

# WHITE OAK BAYOU WATERSHED MANAGEMENT PLAN

Developed by Alliance Technical Group  
for the City of Maumelle



# CONTENTS

---

- EXECUTIVE SUMMARY ..... i**
  
- 1.0 INTRODUCTION ..... 1**
  
- 2.0 WATERSHED DESCRIPTION..... 3**
  
- 3.0 WATERSHED ASSESSMENT ..... 7**
  - 3.1 GIS Non-point source assessment ..... 10
    - 3.1.1 Land use by sub-watershed ..... 10
  - 3.2 Unified stream assessment ..... 13
  - 3.3 Geomorphology and channel stability ..... 19
    - 3.3.1 Riparian buffer impacts ..... 20
    - 3.3.2 Unpaved roads ..... 21
    - 3.3.3 Land slope.....23
    - 3.3.4 Soils..... 25
    - 3.3.5 Agriculture ..... 26
  - 3.4 Water Quality ..... 26
    - 3.4.1 Historical efforts..... 26
    - 3.4.2 Watershed hydrology ..... 32
    - 3.4.3 Water quality data collected specifically for the WMP ..... 33
  - 3.5 Designated uses ..... 39
  - 3.6 SWAT modeling ..... 40
  
- 4.0 LOADING ANALYSIS ..... 43**
  - 4.1 Pollutant loading from key recent monitoring studies ..... 43
  
- 5.0 POLLUTION SOURCE ASSESSMENT ..... 49**
  - 5.1 Point sources ..... 49
  - 5.2 Non-point sources ..... 51
  - 5.3 Priority sub-watershed ranking ..... 51
  
- 6.0 RECOMMENDATIONS FOR WATERSHED MANAGEMENT POLLUTION SOURCE ASSESSMENT ..... 55**
  - 6.1 Recommended load reductions ..... 55
    - 6.1.1 SWAT modeling non-point source (NPS) load reduction potential ..... 56
  - 6.2 Land use and runoff management ..... 57
    - 6.2.1 Agricultural land use..... 57
    - 6.2.2 Developed - Commercial and Industrial land uses..... 58
    - 6.2.3 Developed - Residential land uses..... 59
    - 6.2.4 Unpaved roads management..... 62
  - 6.3 Stream corridor restoration/enhancement ..... 63
    - 6.3.1 Riparian buffers..... 63
    - 6.3.2 Streambank and channel stabilaztion ..... 64
    - 6.3.3 Critical area conservation..... 66
  - 6.4 Priority recommendations and implementation schedule ..... 67
  - 6.5 Interim milestones..... 70
  - 6.6 Adaptive management ..... 71

# CONTENTS (Cont.)

---

<b>7.0 WATER QUALITY TARGETS (SUCCESS CRITERIA) AND MONITORING .....</b>	<b>71</b>
<b>8.0 PUBLIC INVOLVEMENT, EDUCATION AND STAKEHOLDERS .....</b>	<b>72</b>
8.1 Stakeholder Involvement .....	72
8.2 Educational Outreach .....	73
8.3 Continuing Education.....	75
<b>9.0 TECHNICAL AND FINANCIAL ASSISTANCE .....</b>	<b>75</b>
<b>10.0 REFERENCES CITED .....</b>	<b>78</b>

## TABLES

---

Table ES-1 Prioritization of recommended watershed management practices. ....	iii
Table 1.1 EPA nine minimum elements. ....	1
Table 3.1.1 Percent land use by sub-watershed (2021 NLCD) .....	11
Table 3.2.1 Summary of Impacts observed during USA's .....	15
Table 3.2.2 Estimated bank erosion rates for each stream reach and sub-watershed .....	18
Table 3.3.1 Summary of geomorphic characteristics observed during the USAs .....	20
Table 3.3.1.1 Summary of riparian evaluation from desktop analysis (% of impacted riparian buffer) ...	21
Table 3.3.2.1 Unpaved road lengths in the WOB and estimates of sediment loading from run-off events .....	22
Table 3.3.3.1 Summary of land slope analysis (NLCD, 2021) .....	23
Table 3.4.3.1 Summary of water quality data collected by UCA in the WOB watershed.....	36
Table 3.4.3.2 Summary of mean data from the two storm flow sampling events.....	36
Table 3.4.3.3 Correlation analysis completed by UCA (UCA, 2022) for relationships between water quality variables and land use at each of three spatial scales (proximal, intermediate, and distal) across all sample sites in WOB.....	39
Table 3.5.1 Water quality standards assessment criteria.....	40
Table 4.1.1 Loading of key constituents normalized on a per mi <sup>2</sup> basis.....	44
Table 5.1.1 NPDES discharges with continuous flow >0.01 mgd .....	50
Table 5.2.1 Key non-point source impacts for each sub-watershed assessed in the WOB.....	51
Table 5.3.1 Ranking of each impact category for each sub-watershed.....	53
Table 6.1.1 Load reduction goals.....	56
Table 6.2.4 Potential load reductions from implementation of unpaved road BMPs .....	63
Table 6.3.2.1 Yearly loads from streambank erosion and load reductions possible from streambank stabilization.....	66
Table 6.3.3.1 Key management measures to encourage, develop and manage .....	67
Table 6.4.1 Prioritization of recommended watershed management practices .....	69
Table 6.4.2 Implementation schedule <sup>2</sup> .....	70
Table 6.5.1 Interim measurable milestones .....	70
Table 9.0.1 Sediment load reductions for the WOB.....	75

# TABLES (Cont.)

---

Table 9.0.2 Private/match funding entities for watershed management .....	76
Table 9.0.3 Federal funding opportunities for watershed management .....	77

# FIGURES

---

Figure ES-1 Ranked key sub-watersheds for implementation .....	ii
Figure 2.1 Location of White Oak Bayou in Pulaski County, Arkansas .....	4
Figure 2.2 Land use of the watershed (NLCD, 2021) .....	5
Figure 2.3 Representative wetlands and streams starting at the headwaters of WOB to the input at the Arkansas River .....	7
Figure 3.1 Sub-watersheds assessed and monitoring locations .....	9
Figure 3.1.1 WOB land use land cover by sub-watershed (2021 NLCD) .....	12
Figure 3.1.2 Land use land cover for the WOB by sub-watershed (2021 NLCD) .....	13
Figure 3.2.1 Common riparian impacts observed in the developed areas of the watershed .....	16
Figure 3.2.2 Streambank erosion in Henry sub-watershed .....	19
Figure 3.3.3.1 Land surface slope in WOB watershed .....	24
Figure 3.3.3.2 Map of soils in the WOB .....	25
Figure 3.4.1.1 Mean suspended sediment and dissolved solids In WOB samples collected by DEQ 2010-2018 .....	27
Figure 3.4.1.2 Mean nitrogen and phosphorus levels in WOB samples collected by DEQ 2010-2018 .....	27
Figure 3.4.1.3 Stream water quality monitoring stations used by UCA and OBU, and the sub-watersheds that they represent .....	29
Figure 3.4.1.4 Measurement of flow by UCA during a sample event .....	30
Figure 3.4.1.5 Summary of mean storm flow nutrient levels in WOB (2016-2017) key drainages arranged by percent urban (developed) land use .....	31
Figure 3.4.1.6 Mean total suspended sediment in-stream during run-off events (2016-2017) .....	31
Figure 3.4.1.7 Water nutrient levels in inundated wetlands .....	32
Figure 3.4.2.1 Comparison of stage hydrograph on WOB above and below large wetland complex .....	33
Figure 3.4.3.1 UCA sample stations and represented sub-watershed monitored during the 2021/22 study .....	34
Figure 3.4.3.2 Average total nitrogen base and storm flow concentrations from each sub-watershed .....	37
Figure 3.4.3.3 Average total phosphorus base and storm flow concentrations from each sub-watershed .....	37
Figure 3.4.3.4 Average TSS base and storm flow concentrations from each sub-watershed .....	38
Figure 3.6.1 SWAT sediment output from land surface (lbs./mi <sup>2</sup> ) run-off .....	42
Figure 3.6.2 SWAT sediment loading calculations for each sub-watershed outlet .....	43
Figure 4.1.1 Average loads of Pb (lb./mi <sup>2</sup> ) .....	45
Figure 4.1.2 Average storm event loads of Pb (lb./mi <sup>2</sup> ) .....	45
Figure 4.1.3 Average loads of total nitrogen (lb./mi <sup>2</sup> ) .....	46
Figure 4.1.4 Average storm event loads of total nitrogen (lb./mi <sup>2</sup> ) .....	46
Figure 4.1.5 Average loads of total phosphorus (lb./mi <sup>2</sup> ) .....	47

# FIGURES (Cont.)

---

Figure 4.1.6 Average loads of total suspended solids (lb./mi <sup>2</sup> ).....	47
Figure 4.1.7 Average storm event loads of total suspended solids (lb./mi <sup>2</sup> ) .....	48
Figure 5.1.1 Active NPDES permits, including stormwater outfalls/other known non-point sources .....	50
Figure 5.3.1 Matrix rankings of top watershed concerns in the WOB .....	54
Figure 6.2.1 A Bioswale (Bioretention) that is effective in reducing pollutant load in stormwater run-off from commercial and institutional areas .....	59
Figure 6.2.2 Example of a raingarden that can be easily and inexpensively installed in most yards and/or commercial areas to improve stormwater quality.....	61
Figure 6.2.3 Identified locations for potential new stormwater treatment/retrofits .....	62
Figure 6.3.1 Generic representation of the ideal riparian buffer zone and key function in each zone.....	64
Figure 6.4.1 Source and scale of Total Suspended Solids (TSS) BMP load reduction (pounds) potential..	68
Figure 8.2.1 Map reflects the history of workshop attendee property locations .....	74

# APPENDICES

---

- Appendix A – USA Forms
- Appendix B – DEQ Data
- Appendix C – Data collected by Universities
- Appendix D – Possible BMPs

# EXECUTIVE SUMMARY

---

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. Preparation of this plan was funded partially by an EPA 319 Grant (Sub-Grant Agreement 20-1100) through the Arkansas Department of Agriculture, Natural Resources Division (NRD). The City of Maumelle, the sub-grantee, and the White Oak Bayou Wetland Conservancy (WOBWC) have been the driving force, and the catalyst for this watershed plan, in the White Oak Bayou Watershed (WOB) over the past six years.

The WOB is not on the NRD priority watershed list but is a locally at-risk water. The Arkansas Department of Energy and Environment, Division of Environmental Quality (DEQ) placed the White Oak Bayou on the Arkansas 303(d) list for dissolved oxygen, pH, copper, and lead. The listing is considered low priority, but its proximity to one of the fastest growing areas in Arkansas make it highly vulnerable to continued degradation. Many waterways are encroached on by development and hydrographs are showing some spikes that are causing land and stream channel erosion in areas. Beaver dams throughout the area are backing up water, causing localized flooding, slowing velocities, and increasing residence time in wetland areas, which could be a contributor to low dissolved oxygen levels.

The WMP includes identification of critical sub-watersheds and ranked implementation measures to reduce non-point source pollution loading from critical areas. The assessment portion of this plan contains data collected over approximately 9 years, with the most recent data being collected from 2020-2023 specifically for development of this plan. The ranking of key/critical sub-watersheds (Figure ES-1) and the proposed management measures are based largely on that assessment work.

The White Oak Bayou is a HUC-12 watershed (HUC- 111102070401) where it discharges to the Lower Arkansas River (HUC- 11110207) and is approximately 42 mi<sup>2</sup> in size (Figure 2.1). The watershed is located in the Arkansas River Valley Ecoregion (Omernick, 1987), in Pulaski County Arkansas. Overall, the watershed is dominated by forest land uses (52%) (Figure 2.2) which are mostly on the grounds of Camp Robinson and in lower reaches of the watershed. Hay and/or pasture land uses comprise approximately 8%, water and wetlands comprise approximately 4%, while developed areas make up approximately 32% of the watershed (NLCD, 2021).

Due to the obvious large percentage of developed (urban) area in the watershed this is a primary concern and a focus of assessment and implementation efforts.

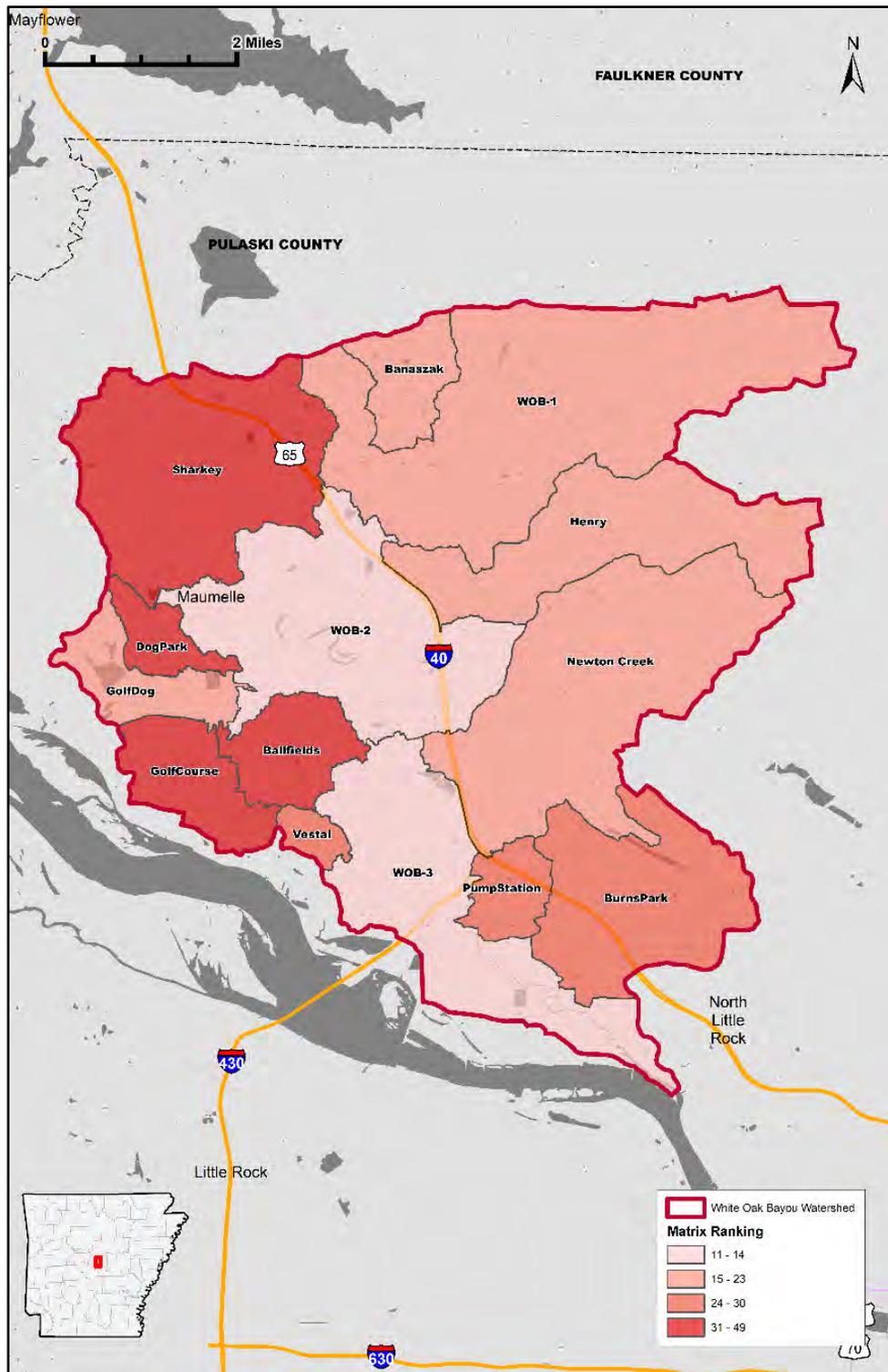


Figure ES-1. Ranked key sub-watersheds for implementation.

Reductions in total suspended sediment (TSS) loading of approximately 20%, will be targeted in critical/priority areas in an effort to improve water quality, ensure improvement

and maintenance of the state in-stream criteria and reduce sediment loading (and other associated pollutants) to the Bayou and the greater Arkansas River.

The primary recommendations to improve water quality, for the key/priority sub-watersheds in this WMP, are provided in Section 6, and a summary is provided the table below.

Table ES-1. Prioritization of recommended Watershed Management Practices.

<b>Rank</b>	<b>White Oak Bayou Sub-Basin</b>	<b>Management Action (Practice)</b>
1	Henry, Golfcourse, Banaszak, Newton Creek, Sharkey and Dogpark	Streambank stabilization
2	Sharkey, Golfcourse, Golfdog, Dogpark, Ballfields and Banaszak	Riparian buffer/Vegetated filter Strips
3	Vestal, Dogpark, Ballfields, Golfcourse and Golfdog	Implementation of residential/commercial BMPs (including street sweeping)
4	WOB-1, Burnspark and Sharkey	Unpaved road maintenance and upgrades
5	All sub-watersheds	Conservation of wetlands and other key green areas
6	Pumpstation, Sharkey and Burnspark	Implementation of residential/commercial BMPs
7	Pumpstation and Burnspark	Riparian buffer/Vegetated filter Strips

# 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. Using a watershed basin approach, the attention not focused only on point source discharges (sewage and wastewater treatment plants) and stream disturbances in the stream corridors, but also on of anthropogenic land uses and the effects they have on stormwater run-off (non-point sources) in the 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 1.1). Preparation of this plan was funded partially by an EPA 319 Grant (Sub-Grant Agreement 20-1100) through the Arkansas Department of Agriculture, Natural Resources Division (NRD). The City of Maumelle, the sub-grantee, and the White Oak Bayou Wetland Conservancy (WOBWC) have been the driving force, and the catalyst for this watershed plan, in the White Oak Bayou Watershed (WOB) over the past six years.

Table 1.1. EPA nine minimum elements.

EPA Nine Minimum Elements	Location Addressed in Watershed Management Plan
Element 1- Identification of causes of impairment and pollutant sources	Section 3.0, 4.0, 5.0
Element 2- Estimate of load reductions expected from management measures	Section 4.0
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	Section 7.0

The WOB is not on the NRD priority watershed list but is a locally at-risk water. The Arkansas Department of Energy and Environment, Division of Environmental Quality (DEQ) placed a section of the White Oak Bayou on the Arkansas 303(d) list for dissolved oxygen, pH,

copper, and lead. The listing is considered low priority, but its proximity to one of the fastest growing areas in Arkansas make it highly vulnerable to continued degradation. Urbanization is encroaching on many streams and wetlands which is impacting both peak storm hydrographs and water quality. Beaver dams throughout the area are backing up water, causing localized flooding, slowing velocities, and increasing residence time in wetland areas, which is generally considered beneficial ecologically, but could be a contributor to low dissolved oxygen levels.

Various concerns have been raised over the years by local agencies and concerned citizens regarding development in and around the bayou's watershed. The U.S. Army Corps of Engineers, Little Rock District started working toward a management strategy to protect wetlands within the White Oak Bayou watershed in the 1970s. However, it was not until 2007 that funding was secured to develop a process for managing wetlands more effectively within the White Oak Bayou Watershed. It was at that time the City of Maumelle applied for and received funding from an EPA Region 6 Wetland Program Development Grant (WPDG) to pursue a management strategy for wetlands within the White Oak Bayou watershed. Additional funding has been received since that time to continue the development of the project. This funding has provided an avenue for mapping, assessment, and management planning related to wetlands within the watershed, and has created a springboard for educational programs and community interactions related to the White Oak Bayou. The wetland management plan was finally completed in 2018 with the following primary objective:

*The White Oak Bayou Wetland Management Plan manages, protects, and enhances wetlands in the White Oak Bayou watershed consistent with environmental, economic, and social values of interested and affected groups including the general public. The plan educates the public, identifies best management practices, and develops management tools and wetland usage options specific to the locale. As an ecosystem-based plan, it stresses that urban development proceeds best when it balances property rights and interests with aesthetics and wetland system function within the watershed.*

Historically, wetlands associated with White Oak Bayou were used for a variety of purposes including providing an important source of food through hunting and fishing activities. Harvested timber from both wetland and non-wetland areas was utilized for building homes, fences, etc. Many of the historically forested areas were cleared to make way for small pastures and hayfields in the more agrarian portions of the watershed east of Interstate 40. Currently, development in the urbanizing portions of the watershed provides even greater threats to the long-term viability of the wetland ecosystem within the watershed.

Six of the NRDs objectives for watersheds in Arkansas (ANRC, 2018) will be accomplished through, or as a result of development of this WMP, and many of the remaining 11 objectives will be set in motion by this plan's implementation priorities. The six that will be accomplished are:

- 19.1. Continue development of the Nine Element Plan until U.S. Environmental Protection Agency (EPA) approval is obtained.
- 19.2. Continue to develop support for implementation of the Nine Element Plan among potential cooperating entities and the general public.
- 19.3. Provide technical and financial assistance to local cooperating entities to implement the Nine Element Plan as resources allow.
- 19.5. As resources allow, use remote sensing and Geographical Information Systems (GIS) analysis to identify sub-watersheds where more extensive assessment is needed. Conduct targeted geomorphological and bioassessment to identify and target implementation of streambank stabilization projects for high impact sites.
- 19.6. Continue to refine models as new data becomes available to represent sediment and nutrient loads in the watershed and instream processes to enable prioritization of implementation projects in sub-watersheds.
- 19.12. Continue to increase public awareness and provide education to build support for citizen action to improve water quality in the watershed.

Based on the study results and the 2018 and 2020 (draft) 303(d) listing, sediment (turbidity), pH, oxygen demanding wastes and metals appear to be the principal concerns in run-off from land surfaces in the watershed and from in-channel processes (i.e., erosion and scour).

This WMP has been developed based primarily on evaluation/analysis of existing watershed monitoring data and new data collected over the past three years specifically to develop this WMP. The WMP includes identification of critical sub-watersheds at a small scale and ranked implementation measures to reduce non-point source pollution loading from critical areas. This WMP will be used to direct watershed protection activities and watershed restoration activities with the goal being reduction of pollutant loading and protection of the watershed.

## 2.0 WATERSHED DESCRIPTION

---

The White Oak Bayou is a HUC-12 watershed (HUC- 111102070401) where it discharges to the Lower Arkansas River (HUC- 11110207) and is approximately 42 mi<sup>2</sup> in size (Figure 2.1).

The watershed is located in the Arkansas River Valley Ecoregion (Omernick, 1987), in Pulaski County Arkansas.

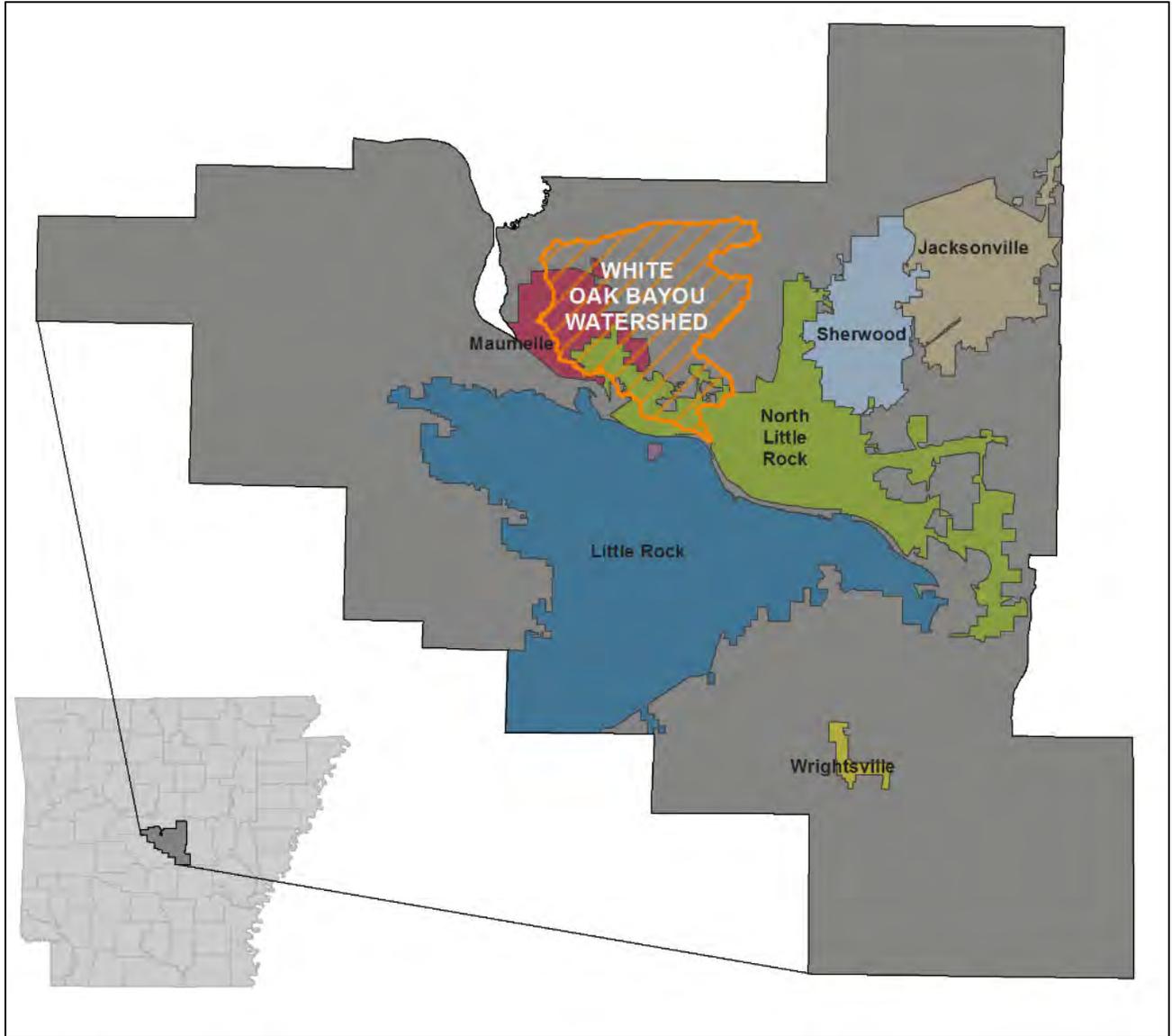


Figure 2.1. Location of White Oak Bayou in Pulaski County, Arkansas.

Overall, the watershed is dominated by forest land uses (52%) (Figure 2.2) which are mostly on the grounds of Camp Robinson and in lower reaches of the watershed. Hay and/or pasture land uses comprise approximately 8%, water and wetlands comprise approximately 4%, while developed areas make up approximately 32% of the watershed (NLCD, 2021).

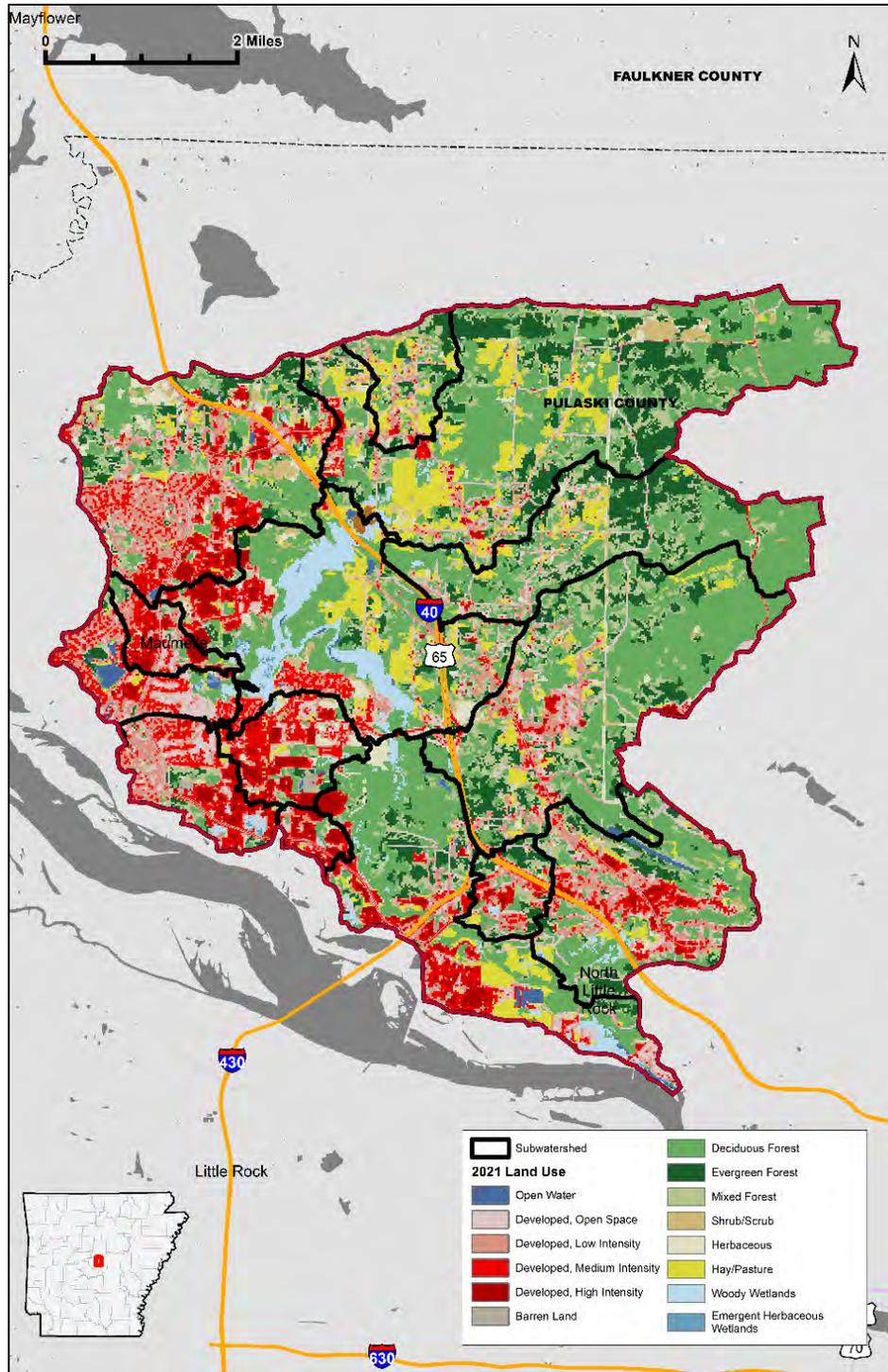


Figure 2.2 Land use map of the watershed (NLCD, 2021)

Soils on the land surface in the sub-watersheds are primarily dominated by the Linker-Mountainburg association, Linker, and Leadvale soils. These soils are composed mostly of a gravelly fine sandy loam, fine sandy loam and silt loam and have a moderate overall potential for erosion. Slopes are fairly flat overall (10 sub-watersheds less than 8% on average) with the

remaining sub-watersheds averaging a moderately steep slope between 8% and 13%. The moderately steep slopes in the watershed make it somewhat vulnerable to erosion in un-forested areas. Maps of slope and soils are provided in Section 3.3 of this WMP.

Issues affecting water quality within the watershed vary dependent upon the geographic location, nature of potential inputs, and wetland type receiving stormwater inputs. Figure 2.3 provides a visual glance at the types of streams, wetlands, and topography found within the White Oak Bayou watershed as one moves from the headwaters to the inlet at the Arkansas River. The headwaters of White Oak Bayou and some of its major tributaries such as Winifree Creek and Newton Creek are relatively protected because they originate in the State National Guard military base of Camp Robinson which is still largely forested in areas surrounding tributaries that feed into White Oak Bayou. The primary source of contaminant inputs from Camp Robinson is likely sediment loading from unpaved roads and erosion of banks along the bayou and its tributaries. As one moves further downstream along the channel of White Oak Bayou potential inputs include nutrients associated with stormwater runoff and leaking septic systems; sediment from eroding banks, loss of forests, and urban development; petroleum-based chemicals from vehicles leaking onto impervious surfaces such as parking lots; and general trash and debris that is washed into the bayou during large storm events. Other sources of nutrients into the bayou may include lawn fertilizer, livestock manure, and even pet wastes from neighborhoods or droppings from waterfowl populations in the bayou itself. In addition, as with most aquatic systems associated with urban areas, there is the potential for large sudden pollutant impacts due to accidental spills, from petroleum releases from pipelines, underground storage tanks, and tanker truck spills, etc. Non-point source will be further explored/assessed in Section 3.0.



Figure 2.3. Representative wetlands and streams starting at the headwaters of White Oak Bayou (upper left) to the Input at the Arkansas River (lower right).

## 3.0 WATERSHED ASSESSMENT

---

All waters in the state of Arkansas have Designated Uses applied to them that dictate the level of water quality that must be maintained. WOB is designated for the following uses by the Arkansas Pollution Control and Ecology Commission (ADPCE):

- Primary contact recreation
- Secondary contact recreation
- Domestic, industrial, and agricultural water supply
- Fisheries (Aquatic life), Perennial in Arkansas River Valley

Currently the White Oak Bayou is listed on Arkansas' 303(d) list for dissolved oxygen, pH, copper, and lead, which indicates it may be at risk for attainment of some of these uses. A comprehensive assessment was completed on the WOB to evaluate its physical, chemical, and hydrologic condition. This assessment primarily focused on 14 sub-watersheds with 12 monitoring stations. A large portion of the historical assessment data originated in the Wetland Management Plan for WOB (GBMc, 2018). The 319 project, of which preparation of this WMP

was the focus, included some new data collection to fill gaps and augment existing historical data. All available data was considered for use in this assessment.

Each of the 14 sub-watersheds and 12 monitoring stations depicted on the map (Figure 3.1) were sampled over multiple years by various university partners including, University of Central Arkansas (UCA) and Ouachita Baptist University (OBU). These university monitoring efforts allowed students to complete water quality research projects, some of which led to master's theses. The 2018 Wetland Management Plan provided much of the assessment related data including historical data review, Unified Stream Assessments (USAs), desktop analysis (in-part) and streambank erosion. The Soil and Water Assessment Tool (SWAT) was used as a part of the final level of assessment completed with this project.

A description and results of each assessment component is contained in the following sections. The sub-watersheds that have been assessed in detail (water quality sampling, USAs, flow monitoring, etc.) will be the basis for the overall watershed assessment and sub-watershed priority ranking. These sub-watersheds are believed to be a reasonable transect of all the sub-watersheds in the WOB and should facilitate informed management for the entire watershed. Sub-watersheds that were not assessed directly will be compared to similar sub-watersheds that were assessed. Each sub-watershed has a unique name to identify either its associated stream name or the type of area it drains. The majority of these names originated with the universities that were working on the system in the early days. The names were primarily derived from nearby land features or street names identifiable to the university student researchers and have simply stuck throughout the study period. The 14 watersheds assessed are:

- |               |                          |            |
|---------------|--------------------------|------------|
| 1. Ballfields | 6. Golfdog               | 11. Vestal |
| 2. Banaszak   | 7. Henry (Winifry Creek) | 12. WOB-1  |
| 3. Burnspark  | 8. Newton Creek          | 13. WOB-2  |
| 4. Dogpark    | 9. Pumpstation           | 14. WOB-3  |
| 5. Golfcourse | 10. Sharkey              |            |

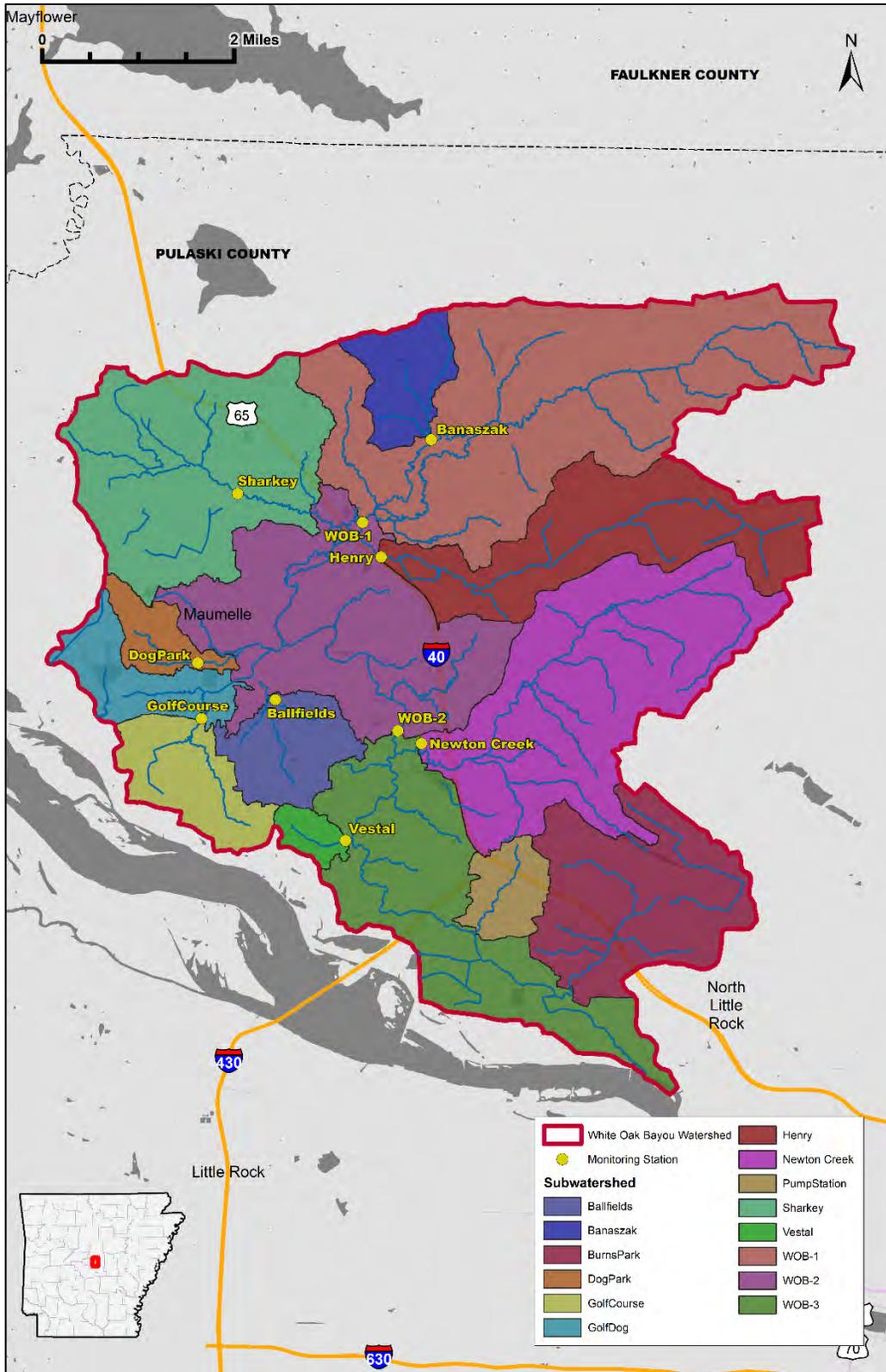


Figure 3.1. Sub-watersheds assessed and monitoring locations.

### **3.1 GIS Non-point Source Assessment**

A desktop assessment of the WOB was completed using GIS resources including soils maps, land surface slope (DEM), land use, aerial photographs, etc. The assessment was focused on identifying possible critical land areas and non-point sources of pollutants that could be transported to the stream system during stormwater runoff events. The assessment was completed on all sub-watersheds.

#### **3.1.1 Land Use by Sub-watershed**

Land use was evaluated using 2021 NLCD land use land cover data from the Multi-Resolution Land Characteristics Consortium. Land use is an important attribute in a watershed analysis. The percent of pasture and developed areas can provide great insight into a watershed's potential for NPS pollution. A summary of the land use assessment is provided in Table 3.1.1.

In the WOB watershed there is only a small amount of agriculture. What agriculture is present is almost entirely composed of hay operations. The sub-watersheds with the highest percent of hay/pasture were Banaszak (21.1%), WOB-1 (13.5%) and WOB-2 (10.4%). Cultivated crops make up less than 1% of the entire watershed and even on a sub-watershed basis no sub-watershed has more than 1% cultivated crop land-use. Pastures are generally associated with cattle use, and/or hay, commercial fertilizer, poultry litter used as fertilizer, or any combination of the four. However, since the watershed has very low cattle numbers, and no commercial poultry, these land uses are unlikely to be having a significant effect on the nutrient loading to the system. The land use with the most potential for impact to water quality is developed area. The overall WOB watershed has approximately 32% developed land with over 12% of that being in medium to high intensity development. Figures 3.1.1 and 3.1.2 below is a visual representation of each sub-watersheds' land use.

Table 3.1.1 Percent land use by sub-watershed (2021 NLCD).

<b>Sub-watershed</b>	<b>Sub-watershed Area (mi<sup>2</sup>)</b>	<b>Forest</b>	<b>Hay / Pasture</b>	<b>Developed Open Space/Low Intensity &amp; Barren</b>	<b>Developed Medium &amp; High Intensity</b>	<b>Herbaceous, Wetlands &amp; Shrub/Scrub</b>
Ballfields	1.2	16.2	2.9	25.2	46.2	0.4
Banaszak	1.0	49.1	21.1	21.4	3.3	0.3
Burnspark	3.4	51.3	4.1	26.1	13.3	1.1
Dogpark	0.6	16.9	1.0	32.1	46.5	0.9
Golfcourse	1.4	13.6	0.4	43.3	37.7	0.5
Golfdog	1.2	11.4	3.3	44.6	29.5	10.6
Henry (Winifry Creek)	3.7	79.6	6.4	9.2	1.1	0.2
Newton Creek	6.0	72.4	5.1	15.1	3.7	0.3
Pumpstation	0.7	41.0	3.4	31.4	21.3	1.6
Sharkey	4.9	36.4	4.2	31.1	20.7	0.6
Vestal	0.3	10.9	0.7	25.4	60.8	1.0
WOB-1	8.3	70.4	13.5	8.9	2.0	0.8
WOB-2	5.2	38.7	10.4	15.6	12.5	16.8
WOB-3	4.4	48.0	8.0	16.6	17.5	7.0
Overall WOB watershed	42.4	52.4	7.6	19.1	12.8	3.8

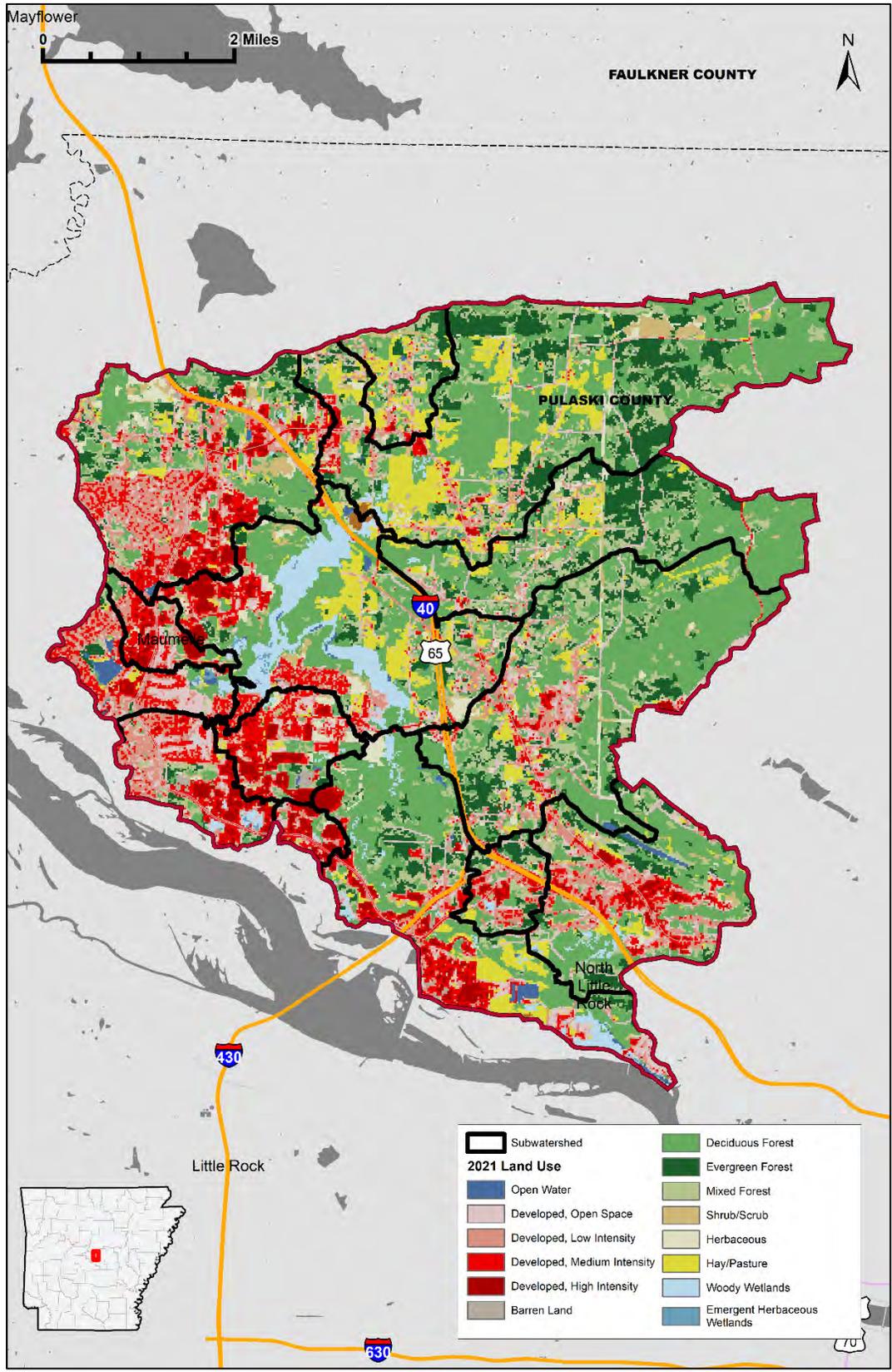


Figure 3.1.1 WOB land use land cover by sub-watershed (2021 NLCD).

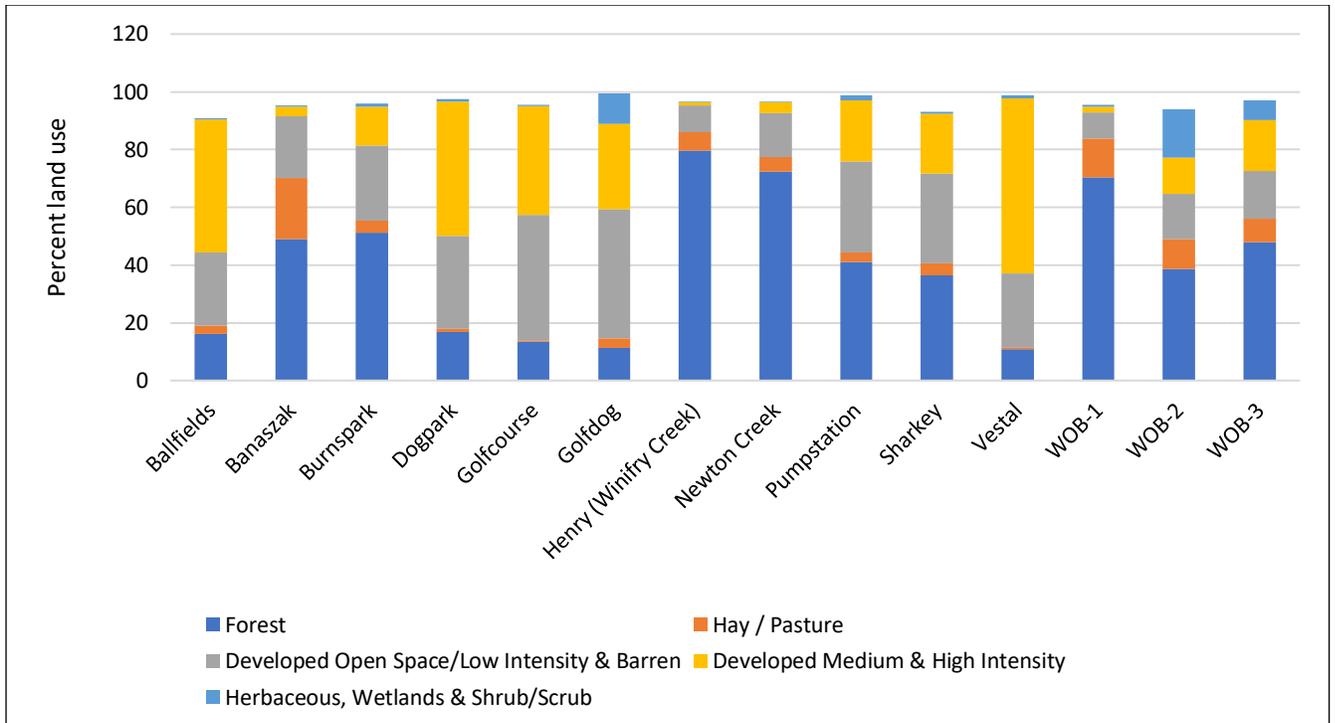


Figure 3.1.2 Land use land cover for the White Oak Bayou by sub-watershed (2021 NLCD)

### 3.2 Unified Stream Assessment

A variation (modified to address rural streams) of the Unified Stream Assessment (USA) protocol (Kitchel and Schueler, 2004) was completed in the White Oak Bayou sub-watersheds in 2017-2018. This visual based field assessment protocol consists of breaking the stream into manageable reaches and evaluating, on foot, each defined 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 bank erosion)
9. Floodplain dynamics

10. Geomorphic attributes (channel stability)
11. Restoration/retrofit opportunities

Field data forms completed during the survey are included in Appendix A. A summary of the pertinent findings is provided in Table 3.2.1. A 1,500-foot (minimum where possible) representative section in each sub-watershed was assessed following the USA protocol. The impacts observed and their frequency of occurrence is assumed to be consistent with additional comparable stream reaches in that sub-watershed. That is, stream reaches not assessed on that stream that have similar channel size to the assessed reach are anticipated to have similar characteristics and issues at a similar frequency to those of the reach assessed.

Stream (road) crossings, riparian impacts, and streambank erosion were noted most frequently, but several sub-watersheds also had issues with utilities in the channel and significant stormwater outfalls. Each of these had variable severity rankings with impacted riparian buffers and stream crossings generally considered more of an issue (more frequent with greater severity) than the others. These stream impacts are commonly associated with developed areas where riparian buffers areas are commonly reduced or eliminated by the process of urbanization. Bank erosion is often associated with these areas where riparian vegetation has been disturbed or removed (Figure 3.2.1). Riparian buffers provide several benefits to streams, they provide stabilization to streambanks that prevents erosion, provides shading that helps cool the water and limit periphyton growth, and they provide organic matter inputs which serve as food and habitat for aquatic biota. Well-developed riparian buffers can also filter stormwater pollutants and allow for increased rainwater infiltration which aids in protecting the streams hydrology (through decreased peak flows and increased baseflow).

Table 3.2.1. Summary of impacts observed during USA's.

<b>Stream</b>	<b>Impacts</b>	<b>Severity</b>	<b>Description</b>
Ballfields	Channel Modification	Minor	Flow control structure and manmade channel
	Impacted Buffer	Moderate to Severe	Vegetation clearing and storage lot near bank
	Stream Crossing	Minor	Small concrete bridge
	Outfall	Minor	Two stormwater drains
Banaszak	Erosion	Minor	Souring and undercutting at two locations
	Stream Crossing	Minor	Road crossing
Dogpark	Stream Crossing	Minimal to Severe	Road crossings at five locations, golf cart crossings at two locations
	Outfall	Minor to Moderate	Stormwater drains at six locations
	Impacted Buffer	Severe	Mowed up to bank in multiple areas, rip-rap on bank, lawns
	Trash	Moderate to Severe	Trash from parking lots and dumpster near bank
	Utilities in Channel	Moderate	Pipes in channel
	Channel Modification	Severe	Concrete lined channel in residential area
	Erosion	Moderate	Erosion at two locations
Golfcourse 1	Channel Modification	Severe	Concrete lined channel
	Utilities in Channel	Minor to Severe	Cables in stream, large pipe blocking flow
	Impacted Buffer	Severe	Vegetation clearing up to bank, yards, golf course
	Outfall	Minor to Severe	Pipes and stormwater drains at two locations
	Stream Crossing	Minor to Severe	Road crossing and golf cart crossing
Golfcourse 2	Erosion	Minor	Steep incised erosion
	Stream Crossing	Minor	One road crossing and two golf course crossings
	Outfall	Minor	Culvert from apartments
	Impacted Buffer	Moderate	Parking lot near bank, poor riparian vegetation
Henry 1	Erosion	Minor to Severe	Undercutting and steep banks throughout most of the assessment area
Henry 2	Erosion	Minor	Some scouring at three locations
	Utilities in Channel	Minor	Distribution lines at two locations
	Trash	Minor	Trash dump
	Stream Crossing	Minor	Road crossing
Newton Creek 1	Trash	Minor	Debris deposits with trash at two locations
	Erosion	Minor	Steep banks with some undercutting at two locations
Newton Creek 2	Erosion	Minor to Severe	Steep banks, undercutting, bank failure
	Utilities in Creek	Minor	Powerlines
	Stream Crossings	Minor	Foot bridge, private drive, highway, railroad
	Impacted Buffer	Minor to Moderate	Junkyard near bank, homes, and businesses adjacent to stream
Sharkey 1	Erosion	Minor to Severe	Erosion at seven locations

Stream	Impacts	Severity	Description
	Impacted Buffer	Severe	Little riparian buffer
	Trash	Minor to Moderate	Trash at two locations
	Channel Modification	Severe	Concrete lined channel under overpass
	Stream Crossing	Severe	Overpass
	Utilities in Channel	Minor	Utilities in channel at two locations
Sharkey 2	Stream Crossing	Minor to Moderate	Road crossing and railroad crossing
WOB 1	Impacted Buffer	Severe	Cropland with little to no buffer
	Stream Crossing	Minor	Small farm bridge and road crossing
WOB 2	Utilities in Channel	Minor	50 ft Right of Way crossed at three locations
	Stream Crossing	Minor	I-40 Bridge
	Trash	Minor	Some trash in water
	Outfall	Minor	Two stormwater outlets causing some erosion



Figure 3.2.1. Common riparian impacts observed in the developed areas of the watershed.

Bank erosion was noted in several areas, particularly in the Henry and Golfcourse sub-watersheds. Each instance of bank erosion 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 erosion levels are low, moderate, high, very high, and extremely high. Bank erosion observed in the WOB watershed reaches ranged from none to very high active erosion. The soils in the overall WOB are mostly composed of silt loam with only moderate potential for erosion.

Streambank erosion can add hundreds of tons of sediment (including nutrients, metals, and other constituents) to a stream system annually. The number and length of eroded banks were calculated using the representative USA reach to scale up to the main tributary stream length in each sub-watershed. The main tributary stream length, the percent of USA reach affected by bank erosion, average bank height, dominant substrate, and an erosion rate coefficient (from 0.25 ft-1.0 ft based on BEHI scores) were used to determine pounds of sediment/foot of eroded bank (Table 3.2.2). There were 14 USAs completed in the WOB which provided assessment in 10 sub-watersheds.

Table 3.2.2. Estimated bank erosion rates for each stream reach and sub-watershed.

Sub-watershed	Stream Reach	Reach Length (ft)	Bank Erosion Length (LB+RB,ft)	% Reach Eroded	NHD Stream Length (ft)	Stream Length Eroded (ft)*	Average Bank Height (ft)	Erosion Rate (ft/yr.)	Volume Sediment Eroded (ft <sup>3</sup> /yr.)	% Gravel/Cobble	Sediment Eroded Adjusted for gravel/cobble (ft <sup>3</sup> /yr.)	Sediment Eroded Adjusted for gravel/cobble (lb./yr.)	Sediment Eroded (ft <sup>3</sup> /mi)
Sharkey	Sharkey	3,660	401	11.0%	11,792	1,292	6.3	0.5	4,037	0	4,037	370,754	1,808
Banaszak	Banaszak	1,167	332	28.4%	7,691	2,188	4.75	0.50	5,197	0	5,197	477,198	3,568
Golfcourse	Golfcourse	4,484	1,599	35.7%	7348	2,620	4.1	0.5	5,794	0	5,794	532,044	4,163
Dogpark	Dogpark	2,007	174	8.7%	4,883	423	3.50	1.00	1,482	0	1,482	136,063	1,602
WOB-2	WOB 2	2,684	0	0.0%	24,022	0	0.00	0.00	0	0	0	0	0
Henry	Henry	2,146	1,621	75.5%	30,183	22,799	5.6	0.5	58,670	0	58,670	5,387,628	10,263
Newton Creek	Newton Creek	4,113	591	14.4%	26884	3,863	5.6	0.4	9,564	0	9,564	878,267	1,878
WOB-1	WOB 1	2,642	0	0.0%	38,565	0	0.00	1.00	0	0	0	0	0
Ballfields	Ballfields	2,754	0	0.0%	5,568	0	0.00	1.00	0	0	0	0	0
WOB-2	WOB 2b**	15,808	0	0.0%	36,172	0	0.00	1.00	0	0	0	0	0

\*Bank erosion was estimated using the percent reach eroded and the NHD stream length

\*\*WOB-2b USA completed via kayak, providing a much longer reach length and encompassing reach WOB-2.

The two streams with the highest stream bank erosion were Henry and Golfcourse (Figure 3.2.2). Streambank erosion ( $\text{ft}^3/\text{mi}$ ) is a key attribute used in the ranking matrix.



Figure 3.2.2. Streambank erosion in Henry sub-watershed.

### 3.3 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 and streambank 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 each sub-watershed was beyond the scope of this project, but some

basic assumptions can be gleaned from the data collected. Table 3.3.1 provides a summary of the channel dimensions estimated (and some measured) during the USAs.

Table 3.3.1. Summary of geomorphic characteristics observed during the USAs.

	Sharkey	Banaszak	Golfcourse	Dogpark	WOB-2	Henry	Newton Creek	Ballfields	WOB-1	WOB-2b
Watershed area (mi <sup>2</sup> )	4.9	1.0	1.4	0.6	5.2	3.7	6.0	1.2	8.3	5.2
Bankfull depth (ft)	2.0	1.0	2.4	1.0	5.0	3.5	5.3	2.5	2.5	5.0
Bankfull width (ft)	11	7.5	15	7	70	27	16	14	30	40
Dominate Substrate size class	Silt/clay	Silt/clay	Silt/clay	Silt/clay	Silt/clay	Silt/clay	Silt/clay	Silt/clay	Silt/clay	Silt/clay
Overall BEHI	High	High	High	Very High	Very Low	High	High	Very Low	Very Low	Very Low

### 3.3.1 Riparian Buffer Impacts

Riparian buffers are the vegetated area directly adjacent to the streambank. When riparian buffers are impacted (reduced buffer width and/or quality) they provide a more direct pathway for NPS pollution to enter streams. Riparian buffers were assessed during the USA's and are a part of the desktop assessment described here.

Impacted riparian buffers are often associated with higher streambank erosion because a lesser riparian area can allow an increasing amount of unfiltered stormwater to enter the stream. Without sufficient riparian buffer, infiltration into the riparian is not readily occurring and the roots of the riparian buffer, which usually help secure soil, are insufficient to secure the banks to mitigate erosion. To account for more than just reach scale (USA based) riparian buffer condition and since USAs were not conducted on all watersheds, each main stem perennial or intermittent stream (identified per aerial imagery from Google Earth) in each associated sub-watershed was examined using aerial photography to determine how many linear feet of stream was affected by impacted riparian buffer (< 50 ft of riparian width). These lengths were then divided by the total length (total length x2 to account for left and right bank riparian) of the stream in that sub-watershed to represent percent of stream with impacted riparian buffers, to help identify and assess where significant problems might exist (Table 3.3.1.1).

Table 3.3.1.1. Summary of riparian evaluation from desktop analysis (% of impacted riparian buffer).

<b>Sub-watershed</b>	<b>% of Impacted Riparian Buffer (&lt;50 ft)</b>
Ballfields	45
Banaszak	43
Burnspark	18
Dogpark	45
Golfcourse	61
Golfdog	48
Henry (Winifry Creek)	9.3
Newton Creek	13
Pumpstation	38
Sharkey	65
Vestal	7.0
WOB-1	16
WOB-2	2.1
WOB-3	2.9

According to Table 3.3.1.1, sub-watersheds Sharkey and Golfcourse have the largest percentages of impacted riparian buffer at 65% and 61%, respectively. Impacted riparian buffer is a key attribute included in the ranking matrix that will be described and provided in Section 5.3.

### **3.3.2 Unpaved Roads**

Unpaved roads are common in rural Arkansas. Over 85% of Arkansas county roads are gravel. However, in more developed/populated watersheds this may not be the case. There are only approximately 20 miles of unpaved roads in the WOB watershed. During storm events these roads can transport 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. Gravel roads can be designed to include best management practices (BMPs) that reduce erosion of the bed material and the transport of that material into streams.

An unpaved road assessment was completed using GIS road layers for each sub-watershed in the WOB. A summary of this data is provided in Table 3.3.2.1. Sediment loading for each mile of unpaved road was estimated based on a study completed in Pennsylvania by

the Center for Dirt and Gravel Road Studies (Bloser and Scheetz, 2012). 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. Unpaved roads in the Pennsylvania study are not unlike unpaved roads in Arkansas.

For purposes of the WOB assessment an average rate of sediment transport was set at 485 lb./mile of unpaved road per rain event. The 485 lb./mi sediment rate was the average 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 and each rain event would result in 485 lb. sediment per mile of road (Table 3.3.2.1) (Bloser and Scheetz, 2012). Potential load of sediment from unpaved roads is a key attribute used in the ranking matrix.

Table 3.3.2.1. Unpaved road lengths in the WOB and estimates of sediment loading from run-off events.

Sub-watershed	Unpaved Roads (miles)	TSS load per rain event (lbs)	Annual Loads (12 rain events) (lbs)
Ballfields	0.79	383	4,598
Banaszak	0.92	446	5,354
Burnspark	2.70	1,310	15,714
Dogpark	0.06	29	349
Golfcourse	0.14	68	815
Golfdog	0.15	73	873
Henry (Winifry Creek)	1.39	674	8,090
Newton Creek	2.20	1,067	12,804
Pumpstation	0	0	0
Sharkey	2.53	1,227	14,725
Vestal	0	0	0
WOB-1	5.25	2,546	30,555
WOB-2	2.14	1,038	12,455
WOB-3	2.03	985	11,815

### 3.3.3 Land Slope

A land slope analysis was also completed for the watershed and is provided in Table 3.3.3.1. Slopes are generally homogenous between sub-watersheds. On average the slope was low, 6.6%, for our sub-watersheds and ranged from 2.8% to 12.3% (Figure 3.3.3.1). 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, besides carrying a large sediment load, can cause increased streambank erosion and channel scour compounding the issue. Slope in the majority of the WOB is less than 7%. High slope areas, which mostly occur in the upper portions of the watershed and near Burnspark, are a key attribute considered in the ranking matrix (NLCD, 2021).

Table 3.3.3.1. Summary of land slope analysis (NLCD, 2021).

