PRE-RESTORATION ANALYSIS OF DISCHARGE, SEDIMENT TRANSPORT RATES, AND WATER QUALITY IN WEST FOWL RIVER AND TRIBUTARIES, MOBILE COUNTY, ALABAMA

Mobile Bay National Estuary Program

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By

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INTRODUCTION

The West Fowl River watershed is in southeastern Mobile County and is the subject of the following assessment of sediment transport and water quality. Commonly, land-use and climate are major contributors to non-point source contaminants that impact surface-water quality. Population growth and economic development are critical issues leading to land-use change in much of Baldwin and Mobile Counties. However, southern Mobile County is dominated by agriculture and low density residential development at higher elevations and forested wetlands and coastal marsh at lower elevations. The West Fowl River watershed also has several petro-chemical facilities involved in processing natural gas from Mobile County, Mobile Bay, and the Gulf of Mexico.

The purpose of this investigation is to assess general hydrogeologic and water-quality conditions, to estimate sediment loads, to measure nutrient and other contaminant concentrations, and evaluate land-use impacts for West Fowl River and its tributaries. These data will be used to quantify water-quality impacts and to support development of a watershed management plan, designed to preserve, protect, and restore the West Fowl River watershed.

ACKNOWLEDGMENTS

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PROJECT AREA

The Fowl River watershed covers 7,424 acres (11.6 square miles (mi^2) (USGS, 2017) in southeastern Mobile County and includes monitoring sites on two tributaries and the main stem of West Fowl River (fig. 1). West Fowl River flows southwest from its headwaters at Delchamps to its mouth at Fowl River Bay, about 4 miles southeast of Bayou La Batre (fig 1). Elevations in the project area vary from 13 feet above mean sea level (ft MSL) to sea level. Monitored streams include Bayou Jonas, Heron Bayou, and West Fowl River.

Figure 1.—West Fowl River watershed assessment area

PROJECT MONITORING STRATEGY AND SITE CHARACTERISTICS

The monitoring strategy employed for the West Fowl River project was to collect water samples at each site over a wide range of discharge from base flow to flood for sediment load estimation, and analytical evaluation of selected nutrients, toxic metals, and organic compounds. Site accessibility in a rural setting, extensive wetlands and tidal influence that constrains stream flow and impacts water chemical character, were considered during selection of monitoring sites.

Site WFR1 is near the headwaters of Bayou Jonas, flowing southeastward in the northwestern part of the West Fowl River watershed (latitude (lat) 30.39825, longitude (long) -88.18271). The monitored site is at the Rock Road crossing, about 1.2 miles from its headwaters (fig. 2). The watershed upstream from site WFR1 covers 4.1 mi^2.

Site WFR2 is on Bayou Jonas at the Bellingrath Road crossing (lat 30.39410, long -88.14987), about 0.7 mi upstream from the confluence with West Fowl River (fig. 2). The watershed upstream from site WFR2 covers 6.4 mi^2.

Site FR3 is on West Fowl River at the Alabama Highway 188 crossing (lat 30.37647, long -88.15888). The monitored site is 2.5 mi upstream from the mouth of West Fowl River at Fowl River Bay (fig. 2). The watershed upstream from site WFR3 covers 11.6 mi^2.

Site WFR4 is on Heron Bayou at the Zirlott Road crossing, 0.5 mi upstream from its confluence with West Fowl River (lat 30.38904, long -88.13650) (fig. 2). The watershed upstream from site WFR4 covers 2.8 mi^2.

LAND USE

Land use is directly correlated with water quality, hydrologic function, ecosystem health, biodiversity, and the integrity of streams and wetlands. Land use classification for the project area was determined from the USDA National Agricultural Statistics Service 2013 Alabama Cropland Data Layer (NASS CDL) raster dataset. The CDL is produced using satellite imagery from the Landsat 5 TM sensor, Landsat 7 ETM+ sensor, the Spanish DEIMOS-1 sensor, the British UK-DMC 2 sensor, and the Indian Remote Sensing RESOURCESAT-1 (IRS-P6) Advanced Wide Field Sensor (AWiFS) collected during recent growing seasons (USDA, 2013). Land use/land cover in the project area was subdivided into six classified groups defined as developed, forested, agricultural, grassland/shrub/scrub, wetlands, and open water (fig. 3).

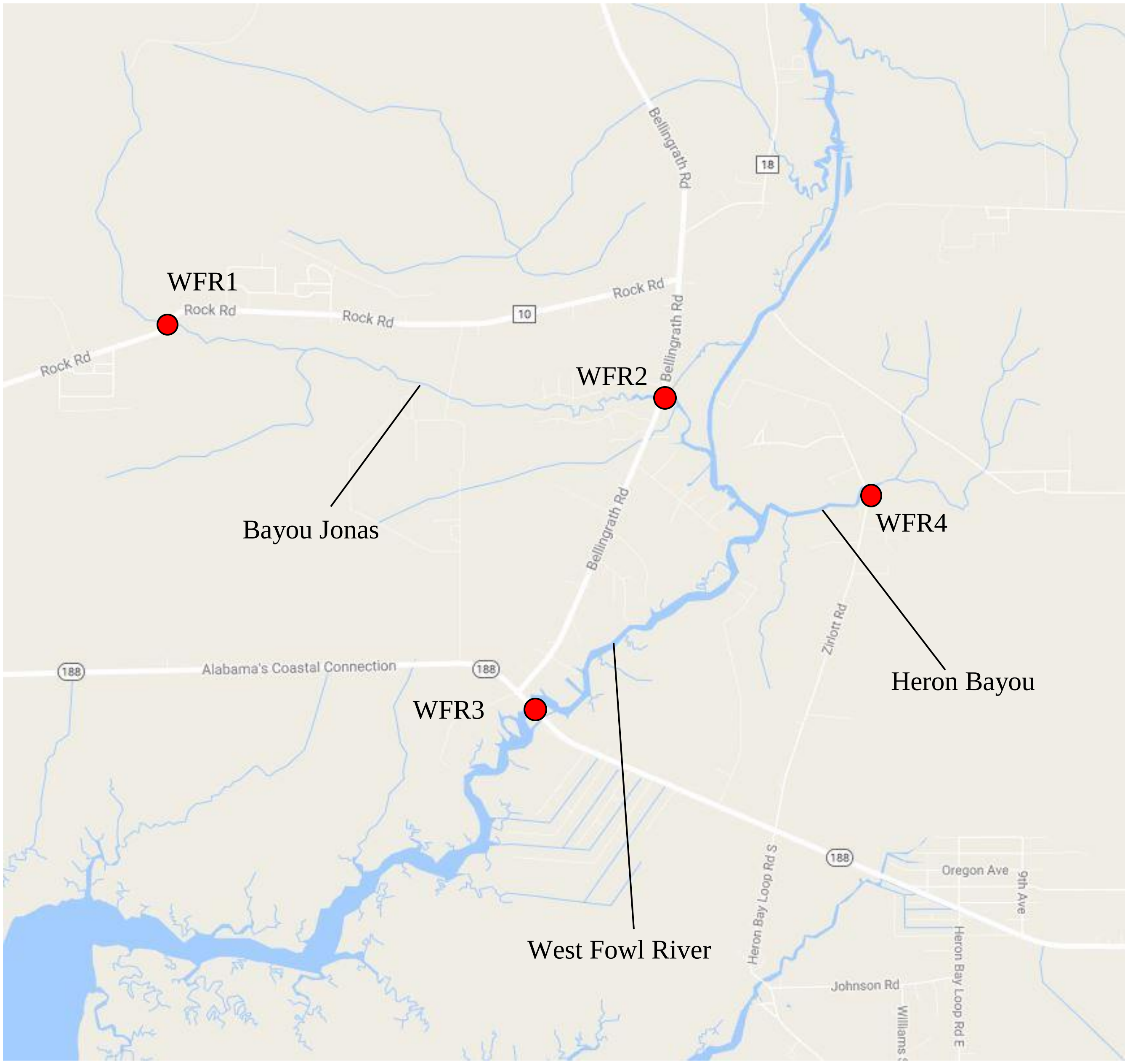

Figure 2.—West Fowl River watershed with monitoring sites.

The dominant land use/land cover categories composing about 60 percent (%) of the West Fowl River project area are wetlands and forests (fig.3). Wetlands are important because they provide water quality improvement and management services such as: flood abatement, storm water management, water purification, shoreline stabilization, groundwater recharge, and streamflow maintenance. Developed land is about 30% of the project area and is composed of residential development, roadways, and petrochemical facilities (fig.3). Part of the Bayou Jonas-South Amos gas field is in the West Fowl River

