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

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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

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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.

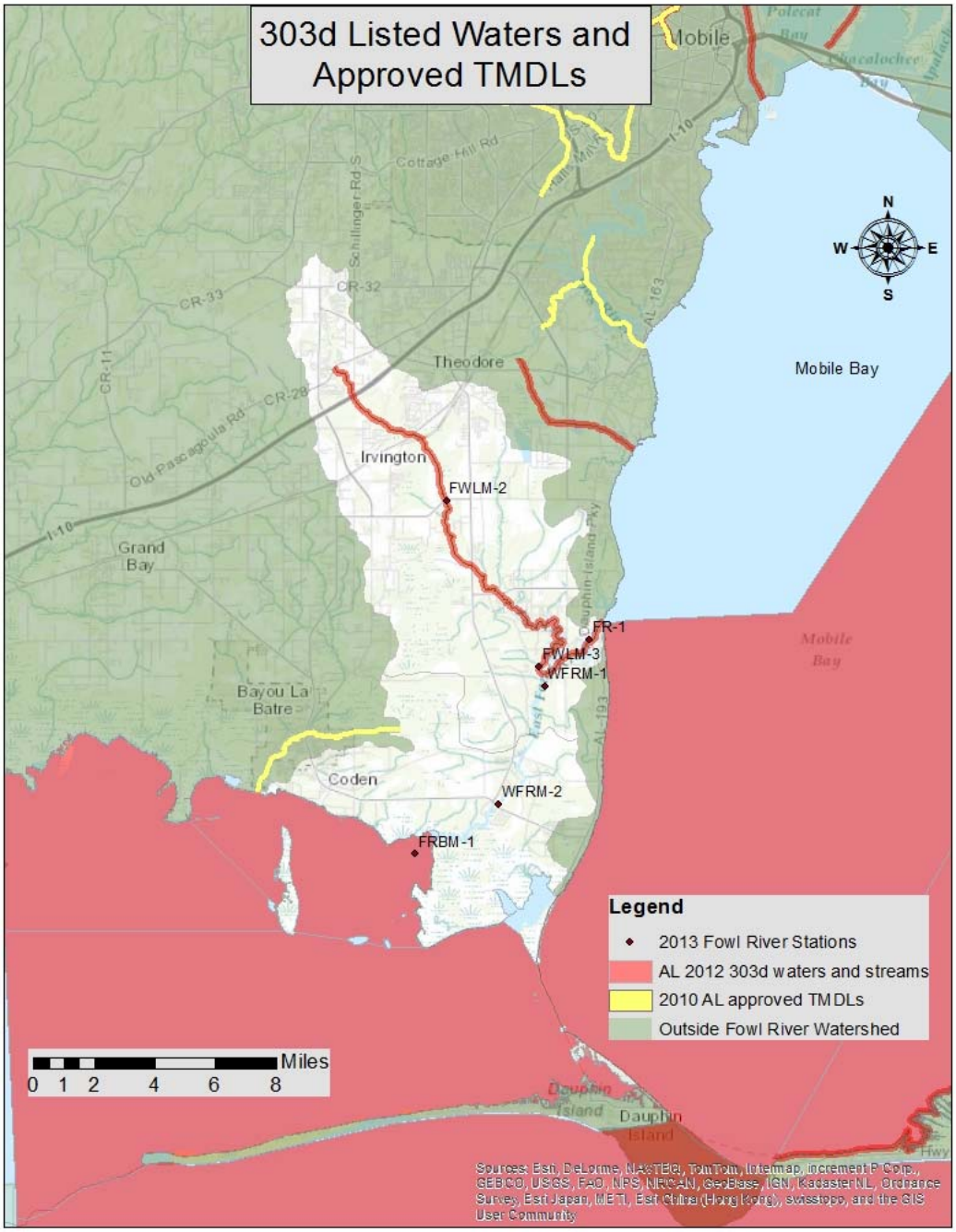


Table 2. Descriptions of the monitoring stations in 2013 for the Fowl River Sub-Watershed.

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

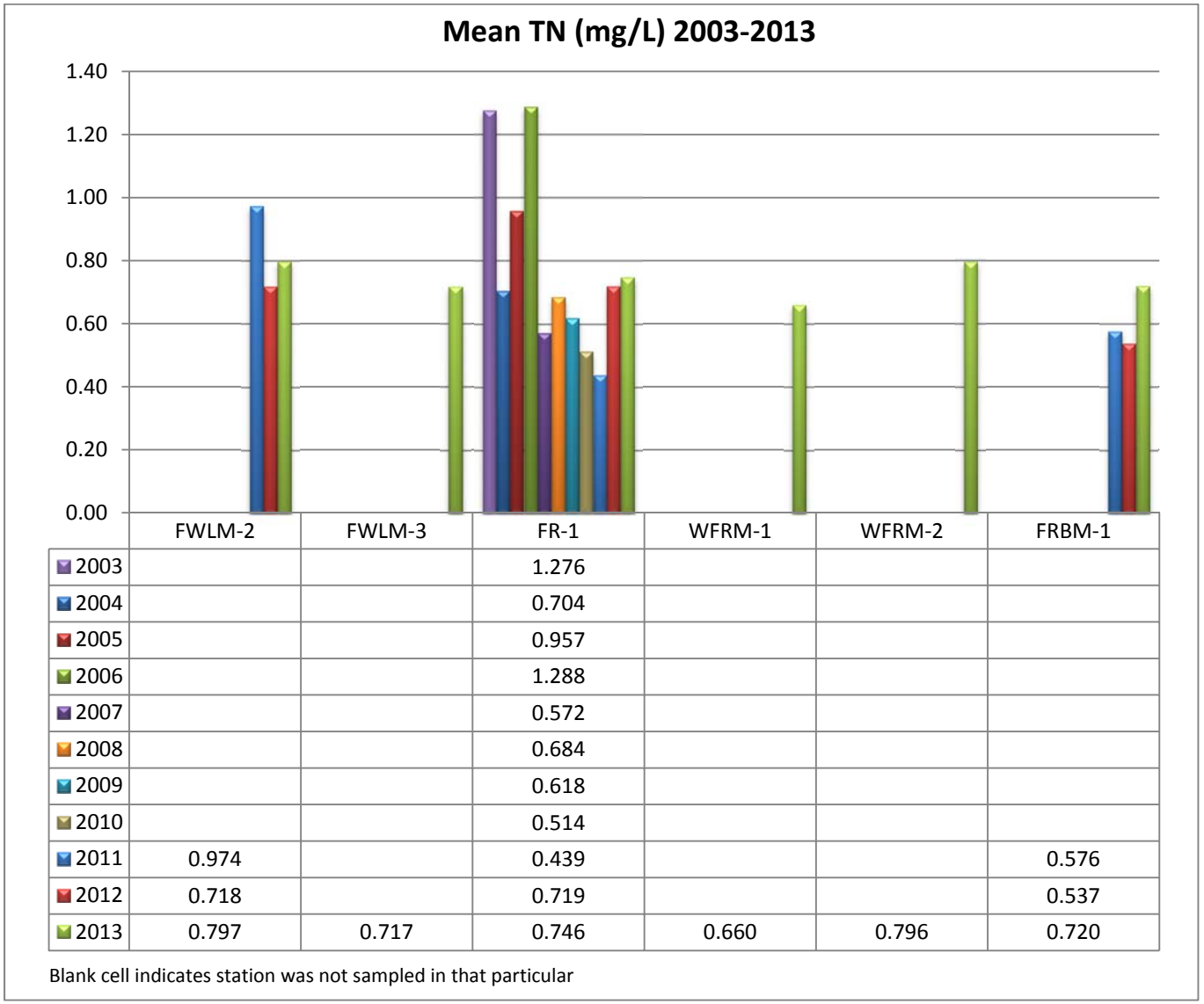
August at Fowl River Bay (FRBM-1), and were above the mean in all months except March and June at FR-1.

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.

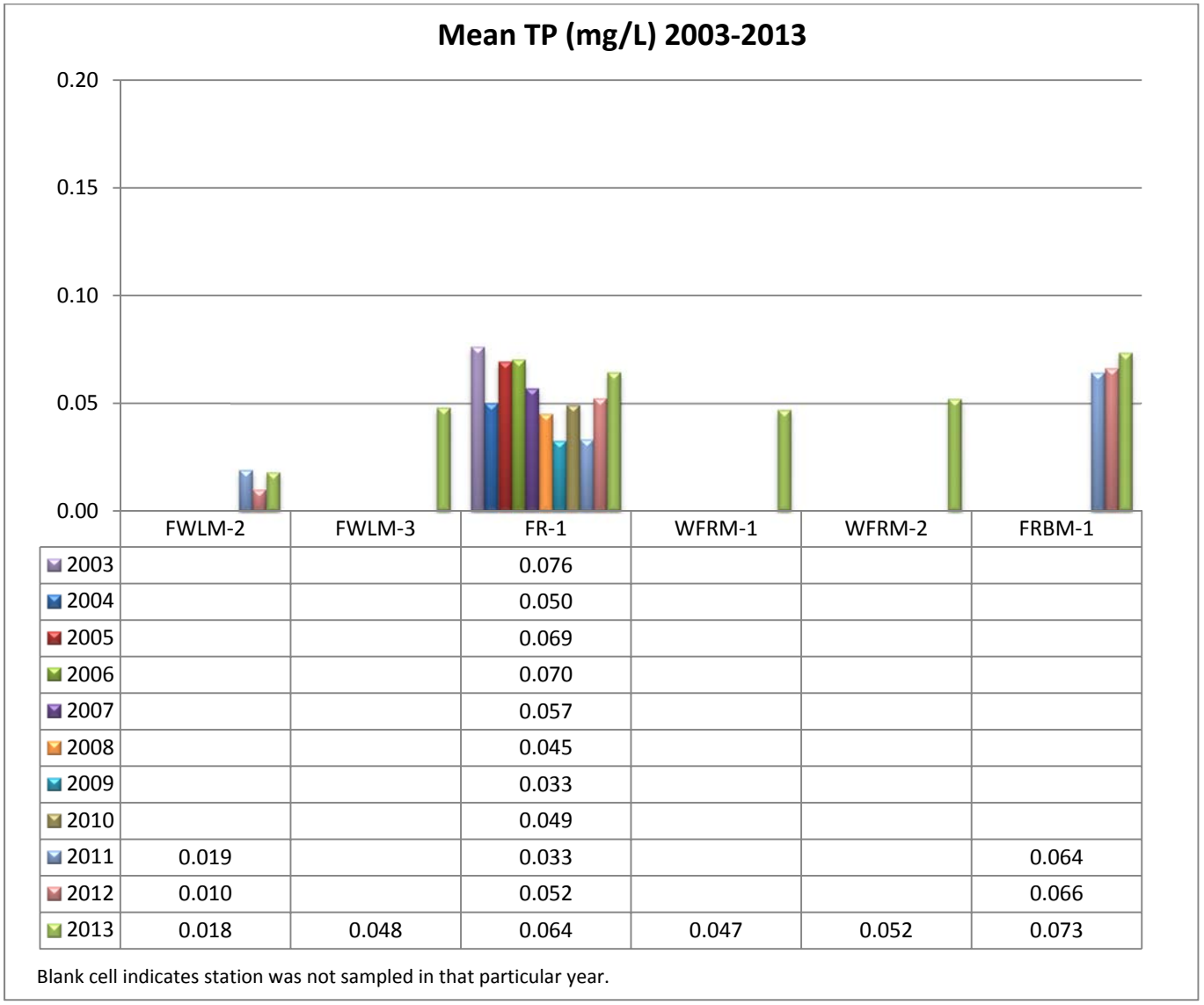
Figure 2. Mean growing season TN measured for the trend stations in the Fowl River Sub-Watershed, 2003-2013.



