interpretation of seismic data from near the center of Lake Jackson illustrating growth faults.

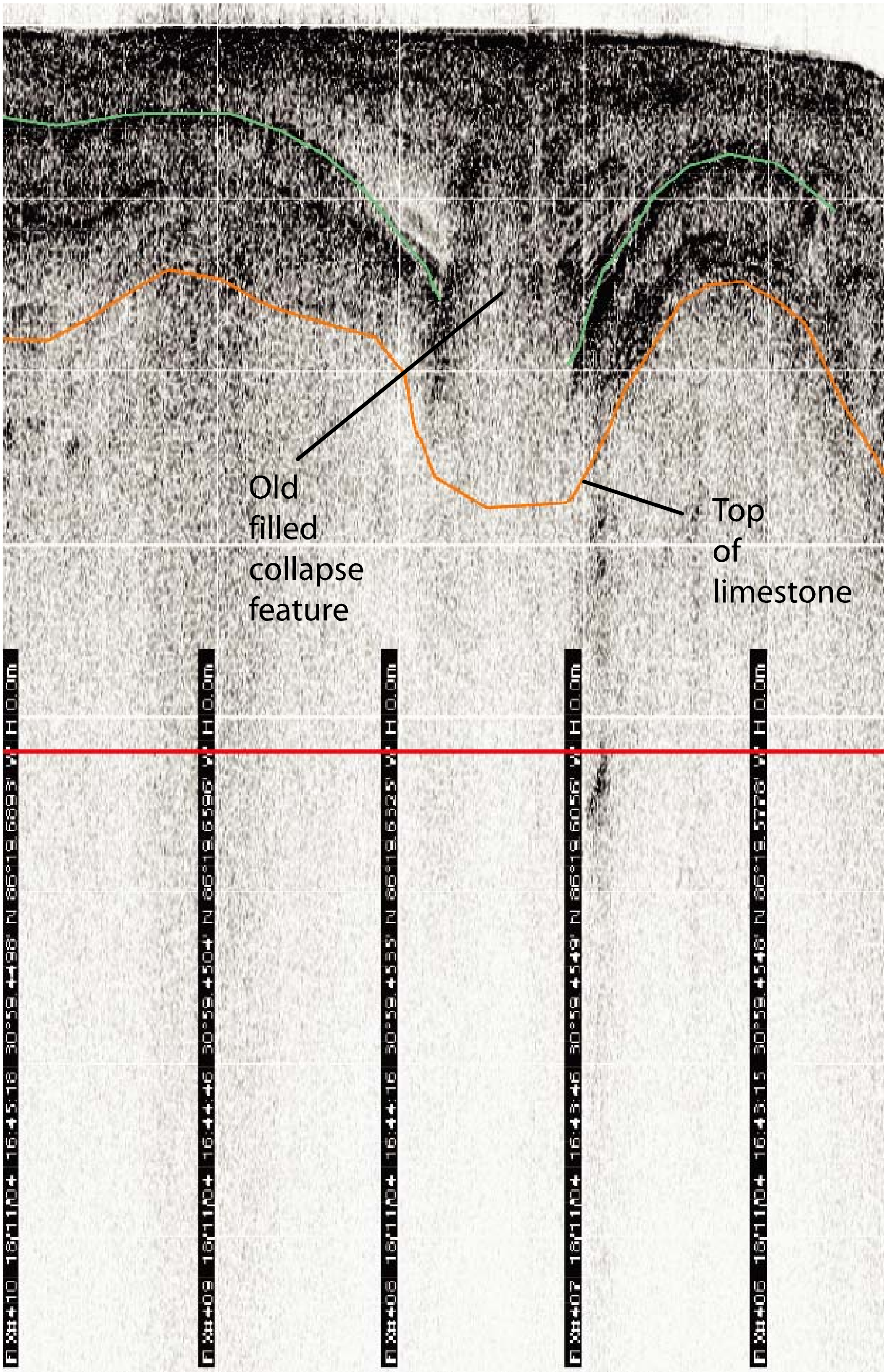


Figure 13.— Seismic interpretation of a filled collapse feature in Lake Jackson.

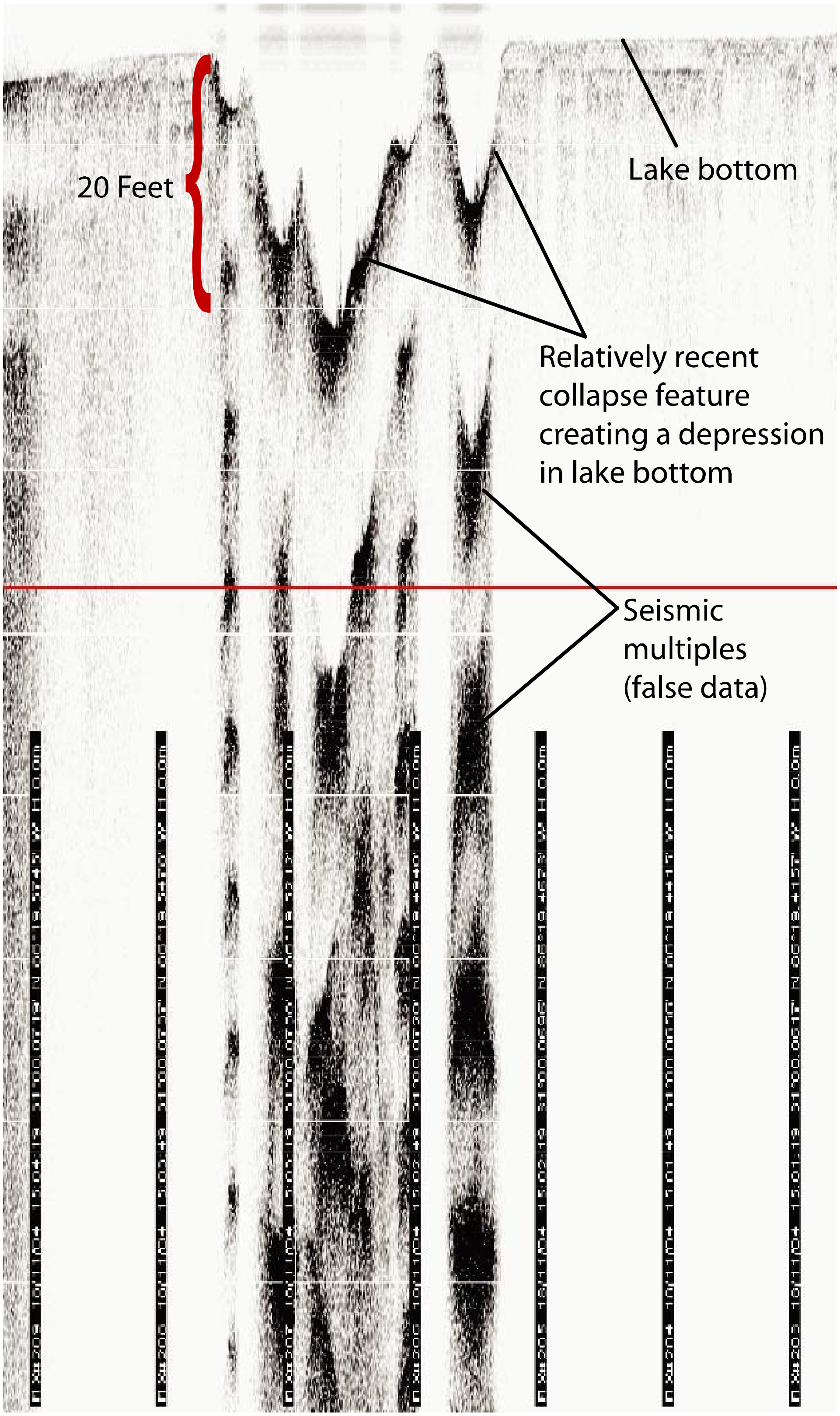


Figure 14.— Seismic interpretation of an open collapse feature in Lake Jackson.

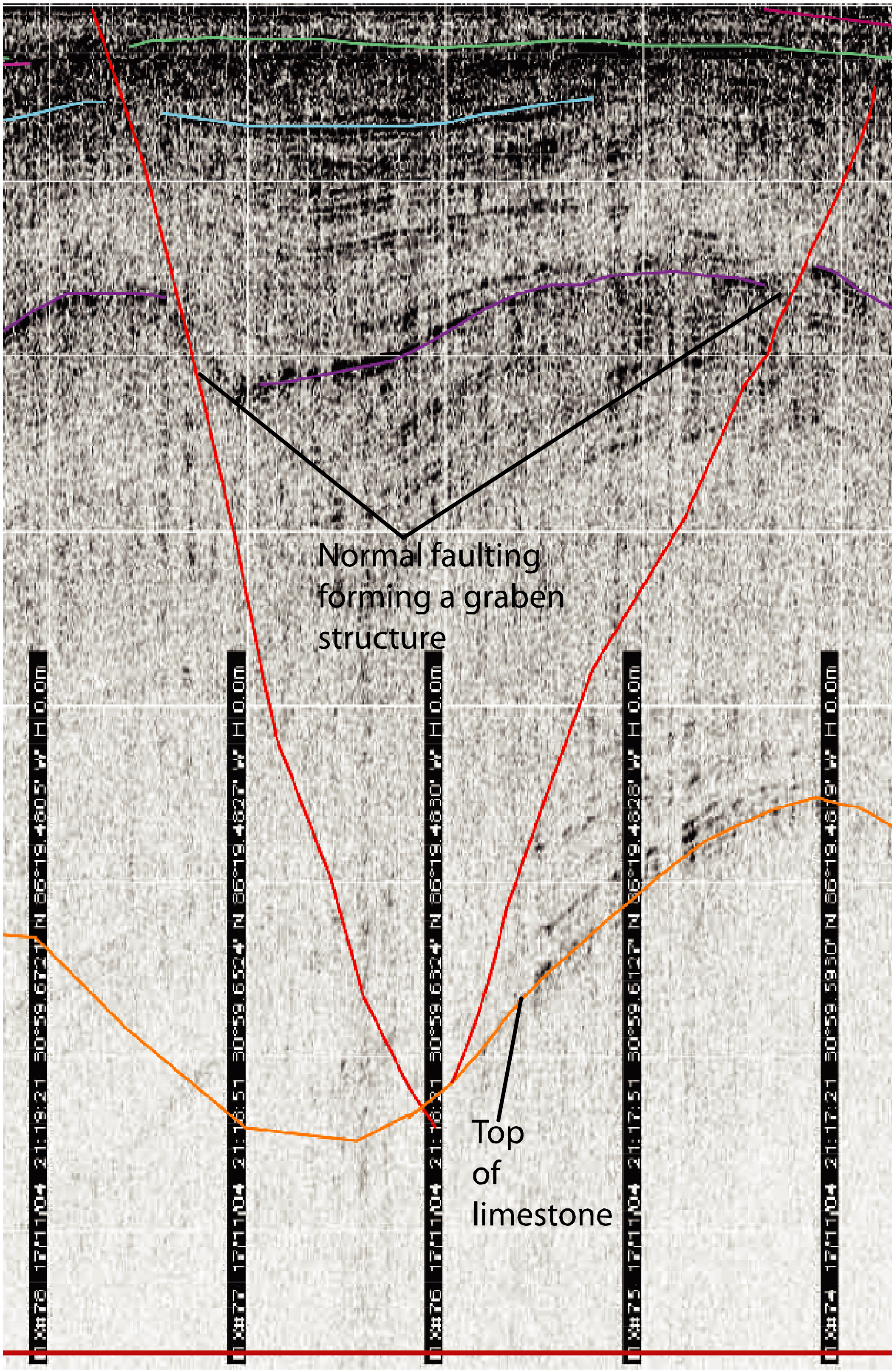


Figure 15.— Seismic interpretation of a graben feature underlying Lake Jackson.