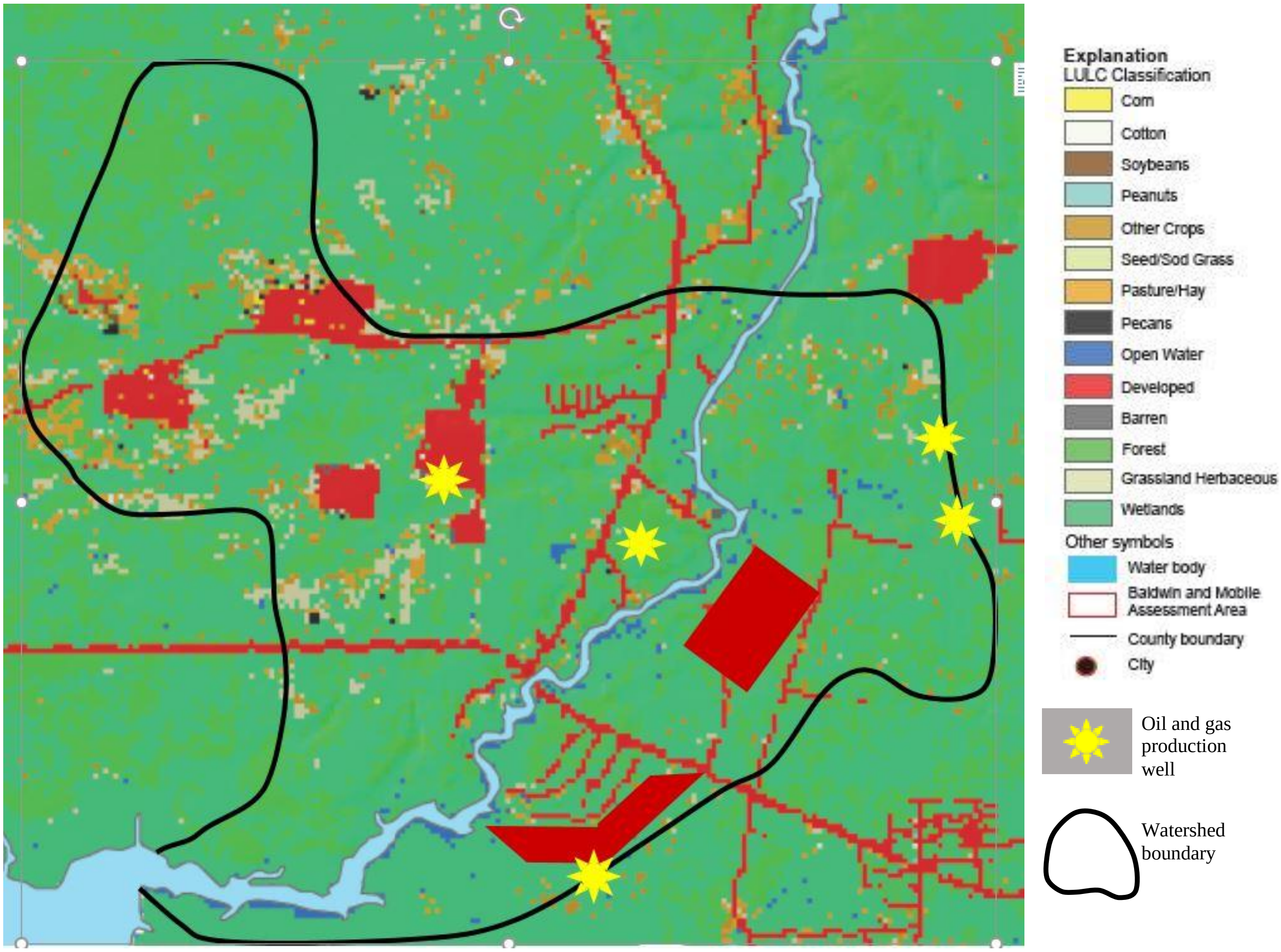

Figure 3.—Land use in the West Fowl River watershed.

watershed. Five wells are in the watershed that produce gas from the Miocene aged Amos Sand (Alabama Oil and Gas Board, 2017). Residential development includes small subdivisions, and residences along West Fowl River and along roadways. Recent aerial photography shows that land was cleared for two additional residential developments but no houses were constructed (fig. 4). Agriculture accounts for about 10% of the land use in the watershed. Open water covers about 5% percent of total land area, consisting of streams, small lakes, and ponds.

STREAM DISCHARGE

Unlike streams in Baldwin County, which are extremely flashy due to relatively high topographic relief and land-use change or streams in the metropolitan Mobile area that are also extremely flashy with relatively high velocities, due to channelization and

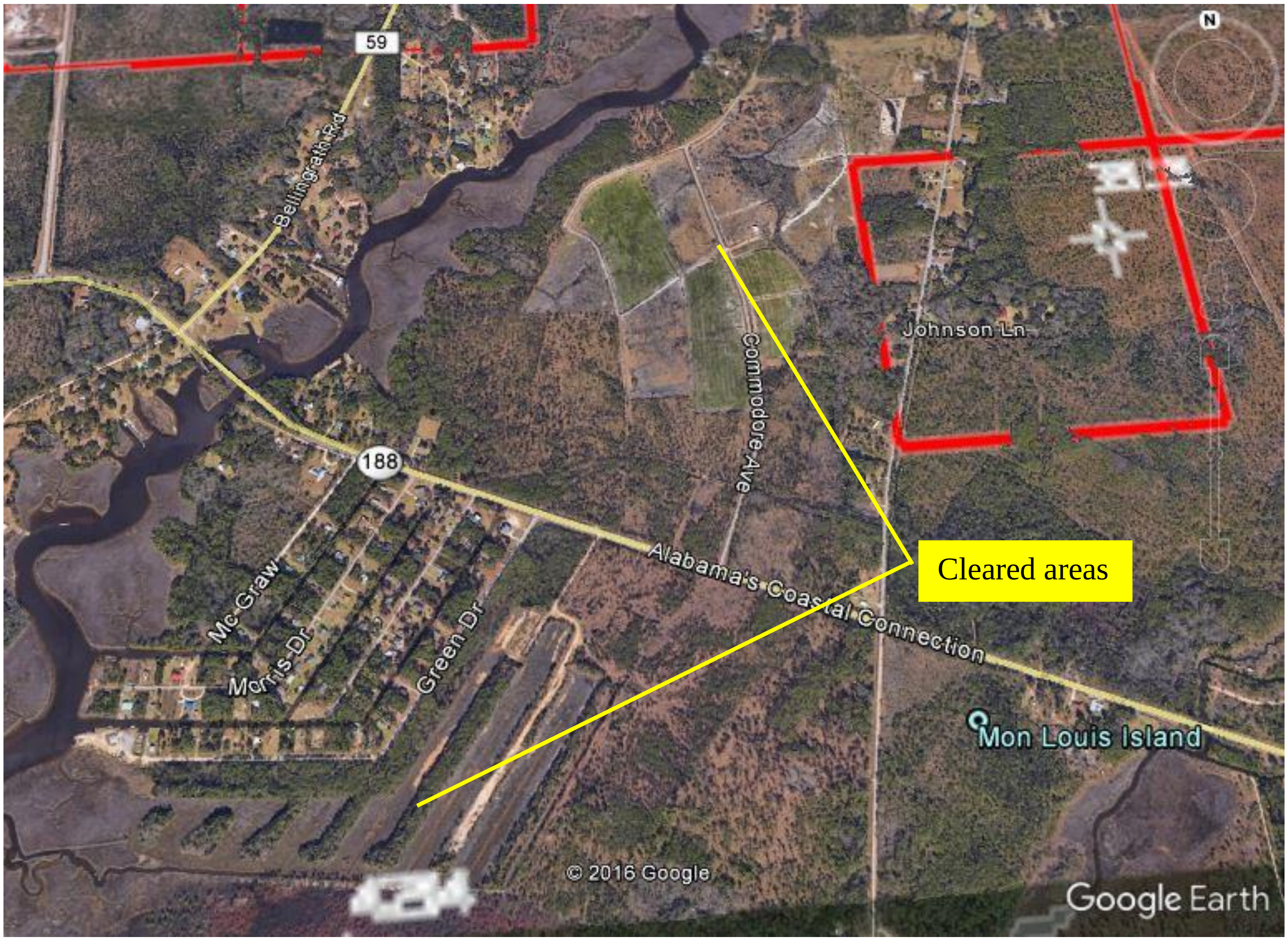

Figure 4.—Cleared areas for potential future residential development in the West Fowl River watershed.

urbanization, the character of stream flows in West Fowl River and its tributaries are relatively unimpacted my man and is primarily influenced by relatively low topographic relief, extensive wetlands, salt marsh, and tidal effects. The average gradient for streams in the Dog River watershed is 48.0 ft/mi as compared to the West Fowl River watershed, which is 2.4 ft/mi.

A wide range of discharge events is required to adequately evaluate hydrologic conditions in West Fowl River. Table 1 shows that sampling occurred in the Fowl River watershed during a range of discharge events. Average daily discharge for each monitored stream is also required to adequately assess constituent loading. Discharge data collected at Fowl River site FR2 (U.S. Geological Survey stream gaging site 02471078, Fowl River at Half Mile Road, near Laurendine, Alabama) was used as a basis for average daily discharge estimation for each monitored stream.

Table 1.--Stream flow characteristics for monitored sites in the West Fowl River watershed.

Monitored site	Average discharge (cfs)	Maximum discharge (cfs)	Minimum discharge (cfs)	Stream gradient (ft/mi)[2]
1	16	30	8	3.1
2	26[1]	48	9	3.3
3	46[1]	87	16	0.6
4	11[1]	21	6	3.2

[1]TI- tidal influence
[2]ft/mi- feet per mile

SPECIFIC CONDUCTANCE

Surface water in each project watershed is characterized by a unique specific conductance (SC) (microseimens/centimeter (µS/cm)) profile based on physical and chemical properties. The variability of SC is influenced by differences in stream temperature, discharge, total dissolved solids, local geology and soil conditions, and ionic influxes from nonpoint sources of pollution characteristic of urban runoff or from increased salinity in coastal streams influenced by tidal fluctuations. Streams without significant contaminant sources exhibit increased SC values with decreasing discharge due to increasing volumes of relatively high SC groundwater inflow and decreased SC with increasing discharge due to increasing volumes of relatively low SC runoff.

Most water samples collected at West Fowl River monitoring sites WFR2, WFR3, and WFR4 were impacted by tidal fluctuations (table 2). However, during March and April 2016, samples had relatively low SC due to increased freshwater runoff during spring storms (table 2). Site WFR1 is near the headwaters of Bayou Jonas and had no salinity impact but exhibited increased SC during base flow conditions due to the dominance of groundwater inflows (table 2).