	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

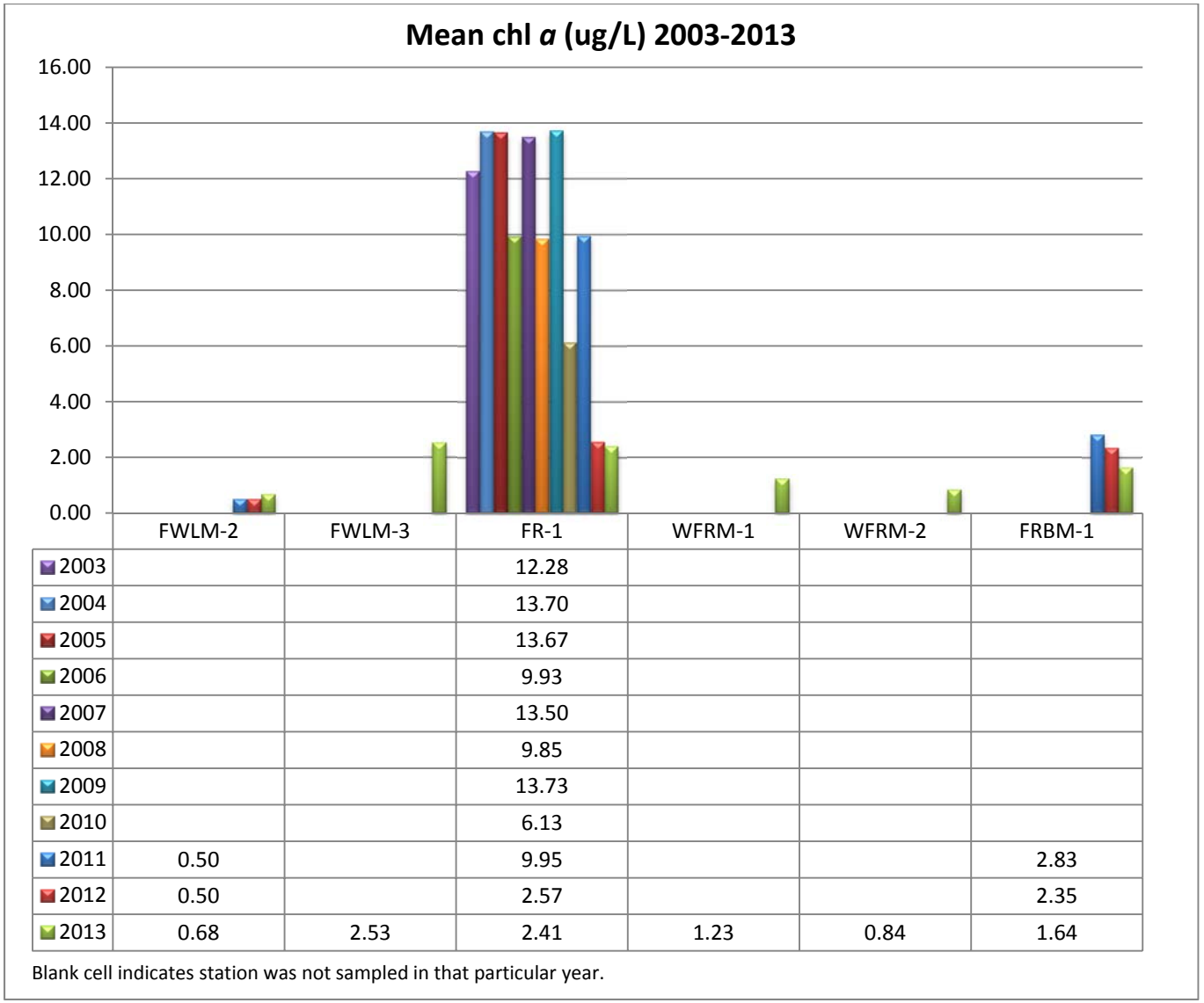
Figure 3. Mean growing season TP measured for the trend stations in the Fowl River Sub-Watershed, 2003-2013.



	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.

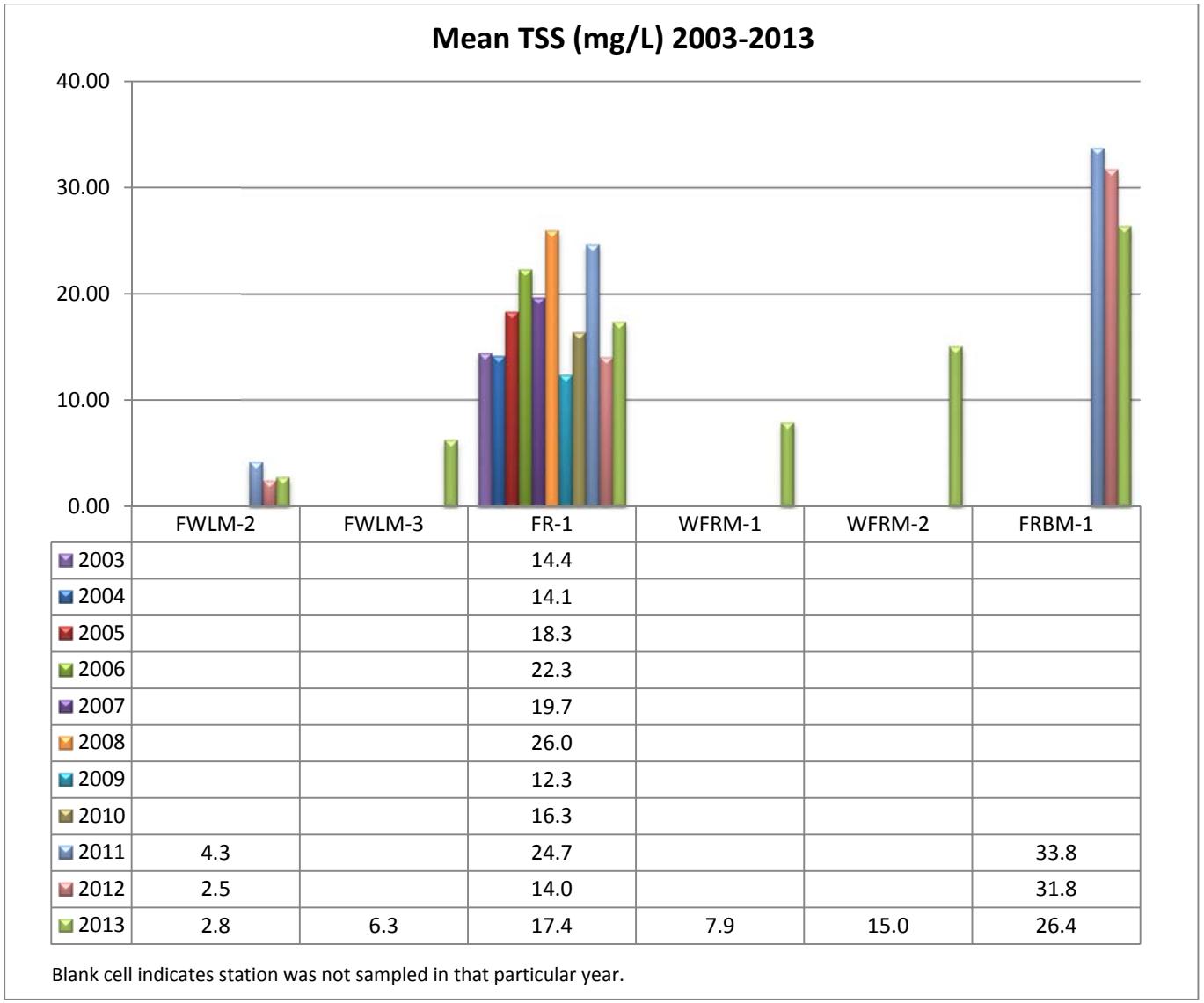
Figure 4. Mean growing season chl *a* measured for the trend stations in the Fowl River Sub-Watershed, 2003-2013.



	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.

