APPENDIX A ADEM 2013 FOWL RIVER SUB-ESTUARY REPORT

2013 Fowl River Sub-Estuary Report

Alabama Department of Environmental Management

Field Operations Division
Environmental Assessment Section
Water Unit
November 2017

Coastal Waters Monitoring Program

2013

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Table of Contents

LIST OF ACRONYMS

A&I	Agriculture and Industry water supply use classification
ADEM	Alabama Department of Environmental Management
CHL *a*	Chlorophyll *a*
CWA	Clean Water Act
CWMP	Coastal Waters Monitoring Program
DO	Dissolved Oxygen
F&W	Fish and Wildlife
MAX	Maximum
MDL	Method Detection Limit
MIN	Minimum
NTU	Nephelometric Turbidity Units
OAW	Outstanding Alabama Waters
PWS	Public Water Supply
QAPP	Quality Assurance Project Plan
S	Swimming and Other Whole Body Water-Contact Sports
SD	Standard Deviation
SH	Shellfish Harvesting
SOP	Standard Operating Procedures
TEMP	Temperature
TN	Total Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
USACE	United States Army Corp of Engineers
USEPA	United States Environmental Protection Agency

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The Fowl River is located in Mobile County, Alabama on the western shore of Mobile Bay. The river originates south and west of the city of Mobile in the town of Theodore and flows southeast towards Mobile Bay. As the river approaches the bay it forks into the East Fowl River and West Fowl River. The East Fowl River turns to the north east and meets Mobile Bay while the West Fowl River turns south and slowly makes its way to the Mississippi Sound. The Fowl River sub-watershed encompasses approximately 52,782 acres within the Southern Pine Hills and Coastal Lowlands physiographic regions. The Fowl River and its watershed and corresponding estuary provide valuable economic and environmental resources to the region including agriculture, spawning habitats for commercially and recreationally important fish and shellfish, and recreational activities such as boating, fishing, and swimming.

The Alabama Department of Environmental Management (ADEM) monitored six stations within the Fowl River watershed as part of the 2013 assessment under the Coastal Waters Monitoring Program (CWMP). Implemented in 2011, the CWMP is designed to provide data to assess current water quality conditions, identify long-term trends in water quality conditions and to develop Total Maximum Daily Loads (TMDLs) and nutrient criteria. The program is also being used to update protocols and methodologies to more accurately assess water quality conditions for estuaries and coastal rivers and streams. Although the CWMP is relatively new, most sites within it have been sampled in other programs throughout ADEM's history, with many having been sampled since the 1970's. Descriptions of all CWMP monitoring activities are available in ADEM's 2017 Monitoring Strategy (ADEM 2017).

Surface waters within Alabama are categorized according to their designated use classification and the degree to which the water quality supports its use classification. As required by Section 303(d) of the 1972 Clean Water Act (CWA), surface waters that do not meet their use classification are placed on Alabama's 303(d) List of Impaired Waters. Once a waterbody is listed as impaired, a TMDL is implemented to take measures needed for the waterbody to meet or exceed its water quality standards. Waterbodies that are currently on Alabama's 303(d) list of impaired waters are shown in Table 1. A map of waterbodies within the Fowl River watershed that are on the 2012 CWA 303(d) list are shown in Figure 1.

The purpose of this report is to summarize data collected at six stations within the Fowl River watershed during the 2013 growing season and to evaluate trends in nutrient concentrations using ADEM's historic dataset. Monthly and/or mean concentrations of nutrients [total nitrogen (TN); total phosphorus (TP)], algal biomass/productivity [chl *a*], and sediment [total suspended solids (TSS)] were compared to ADEM's historical data.

METHODS

Sampling stations were selected using historical data and previous assessments (Fig. 1). Specific location information can be found in Table 2. East Fowl River, West Fowl River and the Fowl River Bay were sampled within the Fowl River watershed.

Water quality assessments were conducted monthly, bi-monthly, or quarterly March or April-October. Sampling frequency varied year-to-year dependent on available resources. All samples were collected, preserved, stored, and transported according to procedures in the ADEM Field Operations Division Standard Operation Procedures (ADEM 2012), Surface Water Quality Assurance Project Plan (ADEM 2008a), and Quality Management Plan (ADEM 2008b).

Mean growing season, March-October, TN, TP, chl *a*, and TSS were calculated to evaluate water quality conditions at each site using data from 2005 through 2012. Monthly concentrations of these parameters were graphed with ADEM's previously collected data for all stations within the focus watersheds. Monthly growing season readings of dissolved oxygen (DO), salinity, and temperature were graphed at 1.5m (5ft), or mid-depth if less than 10ft deep, for comparison with ADEM's water quality criteria level of 5.0 mg/L DO. Growing season profiles of DO, salinity, and temperature were also graphed to show stratification of each parameter. Chemical analysis also includes select total and dissolved metals.

Table 1. 303(d) listed waterbodies in the Fowl River Sub-Estuary.

Assessment Unit ID	Waterbody Name	County	Uses	Causes	Sources	Date of Data	Size	Year Listed	Draft TMDL Date
AL03160205-0104-110	Fowl River	Mobile	SF&W	Metals (Mercury)	Atmospheric deposition	2000	20.56 miles	2000	2020
AL03170009-0201-200	Portersville Bay	Mobile	SH/SF&W	Pathogens	Municipal	1996	18.81 square miles	1998	

Figure 1. 2013 Fowl River stations & impaired waterbodies.

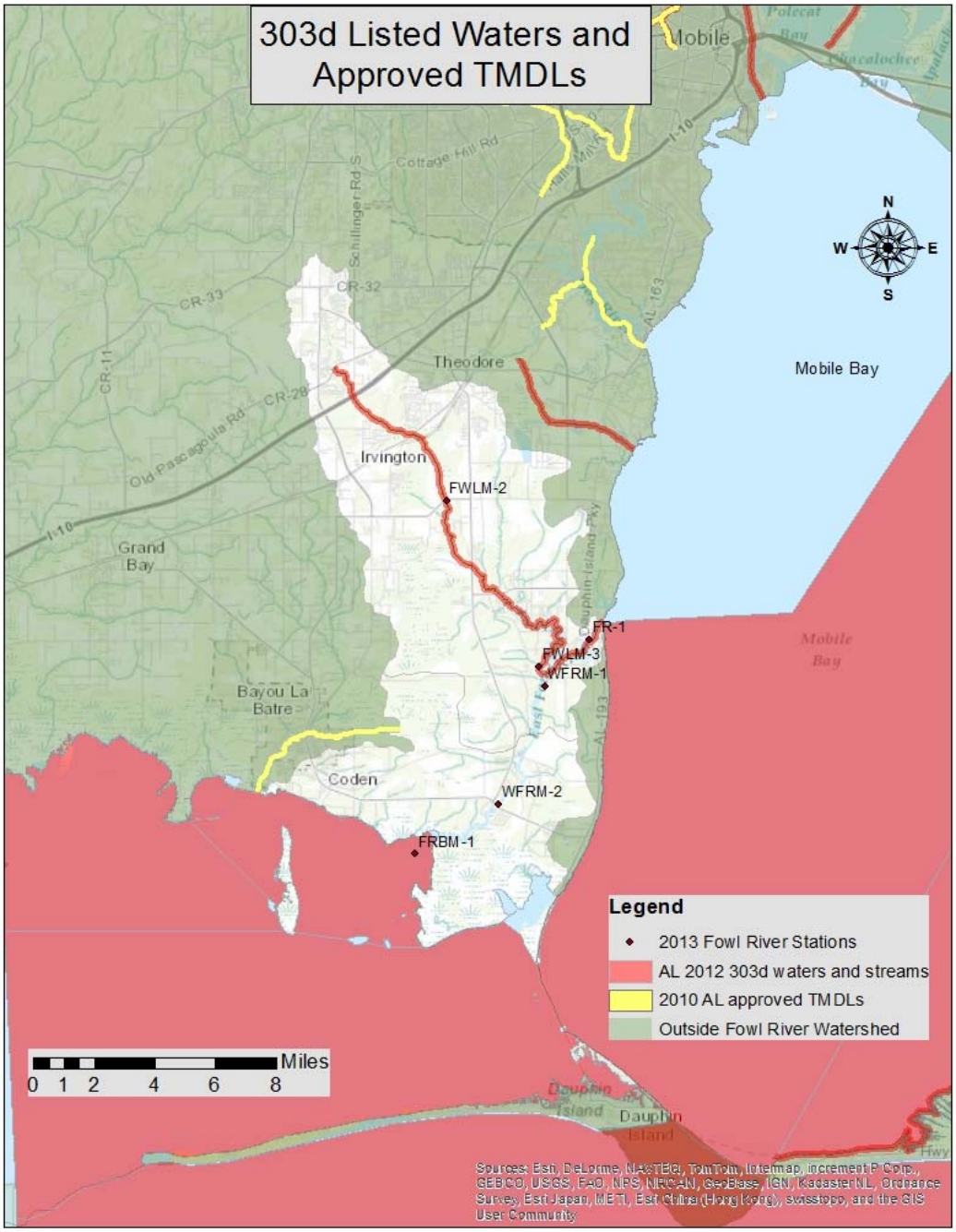


Table 2. Descriptions of the monitoring stations in 2013 for the Fowl River Sub-Watershed.

HUC8	County	Station Number	Use Classification	Waterbody Name	Station Description	Latitude	Longitude
03160205	Mobile	FWLM-3	SF&W	Fowl River	Approximately .25 mile upstream of the confluence	30.43307	-88.13713
03160205	Mobile	WFRM-1	SF&W	West Fowl River	Approximately .5 mile downstream of the confluence	30.42501	-88.1343
03170009	Mobile	WFRM-2	SF&W	West Fowl River	Just upstream of Hwy 188	30.37625	-88.15639
03170009	Mobile	FRBM-1	SH/SF&W	Fowl River Bay	Middle of Fowl River Bay	30.35590	-88.19650
03160205	Mobile	FWLM-2	SF&W	Fowl River	Fowl R @ Half Mile Rd-USGS gage-02471078	30.50110	-88.18140
03160205	Mobile	FR-1	SF&W	East Fowl River	Fowl River @ Alabama Highway 193 – Dauphin Island Parkway Bridge	30.44416	-88.11305

RESULTS

Growing season mean graphs of TN, TP, chl *a*, and TSS are provided in this section (Figs. 2-5). Monthly graphs for TN, TP, chl *a*, TSS, DO, temperature, and salinity are also provided (Figs. 6-10). Depth profile graphs of DO, temperature, and salinity appear in Fig. 11. Summary statistics of all data collected during 2013 are presented in Appendix Table 1. The table contains the minimum, maximum, median, mean, and standard deviation of each parameter analyzed.

Stations with the highest concentrations of nutrients, chlorophyll, and TSS are noted in the paragraphs to follow. Though stations with the lowest concentrations may not always be mentioned, review of the graphs that follow will indicate these stations that may be potential candidates for reference waterbodies and watersheds.

In 2013 two sites, FWLM-2 and WFRM-2, had similar mean TN values that were highest among sites monitored (Fig. 2). Mean TN values at the trend location on the East Fowl River, FR-1, declined 2006 through 2011 then increased through 2013. Mean TN values in the Fowl River Bay (FRBM-1) were the highest since 2011, when regular sampling began for this station. Monthly TN concentrations for all stations were similar to historical means (Fig. 6).

In 2013 mean growing season TP values increased from upstream to the downstream most monitoring locations of the Fowl River (FR-1) and Fowl River Bay (FRBM-1) (Fig. 3). From 2011-2013 mean TP values have increased in East Fowl River (FR-1) and Fowl River Bay (FRBM-1). The highest monthly TP concentration measured in 2013 was in October in the East Fowl River location (FR-1) (Fig. 7). While most monthly TP concentrations in 2013 were similar to historic means, historic high concentrations were measured during April, June and

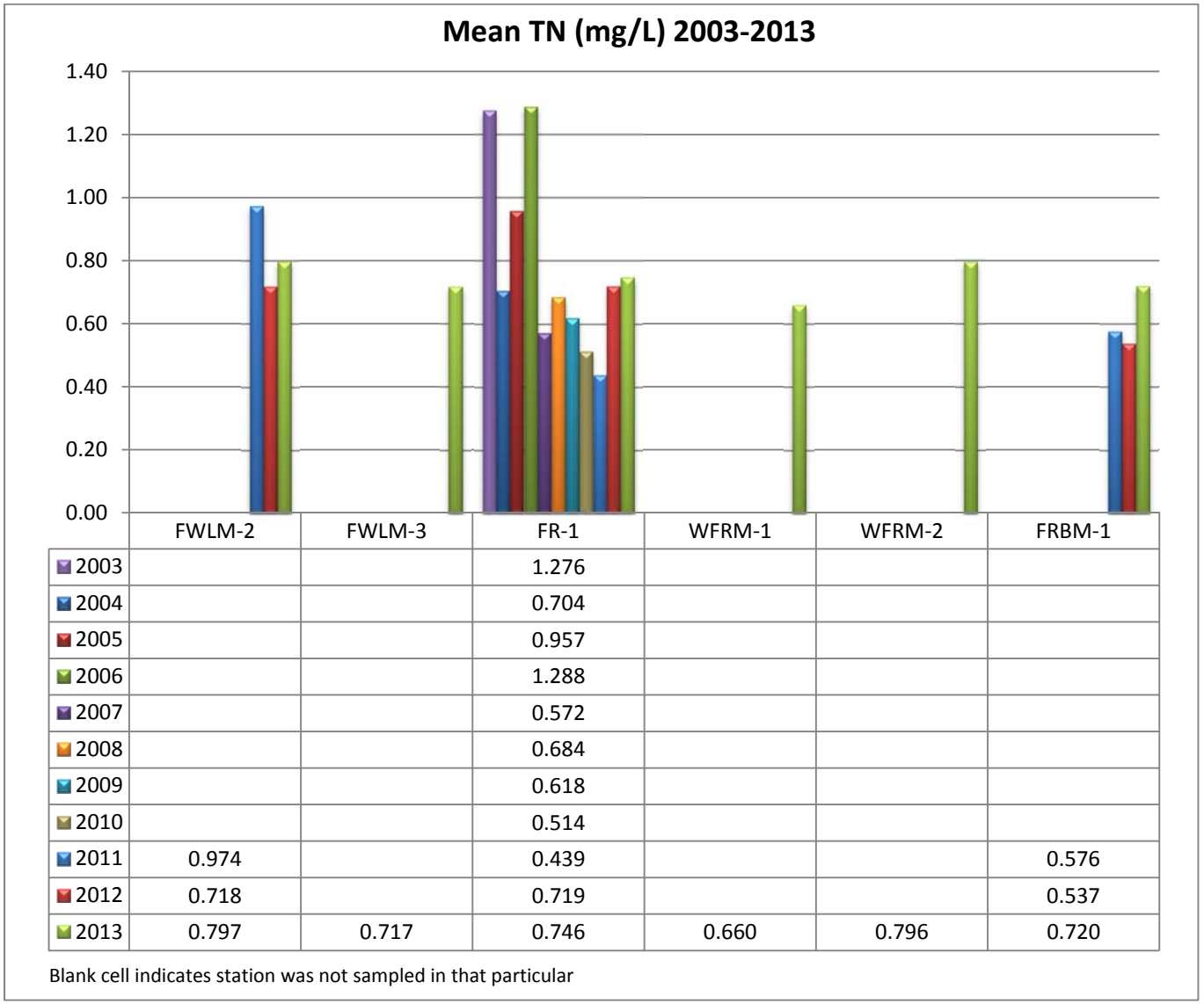
August at Fowl River Bay (FRBM-1), and were above the mean in all months except March and June at FR-1.

Mean growing season chl *a* values have declined in the East Fowl River (FR-1) and Fowl River Bay (FRBM-1) since monitoring began in 2003 and 2011 respectively (Fig. 4). The highest monthly chl *a* concentrations were measured in the East Fowl River at FR-1. Most monthly chl *a* concentrations were similar to or lower than historic means (Fig. 8). Chl *a* criteria have not been established in this area.

In 2013 mean growing season TSS values increased from upstream to the downstream most monitoring locations of the East Fowl River (FR-1) and Fowl River Bay (FRBM-1) (Fig. 5). Mean concentrations in the Fowl River (FWLM-2) and Fowl River Bay (FRBM-1) stations have declined since monitoring began in 2011 while no clear trend can be seen at the East Fowl River (FR-1) location since 2003. The highest monthly TSS concentrations were measured in October at East Fowl River (FR-1) and June at Fowl River Bay (FRBM-1) (Fig. 9). Most monthly TSS concentrations were at or below historic means.

Dissolved oxygen concentrations in Fowl River (FWLM-3) and West Fowl River (WFRM-1) were below the ADEM criteria limit of 5.0 mg/L at 5.0ft (1.5m) or mid-depth in June and August (ADEM Admin. Code R. 335-6-10-09) (Fig. 10). DO concentrations in East Fowl River (FR-1) were below the criteria in August and the West Fowl River (WFRM-2) was below the limit in September. While DO concentrations in Fowl River Bay (FRBM-1) were near 5.0 mg/L in September all DO measurements remained above the ADEM criteria. DO concentrations in Fowl River at FWLM-2 also remained above the ADEM criteria.

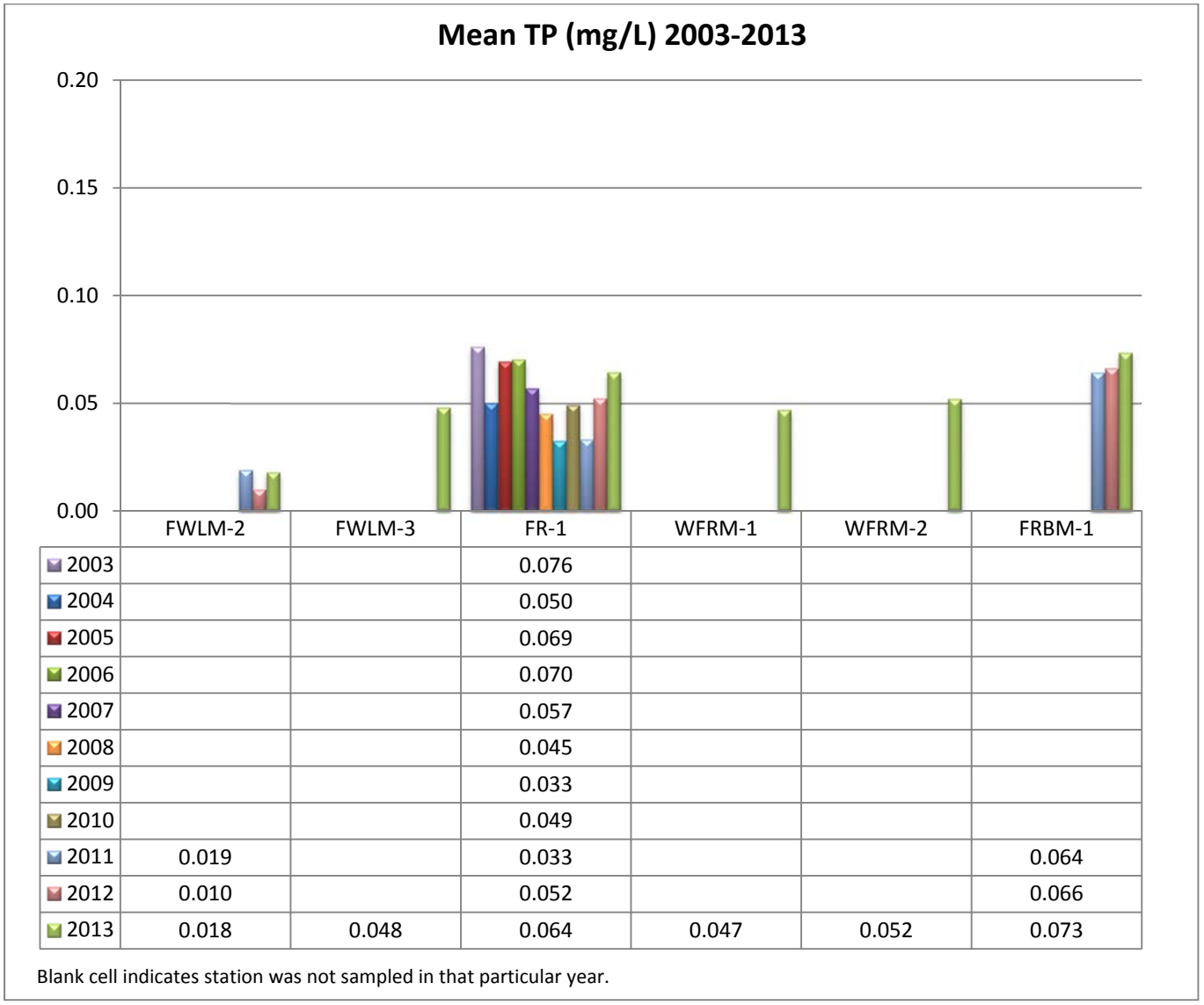
Figure 2. Mean growing season TN measured for the trend stations in the Fowl River Sub-Watershed, 2003-2013.



	FWLM-2	FWLM-3	FR-1	WFRM-1	WFRM-2	FRBM-1
2003			1.276			
2004			0.704			
2005			0.957			
2006			1.288			
2007			0.572			
2008			0.684			
2009			0.618			
2010			0.514			
2011	0.974		0.439			0.576
2012	0.718		0.719			0.537
2013	0.797	0.717	0.746	0.660	0.796	0.720

Blank cell indicates station was not sampled in that particular

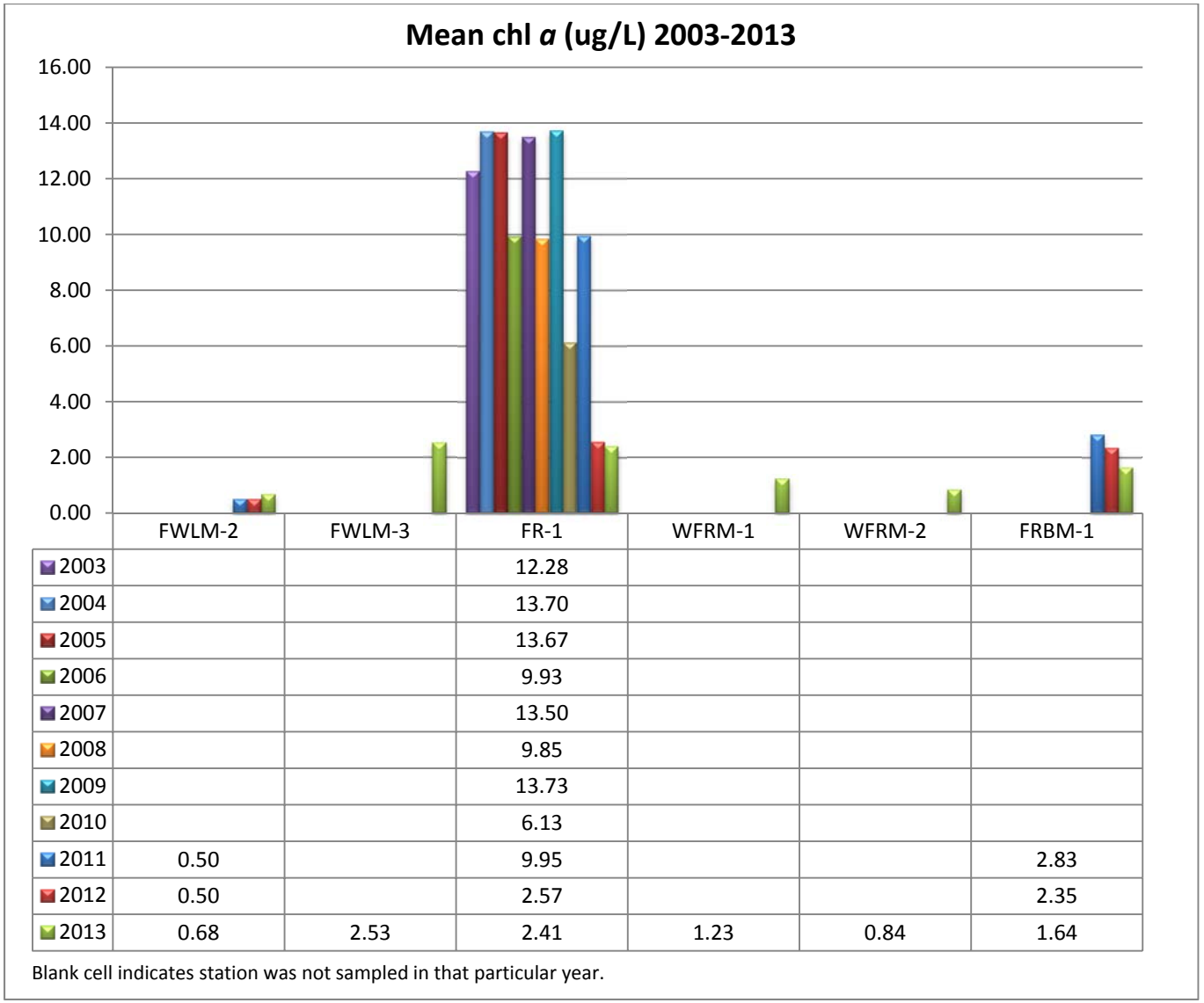
Figure 3. Mean growing season TP measured for the trend stations in the Fowl River Sub-Watershed, 2003-2013.



	FWLM-2	FWLM-3	FR-1	WFRM-1	WFRM-2	FRBM-1
2003			0.076			
2004			0.050			
2005			0.069			
2006			0.070			
2007			0.057			
2008			0.045			
2009			0.033			
2010			0.049			
2011	0.019		0.033			0.064
2012	0.010		0.052			0.066
2013	0.018	0.048	0.064	0.047	0.052	0.073

Blank cell indicates station was not sampled in that particular year.

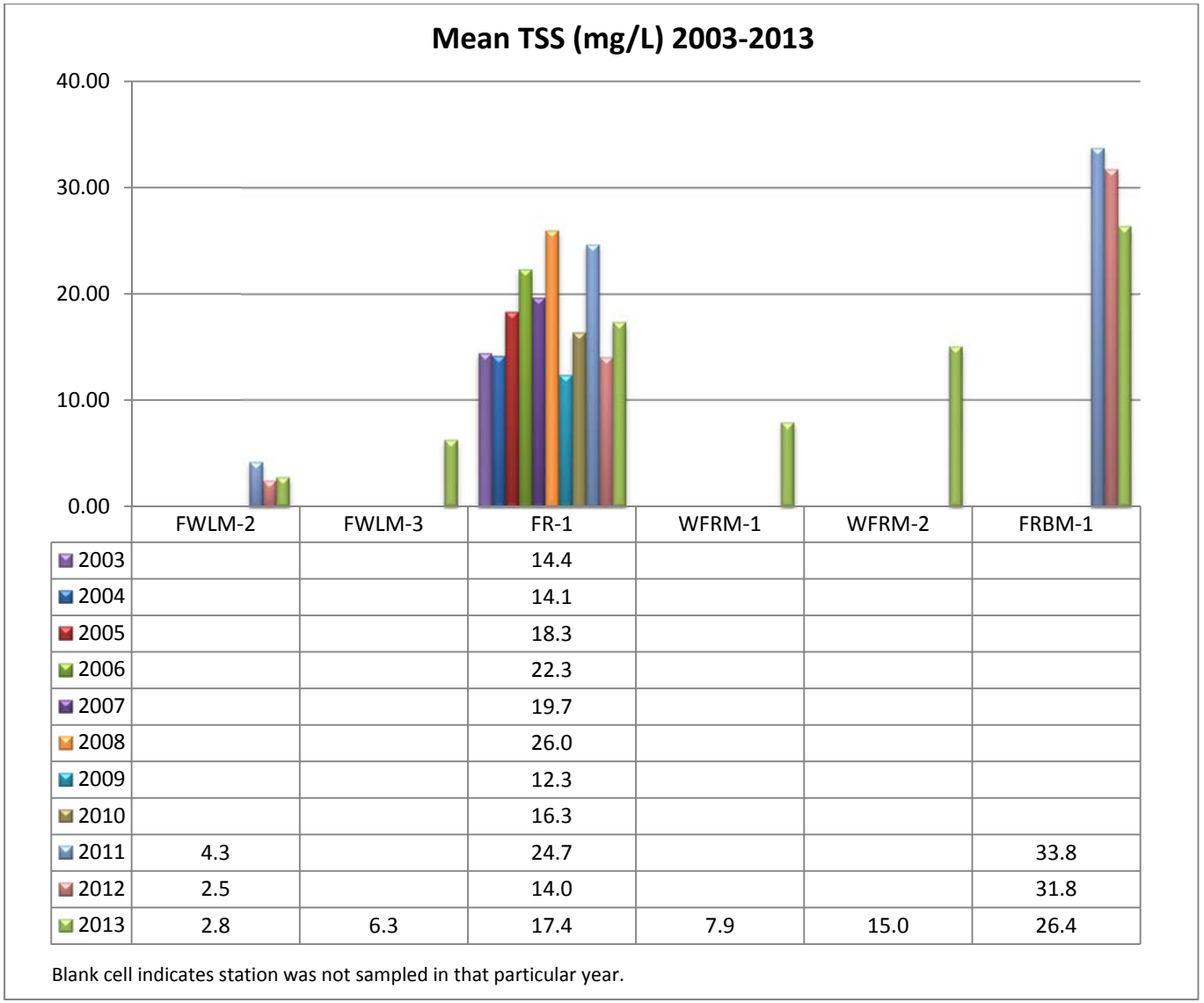
Figure 4. Mean growing season chl *a* measured for the trend stations in the Fowl River Sub-Watershed, 2003-2013.



	FWLM-2	FWLM-3	FR-1	WFRM-1	WFRM-2	FRBM-1
2003			12.28			
2004			13.70			
2005			13.67			
2006			9.93			
2007			13.50			
2008			9.85			
2009			13.73			
2010			6.13			
2011	0.50		9.95			2.83
2012	0.50		2.57			2.35
2013	0.68	2.53	2.41	1.23	0.84	1.64

Blank cell indicates station was not sampled in that particular year.

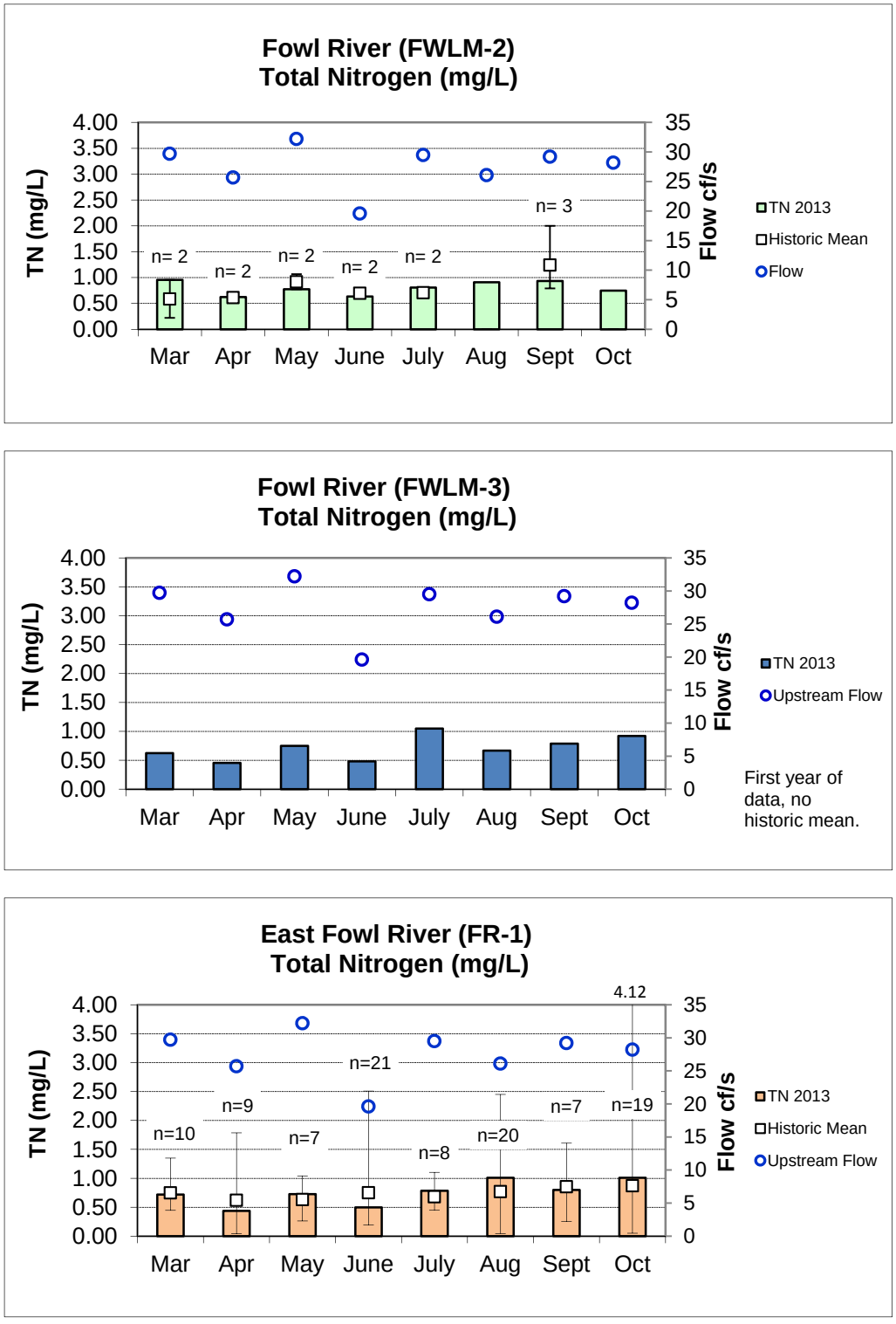
Figure 5. Mean growing season TSS measured for the trend stations in the Fowl River Sub-Watershed, 2003-2013.



	FWLM-2	FWLM-3	FR-1	WFRM-1	WFRM-2	FRBM-1
2003			14.4			
2004			14.1			
2005			18.3			
2006			22.3			
2007			19.7			
2008			26.0			
2009			12.3			
2010			16.3			
2011	4.3		24.7			33.8
2012	2.5		14.0			31.8
2013	2.8	6.3	17.4	7.9	15.0	26.4

Blank cell indicates station was not sampled in that particular year.

Figure 6. Monthly TN concentrations measured in the Fowl River Sub-Watershed, March-October 2013. Each bar graph depicts changes in each station. The historic mean (1990-2013) and min/max ranges are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. Flow was measured at the most upstream station, FWLM-2.



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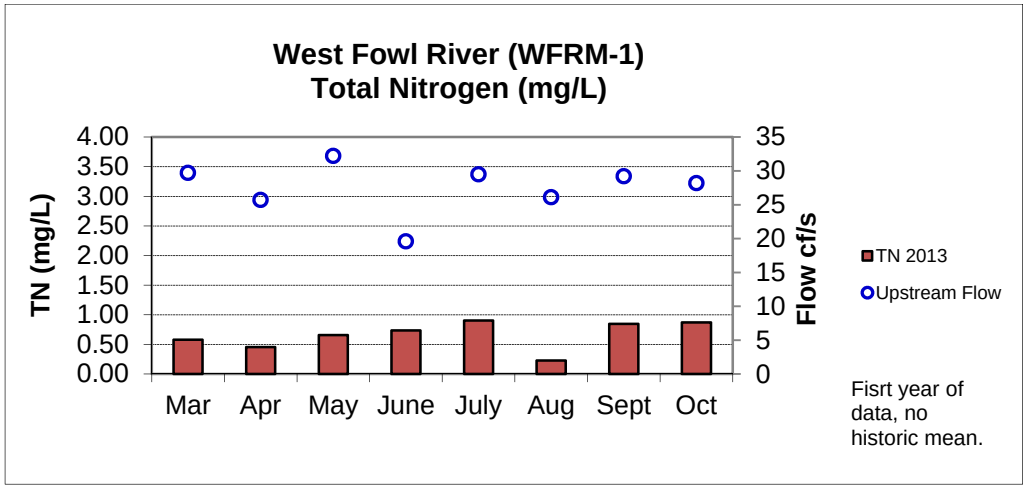
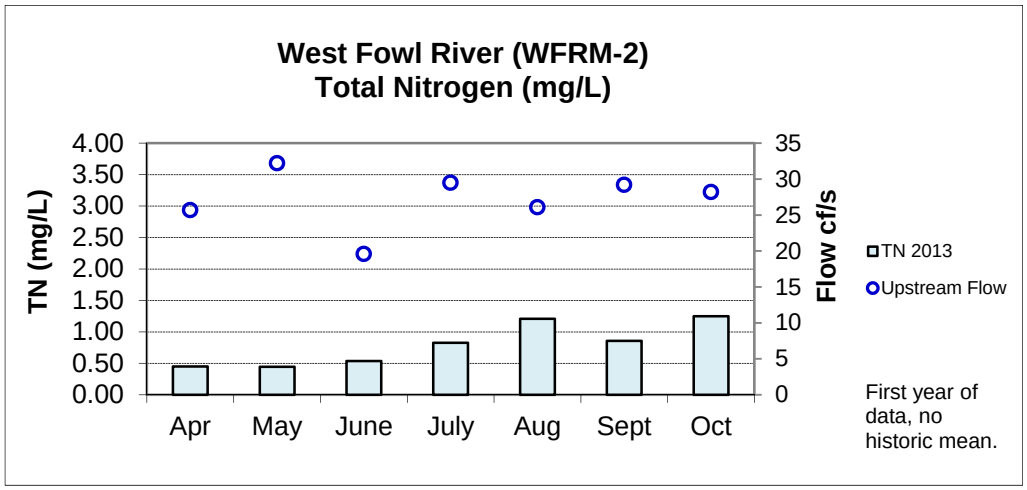




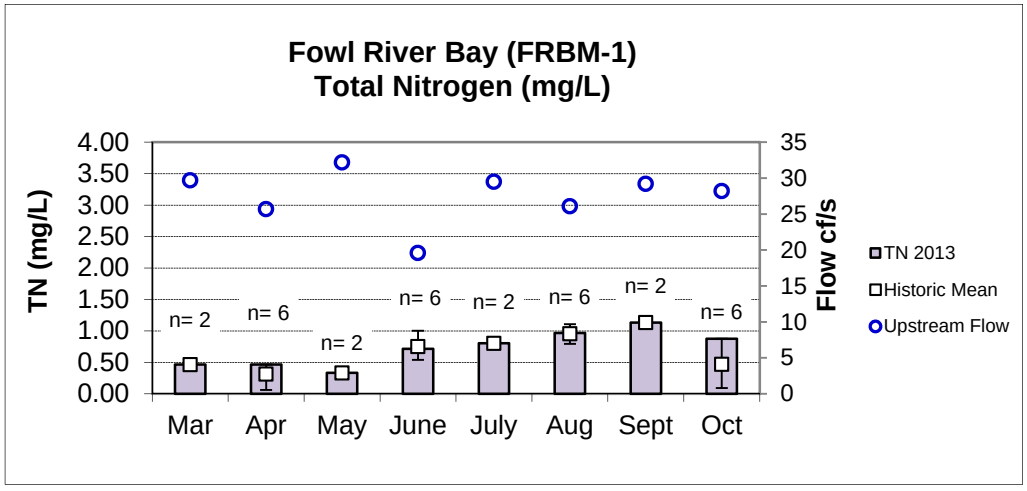
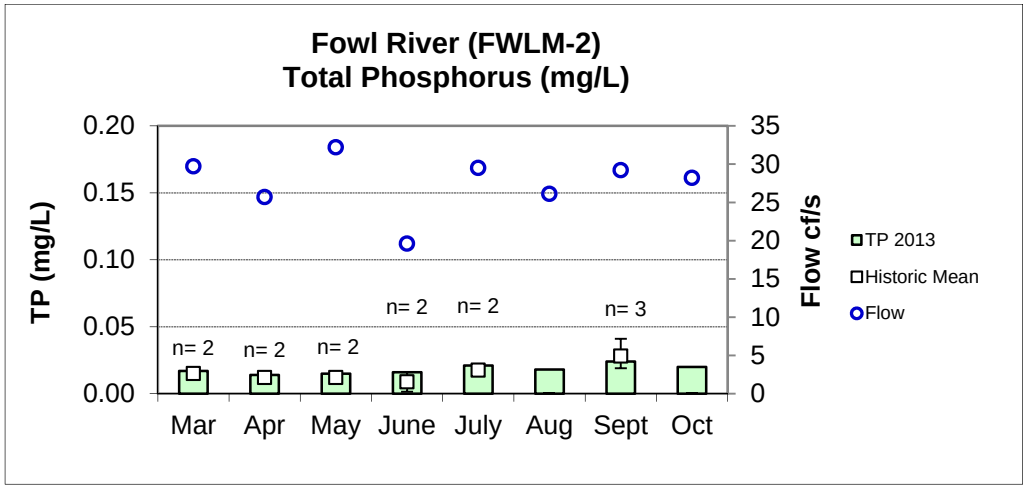
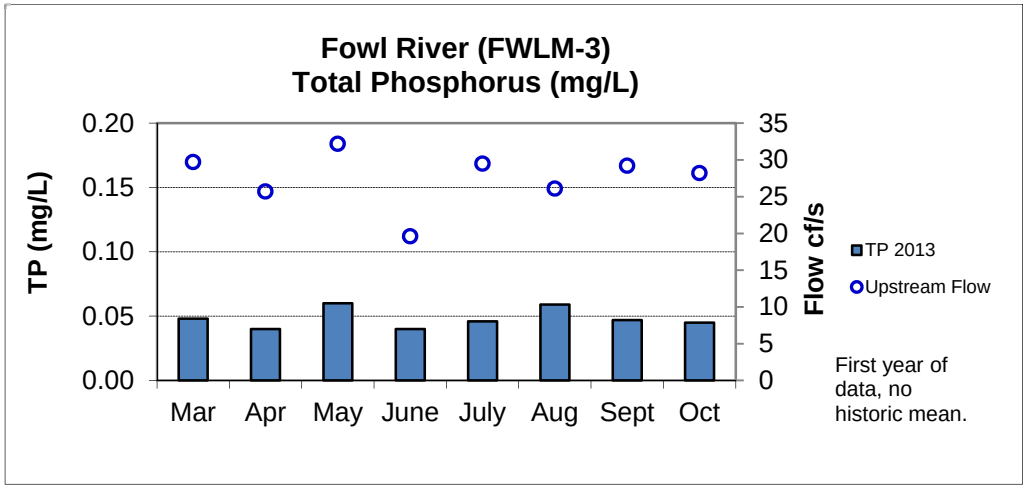
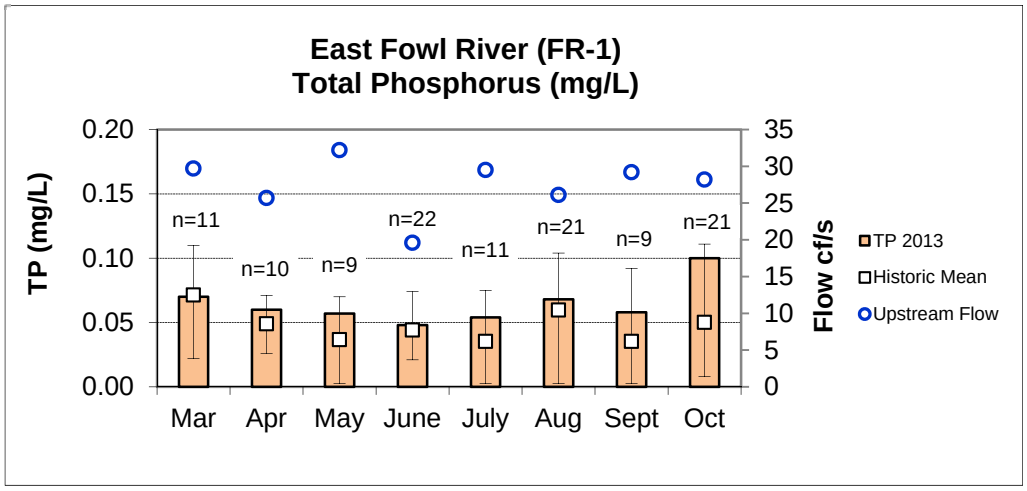


Figure 7. Monthly TP concentrations measured in the Fowl River Sub-Watershed, March-October 2013. Each bar graph depicts changes in each station. The historic mean (1990-2013) and min/max ranges are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations**.** Flow was measured at the most upstream station, FWLM-2.







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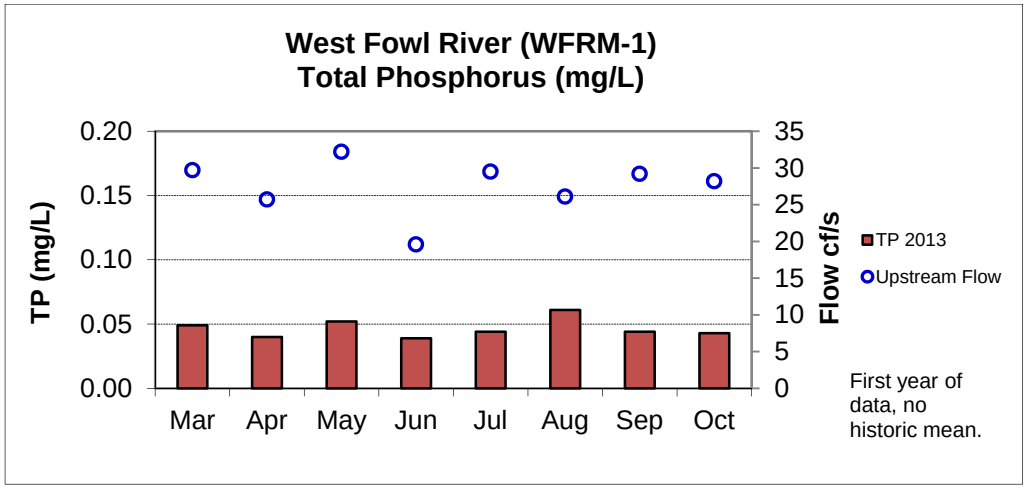
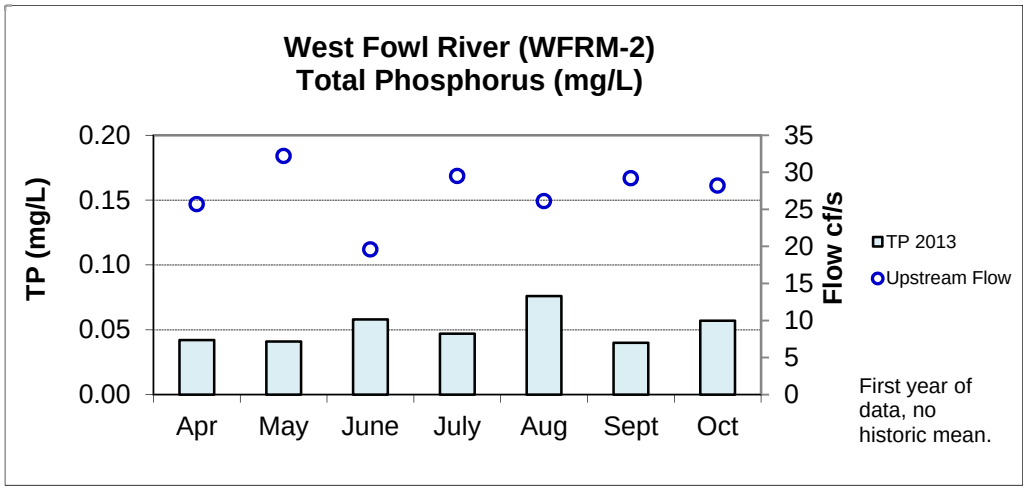




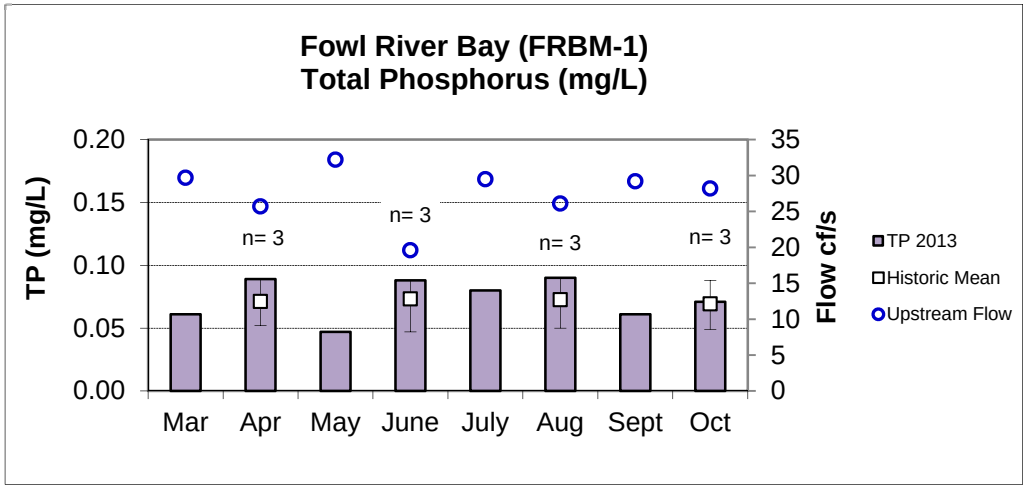
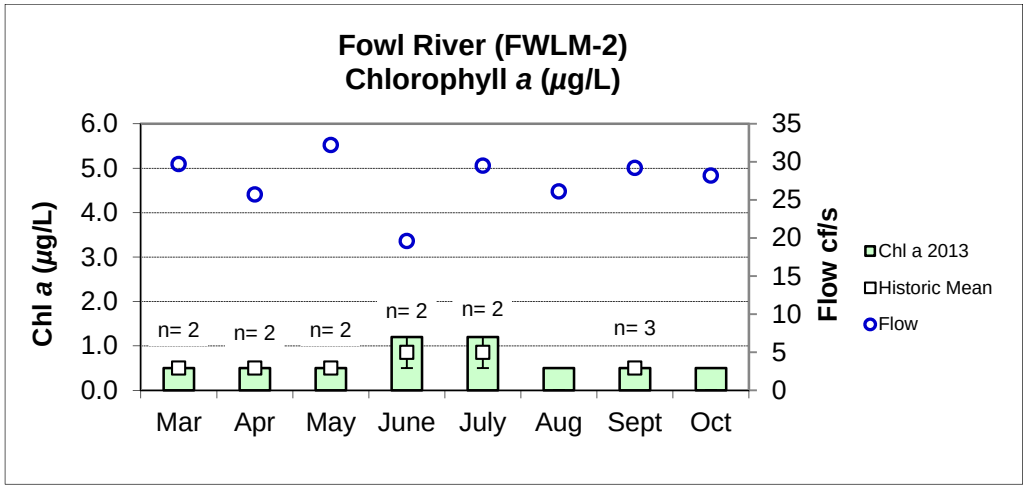
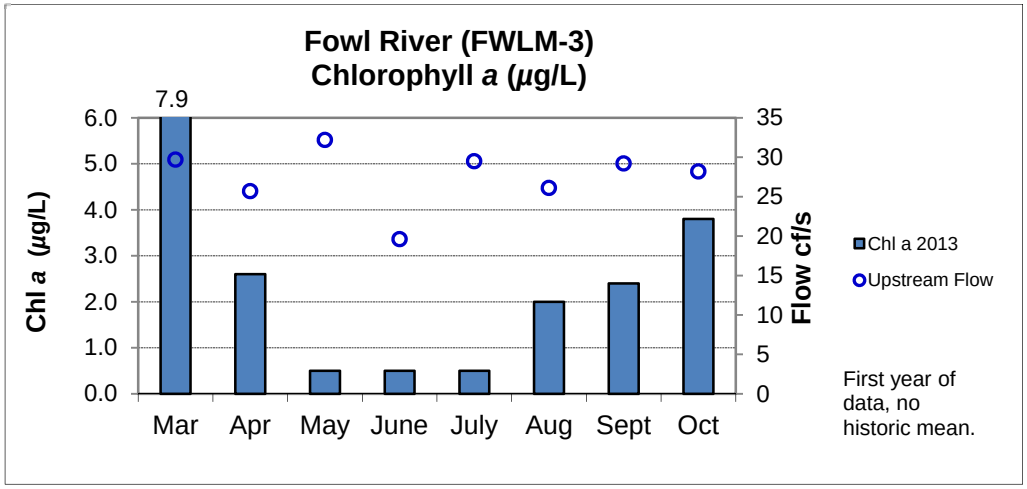
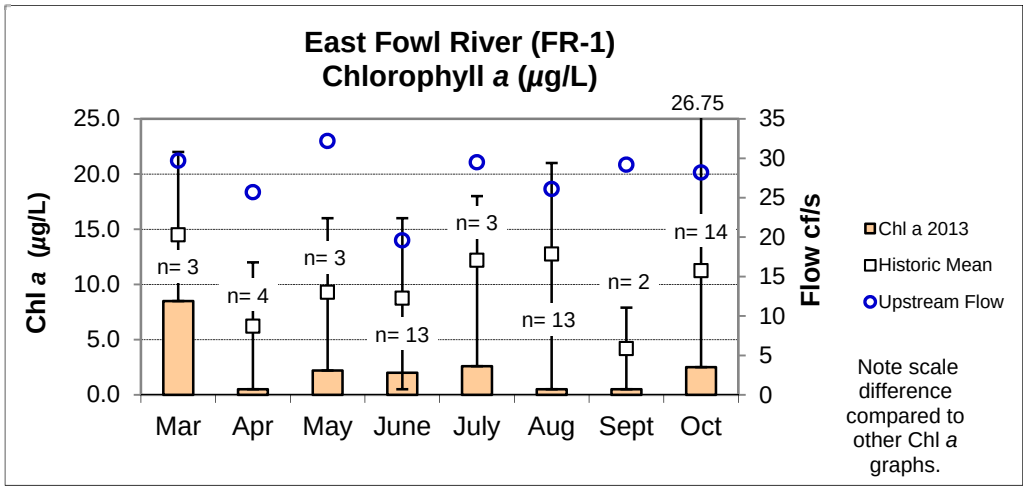


Figure 8. Monthly chl *a* concentrations measured in the Fowl River Sub-Watershed, March-October 2013. Each bar graph depicts changes in each station. The historic mean (1990-2013) and min/max ranges are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. Flow was measured at the most upstream station, FWLM-2.







