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Hydrogeological Assessment for a Suitable Location of a Reservoir Lake in George County, Mississippi

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Hydrogeological assessment for a suitable location of a reservoir lake in George County,

Mississippi

By

Corey Tanner Ladner

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The construction of a reservoir lake was proposed in 2010 for George County, Mississippi, USA. The proposed reservoir would be designed to serve primarily for industrial water storage. As the preliminary portion of the reservoir project, a baseline watershed assessment was performed for the purpose of identifying a reservoir site with potential to fill a lake volume capable of providing a sufficient water supply to prevent the Pascagoula River near Graham Ferry, Mississippi from dropping below a measured 7Q10 base flow when 100 million gallons of water per day are withdrawn from the river for industrial use. The initial focus of the assessment was on three watersheds Big Creek, Big and Little Cedar Creek, and Escatawpa River. Evaluations of surface water quantity and quality measurements along with reservoir daily water storage models suggested two reservoirs were suitable for continuation of the reservoir project.

DEDICATION

This thesis is dedicated to my family and friends for all their love, prayers, and support throughout my graduate study.

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CHAPTER I

INTRODUCTION

The Mississippi construction of a reservoir lake was proposed in 2010 for George County, Mississippi, USA. The proposed reservoir would be designed to serve primarily for industrial water storage. Assuming that the reservoir is constructed, it would be implemented to supplement water withdrawal for industrial use near Graham Ferry, Mississippi. Historically, the industrial water withdrawals from the Pascagoula River near Grahman Ferry were supplemented by discharges from Okatibbee Lake located in Lauderdale, Mississippi. However, the water volumes discharged from Okatibbee Lake have proven to be inefficient, suffering major volume loss to evaporation and stream bank storage over the distance traveled to Graham Ferry, posing the need for a closer storage reservoir.

As a part of the preliminary work for this reservoir project, personnel of Mississippi State University Department of Geosciences were contracted to perform a baseline watershed assessment for the purpose of identifying a reservoir site with potential to fill a lake volume capable of providing a sufficient water supply to prevent the Pascagoula River near Graham Ferry, Mississippi from dropping below a measured 7Q10 base flow when 100 million gallons of water per day are withdrawn from the river for industrial use. The initial focus of the assessment was on three watersheds that were identified as having potential for large volume water supply. These watersheds (Figure

4) consisted of the Big Cedar Creek, Big Creek, and Escatawpa River, which lie within the Pascagoula River Drainage Basin (Figure 3). Each of these watersheds were assessed by surface water quantity measurements, surface water quality measurements, continuous real-time stream monitoring. Additionally, a spring inventory and evaluation was performed on the Big Creek and Big and Little Cedar Creek watersheds. Following the field study, reservoir footprints and storage models were constructed to aid in determining the suitability of each watershed. At the completion of the watershed assessment, the hydrogeologic suitability of each of the three watersheds was evaluated and presented for the continuation of the reservoir project.

CHAPTER II

SETTING

Location and Population

The study area, George County, Mississippi, USA, is located in the extreme southeastern portion of the state as shown in Figure 1. According to the U.S. Census Bureau, the population of George County in 2010 was recorded as 22,600 (U.S. Census Bureau, 2013). The county area measures 483 square miles, having an approximate maximum north-south boundary of 18 miles and maximum east-west boundary of 28 miles (Southern, 2007; Williams et. al, 1967). The county is located to the west of Mobile, Alabama, southeast of Hattiesburg, Mississippi, and north of the Mississippi Gulf Coast city Pascagoula. The main transportation corridors passing through the county to the north and south are U.S. Highway 98 and State Highway 63. State Highway 26 enters into the county from the east and ends in the town of Lucedale, the only incorporated municipality within the County (Southern, 2007).

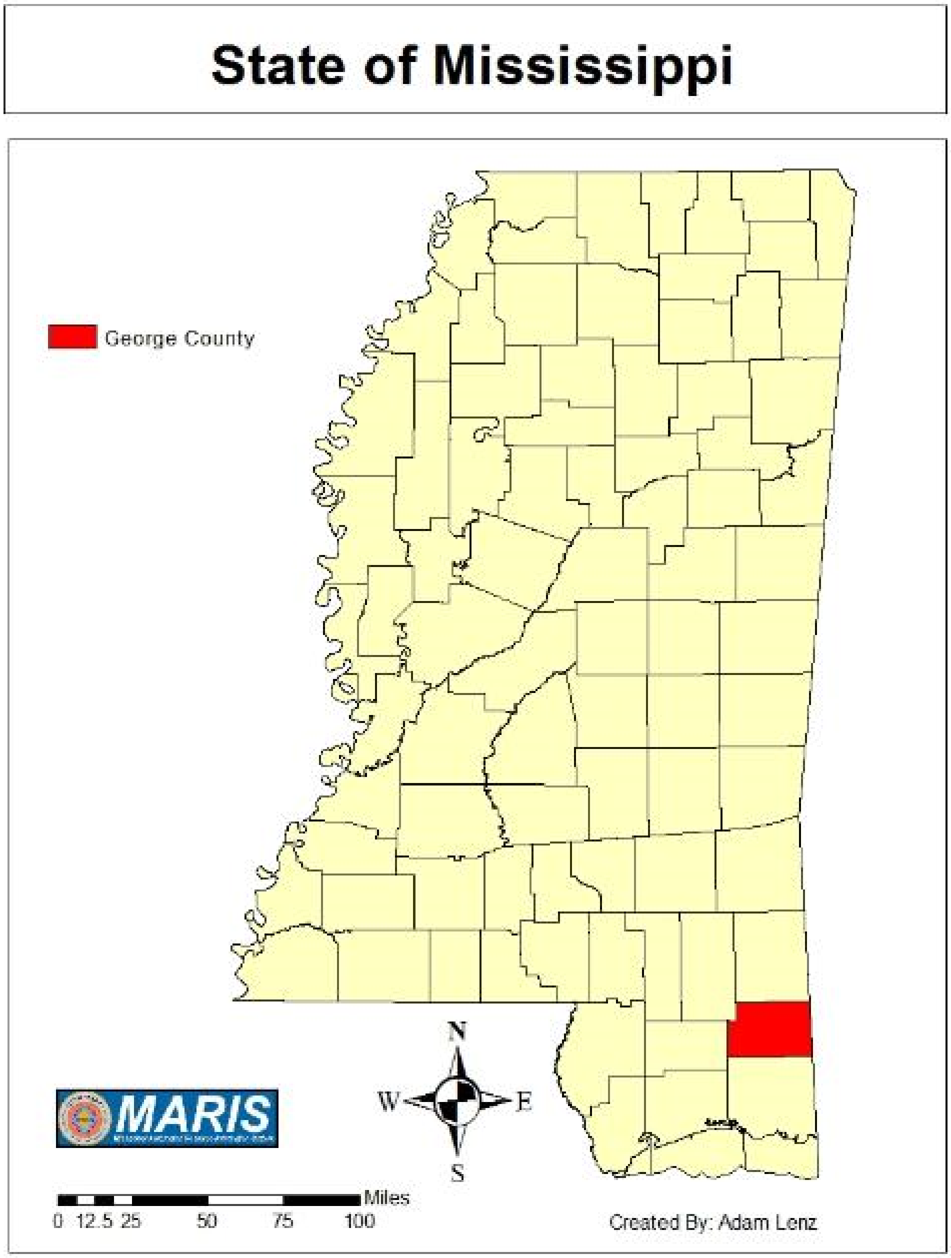

Figure 1 Map of Counties in the state of Mississippi

Land Use

Historically, George County is described by Williams et. al, 1967 as being predominantly used for agricultural produce of livestock, tung, pecan, fruit, and row crops. The 1960 census classified 30.4 percent of the county's land area as farmland (Williams et. al, 1967). More Recently, the Southern Mississippi Planning and Development District reported that 80 percent of the land in George County is classified as timber, open, or agriculture use and an estimated 72 percent of the county's land area consists of commercial forests (Southern, 2007).

Physiography

Mississippi is a portion of the physiographic lowland bordering the Gulf of Mexico identified as the Gulf Coastal Plain Province. Of the twelve subdivisions within Mississippi, George County is located within the Piney Woods physiographic unit, which was once forested by long-leaf pines until deforestation in the early nineteen hundreds. The Piney Woods unit is bounded by the Vicksburg Hills unit to the north and the Coastal Meadows unit to the south (Williams et. al, 1967).

Topography

George County topography is described as gently rolling with moderate hills, forming two distinct features: uplands and lowlands. These topographic features are strongly influenced by the more resistant sandy beds of the Citronelle formation that overlap the less resistant clay beds of the Pascagoula formation. The flat surfaces of the Critronelle uplands with altitudes greater than 200 feet often contain small depressions that retain surface water with eventual recharge into the underlying sands. The land surface has been dissected by streams draining in an elaborate dendritic pattern. The elevation of George County ranges from 320 feet above sea level in the northeast to 20 feet above sea level along the extensive bottomlands of the Pascagoula River in the south, giving the county a total relief of about 300 feet (Williams et al., 1967; Harvey et al., 1965).

Climate

George County being located within the Mississippi Gulf Coastal Plain region (Figure 2), is influenced by the coastal semitropical climate. The humid and semitropical climate of Mississippi is predominantly controlled by the vast North America landmass to the north, the Gulf of Mexico to the south, and the subtropical latitudinal position (Williams et al., 1967; Harvey et al., 1965).

The National Climate Data Center (NCDC) weather station located in Merrill, Mississippi was referenced for the following weather descriptions. Merrill, Mississippi is located within George County nearly nine miles to the northeast of Lucedale, Mississippi. The weather data provided in table 1 was produced from a 97 year record (1905 – 2002) obtained from the NCDC. The average maximum temperatures range from 60.3 to 92.7 degrees Fahrenheit. The average minimum temperatures range from 35.5 to 68.6 degrees Fahrenheit. Average monthly precipitation amounts range from 2.93 to 7.05 inches (Southern, 2013).

Table 1 Merrill, Mississippi NCDC Weather Station Data (1905 - 2002)

	Max. Temperature (°F)	Min. Temperature (°F)	Avg. Temperature (°F)	Normal Precipitation (inches)
Jan	60.3	35.5	47.9	6.86
Feb	65	37.9	51.5	5.76
Mar	72.3	45.4	58.9	7.05
Apr	78.6	50.7	64.7	5.02
May	85.4	58.6	72	6.15
Jun	90.8	65.3	78.1	4.72
Jul	92.7	68.6	80.7	6.72
Aug	92.4	67.7	80.1	4.66
Sep	88.7	62.9	75.8	4.92
Oct	80.3	49.9	65.1	2.93
Nov	70.6	42.1	56.4	5.32
Dec	62.6	36.6	49.6	5.11
Annual	78.3	51.8	65.1	65.22

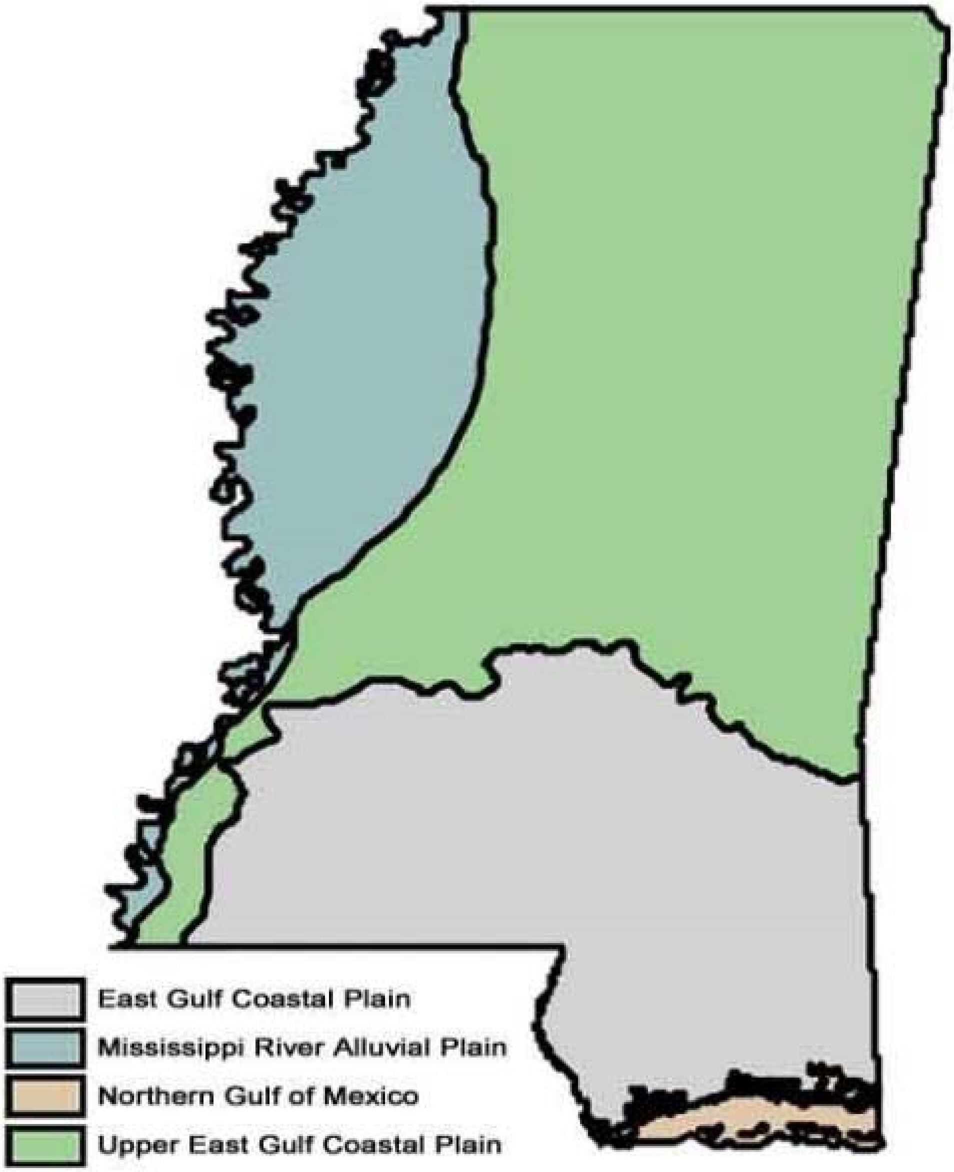

Figure 2 Physiographic Units within Mississippi

Hydrology

George County lies within the Pascagoula River Drainage Basin (Figure 3) with the Pascagoula and Escatawpa Rivers being the largest streams flowing through the county. In total area, the Pascagoula drains approximately 9,400 square miles. The Leaf and Chickasawhay Rivers join the Pascagoula near Merrill, Mississippi in the Northwest portion of George County. The stream channel of the Pascagoula River is generally straight apart from minor meanders within its floodplain. The three watersheds (Figure 4) that are the focus of the watershed assessment, Big Creek, Big and Little Cedar Creek, and Escatawpa River, all drain in a overall southwestward direction and empty into the Pascagoula River. The Escatawpa River watershed drains an area of about 1,000 square miles. Escatawpa's headwaters begin in Washington County, Alabama and the river enters into George County about 55 miles downstream. The Big Creek and Big and Little Cedar Creek watersheds have drainage areas of 51.2 and 73.8 square miles, which both lie solely within George County (Williams et al., 1967; Harvey et al., 1965).

Precipitation is the predominant source of freshwater within George County. The portion of precipitation that is not retained by lakes, swamps, or vegetation enters into streams or seeps into the ground. Water captured by the ground either adheres to the soil or percolates down into groundwater systems, some of which eventually returns to the surface as seeps or springs. In the event of extended periods of drought, the flow from these seeps and springs account for the majority of the water supplied to streams in the area (Williams et al., 1967; Harvey et al., 1965).

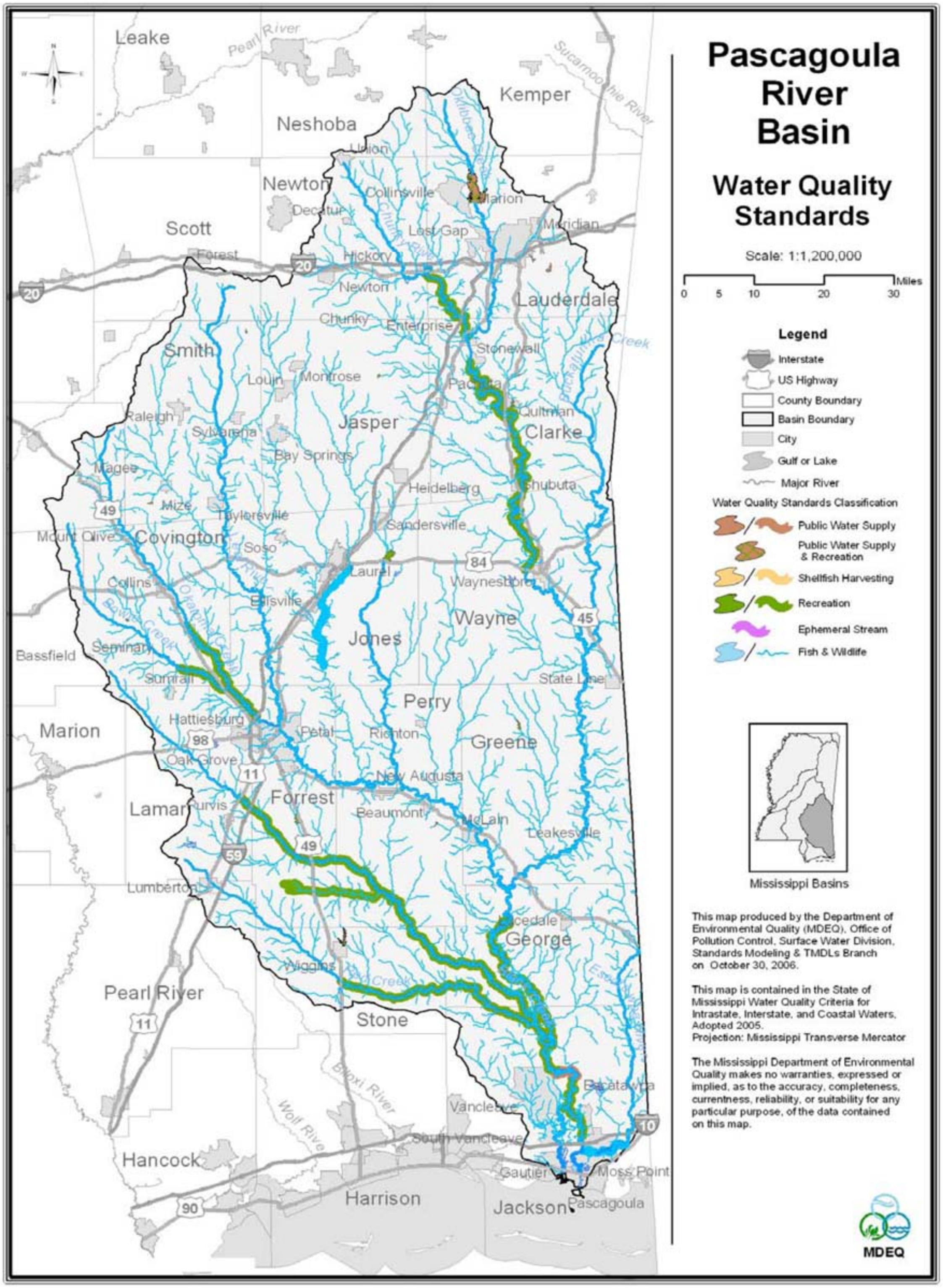

Figure 3 Pascagoula River Basin Boundary

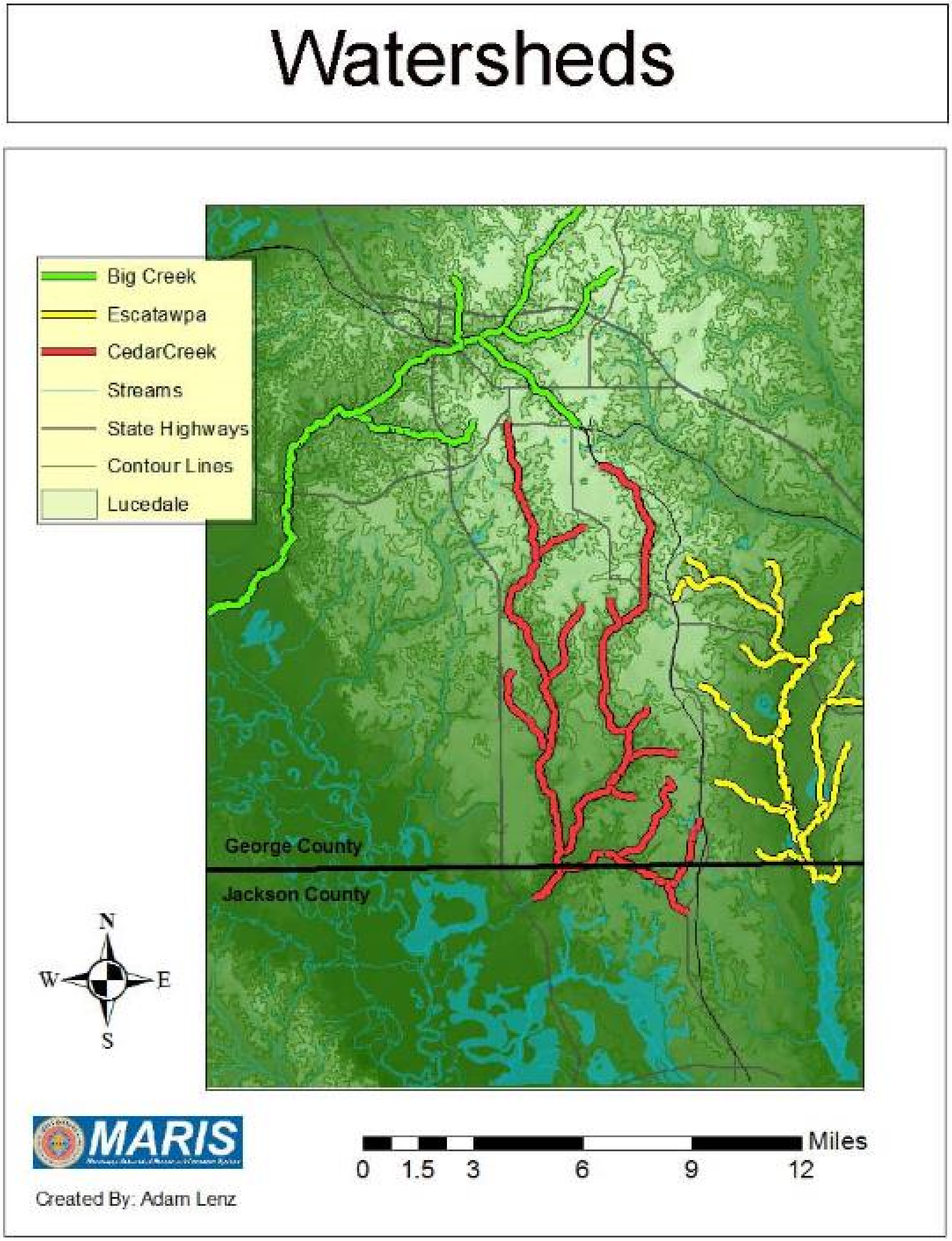

Figure 4 Watersheds investigated in the study area

Surface Geology

The geologic units exposed in George County range from Miocene to Recent. In ascending order, units consist of Miocene Pascagoula Formation, Pleistocene Citronelle Formation and Low Terrace Deposits, and present day alluvium deposits. The Pascagoula Formation unconformably overlies the Miocene Hattiesburg Formation and the Citronelle Formation is reported to be unconformable to the Pascagoula Formation. Topographic highs and uplands formed on sediments more resistant to erosion, where as the lowlands resulted from less resistant sediments. Williams et al. (1967) divides the county into uplands and lowlands. The uplands are described as being confined to Citronelle sand, gravel, and clay lenses along with high terrace deposits. The lowlands are described as a composite of the clays and sand beds of the Pascagoula unit, clay, silt, sand, and gravel beds of the Low Terrace deposits, and alluvium deposits. There are three levels of low terraces formed in George County and are thought to be related to inter-glacial phases of the Pleistocene epoch (Williams et al., 1967).

Structural Geology

Regionally, George County is positioned near several historic geologic features as shown in Figure 5. Rifting associated with the breakup of Pangea began the formation of the Gulf of Mexico during the late Triassic. The Gulf of Mexico basin formed on a divergent margin that was exposed to tectonic rifting and wrench faulting along with phases of crustal extension, sea-floor spreading, and thermal subsidence. Extensive east-west trending Jurrassic normal faults, such as the Lower Mobile Bay fault system present in offshore Alabama, extend upward into Cretaceous units (Mancini et al., 1992). As a result of Late Paleozoic continental collision and late Triassic - early Jurassic rifting, basement highs and lows were formed. The positive basement features are continental blocks formed by rifting and the negative features are interpreted to be basement depressions that formed from crustal extension between the continental blocks. The basement surface was dissected by wrench faults and associated grabens (Mancini et al., 1999). Widespread salt movement during the Jurassic age created a complex array of salt-related structures such as diapirs, anticlines, graben systems (Mancini and Tew, 1990). Located approximately 40 miles inland from the present day Gulf of Mexico, George County is positioned at the southern most edge of the Mississippi Interior Salt Basin and East Mississippi Syncline (Figure 5). George County is located north of the axis of the Gulf Coast Geosyncline and the Lower Mobile Bay Fault System (Figure 5). The Wiggins Anticline and Arch (Figure 5) cross through the county from east to west. The Hancock Ridge (Figure 5) begins near the western border of George County and runs southwestward through Hancock County, Mississippi. The axis of the Mobile Graben (Figure #) runs north to south through Mobile County, Alabama, which lies adjacent to the eastern border of George County (Williams et al., 1967).

Locally, there is evidence of some of these structural features in the subsurface of George County. Although the geologic cross-sections of George County constructed by Williams et al. (1967) show no distinctive evidence of structural deformation or folding in the subsurface deposited above sea level, structural maps of the Lower Tuscaloosa Formation show the Wiggins Anticline plunging southwestward across George County and entering from the northeast. Williams et al. (1967) suggest that the Wiggins Anticline formed between the Late Cretaceous and Late Tertiary. The formation is explained by thick sediment accumulation and subsidence occurring early in the north to form the East Mississippi Syncline and a thinning sediment supply near George County, then with a gradual shift of the center of deposition to the south caused subsidence and development of the Gulf Coast Geosyncline. Surface evidence of the Wiggins Anticline is presented by westward nosing causing the Pascagoula river alluvial plain to be "bowed to the west in George County closely following the plunge of the Wiggins Anticline (Williams et al., 1967)."

The Mississippi Interior Salt Basin in Mississippi and Alabama was a large, subsiding depocenter throughout the Jurassic and into the early Cenozoic time (Mancini et al., 1992; Mancini and Tew, 1990). The Mobile Graben is a major subsurface salt withdrawal feature that trends north-south and defines the eastern limit of the Mississippi Interior Salt Basin. Contrary to interpretations of Williams et al. (1967), Tew et al. (1991) incorporate research of older strata to describe the Wiggins Arch and Hancock Ridge as some of the major preformed basement highs that affected the distribution and nature of sediments during the Jurassic – Mesozoic time. (Ms Salt Basin) consider the Wiggins Arch to represent an uplifted horst block related to extension and rifting of the continental margin of North America during the late Triassic. During the Jurassic, transgression of the Gulf of Mexico, the Wiggins Arch structure allowed for thick evaporites to be retained and deposited within the Mississippi Interior Salt Basin. Salt pillows were normally associated with the basin rises where as salt diapirs formed near the basin center (Tew et al., 1991). The Jurassic Smackover Formation was the earliest carbonate unit deposited in the Mississippi Interior Salt Basin during a transgression - regression cycle. However, as basin filling and regression began, the Wiggins Arch formed a platform barrier between the basin and open marine conditions resulting in the end of carbonate production and Smackover deposition within the basin. The barrier effect created by the Wiggins Arch allowed for siliciclastic, evaporitic, and carbonate deposits to form landward in the restricted environment while dense, dark micritic limestones were limited to the distal offshore ramp (Mancini et al., 1999). The Lower Mobile Fault System is a regional basement rift trend that formed in response to the breakup of Pangea and the opening of the Gulf of Mexico. The fault system is thought to have formed along with the deposition of the Late Triassic – Early Jurassic Eagle Mills Formation (Mink et al., 1991).

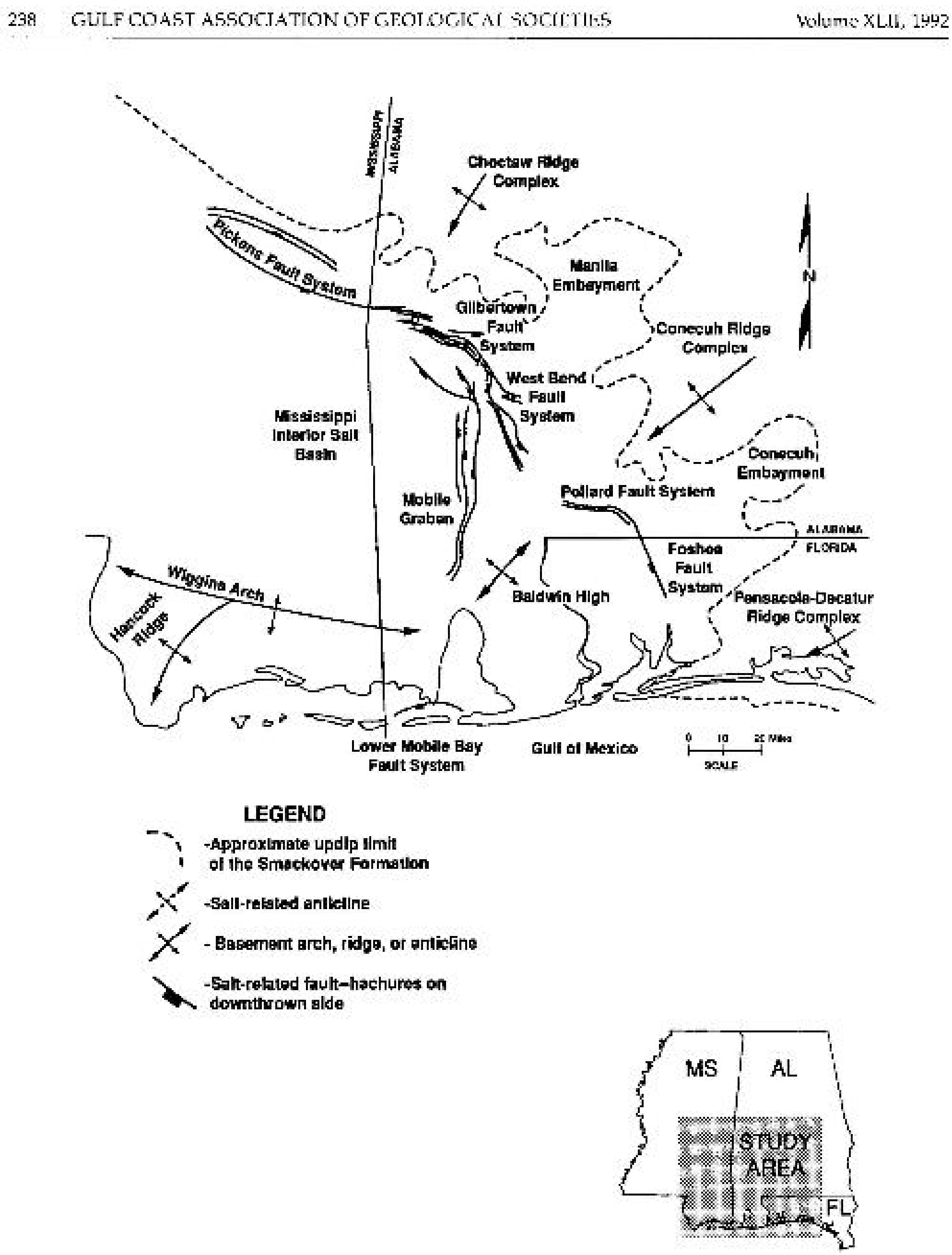

Figure 5 Locations of major structural features in the eastern Gulf Coastal Plain

Seismic Activity

The state of Mississippi has been the center of only a few earthquakes throughout history; however, the state has been affected numerous times by earthquakes originating in neighboring states. In 1811 and 1812, several earthquakes occurred along the New Madred Fault in Missouri, which were felt as far as the Mississippi Gulf Coast. Within Mississippi, the first and most severe earthquake recorded was centered near Charleston on December 16, 1931. The earthquake's shocks were observed over an area of 65,000 mile area. A minor earthquake was reported along the Mississippi Gulf Coast on February 1, 1955. Rattling of windows and creaking of buildings were the main affects witnessed along the coast. On June 4 and June 29 of 1967, two earthquakes occurred near Greenville, Mississippi. The earthquake on June 4 measured a 3.8 magnitude on the Richter Scale and affected an area of 25,000 square miles. On June 29, the second earthquake measured a magnitude of 3.4. Later, another earthquake occurred near New Madrid, Missouri on March 29, 1972 and reached an intensity of IV in northern parts of Mississippi (Von Hake, 2009). The last recorded earthquake in Mississippi occurred near the town of Olive Branch on June 2, 2008. The earthquake was given a magnitude of 2.2 and determined to be associated with the New Madrid Fault (United, 2010). Today, the New Madrid Fault system still remains the major source of future seismic activity with potential to affect Mississippi. Therefore, the United States Geological Survey currently rates George County, Mississippi with a seismic hazard of 0.02 - 0.04 g (Figure 6) (United, 2009).

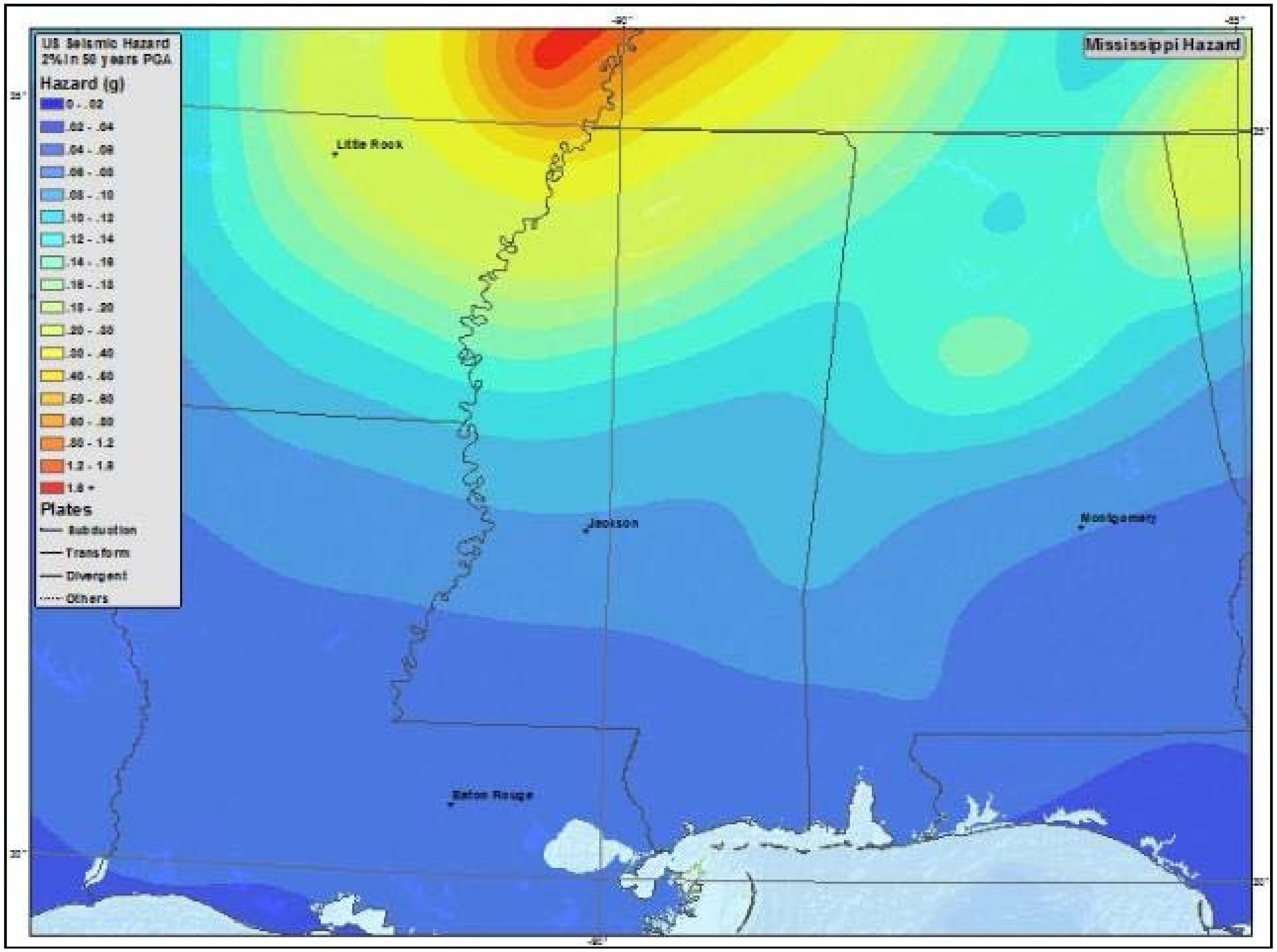

Figure 6 United States Geological Survey Mississippi Seismic Hazard Map

CHAPTER III

LITURATURE REVIEW

Brahana and Dalsin (1977) present an elaborate water assessment of George, Hancock, Pearl River, and Stone Counties in Mississippi for the purpose of industrial development. The assessment provides a description of each county's hydrologic setting including details on climate, land surface drainage, and geology. Through the water assessment, data were obtained to describe quality and quantity of surface and ground water. The Brahana and Dalsin discuss surface water in terms of stream flow characteristics and surface water quality, while also addressing ground water sources, quality, and supply potential prior to 1977. Numerical values for drainage area, low flow, minimum discharge, and chemical analysis of streams within George County are presented in this work. Brahana and Dalsin describe the subsurface of George County as undifferentiated Miocene deposits overlain by Pliocene Citronelle Formation. The Miocene age bedded sands and clays are reported to range up to 1,700 feet in depth and are known to form vast reservoirs for groundwater, which can exist from the surface to a depth of 1,000 feet below sea level. Stream dissection of the Citronelle Formation is thought to have allowed for constant drainage of sediments to maintain base flow of the streams. Within George County, Brahana and Dalsin determined that the Miocene aquifers were the most dependable groundwater sources and are capable of supplying 25 million gallons per day.

Carlson and Archfield (2009) preformed a hydrogeological investigation and firm-yield assessment for J.B Converse Lake, Mobile County, Alabama in order to address "concerns regarding the ability of the reservoir to meet current and future water demands during drought conditions." The study involved the investigation of hydrogeological conditions of the lake and the use of a firm-yield estimator to predict the limitations for rate of withdrawal from the reservoir during recorded drought conditions. Being located in climate, geography, and geology similar to George County, Mississippi, J. B. Converse Lake will serve as an applicable template for the site selection and construction of the proposed reservoir in George County, Mississippi. The hydrogeological description, reservoir characterization, and firm yield results presented for J.B Converse Lake in Carlson and Archfield's study is applicable to the George County Watershed Assessment.

The Mississippi Engineering Group, Inc. (2007) developed the Mississippi Gulf Water and Wastewater Plan on the behalf of the Mississippi Department of Environmental Quality, in order to address the deficiencies of the water resources and related infrastructure in the Mississippi coastal counties following the devastation of Hurricane Katrina. Although the plan was created for enhancement of municipal water usage, it is a valuable reference for the George County watershed assessment and reservoir construction. Section two of the plan provides information on water management practices, historical water resource, wastewater, and storm water infrastructure. The section also depicts locations of private water wells, streams, and stream road crossings throughout George County. Locations of water and wastewater infrastructure will be considered in the proposal of the reservoir site in order to avoid any major interference that could occur in the subsurface within the reservoir boundary as a result of pre-existing infrastructure. George County water and sewer associations identified in section two will be consulted in efforts to maintain collaboration throughout the Reservoir project. The section also identifies the ten largest users of groundwater within George County, whose location and characterization will be taken into consideration for the suitability of the proposed reservoir site. An included map (Section 6, page 37) depicts locations of road, natural gas pipeline, and railroad crossings of streams as well as existing reservoir dams within the county. Section three of the plan describes historical water quality impacts as well as the recent water quality impacts of Hurricane Katrina. The plan includes a table (Section 3, page 7) of water quality impairments and Total Maximum Daily Load (TMDL) values of pollutants for water bodies and streams within the Mississippi Gulf Region. The table presents causes and sources of stream impairments as well as TMDL values for detected pollutants of Escatawpa River within George County during the years of 1999 -2000. The water quality information will be useful information to incorporate, while testing the water quality of Escatawpa River. Section four presents information on wastewater and drainage basin flow projections along with storm water runoff projections. An included table provides projected average daily flow and peak hourly flow rates for Lower Escatawpa River of George County during the years of 2005 to 2025. Flow projections will be considered in the assessment and evaluation of the Escatawpa River watershed. Section four also presents projections of developed areas and storm water runoff that existed prior to destruction of Hurricane Katrina as well as that which was predicted for the years of 2010 and 2025. The runoff values will be regarded in developing volume models to project reservoir size within each examined watershed as well as the time required for filling. Section five of the plan depicts local drainage infrastructure and regional drainage systems, as well as propositions of development and evaluation of reservoir alternatives including: purpose and need for reservoirs, previous reservoir investigations and proposed reservoir site evaluations, and maps of previously studied reservoir sites. The section identifies six reservoir investigations that have been performed within George County. The reservoir investigations were selected based on potential for domestic and industrial water supply and generating economic development.

Williams et al. (1967) has written extensively on the geomorphology, stratigraphy, and water resources of George County, Mississippi for the main purpose of interpreting the county's geology and natural resources. The geomorphology section (page 19) of this work provides information on the alluvial plains, surface drainage, surface geology, and topography of George County. The Pascagoula River and Escatawpa River are noted as the two largest streams within the county. Big Creek is identified as the main eastern tributary to the Pascagoula River within the county. The county's topographic character is divided into uplands, composed of Citronelle deposits and high terraces, and lowlands, including the Pascagoula Formation, low terraces, and alluvial deposits. The stratigraphy section of the work includes a wealth of information on the surface geology. Geological units exposed at the surface in George County include the Miocene Pascagoula Formation, Pleistocene Citronelle Formation, and alluvium deposits. As for water resources, Williams et al. (1967) discusses availability and character of groundwater and surface water supplies within George County. The major rock units reported to contain aquifers are the Catahoula, Hattiesburg, Pascagoula, Citronelle, Terraces, and Alluvium. The George County aquifers are recharged from the area extending from southern George County northward to Green and Wayne Counties. Based on the surface water quality data gathered, Williams et al. (1967) reported that George County's surface water is abundant and of good quality.

CHAPTER IV

STATEMENT OF PURPOSE

When considering a location for a reservoir site with potential to fill a lake volume capable of providing a sufficient water supply to prevent the Pascagoula River near Graham Ferry, Mississippi from dropping below a measured 7Q10 base flow when 100 million gallons of water per day are withdrawn from the river, it is important to understand the specific hydrogeological conditions of each potential watershed for the reservoir. Existing research and published literature are insufficient for the hydrogeological assessment required for the George County Reservoir Project. Previous research performed regionally does not provide detailed information on surface water flow and water quality of the Big Creek, Big Cedar Creek, and Escatawpa River watersheds within George County. Therefore, further investigation of each watershed is needed to fulfill the requirements of the Reservoir Project.

CHAPTER V

OBJECTIVES

The objectives of the research were to conduct a baseline watershed assessment in order to identify one preferred, and one alternative, reservoir site through an extensive evaluation of surface water quantity and quality, spring inventories, and reservoir daily storage models. Water quantity and quality evaluations involved collection of flow measurements, measurements of field parameters, and laboratory chemical analysis. The reservoir modeling involved creation of lake footprints, calculation of lake volumes, and application historical climate data in daily water storages.

CHAPTER VI

HYPOTHESIS

Based on the water quality and supply information gathered through the field analysis and theoretical modeling of the watersheds, one or more of the three water watersheds will prove to be a suitable reservoir site with potential to fill a lake volume capable of providing a sufficient water supply to prevent the Pascagoula River near Graham Ferry, Mississippi from dropping below a measured 7Q10 base flow when 100 million gallons of water per day are withdrawn from the river for industrial use.

CHAPTER VII

METHODS

For each of the three watersheds (Figure 4), there were three components of research methodology for the field study portion of the watershed assessment. Each watershed was assessed by surface water quantity measurements, surface water quality measurements, and continuous real-time stream monitoring of precipitation, water column depth, and water temperature. Additionally, a spring inventory and evaluation was performed on the Big Creek and Big and Little Cedar Creek watersheds. Following the field study, reservoir footprints and storage models were constructed to aid in determining the suitability of each watershed. Surface water quantity was assessed by measurements of stream stage and flow discharge, while surface water quality was sampled via field analyses parameters and laboratory analyses of stream water samples. Collection of measurements and samples were performed at 19 chosen sites (Table 2) along bridge crossings of the Big Creek (Figure 7), Big and Little Cedar Creek (Figure 8), Escatawpa River (Figure 9), and supporting tributaries during several low, intermediate, and high flow events.

Table 2 Sampling Site Locations

Site ID	Latitude (W)	Longitude (N)
B1	30.948056	-88.595556
B2	30.934056	-88.591278
B3	30.940287	-88.626316
B3A	30.940830	-88.617259
B4	30.913314	-88.676340
B5	30.883779	-88.694931
B6	30.856836	-88.698456
CL1	30.843549	-88.531477
CL2	30.809650	-88.550147
CL3	30.749360	-88.565412
CB1	30.912626	-88.597751
CB2	30.838853	-88.594177
CB3	30.809794	-88.576126
CB4	30.810756	-88.577554
CB5	30.762549	-88.574662
CB6	30.718872	-88.589600
CB7	30.735028	-88.557565
E1	30.812020	-88.458510
E2	30.724540	-88.453980

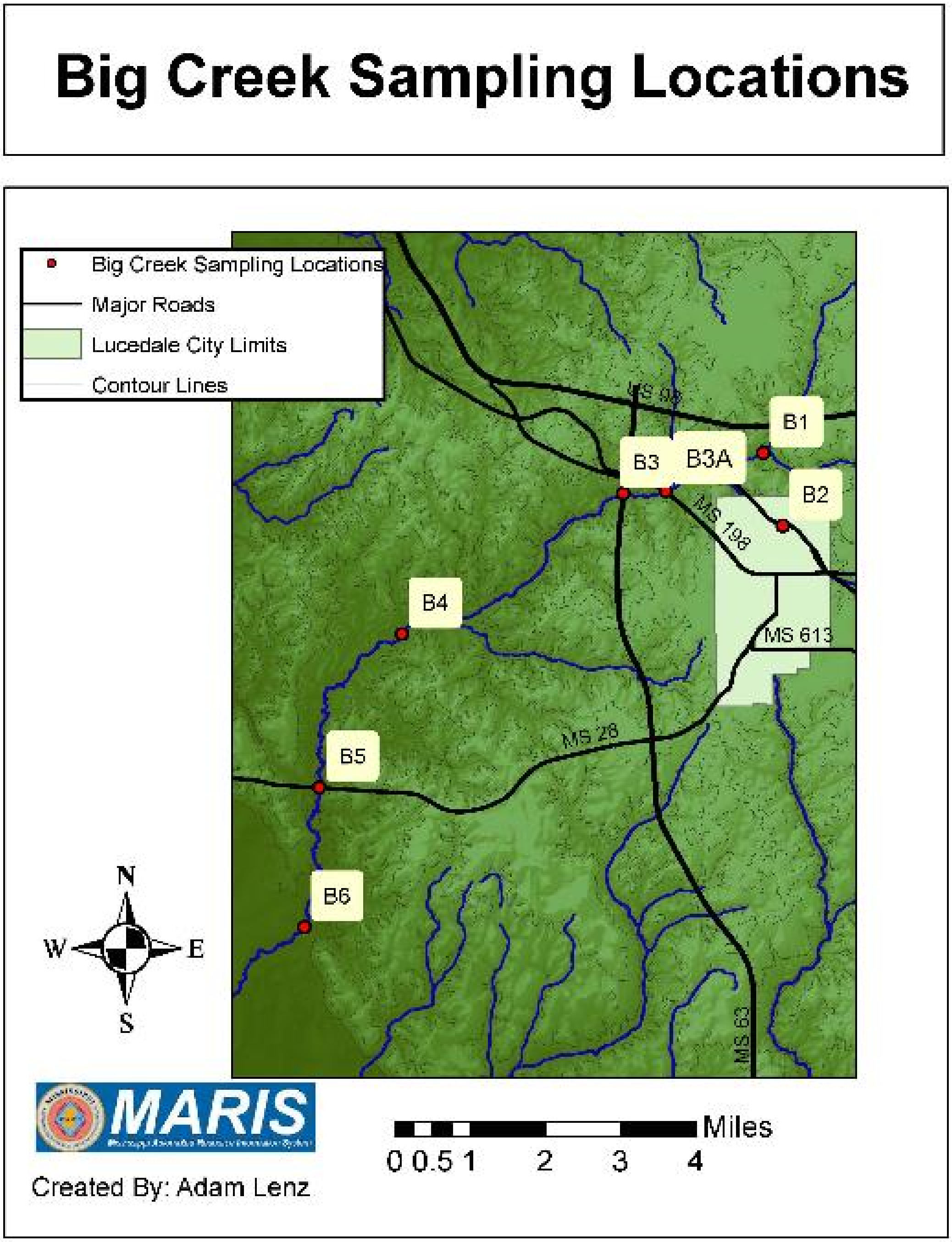

Figure 7 Sampling site locations for the Big Creek watershed

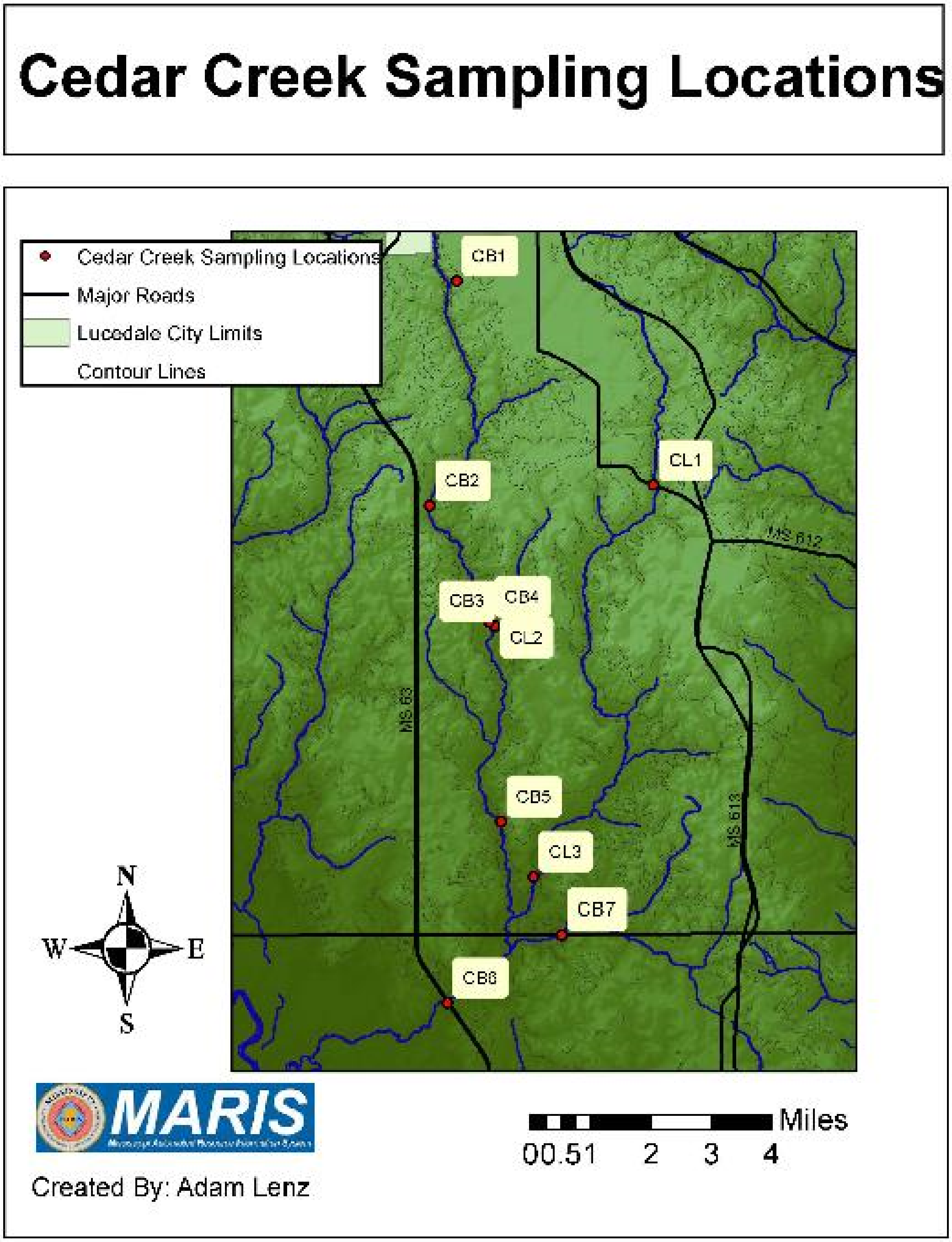

Figure 8 Sampling site locations for the Big and Little Cedar Creek watershed

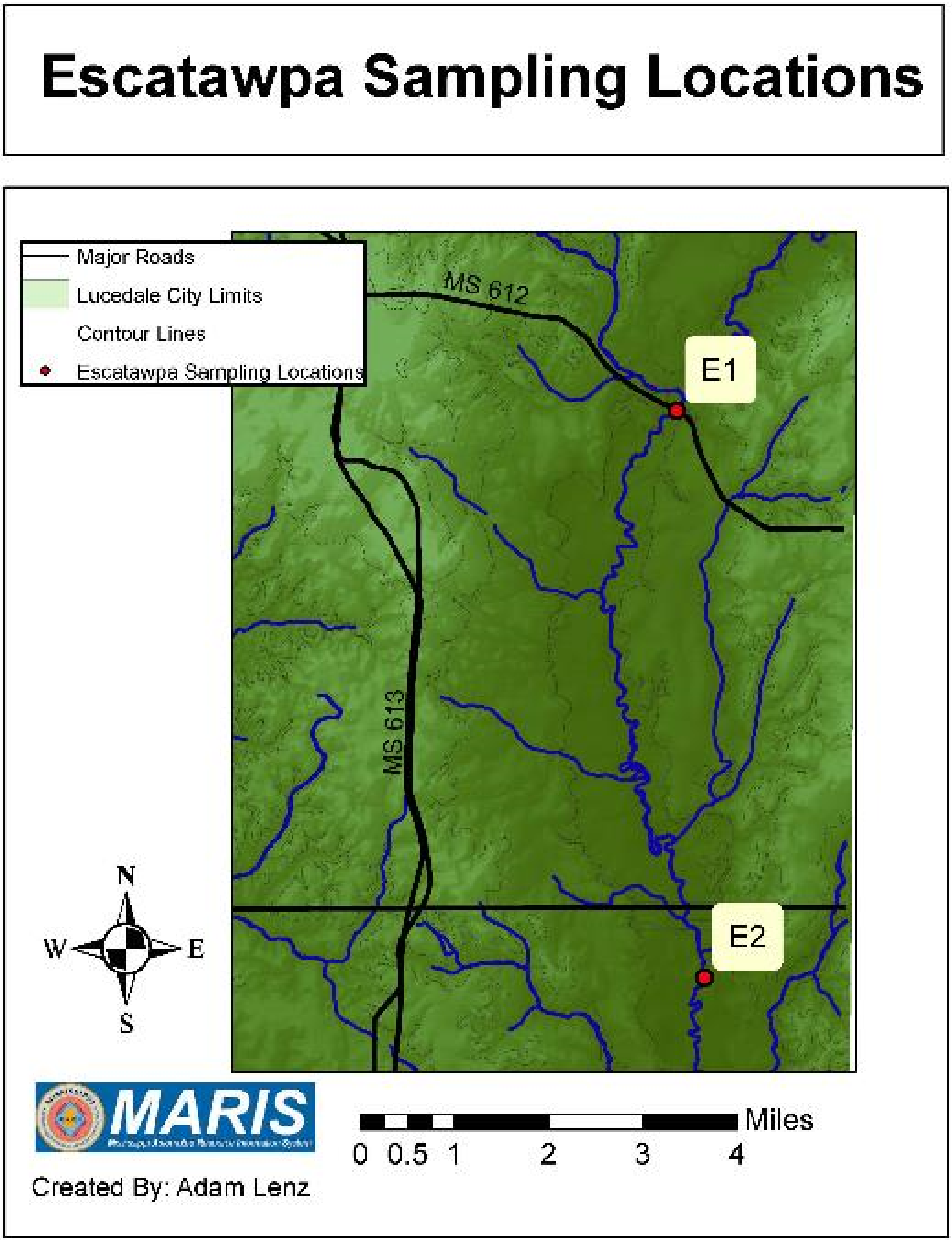

Figure 9 Sampling site locations for the Escatawpa River watershed

Surface Water Quantity Measurements

Stream stage gauge measurements were taken at each site at designated points on bridge crossings for later use in the construction of stage versus discharge hydrographs (Figure 10). Stage gauging points were clearly marked with orange paint near the middle of the stream channel on the downstream portion of culverts or bridge railings. Stage measurements were taken with the use of a DeWalt 100 foot fiberglass long tape measure attached by a carbineer to a weighted PVC pipe, allowing for more effective measurements in flowing stream settings. The weighted PVC pipe attachment required an addition of 1.2 feet to all stage measurements.

