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The geology and hydrology of a proposed impoundment of the upper Sand Creek, Choctaw County, Mississippi

Jonathan R. McMillin

THE GEOLOGY AND HYDROLOGY OF A PROPOSED

IMPOUNDMENT OF THE UPPER SAND CREEK,

CHOCTAW COUNTY, MISSISSIPPI

By

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THE GEOLOGY AND HYDROLOGY OF A PROPOSED IMPOUNDMENT OF THE UPPER SAND CREEK, CHOCTAW COUNTY, MISSISSIPPI

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The Sand Creek watershed, Choctaw County, Mississippi, constitutes a proposed site for a recreational and water management reservoir. Prior to the development of the site, the geology and hydrogeology of the watershed must be investigated to determine suitability for impoundment. Geological cross sections derived from geophysical logs and field exploration provides information regarding facies distributions within the proposed site area. Discharge characteristics of streams provide data concerning surface runoff that can then be related to the amount of water that is beneficial to the reservoir filling and remaining filled. All data collected and the characteristics of the reservoir are mapped using ArcGIS 9.1 software. The amount of sand located near the abutment of the levee and possible thin ridge with prospect of faulting to the southeast of the abutment is cause

for concern. Analysis of the study area suggests that the proposed site is suitable for location of a reservoir.

DEDICATION

To the late Julie McMillin Sloan, keep smiling we are all doing great!

ACKNOWLEDGEMENTS

I would like to express my gratitude to Dr. Darrel Schmitz, for the many hours of guidance and support. I would also like to thank my committee members Dr. James May and Dr. Christopher Dewey for all of their recommendations and direction, the completion of this work would not have been possible without your great minds. I would also like to give a special thanks to The North American Coal Corporation for the use of the geophysical logs to characterize the geology for this project. I would like to thank the faculty and staff of the Department of Geosciences. Furthermore, I would like to personally thank, Jason "L." McIlwain, Rebecca Buele, and Rodney Beasley for their help in collecting field data and many hours of persistent influence not only in this research but in life lessons. Finally I would like to thank my family for their leadership, counseling, and guidance without the long "conferences" none of this could have been accomplished…..THANK YOU.

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CHAPTER I

INTRODUCTION

The research herein records, interprets, and documents the subsurface geology of the Sand Creek drainage basin in East Choctaw County, Mississippi and the relationship to surface and subsurface hydrology for a proposed multiuse multi-purpose reservoir. The Board of Supervisors and the Economic Development Foundation of Choctaw County are seeking innovative and aggressive ways to stimulate economic development opportunities and enhance the quality of life for residents and tourists in Choctaw County (Steil and Ballwebber, 2002). Therefore a 1,400 acre (566.58 ha) reservoir, has been proposed, which holds the potential to the local economy by attracting financial gain form outside Choctaw County.

The preliminary design of the reservoir, north of Mississippi highway 12, placed the pool elevation at 440ft (134.11 m). The Upper Noxubee watershed is defined by spring flow from the Lower Wilcox aquifer which underlies the entire Sand Creek drainage basin. The selection of elevation directly impacts water flow with adjoining drainage basins and is will therefore be a critical element of an Environmental Impact Statement (EIS). A comprehensive discussion of the findings will be used for assessing the feasibility of the proposed reservoir.

CHAPTER II

SETTING

LOCATION

The Sand Creek watershed is located in Choctaw County, Mississippi (Figure 1) in the northeast region of the state. The site is in the physiographic province of the North Central Hills (McMullen, 1986). The total land area of the county is nearly 417 square miles (1,062 km^2) and the dimensions north to south are approximately 29 miles (46km) by 21 (34km) miles east to west (McMullen, 1986). The northern boundary is the Big Black River and the southern boundary is referred to as the "panhandle" (Vestal and McCutcheon, 1943). The town of Ackerman is located in the center of the county, and serves as the County Seat. The total population of the county has shown little variation over the past 25 years and has remained stable around 9,758 (U.S. Census Bureau, 2003). The town of Ackerman is the largest town in the county and is located 109 miles northeast of the state capital of Jackson and 28 southwest of Mississippi State University.

The upper portion of Sand Creek is located in the northeast portion of the county. The proposed area of the reservoir is approximately 1 mile (1.6 km) north of Mississippi highway 12 (Figure 2). The proposed site is located 4.8 (7.6 km) miles from the town of Ackerman and 2.3 miles (3.6km) from the town of Sturgis. Sand Creek is located within

4 USGS Topographic Quadrangles: Sturgis, Double Springs, Reform, and Ackerman and falls between the latitudes of 33º22' and 33º18' and longitudes of 89º21' and 89º17'.

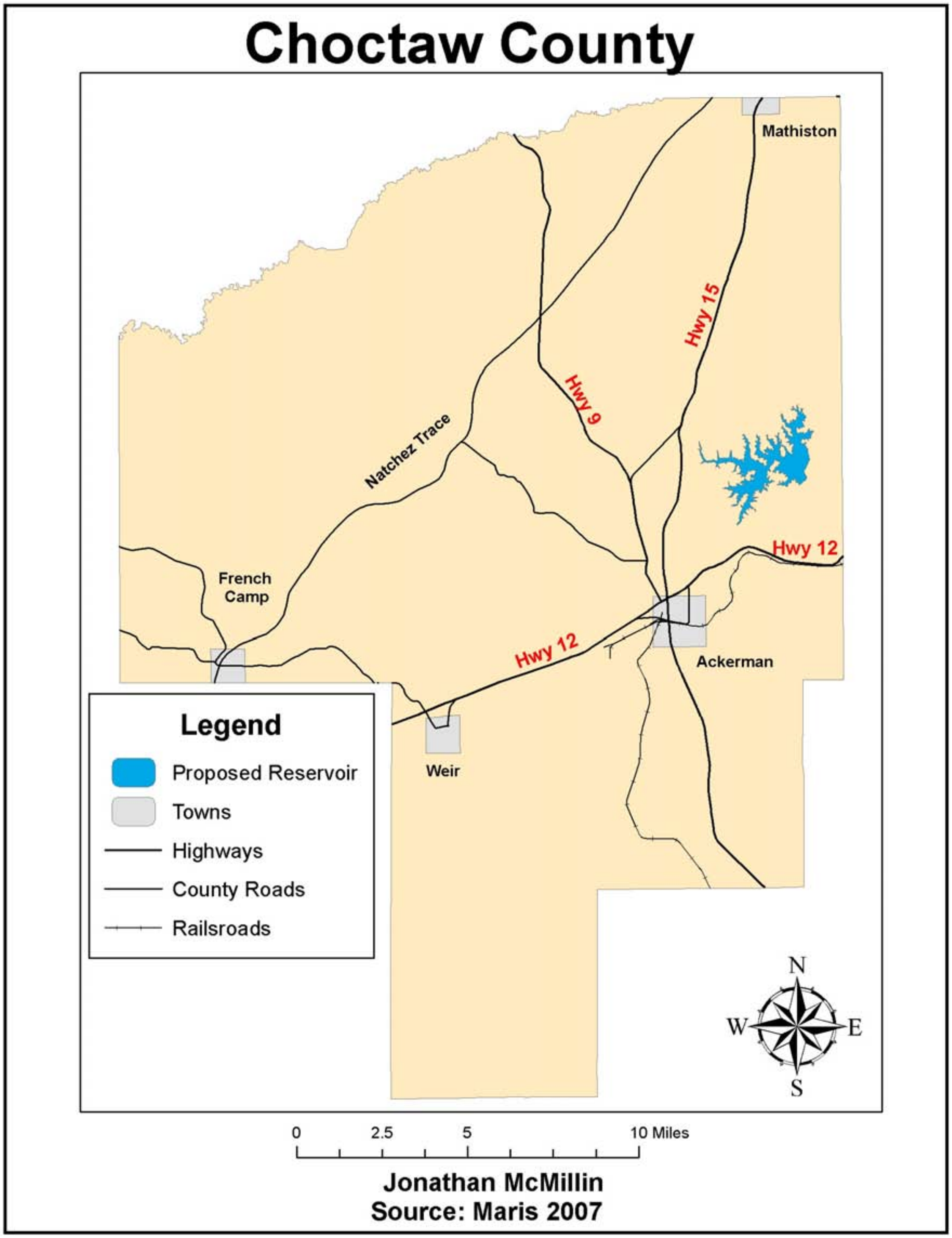


Figure 1:

Choctaw County with Proposed Reservoir Location

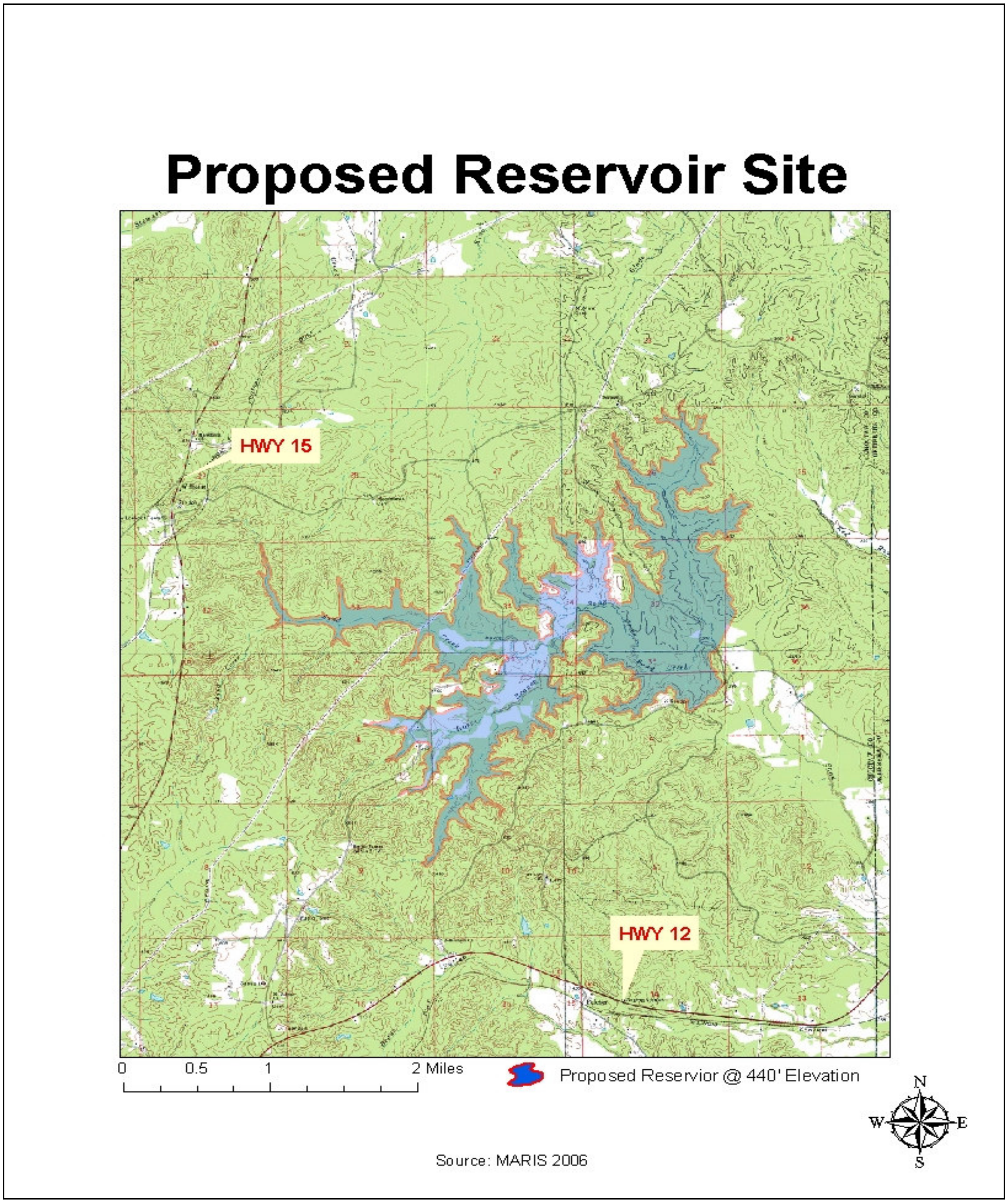


Figure 2:

Proposed Sand Creek Reservoir

TOPOGRAPHY

Choctaw County is located in the North Central Hills, which is the highest and most hilly part of Central Mississippi and contains numerous stream flood plains. The current topography is the result of erosion, and is characterized by slopes, thoroughly dissected uplands, and broad flats (McMullen, 1986). It should be noted that in areas where sand is exposed, the slopes are steeper and the elevation is greater. The surface of the county is uneven, but is part of the surface of an old plateau which sloped gently southwards and westwards (Vestal and McCutcheon, 1943).

The highest point in the county is Williams Hill which is 660 ft (201.17 m) and the lowest point located south of Ackerman is 210 ft (64.01 m). (McMullen, 1986). Area streams exhibiting dendritic drainage dissect steep, extensively eroded hills. Some of the larger streams have developed relatively wide, low-gradient floodplains (TVA, 1998 and McMullen, 1986). The topographic relief for the study area ranges from a high of 620 feet to a low of 374 feet at the proposed site of the levee. The total relief is 246 feet.

CLIMATE

Choctaw County receives a steady flow of moist tropical air from the Gulf of Mexico. The data used to generate Table 1 comes from The National Oceanographic and Atmospheric Administration which shows the 30 year rainfall totals from two surrounding towns near the study area. The average annual rainfall for the past 30 years is 56 inches (142.24 cm) per year, with much of the precipitation being evenly distributed through spring, summer, and fall; but slightly greater during the winter months (McMullen, 1986). The annual temperature is 61°F (16.1°C). Winters are short, mild, and humid with highs averaging 46°F (28.2°C). Summers are long, hot, and very humid with highs averaging 91°F (73.2°C) (McMullen, 1986). The summer high can reach into the 100°F range and the winter extreme low can dip to 0°F. TVA (1998), p. 3-2 cites Hersfield (1961) indicates that the precipitation extreme at any "given location in the project area can be a 1-hour rainfall of about 3.2 inches (8.1 cm) once in 50 years, a 1-hour rainfall of about 3.6 inches (9.1 cm) once in 100 years, a 24-hour rainfall of about 6.2 inches (15.7 cm) once in 10 years, a 24-hour rainfall of about 8.0 inches (20.3 cm) in 50 years, and a 24-hour rainfall of about 8.8 inches (22.4 cm) once in 100 years." Precipitation is estimated to be 16-20 inches (41-51 cm) per year with losses mainly due to evapotranspiration and infiltration. There is sufficient recharge to maintain spring flow throughout the year (Charleton, 1999 and Newcome and Bettandorf, 1973).

Table 1:

30 Year rainfall totals for surrounding towns.

			JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Ackerman	Temp (°F)	Max	51.2	56.4	65.5	74.3	80.6	87.2	89.3	89.1	83.7	74.4	64.8	55.3	72.7
		Min	30.6	33.9	42.6	51.0	58.8	65.7	68.7	67.9	62.7	50.5	42.5	34.2	50.8
		Mean	40.9	45.2	54.1	62.7	69.7	76.5	79.0	78.5	73.2	62.5	53.7	44.8	61.7
	Precipitation (in)		5.89	4.53	6.17	5.47	5.06	4.43	4.38	3.27	3.67	3.51	4.96	5.43	56.77
Eupora	Temp (°F)	Max	52.2	57.8	66.2	73.9	81.1	87.8	91.0	90.6	85.1	75.5	64.5	55.2	73.4
		Min	29.9	32.6	40.6	48.2	57.5	64.9	68.4	67.0	60.5	48.0	39.5	32.9	49.2
		Mean	41.1	45.2	53.4	61.1	69.3	76.4	79.7	78.8	72.8	61.8	52.0	44.1	61.3
	Precipitation (in)		5.72	4.53	6.60	5.54	5.16	4.17	4.06	2.99	3.79	3.65	5.21	5.91	57.33

GEOLOGY/HYDROLOGY

The geologic units exposed at the surface in Choctaw County are part of the Wilcox Group (Eocene Epoch). The Wilcox Group has an outcrop that stretches from Tippah County near the Tennessee border south to the Alabama border in Lauderdale County (Figure 3). The proposed location of the reservoir is located completely within the Wilcox Group (Figures 4 and 5). The Wilcox Group consist primarily of fluvial deposited continental sediments; consisting of rapid transformation in lithology, thickness, and lateral continuity of individual beds due to the complexity of fluvial and transitional sedimentary sequences (Dueitt, 1985). The Wilcox Group consists of the

Tuscahoma and Nanafalia Formations. The Nanafalia Formation consists of the Grampian Hills and Gravel Creek Sand Members. Both the formations and members of the Wilcox Group can be identified by orange to yellow coarse or fine

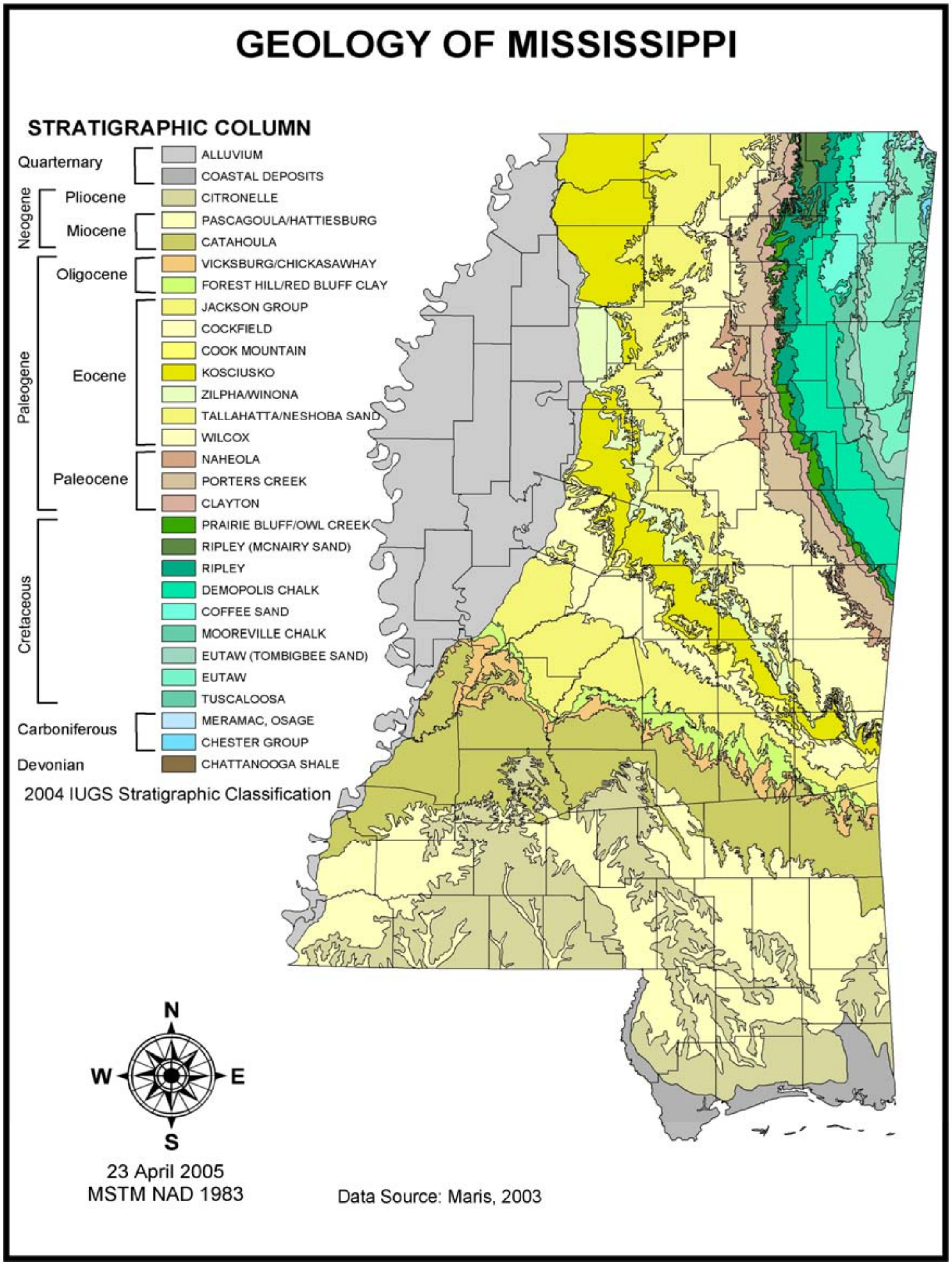


Figure 3:

Surficial Geology of Mississippi (adapted from Rawlings, 2005)

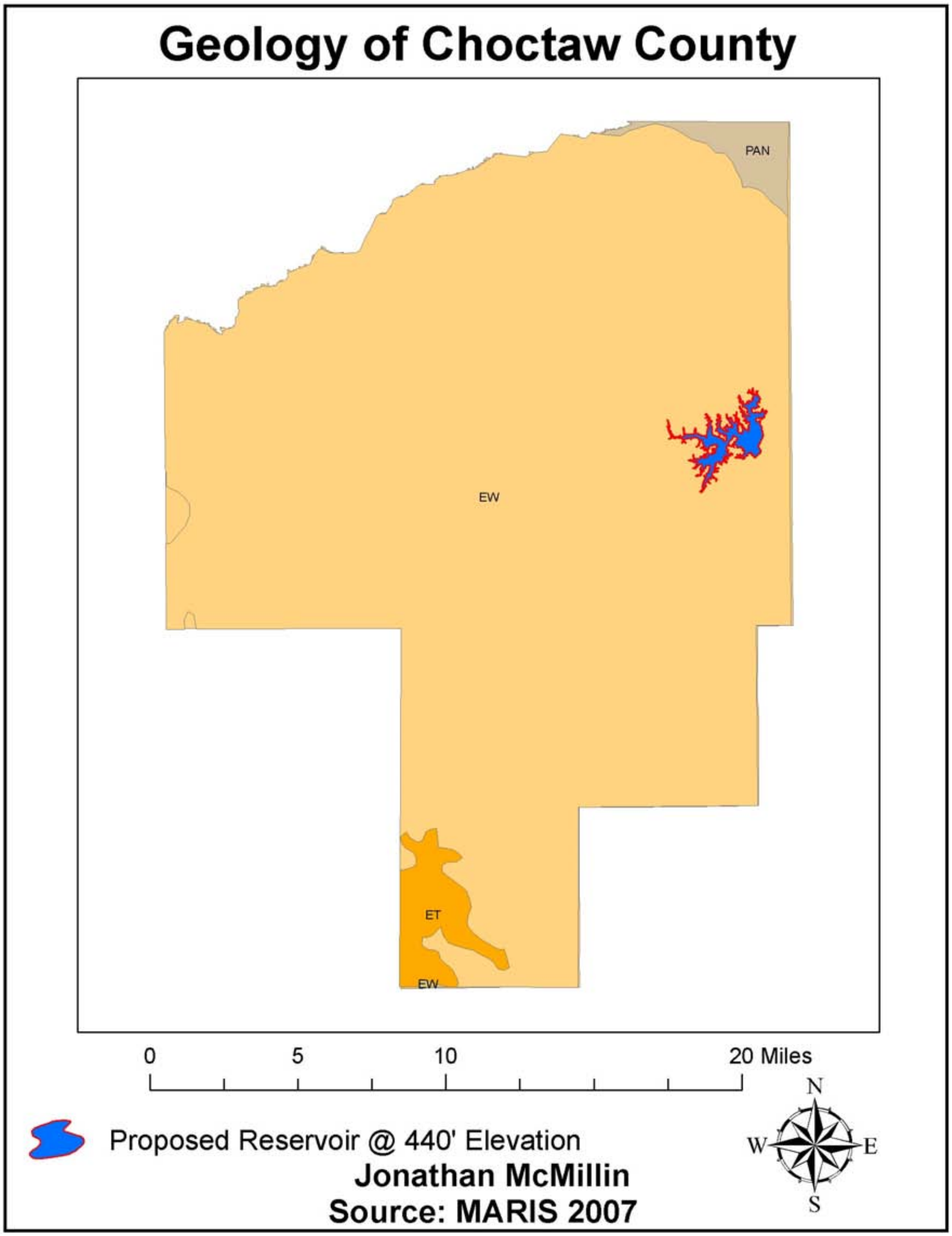
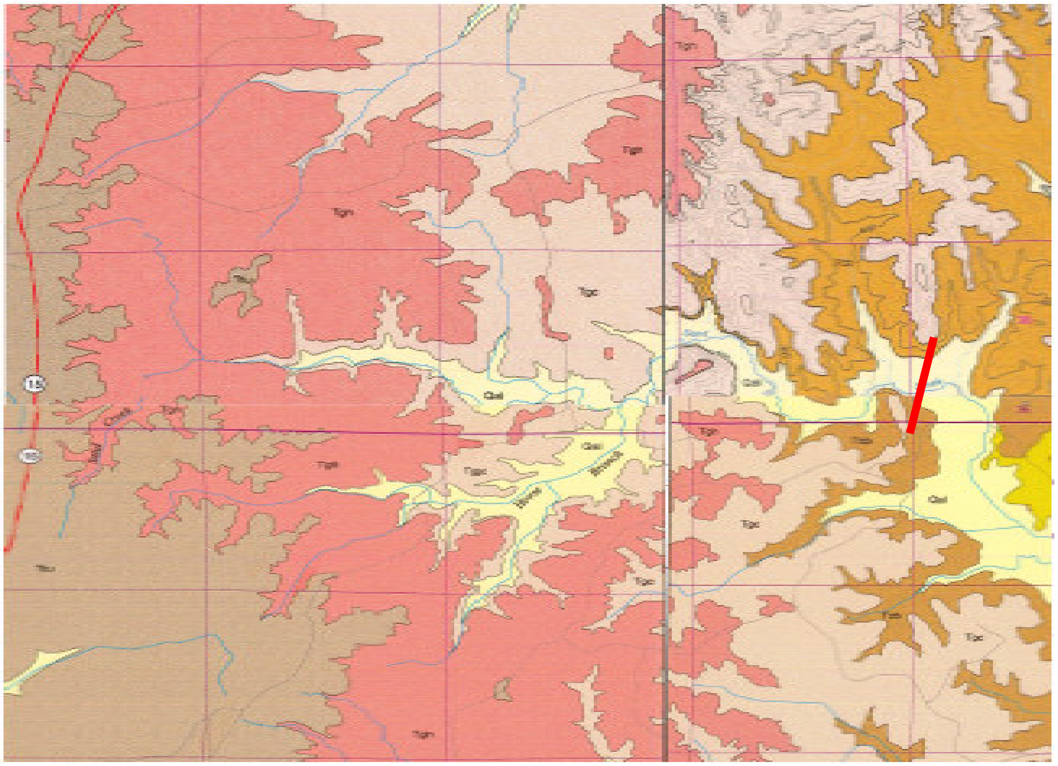
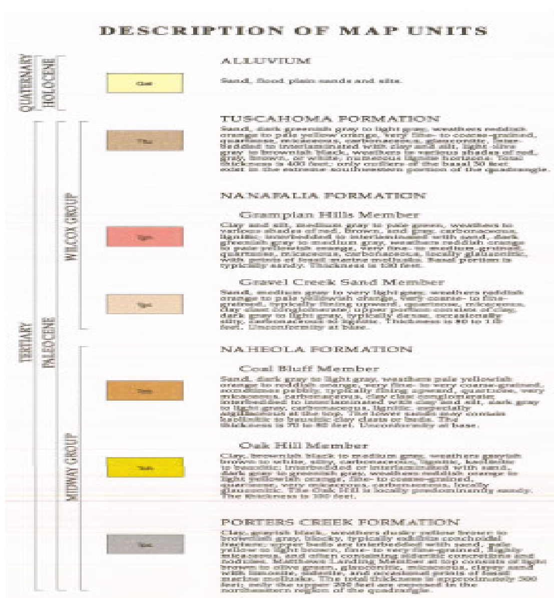


Figure 4:

Geology of Choctaw County Pertaining to Reservoir

Surface Geology of Basin





Legend

Site of Proposed Levee

Source: Reform, Sturgis, Double Springs, and Ackerman Surface Geology Quadrangles

Figure: 5

Surface Geology of Sand Creek Basin

grain sands, dark green to light grey clay, silts, silty-sands, silty-clays, quartzose along with micaceous deposits, and lignite seams.