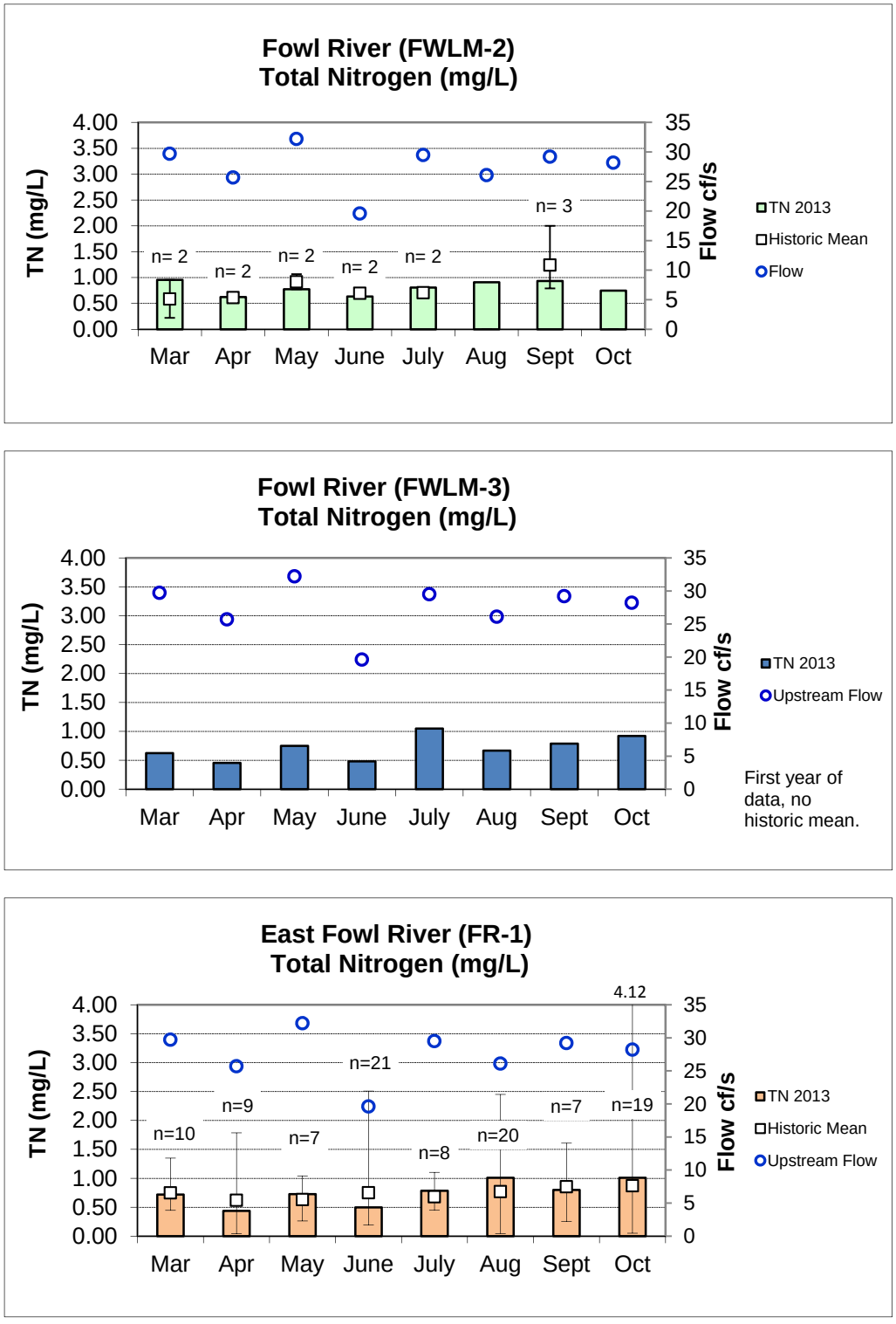
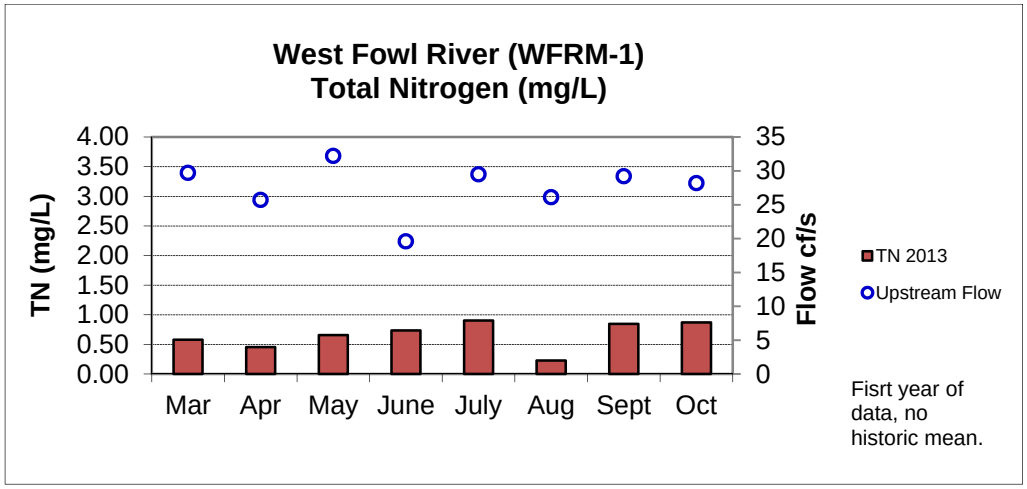
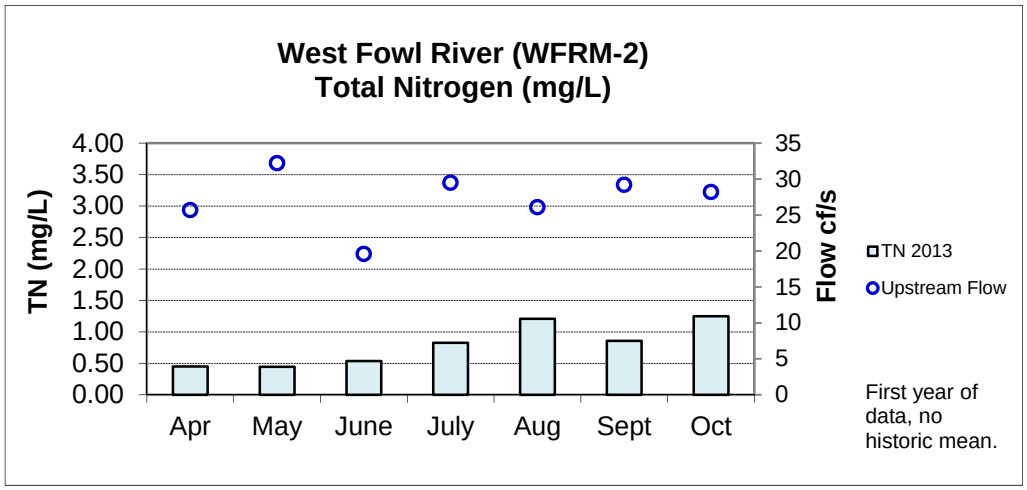


Figure 6. (continued)





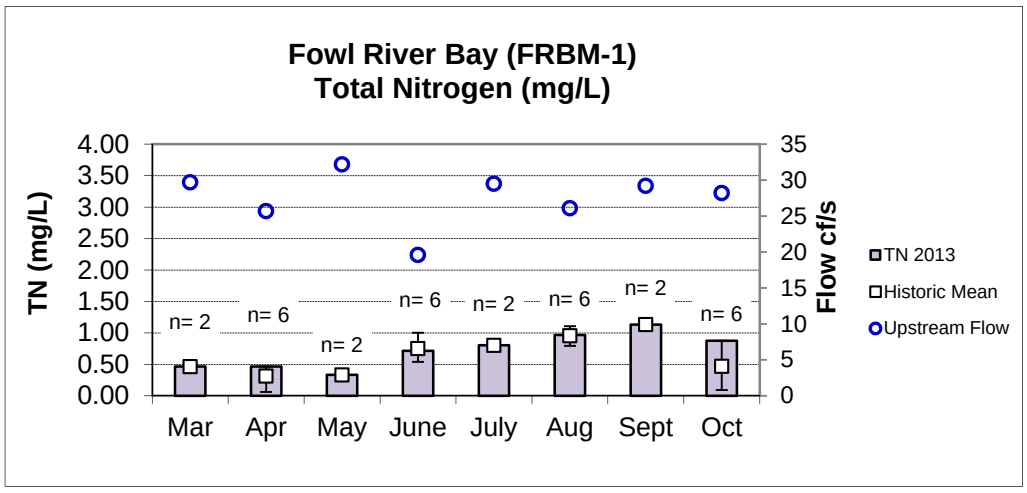
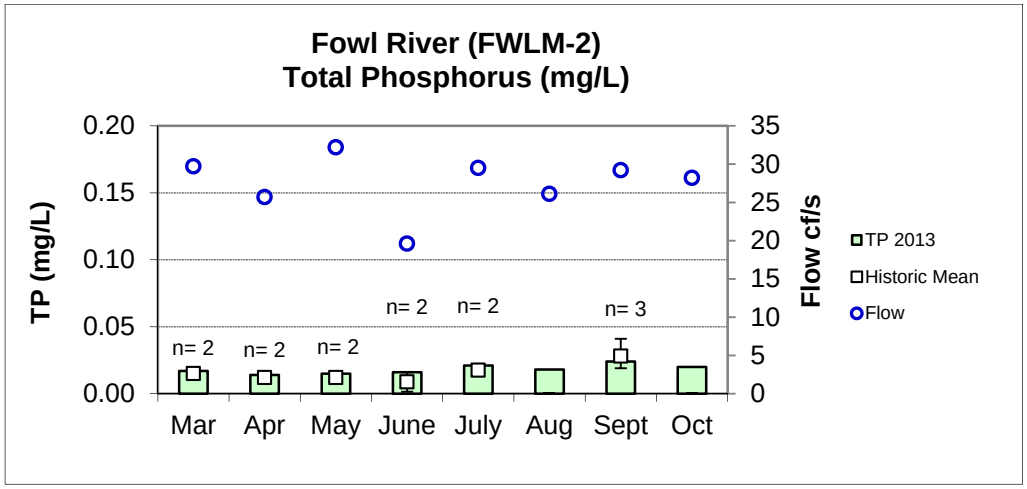
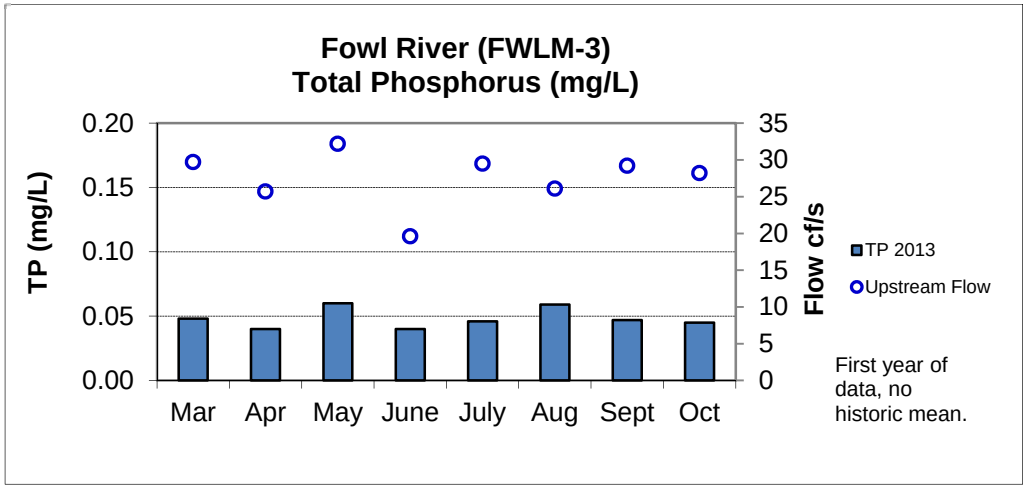
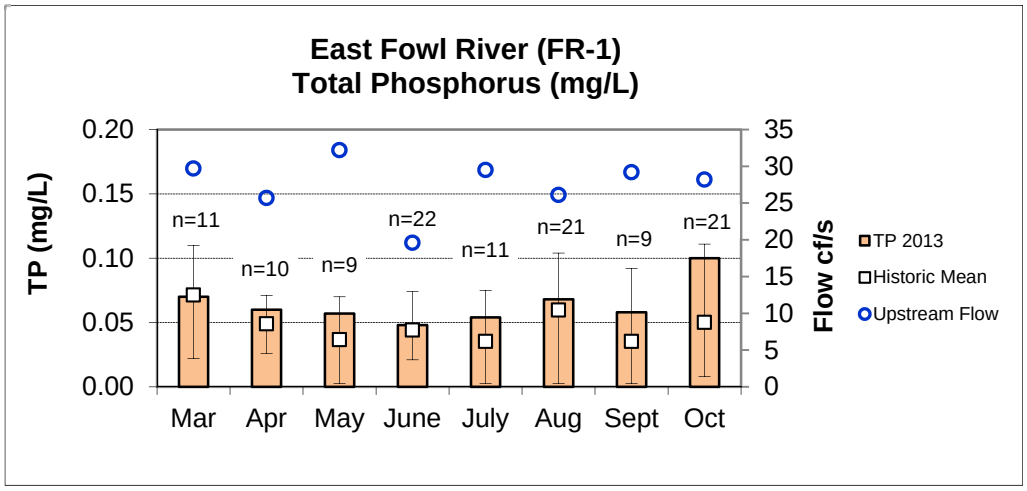


