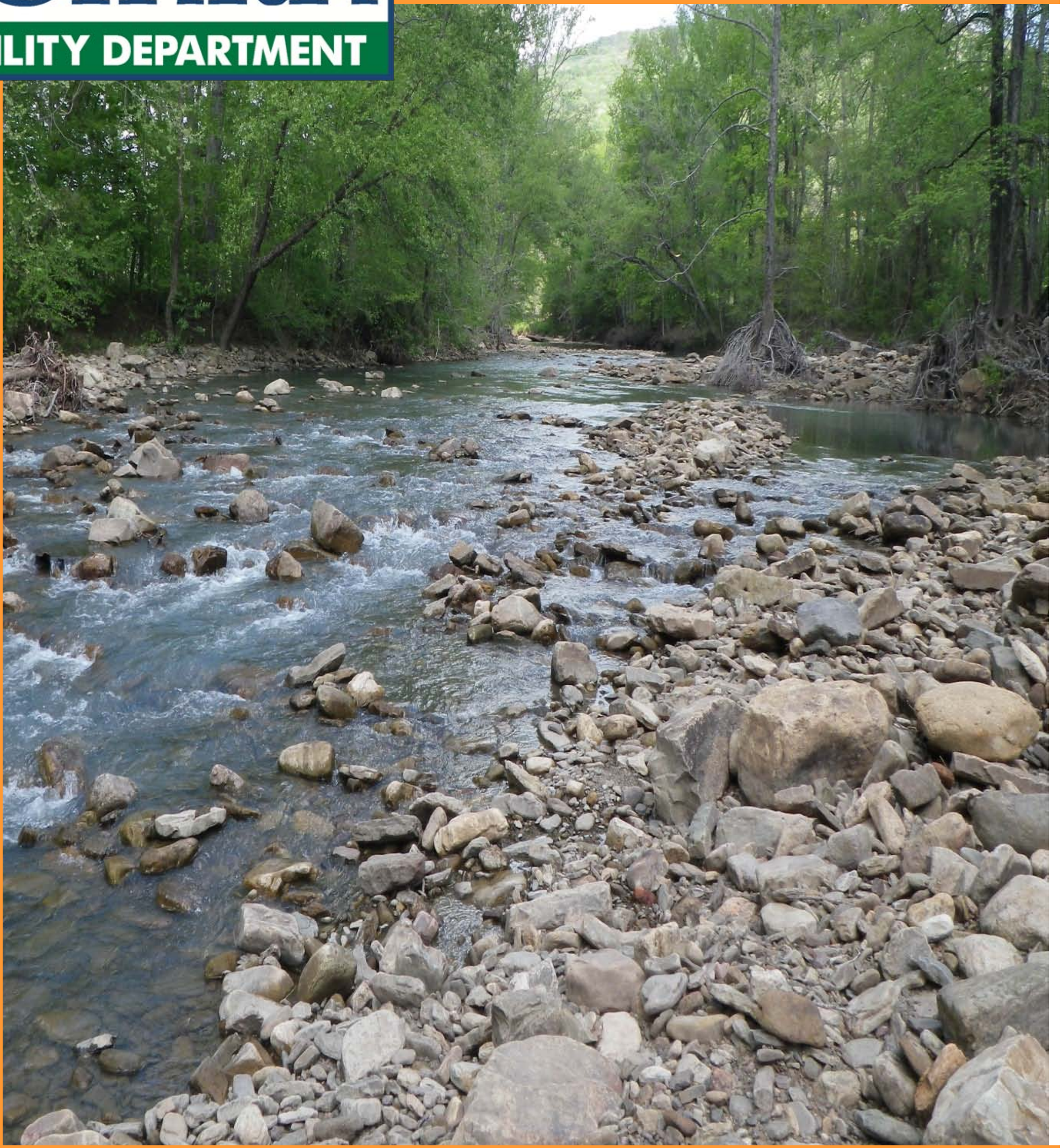
Upper Frog Bayou Watershed

Watershed Management Plan



Prepared for the City of Fort Smith
June 1, 2015

GBM^c & Associates
Strategic Environmental Services

CONTENTS

CONTENTS (cont)

FIGURES

FIGURES (cont)

TABLES

APPENDICES

Executive Summary

This watershed management plan (WMP) has been developed based largely on the 2005 EPA guidance and addresses EPA's nine minimum control measures. The plan complies with AWWA G300 Standard and contains many of the required components for Source Water Protection. This WMP has been developed based primarily on evaluation/analysis of historical data collected by the Fort Smith Utility (FSU), from 2007 to 2013, then integrated with new data (water quality and unified stream assessments) collected during this project to form a comprehensive WMP. The WMP includes identification of critical sub-watersheds at a small scale (12 digit HUC) and ranked implementation measures to reduce non-point source pollution loading from critical areas.

Sediment levels appear to be a principal concern in the watershed at this time and are known to be elevated due to storm water runoff from the numerous unpaved roads, pastures and eroded stream banks in the watershed. A substantial portion of the watershed is agricultural. Some areas, especially adjacent to agricultural land, lack riparian buffers and have ongoing stream bank erosion issues. Nutrient levels are not high but have been identified as elevated during storm flow events. Concerns over increased agricultural activity in the watershed potentially threaten Frog Bayou in the years to come, if not protected. In addition to agricultural concerns, Hwy 71 is a major highway that meander through the watershed and is a potential sources of additional pollutant loading and new contaminates.

The Frog Bayou watershed is a part of the Frog-Mulberry Watershed (HUC- 11110201), and is approximately 271 mi^2 in size (Figure 1). The watershed drains directly into the Arkansas River Basin.

The Upper Frog Bayou watershed (HUC-1111020104) has an impoundment (Lake Fort Smith) that serves as a drinking water source for Fort Smith. A portion of the watersh is approximately 84 mi^2 in size and is located in the Boston Mountains Ecoregion (Omernick, 1987), primarily in Crawford County, Arkansas. The water supply serves a population of approximately 200,000 (US Census, 2000).

Land use in the upper watershed is mostly forest or agricultural. The watershed is dominated by forest land-uses (83%). Agricultural land-uses (mostly pasture) comprise a fairly high percentage (11%) of the watershed.

In general, water quality during baseflow events, when the streams were not directly influenced by storm water runoff, was good. However, storm water runoff events did produce moderate pollutant levels, and when coupled with potentially high flow, are capable of significant pollutant loading from each sub-watershed (see Section 4.0). When loading is evaluated on a per unit area basis, it becomes clear which sub-watersheds have land uses that are producing the most pollutants during runoff events.

It is the goal of the FSU to continually improve upon the drinking water quality in Lake Fort Smith and to protect the watershed from water quality degradation. In order to meet this goal a proactive target for 10% reduction of sediment and phosphorus loading to Lake Fort Smith will be designed to protect and improve water quality. For this reason this WMP will focus on the Upper Frog Bayou watershed. These reductions will be achieved following the plan outlined in the sections that follow.

1.0 Introduction

Since the late 1980s the Environmental Protection Agency (EPA) has encouraged states and territories to manage their waters using a watershed approach. The watershed approach provides a framework to assess and manage water quality and water resources on a drainage basin (watershed) basis, focusing attention not just on point source discharges and stream disturbances in the stream corridors, but also on the effects of anthropogenic land uses (non-point sources) in the entire watershed on the waters in that watershed. In 2005 EPA released a guidance handbook for developing watershed based management plans (EPA, 2005). This watershed management plan (WMP) has been developed based largely on the 2005 EPA guidance and addresses the nine minimum elements required by EPA in plans written for the 319 Non-Point Source Control Program (Table 1). Preparation of this plan was funded by an EPA 319 Grant through the Arkansas Natural Resources Commission. Historical data collected by the Fort Smith Utility (FSU) and new data collected during this project have been utilized in preparation of this plan.

Table 1. EPA nine minimum elements.

EPA Nine Minimum Elements	Location Element Addressed in Watershed Management Plan
Element 1- Identification of causes of impairment and pollutant sources	Section 3.7, 4.0, 5.0
Element 2- Estimate of load reductions expected from management measures	Section 5.0, 6.0
Element 3- Non-point source measures required to achieve load reductions	Section 6.0
Element 4- Estimate of funding needed and sources of funding to implement plan	Section 9.0
Element 5- Information and education component	Section 8.0
Element 6- schedule for implementation	Section 6.0
Element 7- Interim measurable milestones	Section 6.0
Element 8- Criteria to measure success of reduction goals	Section 7.0
Element 9- Monitoring component to evaluate effectiveness of implementation measures	Sections 3.1.1, 3.2, 7.0

The FSU is a regional water supplier that produces, delivers and sells potable water to 13 contract users who ultimately provide drinking water, from Lake Fort Smith and Lee Creek Reservoir, to approximately 200,000 people in Western Arkansas and Eastern Oklahoma. The utility strives to provide the best quality water to its users at a reasonable cost. Protection of the watersheds that supply this water not only will reduce pollutant transport to the Arkansas and Mississippi River Basins but will also allow the City to continue providing its users with affordable clean drinking water. This plan complies with the AWWA G300 Standard for source water protection. It includes the bulk of the components recommended by the G300 Standard including: characterization of source water and source water protection area, source water protection goals, an action plan, implementation strategies and a plan for evaluation and revision (Table 2).

Table 2. AWWA G300 Standard.

AWWA G300 Standard Component	Location Component Addressed in Watershed Management Plan
Sec.4.2 -Characterization of Source Water and Source Water Protection Area	Sections 2.0, 3.1, 3.2, 3.3, 3.4, 3.6, 3.7, 4.0, 5.0, 7.0
Sec. 4.3-Source Water protection goals	Sections 4.0, 6.0, 8.0
Sec.4.4-Action Plan	Sections 4.0, 6.0, 8.0, 9.0
Sec.4.5-Program Implementation	Sections 6.0, 7.0, 8.0
Sec.4.6-Evaluation and Revision	Section 8.0

Suspended sediment levels appear to be a principal concern in the watershed at this time and are known to be elevated due to storm water runoff from the numerous unpaved roads in the watershed, and from stream bank erosion. A substantial and growing portion of the watershed is agricultural. Some areas, especially adjacent to agricultural land, lack riparian buffers and have ongoing erosion issues that can potentially export nutrients into streams. Nutrient levels have not yet been found to be alarmingly high. However, concerns over increased agricultural activity in the watershed potentially leave the Upper Frog Bayou watershed threatened in the years to come if not protected. In addition to the agricultural concerns, Interstate 49 and Hwy 71 are major highways that meander through the watershed and are potential sources of contamination and may result in additional soil erosion sources, increased storm water runoff, and concerns for the potential of hazardous chemical spills.

The FSU has maintained an ongoing watershed monitoring program since 1992. FSU staff conducts extensive water quality sampling and physicochemical analysis on a quarterly basis, under various flow regimes, at multiple creek stations in the watershed. Staff completes annual bioassessments of the fish and macroinvertebrate community in key stream reaches (generally near water quality monitoring sites) in the watershed. In addition, the monitoring program includes weekly lake water quality profiles to assess lake trophic status and raw water intake water quality.

This WMP has been developed based primarily on evaluation/analysis of existing watershed monitoring data collected by the FSU, from 2007 to 2013, then integrated with the existing water resource management documents and new data collected during this project to form a comprehensive WMP. The WMP includes identification of critical sub-watersheds at a small scale (12 digit HUC) and ranked implementation measures to reduce non-point source pollution loading from critical areas. The implementation measures recommended will be focused in the critical upper sub-watersheds, which drain into Lake Fort Smith. These sub-watersheds have the greatest influence on lake water quality. This WMP will be used to direct watershed protection activities and watershed restoration activities in the upper watershed with the ultimate goal being immediate reduction of pollutant loading and protection of the upper watershed into the future.

2.0 Watershed Description

The Frog Bayou watershed is a part of the Frog-Mulberry Watershed (HUC- 11110201), and is approximately 271 mi^2 in size (Figure 1). The watershed drains directly into the Arkansas River Basin.

The Upper Frog Bayou watershed (HUC-1111020104) has an impoundment (Lake Fort Smith) that serves as a drinking water source for Fort Smith. The upper portion of the watershed above Lake Fort Smith which drains directly into the lake is approximately 84 mi^2 in size, and is located in the Boston Mountains Ecoregion (Omernick, 1987), primarily in Crawford County, Arkansas. The area served by the lake has a population of approximately 200,000 (US Census, 2000).

Land use in the Upper Frog Bayou watershed is mostly forest or agricultural. The watershed is dominated by forest land-uses (83%). Agricultural land-uses (mostly pasture) comprise approximately (11%) of the watershed (Figure 1.) The soils in the watershed are dominated by Nella-Enders, Enders and Linker-Mountainburg complexes. Slopes are generally steep and typically range from 3% - 60%, with over half the slopes in excess of 16% (Figure 2.) The high slopes in the watershed make it vulnerable to erosion in un-forested areas.

All waters in the state of Arkansas have uses designated for them that dictate the level of water quality that must be maintained. The Upper Frog Bayou watershed is designated for the following uses by the Arkansas Department of Environmental Quality (ADEQ):

- Primary contact recreation
- Secondary contact recreation
- Domestic, industrial and agricultural water supply
- Fisheries (Aquatic life), Perennial Boston Mountain

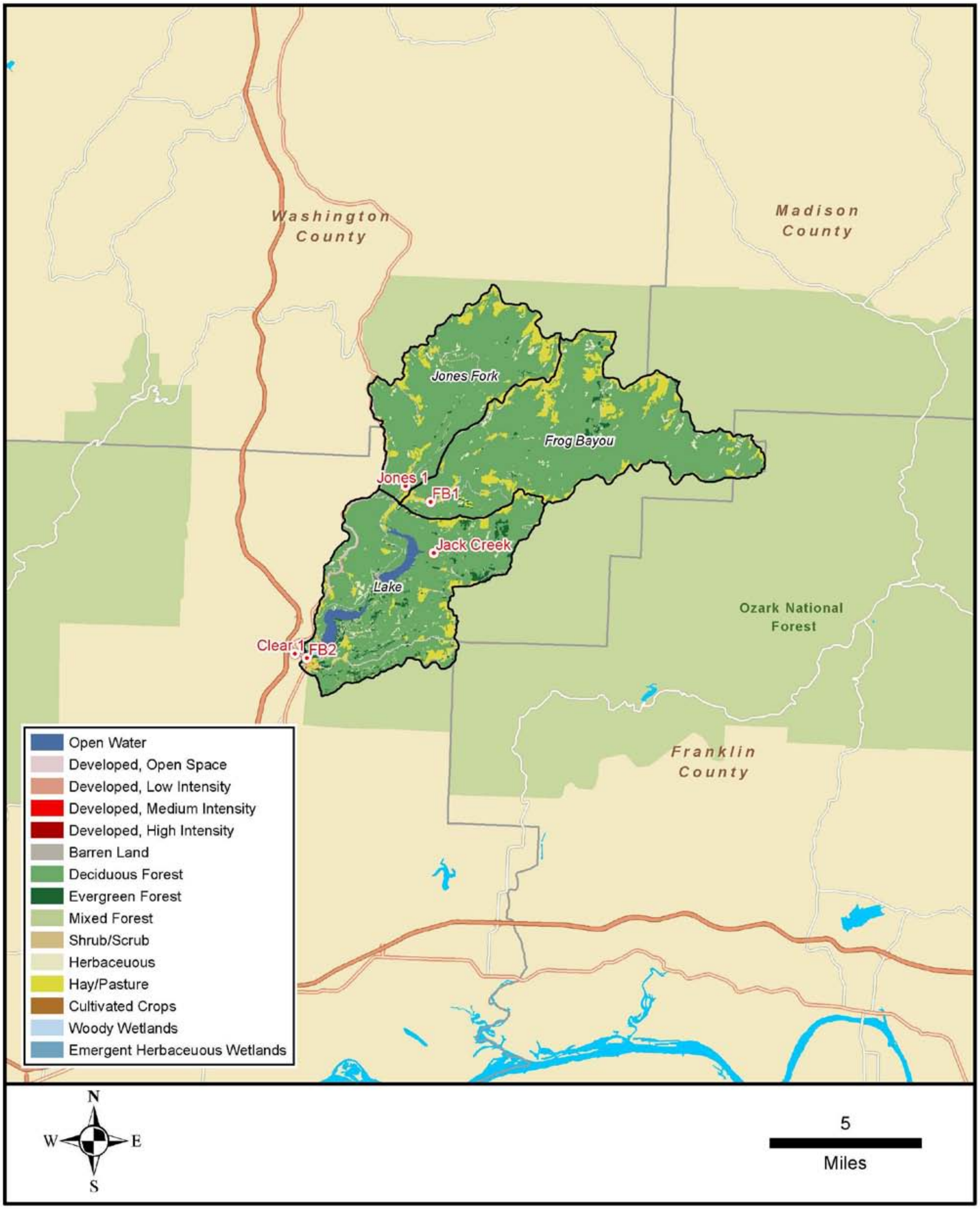


Figure 1. Land-uses in the Frog Bayou watershed.

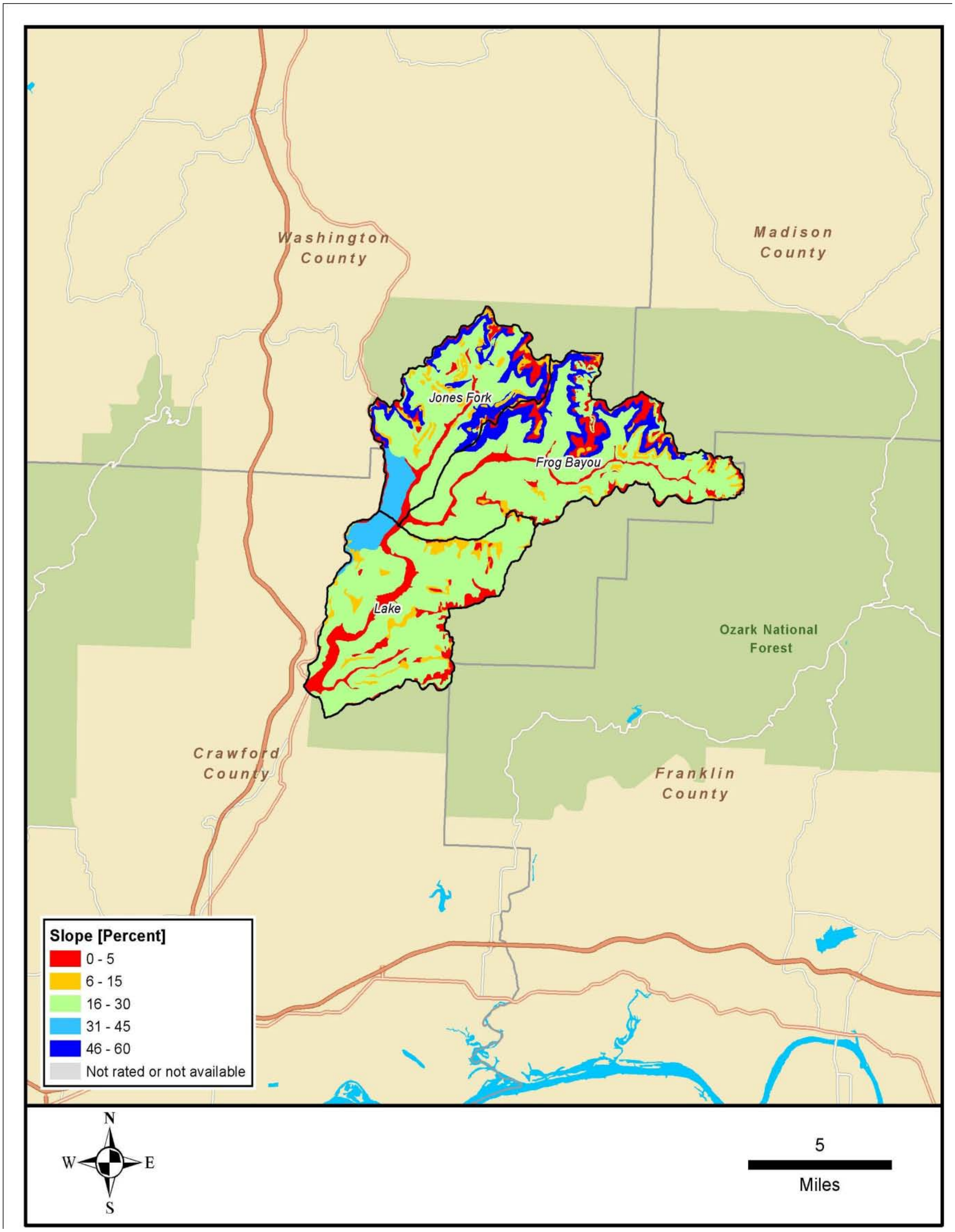


Figure 2. Land surface slope in the Frog Bayou watershed.

3.0 Watershed Assessment

A comprehensive assessment was completed on the Frog Bayou watershed to evaluate its physical, chemical, ecological and hydrologic condition. All six sub-watersheds (defined at approximately a 12-digit HUC level) depicted on the map (Figures 1 and 2) were evaluated during Phase 1 of this project. Phase 2 of this project narrowed the focus to the three sub-watersheds of the Upper Frog Bayou watershed that flow into Lake Fort Smith, (Jones Fork, Frog Bayou, and Lake). Historical data collected by FSU's ongoing monitoring program, GIS data and new data collected in the field by GBMc & Associates was utilized for the assessment. A description of each assessment component is contained in the following sections. A list of the three sub-watersheds and the monitoring stations they represent is provided below.

1. Jones Fork Creek (Jones-1) (HUC-111102010401)
2. Headwaters Frog Bayou (FB-1) (HUC-111102010402)
3. Lakes (FB-2) (HUC-111102010404)

3.1 Water Quality

3.1.1 Fort Smith Utility Ongoing Monitoring Program

The FSU has been managing the Upper Frog Bayou watershed for over 20 years. They have an ongoing monitoring program that includes baseflow and storm flow monitoring of water quality at three critical locations in the upper watershed, above Lake Fort Smith. Samples are collected multiple times each year in Headwaters Frog Bayou (at Bidville Road Bridge), Jones Fork (at Winfrey Road Bridge) and Jack Creek (just above the lake). Data from the monitoring program (collected primarily between 2007-2013) has been analyzed and summarized in Table 3. All historical data used in this WMP is provided in Appendix A.

Table 3. Summary of historical monitoring data collected by FSU.

Station	Parameters											
	TSS (mg/L)		T.Phos (mg/L)		Orthophos. (mg/L)		NO3+NO2-N (mg/L)		TOC (mg/L)		Chloride (mg/L)	
	mean	range	mean	range	mean	range	mean	range	mean	range	mean	range
Baseflow Sample Results												
Jones-1	<5.0	<5.0	0.038	<0.020 - 0.130	0.038	<0.010 - 0.064	0.52	0.16 - 1.19	1.04	0.20 - 2.04	2.25	1.48 - 6.03
FB-1	<5.0	<5.0	0.039	<0.020 - 0.160	0.030	<0.010 - 0.061	0.59	0.08 - 5.90	1.18	0.20 - 2.55	1.77	1.04 - 7.90
Jack-1	<5.0	<5.0	0.043	<0.020 - 0.280	0.032	<0.010 - 0.061	0.26	0.04 - 0.72	1.04	0.20 - 2.21	1.78	1.30 - 3.21
Storm Flow Sample Results												
Jones-1	144.4	5.8 - 647.2	0.391	0.045 - 1.148	0.099	<0.010 - 0.510	0.57	0.09 - 1.35	2.42	0.05 - 7.79	2.19	1.46 - 3.27
FB-1	201.3	23.2 - 1230.6	0.548	0.088 - 3.083	0.062	<0.010 - 0.318	0.39	0.13 - 0.79	2.69	0.66 - 3.84	1.63	1.19 - 2.68
Jack-1	87.5	12.5 - 296.5	0.202	0.065 - 0.540	0.048	0.040 - 0.061	0.21	0.01 - 0.46	2.50	1.03 - 3.88	1.42	1.04 - 2.17

The Jack Creek watershed is relatively undeveloped; approximately 96% of it is forest (See Section 3.7). Water quality in Jack Creek is very good; sample results reflect fairly stable good water quality at baseflow, and the lowest levels of phosphorus, nitrates and TSS (Figures 3-5) observed during storm flow sampling events. The water quality data collected by FSU supports their use of Jack Creek as a reference site for comparing the other streams in the watershed.

Under baseflow conditions each streams water quality was generally comparable to that of Jack Creek with the exception of Nitrate+Nitrite-N which was elevated at FB-1 and Jones-1. Under storm flow conditions, phosphorus was noted to be slightly elevated in FB-1 compared to Jack-1 and Jones-1. Nitrate+Nitrite-N was slightly elevated at Jones-1 (but still very low at less than 1 mg/L). All three streams are high quality Boston Mountain streams. A summary of the data discussed in the section is provided in Appendix A.

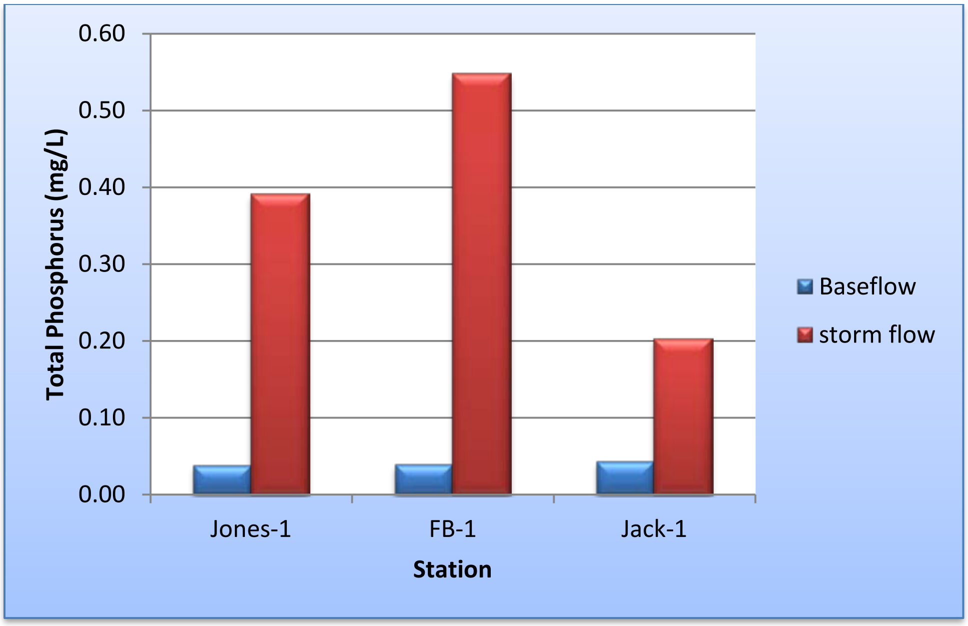


Figure 3. FSU phosphorous data (averages).

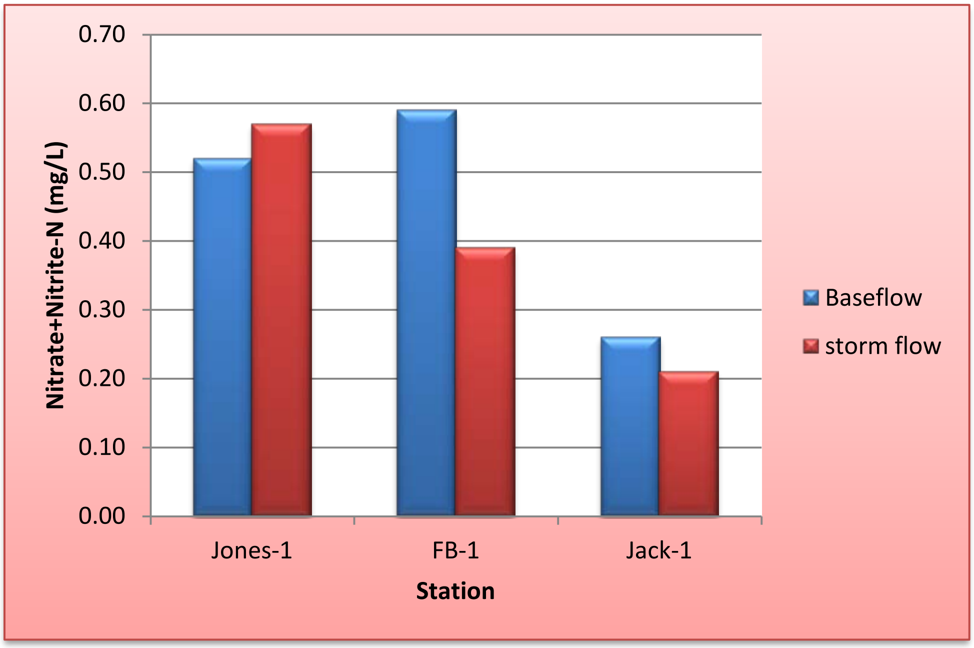


Figure 4. FSU nitrate+nitrite-N data (averages).

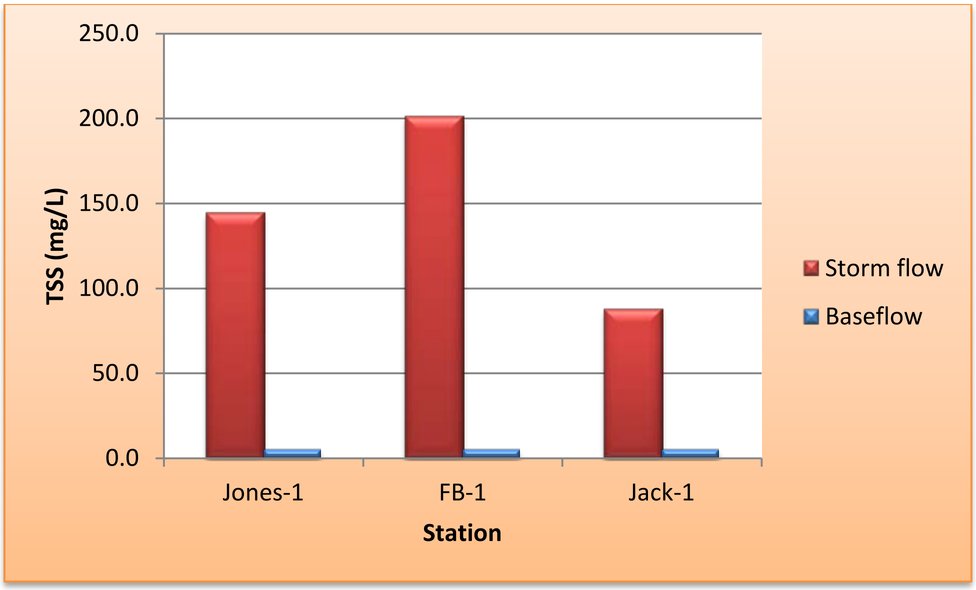


Figure 5. FSU TSS data (averages).

3.1.2 Water Quality Data Collected Specifically for the WMP

Water samples and *in-situ* data were collected from several points along Frog Bayou and its tributaries to supplement the data collected routinely by FSU and to help determine the water quality during baseflow and storm flow conditions. Sample stations were selected to represent each of the six sub-watersheds depicted in Figure 6. A total of 6 stations were utilized during Phase 1 of the study, and only the three stations above Lake Fort Smith were utilized during Phase 2 (Figure 6) of this study. Samples were collected on two[1] occasions to represent baseflow conditions and five[1] occasions to represent storm flow conditions. A description of each sample station is provided in Table 4. These stations generally coincide with the monitoring stations used by FSU. Jack Creek was omitted during Phase 1 due to its small size and unlikelihood that it would be a significant source for pollutants, but was added back in for the Phase 2 study to serve as a reference.[2]

---

[1] One baseflow sample and one storm flow sample were collected from each station for Phase 1 of this project (following the draft QAPP guidelines), but were collected prior to EPA approval of the QAPP. However, no quality assurance changes to the QAPP were required by EPA so the data is included here.

[2] The autosampler on Jack Creek failed to initiate on one occasion during Phase 2 sampling. Therefore, only two samples were collected from that station.

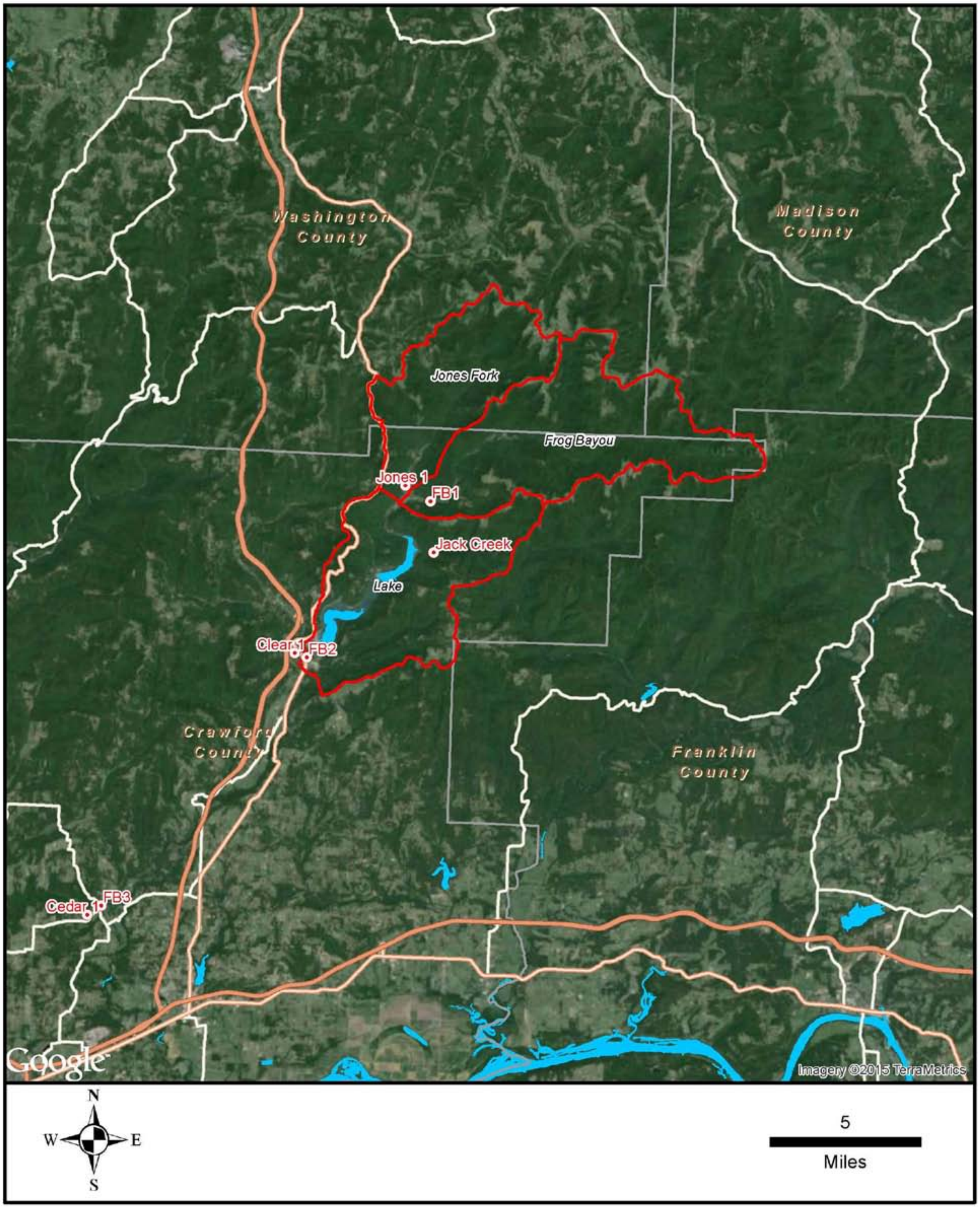


Figure 6. Frog Bayou sub-watersheds and sample stations in each sub-watershed.

Samples were collected according to the Quality Assurance Project Plan (QAPP) approved by the ANRC and EPA Region 6. In brief, grab samples were collected in clean, labeled containers from within the main area of flow in the channel and delivered to the FSU's Environmental Quality Analytical Laboratory for analysis following all chain of custody procedures (see QAPP for this project). Samples were collected for analysis of nitrate+nitrite-N, ammonia, total phosphorus, ortho-phosphorus, BOD5, TOC, and TSS. Chloride analysis was requested to be added by EPA half-way into Phase 1 of the Project. During Phase 2 samples were collected for the same analysis with the exception of BOD5 and TOC which were omitted due to insignificant loading observed during Phase 1. At the time of sample collection, *in-situ* measurements were taken for pH, specific conductance, dissolved oxygen, temperature, and turbidity. *In-situ* measurements were made following GBM^c SOP's (Nos.1-4 and 14). Water quality results, including *in-situ* parameters, from each station, are provided in Appendix B.

Table 4. Phase 2 sample station descriptions.

Station Identification	Station Description
Jones 1	Jones Fork near confluence with Frog Bayou above Lake Fort Smith. Same location used by FSU.
FB-1	Frog Bayou in headwaters of watershed above confluence of Jones Fork and above Lake Fort Smith. Just downstream of station used by FSU.
FB-2	Frog Bayou at Mountainburg, AR, (just upstream of HWY 71) below Lake Fort Smith.
Jack-1	Jack Creek about 1/4 mile upstream of discharge into Lake Fort Smith

Water quality during baseflow conditions was found to be good and fairly consistent, in each sub-watershed. Table 5 provides a summary of water quality data for the Phase I and Phase II of the Upper Frog Bayou watershed stations for select constituents. All water quality data collected during the study is provided in Appendix B. Each station is near the outlet of it respective sub-watershed and should be typical of pollutant concentrations in that system. Total phosphorus and ortho-phosphorus (the dissolved fraction of phosphorus that is generally considered biologically available) were typically at or below the 0.02 mg/L detection level. Nitrate+Nitrite-N levels were very low, all less than 0.60 mg/L. TSS was less than detection (5.0 mg/l) and turbidity was less than or equal to ten (≤10) NTUs at all stations (with the exception of FB-2) during baseflow conditions. TOC and BOD5 levels, which measure carbon based organic material in the water were all very low, BOD5 levels were all less than the 2.0 mg/L detection level and TOC was less than 1.5 mg/L in all samples. These data are indicative of water that is very clear, and free of suspended matter (Figure 7). Conductivity measurements were low at all stations, (all less than 100 us/cm and most less than 50 us/cm) indicating the water was low in dissolved constituents.