<b>Sub-watershed</b>	<b>Mean Slope (percent rise)</b>
Ballfields	3.5
Banaszak	6.1
Burnspark	11.1
Dogpark	4.9
Golfcourse	5.1
Golfdog	3.7
Henry (Winifry Creek)	7.4
Newton Creek	8.3
Pumpstation	12.3
Sharkey	5.8
Vestal	8.1
WOB-1	5.4
WOB-2	2.8
WOB-3	7.6

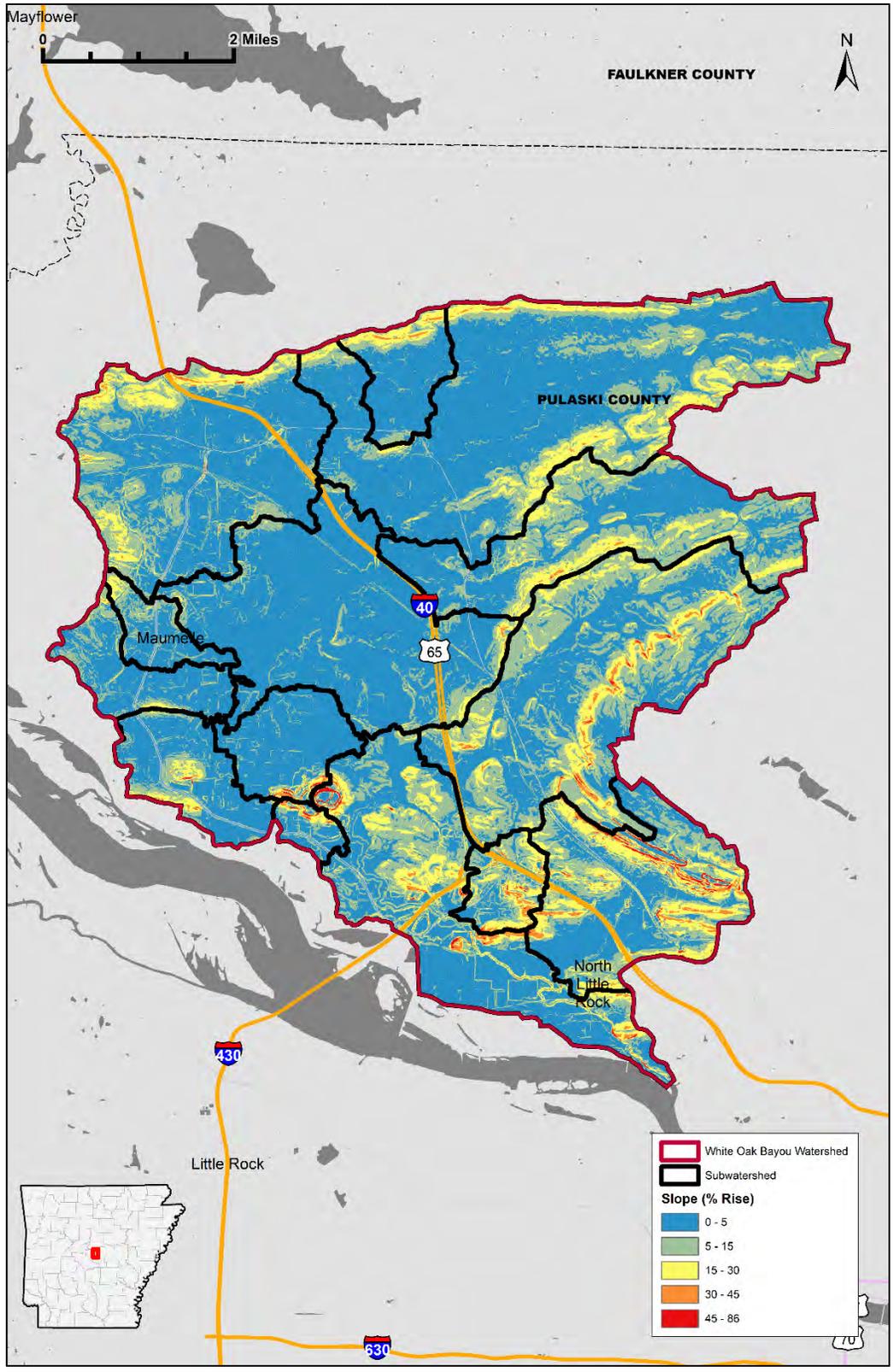


Figure 3.3.3.1 Land surface slope in WOB watershed.

### 3.3.4 Soils

Soils on the land surface in the overall WOB are mostly composed of silt loam (Figure 3.3.3.2) in lower areas and sandy loam or loam in more upland areas, with a moderate overall potential for erosion. Soils in concert with land slope and land use are the three primary factors that drive sediment (and other pollutant) run-off from the land surface in the watershed.

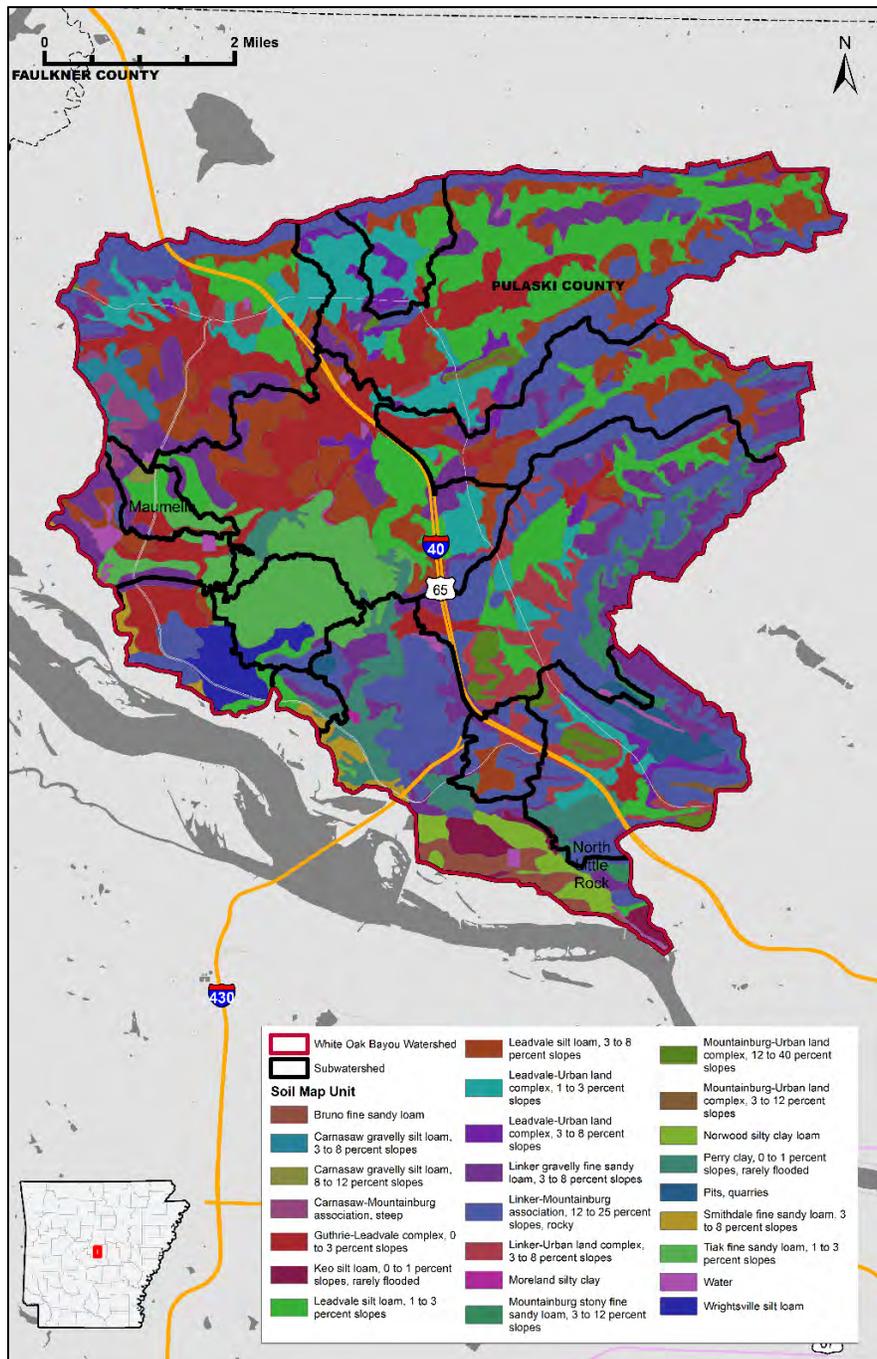


Figure 3.3.3.2 Map of soils in the WOB.

### **3.3.5 Agriculture**

When evaluating non-point sources in Arkansas numbers of agricultural animals are typically estimated in the watershed. This usually includes cattle, dairy, hogs, and poultry counts. However, due to the more urban and sub-urban nature of this watershed, the area encompassing agricultural land uses is very low, less than 7% combined for pasture, hay, and row crops. Cattle number estimates (observed by reviewing the last 6 years of aerial images) for the entire watershed were less than 100, with the majority, approximately 75 occurring in the WOB-1 sub-watershed. The only other cattle noted were in sub-watershed WOB-2 (approximately 20) and Banaszak (approximately 7). Therefore, agriculture was not believed to be a significant contributor to pollutant loading.

## **3.4 Water Quality**

### **3.4.1 Historical Efforts**

The WOB has had ongoing water quality monitoring since approximately 2010 that has included base and storm flow monitoring, bioassessment and various other stream and wetland related assessments. Historical data has been collected by universities (UCA, OBU, ATech) working independently and through Wetland Program Development Grant funding, by contractors and by the Division of Environmental Quality (DEQ). The following sections contain a synopsis of this historical data.

### **DEQ Assessment Work - Water Quality and Fish Species**

The DEQ has conducted monitoring of fish (2011) and water quality (2010-2018) within the mainstem of White Oak Bayou. This was the first effort on record to document these parameters within the bayou and provides valuable baseline information for future comparative purposes as part of an overall management strategy. Changes in water quality and/or fish assemblages in the future could provide important information regarding impacts from various pollutants and sub-watershed sources that could steer or re-direct management recommendations. The data collected by the DEQ is provided in Appendix B. The DEQ monitored water quality at four stations on the main stem of WOB for approximately four years. They sampled each station approximately 22 times for basic water chemistry parameters and approximately 2-8 times for metals and minerals. A summary of key water quality parameters is provided in Figures 3.4.1.1 and 3.4.1.2.

The DEQ collected 35 different species from three sites in the WOB. They concluded in their report (Appendix B) that all were “typical of low gradient streams in multiple ecoregions

of the state.” They noted that multiple age classes were collected indicating that “...habitat, hydrology and forage requirements are being met.”

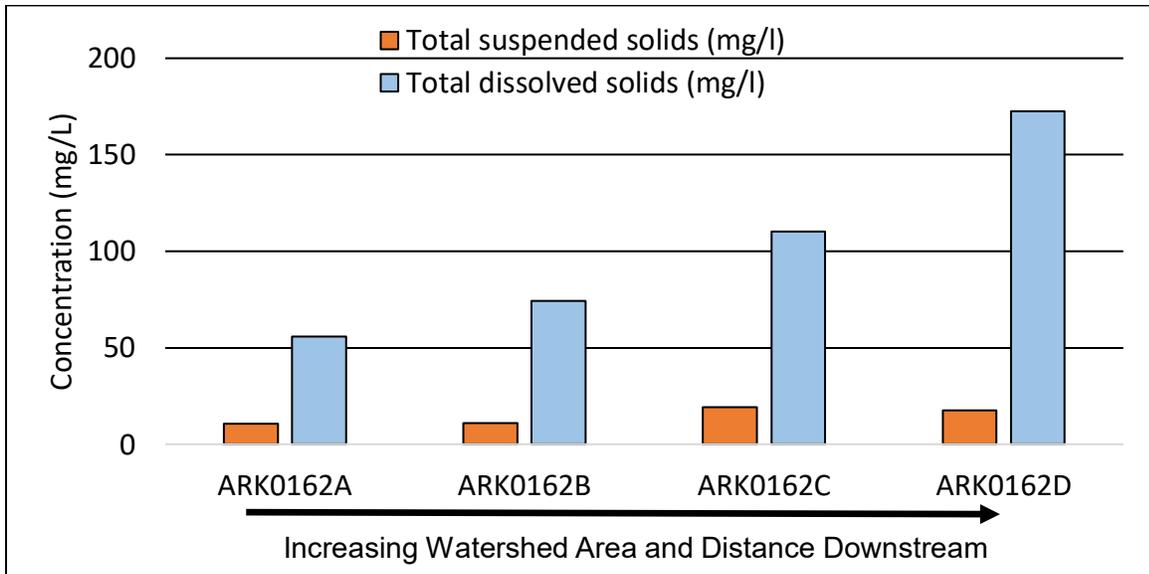


Figure 3.4.1.1. Mean suspended sediment and dissolved solids in White Oak Bayou samples collected by DEQ 2010-2018.

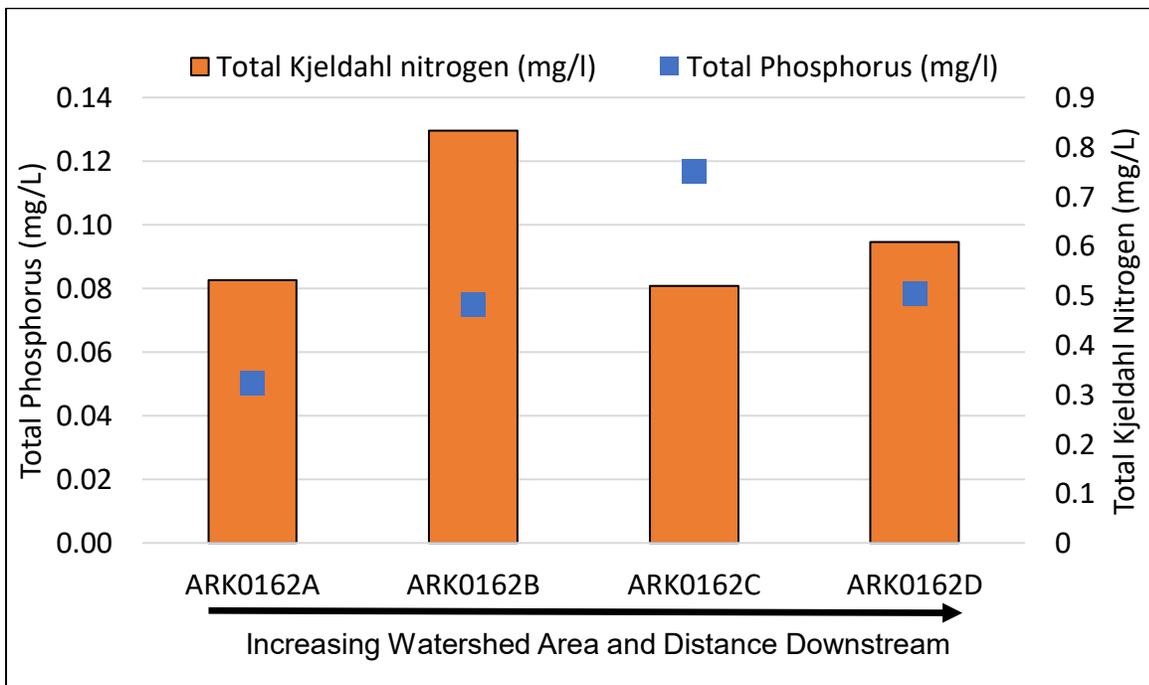


Figure 3.4.1.2. Mean nitrogen and phosphorus levels in White Oak Bayou samples collected by DEQ 2010-2018.

## University Assessment Work – Water Quality and Biology

The University of Central Arkansas has been a strong collaborator on the White Oak Bayou project since 2010 and has conducted numerous ecological studies within the watershed through Senior Environmental Practicum course work and two master's thesis projects. Practicum studies included HGM wetland assessments, GIS analysis of land use impacts, insect density and diversity, effects of urbanization on benthic organisms, stream geomorphology, water quality, basal food resource analysis, impacts of road construction on water quality and avian diversity/abundance, and hydrology relationships to taxa richness of trees and macroinvertebrates. A UCA master's thesis was completed in 2017 using data collected on stormwater and potential effects on the aquatic ecosystem in the WOB watershed. As with the aforementioned ADEQ work, this research provides valuable information for future planning and comparative purposes with respect to watershed management and monitoring.

In 2018/19 students from Ouachita Baptist University (OBU) completed 8-months of additional water quality monitoring at approximately the same stations used by UCA in 2016/17 (Pumpstation and Burnspark were substituted by two stations on WOB, one upstream of the wetlands complex and one downstream). OBU data collection efforts focused on baseflow conditions in each of the key tributaries. Nutrients, dissolved minerals, and suspended sediment were the focus of the analysis.

A synopsis of the data collected during these projects are provided below. The focus of this monitoring has been the assessment of key small catchments (sub-watersheds) with some associated non-point source impact potential. Figure 3.4.1.3 shows the location of monitoring stations used for water quality and the sub-watersheds they represent. Several baseflow and stormflow events were sampled (Figure 3.4.1.4) at key drainages entering the WOB wetland system. Wetland water quality and benthic macroinvertebrate communities near these drainage outlets were also evaluated. The water quality data indicates that the highest constituent/pollutant concentrations are generally from sub-watersheds Golfcourse, Sharkey, Burnspark, and Pumpstation. A summary of the water quality data is provided in Appendix C. A chart depicting storm flow nutrient levels (UCA collected data 2016-2017) is provided below (Figure 3.4.1.5) and a chart depicting total suspended sediment levels (also UCA data) is provided in Figure 3.4.1.6. Nutrient data from storm events indicates that urban land use does not appear to be directly correlated to nutrient levels, though some nutrient levels are somewhat higher than anticipated and appear to be from anthropogenic sources. Though not "urbanized" in all areas, the WOB watershed is populated through most of its rural area south of Camp Robinson, particularly along Highway 365.

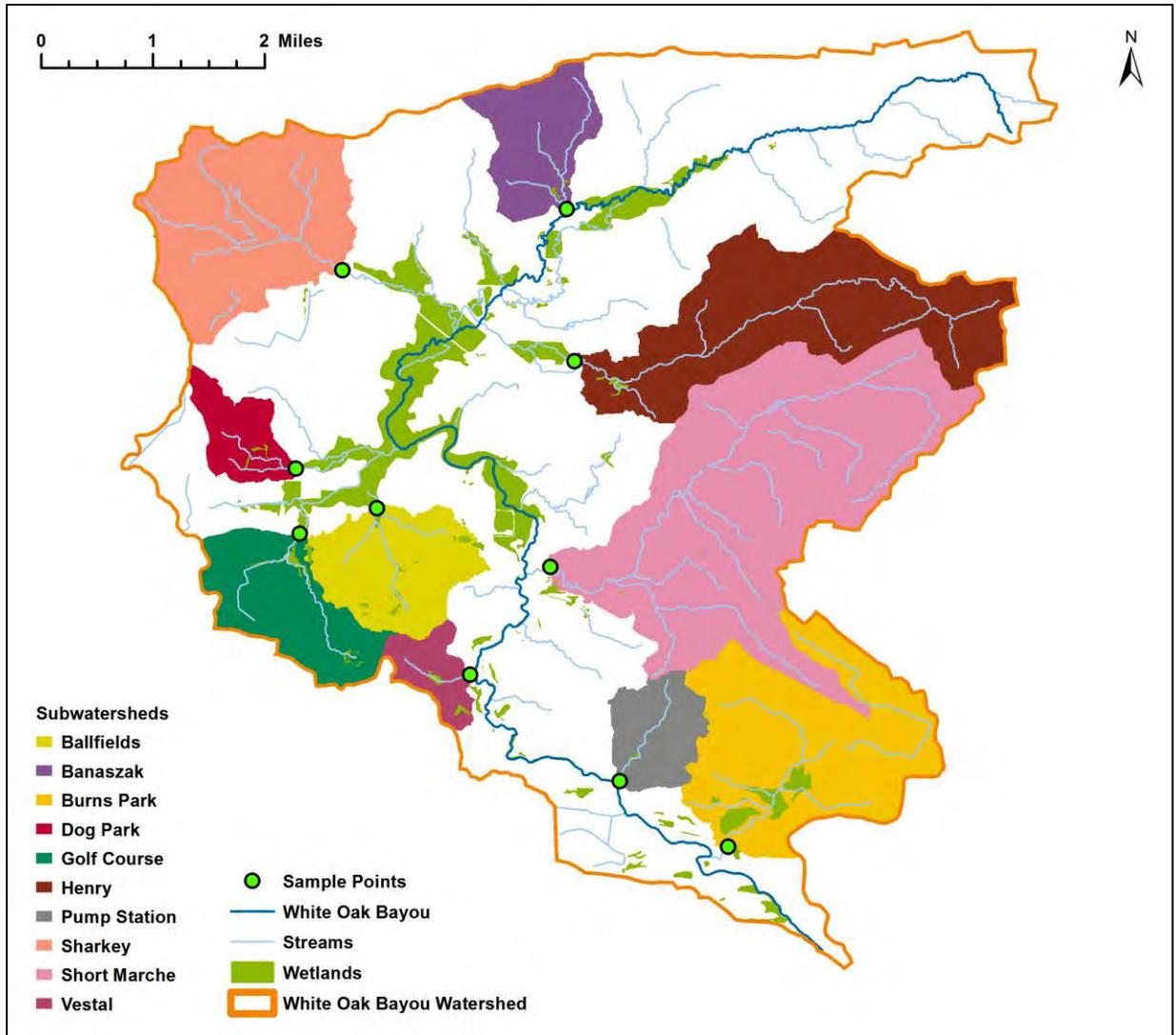


Figure 3.4.1.3 Stream water quality monitoring stations used by UCA And OBU, and the sub-watersheds that they represent.



Figure 3.4.1.4 Measurement of flow by UCA during a sample event.

The data collected by OBU in 2018-2019 does not appear to reveal any new trends or verify possible critical pollutant sources. However, samples collected during that period were highest at the Ballfields for nitrogen, phosphorus, and suspended sediment. Is it unclear if these are connected to local land use run-off or stream channel erosion. This data is provided in Appendix C.

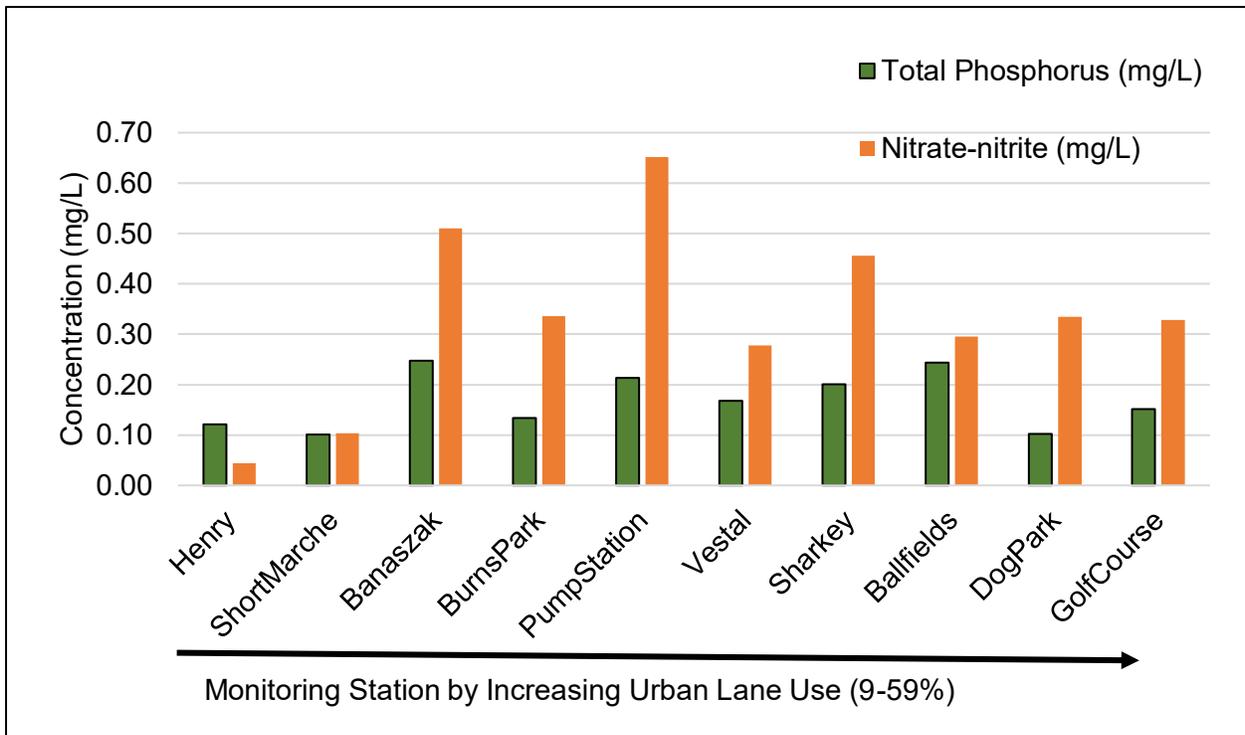


Figure 3.4.1.5 Summary of mean storm flow nutrient levels in WOB (2016-2017) key drainages arranged by percent urban (developed) land use.

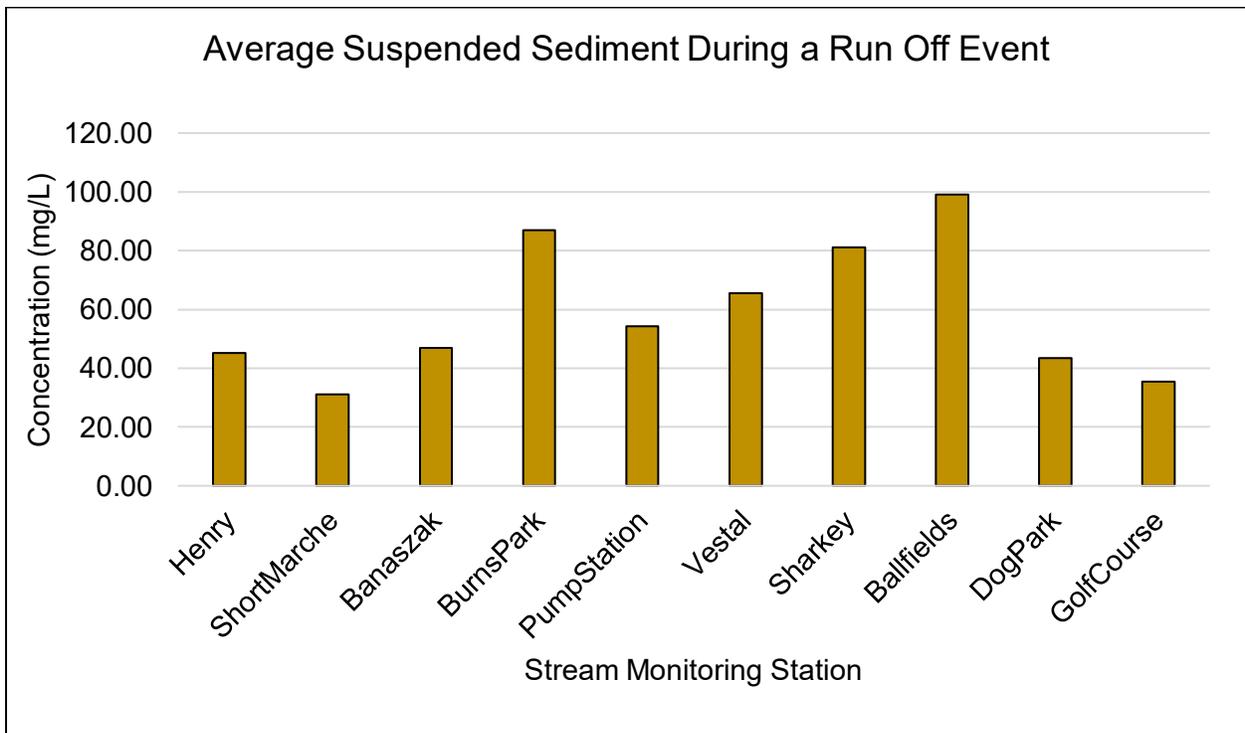


Figure 3.4.1.6 Mean total suspended sediment in-stream during run-off events (2016-2017).

In addition to stream monitoring assessment effort has been focused historically on wetlands. The WOB watershed contains a high percentage of wetlands, and these wetlands serve various important functions including water quality enhancement/pollutant removal and peak flow mitigation. As such their health is of great importance to stream water quality and to the overall watershed. Water quality data in wetlands was collected during the winter and spring 2016/17 when standing water was more likely to be present in wetland areas. This data set is very limited as most of the wetlands (aside from the main flooded wetland complex) do not typically hold water for more than a few weeks each year. A summary of nutrient levels from the data collected in wetlands is provided in Figure 3.4.1.7.

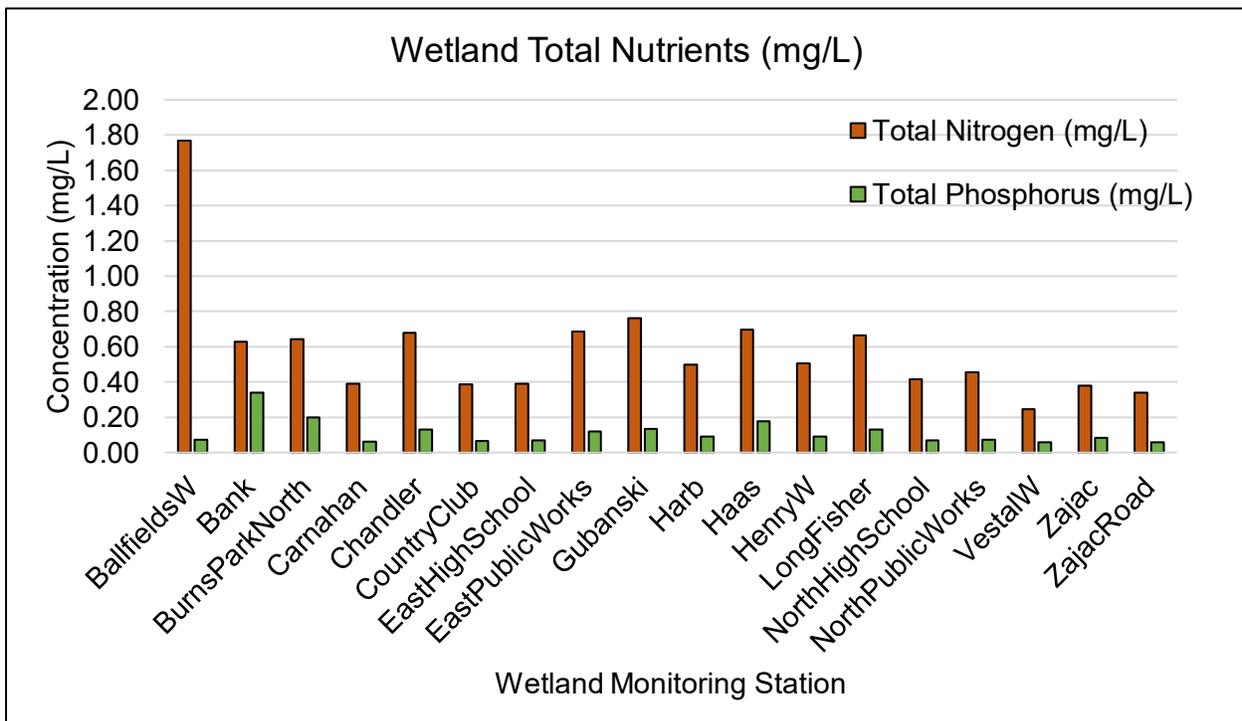


Figure 3.4.1.7 Water nutrient levels in inundated wetlands.

### 3.4.2 Watershed Hydrology

In 2016 water level loggers (gauges) were installed at several locations in major drainages (and in key wetlands) to begin an effort to quantify stage, flow, and pollutant loads, from key WOB sub-watersheds. More permanent gauges were installed in late 2017 on the main stem of the bayou to track flood flows and pollutant loading. These gauges were installed upstream of the main wetland complex near the I-40 Bridge and downstream of the main wetland complex on the new White Oak Crossing bridge (old Counts Massie Road). These gauges include telemetry, so the stage can be accessed from the web allowing use for a wide array of real-time resource management purposes. One of the many uses of these new gauges includes tracking of residence time in the wetland complex and monitoring the peak

hydrograph exiting the wetland complex. Residence time in the wetlands appears to be approximately 18 hours, on average, for peak storm flow and 2-4 days for the majority of the storm curve (hydrograph) to subside to near-normal levels (Figure 3.4.2.1). As expected, the wetlands serve to mitigate storm peak flows and with their long residence time provide an opportunity for pollutant assimilation.

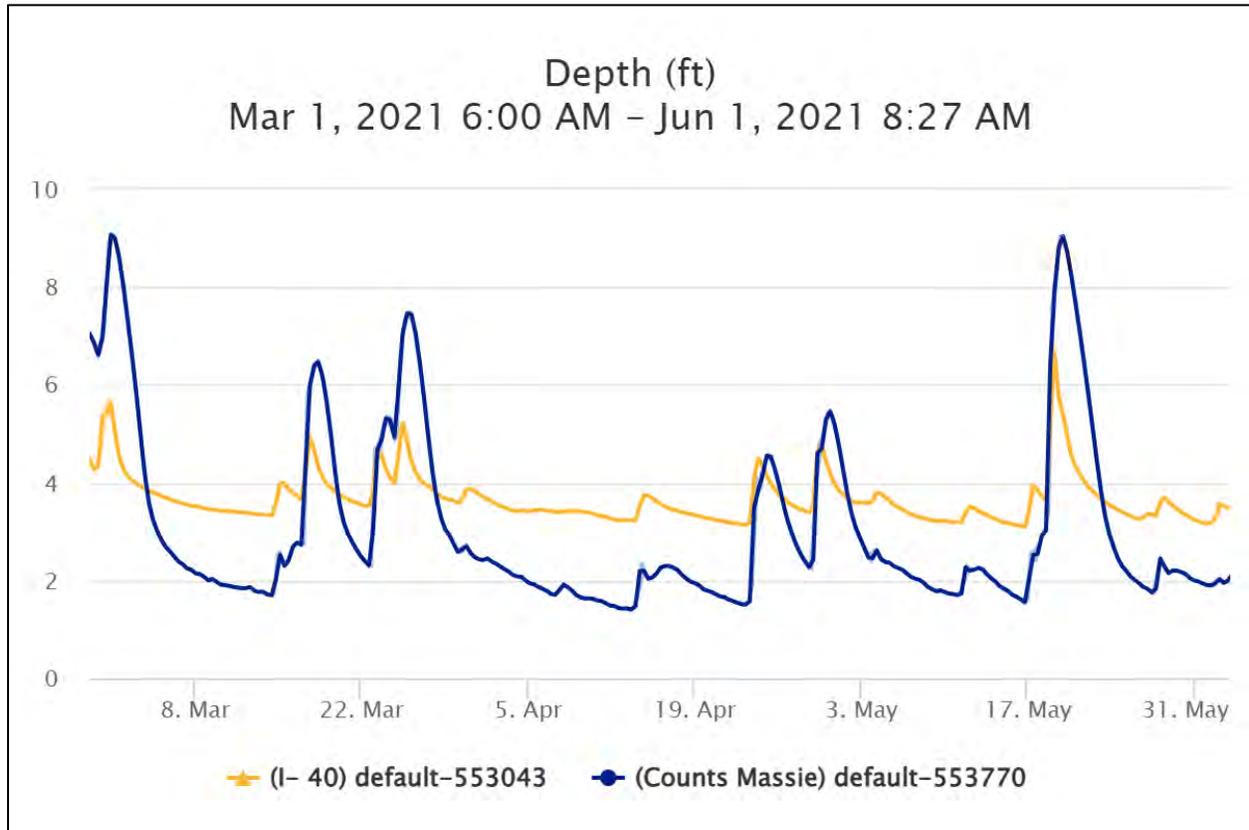


Figure 3.4.2.1 Comparison of stage hydrograph on WOB above and below large wetland complex.

### 3.4.3 Water Quality Data Collected Specifically for the WMP

Water quality data was collected by UCA in cooperation with GBMc & Associates (Now Alliance Technical Group) (under 319 Grant 20-1100) to assess water quality and watershed loading that could later be used to help calibrate a SWAT model and in development of a WMP. Water samples and *in-situ* data were collected from 10 sample locations, representing 10 sub-watersheds (Figure 3.4.3.1), in the WOB to determine the water quality during base flow and storm flow conditions. These 10 sampling stations were believed to represent a reasonable transect of the watershed and include key sub-watersheds. The stations were sampled monthly for one year (March 2021-February 2022), at primarily baseflow, but also included two storm flow events where flows were somewhat elevated. The storm sampling days during the study period were April 17, 2021, and May 20, 2021.

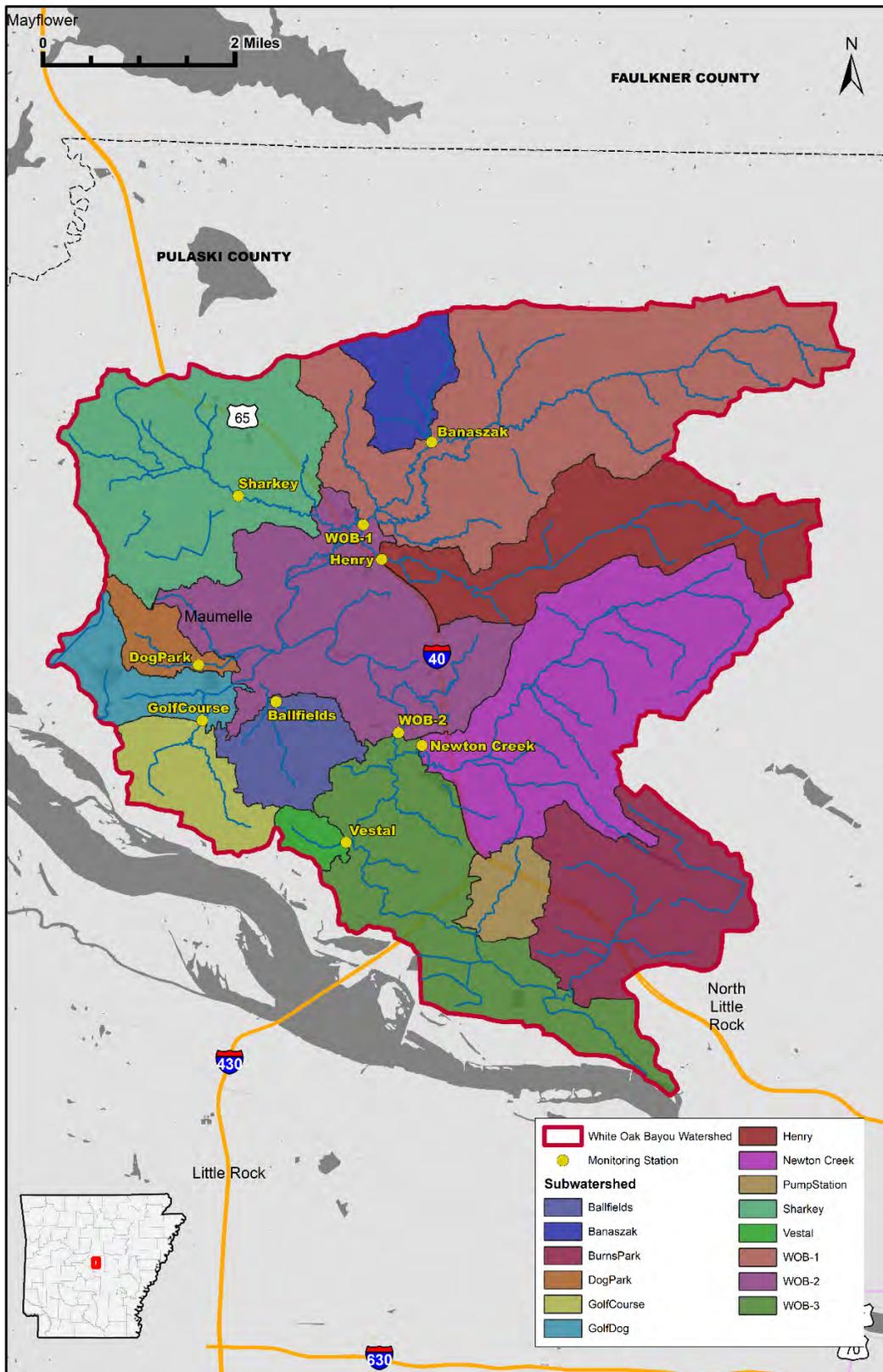


Figure 3.4.3.1 UCA Sample Stations and Represented Sub-Watersheds Monitored During the 2021/22 Study.

All water quality samples collected for this WMP were handled according to a Quality Assurance Project Plan (QAPP) approved by the NRD and EPA Region 6 (QTRAK No. 21-180). In brief, grab samples were collected in clean, labeled containers from within the main area of flow in the channel and delivered to the University of Arkansas Water Resource Laboratory for analysis following all chain of custody procedures (see QAPP for project, GBMc, 2020). Water quality during baseflow conditions were found to be good and fairly consistent. Table 3.4.3.1 provides a summary of water quality data for the WOB stations.

Water quality during storm flow conditions is summarized in Table 3.4.3.2. The concentration of some pollutants increased as flow increased, while other pollutants decreased or remained stable. TSS and total phosphorus (Figures 3.4.3.1 and 3.4.3.2) increased most consistently during storm flow events. Data from additional high flow events would be beneficial to improve (strengthen) both the correlations completed by UCA and the graphical analysis depicted here.

UCA scientists completed correlation analysis (Table 3.4.3.3) to evaluate if any of the monitoring parameters were correlated to land use at varying spatial resolutions, proximally (within the stream buffer), distally (within the overall sub-watershed) and intermediate (in between the other two). Statistically significant correlations were determined between percent agriculture and several parameters, including TP, TSS, BOD5 and turbidity. These correlations usually decreased in significance as the scale broadened. Significant correlations were also determined between percent developed (urbanized) land use and lead, BOD5 and specific conductance.

Table 3.4.3.1 Summary of Water Quality Data Collected by UCA in the WOB Watershed.

Station	Copper (mg/L)				Lead (mg/L)				Nitrate-nitrite (mg/L)				SRP (mg/L)				TN (mg/L)				TP (mg/L)				TSS (mg/L)			
	Min	Max	Average	N	Min	Max	Average	N	Min	Max	Average	N	Min	Max	Average	N	Min	Max	Average	N	Min	Max	Average	N	Min	Max	Average	N
Ballfields	0.0000	0.0020	0.0008	12	0.0000	0.0060	0.0018	12	0.01	0.20	0.10	12	0.001	0.026	0.008	12	0.36	1.21	0.66	12	0.026	0.169	0.087	12	8.6	169.1	39.3	12
Banaszak	0.0000	0.0040	0.0014	11	0.0000	0.0060	0.0010	11	0.05	0.71	0.22	11	0.003	0.062	0.021	11	0.36	1.21	0.65	11	0.026	0.169	0.091	11	8.6	169.1	39.4	11
Dogpark	0.0000	0.0040	0.0008	12	0.0000	0.0030	0.0009	12	0.00	0.49	0.13	12	0.000	0.034	0.010	12	0.29	1.73	0.89	12	0.032	0.217	0.104	12	2.3	27.5	12.8	12
Golfcourse	0.0000	0.0020	0.0006	12	0.0000	0.0080	0.0022	12	0.02	0.22	0.09	12	0.007	0.036	0.019	12	0.41	1.06	0.68	12	0.045	0.160	0.075	12	3.0	52.6	10.2	12
Henry	0.0000	0.0120	0.0015	12	0.0000	0.0190	0.0028	12	0.00	0.17	0.06	12	0.004	0.070	0.019	12	0.15	1.07	0.62	12	0.022	0.128	0.070	12	6.1	58.0	14.9	12
NC-1	0.0000	0.0010	0.0002	12	0.0000	0.0060	0.0016	14	0.00	0.21	0.08	12	0.003	0.049	0.014	14	0.13	1.03	0.52	14	0.004	0.153	0.064	14	1.3	19.4	8.2	14
Sharkey	0.0000	0.0040	0.0013	11	0.0000	0.0050	0.0014	14	0.04	0.53	0.22	12	0.000	0.034	0.016	14	0.25	1.74	0.77	14	0.015	0.138	0.076	14	2.9	34.8	11.2	14
Vestal	0.0000	0.0040	0.0010	12	0.0000	0.0030	0.0003	14	0.01	1.10	0.25	12	0.006	0.051	0.017	14	0.38	2.04	0.82	14	0.018	0.129	0.058	14	2.1	20.9	6.7	14
WOB-1	0.0000	0.0030	0.0008	12	0.0000	0.0060	0.0016	14	0.01	1.10	0.09	12	0.002	0.035	0.015	14	0.24	1.47	0.76	14	0.027	0.155	0.081	14	3.9	32.4	15.0	14
WOB-2	0.0000	0.0020	0.0005	10	0.0000	0.0070	0.0007	12	0.00	0.19	0.05	10	0.001	0.044	0.016	12	0.00	0.95	0.51	12	0.005	0.100	0.060	12	1.8	50.8	16.4	12

Table 3.4.3.2 Summary of Mean Data from the Two Storm Flow Sampling Events.

Station	BOD5 (mg/L)	Copper (mg/L)	Lead (mg/L)	Nitrate+Nitrite-N (mg/L)	SRP (mg/L as P)	Total Nitrogen (mg/L as N)	Total Phosphorus (mg/L as P)	Total Suspended Solids (mg/L)
Golfcourse	2.55	0.0000	0.003	0.11	0.020	0.88	0.097	14.15
Vestal	2.6	0.0000	0.000	0.14	0.014	0.83	0.076	11.15
Dogpark	2.1	0.0000	0.002	0.10	0.008	0.67	0.063	10.90
Sharkey	1.79	0.0000	0.003	0.10	0.009	0.67	0.075	11.20
Banaszak	1.61	0.0000	0.000	0.10	0.014	0.64	0.087	11.90
WOB-1	2.66	0.0005	0.003	0.02	0.009	0.66	0.075	12.95
WC-1 (Henry)	1.59	0.0000	0.001	0.02	0.009	0.50	0.080	36.75
NC-1	2.36	0.0000	0.001	0.03	0.009	0.44	0.050	6.20
WOB -2	2.32	0.0000	0.000	0.01	0.011	0.51	0.067	9.60
Ballfields	2.54	0.0005	0.002	0.09	0.011	0.75	0.130	47.15

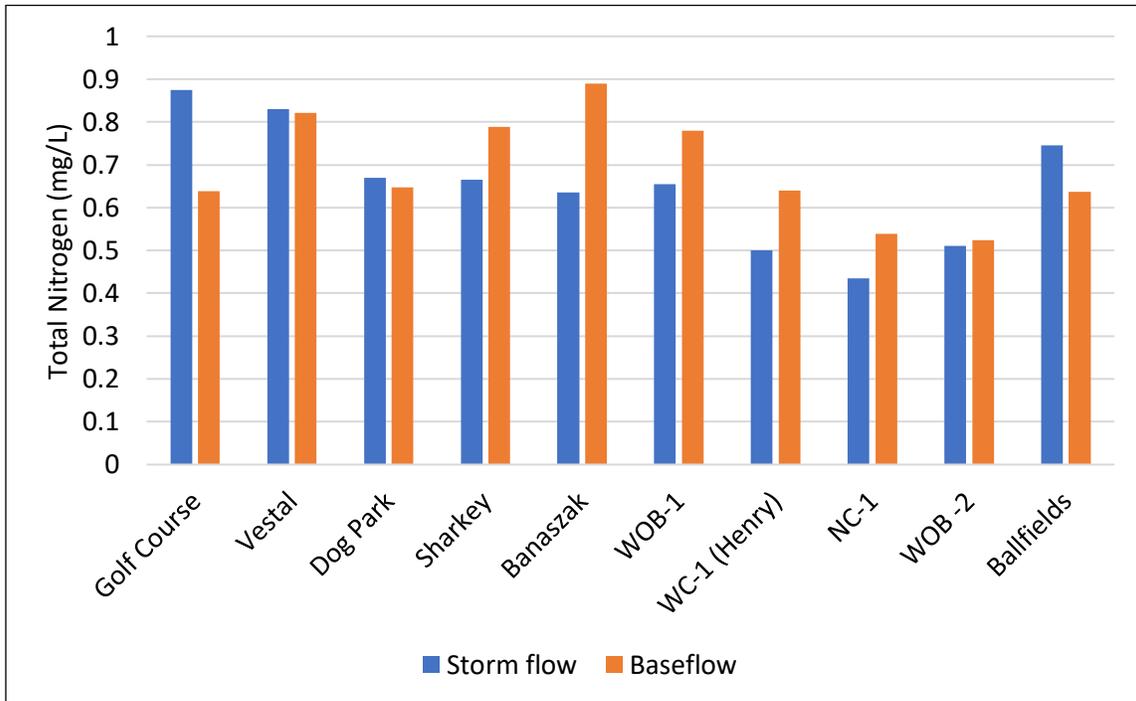


Figure 3.4.3.2 Average total nitrogen base and storm flow concentrations from each sub-watershed.

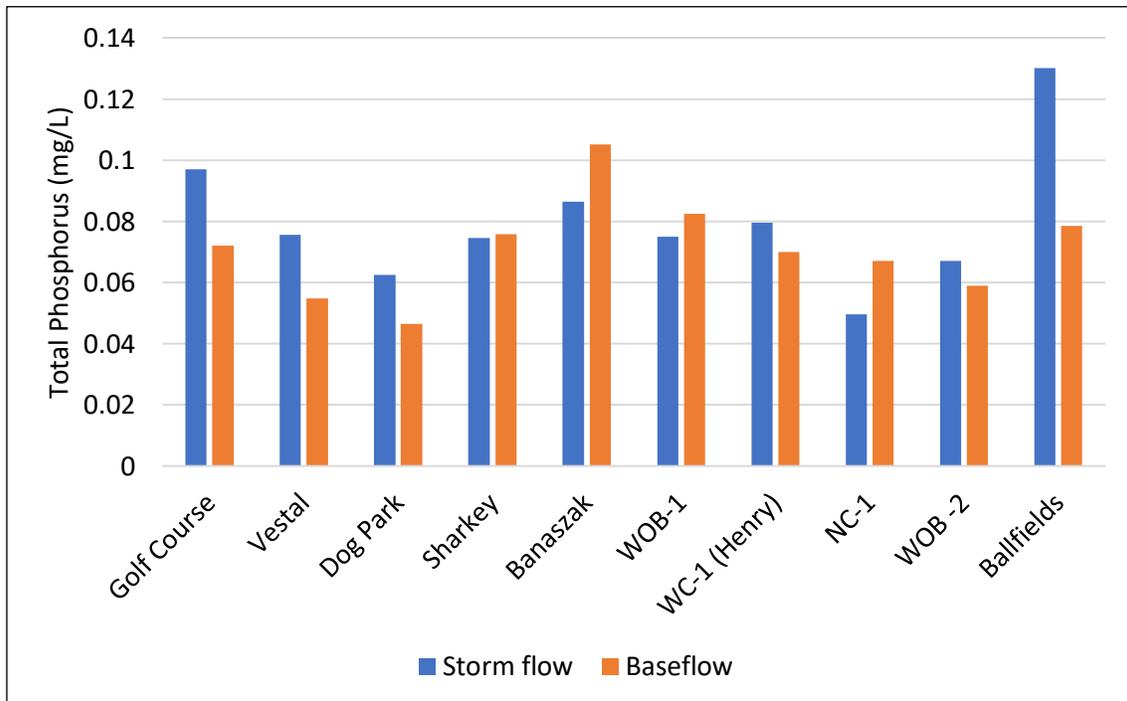


Figure 3.4.3.3 Average total phosphorus base and storm flow concentrations from each sub-watershed.

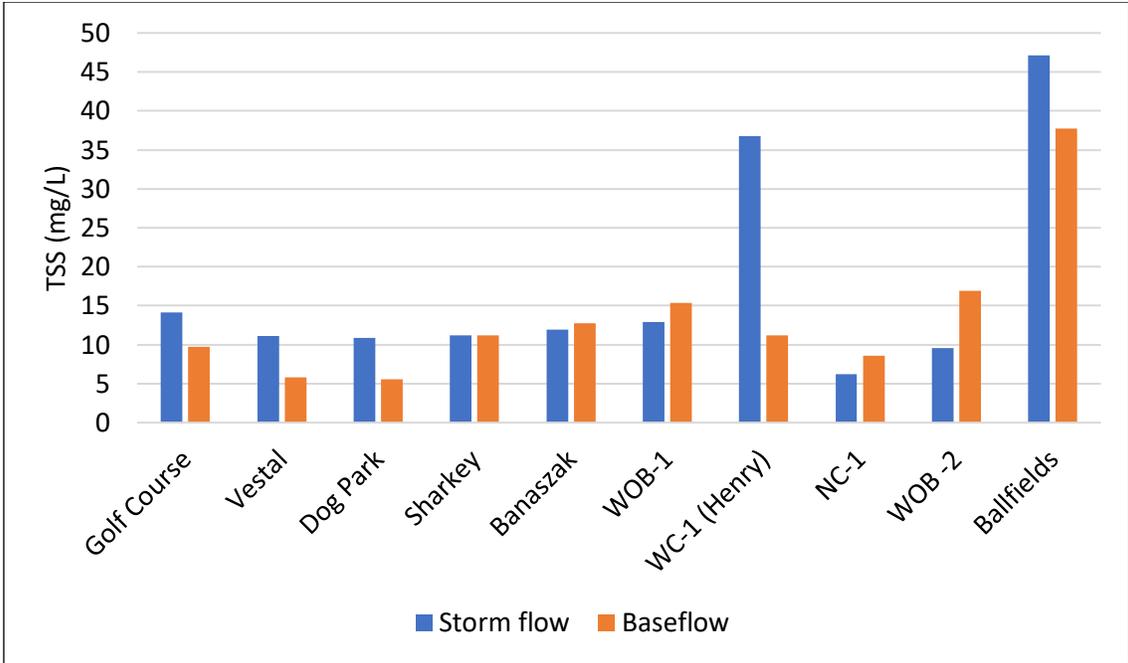


Figure 3.4.3.4 Average TSS base and storm flow concentrations from each sub-watershed.

Table 3.4.3.3 Correlation analysis completed by UCA (UCA, 2022) for relationships between water quality variables and land use at each of three spatial scales (proximal, intermediate, and distal) across all sample sites in White Oak Bayou. Asterisks denote statistically significant correlations (\*P<0.05; \*\*P<0.01).

Water quality variable	Upstream buffer (proximal)			Adjusted full catchment (intermediate)			Full catchment (distal)		
	% agriculture	% development	% forest	% agriculture	% development	% forest	% agriculture	% development	% forest
Copper (mg/L)	0.356	0.262	-0.262	0.352	0	-0.135	-0.112	-0.067	-0.067
Lead (mg/L)	0.223	-0.427	0.239	0	-0.375	0.323	0.019	-0.679*	0.575
Nitrate-nitrite (mg/L)	-0.08	0.491	-0.43	0.006	0.37	-0.491	-0.139	0.539	-0.552
SRP (mg/L)	0.006	0.25	0.012	0.274	0.085	0.073	0.244	0.171	-0.25
TN (mg/L)	0.276	0.43	-0.406	0.37	0.224	-0.43	0.115	0.297	-0.43
TP (mg/L)	0.656*	-0.115	-0.127	0.539	-0.127	-0.091	0.37	-0.418	0.2
TSS (mg/L)	0.706*	-0.479	0.139	0.612	-0.43	0.236	0.418	-0.612	0.491
BOD5 (mg/L)	0.669*	-0.467	0.552	0.733*	-0.564	0.576	0.770**	-0.636*	0.612
Temperature (C)	0.068	-0.049	-0.219	-0.109	0.103	-0.182	-0.219	-0.103	0.061
DO (%)	-0.104	-0.394	0.394	0.042	-0.248	0.358	0.321	0.018	0.176
DO (mg/L)	-0.031	-0.442	0.539	0.127	-0.345	0.491	0.43	-0.079	0.297
Turbidity (NTUs)	0.767**	-0.442	0.115	0.071	-0.406	0.152	0.515	-0.552	0.43
pH	-0.025	0.505	-0.444	0.036	0.426	-0.529	-0.146	0.602	-0.529
Specific conductivity (uS/cm)	-0.301	0.758*	-0.818**	-0.212	0.745*	-0.770**	-0.588	0.855**	0.867**

### 3.5 Designated Uses

The EPA approved Arkansas 2018 303(d) list includes the entire main stem of WOB. Therefore, the listing is pertinent to all sub-basins from a loading perspective. The listed reach is in Category 5, as those parameters are not meeting water quality criteria for one or more designated uses and have been prioritized as low priority. The designated use that is not supported is aquatic life. The non-attainment designation occurred as a result of low dissolved oxygen with cause/source unknown.

The draft Arkansas 2020 and 2022 303 (d) lists are currently still under review but in 2020 pH was added to the list of parameters not in attainment in WOB. The assessment criteria for the Arkansas River Valley are provided below.

Table 3.5.1 Water quality standards assessment criteria.

Parameter	Standard		Support	Non-Support
ARV Temperature <sup>1</sup>	31°C		≤10 %	>10 %
ARV Dissolved Oxygen <sup>1</sup> (mg/L)	Primary	Critical		
<10 mi <sup>2</sup>	5	2		
10-150 mi <sup>2</sup>	5	3		
pH	6.0-9.0 S.U.			
Cl/SO <sub>4</sub> /TDS	250/250/500			
Ammonia				
Acute (Salmonids absent, pH=6.5)	48.8 mg/L			
Chronic (using 14°C and pH=6.5)	6.67 mg/L			
Turbidity				
Base flows	21 NTU		≤20 %	
All flows	40 NTU		≤25 %	

<sup>1</sup>Except for site specific standards/criteria approved in water quality standards.

### 3.6 SWAT Modeling

The Soil and Water Assessment Tool (SWAT) is a widely used land use-based watershed model that can evaluate point source and non-point source loading of pollutants, transport, and their effect on water quality parameters. SWAT was used in this report to calculate sub-watershed loading and to evaluate BMP removal rates from various practices and land uses in the WOB. The model addresses load reductions from BMPs on a land use by land use basis. Each BMP can be set-up in the model as a BMP type, type of land use the BMP is effective for, and the percentage of that land use area (acres) that it is applied to.

To assess and manage NPS pollution, the NRD recommends evaluating pollutant loading and implementing mitigation efforts on the sub-watershed scale. Watershed models, particularly SWAT, are often used for assessing, planning, and prioritizing NPS mitigation efforts and watershed management activities (Ghafari et al., 2017). The SWAT model can be used to predict the impacts of differing land uses and land management practices under various climatic conditions on water, sediment, and nutrient yields on the watershed scale over long periods of time.

A QSWAT (QGIS interface for SWAT) model was developed for the WOB by the Alliance Technical Group to prioritize sub-watersheds and simulate BMP effectiveness. The SWAT model was developed using a variety of datasets including topography, land use/land cover, soil,

weather, point sources, and existing management practices. The elevation dataset was used to delineate the WOB into 46 sub-watersheds, which are further delineated into smaller hydrologic response units (HRUs) based on unique combinations of soil, land cover, and slope within each sub-watershed.

Weather data was obtained from the National Oceanic and Atmospheric Administration (NOAA) for years 2011 through 2022. Fourteen different weather stations were used for temperature and/or precipitation including Marche, North Little Rock Airport, Little Rock AFB, North Little Rock, Little Rock, Crystal Valley, Lake Maumelle, Sherwood, etc. Other climatic inputs including solar radiation, relative humidity, and wind velocity were simulated by QSWAT's weather generator.

Point sources identified and operating in the WOB between 2015 and 2022 included only two minor dischargers, a church, and a quarry (see Section 5.1). Loading data were aggregated on an annual scale and integrated into the model along with annual average flow. Pasture management practices for grazing were adapted from an earlier Illinois River SWAT model (Pai, et. Al., 2011) for the WOB using cattle counts from aerial photos and sub-watershed pasture land use area. Hay operations were also implemented on pasture land uses and assumed to be mostly bermudagrass as is typical in central and south Arkansas.

The model was run from 2015 to 2022, with the first 3 years as warm-up, and then was manually calibrated. Flow data between 2018 and 2022 from the WOB-1 gage near the I-40 bridge was used for calibration. The model calibration produces R2 values in excess of 0.5 (0.53) which is considered an acceptable relationship for modeling. The peaks match up well but the baseflow was found to be over-predicted by the model for some time periods. Calibration to sediment was more problematic as there was insufficient sample data collected at higher flows to get good correlations.

Once the model was flow calibrated, it was used to predict annual loading of key constituents for the smaller sub-watersheds. These sub-watershed loads were compared to that determined from the sample data to assess if the model predictions were reasonable, and they were found to be so. The SWAT model spatial loading data was used to determine priority areas (i.e., those with the greatest loading of key constituents in the overall watershed). Unlike the sampled water quality data and the on-the-ground assessment work (USA's, etc.), the SWAT model estimated loads for all sub-watersheds within the larger WOB HUC-12 watershed.

The highest priority sub-watersheds based on sediment loads washed off of each land use area (lbs./mi<sup>2</sup>) were Golfcourse, Vestal, Sharkey, Golfdog and Dogpark (Figure 3.6.1). Loading was also calculated at each sub-watershed outlet, which is a combination of wash off of land uses plus channel scour & re-suspension. SWAT outlet outputs were then compiled to achieve approximate loading for each of the 14 Sub-watersheds (Figure 3.6.2).

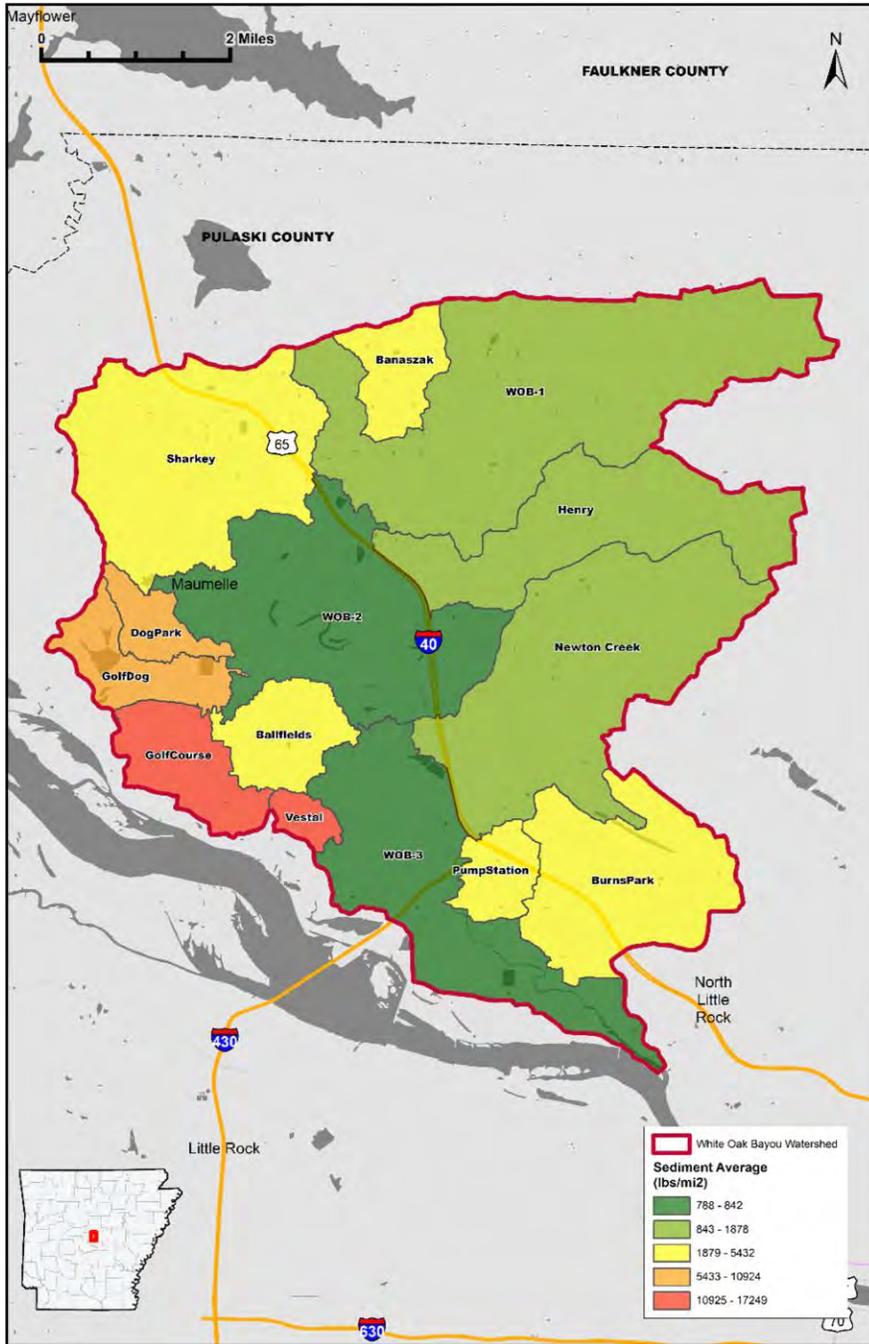


Figure 3.6.1. SWAT sediment output from land surface (lbs./mi<sup>2</sup>) run-off.