The Upper Noxubee watershed originates toward the west in the North Central Hills and Sand Creek flows eastward in the direction of Sturgis (Figure 6) . Also, a tributary inlet named Horse Branch feeds into Sand Creek. Sand Creek flows into the Noxubee River, which empties into the Tombigbee River which eventually drains into the Gulf of Mexico. Groundwater movement has been researched by Newcome and Bettandorf (1973). They concluded that the Eocene Epoch middle Wilcox Group aquifers are locally important sources of water and that the Lower Wilcox is the major aquifer in Choctaw County (Figure 7).

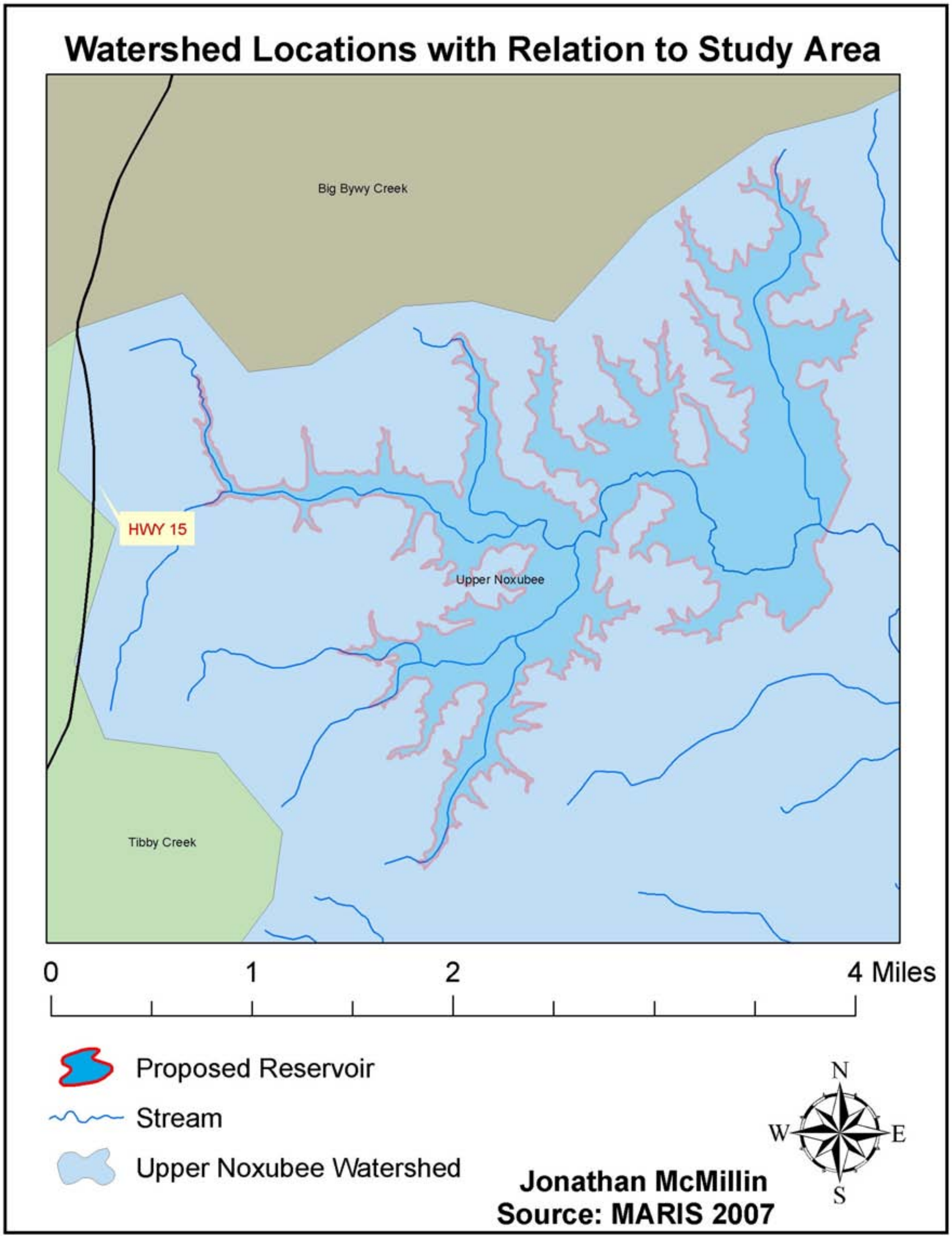


Figure 6:

Upper Noxubee Watershed with Relation to Proposed Reservoir**.**

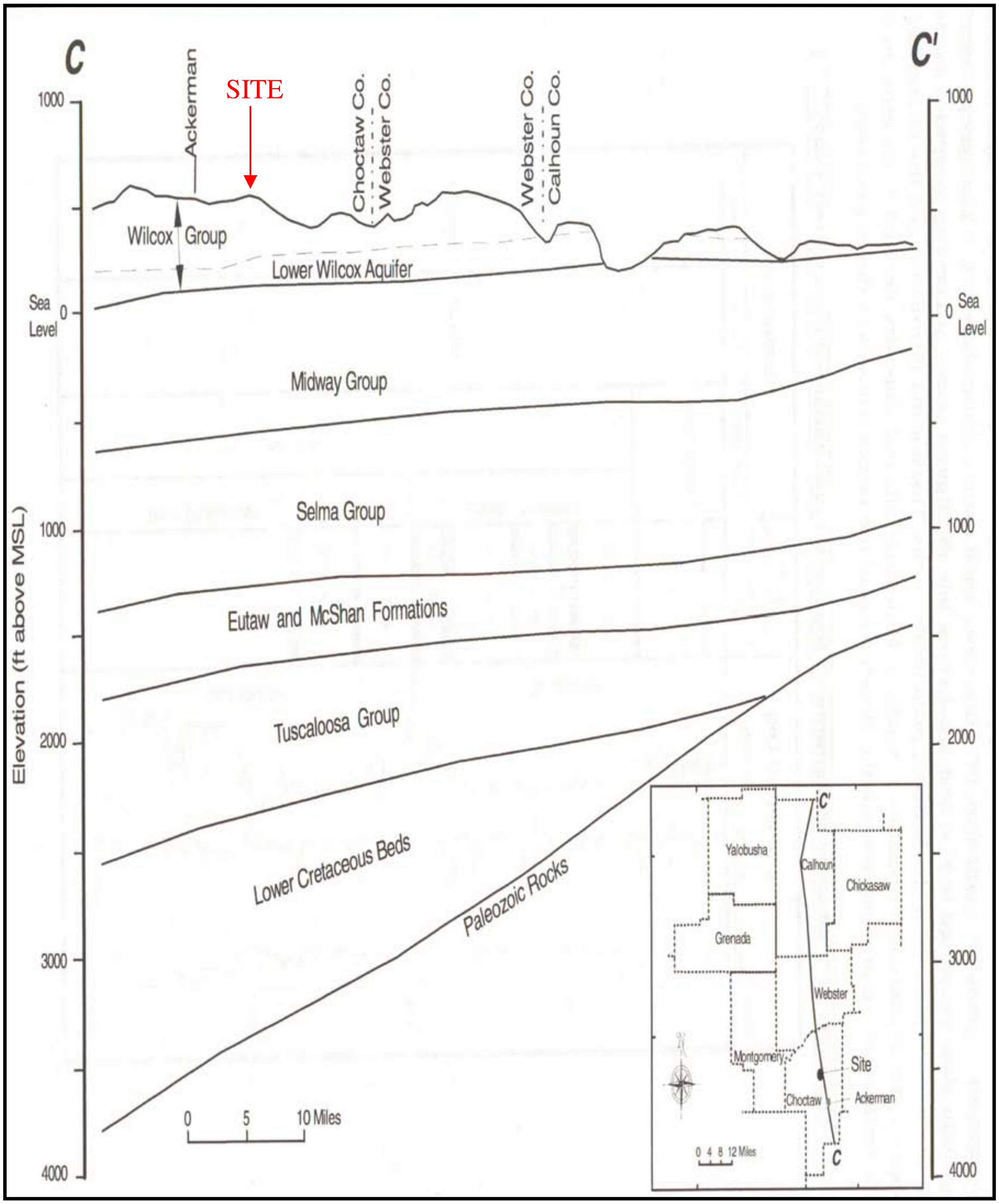


Figure 7:

Hydrogeologic Cross Section of Choctaw, Webster, Calhoun Counties, Mississippi (adapted from TVA, 1998)

STRATIGRAPHY

Vestal and McCutcheon (1943) mapped Choctaw County noting surficial outcrops and using data from borings less than 50 feet (15 m) deep. In the study area, Vestal and McCutcheon (1943) concluded that a highly dissected topography was formed during the Eocene Epoch on the Holly Springs Formation of the Wilcox Group. The depth of the Wilcox averages 400 feet to 500 feet (122 m to 152 m). The possibility of an unconformable contact exists pertaining to the Meridian Sand Member of the Tallahata Formation of the Claiborne Group. The Meridian Sand Member in found on hilltops west the study area. At the study area the formation strikes northwestward to southeastward (N 55º W) with a dip to the southwest at 25-30 feet/mile or 0.30º (Vestal and McCutcheon, 1943). While approximately 40 miles to the south, Lusk (1963) provided more detail to the local stratigraphy of the Selma, Midway, Wilcox, and Claiborne groups by surveying down-dip along Mississippi Highway 25. Lusk agreed with previous investigations on strike but concluded the regional dip was 30-35 feet/mile or 0.35º south southwestward.

Regional geological studies that included Choctaw County have centered on the economic development of lignite seams in the Red Hills Area. Dueitt (1985) studied the petrography and stratigraphy of the lignite seams of the Wilcox group. During the initial stratigraphic analysis of Choctaw and Winston Counties, Dueitt (1985) compared the differing nomenclature for the formations of the Wilcox including the Wilcox Group Undifferentiated, Holly Springs and Ackerman Formations, and Hatchetigbee, Holly Springs, and Ackerman Formations. According to Dueitt (1985) the overlying and underlying unconformities correspond to previous geologic investigations, yet unit thicknesses do not. Moreover, Dueitt (1985) does not follow the stratigraphic nomenclature of Dockery (1981), thereby creating a discrepancy in the literature.

The aquifers and stratigraphy of the area are defined by Charleton (1999) in which baseline information of the shallow groundwater aquifers were researched indepth prior to commissioning the Red Hills Lignite Mine. Charleton (1999) describes the portion of the middle and lower Wilcox as the "thin interbedded sands, clays, silts, and lignites. The stratified clays, silts, and lignites retard the vertical movement of water throughout the unit." Thus far, Thompson and Morse (1997a-b, 1998a, and 2003) have completed six 7.5 minute geologic maps within Choctaw County, and efforts to produce remaining quadrangles for the county continue. The stratigraphy nomenclature used herein corresponds to the data presented by the USGS with the exception of the Meridian Sands which do not occur in the study area (USGS, 1997). The unit descriptions offered by Thompson and Morse will be used for the remainder of this study. Table 2 along with Figure 5 present the lithological units as well as the surface geology that will be used in this study.

Table 2:

Lithology Units (Descriptions from Thompson and Morse, 1997a-b, 1998 a, 2003)

	Series	Group	Stratigraphic Unit	Symbol	Thickness (feet)	Lithological Characteristics
Quarternary			Alluvium	Qal	Varies	Sand, flood plain sands and silts.
Tertiary	Eocene	Claiborne	l Formation	Tms	-	Sand, buff gray and weathers reddish orange to pale yellow, course- to medium grained resembling the Tuscohoma; erodes differently with steeper banks. Expect to find in uppermost hills of the study area at elevations near 550 ft m.s.l. *
Tertiary	Paleocene	Wilcox	Tuscohoma Formation	Ttu	400	Sand, dark greenish gray to light gray, weathers reddish orange to pale yellow orange, very fine- to course-grained, quartzose, micaceous, carbonaceous, glauconitic. Interbedded to interlaminated with clay and silt, light olive gray to brownish black, weathers to various shades of red, gray, brown, or white; lignite, contains Red Hills Mine lignite seams H through L. Basal sandy interval constitutes the Middle Wilcox Aquifer.
Tertiary	Paleocene	Wilcox	Nanafalia Formation - Grapian Hills Member	Tgh	130	Clay and silt, medium gray to pale green, weathers to various shades of red, brown, and gray, carbonaceous, lignitic, contains Red Hills Mine lignite seams C through G; interbedded to interlaminated with sand, dark greenish gray to medium gray, weathers reddish orange to pale yellowish orange, very fine- to medium grained, quartzose, micaceous, carbonaceous, locally glauconitic. Basal portion is typically sandy.
Tertiary	Paleocene	Wilcox	Nanafalia Formation - Gravel Creek Sand Member	Tgc	80-110	Sand, medium gray to very light gray, weathers reddish orange to pale yellowish orange, very course- to fine-grained, typically fining upward, quartzose, micaceous, clay clast conglomerate; upper portion consists of clay, dark gray to light gray, typically dense, occasionally silty carbonaceous to lignitic. Contains Red Hills Mine lignite seams A and B. Unconformity at base. Basal sandy interval (along with the underlying Coal Bluff sand) constitutes the Lower Wilcox Aquifer.
Tertiary	Paleocene	Midway	Naheola Formation - Coal Bluff Member	Tcb	70-80	Sand, dark gray to light gray, weathers pale yellowish orange to reddish orange, very fine- to coarse-grained, sometimes pebbly, typically fining upward, quartzose, very micaceous, carbonaceous, clay clast conglomerate; interbedded to interlaminated with clay and silt, dark gray, carbonaceous, lignitic, especially argillaceous at the top. The lower sands may contain kaolinitic to bauxitic clay clasts or beds. Unconformity at base. Along with the overlying Gravel Creek sand, constitutes the Lower Wilcox Aquifer.
Tertiary	Paleocene	Midway	Porters Creek Formation	Tpc	500	Clay, grayish black, weathers dusky yellow brown to brownish gray, blocky, typically exhibits conchoidal fracture; upper beds are interbedded with sand, pale yellow to light brown, fine- to very fine-grained, highly micaceous, and often containing sideritic concretions and nodules.

STRUCTURE

The immediate study area is devoid of visible or reported structural features such as faults, joints, and folding. Lusk (1963, p 34) describes the "structural condition of the beds [as] homoclinal and primary." Thus, a review of the literature and aerial photography (Digital Orthogonal Quaterquads) (MARIS, 2003) for the Sturgis, Double Springs, Reform, and Ackerman Quadrangle for liniments and other structural features found no conclusive evidence of faulting. Any evidence of past faulting has been eroded away or is thousands of feet below the surface. The Kilmichael Dome is located approximately 15 miles (24.0 km) to the northwest is in neighboring Montgomery County. Priddy and McCutcheon (1943) report that the uplift feature is roughly circular and approximately 8.5 miles (13.6 km) in diameter and is characterized by intense faulting and reverse dips. The dome exposes the strata of the Wilcox and Midway Series with marginal fault blocks creating several sets of horst and graben blocks involving successively younger beds. Furthermore, the authors report that if the normal dip is projected through the dome, they calculate that there has been 800 to 1200 feet (243 to 366 m) of uplift in the area (Priddy and McCutcheon, 1943). Since Priddy (1946), little has been published on the cause of this uplift; however, several recent proceedings abstracts have been published suggest that uplift is due to the effects of a bollide impact structure or rotational uplifting (Ingram, 1998; Schmitz, 1999; King 2002; and Sloan, 2003).

Recent quarrying at the Red Hills Lignite Mine's north quarry face reveal the existence of a normal fault (as per conversations with Schmitz, 2007). Other significant structures within the county do exist. Vestal and McCutcheon (1943) noted some folding or doming occurring near Ackerman with dips between 30º-40º in an exposed outcrop and reverse dips in the Blantons Gap, 5 miles (8 km) southeast of Williams. Also, Vestal and McCutcheon (1943) note the existence of a dome near Sturgis (NE1/4, SE1/4, SE1/4, Sect. 3, T.17N, R.12E) with a major fault cutting into Oktibbeha County which is not indicated on the Sturgis Geologic Quadrangle (Thompson and Morse, 1997a) and minor faulting and jointing in outcrops east of the study area in which stream flow is controlled by these structural features.

SOILS

An understanding of the soils for the study area is vital because certain soil types have definite characteristics which pertain to slope, drainage, and water table location. The U. S. Department of Agriculture Natural Resources Conservation Service (McMullen, 1986) (formerly Soil Conservation Service) and MARIS (2005) shapefiles identify four relevant soil series for the watershed area: Maben Series, Ora Series, Smithdale Series, Tippah Series, and Oaklimeter Series (Figure 8). They are characterized by gently sloping to steep, with moderately- to well-drained silty to loamy soils. These soils are drained by numerous meandering streams. The slopes for the soils can range from 2 to 35 percent (McMullen, 1986).

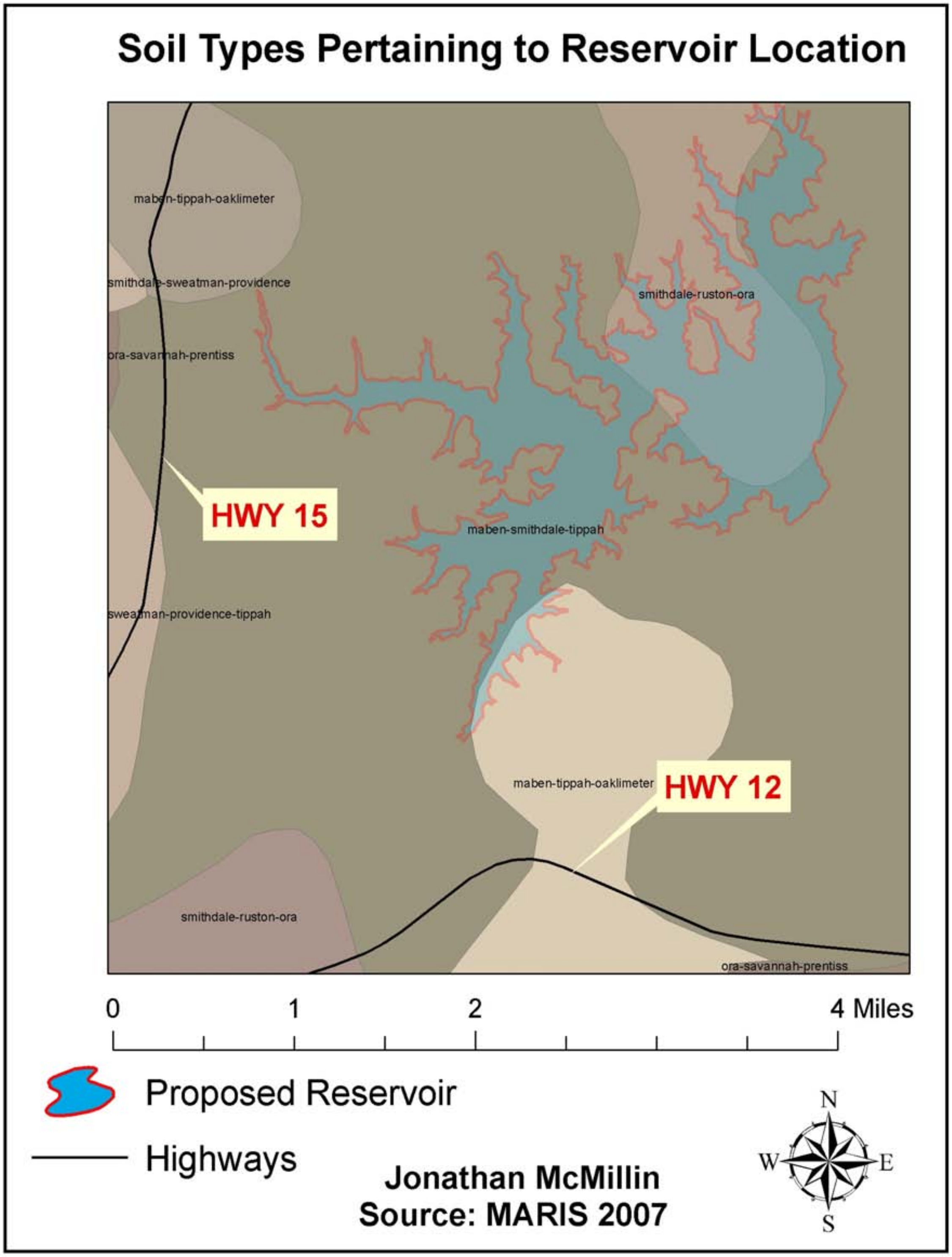


Figure 8:

Soil Series Pertaining to Proposed Reservoir

CHAPTER III

REVIEW OF LITERATURE

T. C. Winter has written extensively about the interaction of surface water and groundwater but most of his work is concentrating on the interaction of lakes with groundwater primarily in the northern United States (Winter and others, 2000; Winter and others, 1998; Mau and Winter, 1997, Winter and others, 1988; and Winter, 1984, Winter, 1976). Very little research, however, has been performed concerning Mississippi or Alabama, and a literature search reveals no published data. The literature review will be restricted to published generalized groundwater/surface water interaction investigations that can be used to discuss the hydrogeologic investigations within northeast Choctaw County.

GENERAL CHOCTAW COUNTY WATER RESOURCE INVESTIGATION

Prior to the Red Hills Mine coming online in 2000 and the baseline studies that were conducted for the mine, little detailed hydrogeologic information existed for northern Choctaw County. Regional studies have been performed for several counties and for the entire Mississippi Embayment, such as the studies of the Regional Aquifer-System Analysis (RASA) Program. No data concerning groundwater/surface water interaction were found. Chronologically, the following have included this study area.

Lang and Boswell (1960) assessed water resources for Northern Mississippi. Keady (1970) conducted studies on the Wilcox aquifers in Mississippi to determine the geochemistry. Newcombe and Bettandorf (1973) compiled well log data from Mississippi Office of Land and Water Resources that date back to the early 1900's to provide water resources data for industrial use for eight counties in Central Mississippi that included Choctaw County. Hossman and Wiess (1991) studied the geological units of the Mississippi Embayment and the aquifers associated with the subsurface units while Mallory (1991) focused on the hydrogeology of eastern Mississippi and western Alabama. Oakley and others (1994) compiled a potentiometric map of the Lower Wilcox Aquifer in Mississippi and used 1979-1988 data from wells in Choctaw County. Charlton (1999) and Charlton and Schmitz, 1999) gathered baseline physical and chemical properties of the ground water resources in the early development of the Red Hills Mine. The TVA (1998) published its final environmental impact study (EIS) for the projected mine which duplicates the hydrogeologic data found in Charlton thesis. Williamson and Grub (2001) completed a study analyzing the Gulf Coast Regional Aquifer as a part of the RASA Program begun by the USGS in 1978 and included the study area, specifically the Middle and Lower Wilcox. Lockhart (2004) studied geohydrochemical relationships of iron affecting the water quality of the Middle and Lower Wilcox Aquifers. Finally, Schmitz and others (2004) presented a report to Pickering and Associates detailing the locations of 59 springs, climatological water budgets, chemical and physical properties of the McCurtain Creek Watershed.

CHAPTER IV

STATEMENT OF PROBLEM

A proposed location for a surface water impoundment has been selected in the Sand Creek drainage basin. A detailed study of the underlying geology and its hydrogeological characteristics is needed to determine if the site is suitable. The study was necessary to determine whether the geology and hydrology of the area and the impound structures will support a large reservoir.

HYPOTHEISIS

The geology and hydrogeology indicate that the proposed reservoir site on Sand Creek, Choctaw County, Mississippi is a suitable location for the impoundment and development of a multi-use/ multi-purpose reservoir.

OBJECTIVES

The primary concern for the successful completion of the proposed reservoir at Sand Creek is the ability of the reservoir to fill and remain filled. The potential likelihood of meeting these two conditions will be determined by the geology and hydrogeology conditions at the site.