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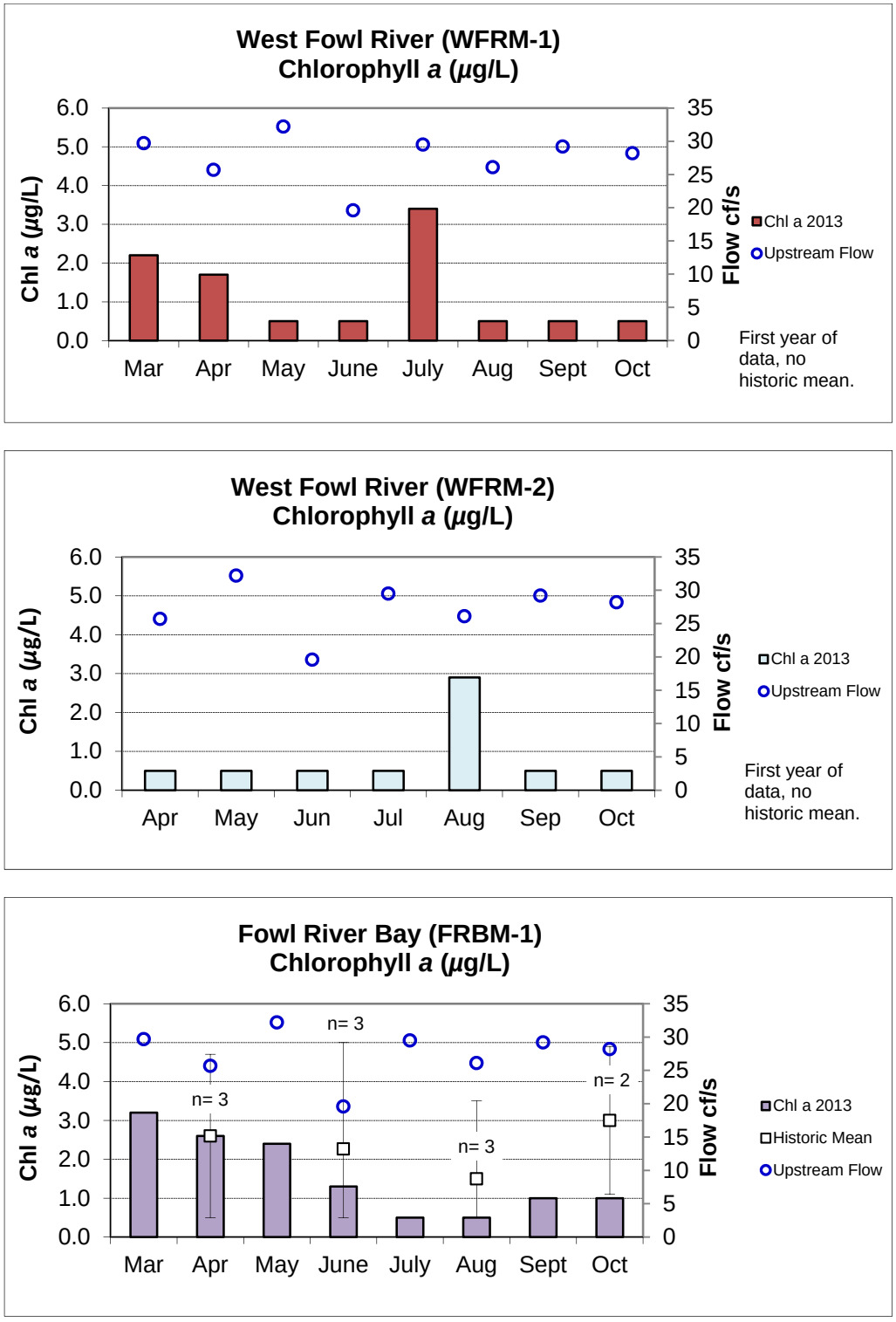
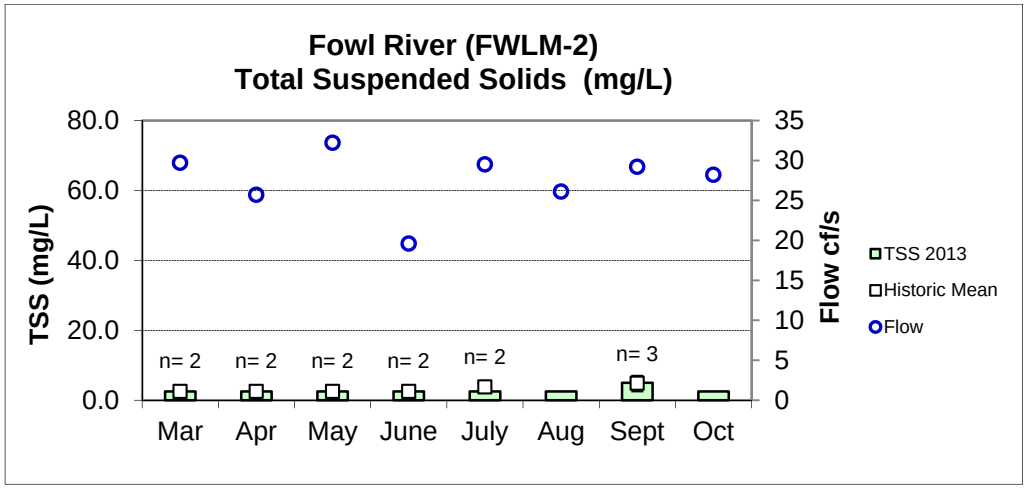
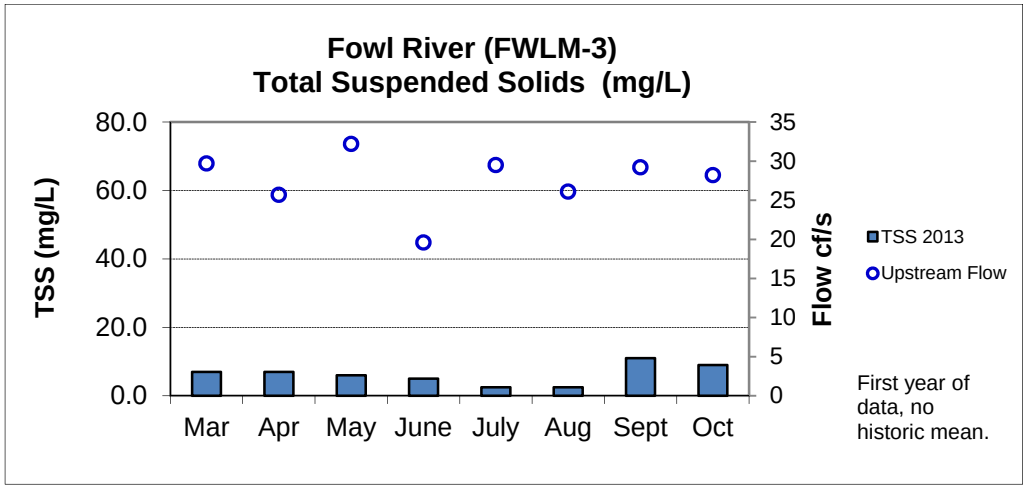
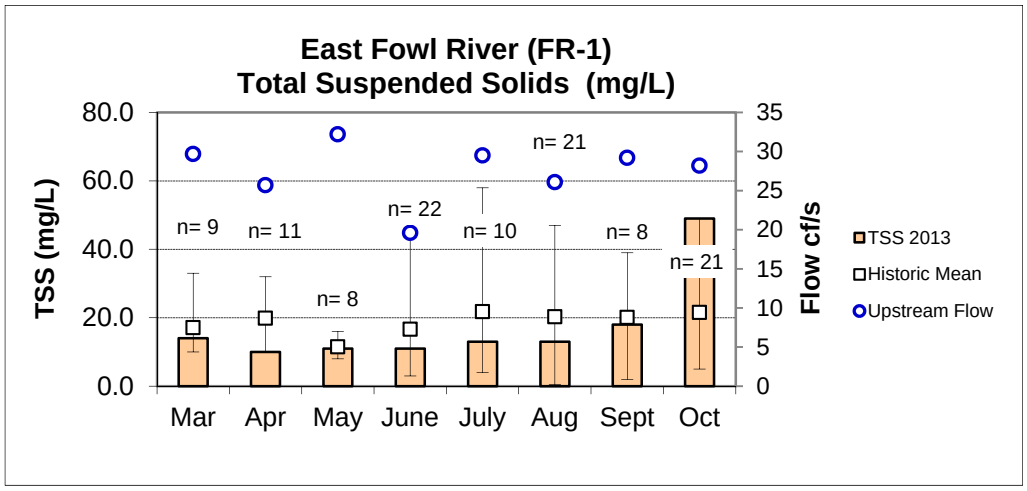


Figure 9. Monthly TSS concentrations measured in the Fowl River Sub-Watershed, March-October 2013. Each bar graph depicts changes in each station. The historic mean (1990-2013) and min/max ranges are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. Flow was measured at the most upstream station, FWLM-2.







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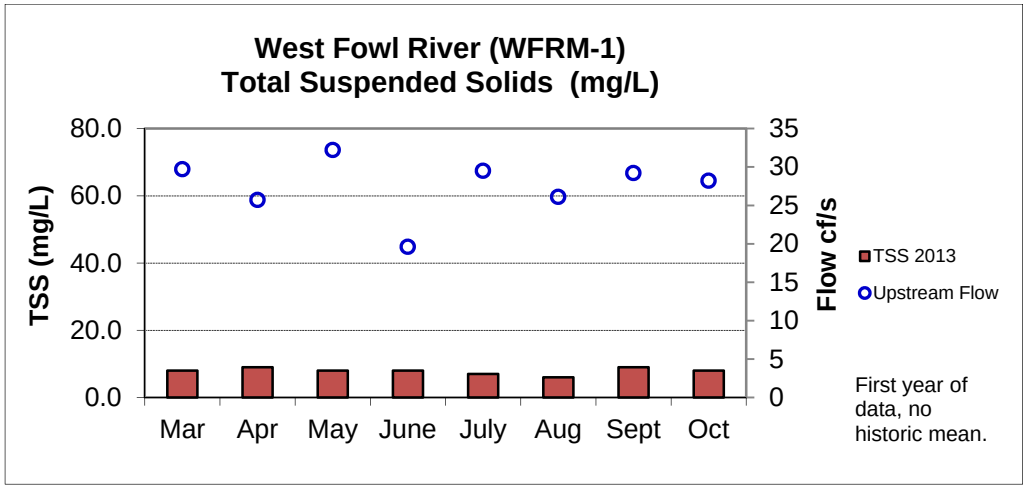
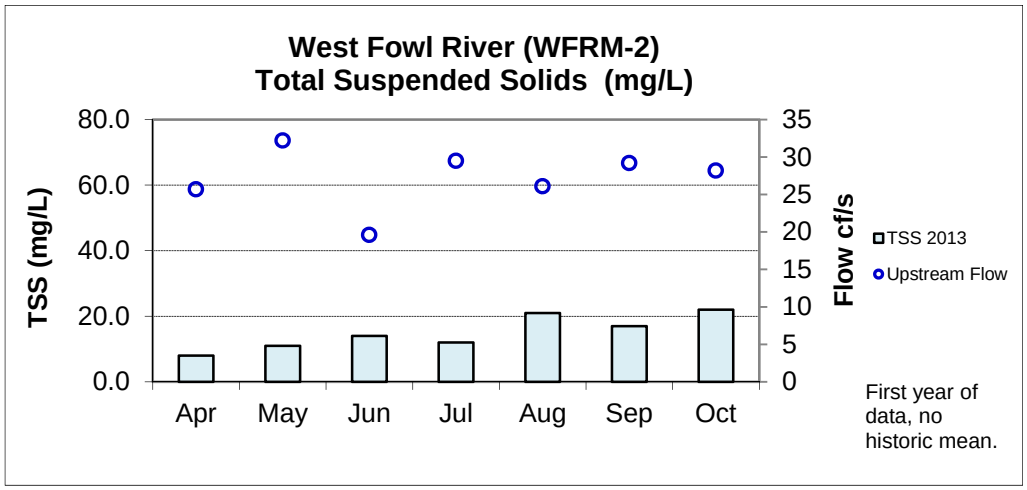




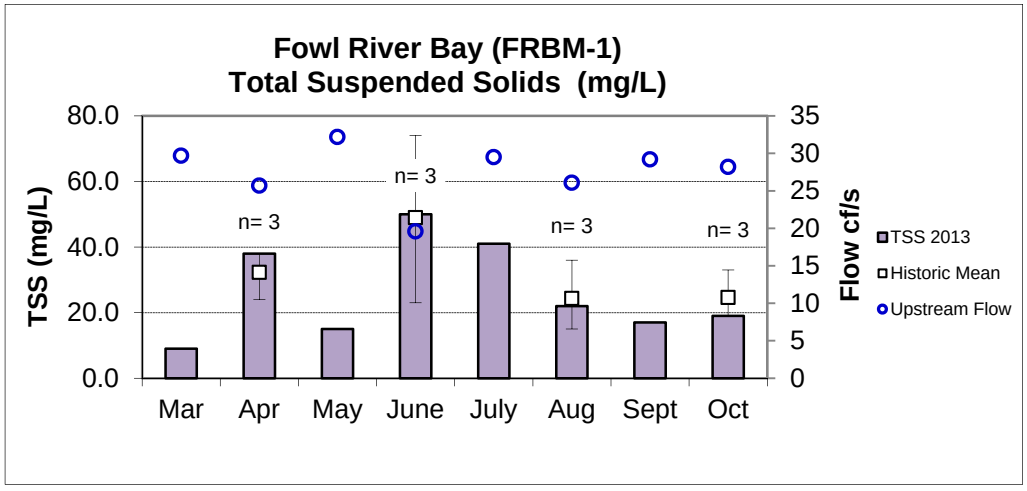
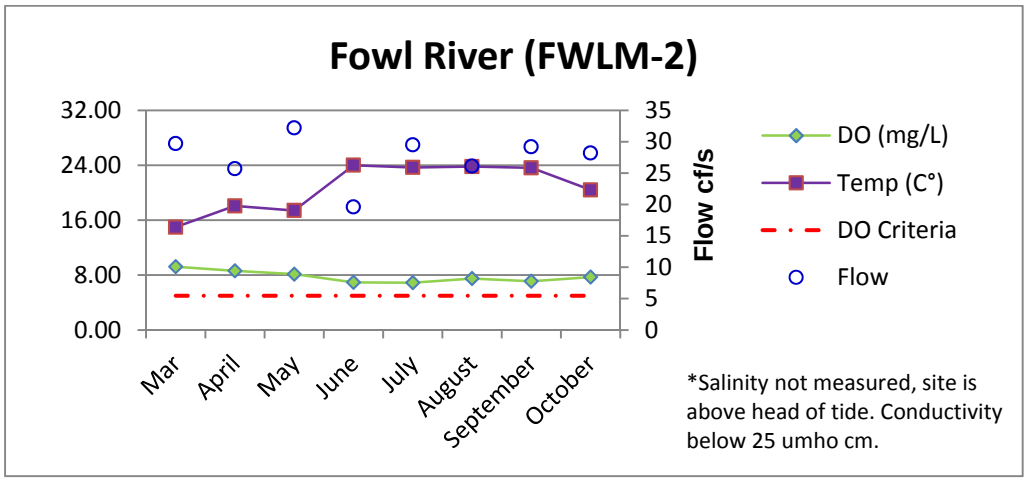
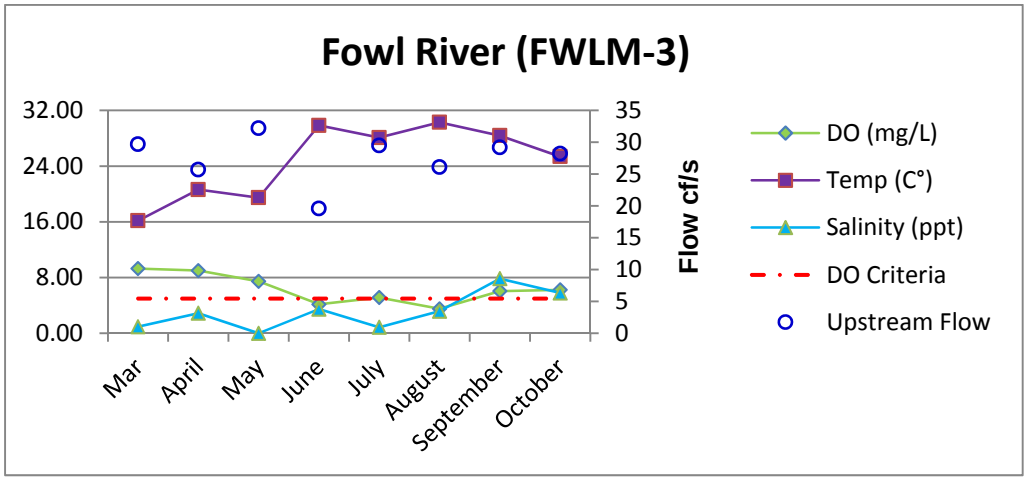
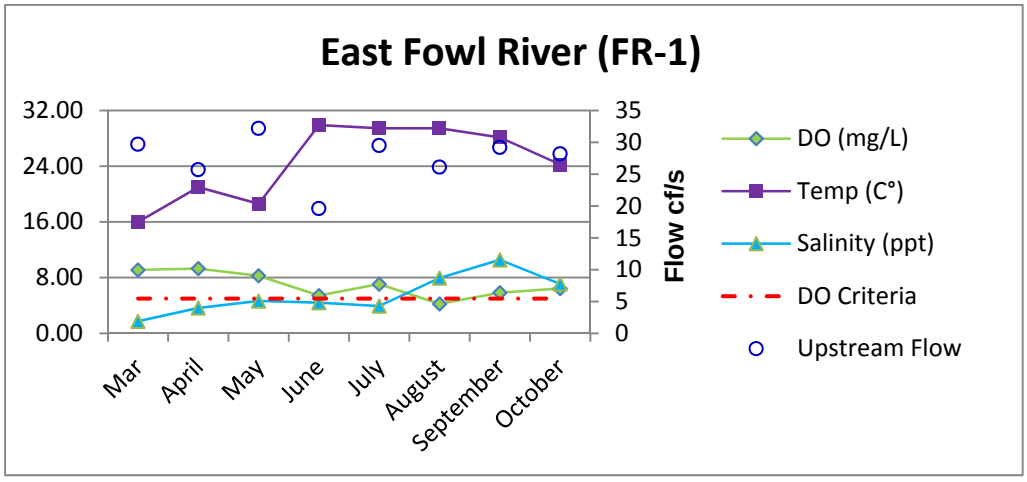


Figure 10. Monthly DO, temperature, and salinity concentrations at 1.5 m (5 ft), or mid-depth, for the Fowl River Sub-Watershed stations collected March-October 2013. ADEM Water Quality Criteria requires a DO concentration of 5.0 mg/L at this depth (ADEM 2012). Flow was measured at the most upstream station, FWLM-2.







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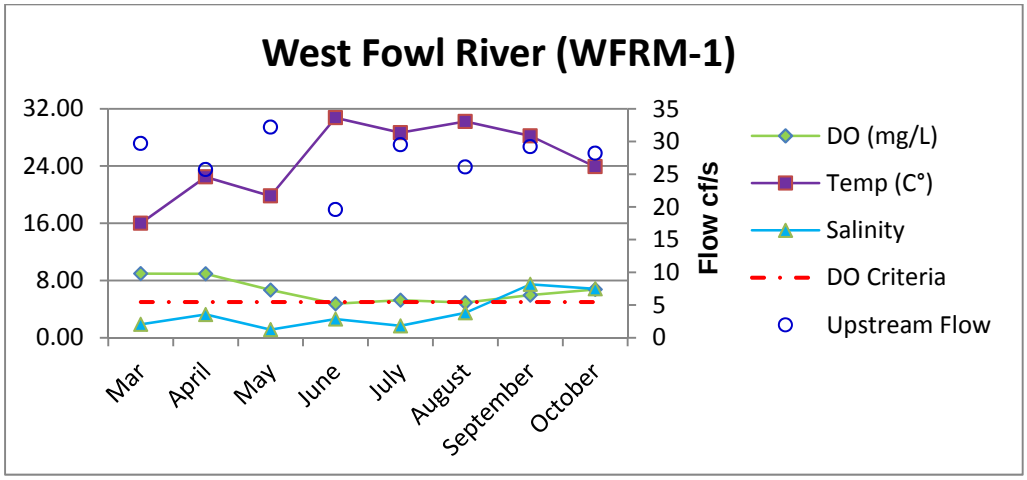
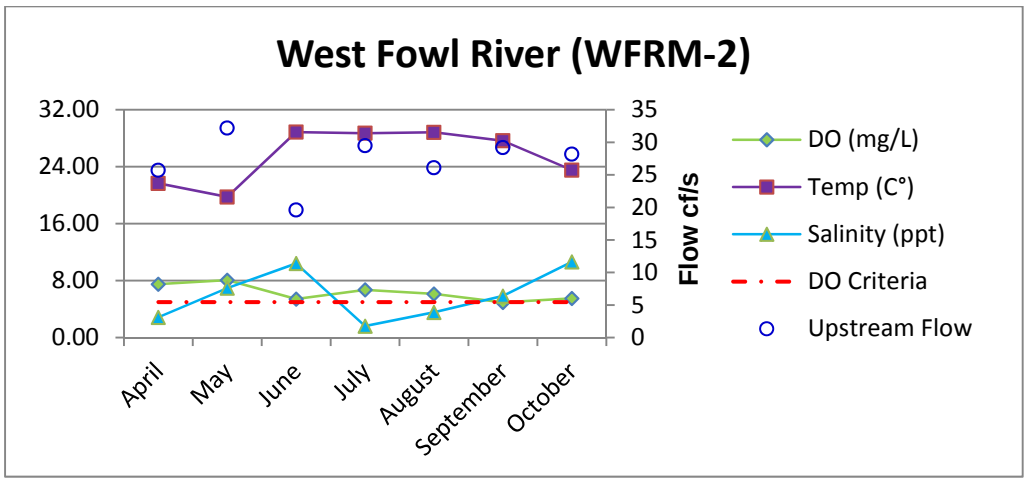




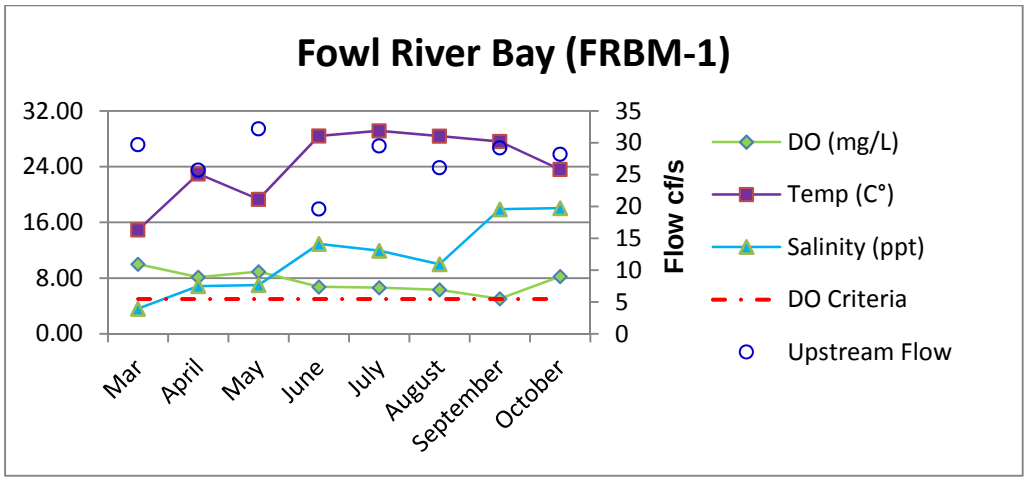


Figure 11. Monthly depth profiles of dissolved oxygen, temperature, and salinity for Fowl River Sub-Watershed, March-October 2013.

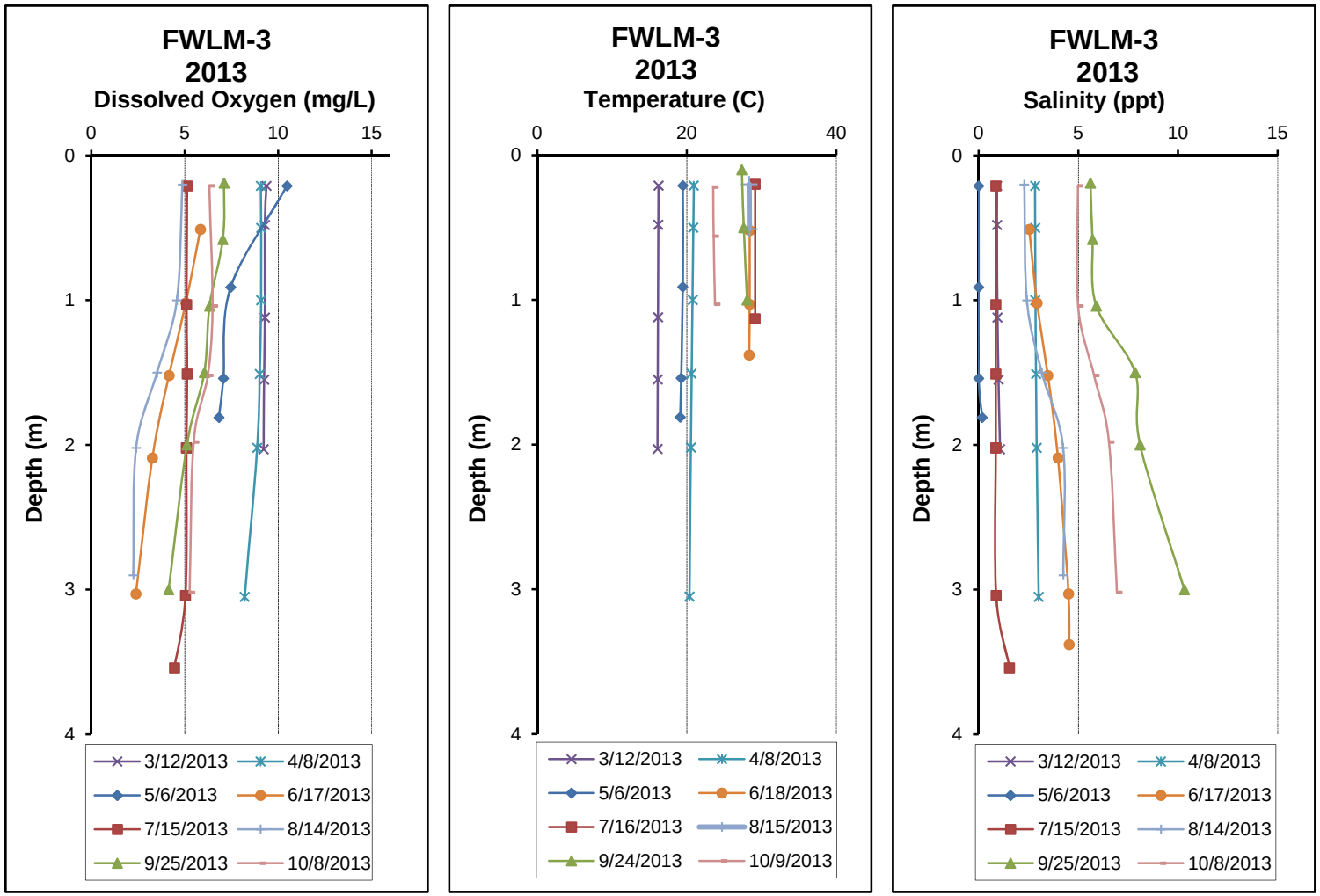


Figure 11. (continued)

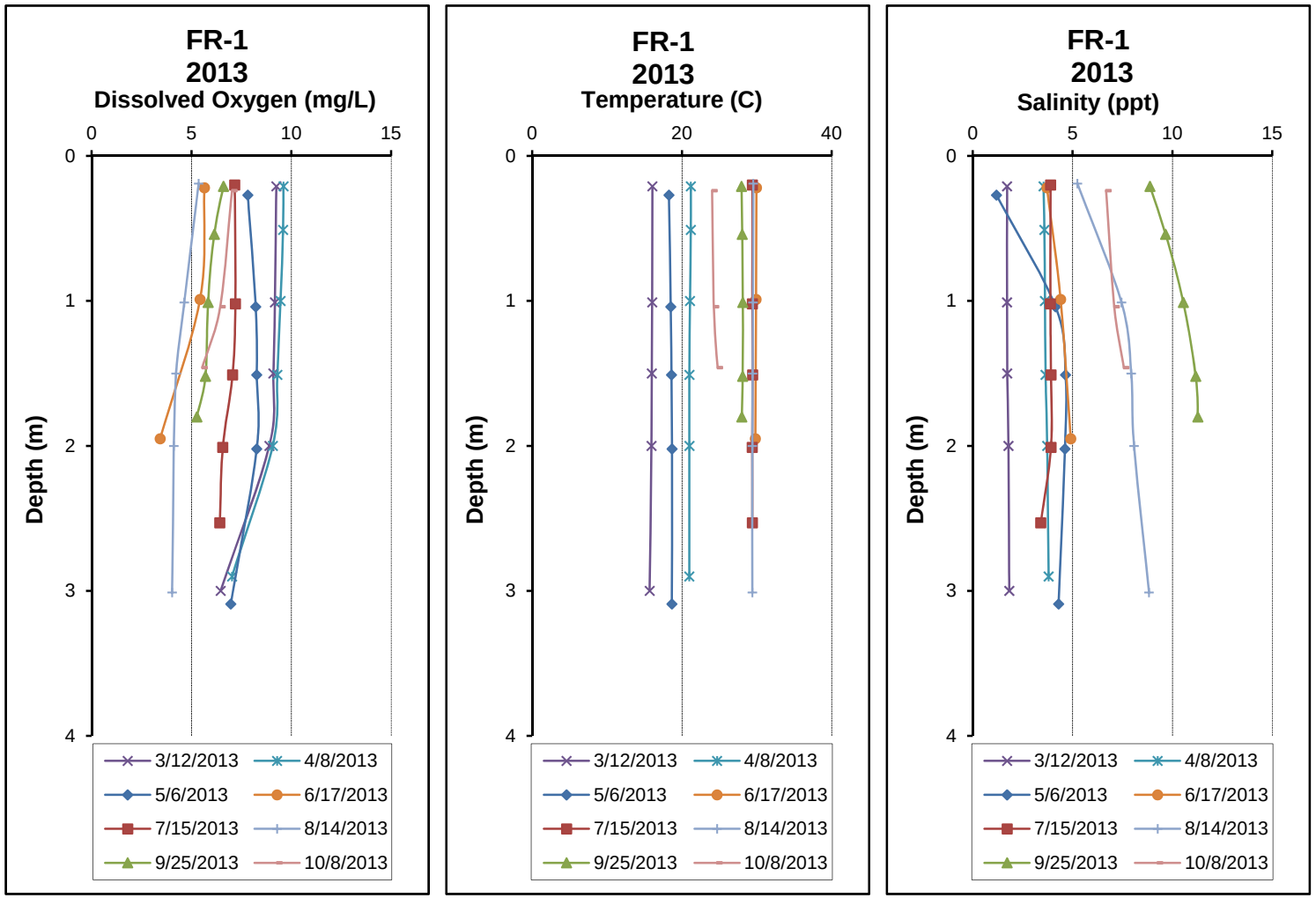


Figure 11. (continued)

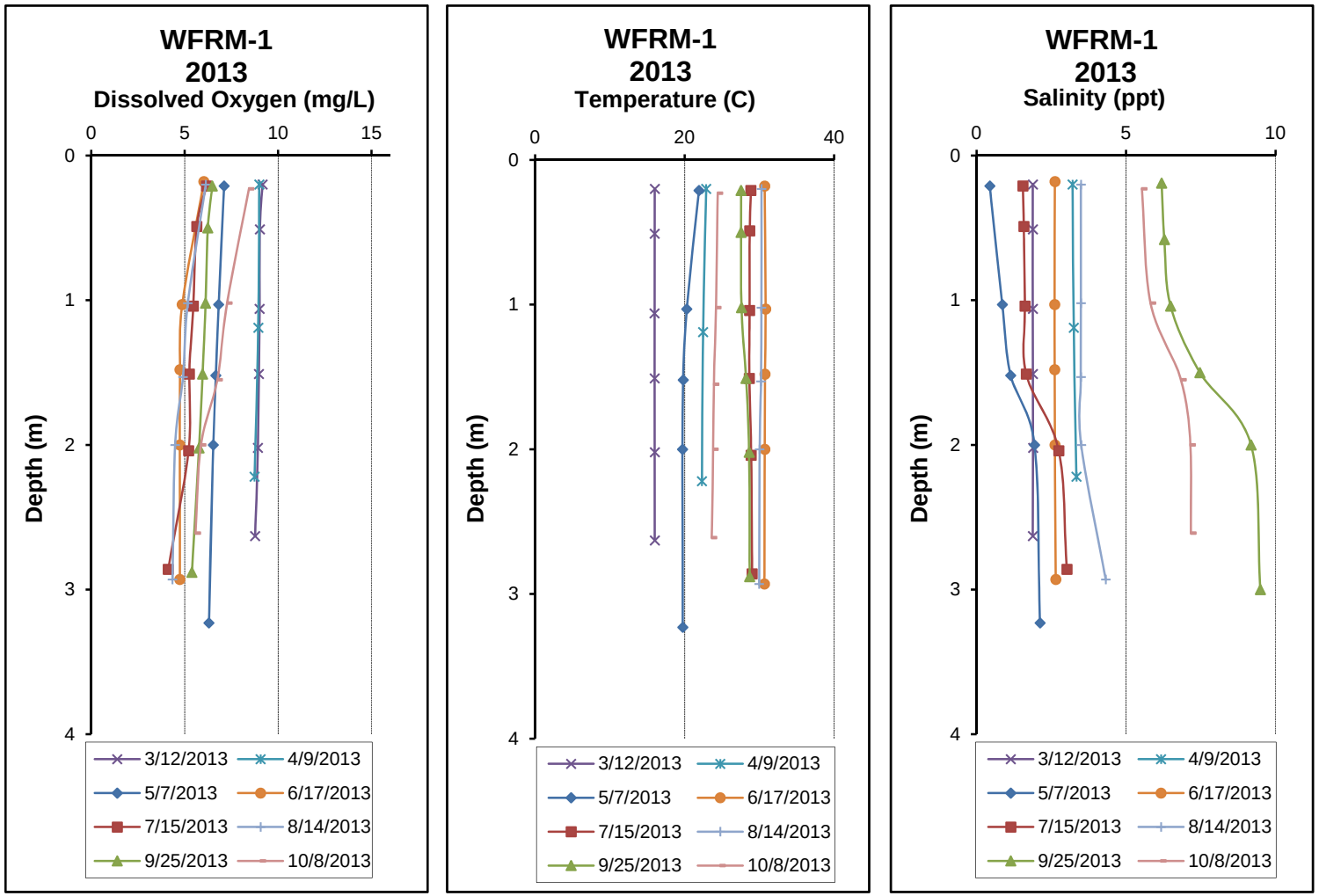


Figure 11. (continued)

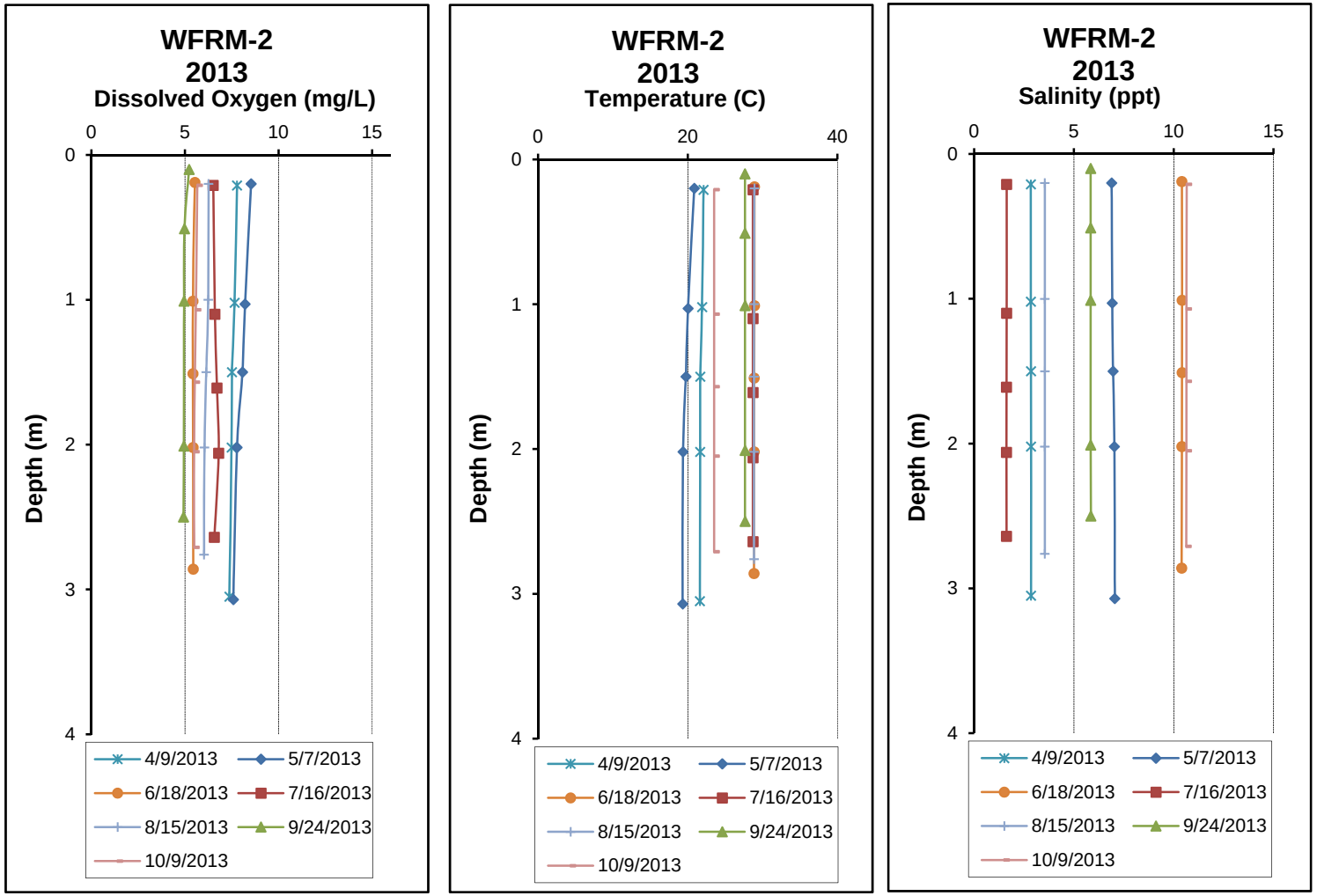
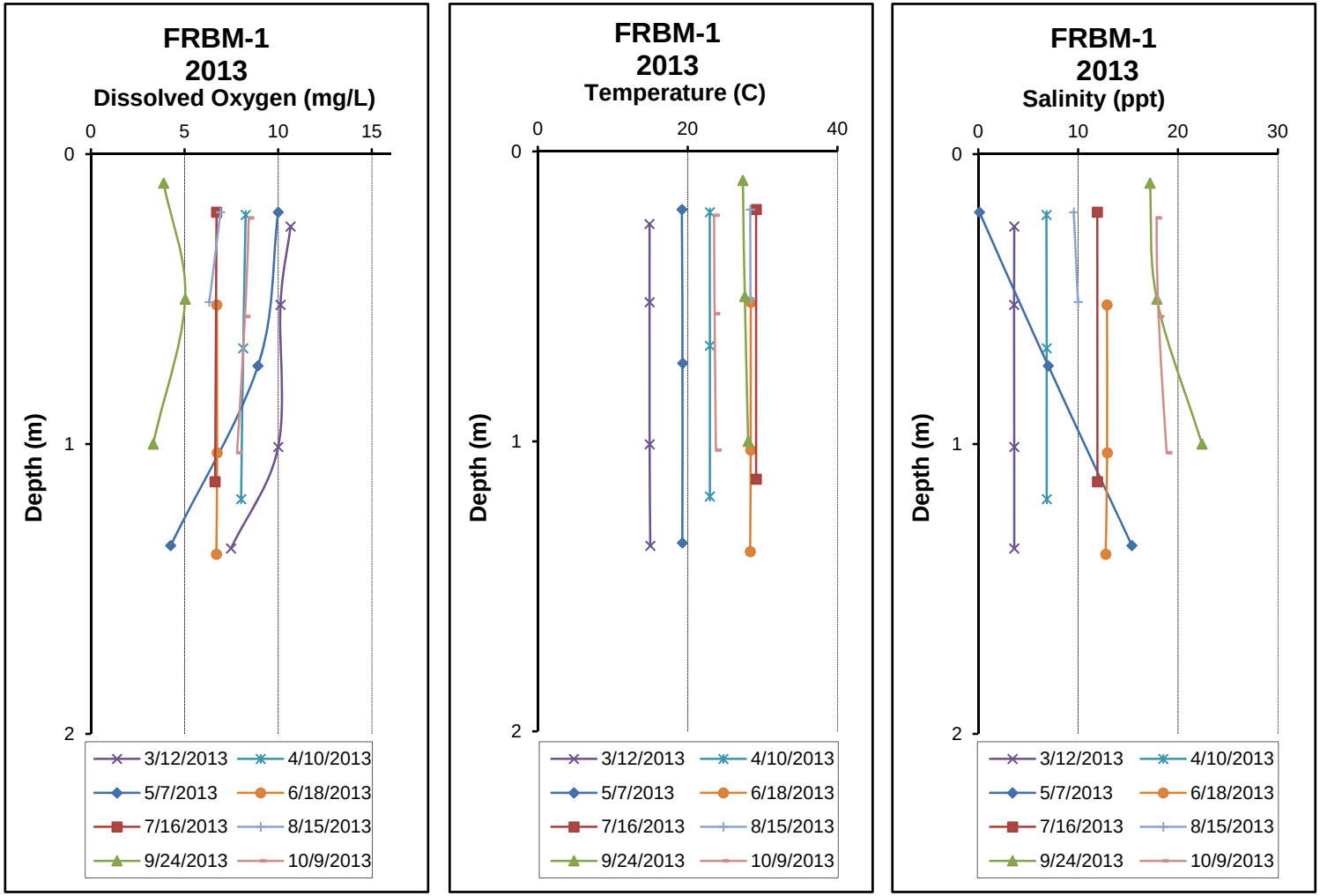


Figure 11. (continued)



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APPENDIX

Appendix Table 1. Summary of Fowl River Sub-Watershed water quality data collected March-October, 2013. Minimum (min) and maximum (max) values calculated using minimum detection limits when results were less than this value. Median (med), mean, and standard deviation (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

Station	Parameter	N	Min	Max	Med	Avg	SD	E	Q
FR-1	**Physical**								
	Temperature (°C)	8	16.0	29.9	26.2	24.6	5.5		
	Turbidity (NTU)	8	12.8	31.2	16.6	18.6	6.2		
	Total Dissolved Solids (mg/L)	8	1800.0	9930.0	4,090.0	4906.2	2745.9		
	Total Suspended Solids (mg/L)	8	10.0	49.0	13.0	17.4	13.0		
	Specific Conductance (µmhos)	8	3292.1	17942.0	8,166.6	9701.3	4684.3		
	Hardness (mg/L)	3	591.0	1620.0	752.0	987.7	553.5		
J	Alkalinity (mg/L)	8	22.0	64.0	40.0	42.4	15.3		
	Stream Flow (cfs)	7	-1297.3	2366.3	604.9	916.2	1307.9		
	Chemical								
	Dissolved Oxygen (mg/L)	8	4.2 C	9.3	6.8	7.0	1.8	2	
	pH (su)	8	7.0	8.1	7.5	7.4	0.4		
J	Ammonia Nitrogen (mg/L)	8	< 0.020	0.120	0.035	0.046	0.037		
J	Nitrate+Nitrite Nitrogen (mg/L)	8	< 0.011	0.047	0.008	0.014	0.014		
J	Total Kjeldahl Nitrogen (mg/L)	8	0.430	1.000	0.735	0.732	0.208		
J	Total Nitrogen (mg/L)	8	< 0.436	< 1.008	0.755	0.746	0.207		
J	Dissolved Reactive Phosphorus (mg/	8	0.007	0.017	0.012	0.012	0.003		
J	Total Phosphorus (mg/L)	8	0.048	0.100	0.059	0.064	0.016		
J	CBOD-5 (mg/L)	8	< 2.0	2.5	1.0	1.3	0.6		
	Chlorides (mg/L)	8	960.0	6100.0	2,300.0	2882.5	1728.8		
	Total Metals								
J	Aluminum (mg/L)	3	0.611	0.927	0.706	0.748	0.162		
	Iron (mg/L)	3	0.356	0.528	0.397	0.427	0.090		
	Manganese (mg/L)	3	0.054	0.103	0.054	0.070	0.028		
	Dissolved Metals								
J	Aluminum (mg/L)	3	< 0.077	< 0.077	0.038	0.038	0.000		
J	Antimony (µg/L)	3	0.1	0.7	0.3	0.4	0.3		
J	Arsenic (µg/L)	3	1.8	4.4 A	2.1	2.8	1.4	3	2
	Cadmium (µg/L)	3	< 0.080	< 0.080	0.040	0.040	0.000		
J	Chromium (µg/L)	3	0.041	1.590	0.914	0.848	0.776		
J	Copper (mg/L)	3	0.001	0.008	0.002	0.004	0.004		
	Iron (mg/L)	3	< 0.016	< 0.016	0.008	0.008	0.000		
J	Lead (µg/L)	3	0.1	0.2	0.2	0.2	0.1		
J	Manganese (mg/L)	3	< 0.003	0.046	0.017	0.022	0.022		
J	Nickel (mg/L)	3	0.002	0.002	0.002	0.002	0.000		
J	Selenium (µg/L)	3	6.0	14.2 A	6.8	9.0	4.5	3	
	Silver (µg/L)	3	< 2.110	< 2.110	1.055	1.055	0.000		
J	Thallium (µg/L)	3	0.007	0.027	0.018	0.017	0.010		
J	Zinc (mg/L)	3	< 0.002	0.028	0.005	0.011	0.015		
	Biological								
	Chlorophyll a (ug/L)	8	< 1.00	8.50	2.10	2.41	2.63		
J	Enterococci(col/dL)	5	2	8	4	4	4		
J	Enterococci(mpn/dL)	3	10	20	10	12	8		

A=*S,F&W* aquatic life use criterion exceeded; C=*S,F&W* criterion violated; E=# samples that exceeded criteria; J= estimate N=# samples; Q=number of samples that have uncertain exceedances.