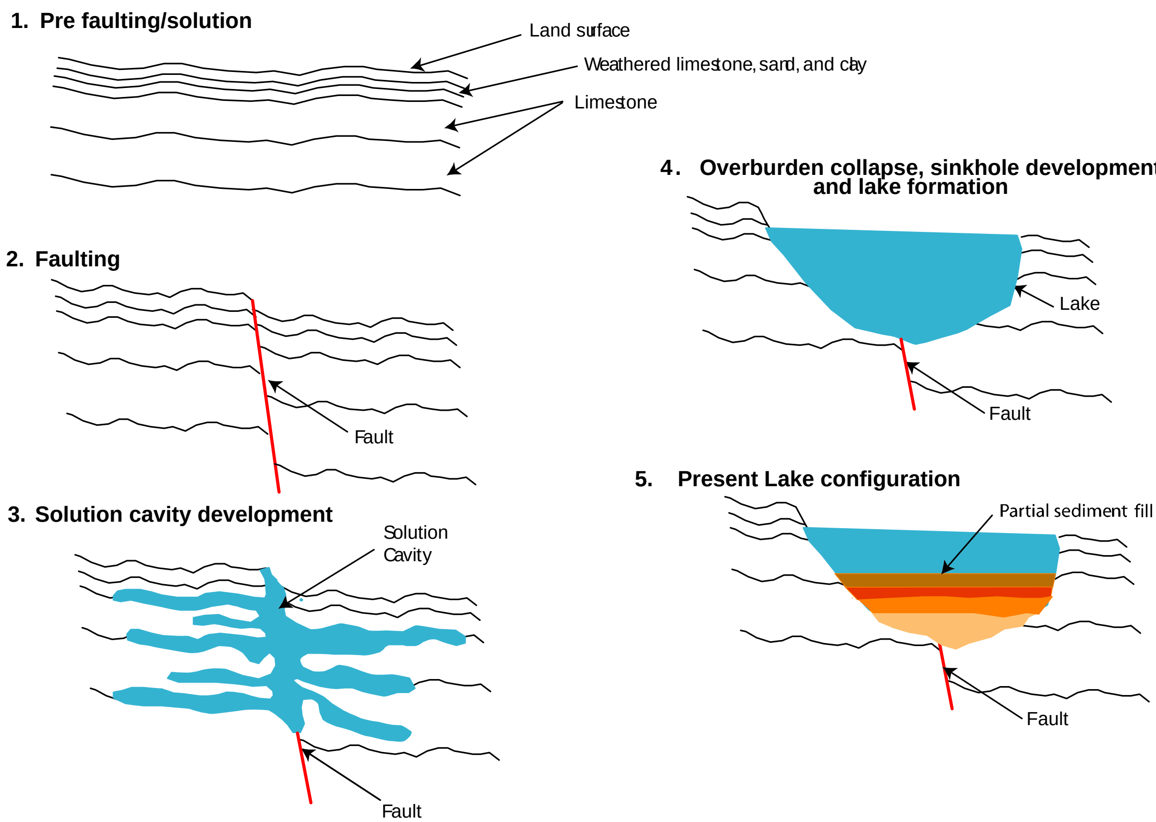


Figure 16.— Developmental structure and formation of Lake Jackson.

SURFACE WATER

The City of Florala lies on the divide between the Yellow River drainage basin (hydrologic unit 03140103) to the west and the Pea River drainage basin (hydrologic unit 03140202) to the northeast (USDA, 1984). Lake Jackson lies solely within the Yellow River basin. The Lake and its surrounding land surface drainage area comprise about 1,134 acres (408 acres water surface and 726 acres land area). No significant or named surface water streams flow into Lake Jackson. A low lying, swampy area lies to the north of the lake (in the Pea River basin) and drainage here is generally northward. Pond Creek drains southward on the western side of the lake (in the Yellow River basin). On the southeastern side of the lake, primarily in Florida, an ill-defined, swampy drainage that receives some overflow discharge from the lake directs runoff to Pond Creek southwest of the lake. An unknown amount of water flows out of the lake during periods of high rainfall and associated high lake levels. However, from general observation and local knowledge this value is thought to be small.

The hydrologic unit boundaries and Lake Jackson drainage basin boundaries are shown in figure 17. As previously noted, 36% of the total annual precipitation in the area runs off as surface water flow.

Figure 17.— Lake Jackson drainage basin.

LAKE JACKSON HYDROLOGIC CHARACTERISTICS

Hydrologically, Lake Jackson is unique in the State of Alabama; it is thought to be the largest natural sinkhole lake in the state. Covering approximately 408 acres, 51% lies in Alabama and 49% in Florida. The lake contains about 1.58 billion gallons of water. The lake's geographic position astride the Alabama-Florida state line requires special consideration in planning and management activities. Presented in the following sections are discussions of the lake's hydrologic characteristics such as bathymetry, recharge, and safe yield.

BATHYMETRY

The initial process in developing a bathymetric or depth map for Lake Jackson was to define the current shoreline of the lake. The shoreline, as mapped, was based upon the USGS Digital Ortho Quarter Quads (DOQQ) produced in 1997. A separate survey of points along the shoreline was created by a field crew in order to verify its accuracy. Changes in the shoreline could be observed when compared with the USGS 7.5 minute quadrangle maps of Forala (1971, photo revised 1984) and Paxton (1973, photo revised 1987). The most significant difference between the maps was found on the northwest shoreline. Approximately 60 feet of the shoreline had receded along an area of about 1,000 feet. The other changes along the shoreline were not nearly as significant.

Bathymetric data and point location data was collected by an Edge Tech SB216 full-spectrum "chirp" towfish. In all, 5,274 depth/location points were collected, providing excellent control and confidence in this dataset. The lake bottom is relatively bowl shaped, averaging 12-14 feet in depth. The deepest portions of the lake are found in four major and two minor areas of depression which can be seen on plate 5. Lake Jackson contains an estimated 1.58 billion gallons of water. On the western perimeter of the lake, approximately 150 feet from the shoreline, the lake bottom rapidly slopes downward dropping from 8 to12 feet. On the eastern side, the lake bottom slopes more gently from 2 feet at the lake edge to 10 feet approximately 150 feet from the shoreline. Most of the lake bottom varies from 12 to 14 feet below the water surface. There are 2 major depressions in the lake bottom on the north end of the lake. From the public access area pier on the northern shore, there is a major depression approximately 300 feet southeast. This depression is 200 to 250 feet across with a depth of 28 feet. Roughly 30 feet to the east is a much smaller depression, approximately 60 feet across with a depth of 19 feet. The second depression near the northern shore is circular shaped, 250 to 600 feet across and has a depth of 27 feet. This depression is shown on plates 5 and 6 and on figure18. Another major depression is approximately 12 to 15 feet from the western shoreline close to a private pier. Anecdotal evidence indicates that this depression is man-made. It varies from approximately 60 to 140 feet across. It is elliptically shaped, trending southeast, with a maximum depth of 23 feet. The last major depression is in the southeastern portion of the lake and is approximately 600 to 700 feet from the shoreline. It is shown on the bathymetric cross section plate 6, bathymetry plate 5, and on figure19. It varies from 420 to 550 feet across, is elliptically shaped, and is approximately 25 feet in depth.

Two minor depressions in the lake are near the southern and eastern shorelines at the Alabama/Florida state line. The depression on the eastern side is approximately 150 feet across and is circular in shape with a depth of 14 feet. It can be observed on the eastern end of the east-west cross section line (plate 3) and is roughly 150 feet from the lake shore. The second depression is located approximately 200 feet from the southern shoreline of the lake. It is elliptically shaped, varies from 100 to 500 feet across and trends southwestward. The maximum depth is 19 feet.

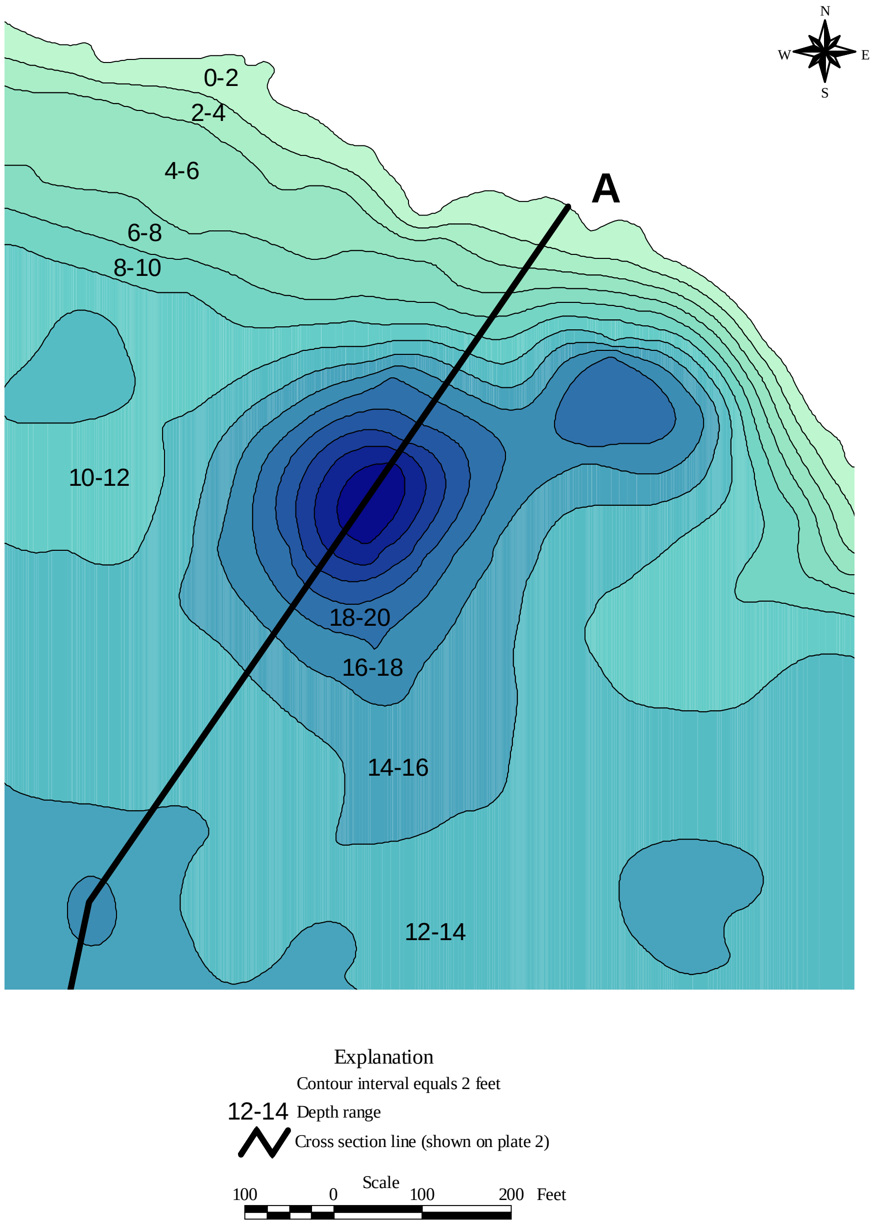


Figure 18.— Depression located on the northern end of cross section A-A'.