Figure 7. Monthly TP concentrations measured in the Fowl River Sub-Watershed, March-October 2013. Each bar graph depicts changes in each station. The historic mean (1990-2013) and min/max ranges are also displayed for comparison. The "n" value equals the number of data points included in the monthly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







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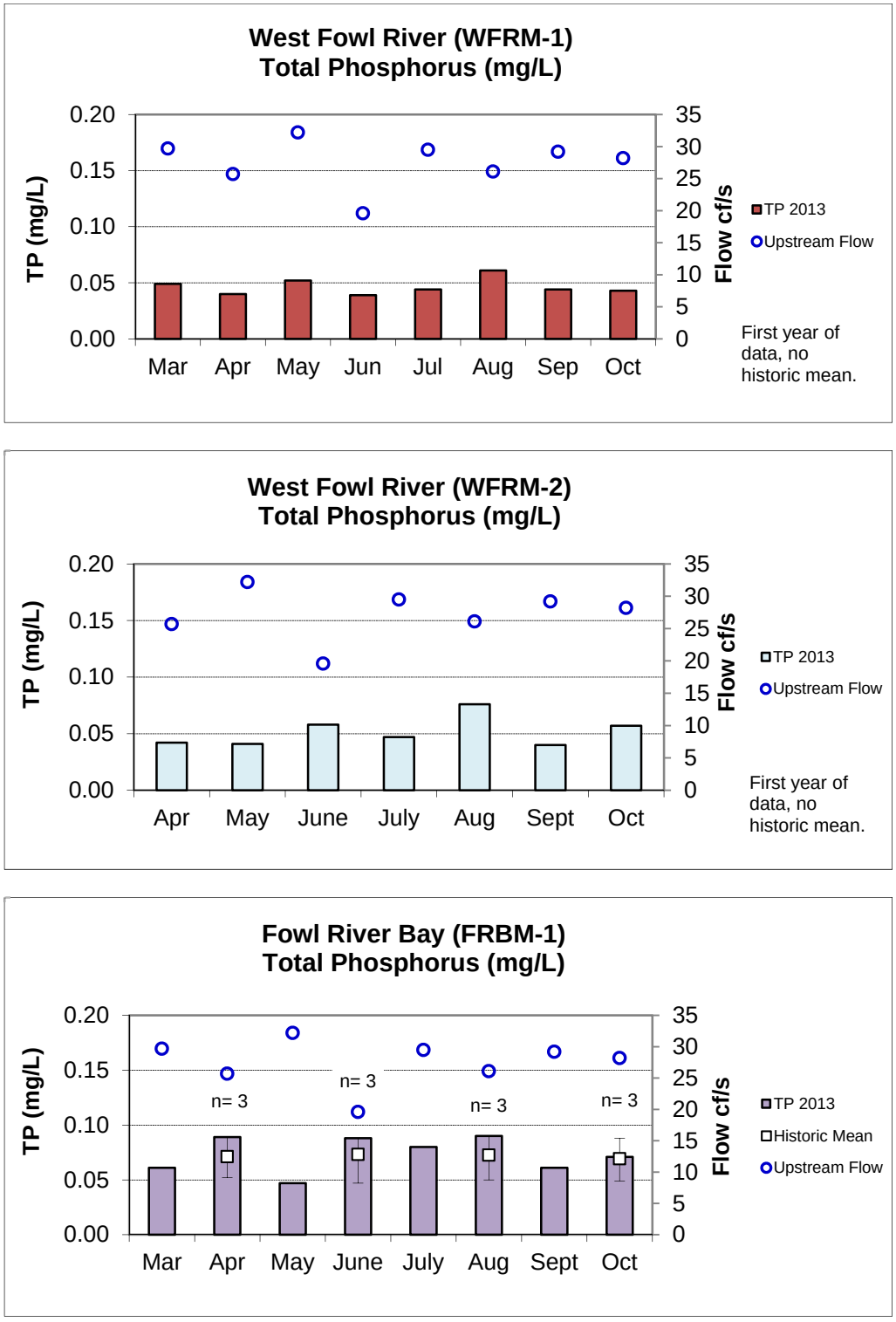
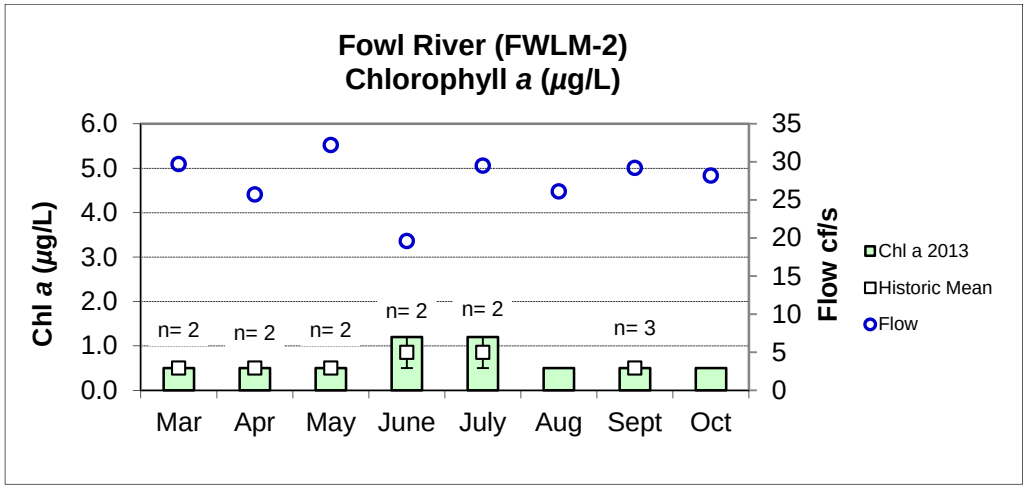
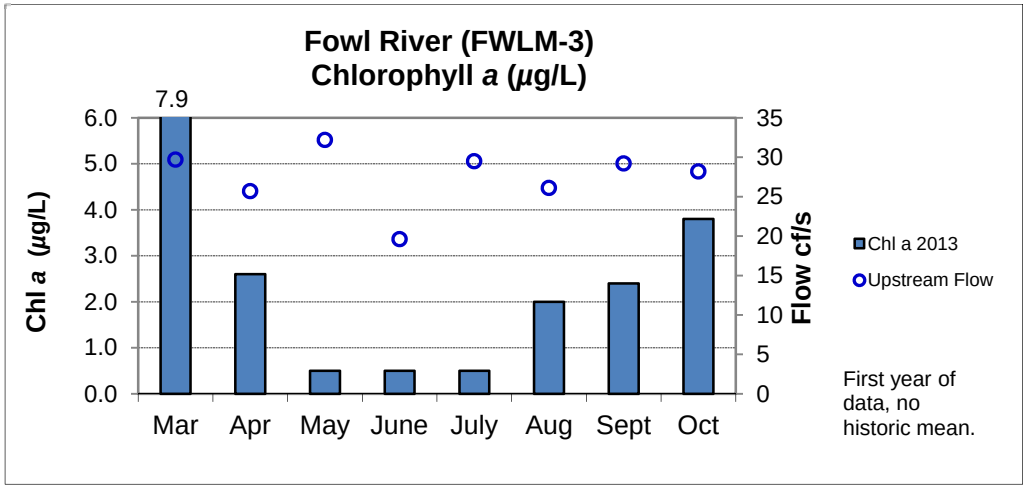
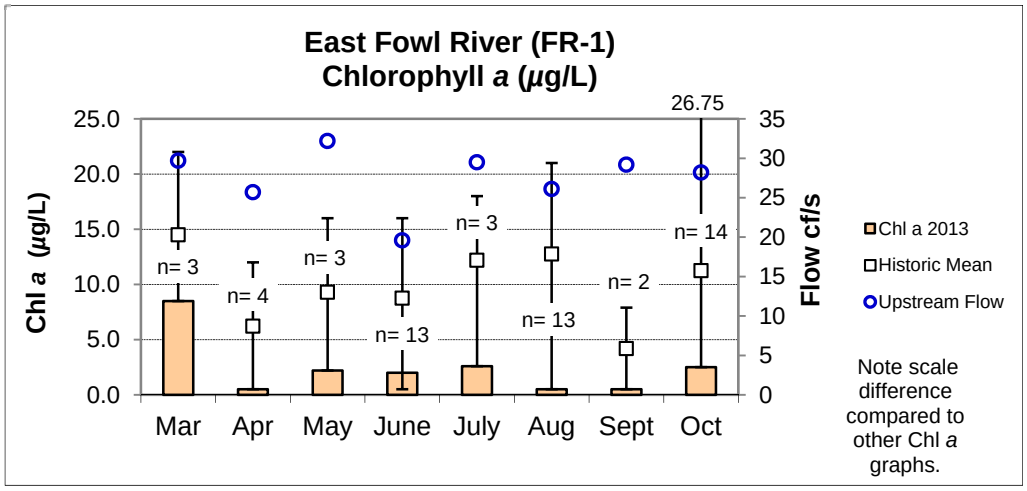


Figure 8. Monthly chl *a* concentrations measured in the Fowl River Sub-Watershed, March-October 2013. Each bar graph depicts changes in each station. The historic mean (1990-2013) and min/max ranges are also displayed for comparison. The "n" value equals the number of data points included in the monthly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