Station		Parameter	N		Min		Max		Med	Avg	SD	E	Q
FRBM-1		**Physical**											
		Temperature (°C)	8		14.9		29.1		25.6	24.3	5.1		
		Turbidity (NTU)	8		8.8		50.6		26.8	27.6	14.6		
		Total Dissolved Solids (mg/L)	8		3710.0		17800.0		12,600.0	11887.5	4569.8		
		Total Suspended Solids (mg/L)	8		9.0		50.0		20.5	26.4	14.6		
		Specific Conductance (µmhos)	8		6539.0		29207.1		18,584.8	18465.5	8157.6		
		Hardness (mg/L)	3		1190.0		2500.0		1,500.0	1730.0	684.6		
		Alkalinity (mg/L)	8		41.0		88.0		51.5	58.6	17.5		
		Chemical											
		Dissolved Oxygen (mg/L)	8		5.0		10.0		7.4	7.5	1.6		
		pH (su)	8		7.4		8.0		7.8	7.7	0.2		
	J	Ammonia Nitrogen (mg/L)	8	<	0.025		0.110		0.030	0.050	0.040		
	J	Nitrate+Nitrite Nitrogen (mg/L)	8	<	0.011		0.056		0.024	0.026	0.021		
	J	Total Kjeldahl Nitrogen (mg/L)	8		0.310		1.100		0.745	0.694	0.278		
	J	Total Nitrogen (mg/L)	8	<	0.333		1.133		0.760	0.720	0.278		
	J	Dissolved Reactive Phosphorus (mg/L)	8	<	0.006		0.035		0.020	0.017	0.013		
	J	Total Phosphorus (mg/L)	8		0.047		0.090		0.076	0.073	0.016		
	J	CBOD-5 (mg/L)	8	<	2.0		2.6		2.2	1.8	0.7		
		Chlorides (mg/L)	8		2100.0		9990.0		7,400.0	6973.8	2671.9		
		Total Metals											
	J	Aluminum (mg/L)	4		0.560		3.630		2.060	2.078	1.433		
	J	Iron (mg/L)	4		0.217		1.830		1.079	1.051	0.755		
	J	Manganese (mg/L)	4		0.048		0.094		0.088	0.080	0.021		
		Dissolved Metals											
	J	Aluminum (mg/L)	4	<	0.077	<	0.077		0.038	0.038	0.000		
	J	Antimony (µg/L)	4		0.200		1.890		0.200	0.600	0.800		
	J	Arsenic (µg/L)	4		2.69		7.69	A	5.40	5.29	2.09	4	1
	J	Cadmium (µg/L)	4	<	0.080		0.111		0.040	0.058	0.036		
	J	Chromium (µg/L)	4		0.294		3.570		1.247	1.590	1.416		
	J	Copper (mg/L)	4		0.002		0.003		0.002	0.002	0.001		
	J	Iron (mg/L)	4	<	0.016	<	0.016		0.008	0.008	0.000		
	J	Lead (µg/L)	4	<	0.024		0.600		0.090	0.200	0.290		
	J	Manganese (mg/L)	4	<	0.003		0.014		0.005	0.006	0.006		
	J	Nickel (mg/L)	4		0.002		0.005		0.003	0.003	0.001		
	J	Selenium (µg/L)	4		12.3		28.0	A	22.0	21.1	7.4	4	
	J	Silver (µg/L)	4	<	2.110	<	4.220		1.055	1.319	0.528		
	J	Thallium (µg/L)	4	<	0.003		0.090		0.003	0.021	0.037		
	J	Zinc (mg/L)	4	<	0.002		0.018		0.002	0.006	0.008		
		Biological											
		Chlorophyll a (ug/L)	7	<	1.00		3.20		1.30	1.64	1.08		
	J	Fecal Coliform (col/100 mL)	8		1		10		1	2	3		
		Enterococci (col/dL)	5		2		2		1	1	0		
	J	Enterococci (mpn/dL)	3		10		60		10	25	30		

A=*S,F&W* aquatic life use criterion exceeded; E=# samples that exceeded criteria; J= estimate; N=# samples; Q=number of samples that have uncertain exceedances.

Station		Parameter	N		Min		Max		Med	Avg	SD	E	Q
FWLM-2		**Physical**											
		Temperature (° C)	8		15.0		24.0		22.0	20.7	3.6		
		Turbidity (NTU)	8		3.3		7.0		5.5	5.4	1.5		
		Total Dissolved Solids (mg/L)	8		40.0		61.0		49.5	49.6	6.8		
		Total Suspended Solids (mg/L)	8	<	5.0		5.0		2.5	2.8	0.9		
		Specific Conductance (µmhos)	8		62.0		67.0		64.0	64.1	1.6		
	J	Hardness (mg/L)	4		11.6		16.0		14.6	14.2	2.0		
	J	Alkalinity (mg/L)	8		4.0		26.0		8.8	10.8	6.8		
		Stream Flow (cfs)	8		18.0		32.0		27.5	26.6	4.7		
		Chemical											
		Dissolved Oxygen (mg/L)	8		6.9		9.2		7.6	7.8	0.8		
		pH (su)	8		6.0		7.6		6.4	6.6	0.7		
	J	Ammonia Nitrogen (mg/L)	8	<	0.025		0.120		0.034	0.047	0.038		
	J	Nitrate+Nitrite Nitrogen (mg/L)	8		0.427		0.587		0.523	0.520	0.057		
	J	Total Kjeldahl Nitrogen (mg/L)	8	<	0.071		0.430		0.320	0.277	0.144		
	J	Total Nitrogen (mg/L)	8	<	0.622		0.954		0.790	0.797	0.129		
	J	Dissolved Reactive Phosphorus (mg/L)	8	<	0.006		0.010		0.004	0.006	0.003		
	J	Total Phosphorus (mg/L)	8		0.014		0.024		0.018	0.018	0.003		
	J	CBOD-5 (mg/L)	8	<	2.0	<	2.0		1.0	1.0	0.0		
		Chlorides (mg/L)	8		8.0		9.4		8.8	8.7	0.5		
		Total Metals											
	J	Aluminum (mg/L)	4		0.216		0.370		0.250	0.272	0.068		
		Iron (mg/L)	4		0.703		0.981		0.800	0.821	0.131		
	J	Manganese (mg/L)	4		0.034		0.044		0.038	0.038	0.005		
		Dissolved Metals											
	J	Aluminum (mg/L)	4	<	0.077		0.236		0.073	0.105	0.093		
	J	Antimony (µg/L)	4	<	0.04	<	0.04		0.04	0.04	0.00		
	J	Arsenic (µg/L)	4		0.2		0.5	A	0.4	0.4	0.1		4
	J	Cadmium (µg/L)	4	<	0.080		0.151	S	0.040	0.068	0.056	1	
	J	Chromium (µg/L)	4		0.308		0.709		0.496	0.502	0.206		
	J	Copper (mg/L)	4		0.0002		0.0006		0.0004	0.0004	0.0001		
		Iron (mg/L)	4		0.441		0.663		0.530	0.541	0.103		
	J	Lead (µg/L)	4		0.2		0.3	S	0.2	0.2	0.0		2
	J	Manganese (mg/L)	4		0.023		0.033		0.026	0.027	0.005		
	J	Nickel (mg/L)	4	<	0.0002		0.0003		0.0003	0.0003	0.0001		
	J	Selenium (µg/L)	4	<	0.09	<	0.29		0.09	0.09	0.00		
	J	Silver (µg/L)	4	<	2.110	<	2.110		1.055	1.055	0.000		
	J	Thallium (µg/L)	4	<	0.003		0.017		0.003	0.007	0.007		
	J	Zinc (mg/L)	4	<	0.002		0.003		0.001	0.002	0.001		
		Biological											
		Chlorophyll a (ug/L)	8	<	1.00		1.20		0.50	0.68	0.32		
	J,G	Enterococci(col/dL)	5		28		600		100	182	236		
	J	Enterococci(mpn/dL)	3		120		700		120	313	335		

A=*S,F&W* aquatic life use criterion exceeded; E=# samples that exceeded criteria; G=value higher than median concentration of all verified ecoregional reference reach data collection in the ecoregion 75a; J= estimate; N=# samples; Q=number of samples that have uncertain exceedances; S=SF&W hardness-adjusted aquatic life use criteria exceeded.

Station		Parameter	N		Min		Max	Med	Avg	SD	E	Q
FWLM-3		**Physical**										
		Temperature (° C)	10		16.1		30.9	26.7	24.5	5.9		
		Turbidity (NTU)	8		5.5		19.0	7.6	9.7	4.7		
		Total Dissolved Solids (mg/L)	8		167.0		6560.0	2,765.0	2878.1	2244.8		
		Total Suspended Solids (mg/L)	8	<	5.0		11.0	6.5	6.2	3.0		
		Specific Conductance (µmhos)	10		2.2		13673.3	5,610.1	5481.5	4297.3		
		Hardness (mg/L)	3		461.0		1180.0	601.0	747.3	381.2		
	J	Alkalinity (mg/L)	8		6.0		50.0	28.0	27.1	16.5		
		Stream Flow (cfs)	6		-556.8		1787.3	611.4	653.4	830.7		
		Chemical										
		Dissolved Oxygen (mg/L)	10		2.4	C	9.3	6.1	6.2	2.5	3	
		pH (su)	10		6.7		7.6	7.1	7.1	0.4		
	J	Ammonia Nitrogen (mg/L)	8	<	0.010		0.120	0.052	0.061	0.047		
	J	Nitrate+Nitrite Nitrogen (mg/L)	8	<	0.011		0.188	0.055	0.062	0.061		
	J	Total Kjeldahl Nitrogen (mg/L)	8		0.380		0.880	0.670	0.655	0.183		
	J	Total Nitrogen (mg/L)	8	<	0.455		1.048	0.708	0.717	0.204		
	J	Dissolved Reactive Phosphorus (mg/L)	8	<	0.003		0.014	0.008	0.008	0.004		
	J	Total Phosphorus (mg/L)	8		0.040		0.060	0.046	0.048	0.008		
	J	CBOD-5 (mg/L)	8	<	2.0		2.0	1.0	1.0	0.0		
	J	Chlorides (mg/L)	8		65.0		4100.0	1,500.0	1671.9	1413.4		
		Total Metals										
	J	Aluminum (mg/L)	3		0.207		0.505	0.421	0.378	0.154		
	J	Iron (mg/L)	3		0.128		0.346	0.311	0.262	0.117		
		Manganese (mg/L)	3		0.062		0.138	0.064	0.088	0.043		
		Dissolved Metals										
	J	Aluminum (mg/L)	3	<	0.077		0.106	0.080	0.075	0.034		
	J	Antimony (µg/L)	3		0.1		0.4	0.2	0.2	0.2		
	J	Arsenic (µg/L)	3		1.6		3.3	A 2.3	2.4	0.9	3	2
		Cadmium (µg/L)	3	<	0.080	<	0.080	0.040	0.040	0.000		
	J	Chromium (µg/L)	3		0.318		1.470	0.782	0.857	0.580		
	J	Copper (mg/L)	3		0.001		0.002	0.001	0.001	0.000		
	J	Iron (mg/L)	3	<	0.016		0.054	0.018	0.027	0.024		
	J	Lead (µg/L)	3		0.1		0.2	0.1	0.1	0.0		
	J	Manganese (mg/L)	3		0.021		0.102	0.023	0.049	0.046		
	J	Nickel (mg/L)	3		0.001		0.002	0.001	0.001	0.000		
	J	Selenium (µg/L)	3		5.2		9.0	A 6.4	6.9	1.9	2	
	J	Silver (µg/L)	3	<	2.110	<	2.110	1.055	1.055	0.000		
	J	Thallium (µg/L)	3	<	0.003		0.010	0.003	0.005	0.004		
		Zinc (mg/L)	3	<	0.002		0.022	0.005	0.009	0.011		
		Biological										
		Chlorophyll a (ug/L)	8	<	1.00		7.90	2.20	2.52	2.48		
	J	Enterococci(col/dL)	5		2		8	6	4	3		
	J	Enterococci(mpn/dL)	3		20		30	30	27	6		

A=*S,F&W* aquatic life use criterion exceeded; C=*S,F&W* criterion violated; E=# samples that exceeded criteria; J= estimate; N=# samples; Q=number of samples that have uncertain exceedances.

Station		Parameter	N		Min		Max	Med	Avg	SD	E	Q
WFRM-1		**Physical**										
		Temperature (°C)	10		16.0		30.8	26.1	24.5	5.7		
		Turbidity (NTU)	8		5.4		18.3	9.6	11.4	4.5		
		Total Dissolved Solids (mg/L)	8		557.0		6890.0	2,990.0	3334.6	2206.9		
		Total Suspended Solids (mg/L)	8		6.0		9.0	8.0	7.9	1.0		
		Specific Conductance (µmhos)	10		2220.3		15796.7	5,443.4	7071.0	4777.2		
		Hardness (mg/L)	3		503.0		1250.0	541.0	764.7	420.7		
	J	Alkalinity (mg/L)	8		8.0		51.0	31.5	33.4	14.0		
		Stream Flow (cfs)	5		156.5		657.5	392.8	384.5	190.5		
		Chemical										
		Dissolved Oxygen (mg/L)	10		4.8 [C]		9.0	6.3	6.7	1.7	2	
		pH (su)	10		6.8		7.6	7.3	7.2	0.2		
	J	Ammonia Nitrogen (mg/L)	8	<	0.025		0.120	0.065	0.065	0.040		
	J	Nitrate+Nitrite Nitrogen (mg/L)	8	<	0.011		0.144	0.013	0.037	0.048		
	J	Total Kjeldahl Nitrogen (mg/L)	8		0.220		0.840	0.660	0.622	0.213		
	J	Total Nitrogen (mg/L)	8	<	0.228		0.904	0.696	0.660	0.233		
	J	Dissolved Reactive Phosphorus (mg/L)	8	<	0.003		0.013	0.008	0.008	0.005		
	J	Total Phosphorus (mg/L)	8		0.039		0.061	0.044	0.046	0.007		
	J	CBOD-5 (mg/L)	8	<	2.0		2.1	1.0	1.1	0.4		
		Chlorides (mg/L)	8		290.0		4300.0	1,700.0	1951.2	1380.0		
		Total Metals										
	J	Aluminum (mg/L)	3		0.355		0.676	0.495	0.509	0.161		
	J	Iron (mg/L)	3		0.163		0.437	0.295	0.298	0.137		
		Manganese (mg/L)	3		0.054		0.109	0.059	0.074	0.030		
		Dissolved Metals										
	J	Aluminum (mg/L)	3	<	0.077		0.080	0.038	0.052	0.024		
	J	Antimony (µg/L)	3		0.1		0.4	0.1	0.2	0.2		
	J	Arsenic (µg/L)	3		1.8		3.5 [A]	2.2	2.5	0.9	3	2
	J	Cadmium (µg/L)	3	<	0.080		0.109	0.040	0.063	0.040		
	J	Chromium (µg/L)	3		0.418		1.280	0.749	0.816	0.435		
	J	Copper (mg/L)	3		0.001		0.002	0.001	0.001	0.000		
	J	Iron (mg/L)	3	<	0.016		0.110	0.008	0.042	0.059		
	J	Lead (µg/L)	3		0.1		0.2	0.2	0.2	0.1		
	J	Manganese (mg/L)	3		0.008		0.085	0.026	0.040	0.040		
	J	Nickel (mg/L)	3		0.001		0.001	0.001	0.001	0.000		
	J	Selenium (µg/L)	3		5.7		9.3 [A]	6.0	7.0	2.0	3	1
	J	Silver (µg/L)	3	<	2.110	<	2.110	1.055	1.055	0.000		
	J	Thallium (µg/L)	3	<	0.003		0.016	0.003	0.007	0.008		
	J	Zinc (mg/L)	3	<	0.002		0.031	0.004	0.012	0.017		
		Biological										
		Chlorophyll a (ug/L)	8	<	1.00		3.40	0.50	1.22	1.10		
	J	Enterococci (col/dL)	4		6		12	10	10	3		
	J	Enterococci (mpn/dL)	3		10		30	20	18	13		

A=*S,F&W* aquatic life use criterion exceeded; C=*S,F&W* criterion violated; E=# samples that exceeded criteria; J= estimate; N=# samples; Q=number of samples that have uncertain exceedances.

Station		Parameter	N		Min		Max	Med	Avg	SD	E	Q
WFRM-2		**Physical**										
		Temperature (° C)	8		19.8		28.9	28.2	26.0	3.7		
		Turbidity (NTU)	7		10.6		31.7	13.9	16.8	7.1		
		Total Dissolved Solids (mg/L)	7		1720.0		10700.0	4,960.0	5852.8	3554.1		
		Total Suspended Solids (mg/L)	7		8.0		22.0	14.0	15.0	5.2		
		Specific Conductance (µmhos)	8		3133.8		18000.9	11,259.2	11368.9	6038.2		
		Hardness (mg/L)	3		484.0		1980.0	1,040.0	1168.0	756.2		
		Alkalinity (mg/L)	7		26.0		65.0	48.0	46.4	15.2		
		Stream Flow (cfs)	5		441.7		705.9	549.0	565.3	96.1		
		Chemical										
		Dissolved Oxygen (mg/L)	8		4.9 [C]		8.1	5.8	6.2	1.1	1	
		pH (su)	8		6.8		7.5	7.2	7.2	0.3		
	J	Ammonia Nitrogen (mg/L)	7	<	0.025		0.070	0.040	0.040	0.024		
	J	Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.011		0.097	0.008	0.036	0.039		
	J	Total Kjeldahl Nitrogen (mg/L)	7		0.370		1.200	0.730	0.760	0.342		
	J	Total Nitrogen (mg/L)	7	<	0.446		1.248	0.827	0.796	0.339		
	J	Dissolved Reactive Phosphorus (mg/L)	7	<	0.006		0.019	0.008	0.008	0.006		
	J	Total Phosphorus (mg/L)	7		0.040		0.076	0.047	0.052	0.013		
	J	CBOD-5 (mg/L)	7	<	2.0		2.6	1.0	1.2	0.6		
		Chlorides (mg/L)	7		950.0		6400.0	3,300.0	3544.3	2178.7		
		Total Metals										
	J	Aluminum (mg/L)	4		0.567		1.570	0.740	0.904	0.452		
		Iron (mg/L)	4		0.304		0.812	0.379	0.468	0.232		
	J	Manganese (mg/L)	4		0.042		0.062	0.050	0.051	0.009		
		Dissolved Metals										
	J	Aluminum (mg/L)	4	<	0.077		0.094	0.038	0.052	0.028		
	J	Antimony (µg/L)	4		0.1		0.4	0.2	0.2	0.1		
	J	Arsenic (µg/L)	4		1.3		4.3 [A]	2.9	2.8	1.2	4	1
	J	Cadmium (µg/L)	4	<	0.080		0.095	0.040	0.054	0.028		
	J	Chromium (µg/L)	4		0.349		2.890	0.883	1.251	1.128		
	J	Copper (mg/L)	4		0.001		0.003	0.002	0.002	0.001		
	J	Iron (mg/L)	4	<	0.016		0.066	0.014	0.025	0.028		
	J	Lead (µg/L)	4		0.1		0.4	0.2	0.2	0.1		
	J	Manganese (mg/L)	4		0.013		0.041	0.021	0.024	0.013		
	J	Nickel (mg/L)	4		0.000		0.004	0.001	0.002	0.002		
	J	Selenium (µg/L)	4		4.9		18.1 [A]	6.7	9.1	6.1	3	
	J	Silver (µg/L)	4	<	2.110	<	2.110	1.055	1.055	0.000		
	J	Thallium (µg/L)	4	<	0.003		0.026	0.003	0.009	0.012		
	J	Zinc (mg/L)	4	<	0.002		0.062	0.003	0.017	0.030		
		Biological										
		Chlorophyll a (ug/L)	7	<	1.00		2.90	0.50	0.84	0.91		
	J	Enterococci (col/dL)	4		6		22	12	13	7		
	J	Enterococci (mpn/dL)	3		20		60	30	37	21		

A=*S,F&W* aquatic life use criterion exceeded; C=*S,F&W* criterion violated; E=# samples that exceeded criteria;
J= estimate; N=# samples; Q=number of samples that have uncertain exceedances.

APPENDIX B SLAMM REPORT

ESA

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memorandum

date	November 10, 2017
to	Dewberry Engineers Inc
cc	
from	Hennessy Miller and Lindsey Sheehan, P.E.
subject	West Fowl River Habitat Evolution with Sea Level Rise

Over the past two decades, geospatial modeling tools have been developed to forecast changes in coastal wetland habitats in response to sea-level rise (SLR). These tools include the Environmental Protection Agency's Sea Level Affecting Marshes Model (SLAMM), which simulates the dominant processes involved in coastal wetland migration and conversions with long-term SLR. The basis of the model is a decision tree that maps out how quantified linkages between habitat response and SLR will drive habitat locations across a landscape, considering the effects of coastal elevations, SLR, accretion and erosion, and freshwater inflow. The model calculates habitat areas and maps habitat distribution over time based on inputs of existing vegetation, topography, accretion rates, and SLR.

Tools like SLAMM can be used in watershed management to identify restoration and conservation opportunities for changing coastal habitats. This memo summarizes past studies that cover the Gulf Coast region (Section 1), and analyzes how they can be applied to the West Fowl River watershed (Section 2). Section 3 identifies opportunities in the watershed and provides recommendations for possible next steps to refine this analysis.

1. Previous Studies

Many organizations have begun evaluating how habitats may evolve with sea level rise in the Gulf Coast region. The Nature Conservancy (TNC) and Warren Pinnacle Consulting (WPC) used SLAMM to model the Gulf Coast (TNC 2013, WPC 2015), while the USGS has used a simplified GIS model and hydrodynamic modeling to evaluate habitat evolution and erosion along the coast (Enwright et al. 2015, 2016, Passeri et al. 2016). ESA has used SLAMM to model the Fowl River and Bayou La Batre watersheds, which border the West Fowl River watershed and provide estimates of local accretion and erosion rates. Each of these studies is summarized in more detail below.

The Nature Conservancy 2013

TNC used SLAMM 6.2 to model SLR for five sub-areas along the Gulf Coast of Mexico, including Mobile Bay (2013). The primary objectives of the study were to 1) model SLR in five coastal estuaries, 2) use the results to identify nearby areas highly-susceptible to SLR, and 3) present the SLAMM results to stakeholders as a means to encourage dialogue and development of locally relevant adaptation strategies. Additionally, the study assessed the impacts to vulnerable species by evaluating habitat loss under the three SLR scenarios (0.7 m, 1.0 m, 2.0 m) at four time steps (2025, 2050, 2075, 2100). For the Mobile Bay area, vulnerable species assessed included the snowy plover (*Charadrius alexandrines),* the piping plover (*C. melodus),* the Alabama beach mouse (*P. polionotus ammobates),* and the hairy-peduncled beakrush (*Rhynchospora crinipes).*

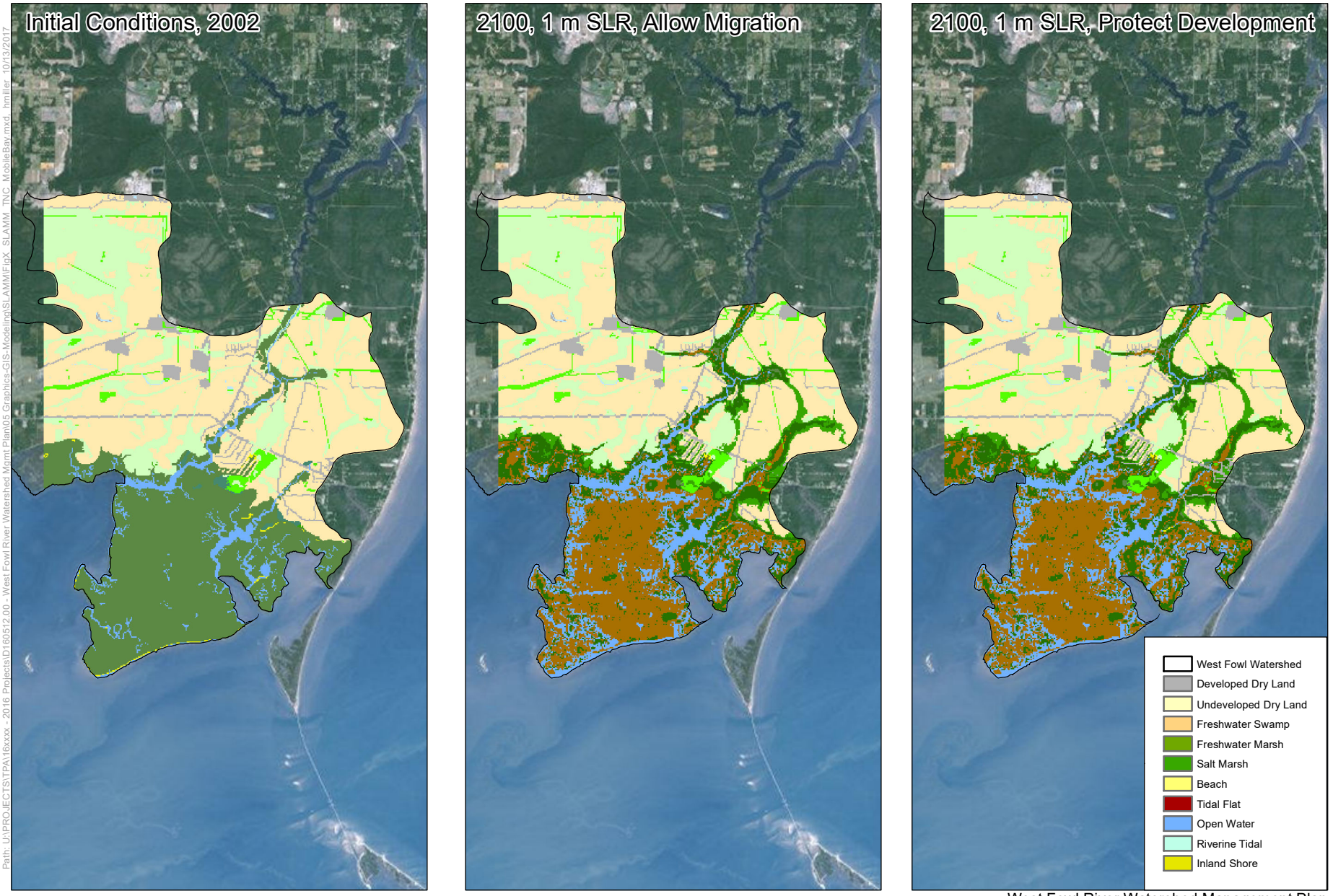
The Mobile Bay portion of the TNC study covers approximately 80% of the West Fowl River watershed. For each time step and SLR scenario, habitat evolution was modeled under an "allow migration" scenario (allowing habitat evolution onto developed lands) and a "protect development" scenario (limiting transgression to undeveloped land). Figure 1 shows the SLAMM results of Mobile Bay for 2100 with 1.0 m of SLR, compared to initial conditions in 2002, and Table 1 details the habitat acreage of the two management scenarios. Because the coastal areas of the West Fowl River are largely undeveloped, the results from the two runs are similar and show only minor differences.

TABLE 1

HABITAT ACREAGE IN WEST FOWL RIVER WATERSHED FROM TNC SLAMM ANALYSIS

Habitats[1]	2002: Initial Conditions (Acres)	2100: 1 m SLR + Allow Migration (1 m SLR) (Acres)	2100: 1 m SLR + Protect Development (1 m SLR) (Acres)	Difference between Allow Migration and Initial Conditions (Acres)	Difference between Scenarios (Acres)
Developed Dry Land	655	591	655	-64	+64
Undeveloped Dry Land	6,822	5,917	5,917	-905	0
Freshwater Swamp	2,808	2,375	2,375	-433	0
Freshwater Marsh	376	910	873	+534	-37
Salt Marsh	5,250	2,021	1,996	-3,229	-25
Tidal Flat	0	3,206	3,203	+3,206	-3
Beach	45	7	7	-38	0
Open Water	754	1,686	1,685	+932	-1

1. SLAMM habitats have been combined into simplified categories. See Appendix A for habitat cross-walk.



SOURCE: TNC 2013

West Fowl River Watershed Management Plan

Figure 1
TNC SLAMM Modeling Results of West Fowl Watershed in Mobile Bay Study Area
Habitat Evolution

Warren Pinnacle Consulting 2015

WPC modeled habitat evolution throughout the Gulf Coast using SLAMM 6.5. Prior to the WPC report, individual studies had modeled different pieces of the region with variable domain definitions, model parameters, and SLR scenarios, which rendered the disparate projections incompatible for direct comparison. The primary goals of the WPC project were to generate a "seamless set of landcover projections for the Gulf of Mexico Coast," allowing for direct comparison across the region, and to derive and use a mechanistic accretion feedback rate in the modeling process. The evaluation assessed SLR for the entire Gulf Coast (from the U.S./Mexico Border in Texas to Key West, Florida). Twenty-five areas within the study region had been previously modeled using SLAMM, including Mobile Bay in the 2013 TNC study (see previous section), and twenty new gap areas were identified and modeled for the first time in the 2015 WPC evaluation.

For previously modeled study areas, the 2015 regional evaluation kept the same original inputs, but adjusted the SLR scenarios (0.5, 1.0, 1.2, 1.5, and 2.0 m), and added additional regularly-flooded marsh (RFM) accretion feedback rates, if not included in the initial study, to ensure consistency and allow for comparison across study areas. In some areas, the regional effort also included a "freshwater flow polygon" within the SLAMM parameterization to account for the influence of surface flows in habitat evolution. Finally, the regional model employed only an "allow migration" approach, allowing habitat transgression onto developed lands. The regional model used four time steps: 2025, 2050, 2075, and 2100.

The West Fowl River watershed overlaps two primary regions in the WPC study: Mobile Bay and SA-14. For the Mobile Bay region, SLAMM was run using the same inputs as the 2013 TNC study with the exception of: 1) changing the SLR scenarios and 2) including three additional accretion rates (inland-fresh marsh, tidal swamp, and swamp; these rates and additional model inputs are detailed in Table 4 below). Additionally, the WPC study used a newer version of SLAMM.

Figure 2 shows the combined SLAMM results of the Mobile Bay and SA-14 study regions at initial conditions (2002 and 2007) and in 2100 with 1.0 m SLR within the West Fowl River watershed. Because the models for the two regions are based on land uses from different dates (2002 and 2007), the boundary between the regions does not fully align. Table 2 details the habitat acreage shown in Figure 2. Note that twelve acres of open-water on the easternmost portion of the West Fowl River Watershed were modeled in a third region of the study (Grand Bay, Mississippi). Though these twelve acres of open-water are included in acreage totals in Table 2, Figure 2 does not include a separate box indicating the bounds of the Grand Bay study due to its small spatial extent.

TABLE 2

HABITAT ACREAGE IN THE WEST FOWL RIVER WATERSHED FROM WPC SLAMM ANALYSIS

Habitats[1]	Initial Conditions (2002/2007) (Acres)	2100, 1 m SLR (Acres)	Difference from initial conditions (Acres)
Developed Dryland	777	672	-105
Undeveloped Dry Land	9,522	8,139	-1383
Freshwater Swamp	3,304	2,787	-517
Freshwater Marsh	403	1,311	+908
Salt Marsh	5,591	1,797	-3794
Tidal Flat	0	3,378	+3378
Beach	55	8	-47
Open Water	785	2,131	+1346
No data[2]	44	247	

1. SLAMM habitats have been combined into simplified categories. See Appendix A for habitat cross-walk.
2. The results include a gap between the Mobile Bay and SA-14 study region

With the slightly varied SLAMM inputs, WPC found "similar susceptibility but different future wetland categories predicted" compared to the TNC study (Figure 3). The WPC 2100 habitat projection showed slightly different habitat acreages for dry land, freshwater swamp, freshwater marsh, and beach, but showed a larger conversion of salt marsh to open water (a decrease of 426 acres of salt marsh) compared to the TNC study (Table 3).

The larger conversion of salt marsh to open water is likely due to the difference in model versions used between the two studies. SLAMM 6.5, used in the WPC study, allows direct conversion of freshwater marsh to regularly flooded marsh, irregularly flooded marsh, open water, OR tidal flat, depending on elevation. The previous versions of SLAMM, including SLAMM 6.2 used for the TNC modeling, employed a linear conversion pathway for freshwater marsh, where freshwater marsh had to convert to irregularly flooded marsh, then regularly flooded marsh, then tidal flat, and then open water, as opposed to converting straight to the appropriate habitat for that elevation. This means that the TNC results overestimate salt marsh due to habitat conversion steps as represented in the model.

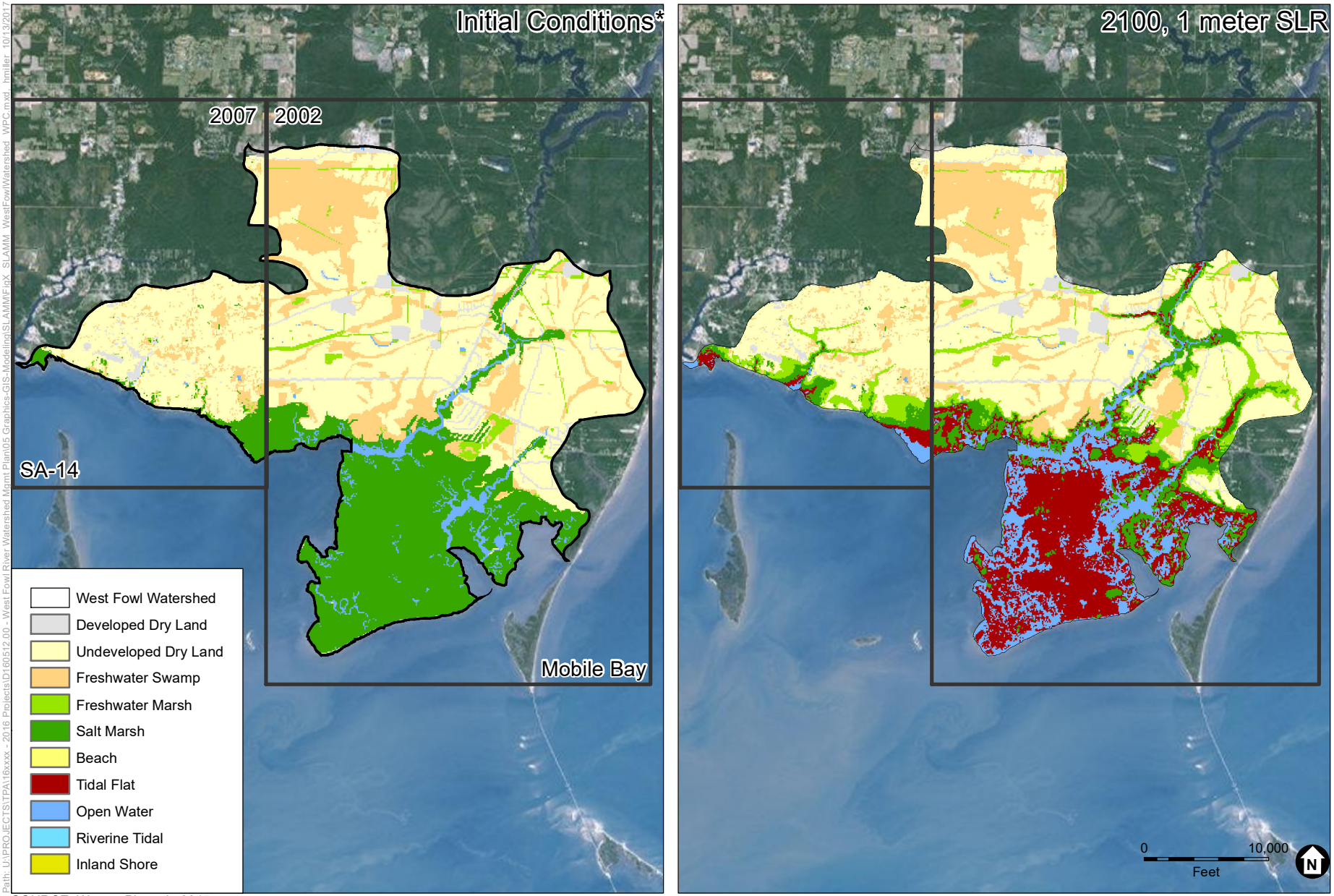
The smaller differences in the remaining habitat types is likely due to the habitat conversion steps or two other differences between the two modeling efforts. First, WPC changed the minimum elevation thresholds for swamp, tidal-fresh marsh, and tidal swamp habitats to ensure consistency with the other regional models, although this change was small. Second, WPC added an additional dynamic regularly-flooded accretion rate. Both of these changes would likely result in minor differences in the habitat acreages.

TABLE 3

HABITAT ACREAGE IN THE "MOBILE BAY" PORTION[1] OF WEST FOWL RIVER WATERSHED FROM TNC AND WPC SLAMM ANALYSES

Habitats[2]	Initial Conditions (2002) (Acres)	TNC (2100, 1 m SLR) (Acres)	WPC (2100, 1 m SLR) (Acres)	Difference between TNC and WPC Model Runs (Acres)
Developed Dry Land	655	591	590	-1
Undeveloped Dry Land	6,822	5,917	5,917	0
Freshwater Swamp	2,808	2,375	2,392	+17
Freshwater Marsh	376	910	908	-2
Salt Marsh	5,250	2,021	1,595	-426
Tidal Flat	0	3,206	3,255	+49
Beach	45	7	7	0
Open Water	754	1,686	2,043	+357

1. The Mobile Bay portion of the studies covers approximately 80% of the West Fowl River watershed.
2. SLAMM habitats have been combined into simplified categories. See Appendix A for habitat cross-walk.



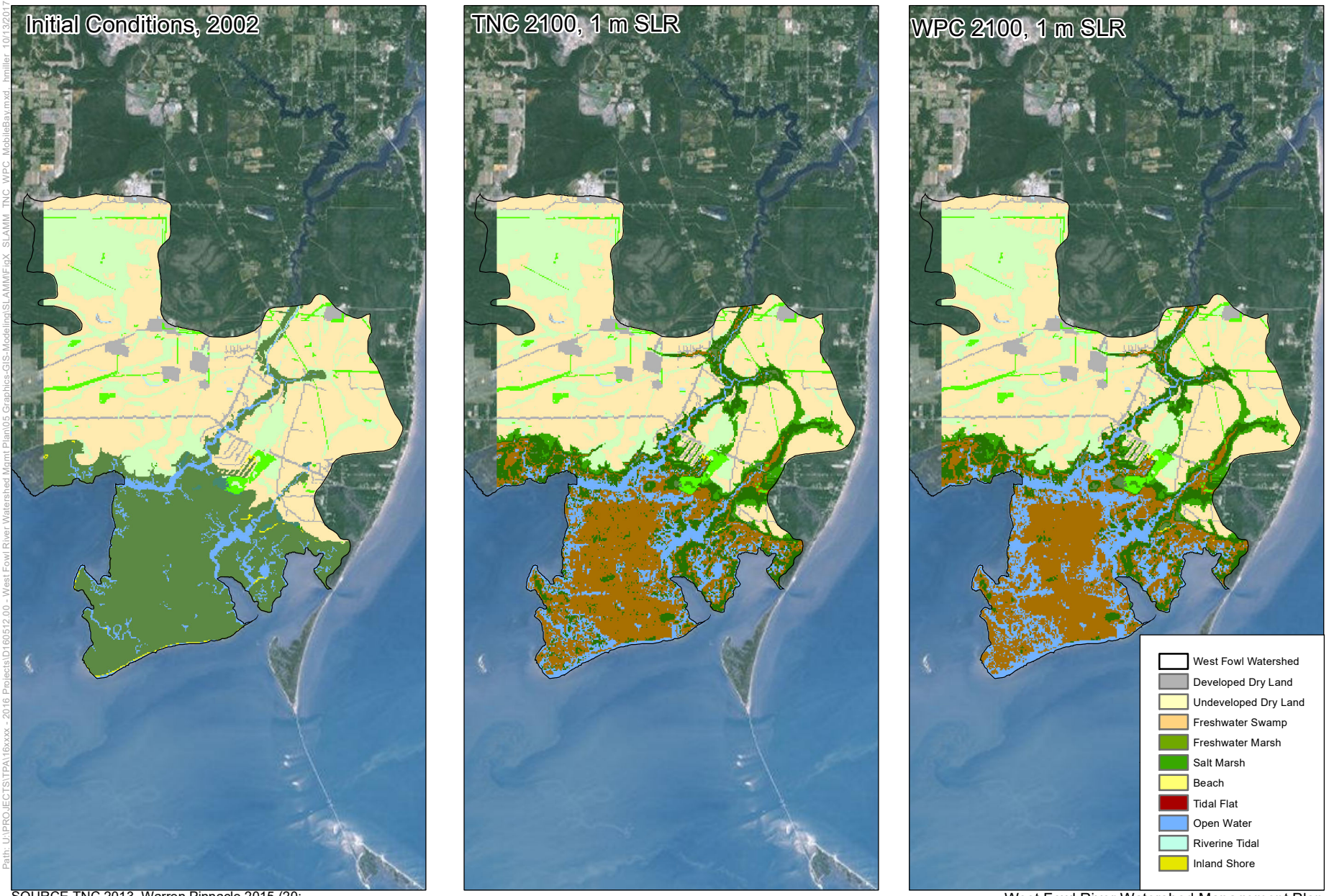
SOURCE: Warren Pinnacle 2015

*Note that the initial conditions for SA-14 and Mobile Bay were determined from different baseline years

West Fowl River Watershed Management Plan

Figure 2

WPC SLAMM Modeling Results of West Fowl River Watershed Habitat Evolution



SOURCE TNC 2013, Warren Pinnacle 2015 (20:

West Fowl River Watershed Management Plan

Figure 3
SLAMM Modeling of West Fowl River Watershed in Mobile Bay Study Area
Comparison of TNC and WPC Results

ESA

ESA 2015 and Goodwyn Mills Cawood 2016

Goodwyn Mills and Cawood (GMC 2016) led the Fowl River Watershed Management Plan, which included a SLAMM 6.5 analysis of the Fowl River estuary in Mobile Bay performed by ESA (ESA 2015). The goal of the modeling effort was to examine watershed opportunities for habitat restoration and conservation. Due to the proximity of the Fowl River watershed, the model inputs used in the ESA model are likely representative of the conditions in the West Fowl River watershed. The ESA model assessed habitat evolution at two SLR scenarios (0.53 m (21 in) and 0.74 m (29 in)) and four time steps (2030, 2050, 2070, and 2100).

ESA 2016

ESA (2016) used SLAMM 6.5 to model habitat evolution in Bayou La Batre, Alabama as part of the Bayou La Batre Watershed Management Plan (Dewberry, in development). The ESA model assessed habitat acreage in 2030, 2050, 2070, and 2100 under two different SLR scenarios (0.53 m (21 in) and 0.74 m (29 in)). The modeling effort also included habitat evolution evaluation at two different accretion rates (high and low) and two different management scenarios ("allow migration" and "protect development"). Bayou La Batre is to the west of West Fowl River watershed, so the model inputs used in the ESA model are also good estimates of the conditions in the West Fowl River watershed.

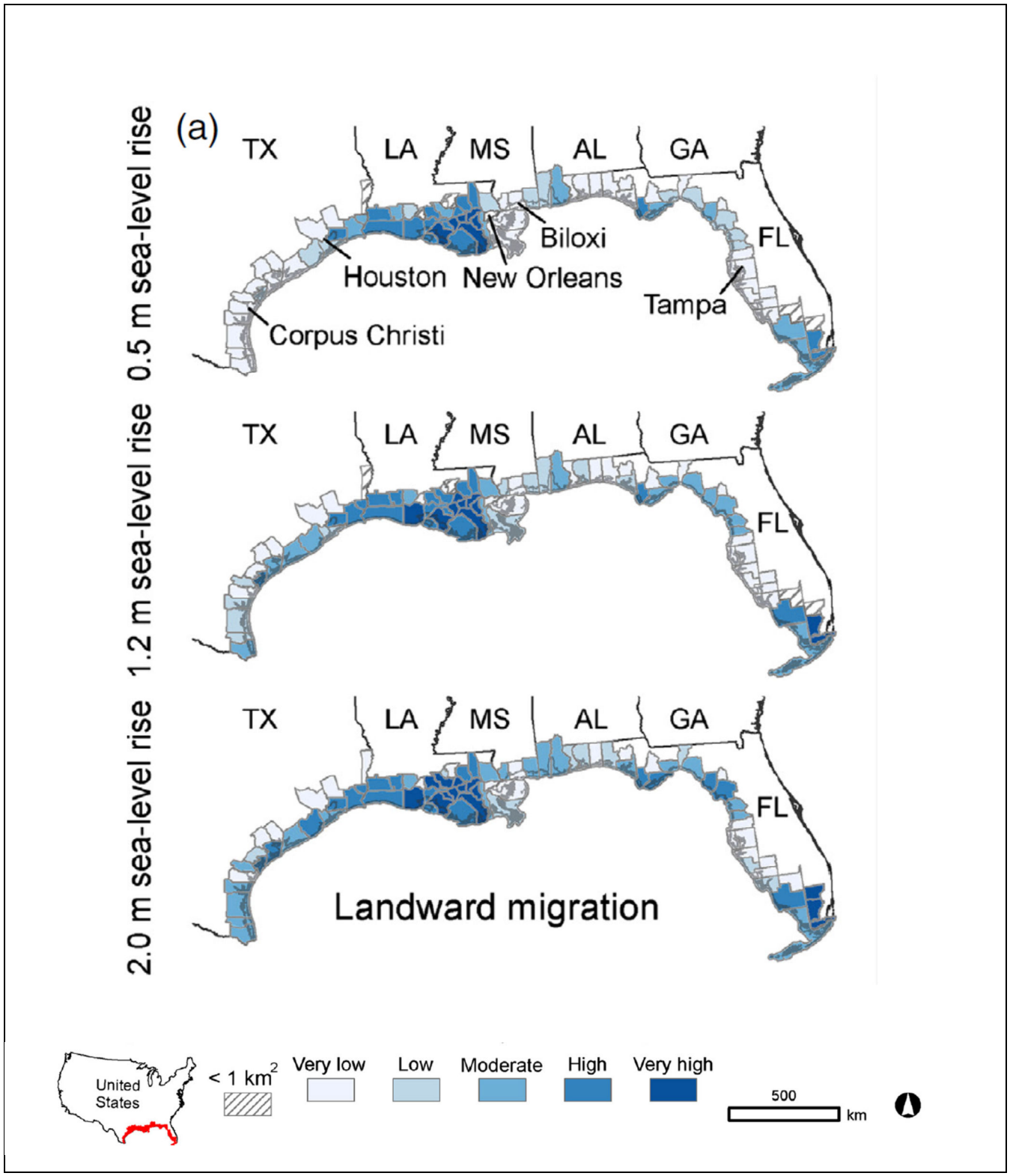
Table 4 (below) presents a comparison of the different SLAMM inputs for TNC 2013, Warren Pinnacle 2015, and ESA 2015 and 2016.

Enwright et al. 2015

The USGS and the U.S. Fish and Wildlife Service (USFWS) quantified the landward migration of mangrove forests, salt marshes, and salt flats (collectively tidal saline wetlands (TSW)) in the Gulf of Mexico. The simplistic GIS model incorporated five different SLR scenarios (0.5, 1.0, 1.2, 1.5, and 2.0 m) and used existing and expected development barriers to model TSW migration by county at five discrete times: 2030, 2040, 2050, 2060, and 2100. The USGS and USFWS aimed to provide a public dataset detailing areas of expected TWS landward migration and areas where migration is prevented due to an existing or future barrier. The results of the five time steps and five SLR scenarios are available through the USGS. The results of this modeling effort were used in the paper by Enwright et al. (2016) as detailed below.

Enwright et al. 2016

The results of the Enwright et al. (2015) modeling report were published in *Frontiers in Ecology and the Environment.* The goals of the publication were to generate discussion on specific SLR adaptation strategies and identify TSW migration corridors of high priority. The paper used only three of the five SLR scenarios outlined in the 2015 report (0.5, 1.2, and 2.0 m) to evaluate and qualitatively rank locations of TSW migration and impediment due to development and levees (Figure 4). Under the 2.0 m SLR scenario, the report found 25,792 km^2 available for TSWs migration in the Gulf of Mexico; the West Fowl River region has moderate opportunities for landward migration. The study did not consider adaptation via local elevation changes (i.e. accretion and erosion) or make any predictions on habitat evolution.



SOURCE: Enwright et al. (2016)

West Fowl River Watershed Management Plan

Figure 4
TSW Land Migration Opportunities

Passeri et al. 2016

The U.S. Geological Survey (USGS) examined the hydrodynamic impacts of SLR and projected morphologic changes in the Northern Gulf of Mexico, specifically focusing on three embayments (Apalachicola, Florida, Grand Bay, Mississippi, and Weeks Bay, Alabama). Weeks Bay is an embayment on the east side of Mobile Bay about 20 miles away from the West Fowl River watershed, while Grand Bay is west of the watershed, about 15 miles away. The objective of the study was to develop a large-domain hydrodynamic model to assess changes in water levels, tidal amplitudes and inundation, flood-ebb ratios, and current velocities under varying SLR scenarios (0.11, 0.19, 0.39, 0.62 m in 2050 and 0.2, 0.5, 1.2, and 2.0 m in 2100) and the corresponding alterations to shoreline morphology and boundary conditions. Though the authors noted that prior studies had recognized the dynamic nature of coastal morphology, few had evaluated what impact this may have on coastal hydrodynamics. The model used an existing Bayesian Network developed by Gutierrez (2014) to make probabilistic predictions of coastal morphology (shoreline and dune erosion and accretion) under each of the SLR scenarios.

The model found tidal amplitudes in Weeks Bay to increase by 15% (6.5 cm) in 2100 under the 2.0 SLR scenario, but found negligible changes in tidal amplitude in Grand Bay due to the open exposure of the Gulf of Mexico. Since West Fowl River also has open exposure, it would likely see similarly negligible changes in tidal amplitude. Under the same SLR scenario and time step, Mobile Bay experienced a 33% increase in inlet cross-sectional area, which could imply increased erosion in the West Fowl River watershed. Tidal velocities increased by 6.1 cm/s (102%) in Grand Bay, and 10.8 cm/s (63%) in Weeks Bay, which would also result in increased erosion.