TURBIDITY

Turbidity in water is caused by suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and plankton and other microscopic organisms (Eaton, 1995). Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted with no change in direction or flux level through the stream (Eaton, 1995). Turbidity values measured in nephlametric turbidity units (NTU) from water samples may be utilized to formulate a rough estimate

Table 2.—Measured specific conductance in West Fowl River watershed samples.

Monitoring site	Maximum SC (µS/cm)	Minimum SC (µS/cm)	Average SC (µS/cm)
WFR1	302	28	122
WFR2	15,600	40	5,522
WFR3	33,200	205	11,452
WFR4	22,300	28	8,443

of long-term trends of total suspended solids (TSS). This correlation of turbidity and TSS is observed in figure 5, where measured turbidity and TSS values for site WFR1 are plotted.

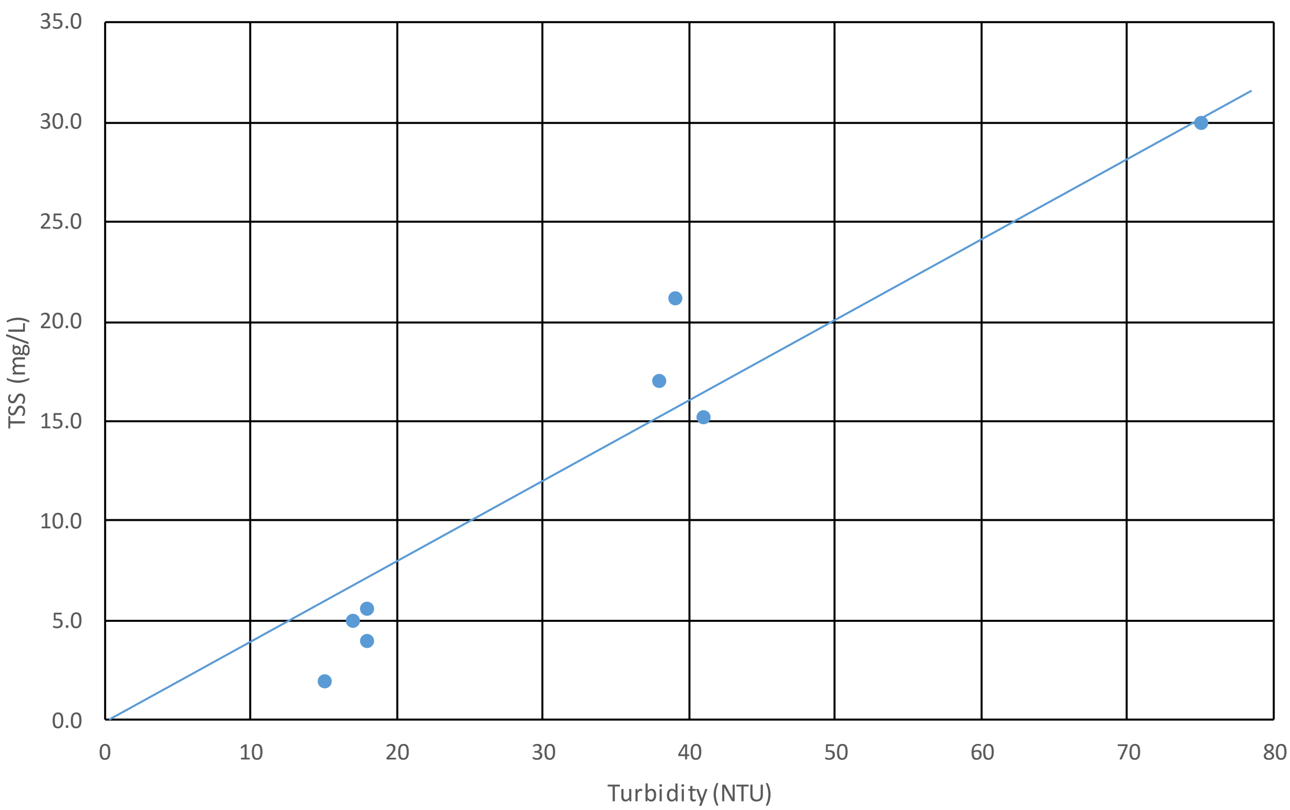

Figure 5. Measured turbidity and TSS at site WFR1.

Analyses of turbidity and stream discharge provide and insights into hydrologic, land-use, and general water-quality characteristics of a watershed. Average measured turbidity and discharge, shown in figure 6, illustrates that generally, watersheds with the highest average discharge have the lowest average turbidity, which indicates that the monitored West Fowl River watersheds have limited sources of turbidity so that elevated discharge events provide dilution, resulting in relatively low turbidity. A similar finding occurred at Fowl River, which indicates that this characteristic is common to coastal streams dominated by wetland and marsh. An exception occurred at site WFR3 where resuspension of bed sediment by tidal fluctuation is the probable cause of elevated turbidity (fig. 6).

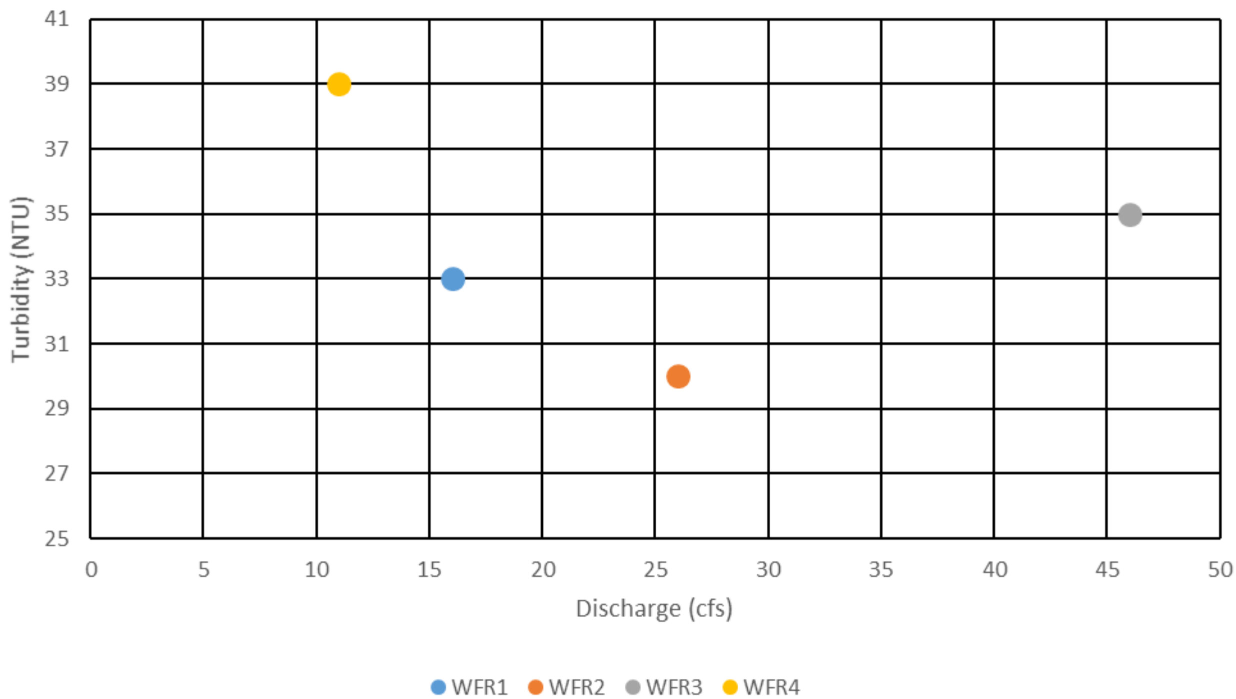

Figure 6.—Average discharge and turbidity for West Fowl River watershed monitoring sites.

Commonly, excessive turbidity is closely tied to land uses that cause land disturbances that lead to erosion or to land uses that cause excessive runoff. Although developed land and agriculture accounts for about 40% of land use/cover in the West Fowl River watershed, buffering provided by extensive wetlands and marsh detain and filter runoff and minimize turbidity to streams.

SEDIMENTATION

Sedimentation is a process by which eroded particles of rock are transported primarily by moving water from areas of relatively high elevation to areas of relatively low elevation, where the particles are deposited. Upland sediment transport is primarily accomplished by overland flow and rill and gully development. Lowland or flood plain transport occurs in streams of varying order, where upland sediment joins sediment eroded from flood plains, stream banks, and stream beds. Erosion rates are accelerated by human activity related to agriculture, construction, timber harvesting, unimproved roadways, or any activity where soils or geologic units are exposed or disturbed. Excessive sedimentation is detrimental to water quality, destroys biological habitat, reduces storage volume of water impoundments, impedes the usability of aquatic recreational areas, and causes damage to structures.

Precipitation, stream gradient, geology and soils, and land use are all important factors that influence sediment transport characteristics of streams. Sediment transport conditions in the West Fowl River watershed area are evaluated and quantified by tributary, in order to evaluate factors impacting erosion and sediment transport at a localized scale. In addition to commonly observed factors above, wetlands, vegetation, and tidal effects also play prominent roles in sediment transport and overall water quality. Estimates of sediment loads for this assessment are based on measured sediment and stream discharge.

Therefore, a stream flow dataset composed of values ranging from base flow to high flow is desirable. However, no overbank discharge events occurred during the project monitoring period. Average observed stream flow conditions are shown in table 1.

Sediment loads in streams are composed of relatively small particles suspended in the water column (suspended solids) and larger particles that move on or periodically near the streambed (bed load). A pre-monitoring assessment of sediment characteristics indicated that relatively little bed sediment transport occurs in the streams at selected West Fowl River monitoring sites. Therefore, total sediment loads were assumed to be suspended.