Specific objectives were to:

- Determine flow characteristics of the drainage basin to be impounded.
- Determine if the geological conditions are detrimental to a reservoir.
- Determine if the springs in the area can feed the reservoir.
- Determine basic water quality of the water that would potentially fill the reservoir.

CHAPTER V

METHODOLOGY

WATER INTERACTIONS

There are several ways in which groundwater and surface water interact in a drainage basin: (1) Interactions occur as rain falls on the surface and infiltrates into recharge zones of connected confined and unconfined aquifers. (2) Confined and unconfined aquifers outcropping into slopes or valley bottoms and then discharge as springs. (3) Interactions occur at streams in all terrains through gaining streams and losing streams. The controlling factors with groundwater/surface water are topography, geology, hydrogeologic properties, precipitation, and groundwater flow conditions (Cey and others, 1998).

The interaction of surface water and groundwater begins in the unsaturated zone where surface water infiltrating the ground surface moves downward due to effect of gravity (Deming, 2002; Winter, 1984). Over time, the water continues to percolate towards the water table where it enters the regional flow. Recharge sites are usually found in areas of high topography (Fetter, 2001). Once the water percolates through to the water table, groundwater flow begins (Figure 9). Deming (2002, p 158) defines a groundwater divide as "a ridge on the water table that separates areas of lesser head values." This concept can be demonstrated in the study area at Sand Creek.

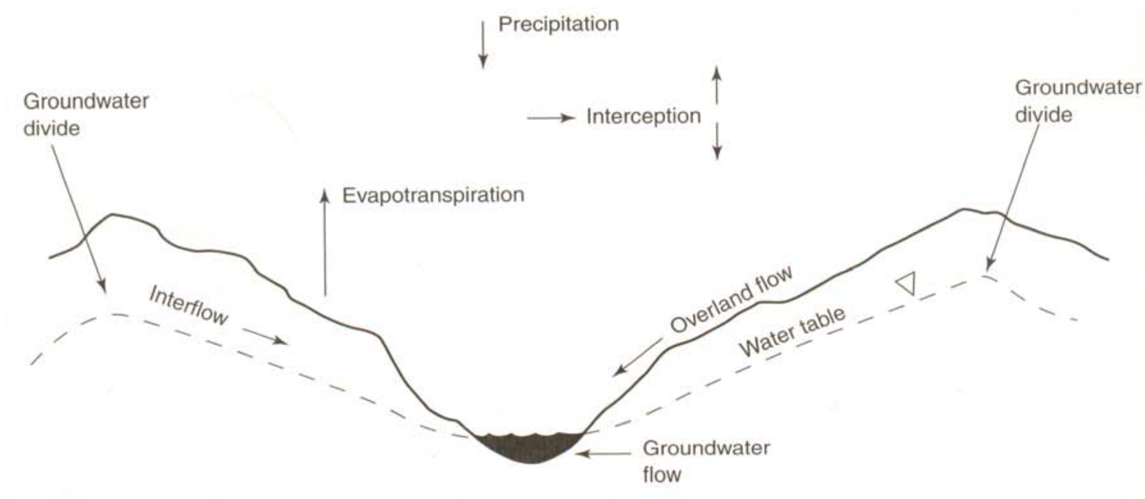


Figure 9:
Graphic representation of ground water divides (Deming, 2002, p 158).

In the Sand Creek and the McCurtain Creek (Rawlings, 2005) watersheds in Choctaw County two types of springs are prevalent. They are depression and contact springs. Contact springs form when permeable water-bearing formations overly a less permeable stratum that intersects the ground surface (Todd, 1980). Where the water table intersects topography, springs or seeps may be present and are called depression springs (Fetter, 2001).

METHODS OF INVESTIGATION

Geological cross sections were constructed by analyzing the geophysical logs from borings collected during the 1970's and 80's (by Phillips Coal Company) which were supplied by The North American Coal Corporation. Geologic maps, topography maps, public geophysical logs, and previous geology reports of the study area were compiled. Logs were use to determine the geology of the proposed area. Specifically, 51 logs of borings up to 300 feet (121.91 m) deep were analyzed and five cross sections and surfaces of the area were generated. The five cross sections generated were divided into three sections trending down dip and three trending along the strike of the regional geology described in the setting. The cross sections and surfaces were developed using ArcGIS 9.1 and Microsoft Illustrator.

Another phase of this study was field to determine hydrologic properties of the proposed basin, to determine the hydrographic stage-discharge relationships. Field and chemical analysis were taken to establish the water quality of the area. Spring inventory was conducted to determine discharge contribution and their location will be mapped using Arc GIS 9.1. Six stream crossing locations were used to take discharge measurements to establish flow conditions of the basin the were labels Site A, Site B, Site C, Site D, Site E, and Site F (Figure 10).

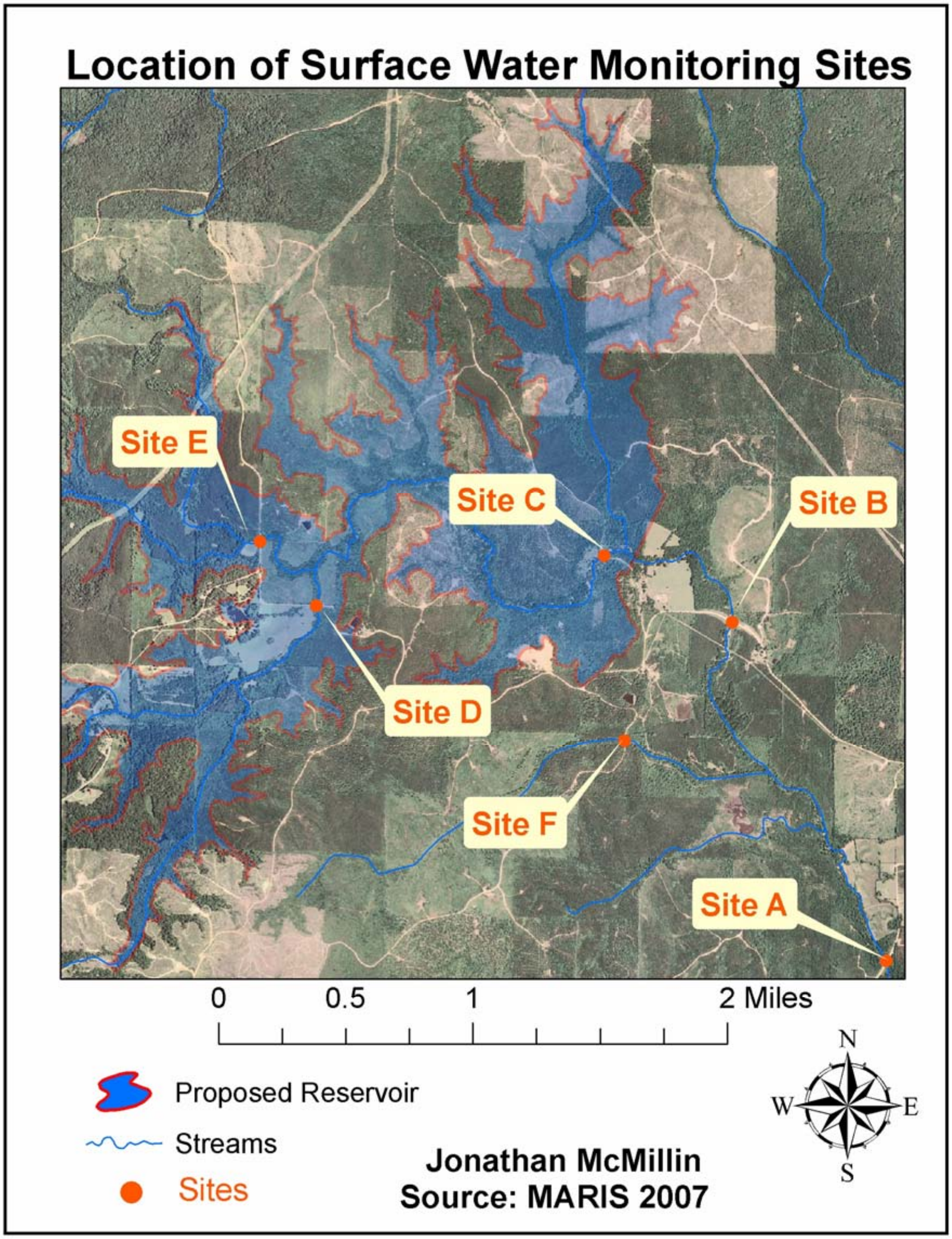


Figure 10:

Monitoring Site Locations

Site A: This bridge crossing site is located on Phillips road in Oktibbeha County (Figure 25). The latitude/longitude of the site is 33.35291°N and 89.08906°W. Site A is located approximately 10,000ft (32,810 m) south east of the proposed levee. This site is positioned in Sand Creek with a relatively wide channel (figure 11). There were a total of six discharge measurements taken from this site, all measurements were taken from the same location within the creek or when flow was elevated measurements were taken from the bridge abutment. Stage was taken from a known point on the bridge above the creek at an elevation of 341ft (1118.82 m).

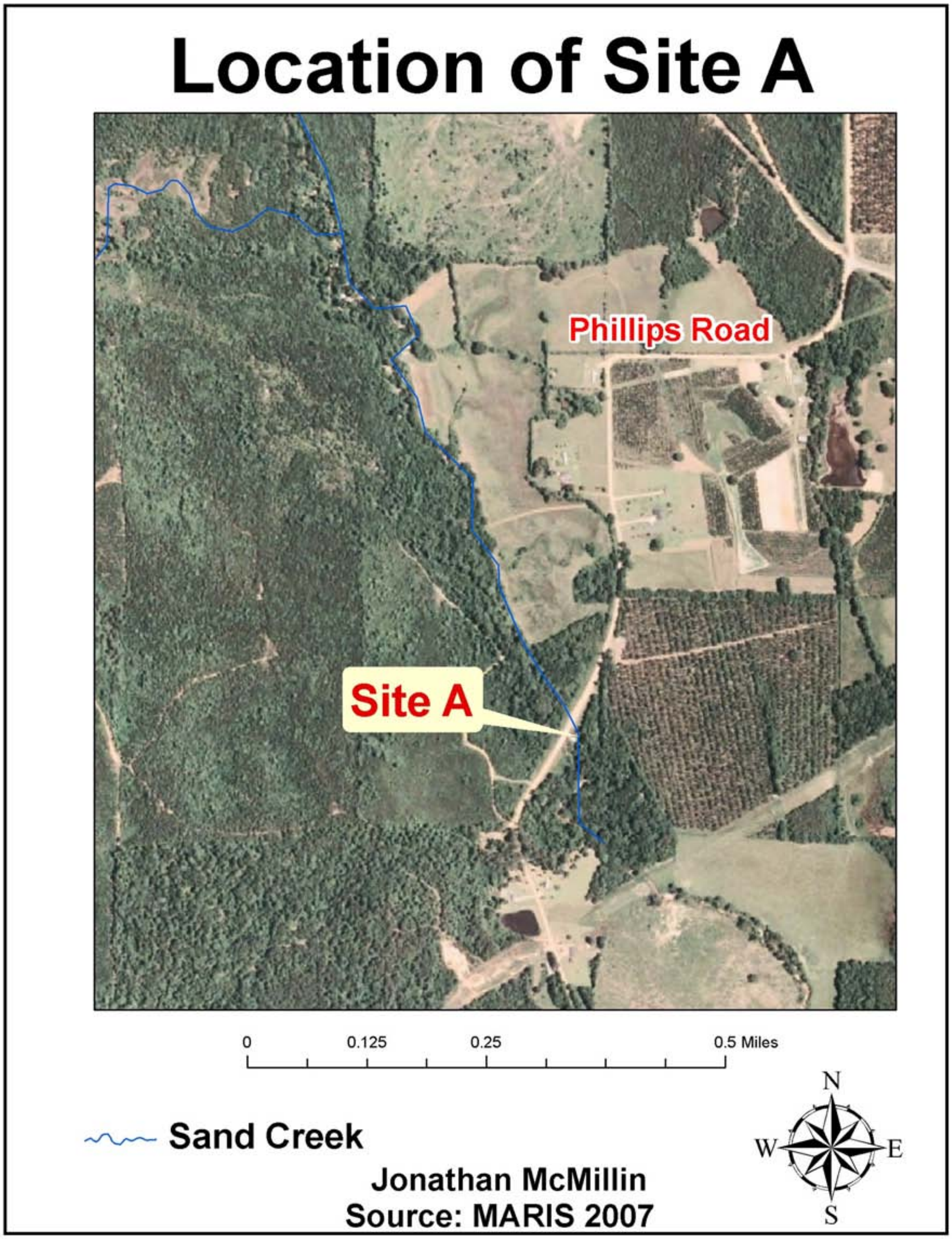


Figure 11:

Location of Monitoring Site A

Site B: This bridge crossing is located on Bethlehem road in Choctaw County (Figure 12). The latitude/longitude of this site is 33.35291°N and 89.10030°W. Site B is located approximately 3,500 ft (11,483.5 m) south east of the proposed levee. A stage gauge was place on a point bar with in the creek to measure the stage of the creek during elevated flow (Figure 29). There were a total of six discharge measurements taken from this site. All measurements were taken from the same location within the creek or when flow was elevated measurements were taken from the bridge abutment. Stage was taken from a known point on the bridge above the creek at an elevation of 395 ft (1295.9 m).

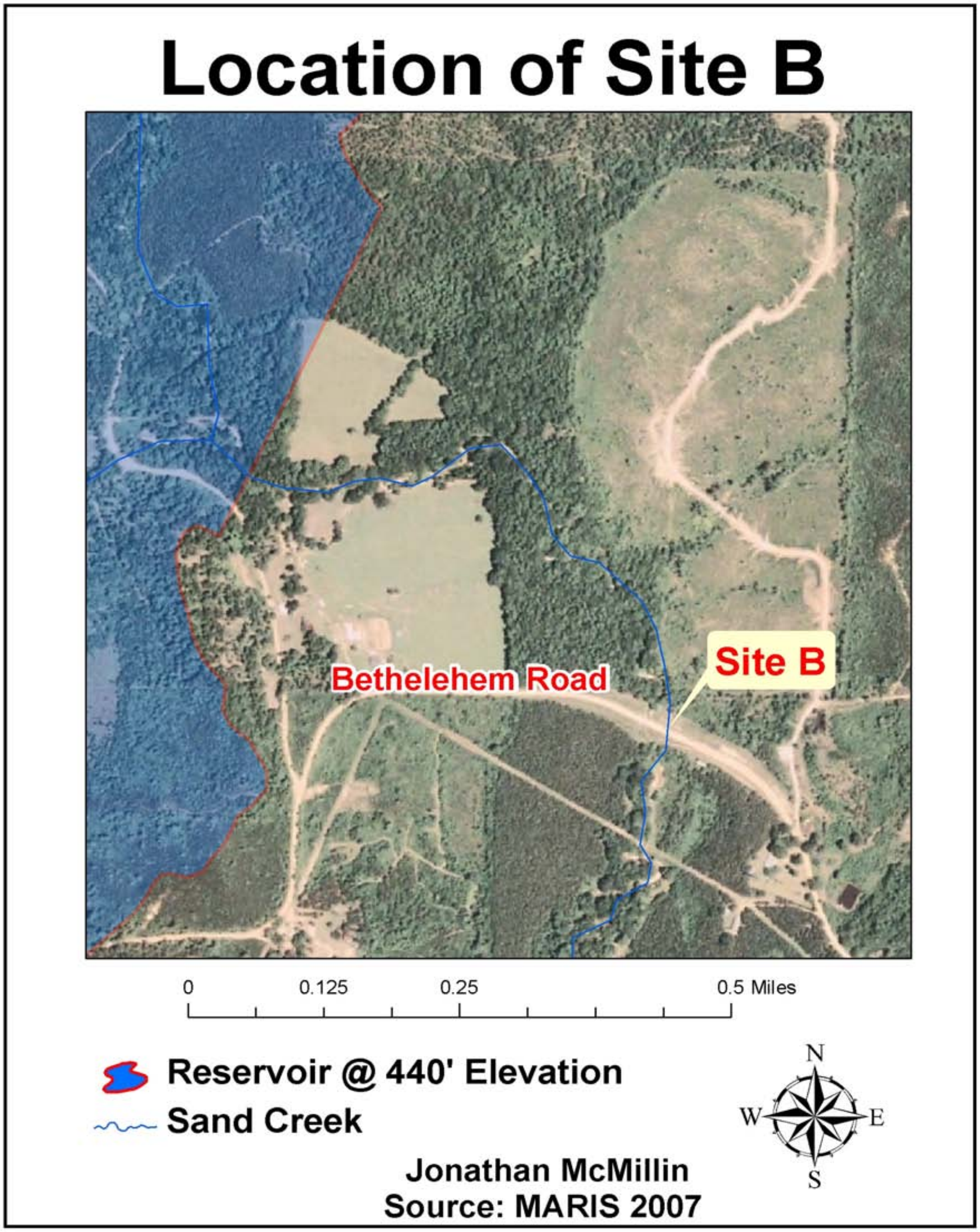


Figure 12:

Location of Monitoring Site B

Site C: This bridge crossing is located on Sand Creek road in Choctaw County (Figure 13). The latitude/longitude of this site is 33.37258°N and 89.10868°W. Site C is located approximately 500 ft (1640.4 m) east of the proposed levee. The bridge abutment is new due to wash out of the old bridge. There were a total of five discharge measurements taken from this site. All measurements were taken from the same location with in the creek or when flow was elevated measurements were taken from the bridge abutment. Stage was taken from a known point on the bridge above the creek at an elevation of 400 ft (1312.4 m).

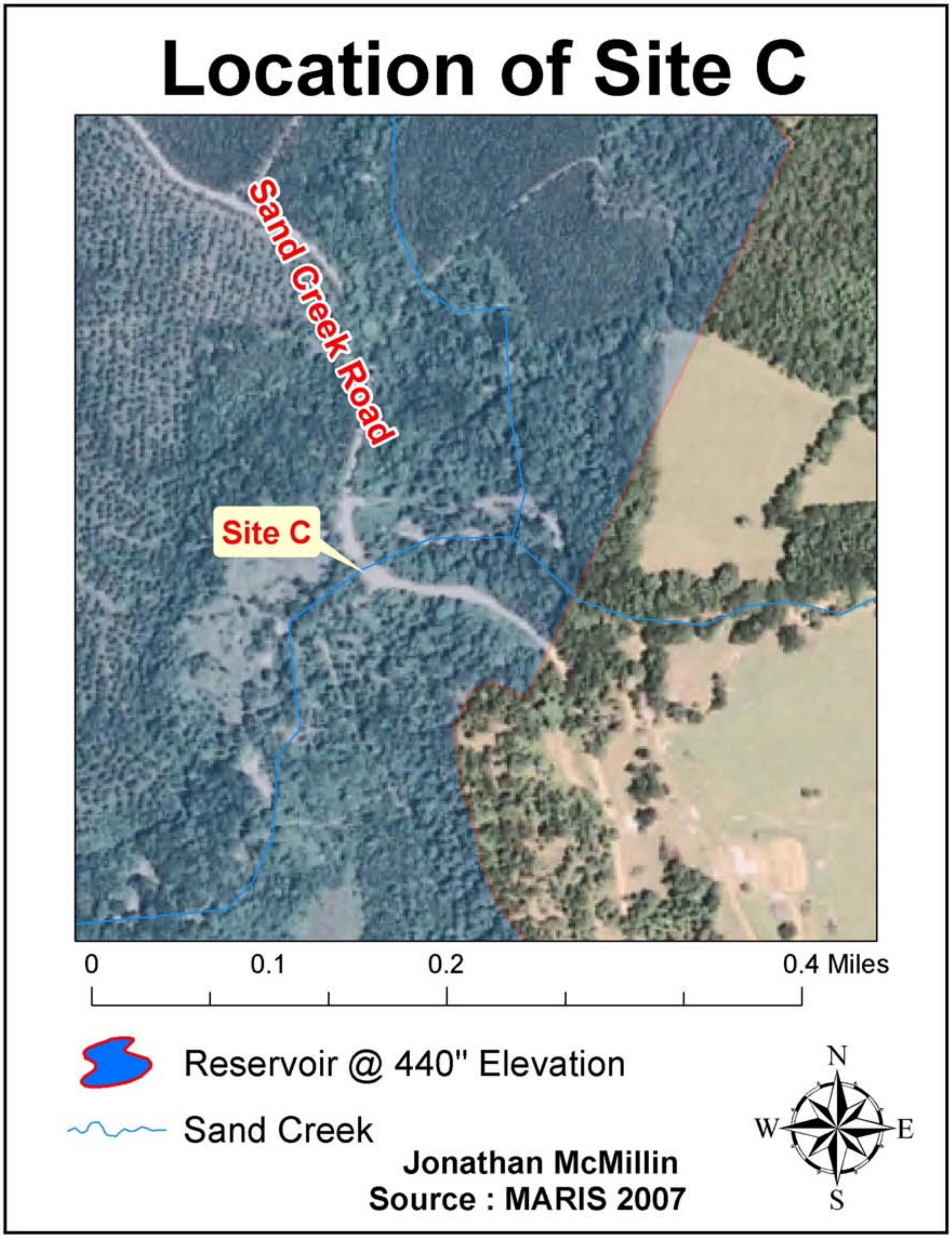


Figure 13:

Location of Monitoring Site C

Site D: This road crossing is located on Wood road in Choctaw County (Figure 14). The latitude/longitude of this site is 33.37276°N and 89.12825°W. Site D is located approximately 5500 ft (18,045.5m) south west of the proposed levee. There were a total of five discharge measurements taken from this site. All measurements were taken from the same location within the creek or when flow was elevated measurements were taken from a large six foot culvert facing up stream. Stage was taken from a known point on the culvert at an elevation of 410 ft (1345.21 m).

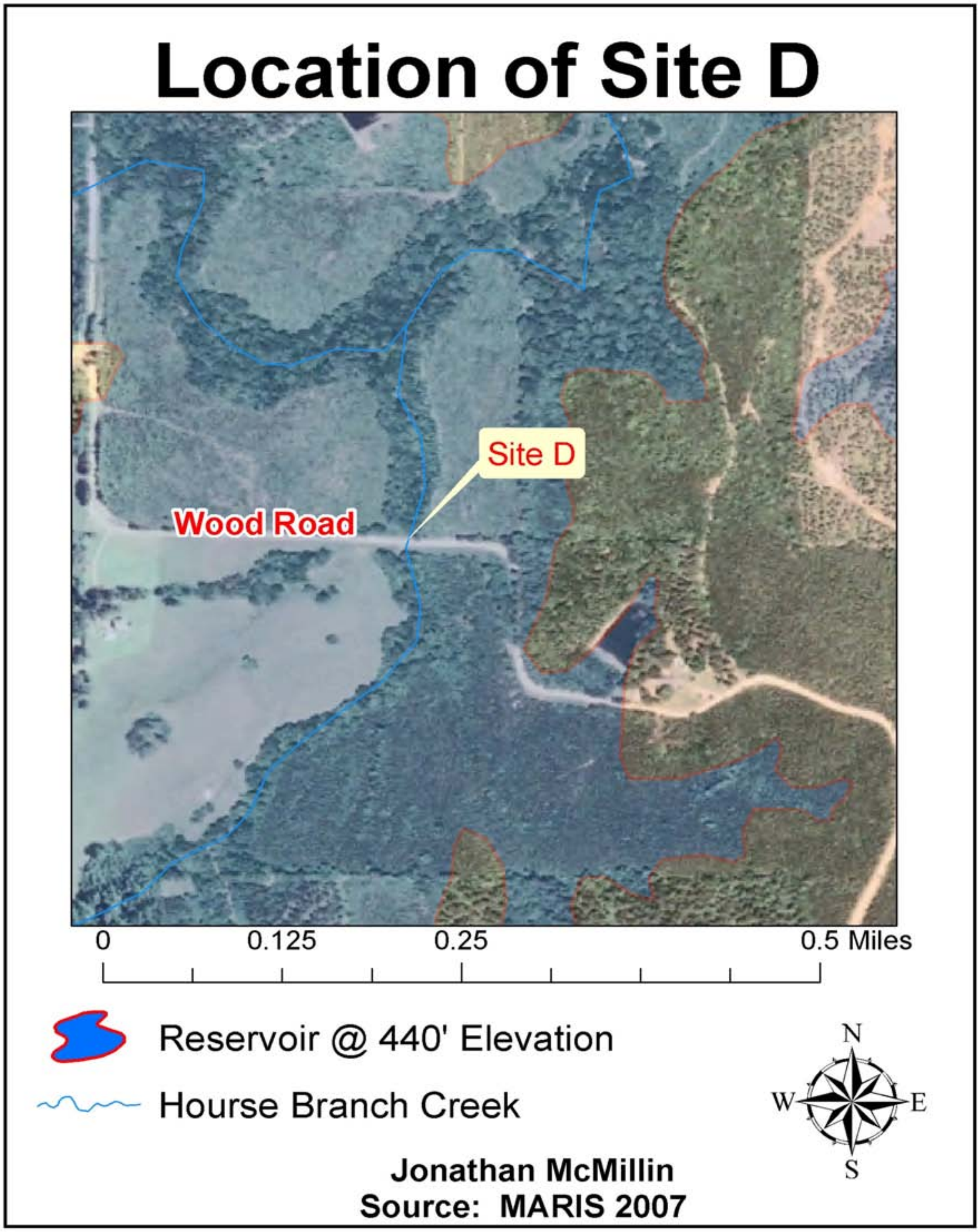


Figure 14:

Location of Monitoring Site D

Site E: This road crossing is located on Dido road in Choctaw County (Figure 15). The latitude/longitude of this site is 33.37647°N and 89.13211°W. This site is located approximately 8000 ft (26248m) east of the proposed levee. There were at total of five discharge measurements taken from this site. All measurements were taken from the same location within the creek or when flow was elevated measurements were taken from two culverts at the road crossing facing up stream. Stage was taken from a known point on the largest culvert facing up stream above the creek at an elevation of 410 ft (1345.21 m).