TABLE 4

PREVIOUS STUDIES MODEL INPUTS

Study	Model Used	Area/Region Modeled	Sea-Level Rise Values Modeled (m)	Accretion (mm/yr)	Erosion (m/yr)	Other notes
TNC 2013	SLAMM 6.2	Mobile Bay, AL	0.7, 1.0, 2.0	Saltmarsh: 11 Brackish Marsh: 4.4 Tidal Freshwater Marsh: 9 Beach Sediment Rate: 4.45	Marsh: 1.5 Tidal Flat: 0.8 Coastal Forest: 1	Freshwater influence polygon used
Warren Pinnacle 2015	SLAMM 6.5	Northern Gulf of Mexico	0.5, 1.0, 1.2, 1.5, 2.0	Saltmarsh: 11 Brackish Marsh: 4.4 Tidal Freshwater Marsh: 9 Beach Sediment Rate: 4.45 Mangrove: 7 Swamp: 0.3 Tidal Swamp: 1.1 Inland fresh marsh: 9	Marsh: 1.5 Tidal Flats: 0.8 Coastal Forest: 1	Freshwater influence polygon used
ESA 2015	SLAMM 6.5	Fowl River estuary	0.53, 0.74	Saltmarsh: 3.1 and 13.2 Brackish Marsh: 3.1 and 13.2 Tidal Freshwater Marsh: 3.1 and 13.2 Beach Sediment Rate: 3.1 and 13.2 Mangrove: 3.1 and 13.2 Swamp: 3.1 and 13.2 Tidal Swamp: 3.1 and 13.2 Inland Fresh Marsh: 3.1 and 13.2	Marsh: 0.82 Tidal Flat: 0.82 Swamp: 0.82	Freshwater influence polygon used
ESA 2016	SLAMM 6.5	Bayou La Batre	0.52, 0.74	Saltmarsh: 5.6 and 6.1 Tidal Freshwater Marsh: 5.6 and 6.1 Beach Sediment Rate: 5.6 and 6.1 Mangrove: 5.6 and 6.1 Swamp: 5.6 and 6.1 Tidal Swamp: 5.6 and 6.1 Inland Fresh Marsh: 5.6 and 6.1	Marsh: 0.571 Tidal Flat: 0.571 Swamp: 0.571	Freshwater influence polygon used
Enwright et. al. 2015	GIS model	Northern Gulf of Mexico	0.5, 1.0, 1.2, 1.5, 2.0	Not included in model	Not included in model	
Enwright et. al. 2016	GIS model	Northern Gulf of Mexico	0.5, 1.2, 2.0	Not included in model	Not included in model	
Passeri et. al. 2016	ADCIRC-2DDI	Northern Gulf of Mexico	0.11, 0.19, 0.20, 0.39, 0.50, 0.62, 1.2, 2.0		Up to 2 m total shoreline change	

2. Application to West Fowl River Watershed

The SLAMM studies by TNC (2013) and WPC (2015) provide the most useful information to understanding habitat evolution and restoration opportunities in the West Fowl River watershed. The model results show that most of the existing brackish/salt marsh will be inundated with 1.0 m of SLR and will convert to tidal flat and open water. Some areas of freshwater swamp will convert to salt marsh and freshwater marsh as these habitats move inland and upstream. Areas along the coast that are undeveloped will provide key opportunities for wetland migration.

The modeling effort conducted by Enwright et al. (2015 and 2016) provides a high-level understanding of potential habitat evolution in the county (and the whole Gulf Coast), but does not offer details at the watershed-level.

The modeling efforts by ESA (2015 and 2016) and Passeri et al. (2016) can be used to evaluate the inputs used in the TNC and WPC models. For example, ESA modeled varying levels of accretion in the Fowl River and Bayou La Batre watersheds and concluded that the model was most sensitive to this factor. However, the TNC and WPC models only evaluated one accretion scenario. ESA found that the different levels of accretion rates resulted in different arrangements of habitats, and not necessarily in the expected patterns (e.g. high accretion rates resulting in more wetland habitat for longer), because when certain habitats kept up with sea level rise, it was at the expense of the expansion of other habitats. Therefore, using accurate accretion rates or modeling a range of accretion rates to bookend the possible results is key to understanding habitat evolution in the West Fowl River watershed.

3. Opportunities and Recommendations

The following section discusses potential restoration and conservation opportunities and recommendations for further analysis.

3.1 Restoration and Conservation Opportunities

The TNC (2013) and WPC (2015) modeling identified areas in the West Fowl River watershed that could provide restoration opportunities in the future. From west to east:

- The area between Bayou La Batre and Bayou Coden along the coast is expected to evolve to freshwater marsh with 1 m of SLR if development is not protected. However, the area is heavily armored to protect Shell Belt Road, which runs along the coastline in this area. Coastal managers may eventually want to consider managed retreat and moving this road inland as inundation becomes more frequent. The area would then provide an ideal restoration opportunity.

- The land surrounding Bayou Coden is projected to evolve to salt and freshwater marsh with 1 m of SLR if development is not protected. This area could provide one of the more contiguous habitats in the watershed, but current land uses may limit the land available for habitat migration. Currently, dredging the bayou is being considered to accommodate larger vessels, so retreat in this area may not be feasible. However, as these areas become inundated more frequently during storm events, coastal managers may consider managed retreat of this area.

- Freshwater marsh is expected to migrate up into Bayou Como along its full extent under 1 m of SLR. The area is currently constrained by Clark Road, which crosses the bayou at the mouth, and may limit the amount

of tidal flow that can enter the area. Additionally, there are a few houses in the area, although large swaths remain undeveloped and may offer good areas for habitat migration.

- Another large swath of undeveloped dry land to the north of Bayou Sullivan is expected to convert to freshwater marsh under 1 m of SLR. This area appears to be largely undeveloped, so it could provide an ideal restoration opportunity.

- The area north of Negro Bay to the west of Negro Bayou is currently a large area of undeveloped dry land with some swamp. With 1 m of SLR, this area is expected to convert to salt and freshwater marsh.

- Along West Fowl River near the north and east branch, salt marsh is expected to expand into areas of freshwater swamp and undeveloped land with 1 m of SLR. Some of the areas along the river have light development, but there are other swaths that are undeveloped that could provide good opportunities for habitat migration.

- Heron Bayou also provides a large area where salt and freshwater marsh is expected to expand with 1 m of SLR. Some of this area is already swamp and other areas are undeveloped or lightly developed.

These opportunities focus on areas that would be inundated under 1 m of SLR, but it is important to keep in mind that SLR will continue well beyond 1 m, which may provide additional opportunities moving into the future.

3.2 Recommendations

The TNC and WPC models provide insight into how habitats may evolve in the future in the West Fowl River watershed, but exact acreages should be considered approximate. As discussed in Section 2, accretion rates can have dramatic impacts on the model results and both the TNC and WPC models only considered one accretion scenario. Future efforts should focus on gathering data on local accretion rates for each habitat type and modeling multiple accretion scenarios to bookend the range of habitat evolution.

Since the West Fowl River watershed is relatively sparsely developed, the modeling results show that tidal marsh habitats have adequate space to migrate into low lying undeveloped upland areas as sea levels rise. It is recommended that the West Fowl River Watershed Management Plan identify large undeveloped tracts in the watershed for potential public acquisition conservation easements or to ensure that there is adequate land area to allow for the upland migration of tidal marsh habitats with future sea-level rise.

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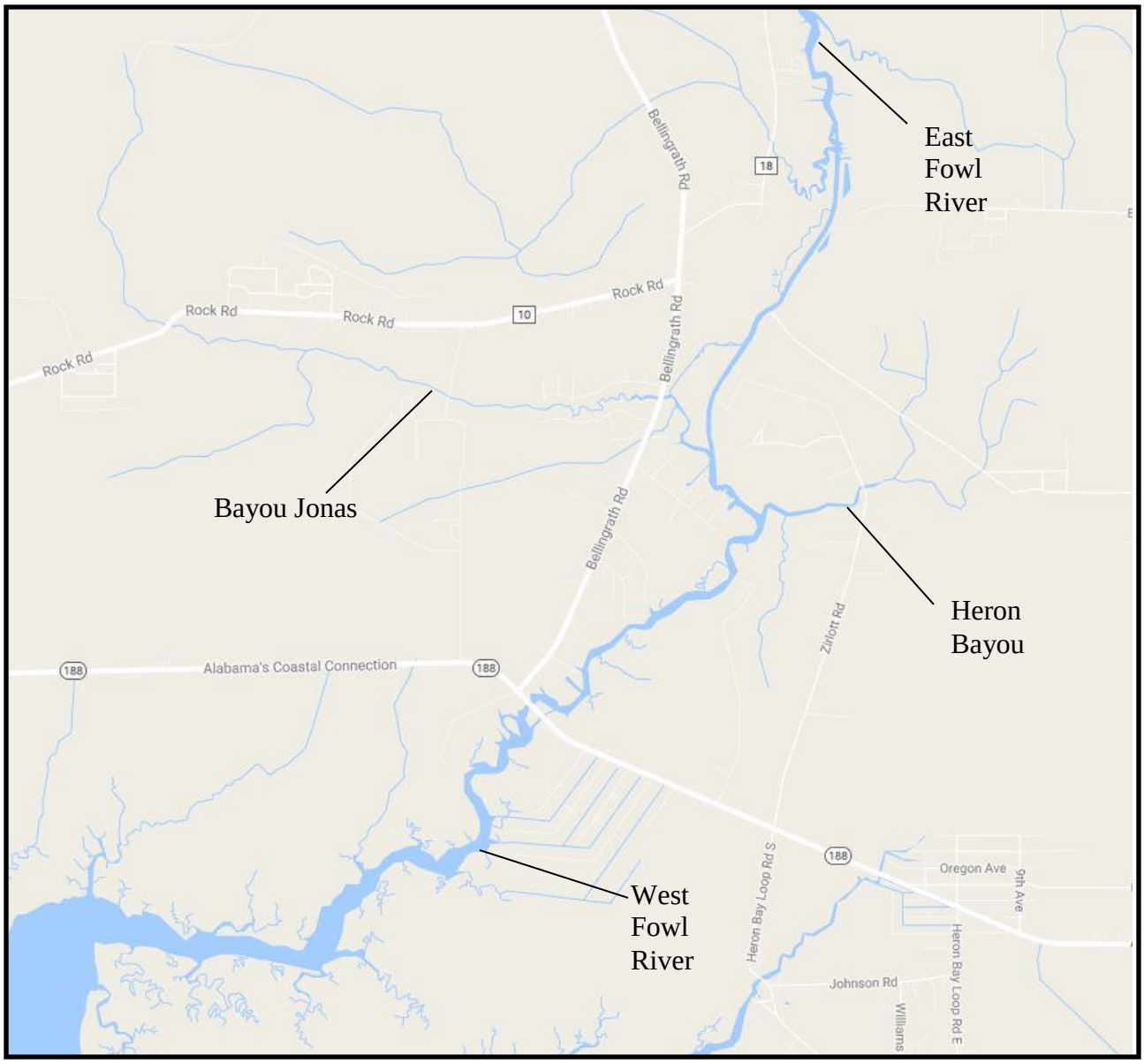
Appendix A

Habitat Cross-Walk

Simplified Habitat Categories	SLAMM Habitat Categories
Developed Dryland	Developed Dryland
Undeveloped Dryland	Undeveloped Dryland
Freshwater Swamp	Swamp Cypress Swamp Tidal Swamp
Freshwater Marsh	Tidal Fresh Marsh Transitional Fresh Marsh Inland Fresh Marsh
Salt Marsh	Regularly-flooded marsh Irregularly-flooded marsh
Beach	Estuarine Beach Ocean Beach
Tidal Flat	Tidal Flat
Open Water	Open Ocean Inland Open Water Estuarine Open Water
Riverine Tidal	Riverine Tidal
Inland Shore	Inland Shore

APPENDIX C COOK REPORT

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



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

By

Marlon R. Cook,
Polyengineering, Inc.

Funding for this project was provided by the
Mobile Bay National Estuary Program

April, 2017

TABLE OF CONTENTS

ILLUSTRATIONS

TABLES

.

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

Ms. Roberta Swann, Director; and Mr. Tom Herder, Watershed Protection Coordinator, Mobile Bay National Estuary Program, provided administrative and coordination assistance for the project; Mr. Steve Davis, Laboratory Manager, Polyenvironmental Corp., provided analytical services and technical assistance; and Mr. Bruce Bradley, President, Polyengineering, Inc., provided administrative assistance.

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).

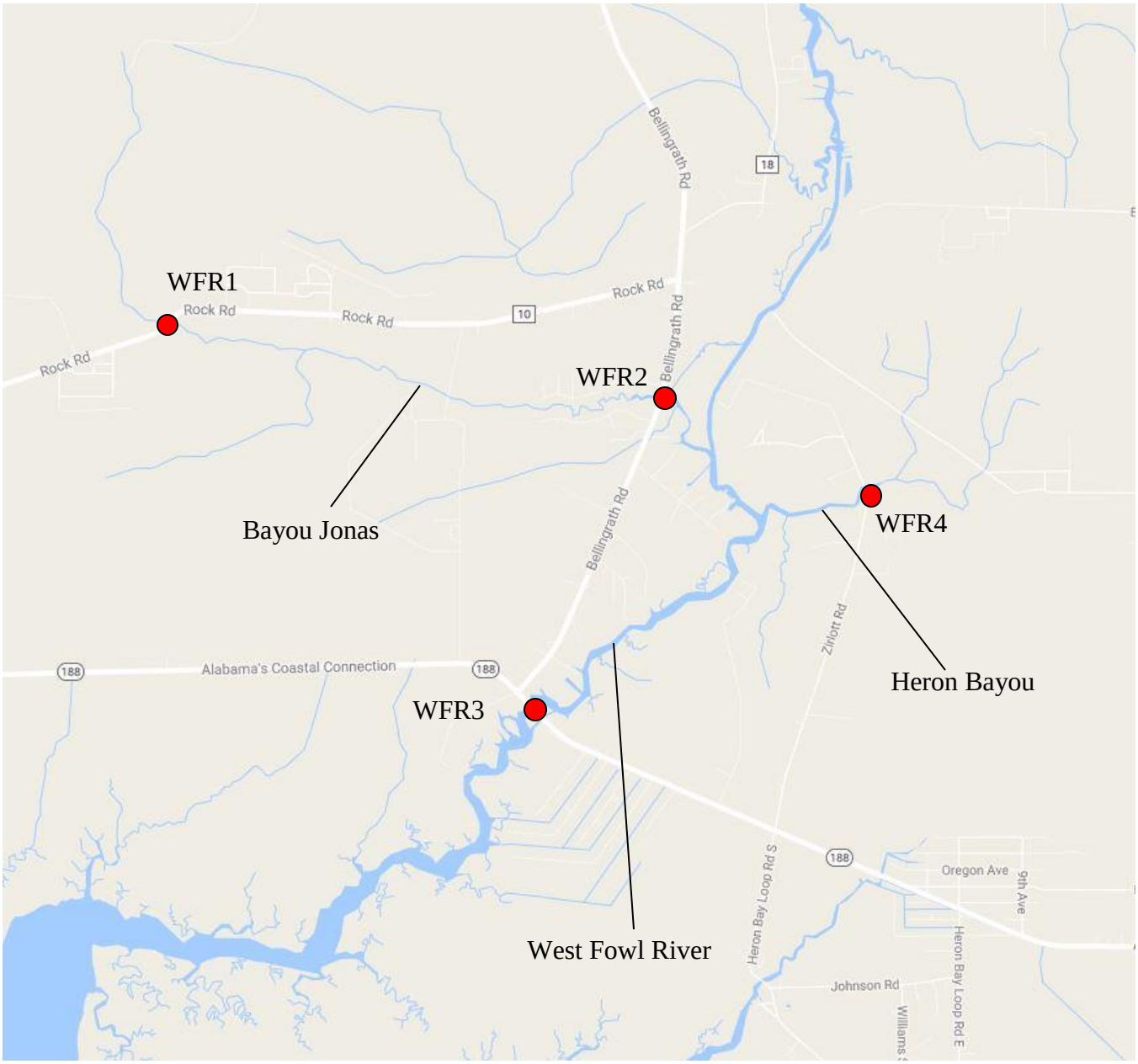

Figure 2.—West Fowl River watershed with monitoring sites.

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

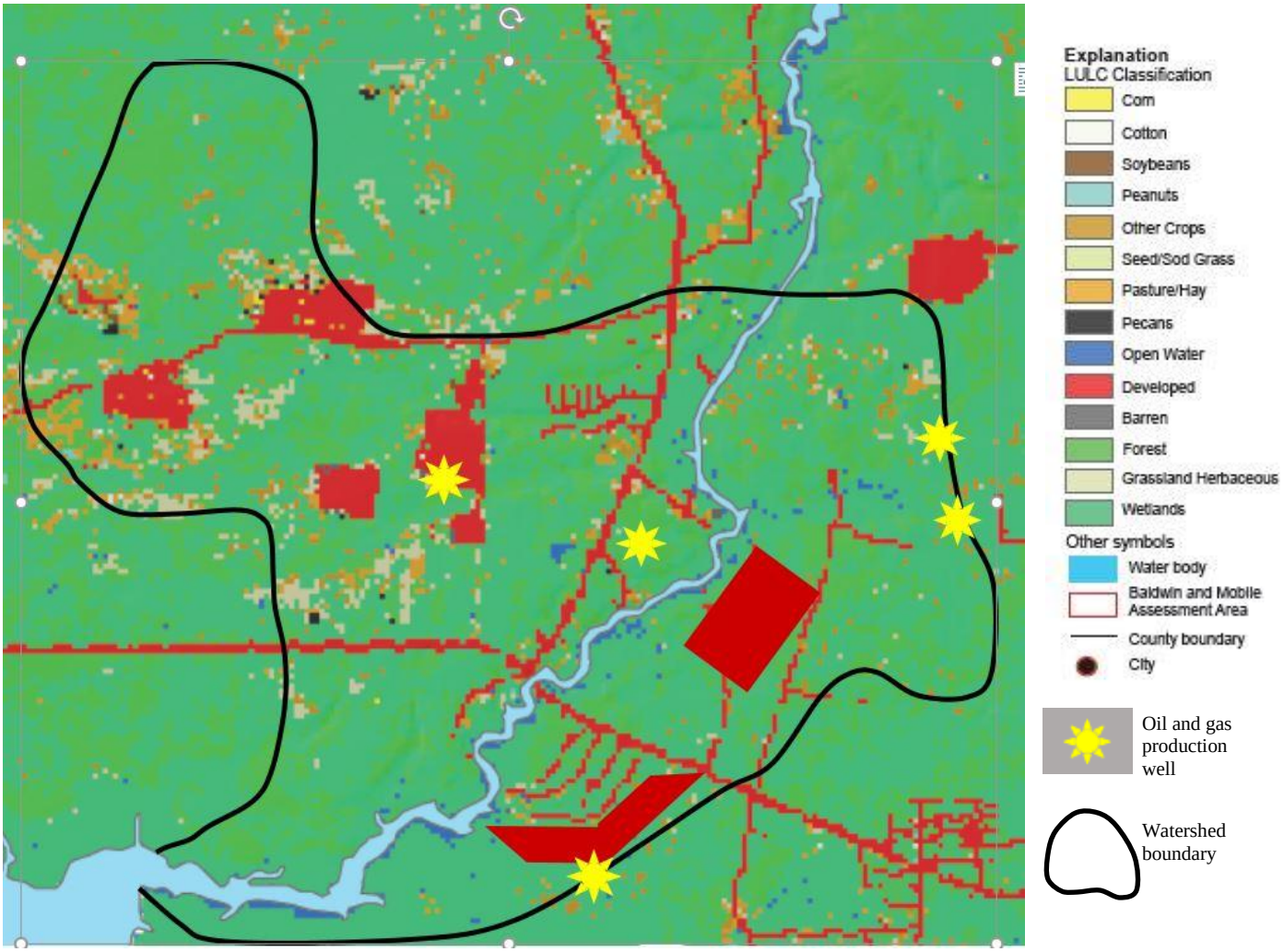

Figure 3.—Land use in the West Fowl River watershed.

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

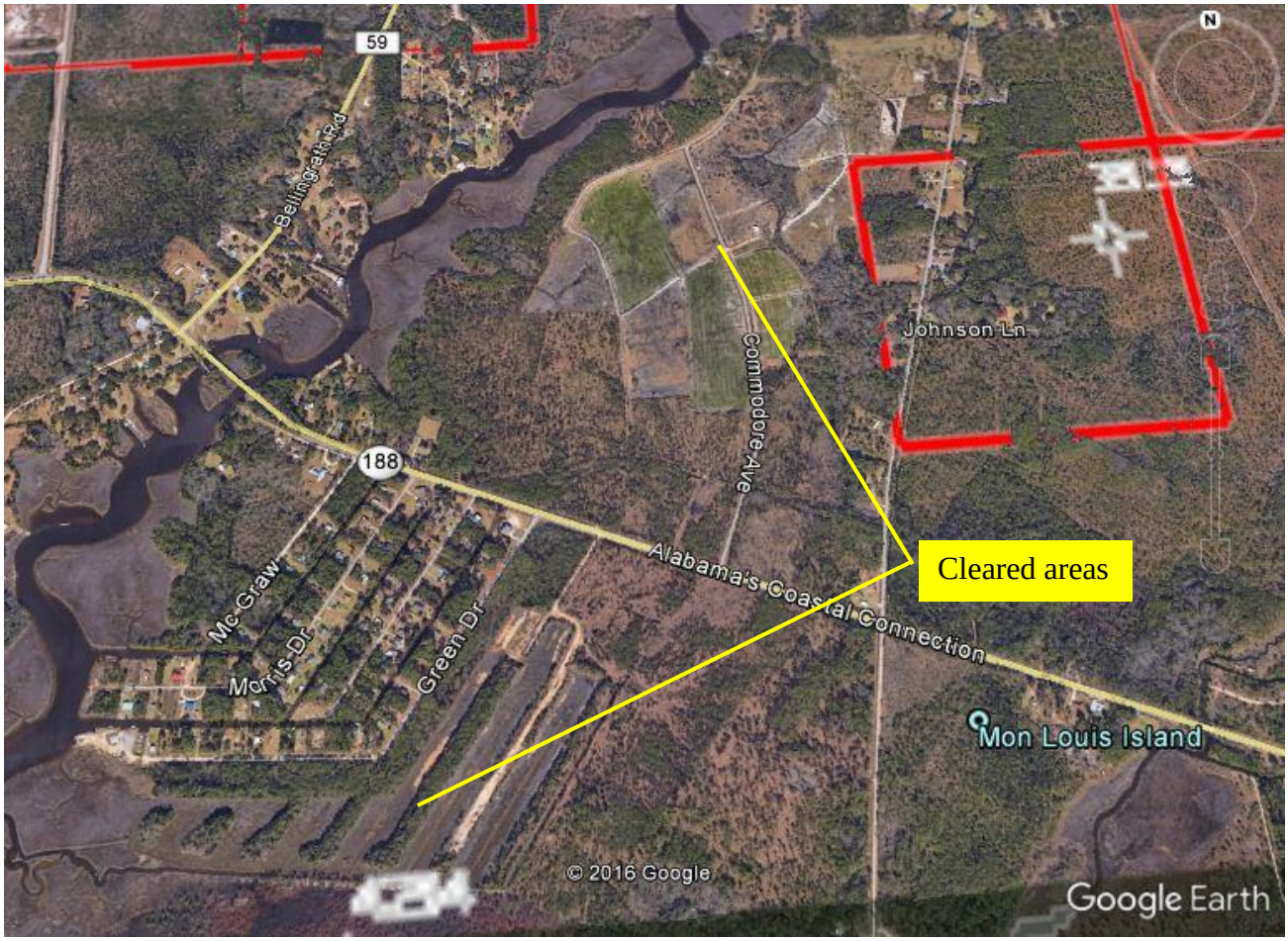

Figure 4.—Cleared areas for potential future residential development in the West Fowl River watershed.

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.

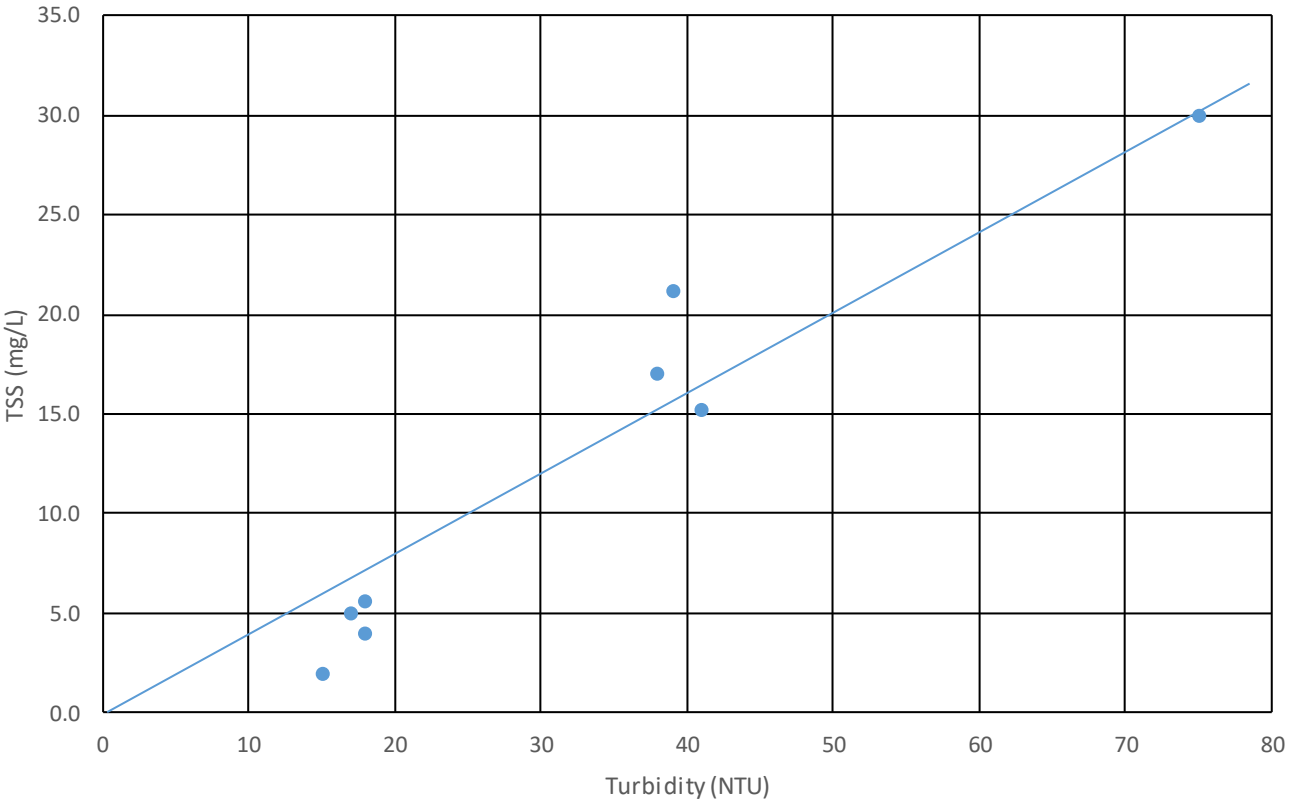

Figure 5. Measured turbidity and TSS at site WFR1.

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).

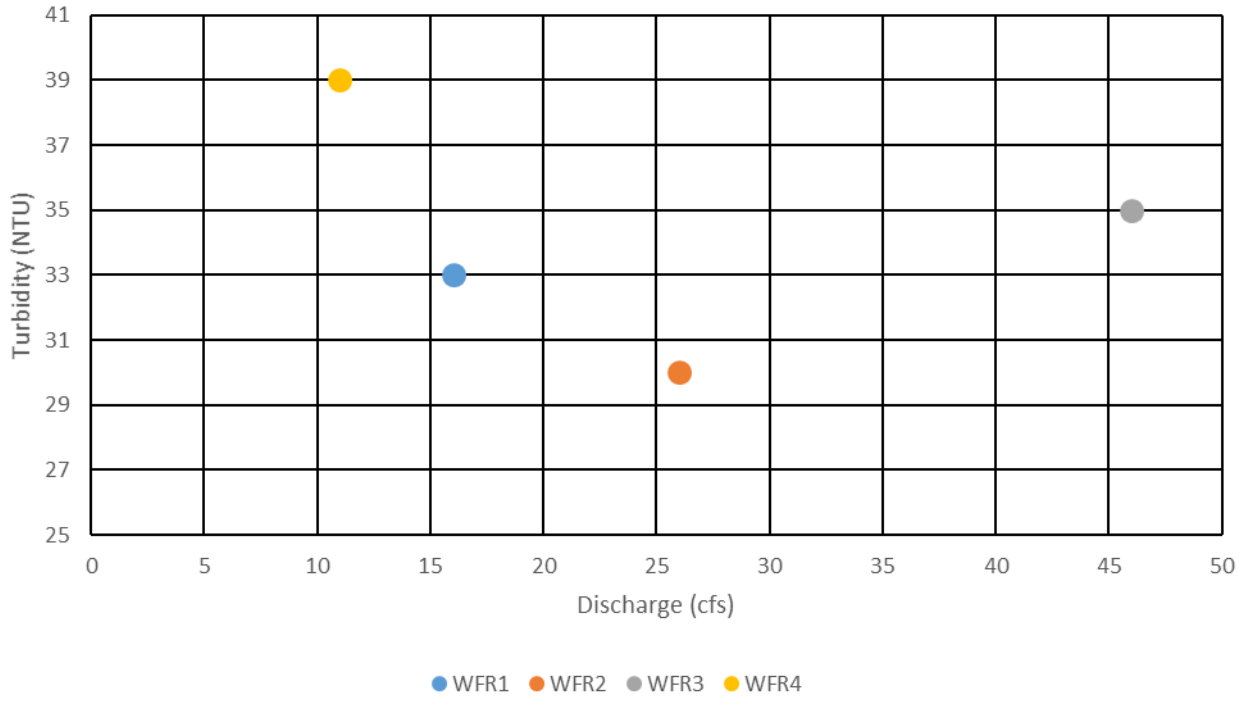

Figure 6.—Average discharge and turbidity for West Fowl River watershed monitoring sites.

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

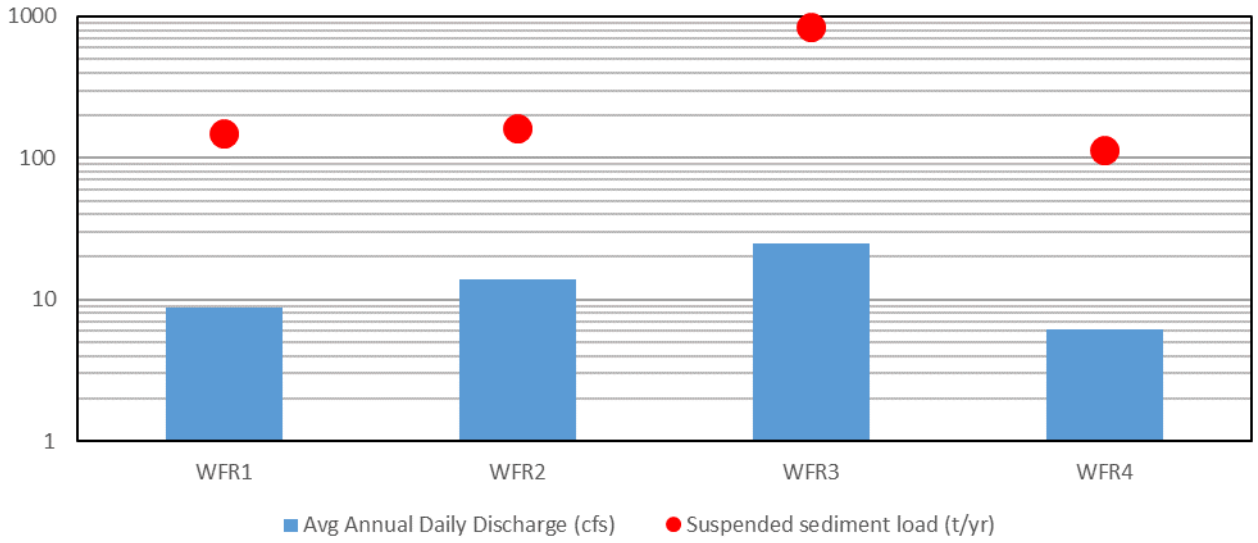

Figure 7.—Average annual daily discharge and suspended sediment loads for West Fowl River watershed monitoring sites.

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.

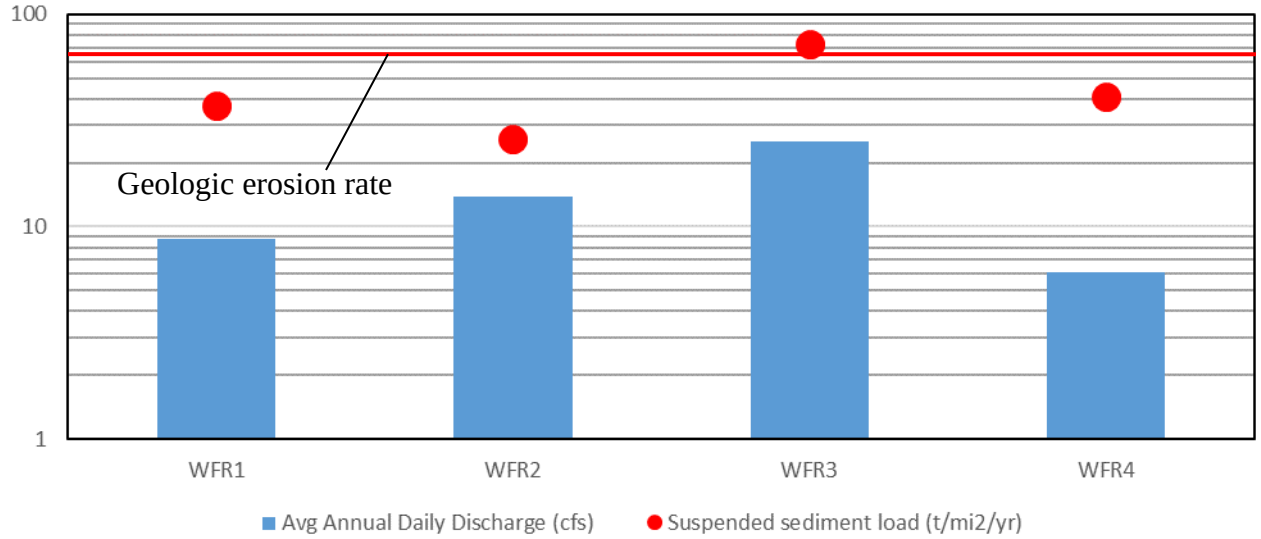

Figure 8.—Average annual daily discharge and normalized suspended sediment loads for West Fowl River watershed monitoring sites.

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

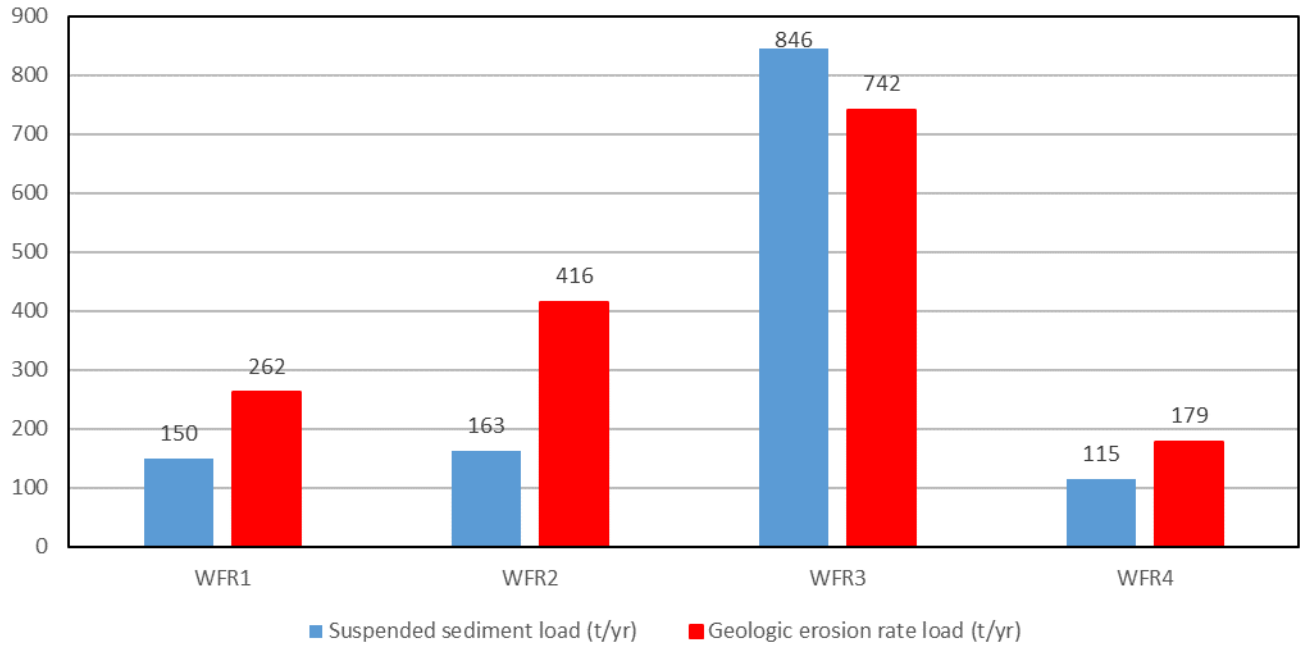

Figure 9.—Suspended sediment loads and calculated geologic erosion rate loads for West Fowl River watershed monitoring sites.

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

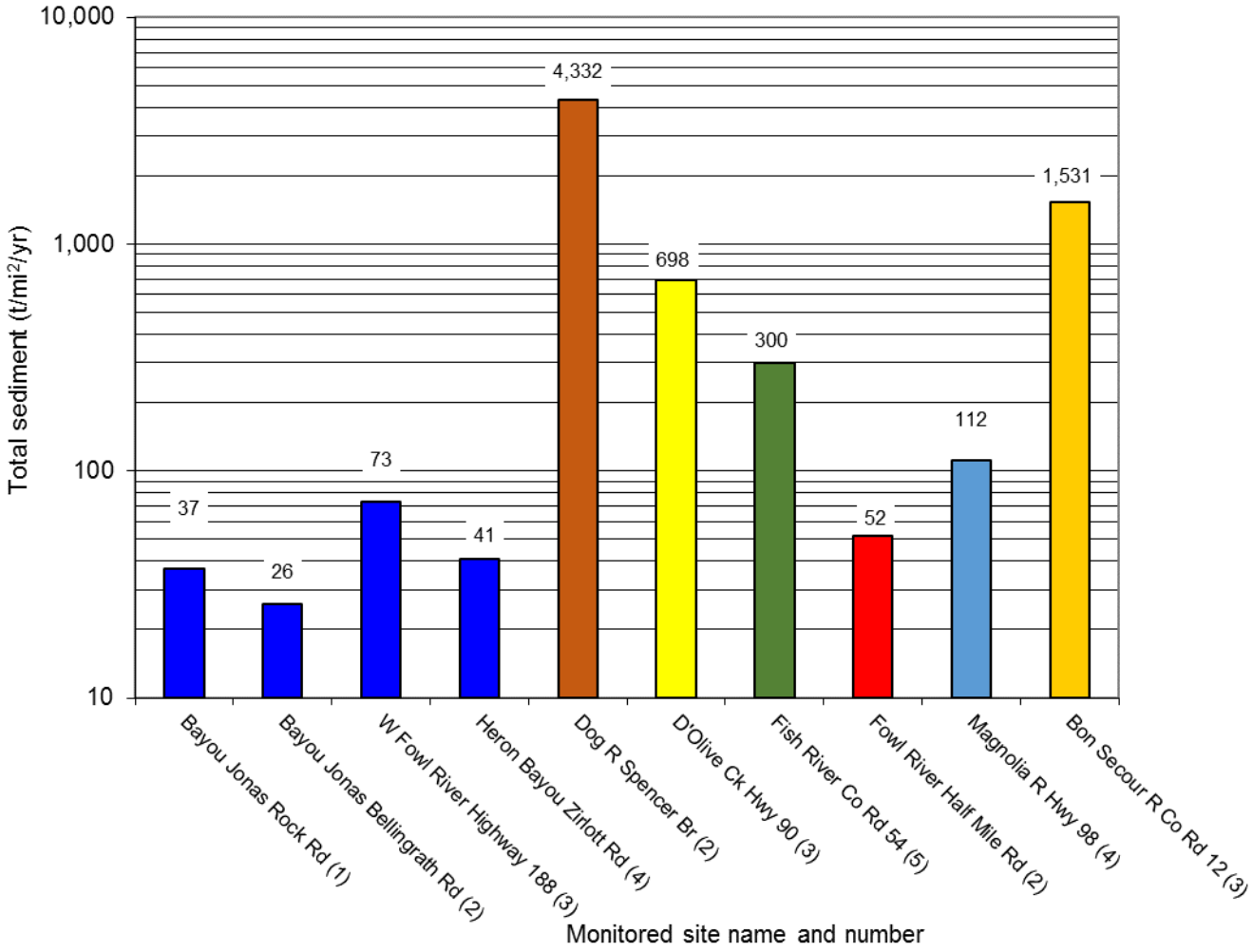

Figure 10.—Comparison of normalized total sediment loads for monitoring sites in theWest Fowl River with sites in other watersheds in Mobile and Baldwin Counties.

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.

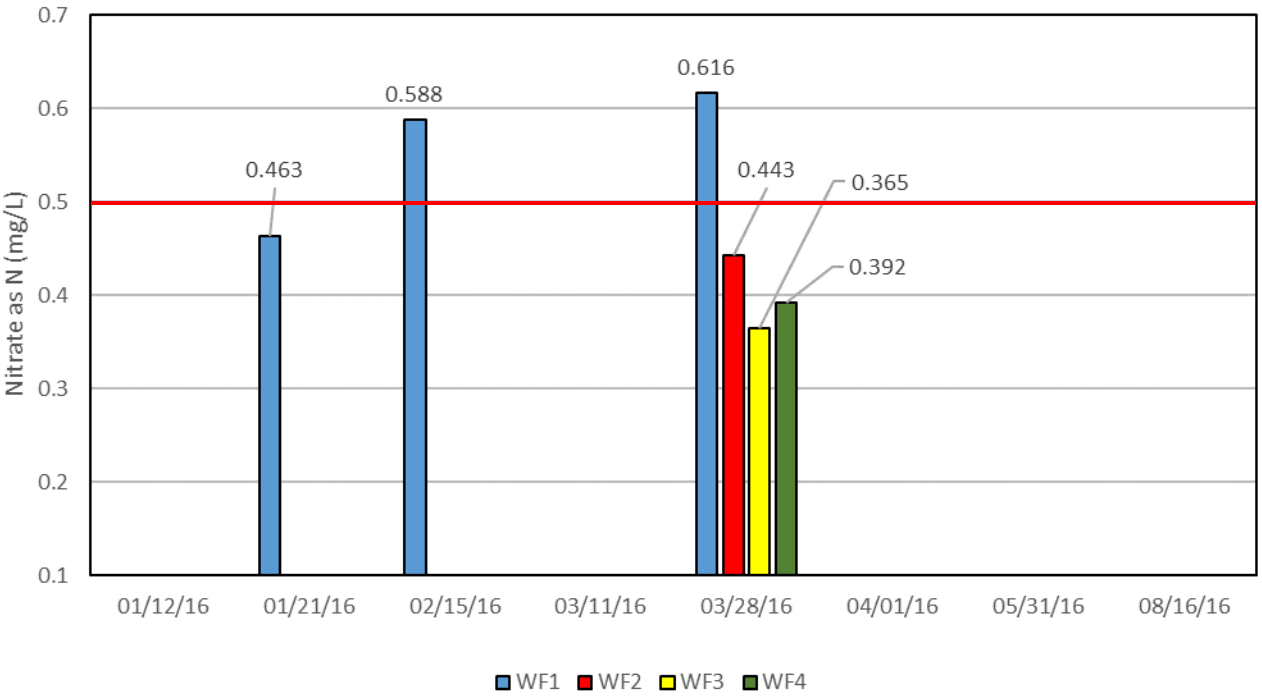

Figure 11.—Nitrate concentrations in samples collected at West Fowl River monitoring sites.

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

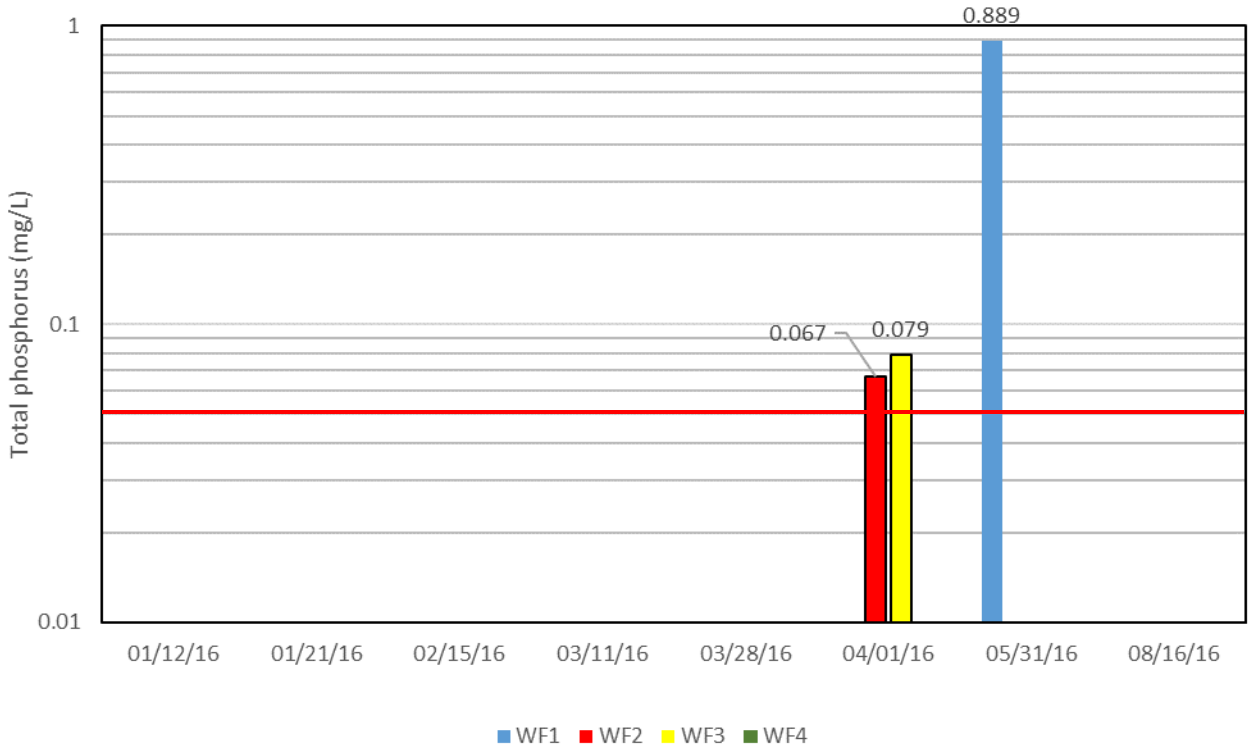

Figure 12.—Total phosphorus concentrations in samples collected at West Fowl River watershed monitoring sites.

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.

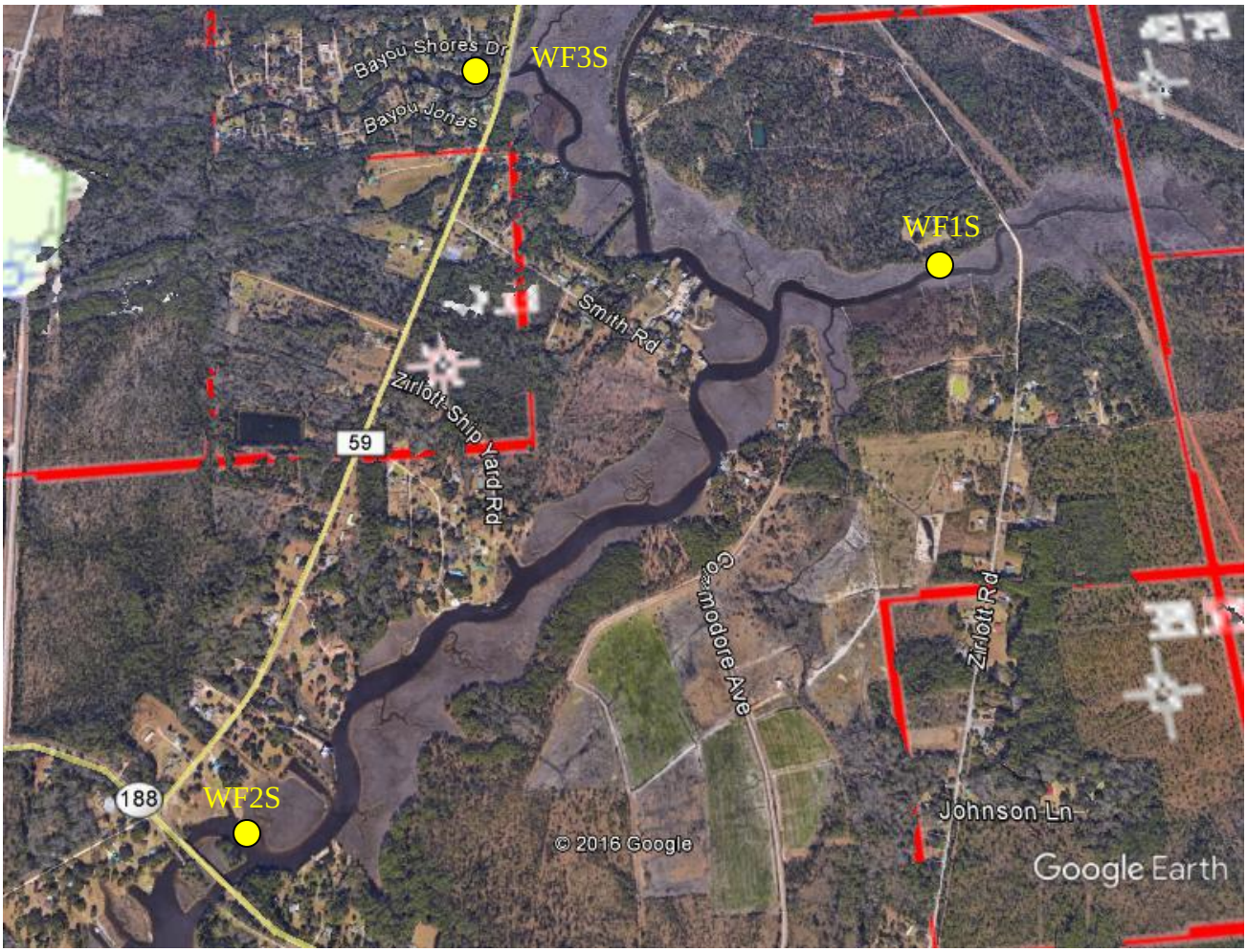

Figure 14.—Stream bed sediment sampling sites in the West Fowl River watershed.