SEDIMENT LOADS TRANSPORTED BY PROJECT STREAMS

The rate of transport of sediment is a complex process controlled by a number of factors primarily related to land use, precipitation runoff, erosion, stream discharge and flow velocity, stream base level, and physical properties of the transported sediment.

In much of Baldwin and Mobile Counties, highly erodible soils formed from sand, clayey sand, and sandy clay of the undifferentiated Miocene Series, Citronelle Formation, and alluvial, coastal, and low terrace deposits, combined with relatively high topographic relief related to the formation of Mobile Bay and land disturbance related to development and agriculture are major contributing factors to high rates of erosion and sedimentation.

Excessive sedimentation causes changes in base level elevation of streams in the watershed and triggers downstream movement of the material as streams reestablish base level equilibrium. Deterrents to excessive erosion and sediment transport include wetlands, forests, vegetative cover and field buffers for croplands, limitations on impervious surfaces, and a number of constructed features to promote infiltration of precipitation and to store and slow runoff. Currently, the West Fowl River watershed maintains a relatively healthy hydrologic environment characterized by a relatively rural setting, minimal row crop agriculture, low topographic relief, abundant wetlands and marsh, and anastomosing and natural stream channels.

SUSPENDED SEDIMENT

The basic concept of constituent loads in a river or stream is simple. However, the mathematics of determining a constituent load may be quite complex. The constituent load is the mass or weight of a constituent that passes a cross-section of a stream in a specific amount of time. Loads are expressed in mass units (tons or kilograms) and are measured for time intervals that are relative to the type of pollutant and the watershed area for which the loads are calculated. Loads are calculated from concentrations of constituents obtained from analyses of water samples and stream discharge, which is the volume of water that passes a cross-section of the river in a specific amount of time.

Suspended sediment is defined as that portion of a water sample that is separated from the water by filtering. This solid material may be composed of organic and inorganic particles that include algae, industrial and municipal wastes, urban and agricultural runoff, and eroded material from geologic formations. These materials are transported to stream channels by overland flow related to storm-water runoff and cause varying degrees of turbidity. Figure 5 shows that turbidity and suspended sediment are closely related in the Fowl River watershed. Turbidity, TSS, suspended sediment loads, and discharge values for all monitoring sites are shown in table 3.

Annual suspended sediment loads were estimated for Fowl River monitored streams using the computer regression model Regr_Cntr.xls (*Regression with Centering*) (Richards, 1999). The program is an Excel adaptation of the U.S. Geological Survey (USGS) seven-parameter regression model for load estimation in perennial streams

(Cohn and others, 1992). The regression with centering program requires total suspended solids (TSS) concentrations and average daily stream discharge to estimate annual loads. Although average daily discharge for project streams was not available from direct measurement for the West Fowl River monitored sites, it was estimated by establishing a ratio between periodic measured discharge in project streams and discharge values for the same times obtained from the U.S. Geological Survey stream gaging site (02471078, Fowl River at Half Mile Road, near Laurendine, Alabama).

Table 3.—Measured total suspended solids and estimated suspended sediment loads in monitored streams.

Monitored site	Average Discharge (cfs)	Average turbidity (NTU)	Maximum turbidity (NTU)	Average TSS (mg/L)	Maximum TSS (mg/L)	Estimated suspended sediment load (t/yr)	Estimated normalized suspended sediment load ($t/mi^2/yr$)
1	16	33	75	13	30	150	37
2	26	30	68	14	24	163	26
3	46	35	58	37	93	846	73
4	11	39	92	23	52	115	41

Concentrations of TSS in mg/L were determined by laboratory analysis of periodic water grab samples. These results were used to estimate the mass of TSS for the period of stream flow (1/1/16-12/31/16). Site 3 (West Fowl River at Alabama highway 188), had the largest suspended sediment loads with 846 tons per year (t/yr) (table 3). For comparison, the largest suspended sediment loads in the Dog River watershed were Eslava Creek, Spencer Branch, and Spring Creek (sites 10, 7, and 2) with 10,803, 5,970, and 5,198 tons per year (t/yr), respectively (Cook, 2012). Other loads in the West Fowl River watershed were 150, 163, and 115 t/yr at tributary sites 1, 2, and 4, respectively (table 3). Discharge and watershed area are two of the primary factors that influence sediment transport rates in the Fowl River watershed. Figure 7 depicts discharge and suspended sediments loads and shows that generally, increased discharge results in increased suspended sediment loads.

Normalizing suspended loads to unit watershed area permits comparison of monitored watersheds and negates the influence of drainage area size and discharge on sediment loads. Site 3 (West Fowl River at Alabama Highway 188) had the largest

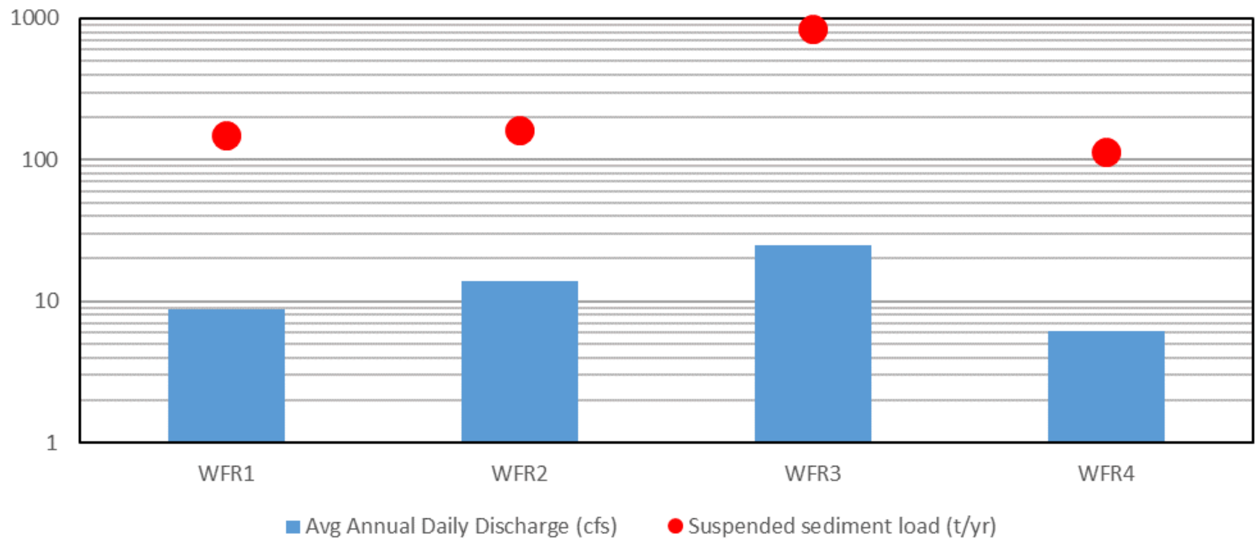

Figure 7.—Average annual daily discharge and suspended sediment loads for West Fowl River watershed monitoring sites.

normalized loads with 73 t/mi^2/yr (table 3, fig. 7). Normalized suspended sediment loads at sites 1, 2, and 4 were 37, 26, and 41 t/mi^2/yr, respectively. For comparison, the largest normalized suspended sediment loads in the Dog River watershed (urban watershed) were Spencer Branch, Spring Creek, and Eslava Creek (sites 2, 7, 10) with 4,332 and 2,985, and 1,662 t/mi^2/yr), respectively (Cook, 2012). Figure 8 shows normalized suspended sediment loads and average annual daily discharge and indicates that watershed area is a major factor for sediment load transport in the Fowl River watershed.

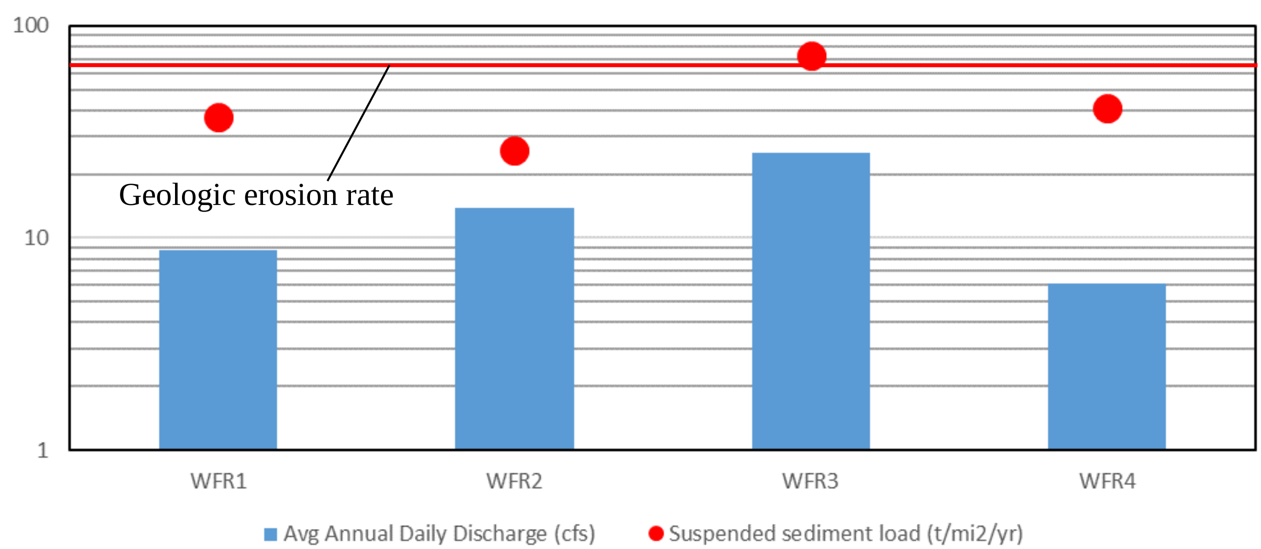

Figure 8.—Average annual daily discharge and normalized suspended sediment loads for West Fowl River watershed monitoring sites.