Figure 7. Clear-1 and FB-1 during baseflow conditions.

Table 5. Summary of average baseflow and storm flow water quality.

Station[1]	Parameters											
	TSS (mg/L)		T.Phos (mg/L)		Orthophos. (mg/L)		NO3+NO2-N (mg/L)		TOC (mg/L)		Chloride (mg/L)	
	mean	range	mean	range	mean	range	mean	range	mean	range	mean	range
Baseflow Sample Results												
Jones-1	<5.0	---	<0.02	---	<0.02	---	0.49	0.48 - 0.50	0.77	0.47 - 1.08	1.70	---
FB-1	<5.0	---	<0.02	---	<0.02	---	0.42	0.34 - 0.50	0.77	0.52 - 1.01	1.40	---
FB-2	<5.0	---	0.02	<0.02 - 0.02	<0.02	---	0.53	0.50 - 0.56	1.60	1.4 - 1.8	1.30	---
Storm Flow Sample Results												
Jones-1	39.2	<5.0 - 122.0	0.11	<0.02 - 0.28	<0.02	all <0.02	0.45	0.21 - 0.68	2.52	1.44 - 3.60	1.83	1.48 - 2.50
FB-1	49.2	<5.0 - 152.0	0.12	<0.02 - 0.32	<0.02	all <0.02	0.42	0.22 - 0.56	2.65	1.88 - 3.43	1.33	1.02 - 1.90
FB-2	9.5	7.0 - 12.0	0.03	0.02 - 0.03	0.02	---	0.55	0.50 - 0.60	1.71	1.60 - 1.83	1.60	---
Jack-1	7.0	5.0 - 9.0	0.03	<0.02 - 0.03	<0.02	all <0.02	0.22	0.16 - 0.28	---	---	1.23	1.15 - 1.31

[1] Each station had two baseflow samples and five storm flow samples represented. Where a range is noted as "—" it indicates a SD of 0.

Water quality data for the Upper Frog Bayou watershed collected during storm flow conditions for Phase I and Phase II is summarized in Table 5. Under a storm flow scenario the amount of flow in several of the main tributaries was elevated dramatically. The concentration of some pollutants also increased as flow increased, while others pollutants decreased or remained stable. Most notably TSS (Figure 8) and total phosphorus (Figure 9) increased an order of magnitude (on average) during storm flow events. TSS levels were as high as 152 mg/L (in FB-1) and total phosphorus as high as 0.32 mg/l (also in FB-1). Other constituents that increased during storm events (though not dramatically) were TOC, BOD5 and chloride.

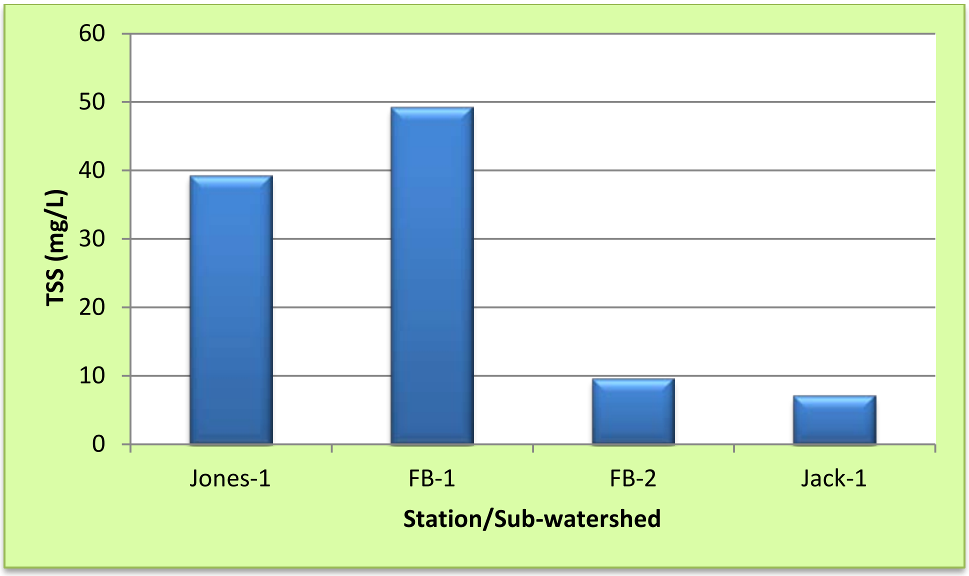


Figure 8. Average TSS under storm flow conditions.

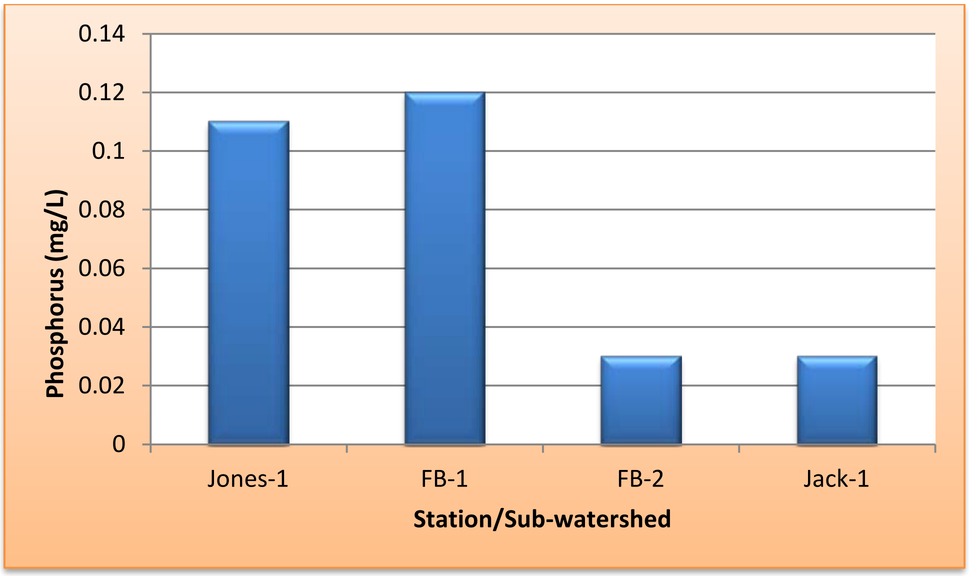


Figure 9. Average total phosphorus under storm flow conditions.

In general, water quality during baseflow events, when the streams were not directly influenced by storm flow, was good. However, storm flow events did produce moderate pollutant levels, and when coupled with high volumes of flow are capable of significant pollutant loading from each sub-watershed (see Section 4.0).

Figure 10. FB-1 during storm event.

Figure 11. Jones-1 during storm event.

Designated Use Assessment Criteria

In order to evaluate the maintenance of Upper Frog Bayou watershed's designated uses based on water quality data, the Arkansas Assessment Criteria for the Boston Mountains Ecoregion was utilized. Table 6 provides a summary of the assessment criteria that are pertinent to this WMP's study focus.

Table 6. Boston Mountain assessment criteria standard.

Parameter	Standard	Frog Bayou Assessment	Use assessed
Temperature (ºC) Maximum	29	All <29	Aquatic life (fisheries)
Dissolved Oxygen (mg/L) Minimum, watersheds >10mi^2	6	All >6.0	Aquatic life (fisheries)
pH (s.u.)	6 – 9	All in range	All
Turbidity (primary flow) ntu	10	All in range	All
Turbidity (storm flow) ntu	19	Some exceedances (see text)	All
Chloride (mg/L)	250/23[1]	All < 23	Drinking water
Nitrate (mg/L)	10	All <1.0	Drinking water
Ammonia (mg/L) (4-d avg/30-d avg)	5.3/2.1	All <0.10	Aquatic life (fisheries)

[1] Chloride is assessed with a general 250 mg/l for drinking water and an ecoregion based value 33% greater than the ecoregion reference value.

All designated uses are being maintained in each sub-watershed according to the assessment criteria. However, storm flow turbidity was exceeded at some sub-watershed monitoring stations on at least one occasion. According to the assessment criteria for turbidity, if more than 20% of samples collected (with at least 24 samples) exceed the storm flow value, the stream is listed as impaired for turbidity.

3.2 Lake Fort Smith

Water Quality

Water samples were collected by FSU from six routine sampling locations distributed throughout Lake Fort Smith to characterize the water quality of the lake as part of the FSU monitoring program. Monitoring data reviewed for this analysis were for samples collected once a week beginning in January 2009 and ending in February 2014. For this analysis, only two sampling locations were utilized, one which is in the middle of the lake (LFS 04) and one which is located down lake, just above the dam (LFS 01). Only data from the summer months (July-August) and winter months (January and February) from the two sampling locations were evaluated to best depict contrasting conditions in Lake Fort Smith.

Grab samples were collected by FSU in clean, labeled containers at the surface of the lake. Samples were stored in ice filled coolers and delivered to the laboratory for analysis following all chain of custody procedures. Samples were collected once per week for analysis of total phosphorus (P), and total dissolved solids (TDS). Samples were also collected at station LFS 01 for the analysis of chlorophyll-α (C-α). Chlorophyll-α samples were collected at one quarter the photic zone, maintained in the dark, filtered within 24 hours of collection, and frozen prior to laboratory analysis to prolong the holding time. I*n-situ* measurements were taken at one meter increments from the water's surface to the bottom of the lake for pH, dissolved oxygen, specific conductivity, temperature, and turbidity. Only the data collected from within the top meter (in the prime photic zone) at the two sampling locations were considered, for continuity. Table 7 summarizes the averages of these data at the two sampling locations within the lake in the summer and winter months.

Table 7. Averages of summary data (±stdev) from Lake Fort Smith.

Site	Season	Temperature (˚C)	Dissolved oxygen (mg/L)	pH	Specific Conductivity (µs/cm)	Total dissolved solids (g/L)	Turbidity (NTU)	Total Phosphorus (mg/L)	Chlorophyll-α (µg/L)
LFS 01	Summer	28.79 ± 1.49	7.80 ± 0.47	8.27 ± 0.56	42.88 ± 4.60	0.03 ± 0.01	2.95 ± 2.39	0.06 ± 0.06	3.49 ± 1.84
LFS 01	Winter	6.62 ± 1.18	10.75 ± 0.67	7.64 ± 0.62	46.06 ± 3.41	0.03 ± 0.00	12.68 ± 13.00	0.05 ± 0.04	2.12 ± 0.73
LFS 04	Summer	28.97 ± 1.47	7.77 ± 0.50	7.90 ± 0.63	43.26 ± 4.01	0.03 ± 0.01	3.20 ± 0.88	0.06 ± 0.04	-
LFS 04	Winter	9.74 ± 8.27	10.85 ± 1.33	7.47 ± 0.40	43.49 ± 2.60	0.03 ± 0.00	15.61 ± 13.74	0.05 ± 0.03	-

A comparison was made between Lake Fort Smith water quality and other type B lakes in Arkansas. The Arkansas Department of Environmental Quality considers type B lakes to be small lakes in mountainous terrain. ADEQ lake samples were collected during a two-month summer period, July 12, 1999 to August 26, 1999. Therefore, Lake Fort Smith data from only the summer months will be compared with the type B lakes in Northwest Arkansas. Compared to other type B lakes in Arkansas, Lake Fort Smith's water temperature on average, (28.9 ˚C), was lower than the average, (29.70˚C), found in other type B lakes in Northwest Arkansas (Figure 12). Turbidity in Lake Fort Smith, (3.1 NTU), is lower than the average, (4.3 NTU), found in type B lakes in Northwest Arkansas (Figure 12). Chlorophyll-α in Lake Fort Smith, (3.49 µg/L), was lower than the average, (7.60 µg/L), found in other type B lakes (Figure 12). Total Phosphorus in Lake Fort Smith, (0.06 mg/L), was higher than the average, (0.04 mg/L), found in other type B lakes (Figure 12). Temperature, turbidity, and chlorophyll-α were lower, and total phosphorus were higher on average than other type B lakes in Northwest Arkansas in the summer months. Overall Lake Fort Smith has good water quality when compared to other type B lakes found in Northwest Arkansas.

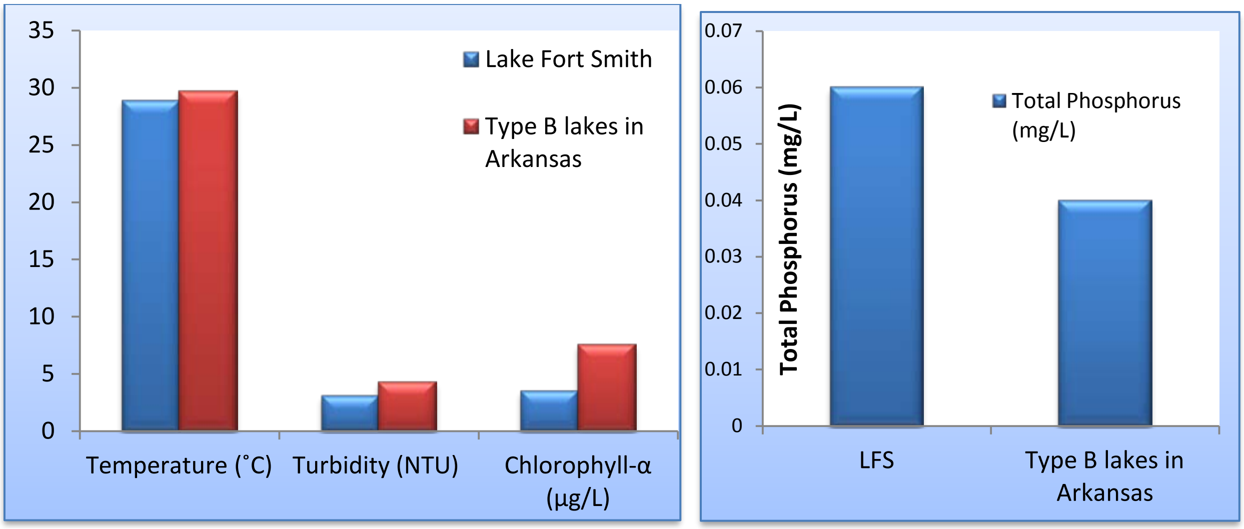


Figure 12. Comparison of Lake Fort Smith average values and other Type B lakes in Northwest Arkansas.

Trophic Status

Lakes are often classified according to their trophic status. A lake's trophic status, or trophic state index is a measurement of how productive a lake's biota are, particularly in regard to its primary producers such as algae and aquatic plants that are found on the bottom end of the food chain. The index is based on changes in nutrient levels, which cause changes in algal biomass, in turn changing the clarity of the water. Dr. Robert Carlson developed a trophic state index for classifying lakes based on nutrient concentrations and productivity (Table 8) (Carlson, 1977). Oligotrophic lakes contain very low concentrations of nutrients that are required for plant growth; therefore oligotrophic lakes have low productivity. Newly built lakes are often classified oligotrophic as their nutrient concentrations have not yet been influenced by land use practices such as agriculture or urbanization. Oligotrophic lakes are clear water lakes with water that is well-oxygenated. An oligotrophic lake is typically a high quality drinking water source. Mesotrophic lakes have an intermediate level of productivity, they have enough nutrients within them to support submerged aquatic plants beds, and usually have clear water. Eutrophic lakes have a high productivity level that can support an abundant amount of aquatic plants and algae. If aquatic plants dominate the lake, the water tends to be clear, and if algae dominates the lake, the water tends to be darker. Hypereutrophic lakes are very nutrient-rich lakes; algal blooms occur often and cause low transparency within the lake. Hypereutrophic lakes support the most aquatic plants, fish, and other biota compared to other types of lakes in the classification system. However, these excess nutrients may impact oxygen levels and prevent life from occurring at lower levels in the lake.

Table 8. Carlson's trophic state index.

Trophic State	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Range	<40	40-50	50-70	>70

The trophic state index was calculated for Lake Fort Smith at two different sampling locations in the lake, during the summer (July-August) and winter (January-February) months. Table 9 shows the Carlson trophic state index for Lake Fort Smith using chlorophyll-α, secchi depth, and total phosphorus. Sampling station LFS 01 averaged 48.3 during the summer months, which is classified as a mesotrophic. The trophic state index scored higher for total phosphorus and lower for secchi depth and chlorophyll-α (Table 9). At sampling location LFS 04, the average trophic state index was 52.6 during the summer months and classifies the lake as eutrophic (Table 9 and Figure 13). LFS 01 in the winter months averaged 46.3 which again classifies the lake as mesotrophic. Data from LFS 04 in the winter months had an average trophic state index of 54.74, classifying this location as eutrophic (Table 9 and Figure 13). Therefore, Lake Fort Smith can be generally classified as on the border of mesotrophic and eutrophic based on the two sampling location LFS 01 and LFS 04 in both the summer and winter months (Table 9 and Figure 13).

Table 9. Summary of Carlson's TSI scores for LFS 01 and LFS 04 in the summer and winter months.

Site	Season	TSI (SD)	TSI (TP)	TSI (Chl-a)
LFS 01	Summer	44.5	58.9	41.6
		28.1 – 84.5	47.4 – 83.8	24.7 – 52.3
		Mesotrophic	Eutrophic	Mesotrophic
LFS 01	Winter	45.0	56.4	37.4
		19.2 – 65.4	47.4 - 77.3	29.7 – 45.4
		Mesotrophic	Eutrophic	Oligotrophic
LFS 04	Summer	48.7	56.4	---
		27.7 – 67.1	47.4 – 77.3	---
		Mesotrophic	Eutrophic	---
LFS 04	Winter	52.2	57.1	---
		23.6 – 71.3	47.4 – 75.4	---
		Eutrophic	Eutrophic	---

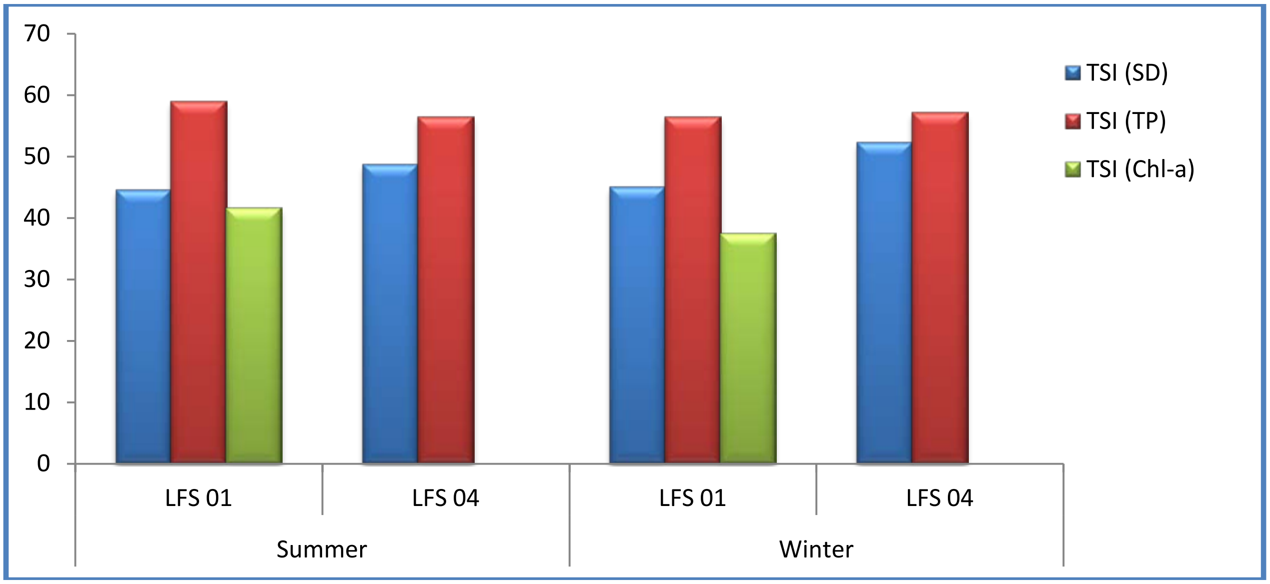


Figure 13. Average trophic state index in Lake Fort Smith in two sampling locations in the summer (July-August) and winter (January-February) months.

3.3 Unified Stream Assessment

A variation of the Unified Stream Assessment (USA) protocol (Kitchel and Schueler, 2004) was completed on the Upper Frog Bayou watershed in April 2012. This visual based field assessment protocol consists of breaking the stream into manageable reaches and evaluating, on foot or by canoe, each reach in its entirety. The evaluation is a screening level tool intended to provide a quick characterization of stream corridor attributes that can be used in determining the most significant problems in each stream reach from a physical, ecological, chemical and hydrologic perspective. General categories of stream corridor characteristics assessed are:

1. Hydrology
2. Channel morphology
3. Substrate
4. Aquatic habitats
5. Land use
6. Riparian buffer
7. Water/sediment observations
8. Stream impacts (non-point source related including stream bank erosion)
9. Floodplain dynamics
10. Geomorphic attributes
11. Restoration/retrofit opportunities

Field data forms completed during the survey are included in Appendix C. A summary of the pertinent findings are summarized in Table 10. Figure 14 provides a color aerial photograph depicting the location of some of the impacts identified. The USA was focused in the upper watershed, above Lake Fort Smith and in the reach immediately below the lake. Jones Fork, Frog Bayou at FB-1 and Frog Bayou between FB-2 and FB-3 were the primary focus areas. The impacts observed and their frequency of occurrence is assumed to be consistent with other comparable stream reaches in the watershed. That is, Jones Fork and/or Frog Bayou above the lake, in reaches not evaluated during the USA, are anticipated to have similar characteristics and issues at a similar frequency to those of the reaches assessed.

Stream bank erosion, impacted riparian buffers (the vegetated zone, including stream banks, along stream corridors) and stream crossings were noted at several areas along Frog Bayou. Stream bank erosion was noted most frequently and varied in severity from moderate to excessive. Bank erosion was often times associated with pasture land uses where the riparian vegetation had been disturbed or removed. Impacted riparian buffers were generally noted in pastures dominated by hay grasses that extended to the stream bank edge and the absence of well-developed vegetated buffers (both trees and under story vegetation) along the stream (Figure 15 and 16). Riparian buffers provide streams with shading that helps cool the water and limit periphyton growth, they provide organic matter inputs which serve as food and habitat for aquatic biota, and they provide stabilization to stream banks that prevents erosion. Well-developed riparian buffers can also filter storm water pollutants and allow for increased rainwater infiltration which aids in protecting the streams hydrology (through decreased peak flows and increased baseflow).

Table 10. Summary of pertinent findings from the USA.

Stream Reach	Significant Problem/Issue	Percent of Stream Length Affected by Number Issue
Jones-1 - Starting near confluence of Frog Bayou upstream to Jones Fork Rd. crossing (1.3 mi)	1- Stream bank erosion 2- Impacted riparian buffers	1- 20% 2- 3.3%
FB-1 – Starting at Bidville Rd crossing downstream approximately 1.5 mi.	1- Stream bank erosion 2- Impacted riparian buffers	1- 17% 2- 7.6%
FB-2 – Beginning at Ash Rd. (CR 333) and downstream to confluence with Hurricane Creek (3.3 mi.)	1- Stream bank erosion 2- Impacted riparian buffer 3- Outfall - Field drain 4- Stream crossings (roads, railroad)	1- 19% 2-0%[1] 3- n/a 4- n/a

[1] Impacted riparian areas did occur in reach FB-2, but were very minor or only associated with road/railroad crossings.

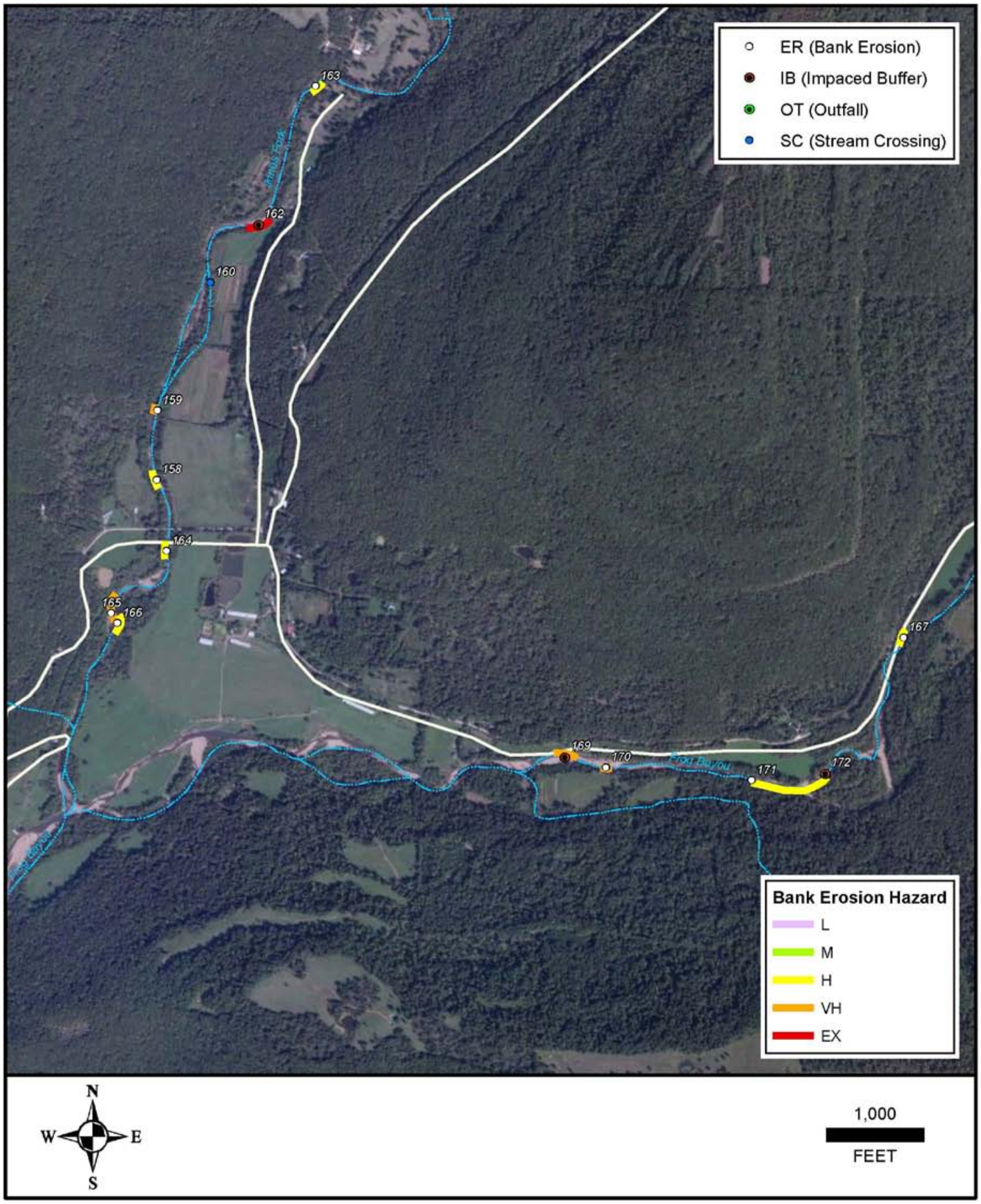


Figure 14. Locations of selected stream impacts identified during the USA in reaches FB-1 and Jones-1. Ratings for bank erosion are: L=low, M=moderate, H=high, VH=very high and EX=excessive.

Figure 15 and 16. Comparison of impacted riparian buffer (little to none) to well-developed riparian buffer.

Bank erosion was noted in several areas. Each instance of bank erosion perceived as moderate risk or greater was tagged with a GPS coordinate and the length of the affected bank measured or estimated. The severity of bank erosion was then characterized using a bank erosion hazard index (BEHI) developed by Dave Rosgen (Rosgen, 2006). The BEHI uses several characteristics of the eroded bank (height, vegetated protection, bank angle, soil composition, etc.) to calculate an overall score that relates to level of erosion hazard. The possible levels are low, moderate, high, very high, and extremely high. Bank erosion observed in the Upper Frog Bayou watershed ranged from moderate erosion and erosion hazard to extremely high (excessive) erosion and erosion hazard. Some of the high to extremely high erosion hazard (Figure 17) were in areas where the riparian buffers had been removed and the banks were greater than 6 feet high. High stream slopes, clear water and the gravel/cobble content of the bank soils in the Frog Bayou watershed make the banks susceptible to erosion when not protected by intact riparian areas.

Figure 17. Stream bank with very high bank erosion hazard in the Upper Frog Bayou watershed.

3.4 Geomorphology and Channel Stability

Fluvial geomorphology refers to the interrelationship between the land surface (topography, geology and land-use) and stream channel shape (morphology). When the force of running water is exerted on the land surface it can have significant effects on the morphology of stream channels. A stable stream, or one said to be in "equilibrium", is one where water flows do not significantly alter the channel morphology over short periods of time. The most important flow level in defining the shape of a stream is its bankfull flow (or effective discharge). Bankfull discharge is the stage at which water first begins to enter the active flood plain. A detailed geomorphic assessment of Upper Frog Bayou watershed was beyond the scope of this project. However, several geomorphic attributes were estimated during the USA, and are helpful in assessing channel stability (Rosgen, 1996). Table 11 provides a summary of the channel dimensions estimated (and some measured) during the USA as well as key stability issues noted.

Table 11. Summary of geomorphic characteristics.

Parameter (approximate/estimated)	Station Identification		
	Jones-1	**FB-1**	**FB-2**
Watershed size (mi^2)	21	34	128
Bankfull depth (ft.)	2.6	4.0	4.5
Bankfull width (ft.)	90	108	130
Substrate size class	Cobble	Cobble	Cobble
Width: Depth ratio	35	27	29
Overall stream bank erosion hazard	Low-moderate	Low-moderate	Moderate
Channel stability issues	Minor widening/bank scour	Minor widening/bank scour	Minor widening/bank scour

In general, each stream reach surveyed was found to be fairly stable, with bank erosion occurring intermittently and erosion hazard for those banks typically in the high to very high range. The channel displayed some minor signs of channel widening and bank scour but no major problems with degradation (channel deepening) or aggradation (channel filling, shallowing) were noted. Many mountain streams in rocky terrain can be flashy during thunderstorms. If those mountain streams are also accompanied by inadequate riparian buffers and banks composed largely of gravel, they can erode quickly, ultimately leading to channel widening and aggradation. There are areas in the Upper Frog Bayou watershed that are at risk of erosion becoming excessive and causing channel widening (See Section 3.3 and 3.7).

3.5 Ecological Condition

Monitoring of aquatic communities is a vital component to understanding potential perturbations to water and habitat quality. The condition of aquatic communities (abundances, diversity, richness, sensitivity, and biological index, etc.) provides important insight regarding water body health and is useful when assessing the aquatic life (fisheries) status of a water body. Macroinvertebrate communities have been sampled by FSU personnel since 1992 at three (3) to four (4) locations in the Upper Frog Bayou watershed as part of their routine watershed monitoring program. Collection and analysis methods generally followed EPA’s Rapid Bioassessment (RBA) protocols (Barbour et al. 1999) for samples collected prior to 2006. Surber samplers are currently used to collect macroinvertebrate samples from riffle areas at each station assessed. Fish communities were sampled in the Upper Frog Bayou watershed from 2002 to 2013 using electroshocking methodology based on EPA’s RBA protocols (Barbour et al. 1999). Fish samples were analyzed to determine community metrics typically associated with fish bioassessment and to calculate an index of biotic integrity (Plafkin, 1989). Data from the more recent collections of both macroinvertebrates and fish will be the focus of this evaluation.

3.5.1 Macroinvertebrate Community

Benthic macroinvertebrates inhabit the sediment or live on the bottom substrates of streams, rivers and lakes. The presence of these organisms and their diversity and tolerance to environmental perturbation at an expected level reflects the maintenance of a systems biological integrity. Monitoring these assemblages is useful in assessing the aquatic life status of the water body and detecting trends in ecological condition.

Several macroinvertebrate metrics are calculated for the collections completed by FSU. These metrics include: taxa richness and Ephemeroptera, Plecoptera, Trichoptera (EPT) richness, average tolerance and percent clingers. Several of the metrics calculated are used to determine a stream condition index (SCI) originally developed by the National Park Service (NPS) for National Scenic Riverways (Bowles, 2007). Taxa richness and EPT richness of the Upper Frog Bayou watershed stations have shown a general trend for increasing from 2003 to 2011. Taxa richness has increased from 22-28 species in 2003 to 34-53 species in 2012, with a decline in 2013. In 2003, EPT richness ranged from 10 to 14 species, increasing to a richness of 16 to 18 species in 2012, with a decline in 2013 (Table 12). All of the taxa richness values score above the quartile of the NPS SCI data from 2005-2012. Higher taxa richness indicates improving water quality and more habitat diversity. Rather than using the NPS SCI, FSU developed their own SCI using the same methodology that the NPS used. The FSU SCI uses four metrics (taxa richness, EPT richness, tolerance and % clingers) each scored independently as either a 5, 3 or 1, depending on how it compares to the reference condition. A total score (sum of all four metric scores) between 16 and 20 indicates a community that is unimpaired and is fully maintaining all designated uses, a score between 10 to 14 indicates impairment (Table 13). The lowest SCI score calculated for the Upper Frog Bayou watershed stations (FB-1, Jones-1 and Jack Creek) from 2005 to 2011 was a 16, indicating that all the streams assessed were unimpaired. In 2012 and 2013, scores ranged from 8 to 16 indicating impairment. Climatic conditions could have had a large impact on the biotic communities in 2012. In May and June of 2011, very high flood events occurred. Following what is assumed to be a 100 year storm event which resulted in a large scour to the biota, was an extreme drought period. These climatic conditions could have been temporarily detrimental to the macroinvertebrate communities, explaining the low SCI scores for winter 2012 and 2013. However, the spring 2013 communities seem to be recovering and future sampling periods will hopefully show a return to the conditions prior to winter 2012 (Table 13).

Table 12. Comparison of SCI metrics for first quarter samples from the Upper Frog Bayou watershed.

	Frog Bayou -1	Jack -1	Jones -1
Date	Taxa Richness		
3/6/2003	24	22	28
2/20/2004	25	28	33
3/10/2005	30	29	32
3/20/2010	--	--	41
3/3/2011*	40	36	36
3/28/2012*	46	53	34
3/4/2013*	19	25	28
EPT Richness			
3/6/2003	13	10	14
2/20/2004	14	15	18
3/10/2005	17	17	18
3/20/2010	--	--	21
3/3/2011*	17	15	12
3/28/2012*	16	18	18
3/4/2013*	9	10	12
Average Tolerance			
3/6/2003	4.52	4.14	4.26
2/20/2004	4.72	4.22	4.25
3/10/2005	4.18	4.16	4.11
3/20/2010	--	--	3.66
3/3/2011*	3.45	3.82	4.33
3/28/2012*	5.49	5.62	4.67
3/4/2013*	4.45	4.40	4.30
% Clingers			
3/6/2003	34.8	30.0	42.3
2/20/2004	37.5	30.8	45.2
3/10/2005	39.3	40.7	40.0
3/20/2010	--	--	31.7
3/3/2011*	38.9	13.2	46.1
3/28/2012*	17.4	22.6	35.3
3/4/2013*	31.6	20.0	35.7

*Pennington and Associates composite method.

Table 13. Comparison of SCI scores for first quarter samples from the Upper Frog Bayou watershed.

	Frog Bayou -1	Jack -1	Jones -1
Date	Stream Condition Index		
3/6/2003	12	14	16
2/20/2004	12	18	20
3/10/2005	20	20	20
3/20/2010*	--	--	18
3/3/2011*	20	16	16
3/28/2012*	12	12	14
3/4/2013*	8	10	16

*Pennington and Associates composite method.

3.5.2 Fish Community

Fish communities of the Upper Frog Bayou watershed were examined using community tolerance structure, % dominant functional feeding groups, and Index of biotic integrity (IBI) scores for fishes collected by FSU from 2010 to 2013. Based on available data, fish communities were dominated by species intermediate to pollution perturbation (Table 12). Data indicate community tolerance structure may represent relatively sensitive fish communities within the Upper Frog Bayou watershed. Fish communities of the Upper Frog Bayou watershed have been consistently dominated by insectivores (57.1-83.3%; Table 14). Fish communities are typically dominated by insectivorous fishes in most North American waters (Barbour et al. 1999). Percent insectivorous fishes in a community provides information regarding the condition of the fish food base. As the fish food base responds to changes in the quality and quantity of available resources (natural or anthropogenic), changes in the functional feeding structure of fish communities are expected to occur (Barbour et al. 1999). IBI scores were calculated using 12 metrics from Rapid Bioassessment Protocols for Use in Stream and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition. EPA 841-B-99-002. Metrics included: percent native fishes, percent darters and madtoms, percent sunfish, percent cyprinids, percent tolerant fish, percent omnivores, percent insectivores, percent carnivores, number of individuals, percent hybrids, percent disease. Scores for all 12 metrics were added ranging from a maximum IBI score of 60 (excellent) to a minimum of 12 (very poor). IBI scores varied across sites and across years and ranged between a minimum of 40 to a maximum score of 48 (Table 14). Using Fort Smith's IBI criteria, fish communities of the

Upper Frog Bayou watershed fluctuate within the fair to good range, yet remain relatively stable over time (Table 14).

Table 14. Comparison of fish community tolerance structure, functional feeding groups, and IBI scores among stations within the Upper Frog Bayou watershed for 2010 or 2011 to 2013.