Figure 10 Measuring tape being used to measure stream stage from bridge railing

Discharge measurements were taken from cross-sections of the stream channels at each site. Three techniques for discharge measurement were used according to stream channel depth. The StreamPro RDI Acoustic Doppler unit, by Teledyne Instruments, and a Bluetooth enabled HP iPAQ Pocket PC equipped with StreamPro ADCP software was used for larger streams having a water depth not less than two feet. The Doppler unit was operated according to guidelines found in the equipment handbook (Teledyne RD Instruments, 2008). The Doppler unit uses "bottom tracking" technology to obtain stream information such as discharge, velocity, channel width, and cross-sectional area, which is recorded as files through the StreamPro ADCP software on the HP iPAQ Pocket PC (StreamPro ADCP Operational Manual, 2008). Collected data were based on the standards of four successful cross-sectional readings within 5% error or a count of eight cross-sectional readings not exceeding a 100% error. The Dopper unit was operated on the downstream portion of culverts and bridges. Figures 11 and 12 show the Doppler unit at work in the field. Files recorded on the HP iPAQ Pocket PC were later transferred to a Dell laptop PC equipped with Teledyne RDI WinRiver II software. The files were used with the WinRiver software to generate tables of the cross-sectional readings and stream channel profiles such as shown in Figures 13 - 16.

Figure 11 StreamPro RDI Dopper Unit at use in the field

Figure 12 StreamPro RDI Dopper Unit at use in the field

Detailed Discharge Tabular 1 - TRDI

Discharge (Ref: BT) Right to Left

Nmb. of Ens.	**86**	
Start Time	**10:18:00**	
Duration	**89.64**	[s]
Total Q	**575.72**	[ft³/s]
Top Q	**49.09**	[ft³/s]
Measured Q	**387.75**	[ft³/s]
Bottom Q	**129.19**	[ft³/s]
(T+M+B) Q	**566.04**	[ft³/s]
Left Dist.	**10.00**	[ft]
Left Vel.	**0.353**	[ft/s]
Left Depth	**2.25**	[ft]
Left Area	**11.26**	[ft²]
Left Q	**2.81**	[ft³/s]
Right Dist.	**5.00**	[ft]
Right Vel.	**1.183**	[ft/s]
Right Depth	**3.29**	[ft]
Right Area	**8.23**	[ft²]
Right Q	**6.88**	[ft³/s]
Width	**74.09**	[ft]
Total Area	**394.14**	[ft²]
Q/Area	**1.461**	[ft/s]
Flow Speed	**1.690**	[ft/s]
Flow Dir.	**94.99**	[°]
Course MG	**13.02**	[°]
Avg Boat Spd	**0.757**	[ft/s]
Beg Ens Nmb	**321**	
End Ens Nmb	**406**	

Figure 13 Flow Data collected by StreamPro RDI Doppler Unit

Discharge Summary - TRDI

Transect	Start Bank	# Ens.	Start Time	Total Q ft³/s	Delta Q %	Top Q ft³/s	Meas. Q ft³/s	Bottom Q ft³/s	Left Q ft³/s	Left Dist ft	Right Q ft³/s	Right Dist ft	Width ft	Total Area ft²	Q/Area ft/s	Boat Speed ft/s	Flow Speed ft/s
CL3000	Left	86	10:12:40	608.507	4.68	48.361	406.896	132.396	1.660	10.00	19.141	5.00	79.36	440.01	1.385	0.765	1.608
CL3001	Right	78	10:14:26	586.583	0.73	48.876	396.372	134.266	1.942	10.00	4.132	5.00	78.02	403.46	1.450	0.863	1.683
CL3002	Left	100	10:16:03	556.464	-4.45	43.119	370.098	114.631	0.989	10.00	26.627	5.00	74.82	426.27	1.302	0.630	1.572
CL3003	Right	86	10:18:00	576.735	-0.96	49.087	387.756	129.161	2.825	10.00	6.886	5.00	74.09	394.14	1.460	0.758	1.690
Average		87		581.324	0.00	47.366	390.280	127.618	1.854	10.00	14.196	5.00	76.57	415.97	1.399	0.749	1.638
Std Dev.		9		22.036	3.79	2.848	15.566	8.909	0.781	0.00	10.547	0.00	2.62	20.96	0.073	0.091	0.058
Std./|Avg.|		0.10		0.04	0.00	0.06	0.04	0.07	0.41	0.00	0.74	0.00	0.03	0.05	0.05	0.12	0.04

Figure 14 StreamPro RDI Doppler Unit stream flow data collected for each cross-section measured

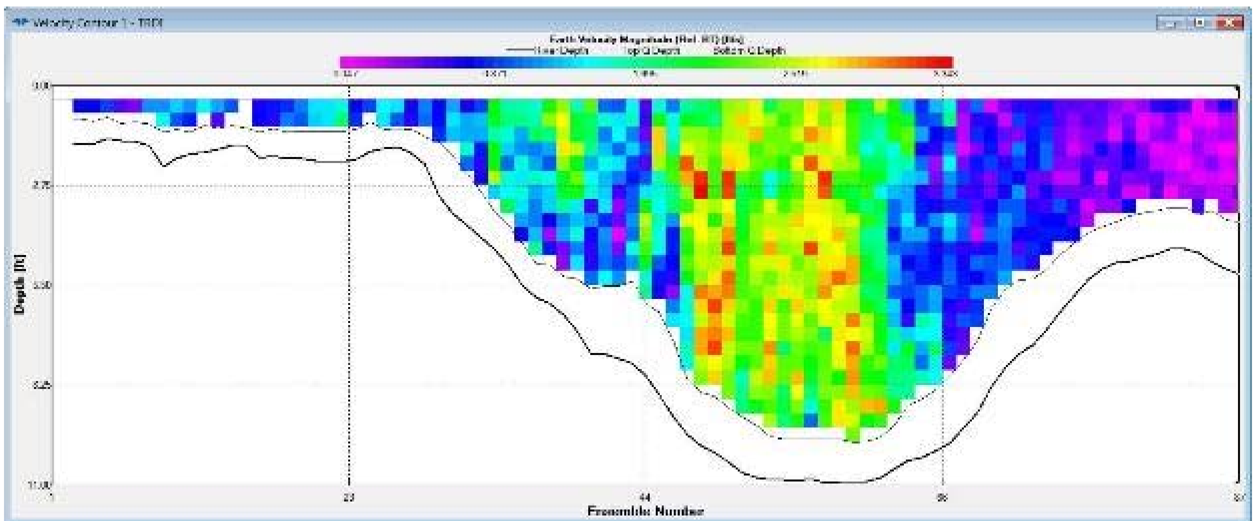

Figure 15 Graphical illustration of water flow velocity data collected for a cross-section of a strea

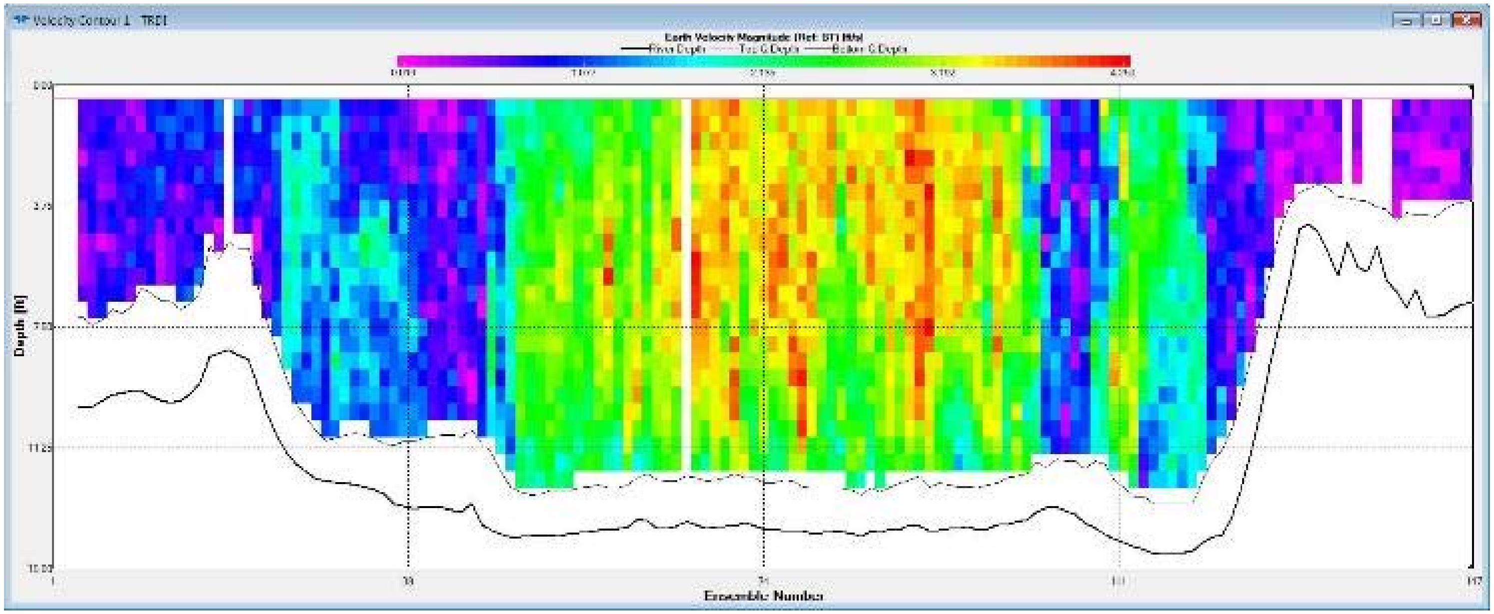

Figure 16 Graphical Illustration of water flow velocity data collected as a cross-section of a stream

In shallower streams, where the Doppler unit would not be effective, the Price AA Current Meter was used. During operation, the current meter was mounted onto a wading rod (Figure 17) and attached to a Rickly Hydrological AquaCount Digitizer (Figure 18). Instructions recommended by the United States Geological Survey were followed for collecting discharge measurements with the current meter. Current meter flow velocity measurements were taken at 10% intervals across the total stream width. A measuring tape was stretched across the stream channel to determine the total stream width and to ensure proper location of each 10% interval. Using the wading rod depth markings (Figure 19), the current meter was adjusted to the 6/10 position of the water depth at each interval location before performing a flow velocity measurement. Depth, width, and velocity values of each 10% interval were multiplied to obtain interval discharge values, which were then summed together to calculate the total discharge of the stream (Buchanan and Somers, 1969). Figure 20 shows the current meter at work in the field.

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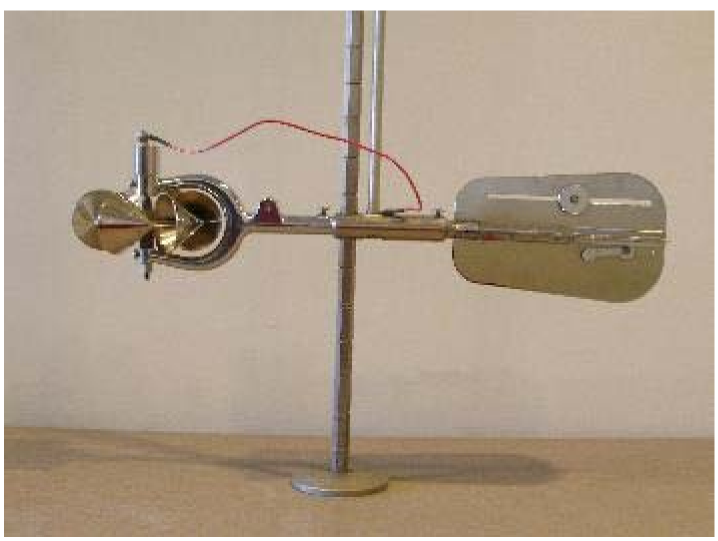

Figure 17 Price AA Current Meter mounted on a wading rod

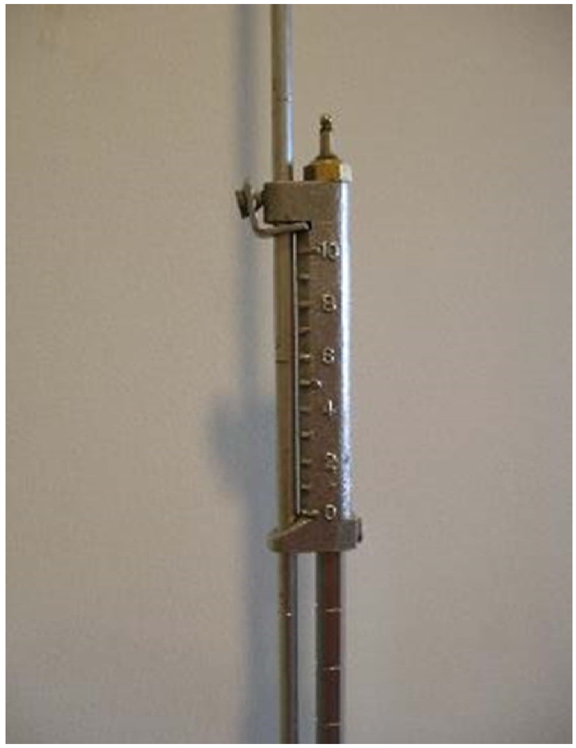

Figure 18 Rickly Hydrological AquaCount Digitizer

Figure 19 Wading rod measurement markings for current meter

Figure 20 Price AA Current Meter being used in the field

For even shallower streams that could not be measured by the current meter, an average depth, width, and flow velocity was measured by the Debris Flow Estimation Method to calculate a total discharge (Hanks et al., 2003). The estimation method involves a measurement of the total stream width and average depth of the stream. The flow velocity of debris (i.e. leaves) is timed with a stopwatch for a premeasured distance (e.g. 1 -3 feet) (McIlwain, 2007).

Surface Water Quality Measurements

For field analysis of water quality and chemistry, the equipment, as shown in Figure 21, consisted of an In-Situ Troll 9500 multi-parameter sonde connected by a 50

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foot cable to an In-Situ Ultra RuggedReader installed with Pocket-Situ 4 software. The Troll 9500 provided in-situ readings of temperature (°F), pH (s.u.), specific conductivity (μS/cm), dissolved oxygen (mg/L), turbidity (NTU). Prior to field measurement events, calibrations were performed for pH, specific conductivity, dissolved oxygen, and turbidity. A three point calibration was performed for pH, using buffer solutions of 4.0, 7.0, and 10.0. Conductivity was calibrated with a 147μS/cm solution standard. Turbidity was calibrated with standards of 0 NTU (i.e. distilled water), 10 NTU, and 100 NTU. Dissolved Oxygen was calibrated using tap water according to the air saturated with water method. The field parameters were measured from the stream channel at each of the 18 sites. The measured parameters were saved as files on the RuggedReader using the snapshot feature. Following field measurement events, the RuggedReader was docked to a desktop PC in order to download the data files.

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Figure 21 In-Situ, Inc. Troll 9500 multi-parameter sonde and handheld Rugged Reader

In addition to field measurements, stream water samples were collected and delivered to a chemical laboratory near Ocean Springs, Mississippi where they were analyzed for Acidity, Ammonia as N, Total Alkalinity, Chloride, Fluoride, Nitrate as N, Nitrite as N, Phosphorus, Sulfate as SO4, Total Kjeldahl Nitrogen, Total Dissolved Solids, Iron, Lead, Potassium, and Sodium. The laboratory provided labeled sampling bottles (Figure 22) with sample preservatives, ice chests, and chain of custody forms. Water samples were collected by an individual standing in the water on the upstream portion of the culvert or bridge at each sampling site. The sample bottles containing preservatives were filled by pouring stream water from a clean sample bottle without preservatives. For streams that did not permit in-stream sampling, a stainless steel pale and nylon rope was used to allow an individual to collect stream water while standing on the bridge. The collected stream water was poured from the stainless steel pale into the sampling bottles as shown in Figure 23. To prevent contamination of water samples, the stainless steel pale was rinsed with stream water before use, and for all sampling events, rubber medical gloves were worn by the individual collecting the water samples. After samples were collected, the bottles were placed in plastic bags and stored on ice in the ice chests until delivery to the chemical laboratory. The water quality results obtained via field measurements and laboratory analysis were evaluated according to applicable surface water quality standards issued by Mississippi Department of Environmental Quality and United States Environmental Protection Agency as shown in Table 3 (MDEQ, 2012; USEPA, 2012; USEPA, 2013).

Figure 22 Stream water sampling bottles for laboratory water quality analysis

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Figure 23 Stream water samples being taken from bridge-side using a stainless steel pale

Table 3 MDEQ and EPA Surface Water Quality Standards

Dissolved Oxygen	≥ 4.0 mg/L
pH	6 - 9 +/- 1
Temperature	< 90 °F
Conductivity	≤ 1000 mS/cm
Turbidity	NA
Acidity	NA
Alkalinity	≤ 20 mg/L
Ammonia	0.083 - 4.60 mg/L
Chloride	≤ 0.019 mg/L
Fluoride	≤ 4.0 mg/L
Nitrate	≤ 10mg/L
Nitrite	≤ 1 mg/L
Phosphorous	≤ 0.1 mg/L
Sulfate	NA
Total Kjeldahl Nitrogen	NA
Dissolved Solids	1500 mg/L
Iron	≤ 1.0 mg/L
Lead	≤ 0.030 mg/L
Potassium	NA
Sodium	NA

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Continuous Real-time Stream Monitoring

In addition to the surface water quantity measurements, two stationary stream monitoring stations were installed at the furthermost downstream sampling site (i.e. B6, CB5) of the Big Creek and Cedar Creek watershed. The monitoring stations assisted in coordinating sampling events with respect to times of low flow, peak flow, and rainfall. The equipment for the monitoring system was installed on a 14 foot, 6x6 inch wooden post concreted in place, three feet within the ground. The installation setup of the two systems is shown in Figures 24 - 25. The monitoring system consist of the following: Morningstar SunSaver 6 solar controller panel, 12 volt battery, Teledyne ISCO 2150C telemetry modem, In-Situ Leveltroll 500 sensor, and a tipping bucket rain gauge. The Leveltroll sensor and cable (attached to the modem) was encased in 2 inch PVC pipe.

The pipe was buried underground until reaching the stream channel, at which PVC elbow joints were implemented to angle the encased sensor downstream into the water column. The PVC pipe was secure in place at the stream channel by metal T-posts and wire. The PVC pipe was perforated at the location of the Leveltroll in order to allow exposure to water. The monitoring system collected continuous real-time readings of precipitation, water column depth, water temperature, and battery voltage in 15 minute intervals and reported them hourly to a secure website via wireless phone service. C.C. Lynch and Associates of Pass Christian, MS and Mississippi State University Department of Geosciences were both responsible for installation and maintenance of the equipment and website.

At the start of the field study, the Escatawpa River was previously equipped with a USGS sampling station at the location of site E1, as shown in Figure 26. The USGS station reported hourly stage and discharge measurements and made available on the USGS website.

Figure 24	Continuous real-time monitoring station installed at site B6

Figure 25 Continuous real-time monitoring station installed at site CB5

Figure 26 USGS continuous monitoring station at site E1

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Spring Inventory and Evaluation

A county-wide spring inventory was performed on the Big Creek and Little and Big Cedar Creek Watersheds. Spring heads were located by field investigations of areas near stream heads as well as by guidance received from local residents and land owners. The Escatawpa River watershed was deemed unnecessary for investigations of feeding springs because the Escatawpa River, itself, serves as the principle source of water supply for the watershed within George County. Furthermore, the stream head of the Escatawpa River does not exist within George County nor within the state of Mississippi. Located springs were assigned GPS coordinates, and assessed by water quantity and water quality if measurable.

Water Quantity

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Water quantity measurements were taken using the Debris Flow Estimation Method as incorporated in the stream water quantity measurements (Hanks et al., 2003; McIlwain, 2007).

Water Quality

Similar to methods used for the stream water quality measurements, the spring water quality was analyzed by the field parameters, temperature (°F), pH (s.u.), specific conductivity (µS/cm), dissolved oxygen (mg/L), and turbidity (NTU) using the In-Situ Troll 9500 multi-parameter sonde connected to an In-Situ Ultra RuggedReader installed with Pocket-Situ 4 software. Water quality measurements were analyzed according to the surface water quality standards issued by MDEQ and EPA (MDEQ, 2012; USEPA, 2012;

USEPA, 2013). Figure 27 shows the equipment at work in the field, analyzing spring water quality.

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Figure 27 In-Situ, Inc. Troll 9500 multi-parameter sonde being used to measure field water quality parameters of a spring

Reservoir Modeling

Following the completion of the fieldwork, reservoir modeling was performed for each of the three watersheds. The modeling consisted of three parts: creation of lake footprints, calculation of lake footprint volumes, and creation of reservoir daily water storage models. Creation of lake footprints and calculation of footprint volumes were performed in ArcGIS 10.1 software using a digital elevation map downloaded from the

Mississippi Automated Resource Information System (MARIS) and the ArcGIS Polygon Volume tool. The cubic feet measurements of the lake volume calculations were converted to acre-feet for use in the daily water storage models.

The purpose of the reservoir daily storage model was to address the question of whether a lake constructed on one of the three watersheds could provide enough water supply to prevent the Pascagoula River from dropping below a measured 7Q10 base flow when 100 million gallons of water per day are withdrawn from the river near the site of the Chevron Refinery in Pascagoula, Mississippi. Microsoft Excel software was used to develop the reservoir daily water storage models. For each model two versions of a daily simulation was performed for the lake's water volume as if it was in operational use over a historical 50 year period, 1961 – 2010.

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Apart from the parameters specific to each simulation, similar data of rainfall evaporation, infiltration, runoff, and outflow for the lake model were used in both simulations. All values were incorporated in Julian calendar form. Historical precipitation of the 50 year period was incorporated as data obtained from the National Weather Service climate station #225789 located at Merrill, Mississippi. Merrill, Mississippi precipitation data was chosen because of the station's location is in George County within close proximity of the footprinted lakes. There were two locations found near George County having historical evaporation data available. The two locations, Fairhope, Alabama and Starkville, Mississippi, provided evaporation data similar in value; although, the Fairhope data had a slightly lower cumulative value than Starkville due to its coastal location. Generally, Evaporation is subject to change considerably from coastal to inland environments; therefore, since the theoretical lakes would be located more than 20 miles inland, the Starkville data of the 50 year period was used, making a more conservative model (i.e. higher evaporation rates than what may exist in reality). Percipitation directly into the lake and precipitation runoff into the watershed were the only inputs allowed for the lake model. Stream base flow into the lake model was set at zero, making a more conservative model. As for outflow or base flow out of the lake, no 7Q10 flow analysis was previously performed for Big Creek, Big Cedar Creek, or Escatawpa River. Therefore, the outflow was set to an estimated value of 10 acre-feet per day.

The first simulation modeled the lakes as if they were being used to supplement base flow of the Pascagoula River as water was withdrawn near the anticipated location. For this simulation, historical stream stage and discharge rates for the 50 year period were incorporated as data obtained online from the United States Geological Survey's (USGS) monitoring site #02479310 located on the Pascagoula River at Graham Ferry, Mississippi, which is in the vicinity of the anticipated water withdrawal location. The simulation applied the function of: when the flow of the Pascagoula River at Graham Ferry, Mississippi falls below the 7Q10 base flow, sufficient volume is released from the lake to raise the flow back to 7Q10 level. The supplemental discharge from the lake does not cease until the event that the lake is drained completely. The second simulation modeled was performed as a background, analyzing the lakes according to climate change without any use for supplementing the withdrawals from the Pascagoula River.

The model created in Microsoft Excel consisted of 12 columns of data for the first simulation and later modified for the second simulation. The first column contained the days of the year according to the Julian calendar having the day of February 29th removed

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due to leap year. The second column contained daily calculations of precipitation minus evaporation values recorded for each day, which represents the climate's delivery to and demand from the reservoir. The third column assessed for climatic influence on the lake by generating a product of the value calculated in column two multiplied by a conversion factor of 433. The conversion factor of 433 was used to adjust the value in column two to represent the amount of water in units of acre-feet that the lake footprint would receive. The 433 value was derived from the assumption that surface area of the lake is 5,200 acres, which was divided by 12 inches. The fourth column assessed climatic effects on the reservoir drainage area by estimating the amount of water that the lake would received indirectly as runoff from the reservoir drainage area. Column four was the product of the value in column two multiplied by values of 1462 and 0.6. The value of 1462 represented a conversion factor used to adjust the value in column two to represent the amount of water in units of acre-feet that would be received by the reservoir drainage area. The 1462 value was derived by subtracting the simulated lake surface area (5200 acres) from a simulated reservoir drainage area (17,550 acres) and then dividing that product by 12 inches. The 0.6 value represented the percentage of the runoff water that would be contained within the lake based the factors of soil character, slope, urban development, and vegetation. The book, *Soil and Water Management Systems*, by Schwab et al. (1996), was referenced for these factors. If the calculated value in column four was less than zero, then the value was set to zero by the use of an Excel function. The fifth column, entitled base flow, accounted for the amount of water flowing into the lake from streams. The value of column five was set at a constant of zero acre-feet, making a more conservative model. Column six, entitled infiltration, accounted for the

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amount of runoff water within the reservoir drainage area that would be lost to seepage into the subsurface. An infiltration value of 0.0023 feet per day was used based on soil type. The seventh column, entitled outflow, was the amount of water that would be required to discharge daily into the downstream portion of the watershed that the reservoir was built upon. Outflow was estimated at a value of 10 acre-feet per day. The eighth column, entitled withdrawal, accounted for any water taken from the reservoir for commercial activities. A constant withdrawal value of zero was assumed because of no commercial activities present in the area. The ninth column, daily change, calculated the change in daily lake volume. The calculation was performed by added the values of columns 3, 4, and 5, then subtracting the values of 6, 7, and 8. The tenth column, daily storage of the reservoir volume, first began on day 1 of year 1961 with the total volume of that calculated from the lake footprints in ArcGIS 10.1. After day 1, the daily storage was derived from the daily change. The eleventh column, river flow, provides the daily discharge of the Pascagoula River at Graham Ferry, Mississippi. The twelfth column, additions, shows amount of water taken from the lake to supplement the river flow when the flow of the Pascagoula River at Graham Ferry, Mississippi drops below the 7Q10 base flow. Table 4 depicts an example of the headers of each data column in the model for the first simulation. Columns nine, eleven, and twelve, containing daily change, river flow, and additions data, were removed for the second simulation (table 4), which modeled the lakes without supplemental withdrawals. Following the completion of the daily storage models the daily water volume storage values attained from the two simulations were displayed in a line graph of storage volume (acre-feet) versus days of the 50 year period (1961 – 2010).

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Table 4 Example of headers in Microsoft Excel Daily Storage Model

Day	Daily Average P-E (inches)	Climate Lake (P-E*433) (A-F)	Climate-Basin (P-E*1462*0.6) (A-F)	Base Flow (0 cfs) (A-F)	Infiltration (0.0023ft/day) (A-F)	Outflow (10 A-F/day) (A-F)	Withdrawal (0 MGD) (A-F)	Daily Change (A-F)	Daily Storage (A-F)	River Flow (A-F/day)	Additions (A-F)
1	0.05	21.99	44.55	0	12	10	0	44.53978	64717.00	28334.94	0
2	-0.05	-21.55	0.00	0	12	10	0	-43.5454	64673.45	27316.14	0
3	-0.05	-22.37	0.00	0	12	10	0	-44.3675	64629.09	25844.53	0
4	-0.05	-20.08	0.00	0	12	10	0	-42.0789	64587.01	23014.52	0
5	-0.07	-28.72	0.00	0	12	10	0	-50.7196	64536.29	20184.51	0
6	-0.03	-11.04	0.00	0	12	10	0	-33.0402	64503.25	17580.90	0
7	-0.04	-16.18	0.00	0	12	10	0	-38.1751	64465.07	15430.09	0
8	-0.05	-19.95	0.00	0	12	10	0	-41.9493	64423.12	14071.68	0
9	-0.05	-20.55	0.00	0	12	10	0	-42.5494	64380.57	13392.48	0
10	-0.05	-21.27	0.00	0	12	10	0	-43.2708	64337.30	13166.08	0

CHAPTER VIII

RESULTS

Surface Water Quantity Measurements

Two stationary stream monitoring stations were installed at sampling sites B6 and CB5, the furthermost downstream sampling sites of the Big Creek and Cedar Creek watersheds. On December 13, 2011, the stations were connected to the secure web server and began generating continuous data for precipitation, water column depth, water temperature, and battery voltage. The stations reported data throughout the time span of the field study ending December 31, 2012. Precipitation, water column depth, water temperature, and battery voltage data for B6 and CB5 monitoring stations are presented as line graphs in Figures 28- 31. The water depth graphs for Monitoring Station B6 show an expected correlation with the rainfall graphs by having substantial water depth peaks during recorded rainfall events. However, the data presented in the water depth graphs often exhibit a small fluctuation pattern in the graphed line at times when no rainfall was recorded. The minute fluctuation patterns observed in the water depth graphs are interpreted as skewed data recordings caused by stream sediment built up around the In-Situ Leveltroll 500 sensor housed within the protective PVC casing, altering the observed pressure by which the sensor generates a water depth reading. Monitoring Station CB5 lost wireless signal and battery power with the web server on August 30, 2012 due to the weather effects of Hurricane Isaac making landfall on the coast of the Gulf of Mexico near the west border of Mississippi. The wireless signal and power was restored with data collection resumed on October 19, 2012. The station downtime created an obvious anomaly in the line graphs of Figure 31. Station CB5 experienced an additional recording error on November 12, 2012, resulting in false peaks in the line graphs of Figure 31. The recording error is reflected by the extremely low temperature peak graphed in Figure 31. At the start of the field study in July 2011, sampling site E1 of the Escatawpa River was previously equipped with a USGS sampling station, which recorded continuous stage and discharge measurements hourly and made available on the USGS website. Hourly stage and discharge measurements of site E1 were retrieved from USGS archives for the complete time span of the field study (USGS, 2013).

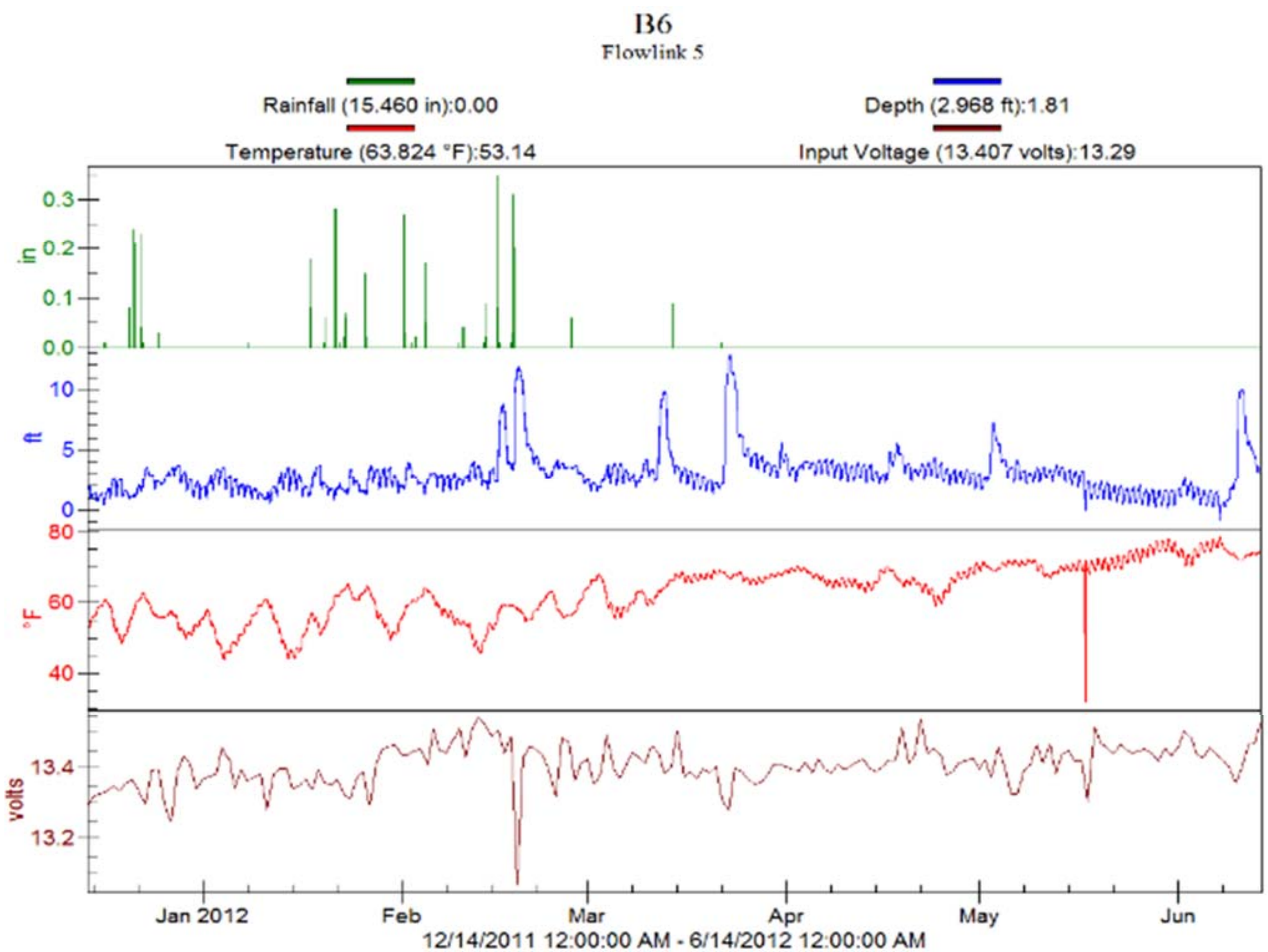

Figure 28 Rainfall, water column depth, temperature, and battery voltage data collected by site B6 monitoring station from 12/14/2011 – 6/14/2012

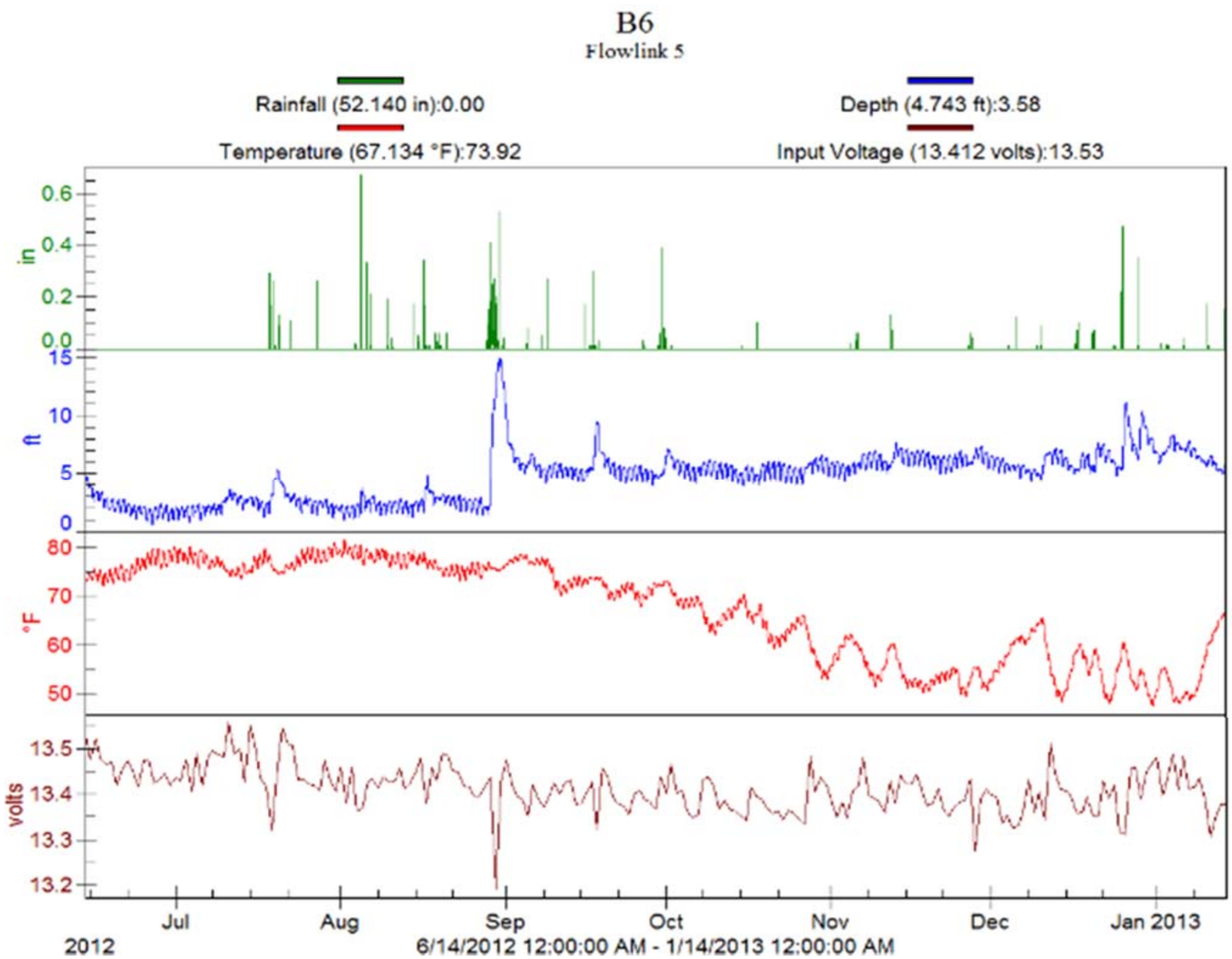

Figure 29 Rainfall, water column depth, temperature, and battery voltage data collected by site B6 monitoring station from 6/14/2012 – 1/14/2013

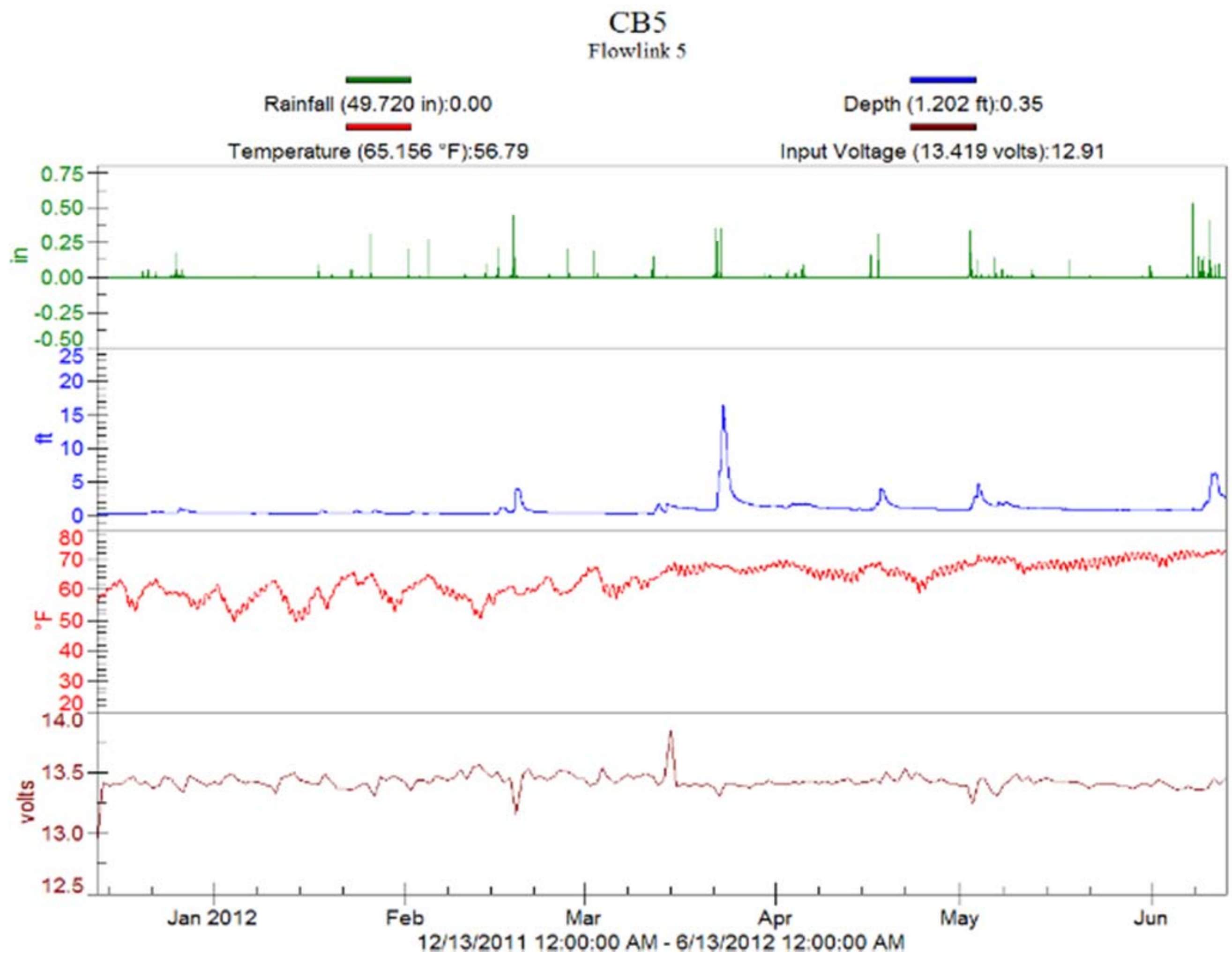

Figure 30 Rainfall, water column depth, temperature, and battery voltage data collected by site CB5 monitoring station from 12/13/2011 – 6/13/2012

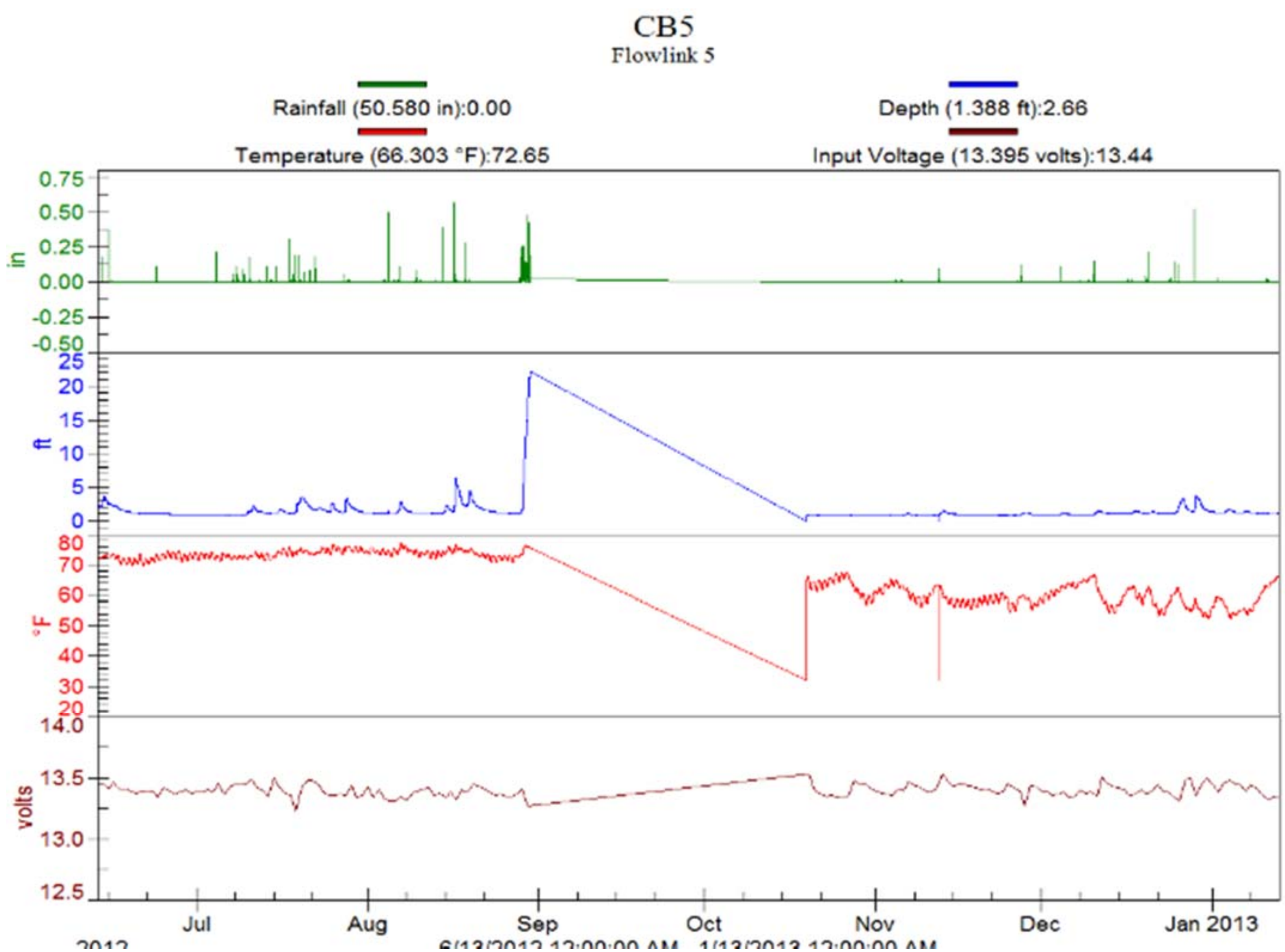

Figure 31 Rainfall, water column depth, temperature, and battery voltage data collected by site CB5 monitoring station from 6/13/2012 – 1/13/2013

Surface water discharge measurements were taken from six sites along the Big Creek watershed, 10 sites along the Big and Little Cedar Creek watershed, and two sites along the Escatawpa River watershed. Measurements were made by the use of the Teledyne StreamPro RDI Doppler unit, Price AA Current Meter, and the Debris Flow Estimation method respective to flow conditions. Additionally, discharge measurements for site E1 were primarily recorded from the USGS permanent monitoring station. From the discharge measurements taken periodically from July 2011 to December 2012, two high flow events, two or more low flow events, and multiple intermediate flow events were intercepted. Discharge measurements of each sampling site were used to construct hydrographs, plotting discharge versus stage gauge height. In July 2012, sampling site B3 was discontinued and replaced by an upstream location named B3A, where reconstruction of a bridge crossing of Big Creek was recently completed on a less traveled road, Highway 198, Lucedale, Mississippi, deeming B3A a safer location for sampling events. Sampling site CB7 was not incorporated as a significant tributary to Big Cedar Creek for periodic sampling until May 2012; therefore, only six discharge measurements were represented. On January 27, 2012, sampling site B4 did produce sufficient flow for measurement; however, the Doppler unit experienced recording errors, not allowing for a measurement to be obtained. On March 13, 2012, the discharge measurement for sampling site E1 was taken using the doppler unit, which generated a value of 3,581.8 ft^3/sec while the USGS monitoring station provided a comparable value of 3,490.0 ft^3/sec.

The specific bridge crossing locations, from which stage gauge was measured for each of the 18 sampling sites, were not surveyed in to actual elevation. Therefore, elevation values were generated from the sampling sites' GPS coordinates projected onto a MARIS Digital Elevation Map were used for the calculations of stage values in the hydrographs. Numerical data for the hydrographs are provided in Table 5-10. The Big Creek watershed is considered to have exhibited low flows during sampling events August 29-30, 2011 and August 2-3, 2012 and high flow events during sampling events 3.23.12 and 8.30.12 - 8.31.12. The Big and Little Cedar Creek watershed is considered to have exhibited low flows during sampling events 8.30.11, 7.9.12, and 8.3.12 and high flow events during sampling events 3.23.12 and 8.30.12 - 8.31.12. The Escatawpa River watershed is considered to have exhibited low flows during sampling events 8.30.11 and 11.15.11 and high flow events during sampling events 3.24.12 and 8.31.12. Of the 18 sampling sites, hydrographs of the furthermost downstream locations of the three watersheds, Big Creek B6, Big and Little Cedar Creek CB6, and Escatawpa River E2 are displayed in Figures 32 - 34. Hydrographs of all 18 sampling sites are provided in Appendix A.