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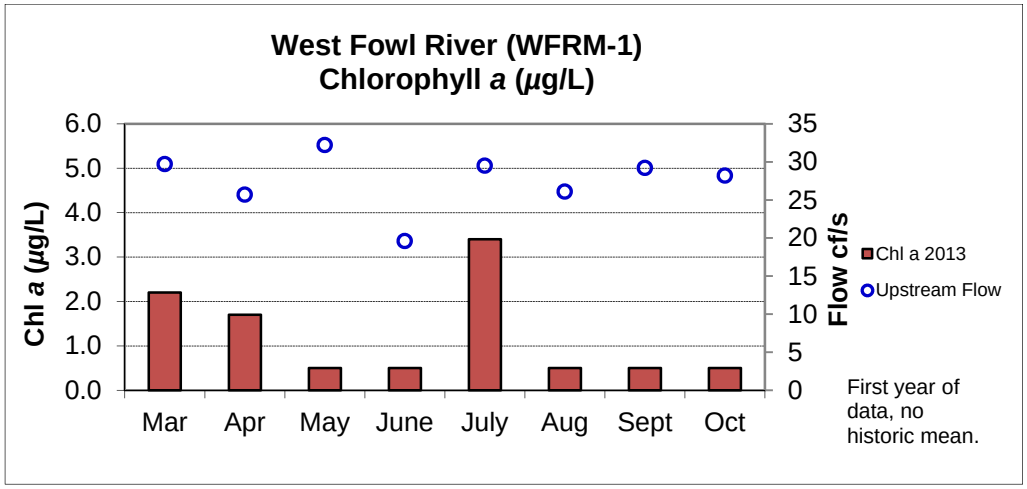
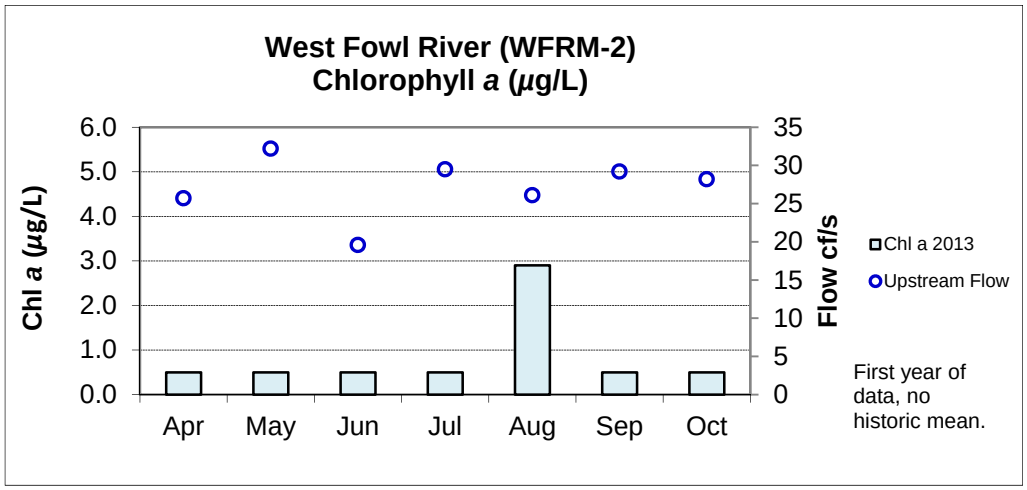




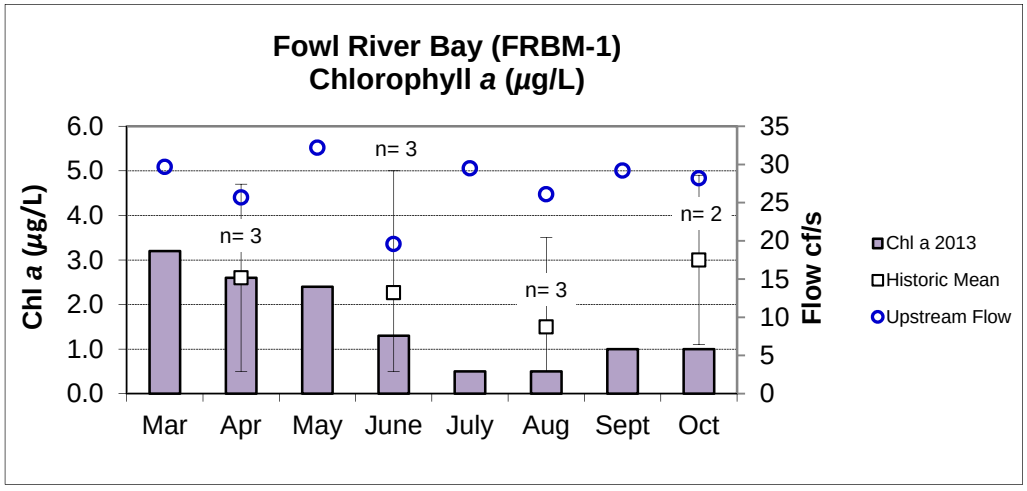
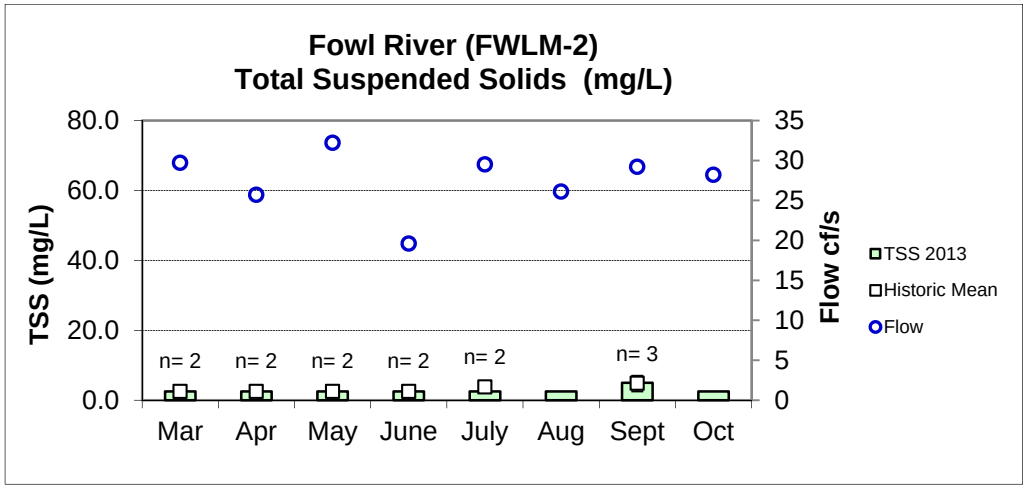
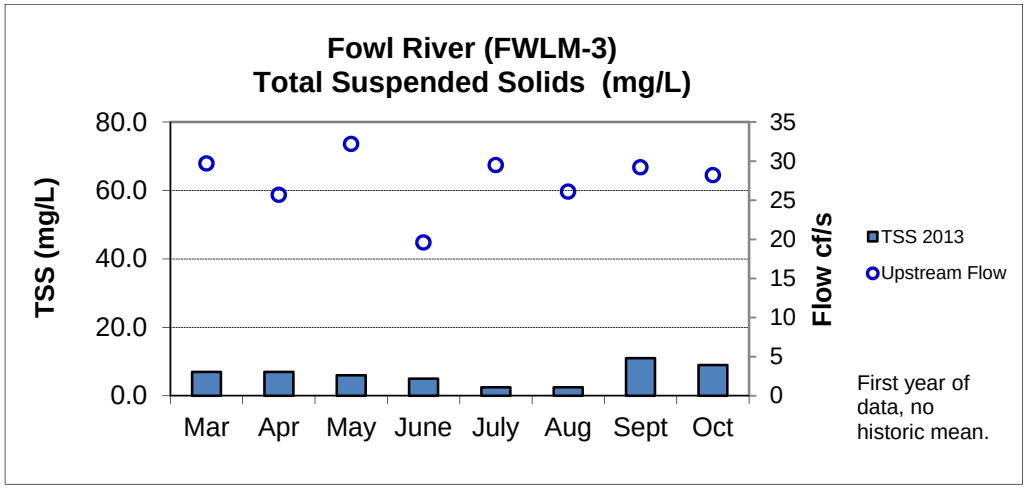
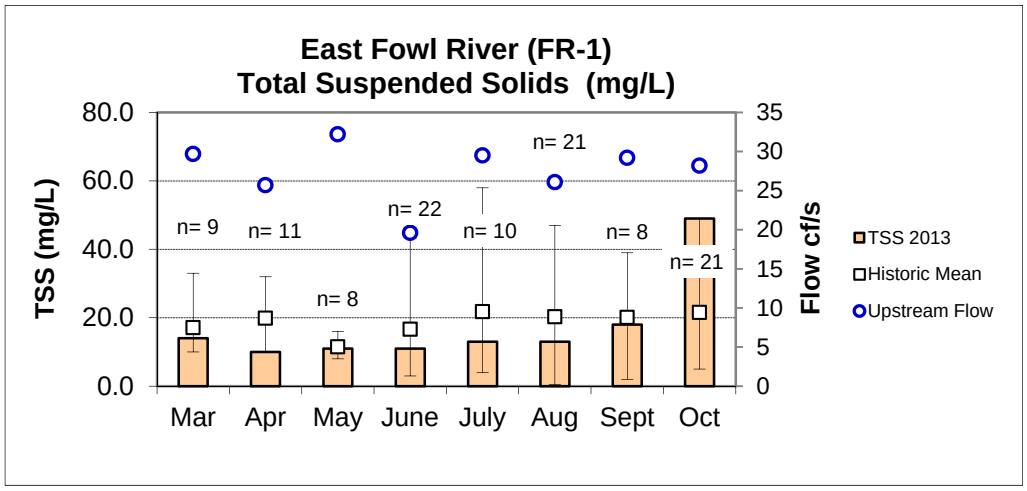


Figure 9. Monthly TSS concentrations measured in the Fowl River Sub-Watershed, March-October 2013. Each bar graph depicts changes in each station. The historic mean (1990-2013) and min/max ranges are also displayed for comparison. The "n" value equals the number of data points included in the monthly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







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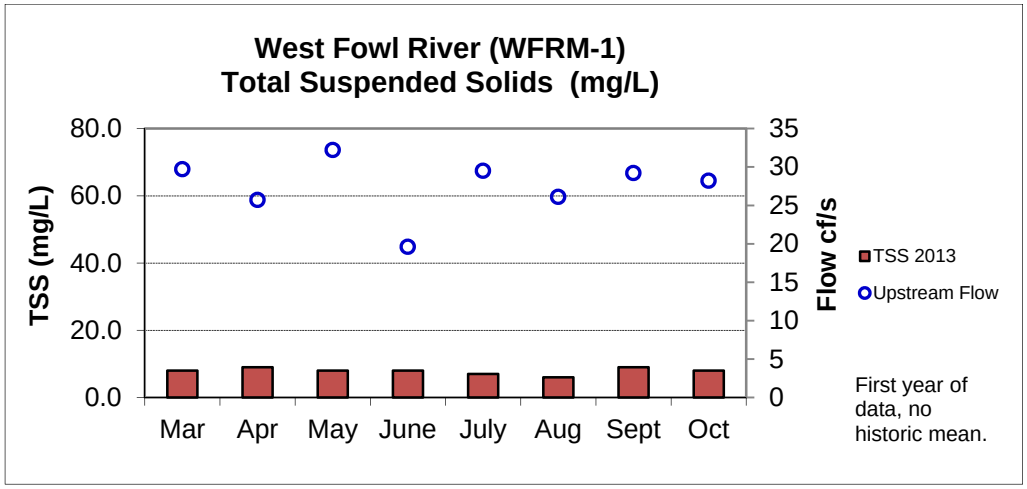
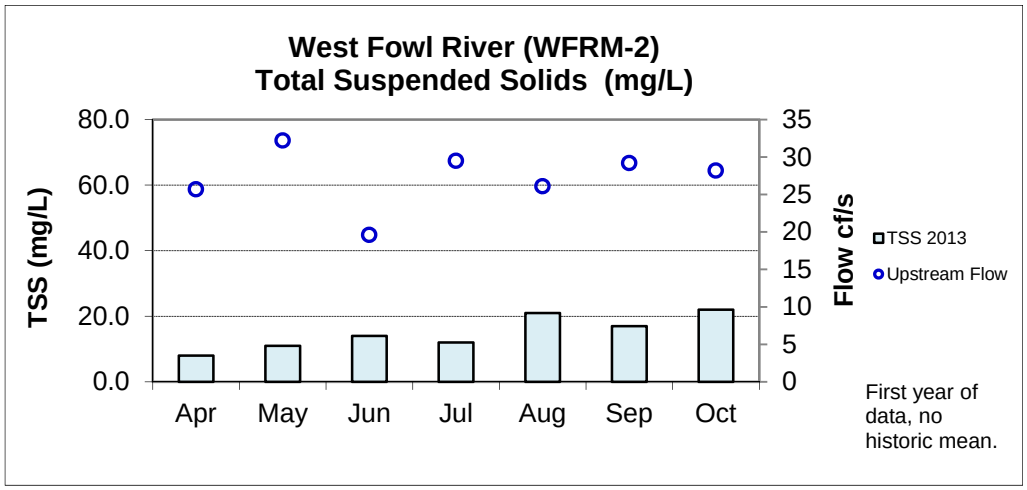