Sites	Year	% Intolerant Taxa	% Intermediate Taxa	% Tolerant Taxa	% Insectivore	% Herbivore	% Other	IBI
Jack Creek	2010	25.0	75.0	0.0	83.3	8.3	8.3	46.0
	2013	14.3	53.3	28.6	57.1	7.1	35.7	40.0
Frog Bayou	2010	28.6	71.4	0.0	71.4	14.3	14.3	48.0
	2013	16.7	58.3	25.0	75.0	8.3	16.7	44.0
Jones Fork	2011	18.2	63.6	18.2	81.8	9.1	9.1	40.0
	2013	11.8	70.5	17.6	70.6	5.8	23.5	44.0

Summary

Overall, macroinvertebrate and fish communities within the Upper Frog Bayou watershed seem to be relatively diverse and stable compared to reference conditions. Although community metrics varied across sites and years, all macroinvertebrate communities have shown a general trend for increased quality. Over the years, all fish communities have been dominated by intermediate tolerance species, insectivorous fishes, and IBI scores that range within the fair to good category. Based on fish and macroinvertebrate metrics evaluated the aquatic community appears to be maintaining its biological integrity with relatively sensitive and diverse communities throughout the Upper Frog Bayou watershed.

3.5.3 Periphyton Community

Periphyton are algae that live attached to bottom substrates in streams, rivers and lakes. They are the foundation of the food web in most aquatic systems and as such are referred to as primary producers. The abundance and diversity of periphyton may serve as an indicator of habitat suitability and water quality, particularly in regards to nutrient enrichment and energy availability.

The periphyton community was assessed in a qualitative fashion as part of the USA. Estimates of algal coverage were made in each reach for three groups of algae: filamentous, prostrate and floating. The results of the qualitative observations are provided in Table 15.

Table 15. Summary of periphyton abundance (coverage) assessment.

Station	Filamentous	Prostrate	Floating
Jones-1	Sparse	Moderate	None
FB-1	Sparse	Moderate	None
FB-2	None	Moderate	None
FB-2.5	None	Moderate	None

Periphyton (filamentous and prostrate) requires four main things to grow; light, nutrients, warmth and a suitable substrate. Nutrient levels are fairly low in the Upper Frog Bayou sub-watershed. However, there is still ample phosphorus and nitrogen for algal growth. The water in Upper Frog Bayou watershed is clean and clear allowing for plenty of light penetration. Arkansas' mild climate allows for algal growth nearly anytime during the year, but the hot summers are still expected to create the best conditions for proliferation of periphyton. The cobble, boulders and bedrock substrates dominating in the Upper Frog Bayou watershed are the good substrate for growth of these algae. Considering all these factors which are conducive for algal growth, periphyton coverage was only moderate, indicating an equilibrium of nutrient levels, stream flow and habitat conditions in the reaches assessed.

3.5.4 Habitat for Aquatic Biota

Physical habitat in streams includes all those physical characteristics that influence or provide sustenance to biological attributes, both botanical and zoological, within the stream. Stream physical habitat varies naturally, as do biological characteristics; thus, habitat conditions differ even in the absence of point and anthropogenic non-point disturbance. Within a given ecoregion, stream drainage area, stream gradient, and geology (geomorphology) are likely to be strong natural determinants of many aspects of stream habitat, because of their influence on discharge, flood stage, and stream energy (both static and kinetic). In addition, land-use activities or instream physical modifications, such as channelization, channel diversion, or dam construction directly or indirectly impact the habitat in a stream.

Habitat for aquatic biota was visually evaluated as part of the USA. The habitat observed in the stream reaches assessed during the USA appeared to offer good habitat for aquatic biota, particularly for macroinvertebrates. Some of the upper stream reaches (Jones-1 and FB-1) have less developed habitat due to their smaller watershed sizes and reduced flow, but are still capable of sustaining a healthy and relatively diverse perennial fishery. Substrate was mostly cobble or coarse gravel, with frequent riffles and pools. Riparian areas were generally forested and provided some shading and organic material to the streams to support aquatic life.

3.6 Hydrologic Analysis

The hydrologic regime of a stream (magnitude and frequency of flow) influences the shape of the stream channel, the type and abundance of habitat available to biota, and the type and load of pollutants transported in the system. Geology, land use, weather patterns or seasons affect the hydrologic regime of a stream. Understanding a streams hydrology is integral to the assessment of stream stability, ecology and water quality.

Historical Streamflow Analysis

Stream flow in the Upper Frog Bayou watershed was analyzed using data from the United States Geological Survey (USGS) website (http://waterdata.usgs.gov/nwis/rt). USGS has gauging stations at three stream locations in the Upper Frog Bayou watershed: Frog Bayou at Winfrey, AR (USGS gauge No. 07250965); Jack Creek near Winfrey, AR (USGS gauge No. 07250974); and Jones Fork at Winfrey, AR (USGS gauge No. 07250935). The most recent 10 years of annual summary and daily data from USGS for each of the four locations of interest in the Upper Frog Bayou watershed were compiled and analyzed. The annual summary and daily data from USGS provides the annual average discharge (cfs), lowest average monthly discharge (cfs), highest average monthly discharge (cfs), the seven-day low flow (cfs), 90 percent exceedance (cfs), and the peak flow (cfs). The 90 percent exceedance statistic is the discharge that has been exceeded 90 percent of the time for the designated period, which in this case is 10 years.

The three gages analyzed represent three stream sub-watersheds in the Upper Frog Bayou watershed (Table 16). Each stream gauge analyzed in the Upper Frog Bayou watershed has a seven-day, low flow 10-year (7Q10) of zero, indicating that for at least seven consecutive days all of the study streams ceased flow at least once in the last 10 years. Water quality may deteriorate as streams begin to dry. Stream water becomes shallow when drying, increasing water temperatures, and decreasing dissolved oxygen levels, which has the potential to impact fish and some macroinvertebrates. Studies have found that longer-lived more sensitive taxa such as stoneflies, and free-living caddisflies are less likely to proliferate in streams that dry seasonally. The studies found that those taxa did not successfully recruit the following year despite the fact that the baseflow water levels were higher than the year prior. Taxa that are highly mobile or can withstand drying can recolonize a stream more quickly and can be found in seasonally dry streams. Water is essential to maintain healthy fish communities. Fish are forced to move downstream or to intermittent pools when flow ceases and streams begin to dry. Streams that have a history of drying seasonally have biotic communities that are adapted to drying, living in intermittent pools, or finding refugia in the hyporheic zone. Streams that dry seasonally may have less diverse, less sensitive taxa depending on the longevity and severity of the drying compared to streams that flow year around (Boulton, 2003).

Table 16. Summary of discharge data from 2001-2014, collected from USGS gauge data.

Site	Annual average discharge (cfs)	Lowest monthly discharge (cfs)	Highest monthly discharge (cfs)	7 day, 10 yr. low flow (cfs)	90% exceed (cfs)	Peak flow (cfs)
Frog Bayou at Winfrey	81.3	0.02	561	0	0.9	21,800
Jack Creek	8.9	0.00	61	0	0.0	681
Jones Fork	51.9	0.00	643	0	0.0	15,100

All three study streams have a peak flow at least two orders of magnitude higher than the annual average discharge (Figure 18). The Upper Frog Bayou watershed has a moderate level of pasture land use with the remainder of the land being forested. Pasture land use may be influencing stream flow as a result of reduced forest riparian area and the installation of drainage systems. When comparing a stream surrounded by forested land use to streams surrounded by altered land whether it is urban, pasture, or both, stream channels are often scoured to a greater mid-channel depth from unnaturally high peak flows resulting from the greater runoff created when forest land is altered (Poff et.al, 1997). In addition to scouring, streams surrounded by pasture land have a higher potential to acquire sedimentation within a stream reach from exposed soils and altered riparian areas along the stream bank. Although streams in the Upper Frog Bayou watershed have a notable level of pasture land use surrounding the streams, the majority of the watershed is mountainous-forested land. The topography may be influencing the hydrologic regime more than pasture land use. Mountain streams are usually considered to be flashy systems or systems that have rapid rates of change (Allan, 1995, Poff et. al, 1997). Figure 19 shows the flashy hydrograph of Frog Bayou near Winfrey, AR during a storm event. Flashy streams such as Frog Bayou have potential for bank erosion with such a large flux of water in a short amount of time. The stream flow increases by an order of magnitude in less than one day. Frog Bayou rises very quickly but the hydrograph shows that it drops much slower than it rose and could be a consequence of the steep terrain and well drained soils.

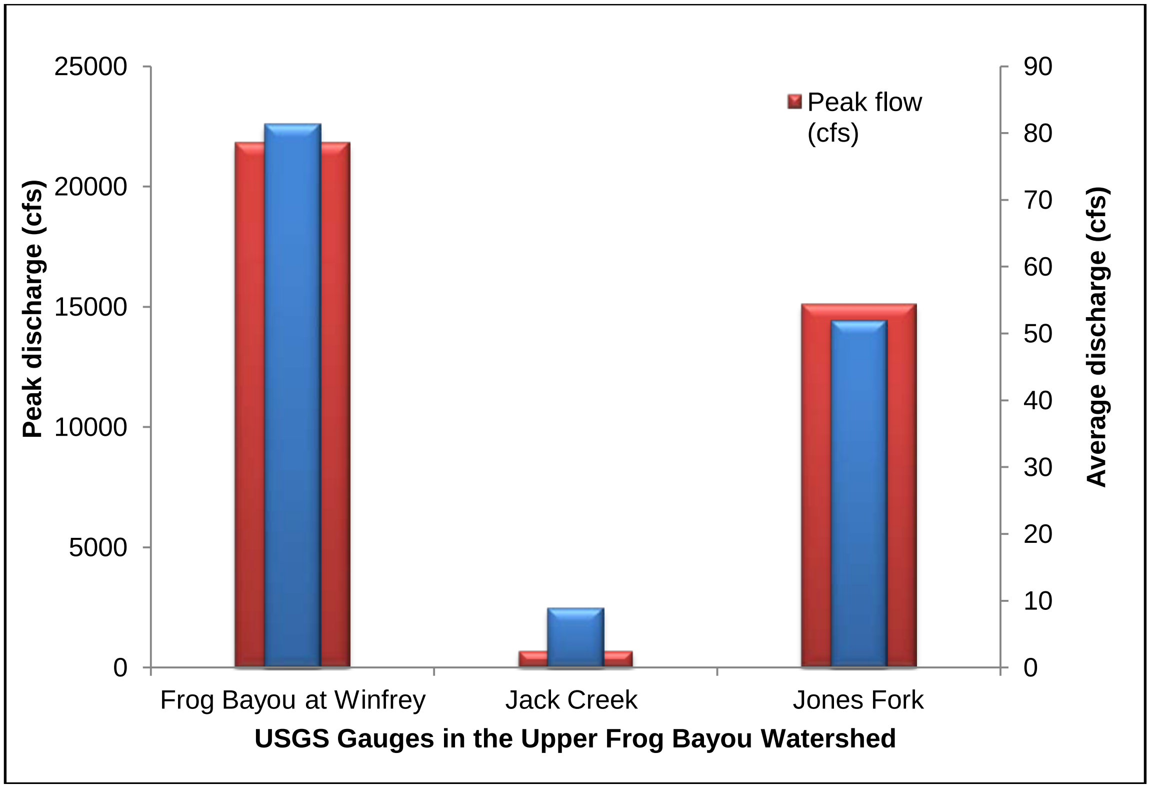


Figure 18. Comparison of the annual average and peak flows of the study sites in the Upper Frog Bayou watershed.

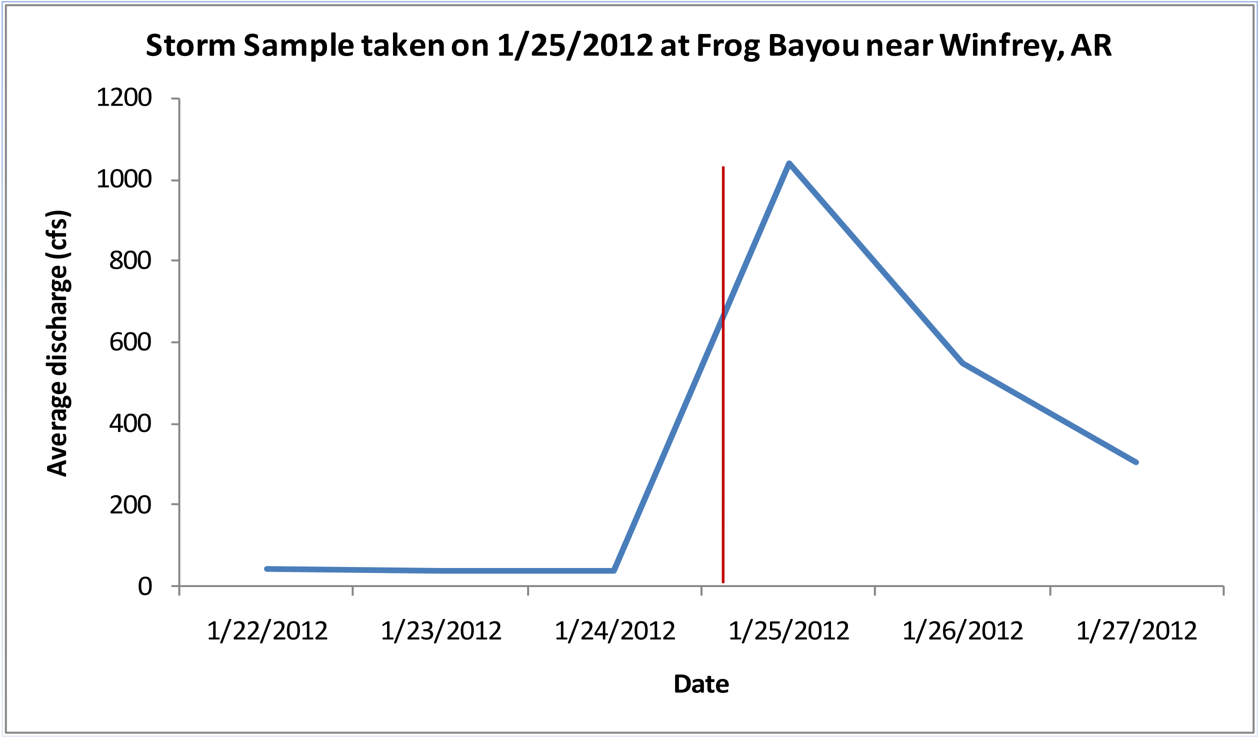


Figure 19. Storm hydrograph from Frog Bayou near Winfrey, Arkansas (FB-1) on January 25th, 2012. Hydrograph data was collected from USGS. Vertical red line indicates sample collection time in the hydrograph.

Hydrologic regime is a major determinant of physical form in streams and physical form is a major determinant in biotic diversity in streams (Bunn and Arthington, 2002). Biological communities are adapted to the historical flow conditions and these conditions should be considered when analyzing biological data in any watershed.

3.7 GIS Non-point Source Assessment

An assessment of the Upper Frog Bayou watershed was completed using GIS resources including soils maps, land surface slope (DEM), land use, aerial photographs, etc. The assessment was focused on identifying possible non-point sources of pollutants that could be transported to the stream system during storm runoff events. The assessment was completed on a sub-watershed basis.

3.7.1 Land Use by Watershed

Land use was evaluated using 2006 land-use land cover data from the United States Geological Survey. Land use is an important attribute in a watershed analysis. The percent of pasture, row crops, and developed areas can provide great insight into a watersheds potential for NPS pollution. A summary of the land use assessment is provided in Table 17.

Table 17. Land use by sub-watershed.

Land use	Sub-watershed		
	Jones-1	FB-1	FB-2 (Lake)
Watershed Area (mi^2)	20.9	34.0	29.3
Water	0.01	0.00	4.82
Open space (developed)	2.35	1.24	3.57
Developed (urban/suburban)	0.46	0.05	0.77
Forest	82.91	84.06	81.13
Herbaceous/Scrub/Shrub	1.59	2.09	1.65
Pasture	12.66	12.43	7.86
Crops	0.00	0.00	0.01
Wetlands	0.01	0.14	0.18

None of the sub-watersheds have significant levels of row crops or wetlands (all less than 1%). The Jones Fork and the Headwaters sub-watersheds (Jones-1 and FB-1) have very low percentages of development (less than 0.50%) but have a fair amount of pasture (just over 12% in each). Pastures are generally associated with cattle use, commercial fertilizer, poultry litter use as fertilizer, or any combination of the three. Each association can be, and generally is, a source of nutrients to the stream system.

Development is low throughout the Upper Frog Bayou watershed, with the highest concentration of developed area being in the Lakes sub-watershed, which includes some of HWY 71. Developed areas are known to contribute several different pollutants to stream systems, such as nutrients and organic constituents such as BOD and TOC, and create much greater volumes of runoff than do forests or pasture land uses. The greater volumes of runoff have negative effects on stream channels causing increased bank erosion (due to higher storm peak flow) which adds sediment and nutrients to the stream and causes channel bed scour, which can disrupt aquatic habitats.

3.7.2 Riparian Buffer Impacts

Often times pasture land use can be associated with impact to riparian buffers as farmers clear forest to create larger pastures and as cattle grazing encroaches on the stream banks. Impacts from cattle overgrazing and frequent stream access was assessed during the USAs and was not found to be an obvious problem in the watershed. However, impacted riparian buffers from pasture creation (and loss of buffer from bank erosion) were found to be a common problem. Therefore, each main stem perennial stream (identified per USGS maps) in the associated sub-watershed was examined through aerial photography to estimate how many linear feet of stream was affected by loss of riparian buffer. These lengths were than divided by the total length of perennial stream in that sub-watershed to represent percent of stream with impacted riparian buffers and assess where significant problems might exist (Table 18).

Table 18. Summary of impacted riparian buffer analysis.

Parameter	Sub-watershed		
	Jones-1	FB-1	FB-2 (Lake)
Length impacted buffer (ft.)	1,079	1,007	981
Total stream length (ft.)	32,577	30,993	6,230
Percent stream affected	3.3	3.2	15.7

Jones Fork (Jones-1) and Headwaters (FB-1) have small percentages of impacted riparian buffer (<4%) while the lower reaches of Upper Frog Bayou watershed (FB-2) has a higher percentage, in excess of 15%.

3.7.3 Land Slope

A land slope analysis was also completed for the watershed, and is provided in Table 19. Slope data supports the concept that pasture abundance and size increases along with the associated riparian disturbance in flatter slope areas lower in the watershed. In addition to the connection between flatter slopes and increased pasture land use, there is a connection between steeper slopes and increased erosion potential, both on the land and stream banks. High slope (steep) areas have a higher potential for soil loss during high volume rain events and those areas also provide less opportunity for infiltration, allowing more water to runoff into the stream channels which can cause increased stream bank erosion and channel scour. Slope in the headwaters of Frog Bayou (Jones Fork (Jones-1) and Headwaters (FB-1) sub-watersheds) are very high, providing the potential for rainfall to be highly erosive and stream channels to scour during large rain events.

Table 19. Summary of land slope analysis.

Slope (percent)	Sub-watershed		
	Jones-1	FB-1	FB-2 (Lake)
0-5	11.3	16.1	16.4
6-15	8.1	4.5	9.6
16-30	53.1	65.1	69.3
31-45	7.6	0.1	4.7
46-60	20.0	14.2	0.0

3.7.4 Soils

Soils on the land surface in the watershed are primarily dominated by the Nella, Enders and Linker soil series. These soils are composed mostly of a gravely sandy loam, and have a moderate overall potential for erosion. However, linked with the high slopes in some of the sub-watersheds, they can produce significant soil loss during heavy rain events.

3.7.5 Agricultural Animal Numbers

Lastly, numbers of agricultural animals were estimated in the watershed using poultry house counts from ground truth surveys in the upper watershed and the county agricultural census data in the lower watershed. Cattle counts were also conducted in the upper watershed and estimates made in the lower watershed using census data. In the case of poultry houses, each broiler house is assumed to be managed consistent with industry standards. Houses generally contain approximately 24,000 birds each, have 5-6 batches per year and are cleaned out approximately 2 times per year. Poultry litter (a combination of manure and bedding material) is frequently used as fertilizer on pastures in Arkansas and its use was observed in the Upper Frog Bayou watershed during the USA. For cows the number of “all cattle and calves” for the county were used along with the number of acres of pasture in the county to calculate number of cows per acre. Cows were assumed to be evenly spread out over the pastures in the county. A cows/acre number was then applied to each sub-watershed using the number of acres of pasture determined through the land use analysis. A table presenting the agricultural animal estimates is provided in Table 20. No active poultry houses were identified in the Upper Frog Bayou watershed.

Table 20. Agricultural animal estimates per sub-watershed.

	Sub-watershed		
Animal	**Jones-1**	**FB-1**	**FB-2 (Lake)**
All Cattle/Calves	762	1220	663
Poultry-Broilers[1]	0	0	0

[1] Poultry numbers based on total number on farms at a point in time, not total produced annually.

Cattle numbers in the Upper Frog Bayou watershed are typical of the region.

3.7.6 Unpaved Roads

Unpaved roads (gravel forest roads and OHV trails) are common in the Upper Frog Bayou watershed. There are over 100 miles of unpaved roads in the Upper Frog Bayou watershed. During storm events these roads can transport significant loads of sediment into adjacent streams. The magnitude of the sediment load varies dependent on many factors including; proximity to streams, condition of the road, slope and the design of the road. Forest roads can be designed to include BMPs that reduce erosion and transport of sediment.

Miles of unpaved road were determined from GIS road layers for each sub-watershed in Arkansas. A summary of this data is provided in Table 21. Sediment loading for each mile of unpaved road was estimated based on a recent study completed in Pennsylvania by the Center for Dirt and Gravel Road Studies (Penn State University). The study determined the load of sediment transported for several different unpaved road types and conditions that would result from a 0.6 inch rain event occurring over 30 minutes. For purposes of the Upper Frog Bayou watershed assessment an average rate of sediment transport was set at 485 lbs. /mile of unpaved road per rain event. The 485 lbs. /mi sediment rate was the average of the runoff rate from roads with average maintenance and traffic levels and roads that had been recently topped with fresh aggregates which produce much lower levels of sediment runoff. Twelve rain events (>1.0 inch) were assumed to occur each year (data from Fort Smith, AR station (FSM) and each rain event would result in 485 lbs. sediment per mile of road (Table 21).

Table 21. Summary of Unpaved Roads in the Upper Frog Bayou Watershed.

	Jones-1	FB-1	FB-2 (Lake)
Unpaved Roads (mi)	31.4	31.2	42.1
TSS Load Annually (lbs.)	182,457	181,759	245,022

4.0 Loading Analysis

4.1 Delineation of the Upper Frog Bayou Watershed Loads

Loading of pollutants in the Upper Frog Bayou watershed was calculated from the baseflow and storm flow data collected during the study. Loading was also calculated from the historical data collected by the FSU at monitoring stations where USGS gauge data was available (Jones-1, FB-1, and Jack Creek). The focus of the loading analysis will be on the new data collected during this study and the FSU storm data collected at the gauging station locations. A summary of the load for key constituents is provided in Table 22. Loads were calculated on a daily basis from new sample data collected and flow data recorded during each sample event.

Table 22. Average Loading of Key Constituents.

Station	Baseflow Load (lbs./d)			Storm Flow Load (lbs./d)		
	TSS	NO3+NO2-N	TP	TSS	NO3+NO2-N	TP
Jones-1	782	77.2	3.1	85139	625	229
FB-1	913	77.1	3.7	199407	1276	499
FB-2	1375	146.4	5.5	6256	299	15.9
Jack-1	--	--	--	767	36	3.0

The storm flow loading of TSS appears to be greatest in the sub-watersheds FB-1 (Headwaters) and Jones-1 (Jones Fork). Storm flow loading of nitrate+nitrite-N and phosphorus also appears to be greatest in the FB-1 and Jones-1 sub-watersheds. However, loading viewed in this fashion is misleading when used to assess critical NPS that need to be addressed, as some of the sub-watersheds are much larger than others and thus will have greater flows which have a direct influence on load. In order to account for watershed size, loads from each of the sub-watersheds were normalized according to watershed area (in acres) to arrive at a loading in each watershed on a per acre basis. The load used for this analysis was from the largest storm event sampled during the study (Table 23) as it is believed to portray potential loading from NPS best.

Table 23. Storm flow loading of key constituents on a per acre basis.

Station	TSS (lbs./acre)	NO3+NO2-N (lbs./acre)	TP (lbs./acre)
Jones-1	6.365	0.047	0.017
FB-1	9.164	0.059	0.023
FB-2	0.334	0.016	0.001
Jack-1	0.174	0.008	0.001

When loading is evaluated on a per unit area basis it becomes clear which sub-watersheds have land uses that are producing the most pollutants during runoff events. Sub-watersheds FB-1 and Jones-1 have the highest TSS and nutrient loads per acre of land in the overall watershed (Figures 20 and 21).

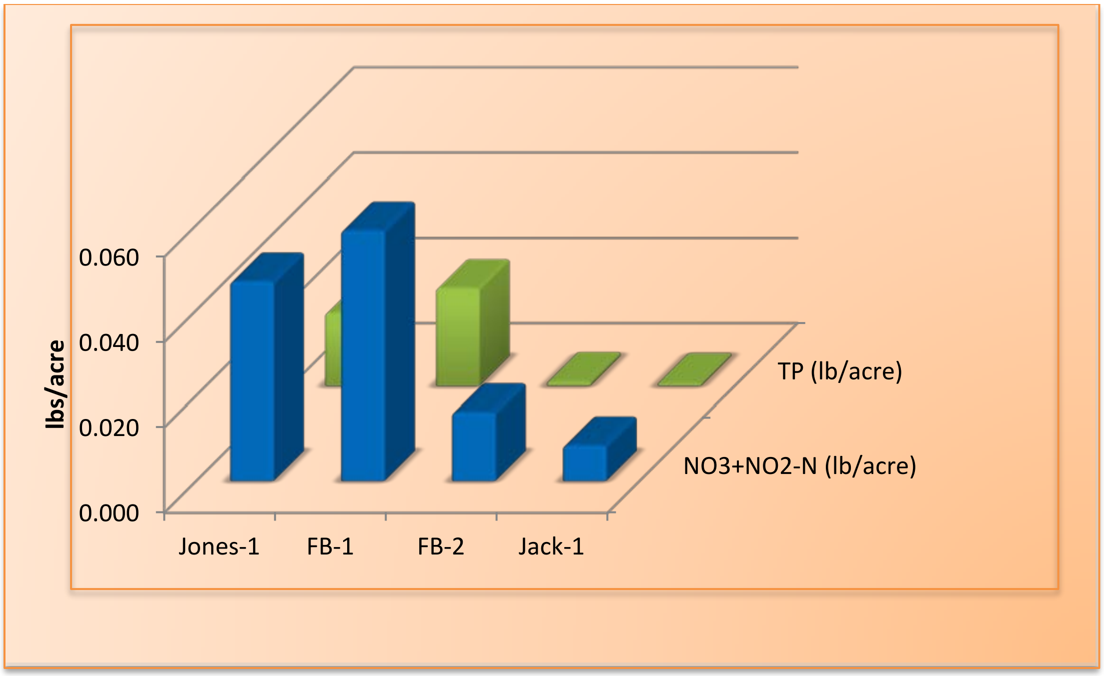


Figure 20. Pounds of nutrients on a per acre basis during storm events.

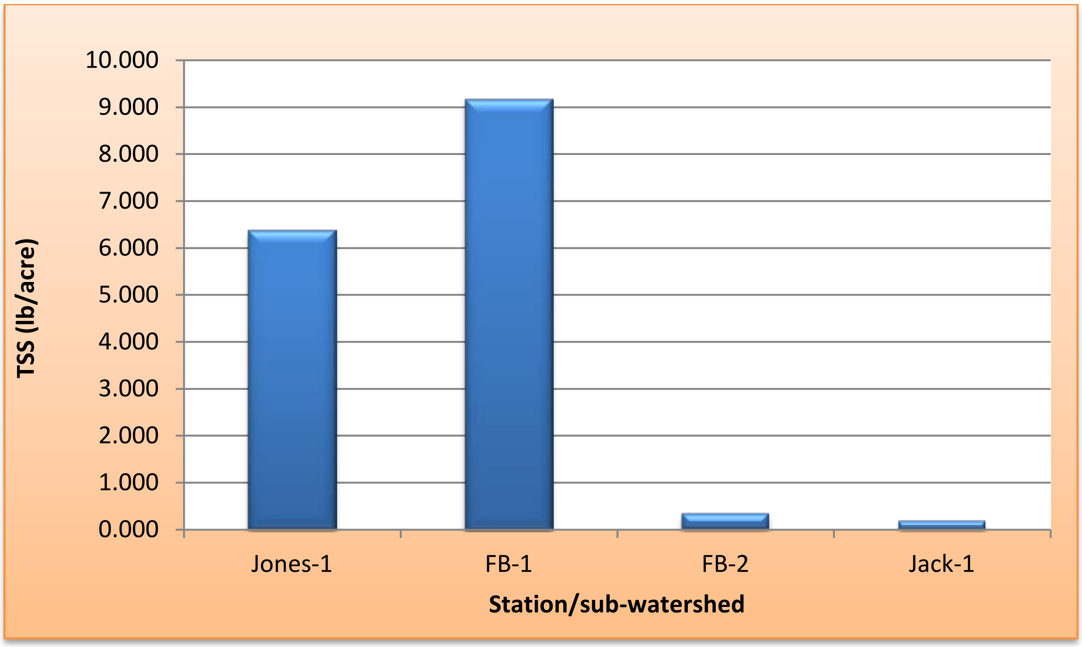


Figure 21. Load of TSS during storm flow in pounds/acre.

The focus of load reductions will be in sub-watersheds producing the most TSS (sediment) per acre (Figure 22). Sediment reduction efforts achieved through implementation of management measures will also be accompanied by nearly proportional decreases in nutrients and other sediment born pollutants. The FSU has the best opportunity to work with land owners in Upper Frog Bayou watershed, sub-watersheds FB-1, FB-2 and Jones-1, in areas that drain to Lake

Fort Smith. Again, watershed management efforts will be focused in these sub-watersheds (Figure 23).

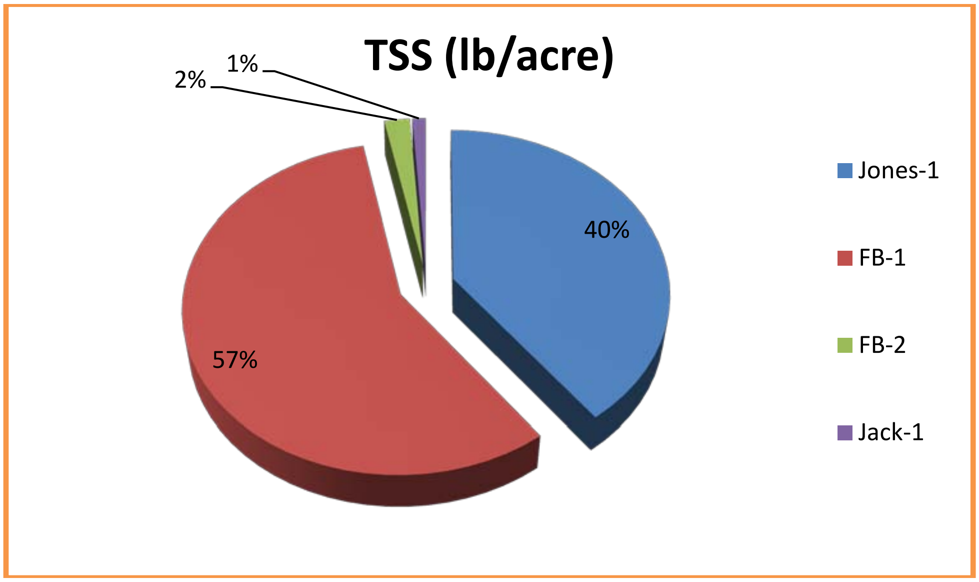


Figure 22. TSS loading during storm flow proportional to whole upper watershed.

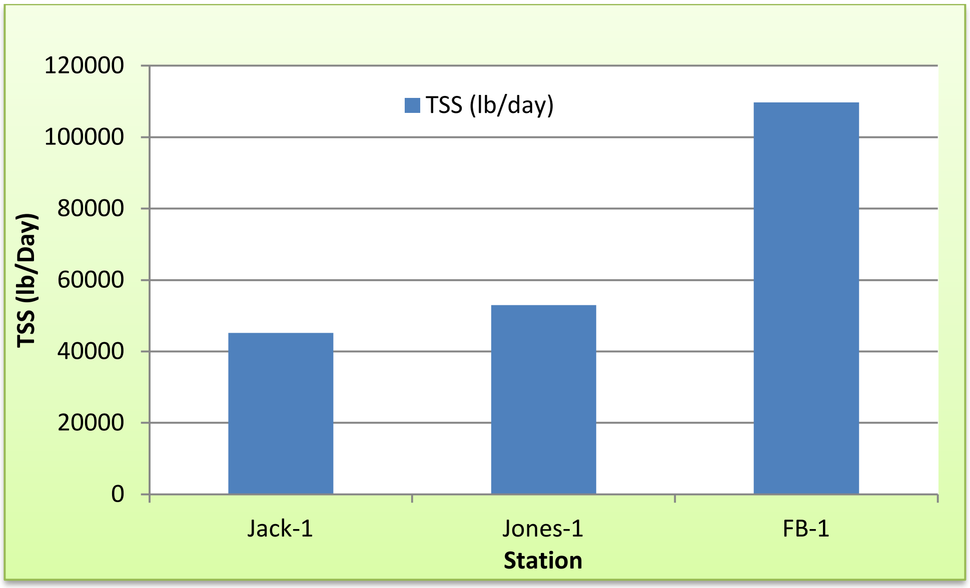


Figure 23. Average daily TSS loading during storm flow in upper watershed per FSU data.

4.2 Recommended Load Reductions

Based on the Designated Use Assessment Criteria (Section 3.1) sub-watersheds in the Upper Frog Bayou watershed appear to be maintaining their Arkansas designated uses and are producing high quality water.

A comparison was made between the FSU data collected since 1992 and ambient water quality data collected by the Arkansas Department of Environmental Quality from the least disturbed streams in the Boston Mountain Ecoregion of Arkansas. Figures 24-26 present the comparisons of the sites water quality for total phosphorus, TSS and nitrate+nitrite-N. Note, different detection levels were used by the two reporting entities and had to be normalized in order to compare this data. This was done by using the FSU detection levels for all data. These charts depict the mean and 95% confidence interval as diamonds and also represent the mean plus or minus two standard deviations. ADEQ reference stations are identified with a "Ref" in the site name.

The water quality in the Upper Frog Bayou watershed, for these key constituents, is similar to the high quality Boston Mountain streams for sediment but slightly different for phosphorus and nitrate+nitrite-N. On average total phosphorus and nitrate+nitrite-N data has been slightly higher in each of the headwater streams compared to the reference conditions. New data collected during this study is lower for both total phosphorus and nitrate+nitrite-N (more similar to the ADEQ reference data), and indicates that the differences may be more a result of elevated detection levels seen in older data (see comparison of means presented in Tables 1 and 3 in this report) than actual water quality differences.

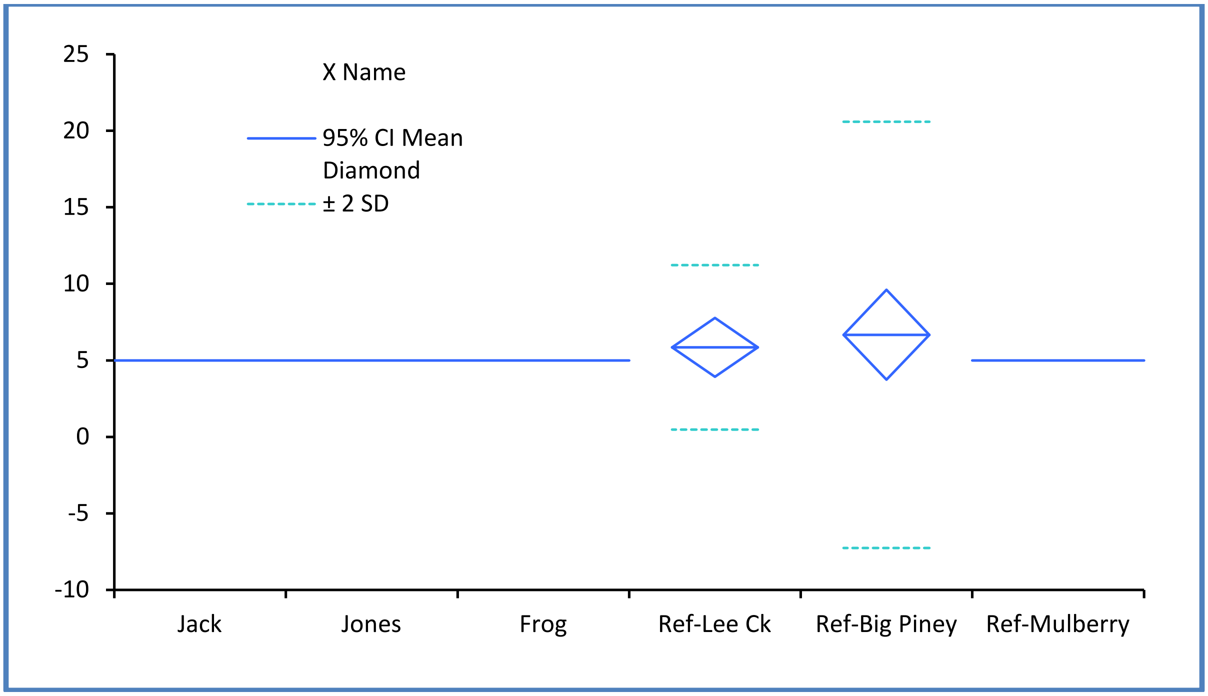


Figure 24. Comparison of TSS levels in Frog Bayou watershed to Boston Mountain least disturbed streams.