Table 5 Little Cedar Creek Watershed Hydrograph Data

SITE	DATE	STAGE	DISCHARGE
CL1	7.26.11	146.22	1.74
CL1	8.29.11	138.15	8.42
CL1	10.5.11	138.13	4.63
CL1	11.15.11	138.23	6.00
CL1	1.28.12	138.11	5.21
CL1	3.12.12	138.53	8.59
CL1	3.23.12	142.46	129.93
CL1	5.16.12	138.38	5.10
CL1	7.9.12	138.13	4.10
CL1	8.2.12	138.19	5.02
CL1	8.30.12	145.68	1004.97
CL1	10.18.12	138.59	6.58
CL1	12.17.12	139.13	9.68
CL2	7.26.11	74.20	22.74
CL2	8.29.11	73.55	15.80
CL2	10.5.11	73.80	9.38
CL2	11.15.11	74.05	15.04
CL2	3.13.12	74.38	23.32
CL2	3.23.12	79.55	28.66
CL2	5.16.12	73.60	11.15
CL2	7.9.12	73.55	10.00
CL2	8.2.12	73.72	12.42
CL2	8.30.12	83.98	1438.61
CL2	10.18.12	74.40	17.17
CL2	12.18.12	74.55	22.88
CL3	7.26.11	25.50	39.67
CL3	8.29.11	24.45	11.77
CL3	10.5.11	24.85	16.78
CL3	11.15.11	24.75	19.70
CL3	1.28.12	25.13	28.80
CL3	3.13.12	25.50	54.48
CL3	3.23.12	30.63	278.31
CL3	5.16.12	24.50	17.70
CL3	7.9.12	24.45	19.60
CL3	8.2.12	24.54	19.11
CL3	8.31.12	31.45	581.32
CL3	10.18.12	24.74	32.82
CL3	12.18.12	24.84	31.23

Table 6 Big Cedar Creek Watershed Hydrograph Data

SITE	DATE	STAGE	DISCHARGE
CB1	7.26.11	178.07	6.26
CB1	8.29.11	183.97	0.38
CB1	10.04.11	185.15	0.53
CB1	11.15.11	184.47	0.32
CB1	1.28.12	184.77	2.97
CB1	3.12.12	185.07	7.31
CB1	3.23.12	185.07	8.52
CB1	5.16.12	183.97	0.66
CB1	7.9.12	183.92	0.60
CB1	8.2.12	183.89	0.74
CB1	8.29.12	185.02	12.45
CB1	8.30.12	186.54	104.86
CB1	10.18.12	184.19	0.85
CB1	12.17.12	184.77	3.44
CB2	7.26.11	57.67	20.26
CB2	8.29.11	57.81	7.67
CB2	10.5.11	56.97	10.46
CB2	11.15.11	57.42	14.29
CB2	1.28.12	57.15	14.99
CB2	3.12.12	62.67	197.14
CB2	3.23.12	63.45	243.50
CB2	5.16.12	56.62	10.31
CB2	7.9.12	56.62	9.44
CB2	8.2.12	56.60	9.94
CB2	8.30.12	66.40	890.41
CB2	10.18.12	57.11	17.18
CB2	12.18.12	57.47	19.20
CB3	7.26.11	76.69	1.43
CB3	8.29.11	75.04	0.08
CB3	10.5.11	75.19	0.79
CB3	11.15.11	75.24	19.71
CB3	3.12.12	76.24	12.49
CB3	3.23.12	82.42	253.54
CB3	5.17.12	75.19	0.77
CB3	7.9.12	75.29	0.47
CB3	8.2.12	72.48	0.72
CB3	8.29.12	80.25	79.20
CB3	8.30.12	85.27	579.02
CB3	10.18.12	75.06	1.50
CB3	12.18.12	75.27	2.07

Table 7 Big Cedar Creek Watershed Hydrograph Data

SITE	DATE	STAGE	DISCHARGE
CB4	7.26.11	55.14	23.09
CB4	8.29.11	53.24	5.52
CB4	10.5.11	53.44	11.96
CB4	11.15.11	53.54	14.43
CB4	3.13.12	56.09	96.12
CB4	3.23.12	62.44	491.77
CB4	5.17.12	53.13	12.26
CB4	7.9.12	53.09	9.14
CB4	8.2.12	53.17	11.91
CB4	8.30.12	66.37	1875.97
CB4	10.18.12	53.37	17.17
CB4	12.18.12	53.64	23.96
CB5	7.26.11	32.60	47.73
CB5	8.29.11	31.50	17.08
CB5	10.5.11	31.70	22.71
CB5	11.15.11	31.70	22.16
CB5	1.28.12	32.05	34.57
CB5	3.13.12	34.33	147.18
CB5	3.23.12	41.63	892.87
CB5	5.17.12	31.53	23.11
CB5	7.9.12	31.55	13.57
CB5	8.2.12	31.63	23.88
CB5	8.30.12	46.25	2843.84
CB5	10.18.12	31.89	31.48
CB5	12.18.12	32.10	39.87
CB6	7.26.11	6.24	154.16
CB6	8.29.11	4.19	33.04
CB6	10.5.11	4.74	51.39
CB6	11.15.11	4.69	48.07
CB6	1.28.12	5.34	87.81
CB6	3.13.12	8.04	279.81
CB6	3.23.12	13.19	1053.05
CB6	5.17.12	4.79	47.02
CB6	7.9.12	4.74	52.55
CB6	8.3.12	4.74	46.91
CB6	8.31.12	15.05	2231.00
CB6	10.18.12	5.29	80.69
CB6	12.18.12	5.31	87.98
CB7	5.21.12	38.52	2.09
CB7	6.11.12	41.62	177.85
CB7	7.9.12	38.62	7.29
CB7	8.2.12	38.11	1.38
CB7	10.18.12	38.02	5.16
CB7	12.18.12	38.07	5.75

Table 8 Big Creek Watershed Hydrograph Data

SITE	DATE	STAGE	DISCHARGE
B1	7.27.11	121.71	29.10
B1	8.29.11	120.76	9.21
B1	10.5.11	120.91	9.53
B1	11.16.11	121.16	13.32
B1	1.27.12	121.21	25.02
B1	3.12.12	127.18	281.69
B1	5.17.12	120.86	17.00
B1	7.10.12	120.97	18.71
B1	8.2.12	120.80	16.15
B1	8.30.12	128.15	683.27
B1	10.18.12	120.91	15.37
B1	12.17.12	121.31	26.36
B2	7.27.11	150.22	10.79
B2	8.29.11	149.82	4.44
B2	10.4.11	149.87	6.46
B2	11.16.11	150.02	5.46
B2	1.27.12	150.05	7.30
B2	3.12.12	151.35	48.04
B2	5.17.12	149.72	6.02
B2	7.10.12	149.82	6.37
B2	8.2.12	149.77	4.90
B2	8.30.12	154.61	537.81
B2	10.18.12	149.68	7.18
B2	12.17.12	150.02	11.13
B3	7.27.11	85.17	80.31
B3	8.30.11	84.17	12.65
B3	10.5.11	84.32	20.78
B3	11.16.11	84.42	26.73
B3	3.13.12	85.10	84.52
B3	3.23.12	87.05	282.74
B3	5.17.12	84.27	26.68
B3A	7.10.12	93.75	22.67
B3A	8.3.12	93.58	17.87
B3A	8.30.12	101.76	183.74
B3A	10.18.12	93.77	25.51
B3A	12.17.12	94.23	47.62

Table 9 Big Creek Watershed Hydrograph Data

SITE	DATE	STAGE	DISCHARGE
B4	7.26.11	58.22	134.91
B4	8.30.11	56.02	15.08
B4	10.5.11	56.32	27.98
B4	11.16.11	56.62	39.16
B4	1.27.12	58.65	171.66
B4	3.13.12	65.38	727.22
B4	3.23.12	56.27	32.69
B4	5.17.12	56.31	30.77
B4	7.9.12	50.62	25.00
B4	8.3.12	56.48	38.95
B4	10.18.12	56.72	47.65
B4	12.17.12	121.31	26.36
B5	7.26.11	33.70	188.97
B5	8.30.11	31.10	14.86
B5	10.5.11	31.40	29.28
B5	11.16.11	31.70	40.92
B5	1.27.12	32.23	84.56
B5	3.13.12	35.53	261.25
B5	3.23.12	40.78	1202.00
B5	5.18.12	31.35	27.99
B5	7.9.12	31.18	30.69
B5	8.3.12	31.09	23.01
B5	10.18.12	31.56	40.64
B5	12.17.12	31.75	46.74
B6	7.26.11	23.42	258.29
B6	8.30.11	19.14	19.16
B6	10.6.11	19.57	28.90
B6	11.16.11	20.07	46.25
B6	1.27.12	20.85	85.71
B6	3.13.12	24.32	331.54
B6	3.23.12	28.87	1396.66
B6	5.18.12	19.27	32.32
B6	7.9.12	19.27	29.44
B6	8.3.12	19.26	24.96
B6	8.31.12	28.82	1491.27
B6	10.18.12	19.54	35.00
B6	12.17.12	19.92	46.88

Table 10 Escatawpa River Watershed Hydrograph Data

SITE	DATE	STAGE	DISCHARGE
E1	07.25.11	40.21	2170.00
E1	8.30.11	16.45	76.00
E1	10.6.11	17.40	190.00
E1	11.15.11	17.15	160.50
E1	1.28.12	27.35	3581.80
E1	3.13.12	30.70	7250.00
E1	3.24.12	29.82	1520.00
E1	5.21.12	17.64	180.00
E1	7.10.12	18.39	122.00
E1	8.2.12	17.78	197.00
E1	8.31.12	35.31	20300.00
E1	10.19.12	18.59	337.00
E1	12.18.12	18.85	436.00
E2	07.25.11	17.26	1724.90
E2	8.30.11	10.46	122.20
E2	10.6.11	11.51	239.14
E2	11.15.11	11.11	176.74
E2	3.13.12	19.79	2619.33
E2	3.24.12	11.86	271.64
E2	5.21.12	11.43	206.11
E2	7.10.12	11.96	285.45
E2	8.2.12	12.66	337.18
E2	10.19.12	13.01	472.60
E2	12.18.12	31.75	46.74

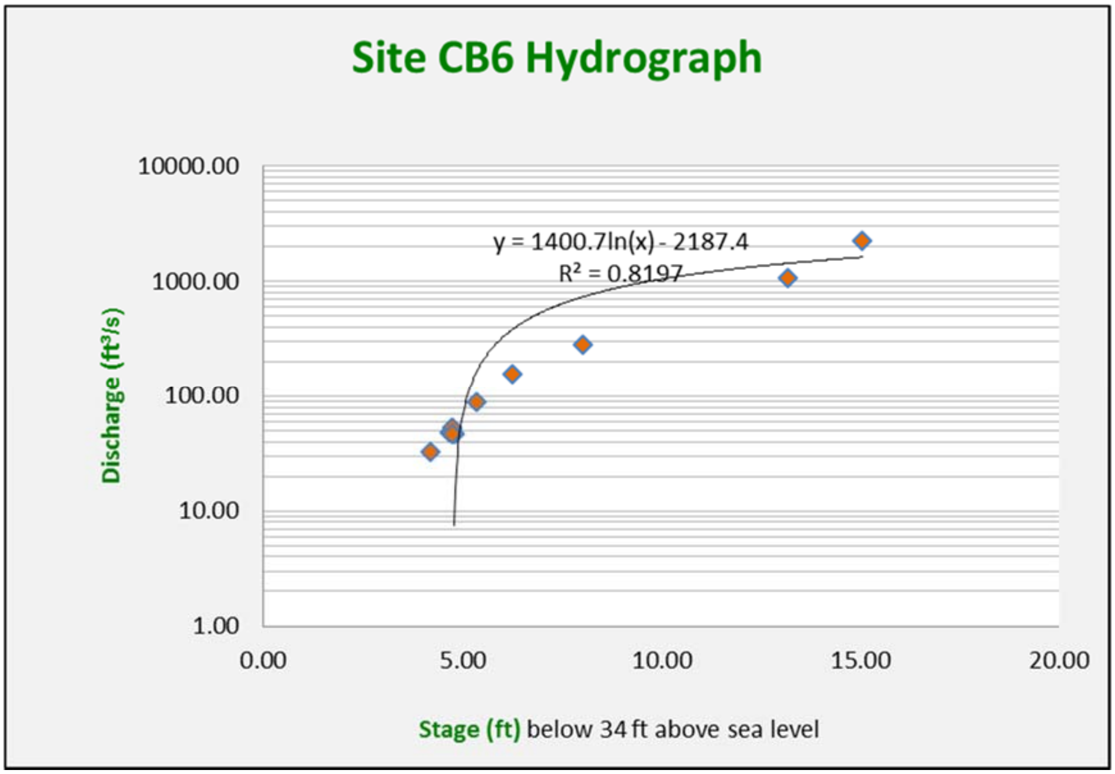

Figure 32 Hydrograph for site CB6 depicting discharge versus stage

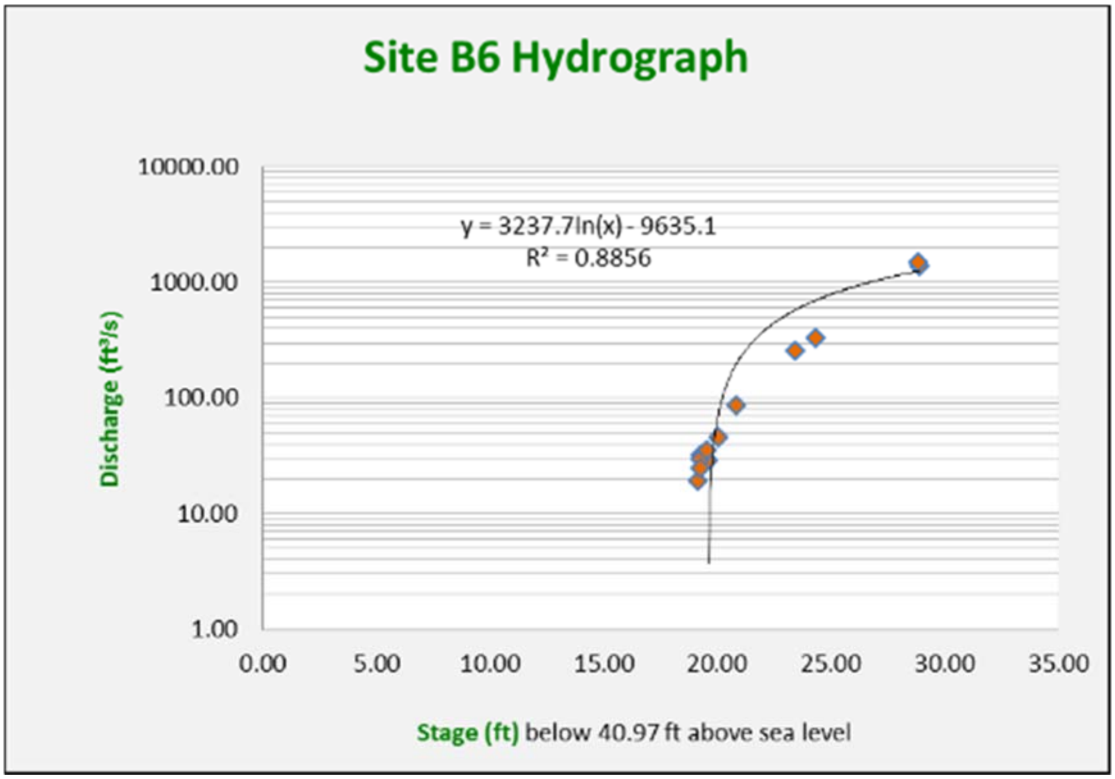

Figure 33 Hydrograph for site B6 depicting discharge versus stage

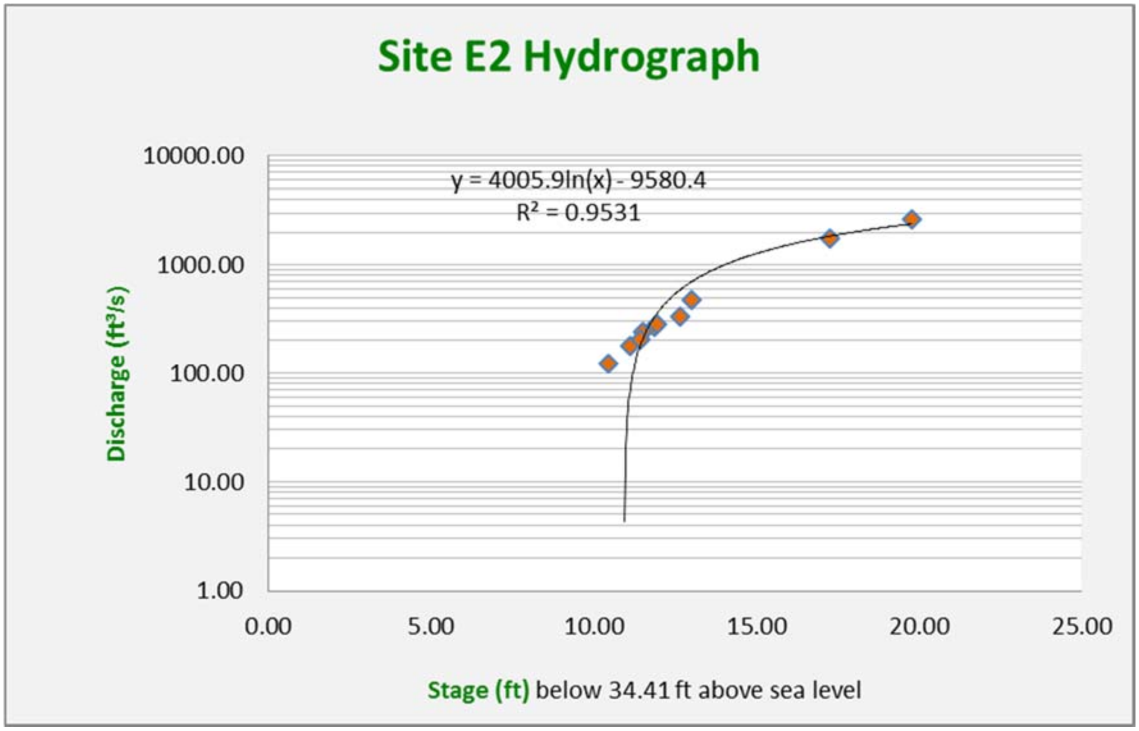

Figure 34 Hydrograph for site E2 depicting discharge versus stage

Surface Water Quality Measurements

Surface water quality analysis was performed for each sampling site by field measurements and laboratory chemical analysis. Detailed data for field measurements of water temperature, pH, conductivity, dissolved oxygen, and turbidity are shown in Appendix B. Complete analysis from the laboratory containing values for acidity, ammonia, alkalinity, chloride, fluoride, nitrate, nitrite, phosphorus, sulfate, Total Kjeldahl Nitrogen (TKN), total dissolved solids (TDS), Iron, Lead, Potassium, and Sodium is shown in Appendix C. Tables 11- 20 show field measurements and laboratory analysis of base flow and high flow events. The water quality results obtained via field measurements and laboratory analysis were evaluated according to applicable surface water quality standards (Table 3) issued by Mississippi Department of Environmental Quality and United States Environmental Protection Agency. The occasional incompliant water quality results of pH, dissolved oxygen, chloride, iron, and phosphorus for each sampling event are indicated by the color red in Appendix B. The chloride values for each site were detected at values above the allotted standard of 0.019 mg/L for all sampling events throughout the field study.

Additionally, the water quality standards were applied to the composite averages calculated for the combined water quality results of all sampling sites for each watershed as well as for the furthermost downstream sites (B6, CL3, CB6, E2), forming an overall view of the water quality character of each watershed throughout the complete duration of the field study. Appendix D contains the graphical analyses of field and laboratory water quality results for all composite averages. As shown in figures 35 – 56, the analyses of the composite averages calculated for detected parameters produced values that were compliant with the standards provided in table 3.

Table 11 Big Creek Watershed Field and Laboratory Water Quality Analysis Results

Site	Analyte Description	Low Flow (08/29-30/2011)	Low Flow (08/2-3/2012)	High Flow (03/23/2012)	High Flow (8/30-31/2012)
B1	Temperature (°F)	72.76	77.58	NT	75.23
B1	Conductivity (µS/cm)	25.97	33.08	NT	20.49
B1	pH (s.u.)	5.66	5.90	NT	2.19
B1	Dissolved Oxygen (mg/L)	8.79	0.03	NT	13.48
B1	Turbidity (NTU)	1.80	1.20	NT	31.10
B1	Acidity (mg/L)	NT	1.90	NT	8.60
B1	Ammonia as N (mg/L)	NT	ND	NT	ND
B1	Alkalinity (mg/L)	NT	5.50	NT	3.70
B1	Chloride (mg/L)	NT	5.19	NT	1.68
B1	Sulfate as S04 (mg/L)	NT	ND	NT	1.32
B1	Fluoride (mg/L)	NT	ND	NT	ND
B1	Nitrate (mg/L)	NT	ND	NT	ND
B1	Nitrite (mg/L)	NT	ND	NT	ND
B1	Phosphorus (mg/L)	NT	ND	NT	ND
B1	Total Kjeldahl Nitrogen (mg/L)	NT	0.41	NT	ND
B1	Total Dissolved Solids (mg/L)	NT	35.00	NT	56.00
B1	Iron (mg/L)	NT	0.76	NT	2.75
B1	Lead (mg/L)	NT	ND	NT	ND
B1	Potassium (mg/L)	NT	0.55	NT	1.43
B1	Sodium (mg/L)	NT	2.20	NT	0.90
B2	Temperature (°F)	75.18	81.29	NT	74.79
B2	Conductivity (µS/cm)	37.09	52.00	NT	22.99
B2	pH (s.u.)	5.78	6.17	NT	5.22
B2	Dissolved Oxygen (mg/L)	8.26	0.03	NT	5.27
B2	Turbidity (NTU)	11.90	6.00	NT	101.70
B2	Acidity (mg/L)	NT	2.90	NT	4.80
B2	Ammonia as N (mg/L)	NT	ND	NT	ND
B2	Alkalinity (mg/L)	NT	14.80	NT	6.50
B2	Chloride (mg/L)	NT	5.82	NT	1.44
B2	Sulfate as S04 (mg/L)	NT	1.18	NT	1.50
B2	Fluoride (mg/L)	NT	ND	NT	ND
B2	Nitrate (mg/L)	NT	ND	NT	ND
B2	Nitrite (mg/L)	NT	ND	NT	ND
B2	Phosphorus (mg/L)	NT	ND	NT	ND
B2	Total Kjeldahl Nitrogen (mg/L)	NT	0.27	NT	0.53
B2	Total Dissolved Solids (mg/L)	NT	38.00	NT	36.00
B2	Iron (mg/L)	NT	2.24	NT	1.76
B2	Lead (mg/L)	NT	ND	NT	ND
B2	Potassium (mg/L)	NT	0.95	NT	1.22
B2	Sodium (mg/L)	NT	3.17	NT	0.86

Table 12 Big Creek Watershed Field and Laboratory Water Quality Analysis Results

Site	Analyte Description	Low Flow (08/29-30/2011)	Low Flow (08/2-3/2012)	High Flow (03/23/2012)	High Flow (8/30-31/2012)
B3	Temperature (°F)	72.82	76.27	67.56	75.03
B3	Conductivity (µS/cm)	25.96	39.50	25.84	20.38
B3	pH (s.u.)	5.68	5.45	5.38	3.04
B3	Dissolved Oxygen (mg/L)	8.72	11.17	6.71	91.82
B3	Turbidity (NTU)	5.40	4.90	76.50	90.80
B3	Acidity (mg/L)	NT	1.90	6.80	5.80
B3	Ammonia as N (mg/L)	NT	ND	ND	ND
B3	Alkalinity (mg/L)	NT	9.20	6.50	3.70
B3	Chloride (mg/L)	NT	5.67	2.88	1.77
B3	Sulfate as S04 (mg/L)	NT	0.85	1.86	1.64
B3	Fluoride (mg/L)	NT	ND	NT	ND
B3	Nitrate (mg/L)	NT	ND	NT	ND
B3	Nitrite (mg/L)	NT	ND	NT	ND
B3	Phosphorus (mg/L)	NT	ND	NT	ND
B3	Total Kjeldahl Nitrogen (mg/L)	NT	0.27	0.26	ND
B3	Total Dissolved Solids (mg/L)	NT	33.00	46.00	46.00
B3	Iron (mg/L)	NT	1.06	0.61	1.96
B3	Lead (mg/L)	NT	ND	ND	ND
B3	Potassium (mg/L)	NT	0.65	0.78	1.22
B3	Sodium (mg/L)	NT	2.65	1.73	1.10
B4	Temperature (°F)	73.09	76.86	67.43	NT
B4	Conductivity (µS/cm)	25.57	39.18	23.80	NT
B4	pH (s.u.)	6.25	6.18	5.14	NT
B4	Dissolved Oxygen (mg/L)	8.66	8.77	6.85	NT
B4	Turbidity (NTU)	4.80	5.50	31.90	NT
B4	Acidity (mg/L)	NT	2.40	5.30	NT
B4	Ammonia as N (mg/L)	NT	ND	ND	NT
B4	Alkalinity (mg/L)	NT	9.20	5.50	NT
B4	Chloride (mg/L)	NT	5.29	2.72	NT
B4	Sulfate as S04 (mg/L)	NT	0.93	1.88	NT
B4	Fluoride (mg/L)	NT	ND	ND	NT
B4	Nitrate (mg/L)	NT	ND	ND	NT
B4	Nitrite (mg/L)	NT	ND	ND	NT
B4	Phosphorus (mg/L)	NT	ND	ND	NT
B4	Total Kjeldahl Nitrogen (mg/L)	NT	0.41	0.26	NT
B4	Total Dissolved Solids (mg/L)	NT	36.00	39.00	NT
B4	Iron (mg/L)	NT	0.99	0.58	NT
B4	Lead (mg/L)	NT	ND	ND	NT
B4	Potassium (mg/L)	NT	0.69	0.74	NT
B4	Sodium (mg/L)	NT	2.80	1.80	NT

Table 13 Big Creek Watershed Field and Laboratory Water Quality Analysis Results

Site	Analyte Description	Low Flow (08/29-30/2011)	Low Flow (08/2-3/2012)	High Flow (03/23/2012)	High Flow (8/30-31/2012)
B5	Temperature (°F)	73.74	77.34	67.57	NT
B5	Conductivity (µS/cm)	26.32	39.45	22.32	NT
B5	pH (s.u.)	6.52	6.06	5.02	NT
B5	Dissolved Oxygen (mg/L)	8.52	8.01	6.76	NT
B5	Turbidity (NTU)	8.10	5.30	33.40	NT
B5	Acidity (mg/L)	NT	3.80	3.90	NT
B5	Ammonia as N (mg/L)	NT	ND	ND	NT
B5	Alkalinity (mg/L)	NT	9.20	7.40	NT
B5	Chloride (mg/L)	NT	5.23	2.52	NT
B5	Sulfate as S04 (mg/L)	NT	0.99	1.71	NT
B5	Fluoride (mg/L)	NT	ND	ND	NT
B5	Nitrate (mg/L)	NT	ND	ND	NT
B5	Nitrite (mg/L)	NT	ND	ND	NT
B5	Phosphorus (mg/L)	NT	ND	ND	NT
B5	Total Kjeldahl Nitrogen (mg/L)	NT	0.27	0.26	NT
B5	Total Dissolved Solids (mg/L)	NT	43.00	57.00	NT
B5	Iron (mg/L)	NT	0.96	1.23	NT
B5	Lead (mg/L)	NT	ND	ND	NT
B5	Potassium (mg/L)	NT	0.71	0.75	NT
B5	Sodium (mg/L)	NT	2.87	1.64	NT
B6	Temperature (°F)	74.53	77.97	67.75	75.47
B6	Conductivity (µS/cm)	26.39	39.53	22.08	21.14
B6	pH (s.u.)	6.56	5.94	4.87	4.15
B6	Dissolved Oxygen (mg/L)	8.35	7.88	6.65	12.37
B6	Turbidity (NTU)	6.40	16.70	31.20	50.20
B6	Acidity (mg/L)	NT	2.40	5.30	8.20
B6	Ammonia as N (mg/L)	NT	ND	ND	ND
B6	Alkalinity (mg/L)	NT	8.30	7.40	2.80
B6	Chloride (mg/L)	NT	5.21	2.49	2.06
B6	Sulfate as S04 (mg/L)	NT	1.06	ND	1.69
B6	Fluoride (mg/L)	NT	ND	ND	ND
B6	Nitrate (mg/L)	NT	ND	ND	ND
B6	Nitrite (mg/L)	NT	ND	ND	ND
B6	Phosphorus (mg/L)	NT	ND	ND	ND
B6	Total Kjeldahl Nitrogen (mg/L)	NT	0.27	0.26	0.26
B6	Total Dissolved Solids (mg/L)	NT	32.00	55.00	46.00
B6	Iron (mg/L)	NT	0.96	0.65	1.09
B6	Lead (mg/L)	NT	ND	ND	ND
B6	Potassium (mg/L)	NT	0.76	0.72	1.04
B6	Sodium (mg/L)	NT	2.88	1.65	1.23

Table 14 Big and Little Cedar Creek Watershed Field and Laboratory Water Quality Analysis Results

Site	Analyte Description	Low Flow (8/29-30/2011)	Low Flow (7/9/2012)	Low Flow (8/2-3/2012)	High Flow (3/23/2012)	High Flow (8/30-31/2012)
CL1	Temperature (°F)	69.80	70.92	72.97	67.19	74.72
CL1	Conductivity (µS/cm)	22.41	31.42	31.68	23.76	15.37
CL1	pH (s.u.)	4.67	5.51	5.26	4.68	3.22
CL1	Dissolved Oxygen (mg/L)	9.47	14.57	0.03	6.98	8.85
CL1	Turbidity (NTU)	1.40	2.50	0.70	28.10	31.90
CL1	Acidity (mg/L)	NT	3.80	2.90	6.80	4.30
CL1	Ammonia as N (mg/L)	NT	ND	ND	ND	ND
CL1	Alkalinity (mg/L)	NT	4.60	4.60	3.70	3.70
CL1	Chloride (mg/L)	NT	5.05	5.25	2.28	1.33
CL1	Sulfate as S04 (mg/L)	NT	ND	ND	1.35	ND
CL1	Fluoride (mg/L)	NT	ND	ND	ND	ND
CL1	Nitrate (mg/L)	NT	ND	ND	ND	ND
CL1	Nitrite (mg/L)	NT	ND	ND	ND	ND
CL1	Phosphorus (mg/L)	NT	ND	ND	ND	ND
CL1	Total Kjeldahl Nitrogen (mg/L)	NT	0.41	0.27	0.26	0.53
CL1	Total Dissolved Solids (mg/L)	NT	25.00	18.00	43.00	20.00
CL1	Iron (mg/L)	NT	0.20	0.30	1.17	0.36
CL1	Lead (mg/L)	NT	ND	ND	ND	ND
CL1	Potassium (mg/L)	NT	0.40	0.48	1.15	1.14
CL1	Sodium (mg/L)	NT	2.26	2.24	1.42	0.69
CL2	Temperature (°F)	73.66	73.83	75.86	67.02	74.71
CL2	Conductivity (µS/cm)	27.60	36.41	35.68	25.57	13.34
CL2	pH (s.u.)	5.28	6.13	5.88	4.48	2.72
CL2	Dissolved Oxygen (mg/L)	8.59	1.52	0.03	6.97	37.37
CL2	Turbidity (NTU)	4.40	0.40	2.60	14.10	81.50
CL2	Acidity (mg/L)	NT	1.90	1.40	7.20	3.80
CL2	Ammonia as N (mg/L)	NT	ND	ND	ND	ND
CL2	Alkalinity (mg/L)	NT	5.50	5.50	5.50	2.80
CL2	Chloride (mg/L)	NT	5.80	5.84	2.74	1.29
CL2	Sulfate as S04 (mg/L)	NT	ND	ND	1.68	1.02
CL2	Fluoride (mg/L)	NT	ND	ND	ND	ND
CL2	Nitrate (mg/L)	NT	ND	ND	ND	ND
CL2	Nitrite (mg/L)	NT	ND	ND	ND	ND
CL2	Phosphorus (mg/L)	NT	ND	ND	ND	ND
CL2	Total Kjeldahl Nitrogen (mg/L)	NT	0.55	0.27	0.26	0.40
CL2	Total Dissolved Solids (mg/L)	NT	33.00	27.00	43.00	37.00
CL2	Iron (mg/L)	NT	0.37	0.50	0.60	1.20
CL2	Lead (mg/L)	NT	ND	ND	ND	ND
CL2	Potassium (mg/L)	NT	0.58	0.68	0.73	1.14
CL2	Sodium (mg/L)	NT	2.21	2.27	1.54	0.66

Table 15 Big and Little Cedar Creek Watershed Field and Laboratory Water Quality Analysis Results

Site	Analyte Description	Low Flow (08/29-30/2011)	Low Flow (07/9/2012)	Low Flow (08/2-3/2012)	High Flow (03/23/2012)	High Flow (8/30-31/2012)
CL3	Temperature (°F)	74.35	73.90	75.90	67.49	75.42
CL3	Conductivity (µS/cm)	25.60	33.24	32.52	28.76	19.30
CL3	pH (s.u.)	5.45	5.99	5.78	4.35	2.32
CL3	Dissolved Oxygen (mg/L)	8.44	1.83	8.97	6.29	3.61
CL3	Turbidity (NTU)	2.30	5.30	1.90	11.10	21.70
CL3	Acidity (mg/L)	NT	2.30	3.40	7.20	6.20
CL3	Ammonia as N (mg/L)	NT	ND	ND	ND	ND
CL3	Alkalinity (mg/L)	NT	7.40	5.50	47.00	1.90
CL3	Chloride (mg/L)	NT	5.19	5.14	3.38	1.71
CL3	Sulfate as S04 (mg/L)	NT	ND	ND	1.94	1.50
CL3	Fluoride (mg/L)	NT	ND	ND	ND	ND
CL3	Nitrate (mg/L)	NT	ND	ND	ND	ND
CL3	Nitrite (mg/L)	NT	ND	ND	ND	ND
CL3	Phosphorus (mg/L)	NT	ND	ND	ND	ND
CL3	Total Kjeldahl Nitrogen (mg/L)	NT	0.55	0.27	0.26	ND
CL3	Total Dissolved Solids (mg/L)	NT	31.00	27.00	47.00	48.00
CL3	Iron (mg/L)	NT	0.41	0.49	0.44	0.46
CL3	Lead (mg/L)	NT	ND	ND	ND	ND
CL3	Potassium (mg/L)	NT	0.66	0.70	0.76	1.03
CL3	Sodium (mg/L)	NT	2.20	2.23	1.91	0.94

Table 16 Big and Little Cedar Creek Watershed Field and Laboratory Water Quality Analysis Results

Site	Analyte Description	Low Flow (8/29-30/2011)	Low Flow (7/9/2012)	Low Flow (8/2-3/2012)	High Flow (3/23/2012)	High Flow (8/30-31/2012)
CB1	Temperature (°F)	NT	77.32	77.74	66.80	74.78
CB1	Conductivity (µS/cm)	NT	37.37	198.08	24.67	15.04
CB1	pH (s.u.)	NT	5.60	6.08	5.04	3.68
CB1	Dissolved Oxygen (mg/L)	NT	8.62	0.05	64.69	6.10
CB1	Turbidity (NTU)	NT	4.20	15.20	24.10	303.70
CB1	Acidity (mg/L)	NT	8.90	4.30	6.30	NT
CB1	Ammonia as N (mg/L)	NT	ND	ND	ND	NT
CB1	Alkalinity (mg/L)	NT	6.50	4.60	5.50	NT
CB1	Chloride (mg/L)	NT	6.63	5.99	3.52	NT
CB1	Sulfate as S04 (mg/L)	NT	ND	ND	1.41	NT
CB1	Fluoride (mg/L)	NT	ND	ND	ND	NT
CB1	Nitrate (mg/L)	NT	ND	ND	ND	NT
CB1	Nitrite (mg/L)	NT	ND	ND	ND	NT
CB1	Phosphorus (mg/L)	NT	ND	ND	ND	NT
CB1	Total Kjeldahl Nitrogen (mg/L)	NT	0.27	0.27	0.26	NT
CB1	Total Dissolved Solids (mg/L)	NT	40.00	74.00	30.00	NT
CB1	Iron (mg/L)	NT	2.74	2.85	0.77	NT
CB1	Lead (mg/L)	NT	ND	ND	ND	NT
CB1	Potassium (mg/L)	NT	0.89	0.89	1.02	NT
CB1	Sodium (mg/L)	NT	3.79	3.43	2.18	NT
CB2	Temperature (°F)	74.08	74.89	76.94	66.97	74.87
CB2	Conductivity (µS/cm)	45.60	60.63	50.50	26.22	19.00
CB2	pH (s.u.)	5.87	6.29	5.91	4.67	2.40
CB2	Dissolved Oxygen (mg/L)	8.50	4.74	0.16	6.26	10.69
CB2	Turbidity (NTU)	3.10	3.10	3.90	16.20	45.70
CB2	Acidity (mg/L)	NT	3.80	2.90	7.20	7.20
CB2	Ammonia as N (mg/L)	NT	ND	ND	ND	ND
CB2	Alkalinity (mg/L)	NT	9.20	8.30	2.80	2.80
CB2	Chloride (mg/L)	NT	10.30	8.34	2.98	1.52
CB2	Sulfate as S04 (mg/L)	NT	0.95	1.10	1.89	1.77
CB2	Fluoride (mg/L)	NT	ND	ND	ND	ND
CB2	Nitrate (mg/L)	NT	ND	ND	ND	ND
CB2	Nitrite (mg/L)	NT	ND	ND	ND	ND
CB2	Phosphorus (mg/L)	NT	ND	ND	ND	ND
CB2	Total Kjeldahl Nitrogen (mg/L)	NT	0.68	0.27	0.26	0.40
CB2	Total Dissolved Solids (mg/L)	NT	44.00	36.00	44.00	41.00
CB2	Iron (mg/L)	NT	2.20	0.87	0.60	0.67
CB2	Lead (mg/L)	NT	ND	ND	ND	ND
CB2	Potassium (mg/L)	NT	0.89	0.76	0.67	1.18
CB2	Sodium (mg/L)	NT	8.61	6.32	2.20	0.92

Table 17 Big and Little Cedar Creek Watershed Field and Laboratory Water Quality Analysis Results

Site	Analyte Description	Low Flow (8/29-30/2011)	Low Flow (7/9/2012)	Low Flow (8/2-3/2012)	High Flow (3/23/2012)	High Flow (8/30-31/2012)
CB3	Temperature (°F)	76.31	76.57	75.90	67.51	75.81
CB3	Conductivity (µS/cm)	40.79	43.41	32.52	22.34	19.11
CB3	pH (s.u.)	5.88	6.33	5.78	5.14	4.24
CB3	Dissolved Oxygen (mg/L)	8.03	2.17	8.97	7.53	6.21
CB3	Turbidity (NTU)	7.70	2.70	1.90	71.70	68.80
CB3	Acidity (mg/L)	NT	3.30	4.30	4.30	4.30
CB3	Ammonia as N (mg/L)	NT	ND	ND	ND	ND
CB3	Alkalinity (mg/L)	NT	9.20	10.20	4.60	4.60
CB3	Chloride (mg/L)	NT	6.98	6.47	2.53	2.28
CB3	Sulfate as S04 (mg/L)	NT	ND	ND	1.55	ND
CB3	Fluoride (mg/L)	NT	ND	ND	ND	ND
CB3	Nitrate (mg/L)	NT	ND	ND	ND	ND
CB3	Nitrite (mg/L)	NT	ND	ND	ND	ND
CB3	Phosphorus (mg/L)	NT	ND	ND	ND	1.00
CB3	Total Kjeldahl Nitrogen (mg/L)	NT	0.41	0.27	0.26	0.79
CB3	Total Dissolved Solids (mg/L)	NT	35.00	38.00	50.00	32.00
CB3	Iron (mg/L)	NT	1.44	1.45	1.50	1.76
CB3	Lead (mg/L)	NT	ND	ND	ND	ND
CB3	Potassium (mg/L)	NT	0.75	0.95	0.93	1.41
CB3	Sodium (mg/L)	NT	2.14	2.30	1.54	0.92
CB4	Temperature (°F)	74.11	74.12	76.17	67.10	74.92
CB4	Conductivity (µS/cm)	40.54	45.11	47.07	25.64	24.37
CB4	pH (s.u.)	5.99	6.16	5.84	4.38	0.86
CB4	Dissolved Oxygen (mg/L)	8.49	1.75	8.89	6.60	0.22
CB4	Turbidity (NTU)	4.30	4.60	3.90	15.90	35.30
CB4	Acidity (mg/L)	NT	2.80	2.90	7.20	7.20
CB4	Ammonia as N (mg/L)	NT	ND	ND	ND	ND
CB4	Alkalinity (mg/L)	NT	7.40	6.50	2.80	1.90
CB4	Chloride (mg/L)	NT	7.57	7.75	2.60	2.01
CB4	Sulfate as S04 (mg/L)	NT	0.84	1.37	1.95	1.77
CB4	Fluoride (mg/L)	NT	ND	ND	ND	ND
CB4	Nitrate (mg/L)	NT	ND	ND	ND	ND
CB4	Nitrite (mg/L)	NT	ND	ND	ND	ND
CB4	Phosphorus (mg/L)	NT	ND	ND	ND	ND
CB4	Total Kjeldahl Nitrogen (mg/L)	NT	0.55	0.41	0.26	0.40
CB4	Total Dissolved Solids (mg/L)	NT	34.00	31.00	37.00	42.00
CB4	Iron (mg/L)	NT	0.77	0.80	9.11	0.55
CB4	Lead (mg/L)	NT	ND	ND	ND	ND
CB4	Potassium (mg/L)	NT	0.67	0.79	13.49	0.86
CB4	Sodium (mg/L)	NT	5.40	5.99	1.82	1.27

Table 18 Big and Little Cedar Creek Watershed Field and Laboratory Water Quality Analysis Results

Site	Analyte Description	Low Flow (8/29-30/2011)	Low Flow (7/9/2012)	Low Flow (8/2-3/2012)	High Flow (3/23/2012)	High Flow (8/30-31/2012)
CB5	Temperature (°F)	73.56	72.35	74.34	67.84	75.23
CB5	Conductivity (µS/cm)	18.54	33.48	39.20	24.02	20.49
CB5	pH (s.u.)	5.45	5.87	5.87	4.70	NT
CB5	Dissolved Oxygen (mg/L)	8.61	1.72	9.40	7.10	13.48
CB5	Turbidity (NTU)	1.20	0.80	3.20	31.90	31.10
CB5	Acidity (mg/L)	NT	3.30	2.40	7.20	6.70
CB5	Ammonia as N (mg/L)	NT	ND	ND	ND	ND
CB5	Alkalinity (mg/L)	NT	6.50	5.50	4.60	1.90
CB5	Chloride (mg/L)	NT	4.84	6.01	2.57	1.86
CB5	Sulfate as S04 (mg/L)	NT	ND	1.20	1.67	1.45
CB5	Fluoride (mg/L)	NT	ND	ND	ND	ND
CB5	Nitrate (mg/L)	NT	ND	ND	ND	ND
CB5	Nitrite (mg/L)	NT	ND	ND	ND	ND
CB5	Phosphorus (mg/L)	NT	ND	ND	ND	ND
CB5	Total Kjeldahl Nitrogen (mg/L)	NT	0.55	0.27	0.26	0.40
CB5	Total Dissolved Solids (mg/L)	NT	30.00	29.00	45.00	32.00
CB5	Iron (mg/L)	NT	0.40	0.49	0.73	0.61
CB5	Lead (mg/L)	NT	ND	ND	ND	ND
CB5	Potassium (mg/L)	NT	0.76	0.89	1.47	0.96
CB5	Sodium (mg/L)	NT	3.07	4.14	1.65	1.08
CB6	Temperature (°F)	76.87	74.41	75.08	68.26	75.54
CB6	Conductivity (µS/cm)	28.47	31.85	34.89	27.01	19.40
CB6	pH (s.u.)	5.87	5.94	5.95	4.71	2.92
CB6	Dissolved Oxygen (mg/L)	7.92	1.55	7.65	6.57	4.65
CB6	Turbidity (NTU)	3.40	48.30	3.70	35.80	26.10
CB6	Acidity (mg/L)	NT	1.90	1.90	7.20	7.70
CB6	Ammonia as N (mg/L)	NT	ND	ND	ND	ND
CB6	Alkalinity (mg/L)	NT	6.50	4.60	4.60	1.90
CB6	Chloride (mg/L)	NT	4.85	5.52	3.10	1.75
CB6	Sulfate as S04 (mg/L)	NT	0.80	1.05	1.89	1.45
CB6	Fluoride (mg/L)	NT	ND	ND	ND	ND
CB6	Nitrate (mg/L)	NT	ND	ND	ND	ND
CB6	Nitrite (mg/L)	NT	ND	ND	ND	ND
CB6	Phosphorus (mg/L)	NT	ND	ND	ND	ND
CB6	Total Kjeldahl Nitrogen (mg/L)	NT	0.55	0.27	0.26	ND
CB6	Total Dissolved Solids (mg/L)	NT	31.00	35.00	60.00	34.00
CB6	Iron (mg/L)	NT	0.39	0.46	0.63	0.49
CB6	Lead (mg/L)	NT	ND	ND	ND	ND
CB6	Potassium (mg/L)	NT	0.69	0.78	1.20	0.99
CB6	Sodium (mg/L)	NT	2.54	3.09	1.82	1.00

Table 19 Big and Little Cedar Creek Watershed Field and Laboratory Water Quality Analysis Results

Site	Analyte Description	Low Flow (8/29-30/2011)	Low Flow (7/9/2012)	Low Flow (8/2-3/2012)	High Flow (3/23/2012)	High Flow (8/30-31/2012)
CB7	Temperature (°F)	NT	75.76	78.78	NT	NT
CB7	Conductivity (µS/cm)	NT	31.29	30.92	NT	NT
CB7	pH (s.u.)	NT	5.20	5.38	NT	NT
CB7	Dissolved Oxygen (mg/L)	NT	1.49	8.22	NT	NT
CB7	Turbidity (NTU)	NT	4.60	3.80	NT	NT
CB7	Acidity (mg/L)	NT	5.20	2.90	NT	NT
CB7	Ammonia as N (mg/L)	NT	ND	ND	NT	NT
CB7	Alkalinity (mg/L)	NT	3.70	4.60	NT	NT
CB7	Chloride (mg/L)	NT	4.96	5.61	NT	NT
CB7	Sulfate as S04 (mg/L)	NT	1.67	0.97	NT	NT
CB7	Fluoride (mg/L)	NT	ND	ND	NT	NT
CB7	Nitrate (mg/L)	NT	ND	ND	NT	NT
CB7	Nitrite (mg/L)	NT	ND	ND	NT	NT
CB7	Phosphorus (mg/L)	NT	ND	ND	NT	NT
CB7	Total Kjeldahl Nitrogen (mg/L)	NT	0.27	0.41	NT	NT
CB7	Total Dissolved Solids (mg/L)	NT	43.00	35.00	NT	NT
CB7	Iron (mg/L)	NT	0.67	0.86	NT	NT
CB7	Lead (mg/L)	NT	ND	ND	NT	NT
CB7	Potassium (mg/L)	NT	0.51	0.62	NT	NT
CB7	Sodium (mg/L)	NT	2.41	2.53	NT	NT

Table 20 Escatawpa River Watershed Field and Laboratory Water Quality Analysis Results

Site	Analyte Description	Low Flow (8/29-30/2011)	Low Flow (11/15/2011)	High Flow (3/24/2012)	High Flow (8/30-31/2012)
E1	Temperature (°F)	80.51	66.58	67.14	75.48
E1	Conductivity (µS/cm)	22.52	33.72	24.00	21.87
E1	pH (s.u.)	6.15	6.49	4.48	2.78
E1	Dissolved Oxygen (mg/L)	7.18	9.02	8.23	4.34
E1	Turbidity (NTU)	4.80	1.10	40.00	59.70
E1	Acidity (mg/L)	NT	2.00	8.20	8.60
E1	Ammonia as N (mg/L)	NT	ND	ND	ND
E1	Alkalinity (mg/L)	NT	4.60	3.70	1.90
E1	Chloride (mg/L)	NT	5.15	2.56	2.29
E1	Sulfate as S04 (mg/L)	NT	1.51	1.72	1.55
E1	Fluoride (mg/L)	NT	ND	ND	ND
E1	Nitrate (mg/L)	NT	ND	ND	ND
E1	Nitrite (mg/L)	NT	ND	ND	ND
E1	Phosphorus (mg/L)	NT	ND	ND	ND
E1	Total Kjeldahl Nitrogen (mg/L)	NT	0.55	0.26	ND
E1	Total Dissolved Solids (mg/L)	NT	21.00	60.00	47.00
E1	Iron (mg/L)	NT	0.44	0.78	1.23
E1	Lead (mg/L)	NT	ND	ND	ND
E1	Potassium (mg/L)	NT	0.68	0.49	0.78
E1	Sodium (mg/L)	NT	2.82	1.50	1.22
E2	Temperature (°F)	NT	66.41	67.28	NT
E2	Conductivity (µS/cm)	NT	31.95	24.18	NT
E2	pH (s.u.)	NT	6.19	4.56	NT
E2	Dissolved Oxygen (mg/L)	NT	9.24	9.62	NT
E2	Turbidity (NTU)	NT	12.60	39.80	NT
E2	Acidity (mg/L)	NT	2.00	7.20	NT
E2	Ammonia as N (mg/L)	NT	ND	ND	NT
E2	Alkalinity (mg/L)	NT	5.50	3.70	NT
E2	Chloride (mg/L)	NT	4.89	2.67	NT
E2	Sulfate as S04 (mg/L)	NT	1.47	1.70	NT
E2	Fluoride (mg/L)	NT	ND	ND	NT
E2	Nitrate (mg/L)	NT	ND	ND	NT
E2	Nitrite (mg/L)	NT	ND	ND	NT
E2	Phosphorus (mg/L)	NT	ND	ND	NT
E2	Total Kjeldahl Nitrogen (mg/L)	NT	0.55	0.26	NT
E2	Total Dissolved Solids (mg/L)	NT	40.00	54.00	NT
E2	Iron (mg/L)	NT	0.48	0.78	NT
E2	Lead (mg/L)	NT	ND	ND	NT
E2	Potassium (mg/L)	NT	0.68	0.62	NT
E2	Sodium (mg/L)	NT	2.87	1.69	NT

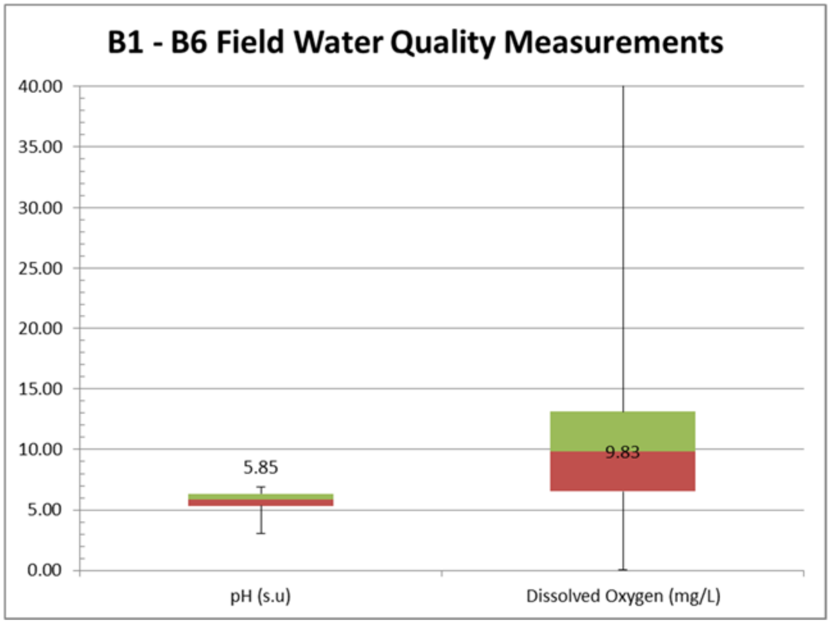

Figure 35 Graphical representation of composite averages of field water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

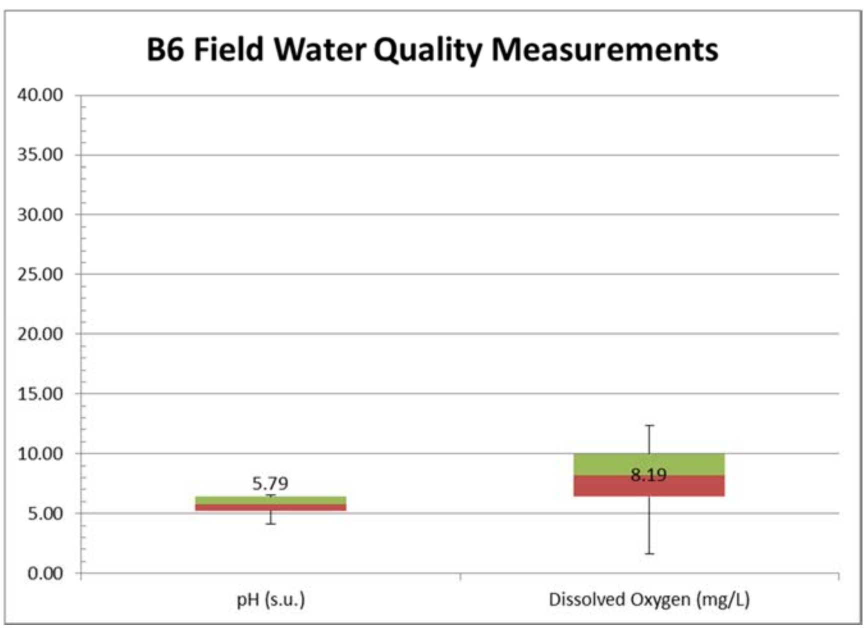

Figure 36 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site of Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

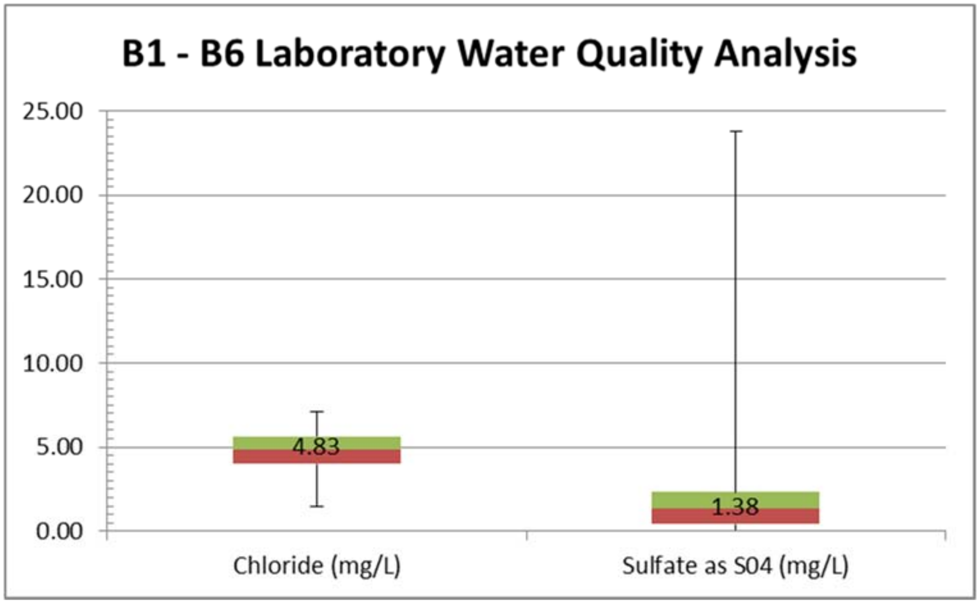

Figure 37 Graphical representation of composite averages of laboratory water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

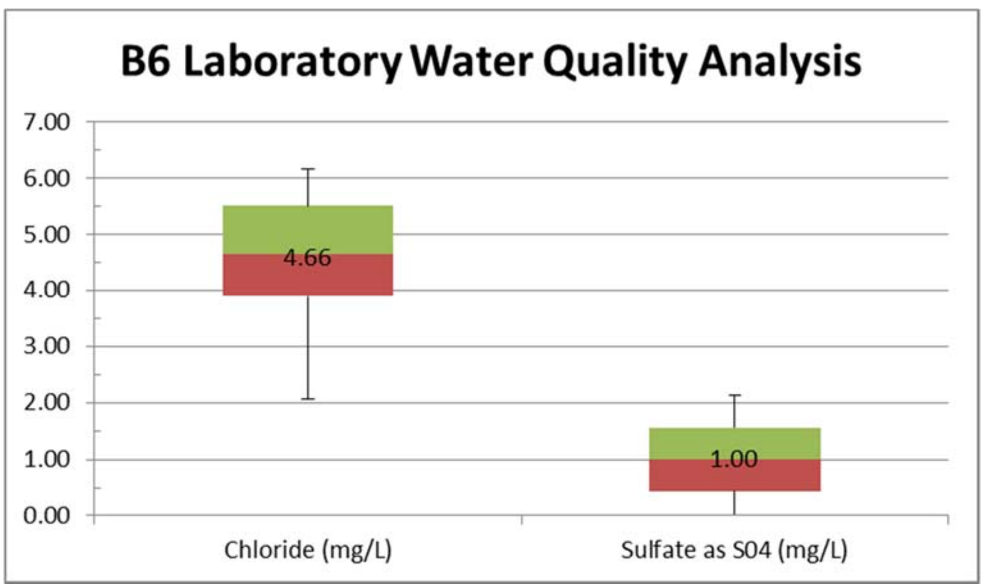

Figure 38 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (B6) of the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

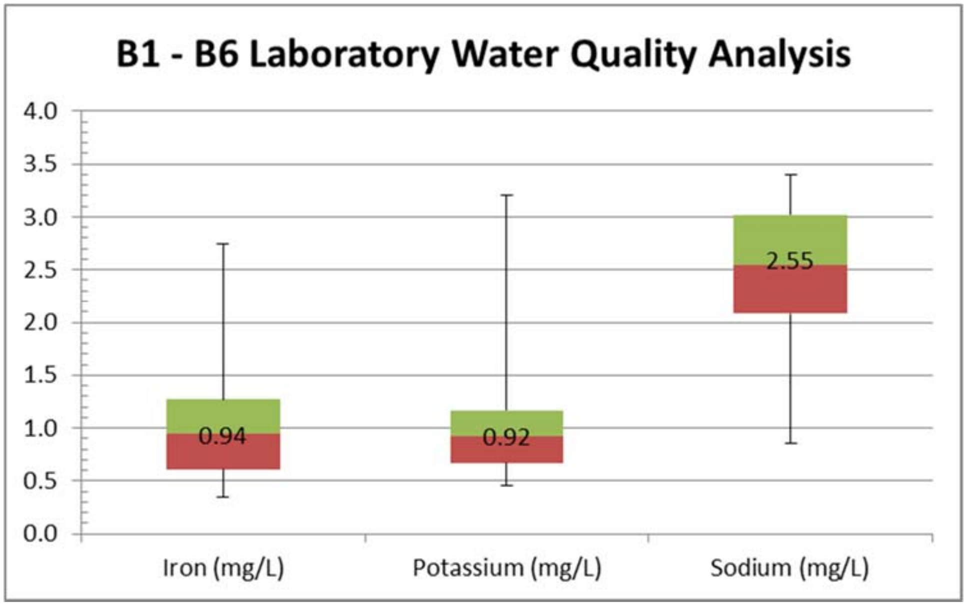

Figure 39 Graphical representation of composite averages of laboratory water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

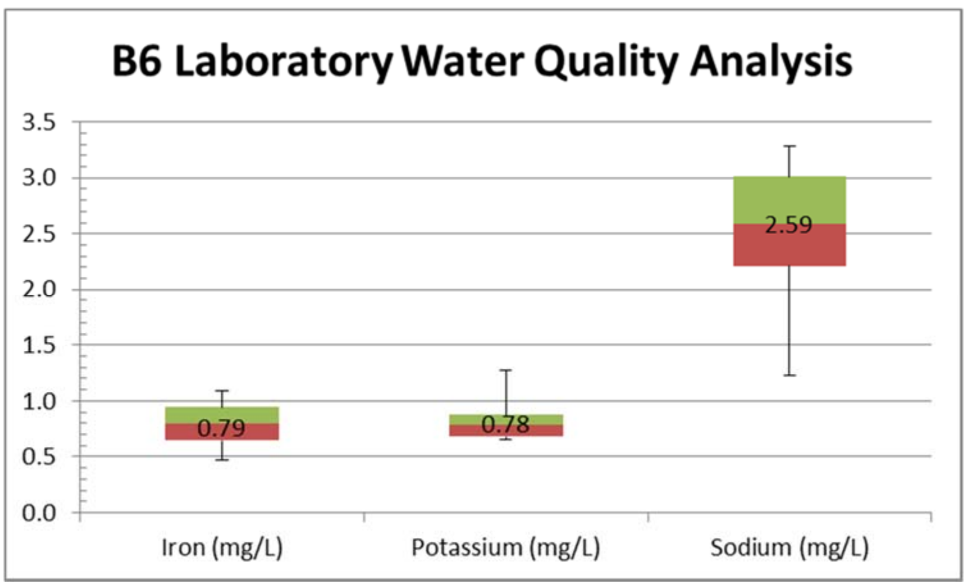

Figure 40 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (B6) of the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

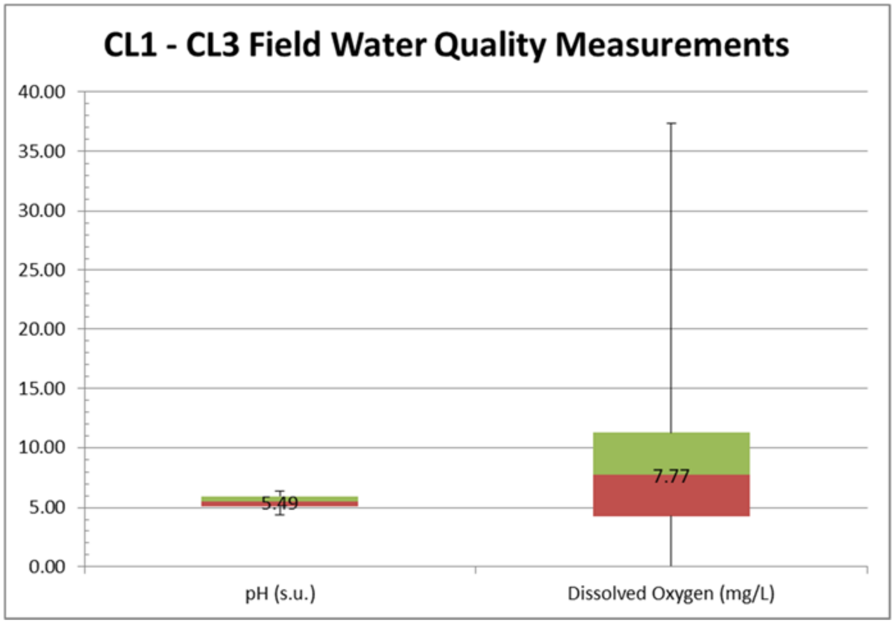

Figure 41 Graphical representation of composite averages of field water quality measurements for Little Cedar Creek watershed sampling sites