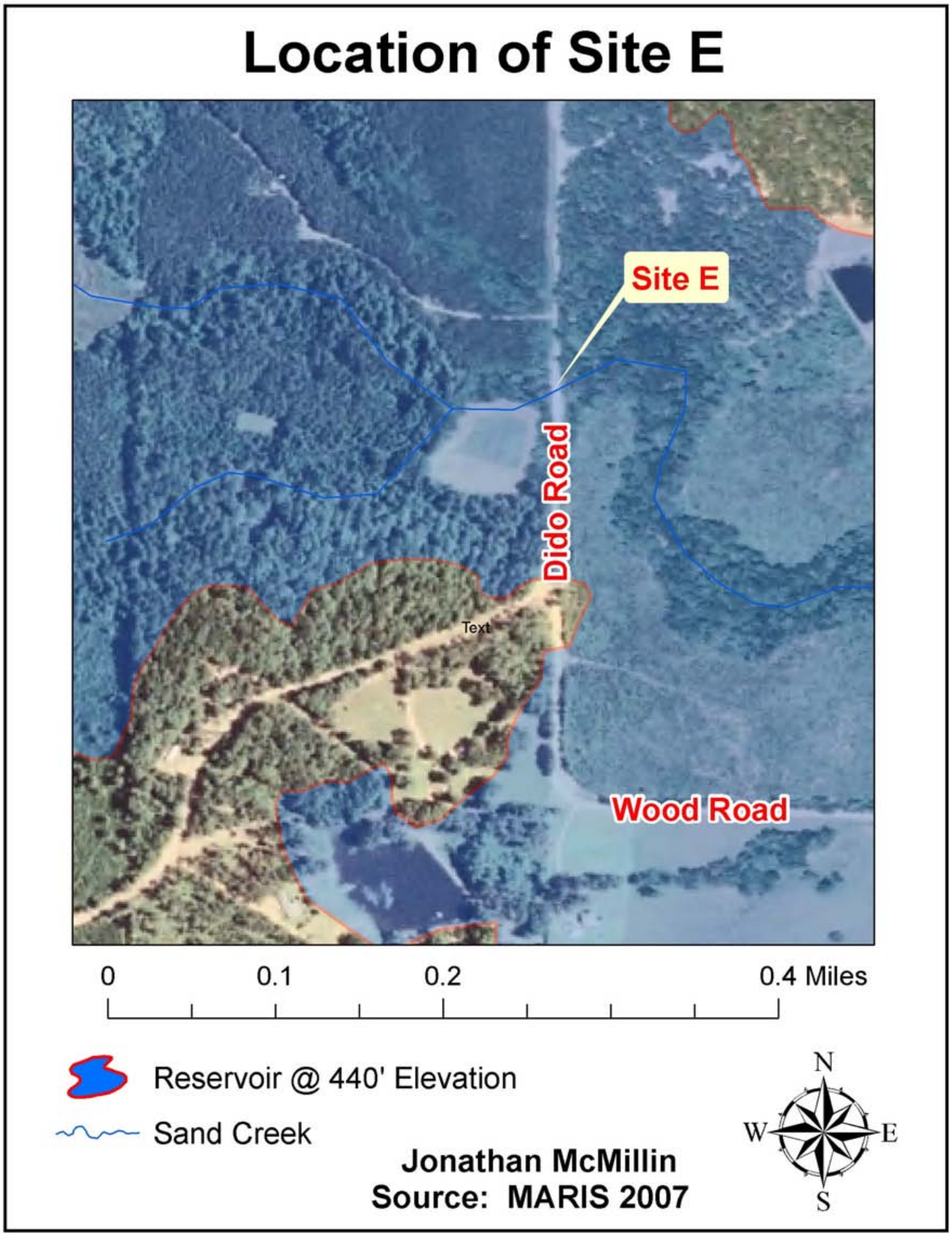


Figure 15:

Location of Monitoring Site E

Site F: This bridge crossing is located on Mt. Airy road in Choctaw County (Figure 16). The latitude/longitude of this site is 33.36548°N and 89.10713°W. Site F is located approximately 4000 ft (13124 m) due south of the proposed levee. There were at total of five discharge measurements taken from this site facing up stream. Stage was taken from a known point on an eight foot culvert above the creek at an elevation of 390 ft (1279.59 m)

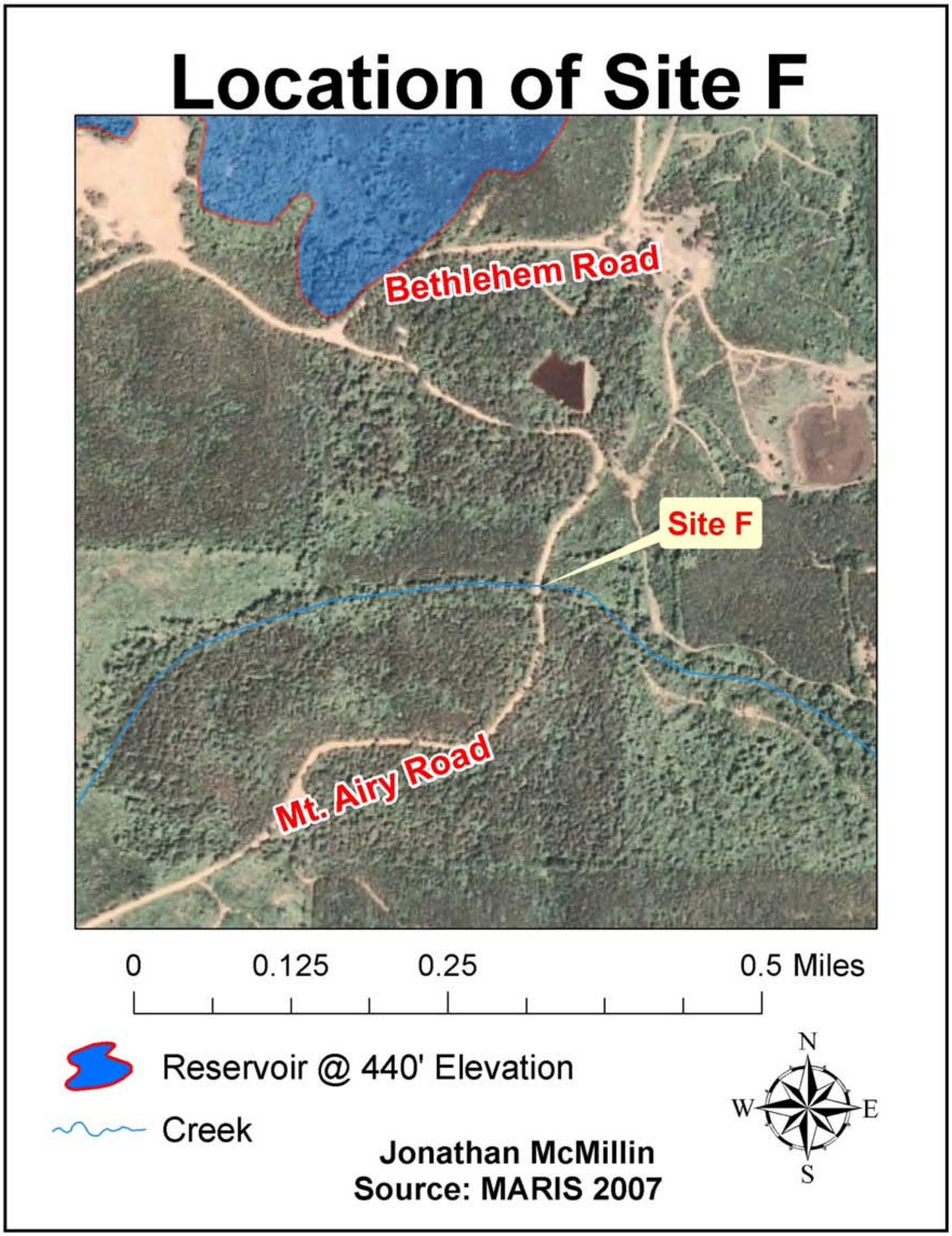


Figure 16:

Location of Monitoring Site F

CHAPTER VI

RESULTS

The research and field analysis were conducted from February 2006 to January 2007. Although all objectives were being met simultaneously, in this chapter the phases of this study will be outlined according to the order each study was conducted. The research objectives were to characterize surface water flow, conduct basic water quality analysis, determine the geological characteristics, and locate spring discharge within the study area.

SURFACE WATER MONITORING

Within the recommended drainage basin, water monitoring was performed at six sites between February 2006 and October 2006. The sites were named Site A, Site B, Site C, Site D, Site E, Site F (Figure 10). The data collected included base flow, regular flow, and high flow events. Data collected from flow events at seven road crossing sights were used to generate the hydrographs. The hydrographs contain stage/elevation data for up to six total events and no less than five events ranging from base flow to high flow measurements. A bottled water analysis was conducted by Mississippi Chemical Lab (Appendix A) twice during the study, once at a base flow event and once at a high flow event (Tables 3 and 4). The bottled water analysis tests for more chemicals than drinking water analysis. Also, additional water quality was analyzed using two different sonde types, an YSI sonde and an INSITU sonde. The YSI sonde was used from February 2006 until August 2006; the INSITU sonde was used for the remainder of the study. These two sondes measured temperature, specific conductivity, dissolved oxygen, and turbidity and when readings were previously compared there was no measurable difference in the readings. The discharge events (Appendix B) hydrographs was created using the discharge versus elevation at each site location. The 24-hour rain fall totals were obtained from the National Weather Service Observation System.

Table 3:

Mississippi State Chemical Lab Results (*MCL= Mean Contaminate Level)

BASE FLOW 8-21-2006	Site A	Site B	Site C	Site D	Site E	Site F	MCL*
pH	6.2	6.5	6.4	6.5	6.5	6.5	
Turbidity (NTU)	14	12	8.6	10	10	29	
Inorganics (ppm)							
Bicarbonate Alkalinity	15	15	12	12	22	29	
Total Alkalinity	12	12	10	10	18	24	
Free Carbon Dioxide	<10	<10	<10	<10	<10	<10	
Sodium	2.3	2.2	2.1	2.6	2.5	2.6	
Potassium	1.3	1.2	1	1.3	1.5	1.4	
Calcium	2.8	2.4	2.3	2.3	2.5	3.3	
Magnesium	1.6	1.4	1.3	1.5	1.5	1.8	
Total Hardness	13	11	11	12	12	16	
Fluoride	<0.1	<0.1	<0.1	0.24	<0.1	<0.1	4.0
Chloride	2.2	2	2	2.6	2.2	2.1	250.0
Sulfate	1.1	0.81	0.8	1.8	1.7	1.5	250.0
Nitrate Nitrogen	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10.0
Nitrite Nitrogen	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0
Total Nitrogen	<1	<1	<1	<1	<1	<1	10.0
Total Dissolved Solids	26	21	20	25	23	28	500.0
Cyanide	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.2
Phenol	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Ammonia-N	0.14	0.1	0.19	<0.1	<0.1	<0.1	
Total Phosphorous	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Biological Oxygen Demand	6	5	5	4	4	6	
Total Coliform	1300	1400	1400	7000	8000	2300	
Fecal Coliform	170	500	300	700	1100	80	
BASE FLOW 8-21-2006							
Metals (ppm)	**Site A**	**Site B**	**Site C**	**Site D**	**Site E**	**Site F**	**MCL***
Aluminum	0.15	0.13	0.11	0.48	0.4	0.48	0.2
Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006
Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.05	0.072	0.079	0.065	0.052	0.071	2.0
Beryllium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.100
Copper	0.079	0.05	0.034	0.047	0.04	0.049	1.0
Iron	2.1	1.7	15	4.1	3.2	5.5	0.30
Lead	0.0056	<0.001	<0.001	<0.001	<0.001	0.001	0.005
Manganese	0.15	0.11	0.097	0.25	0.16	0.44	0.05
Mercury	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.002
Nickel	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
Selenium	0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.05
Silver	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.1
Thalium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Zinc	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	5.0

Table 4:

Mississippi State Chemical Lab Results (*MCL= Mean Contaminate Level)

HIGH FLOW 10-20-2006	Site A	Site B	Site C	Site D	Site E	Site F	MCL*
pH	5.9	5.7	5.7	2.6	5.5	5.5	
Turbidity (NTU)	43	91	110	94	81	110	
Inorganics (ppm)							
Bicarbonate Alkalinity	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	
Total Alkalinity	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	
Free Carbon Dioxide	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	
Sodium	0.46	1.2	0.64	0.62	0.8	0.73	
Potassium	0.19	1.6	1.9	2	1.7	2.1	
Calcium	2.8	1.8	1.9	1.7	1.6	1.6	
Magnesium	1.1	1.3	0.94	1	0.92	0.97	
Total Hardness	12.0	9.8	8.7	8.4	7.9	8.0	
Fluoride	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.0
Chloride	0.6	1.2	0.72	0.75	0.78	0.73	250.0
Sulfate	2.5	6.1	3.2	2.7	3	3.2	250.0
Nitrate Nitrogen	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10.0
Nitrite Nitrogen	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0
Total Nitrogen	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10.0
Total Dissolved Solids	17	20	15	15	15	16	500.0
Cyanide	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.2
Phenol	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Ammonia-N	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Total Phosphorous	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	
Biological Oxygen Demand	2	4	2	3	1	3	
HIGH FLOW 10-20-2006							
Metals (ppm)	**Site A**	**Site B**	**Site C**	**Site D**	**Site E**	**Site F**	**MCL***
Aluminum	1	3.7	3.5	2.7	3.1	4.1	0.2
Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006
Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
Barium	0.025	0.082	0.073	0.056	0.066	0.081	2.0
Beryllium	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005
Chromium	0.011	0.016	0.016	0.016	0.018	0.02	0.100
Copper	0.033	0.071	0.087	0.03	0.055	<0.03	1.0
Iron	0.0028	1.1	1.2	0.66	1.1	1.7	0.30
Lead	0.065	0.0073	0.0063	0.0037	0.0057	0.006	0.005
Manganese	0.065	0.31	0.25	0.14	0.21	0.37	0.05
Mercury	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.002
Nickel	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1
Selenium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
Silver	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.1
Thalium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Zinc	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5.0

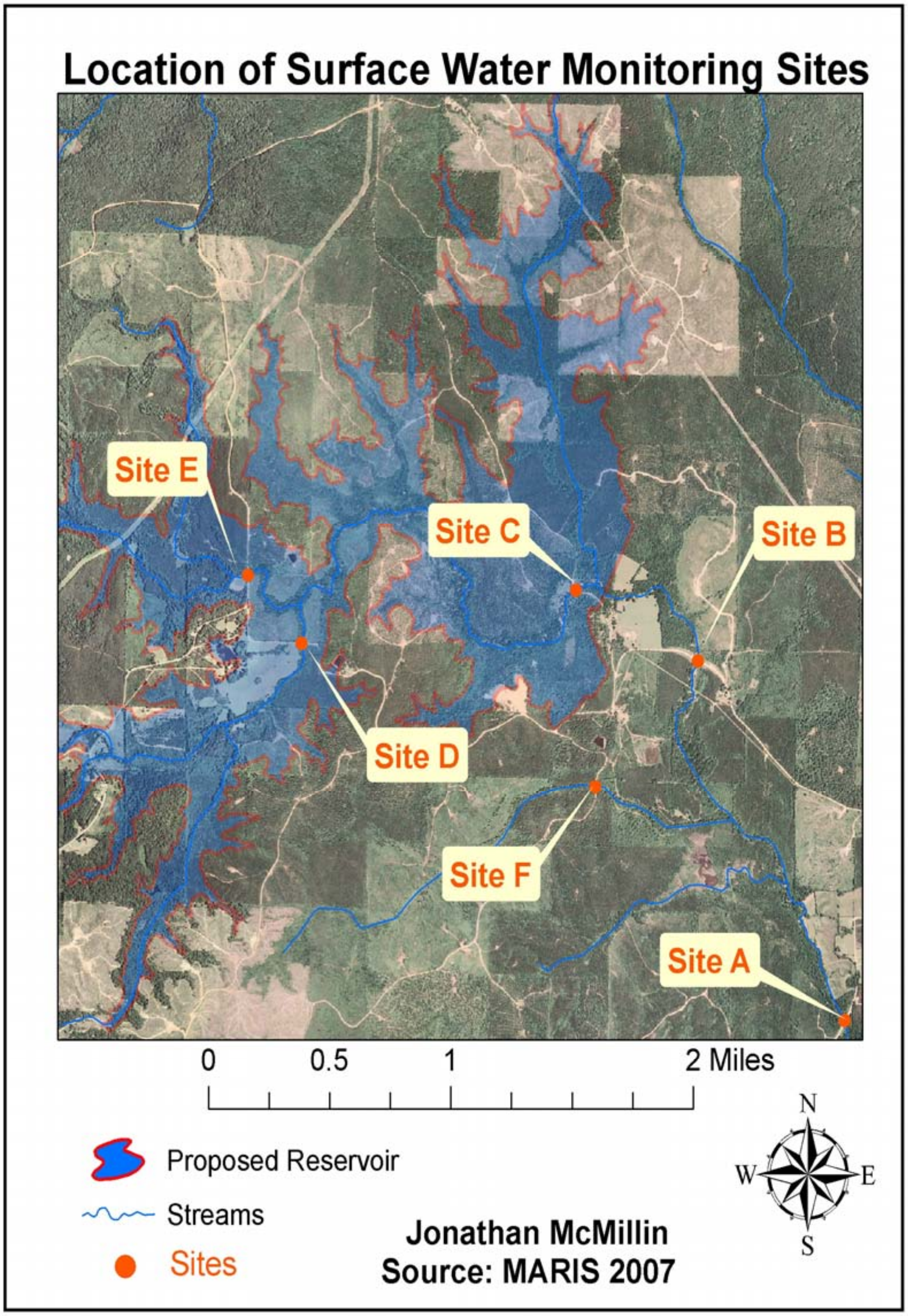


Figure10:

Monitoring Sites Located within the Proposed Reservoir**.**

Site A- Base flow for the site is ~ 331.3 ft (1086.99 m). The high flow measurement was taken on October 21, 2006 and flow was outside the banks of the creek (Figure 17). The base flow (Figure 18) discharge for the site is 1.18 ft^3/s (3.87 m^3/s) and high flow discharge is 121.30 ft^3/s (397.98 m^3/s). A hydrograph was generated (figure 19) using the log of the discharge plotted over the elevation of the water level relevant to sea level. The trend line has an excellent linear fit with a R^2 value of 0.9917 and a line equation of $y = 0.4214x - 139.19$ establishes the rating line for the site.

Figure 17:

Site A at High Flow Event 10-21-2006

Figure 18:

Site A at Base Flow Event 8 -21-2007

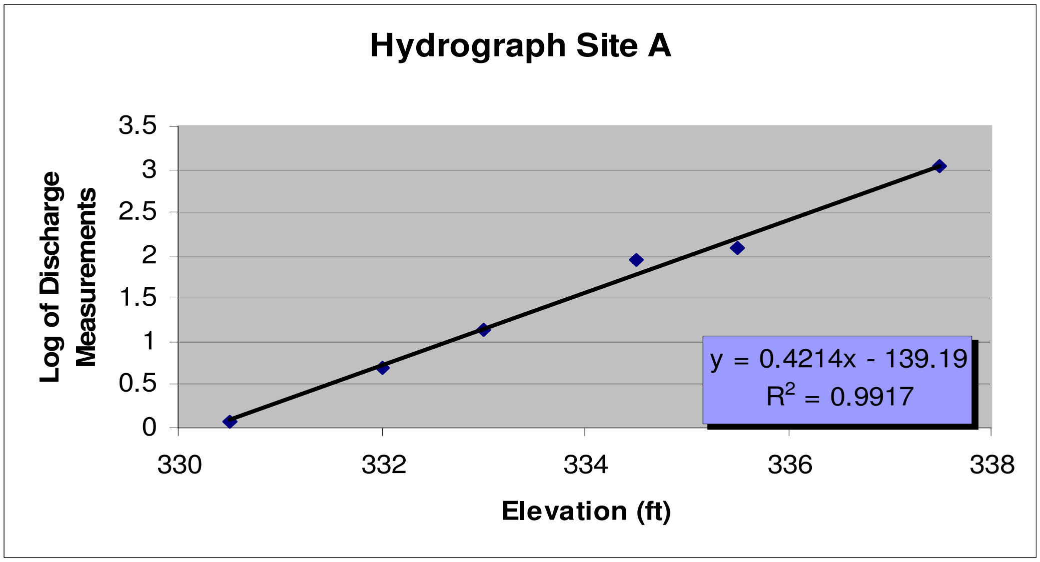


Figure 19:

Stage/Elevation Hydrograph for Site A

Table 5:

Discharge for Site A

Location	Date	24 hr Rainfall (in)	Discharge ft^3/s	Elevation Above Sea Level (ft)
Site A	2/28/2006	1.0	13.61	334.5
	4/21/2006	0.0	90.71	335.5
	5/10/2006	1.26	4.97	332.6
	8/21/2006	0.0	1.18	331.3
	10/21/2006	2.8	121.30	337.5
	10/27/2006	1.58	10.68	333.4

Table 6:

Field Analysis for Site A

Location	Date	Temp (°C)	Conductivity (m	Turbity (NTU)	DO %	pH	NO3-N Mg/L
Site A	2/28/2006	10.8	0.014	17	89.5	7.53	0.33
	4/21/2006	12.26	0.195	16.9	97.3	7.4	0.43
	5/10/2006	N/A	N/A	N/A	N/A	N/A	N/A
	8/21/2006	15.16	0.12	14	93.4	6.5	0.38
	10/21/2006	13.91	0.063	43	88.4	5.9	0.41
	10/27/2006	N/A	N/A	N/A	N/A	N/A	N/A

Site B: Base flow for this site is 375.3 ft (1230.3 m). The high flow measurement for this site was taken on October 21, 2006 the stage was 387.1 ft (1270.0 m) (Figure 20). The base flow (Figure 21) discharge for the site is 1.81 ft^3/s ($5.93 m^3/s$) and high flow discharge is 887.70 ft^3/s ($2912.5 m^3/s$). A hydrograph was generated (Figure 22) using the log of the discharge plotted over the elevation of the water level relevant to sea level. The trend line has a linear fit with a R^2 value of 0.9522 and a line equation of $y = 0.3662x - 136.7$ establishes the rating line for the site.

Figure 20:

Stage Gage Located at Site B. High Flow event 10-21-2006

Figure 21:

Stage Gage Located at Site B. Base Flow Event 8-21-2006

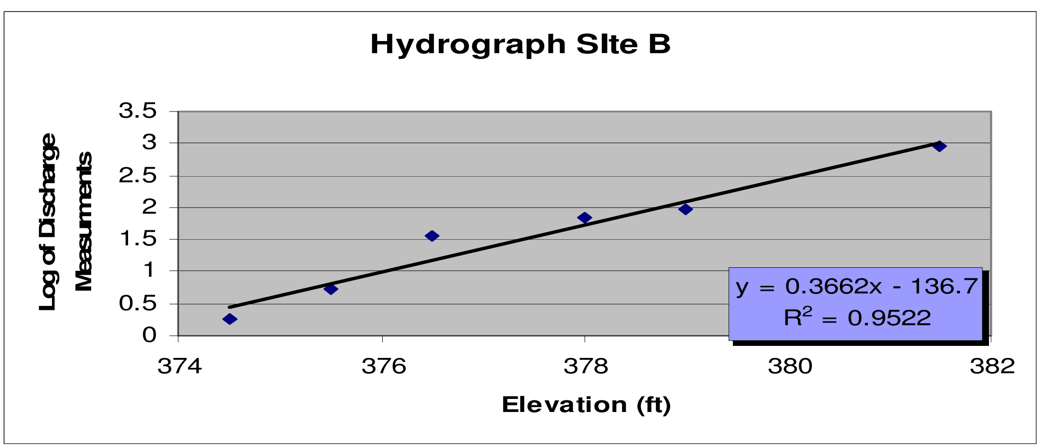


Figure 22:

Stage/Elevation Hydrograph for Site B

Table 7:

Discharge for Site B

Location	Date	24 hr Rainfall (in)	Discharge ft^3/s	Elevation Above Sea Level (ft)
Site B	2/28/2006	1.0	36.1	376.6
	4/21/2006	0.0	69.66	378.2
	5/10/2006	1.26	5.25	377.5
	8/21/2006	0.0	1.81	375.3
	10/21/2006	2.8	94.03	379.0
	10/27/2006	1.58	887.70	387.1

Table 8:

Field Analysis for Site B

Location	Date	Temp (°C)	Conductivity (m	Turbity (NTU)	DO %	pH	NO3-N Mg/L
Site B	2/28/2006	15.3	0.285	33.5	94.2	7.34	0.55
	4/21/2006	11.25	0.132	24.9	86.4	7.6	0.43
	5/10/2006	N/A	N/A	N/A	N/A	N/A	N/A
	8/21/2006	29.07	0.185	12	118.7	6.5	0.10
	10/21/2006	17.17	0.08	91	80.1	5.7	0.65
	10/27/2006	N/A	N/A	N/A	N/A	N/A	N/A

Site C: Base flow for this site is 381.1 ft (1250.3 m). The high flow (Figure 23) measurement for this site was taken on October 21, 2006 the stage was 387.1 ft (1270.0 m). The base flow discharge for the site is 1.67 ft^3/s (5.47 m^3/s) (Figure 24), and high flow discharge is 606.78 ft^3/s (1990.84 m^3/s). A hydrograph was generated (Figure 25) using the log of the discharge plotted over the elevation of the water level relevant to sea level. The trend line has a linear fit with a R^2 value of 0.974 and a line equation of $y = 0.4344x – 164.97$ establishes the rating line for the site.