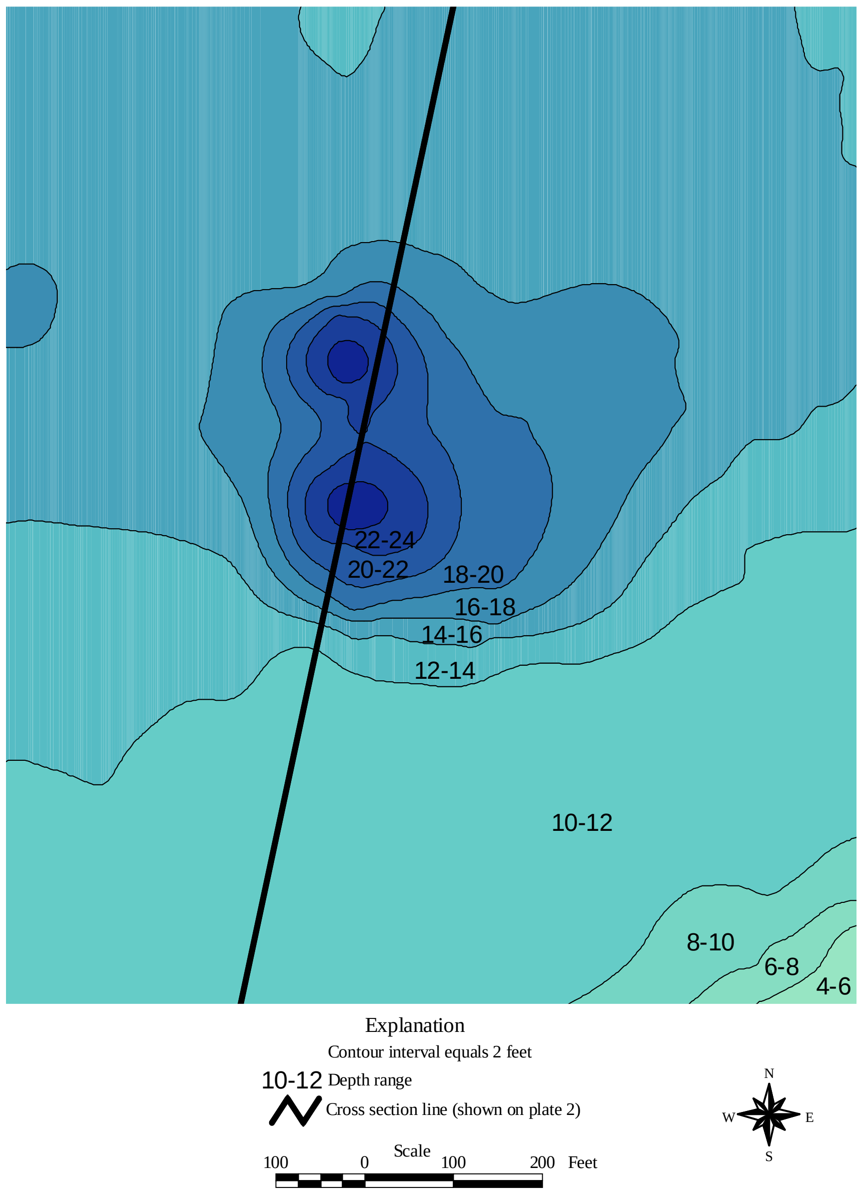


Figure 19.— Depression located on the southern end of cross section A-A’.

LAKE RECHARGE

Lake Jackson is primarily recharged from precipitation in the form of rainfall. Figures 20 and 21 show the effects of rainfall on lake level. The graphs clearly show the rise in lake level after rainfall events. Figure 22 is a plot of rainfall verses observed lake level rise. As previously noted the area receives approximately 60 inches annually. From this value approximately 23 inches is lost to evaporation from the lake's surface, leaving a potential rainfall recharge value of 37 inches. An acre inch of water is equal to about 27,154 gallons of water. Multiplying inches of rainfall x gallons per inch x acres of lake surface results in a recharge value of approximately 410,000,000 gallons per year or 1.12 million gallons per day (mgd). To this amount, overland or sheet runoff from the land area (726 acres) draining to the lake can be added. Using the water budget values previously presented, about 21.6 inches of rainfall is thought to runoff into the lake. This equates to about 426,000,000 gallons per year or 1.17 mgd. The estimated annual amount of water recharged to Lake Jackson from rainfall is therefore 2.39 mgd.

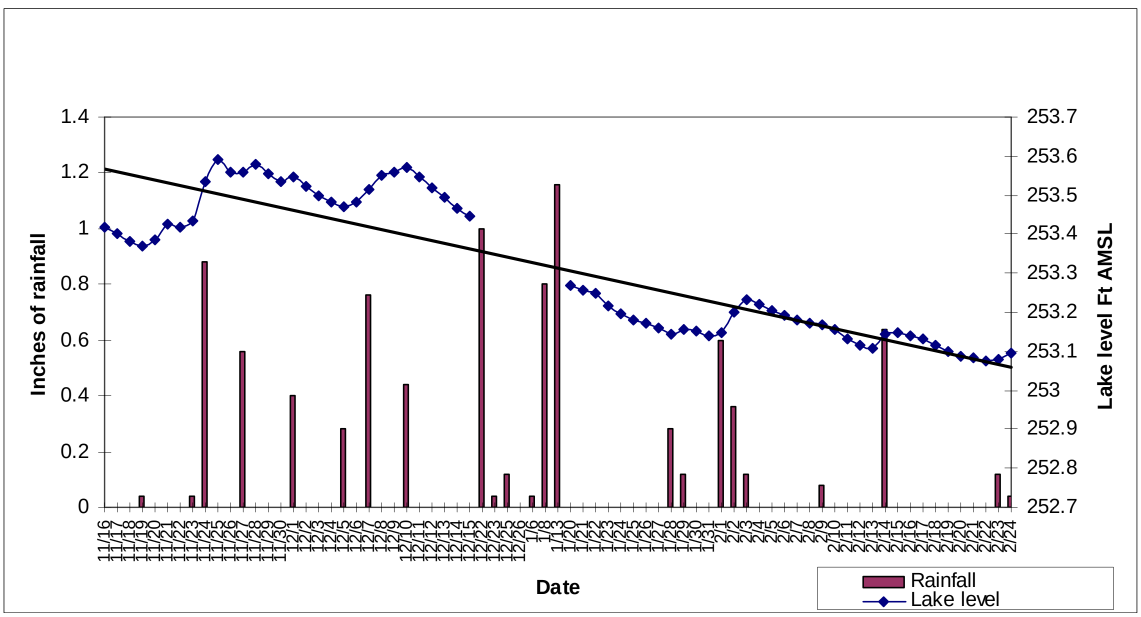


Figure 20.– Lake Jackson water level and precipitation from November 2004 through February 2005.

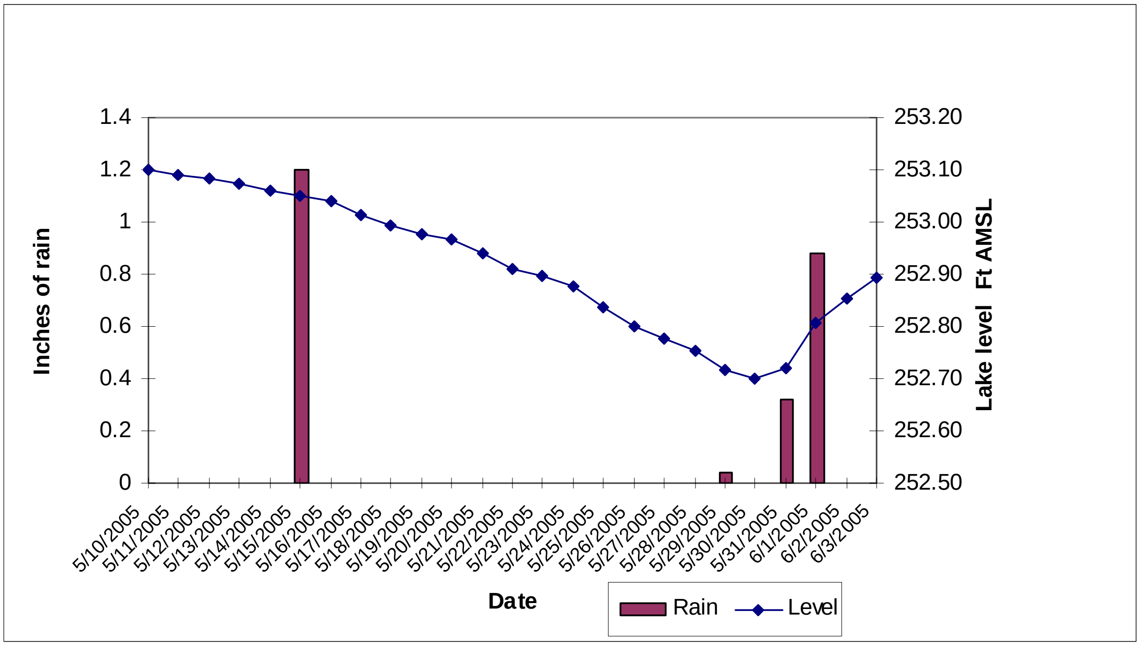


Figure 21.– Lake Jackson water level and precipitation during May 2005.

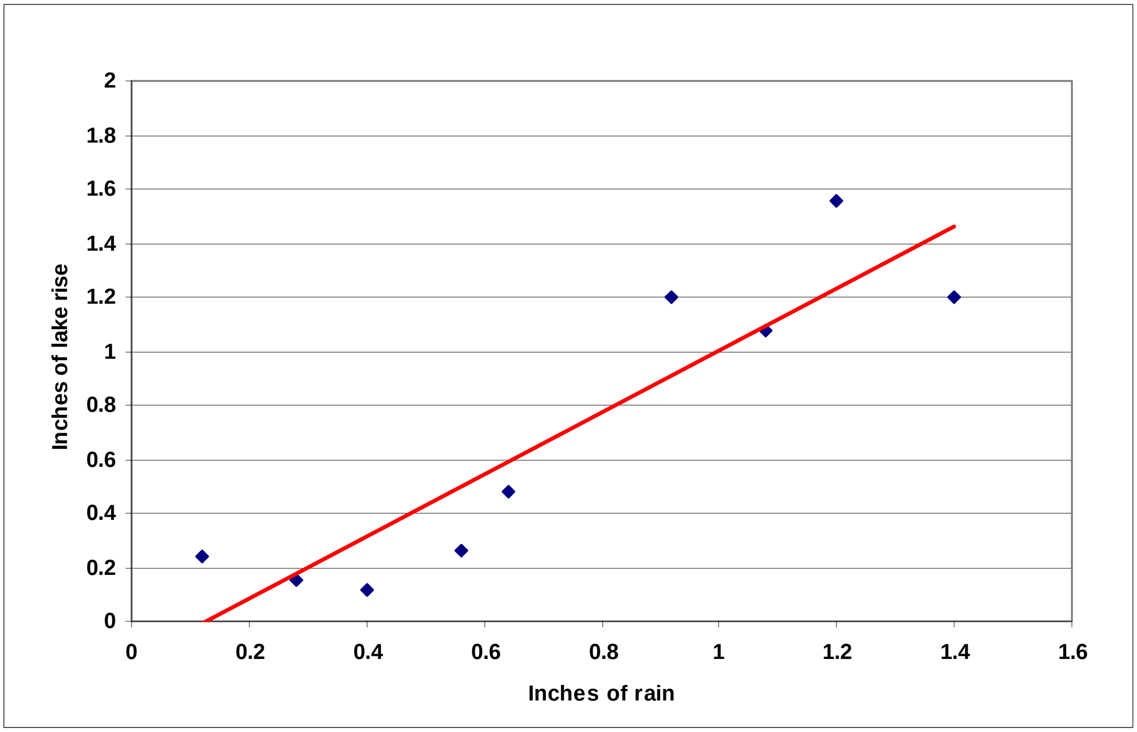


Figure 22.– Lake Jackson water-level rise as a result of rainfall.