Figure 3.6.2. SWAT sediment loading calculations for each sub-watershed outlet.

## 4.0 LOADING ANALYSIS

### 4.1 Pollutant Loading from Key Recent Monitoring Studies

Water quality data used in this section was collected by the University of Central Arkansas (EPA 319 Grant # 17-300) during 2020-2021. Loading of pollutants in the WOB was

calculated from the base and storm flow data collected and the flow estimations from the WOB-1 rating curve adjusted for the smaller sub-watershed drainages. To account for differences in watershed size that makes larger watersheds appear to have larger loads, loads from each of the sub-watersheds were normalized according to watershed area to arrive at a loading in each watershed on a per mi<sup>2</sup> basis (Table 4.1.1). For most constituents, loads appear to be greatest, on a per mi<sup>2</sup> basis, in Dogpark, Ballfields, Golfcourse and Sharkey. Looking at loading in this way focusses on land areas that produce higher concentrations of constituents/pollutants rather than accepting the premise that the larger the watershed the greater the load.

Table 4.1.1. Loading of key constituents normalized on a per mi<sup>2</sup> Basis.

Sub-watershed	BOD (mg/L)	Cu (mg/L)	Pb (mg/L)	Nitrate-Nitrite (mg/L)	SRP (mg/L)	Total N (mg/L)	Total P (mg/L)	TSS (mg/L)
WOB 2	7.4	0.000	0.001	0.078	0.041	1.40	0.163	24.7
WOB 1	7.6	0.002	0.010	0.122	0.034	1.55	0.170	31.7
Vestal	8.4	0.001	0.000	0.295	0.040	1.68	0.166	27.7
Dogpark	10.2	0.000	0.005	0.594	0.049	2.73	0.265	41.2
Sharkey	5.3	0.001	0.008	0.388	0.041	1.78	0.195	30.8
NC-1	7.6	0.000	0.002	0.138	0.026	1.21	0.139	18.4
Henry	4.8	0.001	0.004	0.114	0.033	1.25	0.149	36.5
Golfcourse	7.4	0.001	0.008	0.302	0.062	2.11	0.233	39.7
Banaszak	5.5	0.001	0.001	0.300	0.044	1.61	0.193	29.6
Ballfields	6.5	0.002	0.004	0.189	0.015	1.79	0.264	108.3

Figures 4.1.1-4.1.7 depict the portion of pollutant loading attributed to each sub-watershed for average lead (Pb), total nitrogen, total phosphorus and TSS. Ballfields, Dogpark and Golfcourse were identified with the highest loading of TSS. Ballfields was over two times the load as the other two. This was initially believed due to ongoing construction in the sub-watershed during the time of the study. However, the historical data also shows high concentrations of TSS in the Ballparks sub-watershed. Of note here is that all four of these sub-watersheds reflect the more urbanized and urbanizing portions of the watershed. Load reductions will be accomplished accordingly for these key sub-watersheds as well as other sub-watersheds according to the plan outlined in Sections 5 and 6. TSS, phosphorus and lead loading in sub-watersheds is used in the ranking matrix.

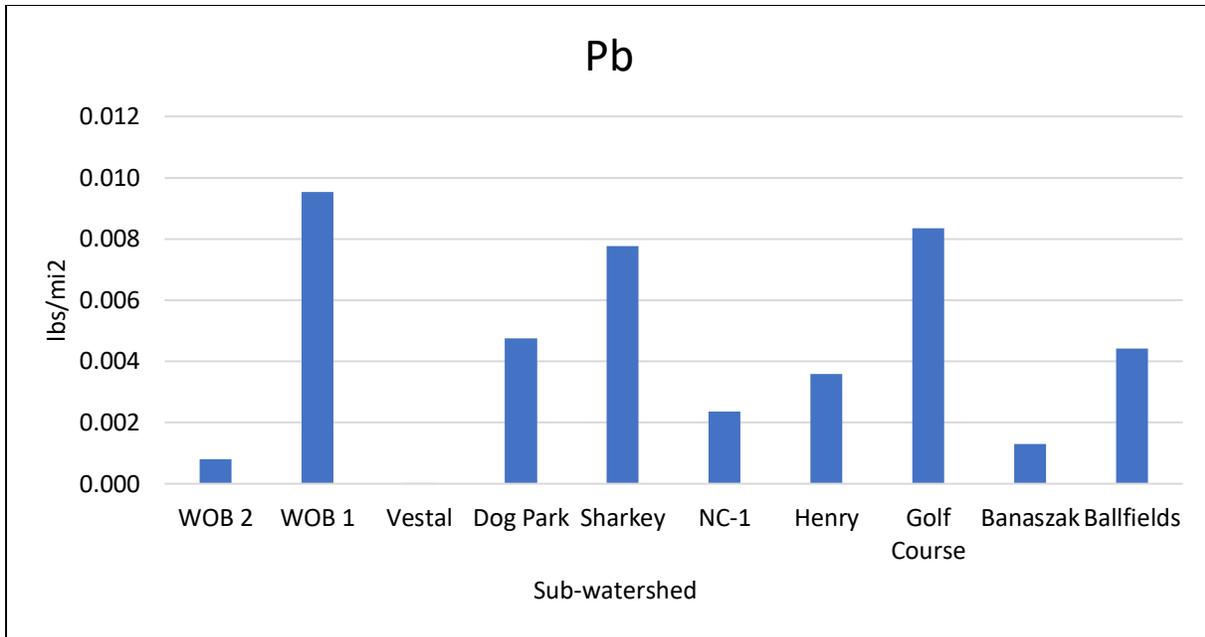


Figure 4.1.1. Average loads of Pb (lb./mi<sup>2</sup>)

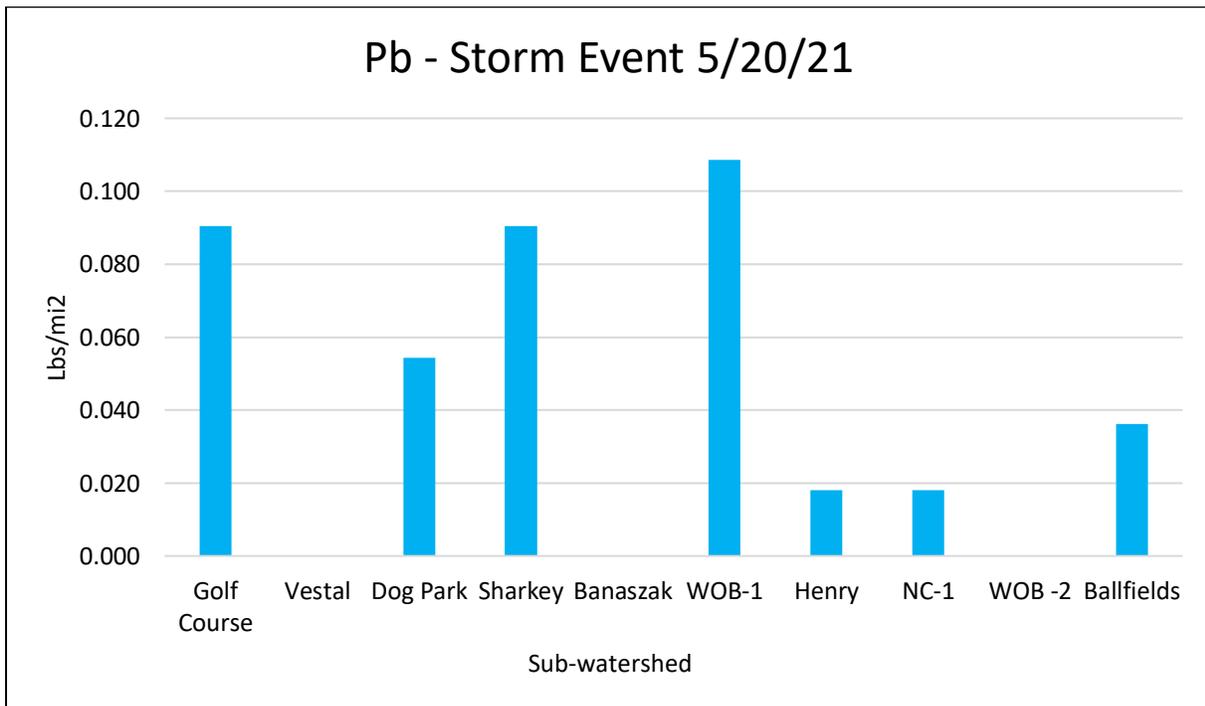


Figure 4.1.2. Average storm event loads of Pb (lb./mi<sup>2</sup>)

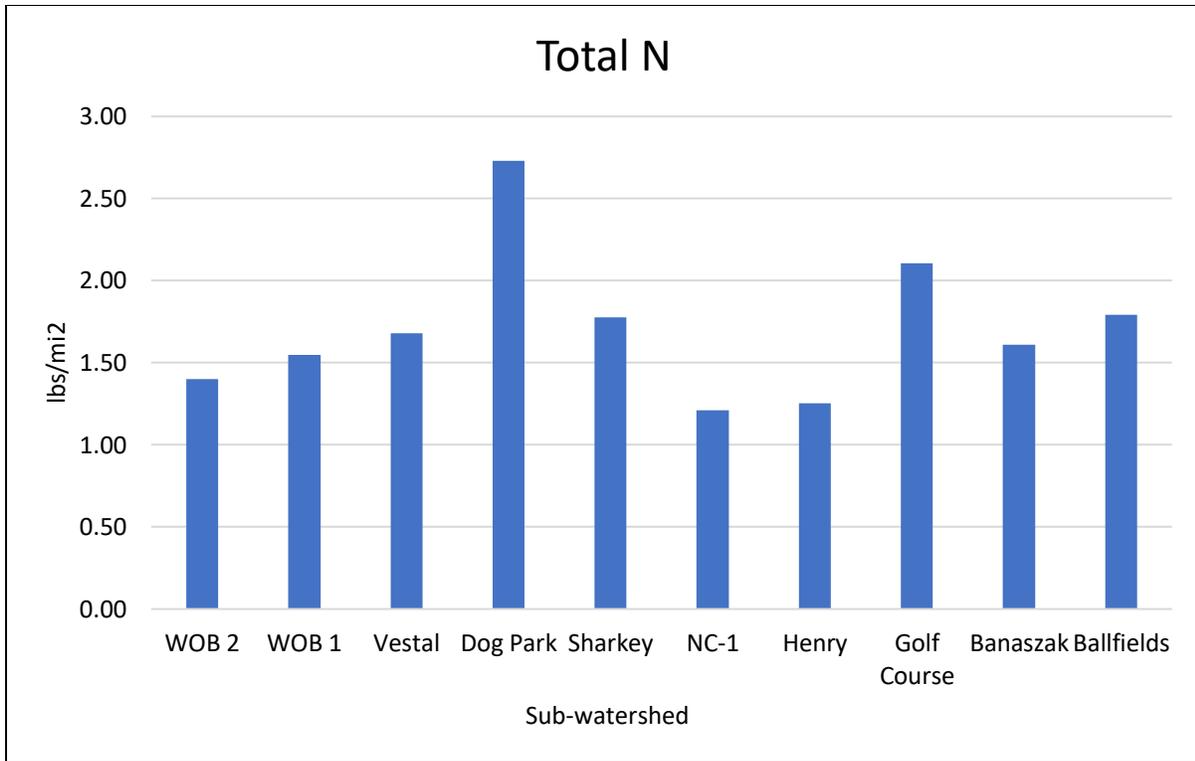


Figure 4.1.3. Average loads of total nitrogen (lb./mi²).

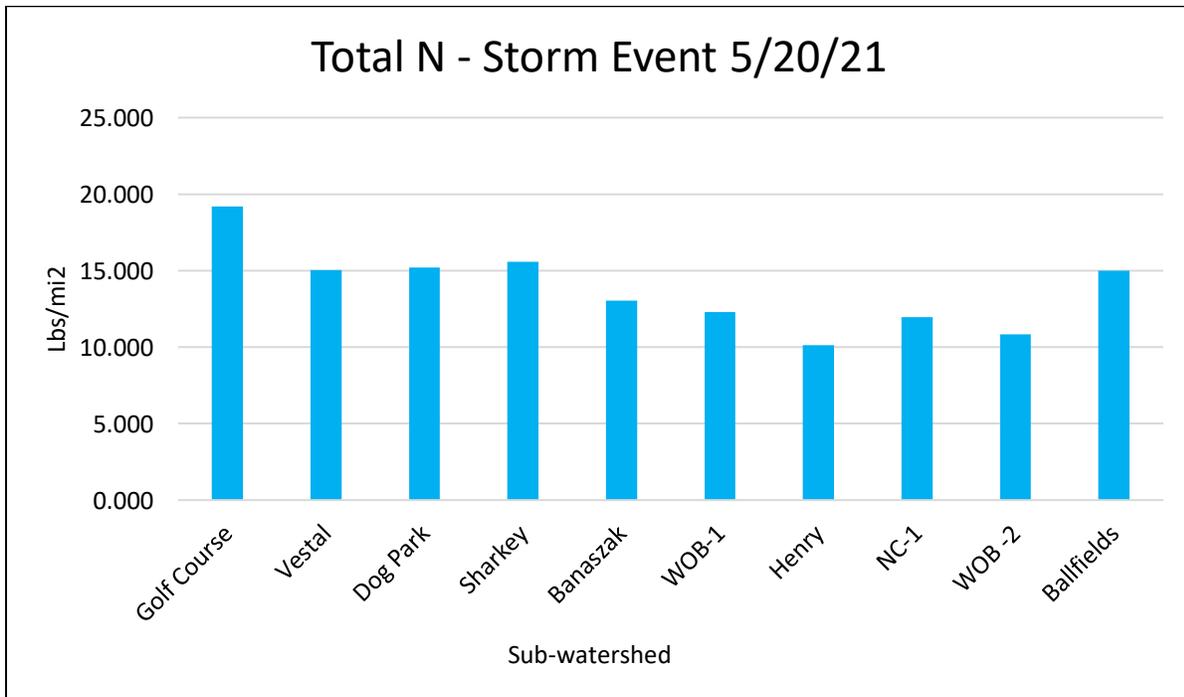


Figure 4.1.4. Average storm event loads of total nitrogen (lb./mi²).

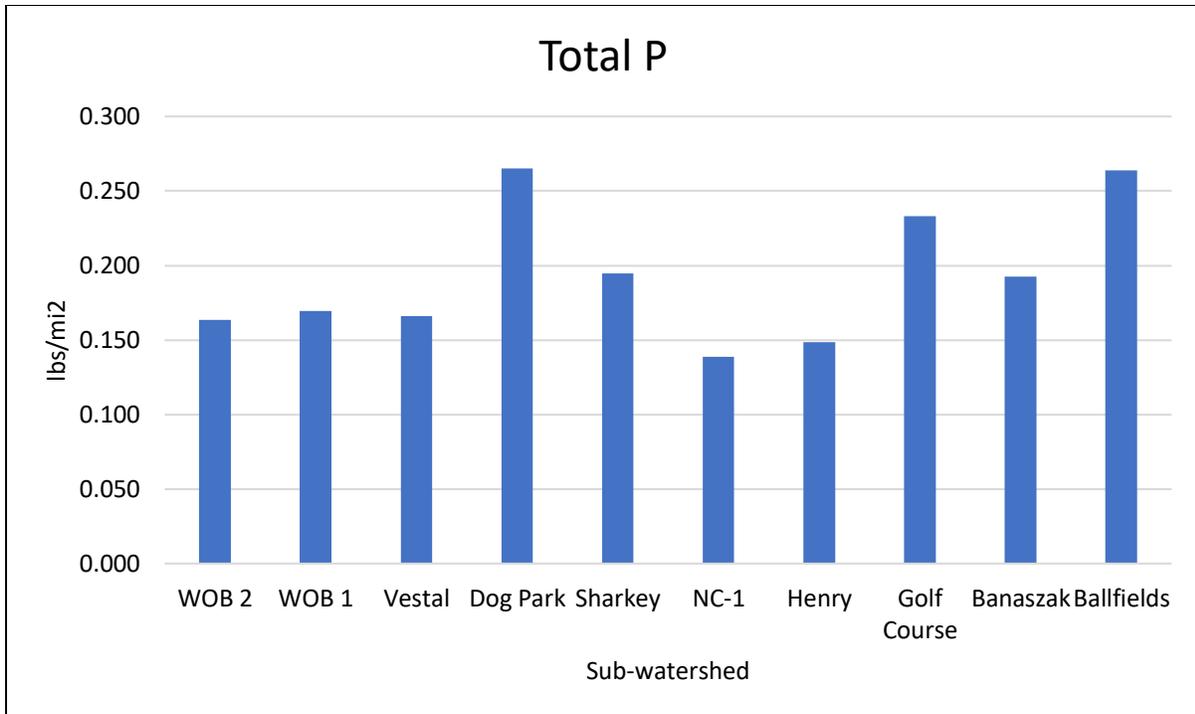


Figure 4.1.5. Average loads of total phosphorus (lb./mi<sup>2</sup>).

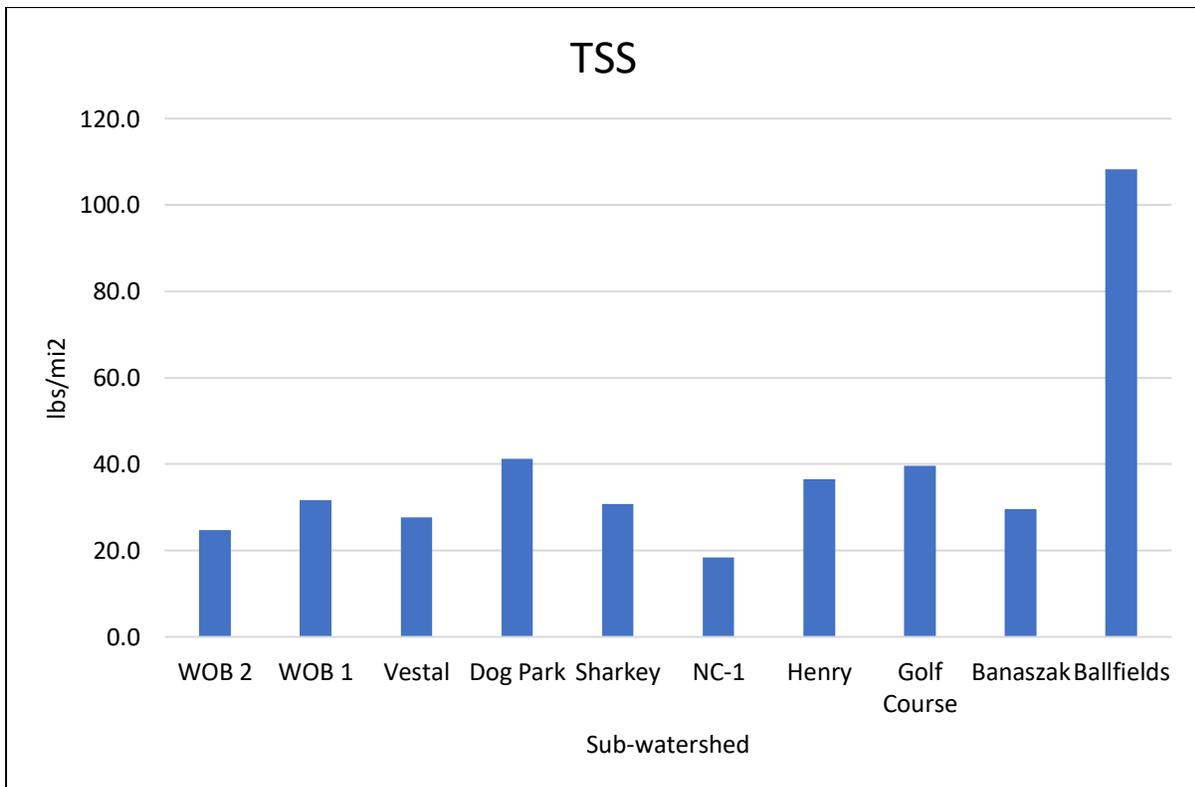


Figure 4.1.6. Average loads of total suspended solids (lb./mi<sup>2</sup>).

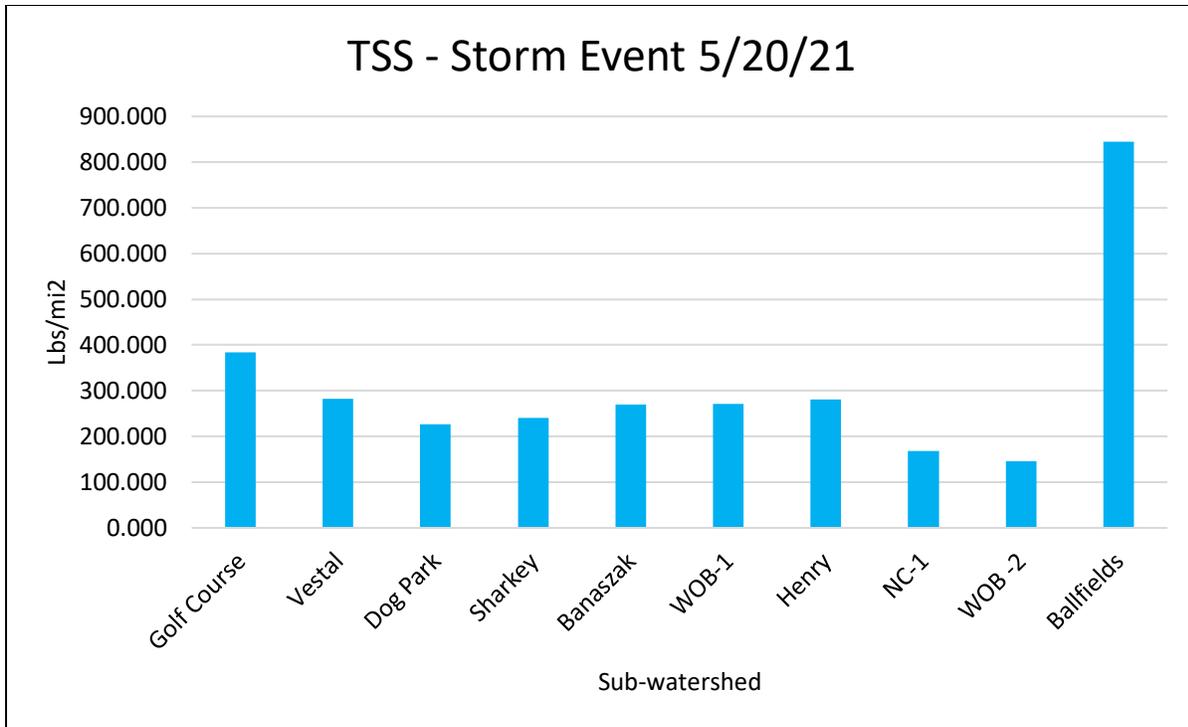


Figure 4.1.7. Average storm event loads of total suspended solids (lb./mi<sup>2</sup>).

## 5.0 POLLUTION SOURCE ASSESSMENT

---

The WOB was broken down into 14 sub-watersheds based on the location of monitoring stations and to render the overall assessment manageable for planning, and implementation purposes.

### 5.1 Point Sources

There are no major NPDES outfalls in the WOB watershed. There are two wastewater facilities, North Little Rock-Maumelle, and North Little Rock-White Oak Bayou, that are located in the watershed but they both discharge directly to the Arkansas River. There are two minor dischargers (greater than 0.01 mgd) in the watershed, a quarry, and a church, but these are believed to be of little significance to overall watershed loading. The majority of the NPDES permitted facilities that show up in a search are stormwater related and not continuous PS discharges (Figure 5.1.1). Table 5.1.1 provides a summary of the NPDES discharges (PS and NPDES stormwater) in the watershed.

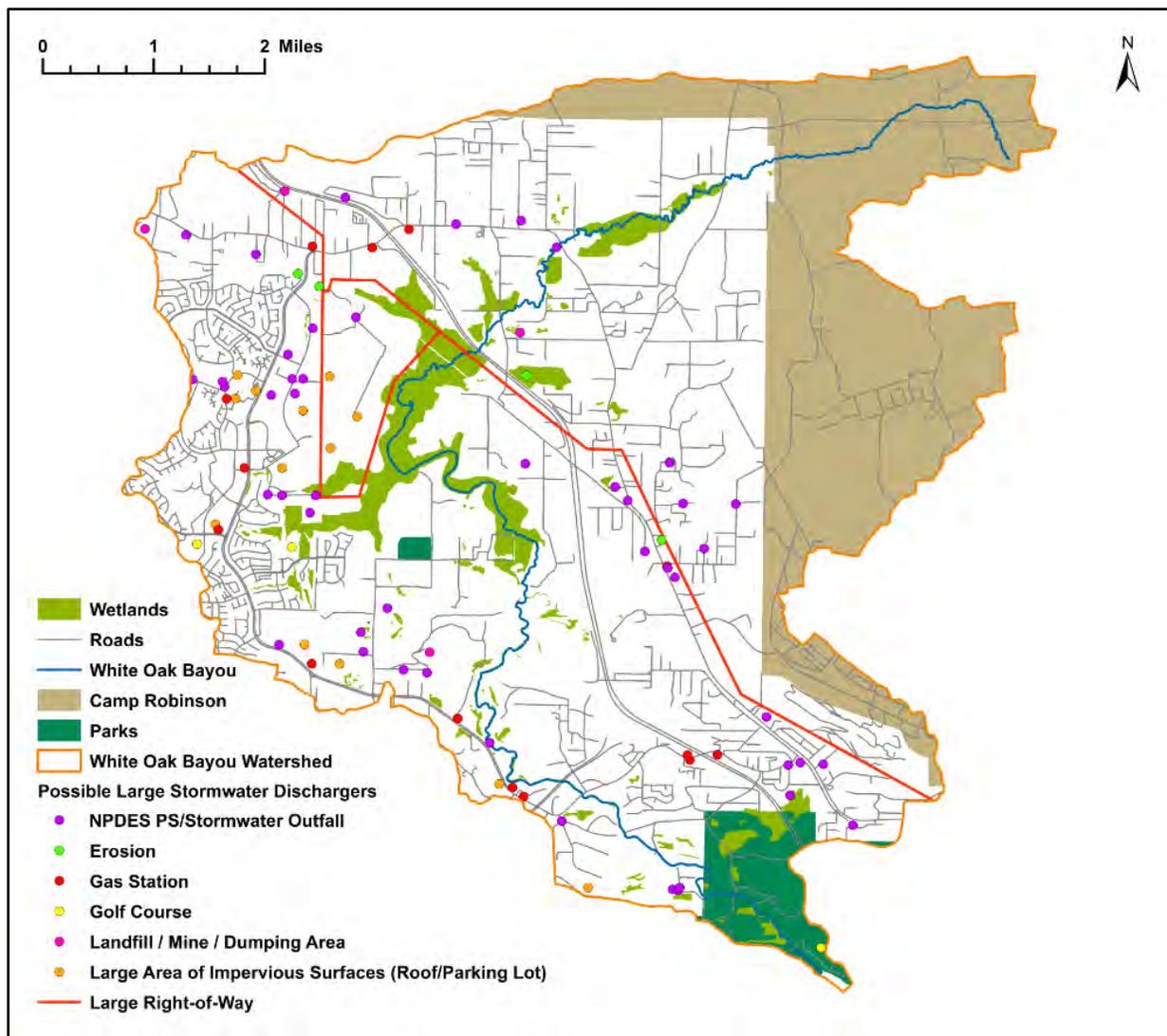


Figure 5.1.1. Active NPDES permits, including stormwater outfalls and other known non-point sources in the WOB.

Table 5.1.1 NPDES discharges with continuous flow >0.01 mgd.

Discharger	Average Daily Flow (mgd)	BOD (lbs/day)	Ammonia (lbs/day)	TSS (lbs/day)
EC Rowlett Quarry*	0.057	---	---	---
Cedar Heights Baptist Church	0.070	0.21	0.02	0.09

\*No chemical data for EC Rowlett reported in EPA Storet database.

## 5.2 Non-point Sources

Based on the results of the assessment work completed in the watershed, the following is a summary of what are believed to be the top three sources of pollutants in each sub-watershed evaluated (Table 5.2.1).

Table 5.2.1 Key non-point source impacts for each sub-watershed assessed in the WOB.

Sub-watershed	Unpaved roads	Urban land use	On-going development/urbanization	Impacted Riparian buffer	Pasture land use	Streambank erosion
Ballfields		X	X	X		
Banaszak				X	X	X
Burnspark			X			
Dogpark		X		X		
Golfcourse		X	X	X		X
Golfdog		X	X			
Henry (Winifry Creek)						X
Newton Creek						
Pumpstation		X				
Sharkey	X	X	X	X		
Vestal		X	X			
WOB-1	X				X	
WOB-2			X		X	
WOB-3						

## 5.3 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 to consider each of the impact assessment categories including developed (urban/suburban) land use, hay/pasture land use percent, amount of on-going (active) development, streambank erosion, total phosphorus, lead load, TSS load, slope of the watershed, amount of impacted riparian buffers, miles of unpaved roads, and SWAT model load predictions, both on a sub-watershed output basis and on a wash-off of the land basis. There were four water quality loading parameters that were included in the matrix and two SWAT loading parameters to ensure actual data received a strong affect.

Each matrix parameter was given a possible total score of either a 5 or 10 depending on how it was weighted in the scale (how important it is believed to be in the watershed). Scores were assigned to sub-watersheds according to their ranking for each parameter. That is, the worse the parameter value (high loading, high percent developed land use, etc.) the higher the ranking and associated assigned matrix score. For example, a ranking of first/worst would receive a 10, next worst a 9, and so forth. Parameter scores were summed for each sub-watershed. Maximum possible score was 90. The higher the total matrix score for a sub-watershed, the higher the priority. Table 5.3.1 provides a summary of the score totals for each sub-watershed. As noted previously, not all sub-watersheds had monitoring stations or were the focus of assessment efforts, but each should overlap at least one that does and later included for BMPs by association.

According to the matrix ranking, the five key sub-watersheds in most need of land use management and source reductions are Dogpark, Ballfields, Golfcourse, Sharkey and Burnspark. A visualization of the matrix rankings in each of the watersheds is provided below in Figure 5.3.1.

Table 5.3.1 Ranking of each impact category for each sub-watershed.

Sub-watershed	Parameter Max Value	Ballfields	Banaszak	Burnspark	Dogpark	Golfcourse	Golfdog	Henry (Winifry Creek)	Newton Creek	Pumpstation	Sharkey	Vestal	WOB-1	WOB-2	WOB-3
%Developed land use	10	8	---	2	9	7	6	---	---	5	4	10	---	1	3
Amount on-going (new) development	10	10		7	2	6			4	1	8		3	9	5
%Hay/Pasture	5		5					1					4	3	2
% of Impacted Riparian Buffer (<50 ft)	10	8	6		7	9		3	4		10	2	5	1	
Streambank Erosion (ft <sup>3</sup> /mi/year)	5		3			4		5	2		1				
Mean Land Slope (percent rise)	5			4				1	3	5		2			
Unpaved Roads (miles)	5				4				2		3		5	1	
(WQD) Lead Load (lb/mi <sup>2</sup> )	5	1			2	4					3		5		
(WQD) TSS Load (lb/mi <sup>2</sup> )	5	5			4	3		2					1		
(WQD) P Load (lb/mi <sup>2</sup> )	5	4	1		5	3					2				
(WQD) TSS Concentration (Historical Data)	5	5		4						1	3	2			
SWAT Sediment (lbs/mi <sup>2</sup> )	10		5	10	8	1	6	7	3	9	2				4
SWAT Sediment lbs/mi <sup>2</sup> from land only	10	6	2	3	8	9	7		1	5	4	10			
Total	90	47	22	30	49	46	19	19	19	26	40	26	23	14	11

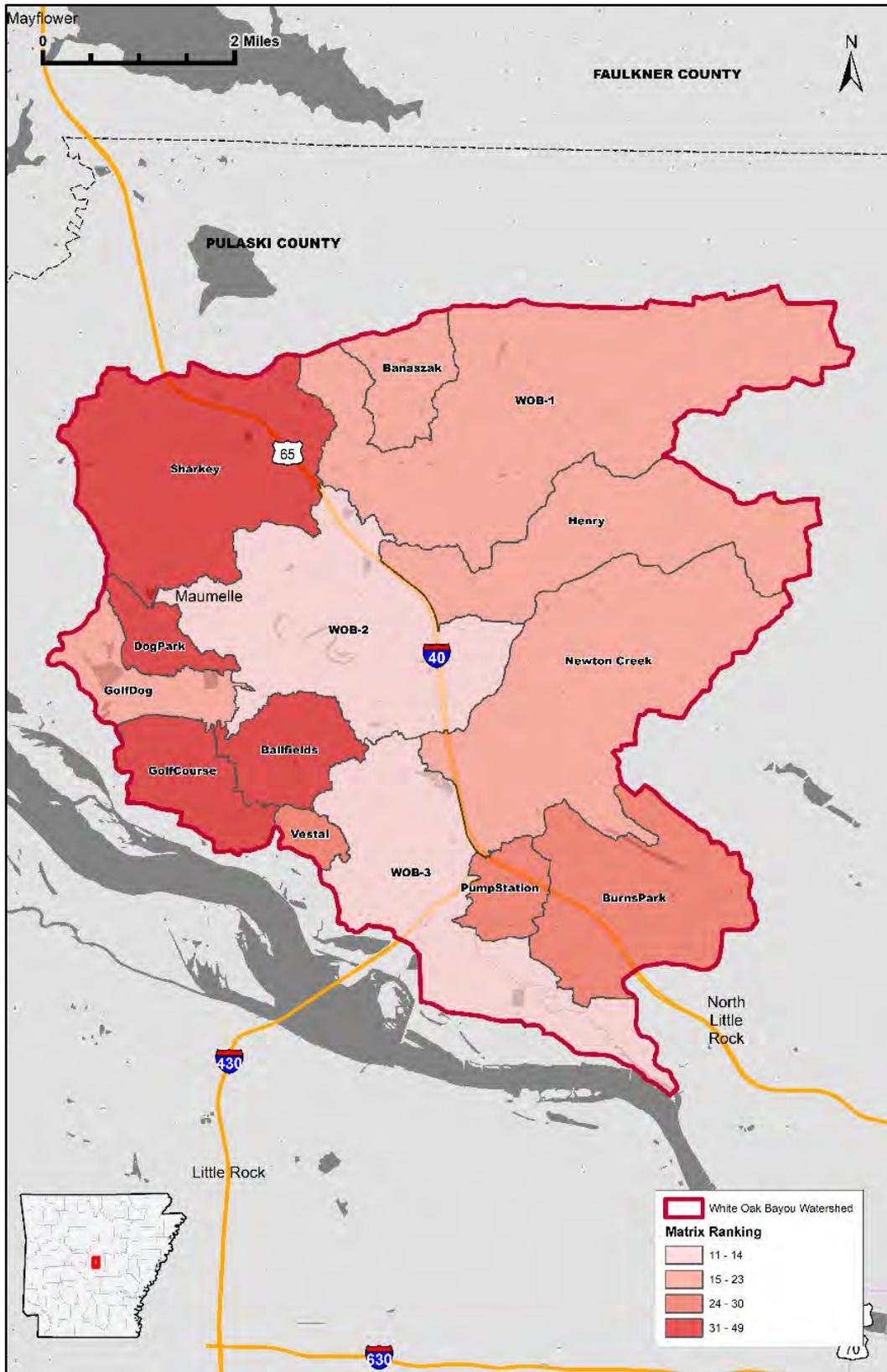


Figure 5.3.1 Matrix rankings of top watershed concerns in the WOB.

# 6.0 RECOMMENDATIONS FOR WATERSHED MANAGEMENT POLLUTION SOURCE ASSESSMENT

---

The following sections provide recommendations for management of the WOB 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 address and remedy the critical problem areas/sources discussed in the previous sections. In many circumstances management practices recommended to reduce pollutants will also have some positive impact on flooding. This is particularly true for stormwater management recommendations for developed areas (Sections 6.2.2/6.2.3). The practice of preserving or restoring natural lands, such as wetlands and riparian buffers, can have a great impact on flood water mitigation.

## 6.1 Recommended Load Reductions

The focus of the reduction strategy will be reductions of TSS (sediment). Reductions in TSS will also carry along with it some reduction in nutrients, metals, and oxygen demand, as many of these are at some level connected to sediment. Since there is no TMDL for the WOB, and no direct measurement that would point to a required reduction to meet a water quality standard, an overall TSS reduction of 20% will be targeted. This reduction target is a reasonable and attainable target that should improve water quality, including dissolved oxygen once achieved.

Annual loading for each of the assessed sub-watersheds was evaluated using the SWAT model and calculated from the most recent water quality data. The SWAT model predictions are more complete and represent all of the sub-watersheds, while the water quality data does not. Therefore, annual loading predictions from SWAT were used to assess load reduction targets (Table 6.1.1).

Table 6.1.1. Load reduction goals.

Loading Source	TSS (lb/yr)
SWAT	8,862,546
A 20% load reduction goal from SWAT data	1,772,509
Watershed Target New Load (Goal)	7,090,037

### 6.1.1 SWAT Modeling Non-Point Source (NPS) Load Reduction Potential

The soil and water assessment tool (SWAT) is a widely used watershed model based on hydrologic response units that can evaluate point source and non-point source loading of pollutants, transport, and their effect on water quality. The hydrologic response units group areas of similar land use, soils, etc. SWAT was used in this report to evaluate BMP removal rates from various land uses in the watershed. The model addresses load reductions from BMPs on a land use by land use basis. Each BMP is set-up in the model with BMP type, type of land use the BMP is effective for, and the percentage of that land use area (acres) that it is applied to.

To assess and manage NPS pollution, the NRD recommends evaluating pollutant loading and implementing mitigation efforts on the sub-watershed scale. Watershed models, particularly SWAT, are often used for assessing, planning, and prioritizing NPS mitigation efforts and watershed management activities (Ghafari et al., 2017). The SWAT model can be used to predict the impacts of differing land uses and land management practices under various climatic conditions on water, sediment, and nutrient yields on the watershed scale over long periods of time.

To evaluate the effect that implementation of management practices could have on pollutant loadings, several feasible BMPs were evaluated. Best management practices were simulated across 25% of the watershed and loadings of sediments were compared to the base model to assess changes. The BMPs simulated in SWAT include:

1. A 50-foot riparian buffer in urban and hay land uses.
2. Green area enlargement, which was simulated as a 10% reduction in curve numbers in urban land uses.
3. Stormwater treatment features (bioswales, detention, etc.) were applied to 20% of developed land uses (modeled using SWAT and/or WTM) (Caraco/Cup, 2013)

Based on the results of the modeling, the most effective BMP applied to the watershed in SWAT was a 50-foot riparian buffer in urban and hay land uses. Riparian buffers protect the

streambanks from erosion and provides a filtration mechanism for sediments and pollutants in runoff.

## **6.2 Land Use and Runoff Management**

The following sections are best management practices recommended to protect water quality and/or the hydrologic regime of the major tributaries of the WOB. 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 this watershed. Reduction estimates (below) are from modeling or assessments described in this report, and costs (Section 9.0) are based on a survey of literature values.

### **6.2.1 Agricultural Land Use**

Agricultural land is not prevalent in the WOB watershed. Row crops are negligible, and cattle numbers are low. The primary agricultural land is hay fields. In spite of the minimal threat from agriculture, landowners with on-going agricultural activities should be encouraged to implement BMPs appropriate to their land use habits. This encouragement probably needs to occur as some form of educational material mail out, forums and face to face meetings. Assistance (including financial) with these types of efforts is available through the National Resource Conservation Service (NRCS), the Arkansas Department of Agriculture NRD, the University of Arkansas Cooperative Extension Service and others. Frequently farmers engage in cost share agreements with federal or state entities, which provides the majority of funds to satisfy and comply with required BMPs.

**Pasture** - It is likely that many farmers in the watershed already implement some BMPs to enhance hay and cattle production. However, experience has shown that these are not as widespread and/or consistent as needed. In each sub-watershed, and particularly in sub-watersheds Banaszak, WOB-1 and WOB-2, where pasture and cattle numbers are highest, it is recommended that landowners be encouraged to consider implementation of pasture management practices. 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 streambanks 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 (rotational/prescribed grazing). 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/reduce stocking rate, number of head per acre of pasture.

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

- Riparian buffers/filter strips along stream corridors (see detail above).
- Though required by Nutrient Management Plans it should be emphasized to 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, i.e., use perennial and seasonal grasses to maximize grass density throughout all seasons. Prevents topsoil erosion and utilizes remaining nutrients.

Since this land use type is not believed to be a large contributor to TSS or even nutrient loading, no load reductions have been calculated for use of these management measure.

### **6.2.2 Developed - Commercial and Industrial Land Uses**

The WOB watershed is dominated by developed/urban land uses. This is the primary land use in need of managing to reduce pollutants in stormwater. Many of the management measures described below are consistent with the City of Maumelle’s current stormwater drainage and pollution prevention ordinances and will reduce both the volume of stormwater runoff and reduce pollutants transported in the runoff to WOB. Details on each BMP is provided later in this section or Appendix D. The key sub-watersheds (primary), to be addressed with the BMPs listed below are Vestal, Dogpark, Ballfields, Golfcourse and Golfdog. Secondary efforts should be focused in the Pumpstation and Sharkey sub-watersheds.

The following BMPs should be considered:

- Riparian buffers along stream corridors. In addition to the benefits discussed previously, buffers help control storm flow hydrographs. Riparian buffers with a width of 50-100 ft (minimum 25 feet) on each side of streams.
- 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.
- Improve current street sweeping program's frequency and consistency.
- Enforce and place a priority on construction stormwater management plans.
- Request that ADEQ advise the WMP coordinators of any new stormwater Notice of Intent (NOI's) in the watershed before permit approval.
- Enforce stormwater detention ordinance.
- Encourage and/or implement stormwater detention/retention/treatment requirements for large impervious areas. In some cases, particularly in commercial and institutional areas, bioswale/bioretention may be appropriate (Figure 6.2.1).
- Land conservation. Where possible attain land or establish easements in areas critical to the stream (i.e., wetlands, buffer zones, riparian areas, etc.) and maintain these as permanently protected green areas.

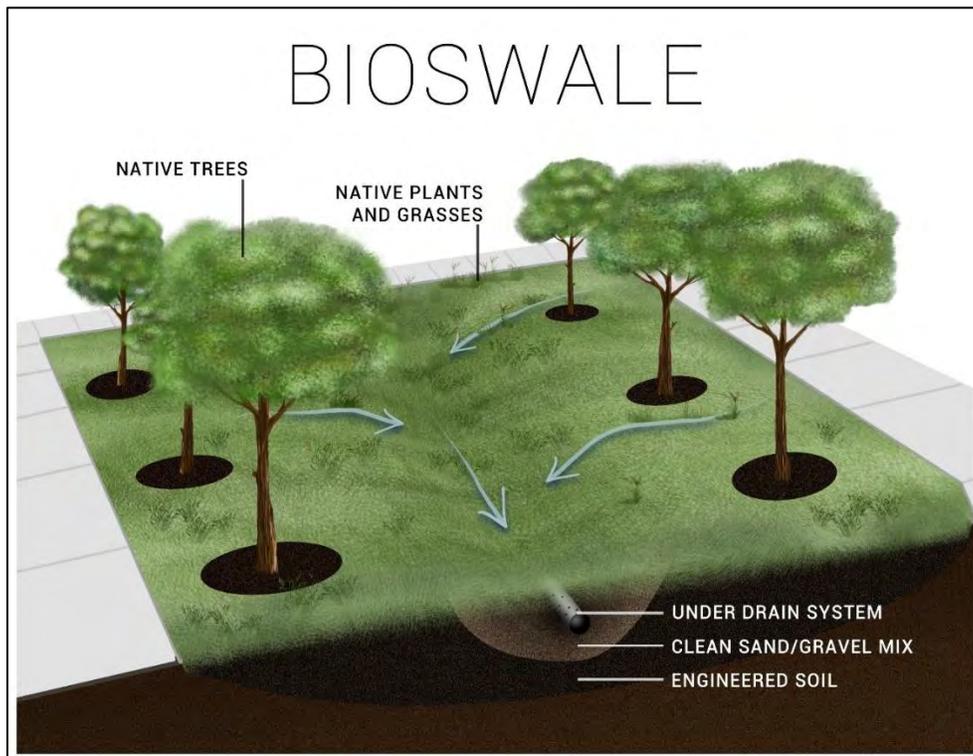


Figure 6.2.1. A Bioswale (bioretention) that is effective in reducing pollutant load in stormwater run-off from commercial and institutional areas.

### 6.2.3 Developed - Residential Land Uses

As stated in the section above for Industrial/Commercial development urban and suburban areas comprise the bulk of the WOB watershed and residential areas that occur there

should receive a similar level of stormwater management as the commercial areas. The key sub-watersheds (primary), to be addressed with the BMPs listed below are Vestal, Dogpark, Ballfields, Golfcourse and Golfdog. Secondary efforts should be focused in the Pumpstation and Sharkey sub-watersheds.

For residential developments the following BMPs should be considered:

- Riparian buffers along stream corridors. Riparian buffers with a width of 50-100 ft (minimum 25 feet) on each side of streams.
- Encourage green area enlargement and enhancement and reduce impervious surfaces on new and existing developments.
- Encourage good neighbor practices. Keep yard free of junk and garbage, proper disposal of pet waste, proper disposal of household chemicals, etc.
- Strictly enforce and put a priority on construction stormwater management.
- Improve street sweeping program's frequency and consistency.
- Enforce detention ordinance and encourage use of detention.
- Encourage and/or implement stormwater detention/retention/treatment requirements for development.
- Encourage (through incentives) or require use of low impact development techniques (LID) in new developments in critical areas or on steep slopes. Encourage current homeowners to install raingardens or similar small on-site stormwater retrofits (Figure 6.2.2). Most of these features also serve to help reduce flooding.
- Limit and manage fertilizer application.
- Encourage watershed stewardship through education.

An assessment of stormwater treatment opportunities in the commercial and light industrial areas around the City of Maumelle was completed during this project. A summary of potential locations for stormwater treatment features/retrofits is provided in Figure 6.2.3.

Potential load reductions (in pounds and % of target reduction) from use of urban/developed land management practices such as green area enlargement and stormwater treatment features in urban areas (riparian buffers are addressed in Section 6.3.1), in key sub-watersheds are:

- **TSS – 87,861 (5%) (detention/retrofits)**
- **TSS – 14,829 (1%) (street sweeping)**

# RAINGARDEN

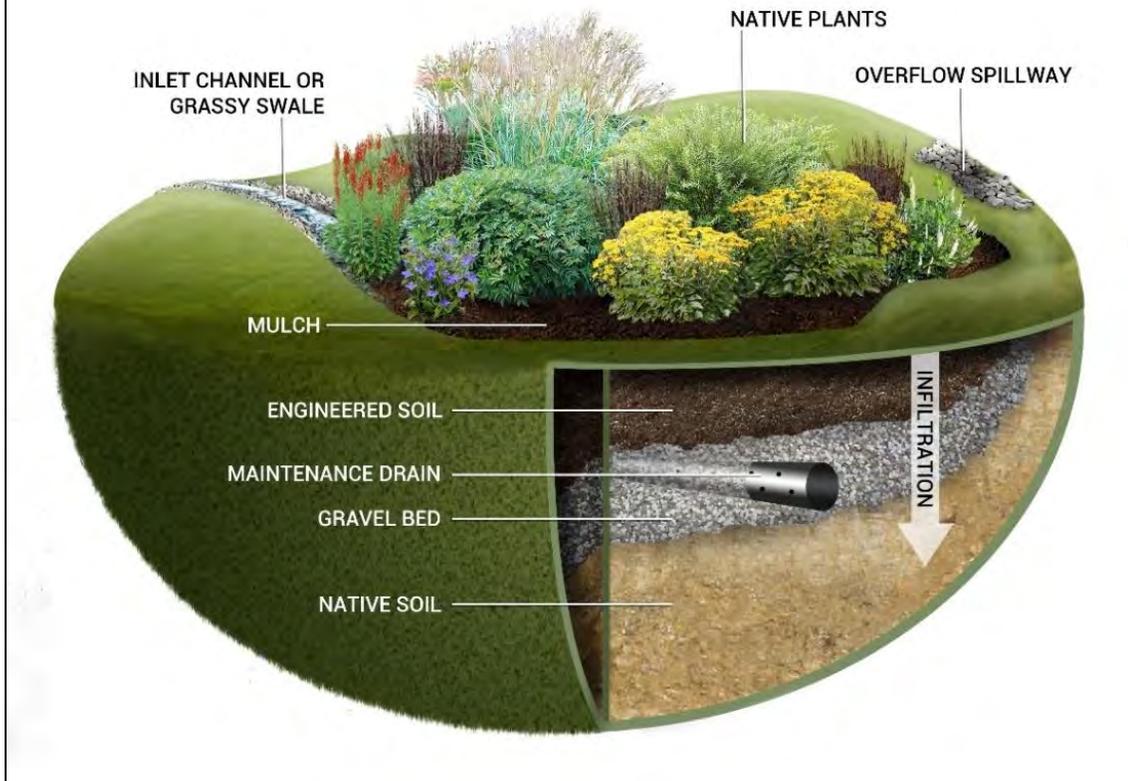


Figure 6.2.2. Example of a raingarden that can be easily and inexpensively installed in most yards and/or commercial areas to improve stormwater quality.

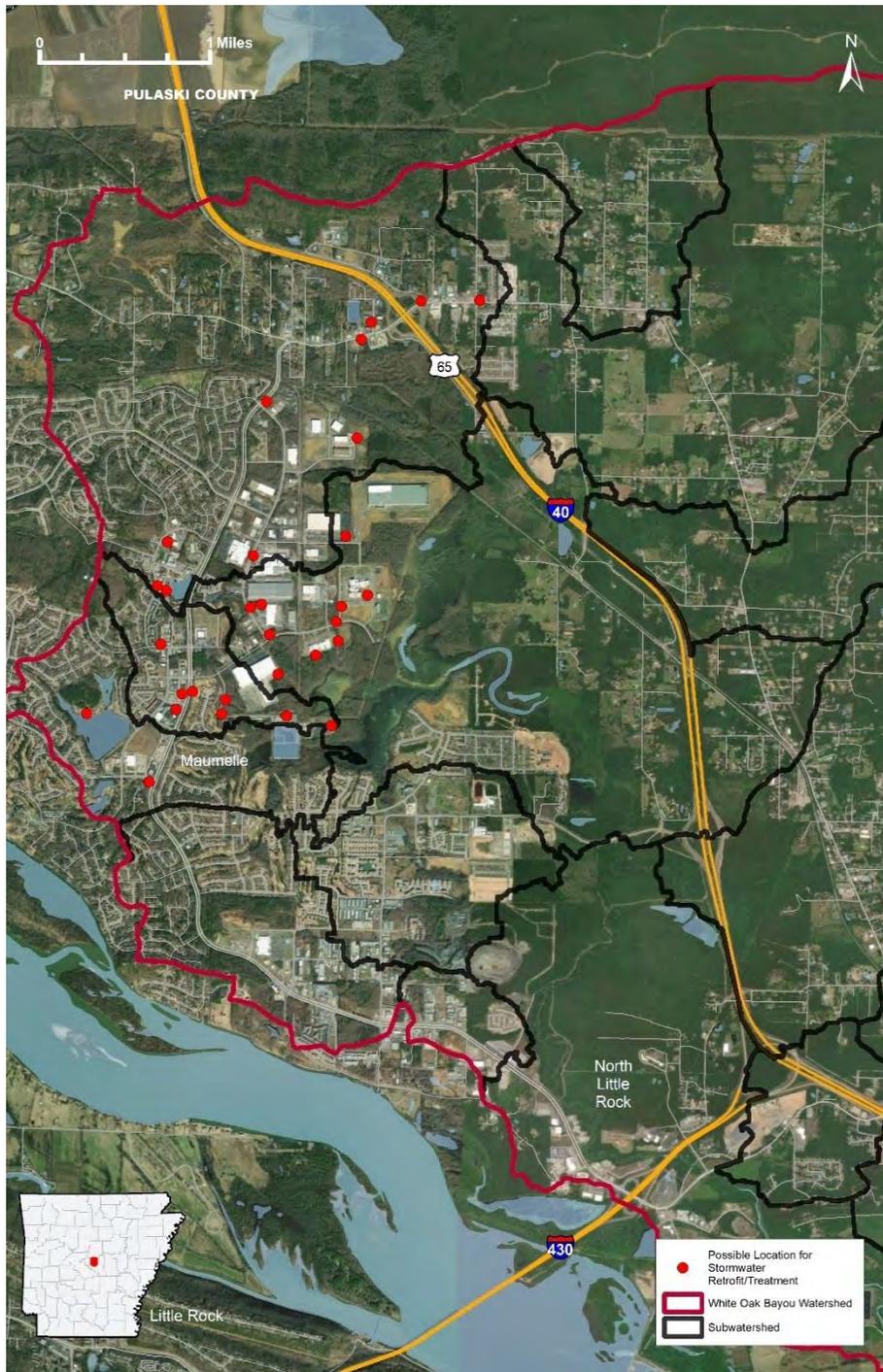


Figure 6.2.3. Identified locations for potential new stormwater treatment/retrofits.

## 6.2.4 Unpaved Roads Management

Several BMPs are available to decrease sediment transport from unpaved roads. WOB does not have a large number of unpaved roads, but the ones in existence do add to the pollutant loading in waterways. Key sub-watersheds to address are WOB-1, Burnspark and

Sharkey. The following BMPs are believed to be appropriate to the forest roads and dirt roads in the watershed:

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

Table 6.2.4. Potential load reductions from implementation of unpaved road BMPs.

Parameter	Total Current Load (lbs)	50% Reduction (lbs)
TSS (12 rain events)	118,146	59,073

Potential load reductions (in pounds and % of target reduction) from use of a combination of these management practices on approximately 50% of unpaved roads in key sub-watersheds, based on info from Bloser, S.M. and Scheetz B.E., 2012 are:

➤ **TSS – 59,073 (3.3%)**

## 6.3 Stream Corridor Restoration/Enhancement

### 6.3.1 Riparian Buffers

Riparian vegetated buffers are lacking or limited in several reaches in the WOB with problems in the more urbanized portions of the watershed. As discussed previously in this report (Section 3.0) riparian buffers are critical to the health of a stream system. The following areas are indicated as having impacted riparian buffers and should be targeted for establishment or enhancement of vegetative riparian buffers: Sharkey, Golfcourse, Golfdog, Dogpark, Ballfields and Banaszak.

Buffer widths should be planted as wide as possible on each side of the stream. A width of 50 ft on each side of the stream should be the minimum target with widths less than 50 feet allowed in already developed areas where space does not allow for the restoration of wider zones. When riparian buffers are considered, more is always better. Buffers should be composed of native vegetation including trees, shrubs, herbaceous plants, and grasses. Figure 6.3.1 presents a representation of how buffers are designed.

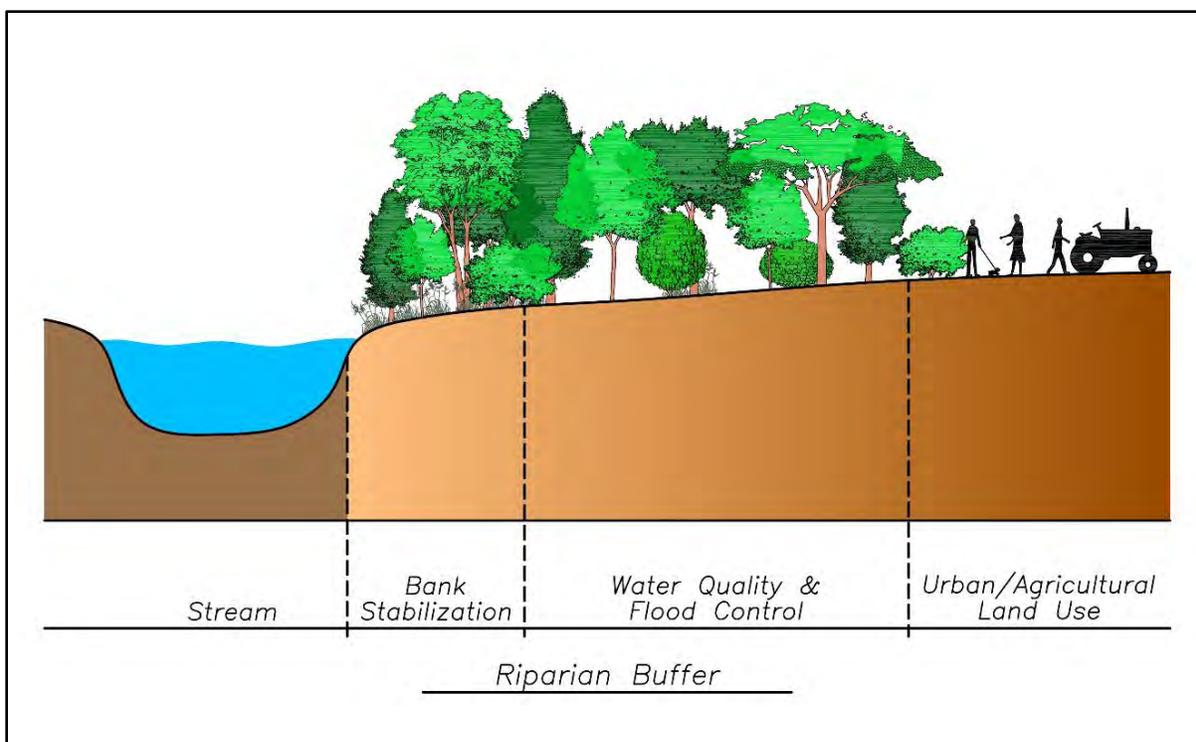


Figure 6.3.1. Generic representation of the ideal Riparian Buffer Zone and key function in Each Zone.

Potential load reductions from use of these management practices (50-foot riparian buffer in developed land) were evaluated using the SWAT model. Results (in pounds and % of target reduction) of the analysis are below:

➤ **TSS – 136,685 (7.7%)**

### 6.3.2 Streambank and Channel Stabilization

Several of the streams in the WOB are exhibiting significant streambank erosion at several locations. Streambanks should be stabilized in as many of the locations as possible and particularly in the critical areas that are easily accessible for the required heavy construction equipment. Henry, Golfcourse, Banaszak, Newton Creek, Sharkey and Dogpark should all be primary targets of these efforts. Potential load reductions from bank stabilization averages over 200 lb sediment/foot of eroded bank restored (Table 6.3.2.1). Root causes of streambank instability should be evaluated in each reach and necessary measures taken to reduce the risk of bank erosion. These measures frequently include reduction in stormwater run-off peak flows to the system including riparian restoration/enhancement and changes in land uses throughout the watershed to slow down stormwater run-off and increase infiltration. Measures can also

include completion of channel restoration features (i.e., installation of grade control, flow training and key habitat features, etc.).

Each streambank and channel stabilization project come 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 reduction. Where possible, preference should be given to techniques that focus on bioengineering.

- Bank re-sloping (to flatten slope) and creation of bankfull benches.
- Toe protection in conjunction with various vegetative protection measures (such as live stakes, live cribwalls, etc.).
- Stone armoring (such as the use of boulder toes/revetments, vegetated riprap, etc.)  
Stone armoring should be used as a last resort, and only in high velocity/scour areas or areas too steep for bioengineering.
- Use of bioengineered materials (coir, jute, excelsior™, etc.) including erosion control blankets, wattles, fiber rolls, soil wraps, etc.
- Engineered structures for grade control, energy dissipation and flow guidance, (cross veins, J-hooks, step pools, riffles, etc.)
- Revegetation of the streambanks and riparian area using native grasses and trees.

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 streambank stabilization.

Table 6.3.2.1. Yearly loads from streambank erosion and load reductions possible from streambank stabilization.

Watershed	HUC-12 Watershed	Annual Sediment Load (lb/yr)
White Oak Bayou	Sharkey	370,754
	Banaszak	477,198
	Golfcourse	532,044
	Dogpark	136,063
	WOB-2	0
	Henry	5,387,628
	Newton Creek	878,267
	WOB-1	0
	Ballfields	0
	WOB-2	0
Total		7,781,954
15% reduction		1,167,293

Potential load reductions from use of these management practices on 15% of eroded banks in all sub-watersheds affected:

➤ **TSS – 1,167,293 (66%)**

### 6.3.3 Critical Area Conservation

Land conservation is a current priority in the WOB watershed and should continue to be so. To date over 500 acres of wetlands and over 4000 feet of white Oak bayou channel and riparian buffer have been preserved with another approximately 150 acres and 7100 feet anticipated to be added in 2024. Where possible, attainment of land and/or establishment of conservation easements should be considered in areas critical to the stream (i.e., buffer zones, wetlands, etc.) and maintain these as green areas. This practice typically helps to reduce localized flooding as well as serving to improve water quality. The focus should be in areas controlled by the City of Maumelle or The City of North Little Rock as they have the majority of the watershed in their planning boundaries and have a greater ability to leverage action (i.e., funding and resources) and to garner approval from local residents. Key elements that should be developed in stream corridors and key area that drain to them are provided in Table 6.3.3.1.

Table 6.3.3.1. Key management measures to encourage, develop and manage.

Technique	Description of Technique
Natural area conservation	Protect wetland areas from development and encroachment. 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 and be protected by local ordinance or easement where possible.
Avoid septic system use	All homes should be connected to local sewers and wastewater treatment facilities when possible.
Stormwater management	As recommended in Section 6.2, the use of low impact stormwater management features (rain gardens, bioswale, detention/retention, etc.) should be encouraged to reduce the impact of run-off peak flows and improve water quality.

Potential load reductions from use of green area procurement were evaluated using the SWAT model. The model resulted in negligible amounts of sediment load reductions using the modeling protocol described in Section 6.1.1. However, the results for riparian buffers were much better and should be a good indicator of the potential success of critical green area protection.

#### 6.4 Priority Recommendations and Implementation Schedule

Based on the load reductions projected in Section 6.2 for various BMPs, the most effective for sediment appear to be streambank stabilization and vegetated filter Strips/riparian buffers (Figure 6.4.1).

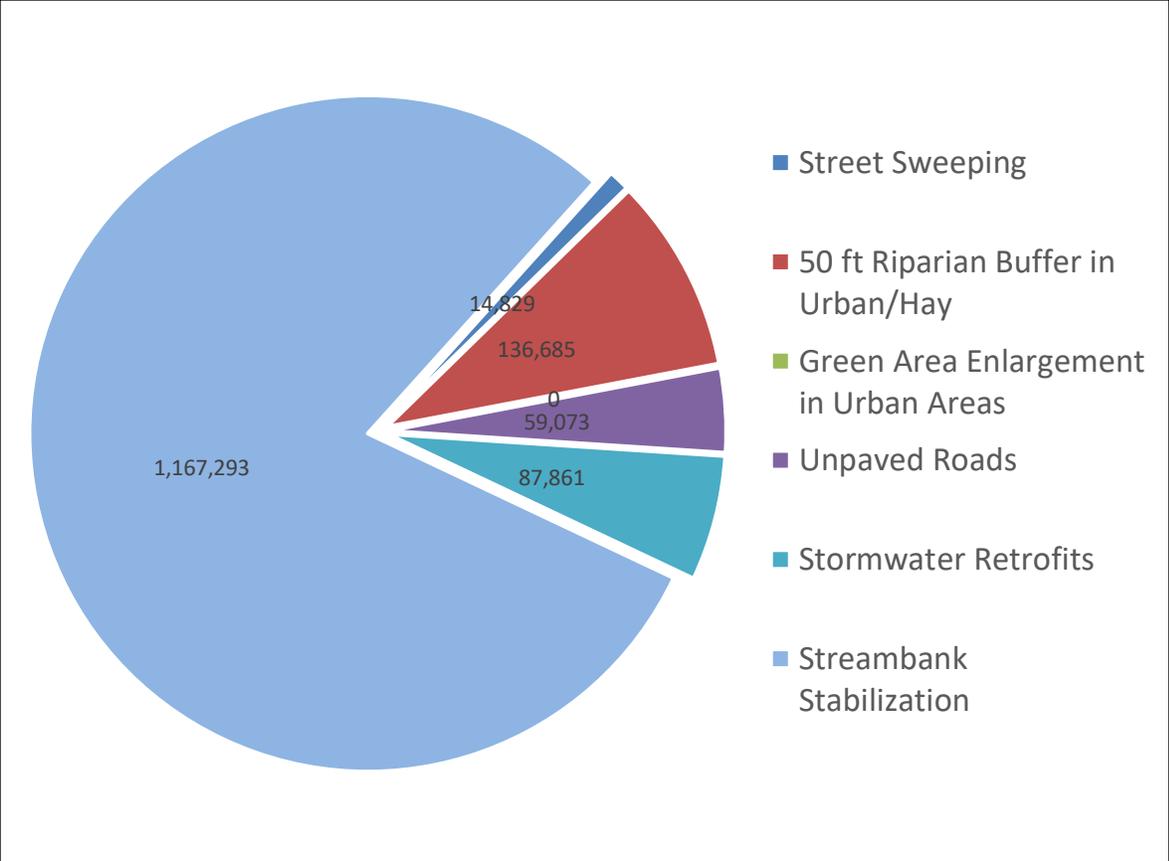


Figure 6.4.1. Source and scale of Total Suspended Solids (TSS) BMP load reduction (pounds) potential.