Notes: Error bars depict maximum and minimum values measured for each parameter

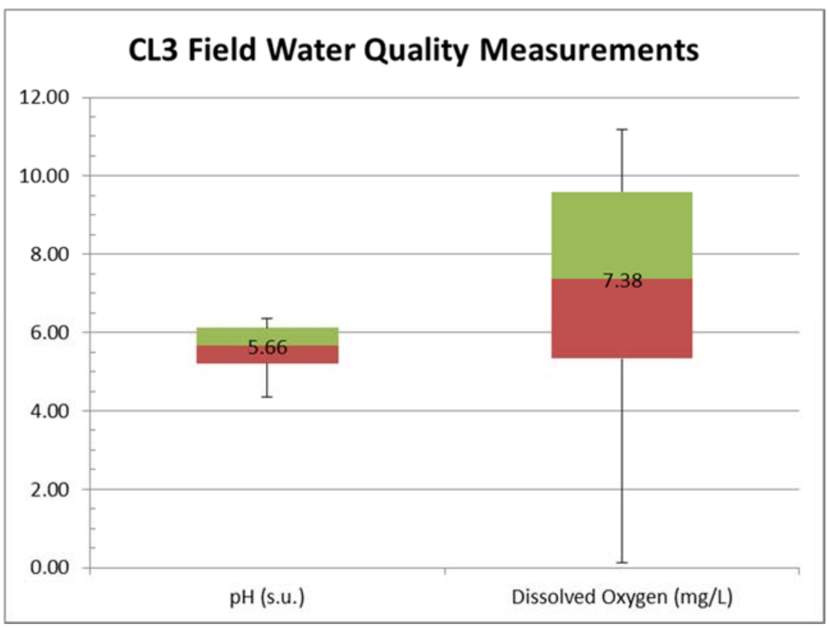

Figure 42 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

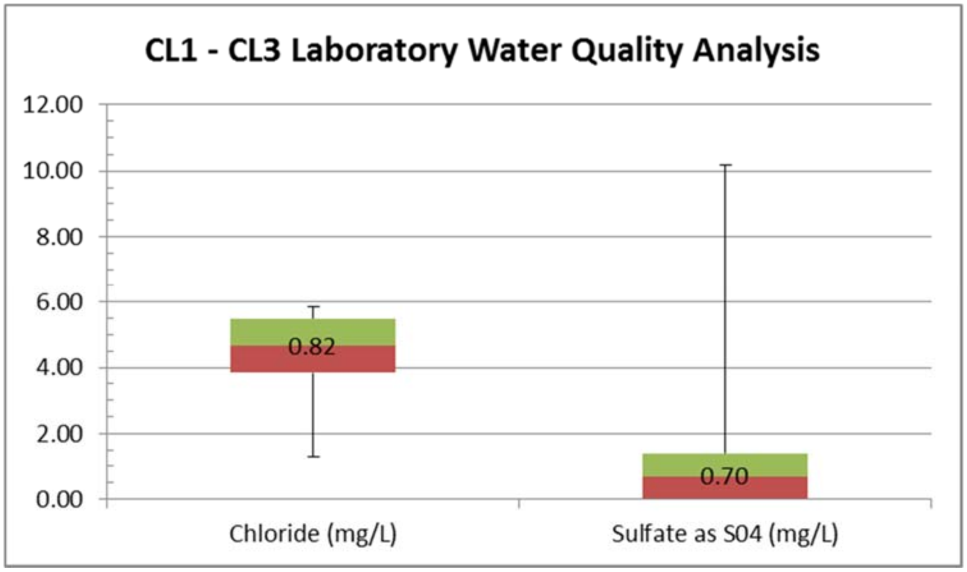

Figure 43 Graphical representation of composite averages of laboratory water quality measurements for the Little Cedar Creek watershed sampling sites

Notes: Error bars depict maximum and minimum values measured for each parameter

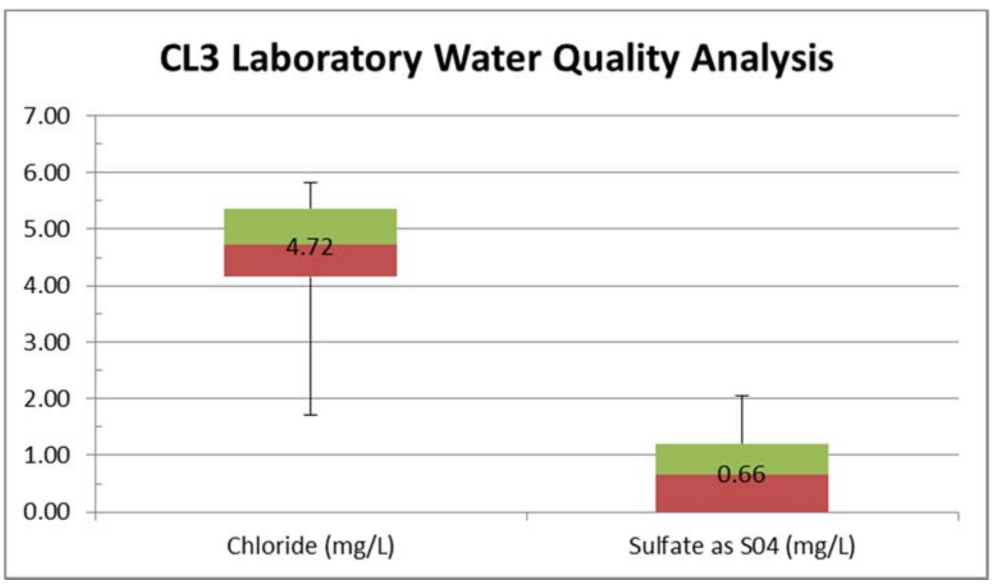

Figure 44 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

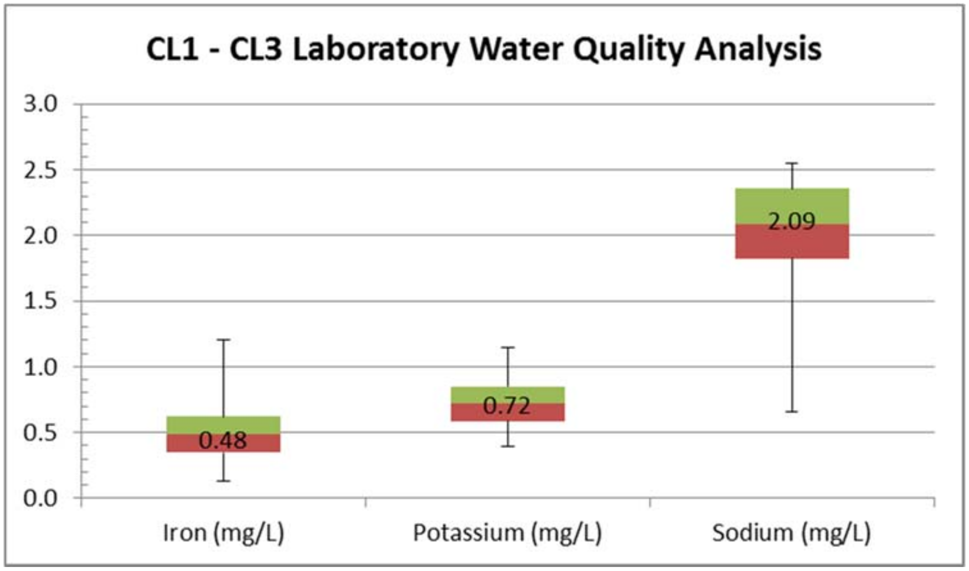

Figure 45 Graphical representation of composite averages of laboratory water quality measurements for Little Cedar Creek watershed sampling sites

Notes: Error bars depict maximum and minimum values measured for each parameter

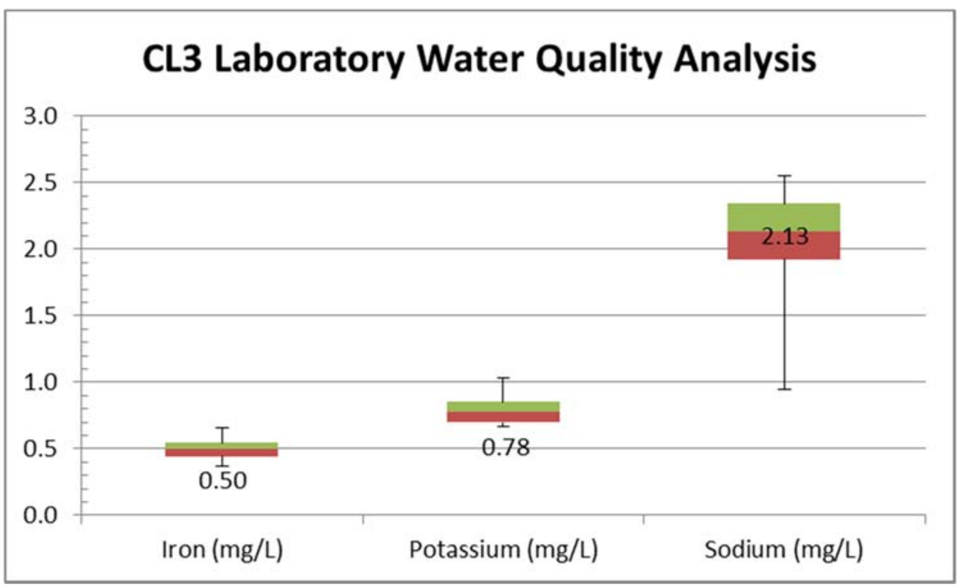

Figure 46 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

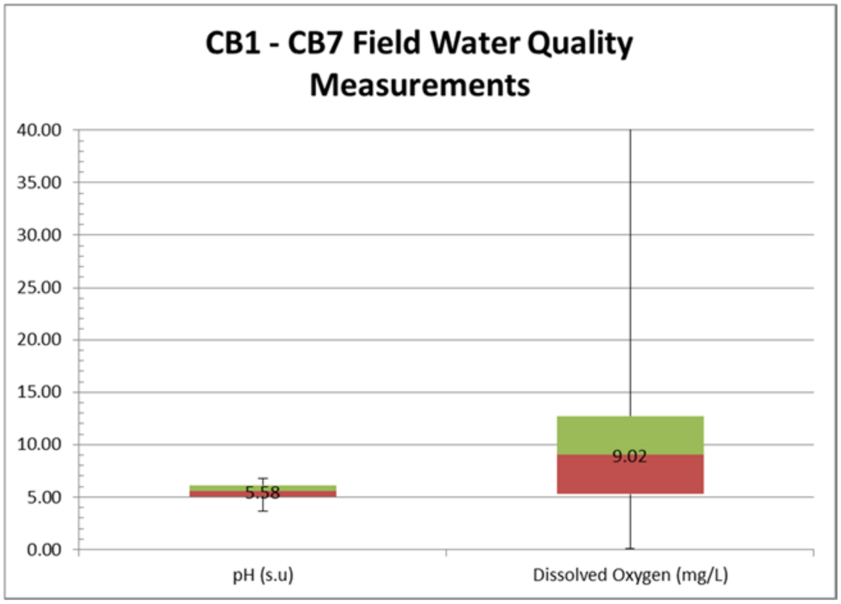

Figure 47 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site of Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

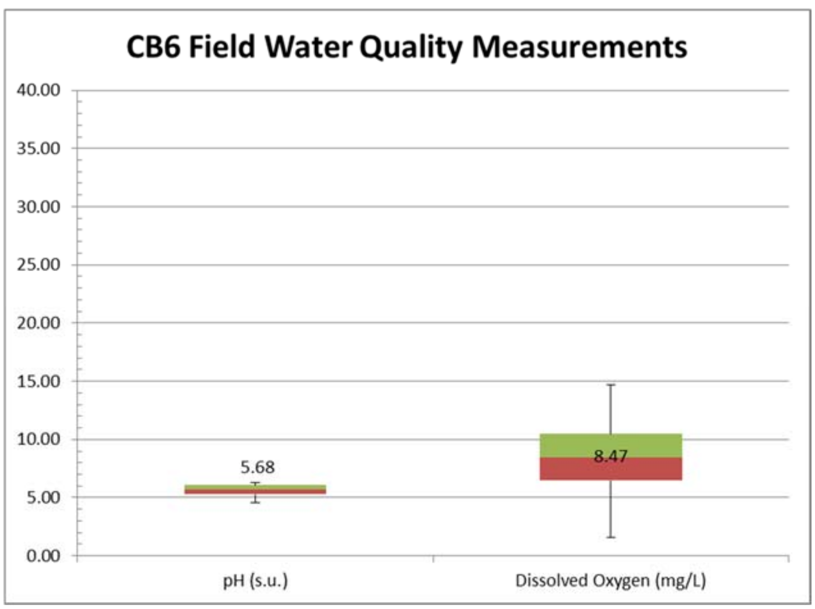

Figure 48 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (CB6) of Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

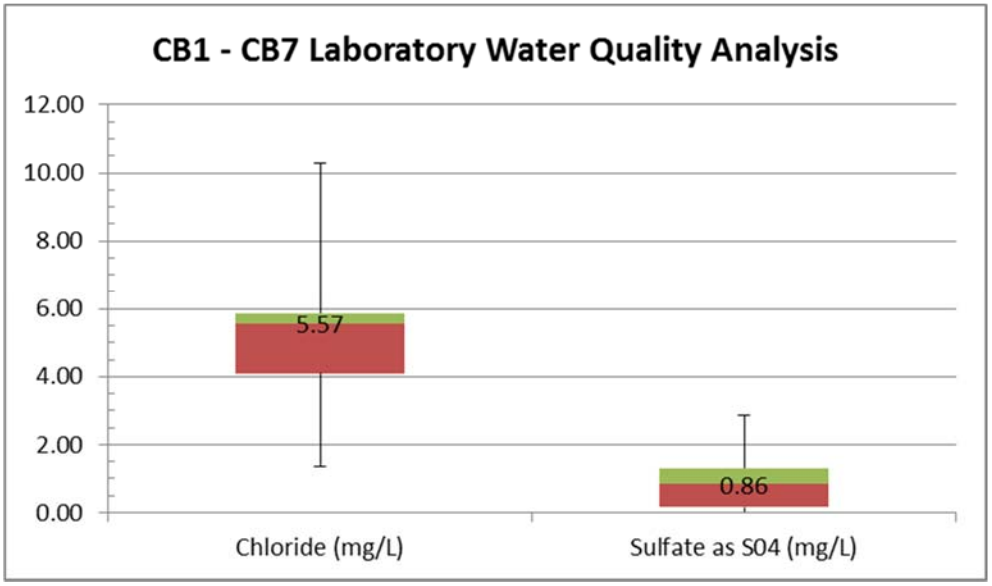

Figure 49 Graphical representation of composite averages of laboratory water quality measurements of Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

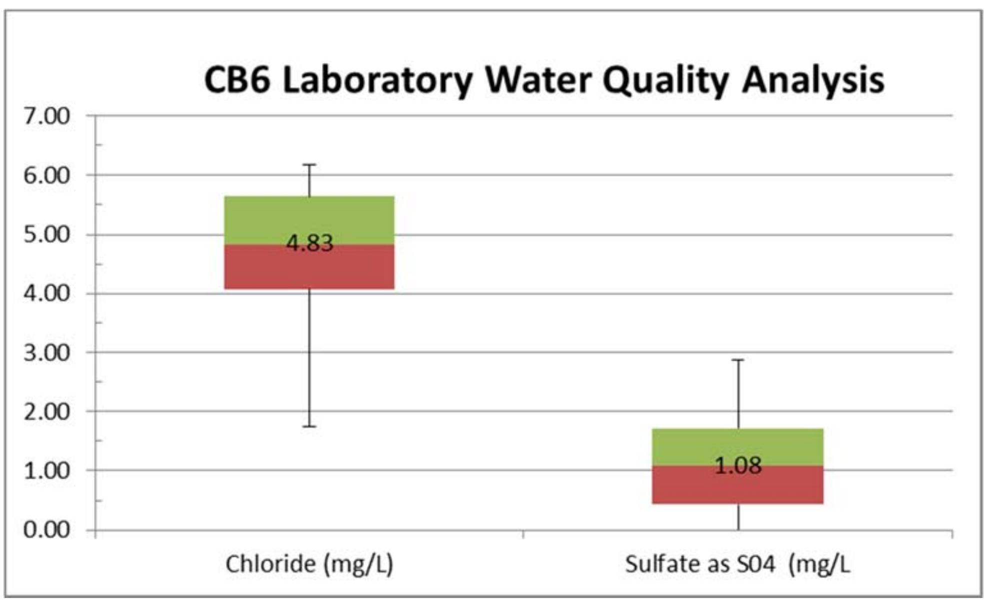

Figure 50 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CB6) of Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

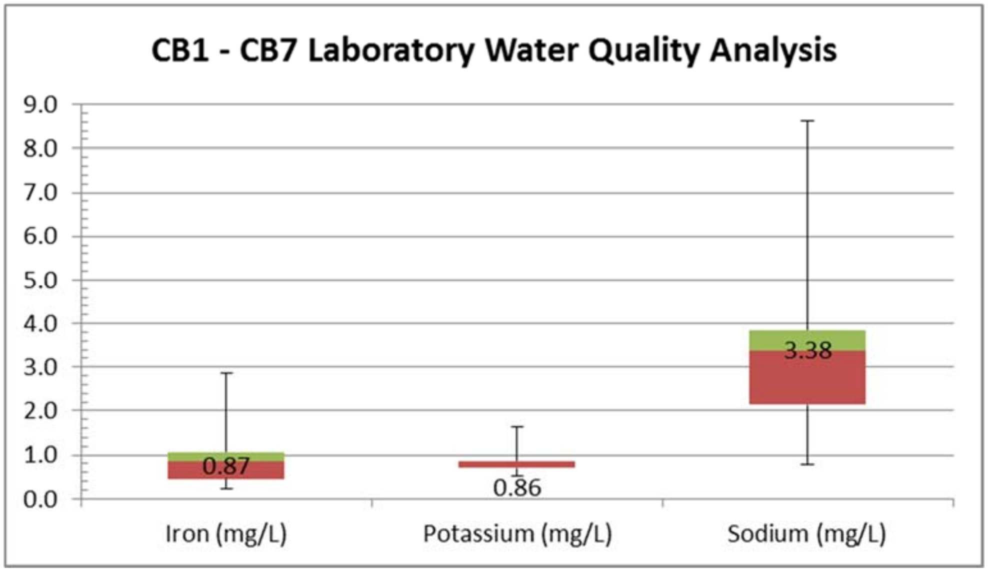

Figure 51 Graphical representation of composite averages of laboratory water quality measurements of Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

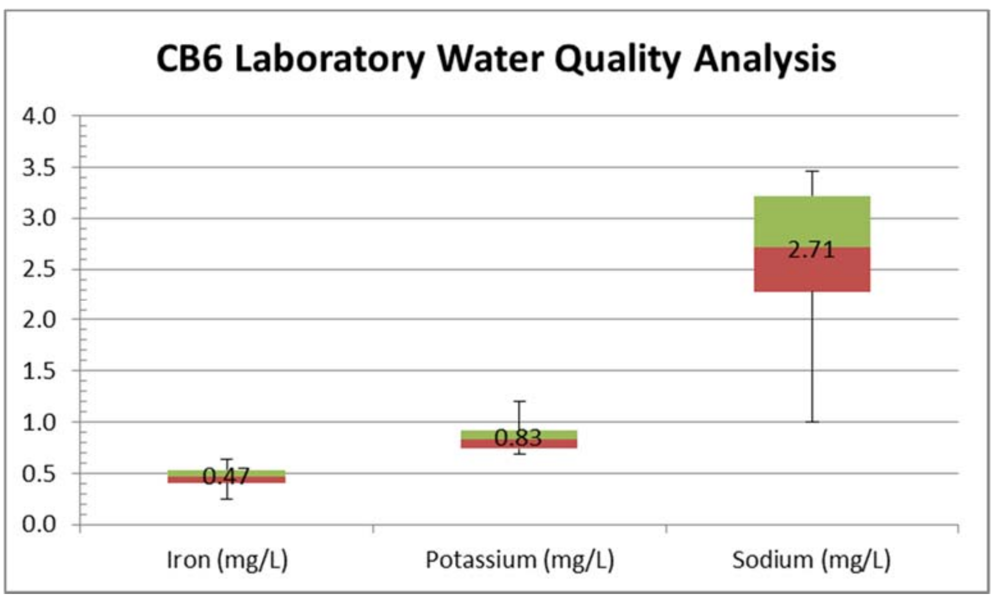

Figure 52 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CB6) of Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

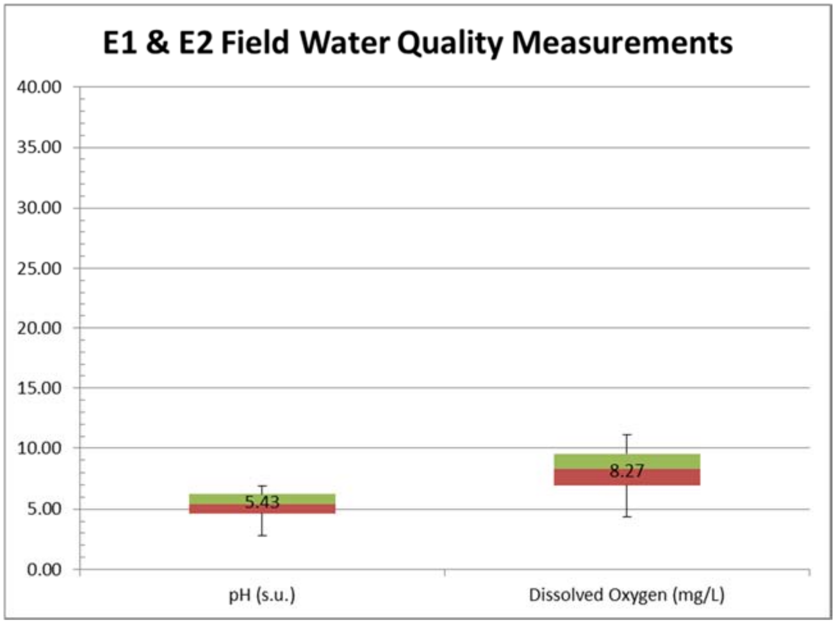

Figure 53 Graphical representation of composite averages of field water quality measurements for the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

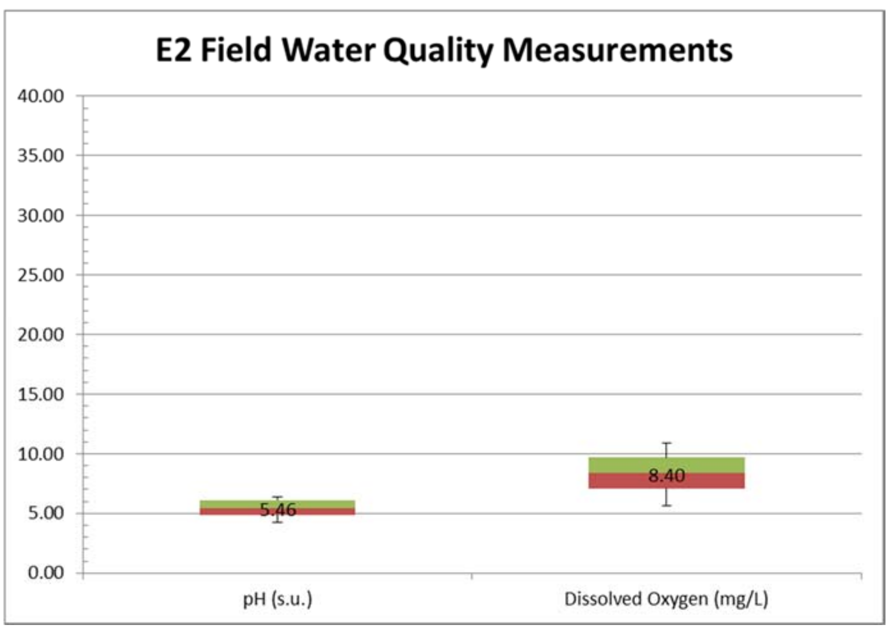

Figure 54 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (E2) of the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

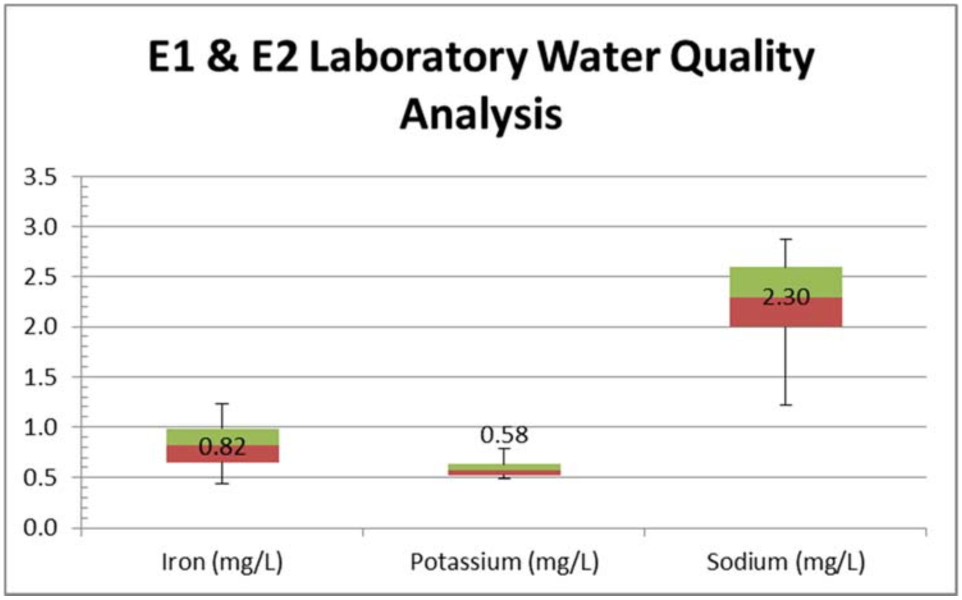

Figure 55 Graphical representation of composite averages of laboratory water quality measurements for the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

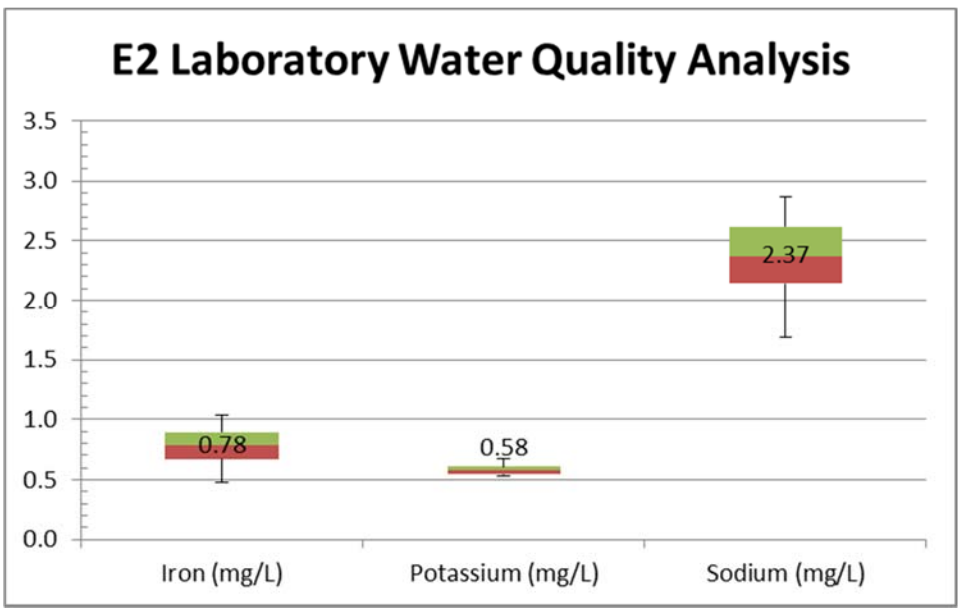

Figure 56 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (E2) of the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

Spring Inventory and Analysis

A county-wide spring inventory for the Big Creek and Little and Big Cedar Creek Watersheds were performed from May 1, 2012 to December 31, 2012. A total of 40 spring heads were located, assigned GPS coordinates, and analyzed by field parameters and flow discharge if measurable.

Water Quantity

Of the 40 springs, 21 were found feeding into the Big Creek watershed and 19 into the Big and Little Cedar watershed.

Water Quality

Field parameter values of table 21 that are colored in red, indicate their incompliance with the MDEQ and EPA water quality standards that were applied to the surface water quality measurements of the 19 sampling sites. Field parameter and discharge data obtained from measurable springs are provided in table 21. Figure 100 depicts the map locations of the 40 springs listed in table 22.

Table 21 George County Spring Inventory Field Analyses

Date	Spring ID	Sample Time	Discharge ft³/sec	Temperature °F	pH s.u.	Conductivity µS/cm	Dissolved Oxygen mg/L	Turbidity NTU
6.13.12	SPB1001	17:01	NM	73.48	5.70	69.21	12.91	5.90
8.9.12	SPB1002	14:13	0.002	72.26	5.27	19.73	6.78	6.10
5.25.12	SPC1001	9:17	0.023	77.69	7.32	146.00	7.01	-0.05
5.24.12	SPC1002	17:01	0.029	76.60	7.28	49.14	36.19	46.80
5.23.12	SPC1003	8:58	NM	66.67	5.12	44.25	4.57	4.30
5.22.12	SPC1008	NT	0.092	NT	NT	NT	NT	NT
5.23.12	SPC1009	NT	0.170	NT	NT	NT	NT	NT
5.23.12	SPC1010	10:42	0.012	67.65	5.14	33.13	4.50	49.00
5.23.12	SPC1011	11:31	0.011	67.95	5.88	79.14	17.79	18.00
5.24.12	SPC1014	14:53	0.044	73.31	5.70	35.08	5.58	2.10
5.24.12	SPC1015	15:23	4.136	84.76	5.52	77.99	8.49	60.70
5.24.12	SPC1016	15:44	0.026	69.86	5.45	35.06	107.55	1.50
5.24.12	SPC1017	16:18	0.005	68.75	5.30	14.08	128.78	139.50
5.24.12	SPC1018	16:36	0.003	84.46	7.03	328.55	48.18	12.10
6.13.12	SPC1019	14:53	NM	74.22	6.53	231.95	11.12	140.00
6.14.12	SPC1020	16:42	0.003	75.06	7.30	226.87	17.87	53.80
6.14.12	SPC1021	17:07	0.043	72.01	5.07	23.80	19.65	0.50
6.14.12	SPF1001	14:55	0.344	72.10	5.87	49.82	19.20	1.20
7.19.12	SPG1001	10:10	0.659	74.95	4.91	43.74	7.38	77.42
7.19.12	SPG1002	15:13	0.012	71.32	4.65	31.10	2.79	282.30
8.9.12	SPG1003	10:07	0.026	74.55	4.95	39.47	6.11	1.70
8.9.12	SPG1004	15:53	0.008	76.13	5.60	72.58	5.96	5.80
12.6.12	SPG1005	13:52	0.024	66.39	6.38	54.54	12.55	13.30
12.6.12	SPG1007	15:08	0.444	65.99	5.28	17.22	12.70	26.00
12.6.12	SPG1008	15:20	included in SPG1007	67.35	4.86	22.33	12.18	191.90
12.6.12	SPG1009	15:50	0.024	63.33	5.09	18.45	13.77	-0.90
12.7.12	SPG1010	9:50	0.011	65.73	5.02	20.20	9.51	426.20
12.7.12	SPG1011	10:09	0.005	65.52	4.92	24.94	9.57	1628.00
12.7.12	SPG1012	10:25	0.025	66.61	5.09	25.77	9.26	614.50
12.7.12	SPG1013	12:13	0.007	63.41	5.08	30.88	10.21	11.20
12.7.12	SPG1014	12:59	0.007	65.60	4.78	18.37	9.55	52.00
12.7.12	SPG1015	13:26	0.054	60.65	4.45	22.25	11.10	1.60
8.8.12	SPL1002	11:18	0.027	75.38	5.04	34.40	4.45	2.20
12.6.12	SPL1004	10:11	NM	60.31	4.83	32.95	15.10	2.30
12.6.12	SPL1005	11:02	0.024	61.31	5.73	28.86	14.64	45.90

Table 22 Spring Inventory Locations

Spring ID	Latitude (W)	Longitude (N)
SPB1001	30.95410799	-88.63642789
SPB1002	30.94978569	-88.6358207
SPC1019	30.92507877	-88.60232025
SPC1020	30.91378206	-88.56767315
SPC1021	30.91765777	-88.57194984
SPC1003	30.93201304	-88.59019348
SPC1004	30.92053997	-88.58193998
SPC1005	30.91930993	-88.58412992
SPC1006	30.92745999	-88.58545996
SPC1007	30.92779996	-88.58444994
SPC1008	30.92672347	-88.58278605
SPC1009	30.93326194	-88.59179257
SPC1010	30.93197993	-88.59446992
SPC1011	30.93371725	-88.59373273
SPC1012	30.92425467	-88.58027106
SPC1013	30.92266956	-88.57763118
SPC1014	30.9537054	-88.600394
SPC1015	30.95391713	-88.60452854
SPC1016	30.954815	-88.60788013
SPC1017	30.95564682	-88.61281062
SPC1018	30.95705624	-88.61974061
SPF 1001	30.89127322	-88.64647511
SPG1001	30.8602072	-88.57734243
SPG1002	30.88561786	-88.57607827
SPG1003	30.83518228	-88.55302963
SPG1004	30.84210162	-88.54530738
SPG1005	30.87374909	-88.56293787
SPG1006	30.87378563	-88.56224712
SPG1007	30.85167686	-88.53180614
SPG1008	30.85193393	-88.53197588
SPG1009	30.85435219	-88.53367908
SPG1010	30.86997891	-88.55960548
SPG1011	30.87094459	-88.55929225
SPG1012	30.87109119	-88.55791929
SPG1013	30.8674894	-88.57245108
SPG1014	30.86813321	-88.57971727
SPG1015	30.87542254	-88.57732264
SPL1002	30.74034934	-88.57919709
SPL1003	30.77657249	-88.52586052
SPL1004	30.77992693	-88.53188753
SPL1005	30.77593865	-88.51789612

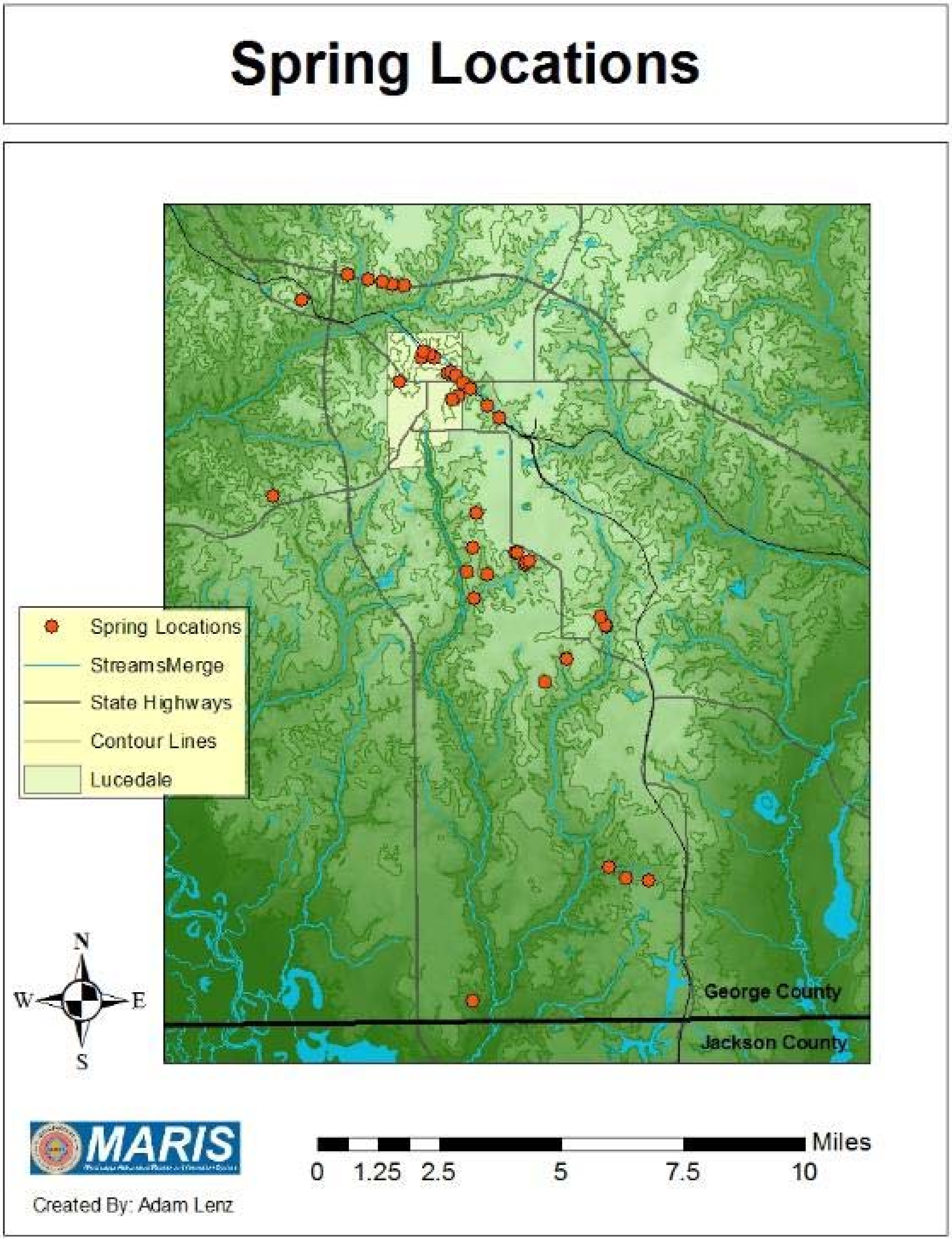

Figure 57 Location of springs found during the spring inventory

Reservoir Modeling

Reservoir modeling performed for each of the three watersheds of three parts: creation of lake footprints, calculation of lake footprint volumes, and creation of reservoir daily water storage models. The lake footprints created in ArcGIS 10.1 were based on topographic contours of a digital elevation map downloaded from the Mississippi Automated Resource Information System (MARIS). The elevation contours chosen for the Big Creek, Big and Little Cedar Creek, and Escatawpa reservoirs were 120 feet above sea level, 100 feet above sea level, and 60 feet above sea level, respectively. Big Creek and Cedar Creek contours of 120 feet and 100 feet were chosen because they produce lake footprints that show the least potential impact to county infrastructure and urban development while featuring a practical dam location and construction. The Escatawpa contour of 60 feet was chosen because it produced the largest lake area possible without engulfing any land within the boundaries of the state of Alabama. The dam placement of the Escatawpa footprint was chosen based on construction feasibility with respect to the elevation contour character. Figures 101 - 103 show the three theoretical lake footprints created in ArcGIS 10.1. The created lake footprints and the ArcGIS Polygon Volume tool were used to calculate a total volume for each of the three lakes. The Big Creek lake footprint generated a volume of 64,717 acre-feet. The Big and Little Cedar Creek lake footprint generated a volume of 123,417 acre-feet. The Escatawpa River lake footprint generated a volume of 18,268 acre-feet.

The lake footprint volumes were incorporated as the initial daily storage values in the daily water storage models. The Escatawpa River lake footprint volume (18,268 acre-feet) was considered to be a highly inefficient volume that would not supply the water needed for the project; therefore, simulations of the daily storage model were not performed for the theoretical Escatawpa reservoir. Figures 104 and 105 show line graphs of the two model simulations (i.e. Lake with use, Lake without use) performed for the Big Creek 120 foot elevation lake footprint and the Big and Little Cedar 100 foot elevation lake footprint. Following the performed field work and creation of the three lake footprints, it was discovered that the Big Cedar Creek Wetlands Mitigation Bank maintained control over a large portion of the land that would be engulfed by the Big and Little Cedar 100 foot elevation lake footprint. This new knowledge of the mitigation bank property consequently meant that the construction of the Big and Little Cedar lake footprint design would never realistically be granted. Therefore an alternative lake footprint was constructed at a 110 foot elevation contour with a different dam location that avoids flooding the mitigation bank property. Figure 106 shows the new lake footprint created at the 110 foot elevation contour, which incorporates much more of the Little Cedar Creek drainage area as the majority of the lake area. This lake footprint generated a total volume of 80, 954 acre-feet. Figure 107 shows a line graph of the daily storage model simulations (i.e. Lake with use, Lake without use) performed for the Little Cedar Creek 110 foot elevation lake footprint.

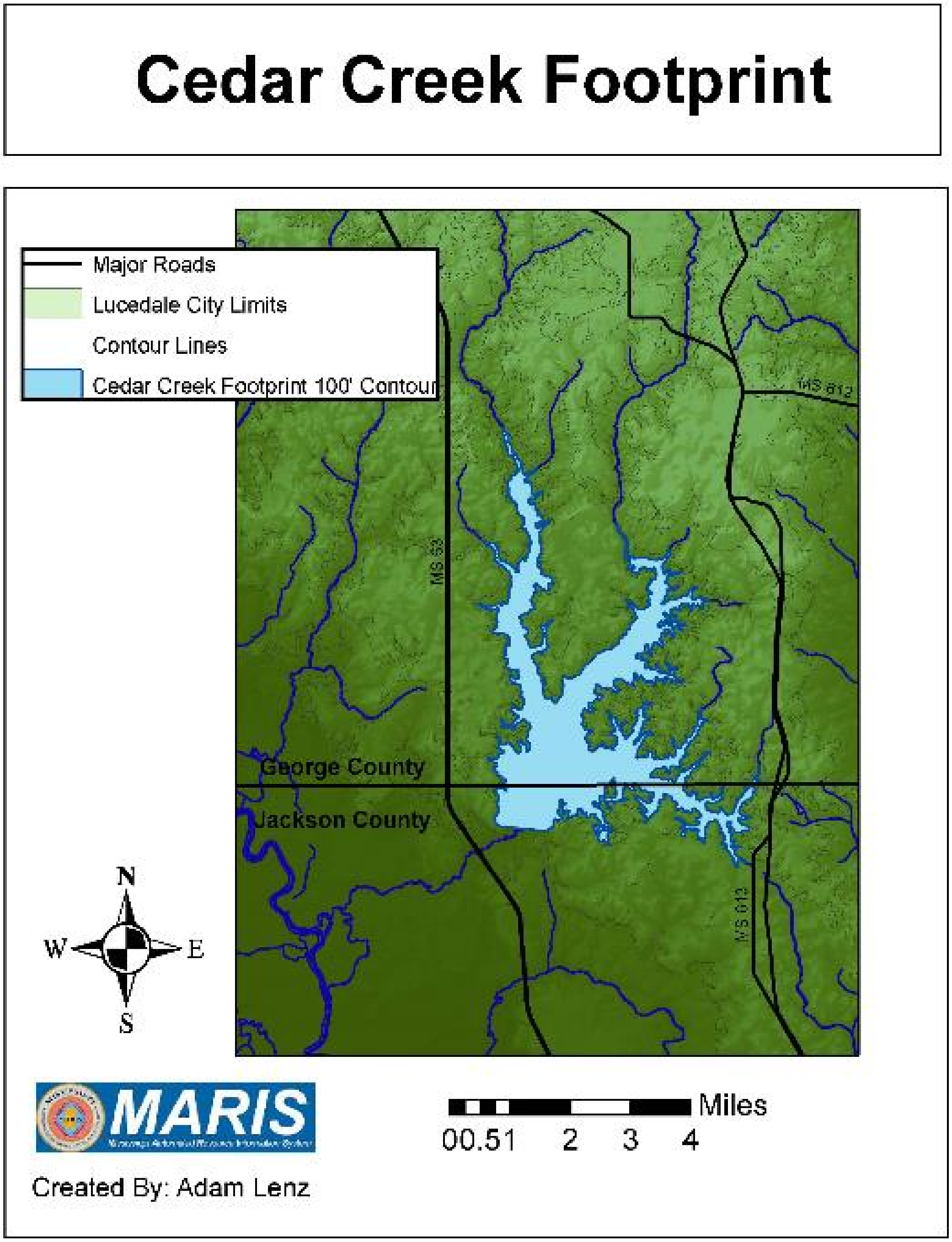

Figure 58 Big and Little Cedar Creek lake footprint created a 110 foot elevation contour

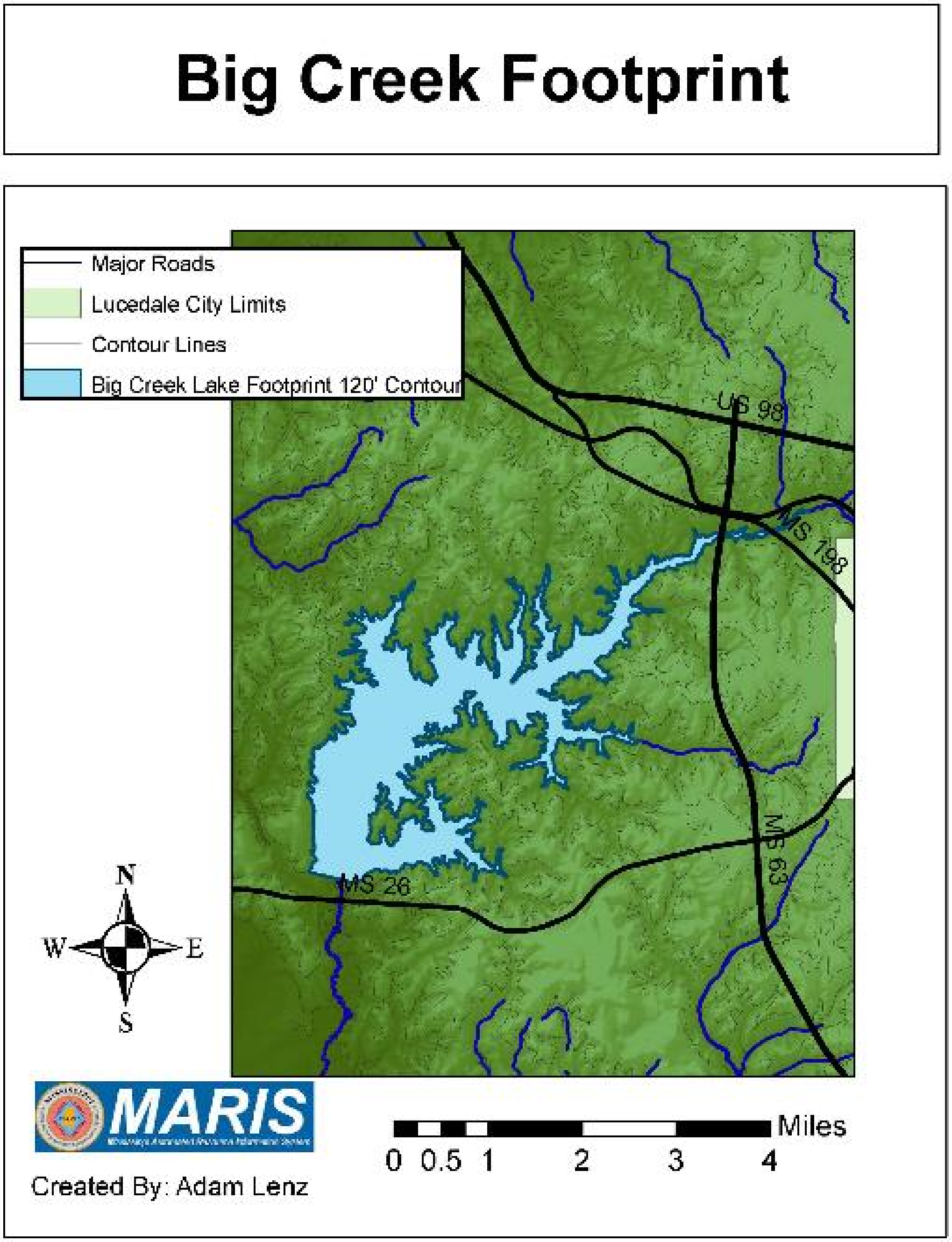

Figure 59 Big Creek lake footprint created at 120 feet elevation contour

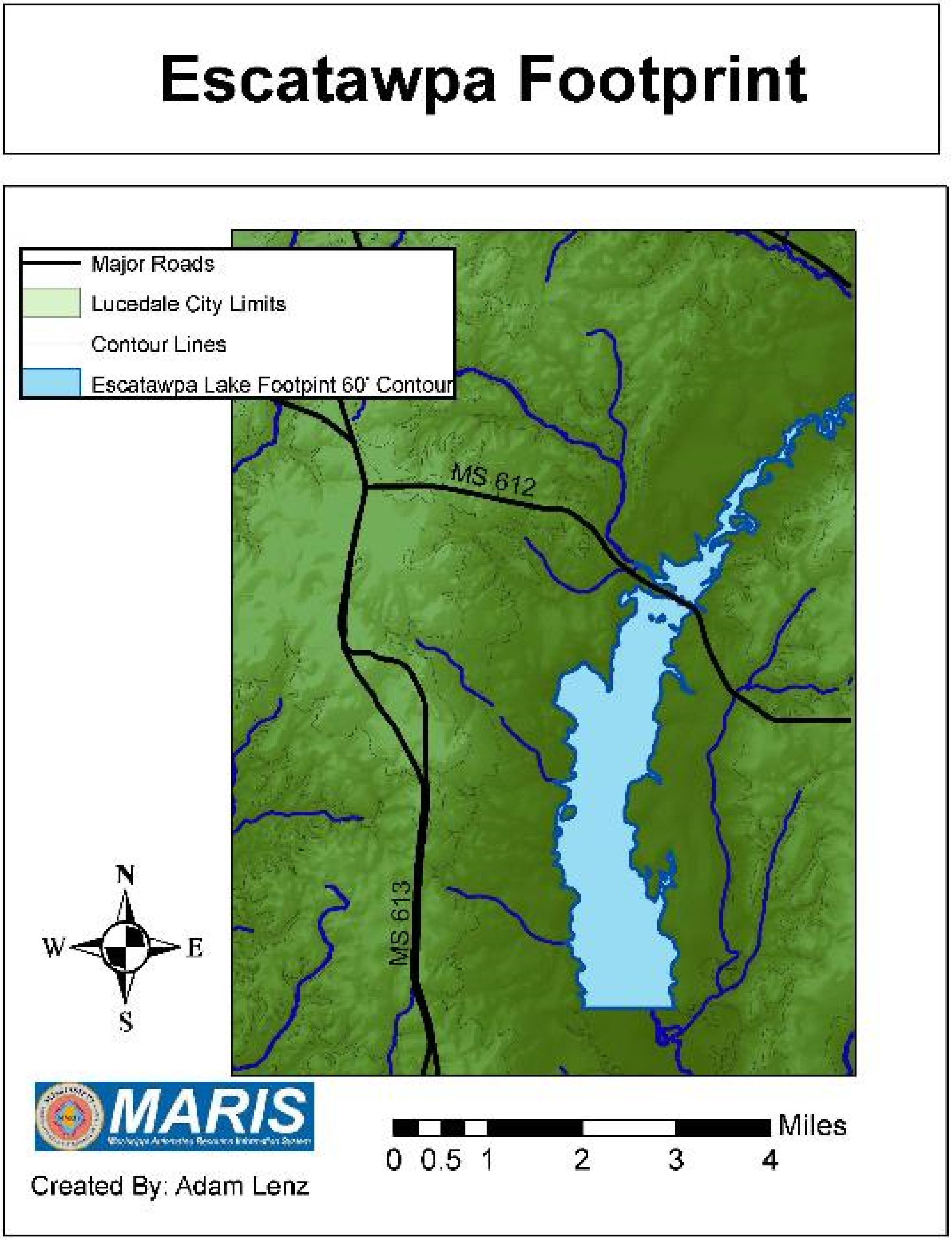

Figure 60 Escatawpa River lake footprint created at 60 feet elevation contour

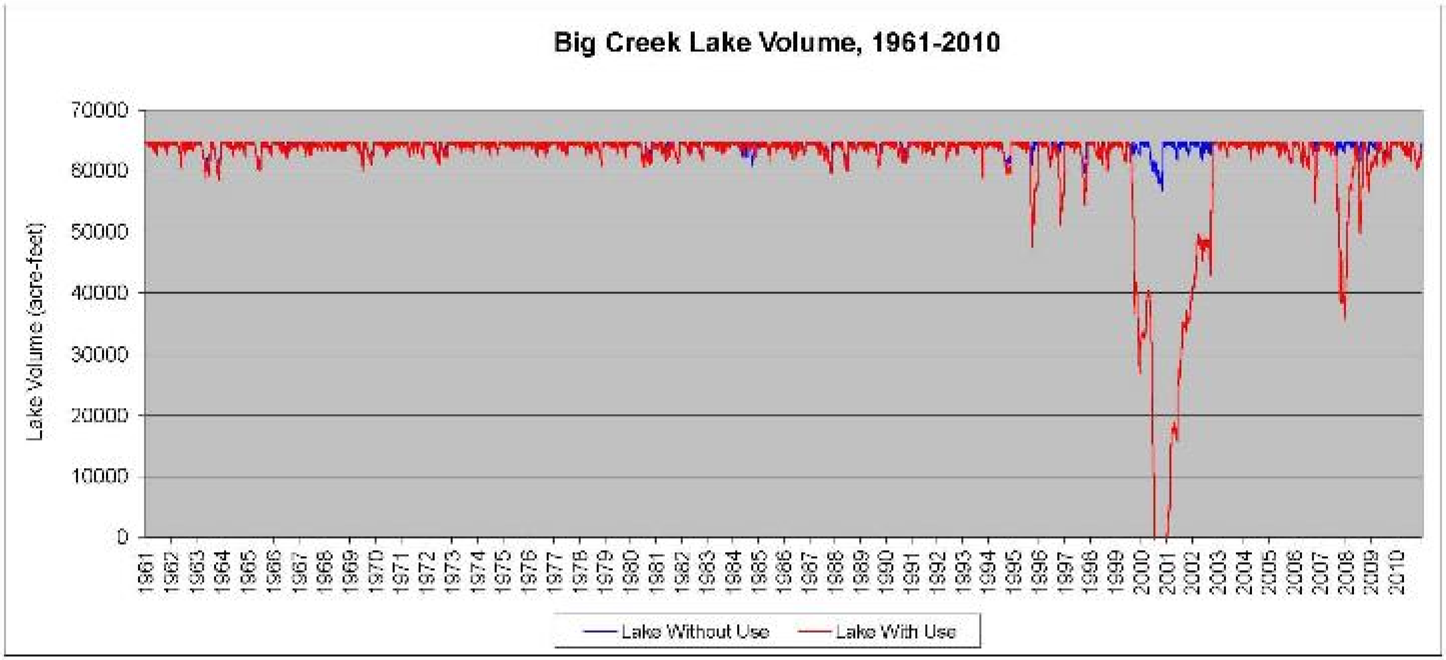

Figure 61 Daily water storage model for Big Creek lake footprint

Notes: The model is for a 120 feet elevation footprint and a volume of 64,717 acre-feet