SAFE YIELD

The apparent daily inflow of 2.39 mgd of water to Lake Jackson does not mean that this amount can be safely withdrawn from the lake and used for public supply, agricultural, or industrial and commercial uses while maintaining the lake at near current levels. It is thought that this amount is actually lost, under certain conditions, to the underlying unconsolidated sediments and an unknown, but thought to be small, amount of water exits the lake via surface runoff. If this did not happen the lake level would rise during years of near normal rainfall which it does not. There is evidence, based on local observations, that during years or periods of reduced or less than normal rainfall a steady decline in lake level occurs. Thus, considering the overall hydrologic water budget, Lake Jackson is in a delicate balance and should only be used for recreational purposes.

WATER QUALITY

Knowledge of the geochemical composition of ground and surface waters in the Lake Jackson area serves two major purposes. Comparisons of hydrochemical facies of surface water from the lake and ground water from wells in the area may provide clues as to the origin of water that recharges the lake and the hydrogeologic character of the lake and surrounding area. Secondly, the general geochemical composition of the lake water indicates the current quality of the water and health of the lake, and future requirements for remedial or protective measures to insure the lake's health.

Interpretations of geologic and geophysical data indicate that Lake Jackson formed as a large sink hole developed in the Chickasawhay and Marianna Limestone. If the water in Lake Jackson originates from these geologic units, the hydrochemical facies of the water would indicate a carbonate source. The calcium bicarbonate hydrochemical facies is commonly found in water from carbonate aquifers and in the recharge areas of Gulf Coastal Plain aquifers where concentrations of carbon dioxide (CO_2) are sufficient to cause dissolution of calcium carbonate from limestone and calcite cement. Ground water with high concentrations of calcium and high pH may be near calcite equilibrium and probably originated from a carbonate host formation (Cook, 1997). A calcium carbonate source for calcium in ground water from the study area is substantiated by calcium bicarbonate hydrochemical facies and small concentrations of sulfate that preclude a calcium sulfate source. Ground-water samples from wells CC-01 and CC-04, at Florala, were classified as calcium bicarbonate. Values of pH for water samples from wells CC-01 and CC-04, constructed in the Chickasawhay and Marianna aquifers in the lake area were 7.9 and 7.5 at 19 ^{o}C, respectively. Calcium concentrations were 32.5 and 52.4 milligrams per liter (mg/L), respectively. Values of pH for nine samples collected from Lake Jackson varied from 5.1 to 6.3 at 10 to 32 ^{o}C. Calcium concentrations in water from the lake varied from 1.2 to 1.8 mg/L. The disparity of the analyzed parameters indicates that the water in Lake Jackson originates primarily from rainfall and surface-water runoff. Comparisons of hydrochemical facies determined from ground- and surface-water samples collected from wells and Lake Jackson are depicted on the trilinear diagram on figure 23.

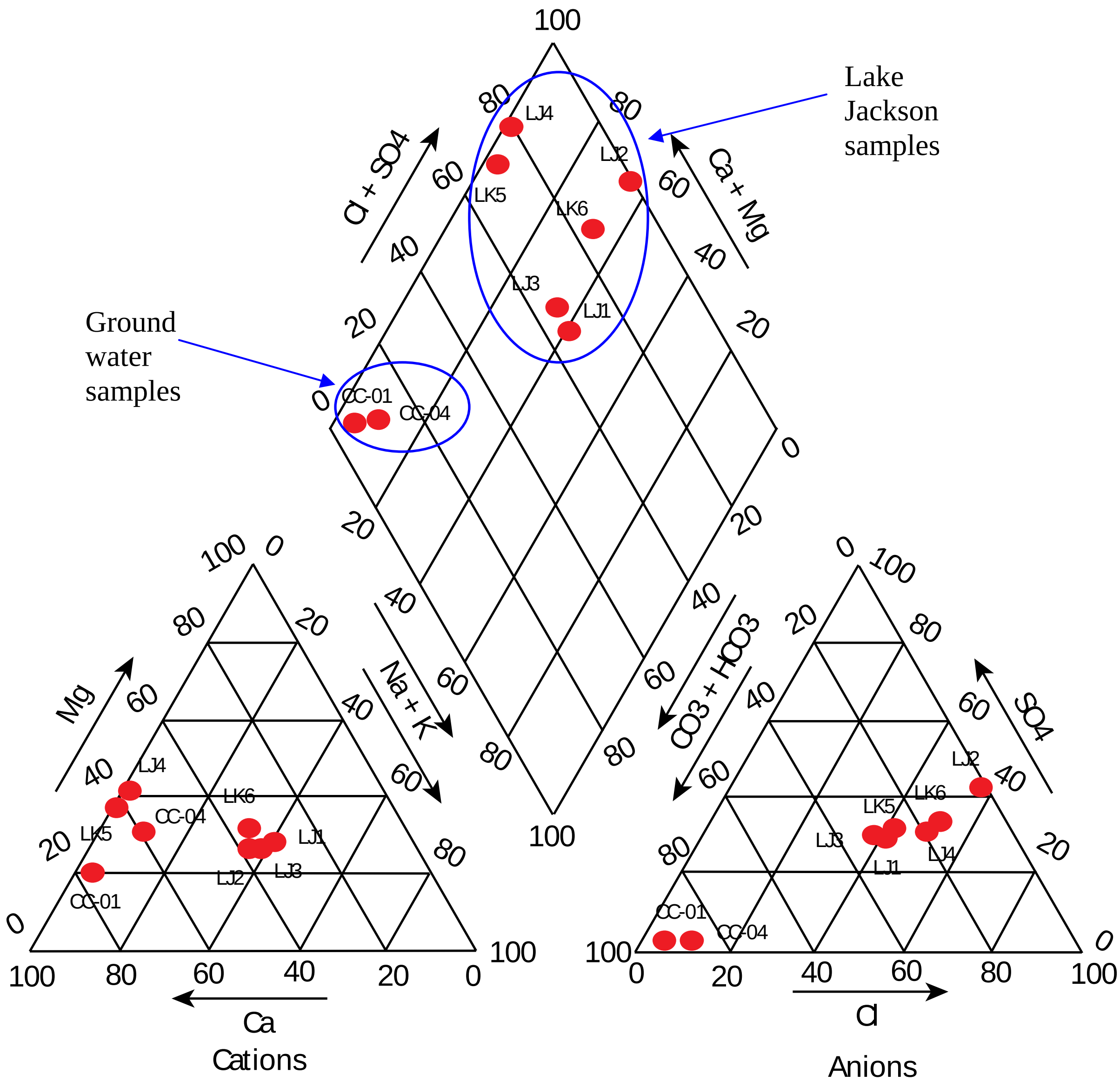


Figure 23.—Trilinear diagram depicting hydrochemical facies of water from Lake Jackson and selected wells in the Lake Jackson area.

Lake Jackson is heavily used for recreation, especially during summer. The area surrounding the lake is characterized by both residential and urban development. When considered in combination with the source of water recharging the lake, these land uses cause concern for the future quality and health of the lake. Water samples collected during 2004 and 2005 indicate that the water in Lake Jackson is of excellent quality. The primary constituents of concern for the lake include bacteria, nutrient concentrations (ammonia, nitrate, and phosphorus), and organic contaminants such as petroleum products and phenols.

BACTERIA

Microorganisms are present in all surface waters and include viruses, bacteria, fungi, algae, and protozoa. Analyses of bacteria levels may be used to assess the quality of water and to indicate the presence of human and animal waste in surface and ground water. Fecal coliform groups of bacteria are used as the primary indicator organisms of this type of water pollution. The membrane filter procedure as described in the 19th edition of standard methods (Eaton and others, 1995) was used for determining fecal coliform bacteria counts for water samples collected from Lake Jackson sampling sites. The Alabama Department of Environmental Management (ADEM) has established limits on the numbers of fecal coliform bacteria that can safely be present in a stream. In a typical stream, the limit is 2000 bacteria colonies per 100 milliliters of water. In waterways used primarily for swimming the limit is 200 colonies per 100 milliliters of water.

Water samples were collected from Lake Jackson and analyzed for bacteria on July 28, 2004 and August 4, 2005. Samples were collected during summer when lake use is highest at selected areas around the lake including swimming areas. July 2004 sampling revealed 2 fecal coliform colonies in the swimming area on the north side of the lake. August 2005 sampling indicated 15 colonies on the east side of the lake near the state park, 12 colonies on the west side, and 26 colonies in the swimming area on the north side of the lake. These counts are much less than the 200 colony limit and reflects the current excellent water quality in Lake Jackson.

NUTRIENTS

Ammonia

Concentrations of ammonia (NH_3 as N) in uncontaminated streams may be as low as 0.01 mg/L. Concentrations of ammonia in contaminated streams and in streams downstream from wastewater discharges are generally from 0.5 to 3.0 mg/L. Concentrations higher than 0.5 mg/L may cause significant ammonia toxicity to fish and other organisms (Maidment, 1993). Results of analysis of samples from Lake Jackson indicated that ammonia concentrations did not exceed 0.02 mg/L in any sample.

Nitrate

The U.S. EPA Maximum Contaminant Level (MCL) for nitrate in drinking water is 10 mg/L. Typical nitrate (NO_3 as N) concentrations in streams vary from 0.5 to 3.0 mg/L. Concentrations of nitrate in streams without significant nonpoint sources of pollution vary from 0.1 to 0.5 mg/L. Streams fed by shallow ground water draining agricultural areas may approach 10 mg/L (Maidment, 1993). Nitrate concentrations in streams without significant nonpoint sources of pollution generally do not exceed 0.5 mg/L (Maidment, 1993).

Results of analysis of samples from Lake Jackson indicated that nitrate concentrations did not exceed 0.2 mg/L in any sample.

Phosphorus

The origin of phosphorus in surface-water bodies is the mineralization of phosphates from the soil and rocks, or drainage containing fertilizer or other industrial products. The principal components of the phosphorus cycle involve organic phosphorus and inorganic phosphorus, in the form of orthophosphate (PO_4) (Maidment, 1993). Orthophosphate is soluble and considered to be the only biologically available form of phosphorus. The natural background concentration of total dissolved phosphorus is approximately 0.025 mg/L. Phosphorus concentrations as low as 0.01 to 0.005 mg/L may cause excessive algae growth, but the critical level of phosphorus necessary for excessive algae is around 0.05 mg/L. Although no official water quality criterion has been established in the United States for phosphorus, to prevent the development of biological nuisances, total phosphorus should not exceed 0.05 mg/L in any stream or 0.025 mg/L within a lake or reservoir (Maidment, 1993). Results of analysis of samples from Lake Jackson indicated that orthophosphate was not detected in any sample. However, total phosphorus concentrations were 0.17, 0.21, and 0.33 in three samples collected in January 2005 and 0.23 in a sample collected in August 2005. These concentrations exceed the standard and should be monitored in the future.

Chlorophyll

Phytoplankton, one of many forms of life in a lake, are microscopic one-celled algae living everywhere in the water. Chlorophyll is the green photosynthetic pigment found in these phytoplankton, giving the lake water its green color. Phytoplankton are important not only because they are lowest on the lake’s food chain, but also because their abundance directly affect numerous water quality characteristics such as oxygen, temperature, and water clarity. Analyses of chlorophyll concentrations in a lake may help determine the current water quality conditions. A series of chlorophyll analyses, over time can give an idea of how quickly water quality is changing. Chlorophyll concentrations from samples collected in July 2004 and January 2005 were below detectable levels (0.0002 mg/L). Chlorophyll concentrations from two samples collected in August 2005 were 0.0014 and 0.0042 mg/L.

The trophic state of an impounded water body is another indicator of water quality. Lakes may be divided into three categories based on trophic state. These are oligotrophic, mesotrophic, and eutrophic. These categories define the nutrient and clarity conditions of an impoundment. Oligotrophic lakes are generally clear, deep, and free of weeds or large algae blooms. They are low in nutrients and do not support large fish populations. Mesotrophic lakes lie between the oligotrophic and eutrophic stages. They may be oxygen depleted in late summer. Eutrophic lakes are high in nutrients and support a large biomass (all the plants and animals living in the lake). They are usually weedy and may be subject to frequent algae blooms. Eutrophic lakes often support large fish populations, but are also susceptible to oxygen depletion.