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

APPENDIX D GRANT INFORMATION

Federal/State			
Clearinghouse for Federal Grant Opportunities (Grants.gov)	Grants.gov Contact Center Phone: 1-800-518-4726 24 hours/day,7days/week	Administered by the U.S. Department of Health and Human Services, Grants.gov is a central storehouse for information on over 1,000 grant programs and provides access to approximately $500 billion in annual awards. This site also includes information about project funding that is available under the American Recovery and Reinvestment Act. www.grants.gov,	
EPA Catalog of Federal Funding Sources for Watershed Protection	N/A	The Catalog of Federal Funding Sources for Watershed Protection Web site is a searchable database of financial assistance sources (grants, loans, and cost-sharing) available to fund a variety of watershed protection projects. https://ofmpub.epa.gov/apex/watershedfunding/f?p=fedfund:1	
EPA Clean Water and Drinking State Revolving Loan/Grants Funds	James Dailey ADEM P.O. Box 301463 Montgomery, AL 36130 1-334-271-7805 Email: jwd@adem.state.al.us http://water.epa.gov/grants_funding /cwsrf /cwsrf_index.cfm	The Clean Water State Revolving Fund and the Drinking Water State Revolving Funds (SRF) are low-interest loan programs intended to finance public water and wastewater infrastructure improvements in Alabama. ADEM administers these funds for EPA, performs the required technical/environmental reviews of projects, and disburses funds to recipients. States establish limits for project awards; there is no statutory limit. www.adem.state.al.us/ www.adem.state.al.us/programs/water/srf.cnt	August - December
EPA Five-Star Restoration Program Grants	Lindsay Vacek lindsay.vacek@nfwf.org Coordinator, Eastern Partnership Office Add phone number	This program provides challenge grants, technical support and opportunities for information exchange to enable community-based projects that restore wetlands and streams. Grant awards typically range from $5,000 to $20,000. www.epa.gov/wetlands/restore/5star and www.epa.gov/water/funding.html (List of funding and financing resources)	November – February

Funding Program	Contact	Description	Grant Application Date
EPA Non-Point Source Grant Program (Clean Water Act Section 319)	Susan Dingman, Chief Nonpoint Source Unit Office of External Affairs Alabama Department of Environmental Management Telephone (334) 394-4354 E-mail: sdingman@adem.state.al.us	Through its 319 program, EPA provides formula grants to the states and tribes to implement nonpoint source projects and programs in accordance with Section 319 of the Clean Water Act (CWA). Nonpoint source pollution reduction projects can be used to protect source water areas and the general quality of water resources in a watershed. Examples of previously funded projects include the design and implementation of BMP systems for stream, lake and estuary watersheds. Grant awards vary by State. http://adem.alabama.gov/programs/water/nps/319grant.cnt	April-May
EPA Wetlands Program Development Grants (State-Tribal-Local Governments and State Universities only)	Contact Region 4 EPA office Phone: 404-562-9393 E-mail: Geryl Ricks (ricks.geryl@epa.gov)	The EPA Wetland Program Development Grants are intended to encourage comprehensive wetlands program development by promoting the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, reduction, and elimination of water pollution. Projects build the capacity of states, tribes, and local governments to effectively protect wetland and riparian resources. Projects funded under this program support the initial development of a wetlands protection, restoration or management program or support the enhancement/refinement of an existing program. www.epa.gov/owow/wetlands/grantguidelines/	Deadlines are determined annually and vary from region to region.
Mitigation Grant Program	Mitigation Officer and local government official(s) for specific details	The Federal Emergency Management Agency Hazard Mitigation Grant Program (HMGP) provides states and communities with resources to invest in long-term actions that help to reduce the toll from potential natural and manmade hazards. The program also supports the implementation of mitigation measures during the immediate recovery from a disaster. The HMGP funds projects to protect either public or private property, as long as the project fits within the overall mitigation strategy of the state and/or local government and complies with program guidelines. In response to flood hazards, eligible projects include the elevation, relocation or acquisition and demolition of flood-prone structures, stormwater management projects and certain types of minor flood control projects. The state is responsible for setting priorities for funding and administering the HMGP. http://www.fema.gov/hazard-mitigation-assistance	
NOAA Coastal Services Center Cooperative Agreements	James L. Free U.S. Department of Commerce National Oceanic and Atmospheric Administration Services Center 2234 South Hobson Avenue Charleston, SC 29405-2413 843-740-1185	The National Oceanic and Atmospheric Administration (NOAA) guides the conservation and management of coastal resources through a variety of mechanisms, including collaboration with the coastal resource management programs of the nation's states and territories. The mission of the NOAA Coastal Services Center is to support the environmental, social, and economic well-being of the coast by linking people, information, and technology. The vision of the NOAA Coastal Services Center is to be the most useful government organization to those who manage and care for our nation's coasts. $4.65 Million (est.) http://www.noaa.gov/	Varies by state. Consolidated state CZMA program applications are provided to NOAA in March through May.
NOAA Coastal Zone Management Administration Awards	U.S. Department of Commerce National Oceanic and Atmospheric Administration	The program assists states in implementing and enhancing Coastal Zone Management programs that have been approved by the Secretary of Commerce. Funds are available for projects in areas such as coastal wetlands management and protection, natural hazards management, public access	Varies depending on opportunity.

	National Ocean Service, Office for Coastal Management 2234 South Hobson Ave. Charleston, SC 29405-2413 (301) 713-3155 Joelle.gore @noaa.gov www.coast.noaa.gov or www.coast.noaa.gov/czm/	improvements, reduction of marine debris, assessment of impacts of coastal growth and development, special area management planning, regional management issues, and demonstration projects with potential to improve coastal zone management.www.coastalmanagement.noaa.gov	
Coastal and Marine Habitat Restoration Grants	Melanie Gange U.S. Department of Commerce National Oceanic and Atmospheric Administration Office of Habitat Conservation, HC-3 1315 East-West Highway Silver Spring, MD 20910 301-713-01714 Melanie.Gange@noaa.gov http://www.habitat.noaa.gov/funding/index.html	The principal objective of the National Marine Fisheries Service's (NMFS) Coastal and Marine Habitat Restoration Project solicitation is to identify and support proactive restoration project(s), which use a habitat-based approach to foster species recovery and increase fish production. Proposals submitted under this solicitation will be selected based on their ability to demonstrate how the proposed habitat restoration actions will help recover threatened and endangered species listed under the Endangered Species Act, sustain or help rebuild fish stocks managed under the Magnuson-Stevens Fishery Conservation and Management Act, or benefit other coastal and marine species with a nexus to NMFS management. Successful proposals will 1) identify a habitat-based issue/concern limiting the recovery or sustainability of one or more target species (e.g. fish marine mammals, sea turtles); 2) identify the project(s)' goal(s) and describe in detail the actions and on-the-ground habitat restoration project(s) to be undertaken to resolve the issue/concern and; 3) describe the measurable impact on the target species, including evaluation techniques.	Every three years. Anticipated in fall 2015.
NOAA Estuary Habitat Restoration Project Funding	http://www.era.noaa.gov/information/funding.html	The Estuary Restoration Act (ERA) Council seeks projects that achieve cost effective restoration while promoting partnerships among agencies and between public and private sectors. Eligible habitat restoration activities may include (but are not limited to) improvement of estuarine wetland tidal exchange or re-establishment of historic hydrology; dam or berm removal; improvement or reestablishment of fish passage; appropriate reef/substrate/habitat creation; planting of native estuarine wetland and submerged aquatic vegetation; reintroduction of native species; control of invasive species; and establishment of riparian buffer zones in the estuary. Projects will be evaluated for their support of the Estuary Habitat Restoration Strategy. Awarded proposal may be funded by any of the five ERA agencies, depending on annual appropriated ERA funds. http://noaa.gov	No Funding could come at a later date
Engineers Aquatic Ecosystem Restoration (CAP Section 206)	Todd Boatman Mobile District Office 216-694-4101 Go to www.usace.army.mil; look for your state and district to find your local contact person.	Work done under this authority may carry out aquatic ecosystem restoration projects that will improve the quality of the environment, are in the public interest, and are cost-effective. There is no requirement that an existing Corps project be involved. The median grant awarded under this program is $300,000. A ceiling of $5,000,000 is established for each project. http://www.usace.army.mil/	None
U.S. Army Corps of Engineers Emergency Streambank and Shoreline Protection (Section 14)	Todd Boatman Mobile District Office 251-694-4101	Section 14 of the 1946 Flood Control Act provides authority for the Corps of Engineers to develop and construct emergency streambank and shoreline protection projects to prevent erosion damages to endangered highways, highway bridge approaches, public work facilities such as water and sewer lines,	Check with your local US Army Corp of Engineers for funding information

		churches, public and private non- profit schools and hospitals, and other non-profit public facilities. Each project is limited to a Federal cost of $1,000,000. http://www.sam.usace.army.mil/pd/custguide/custguide.htm	
U.S. Army Corps of Engineers Environmental Infrastructure Program (Section 219)	Todd Boatman Mobile District Office 251-694-4101	Section 219 of the Water Resources Development Act of 1992 provides authority for the Corps of Engineers to assist non-Federal interests carry out water-related environmental infrastructure and resource protection and development projects. Such assistance may be in the form of technical planning, design assistance, and construction assistance. http://www.sam.usace.army.mil	Check with your local US Army Corp of Engineers for funding information
U.S. Army Corps of Engineers General Investigation Study	Todd Boatman Mobile District Office 251-694-4101	Authority for the study must be provided by a specific Congressional resolution or identified in a Water Resources Development Act. The Congressional authority determines the purpose and scope of the study. Funds to conduct the study must be specifically identified for that purpose in an Appropriations Act. Studies could lead to recommendations for construction of a Corps construction project. http://www.sam.usace.army.mil	
Engineers Planning Assistance to the States (Section 22)	Todd Boatman Mobile District Office 251-694-4101	Section 22 of the Water Resources Development Act of 1974 provides authority for the Corps of Engineers to assist the States, local governments, and other non-Federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land. Federal allotments for each State are limited to 500,000 annually, but are typically much less. Typical cost of an individual study is $25,000 to $75,000. The studies generally involve the analysis of existing data for planning purposes using standard engineering techniques, although some data collection is often necessary. Most studies become the basis for State and local planning decisions and can lead to a project under Section 206 or a congressionally authorized project in a future Water Resources Development Act. http://www.sam.usace.army.mil	
U.S. Army Corps of Engineers Small Flood Damage Reduction Projects (CAP Section 205)	Todd Boatman Mobile district Office 251-694-4101 U.S. Army Corps of Engineers 202-761-7763 internet www.usace.army.mil	Work under this authority provides for local protection from flooding by the construction or improvements of structural flood damage reduction features such as levees, channels and dams. Non-structural alternatives are also considered and may include measures such as installation of flood warning systems, raising and/or flood proofing of structures, and relocation of flood prone facilities. http://www.sam.usace.army.mil/pd/custguide/custguide.htm	none
USDA Forest Service Urban and Community Forestry Challenge Cost-Share Grants	Nancy Stremple Urban and Community Forestry Staff, Mail Stop 1151 USDA Forestry Service 1400 Independence Avenue, S.W. Washington, DC 20250-1151 202-205-7829	The U.S. Forest Service Urban and Community Forestry Grant Program seeks to establish sustainable urban and community forests by encouraging communities to manage and protect their natural resources. The program works to achieve a number of goals, including (1) effectively communicating information about the social, economic, and ecological values of urban forests; (2) involving diverse resource professionals in urban and community forestry issues; and (3)	Pre-proposals must be posted to Grants.gov or courier hard copies received by 11:59 PM Eastern, November 23 Pre-proposals selected for full proposals will be (tentatively) due by

	nstremple@fs.fed.us	supporting a holistic view of urban and community forestry. In particular, the program supports an ecosystem approach to managing urban forests for their benefits to air quality, stormwater runoff, wildlife and fish habitat, and other related ecosystem concerns. The Forest Service awards these grants based on recommendations made by the National Urban and Community Forestry Advisory Council, a 15-member advisory council created by the 1990 Farm Bill to provide advice to the Secretary of Agriculture on urban and community forestry. http://www.fs.fed.us/ucf/nucfac.shtml	11:59 PM Eastern, March 15 The U.S. Forest Service anticipates that the statutory authority (Sub Title 9 of the Cooperative Forestry Assistance Act) for the Fiscal Year 2016 Urban and Community Forestry (U&CF) Program may provide, approximately $900,000 ($300,000 per category) in grant funds to be awarded through the 2016 National Urban and Community Forestry Challenge Cost-Share Grant Program. Funds are to support national urban and community forestry projects on nonfederal public land that have a national or multi-state impact and application. All awards are based on the availability of funding, which may be subject to change. Eligible Applicants: Any U.S. non-Federal organization and Tribal agencies, operating within the United States or its territories, may apply for the Challenge Cost-Share grant. While collaboration with Federal agencies is encouraged, a Federal agency may not receive funding or be used as match to the Federal funds being requested. Individuals and private land are not eligible. The Forest Service will address any conflicts of interest. Not Eligible: If an entity has a local/State tree-planting projects, capital improvements to property of any ownership, and/or projects that have only a local impact and applicability are not eligible and they
USDA Natural Resources Conservation Service (NRCS) Emergency Watershed Protection Program	Contact your local USDA Service Center. For a list, see www.usda.gov/offices.html. Click on the County Office Locator	The USDA NRCS Emergency Watershed Protection (EWP) program helps protect lives and property threatened by natural disasters such as floods, hurricanes, tornadoes, droughts, and wildfires. EWP provides funding for such work as clearing debris from clogged waterways, restoring vegetation, and stabilizing river banks. The measures that are taken must be environmentally and economically sound and generally benefit more than one property owner. EWP also provides funds to purchase floodplain easements as an emergency measure. Floodplain easements restore, protect, maintain, and enhance the functions of the floodplain; conserve natural values including fish and wildlife habitat, water quality, flood water retention, ground water recharge, and open space; reduce long-term federal disaster assistance; and safeguard lives and property from floods drought and the products of erosion. EWP can provide up to 90 percent cost share in limited resource areas as determined by the U.S. Census. www.nrcs.usda.gov/programs/ewp	Funds are issued on an emergency basis only. The sponsor has 60 days to request assistance from the time of an emergency declaration

USDA Natural Resources Conservation Service (NRCS) Watershed Rehabilitation Program	National Watershed Rehabilitation Contact: Lorenzo Henderson Watershed Rehabilitation Specialist USDA Natural Resources Conservation Service 14th and Independence Ave. SW, Room 6021-S Washington D.C. 20250 Telephone: 202-205-4098 Lorenzo.henderson@wdc.usda.gov	This program provides Federal cost-share funding for the rehabilitation of aging dams that were installed primarily through the Watershed Protection and Flood Prevention Program over the past 55 years. The purpose for rehabilitation is to extend the service life of dams and bring them into compliance with applicable safety and performance standards or to decommission the dams so they no longer pose a threat to life and property. As of January 2013, there are 202 approved rehabilitation projects in 25 states. One hundred and twenty-one of these projects in 20 states have been completed; 50 projects in 12 states are being implemented (either in design or construction phase0; and 31 projects in 12 states are in the planning stage. It also includes case studies of rehabilitation projects in Georgia, Oklahoma, Texas, and Virginia www.nrcs.usda.gov/programs/WSRehab	Applications may be submitted anytime during the year
U.S. Department of Transportation Federal Highway Administration National Scenic Byways Discretionary Grant program	Collette E. Boehm Special Projects Director Alabama's Coastal Connection P.O. Drawer 457, 900 Commerce loop (36542)Gulf Shores, AL 36547 251-974-4632 cboehm@gulfshores.com Cindi Ptak National Scenic Byways Program Manager 202-366-1586	To implement projects on roads designated as national Scenic Byways or All American Roads, State scenic byways, or Indian tribe scenic byways. Eligible projects must be from one of the following eight eligible activities: State or Indian tribe Scenic Byway Programs, Corridor Management Plans, Safety Improvements, Byways Facilities, Access to Recreation, Resource Protection, Interpretive Information or marketing. Alabama's Coastal Connection is a designated Scenic Byway. http://www.bywaysonline.org/grants	Check Website for funding.
U.S. Fish and Wildlife Service Coastal Program	Patric Harper Northern Gulf Coastal Program Coordinator Phone: 228-475-0765 x 105 E-mail: Patric_Harper@fws.gov	The U.S. Fish and Wildlife Service Coastal Program works to conserve healthy Coastal habitats on public or private land for the benefit of fish, wildlife, and people in 22 specific coastal areas. The program forms cooperative partnerships designed to (1) protect coastal habitats by providing technical assistance for conservation easements and acquisitions: (2) restore coastal wetlands, uplands, and riparian areas: and (3) remove barriers to fish passage in coastal watersheds and estuaries. Program biologists provide restoration expertise and financial assistance to federal and state agencies, local and tribal governments, businesses, private landowners and conservation organizations such as local land trusts and watershed councils. http://www.fws.gov/coastal/ : http://www.fws.gov/daphne	Check with the individual Coastal Program location
U.S. Fish and Wildlife Service Landowner Incentive Program	Contact the state Fish and Wildlife office directly. See web site link at right.	The U.S. Fish and Wildlife Service Landowner Incentive Program (LIP) grant program provides competitive matching grants to states to establish or supplement landowner incentive programs. These programs provide technical and financial assistance to private landowners for projects that protect and	

		restore habitats of listed species or species determined to be at-risk. LIP projects involve activities such as the restoration of marginal farmlands to wetlands, the removal of exotic plants to restore natural prairies, a change in grazing practices and fencing to enhance important riparian habitats, instream structural improvements to benefit aquatic species, road closures to protect habitats and reduce harassment of wildlife, and acquisition of conservation easements. Although not directly eligible for these funds, third parties such as nonprofit organizations may benefit from these funds by working directly with their states to see if either grants or partnering opportunities are available. http://wsfrprograms.fws.gov/Subpages/GrantPrograms/LIP/LIP.htm	
U.S. Fish and Wildlife Service North American Wetlands Conservation Act Grants Program	http://www.fws.gov/birds/grants/north-american-wetland-conservation-act.php U.S. Department of the Interior U.S. Fish and Wildlife Service North American Waterfowl and Wetlands Office (NAWWO) 4401 North Fairfax Drive, Room 110, Arlington, VA 22203 (703) 358-1784 Email dbhc@fws.gov Internet http://birdhabitat.fws.gov	The U.S. Fish and Wildlife Service Division of Bird Habitat Conservation administers this matching grants program to carry out wetlands and associated uplands conservation projects in the United States, Canada, and Mexico. Grant requests must be matched by a partnership with nonfederal funds at a minimum 1:1 ratio. Conservation activities supported by the Act in the United States and Canada include habitat protection, restoration, and enhancement. Project proposals must meet certain biological criteria established under the Act. http://birdhabitat.fws.gov; www.cfda.gov	July
U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program	U.S. Fish and Wildlife Service Branch of Habitat Restoration Division of Fish and Wildlife management and Habitat Restoration 4401 North Fairfax Drive Room 400 Arlington, VA 22203 703-358-2031	The Partners for Fish and Wildlife Program provides technical and financial assistance to private landowners to restore fish and wildlife habitats on their lands. Since 1987, the program has partnered with more than 37,700 landowners to restore 765,400 acres of wetlands; over 1.9 million acres of grasslands and other upland habitats: and 6,560 miles of in-stream and streamside habitat. In addition, the program has reopened stream habitat for fish and other aquatic species by removing barriers to passage. www.fws.gov/partners	No deadline. Check Website for funding
U.S. Housing and Urban Development Community Development Block Grants (CDBG)	Community Development Block Grants/Entitlement Grants Contact your state's CDBG grantees)	The objective of this program is to develop viable urban communities, by providing decent housing and a suitable living environment, and by expanding economic opportunities, principally for persons of low and moderate income. Recipients may undertake a wide range of activities directed toward neighborhood revitalization, economic development and provision of improved community facilities and services. http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs	For formula grants, no earlier than November 15 or no later than August 16 of the fiscal year for which the funds are allocated
Environmental Solutions for Communities	National Fish and Wildlife Fouwww.nfwf.org National Fish and Wildlife Foundation	In 2012, Wells Fargo and the National Fish and Wildlife Foundation launched the Environmental Solutions for Communities initiative, designed to support projects that link economic development and community well-being to the stewardship and health of the environment. This 5-year initiative is supported	December

	1133 15th Street NW, Suite 1100 Washington, DC 20005 Primary Telephone 202-595-2471 Primary Email Carrie.Clingan@nfwf.org	through a $15 million contribution from Wells Fargo that will be used to leverage other public and private investments with an expected total impact of over $37.5 million. Funding priorities for this program include: (1) supporting sustainable agricultural practices and private lands stewardship; (2) conserving critical land and water resources and improving local water quality (3) restoring and managing natural habitat species and ecosystems that are important to community livelihoods; (4) facilitating investments in green infrastructure, renewable energy and energy efficiency; and (5) encouraging broad-based citizen participation in project implementation. www.nfwf.org	
Conservation Partners	U.S. Department of Agriculture's natural Resources Conservation Service National Fish and Wildlife Foundation Other regional/specific partners	Conservation Partners is a partnership between the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) (www.nrcs.usda.gov), the National Fish and Wildlife Foundation (NFWF) (www.nfwf.ortg), and other regional/initiative specific partners. The purpose of this program is to provide grants on a competitive basis to support field biologist and other habitat conservation professionals (ecologists, foresters, range cons, etc.) working with NRCS field offices in providing technical assistance to farmers, ranchers, foresters and other private landowners to optimize wildlife habitat conservation on private lands. Conservation Partners aims to better focus and increase the effectiveness of Farm Bill assistance funded through programs such as Wildlife Habitat Incentives Program (WHIP), Environmental Quality Incentives Program (EQIP), Conservation Reserve Program (CRP) and others. In addition, Conservation Partners will consider funding capacity and outreach for organizations whose mission matches the goals of this program. www.nfwf.org/ConservationPartners	Multiple funding opportunities are available Throughout the year. All applications must be submitted online through the Easygrants application system.
Marine Debris Fishing for Energy Fund	National Fish and Wildlife Foundation	The Fishing for Energy Fund is a partnership between the NOAA Marine Debris Program, Covanta Energy Corporation and National Fish and Wildlife Foundation to provide grants on a variety of proposal topics to support public outreach and prevention strategies to reduce the impacts of derelict fishing gear to the marine and coastal environments. The Program supports projects that proactively engage the fishing community and state managers in developing prevention strategies to address derelict fishing gear. www.nfwf.org www.nfwf.org/fishingforenergy	Application Deadline: October

National Wildlife Refuge Friends Group Grant Program	National Fish and Wildlife Foundation National Fish and Wildlife Foundation 1133 15th Street, NW Suite 1100 Washington, DC 20005 Telephone (202) 857-0166 teal.edelen@nfwf.org www.nfwf.org	The National Fish and Wildlife Foundation provides grants for projects that help organizations to be effective co-stewards of our nation's important natural resources within the national Wildlife Refuge System. This program provides competitive seed grants to help increase the number and effectiveness of organizations interested in assisting the refuge system nationwide. The program will fund: (1) Start-up Grants to assist starting refuge support groups with formative and/or initial operational support (membership drives, training, postage, etc.); (2) Capacity Building Grants to strengthen existing refuge support groups' capacity to be more effective (outreach efforts, strategic planning, membership development) and (3) Project Specific Grants to support a specific project (conservation education programs for local schools, outreach programs for private landowners, habitat restoration projects, etc.) www.nfwf.org	See Website
Pulling Together Initiative	National Fish and Wildlife www.nfwf.org National Fish and Wildlife Foundation, 1133 15th Street, NW, Suite 1100, Washington, DC 20005 teal.edelen@nfwf.org	The National Fish and Wildlife Foundation's Pulling Together Initiative (PTI) provides a means for federal agencies to partner with state and local agencies, private landowners, and other interested parties to develop long-term weed management projects within the scope of an integrated pest management strategy. The goals of PTI are: (1) to prevent, manage, or eradicate invasive and noxious plants through a coordinated program of public/private partnerships; and (2) to increase public awareness of the adverse impacts of invasive and noxious plants. PTI provides support on a competitive basis for the formation of local weed management area (WMA) partnerships, allowing them to demonstrate successful collaborative efforts and develop permanent funding sources for the maintenance of WMAs from the involved parties. Successful projects will serve to increase public awareness and interest in future partnership projects. www.nfwf.org	Pre Proposal Due August 3 Full Proposal Due Sept. 30
Shell Marine Habitat Program	National Fish and Wildlife Foundation National Fish and Wildlife Foundation 1133 15th Street, NW, Suite 1100 Washington, DC 20005 Telephone 202-857-0166 lSuzanne.Sessine@nfwf.org	The Shell marine Habitat Program is a partnership between the Shell Oil Company and the National Fish and Wildlife Foundation (NFWF). The purpose of this partnership is to provide grants for projects that benefit marine and coastal habitats in and around the Gulf of Mexico, as well as the North Aleutian Basin, North Slope Borough, and Northwest Arctic Borough areas of Alaska. The National Oceanic and the Atmospheric Administration recently joined Shell and NFWF in their efforts to support projects that benefit the habitat for living marine resources in the Gulf of Mexico. www.nfwf.org	April or May annually; Full proposals invited forward are due June-July; only electronic preproposals submitted through the on-line application system will be considered
Southern Company Power of Flight Program	National Fish and Wildlife Foundation National Fish and Wildlife Foundation 1133 15th Street, NW, Suite 1100 Washington, DC 20005 202-857-0166 x2479 heather.fox@nfwf.org	Through the Southern Company Power of Flight program, a minimum of $600,000 is available annually to fund bird conservation projects within the Southern Company service area of Georgia, Alabama, northwestern Florida, and southeastern Mississippi. www.nfwf.org	March

National Sea Grant College Program	National Oceanic and Atmospheric Administration U.S. Department of Commerce National Oceanic and Atmospheric Administration National Sea Grant College Program, ATTN:Dorn Carlson, Research Director 1315 East-West Highway Silver Spring, MD 20910 (301) 734-1080 dorn.carlson@noaa.gov	The National Sea Grant College Program encourages the wise use and stewardship of marine and coastal environmental resources through research, education, outreach and technology transfer. Sea Grant works in partnership between the nation's universities and the National Oceanic and Atmospheric Administration. There are 33 Sea Grant Programs in every coastal and Great Lakes state, Puerto Rico, Lake Champlain and Guam. Sea Grant serves as a bridge between government academia, industry, scientists and private citizens to promote the sustainable use of Great Lakes and ocean waters for long-term economic growth. Funding opportunities are available through national-and state-level competitions. (Click on the program name and refer to the link listed under "primary Internet" for information on national-level competitions and links to all state Sea Grant Program offices) http://seagrant.oarhq.noaa.gov/Home.aspx	Full proposals due June 8 Notification of funding decisions September 7 Meetings with funded PIs to develop outreach plans Mid-Sept. Project initiation February 1
Community-based Marine Debris Prevention and Removal Grants	National Oceanic and Atmospheric Administration marinedebris.web@noaa.gov Asma Mahdi asma.mahdi@noaa.gov Nancy Wallace, Director nancy.wallace@noaa.gov	The NOAA Marine Debris Program (MDP) provides funding to catalyze the implementation of locally driven, community-based marine debris prevention, assessment, and removal projects that benefit coastal habitat, waterways, and NOAA trust resources. The primary priorities for removal are large-scale debris, derelict fishing gear, derelict vessels, tsunami debris clean-ups and targeted shoreline and watershed projects. Projects funded through the MDP have strong on-the-ground habitat components and provide long-term ecological habitat improvements for NOAA trust resources, and provide educational and social benefits for people and their communities. http://marinedebris.noaa.gov/funding/funding-opportunities	NOW OPEN: The NOAA Marine Debris Program is proud to announce the FY2016 Community-based Marine Debris Removal Federal Funding Opportunity. This application is open until Nov 2, 2015. To apply and for the complete details, visit Grants.gov (link is external).
Beneficial Uses of Dredged Material (CAP Section 204)	U.S. Army Corps of Engineers Go to www.usace.army.mil Look for your state and district to find your local contact.	Work under this authority provides for the use of dredged material from new or existing Federal projects to protect, restore, or create aquatic and ecologically related habitats, including wetlands. www.usace.army.mil	None
Project Modifications for Improvement of the Environment (CAP Section 1135)	U.S. Army Corps of Engineers See www.usace.army.mil; find your state and district to identify your local contact person U.S. Army Corps of Engineers Telephone 202-761-7763	Work under this authority provides for modifications in the structures and operations of water resources projects constructed by the Corps of Engineers to improve the quality of the environment. Additionally, the Corps may undertake restoration projects at locations where an existing Corps project has contributed to the degradation. The primary goal of these projects is ecosystem restoration with an emphasis on projects benefiting fish and wildlife. The project must be consistent with the authorized purposes of the project being modified, environmentally acceptable, and complete within itself.	None
Sustainable Agriculture Research and Education	U.S. Department of Agriculture 1400 Independenc Ave., SW, Stop 2240	The Sustainable Agriculture Research and Education (SARE) program of the U.S. Department of Agriculture National Institute of Food and Agriculture (NIFA) works to advance farming systems that are productive, profitable,	Research and Education Grant March: Call for Pre-proposal released June: Pre-proposals due

	Washington, DC 20250 (202) 720-5384 Email: rhedberg@nifa.usda.gov www.sare.org	environmentally sound and good for communities through a regional grants program. SARE funds research and extension activities to reduce the use of chemical pesticides, fertilizers, and toxic materials in agricultural production; to improve management of on-farm resources to enhance productivity, profitability, and competitiveness; to promote crop, livestock, and enterprise diversification and to facilitate the research of agricultural production systems in areas that possess various soil, climatic, and physical characteristics; to study farms that are managed using farm practices that optimize on-farm resources and conservation practices; and to promote partnerships among farmers, nonprofit organizations, agribusiness, and public and private research and extension institutions. Click on program name and check the link in the Primary Internet box for more information about grant opportunities and program results. http://www.southernsare.org/Grants/Apply-for-a-Grant www.sare.org	August: Selected pre-proposals invited to submit full proposals November: Full proposals due February: Grants awarded Large Systems Research Grant September: Call for Proposal released November: Proposals due February: Grants awarded Professional Development Program Grant March: Call for Pre-proposal released June: Pre-proposal due August: Selected pre-proposals invited to submit full proposals November: Full proposals due February: Grants awarded On-Farm Research Grant September: Call for Proposal released November: Proposal due March: Grants awarded Producer Grant September: Call for Proposal released November: Proposal due March: Grants awarded Sustainable Community Innovation Grant March: Call for Proposal released May: Proposal due July: Grants awarded Graduate Student Grant February: Call for Proposal released May: Proposal due September: Grants awarded
Land and Water Conservation Fund (Outdoor Recreation, Acquisition, Development and Planning Grants)	U S Department of Interior Alabama Director Department of Economic & Community Affairs 401 Adams Street, P.O. Box 5690 Montgomery, AL 36103-5690 Tel: 334-242-5090	To provide financial assistance to the States and their political subdivisions for the preparation of Statewide Comprehensive Outdoor recreation Plans (SCORPs) and acquisition and development of outdoor recreation areas and facilities for the general public, to meet current and future needs. www.nps.gov/lwcf http://www.adeca.alabama.gov/Divisions/ced/Recreation/Pages/Programs.aspx	Contact State Director

Pollution Prevention Grant Program	U.S. Environmental Protection Agency U.S. Environmental Protection Agency Office of Pollution Prevention and Toxic Substances Pollution Prevention Division (7409 M) 1200 Pennsylvania Ave., NW Washington, DC 20460 Telephone 202-564-8857 Email: amhaz.michele@epa.gov www.epa.gov/p2/pubs/grants/index.htm	The Pollution Prevention Grant program provides grants and cooperative agreements to state agencies, instrumentalities of a state and federally recognized tribes to implement pollution prevention projects that provide technical assistance to businesses. The program requires applicants to work towards reducing pollution, conserving energy and water, and saving dollars through P2 efforts; as identified in EPA's Strategic Plan under Goal 4: Ensuring Safety of Chemicals and Preventing Pollution, Objective 4.2: Promote Pollution Prevention http://www2.epa.gov/p2	May 14
Urban Waters Small Grants	U.S. Environmental Protection Agency Environmental Protection Agency Office of Water 1200 Pennsylvania Ave, NW 4101M Washington, DC 20460 202-566-0730 urbanwaters@epa.gov	EPA's Urban Waters Program protects and restores America's urban waterways. EPA's funding priority is to achieve the goals and commitments established in the Agency's Urban Waters Strategic Framework (www.epa.gov/urbanwaters/urban-waters-strategic-framework). This program has an emphasis on engaging communities with environmental justice concerns. The objective of the Urban Waters Small Grants is to fund projects that will foster a comprehensive understanding of local urban water issues, identify and address these issues at the local level, and educate and empower the community. In particular, the Urban Waters Small Grants seek to help restore and protect urban water quality and revitalize adjacent neighborhoods by engaging communities in activities that increase their connection to, understanding of, and stewardship of local urban waterways.	Grants are awarded every other year. Next awards will be funded FY 2016. The total anticipated award amount (combining funding years 2015/2016) is $1.6 million, with each individual award amount of up to $60K. CFDA Program 66.440
State Wildlife Grant Program (Non-Tribal and Non-Competitive)	U S Fish and Wildlife Service paul_vanryzin@fws.gov 404-679-4124	The U.S. Fish and Wildlife Service's (USFWS) State Wildlife Grant (SWG) program provides grants to states, territories, and the District of Columbia for wildlife conservation. The SWG program provides funds to help develop and implement programs that benefit wildlife and their habitat, including species that are not hunted or fished. Although not directly eligible for these grants, third parties such as nonprofit organizations may benefit from these funds by working directly with their states to see if either grants or partnering opportunities are available. http://wsfrprograms.fws.gov/Subpages/GrantPrograms/SWG/SWG_Funding.htm http://www.fws.gov/offices/Directory/ListOffices.cfm?statecode=1	No deadline. State fish and wildlife agencies may submit applications until all funds are obligated.
Cooperative Endangered Species Conservation Fund	U S Fish and Wildlife Service Region 4 - Southeast Chief, Endangered Species U.S. Fish and Wildlife Service 1875 Century Blvd., Suite 200 Atlanta, GA 30345 http://www.fws.gov/southeast/es/	The U.S. Fish and Wildlife Service's (USFWS) Cooperative Endangered Species Conservation Fund provides financial assistance to states and territories that have entered into cooperative agreements with the USFWS to assist in the development of programs for the conservation of endangered and threatened species. The assistance provided to the state or territorial wildlife agency can include animal, plant, and habitat surveys; research; planning; monitoring; habitat protection, restoration, management, and acquisition; and public education. The Fund is dispersed to the states and territories through four	Late Fall

		programs: Conservation Grants, Habitat Conservation Planning Assistance Grants, Habitat Conservation Plan Land Acquisition Grants, and Recovery Land Acquisition Grants. Although not directly eligible for these grants, third parties such as nonprofit organizations and local governments may work with their state or territorial wildlife agency to apply for these funds. http://www.fws.gov/endangered/grants/index.html	
North American Wetlands Conservation Act Grants Program	U.S. Fish and Wildlife Service U.S. Department of the Interior U.S. Fish and Wildlife Service North American Waterfowl and Wetlands Office (NAWWO) 4401 North Fairfax Drive, Room 110, Arlington, VA 22203 (703) 358-1784 dbhc@fws.gov	The U.S. Fish and Wildlife Service's Division of Bird Habitat conservation administers this matching grants program to carry out wetlands and associated uplands conservation projects in the United States, Canada, and Mexico. Grant requests must be matched by a partnership with nonfederal funds at a minimum 1:1 ratio. Conservation activities supported by the Act in the United States and Canada include habitat protection, restoration, and enhancement. Mexican partnerships may also develop training, educational, and management programs and conduct sustainable-use studies. Project proposals must meet certain biological criteria established under the Act. Visit the program web site for more information. http://birdhabitat.fws.gov	March 7 and August 27
U.S. Department of Interior Gulf of Mexico Energy Security Act (GOMESA)	Office of Minerals Management Services	The Gulf of Mexico Energy Security Act of 2006 (GOMESA) shares leasing revenues for the four Gulf oil and gas producing states of Alabama, Louisiana, Mississippi, and Texas, and to their coastal political subdivisions. GOMESA funds are to be used for coastal conservation, restoration, and hurricane protection. http://www.mms.gov/offshore/GOMESARevenueSharing.htm	
Bring Back the Natives Grant Program	Cara Rose National Fish and Wildlife Foundation Western Partnership Office 421 SW 6th Avenue Suite 950 Portland, OR 97204 Telephone 503-417-8700 x 6008 Cara.Rose@nfwf.org	The Bring Back the Natives initiative (BBN) funds on-the-ground efforts to restore native aquatic species to their historic range. Projects should involve partnerships between communities, agencies, private landowners, and organizations that seek to rehabilitate streamside and watershed habitats. Projects should focus on habitat needs of species such as fish, invertebrates, and amphibians that originally inhabited the waterways across the country. Funding for the BBN program is administered through NFWF from federal agencies cooperating to support this program. Cooperating agencies and organizations include the US Fish and Wildlife Service (FWS), Bureau of Land Management (BLM), USDA Forest Service (FS), and Trout Unlimited (TU). www.nfwf.org/bbn	Pre-proposal Due Date: January of each year; Full Proposal Due Date: March of each year
Forest Legacy Program	Southern Region -- Region 8 (AL, AR, FL, GA, KY, LA, MS, NC, OK, Mike Murphy U.S. Forest Service 1720 Peachtree Rd., N.W. Suite 700B North Atlanta, GA 30309 404-347-5214 (phone) mwmurphy@fs.fed.us	The 2014 Omnibus funds the Forest Legacy Program (FLP). The USDA Forest Service supports state efforts to protect environmentally important forest lands from the conversion to non-forest uses through the use of conservation easements and fee-simple purchase. Designed to encourage the protection of privately owned forest lands, FLP is an entirely voluntary program. The program enables landowners to retain ownership of their land and continue to earn income from it while keeping drinking water safe and clean, conserving valuable open space as well as protecting critical wildlife habitats and outdoor recreation opportunities. The program promotes professional forest management and requires forest management plans. The program emphasizes strategic conservation - working in partnership with States, local communities and non-	Applications are submitted to the State Lead Agency in each participating State. While some States have discrete open seasons others accept applications year-round. There are currently 53 participating States and Territories in FLP. A list of State and regional Forest Service contacts can be viewed at

		governmental organizations to make a difference on the land and for communities by conserving areas of unbroken forest, watershed or river corridor forests or by complimenting existing land conservation efforts. FLP conservation easements restrict development, protect a range of public values and many require public access for recreation. http://www.fs.fed.us/spf/coop/programs/loa/flp.shtml	
Non-Governmental Organization and Other Private Funding			
Chronicle of Philanthropy Guide to Grants	The Chronicle of Philanthropy 1255 Twenty-Third Street, N.W. Seventh Floor Washington, D.C. 20037 PHONE: 202-466-1200 FAX: 202-466-2078	The Guide to Grants is an electronic database of all foundation and corporate grants listed in The Chronicle since 1995. To search this database, users must purchase a subscription; subscription rates are available for terms ranging from one week to one year. http://philanthropy.com/section/Guide-to-Grants/270	
Community of Science Database (COS)	1 North Charles Street Suite 2305 Baltimore, MD 21201 PHONE: 410-563-2378 FAX: 410-563-5389	COS is the leading global resource for hard-to-find information critical to scientific research and other projects across all disciplines. The COS Funding Opportunities web site allows users to search more than 23,000 records, representing over 400,000 funding opportunities, worth over $33 billion. A subscription fee may be required, depending on the type of organization conducting a search. http://www.cos.com	
The Foundation Center	Contact may be made through the web site address shown in the column to the right.	The Foundation Center Foundation Finder allows users to search for basic information (contact information, web site address, and IRS 990 form) on 70,000 private and community foundations in the United States (free service). They also offer two subscription-based online searchable databases, the Foundation Director and Foundation Grants to Individuals. http://foundationcenter.org	
The Kodak American Greenways Program	The Conservation Fund 703-908-5809	Eastman Kodak Company, the National Geographic Society, and The Conservation Fund are the partners in the Kodak American Greenways Program, an annual program that recognizes outstanding individuals and organizations for exemplary leadership in the enhancement of our nation's outdoor heritage. The program was established in response to the recommendation from the President's Commission on Americans Outdoors that a national network of greenways be created. Since the program's inception in 1989, more than $800,000 has been granted to nearly 700 organizations in all 50 states. The program also provides small grants to land trusts, watershed organizations, local governments and others seeking to create or enhance greenways in communities throughout America. www.conservationfund.org/kodak_awards	
RBC Bank Blue Water Project Gran	Contact may be made through the web site address shown in the column to the right.	In 2013-2014, the RBC Blue Water Project will focus on supporting initiatives that help protect and preserve water in towns, cities and urbanized areas with populations of more than 10,000 people that focus on: Improved control and management of urban storm or rain water, Efficient and innovative use (or capture and reuse) of water in towns and cities, Protection and restoration of urban waterways ,Improved urban water quality http://www.rbc.com/donations/blue-water-apply.html	

Surdna Foundation Substainable Environments Grants	Surdna Foundation 330 Madison Avenue 30th Floor New York, NY 10017 212-557-0010 questions@surdna.org	The Surdna Foundation seeks to create just and sustainable communities where consumption and conservation are balanced and innovative solutions to environmental problems improve people's lives. The Foundation works from a sustainable development perspective to demonstrate that a healthy environment is the backbone of a healthy economy and a democratic society. They fund three key related priority areas-Climate Change, Green Economy, and Transportation and Smart Growth-that aim to transform how Americans work, consume and move. Grants are approved in February, May and September. www.surdna.org	
Water Environmental Research Foundation Werf Cooperative Agreement	Carrie Capuco Communications Director ccapuco@werf.org 571-384-2097	Funding for the research is through EPA's Aging Water Infrastructure Research Program, a research agenda that supports efforts to put the nation's aging infrastructure on a pathway toward sustainability. Research efforts will include treatment technologies for wastewater, stormwater, water reuse, and drinking water. The innovative tools and cost-effective solutions that will be developed through this research should provide assistance to municipalities in their ongoing efforts to serve the public and improve water quality. www.werf.org	
KaBOOM	http://kaboom.org/about_kaboom/pro grams/grants	The Build It with KaBOOM! Playground Grant provides eligible communities with the majority of funds, tools and resources they need to build a custom-made playground – all in one day! Through this grant program, the majority of the playground funding for the project is provided by one of our generous Funding Partners. Selected groups, referred to as Community Partners, will work closely with a KaBOOM! Project Manager who will lead Design Day and Build Day activities as well as coordinate the equipment and material purchases for the project. Community members will take the lead in recruiting volunteers, securing food and tool donations and completing any necessary site preparation.	
The W.K. Kellogg Foundation	http://www.wkkf.org/who-we-are/overview	Over the years, the Kellogg Foundation's programming has continued to evolve, striving to remain innovative and responsive to the ever-changing needs of society. Today, the organization ranks among the world's largest private foundations, awarding grants in the United States, Mexico, Haiti, northeastern Brazil and southern Africa.	

APPENDIX E MOBILE BAY SUBWATERSHED RESTORATION MONITORING FRAMEWORK

Mobile Bay Subwatershed Restoration Monitoring Framework

Science Advisory Committee: Monitoring Working Group, 2015

Mobile Bay Subwatershed Restoration Monitoring Framework

Vision: Comprehensive restoration monitoring that enables quantitative assessment of restoration success and assessment of overall ecosystem function

Goals: To answer three questions:

1. What, if any, changes are there in the water quality, sedimentation, flow, biology, and habitat quantity and quality as a result of restoration efforts and management plan implementation?
2. How are potential ecosystem health indicators related to stressors and ecosystem functions/services?
3. What is the long-term status of the biological condition in the Mobile Bay watershed?

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COMMENTS ON THE PROCESS AND RECOMMENDATIONS

This framework outlines recommended monitoring procedures in relation to watershed restoration and watershed management plan implementation to understand ensuing impacts on the entire subwatershed. Development and implementation of a standardized monitoring protocol across the larger Mobile Bay watershed in all subwatersheds is critical for understanding the current health and function of the Mobile Bay Estuary and any shifts due to restoration. Recognizing the existing gap and need for such a plan in Mobile and Baldwin Counties the Mobile Bay National Estuary Program (MBNEP) tasked their Science Advisory Committee with the development of a comprehensive monitoring framework. This plan contributes to the MBNEP's Five Year Comprehensive Conservation Management Plan and can be integrated with larger monitoring networks being developed by the Gulf of Mexico Alliance, the Gulf of Mexico Coastal Ocean Observing System, and other partners.

This plan was developed by a working group of the Mobile Bay National Estuary Program Science Advisory Committee (SAC) and then approved by the rest of the SAC. These are thought to be the best available practices necessary to answer the questions laid forth in our goals. Recommendations of best practices reflect the group's professional opinion.

Desired Outcomes:

The recommended protocols will result in standardized data collection for restoration efforts throughout Mobile and Baldwin Counties, allowing comparisons both temporally and spatially, improved decision making, and data preservation for future use. We recommend the monitoring program outlined within this framework be incorporated into all watershed management plans and restoration

proposals and contracts. Ensuring utilization of this framework uniformly across all restorations and watersheds in Mobile and Baldwin counties will allow an interconnected network of data that can improve understanding of the processes of Mobile Bay as a whole. This will also serve as a model for future efforts across the Gulf Coast in developing larger, regional networks, including those envisioned by the Gulf of Mexico Alliance, the National Oceanic and Atmospheric Administration, and the Gulf of Mexico Coastal Ocean Observing System. To achieve these goals we recommend:

1) The adoption of this framework in every restoration request for proposals (RFP) and restoration contracts for Mobile and Baldwin County
2) Long-term monitoring based on this framework in every watershed management plan for all watersheds in Mobile and Baldwin County
3) Data synthesis to develop tools and products for assessment of restoration success, adaptive resource management, and baseline establishment
4) Active engagement with county and municipality planners, resource managers, agencies working within the watershed, and other stakeholders to encourage implementation of monitoring and broad application of tools developed from data synthesis.

Efficiency:

These recommendations are not all inexpensive or new. Prior to design and implementation in specific watersheds we highly encourage an inventory of required and ongoing monitoring within the watershed to assess what resources are available and what can be leveraged. For example municipalities, businesses, and state and local agencies frequently must monitor to some degree to meet Clean Water Act MS4 requirements. Interagency cooperation will avoid redundancy and provide maximum success for the minimum investment for all partners.

Data Utilization and Storage:

In addition to the monitoring scheme laid forth here, we highly recommend implementation of a feedback mechanism in both developing and existing watershed management plans (WMP). Collection of data is not enough; synthesis and analysis is required to determine if restoration and management practices are successful. While this implementation will be different for each watershed, a set of essential minimum requirements need to be met. It is critical that a committee be composed of representatives from:

- The drafter of the WMP – to navigate any changes necessary to the plan
- The municipalities and counties within the watershed – to ensure buy in to the adaptive management process and to supplement their efforts
- Agencies that will derive use from these data – to encourage focus on the watershed and implementation of necessary regulation or status change (i.e. EPA or FDA)
- Those performing the restoration – to evaluate progress of the restoration and give context to observed outcomes

- The Mobile Bay National Estuary Program – to coordinate effort and outcomes between surrounding watersheds and leverage existing partnerships
- Expert researchers – to perform analyses and interpret results

It is imperative that this committee be afforded the power needed to influence or direct the actions in the WMP based on monitoring results. Suggestions include: annual review and restructuring of the WMP based on monitoring data, review of the effectiveness of the restoration, a mechanism to address, edit, or introduce local policy based on baseline and restoration results, and implement adaptive management measures.

We also recommend that these data be housed within a regional partner to facilitate consistency, development of metadata, and promote public access to the data. Establishing a regional data repository will encourage integration within larger monitoring programs, expanding the context of the restoration effort and subsequent monitoring. This will also promote more research and data analysis, thereby improving our understanding of system function and management capabilities. As part of these recommendations metadata should be in ISO 19115-2 standard format. Utilizing a nationally recognized metadata standard will encourage data utilization across Mobile Bay and within larger regional data analyses and inventories.

Incorporating historical datasets to obtain a longer time series for analysis of system status and trends is encouraged; however, such datasets should be utilized in context and not applied beyond the scope of the original sampling.

Final Remarks

This document was developed as a framework to guide individual subwatersheds in the Mobile Bay watershed in standardizing their restoration monitoring. This standardization encourages integration of data and assessment of health of the entire Mobile Bay Estuary. Commitment to these protocols ensures relevance of data and increases the capacity of our region to better manage our resources. This sampling regime will develop an understanding of what drives the successes and failures of restoration efforts. Applying this understanding to adaptive watershed management is critical to utilizing our scarce financial and ecological resources efficiently.

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SAMPLING PROTOCOLS

We recommend that all of these monitoring efforts begin at least one year prior to implementation of restoration efforts to establish baselines. Monitoring should continue after restoration to track both short-term and long-term impacts. The minimum length of monitoring post restoration should be 3-5

years. We strongly recommend, if at all possible, transition of this monitoring into a sustained, long-term program for each subwatershed to continue tracking response to restoration and overall shifts in subwatershed health and function.

Sedimentation and Flow

Reducing sedimentation and flow are often at the core of restoration aims. If the primary goal of the restoration is to reduce sedimentation and flow, we recommend development of performance metrics specific to each restoration project for assessing success. We recommend the following monitoring metrics:

	Timing and Frequency	**Location**	**Methodology**
Erosion Rates	• Begin in Nov/Dec • After every rainfall event ≥ 1 inch • Post catastrophic events related to flow but not precipitation (e.g., dam failure)	• Upstream of restoration • Downstream of restoration • At restoration	*Staley et al., 2006*
Continuous Monitoring - Sondes	Every 15 minutes	• Mouth of all 2nd order streams or strategically important locations • Receiving sub-basin • Prior to and after in-stream retention water bodies (e.g. small lakes or large retention ponds)	• Flow • Turbidity: *EPA, 2012*
Continuous Monitoring – Automatic Water Grabs	• Any rainfall event ≥ 0.1 inch preceded by 72 dry hours • Continue every 15 min there has been no precipitation for 72 hours *Citation: EPA, 1992*	• Mouth of all 2nd order streams or strategically important locations • Receiving sub-basin • Prior to and after in-stream retention water bodies (e.g. small lakes or larger retention ponds)	• Total Suspended Solids • Suspended Sediment Annual Loading: *Cook & Moss, 2008*
Soil/sediment characterization	• Annually, beginning prior to restoration.	• Upstream of restoration • At restoration site • Downstream	• Grain size • Fraction distribution • TOC

		depositional site	
Manual Monitoring – Develop Sediment Transport Model	• After any rainfall event ≥ 1 inch for 12 months	• Upstream of restoration • Downstream of restoration • Mouth of all 2nd order streams or strategically important locations	• *Cohn et al., 1992*
Manual Monitoring – Maintain Sediment Transport Model	• Two rainfall events annually: ○ Moderate flow event ○ High flow event	• Upstream of restoration • Downstream of restoration • Mouth of all 2nd order streams or strategically important locations	• Bed Sediment Transport Rates • Bed Sediment Annual Loading: *Cook & Moss, 2008*

The Geological Survey of Alabama (GSA) has extensive experience and historical data regarding sediment and flow in many of the subwatersheds around Mobile Bay. It is highly recommended to coordinate effort and standard methods with this agency to improve efficiency and standardization.