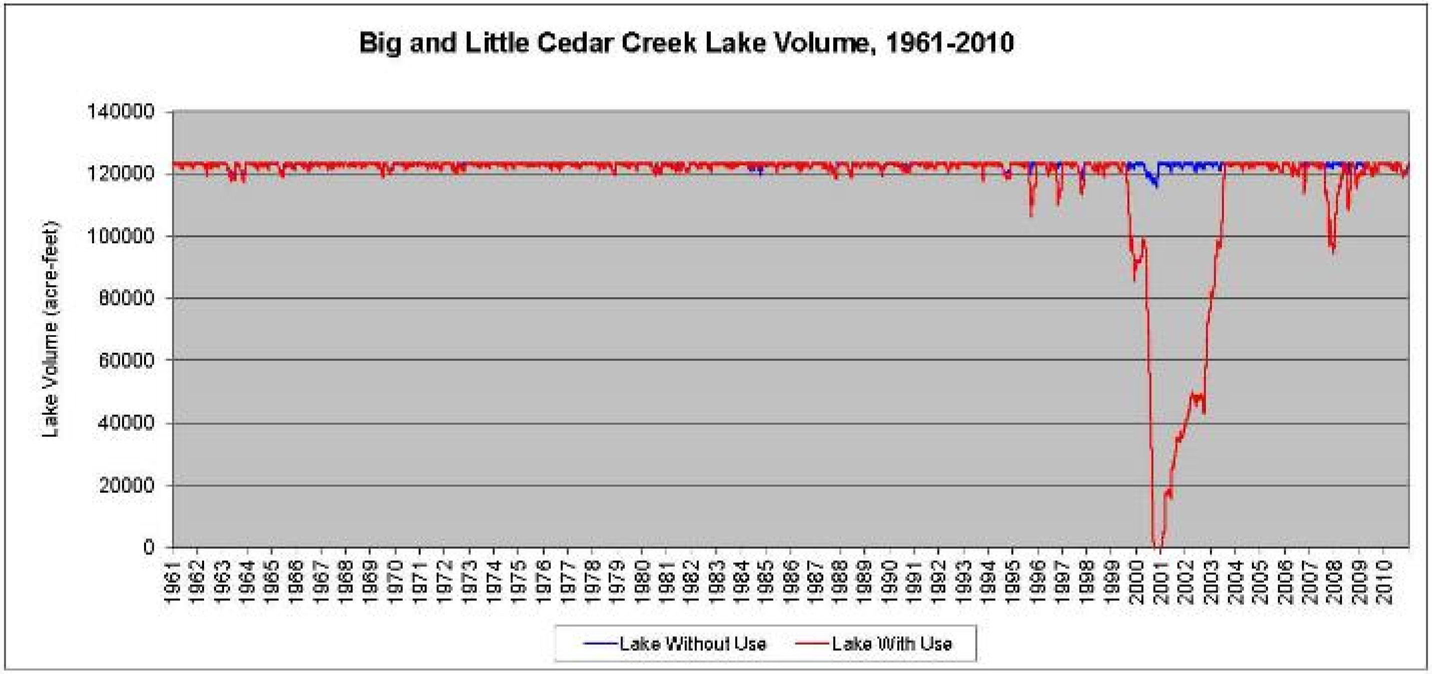

Figure 62 Daily water storage model for Big and Little Cedar Creek lake footprint

Notes: The model is for a 100 feet elevation footprint and a volume of 123,417 acre-feet

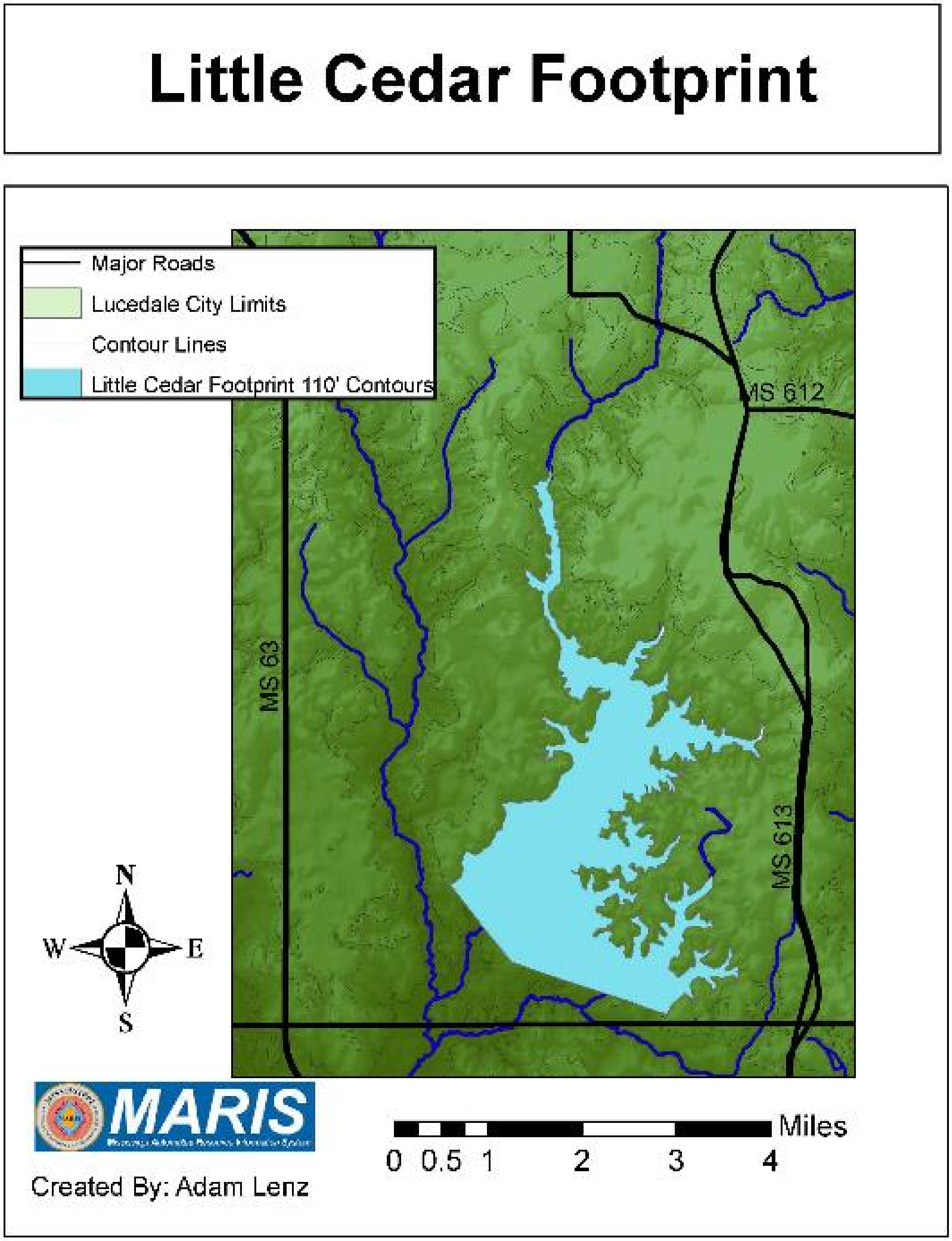

Figure 63 Little Cedar Creek lake footprint created at 110 feet elevation contour

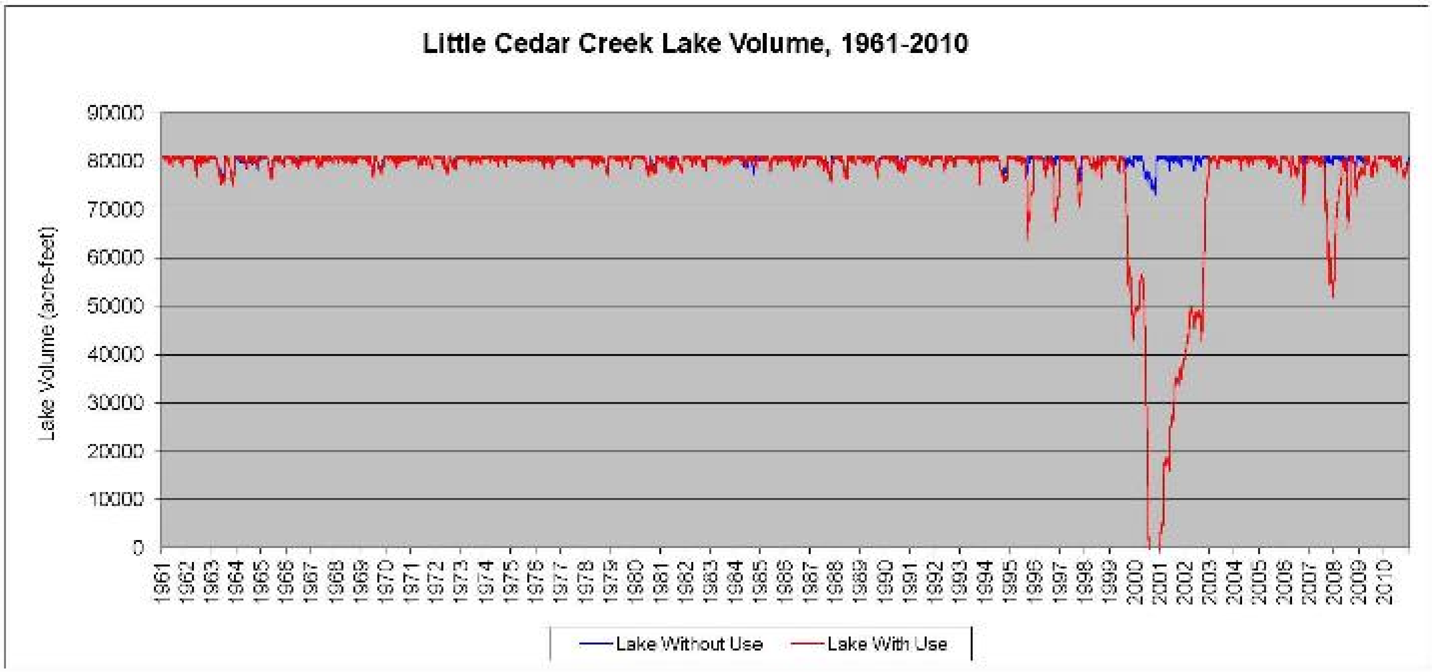

Figure 64 Daily water storage model for Little Cedar Creek lake footprint

Notes: The model is for a 110 feet elevation footprint and a volume of 80,954 acre-feet

CHAPTER IX

DISCUSSION

Surface Water Quantity Measurements

Two stationary stream monitoring stations installed at sampling sites B6 and CB5 were not operational until 5 months following the start of the field work. However, once operations were initiated on December 13, 2011, the stations were effective in reporting data supportive to coordinating sampling events. Monitoring station CB5 did lose wireless signal two times during the field work; although, the effects were not considered detrimental to the study. The water depth graphs for Monitoring station B6 often exhibited a minute fluctuation pattern in the graphed line at times of no rainfall due to sediment build up in the Leveltroll 500 sensor PVC casing, but the depth readings did show proper correlations with rainfall events.

Utilization of the Teledyne StreamPro RDI Doppler unit, Price AA Current Meter, and the Debris Flow Estimation method proved to be effective in performing surface water discharge measurements. The accuracy of discharge measurements taken throughout the field work is represented by the R^2 values displayed in each sampling site's hydrograph found in Appendix A. It is observed in the hydrograph of site CB1 that the data points of discharge versus stage do not form a satisfying trend line pattern. This occurrence can be explained by restrictions in site flow character. Big Cedar Creek at site CB1 flows through a cement culvert that features a cement impoundment on the upstream side as shown in Figure 108. Consequently, the cement impoundment prevents the stage readings from having expected fluctuations with the measured discharges. In general, the hydrographs of the Big Creek, Big and Little Cedar Creek, and Escatawpa River watershed proved that discharge increases in order of upstream to downstream site location. No consistent or substantial water losses were recorded between sampling sites that would infer a loss of water to the subsurface.

Figure 65 Upstream portion of sampling site CB1 featuring a cement overflow wall and beaver damming

Surface Water Quality Measurements

The majority of water quality results obtained via field measurements and laboratory analysis were found to be compliant with the applicable surface water quality standards issued by Mississippi Department of Environmental Quality and United States Environmental Protection Agency. During several sampling events, each site except B2 produced pH values below the minimum standard of 5.0 s.u. Many of the low pH values correlated with high flow or rainfall events. An investigation of rainfall water quality would be necessary to determine if acidic rain water is a common occurrence in the study area. Furthermore, the low pH values could also be related to the low pH of spring water, as discovered in several of the springs analyzed during the spring inventory.

All sites except B3, E1, and E2 produced dissolved oxygen (DO) values that were occasionally below the minimum standard of 4.0 mg/L. Much of the incompliant DO readings correlated with discharge measurements near base flow. The correlation implies that at low flow stream conditions, DO levels decrease because of the lack of rejuvenating higher energy water flow, rainfall, or surface runoff. There were some cases of beaver damming along the measured streams, creating moderately stagnant flow conditions. The explanation for the incompliant DO values is supported by the character of sampling site CB1. Site CB1 produced incompliant DO readings for 5 of the 14 sampling events, the most incompliant readings of all sites. It is reasoned that the incompliant DO readings at site CB1 were a result of Big Cedar Creek being impounded by a concrete overflow wall on the upstream portion of the concrete culvert through which the stream flowed (Figure 65). Furthermore, beaver dams were present upstream and downstream locations adjacent to the concrete overflow wall.

All chloride values measure throughout the field study for each site were detected at values incompliant with the maximum standard of 0.019 mg/L for MDEQ wildlife and fisheries classified streams. Chloride measurements measured for all sites of the three watersheds ranged from 1.29 – 10.30 mg/L, which seems to be a major concern in terms of water quality of the streams. Although, according to a historical chemical analysis performed by Williams et al. (1967), Big Creek and Escatawpa River produced chloride values of 3.5 ppm or mg/L. Therefore, historical chloride concentrations in the streams were also likely incompliant with the present standard of 0.019 mg/L. If a storage reservoir were to be constructed on Big Creek, Big and Little Cedar Creek, or Escatawpa River the MDEQ would then reclassify that streams watershed in the public water supply category, which has a maximum chloride standard of 230 mg/L. Upon the event that a reservoir is built on any of the three watersheds, the range of chloride concentrations measured throughout the field study would be compliant under the new stream classification.

Composite averages of all iron concentration measurements for each of the three watersheds calculated values that were compliant with the maximum standard of 1.0 mg/L. However, many of the 19 sampling sites presented one to three measurements of iron concentration just above 1.0 mg/L. In contrast, the majority of water quality samples taken at sites CB1 and CB3 produced incompliant iron concentrations between the range of 1.0 – 3.0 mg/L. Elevated iron concentrations at site CB1 could be linked to a number of environmental issues such as the stagnant water conditions caused by the character of the concrete culvert as well as by the constructed beaver dams on the upstream and downstream portions of the culvert. The common occurrence of elevated iron concentrations in stagnant water conditions is likely linked to soluble iron released from the high organic sediment or soil deposited upstream of the culvert at site CB1. The stream channel of Big Cedar Creek at site CB3 is rather polluted with metal objects (e.g. bed springs, household items) littered by people. Iron oxidation of the littered objects in the stream could be the source of elevated iron concentrations measured at site CB3. Furthermore, since sites CB1 and CB3 are located near the head waters of the watershed, the soluble iron may be sourced to the significant amount of soluble iron observed as a brownish residue in many of the springs.

Spring Inventory and Analysis

The spring inventory performed for Big Creek and Big and Little Cedar Creek did find that two watersheds were fed by a substantial number of freshwater springs. Although, the number and locations of springs located were less than anticipated. Many areas near stream heads that were anticipated to be fed by springs were found to be occupied by residential ponds. The residential ponds were likely built upon once flowing springs.

The water quality analysis performed on the located springs with the In-Situ Troll 9500 found that 8 of the springs presented pH readings just below the minimum standard of 5.0 s.u. The incompliant pH values are likely related to ion exchange with the subsurface soil from which the springs flowed. Several springs were found with reddish oxidized iron residue floating at the surface of the spring water and precipitating on the land surface near the edges of the spring flow. Although turbidity standards do not exist for the watersheds of the study area, the turbidity values measured for the springs could be observed as larger than normal. The elevated turbidity of the springs could be explained by the heavy mixing land surface soil and debris in the extremely shallow water column of the springs.

Reservoir Modeling

The daily storage models proved that the three theoretical lakes of Big Creek at 120 foot elevation, Big and Little Cedar Creek at 100 foot elevation, and Little Cedar Creek at 110 foot elevation were effective most of the simulated 50 year period, providing enough water supply to prevent the Pascagoula River from dropping below a measured 7Q10 base flow when 100 million gallons of water per day are withdrawn from the river near Graham Ferry, Mississippi. However, the models did show that the three reservoirs would be completely depleted of their water storage in the event of severe drought conditions similar to the one experienced in year 2000. Although, the models did suggest that the lakes could sustain a substantial lake volume during a less severe drought like which occurred in year 2007. Figure 109 depicts a line graph of rainfall for driest year (2002), intermediate year (1984), and wettest year (1961) experienced during the 50 year period of 1961 - 2010. Since each of the three models incorporated the same values for precipitation, evaporation, runoff, infiltration, base flow, outflow, withdrawals, and Pascagoula River daily discharge, the three models shared a proportional daily storage pattern throughout all of the 50 year period. Therefore, the only distinguishing factor in daily storage of the models was each lake's initial volume calculated from the ArcGIS lake footprint. During the drought of year 2000, the model calculated that the Big and Little Cedar Creek at 100 foot elevation, Little Cedar Creek at 110 foot elevation, and Big Creek at 120 foot elevation would theoretically experience completely depleted water storage for 113, 161, and 178 days, respectively. A statistical analysis of the number of days of depleted water storage was performed by dividing the number of days of depleted storage by the total number of days in the 50 year period (18,250 days). This analysis generated a frequency percent of the amount of time that each reservoir could be expected to be depleted of all water storage. Statistically, the Big and Little Cedar Creek lake, Little Cedar Creek lake, and Big Creek could be expected to be depleted of all water 0.62%, 0.88%, and 0.98% according to the 50 year period of 1961 – 2010. In a qualitative comparison of the daily productivity of water supply, the three reservoirs ranked in descending order: Big and Little Cedar Creek at 100 foot elevation, Little Cedar Creek at 110 foot elevation, Big Creek at 120 foot elevation. In a qualitative comparison of the daily productivity of water supply, the three reservoirs ranked in descending order: Big and Little Cedar Creek at 100 foot elevation, Little Cedar Creek at 110 foot elevation, Big Creek at 120 foot elevation.

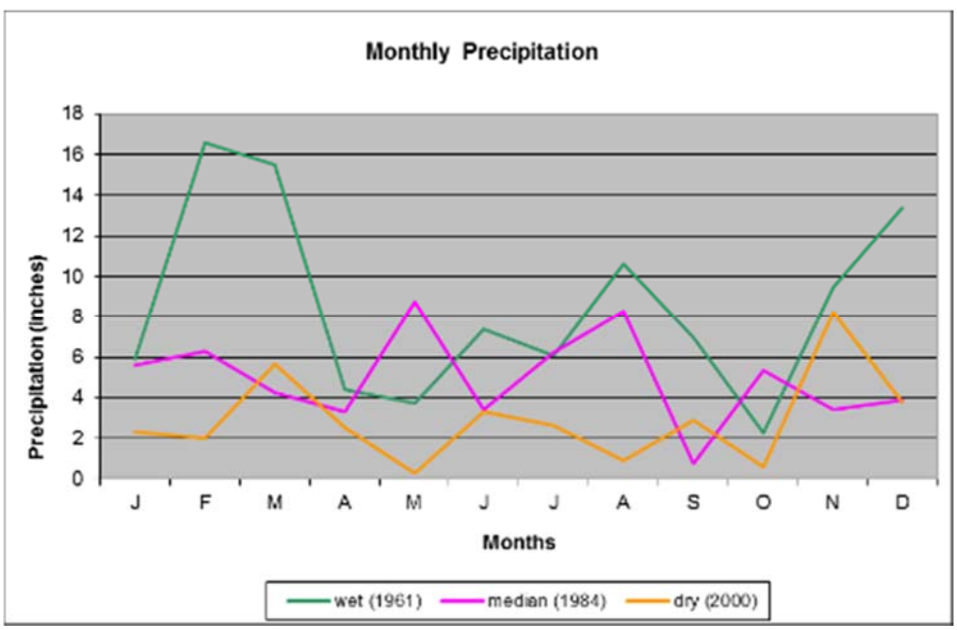

Figure 66 Graphical representation of driest, median, and wettest precipitation years of the 50 year (1961 – 2010) daily water storage model

CHAPTER X

CONCLUSIONS

The hydrogeology of the Big Creek, Big and Little Cedar Creek, and Escatawpa River watersheds was assessed. The assessment focused the ultimate objective of identifying one preferred, and one alternative, reservoir with the potential to fill a lake volume capable of providing sufficient water supply to prevent the Pascagoula River near Graham Ferry, Mississippi from dropping below a measured 7Q10 base flow when 100 million gallons of water per day are withdrawn from the river for industrial use. The surface water quantity and water quality measurements performed on the three watersheds throughout the field study period of July 2011 – December 2012 proved that all three watersheds presented a hydrological character that is satisfactory for the construction of a reservoir lake.

The three watersheds differed significantly when analyzed by the reservoir modeling procedures. The Escatawpa watershed was naturally restricted by much of its drainage area located within the boundaries of the state of Alabama. This restriction limited the Escatawpa watershed to support a maximum lake elevation of 60 feet above sea level. An Escatawpa lake footprint created at an elevation contour of 60 feet generated a lake volume that would not support the objective of the project. Consequently, the Escatawpa River watershed was dismissed from further consideration as a suitable reservoir site. Lake footprints created for a 120 foot elevation contour of the

Big Creek watershed and a 100 elevation contour of the Big and Little Cedar Creek watershed produced adequate lake volumes that performed well in most of the 50 year daily reservoir storage model. The Big and Little Cedar Creek lake footprint, having the larger lake volume was initially deemed as the preferred reservoir site, with the Big Creek Lake footprint as a satisfactory alternative reservoir site. However, following the reservoir modeling of the three watersheds, the discovery of the Big Cedar Creek Wetland Mitigation Bank property located within the Big and Little Cedar Creek lake footprint unfortunately eliminated the Big and Little Cedar Creek lake with a 100 foot elevation contour as a realistic reservoir design. Consequently, the Little Cedar Creek lake footprint was created at a 110 foot elevation contour to avoid flooding the mitigation bank property. The Little Cedar Creek lake footprint generated a lake volume still larger than that of the Big Creek lake footprint. Furthermore, the daily reservoir storage model for the Little Cedar Creek lake showed a greater theoretical productivity of daily water storage, which deemed the Little Cedar Creek lake footprint as the new preferred reservoir site. Ultimately, because all three of the theoretical lakes went dry during the low precipitation period in year 2000, the proposed hypothesis must be rejected. However, since the lakes did maintain the greater portion of their initial volumes for more than 90 percent of the 50 year period, the Big Creek and Cedar Creek watersheds are still considered suitable locations for a reservoir.

Additional research is anticipated to resume in the near future with more intensive hydrogeological investigations of the Big Creek and Cedar Creek watersheds. A 7Q10 flow analysis is recommended for each watershed for the purpose of obtaining site specific base flows that would be incorporated into in the daily reservoir storage models.

A site specific investigation of surface runoff and infiltration character would also be beneficial to the reservoir modeling data. An economical analysis of property ownership, infrastructural impact, and reservoir construction costs should be performed according to the preferred and alternative lake footprints.

REFERENCES

Brahana J. V. and Dalsin G. J., 1977, *Water for Industrial Development:* Mississippi Research and Development Center, 70 p.

Buchanan T. J. and Somers W. P., 1969, *Techniques of Water-Resources Investigations of the United States Geological Survey, Book 3, Chapter A8: Discharge Measurements at Gaging Stations:* United States Department of Interior, 65 p.

Carlson C.S. and Archfield S. A., 2009, *Hydrogeologic Conditions and a Firm-Yield Assessment for J.B. Converse Lake, Mobile County, Alabama, 1991-2006*: United States Geological Survey, 21p.

Hanks, M.G., Hughes, A.M., McIlwain, J.A., and Schmitz, D.W., 2003. *Estimated Discharge Versus Measured Discharge of Selected Streams in the Ackerman Unit of the Tombigbee National Forest, Mississipp*i: Geological Society of America Abstracts With Programs, v.35, no. 6.

Harvey E. J., Golden H. G., Jeffery H. G., 1965, *Water Resources of the Pascagoula Area Mississippi:* Geological Survey Water Supply Paper 1763, 135 p.

Mancini E. A., Puckett, T. M., Parcell, W. C., Panetta, B. J., 1999, *Basin Analysis of the Mississippi Interior Salt Basin and Petroleum system modeling of the Jurassic Smackover Formation, Eastern Gulf Coastal Plain:* Center for Sedimentary Basin Studies University of Alabama, 337 p.

Mancini, E. A. and Tew B. H., 1990, *Tertiary Sequence Stratigraphy and Biostratigraphy of Southwestern Alabama:* Geological Survey of Alabama, 51 p.

Mancini, E. A., Tew B. H., Mink R. M., 1992, *Hydrocarbon Productivity Characteristics of Upper Jurassic Smackover Carbonates, Eastern Gulf Coastal Plain:* Gulf Coast Association of Geological Societies Transactions, v. 42, p. 237-244.

McIlwain, J.A., 2007, Hydrogeologic Assessment of a Propsed Reservoir Site, Smith County, Mississippi, Master's Thesis, Mississippi State University, Starkville, MS.

Mink, R. M, Tew B. H., Bearden, B. L., Mancini E. A., 1991, *Jurassic Faults of the Southwest Alabama and Offshore Areas*: AAPG Bulletin, v. 75.3, p. 636 -637.

Mississippi Department of Environmental Quality, 2012, State of Mississippi Water Quality Criteria for Intrastate, Interstate, and Coastal Waters, 39 p.

Mississippi Engineering Group, Inc., 2007, Mississippi Gulf Region Water and Wastewater Plan, 254 p.

Ross, D.P., 2005, U.S. Climate Normals: NOAA Satellite and Information Service, http://hurricane.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl

Southern Mississippi Planning and Development District, 2007, *George County, Mississippi County Wildfire Protection Plan,* 36 p.

Southern Regional Climate Center, Louisianna State University, Baton Rouge, LA, 2013, Merrill, MS Single Station Climate Summary, < www.srcc.lsu.edu/>.

StreamPro ADCP Operation Manual, Teledyne RD Instruments, February, 2008.

Teledyne RD Instruments, 2008, *StreamPro Quick Start Guide*: Teledyne Technologies Company, 51 p.

Tew B. H., Mink R. M., Mann S. D., Bearden B. L., Mancini E. A., 1991, *Geologic Framework of Norphlet and Pre-Norphlet Strata of the Onshore and Offshore Eastern Gulf of Mexico Area:* Gulf Coast Association of Geological Societies Transactions, v. 41, p. 590-600.

United States Census Bureau, 2013, *2010 Census Interactive Population: George County, Mississippi*, <http://www.census.gov/2010census/popmap/ipmtext.php?fl=28>.

United States Environmental Protection Agency, 2012, Drinking Water Contaminants: National Primary Drinking Water Regulations, <http://water.epa.gov/drink/contaminants/index.cfm#List>

United States Environmental Protection Agency, 2013, Current Water Quality Criteria: National Recommended Water Quality Criteria, <http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm>

United States Geological Survey, 2009, *Mississippi Seizmic Hazard Map: Earthquake Hazards Program:* < http://earthquake.usgs.gov/earthquakes/states/mississippi/hazards.php>

United States Geological Survey, 2010, *Last Earthquake in Mississippi: Earthquake Hazards Program*: < http://earthquake.usgs.gov/earthquakes/eqarchives/last_event/states/ states_mississippi.php>.

United States Geological Survey, 2013, *USGS Current Conditions for Mississippi*: *USGS Agricola MS:* <http://nwis.waterdata.usgs.gov/ms/nwis/uv?cb_00060=on&format=html&period =&begin_date=2011-07-24&end_date=2012-12-31&site_no=02479560>.

Von Hake, C. A, 2009, *Mississippi Earthquake History: Earthquake Hazards Program*: United States Geological Survey, <http://earthquake.usgs.gov/earthquakes/states/mississippi/ history.php>.

Walker, W.W., 2006, *Bathtub Version 6.1: Simplified Techniques for Eutrophication Assessment and Prediction:* USAE Waterways Experiment Station.

Williams Jr. C. H., Dinkins Jr. T., McCutcheon T., 1967, *George County Geology and Mineral Resources:* Mississippi Geological, Economic, and Topographical Survey, 227 p.