Trophic conditions may be classified by measuring concentrations of constituents that determine the trophic state. These constituents include total phosphorus, total nitrogen, chlorophyll a, and water clarity. Selected critical constituent concentrations and mean concentrations of critical constituents measured in Lake Jackson are given in table 3. These data indicate that Lake Jackson is probably in the Oligotrophic range of trophic condition.

Table 3.—Selected critical constituent concentrations for general trophic classifications and mean concentrations of selected critical constituents measured in Lake Jackson.

Constituent	Oligotrophic Concentration Range (mg/L)	Mesotrophic Concentration Range (mg/L)	Eutrophic Concentration Range (mg/L)	Lake Jackson Mean Concentration (mg/L)
Total Phosphorus	0.003-0.018	0.011-0.096	0.016-0.386	0.14
Total Nitrogen	0.3-1.6	0.4-1.4	0.4-1.6	0.01
Chlorophyll a	0.0003-0.005	0.003-0.011	0.003-0.078	0.001

Modified from Wetzel, 2001

ORGANIC CONSTITUENTS

Phenol

Organic compounds are commonly used in our society today. Frequently, these compounds appear in streams, lakes, and ground-water aquifers. Many of these compounds are harmful to human health and to the health of the aquatic environment.

Phenols are used in the production of phenolic resins, germicides, herbicides, fungicides, pharmaceuticals, dyes, plastics, and explosives (USGS, 1992-96). They may occur in domestic and industrial wastewaters, natural waters, and potable water supplies. They generally are traceable to industrial effluents or landfills (Eaton and others, 1995). The EPA states that phenol should be limited to 0.3 mg/L (milligrams per liter) in lakes and streams to protect humans from the possible harmful effects of exposure. Phenols cause acute and chronic toxicity to freshwater aquatic life. Phenol concentrations were detected in three samples collected in Lake Jackson. Concentrations varied from 0.0046 to 0.007 mg/L and were well below recommended levels.

Total Organic Carbon

Total organic carbon (TOC) analysis is a well-defined and commonly used methodology that measures the carbon content of dissolved and particulate organic matter present in water. Many water utilities monitor TOC to determine raw water quality or to evaluate the effectiveness of processes designed to remove organic carbon. Some wastewater utilities also employ TOC analysis to monitor the efficiency of the treatment process. In addition to these uses for TOC monitoring, measuring changes in TOC concentrations can be an effective "surrogate" for detecting contamination from organic compounds (e.g., petrochemicals, solvents, pesticides). Thus, while TOC analysis does not give specific information about the nature of the threat, identifying changes in TOC can be a good indicator of potential threats to a system (USEPA, 2005). Typical TOC values for natural waters vary from 1 to 10 mg/L (Mays, 1996). Concentrations of TOC in samples collected from Lake Jackson varied from 4.10 to 5.87 mg/L.

SUMMARY

Lake Jackson formed as a result of faulting and subsequent solution of limestone bedrock that resulted in the formation of a sinkhole. Over time the water filled sinkhole filled with sediments, attaining its present configuration and depth.

Rainfall is the primary source of water replenishment for the lake. With a very small surface recharge area, no input streams, and little ground-water recharge, the lake is in a delicate balance. During periods of near normal rainfall the lake level is stable, however, during an extended drought or if water were to be withdrawn from the lake for off-site uses, water level would rapidly decline.

Lake Jackson is a prime recreation site for local citizens and tourists. It is not suitable as a source of water supply for off-site uses. Maintaining the lake in its present good condition will require an effective management plan and on-going educational programs designed to stimulate interest in lake preservation.

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APPENDIX

Drillers' Descriptions, Sample Descriptions, and Lithologic Logs
Showing Geologic Evaluation of Sediments and
Stratigraphic Locations of Water Production

INTRODUCTION

This appendix contains copies of drillers' descriptions of lithologies encountered in project area wells, samples descriptions made during this investigation, and pictorial, or diagrammatic, lithologic logs derived from drillers' descriptions and from microscopic examination of samples. These data are arranged alphabetically and numerically consistent with the site-numbering system used by the Geological Survey of Alabama and the U.S. Geological Survey.

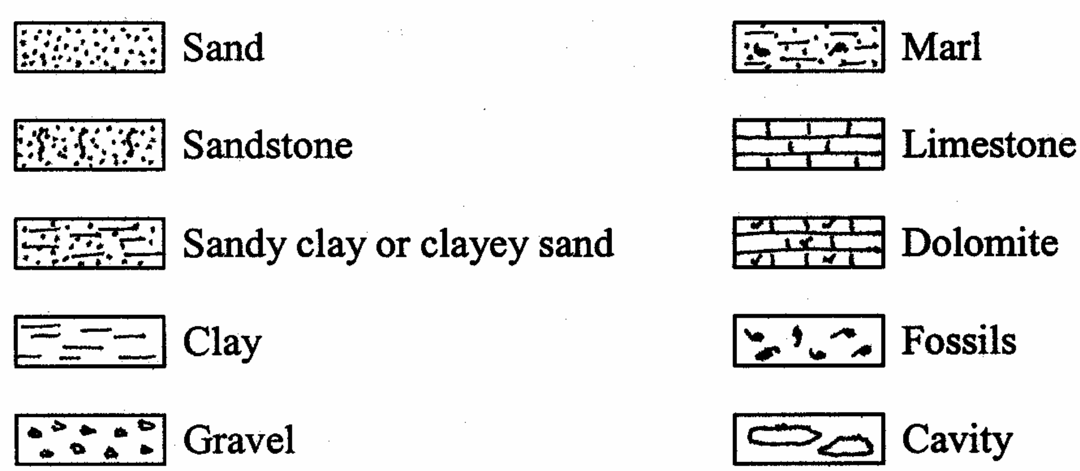
Drillers' descriptions are reproduced verbatim from records retained in the Water Investigations Program of the GSA. The interpretation of the geology shown on each driller's description is based on the record of types of sediment penetrated and, where available, by the accompanying electric log, as well as through both local and regional geologic correlation of the well. Each driller's log is accompanied by a geologic summary of the well which includes the drilled depth interval for each geologic unit encountered and, where applicable, the electric log depth recorded for the top of each formation. The top and base of screened intervals and the interpretation of the geology in which each screen is located also accompanies the summary page.

In instances where samples were available from a well, the driller's description and accompanying summary page is immediately followed by a detailed lithologic description of samples from the well. These descriptions include the identity and detailed description of each different constituent of the sample, with an estimate of the relative abundance (in percent) that each constituent contributes to the total volume of the sample. As with the drillers' descriptions, an interpretation of the geology is presented for each well. The sample descriptions are followed by a summary page listing the drilled intervals of each geologic formation encountered in the well.

In some instances, the depth recorded for the top of a unit based on the driller's descriptions is different from the top of the unit based on sample descriptions. Much of the this discrepancy is caused by long drill log intervals being recorded as "sand and shale," or some other admixture of lithologic types. Invariably, the more detailed drillers' descriptions will more accurately reflect changes in lithology, and thus record lithologic data more readily comparable with the sample descriptions and thus be more useful in geologic interpretation. These conflicts in interpretation are usually resolved in wells accompanied by electric logs;

however, if no electric log is available, the information generated from the description of individual samples has proven to yield more reliable data.

Individual driller's logs and logs based on sample descriptions are also accompanied by a graphic driller's log and/or sample log following each well description. These lithologic logs represent a visual characterization of lithologies recorded by the driller or identified during sample investigation. Percentage estimates are plotted horizontally sample by sample within the lithologic column of the sample log, such that a sample with 70 percent sand and 30 percent clay will be reflected by 70 percent of the width of the depth column occupied by sand and 30 percent occupied by clay. The lithology shown in the depth column reflects personal interpretation of drillers' descriptions of sediments. For example, the term "rock" is interpreted and plotted on the lithologic log as a limestone or sandstone depending on its occurrence in individual formations. The symbols used on the lithologic logs are as follows:



Constructed at a vertical scale of 2 inches equal 100 feet, each log shows the lithologies encountered in the hole, an interpretation of the stratigraphy and definition of formation tops, the location of screened intervals (indicated by vertical lines to the left of the depth column), and well depth. When available, the electric log (spontaneous potential or gamma ray log on left of log and resistivity on right of log) has been reproduced to scale and accompanies each lithologic log. Although the logs included in this report are copies of penciled working logs constructed and used throughout this study, the logs have proven invaluable in readily observing lithological changes in the borehole and the placement of formation tops, in the interpretation and correlation of the stratigraphy from well to well, and in determining not only the unit(s) which are yielding water to the borehole but precisely where the screens have been set within the formation. These logs have additionally proven invaluable in the construction of the enclosed cross sections. Because of their importance during all stages of this investigation, working copies of lithological logs from each well used in this study are included in this appendix.

Layne Central Drilling Company	Well No. CC-3
City of Florala–Well No. 3	GSA No. (no samples)
SW¼SW¼ sec. 35, T. 1 N., R. 17 E.	Elevation (feet): G.L. 245
Covington County, Alabama	

Note that there are no samples or electric logs available from this well.

Depth (feet)	Driller's Log
	MIOCENE (UNDIFFERENTIATED)
0-16	Clay.
16-20	Sandy clay.
20-30	White clay.
	OLIGOCENE
	CHICKASAWHAY LIMESTONE RESIDUUM
30-35	Yellow sandy clay.
35-66	White sand, packed.
66-75	White sand, packed.
75-97	Red sand.
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
97-103	Clay.
103-122	Loose sand and gravel.
122-148	Clay.
	OLIGOCENE AND EOCENE
	VICKSBURG AND JACKSON GROUPS, MARIANNA LIMESTONE AND CRYSTAL RIVER FORMATION (UNDIFFERENTIATED)
148-152	Rock.
152-159	Clay.
159-161	Rock.
161-163	Clay.
163-164	Rock, soft.
164-165	Hard rock.
165-169	Clay.
169-170	Hard rock.
170-174	Clay.

174-190	Limerock, white.
190-236	Limerock, white.
236-243	Limerock, red.
243-264	Limerock, white.
264-316	Limerock, brown.
316-316.5	Sand.

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS

Layne Central Drilling Company
City of Florala–Well No. 3
Well No. CC-3

	Sample interval			E log top
Miocene (undifferentiated)	0	-	30	--
Oligocene				
Chickasawhay Limestone residuum	30	-	97	--
Vicksburg Group				
Byram Formation				
Bucatunna Clay	97	-	148	--
Oligocene and Eocene				
Vicksburg and Jackson Groups				
Marianna Limestone and Crystal River Formation (undifferentiated)	148	-		
Well total depth: 316.5 feet				

SCREENS

open hole completion 186-316.5 feet	Marianna Limestone and Crystal River Formation (undifferentiated)

Layne Central Drilling Company
City of Florala–Well No. 2
SW¼SW¼ sec. 35, T. 1 N., R. 17 E.
Covington County, Alabama

Well No. CC-4
GSA No. (no samples)
Elevation (feet): G.L. 250

Note that there are no samples or electric logs available from this well.

Depth (feet)	Driller's Log
	MIOCENE (UNDIFFERENTIATED)
0-3	Cinders.
3-23	White chalk and clay.
23-65	Sand with clay.
	OLIGOCENE
	CHICKASAWHAY LIMESTONE RESIDUUM
65-88	White sand.
88-95	Clay and sand.
95-122	Sand.
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
122-128	Clay.
128-139	Sand.
139-168	Sandy clay and gravel.
168-169	Rock.
169-179	Clay and blue marl.
	OLIGOCENE AND EOCENE
	VICKSBURG AND JACKSON GROUPS, MARIANNA LIMESTONE, AND CRYSTAL RIVER FORMATION (UNDIFFERENTIATED)
179-378	Lime rock.
	EOCENE
	JACKSON GROUP, YAZOO CLAY
378-416	Sand.
	MOODYS BRANCH FORMATION
416-511	Lime rock.