Table 6.4.1 provides a ranking of the watershed management practices recommended as a result of the assessment and the matrix scores. Each management action is ranked based on its ability to move the watershed towards attainment of the goals expressed.

Table 6.4.1. Prioritization of recommended Watershed Management Practices.

Rank	White Oak Bayou Sub-Basin	Management Action (Practice)
1	Henry, Golfcourse, Banaszak, Newton Creek, Sharkey and Dogpark	Streambank stabilization
2	Sharkey, Golfcourse, Golfdog, Dogpark, Ballfields and Banaszak	Riparian buffer/Vegetated filter Strips
3	Vestal, Dogpark, Ballfields, Golfcourse and Golfdog	Implementation of residential/commercial BMPs (including street sweeping)
4	WOB-1, Burnspark and Sharkey	Unpaved road maintenance and upgrades
5	All sub-watersheds	Conservation of wetlands and other key green areas
6	Pumpstation, Sharkey and Burnspark	Implementation of residential/commercial BMPs
7	Pumpstation and Burnspark	Riparian buffer/Vegetated filter Strips

When and where applicable, watershed management practices implementation should consider societal and environmental co-benefits such as, but not limited to: communities or areas identified as undeserved or disadvantaged, flood reduction and long-term climate resiliency, and ecological habitat creation.

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 6.4.2. The schedule provides ten years for actions to be accomplished that will result in a 20% reduction of sediment and nutrients in the watershed.

Table 6.4.2. Implementation Schedule<sup>1</sup>.

Action Item	Target Date for completion
Meet with stakeholder group to coordinate implementation projects and monitoring and plan for future funding	June-2024
Apply for grants to fund future monitoring and implementation projects	30-Dec-24
Meet with city officials and county judges to discuss unpaved road maintenance	30-Jun-25
Install urban BMPs (LID features) to affect 20% of drainages in Vestal, Dogpark, Ballfields and Golfcourse	30-Dec-26
See 50% of unpaved roads in WOB-1, Burnspark and Sharkey receive new BMP application	30-Dec-27
Bank stabilization of 15% of eroded banks Henry, Golfcourse, Banaszak	30-Dec-28
Bank stabilization of 15% of eroded banks in remaining sub-watersheds	30-Dec-30
Install urban BMPs (LID features) to affect 20% of drainages in Golfdog, Sharkey, Pumpstation and Burnspark.	30-Dec-32
See 50% of the remaining unpaved roads in in WOB receive new BMPs	30-Dec-33

<sup>1</sup> Participation by landowners and funding are an unknown and could have a significant effect on the schedule and implementation success.

## 6.5 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 6.5.1.

Table 6.5.1. Interim Measurable Milestones.

Milestone	Measurement method
Stakeholder (WOBWC) group success	Meetings at least 4/year and attendance of at least 55% of group on average
Monitoring program initiated	First round of routine samples collected
Meeting held concerning Urban BMPs	Meeting occurred on schedule
Unpaved road BMP meeting	Meeting occurred on schedule
Bank stabilization	Stabilization completed on schedule Length of stream completed as planned
Monitoring shows TSS loading is stable or decreasing	Data analysis (per Section 7.0) of first three-year monitoring cycle (2026-2028)
Urban management practices implemented	Completed on schedule and attaining percentage goals
WMP reviewed and updated every five years	Plan review is completed in 2029 and needed updates included

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 and/or positive movement in water quality trends.

## **6.6 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 adapted and 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 the 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 five 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**

---

A load reduction target of 20% (Section 6.1) for sediment has been established to ensure continued maintenance of the water quality criteria and the overall integrity of these waters and reduce sediment and associated pollutant (nutrients and metals). White Oak Bayou has had a stakeholder group (the WOBWC) for several years. The WOBWC teamed with the Cities of Maumelle and North Little Rock will lead efforts in the watershed. Once BMPs begin to be implemented, a routine watershed monitoring program should be implemented to track reductions within the WOB. Any new monitoring data collected will be compared to historical data.

The first year and possibly even the second year of WMP implementation (2024 and 2025) will not be assessed through monitoring. Those years will be assumed to be “building” years for the implementation measures. That is, it is unlikely that many new BMPs will have been implemented within the first year and those implemented during the second year will need time to stabilize prior to producing their maximum benefits. After the first five years of post WMP approval the assessment of loading status will be completed for the most recent three years of data. That is, monitoring will begin on or around January 2026 and continue for 3 years through 2028. This cycle of monitoring and evaluation will then continue forward until what time as revisions are needed.

In addition to load monitoring, BMP effectiveness will also be monitored in two of four ways:

1. Implementation of BMPs on the ground, and
2. Acres of wetland or other critical water or land resources protected, or
3. Modeling of reductions from BMPs implemented, or
4. Monitoring of runoff above and below BMPs.

BMP monitoring provides a good measure of which BMPs are the most effective and which are lacking or need adjustment.

## 8.0 PUBLIC INVOLVEMENT, EDUCATION AND STAKEHOLDERS

---

### 8.1 Stakeholder Involvement

After years of efforts from a formal steering committee and a technical advisory committee, all focused on WOB wetlands, in November 2018, a 501(c)(3) non-profit group was formed called the White Oak Bayou Wetlands Conservancy (WOBWC). This group was formed largely out of past steering committee members that helped develop the Wetland Management Plan. The conservancy carries on with the primary mission to continue the management and conservation of WOB. Both the City of Maumelle and the City of North Little Rock have senior level staff that attend these meetings (some serving as board members). This stakeholder group has met quarterly, at a minimum, to discuss new concerns, coordinate watershed efforts and work on the WMP.

## 8.2 Educational Outreach

Public outreach has been an important part of the wetland/watershed management program for White Oak Bayou since the first steering committee meeting in/around 2009. This strategy of reaching out to the public about wetland/watershed education helped to ensure public support for the original wetland management plan and this watershed plan from the beginning. As other water resource managers have learned, the public voice is a crucial component to a successful management plan (Owen, et al 2009), and getting the public on board with the concept of a plan designed to oversee proper wetland/watershed management from the onset would save time, money, and headaches by addressing opposition and issues as they arise, not after the plan has been written.

Public education of the importance of the watershed and its vast water resources was and will continue to be an important component of this WMP and of future management efforts. Without a continued understanding of why the WOB water resources are important to the community, what functions, and services they provide, the WMP will lose stakeholder support. Part of this education is directed at the community at large, and particularly those who own land containing wetlands and streams and who are directly affected by management efforts (Figure 8.2.1). Just as important is educating community leaders, so they will make informed decisions about future planning that may directly or indirectly impact watershed management. Other education efforts are directed at the schools through presentations and environmental projects (EAST program), so that children will learn at an early age the important functions healthy watersheds provide to the community and why the wetlands and streams around their community are important to manage properly for continued functionality. There is a history of educational opportunities with local colleges and universities for undergraduate and graduate research, which has been taking place in the White Oak Bayou watershed since 2010 and is a current focus. Continued research and monitoring by college students is a tool that could (and should) provide long-term data for gauging the success of the WMP and is likely to become the foundation for future routine monitoring of the bayou. All communities in the watershed benefit from relevant environmental and watershed education.

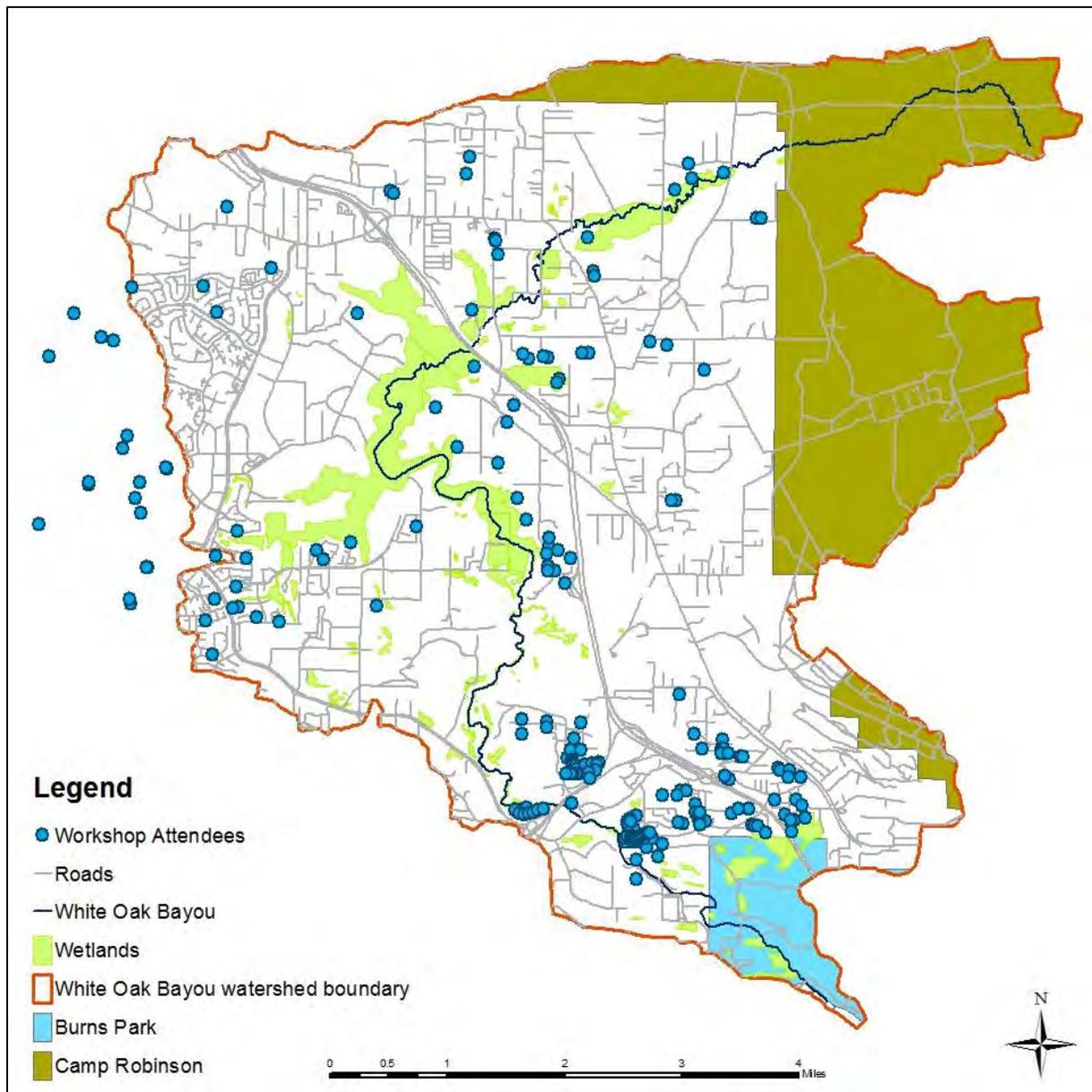


Figure 8.2.1. Map reflects the history of workshop attendee property locations.

Most recently a public meeting/workshop was held on April 5, 2022. Approximately 21 people attended the event including the five presenters. The meeting included key stakeholders and citizens living in the watershed potentially impacted by activities in the watershed. Through these meetings, and other communications with stakeholder’s a reasonable and implementable WMP can be, and was, developed.

The final draft of the watershed management plan will be made available electronically to the WOBWC and to all other key stakeholders upon request. The WMP will be posted on the City of Maumelle’s stormwater webpage. Future proposed revisions of the watershed

management plan and schedules will be spearheaded by the WOBWC and the City of Maumelle.

Key details pertaining to this WMP are being transferred to an educational brochure, in a summary format, that will be posted online and made available at City Hall for interested public to learn more about this important effort.

### 8.3 Continuing Education

The WOBWC has on-going education efforts to the public that includes two annual float trips on the WOB, an annual tree planting event and multiple other presentations and community events that allows the public to engage and learn about the importance of WOB and its watershed. The WOBWC has plans to re-invigorate its educational efforts in the schools with goals of getting into the high school and middle school on an annual basis.

The City of Maumelle and the WOBWC will continue to work with the residents of the WOB watershed on implementation of BMPs and what programs can assist residents financially to implement BMPs. Annual efforts will continue to educate landowners on a series of practical BMP related activities and how to fund such efforts. During each 5-year WMP review a public meeting will be held to receive comment regarding water quality related issues that still need to be addressed in the watershed and to gage success of programs already implemented.

## 9.0 TECHNICAL AND FINANCIAL ASSISTANCE

---

The projected costs to accomplish a 20% reduction in sediment in the WOB is summarized in the table below.

Table 9.0.1 Sediment load reductions for the WOB.

Management Measure	TSS Reduced	Cost per lb. reduced	Cost Estimate
50 ft Riparian Buffer in Urban/Hay	136,685	\$0.70	\$95,679
Green Area Enlargement in Urban Areas	Negligible <sup>1</sup>	\$18.00	n/a
Unpaved Roads	59,073	\$4.56	\$269,372.88
Stormwater Retrofits	87,861	\$21.60	\$1,897,797.60
Street sweeping	14,829	0.69	\$10,232.01
Streambank Stabilization	1,167,293	\$0.72	\$840,451.03

<sup>1</sup>See explanation in Section 6.3.3.

A vast array of federal funding opportunities exists for developing and implementing effective watershed management activities. Multiple incentives and grants are available for landowners to implement agricultural BMPs; and grants are available to communities to install stormwater treatment practices and replant riparian areas. Some grants will be more easily obtained by non-profit or community groups, such as the WOBWC, which has already successfully leveraged federal funding for some watershed related activities.

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 38 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. Grants highlighted in yellow are those which best fit the overall goals of the assessment findings and recommendations. It is anticipated that approximately one-third of the funding will come from a combination of these programs. Section 319 grants and NAWCA grants are anticipated to be a good potential source to fund BMPs in the watershed. The remainder of the funding will come from local landowners and investors/doners.

Table 9.0.2. Private/Match Funding Entities for Watershed Management.

Entity
Pulaski County (Unpaved roads)
City of Maumelle
City of North Little Rock
State Conservation Districts in Pulaski County
AGFC
Local Landowners

To ensure continued financial efficiency and transparency, this plan will incorporate regular financial monitoring and reporting practices. This includes tracking fund usage in real-time and maintaining open communication with funding agencies to ensure funds are used as planned and milestones are met on schedule.

Table 9.0.3. Federal Funding Opportunities for Watershed Management.

Grant Name	Source	Type/Purpose
American Rescue Plan (ARP)	EPA/States	Non-point source reduction, stormwater drainage improvements related to watershed management and climate change
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 – (North American Wetlands Conservation Act (NAWCA))	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)	EPA (NRD in Arkansas)	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

# 10.0 REFERENCES CITED

---

- Arkansas Natural Resources Commission, 2018. 2018-2023 Nonpoint Source Pollution Management Plan. ANRC, Little Rock, AR.
- Bloser, S.M. and B.E. Scheetz, 2012. Sediment Production from Unpaved Oil Well Access Roads in the Allegheny National Forest. Pennsylvania State University, University Park, PA.
- Caraco, D. 2013. Watershed Treatment Model (WTM). Center for Watershed Protection, Inc. Fulton, MD
- GBMc & Associates, 2018. White Oak Bayou Wetland Management Plan. City of Maumelle, Maumelle, AR
- Ghafari, H., Gorji, M., Arabkhedri, M., Roshani, G.A., Heidari, A., and S. Akhavan S. 2017. Identification and prioritization of critical erosion areas based on onsite and offsite effects. *Catena*.
- Kitchell, A. and T. Schueler. 2004. Unified Stream Assessment: A User's Manual. Center for Watershed Protection. Ellicott City, MD.
- Moriasi, D.N., Arnold, J.G., Van Liew, M.W., Bingner, R.L., Harmel, R.D. and Veith, T.L., 2007. Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. *Transactions of the ASABE*, 50(3), pp.885-900.
- Omernick, J.M., 1987. *Aquatic ecoregions of the conterminous United States*. US Geological Survey.
- Pai, N., Saraswat, D., Daniels, M. 2011. Identifying Priority Subwatersheds in the Illinois River Drainage Area in Arkansas Watershed Using a Distributed Modeling Approach. *Transactions of the ASABE*, 54(6), pp.2181-2196.
- 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 Prestegard, 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.
- Rosgen, D. L., 2006. "The application of stream classification using the fluvial geomorphology approach for natural channel design: the rest of the story." *World Environmental and Water*

*Resource Congress 2006: Examining the Confluence of Environmental and Water Concerns.*

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.

USEPA. 2016. Climate change indicators in the United States, 2016. Fourth edition. PA 430-R-16-004. [www.epa.gov/climate-indicators](http://www.epa.gov/climate-indicators).

# Appendix A

USA forms

# Unified Stream Assessment (USA)

REACH ID: <i>Bullfield</i>	STREAM: <i>Unnamed Trib to L20B</i>	DATE/TIME: <i>5/16/19</i>	INITIALS: <i>Sam</i>
REACH START <i>WP 344</i>	REACH END <i>LP</i>		
LAT: <i>34.836767</i>	LAT: <i>34.842944</i>		
LONG: <i>-92.381382</i>	LONG: <i>-92.381009</i>		

Average Conditions (check applicable)	
<b>Weather - Antecedent (24-h)</b> Rain in past 72-h: y (n) <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather - Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input checked="" type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100%      Flows Measured: Yes (No) Stream Gradient: <input type="checkbox"/> High (≥25ft/mi) <input type="checkbox"/> Moderate (10-24 ft/mi) <input checked="" type="checkbox"/> Low (<10 ft/mi)      ~Slope: _____ ft/mi Sinuosity: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low	
<b>Channel Morphology</b> System: Step/Pool - Riffle/Pool - Pool (circle) <input type="checkbox"/> Riffle _____ % <input type="checkbox"/> Run <i>25</i> % <input type="checkbox"/> Pool <i>75</i> % <input type="checkbox"/> Steps _____ % <i>Riffle/Pool</i>	
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input type="checkbox"/> Woody Debris <input type="checkbox"/> Root Wads <input checked="" type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input checked="" type="checkbox"/> Aquatic Plants <input checked="" type="checkbox"/> Overhanging Vegetation Habitat Quality: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input type="checkbox"/> Forest _____ % <input type="checkbox"/> Pasture <i>55</i> % <input type="checkbox"/> Urban _____ % <input type="checkbox"/> Commercial <i>10</i> % <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay _____ % <input type="checkbox"/> Industrial _____ % <input type="checkbox"/> Sub-Urban <i>35</i> %	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest <i>5</i> % <input checked="" type="checkbox"/> Shrub/Sapling <i>45</i> % <input checked="" type="checkbox"/> Herbs/Grasses <i>50</i> % <input type="checkbox"/> Turf/Crops _____ % Riparian Width: <input type="checkbox"/> <10 ft <input checked="" type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input type="checkbox"/> Mostly shaded (≥75% coverage) <input checked="" type="checkbox"/> Partially shaded (≥25% coverage) <input type="checkbox"/> Halfway shaded (≥50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b> <b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ <b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ <b>Turbidity/Water Clarity:</b> <input checked="" type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____ <b>Sediment Deposits:</b> <input type="checkbox"/> None <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells <input checked="" type="checkbox"/> <i>Silt</i>	

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

### USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: <i>Ballfields / UT-6 WPB</i>	Date: <i>3/6/19</i>	Initials: <i>JWW/JFF</i>
--	------------------------	-----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
<del>IT</del> OT-1	345	1	1	Storm water drain (culvert)
CM-1	344 344-346	1	1	flow control structure @ 346 debris & trash also & channelization
<del>IT</del> OT-2	25ft W/S of <del>CM-1</del> WP 344	1	1	Storm water drain (culvert) stream changes to small stream dimension
IB-1	loss of veg see aerial near Apt	2	3	460' of buffer impact on both banks, loss of veg.
TR-1	WP 349	NA	NA	small trash upstream water
SC-1	WP 350	1	1	small concrete bridge
CM	WP 351 → 352 -30'	1	1	Spill Bank, near water channel navigation, lots behind storage building

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - % _____

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

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



# USA, Cont.

<b>REACH ID:</b> Ballfield	<b>STREAM:</b> <del>UT</del> - WOB	<b>DATE/TIME:</b> 5/16/18 0955	<b>INITIALS:</b> JCM / JFF
<b>OTHER INFO:</b>			

## Average Conditions (check applicable)

<b>Flood Plain Dynamics</b>		<b>Vegetation:</b>	
Connection: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good		<input type="checkbox"/> Forest <input checked="" type="checkbox"/> Shrub/Sapling <input checked="" type="checkbox"/> Tall grasses <input type="checkbox"/> Turf/crops	
Habitat: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good		Encroachment: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good	
<b>Periphyton (attached algae):</b>		<b>Suspended Algae (phytoplankton) abundance:</b>	
Filamentous: <input type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Abundant		<input checked="" type="checkbox"/> None noticeable (water basically clear)	
Prostrate: <input type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Abundant		<input type="checkbox"/> Moderate (water slightly green tinted)	
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant		<input type="checkbox"/> Abundant (water appears green)	
<b>Aquatic Plants In Stream:</b>			
Submerged: <input type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			
Emergent: <input type="checkbox"/> None <input type="checkbox"/> Sparse <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Abundant			
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Abundant			

<b>Aquatic Life Observed:</b> <input type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input type="checkbox"/> Macroinvertebrates	none	<b>Wildlife/Livestock In or Around Stream (evidence of):</b> <input type="checkbox"/> Cattle <input checked="" type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other
--	------	--

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

<input checked="" type="checkbox"/> Outfalls(OT): 1 2 3 Wpt	<input checked="" type="checkbox"/> Impacted Buffers(IB): 1 2 3 Wpt
<input checked="" type="checkbox"/> Stream Crossing(SC): 1 2 3 Wpt	<input type="checkbox"/> Trash(TR): 1 2 3 Wpt
<input type="checkbox"/> Bank Erosion(ER): 1 2 3 Wpt	<input type="checkbox"/> Utilities(UT): 1 2 3 Wpt
<input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt	<input type="checkbox"/> 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:**

<input type="checkbox"/> Incised (degrading)	<input checked="" type="checkbox"/> Channelized	<input type="checkbox"/> Bed Scour	<input checked="" type="checkbox"/> Sediment Deposition
<input type="checkbox"/> Widening	<input type="checkbox"/> Aggrading	<input type="checkbox"/> Bank Failure	<input type="checkbox"/> Culvert Scour (upstream / downstream / top)
<input type="checkbox"/> Headcutting	<input type="checkbox"/> Bank scour	<input type="checkbox"/> Slope failure	<input type="checkbox"/> None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: 5.05 ft (ft) Bankfull Depth: 14.02 ft (ft) Wetted Width: \_\_\_\_\_ (ft) Riffle/Run Depth: 0.21 ft (ft)

Rt bank Ht: 6.05 ft (ft) Bankfull Width: \_\_\_\_\_ (ft) TOB Width: \_\_\_\_\_ (ft) Pool Depth: 1.24 ft (ft)

**Channel Stability:**

Lt Bank: Angle 20 degrees  
 LtBank Vegetation protection: 80 % cover  
 LtBank Erosion Hazard: D M H VH EX (circle one)  
 Length Lt Bank Affected: no erosion

Rt Bank: Angle 20 degrees  
 RtBank Vegetation protection: 80 % cover  
 RtBank Erosion Hazard: D M H VH EX (circle one)  
 Length Rt Bank Affected: no erosion

**Reach Accessibility For Restoration**

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

<p>Notes: (biggest problem(s) you see in survey reach)</p> <p>Stable Banks - Locally Impacted buffers w/ areas of poor veg &amp; sources of run off</p> <p>Wetlands along upper stream</p>	<p><b>Restoration Potential:</b></p> <p><input checked="" type="checkbox"/> Riparian reforestation <input type="checkbox"/> Bank stabilization</p> <p><input type="checkbox"/> Stormwater retrofit <input type="checkbox"/> Outfall stabilization</p> <p><input checked="" type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation</p> <p><input type="checkbox"/> Culvert rehab <input type="checkbox"/> Other</p> <p>add sensitivity</p>
--	---

Place sketch of reach on back of page.

## Unified Stream Assessment (USA)

REACH ID: <u>W0B-1</u>	STREAM: <u>W0B</u>	DATE/TIME: <u>3/6/19 1330</u>	INITIALS: <u>SLM</u>
REACH START		REACH END	
LAT: <u>34.874723°</u>	LAT: <u>34.870479°</u>		
LONG: <u>-92.360494</u>	LONG: <u>-92.365535°</u>		

Average Conditions (check applicable)	
<b>Weather - Antecedent (24-h)</b> Rain in past 72-h: y/ <u>6</u> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input checked="" type="checkbox"/> Partly cloudy	<b>Weather - Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input checked="" type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100%      Flows Measured: Yes / No Stream Gradient: <input type="checkbox"/> High (>25ft/mi) <input type="checkbox"/> Moderate (10-24 ft/mi) <input checked="" type="checkbox"/> Low (<10 ft/mi)      ~Slope: _____ ft/mi Sinuosity: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low = <u>1.2</u>	
<b>Channel Morphology</b> System: Step/Pool - Riffle/Pool - <u>Pool</u> (circle) <input type="checkbox"/> Riffle _____ % <input type="checkbox"/> Run _____ % <input checked="" type="checkbox"/> Pool <u>100</u> % <input type="checkbox"/> Steps _____ %	
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input type="checkbox"/> Woody Debris <input type="checkbox"/> Root Wads <input checked="" type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input checked="" type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input checked="" type="checkbox"/> Forest <u>10</u> % <input checked="" type="checkbox"/> Pasture <u>10</u> % <input type="checkbox"/> Urban _____ % <input type="checkbox"/> Commercial _____ % <input checked="" type="checkbox"/> Row Crops <u>80</u> % <input type="checkbox"/> Hay _____ % <input type="checkbox"/> Industrial _____ % <input type="checkbox"/> Sub-Urban _____ %	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input type="checkbox"/> Urban/Sub-Urban Storm Water <input checked="" type="checkbox"/> Row crops <input checked="" type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input type="checkbox"/> Forest <u>20</u> % <input type="checkbox"/> Shrub/Sapling _____ % <input checked="" type="checkbox"/> Herbs/Grasses <u>30</u> % <input checked="" type="checkbox"/> Turf/Crops <u>50</u> % Riparian Width: <input type="checkbox"/> <10 ft <input checked="" type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input type="checkbox"/> Mostly shaded (≥75% coverage) <input type="checkbox"/> Partially shaded (≥25% coverage) <input type="checkbox"/> Halfway shaded (≥50% coverage) <input checked="" type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b> <b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ <b>Turbidity/Water Clarity:</b> <input type="checkbox"/> Clear <input checked="" type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____ <b>Sediment Deposits:</b> <input type="checkbox"/> None <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells <input checked="" type="checkbox"/> Silt	

### USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: <i>WOB 1 White Oak Bayou</i>	Date: <i>3/6/19</i>	Initials: <i>JCM / JFF</i>
--	------------------------	-------------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
<i>IB-1</i>	<i>28 → 21 → 22 23 → 24</i>	<i>3</i>	<i>2-3</i>	<i>The majority of the reach is dominated by cropland (Rice) Both Banks w/ little to no buffer ~1590'</i>
<i>IB-2</i>	<i>LP-WP 25 → WA 21</i>	<i>2-3</i>	<i>2-3</i>	<i>~1400 ft former road - long much of it</i>
<i>SC-1</i>	<i>34.872864° -92.364252°</i>	<i>1</i>	<i>1</i>	<i>farmers small metal bridges</i>

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - % _____

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

<sup>4</sup>Bank material: circle base type, silt/clay or sand and if present circle rock type and note %

**USA, Cont.**

<b>REACH ID:</b> WOB-1	<b>STREAM:</b> White Oak Bayou	<b>DATE/TIME:</b> 5/4/19	<b>INITIALS:</b> SM/JAP
<b>OTHER INFO:</b>			

**Average Conditions (check applicable)**

<b>Flood Plain Dynamics</b>	
Connection: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	Vegetation: <input type="checkbox"/> Forest <input type="checkbox"/> Shrub/Sapling <input checked="" type="checkbox"/> Tall grasses <input type="checkbox"/> Turf/crops
Habitat: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good	Encroachment: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good
<b>Periphyton (attached algae):</b>	
Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<b>Suspended Algae (phytoplankton) abundance:</b>
Prostrate: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input checked="" type="checkbox"/> None noticeable (water basically clear)
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Moderate (water slightly green tinted)
	<input type="checkbox"/> Abundant (water appears green)
<b>Aquatic Plants In Stream:</b>	
Submerged: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	
Emergent: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	
Floating: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	

<b>Aquatic Life Observed:</b> <input checked="" type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input checked="" type="checkbox"/> Macroinvertebrates	<b>Wildlife/Livestock In or Around Stream (evidence of):</b> <input type="checkbox"/> Cattle <input checked="" type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other _____
--	--

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

<input type="checkbox"/> Outfalls(OT): 1 2 3 Wpt _____	<input type="checkbox"/> Impacted Buffers(IB): 1 2 3 Wpt _____
<input checked="" type="checkbox"/> Stream Crossing(SC): ① 2 3 Wpt _____	<input checked="" type="checkbox"/> Trash(TR): ① 2 3 Wpt _____
<input type="checkbox"/> Bank Erosion(ER): 1 2 3 Wpt _____	<input type="checkbox"/> Utilities(UT): 1 2 3 Wpt _____
<input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt _____	<input checked="" type="checkbox"/> Other (water irrigation): ① 2 3 Wpt _____

**Notes:**

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

**Channel Dynamics:**

<input type="checkbox"/> Incised (degrading)	<input type="checkbox"/> Channelized	<input type="checkbox"/> Bed Scour	<input checked="" type="checkbox"/> Sediment Deposition
<input type="checkbox"/> Widening	<input type="checkbox"/> Aggrading	<input type="checkbox"/> Bank Failure	<input type="checkbox"/> Culvert Scour (upstream / downstream / top)
<input type="checkbox"/> Headcutting	<input type="checkbox"/> Bank scour	<input type="checkbox"/> Slope failure	<input type="checkbox"/> None (natural stable channel) <i>channel are stable</i>

**Channel Dimensions (facing downstream):**

Lt bank Ht: 5.0 (ft) Bankfull Depth 5.0 (ft) Wetted Width: 26 (ft) Riffle/Run Depth \_\_\_\_\_ (ft)  
 Rt bank Ht: 5.475 (ft) Bankfull Width 20 (ft) TOB Width: 30 (ft) Pool Depth 3.0 (ft)

**Channel Stability:**

Lt Bank: Angle 70 degrees Rt Bank: Angle 55 degrees  
 LtBank Vegetation protection: 20 % cover RtBank Vegetation protection 45 % cover  
 LtBank Erosion Hazard: ① M H VH EX (circle one) RtBank Erosion Hazard: ① M H VH EX (circle one)  
 Length Lt Bank Affected: mostly stable Length Rt Bank Affected: mostly stable  
 Wpt(s): \_\_\_\_\_ Wpt(s): \_\_\_\_\_

**Reach Accessibility For Restoration**

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

<p><b>Notes:</b> (biggest problem(s) you see in survey reach)</p> <p><i>Agri, no buffer, stream sliding</i></p> <p><i>farmer owned water</i></p> <p>Place sketch of reach on back of page.</p>	<p><b>Restoration Potential:</b></p> <p><input type="checkbox"/> Riparian reforestation <input type="checkbox"/> Bank stabilization</p> <p><input type="checkbox"/> Stormwater retrofit <input type="checkbox"/> Outfall stabilization</p> <p><input type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation</p> <p><input type="checkbox"/> Culvert rehab. <input type="checkbox"/> Other _____</p>
--	---



## Unified Stream Assessment (USA)

REACH ID: <i>GC-2</i>	STREAM: <i>Unamed Trib</i>	DATE/TIME: <i>2/6/13 11:10</i>	INITIALS: <i>Scm/JFP</i>
REACH START <i>34.830865°</i>	REACH END		
LAT: <i>34.830865</i>	LAT: <i>34.830865</i>		
LONG: <i>-92.389938</i>	LONG: <i>-92.392525</i>		

Average Conditions (check applicable)					
<b>Weather – Antecedent (24-h)</b> Rain in past 72-h: y/n <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input checked="" type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy				
<b>Stream Classification</b> <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____				
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100%      Flows Measured: Yes / <input checked="" type="checkbox"/> No Stream Gradient: <input type="checkbox"/> High (>25ft/mi) <input type="checkbox"/> Moderate (10-24 ft/mi) <input type="checkbox"/> Low (<10 ft/mi)      ~Slope: _____ ft/mi Sinuosity: <input type="checkbox"/> High <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Low					
<b>Channel Morphology</b> System: Step/Pool - Riffle/Pool - <input checked="" type="checkbox"/> Pool (circle) <input type="checkbox"/> Riffle _____ % <input type="checkbox"/> Run _____ % <input type="checkbox"/> Pool <i>100</i> % <input type="checkbox"/> Steps _____ %					
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or silt) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input type="checkbox"/> Woody Debris <input checked="" type="checkbox"/> Root Wads <input type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal				
<b>Land use</b> <input checked="" type="checkbox"/> Forest <i>5</i> % <input type="checkbox"/> Pasture _____ % <input type="checkbox"/> Urban _____ % <input checked="" type="checkbox"/> Commercial <i>45</i> % <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay _____ % <input type="checkbox"/> Industrial _____ % <input checked="" type="checkbox"/> Sub-Urban <i>55</i> % <input checked="" type="checkbox"/> <i>Golf Course 15%</i>	<b>Local Watershed NPS Pollution</b> <input checked="" type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input checked="" type="checkbox"/> Other <i>Golf Course</i> <input type="checkbox"/> No evidence				
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest <i>25</i> % <input type="checkbox"/> Shrub/Sapling <i>10</i> % <input checked="" type="checkbox"/> Herbs/Grasses <i>5</i> % <input checked="" type="checkbox"/> Turf/Crops <i>60</i> % Riparian Width: <input type="checkbox"/> <10 ft <input checked="" type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input type="checkbox"/> > 50 ft					
<b>Stream Shading (water surface)</b> <input type="checkbox"/> Mostly shaded (≥75% coverage) <input type="checkbox"/> Partially shaded (≥25% coverage) <input checked="" type="checkbox"/> Halfway shaded (≥50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)					
<b>Water Quality Observations</b> <table style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> <b>Odors Noted:</b>  <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic  <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____               </td> <td style="width: 50%; vertical-align: top;"> <b>Water Surface Appearance:</b>  <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs  <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____               </td> </tr> <tr> <td style="vertical-align: top;"> <b>Turbidity/Water Clarity:</b>  <input type="checkbox"/> Clear <input checked="" type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid  <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____               </td> <td></td> </tr> </table>		<b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____	<b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____	<b>Turbidity/Water Clarity:</b> <input type="checkbox"/> Clear <input checked="" type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____	
<b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____	<b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____				
<b>Turbidity/Water Clarity:</b> <input type="checkbox"/> Clear <input checked="" type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____					
<b>Sediment Deposits:</b> <input checked="" type="checkbox"/> None <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells					

**USA Reach Impact Data Detail Sheet (optional)**

<b>Reach ID/Stream:</b> BC-2 UT	<b>Date:</b> 5/6/19 1110	<b>Initials:</b> JW/JPF
------------------------------------	-----------------------------	----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
ER-1 L&R/B	WP 355 → 358	2	2	some fresh bank banks steep incised, erosion ~ 1000'
SC-1	WP 358	1	1	Road for links Apt power
Golf course	WP 359 → 363	2	1	Golf course 519'
SC-2	WP 360	1	1	power GC crossing
OT-1	WP 361	1	1	culvert from Apt
SC-3	WP 361	1	1	power to Apt

~~SC-4~~ ~~with below~~ GC

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER-4 L&R/B	WP 355 → JPF	<u>L</u> M H VH EX (circle one)	1000 1000	1	Bank: Height 4.5L 3.0R ft, Angle 65 Deg Protection: Roots 65%, Root Depth 0.5 ft Vegetation 60% 4Material: <u>Silt/Clay</u> Sand / Gravel Cobble - %
ER-7	WP 363 → 364 end of GC	<u>L</u> M H VH EX (circle one)	489' 489'	1	Bank: Height 4.0 4.5 ft, Angle 75 Deg Protection: Roots 60%, Root Depth 1 ft Vegetation 40% 4Material: <u>Silt/Clay</u> Sand / Gravel Cobble - %
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____%, Root Depth _____ ft Vegetation _____% 4Material: Silt/Clay Sand / Gravel Cobble - %
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____%, Root Depth _____ ft Vegetation _____% 4Material: Silt/Clay Sand / Gravel Cobble - %
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____%, Root Depth _____ ft Vegetation _____% 4Material: Silt/Clay Sand / Gravel Cobble - %

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

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



**USA, Cont.**

<b>REACH ID:</b> GC-2	<b>STREAM:</b> WT	<b>DATE/TIME:</b> 3/11/17 11:10	<b>INITIALS:</b> JUN/JFP
<b>OTHER INFO:</b>			

**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 Beavers

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

<input checked="" type="checkbox"/> Outfalls(OT): <u>2</u> 3 Wpt _____	<input checked="" type="checkbox"/> Impacted Buffers(IB): 1 <u>2</u> 3 Wpt _____
<input type="checkbox"/> Stream Crossing(SC): <u>1</u> 2 3 Wpt _____	<input type="checkbox"/> Trash(TR): <u>2</u> 3 Wpt _____
<input checked="" type="checkbox"/> Bank Erosion(ER): 1 <u>2</u> 3 Wpt _____	<input checked="" type="checkbox"/> Utilities(UT): <u>1</u> 2 3 Wpt _____
<input checked="" type="checkbox"/> Channel Modification(CM): <u>1</u> 2 3 Wpt _____	<input checked="" type="checkbox"/> Other <u>Golf course</u> : 1 <u>3</u> 3 Wpt _____

Notes:

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

**Channel Dynamics:**

<input checked="" type="checkbox"/> Incised (degrading)	<input type="checkbox"/> Channelized	<input type="checkbox"/> Bed Scour	<input checked="" type="checkbox"/> Sediment Deposition
<input type="checkbox"/> Widening	<input type="checkbox"/> Aggrading	<input type="checkbox"/> Bank Failure	<input type="checkbox"/> Culvert Scour (upstream / downstream / top)
<input type="checkbox"/> Headcutting	<input checked="" type="checkbox"/> Bank scour	<input type="checkbox"/> Slope failure	<input type="checkbox"/> None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: 4.5, 4.5 (ft) Bankfull Depth 2, 10, 3.5 (ft) Wetted Width: 7, 8.5, 14 (ft) Riffle/Run Depth \_\_\_\_\_ (ft)  
 Rt bank Ht: 3, 4.8, 4.5 (ft) Bankfull Width 5, 2, 14 (ft) TOB Width: 8, 12, 22 (ft) Pool Depth 1, 1.2, 3 (ft)

**Channel Stability:**

Lt Bank: Angle 70 degrees Rt Bank: Angle 70 degrees  
 LtBank Vegetation protection: 40 % cover RtBank Vegetation protection 40 % cover  
 LtBank Erosion Hazard: L M H VH EX (circle one) RtBank Erosion Hazard: L M H VH EX (circle one)  
 Length Lt Bank Affected: 1489 In undred Length Rt Bank Affected: 1489  
 Wpt(s): see impacts form Wpt(s): see impacts

**Reach Accessibility For Restoration**

<b>Good:</b> Open area in public ownership. Easy stream channel access by vehicle.	<b>Fair:</b> Forested or developed near stream. Vehicle access limited.	<b>Difficult:</b> 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)  
Incising & poor FP control  
Bank stability, golf course

**Restoration Potential:**

<input type="checkbox"/> Riparian reforestation	<input type="checkbox"/> Bank stabilization
<input type="checkbox"/> Stormwater retrofit	<input type="checkbox"/> Outfall stabilization
<input type="checkbox"/> Channel modification	<input type="checkbox"/> PS investigation
<input type="checkbox"/> Culvert rehab.	<input checked="" type="checkbox"/> Other <u>post-dred</u>

you could bank riparian bank stabilization but not likely

Place sketch of reach on back of page.

## Unified Stream Assessment (USA)

REACH ID: NC-2	STREAM: Newton Creek	DATE/TIME: 3/16/2017 1130	INITIALS: Jum/JFF
REACH START		REACH END	
LAT: 34.847590°	LAT: 34.843553°		
LONG: -92.235448°	LONG: -92.239678°		

Average Conditions (check applicable)	
<b>Weather – Antecedent (24-h)</b> Rain in past 72-h: y / ( ) <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input checked="" type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100% <b>Flows Measured:</b> Yes ( ) No ( ) Stream Gradient: <input type="checkbox"/> High (≥25ft/mi) <input checked="" type="checkbox"/> Moderate (10-24 ft/mi) <input type="checkbox"/> Low (<10 ft/mi)      ~Slope: 20 ft/mi Sinuosity: <input type="checkbox"/> High <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Low 1.38	
<b>Channel Morphology</b> <b>System:</b> Step/Pool <input checked="" type="checkbox"/> Riffle/Pool - Pool (circle) <input type="checkbox"/> Riffle 20% <input checked="" type="checkbox"/> Run 10% <input checked="" type="checkbox"/> Pool 65% <input type="checkbox"/> Steps _____ %	
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> 10cm <input type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input checked="" type="checkbox"/> Woody Debris <input type="checkbox"/> Root Wads <input type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input type="checkbox"/> Forest 20% <input checked="" type="checkbox"/> Pasture 5% <input type="checkbox"/> Urban 70% <input type="checkbox"/> Commercial 10% <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay _____ % <input type="checkbox"/> Industrial _____ % <input type="checkbox"/> Sub-Urban 70%	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input checked="" type="checkbox"/> Other 'junk yard' <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input type="checkbox"/> Forest 20% <input checked="" type="checkbox"/> Shrub/Sapling 5% <input checked="" type="checkbox"/> Herbs/Grasses 75% <input type="checkbox"/> Turf/Crops _____ % Riparian Width: <input type="checkbox"/> <10 ft <input checked="" type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input type="checkbox"/> Mostly shaded (≥75% coverage) <input type="checkbox"/> Partially shaded (≥25% coverage) <input checked="" type="checkbox"/> Halfway shaded (≥50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b> <b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ <b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____	
<b>Turbidity/Water Clarity:</b> <input checked="" type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____	
<b>Sediment Deposits:</b> <input checked="" type="checkbox"/> None <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells	

**USA Reach Impact Data Detail Sheet (optional)**

<b>Reach ID/Stream:</b> NC-2 Newton Creek	<b>Date:</b> 3/6/2019 1430	<b>Initials:</b> SCM/JFF
--	-------------------------------	-----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
ER-1 ZB	See below	1	1	steep with some erosion but heavily eroded. Private property w/ poor access
ER-2 LB	See below	2	2	Bankway cut, poor riparian needs cover
UT-1	34.844345° -92.336291°	1	1	T-line
UT-2	34.844401° -92.337212°	1	1	D-line
SC-1	34.845518° -92.337279°	1	1	foot bridge
SC-2	34.844586° -92.337261°	1	1	private drive bridge
ER-3 LB	34.845385°	2-3	2	Bank failure & widening poor buffer
RB ER-4	-92.337526° <i>see below</i>	1	1	private prop. / ER-4 no buffer, right adjacent house
SC-3	34.844983° -92.337580°	1	1	highway bridge
SC-4	34.843912° -92.338034°	1	1	Railroad Bridge
ER-5	see below	2	2	widening, blocks of buffer, significant rock cover

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER-1 RB	34.847571° → -92.335482° 34.847823° -92.335683°	Ⓛ M H VH EX (circle one)	112'	1	Bank: Height <u>6</u> ft, Angle <u>90</u> Deg Protection: Roots <u>60</u> %, Root Depth <u>2</u> ft Vegetation <u>90</u> % *Material: <u>Silt/Clay Sand / Gravel</u> Cobble - % <u>15</u>
ER-2 LB	34.845896° → -92.336117° → 34.845517° → -92.336075°	L Ⓜ H VH EX (circle one)	140'	2	Bank: Height <u>4.5</u> ft, Angle <u>90</u> Deg Protection: Roots <u>25</u> %, Root Depth <u>0.5</u> ft Vegetation <u>5</u> % *Material: <u>Silt/Clay Sand / Gravel</u> Cobble - % <u>15</u>
ER-3 LB	34.845385° → -92.337526° → 34.845129° -92.337620°	L M Ⓜ VH EX (circle one)	100'	2	Bank: Height <u>3.5</u> ft, Angle <u>25</u> Deg Protection: Roots <u>25</u> %, Root Depth <u>0.1</u> ft Vegetation <u>5</u> % *Material: <u>Silt/Clay Sand / Gravel</u> Cobble - % <u>5</u>
ER-4 RB	34.844854° → -92.337523° → 34.844793° -92.337455°	Ⓛ M H VH EX (circle one)	45'	1	Bank: Height <u>7</u> ft, Angle <u>20</u> Deg Protection: Roots <u>50</u> %, Root Depth <u>3</u> ft Vegetation <u>25</u> % *Material: <u>Silt/Clay Sand / Gravel</u> Cobble - % <u>25</u>
ER-5 LB	34.844809° → -92.337215° → 34.844175° -92.337263°	L Ⓜ H VH EX (circle one)	50'	2	Bank: Height <u>5</u> ft, Angle <u>90</u> Deg Protection: Roots <u>15</u> %, Root Depth <u>0.75</u> ft Vegetation <u>10</u> % *Material: <u>Silt/Clay Sand / Gravel</u> Cobble - % <u>60</u>

<sup>1</sup> Impacts: Outfall(OT), Bank Erosion(ER), Impacted buffer(IB), Utilities in channel(UT), Stream crossing(SC), Channel modification(CM), Trash in stream(TR), other.  
<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe  
<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high  
<sup>4</sup> Bank material: circle base type, silt/clay or sand and if present circle rock type and note %.



## USA, Cont.

<b>REACH ID:</b> NC-2	<b>STREAM:</b> Newton Creek	<b>DATE/TIME:</b> 3/4/19 1430	<b>INITIALS:</b> JUN JST
<b>OTHER INFO:</b>			

### Average Conditions (check applicable)

<b>Flood Plain Dynamics</b>			
Connection: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good	Vegetation: <input checked="" type="checkbox"/> Forest <input type="checkbox"/> Shrub/Sapling <input type="checkbox"/> Tall grasses <input checked="" type="checkbox"/> Turf/crops		
Habitat: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good	Encroachment: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good		
<b>Periphyton (attached algae):</b>		<b>Suspended Algae (phytoplankton) abundance:</b>	
Filamentous: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input checked="" type="checkbox"/> None noticeable (water basically clear)	Prostrate: <input type="checkbox"/> None <input type="checkbox"/> Sparse <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Moderate (water slightly green tinted)
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Abundant (water appears green)		
<b>Aquatic Plants in Stream:</b>			
Submerged: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant		Emergent: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			

<b>Aquatic Life Observed:</b> <input checked="" type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input checked="" type="checkbox"/> Macroinvertebrates	<b>Wildlife/Livestock In or Around Stream (evidence of):</b> <input type="checkbox"/> Cattle <input type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other
--	---

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

<input type="checkbox"/> Outfalls(OT): 1 2 3 Wpt _____	<input type="checkbox"/> Impacted Buffers(IB): 1 2 3 Wpt _____
<input checked="" type="checkbox"/> Stream Crossing(SC): 1 2 3 Wpt _____	<input type="checkbox"/> Trash(TR): 1 2 3 Wpt _____
<input checked="" type="checkbox"/> Bank Erosion(ER): 1 2 3 Wpt _____	<input checked="" type="checkbox"/> Utilities(UT): 1 2 3 Wpt _____
<input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt _____	<input type="checkbox"/> 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:**

<input type="checkbox"/> Incised (degrading)	<input type="checkbox"/> Channelized	<input type="checkbox"/> Bed Scour	<input type="checkbox"/> Sediment Deposition
<input checked="" type="checkbox"/> Widening	<input type="checkbox"/> Aggrading	<input checked="" type="checkbox"/> Bank Failure	<input type="checkbox"/> Culvert Scour (upstream / downstream / top)
<input type="checkbox"/> Headcutting	<input checked="" type="checkbox"/> Bank scour	<input type="checkbox"/> Slope failure	<input type="checkbox"/> None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: 4.5 (ft)	Bankfull Depth: 4.5 (ft)	Wetted Width: 13.5 (ft)	Riffle/Run Depth: 0.25 (ft)
Rt bank Ht: 6 (ft)	Bankfull Width: 16 (ft)	TOB Width: 16.5 (ft)	Pool Depth: 2.5 (ft)

**Channel Stability:**

Lt Bank: Angle 50 degrees	Rt Bank: Angle 50 degrees
LtBank Vegetation protection: 15 % cover	RtBank Vegetation protection: 10 % cover
LtBank Erosion Hazard: L M <b>B</b> VH EX (circle one)	RtBank Erosion Hazard: L <b>M</b> H VH EX (circle one)
Length Lt Bank Affected: 790'	Length Rt Bank Affected: 157'
Wpt(s): see in points	Wpt(s): see in points

**Reach Accessibility For Restoration**

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

<p><b>Notes:</b> (biggest problem(s) you see in survey reach)</p> <p>loss of riparian veg + encroachment incising - caused by bank failure</p>	<p><b>Restoration Potential:</b></p> <p><input checked="" type="checkbox"/> Riparian reforestation <input type="checkbox"/> Bank stabilization</p> <p><input type="checkbox"/> Stormwater retrofit <input type="checkbox"/> Outfall stabilization</p> <p><input type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation</p> <p><input type="checkbox"/> Culvert rehab <input type="checkbox"/> Other _____</p>
Place sketch of reach on back of page.	

$$2660' / 1930 = 1.37$$

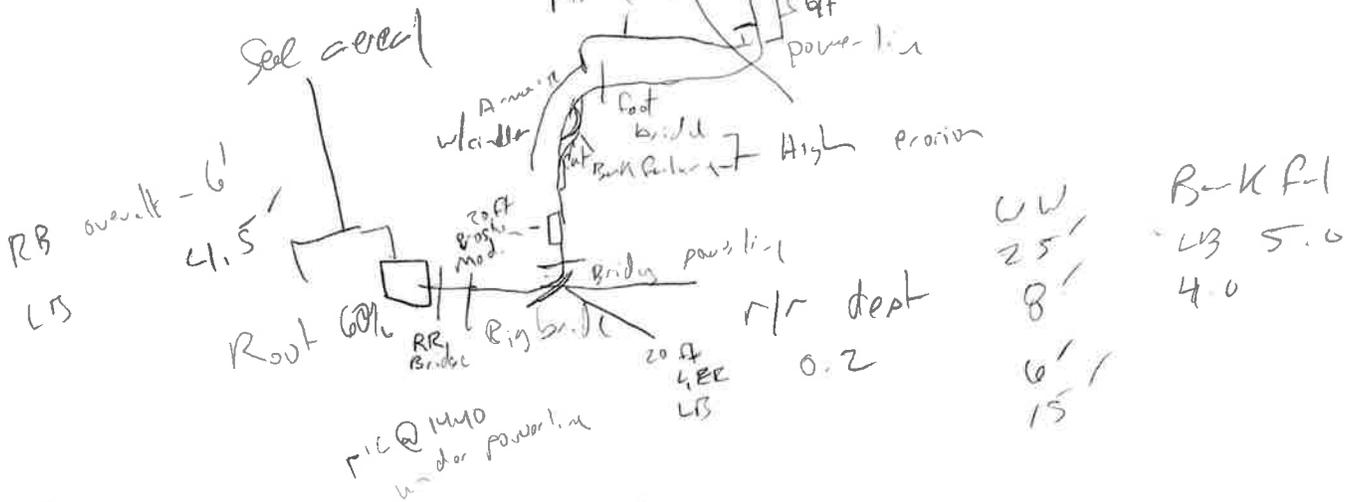
286 276  $\frac{10}{2660}$   $\frac{1}{266}$

RB 50' L to MER

50 to 60%

pool depth 2.5'

LB - 4





## Unified Stream Assessment (USA)

REACH ID: <i>Dog Park</i>	STREAM:	DATE/TIME:	INITIALS:
REACH START		REACH END	
LAT:		LAT:	
LONG:		LONG:	

Average Conditions (check applicable)	
<b>Weather – Antecedent (24-h)</b> Rain in past 72-h: y / n <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100% <b>Flows Measured:</b> Yes <input checked="" type="checkbox"/> No Stream Gradient: <input type="checkbox"/> High (≥25ft/mi) <input type="checkbox"/> Moderate (10-24 ft/mi) <input checked="" type="checkbox"/> Low (<10 ft/mi)      ~Slope: _____ ft/mi Sinuosity: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low	
<b>Channel Morphology</b> <b>System:</b> Step/Pool - Riffle/Pool - Pool (circle) <input type="checkbox"/> Riffle <u>0</u> % <input checked="" type="checkbox"/> Run <u>70</u> % <input checked="" type="checkbox"/> Pool <u>30</u> % <input type="checkbox"/> Steps <u>0</u> %	
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input type="checkbox"/> Woody Debris <input type="checkbox"/> Root Wads <input type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input checked="" type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input type="checkbox"/> Forest _____% <input type="checkbox"/> Pasture _____% <input checked="" type="checkbox"/> Urban _____% <input type="checkbox"/> Commercial _____% <input type="checkbox"/> Row Crops _____% <input type="checkbox"/> Hay _____% <input type="checkbox"/> Industrial _____% <input type="checkbox"/> Sub-Urban _____%	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest <u>5</u> % <input checked="" type="checkbox"/> Shrub/Sapling <u>35</u> % <input checked="" type="checkbox"/> Herbs/Grasses <u>10</u> % <input checked="" type="checkbox"/> Turf/Crops <u>50</u> % Riparian Width: <input checked="" type="checkbox"/> <10 ft <input type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input type="checkbox"/> Mostly shaded (≥75% coverage) <input checked="" type="checkbox"/> Partially shaded (≥25% coverage) <input type="checkbox"/> Halfway shaded (≥50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b> <i>(WQP 152 (1/10/11))</i> <b>Odors Noted:</b> <input type="checkbox"/> Normal/None <input checked="" type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ <b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input checked="" type="checkbox"/> Sheen <input type="checkbox"/> Globs <input type="checkbox"/> Flecks <input type="checkbox"/> None <input type="checkbox"/> Other _____ <b>Turbidity/Water Clarity:</b> <input checked="" type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____ <b>Sediment Deposits:</b> <input type="checkbox"/> None <input checked="" type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells <div style="text-align: center;"><i>(Silt)</i></div>	

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

### USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: <b>DOG PARK</b>	Date: <b>12/5/18</b>	Initials: <b>JF/KJH</b>
-------------------------------------	-------------------------	----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
SC, OT IB, TR SC - 150	149 JLF 150	3,2 3,2 3	3 3	SW runoff from impervious surfaces of mowed grasses, driveways - culverts TR also
IB, OT TR IB, UT, TR OT	151 JLF 152 154 (Culverts)	3,2 3 3,2,2	2 2 1	SW runoff from impervious surfaces, rip rap on L Bank, Dumpster near L Bank Culverts, rip rap along rd. @ 154
IB, SC SC CM, OT, IB	155 (Culverts) 157 (Culverts) 15a (Silt of concrete)	3,3 3 3,2,3	3 3 3	155 Street on bank's side from under rd. (Silt) through gate, concrete, rip rap Major impacts, lawns/towers, embankment
OT, SC, IB SC, IB SC, IB	160 161 (end of concrete) 162	2,2,3 2,3 1,3	1 3	Concrete lined ditch from 15a to 160 162 gdf cart x-ing wooden bank
SC, UT, IB	163	3,2,3		

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER	151a	L (M) H VH EX (circle one)			Bank: Height <u>3.5</u> ft, Angle <u>90</u> Deg Protection: Roots <u>0</u> %, Root Depth <u>5</u> ft Vegetation <u>10</u> % <sup>4</sup> Material: (Silt/Clay) Sand / Gravel Cobble - %
ER	152	L (M) H VH EX (circle one)			Bank: Height <u>NA</u> ft, Angle <u>NA</u> Deg Protection: Roots <u>NA</u> %, Root Depth <u>NA</u> ft Vegetation <u>10</u> % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - %

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

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

## USA, Cont.

<b>REACH ID:</b> Dog Park	<b>STREAM:</b> UT	<b>DATE/TIME:</b> 12/5/18 10:45	<b>INITIALS:</b> JH/JJF
<b>OTHER INFO:</b>			

### Average Conditions (check applicable)

<b>Flood Plain Dynamics</b>	<b>Vegetation:</b> <input type="checkbox"/> Forest <input type="checkbox"/> Shrub/Sapling <input type="checkbox"/> Tall grasses <input checked="" type="checkbox"/> Turf/crops
Connection: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good	Encroachment: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good
Habitat: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good	

<b>Periphyton (attached algae):</b>	<b>Suspended Algae (phytoplankton) abundance:</b>
Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input checked="" type="checkbox"/> None noticeable (water basically clear)
Prostrate: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Moderate (water slightly green tinted)
Floating: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Abundant (water appears green)

<b>Aquatic Plants In Stream:</b>	
Submerged: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	
Emergent: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Abundant	Upper reach
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	

<b>Aquatic Life Observed:</b> None	<b>Wildlife/Livestock In or Around Stream (evidence of):</b>
<input type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input type="checkbox"/> Macroinvertebrates	<input type="checkbox"/> Cattle <input type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other

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

<input checked="" type="checkbox"/> Outfalls(OT): 1 2 3 Wpt	<input checked="" type="checkbox"/> Impacted Buffers(IB): 1 2 3 Wpt
<input checked="" type="checkbox"/> Stream Crossing(SC): 1 2 3 Wpt	<input checked="" type="checkbox"/> Trash(TR): 1 2 3 Wpt
<input checked="" type="checkbox"/> Bank Erosion(ER): 1 2 3 Wpt	<input checked="" type="checkbox"/> Utilities(UT): 1 2 3 Wpt
<input checked="" type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt	<input type="checkbox"/> 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:**

<input type="checkbox"/> Incised (degrading)	<input checked="" type="checkbox"/> Channelized	<input type="checkbox"/> Bed Scour	<input checked="" type="checkbox"/> Sediment Deposition
<input type="checkbox"/> Widening	<input checked="" type="checkbox"/> Aggrading	<input type="checkbox"/> Bank Failure	<input checked="" type="checkbox"/> Culvert Scour (upstream / downstream) / top
<input type="checkbox"/> Headcutting	<input type="checkbox"/> Bank scour	<input type="checkbox"/> Slope failure	<input type="checkbox"/> None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: 6 (ft)	Bankfull Depth: 1.0 (ft)	Wetted Width: 3.5 (ft)	Riffle/Run Depth: NA (ft)
Rt bank Ht: 3 (ft)	Bankfull Width: 7 (ft)	TOB Width: 12 (ft)	Pool Depth: 1.3 (ft)

**Channel Stability:** \*Consider upper, mid, lower assessment

Lt Bank: Angle 20-90 degrees	Rt Bank: Angle 20-90 degrees
LtBank Vegetation protection: 70 % cover	RtBank Vegetation protection: 75 % cover
LtBank Erosion Hazard: (L) M H VH EX (circle one)	RtBank Erosion Hazard: (L) M H VH EX (circle one)
Length Lt Bank Affected: See pg 2	Length Rt Bank Affected: _____
Wpt(s): See pg 2	Wpt(s): _____

**Reach Accessibility For Restoration**

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

<b>Notes:</b> (biggest problem(s) you see in survey reach) IB, SC, Sedimentation, Trash in upper reach	<b>Restoration Potential:</b>
	<input checked="" type="checkbox"/> Riparian reforestation <input type="checkbox"/> Bank stabilization
	<input checked="" type="checkbox"/> Stormwater retrofit <input type="checkbox"/> Outfall stabilization
	<input type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation
	<input type="checkbox"/> Culvert rehab. <input type="checkbox"/> Other _____

**Place sketch of reach on back of page.**



## Unified Stream Assessment (USA)

REACH ID: <b>WOB2</b>	STREAM: <b>White Oak Bayou</b>	DATE/TIME: <b>12/5/18 1345-</b>	INITIALS: <b>SJH/JJF</b>
REACH START		REACH END	
LAT:		LAT:	
LONG:		LONG:	

Average Conditions (check applicable) <sup>1</sup>	
<b>Weather – Antecedent (24-h)</b> Rain in past 72-h: y / n <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input checked="" type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input checked="" type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100%      Flows Measured: Yes <input checked="" type="checkbox"/> No Stream Gradient: <input type="checkbox"/> High (≥25ft/mi) <input type="checkbox"/> Moderate (10-24 ft/mi) <input checked="" type="checkbox"/> Low (<10 ft/mi)      ~Slope: _____ ft/mi Sinuosity: <input type="checkbox"/> High <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Low	
<b>Channel Morphology</b> System: Step/Pool - Riffle/Pool - Pool (circle) <input type="checkbox"/> Riffle _____ % <input checked="" type="checkbox"/> Run <u>25</u> % <input checked="" type="checkbox"/> Pool <u>75</u> % <input type="checkbox"/> Steps _____ %	
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input checked="" type="checkbox"/> Woody Debris <input checked="" type="checkbox"/> Root Wads <input type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input type="checkbox"/> Forest _____ % <input type="checkbox"/> Pasture _____ % <input type="checkbox"/> Urban _____ % <input type="checkbox"/> Commercial _____ % <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay _____ % <input type="checkbox"/> Industrial _____ % <input type="checkbox"/> Sub-Urban _____ %	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest <u>50</u> % <input checked="" type="checkbox"/> Shrub/Sapling <u>15</u> % <input checked="" type="checkbox"/> Herbs/Grasses <u>35</u> % <input type="checkbox"/> Turf/Crops _____ % Riparian Width: <input type="checkbox"/> <10 ft <input type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input checked="" type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input checked="" type="checkbox"/> Mostly shaded (≥75% coverage) <input type="checkbox"/> Partially shaded (≥25% coverage) <input type="checkbox"/> Halfway shaded (≥50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b> <b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ <b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ <b>Turbidity/Water Clarity:</b> <input type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input checked="" type="checkbox"/> Stained <input type="checkbox"/> Other _____ <b>Sediment Deposits:</b> <input type="checkbox"/> None <input checked="" type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells	

<sup>1</sup> Modified from *Unified Stream Assessment: A Users Manual*, (Kitchall & Schuller, 2004)

12/15

**USA Reach Impact Data Detail Sheet (optional)**

Reach ID/Stream: <b>WOB 2</b>	Date: <b>12/5/18</b>	Initials: <b>SJH/JJF</b>
----------------------------------	-------------------------	-----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
OT	174 Storm Dec 1-2018 175 12/1/18 WOB 2 series			

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - % _____

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

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

## USA, Cont.

<b>REACH ID:</b> <u>WOB 2</u>	<b>STREAM:</b> <u>White Oak Bayou</u>	<b>DATE/TIME:</b> <u>12/5/10 1513</u>	<b>INITIALS:</b> <u>SJH/JJF</u>
<b>OTHER INFO:</b>			

### Average Conditions (check applicable)

<b>Flood Plain Dynamics</b>	
Connection: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	Vegetation: <input checked="" type="checkbox"/> Forest <input checked="" type="checkbox"/> Shrub/Sapling <input type="checkbox"/> Tall grasses <input type="checkbox"/> Turf/crops
Habitat: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	Encroachment: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good
<b>Periphyton (attached algae):</b>	
Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<b>Suspended Algae (phytoplankton) abundance:</b>
Prostrate: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input checked="" type="checkbox"/> None noticeable (water basically clear)
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Moderate (water slightly green tinted)
	<input type="checkbox"/> Abundant (water appears green)
<b>Aquatic Plants In Stream:</b>	
Submerged: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	
Emergent: <input type="checkbox"/> None <input type="checkbox"/> Sparse <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Abundant	
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	

<b>Aquatic Life Observed:</b> <input type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input type="checkbox"/> Macroinvertebrates	<b>Wildlife/Livestock In or Around Stream (evidence of):</b> <input type="checkbox"/> Cattle <input checked="" type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other _____
--	--

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

<input type="checkbox"/> Outfalls(OT): 1 2 3 Wpt _____	<input type="checkbox"/> Impacted Buffers(IB): 1 2 3 Wpt _____
<input type="checkbox"/> Stream Crossing(SC): 1 2 3 Wpt _____	<input type="checkbox"/> Trash(TR): 1 2 3 Wpt _____
<input type="checkbox"/> Bank Erosion(ER): 1 2 3 Wpt _____	<input checked="" type="checkbox"/> Utilities(UT): <u>(1)</u> 2 3 Wpt <u>174</u>
<input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt _____	<input type="checkbox"/> 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:**

<input type="checkbox"/> Incised (degrading)	<input type="checkbox"/> Channelized	<input type="checkbox"/> Bed Scour	<input checked="" type="checkbox"/> Sediment Deposition
<input type="checkbox"/> Widening	<input type="checkbox"/> Aggrading	<input type="checkbox"/> Bank Failure	<input type="checkbox"/> Culvert Scour (upstream / downstream / top)
<input type="checkbox"/> Headcutting	<input type="checkbox"/> Bank scour	<input type="checkbox"/> Slope failure	<input type="checkbox"/> None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: <u>7</u> (ft)	Bankfull Depth: <u>5</u> (ft)	Wetted Width: <u>45</u> (ft)	Riffle/Run Depth: <u>NA</u> (ft)
Rt bank Ht: <u>4</u> (ft)	Bankfull Width: <u>70</u> (ft)	TOB Width: <u>110</u> (ft)	Pool Depth: <u>NA</u> (ft)

**Channel Stability:**

Lt Bank: Angle <u>10-45</u> degrees	Rt Bank: Angle <u>10-25</u> degrees
LtBank Vegetation protection: <u>90</u> % cover	RtBank Vegetation protection: <u>90</u> % cover
LtBank Erosion Hazard: <u>(L)</u> M H VH EX (circle one)	RtBank Erosion Hazard: <u>(L)</u> M H VH EX (circle one)
Length Lt Bank Affected: <u>NONE</u>	Length Rt Bank Affected: <u>NONE</u>
Wpt(s): _____	Wpt(s): _____

**Reach Accessibility For Restoration**

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

<p>5                      4                      3                      2                      1</p>	
<p><b>Notes:</b> (biggest problem(s) you see in survey reach)</p> <p><u>Sedimentation, Proximity to utilities &amp; roads, (minor)</u></p>	<p><b>Restoration Potential:</b></p> <p><input type="checkbox"/> Riparian reforestation <input type="checkbox"/> Bank stabilization</p> <p><input type="checkbox"/> Stormwater retrofit <input type="checkbox"/> Outfall stabilization</p> <p><input type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation</p> <p><input type="checkbox"/> Culvert rehab. <input type="checkbox"/> Other _____</p> <p style="text-align: center;"><u>NA</u></p>

Place sketch of reach on back of page.