BED SEDIMENT

Transport of streambed material is controlled by several factors including stream discharge and flow velocity, erosion and sediment supply, stream base level, and physical properties of the streambed material. Most streambeds are in a state of constant flux in order to maintain a stable base level elevation. The energy of flowing water in a stream is constantly changing to supply the required power for erosion or deposition of bed load to maintain equilibrium with the local water table and regional or global sea level. Stream base level may be affected by regional or global events including fluctuations of sea level or tectonic movement. Local factors affecting base level include fluctuations in the water table elevation, changes in the supply of sediment to the stream caused by changing precipitation rates, and/or land use practices that promote excessive erosion in the floodplain or upland areas of the watershed.

Bed sediment is composed of particles that are too large or too dense to be carried in suspension by stream flow. These particles roll, tumble, or are periodically suspended as they move downstream.

Due to a number of factors including relatively small areas of development or land disturbance, limited sources of coarse-grained sediment, relatively low stream gradients and stream flow velocities, and extensive wetlands and marsh that slow stream flow velocities and detain sediment, all monitored streams had bed sediment loads that were too small to measure. Therefore, all sediment loads are assumed to be suspended. Bed sediment samples were collected at sites 2, 3, and 4 for metals analysis (discussed later in this report). Stream bed samples contained small amounts of fine grained quartz sand, silt, and large amounts of organic rich clay, and partially decomposed organic matter.

TOTAL SEDIMENT LOADS

Without human impact, erosion rates in the watershed, called the geologic erosion rate, would be 64 t/mi^2/yr (Maidment, 1993). Figure 8 shows that sediment loads are slightly above (site 3) or below (sites 1,2, and 4) the geologic erosion rate of 64 t/mi^2/yr. Calculated non-normalized geologic erosion rate loads are compared to total estimated loads in figure 9.

Comparisons of sediment loads from other watersheds are helpful in determining the severity of erosion problems in a watershed of interest. Estimates of total sediment

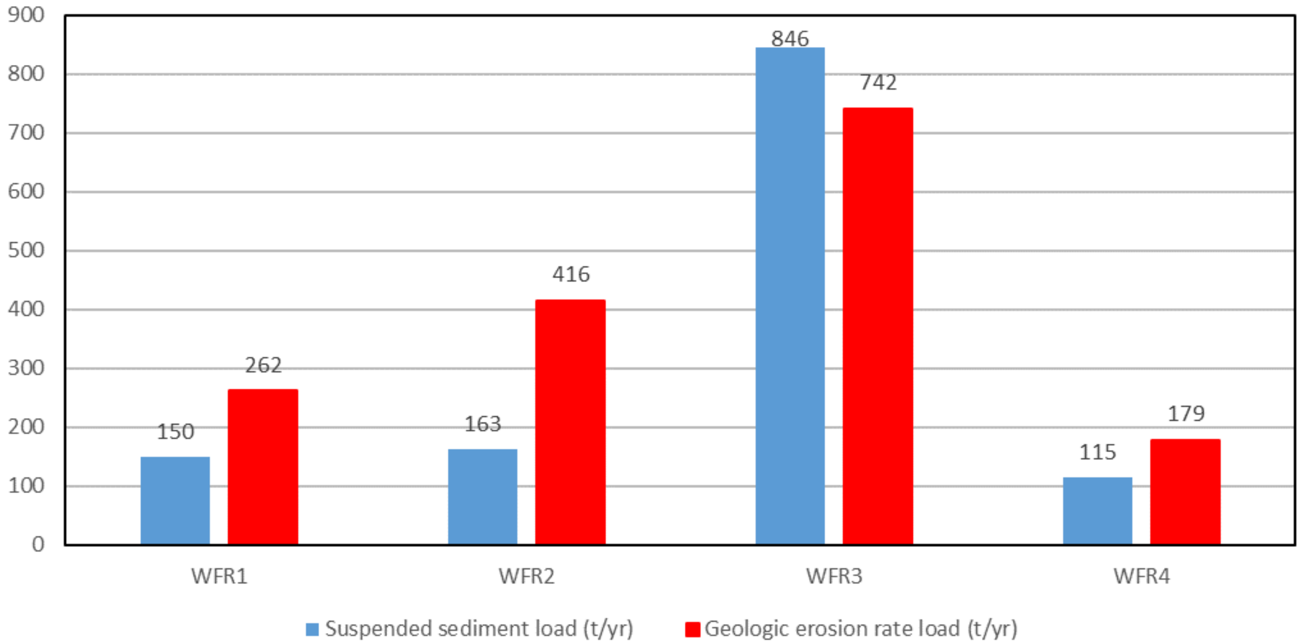

Figure 9.—Suspended sediment loads and calculated geologic erosion rate loads for West Fowl River watershed monitoring sites.

loads from Dog River site 2 (Spencer Branch at Cottage Hill Road in the city of Mobile) (Cook, 2012), D'Olive Creek site 3 (D'Olive Creek at U.S. Highway 90 in Daphne) (Cook, 2008), Fish River site 5 (Fish River at Baldwin County Road 54), Fish River site 8 (Pensacola Branch at Baldwin County Road 48) (Cook, 2016), Fowl River site 2 (Fowl River at Half Mile Road) (Cook, 2015), Magnolia River site 4 (at U.S. Highway 98) (Cook, 2009), and Bon Secour River site 3 (County Road 12 in Foley) (Cook, 2013), are compared to West Fowl River monitored sites in figure 10.

GEOCHEMICAL ASSESSMENT

An assessment of geochemical constituents was performed from grab water samples collected throughout the project period and streambed sediment samples collected on 12/5/16. Although not comprehensive, this assessment is meant to provide a synoptic view of water-quality conditions related to nutrients and selected metals and organics in streambed sediment.

NUTRIENTS

Excessive nutrient enrichment is a major cause of water-quality impairment. Excessive concentrations of nutrients, primarily nitrogen and phosphorus, in the aquatic environment may lead to increased biological activity, increased algal growth, decreased

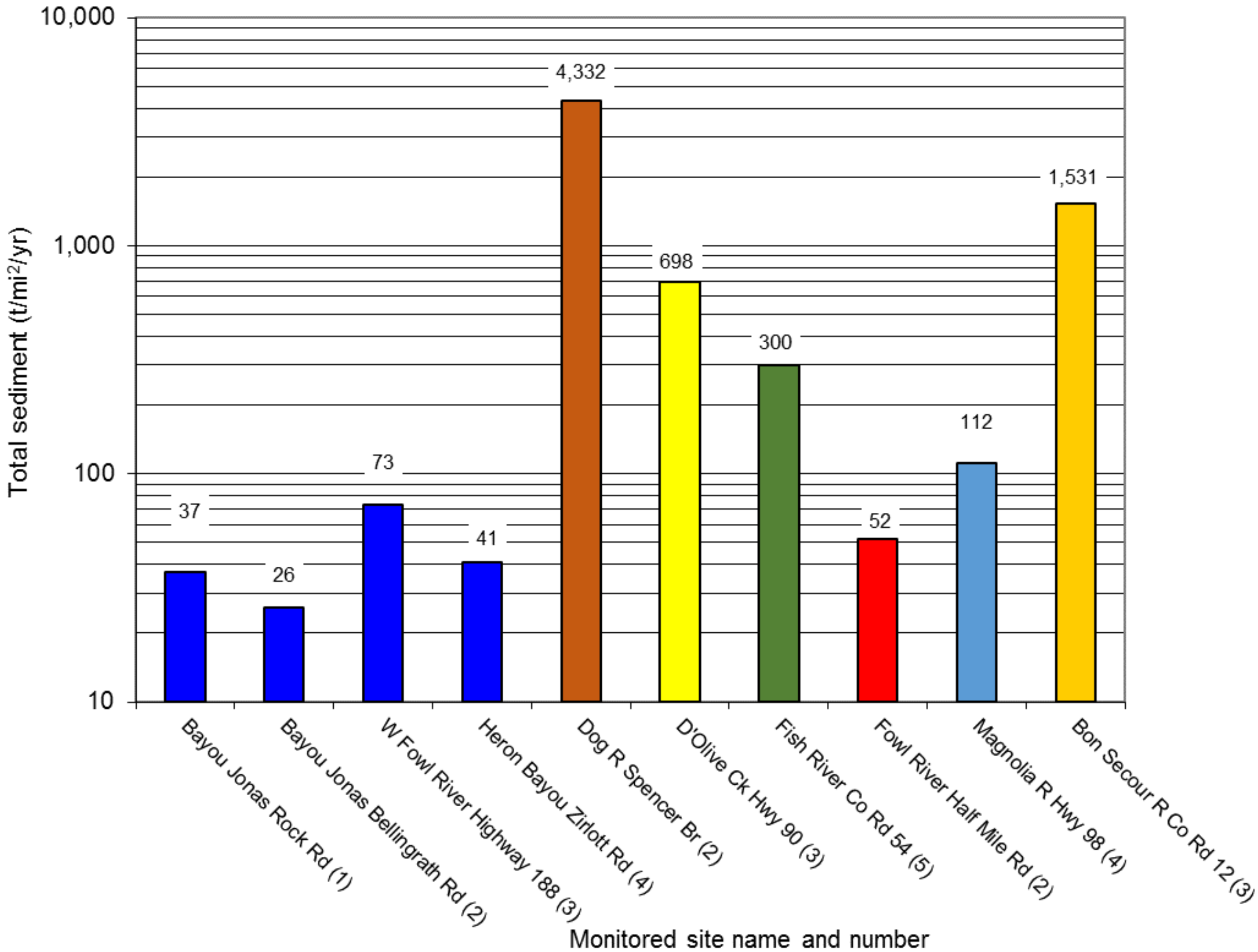

Figure 10.—Comparison of normalized total sediment loads for monitoring sites in theWest Fowl River with sites in other watersheds in Mobile and Baldwin Counties.

dissolved oxygen concentrations at times, and decreased numbers of species (Mays, 1996). Nutrient-impaired waters are characterized by numerous problems related to growth of algae, other aquatic vegetation, and associated bacterial strains. Blooms of algae and associated bacteria can cause taste and odor problems in drinking water and decrease oxygen concentrations to euthrophic levels. Toxins also can be produced during blooms of particular algal species. Nutrient-impaired water can dramatically increase treatment costs required to meet drinking water standards. Nutrients discussed in this report are nitrate (NO_3-N) and phosphorus (P-total).