CLAIBORNE GROUP, LISBON FORMATION

511-515	Sand.
515-535	Sand.
535-548	Lime rock.
548-552	Lime rock.
552-562	Sand.
562-564	Soft lime rock.
546-581	Sand.
581-604	Rock.
604-620	Sand.
620-625	Lime rock.
625-632	Sand.
632-654	Sand.

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS
Layne Central Drilling Company

City of Florala–Well No. 2
Well No. CC-4

	Sample interval			E-log top
Miocene (undifferentiated)	0	-	65	--
Oligocene				
Chickasawhay Limestone residuum	65	-	122	--
Vicksburg Group				
Byram Formation				
Bucatunna Clay Member	122	-	179	--
Oligocene and Eocene				
Vicksburg and Jackson Groups				
Marianna Limestone and Crystal River Formation (undifferentiated)	179	-	378	--
Eocene				
Jackson Group				
Yazoo Clay	378	-	416	--
Moodys Branch Formation	416	-	511	--
Claiborne Group				
Lisbon Formation	511	-		--
Well total depth: 654 feet				

SCREENS

339-369	Marianna Limestone and Crystal River Formation (undifferentiated)
469-484	Moodys Branch Formation
510-530	Lisbon Formation
560-570	Lisbon Formation
582-597	Lisbon Formation

Layne Central Drilling Company Well No. CC-01
City of Florala-Test Hole GSA No. (no samples)
SW¼NE¼ sec. 23, T. 1 N., R. 17 E. Elevation (feet): G.L. 300
Covington County, Alabama

Depth (feet)	Driller's Log
Miocene and Oligocene Chickasawhay Limestone (undifferentiated)	
0-2	Topsoil.
2-14	White chalk.
14-20	Sand, white.
20-30	Sand, red-muddy.
Vicksburg Group, Byram Formation, Bucatunna Clay Member	
30-70	Clay (gray).
70-82	Limey-clay.
82-84	Sand.
84-90	Clay, blue and brown.
90-110	Sand (white), with pea gravel.
Oligocene and Eocene	
Vicksburg and Jackson Groups, Marianna Limestone, and Crystal River Formation (undifferentiated)	
110-115	Limey clay.
115-127	Lime brown, with hard and soft spots.
127-134	Lime (yellow), brittle.
134-135	Rock, hard.
135-194	Lime (yellow), lost circulation at 150 feet.
194-196	Lime (hard).
196-200	Lime (firm), yellow.
200-202	Lime (hard).
202-238	Lime (firm), yellow.
238-240	Lime (hard).
240-244	Lime (Hard).
244-309	Lime (brittle), yellow.
309-311	Lime (hard).

311-314	Lime (brittle).
314-320	Lime (hard).
320-350	Lime (brittle).

Eocene

Jackson Group, Yazoo Clay

350-375	Limey clay.
375-376	Rock.
376-377	Clay.
377-378	Rock.
378-380	Clay, sandy (gray).
380-382	Rock.
382-392	Clay, (gumbo).

Moodys Branch Formation

392-393	Rock.
393-407	Clay, limey with shells.
407-408	Rock.
408-410	Clay.
410-411	Rock.
411-420	Clay and streaks rock, limey.
420-421	Rock, hard.
421-423	Clay, white.
423-424	Rock.
424-443	Limey clay, with shells.
443-444	Rock.
444-458	Lime (brittle), gray.
458-459	Rock.
459-462	Clay, white.
462-480	Lime (gray), hard and soft spots.
480-520	Lime (gray to white), with gray clay.

Claiborne Group, Lisbon Formation

520-529	Sandy clay.
529-530	Rock.
530-535	Clay, gray-sandy.

535-536	Rock.
536-541	Clay, gray sandy with black specks.
541-542	Rock, hard.
542-544	Sand, (coarse).
544-545	Rock.
545-553	Limey sand, fine with clay and shells.
553-553.5	Rock break.
553.5-556	Lime, medium.
556-557	Lime, hard.
557-562	Limey clay.
562-566	Sand, with shell and lime.
566-569	Lime hard.
569-578	Sand, fine.
578-582	Clay.
582-588	Sand, with lime sand fine.
588-600	Clay, sandy.
600-627	Sand with streaks of clay, with lime fine.
627-628	Rock.
628-657	Clay with streaks of sand, fine blue.
657-672	Sandy clay.
672-673	Rock.
673-677	Clay, soft.
677-678	Rock.
678-685	Clay.
685-703	Clay, cuts like clay shows up sand.

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS
Layne Central Drilling Company

City of Florala–Test Hole
Well No. CC-01

	Sample interval			E-log top
Miocene and Oligocene (undifferentiated)	0	-	30	--
Oligocene				
Vicksburg Group				
Byram Formation				
Bucatunna Clay Member	30	-	110	--
Oligocene and Eocene				
Vicksburg and Jackson Groups				
Mariana Limestone and Crystal River Formation (undifferentiated)	110	-	350	--
Eocene				
Jackson Group				
Yazoo Clay	350	-	392	--
Moodys Branch Formation	392	-	520	--
Claiborne Group				
Lisbon Formation	520	-		--
Well total depth: 703 feet				

Acme Drilling Company Well No. CC-01
City of Florala-Well No. 1 GSA No. 4183
SW¼NE¼ sec. 23, T. 1 N., R. 17 E. Elevation (feet): G.L. 300
Covington County, Alabama

Depth (feet)	Description

Miocene and Oligocene Chickasawhay Limestone (undifferentiated)

0-20 Ctgs: Sand, grayish-orange-pink (10R8/2), fine- to medium-grained, subangular, quartz; and traces of clay, moderate-pink (5R7/9).

20-30 Ctgs: Sand, very pale orange (10R8/2), medium- to coarse-grained, subangular, quartz, clean.

Oligocene

Vicksburg Group, Byram Formation, Bucatunna Clay Member

30-40 Ctgs: Sand, moderate-orange-pink (5YR8/4), fine to very coarse grained, subangular to subrounded, quartz; and clay, light-brown (5YR5/6).

40-60 Ctgs: Sand, same; clay, same; and some clay, medium-dark-gray (N4), arenaceous.

60-80 Ctgs: Sand, pinkish-gray (5YR8/1), fine- to coarse-grained, subangular, quartzose, mixed with clay, light-brown; and limestone, white, sucrosic, deeply weathered.

80-90 Ctgs: Sand, pinkish-gray, fine- to very coarse-grained, subangular to subrounded, quartzose mixed with clay, light-olive-gray (5Y6/1) to light-brown.

90-100 Ctgs: Sand, very light gray (N8), fine- to very coarse-grained, angular to subrounded, quartzose, poorly sorted, mixed with some clay, light-brown.

100-110 Ctgs: Sand, light-gray (N7), medium- to very coarse-grained, angular to subrounded, quartzose, poorly sorted.

110-120 Ctgs: Clay, light-olive-gray, arenaceous, calcareous; sand, same; fossil shell fragments.

Marianna Limestone

120-135 Ctgs: Limestone, pinkish-gray, deeply weathered, sucrosic, dolomitized, *Lepidocyclina*, *Nummulites*, gastropod internal molds, *Pecten* shell fragments, internal molds of brachiopods, bryozoan fragments; quartz and quartzite fragments.

135-140 Ctgs: Limestone, very pale orange, deeply weathered, very fossiliferous, same as above; and some sand.

140-160 Ctgs: Limestone, marly, same; and sand, same.

160-180 Ctgs: Limestone, same; and sand, same.

180-200 Ctgs: Limestone, same; and sand, same.

200-220 Ctgs: Limestone, same; and sand grains, same.

220-240 Ctgs: Limestone, same.

Eocene

Jackson Group, Crystal River Formation (E-log top at 247 feet)

240-260 Ctgs: Limestone, pinkish-gray and light-brown, dolomitized, ?deeply weathered, siliceous, sucrosic. Light brown has vugs (8-15mm) containing euhedral quartz crystals. Fossiliferous, contains *Lepidocyclina chaperi* ?, abundant *Nummulites*, bryozoan fragments, shell fragments, and internal molds of gastropods.

260-280 Ctgs: Limestone, very pale orange to light-brown, very weathered, sucrosic, recrystallized, fossiliferous, ? *Globigerina increbescens*.

280-300 Ctgs: Limestone, same, coquinoid.

300-320 Ctgs: Limestone, very pale orange, weathered, sucrosic, recrystallized, siliceous, fossiliferous, *Lepidocyclina*, bryozoan fragments.

320-340 Ctgs: Limestone, same.

340-360 Ctgs: Limestone, same.

Yazoo Clay (E-log top not recognized)

360-375 Ctgs: Limestone, very pale orange, sucrosic, dolomitized; sand, light-gray, fine- to medium-grained, subangular to angular, quartz, in a matrix of pinkish-gray clay.

375-380 Ctgs: Sand, light-gray, fine- to medium-grained, angular to subrounded, clayey; and limestone, same.

380-400 Ctgs: Clay, light-gray, arenaceous, calcareous limy streaks ?, glauconitic, fossiliferous.

Moodys Branch Formation (E-log top at 405 feet)

400-420 Ctgs: Clay, light-gray, arenaceous, glauconitic, fossiliferous, *Camerina* ? and *Operculina* abundant, some *Lepidocyclina.*

420-440 Ctgs: Marl, arenaceous, glauconitic, phosphatic, abundant *Nummulites.*

440-460 Ctgs: Marl, same.

460-480 Ctgs: Marl, same.

480-500 Ctgs: Marl, yellowish-gray (5Y8/1), argillaceous, arenaceous, glauconitic, fossiliferous, abundant *Lepidocyclina*, and *Nummulites*, bryozoan fragments, shell fragments.

500-520 Ctgs: Marl, same with light-gray clay.

Description by
Janyth S. Tolson
Geologist

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS
Acme Drilling Company

City of Florala–Well No. 1
Well No. CC-01

	Sample interval			E-log top
Miocene and Oligocene (undifferentiated)	0	-	30	--
Oligocene				
Vicksburg Group				
Byram Formation				
Bucatunna Clay Member	30	-	120	--
Mariana Limestone	120	-	240	--
Eocene				
Jackson Group				
Crystal River Formation	240	-	360	247
Yazoo Clay	360	-	400	Not recognized
Moodys Branch Formation	400	-		405
Well total depth: 520 feet				

SCREENS

open hole completion 142-315 feet	Marianna Limestone and Crystal River Formation

Griner Drilling Service, Inc.   Well No. CC-02
Tensor Petroleum Corporation
SW¼NE¼ sec. 28, T. 1 N., R. 17 E.
Covington County, Alabama

GSA No. (no samples)
Elevation (feet): G.L. 315

Note that there are no samples or electric logs available from this well.

Depth (feet)	Driller's Log
	MIOCENE AND OLIGOCENE CHICKASAWHAY LIMESTONE RESIDUUM
0-20	Top soil.
20-60	Sand.
	OLIGOCENE
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
60-120	Chalk.
	OLIGOCENE AND EOCENE
	Vicksburg and Jackson Groups, Marianna Limestone and Crystal River Formation
120-336	Lime rock, sand.

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS
Griner Drilling Service, Inc.