Water Quality

Improved water quality is desired outcome from all restoration efforts. Given that water quality is a direct link to biological condition and ecosystem health, impacts must be quantified. It is critical to the evaluation of a restoration project to measure baselines and changes of water quality over time. For accurate assessment of water quality baselines and quantified changes in response to restoration we recommend monitoring:

	Timing and Frequency	**Location**	**Method**
Continuous Monitoring – Sondes	Every 15 minutes (to sample first flush)	• Reference site • Upstream from restoration • Downstream from restoration ○ Combine with sediment and flow continuous monitoring • Receiving Sub-basin • In-stream retention water bodies	• Temperature • Dissolved Oxygen • pH • Conductivity • Photosythetically Active Radiation ○ Only in receiving sub-basin • NO3 • CDOM • Turbidity
Continuous Monitoring – Automatic Water	• Any rainfall event ≥ 1 inch • Continue every	• Reference Site • Upstream from restoration • Downstream from	• Nutrients ○ NO3 ○ NH4

Grabs	15 min until it has been dry for 3 days: *EPA, 1992*	restoration ○ Combine with sediment and flow continuous monitoring • Receiving sub-basin • In-stream retention water bodies	○ DON ○ PN ○ PO4 ○ DOP ○ POP ○ *Lehrter et al., 2013* • Total Suspended Solids • Dissolved Organic Carbon • Particulate Organic Carbon *Welschmeyer, 1994*
Manual Sampling – Monthly Water Grabs	Sample based on turnover in the receiving sub-basin	Receiving sub-basin • Determine sampling locations within the sub-basin based on size and dynamics of the system	• Nutrients ○ NO3 ○ NH4 ○ DON ○ PN ○ PO4 ○ DOP ○ POP • Chlorophyll-a • Dissolved Organic Carbon • Particulate Organic Carbon *Welschmeyer, 1994*
Other	• Consider additional 303d issues based on initial screening sampling with subsequent periodic reevaluations for both continuous and manual sampling • Any additional issues specific to a subwatershed should be addressed with a detailed monitoring protocol ▪ Protocols used should be submitted to the MBNEP SAC for integration into this framework to ensure consistency and standardization across the Mobile Bay Watershed		

Habitats

Habitats are the foundation of an ecosystem; shifts in habitat health and function directly impact the ecological and economic benefits of the watershed. To accurately assess the health of individual habitats we recommend the following monitoring for each habitat:

<u>Submerged Aquatic Vegetation</u>

	Timing and Frequency	**Location**	**Method**

Bed Boundaries	Annually at peak biomass	Receiving sub-basins	Aerial Photography; Tier 1, *Neckles et al., 2012*
Species Composition and Density	Annually at peak biomass	Receiving sub-basins – determine sampling locations depending on the size and dynamics of the system and the SAV beds	Percent Cover & Cores; Tier 2,3, *Neckles et al., 2012*

Wetlands

	Timing and Frequency	**Location**	**Methods**
Acreage*	Annually at peak biomass	• Reference Site • Restoration Site • Downstream of restoration site	Aerial imagery and existing spatial data with field verification. *USACE, 2010*
Floristic Quality Index (FQI)	Annually at peak biomass	• Reference Site • Restoration Site • Downstream of restoration (if applicable)	*Lopez & Fennessy, 2002*
Wetlands Rapid Assessment Protocol (WRAP)	Annually at peak biomass	• Same locations as the FQI	*Miller and Gunsalus, 1999*
Hydrogeomorphic (HGM) Model	Annually at peak biomass	• Receiving sub-basins	*Shafer et al., 2007*

* Mobile and Baldwin Counties will have detailed mapping of critical habitat including wetlands conducted in 2015. It is the recommendation of this team that such mapping occur annually as part of a comprehensive watershed management plan for each sub-watershed. If complete watershed mapping is not scheduled in the year prior to and at least 3 years after restoration then follow this recommendation.

Streams and Riparian Buffers

	Timing and Frequency	**Location**	**Method**
Rapid Stream Assessment for Riparian Buffers	Annually at peak biomass	Entire watershed	• *Barbour et al., 1999* • *Look to leverage effort with ADEM: ADEM conducts these around the state*
Stream Quality Score	Annually, during early spring, prior to adult insect emergence	• 100 m reach segments • Upstream from	• *Barbour et al., 1999* • *Be aware of agriculture, golf*

		restoration or a reference site • At restoration • Downstream from restoration	*courses, and other potential sources of insecticide that could artificially skew results*

Oyster Reefs

	Timing and Frequency	**Location**	**Method**
Reef Areal Dimension	Annually and after events that impact oyster survival (i.e. hurricanes)	Receiving sub-basins	*Bagget et al, 2014*
Reef Height *	Annually and after events that impact oyster survival (i.e. hurricanes)	Reference sites within receiving sub-basins	*Bagget et al, 2014*
Oyster Density	Annually after peak growing season	Receiving sub-basins	*Bagget et al, 2014*
Oyster Size-Frequency Distribution	Annually after peak growing season	Receiving sub-basins	*Bagget et al, 2014*
Other	Coordination with Alabama Department of Conservation and Natural Resources Marine Resources Division (ADCNR MRD) is highly recommended as ADCNR MRD have a long-term oyster data set and expertise in oyster sampling methodologies. Any additional concerns such as HABs or fecal coliforms should be considered and coordination with the Alabama Department of Public Health (ADPH) is highly recommended to reduce redundancy and incorporate experts in sampling and analysis of results. (*National Shellfish Sanitation Program*)		

*Monitoring oyster reef height provides understanding of how upstream or adjacent land-based activities that change rates of sedimentation, dissolved oxygen, or other water column attributes may, in turn, impact the overall function and productivity of reefs (which can change based on vertical distribution). Low height oyster reefs are naturally occurring in and around Mobile Bay, and a low reef height alone is not to be considered a sign of a poorly functioning reef.

Other Foundational Habitats

There are other habitats that may be critical within individual subwatersheds. For each of these habitats we recommend following a protocol based on published and standardized methods that details frequency and location. Protocols used should be submitted to the MBNEP SAC for integration into this framework to ensure consistency and standardization across the Mobile Bay Watershed

Biological Communities

Biological communities are a critical component of both ecological function and services including fisheries. Many of the native species are captured in the stream and marsh indices; however, specific species and their associated habitats should be considered. Targeted species differ for individual subwatershed. To ensure that no critical species are overlooked the following should be considered in detail for each subwatershed monitoring program:

- Sensitive habitats
    - Determine if there are any habitats (e.g. marine mammal feeding, resting, breeding habitats, nesting bird habitat etc.)
    - Develop a protocol based on published or standardized methods that details frequency and location
        - Developed protocol should be submitted to the MBNEP SAC for integration into this framework to ensure consistency and standardization across the Mobile Bay Watershed
- Invasive Species
    - Develop a protocol based on published and standardized methods that details frequency and location
- Endangered and Threatened Species
    - Determine if there are any endangered or threatened species
    - Develop a protocol based on published methods or standardized methods that details frequency and location

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APPENDIX F WATERSHED MANAGEMENT PLAN COMPONENT CHECKLIST

Watershed Management Plan Component Checklist
Watershed Management Plan Title: West Fowl River Watershed Management Plan
Waterbody ID, Hydrologic Unit Code, Watershed Boundary Data Set, or Hydrologic Response Unit: U.S. Geological Survey (USGS) 12-digit hydrologic unit code (HUC) HUC 031700090103 (USGS 2013).
River Basin: Escatawpa River Basin
County(ies): Mobile County
Title of TMDL: a) A TMDL for This Watershed is ("X" as applicable): ( ) Approved ( ) In Draft b) No TMDL Has Been Developed to Date: (X) c) The Watershed Plan Addresses a Non-Impaired or Threatened Waterbody: (X) Yes ( ) No
Comments: No approved TMDLs have been developed for the West Fowl River Watershed; Section 4.2.1 Addresses Degraded Stream & Wetlands

Component (A) Watershed Conditions	Yes	No	N/A	Chapter, Section, Table, List, etc.	Page No.(s)
I. The plan assesses the conditions of shorelines, wetlands, and riparian areas. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters: 2, 3, 4, 6 Section 2.2 Section 3.5 Section 4.4 Section 6.2; Table 2.5 Table 2.8 Table 2.10 Table 3.6 Table 3.8 Figure 2.5 Figure 2.6 Figure 3.25 Figure 4.5 Figure 4.8	 38-54 106-128 170-171 187- 221 41 45 55 92 97 40 42 115 143 148
II. The plan characterizes watershed biological resources, including fauna, flora, invasive species, and threatened and endangered species. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 2, 3, 4; Section 2.1 Section 2.2 Section 3.3 Section 4.2 Table 2.3 Table 2.4	 27-37 38-54 88-89 156-162 37 38
III. The plan characterizes customary uses of biological resources. (If "No" or "N/A" provide comments below.) Comments:	X			Chapter 2; Section 2.2 Table 2.5 Table 2.7 Figure 2.4 Figure 2.5 Figure 2.6 Figure 2.9 Figure 2.10	 38-54 41 43 34 40 42 48 50
IV. The plan identifies vulnerabilities on the watershed from increased sea level rise, storm surge, temperature increases, and precipitation. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 2,3,4; Section 2.1 Section 3.4 Section 3.5 Section 4.3 Table 2.1 Table 3.11 Table 4.5 Table 4.6 Table 4.7 Figure 2.3 Figure 3.17-21 Figure 4.8	 27-37 89-106 106-128 162-170 30 111 163 167 168 33 89-98 148
V. The plan characterizes existing opportunities for public access, recreation, and ecotourism. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 2, 3, 4, 5; Section 2.2 Section 3.6 Section 3.7	 38-54 129-139 136-139

				Section 4.5 Section 4.6 Section 6.3 Section 6.4 Section 6.7 Figure 3.44	171-172 172-178 221-241 242-243 254-256 134

Component (B) **Identification of Pollutant Causes and Sources**	**Yes**	**No**	**N/A**	**Chapter, Section, Table, List, etc.**	**Page No.(s)**
I. The plan identifies the pollutant *causes* and *sources* or groups of similar sources that will need to be managed to achieve the load reductions identified in a TMDL, or elsewhere in this plan. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 3, 4, 6 Section 3.1 Section 4.1 Section 6.2 Section 6.3 Table 3.1 Table 4.1 Table 4.2 Table 4.3 Figure 4.1-14 Figure 6.17 Figure 6.18 Figure 6.27	 51-64 139-156 187-221 221-241 61 151 155 156 141-159 211 212 225
II. The plan addresses *other* watershed/natural resource/stakeholder issues and concerns that *may be* problematic, but are *not* addressed by a TMDL. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 1, 3, 4, 5, 6, 10 Section 1.3 Section 3.6 Section 3.7 Section 4.6 Section 5.1 Section 6.5 Section 10.4 Section 10.5 Table 10.2 Table 10.3 Figure 6.29 Figure 6.30 Figure 10.1 Figure 10.5	 23 129-136 125-126 172-177 179-180 243-247 322-326 326-331 321 323 227 231 314 326

Component (C) Pollutant Load Reduction Estimates	Yes	No	N/A	Chapter, Section, Table, List, etc.	Page No.(s)
I. The plan provides estimates of load reductions needed to achieve a TMDL. (If "No" or "N/A" provide comments below.) Comments: As of 2018, a TMDL had not been developed for the West Fowl River Watershed.			X		
II. The plan provides *estimates* of potential load reductions for each pollutant cause or source, or groups of similar sources that need to be managed. (If "No" or "N/A" provide comments below.) Comments: As of 2018, a TMDL had not been developed for the West Fowl River Watershed.			X		
III. The plan provides locations where *potential* BMPs may be implemented. (If "No" or "N/A" provide comments below.) Comments: As of 2018, a TMDL had not been developed for the West Fowl River Watershed.			X		
IV. A reasonable approach is used to *estimate* pollutant load reductions (assumptions and limitations should be stated). (If "No" or "N/A" provide comments below.) Comments: As of 2018, a TMDL had not been developed for the West Fowl River Watershed.			X		

Component (D) Best Management Practices	Yes	No	N/A	Chapter, Section, Table, List, etc.	Page No.(s)
I. The plan identifies *potential* BMPs to be installed in "critical" areas. Comments; (If "No" or "N/A" provide comments below.)	X			Chapter 6; Section 6.2 Section 6.3 Table 6.3 Table 6.4 Table 6.5 Figure 6.9 Figure 6.11-16 Figure 6.19 Figure 6.21 Figure 6.26 Figure 6.27	 187-221 221-242 197 199 205 199 205-210 213 215 220 225
II. The plan identifies actions to improve habitats necessary to support healthy populations of fish and shellfish. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 6, 7; Section 6.3 Section 6.6 Section 7.1 Table 7.1 Table 7.2	 221-242 227-254 258-289 262-273 274-278
III. The plan identifies actions to reduce the incidence and impacts of invasive flora and fauna. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 6, 7; Section 6.3 Section 7.1 Table 7.1 Table 7.2	 221-242 225-289 262-273 274-278
IV. The plan identifies actions to preserve culture, heritage, and traditional ecological knowledge of the watershed. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 6, 7; Section 6.5 Section 7.1 Table 7.1 Table 7.2	 245-248 225-289 262-273 274-278
V. The plan recommends strategies to remediate effects of environmental degradation. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 6, 7; Section 6.2 Section 6.3 Section 7.1; Table 7.1 Table 7.2	 187-221 221-242 225-289 262-273 274-278
VII. The plan identifies strategic areas for shoreline stabilization, wetland and stream restoration/conservation, and fishery enhancements. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 6, 7; Section 6.3 Section 6.6 Section 7.1 Table 7.1 Table 7.2	 221-242 248-255 225-289 262-273 274-278
VIII. The plan provides recommendations to improve watershed resiliency through adaptation strategies. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 6, 7; Section 6.7 Section 7.1 Table 7.1 Table 7.2	 255-257 225-289 262-273 274-278
IX. The plan identifies potential sites to expand access to open spaces and waters within the watershed. (If "No" or "N/A" provide comments below.) Comments:	X			Chapters 6, 7; Section 6.4 Section 7.1 Table 7.1 Table 7.2	 243-244 225-289 262-273 274-278

X. The plan incorporates established programs in implementation strategies (Clean Marina, Alabama Water Watch, Community Ratings System, Smart Yards, etc) . (If “No” or “N/A” provide comments below.) Comments:	X			Chapters 6; Section 6.5 Section 7.1 Section 10.6 Section 11.5 Table 7.1 Figure 6.1-6.9 Figure 6.22	 244-247 225-289 332-340 348 262-273 192-199 217

Component (E) Financial and Technical Assistance	Yes	No	N/A	Chapter, Section, Table, List, etc.	Page No.(s)
I: The plan provides estimates of the financial and technical assistance that will be needed to implement the plan. (If “No” or “N/A” provide comments below.) Comments:	X			Chapters 6. 7, 9; Section 6.3 Section 6.6 Section 7.1 Section 9.2 Table 6.8 Table 7.3 Table 9.1	 221-242 248-255 262-273 305-312 237 281 309
II: The plan identifies sources and authorities that will be relied upon to implement the plan. (If “No” or “N/A” provide comments below.) Comments:	X			Chapter 7; Section 7.1	 262-273
III. The plan contains a strategy for driving regulatory change. (If “No” or “N/A” provide comments below.) Comments:	X			Chapters 5, 6, 7, 8 Section 5.2 Section 6.2 Section 6.6 Section 7.1 Section 8.6 Section 8.7	 180-183 187-221 247-254 262-273 299-302 302

Component (F) Education and Outreach	Yes	No	N/A	Chapter, Section, Table, List, etc.	Page No.(s)
I. The plan provides an information/education component that will enhance public understanding of the plan and encourage their early and continued participation in project development. (If “No” or “N/A” provide comments below.) Comments:	X			Chapters 1, 6, 7, 10 Section 1.5 Section 6.2 Section 7.1 Section 10.6 Table 7.1 Table 7.2	 25-26 187-221 262-273 331-339 262-273 274-278

Component (G) Plan Implementation Schedule	Yes	No	N/A	Chapter, Section, Table, List, etc.	Page No.(s)
I. The plan provides a reasonably expeditious schedule for implementing management measures. (Should base implementation timetable on BMPs in “C” above.) Comments: (If “No” or “N/A” provide comments below.)	X			Chapters 7, 11 Section 7.1 Section 11.4 Table 7.1	 262-273 347 262-273

				Table 7.2	274-278

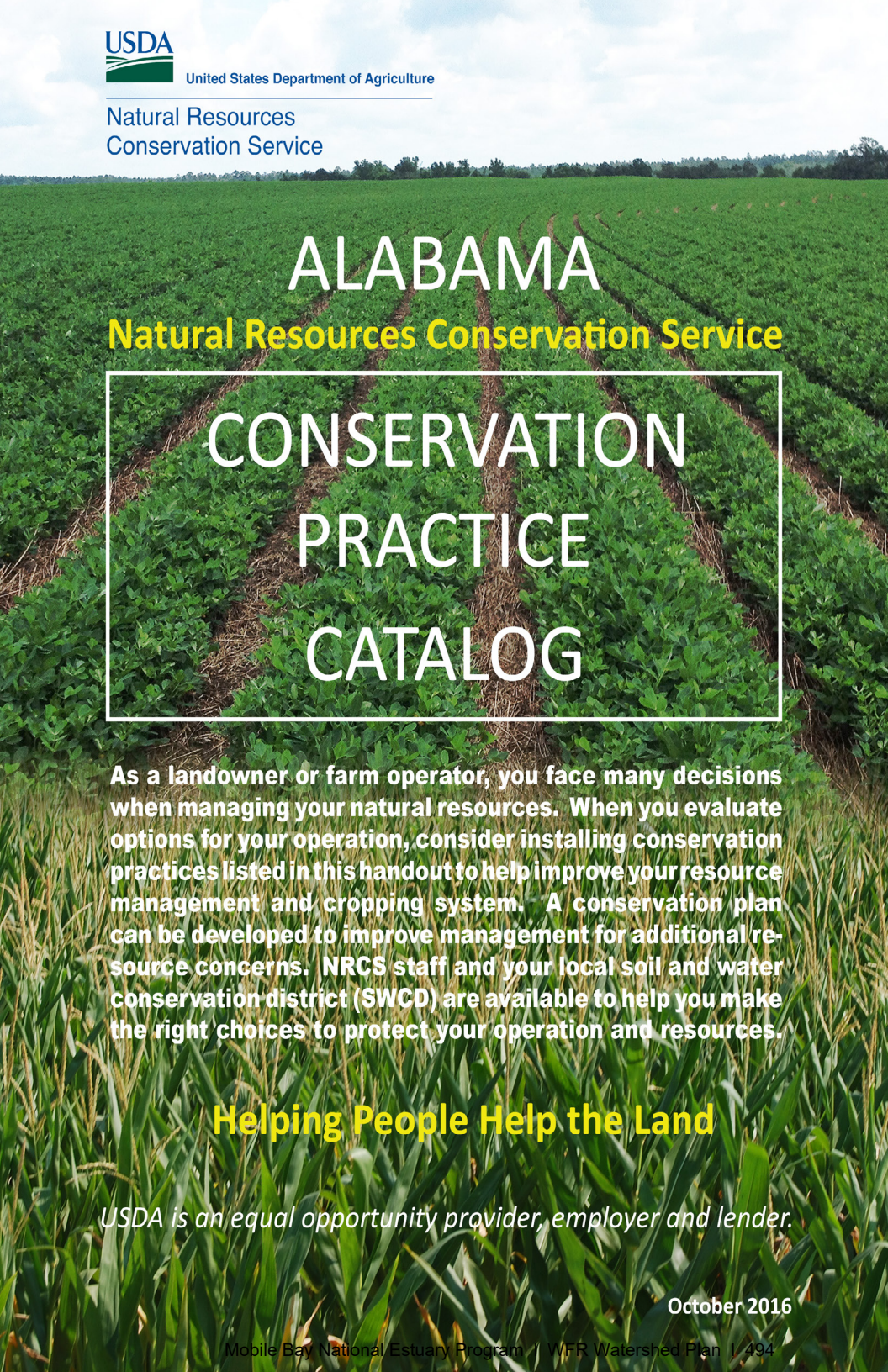
Component (H) Interim Milestones	Yes	No	N/A	Chapter, Section, Table, List, etc.	Page No.(s)
I. The plan provides a list or description of interim milestones for determining whether NPS management measures are being implemented. (If “No” or “N/A” provide comments below.) Comments:	X			Chapter 7 Section 7.1	262-273

Component (I) Monitoring and Assessment	Yes	No	N/A	Chapter, Section, Table, List, etc.	Page No.(s)
I. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards, and if not, the criteria for determining whether the watershed plan needs to be revised - or if a NPS TMDL has been established - whether the NPS TMDL needs to be revised. (If “No” or “N/A” provide comments below.) Comments:	X			Chapter 11 Section 11.2	341-344
The plan identifies key locations for volunteer water monitoring. (If “No” or “N/A” provide comments below.) Comments:	X			Chapter 11 Section 11.3 Table 11.1 Figure 11.2	344-347 343 347

Component (J) Plan Implementation Effectiveness	Yes	No	N/A	Chapter, Section, Table, List, etc.	Page No.(s)
I. A monitoring component to evaluate the effectiveness of the implementation efforts over time measured against the criteria established under item (I). (If “No” or “N/A” provide comments below.) Comments:	X			Chapter 11 Section 11.6 Section 11.7 Figure 11.3	347-355 355 350

APPENDIX G AGRICULTURE AND FORESTRY BEST MANAGEMENT PRACTICES

1. Alabama NRCS Conservation Practice Catalog
2. Alabama's Best Management Practices for Forestry



USDA
United States Department of Agriculture
Natural Resources
Conservation Service

ALABAMA

Natural Resources Conservation Service

CONSERVATION PRACTICE CATALOG

As a landowner or farm operator, you face many decisions when managing your natural resources. When you evaluate options for your operation, consider installing conservation practices listed in this handout to help improve your resource management and cropping system. A conservation plan can be developed to improve management for additional resource concerns. NRCS staff and your local soil and water conservation district (SWCD) are available to help you make the right choices to protect your operation and resources.

Helping People Help the Land

USDA is an equal opportunity provider, employer and lender.

October 2016

This document is not to be used as technical guidance or policy. All NRCS practices shall be applied according to current Conservation Practice Standards available in the Field Office Technical Guide, Section IV (http://efotg.sc.egov.usda.gov/efotg_locator.aspx?map=).

For information on the USDA Natural Resources Conservation Service in Alabama, visit www.al.nrcs.usda.gov or follow us on Twitter at http://twitter.com/NRCS_AL

INDEX

INDEX

INDEX

Access Control - 472

Practice Description
The temporary or permanent exclusion of animals, people, vehicles, and/or equipment from an area

Purpose
Acheive and maintain by monitoring and managing animals people, vehicles, coordination with the practices, measures conservation plan

Access Road - 560

Practice Description
A travel-way for equipment and vehicles constructed to provide a fixed route for vehicular travel for resource activities involving the management of timber, livestock, agriculture, wildlife habitat, and other conservation enterprises while protecting the soil, water, air, fish, wildlife, and other adjacent natural resources

Purpose
This practice is planned where access is needed from a private or public road or highway to a land use enterprise or conservation measure, or where travel ways are needed in a planned land use area. Access roads range from seasonal use roads, designed for low speed and rough driving conditions, to all-weather roads heavily used by the public and designed with safety as a high priority. Some roads are only constructed for a single purpose; i.e. control of forest fires, logging and forest management activities, access to remote recreation areas, or access for maintenance of facilities.

Agrichemical Handling Facility - 309

Practice Description
A facility with an impervious surface to provide an environmentally safe area for on-farm agrichemicals. Provides a safe environment to store, mix, load and cleanup agrichemicals, retain incidental spillage, retain leakage, and reduce surface water, groundwater, air, and/or soil pollution

Purpose
Practice applies where:

- The handling of agrichemicals creates significant potential for pollution of surface water, groundwater, air or soil and a facility is needed to properly manage and handle the chemical operation;
- An adequate water supply is available for filling application equipment tanks, rinsing application equipment and chemical containers as needed;
- Soils and topography are suitable for construction.

NOTE: This practice does not apply to the handling or storage of fuels, or to commercial or multi-landowner agrichemical handling operations.

Amendments for Treatment of Ag Waste - 591

Practice Description

The treatment of manure, wastewater, storm water runoff from high use areas, and other wastes, with chemical or biological additives

Purpose

This practice applies where the use of a chemical or biological amendments will alter the physical and chemical characteristics of animal waste as a part of a planned waste management system to:

- Improve or protect air quality
- Improve or protect water quality
- Improve or protect animal health
- Alter the consistency of the waste stream of facilitates implementation of a waste management system

Anerobic Digester - 366

Practice Description

A component of a waste management system that provides biological treatment in the absence of oxygen

Purpose

This practice is applied for the treatment of manure and other byproducts of animal agricultural operations for one or more of the following reasons:

- Capture biogas for energy production
- Manage odors
- Reduce the net effect of greenhouse gas emissions
- Reduce pathogens

Animal Mortality Facility - 316

Practice Description

An on-farm facility for the treatment or disposal of livestock and poultry carcasses for routine and catastrophic mortality events

Purpose

This practice is applied for one or more of the following purposes:

- Reduce impacts to surface and groundwater resources
- Reduce the impact of odors
- Decrease the spread of pathogens

Animal Trails and Walkways - 575

Practice Description
Established lanes or travel ways that facilitate animal movement

Purpose
This practice is applied to achieve one or more of the following:

• Provide or improve access to forage, water, working/handling facilities, and/or shelter
• Improve grazing efficiency and distribution, and/or
• Protect ecologically sensitive, erosive and/or potentially erosive sites

Anionic Polyacrylamide Erosion Control - 450

Practice Description
Application of water-soluble Anionic Polyacrylamide (PAM) to meet a resource concern

Purpose
This practice is applied as part of a conservation system to support one or more of the following:

• Reduce soil erosion by water or wind
• Improve water quality
• Improve air quality by reducing dust emissions

Aquaculture Ponds - 397

Practice Description
A water impoundment constructed and managed for commercial production of fish and other aquaculture products

Purpose
This practice applies to all types of ponds installed or modified for commercial production of fish and other animals and plants. The purpose of the practice is to provide a favorable water environment for producing, growing, harvesting, and marketing commercial aquaculture crops.

Brush Management - 314

Practice Description
The management or removal of woody (non-herbaceous or succulent) plants including those that are invasive and noxious

Purpose
This practice is applied to achieve one or more of the following:

- Create the desired plant community consistent with the ecological site
- Restore or release desired vegetative cover to protect soils, control erosion, reduce sediment, improve water quality or enhance stream flow
- Maintain, modify, or enhance fish and wildlife habitat
- Improve forage accessibility, quality and quantity for livestock and wildlife
- Manage fuel loads to achieve desired conditions

Channel Bed Stabilization - 584

Practice Description
Measure(s) used to stabilize the bed or bottom of a channel. This practice applies to the beds of existing or newly constructed alluvial or threshold channels that are undergoing damaging aggradation or degradation and that cannot be feasibly controlled by clearing or snagging, by the establishment of vegetative protection, by the installation of bank protection, or by the installation of upstream water control measures

Purpose
This practice may be applied as part of a conservation management system to support one or more of the following:

- Maintain or alter channel bed elevation or gradient
- Modify sediment transport or deposition
- Manage surface water and groundwater levels in floodplains, riparian areas, and wetlands

Clearing and Snagging - 326

Practice Description
Removal of vegetation along the bank (clearing) and/or selective removal of snags, drifts, or other obstructions (snagging) from natural or improved channels and streams

Purpose
Reduce risks to agricultural resources or civil infrastructure by removing obstructions that hinder channel flow or sediment transport in order to accomplish one or more of the following:

- Restore flow capacity and direction
- Prevent excessive bank erosion by eddies or redirection of flow
- Reduce the undesirable formation of bars; and/or;
- Minimize blockages by debris and ice

Combustion System Improvement - 372

Practice Description
Installing, replacing, or retrofitting agricultural combustion systems and/or related components or devices for air quality and energy efficiency improvement

Purpose
This practice is applied to achieve one or more of the following:

• To improve air quality by addressing the air quality resource concerns for particulate matter and ozone precursors by mitigating actual or potential emissions of oxides of nitrogen and/or fine particulate matter
• To improve the energy efficiency of agricultural combustion systems

Composting Facility - 317

Practice Description
A facility to process raw organic by-products such as, animal mortality and manure into biologically stable organic material

Purpose
This practice is applied to reduce the pollution potential of organic agricultural wastes to surface and groundwater by one or more of the following:

• Reduces volume by 25 to 50 percent
• Improves fertilizing capabilities by converting nitrogen to less soluble form
• Aids in nutrient management

Conservation Cover - 327

Practice Description
Establishing and maintaining permanent vegetative cover

Purpose
This practice may be applied to accomplish one or more of the following:

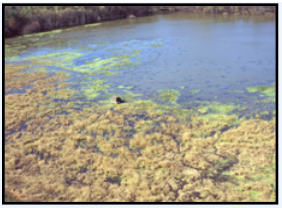
• Reduce soil erosion and sedimentation
• Improve water quality
• Enhance wildlife habitat

Conservation Crop Rotation - 328

Practice Description
Growing crops in a recurring sequence on the same field

Purpose
This practice may be applied as part of a conservation management system to support one or more of the following:

- Reduce sheet and rill erosion
- Reduce soil erosion from wind
- Maintain or improve soil organic matter content
- Manage the balance of plant nutrients
- Improve water use efficiency
- Manage plant pests (weeds, insects, and diseases)
- Provide food for domestic livestock
- Provide food and cover for wildlife



Constructed Wetland - 656

Practice Description
An artificial ecosystem with hydrophytic vegetation for water treatment

Purpose
For treatment of wastewater and contaminated runoff from agricultural processing, livestock, and aquaculture facilities, or for improving the quality of storm water runoff or other water flows lacking specific water quality discharge criteria

Contour Buffer Strips - 332

Practice Description
Narrow strips of permanent, herbaceous vegetative cover established around the hill slope, and alternated down the slope with wider cropped strips that are farmed on the contour

Purpose
This practice is applied to achieve one or more of the following:

- Reduce sheet and rill erosion
- Reduce transport of sediment and other water-borne contaminants downslope
- Increase water infiltration

Contour Farming - 330

Practice Description
Using ridges and furrows formed by tillage, planting and other farming operations to change the direction of runoff from directly downslope to around the hillslope

Purpose
This practice is applied to achieve one or more of the following:

- Reduce sheet and rill erosion
- Reduce transport of sediment, other solids and the contaminants attached to them
- Increase water infiltration

Contour Orchard and Other Perennial Crops - 331

Practice Description
Planting orchards, vineyards, or small fruits so that all cultural operations are done on the countour

Purpose
- Reduce soil erosion
- Reduce water loss

Cover Crop - 340

Practice Description
Crops including grasses, legumes and forbs for seasonal cover and other conservation purposes

Purpose
This practice is applied to achieve one or more of the following:

- Reduce erosion from wind and water
- Increase soil organic matter content
- Promote biological nitrogen fixation
- Increase biodiversity
- Weed suppression
- Provide supplemental forage
- Soil moisture management
- Minimize and reduce soil compaction

Critical Area Planting - 342

Practice Description
Establishing permanent vegetation on sites that have or are expected to have high erosion rates, and on sites that have physical, chemical or biological conditions that prevent the establishment of vegetation with normal practices

Purpose

• Stabilize areas with existing or expected high rates of soil erosion by water.
• Stabilize areas with existing or expected high rates of soil erosion by wind
• Rehabilitate and re-vegetate degraded sites that cannot be stabilized through normal farming practices.
• Stabilize coastal areas, such as sand dunes and riparian areas.

Dam - 402

Practice Description
An artificial barrier that can impound water for one or more beneficial purposes

Purpose
This practice is applied to achieve one or more of the following:

• Reduce downstream flood damage
• Provide permanent water storage for one or more beneficial uses such as irrigation or livestock supply, fire control, municipal or industrial uses, or recreational uses
• Create or improve habitat for fish and wildlife

Deep Tillage - 324

Practice Description
Performing tillage operations below the normal tillage depth to modify adverse physical or chemical properties of a soil

Purpose
This practice is applied to achieve one or more of the following:

• Bury or mix soil deposits from wind or water erosion or flood overwash
• Reduce concentration of soil contaminants, which inhibit plant growth
• Fracture restrictive soil layers

Dike - 356

Practice Description
A berm or ridge, or ridge and channel combination of compacted soil to channel water to a desired location or away from an undesired location

Purpose
This practice is applied to achieve one or more of the following:

- Protect people and property from floods
- Control water level in connection with crop production, fish and wildlife management; or wetland maintenance, improvement, restoration, or construction
- Direct water to stable outlets or traps
- Direct clean water away from disturbed or polluted areas

Diversion - 362

Practice Description
A channel constructed across the slope with a supporting ridge on the lower side

Purpose
This practice may be applied as part of a resource management system to support one or more of the following purposes:

- Break up concentrations of water on long slopes, on undulating land surfaces, and on land that is generally considered too flat or irregular for terracing
- Increase or decrease the drainage area above ponds
- Protect terrace systems by diverting water from the top terrace where topography, land use, or land ownership prevents terracing the land above
- Intercept surface and shallow subsurface flow
- Reduce runoff damages from upland runoff

Drainage Water Management - 554

Practice Description
The use of structures for water control in the process of managing water discharges from surface and/or subsurface agricultural drainage systems

Purpose
The purpose of this practice is:

- Reduce nutrient, pathogen, and/or pesticide loading from drainage systems into downstream receiving waters
- Improve productivity, health, and vigor of plants
- Reduce oxidation of organic matter in soils
- Reduce wind erosion or particulate matter (dust) emissions
- Provide seasonal wildlife habitat

Dry Hydrant - 432

Practice Description
A non-pressurized permanent pipe assembly system installed into water source that permits the withdrawal of water by suction. To provide all weather access to an available water source for fire suppression

Purpose
Where a dependable source of water is available, where transport vehicles can access the site, and where a source of water is needed for fire suppression.

Early Successional Habitat Development / Management - 647

Practice Description
Manage plant succession to develop and maintain early successional habitat to benefit desired wildlife and/or natural communities. To provide habitat for species requiring early successional habitat for all or part of their life cycle

Purpose
This practice is applied on all lands that are suitable for the kinds of desired wildlife and plant species. Management will be designed to achieve the desired plant community structure (e.g., density, vertical and horizontal cover) and plant species diversity.

Farmstead Energy Improvement - 374

Practice Description
Installing, replacing, or retrofitting agricultural equipment systems and/or related components or devices which results in an on-farm and/or off-site reduction in actual or potential emissions of greenhouse gases

Purpose
This practice is applied to achieve the following:

• Reduce net greenhouse gas emissions (on farm and/or off-site) from agricultural systems or components by implementing the recommendations from on-site energy audits

Fence - 382

Practice Description
A constructed barrier to animals or people

Purpose
This practice facilitates the accomplishment of conservation objectives by providing a means to control movement of animals, people, and vehicles.

Feral Swine Management Conservation Activity - 297

Practice Description
Feral swine management is a component of an area wide effort of assessment, planning, exclusion, scouting, control, and monitoring to document and reduce resource damage caused by
feral swine and focus interagency management efforts to reduce adverse resource impacts and health concerns for other animals and humans.

Purpose
• Determine locations and intensity of feral swine impacts upon resource conditions and potential means to reduce or eliminate these impacts
• Develop a management plan to address feral-swine-impacted resources of concern using a conservation practice or system of conservation practices
• Evaluate the effectiveness of a practice or system of practices in reducing resource impacts from feral swine

Field Border - 386

Practice Description
A strip of permanent vegetation established at the edge or around the perimeter of a field

Purpose
This practice may be applied to accomplish one or more of the following:

• Reduce soil erosion
• Provide turn rows for farm machinery
• Soil and water quality protection
• Management of harmful insect populations
• Provide wildlife food and cover
• Increase carbon storage in biomass and soils
• Improve air quality

Filter Strip - 393

Practice Description
A strip or area of herbaceous vegetation that removes contaminants from overland flow

Purpose
This practice is applied to achieve one or more of the following:

- Reduce suspended solids and associated contaminants in runoff
- Reduce dissolved contaminant loadings in runoff
- Reduce suspended solids and associated contaminants in irrigation tailwater

Firebreak - 394

Practice Description
A permanent or temporary strip of bare or vegetated land planned to retard fire

Purpose
This practice applies on all land uses where protection from wildfire is needed or prescribed burning is applied to accomplish one or more of the following:

- Reduce the spread of wildfire
- Contain prescribed burns

Fishpond Management - 399

Practice Description
Managing impounded water for the production of fish or other aquatic organisms

Purpose
This practice is applied in warm and cold water ponds, lakes, and reservoirs not managed for commercial aquaculture purposes to accomplish one or more of the following:

- To provide favorable habitat for fish and other aquatic organisms.
- To develop and maintain a desired species composition and ratio.
- To develop and maintain a desired level of production

Forage and Biomass Planting - 512

Practice Description
Establishing adapted and/or compatible species, varieties, or cultivars of herbaceous species suitable for pasture, hay, or biomass production

Purpose
This practice is applied to achieve one or more of the following:

•Improve or maintain livestock nutrition and/or health
•Provide or increase forage supply during periods of low forage production
• Reduce soil erosion
• Improve soil quality and water quality
• Produce feedstock for biofuel or energy production

Forage Harvest Management - 511

Practice Description
The timely cutting and removal of forages from the field as hay, green-chop or ensilage

Purpose
• Optimize yield and quality of forage at the desired levels
• Promote vigorous plant re-growth
• Manage for the desired species composition
• Use forage plant biomass as a soil nutrient uptake tool
• Control insects, diseases and weeds
• Maintain and/or improve wildlife habitat

Forest Stand Improvement - 666

Practice Description
The manipulation of species composition, stand structure and stocking by cutting or killing selected trees and understory vegetation

Purpose
This practice may be applied to accomplish one or more of the following:

• Increase the quantity and quality of forest products by manipulating stand density and structure
• Harvest forest products
• Initiate forest stand regeneration
• Reduce wildfire hazard
• Improve forest health reducing the potential of damage from pests and moisture stress
• Restore natural plant communities
• Achieve or maintain a desired native understory plant community for special forest products, grazing, and browsing
• Improve aesthetic and recreation, values
• Improve wildlife habitat
• Alter water yield
• Increase carbon storage in selected trees

Forest Trails and Landings - 655

Practice Description
A temporary or infrequently used route, path or cleared area. Trails and landings including skid trails are applicable on forest land. They typically connect to an Access Road (560)

Purpose
This practice may be applied to accomplish one or more of the following:

• Provide routes for temporary or infrequent travel by people or equipment for management activities
• Provide periodic access for removal and collection of forest products

Fuel Break - 383

Practice Description
A strip or block of land on which the vegetation, debris and detritus have been reduced and/or modified to control or diminish the risk of the spread of fire crossing the strip or block of land

Purpose
This practice applies on all land where protection from wildfire is needed to control and reduce the risk of the spread of fire by treating, removing or modifying vegetation, debris and detritus.

Grade Stabilization Structure - 410

Practice Description
A structure used to control the grade and head cutting in natural or artificial channels

Purpose
The purpose of this practice is to stabilize the grade and control erosion in natural or artificial channels, to prevent the formation or advance of gullies, and to enhance environmental quality and reduce pollution hazards.

Grassed Waterways - 412

Practice Description
A shaped or graded channel that is established with suitable vegetation to carry surface water at a non-erosive velocity to a stable outlet

Purpose
This practice is applied to achieve one or more of the following:

• Convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding
• Reduce gully erosion
• Protect/improve water quality

Heavy Use Area Protection - 561

Practice Description
The stabilization of areas frequently and intensively used by people, animals or vehicles by establishing vegetative cover, by surfacing with suitable materials, and/or by installing needed structures

Purpose
This practice is applied to achieve one or more of the following:

• Reduce soil erosion
• Improve water quantity and quality
• Improve air quality
• Improve aesthetics
• Improve livestock health

Hedgerow Planting - 422

Practice Description
Establishment of dense vegetation in a linear design to achieve a natural resource conservation purpose

Purpose
This practice may be installed to accomplish one or more of the following:

• Habitat, including food, cover, and corridors for terrestrial wildlife
• To enhance pollen, nectar, and nesting habitat for pollinators
• Food, cover, and shade for aquatic organisms that live in adjacent streams or watercourses
• To provide substrate for predaceous and beneficial invertebrates as a component of integrated pest management
• To intercept airborne particulate matter
• To reduce chemical drift and odor movement
• Screens and barriers to noise and dust
• To increase carbon storage in biomass and soils
• Living fences
• Boundary delineation and contour guidelines

Herbaceous Weed Control - 315

Practice Description
The removal or control of herbaceous weeds including invasive, noxious and prohibited plants

Purpose
• Enhance accesibility, quantity, and quality of forage and/or browse.
• Restore or release native ore create desired plant communities and wildlife habitats consistent with the ecological site.
• Protect soils and control erosion
• Reduce fine-fuels fire hazard and improve air quality

Integrated Pest Management - 595

Practice Description
A site-specific combination of pest prevention, pest avoidance, pest monitoring, and pest suppression strategies

Purpose
This practice is applied on all lands where pests will be managed to accomplish one or more of the following:

• Prevent or mitigate off-site pesticide risks to water quality from leaching, solution runoff and adsorbed runoff losses
• Prevent or mitigate off-site pesticide risks to soil, water, air, plants, animals and humans from drift and volatilization losses
• Prevent or mitigate on-site pesticide risks to pollinators and other beneficial species through direct contact
• Prevent or mitigate cultural, mechanical and biological pest suppression risks to soil, water, air, plants, animals and humans

Irrigation Canal or Lateral - 320

Practice Description
A permanent channel constructed to convey irrigation water from the source of supply to one or more irrigated areas

Purpose
Apply this practice to facilitate the efficient distribution and use of water on irrigated land to accomplish one or more of the following:

• Where a canal or lateral and related structures are needed as an integral part of an irrigation water conveyance system
• Where water supplies for the area served are sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used

Conservation Practice Standard Irrigation Field Ditch (388) should be used for on-farm irrigation water conveyance and/or distribution of less than 25 cubic feet per second

Irrigation Field Ditch - 388

Practice Description
A permanent irrigation ditch constructed in or with earth materials, to convey water from the source of supply to a field or fields in an irrigation system

Purpose
This practice may be applied as part of an irrigation water management system to efficiently convey and distribute irrigation waters. This standard is limited to open channels and elevated ditches of 25 cubic feet per second or less in capacity and constructed of earth materials. The practice applies where field ditches are needed as an integral part of an irrigation water distribution system design to facilitate the conservation use of soil and water resources.

Irrigation Land Leveling - 464

Practice Description
Reshaping the surface of land to be irrigated, to planned lines and grades

Purpose
This practice applies to the leveling of land irrigated by surface or subsurface irrigation systems. The leveling is based on a detailed engineering survey, design, and layout. Land to be leveled shall be suitable for irrigation and for the proposed methods of water application. Soils shall be deep enough that, after leveling, an adequate usable root zone remains that will permit satisfactory crop production with proper conservation measures. Limited areas of shallow soils may be leveled to provide adequate irrigation grades or an improved field alignment. The finished leveling work must not result in exposed areas of highly permeable soil materials that would inhibit proper distribution of water over the field.

Irrigation Pipeline - 430

Practice Description
A pipeline and appurtenances installed in an irrigation system to convey water

Purpose
This practice is applied to convey water from a source of supply to an irrigation system or storage reservoir.

Irrigation Reservoir - 436

Practice Description
An irrigation water storage structure made by constructing a dam, embankment, pit, or tank

Purpose
This practice may be applied as part of a resource conservation system to achieve one or more of the following:

• Store water to provide a reliable irrigation water supply or regulate available irrigation flows
• Improve water use efficiency on irrigated land
• Provide storage for tailwater recovery and reuse
• Provide irrigation runoff retention time to increase breakdown of chemical contaminants
• Reduce energy consumption

Irrigation System, Microirrigation - 441

Practice Description
An irrigation system for frequent application of small quantities of water on or below the soil surface: as drops, tiny streams or miniature spray through emitters or applicators placed along a water delivery line

Purpose
This practice may be applied as part of a conservation management system to support one or more of the following purposes:

• To efficiently and uniformly apply irrigation water and maintain soil moisture for plant growth
• Prevent contamination of ground and surface water by efficiently and uniformly applying chemicals
•Establish desired vegetation

Irrigation System, Sprinkler - 442

Practice Description
An irrigation system in which all necessary equipment and facilities are installed for efficiently applying water by means of nozzles operated under pressure

Purpose
This practice may be applied as part of a conservation management system to achieve one or more of the following:

• Efficiently and uniformly apply irrigation water to maintain adequate soil water for the desired level of plant growth and production without causing excessive water loss, erosion, or water quality impairment
• Climate control and/or modification
• Applying chemicals, nutrients, and/or waste water
• Leaching for control or reclamation of saline or sodic soils
• Reduction in particulate matter emissions to improve air quality

Irrigation System, Surface and Subsurface - 443

Practice Description
A system in which all necessary earthwork, multi-outlet pipelines, and water-control structures have been installed for distribution of water by surface means, such as furrows, borders, and contour levees, or by subsurface means through water table control

Purpose
Applied as part of a resource conservation system to achieve one or more of the following:

• Efficiently convey and distribute irrigation water to the surface point of application without causing excessive water loss, erosion, or water quality impairment
• Efficiently convey and distribute irrigation water to the subsurface point of application without causing excessive water loss or water quality impairment
• Apply chemicals and/or nutrients as part of a surface irrigation system in a manner which protects water quality
• Improve energy use efficiency

Irrigation Tailwater Recovery - 447

Practice Description
A planned irrigation system in which all facilities utilized for the collection, storage, and transportation of irrigation tailwater and/or rainfall runoff for reuse have been installed

Purpose
This practice shall be applied as part of a conservation management system to support one or more of the following:

• Conserve irrigation water supplies
• Improve off-site water quality

Irrigation Water Management - 449

Practice Description
The process of determining and controlling the volume, frequency and application rate of irrigation water in a planned, efficient manner

Purpose
This practice is applied to achieve one or more of the following:

• Manage soil moisture to promote desired crop response
• Optimize use of available water supplies
• Minimize irrigation induced soil erosion
• Decrease non-point source pollution of surface and groundwater resources
• Manage salts in the crop root zone
• Manage air, soil, or plant micro-climate
• Proper and safe chemigation or fertigation
• Improve air quality by managing soil moisture to reduce particulate matter movement

Karst Sinkhole Treatment - 527

Practice Description
The treatment of sinkholes in karst areas to reduce contamination of groundwater resources, and/or to improve farm safety

Purpose
This practice may be applied as part of a conservation management system in karst topography, which is an area underlain by solutioned carbonate bedrock with sinkholes and caverns. The practice supports one or more of the following purposes:

- Improve water quality
- Improve farm safety

Land Clearing - 460

Practice Description
Removing trees, stumps, and other vegetation to achieve a conservation objective

Purpose
This practice applies to wooded areas where the removal of trees, stumps, brush, and other vegetation is needed in carrying out a conservation plan to allow needed land use adjustments and improvements in the interest of conservation.

Land Reclamation, Abandoned Mined Land - 543

Practice Description
Reclamation of land and water areas adversely affected by past mining activities

Purpose
Apply this practice to abandoned mined land that degrades the quality of the environment and prevents or interferes with the beneficial uses of soil, water, air, plant or animal resources, or endangers human health and safety to accomplish one or more of the following:

- Stabilize abandoned mined areas to decrease erosion and sedimentation, support desirable vegetation and improve off-site water quality and or quantity
- Maintain or improve landscape visual and functional quality
- Protect public health, safety and general welfare

Land Reclamation, Landslide Treatment - 453

Practice Description
Managing natural materials, mine spoil (excavated over-burden), mine waste or overburden to reduce down-slope movement.

Purpose
Apply where in-place material, mine spoil, waste, or overburden, or rock cut road banks are unstable, moving, or judged to have potential of moving down slope in a manner that will cause damage to life, property, or the environment to accomplish one or more of the following:

- Repair unstable slopes caused by slope failure, and reduce the chance of enlargement or movement of slope surfaces
- Protect life and property
- Prevent excessive erosion and sedimentation
- Improve water quality and landscape resource quality
- Create a condition conducive to establishing surface protection and beneficial land use

This practice does not apply to constructed embankment surfaces (road fills, dams, dikes, levees and terraces.

Land Smoothing - 466

Practice Description
Removing irregularities on the land surface. To improve surface drainage, provide for more uniform cultivation, and improve equipment operation and efficiency.

Purpose
This practice applies on areas where depressions, mounds, old terraces, turn-rows, and other surface irregularities interfere with the application of needed soil and water conservation and management practices. It is limited to areas having adequate soil depth or where topsoil can be salvaged and replaced. This practice does not apply to the regular maintenance on irrigated land or on land that has been modified using practice standards Precision Land Forming (462) or Irrigation Land Leveling (464).

Lighting System Improvement - 670

Practice Description
Complete replacement or retrofitting of one or more components of an existing agricultural lighting system.

Purpose
This practice may be applied as part of a conservation management system to reduce energy use.