NITRATE

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

A total of 32 samples were collected at project monitoring sites during the monitoring period. Nitrate was detected in six samples and the 0.5 mg/L nitrate criterion was exceeded in two samples collected at site WFR1 (fig. 11). It is interesting to note that nitrate was detected in samples at all four monitoring sites on March 28, 2016. Samples were collected during a moderately high flow event in which conductance and TSS were at or near their lowest values for the project period.

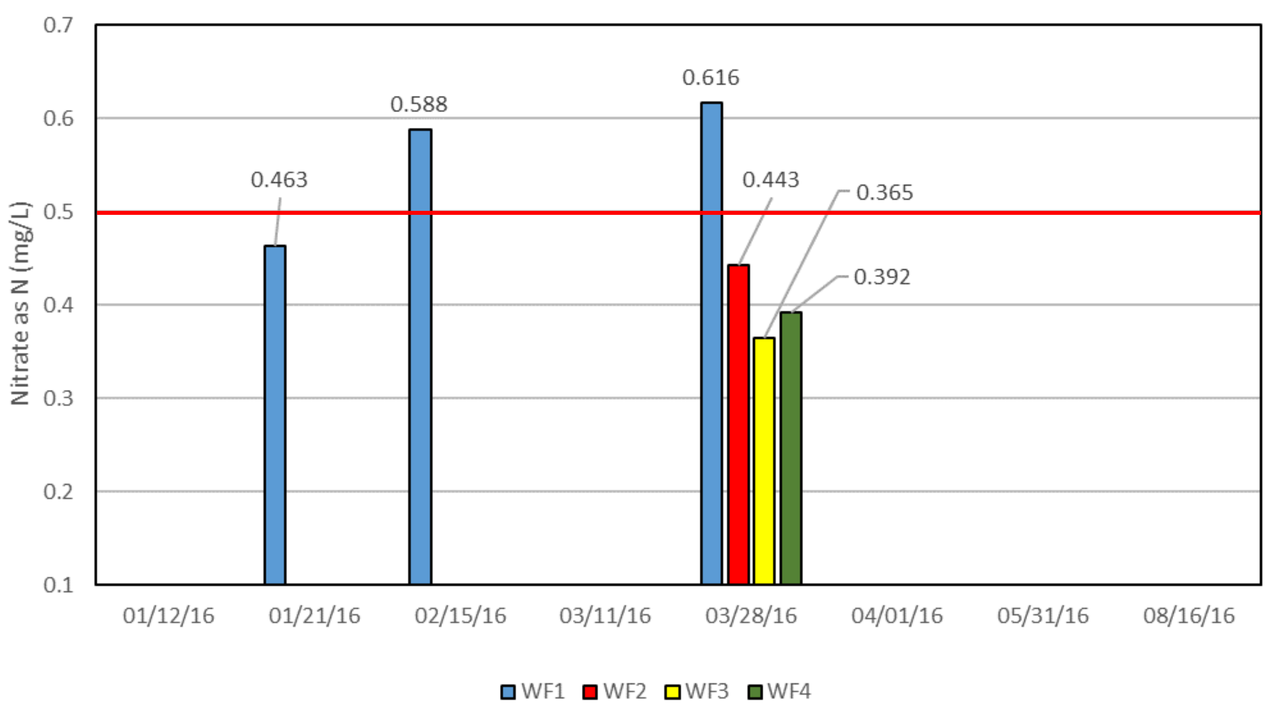

Figure 11.—Nitrate concentrations in samples collected at West Fowl River monitoring sites.

PHOSPHORUS

Phosphorus in streams originates from the mineralization of phosphates from soil and rocks or runoff and effluent containing fertilizer or other industrial products. The principal components of the phosphorus cycle involve organic phosphorus and inorganic phosphorus in the form of orthophosphate (PO_4) (Maidment, 1993). Orthophosphate is soluble and is the only biologically available form of phosphorus. Since phosphorus strongly associates with solid particles and is a significant part of organic material, sediments influence water column concentrations and are an important component of the phosphorus cycle in streams.

The natural background concentration of total dissolved phosphorus is approximately 0.025 mg/L. Phosphorus concentrations as low as 0.005 to 0.01 mg/L may cause algae growth, but the critical level of phosphorus necessary for excessive algae is around 0.05 mg/L (Maidment, 1993). Although no official water-quality criterion for phosphorus has been established in the United States, total phosphorus should not exceed 0.05 mg/L in any stream or 0.025 mg/L within a lake or reservoir in order to prevent the development of biological nuisances (Maidment, 1993). In many streams phosphorus is the primary nutrient that influences excessive biological activity. These streams are termed "phosphorus limited."

Thirty two samples were collected and analyzed for total phosphorus, which was detected in three samples from sites WFR1, WFR2, and WFR3. The 0.05 mg/L phosphorus criterion was exceeded in all three samples, with the highest concentration (0.889 mg/L) at site WFR1 on May 31, 2016 (fig. 12).

METALS AND ORGANIC CONSTITUENTS IN STREAM SEDIMENTS

Sediments accumulate contaminants and serve as sources of pollution to the ecosystems they reside in. Pathogens, nutrients, metals, and organic chemicals tend to sorb onto both inorganic and organic materials that eventually settle in depositional areas. If the loading of these contaminants into waterways is large enough, the sediments may accumulate excessive quantities of contaminants that directly and indirectly disrupt the ecosystem, causing significant contamination and loss of desirable species.

Numerous sediment quality guidelines (SQGs) were developed during the past 20 years to assist regulators in dealing with contaminated sediments. Early SQGs compared bulk chemical concentrations to a reference or to background and provided little insight

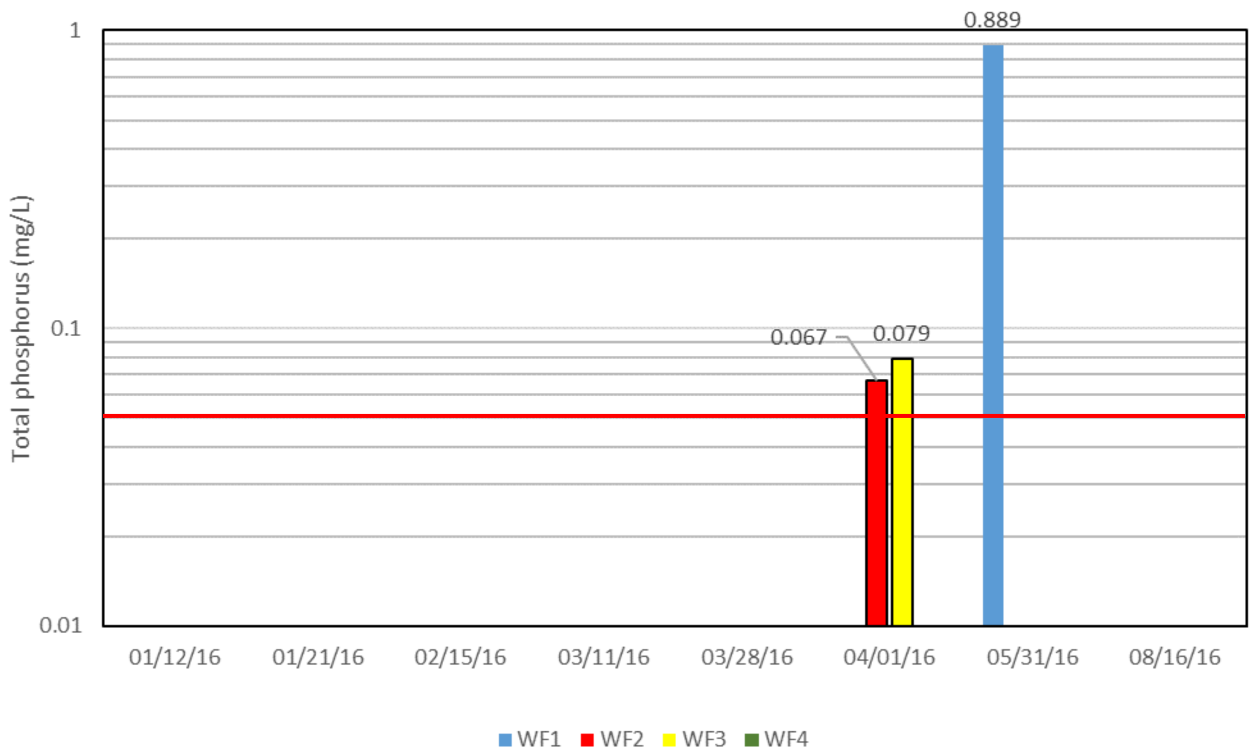

Figure 12.—Total phosphorus concentrations in samples collected at West Fowl River watershed monitoring sites.

into the ecosystem impact of sediment contaminants. More recent work developed SQGs for individual chemicals that relied on field sediment chemistry paired with field or laboratory-based biological effects data. Several effects approaches were developed including the effects level approach, apparent effects threshold approach, and screening level concentration approach (Burton, 2001). These approaches generally set two media, threshold levels, one below which effects rarely occur [e.g., the lowest effect level (LEL), threshold effect level (TEL), effects range low (ERL), minimal effect threshold (MET), and threshold effect concentration (TEC)], and one above which effects are likely to occur [e.g., the severe effect level (SEL), probable effects level (PEL), effect range median (ERM), toxic effect threshold (TET), and probable effect concentration (PEC)]. The National Oceanic and Atmospheric Administration (NOAA), Screening Quick Reference Table (SQuiRTs) presents screening concentrations of organic and inorganic contaminants in various environmental media including stream sediment (NOAA, 2008). Figure 13 shows the SQuiRTs concentrations for freshwater and marine sediment for each screening level.