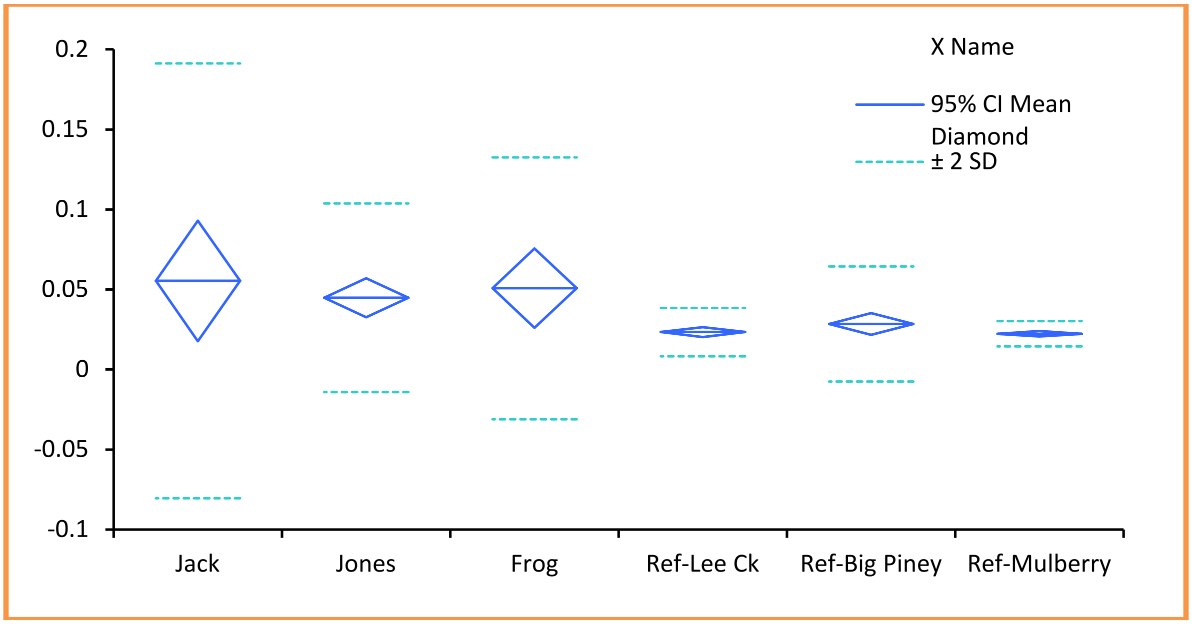


Figure 25. Comparison of total phosphorus levels in Frog Bayou watershed to Boston Mountain least disturbed streams.

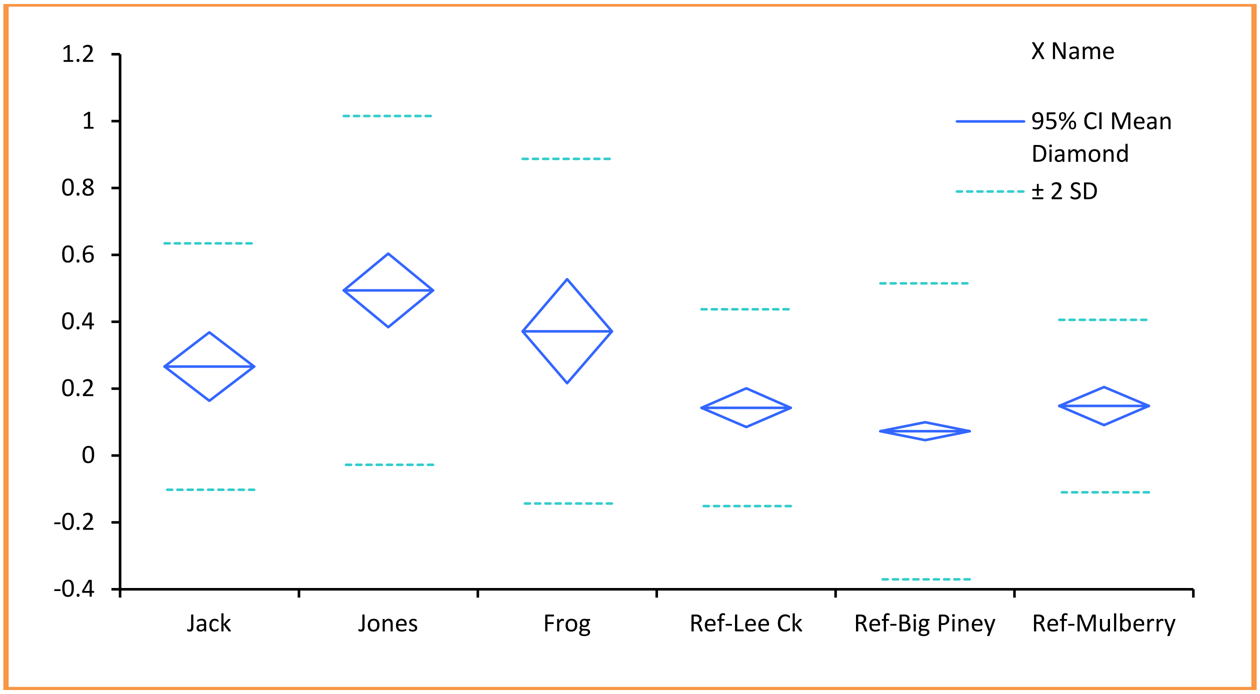


Figure 26. Comparison of nitrate+nitrite-N levels in Frog Bayou watershed to Boston Mountain least disturbed streams.

Considering the results of the Designated Use Assessment and the similarity of the water quality to least disturbed Boston mountain Streams no load reductions are required to meet Arkansas water quality standards. The FSU understands that the Upper Frog Bayou watershed is directly adjacent to watersheds classified by the Arkansas legislature as “nutrient surplus watersheds (i.e. the Illinois River).” It is a concern that nutrients from agricultural animal manure could be transported into the Upper Frog Bayou watershed from adjacent watersheds.

It is the goal of the FSU to continually improve upon the drinking water quality in Lake Fort Smith and to protect the watershed from water quality degradation. In order to meet this goal a proactive target for 10% reduction of sediment and phosphorus loading to Lake Fort Smith will be designed to protect and improve water quality. Reduction of sediment loading (Figure 27) will be the main focus of the implementation efforts and monitoring, as a proportional reduction in nutrients generally parallels sediment or total suspended solids (TSS) reduction. These reductions will be achieved following the plan outlined in the sections that follow.

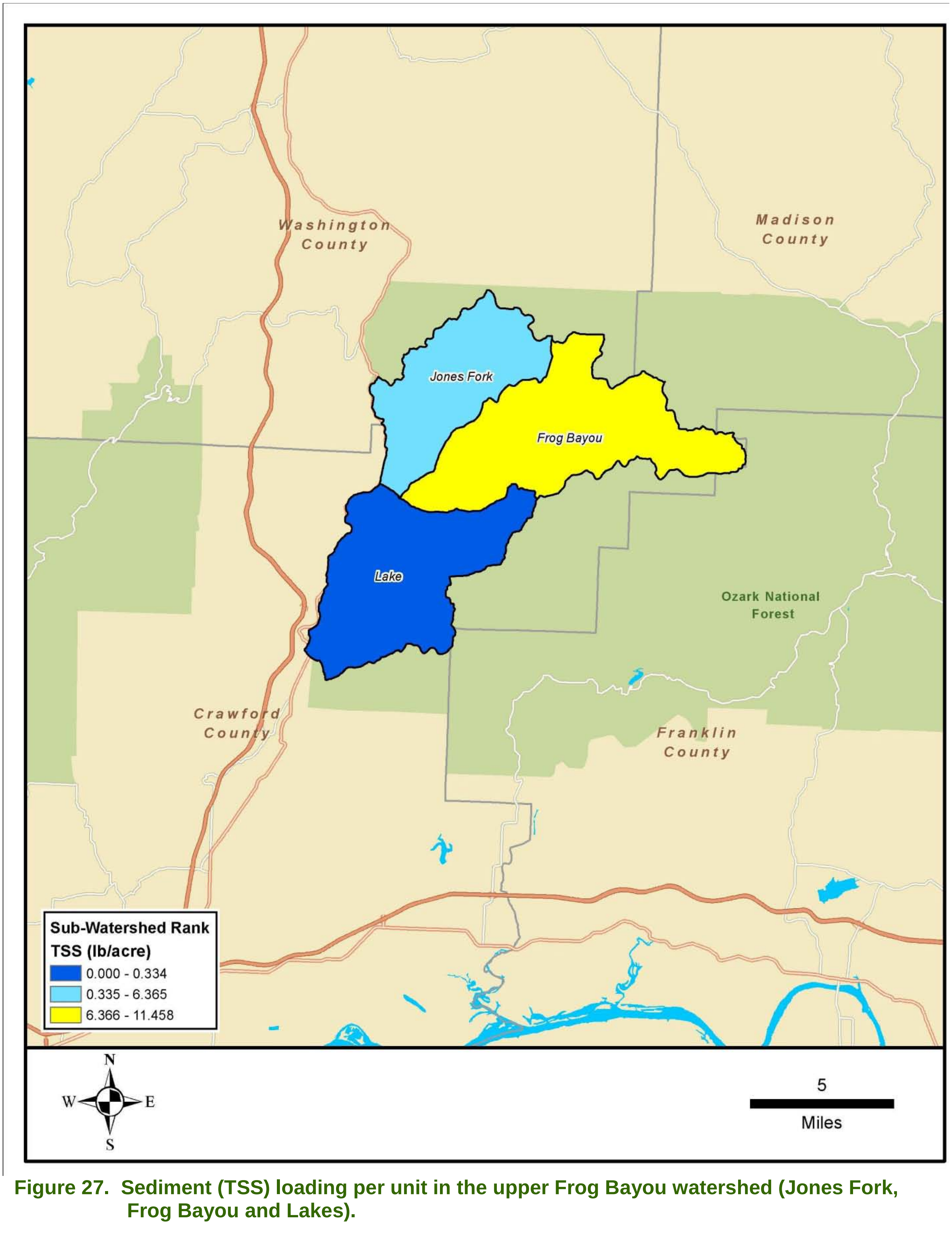


Figure 27. Sediment (TSS) loading per unit in the upper Frog Bayou watershed (Jones Fork, Frog Bayou and Lakes).

5.0 Pollution Source Assessment

The Upper Frog Bayou watershed was broken down into four sub-watersheds to simplify the identification of potential sources of pollution from point sources and non-point sources associated with storm water runoff, and to ease the analysis process. Clear Creek sub-watershed was not analyzed for this WMP. Potential sources of pollution in the remaining three (3) sub-watersheds delineated and analyzed are presented below. These three (3) sub-watersheds are above Lake Fort Smith and due to their influence on lake water quality and FSU's greater ability to measure and control loading from these areas are the focus of the point source and non-point source assessment.

5.1 Point Sources

There are no known point sources in the Upper Frog Bayou watershed.

5.2 Non-point Sources

Jones 1 (Jones Fork) Sub-Watershed – this is in the headwaters portion of the watershed and is mostly composed of forest. Cattle pasture is the dominate land use with potential for non-point source pollution. A list of all potential non-point sources identified in the sub-watershed are listed below:

Non-point source	Severity/Risk
Cattle (140)	Low
Fertilized pastures	Low
Stream bank erosion	Moderate
Septic tanks	Low
Un-paved roads	Moderate
Natural Gas Wells (4)[1]	Low

[1] Risk is low as these wells were installed several years ago, sites have stabilized, and the wells are currently not in production.

FB-1 (Headwaters) Sub-Watershed – this sub-watershed is also in the headwaters portion of the watershed and is mostly composed of forest. Cattle pasture is the dominate land use with potential for non-point source pollution. Historically there were several active poultry houses in the FB-1 watershed. However, these are all currently inactive. A list of all potential non-point sources identified in the sub-watershed are listed below:

Non-point source	Severity/Risk
Cattle (360)	Low
Fertilized pastures	Moderate
Stream bank erosion	Moderate
Septic tanks	Low
Un-paved roads	Moderate

FB-2 (Lake) Sub-Watershed – this sub-watershed drains the entire watershed that flows through Lake Fort Smith and therefore includes all lateral streams to the lake. The area around the lake is mostly forest so NPS potential is fairly low. However, this sub-watershed is critical to FSU due to its proximity to the lake and the lake's intake structure. Potential non-point sources in the sub-watershed are listed below:

Non-point source	Severity/Risk
Cattle (80)	Low
Fertilized pastures	Moderate
Septic tanks	Low
Un-paved roads	Moderate
Hwy 71 and part of Mountainburg	Low-moderate
Barren hill slope on east mountain face	Moderate

5.3 Source Water Assessment by ADH

In 2000 a Source Water Assessment was completed for Lake Fort Smith by the Arkansas Department of Health. This assessment evaluated the vulnerability and susceptibility of the lake to potential sources of contamination (PSOC) in the watershed. The assessment ranked each PSOC based on where it was located in proximity to the intake structure and what its potential was for health concerns. Lake Fort Smith was classified with a medium susceptibility rating based on its small size (small volume) and large intake volume. The top two PSOC's identified that affected the rating were:

1. Multiple County road crossings
2. Septic systems

5.4 Priority Sub-watershed Ranking

Many factors play into determining which sub-watersheds are priority to address with implementation efforts and what impacts need to be addressed first. To aid in this analysis a matrix was developed (Appendix D) to consider each of the impact assessment categories including; storm water pollutant loading (TSS and phosphorus), % pasture, amount of impacted riparian buffers, amount of bank erosion, miles of unpaved roads and concentration of agricultural animals. Scores were assigned to Upper Frog Bayou sub-watersheds that ranked either first (3 points), second (2 points) or third (1 point) worst in a given impact category (Table 24). Table 25 provides a summary of the score totals for each sub-watershed.

Table 24. Ranking of impact categories in each of the key Upper Frog Bayou sub-watersheds.

Rank #	TSS Loading	Phosphorus Loading	% Pasture	Impacted Riparian	Bank Erosion	Cattle	Unpaved Roads
1	FB-1	FB-1	Jones-1	Lake	FB-1	FB-1	Lake
2	Jones-1	Jones-1	FB-1	Jones-1	Jones-1	Jones-1	Jones-1
3	Lake	Lake	Lake	FB-1	Lake	Lake	FB-1

Table 25. Total scores for the Upper Frog Bayou watershed.

Sub-watershed	Score
FB-1	18
Jones-1	15
Lake (FB-2)	9

5.5 Modeling NPS Loads and Reduction Potential

A simple water quality model was used to determine the potential of different management practices to reduce TSS and nutrients in the watershed. The Center for Watershed Protections Watershed Treatment Model (WTM) was used for this purpose. Modeling was focused on the Upper Frog Bayou watershed. Each of the three sub-watersheds (FB-1, Jones-1 and FB-2) were modeled independently to arrive at a predicted total load without management measures. Then appropriate management measures were implemented in the model to assess their potential to reduce TSS and nutrients.

The WTM is a land-use based model that utilizes annual rainfall, soil hydrologic groups and land-use categories to calculate primary pollutant loading in a watershed. Additional inputs for secondary pollutant loading can be added to fine tune the loading estimates. Secondary inputs utilized for this study include: septic systems, unpaved roads, stream channel erosion and livestock.

Management practices evaluated with the WTM model include: septic system education (Section 6.1) and repair programs, stream restoration (Section 6.2), riparian buffer restoration (Section 6.2) and urban storm water BMPs (SW retrofits) (Section 6.1).

The WTM model is used in this study exclusively as a tool to determine which sources of sediment and nutrients appears to be having the most affect, and from a management perspective, which practices will achieve the load reduction goals of the WMP. A summary of the model load estimates is provided in Table 26 and 27, for TSS and phosphorus, respectively. Model excerpts are provided in Appendix E.

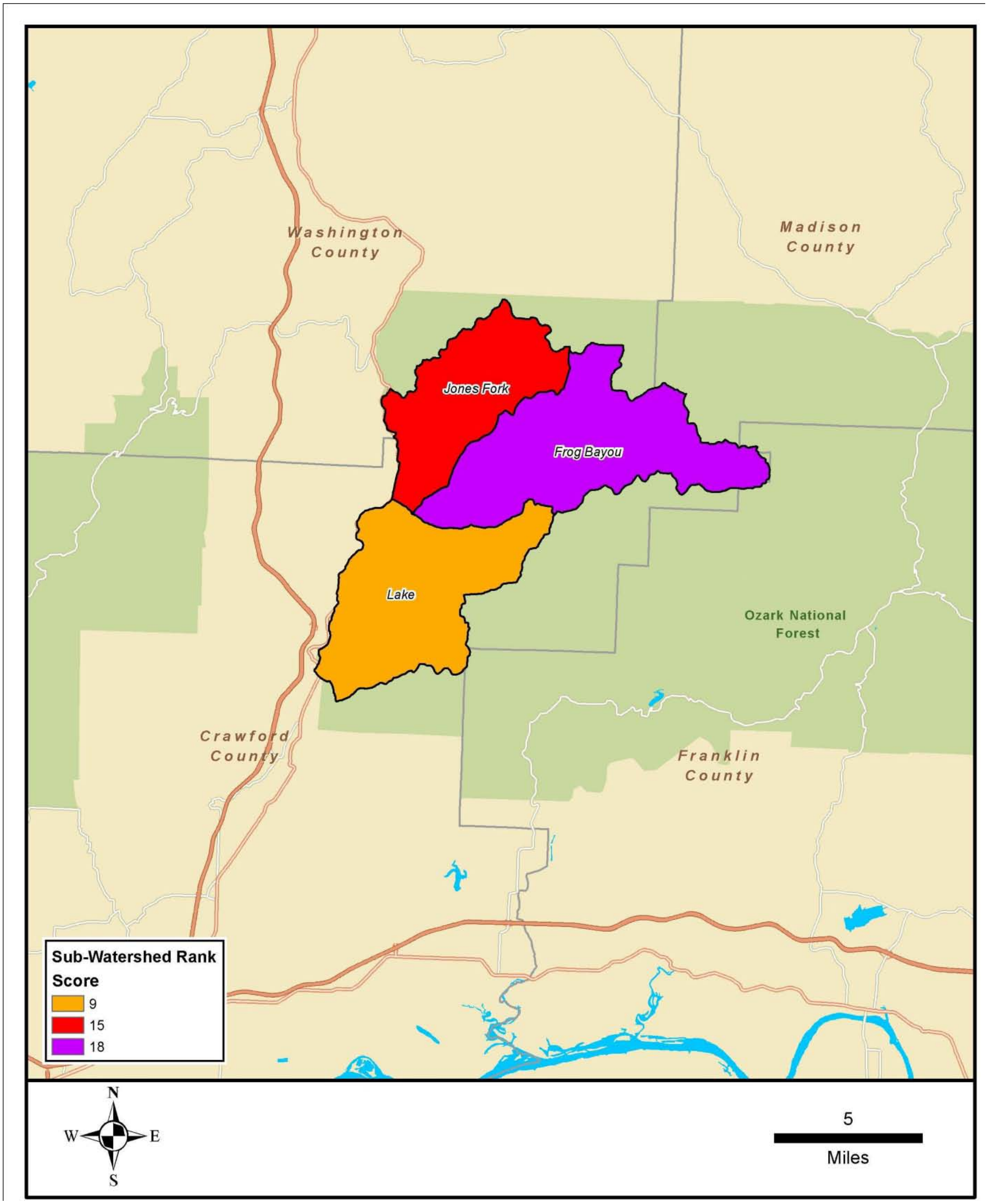


Figure 28. Non-point source scoring and priority ranking by sub-watershed.

Table 26. Summary of model predicted TSS loading.

Source	Sub-watershed (TSS lbs./year)			
	FB-1	Jones-1	FB-2 (lake)	Total Sediment
LDR[1]	35,071	40,831	86,741	162,643
MDR[1]	1,794	10,035	23,592	35,421
Unpaved Roads	181,769	182,455	244,873	609,097
Forest	1,823,900	1,103,684	1,514,260	4,441,844
Rural[2]	316,000	190,742	181,900	688,642
Water	4,185	208	140,120	144,513
OSDS[3]	676	1,363	1,182	3,221
Channel erosion	892,000	704,000	94,000	1,690,000
Livestock	0	0	0	0
Total	3,255,395	2,233,318	2,286,668	7,775,381

[1] LDR stands for low density residential and MDR stands for medium density residential (which also includes commercial areas in this model).

[2] Rural land loading calculations are the default rates in the model, they include pollutants from grazed cattle, fertilizer used for hay and other common uses of rural land.

[3] OSDS stands for On-Site Disposal System which is another term for septic system.

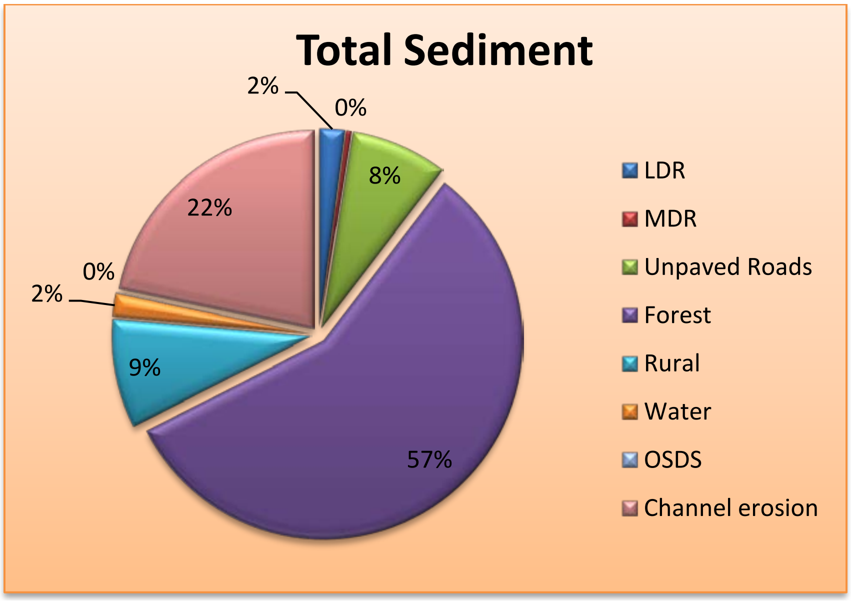


Figure 29. Overall sources of sediment.

Table 27. Summary of model predicted phosphorus loading.

Source	Sub-watershed (TP lbs./year)			
	FB-1	Jones-1	FB-2 (Lake)	Total
LDR	222	258	549	1,029
MDR	11	63	149	223
Unpaved Roads	27	27	37	91
Forest	3,648	2,207	3,029	8,884
Rural	2,212	1,335	1,273	4,820
Water	14	1	452	467
OSDS	17	34	30	81
Channel erosion	312	246	33	591
Livestock	0	0	0	0
Total	6,463	4,171	5,552	16,186

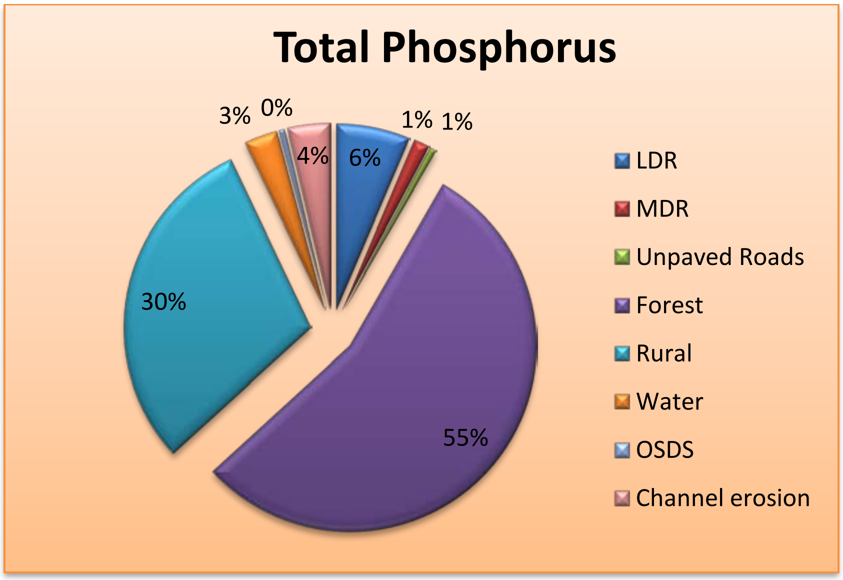


Figure 30. Overall sources of total phosphorus.

The largest source of TSS and phosphorus is shown by the modeling to be from forested land-uses. However, pollutant loading from forest can generally be considered to be naturally occurring (background) load that is not practically targeted for reductions.

Based on the results of the modeling it appears that the key sources of TSS that need to be addressed for sediment reduction in the Upper Frog Bayou watershed are:

- Stream channel erosion
- Pasture management
- Unpaved roads

These key sources of pollutants can be prioritized in the above order for each sub-watershed, with the exception of FB-2, where unpaved roads top the list of key sources.

Nutrient loads were assessed in the model primarily looking at phosphorus. Based on the modeling of phosphorus loading the key sources of nutrients that need to be addressed are:

- Pasture management
- Residential/commercial
- Stream channel erosion

The portion of sediment and nutrients coming from each sub-watershed varies as does the load from each source. For example, some sub-watersheds will benefit more from stream bank restoration and other watersheds will benefit more from maintenance or upgrades to unpaved roads. However, overall the key sources noted above are those that need to be addressed first in the Upper Frog Bayou watershed.

5.6 Discussion of Priority Area Ranking

A ranking of the stream impacts/disturbances identified in the upper watershed was compiled, consistent with the matrix and modeling results, and presented in Table 28. Rankings are based on which impacts could be expected to provide the most load reduction of sediment and nutrients to the system if appropriate management measures were implemented. The most critical problem area is ranked first and the least critical, last.

Stream bank erosion is fairly prominent in Upper Frog Bayou watershed (FB-1 and Jones-1) reaches. Active bank erosion can add thousands of pounds of sediment and nutrients to the stream system during high flow events. In the sub-watersheds above Lake Fort Smith, these sediment and nutrient loads will ultimately end up at the bottom of the lake or in the drinking water treatment plant. It is costly to remove sediment/turbidity from drinking water. Therefore, reduction and prevention of stream bank erosion should be a primary goal in the watershed.

Unpaved roads appear to be a significant source of sediment in the FB-2 sub-watershed that forms the perimeter of the lake. Due to their close proximity to the lake, and potential for direct discharge into the lake those roads are a top priority for maintenance and load reduction BMPs.

Pastures and hay fields can provide a substantial load of nutrients to streams. BMPs appropriate to these land-uses (Section 6.1) should be implemented and maintained to reduce nutrient loading to each key sub-watershed.

The lack of adequate riparian vegetated buffers in several reaches of the streams are a potential problem. Well-developed riparian buffers serve to shade the stream, reducing solar energy inputs and decreasing water temperature; and they serve to stabilize the stream banks, protecting them from erosion and providing habitat for aquatic biota. Riparian buffers also serve to filter out pollutants in storm water runoff and help to regulate the stream hydrograph during runoff events (see Section 3.6). Sections of stream lacking riparian buffers should be considered for re-vegetation with native trees and under story plants.

Table 28. Priority ranking of Upper Frog Bayou watershed impacts/disturbances from worst to least.

Rank	**Location**	**Impact/Disturbance**
1	FB-1	Stream bank erosion
2	Jones-1	Stream bank erosion
3	Lake (FB-2)	Stream bank erosion
4	FB-1	Pasture runoff
5	Jones-1	Pasture runoff
6	Jones-1	Unpaved roads
7	FB-1	Unpaved roads
8	Lake (FB-2)	Unpaved roads
9	Lake (FB-2)	Urban (developed areas) runoff

6.0 Recommendations For Watershed Management

The following sections provide recommendations for management of the Upper Frog Bayou watershed through protection, enhancement and restoration. Ideally all recommendations could be easily implemented. However, this not being the case, the final portion of this section provides a ranked list of recommendations based on priority and necessity. The recommendations for watershed management are designed to: 1) be consistent with FSU's priority goal, which is protection and improvement of water quality in Lake Fort Smith, and 2) address and remedy the critical problem areas/sources discussed in the previous section and listed in Table 25. It is assumed in this plan that a reduction in TSS will also bring a proportional reduction in nutrients and other pollutants typically associated with sediment. Therefore, only sediment load reductions are addressed in this section.

6.1 Runoff Management

The following are a list of best management practices recommended to protect water quality and/or the hydrologic regime of the Upper Frog Bayou watershed. Practices are recommended according to land-use type. The listings are not comprehensive but provide those typically applied successfully to such land-uses as those found in the Upper Frog Bayou watershed. Reduction estimates and costs (Section 9.0) are based on a survey of literature values from the documents cited in Section 10.0 or from the WTM modeling.

Agricultural Land-Use

In each sub-watershed, and particularly in sub-watersheds FB-1 and Jones-1, where pasture is the most prevalent, it is recommended that landowners be encouraged to consider implementation of storm water BMPs. This encouragement probably needs to occur as some form of educational materials mail out or forum. Assistance with these types of efforts is available through the National Resource Conservation Service, the Arkansas Natural Resources Commission, the University of Arkansas Cooperative Extension Service and others.

For pasture with on-going grazing operations the following BMPs should be considered in all sub-watersheds:

- Riparian buffers along stream corridors. Minimum of 25 feet forest and 25 feet native grasses. This protects the stream banks from erosion and provides filtration of sediment and associated pollutants in the runoff.

- Alternative water sources (away from stream) for cattle use. This helps keep the cattle out of the stream and away from the banks where they contribute to erosion.
- Fencing cattle out of stream.
- Rotating pasture usage. This helps prevent over grazing, preventing grasses from becoming too thin or trampled, allowing them to help buffer the stream. It also helps prevent soil compaction.
- Control stocking rate, number of head per acre of pasture.

➢ The Potential load reduction from use of these management practices on 25% of pastures in key sub-watersheds is: 33,114 lbs. TSS annually. The reduction estimate is based on use of alternate water sources alone and more reduction is possible with implementation of additional BMPs (Evans, B.M. 2001).

For agricultural land being used for hay operations in all sub-watersheds the following BMPs should be considered:

- Riparian buffers along stream corridors (see detail above).
- Control fertilizer applications (magnitude, timing and method) according to soil tests and USDA or NRCS recommendations to maximize productivity yet protect water quality.
- Use of cover crops during off season. Prevents top soil erosion, and utilizes remaining nutrients.
- Crop rotation. Maintains cover on soils and improves soils.

➢ Potential load reduction from use of cover crops or fertilizer management on 25% of hay pastures in key sub-watersheds is: 33,114 lbs. TSS annually (Evans, B.M. 2001).

Rural Residence On-Site Treatment Systems (Septic systems)

For rural residences that use septic systems the following BMPs are recommended:

- Septic system education.
- Septic system inspection and repair program.
- Septic system upgrades.
- Septic system retirement (convert to city sewer where available).

➢ Not a key source, so reductions not quantified (see Section 5.0).

Developed - Commercial and Industrial Land-Uses

In sub-watershed FB-2 and Jones-1, it is recommended that facilities and commercial establishments be encouraged to adopt industry specific BMPs. Jones-1 is included as it contains the largest number of natural gas wells (Figure 31) in the watershed.

The following BMPs should be considered:

- Riparian buffers along stream corridors. In addition to the benefits discussed previously, buffers help control the storm flow hydrograph. Minimum 50 feet.
- Encourage green area enlargement and enhancement and reduce impervious surfaces on new and existing developments. Encourage good housekeeping practices. Keep outside storage areas covered, immediately clean up spills of liquid or dry materials, etc.
- Enforce construction storm water management plans.
- Land conservation. Where possible attain land or establish easements in areas critical to the stream (i.e. buffer zones, wetlands, etc.) and maintain these as green areas. There should be a minimum of 100 feet of protected riparian buffer around Lake Fort Smith to protect the shoreline and the valuable drinking water source. In addition, the wetland areas adjacent to the lake and in its littoral region in the upper lake should also be protected to enhance water quality and provide good spawning areas for fish.

➢ Not a key source (see Section 5.0) so reductions not quantified.

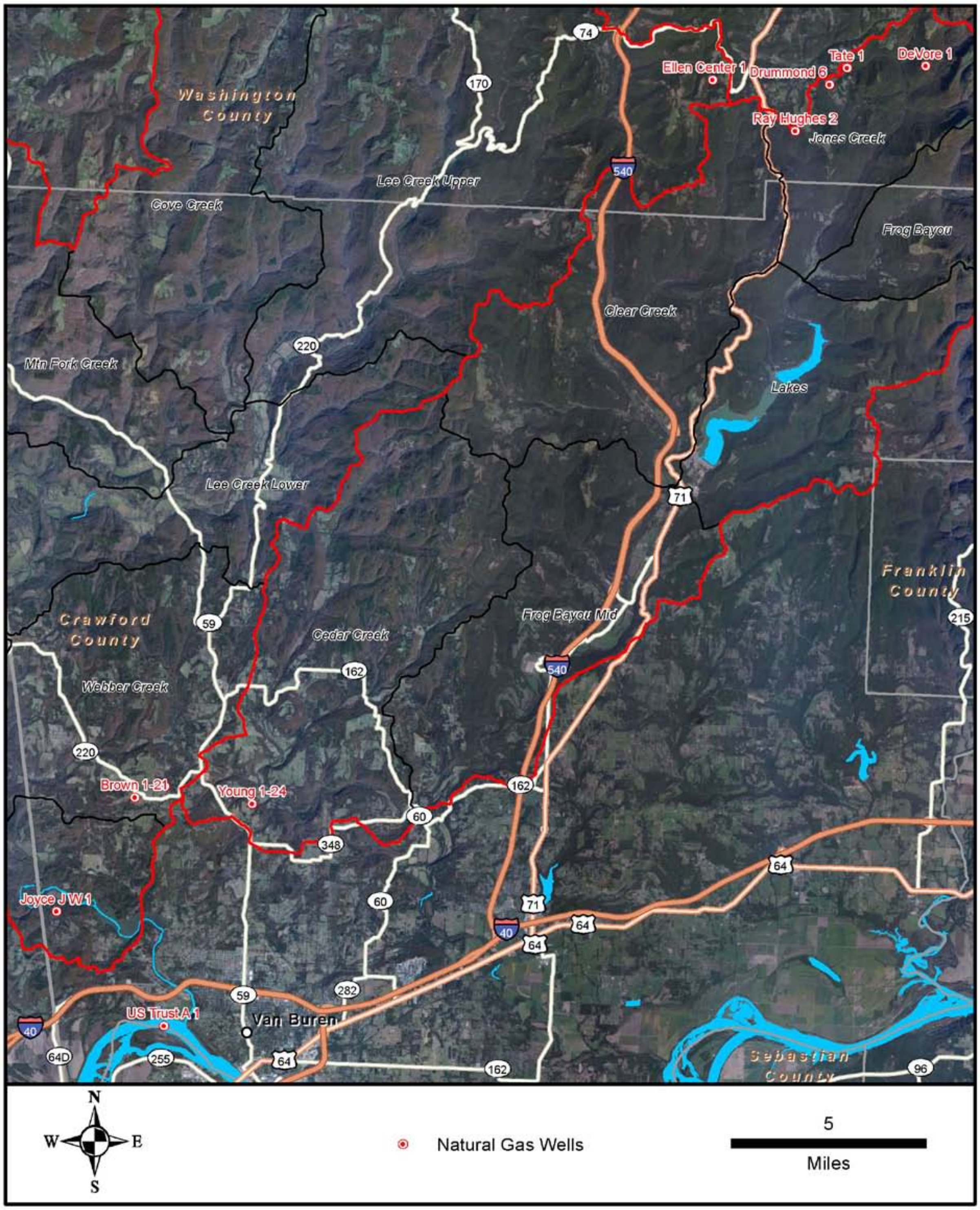


Figure 31. Natural gas wells in the watershed.

Developed - Residential Land-Uses

In the overall watershed and particularly in sub-watershed FB-2 it is recommended that to encourage implementation of best management practices by residents.

For residential developments the following BMPs should be considered:

- Riparian buffers along stream corridors. Minimum 50 feet.
- Encourage green area enlargement and enhancement and reduce impervious surfaces on new and existing developments. .
- Encourage good neighbor practices. Keep yards free of trash, proper disposal of pet waste, proper disposal of household chemicals, etc.
- Strictly enforce construction storm water management plans.
- Encourage (through incentives) or require use of low impact development techniques (LID) in new developments in critical areas or on steep slopes.
- Limit and manage fertilizer application
- Encourage watershed stewardship through education.

➢ Not a key source (see Section 5.0) so reductions not quantified.

Unpaved Roads Management

Several BMPs are available to decrease sediment transport form unpaved roads. The following BMPs are believed to be appropriate to the forest roads and dirt roads in the Upper Frog Bayou watershed:

- Aggregates replacement
- Water bars in steep sections
- Roadside ditch maintenance, vegetation and check dams
- Proper road surface stabilization/road grading/maintenance
- Turnouts

➢ The potential load reduction from use of a combination of these management practices on 50% of the roads in each sub-watershed is: 152,274 lbs. TSS annually (Bloser, S.M. and Sheets B.E., 2012).

6.2 Stream Restoration/Enhancement

Riparian Buffers

Riparian vegetated buffers are lacking or limited in several reaches of Upper Frog Bayou watershed. As discussed previously in this report (Section 4.0) riparian buffers are critical to the health of a stream system. The following areas should be targeted for establishment or enhancement of vegetative riparian buffers:

1. FB-1, intermittent areas in main channel between the confluence with Jones Fork and Bidville Road bridge.
2. Jones-1, intermittent areas between confluence with Frog Bayou and Jones Fork Road crossing.
3. Areas in Lake (FB-2), on Frog Bayou, between the confluence of Jones Fork and the mouth of the lake.

➢ The potential TSS reduction from riparian restoration of 50% of impacted buffers in key sub-watersheds is: 20,160 lbs. annually (WTM Model).