Livestock Shelter Structure - 576

Practice Description
A permanent or portable structure with less than four walls and/or a roof to provide for improved utilization of pastureland and rangeland and to shelter livestock from negative environmental factors. This structure is not to be construed to be a building

Purpose
• To provide protection for livestock from excessive heat, wind, cold, or snow.
• Protect surface waters from nutrient and pathogen loading.
• Protect wooded areas from accelerated erosion and excessive nutrient deposition by providing alternative livestock shelter/shade location.
• Improve the distribution of grazing livestock to enhance wildlife habitat, reduce overused areas, or correct other resource
concerns resulting from improper livestock distribution

Mulching - 484

Practice Description
Applying plant residues or other suitable materials produced off site, to the land surface

Purpose
This practice is applied to achieve one or more of the following:

• Conserve soil moisture
• Moderate soil temperature
• Provide erosion control
• Suppress weed growth
• Establish vegetative cover
• Improve soil condition and increase soil fertility

Nutrient Management - 590

Practice Description
Managing the amount, source, placement, form and timing of the application of plant nutrients and soil amendments

Purpose
This practice is applied to achieve one or more of the following:

• Budget and supply nutrients for plant production
• Properly utilize manure or organic by-products as a plant nutrient source
• Minimize agricultural non-point source pollution of surface and groundwater resources
• Protect air quality by reducing nitrogen emissions (ammonia and NO2 compounds) and the formation of atmospheric particulates
• Maintain or improve the physical, chemical and biological condition of soil

Obstruction Removal - 500

Practice Description
Removal and disposal of buildings, structures, other works of improvement, vegetation, debris or other materials

Purpose
To safely remove and dispose of unwanted obstructions in order to apply conservation practices or facilitate the planned land use.

CONDITIONS WHERE PRACTICE APPLIES
On any land where existing obstructions interfere with planned land use development, public safety or infrastructure. This standard is not intended for the removal of obstructions from aquatic environments

Open Channel - 582

Practice Description
Pipeline having an inside diameter of 4 inches or less where conveyance of water is desirable or necessary to conserve the supply, or maintain the quality of water

Purpose
This practice is applied to improve water quantity and quality by conveying water from a source of supply to points of use for livestock or wildlife; make practical the exclusion of livestock from ponds and streams.

Pipeline (Livestock Pipeline) - 516

Practice Description
A pipeline and appurtenances installed to convey water for livestock and wildlife

Purpose
This practice may be applied as part of a resource management system to achieve one or more of the following purposes:
• Convey water to the points of use for livestock or wildlife
• Reduce energy use
• Develop renewable energy systems

Pond - 378

Practice Description
A water impoundment made by constructing an embankment or by excavating a pit or dugout. Ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at the auxiliary spillway elevation is 3 feet or more

Purpose
This practice is applied to provide water for livestock, fish and wildlife, recreation, fire control, and other related uses, and to maintain or improve water quality.

Pond Sealing or Lining, Bentonite Sealant - 521c

Practice Description
A liner for a pond or waste storage impoundment consisting of a compacted soil-bentonite mixture.

Purpose
This practice is applied to reduce seepage losses from ponds or waste impoundments for water conservation and environmental protection to accomplish one or more of the following:

- Soils are suitable for treatment with bentonite
- Ponds or waste storage impoundments require treatment to reduce seepage rates and to impede the migration of contaminants to within acceptable limits

Pond Sealing or Lining, Compacted Clay Treatment - 521d

Practice Description
A liner for a pond or waste storage impoundment constructed using compacted soil without soil amendments

Purpose
Apply this practice to reduce seepage losses from ponds or waste storage impoundments constructed for water conservation and environmental protection to accomplish one or more of the following:

- In-place soils at the site would exhibit seepage rates in excess of acceptable limits or would allow an unacceptable migration of contaminants from the impoundment
- An adequate quantity of soil suitable for constructing a clay liner without amendments is available at an economical haul distance

Pond Sealing or Lining, Flexible Membrane - 521a

Practice Description
Pond sealing with a flexible membrane is installing a liner made of impervious flexible material to reduce seepage to an acceptable level

Purpose
This practice is used to improve the functionality of a pond, and prevent damage to the natural resources including unacceptable loss of water from seepage. This method of pond sealing is relatively expensive, but often necessary for sandy textured sites and projects that require a very effective sealant. Ponds to be lined may include Irrigation Storage Reservoirs, Irrigation Pits, Waste Treatment Lagoons, Waste Treatment Ponds, and Ponds For Livestock/Wildlife.

Pond Sealing or Lining, Soil Dispersant - 521b

Practice Description
A liner for a pond or waste storage impoundment consisting of a compacted soil-dispersant mixture

Purpose
Apply this practice to reduce seepage losses from ponds or waste impoundments for water conservation and environmental protection to accomplish one or more of the following:

- Soils are suitable for treatment with dispersants
- Ponds or waste storage impoundments require treatment to reduce seepage rates and to impede the migration of contaminants to within acceptable limits

Precision Land Forming - 462

Practice Description
Reshaping the surface of land to planned grades

Purpose
All precision land forming shall be planned as an integral part of an overall system to facilitate the conservative use to improve surface drainage and control erosion.

Prescribed Burning - 338

Practice Description
Controlled fire applied to a predetermined area

Purpose
This practice is applied to achieve one or more of the following:

- Control undesirable vegetation
- Prepare sites for harvesting, planting or seeding.
- Control plant disease.
- Reduce wildfire hazards
- Improve wildlife habitat
- Improve plant production quantity and/or quality
- Remove slash and debris
- Enhance seed and seedling production
- Facilitate distribution of grazing and browsing animals
- Restore and maintain ecological sites

Prescribed Grazing - 528

Practice Description
Managing the harvest of vegetation with grazing and/or browsing animals

Purpose
This practice may be applied as a part of conservation management system to achieve one or more of the following:

- Improve or maintain desired species composition and vigor of plant communities
- Improve or maintain quantity and quality of forage for grazing
- Improve or maintain surface and/or subsurface water quality and quantity
- Improve or maintain riparian and watershed function
- Reduce accelerated soil erosion, and maintain or improve soil condition
- Improve or maintain the quantity and quality of food and/or cover available for wildlife
- Manage fine fuel loads to achieve desired conditions

Pumping Plant - 533

Practice Description
A facility that delivers water at a designed pressure and flow rate. Includes the required pump, associated power unit(s), plumbing, appurtenances, and may include on-site fuel or energy sources, and protective structures.

Purpose
This practice may be applied as a part of a resource management system to achieve one or more of the following:

- Delivery of water irrigation, water facilities
- Removal of excessive surface water
- Provide efficient use of water on irrigated land
- Transfer of animal waste as part of a manure transfer system
- Improve energy use efficiency
- Improve air quality

Residue & Tillage Management, Reduce Till - 345

Practice Description
Managing the amount, orientation and distribution of crop and other plant residue on the soil surface year round while limiting the soil-disturbing activities used to grow crops in systems where the entire field surface is tilled prior to planting.

Purpose
This practice is applied as part of a conservation management system to support one or more of the following purposes:

- Reduce sheet and rill erosion
- Reduce tillage-induced particulate emissions
- Maintain or increase soil quality and organic matter content
- Reduce energy use
- Increase plant-available moisture

Residue Management, No-Till, and Strip Till - 329

Practice Description
Managing the amount, orientation and distribution of crop and other plant residue on the soil surface year round while limiting soil-disturbing activities to only those necessary to place nutrients, condition residue and plant crops.

Purpose
This practice is applied to achieve one or more of the following:

- Reduce sheet and rill erosion
- Reduce wind erosion
- Improve soil organic matter content
- Reduce CO2 losses from soil
- Increase plant-available moisture
- Provide food and escape cover for wildlife

Restoration and Management of Rare and Declining Habitats - 643

Practice Description
Restoring and managing rare and declining habitats and their associated wildlife species to conserve biodiversity.

Purpose
This practice may be installed to provide habitat for rare and declining species.

Riparian Forest Buffer - 391

Practice Description
An area predominantly trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies

Purpose
This practice is applied to achieve one or more of the following:

- Create shade to lower or maintain water temperatures to improve habitat for aquatic organisms
- Create or improve riparian habitat and provide a source of detritus and large woody debris
- Reduce excess amounts of sediment, organic material, nutrients and pesticides in surface runoff and reduce excess nutrients and other chemicals in shallow groundwater flow
- Reduce pesticide drift entering the water body
- Restore riparian plant communities
- Increase carbon storage in plant biomass and soils

Road / Trail / Landing Closure - Treatment - 654

Practice Description
The closure, decommissioning, or abandonment of roads, trails, and/or landings and associated treatment to achieve conservation objectives.

Purpose
To minimize various resource concerns associated with existing roads, trails, and/or landings by closing them and treating to a level where one or more the following objectives are achieved:

- Controlling erosion (road, sheet and rill, gully, wind), chemical residues and off-site movement, sediment deposition and damage, accentuated storm runoff, and particulate matter generation;
- Restoring land to a productive state by reestablishing adapted plants and habitat (wildlife food, cover, and shelter), reconnecting wildlife habitat and migration corridors including streams and riparian areas, and controlling noxious and invasive species;
- Reestablishing drainage patterns that existed prior to construction of the road, trail, or landing to restore the form and integrity of associated hill slopes, channels and floodplains and their related hydrologic and geomorphic processes;
- Minimizing human impacts to the closure area to meet safety, aesthetic, sensitive area protection, or wildlife habitat requirements

Roof Runoff Structure - 558

Practice Description
Structures that collect, control, and transport precipitation from roofs

Purpose
This practice may be installed to improve water quality, reduce soil erosion, increase infiltration, protect structures, improve animal health, and/or increase water quantity.

Roofs and Covers - 367

Practice Description
A rigid, semi-rigid, or flexible manufactured membrane, composite material, or roof structure placed over a waste management facility

Purpose
This practice is applied to achieve one or more of the following:

- Water quality improvement
- Diversion of clean water from animal management areas (i.e. barnyard, feedlot or exercise area) and/or waste storage facilities
- Capture of biogas for energy production
- Reducing net effect of greenhouse gas emissions
- Air quality improvement and odor reduction

High Tunnel System - 325

Practice Description
An enclosed polyethylene, polycarbonate, plastic, or fabric covered structure that is used to cover and protect crops from sun, wind, execessive rainfall, or cold to extend the growing season in an envrionmentally safe manner

Purpose
Improve plant health and vigor.

Sediment Basin - 350

Practice Description
A basin constructed to collect and store debris or sediment

Purpose
This practice is applied to achieve one or more of the following:

- Preserve the capacity of reservoirs, wetlands, ditches, canals, diversion, waterways, and streams
- Prevent undesirable deposition on bottom lands and developed areas
- Trap sediment originating from construction sites or other disturbed areas
- Reduce or abate pollution by providing basins for deposition and storage of silt, sand, gravel, stone, agricultural waste solids, and other detritus

Shallow Water Development and Management - 646

Practice Description
The inundation of lands to provide habitat for fish and/or wildlife

Purpose
To provide habitat for wildlife such as shorebirds, waterfowl, wading birds, mammals, fish, reptiles, amphibians and other species that require shallow water for at least a part of their life cycle.

Silvopasture Establishment - 381

Practice Description
An application establishing a combination of trees or shrubs and compatible forages on the same acreage

Purpose
This practice is applied to achieve one or more of the following:

- Provide forage for livestock and the production of wood products
- Increase carbon sequestration
- Improve water quality
- Reduce erosion
- Enhance wildlife habitat
- Reduce fire hazard
- Provide shade for livestock
- Develop renewable energy systems

Solid/Liquid Waste Separation Facility - 632

Practice Description
A filtration or screening device, settling tank, settling basin, or settling channel used to separate a portion of solids from a liquid waste stream

Purpose
This practice is applied to partition solids, liquids and their associated nutrients as part of a conservation management system to achieve one or more of the following:

- Improve or protect air quality
- Improve or protect water quality
- Improve or protect animal health
- Meet management objectives

Spoil Spreading - 572

Practice Description
Disposal of surplus excavated materials

Purpose
This practice applies to sites where spoil material is available from the excavation of open channels, ponds or other construction sites to dispose of excess soil from construction activities in an environmentally sound manner that minimizes soil erosion, protects water quality and fits with the land use and landscape

Spring Development - 574

Practice Description
Collection of water from springs or seeps to provide water for a conservation need

Purpose
In areas where a spring or seep will provide a dependable supply of suitable water to improve the quantity and/or quality of water for livestock, wildlife or other agricultural uses

Stream Crossing - 578

Practice Description
Controlling the quantity and quality of stormwater runoff

Purpose
To control stormwater runoff to achieve one or more of the following:
• Minimize erosion and sedimentation during and following construction activities.
• Reduce the quantity of stormwater leaving developing or developed sites.
• Improve the quality of stormwater leaving developing or developed sites

Storm Water Runoff Control - 570

Practice Description
A stabilized area or structure constructed across a stream to provide a travel way for people, livestock,equipment, or vehicles

Purpose
This practice may be applied to achieve improved water quality by the following:

• Reduce sediment, nutrient, organic, and inorganic loading of the stream
• Reduce stream bank and streambed erosion
• Provide crossing for access to another land unit
• Provide limited access for livestock water use

Stream Habitat Improvement and Management - 395

Practice Description
Maintain, improve or restore physical, chemical and biological functions of a stream, and its associated riparian zone, necessary for meeting the life history requirements of desired aquatic species.

Purpose
This practice is applied to achieve one or more of the following:

• Provide suitable habitat for desired fish and other aquatic species
• Provide stream channel and associated riparian conditions that maintain stream corridor ecological processes and hydrological connections of diverse stream habitat types important to aquatic species

Streambank and Shoreline Protection - 580

Practice Description
Treatment(s) used to stabilize and protect banks of streams or constructed channels, and shorelines of lakes, reservoirs, or estuaries

Purpose
This practice is applied to achieve one or more of the following:

• To prevent the loss of land or damage to land uses, or facilities adjacent to the banks of streams or constructed channels, shoreline of lakes, reservoirs, or estuaries including the protection of known historical, archeological, and traditional cultural properties
• To maintain the flow capacity of streams or channels
• Reduce the off-site or downstream effects of sediment resulting from bank erosion
• To improve or enhance the stream corridor for fish and wildlife habitat, aesthetics, and recreation

Stripcropping - 585

Practice Description
Growing planned rotations of row crops, forages, small grains, or fallow in a systematic arrangement of equal width strips across a field

Purpose
This practice may be applied to achieve one or more of the following:

• Reduce soil erosion from water and transport of sediment and other water-borne contaminants
• Reduce soil erosion from wind
• Protect growing crops from damage by wind-borne soil particles

Structure For Water Control - 587

Practice Description
A structure in a water management system that conveys water, controls the direction or rate of flow, maintains a desired water surface elevation or measures water

Purpose
The practice may be applied as a management component of a water management system to control the stage, discharge, distribution, delivery or direction of water flow.

Structure for Wildlife - 649

Practice Description
A structure installed to replace or modify a missing or deficient wildlife habitat component.
PURPOSE
To provide structures, in proper amounts, locations and seasons to:

Purpose
A structure installed to replace or modify a missing or deficient wildlife habitat component.
PURPOSE
To provide structures, in proper amounts, locations and seasons to:
• Enhance or sustain non-domesticated wildlife; or
• Modify existing structures that pose a hazard to wildlife

Surface Drain Field Ditch - 607

Practice Description
A graded ditch for collecting excess water in a field

Purpose
This practice may be applied as part of a resource conservation system to achieve one or more of the following:

• Interception of excess subsurface water and conveyance to an outlet
• Collection or interception of excess surface water, such as sheet flow from natural and graded land surfaces or channel flow from furrows, and conveyance to an outlet
• Drainage of surface depressions

Surface Drain, Main or Lateral - 608

Practice Description
An open drainage constructed to a designed cross section alignment and grade

Purpose
This practice is applied as part of a water management system (tailwater recovery) to collect and convey excess irrigation water to storage area for reuse through out the growing season.

Terrace - 600

Practice Description
An earthen embankment, or a combination ridge and channel, constructed across the field slope

Purpose
This practice is applied as a part of a resource management system for one or more of the following purposes:

• Reduce erosion by reducing slope length
• Retain runoff for moisture conservation

Tree/Shrub Establishment - 612

Practice Description
Establishing woody plants by planting seedlings or cuttings, direct seeding, or natural regeneration

Purpose
This practice is applied to establish woody plants for:

- Forest products such as timber, pulpwood, and energy biomass
- Wildlife habitat
- Long-term erosion control and improvement of water quality
- Treating waste
- Storing carbon in biomass
- Energy conservation
- Improving or restoring natural diversity
- Enhancing aesthetics

Tree/Shrub Pruning - 660

Practice Description
The removal of all or part of selected branches, leaders or roots from trees and shrubs

Purpose
This practice when applied may achieve one or more of the following:

- Improve the appearance of trees or shrubs, e.g., ornamental plants and Christmas trees
- Improve the quality of wood products
- Improve the production of plant products, e.g., nuts, fruits, boughs and tips
- Reduce fire and/or safety hazards
- Improve the growth and vigor of understory plants
- Adjust the foliage and branching density or rooting length for other specific intents, such as wind and snow control, noise abatement, access control, and visual screens and managing competition
- Improve health and vigor of woody plants e.g. disease, insect and injury management

Tree/Shrub Site Preparation - 490

Practice Description
Treatment of areas to improve site conditions for establishing trees and/or shrubs

Purpose
This practice when applied may achieve one or more of the following:

- Encourage natural regeneration of desirable woody plants
- Permit artificial establishment of woody plants

Underground Outlet - 620

Practice Description
A conduit or system of conduits installed beneath the surface of the ground to convey surface water to a suitable outlet.

Purpose
This practice is applied to carry water to a suitable outlet from terraces, water and sediment control basins, diversions, waterways, surface drains or other similar practices without causing damage by erosion or flooding.

Upland Wildlife Habitat Management - 645

Practice Description
Provide and manage upland habitats and connectivity within the landscape for wildlife.

Purpose
Treating upland wildlife habitat concerns identified during the conservation planning process that enable movement, or provide shelter, cover, food in proper amounts, locations and times to sustain wild animals that inhabit uplands during a portion of their life cycle.

Vegetated Treatment Area - 635

Practice Description
An area of permanent vegetation used for agricultural wastewater treatment.

Purpose
To improve water quality by reducing loading of nutrients, organics, pathogens, and other contaminants associated with livestock, poultry, and other agricultural operations.

Waste Facility Closure - 360

Practice Description
The closure of waste impoundments (treatment lagoons and liquid storage facilities), that are no longer used for their intended purpose, in an environmentally safe manner

Purpose
This practice is applied to achieve one or more of the following:

- Protect the quality of surface water and groundwater resources
- Eliminate a safety hazard for humans and livestock
- Safeguard the public health

Waste Recycling - 633

Practice Description
Using agricultural wastes such as manure and wastewater or other organic residues

Purpose
This practice is applied to achieve one or more of the following:

- Protect water quality
- Protect air quality
- Provide fertility for crop, forage, fiber production and forest products
- Improve or maintain soil structure
- Provide feedstock for livestock
- Provide a source of energy

Waste Storage Facility - 313

Practice Description
A waste storage impoundment made by constructing an embankment and/or excavating a pit or dugout, or by building a structure

Purpose
This practice is installed to temporarily store wastes such as manure, to protect from runoff as a component of an agricultural waste management system.

Waste Transfer - 634

Practice Description
A system using structures, conduits or equipment to convey by-products (wastes) from agricultural operations to points of usage

Purpose
To transfer agricultural material associated with production, processing, and/or harvesting through a hopper or reception pit, a pump (if applicable), a conduit, and/or hauling equipment to:

• A storage/treatment facility
• A loading area, and/or
• Agricultural land for final utilization as a resource

Waste Treatment - 629

Practice Description
The mechanical, chemical or biological treatment of agricultural waste

Purpose
To use mechanical, chemical, or biological treatment facilities and/processes as part of an agricultural waste management system:

• Improve ground and surface water quality by reducing the nutrient content, organic strength, and/or pathogen levels of agricultural waste
• Improve air quality by reducing odors and gaseous emissions
• Produce value added by-products
• Facilitate desirable waste handling, storage, or land application alternatives

Waste Treatment Lagoon - 359

Practice Description
A waste treatment impoundment made by constructing an embankment and/or excavating a pit or dugout

Purpose
To biologically treat waste, such as manure and wastewater, and thereby reduce pollution potential by serving as a treatment component of a waste management system.

• Where the lagoon is a component of a planned agricultural waste management system
• Where treatment is needed for organic wastes generated by agricultural production or processing
• On any site where the lagoon can be constructed, operated and maintained without polluting air or water resources
• To lagoons utilizing embankments with an effective height of 35 feet or less where damage resulting from failure would be limited to damage of farm buildings, agricultural land, or township and country roads

Water Harvesting Catchment - 636

Practice Description
The closure of waste impoundments (treatment lagoons and liquid storage facilities), that are no longer used for their intended purpose, in an environmentally safe manner

Purpose
This practice is applied to achieve one or more of the following:

• Protect the quality of surface water and groundwater resources
• Eliminate a safety hazard for humans and livestock
• Safeguard the public health

Water and Sediment Control Basin - 638

Practice Description
An earthen embankment or a combination ridge and channel constructed across the slope of minor watercourses to form a sediment trap and water detention basin with a stable outlet

Purpose
This practice may be applied as part of a resource management system for one or more of the following purposes:

• Reduce watercourse and gully erosion
• Trap sediment
• Reduce and manage on-site and downstream runoff

Watering Facility - 614

Practice Description
A permanent or portable device to provide an adequate amount and quality of drinking water for livestock and or wildlife

Purpose
To provide access to drinking water for livestock and/or wildlife in order to:

• Meet daily water requirements
• Improve animal distribution

Water Well - 642

Practice Description
A hole drilled, dug, driven, bored, jetted or otherwise constructed to an aquifer for water supply

Purpose
This practice is applied to achieve one or more of the following:

- Provide water for livestock, wildlife, irrigation, and other agricultural uses
- Facilitate proper use of vegetation, such as keeping animals on rangeland and pastures and away from streams, and providing water for wildlife

Water Well Decommissioning - 351

Practice Description
The sealing and permanent closure of an inactive, abandoned, or unusable water well

Purpose
This practice is applied to achieve one or more of the following:

- Eliminate physical hazard to people, animals, and farm machinery; and to prevent entry of animals, debris, or other foreign substances
- Prevent contamination of groundwater by surface water inflow
- Restore the natural hydrogeologic conditions, to the extent possible, by preventing vertical cross-contamination or commingling of groundwaters between separate water bearing zones
- Eliminate the possibility of the water well being used for any other purpose
- Allow future alternative use or management of the site

Wetland Creation - 658

Practice Description
The creation of a wetland on a site that was historically non-wetland

Purpose
This practice may be applied as part of a resource management system to create wetland functions and values.

Wetland Enhancement - 659

Practice Description
The rehabilitation of a degraded wetland or the re-establishment of a former wetland so that soils, hydrology, vegetative community, and habitat are a close approximation of the original natural condition and boundary that existed prior to the modification

Purpose
To provide specific wetland conditions to favor specific wetland functions and targeted species by:

- Hydrologic enhancement (depth duration and season of inundation, and/or duration and season of soil saturation)
- Vegetative enhancement (including the removal of undesired species, and/or seeding or planting of desired species)

Wetland Restoration - 657

Practice Description
The rehabilitation of a degraded wetland or the reestablishment of a wetland so that soils, hydrology, vegetative community, and habitat are a close approximation of the original natural condition that existed prior to modification to the extent practicable

Purpose
To restore wetland function, value, habitat, diversity, and capacity to a close approximation of the pre-disturbance by:

- Restoring hydric soil
- Restoring hydrology (depth duration and season of inundation, and/or duration and season of soil saturation)
- Restoring native vegetation (including the removal of undesired species, and/or seeding or planting of desired species

Wetland Wildlife Habitat Management - 644

Practice Description
Retaining, developing or managing wetland habitat for wetland wildlife

Purpose
To maintain, develop, or improve wetland habitat for waterfowl, shorebirds, fur-bearers, or other wetland dependent or associated flora and fauna on or adjacent to wetlands, rivers, lakes and other water bodies where wetland associated wildlife habitat can be managed. This practice applies to natural wetlands and/or water bodies as well as wetlands that may have been previously restored (657), enhanced (659), and created (658).

Woody Residue Treatment - 384

Practice Description
Treating woody plant residues created during forestry, agroforestry and horticultural activities to achieve management objectives

Purpose
This practice is applied to achieve one or more of the following:

- Reduce hazardous fuels
- Reduce the risk of harmful insects and disease
- Protect/maintain air quality by reducing the risk of wildfire
- Improve access to forage for grazing and browsing animals
- Enhance aesthetics
- Reduce the risk of harm to humans and livestock
- Improve the soil organic matter
- Improve the site for natural or artificial regeneration

County/Field Service Center Index

County	Field Service Center	Phone
Autauga	Autaugaville	(334) 365-5532
Baldwin	Bay Minette	(251) 937-3297
Barbour	Clayton	(334) 775-3266
*Bibb	Centerville	(334) 926-4360
Blount	Oneonta	(205) 274-2363
*Bullock	Union Springs	(334) 738-2079
Butler	Greenville	(334) 382-8538
Calhoun	Anniston	(256) 835-7821
*Chambers	LaFayette	(334) 864-9983
Cherokee	Centre	(256) 927-8732
*Chilton	Clanton	(205) 646-0277
*Choctaw	Butler	(205) 459-2496
Clarke	Jackson	(251) 246-0245
*Clay	Ashland	(256) 354-7512
*Cleburne	Heflin	(256) 463-2877
Coffee	New Brockton	(334) 894-5581
Colbert	Tuscumbia	(256) 383-4323
Conecuh	Evergreen	(251) 578-1520
*Coosa	Rockford	(256) 377-4750
Covington	Andalusia	(334) 222-3519
Crenshaw	Luverne	(334) 335-3613
Cullman	Cullman	(256) 734-6471
Dale	Ozark	(334) 774-4749
Dallas	Selma	(334) 872-2611
Dekalb	Rainsville	(256) 638-6398
Elmore	Wetumpka	(334) 567-2264
Escambia	Brewton	(251) 867-3185
Poarch Band of Creek Indians		(251) 368-0826
Etowah	Gadsden	(256) 546-2336
Fayette	Fayette	(205) 932-8959
Franklin	Russellville	(256) 332-0274
Geneva	Geneva	(334) 684-2235
Greene	Eutaw	(205) 372-3271
Hale	Greensboro	(334) 624-3856
Henry	Abbeville	(334) 585-2284
Houston	Dothan	(334) 793-2310
Jackson	Scottsboro	(256) 574-1005
Jefferson	Bessemer	(205) 424-9990
Lamar	Vernon	(205) 695-7622

*Note | Offices with an asterisk (*) are Soil and Water Conservation District Offices.

County/Field Service Center Index

County	Field Office	Phone
Laurderdale	Florence	(256) 764-5833
Lawrence	Moulton	(256) 974-1174
Lee	Opelika	(334) 745-4791
Limestone	Athens	(256) 232-4025
Lowndes	Haynesville	(334) 548-2767
Macon	Tuskegee	(334) 725-3321
Madison	Huntsville	(256) 532-1677
Marengo	Linden	(334) 295-8724
Marion	Hamilton	(205) 921-3103
Marshall	Guntersville	(256) 582-3923
Mobile	Mobile	(251) 441-6505
Monroe	Monroeville	(251) 743-2587
Montgomery	Montgomery	(334) 279-3579
Morgan	Hartselle	(256) 773-6541
Perry	Marion	(334) 683-9017
Pickens	Carrollton	(205) 367-8168
Pike	Troy	(334) 566-2300
Randolph	Wedowee	(256) 357-4561
Russell	Phenix City	(334) 297-6692
Shelby	Columbiana	(205) 669-5121
*St. Clair	Pell City	(205) 338-7215
Sumter	Livingston	(205) 652-5105
Talladega	Talladega	(256) 362-8210
Tallapoosa	Alexander City	(256) 329-3084
Tuscaloosa	Tuscaloosa	(205) 553-1733
Walker	Jasper	(205) 387-1879
*Washington	Chatom	(251) 847-6041
Wilcox	Camden	(334) 682-4117
*Winston	Double Springs	(205) 489-5227

*Note | Offices with an asterisk (*) are Soil and Water Conservation District Offices.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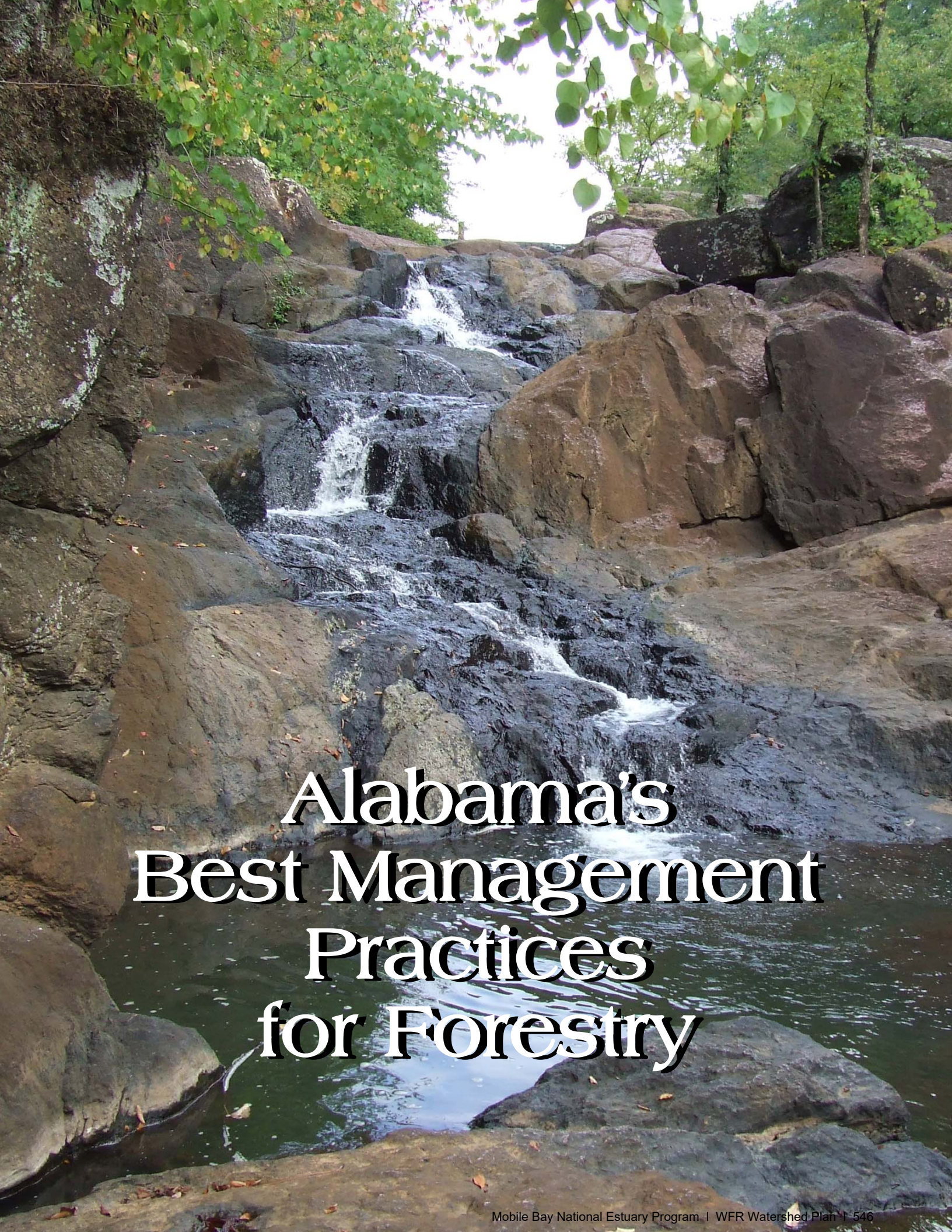

Alabama's Best Management Practices for Forestry

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ALABAMA FORESTRY COMMISSION

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FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

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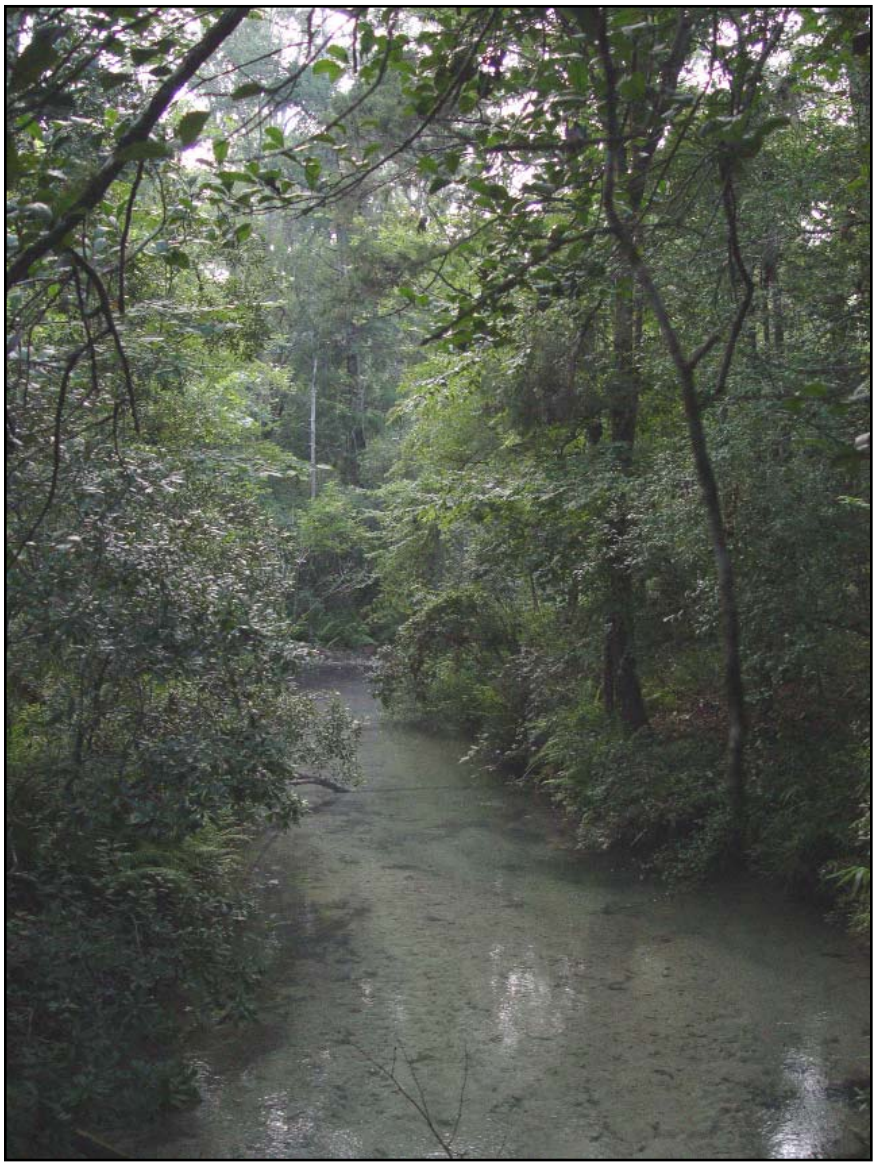
TABLE OF CONTENTS

FOREWORD

Water Quality Management in Alabama

The Alabama Environmental Management Act authorizes the Alabama Department of Environmental Management (ADEM) to establish and enforce water quality standards, regulations and penalties in order to carry out the provisions of state and federal water quality laws. From that authorization, ADEM Administrative Code prohibits the deposition of pollutants into or the degradation of the physical, chemical, or biological integrity of waters of the state (see glossary for definitions). With regard to silviculture, nonpoint source pollutants include, but are not limited to, sediment, organic materials, temperature, trash, pesticides and nutrients (see glossary for definitions and impacts) that are man induced.



In addition, the Alabama Water Pollution Control Act states that ADEM shall have the authority to propose remedial measures necessary to clean up waters that have been determined to be polluted. ADEM advocates, however, that avoiding environmental problems through voluntary application of preventative techniques is much less expensive, more cost effective and practical than restoration after the fact.

The Alabama Forestry Commission's Role in Best Management Practices

The Alabama Forestry Commission was established and is mandated by Code of Alabama, 1975, Section 9-3-4 (1), to protect, conserve, and increase the timber and forest resources of the state. All citizens of Alabama are our valued customers. However, as the lead agency for forestry in the state, we seek to strike a balance between serving Alabama forest owners' needs and enhancing the benefits flowing to society from their forests. Our mission is to promote environmentally and economically sound forestry practices, and we are committed to optimizing available resources to achieve this mission.

The Alabama Forestry Commission is not an environmental regulatory or enforcement agency, but it does accept the responsibility to maintain and update *Alabama's Best Management Practices (BMPs) for Forestry* whenever necessary to help Alabama's forestry community meet state water quality needs. The Commission will work in a cooperative manner with all state and federal agencies concerned, and is determined to utilize technical expertise from within and without the forestry community in any BMP revision process.

The Alabama Forestry Commission also accepts responsibility to provide education and technical assistance to landowners, loggers, foresters, vendors and the general public to ensure that good stewardship principles are understood and used.

Purpose of Best Management Practices

Alabama's Best Management Practices for Forestry are **non-regulatory guidelines** (except for the U.S. Army Corps of Engineer's baseline BMPs on pages 16 and 17 which are mandatory) suggested to help Alabama's forestry community maintain and protect the physical, chemical and biological integrity of waters of the state as required by the Federal Water Pollution Control Act, the Alabama Water Pollution Control Act, the Clean Water Act, the Water Quality Act, and the Coastal Zone Management Act.

The BMPs in this booklet lay out a framework of sound stewardship practices that, when consistently applied, will contribute positively to maintaining a high degree of water quality flowing from a forest. These BMPs are not intended to be all inclusive. Rational and objective on-site judgement must be applied to ensure that water quality standards are maintained.

The most important guidance that these BMPs can offer the forestry community is to **think and plan before you act**. Adequate forethought will pay off in two ways: to avoid unnecessary site disturbance or damage in the first place and to minimize the expense of stabilizing or restoring unavoidable disturbances when the operation is finished.

The enclosed BMPs are directed only toward the maintenance of water quality.

However, these BMPs will have an indirect, positive impact on other forest resource values. Sound stewardship principles that enhance wildlife habitat, clean air, aesthetics and general environmental quality are compatible with water quality BMPs and the Alabama Forestry Commission encourages their use when applicable to the landowner's objectives.

Following sound stewardship principles in carrying out forestry practices will ensure that our forests continue to meet the needs of their owners, provide jobs, forest products, clean water and a healthy environment without costly regulations. Only through sound stewardship principles will all of these needs be met.

Responsibility

Responsibility for maintaining water quality standards during a forestry operation has been broadly interpreted to include all parties involved in the authorization, planning or implementation of the operation. **The responsible parties may include professional forestry practitioner(s) such as forest resource managers, timber purchasers, loggers, vendors, forest engineers or others.**

Due to this inherent responsibility it is in the best interest of all those involved in silvicultural operations to make every effort to prevent and correct violations of state and federal water quality laws, regulations and standards by consistently implementing BMPs.

SPECIFICATIONS FOR INDIVIDUAL BMPs

1. STREAMSIDE MANAGEMENT ZONES

A streamside management zone (SMZ) is a strip of land immediately adjacent to a water of the state where soils, organic matter and vegetation are managed to protect the physical, chemical and biological integrity of surface water adjacent to and downstream from forestry operations. Table 1 provides guidelines for protecting the critical area within a SMZ.

Landowners should have adequate streamside management zones marked before negotiating bids for timber sales.

Harvesting in streamside management zones should be done so as to protect the forest floor and under story vegetation from damage. Do not remove (harvest) trees from banks, beds, or steep slopes if it will destabilize the soil and cause degradation of the water. Trees on the south and west banks provide the most critical shading of water. Fell and skid trees directly away from waters of the state. According to Alabama Department of Environmental Management (ADEM) regulations, any tops or other logging debris dropped into the water or channel must be removed; **however, organic debris in the water prior to harvest should not be removed from the stream.** Stabilize wheel ruts if they could carry sediment into waters of the state. Locate log decks and roads outside of SMZs (except at proper stream crossings and access points or unless steep topography/wetland conditions necessitate location within the SMZ).

Courtesy of the South Carolina Forestry Commission

Table 1: SMZ Minimum Standards[1]

Purpose:	Protect banks, bed, and floodplains from erosion; control direct deposition of pollutants; provide shade, food, and cover for aquatic ecosystems; filter out pollutants from uplands.	
Management	**Perennial Stream**	**Intermittent Stream**
Minimum width on each side of channel	In no cases should SMZs be less than 35 feet from a definable bank.[2] A landowner's personal management objectives, on-site condition or stream sensitivity may require wider SMZs and more stringent control of forestry operations within the SMZ. For example, width should be extended to account for erodibility of soil, steepness of slopes and activities to be performed outside of the SMZ.[3] SMZs must always be wide enough to maintain water quality standards.	
Delineation	Outside boundaries should be well marked before operations begin.	
Roads	Follow state and federal BMPs (see Sections 2, 3, and 6) for roads and stream crossings.	
Harvesting Method	Partial cut only within minimum of 35 feet; partial cut or regeneration cut can take place beyond 35 feet.	Partial cut or regeneration cut when water quality degradation can be avoided.
Minimum Residual Cover	50% Crown cover	Vegetative[4]
Reforestation	Natural regeneration, hand planting, direct seeding.	
Mechanical Site Preparation	No	
Herbicide	If herbicide is used, adhere strictly to label restrictions. Direct application is preferred over broadcast spraying.	
Fertilizer	No	

[1] *In cases where the stream channel is significantly braided, the forest should be managed under wetland BMP management recommendations (Section 6).*

[2] *If wildlife is a major objective, a minimum SMZ of 50 feet is recommended.*

[3] *USDA Natural Resources Conservation Service can provide information on soil erodibility.*

[4] *Permanent residual tree cover is not required along intermittent streams as long as other vegetation and organic debris are left to protect the forest floor during regeneration.*

2. STREAM CROSSINGS

The crossing of streams by roads, skid trails, or firebreaks should be avoided. Stream crossings cause a break in the canopy and filtration strip provided by an SMZ. It may take a large amount of time and effort to stabilize water quality impairment from excessive stream crossings. If stream crossings are unavoidable, use the fewest number, cross the stream/SMZ by the least disruptive manner possible, and control sediment and other pollutants.

In general, stream crossings should be located where the bank and SMZ will be least disturbed. They should be installed at right angles to the stream where the stream channel is straight, and should have gentle slopes and straight paths in and out of the SMZ. Water diversions should divert upland runoff so that sediment and other pollutants can be filtered out on the forest floor before reaching the stream. At no time should a perennial or intermittent stream be crossed without providing a way for normal passage of water or aquatic animals within the channel. **Follow mandatory federal BMPs listed on pages 19 and 20 when roads cross streams or any other wetlands.**

Log crossings involve placing hollow or solid logs into shallow channels. Green and/or small diameter tops, limbs and brush should not be used for this purpose. The surface can be improved by use of secured decking or portable logging mats; do not use fill dirt. All log crossings must be removed when the logging operation is complete.

Fords can be used where the stream bed is firm, banks are low and stream is shallow. Banks should be back bladed away from water and used to improve the approaches. Rock may be brought in to stabilize the approaches and stream bottom.

Culverts, properly sized and installed, should be used to reduce road washouts and impoundments of water. Culvert sizes in Table II are best estimates for normal rainfall but may not handle the largest storm events. One large pipe is better than several smaller pipes. Culverts should be long enough to extend at least one foot beyond the fill on either end. Fill material upstream and down must be stabilized. Possible techniques include use of sand bags, concrete, rip-rap, hay bales, mulch, and vegetation. Culverts should be cleaned out regularly.

Proper culvert installation.

After an operation or phase of an operation has been completed or is going into a period of inactivity, all temporary crossings must be removed and the site stabilized; all permanent crossings must be stabilized and maintained.

Table II

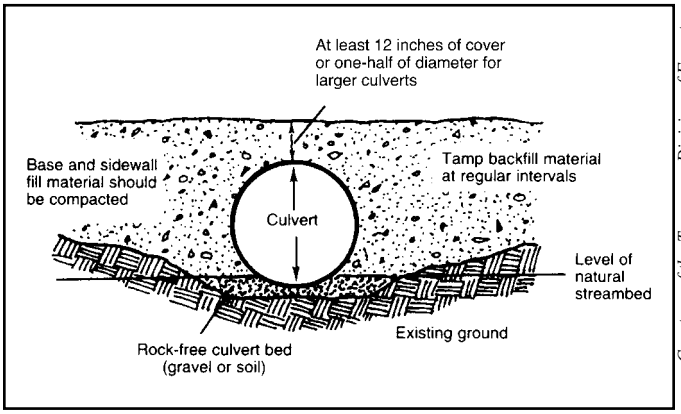
Recommended Diameters for Culverts

Drain Area (acres)	Lower Coastal Plain	Upper Coastal Plain	Piedmont	Mountains
10	12”	12”	12”	18”
50	30”	18”	30”	36”
100	48’’	30”	42”	48”
200	60”	42”	54”	two 48” pipes

Cleared stream crossing, stabilized with hay.

Culvert Installation

- Place culvert on stream bottom; do not dig below natural stream level to bury pipe.
- Culvert should have 2-3% pitch downstream for self-cleaning.
- Compact lower half of fill during installation.
- Earth cover over pipe should be a minimum of 12” or half the culvert’s diameter, whichever is greater. Make fill over a culvert the high spot in the stream crossing.
- Provide for stream overflow away from culvert fill to prevent blowouts.



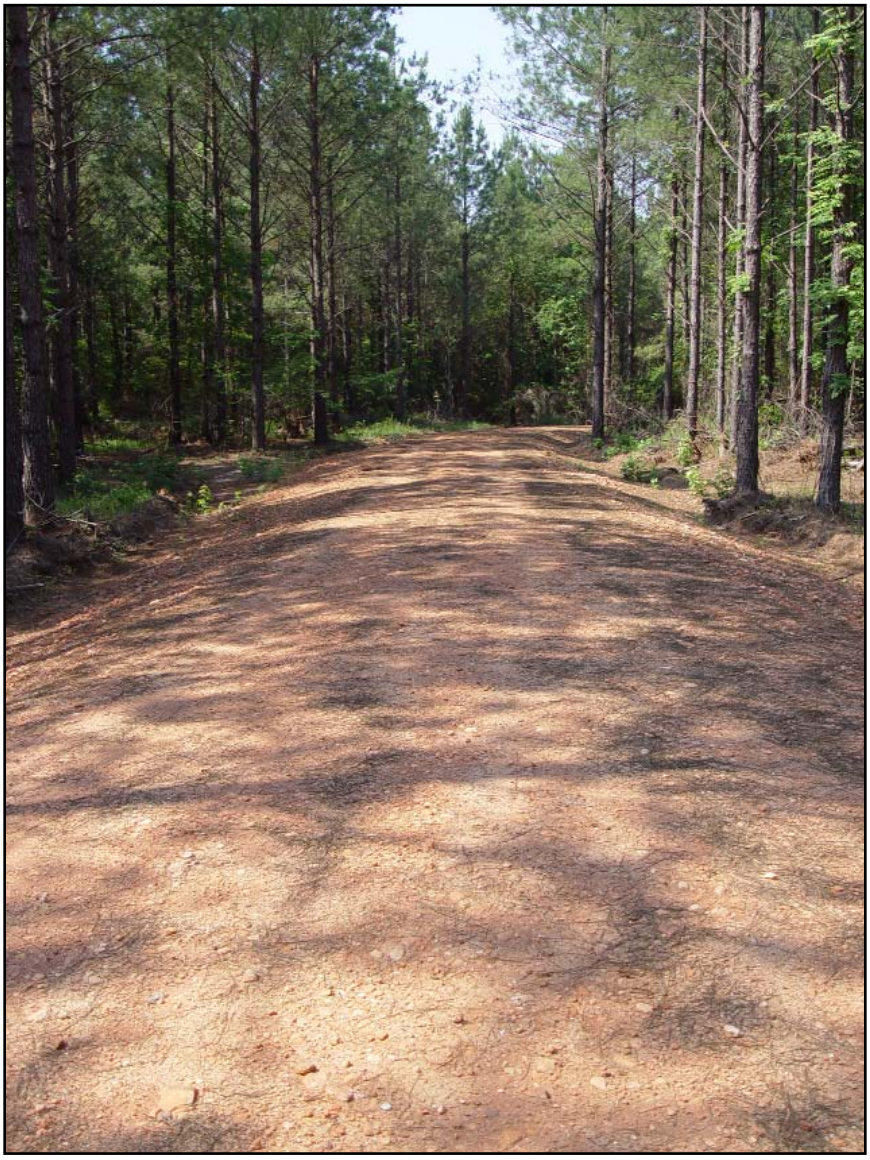
Courtesy of the Tennessee Division of Forestry

Proper installation prevents culverts from being crushed by heavy roads.

***Bridges** create the least disruption to stream flow. According to the Alabama Department of Environmental Management (ADEM) and Corps of Engineer regulations, banks and fill material must be stabilized and protected from erosion. Spans must be installed to permit passage of all expected high flow.*

Portable bridges can be used in a way that protects water quality and reduces effort and expense in the long run.

3. FOREST ROADS



Crowned forest road.

Proper planning and location of roads will minimize the potential for deposition of pollutants into waters of the state, future maintenance and expense, and the amount of land taken out of production. Old roads should be reopened only if they are properly located and drainage devices will function properly. New roads must avoid streamside management zones (except at proper stream crossings and access points or unless steep topography/wetland conditions necessitate location within the SMZ), troublesome or sensitive moisture-laden soils, eroded gullies, etc. Road grades should also be minimized where soils are highly erodible and/or topography is steep. Dredge and fill operations which may alter the flow, circulation or reach of waters of the state, especially wetlands, may require a permit from the Corps of Engineers.

Adequate drainage is the most important factor in controlling soil erosion and keeping roads in a serviceable condition. Construction techniques such as crowned roads, turnout ditches, out-sloping and in-sloping should be used to provide some slope to flat roads which would hold water.

Crowned roads are designed to quickly drain road surfaces from the center of the road to side ditches. This technique helps to prevent water from soaking into the road and making it soft and muddy.

Turnout ditches should be installed at appropriate intervals to disperse water collected in roadside ditches away from the road base into surrounding vegetation.

Outsloped roads in hilly or mountainous terrain are graded at a 2-4% pitch to the downhill side of the road to drain off water as quickly as possible. Avoid berms of dirt along the outer edge of outsloped roads because they hold water in the road.