## Unified Stream Assessment (USA)

<b>REACH ID:</b> Golf Course 1	<b>STREAM:</b>	<b>DATE/TIME:</b> 11:00 - 12/5/18 13:15	<b>INITIALS:</b> SJH / JJF
<b>REACH START</b>		<b>REACH END</b>	
<b>LAT:</b>	<b>LAT:</b>		
<b>LONG:</b>	<b>LONG:</b>		

Average Conditions (check applicable)	
<b>Weather – Antecedent (24-h)</b> Rain in past 72-h: y / n <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input checked="" type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input checked="" type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> <b>Flow:</b> <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low <input type="checkbox"/> None <span style="margin-left: 20px;"><i>Upper</i></span> <span style="margin-left: 20px;"><i>Lower</i></span> <b>Base Flow as %Channel Width:</b> <input type="checkbox"/> 0-25% <input checked="" type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100% <span style="float: right;"><b>Flows Measured:</b> Yes <input checked="" type="checkbox"/> No <input type="checkbox"/></span> <b>Stream Gradient:</b> <input type="checkbox"/> High (≥25ft/mi) <input type="checkbox"/> Moderate (10-24 ft/mi) <input checked="" type="checkbox"/> Low (<10 ft/mi) <span style="float: right;">~Slope: _____ ft/mi</span> <b>Sinuosity:</b> <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low	
<b>Channel Morphology</b> <span style="float: right;"><b>System:</b> Step/Pool - Riffle/Pool - Pool (circle)</span> <input type="checkbox"/> Riffle <input type="checkbox"/> % <input checked="" type="checkbox"/> Run <input type="checkbox"/> 50 % <input checked="" type="checkbox"/> Pool <input type="checkbox"/> 50 % <input type="checkbox"/> Steps <input type="checkbox"/> 0 %	
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input checked="" type="checkbox"/> Gravel (0.1-2.5") <span style="margin-left: 20px;"><i>Lower</i></span> <input type="checkbox"/> Bed Rock <span style="margin-left: 20px;"><i>Concrete in Upper</i></span>	<b>Dominant In-Stream Habitats</b> <input type="checkbox"/> Woody Debris <input checked="" type="checkbox"/> Root Wads <input checked="" type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input checked="" type="checkbox"/> Overhanging Vegetation Habitat Quality: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input type="checkbox"/> Forest _____% <input type="checkbox"/> Pasture _____% <input type="checkbox"/> Urban _____% <input type="checkbox"/> Commercial _____% <input type="checkbox"/> Row Crops _____% <input type="checkbox"/> Hay _____% <input type="checkbox"/> Industrial _____% <input type="checkbox"/> Sub-Urban _____%	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest <input type="checkbox"/> 5 % <input checked="" type="checkbox"/> Shrub/Sapling <input type="checkbox"/> 20 % <input checked="" type="checkbox"/> Herbs/Grasses <input type="checkbox"/> 15 % <input checked="" type="checkbox"/> Turf/Crops <input type="checkbox"/> 60 % Riparian Width: <input type="checkbox"/> <10 ft <input type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input type="checkbox"/> Mostly shaded (≥75% coverage) <input checked="" type="checkbox"/> Partially shaded (≥25% coverage) <input type="checkbox"/> Halfway shaded (≥50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b> <b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____	
<b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> Flecks <input type="checkbox"/> None <input checked="" type="checkbox"/> Other <i>scum</i> <span style="float: right;"><i>wpt 1/68</i></span>	
<b>Turbidity/Water Clarity:</b> <input checked="" type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____	
<b>Sediment Deposits:</b> <input type="checkbox"/> None <input checked="" type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells	

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

### USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: <i>Golf Course 1</i>	Date: <i>12/5/18</i>	Initials: <i>SJH / JJF</i>
--	-------------------------	-------------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
<i>CM, UT, IB 17, 18</i>	<i>165 JIF 1120 167 JIF</i>	<i>3, 1, 3 3, 3</i>		<i>Clogs in stream, concrete channels</i>
<i>18, UT, SC, CM ER, UT, SC, IB SC</i>	<i>168 169 170</i>	<i>3, 1, 3 2, 3, 3, 2 1</i>		<i>Culvert, 2 out falls, concrete channels down on surface, pipe, utility and stream channel, etc. debris, trash and logs, etc. debris, etc. debris, etc. Woods, golf cart bridge, fish, water</i>
<i>18, OT</i>	<i>173</i>	<i>3, 1</i>		<i>Old storm drain</i>

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
<i>ER</i>	<i>171 (incoming to the stream)</i>	<i>L M (H) VH EX (circle one)</i>	<i>70</i>	<i>3</i>	Bank: Height <u>7</u> ft, Angle <u>80</u> Deg Protection: Roots <u>20</u> %, Root Depth <u>4</u> ft Vegetation <u>10</u> % <sup>4</sup> Material: <u>(Silt/Clay)</u> Sand / Gravel Cobble - %
<i>ER</i>	<i>172 (incoming to the stream)</i>	<i>L M H VH EX (circle one)</i>	<i>40</i>	<i>3</i>	Bank: Height <u>5</u> ft, Angle <u>85</u> Deg Protection: Roots <u>15</u> %, Root Depth <u>1</u> ft Vegetation <u>10</u> % <sup>4</sup> Material: <u>(Silt/Clay)</u> Sand / Gravel Cobble - %
<i>ER</i>		<i>L M H VH EX (circle one)</i>			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> Material: <u>(Silt/Clay)</u> Sand / Gravel Cobble - %
<i>ER</i>		<i>L M H VH EX (circle one)</i>			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> Material: <u>(Silt/Clay)</u> Sand / Gravel Cobble - %
<i>ER</i>		<i>L M H VH EX (circle one)</i>			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> Material: <u>(Silt/Clay)</u> Sand / Gravel Cobble - %

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

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

**USA, Cont.**

<b>REACH ID:</b> Golf Course 1	<b>STREAM:</b>	<b>DATE/TIME:</b> 12/5/18 1315	<b>INITIALS:</b> SJH/JJF
<b>OTHER INFO:</b>			

**Average Conditions (check applicable)**

**Flood Plain Dynamics** Upstream Poor, lower reach fair

Connection:  Poor  Fair  Good      Vegetation:  Forest  Shrub/Sapling  Tall grasses  Turf/crops

Habitat:  Poor  Fair  Good      Encroachment:  Poor  Fair  Good

<b>Periphyton (attached algae):</b>	<b>Suspended Algae (phytoplankton) abundance:</b>
Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input checked="" type="checkbox"/> None noticeable (water basically clear)
Prostrate: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Moderate (water slightly green tinted)
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Abundant (water appears green)

**Aquatic Plants In Stream:**

Submerged:  None  Sparse  Moderate  Abundant

Emergent:  None  Sparse  Moderate  Abundant *None in upper part of stream (conc. at bottom)*

Floating:  None  Sparse  Moderate  Abundant

<b>Aquatic Life Observed:</b> <i>None in upper reach</i>	<b>Wildlife/Livestock In or Around Stream (evidence of):</b>
<input checked="" type="checkbox"/> Fish <input checked="" type="checkbox"/> Snails <input checked="" type="checkbox"/> Crawfish <input checked="" type="checkbox"/> Macroinvertebrates	<input type="checkbox"/> Cattle <input type="checkbox"/> Beaver <input type="checkbox"/> Deer <input checked="" type="checkbox"/> Other <i>Cynodon</i>

**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 \_\_\_\_\_       Impacted Buffers(IB): 1 2 3 Wpt \_\_\_\_\_

Stream Crossing(SC): 1 2 3 Wpt \_\_\_\_\_       Trash(TR): 1 2 3 Wpt \_\_\_\_\_

Bank Erosion(ER): 1 2 3 Wpt \_\_\_\_\_       Utilities(UT): 1 2 3 Wpt \_\_\_\_\_

Channel Modification(CM): 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 stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: 5.5 (ft) Bankfull Depth 2.5 (ft) Wetted Width: 17 (ft) Riffle/Run Depth NA (ft)

Rt bank Ht: 4 (ft) Bankfull Width 18 (ft) TOB Width: 30 (ft) Pool Depth 1.6 (ft)

**Channel Stability:**

Lt Bank: Angle 40 degrees      Rt Bank: Angle 40 degrees

LtBank Vegetation protection: 100 % cover      RtBank Vegetation protection 100 % cover

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

Length Lt Bank Affected: 35      Length Rt Bank Affected: 35

Wpt(s): \_\_\_\_\_      Wpt(s): \_\_\_\_\_

**Reach Accessibility For Restoration**

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

5      4      3      2      1

<b>Notes:</b> (biggest problem(s) you see in survey reach) Channelization, concrete channel in upper reach, IB	<b>Restoration Potential:</b>
	<input checked="" type="checkbox"/> Riparian reforestation <input type="checkbox"/> Bank stabilization
	<input checked="" type="checkbox"/> Stormwater retrofit <input checked="" type="checkbox"/> Outfall stabilization
	<input checked="" type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation
	<input type="checkbox"/> Culvert rehab. <input type="checkbox"/> Other _____

*Storm Ditch*

Place sketch of reach on back of page.



## Unified Stream Assessment (USA)

REACH ID: <b>HC-2</b>	STREAM: <b>Henry Creek</b>	DATE/TIME: <b>2/27/19 14:00</b>	INITIALS: <b>JCM/ZDW</b>
REACH START <b>WP 798</b>	REACH END <b>WP 807</b>		
LAT: <b>34.86654</b>	LAT: <b>34.86604</b>		
LONG: <b>-92.33121</b>	LONG: <b>-92.33379</b>		

Average Conditions (check applicable)	
<b>Weather – Antecedent (24-h)</b> Rain in past 72-h: y/n <input checked="" type="checkbox"/> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input checked="" type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100%      Flows Measured: Yes <input checked="" type="checkbox"/> No Stream Gradient: <input type="checkbox"/> High (>25ft/mi) <input checked="" type="checkbox"/> Moderate (10-24 ft/mi) <input type="checkbox"/> Low (<10 ft/mi)      ~Slope: _____ ft/mi Sinuosity: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low      1.02	
<b>Channel Morphology</b> System: Step/Pool - <u>Riffle/Pool</u> - Pool (circle) <input type="checkbox"/> Riffle <u>10</u> % <input type="checkbox"/> Run <u>25</u> % <input type="checkbox"/> Pool <u>65</u> % <input type="checkbox"/> Steps _____ % <i>see WP</i>	
<b>Dominant Substrate</b> <input type="checkbox"/> Silt/clay (fine or slick) <input checked="" type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input checked="" type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock <i>Sandy in last pool</i>	<b>Dominant In-Stream Habitats</b> <input type="checkbox"/> Woody Debris <input checked="" type="checkbox"/> Root Wads <input type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input type="checkbox"/> Forest <u>60</u> % <input type="checkbox"/> Pasture <u>10</u> % <input type="checkbox"/> Urban _____ % <input type="checkbox"/> Commercial _____ % <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay <u>5</u> % <input type="checkbox"/> Industrial _____ % <input type="checkbox"/> Sub-Urban <u>10</u> %	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input checked="" type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest <u>60</u> % <input type="checkbox"/> Shrub/Sapling <u>35</u> % <input type="checkbox"/> Herbs/Grasses <u>5</u> % <input type="checkbox"/> Turf/Crops _____ % Riparian Width: <input type="checkbox"/> <10 ft <input type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input checked="" type="checkbox"/> Mostly shaded (>75% coverage) <input type="checkbox"/> Partially shaded (>25% coverage) <input type="checkbox"/> Halfway shaded (>50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b>	
<b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____	<b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____
<b>Turbidity/Water Clarity:</b> <input type="checkbox"/> Clear <input checked="" type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____	<input type="checkbox"/> Turbid <input type="checkbox"/> Other _____
<b>Sediment Deposits:</b> <input type="checkbox"/> None <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input checked="" type="checkbox"/> Sand <input type="checkbox"/> Relict shells	

**USA Reach Impact Data Detail Sheet (optional)**

<b>Reach ID/Stream:</b> HC-2 Henry Creek	<b>Date:</b> 2/27/15	<b>Initials:</b> Jum/ZDW
---	-------------------------	-----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
ER-1	WP 798-WP 799 ~35 yds	1	1	RB - some scour but heavily armored w/ rock + root
UT-1	WP 800	1	NA	Dist. power line 30' ROW
TR-1	WP 800	1	3	trash dump on LB
SC-1	WP 801	1	NA	Road bridge ~25 yds
ER-2	WP 802 → 803	1	1	RB heavily armored w/ root + rock
ER-3	WP 806 → 807	1	2	LB - part of someone's back yard, poor buffer. Erosion continues well past reach + appears to become severe
UT-2	WP 804	1	NA	D line run along down stream

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER-1 RB	798-799 RB	(L) M H VH EX (circle one)	35 yds. 82 ft	1	Bank: Height 2.5 ft, Angle 80 Deg Protection: Roots 75%, Root Depth 1.5 ft Vegetation 30% 4Material: Silt/Clay Sand / Gravel Cobble %25
ER-2 RB	802 → 803	(L) M H VH EX (circle one)	40 yds 87 ft	1	Bank: Height 4.5 ft, Angle 90 Deg Protection: Roots 70%, Root Depth 1.2 ft Vegetation 15% 4Material: Silt/Clay Sand / Gravel Cobble - %60
ER-3 LB	WP 806-807	(L) M H VH EX (circle one)	see WP 100 ft	2	Bank: Height 5 ft, Angle 2 Deg Protection: Roots 80%, Root Depth 2.5 ft Vegetation 60% 4Material: Silt/Clay Sand / Gravel Cobble - %
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____%, Root Depth _____ ft Vegetation _____% 4Material: Silt/Clay Sand / Gravel Cobble - %
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____%, Root Depth _____ ft Vegetation _____% 4Material: Silt/Clay Sand / Gravel Cobble - %

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

<sup>4</sup>Bank material: circle base type, silt/clay or sand and if present circle rock type and note %

IB-1 Left Bank  $\frac{\text{Severe}}{1}$  Rest  
WP 801 - 807 2

Looked Aerial Co IB-2 at start  
164' backyard LB

## USA, Cont.

<b>REACH ID:</b> HC-2	<b>STREAM:</b> Harry Creek 2	<b>DATE/TIME:</b> 2/27/19	<b>INITIALS:</b> Jen/2012
<b>OTHER INFO:</b>			

### Average Conditions (check applicable)

<b>Flood Plain Dynamics</b>		<b>Vegetation:</b>	
Connection: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good	<input type="checkbox"/> Forest <input checked="" type="checkbox"/> Shrub/Sapling <input type="checkbox"/> Tall grasses <input type="checkbox"/> Turf/crops	Habitat: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	Encroachment: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good
<b>Periphyton (attached algae):</b>		<b>Suspended Algae (phytoplankton) abundance:</b>	
Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input checked="" type="checkbox"/> None noticeable (water basically clear)	Prostrate: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Moderate (water slightly green tinted)
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Abundant (water appears green)		
<b>Aquatic Plants In Stream:</b>			
Submerged: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			
Emergent: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			

<b>Aquatic Life Observed:</b> <input checked="" type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input checked="" type="checkbox"/> Macroinvertebrates	<b>Wildlife/Livestock In or Around Stream (evidence of):</b> <input checked="" type="checkbox"/> Cattle <input checked="" type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other
--	---

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

<input type="checkbox"/> Outfalls(OT): 1 2 3 Wpt _____	<input checked="" type="checkbox"/> Impacted Buffers(IB): 1 2 3 Wpt _____
<input checked="" type="checkbox"/> Stream Crossing(SC): 1 2 3 Wpt <u>see impacts</u>	<input type="checkbox"/> Trash(TR): 1 2 3 Wpt _____
<input checked="" type="checkbox"/> Bank Erosion(ER): 1 2 3 Wpt _____	<input type="checkbox"/> Utilities(UT): 1 2 3 Wpt _____
<input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt _____	<input type="checkbox"/> 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:**

<input type="checkbox"/> Incised (degrading)	<input type="checkbox"/> Channelized	<input type="checkbox"/> Bed Scour	<input type="checkbox"/> Sediment Deposition
<input type="checkbox"/> Widening	<input type="checkbox"/> Aggrading	<input type="checkbox"/> Bank Failure	<input type="checkbox"/> Culvert Scour (upstream / downstream / top)
<input type="checkbox"/> Headcutting	<input checked="" type="checkbox"/> Bank scour	<input type="checkbox"/> Slope failure	<input type="checkbox"/> None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: <u>1.5-2.0</u> (ft)	Bankfull Depth: <u>2.5</u> (ft)	Wetted Width: <u>7</u> (ft)	Riffle/Run Depth: <u>1.0</u> (ft)
Rt bank Ht: <u>1.5</u> (ft)	Bankfull Width: <u>9 yd</u> (ft)	TOB Width: <u>9.5 yd</u> (ft)	Pool Depth: <u>3.5</u> (ft)

*~ 1.5 yd width*

**Channel Stability:**

Lt Bank: Angle <u>45</u> degrees	Rt Bank: Angle <u>45</u> degrees
LtBank Vegetation protection: <u>40</u> % cover	RtBank Vegetation protection: <u>40</u> % cover
LtBank Erosion Hazard: <u>(1)</u> M H VH EX (circle one)	RtBank Erosion Hazard: <u>(1)</u> M H VH EX (circle one)
Length Lt Bank Affected: <u>100 ft</u>	Length Rt Bank Affected: <u>110 ft</u>
Wpt(s): <u>see impacts / notes</u>	Wpt(s): <u>see impacts / notes</u>

**Reach Accessibility For Restoration**

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

<p><b>Notes:</b> (biggest problem(s) you see in survey reach)</p> <p>Loss of buffer due to housing some erosion but heavy armor Below reach erosion appeared to increase Faintly visible riffle/run</p> <p>Place sketch of reach on back of page.</p>	<p><b>Restoration Potential:</b></p> <table border="0"> <tr> <td><input checked="" type="checkbox"/> Riparian reforestation</td> <td><input checked="" type="checkbox"/> Bank stabilization</td> </tr> <tr> <td><input type="checkbox"/> Stormwater retrofit</td> <td><input type="checkbox"/> Outfall stabilization</td> </tr> <tr> <td><input type="checkbox"/> Channel modification</td> <td><input type="checkbox"/> PS investigation</td> </tr> <tr> <td><input type="checkbox"/> Culvert rehab</td> <td><input type="checkbox"/> Other _____</td> </tr> </table>	<input checked="" type="checkbox"/> Riparian reforestation	<input checked="" type="checkbox"/> Bank stabilization	<input type="checkbox"/> Stormwater retrofit	<input type="checkbox"/> Outfall stabilization	<input type="checkbox"/> Channel modification	<input type="checkbox"/> PS investigation	<input type="checkbox"/> Culvert rehab	<input type="checkbox"/> Other _____
<input checked="" type="checkbox"/> Riparian reforestation	<input checked="" type="checkbox"/> Bank stabilization								
<input type="checkbox"/> Stormwater retrofit	<input type="checkbox"/> Outfall stabilization								
<input type="checkbox"/> Channel modification	<input type="checkbox"/> PS investigation								
<input type="checkbox"/> Culvert rehab	<input type="checkbox"/> Other _____								

## Unified Stream Assessment (USA)

REACH ID: <b>HC-2</b>	STREAM: <b>Henry Creek</b>	DATE/TIME: <b>2/27/19 14:00</b>	INITIALS: <b>JCM/ZDW</b>
REACH START <b>WP 798</b>	REACH END <b>WP 807</b>		
LAT: <b>34.86654</b>	LAT: <b>34.86604</b>		
LONG: <b>-92.33121</b>	LONG: <b>-92.33379</b>		

### Average Conditions (check applicable)

<b>Weather - Antecedent (24-h)</b> Rain in past 72-h: y/n <input checked="" type="checkbox"/> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather - Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input checked="" type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> <b>Flow:</b> <input type="checkbox"/> High <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Low <input type="checkbox"/> None <b>Base Flow as %Channel Width:</b> <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100% <b>Flows Measured:</b> Yes <input checked="" type="checkbox"/> No <b>Stream Gradient:</b> <input type="checkbox"/> High (>25ft/mi) <input checked="" type="checkbox"/> Moderate (10-24 ft/mi) <input type="checkbox"/> Low (<10 ft/mi)      ~Slope: _____ ft/mi <b>Sinuosity:</b> <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low      1.02	
<b>Channel Morphology</b> <b>System:</b> Step/Pool - <u>Riffle/Pool</u> - Pool (circle) <input type="checkbox"/> Riffle <u>10</u> % <input type="checkbox"/> Run <u>25</u> % <input type="checkbox"/> Pool <u>65</u> % <input type="checkbox"/> Steps _____ % <i>see up</i>	
<b>Dominant Substrate</b> <input type="checkbox"/> Silt/clay (fine or slick) <input checked="" type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input checked="" type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock <i>bed in</i>	<b>Dominant In-Stream Habitats</b> <input type="checkbox"/> Woody Debris <input checked="" type="checkbox"/> Root Wads <input type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <i>last pool</i> <input type="checkbox"/> Forest <u>76</u> % <input type="checkbox"/> Pasture <u>15</u> % <input type="checkbox"/> Urban _____ % <input type="checkbox"/> Commercial _____ % <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay <u>5</u> % <input type="checkbox"/> Industrial _____ % <input type="checkbox"/> Sub-Urban <u>10</u> %	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input checked="" type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest <u>60</u> % <input type="checkbox"/> Shrub/Sapling <u>35</u> % <input type="checkbox"/> Herbs/Grasses <u>5</u> % <input type="checkbox"/> Turf/Crops _____ % Riparian Width: <input type="checkbox"/> <10 ft <input type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input checked="" type="checkbox"/> Mostly shaded (≥75% coverage) <input type="checkbox"/> Partially shaded (≥25% coverage) <input type="checkbox"/> Halfway shaded (≥50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b> <b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ <b>Turbidity/Water Clarity:</b> <input type="checkbox"/> Clear <input checked="" type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____ <b>Sediment Deposits:</b> <input type="checkbox"/> None <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input checked="" type="checkbox"/> Sand <input type="checkbox"/> Relict shells	



**USA Reach Impact Data Detail Sheet (optional)**

<b>Reach ID/Stream:</b> HC-2 Henry Creek	<b>Date:</b> 2/27/15	<b>Initials:</b> Jum/EDW
---	-------------------------	-----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
ER-1	WP 798-WP 799 ~35 yds	1	1	RB - some scum but heavily armored w/ rock & root
UT-1	WP 800	1	NA	Dist. power line 30' ROW
TR-1	WP 800	1	3	trash dump on LB
SC-1	WP 801	1	NA	Road bridge ~25 yds
ER-2	WP 802 → 803	1	1	RB heavily armored w/ root & rock
ER-3	WP 806 → 807	1	2	LB - part of someone's back yard, poor buffer. Erosion continues well past reach & appears to become severe
UT-2	WP 804	1	NA	D Line run along down stream

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER-1 RB	798-799 RB	(L) M H VH EX (circle one)	35 yds. 82 ft	1	Bank: Height <u>2.5</u> ft, Angle <u>80</u> Deg Protection: Roots <u>75</u> %, Root Depth <u>1.5</u> ft Vegetation <u>30</u> % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble % <u>25</u>
ER-2 RB	802 → 803	(L) M H VH EX (circle one)	40 yds 87 ft	1	Bank: Height <u>4.5</u> ft, Angle <u>90</u> Deg Protection: Roots <u>75</u> %, Root Depth <u>1.5</u> ft Vegetation <u>15</u> % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - % <u>60</u>
ER-3 LB	WP 806-807	(L) M H VH EX (circle one)	see WP 100 ft	2	Bank: Height <u>5.5</u> ft, Angle <u>2</u> Deg Protection: Roots <u>80</u> %, Root Depth <u>2.5</u> ft Vegetation <u>60</u> % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - %

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

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

IB-1 Left Bank  $\frac{\text{Severe}}{1}$  Rest  
WP 801 - 807 2

Look~~ed~~ Aerial Co IB-2 at start  
164' backyard LB

## USA, Cont.

<b>REACH ID:</b> HC-2	<b>STREAM:</b> Harry Creek 2	<b>DATE/TIME:</b> 2/27/19	<b>INITIALS:</b> Sun/201
<b>OTHER INFO:</b>			

### Average Conditions (check applicable)

<b>Flood Plain Dynamics</b>	<b>Vegetation:</b>
Connection: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good	<input type="checkbox"/> Forest <input checked="" type="checkbox"/> Shrub/Sapling <input type="checkbox"/> Tall grasses <input type="checkbox"/> Turf/crops
Habitat: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	Encroachment: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good

<b>Periphyton (attached algae):</b>	<b>Suspended Algae (phytoplankton) abundance:</b>
Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input checked="" type="checkbox"/> None noticeable (water basically clear)
Prostrate: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Moderate (water slightly green tinted)
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Abundant (water appears green)

<b>Aquatic Plants In Stream:</b>
Submerged: <input type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant
Emergent: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant

<b>Aquatic Life Observed:</b>	<b>Wildlife/Livestock In or Around Stream (evidence of):</b>
<input checked="" type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input checked="" type="checkbox"/> Macroinvertebrates	<input checked="" type="checkbox"/> Cattle <input checked="" type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other

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

<input type="checkbox"/> Outfalls(OT): 1 2 3 Wpt _____	<input checked="" type="checkbox"/> Impacted Buffers(IB): 1 2 3 Wpt _____
<input checked="" type="checkbox"/> Stream Crossing(SC): ① 2 3 Wpt <i>see impacts</i>	<input type="checkbox"/> Trash(TR): ① 2 3 Wpt _____
<input checked="" type="checkbox"/> Bank Erosion(ER): ① 2 3 Wpt _____	<input type="checkbox"/> Utilities(UT): ① 2 3 Wpt _____
<input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt _____	<input type="checkbox"/> Other: _____ : 1 2 3 Wpt _____

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

<b>Channel Dynamics:</b>
<input type="checkbox"/> Incised (degrading) <input type="checkbox"/> Channelized <input type="checkbox"/> Bed Scour <input type="checkbox"/> Sediment Deposition
<input type="checkbox"/> Widening <input type="checkbox"/> Aggrading <input type="checkbox"/> Bank Failure <input type="checkbox"/> Culvert Scour (upstream / downstream / top)
<input type="checkbox"/> Headcutting <input checked="" type="checkbox"/> Bank scour <input type="checkbox"/> Slope failure <input type="checkbox"/> None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: <u>1.5-2.0</u> (ft)	Bankfull Depth: <u>2.5</u> (ft)	Wetted Width: <u>7</u> (ft)	Riffle/Run Depth: <u>1.0</u> (ft)
Rt bank Ht: <u>1.5</u> (ft)	Bankfull Width: <u>9 yd</u> (ft)	TOB Width: <u>9.5 yd</u> (ft)	Pool Depth: <u>3.5</u> (ft)

*~ 1.5 yd width*

<b>Channel Stability:</b>	
Lt Bank: Angle <u>45</u> degrees	Rt Bank: Angle <u>45</u> degrees
LtBank Vegetation protection: <u>40</u> % cover	RtBank Vegetation protection: <u>40</u> % cover
LtBank Erosion Hazard: ① M H VH EX (circle one)	RtBank Erosion Hazard: ① M H VH EX (circle one)
Length Lt Bank Affected: <u>100 ft</u>	Length Rt Bank Affected: <u>169 ft</u>
Wpt(s): <u>see impacts / notes</u>	Wpt(s): <u>see impacts / notes</u>

<b>Reach Accessibility For Restoration</b>		
<b>Good:</b> Open area in public ownership. Easy stream channel access by vehicle	<b>Fair:</b> Forested or developed near stream. Vehicle access limited	<b>Difficult:</b> Must cross wetland, steep slope, heavy forest or sensitive areas to get to stream. Access by foot/ATV only
5	4	3

<b>Notes:</b> (biggest problem(s) you see in survey reach) <i>Loss of buffer due to housing some erosion but heavy armor Below reach erosion appeared to increase Fuels &amp; Sude raffle/run</i>	<b>Restoration Potential:</b>
<b>Place sketch of reach on back of page.</b>	<input checked="" type="checkbox"/> Riparian reforestation <input checked="" type="checkbox"/> Bank stabilization
	<input type="checkbox"/> Stormwater retrofit <input type="checkbox"/> Outfall stabilization
	<input type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation
	<input type="checkbox"/> Culvert rehab. <input type="checkbox"/> Other _____

## Unified Stream Assessment (USA)

REACH ID: NC-1	STREAM: Newton Creek	DATE/TIME: 2/27/19 0930	INITIALS: JCM/ZPL
REACH START Upstream	REACH END		
LAT: 34.83881	LAT: 34.83800		
LONG: -92.35498	LONG: -92.35858		

Average Conditions (check applicable)	
<b>Weather – Antecedent (24-h)</b> Rain in past 72-h: y/n <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input checked="" type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100% <b>Flows Measured:</b> Yes <input checked="" type="checkbox"/> No Stream Gradient: <input type="checkbox"/> High (>25ft/mi) <input type="checkbox"/> Moderate (10-24 ft/mi) <input checked="" type="checkbox"/> Low (<10 ft/mi)      ~Slope: _____ ft/mi Sinuosity: <input checked="" type="checkbox"/> High <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Low      1.3	
<b>Channel Morphology</b> <b>System:</b> Step/Pool - Riffle/Pool - <input checked="" type="checkbox"/> Pool (circle) <input type="checkbox"/> Riffle _____ % <input type="checkbox"/> Run 5 % <input type="checkbox"/> Pool 90-95 % <input type="checkbox"/> Steps _____ %	
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input checked="" type="checkbox"/> Woody Debris <input checked="" type="checkbox"/> Root Wads <input checked="" type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input type="checkbox"/> Forest 90-95 % <input type="checkbox"/> Pasture 5 % <input type="checkbox"/> Urban <del>5</del> % <input type="checkbox"/> Commercial 5 % <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay _____ % <input type="checkbox"/> Industrial _____ % <input type="checkbox"/> Sub-Urban 10 %	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input checked="" type="checkbox"/> Other runway <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest 20 % <input checked="" type="checkbox"/> Shrub/Sapling 5 % <input checked="" type="checkbox"/> Herbs/Grasses 5 % <input type="checkbox"/> Turf/Crops _____ % Riparian Width: <input type="checkbox"/> <10 ft <input type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input checked="" type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input checked="" type="checkbox"/> Mostly shaded (≥75% coverage) <input type="checkbox"/> Partially shaded (≥25% coverage) <input type="checkbox"/> Halfway shaded (≥50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b> <b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ <b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ <b>Turbidity/Water Clarity:</b> <input type="checkbox"/> Clear <input checked="" type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____ <b>Sediment Deposits:</b> <input type="checkbox"/> None <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells <span style="float: right; border: 1px solid black; border-radius: 50%; padding: 2px;">Silt</span>	

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

**USA Reach Impact Data Detail Sheet (optional)**

<b>Reach ID/Stream:</b> NC-1 Newton Creek	<b>Date:</b> 2/27/19	<b>Initials:</b> SLW/ZDL
--	-------------------------	-----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
TR-1	WP-781	1	2	Wood debris deposits w/ trash see pics
TR-2	WP-733	1	2	" "
ER-1	782	1	1	steep bank w/ some under cut, good armor
ER-2	784	1	1	steep bank, good armor for now has lost some buffer

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER-1 LB	WP-782 Steep	L M H VH EX (circle one)	LB 20yds or 60ft	1	Bank: Height <u>4+3.5</u> ft, Angle <u>80</u> Deg Protection: Roots <u>60</u> %, Root Depth <u>3</u> ft Vegetation <u>50</u> % *Material: <u>Silt/Clay</u> Sand / Gravel Cobble - % <u>0</u>
ER-2 LB	WP-784 Steep + ends @ confluence	L M H VH EX (circle one)	LB 28yds or 54 ft	1	Bank: Height <u>3+3.5</u> ft, Angle <u>75</u> Deg Protection: Roots <u>50</u> %, Root Depth <u>2</u> ft Vegetation <u>30%</u> *Material: <u>Silt/Clay</u> Sand / Gravel Cobble - % <u>0</u>
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % *Material: <u>Silt/Clay</u> Sand / Gravel Cobble - % _____
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % *Material: <u>Silt/Clay</u> Sand / Gravel Cobble - % _____
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % *Material: <u>Silt/Clay</u> Sand / Gravel Cobble - % _____

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

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

## USA, Cont.

REACH ID: <u>NC-1</u>	STREAM: <u>Newton Creek</u>	DATE/TIME: <u>2/27/19</u>	INITIALS: <u>SM / ZDU</u>
OTHER INFO:			

Average Conditions (check applicable)	
<b>Flood Plain Dynamics</b> Connection: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good Habitat: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good Vegetation: <input checked="" type="checkbox"/> Forest <input type="checkbox"/> Shrub/Sapling <input type="checkbox"/> Tall grasses <input type="checkbox"/> Turf/crops Encroachment: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	
<b>Periphyton (attached algae):</b> Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant Prostrate: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<b>Suspended Algae (phytoplankton) abundance:</b> <input type="checkbox"/> None noticeable (water basically clear) <input type="checkbox"/> Moderate (water slightly green tinted) <input type="checkbox"/> Abundant (water appears green)
<b>Aquatic Plants In Stream:</b> Submerged: <input type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant Emergent: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant <u>cyprus</u> Floating: <input type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	
<b>Aquatic Life Observed:</b> <input checked="" type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input checked="" type="checkbox"/> Macroinvertebrates <u>Turtles Frogs</u>	<b>Wildlife/Livestock In or Around Stream (evidence of):</b> <input type="checkbox"/> Cattle <input checked="" type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other
<b>Reach Impacts:</b> (circle impact level 1=minor, 2=moderate, 3=major, and tag with a GPS waypoint(s) (Wpt) ID) <input type="checkbox"/> Outfalls(OT): 1 2 3 Wpt _____ <input type="checkbox"/> Stream Crossing(SC): 1 2 3 Wpt _____ <input type="checkbox"/> Bank Erosion(ER): <u>2</u> 2 3 Wpt <u>see impact form</u> <input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt _____ <input type="checkbox"/> Impacted Buffers(IB): <u>2</u> 2 3 Wpt _____ <input checked="" type="checkbox"/> Trash(TR): 1 <u>2</u> 3 Wpt <u>see impact</u> <input type="checkbox"/> Utilities(UT): 1 2 3 Wpt _____ <input type="checkbox"/> Other: _____ : 1 2 3 Wpt _____	
<b>Notes:</b> <u>up stream heavy offroad vehicle use obs stream in buffer</u> If any of these impacts are significant use back of page 1 (pg. 2) for detailed description. <u>A lot of trash deposited in flood plain.</u>	
<b>Channel Dynamics:</b> <input type="checkbox"/> Incised (degrading) <input type="checkbox"/> Channelized <input type="checkbox"/> Bed Scour <input checked="" type="checkbox"/> Sediment Deposition <input type="checkbox"/> Widening <input type="checkbox"/> Aggrading <input type="checkbox"/> Bank Failure <input type="checkbox"/> Culvert Scour (upstream / downstream / top) <input type="checkbox"/> Headcutting <u>sight</u> <input checked="" type="checkbox"/> Bank scour <input type="checkbox"/> Slope failure <input type="checkbox"/> None (natural stable channel) <u>mostly stable</u>	
<b>Channel Dimensions (facing downstream):</b> Lt bank Ht: <u>4</u> (ft) Bankfull Depth: <u>2</u> (ft) Wetted Width: <u>8</u> (ft) Riffle/Run Depth: <u>NA</u> (ft) Rt bank Ht: <u>2</u> (ft) Bankfull Width: <u>2</u> (ft) TOB Width: <u>10</u> (ft) Pool Depth: <u>4</u> (ft)	
<b>Channel Stability:</b> Lt Bank: Angle <u>65</u> degrees Lt Bank Vegetation protection: <u>80</u> % cover Lt Bank Erosion Hazard: <u>L</u> M H VH EX (circle one) Length Lt Bank Affected: <u>48' wide or 144' ft</u> Wpt(s): <u>see impact</u>	
Rt Bank: Angle <u>45</u> degrees <u>80</u> Rt Bank Vegetation protection: <u>80</u> % cover Rt Bank Erosion Hazard: <u>L</u> M H VH EX (circle one) Length Rt Bank Affected: <u>NA</u> Wpt(s): _____	
<b>Reach Accessibility For Restoration</b> Good: Open area in public ownership. Easy stream channel access by vehicle. <input checked="" type="checkbox"/> Fair: Forested or developed near stream. Vehicle access limited. <input type="checkbox"/> Difficult: Must cross wetland, steep slope, heavy forest or sensitive areas to get to stream. Access by foot/ATV only. <input type="checkbox"/>	
5      4      3      2      1	
<b>Notes:</b> (biggest problem(s) you see in survey reach) <u>Encroachment by development</u> <u>Trash/debris</u> <u>OHV use</u>	<b>Restoration Potential:</b> <input type="checkbox"/> Riparian reforestation <input type="checkbox"/> Bank stabilization <input type="checkbox"/> Stormwater retrofit <input type="checkbox"/> Outfall stabilization <input type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation <input type="checkbox"/> Culvert rehab. <input checked="" type="checkbox"/> Other <u>pick up trash &amp; protect limit OHV use</u>
Place sketch of reach on back of page.	



## Unified Stream Assessment (USA)

REACH ID: <u>HC-1</u>	STREAM: <u>Honey Creek</u>	DATE/TIME: <u>2/27/2013</u>	INITIALS: <u>Jim ZDL</u>
REACH START <u>WP 786</u>	REACH END <u>WP 797</u>		
LAT: <u>34.86777</u>	LAT: <u>34.86768</u>		
LONG: <u>-92.35724</u>	LONG: <u>-92.36062</u>		

Average Conditions (check applicable)	
<b>Weather – Antecedent (24-h)</b> Rain in past 72-h: y/n <u>1/0</u> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input checked="" type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input checked="" type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input checked="" type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100%      Flows Measured: Yes (No) <u>No</u> Stream Gradient: <input type="checkbox"/> High ( $\geq 25$ ft/mi) <input checked="" type="checkbox"/> Moderate (10-24 ft/mi) <input checked="" type="checkbox"/> Low ( $< 10$ ft/mi)      ~Slope: _____ ft/mi Sinuosity: <input type="checkbox"/> High <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Low <u>1.32</u>	
<b>Channel Morphology</b> System: Step/Pool - Riffle/Pool - <u>Pool</u> (circle) <input type="checkbox"/> Riffle _____ % <input type="checkbox"/> Run <u>5</u> % <input type="checkbox"/> Pool <u>95</u> % <input type="checkbox"/> Steps _____ %	
<b>Dominant Substrate</b> <input type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input checked="" type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder ( $> 10$ ") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input checked="" type="checkbox"/> Woody Debris <input checked="" type="checkbox"/> Root Wads <input type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input type="checkbox"/> Forest <u>75</u> % <input type="checkbox"/> Pasture <u>15</u> % <input type="checkbox"/> Urban _____ % <input type="checkbox"/> Commercial _____ % <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay _____ % <input type="checkbox"/> Industrial _____ % <input type="checkbox"/> Sub-Urban <u>10</u> %	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input checked="" type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence <u>or other livestock - not heavy</u>
<b>Riparian Buffer</b> Vegetation Type: <input type="checkbox"/> Forest <u>85</u> % <input type="checkbox"/> Shrub/Sapling <u>10</u> % <input type="checkbox"/> Herbs/Grasses <u>5</u> % <input type="checkbox"/> Turf/Crops _____ % Riparian Width: <input type="checkbox"/> $< 10$ ft <input type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input checked="" type="checkbox"/> $> 50$ ft	
<b>Stream Shading (water surface)</b> <input checked="" type="checkbox"/> Mostly shaded ( $\geq 75$ % coverage) <input type="checkbox"/> Partially shaded ( $\geq 25$ % coverage) <input type="checkbox"/> Halfway shaded ( $\geq 50$ % coverage) <input type="checkbox"/> Unshaded ( $< 25$ % coverage)	
<b>Water Quality Observations</b> <b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ <b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ <b>Turbidity/Water Clarity:</b> <input type="checkbox"/> Clear <input checked="" type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____ <b>Sediment Deposits:</b> <input type="checkbox"/> None <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells	

**USA Reach Impact Data Detail Sheet (optional)**

Reach ID/Stream: <u>HC-1 Henry Creek</u>	Date: <u>2/27/18</u>	Initials: <u>SW/ZD/L</u>
---	-------------------------	-----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
ER-1	WP 786 → 793	2	1 to 2	LB - 10yd stable @ 789 / might be a bit of old Bentley was
ER-2	WP 786 → 792	2	1	RB - 10yd stable @ WP 789 heavy under-cuttings / steep banks but much of it is armored RB
ER-3	793 → 794	2	1	steep but armored w/ root mass
ER-4	794 → 796	2	1 to 2	LB steep / undercut but armored
ER-5	795 → 796	1	1 to 2	RB - steep, animal crossings some armoring

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER-1 LB	786 → 793	L M <u>(H)</u> VH EX (circle one) <i>led mass</i>	883 ft	1 to 2	Bank: Height <u>7</u> ft, Angle <u>95°</u> Deg Protection: Roots <u>100%</u> , Root Depth <u>2</u> ft Vegetation <u>10</u> % <sup>4</sup> Material: <u>Silt/Clay Sand</u> / Gravel Cobble - %
ER-2 RB	WP 786 to 792	L <u>(M)</u> H VH EX (circle one)	<del>879 ft</del> 678 ft 790 ft	1 to 2	Bank: Height <u>6</u> ft, Angle <u>95°</u> Deg Protection: Roots <u>40</u> %, Root Depth <u>2.5</u> ft Vegetation <u>15</u> % <sup>4</sup> Material: <u>Silt/Clay Sand</u> / Gravel Cobble - %
ER-3 RB	793-794	L <u>(M)</u> H VH EX (circle one)	85 ft	1 to 2	Bank: Height <u>6</u> ft, Angle <u>90</u> Deg Protection: Roots <u>65</u> %, Root Depth <u>2</u> ft Vegetation <u>40</u> % <sup>4</sup> Material: <u>Silt/Clay Sand</u> / Gravel Cobble - %
ER-4 LB	794 → 796	L <u>(M)</u> H VH EX (circle one)	298 ft	1-2	Bank: Height <u>5.5</u> ft, Angle <u>90</u> Deg Protection: Roots <u>30</u> %, Root Depth <u>2.5</u> ft Vegetation <u>10</u> % <sup>4</sup> Material: <u>Silt/Clay Sand</u> / Gravel Cobble - %
ER-5 RB	795 → 796	L <u>(M)</u> H VH EX (circle one)	82 ft	1-2	Bank: Height <u>5</u> ft, Angle <u>80-75</u> Deg Protection: Roots <u>30</u> %, Root Depth <u>2.5</u> ft Vegetation <u>20</u> % <sup>4</sup> Material: <u>Silt/Clay Sand</u> / Gravel Cobble - %

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

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

# USA, Cont.

REACH ID: <u>HC-1</u>	STREAM: <u>Henry Creek</u>	DATE/TIME: <u>2/27/17</u>	INITIALS: <u>SM / ZDW</u>
OTHER INFO:			

## Average Conditions (check applicable)

<b>Flood Plain Dynamics</b>			
Connection: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good	Vegetation: <input checked="" type="checkbox"/> Forest <input type="checkbox"/> Shrub/Sapling <input type="checkbox"/> Tall grasses <input type="checkbox"/> Turf/crops		
Habitat: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	Encroachment: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good		
<b>Periphyton (attached algae):</b>		<b>Suspended Algae (phytoplankton) abundance:</b>	
Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input checked="" type="checkbox"/> None noticeable (water basically clear)		
Prostrate: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Moderate (water slightly green tinted)		
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Abundant (water appears green)		
<b>Aquatic Plants In Stream:</b>			
Submerged: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			
Emergent: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			

<b>Aquatic Life Observed:</b> <input checked="" type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input checked="" type="checkbox"/> Macroinvertebrates	<b>Wildlife/Livestock In or Around Stream (evidence of):</b> <input type="checkbox"/> Cattle <input checked="" type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input checked="" type="checkbox"/> Other <u>Horse</u>
--	--

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

<input type="checkbox"/> Outfalls(OT): 1 2 3 Wpt _____	<input type="checkbox"/> Impacted Buffers(IB): 1 2 3 Wpt _____
<input type="checkbox"/> Stream Crossing(SC): 1 2 3 Wpt _____	<input checked="" type="checkbox"/> Trash(TR): <u>2</u> 3 Wpt _____
<input checked="" type="checkbox"/> Bank Erosion(ER): 1 <u>2</u> 3 Wpt _____	<input type="checkbox"/> Utilities(UT): 1 2 3 Wpt _____
<input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt _____	<input type="checkbox"/> 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:**

<input checked="" type="checkbox"/> Incised (degrading)	<input type="checkbox"/> Channelized	<input type="checkbox"/> Bed Scour	<input type="checkbox"/> Sediment Deposition
<input type="checkbox"/> Widening	<input type="checkbox"/> Aggrading	<input type="checkbox"/> Bank Failure	<input type="checkbox"/> Culvert Scour (upstream / downstream / top)
<input type="checkbox"/> Headcutting	<input checked="" type="checkbox"/> Bank scour	<input type="checkbox"/> Slope failure	<input type="checkbox"/> None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: <u>6.4</u> (ft)	Bankfull Depth: <u>6</u> (ft)	Wetted Width: <u>9.5</u> (ft)	Riffle/Run Depth: <u>NA</u> (ft)
Rt bank Ht: <u>6.5</u> (ft)	Bankfull Width: <u>4</u> (ft)	TOB Width: <u>1.5</u> (ft)	Pool Depth: <u>3.5</u> (ft)

**Channel Stability:**

Lt Bank: Angle <u>95</u> degrees	Rt Bank: Angle <u>95</u> degrees
LtBank Vegetation protection: <u>20</u> % cover	RtBank Vegetation protection <u>15</u> % cover
LtBank Erosion Hazard: L M <u>H</u> VH EX (circle one)	RtBank Erosion Hazard: L M <u>H</u> VH EX (circle one)
Length Lt Bank Affected: <u>1181</u>	Length Rt Bank Affected: <u>957</u>
Wpt(s): <u>see impacts/note</u>	Wpt(s): <u>see impacts/note</u>

**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

<p><b>Notes:</b> (biggest problem(s) you see in survey reach)</p> <p><u>Incised w/ poor flood plain connectivity causing banks to erode</u></p> <p><u>Vegetative buffer - is preventing severe erosion. Protect buffer to sustain</u></p> <p>Place sketch of reach on back of page.</p>	<p><b>Restoration Potential:</b></p> <table style="width: 100%;"> <tr> <td><input type="checkbox"/> Riparian reforestation</td> <td><input checked="" type="checkbox"/> Bank stabilization</td> </tr> <tr> <td><input type="checkbox"/> Stormwater retrofit</td> <td><input type="checkbox"/> Outfall stabilization</td> </tr> <tr> <td><input type="checkbox"/> Channel modification</td> <td><input type="checkbox"/> PS investigation</td> </tr> <tr> <td><input type="checkbox"/> Culvert rehab.</td> <td><input type="checkbox"/> Other _____</td> </tr> </table> <p><u>Boundary works</u></p>	<input type="checkbox"/> Riparian reforestation	<input checked="" type="checkbox"/> Bank stabilization	<input type="checkbox"/> Stormwater retrofit	<input type="checkbox"/> Outfall stabilization	<input type="checkbox"/> Channel modification	<input type="checkbox"/> PS investigation	<input type="checkbox"/> Culvert rehab.	<input type="checkbox"/> Other _____
<input type="checkbox"/> Riparian reforestation	<input checked="" type="checkbox"/> Bank stabilization								
<input type="checkbox"/> Stormwater retrofit	<input type="checkbox"/> Outfall stabilization								
<input type="checkbox"/> Channel modification	<input type="checkbox"/> PS investigation								
<input type="checkbox"/> Culvert rehab.	<input type="checkbox"/> Other _____								



## Unified Stream Assessment (USA)

REACH ID: <i>Sheskey 1</i>	STREAM:	DATE/TIME: <i>11/19/18 0900</i>	INITIALS: <i>TLG/JJF</i>
REACH START	REACH END		
LAT: <i>34.880895</i>	LAT: <i>34.877477</i>		
LONG: <i>-92.395401</i>	LONG: <i>-92.387763</i>		

Average Conditions (check applicable)	
<b>Weather – Antecedent (24-h)</b> Rain in past 72-h: <input checked="" type="checkbox"/> y / <input type="checkbox"/> n <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100%      Flows Measured: Yes <input checked="" type="checkbox"/> No Stream Gradient: <input type="checkbox"/> High ( $\geq 25$ ft/mi) <input type="checkbox"/> Moderate (10-24 ft/mi) <input checked="" type="checkbox"/> Low ( $< 10$ ft/mi)      ~Slope: _____ ft/mi Sinuosity: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low	
<b>Channel Morphology</b> System: Step/Pool - <input checked="" type="checkbox"/> Riffle/Pool <input type="checkbox"/> Pool (circle) <input type="checkbox"/> Riffle _____ % <input checked="" type="checkbox"/> Run <i>80</i> % <input checked="" type="checkbox"/> Pool <i>20</i> % <input type="checkbox"/> Steps _____ %	
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder ( $> 10$ ") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input type="checkbox"/> Woody Debris <input type="checkbox"/> Root Wads <input type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input checked="" type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input checked="" type="checkbox"/> Overhanging Vegetation Habitat Quality: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input checked="" type="checkbox"/> Forest <i>30</i> % <input type="checkbox"/> Pasture _____ % <input type="checkbox"/> Urban _____ % <input type="checkbox"/> Commercial _____ % <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay _____ % <input checked="" type="checkbox"/> Industrial <i>20</i> % <input checked="" type="checkbox"/> Sub-Urban <i>50</i> %	<b>Local Watershed NPS Pollution</b> <input checked="" type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest <i>50</i> % <input type="checkbox"/> Shrub/Sapling _____ % <input checked="" type="checkbox"/> Herbs/Grasses <i>50</i> % <input type="checkbox"/> Turf/Crops _____ % Riparian Width: <input type="checkbox"/> $< 10$ ft <input type="checkbox"/> 11-25 ft <input checked="" type="checkbox"/> 26-50 ft <input type="checkbox"/> $> 50$ ft	
<b>Stream Shading (water surface)</b> <input type="checkbox"/> Mostly shaded ( $\geq 75$ % coverage) <input type="checkbox"/> Partially shaded ( $\geq 25$ % coverage) <input checked="" type="checkbox"/> Halfway shaded ( $\geq 50$ % coverage) <input type="checkbox"/> Unshaded ( $< 25$ % coverage)	
<b>Water Quality Observations</b> <b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____ <b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____ <b>Turbidity/Water Clarity:</b> <input checked="" type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____ <b>Sediment Deposits:</b> <input type="checkbox"/> None <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells	

### USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: <i>Shurtweg /</i>	Date: <i>11/14/18</i>	Initials: <i>TLG/JJF</i>
---------------------------------------	--------------------------	-----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
ER IB	1427/start	2	3	RR of LB utrow d apartments on RB little riparian, limited space for rest.
	1430 1433-1434 1431 1438-1440	3	1	
TR	1427-1434	1		Minimal trash
CM/SC	<i>Wpts</i> 1435-1436	3		Concrete lined channel under overpass
TR	1441	2		Moderate trash, old tires
TR	1442	2	3	3 small concrete culverts on LB, Bank failure on RB
SC	1445			R/R crossing, road flows into 3 large culverts

1  
2  
3  
4

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER RB	N 34.88089° W 92.39547° <i>TLG Wpt 1427</i>	L (M) H VH EX (circle one)	50'	3	Bank: Height <u>3.5</u> ft, Angle <u>80</u> Deg Protection: Roots <u>65</u> %, Root Depth <u>2.5</u> ft Vegetation <u>30</u> % *Material: <u>Silt/Clay</u> Sand / Gravel Cobble - %
ER RB	N. 34.88071° W 92.39503° <i>TLG Wpt 1430</i>	L M (H) VH EX (circle one)	160'	3	Bank: Height <u>7.5</u> ft, Angle <u>80</u> Deg Protection: Roots <u>15</u> %, Root Depth <u>3.0</u> ft Vegetation <u>5</u> % *Material: <u>Silt/Clay</u> Sand / Gravel Cobble - %
ER RB	N. 34.88057° W 92.39432° <i>TLG Wpt 1431</i>	L M (H) VH EX (circle one)	110'	3	Bank: Height <u>7.0</u> ft, Angle <u>80</u> Deg Protection: Roots <u>10</u> %, Root Depth <u>1.0</u> ft Vegetation <u>5</u> % *Material: <u>Silt/Clay</u> Sand / Gravel Cobble - %
ER RB	<i>TLG Wpt</i> 1433-1434	L M (H) VH EX (circle one)		3	Bank: Height <u>7.6</u> ft, Angle <u>80</u> Deg Protection: Roots <u>10</u> %, Root Depth <u>1.5</u> ft Vegetation <u>5</u> % *Material: <u>Silt/Clay</u> Sand / Gravel Cobble - %
ER	1438-1440 LB-1443-1444	L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % *Material: <u>Silt/Clay</u> Sand / Gravel Cobble - %

<sup>1</sup> Impacts: Outfall(OT), Bank Erosion(ER), Impacted buffer(IB), Utilities in channel(UT), Stream crossing(SC), Channel modification(CM), Trash in stream(TR), other.  
<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe  
<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high  
<sup>4</sup> Bank material: circle base type, silt/clay or sand and if present circle rock type and note %.



## USA, Cont.

REACH ID: <i>Sherry 1</i>	STREAM:	DATE/TIME: <i>11/19/18</i>	INITIALS: <i>TLG/SJF</i>
OTHER INFO:			

### Average Conditions (check applicable)

**Flood Plain Dynamics**

Connection:  Poor  Fair  Good      Vegetation:  Forest  Shrub/Sapling  Tall grasses  Turf/crops  
Habitat:  Poor  Fair  Good      Encroachment:  Poor  Fair  Good

<p><b>Periphyton (attached algae):</b></p> <p>Filamentous: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant  Prostrate: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant  Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant</p>	<p><b>Suspended Algae (phytoplankton) abundance:</b></p> <p><input checked="" type="checkbox"/> None noticeable (water basically clear)  <input type="checkbox"/> Moderate (water slightly green tinted)  <input type="checkbox"/> Abundant (water appears green)</p>
--	---

**Aquatic Plants In Stream:**

Submerged:  None  Sparse  Moderate  Abundant  
Emergent:  None  Sparse  Moderate  Abundant  
Floating:  None  Sparse  Moderate  Abundant

<p><b>Aquatic Life Observed:</b> <i>None</i></p> <p><input type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input type="checkbox"/> Macroinvertebrates</p>	<p><b>Wildlife/Livestock In or Around Stream (evidence of):</b></p> <p><input type="checkbox"/> Cattle <input checked="" type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other _____</p>
---	---

**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 \_\_\_\_\_       Impacted Buffers(IB): 1 2 **(3)** Wpt \_\_\_\_\_  
 Stream Crossing(SC): **(1)** 2 3 Wpt \_\_\_\_\_       Trash(TR): 1 **(2)** 3 Wpt \_\_\_\_\_  
 Bank Erosion(ER): 1 **(2)** 3 Wpt \_\_\_\_\_       Utilities(UT): **(1)** 2 3 Wpt \_\_\_\_\_  
 Channel Modification(CM): 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 **(1)**       Culvert Scour (upstream / downstream / top)  
 Headcutting       Bank scour       Slope failure       None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: 3.0 (ft)      Bankfull Depth 2.0 (ft)      Wetted Width: 13.0 (ft)      Riffle/Run Depth 0.3 (ft)  
Rt bank Ht: 10.0 (ft)      Bankfull Width 15.0 (ft)      TOB Width: 20.0 (ft)      Pool Depth 1.0 (ft)

**Channel Stability:**

Lt Bank: Angle 70 degrees      Rt Bank: Angle 80 degrees  
LtBank Vegetation protection: 70 % cover      RtBank Vegetation protection 30 % cover  
LtBank Erosion Hazard: **(L)** M H VH EX (circle one)      RtBank Erosion Hazard: L M **(H)** VH EX (circle one)  
Length Lt Bank Affected: \_\_\_\_\_      Length Rt Bank Affected: \_\_\_\_\_  
Wpt(s): \_\_\_\_\_      Wpt(s): \_\_\_\_\_

**Reach Accessibility For Restoration**

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

<p>Notes: (biggest problem(s) you see in survey reach)</p> <p><i>Erosion, trash, and lack of riparian buffer</i></p>	<p><b>Restoration Potential:</b></p> <p><input checked="" type="checkbox"/> Riparian reforestation      <input checked="" type="checkbox"/> Bank stabilization  <input type="checkbox"/> Stormwater retrofit      <input type="checkbox"/> Outfall stabilization  <input type="checkbox"/> Channel modification      <input type="checkbox"/> PS investigation  <input checked="" type="checkbox"/> Culvert rehab.      <input checked="" type="checkbox"/> Other <i>grade control</i></p>
--	--

Place sketch of reach on back of page.