Buffers widths should be planted as wide as possible on each side of the stream. A width of at least twenty-five (25) feet on each side of the stream should be targeted as a minimum in all space restricted areas with ideal widths of around fifty (50) feet or greater. When riparian buffers are considered, more is always better. Buffers should be composed of native vegetation including trees, shrubs, herbaceous plants, and grasses. Figure 32 presents a representation of how buffers are designed. Open space along the lake shore should be kept to a minimum. Vegetated buffers here should closely follow the buffer zone requirements outlined in the Lake Buffer Zone Management document.

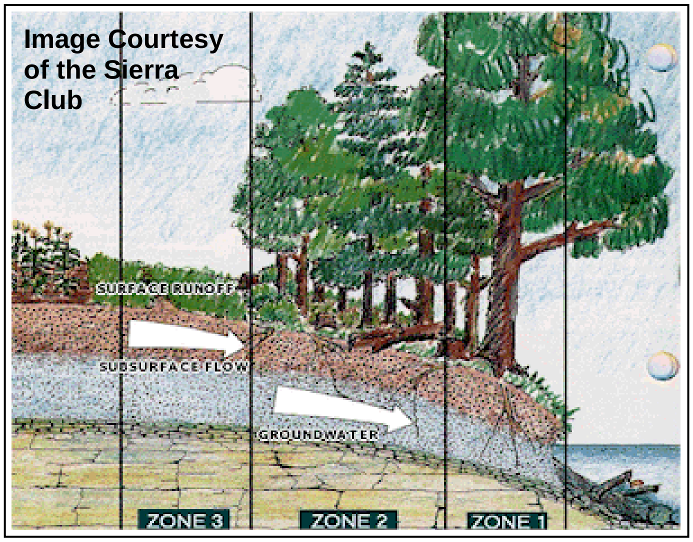


Figure 32. Generic representation of riparian buffer zone.

Stream Bank and Channel Stabilization

Headwaters (FB-1), Lake (FB-2) and Jones Fork (Jones-1), are exhibiting significant stream bank erosion at several locations. Stream banks should be stabilized in the critical areas that are also accessible for the required heavy construction equipment:

1. FB-1, intermittent areas in main channel between the confluence with Jones Fork and Bidville Road bridge.
2. Lake (FB-2), area below the confluence of Jones Fork and Frog Bayou in the area known as the Murdock place.
3. Jones-1, intermittent areas between confluence with Frog Bayou and Jones Fork Road crossing.

Each stream bank and channel stabilization project comes with its own individual challenges and opportunities. Each stream stretch will need to be evaluated to determine what restoration techniques work best and meet the needs for sediment and nutrient reduction. Where possible, preference will be given to techniques that focus on bioengineering.

- Toe protection in conjunction with various vegetative protection measures (such as live stakes, live cribwalls, etc.)
- Stone armoring (such as the use of riprap, windrowing, etc.)
- Use of bioengineered materials including erosion control blankets, wattles, soil wraps, etc.
- Flexible mattresses (such as concrete block mattress, gabion mattress, wooded mattress, etc.)
- Engineered structures for grade control, energy dissipation and flow guidance, (cross veins, J-hooks, step pools, riffles, etc.).

The projects would generally utilize natural channel design techniques (Rosgen, 1996) and be supplemented with other guidance including *The WES Stream Investigation and Streambank Stabilization Handbook and USDA Engineering Field Handbook* “Chapter 16: Streambank and Shoreline Protection” as guidance for the projects in the watershed. Additional help may come from contract engineering companies who have additional experience with stream bank stabilization.

- ➢ The potential load reduction from stream bank stabilization of 25%-40% of severely eroded banks in each of the key upper sub-watersheds is: 582,517 lbs. TSS annually (calculated using site specific data).

Critical Area Conservation

Land conservation should become a priority. Where possible, attaining land or establishing easements in areas critical to the stream (i.e. buffer zones, wetlands, etc.) and maintaining these as green areas should be considered. The FSU has established a 300' buffer zone around the lake to protect its shoreline and provide a zone for storm water to infiltrate before it reaches the lake. FSU has developed watershed management areas that are critical to the City's drinking water resources. In addition, much of the land adjacent to the lake is under conservation easements to protect the water resource. Several areas in the upper reaches of Lake Fort Smith are designated wetland mitigation areas and these areas are also under construction easements. Riparian vegetated buffers (discussed in multiple sections above) are a major consideration in the land conservation arena. Buffers should be required along all stream corridors. Minimum widths for the buffers should be set at no less than fifty (50) feet on each side of the stream. Other key elements that should be developed and in tributaries in close proximity to the lake managed are provided in Table 29.

Table 29. Key management measures to encourage, develop and manage.

Technique	Description of Technique
Construction storm water protection plans	Require for all new developments to reduce site run-on and reduce sediment and other pollutants leaving the work site. Includes diversion ditches/berms, silt fences, temporary detention ponds, hay bales, mulch, grass covers, synthetic erosion control blankets, etc.
Natural area conservation	Minimize lot clearing to that essential for the home and a small yard, maintain as many trees as possible. Riparian vegetated buffers will be along all stream corridors.
Avoid septic system use	All homes should be connected to local sewers and wastewater treatment facilities when possible.

Table 30 provides a ranking of the watershed management practices recommended as a result of the assessment. Each management action is ranked based on its ability to move the watershed towards attainment of the goals expressed. Priority is given to management practices in sub-watersheds upstream of Lake Fort Smith, consistent with the primary goal of FSU, protection and improvement of water quality in Lake Fort Smith and downstream waters.

Table 30. Recommend watershed management practices.

Rank	Sub-watershed	Management Type	Management Action (Practice)
1	FB-1	Restoration	Stream bank stabilization
2	Jones-1	Restoration	Stream bank stabilization
3	Lake (FB-2)	Restoration	Stream bank stabilization
4	FB-1	BMP	Pasture management BMPs
5	Jones-1	BMP	Pasture management BMPs
6	Jones-1	BMP	Unpaved roads maintenance/upgrade
7	FB-1	BMP	Unpaved roads maintenance/upgrade
8	Lake (FB-2)	BMP	Unpaved roads maintenance/upgrade
9	Lake (FB-2)	BMP	Urban (developed areas) storm water BMPs
10	FB-1/Jones-1	Restoration	Restoration of riparian buffers on rural and urban land

6.3 Implementation Schedule

A watershed management plan should be a living and active document that serves as the guide to direct watershed management activities, including; implementation projects to achieve load reductions, monitoring water quality and biota to gauge goal attainment, continuing education efforts, etc. The plan should be updated at least every 5 years to ensure it is still relevant to the current conditions of the watershed. In order to help ensure all these action items are completed it is necessary to have a schedule listing the tasks that need to be accomplished. A summary of the action items that resulted from this WMP are provided in Table 31. The schedule provides ten years for actions to be accomplished that will result in a 10% reduction of sediment and phosphorus in the watershed.

Table 31. Implementation Schedule (Depending on Funding and Property Owner Cooperation/Participation).

Action Item	Target Date for completion
Meet with stakeholder group to coordinate implementation projects	October 5, 2015
Meet with county judges and USFS to discuss unpaved road maintenance	December 30, 2016
Implement a pasture management education effort and invite all farmers in the watershed	August 15, 2017
See 20% of roads in FB-2 be improved/upgraded	August 15, 2018
Bank stabilization of 25% of eroded banks FB-2 (moderate or worse rating)	December 30, 2018
Bank stabilization of 25% of eroded banks in FB-1 (moderate or worse rating)	December 30, 2019
Bank stabilization of 25% of eroded banks in Jones-1 (moderate or worse rating)	December 30, 2020
See 25% of pastures in FB-1 and Jones-1 have management measures implemented.	December 30, 2021
See 40% of impacted riparian area restored in FB-1 and Jones-1	December 30, 2025

6.4 Interim Milestones

In order to monitor progress it is necessary to have measurable milestones that can be easily interpreted. The milestones that will be used for gauging progress on of this WMP are provided in Table 32.

Table 32. Interim Measurable Milestones.

Milestone	Measurement method
Stakeholder group success	Meetings at least 2/year and attendance of at least 40% of group on average
Unpaved road BMP meeting	Meeting occurred on schedule
Pasture BMP meetings	Meeting occurred on schedule
Future Watershed loading is monitored and assessed	FSU completes annual monitoring as planned, per the plan in Section 7.0
First two years of monitoring complete and complied with historical data to set a baseline	Monitoring baseline established
Monitoring shows TSS and TP loading is stable or decreasing	Data analysis (per Section 7.0) of first three-year monitoring cycle (2017-2019)
Bank stabilization in FB-2 complete	Stabilization completed on schedule Length of stream completed as planned
Pasture management practice implemented	Completed on schedule and attaining percentage goals
Unpaved road improved	Completed on schedule and attaining percentage goals
WMP reviewed and updated every five years	Plan review is completed in 2020 and needed updates included
Bank stabilization in FB-1 completed	Stabilization completed on schedule and length of stream completed as planned

Success will be achieved if the above tasks are completed according to schedule. Future success will be measured by number of implementation projects that are completed. In addition, the FSU will continue their watershed monitoring program and continue to evaluate sediment and nutrient loading to Lake Fort Smith. During the 2020 5-year/review update these milestones will be revised and updated along with the rest of the WMP.

6.5 Adaptive Management

As with any undertaking of this magnitude, obstacles will arise, and plans change. Therefore, every effort will be made to make this management plan dynamic, so that it can be easily adjusted to the needs of the watershed to benefit water quality, aesthetics, biotic communities and the public.

Every five years the plan will be reviewed to evaluate effectiveness of:

1. BMPs/Management practices,
2. Monitoring of loading,
3. Interim milestone completion, and
4. Education Outreach

Should any one of these components be found to be ineffective or insufficient then the plan will be revised accordingly to improve that component. After every 10 years the WMP will be updated. The update will include goals, revisions to key components that have changed over time as well as revisions needed to improve accomplishment of its goals.

7.0 Water Quality Targets (Success Criteria) and Monitoring

FSU will continue its current monitoring program supplemented by additional grab sampling in key sub-watersheds where appropriate. Monitoring will be focused in the sub-watersheds that drain into Lake Fort Smith. The FSU currently monitors water quality through sample collection, physio-chemical measurement and bioassessment see Sections 3.1, 3.2 and 3.5 for a summary of FSU monitoring program. The existing USGS gauge stations in the watershed, should allow fairly accurate loading to be calculated for the Upper Frog Bayou watershed. FSU will use loading data (TSS, TP) collected in the future to compare to the loading data collected historically in their program and data collected during this watershed assessment. Load reductions or increases will be determined using the loading data, control charts and trend analysis. FSU will use control charts and trend analysis to gauge if the watershed loading is responding positively or negatively to load reduction efforts.

Bioassessment data will also be used as it has been used historically and is depicted in this WMP. Should the bioassessment metrics and stream condition indices vary from the historical norms (as observed in control charts) then it will be evidence of either positive effects or negative within the watershed. If the monitoring results, both water and bioassessment, indicate that loading has not been decreasing on three consecutive years then additional monitoring will be completed to assess the problem and determine if it was a data issue or if new load sources could be to blame, or the measures did not function properly. The first two years of WMP implementation (2015-2016) monitoring data will not be used in the three year assessment cycle. Those years will be assumed to be "building" years for the monitoring database. After five years of post WMP monitoring is complete loading will be evaluated using the most recent three years of data (2017-2019). From that point forward monitoring data will be evaluated on a three year basis.

BMP effectiveness will be monitored in two of three possible ways:

1. Implementation of actual BMPs completed on the ground, and
2. Modeling of reductions from each specific BMP implemented, or
3. Monitoring of runoff above and below BMPs.

8.0 Public Involvement, Education and Stakeholders

The FSU is active in educating the public concerning relevant environmental and watershed issues. The City currently conducts a Citizens Academy which provides facility tours and educates public groups on water related issues. Fort Smith's Environmental Quality Management Group also serves as a science fair resource for the Fort Smith School District and surrounding districts, providing project guidance and science fair judges. Fort Smith currently partners with Lake Fort Smith State Park to increase awareness of water quality/watershed management issues through interpretive programs, developing educational material and hosting public events.

As with any major public undertaking the support of the general public and key local personalities and stakeholders is critical. The stakeholder group, should be composed of key individuals, stakeholders (those with property in the watershed, and/or those who are affected by management decisions in the watershed) and local partners who would review recommendations for management, help determine what management measures would be adopted, and help implement the plan. Advantages of utilizing such groups are multifaceted, they include; a broader perspective on the issues, a higher level of public comfort with decisions, and a better platform for informing the public, to mention a few. Watershed advisory groups illicit a spirit of sharing and cooperation that can energize the management process. Historically, watershed management has been more successful when such advisory groups have been involved in the process.

The FSU has taken large steps towards protecting and enhancing the Upper Frog Bayou watershed in the Lake Fort Smith area and in educating the public about drinking water quality. One of the first tasks of the steering committee should be to continue development of a strategy to educate the public about the Upper Frog Bayou watershed management. The general public must begin to understand ways their activities affect waters in the watershed. They must also begin to see the ways the waterways enhances their lives so they begin to value it more. This effort could include actions such as public meetings, informational brochures, workshops, field trips and information sessions. The advisory group and the city could host Upper Frog Bayou clean-ups or restoration days, where the public, including students, can become engaged in watershed management activities.

Educational Outreach

A public and stakeholder meeting was held for the Upper Frog Bayou watershed on Wednesday, June 30, 2014. The meeting was held to increase awareness and knowledge of the efforts being made to improve and preserve the Upper Frog Bayou watershed. The meeting was advertised by posting flyers, sending mail-outs, e-mailing announcements to organizations/agencies, announcements on the radio and local news stations. For those who were interested and could not attend, a specific e-mail address (FrogBayouWMP@FortSmithAR.gov) was set-up and is still currently operational for those wanting more information or to participate in the development and execution of the watershed management plan. The meeting was a success as there were 19 people in attendance for the meeting with 5 stakeholders signing on to continue watershed measurement efforts. Stakeholder organizations include U.S. Forest Service, The Nature Conservancy, and Arkansas Department of Health. An informational brochure was given to everyone in attendance that included a summary of information of the management plan, key points of the meeting and contact information. These brochures are available to the public.

Goals of the meeting were to identify water quality concerns in the watershed, increase education and involvement, coordinate efforts with the public and stakeholders and explain how the success will be measured. The initial draft of the watershed management plan was covered in the meeting explaining data that have been collected in the past. Citizens and stakeholders gave feedback on the plan and suggestions concerning sources of pollutants in the watershed. One concern was that unpaved roads and bridges could be contributing to the amount of TSS within the watershed. To address this concern we quantified unpaved roads lengths and sediment loading from them as a source in the model analysis to determine the impacts in the watershed. Stakeholders were given the opportunity to review information in the draft WMP and will be sent future drafts of the plan for review until the watershed management plan is finalized. Key stakeholders involved in this process include the Arkansas Department of Environmental Quality, Arkansas Department of Health, Arkansas Natural Resource Commission, Arkansas Department of Parks and Tourism, and the Arkansas Forestry Commission.

Stakeholder Involvement

As stated earlier, stakeholders gave feedback on the plan and suggestions concerning sources of pollutants in the watershed.   This information was evaluated and used to set priorities in the action plan. The final draft of the watershed management plan was sent via e-mail to the stakeholders for review and comment prior to it being submitted for acceptance. Future proposed revisions of the watershed management plan and schedules will be sent to all stakeholders.

Stakeholders have already been involved in scheduling clean-up events and discussions about improvements to the watershed and Lake Fort Smith.

Continuing Educational Outreach

Fort Smith Utility and the Lake Fort Smith State Park are working with schools to educate the students on the importance of watersheds and watershed management. These educational sessions include allowing students to collect macroinvertebrates from a small stream located inside the Park under the direction of the FSU biologists, collection of fish, a discussion on birds and frogs. This is all tied into a closing lesson on the impact of humans on the health of the watershed, and the possible consequences if the watershed is not protected through conservation and BMPs such as not littering, properly disposing of trash and chemicals, etc.

Additionally FSU works with the Lake Fort Smith State Park on shoreline clean-up days and also provides speakers for park events to discuss the importance of the watershed and watershed management.

FSU currently hosts a website for the Upper Frog Bayou and Lake Fort Smith where information on the watershed management plan as well as the plan itself is accessible. FSU continues to work with stakeholders to inform, educate, and involve new stakeholders and the public.

- FSU utilizes the EPA document “Getting in Step: Engaging Stakeholders in Your Watershed” as a guidance and source of information on how best to reach out to current and future stakeholders.
- The EPA Nonpoint Source program has created a nonpoint source outreach tool box that will be reviewed and used to increase awareness (http://www.epa.gov/nps/toolbox/). Relevant information and material from the Tool Box will be adapted for stakeholders in the Upper Frog Bayou Watershed.
- Annually an FSU representative discusses the importance of watersheds on a local talk-radio station.
- Printed flyers, fact sheets, booklets and educational meetings will be used to share information and educate the public on watershed management, watershed concerns, and the use of different BMPs and their maintenance.
- Ecosystem services are the benefits people obtain from nature. Examples include freshwater, timber, water purification, soil regeneration, flood control, pollination, and similar services, many of which are considered “free.” The EPA Ecosystem Services Research Program and the USDA Office of Ecosystem Services are developing approaches for quantifying the economic value of some of the non-market services (e.g., waste assimilation, water purification, soil development). Creating a better understanding among stakeholders of the monetary value of these “free” services, as well as potential markets will help inform them for better decisions.

9.0 Technical and Financial Assistance

The projected costs to accomplish a 10% reduction in sediment and phosphorus in the Upper Frog Bayou watershed is summarized in the table below. Phosphorous reduction is closely correlated to sediment reduction and is assumed to be reduced proportional to TSS reduction.

Management measure	Area BMP Applied	Sediment Reduction lbs./unit area	lbs. TSS Reduced	Cost ($)	Cost/lbs.
Stream restoration (bank stabilization)	3910 ft	108-169 lbs./ft.	582,517	533,500	$0.92
Riparian buffer restoration	1540 ft	13.1 lbs./ft.	20,160	1,408	$0.07
Unpaved road improvement	52.4 mi	0.55 lbs./ft.	152,274	409,037	$2.69
Agricultural BMPs (Pastures)	1107 ac	29.9 lbs./ac	33,114	226,600	$6.84
Education/Public Outreach	---	---	---	40,000	Every 3 yrs.

Funding Opportunities

A vast array of federal funding opportunities exists for developing and implementing effective watershed management activities. A number of incentives and grants are available for land owners to implement agricultural BMPs; and grants are available to communities to install storm water treatment practices and replant riparian areas. Some grants will be more easily obtained by non-profit or community groups, such as a “Friends of Frog Bayou” (possible steering committee name) discussed previously. The majority of grant applications cycle on an annual basis with applications due the same time each year. Many of the grants listed in Table 34 require matching funds from the applicant. Awards are usually distributed within a few months of the application deadline. Many grants require recommendations by the Governor or a state/federal agency of the respective state in which a project will be completed. Table 34 lists grant/incentive opportunities that could potentially provide funding to Upper Frog Bayou watershed projects. Funding is divided into two categories; overall watershed management, and individual land owner incentives. Grants highlighted in yellow are those which best fit the overall goals of the Frog Bayou assessment findings and recommendations. It is anticipated that approximately 1/3 of the funding will come from a combination of these programs. The remainder of the funding will come from the City of Fort Smith, local land owners and investors.

Table 33. Private/match funding entities for watershed management.

Entity
Arkansas Master Nationalist
City of Fort Smith
Crawford County Government (Roads)
Local Land Owners

Table 34. Funding opportunities for watershed management.

Grant Name	Source	Type/Purpose
Conservation Reserve Program (CRP)	USDA	Agricultural BMPs
Cooperative Forestry Assistance	US Forest Service	Preservation of forested land
Environmental Education Grants	EPA	Community education
Environmental Quality Incentives Program (EQIP)	USDA (NRCS)	Agricultural BMPs
Five Star Restoration Matching Grants Program	EPA and National Fish and Wildlife Foundation	Restoration of riparian and aquatic habitats
Flood Mitigation Assistance Program	FEMA	Flood mitigation
National Fish and Wildlife Service General Matching Grants	National Fish and Wildlife Foundation	Fish, wildlife, habitat conservation
Native Plant Conservation Initiative	National Fish and Wildlife Foundation	Protect/enhance/restore native plant communities
Non-point Source Implementation Grants (319 Program)	USDA (NRCS) EPA (ANRC)	Non-point source reduction and watershed protection
Targeted Watershed Grants	EPA	Watershed protection and management
Urban and Community Forestry Challenge Cost-Share Grants	US Forest Service	Forest conservation and restoration in urban settings
Water Quality Cooperative Agreements	EPA	Watershed protection and pollution prevention
Watershed Processes and Water Resources Program	Cooperative State Research, Education and Extension Service	Watershed management
Watershed Protection and Flood Protection Program	USDA (NRCS)	Watershed protection and management
Conservation Innovation Grants	USDA (NRCS)	Conservation related to agriculture

The need for technical assistance to achieve the goals of this WMP are obvious. FSU has a qualified team of watershed managers that will be able to handle the monitoring and daily water quality assessment needs. However, FSU will need assistance from the stakeholders, the Arkansas Coop Extension Service, and the NRCS to work with local cities and farmers in addressing agricultural BMPs. FSU will also need cooperation from county judges and road maintenance crews to address unpaved roads. Construction contractors will be required to address stream bank erosion and to stabilize channels.

10.0 References Cited

AWWA, 2007. Source Water Protection. ANSI/AWWA G300-07 Standard. AWWA, Denver, CO.

Allan, David 1994. Stream ecology: Structure and function of running waters. Chapman and Hall, Boundary Row, London.

Barbour, M.T. 1999. Rapid Bioassessment Protocols for use in Wadeable Streams and Rivers: Periphyton, Benthic Macroinvertebrates, and Fish. USEPA. EPA 841-B-99-002.

Bloser, S.M. and Sheets B.E., 2012. Sediment Production from Unpaved Oil Well Access Roads in the Alleghey National Forest. Pennsylvania State University, University Park, PA.

Boulton, Andrew (2003). Parallels and contrasts in the effects of drought on stream macroinvertebrate assemblages. *Freshwater Biology* 48; 1173-1185.

Bowles, D.E. et.al. 2007. Protocol for Monitoring Aquatic Invertebrates at Ozark National Scenic Riverways, Missouri, and Buffalo National River, Arkansas. National Park Service Report NPS/HTLN/NRR-2007/009.

Bunn, Stuart and Angela Arthington (2002). Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. *Environmental Management* 43; 492-507.

Carlson, Robert 1977. A trophic state index for lakes. *Limnology and Oceanography*. 22; 361-369.

Claytor, R.A. and T.R. Schueler. 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection. Ellicott City, MD.

Davis, J.V. et al. 1995. Water Quality Assessment of the Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri, and Oklahoma—Analysis of Information on Nutrients, Suspended Sediment, and Suspended Solids, 1970-92. USGS. Little Rock, AR.

Evans, B.M. 2001. BMP Pollution Reduction Guidance Document. Bureau of Watershed Conservation and PDEP, PA.

Kitchell, A. and T. Schueler. 2004. Unified Stream Assessment: A User’s Manual. Center for Watershed Protection. Ellicott City, MD.

MDEP, 2001. Unpaved Roads BMP Manual. MDEP and USEPA Project 98-06/319.

Merritt, R.W. 1996. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Co. Dubuque, IA.

Plafkin. J.L. 1989. Rapid Bioassessment for use Protocols for use in Wadeable Streams and Rivers: Benthic Macroinvertebrates and Fish. USEPA. EPA 440-4-89-001.

Poff, LeRoy, David Allan, Mark Bain, James Karr, Karen Prestegaard, Brian Ritcher, Richard Spraks, and Jullie Stromberg (1997). The natural flow regime. *Bioscience* 47; 769-784.

Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, CO.

RTI International. 2012. Nutrient Credit Trading for the Chesapeake Bay. Chesapeake Bay Commission.

Schueler, T.R. 2000. The Practice of Watershed Protection. Center for Watershed Protection. Ellicott City, MD.

USEPA. 2003. National Management Measures for the Control of Nonpoint Pollution from Agriculture. USEPA, Office of Water. Washington D.C.

USEPA. 2005. Handbook for Developing Watershed Plans to Restore and Protect Our Waters. EPA 841-B-05-005. USEPA, Office of Water, Washington D.C.

USEPA. 2013. Getting in Step: Engaging Stakeholders in Your Watershed. EPA 841-B-11-001. USEPA, Office of Water, Washington D.C.

Wieland R. 2009. Cost Efficiencies for Nutrient Reduction Practices in Maryland. NOAA and MDNR.

Appendix A

FSU Water Quality Data

Control Number	Type	Sample Number	Date Collected	TSS, mg/L	Turbidity, NTU	Total Alkalinity, mg/L as $CaCO_3$	Total Hardness, mg/L as $CaCO_3$	Total Phosphorous, mg/L	TOC, mg/L	Total Nitrogen, mg/L	Orthophosphate, mg/L	Chloride, mg/L	Nitrate, mg/L	Nitrate as N, mg/L	Nitrite. mg/L	Nitrite as N, mg/L	Sulfate, mg/L	NO3-NO2-N (mg/L)	Cond	TDS	Total Coliform, Colony/100	E. coli, Colony/100 mL
02-05631	b	Jack Creek baselir	7/10/2002	< 5.00		28.00	34.00	< 0.030	< 0.50			2.35		0.26		0.00	3.67	0.26				
03-00442	b	Jack Creek baselir	1/14/2003	< 5.00		18.00	26.00	0.030	< 0.50			3.21		0.35		< 0.01	4.29	0.36				
05-01527	b	Jack Creek baselir	3/8/2005	< 5.00		6.00	10.00	0.090	< 0.70			1.38		0.11		< 0.01	2.29	0.12				
07-01165	b	Jack Grab	2/20/2007	< 5.00		2.00		0.020	0.91	0.17	< 0.040	1.55	0.01	0.00	0.59	0.13	2.63	0.14				
08-01163	b	Jack Grab	2/19/2008	< 5.00		6.00		< 0.020	1.04	0.32	< 0.040	1.67	< 0.01	< 0.00	1.71	0.39	2.74	0.39				
08-05071	b	Jack Grab	7/22/2008			12.00	10.00	0.040	0.67	0.28	< 0.040	1.60	< 0.01	< 0.00	0.98	0.22	2.33	0.22				
09-01559	b	Jack Grab	3/10/2009	< 5.00		8.00	8.00	0.020	0.70	0.10	< 0.040	1.51	< 0.01	< 0.00	0.19	0.04	2.74	0.05				
09-03138	b	JC Grab	5/12/2009	< 5.00		8.00	8.00	0.280	0.75	0.28	< 0.040	1.33	< 0.01	< 0.00	0.84	0.19	2.49	0.19				
09-06756	b	JC Grab	10/14/2009	< 5.00		8.00	8.00	0.040	1.25	0.25	< 0.040	1.32	< 0.01	< 0.00	0.91	0.21	2.54	0.21				
10-03320	b	Jack Grab	5/25/2010	< 5.00		6.00	8.00	0.060	1.20	0.23	< 0.061	2.30	< 0.16	< 0.05	0.53	0.12	2.20	0.17				
10-07449	b	Jack Creek baselir	12/7/2010	< 5.00	5.10	8.00	8.00	0.020	1.36	0.10	< 0.061	1.80	< 0.22	< 0.05	< 0.16	< 0.05	3.10	0.10			461.10	7.30
10-07449	b	Jack Creek	12/7/2010	< 5.00				0.02	1.36		< 0.02	1.80						< 0.05				
11-00865	b	Jack Creek baselir	2/14/2011	< 5.00	9.40	6.00	10.00	0.110	1.28	0.43	< 0.061	2.30	1.82	0.41	< 0.18	< 0.05	3.70	0.46			214.30	151.50
11-00865	b	Jack Creek	2/14/2011	< 5.00				0.11	1.28		< 0.02	2.30						0.41				
11-02764	b	Jack Creek baselir	5/17/2011	< 5.00	9.60	8.00	10.00	< 0.020	2.21	0.20	< 0.061	1.30	0.27	0.06	< 0.18	< 0.05	3.70	0.11			2419.60	6.30
11-02764	b	Jack Creek	5/17/2011	< 5.00				< 0.02	2.21		< 0.02	1.30						0.06				
11-07032	b	Jack Creek baselir	12/13/2011	< 5.00	2.50	4.00	8.00	< 0.020	1.30	NA	0.061	1.70	2.97	0.67	< 0.16	< 0.05	4.20	0.72			1203.30	60.50
11-07032	b	Jack Creek	12/13/2011	< 5.00				< 0.02	1.30		0.02	1.70						0.67				
12-00709	b	Jack Grab	1/31/2012	< 5.00	3.80	4.00	6.00	0.030	0.89	0.50	< 0.061	1.30	1.95	0.44	< 0.16	< 0.05	2.10	0.49	25.60	11.70		
12-01305	b	Jack Creek	2/29/2012	< 5.00				< 0.02	1.62		< 0.01	2.40						0.62				
12-02810	b	Jack Creek	5/10/2012	< 5.00				< 0.02	1.37		< 0.01	1.39						0.11				
12-06211	b	Jack Creek	10/24/2012	< 5.00				< 0.02	1.40		< 0.01	1.59						0.11				
13-00745	b	Jack Creek	2/5/2013	< 5.00				< 0.02	1.01		< 0.01	2.05						0.54				
13-02626	b	Jack Creek	5/7/2013	< 5.00				< 0.02	0.63		< 0.01	1.48						0.11				
13-04848	b	Jack Creek	8/20/2013	< 5.00				< 0.02	< 0.20		< 0.01	2.18						0.04				
13-06086	b	Jack Creek	10/22/2013	< 5.00				< 0.02	< 0.20		< 0.01	1.62						0.16				
14-00553	b	Jack Creek	1/28/2014	< 5.00				< 0.02	< 0.20		< 0.01	1.67						0.28				
	s	Jack-SW comosite	2/19/2007	12.50		3.00		0.093	2.21	0.28	0.040	1.38	0.01	0.00	0.77	0.17	2.64	0.18				
	s	Jack-SW composite	2/18/2008	68.00		7.00		0.130	1.03	0.16	0.040	2.17	0.01	0.00	0.02	0.00	2.98	0.01				
	s	Jack-SW composite	7/21/2008			6.50	8.50	0.168	1.75	0.54	0.040	1.44	0.01	0.00	1.89	0.43	2.47	0.43				
	s	Jack-SW composite	3/9/2009	20.00		7.50	8.50	0.065	1.22	0.46	0.040	1.49	0.01	0.00	0.35	0.08	2.67	0.08				
	s	Jack-SW composite	5/11/2009	152.79		10.00	6.00	0.333	2.63	0.89	0.040	1.36	0.02	0.01	0.74	0.17	2.20	0.17				
	s	Jack-SW composite	10/13/2009	18.25		9.50	10.00	0.093	3.53	0.27	0.061	1.27	0.01	0.00	0.46	0.10	2.30	0.11				
	s	Jack-SW composite	5/24/2010	44.50		7.00	9.00	0.195	3.72	0.33	0.061	1.20	0.16	0.05	0.79	0.18	2.20	0.23				
	s	Jack-SW composit	1/25/2012	296.50	154.95	5.00	7.50	0.540	3.88	0.67	0.061	1.04	1.83	0.41	0.16	0.05	2.00	0.46	23.45	10.70		

Jack Creek Baseline Summary Statistics	TSS, mg/L	Turbidity, NTU	Total Alkalinity, mg/L as $CaCO_3$	Total Hardness, mg/L as $CaCO_3$	Total Phosphorous, mg/L	TOC, mg/L	Total Nitrogen, mg/L	Orthophosphate, mg/L	Chloride, mg/L	Nitrate, mg/L	Nitrate as N, mg/L	Nitrite, mg/L	Nitrite as N, mg/L	Sulfate, mg/L	NO3-NO2-N (mg/L)	Cond	TDS	Total Coliform, Colony/100 mL	E. coli, Colony/100 mL
Average	5.00	6.08	8.80	11.85	0.043	1.04	0.26	0.032	1.78	0.62	0.16	0.55	0.10	2.98	0.26	25.60	11.70	1074.58	56.40
Min	5.00	2.50	2.00	6.00	0.020	0.20	0.10	0.010	1.30	0.01	0.00	0.16	0.00	2.10	0.04	25.60	11.70	214.30	6.30
Max	5.00	9.60	28.00	34.00	0.280	2.21	0.50	0.061	3.21	2.97	0.67	1.71	0.39	4.29	0.72	25.60	11.70	2419.60	151.50
Median	5.00	5.10	8.00	8.00	0.020	1.04	0.25	0.030	1.67	0.09	0.05	0.36	0.05	2.74	0.19	25.60	11.70	832.20	33.90
SD	0.00	3.26	6.49	8.31	0.054	0.53	0.12	0.021	0.46	1.02	0.21	0.49	0.11	0.74	0.20	#DIV/0!	#DIV/0!	990.30	68.27
75th%tile	5.00	9.40	8.00	10.00	0.035	1.33	0.30	0.045	2.12	0.66	0.31	0.86	0.16	3.68	0.40	25.60	11.70	1507.38	83.25
Count	26.00	5.00	15.00	13.00	27.000	27.00	11.00	24.000	27.00	12.00	15.00	12.00	15.00	15.00	27.00	1.00	1.00	4.00	4.00
90th%tile	5	9.52	15.6	22.8	0.098	1.4882	0.4299	0.061	2.3196	1.934599	0.428	0.9701	0.214457	4	0.572	25.6	11.7	2054.71	124.2

Jack Creek Storm Water Summary Statistics	TSS, mg/L	Turbidity, NTU	Total Alkalinity, mg/L as $CaCO_3$	Total Hardness, mg/L as $CaCO_3$	Total Phosphorous, mg/L	TOC, mg/L	Total Nitrogen, mg/L	Orthophosphate, mg/L	Chloride, mg/L	Nitrate, mg/L	Nitrate as N, mg/L	Nitrite, mg/L	Nitrite as N, mg/L	Sulfate, mg/L	NO3-NO2-N (mg/L)	Cond	TDS	Total Coliform, Colony/100 mL	E. coli, Colony/100 mL
Average	87.51	154.95	6.94	8.25	0.202	2.50	0.45	0.048	1.42	0.26	0.06	0.65	0.15	2.43	0.21	23.45	10.70	#DIV/0!	#DIV/0!
Min	12.50	154.95	3.00	6.00	0.065	1.03	0.16	0.040	1.04	0.01	0.00	0.02	0.00	2.00	0.01	23.45	10.70	0.00	0.00
Max	296.50	154.95	10.00	10.00	0.540	3.88	0.89	0.061	2.17	1.83	0.41	1.89	0.43	2.98	0.46	23.45	10.70	0.00	0.00
Median	44.50	154.95	7.00	8.50	0.149	2.42	0.40	0.040	1.37	0.01	0.00	0.60	0.14	2.39	0.18	23.45	10.70	#NUM!	#NUM!
SD	104.20	#DIV/0!	2.26	1.37	0.161	1.13	0.24	0.011	0.34	0.64	0.14	0.58	0.13	0.32	0.16	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
75th%tile	110.39	154.95	8.00	8.88	0.229	3.58	0.57	0.061	1.45	0.05	0.02	0.78	0.18	2.65	0.28	23.45	10.70	#NUM!	#NUM!
Count	7.00	1.00	8.00	6.00	8.000	8.00	8.00	8.000	8.00	8.00	8.00	8.00	8.00	8.00	8.00	1.00	1.00	0.00	0.00
90th%tile	210.27	154.95	9.65	9.50	0.395	3.77	0.73	0.061	1.69	0.66	0.16	1.12	0.25	2.76	0.44	23.45	10.70	#NUM!	#NUM!