Figure 23:

High Flow Event at Site C 10-21-2006

Figure 24:

Base Flow Event at Site C 8-21-2006

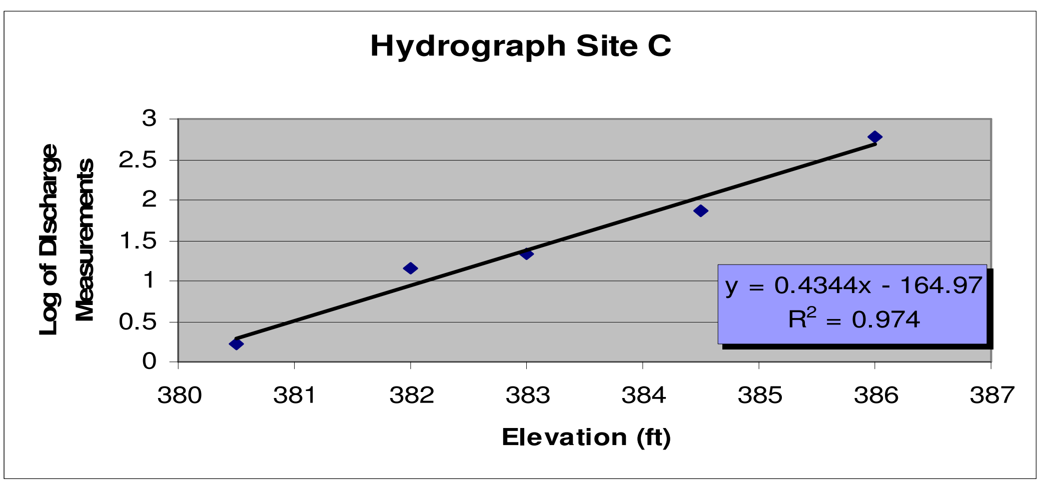


Figure 25:

Stage/Elevation Hydrograph for Site C

Table 9:

Discharge for Site C

Location	Date	24 hr Rainfall (in)	Discharge ft^3/s	Elevation Above Sea Level (ft)
Site C	2/28/2006	1.0	14.4	382.8
	4/21/2006	0.0	72.25	385.2
	5/10/2006	1.26	21.51	383.4
	8/21/2006	0.0	1.67	381.1
	10/21/2006	2.8	606.78	386.4

Table 10:

Field Analysis for Site C

Location	Date	Temp (°C)	Conductivity (m	Turbity (NTU)	DO %	pH	NO3-N Mg/L
Site C	2/28/2006	9.7	0.144	14	71.6	6.7	0.44
	4/21/2006	13.5	0.223	18.6	91.2	7.1	0.76
	5/10/2006	N/A	N/A	N/A	N/A	N/A	N/A
	8/21/2006	30.01	0.07	8.6	88.3	6.4	0.81
	10/21/2006	16.14	0.203	110	64.1	5.7	0.11

Site D: Base flow elevation for this site is 400.0 ft (13124.4 m) (Figure 26). The high flow (Figure 27) measurement for this site was taken on October 21, 2006 the stage was 408.3 ft (1339.6 m). The base flow discharge for the site is 1.36 ft^3/s (4.46 m^3/s) and high flow discharge is 78.01 ft^3/s (255.95 m^3/s). A hydrograph was generated (Figure 28) using the log of the discharge plotted over the elevation of the water level relevant to sea level. The trend line has a linear fit with a R^2 value of 0.974 and a line equation of $y = 0.4344x - 164.97$ establishes the rating line for the site.

Figure 26:

Base Flow Event at Site D. 8-21-2007

Figure 27:

High Flow event at Site D. 10-21-2006

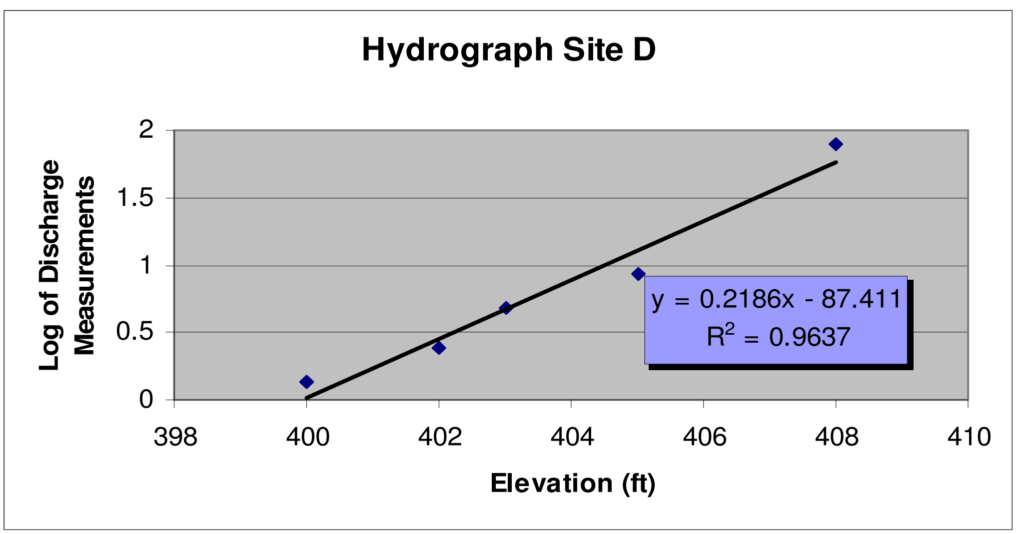


Figure 28:

Stage/Elevation Hydrograph for Site D

Table 11:

Discharge for Site D

Location	Date	24 hr Rainfall (in)	Discharge ft³/s	Elevation Above Sea Level (ft)
Site D	2/28/2006	1.0	4.81	403.1
	4/21/2006	0.0	8.51	405.3
	5/10/2006	1.26	2.41	402.2
	8/21/2006	0.0	1.36	400.0
	10/21/2006	2.8	78.01	408.3

Table 12:

Field Analysis for Site D

Location	Date	Temp (°C)	Sp Conductivity (mS)	Turbity (NTU)	DO %	pH	NO3-N Mg/L
Site D	2/28/2006	9.99	0.197	13.1	112.4	7.11	0.47
	4/21/2006	11.6	0.121	21.8	86.4	7.41	0.17
	5/10/2006	N/A	N/A	N/A	N/A	N/A	N/A
	8/21/2006	31.2	0.221	10	89.4	6.5	0.27
	10/21/2006	17.9	0.231	94	77.4	5.6	0.14

Site E: Base flow elevation for this site is 395.4 ft (1297.30 m) and the high flow elevation for this site was taken on October 21, 2006 and the stage was 405.0 ft (1328.80 m). The base flow discharge for the site is 1.10 ft³/s (3.60 m³/s) and high flow discharge is 120.11 ft³/s (394.08 m³/s). A hydrograph was genrated (figure 29) using the log of the discharge plotted over the elevation of the water level relevant to sea level. The trend line has a linear fit with a R^2 value of 0.9507 and a line equation of y = 0.2032x – 80.15 establishes the rating line for the site.

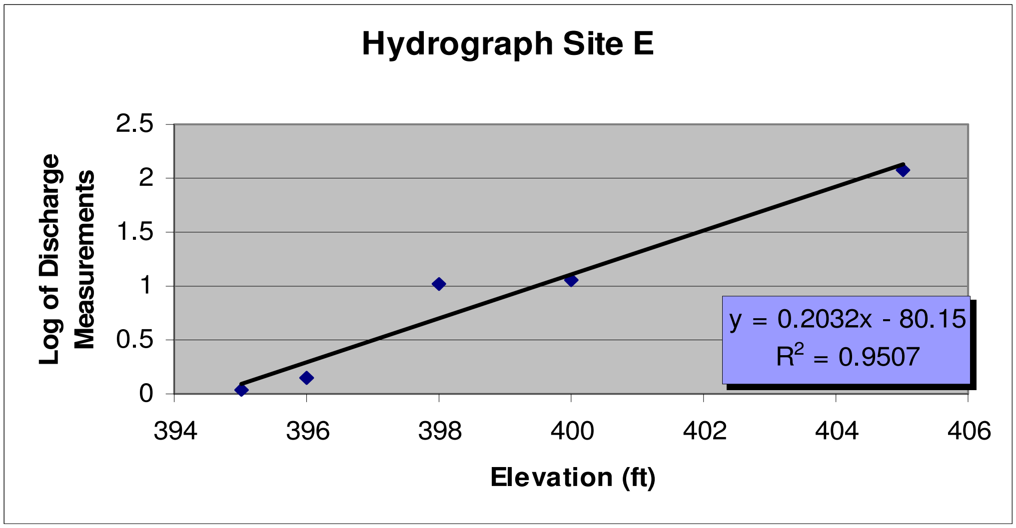


Figure 29:

Stage/Elevation Hydrograph at Site E

Table 13:

Discharge Data for Site E

Location	Date	24 hr Rainfall (in)	Discharge ft^3/s	Elevation Above Sea Level (ft)
Site E	2/28/2006	1.0	11.25	399.6
	4/21/2006	0.0	10.62	398.3
	5/10/2006	1.26	1.41	395.9
	8/21/2006	0.0	1.10	395.4
	10/21/2006	2.8	120.11	405.0

Table 14:

Field Analysis for Site E

Location	Date	Temp (°C)	Sp Conductivity (mS)	Turbity (NTU)	DO %	pH	NO3-N Mg/L
Site E	2/28/2006	11.2	0.218	12.56	68.4	5.9	0.61
	4/21/2006	12.6	0.301	22.6	83.54	6.3	0.19
	5/10/2006	N/A	N/A	N/A	N/A	N/A	N/A
	8/21/2006	29.5	0.12	16	81.02	6.5	0.25
	10/21/2006	15.9	0.132	81	84.2	5.5	0.33

Site F: Base flow (Figure 30) elevation for this site is 379.7 ft (1245.79 m). The high flow (Figure 31) elevation for this site was taken on October 21, 2006 and the stage was 388.1 ft (1273.35 m). The base flow discharge for the site is 1.14 ft^3/s (3.74 m^3/s) and high flow discharge is 50.11 ft^3/s (164.41 m^3/s). A hydrograph was generated (Figure 32) using the log of the discharge plotted over the elevation of the water level relevant to sea level. The trend line has an excellent fit with a R^2 value of 0.9987 and a line equation of $y = 0.183x - 69.297$ establishes the rating line for the site.

Figure 30:

Base Flow Event at Site F. 8-21-2006

Figure 31:

High Flow Event at Site F. 10-21-2006

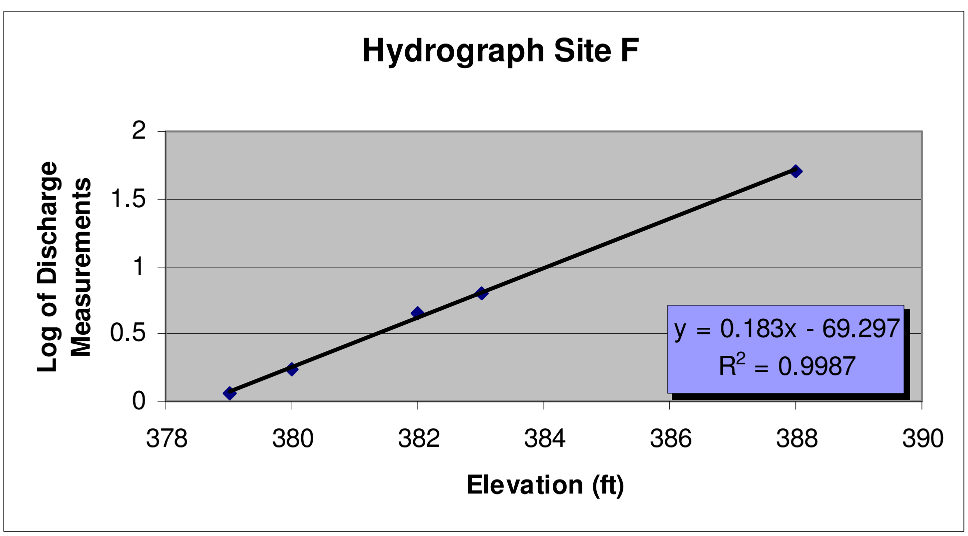


Figure 32:

Stage/Elevation Hydrograph for Site F

Table 15:

Discharge Data for Site F

Location	Date	24 hr Rainfall (in)	Discharge ft^3/s	Elevation Above Sea Level (ft)
Site F	2/28/2006	1.0	4.51	382.0
	4/21/2006	0.0	6.37	383.2
	5/10/2006	1.26	1.70	380.1
	8/21/2006	0.0	1.14	379.7
	10/21/2006	2.8	50.33	388.1

Table 16:

Sonde Data for Site F

Location	Date	Temp (°C)	Sp Conductivity (mS)	Turbity (NTU)	DO %	pH	NO3-N Mg/L
Site F	2/28/2006	10.11	0.201	21.1	79.8	7.4	0.45
	4/21/2006	12.4	0.145	12.3	94.1	6.9	0.23
	5/10/2006	N/A	N/A	N/A	N/A	N/A	N/A
	8/21/2006	33.5	0.09	29	89.23	6.5	0.18
	10/21/2006	15.8	0.215	110	36.1	5.5	0.14

GEOLOGIC CHARACTERISTICS

Geological cross sections were created from geophysical logs of 51 boreholes that were drilled between 1974 through 1980, along with existing maps of surface geology from Mississippi Department of Environmental Quality. The borehole data was provided by North American Coal Corporation. From the data provided five lithological cross sections of the Wilcox Group were generated within the drainage basin of the proposed reservoir (Figure 33). An idealized geophysical log (Figure 34) represents a similar version of logs used in the study. The data provided information ranging from a depth of 190 (ft) to 300 (ft) and showed how the geology could possibly hinder the impoundment. Numerous coal seams within the study area were used to correlate the strata but are not depicted in the five cross sections in accordance with The North American Coal Corporation (Figures 35-39).

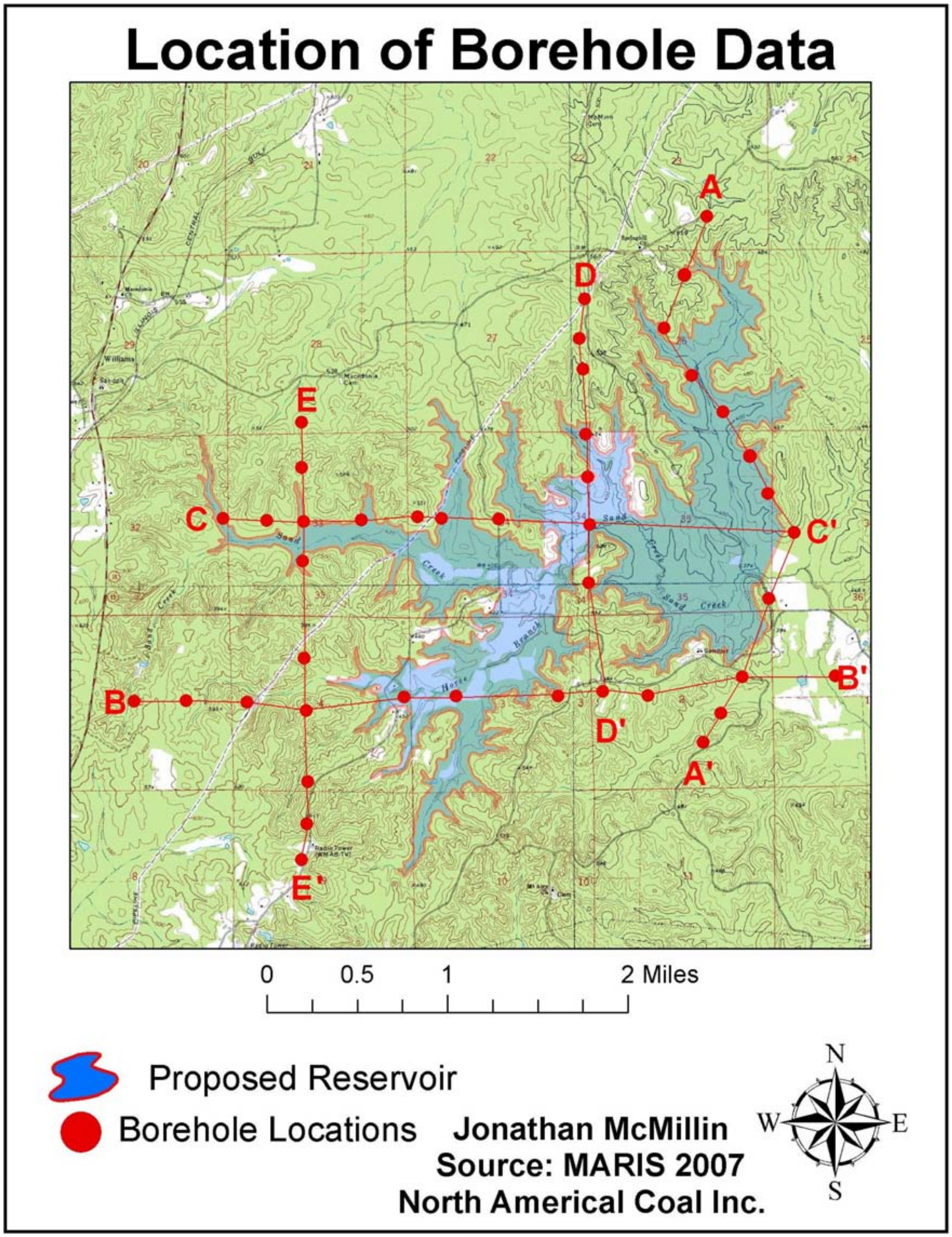


Figure 33:

Borehole Locations Pertaining to Proposed Reservoir Location

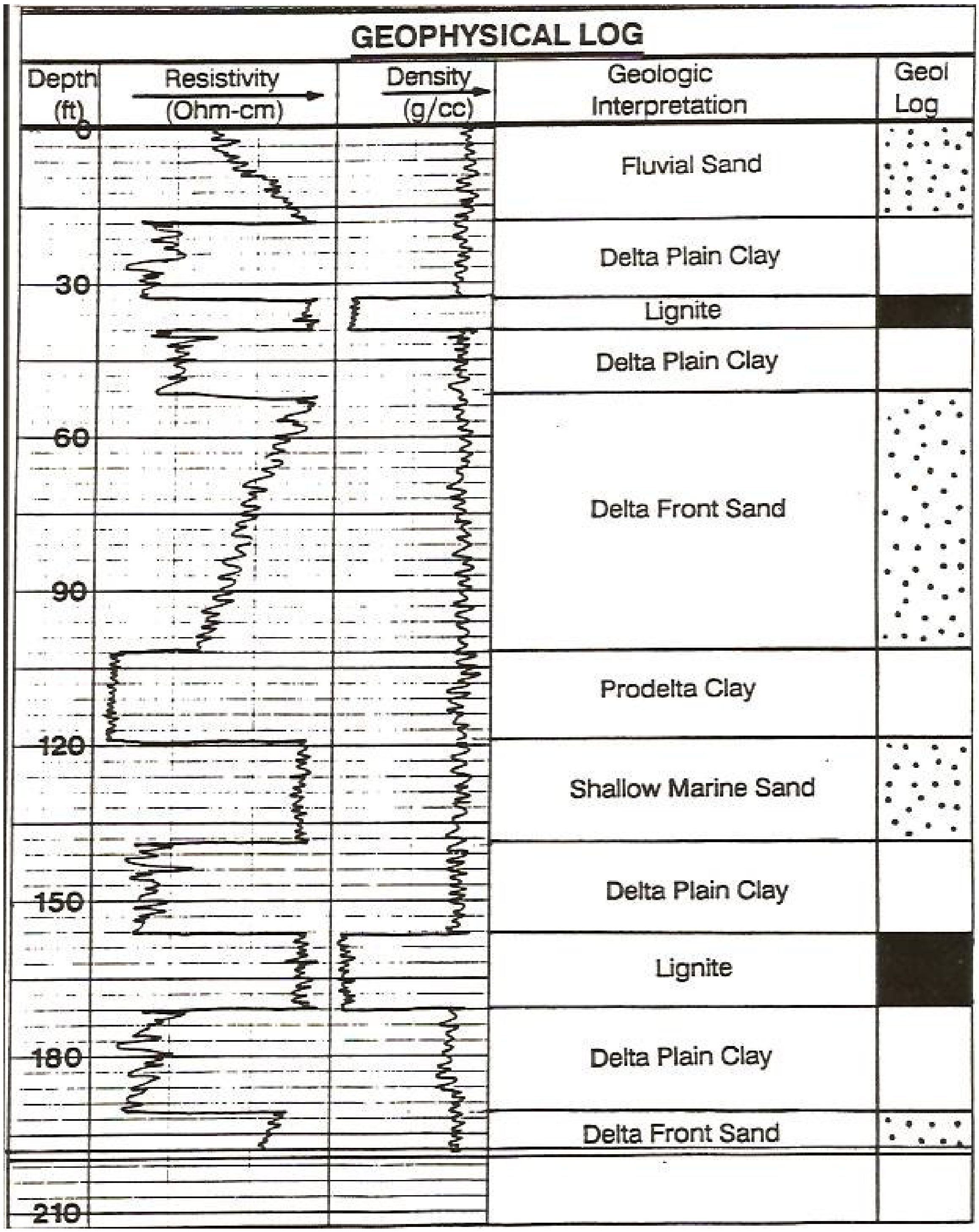


Figure 34:

Idealized Geophysical log used for interpretation of Strata (Source: TMRA 1999)

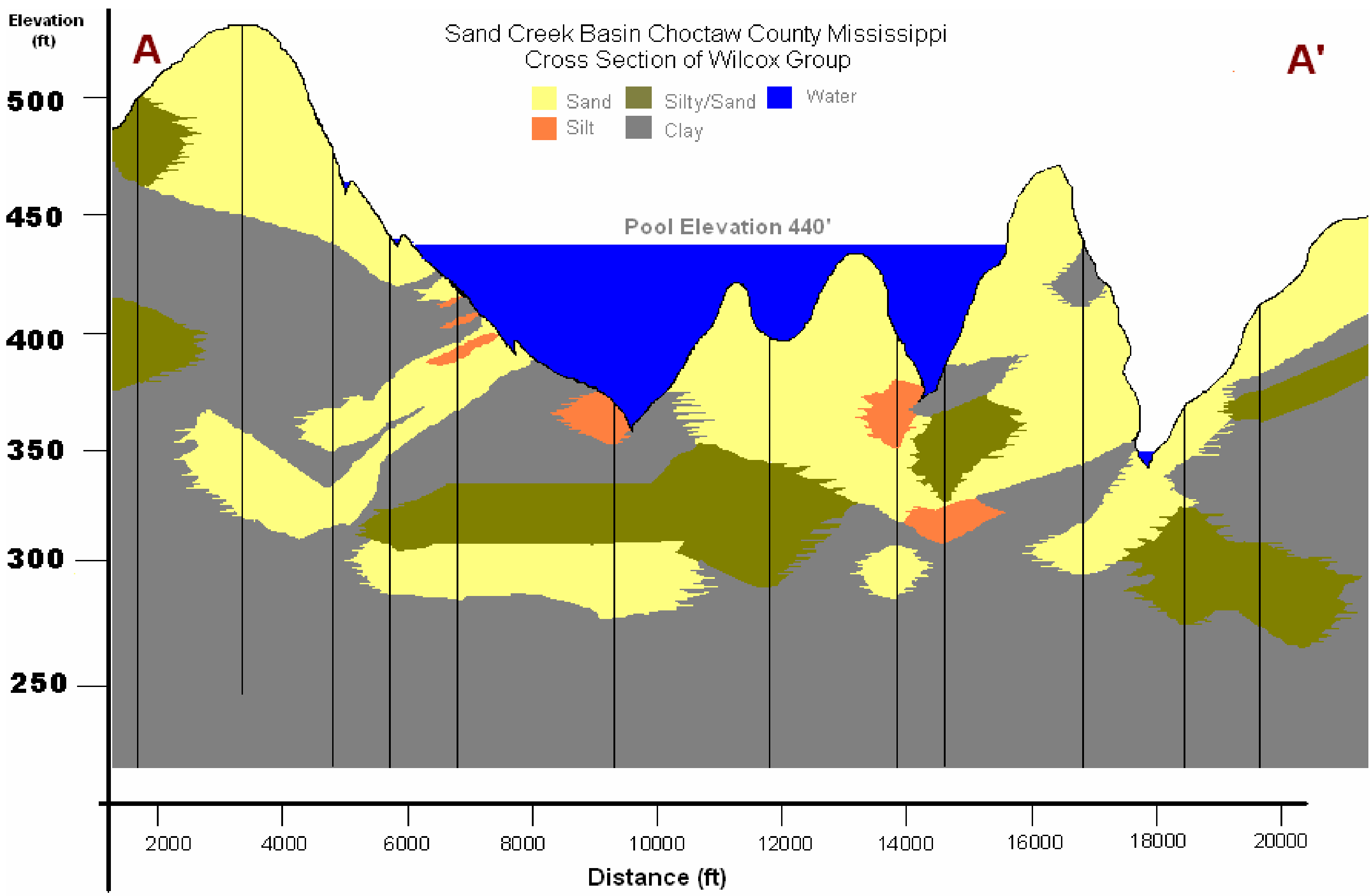


Figure 35:

Cross Section A to A'