## Unified Stream Assessment (USA)

REACH ID: <i>Shorkey 2</i>	STREAM:	DATE/TIME: <i>11/15/18 1300</i>	INITIALS: <i>JLB/JSF</i>
REACH START		REACH END	
LAT: <i>34.881425</i>	LAT: <i>34.879925</i>		
LONG: <i>-92.393693</i>	LONG: <i>-92.392382</i>		

Average Conditions (check applicable)	
<b>Weather – Antecedent (24-h)</b> Rain in past 72-h <input checked="" type="checkbox"/> n <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Low <input type="checkbox"/> None Base Flow as %Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100%      Flows Measured: Yes / <input checked="" type="checkbox"/> No Stream Gradient: <input type="checkbox"/> High (≥25ft/mi) <input type="checkbox"/> Moderate (10-24 ft/mi) <input checked="" type="checkbox"/> Low (<10 ft/mi)      ~Slope: _____ ft/mi Sinuosity: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low	
<b>Channel Morphology</b> <b>System:</b> Step/Pool - Riffle/Pool - Pool (circle) <input checked="" type="checkbox"/> Riffle <u>5</u> % <input checked="" type="checkbox"/> Run <u>45</u> % <input checked="" type="checkbox"/> Pool <u>50</u> % <input type="checkbox"/> Steps _____ %	
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input checked="" type="checkbox"/> Woody Debris <input type="checkbox"/> Root Wads <input type="checkbox"/> Leaf Packs <input checked="" type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input checked="" type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input type="checkbox"/> Forest _____ % <input type="checkbox"/> Pasture _____ % <input type="checkbox"/> Urban _____ % <input type="checkbox"/> Commercial _____ % <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay _____ % <input type="checkbox"/> Industrial _____ % <input type="checkbox"/> Sub-Urban _____ %	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest <u>50</u> % <input type="checkbox"/> Shrub/Sapling _____ % <input checked="" type="checkbox"/> Herbs/Grasses <u>50</u> % <input type="checkbox"/> Turf/Crops _____ % Riparian Width: <input type="checkbox"/> <10 ft <input type="checkbox"/> 11-25 ft <input checked="" type="checkbox"/> 26-50 ft <input type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input type="checkbox"/> Mostly shaded (≥75% coverage) <input type="checkbox"/> Partially shaded (≥25% coverage) <input checked="" type="checkbox"/> Halfway shaded (≥50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b>	
<b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____	<b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> Flecks <input type="checkbox"/> None <input type="checkbox"/> Other _____
<b>Turbidity/Water Clarity:</b> <input checked="" type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____	
<b>Sediment Deposits:</b> <input type="checkbox"/> None <input checked="" type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells	

*Silts*

### USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: <i>Sharkbay 2</i>	Date: <i>11/17/18</i>	Initials: <i>TJL/JTF</i>
---------------------------------------	--------------------------	-----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
<i>SC</i>	<i>Wpt 1453-1454</i>	<i>2</i>	<i>N/A</i>	<i>Double bog culvert crossing under road</i>
<i>SC</i>	<i>Wpt 1455</i>	<i>1</i>	<i>N/A</i>	<i>RR crossing</i>

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
<i>ER</i>		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - % _____
<i>ER</i>		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - % _____
<i>ER</i>		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - % _____
<i>ER</i>		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - % _____
<i>ER</i>		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - % _____

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

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

## USA, Cont.

REACH ID: <i>Shelter 2</i>	STREAM:	DATE/TIME: <i>11/19/18 1:30</i>	INITIALS: <i>TJB / JSE</i>
OTHER INFO: <i>1</i>			

### Average Conditions (check applicable)

<b>Flood Plain Dynamics</b>			
Connection: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good	Vegetation: <input checked="" type="checkbox"/> Forest <input type="checkbox"/> Shrub/Sapling <input checked="" type="checkbox"/> Tall grasses <input type="checkbox"/> Turf/crops		
Habitat: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	Encroachment: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good		
<b>Periphyton (attached algae):</b>		<b>Suspended Algae (phytoplankton) abundance:</b>	
Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input checked="" type="checkbox"/> None noticeable (water basically clear)		
Prostrate: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Moderate (water slightly green tinted)		
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input type="checkbox"/> Abundant (water appears green)		
<b>Aquatic Plants in Stream:</b>			
Submerged: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			
Emergent: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			

<b>Aquatic Life Observed:</b> <i>None</i> <input type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input type="checkbox"/> Macroinvertebrates	<b>Wildlife/Livestock In or Around Stream (evidence of):</b> <input type="checkbox"/> Cattle <input type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other
--	---

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

<input type="checkbox"/> Outfalls(OT): 1 2 3 Wpt _____	<input checked="" type="checkbox"/> Impacted Buffers(IB): <u>1</u> 2 3 Wpt _____
<input checked="" type="checkbox"/> Stream Crossing(SC): 1 2 <u>3</u> Wpt _____	<input type="checkbox"/> Trash(TR): 1 2 3 Wpt _____
<input type="checkbox"/> Bank Erosion(ER): 1 2 3 Wpt _____	<input type="checkbox"/> Utilities(UT): 1 2 3 Wpt _____
<input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt _____	<input type="checkbox"/> Other: 1 2 3 Wpt _____

**Notes:** *long box culvert under road*

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

**Channel Dynamics:**

<input type="checkbox"/> Incised (degrading)	<input checked="" type="checkbox"/> Channelized	<input type="checkbox"/> Bed Scour	<input checked="" type="checkbox"/> Sediment Deposition
<input type="checkbox"/> Widening	<input type="checkbox"/> Aggrading	<input type="checkbox"/> Bank Failure	<input type="checkbox"/> Culvert Scour (upstream / downstream / top)
<input type="checkbox"/> Headcutting	<input type="checkbox"/> Bank scour	<input type="checkbox"/> Slope failure	<input type="checkbox"/> None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: 2.5 (ft) Bankfull Depth 2.5 (ft) Wetted Width: 4.5 (ft) Riffle/Run Depth 0.2 (ft)  
 Rt bank Ht: 2.5 (ft) Bankfull Width 6.0 (ft) TOB Width: 8.0 (ft) Pool Depth 2.2 (ft)

**Channel Stability:**

Lt Bank: Angle <u>45</u> degrees	Rt Bank: Angle <u>45</u> degrees
LtBank Vegetation protection: <u>80</u> % cover	RtBank Vegetation protection <u>80</u> % cover
LtBank Erosion Hazard: <u>1</u> M H VH EX (circle one)	RtBank Erosion Hazard: <u>1</u> M H VH EX (circle one)
Length Lt Bank Affected: _____	Length Rt Bank Affected: _____
Wpt(s): _____	Wpt(s): _____

**Reach Accessibility For Restoration**

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

<p><b>Notes:</b> (biggest problem(s) you see in survey reach)</p> <p><i>Stream crossings</i></p> <p>Place sketch of reach on back of page.</p>	<p><b>Restoration Potential:</b> <i>None</i></p> <p><input type="checkbox"/> Riparian reforestation <input type="checkbox"/> Bank stabilization</p> <p><input type="checkbox"/> Stormwater retrofit <input type="checkbox"/> Outfall stabilization</p> <p><input type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation</p> <p><input type="checkbox"/> Culvert rehab. <input type="checkbox"/> Other _____</p>
--	---

## Unified Stream Assessment (USA)

REACH ID: <i>Benaszan</i>	STREAM:	DATE/TIME: <i>11/19/18 1400</i>	INITIALS: <i>TLG/JJF</i>
REACH START		REACH END	
LAT: <i>34.886583°</i>	LAT: <i>34.884822°</i>		
LONG: <i>-92.351946°</i>	LONG: <i>-92.351385°</i>		

**Average Conditions (check applicable)**

<b>Weather – Antecedent (24-h)</b> Rain in past 72-h <input checked="" type="checkbox"/> / n <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather – Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input type="checkbox"/> Perennial <input checked="" type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> 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 *30* %  Pool *60* %  Steps \_\_\_\_\_ %

<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input type="checkbox"/> Woody Debris <input type="checkbox"/> Root Wads <input checked="" type="checkbox"/> Leaf Packs <input checked="" type="checkbox"/> Deposition <input checked="" type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good <input type="checkbox"/> Optimal
--	--

<b>Land use</b> <input type="checkbox"/> Forest _____ % <input type="checkbox"/> Pasture _____ % <input type="checkbox"/> Urban _____ % <input type="checkbox"/> Commercial _____ % <input type="checkbox"/> Row Crops _____ % <input type="checkbox"/> Hay _____ % <input type="checkbox"/> Industrial _____ % <input type="checkbox"/> Sub-Urban _____ %	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
---	--

**Riparian Buffer**

Vegetation Type:  Forest \_\_\_\_\_ %  Shrub/Sapling \_\_\_\_\_ %  Herbs/Grasses \_\_\_\_\_ %  Turf/Crops \_\_\_\_\_ %

Riparian Width:  <10 ft  11-25 ft  26-50 ft  > 50 ft

**Stream Shading (water surface)**

Mostly shaded (≥75% coverage)  Partially shaded (≥25% coverage)  
 Halfway shaded (≥50% coverage)  Unshaded (<25% coverage)

**Water Quality Observations**

<b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____	<b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____
---	--

**Turbidity/Water Clarity:**

Clear  Slightly turbid  Turbid  
 Opaque  Stained  Other \_\_\_\_\_

**Sediment Deposits:**  None  Sludge  Sawdust  Oils  Sand  Relict shells

*Silt*

**USA Reach Impact Data Detail Sheet (optional)**

Reach ID/Stream: <u>Benaszech</u>	Date: <u>11/17/18 1400</u>	Initials: <u>TLG/JSF</u>
-----------------------------------	----------------------------	--------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
ER	Wpt 1456-1458 1459-1460	1	1	Moderate scouring/undercutting at LB + RB
SC	Wpt 1457	1	N/A	Road crossing with 2 culverts

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER	Wpt 1456 - 1458	L (M) H VH EX (circle one)		1	Bank: Height <u>4.5</u> ft, Angle <u>30</u> Deg Protection: Roots <u>40</u> %, Root Depth <u>3.0</u> ft Vegetation <u>5</u> % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - %
ER	Wpt 1459 - 1460	L (M) H VH EX (circle one)		2	Bank: Height <u>5.0</u> ft, Angle <u>80</u> Deg Protection: Roots <u>40</u> %, Root Depth <u>3.0</u> ft Vegetation <u>5</u> % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> 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 _____ % <sup>4</sup> Material: Silt/Clay Sand / Gravel Cobble - %

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

<sup>4</sup>Bank material: circle base type, silt/clay or sand and if present circle rock type and note %

## USA, Cont.

REACH ID: <i>Benezzah</i>	STREAM:	DATE/TIME: <i>11/19/10 1400</i>	INITIALS: <i>TLL/JSF</i>
OTHER INFO:			

### Average Conditions (check applicable)

<b>Flood Plain Dynamics</b> Connection: <input checked="" type="checkbox"/> Poor <input type="checkbox"/> Fair <input type="checkbox"/> Good Habitat: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	Vegetation: <input checked="" type="checkbox"/> Forest <input type="checkbox"/> Shrub/Sapling <input checked="" type="checkbox"/> Tall grasses <input type="checkbox"/> Turf/crops Encroachment: <input type="checkbox"/> Poor <input checked="" type="checkbox"/> Fair <input type="checkbox"/> Good
--	--

<b>Periphyton (attached algae):</b> Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant Prostrate: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<b>Suspended Algae (phytoplankton) abundance:</b> <input checked="" type="checkbox"/> None noticeable (water basically clear) <input type="checkbox"/> Moderate (water slightly green tinted) <input type="checkbox"/> Abundant (water appears green)
---	--

<b>Aquatic Plants in Stream:</b> Submerged: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant Emergent: <input type="checkbox"/> None <input checked="" type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			
---	--	--	--

<b>Aquatic Life Observed:</b> <input type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input type="checkbox"/> Macroinvertebrates	<b>Wildlife/Livestock In or Around Stream (evidence of):</b> <input type="checkbox"/> Cattle <input type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other
--	---

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

<input type="checkbox"/> Outfalls(OT): 1 2 3 Wpt _____	<input type="checkbox"/> Impacted Buffers(IB): 1 2 3 Wpt _____
<input checked="" type="checkbox"/> Stream Crossing(SC): <u>1</u> 2 3 Wpt _____	<input type="checkbox"/> Trash(TR): 1 2 3 Wpt _____
<input checked="" type="checkbox"/> Bank Erosion(ER): <u>1</u> 2 3 Wpt _____	<input type="checkbox"/> Utilities(UT): 1 2 3 Wpt _____
<input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt _____	<input type="checkbox"/> Other: 1 2 3 Wpt _____

Notes:

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

<b>Channel Dynamics:</b> <input checked="" type="checkbox"/> Incised (degrading) <input type="checkbox"/> Channelized <input type="checkbox"/> Bed Scour <input type="checkbox"/> Sediment Deposition <input type="checkbox"/> Widening <input type="checkbox"/> Aggrading <input type="checkbox"/> Bank Failure <input type="checkbox"/> Culvert Scour (upstream / downstream / top) <input type="checkbox"/> Headcutting <input checked="" type="checkbox"/> Bank scour <input type="checkbox"/> Slope failure <input type="checkbox"/> None (natural stable channel)			
--	--	--	--

**Channel Dimensions (facing downstream):**

Lt bank Ht: <u>4.0</u> (ft)	Bankfull Depth: <u>1.0</u> (ft)	Wetted Width: <u>7.0</u> (ft)	Riffle/Run Depth: <u>0.1</u> (ft)
Rt bank Ht: <u>4.5</u> (ft)	Bankfull Width: <u>7.5</u> (ft)	TOB Width: <u>13.0</u> (ft)	Pool Depth: <u>1.5</u> (ft)

<b>Channel Stability:</b> Lt Bank: Angle <u>75</u> degrees LtBank Vegetation protection: <u>15</u> % cover LtBank Erosion Hazard: L <u>(M)</u> H VH EX (circle one) Length Lt Bank Affected: _____ Wpt(s): _____	Rt Bank: Angle <u>75</u> degrees RtBank Vegetation protection: <u>15</u> % cover RtBank Erosion Hazard: L <u>(M)</u> H VH EX (circle one) Length Rt Bank Affected: _____ Wpt(s): _____
---	--

<b>Reach Accessibility For Restoration</b>		
<b>Good:</b> Open area in public ownership. Easy stream channel access by vehicle.	<b>Fair:</b> Forested or developed near stream. Vehicle access limited.	<b>Difficult:</b> 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)  <div style="font-family: cursive; font-size: 1.2em; margin-top: 10px;">Bank erosion</div>	<b>Restoration Potential:</b> <input type="checkbox"/> Riparian reforestation <input checked="" type="checkbox"/> Bank stabilization <input type="checkbox"/> Stormwater retrofit <input type="checkbox"/> Outfall stabilization <input type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation <input type="checkbox"/> Culvert rehab. <input type="checkbox"/> Other _____
Place sketch of reach on back of page.	

## Unified Stream Assessment (USA)

REACH ID: <u>WOB 2.6</u>	STREAM: <u>White Oak Bayou</u>	DATE/TIME: <u>3/12/2019</u>	INITIALS: <u>JFF/WAG</u>
REACH START		REACH END	
LAT: <u>34.840442°</u>	LAT: <u>34.814020</u>		
LONG: <u>-92.358596°</u>	LONG: <u>-92.354672</u>		

Average Conditions (check applicable)	
<b>Weather - Antecedent (24-h)</b> Rain in past 72-h (y/n) <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input checked="" type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy	<b>Weather - Current conditions</b> <input type="checkbox"/> Heavy rain <input type="checkbox"/> Steady rain <input type="checkbox"/> Showers <input type="checkbox"/> Clear/sunny <input checked="" type="checkbox"/> Mostly cloudy <input type="checkbox"/> Partly cloudy
<b>Stream Classification</b> <input checked="" type="checkbox"/> Perennial <input type="checkbox"/> Intermittent <input type="checkbox"/> Ephemeral <input type="checkbox"/> Tidal <input type="checkbox"/> Coldwater <input type="checkbox"/> Coolwater <input type="checkbox"/> Warmwater Order _____	<b>Stream Origin</b> <input type="checkbox"/> Spring-fed <input checked="" type="checkbox"/> Mixture of origins <input type="checkbox"/> Glacial <input type="checkbox"/> Montane (non-glacial) <input type="checkbox"/> Swamp/bog <input type="checkbox"/> Other _____
<b>Hydrology</b> Flow: <input type="checkbox"/> High <input type="checkbox"/> Moderate <input checked="" type="checkbox"/> Low <input type="checkbox"/> None Base Flow as % Channel Width: <input type="checkbox"/> 0-25% <input type="checkbox"/> 50-75% <input type="checkbox"/> 25-50% <input checked="" type="checkbox"/> 75-100%      Flows Measured: Yes <input checked="" type="checkbox"/> No Stream Gradient: <input type="checkbox"/> High (≥25ft/mi) <input type="checkbox"/> Moderate (10-24 ft/mi) <input checked="" type="checkbox"/> Low (<10 ft/mi)      ~Slope: <u>3.9</u> ft/mi Sinuosity: <input checked="" type="checkbox"/> High <input type="checkbox"/> Moderate <input type="checkbox"/> Low <u>1.65</u>	
<b>Channel Morphology</b> System: Step/Pool - Riffle/Pool - <u>Pool</u> (circle) <input type="checkbox"/> Riffle _____% <input type="checkbox"/> Run <u>10</u> % <input type="checkbox"/> Pool <u>90</u> % <input type="checkbox"/> Steps _____%	
<b>Dominant Substrate</b> <input checked="" type="checkbox"/> Silt/clay (fine or slick) <input type="checkbox"/> Cobble (2.5-10") <input type="checkbox"/> Sand (gritty) <input type="checkbox"/> Boulder (>10") <input type="checkbox"/> Gravel (0.1-2.5") <input type="checkbox"/> Bed Rock	<b>Dominant In-Stream Habitats</b> <input checked="" type="checkbox"/> Woody Debris <input type="checkbox"/> Root Wads <input type="checkbox"/> Leaf Packs <input type="checkbox"/> Deposition <input type="checkbox"/> Undercut Bank <input type="checkbox"/> Aquatic Plants <input type="checkbox"/> Overhanging Vegetation Habitat Quality: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good <input type="checkbox"/> Optimal
<b>Land use</b> <input checked="" type="checkbox"/> Forest <u>90</u> % <input type="checkbox"/> Pasture _____% <input type="checkbox"/> Urban _____% <input type="checkbox"/> Commercial _____% <input type="checkbox"/> Row Crops _____% <input type="checkbox"/> Hay _____% <input type="checkbox"/> Industrial _____% <input type="checkbox"/> Sub-Urban _____%	<b>Local Watershed NPS Pollution</b> <input type="checkbox"/> Industrial Storm Water <input checked="" type="checkbox"/> Urban/Sub-Urban Storm Water <input type="checkbox"/> Row crops <input type="checkbox"/> Cattle <input type="checkbox"/> Other _____ <input type="checkbox"/> No evidence
<b>Riparian Buffer</b> Vegetation Type: <input checked="" type="checkbox"/> Forest _____% <input type="checkbox"/> Shrub/Sapling _____% <input type="checkbox"/> Herbs/Grasses _____% <input type="checkbox"/> Turf/Crops _____% Riparian Width: <input type="checkbox"/> <10 ft <input type="checkbox"/> 11-25 ft <input type="checkbox"/> 26-50 ft <input checked="" type="checkbox"/> > 50 ft	
<b>Stream Shading (water surface)</b> <input checked="" type="checkbox"/> Mostly shaded (≥75% coverage) <input type="checkbox"/> Partially shaded (≥25% coverage) <input type="checkbox"/> Halfway shaded (≥50% coverage) <input type="checkbox"/> Unshaded (<25% coverage)	
<b>Water Quality Observations</b>	
<b>Odors Noted:</b> <input checked="" type="checkbox"/> Normal/None <input type="checkbox"/> Sewage <input type="checkbox"/> Anaerobic <input type="checkbox"/> Petroleum <input type="checkbox"/> Chemical <input type="checkbox"/> Fishy <input type="checkbox"/> Other _____	<b>Water Surface Appearance:</b> <input type="checkbox"/> Slick <input type="checkbox"/> Sheen <input type="checkbox"/> Globbs <input type="checkbox"/> Flecks <input checked="" type="checkbox"/> None <input type="checkbox"/> Other _____
<b>Turbidity/Water Clarity:</b> <input type="checkbox"/> Clear <input type="checkbox"/> Slightly turbid <input checked="" type="checkbox"/> Turbid <input type="checkbox"/> Opaque <input type="checkbox"/> Stained <input type="checkbox"/> Other _____	
<b>Sediment Deposits:</b> <input checked="" type="checkbox"/> None <input type="checkbox"/> Sludge <input type="checkbox"/> Sawdust <input type="checkbox"/> Oils <input type="checkbox"/> Sand <input type="checkbox"/> Relict shells	

**USA Reach Impact Data Detail Sheet (optional)**

Reach ID/Stream: <i>WOB 26</i>	Date: <i>3/12/12</i>	Initials: <i>JFF/WHG</i>
-----------------------------------	-------------------------	-----------------------------

Impact I.D. <sup>1</sup>	Coordinates (Lat / Long) or Waypoint	Severity (1-3) <sup>2</sup>	Restoration Opportunity (1-3) <sup>3</sup>	Description
<i>UT-1</i>	<i>WPT 367</i>	<i>1</i>	<i>1</i>	<i>50' ROW</i>
<i>UT-2</i>	<i>WPT 373</i>	<i>1</i>	<i>1</i>	<i>50' ROW</i>
<i>UT-3</i>	<i>WPT 377</i>	<i>1</i>	<i>1</i>	<i>50' ROW</i>
<i>SC-1</i>	<i>34.813876 -92.352994</i>	<i>1</i>	<i>1</i>	<i>T-130 B. dyo</i>
<i>TR</i>	<i>between 367 &amp; 367</i>	<i>1</i>	<i>1</i>	

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3) <sup>3</sup>	Bank information for BEHI
ER		L M H VH EX (circle one)			Bank: Height _____ ft, Angle _____ Deg Protection: Roots _____ %, Root Depth _____ ft Vegetation _____ % *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 _____ % *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 _____ % *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 _____ % *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 _____ % *Material: Silt/Clay Sand / Gravel Cobble - % _____

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

<sup>2</sup> Severity: 1=minor, 2=moderate, 3=severe

<sup>3</sup> Restoration Potential: 1=minimal, 2=moderate, 3=high

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

**USA, Cont.**

<b>REACH ID:</b> WOB 2b	<b>STREAM:</b> White Oak Bayou	<b>DATE/TIME:</b> 3/12/2019	<b>INITIALS:</b> JFF / WHG
<b>OTHER INFO:</b>			

**Average Conditions (check applicable)**

<b>Flood Plain Dynamics</b>		<b>Vegetation:</b> <input type="checkbox"/> Forest <input checked="" type="checkbox"/> Shrub/Sapling <input type="checkbox"/> Tall grasses <input type="checkbox"/> Turf/crops	
Connection: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	Habitat: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	Encroachment: <input type="checkbox"/> Poor <input type="checkbox"/> Fair <input checked="" type="checkbox"/> Good	
<b>Periphyton (attached algae):</b>		<b>Suspended Algae (phytoplankton) abundance:</b>	
Filamentous: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	Prostrate: <input type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	<input checked="" type="checkbox"/> None noticeable (water basically clear)	
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant		<input type="checkbox"/> Moderate (water slightly green tinted)	
<b>Aquatic Plants In Stream:</b>		<input type="checkbox"/> Abundant (water appears green)	
Submerged: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant	Emergent: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input checked="" type="checkbox"/> Moderate <input type="checkbox"/> Abundant		
Floating: <input checked="" type="checkbox"/> None <input type="checkbox"/> Sparse <input type="checkbox"/> Moderate <input type="checkbox"/> Abundant			

<b>Aquatic Life Observed:</b> <input checked="" type="checkbox"/> Fish <input type="checkbox"/> Snails <input type="checkbox"/> Crawfish <input type="checkbox"/> Macroinvertebrates	<b>Wildlife/Livestock In or Around Stream (evidence of):</b> <input type="checkbox"/> Cattle <input checked="" type="checkbox"/> Beaver <input checked="" type="checkbox"/> Deer <input type="checkbox"/> Other
---	--

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

<input type="checkbox"/> Outfalls(OT): 1 2 3 Wpt _____	<input type="checkbox"/> Impacted Buffers(IB): ① 2 3 Wpt _____
<input checked="" type="checkbox"/> Stream Crossing(SC): ① 2 3 Wpt _____	<input checked="" type="checkbox"/> Trash(TR): ① 2 3 Wpt _____
<input type="checkbox"/> Bank Erosion(ER): 1 2 3 Wpt _____	<input checked="" type="checkbox"/> Utilities(UT): ① 2 3 Wpt _____
<input type="checkbox"/> Channel Modification(CM): 1 2 3 Wpt _____	<input type="checkbox"/> 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:**

<input type="checkbox"/> Incised (degrading)	<input type="checkbox"/> Channelized	<input type="checkbox"/> Bed Scour	<input type="checkbox"/> Sediment Deposition
<input type="checkbox"/> Widening	<input type="checkbox"/> Aggrading	<input type="checkbox"/> Bank Failure	<input type="checkbox"/> Culvert Scour (upstream / downstream / top)
<input type="checkbox"/> Headcutting	<input type="checkbox"/> Bank scour	<input type="checkbox"/> Slope failure	<input checked="" type="checkbox"/> None (natural stable channel)

**Channel Dimensions (facing downstream):**

Lt bank Ht: 5.5 (ft)	Bankfull Depth: 5.25 (ft)	Wetted Width: 36.25 (ft)	Riffle/Run Depth: 4.5 (ft)
Rt bank Ht: 5.5 (ft)	Bankfull Width: 40 (ft)	TOB Width: 45 (ft)	Pool Depth: 5.25 (ft)

**Channel Stability:**

Lt Bank: Angle 25 degrees	Rt Bank: Angle 25 degrees
LtBank Vegetation protection: 75 % cover	RtBank Vegetation protection: 75 % cover
LtBank Erosion Hazard: ① M H VH EX (circle one)	RtBank Erosion Hazard: ① M H VH EX (circle one)
Length Lt Bank Affected: NA	Length Rt Bank Affected: NA
Wpt(s): _____	Wpt(s): _____

**Reach Accessibility For Restoration**

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

<p><b>Notes:</b> (biggest problem(s) you see in survey reach)</p> <p>Encroachment/development</p> <p>Banks very stable w/ great flood plain connectivity</p> <p>Place sketch of reach on back of page.</p>	<p><b>Restoration Potential:</b></p> <p><input checked="" type="checkbox"/> Riparian reforestation <input type="checkbox"/> Bank stabilization</p> <p><input type="checkbox"/> Stormwater retrofit <input type="checkbox"/> Outfall stabilization</p> <p><input type="checkbox"/> Channel modification <input type="checkbox"/> PS investigation</p> <p><input type="checkbox"/> Culvert rehab. <input checked="" type="checkbox"/> Other protect</p>
--	---



# Appendix B

DEQ Data

**Summary of Water Quality Data Collected by ADEQ**

	Average of Result				Count of Result			
	ARK0162A	ARK0162B	ARK0162C	ARK0162D	ARK0162A	ARK0162B	ARK0162C	ARK0162D
Alkalinity, total (mg/l CaCO3)	11.37	22.89	23.81	85.76	7	20	20	21
Aluminum (ug/l)	135.01	100.53	73.33	75.47	15	18	19	12
Ammonia-nitrogen (mg/l)	0.13	0.18	0.08	0.06	7	17	10	13
Arsenic (ug/l)	1.24	1.33	1.36	1.22	6	17	16	17
Barium (ug/l)	17.51	29.03	19.71	71.93	15	21	21	21
Boron (ug/l)	10.89	24.18	17.20	27.17	15	21	21	21
Bromide (mg/l)		0.15	0.11	0.11		2	1	4
Cadmium (ug/l)			0.12				1	
Calcium (mg/l)	1.86	6.37	6.73	27.50	15	21	21	21
Chloride (mg/l)	2.28	6.06	8.08	21.28	16	22	22	22
Cobalt (ug/l)	1.29	1.15	1.03	0.52	6	15	11	1
Copper (ug/l)	1.32	2.14	1.40	1.30	13	19	21	20
Dissolved oxygen (DO) (mg/l)	7.07	5.41	5.63	6.85	16	22	22	22
Escherichia coli (cfu/100ml)	336.14	322.14	404.58	342.40	14	16	17	17
Fluoride (mg/l)	0.08	0.11	0.11	0.13	8	16	17	20
Hardness, Ca, Mg (mg/l)	10.37	25.98	31.48	97.21	15	21	21	21
Inorganic nitrogen (nitrate and nitrite) (mg/l)	0.28	0.13	0.10	0.11	7	7	12	13
Iron (ug/l)	518.73	814.55	614.07	439.78	15	20	21	15
Lead (ug/l)	0.52	0.56	0.49	0.42	7	10	6	3
Magnesium (mg/l)	1.37	2.45	3.57	6.92	15	21	21	21
Manganese (ug/l)	319.24	853.70	703.31	211.64	15	21	21	21
Nickel (ug/l)	1.43	1.66	2.59	1.59	15	21	21	21
Orthophosphate (mg/l)	0.02	0.02	0.02	0.02	13	18	18	17
pH (None)	5.43	5.99	6.27	6.80	16	22	22	22
Potassium (mg/l)	1.26	2.32	2.13	2.26	15	21	21	21
Selenium (ug/l)		1.36	1.41	1.42		1	1	1
Silica (mg/l)	6.28	4.86	3.89	6.40	15	21	21	21
Sodium (mg/l)	2.12	5.29	6.52	14.97	15	21	21	21
Sulfate (mg/l)	4.16	6.12	10.77	15.37	16	22	22	22
Temperature, water (deg C)	14.16	15.89	16.74	18.00	16	22	22	22
Total dissolved solids (mg/l)	55.94	72.95	83.86	165.55	16	22	22	22
Total Kjeldahl nitrogen (mg/l)	0.53	0.84	0.66	0.62	16	22	22	22
Total Organic carbon (mg/l)	7.37	10.31	10.27	8.15	16	22	22	22
Total Phosphorus (mg/l)	0.05	0.07	0.06	0.08	16	22	22	22
Total Recoverable Aluminum (ug/l)	566.75	449.64	398.43	447.93	16	22	22	22
Total Recoverable Arsenic (ug/l)	1.55	2.04	1.85	1.73	7	16	16	17
Total Recoverable Barium (ug/l)	23.98	34.80	24.45	78.66	16	22	22	22
Total Recoverable Boron (ug/l)		36.39	44.25	40.69		8	2	10
Total Recoverable Calcium (mg/l)	1.94	6.41	6.82	27.31	16	22	22	22
Total Recoverable Chromium (ug/l)	1.19	1.46	1.20	1.39	4	3	3	4
Total Recoverable Cobalt (ug/l)	1.65	1.52	1.50	1.83	6	13	7	
Total Recoverable Copper (ug/l)	1.98	3.96	1.72	1.83	10	17	22	19
Total Recoverable Iron (ug/l)	1075.19	2131.59	1322.14	1116.00	16	22	22	22
Total Recoverable Lead (ug/l)	1.87	2.01	1.11	1.49	7	10	7	7

	Average of Result				Count of Result			
	ARK0162A	ARK0162B	ARK0162C	ARK0162D	ARK0162A	ARK0162B	ARK0162C	ARK0162D
Total Recoverable Magnesium (mg/l)	1.43	2.48	3.64	6.91	16	22	22	22
Total Recoverable Manganese (ug/l)	335.13	924.18	648.83	271.87	16	22	22	22
Total Recoverable Nickel (ug/l)	3.00	2.77	4.11	3.09	2	7	10	5
Total Recoverable Potassium (mg/l)	1.89	2.41	2.17	2.35	8	21	22	22
Total Recoverable Selenium (ug/l)	13.00	16.40	19.40	16.30	1	1	1	1
Total Recoverable Silica (mg/l)	6.50	7.09	5.15	9.31	2	2	2	2
Total Recoverable Sodium (mg/l)	1.95	5.03	6.20	13.88	16	22	22	22
Total Recoverable Vanadium (ug/l)	4.74	4.96	3.41	3.20	1	1	1	2
Total Recoverable Zinc (ug/l)	7.65	7.59	8.87	6.72	12	21	22	18
Total suspended solids (mg/l)	10.53	10.88	8.10	15.55	16	22	22	22
Turbidity (NTU)	28.63	25.88	19.61	27.48	16	22	22	22
Vanadium (ug/l)	0.68	0.81	0.64	0.85	5	9	10	10
Zinc (ug/l)	5.30	5.17	7.29	3.83	15	21	21	18
Total Nitrogen	0.94	1.14	0.85	0.79				

# ADEQ

ARKANSAS  
Department of Environmental Quality

## **Fish Communities of White Oak Bayou, Pulaski County, Arkansas**

Prepared for the White Oak Bayou Technical Advisory Group

Water Planning Section  
Arkansas Department of Environmental Quality  
5301 Northshore Dr  
North Little Rock, AR 72118

---

## **Introduction**

The Arkansas Department of Environmental Quality (ADEQ) sampled fish communities of White Oak Bayou in Pulaski County, Arkansas, during August 2011. This work was carried out as part of ADEQ's continued monitoring of White Oak Bayou, which also includes routine water quality inspections and macroinvertebrate collections. Further, the ongoing monitoring and this report serve to assist the White Oak Bayou Technical Advisory Committee in making decisions for management of the bayou.

This report details the fish communities in three reaches of the main channel of the bayou. A descriptive analysis of the collections provides information about the habitat availability and overall health of the bayou.

## **Study Site Description**

ADEQ routinely collects water for standard toxicity analyses (total and dissolved metals, total organic carbon, fecal coliform, solids, and several other parameters) at four sites: ARK0162A, ARK0162B, ARK0162C, and ARK0162D (hereafter A, B, C, and D). Site A is at the County Road 52 (Clinton Road) crossing in the community of Marche and is approximately 24.6 river kilometers (rkm) upstream of the bayou's confluence with the Arkansas River. Site B, also in the community of Marche, is at the County Road 54 (Marche Lateral) crossing approximately 18.8 rkm upstream of confluence. Site C, approximately 7.4 rkm upstream of confluence, is a reach east of Hwy 100 (Maumelle Blvd) in Maumelle, and is not associated with a bridge or crossing. Site D is located in Burns Park in North Little Rock, approximately 1.5 rkm upstream of confluence.

Of the four sites, only site C is adjacent to wetlands. Sites A and B are extensively bordered by pasture and have a degraded riparian zone with high rates of bank erosion. Site D appears to have hydrology most similar to a connected backwater of the Arkansas River, and lies within the Arkansas River floodplain.

## **Methods**

Site A was not sampled, as all water present was isolated pools and fish samples would not be an accurate representation of the communities of the bayou. Sites B and C were sampled on August 1, 2011 and Site D was sampled on August 2, 2011. A Smith-Root backpack shocker was used to stun fish and three ecologists collected fish with dip nets. At site D, a Smith-Root boat shocker was used and two ecologists collected fish with dip nets. All sites were sampled within an approximately 200-meter reach. As many fish as possible were identified on site and returned to the water alive. The remainder of each sample was preserved in formalin and returned to the laboratory for identification there. Robison and Buchanan (1988) was the standard for identification.

## **Results**

Sites B, C, and D yielded 14, 22, and 23 species, respectively. All three sites had nine species in common (64.3%, 40.9%, and 39.1% of species collected at that site, for

sites B, C, and D, respectively). Sites B and C had three species in common (21.4% and 13.6%, respectively) that did not appear at Site D, and sites C and D shared two species (9.1% and 8.7%, respectively) not collected at Site B. Site B had two species not found at other sites (14.3%). Site C had eight unique species (36.4%) and Site D had 12 (52.2%). See Appendix 1 for the full species list and taxa shared between sites.

Both species unique to Site B and six of the species unique to Site C prefer slow-moving streams and backwaters, as did all three species common to sites B and C. Of the 12 unique species at Site D, nine (39.1%) are frequently associated with larger streams or rivers and reservoirs. The nine species common to all three sites are habitat generalists, and typically lowland species with a varying range of tolerance to turbidity and current. The two species common to sites C and D are found in a relatively wide range of habitats and both are very common in lowland water bodies in the state. See Appendix 2 for full lists and life history description.

## **Conclusions**

All 35 species collected from White Oak Bayou are typical of low-gradient streams in multiple ecoregions of the state, especially the Arkansas River Valley. With the exception of common carp, all species are also native. Most are frequently associated with backwater habitats. Given that much of White Oak Bayou lies within the Arkansas River floodplain, this is to be expected. Most species have similar requirements for spawning and major habitat characteristics, but taxa-specific requirements do exist. The presence of multiple age classes in many of these species indicate that much of the habitat, hydrology, and forage requirements are being met. Two particularly important requirements for much of the taxa present are a flood-induced spawn and the presence of vegetation and structure throughout the habitat.

The community at Site D appears to be more influenced by the main channel Arkansas River, with 39.1% of collected species typically associated with larger rivers. This is in part logical, considering the more direct influence of the Arkansas River on White Oak Bayou's hydrology. Additionally, many species frequent in the main channel Arkansas River require tributary habitat like White Oak Bayou for spawning during spring floods and for nursery habitat for young-of-year. Sites B and C seem to be more similar to each other and substantially less influenced by the Arkansas River. There is little, if any, hydrological influence from the Arkansas River. However, it is not unreasonable to assume that fish from the Arkansas River can and do make movements this far up the bayou.

## Appendix 1

Family	Site		
	B	C	D
Lepisosteidae	<i>Lepisosteus oculatus</i>	<i>Lepisosteus oculatus</i> <i>L. osseus</i>	<i>Lepisosteus oculatus</i>
Amiidae		<i>Amia calva</i>	
Clupeidae	<i>Dorosoma cepedianum</i>	<i>Dorosoma cepedianum</i>	<i>Dorosoma cepedianum</i> <i>D. petenense</i>
Esocidae		<i>Esox americanus</i>	
Cyprinidae	<i>Opsopoeodus emiliae</i>	<i>Notemigonus crysoleucas</i> <i>Notropis atherinoides</i> <i>Minytrema melanops</i>	<i>Cyprinus carpio</i> <i>Cyprinella venustus</i> <i>Notropis maculatus</i> <i>Notropis</i> spp. (unidentified) <i>Pimephales vigilax</i>
Catostomidae			<i>Carpionodes carpio</i> <i>Ictiobus bubalus</i> <i>I. cyprinellus</i>
Ictaluridae	<i>Ameiurus natalis</i>	<i>Ameiurus natalis</i> <i>Ictalurus punctatus</i>	<i>Ictalurus punctatus</i>
Aphredoderidae		<i>Aphredoderus sayanus</i>	
Fundulidae	<i>Fundulus olivaceus</i>	<i>Fundulus olivaceus</i>	<i>Fundulus olivaceus</i>
Poeciliidae	<i>Gambusia affinis</i>	<i>Gambusia affinis</i>	
Atherinopsidae	<i>Labidesthes sicculus</i>	<i>Labidesthes sicculus</i>	<i>Labidesthes sicculus</i>
Moronidae			<i>Morone chrysops</i>
Elassomatidae		<i>Elassoma zonatum</i>	
Centrarchidae	<i>Lepomis cyanellus</i> <i>L. gulosus</i> <i>L. macrochirus</i> <i>L. megalotis</i> <i>L. microlophus</i>	<i>L. gulosus</i> <i>L. macrochirus</i> <i>L. megalotis</i> <i>L. microlophus</i>	<i>L. gulosus</i> <i>L. macrochirus</i> <i>L. megalotis</i> <i>L. microlophus</i> <i>Lepomis</i> spp. (unidentified) <i>Micropterus salmoides</i> <i>M. punctulatus</i> <i>Pomoxis nigromaculatus</i> <i>P. annularis</i>
Percidae	<i>Etheostoma chlorosomum</i>	<i>Etheostoma chlorosomum</i>	
Sciaenidae			<i>Aplodinotus grunniens</i>
<b>Color Codes:</b>	<b>Present at all sites</b>	<b>Present at two sites</b>	<b>Present at one site</b>

All fish species collected in White Oak Bayou by site. Color codes indicate presence at single or multiple sites.

## **Appendix 2: Species lists by site with life history information**

Site Location	ARK0162B; Pulaski Co Rd 54	Site notes:	Reach bordered by cow pasture on entire right side and ~30% of left side; no riparian buffer. ~60 m of left bank in hardwood w/ sparse understory; heavily channelized with eroding banks; very deep silt-mud substrate with leaf litter; cows have full access to stream							
Sample Date	8/1/2011									
Method	Backpack									
Family	Species	Common Name	Trophic Strategy <sup>1</sup>	Spawning Habitat <sup>1</sup>	Major Habitat <sup>1</sup>	Notes	Key Species <sup>2</sup>	Indicator Species <sup>3</sup>	Sportfish	Count
Lepisosteidae	<i>Lepisosteus oculatus</i>	spotted gar	piscivore, invertivore, omnivore	vegetated backwaters and flooded land	lg rivers & tributaries, connected & isolated backwaters				M	2
Clupeidae	<i>Dorosoma cepedianum</i>	gizzard shad	planktivore, detritivore	shallow backwater w/ vegetation & structure	nearly all aquatic habitat except high-gradient streams	key forage species			N	9
Cyprinidae	<i>Opsopoeodus emiliae</i>	pugnose minnow	invertivore, herbivore	?	slow-moving streams and backwaters with soft substrate				N	2
Ictaluridae	<i>Ameiurus natalis</i>	yellow bullhead	invertivore, piscivore	mud banks, excavatable substrate with logs or other structure	slow-moving backwaters, relatively clear water, most aquatic habitats in state				M	2
Fundulidae	<i>Fundulus olivaceus</i>	blackspotted topminnow	invertivore	?	margins of nearly every aquatic habitat in state, primarily backwaters; avoids current				N	1
Poeciliidae	<i>Gambusia affinis</i>	mosquitofish	invertivore, herbivore	everywhere; livebearer	nearly all aquatic habitat except high-gradient streams; avoids current		Channel altered delta		N	1
Atherinopsidae	<i>Labidesthes sicculus</i>	brook silverside	invertivore, planktivore	over vegetation and gravel	small to medium streams and rivers and lakes; rarely in largest rivers				N	4
Centrarchidae	<i>Lepomis cyanellus</i>	green sunfish	piscivore, invertivore, omnivore	gravel or soft substrate	nearly all aquatic habitats, but primarily backwaters and slow streams		Channel altered delta		Y	1
Centrarchidae	<i>L. gulosus</i>	warmouth	piscivore, invertivore	soft substrate or excavatable gravel near structure	low gradient streams and backwaters with heavy vegetation		Gulf coastal plain		Y	11
Centrarchidae	<i>L. macrochirus</i>	bluegill	invertivore, piscivore	soft substrate or excavatable gravel	slow-moving streams and backwaters; all over state		Least disturbed delta		Y	11
Centrarchidae	<i>L. megalotis</i>	longear sunfish	invertivore, piscivore	soft substrate or excavatable gravel; usually away from structure and vegetation	nearly all aquatic habitats in state; primarily in clear, high- to medium-gradient streams		Arkansas River Valley		Y	9
Centrarchidae	<i>L. microlophus</i>	redeer sunfish	invertivore, piscivore	soft substrate	backwaters with soft substrate, structure, and vegetation, slow-moving streams				Y	1
Centrarchidae	<i>Micropterus salmoides</i>	largemouth bass	piscivore, invertivore	gravel or soft substrate with vegetation	lakes, ponds, backwaters with vegetation and structure; secondarily in streams with current		Least disturbed delta		Y	4
Percidae	<i>Etheostoma chlorosomum</i>	bluntnose darter	probably invertivore	likely on debris and plants	slow-moving turbid streams and backwaters with soft substrate and detritus		Least disturbed delta		N	1

<sup>1</sup> Robison and Buchanan 1988, Pflieger 1975, Fishbase.org

<sup>2</sup> Fishes which are normally the dominant species (except for some ubiquitous species) within the important groups such as fish families or trophic feeding levels (APCEC 2011)

<sup>3</sup> Species of fish which may not be dominant within a species group and may not be limited to one area of the state, but which, because of their presence, are readily associated with a specific ecoregion. (APCEC 2011)

Sportfish category: Y = yes, M = maybe, N = no, C = commercial

Site Location Sample Date Method	ARK0162 C; AR Hwy 100 8/1/2011 Backpack	Site notes: Densely forested on all left bank; right bank with 50 - 100m margin; immediately downstream of two wetlands and ~200 m section bordering Maumelle Blvd; shallow; bottom with silt/mud, high density of LWD and SWD; submergent and emergent vegetation; cypress and other wetland trees								
Family	Species	Common Name	Trophic Strategy <sup>1</sup>	Spawning Habitat <sup>1</sup>	Major Habitat <sup>1</sup>	Notes	Key Species <sup>2</sup>	Indicator Species <sup>3</sup>	Sportfish	Count
Lepisosteidae	<i>Lepisosteus oculatus</i>	spotted gar	piscivore, invertivore, omnivore	vegetated backwaters and flooded land	lg rivers & tributaries, connected & isolated backwaters				M	1
Lepisosteidae	<i>L. osseus</i>	longnose gar	piscivore	flooded backwater w/ vegetation, rocks, sometimes main channel river	lg rivers & tributaries, connected & isolated backwaters, upland rivers, lakes				M	2
Amiidae	<i>Amia calva</i>	bowfin	piscivore	slow water w/ vegetation	lowland, slow-moving streams, backwaters, and swamps	nest host for <i>N. crysoleucas</i>			M	4
Clupeidae	<i>Dorosoma cepedianum</i>	gizzard shad	planktivore, detritivore	shallow backwater w/ vegetation & structure	nearly all aquatic habitat except high-gradient streams	key forage species			N	6
Esocidae	<i>Esox americanus</i>	redfin pickerel	piscivore, invertivore	backwaters	slow-moving streams & backwaters with vegetation	sensitive to riparian degradation, especially by cattle	Gulf Coastal Plain		M	2
Cyprinidae	<i>Notemigonus crysoleucas</i>	golden shiner	planktivore, invertivore, omnivore	?	vegetated, slow-moving water, nearly all habitat except high-gradient streams				N	1
Cyprinidae	<i>Notropis atherinoides</i>	emerald shiner	planktivore, invertivore	open water over hard substrate	medium to large rivers & streams, lakes			Channel altered delta	N	2
Catostomidae	<i>Minytrema melanops</i>	spotted sucker	detritivore, invertivore	?	slow, turbid backwaters w/ soft substrate and vegetation	pollution intolerant	Gulf Coastal Plain	Channel altered delta	N	3
Ictaluridae	<i>Ameiurus natalis</i>	yellow bullhead	invertivore, piscivore	mud banks, excavatable substrate with logs or other structure	slow-moving backwaters, relatively clear water, most aquatic habitats in state				M	1
Ictaluridae	<i>Ictalurus punctatus</i>	channel catfish	piscivore, invertivore, omnivore	undercut banks or debris	most aquatic habitat			Channel altered delta	Y	2
Aphredoderidae	<i>Aphredoderus sayanus</i>	pirate perch	invertivore, occasionally piscivore	undercut vegetated banks	slow-moving streams and backwaters with soft substrate; must have vegetated banks				N	8
Fundulidae	<i>Fundulus olivaceus</i>	blackspotted topminnow	invertivore	?	margins of nearly every aquatic habitat in state, primarily backwaters; avoids current				N	35
Poeciliidae	<i>Gambusia affinis</i>	mosquitofish	invertivore, herbivore	everywhere	nearly all aquatic habitat except high-gradient streams; avoids current				N	30
Atherinopsidae	<i>Labidesthes sicculus</i>	brook silverside	invertivore, planktivore	over vegetation and gravel	small to medium streams and rivers and dlakes; rarely in largest rivers				N	58
Elassomatidae	<i>Elassoma zonatum</i>	banded pygmy sunfish	invertivore	over vegetation	backwaters with soft substrate and heavy vegetation				N	6
Centrarchidae	<i>L. gulosus</i>	warmouth	piscivore, invertivore	soft substrate or excavatable gravel near structure	low gradient streams and backwaters with heavy vegetation		Gulf coastal plain		Y	9

Family	Species	Common Name	Trophic Strategy <sup>1</sup>	Spawning Habitat <sup>1</sup>	Major Habitat <sup>1</sup>	Key Species <sup>2</sup>	Indicator Species: Sportfish	Count
Centrarchidae	<i>L. macrochirus</i>	bluegill	invertivore, piscivore	soft substrate or excavatable gravel	slow-moving streams and backwaters; all over state	Least disturbed delta	Y	62
Centrarchidae	<i>L. megalotis</i>	longear sunfish	invertivore, piscivore	soft substrate or excavatable gravel; usually away from structure and vegetation	nearly all aquatic habitats in state; primarily in clear, high- to medium-gradient streams	Arkansas River Valley	Y	24
Centrarchidae	<i>L. micolophus</i>	redear sunfish	invertivore, piscivore	soft substrate	backwaters with soft substrate, structure, and vegetation, slow-moving streams		Y	25
Centrarchidae	<i>Micropterus salmoides</i>	largemouth bass	piscivore, invertivore	gravel or soft substrate with vegetation	lakes, ponds, backwaters with vegetation and structure; secondarily in streams with current	Least disturbed delta	Y	10
Centrarchidae	<i>Pomoxis nigromaculatus</i>	black crappie	piscivore, invertivore	soft substrate with heavy vegetation and cover	lakes, ponds, backwaters with heavy vegetation and structure; secondarily in streams with current		Y	1
Percidae	<i>Etheostoma chlorosomum</i>	bluntnose darter	probably invertivore	likely on debris and plants	slow-moving turbid streams and backwaters with soft substrate and detritus	Least disturbed delta	N	35
<sup>1</sup> Robison and Buchanan 1988, Pflieger 1975, Fishbase.org								
<sup>2</sup> Fishes which are normally the dominant species (except for some ubiquitous species) within the important groups such as fish families or trophic feeding levels (APCEC 2011)								
<sup>3</sup> Species of fish which may not be dominant within a species group and may not be limited to one area of the state, but which, because of their presence, are readily associated with a specific ecoregion. (APCEC 2011)								
Sportfish category: Y = yes, M = maybe, N = no, C = commercial								

Site Location	ARK0162 D; Burns Park	Site notes: Intact riparian buffer on both banks; bank erosion, but not substantial; low banks, water level typically very near bankfull/floodplain; heavily influenced by Arkansas River Pool 6;								
Sample Date	8/2/2011									
Method	Boat									
Family	Species	Common Name	Trophic Strategy <sup>1</sup>	Spawning Habitat <sup>1</sup>	Major Habitat <sup>1</sup>	Notes	Key Species <sup>2</sup>	Indicator Species <sup>3</sup>	Sportfish	Count
Lepisosteidae	<i>Lepisosteus oculatus</i>	spotted gar	piscivore, invertivore, omnivore	vegetated backwaters and flooded land	lg rivers & tributaries, connected & isolated backwaters				M	1
Clupeidae	<i>Dorosoma cepedianum</i>	gizzard shad	planktivore, detritivore	shallow backwater w/ vegetation & structure	nearly all aquatic habitat except high-gradient streams	key forage species		Channel-altered delta	N	152
Clupeidae	<i>D. petenense</i>	threadfin shad	planktivore, detritivore	shallow marginal waters with substrate and vegetation	med to lg rivers and reservoirs	key forage species			N	147
Cyprinidae	<i>Cyprinus carpio</i>	common carp	herbivore, omnivore	shallow, heavily vegetated backwaters and flooded land	successful in backwaters waters with vegetation	invasive; destructive to benthos and vegetation	Channel-altered delta		M	7
Cyprinidae	<i>Cyprinella venustus</i>	blacktail shiner	invertivore, herbivore	over structure	med to lg rivers, sparsely vegetated backwaters; prefers current		Channel-altered delta		N	5
Cyprinidae	<i>Notropis maculatus</i>	taillight shiner	invertivore, herbivore	?	slow-moving streams and backwaters with soft substrate and vegetation				N	11
Cyprinidae	<i>Notropis</i> spp.	YOY shiners							N	6
Cyprinidae	<i>Pimephales vigilax</i>	bullhead minnow	omnivore	soft substrate with structure	lg streams and rivers and backwaters with soft substrate				N	23
Catostomidae	<i>Carpiodes carpio</i>	river carpsucker	benthic omnivore	variable; reported over both structure and open sand	med to lg rivers and cpnnected backwaters with sand substrate				N	2
Catostomidae	<i>Ictiobus bubalus</i>	smallmouth buffalo	benthic omnivore	shallow, vegetated backwaters and flooded land	lg streams and rivers and backwaters with clear water and soft substrate		Least disturbed delta		M/C	11
Catostomidae	<i>I. cyprinellus</i>	bigmouth buffalo	planktivore	shallow, vegetated backwaters and flooded land	med to lg streams and rivers, lg pools				M/C	3
Ictaluridae	<i>Ictalurus punctatus</i>	channel catfish	piscivore, invertivore, omnivore	undercut banks or debris	most aquatic habitat		Channel-altered delta		Y/C	6
Fundulidae	<i>Fundulus olivaceus</i>	blackspotted topminnow	invertivore	?	margins of nearly every aquatic habitat in state, primarily backwaters; avoids current				N	2
Atherinopsidae	<i>Labidesthes sicculus</i>	brook silverside	invertivore, planktivore	over vegetation and gravel	small to med streams and rivers and dlakes; rarely in lgst rivers				N	11
Moronidae	<i>Morone chrysops</i>	white bass	piscivore	shallow water over hard substrate in tributaries of lg rivers and reservoirs	med to lg streams and rivers, lakes and reservoirs with clear water				Y	2
Centrarchidae	<i>L. gulosus</i>	warmouth	piscivore, invertivore	soft substrate or excavatable gravel near structure	low gradient streams and backwaters with heavy vegetation		Gulf coastal plain		Y	1

Family	Species	Common Name	Trophic Strategy <sup>1</sup>	Spawning Habitat <sup>1</sup>	Major Habitat <sup>1</sup>	Key Species <sup>2</sup>	Indicator Species	Sportfish	Count
Centrarchidae	<i>L. macrochirus</i>	bluegill	invertivore, piscivore	soft substrate or excavatable gravel	slow-moving streams and backwaters; all over state	Least disturbed delta		Y	139
Centrarchidae	<i>L. megalotis</i>	longear sunfish	invertivore, piscivore	soft substrate or excavatable gravel; usually away from structure and vegetation	nearly all aquatic habitats in state; primarily in clear, high- to med-gradient streams	Arkansas River Valley		Y	110
Centrarchidae	<i>L. micolophus</i>	redeer sunfish	invertivore, piscivore	soft substrate	backwaters with soft substrate, structure, and vegetation, slow-moving streams			Y	10
Centrarchidae	<i>Lepomis</i> spp.	YOY sunfish							34
Centrarchidae	<i>Micropterus salmoides</i>	largemouth bass	piscivore, invertivore	gravel or soft substrate with vegetation	lakes, ponds, backwaters with vegetation and structure; secondarily in streams with current	Least disturbed delta		Y	35
Centrarchidae	<i>M. punctulatus</i>	spotted bass	piscivore, invertivore	excavatable hard substrate near structure	med to lg streams and rivers; primarily in streams with open water and current; rock substrate	Arkansas River Valley		Y	2
Centrarchidae	<i>Pomoxis nigromaculatus</i>	black crappie	piscivore, invertivore	soft substrate with heavy vegetation and cover	lakes, ponds, backwaters with heavy vegetation and structure; secondarily in streams with current			Y	12
Centrarchidae	<i>P. annularis</i>	white crappie	piscivore, invertivore	silt-free substrate with vegetation	slow-moving streams and lakes with dense cover			Y	1
Sciaenidae	<i>Aplodinotus grunniens</i>	drum	invertivore	open water	med to lg rivers, lakes; deep water; very tolerant of current, often schools near dams	Channel-altered delta		M	8
<sup>1</sup> Robison and Buchanan 1988, Pflieger 1975, Fishbase.org									
<sup>2</sup> Fishes which are normally the dominant species (except for some ubiquitous species) within the important groups such as fish families or trophic feeding levels (APCEC 2011)									
<sup>3</sup> Species of fish which may not be dominant within a species group and may not be limited to one area of the state, but which, because of their presence, are readily associated with a specific ecoregion. (APCEC 2011)									
Sportfish category: Y = yes, M = maybe, N = no, C = commercial									

## **Literature Cited**

Arkansas Pollution Control and Ecology Commission. Regulation 2: Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas. Revised August 2011.

Pflieger, W. L. 1975. The Fishes of Missouri. Missouri Department of Conservation. Jefferson City, Missouri.

Robison, H. W. and T. M. Buchanan. 1988. Fishes of Arkansas. University of Arkansas Press. Fayetteville, Arkansas.

# Appendix C

Data collected by Universities

## **Final report - White Oak Bayou water quality monitoring by UCA, 2020-2022**

Dr. Halvor M. Halvorson, UCA Department of Biology

Dr. Matthew H. Connolly, UCA Department of Geography

### **Outline of work completed**

#### *Study Area*

The White Oak Bayou (WOB) watershed is located in the northwest corner of Pulaski County in Central Arkansas and includes parts of several major cities in the region, as well as several unincorporated Pulaski County communities. The majority of western Maumelle, and small parts of northwestern Little Rock and northwestern North Little Rock are within the WOB watershed (Figure 1). According to the 2020 U.S. Decennial Census (USCB, 2020), Pulaski County, Arkansas' population was approximately 399,125 people. The WOB accounts for about 6.83% of Pulaski County's total land area, placing WOB 2020 population estimates near 27,265 people assuming a homogeneous spatial distribution of population throughout the county. This estimate likely overestimates the current number of WOB residents, but is a reasonable approximation given the simplicity of the calculation and the goals of the study (biogeochemical constituents and physical stream characteristic monitoring).

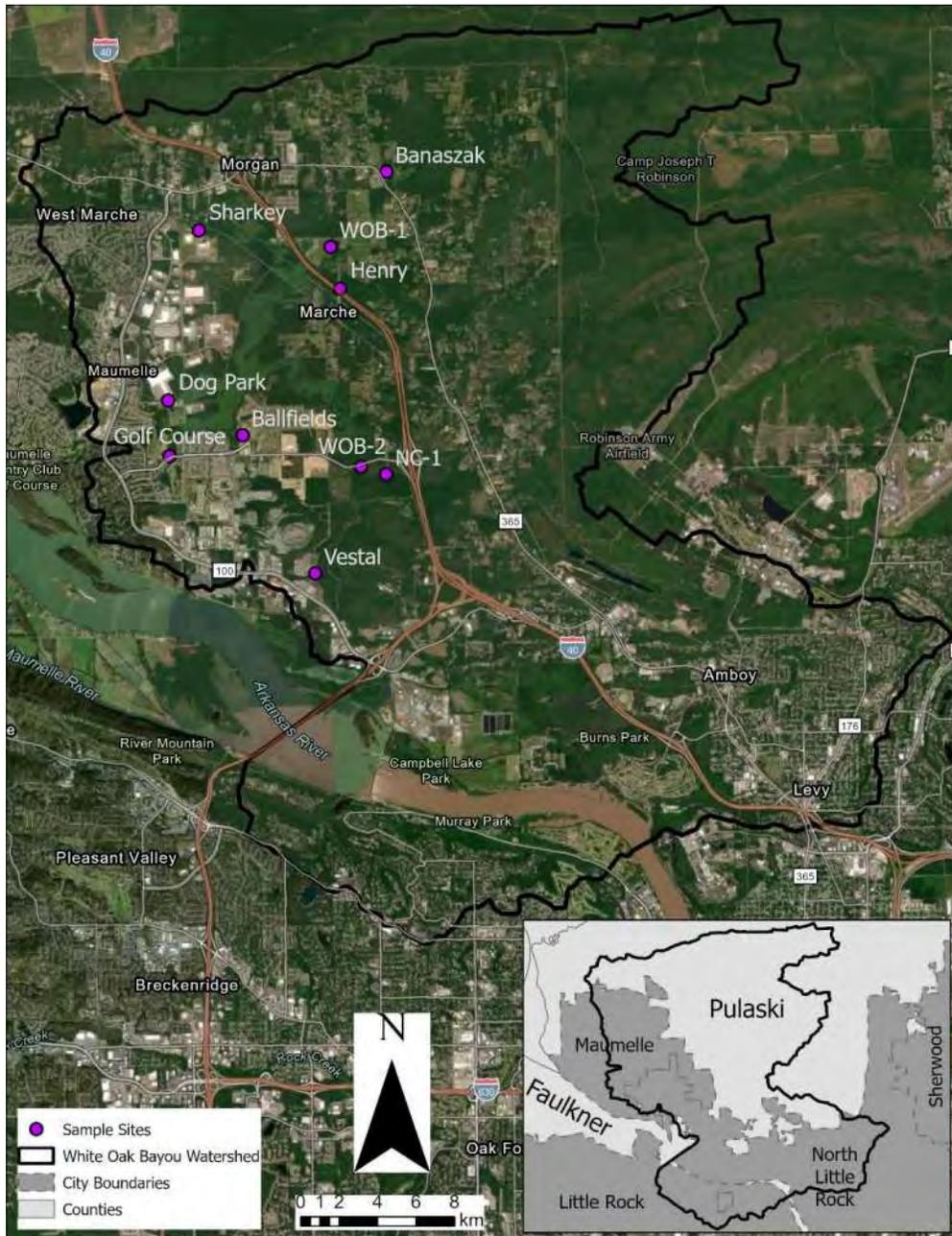


Figure 1. The main map frame shows the White Oak Bayou HUC-12 watershed boundary and spatial distribution of sampling sites, and the inset provides the relative location of the WOB watershed in Pulaski County.

From a physical perspective, the White Oak Bayou watershed is part of the Arkansas Valley Ecoregion and receives an approximate annual average precipitation of 1120 mm to 1270 mm (USFS, 2022) and has the general rainfall and temperature characteristics of a Köppen-Geiger Cfa Humid Subtropical climate (Kottek et al., 2006). Specific sampling locations were predetermined by Project Partners GBMc & Associates and the City of Maumelle, Arkansas as part of an ongoing longitudinal water quality assessment of the White Oak Bayou watershed (see Figure 1). These sites represented a gradient of developed (urban), agricultural, and forested land uses and land covers (LULC) in the northern and northwestern parts of the watershed. Across all sampling site catchments, developed LULC ranged from 81.80% to 12.21%, forested LULC ranged from 79.56% to 12.32%, and agricultural LULC ranged from 0.28% to 21.66% in the most recent National Land Cover Database for the Conterminous United States (MRLC, 2019).

#### *Field component*

The UCA water quality monitoring team began collecting samples across all ten selected sites within WOB beginning in March 2021. We sampled each site once monthly through February 2022. Before sampling, the UCA team joined GBMc associates Nicki Johnson and Greg Phillips on a site scouting day to determine site locations and access. On the first sample date (March 13, 2021), the team established consistent sampling locations. At each site, the team drew a site sketch, placed permanent wood stakes, and used a Trimble Geo7X GPS unit to record GPS coordinates for sample locations to provide consistent reference points for all sampling events.

Standard protocols were implemented during each sampling event. First, the team used a bucket pre-rinsed with site water to collect a surface water sample. Each water sample was then divided among appropriate acid-washed and triple-rinsed water collection bottles (250 mL for TN/TP, 125 mL for dissolved nutrients and metals, and 500 mL for TSS) and placed on ice. The team then used a handheld YSI proSolo multiparameter sensor to measure surface water dissolved oxygen, temperature, and specific conductivity at the sample site. The team used meter tape to establish channel wetted width and used a depth rod to collect depths at regular intervals of 0.5 to 1.0 meters width. At each depth point, the team also measured water velocity using a Hach FH950 handheld flow meter, placed at 0.6 of the fractional depth to measure mean water column velocity. Finally, the team used the floating orange method to measure

water velocity in the thalweg of each site. An orange was placed upstream and the length of time for the orange to float downstream 1 meter distance was recorded at three consecutive times at each site. Collection site, upstream and downstream photographs were taken at each site to archive physical site conditions during each sampling event.

Sites were sampled once monthly, to include ten sampling events under baseflow conditions and two sampling events under stormflow conditions. We defined stormflow conditions as sampling times during active runoff, or significant runoff within 24 hours of sampling. The storm sampling days during the study period were April 17, 2021 and May 20, 2021.

### *Laboratory component*

Water samples were returned to the UCA campus and processed for water chemistry analysis. Briefly, a 125 mL unfiltered sample was acidified with 125  $\mu$ L American Chemical Society grade concentrated sulfuric acid for analysis of Total Nitrogen (TN) and Total Phosphorus (TP). A separate 40 mL sample was filtered (0.45  $\mu$ m pore) and acidified with 40  $\mu$ L trace-metal grade concentrated sulfuric acid for analysis of dissolved nutrients (nitrate/nitrite and phosphate). A second separate 40 mL sample was filtered (0.45  $\mu$ m pore) and acidified with 200  $\mu$ L trace-metal grade concentrated hydrochloric acid and 460  $\mu$ L trace-metal grade concentrated nitric acid for analysis of dissolved metals copper and lead. A 500 mL unfiltered water sample was reserved for analysis of total suspended solids. Finally, an unfiltered subsample from each site was also analyzed for turbidity using a turbidimeter.

Samples designated for TN/TP, dissolved nutrients, dissolved metals, and total suspended solids were kept in the refrigerator at 4°C. Samples were then packed on ice in a cooler and shipped overnight to the Arkansas Water Resources Center (AWRC) in Fayetteville, Arkansas for analysis. The AWRC provided a summary of results after each month of sampling.

On a quarterly basis, routine sampling included additional collection of samples to measure Biological Oxygen Demand over 5 days (BOD5). Briefly, a one-liter sample was collected at each site and kept on ice until shipment overnight to the AWRC to measure BOD5 over five days. All samples were collected within a 24-hour period of initiating BOD5 measurements at AWRC.

On the first day of sampling, the team collected a field blank sample which entailed a nanopure water sample transported and collected in the field, and subsequently filtered and acidified as with all other water chemistry samples. Each subsequent sampling event also included a duplicate sample collected from one field site such that each site was duplicated at

least once during the study period. These duplicates were included in all subsequent filtering and acidification steps prior to shipment to AWRC for analysis.

Upon completion of a sampling event, the UCA team entered all field data into Excel spreadsheets. The team used measured site wetted width, as well as depth and velocity point measures, to calculate discharge at each site. Water chemistry data sent by AWRC were also transferred into Excel spreadsheets.

#### *Land Use Land Cover (LULC) analysis*

We calculated the LULC for each sample site using the 2019 National Land Cover Database (MRLC, 2019), ArcGIS Pro (v. 2.9), and USGS StreamStats (v. 4.10.0) (USGS, 2022). Sampling site GPS data were differentially corrected with Trimble Pathfinder Office (v. 5.30) to improve the horizontal accuracy to within +/- 0.2 m of each site's actual location on the Earth's surface, and the resulting GPS data were exported to ArcGIS Pro shapefiles. We submitted the sample site shapefile to the USGS StreamStats Batch Processor to delineate the individual catchments for each site. The USGS StreamStats Batch Processor delineated the individual site catchments using a hydrologically conditioned Digital Elevation Model to determine flow paths, topographic drainage divides, and drainage areas (USGS, 2022).