Screening Quick Reference Table for Inorganics in Sediment

These tables were developed for screening purposes only: they do not represent official NOAA policy and do not constitute criteria or clean-up levels.
All attempts have been made to ensure accuracy; however, NOAA is not liable for errors. Values are subject to changes as new data become available.

Analyte		FRESHWATER SEDIMENT									MARINE SEDIMENT						
All concentrations in parts per billion dry weight unless specified otherwise		"Background" [1]	ARCS *H. azteca* TEL [2]	TEC [3]	TEL [3]	LEL [4]	PEC [3]	PEL [3]	SEL [4]	UET [1]	T_{20} [5]	TEL [6]	ERL [6]	T_{50} [5]	PEL [6]	ERM [6]	AET [7]
Predicted Toxicity Gradient:			Increasing →								Increasing →						
Aluminum (%)	Al	0.26%	2.55%														1.8% N
Antimony	Sb	160								3,000 M	630			2,400			9,300 E
Arsenic	As	1,100	10,798	9,790	5,900	6,000	33,000	17,000	33,000	17,000 I	7,400	7,240	8,200	20,000	41,600	70,000	35,000 B
Barium	Ba	700										130,100#					48,000 A
Cadmium	Cd	100-300	583	990	596	600	4,980	3,530	10,000	3,000 I	380	680	1,200	1,400	4,210	9,600	3,000 N
Chromium	Cr	7,000-13,000	36,286	43,400	37,300	26,000	111,000	90,000	110,000	95,000 H	49,000	52,300	81,000	141,000	160,000	370,000	62,000 N
Cobalt	Co	10,000				50,000+											10,000 N
Copper	Cu	10,000-25,000	28,012	31,600	35,700	16,000	149,000	197,000	110,000	86,000 I	32,000	18,700	34,000	94,000	108,000	270,000	390,000 MO
Iron (%)	Fe	0.99-1.8 %	18.84%			2%			4%	4% I							22% N
Lead	Pb	4,000-17,000	37,000	35,800	35,000	31,000	128,000	91,300	250,000	127,000 H	30,000	30,240	46,700	94,000	112,000	218,000	400,000 B
Manganese	Mn	400,000	630,000			460,000			1,100,000	1,100,000 I							260,000 N
Mercury	Hg	4-51		180	174	200	1,060	486	2,000	560 M	140	130	150	480	700	710	410 M
Nickel	Ni	9,900	19,514	22,700	18,000	16,000	48,600	36,000	75,000	43,000 H	15,000	15,900	20,900	47,000	42,800	51,600	110,000 EL
Selenium	Se	290															1,000 A
Silver	Ag	<500				500 +				4,500 H	230	730	1,000	1,100	1,770	3,700	3,100 B
Strontium	Sr	49,000															
Tin	Sn	5,000										48 *					> 3,400 N
Vanadium	V	50,000															57,000 N
Zinc	Zn	7,000-38,000	98,000	121,000	123,000	120,000	459,000	315,000	820,000	520,000 M	94,000	124,000	150,000	245,000	271,000	410,000	410,000 I
Lead 210 bq/g dw						0.5 ^			< 9.7 ^								
Polonium 210 bq/g dw						0.6 ^			< 8.7 ^								
Radium 226 bq/g dw						0.1 ^			< 13 ^								
Sulfides										130,000 M							4,500 MO

- Based on SLC approach using sensitive species HC5%; ES&T 2005 39(14):5148-5156.
* - Based upon EQp approach using current AWQC CCC
^ - Based on SLC approach to derive LEL and SEL; Env'al Monitor & Ass'ment 2005 110:71-85
+ - Carried over from Open Water disposal Guidelines; treated as if LEL for management decisions.
Bioassay endpoints: M – Microtox; B – Bivalve; E – Echinoderm larvae; O – Oyster larvae; A – Amphipod; N – Neanthes; L –Larval bioassay; plus, I – Infaunal community impacts

Sources
1 – Buchman, M. 1999. NOAA HAZMAT Report 99-1.
2 – EPA 905-R96-008
3 – Arch ET&C 2000, 39(1)20- TEL and PEL are also known as Canadian ISQGs and PELs
4 – Guidelines for the protection and management of aquatic sediment quality in Ontario Aug 1993
5 – ET&C 2002, 21(9)1993-
6 – Ecotox. 1996, 5(4):253-
7 – Chapter 173-204 WAC, 1991/95 as supplemented by WA Dept of Ecology staff with unpublished data.

Figure. 13--NOAA SQuiRTs table for freshwater and marine sediment.

Public meetings held in the West Fowl River watershed in late 2016 revealed concerns on the part of residents that industrial activities in the watershed may have contaminated sediments in streams. In response to these concerns, bed sediment samples were collected at selected sites in Bayou Jonas, Heron Bayou, and West Fowl River and analyzed for a select group of toxic metals including cadmium, chromium III, chromium VI, lead, mercury, and methylmercury. Stream bed sediment samples were collected at three sites (WF1S, WF2S, WF3S) near existing water quality monitoring sites WFR2, WFR3, and WFR4 (fig. 14). Sampling sites were selected in areas where fine grained sediments and contaminants were likely to be deposited.

Table 4 shows comparisons of SQuiRTs concentrations with analytical results for selected metals from sediment samples collected at West Fowl River watershed sites. Cadmium, chromium V1, and mercury were not detected in any samples. Chromium and lead were detected in all samples but concentrations were in the range of natural background levels.

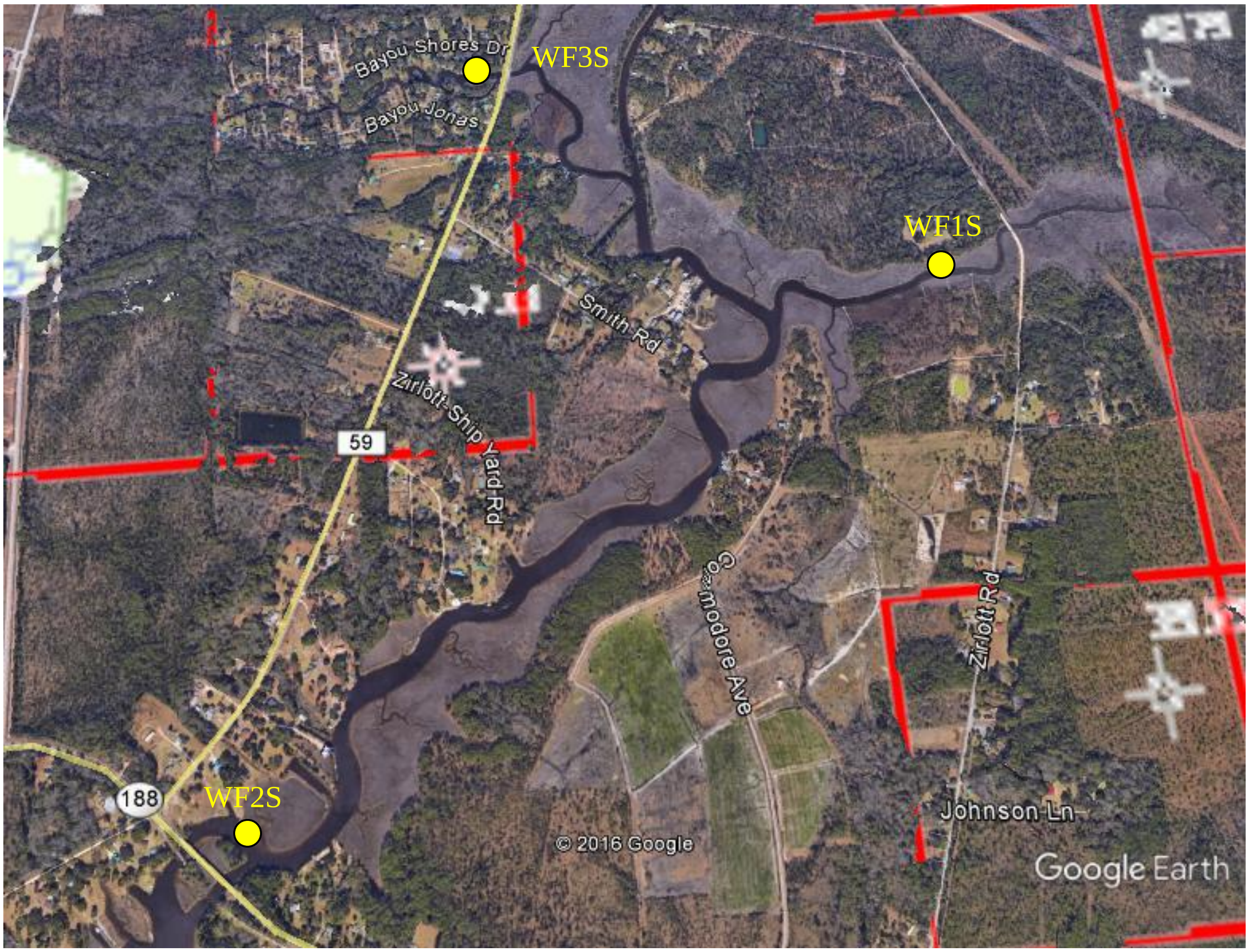

Figure 14.—Stream bed sediment sampling sites in the West Fowl River watershed.