Control Number	Type	Sample Number	Date Collected	TSS, mg/L	Turbidity, NTU	Total Alkalinity, mg/L as $CaCO_3$	Total Hardness, mg/L as $CaCO_3$	Total Phosphorous, mg/L	TOC, mg/L	Total Nitrogen, mg/L	Orthophosphate, mg/L	Chloride, mg/L	Nitrate, mg/L	Nitrate as N, mg/L	Nitrite, mg/L	Nitrite as N, mg/L	Sulfate, mg/L	No3-No2-N (mg/L)	Cond	TDS	mean daily discharge	TSS (lb/day)	Total Phosphorus (lb/day)	NO3-NO2-N (lb/day
02-05632	b	Jones Fork baseline	7/10/2002	< 5.00		12.00	14.00	0.050	< 0.50			1.48		0.16		< 0.00	2.01	0.16			0.02	0.54	0.01	0.02
03-00480	b	Jones Fork baseline	1/15/2003	< 5.00		6.00	8.00	0.030	0.73			2.37		0.20		< 0.01	2.82	0.20			2	53.88	0.32	2.19
05-01567	b	Jones Fork baseline	3/10/2005	< 5.00		10.00	16.00	0.130	< 0.70			2.13		0.33		< 0.01	3.34	0.34			14	377.13	9.81	25.82
08-00991	b	Jones fork grab	2/12/2008	< 5.00		14.00	18.00	< 0.020	0.61	0.52	< 0.040	2.92	2.38	0.54	< 0.01	< 0.00	4.65	0.54			16	431.01	1.72	46.61
08-03101	b	Jones Grab	6/1/2008	< 5.00		12.00	16.00	0.050	0.51	0.25	< 0.040	1.73	1.02	0.23	< 0.01	< 0.00	3.69	0.23			34	915.90	9.16	42.76
09-01554	b	Jones Grab	3/11/2009	< 5.00		16.00	20.00	0.040	0.91	0.29	< 0.040	2.80	1.06	0.24	< 0.01	< 0.00	4.22	0.24			8.8	237.06	1.90	11.54
09-03312	b	Grab	5/21/2009	< 5.00		16.00	16.00	0.050	0.64	0.46	< 0.040	1.78	1.47	0.33	< 0.01	< 0.00	3.71	0.33			9.5	255.91	2.56	17.11
09-06257	b	Grab	9/23/2009	< 5.00		20.00	22.00	0.050	1.48	0.90	< 0.040	1.65	3.55	0.80	< 0.01	< 0.00	3.87	0.81			40	1077.53	10.78	173.66
09-06731	b	Grab	10/13/2009	< 5.00		18.00	18.00	0.090	1.94	0.49	< 0.040	1.78	1.74	0.39	< 0.01	< 0.00	3.37	0.40			119	3205.65	57.70	254.23
09-07426	b	Jones Grab	11/4/2009	< 5.00		16.00	18.00	0.090	0.84	0.39	< 0.040	1.49	1.34	0.30	< 0.01	< 0.00	3.39	0.31			45	1212.22	21.82	74.01
09-08673	b	Jones Grab	12/30/2009	< 5.00		14.00	20.00	0.020	0.57	0.60	< 0.040	1.96	2.00	0.45	< 0.01	< 0.00	3.94	0.45			41	1104.47	4.42	100.26
10-01299	b	Jones Grab	2/25/2010	< 5.00		12.00	16.00	0.020	0.86	0.62	< 0.061	1.70	2.04	0.46	< 0.16	< 0.05	3.80	0.51			43	1158.34	4.63	118.15
10-01658	b	Jones Fork baseline	3/15/2010					0.020													16	0.00	1.72	0.00
10-01981	b	Jones Grab	3/25/2010	< 5.00		12.00	14.00	0.080	1.40	0.75	0.061	1.50	2.74	0.62	< 0.16	< 0.05	3.40	0.67			192	5172.13	82.75	693.07
10-04108	b	Jones Grab	6/28/2010	< 5.00		30.00	30.00	0.050	1.73	0.62	< 0.061	2.50	2.57	0.58	< 0.16	< 0.05	4.60	0.63			2.3	61.96	0.62	7.81
10-04523	b	Jones Grab	7/15/2010	< 5.00		24.00	24.00	< 0.020	1.39	0.38	< 0.061	2.00	1.59	0.36	< 0.16	< 0.05	4.40	0.41			6.9	185.87	0.74	15.24
10-06042	b	Jones Grab	9/29/2010	< 5.00		26.00	28.00	< 0.020	0.50	0.38	< 0.061	2.30	1.73	0.39	< 0.16	< 0.05	4.50	0.44			9.8	263.99	1.06	23.23
10-06675	b	Jones Grab	11/1/2010	< 5	0.90	28.00	28	< 0.020	0.2031	0.1819	< 0.061	3.20	0.71	0.16	< 0.16	< 0.05	5.70	0.21	74.5	35.2	2.6	70.04	0.28	2.94
10-07327	b	Jones Fork baseline	12/2/2010	< 5.00	4.80	20.00	26.00	0.060	1.82	0.44	< 0.061	2.30	1.99	0.45	< 0.16	< 0.05	4.50	0.50			9.1	245.14	2.94	24.51
10-07327	b	Jones Fork	12/2/2010	< 5.00				0.06	1.82		< 0.02	2.30						0.45						
10-07409	b	Jones Grab	12/6/2010	< 5	2.80	22.00	26	0.030	NA	NA	< 0.061	2.30	1.68	0.38	< 0.16	< 0.05	4.50	0.43	64.2	30.2	6	161.63	0.97	13.90
11-00878	b	Jones Fork baseline	2/15/2011	< 5.00	15.00	12.00	16.00	0.040	1.27	1.05	< 0.061	2.80	4.07	0.92	< 0.16	< 0.05	4.80	0.97			66	1777.92	14.22	344.92
11-00878	b	Jones Fork	2/15/2011	< 5.00				0.04	1.27		< 0.02	2.80						0.92						
11-01084	b	Jones Grab	2/23/2011	< 5	5.20	14.00	16	0.080	0.7415	0.73	0.064	2.70	3.45	0.78	< 0.16	< 0.05	5.30	0.83	50	23.4	16	431.01	6.90	71.55
11-01267	b	Jones Grab	3/3/2011	< 5	7.70	14.00	16	0.020	1.172	0.7467	< 0.061	2.80	3.59	0.81	< 0.16	< 0.05	5.00	0.86	48	22.4	35	942.84	3.77	162.17
11-02812	b	Jones Fork baseline	5/19/2011	< 5.00	7.60	16.00	18.00	0.020	2.04	0.28	< 0.061	1.60	0.90	0.21	< 0.16	< 0.05	3.90	0.26			9.4	253.22	1.01	13.17
11-02812	b	Jones Fork	5/19/2011	< 5.00				0.02	2.04		< 0.02	1.60						0.21						
11-07070	b	Jones Fork baseline	12/14/2011	< 5.00	5.30	12.00	38.00	< 0.020	1.20	NA	< 0.030	2.00	4.87	1.10	< 0.02	< 0.01	4.20	1.11				0.00	0.00	0.00
11-07070	b	Jones Fork	12/14/2011	< 5.00				< 0.02	1.20		< 0.01	2.00						1.10						
12-01303	b	Jones Fork	2/29/2012	< 5.00				< 0.02	1.03		< 0.01	2.30						0.50						
12-02812	b	Jones Fork	5/10/2012	< 5.00				< 0.02	1.22		< 0.01	1.96						0.26						
12-06210	b	Jones Fork	10/24/2012	< 5.00				< 0.02	1.92		< 0.01	6.03						1.19						
13-00778	b	Jones Fork	2/6/2013	< 5.00				< 0.02	0.80		< 0.01	2.97						1.02						
13-02818	b	Jones Fork	5/15/2013	< 5.00				< 0.02	0.69		< 0.01	1.83						0.29						
13-04870	b	Jones Fork	8/21/2013	< 5.00				< 0.02	0.29		< 0.01	1.51						0.20						
13-06108	b	Jones Fork	10/23/2013	< 5.00				< 0.02	< 0.20		< 0.01	1.81						0.21						
14-00552	b	Jones Fork	1/28/2014	< 5.00				< 0.02	< 0.20		< 0.01	1.99						0.40						
	s	Jones SW-composite	2/6/2008	16.50		12.50	19.00	0.103	2.65	0.46	0.040	3.19	0.37	0.08	0.01	0.00	4.59	0.09			59	5244.87	32.85	27.53
	s	Jones-SW composite	4/24/2008	100.18		14.00	16.00	0.253	1.71	0.49	0.040	1.81	1.61	0.36	0.01	0.00	3.86	0.37			123	66385.05	167.88	243.02
	s	Jones-SW composite	2/19/2009	34.00		12.50	16.00	0.158	1.14	0.76	0.061	2.00	2.93	0.66	0.16	0.05	3.95	0.71			32	5861.75	27.15	122.84
	s	Jones-SW composite	3/10/2009	99.67		16.00	19.33	0.367	2.08	0.51	0.040	2.01	1.39	0.31	0.01	0.00	4.16	0.32			7	3758.78	13.83	11.96
	s	Jones-SW composite	5/14/2009	41.50		12.50	16.00	0.188	2.23	0.78	0.040	1.59	2.83	0.64	0.01	0.00	4.02	0.64			174	38904.15	175.77	601.12
	s	Jones-SW composite	9/22/2009	34.00		24.50	25.00	0.045	2.49	0.59	0.040	2.01	1.42	0.32	0.01	0.00	4.45	0.32			185	33888.26	44.85	323.81
	s	Jones-SW composite	10/9/2009	16.25		24.00	26.00	0.073	1.39	0.36	0.040	2.10	1.28	0.29	0.03	0.01	4.33	0.30			304	26614.94	118.74	487.98
	s	Jones-SW composite	10/30/2009	101.44		22.00	26.00	0.383	3.48	0.61	0.040	1.88	1.42	0.32	0.03	0.01	5.07	0.33			249	136088.50	514.25	442.15
	s	Jones-SW composite	12/25/2009	40.67		14.67	23.33	0.280	3.73	0.69	0.040	1.78	2.09	0.47	0.01	0.00	3.53	0.48			125	27387.17	188.57	320.09
	s	Jones-SW composite	3/23/2010	409.08		25.00	29.00	1.148	7.79	1.52	0.393	1.88	4.38	0.99	1.19	0.36	5.20	1.35			203	447409.82	1255.01	1479.22
	s	Jones-SW composite	6/20/2010	208.11		22.67	26.67	0.833	2.28	1.01	0.510	2.23	4.84	1.09	0.16	0.05	4.43	1.14			5.2	5830.35	23.35	32.03
	s	Jones-SW composite	7/13/2010	87.00		28.00	28.00	0.270	2.71	0.63	0.063	1.46	2.77	0.63	0.16	0.05	3.73	0.68			14	6562.15	20.37	51.04
	s	Jones-SW composite	9/25/2010	50.00		28.67	31.33	0.203	2.52	0.49	0.061	2.53	1.95	0.44	0.16	0.05	5.57	0.49			13	3501.97	14.24	34.32
	s	Jones-SW composite	10/19/2010	125.5533	333.97	33.33	37.3333333	0.397	0.30915	0.329567	0.073	3.27	1.95	0.44	0.16	0.05	7.70	0.49	91.93333	43.56667	1.3	879.37	2.78	3.43
	s	Jones-SW composite	11/26/2010	76.75	146.58	25.00	28.5	0.148			0.074	2.38	2.22	0.50	0.16	0.05	5.25	0.55	74.025	34.925	23	9510.53	18.28	68.46
	s	Jones-SW composite	2/15/2011	5.75	17.50	13.00	18	0.113			0.064	2.78	4.23	0.96	0.16	0.05	5.23	1.01	51.475	24.125	66	2044.61	40.00	357.36
	s	Jones-SW composite	2/25/2011	263	656.48	17.50	19.5	0.983			0.362	2.85	3.81	0.86	0.16	0.05	6.15	0.91	56.125	26.35	98	138861.03	518.75	480.47
	s	Jones-SW composite	4/21/2011	511.5	552.25	18.00	25	0.998			0.068	1.77	1.99	0.45	0.16	0.05	3.90	0.50	#REF!	#REF!	47	129521.56	252.59	126.61
	s	Jones-SW composite	1/29/2013	127.25				0.18	3.08		0.016	2.87						0.78			8.6	5895.96	8.34	36.36
	s	Jones-SW composite	5/20/2013	647.17				0.96	1.32		0.010	1.54						0.37			5.1	17782.20	26.38	10.25
	s	Jones-SW composite	10/15/2013	36.75				0.12	0.20		0.010	2.14						0.23			4.6	910.78	3.04	5.64

Jones Fork Baseline Summary Statistics	TSS, mg/L	Turbidity, NTU	Total Alkalinity, mg/L as $CaCO_3$	Total Hardness, mg/L as $CaCO_3$	Total Phosphorous, mg/L	TOC, mg/L	Total Nitrogen, mg/L	Orthophosphate, mg/L	Chloride, mg/L	Nitrate, mg/L	Nitrate as N, mg/L	Nitrite, mg/L	Nitrite as N, mg/L	Sulfate, mg/L	No3-No2-N (mg/L)	Cond	TDS	USGS mean daily	TSS (lb/day)	Total Phosphorus (lb/day)	NO3-NO2-N (lb/day
Average	5.00	6.16	16.42	20.08	0.038	1.04	0.53	0.038	2.25	2.22	0.47	0.10	0.03	4.07	0.52	59.18	27.80	30.98	783.82	9.67	89.55
Min	5.00	0.90	6.00	8.00	0.020	0.20	0.18	0.010	1.48	0.71	0.16	0.01	0.00	2.01	0.16	48.00	22.40	0.02	0.00	0.00	0.00
Max	5.00	15.00	30.00	38.00	0.130	2.04	1.05	0.064	6.03	4.87	1.10	0.16	0.05	5.70	1.19	74.50	35.20	192.00	5172.13	82.75	693.07
Median	5.00	5.25	15.00	18.00	0.020	0.91	0.49	0.040	2.00	1.99	0.39	0.16	0.03	4.07	0.44	57.10	26.80	15.00	263.99	2.56	24.51
SD	0.00	4.23	5.36	6.55	0.027	0.56	0.23	0.022	0.81	1.13	0.26	0.08	0.02	0.81	0.30	12.51	6.03	43.43	1166.38	19.31	152.95
75th%tile	5.00	7.63	20.00	24.50	0.050	1.40	0.67	0.061	2.55	2.74	0.59	0.16	0.05	4.53	0.70	66.78	31.45	40.25	1077.53	9.16	100.26
Count	36.00	8.00	24.00	24.00	37.000	35.00	19.00	33.000	36.00	21.00	24.00	21.00	24.00	24.00	36.00	4.00	4.00	24.00	25.00	25.00	25.00
90th%tile	5	9.89	25.4	28	0.080	1.8812	0.779	0.061	2.8615	3.58587	0.80784	0.1642	0.05	4.94	0.9955	71.41	33.7	59.7	1551.64032	18.78131304	222.00557

Jones Fork Storm Water Summary Statistics	TSS, mg/L	Turbidity, NTU	Total Alkalinity, mg/L as $CaCO_3$	Total Hardness, mg/L as $CaCO_3$	Total Phosphorous, mg/L	TOC, mg/L	Total Nitrogen, mg/L	Orthophosphate, mg/L	Chloride, mg/L	Nitrate, mg/L	Nitrate as N, mg/L	Nitrite, mg/L	Nitrite as N, mg/L	Sulfate, mg/L	No3-No2-N (mg/L)	Cond	TDS	USGS mean daily discharge (cfs)	TSS (lb/day)	Total Phosphorus (lb/day)	NO3-NO2-N (lb/day
Average	144.39	341.35	20.21	23.89	0.391	2.42	0.66	0.099	2.19	2.42	0.55	0.15	0.05	4.73	0.57	#REF!	#REF!	83.18	52992.56	165.10	250.75
Min	5.75	17.50	12.50	16.00	0.045	0.20	0.33	0.010	1.46	0.37	0.08	0.01	0.00	3.53	0.09	#REF!	#REF!	1.30	879.37	2.78	3.43
Max	647.17	656.48	33.33	37.33	1.148	7.79	1.52	0.510	3.27	4.84	1.09	1.19	0.36	7.70	1.35	#REF!	#REF!	304.00	447409.82	1255.01	1479.22
Median	87.00	333.97	20.00	25.00	0.253	2.28	0.60	0.040	2.01	2.04	0.46	0.16	0.05	4.44	0.49	#REF!	#REF!	47.00	9510.53	32.85	122.84
SD	174.39	267.70	6.52	5.97	0.357	1.70	0.31	0.138	0.53	1.22	0.28	0.27	0.08	1.03	0.32	#REF!	#REF!	91.47	101227.84	292.97	341.37
75th%tile	127.25	552.25	24.88	27.67	0.397	2.71	0.74	0.068	2.53	2.91	0.66	0.16	0.05	5.22	0.71	#REF!	#REF!	125.00	38904.15		357.36
Count	21.00	5.00	18.00	18.00	21.000	17.00	14.00	21.000	21.00	18.00	18.00	18.00	18.00	18.00	21.00	4.00	4.00	21.00	21.00	21.00	21.00
90th%tile	409.08	614.79	28.20	29.70	0.983	3.58	0.94	0.362	2.87	4.27	0.97	0.16	0.05	5.74	1.01	#REF!	#REF!	203.00	136088.50	514.25	487.98

Control Number	Type	Sample Number	Date Collected	TSS, mg/L	Turbidity, NTU	Total Alkalinity, mg/L as CaCO$_3$	Total Hardness, mg/L as CaCO$_3$	Total Phosphorous, mg/L	TOC, mg/L	Total Nitrogen, mg/L	Orthophosphate, mg/L	Chloride, mg/L	Nitrate, mg/L	Nitrate as N, mg/L	Nitrite, mg/L	Nitrite as N, mg/L	Sulfate, mg/L	NO3-NO2-N (mg/L)	Conductivity (uS)	TDS (mg/L)	Total Coliform, Colony/100 mL	E. coli, Colony/100 mL	USGS mean daily discharge (cfs)	TSS (lb/day)	Total Phosphorus (lb/day)	NO3-NO2-N (lb/day)
02-05630	b	Frog Bayou base	7/10/2002	< 5.00		10.00	14.00	0.040	0.56			1.39		0.19		< 0.00	4.36	0.19						0	0	0
03-00441	b	Frog Bayou base	1/14/2003	< 5.00		6.00	10.00	< 0.030	0.57			1.68		0.28		< 0.01	3.12	0.29					9.820833333	264.555573	1.58733344	15.1785
05-01570	b	Frog Bayou base	3/10/2005	< 5.00		14.00	8.00	0.160	1.16			1.38		0.19		< 0.01	3.12	0.20					36.73958333	989.698744	31.6703438	39.5004
07-07587	b	Frog Grab	12/20/2007	< 5.00		6.00	12.00	0.110	0.69	0.27	< 0.040	1.82	1.15	0.26	< 0.01	< 0.00	3.41	0.26						0	0	0
08-03097	b	Frog Grab	5/1/2008	< 5.00		8.00	8.00	0.040	0.69	0.13	< 0.040	1.39	0.37	0.08	< 0.01	< 0.00	3.41	0.09						0	0	0
09-06865	b	Frog Grab	10/15/2009	< 5.00		10.00	10.00	0.050	1.24	0.22	< 0.040	1.04	0.69	0.16	< 0.01	< 0.00	3.03	0.16						0	0	0
10-07326	b	Frog Bayou base	12/2/2010	< 5.00	8.60	10.00	14.00	0.060	1.84	0.23	< 0.061	1.50	1.06	0.24	< 0.16	< 0.05	4.50	0.29			1046.2	19.5		0	0	0
10-07326	b	Frog Bayou	12/2/2010	< 5.00				0.06	1.84		< 0.02	1.50						0.24								
10-07404	b	Frog Grab	12/3/2010	< 5.00	6.70	16.00	16.00	0.070	NA	NA	< 0.061	1.60	1.24	0.28	< 0.16	< 0.05	3.80	0.33	44.8	20.9				0	0	0
11-00877	b	Frog Bayou base	2/15/2011	< 5.00	17.00	8.00	14.00	0.040	1.71	0.83	< 0.061	1.80	2.74	0.62	< 0.16	< 0.05	4.40	0.67			517.2	13.4		0	0	0
11-00877	b	Frog Bayou	2/15/2011	< 5.00				0.04	1.71		< 0.02	1.80						0.62								
11-01272	b	Frog Grab	3/3/2011	< 5.00	10.00	10.00	12.00	< 0.020	1.12	0.52	< 0.061	1.80	2.52	0.57	< 0.16	< 0.05	5.70	0.62	36.7	17.1				0	0	0
11-02811	b	Frog Bayou base	5/19/2011	< 5.00	11.00	12.00	14.00	0.020	2.55	0.24	< 0.061	1.30	0.34	0.08	< 0.16	< 0.05	3.60	0.13			1119.9	13.5		0	0	0
11-02811	b	Frog Bayou	5/19/2011	< 5.00				0.02	2.55		< 0.02	1.30						0.08								
11-07069	b	Frog Bayou base	12/14/2011	< 5.00	3.60	18.00	14.00	< 0.020	1.30	NA	< 0.030	1.60	3.59	0.81	< 0.02	< 0.01	3.90	0.82			686.7	13.2		0	0	0
11-07069	b	Frog Bayou	12/14/2011	< 5.00				< 0.02	1.30		< 0.01	1.60						0.81								
12-00674	b	Frog Grab	1/30/2012	< 5.00	5.80	10.00	12.00	0.050	1.11	0.80	< 0.061	1.30	3.28	0.74	< 0.16	< 0.05	5.10	0.79	41.7	19.4				0	0	0
12-01304	b	Frog Bayou	2/29/2012	< 5.00				< 0.02	1.00		< 0.01	7.90						5.90								
12-02811	b	Frog Bayou	5/10/2012	< 5.00				< 0.02	1.52		< 0.01	1.48						0.08								
12-06209	b	Frog Bayou	10/24/2012	< 5.00				< 0.02	2.08		< 0.01	1.70						0.38								
13-00777	b	Frog Bayou	2/6/2013	< 5.00				< 0.02	0.84		< 0.01	1.53						0.61								
15-02675	b	Frog Bayou	5/9/2013	< 5.00				< 0.02	0.44		< 0.01	1.66						0.37								
13-04869	b	Frog Bayou	8/21/2013	< 5.00				< 0.02	< 0.20		< 0.01	1.14						0.19								
13-06109	b	Frog Bayou	10/23/2013	< 5.00				0.02	< 0.20		< 0.01	1.53						0.30								
14-00551	b	Frog Bayou	1/28/2014	< 5.00				0.04	< 0.20		< 0.01	1.43						0.31								
	s	Frog-SW composite	12/19/2007	23.25		7.50	10.00	0.138	3.61	0.47	0.068	2.27	1.14	0.26	0.01	0.00	3.35	0.26					27.7	3469.77485	20.5201739	38.7499
	s	Frog-SW composite	4/30/2008	36.25		6.50	9.50	0.088	1.51	0.47	0.040	1.37	1.52	0.34	0.01	0.00	#DIV/0!	0.35								
	s	Frog-SW composite	10/14/2009	150.75		14.00	13.50	0.300	3.74	0.92	0.059	1.27	0.56	0.13	0.01	0.00	2.72	0.13					182	147817.985	294.165144	126.935
13-03109	s	Frog-SW composite	11/25/2010	1230.58				3.08			0.02	1.52						0.35								
13-03110	s	Frog-SW composite	2/23/2011	72.14				0.10	3.62		0.07	2.68						0.58								
13-06546	s	Frog-SW composite	1/25/2012	71.50				0.19	2.66		0.02	1.20						0.79					642	247308.839	657.184327	2720.97
13-06547	s	Frog-SW composite	10/14/2012	101.25				0.84	3.84		0.32	1.63						0.38					89.5	48822.1202	406.24826	181.425
13-06548	s	Frog-SW composite	1/29/2013	195.95				0.51	3.25		0.01	1.71						0.48					104.4	110215.921	286.859504	270.173
13-06549	s	Frog-SW composite	5/21/2013	58.50				0.09	1.38		0.01	1.19						0.34					487	153491.17	236.140261	892.085
13-06550	s	Frog-SW composite	11/6/2013	73.25				0.14	0.66		0.01	1.46						0.28					144.9	57184.0069	105.39032	220.344

Frog Bayou Baseline Summary Statistics	TSS, mg/L	Turbidity, NTU	Total Alkalinity, mg/L as CaCO$_3$	Total Hardness, mg/L as CaCO$_3$	Total Phosphorous, mg/L	TOC, mg/L	Total Nitrogen, mg/L	Orthophosphate, mg/L	Chloride, mg/L	Nitrate, mg/L	Nitrate as N, mg/L	Nitrite, mg/L	Nitrite as N, mg/L	Sulfate, mg/L	NO3-NO2-N (mg/L)	Conductivity (uS)	TDS (mg/L)	Total Coliform, Colony/100 mL	E. coli, Colony/100 mL	USGS mean daily discharge (cfs)	TSS (lb/day)	Total Phosphorus (lb/day)	NO3-NO2-N (lb/day)
Average	5.00	8.96	10.62	12.15	0.039	1.18	0.41	0.030	1.77	1.70	0.35	0.10	0.03	3.80	0.59	41.07	19.13	842.50	14.90	23.28	96.48	2.56	4.21
Min	5.00	3.60	6.00	8.00	0.020	0.20	0.13	0.010	1.04	0.34	0.08	0.01	0.00	3.03	0.08	36.70	17.10	517.20	13.20	9.82	0.00	0.00	0.00
Max	5.00	17.00	18.00	16.00	0.160	2.55	0.83	0.061	7.90	3.59	0.81	0.16	0.05	5.70	5.90	44.80	20.90	1119.90	19.50	36.74	989.70	31.67	39.50
Median	5.00	8.60	10.00	12.00	0.020	1.14	0.25	0.020	1.53	1.19	0.26	0.16	0.01	3.60	0.30	41.70	19.40	866.45	13.45	23.28	0.00	0.00	0.00
SD	0.00	4.36	3.59	2.51	0.033	0.69	0.28	0.022	1.29	1.22	0.25	0.08	0.02	0.77	1.13	4.09	1.91	287.83	3.07	19.03	278.16	8.76	11.40
75th%tile	5.00	10.50	12.00	14.00	0.040	1.71	0.59	0.056	1.68	2.69	0.57	0.16	0.05	4.36	0.62	43.25	20.15	1064.63	15.00	30.01	0.00	0.00	0.00
Count	25.00	7.00	13.00	13.00	25.000	24.00	8.00	22.000	25.00	10.00	13.00	10.00	13.00	13.00	25.00	3.00	3.00	4.00	4.00	2.00	13.00	13.00	13.00
90th%tile	5	13.4	15.6	14	0.060	2.0057	0.80927	0.061	1.8	3.306069	0.716	0.1642	0.05	4.48	0.802	44.18	20.6	1097.79	17.7	34.04770833	211.644458	1.26986675	12.1428

Frog Bayou Storm Water Summary Statistics	TSS, mg/L	Turbidity, NTU	Total Alkalinity, mg/L as CaCO$_3$	Total Hardness, mg/L as CaCO$_3$	Total Phosphorous, mg/L	TOC, mg/L	Total Nitrogen, mg/L	Orthophosphate, mg/L	Chloride, mg/L	Nitrate, mg/L	Nitrate as N, mg/L	Nitrite, mg/L	Nitrite as N, mg/L	Sulfate, mg/L	NO3-NO2-N (mg/L)	Conductivity (uS)	TDS (mg/L)	Total Coliform, Colony/100 mL	E. coli, Colony/100 mL	USGS mean daily discharge (cfs)	TSS (lb/day)	Total Phosphorus (lb/day)	NO3-NO2-N (lb/day)
Average	201.34	#DIV/0!	9.33	11.00	0.548	2.69	0.62	0.062	1.63	1.07	0.24	0.01	0.00	#DIV/0!	0.39	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	239.64	109758.55	286.64	635.81
Min	23.25	0.00	6.50	9.50	0.088	0.66	0.47	0.010	1.19	0.56	0.13	0.01	0.00	#DIV/0!	0.13	0.00	0.00	0.00	0.00	27.70	3469.77	20.52	38.75
Max	1230.58	0.00	14.00	13.50	3.083	3.84	0.92	0.318	2.68	1.52	0.34	0.01	0.00	#DIV/0!	0.79	0.00	0.00	0.00	0.00	642.00	247308.84	657.18	2720.97
Median	72.70	#NUM!	7.50	10.00	0.164	3.25	0.47	0.030	1.49	1.14	0.26	0.01	0.00	#DIV/0!	0.35	#NUM!	#NUM!	#NUM!	#NUM!	144.90	110215.92	286.86	220.34
SD	365.34	#DIV/0!	4.07	2.18	0.923	1.21	0.26	0.093	0.49	0.48	0.11	0.00	0.00	#DIV/0!	0.18	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	231.35	81706.78	207.32	961.06
75th%tile	138.38	#NUM!	10.75	11.75	0.458	3.62	0.69	0.064	1.69	1.33	0.30	0.01	0.00	#DIV/0!	0.45	#NUM!	#NUM!	#NUM!	#NUM!	334.50	150654.58	350.21	581.13
Count	10.00	0.00	3.00	3.00	10.000	9.00	3.00	10.000	10.00	3.00	3.00	3.00	3.00	2.00	10.00	0.00	0.00	0.00	0.00	7.00	7.00	7.00	7.00
90th%tile	299.41	#NUM!	12.70	12.80	1.067	3.76	0.83	0.093	2.31	1.44	0.33	0.01	0.00	#DIV/0!	0.60	#NUM!	#NUM!	#NUM!	#NUM!	549.00	191018.24	506.62	1623.64

Appendix B

GBMc Water Quality Data

Sample Type	Sample ID	Sample Date	Sample Time	Flow (cfs)	BOD, mg/L	TSS, mg/L	PO₄ as P, mg/L	NH_3 as N, mg/L	NO_3+NO_2 as N, mg/L	Chloride, mg/L	Phosphorous as P, mg/L	TOC, mg/L	Load-OrhtoP (lb/d)	Load-TSS (lb/d)	Load-NH3 (lb/d)	NO3-NO2-N (lb/d)	Load-TP (lb/d)	Load-BOD	Load-TOC	WS-area (mi2)	WS-area (Acres)	TSS-lb/acre	NO3-NO2-lb/acre	TP-lb/acre
Baseline	FB-1	1/18/2012	6:50	34.70	< 2.00	< 5.00	< 0.02	< 0.05	< 0.5	NA	< 0.02	0.52	3.7	934.8	9.3	93.5	3.7	373.9	98.0	34	21760	0.04296	0.0043	0.00017
Storm Event	FB-1	1/25/2012	7:05	409.00	i 2.59	152.00	< 0.02	< 0.05	< 0.5	NA	0.32	3.43	44.1	334938.8	110.2	1101.8	705.1	5707.2	7558.2	34	21760	15.3924	0.05063	0.03241
Storm Event	FB-1	3/8/2012	13:00	29.10	< 2.00	< 5.00	< 0.02	< 0.05	0.48	1.9	< 0.02	1.88	3.1	783.9	7.8	75.3	3.1	313.6	294.4	34	21760	0.03602	0.00346	0.00014
Baseline	FB-1	4/3/2012	16:43	33.10	< 2.00	< 5.00	< 0.02	< 0.05	0.34	1.4	< 0.02	1.01	3.6	891.7	8.9	60.6	3.6	356.7	180.8	34	21760	0.04098	0.00279	0.00016
Storm Event	FB-1	3/16/2014	16:20	1553.00		78.00	< 0.02	< 0.05	0.56	1.02	0.21		167.3	652626.4	418.4	4719.0	1757.1			34	21760	29.992	0.21687	0.08075
Storm Event	FB-1	4/4/2014	16:05	262.00		6.00	< 0.02	< 0.05	0.34	1.10	0.02		28.2	8469.4	70.6	477.1	28.2			34	21760	0.38922	0.02193	0.0013
Storm Event D	FB-1D	4/4/2014	16:05	262.00		5.00	< 0.02	< 0.05	0.34	1.09	< 0.02		28.2	7057.8	70.6	479.9	28.2			34	21760	0.32435	0.02206	0.0013
Storm Event	FB-1	5/8/2014	21:00	8.00		< 5.00	< 0.02	< 0.05	0.22	1.29	0.04		0.86202	215.5056	2.15506	9.26674	1.72404			34	21760	0.0099	0.00043	7.9E-05
Storm Event D	FB-1D	5/8/2014	21:05	8.00		< 5.00	< 0.02	< 0.05	0.22	1.31	0.03		0.86202	215.5056	2.15506	9.26674	1.29303			34	21760	0.0099	0.00043	5.9E-05
Baseline																								
Average					2.00	5.00	0.02	0.05	0.42	1.40	0.02	0.77	3.7	913.2	9.1	77.1	3.7	365.3	139.4					
min					2.00	5.00	0.02	0.05	0.34	1.40	0.02	0.52	3.6	891.7	8.9	60.6	3.6	356.7	98.0					
Max					2.00	5.00	0.02	0.05	0.50	1.40	0.02	1.01	3.7	934.8	9.3	93.5	3.7	373.9	180.8					
Median					2.00	5.00	0.02	0.05	0.42	1.40	0.02	0.77	3.7	913.2	9.1	77.1	3.7	365.3	139.4					
Stdev					0	0	0	0	0.11314	#DIV/0!	0	0.34648	0.1	30.5	0.3	23.2	0.1	12.2	58.6					
Storm water																								
Average					2.30	49.20	0.02	0.05	0.42	1.33	0.12	2.65	48.73	199406.79	121.82	1276.48	499.06	3010.37	3926.30			9.1639	0.0587	0.0229
min					2.00	5.00	0.02	0.05	0.22	1.02	0.02	1.88	0.86	215.51	2.16	9.27	1.72	313.56	294.43			0.0099	0.0004	0.0001
Max					2.59	152.00	0.02	0.05	0.56	1.90	0.32	3.43	167.34	652626.38	418.35	4718.99	1757.07	5707.18	7558.16			29.9920	0.2169	0.0807
Median					2.30	6.00	0.02	0.05	0.48	1.20	0.04	2.65	28.23	8469.37	70.58	477.11	28.23	3010.37	3926.30			0.3892	0.0219	0.0013
Stdev					0.42	65.52	0.00	0.00	0.14	0.40	0.14	1.10	68.70	291274.03	171.76	1972.89	764.86	3813.87	5136.23			13.3858	0.0907	0.0351
Count (n)					2	5	5	5	5	4	5		5	5	5	5	5	2	2			5.0000	5.0000	5.0000

Sample Type	Sample ID	Sample Date	Sample Time	Flow (cfs)	BOD, mg/L	TSS, mg/L	PO_4 as P, mg/L	NH_3 as N, mg/L	NO_3+NO_2 as N, mg/L	Chloride, mg/L	Phosphorous as P, mg/L	TOC, mg/L	Load-OrhtoP (lb/d)	Load-TSS (lb/d)	Load-NH3 (lb/d)	Load-NO3-NO2-N (lb/d)	Load-TP (lb/d)	Load-BOD	Load-TOC	WS-area (mi2)	WS-area (Acres)	TSS-lb/acre	NO3-NO2-lb/acre	TP-lb/acre
Baseline	Jones 1	1/18/2012	8:20	38.00	< 2.00	< 5.00	< 0.02	< 0.05	< 0.5	NA	< 0.02	0.47	4.1	1023.7	10.2	102.4	4.1	409.5	96.8	20.9	13376	0.076529	0.007653	0.000306
Storm Event	Jones 1	1/25/2012	6:30	415.00	i 2.31	122.00	< 0.02	< 0.05	< 0.5	NA	0.28	3.60	44.7	272776.2	111.8	1117.9	626.0	5164.9	8051.4	20.9	13376	20.39296	0.083578	0.046804
Storm Event	Jones 1	3/8/2012	12:30	27.00	< 2.00	< 5.00	< 0.02	< 0.05	0.52	2.5	< 0.02	1.44	2.9	727.3	7.3	75.6	2.9	290.9	208.9	20.9	13376	0.054376	0.005655	0.000218
Baseline	Jones 1	4/3/2012	17:10	20.09	< 2.00	< 5.00	< 0.02	< 0.05	0.48	1.7	< 0.02	1.08	2.2	541.2	5.4	52.0	2.2	216.5	116.4	20.9	13376	0.04046	0.003884	0.000162
Storm Event	Jones-1	3/16/2014	16:10	467.00		59.00	< 0.02	< 0.05	0.68	1.48	0.20		50.3	148445.6	125.8	1700.8	503.2			20.9	13376	11.09791	0.127156	0.03762
Storm Event*	Jones-1	3/16/2014	09:30/11:30	690.00		392.00	< 0.02	< 0.05	0.50	1.64	0.62		74.3	1457248.9	185.9	1873.6	2304.8			20.9	13376	108.945	0.140072	0.172311
Storm Event Dup*	Jones1- D	3/16/2014	09:30/11:30	690.00		431.11	< 0.02	< 0.05	0.51	1.65	0.56		74.3	1602639.2	185.9	1881.0	2081.8			20.9	13376	119.8145	0.140628	0.155636
Storm Event	Jones-1	4/4/2014	15:50	122.00		< 5.00	< 0.02	< 0.05	0.32	1.59	< 0.02		13.1	3286.5	32.9	209.7	13.1			20.9	13376	0.245698	0.015676	0.000983
Storm Event	Jones-1	5/8/2014	20:50	17.00		< 5.00	< 0.02	< 0.05	0.21	1.74	< 0.02		1.831798	457.9494	4.579494	19.508644	1.831798			20.9	13376	0.034237	0.001458	0.000137
Baseline																								
Average					2.00	5.00	0.02	0.05	0.49	1.70	0.02	0.77	3.1	782.4	7.8	77.2	3.1	313.0	106.6			0.058	0.006	0.000
min					2.00	5.00	0.02	0.05	0.48	1.70	0.02	0.47	2.2	541.2	5.4	52.0	2.2	216.5	96.8			0.040	0.004	0.000
Max					2.00	5.00	0.02	0.05	0.50	1.70	0.02	1.08	4.1	1023.7	10.2	102.4	4.1	409.5	116.4			0.077	0.008	0.000
Median					2.00	5.00	0.02	0.05	0.49	1.70	0.02	0.77	3.1	782.4	7.8	77.2	3.1	313.0	106.6			0.058	0.006	0.000
Stdev					0	0	0	0	0.01414	#DIV/0!	0	0.425678	1.4	341.2	3.4	35.6	1.4	136.5	13.8			0.026	0.003	0.000
Storm water																								
Average					2.16	39.20	0.02	0.05	0.45	1.83	0.11	2.52	22.58	85138.72	56.46	624.72	229.43	2727.90	4130.13			6.3650	0.0467	0.0172
min					2.00	5.00	0.02	0.05	0.21	1.48	0.02	1.44	1.83	457.95	4.58	19.51	1.83	290.93	208.89			0.0342	0.0015	0.0001
Max					2.31	122.00	0.02	0.05	0.68	2.50	0.28	3.60	50.32	272776.21	125.80	1700.83	626.04	5164.86	8051.37			20.3930	0.1272	0.0468
Median					2.16	5.00	0.02	0.05	0.50	1.66	0.02	2.52	13.15	3286.46	32.86	209.68	13.15	2727.90	4130.13			0.2457	0.0157	0.0010
Stdev					0.22	51.86	0.00	0.00	0.18	0.46	0.12	1.53	23.27	122690.16	58.18	748.55	309.09	3446.39	5545.47			9.1724	0.0560	0.0231
count (n)					2	5	5	5	5	4	5	2	5	5	5	5	5	2	2			5.0000	5.0000	5.0000

Notations:
<: The value was below the MDL for that analysis.
i: The sample was incubated 6 days instead of the required 5 days.
*: Samples collected by FSU near end of same runoff event, serves as our QA/QC from Frog Bayou for this event

Jack Ck (JK-1)