Tensor Petroleum Corporation

Well No. CC-02

	Sample interval			E-log top
Miocene and Oligocene undifferentiated	0	-	60	--
Oligocene				
Vicksburg Group				
Byram Formation				
Bucatunna Clay Member	60	-	120	--
Oligocene and Eocene				
Vicksburg and Jackson Groups				
Marianna Limestone and Crystal River Formation	120	-		--
Well total depth: 336 feet				

SCREENS

open hole completion 273-336 feet	Marianna Limestone and Crystal River Formation

Hacoda Drilling Co. Well No. CC-03
James W. Laird
SE¼SE¼ sec. 20, T. 1 N., R. 17 E.
Covington County, Alabama

GSA No. (no samples)
Elevation (feet): G.L. 330

Note that there are no samples or electric logs available from this well.

Depth (feet)	Driller's Log
	MIOCENE AND OLIGOCENE CHICKASAWHAY LIMESTONE RESIDUUM
0-10	Clay.
10-36	Clay.
36-80	Sand and clay.
	OLIGOCENE
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
80-118	Clay.
118-155	Sand and clay.
	OLIGOCENE AND EOCENE
Vicksburg and Jackson Groups, Marianna Limestone and Crystal River Formation	
155-160	Hard blue rock.
160-195	Blue rock and blue clay.
195-233	Blue clay.
233-385	Limestone.
	EOCENE
Jackson Group, Yazoo Clay	
385-410	Hard sand and shells.

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS

Hacoda Drilling Co.
James W. Laird
Well No. CC-03

	Sample interval			E-log top
Miocene and Oligocene (undifferentiated)	0	-	80	--
Oligocene				
Vicksburg Group				
Byram Formation				
Bucatunna Clay Member	80	-	155	--
Oligocene and Eocene				
Vicksburg and Jackson Groups				
Marianna Limestone and Crystal River Formation (undifferentiated)	155	-	385	--
Eocene				
Jackson Group				
Yazoo Clay	385	-		--
Well total depth: 410 feet				

SCREENS

open hole completion 252-410 feet	Marianna Limestone, Crystal River Formation, and Yazoo Clay

Hacoda Drilling Company Well No. CC-04
Paul Mitchell GSA No. (no samples)
NE¼NE¼ sec. 36, T. 1 N., R. 17 E. Elevation (feet): G.L. 240
Covington County, Alabama

Note that there are no samples or electric logs available from this well.

Depth (feet)	Driller's Log
	MIOCENE AND OLIGOCENE RESIDUUM
0-10	Clay and topsoil.
10-20	Clay.
20-30	Clay.
30-40	Sand and clay.
40-50	Sand.
	OLIGOCENE
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
50-60	Clay.
60-70	Sand and gravel.
70-75	Sand and gravel.

Interpretation by Charles C. Smith Geologist

SUMMARY
Hacoda Drilling Company

Paul Mitchell

Well No. CC-04

	Sample interval	E-log top
Miocene and Oligocene		
undifferentiated residuum	0 - 50	--
Oligocene		
Vicksburg Group		
Byram Formation		
Bucatunna Clay Member	50 -	--
Well total depth: 75 feet		

SCREENS
65-75 feet Bucatunna Clay Member

Hacoda Drilling Company
Randy Holtz
SW¼SW¼ sec. 30, T. 1 N., R. 18 E.
Covington County, Alabama

Well No. DD-02
GSA No. (no samples)
Elevation (feet): G.L. 290

Note that there are no samples or electric logs available from this well.

Depth (feet)	Driller's Log
	MIOCENE AND OLIGOCENE RESIDUUM
0-10	Sandy clay.
10-20	Sand.
20-30	Sand and clay mixed.
30-50	Blue clay and sand.
	OLIGOCENE
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
50-60	Clay.
60-70	Clay.
70-80	Clay.
80-90	Clay.
	MARIANNA LIMESTONE RESIDUUM
90-100	Sand (fine).
100-120	Sand and clay mixed.
120-130	Clay.
130-142	Sand and shells.

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS

Hacoda Drilling Company
Randy Holtz
Well No. DD-02

	Sample interval	E-log top
Miocene and Oligocene		
undifferentiated residuum	0 - 50	--
Oligocene		
Vicksburg Group		
Byram Formation		
Bucatunna Clay Member	50 - 90	--
Marianna Limestone residuum	90 -	--
Well total depth: 142 feet		

SCREENS

132-142 feet Marianna Limestone residuum

Jerry Hughes Drilling Co. Well No. DD-05
Jackie Sims GSA No. (no samples)
NE¼NW¼ sec. 33, T. 1 N., R. 18 E. Elevation (feet): G.L. 230
Covington County, Alabama

Note that there are no samples or electric logs available from this well.

Depth (feet)	Driller's Log
	MIOCENE AND OLIGOCENE RESIDUUM
0-45	Clay.
45-55	Sand.
	OLIGOCENE
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
55-90	Clay.
	OLIGOCENE AND EOCENE
Vicksburg Group, Marianna Limestone	
90-120	Limerock.

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS
Jerry Hughes Drilling Co.
Jackie Sims
Well No. DD-05

	Sample interval			E-log top
Miocene and Oligocene **undifferentiated residuum**	0	-	55	--
Oligocene				
Vicksburg Group				
Byram Formation				
Bucatunna Clay Member	55	-	90	--
Marianna Limestone	90	-		--
Well total depth: 120 feet				

SCREENS

open hole completion 96-120 feet — Marianna Limestone

Hacoda Drilling Company Well No. DD-06
Eulon Mills
NE¼NW¼ sec. 20, T. 1 N., R. 18 E.
Covington County, Alabama

GSA No. (no samples)
Elevation (feet): G.L. 265

Note that there are no samples or electric logs available from this well.

Depth (feet)	Driller's Log
	MIOCENE AND OLIGOCENE RESIDUUM
0-10	Clay.
10-20	Clay.
20-30	Clay and sand mixed.
30-40	Sandy clay.
	OLIGOCENE
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
40-50	Hard clay.
50-60	Sand and clay.
60-70	Clay.
70-80	Clay and sand mixed.
80-90	Clay.
90-100	Clay.
100-115	Sand (water bearing).

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS

Hacoda Drilling Company
Eulon Mills
Well No. DD-06

	Sample interval	E-log top
Miocene and Oligocene **undifferentiated residuum**	0 - 40	--
Oligocene Vicksburg Group Byram Formation		

Bucatunna Clay Member Well total depth: 115 feet	40	-	--

SCREENS

open hole completion Bucatunna Clay Member
105-115 feet

Hughes Well Drilling Co. Well No. DD-07
Becky Stewart
SW¼NW¼ sec. 21, T. 1 N., R. 18 E.
Covington County, Alabama

GSA No. (no samples)
Elevation (feet): G.L. 205

Note that there are no samples or electric logs available from this well.

Depth (feet)	Driller's Log
	MIOCENE AND OLIGOCENE RESIDUUM
0-20	Red sandy clay.
20-40	Red sandy clay.
	OLIGOCENE AND EOCENE
	VICKSBURG AND JACKSON GROUPS, MARIANNA LIMESTONE AND CRYSTAL RIVER FORMATION
60-300	Bedrock.
	EOCENE
Jackson Group, Yazoo Clay	
300-380	Sand and shell rock.

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS

Hughes Well Drilling
Becky Stewart
Well No. DD-07

	Sample interval	E-log top
Miocene and Oligocene **undifferentiated residuum**	0 - 60	--
Oligocene and Eocene Vicksburg and Jackson Groups Marianna Limestone and Crystal River Formation	60 - 300	--
Eocene Jackson Group Yazoo Clay	300 -	--

Well total depth: 380 feet		

SCREENS

open hole completion 300-380 feet	Yazoo Clay

Layne Central Drilling Company Well No. FF-01
City of Florala–Well No. 3 GSA No. 1050
NE¼SW¼ sec. 23, T. 1 S., R. 21 W. Elevation (feet): G.L. 260
Covington County, Alabama

Note that there is no electric log available from this well.

Depth (feet)	Driller's Log
	MIOCENE (UNDIFFERENTIATED)
0-6	Sand.
	OLIGOCENE
	CHICKASAWHAY LIMESTONE
6-15	Limestone.
15-49	Sandy clay.
49-52	Thin clay seam.
52-78	Limestone.
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
78-122	Sandy clay.
	OLIGOCENE AND EOCENE
	VICKSBURG AND JACKSON GROUPS, MARIANNA LIMESTONE AND CRYSTAL RIVER FORMATION (UNDIFFERENTIATED)
122-134	Thin limestone and clay.
134-330	Limestone.
	EOCENE
	JACKSON GROUP, YAZOO CLAY
330-361	Sand.
	MOODYS BRANCH FORMATION
361-423	Limestone.
423-426	Thin sand.
426-457	Limestone.
	CLAIBORNE GROUP, LISBON FORMATION
457-467	Sand.
467-472	Limestone.
472-488	Sand.
488-514	Limestone.
514-521	Sand.

521-555	Limestone.
555-618	Sand.
618-643	Sand with thin sandstone seams.
643-683	Sandy limestone.

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS
Layne Central Drilling Company

City of Florala–Well No. 3
Well No. FF-01

	Sample interval			E-log top
Miocene (undifferentiated)	0	-	6	--
Oligocene				
Chickasawhay Limestone	6	-	78	--
Vicksburg Group				
Byram Formation				
Bucatunna Clay Member	78	-	122	--
Oligocene and Eocene				
Vicksburg and Jackson Groups				
Marianna Limestone and Crystal River Formation (undifferentiated)	122	-	330	--
Eocene				
Jackson Group				
Yazoo Clay	330	-	361	--
Moodys Branch Formation	361	-	457	--
Claiborne Group				
Lisbon Formation	457	-		--
Well total depth: 683 feet				

SCREENS

265-295 feet	Marianna Limestone and Crystal River Formation undifferentiated
330-360 feet	Yazoo Clay
460-480 feet	Moodys Branch Formation
556-566 feet	Lisbon Formation
578-588 feet	Lisbon Formation
600-610 feet	Lisbon Formation
630-640 feet	Lisbon Formation

Layne Central Drilling Company
City of Florala-Test Well
NE¼SW¼ sec. 23, T. 1 S., R. 21 W.
Covington County, Alabama

Well No. FF-01
GSA No. 1050
Elevation (feet): G.L. 260

Note that there is no electric log available from this well.

Depth (feet)	Description
	MIOCENE (UNDIFFERENTIATED)
0-21 Ctgs:	Unwashed: Sand, slightly argillaceous, partially indurated, pinkish-gray (5YR8/1) to very pale-orange (10YR8/2) mottled grayish-orange (10YR7/4), quartzose, coarse- to medium-grained (predominantly medium), angular to subangular.
	Washed: Sand, very light-gray (N8) to pinkish-gray (5YR8/1), unconsolidated, as above.
	OLIGOCENE
	CHICKASAWHAY LIMESTONE
21-43 Ctgs:	Washed: Sand, very pale-orange to grayish-orange, unconsolidated, as above, slightly calcareous; rare *Nummulites* sp. and Bryozoa.
43-65 Ctgs:	Unwashed: Sand, argillaceous, very slightly calcareous, partially indurated, grayish-orange mottled with dark-yellowish-brown (10YR4/2), quartzose with few black opaques, very coarse- to fine-grained, subangular to subrounded; few fragments of grayish-brown (organic?) sandy clay; fragment of grayish-pink (5R8/2) and moderate-orange-pink (10R7/4), very argillaceous, partially indurated sand.
	Washed: Sand, very light-gray to pinkish-gray, quartzose, very coarse- to fine-grained.
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
65-88 Ctgs:	Unwashed: sand, slightly argillaceous and calcareous, partially indurated, pale-yellowish-brown (10YR6/2) to very pale-orange, quartzose, fine- to coarse-grained, subangular; rare pyrite.
	Washed: Sand, clean, quartzose, as in unwashed sample, pinkish-gray few *Sphaerogypsina* preserved primarily as pyritic internal molds; few opaques.
88-109 Ctgs:	Unwashed: Sand, slightly argillaceous, pale-yellowish-brown to very pale-orange, quartzose, medium- to very coarse-grained; few partially indurated argillaceous olive-gray fragments.
	Washed: Sand, clean, quartzose as in unwashed fraction of sample.