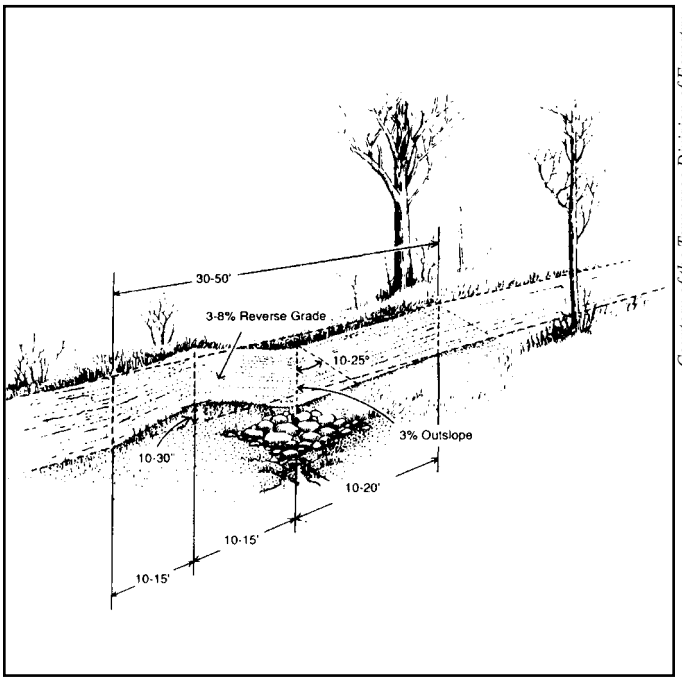
Insloped roads may be preferable when roads are built on side slopes with slippery soils and/or in steep terrain. Water collecting in the inside ditch, however, will have to be drained under the roads through culverts and be dispersed into vegetation on the outside of the road.

Construction of permanent roads should take place with the following considerations:

- Use at least the minimum design standard consistent with anticipated traffic and reasonable safety.
- Merchantable timber should be cleared from the right of way before the arrival of grubbing equipment.
- Stumps, logs, slash and other organic debris should not be covered with fill material and incorporated into road beds.
- Minimize the amount of soil on the road banks or roadsides that is exposed to soil erosion. Balancing cuts and fills whenever practical is one means of minimizing soil exposure. Stabilize these areas as they are created to minimize any problems.
- Functional water diversion techniques or devices should be installed at the same time that roads are constructed. Drainage water should be dispersed onto the undisturbed forest floor whenever possible.

Excessive road steepness, on the other hand, may allow surface water to build up velocity and cause erosion. A variety of water diversion devices can be used to direct water from roads and ditches into vegetated areas upslope from streams in order to slow water down and filter out sediment.

Broad-based dips are an effective means of diverting water off a permanent road without interfering with truck or skidder traffic. They hold up well and remain effective under traffic as long as the outfall remains below the dip in the road grade. Gravel in the bottom of the dip may be necessary on some soils to hold up vehicles operating in wet conditions.



Courtesy of the Tennessee Division of Forestry

Broad-based dips are designed to move water off roads and facilitate the ease of vehicle use.

Water bars (and turnouts) installed at 30-45 degree angles are best used to stabilize temporary roads and skid trails that will no longer be used. Water bars may not hold up well or maintain their effectiveness when they are packed down or rutted by truck, skidder or four-wheeler traffic. A series of small water bars, well anchored into the hillside, can be constructed by a skidder or bulldozer.

Outfall protection should be provided to prevent erosion by absorbing the energy of water falling from the outlet end of water diversion devices. Use rocks, concrete, mulch, woody debris or dense vegetation. Outfalls must never be installed where runoff can be discharged or flushed directly into waters of the state.

Table III

Diversion devices can generally be installed using the following spacing guide. However, soil erodibility and natural drainage opportunities should also be considered for determining appropriate spacings. The USDA Natural Resources Conservation Service can provide information about the erodibility of soils.

% Slope	Distance between water bars	Distance between broad-base dips and turnouts
3%	200’	235’
5%	135’	180’
10%	80’	140’
15%	60’	125’
20%	45’	
30%	35’	
40%	30’	

Maintenance of permanent roads should take place with the following considerations:

- Regular periodic inspection should start immediately after construction to determine maintenance requirements that prevent excessive erosion, impairment of natural drainage, or water quality problems.
- After an operation is completed, rutted or channeled roads should be reshaped and stabilized with functional water diversion devices to allow good drainage and control erosion.
- Seeding and mulching may be necessary to stabilize roadsides and closed temporary roads.
- Special soil stabilizing materials are available for particularly vulnerable areas (see USDA Natural Resources Conservation Service for dealers).

Control non-essential traffic during wet weather on roads which have a high potential for erosion; particularly immediately following construction.

A single large water bar constructed by a bulldozer can be used to close temporary roads to any further two-wheel drive traffic.

4. TIMBER HARVESTING

Harvesting activities should be conducted to ensure long-term maintenance of water quality. The following suggestions will help timber harvesters achieve this objective.

Temporary access roads (logging roads) and landing locations should be planned before operations begin to minimize soil disturbance. Road construction should be kept to a minimum, consistent with reasonable skidding distance. Spring heads, natural drainages and gullies should be avoided. Landings should also be kept as small as possible, consistent with safe and efficient operation. Logging roads and landings must be located on firm ground, outside of Streamside Management Zones and above the ordinary high water mark of streams.

Landings must be located to prevent the adverse impact of skidding on water quality. Locating logging decks uphill and skidding up to them results in a cone-shaped pattern of skid trails which disperses water running downhill. If the logging deck is on the lower slope, the V-shaped pattern of skid trails could concentrate runoff and erode the logging deck areas. If the trees must be skidded downhill, erosion can be minimized by using several, smaller logging decks with fewer, smaller skid trails leading to any one.

When operations are completed, landings and temporary roads should be stabilized with water diversion devices and/or vegetation where there is a possibility of significant erosion and/or water quality degradation.

Felling should be done carefully to minimize the impact of subsequent phases of logging operations on water quality. Timber cut in Streamside Management Zones should be harvested in accordance with recommended guidelines on pages 4 and 5.

Skidding should be done to avoid disrupting natural drainages, prevent excessive soil displacement, and minimize impacts of rutting, compaction, and puddling on water quality and soil stability.

Stream channels and natural drainages must not be used as skid trails. They should be crossed following guidelines in Section 2.

Where slopes are steep but short in duration, trees can be felled uphill and winched to the skidder. Skid trails on steep slopes should have occasional breaks in grade and upon completion of use, must be water barred. Erosion in skid trails can sometimes be reduced by covering them with logging slash. Logging slash can also be scattered over temporary landings to help stabilize them.

When wet and/or soft ground conditions cannot be avoided, it is better to concentrate soil compaction from skidder traffic on a few trails that can be stabilized rather than disperse the effects over many trails.

Cut-to-length harvesting systems offer state-of-the-art equipment and best available technology to maximize timber production and protect water quality and other forest resources at the same time.

Primary benefits of this system are from forwarders (or prehaulers) which can haul wood off the ground for long distances and need only minimum skid trails or landings. Less soil is displaced, rutted, and compacted. The on-board loader can be used to place logs for stream crossings and easily remove them when the crossing is no longer needed. In addition to high initial costs, however, this equipment is also limited by very steep terrain.

Trash disposal must be properly handled throughout the operation in accordance with all applicable laws. Fuel, lubricants and other toxic chemicals must never be drained into the soil. Food and drink containers, discarded equipment parts, and used fluids must be properly removed and disposed of. Trash must not be burned or buried on site.

5. REFORESTATION / STAND MANAGEMENT

Bedding on a contour.

Mechanical site preparation treatments must be used in such a manner as to minimize displacement of forest litter and topsoil, soil compaction and erosion, stream sedimentation and the deposition of debris into waters of the state. The degree of mechanical site preparation should be limited to the amount that is needed to get a well stocked stand of desirable trees. In general, mechanical site preparation should be excluded from soils with slopes exceeding 25%. No mechanical site preparation should be used in SMZs.

Drum chopping is one of the most desirable methods of mechanical site preparation for the protection of soil and water quality. When chopping is done on steep slopes it should always be done up and down hill so that sediment can be trapped in the slits created by the chopper blades.

Bedding on slopes exceeding 2% should follow the contour. On slopes 2% or less, beds should follow the natural drainage of the land. *Ripping and/or sub-soiling* should be done on the contour.

Disking should be done on the contour and restricted to areas with slopes 10% or less.

Shearing requires that the operator keep the blade out of the soil to minimize soil disturbance. Avoid over-raking the area. The retention of small limbs, twigs, bark and rock on the ground surface helps reduce soil erosion.

Windrows should be laid out on the contour of the land 100 to 300 feet apart depending upon the slope of the land and erodibility of the soil. Topsoil should not be pushed into windrows. Debris may not be piled into any water of the state.

Straight blade bulldozing is the least desirable method of mechanical site preparation.

Windrows.

Chemical site preparation, with or without the use of fire, can duplicate or surpass mechanical site preparation results with less water quality impact.

Herbicide applications must follow the manufacturer's label instructions, EPA guidelines and Alabama State Law. Herbicides should not be aerially or broadcast applied in SMZs. Under no circumstances should herbicides be applied directly onto or allowed to drift or wash into surface waters unless labeled for such applications. Do not mix or clean equipment or herbicide containers in or near streams or water bodies. Frequent inspection of equipment is recommended.

Prescribed burning should be designed and managed to minimize adverse environmental effects. Avoid intense spray and burns on steep slopes and highly erodible soils if water quality would be impacted.

Constructed firebreaks can be tied into existing natural barriers to minimize the need for fresh soil disturbances. Firebreaks should be stabilized with water diversion devices to minimize erosion and conveyance of sediment laden runoff into waters of the state. Vegetating firebreaks can further reduce erosion and the movement of sediment and other pollutants into waters of the state.

Wildfires demand that the primary objective of firebreak construction is to bring the fire under control.

Tree planting with a furrow type machine should be done on the contour.

Planting on a contour.

Constructed firebreak.

6. FORESTED WETLAND MANAGEMENT

Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency or duration sufficient to support (and under normal circumstances do support) a prevalence of vegetation typically adapted for life in saturated soil conditions.

The U.S. Army Corps of Engineers, using the *Federal Manual for Delineating Jurisdictional Wetlands*, determines under which conditions hydrophytic vegetation, hydric soils, and wetland hydrology must be present on the same site, under normal circumstances, for an area to be classified as a wetland. Jurisdictional wetlands may be found in the following

- Coves and lower slopes
- Branch bottoms
- Creek bottoms
- River bottoms
- Muck swamps
- Peat swamps and cypress/gum ponds
- Wet flats

Section 404 of the Clean Water Act usually requires that a permit be obtained from the Corps of Engineers before a discharge of dredged or fill materials can be made into waters of the United States (U.S.), including wetlands. A regulated discharge occurs when fill or dredged material is deposited into wetlands.

Exemptions for forestry activities from having to obtain an individual Section 404 permit from the Corps of Engineers may apply if the activities meet the following conditions:

1. It is not part of an activity whose purpose is to convert a wetland into an upland, where the flow or circulation of the waters of the U.S. may be impaired or the reach of water reduced; and

2. It is part of an established (i.e. ongoing) silvicultural, farming or ranching operation and not a new use to which the wetland was not previously subject; and

3. It uses "normal" silvicultural, farming or ranching activities which are in compliance with federal BMPs (listed under "Roads and Stream Crossings . . ." on, pages 19 and 20); and

4. It has not lain idle for so long that hydrological modifications will be necessary to resume operations; and

5. It does not contain any toxic pollutant listed under Section 307 of the Clean Water Act.

What is an established silvicultural operation? Established or ongoing operations are included in a management system (not necessarily written) which is planned over conventional rotation cycles for a property or are introduced as part of an ongoing operation.

Evidence of use of the property may be used to determine whether an operation is ongoing. Such evidence includes the following:

1) a history of harvesting with either natural or artificial regeneration; 2) a history of fire, insect, and disease control to protect the maturing timber; and 3) the presence of stumps, logging roads, landings, or other indications of established silvicultural operations that will continue on the site.

While past management may have been relatively non-intensive, intensification of management involving artificial regeneration and other practices can occur as part of a conventional rotation and be considered an established operation.

Although wetland regulations do not require a written forest management plan, it is in a landowner's best interest to have one to document that operations are established, that BMPs are implemented and effective, and that all activities are consistent with other Section 404 exemption criteria.

A change in ownership between landowners (both of which manage forested wetlands for silvicultural purposes) has no bearing on whether a forestry operation is part of an established ongoing activity. Continuation or strict adherence to a management plan written for the previous owner is not required by Section 404 silvicultural exemptions.

"Normal" silvicultural activities (such as road construction, timber harvesting, mechanical or chemical site preparation, reforestation, timber stand improvement, and minor drainage) conducted as part of established ongoing silvicultural operations are exempt from Section 404 Corps of Engineers permit requirements as long as the appropriate measures are implemented. Those measures are listed under "Roads and Stream Crossings. . ." on pages 19-20. *Alabama's Best Management Practices for Forestry* are not required for exemption from Section 404 Corps of Engineer permit requirements; they are, however, **strongly** recommended to minimize nonpoint source pollution of waters of the state and/or waters of the U.S.

A forestry activity or operation WILL require a 404 permit from the Corps of Engineers when the following applies:

1. The activity results in the immediate or gradual conversion of a wetland to an upland as a consequence of altering the flow and circulation or reducing the reach of waters of the U.S.

   Changes in flow, circulation or reach of waters can be affected by permanent major drainage such as channelization or by placement of fill material. A discharge which changes the bottom elevation of waters of the U.S., without converting it to dry land, does not reduce the reach of waters but may alter flow or circulation and therefore may be subject to permitting requirements.

   The criteria that are used to determine if a wetland has been converted include a change in hydrology, soils and vegetation to such an extent that the area no longer qualifies as a jurisdictional wetland according to the *Federal Manual for Delineating Jurisdictional Wetlands.*

2. A new activity results in a change from the past, historical use of the wetland into a different use to which it was not previously subject where the flow or circulation of waters is impaired or the reach of the water is reduced. Such a change does not meet the established, ongoing requirement and causes the activity or operation to lose its exemption.

   Examples of this situation are areas where tree harvesting has been the established use and the landowner wishes to convert the site for use as pasture, green tree reservoir, agriculture, real

estate or aquaculture. In such cases the landowner must first obtain a 404 permit before proceeding with the change. (Changes of use to farm stock ponds may be exempt under a nationwide Corps of Engineers permit).

3. Roads and stream crossings are constructed in a wetland without following the mandatory, federal BMPs listed under the wetland road regulations.

4. The area has lain idle for so long that hydrologic modifications are necessary to resume operations. This does not refer to temporary water management techniques such as minor drainage, plowing, bedding and seeding which exempt, normal silvicultural activities as long as they don't result in the conversion of wetlands to uplands. However, it does apply to reopening ditches which were once established as permanent wetland drainage structures but have lost their effectiveness for this purpose as they filled in with soil and vegetation.

BMPs for wetlands are not intended to make up for uncontrolled negative impacts on uplands but are part of the overall management of the full landscape to protect water quality.

Streamside management zones should be established and managed around the perimeter of all major drainages and open bodies of water (i.e., main stream courses, oxbow lakes, sloughs) contained within wetlands.

Minor drainage refers to installation of ditches or other water control facilities for temporary dewatering of an area. Minor drainage is considered a normal silvicultural activity in wetlands to temporarily lower the water level and minimize adverse impacts on a wetland site during road construction, timber harvesting and reforestation activities. Minor drainage does not include construction of a canal, dike or any other structure which continuously drains or significantly modifies a wetland or other aquatic area.

Minor drainage is exempt from needing an individual 404 permit if it is part of an ongoing silvicultural operation and does not result in the immediate or gradual conversion of a wetland to an upland or other uses. Artificial drainage must be managed. Once silvicultural activity has been completed the hydrology that existed prior to the activity should be restored by closing drainage channels.

Roads and stream crossings within wetlands and other waters of the U.S. *must* be constructed and maintained in accordance with the following U.S. Army Corps of Engineer baseline BMPs (from Section 404, Corps of Engineers Permit Requirements, 40 CFR Part 233.22) in order to retain exemption status for the road operation:

1. Permanent roads, temporary access roads and skid trails (all for forestry) in waters of the U.S. shall be held to the minimum feasible number, width, and total length consistent with the purpose of specific silvicultural operations, and local topographic and climatic conditions;

2. All roads, temporary or permanent, shall be located sufficiently far from streams or other water bodies (except for portions of such roads which must cross water bodies) to minimize discharges of dredged or fill material into waters of the U.S.;

3. The road fill shall be bridged, culverted or otherwise designed to prevent the restriction of expected flood flows;

4. The fill shall be properly stabilized and maintained during and following construction to prevent erosion;

5. Discharges of dredged or fill material into waters of the U.S. to construct a road fill shall be made in a manner that minimizes the encroachment of trucks, tractors, bulldozers, or other heavy equipment within waters of the U.S. (including adjacent wetlands) that lie outside the lateral boundaries of the fill itself;

6. In designing, constructing and maintaining roads, vegetative disturbance in the waters of the U.S. shall be kept to a minimum;

7. The design, construction and maintenance of the road crossing shall not disrupt the migration or other movement of those species of aquatic life inhabiting the water body;

8. Borrow material shall be taken from upland sources whenever feasible;

9. The discharge shall not take, or jeopardize the continued existence of a threatened or endangered species as defined under the Endangered Species Act, or adversely modify or destroy the critical habitat of such species;

10. Discharges into breeding and nesting areas for water fowl, spawning, and wetlands shall be avoided if less harmful alternatives exist;

11. The discharge shall not be located in the proximity of a public water supply intake;

12. The discharge shall not occur in areas of concentrated shellfish production;

13. The discharge shall not occur in a component of the National Wild and Scenic River System;

14. The discharge of material shall consist of suitable material free from toxic pollutants in toxic amounts; and

15. All temporary fills shall be removed in their entirety and the area restored to its original elevation.

Timber harvesting using normal methods and equipment may be appropriate if harvesting is timed during dry periods.

Harvesting during wet periods or sites that remain wet require special precautions and harvesting systems to minimize water quality hazards and other negative site impacts. Site damaging effects from harvesting equipment such as rutting, puddling and compaction should be controlled and minimized. For example, concentrate skidder traffic on a few trails rather than over the entire area. Do not harvest sites during periods of flowing water whether from overbank flooding or other water accumulation.

Roads must be constructed and maintained in accordance with BMPs to assure that flow and circulation pattern and chemical and biological characteristics of waters of the U.S. are not impaired, that the reach of the waters of the U.S. is not reduced and that any adverse effect on the aquatic environment will be otherwise minimized.

Minor drainage is allowed (i.e., to maintain a dry road bed) unless it becomes obvious that BMPs have not been followed or that the road is serving some function other than conveyance of vehicles (i.e., a continuous roadside barrow ditch may not be used to drain adjacent wetlands.

Reforestation in wetlands is not much different from regenerating uplands in regards to water quality; the main factors to consider are the site's potential for erosion/sedimentation and hydrology.

Land clearing is an exempt silvicultural activity if it is associated with timber harvesting or reforestation operations. However, land clearing using mechanical equipment for purpose of removing vegetation in preparation for converting the site to a different land use is not part of an established silvicultural operation and is not exempt from having to go through the Corps of Engineer permitting process.

Herbicides bearing the "wetlands" warning on the label can be applied to vegetation on dry soils of jurisdictional wetland areas but must not be applied directly to surface water or to inter-tidal areas below the main high water mark.

Bedding is the construction of earthen mounds from surrounding soil resulting in adjacent and alternating "beds" and furrows. Seedling beds create temporary elevated soil conditions which allow seedlings to escape saturated soil conditions and have a greater opportunity to survive and grow.

Bedding is considered a normal silvicultural activity that is exempt from Section 404 permitting requirements if the following conditions exist:

- The bedding does not result in the gradual or immediate conversion of a wetland to upland as a consequence of impairing the flow or circulation or reducing the reach of waters of the U.S.; and
- It is performed as part of an established, ongoing silvicultural operation.

However, if bedding were to significantly alter the flow, circulation, or reach of waters of the U.S. and consequently result in conversion of a wetland to an upland, the exemption would no longer apply.

Species composition change (i.e., bottomland hardwood to pine plantation) resulting from intensification of management is considered a normal, silvicultural activity that is exempt from 404 permitting if the property is in silvicultural usage before and after the harvesting and planting.

However, a species composition change is not exempt if the activities used to clear, prepare or plant the site would result in a change in use that is accompanied by an impairment of the flow or circulation or the reduction of the reach of waters. An example of such a new use situation would be where the change in species composition would cause a conversion of wetlands to uplands.

Removal of beaver dams and other blockages to remove impounded surface water is considered exempt from 404 permitting as long as the process does not include enlarging or extending the dimension or changing the bottom elevation of the affected drainage way as it existed prior to the formation of the blockage, or without changing the use of the land in question.

Beaver dams can be dismantled by hand without any problems. Dynamite and heavy equipment can also be used to destroy dams as long as they are not used to construct drainage channels that will result in conversion of wetlands to uplands. However, when dynamite or heavy equipment is to be used to remove beaver dams or other blockages, the Corps of Engineers should be contacted for possible permit requirements.

***Before and After**: Top photo shows blockage caused by beaver dam. Bottom photo illustrates flow restored.*

7. Revegetation/Stabilization

Skid trail stabilized with logging slash.

As already pointed out in previous sections, some temporary haul roads, skid trails, log landings, firebreaks and other forestry related soil disturbing activities require the establishment of a vegetative cover to stabilize mineral soil surfaces so as to reduce erosion and runoff of sediment into state waters. The USDA Natural Resources Conservation Service can provide a detailed plan for establishing vegetation on these disturbed sites.

Site preparation, such as smoothing or reshaping rutted roads and landings, may be required before conventional equipment can be used for seedbed preparation, seeding, mulching and drainage improvement. Heavily compacted areas may require ripping and/or disking to allow water infiltration and provide a suitable seedbed for root growth.

Agricultural limestone and fertilizer may be needed to ensure success in establishing a vegetative cover. Soil tests are recommended. Incorporate lime and fertilizer into the top 2-4" of soil on slopes less than 6%; into the top 2"of soil on slopes of 6-10%; and onto the surface only on slopes greater than 10%.

Plant species recommendations can be obtained from the local county office of the USDA Natural Resources Conservation Service or Cooperative Extension Service. Areas treated by temporary seeding or mulch should be reseeded with permanent vegetative species as soon as possible during the correct growing season to ensure stabilization of disturbed areas. Disking or mowing of temporary cover is recommended before application of permanent seed and fertilizer.

Mulch is recommended for critical situations to hold seed, lime and fertilizer in place, maintain moisture and prevent extreme temperatures on the soil surface. Mulch needs to be applied immediately after seeding to provide best benefits.

Vegetative establishment for control of erosion and sedimentation can be considered successful once a 75% cover has been obtained. Within one

Vegetated forest road.

year of establishment, a second broadcast application of fertilizer at half the original rate is recommended to ensure plant survival and growth.

Silt screen and hay bales can be used to filter runoff water from closed roads and skid trails to prevent or stop sediment from flowing downslope into waters of the state. When using silt screen, 5-6 foot-long posts should be staked 5-10 feet apart across the problem area. The porous material is stapled 3 feet high on the post and excess material at the bottom of the screen is folded uphill and anchored down with rocks or fill material. Hog wire can be stapled to the stakes before the material is attached to give strength to the silt screen as intercepted sediment builds up.

Square hay bales can be used for the same purpose by lining them up across the road, end to end and one to two bales high. Stake the bales in place on their sides with the strings off the ground to prevent rotting.

Gully stabilization should receive high priority during all land management activities. The most effective way to reduce sediment production and/or reduce the change of reactivating the erosion process in healed gully systems is to avoid operating in them and maintain all existing vegetation. Site preparation, including herbicide and burning, should be excluded.

Actively eroding gully systems need to be stabilized. The USDA Natural Resources Conservation Service can provide technical assistance in planning and installing gully stabilization measures.

APPENDICES

Glossary

ADEM – The state regulatory agency (Alabama Department of Environmental Management) which administers and enforces the Alabama Water Pollution Control Act.

Approaches – The entry and exit of a road or skid trail through a stream crossing.

Aquatic ecosystem – An interacting community of plants and animals (i.e., insects, crayfish, fish and amphibians) requiring an abundance of water during some part of their life cycle.

Backblade – To pull dirt by dropping a dozer blade into the soil and operating the tractor in reverse.

Back slope – The soil profile in the side of a hill that is exposed from cut and fill type road construction.

Banks – The sides of a channel which holds or carries water.

Bed – The bottom of a stream.

Bedding – A mechanical site preparation technique where top soil is mounded into rows. Trees planted on top of the row will be well drained and will benefit from a concentration of nutrients and organic matter during initial stages of growth.

Biological integrity of waters of the state – The ability of a body of water to support the natural level of diverse plants and animals that would normally occur without man-made disturbance or manipulation of the landscape.

Broad based dip – An alteration of a road grade to intercept water from the surface and dispel it to the side without seriously interfering with vehicular traffic.

Canopy – The upper leafy branches of dominant and codominant trees and shrubs which intercept sunlight and shade the ground.

Chemical integrity of waters of the state – The natural range of nutrient and pH levels which would normally occur in waters passing through an undisturbed site.

Compaction – The result of all air and moisture holding spaces being squeezed out from between soil particles by operation of heavy equipment during unfavorable ground conditions. All soils are generally more easily compacted when wet. Compacted soil is less productive and more erodible.

Contour – An imaginary line on the surface of the earth connecting points of the same elevation.

Corps of Engineers – The federal regulatory agency, a branch of the U.S. Army, which administers and enforces the Section 404 permitting program of the Clean Water Act.

Critical shading of water – Shading when water receives the greatest protection from overheating and ultraviolet exposure caused by solar radiation.

Cross drain – A pipe, ditch or channel which safely conveys water from one side of the road to the other.

Crown – The top of a tree consisting of trunk and expanding branches.

Culverts – Usually metal or plastic pipe but can be a constructed wooden trough.

Cut and fill – Earthen material which is dug out of a hill and placed down slope to provide a relatively level road bed.

Deck – An area cleared to provide a site for loading logs onto a transport vehicle.

Decking – Rough or unfinished lumber used to provide a stable surface for roads, stream crossings or landings.

Definable bank – The bounds of a water body at or below its normal flow level which is usually devoid of terrestrial plants and accumulations of light organic debris.

Deposition – The act of depositing or putting into.

Destabilize (the soil) – To expose and/or loosen soil thus making it more susceptible to erosion.

Direct seeding – Artificially placing seed by hand, land machine or aircraft onto a germination surface.

Disking – Breaking up plants (above and below ground portions), organic matter and soil in preparation to improve the ground for replanting and to reduce plant competition.

Diversion device – A structure to intercept and re-route water from a road surface.

Drainage device – Same as diversion device.

Dredge – Earthen material that is dug from a channel or removed from the bottom of a water body, often to improve drainage.

Ephemeral streams – Low places in the landscape that only flow shortly after significant rainfall. Does not have a well defined channel.

EPA – The U.S. Environmental Protection Agency. The federal agency created and mandated by the U.S. Congress to administer and enforce the Clean Water Act upon waters of the United States.

Erosion – The dislodging and carrying away of soil particles by wind or water.

Fell – To cut or knock down standing trees or other vegetation.

Fill – To raise the elevation of a surface by depositing dredged or excavated material onto it.

Filtration strip – A strip of land where vegetation, mulch, or fabric is maintained or placed to intercept and prevent upland sediment and other pollutants from flowing into water.

Firebreaks – Natural or artificially constructed barriers to the spread of fire.

Floodplain – Areas adjacent to bodies of water that are most prone to flooding when the water overflows its banks.

Forest floor – Accumulations of organic debris and low vegetation on the ground beneath a stand of trees.

Forest resource managers – This group includes foresters, wildlife biologists, recreational planners and other developers.

Fragile area – Areas that are easily altered physically, biologically, or chemically, and are difficult or slow to recover.

Grade – The steepness of rise or fall of a road surface.

Ground cover – Low growing vegetation such as grass, forbs, vines, or shrubs.

Ground water – Water stored and/or flowing out of sight under the surface of the ground.

Hand planting – Re-establishing vegetation by planting seed or seedlings into prepared planting holes in the ground.

Harvests – Gathering merchantable portions of trees for commercial or domestic use.

Herbicide – a natural or synthetic chemical pesticide applied specifically to control competition from undesirable plant species.

High flow – The increased volume and speed of water that exceeds a stream's normal rate of flow.

High water mark – Physical evidence of past flooding such as discoloration of the lower portions of vegetation or debris suspended in branches off the ground.

Implementation – The carrying out of instructions contained in a management plan, harvest plan or reforestation plan (written or verbal).

Impoundments – An accumulation of water into pools or ponds formed by blocking the natural drainage.

Inslope – Sloping of a road surface so drainage is toward a ditch between the road and hill.

Intermittent bodies of water – Contain water within well defined channels during part of the year.

Label restrictions – Explicit instructions from the manufacturer with approval from federal and state authorities on when, where, and how a particular pesticide may be applied. Instructions also usually include worker and environmental safety precautions.

Landing - A site where logs are sorted and loaded onto trucks for hauling to handling or processing facilities.

Litter Layer – The natural buildup of dead leaves, branches and stems of dead trees and other forest vegetation which accumulate on the ground and then decay with time.

Log decks – Same as landings.

Mechanical planter – A tree planting machine pulled by a tractor and manned by a person who places trees into the ground.

Mechanical site preparation – Use of heavy machinery such as bulldozers with special attachments that clear debris or incorporate it into the soil to improve planting, sprouting, growth and or survival conditions for new forest trees.

Minimum residual cover - The fewest number of trees necessary to provide shade, natural recruitment of organic material, and soil holding capability for protection of the biological integrity of aquatic ecosystems.

Mulch – A coarse material used to protect soil from rainfall impact and erosion and to improve germination and growth of vegetation. Examples are hay, straw, bark and geotextile fabric.

Natural barrier – Areas that are devoid of fuel or food to support a spreading fire or insect or disease epidemic.

Natural drainage – Perennial, intermittent and ephemeral stream courses in a watershed that collect and expel runoff water.

Natural regeneration – Young trees that originate from seed or sprouts of trees that do or did grow on the site.

Nonpoint source – Water pollution which is not traceable to any discrete or identifiable facility but comes from a broad treatment area.

Normal passage of water and/or aquatic animals – Movement of water or animals which has not been obstructed or inhibited as the result of man-made activity.

Nutrients – Substances that nourish such as nitrogen, potassium and phosphorus in fertilizer. Excess nutrients can destabilize aquatic ecosystems.

Organic debris – Refuse such as tree tops, limbs or severely damaged tree stems which are left following road construction, logging, or site preparation.

Organic matter – Dead plant parts or animals. While natural recruitment of organic matter is part of the energy and nutrient cycles of an aquatic ecosystem, decay of excess amounts in water depletes oxygen needed by fish and other aquatic animals. Tops and other debris can sometimes block and divert the flow of streams causing additional erosion.

Partial cut – A selective timber harvest method where particular trees are usually designated to remain in the stand and the rest are removed in a thinning harvest.

Perennial bodies of water – Contain water within well defined channels virtually year round under normal climate conditions.

Permanent road – A road constructed, used and maintained beyond the time period of a single operation such as a timber sale.

Pesticide - See herbicide for specific application.

Physical integrity of waters of the state – The retention of water in its natural condition without alteration of stream course, depth, clarity or freedom of obstructions that might occur as the direct result of man-made activity.

Plowed fire control line – A man-made fire break constructed by a heavy piece of equipment such as a small bulldozer pushing or pulling a heavy duty plow designed for cutting through the forest floor and root mat to clear combustible material and expose mineral soil.

Pollutants – Man-induced elements such as sediment, organic debris, increased temperature, nutrients, chemicals, trash and soil degradation which exceed a water's natural ability to neutralize before changes in the physical, chemical or biological integrity of waters of the state occur.

Portable bridge – a stream crossing device that is preassembled, installed across a channel and removed following completion of an activity with minimum adverse impact to water quality.

Portable logging mats – Temporary road or stream crossing surface constructed of rough cut lumber nailed or bolted together. These are usually expected to be removed and reused following completion of a particular operation.

Prescribed burning – Preplanned fire that is deliberately set in a time and manner when prescribed conditions will allow accomplishment of specific objectives and is under control until it burns out or is extinguished.

Puddling – The destruction of root systems and soil structure by the tearing and churning action of heavy equipment operating in saturated soils. Puddled soils are more susceptible to erosion than undisturbed soils.

Reforestation – The restocking of a forest stand through natural regeneration or artificially planted seed or seedlings.

Regeneration – A young stand of a forest.

Regeneration cut – Either partial harvests where selected trees are left to provide adequate seed or silvicultural clearcuts where all merchantable and non-merchantable tree stems are removed or felled to encourage sprouting of desirable tree species.

Riprap – Large stones which are arranged over loose soil to protect it from erosion.

Rutting – Impression left in the ground after soil is compacted by the wheels or tracks of heavy equipment operating in soft earth. Deep rutting can disrupt surface and subsurface hydrology on flat lands and cause soil erosion on steep lands by concentrating surface runoff.

Sediment – Accumulations of loose soil particles. Excessive amounts of sediment can pollute water needed for aquatic ecosystems, drinking, wildlife, outdoor recreation, and industrial use.

Shearing and raking – A site preparation technique that uses a large tractor equipped with a special cutting blade to cut down trees just above the ground surface and a second tractor equipped with a specialized raking blade that pushes the felled trees and other debris into piles or windrows.

Side bank – Same as back slope.

Silviculture – The care and cultivation of forest trees; forestry.

Site preparation – Use of machines, herbicides, fire or combinations thereof to dispose of slash, improve planting conditions and provide initial control of competing vegetation.

Skid – To drag logs with a specialized tractor to a landing.

Skid trails – Paths where logs have been dragged.

Slash – Unmerchantable debris such as brush or tree stems, tops, branches or leaves that are left following a commercial timber harvest operation.

Slough – An open water inlet from a larger body of water.

Soil stabilizing materials – Silt fencing, straw blankets, geotextile fabric, geoweb, etc., applied to protect soil from erosion.

Soil type – Consistent characteristics of an identifiable soil such as particle sizes, moisture holding capacity, plasticity and ease of compaction.

Span – A structural beam designed to hold other bridge components and traffic above a stream or channel.

Steep gradient – A high rate of ascent or descent on a road.

Stringent – Tightly regulated or controlled.

Surface water – Exposed water above the ground surface.

Temperature – The degree of hotness or coldness of an environment. Removal of vegetative shade from banks of streams and shores will directly raise water temperature and indirectly result in lower dissolved oxygen levels. These influences place some fish and other organisms under stress.

Temporary access roads – Roads not expected to be maintained much longer than the activity for which they were installed to support.

Timber purchasers – Agents who locate commercial stands of timber and negotiate terms of purchase on either their own behalf or on the behalf of timber brokerage or forest product companies.

Topography – The lay of the land.

Tops – The upper (usually referring to unmerchantable) portions of trees.

Trash – Unnaturally occurring, man-made refuse or discarded substances. Openly discarded trash and petroleum wastes may be carried into waters of the state by storm runoff and is unsightly.

Understory vegetation – Small trees, shrubs or other plants which grow beneath the canopy of more dominant trees.

Upland runoff – Surface drainage water which flows from higher elevations of a landscape into the natural drainage system of a watershed.

Vendors – Contractors who provide tree harvesting, site preparation, tree planting or other forestry services for a fee.

Washouts – Clearing of natural or man made obstructions of drainage systems during high stream flows.

Water bar – A long mound of dirt constructed to prevent soil erosion and water pollution by diverting drainage from a road or skid trail into a filter strip.

Water bodies – Branches, creeks, rivers, ponds, lakes, bays, etc.

Water diversions – Structures or devices which change the direction of drainage flow.

Water quality impairment – The reduction of water quality below established water quality standards.

Waters of the State – Include every watercourse, stream, river, wetland, pond, lake, coastal, ground or surface water, wholly or partially in the state, natural or artificial which is not entirely confined and retained on the property of a single landowner.

Waters of the United States (U.S.) – Include all waters such as lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands and sloughs which are susceptible to use in interstate or foreign commerce, recreation, fish and shellfish production and industrial use; impoundments of waters just described; tributaries of waters just described (other than waters that are themselves wetlands).

Wildfire – Fires burning without the control of a responsible person.

Windrows – Long piles of accumulated debris.

Wing ditch – A secondary "turn out" ditch that diverts drainage water from primary roadside ditches, to be filtered out into the surrounding area.

Additional Resources

Additional information pertaining to silvicultural BMPs and water quality is available from the following publications and sources of assistance:

Streamside Management Zones

Comerford, N.B., D.G. Neary and R.S Mansel. *The Utility of Buffer Strips to Protect Forested Wetlands from Impacts Due to Forest Silvicultural Operations,* Gainesville, FL, National Council of the Paper Industry for Air and Stream Improvement, In Press.

Dickson, J.G. and J.C. Huntley. "Riparian Zones and Wildlife in Southern Forests," *Managing Southern Forests for Wildlife and Fish*, Ed. J. Dickson and O. Maughan, USDA Forest Service General Technical Report 50-65, (1987), 37-39.

Helfrich, L.A. et al. *Landowner's Guide to Managing Streams in the Eastern United States,* Virginia Cooperative Extension Service Publication 420-141, 1986.

James, B.R. "Riparian Vegetation Effects on Nitrate Removal from Groundwater," *Journal of Environmental Quality*, University of Maryland, In Press.

Kundt, J.F. et al. *Streamside Forests: The Vital Beneficial Resource*, Maryland Cooperative Extension Service, 1988.

Miller, E. "Effects of Forest Practices on Relationships Between Riparian Areas and Aquatic Ecosystems," *Managing Southern Forests for Wildlife and Fish*, Ed. J. Dickson and O. Maughan, USDA Forest Service General Technical Report 50-65, (1987), 40-47.

Practical Approaches to Riparian Resource Management: An Educational Workshop, Billings, MT, US Bureau of Land Management BLM-MT-PT-89-001-4351, 1989.

Rudolph, D.G and J.G. Dickinson. "Streamside Zone Width and Amphibian and Reptile Abundance," *The Southwestern Naturalist,* 35, (1990), 472-476.

Schilling, Erik B. and B. Graeme Lockaby. *Streamside Management Zones in Alabama: Functions and Management,* Auburn University Center for Forest Sustainability.

Swift, L.W. "Filter Strip Widths for Forest Roads in Southern Appalachians," *Southern Journal of Applied Forestry*, 10 (1984), 27-34.

Warmwater Streams Symposium: A National Symposium on Fisheries Aspects of Warmwater Streams, Southern Division American Fisheries Society, (1980).

Stream Crossings

Baker, C.O. and F.E. Votapka. "Fish Passage Through Culverts," *USDA Forest Service Technology and Development Center Report No. FHWA-FL-90-006*, 1990.

Mason, L. *Portable Wetland Area and Stream Crossings*, USDA Forest Service Technology and Development Center, 1990.

Forest Roads

Kochenderfer, J.N. *Cost of and Soil Loss in "Minimum-Standard" Forest Truck Roads Constructed in the Central Appalachians,* USDA Forest Service Research Paper NE-544, 1984.

Swift, L.W. "Soil Losses from Roadbeds and Cut and Fill Slopes in the Slopes in the Southern Appalachian Mountains," *Southern Journal of Applied Forestry,* 8, (1984), 209-215.

Swift, L.W. "Gravel and Grass Surfacing Reduces Soil Loss from Mountain Roads," *Forest Science,* 30, (1984), 656-670.

The Layman's Guide to Private Access Road Construction in the Southern Appalachian Mountains, Tennessee Valley Authority, Waynesville, N. C.: Haywood Press, Inc. 1985.

Wallbridge, T.A., Jr. *The Paper Location of Forest Roads*, Blackburge, AA, Virginia Polytechnical Institute and State University, 1989.

Wallbridge, T.A., Jr. *The Direct Location of Forest Roads*, Blacksburg, VA, Virginia Polytechnical Institute State University, 1990.

Timber Harvesting

Brinker, R.W. *Best Management Practices for Timber Harvesters*, Alabama Cooperative Extension Service Circular ANR-539, 1989.

Simmons, F.C. *Handbook for Eastern Timber Harvesting,* USDA Forest Service Northeastern Area State and Private Forestry, 1979.

Swindel, B.F. "Multi-Resource Effects of Harvest, Site Preparation and Planting in Flatwoods," *Southern Journal of Applied Forestry*, 7, (1983), 6-15.

Reforestation/Stand Management

Beasley, R.S., and A. Granillo, "Water Yields and Sediment Losses from Chemical and Mechnical Site Preparation in Southwest Arkansas," *Forestry and Water Quality. A Mid-South Symposium*, Arkansas Cooperative Extension Service, 1985.

Wetlands

Gosselink, J.G. and L.C. Lee. *Cumulative Impact Assessment in Bottomland Hardwood Forest*, Baton Rouge, LA, Center for Wetlands Resources, Louisiana State University LSU-CEI-86-09, 1987.

Federal Manual for Identifying and Delineating Jurisdictional Wetlands, Federal Interagency Committee for Wetland Delineation, 1989.

Forested Wetlands of the Southeast: Review of Major Characteristics and Role in Maintaining Water Quality, USDI Fish and Wildlife Service Publication 163, 1986.

Forested Wetlands of the United States: Proceedings of the Symposium, USDA Forest Service Southeastern Forest Experiment Station General Technical Report SE-50, 1988.

Good, R.E., D.F. Whigham and R. L. Simpson. *Freshwater Wetlands: Ecological Processes and Management Potential*, New York, Academic Press, 1978.

Kellison, R.C. et al. *Regenerating and Managing Natural Stands of Bottomland Hardwoods,* American Pulpwood Association, 88-A-6, 1988.

Kibby, H.V. "Effects of Wetlands on Water Quality," *Proceedings of the Symposium on Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems,* USDA Forest Service Publication GTR-WO-12, 1978.

Larson, J.S. "Wetland Value Assessment: State of the Art," *National Wetlands Newsletter*, Vol. 3, No. 2, Mar-Apr 1981.

National List of Plant Species That Occur in Wetlands: Southeast (Region 2), U.S. Fish and Wildlife Service, Biological Report 88 (26.2), 1988.

National Wetlands Policy Forum, The Conservation Foundation, 1989.

Wharton, C. H. et al. *Forested Wetlands of Florida, Their Management and Use,* Gainesville, FL, Center for Wetlands, University of Florida, 1977.

General BMPs

Alabama Nonpoint Source Management Program, Montgomery, Alabama. Alabama Department of Environmental Management. October 2000. http://www.adem.state.al.us/Education%20Div/Nonpoint%20Program/ManagePlan/partIIsi.pdf

Best Management Practices for Silvicultural Activities on TVA Lands, Norris, TN, Division of Land Resources, Tennessee Valley Authority, 1990.

Burns, R.G., and J.D. Hewlett. “A Decision Model to Predict Sediment Yield from Forest Practices,” *Water Resources Bulletin 19*, (1983), 9-14.

Dissmeyer, G.E. and G.R. Foster. *A Guide for Predicting Sheet and Rill Erosion on Forest Land,* USDA Forest Service State and Private Forestry Southeastern Area, Technical Publication SA-TP 11, 1980.

Dissmeyer, G.E. and N.D. Kidd. “Multiresource Inventories: Watershed Condition of Commercial Forest Land in South Carolina,” *USDA Forest Service Research Paper SE-247*, 1984.

Erosion Control on Forest Land in Georgia, Georgia Cooperative Extension Service, 1979.

Forestry and Water Quality: A mid-south symposium, Arkansas Cooperative Extension Service, 1985.

Glasser, S.P. *Summary of Water Quality Effects from Forest Practices in the South*, Atlanta, GA, USDA Forest Service Southern Region, 1982.

Golden, M.S. et al. *Forestry Activities and Water Quality in Alabama: Effects, Recommended Practices, and an Erosion Classification System,* Alabama Agricultural Experimental Station Auburn University, Bulletin 555, 1984.

Golden, M.S. et al. *Guidelines for Refinement of Best Management Practices in Alabama*, Auburn University, AL, Department of Forestry, 1984.

National Management Measures to Control Nonpoint Source Pollution from Forestry, U.S. Environmental Protection Agency, Office of Water, Washington DC 20460 (4503F) EPA-841-B-05-001 April 2005. http://www.epa.gov/owow/nps/forestrymgmt/ (May 2005).

Sources of Technical Assistance

Technical assistance and/or additional information may be available from the following agencies and organizations to help you plan forestry operations that may affect water quality.

Alabama Department of Conservation and Natural Resources

64 North Union Street, Suite 468
Montgomery, AL 36130
(334) 242-3465
www.outdooralabama.com

Alabama Department of Environmental Management (ADEM)

1400 Coliseum Boulevard
Montgomery, AL 36110-2059
or
P. O. Box 301463
Montgomery, AL 36130-1463
(334) 271-7700
http://www.adem.alabama.gov

Alabama Cooperative Extension System

109-D Duncan Hall
Auburn University, AL 36849
(334) 844-4444
www.aces.edu

Alabama Forestry Association

555 Alabama Street
Montgomery, AL 36104
(334) 265-8733
www.alaforestry.org

Alabama Forestry Commission

513 Madison Avenue
Montgomery, AL 36130
(334) 240-9365 or 240-9332
www.forestry.state.al.us

American Forest and Paper Association

1111 19th St. NW, Suite 800
Washington, DC 20036
(800) 878-8878
www.afandpa.org

U.S. Army Corps of Engineers

Mobile District
P.O. Box 2288
Mobile, AL 36628
(251) 471-5966
www.sam.usace.army.mil

Nashville District
P.O. Box 1070
Nashville, TN 37202
(615) 736-7161
www.orn.usace.army.mil

U.S. Environmental Protection Agency (EPA)

Region 4
Sam Nunn Atlanta Federal Center
61 Forsyth Street SW
Atlanta, GA 30303-8960
(404) 562-9900 or 1-800-241-1754
http://www.epa.gov/region04/about/index.html

USDA Forest Service

2946 Chestnut Street
Montgomery, AL 36107
(334) 832-4470
www.fs.fed.us

USDA Natural Resources Conservation Service

P.O. Box 311
Auburn, AL 36830
(334) 887-4560
www.nrcs.usda.gov/programs

U.S. Fish and Wildlife Service

1208-B Main Street
Daphne, AL 36526-4419
(251) 441-5181
www.fws.gov

Alabama Forestry Commission
2007

APPENDIX H PUBLIC COMMENTS

MOBILE BAYKEEPER®

Providing citizens a means to protect the beauty, health and heritage of the Mobile Bay Watershed and our coastal communities.

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April 30, 2019

RE: Draft West Fowl River Watershed Management Plan

To Whom It May Concern:

We are Mobile Baykeeper, a twenty-two-year-old nonprofit organization with the mission of providing citizens a means to protect the beauty, health, and heritage of the Mobile Bay Watershed and our coastal communities. We are submitting comments on behalf of our board, officers, and more than 4,500 members regarding the draft West Fowl River Watershed Management Plan. We commend the Mobile Bay National Estuary Program, the steering committee, Dewberry, and all stakeholders on the development of a very comprehensive and valuable plan. We have several comments after reviewing the document that we believe should be reviewed to ensure the plan is as effective as possible.

Pathogens

Results from the DISL/FDA studies suggest the West Fowl River Watershed as the dominant source of fecal coliform bacteria in Fowl River Bay. Results show a correlation between the amount of rainfall, freshwater inflow, and fecal coliform levels in the area. To address this issue we suggest that the WMP include a recommendation to undertake comprehensive source tracking (microbial or other) to better understand the specific sources of high bacteria (i.e. livestock, wildlife, pets, and human conditions) loads following rain events. This information will help determine strategies to minimize and remediate bacteria levels in West Fowl River and Fowl River Bay. This in turn can potentially alleviate the Bay's "Conditionally Restricted" classification for shellfish harvesting.

Vessel discharges were indicated as one of the likely sources for the presence of bacteria in surface waters particularly in the lower parts of the watershed. To that extent, the WMP recommends a vessel pump out station be installed and education similar to the

Clean Water Marina program. We recommend adding language about the use of current regulations and management measures to enforce proper disposal (E.G. Marine Sanitation Act).

Another source indicated to be a contributor was unpermitted discharges from septic systems. The WMP recommends the extension to the sanitary sewer collection system to allow more residents to connect to the City of Bayou La Batre's system. Although we know that aging septic systems and lack of proper maintenance of systems lead to leaking systems, we also know that without investment and proper planning WWTPs can become overloaded from growth. We suggest the WMP include language about coupling this effort with future planning and investment forecasting to ensure the utility is well equipped for the increase in collection system connections as well recommending utilities that accept new users transitioning from septic have rigorous capacity assurance programs for collection, transmission, and treatment

Sedimentation

One of the major recommendations associated with the sedimentation outcomes includes paving dirt roads. We understand that one of the primary sources of sedimentation in the area comes from surface runoff from unpaved roads. We want to caution the recommendation of paving roads without the inclusion of additional language or requirements to ensure other, related stormwater runoff issues are not a result of such efforts. There are several indirect impacts to consider such as inducing growth and development opportunities and thus increasing the number of impervious surfaces within the watershed. To address this, we suggest recommending the use of Low Impact Development (LID) materials and designs for the roads to reduce the sediment introduction but through more pervious surfaces that likely will not promote heavy development of the area.

Trash

The presence of trash throughout the watershed was determined as an endemic problem and requires a multi-faceted approach. The WMP describes the acquisition of a trash boat, enforcement, zoning restrictions for waste storage, installation of waste transfer stations, and several educational programs as the strategy for controlling the problem. We highly suggest two additions to this list: 1) the implementation of litter collection devices such as Litter Gitters or Marine Debris Interceptors (MarDIs) to reduce introduction of debris and 2) conduct watershed trash assessments utilizing the Escaped Trash Assessment Protocol (ETAP) established by the EPA to evaluate and determine

quantitative reductions in trash and better determine source of material for targeting educational and enforcement efforts.

Storm Surge/Flooding

The draft WMP goes into great detail about the flood zones, storm surge, and hazard areas throughout the watershed. One concern not discussed is the education and preparation needed to ensure industrial facilities in hazard prone areas have plans to ensure spills and chemical releases do not occur in these situations. Mobile Baykeeper and others documented numerous spills following Tropical Storm Nate along with other recent issues seen throughout the Gulf Coast after hurricanes, more emphasis should be placed on reducing pollution in hazard prone locations through preparation, planning, and education.

Education

We are thankful for the amount of educational efforts recommended as solutions to issues identified in this WMP. We suggest recommending efforts are interconnected and intentional so that one group or audience receiving information about littering can also learn about water quality monitoring. This way, the community can receive a more holistic approach to the issues and solutions within their local watershed.

Thank you for the opportunity to provide comments on the draft West Fowl River Watershed Management Plan. If you have any questions or need additional information, please don't hesitate to contact us.

Sincerely,

Casi (kc) Callaway
Executive Director & Baykeeper
Mobile Baykeeper

Cade Kistler
Program Director
Mobile Baykeeper

Laura Stone
Program Coordinator
Mobile Baykeeper