Sample Type	Sample ID	Lab Control Number	Sample Date	Sample Time	Flow (cfs)	TSS, mg/L	PO$_4$ as P, mg/L	NH$_3$ as N, mg/L	NO$_3$+NO$_2$ as N, mg/L	Chloride, mg/L	Phosphorous as P, mg/L	Load-OrhtoP (lb/d)	Load-TSS (lb/d)	Load-NH3 (lb/d)	Load-NO3-NO2-N (lb/d)	Load-TP (lb/d)	WS-area (mi2)	WS-area (Acres)	TSS-lb/acre	NO3-NO2-lb/acre	TP-lb/acre
Storm Ever	Jack Creek	14-01905	4/4/2014	12:37	44.0	5.00	< 0.02	< 0.05	0.28	1.31	< 0.02	4.74	1185.28	11.85	66.61	4.74	6.9	4416	0.268406	0.015084	0.001074
Storm Ever	Jack Creek	14-02629	5/9/2014	21:40	7.2	9.00	< 0.02	< 0.05	0.16	1.15	0.03	0.78	349.12	1.94	6.32	1.16	6.9	4416	0.079058	0.001432	0.000264
Storm water																					
Average						7.00	0.02	0.05	0.22	1.23	0.03	2.76	767.20	6.90	36.47	2.95	6.90	4416.00	0.174	0.008	0.001
min						5.00	0.02	0.05	0.16	1.15	0.02	0.78	349.12	1.94	6.32	1.16	6.90	4416.00	0.079	0.001	0.000
Max						9.00	0.02	0.05	0.28	1.31	0.03	4.74	1185.28	11.85	66.61	4.74	6.90	4416.00	0.268	0.015	0.001
Median						7.00	0.02	0.05	0.22	1.23	0.03	2.76	767.20	6.90	36.47	2.95	6.90	4416.00	0.174	0.008	0.001
Stdev						2.83	0.00	0.00	0.08	0.11	0.01	2.80	591.26	7.01	42.63	2.53	0.00	0.00	0.134	0.010	0.001
Count (n)						2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Sample Type	Sample ID	Sample Date	Flow (cfs)	BOD, mg/L	TSS, mg/L	PO_4 as P, mg/L	NH_3 as N, mg/L	NO_3+NO_2 as N, mg/L	Chloride, mg/L	Phosphorous as P, mg/L	TOC, mg/L	Load-OrhtoP (lb/d)	Load-TSS (lb/d)	Load-NH3 (lb/d)	NO3-NO2-N (lb/d)	Load-TP (lb/d)	Load-BOD	Load-TOC	WS-area (mi2)	WS-area (Acres)	TSS-lb/acre	NO3-NO2-lb/acre	TP-lb/acre
Baseline	Clear 1	1/18/2012	37.60	< 2.00	< 5.00	< 0.02	< 0.05	< 0.5	NA	< 0.02	0.54	4.1	1012.9	10.1	101.3	4.1	405.2	108.6	43.3	27712	0.03655	0.003655	0.00015
Storm Event	Clear 1	1/25/2012	600.00	i 2.05	196.00	0.09	< 0.05	< 0.5	NA	0.38	3.55	290.9	633586.5	161.6	1616.3	1228.4	6626.8	11485.4	43.3	27712	22.8633	0.058325	0.04433
Storm Event	Clear 1	3/8/2012	54.50	< 2.00	< 5.00	0.02	< 0.05	0.2	3.9	0.02	1.13	5.9	1468.1	14.7	58.7	5.9	587.3	332.4	43.3	27712	0.05298	0.002119	0.00021
Storm Event Dup	Clear 1-D	3/8/2012	54.50	< 2.00	< 5.00	< 0.02	< 0.05	0.22	4.1	< 0.02	1.21	5.9	1468.1	14.7	64.6	5.9	587.3	353.8	43.3	27712	0.05298	0.002331	0.00021
Baseline	Clear 1	4/3/2012	37.80	< 2.00	< 5.00	< 0.02	< 0.05	0.16	2.4	< 0.02	0.97	4.1	1018.3	10.2	32.6	4.1	407.3	198.2	43.3	27712	0.03674	0.001176	0.00015
Baseline																							
Average				2.00	5.00	0.02	0.05	0.33	2.40	0.02	0.75	4.1	1015.6	10.2	66.9	4.1	406.2	153.4			0.037	0.002	0.000
min				2.00	5.00	0.02	0.05	0.16	2.40	0.02	0.54	4.1	1012.9	10.1	32.6	4.1	405.2	108.6			0.037	0.001	0.000
Max				2.00	5.00	0.02	0.05	0.50	2.40	0.02	0.97	4.1	1018.3	10.2	101.3	4.1	407.3	198.2			0.037	0.004	0.000
Median				2.00	5.00	0.02	0.05	0.33	2.40	0.02	0.75	4.1	1015.6	10.2	66.9	4.1	406.2	153.4			0.037	0.002	0.000
Stdev				0	0	0	0	0.24042	#DIV/0!	0	0.30901	0.0	3.8	0.0	48.6	0.0	1.5	63.3			0.000	0.002	0.000
Storm water																							
Average				2.03	100.50	0.06	0.05	0.35	3.90	0.20	2.34	148.4	317527.3	88.2	837.5	617.1	3607.0	5908.9	43.3		11.458	0.030	0.022
min				2.00	5.00	0.02	0.05	0.20	3.90	0.02	1.13	5.9	1468.1	14.7	58.7	5.9	587.3	332.4	43.3		0.053	0.002	0.000
Max				2.05	196.00	0.09	0.05	0.50	3.90	0.38	3.55	290.9	633586.5	161.6	1616.3	1228.4	6626.8	11485.4	43.3		22.863	0.058	0.044
Median				2.03	100.50	0.06	0.05	0.35	3.90	0.20	2.34	148.4	317527.3	88.2	837.5	617.1	3607.0	5908.9	43.3		11.458	0.030	0.022
Stdev				0.03536	135.057	0.0495	0	0.21213	#DIV/0!	0.25455844	1.71191	201.6	446975.2	103.9	1101.4	864.4	4270.6	7886.4	0.0		16.129	0.040	0.031

Sample Type	Sample ID	Sample Date	Flow (cfs)	BOD, mg/L	TSS, mg/L	PO$_4$ as P, mg/L	NH$_3$ as N, mg/L	NO$_3$+NO$_2$ as N, mg/L	Chloride, mg/L	Phosphorous as P, mg/L	TOC, mg/L	Load-OrhtoP (lb/d)	Load-TSS (lb/d)	Load-NH3 (lb/d)	NO3-NO2-N (lb/d)	Load-TP (lb/d)	Load-BOD	Load-TOC	WS-area (mi2)	WS-area (Acres)	TSS-lb/acre	NO3-NO2-lb/acre	TP-lb/acre
Baseline	Cedar 1	1/18/2012	45.30	< 2.00	< 5.00	< 0.02	< 0.05	< 0.5	NA	< 0.02	0.82	4.9	1220.3	12.2	122.0	4.9	488.1	201.1	51.5	32960	0.03702	0.0037	0.00015
Storm Event	Cedar 1	1/25/2012	2403.00	i 3.73	300.00	0.06	0.06	< 0.5	NA	0.54	5.64	776.8	3883949.7	776.8	6473.2	6991.1	48290.4	73031.2	51.5	32960	117.838	0.1964	0.21211
Storm Event	Cedar 1	3/8/2012	198.00	< 2.00	18.00	0.03	< 0.05	0.65	4.2	0.07	3.17	32.0	19201.5	53.3	693.4	74.7	2133.5	3376.3	51.5	32960	0.58257	0.02104	0.00227
Baseline	Cedar 1	4/3/2012	28.90	< 2.00	< 5.00	< 0.02	< 0.05	0.25	2.2	< 0.02	1.34	3.1	778.5	7.8	38.9	3.1	311.4	208.6	51.5	32960	0.02362	0.00118	9.4E-05
Baseline																							
Average				2.00	5.00	0.02	0.05	0.38	2.20	0.02	1.08	4.0	999.4	10.0	80.5	4.0	399.8	204.9			0.030	0.002	0.000
min				2.00	5.00	0.02	0.05	0.25	2.20	0.02	0.82	3.1	778.5	7.8	38.9	3.1	311.4	201.1			0.024	0.001	0.000
Max				2.00	5.00	0.02	0.05	0.50	2.20	0.02	1.34	4.9	1220.3	12.2	122.0	4.9	488.1	208.6			0.037	0.004	0.000
Median				2.00	5.00	0.02	0.05	0.38	2.20	0.02	1.08	4.0	999.4	10.0	80.5	4.0	399.8	204.9			0.030	0.002	0.000
Stdev				0	0	0	0	0.17678	#DIV/0!	0	0.36487	1.2	312.4	3.1	58.8	1.2	125.0	5.3			0.009	0.002	0.000
Storm water																							
Average				2.87	159.00	0.05	0.06	0.58	4.20	0.31	4.40	404.4	1951575.6	415.1	3583.3	3532.9	25212.0	38203.7			59.210	0.109	0.107
min				2.00	18.00	0.03	0.05	0.50	4.20	0.07	3.17	32.0	19201.5	53.3	693.4	74.7	2133.5	3376.3			0.583	0.021	0.002
Max				3.73	300.00	0.06	0.06	0.65	4.20	0.54	5.64	776.8	3883949.7	776.8	6473.2	6991.1	48290.4	73031.2			117.838	0.196	0.212
Median				2.87	159.00	0.05	0.06	0.58	4.20	0.31	4.40	404.4	1951575.6	415.1	3583.3	3532.9	25212.0	38203.7			59.210	0.109	0.107
Stdev				1.22	199.40	0.02	0.01	0.11	#DIV/0!	0.33	1.75	526.6	2732789.6	511.6	4087.0	4890.7	32637.9	49253.5			82.912	0.124	0.148

Sample Type	Sample ID	Sample Date	Flow (cfs)	BOD, mg/L	TSS, mg/L	PO_4 as P, mg/L	NH_3 as N, mg/L	NO_3+NO_2 as N, mg/L	Chloride, mg/L	Phosphorous as P, mg/L	TOC, mg/L	Load-OrhtoP (lb/d)	Load-TSS (lb/d)	Load-NH3 (lb/d)	NO3-NO2-N (lb/d)	Load-TP (lb/d)	Load-BOD	Load-TOC	WS-area (mi2)	WS-area (Acres)	TSS-lb/acre	NO3-NO2-lb/acre	TP-lb/acre
Baseline	FB-2	1/18/2012	47.10	< 2.00	< 5.00	< 0.02	< 0.05	< 0.5	NA	< 0.02	1.40	5.1	1268.8	12.7	126.9	5.1	507.5	355.5	29.3	18752	0.06766	0.00677	0.00027
Storm Event	FB-2	1/25/2012	167.00	<,i 2.00	12.00	< 0.02	< 0.05	< 0.5	NA	0.03	1.60	18.0	10796.8	45.0	449.9	27.0	1799.5	1441.4	29.3	18752	0.57577	0.02399	0.00144
Storm Event	FB-2	3/8/2012	45.50	< 2.00	7.00	< 0.02	< 0.05	0.6	1.6	< 0.02	1.83	4.9	1716.0	12.3	147.1	4.9	490.3	447.6	29.3	18752	0.09151	0.00784	0.00026
Baseline	FB-2	4/3/2012	55.00	< 2.00	< 5.00	< 0.02	< 0.05	0.56	1.3	0.02	1.80	5.9	1481.6	14.8	165.9	5.9	592.6	532.2	29.3	18752	0.07901	0.00885	0.00032
Baseline																							
Average				2.00	5.00	0.02	0.05	0.53	1.30	0.02	1.60	5.5	1375.2	13.8	146.4	5.5	550.1	443.9			0.073	0.008	0.000
min				2.00	5.00	0.02	0.05	0.50	1.30	0.02	1.40	5.1	1268.8	12.7	126.9	5.1	507.5	355.5			0.068	0.007	0.000
Max				2.00	5.00	0.02	0.05	0.56	1.30	0.02	1.80	5.9	1481.6	14.8	165.9	5.9	592.6	532.2			0.079	0.009	0.000
Median				2.00	5.00	0.02	0.05	0.53	1.30	0.02	1.60	5.5	1375.2	13.8	146.4	5.5	550.1	443.9			0.073	0.008	0.000
Stdev				0	0	0	0	0.04243	#DIV/0!	0	0.27931	0.6	150.5	1.5	27.6	0.6	60.2	124.9			0.008	0.001	0.000
Storm water																							
Average				2.00	9.50	0.02	0.05	0.55	1.60	0.03	1.71	11.4	6256.4	28.6	298.5	15.9	1144.9	944.5			0.334	0.016	0.001
min				2.00	7.00	0.02	0.05	0.50	1.60	0.02	1.60	4.9	1716.0	12.3	147.1	4.9	490.3	447.6			0.092	0.008	0.000
Max				2.00	12.00	0.02	0.05	0.60	1.60	0.03	1.83	18.0	10796.8	45.0	449.9	27.0	1799.5	1441.4			0.576	0.024	0.001
Median				2.00	9.50	0.02	0.05	0.55	1.60	0.03	1.71	11.4	6256.4	28.6	298.5	15.9	1144.9	944.5			0.334	0.016	0.001
Stdev				0.00	3.54	0.00	0.00	0.07	#DIV/0!	0.01	0.16	9.3	6421.1	23.1	214.1	15.6	925.7	702.7			0.342	0.011	0.001

Sample Type	Sampl e ID	Sample Date	Flow (cfs)	BOD, mg/L	TSS, mg/L	PO$_4$ as P, mg/L	NH$_3$ as N, mg/L	NO$_3$+NO$_2$ as N, mg/L	Chloride, mg/L	Phosphorous as P, mg/L	TOC, mg/L	Load-OrhtoP (lb/d)	Load-TSS (lb/d)	Load-NH3 (lb/d)	NO3-NO2-N (lb/d)	Load-TP (lb/d)	Load-BOD	Load-TOC	WS-area (mi2)1	WS-area (Acres)	TSS-lb/acre	NO3-NO2-lb/acre	TP-lb/acre
Baseline	FB-3	1/18/2012	56.50	< 2.00	< 5.00	< 0.02	< 0.05	< 0.5	NA	0.03	0.96	6.1	1522.0	15.2	152.2	9.1	608.8	291.0	161.7	103488	0.01471	0.00147	8.8E-05
Storm Event	FB-3	1/25/2012	5254.00	i 3.00	133.00	0.08	< 0.05	< 0.5	NA	0.30	3.72	2264.5	3764785.9	1415.3	14153.3	8492.0	84920.0	105244.2	161.7	103488	36.379	0.13676	0.08206
Storm Event Dup	FB-3-D	1/25/2012	5254.00	i 3.24	229.00	0.09	< 0.05	< 0.5	NA	0.29	3.67	2547.6	6482225.3	1415.3	14153.3	8208.9	91713.6	103772.2	161.7	103488	62.6375	0.13676	0.07932
Storm Event	FB-3	3/8/2012	158.00	< 2.00	17.00	0.02	< 0.05	0.58	3.8	0.08	2.94	17.0	14471.2	42.6	493.7	68.1	1702.5	2504.4	161.7	103488	0.13983	0.00477	0.00066
Baseline	FB-3	4/3/2012	215.20	< 2.00	< 5.00	< 5.00	< 0.05	0.52	2	< 0.02	1.43	5797.1	5797.1	58.0	602.9	23.2	2318.8	1659.1	161.7	103488	0.05602	0.00583	0.00022
Baseline Dup	FB-3-D	4/3/2012	215.20	< 2.00	< 5.00	< 5.00	< 0.05	0.48	2	< 0.02	1.47	5797.1	5797.1	58.0	556.5	23.2	2318.8	1700.9	161.7	103488	0.05602	0.00538	0.00022
Baseline																							
Average				2.00	5.00	2.51	0.05	0.51	2.00	0.03	1.19	2901.6	3659.6	36.6	377.5	16.2	1463.8	975.1			0.035	0.004	0.000
min				2.00	5.00	0.02	0.05	0.50	2.00	0.02	0.96	6.1	1522.0	15.2	152.2	9.1	608.8	291.0			0.015	0.001	0.000
Max				2.00	5.00	5.00	0.05	0.52	2.00	0.03	1.43	5797.1	5797.1	58.0	602.9	23.2	2318.8	1659.1			0.056	0.006	0.000
Median				2.00	5.00	2.51	0.05	0.51	2.00	0.03	1.19	2901.6	3659.6	36.6	377.5	16.2	1463.8	975.1			0.035	0.004	0.000
Stdev				0	0	3.52139	0	0.01414	#DIV/0!	0.00707107	0.33588	4094.9	3022.9	30.2	318.7	9.9	1209.2	967.4			0.029	0.003	0.000
Storm water																							
Average				2.50	75.00	0.05	0.05	0.54	3.80	0.19	3.33	1140.8	1889628.5	728.9	7323.5	4280.0	43311.2	53874.3			18.259	0.071	0.041
min				2.00	17.00	0.02	0.05	0.50	3.80	0.08	2.94	17.0	14471.2	42.6	493.7	68.1	1702.5	2504.4			0.140	0.005	0.001
Max				3.00	133.00	0.08	0.05	0.58	3.80	0.30	3.72	2264.5	3764785.9	1415.3	14153.3	8492.0	84920.0	105244.2			36.379	0.137	0.082
Median				2.50	75.00	0.05	0.05	0.54	3.80	0.19	3.33	1140.8	1889628.5	728.9	7323.5	4280.0	43311.2	53874.3			18.259	0.071	0.041
Stdev				0.70711	82.0244	0.04243	0	0.05657	#DIV/0!	0.15556349	0.54871	1589.2	2651872.9	970.7	9658.8	5956.6	58843.6	72648.0			25.625	0.093	0.058

Station	Date	Time	Temp	DO	%Sat	SC	pH	Turb	# bottles		
Cedar 1	1/25/2012	1030	7.5	12.8	107	29	8.88	248	2	Gage 19.2 inch down to water and back	
Cedar1	1/18/2012	1400	6.6	12.6		35	8.3	3.2	2		baseline
Cedar1	3/8/2012	1535	12.09	10.8	100	41	6.91	32.1	2	Collected 2 bottles	
Cedar1	4/3/2012	1910	20.3	9.9	112	35	7.3	4.98			baseline
Clear 1	1/25/2012	915	7.3	13.2	106	24	8.33	223	2	Collected Gage 61.5 inch	
Clear1	1/18/2012	1100	5.9	12.5		38	8	3.7	2		baseline
Clear1	3/8/2012	1430	11.45	10.8	99	45	7.13	9.64	4	Collected bottles & duplicate and measured flow	
Clear1	4/3/2012	1555	19.5	10.2	115	46	7.5	5.56			baseline
FB1	1/18/2012	850	4.6	12.7		33	8.5	3.4	2		baseline
FB1	1/25/2012	705	7.3	12.9	107	27	7.78	164	2	Collected Gage 34 inch	
FB1	3/8/2012	1300	11.01	10.7	97	36	6.64	18.7	2	Collected 2 bottles and gage=8.75	
FB1	4/3/2012	1645	19.8	9.3	108	36	7.8	5.93			baseline
FB1	3/16/2014	1620	7.48	12.1		526	6.86	139	2		
FB1	4/4/2014	1605	13.25	10.56		106	6.98	25.1	6	FB-1D (2) and FB-1B (2)	
FB1	5/8/2014	2100	17.6	8.9		146	7.5	18.5	4	FB-1D (2)	
FB2	1/18/2012	950	6.7	12		50	8.5	19.5	2		baseline
FB2	1/25/2012	810	8	12.6	106	57	6.45	41	2	Collected Flow Measurement	
FB2	3/8/2012	1355	9.78	11.9	105	50	6.58	21.2	2	Collected 2 bottles and flow	
FB2	4/3/2012	1800	22.3	9.5	113	45	7.6	15.6			baseline
FB3	1/18/2012	1220	7.2	12.2		44	8.3	5.8	2		baseline
FB3	1/25/2012	1010	7.8	12.7	107	38	8.37	165	2	Sample and Duplicate collected	
FB3	3/8/2012	1520	12.73	10.4	98	49	6.65	32.7	2	Collected 2 bottles	
FB3	4/3/2012	1840	21.4	9.8	113	46	7.4	7.01			baseline
Jones 1	1/25/2012	630	7.1	13	108	27	6.98	148	2	Collected WQ sample	
Jones1	1/18/2012	820	4.6	12.3		45	6.6	6.2	2		baseline
Jones1	3/8/2012	1230	10.74	10.8	97	41	6.11	16	2	Collected 2 bottles	
Jones1	4/3/2012	1710	19.4	9.7	111	40	7.7	10.2			baseline
Jones1	3/16/2014	1610	7.5	12.4		512	7.11	131	2		
Jones1	4/4/2014	1550	13.91	10.63		124	7.53	20.7	2		
Jones1	5/8/2014	2050	17.7	9.9		70.8	7.9	15.4	2		
avg			11.62	11.33	106.06	81.39	7.47	52.00			
min			4.6	8.9	97	24	6.11	3.2			
max			22.3	13.2	115	526	8.88	248			

Appendix C

USA Field Data Forms

Unified Stream Assessment (USA)

REACH ID: Jones-1
STREAM: Jones Ck – upper
DATE/TIME: 9/4/12
INITIALS: JJLP

REACH START Winfrey Rd – upstream & downstream to near conf. w/ FRog Bayou
REACH END Conf. of main tribs
LAT:
LONG:
LAT:
LONG:

Started @ 1115

Average Conditions (check applicable)

Weather – Antecedent (24-h) Rain in past 72-h: y / n
☐Heavy rain ☐Steady rain ☒Showers ☐Clear/sunny
☐Mostly cloudy ☐Partly cloudy

Weather – Current conditions
☐Heavy rain ☐Steady rain ☐Showers ☐Clear/sunny
☐Mostly cloudy ☒Partly cloudy

Stream Classification
☒ Perennial ☐ Intermittent ☐ Ephemeral ☐ Tidal
☐ Coldwater ☐ Coolwater ☐ Warmwater Order_____

Stream Origin
☐ Spring-fed ☒ Mixture of origins ☐ Glacial
☐ Montane (non-glacial) ☐ Swamp/bog ☐ Other________

Hydrology
Flow: ☐ High ☒ Moderate ☐ Low ☐ None
Base Flow as %Channel Width: ☐0-25% ☒50-75% ☐25-50% ☐75-100%
Flows Measured: [✓ Yes] 4/3 / [✓ No] 9/4
Stream Gradient: ☒ High (≥25ft/mi) ☐ Moderate (10-24 ft/mi) ☐ Low (<10 ft/mi) ~Slope: ________ft/mi
Sinuosity: ☐ High ☒ Moderate ☐ Low

Channel Morphology
System: Step/Pool - [✓ Riffle/Pool] - Pool (circle)
☒ Riffle 50 % ☒ Run 35 % ☒ Pool 15 % ☐ Steps _____%

Dominant Substrate
☐Silt/clay (fine or slick) ☒Cobble (2.5-10”)
☐Sand (gritty) ☐Boulder (>10”)
☐Gravel (0.1-2.5”) ☐Bed Rock

Dominant In-Stream Habitats
☒Woody Debris ☒Root Wads ☐Leaf Packs
☐Deposition ☐Undercut Bank
☐Aquatic Plants ☐Overhanging Vegetation
Habitat Quality: ☐Poor ☒Fair ☒Good ☐ Optimal

Land use
☒ Forest 75 % ☒ Pasture _____% (Remnant) ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

Local Watershed NPS Pollution
☐ Industrial Storm Water
☐ Urban/Sub-Urban Storm Water ☐ Row crops
☐ Cattle ☐ Other____________ ☒ No evidence

Riparian Buffer
Vegetation Type: ☒ Forest 75 % ☐ Shrub/Sapling ____% ☒ Herbs/Grasses 25 % ☐ Turf/Crops ____%
Riparian Width: ☐<10 ft ☐11-25 ft ☒ 26-50 ft ☐ > 50 ft RB – >50 LB – variable

Stream Shading (water surface)
☐Mostly shaded (≥75% coverage) ☒Partially shaded (≥25% coverage) high end
☐Halfway shaded (≥50% coverage) ☐Unshaded (<25% coverage)

Water Quality Observations

Odors Noted:
☒ Normal/None ☐ Sewage ☐ Anaerobic
☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other__________

Water Surface Appearance:
☐ Slick ☐ Sheen ☐ Globs
☐ Flecks ☒ None ☐ Other__________

Turbidity/Water Clarity:
☐ Clear ☐ Slightly turbid ☐ Turbid
☒ Opaque ☐ Stained ☐ Other____________

Sediment Deposits: ☒ None ☐ Sludge ☐ Sawdust ☐ Oils ☐ Sand ☐ Relict shells

Trail along bank at wpt. 160w/4w crossing
wp7 (b) camping access (locals)

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

75'
12.3
6.5
1.2

BF

5 yd W
0.5 D

4 1 yd W
0.6' D
2/3 (width in bar)
6.5' W – 0.1' D

May 22-25

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Jones - 1 (1.3 mi)	Date: 4/4/12	Initials:

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
~~ER~~ RB	165	H-VH	300' / (2)	Ht - 4-5' Angle 85° Roots - 40% Root depth -2' Veg - 20% Cobble 50%
~~ER~~ LB	166	H	200' / (2)	4' H 80° angle 75% Roots 3' Rt. depth 10% Veg. Cobble 80%
IB	162	3	225'	Pasture no trees to edge bank all since
☆ CX	160	1	1	Access to stream in 2-3 spots here. ATV mostly. ☆ new

Much of LB below Road is Eroding (M - H) ~ 100 yds.

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER RB	158 (rock) GLP-603	L M H [✓ VH] [✓ EX] (circle one)	200'	~~3~~ (2.5 H) 2.5	Bank: Height 4 ft, Angle 85 Deg Protection: Roots 70 %, Root Depth 4 ft Vegetation 15 % [4]Material: Silt/Clay Sand / Gravel [✓ Cobble] - % 70
ER RB	159 high bank 8'+	L M H [✓ VH] [✓ EX] (circle one)	100'	1	Bank: Height 8-10 ft, Angle 85 Deg Protection: Roots 10 %, Root Depth 3 ft Vegetation 10 % [4]Material: Silt/Clay Sand / Gravel [✓ Cobble] - % 20
ER LB	162 LB	L M H VH [✓ EX] (circle one)	225'	3	Bank: Height 10 ft, Angle 90 Deg Protection: Roots 5 %, Root Depth 1 ft Vegetation 45 % [4]Material: Silt/Clay Sand / Gravel [✓ Cobble] - %
ER	163 LB	L M [✓ H] VH EX (circle one)	150	2	Bank: Height 7 ft, Angle 80 Deg Protection: Roots 50 %, Root Depth 50 ft Vegetation 20 % [4]Material: Silt/Clay Sand / Gravel [✓ Cobble] - %
ER RB	164	L M [✓ H] VH EX (circle one)	175	3	Bank: Height 4 ft, Angle 85 Deg Protection: Roots 65 %, Root Depth 4 ft Vegetation 10 % [4]Material: Silt/Clay Sand / Gravel [✓ Cobble] - % 65

[1] Impacts: Outfall(OT), Bank Erosion(ER), Impacted buffer(IB), Utilities in channel(UT), Stream crossing(SC), Channel modification(CM), Trash in stream(TR), other.

[2] Severity: 1=minor, 2=moderate, 3=severe

[3] Restoration Potential: 1=minimal, 2=moderate, 3=high

[4] Bank material: circle base type, silt/clay or sand and if present circle rock type and note %.

Total - 1350' bank

eroded

= 19.7%

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

USA, Cont.

REACH ID:	STREAM:	DATE/TIME:	INITIALS:
Jones-1	tz Jones Ck.	4/4/12	JJF

OTHER INFO:

Average Conditions (check applicable)

Flood Plain Dynamics

Connection: ☐ Poor ☐ Fair ☒ Good

Habitat: ☐ Poor ☐ Fair ☒ Good

Vegetation: ☒ Forest ☐ Shrub/Sapling ☒ Tall grasses ☐ Turf/crops

Encroachment: ☐ Poor ☐ Fair ☒ Good

Periphyton (attached algae):

Filamentous: ☐ None ☒ Sparse ☐ Moderate ☐ Abundant

Prostrate: ☐ None ☐ Sparse ☒ Moderate ☐ Abundant

Floating: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant

Suspended Algae (phytoplankton) abundance:

☒ None noticeable (water basically clear)

☐ Moderate (water slightly green tinted)

☐ Abundant (water appears green)

Aquatic Plants In Stream:

Submerged: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant

Emergent: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant

Floating: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant

Aquatic Life Observed:

☒ Fish ☐ Snails ☒ Crawfish ☒ Macroinvertebrates

Wildlife/Livestock In or Around Stream (evidence of):

☐ Cattle ☒ Beaver minor ☒ Deer minor ☐ Other________

Reach Impacts: (circle impact level 1=minor, 2=moderate, 3=major, and tag with a GPS waypoint(s) (Wpt) ID)

☐ Outfalls(OT): 1 2 3 Wpt________

☒ Stream Crossing(SC): [✓ 1] 2 3 Wpt minor

☒ Bank Erosion(ER) : 1 [✓ 2] 3 Wpt________

☐ Channel Modification(CM) : 1 2 3 Wpt________

☒ Impacted Buffers(IB): [✓ 1] [✓ 2] 3 Wpt________

☐ Trash(TR): 1 2 3 Wpt________

☐ Utilities(UT): 1 2 3 Wpt________

☐ Other________: 1 2 3 Wpt________

Notes:

If any of these impacts are significant use back of page 1 (pg. 2) for detailed description.

Channel Dynamics:

☐ Incised (degrading)

☒ Widening minimal

☐ Headcutting

☐ Channelized

☐ Aggrading

☒ Bank scour in areas

☐ Bed Scour

☐ Bank Failure

☐ Slope failure

☐ Sediment Deposition

☐ Culvert Scour (upstream / downstream / top)

☐ None (natural stabile channel)

Channel Dimensions (facing downstream):

Lt bank Ht: 5 (ft) Bankfull Depth ~~11~~10 (ft) 20+ Wetted Width: 55 (ft) Riffle/Run Depth 0.6 (ft)

Rt bank Ht: 6 (ft) Bankfull Width 90 (ft)) TOB Width: 100 (ft) Pool Depth 1-2' (ft)

Channel Stability:

Lt Bank: Angle ________ degrees

LtBank Vegetation protection: ________% cover

LtBank Erosion Hazard: L M H VH EX (circle one)

Length Lt Bank Affected:________

Wpt(s):________

Rt Bank: Angle ________ degrees

RtBank Vegetation protection ________% cover

RtBank Erosion Hazard: L M H VH EX (circle one)

Length Rt Bank Affected:________

Wpt(s):________

Reach Accessibility For Restoration

Good: Open area in public ownership. Easy stream channel access by vehicle.	**Fair:** Forested or developed near stream. Vehicle access limited.	**Difficult:** Must cross wetland, steep slope, heavy forest or sensitive areas to get to stream. Access by foot/ATV only.

5 4 [✓ 3] 2 1

Notes: (biggest problem(s) you see in survey reach)

Place sketch of reach on back of page.

Restoration Potential:

☐ Riparian reforestation ☐ Bank stabilization

☐ Stormwater retrofit ☐ Outfall stabilization

☐ Channel modification ☐ PS investigation

☐ Culvert rehab. ☐ Other________

---

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

Unified Stream Assessment (USA)

REACH ID: FB-1	**STREAM:** Frog Bayou	**DATE/TIME:** 4/4/12	**INITIALS:** JW

REACH START	**REACH END** Bridge over Frog on ~~[illegible]~~ Bienville
LAT:	**LAT:**
LONG:	**LONG:**

wd. 168 middle

Average Conditions (check applicable)

Weather – Antecedent (24-h) Rain in past 72-h: y / n
☐Heavy rain ☐Steady rain ☒Showers ☐Clear/sunny
☐Mostly cloudy ☐Partly cloudy

Weather – Current conditions
☐Heavy rain ☐Steady rain ☐Showers ☐Clear/sunny
☐Mostly cloudy ☒Partly cloudy

Stream Classification
☒ Perennial ☐ Intermittent ☐ Ephemeral ☐ Tidal
☐ Coldwater ☐ Coolwater ☐ Warmwater Order_____

Stream Origin
☐ Spring-fed ☒ Mixture of origins ☐ Glacial
☐ Montane (non-glacial) ☐ Swamp/bog ☐ Other_________

Hydrology
Flow: ☐ High ☒ Moderate ☐ Low ☐ None
4/3 4/9
Base Flow as %Channel Width: ☐0-25% ☒50-75% ☐25-50% ☐75-100% **Flows Measured:** [✓ Yes] / [✓ No]
Stream Gradient: ☒ High (≥25ft/mi) ☐ Moderate (10-24 ft/mi) ☐ Low (<10 ft/mi) ~Slope: ________ft/mi
Sinuosity: ☐ High ☒ Moderate ☐ Low

Channel Morphology **System:** Step/Pool - [✓ Riffle/Pool] - Pool (circle)
☒Riffle 45 % ☒Run 35 % ☒Pool 20 % ☐ Steps _____%

Dominant Substrate
☐Silt/clay (fine or slick) ☒Cobble (2.5-10")
☐Sand (gritty) ☐Boulder (>10")
☐Gravel (0.1-2.5") ☐Bed Rock

Dominant In-Stream Habitats
☒Woody Debris Snags ☒Root Wads ☐Leaf Packs
☐Deposition ☒Undercut Bank
☐Aquatic Plants ☐Overhanging Vegetation
Habitat Quality: ☐Poor ☐Fair ☒Good ☐ Optimal

Land use
☑ Forest ~~55~~ 60 % ☒ Pasture ~~45~~ 40 % ☐ Urban _____% DH
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

Local Watershed NPS Pollution
☐ Industrial Storm Water
☐ Urban/Sub-Urban Storm Water ☐ Row crops
☐ Cattle ☐ Other____________ ☒ No evidence

Riparian Buffer
Vegetation Type: ☒ Forest 70 % ☐ Shrub/Sapling ____% ☒ Herbs/Grasses 30 % ☐ Turf/Crops ____%
Riparian Width: ☐<10 ft ☐11-25 ft ☒26-50 ft ☐ > 50 ft LB – mostly >50' RB – less

Stream Shading (water surface)
☐Mostly shaded (≥75% coverage) ☒Partially shaded (≥25% coverage)
☐Halfway shaded (≥50% coverage) ☐Unshared (<25% coverage)

Water Quality Observations

Odors Noted:
☒ Normal/None ☐ Sewage ☐ Anaerobic
☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other____________

Water Surface Appearance:
☐ Slick ☐ Sheen ☐ Globs
☐ Flecks ☒ None ☐ Other__________

Turbidity/Water Clarity:
☒ Clear ☐ Slightly turbid ☐ Turbid
☒ Opaque ☐ Stained ☐ Other_______________

Sediment Deposits: ☒ None ☐ Sludge ☐ Sawdust ☐ Oils ☐ Sand ☐ Relict shells

---

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

35 wd x 0.8' D 4.5' bkfd
37 wd x 0.8' D 4.0' bkfd

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: FB-1 (1,5 mi)	**Date:** 4/4/12	**Initials:**

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
IB	169	3	3	500' Pasture – no trees Just grass to edge.
IB	near 172	2	~~100~~ 3	160' – Pasture / no trees

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER RB	167	L M [✓ H] VH EX (circle one)	150	1	Bank: Height 7 ft, Angle 80 Deg Protection: Roots 50 %, Root Depth 3 ft Vegetation 20 % [4]Material: Silt/Clay Sand / Gravel [✓ Cobble] - % 70
ER RB	169	L M H [✓ VH] EX (circle one)	250	3	Bank: Height 9 ft, Angle 90 Deg Protection: Roots 5 %, Root Depth 1 ft Vegetation 5 % [4]Material: Silt/Clay Sand / Gravel [✓ Cobble] - % 60
ER LB	170	L M [✓ H] [✓ VH] EX (circle one)	100	3	Bank: Height 13 ft, Angle 90 Deg Protection: Roots 5 %, Root Depth 1.5 ft Vegetation 5 % [4]Material: Silt/Clay Sand / Gravel [✓ Cobble] - % 50
ER LB	171	L M [✓ H] VH EX (circle one)	225	1	Bank: Height 7 ft, Angle 85 Deg Protection: Roots 70 %, Root Depth 5.5 ft Vegetation 10 % [4]Material: Silt/Clay Sand / Gravel [✓ Cobble] - % 55
ER LB	172 erosion upstream edge	L M H VH EX (circle one)	+ (100')		Bank: Height ___ ft, Angle ___ Deg Protection: Roots ___ %, Root Depth ___ ft Vegetation ___ % [4]Material: Silt/Clay Sand / Gravel Cobble - % ___

1325' ER
[illegible]
= 16.7%

---

[1] Impacts: Outfall(OT), Bank Erosion(ER), Impacted buffer(IB), Utilities in channel(UT), Stream crossing(SC), Channel modification(CM), Trash in stream(TR), other.

[2] Severity: 1=minor, 2=moderate, 3=severe

[3] Restoration Potential: 1=minimal, 2=moderate, 3=high

[4] Bank material: circle base type, silt/clay or sand and if present circle rock type and note %.

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

USA, Cont.