Prior to calculating the LULC percentages, we preprocessed the 2019 NCLD data to restrict its spatial extent to the White Oak Bayou HUC-12 watershed boundary and reduce processing time. Then, we reclassified the NLCD data into eight LULC classes. We kept the original Open Water, Barren Land (exposed rock outcrops, bare soil, coarse-grained weathering products, etc.), Grassland/Herbaceous, and Shrub/Scrub (shrubs less than 5 m tall occupying more than 20% of the vegetated canopy), but aggregated the varying levels of Developed (low, medium, and high intensity), Planted/Cultivated (Pasture/Hay and Cultivated Crops), and Wetlands (Woody Wetlands and Herbaceous Wetlands) into a single Developed, Agriculture, and Wetland class respectively. A complete description of the NLCD LULC classes is available on the Multi-Resolution Land Characteristics Consortium website (MRLC, 2022). We obtained the LULC percentage for the WOB and each sampling site by clipping the reclassified NLCD data to the WOB HUC-12 watershed boundary and each individual catchment boundary, and dividing the number of pixels in each LULC class by the total number of pixels in all LULC classes within the watershed and catchment respectively.

### *Proximal and Distal LULC analysis*

Although all LULC, natural processes (precipitation, organismal life processes, nutrient cycling, etc.), and anthropogenic processes (urbanization, water withdrawals, point source pollutant discharge, etc.) within a catchment influence its water chemistry, these effects are not spatially uniform. More specifically, phenomena closer to a sampling location (proximal) may exert greater influence on water chemistry than phenomena farther away (distal) due to hydrologic response differences throughout a drainage basin (Allan, 2004; Gove, Edwards, & Conquest, 2001). These differences in hydrologic response often include differences in surface runoff, infiltration, discharge (Q), and sediment storage and transport, each of which is influenced by LULC and may alter water constituent concentrations at different spatial scales (Sweeney & Newbold, 2014; Allan, 2004). Considering different spatial scales such as riparian buffers (lateral buffers around a stream segment) and partial upstream catchments (reduced catchment areas) potentially changes distances between dominant LULC influences and water sample locations. Therefore, we conceptualized distal and proximal LULC by comparing land uses and land covers for full site catchments (distal), adjusted partial upstream catchments (intermediate), and a partial upstream riparian buffer (proximal).

We used the average distance from each sampling site to its closest upstream confluence to determine the partial adjusted upstream catchment for all sites ( $\cong 559$  m). We adopted this distance as an adaptation of similar methods used by Morrill (2021), Rezac (2021), and Morley & Karr (2002) to account for the hydrological contribution of upstream influences for spatially nested collection points rather than nested study reaches. Morrill (2021) and Rezac (2021) used the shortest distance between study reaches on the same mainstem stream as an adaptation of Morley & Karr's (2002) ideas to examine LULC scale effects on fish community structure in Ozark streams. The majority of our sites were nested within the WOB-2 catchment, but none shared a mainstem stream (Figure 2).

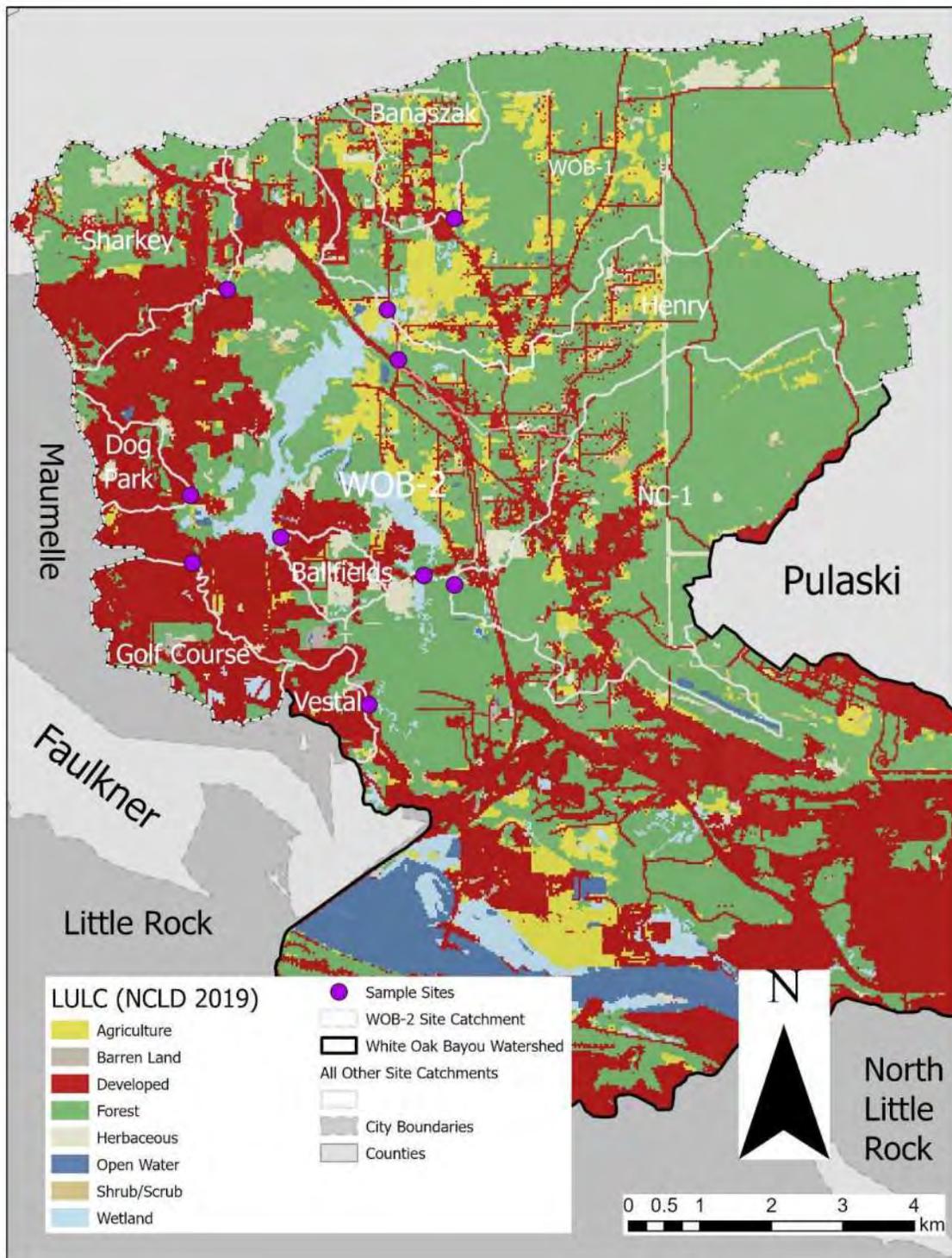


Figure 2. Individual site catchments with 2019 NLCD Land Use and Land Cover. All site catchments are nested within the WOB-2 site catchment except Vestal and NC-1.

The 559 m upstream distance was applied to all site catchments to provide a standardized comparison for the adjusted catchment scale and account for LULC influences unique to each sampling site. We also used this upstream distance to constrain the spatial extent of the riparian buffer. The lateral buffer width around the stream was 200 m due to the influence of LULC inside this buffer size on ecological stream processes that affect water quality and overall stream health (Morley & Karr, 2002). An example visual comparison of site catchment, adjusted catchment, and riparian buffer scales is available in Figure 3.

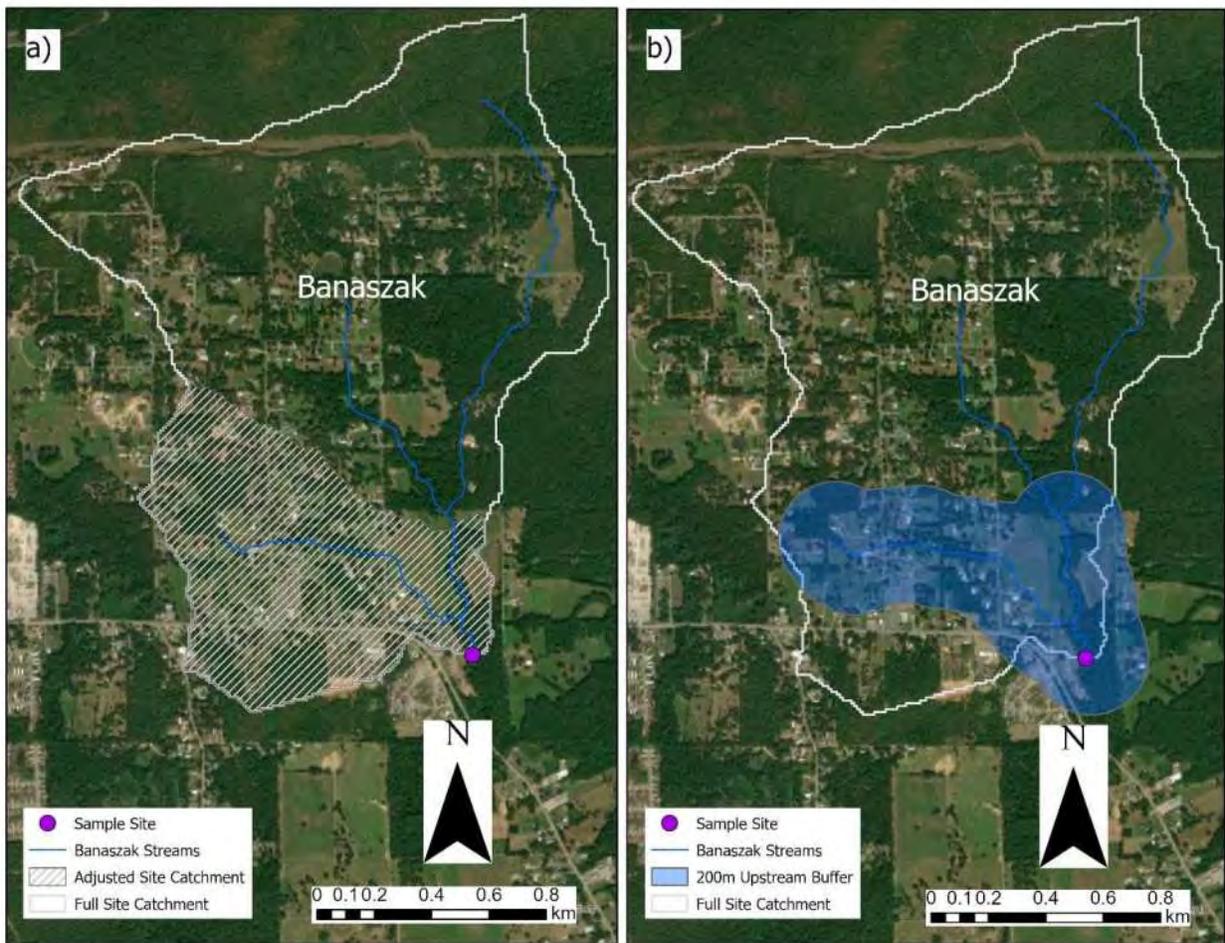


Figure 3. The site (full) catchment and adjusted catchment for the Banaszak site are shown in Panel a), and Panel b) shows the lateral 200 m upstream buffer limited to the spatial extent of the adjusted catchment. The adjusted catchment area is shown with a hatched pattern.

We measured the upstream distances from each sampling site to its closest confluence in ArcGIS Pro to exploit the software's snapping tool (i.e., the measurement cursor is constrained to the stream GIS layer) and recorded the distances in an Excel spreadsheet. Final distances to the closest upstream confluence for each sample site were based on the average of three repeated measurements to control for measurement error. We calculated the average distance to the closest upstream confluence across all sites in Excel, and used this value ( $\cong$  559 m) to create paths (lines with multiple vertices) for each sampling site in Google Earth Pro (v. 7.3.4.8642 (64-bit)). Placemark points were created at the terminus of each path to establish an upstream catchment delineation location and obtain its latitude and longitude coordinates in the WGS84 reference datum used by Google Earth and USGS StreamStats. We archived the paths and placemark points as KML files for future use, recorded the latitude and longitude coordinates in a text file, and use these coordinates to delineate the upstream catchments ( $\cong$  559 m upstream of the original collection point) for each sampling site in USGS StreamStats (v. 4.10.0).

The new upstream catchments from USGS StreamStats represented intermediate outputs, and were used to create the final adjusted catchments (intermediate spatial scale) for each sampling site. We used the Erase tool in ArcGIS Pro (v. 2.9) to geometrically subtract the intermediate catchment area from the full site catchment for each site. See Figure 3 for a visualization of areal differences between the full and adjusted catchment scales. We also used ArcGIS Pro (v. 2.9) to clip the stream shapefile to the adjusted catchment boundary for each site. Then, we used ArcGIS Pro to create the 200 m buffer around the clipped stream shapefiles (Figure 3). After creating the adjusted catchment and 200 m buffer polygons (areas), we used them to clip the 2019 NLCD data to create the LULC datasets for the adjusted catchment (intermediate) and upstream riparian buffer (proximal) scales respectively. The final LULC percentages for the adjusted catchment and upstream riparian buffer were calculated using the methods previously described in the LULC Analysis section. Additionally, we also qualitatively analyzed the most proximal and distal LULCs for each individual site catchment (see the *Proximal and Distal Site Catchment LULC* section in the Results). Land use and land cover classes closest to the collection sites were considered proximal LULCs, and distal LULCs were the land use and land cover classes farthest from the collection sites. A summary of LULCs for each site catchment is provided in the Appendices (see Tables A1 and A2).

### *Statistical analysis*

We investigated site-level variation in each water quality variable using one-way ANOVA with site identity as a factor and sampling events as replicated observations over time. Significant differences across sites were tested *post hoc* using Tukey's honestly significant difference test. We also tested distal, intermediate, and proximal LULC relationships with water quality variables using Spearman Correlation tests between % agricultural, % urban, and % forest cover at each site and all 14 water quality variables, based on site means across all sampling events. All statistical analyses were performed in the computing program R version 4.1.1. Statistical significance thresholds were set to  $\alpha = 0.05$ .

## **Results**

### *Proximal and Distal Site Catchment LULC*

The western border of the White Oak Bayou watershed is dominated by Developed (urban) LULC, and the north-central portion is mostly Agricultural and Forested land covers. Forest is the primary LULC in the northeastern part of the watershed, and the dominant land uses and land covers in the southern WOB are Developed and Forest. There are also a few areas of Agriculture, Open Water, and Wetland complexes in the southwest corner where the WOB includes parts of the Arkansas River and the City of Little Rock, Arkansas. The White Oak Bayou watershed LULC is shown in Figure 4.

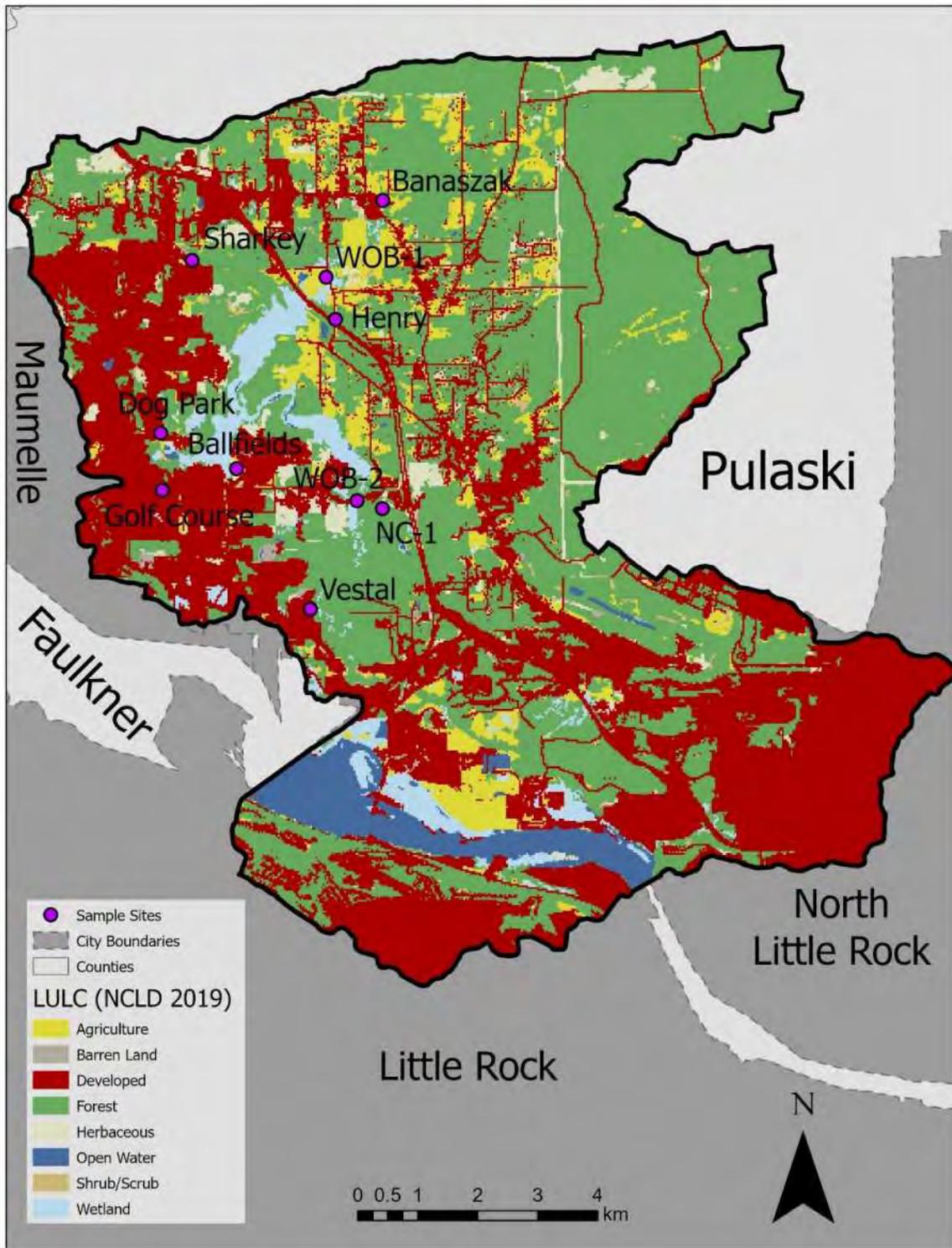


Figure 4. White Oak Bayou watershed (HUC-12) LULC from the 2019 National Land Cover Database (MRLC, 2019).

Our study sites were located in the northern part of the WOB watershed, and most individual site catchments were spatially nested inside at least one other catchment. For example, the WOB-1 catchment contains the Banaszak catchment, and the WOB-2 catchment contains all sites except Vestal and NC-1 (Figure 5). Sharkey's dominant LULCs are Developed (47.67%) and Forested (40.57%), and its proximal land cover is Developed in the southern part of the catchment. Conversely, Sharky's most distal LULCs are Forest and Agriculture in the central and northern catchment areas. South of Sharkey, Dog Park's catchment is 80.54% Developed and 14.16% Forest land uses and covers. Dog Park's most proximal LULC is Developed, and Forest is the dominant land cover class farthest from (distal) from the sampling site. The Golf Course site catchment on the western border of the WOB watershed and south of Dog Park is also heavily urbanized with 79.20% Developed and 14.10% Forest LULCs. Developed and Forest are Golf Course's proximal and distal land cover and land use classes respectively.

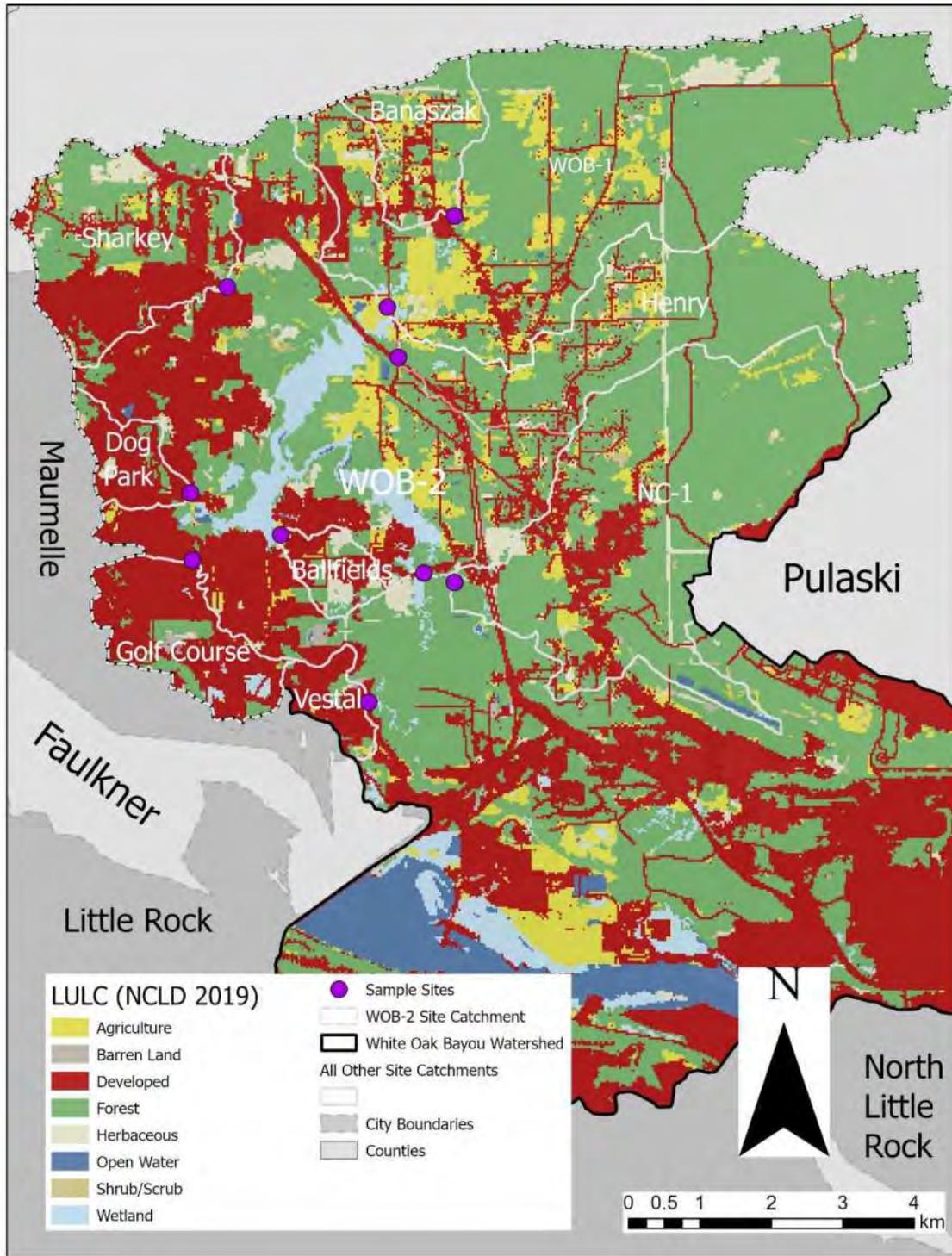


Figure 5. Site catchment LULC from the 2019 National Land Cover Database (MRLC, 2019). Sampling sites are marked with purple dots, and individual catchment boundaries are shown as light gray lines. The WOB-2 boundary is dashed to illustrate the spatial nesting of most sites, and identify the site catchments contained within WOB-2.

Continuing southward, Vestal's dominant LULCs are Developed (81.80%) and Forested (12.32%). Although the collection site itself has forested cover along the stream channel, the most proximal land cover is Developed. Forest land cover is the most distal LULC, and is concentrated in the north-central and southern portions of the catchment. North of Vestal and east of Golf Course, the Ballfields site catchment's dominant LULC is Developed (47.07%) with substantial contributions from Forest (25.06%) and Herbaceous (23.15%). Developed land use is largely concentrated near the northwest corner of the catchment, closest to the collection site (most proximal). Herbaceous cover representing the playing fields is near the center of the catchment with a north-south orientation, and it is surrounded by forest (Figure 5). Forest LULC was also the most distal land cover in the Ballfields catchment, and empirical observations during data collection identified active land disturbances from construction activities adjacent to the stream channel.

East of the Sharkey catchment in the northern WOB, Banaszak's dominant LULC is Forest (49.38%) with Developed accounting for 23.90% of its catchment area. The Developed land use is dispersed throughout the center of the catchment, and Agriculture covers another 21.66% of Banaszak's land area. Developed and Agriculture are Banaszak's most proximal LULCs, and Forest is the most distal. The WOB-1 site catchment is south of, and contains, the Banaszak catchment, and is dominated by Forest (68.23%) LULC. Agriculture (14.58%) and Developed (12.21%) also substantially contribute to land use and land cover in the WOB-1 catchment area. The Developed LULC is interspersed throughout the catchment, but is generally confined to narrow corridors like roads and commercial buildings. Forest cover is concentrated in the north-central and eastern parts of WOB-1, and Agriculture LULC is highest in the southwest corner and central parts of the catchment. Agriculture and Wetland are the most proximal LULCs to the collection site, and Forest land cover is the most distal.

The Henry site catchment shares a drainage divide with, and is immediately south of, the WOB-1 catchment area. Henry's dominant LULC is Forest (79.56%), and Developed and Agriculture land use and land cover classes account for 10.42% and 6.16% of its catchment respectively. The Forest land cover is distributed throughout the catchment, with large continuous swaths in the eastern portion of the drainage in rural Pulaski County. Developed LULC is largely represented by roads and other urban infrastructure, and the Agricultural land use is concentrated in the north-central part of the catchment. The Henry collection site is located next to Interstate-40, but the most proximal LULCs are a mixture of Developed and Forest. Conversely, Agriculture is Henry's most distal land use.

WOB-2's site catchment is south of Henry and encompasses all individual site catchments except Vestal and NC-1 (Figure 5). Forest (50.97%) and Developed (30.65%) account for the majority of the WOB-2 catchment, and Agriculture land use covers another 9.10%. These LULCs are spatially distributed throughout the WOB-2 drainage, with high concentrations of Developed land use along the catchment's western border in the City of Maumelle, Arkansas. Agricultural LULC is mostly in the central part of the WOB-2 catchment, and Forest land cover dominates its eastern section in rural Pulaski County. Forested and Developed are WOB-2's most proximal LULCs, and Agricultural land use is most distal from the collection site. The NC-1 site catchment is dominated by Forest (72.24%), followed by a Developed corridor (17.55%) towards the eastern-central part of the drainage. Relatively small areas of Agriculture land use also abut the central developed core, accounting for another 5.25% of the catchment area. NC-1's most proximal LULCs are Forested and Developed, and Agriculture is most distal. Like Vestal, the NC-1 collection site is not directly hydrologically influenced by the WOB-2 catchment.

#### *Spatial Distribution of Water Quality Constituents*

Water quality constituents that were significantly different between sites during the study period are explained here, and non-significant constituent maps are available in the Appendices. Percent saturation of DO appeared to be higher in the southern Study Area catchments and lower in the northeastern ones. More specifically, the WOB-2 catchment had the highest percent saturation value. This spatial distribution of DO suggests the WOB-2 catchment values reflect the cumulative inputs from its nested catchments (all sites except Vestal and NC-1). Higher water temperatures generally seemed to coincide with lower DO percentage saturations following known relationships between DO and temperature. However, this apparent temperature-DO relationship does not hold for WOB-2 where both values are relatively high (Figure 6). One potential explanation for this departure is that water temperature trends at the WOB collection site could be more strongly influenced by local conditions such as turbidity and water depth. Lower turbidity values would potentially increase sunlight penetration in the water column and increase temperature, and shallower water depths could have similar effect. During the study period, WOB-2's average Turbidity was comparatively low (29.38 ntu) and the average water Depth was approximately 0.5 m.

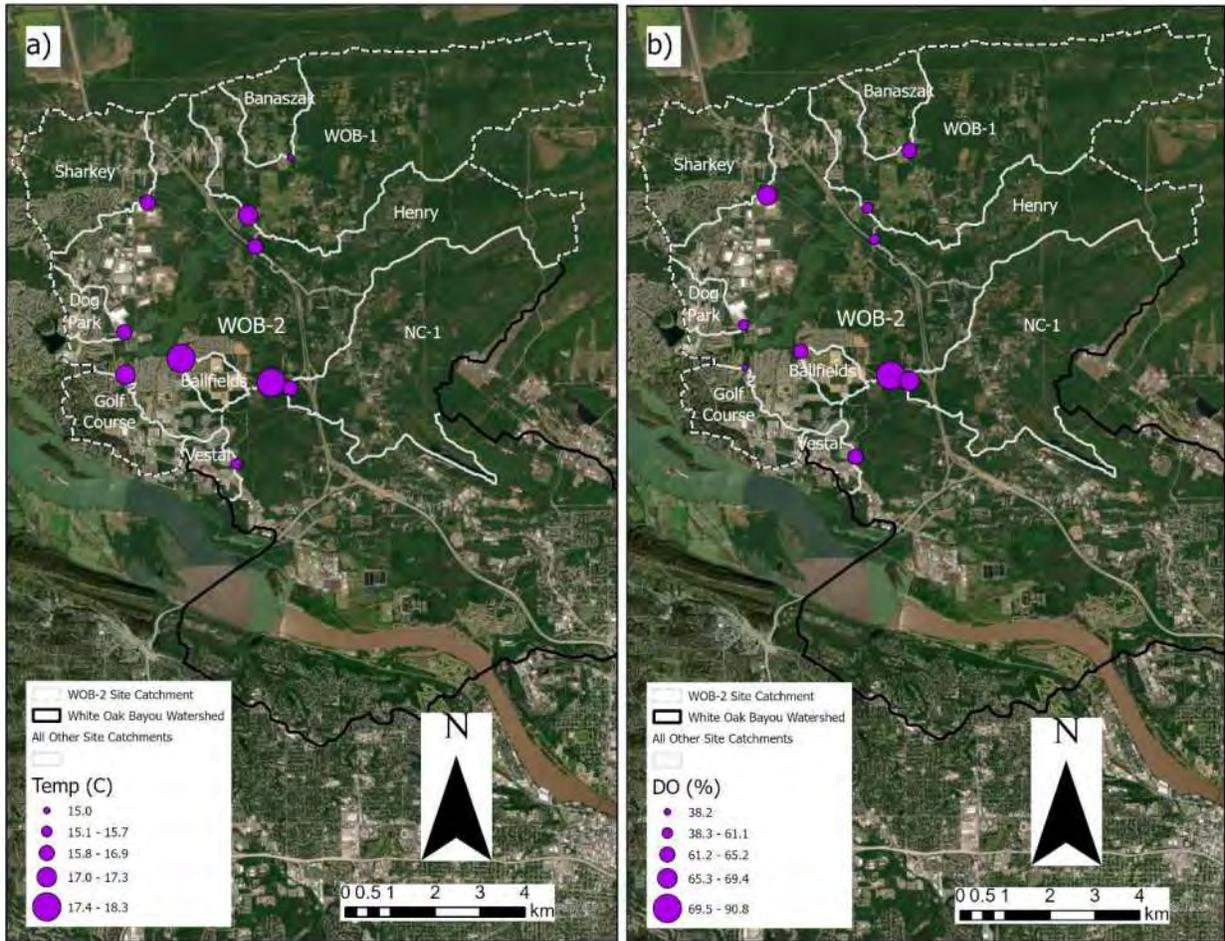


Figure 6. Spatial Distribution of Water Temperature (Pane a) and DO Percent Saturation (Pane b) for full site catchments.

Turbidity and TSS values were generally highest in the northernmost Study Area sites (Sharkey, Banaszak, WOB-1, and Henry) and lowest in the southernmost sites (Dog Park, Golf Course, WOB-2, NC-1, and Vestal). Ballfields did not follow this pattern, and had the highest Turbidity and TSS of all sites. The substantially higher values at Ballfields could be partially explained by ongoing construction activities adjacent to the stream channel during the study period. Overall, Turbidity and TSS appear to have the expected direct relationship (Figure 7).

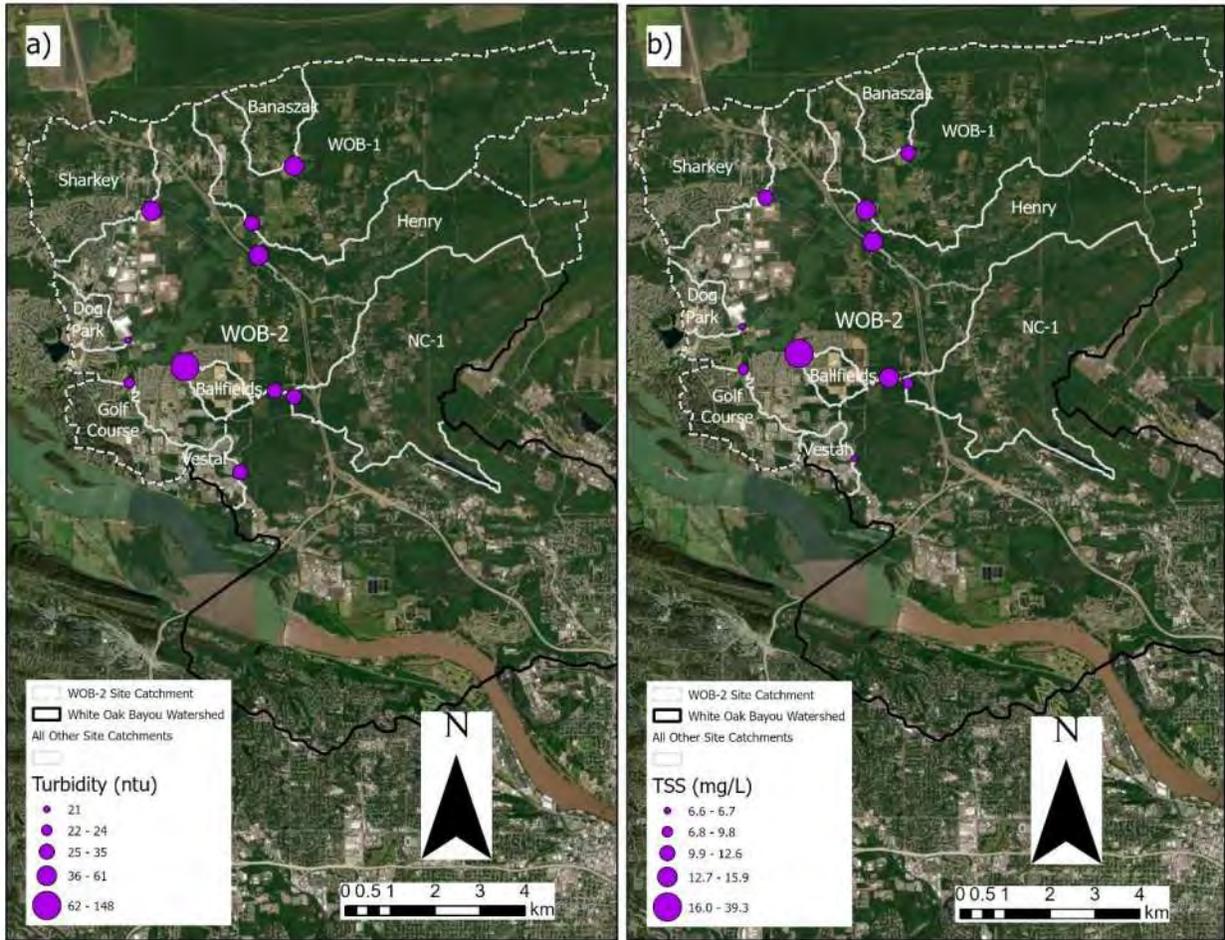


Figure 7. Spatial Distribution of Turbidity (Pane a) and TSS (Pane b) for full site catchments.

The spatial distribution of pH and Specific Conductivity appear to follow a west-east gradient with higher values in the western sites (Sharkey, Dog Park, Ballfields, and Vestal) inside the City of Maumelle, Arkansas and lower values in the eastern sites in the more rural areas of the northern WOB watershed (Banaszak, WOB-1, Henry, WOB-2, and NC-1) (Figure 8). Golf Course's pH is the lowest of all sites and departs from the west-east pattern. Overall, pH and Specific Conductivity appear to have a direct relationship, suggesting more alkaline water had higher salinity levels. Vestal had the highest pH and Specific Conductivity levels during the study period. This circumstance could reflect a large flush of road salts from winter sampling events in March 2021, December 2021, and February 2022.

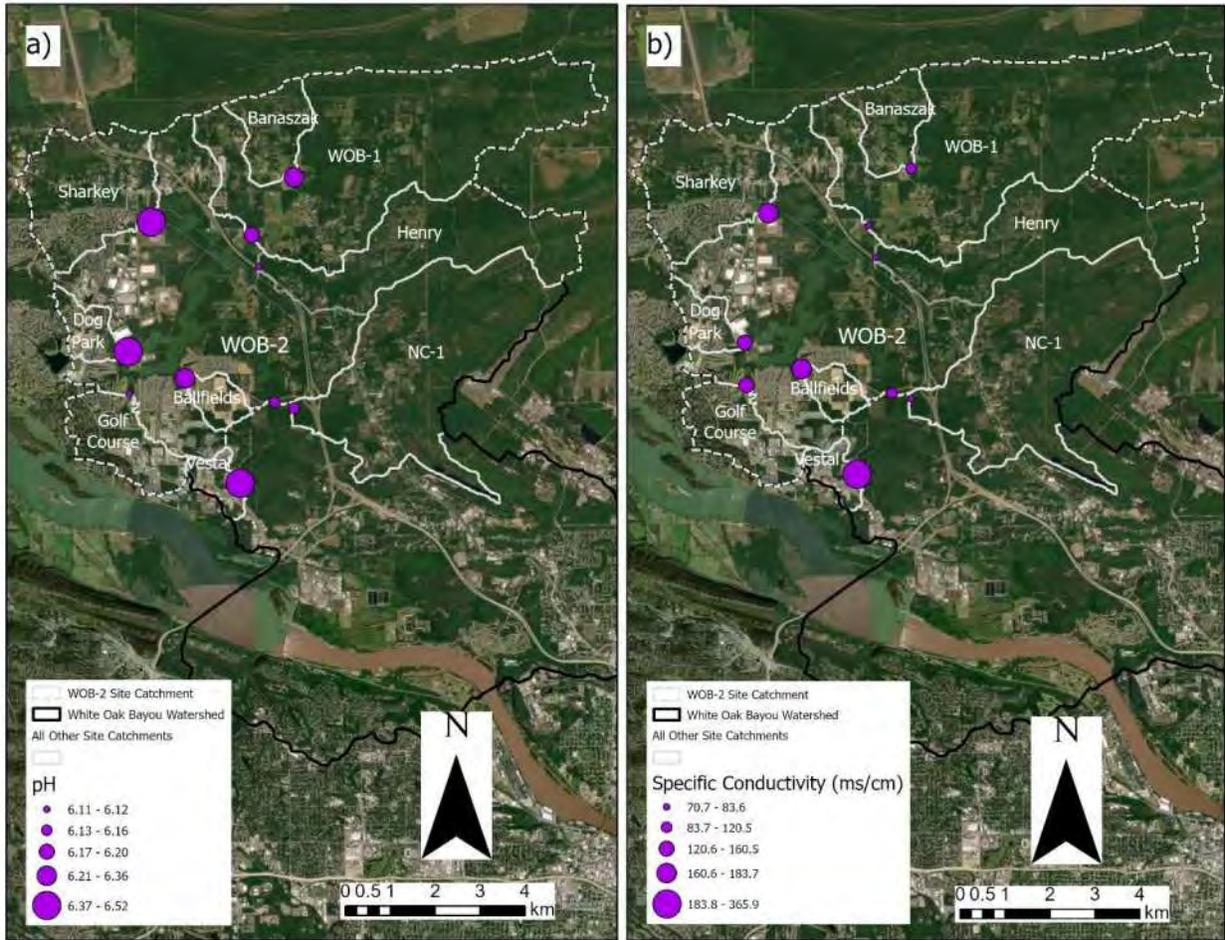


Figure 8. Spatial Distribution of pH (Pane a) and Specific Conductivity (Pane b) for full site catchments.

Nitrate-Nitrite and Total N values do not display a clear geographic pattern or gradient. Higher and lower concentrations of both constituents are mixed throughout the study sites in north-south and west-east directions (Figure 9). Higher Nitrate-Nitrite levels seem to correspond with higher Total N concentrations and vice versa. Vestal had the highest Nitrate-Nitrite levels during the study period which could be reflecting the Developed Open class embedded in the catchment's 81.80% Developed LULC. The Developed Open class often includes urban landscaping and lawns (commercial and residential) (MRLC, 2022). Therefore, fertilizers applied to these surfaces could have elevated the nitrogen concentrations. Sharkey's relatively higher Nitrate-Nitrite values could have a similar explanation, while Banaszak's concentrations could be partially due to the catchment's approximately 22% Agriculture LULC.

Other water chemistry variables including copper, lead, temperature, DO (mg/L), SRP, TP, and BOD5 did not differ significantly across sites based on ANOVA results. Therefore, we do not present the spatial distributions of these variables within the summary report main text. Spatial distributions of these variables may be found in the Appendices, Figures A1-A4.

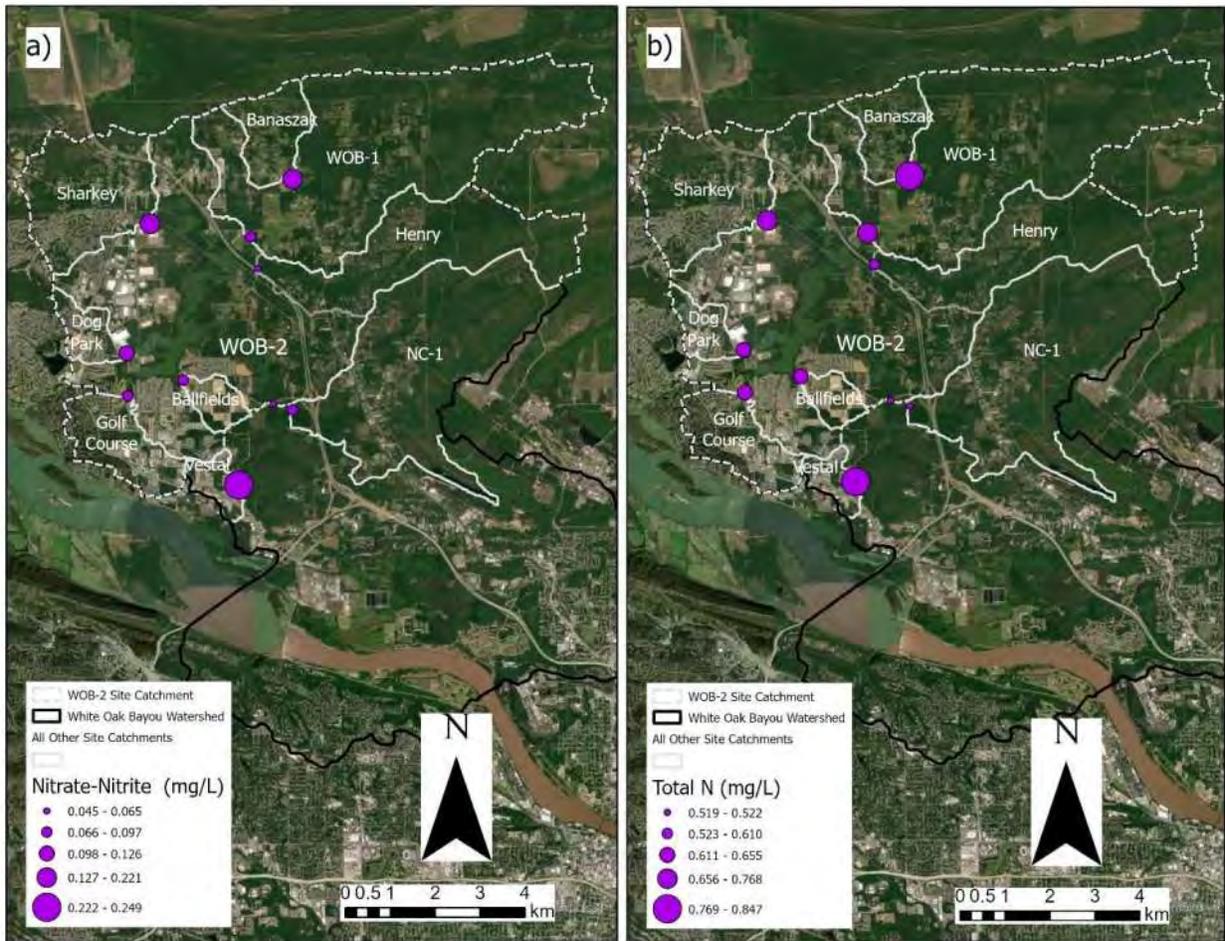


Figure 9. Spatial Distribution of Nitrate-Nitrite (Pane a) and Total N (Pane b) for full site catchments.

### *Site-level variation in water quality*

There was substantial variability in water quality across all sites, with some variables showing significant differences across sites (Table 1). Among the 14 water quality variables measured, five variables exhibited significant differences associated with ANOVA comparisons across sites during the sampling period. Sites differed significantly in % saturation of dissolved oxygen ( $F_{9,110}=3.54$ ;  $P<0.001$ ), with dissolved oxygen significantly higher at WOB-2 (90.8%) as compared to Dog Park (59.1%), WOB-1 (58.3%), and Golf Course (38.2%). Turbidity also differed across sites ( $F_{9,110}=6.58$ ;  $P<0.001$ ) and Ballfields exhibited higher turbidity (148 NTUs) compared to all other sites (next highest site average of 61 NTUs). Similarly, TSS differed across sites ( $F_{9,110}=3.57$ ;  $P<0.001$ ) and Ballfields had higher TSS (39.3 mg/L) as compared to all others (next highest site average of 15.9 mg/L). Nitrate-nitrite concentrations also differed significantly across sites ( $F_{9,110}=3.06$ ;  $P=0.003$ ) and Vestal showed significantly higher concentrations (0.249 mg/L) as compared to WOB-2 (0.045 mg/L). Although ANOVA revealed significant site differences in pH ( $F_{9,110}=2.79$ ;  $P=0.005$ ) with Dog Park the highest average pH (6.52) and Henry the lowest pH (6.11), the Tukey comparisons did not indicate any significant pairwise differences across all sites. Finally, specific conductivity differed strongly across sites ( $F_{9,110}=12.65$ ,  $P<0.001$ ) and was highest at Vestal (365.9 uS/cm), followed by Ballfields (183.7 uS/cm) which were both significantly higher than NC-1 (70.7 uS/cm). A summary of all water quality measures collected during the study may be found in the Appendices, Tables A3-A5.

Table 1. Summary of water quality variables expressed as mean ( $\pm$  SE) across study sites in White Oak Bayou.

Water quality variable	Golf									
	Ballfields	Banaszak	DogPark	Course	Henry	NC1	Sharkey	Vestal	WOB1	WOB2
Copper (mg/L)	0.001 (<0.001)	0.001 (<0.001)	0.001 (<0.001)	0.001 (<0.001)	0.002 (0.001)	<0.001 (<0.001)	0.001 (<0.001)	0.001 (<0.001)	0.001 (<0.001)	<0.001 (<0.001)
Lead (mg/L)	0.002 (0.001)	0.001 (0.001)	0.001 (<0.001)	0.002 (0.001)	0.003 (0.002)	0.002 (0.001)	0.001 (0.001)	<0.001 (<0.001)	0.002 (0.001)	0.001 (0.001)
Nitrate-nitrite (mg/L)*	0.097 (0.015) <sup>ab</sup>	0.220 (0.051) <sup>ab</sup>	0.126 (0.039) <sup>ab</sup>	0.083 (0.018) <sup>ab</sup>	0.065 (0.016) <sup>ab</sup>	0.085 (0.021) <sup>ab</sup>	0.221 (0.046) <sup>ab</sup>	0.249 (0.097) <sup>a</sup>	0.088 (0.028) <sup>ab</sup>	0.045 (0.018) <sup>b</sup>
SRP (mg/L)	0.008 (0.002)	0.021 (0.005)	0.010 (0.003)	0.019 (0.003)	0.015 (0.004)	0.014 (0.004)	0.016 (0.004)	0.017 (0.004)	0.015 (0.003)	0.016 (0.004)
TN (mg/L)	0.655 (0.067)	0.847 (0.120)	0.649 (0.108)	0.633 (0.070)	0.610 (0.082)	0.522 (0.079)	0.768 (0.121)	0.823 (0.154)	0.758 (0.096)	0.519 (0.078)
TP (mg/L)	0.087 (0.014)	0.102 (0.016)	0.049 (0.008)	0.071 (0.011)	0.070 (0.009)	0.064 (0.012)	0.076 (0.012)	0.058 (0.011)	0.081 (0.011)	0.060 (0.009)
TSS (mg/L)*	39.3 (13.1) <sup>b</sup>	12.6 (2.4) <sup>a</sup>	6.6 (1.4) <sup>a</sup>	9.8 (4.2) <sup>a</sup>	15.9 (4.3) <sup>a</sup>	8.2 (1.6) <sup>a</sup>	11.2 (2.7) <sup>a</sup>	6.7 (1.6) <sup>a</sup>	15.0 (2.5) <sup>a</sup>	15.3 (4.4) <sup>a</sup>
BOD5 (mg/L)	1.82 (0.25)	3.36 (1.74)	1.85 (0.32)	2.10 (0.16)	2.88 (1.25)	2.08 (0.62)	2.38 (0.69)	1.67 (0.35)	2.39 (0.40)	3.18 (1.81)
Temperature (C)	18.3 (2.2)	15.0 (1.9)	16.9 (2.0)	17.2 (2.1)	16.7 (2.1)	16.7 (2.1)	16.4 (2.0)	15.7 (2.0)	17.3 (2.2)	17.8 (2.1)
DO (%)*	62.7 (5.8) <sup>ab</sup>	64.2 (8.6) <sup>ab</sup>	59.1 (7.5) <sup>a</sup>	38.2 (5.9) <sup>a</sup>	61.1 (5.9) <sup>ab</sup>	67.3 (9.4) <sup>ab</sup>	69.4 (5.0) <sup>ab</sup>	65.2 (4.1) <sup>ab</sup>	58.3 (5.5) <sup>a</sup>	90.8 (8.5) <sup>b</sup>
DO (mg/L)	6.04 (0.74)	6.85 (1.08)	6.06 (0.99)	3.88 (0.74)	6.20 (0.84)	6.92 (1.11)	7.08 (0.76)	6.69 (0.70)	5.91 (0.83)	8.73 (0.79)
Turbidity (NTUs)*	148 (38) <sup>b</sup>	61 (18) <sup>a</sup>	21 (4) <sup>a</sup>	24 (8) <sup>a</sup>	43 (7) <sup>a</sup>	29 (5) <sup>a</sup>	43 (11) <sup>a</sup>	28 (7) <sup>a</sup>	35 (4) <sup>a</sup>	29 (7) <sup>a</sup>
pH	6.34 (0.10)	6.36 (0.09)	6.52 (0.11)	6.12 (0.13)	6.11 (0.06)	6.15 (0.09)	6.52 (0.09)	6.46 (0.12)	6.20 (0.11)	6.16 (0.06)
Specific conductivity (uS/cm)*	183.7 (41.0) <sup>b</sup>	97.8 (6.4) <sup>ab</sup>	160.5 (14.2) <sup>ab</sup>	151.1 (21.2) <sup>ab</sup>	75.2 (11.1) <sup>ab</sup>	70.7 (5.9) <sup>a</sup>	179.2 (17.1) <sup>ab</sup>	365.9 (51.8) <sup>c</sup>	83.6 (6.6) <sup>ab</sup>	120.5 (21.8) <sup>ab</sup>

\*Denotes variables that differed statistically across all sites (ANOVA, P<0.05). Letter superscripts designate different units across sites (Tukey's Honestly Significant Difference, P<0.05).

A comparison of physical variables demonstrates the full range of wetted width, depth, velocity, and discharge across the sites (Table 2). We did not statistically analyze these physical site data, but some clear trends emerged. First, only one site consistently showed net immeasurable discharge using the velocity meter method - Ballfields was consistently very low in discharge, particularly due to very low (often undetectable) water velocity. Still, the orange method allowed us to detect water velocity and revealed net positive discharge, albeit very low. The site with the greatest discharge was WOB-2, which also had the highest width as well as highest water velocity compared to all other sites - reflective of its largest catchment area which includes seven out of nine of the other sites. Most sites were wetted year-round and we were able to sample throughout the study duration, but discharge during baseflow was minimal at the majority of sites on most sample events. Some sites were dry during summer and Fall; in the case of Banaszak, the stream reach immediately upstream of our sampling location became dry and was disconnected, but we were able to continue sampling in the designated location which was a deep pool. Another site, WOB-2, was dry with a few disconnected pools and we did not collect water samples during our sampling on September 11, 2021.

Table 2. Summary of physical data expressed as mean ( $\pm$ SE) of all study sites in White Oak Bayou.

Physical variable	Ballfields	Banaszak	Dog Park	Golf Course	Henry	NC1	Vestal	Sharkey	WOB1	WOB2
Width (m)	5.6 (<0.1)	4.1 (0.1)	6.4 (0.6)	4.7 (0.1)	7.8 (0.1)	8.7 (0.3)	2.7 (<0.1)	7.0 (<0.1)	9.5 (0.1)	12.1 (1.4)
Depth (m)	0.58 (0.01)	0.24 (0.03)	0.34 (0.01)	0.35 (0.01)	0.62 (0.03)	0.58 (0.03)	0.13 (0.01)	0.60 (0.01)	0.58 (0.03)	0.35 (0.05)
Velocity (m/s)	0.00 (<0.01)	0.00 (<0.01)	0.00 (<0.01)	0.01 (0.01)	0.00 (<0.01)	0.00 (<0.01)	0.01 (0.01)	0.01 (<0.01)	0.00 (<0.01)	0.03 (0.01)
Velocity (Orange) (m/s)	0.01 (<0.01)	0.02 (0.01)	0.01 (<0.01)	0.03 (0.01)	0.01 (<0.01)	0.02 (<0.01)	0.02 (0.01)	0.02 (<0.01)	0.01 (0.01)	0.08 (0.02)
Discharge (L/s)	-2.8 (5.8)	1.7 (1.9)	9.9 (4.1)	21.4 (17.9)	13.0 (7.6)	23.9 (15.6)	7.3 (5.1)	44.6 (29.7)	15.6 (7.1)	355.2 (102.4)
Discharge (Orange) (L/s)	34.0 (14.8)	28.2 (10.1)	24.5 (7.2)	51.6 (19.2)	23.3 (12.8)	78.6 (19.5)	10.0 (6.3)	73.8 (20.6)	56.7 (15.7)	456.9 (112.1)

### *Relationships between water quality and LULC across sites*

The correlation results demonstrated strong relationships between LULC and water quality across all sites, with the strongest correlations occurring for % agriculture and % developed land within the catchments across all the sites (Table 3). Of the total 126 Spearman correlation tests conducted, 14 correlation results (11%) showed significant relationships with water quality variables, most often for BOD5 and specific conductivity. The LULC within upstream buffers (proximal scale) showed the strongest relationships with water quality with six significant correlations, followed by LULC within the full catchment (distal scale), which showed five significant correlations.

Table 3. Spearman correlation coefficients ( $\rho$ ) for relationships between water quality variables and LULC at each of three spatial scales (proximal, intermediate, and distal) across all sample sites in White Oak Bayou. Asterisks denote statistically significant correlations (\* $P < 0.05$ ; \*\* $P < 0.01$ ).

Water quality variable	<u>Upstream buffer (proximal)</u>			<u>Adjusted full catchment (intermediate)</u>			<u>Full catchment (distal)</u>			
	% agriculture	% development	% forest	% agriculture	% development	% forest	% agriculture	% development	% forest	
Copper (mg/L)	0.356	0.262	-0.262	0.352	0	-0.135	-0.112	-0.067	-0.067	
Lead (mg/L)	0.223	-0.427	0.239	0	-0.375	0.323	0.019	-0.679*	0.575	
Nitrate-nitrite (mg/L)	-0.08	0.491	-0.43	0.006	0.37	-0.491	-0.139	0.539	-0.552	
SRP (mg/L)	0.006	0.25	0.012	0.274	0.085	0.073	0.244	0.171	-0.25	
TN (mg/L)	0.276	0.43	-0.406	0.37	0.224	-0.43	0.115	0.297	-0.43	
TP (mg/L)	0.656*	-0.115	-0.127	0.539	-0.127	-0.091	0.37	-0.418	0.2	
TSS (mg/L)	0.706*	-0.479	0.139	0.612	-0.43	0.236	0.418	-0.612	0.491	
BOD5 (mg/L)	0.669*	-0.467	0.552	0.733*	-0.564	0.576	0.770**	-0.636*	0.612	
Temperature (C)	0.068	-0.049	-0.219	-0.109	0.103	-0.182	-0.219	-0.103	0.061	
DO (%)	-0.104	-0.394	0.394	0.042	-0.248	0.358	0.321	0.018	0.176	
DO (mg/L)	-0.031	-0.442	0.539	0.127	-0.345	0.491	0.43	-0.079	0.297	
Turbidity (NTUs)	0.767**	-0.442	0.115	0.071	-0.406	0.152	0.515	-0.552	0.43	
pH	-0.025	0.505	-0.444	0.036	0.426	-0.529	-0.146	0.602	-0.529	
Specific conductivity (uS/cm)	-0.301	0.758*	-0.818**	-0.212	0.745*	-0.770**	-0.588	0.855**	-0.867**	

At the proximal scale of LULC within upstream buffers, there were positive relationships of % agriculture with TP, TSS, BOD5, and turbidity (Table 3; Figure 10a-d). The strongest relationships were for turbidity and TSS, indicating strong links between agricultural land use within the riparian buffer and the concentration of suspended solids within water. These trends suggest sediments or other suspended particles increase with agriculture and contribute to TP loading across the sites. The positive associations may also be consistent with nutrient-rich particulates stimulating microbial metabolism as measured using BOD5. At the proximal scale, % development was also strongly positively correlated with specific conductivity (Figure 10e) and % forested land was negatively associated with specific conductivity (Figure 10f), indicating that development may be increasing salinization within WOB.

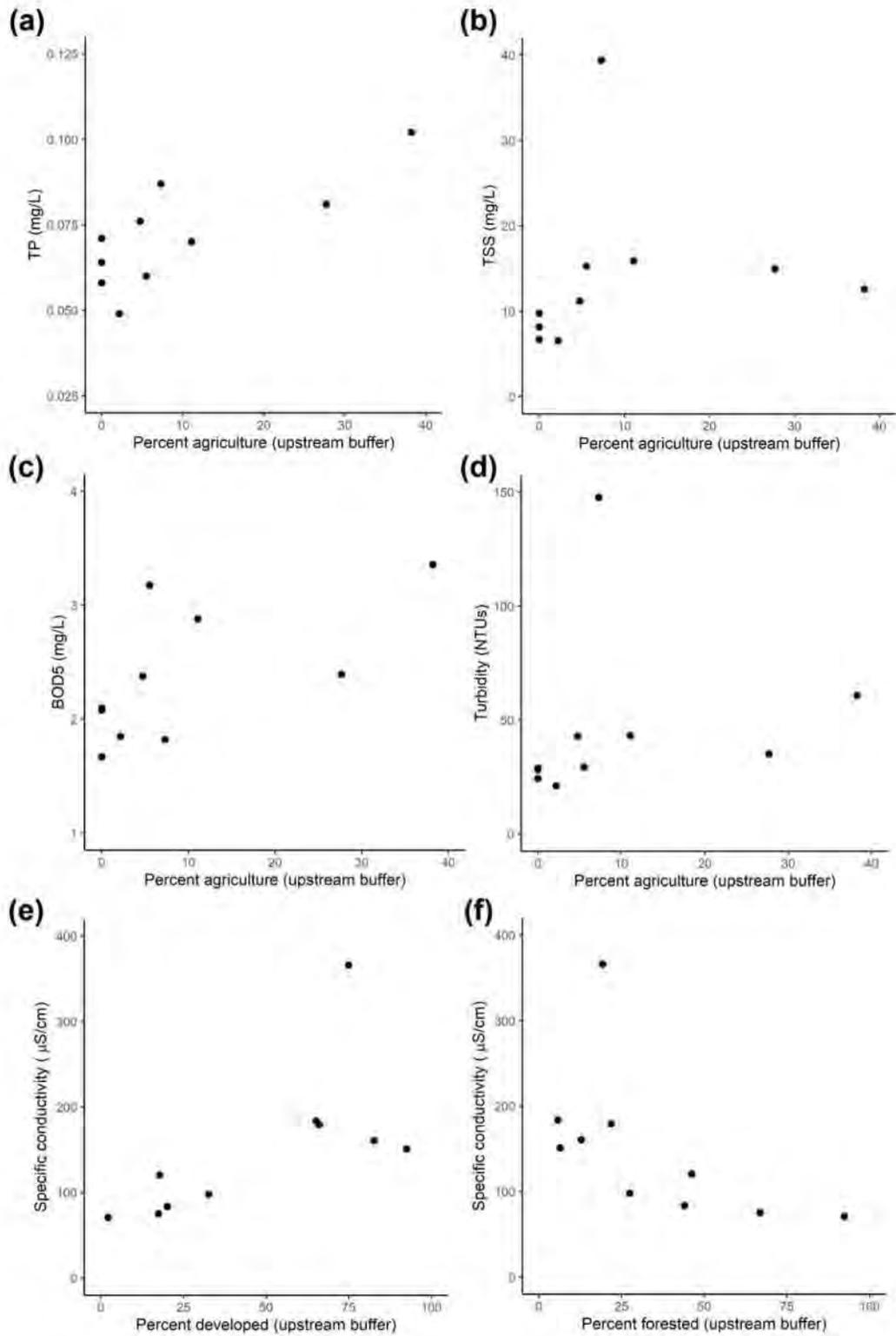


Figure 10. Scatterplots of relationships between LULC and mean water quality variables at the proximal scale of upstream buffers across all ten study sites. Only significant relationships (Spearman's  $\rho$ ;  $P < 0.05$ ) were included.

At the intermediate scale of LULC within adjusted full catchments, three of the above significant correlations at proximal scales were also significant (Table 3). Similar to the proximal scale, there was a positive relationship between % agriculture and BOD5 (Figure 11a). Specific conductivity showed a positive relationship with % development across sites (Figure 11b). Finally, specific conductivity also showed a negative relationship with % forest land use (Figure 11c).