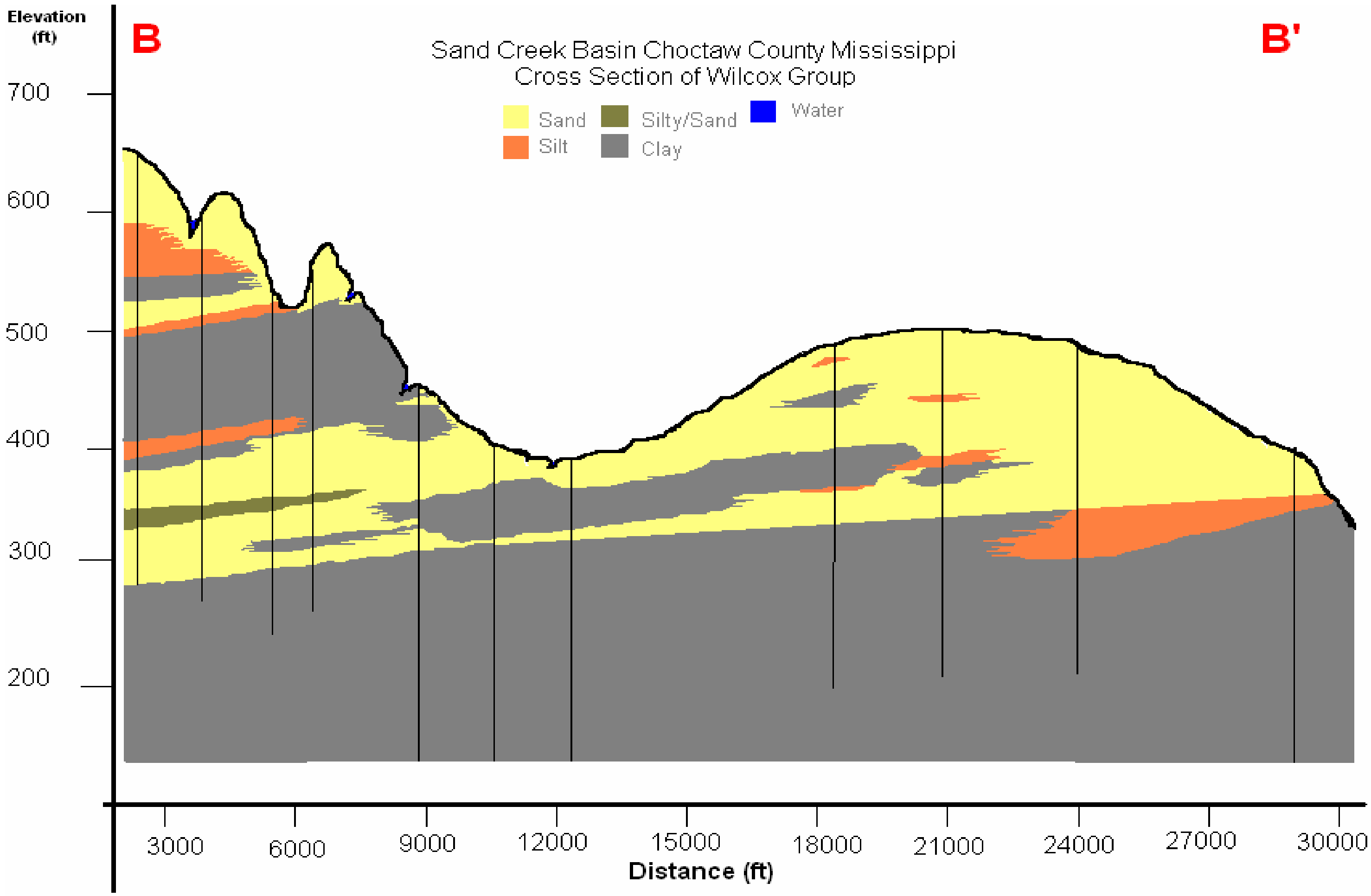


Figure 36:

Cross Section B to B'

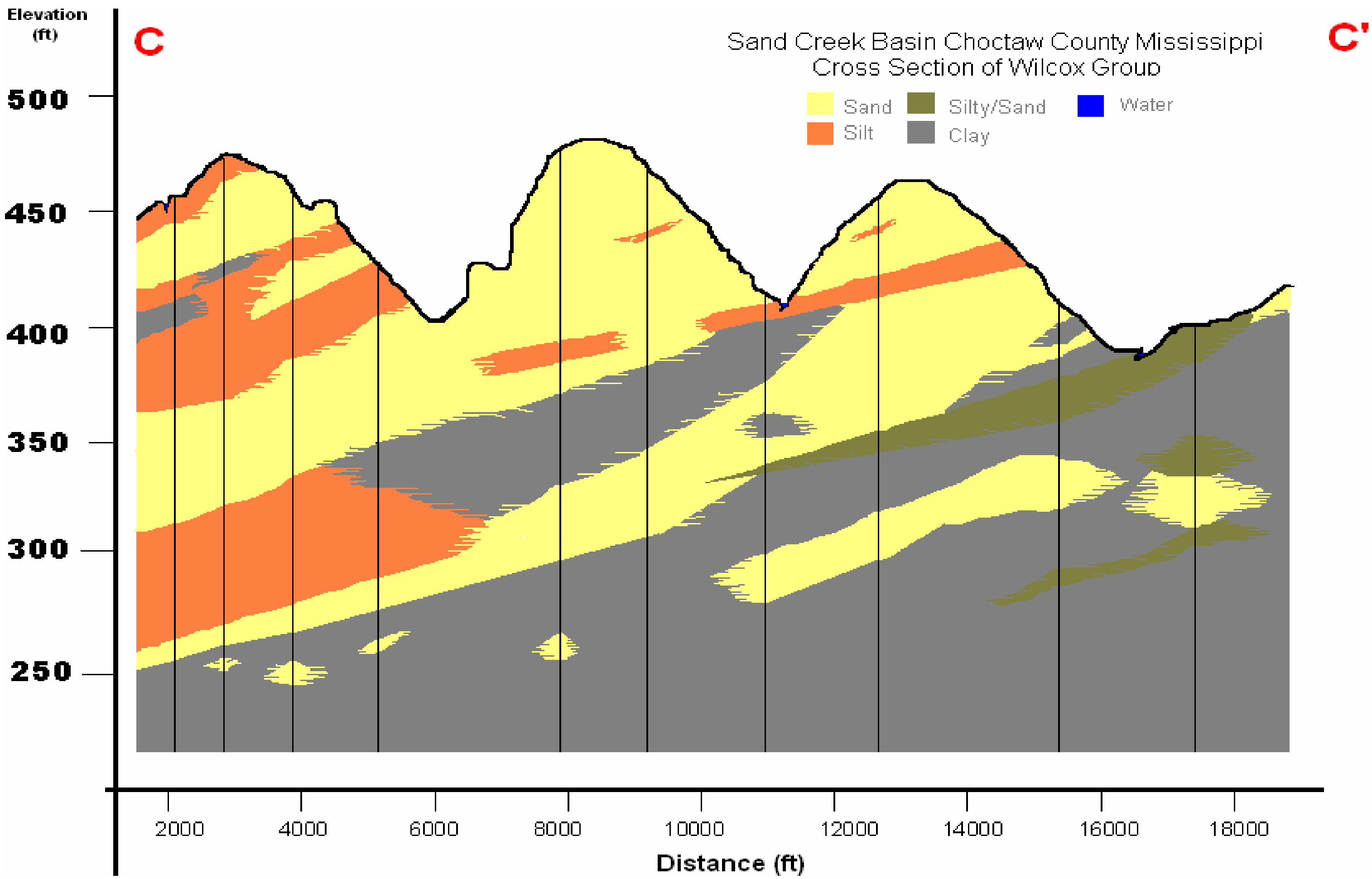


Figure37:

Cross Section C to C'

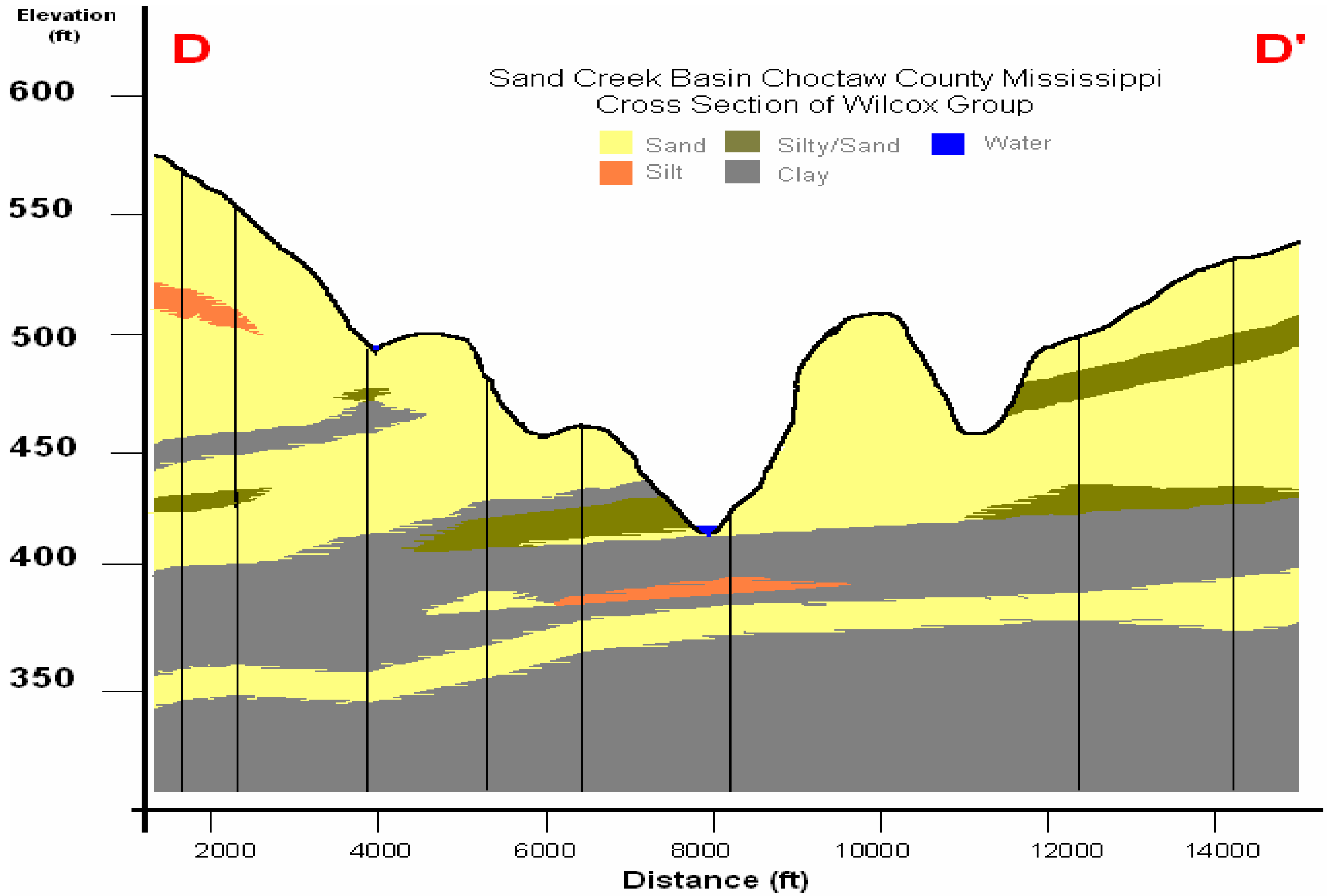


Figure 38:

Cross Section D to D’

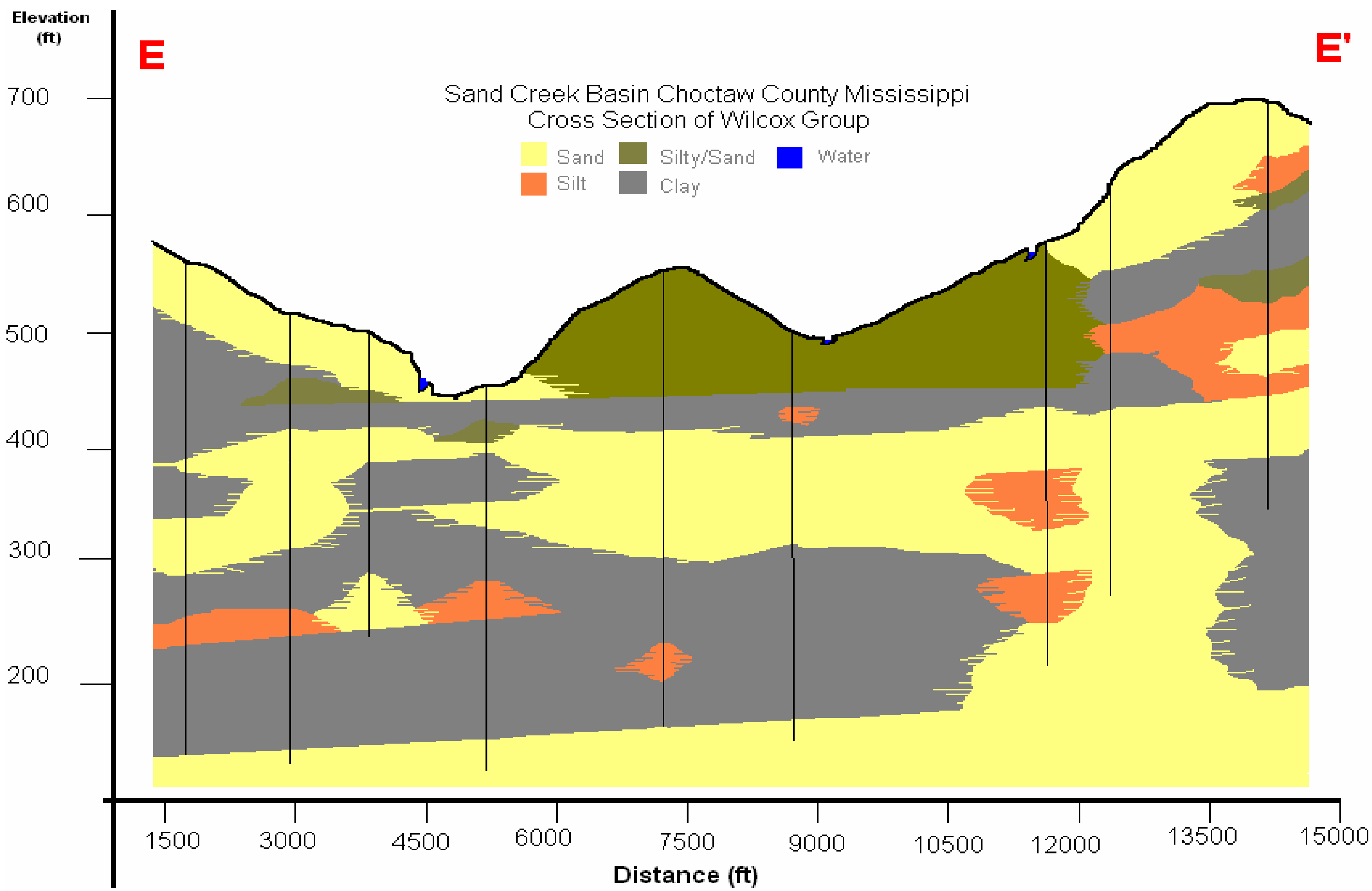


Figure 39:

Cross Section E to E’

SPRING INVENTORY

A spring inventory was conducted within the proposed drainage basin between September and October 2006. Currently 28 springs have been located, but some areas of the proposed reservoir were not investigated due to lack of property access (Figure 40). Once located, each spring's location was recorded using a Global Positioning System Unit (Appendix C). For springs with sufficient flow amounts, discharge estimates were made using velocity-area method (Table 17). The 28 springs were mapped using ArcGIS 9.1 and the topography maps of the study area (Figure 41).

Table 17:

Spring discharge. N/A= No measurable discharge

Date	Spring Number	Discharge (ft^3/sec)
9/28/2006	Sp 1	0.0590
9/28/2006	Sp 2	0.0245
9/28/2006	Sp 3	0.4710
9/28/2006	Sp 4	0.0372
9/28/2006	Sp 5	0.0601
9/28/2006	Sp 6	0.0183
9/28/2006	Sp 7	0.0461
9/28/2006	Sp 8	0.0475
9/28/2006	Sp 9	N/A
9/28/2006	Sp 10	N/A
9/28/2006	Sp11	N/A
9/28/2006	Sp12	0.1053
9/28/2006	Sp 13	N/A
9/28/2006	Sp 14	N/A
9/28/2006	Sp 15	0.4190
9/28/2006	Sp 16	N/A
9/28/2006	Sp 17	N/A
9/28/2006	Sp 18	N/A
9/28/2006	Sp 19	N/A
9/28/2006	Sp 20	0.0498
10/5/2006	Sp 21	0.1125
10/5/2006	Sp 22	N/A
10/5/2006	Sp 23	N/A
10/5/2006	Sp 24	N/A
10/5/2006	Sp 25	N/A
10/5/2006	Sp 26	0.1620
10/5/2006	Sp 27	0.2200
10/5/2006	Sp 28	0.2310

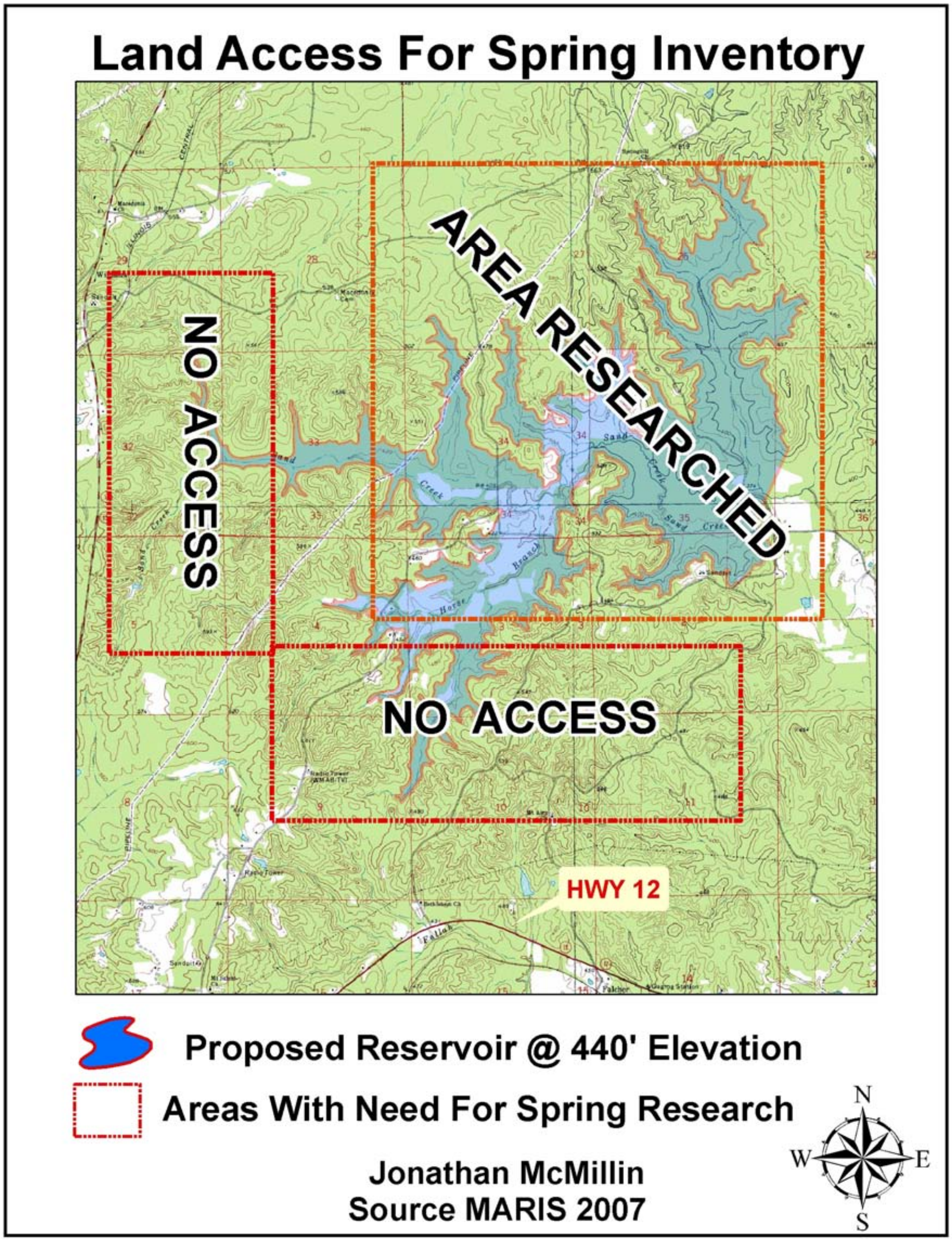


Figure 40:

Land Access of Drainage Basin

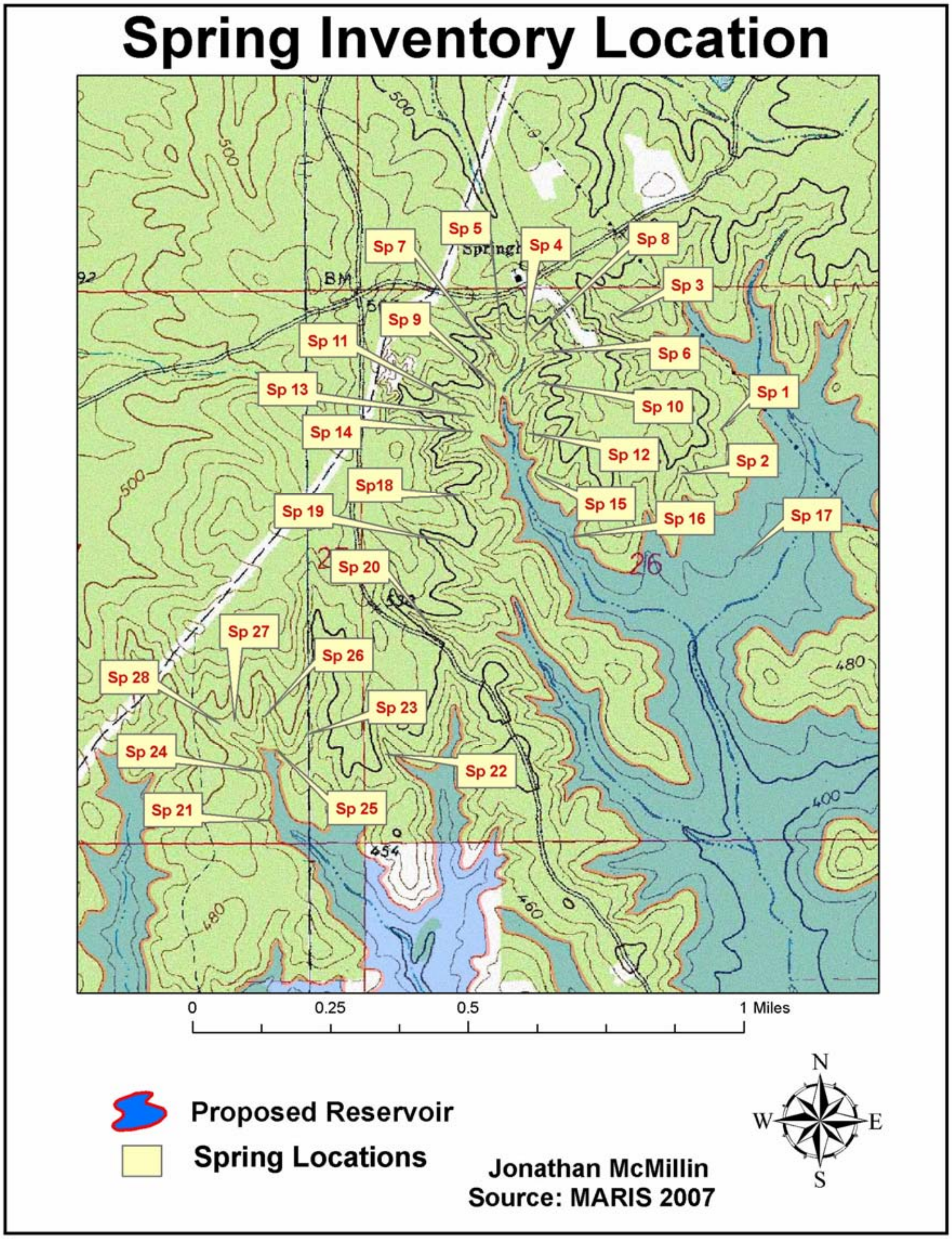


Figure 41:

Spring Locations relative to Proposed Reservoir footprint.