Selected volatile organic compounds (benzene, toluene, ethylbenzene, xylenes (total), and naphthalene) were also analyzed in sediment samples collected at the West Fowl River watershed sites. Volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids and include a variety of chemicals, some of which may have short- and long-term adverse health effects. VOCs are widely used as ingredients in fuels and in household products that contain organic solvents such as paints, varnishes, and waxes as well as many cleaning, disinfecting, cosmetic, degreasing, and hobby products (USEPA, 2016). No VOC's analyzed in West Fowl River watershed sediment samples were detected.

Table 4.--NOAA SQuiRTs screening level and West Fowl watershed sample concentrations for metals of interest.

SQuiRTs Effects Level	Analyte				
	Cadmium (mg/kg)	Chromium (mg/kg)	Chromium VI (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)
Freshwater Sediment					
Background	0.1-0.3	7-13	N/A	4-17	0.004-0.051
ARCS	0.583	36.3	N/A	37	N/A
TEC	0.990	43.4	N/A	35.8	0.180
TEL	0.596	37.3	N/A	35	0.174
PEC	4.980	111	N/A	128	1.060
PEL	3.530	90	N/A	91.3	0.486
SEL	10	110	N/A	250	2
UET	3	95	N/A	127	0.560
Marine Sediment					
T_{20}	0.380	49	N/A	30	0.560
TEL	0.680	52.3	N/A	30.240	0.130
ERL	1.200	81	N/A	46.7	0.150
T_{50}	1.400	141	N/A	94	0.480
PEL	4.210	160	N/A	112	0.700
ERM	9.600	370	N/A	218	0.710
AET	3.000	62	N/A	400	0.410
West Fowl River Watershed Samples					
WF1S	ND[1]	3.10	ND	3.94	ND
WF2S	ND	6.30	ND	4.92	ND
WF3S	ND	9.72	ND	4.97	ND

METHYLMERCURY

Mercury (Hg) is a naturally occurring metal found primarily in cinnabar (mercurysulfate) that is released through the weathering of rock and (or) volcanic activity (National Research Council, 2000). However, the main source of Hg in the environment is from human activity through coal-combustion electrical power generation and industrial waste disposal (National Research Council, 2000; Stahl and Sobat, 2000). Environmental concentrations can be influenced by proximity to point sources such as sewage treatment plants and industrial discharges, and by geographic and physiographic factors that affect vulnerability to atmospheric deposition. Once Hg is released to the environment, it can be converted to a biologically toxic form of methylmercury (MeHg) by microorganisms found in soil and in the aquatic environment (National Research

Council, 2000). MeHg is a potent neurotoxin that affects the central nervous system causing neurological damage, mental retardation, blindness, deafness, kidney malfunction, and, in some cases, death (National Research Council, 2000).

Methylation of Hg is of concern because MeHg is absorbed easily into the food chain (U.S. Environmental Protection Agency, 1997). MeHg readily crosses biological membranes and can accumulate to harmful concentrations in the exposed organism and biomagnify up the food chain (Krabbenhoft and others, 1999). This biomagnification can cause high levels of Hg in top predator fishes and have a detrimental effect on humans and fish-eating wildlife (Krabbenhoft and others, 1999; National Research Council, 2000).

Methylmercury was detected in streambed sediment samples at all three monitoring sites. Sites WF1S (Heron Bayou near Zirlott Road), WF2S (West Fowl River near Alabama Highway 188), and WF3S (Bayou Jonas near Bellingrath Road) had methylmercury concentrations of 0.208, 0.318, and 0.051 nanograms per gram, respectively.

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APPENDIX A

FIELD AND ANALYTICAL DATA

Jonas Bayou at Mobile County Rock Road			Latitue 30.39825									
			Longitude 88.18271									
Site	Date	Time	Discharge	Temperature	Conductance	Turbidity	pH	Dissolved Oxygen	Salinity	TSS	Nitrate	Total Phosphorus
			cfs	°C	mS/cm	NTU		mg/L		mg/L	mg/L	mg/L
WFR1	01/12/16	16:20	8.1		83	18	4.9		0	4.0	<0.3	<.05
WFR1	01/21/16	22:10	11.4		66	18	5.7		0	5.6	0.463	<.05
WFR1	02/15/16	20:20	10.5	15.4	302	41	4.7	8.6	0.1	15.2	0.588	<.05
WFR1	03/11/16	13:50	28.3	19.6	51	75	6.3	8.1	0	30.0	<0.3	<.05
WFR1	03/28/16	10:50	27.0	21.1	32	15	4.8	7.2	0	2.0	0.616	<.05
WFR1	04/01/16	14:15	30.4	21.4	28	39	4.8	6.4	0	21.2	<0.3	<.05
WFR1	05/31/16	17:50	5.7	29.3	211	38	3.5	4.5	0	12.8	<0.3	0.889
WFR1	08/16/16	17:15	8.6	30.3	202	17	4.3	6.3	0	5.0		
Jonas Bayou at AL Bellingrath Road			Latitude 30.3941									
			Longitude 88.14987									
Site	Date	Time	Discharge	Temperature	Conductance	Turbidity	pH	Dissolved Oxygen	Salinity	TSS	Nitrate	Total Phosphorus
			cfs	°C	mS/cm	NTU		mg/L	ppt	mg/L	mg/L	mg/L
WFR2	01/12/16	15:55	12.8		1,470	24	6.7			8.4	<.3	<.05
WFR2	01/21/16	22:00	18.0		9,760	18	5.6			14.4	<.3	<.05
WFR2	02/15/16	20:15	16.6	15.2	15,600	19	7.5	7.5	9.7	12.4	<.3	<.05
WFR2	03/11/16	13:40	44.7	19.7	1,240	55	7.0	6.8	0.6	24.4	<.3	<.05
WFR2	03/28/16	10:40	42.6	20.9	40	20	5.8	7.3	0	4.8	0.443	<.05
WFR2	04/01/16	14:00	48.0	21.4	57	68	6.5	8.5	0	21.6	<.3	0.067
WFR2	05/31/16	17:35	8.9	30.1	8,650	19	5.6	7.2	4.8	8	<.3	<.05
WFR2	08/16/16	17:00	13.5	31.3	7,360	19	6.7	7.3		13		

West Fowl River at AL Hwy 188			Latitude 30.37647									
			Longitude 88.15888									
Site	Date	Time	Discharge	Temperature	Conductance	Turbidity	pH	Dissolved Oxygen	Salinity	TSS	Nitrate	Total Phosphorus
			cfs	°C	mS/cm	NTU		mg/L	ppt	mg/L	mg/L	mg/L
WFR3	01/12/16	15:45	23.2		2,710	27	6.5			16.0	<.3	<.05
WFR3	01/22/16	21:40	32.6		15,100	18	5.7			22.4	<.3	<.05
WFR3	02/15/16	20:00	29.9	15.3	24,700	44	7.8	7.8	15.0	44.0	<.3	<.05
WFR3	03/11/16	13:25	80.7	19.9	3,250	38	7.2	8.5	1.7	93.2	<.3	<.05
WFR3	03/28/16	10:20	77.0	20.7	205	33	6.5	8.6	0.0	13.2	0.365	<.05
WFR3	04/01/16	13:45	86.6	21.6	450	58	6.8	6.6	0.2	33.6	<.3	0.079
WFR3	05/31/16	17:20	16.1	31.0	33,200	16	5.7	5.6		24.8	<.3	<.05
WFR3	08/16/16	16:40	24.4	33.3	12,000	47	7.0	5.9		50.0		
Heron Bayou at Baldwin County Zirlott Road				Latitude 30.38904								
				Longitude 88.1365								
Site	Date	Time	Discharge	Temperature	Conductance	Turbidity	pH	Dissolved Oxygen	Salinity	TSS	Nitrate	Total Phosphorus
			cfs	°C	mS/cm	NTU		mg/L	ppt	mg/L	mg/L	mg/L
WFR4	01/12/16	15:35	5.6		1,720	28	6.6			10.4	<0.3	<0.05
WFR4	01/21/16	21:30	7.9		13,100	13	5.9			22.8	<0.3	<0.05
WFR4	02/15/16	19:50	7.3	15.3	19,700	25	7.4	7.2	11.6	17.6	<0.3	<0.05
WFR4	03/11/16	13:15	19.6	19.3	615	58	6.9	8.2	0.3	42.8	<0.3	<0.05
WFR4	03/28/16	10:00	18.7	20.3	28	92	5.9	7.9	0	8.8	0.392	<0.05
WFR4	04/01/16	13:30	21.1	20.9	79	72	6.3	7.2	0	52.4	<0.3	<0.05
WFR4	05/31/16	17:00	3.9	30.3	22,300	9	5.6	6.3		15.2	<0.3	<0.05
WFR4	08/16/16	16:20	5.9	32.9	10,000	18	6.3	6.2		20.0		

Sediment Samples			Cr^{+6}	Hg	Cd	Cr	Pb	Benzene	Toluene	Ethylbenzene	Xylenes (total)	Naphthalene	MeHg
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	ng/g
WF1S	12/5/2016	13:05	ND	ND	ND	3.10	3.94	ND	ND	ND	ND	ND	0.208
WF2S	12/5/2016	14:30	ND	ND	ND	6.30	4.92	ND	ND	ND	ND	ND	0.318
WF3S	12/6/2016	8:15	ND	ND	ND	9.72	4.97	ND	ND	ND	ND	ND	0.051