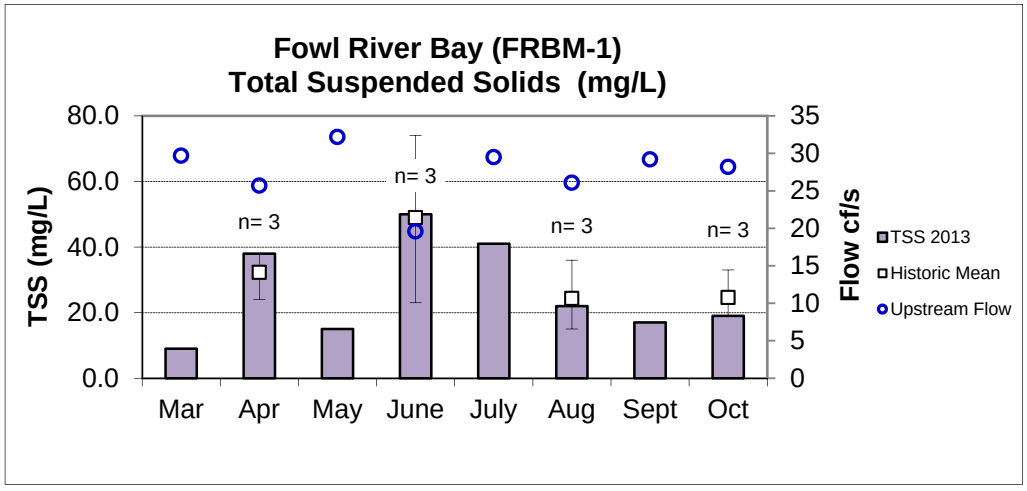
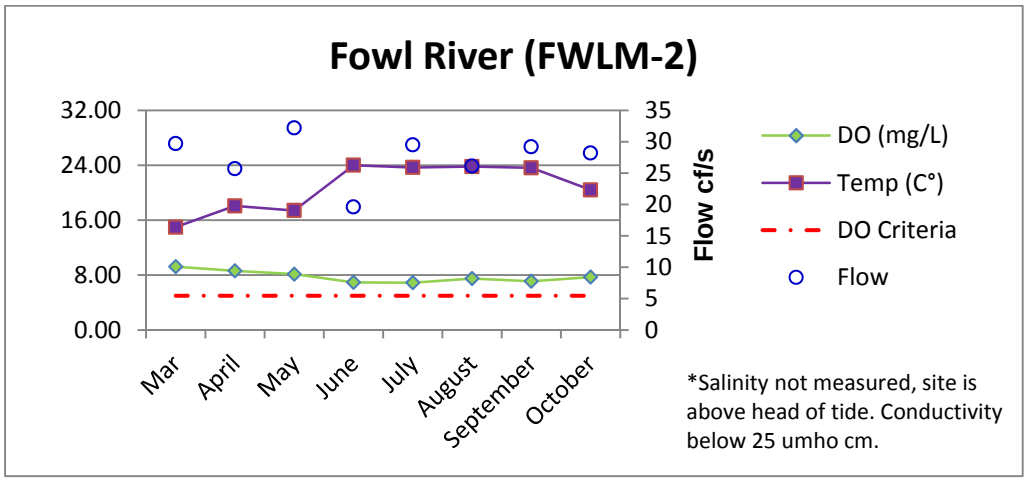
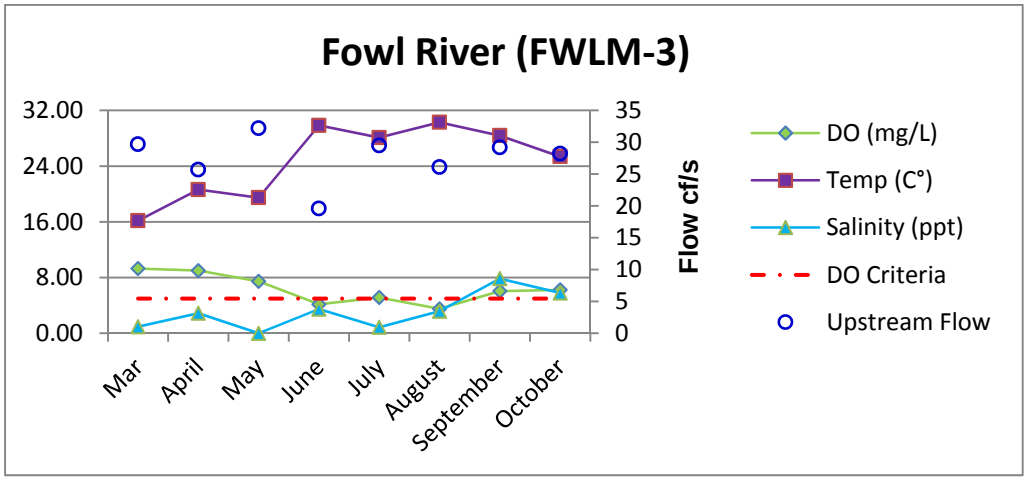
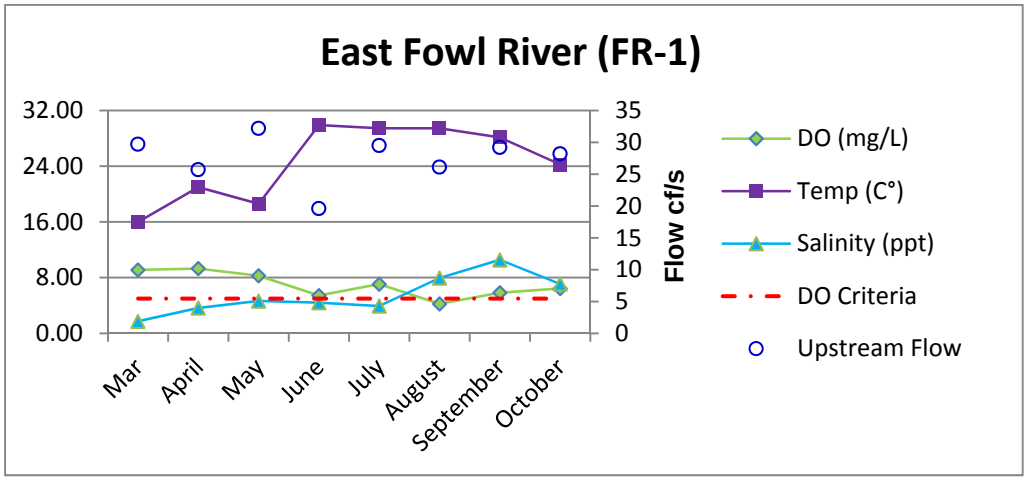


Figure 10. Monthly DO, temperature, and salinity concentrations at 1.5 m (5 ft), or mid-depth, for the Fowl River Sub-Watershed stations collected March-October 2013. ADEM Water Quality Criteria requires a DO concentration of 5.0 mg/L at this depth (ADEM 2012). Flow was measured at the most upstream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







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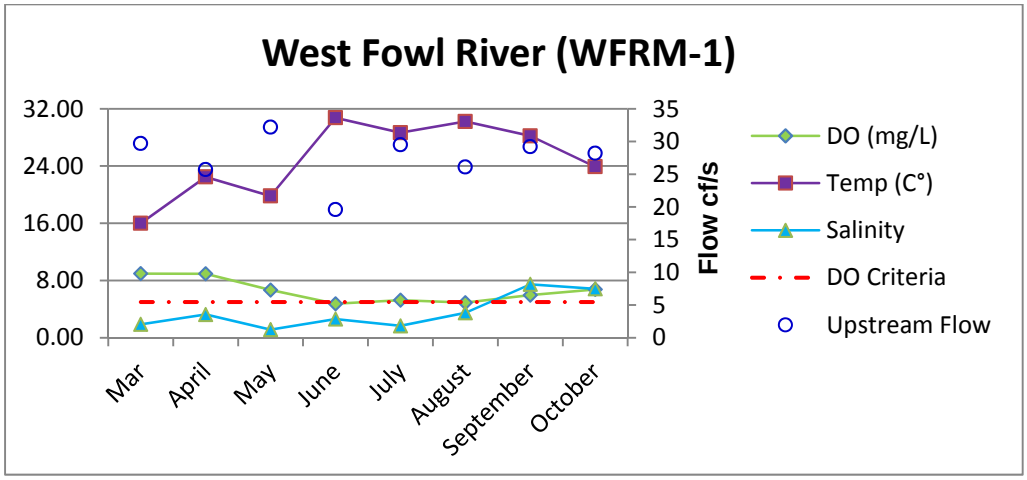
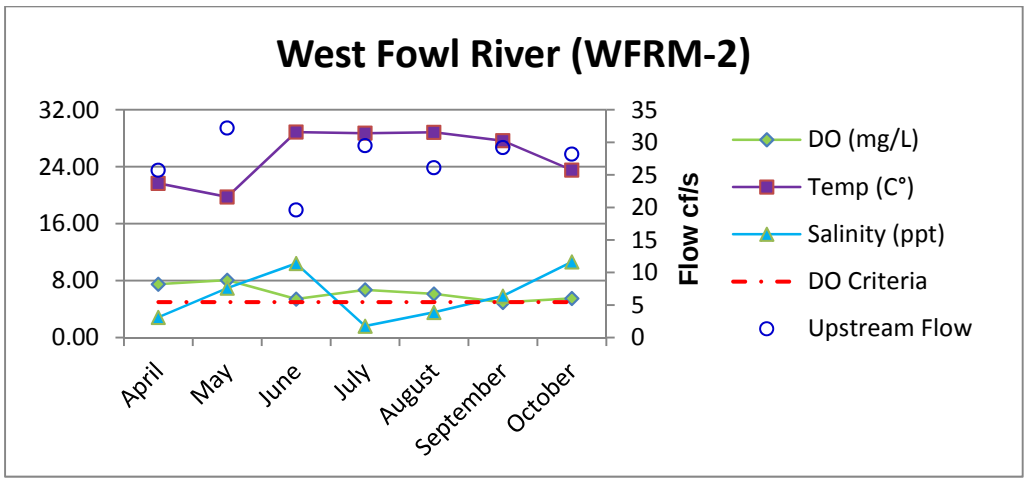