CHAPTER VII

DISCUSSION

WATER QUALITY

Chemical analyses were recorded for the basin; an average for all six sites is shown in Tables 18 and 19. Elevated levels of metals found to be present in the samples included iron, lead, and manganese found at base flow and high flow events (Table 18). The Mississippi State Chemical Lab performed the analyses and found the iron, lead, and manganese to be above the Maximum Contaminate Level (Table 20). It should be noted that all the MCL amounts were found at every monitoring site. High Flow analysis showed an elevated amount of iron, lead, and manganese to be persistent at each site; at base flow iron and manganese were detected above the MCL at every site also. Lead was only detected at Site A for the high flow reading. The amount of iron and manganese has been previously noted in two theses by Charleton (1998) and Lockhart (2004). Their research showed high amounts of iron and manganese in the drainage basin around the Red Hills Lignite Mine as well as the Middle Wilcox Aquifer

Table 18:

Average Base Flow for Maximum Contaminate Levels (ND=None Detected)

BASE FLOW 8-21-2006	Average Detection Site A-F	MCL*
pH	6.43	
Turbidity (NTU)	13.93	
Inorganics (ppm)		
Bicarbonate Alkalinity	17.50	
Total Alkalinity	14.33	
Free Carbon Dioxide	ND	
Sodium	2.38	
Potassium	1.28	
Calcium	2.60	
Magnesium	1.52	
Total Hardness	12.50	
Fluoride	0.24	4.0
Chloride	2.18	250.0
Sulfate	1.29	250.0
Nitrate Nitrogen	ND	10.0
Nitrite Nitrogen	ND	1.0
Total Nitrogen	ND	10.0
Total Dissolved Solids	23.83	500.0
Cyanide	ND	0.2
Phenol	ND	
Ammonia-N	0.14	
Total Phosphorous	ND	
Biological Oxygen Demand	5.00	
Total Coliform	3566.67	
Fecal Coliform	475.00	
BASE FLOW 8-21-2006	**Average Detection Site A-F**	
Metals (ppm)		**MCL***
Aluminum	0.29	0.2
Antimony	ND	0.006
Arsenic	ND	0.05
Barium	0.06	2.0
Beryllium	ND	0.004
Cadmium	ND	0.005
Chromium	ND	0.100
Copper	0.05	1.0
Iron	5.27	0.30
Lead	0.00	0.005
Manganese	0.20	0.05
Mercury	ND	0.002
Nickel	ND	0.1
Selenium	0.00	0.05
Silver	ND	0.1
Thalium	ND	0.002
Zinc	ND	5.0

Table 19:

Average High Flow for Maximum Contaminate Levels (ND=None Detected)

HIGH FLOW 10-20-2006	Average Detection Site A-F	MCL*
pH	5.15	
Turbidity (NTU)	88.17	
Inorganics (ppm)		
Bicarbonate Alkalinity	ND	
Total Alkalinity	ND	
Free Carbon Dioxide	ND	
Sodium	0.74	
Potassium	1.58	
Calcium	1.90	
Magnesium	1.04	
Total Hardness	9.13	
Fluoride	ND	4.0
Chloride	0.80	250.0
Sulfate	3.45	250.0
Nitrate Nitrogen	ND	10.0
Nitrite Nitrogen	ND	1.0
Total Nitrogen	ND	10.0
Total Dissolved Solids	16.33	500.0
Cyanide	ND	0.2
Phenol	ND	
Ammonia-N	ND	
Total Phosphorous	ND	
Biological Oxygen Demand	2.50	
HIGH FLOW 10-20-2006	**Average Detection Site A-F**	
Metals (ppm)		**MCL***
Aluminum	3.02	0.2
Antimony	ND	0.006
Arsenic	ND	0.05
Barium	0.06	2.0
Beryllium	ND	0.004
Cadmium	ND	0.005
Chromium	0.02	0.100
Copper	0.06	1.0
Iron	0.96	0.30
Lead	0.02	0.005
Manganese	0.22	0.05
Mercury	ND	0.002
Nickel	ND	0.1
Selenium	ND	0.05
Silver	ND	0.1
Thalium	ND	0.002
Zinc	ND	5.0

Table 20:

Metals with a High MCL

BASE FLOW 8-21-2006							
Metals (ppm)	**Site A**	**Site B**	**Site C**	**Site D**	**Site E**	**Site F**	**MCL***
Iron	2.1	1.7	15	4.1	3.2	5.5	0.30
Lead	0.0056	<0.001	<0.001	<0.001	<0.001	0.001	0.005
Manganese	0.15	0.11	0.097	0.25	0.16	0.44	0.05
HIGH FLOW 10-20-2006							
Metals (ppm)	**Site A**	**Site B**	**Site C**	**Site D**	**Site E**	**Site F**	**MCL***
Iron	0.0028	1.1	1.2	0.66	1.1	1.7	0.30
Lead	0.065	0.0073	0.0063	0.0037	0.0057	0.006	0.005
Manganese	0.065	0.31	0.25	0.14	0.21	0.37	0.05

FLOW MONITORING

Analysis of the surface water data reveals sufficient water at base flow to support a reservoir due to amount of spring flow in the basin. The high flow events show that when high amounts of rain fall are released into the basin, stage elevation and discharge will drastically increased. High stage and discharge is due to the highly dissected topography of the area which causes rapid runoff from rain events; this will be beneficial to filling the reservoir in the beginning stages of development.

GEOLOGY

The entire study area is underlain by the Wilcox Group, as being a sequence of fluvial deposits of the Paleocene Epoch. The alluvium associated with the site is developed from the hilly landscape highly dissected by meandering streams. Prevalent within the area are the sands, micaceous sands, silts, silty-sands, clays, silty-clays, and lignites associated with the Tuscahoma, Nanafalia, Naheola formations. The 51 geophysical logs provided by North American Coal (NAC) were used to interpret the change in lithology of the different geology formations and members. The geological cross sections show consistent change in lithology as well as the possibility of faulting or possible facies change.

The proposed levee site is located within a large bend of the Sand Creek which after construction of the cross section of A to A' showed high sand content, drastic change in lithology along with rapid facies change or possible normal faulting (Figure 42). The high sand content which has an excessive permeability within the levee area could be a threat to piping, along with the thin ridge located in the abutment area (Figure 43). Although there is a high amount of sand in the area, located within the foot print of the lake is vast amounts of good quality, thick layered clays that could be used for the construction of the levee.

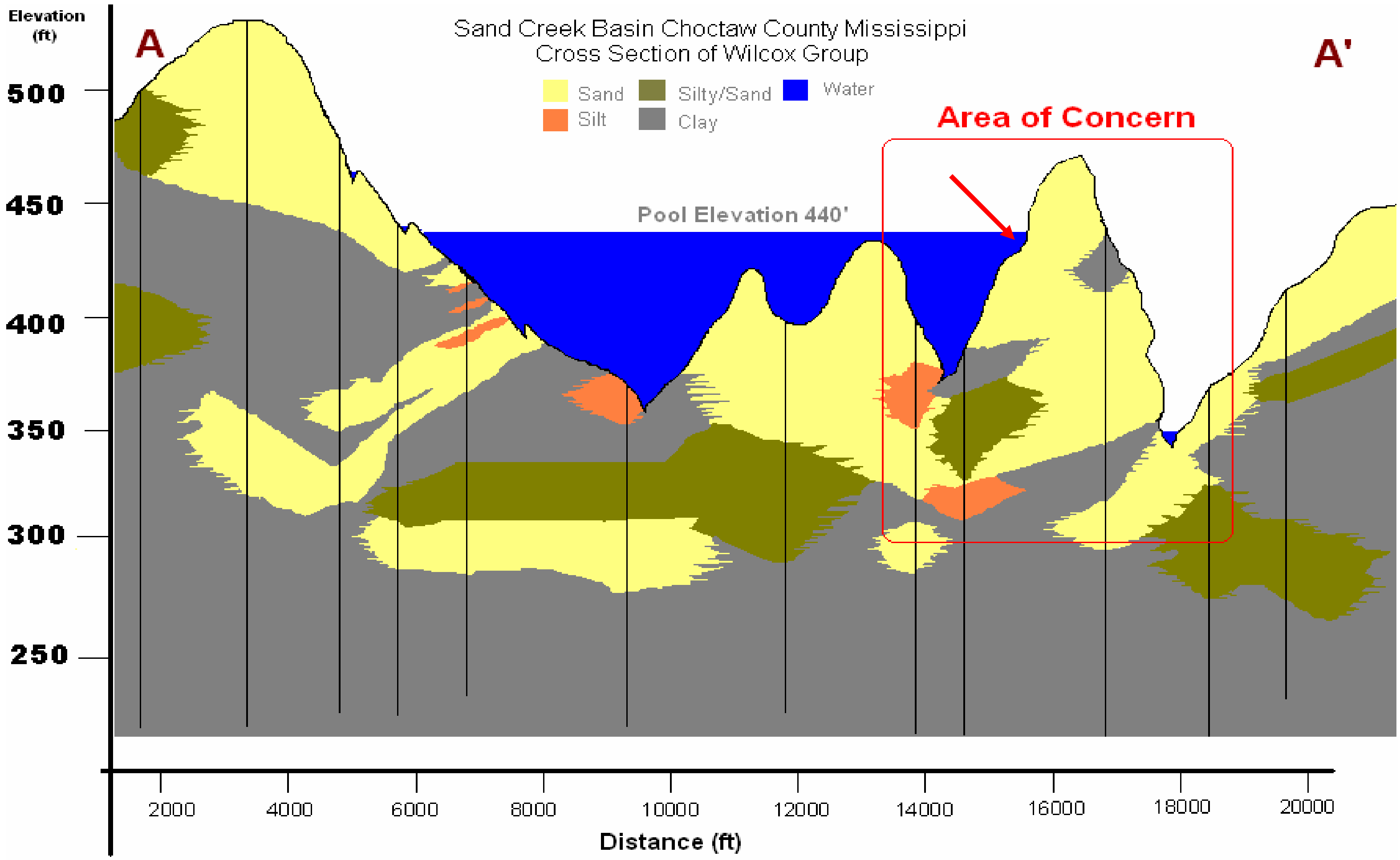


Figure 42:

Detailed Cross Section A to A’ showing area of concern along with red arrow pointing out the proposed levee site.

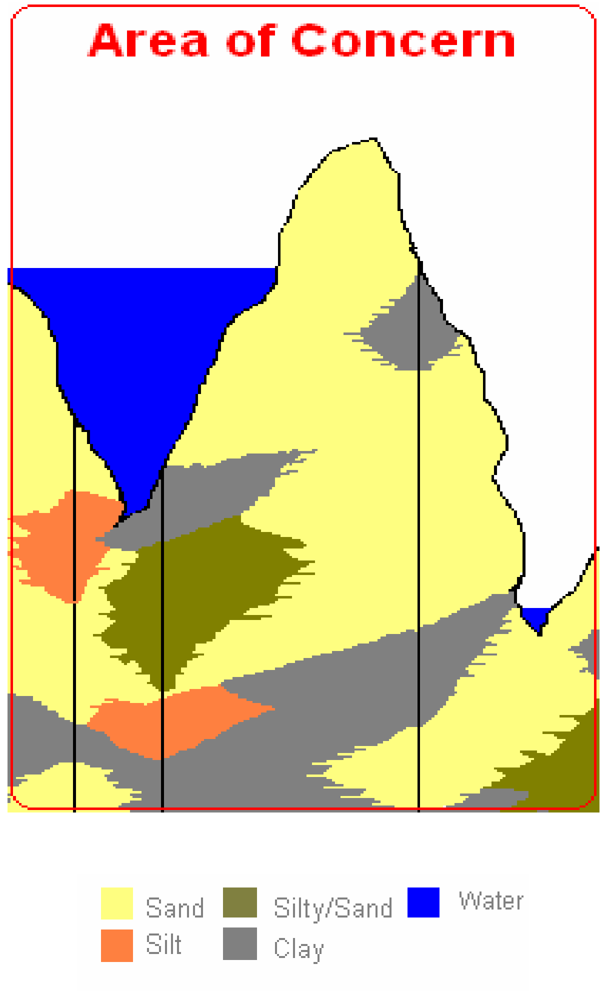


Figure 43:

Enlarged image of Area of Concern.

CHAPTER VIII

CONCLUSION

An in-depth study was undertaken to determine if the geology and hydrology in the Sand Creek drainage basin located within the Upper Noxubee watershed would be suitable for a multi-use/multi-purpose reservoir. From the data gathered the results imply that the reservoir location is suitable because spring flow into Sand Creek is sufficient to provide water to feed the reservoir even during drought periods. Preliminary chemical analysis of the area indicated good water quality, but an in-depth analysis should be conducted to determine why high amounts of metal concentrations are present.

The amount of sand located near and around the abutment of the levee, the possibility of faulting, and a thin ridge to the southeast of the abutment is cause for concern. Mitigation of the permeable sand maybe needed. There is a good source of fill material for the construction of the levee located in the basin. More in-depth testing should be done to determine the suitability of the fill material.

Recommendation for further study include more water quality sampling during base flow and high flow events along with shallow aquifer sampling to assess the potable water quality mainly focusing on the amount of heavy metals. More spring research should be done in the areas where access to property is not permitted. Continuous flow monitoring devices should be installed on stream crossings to calculate base flow recession and aquifer properties. The area near and around the levee should have several rounds of tests borings done to determine if faulting is occurring.

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APPENDIX A

CHEMICAL ANALYSIS

WATER QUALITY ANALYSES FOR BOTTLED WATER
REQUIRED BY MS STATE DEPARTMENT OF HEALTH

MSCL No.	**36,264**
Sample ID	**A**
pH	6.5
PHYSICAL DETERMINATIONS	
Turbidity, NTU	14

INORGANICS	**PARTS PER MILLION**	
	SAMPLE	**MCL**
Bicarbonate Alkalinity as $CaCO_3$	15	
Total Alkalinity as $CaCO_3$	12	
Free Carbon Dioxide	<10	
Sodium	2.3	
Potassium	1.3	
Calcium	2.8	
Magnesium	1.6	
Total Hardness as $CaCO_3$	13	
Fluoride	<0.1	4.0
Chloride	2.2	250
Sulfate	1.1	250
Nitrate Nitrogen	<0.1	10.0
Nitrite Nitrogen	<0.1	1.0
Total NO_3/NO_2 Nitrogen	<1	10.0
Total Dissolved Solids	26	500
Cyanide	<0.02	0.2
Phenol	<0.1	0.00
Ammonia-N	<0.1	
Total Phosphorus	<0.1	
BOD_5	6	
Total Coliform	1300	
Fecal Coliform	170	

*Maximum Contaminant Level for Secondary Contaminants

METALS	**PARTS PER MILLION**	
	SAMPLE	**MCL**
Aluminum	0.15	0.20
Antimony	<0.001	0.006
Arsenic	<0.001	0.05
Barium	0.050	2.0
Beryllium	<0.001	0.004
Cadmium	<0.001	0.005
Chromium	<0.01	0.1
Copper	0.079	1.0
Iron	2.1	0.30
Lead	0.0056	0.005
Manganese	0.15	0.05
Mercury	<0.0005	0.002
Nickel	<0.05	0.1
Selenium	0.001	0.05
Silver	<0.004	0.10
Thallium	<0.001	0.002
Zinc	<0.02	5.0

*MCL = Maximum Contaminant Level for Primary or Secondary Contaminants
Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lowe

MSCL No.	**36,265**
Sample ID	**B**
pH	6.5

PHYSICAL DETERMINATIONS

Turbidity, NTU	12

INORGANICS	**PARTS PER MILLION**	
	SAMPLE	**MCL***
Bicarbonate Alkalinity as $CaCO_3$	15	
Total Alkalinity as $CaCO_3$	12	
Free Carbon Dioxide	<10	
Sodium	2.2	
Potassium	1.2	
Calcium	2.4	
Magnesium	1.4	
Total Hardness as $CaCO_3$	11	
Fluoride	<0.1	4.0
Chloride	2.0	250
Sulfate	0.81	250
Nitrate Nitrogen	<0.1	l0.0
Nitrite Nitrogen	<0.1	l.0
Total NO_3/NO_2 Nitrogen	<1	l0.0
Total Dissolved Solids	21	500
Cyanide	<0.02	0.2
Phenol	<0.1	0.001
Ammonia-N	<0.1	
Total Phosphorus	<0.1	
BOD_5	5	
Total Coliform	1400	
Fecal Coliform	500	

*Maximum Contaminant Level for Secondary Contaminants

METALS	**PARTS PER MILLION**	
	SAMPLE	**MCL***
Aluminum	0.13	0.20
Antimony	<0.001	0.006
Arsenic	<0.001	0.05
Barium	0.072	2.0
Beryllium	<0.001	0.004
Cadmium	<0.001	0.005
Chromium	<0.01	0.l
Copper	0.050	l.0
Iron	1.7	0.30
Lead	<0.001	0.005
Manganese	0.11	0.05
Mercury	<0.0005	0.002
Nickel	<0.05	0.l
Selenium	<0.001	0.05
Silver	<0.004	0.10
Thallium	<0.001	0.002
Zinc	<0.02	5.0

*MCL = Maximum Contaminant Level for Primary or Secondary Contaminants
Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lower level of detection.
Parts Per Million = Milligrams Per Liter.

WATER QUALITY ANALYSES FOR BOTTLED WATER
REQUIRED BY MS STATE DEPARTMENT OF HEALTH

MSCL No.	**36,266**
Sample ID	**C**
pH	6.4

PHYSICAL DETERMINATIONS

Turbidity, NTU	8.6

INORGANICS	**PARTS PER MILLION**	
	SAMPLE	**MCI**
Bicarbonate Alkalinity as $CaCO_3$	12	
Total Alkalinity as $CaCO_3$	10	
Free Carbon Dioxide	<10	
Sodium	2.1	
Potassium	1.0	
Calcium	2.3	
Magnesium	1.3	
Total Hardness as $CaCO_3$	11	
Fluoride	<0.1	4.0
Chloride	2.0	250
Sulfate	0.80	250
Nitrate Nitrogen	<0.1	I0.0
Nitrite Nitrogen	<0.1	I.0
Total NO_3/NO_2 Nitrogen	<1	I0.0
Total Dissolved Solids	20	500
Cyanide	<0.02	0.2
Phenol	<0.1	0.00
Ammonia-N	<0.1	
Total Phosphorus	<0.1	
BOD_5	5	
Total Coliform	1400	
Fecal Coliform	300	

*Maximum Contaminant Level for Secondary Contaminants

METALS	**PARTS PER MILLION**	
	SAMPLE	**MCL**
Aluminum	0.11	0.20
Antimony	<0.001	0.00
Arsenic	<0.001	0.05
Barium	0.079	2.0
Beryllium	<0.001	0.00
Cadmium	<0.001	0.00
Chromium	<0.01	0.I
Copper	0.034	I.0
Iron	15	0.30
Lead	<0.001	0.00
Manganese	0.097	0.05
Mercury	<0.0005	0.00
Nickel	<0.05	0.I
Selenium	<0.001	0.05
Silver	<0.004	0.10
Thallium	<0.001	0.00
Zinc	<0.02	5.0

*MCL = Maximum Contaminant Level for Primary or Secondary Contaminants
Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported low

WATER QUALITY ANALYSES FOR BOTTLED WATER REQUIRED BY MS STATE DEPARTMENT OF HEALTH

MSCL No.	**36,267**	
Sample ID	**D**	
pH	6.5	
PHYSICAL DETERMINATIONS		
Turbidity, NTU	10	

INORGANICS	**PARTS PER MILLION**	
	SAMPLE	**MCL***
Bicarbonate Alkalinity as $CaCO_3$	12	
Total Alkalinity as $CaCO_3$	10	
Free Carbon Dioxide	<10	
Sodium	2.6	
Potassium	1.3	
Calcium	2.3	
Magnesium	1.5	
Total Hardness as $CaCO_3$	12	
Fluoride	0.24	4.0
Chloride	2.6	250
Sulfate	1.8	250
Nitrate Nitrogen	<0.1	10.0
Nitrite Nitrogen	<0.1	1.0
Total NO_3/NO_2 Nitrogen	<1	10.0
Total Dissolved Solids	25	500
Cyanide	<0.02	0.2
Phenol	<0.1	0.001
Ammonia-N	<0.1	
Total Phosphorus	<0.1	
BOD_5	4	
Total Coliform	7000	
Fecal Coliform	700	

*Maximum Contaminant Level for Secondary Contaminants

METALS	**PARTS PER MILLION**	
	SAMPLE	**MCL***
Aluminum	0.48	0.20
Antimony	<0.001	0.006
Arsenic	<0.001	0.05
Barium	0.065	2.0
Beryllium	<0.001	0.004
Cadmium	<0.001	0.005
Chromium	<0.01	0.1
Copper	0.047	1.0
Iron	4.1	0.30
Lead	<0.001	0.005
Manganese	0.25	0.05
Mercury	<0.0005	0.002
Nickel	<0.05	0.1
Selenium	<0.001	0.05
Silver	<0.004	0.10
Thallium	<0.001	0.002
Zinc	<0.02	5.0

*MCL = Maximum Contaminant Level for Primary or Secondary Contaminants
Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lowe

MSCL No.	**36,268**
Sample ID	**E**
pH	6.5

PHYSICAL DETERMINATIONS

Turbidity, NTU	16

INORGANICS	**PARTS PER MILLION**	
	SAMPLE	**MCL***
Bicarbonate Alkalinity as $CaCO_3$	22	
Total Alkalinity as $CaCO_3$	18	
Free Carbon Dioxide	<10	
Sodium	2.5	
Potassium	1.5	
Calcium	2.5	
Magnesium	1.5	
Total Hardness as $CaCO_3$	12	
Fluoride	<0.1	4.0
Chloride	2.2	250
Sulfate	1.7	250
Nitrate Nitrogen	<0.1	I0.0
Nitrite Nitrogen	<0.1	I.0
Total NO_3/NO_2 Nitrogen	<1	I0.0
Total Dissolved Solids	23	500
Cyanide	<0.02	0.2
Phenol	<0.1	0.001
Ammonia-N	<0.1	
Total Phosphorus	<0.1	
BOD_5	4	
Total Coliform	8000	
Fecal Coliform	1100	

*Maximum Contaminant Level for Secondary Contaminants

METALS	**PARTS PER MILLION**	
	SAMPLE	**MCL***
Aluminum	0.40	0.20
Antimony	<0.001	0.006
Arsenic	<0.001	0.05
Barium	0.052	2.0
Beryllium	<0.001	0.004
Cadmium	<0.001	0.005
Chromium	<0.01	0.I
Copper	0.040	I.0
Iron	3.2	0.30
Lead	<0.001	0.005
Manganese	0.16	0.05
Mercury	<0.0005	0.002
Nickel	<0.05	0.I
Selenium	<0.001	0.05
Silver	<0.004	0.10
Thallium	<0.001	0.002
Zinc	<0.02	5.0

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Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lower level of detection.
Parts Per Million = Milligrams Per Liter.

MSCL No.	**36,269**
Sample ID	**F**
pH	6.5

PHYSICAL DETERMINATIONS

Turbidity, NTU	29

INORGANICS

	PARTS PER MILLION	
	SAMPLE	MCL*
Bicarbonate Alkalinity as $CaCO_3$	29	
Total Alkalinity as $CaCO_3$	24	
Free Carbon Dioxide	<10	
Sodium	2.6	
Potassium	1.4	
Calcium	3.3	
Magnesium	1.8	
Total Hardness as $CaCO_3$	16	
Fluoride	<0.1	4.0
Chloride	2.1	250
Sulfate	1.5	250
Nitrate Nitrogen	<0.1	I0.0
Nitrite Nitrogen	<0.1	I.0
Total NO_3/NO_2 Nitrogen	<1	I0.0
Total Dissolved Solids	28	500
Cyanide	<0.02	0.2
Phenol	<0.1	0.001
Ammonia-N	<0.1	
Total Phosphorus	<0.1	
BOD_5	6	
Total Coliform	2300	
Fecal Coliform	80	

*Maximum Contaminant Level for Secondary Contaminants

METALS

	PARTS PER MILLION	
	SAMPLE	MCL*
Aluminum	0.48	0.20
Antimony	<0.001	0.006
Arsenic	<0.001	0.05
Barium	0.071	2.0
Beryllium	<0.001	0.004
Cadmium	<0.001	0.005
Chromium	<0.01	0.I
Copper	0.049	I.0
Iron	5.5	0.30
Lead	0.001	0.005
Manganese	0.44	0.05
Mercury	<0.0005	0.002
Nickel	<0.05	0.I
Selenium	<0.001	0.05
Silver	<0.004	0.10
Thallium	<0.001	0.002
Zinc	<0.02	5.0

*MCL = Maximum Contaminant Level for Primary or Secondary Contaminants
Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lower level of detection.
Parts Per Million = Milligrams Per Liter.

MSCL No.	36,738
Sample ID	A-H

PHYSICAL DETERMINATIONS

Turbidity, NTU	43
pH	5.9

INORGANICS	**PARTS PER MILLION**
	SAMPLE
Bicarbonate Alkalinity as $CaCO_3$	<10
Total Alkalinity as $CaCO_3$	<10
Free Carbon Dioxide	<10
Sodium	0.46
Potassium	0.19
Calcium	2.8
Magnesium	1.1
Total Hardness as $CaCO_3$	12
Fluoride	<0.1
Chloride	0.60
Sulfate	2.5
Nitrate Nitrogen	<0.1
Nitrite Nitrogen	<0.1
Total NO_3/NO_2 Nitrogen	<0.1
Total Dissolved Residue	17
Cyanide	<0.02
Phenol	<0.1
Ammonia-N	<0.1
Total Phosphorus	<0.1
BOD5	2

METALS	**PARTS PER MILLION**
	SAMPLE
Aluminum	1.0
Antimony	<0.001
Arsenic	<0.001
Barium	0.025
Beryllium	<0.002
Cadmium	<0.001
Chromium	0.011
Copper	0.033
Iron	0.34
Lead	0.0028
Manganese	0.065
Mercury	<0.0005
Nickel	<0.05
Selenium	<0.001
Silver	<0.004
Thallium	<0.001
Zinc	<0.01

Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lower level of detection.
Parts Per Million = Milligrams Per Liter.

MSCL No.	36,739
Sample ID	B-H

PHYSICAL DETERMINATIONS	
Turbidity, NTU	91
pH	5.7

INORGANICS	**PARTS PER MILLION**
	SAMPLE
Bicarbonate Alkalinity as $CaCO_3$	<10
Total Alkalinity as $CaCO_3$	<10
Free Carbon Dioxide	<10
Sodium	1.2
Potassium	1.6
Calcium	1.8
Magnesium	1.3
Total Hardness as $CaCO_3$	9.8
Fluoride	<0.1
Chloride	1.2
Sulfate	6.1
Nitrate Nitrogen	<0.1
Nitrite Nitrogen	<0.1
Total NO_3/NO_2 Nitrogen	<0.1
Total Dissolved Residue	20
Cyanide	<0.02
Phenol	<0.1
Ammonia-N	<0.1
Total Phosphorus	<0.1
BOD5	4

METALS	**PARTS PER MILLION**
	SAMPLE
Aluminum	3.7
Antimony	<0.001
Arsenic	<0.001
Barium	0.082
Beryllium	<0.002
Cadmium	<0.001
Chromium	0.016
Copper	0.071
Iron	1.1
Lead	0.0073
Manganese	0.31
Mercury	<0.0005
Nickel	<0.05
Selenium	<0.001
Silver	<0.004
Thallium	<0.001
Zinc	<0.01

Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lower level of detection.
Parts Per Million = Milligrams Per Liter.