APPENDIX A

HYDROGRAPHS OF SAMPLING SITES

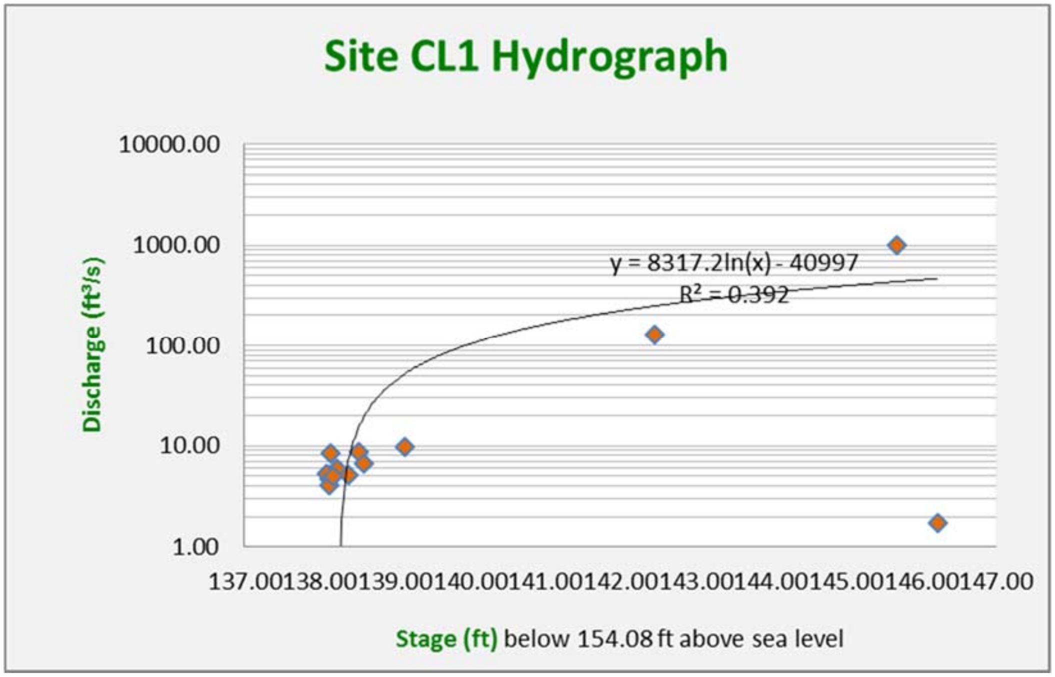

Figure 67 Hydrograph of site CL1 depicting discharge versus stage

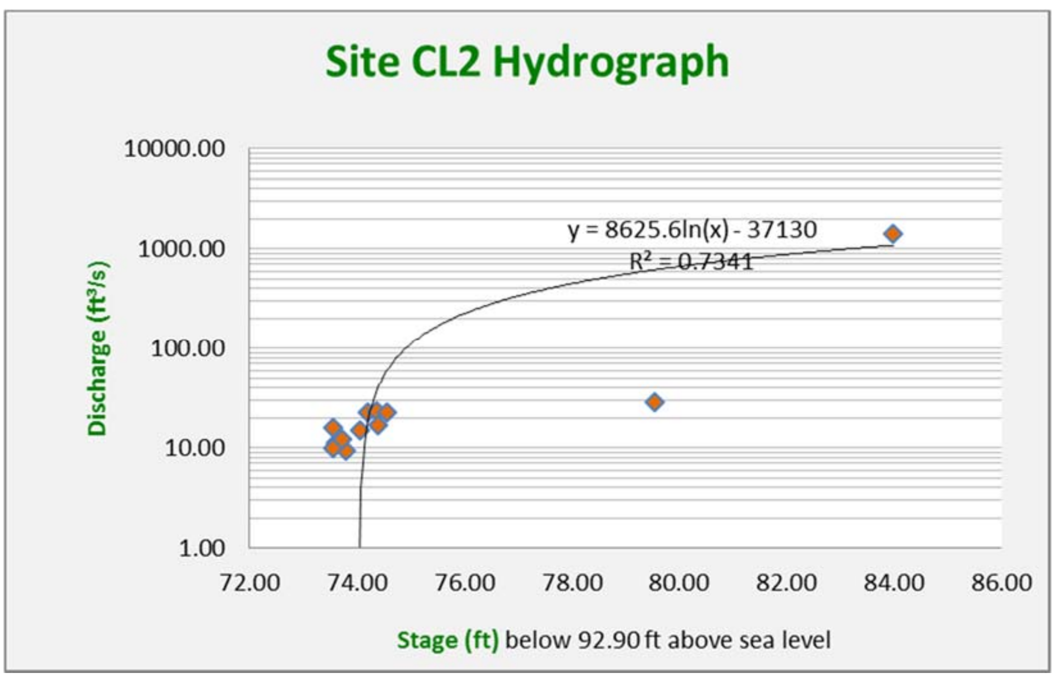

Figure 68 Hydrograph of site CL2 depicting discharge versus stage

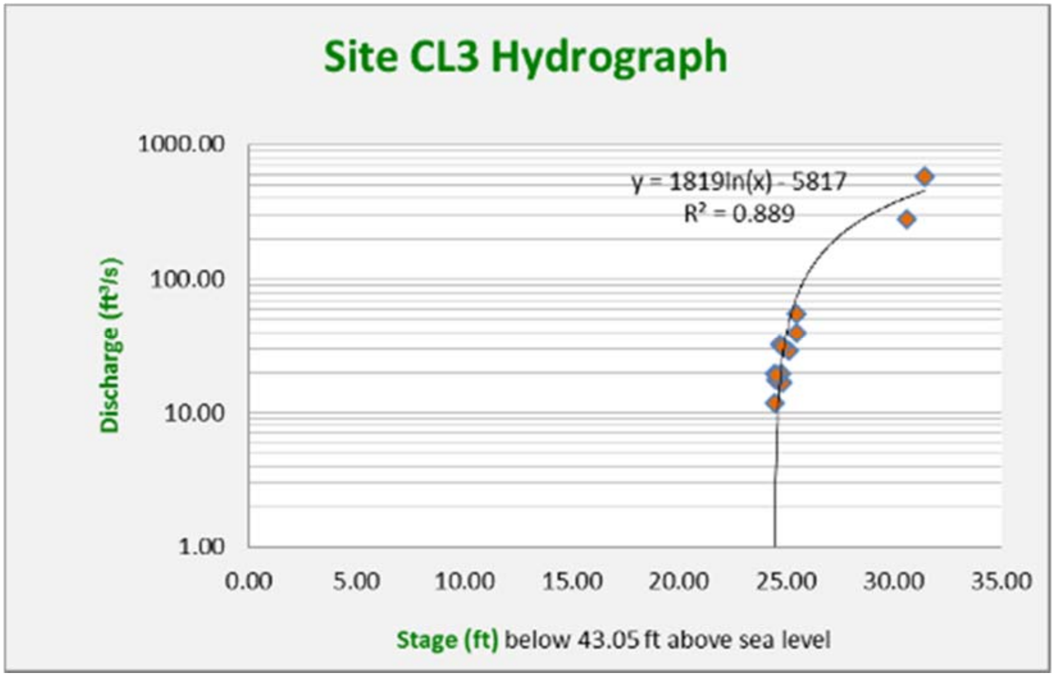

Figure 69 Hydrograph of site CL3 depicting discharge versus stage

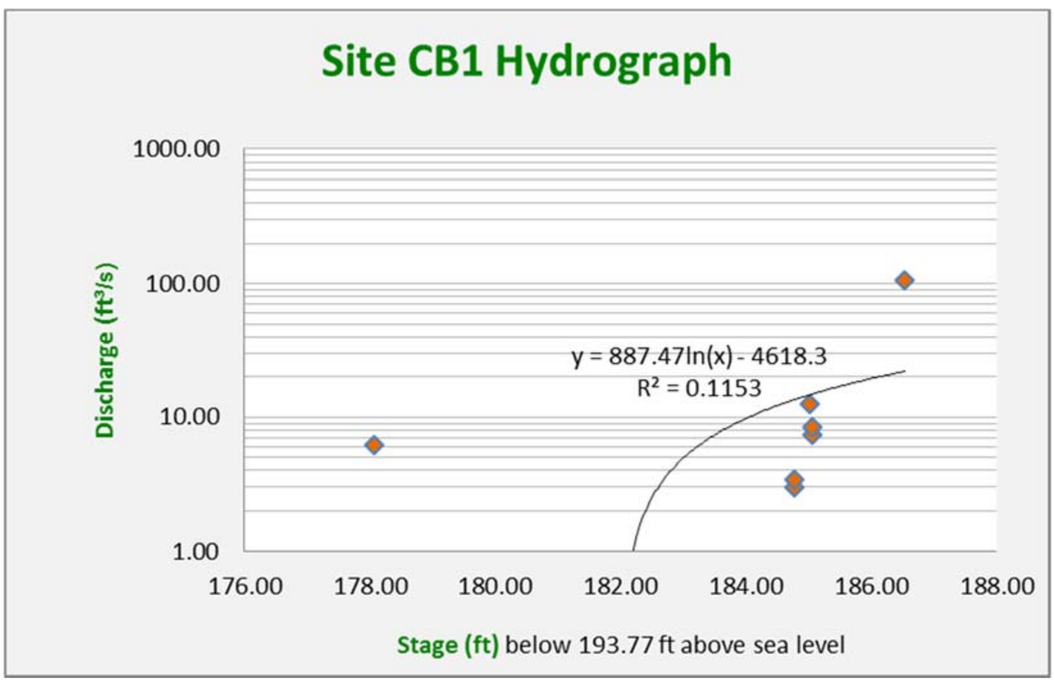

Figure 70 Hydrograph of site CB1 depicting discharge versus stage

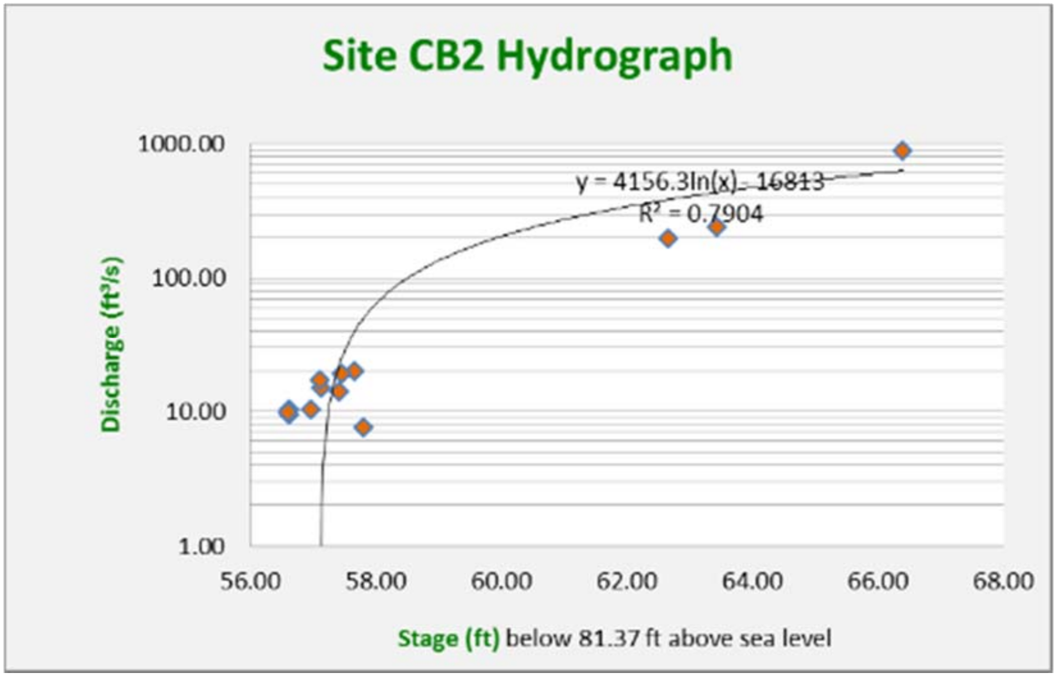

Figure 71 Hydrograph of site CB2 depicting discharge versus stage

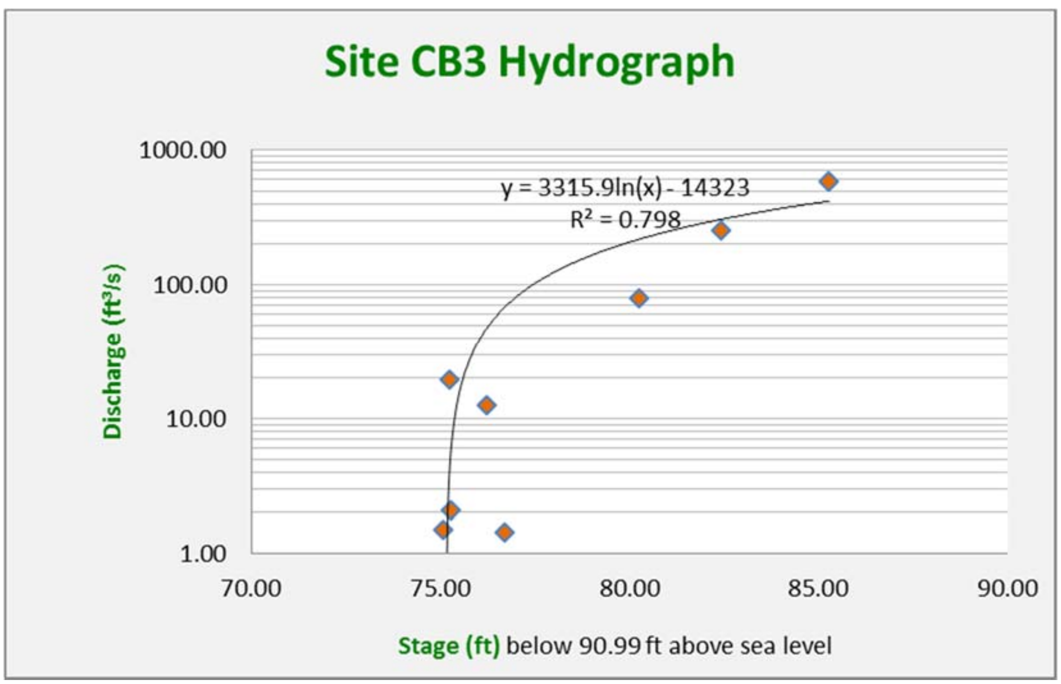

Figure 72 Hydrograph of site CB3 depicting discharge versus stage

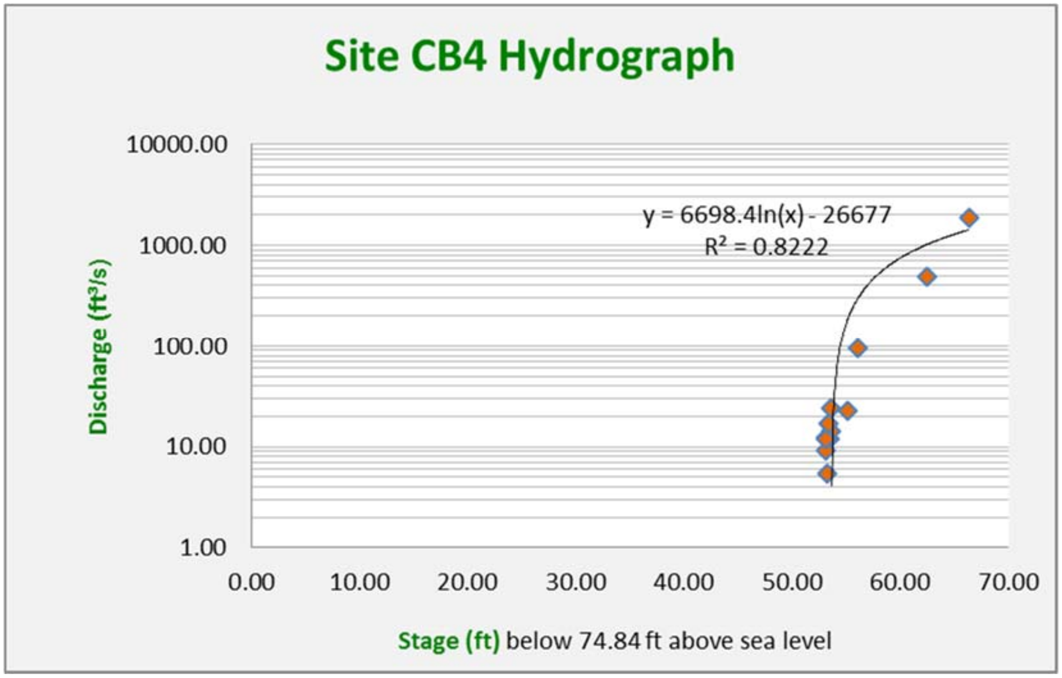

Figure 73 Hydrograph of site CB4 depicting discharge versus stage

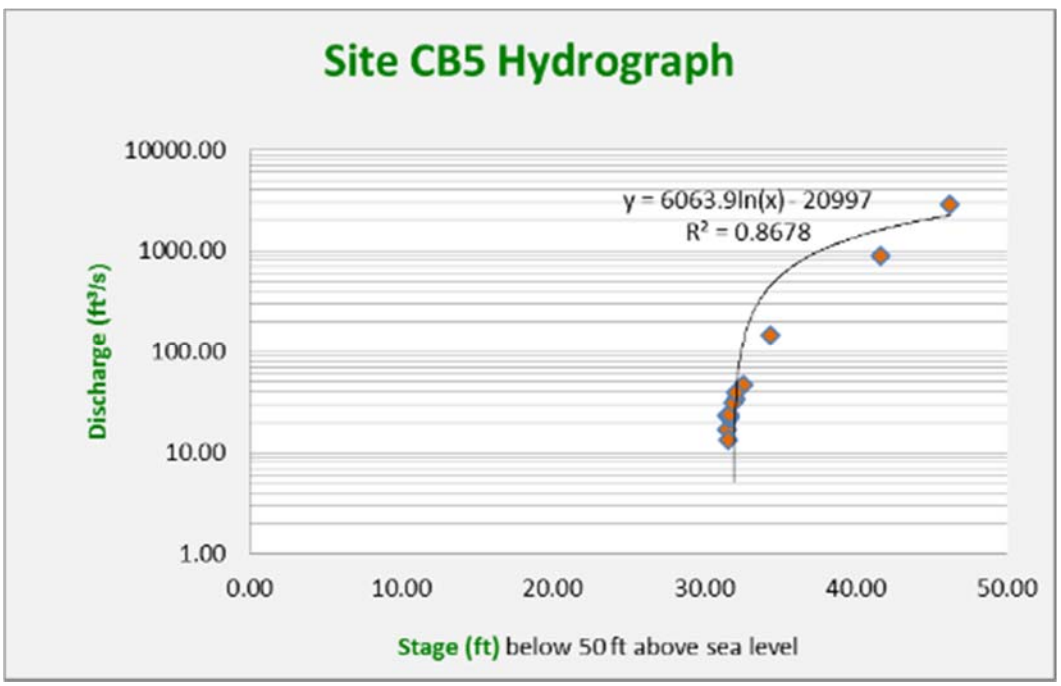

Figure 74 Hydrograph of site CB5 depicting discharge versus stage

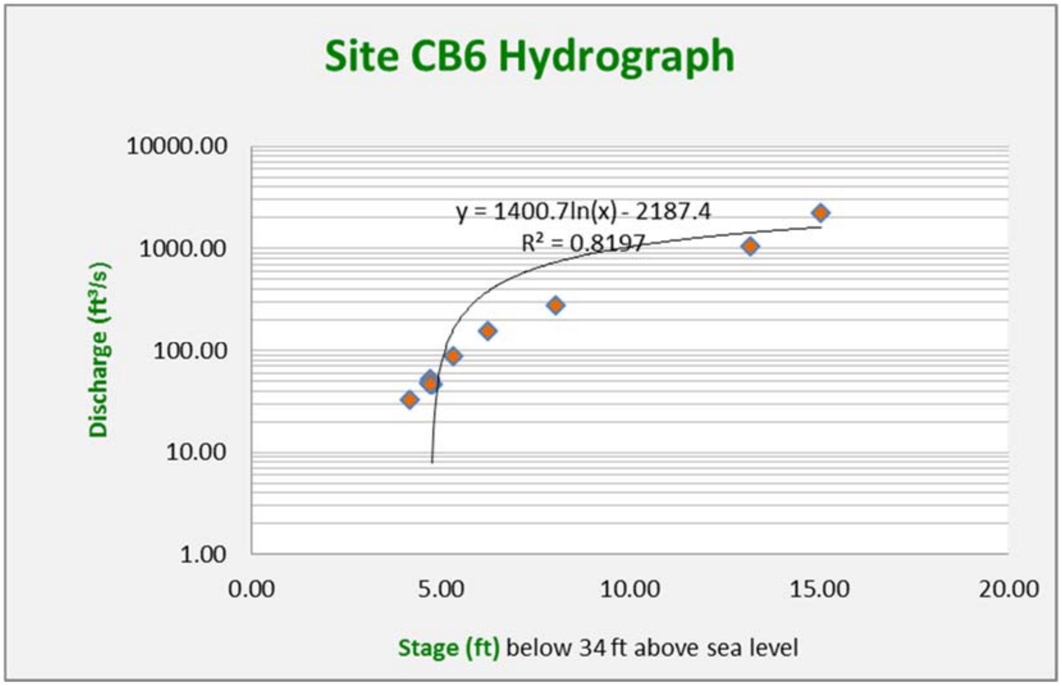

Figure 75 Hydrograph of site CB6 depicting discharge versus stage

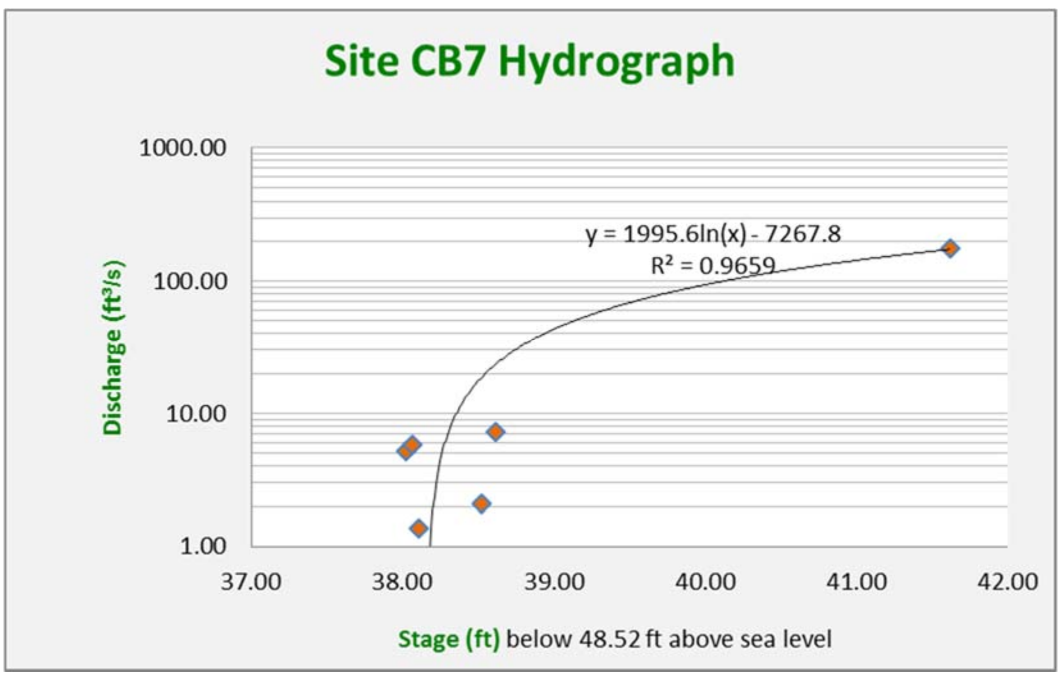

Figure 76 Hydrograph of site CB7 depicting discharge versus stage

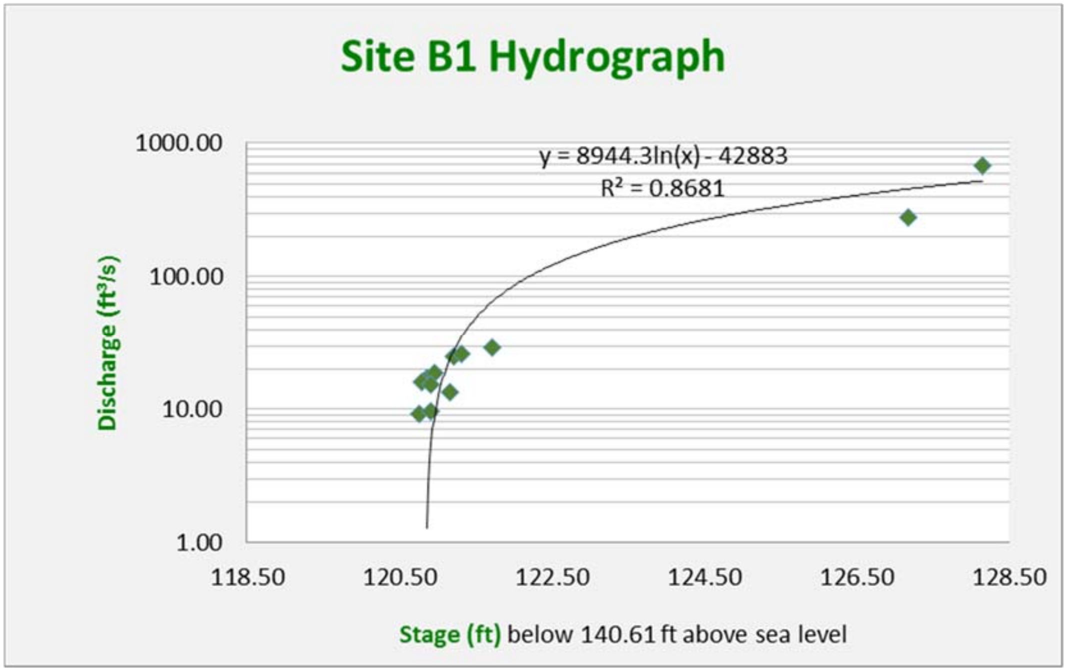

Figure 77 Hydrograph of site B1 depicting discharge versus stage

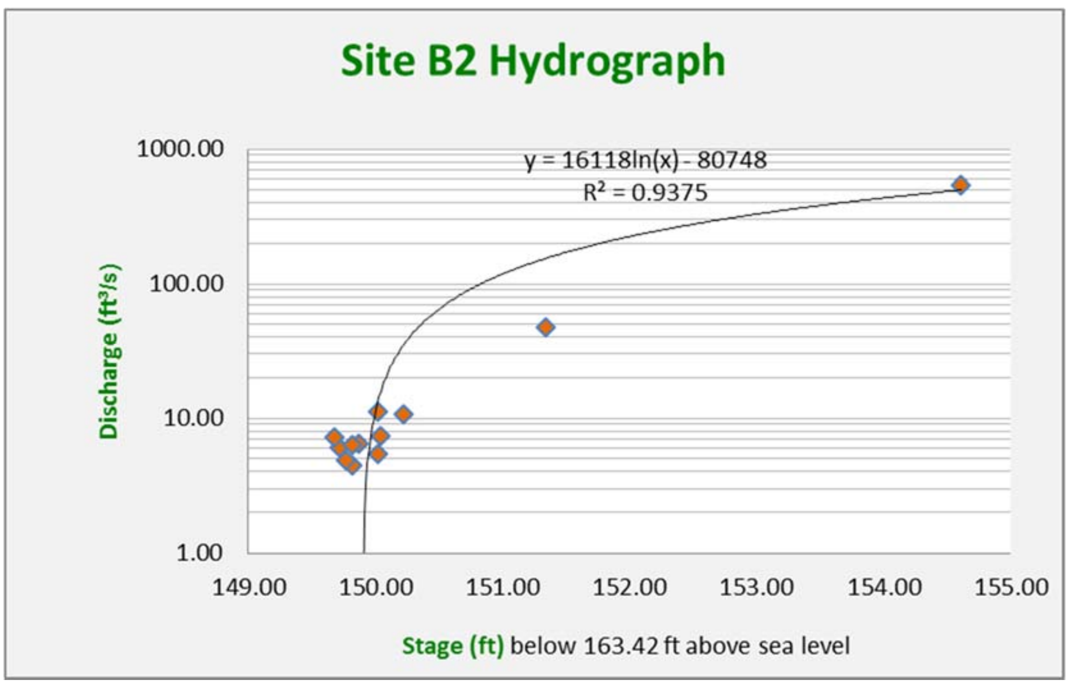

Figure 78 Hydrograph of site B2 depicting discharge versus stage

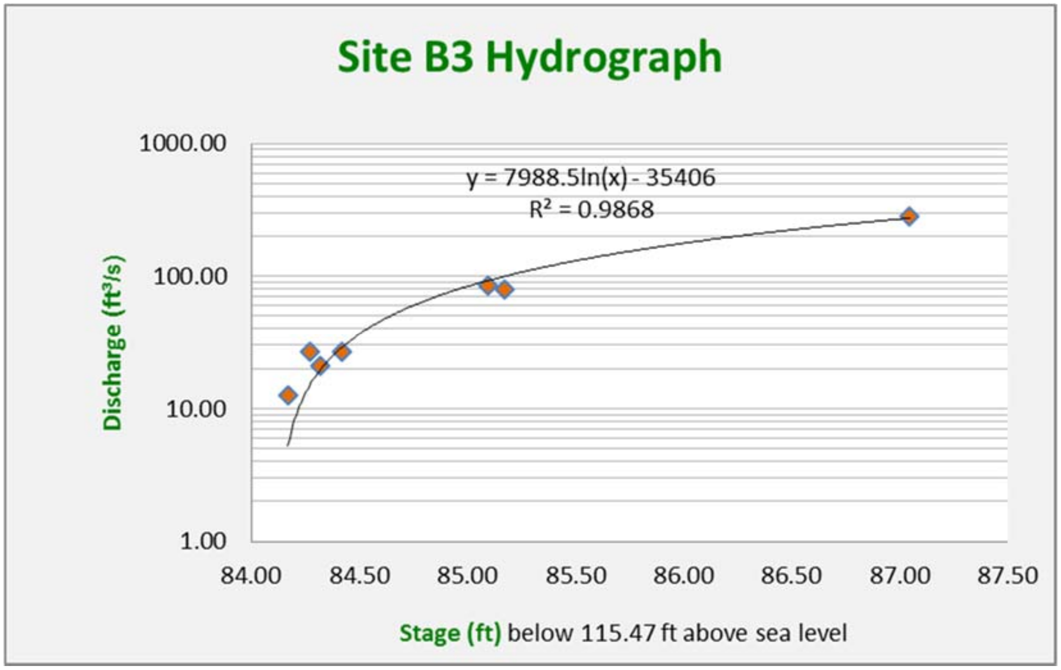

Figure 79 Hydrograph of site B3 depicting discharge versus stage

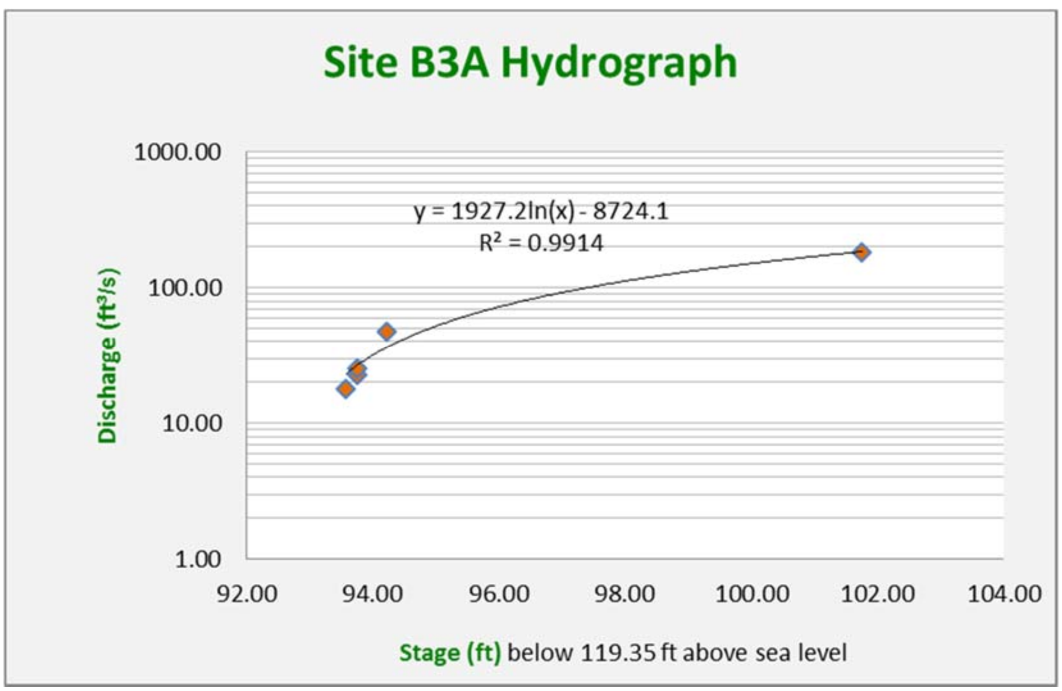

Figure 80 Hydrograph of site B3A depicting discharge versus stage

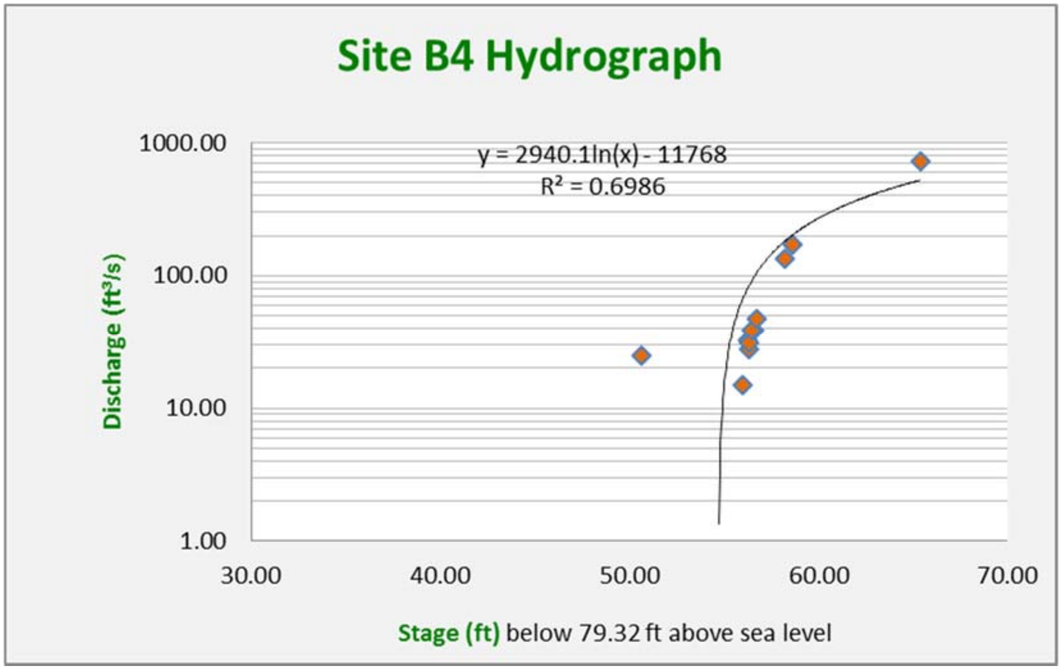

Figure 81 Hydrograph of site B4 depicting discharge versus stage

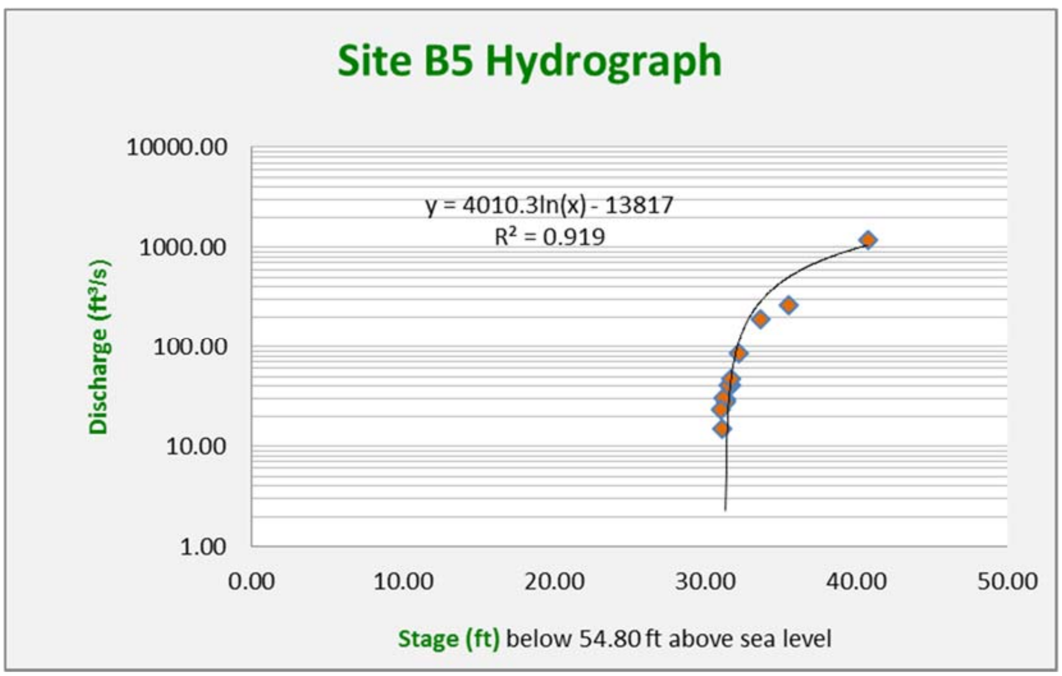

Figure 82 Hydrograph of site B5 depicting discharge versus stage

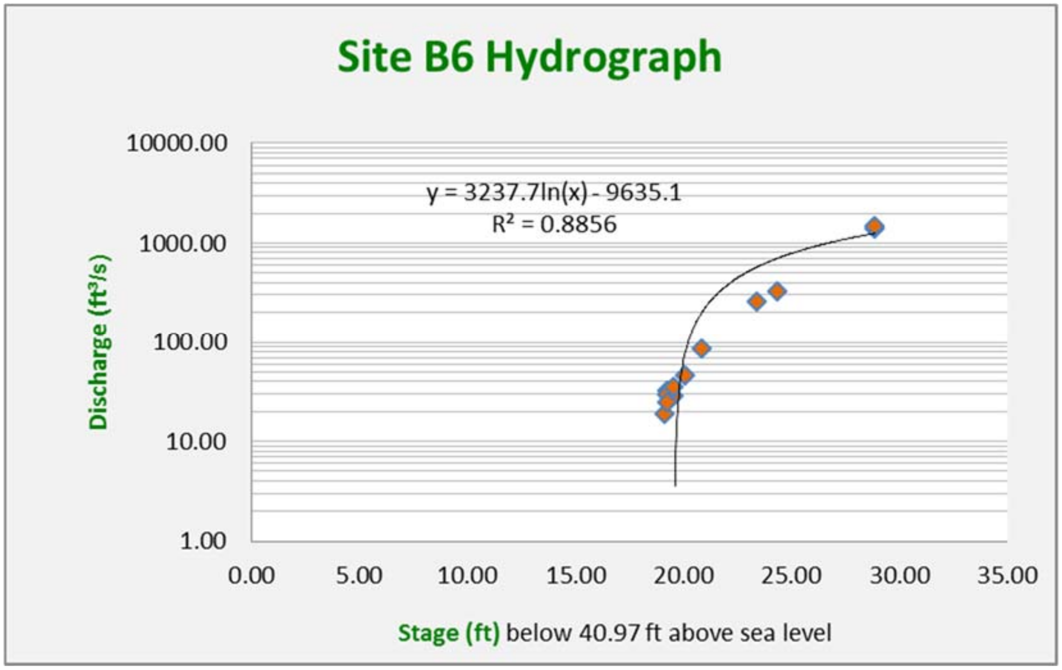

Figure 83 Hydrograph of site B6 depicting discharge versus stage

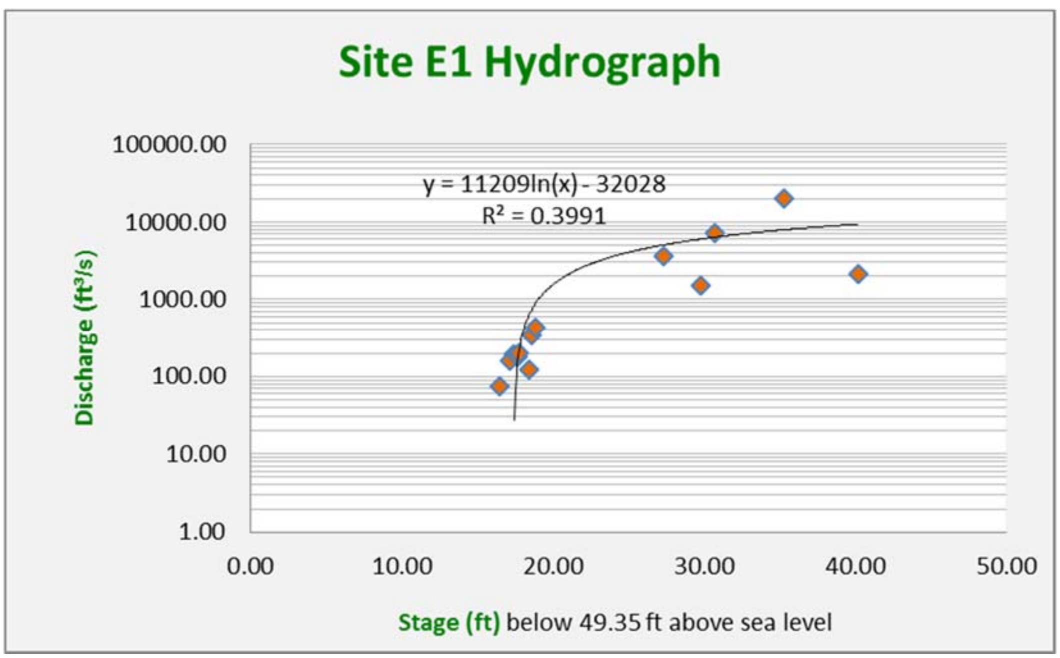

Figure 84 Hydrograph of site E1 depicting discharge versus stage

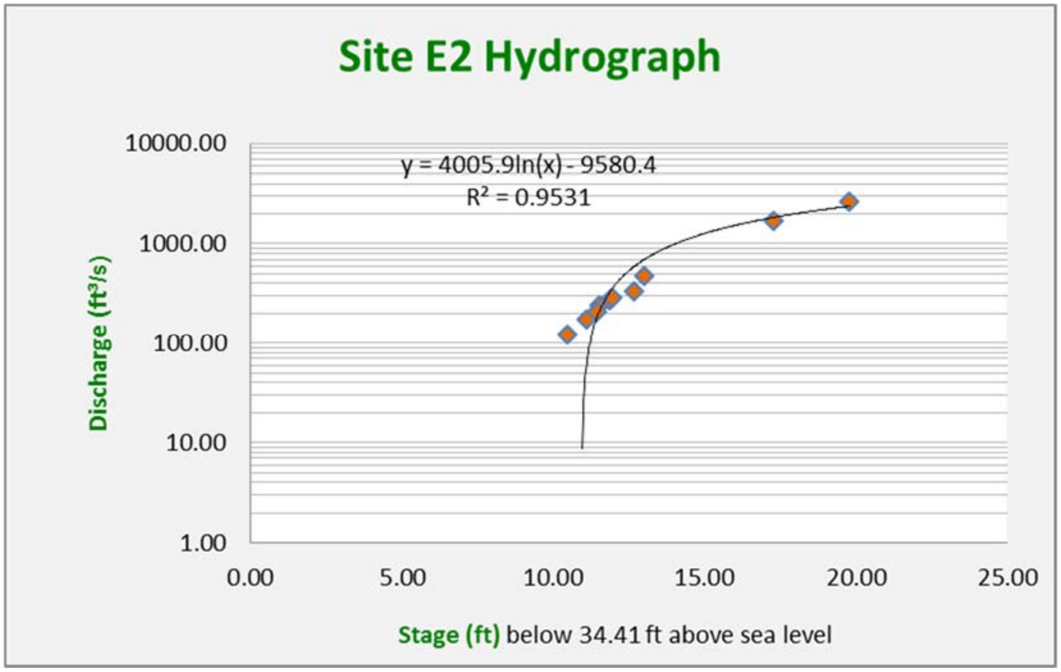

Figure 85 Hydrograph of site E2 depicting discharge versus stage

APPENDIX B

WATER QUALITY FIELD AND LABORATORY MEASUREMENTS

Table 23 Water Quality Fields Measurements for Site B1

Sampling Site B1					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.27.11	75.52	4.85	21.70	9.51	26.90
8.29.11	72.76	5.66	25.97	8.79	1.80
10.5.11	61.59	4.73	29.78	9.37	10.10
11.16.11	66.00	5.92	30.98	8.49	1.00
1.27.12	59.78	5.62	19.02	9.45	2.00
3.12.12	63.14	4.76	17.38	8.22	22.8
5.17.12	68.97	5.54	28.74	9.34	1.40
7.10.12	73.74	5.41	32.29	3.98	1.30
8.2.12	77.58	5.90	33.08	0.03	1.20
8.30.12	75.23	2.19	20.49	13.48	31.10
10.18.12	67.51	6.90	30.46	10.38	1.90
12.17.12	60.43	6.36	22.82	11.12	5.00

Values in red are incompliant with surface water standards.

Table 24 Water Quality Fields Measurements for Site B2

Sampling Site B2					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.27.11	76.79	5.95	49.56	11.12	36.80
8.29.11	75.18	5.78	37.09	8.26	11.90
10.4.11	68.98	5.68	45.52	7.87	5.70
11.16.11	67.76	6.36	50.07	7.44	3.60
1.27.12	62.20	6.33	31.92	8.74	17.5
3.12.12	65.23	6.01	31.6	7.62	305.6
5.17.12	73.48	6.10	45.56	10.65	14.70
7.10.12	74.99	6.16	50.78	4.00	7.00
8.2.12	81.29	6.17	52.00	0.03	6.00
8.30.12	74.79	5.22	22.99	5.27	101.70
10.18.12	68.93	6.36	66.42	10.11	114.50
12.17.12	61.21	6.92	41.20	10.86	183.10

Values in red are incompliant with surface water standards.

Table 25 Water Quality Fields Measurements for Site B3 & B3A

Sampling Site B3 & B3A					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.27.11	75:87	4.98	27.36	35.62	28.80
8.30.11	72.82	5.68	25.96	8.72	5.40
10.5.11	65.19	6.07	34.77	9.42	1.80
11.16.11	66.48	6.24	36.84	8.31	5.00
3.13.12	64.90	5.6	24.61	8.35	45.3
3.23.12	67.56	5.38	25.84	6.71	76.50
5.17.12	71.18	5.91	34.71	8.96	3.20
7.10.12	74.25	6.06	38.86	7.44	7.70
8.3.12	76.27	5.45	39.50	11.17	4.90
8.30.12	75.03	3.04	20.38	91.82	90.80
10.18.12	67.74	6.39	34.65	10.63	183.70
12.17.12	60.66	6.30	36.18	11.04	16.80

Values in red are incompliant with surface water standards.

Table 26 Water Quality Fields Measurements for Site B4

Sampling Site B4					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	76.03	4.87	23.11	8.38	26.60
8.30.11	73.09	6.25	25.57	8.66	4.80
10.5.11	63.94	6.31	34.11	9.78	9.40
11.16.11	66.34	6.44	37.65	8.45	3.10
1.27.12	60.59	6.11	21.92	9.66	13.1
3.13.12	65.02	5.55	24.16	8.31	46.8
3.23.12	67.43	5.14	23.80	6.85	31.90
5.17.12	70.60	6.00	33.95	11.34	4.40
7.9.12	76.05	6.18	35.03	1.49	17.60
8.3.12	76.86	6.18	39.18	8.77	5.50
10.18.12	68.29	6.56	33.75	10.77	111.30
12.17.12	60.59	6.43	26.79	11.07	5.20

Values in red are incompliant with surface water standards.

Table 27 Water Quality Fields Measurements for Site B5

Sampling Site B5					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	76.46	4.83	22.98	8.30	34.40
8.30.11	73.74	6.52	26.32	8.52	8.10
10.5.11	63.40	6.35	34.23	9.51	2.70
11.16.11	66.56	6.43	38.35	8.51	12.20
1.27.12	60.75	6.01	22.03	9.52	15.9
3.13.12	65.14	5.48	23.82	8.18	64.5
3.23.12	67.57	5.02	22.32	6.76	33.4
5.18.12	67.65	6.38	34.33	4.24	3.80
7.9.12	76.75	6.22	41.35	1.46	91.60
8.3.12	77.34	6.06	39.45	8.01	5.30
10.18.12	64.04	6.47	33.69	11.11	72.90
12.17.12	60.13	6.53	25.68	11.22	3.60

Values in red are incompliant with surface water standards.

Table 28 Water Quality Fields Measurements for Site B6

Sampling Site B6					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	76.65	4.50	22.59	8.26	34.40
8.30.11	74.53	6.56	26.39	8.35	6.40
10.6.11	62.10	5.66	37.30	9.10	2.50
11.16.11	66.55	6.42	35.05	8.50	33.90
1.27.12	60.99	6.07	22.13	9.40	19.90
3.13.12	65.31	5.44	23.91	7.91	51.70
3.23.12	67.75	4.87	22.08	6.65	31.20
5.18.12	68.04	6.32	34.29	4.21	3.30
7.9.12	76.86	6.29	37.42	1.60	52.00
8.3.12	77.97	5.94	39.53	7.88	16.70
8.31.12	75.47	4.15	21.14	12.37	50.20
10.18.12	68.29	6.54	40.56	10.96	95.50
12.17.12	60.07	6.55	25.99	11.25	24.00

Values in red are incompliant with surface water standards.

Table 29 Water Quality Fields Measurements for Site CL1

Sampling Site CL1					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	79.74	4.55	23.24	5.53	4.60
8.29.11	69.80	4.67	22.41	9.47	1.40
10.5.11	62.42	4.84	28.21	8.78	10.10
11.15.11	66.07	5.47	32.01	7.53	15.40
1.28.12	56.51	5.25	32.05	8.62	3.10
3.12.12	64.93	5.10	24.91	7.38	4.50
3.23.12	67.19	4.68	23.76	6.98	28.10
5.16.12	70.04	5.68	28.50	0.28	0.70
7.9.12	70.92	5.51	31.42	14.57	2.50
8.2.12	72.97	5.26	31.68	0.03	0.70
8.30.12	74.72	3.22	15.37	8.85	31.90
10.18.12	67.69	5.47	29.05	10.62	118.80
12.17.12	63.37	5.55	23.31	0.69	1.20

Values in red are incompliant with surface water standards.

Table 30 Water Quality Fields Measurements for Site CL2

Sampling Site CL2					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	75.18	5.21	23.31	8.58	6.20
8.29.11	73.66	5.28	27.60	8.59	4.40
10.5.11	62.47	5.20	32.77	9.23	3.50
11.15.11	65.45	6.15	37.39	7.44	2.40
3.13.12	64.49	5.56	27.69	8.20	6.10
3.23.12	67.02	4.48	25.57	6.97	14.1
5.16.12	69.71	6.26	31.95	0.15	1.6
7.9.12	73.83	6.13	36.41	1.52	0.4
8.2.12	75.86	5.88	35.68	0.03	2.6
8.30.12	74.71	2.72	13.34	37.37	81.5
10.18.12	68.11	5.95	31.95	11.04	137
12.18.12	58.70	6.20	26.53	10.75	3.5

Values in red are incompliant with surface water standards.

Table 31 Water Quality Fields Measurements for Site CL3

Sampling Site CL3					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	74.85	4.75	26.50	8.65	12.20
8.29.11	74.35	5.45	25.60	8.44	2.30
10.5.11	62.84	5.72	29.91	9.68	33.30
11.15.11	64.50	6.33	34.03	8.49	0.50
1.28.12	57.43	5.63	33.64	9.37	4.70
3.13.12	64.32	5.36	26.74	8.53	11.50
3.23.12	67.49	4.35	28.76	6.29	11.10
5.16.12	69.73	6.36	29.24	0.13	0.50
7.9.12	73.90	5.99	33.24	1.83	5.30
8.2.12	75.90	5.78	32.52	8.97	1.90
8.31.12	75.42	2.32	19.30	3.61	21.70
10.18.12	67.63	6.12	30.50	11.17	125.90
12.18.12	59.60	6.13	26.40	10.82	2.30

Values in red are incompliant with surface water standards.

Table 32 Water Quality Fields Measurements for Site CB1

Sampling Site CB1					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	74.16	4.67	21.80	7.05	3.40
8.29.11	75.07	4.78	29.57	8.29	14.90
10.04.11	63.78	4.84	31.53	2.16	2.70
11.15.11	53.70	5.68	41.20	0.54	54.60
1.28.12	54.08	4.96	31.42	3.55	3.70
3.12.12	64.34	4.96	19.66	7.78	15.70
3.23.12	66.80	5.04	24.67	64.69	24.10
5.16.12	74.04	5.37	29.13	12.83	1.00
7.9.12	77.32	5.60	37.37	8.62	4.20
8.2.12	77.74	6.08	198.08	0.05	15.20
8.29.12	75.24	5.38	32.87	1.19	11.00
8.30.12	74.78	3.68	15.04	6.10	303.70
10.18.12	65.43	5.53	29.82	11.58	184.80
12.17.12	56.95	6.02	25.15	12.37	19.30

Values in red are incompliant with surface water standards.

Table 33 Water Quality Fields Measurements for Site CB2

Sampling Site CB2					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	76.35	5.57	37.11	8.32	14.40
8.29.11	74.08	5.87	45.60	8.50	3.10
10.5.11	62.53	6.23	44.08	9.09	1.00
11.15.11	66.03	5.14	31.85	7.59	0.20
1.28.12	56.22	5.71	44.96	8.76	3.60
3.12.12	63.93	4.64	24.72	7.02	21.90
3.23.12	66.97	4.67	26.22	6.26	16.20
5.16.12	69.09	6.45	43.07	0.54	2.90
7.9.12	74.89	6.29	60.63	4.74	3.10
8.2.12	76.94	5.91	50.50	0.16	3.90
8.30.12	74.87	2.40	19.00	10.69	45.70
10.18.12	67.20	6.09	37.59	10.84	143.20
12.18.12	58.30	6.76	34.52	10.73	3.10

Values in red are incompliant with surface water standards.

Table 34 Water Quality Fields Measurements for Site CB3

Sampling Site CB3					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	78.96	5.26	32.90	7.79	8.90
8.29.11	76.31	5.88	40.79	8.03	7.70
10.5.11	61.31	6.16	37.70	11.15	4.30
11.15.11	63.60	6.25	48.00	8.38	2.70
3.12.12	67.65	5.08	1.09	8.76	1.30
3.23.12	67.51	5.14	22.34	7.53	71.70
5.17.12	68:63	NT	37.37	11.37	4.30
7.9.12	76.57	6.33	43.41	2.17	2.70
8.2.12	75.90	5.78	32.52	8.97	1.90
8.29.12	76.47	3.64	26.39	0.19	23.10
8.30.12	75.81	4.24	19.11	6.21	68.80
10.18.12	68.36	6.39	39.50	10.49	129.20
12.18.12	55.01	6.37	31.99	11.90	4.60

Values in red are incompliant with surface water standards.

Table 35 Water Quality Fields Measurements for Site CB4

Sampling Site CB4					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	78.87	4.94	26.09	8.43	19.60
8.29.11	74.11	5.99	40.54	8.49	4.30
10.5.11	61.96	6.06	42.63	9.11	2.00
11.15.11	63.55	6.33	46.14	8.37	0.90
3.13.12	63.96	4.87	14.94	6.85	47.30
3.23.12	67.10	4.38	25.64	6.60	15.90
5.17.12	67.11	NT	40.31	46.31	1.90
7.9.12	74.12	6.16	45.11	1.75	4.60
8.2.12	76.17	5.84	47.07	8.89	3.90
8.30.12	74.92	0.86	24.37	0.22	35.30
10.18.12	66.89	6.08	34.78	10.84	129.30
12.18.12	58.42	6.10	32.24	10.88	7.10

Values in red are incompliant with surface water standards.

Table 36 Water Quality Fields Measurements for Site CB5

Sampling Site CB5					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	74.83	4.74	28.05	8.65	20.40
8.29.11	73.56	5.45	18.54	8.61	1.20
10.5.11	64.42	5.74	25.31	9.65	15.40
11.15.11	65.19	6.20	38.97	8.55	0.30
1.28.12	57.60	5.55	36.87	9.37	57.60
3.13.12	64.37	4.96	26.95	8.4	33.9
3.23.12	67.84	4.70	24.02	7.10	31.90
5.17.12	66.72	5.49	36.18	17.75	1.50
7.9.12	72.35	5.87	33.48	1.72	0.80
8.2.12	74.34	5.87	39.20	9.40	3.20
8.30.12	75.23	NT	20.49	13.48	31.10
10.18.12	68.09	6.03	32.17	11.05	118.80
12.18.12	59.79	5.98	29.62	10.67	12.10

Values in red are incompliant with surface water standards.

Table 37 Water Quality Fields Measurements for Site CB6

Sampling Site CB6					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
7.26.11	75.57	4.56	28.40	8.49	26.50
8.29.11	76.87	5.87	28.47	7.92	3.40
10.5.11	65.50	6.08	32.04	9.62	3.70
11.15.11	65.54	6.30	35.04	8.98	1.20
1.28.12	58.22	5.69	35.63	9.84	5.70
3.13.12	64.54	5.09	26.81	8.59	23.30
3.23.12	68.26	4.71	27.01	6.57	35.80
5.17.12	68.14	NT	32.90	14.68	1.30
7.9.12	74.41	5.94	31.85	1.55	48.30
8.3.12	75.08	5.95	34.89	7.65	3.70
8.31.12	75.54	2.92	19.40	4.65	26.10
10.18.12	68.95	6.10	30.89	10.95	123.60
12.18.12	60.12	6.19	28.36	10.65	3.80

Values in red are incompliant with surface water standards.

Table 38 Water Quality Fields Measurements for Site CB7

Sampling Site CB7					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
5.21.12	67.90	6.51	29.86	5.93	1.80
6.11.12	74.49	4.54	23.56	14.87	7.20
7.9.12	75.76	5.20	31.29	1.49	3.40
8.2.12	78.78	5.38	30.92	8.22	3.80
10.18.12	68.49	5.85	31.82	10.95	101.60
12.18.12	57.40	6.00	25.54	11.69	2505.20

Values in red are incompliant with surface water standards.

Table 39 Water Quality Fields Measurements for Site E1

Sampling Site E1					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
07.25.11	79.00	4.51	23.15	8.37	105.80
8.30.11	80.51	6.15	22.52	7.18	4.80
10.6.11	65.73	5.70	30.11	8.62	5.70
11.15.11	66.58	6.49	33.72	9.02	1.10
1.28.12	58.91	4.92	32.51	9.48	42.80
3.13.12	64.93	4.68	22.29	8.45	74.70
3.24.12	67.14	4.48	24.00	8.23	40.00
5.21.12	75.39	6.96	27.19	8.34	5.10
7.10.12	78.59	5.85	32.04	5.73	8.70
8.2.12	82.39	4.96	28.53	7.36	12.80
8.31.12	75.48	2.78	21.87	4.34	59.70
10.19.12	66.24	6.71	26.01	9.70	50.80
12.18.12	57.75	6.03	22.88	11.12	3.90

Values in red are incompliant with surface water standards.

Table 40 Water Quality Fields Measurements for Site E2

Sampling Site E2					
Date	Temperature	pH	Conductivity	D.O.	Turbidity
	°F	s.u.	µS/cm	mg/L	NTU
07.25.11	78.77	4.28	21.50	8.42	107.60
8.30.11	83.00	5.84	22.88	6.74	5.10
10.6.11	68.19	4.75	30.15	10.42	5.00
11.15.11	66.41	6.19	31.95	9.24	12.60
3.13.12	64.63	4.65	21.82	8.02	101.70
3.24.12	67.28	4.56	24.18	9.62	39.80
5.21.12	75.67	6.40	27.04	6.60	4.40
7.10.12	79.72	5.84	31.83	5.64	4.30
8.2.12	83.06	5.31	28.89	7.21	5.30
10.19.12	67.40	6.14	26.54	9.63	47.80
12.18.12	58.54	6.14	23.71	10.88	6.90

Values in red are incompliant with surface water standards.

Table 41 Water Quality Laboratory Analyses for Site B1

Sampling Site B1															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.27.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	2.00	ND	8.20	5.42	ND	ND	0.02	ND	0.68	0.27	46.00	1.50	ND	0.97	3.39
11.16.11	4	ND	3.7	5.32	0.61	ND	ND	ND	0.61	0.55	31	0.346	ND	0.668	2.40
1.27.12	10	ND	7.4	5.46	ND	ND	ND	ND	1.09	0.55	45	0.516	ND	0.556	2.3
3.12.12	10	ND	12.9	2.81	ND	ND	ND	ND	0.9	1.04	52	0.732	ND	0.839	1.54
5.17.12	2.4	ND	4.6	5.0	ND	ND	ND	ND	ND	0.6	30.0	0.6	ND	0.6	2.0
7.10.12	2.3	ND	4.6	4.79	ND	ND	ND	ND	ND	0.82	36	0.631	ND	0.457	2.06
8.2.12	1.9	ND	5.5	5.19	ND	ND	ND	ND	ND	0.41	35	0.755	ND	0.551	2.2
8.30.12	8.6	ND	3.7	1.68	ND	ND	ND	ND	1.32	ND	56	2.75	ND	1.43	0.901
10.18.12	2.3	ND	4.6	5.02	ND	ND	ND	ND	ND	0.32	36	0.433	ND	0.616	2.16
12.17.12	2.3	ND	3.7	5.06	0.31	ND	ND	ND	ND	0.21	39	0.719	ND	0.639	2.24

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 42 Water Quality Laboratory Analyses for Site B2

Sampling Site B2															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.27.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.4.11	5.00	ND	4.60	4.82	ND	ND	ND	ND	ND	0.27	42.00	0.41	ND	0.55	2.32
11.16.11	2.00	ND	9.10	5.96	ND	ND	ND	ND	1.00	0.55	35.00	1.44	ND	1.41	3.40
1.27.12	5.00	0.20	12.00	6.05	ND	ND	ND	ND	1.38	0.55	45.00	1.49	ND	1.08	3.30
3.12.12	10.00	ND	17.60	4.28	ND	ND	ND	ND	2.04	1.30	131.00	1.40	ND	2.13	2.00
5.17.12	1.90	ND	11.10	5.51	ND	ND	ND	ND	1.01	0.55	30.00	1.65	ND	0.94	3.06
7.10.12	4.70	0.18	10.20	5.68	ND	ND	ND	ND	0.90	ND	39.00	1.95	ND	1.08	3.06
8.2.12	2.90	ND	14.80	5.82	ND	ND	ND	ND	1.18	0.27	38.00	2.24	ND	0.95	3.17
8.30.12	4.80	ND	6.50	1.44	ND	ND	ND	ND	1.50	0.53	36.00	1.76	ND	1.22	0.86
10.18.12	8.00	1.46	12.00	7.12	0.39	ND	0.03	0.76	3.26	1.37	46.00	1.51	ND	2.54	3.35
12.17.12	2.8	0.83	14.8	6.12	ND	ND	0.02	0.41	ND	1.05	25	1.47	ND	1.72	3.23

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 43 Water Quality Laboratory Analyses for Site B3

Date	Sampling Site B3														
	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.27.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.30.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	4.00	ND	4.60	5.15	ND	ND	ND	ND	0.65	ND	47.00	0.64	ND	0.70	2.89
11.16.11	2.00	ND	4.6	5.41	ND	ND	ND	ND	1.18	0.55	16	0.514	ND	0.897	2.77
3.13.12	5	ND	10.2	3.6	ND	ND	ND	ND	1.75	0.52	53	0.738	ND	0.954	2.09
3.23.12	6.8	ND	6.5	2.88	ND	ND	ND	ND	1.86	0.26	46	0.613	ND	0.777	1.73
5.17.12	2.9	ND	7.4	5.1	ND	ND	ND	ND	0.8	0.6	31.0	0.8	ND	0.7	2.7

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 44 Water Quality Laboratory Analyses for Site B3A

Date	Sampling Site B3A														
	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.10.12	3.8	ND	7.4	5.52	ND	ND	ND	ND	2.91	0.68	39	0.978	ND	0.752	2.68
8.3.12	1.9	ND	9.2	5.67	ND	ND	ND	ND	0.85	0.27	33	1.06	ND	0.647	2.65
8.30.12	5.8	ND	3.7	1.77	ND	ND	ND	ND	1.64	ND	46	1.96	ND	1.22	1.1
10.18.12	1.4	ND	6.5	5.33	ND	ND	ND	ND	ND	0.32	36	0.666	ND	0.739	2.66
12.17.12	1.9	0.45	7.40	5.94	ND	ND	0.02	ND	ND	0.73	40	0.941	ND	1.25	2.84

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 45 Water Quality Laboratory Analyses for Site B4

Sampling Site B4															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.30.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	3.00	ND	7.30	5.11	ND	ND	ND	ND	0.76	ND	46.00	0.74	ND	0.76	3.14
11.16.11	3.00	ND	5.50	5.89	ND	ND	ND	ND	1.69	0.55	43.00	0.47	ND	1.09	3.01
1.27.12	5.00	ND	4.60	3.61	ND	ND	ND	ND	1.54	0.55	57.00	0.83	ND	0.67	2.90
3.13.12	5.00	ND	5.50	3.63	ND	ND	ND	ND	2.08	0.52	57.00	0.49	ND	0.76	2.13
3.23.12	5.3	ND	5.50	2.72	ND	ND	ND	ND	1.88	0.26	39	0.579	ND	0.744	1.8
5.17.12	1.90	ND	6.50	4.95	ND	ND	ND	ND	0.87	0.55	35.00	0.83	ND	0.72	2.63
7.9.12	2.30	ND	7.40	4.74	ND	ND	ND	ND	0.73	0.68	34.00	1.01	ND	0.76	2.54
8.3.12	2.40	ND	9.20	5.29	ND	ND	ND	ND	0.93	0.41	36.00	0.99	ND	0.69	2.80
10.18.12	2.30	ND	3.70	5.22	ND	ND	ND	ND	ND	0.53	37.00	0.60	ND	0.70	2.82
12.17.12	ND	ND	6.50	5.39	ND	ND	ND	ND	ND	0.21	30.00	0.59	ND	0.77	2.95

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 46 Water Quality Laboratory Analyses for Site B5

Sampling Site B5															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.30.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	4.00	ND	8.20	5.13	ND	ND	ND	ND	0.86	0.27	47.00	0.75	ND	0.70	3.19
11.16.11	3.00	ND	4.60	6.07	ND	ND	ND	ND	1.42	0.55	42.00	0.41	ND	1.08	3.07
1.27.12	10.00	ND	5.50	5.85	ND	ND	ND	ND	1.70	0.55	53.00	0.89	ND	0.72	2.94
3.13.12	5.00	ND	6.50	3.52	ND	ND	ND	ND	1.71	0.52	57.00	0.67	ND	0.79	2.12
3.23.12	3.90	ND	7.40	2.52	ND	ND	ND	ND	1.71	0.26	57.00	1.23	ND	0.75	1.64
5.18.12	2.40	ND	8.30	4.99	ND	ND	ND	ND	0.89	0.55	27.00	0.86	ND	0.70	2.72
7.9.12	1.90	ND	8.30	5.61	ND	ND	ND	ND	1.03	0.55	41.00	0.88	ND	0.90	2.81
8.3.12	3.80	ND	9.20	5.23	ND	ND	ND	ND	0.99	0.27	43.00	0.96	ND	0.71	2.87
10.18.12	2.80	ND	3.70	5.20	ND	ND	ND	ND	ND	0.53	38.00	0.64	ND	0.70	2.78
12.17.12	11.20	ND	ND	5.59	ND	ND	0.01	ND	23.80	0.31	43.00	1.07	ND	3.21	3.14

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 47 Water Quality Laboratory Analyses for Site B6

Sampling Site B6															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.30.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.6.11	5.00	ND	8.20	5.05	ND	ND	ND	ND	0.92	0.27	47.00	0.74	ND	0.68	3.18
11.16.11	4.00	ND	4.6	6.16	ND	ND	ND	ND	1.73	0.55	36	0.469	ND	1.27	3.28
11.16.11	2.00	ND	5.50	6.16	ND	ND	ND	ND	1.74	0.55	38.00	0.49	ND	1.31	3.40
1.27.12	5.00	ND	4.60	5.73	ND	ND	ND	ND	1.78	0.55	52.00	0.87	ND	0.68	2.84
3.13.12	5.00	ND	4.60	3.54	ND	ND	ND	ND	2.12	0.26	58.00	1.04	ND	0.76	2.10
3.23.12	5.30	ND	7.40	2.49	ND	ND	ND	ND	ND	0.26	55.00	0.65	ND	0.72	1.65
5.18.12	1.90	ND	7.40	5.07	ND	ND	ND	ND	0.95	0.55	28.00	0.87	ND	0.66	2.70
5.18.12	1.90	ND	6.50	5.00	ND	ND	ND	ND	1.00	0.55	27.00	0.84	ND	0.64	2.65
7.9.12	1.40	ND	8.30	5.13	ND	ND	ND	ND	0.75	0.68	36.00	0.83	ND	0.67	2.76
8.3.12	2.40	ND	8.30	5.21	ND	ND	ND	ND	1.06	0.27	32.00	0.96	ND	0.76	2.88
8.31.12	8.20	ND	2.80	2.06	ND	ND	ND	ND	1.69	0.26	46.00	1.09	ND	1.04	1.23
10.18.12	2.80	ND	2.80	5.26	ND	ND	ND	ND	ND	0.63	44.00	0.66	ND	0.71	2.89
12.17.12	1.40	ND	3.70	5.50	ND	ND	ND	ND	ND	0.21	46.00	0.55	ND	0.69	3.01

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 48 Water Quality Laboratory Analyses for Site CL1

Sampling Site CL1															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	4.00	ND	3.70	4.69	ND	0.98	ND	ND	ND	0.27	36.00	0.13	ND	0.43	2.38
11.15.11	4.00	ND	3.70	5.01	ND	ND	ND	ND	ND	0.55	30.00	0.19	ND	0.64	2.38
1.28.12	14	ND	5.5	5.6	ND	ND	ND	ND	ND	0.55	40	0.501	ND	0.659	2.4
3.12.12	5	ND	8.3	4.56	ND	ND	ND	ND	10.2	0.52	49	0.327	ND	0.637	2.34
3.23.12	6.80	ND	3.70	2.28	ND	ND	ND	ND	1.35	0.26	43.00	1.17	ND	1.15	1.42
5.16.12	2.90	ND	5.50	4.98	ND	ND	ND	ND	ND	0.55	31.00	0.47	ND	0.52	2.25
7.9.12	3.80	ND	4.60	5.05	ND	ND	ND	ND	ND	0.41	25.00	0.20	ND	0.40	2.26
8.2.12	2.90	ND	4.60	5.25	ND	ND	ND	ND	ND	0.27	18.00	0.30	ND	0.48	2.24
8.30.12	4.30	ND	3.70	1.33	ND	ND	ND	ND	ND	0.53	20.00	0.36	ND	1.14	0.69
10.18.12	2.3	ND	1.9	5.08	ND	ND	ND	ND	ND	0.21	23	0.302	ND	0.553	2.27
12.17.12	2.8	ND	3.7	4.95	0.41	ND	ND	ND	ND	0.31	33	0.421	ND	0.559	2.32

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 49 Water Quality Laboratory Analyses for Site CL2

Sampling Site CL2															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	2.00	ND	4.60	5.43	ND	0.91	ND	ND	ND	0.27	39.00	0.39	ND	0.61	2.38
11.15.11	2.00	ND	5.50	5.70	ND	ND	ND	ND	ND	0.27	44.00	0.44	D	0.84	2.26
3.13.12	5	ND	11.1	4.76	ND	ND	ND	ND	1.02	0.52	46	0.476	ND	0.624	2.43
3.23.12	7.2	ND	5.5	2.74	ND	ND	ND	ND	1.68	0.26	43	0.597	ND	0.726	1.54
5.16.12	1.9	ND	5.5	5.75	ND	ND	ND	ND	ND	1.09	26	0.579	ND	0.681	2.22
7.9.12	1.9	ND	5.5	5.8	ND	ND	ND	ND	ND	0.55	33	0.368	ND	0.58	2.21
8.2.12	1.4	ND	5.5	5.84	ND	ND	ND	ND	ND	0.27	27	0.5	ND	0.682	2.27
8.30.12	3.3	ND	2.8	1.29	ND	ND	ND	ND	1.02	0.4	37	1.2	ND	1.14	0.659
10.18.12	1.9	ND	3.7	5.59	ND	ND	ND	ND	ND	0.32	31	0.563	ND	0.726	2.17
12.18.12	3.3	ND	5.5	5.59	ND	ND	ND	ND	ND	0.21	20	0.587	ND	0.697	2.4

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 50 Water Quality Laboratory Analyses for Site CL3

Sampling Site CL3															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	3.00	ND	6.40	4.96	ND	ND	ND	ND	ND	0.27	40.00	0.50	ND	0.71	2.42
11.15.11	2.00	ND	5.50	5.34	ND	ND	ND	ND	ND	0.27	42.00	0.37	ND	0.93	2.18
1.28.12	10	ND	9.2	5.83	ND	ND	ND	ND	2.04	0.82	54	0.548	ND	0.788	2.55
3.13.12	4	ND	11.1	4.72	ND	ND	ND	ND	1.76	0.78	48	0.531	ND	0.681	2.39
3.23.12	7.2	ND	47	3.38	ND	ND	ND	ND	1.94	0.26	47	0.436	ND	0.761	1.91
5.16.12	1.9	ND	5.5	5.27	ND	ND	ND	ND	ND	0.82	23	0.503	ND	0.669	2.13
7.9.12	2.3	ND	7.4	5.19	ND	ND	ND	ND	ND	0.55	31	0.413	ND	0.662	2.2
8.2.12	3.4	ND	5.5	5.14	ND	ND	ND	ND	ND	0.27	27	0.491	ND	0.703	2.23
8.31.12	6.2	ND	1.9	1.71	ND	ND	ND	ND	1.5	ND	48	0.462	ND	1.03	0.942
8.31.12	8.2	ND	1.9	1.71	ND	ND	ND	ND	1.39	ND	35	0.483	ND	0.995	0.932
10.18.12	1.9	ND	1.9	5.02	ND	ND	ND	ND	ND	0.32	36	0.657	ND	0.826	2.19
12.18.12	ND	ND	5.5	5.4	ND	ND	ND	ND	ND	ND	51	0.54	ND	0.779	2.27

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 51 Water Quality Laboratory Analyses for Site CB1

Sampling Site CB1															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.04.11	7.00	ND	4.60	6.36	ND	ND	ND	ND	ND	0.27	64.00	2.13	ND	0.87	3.52
11.15.11	3.00	ND	6.40	6.36	ND	ND	ND	ND	ND	1.09	67.00	2.21	ND	1.13	3.52
1.28.12	10.00	ND	4.6	6.58	ND	ND	ND	ND	1.58	0.55	47	1.21	ND	0.686	3.23
3.12.12	14.00	0.20	10.2	3.52	ND	ND	ND	ND	1.49	0.78	54	0.522	ND	1.56	2.03
3.23.12	6.30	ND	5.50	3.52	ND	ND	ND	ND	1.41	0.26	30.00	0.77	ND	1.02	2.18
5.16.12	2.40	ND	5.50	6.05	ND	ND	ND	ND	ND	1.36	41.00	2.25	ND	0.84	3.36
7.9.12	8.90	ND	6.50	6.63	ND	ND	ND	ND	ND	0.27	40.00	2.74	ND	0.89	3.79
8.2.12	4.30	ND	4.60	5.99	ND	ND	ND	ND	ND	0.27	74.00	2.85	ND	0.89	3.43
8.29.12	7.20	ND	2.80	1.35	ND	ND	ND	ND	1.48	0.26	33.00	0.97	ND	1.62	0.79
8.30.12	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.18.12	7.00	ND	3.70	5.84	ND	ND	0.01	ND	ND	0.42	45.00	2.21	ND	0.80	3.16
12.17.12	3.30	ND	3.70	6.10	ND	ND	ND	ND	ND	0.31	29.00	1.15	ND	0.68	3.32

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 52 Water Quality Laboratory Analyses for Site CB2

Sampling Site CB2															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	3.00	ND	8.20	7.82	ND	ND	ND	ND	0.52	ND	43.00	0.42	ND	0.74	6.73
11.15.11	2.00	ND	7.30	7.92	ND	ND	ND	ND	ND	0.27	39.00	0.38	ND	0.91	6.30
1.28.12	10	ND	5.5	7.47	0.26	ND	ND	ND	1.5	0.55	44	0.519	ND	0.658	5.92
3.12.12	8	ND	2.8	3.39	ND	ND	ND	ND	2.04	0.78	64	0.587	ND	0.818	2.59
3.23.12	7.2	ND	2.8	2.98	ND	ND	ND	ND	1.89	0.26	44	0.603	ND	0.672	2.2
5.16.12	1.9	ND	7.4	8.2	ND	ND	ND	ND	0.8	1.09	31	0.9	ND	0.795	6.4
7.9.12	3.8	ND	9.2	10.3	ND	ND	ND	ND	0.95	0.68	44	2.2	ND	0.894	8.61
8.2.12	2.9	ND	8.3	8.34	ND	ND	ND	ND	1.1	0.27	36	0.873	ND	0.761	6.32
8.30.12	7.2	ND	2.8	1.52	ND	ND	ND	ND	1.77	0.4	41	0.667	ND	1.18	0.92
10.18.12	2.3	ND	5.5	7.08	ND	ND	ND	ND	ND	0.32	27	0.528	ND	0.609	4.7
12.18.12	1.9	ND	4.6	7.61	ND	ND	ND	ND	ND	0.31	22	0.545	ND	0.664	5.52

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 53 Water Quality Laboratory Analyses for Site CB3

Sampling Site CB3															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	6.00	ND	8.20	7.10	ND	ND	ND	ND	ND	ND	50.00	1.29	ND	0.92	2.66
11.15.11	4.00	ND	8.20	8.46	ND	ND	ND	ND	ND	0.55	46.00	0.91	ND	1.56	2.46
3.12.12	5.00	ND	6.50	5.52	ND	ND	ND	ND	2.07	0.52	62.00	0.99	ND	0.92	2.47
3.23.12	4.30	ND	4.60	2.53	ND	ND	ND	ND	1.55	0.26	50	1.5	ND	0.926	1.54
5.17.12	1.9	ND	8.3	6.67	ND	ND	0.009	ND	ND	0.82	36	1.73	ND	0.795	2.46
7.9.12	3.3	ND	9.2	6.98	ND	ND	ND	ND	ND	0.41	35	1.44	ND	0.748	2.14
8.2.12	4.3	ND	10.2	6.47	ND	ND	ND	ND	ND	0.27	38	1.45	ND	0.95	2.3
8.29.12	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.30.12	4.3	ND	4.6	2.28	ND	ND	ND	ND	1	0.79	32	1.76	ND	1.41	0.923
10.18.12	ND	ND	9.2	6.31	ND	ND	0.009	ND	ND	0.21	36	1.19	ND	1.09	2.05
12.18.12	1.4	ND	8.3	7.05	ND	ND	0.009	ND	ND	0.31	29	1.41	ND	0.985	2.26

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 54 Water Quality Laboratory Analyses for Site CB4

Sampling Site CB4															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	3.00	ND	7.30	7.49	0.34	ND	ND	ND	0.91	0.27	48.00	0.49	ND	0.73	6.57
11.15.11	2.00	ND	7.30	7.65	ND	ND	ND	ND	ND	0.55	49.00	0.35	ND	0.89	6.08
3.13.12	6.00	ND	9.20	4.46	ND	ND	ND	ND	2.55	1.30	60.00	0.54	ND	0.65	3.43
3.23.12	7.20	ND	2.80	2.60	ND	ND	ND	ND	1.95	0.26	37.00	9.11	ND	13.49	1.82
5.17.12	1.9	ND	13.9	7.3	ND	ND	ND	ND	1.01	0.82	37	0.725	ND	0.68	5.48
7.9.12	2.8	ND	7.4	7.57	ND	ND	ND	ND	0.84	0.55	34	0.767	ND	0.667	5.4
8.2.12	2.90	ND	6.50	7.75	ND	ND	ND	ND	1.37	0.41	31.00	0.80	ND	0.79	5.99
8.30.12	7.2	ND	1.9	2.01	ND	ND	ND	ND	1.77	0.4	42	0.545	ND	0.859	1.27
10.18.12	1.4	ND	5.5	6.52	ND	ND	ND	ND	0.71	0.32	27	0.513	ND	0.574	4.26
12.18.12	1.9	ND	5.5	6.87	ND	ND	ND	ND	ND	0.21	20	0.525	ND	0.617	5.12

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 55 Water Quality Laboratory Analyses for Site CB5

Sampling Site CB5															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	4.00	ND	6.40	5.70	ND	ND	ND	ND	0.80	ND	49.00	0.37	ND	0.88	4.64
11.15.11	2	ND	6.4	6.12	ND	ND	ND	ND	ND	0.55	46	0.238	ND	1.04	4.48
1.28.12	5	ND	4.6	6.18	ND	ND	ND	ND	1.73	1.09	50	0.392	ND	0.753	3.88
3.13.12	5	ND	8.3	4.08	ND	ND	ND	ND	2.35	0.78	58	0.917	ND	0.774	2.84
3.23.12	7.2	ND	4.6	2.57	ND	ND	ND	ND	1.67	0.26	45	0.733	ND	1.47	1.65
5.17.12	1.9	ND	6.5	5.8	ND	ND	ND	ND	1.09	0.82	20	0.431	ND	0.823	3.97
7.9.12	3.30	ND	6.50	4.84	ND	ND	ND	ND	ND	0.55	30.00	0.40	ND	0.76	3.07
8.2.12	2.4	ND	5.50	6.01	ND	ND	ND	ND	1.2	0.27	29	0.49	ND	0.891	4.14
8.30.12	6.7	ND	1.9	1.86	ND	ND	ND	ND	1.45	0.4	32	0.611	ND	0.959	1.08
10.18.12	1.9	ND	3.7	5.49	ND	ND	ND	ND	ND	0.32	25	0.387	ND	0.821	3.3
12.18.12	ND	ND	7.4	5.88	ND	ND	ND	ND	ND	0.31	36	0.431	ND	0.788	3.88

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 56 Water Quality Laboratory Analyses for Site CB6

Sampling Site CB6															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
7.26.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
8.29.11	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT
10.5.11	3.00	ND	5.50	5.26	ND	ND	ND	ND	0.81	0.27	45.00	0.45	ND	0.74	3.46
11.15.11	3	ND	6.4	5.63	ND	ND	ND	ND	ND	0.55	43	0.252	ND	0.997	3.32
1.28.12	19	ND	4.6	6.19	ND	ND	ND	ND	2.38	1.09	59	0.434	ND	0.732	3.11
3.13.12	6	ND	9.2	4.34	ND	ND	ND	ND	2.07	0.52	43	0.634	ND	0.777	2.57
3.23.12	7.2	ND	4.6	3.1	ND	ND	ND	ND	1.89	0.26	60	0.627	ND	1.2	1.82
5.17.12	1.9	ND	6.5	5.36	ND	ND	ND	ND	0.96	0.55	41	0.508	ND	0.775	3.09
7.9.12	1.9	ND	6.5	4.85	ND	ND	ND	ND	0.8	0.55	31	0.387	ND	0.686	2.54
8.3.12	1.9	ND	4.6	5.52	ND	ND	ND	ND	1.05	0.27	35	0.464	ND	0.777	3.09
8.31.12	7.7	ND	1.9	1.75	ND	ND	ND	ND	1.45	ND	34	0.492	ND	0.989	1
10.18.12	1.9	ND	1.9	5.16	ND	ND	ND	ND	ND	0.21	30	0.452	ND	0.755	2.65
12.18.12	ND	ND	6.5	5.94	ND	ND	ND	ND	ND	0.31	34	0.485	ND	0.752	3.24

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

Table 57 Water Quality Laboratory Analyses for Site CB7

Sampling Site CB7															
Date	Acidity	Ammonia	Alkalinity	Chloride	Fluoride	Nitrate	Nitrite	Phosphorus	Sulfate	Total Kjeldahl Nitrogen	Total Dissolved Solids	Iron	Lead	Potassium	Sodium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
5.21.12	6.3	ND	2.8	6.05	ND	ND	ND	ND	0.89	1.36	39	0.901	ND	0.698	2.8
6.11.12	6.1	ND	2.8	2.65	ND	ND	ND	ND	1.9	ND	43	0.464	ND	1.03	1.51
7.9.12	5.2	ND	3.7	4.96	ND	ND	ND	ND	1.67	0.27	43	0.666	ND	0.512	2.41
8.2.12	2.9	ND	4.6	5.61	ND	ND	ND	ND	0.97	0.41	35	0.855	ND	0.619	2.53
8.2.12	1.9	ND	4.6	5.41	ND	ND	ND	ND	1.07	0.27	37	0.473	ND	0.748	3.1
10.18.12	2.3	ND	1.9	5.67	ND	ND	ND	ND	ND	0.32	40	0.57	ND	0.572	2.41
12.18.12	2.3	ND	5.5	6.85	0.7	ND	0.009	ND	ND	ND	36	0.512	ND	0.673	2.85
12.18.12	1.9	ND	5.5	6.82	ND	ND	0.01	ND	ND	0.21	42	0.499	ND	0.637	2.83