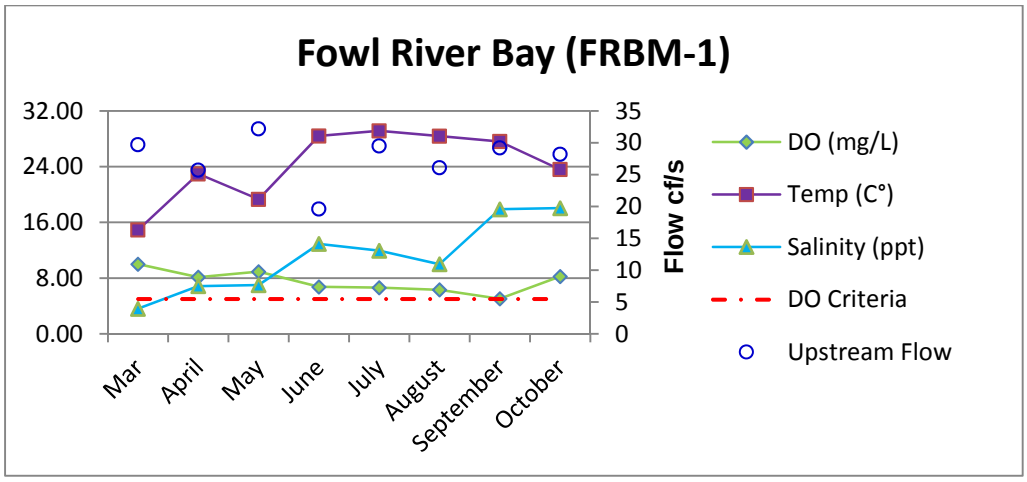


Figure 11. Monthly depth profiles of dissolved oxygen, temperature, and salinity for Fowl River Sub-Watershed, March-October 2013.

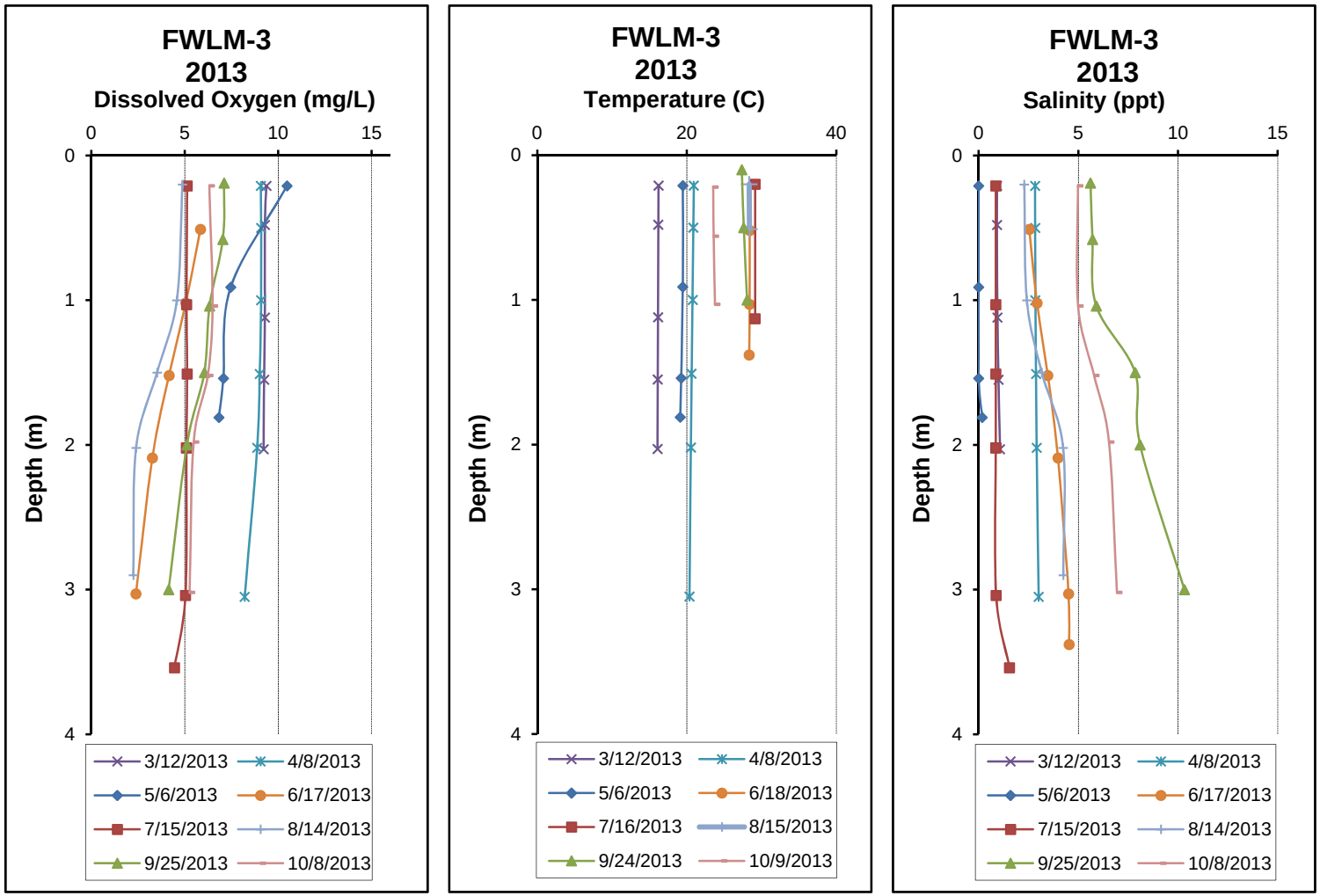


Figure 11. (continued)

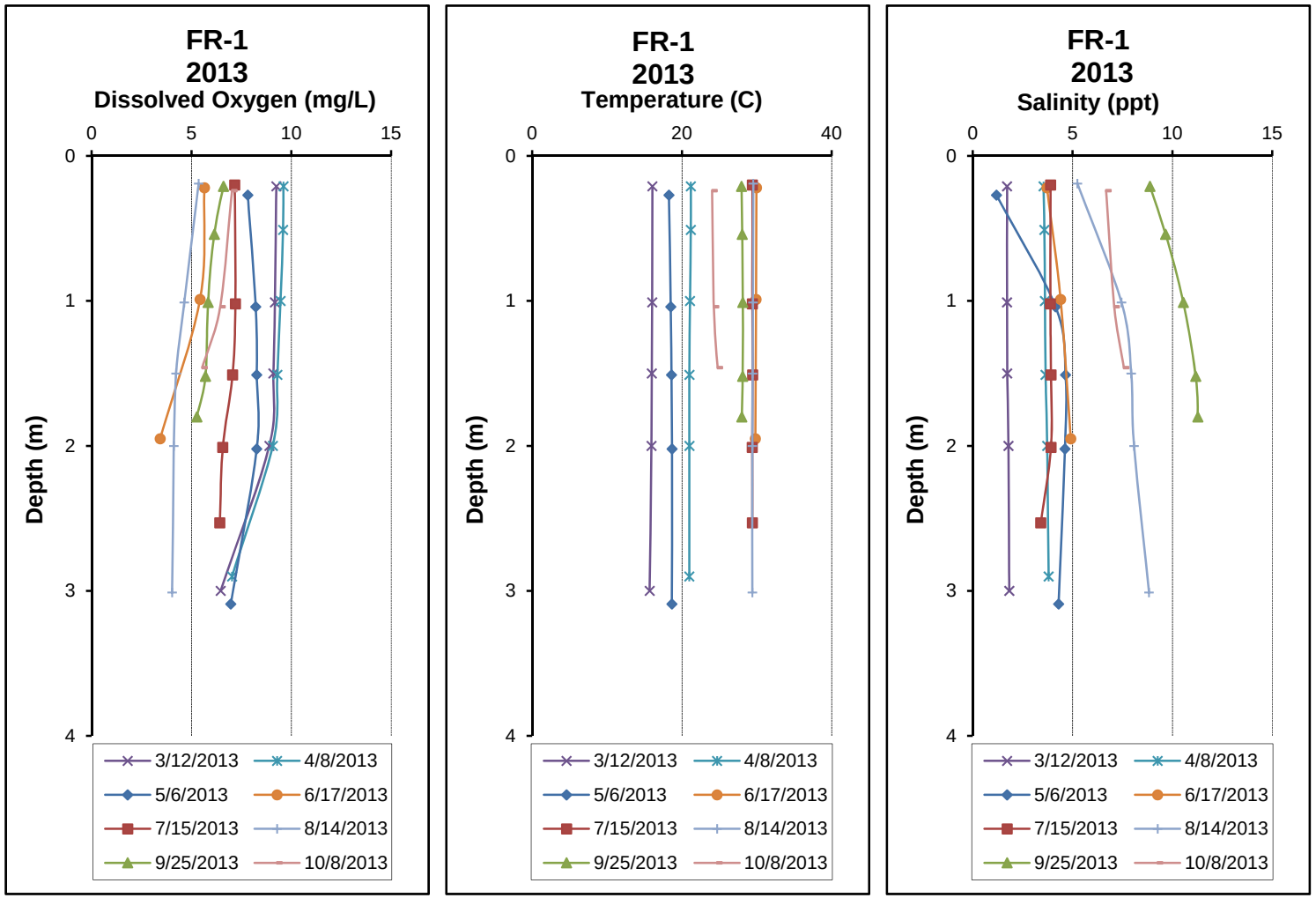


Figure 11. (continued)