MSCL No.	36,740
Sample ID	C-H

PHYSICAL DETERMINATIONS

Turbidity, NTU	110
pH	5.7

INORGANICS	**PARTS PER MILLION SAMPLE**
Bicarbonate Alkalinity as $CaCO_3$	<10
Total Alkalinity as $CaCO_3$	<10
Free Carbon Dioxide	<10
Sodium	0.64
Potassium	1.9
Calcium	1.9
Magnesium	0.94
Total Hardness as $CaCO_3$	8.7
Fluoride	<0.1
Chloride	0.72
Sulfate	3.2
Nitrate Nitrogen	<0.1
Nitrite Nitrogen	<0.1
Total NO_3/NO_2 Nitrogen	<0.1
Total Dissolved Residue	15
Cyanide	<0.02
Phenol	<0.1
Ammonia-N	<0.1
Total Phosphorus	0.13
BOD5	2

METALS	**PARTS PER MILLION SAMPLE**
Aluminum	3.5
Antimony	<0.001
Arsenic	<0.001
Barium	0.073
Beryllium	<0.002
Cadmium	<0.001
Chromium	0.016
Copper	0.087
Iron	1.2
Lead	0.0063
Manganese	0.25
Mercury	<0.0005
Nickel	<0.05
Selenium	<0.001
Silver	<0.004
Thallium	<0.001
Zinc	<0.01

Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lower level of detection.
Parts Per Million = Milligrams Per Liter.

MSCL No.	36,741
Sample ID	D-H

PHYSICAL DETERMINATIONS

Turbidity, NTU	94
pH	5.6

INORGANICS	**PARTS PER MILLION**
	SAMPLE
Bicarbonate Alkalinity as $CaCO_3$	<10
Total Alkalinity as $CaCO_3$	<10
Free Carbon Dioxide	<10
Sodium	0.62
Potassium	2.0
Calcium	1.7
Magnesium	1.0
Total Hardness as $CaCO_3$	8.4
Fluoride	<0.1
Chloride	0.75
Sulfate	2.7
Nitrate Nitrogen	<0.1
Nitrite Nitrogen	<0.1
Total NO_3/NO_2 Nitrogen	<0.1
Total Dissolved Residue	15
Cyanide	<0.02
Phenol	<0.1
Ammonia-N	<0.1
Total Phosphorus	0.68
BOD5	3

METALS	**PARTS PER MILLION**
	SAMPLE
Aluminum	2.7
Antimony	<0.001
Arsenic	<0.001
Barium	0.056
Beryllium	<0.002
Cadmium	<0.001
Chromium	0.016
Copper	0.030
Iron	0.66
Lead	0.0037
Manganese	0.14
Mercury	<0.0005
Nickel	<0.05
Selenium	<0.001
Silver	<0.004
Thallium	<0.001
Zinc	<0.01

Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lower level of detection.
Parts Per Million = Milligrams Per Liter.

MSCL No.	36,742
Sample ID	E-H

PHYSICAL DETERMINATIONS	
Turbidity, NTU	81
pH	5.5

INORGANICS	**PARTS PER MILLION**
	SAMPLE
Bicarbonate Alkalinity as $CaCO_3$	<10
Total Alkalinity as $CaCO_3$	<10
Free Carbon Dioxide	<10
Sodium	0.80
Potassium	1.7
Calcium	1.6
Magnesium	0.92
Total Hardness as $CaCO_3$	7.9
Fluoride	<0.1
Chloride	0.78
Sulfate	3.0
Nitrate Nitrogen	<0.1
Nitrite Nitrogen	<0.1
Total NO_3/NO_2 Nitrogen	<0.1
Total Dissolved Residue	15
Cyanide	<0.02
Phenol	<0.1
Ammonia-N	<0.1
Total Phosphorus	0.45
BOD5	1

METALS	**PARTS PER MILLION**
	SAMPLE
Aluminum	3.1
Antimony	<0.001
Arsenic	<0.001
Barium	0.066
Beryllium	<0.002
Cadmium	<0.001
Chromium	0.018
Copper	0.055
Iron	1.1
Lead	0.0057
Manganese	0.21
Mercury	<0.0005
Nickel	<0.05
Selenium	<0.001
Silver	<0.004
Thallium	<0.001
Zinc	<0.01

Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lower level of detection.
Parts Per Million = Milligrams Per Liter.

MSCL No.	36,743
Sample ID	F-H

PHYSICAL DETERMINATIONS

Turbidity, NTU	110
pH	5.5

INORGANICS	**PARTS PER MILLION** **SAMPLE**
Bicarbonate Alkalinity as $CaCO_3$	<10
Total Alkalinity as $CaCO_3$	<10
Free Carbon Dioxide	<10
Sodium	0.73
Potassium	2.1
Calcium	1.6
Magnesium	0.97
Total Hardness as $CaCO_3$	8.0
Fluoride	<0.1
Chloride	0.73
Sulfate	3.2
Nitrate Nitrogen	<0.1
Nitrite Nitrogen	<0.1
Total NO_3/NO_2 Nitrogen	<0.1
Total Dissolved Residue	16
Cyanide	<0.02
Phenol	<0.1
Ammonia-N	<0.1
Total Phosphorus	<0.1
BOD5	3

METALS	**PARTS PER MILLION** **SAMPLE**
Aluminum	4.1
Antimony	<0.001
Arsenic	<0.001
Barium	0.081
Beryllium	<0.002
Cadmium	<0.001
Chromium	0.020
Copper	<0.03
Iron	1.7
Lead	0.0060
Manganese	0.37
Mercury	<0.0005
Nickel	<0.05
Selenium	<0.001
Silver	<0.004
Thallium	<0.001
Zinc	<0.01

Those values preceded by a "less than" sign (<) indicate "None Detected" at the reported lower level of detection.
Parts Per Million = Milligrams Per Liter.

APPENDIX B

DISCHARGE TABLES

Site A Discharge Measurments 2-28-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Veloctiy	Discharge (cfs)
1	3.3	0.4	3	40	0.184	0.257
2	5.3	0.5	6	40	0.347	0.607
3	7.3	0.6	10	40	0.565	1.187
4	9.3	0.7	18	40	1.001	2.452
5	11.3	0.3	33	40	1.820	1.911
6	13.3	0.4	38	40	2.091	2.927
7	15.3	0.35	43	40	2.363	2.894
8	17.3	0.3	25	40	1.383	1.452
9	19.3	0.2	14	40	0.783	0.548
10	21.3	0.2	5	40	0.293	0.205
						14.44
Site A Discharge Measurments 4-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Veloctiy	Discharge (cfs)
1	2.75	1.6	10	40	0.565	3.164
2	5.3	2	21	40	1.165	8.152
3	7.85	2.2	26	40	1.437	11.065
4	10.4	1.9	30	40	1.655	11.006
5	12.95	2.2	33	40	1.820	14.016
6	15.5	2.1	32	40	1.764	12.965
7	18.05	2.1	29	40	1.603	11.784
8	20.6	2	24	40	1.328	9.296
9	23.15	2	16	40	0.892	6.244
10	25.7	1.1	14	40	0.783	3.015
						90.71
Site A Discharge Measurments 5-10-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Veloctiy	Discharge (cfs)
1	3.9	0.4	7	40	0.402	0.562
2	5.9	0.6	6	40	0.347	0.729
3	7.9	0.45	7	40	0.402	0.632
4	9.9	0.25	4	40	0.238	0.208
5	11.9	0.3	6	40	0.356	0.373
6	13.9	0.3	10	40	0.565	0.593
7	15.9	0.4	8	40	0.464	0.650
8	17.9	0.6	4	40	0.238	0.500
9	19.9	0.7	3	40	0.184	0.450
10	21.9	0.65	2	40	0.129	0.293
						4.99
Site A Discharge Measurments 8-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Veloctiy	Discharge (cfs)
1	2.25	0.1	2	40	0.129	0.045
2	3.2	0.2	3	40	0.184	0.128
3	4.2	0.2	3	40	0.184	0.128
4	5.2	0.1	4	40	0.238	0.083
5	6.2	0.1	4	40	0.247	0.086
6	7.2	0.3	5	40	0.293	0.307
7	8.2	0.2	4	40	0.247	0.173
8	9.2	0.3	3	40	0.184	0.193
9	10.2	0.1	2	40	0.129	0.045
10	11.2	0	2	40	0.129	0.000
						1.19

Site A Discharge Measurments 10-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	4.65	0.9	3	43	0.172	0.542
2	7.95	2	27	42	1.421	9.950
3	11.25	2.4	35	42	1.837	15.428
4	14.55	2.3	39	42	2.044	16.457
5	17.85	2.2	44	41	2.359	18.163
6	21.15	1.8	32	40	1.764	11.113
7	24.45	1.9	44	40	2.417	16.073
8	27.75	2.55	30	41	1.615	14.415
9	31.05	2.7	36	40	1.982	18.730
10	34.35	0.6	4	47	0.206	0.432
						121.302
Site A Discharge Measurments 10-27-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	2.75	1.6	5	40	0.293	1.638
2	5.3	2	12	40	0.674	4.718
3	7.8	2.2	17	40	0.947	7.288
4	10.4	2	22	40	1.219	8.533
5	12.95	2.2	25	40	1.386	10.674
6	15.5	2.1	28	40	1.546	11.363
7	18.05	2.1	38	40	2.092	15.373
8	20.6	2.4	38	40	2.091	17.564
9	23.15	2.5	22	40	1.219	10.666
10	25.7	1.1	14	40	0.783	3.015
						90.83

Site B Discharge Measurments 2-28-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.35	1.1	5	40	0.293	0.547
2	3.34	2	7	40	0.402	1.365
3	5.35	2.1	14	40	0.790	2.819
4	7.35	2.2	20	40	1.115	4.170
5	9.35	2.1	38	40	2.092	7.467
6	11.35	2.2	36	40	1.983	7.416
7	13.35	1.7	38	40	2.091	6.043
8	15.35	1.7	28	40	1.546	4.468
9	17.35	1.3	10	40	0.565	1.249
10	19.35	1.1	6	40	0.347	0.649
						36.192

Site B Discharge Measurments 4-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.35	1.5	22	44	1.110	2.831
2	4.05	2.9	27	42	1.421	7.008
3	6.75	2.7	49	40	2.688	12.339
4	10.45	2.5	51	41	2.729	11.599
5	12.15	2.5	47	42	2.458	10.448
6	14.85	2.4	48	40	2.634	10.747
7	17.55	2.1	39	42	2.044	7.298
8	20.25	1.5	31	42	1.629	4.154
9	22.95	1	22	42	1.162	1.975
10	25.65	0.7	19	43	0.983	1.170
						69.569

Site B Discharge Measurments 5-10-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	3.7	0.2	0	40	0.020	0.007
2	5.3	0.3	0	40	0.020	0.010
3	6.9	0.5	0	40	0.030	0.026
4	8.5	0.8	5	40	0.301	0.410
5	10.1	1	5	40	0.301	0.512
6	11.7	1.3	6	40	0.356	0.786
7	13.3	1.5	10	40	0.565	1.441
8	14.9	1.4	8	40	0.456	1.085
9	16.5	1	10	40	0.565	0.961
10	18.1	0.5	0	40	0.020	0.017
						5.254

Site B Discharge Measurments 8-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	4.6	0.3	0	40	0.020	0.010
2	5.8	0.3	0	40	0.020	0.010
3	7	0.4	0	40	0.030	0.020
4	8.2	0.6	3	40	0.193	0.197
5	9.4	0.5	10	40	0.573	0.487
6	10.6	0.4	11	40	0.627	0.426
7	11.8	0.5	6	40	0.347	0.295
8	13	0.4	9	41	0.499	0.339
9	14.2	0.3	0	40	0.020	0.010
10	15.4	0.2	0	40	0.020	0.007
						1.810

Site B Discharge Measurments 10-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	2.35	1.3	38	40	2.200	13.440
2	7.05	3.9	59	40	3.236	60.122
3	11.75	5.2	113	40	6.160	147.120
4	16.45	7.3	128	40	6.974	233.990
5	21.15	7.6	110	40	5.998	182.810
6	25.85	6.8	98	40	5.347	139.660
7	30.55	5.4	90	40	4.925	81.000
8	35.25	4.1	23	40	1.274	25.243
9	39.95	2.1	8	40	0.456	3.880
10	44.65	0.1	0	40	0.020	0.003
						887.700
Site B Discharge Measurments 10-27-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.35	1.5	30	40	1.655	4.220
2	4.05	2.9	38	42	1.992	9.822
3	6.75	2.7	49	40	2.688	12.339
4	10.45	3.9	51	40	2.797	18.542
5	12.15	3.1	55	42	2.872	15.134
6	14.85	2.4	60	40	3.285	13.403
7	17.55	2.3	39	42	2.044	7.993
8	20.55	1.7	38	42	1.992	5.758
9	22.96	1.8	35	42	1.837	5.620
10	25.65	0.7	19	40	1.056	1.256
						94.088

Site C Discharge Measurments 2-28-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.35	1.1	2	40	0.129	0.241
2	3.34	1.4	7	40	0.402	0.956
3	5.35	1.5	8	40	0.464	1.183
4	7.35	1.4	9	40	0.518	1.233
5	9.35	1.5	17	40	0.952	2.428
6	11.35	1.6	20	40	1.115	3.033
7	13.35	1.5	19	40	1.056	2.692
8	15.35	1.3	11	40	0.620	1.369
9	17.35	1.1	9	40	0.511	0.955
10	19.35	1	3	40	0.184	0.312
						14.402
Site C Discharge Measurments 4-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	2.4	1.1	9	40	0.511	0.955
2	6.4	2.4	12	40	0.674	2.750
3	8.4	2.5	28	40	1.549	6.583
4	10.4	2.4	44	40	2.417	9.861
5	12.4	2.5	51	40	2.797	11.886
6	14.4	2.6	55	40	3.014	13.321
7	16.4	2.3	60	40	3.290	12.864
8	18.4	2.3	48	40	2.636	10.307
9	20.4	1.3	19	40	1.056	2.333
10	22.4	1.1	13	40	0.729	1.362
						72.222
Site C Discharge Measurments 5-10-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	4.4	1	6	40	0.347	0.590
2	5.4	1.1	12	40	0.674	1.260
3	6.4	1.3	11	40	0.627	1.385
4	7.4	1.4	14	40	0.790	1.879
5	8.4	1.5	17	40	0.952	2.428
6	9.4	1.7	32	40	1.766	5.104
7	10.4	1.1	30	40	1.655	3.095
8	11.4	1.3	28	40	1.546	3.417
9	12.4	0.9	19	40	1.056	1.615
10	13.4	0.9	10	40	0.565	0.864
						21.637
Site C Discharge Measurments 8-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	4	0.1	0	40	0.020	0.003
2	4.85	0.4	3	40	0.184	0.125
3	5.7	0.7	3	40	0.193	0.229
4	6.5	0.6	6	40	0.356	0.363
5	7.4	0.55	4	40	0.247	0.231
6	8.25	0.4	8	40	0.464	0.316
7	9.1	0.3	7	40	0.402	0.205
8	9.9	0.4	5	40	0.293	0.199
9	10.8	0.4	0	40	0.020	0.014
10	11.6	0.15	0	40	0.020	0.005
						1.689

Site C Discharge Measurments 10-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.8	3.4	55	40	3.018	17.441
2	5.4	4.5	95	40	5.198	39.761
3	9	5.1	109	40	5.943	51.528
4	12.6	6.9	125	40	6.811	79.896
5	16.2	7.5	127	40	6.920	88.227
6	19.8	8.4	131	44	6.491	92.687
7	23.4	7.8	125	40	6.833	90.599
8	27	7.7	110	40	6.015	78.736
9	30.6	6.5	97	40	5.307	58.637
10	34.2	2.9	35	40	1.928	9.503
						607.014

Site D Discharge Measurments 2-28-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	2.8	0.1	3	40	0.184	0.031
2	3.8	0.4	6	40	0.347	0.236
3	4.8	0.7	9	40	0.518	0.617
4	5.8	0.8	11	40	0.627	0.852
5	6.8	0.5	12	40	0.681	0.579
6	7.8	1.1	12	40	0.681	1.273
7	8.8	0.8	12	40	0.674	0.917
8	9.8	0.2	7	40	0.402	0.137
9	10.8	0.2	6	40	0.347	0.118
10	11.8	0.15	3	40	0.184	0.047
						4.806
Site D Discharge Measurments 4-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	2.4	0.3	4	40	0.238	0.121
2	3.6	0.7	6	40	0.347	0.413
3	4.8	1	9	40	0.518	0.881
4	6	1	11	40	0.627	1.065
5	7.2	1	12	40	0.681	1.158
6	8.4	1.1	15	40	0.844	1.578
7	9.6	1.1	17	40	0.947	1.770
8	10.8	1.2	9	40	0.511	1.041
9	10.8	0.6	7	40	0.402	0.410
10	12	0.4	4	40	0.238	0.162
						8.599
Site D Discharge Measurments 5-10-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.8	0.1	1	40	0.075	0.013
2	2.6	0.2	3	40	0.184	0.062
3	3.4	0.3	3	40	0.193	0.098
4	4.2	0.5	8	40	0.464	0.394
5	5	0.5	11	40	0.627	0.533
6	5.8	0.4	12	40	0.681	0.463
7	6.6	0.4	11	40	0.620	0.421
8	7.4	0.4	8	40	0.456	0.310
9	8.2	0.4	2	40	0.129	0.088
10	9	0.15	2	40	0.129	0.033
						2.416
Site D Discharge Measurments 8-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1	0.1	0	40	0.020	0.003
2	1.6	0.2	3	40	0.184	0.062
3	2.2	0.3	4	40	0.247	0.126
4	2.8	0.4	5	40	0.301	0.205
5	3.4	0.5	6	40	0.356	0.302
6	4	0.4	7	40	0.410	0.279
7	4.6	0.3	5	40	0.293	0.149
8	5.2	0.3	3	40	0.184	0.094
9	5.8	0.4	2	40	0.129	0.088
10	6.4	0.15	0	40	0.020	0.005
						1.313

Site D Discharge Measurments 10-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	3.1	4	10	40	0.565	3.842
2	5.1	4.5	17	40	0.947	7.241
3	7.1	5.1	20	40	1.115	9.667
4	8.1	5.3	20	40	1.115	10.046
5	10.1	5.3	25	40	1.386	12.490
6	12.1	5.4	29	40	1.603	14.718
7	14.1	4.7	18	40	1.001	7.998
8	16.1	3.9	15	40	0.838	5.553
9	18.1	4.1	10	40	0.565	3.938
10	20.1	3.7	7	40	0.402	2.525
						78.018

Site E Discharge Measurments 2-28-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	2.5	0.5	5	40	0.293	0.249
2	3.35	0.7	8	40	0.456	0.543
3	4.2	1.2	13	40	0.735	1.500
4	5.05	1.3	14	40	0.790	1.745
5	5.9	1.2	14	40	0.790	1.611
6	6.75	1.2	16	40	0.898	1.832
7	7.6	1	17	40	0.947	1.609
8	8.45	1	12	40	0.674	1.146
9	9.3	0.8	9	40	0.511	0.694
10	10.15	0.4	7	40	0.402	0.273
						11.201
Site E Discharge Measurments 4-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.9	0.55	12	40	0.674	0.630
2	2.6	0.7	12	40	0.674	0.802
3	3.3	0.9	10	40	0.573	0.876
4	4	1	14	40	0.790	1.342
5	4.7	1	19	40	1.061	1.803
6	5.4	1	18	40	1.007	1.711
7	6.1	0.8	17	40	0.947	1.287
8	6.8	0.7	14	40	0.783	0.932
9	7.5	0.7	13	40	0.729	0.867
10	8.2	0.3	12	40	0.674	0.344
						10.594
Site E Discharge Measurments 5-10-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	2	0.2	5	40	0.293	0.099
2	2.6	0.3	5	40	0.293	0.149
3	3.2	0.4	5	40	0.301	0.205
4	3.8	0.3	6	40	0.356	0.181
5	4.4	0.4	8	40	0.464	0.316
6	5	0.2	9	40	0.518	0.176
7	5.6	0.1	9	40	0.511	0.087
8	6.2	0.1	6	40	0.347	0.059
9	6.8	0.1	7	40	0.402	0.068
10	7.4	0.1	6	40	0.347	0.059
						1.400
Site E Discharge Measurments 5-10-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.8	0.1	5	42	0.280	0.048
2	2.3	0.2	5	42	0.280	0.095
3	2.8	0.3	5	42	0.288	0.147
4	3.3	0.3	6	42	0.340	0.173
5	3.8	0.3	8	44	0.425	0.217
6	4.4	0.2	9	44	0.474	0.161
7	4.8	0.1	9	42	0.487	0.083
8	5.3	0.1	6	42	0.331	0.056
9	5.8	0.1	7	42	0.383	0.065
10	6.3	0.1	6	42	0.331	0.056
						1.101

Site E Discharge Measurments 10-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	2.6	4.7	14	40	0.783	6.256
2	4.4	4.9	17	40	0.947	7.884
3	6.2	5.1	23	40	1.278	11.078
4	8	5.3	25	40	1.386	12.490
5	9.8	5.5	33	40	1.820	17.019
6	11.6	6.4	40	40	2.200	23.936
7	13.4	5.7	34	40	1.873	18.149
8	15.2	4.9	25	40	1.383	11.516
9	17	4.7	18	40	1.001	7.998
10	18.8	4.5	9	40	0.511	3.905
						120.233

Site F Discharge Measurments 2-28-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.2	0.4	2	40	0.129	0.088
2	2	0.4	5	40	0.293	0.199
3	2.8	0.6	10	40	0.573	0.584
4	3.6	0.8	17	40	0.952	1.295
5	4.4	0.7	10	40	0.573	0.681
6	5.2	0.7	7	40	0.410	0.488
7	6	0.5	10	40	0.565	0.480
8	6.8	0.5	9	40	0.511	0.434
9	7.6	0.4	6	40	0.347	0.236
10	8.4	0.3	2	40	0.129	0.066
						4.550
Site F Discharge Measurments 4-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.4	0.3	2	42	0.124	0.063
2	2.25	0.4	6	40	0.347	0.236
3	3.1	0.6	10	40	0.573	0.584
4	3.95	1	16	40	0.898	1.527
5	4.8	0.9	16	40	0.898	1.374
6	5.65	0.9	10	40	0.573	0.876
7	6.5	1	9	40	0.511	0.868
8	7.35	0.5	9	40	0.511	0.434
9	8.2	0.5	6	40	0.347	0.295
10	9.05	0.3	4	42	0.228	0.116
						6.372
Site F Discharge Measurments 5-10-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	3.3	0.1	1	42	0.072	0.012
2	4.05	0.1	6	42	0.331	0.056
3	4.8	0.2	8	40	0.464	0.158
4	5.55	0.3	10	40	0.573	0.292
5	6.3	0.35	10	40	0.573	0.341
6	7.05	0.4	10	40	0.573	0.389
7	7.8	0.3	8	40	0.456	0.233
8	8.55	0.2	9	40	0.511	0.174
9	9.3	0.1	3	42	0.176	0.030
10	10.05	0.1	2	42	0.124	0.021
						1.705
Site F Discharge Measurments 8-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	4	0.1	2	20	0.238	0.040
2	4.45	0.15	5	40	0.293	0.075
3	4.85	0.2	7	40	0.410	0.139
4	5.3	0.2	6	40	0.356	0.121
5	5.75	0.25	9	40	0.518	0.220
6	6.2	0.2	9	40	0.518	0.176
7	6.65	0.2	7	40	0.402	0.137
8	7.1	0.2	9	40	0.511	0.174
9	7.55	0.1	4	40	0.238	0.040
10	8	0.1	1	40	0.075	0.013
						1.135

Site F Discharge Measurments 10-21-2006						
Measurment	Distance (ft)	Depth (ft)	Rotations	Time (s)	Velocity	Discharge (cfs)
1	1.8	1.7	12	40	0.674	1.948
2	4.14	1.9	17	40	0.947	3.057
3	6.44	2.1	23	40	1.278	4.562
4	8.74	2.4	26	40	1.441	5.877
5	11.04	2.5	33	40	1.820	7.736
6	13.34	2.4	36	40	1.983	8.091
7	15.64	2.7	30	40	1.655	7.596
8	17.94	2.9	22	40	1.219	6.010
9	20.24	2.7	18	40	1.001	4.595
10	22.52	1.5	6	40	0.347	0.885
						50.356

APPENDIX C

SPRING INVENTORY LOCATIONS

Date	Spring Number	Location (Latitude)	Location (Longitude)
9/28/2006	Sp 1	33.40009 N	89.11470 W
9/28/2006	Sp 2	33.40098 N	89.11487 W
9/28/2006	Sp 3	33.40090 N	89.11468 W
9/28/2006	Sp 4	33.40124 N	89.11833 W
9/28/2006	Sp 5	33.40092 N	89.11863 W
9/28/2006	Sp 6	33.40095 N	89.11877 W
9/28/2006	Sp 7	33.40094 N	89.11852 W
9/28/2006	Sp 8	33.40098 N	89.11837 W
9/28/2006	Sp 9	33.40058 N	89.11835 W
9/28/2006	Sp 10	33.40046 N	89.11832 W
9/28/2006	Sp11	33.40033 N	89.11830 W
9/28/2006	Sp12	33.40029 N	89.11822 W
9/28/2006	Sp 13	33.40017 N	89.11824 W
9/28/2006	Sp 14	33.40015 N	89.11827 W
9/28/2006	Sp 15	33.40016 N	89.11783 W
9/28/2006	Sp 16	33.39986 N	89.11912 W
9/28/2006	Sp 17	33.39884 N	89.11912 W
9/28/2006	Sp 18	33.39884 N	89.11898 W
9/28/2006	Sp 19	33.39861 N	89.11822 W
9/28/2006	Sp 20	33.39772 N	89.11788 W
10/5/2006	Sp 21	33.38770 N	89.12545 W
10/5/2006	Sp 22	33.38814 N	89.12592 W
10/5/2006	Sp 23	33.38834 N	89.12603 W
10/5/2006	Sp 24	33.38888 N	89.12591 W
10/5/2006	Sp 25	33.38891 N	89.12607 W
10/5/2006	Sp 26	33.38956 N	89.12600 W
10/5/2006	Sp 27	33.38976 N	89.12652 W
10/5/2006	Sp 28	33.38985 N	89.12628 W