Values in red are incompliant with surface water standards; NS = not sampled; NT = not tested

APPENDIX C

LABORATORY ANALAYSES REPORTS

See supplemental file Appendix_C.pdf

APPENDIX D

GRAPHICAL ANALYSES OF FIELD AND LABORATORY WATER QUALITY

RESULTS

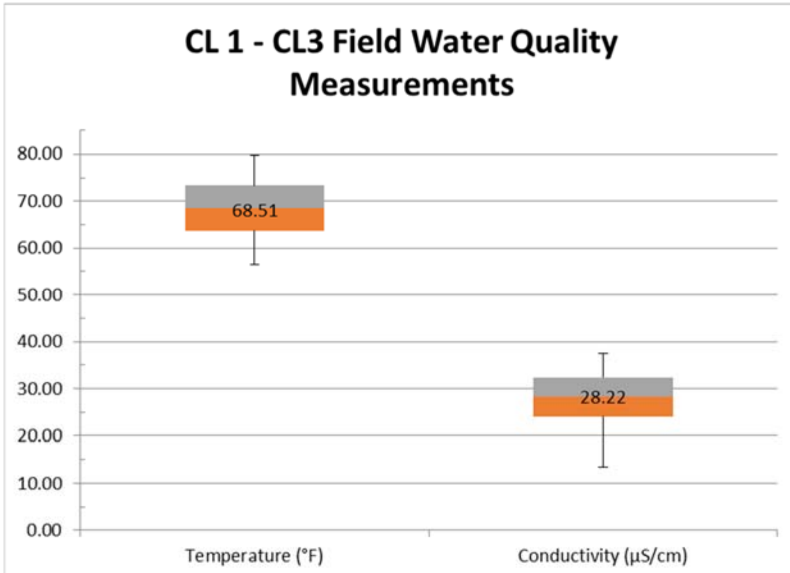

Figure 86 Graphical representation of composite averages of field water quality measurements for the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

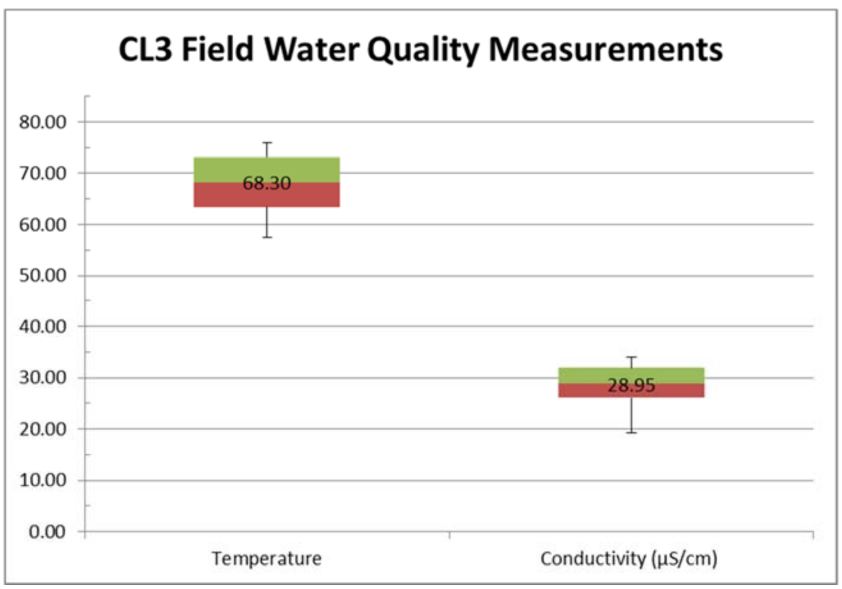

Figure 87 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

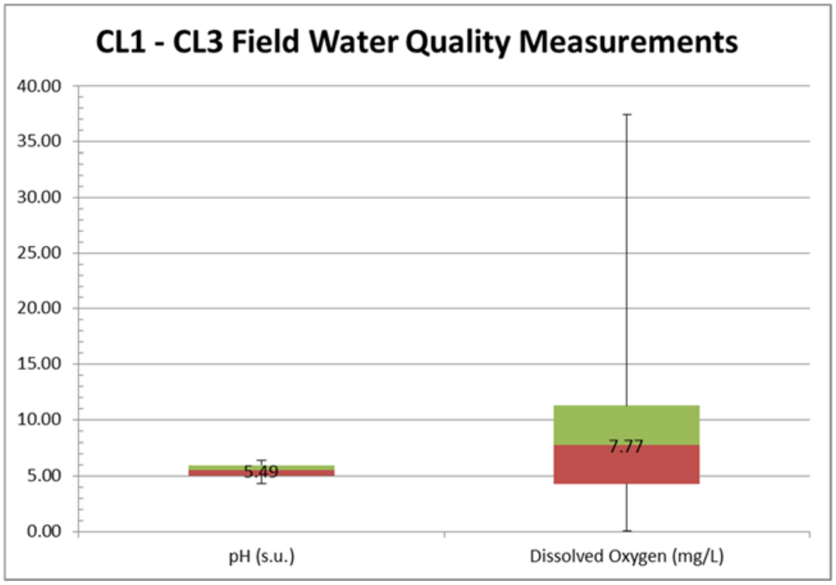

Figure 88 Graphical representation of composite averages of field water quality measurements for the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

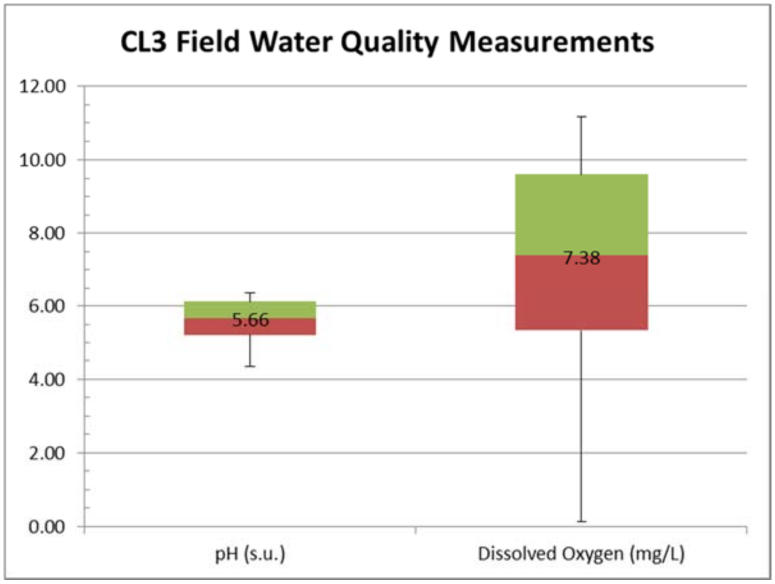

Figure 89 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

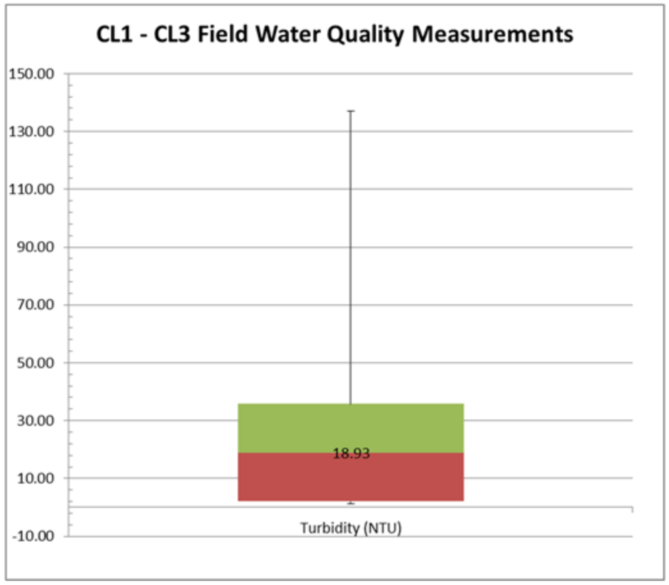

Figure 90 Graphical representation of composite averages of field water quality measurements for the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

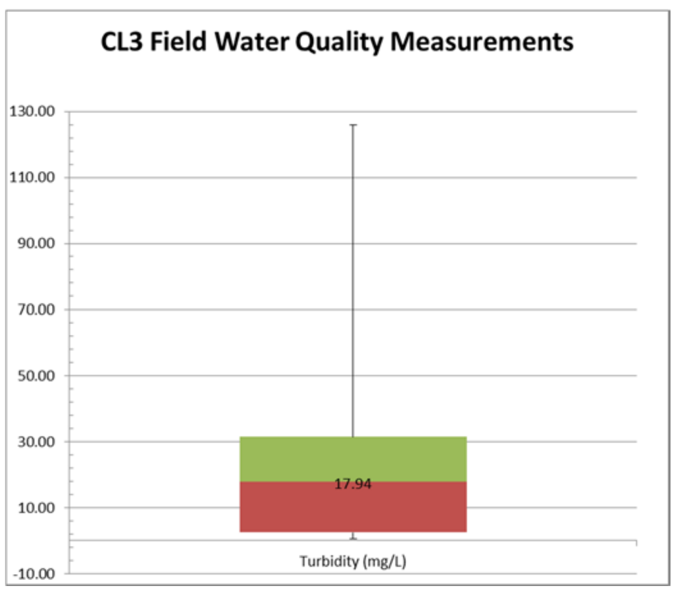

Figure 91 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

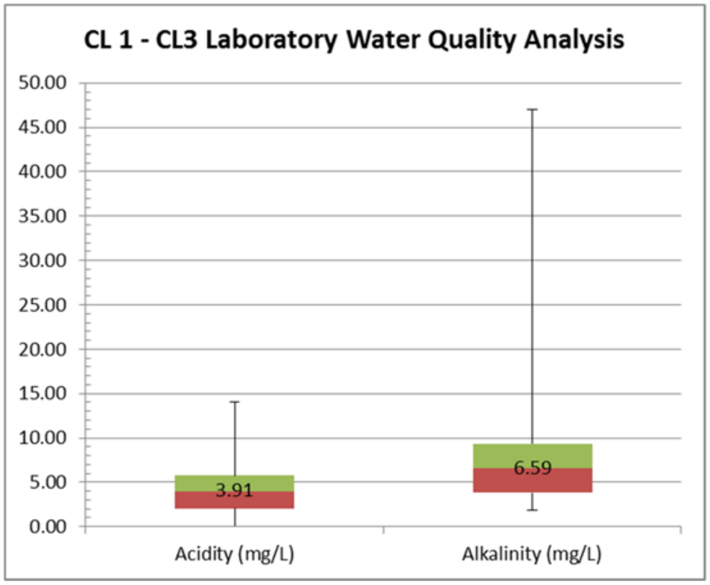

Figure 92 Graphical representation of composite averages of laboratory water quality measurements for the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

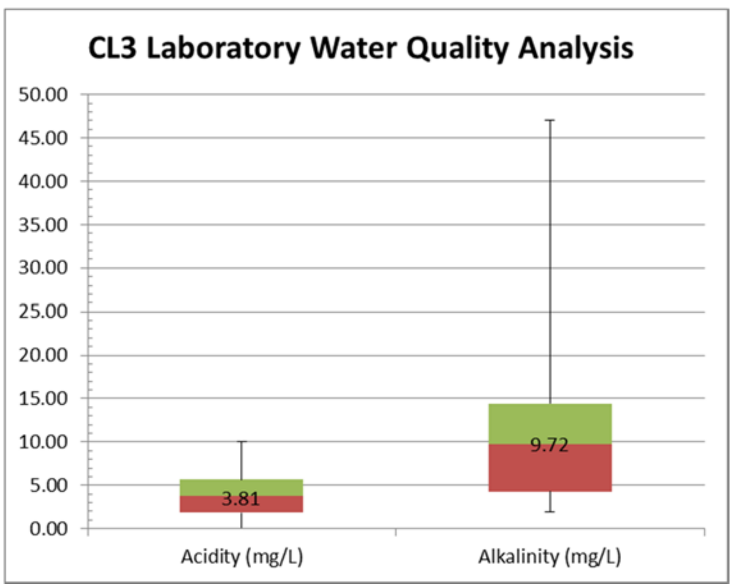

Figure 93 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

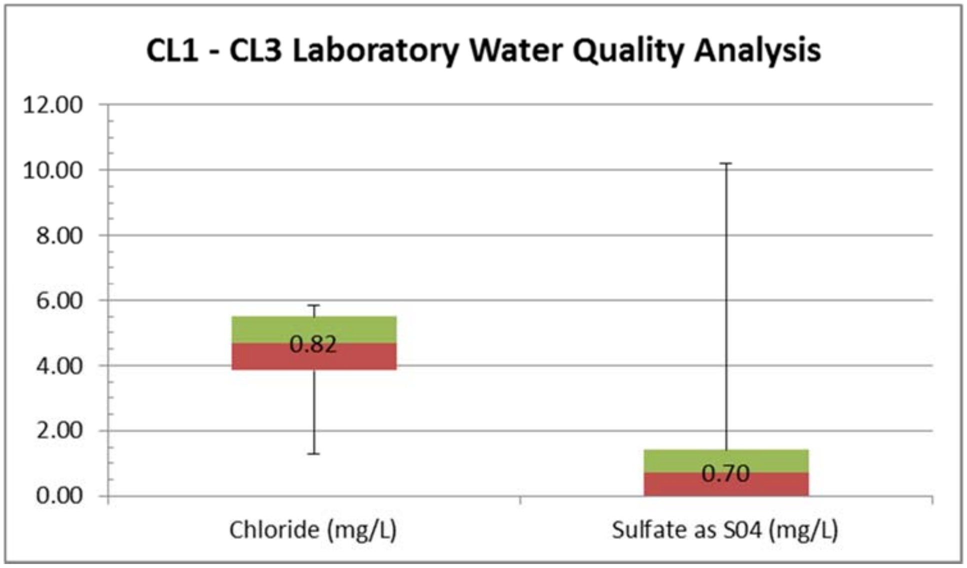

Figure 94 Graphical representation of composite averages of laboratory water quality measurements for the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

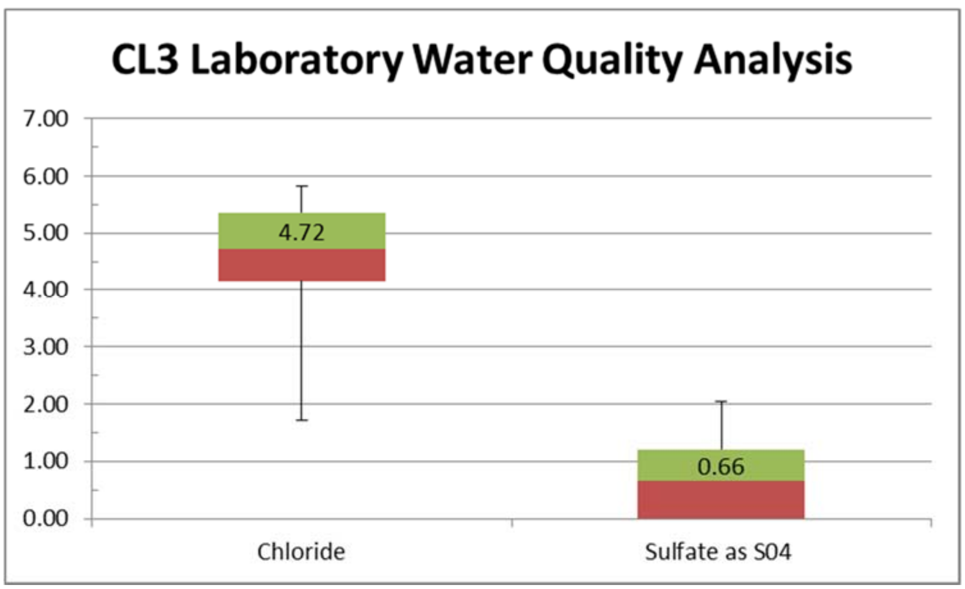

Figure 95 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

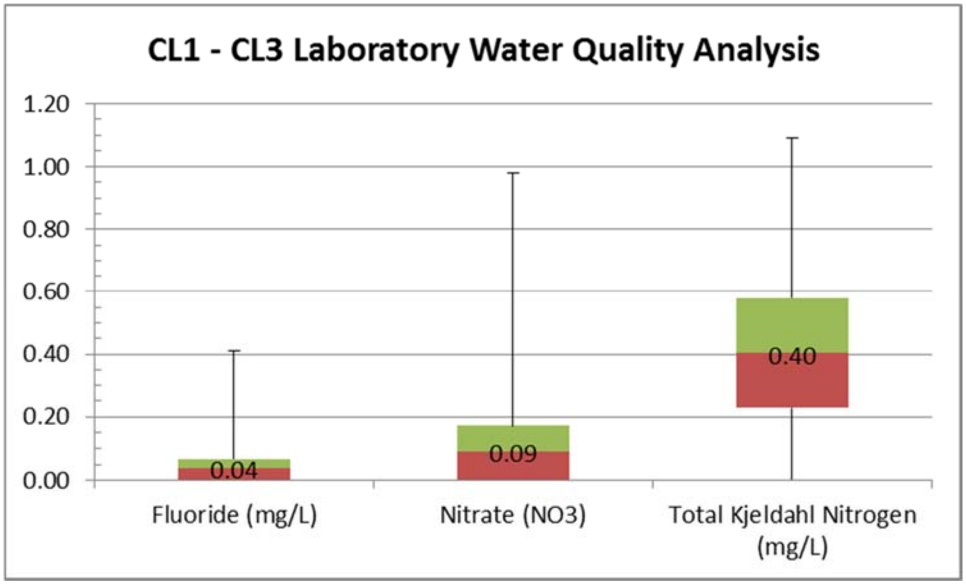

Figure 96 Graphical representation of composite averages of laboratory water quality measurements for the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

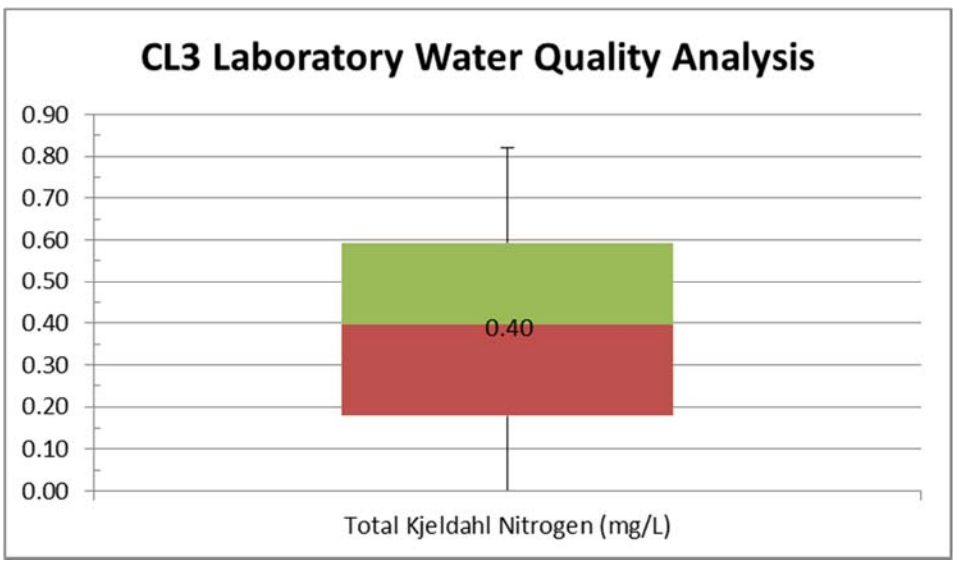

Figure 97 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

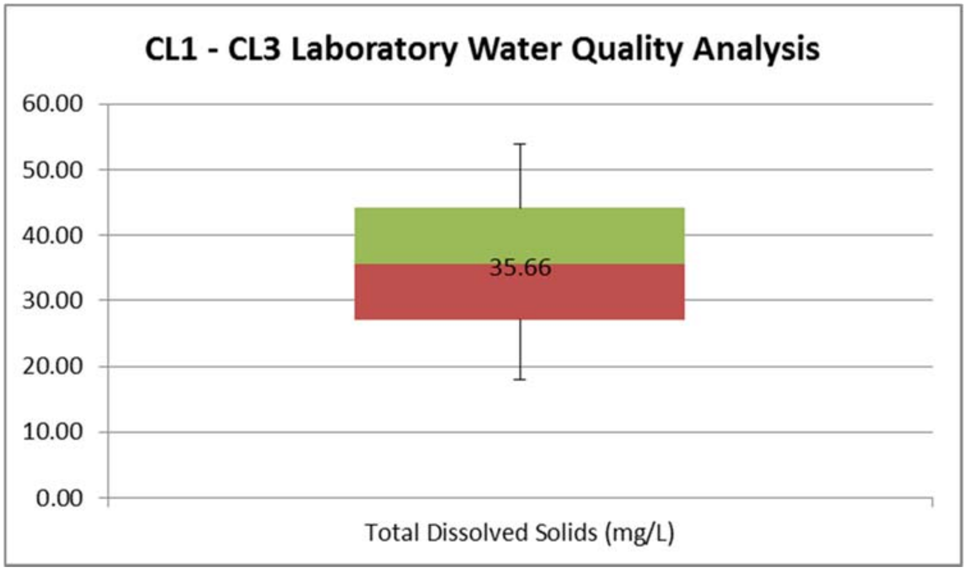

Figure 98 Graphical representation of composite averages of laboratory water quality measurements for the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

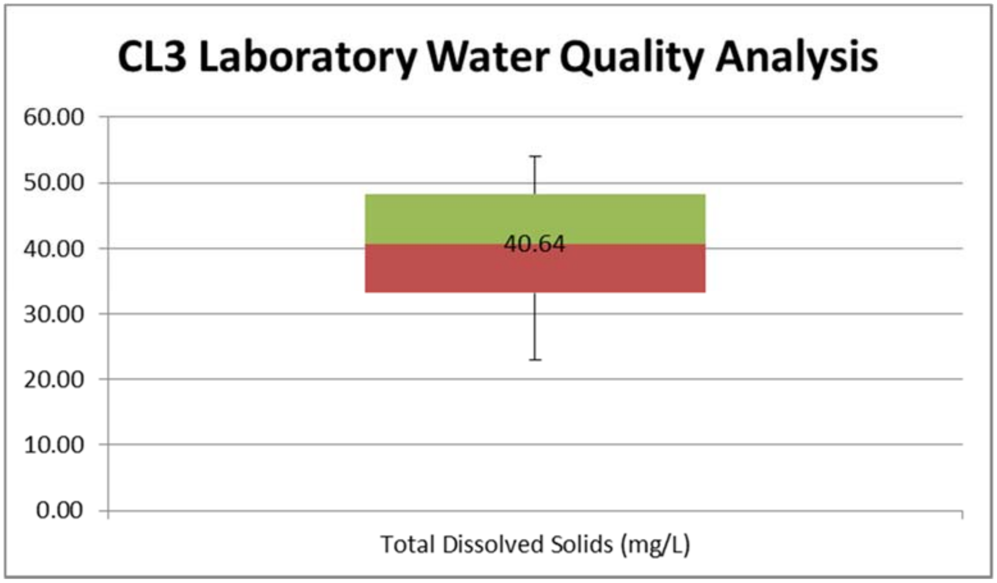

Figure 99 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

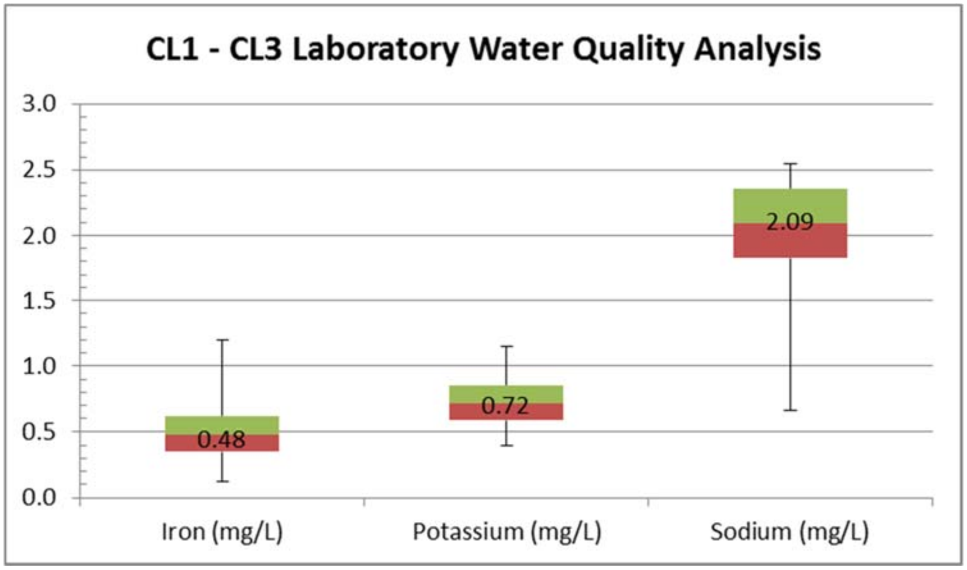

Figure 100 Graphical representation of composite averages of laboratory water quality measurements for the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

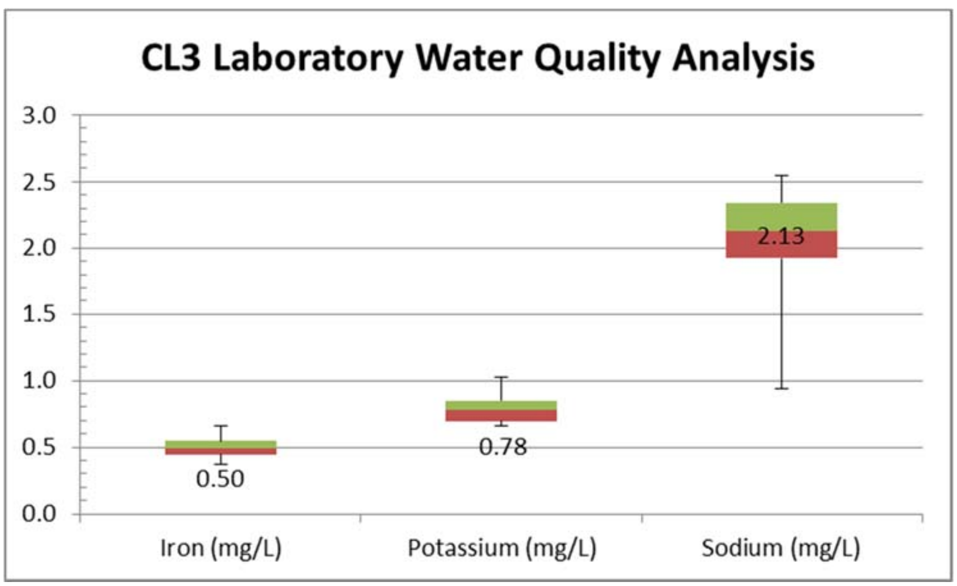

Figure 101 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CL3) of the Little Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

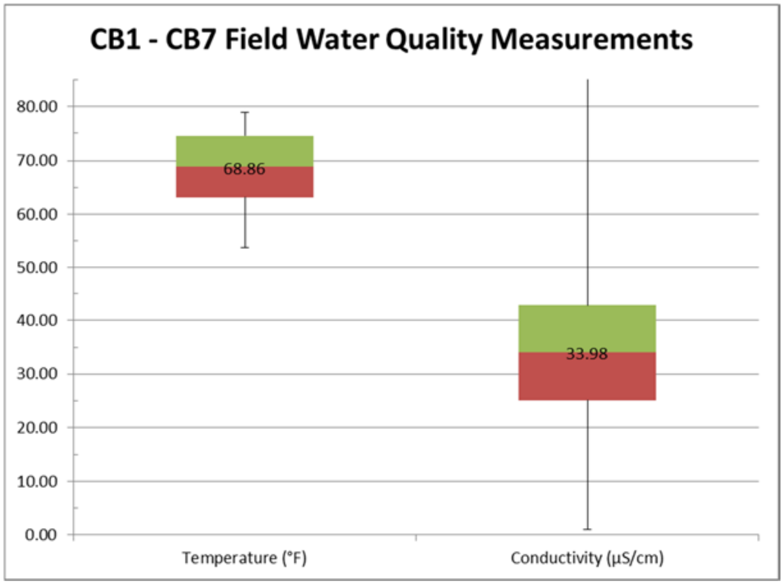

Figure 102 Graphical representation of composite averages of field water quality measurements for the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

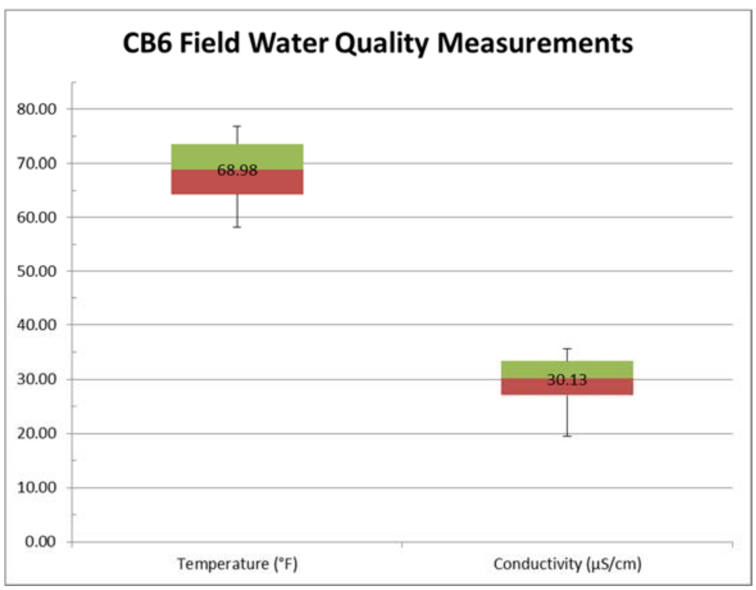

Figure 103 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (CB6) of the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

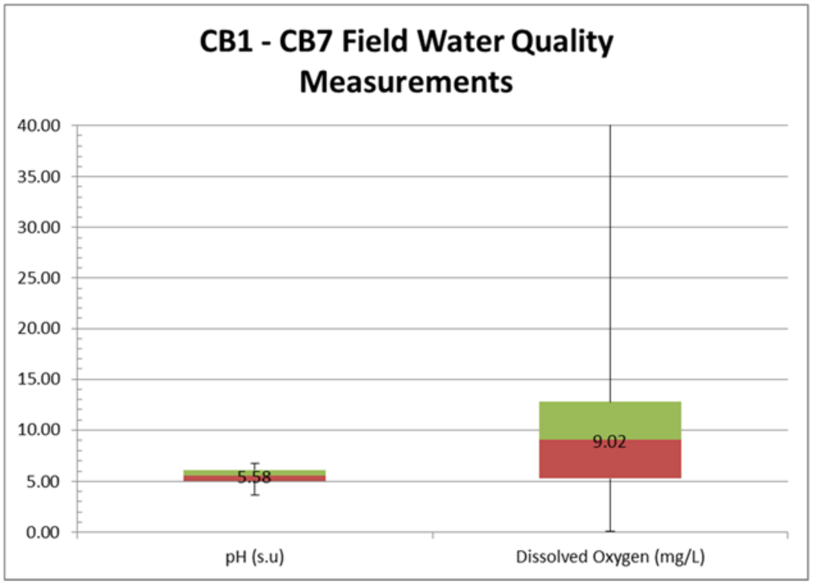

Figure 104 Graphical representation of composite averages of field water quality measurements for the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

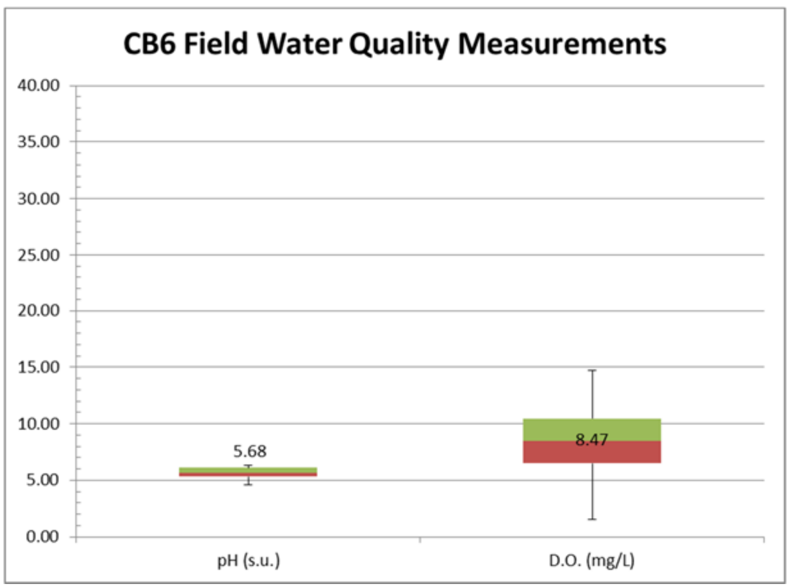

Figure 105 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CB6) of the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

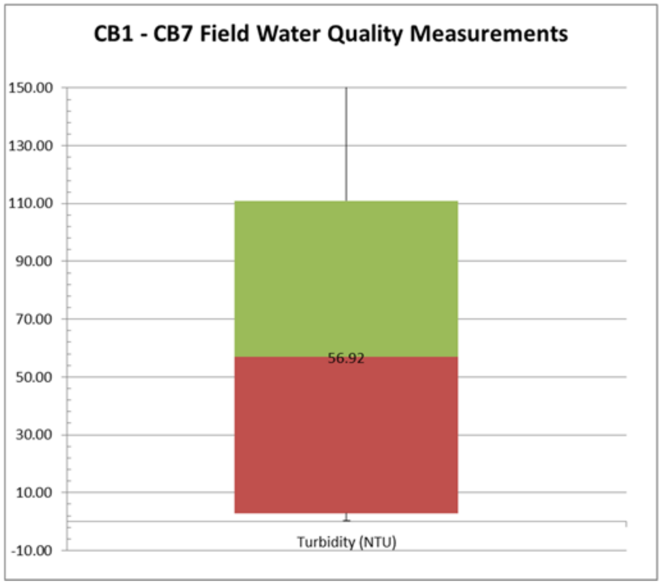

Figure 106 Graphical representation of composite averages of laboratory water quality measurements for the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

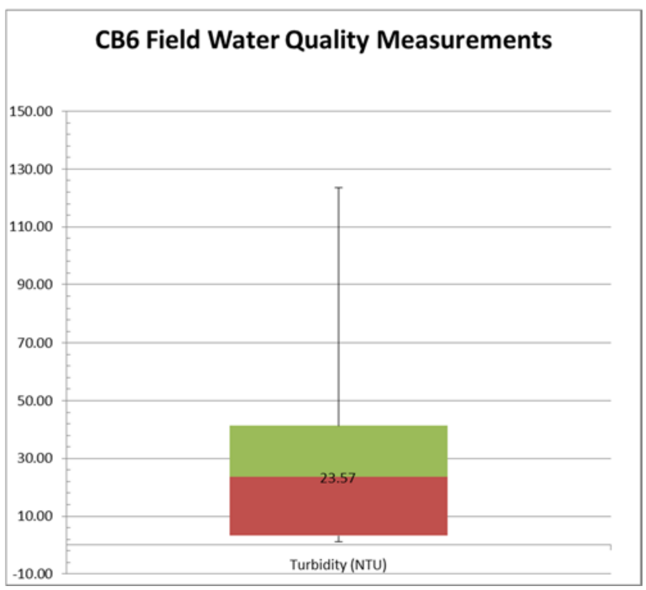

Figure 107 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CB6) of the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

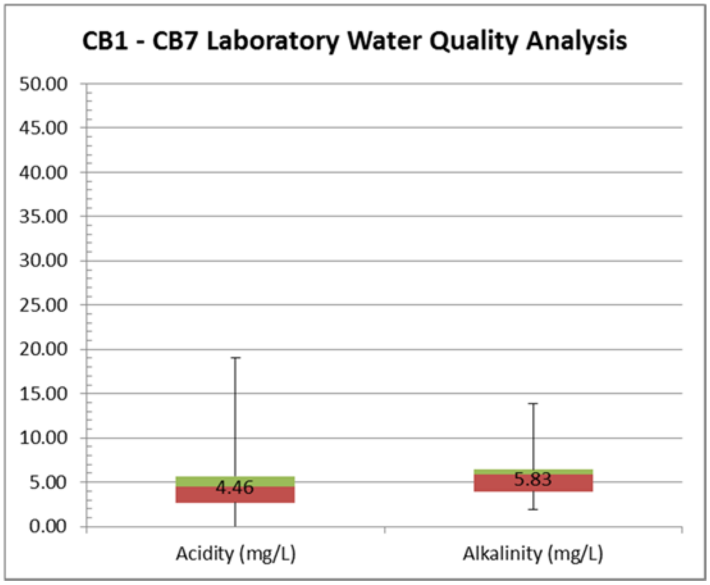

Figure 108 Graphical representation of composite averages of laboratory water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

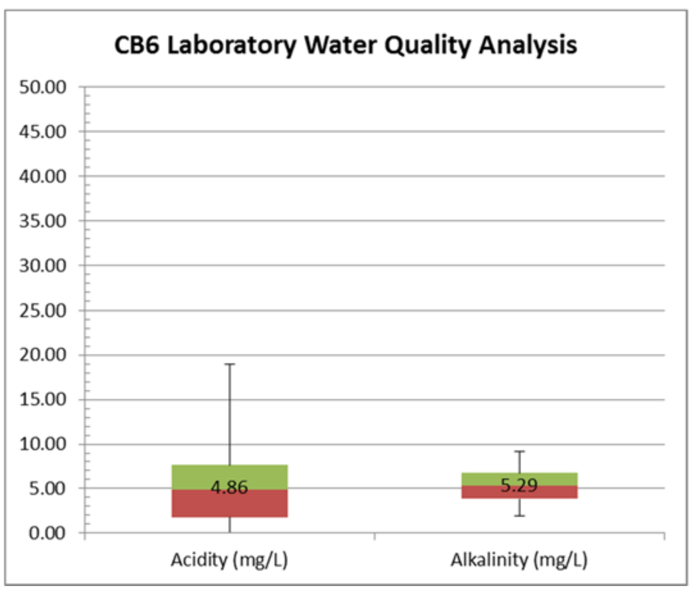

Figure 109 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CB6) of the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

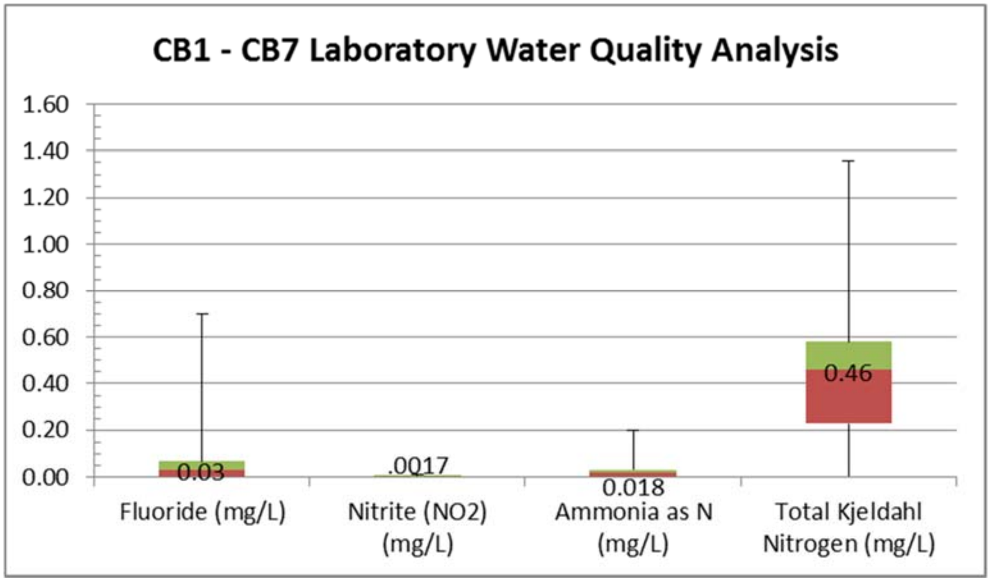

Figure 110 Graphical representation of composite averages of laboratory water quality measurements for the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

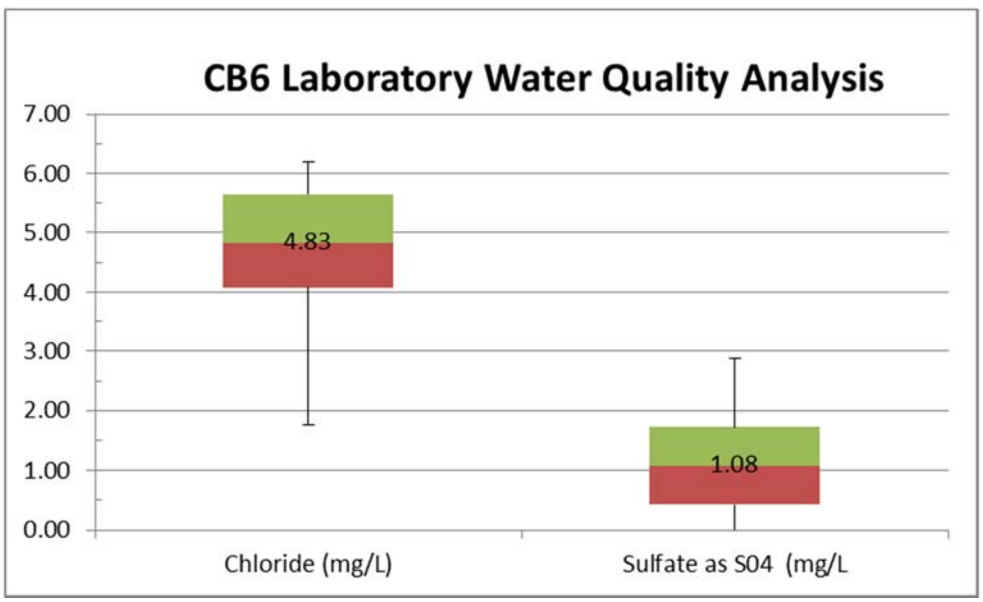

Figure 111 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CB6) of the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

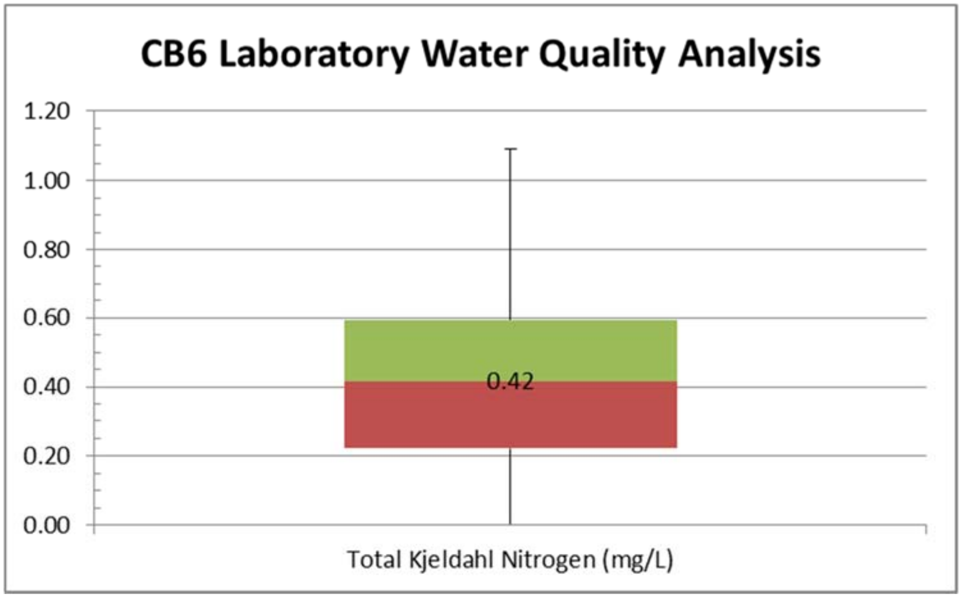

Figure 112 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CB6) of the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

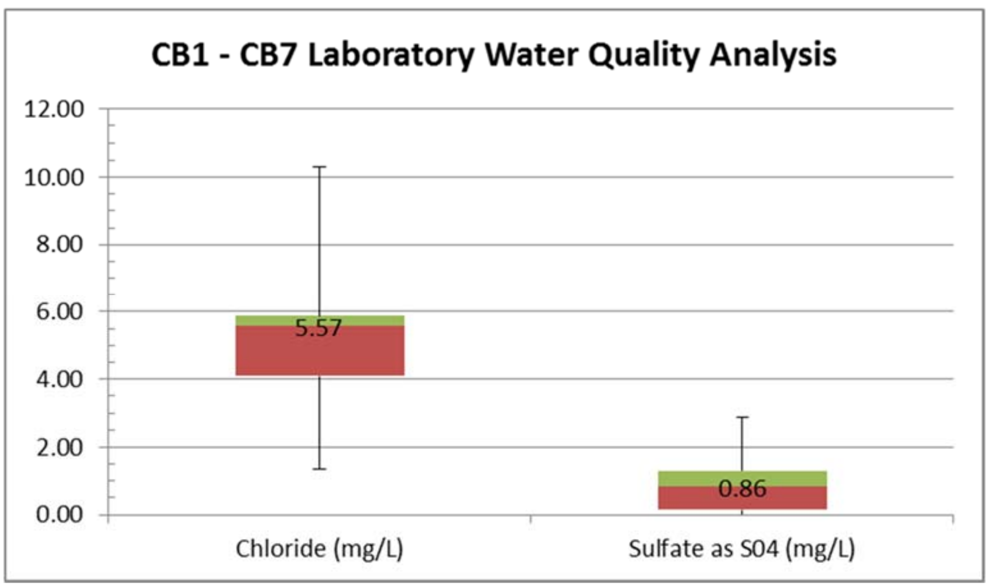

Figure 113 Graphical representation of composite averages of laboratory water quality measurements for the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

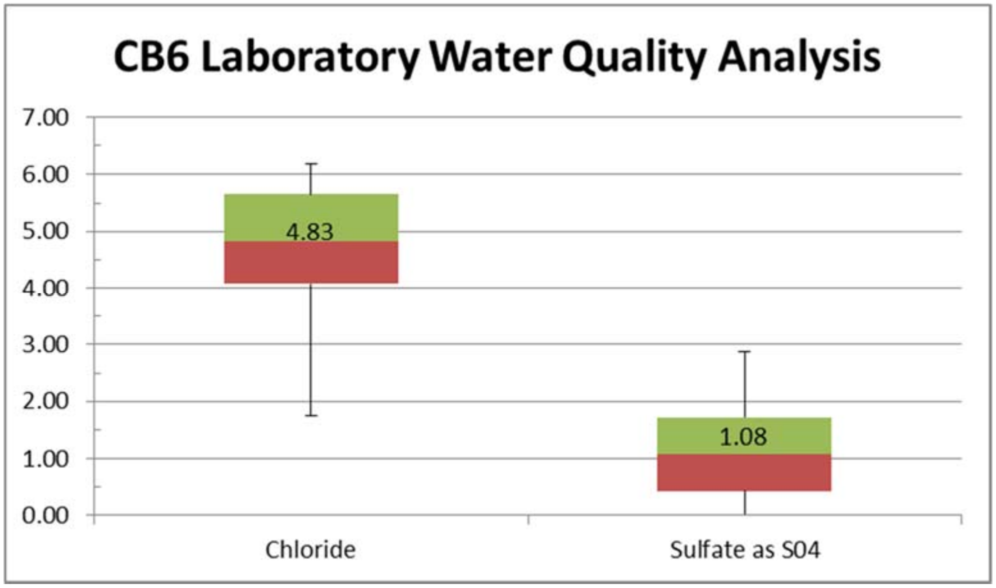

Figure 114 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CB6) of the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

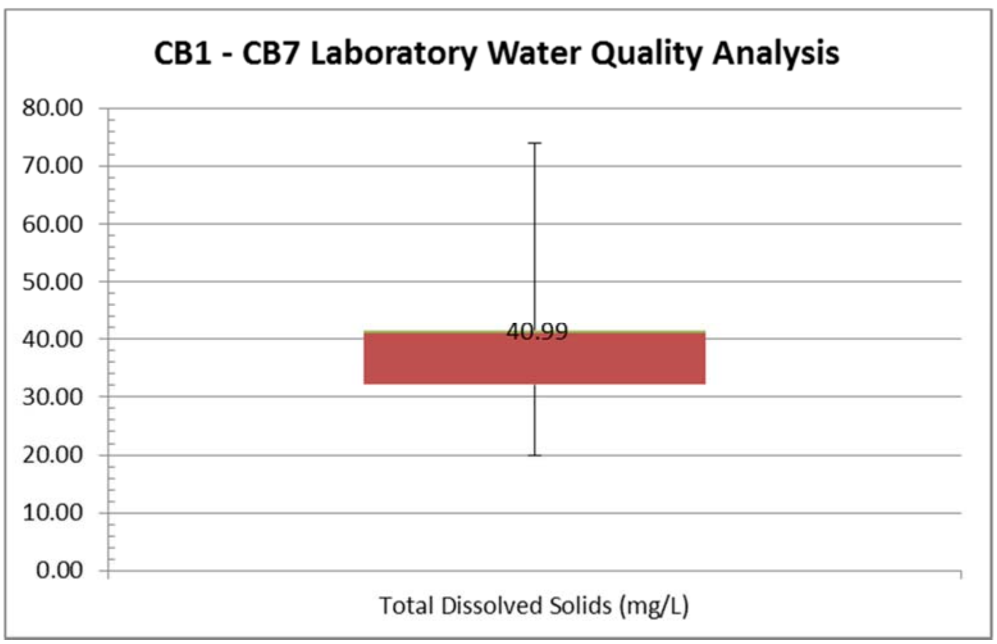

Figure 115 Graphical representation of composite averages of laboratory water quality measurements for the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

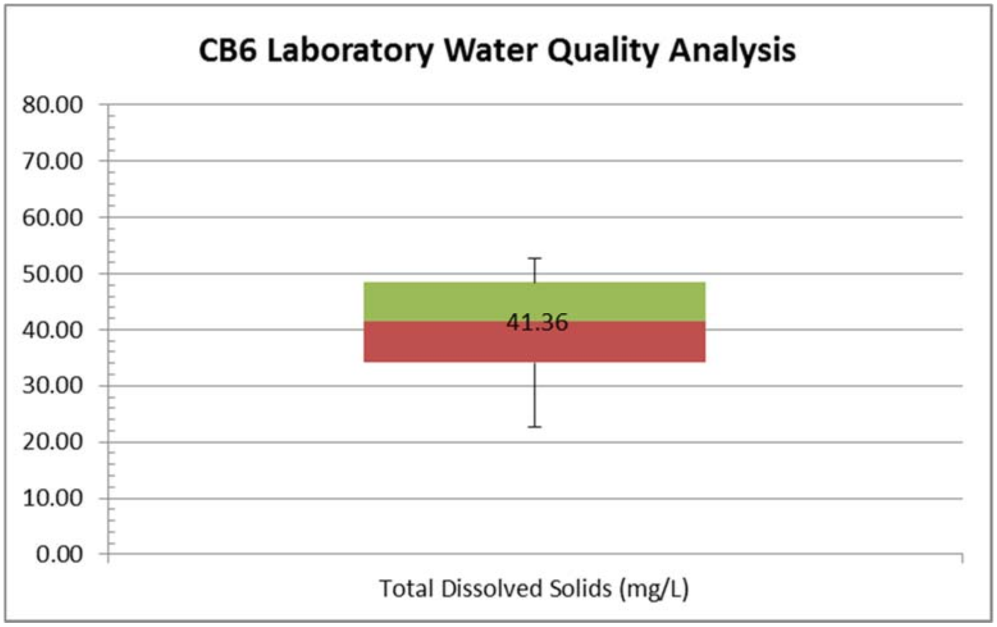

Figure 116 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CB6) of the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

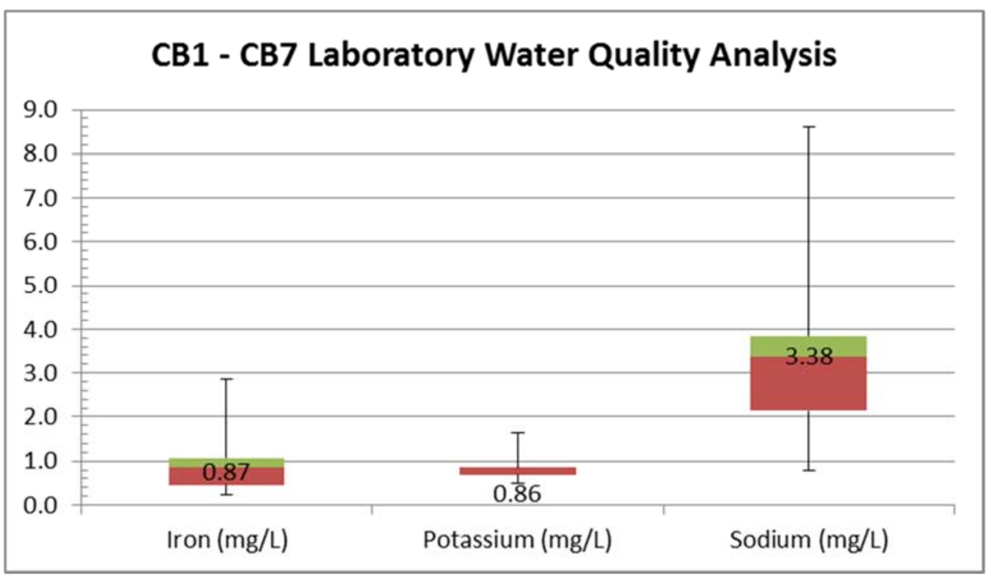

Figure 117 Graphical representation of composite averages of laboratory water quality measurements for the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

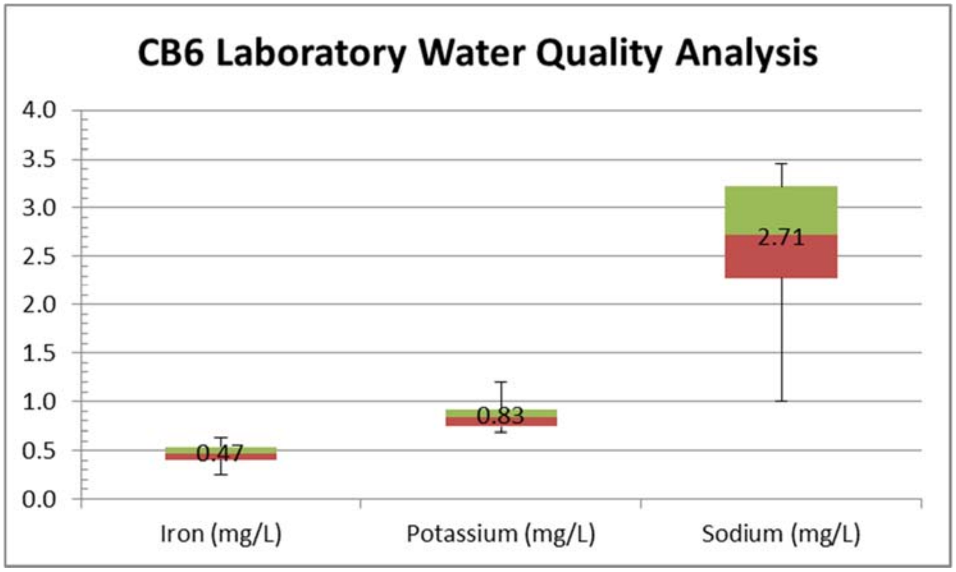

Figure 118 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (CB6) of the Big Cedar Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