MARIANNA LIMESTONE

109-133 Ctgs: Unwashed: Sand, quartzose, moderately calcareous, slightly argillaceous, very pale-orange to grayish-orange, medium- to coarse-grained (predominantly medium); limestone, in part arenaceous (as in rest of sample), micritic to partially recrystallized, soft and weathered, grayish-orange and very pale-orange, fossiliferous (few highly weathered *Lepidocyclina*), slightly glauconitic; few fragments of light-brown (5YR6/4) clay; limestone contains calcite-filled vugs.

Washed: Same but sand has been washed clean of micrite and clay.

133-155 Ctgs: Washed: Limestone, microcrystalline, possibly dolomitic, sucrosic, hard, grayish-orange, fossiliferous (*Nummulites*, molds of shells, and bryozoa); porosity the result of solution of grains (probably fossil fragments or microfossils) in a medium-grained calcarenite; few fragments of nonporous fossiliferous (*Nummulites*) microcrystalline calcarenite.

155-177 Ctgs: Washed: Limestone, micritic, coquinoidal, very pale-orange, slightly sandy; foraminifera (abundant *Lepidocyclina* and *Nummulites* sps., *Marginulina, Sphaerogypsina*, *Denticulina*, agglutinated forms), echinoid spines, bryozoans, small bivalves.

177-201 Ctgs: Washed: Limestone, micritic, slightly argillaceous; arenaceous (quartz, very coarse- to medium-grained), subcoquinoidal, very pale-orange to light-olive-gray, glauconitic; fossils as above.

201-222 Ctgs: Washed: Limestone, micritic, subcoquinoidal, slightly arenaceous (quartz), very pale-orange; fossils similar to above-fewer *Nummulites*, *Lepidocyclina* abundant, *Sphaerogypsina* common, bryozoans.

222-244 Ctgs: Washed: Limestone as above, slightly glauconitic; *Lepidocyclina*, few *Nummulites*, Bryozoa, occ. gastropod mold; bivalve as above.

EOCENE

JACKSON GROUP, CRYSTAL RIVER FORMATION

244-268 Ctgs: Washed: Limestone (calcarenite), micritic to microcrystalline (partially recrystallized, micrite, in part sucrosic), very fossiliferous, very pale-orange, hard, but fragmented in samples; rare tan phosphate grains; *Operculinoides ocalanus*, *Lepidocyclina ocalana pseudomarginata*, *Lepidocyclina* sp., bryozoans common.

268-290 Ctgs: Washed: Limestone, micritic to microcrystalline, arenaceous, very fossiliferous, fragmental, very pale-orange, slightly glauconitic, partially indurated; few *Lepidocyclina*, *Nummulites*, echinoid spine, bryozoans.

290-312 Ctgs: Washed: Limestone as above; forams more abundant; *Lepidocyclina*, *Nummulites mariannensis, Asterocyclina georgiana, Operculinoides ocalanus.* Base of *Asterocyclina* assemblage zone.

YAZOO CLAY

312-333 Ctgs: Unwashed: Sand, micritic and argillaceous, quartzose, pale-yellowish-brown to very pale-orange, slightly glauconitic, medium- to coarse-grained, subangular to subrounded.

333-355 Ctgs: Unwashed: Sand, slightly argillaceous and calcareous, light-olive-gray to pale-yellowish-brown, quartzose, medium- to coarse-grained (predominantly medium), angular to subangular; few shell and *Lepidoycclina* fragments (probably contamination).

355-378 Ctgs: Unwashed: Sand, argillaceous, as above; few fragments of light-olive-gray clay; several *Lepidocyclina* and *Asterocyclina* (probably contamination).

Washed: Sand, clean, as in unwashed fraction of sample; very pale-orange arenaceous limestone.

378-401 Ctgs: Unwashed: Sand, very argillaceous, very pale-orange to pale-yellowish-brown to light-olive-gray, very fine- to very coarse-grained (predominantly very fine to fine), quartzose, slightly glauconitic; few small forams and ostracods.

MOODYS BRANCH FORMATION

401-423 Ctgs: Clay, arenaceous, calcareous, very pale-orange to pale-yellowish-brown; limestone (calcarenite), very pale-orange to pale-yellowish-brown, fossiliferous (*Nummulites moodybranchensis*, *Nummulites* sps., few *Lepidocyclina*, *Sphaerogypsina*, small echinoids, shell fragments, bryozoans), micritic to sparry, in part sucrosic and very finely crystalline, slightly glauconitic.

423-445 Ctgs: Marl, very arenaceous, partially recrystallized, very pale-orange to light-olive-gray, glauconitic (weathered to “bronze”), fossiliferous (*Nummulites).*

445-468 Ctgs: Unwashed: Sand, marly, pale-yellowish-brown to pinkish-gray, quartzose, medium to very coarse-grained, subangular, slightly glauconitic, slightly fossiliferous.

Washed: Sand, same as in unwashed sample; most of marl has been removed by washing.

468-490 Ctgs: Sand, marly, pale-yellowish-brown to pinkish-gray, quartzose, medium- to coarse-grained, subangular, glauconitic, fossiliferous (fragmental, weathered, *Lepidocyclina*, *Nummulites*, occ. echinoid, *Sphaerogypsina).*

CLAIBORNE GROUP, LISBON FORMATION

490-512 Ctgs: Sand, marly, pale-yellowish-brown to pinkish-gray, quartzose, medium- to coarse-grained, subangular to subrounded, glauconitic, fossiliferous (*Lepidocyclina*, *Nummulites*, echinoid spines, gastropods); hard arenaceous micritic to microcrystalline glauconitic, pinkish-gray limestone; quartz sand contains opaques.

512-535 Ctgs:	Sand and limestone as above; fewer *Lepidocyclina* and *Nummulites*; shell fragments common, bryozoa; some limestone fragments are dense, silty, sparry, microcrystalline, and light olive gray.
535-557 Ctgs:	Sand and limestone as above; limestone percentage is greater; *Nummulites* more abundant; fragments of echinoids; slightly glauconitic.
557-579 Ctgs:	Unwashed: Sand, marly (less than above), pale-yellowish-brown to yellowish-gray, quartzose medium-grained, subangular.
	Washed: Sand, clean, quartzose, calcareous (15% of grains are fossils or limestone fragments); slightly glauconitic, fossiliferous (shell fragments, occ. ostracod).
579-600 Ctgs:	Some as above; occ. *Lepidocyclina* and echinoid fragment.
600-623 Ctgs:	Sand similar to above but more calcareous and fossiliferous (small pelecypods, shell fragments, echinoid fragments, *Lepidocyclina*); fragments of micritic to sucrosic arenaceous limestone; rare pyrite, rare garnet (?), sponge spicule.
623-644 Ctgs:	Unwashed: Sand, marly, as above.
	Washed: Sand, clean, quartzose, calcareous (25%, limestone and fossil fragments), glauconitic (5-10%), fossiliferous (*Lenticulina*, few *Nummulites*, shell fragments, echinoids); limestone is arenaceous, micritic to microcrystalline, cherty.
644-666 Ctgs:	Sand and limestone as above but more argillaceous; carbonaceous fragments common and many sand grains and limestone fragments are stained moderate brown (5YR3/4) with carbonaceous residue; glauconite common.
666-688 Ctgs:	Limestone, micritic to microcrystalline and cherty, pinkish-gray, carbonaceous in part, silty to arenaceous in part; sand, argillaceous, fine-to medium-grained, quartzose, glauconitic; lignite; clay, pale-yellowish-brown to dark-yellowish-brown (10YR4/2); *Nummulites*, Bryozoa, shell fragments.
688-709 Ctgs:	Unwashed: Sand, argillaceous, calcareous, pale-yellowish-brown to yellowish-gray.
	Washed: Sand, yellowish-gray, quartzose, glauconitic (10%), fine- to medium-grained, subangular; limestone, micritic to microcrystalline, yellowish-gray, in part siliceous, in part arenaceous to silty; few carbonaceous clay fragments as above; *Lepidocyclina*, echinoid fragments, few shell fragments.
709-733 Ctgs:	Sand as above; few fossils and limestone fragments as above.
733-754 Ctgs:	Unwashed: Sand, slightly calcareous and argillaceous (marly), yellowish-gray to light-olive-gray.

Washed: Sand, clean, very light-gray to light-olive-gray, quartzose, slightly glauconitic (less than 5%), medium-grained; few fossiliferous limestone fragments as above; one light-gray arenaceous limestone fragment.

754-777 Ctgs: Sand as above; very little glauconite.

TALLAHATTA FORMATION

777-800 Ctgs: Sand as above, fine- to very coarse-grained, more marly; claystone, greenish-gray, in part silty to finely sandy, glauconitic; fragments of large thin echinoid and *Lepidocyclina*, shell fragments; limestone as in previous samples.

800-822 Ctgs: Unwashed: Sand, slightly marly, light-olive-gray to pale-yellowish-brown.

Washed: Sand, pinkish-gray, quartzose, medium- to coarse-grained, slightly glauconitic; carbonaceous dark-yellowish-brown silty clay; small amount of claystone as above.

Description by
Dorothy E. Raymond
Geologist

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS

Layne Central Drilling Company

City of Florala-Test Well

Well No. FF-01

	Sample interval			E-log top
Miocene (undifferentiated)	0	-	21	--
Oligocene				
in Chickasawhay Limestone	21	-	65	--
Vicksburg Group				
Byram Formation				
Bucatunna Clay	65	-	109	--
Marianna Limestone	109	-	244	--
Eocene				
Jackson Group				
Crystal River Formation	244	-	312	--
Yazoo Clay	312	-	401	--
Moodys Branch Formation	401	-	490	--
Claiborne Group				
Lisbon Formation	490	-	777	--
Tallahatta Formation	777	-		--
Well total depth: 822 feet				

Jerry Hughes Drilling Company Well No. FF-02
Tommy Sumrall GSA No. (no samples)
SE¼NW¼ sec. 23, T. 6 N., R. 21 W. Elevation (feet): G.L. 275
Covington County, Alabama

Note that there are no samples or electric logs available from this well.

Depth (feet)	Driller's Log
	MIOCENE (UNDIFFERENTIATED)
0-24	Clay.
24-56	Sand.
	OLIGOCENE
	IN CHICKASAWHAY LIMESTONE RESIDUUM
56-110	Gray marl.
	VICKSBURG GROUP, BYRAM FORMATION, BUCATUNNA CLAY MEMBER
110-137	Sand.
137-155	Marl.
	OLIGOCENE AND EOCENE
	VICKSBURG AND JACKSON GROUPS, MARIANNA LIMESTONE, AND CRYSTAL RIVER FORMATION (UNDIFFERENTIATED)
155-172	Limerock.
172-178	Marl.
178-182	Limestone.
182-195	Marl.
195-202	Limerock.
202-220	Cavity.

Interpretation by
Charles C. Smith
Geologist

SUMMARY OF GEOLOGY AND ELECTRIC-LOG TOPS

Jerry Hughes Drilling Company

Tommy Sumrall

Well No. FF-02

	Sample interval			E-log top
Miocene (undifferentiated)	0	-	56	--
Oligocene				
in Chickasawhay Limestone residuum	56	-	110	--
Vicksburg Group				
Byram Formation				
Bucatunna Clay Member	110	-	155	--
Oligocene and Eocene				
Vicksburg and Jackson Groups				
Marianna Limestone and Crystal River Formation (undifferentiated)	155	-		--
Well total depth: 220 feet				

SCREENS

open hole completion	Marianna Limestone and
145-220 feet	Crystal River Formation (undifferentiated)

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