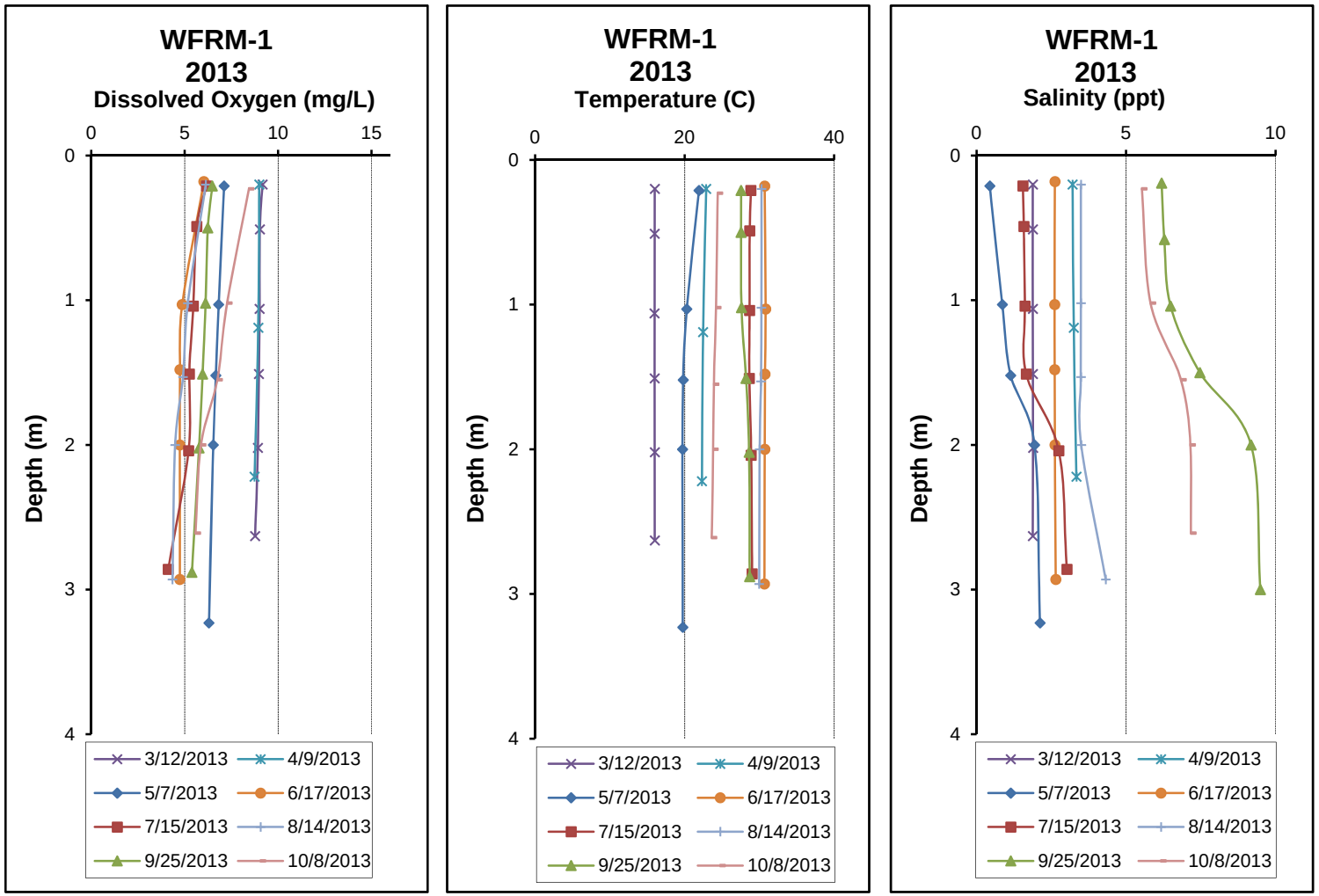


Figure 11. (continued)

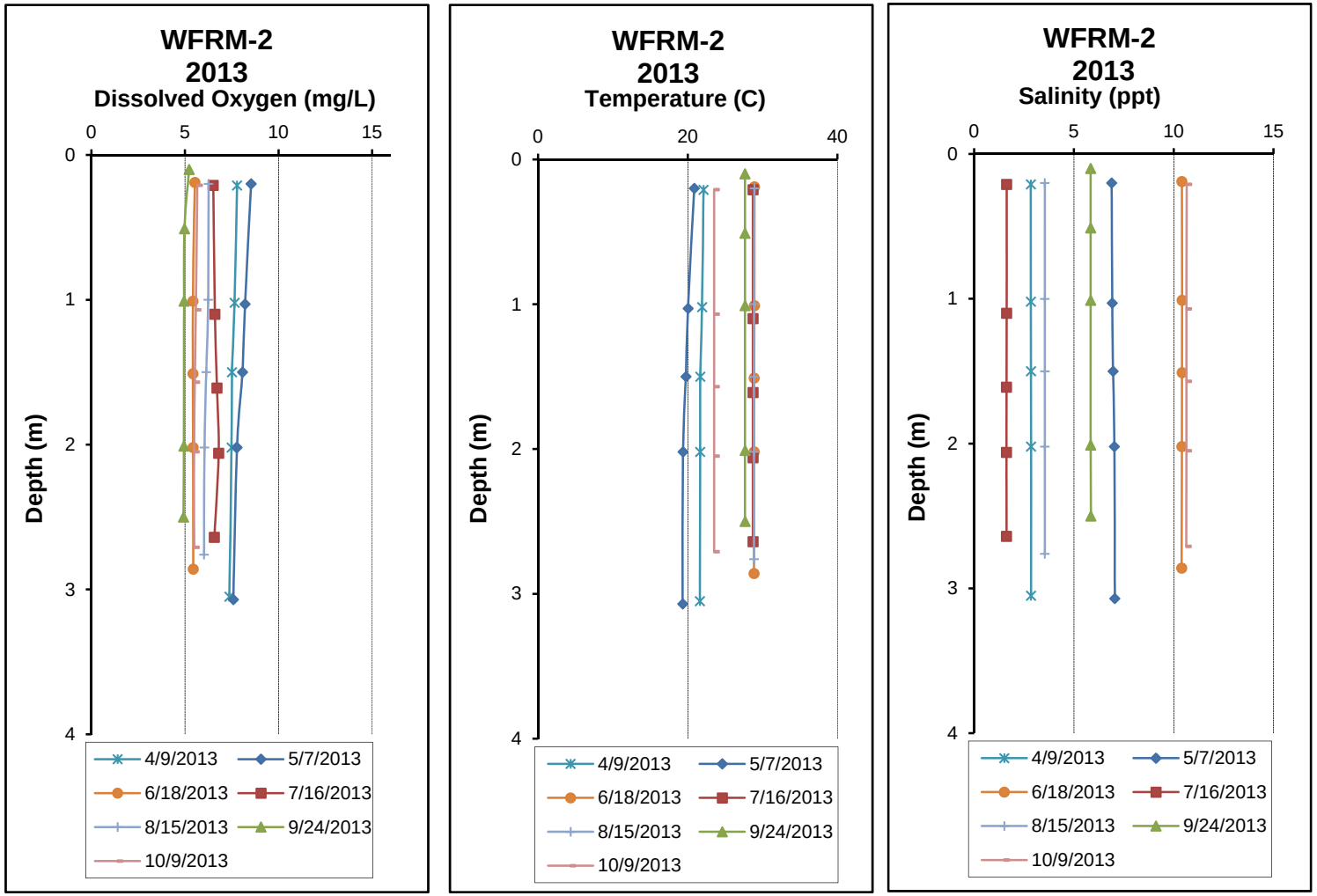
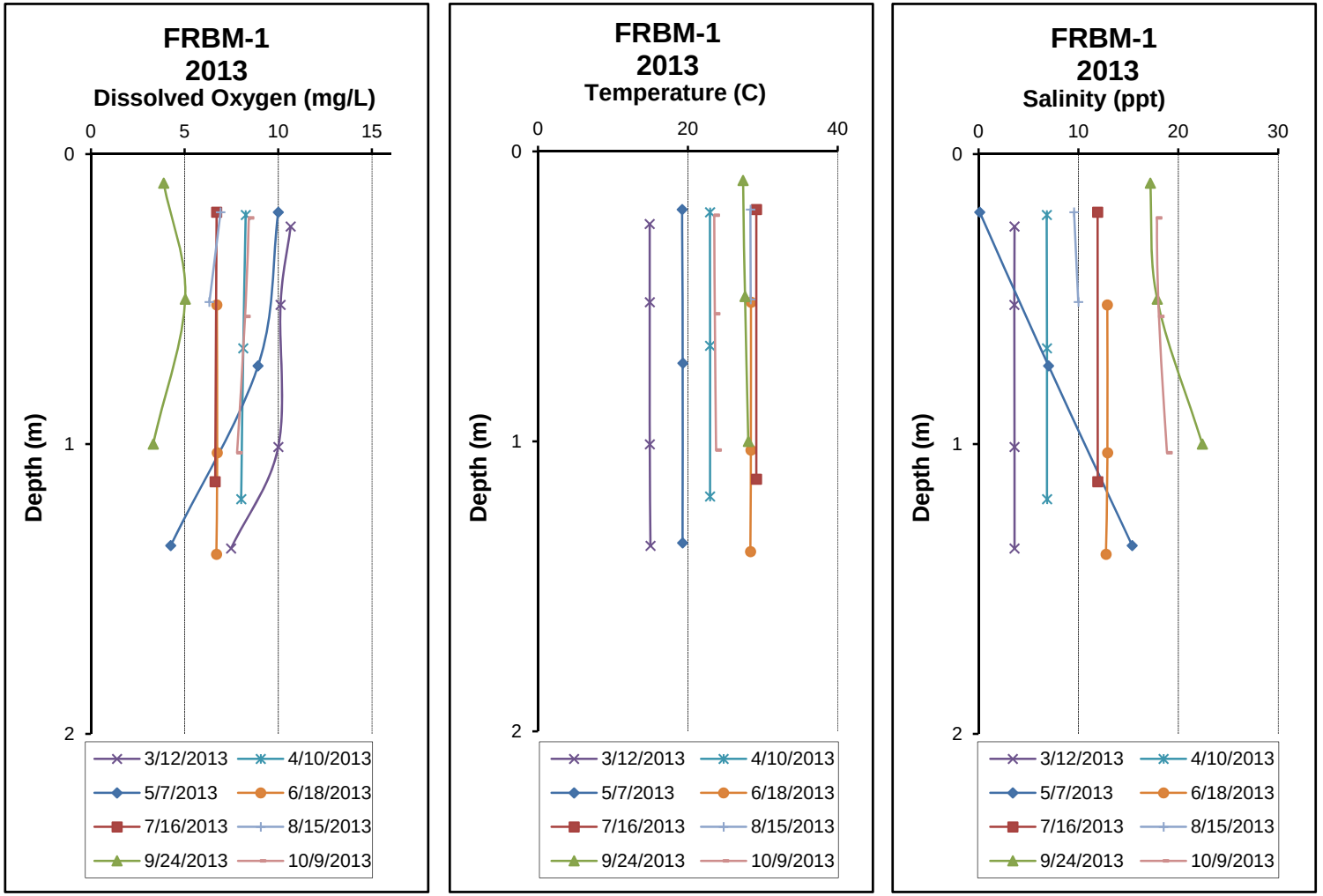


Figure 11. (continued)



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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		

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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		

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