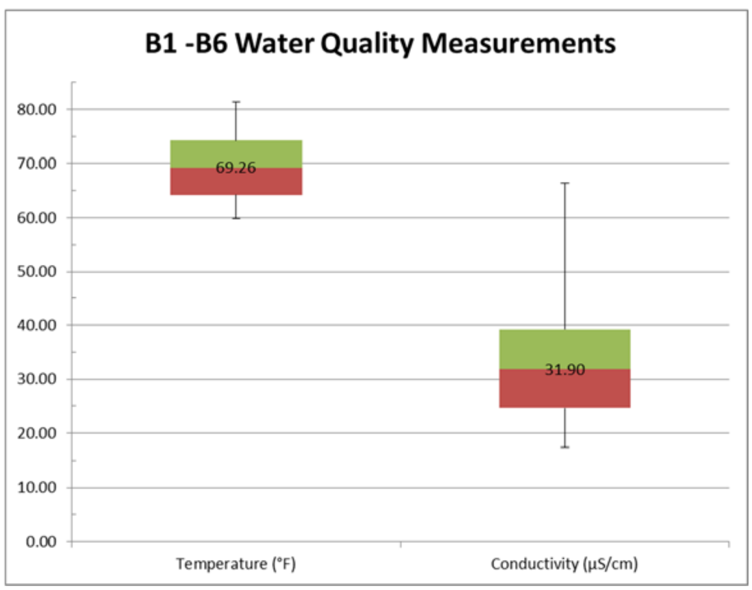

Figure 119 Graphical representation of composite averages of field water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

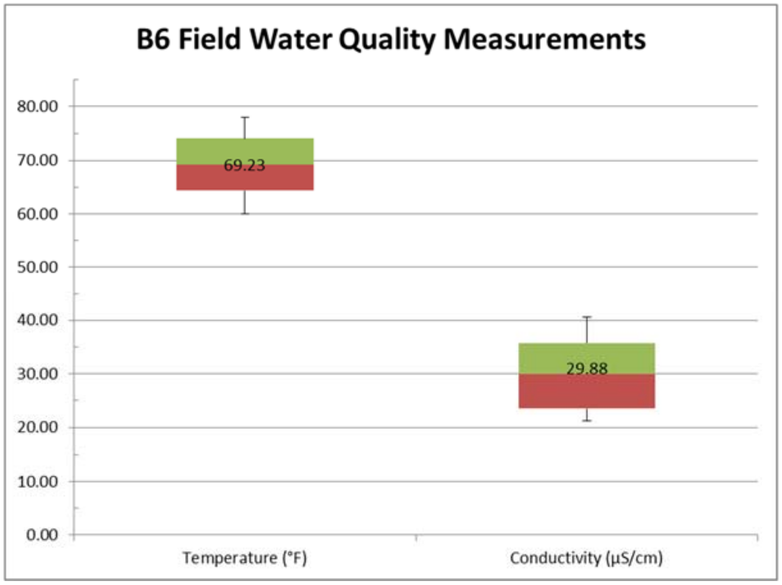

Figure 120 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (B6) of the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

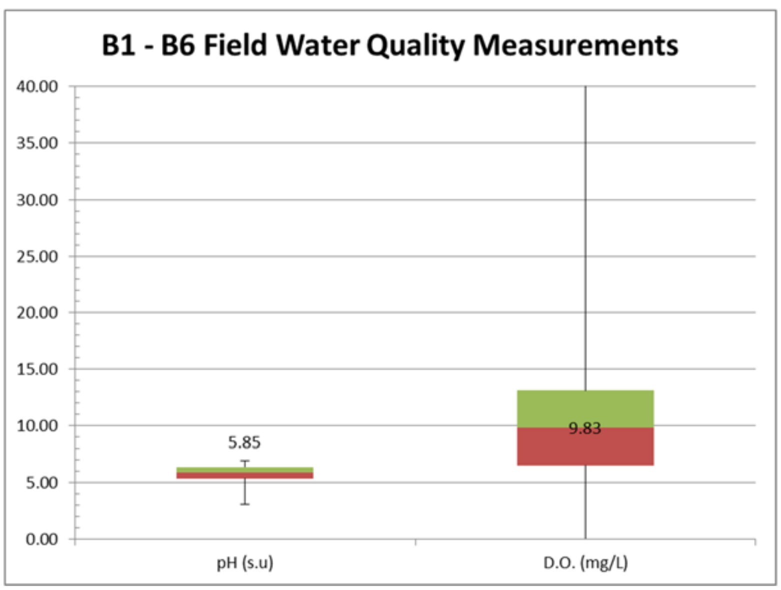

Figure 121 Graphical representation of composite averages of field water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

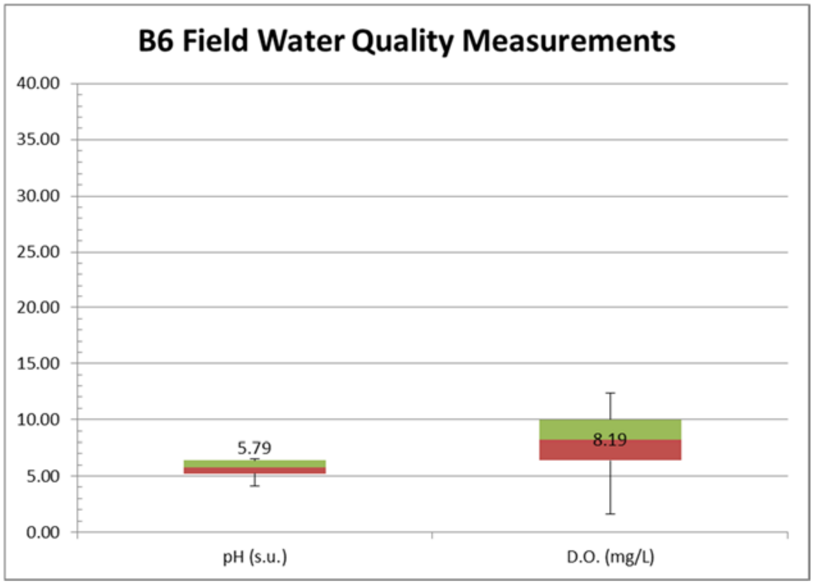

Figure 122 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (B6) of the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

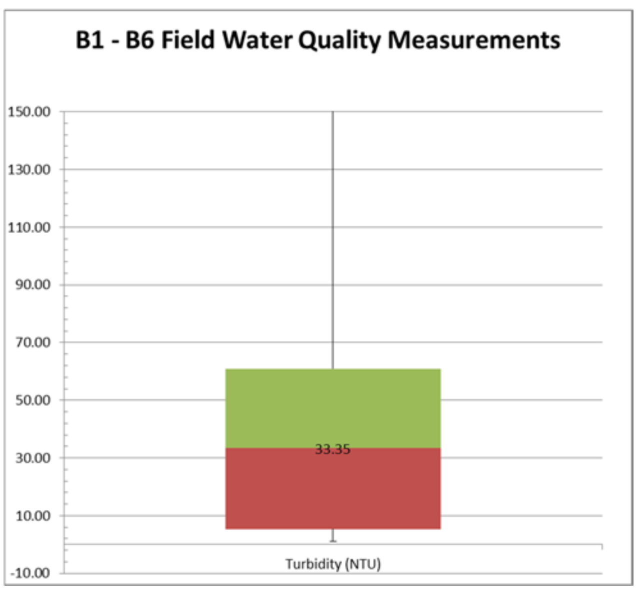

Figure 123 Graphical representation of composite averages of field water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

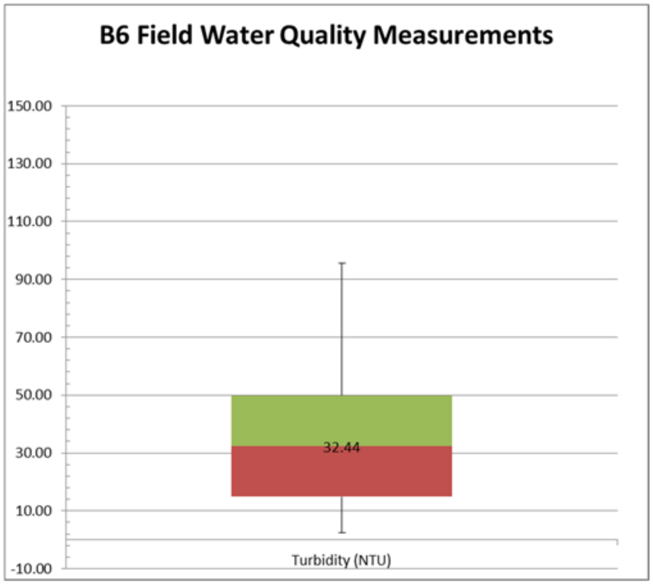

Figure 124 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (B6) of the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

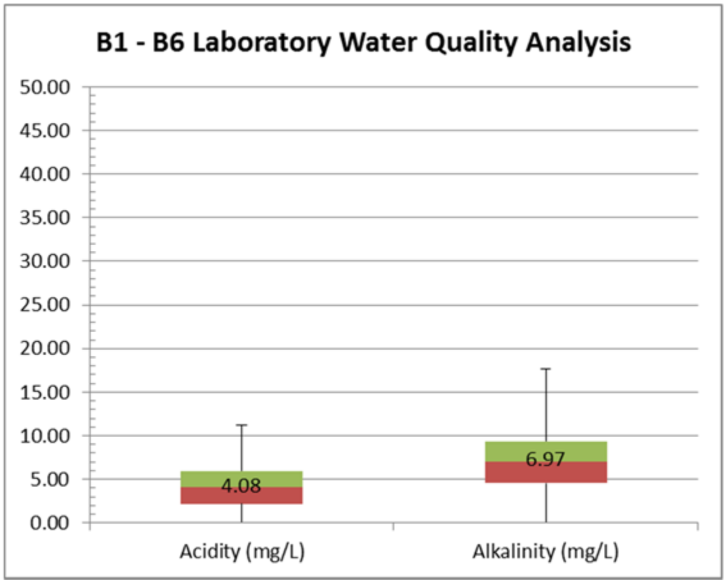

Figure 125 Graphical representation of composite averages of laboratory water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

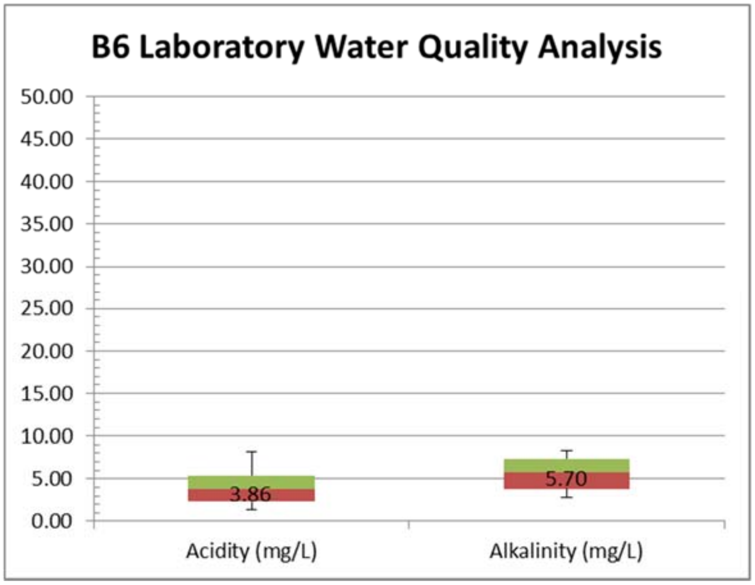

Figure 126 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (B6) of the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

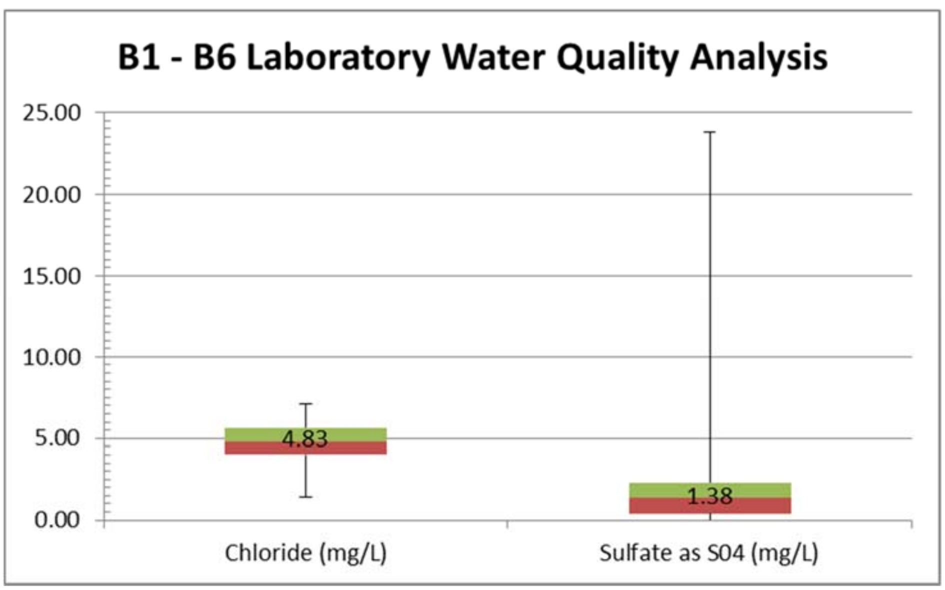

Figure 127 Graphical representation of composite averages of laboratory water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

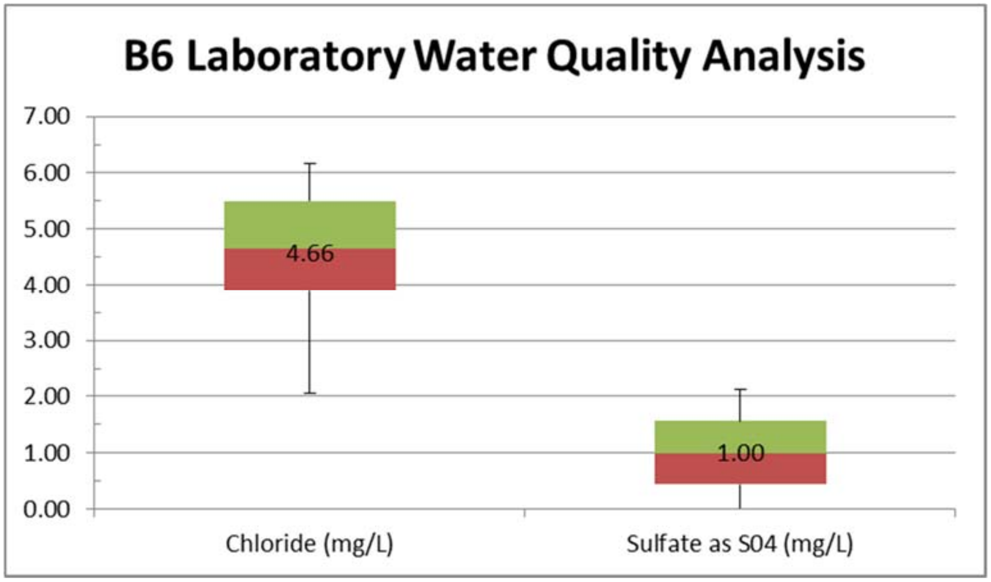

Figure 128 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (B6) of the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

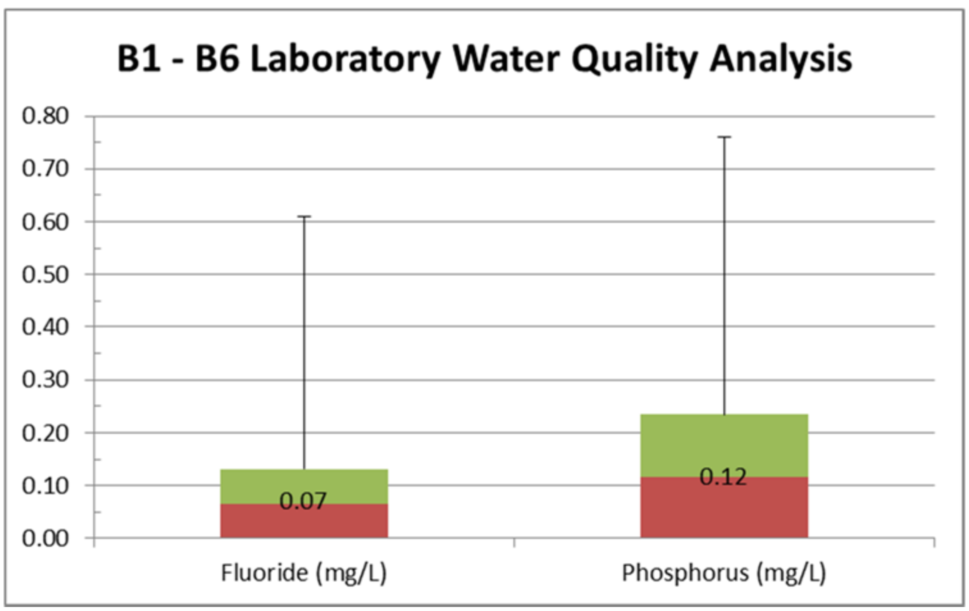

Figure 129 Graphical representation of composite averages of laboratory water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

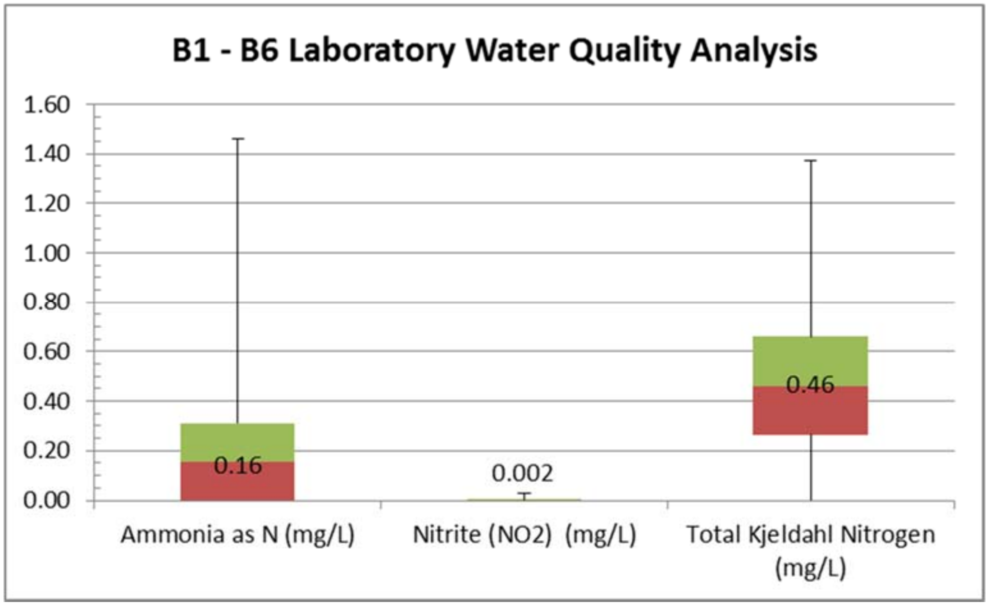

Figure 130 Graphical representation of composite averages of laboratory water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

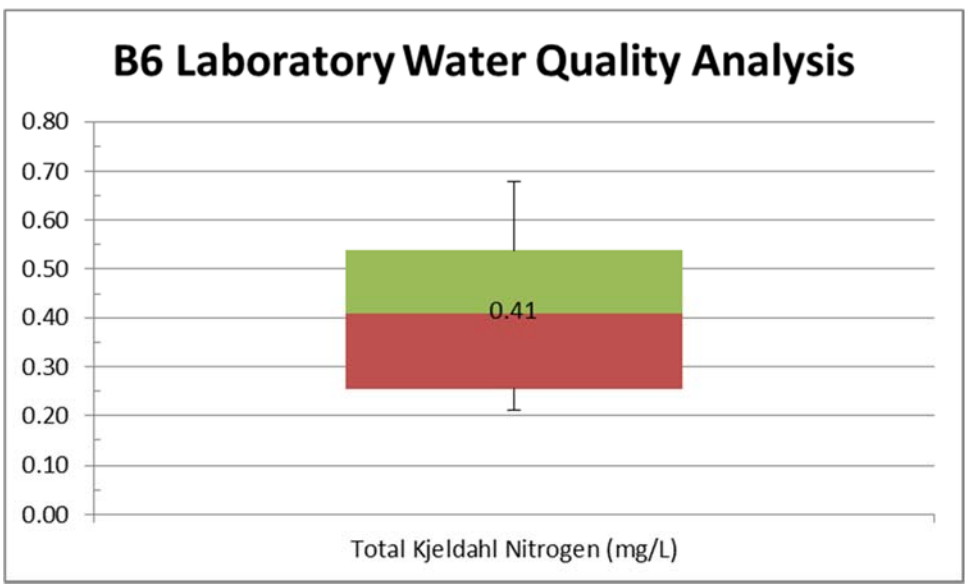

Figure 131 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (B6) of the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

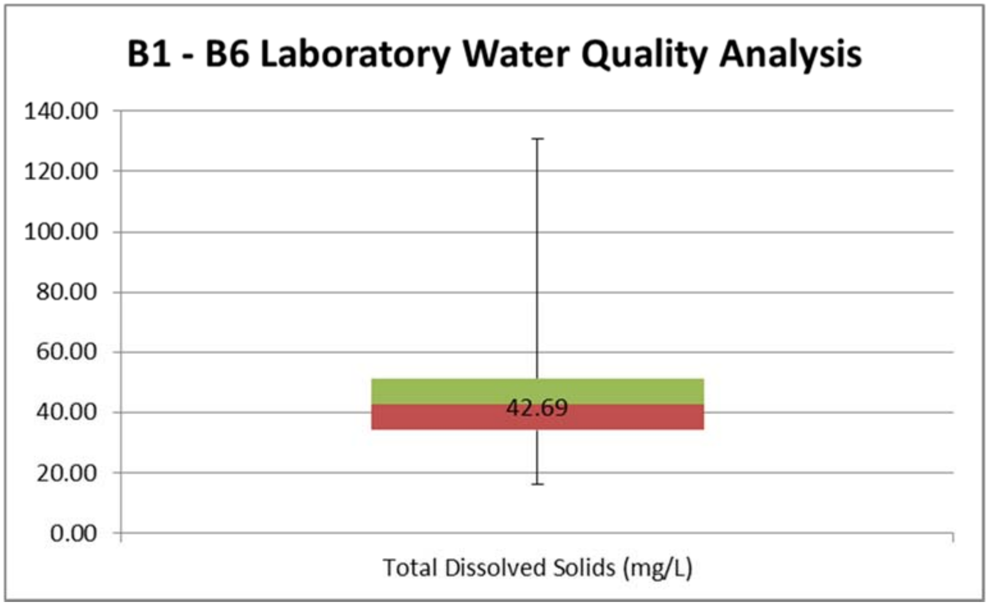

Figure 132 Graphical representation of composite averages of laboratory water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

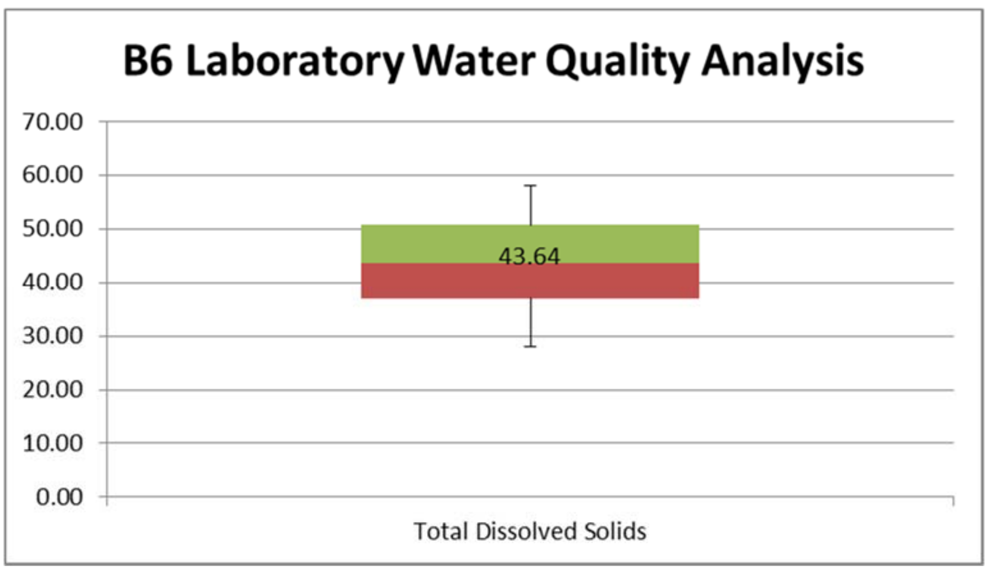

Figure 133 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (B6) of the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

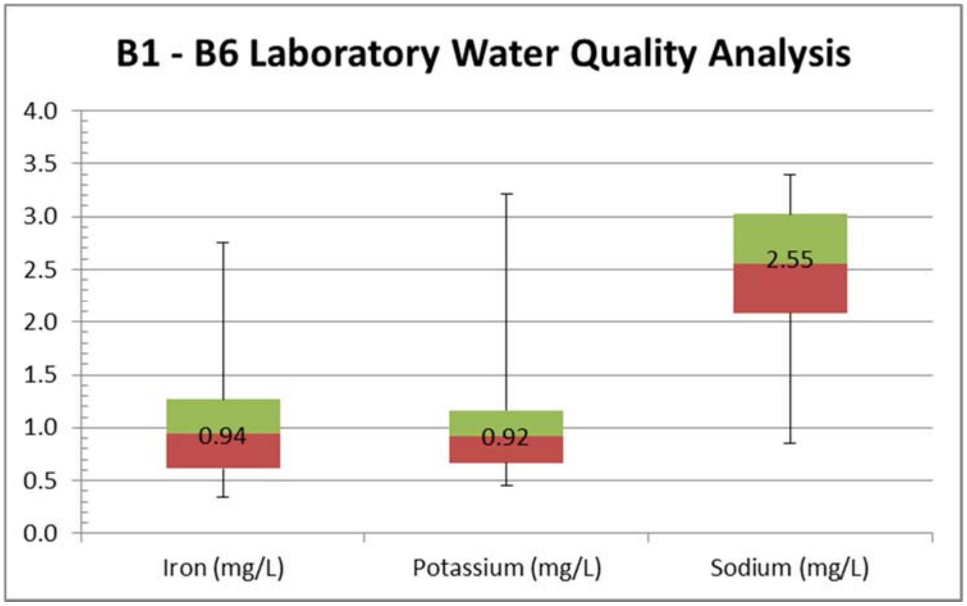

Figure 134 Graphical representation of composite averages of laboratory water quality measurements for the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

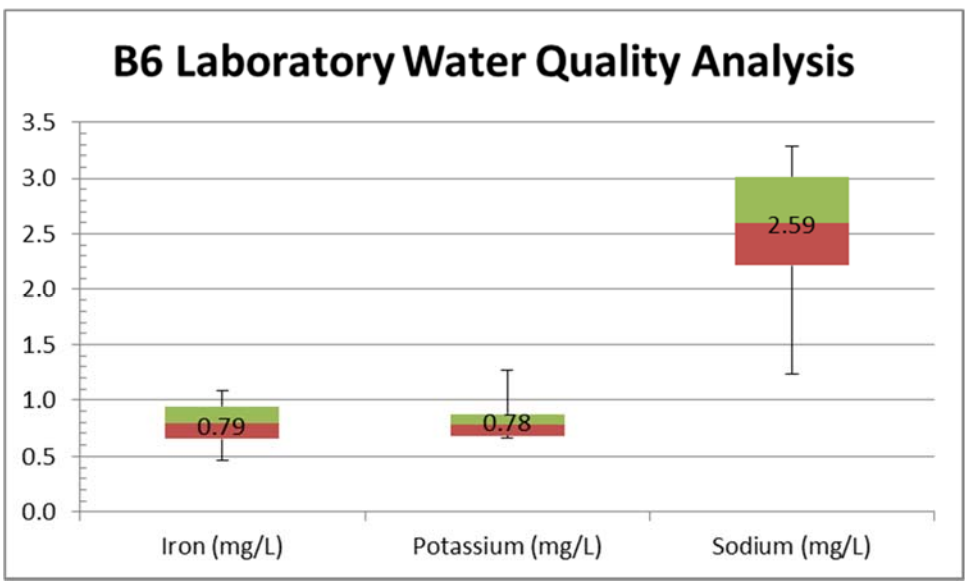

Figure 135 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (B6) of the Big Creek watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

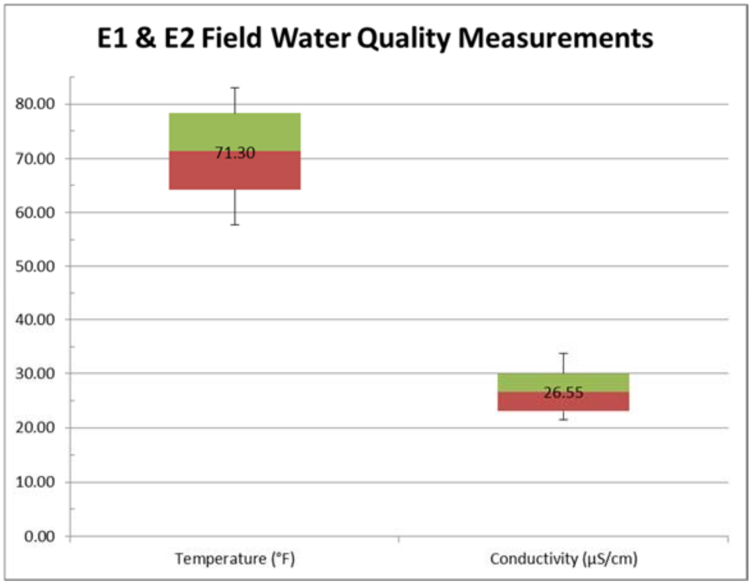

Figure 136 Graphical representation of composite averages of field water quality measurements for the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

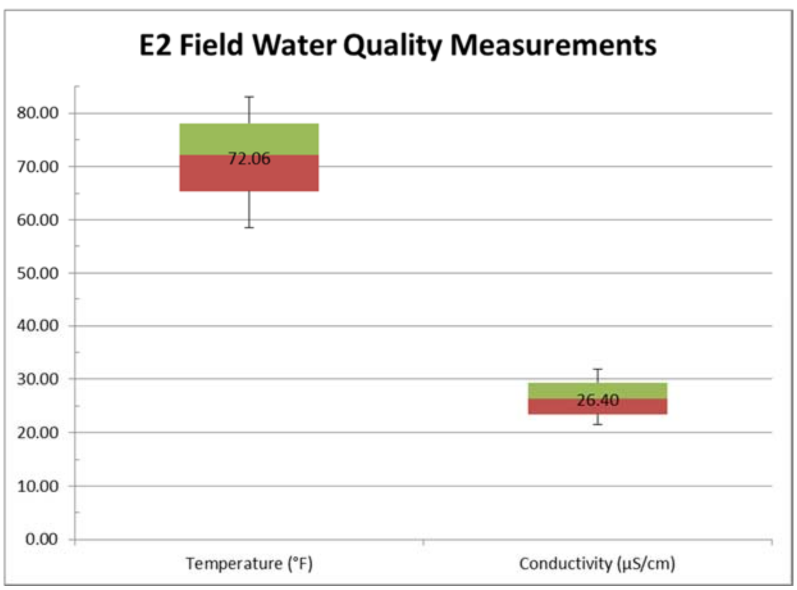

Figure 137 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (E2) of the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

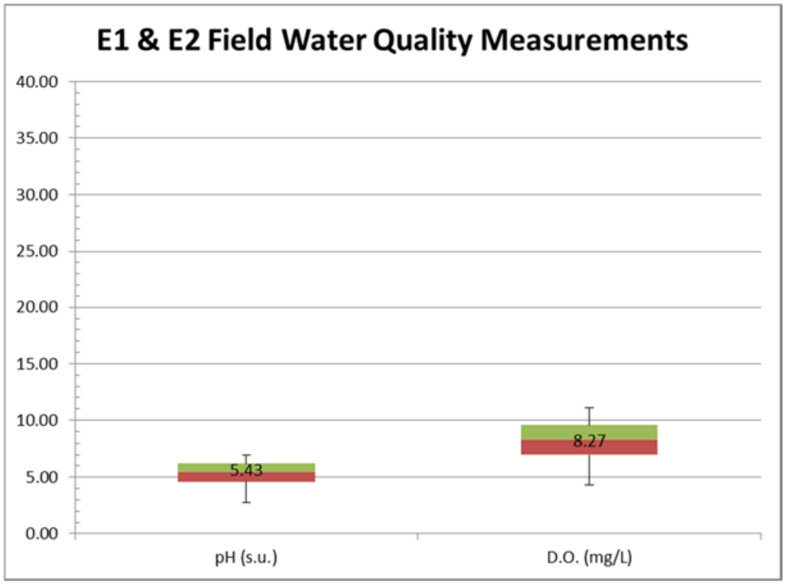

Figure 138 Graphical representation of composite averages of field water quality measurements for the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

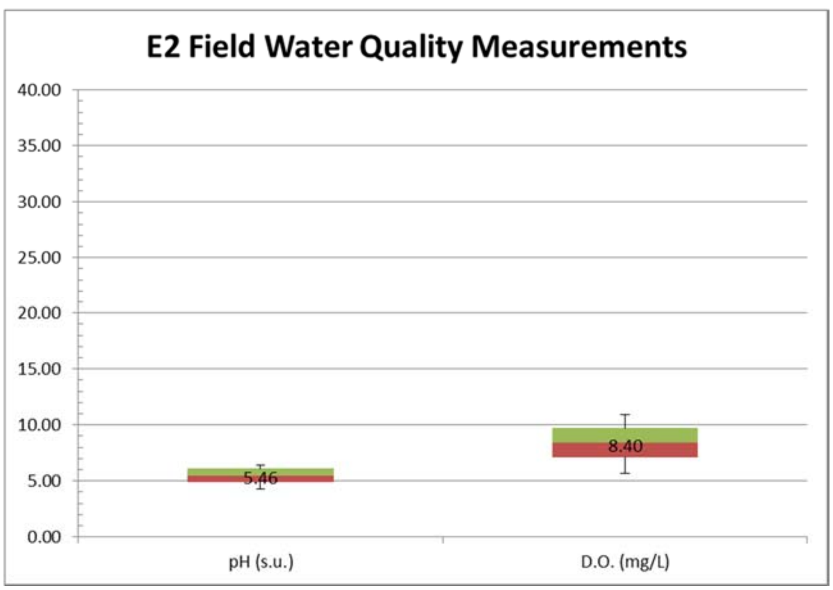

Figure 139 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (E2) of the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

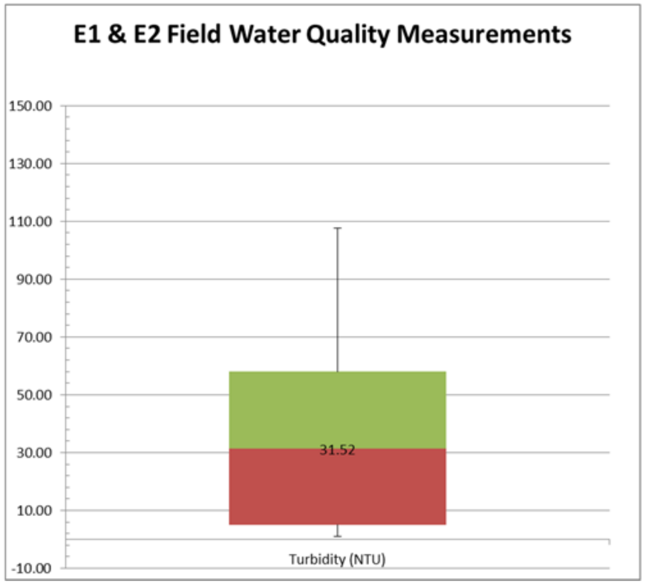

Figure 140 Graphical representation of composite averages of field water quality measurements for Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

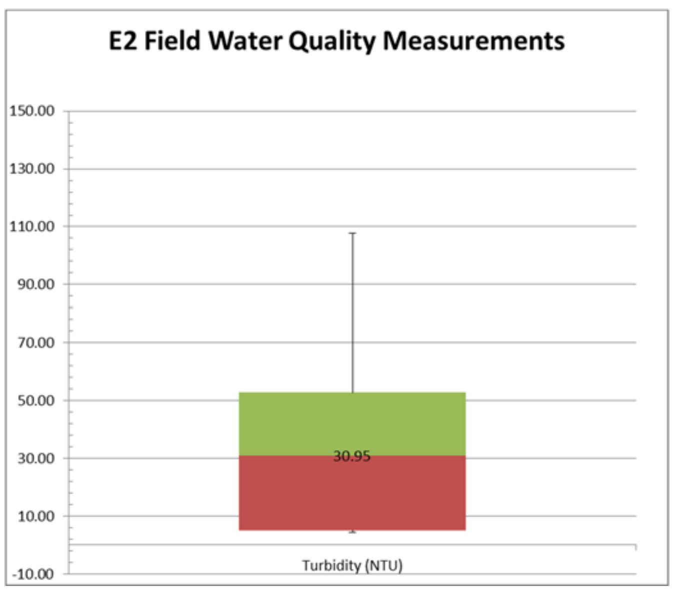

Figure 141 Graphical representation of composite averages of field water quality measurements for the furthermost downstream sampling site (E2) of the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

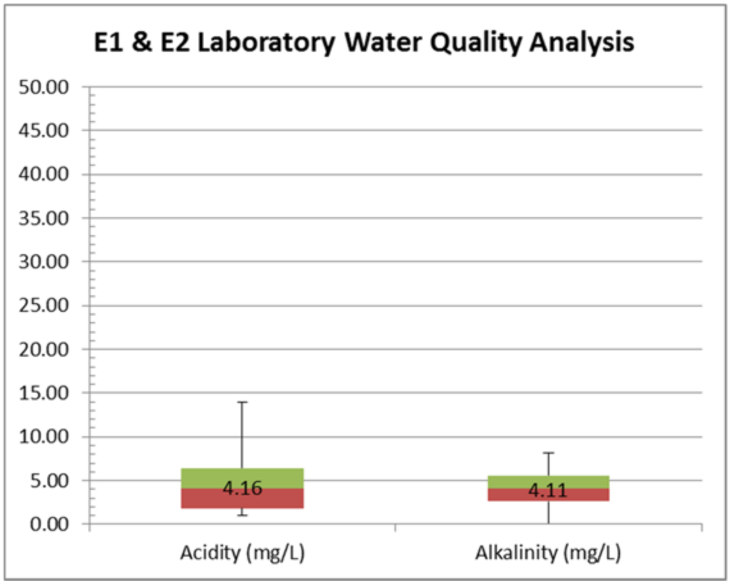

Figure 142 Graphical representation of composite averages of laboratory water quality measurements for the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

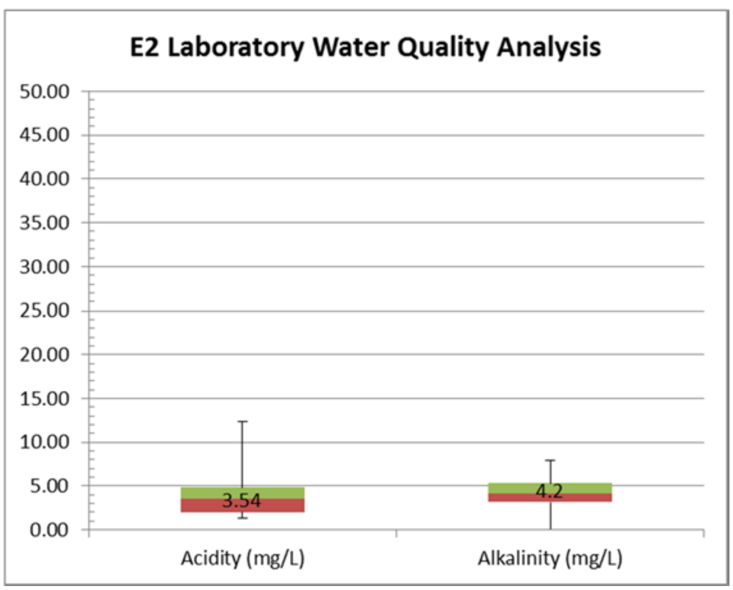

Figure 143 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (E2) of the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

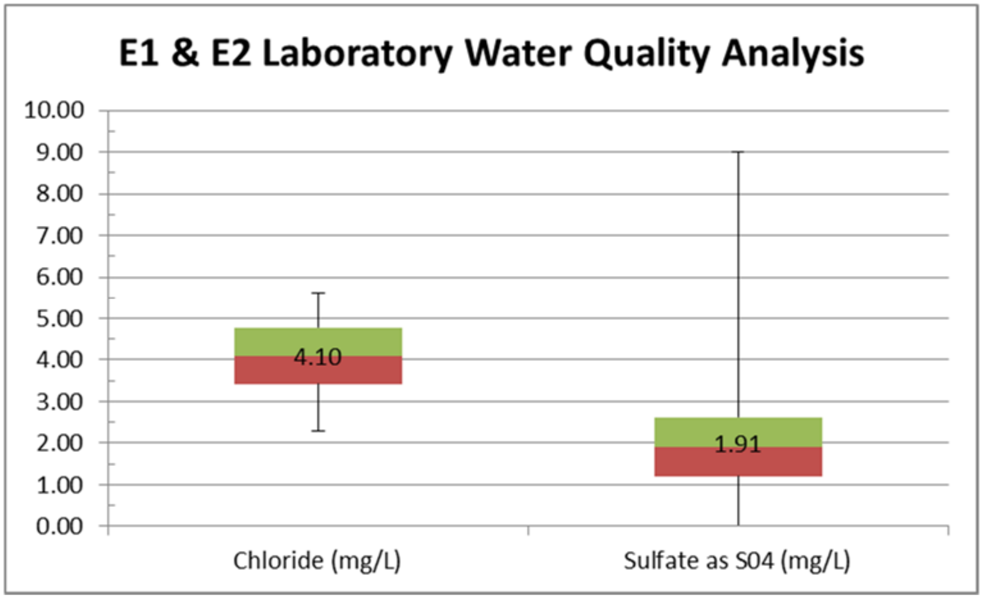

Figure 144 Graphical representation of composite averages of laboratory water quality measurements for the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

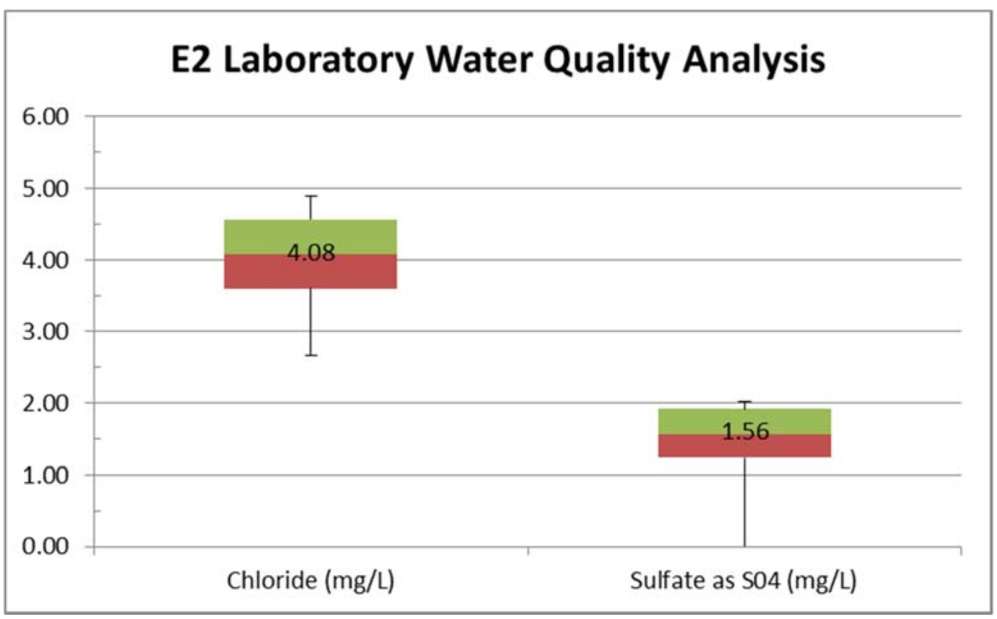

Figure 145 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (E2) of the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

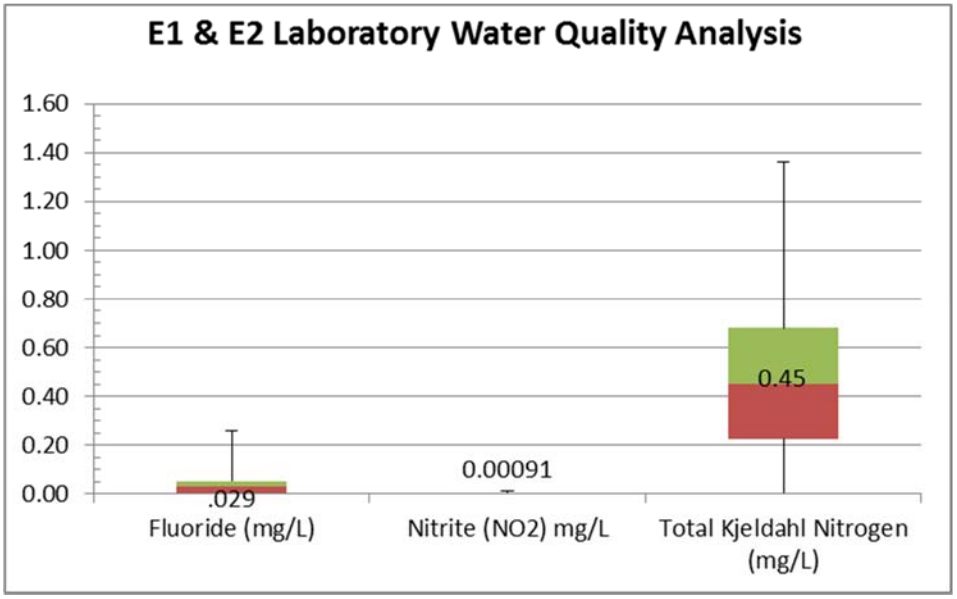

Figure 146 Graphical representation of composite averages of laboratory water quality measurements for Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

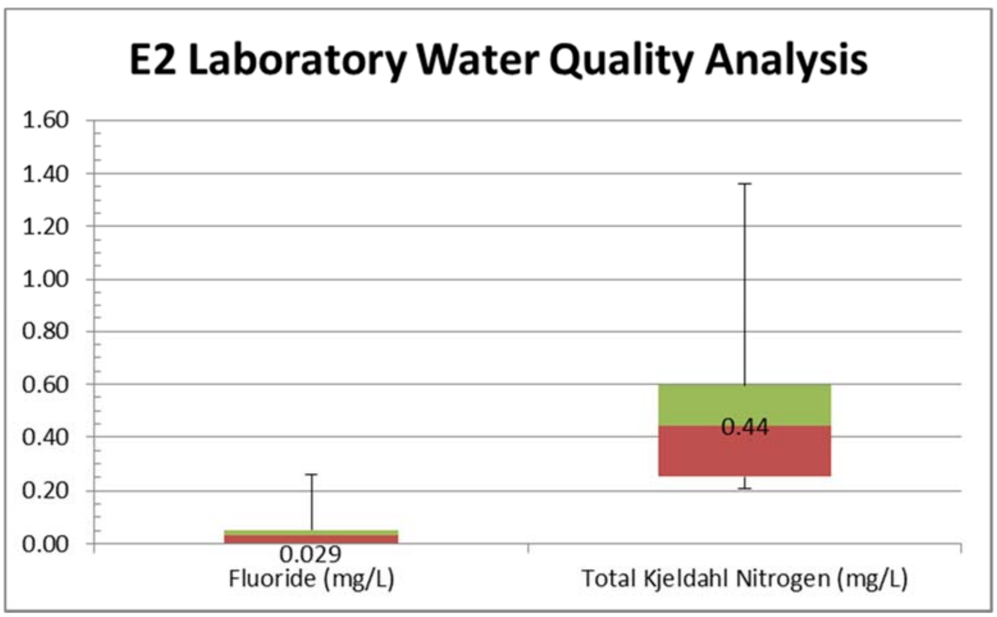

Figure 147 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (E2) of the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

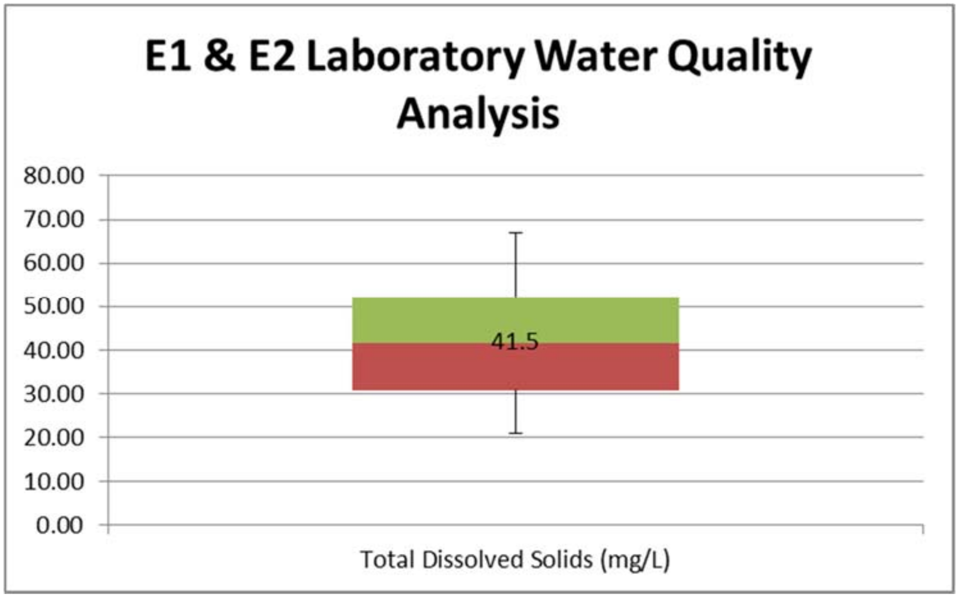

Figure 148 Graphical representation of composite averages of laboratory water quality measurements for the Escatawapa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

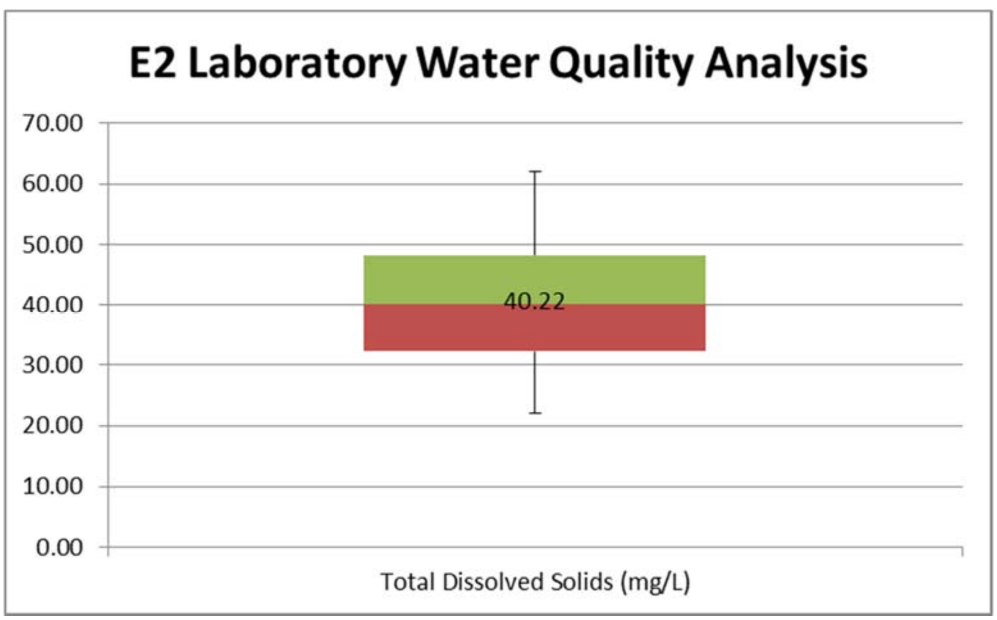

Figure 149 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (E2) of the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

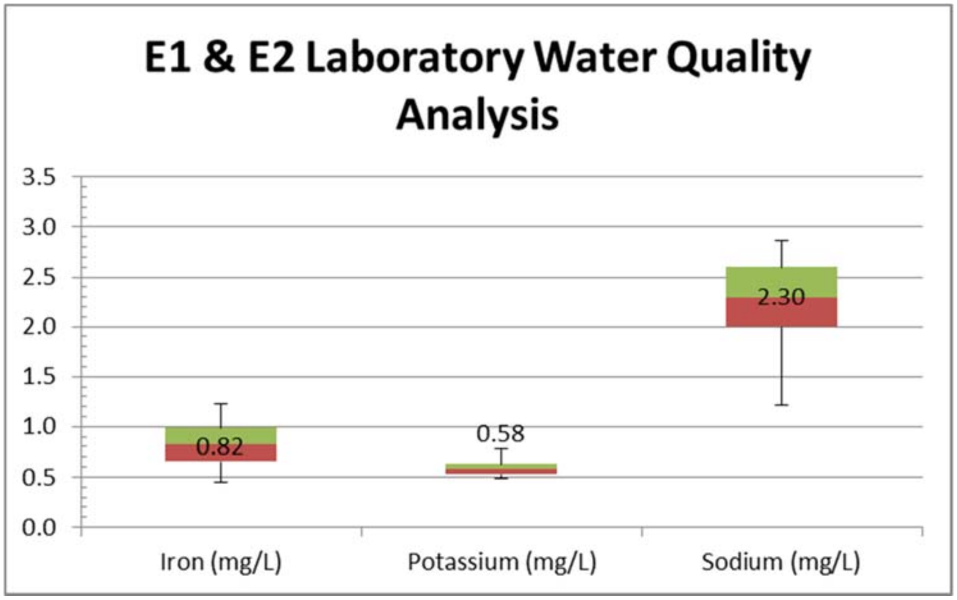

Figure 150 Graphical representation of composite averages of laboratory water quality measurements for the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter

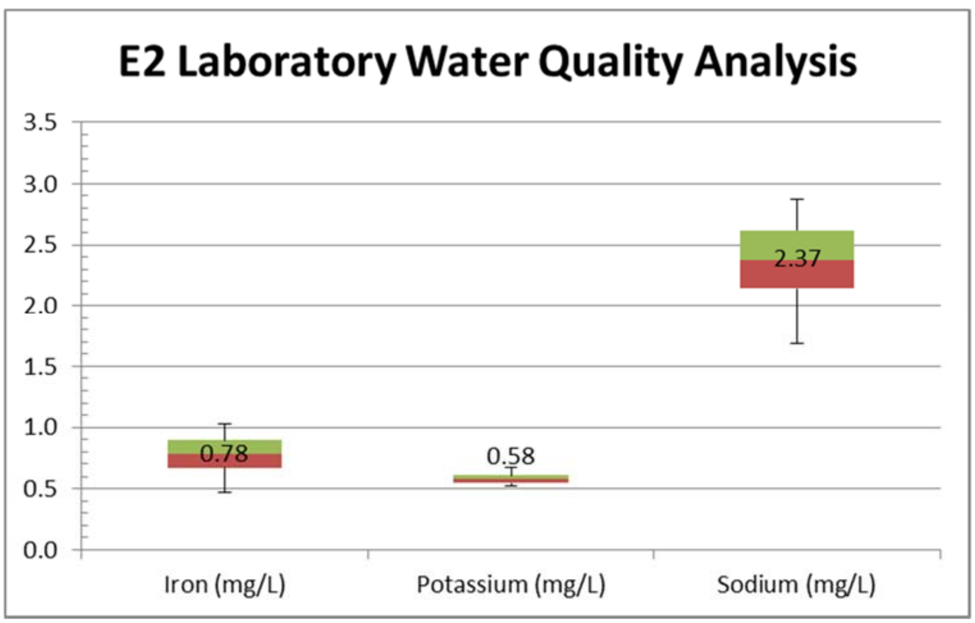

Figure 151 Graphical representation of composite averages of laboratory water quality measurements for the furthermost downstream sampling site (E2) of the Escatawpa River watershed

Notes: Error bars depict maximum and minimum values measured for each parameter