REACH ID: FB-1	**STREAM:** Frog Bayou	**DATE/TIME:** 9/9/12	**INITIALS:** JJHP
OTHER INFO:			

Average Conditions (check applicable)

Flood Plain Dynamics
Connection: ☐ Poor ☐ Fair ☒ Good
Habitat: ☐ Poor ☐ Fair ☒ Good
Vegetation: ☒ Forest ☐ Shrub/Sapling ☒ Tall grasses ☐ Turf/crops
Encroachment: ☐ Poor ☐ Fair ☒ Good

Periphyton (attached algae):
Filamentous: ☐ None ☒ Sparse ☐ Moderate ☐ Abundant
Prostrate: ☐ None ☐ Sparse ☒ Moderate ☐ Abundant
Floating: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant

Suspended Algae (phytoplankton) abundance:
☒ None noticeable (water basically clear)
☐ Moderate (water slightly green tinted)
☐ Abundant (water appears green)

Aquatic Plants In Stream:
Submerged: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant
Emergent: ☐ None ☒ Sparse ☐ Moderate ☐ Abundant
Floating: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant

Aquatic Life Observed:
☒ Fish ☐ Snails ☒ Crawfish ☒ Macroinvertebrates

Wildlife/Livestock In or Around Stream (evidence of):
☐ Cattle ☐ Beaver ☒ Deer ☐ Other________

Reach Impacts: (circle impact level 1=minor, 2=moderate, 3=major, and tag with a GPS waypoint(s) (Wpt) ID)
☐ Outfalls(OT): 1 2 3 Wpt________
☐ Stream Crossing(SC): 1 2 3 Wpt________
☒ Bank Erosion(ER): 1 [✓ 2] 3 Wpt________
☐ Channel Modification(CM): 1 2 3 Wpt________
☒ Impacted Buffers(IB): [✓ 1] 2 3 Wpt________
☐ Trash(TR): 1 2 3 Wpt________
☐ Utilities(UT): 1 2 3 Wpt________
☐ Other________: 1 2 3 Wpt________

Notes:

If any of these impacts are significant use back of page 1 (pg. 2) for detailed description.

Channel Dynamics:
☐ Incised (degrading)
☒ Widening minor
☐ Headcutting
☐ Channelized
☐ Aggrading
☒ Bank scour minor
☐ Bed Scour
☐ Bank Failure
☐ Slope failure
☐ Sediment Deposition
☐ Culvert Scour (upstream / downstream / top)
☐ None (natural stabile channel)

Channel Dimensions (facing downstream):
Lt bank Ht: 5.5 (ft) Bankfull Depth 4.5 (ft) Wetted Width: 70 (ft) Riffle/Run Depth 0.8 (ft)
Rt bank Ht: 4.5 (ft) Bankfull Width 108 (ft)) TOB Width: 120 (ft) Pool Depth 2.5 (ft)

Channel Stability:
Lt Bank: Angle ________ degrees
LtBank Vegetation protection: ________% cover
LtBank Erosion Hazard: L M H VH EX (circle one)
Length Lt Bank Affected:________
Wpt(s):________
Rt Bank: Angle ________ degrees
RtBank Vegetation protection ________% cover
RtBank Erosion Hazard: L M H VH EX (circle one)
Length Rt Bank Affected:________
Wpt(s):________

Reach Accessibility For Restoration

Good: Open area in public ownership. Easy stream channel access by vehicle.		**Fair:** Forested or developed near stream. Vehicle access limited.		**Difficult:** Must cross wetland, steep slope, heavy forest or sensitive areas to get to stream. Access by foot/ATV only.
5	4	[✓ 3]	2	1

Notes: (biggest problem(s) you see in survey reach)

Place sketch of reach on back of page.

Restoration Potential:
☐ Riparian reforestation
☐ Stormwater retrofit
☐ Channel modification
☐ Culvert rehab.
☐ Bank stabilization
☐ Outfall stabilization
☐ PS investigation
☐ Other ________

---

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

Unified Stream Assessment (USA)

REACH ID: FB-2
STREAM: Ash Rd to 282
DATE/TIME: 4/5/12
INITIALS: JLP

REACH START Γ
LAT:
LONG:

REACH END wpt 185
LAT:
LONG:

Average Conditions (check applicable)

Weather – Antecedent (24-h) Rain in past 72-h: y / n
☐Heavy rain ☐Steady rain ☐Showers ☐Clear/sunny
☐Mostly cloudy ☒Partly cloudy

Weather – Current conditions
☐Heavy rain ☐Steady rain ☐Showers ☐Clear/sunny
☐Mostly cloudy ☒Partly cloudy

Stream Classification
☒ Perennial ☐ Intermittent ☐ Ephemeral ☐ Tidal
☐ Coldwater ☐ Coolwater ☐ Warmwater Order_____

Stream Origin
☐ Spring-fed ☒Mixture of origins ☐ Glacial
☐ Montane (non-glacial) ☐ Swamp/bog ☐ Other________

Hydrology
Flow: ☐ High ☒Moderate ☐ Low ☐ None
Base Flow as %Channel Width: ☐0-25% ☐50-75% ☐25-50% ☐75-100% **Flows Measured:** Yes / No
Stream Gradient: ☐ High (≥25ft/mi) ☐ Moderate (10-24 ft/mi) ☐ Low (<10 ft/mi) ~Slope: ________ft/mi
Sinuosity: ☐ High ☐ Moderate ☐ Low

Channel Morphology **System:** Step/Pool - [✓ Riffle/Pool] - Pool (circle)
☒ Riffle 40 % ☒ Run 30 % ☒ Pool 25 % ☒Steps 5 %

Dominant Substrate
☐Silt/clay (fine or slick) ☒Cobble (2.5-10")
☐Sand (gritty) ☐Boulder (>10")
☐Gravel (0.1-2.5") ☐Bed Rock

Dominant In-Stream Habitats
☒Woody Debris ☒Root Wads ☐Leaf Packs
☐Deposition ☒Undercut Bank
☒Aquatic Plants ☒Overhanging Vegetation
Habitat Quality: ☐Poor ☐Fair ☒Good ☐ Optimal

Land use
☒Forest 60 % ☒ Pasture 35 % ☐ Urban _____%
☐ Commercial_____% ☒ Row Crops 5 %
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

Local Watershed NPS Pollution
☐ Industrial Storm Water
☐ Urban/Sub-Urban Storm Water ☒Row crops minor
☐ Cattle ☐ Other____________ ☐ No evidence

Riparian Buffer
Vegetation Type: ☒ Forest 80 % ☐ Shrub/Sapling ____% ☒ Herbs/Grasses 20 % ☐ Turf/Crops ____%
Riparian Width: ☐<10 ft ☐11-25 ft ☒ 26-50 ft ☐ > 50 ft — on RB

Stream Shading (water surface)
☐Mostly shaded (≥75% coverage) ☒Partially shaded (≥25% coverage)
☐Halfway shaded (≥50% coverage) ☐Unshared (<25% coverage)

Water Quality Observations

Odors Noted:
☒ Normal/None ☐ Sewage ☐ Anaerobic
☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other____________

Water Surface Appearance:
☐ Slick ☐ Sheen ☐ Globs
☐ Flecks ☒None ☐ Other__________

Turbidity/Water Clarity:
☐ Clear ☐ Slightly turbid ☐ Turbid
☒ Opaque ☐ Stained ☐ Other_______________

Sediment Deposits: ☒None ☐ Sludge ☐ Sawdust ☐ Oils ☐ Sand ☐ Relict shells

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: FB-2 (3.3mi)	Date: 4/5/12	Initials:

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
OT	175	1	n/a	Farm field drain??
SC	178	1	n/a	Small Bridge in Pasture
SC	181, 182, 183	1.5	1	2 Bridges (1 RR 1 old Rd. Abandoned?)
~~ER~~	~~185~~	~~1.5~~	~~2~~	~~[illegible] bar since~~ ~~[illegible] pasture & Riparian [illegible]~~
~~SC~~	~~188~~	~~1~~	~~1~~	~~LB Road access~~

~~+ RB 184 [illegible] pasture [illegible] [illegible] Riparian [illegible]~~

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER RB	173 - (-75) 174	L M H [✓ VH] EX (circle one)	1200	1.5	Bank: Height 12 ft, Angle 85 Deg Protection: Roots 15 %, Root Depth 3 ft Vegetation 105 % [4]Material: [✓ Silt/Clay] Sand / Gravel [✓ Cobble] - % 20
ER LB	175-176	L M H [✓ VH] EX (circle one)	300	2	Bank: Height ___ ft, Angle ___ Deg Protection: Roots ___ %, Root Depth ___ ft Vegetation ___ % [4]Material: Silt/Clay Sand / Gravel Cobble - % ___
ER LB	176-178 (178)	L M [✓ H] VH EX (circle one)	? 375	1	Bank: Height ___ ft, Angle ___ Deg Protection: Roots ___ %, Root Depth ___ ft Vegetation ___ % [4]Material: Silt/Clay Sand / Gravel Cobble - % ___
ER RB	179 - 180 (-75')	L M H [✓ VH] EX (circle one)	1450	1	Bank: Height 15 ft, Angle 85 Deg Protection: Roots 20 %, Root Depth 3.5 ft Vegetation 10 % [4]Material: [✓ Silt/Clay] Sand / Gravel [✓ Cobble] - % 20
ER ~~RB~~	~~180 - 184~~	L M H VH EX (circle one)	~~2000~~	~~2~~	Bank: Height 9 ft, Angle 35 Deg Protection: Roots 10 ~~%, Root Depth~~ 1 ft Vegetation 25 % [4]Material: [✓ Silt/Clay] Sand / Gravel [✓ Cobble] - % 30

---

[1] Impacts: Outfall(OT), Bank Erosion(ER), Impacted buffer(IB), Utilities in channel(UT), Stream crossing(SC), Channel modification(CM), Trash in stream(TR), other.

[2] Severity: 1=minor, 2=moderate, 3=severe

[3] Restoration Potential: 1=minimal, 2=moderate, 3=high

[4]Bank material: circle base type, silt/clay or sand and if present circle rock type and note %.

~~190-191 - LR~~ ~~189~~ Waterfall (LB)

3325' ER
17424'
= 19.1%

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

USA, Cont.

REACH ID: FB-2
STREAM: Frog Bayou
DATE/TIME: 9/5/12
INITIALS: DJP
OTHER INFO:

Average Conditions (check applicable)

Flood Plain Dynamics
Connection: ☐ Poor ☐ Fair ☒ Good
Habitat: ☐ Poor ☐ Fair ☒ Good
Vegetation: ☒ Forest ☐ Shrub/Sapling ☒ Tall grasses ☐ Turf/crops
Encroachment: ☐ Poor ☐ Fair ☒ Good

Periphyton (attached algae):
Filamentous: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant
Prostrate: ☐ None ☐ Sparse ☒ Moderate ☐ Abundant
Floating: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant

Suspended Algae (phytoplankton) abundance:
☒ None noticeable (water basically clear)
☐ Moderate (water slightly green tinted)
☐ Abundant (water appears green)

Aquatic Plants In Stream:
Submerged: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant
Emergent: ☐ None ☒ Sparse ☐ Moderate ☐ Abundant
Floating: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant

Aquatic Life Observed:
☒Fish ☐Snails ☒Crawfish ☐Macroinvertebrates

Wildlife/Livestock In or Around Stream (evidence of):
☒Cattle ☐Beaver ☒Deer ☐Other turtles/geese

Reach Impacts: (circle impact level 1=minor, 2=moderate, 3=major, and tag with a GPS waypoint(s) (Wpt) ID)
☐Outfalls(OT): [✓ 1] 2 3 Wpt________
☒Stream Crossing(SC): 1 [✓ 2] 3 Wpt________
☒Bank Erosion(ER) : 1 [✓ 2] 3 Wpt________
☐Channel Modification(CM) : 1 2 3 Wpt________
☒Impacted Buffers(IB): [✓ 1] 2 3 Wpt________
☐Trash(TR): 1 2 3 Wpt________
☐Utilities(UT): 1 2 3 Wpt________
☐Other________________: 1 2 3 Wpt________

Notes:

If any of these impacts are significant use back of page 1 (pg. 2) for detailed description.

Channel Dynamics:
☐ Incised (degrading) ☐ Channelized ☐ Bed Scour ☐ Sediment Deposition
☒ Widening ☐ Aggrading ☐ Bank Failure ☐ Culvert Scour (upstream / downstream / top)
☐ Headcutting ☒ Bank scour ☐ Slope failure ☐ None (natural stabile channel)

Channel Dimensions (facing downstream):
Lt bank Ht: 5 (ft) Bankfull Depth 4.5 (ft) Wetted Width: ~~48~~ 90 (DJP) (ft) Riffle/Run Depth ~~3~~ 1.0 (ft)
Rt bank Ht: 5 (ft) Bankfull Width 130 (ft)) TOB Width: 150 (ft) Pool Depth 4.5 (ft)

Channel Stability:
Lt Bank: Angle __________ degrees
LtBank Vegetation protection: _________% cover
LtBank Erosion Hazard: L M H VH EX (circle one)
Length Lt Bank Affected:________________
Wpt(s):________________________

Rt Bank: Angle __________ degrees
RtBank Vegetation protection _________% cover
RtBank Erosion Hazard: L M H VH EX (circle one)
Length Rt Bank Affected:________________
Wpt(s):________________________

Reach Accessibility For Restoration

Good: Open area in public ownership. Easy stream channel access by vehicle.	**Fair:** Forested or developed near stream. Vehicle access limited.	**Difficult:** Must cross wetland, steep slope, heavy forest or sensitive areas to get to stream. Access by foot/ATV only.

5 4 3.5 3 2 1

Notes: (biggest problem(s) you see in survey reach)

Place sketch of reach on back of page.

Restoration Potential:
☐Riparian reforestation ☒Bank stabilization
☐Stormwater retrofit ☐Outfall stabilization
☐Channel modification ☐PS investigation
☐ Culvert rehab. ☐ Other ____________

---

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

Unified Stream Assessment (USA)

REACH ID: FB-2.5	**STREAM:**	**DATE/TIME:** 4/5/12	**INITIALS:** JJHP

REACH START wpt 185	**REACH END** WPT 282 @ RR track
LAT: (edge lg. Pastur.)	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

Weather – Antecedent (24-h) Rain in past 72-h: y / n
☐Heavy rain ☐Steady rain ☐Showers ☐Clear/sunny
☐Mostly cloudy ☒Partly cloudy

Weather – Current conditions
☐Heavy rain ☐Steady rain ☐Showers ☐Clear/sunny
☐Mostly cloudy ☒Partly cloudy

Stream Classification
☒ Perennial ☐ Intermittent ☐ Ephemeral ☐ Tidal
☐ Coldwater ☐ Coolwater ☐ Warmwater Order_____

Stream Origin
☐ Spring-fed ☒ Mixture of origins ☐ Glacial
☐ Montane (non-glacial) ☐ Swamp/bog ☐ Other________

Hydrology
Flow: ☐ High ☒ Moderate ☐ Low ☐ None
Base Flow as %Channel Width: ☐0-25% ☒50-75% ☐25-50% ☐75-100% **Flows Measured:** Yes [✓ No]
Stream Gradient: ☒ High (≥25ft/mi) ☐ Moderate (10-24 ft/mi) ☐ Low (<10 ft/mi) ~Slope: ________ft/mi
Sinuosity: ☐ High ☒ Moderate ☐ Low

Channel Morphology **System:** Step/Pool - [✓ Riffle/Pool] - Pool (circle)
☒ Riffle 10 % ☒ Run 25 % ☒ Pool 35 % ☐ Steps ______%

Dominant Substrate
☐Silt/clay (fine or slick) ☒Cobble (2.5-10")
☐Sand (gritty) ☐Boulder (>10")
☐Gravel (0.1-2.5") ☐Bed Rock

Dominant In-Stream Habitats
☒Woody Debris ☒Root Wads ☐Leaf Packs
☐Deposition ☒Undercut Bank
☒Aquatic Plants ☒Overhanging Vegetation
Habitat Quality: ☐Poor ☐Fair ☒Good ☐ Optimal

Land use
☒ Forest 60 % ☒ Pasture 40 % ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

Local Watershed NPS Pollution
☐ Industrial Storm Water
☐ Urban/Sub-Urban Storm Water ☐ Row crops
☐ Cattle ☐ Other____________ ☐ No evidence

Riparian Buffer
Vegetation Type: ☒ Forest 60 % ☐ Shrub/Sapling ____% ☒ Herbs/Grasses 40 % ☐ Turf/Crops ____%
Riparian Width: ☐<10 ft ☒11-25 ft RB ~~☒ 26-50 ft RB~~ Slp ☒ > 50 ft LB

Stream Shading (water surface)
☐Mostly shaded (≥75% coverage) ☒Partially shaded (≥25% coverage)
☐Halfway shaded (≥50% coverage) ☐Unshared (<25% coverage)

Water Quality Observations

Odors Noted:
☒ Normal/None ☐ Sewage ☐ Anaerobic
☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other___________

Water Surface Appearance:
☐ Slick ☐ Sheen ☐ Globs
☐ Flecks ☒ None ☐ Other__________

Turbidity/Water Clarity:
☐ Clear ☐ Slightly turbid ☐ Turbid
☒ Opaque ☐ Stained ☐ Other______________

Sediment Deposits: ☒ None ☐ Sludge ☐ Sawdust ☐ Oils ☐ Sand ☐ Relict shells

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: LB-2.5 (3.1 mi)	**Date:** 4/5/12	**Initials:**

Impact I.D.[1]	**Coordinates (Lat / Long) or Waypoint**	**Severity (1-3)**[2]	**Restoration Opportunity (1-3)**[3]	**Description**
SC TR	193	1.5	1.5	Some Trash in area Access from RB
IB	185-190	2.5	3	along Big pasture some areas no trees, erosion ~~minor~~ mod here (3400')
SC	188	1	1	RB - Road Access
ER	RB 189	1	1	healing over areas over ER

Impact I.D.[1]	**Coordinates (Lat / Long) or Waypoint**	**Bank Erosion Hazard**	**Bank Lth. (ft)**	**Rest. Opp. (1-3)**[3]	**Bank information for BEHI**
ER RB	185 - ~~193~~ 190	L M [✓ H] VH EX (circle one)	3400 ~~Variable~~ ~~4-8~~	2	Bank: Height 4-8 ft, Angle 45-90 Deg Protection: Roots Var %, Root Depth Var ft Vegetation 50 % avg. [4]Material: [✓ Silt/Clay] Sand / Gravel [✓ Cobble] - % ~40
ER RB	186-187	L M [✓ H] VH EX (circle one)	~400'	2	Bank: Height 9 ft, Angle 85 Deg Protection: Roots ~~20~~ 10 %, Root Depth 1 ft Vegetation 25 % [4]Material: [✓ Silt/Clay] Sand / Gravel [✓ Cobble] - % 30
ER LB	190-191	L M [✓ H] VH EX (circle one)	525 Variable		Bank: Height ____ft, Angle ____Deg Protection: Roots ____%, Root Depth ____ft Vegetation ____% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ____ft, Angle ____Deg Protection: Roots ____%, Root Depth ____ft Vegetation ____% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ____ft, Angle ____Deg Protection: Roots ____%, Root Depth ____ft Vegetation ____% [4]Material: Silt/Clay Sand / Gravel Cobble - %____

4375 / 16,3[illegible] = 26.7%

---

[1] Impacts: Outfall(OT), Bank Erosion(ER), Impacted buffer(IB), Utilities in channel(UT), Stream crossing(SC), Channel modification(CM), Trash in stream(TR), other.

[2] Severity: 1=minor, 2=moderate, 3=severe

[3] Restoration Potential: 1=minimal, 2=moderate, 3=high

[4] Bank material: circle base type, silt/clay or sand and if present circle rock type and note %.

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

USA, Cont.

REACH ID: FB-2.5
STREAM: Frog Bayou
DATE/TIME: 4/5/12
INITIALS: DQ
OTHER INFO:

Average Conditions (check applicable)

Flood Plain Dynamics
Connection: ☐ Poor ☐ Fair ☒ Good
Habitat: ☐ Poor ☐ Fair ☒ Good
Vegetation: ☒ Forest ☐ Shrub/Sapling ☒ Tall grasses ☐ Turf/crops
Encroachment: ☐ Poor ☐ Fair ☒ Good

Periphyton (attached algae):
Filamentous: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant
Prostrate: ☐ None ☐ Sparse ☒ Moderate ☐ Abundant
Floating: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant

Suspended Algae (phytoplankton) abundance:
☐ None noticeable (water basically clear)
☐ Moderate (water slightly green tinted)
☐ Abundant (water appears green)

Aquatic Plants In Stream:
Submerged: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant
Emergent: ☐ None ☒ Sparse ☐ Moderate ☐ Abundant
Floating: ☒ None ☐ Sparse ☐ Moderate ☐ Abundant

Aquatic Life Observed:
☒ Fish ☐ Snails ☒ Crawfish ☐ Macroinvertebrates

Wildlife/Livestock In or Around Stream (evidence of):
☒ Cattle ☐ Beaver ☒ Deer ☐ Other turtles

Reach Impacts: (circle impact level 1=minor, 2=moderate, 3=major, and tag with a GPS waypoint(s) (Wpt) ID)
☐ Outfalls(OT): 1 2 3 Wpt________
☒ Stream Crossing(SC): [✓ 1] 2 3 Wpt________
☒ Bank Erosion(ER): 1 [✓ 2] 3 Wpt________
☐ Channel Modification(CM): 1 2 3 Wpt________
☒ Impacted Buffers(IB): 1 [✓ 2 3] Wpt________
☒ Trash(TR): [✓ 1] 2 3 Wpt________
☐ Utilities(UT): 1 2 3 Wpt________
☐ Other________: 1 2 3 Wpt________

Notes:

If any of these impacts are significant use back of page 1 (pg. 2) for detailed description.

Channel Dynamics:
☐ Incised (degrading) ☐ Channelized ☐ Bed Scour ☐ Sediment Deposition
☒ Widening minor ☐ Aggrading ☐ Bank Failure ☐ Culvert Scour (upstream / downstream / top)
☐ Headcutting ☒ Bank scour minor ☐ Slope failure ☐ None (natural stabile channel)

Channel Dimensions (facing downstream): See FB-2
Lt bank Ht: ________(ft) Bankfull Depth ________(ft) Wetted Width:________(ft) Riffle/Run Depth________(ft)
Rt bank Ht:________(ft) Bankfull Width ________(ft)) TOB Width:________(ft) Pool Depth ________(ft)

Channel Stability:
Lt Bank: Angle ________ degrees
LtBank Vegetation protection: ________% cover
LtBank Erosion Hazard: L M H VH EX (circle one)
Length Lt Bank Affected:________
Wpt(s):________
Rt Bank: Angle ________ degrees
RtBank Vegetation protection ________% cover
RtBank Erosion Hazard: L M H VH EX (circle one)
Length Rt Bank Affected:________
Wpt(s):________

Reach Accessibility For Restoration

Good: Open area in public ownership. Easy stream channel access by vehicle.		**Fair:** Forested or developed near stream. Vehicle access limited.		**Difficult:** Must cross wetland, steep slope, heavy forest or sensitive areas to get to stream. Access by foot/ATV only.
5	[✓ 4]	3	2	1

Notes: (biggest problem(s) you see in survey reach)
- Riparian Buffer absence on RB
- Some bank erosion

Restoration Potential:
☒ Riparian reforestation ☒ Bank stabilization
☐ Stormwater retrofit ☐ Outfall stabilization
☐ Channel modification ☐ PS investigation
☐ Culvert rehab. ☐ Other ________

Place sketch of reach on back of page.

---

* Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

Appendix D

Non-Point Source Matrix

Phase 2 - Ranking of sub-watersheds based on NPS issue

Rank #	TSS Loading	Phosphorus Loading	%pasture	Imapcted riparian	Bank erosion	Cattle	Poultry	unpaved Roads	total scores possible
1	cedar-1	cedar-1	FB3	FB3	FB3	cedar-1	FB-3	cedar-1	24
2	FB-3	FB-3	cedar1	lakes??	cedar1	FB-3	cedar-1	FB-3	16
3	Clear-1	FB-1	jones1	clear1	clear1	clear-1	clear-1	clear-1	8
4	FB-1	Clear-1	FB1	cedar1	FB-1	FB-1		lakes	
5	jones-1	jones-1	clear1	jones1	jones-1	jones-1		jones-1	
6	lakes	lakes	lakes	FB1	lakes	lakes		FB-1	
								Total=	48

?? Imapcted riparian buffer in Lakes sub-watershed is not on the shoreline

lakes = FB2

Matrix Scoring from rankings (3 = rank1, 2 = rank2, 1 = rank3)

	1	2	3	Total
Jones1	0	0	1	1
FB1	0	0	1	1
Lakes	0	2	0	2
Clear1	0	0	6	6
Cedar1	12	6	0	18
FB3	12	8	0	20
Total scores				48

Phase 2 Upper Watershed Only - Ranking of sub-watersheds based on NPS issue

Rank #	TSS Loading	Phosphorus Loading	%pasture	Imapcted riparian	Bank erosion	Cattle	unpaved Roads	total scores possible
1	FB-1	FB-1	jones1	lakes	FB-1	FB-1	lakes	21
2	Jones-1	Jones-1	FB1	jones1	jones-1	jones-1	jones-1	14
3	FB-2	FB-2	lakes	FB1	lakes	lakes	FB-1	7
							Total=	42

?? Imapcted riparian buffer in Lakes sub-watershed is not on the shoreline

lakes = FB2

Matrix Scoring from rankings (3 = rank1, 2 = rank2, 1 = rank3)

	1	2	3	Total
Jones1	3	12	0	15
FB1	12	2	4	18
Lakes	6	0	3	9
Total scores				42

Appendix E

WTM Modeling

Source Loads (Without Practices)

Primary Sources

	TN (lb/year)	TP (lb/year)	TSS (lb/year)	Fecal Coliform (billion/year)	Runoff Volume (acre-feet/year)
LDR (<1du/acre)	1,503	222	35,071	65,240	264
MDR (1-4 du/acre)	77	11	1,794	3,337	13
HDR (>4 du/acre)	0	0	0	0	0
Multifamily	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Commercial	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Roadway	55	27	181,769	37,534	152
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Industrial	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Forest	45,598	3,648	1,823,900	218,868	2,392
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Rural	14,536	2,212	316,000	123,240	414
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Open Water	346	14	4,185	0	0
Active Construction	0	0	0	0	0
Total Surface Water Primary Source Load	**62,114**	**6,134**	**2,362,719**	**448,220**	**3,236**
Primary Source Storm Load	**32,047**	**4,376**	**2,148,729**	**448,220**	**3,236**
Primary Source Non-Stormwater Load	**30,067**	**1,758**	**213,990**	**0**	**0**

Secondary Sources

Secondary Load to Surface Waters					
OSDSs - Surface	101	17	676	1,088	0
SSOs	0	0	0	0	0
CSOs	0	0	0	0	0
Illicit Connections	0	0	0	0	0
Channel Erosion	624	312	892,000	0	0
Hobby Farms/Livestock	0	0	0	0	0
Marinas	0	0	0	0	0
Road Sanding	0	0	0	0	0
Point Source Discharges	0	0	0	0	0
Total Surface Water Secondary Source Surface Load	**726**	**329**	**892,676**	**1,088**	**0**
Secondary Source Storm Load	**624**	**312**	**892,000**	**0**	**0**
Secondary Source Non-Stormwater Load	**101**	**17**	**676**	**1,088**	**0**
Secondary Load to Groundwater					
OSDSs- Subsurface	1,126	25	0	0	0
Total Groundwater Load	**1,126**	**25**	**0**	**0**	**0**

Future Practices

This table summarizes the ***Net pollutant load and runoff reductions*** achieved by practices included in the **"Future Practices"** tab. The reductions presented in this table include only the benefits beyond the practices already in place in the Existing Conditions. So, for example, an improvement to an existing education program would include only the ***additional load reduction*** achieved by improving the program.The purple cells summarize the total load reduction from all practices, while the grey cells report the benefits of individual practices. Note that, while the summary table presents only the Total Surface Water loads, this table also breaks out the reductions from loads during storm events (i.e., the Storm Load) and the loads occuring during dry weather conditions (i.e., the Non-Stormwater Load). In some cases, a *negative load reduction* may be reported. This represents an *increase* in load, which would occur if a program or practice was made *less* effective in the future condition.

Net Benefit (Load Reductions) of Future Practices

	TN (lbs/year)	TP (lbs/year)	TSS (lbs/year)	Bacteria (billion/year)	Runoff Reduction (acre-ft/yr)
Reductions to Surface Water Loads					
Lawn Care Education Surface	0	0	0	0	0
Pet Waste Education	0	0	0	0	0
Erosion and Sediment Control	0	0	0	0	0
Street Sweeping	0	0	0	0	0
Street Sweeping - Sanding	0	0	0	0	0
Structural Stormwater Management Practices	#REF!	#REF!	#REF!	#REF!	#REF!
Riparian Buffers	50	14	5,542	2,690	11
Catch Basin Cleanouts	0	0	0	0	0
Marina Pumpouts	0	0	0	0	0
Urban Downsizing	0	0	0	0	0
Redevelopment With Improvements	0	0	0	0	0
Stormwater Retrofits	0	0	0	0	0
Illicit Connection Removal	0	0	0	0	0
CSO Repair/ Abatement	0	0	0	0	0
SSO Repair/ Abatement	0	0	0	0	0
OSDS Programs - Surface	15	3	103	166	0
Channel Protection	219	109	312,312	0	0
Point Source Reduction	0	0	0	0	0
Total Surface Water Reduction	**284**	**126**	**317,957**	**2,856**	**11**
Storm Load Reduction	**268**	**123**	**317,854**	**2,690**	**11**
Non-Storm Load Reduction	**15**	**3**	**103**	**166**	**0**
Reductions to Groundwater Loads					
Urban Land	0	0	0	0	0
OSDSs	-19	0	0	0	0
Total Groundwater Load Reduction	**-68**	**-1**	**0**	**0**	**0**

Source Loads (Without Practices)					
Primary Sources					
	TN (lb/year)	TP (lb/year)	TSS (lb/year)	Fecal Coliform (billion/year)	Runoff Volume (acre-feet/year)
LDR (<1du/acre)	1,750	258	40,831	75,954	307
MDR (1-4 du/acre)	430	63	10,035	18,667	76
HDR (>4 du/acre)	0	0	0	0	0
Multifamily	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Commercial	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Roadway	55	27	182,455	37,676	152
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Industrial	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Forest	27,592	2,207	1,103,684	132,442	1,447
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Rural	8,774	1,335	190,742	74,389	250
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Open Water	17	1	208	0	0
Active Construction	0	0	0	0	0
Total Surface Water Primary Source Load	**38,618**	**3,892**	**1,527,954**	**339,128**	**2,233**
Primary Source Storm Load	**20,435**	**2,830**	**1,398,511**	**339,128**	**2,233**
Primary Source Non-Stormwater Load	**18,183**	**1,063**	**129,443**	**0**	**0**
Secondary Sources					
Secondary Load to Surface Waters					
OSDSs - Surface	205	34	1,363	2,196	0
SSOs	0	0	0	0	0
CSOs	0	0	0	0	0
Illicit Connections	0	0	0	0	0
Channel Erosion	493	246	704,000	0	0
Hobby Farms/Livestock	0	0	0	0	0
Marinas	0	0	0	0	0
Road Sanding	0	0	0	0	0
Point Source Discharges	0	0	0	0	0
Total Surface Water Secondary Source Surface Load	**697**	**280**	**705,363**	**2,196**	**0**
Secondary Source Storm Load	**493**	**246**	**704,000**	**0**	**0**
Secondary Source Non-Stormwater Load	**205**	**34**	**1,363**	**2,196**	**0**
Secondary Load to Groundwater					
OSDSs- Subsurface	2,272	50	0	0	0
Total Groundwater Load	**2,272**	**50**	**0**	**0**	**0**

Future Practices

This table summarizes the ***Net pollutant load and runoff reductions*** achieved by practices included in the **"Future Practices"** tab. The reductions presented in this table include only the benefits beyond the practices already in place in the Existing Conditions. So, for example, an improvement to an existing education program would include only the ***additional load reduction*** achieved by improving the program.The purple cells summarize the total load reduction from all practices, while the grey cells report the benefits of individual practices. Note that, while the summary table presents only the Total Surface Water loads, this table also breaks out the reductions from loads during storm events (i.e., the Storm Load) and the loads occuring during dry weather conditions (i.e., the Non-Stormwater Load). In some cases, a *negative load reduction* may be reported. This represents an *increase* in load, which would occur if a program or practice was made *less* effective in the future condition.

Net Benefit (Load Reductions) of Future Practices

	TN (lbs/year)	TP (lbs/year)	TSS (lbs/year)	Bacteria (billion/year)	Runoff Reduction (acre-ft/yr)
Reductions to Surface Water Loads					
Lawn Care Education Surface	0	0	0	0	0
Pet Waste Education	0	0	0	0	0
Erosion and Sediment Control	0	0	0	0	0
Street Sweeping	0	0	0	0	0
Street Sweeping - Sanding	0	0	0	0	0
Structural Stormwater Management Practices	#REF!	#REF!	#REF!	#REF!	#REF!
Riparian Buffers	68	19	5,915	3,354	14
Catch Basin Cleanouts	0	0	0	0	0
Marina Pumpouts	0	0	0	0	0
Urban Downsizing	0	0	0	0	0
Redevelopment With Improvements	0	0	0	0	0
Stormwater Retrofits	0	0	0	0	0
Illicit Connection Removal	0	0	0	0	0
CSO Repair/ Abatement	0	0	0	0	0
SSO Repair/ Abatement	0	0	0	0	0
OSDS Programs - Surface	31	5	208	335	0
Channel Protection	172	86	245,700	0	0
Point Source Reduction	0	0	0	0	0
Total Surface Water Reduction	**271**	**110**	**251,822**	**3,688**	**14**
Storm Load Reduction	**240**	**105**	**251,615**	**3,354**	**14**
Non-Storm Load Reduction	**31**	**5**	**208**	**335**	**0**
Reductions to Groundwater Loads					
Urban Land	0	0	0	0	0
OSDSs	-38	-1	0	0	0
Total Groundwater Load Reduction	**-104**	**-2**	**0**	**0**	**0**

Source Loads (Without Practices)

Primary Sources

	TN (lb/year)	TP (lb/year)	TSS (lb/year)	Fecal Coliform (billion/year)	Runoff Volume (acre-feet/year)
LDR (<1du/acre)	3,717	549	86,741	161,358	653
MDR (1-4 du/acre)	1,011	149	23,592	43,887	178
HDR (>4 du/acre)	0	0	0	0	0
Multifamily	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Commercial	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Roadway	73	37	244,873	50,552	204
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Industrial	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Forest	37,857	3,029	1,514,260	181,711	1,979
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Rural	8,387	1,273	181,900	70,941	238
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
	0	0	0	0	0
Open Water	11,571	452	140,120	0	0
Active Construction	0	0	0	0	0
Total Surface Water Primary Source Load	**62,597**	**5,489**	**2,191,487**	**508,449**	**3,251**
Primary Source Storm Load	**39,485**	**4,198**	**2,021,871**	**508,449**	**3,251**
Primary Source Non-Stormwater Load	**23,112**	**1,291**	**169,616**	**0**	**0**

Secondary Sources

Secondary Load to Surface Waters					
OSDSs - Surface	177	30	1,182	1,904	0
SSOs	0	0	0	0	0
CSOs	0	0	0	0	0
Illicit Connections	0	0	0	0	0
Channel Erosion	66	33	94,000	0	0
Hobby Farms/Livestock	0	0	0	0	0
Marinas	0	0	0	0	0
Road Sanding	0	0	0	0	0
Point Source Discharges	0	0	0	0	0
Total Surface Water Secondary Source Surface Load	**243**	**62**	**95,182**	**1,904**	**0**
Secondary Source Storm Load	**66**	**33**	**94,000**	**0**	**0**
Secondary Source Non-Stormwater Load	**177**	**30**	**1,182**	**1,904**	**0**
Secondary Load to Groundwater					
OSDSs- Subsurface	1,970	44	0	0	0
Total Groundwater Load	**1,970**	**44**	**0**	**0**	**0**

Future Practices

This table summarizes the ***Net pollutant load and runoff reductions*** achieved by practices included in the **"Future Practices"** tab. The reductions presented in this table include only the benefits beyond the practices already in place in the Existing Conditions. So, for example, an improvement to an existing education program would include only the ***additional load reduction*** achieved by improving the program.The purple cells summarize the total load reduction from all practices, while the grey cells report the benefits of individual practices. Note that, while the summary table presents only the Total Surface Water loads, this table also breaks out the reductions from loads during storm events (i.e., the Storm Load) and the loads occuring during dry weather conditions (i.e., the Non-Stormwater Load). In some cases, a *negative load reduction* may be reported. This represents an *increase* in load, which would occur if a program or practice was made *less* effective in the future condition.

Net Benefit (Load Reductions) of Future Practices

	TN (lbs/year)	TP (lbs/year)	TSS (lbs/year)	Bacteria (billion/year)	Runoff Reduction (acre-ft/yr)
Reductions to Surface Water Loads					
Lawn Care Education Surface	0	0	0	0	0
Pet Waste Education	0	0	0	0	0
Erosion and Sediment Control	0	0	0	0	0
Street Sweeping	0	0	0	0	0
Street Sweeping - Sanding	0	0	0	0	0
Structural Stormwater Management Practices	#REF!	#REF!	#REF!	#REF!	#REF!
Riparian Buffers	141	38	8,703	6,267	25
Catch Basin Cleanouts	0	0	0	0	0
Marina Pumpouts	0	0	0	0	0
Urban Downsizing	0	0	0	0	0
Redevelopment With Improvements	0	0	0	0	0
Stormwater Retrofits	0	0	0	0	0
Illicit Connection Removal	0	0	0	0	0
CSO Repair/ Abatement	0	0	0	0	0
SSO Repair/ Abatement	0	0	0	0	0
OSDS Programs - Surface	27	5	180	290	0
Channel Protection	17	9	24,505	0	0
Point Source Reduction	0	0	0	0	0
Total Surface Water Reduction	**185**	**51**	**33,388**	**6,557**	**25**
Storm Load Reduction	**158**	**47**	**33,208**	**6,267**	**25**
Non-Storm Load Reduction	**27**	**5**	**180**	**290**	**0**
Reductions to Groundwater Loads					
Urban Land	0	0	0	0	0
OSDSs	-33	-1	0	0	0
Total Groundwater Load Reduction	**-176**	**-3**	**0**	**0**	**0**