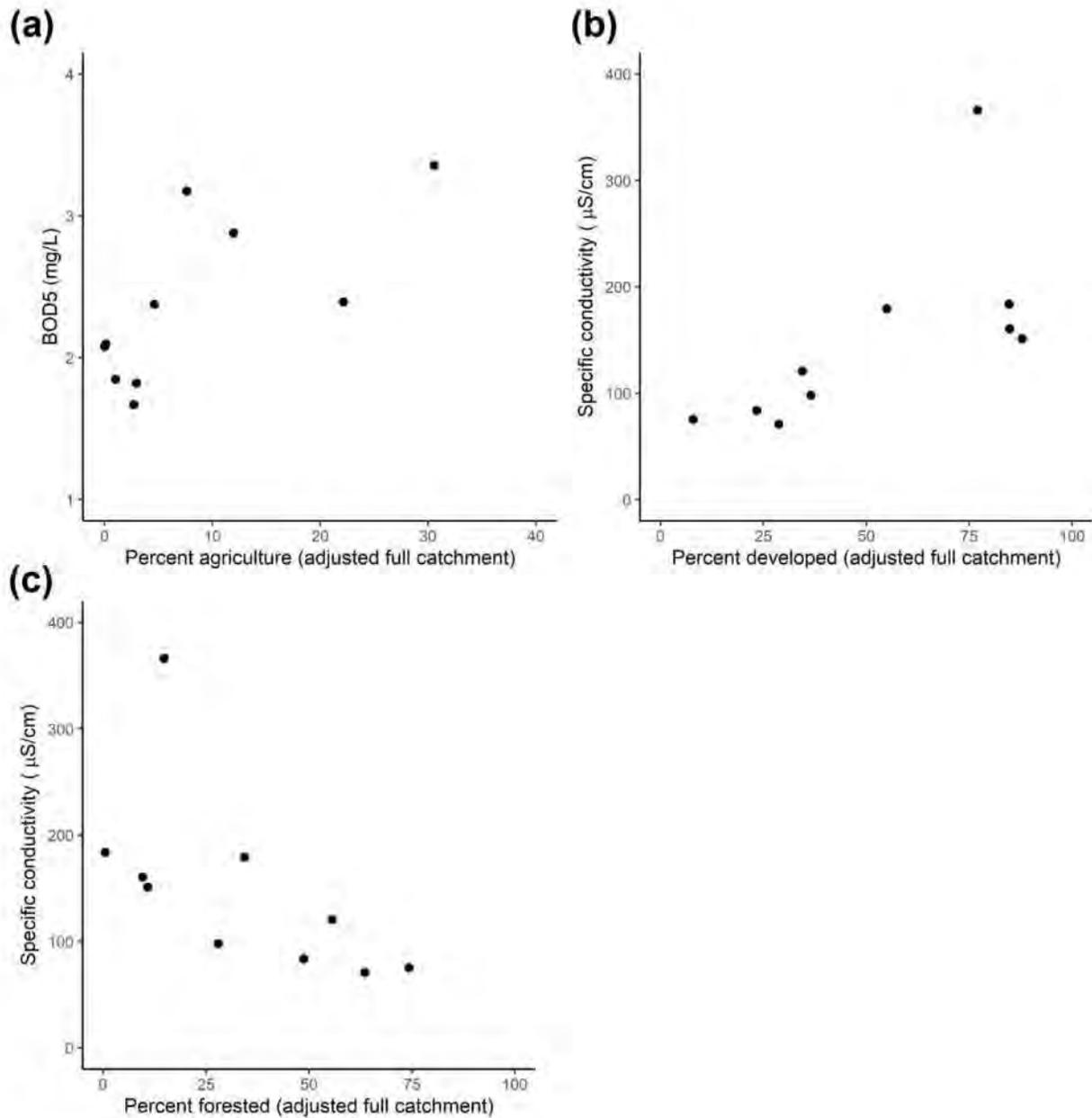


Figure 11. Scatterplots of relationships between LULC and mean water quality variables at the intermediate scale of adjusted full catchments across all ten study sites. Only significant relationships (Spearman's  $\rho$ ;  $P < 0.05$ ) were included.

At the distal scale of LULC within full catchments, all significant LULC correlation trends with water quality at the intermediate scale were again significant. The only water quality variable related to % agriculture was BOD5, which was positively associated (Figure 12a). Lead concentrations were negatively associated with % development (Figure 12b) and BOD5 was also negatively correlated with % development (Figure 12c). Similar to all other scales, specific conductivity was strongly positively correlated with % development in full catchments (Figure 12d) but negatively correlated with % forest in full catchments (Figure 12e).

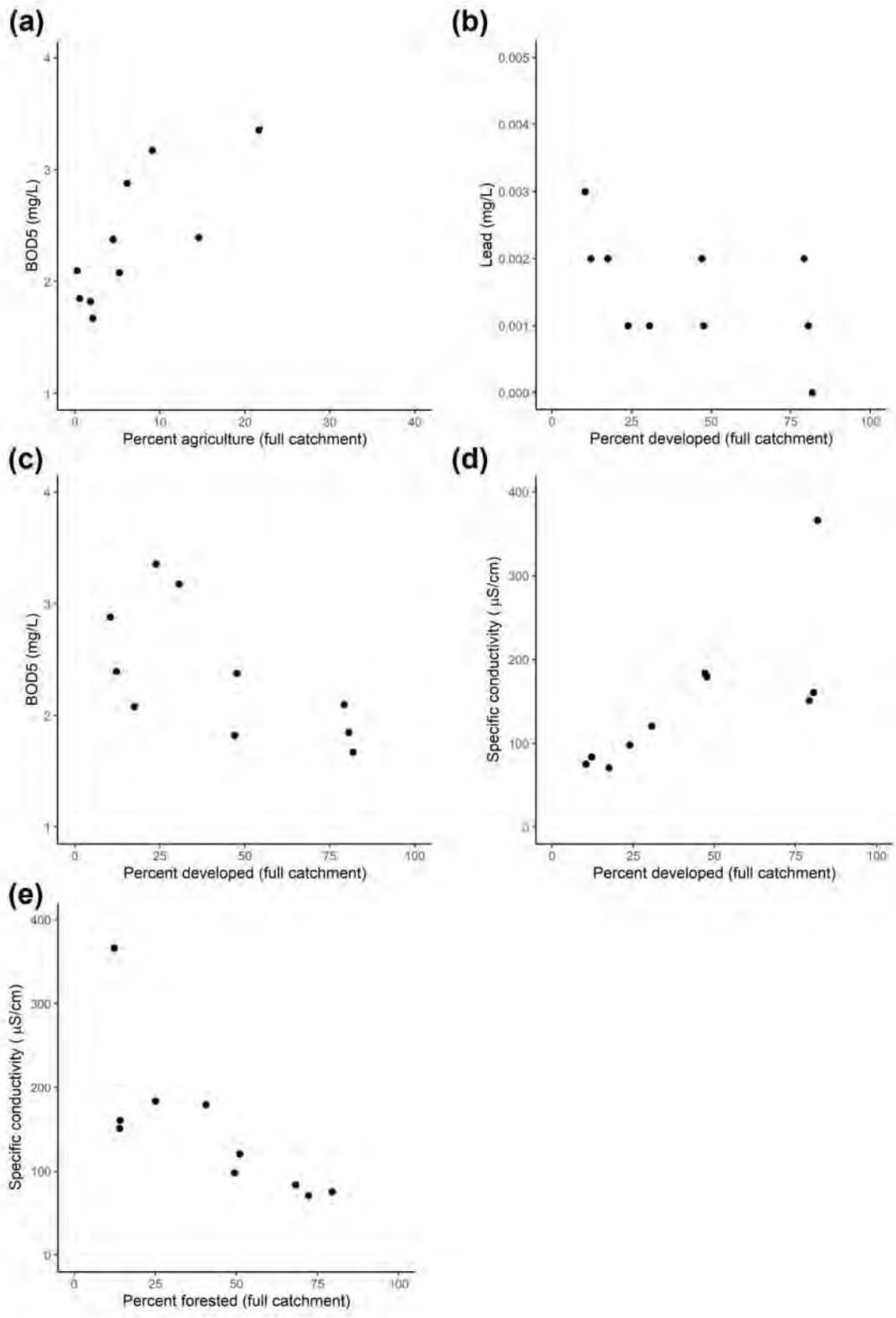


Figure 12. Scatterplots of relationships between LULC and mean water quality variables at the distal scale of full catchments across all ten study sites. Only significant relationships (Spearman's  $\rho$ ;  $P < 0.05$ ) were included.

Cumulatively, the results above suggest that there are consistent positive relationships between agriculture and BOD5, positive relationships between % development and specific conductivity, and negative relationships between % forested land and specific conductivity, at all spatial scales. The proximal scale showed distinct local effects of agricultural cover on TP, TSS, and turbidity - all of which were not found at any other scale. Finally, the full catchment scale uniquely revealed a negative relationship between lead concentrations and % development, as well as between BOD5 and % development. In this way, the intermediate scale was the most redundant with results shown at the other two scales of LULC, and proximal versus distal scales each showed several unique relationships between LULC and water quality. These results suggest that future monitoring should particularly focus on agricultural land use within upstream buffers as a potential source of sediment erosion and TP loading, and on the conversion of forested land to developed land as a driver of freshwater salinization in WOB.

### **Acknowledgements**

We would like to thank GBMc & Associates for their assistance with field work and for their partnership in this research. We thank the City of Maumelle and the Natural Resources Division for the funding of this project. We also thank UCA students Brandy Everett, Brittany Krug, Aimee Dycus, Noah Davis, Celeste Johnson, Anthony Pignatelli, and Connor Tolly for their assistance with field and lab work.

### **References**

- Allan, J.D. (2004). Landscapes and Riverscapes: The influence of land use on stream ecosystems. *Annual Review of Ecology, Evolution, and Systematics*, 35: 257-284.
- Gove, N.E., Edwards, R.T., & Conquest, L.L. (2001). Effects of scale and land use on water quality: A longitudinal basin-wide perspective. *Journal of the American Water Resources Association*, 37(6): 1721-1734.
- Kottek, M., Grieser, J., Beck, C, Rudolf, B., & Rubel, F. (2006). World map of the Köppen-Geiger climate classification updated. *Meteorologische Zeitschrift*, 15(3): 259-263.
- Morley, S.A, & Karr, J.R. (2002). Assessing and restoring the health of urban streams in the Puget Sound. *Conservation Biology*, 16(6): 1498-1509.
- Morrill, D.P. (2021). *Temporal Trends in Fish Assemblage Structure in the Current River Drainage, Missouri over Eighty Years* (Publication No. 28416237) [Master's thesis, University of Central Arkansas]. ProQuest Theses and Dissertations Global.

Multi-Resolution Land Characteristics Consortium (MRLC). (2022). National Land Cover Database Legend and Class Description. (<https://www.mrlc.gov/data/legends/national-land-cover-database-class-legend-and-description>). Last Accessed: 28 June 2022.

Multi-Resolution Land Characteristics Consortium (MRLC). (2019). *NLCD 2019 Land Cover (CONUS)*. <https://www.mrlc.gov/data/nlcd-2019-land-cover-conus>. Last Accessed: 28 June 2022.

Rezac, C.R. (2021). *Spatiotemporal Response of Fish Communities in the Spring River Basin, Arkansas to Chronic Pasture Land Use* (Publication No. 28265222) [Master's thesis, University of Central Arkansas]. ProQuest Theses and Dissertations Global.

Sweeney, B.W. & Newbold, J.D. (2014) Streamside Forest Buffer Width Needed to Protect Stream Water Quality, Habitat, and Organisms: A Literature Review. *Journal of the American Water Resources Association*, 50(3):560–584.

U.S. Census Bureau (USCB). (2020). *Quick Facts: Pulaski County, Arkansas*. <https://www.census.gov/quickfacts/fact/table/pulaskicountyarkansas,US/PST045221>. Last Accessed: 29 June 2022.

U.S. Forest Service (USFS). (2022). Chapter 20: Southeastern Mixed Forest. In U.S. Forest Service (Eds.), *Ecological Subregions of the United States*. [Chapter 20-Ecological Subregions of the United States \(fs.fed.us\)](https://www.fs.fed.us). Last Accessed: 29 June 2022.

U.S. Geological Survey (USGS). (2022). USGS Stream Stats Version 4.10.0. <https://streamstats.usgs.gov/ss/>. Last Accessed: 28 June 2022.

## Appendices

Table A1. Study Site Full Catchment 2019 NLCD Land Use and Land Cover

site	% agriculture	% barren	% developed	% forest	% herbaceous	% open water	% shrub	% wetland
Ballfields	1.83	0.23	47.07	25.06	23.15	0.08	0.3	2.28
Banaszak	21.66	0.23	23.9	49.38	3.66	0.32	0.84	0
Dog Park	0.55	0	80.54	14.15	3.9	0	0.85	0
Golf Course	0.28	1.61	79.21	14.01	0.97	0	0.13	3.8
Henry	6.16	0.06	10.42	79.56	2.56	0.03	1.06	0.16
NC1	5.25	0.38	17.55	72.24	3.02	0.77	0.67	0.12
Sharkey	4.52	0.78	47.68	40.57	6.05	0.08	0.33	0
Vestal	2.09	1.13	81.8	12.32	1.37	0	0.16	1.13
WOB1	14.58	0.13	12.21	68.23	3.64	0.18	0.47	0.56
WOB2	9.1	0.39	30.65	50.97	4.17	0.35	0.56	3.8

Table A2. Study Site Percent Agriculture, Percent Forest, and Percent Developed for All Scales.

Site	<u>Upstream buffer (proximal)</u>			<u>Adjusted full catchment (intermediate)</u>			<u>Full catchment (distal)</u>		
	% agriculture	% development	% forest	% agriculture	% development	% forest	% agriculture	% development	% forest
Ballfields	7.30	65.14	5.68	2.97	84.65	0.50	1.83	47.07	25.06
Banaszak	38.23	32.65	27.48	30.57	36.53	27.92	21.66	23.90	49.38
Dog Park	2.17	82.66	12.86	1.02	84.81	9.56	0.55	80.54	14.15
Golf Course	0.00	92.54	6.38	0.11	87.86	10.78	0.28	79.21	14.01
Henry	11.08	17.49	66.91	11.97	7.91	74.36	6.16	10.42	79.56
NC1	0.00	2.22	92.38	0.00	28.72	63.59	5.25	17.55	72.24
Sharkey	4.74	66.05	21.84	4.63	54.99	34.30	4.52	47.68	40.57
Vestal	0.00	75.00	19.27	2.72	77.04	14.81	2.09	81.80	12.32
WOB1	27.69	20.11	44.04	22.15	23.38	48.79	14.58	12.21	68.23
WOB2	5.51	17.85	46.19	7.62	34.44	55.63	9.10	30.65	50.97

Table A3. Summary of water chemistry variables measured across all ten sites during the study period.

Month	Year	Site	Copper (mg/L)	Lead (mg/L)	Nitrate-nitrite (mg/L)	SRP (mg/L)	TN (mg/L)	TP (mg/L)	TSS (mg/L)
March	2021	Ball fields	0.000	0.000	0.106	0.007	0.840	0.102	39.2
April	2021	Ball fields	0.000	0.002	0.112	0.018	0.660	0.138	47.6
May	2021	Ball fields	0.001	0.002	0.064	0.004	0.830	0.122	46.7
June	2021	Ball fields	0.002	0.000	0.195	0.014	1.210	0.169	169.1
July	2021	Ball fields	0.002	0.000	0.069	0.001	0.610	0.043	11.0
August	2021	Ball fields	0.002	0.006	0.097	0.001	0.630	0.041	8.6
September	2021	Ball fields	0.000	0.001	0.023	0.006	0.360	0.026	11.3
October	2021	Ball fields	0.000	0.006	0.010	0.005	0.420	0.041	10.6
November	2021	Ball fields	0.002	0.003	0.096	0.026	0.560	0.132	36.7
December	2021	Ball fields	0.000	0.002	0.121	0.003	0.600	0.122	69.1
January	2022	Ball fields	0.000	0.000	0.163	0.006	0.720	0.056	10.6
February	2022	Ball fields	0.000	0.000	0.109	0.006	0.420	0.053	11.5
March	2021	Banaszak	0.000	0.000	0.169	0.008	0.540	0.073	14.8
April	2021	Banaszak	0.000	0.000	0.099	0.011	0.550	0.088	8.9
May	2021	Banaszak	0.000	0.000	0.092	0.017	0.720	0.085	14.9
June	2021	Banaszak	0.002	0.001	0.276	0.062	1.230	0.176	25.6
July	2021	Banaszak	0.002	0.000	0.146	0.003	1.100	0.097	17.0
August	2021	Banaszak	0.004	0.000	0.709	0.003	1.730	0.217	27.5
September	2021	Banaszak	0.001	0.000	0.045	0.028	1.070	0.127	14.3
October	2021	Banaszak	0.004	0.000	0.298	0.038	1.140	0.132	12.9
November	2021	Banaszak	0.002	0.000	0.301	0.031	0.810	0.101	5.5
December	2021	Banaszak	0.000	0.006	0.148	0.029	0.550	0.062	3.8
January	2022	Banaszak	0.000	0.005	0.214	0.010	0.430	0.032	2.3
February	2022	Banaszak	0.000	0.000	0.138	0.015	0.290	0.034	3.6
March	2021	Dog Park	0.000	0.000	0.001	0.004	0.360	0.044	9.2
April	2021	Dog Park	0.000	0.000	0.016	0.000	0.500	0.044	9.3
May	2021	Dog Park	0.000	0.000	0.180	0.014	0.810	0.084	13.5

Month	Year	Site	Copper (mg/L)	Lead (mg/L)	Nitrate-nitrite (mg/L)	SRP (mg/L)	TN (mg/L)	TP (mg/L)	TSS (mg/L)
June	2021	Dog Park	0.002	0.000	0.238	0.034	0.930	0.093	16.3
July	2021	Dog Park	0.001	0.000	0.104	0.002	0.750	0.041	3.4
August	2021	Dog Park	0.004	0.003	0.488	0.010	1.670	0.092	6.4
September	2021	Dog Park	0.000	0.000	0.003	0.004	0.520	0.028	5.5
October	2021	Dog Park	0.002	0.000	0.114	0.012	0.630	0.048	3.5
November	2021	Dog Park	0.000	0.000	0.128	0.012	0.440	0.047	6.3
December	2021	Dog Park	0.000	0.002	0.058	0.013	0.450	0.036	2.4
January	2022	Dog Park	0.000	0.003	0.111	0.009	0.370	0.024	1.5
February	2022	Dog Park	0.000	0.000	0.067	0.005	0.360	0.011	1.4
March	2021	Golf Course	0.000	0.000	0.000	0.007	0.020	0.005	0.0
April	2021	Golf Course	0.000	0.002	0.081	0.008	0.730	0.067	7.9
May	2021	Golf Course	0.000	0.005	0.148	0.033	1.060	0.120	21.2
June	2021	Golf Course	0.002	0.002	0.121	0.036	0.810	0.160	52.6
July	2021	Golf Course	0.000	0.000	0.091	0.019	0.640	0.067	4.0
August	2021	Golf Course	0.001	0.008	0.053	0.016	0.660	0.067	4.1
September	2021	Golf Course	0.001	0.000	0.029	0.022	0.410	0.077	5.4
October	2021	Golf Course	0.002	0.005	0.016	0.015	0.620	0.061	4.3
November	2021	Golf Course	0.000	0.000	0.092	0.010	0.630	0.064	6.2
December	2021	Golf Course	0.002	0.006	0.023	0.030	0.650	0.061	4.2
January	2022	Golf Course	0.000	0.000	0.216	0.024	0.700	0.052	3.0
February	2022	Golf Course	0.000	0.000	0.122	0.010	0.660	0.045	4.1
March	2021	Henry	0.001*	0.002*	0.053*	0.009*	0.364*	0.051*	14.9*
April	2021	Henry	0.000	0.000	0.000	0.007	0.440	0.096	58.0
May	2021	Henry	0.000	0.001	0.047	0.010	0.560	0.063	15.5
June	2021	Henry	0.002	0.000	0.133	0.043	0.960	0.123	31.5
July	2021	Henry	0.001	0.000	0.081	0.010	1.000	0.080	9.2
August	2021	Henry	0.001	0.007	0.121	0.008	0.580	0.051	11.7
September	2021	Henry	0.001	0.000	0.015	0.018	0.620	0.060	7.7
October	2021	Henry	0.012	0.019	0.017	0.004	0.660	0.058	8.6

Month	Year	Site	Copper (mg/L)	Lead (mg/L)	Nitrate-nitrite (mg/L)	SRP (mg/L)	TN (mg/L)	TP (mg/L)	TSS (mg/L)
November	2021	Henry	0.002	0.002	0.173	0.032	1.070	0.128	7.3
December	2021	Henry	0.000	0.007	0.022	0.023	0.610	0.078	6.1
January	2022	Henry	0.000	0.000	0.088	0.004	0.300	0.033	12.9
February	2022	Henry	0.000	0.000	0.026	0.007	0.150	0.022	7.1
March	2021	NC-1	0.000	0.000	0.053	0.004	0.190	0.030	4.5
April	2021	NC-1	0.000	0.000	0.024	0.004	0.210	0.025	3.1
May	2021	NC-1	0.000	0.001	0.045	0.014	0.660	0.074	9.3
June	2021	NC-1	0.001	0.001	0.099	0.011	0.600	0.081	19.4
July	2021	NC-1	0.001	0.000	0.039	0.049	1.030	0.153	11.1
August	2021	NC-1	0.000	0.005	0.068	0.032	0.600	0.091	6.9
September	2021	NC-1	0.000	0.000	0.038	0.017	0.750	0.078	12.5
October	2021	NC-1	0.000	0.006	0.003	0.015	0.770	0.115	15.1
November	2021	NC-1	0.000	0.003	0.205	0.003	0.580	0.055	2.6
December	2021	NC-1	0.000	0.003	0.210	0.012	0.450	0.036	8.6
January	2022	NC-1	0.000	0.000	0.170	0.006	0.290	0.027	3.5
February	2022	NC-1	0.000	0.000	0.063	0.003	0.130	0.004	1.3
March	2021	Sharkey	0.000	0.000	0.126	0.024	0.420	0.052	11.0
April	2021	Sharkey	0.000	0.000	0.040	0.000	0.470	0.056	9.1
May	2021	Sharkey	0.000	0.005	0.159	0.017	0.860	0.093	13.3
June	2021	Sharkey	0.003	0.003	0.204	0.031	0.880	0.093	24.5
July	2021	Sharkey	0.004	0.000	0.431	0.007	1.000	0.033	4.6
August	2021	Sharkey	0.003	0.004	0.533	0.032	1.740	0.123	6.5
September	2021	Sharkey	0.001	0.000	0.127	0.004	0.800	0.065	8.1
October	2021	Sharkey	0.003	0.000	0.415	0.034	1.180	0.138	34.8
November	2021	Sharkey	0.001	0.001	0.255	0.002	0.810	0.092	7.9
December	2021	Sharkey	0.000	0.004	0.079	0.028	0.370	0.117	8.6
January	2022	Sharkey	0.000	0.000	0.201	0.011	0.440	0.029	2.9
February	2022	Sharkey	0.000	0.000	0.084	0.005	0.250	0.015	2.9
March	2021	Vestal	0.000	0.000	0.041	0.006	0.380	0.025	4.8

Month	Year	Site	Copper (mg/L)	Lead (mg/L)	Nitrate-nitrite (mg/L)	SRP (mg/L)	TN (mg/L)	TP (mg/L)	TSS (mg/L)
April	2021	Vestal	0.000	0.000	0.176	0.006	0.830	0.055	6.7
May	2021	Vestal	0.000	0.000	0.113	0.022	0.830	0.096	15.6
June	2021	Vestal	0.002	0.000	0.526	0.051	1.380	0.118	20.9
July	2021	Vestal	0.002	0.000	0.644	0.018	1.450	0.061	5.8
August	2021	Vestal	0.004	0.003	1.102	0.035	2.040	0.129	2.2
September	2021	Vestal	0.000	0.000	0.014	0.011	0.380	0.033	4.3
October	2021	Vestal	0.003	0.000	0.092	0.017	0.780	0.066	5.5
November	2021	Vestal	0.000	0.000	0.079	0.013	0.430	0.049	4.9
December	2021	Vestal	0.001	0.000	0.047	0.013	0.420	0.031	3.0
January	2022	Vestal	0.000	0.000	0.079	0.008	0.490	0.018	2.1
February	2022	Vestal	0.000	0.000	0.072	0.006	0.460	0.018	4.3
March	2021	WOB-1	0.000	0.000	0.352	0.007	0.560	0.072	19.7
April	2021	WOB-1	0.000	0.000	0.005	0.002	0.630	0.077	10.9
May	2021	WOB-1	0.001	0.006	0.029	0.015	0.680	0.073	15.0
June	2021	WOB-1	0.001	0.003	0.105	0.031	1.470	0.155	26.1
July	2021	WOB-1	0.001	0.000	0.057	0.014	0.680	0.063	32.4
August	2021	WOB-1	0.001	0.002	0.085	0.007	0.860	0.072	11.1
September	2021	WOB-1	0.000	0.000	0.046	0.011	0.880	0.081	22.1
October	2021	WOB-1	0.002	0.000	0.078	0.019	1.150	0.087	14.5
November	2021	WOB-1	0.003	0.003	0.185	0.035	0.870	0.143	10.5
December	2021	WOB-1	0.001	0.000	0.029	0.025	0.760	0.093	6.7
January	2022	WOB-1	0.000	0.005	0.059	0.008	0.320	0.027	3.9
February	2022	WOB-1	0.000	0.000	0.028	0.005	0.240	0.032	6.6
March	2021	WOB-2	0.000	0.000	0.188	0.011	0.410	0.058	13.8
April	2021	WOB-2	0.000	0.000	0.000	0.007	0.420	0.065	11.1
May	2021	WOB-2	0.000	0.000	0.023	0.015	0.600	0.069	8.1
June	2021	WOB-2	0.002	0.000	0.085	0.044	0.820	0.095	19.7
July	2021	WOB-2	0.001	0.000	0.070	0.025	0.770	0.079	13.1
August	2021	WOB-2	0.000	0.000	0.131	0.001	0.950	0.100	50.8

<b>Month</b>	<b>Year</b>	<b>Site</b>	<b>Copper (mg/L)</b>	<b>Lead (mg/L)</b>	<b>Nitrate-nitrite (mg/L)</b>	<b>SRP (mg/L)</b>	<b>TN (mg/L)</b>	<b>TP (mg/L)</b>	<b>TSS (mg/L)</b>
September	2021	WOB-2	0.000	0.000	0.000	0.014	0.484	0.052	11.7
October	2021	WOB-2	0.002	0.000	0.006	0.031	0.690	0.094	40.9
November	2021	WOB-2	0.000	0.000	0.000	0.013	0.510	0.041	4.1
December	2021	WOB-2	0.000	0.007	0.017	0.019	0.390	0.034	5.1
January	2022	WOB-2	0.000	0.000	0.010	0.007	0.000	0.024	3.2
February	2022	WOB-2	0.000	0.000	0.004	0.005	0.180	0.005	1.8

\*Data reported from Henry in March 2021 and WOB-2 in September 2021 were not directly collected because of an incorrect initial sampling location (Henry) and the site being dry (WOB-2). Instead, the listed values here represent estimates of missing data using a marginal means model.

Table A4. Summary of water physicochemistry variables across all ten study sites throughout the study period.

Month	Year	Site	Temperature (C)	DO (%)	DO (mg/L)	Turbidity (NTU)	pH	Spec. Cond. (uS/cm)
March	2021	Ball fields	18.4	76.8	6.65	106	6.35	174.5
April	2021	Ball fields	15.5	33.8	3.38	178	5.98	125.4
May	2021	Ball fields	22.9	84.8	7.28	201	5.55	50.5
June	2021	Ball fields	23.7	73.8	6.24	431	6.39	113.4
July	2021	Ball fields	26.4	46.1	3.62	25	6.32	277.0
August	2021	Ball fields	27.5	52.0	4.08	23	6.49	197.9
September	2021	Ball fields	26.1	63.9	5.24	22	6.97	596.0
October	2021	Ball fields	19.8	37.1	3.37	38	6.75	189.9
November	2021	Ball fields	10.2	41.3	4.60	314	6.31	130.6
December	2021	Ball fields	15.7	66.8	6.62	250	6.30	105.5
January	2022	Ball fields	5.4	84.0	10.59	94	6.19	102.9
February	2022	Ball fields	7.9	91.4	10.78	89	6.44	140.7
March	2021	Banaszak	14.6	85.1	8.67	33	6.33	107.2
April	2021	Banaszak	13.3	76.7	8.04	32	6.34	112.2
May	2021	Banaszak	20.1	87.3	7.84	53	5.57	57.6
June	2021	Banaszak	21.1	71.0	6.30	68	6.23	133.2
July	2021	Banaszak	22.5	18.6	1.60	56	6.21	96.2
August	2021	Banaszak	23.5	29.3	2.46	249	6.57	66.8
September	2021	Banaszak	19.5	5.0	0.45	49	6.45	114.2
October	2021	Banaszak	14.7	69.4	7.03	74	6.35	71.5
November	2021	Banaszak	7.9	72.3	8.56	47	6.82	103.9
December	2021	Banaszak	13.4	68.1	7.12	33	6.34	114.5
January	2022	Banaszak	2.7	93.8	12.84	17	6.46	94.1
February	2022	Banaszak	7.1	94.3	11.33	18	6.65	101.6
March	2021	Dog Park	15.8	61.6	6.04	16	7.03	211.4
April	2021	Dog Park	14.5	61.8	6.25	17	6.47	195.5

Month	Year	Site	Temperature (C)	DO (%)	DO (mg/L)	Turbidity (NTU)	pH	Spec. Cond. (uS/cm)
May	2021	Dog Park	20.8	82.7	7.40	57	5.96	81.6
June	2021	Dog Park	22.3	76.1	6.59	43	6.13	104.0
July	2021	Dog Park	25.4	20.0	1.61	8	6.35	165.9
August	2021	Dog Park	25.6	33.2	2.67	23	6.35	213.9
September	2021	Dog Park	23.6	33.8	2.88	6	6.73	199.9
October	2021	Dog Park	17.2	38.9	3.75	13	6.15	105.9
November	2021	Dog Park	10.6	57.7	6.36	30	7.23	137.1
December	2021	Dog Park	13.9	45.7	4.69	15	6.45	159.7
January	2022	Dog Park	4.2	102.2	13.33	15	6.66	126.3
February	2022	Dog Park	8.4	95.1	11.09	10	6.75	224.7
March	2021	Golf Course	14.9	56.1	5.66	11	6.59	225.2
April	2021	Golf Course	15.5	21.2	2.02	17	6.02	155.1
May	2021	Golf Course	21.3	58.4	5.16	57	5.84	70.0
June	2021	Golf Course	22.9	46.2	3.86	102	5.48	65.1
July	2021	Golf Course	26.0	17.3	1.39	7	6.80	212.6
August	2021	Golf Course	26.7	17.4	1.37	9	6.14	171.2
September	2021	Golf Course	23.6	16.5	1.35	7	5.98	140.1
October	2021	Golf Course	17.9	30.6	2.86	8	5.39	137.7
November	2021	Golf Course	10.5	34.8	3.88	29	6.28	79.9
December	2021	Golf Course	13.9	21.9	2.24	15	5.85	93.6
January	2022	Golf Course	4.4	70.6	9.08	17	6.71	147.9
February	2022	Golf Course	8.8	67.3	7.74	13	6.38	314.9
March	2021	Henry	17.8*	51.2*	5.46*	65*	6.29*	173.5*
April	2021	Henry	13.9	67.1	6.87	57	6.06	58.7
May	2021	Henry	19.8	83.8	7.65	47	5.56	34.6
June	2021	Henry	20.9	53.4	4.72	85	6.09	69.7
July	2021	Henry	25.4	65.5	5.26	21	6.03	108.7
August	2021	Henry	26.2	69.0	5.59	17	6.04	85.1
September	2021	Henry	23.6	31.7	2.41	16	6.41	104.9
October	2021	Henry	18.7	38.1	3.52	23	6.02	61.6

Month	Year	Site	Temperature (C)	DO (%)	DO (mg/L)	Turbidity (NTU)	pH	Spec. Cond. (uS/cm)
November	2021	Henry	10.5	39.1	4.33	64	6.25	56.7
December	2021	Henry	11.9	50.9	5.47	55	6.05	53.3
January	2022	Henry	3.4	93.7	12.64	44	6.23	49.5
February	2022	Henry	7.9	89.6	10.52	24	6.32	46.1
March	2021	NC-1	16.1	95.9	9.46	13	6.05	60.0
April	2021	NC-1	14.5	83.9	8.52	14	6.02	63.8
May	2021	NC-1	19.5	57.5	5.29	44	5.46	38.3
June	2021	NC-1	22.4	56.5	4.87	59	6.15	87.4
July	2021	NC-1	25.4	15.7	1.22	23	5.93	116.1
August	2021	NC-1	26.1	22.7	1.79	51	6.31	81.7
September	2021	NC-1	24.4	110.4	9.22	19	6.75	77.5
October	2021	NC-1	16.6	22.6	2.17	24	6.25	85.8
November	2021	NC-1	9.3	71.3	8.18	57	6.26	65.2
December	2021	NC-1	13.9	75.1	7.74	22	5.99	67.0
January	2022	NC-1	4.2	98.0	12.92	9	6.32	49.2
February	2022	NC-1	7.4	97.8	11.63	10	6.32	56.5
March	2021	Sharkey	15.6	81.2	8.08	20	6.83	281.7
April	2021	Sharkey	14.3	62.2	6.35	24	6.45	227.5
May	2021	Sharkey	19.9	86.3	7.86	61	5.98	94.5
June	2021	Sharkey	21.7	75.1	6.59	78	6.29	147.3
July	2021	Sharkey	24.7	39.5	3.27	15	6.19	163.3
August	2021	Sharkey	25.5	48.8	3.97	26	6.55	217.7
September	2021	Sharkey	22.6	56.8	4.92	6	6.95	143.8
October	2021	Sharkey	16.6	57.4	5.59	135	6.31	112.8
November	2021	Sharkey	9.3	63.6	7.26	78	6.99	143.3
December	2021	Sharkey	15.1	78.3	7.90	38	6.41	139.1
January	2022	Sharkey	2.7	93.0	12.64	17	6.61	230.7
February	2022	Sharkey	8.5	90.7	10.55	17	6.70	248.3
March	2021	Vestal	14.3	66.5	6.67	8	6.78	600.0
April	2021	Vestal	13.7	64.0	6.63	19	6.38	297.6

Month	Year	Site	Temperature (C)	DO (%)	DO (mg/L)	Turbidity (NTU)	pH	Spec. Cond. (uS/cm)
May	2021	Vestal	20.8	68.1	6.01	57	6.03	86.8
June	2021	Vestal	21.7	78.4	6.85	60	6.13	158.2
July	2021	Vestal	23.9	37.1	3.11	16	6.64	317.2
August	2021	Vestal	24.8	52.5	4.26	76	6.20	205.4
September	2021	Vestal	20.7	59.0	5.29	10	6.64	686.0
October	2021	Vestal	15.2	56.1	5.61	28	5.94	305.6
November	2021	Vestal	9.2	63.7	7.28	15	7.48	386.1
December	2021	Vestal	14.5	62.2	6.32	20	6.30	425.7
January	2022	Vestal	2.2	89.3	12.18	13	6.50	369.3
February	2022	Vestal	7.9	85.2	10.03	17	6.44	553.0
March	2021	WOB-1	16.1	66.2	6.51	40	6.20	87.7
April	2021	WOB-1	14.6	57.6	5.82	31	6.06	65.8
May	2021	WOB-1	20.3	71.2	6.42	42	5.34	36.8
June	2021	WOB-1	23.2	60.3	5.11	42	6.12	104.1
July	2021	WOB-1	27.6	35.0	2.69	15	5.89	98.1
August	2021	WOB-1	27.0	37.5	2.92	28	6.45	113.3
September	2021	WOB-1	24.1	62.9	5.36	36	6.95	110.1
October	2021	WOB-1	18.5	34.5	3.26	38	6.02	85.6
November	2021	WOB-1	11.3	48.5	5.28	70	6.45	82.4
December	2021	WOB-1	14.8	46.2	4.71	32	6.13	95.7
January	2022	WOB-1	3.0	88.6	11.94	24	6.43	62.5
February	2022	WOB-1	7.5	91.6	10.93	23	6.33	61.3
March	2021	WOB-2	18.1	112.2	10.62	22	6.24	88.0
April	2021	WOB-2	16.2	86.3	8.48	18	6.02	89.9
May	2021	WOB-2	20.7	35.8	3.20	33	5.64	36.4
June	2021	WOB-2	23.4	65.4	5.51	42	6.04	86.2
July	2021	WOB-2	27.0	148.2	11.84	27	6.42	108.9
August	2021	WOB-2	26.2	102.6	8.31	13	6.35	266.0
September	2021	WOB-2	24.9	122.7	10.24	94*	6.31	277.0
October	2021	WOB-2	17.9	68.7	6.49	54	6.23	111.9

<b>Month</b>	<b>Year</b>	<b>Site</b>	<b>Temperature (C)</b>	<b>DO (%)</b>	<b>DO (mg/L)</b>	<b>Turbidity (NTU)</b>	<b>pH</b>	<b>Spec. Cond. (uS/cm)</b>
November	2021	WOB-2	10.9	82.5	9.10	16	6.28	73.3
December	2021	WOB-2	16.0	74.8	7.36	14	5.99	84.3
January	2022	WOB-2	4.8	94.6	12.17	13	6.11	74.7
February	2022	WOB-2	7.5	96.2	11.43	6	6.34	149.1

\*Data reported from Henry in March 2021 and WOB-2 in September 2021 were not directly collected because of an incorrect initial sampling location (Henry) and the site being dry (WOB-2). Instead, the listed values here represent estimates of missing data using a marginal means model.

Table A5. Summary of BOD5 measured across all ten sites during the study period.

<b>Month</b>	<b>Year</b>	<b>Site</b>	<b>BOD5 (mg/L)</b>
May	2021	Ball fields	2.54
August	2021	Ball fields	1.71
November	2021	Ball fields	1.66
February	2022	Ball fields	1.37
May	2021	Banaszak	1.61
August	2021	Banaszak	8.50
November	2021	Banaszak	2.39
February	2022	Banaszak	0.92
May	2021	Dog Park	2.10
August	2021	Dog Park	2.57
November	2021	Dog Park	1.67
February	2022	Dog Park	1.05
May	2021	Golf Course	2.55
August	2021	Golf Course	1.87
November	2021	Golf Course	2.07
February	2022	Golf Course	1.90
May	2021	Henry	1.59
August	2021	Henry	6.55
November	2021	Henry	2.28
February	2022	Henry	1.09
May	2021	NC-1	2.36
August	2021	NC-1	3.67
November	2021	NC-1	1.44
February	2022	NC-1	0.84
May	2021	Sharkey	1.79
August	2021	Sharkey	4.39
November	2021	Sharkey	2.09
February	2022	Sharkey	1.23
May	2021	Vestal	2.60
August	2021	Vestal	1.29
November	2021	Vestal	1.80
February	2022	Vestal	0.99
May	2021	WOB-1	2.66
August	2021	WOB-1	3.17
November	2021	WOB-1	2.47
February	2022	WOB-1	1.27
May	2021	WOB-2	2.32
August	2021	WOB-2	8.50
November	2021	WOB-2	1.09
February	2022	WOB-2	0.79

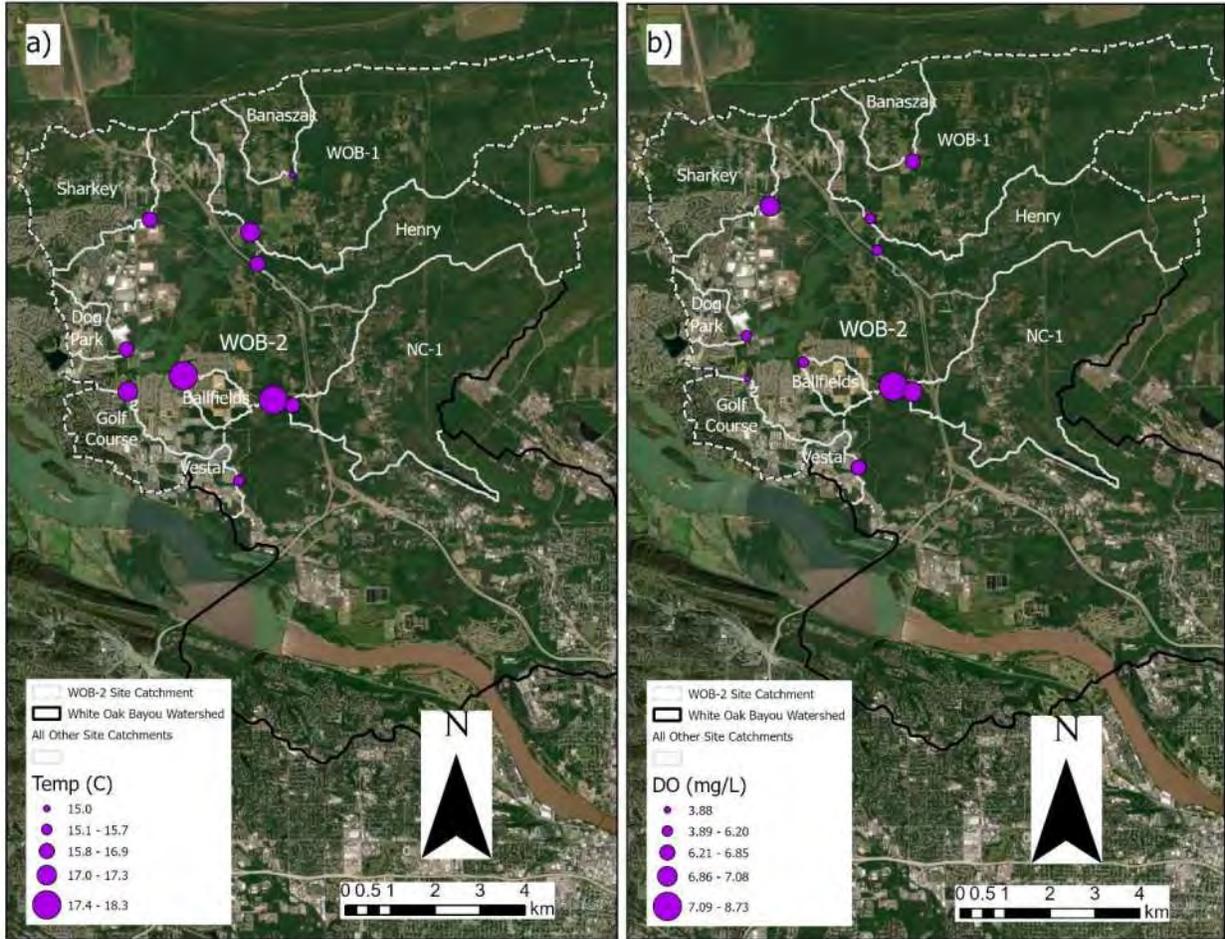


Figure A1. Spatial Distribution of Temperature and DO (mg/L). Water temperatures (Pane a) appeared to be highest in the southern part of the study area where DO values (Pane b) were also generally lowest. The WOB-2 departs from this general pattern where higher temperatures seem to correspond with higher concentrations of DO. This phenomenon was also observed in comparisons of water temperature and percent saturation of DO (See Figure 6).

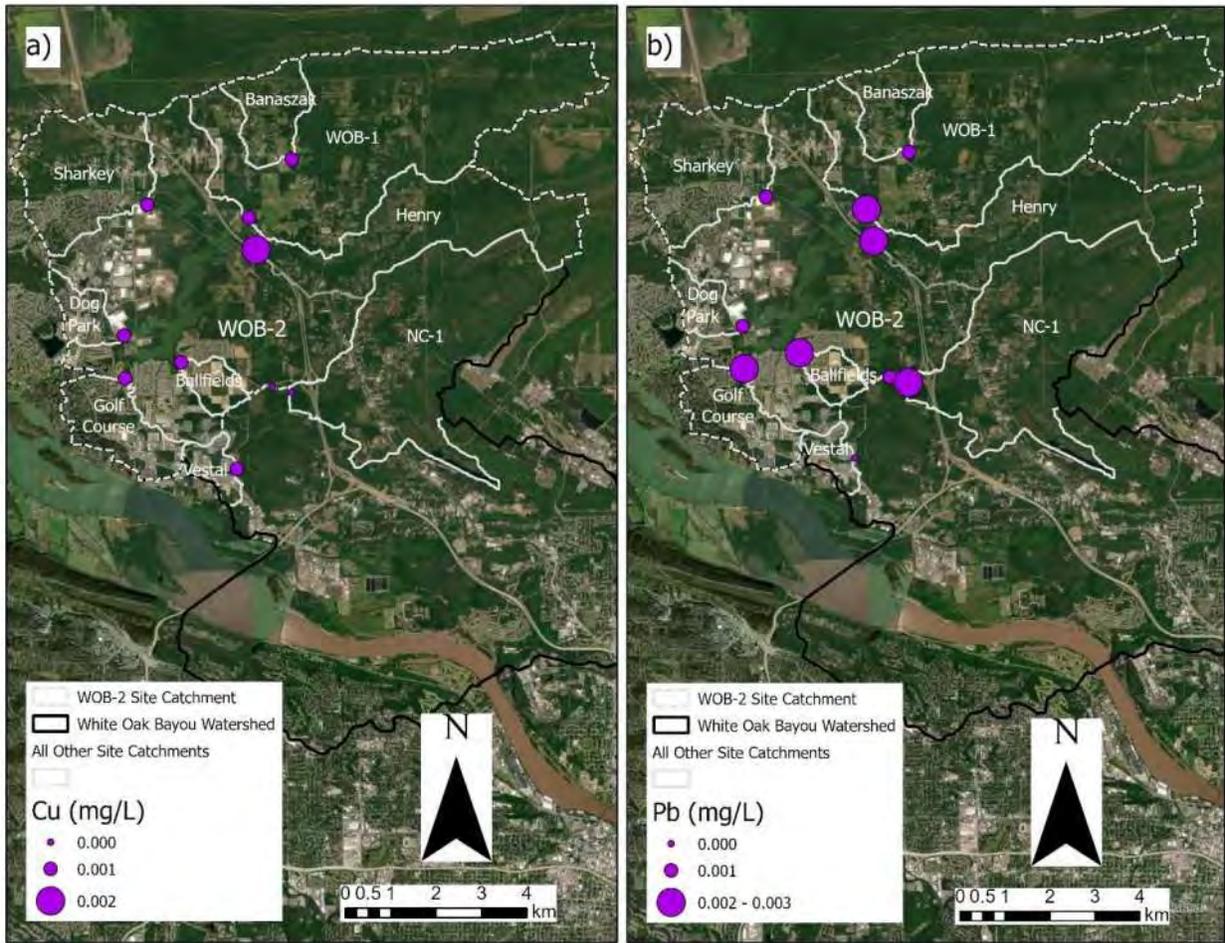


Figure A2. Spatial Distribution of Copper and Lead Concentrations (mg/L). Neither copper (Pane a) nor lead (Pane b) concentrations appeared to follow any clear geographic pattern or gradient (north-south or west-east). Similarly, catchment size did not appear to influence copper or lead concentrations since WOB-2 has lower values than any of its spatially nested drainages.

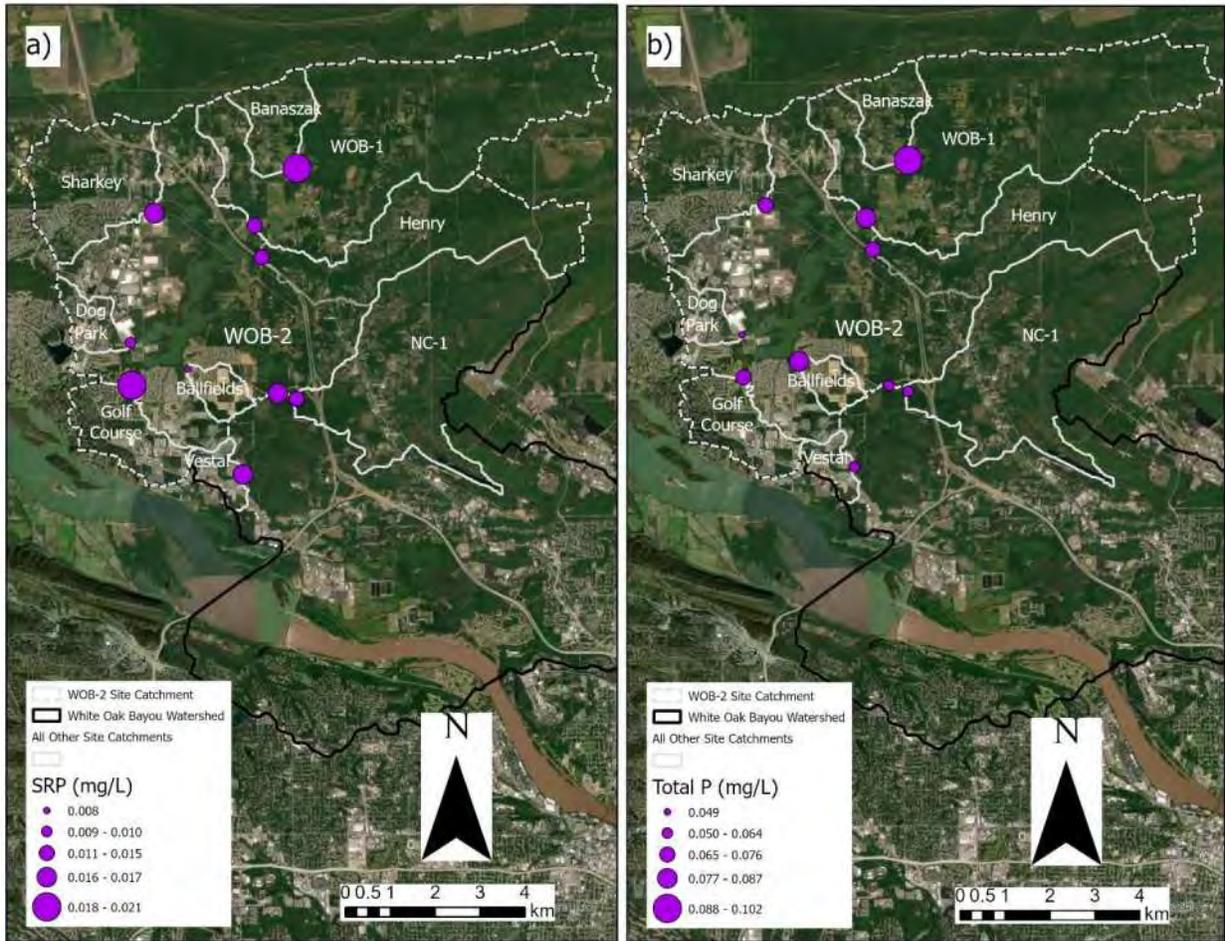


Figure A3. Spatial Distribution of SRP and Total P (mg/L). SRP (Pane a) and Total P (Pane b) concentrations showed the expected positive relationship between variables, but do not appear to follow a clear geographic pattern or gradient (north-south or west-east). The values of both constituents for the WOB-2 catchment are similar to those for Copper and Lead, in that they do not appear to be directly influenced by WOB-2's spatially nested drainages.

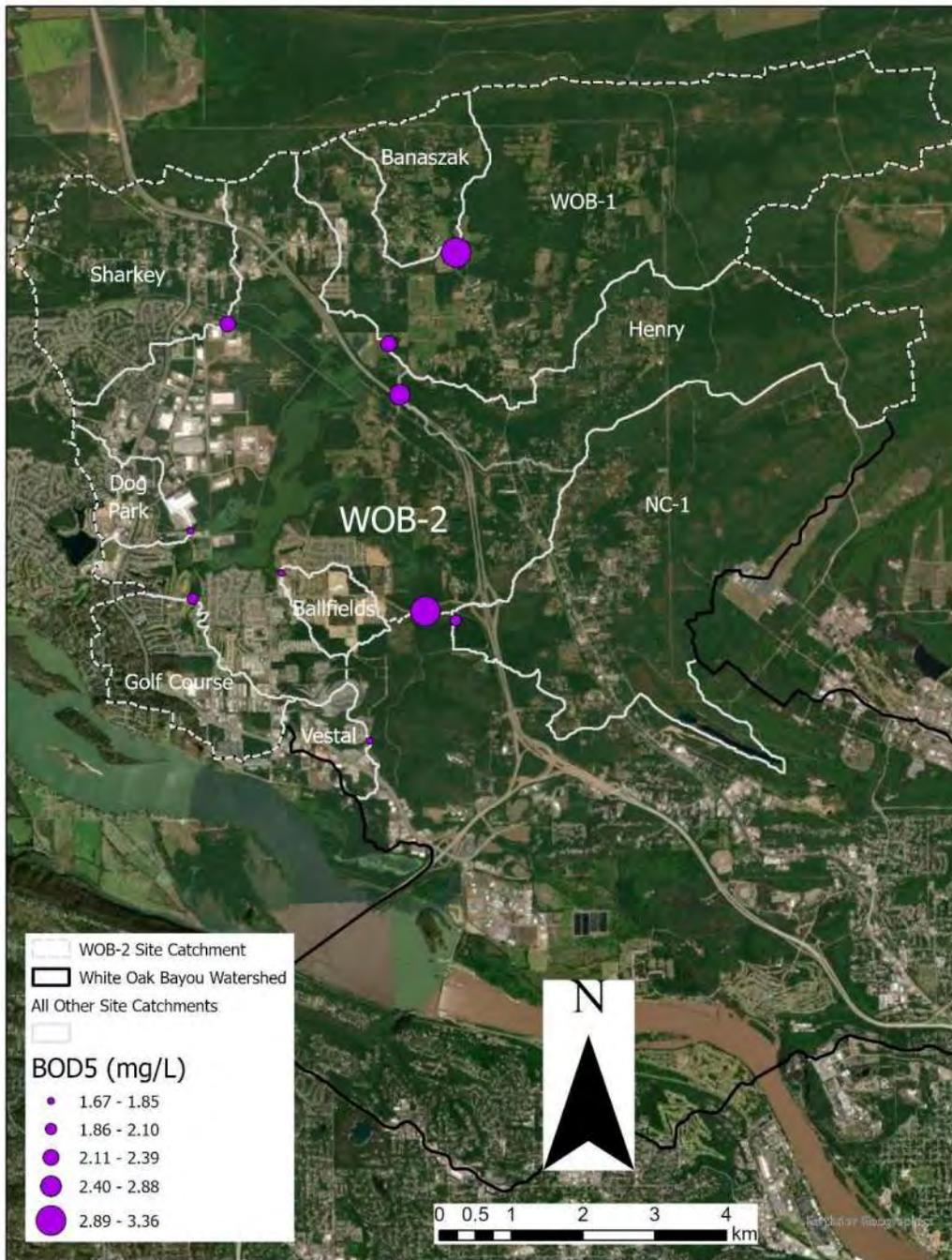


Figure A4. Spatial Distribution of BOD-5 (mg/L). BOD-5 concentrations appear to follow a west-east gradient with lower values along the western border of the study area, and lower values in the east. This pattern also aligns with the overall spatial distribution of LULC in the White Oak Bayou where Developed land use is highest along the WOB's western border inside the City of Maumelle, Arkansas and becomes less frequent in the eastern part of the Study Area in rural Pulaski County.

Water Quality Sampling of the White Oak Bayou Watershed  
Ouachita Water Lab  
Bo Sutton, Clark Kuyper and Tim Knight

The Ouachita Water Lab of Ouachita Baptist University appreciates the opportunity to conduct this work with CBM<sup>c</sup> & Associates. Our lab provides the opportunity for students to be involved in the sampling and analysis of water samples as part of their undergraduate education. Bo Sutton, conducted all the sample collection and participated in analysis for this project. Bo worked under the supervision of Clark Kuyper (Lab Director) and Tim Knight (Dean of the Patterson School of Natural Sciences). Bo also had the opportunity to share preliminary results of this project as a poster presentation in our on-campus Scholar's Day held in April, 2019.

Sampling began in September, 2018 and continued through April, 2019. Ten sites were determined by GBM<sup>c</sup> prior to the start of sampling. Samples were collected following standard field protocols and all holding times fell within the time required for each parameter. The following parameters were analyzed:

- Temperature (in situ)
- pH (in situ)
- Turbidity (in situ)
- Dissolved Oxygen (in situ)
- Conductivity (in situ)
  
- Total Phosphorous
- Total Kjeldahl Nitrogen
- Ammonia Nitrogen
- Total Dissolved Solids
- Total Suspended Solids
- Sulfate
- Chloride
- Nitrate Nitrogen

The Ouachita Water Lab enjoys approval for analysis of these constituents by the Arkansas Department of Environmental Quality. Field blanks, lab spikes and splits were conducted for each sample date. An Excel file containing the raw data will be provided with this report.

The ten sample locations include two stations on White Oak Bayou (WOB-1 and WOB-2). The Banaszak station is above WOB-1. Sample sites labelled Sharkey, Henry and Dog Park, Golf Course and Ballfields join White Oak Bayou between WOB-1 and WOB-2. Stations NC-1 and Vestal join White Oak Bayou below WOB-2 station.

Appendices 1-8 contain graphical representation of the data for each month. Graphs were not created for Temperature and pH. Nothing of note was observed for these parameters. Dissolved oxygen for the

month of September was questioned by us due to trouble calibrating the filed instrument. The following items can be observed from these graphs:

1. Conductivity was high each month for the Vestal site. Sulfate and Chloride were also high at this site each month. TDS was high 7 of 8 months at Vestal.
2. Total phosphorous was higher at the ballfields in all months except September and February. TKN was higher than surrounding sites for the Ball Field all 8 months. TP and nitrogen levels at the Ball Field site indicate possible fertilizer influence from November through January.
3. There are occasionally higher levels of specific parameters at random locations, including but not limited to:
  - a. TP at Henry in September
  - b. TKN at WOB-2 in September
  - c. TP at Sharkey and Vestal sites in October
  - d. TDS at Ball Fields and Vestal in December
  - e. Turbidity and TSS at Ball Fields in January
  - f. TP at Banaszak in February
  - g. TKN at Banzak in February
  - h. Conductivity, TDS, Sulfate and Chloride at Golf Course in March
  - i. TP at Banaszak in April
  - j. Sulfate at Vestal in April

Several other items should be noted. First, flows were almost negligible each date of sampling. Water levels may have been higher or lower based on recent rain events but flows were never high. Second, our lack of familiarity of the industry and urban circumstances of Maumelle prevents us from having a feel for potential sources of contamination, other than the potential from fertilizer being applied in several locations.

# Ouachita Water Laboratory

## Analysis Report

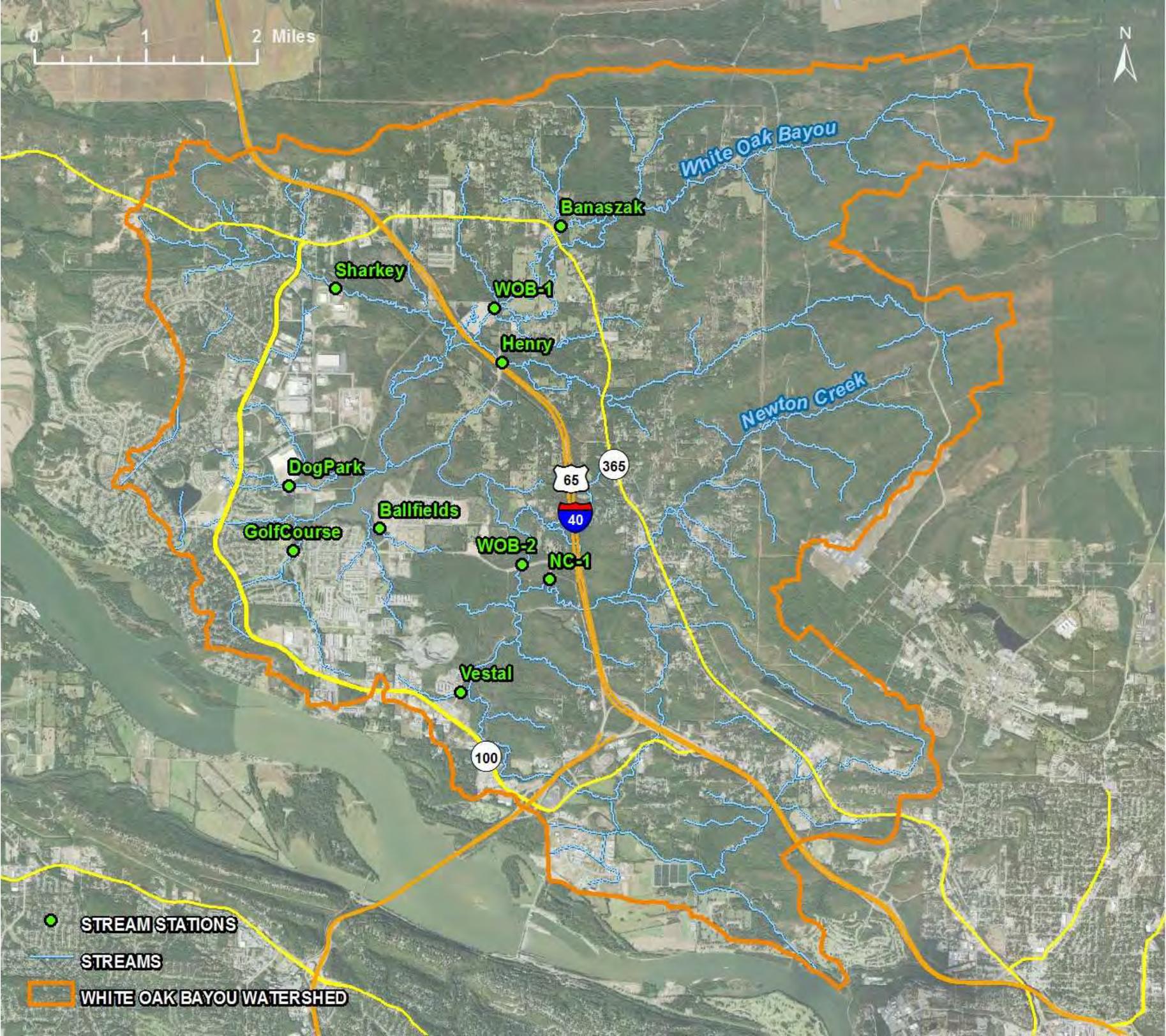
Client: GBM<sup>c</sup>

Project: White Oak Bayou

Sample Date	Station	Temp	pH	Cond	Turb	DO	TP mg/L	SRP mg/L	TKN mg/L	Ammonia-N mg/L	NO3/NO2-N mg/L	TDS mg/L	TSS mg/L	Sulfate mg/L	Chloride mg/L	Flow m/s
9/25/2018	Banaszak	21.4	6.90	81.2	43.7	5.97	0.08	0.019	0.81	0.09	0.18	90	38	6.4	7.5	0.5
9/25/2018	WOB-1	22.2	6.88	103.8	34.2	3.81	0.09	0.022	1.00	0.12	0.18	92	22	9.8	7.0	0
9/25/2018	Sharkey	22.8	6.95	155.2	28.7	6.37	0.05	0.019	0.63	0.04	0.25	104	17	19.0	10.4	0
9/25/2018	Henry	22.0	6.94	94.5	10.9	3.18	0.11	0.036	0.99	0.19	0.09	70	11	6.5	3.8	0
9/25/2018	Dog Pound	23.5	7.04	130.3	12.0	4.88	0.05	0.018	0.50	0.04	0.16	89	14	9.5	7.9	0
9/25/2018	Golf Course	22.7	7.13	107.0	14.1	3.10	0.07	0.029	0.82	0.15	0.20	77	14	7.1	8.1	0
9/25/2018	Ball Fields	21.9	7.21	157.3	13.6	2.34	0.07	0.015	1.24	0.10	<0.02MRL	112	15	3.4	5.0	0
9/25/2018	WOB-2	22.2	6.92	82.9	8.73	4.28	0.08	0.016	2.12	0.04	<0.02MRL	63	9	3.4	5.8	0.4
9/25/2018	NC-1	21.6	6.99	85.3	12.1	3.52	0.05	0.012	0.63	0.08	0.10	64	10	9.9	3.7	0
9/25/2018	Vestal	22.7	7.14	268.7	20.9	5.42	0.07	0.030	0.69	0.05	0.14	170	16	43.1	18.9	0.2
10/23/2018	Banaszak	10.9	6.79	73.3	24.0	9.19	0.04	0.013	0.42	0.04	0.12	69	12	6.1	6.9	0.1
10/23/2018	WOB-1	11.7	6.69	72.9	27.4	7.68	0.05	0.011	0.54	0.06	0.03	65	11	4.0	6.9	0
10/23/2018	Sharkey	12.6	6.63	189.6	19.3	8.25	0.07	0.019	0.54	0.10	0.12	117	13	22.2	11.6	0
10/23/2018	Henry	11.2	7.00	48.3	28.6	8.3	0.05	0.011	0.52	0.07	0.04	62	8	3.5	3.3	0
10/23/2018	Dog Pound	12.6	6.91	145.1	9.0	5.67	0.03	0.011	0.35	0.02	0.06	91	4	8.9	9.4	0
10/23/2018	Golf Course	13.2	7.25	97.8	21.9	5.1	0.05	0.013	0.70	0.08	0.18	66	10	6.2	6.5	0
10/23/2018	Ball Fields	10.1	7.50	112.3	24.9	4.8	0.07	0.010	1.18	0.09	0.34	95	16	5.2	4.7	0
10/23/2018	WOB-2	11.4	7.12	75.0	10.9	7.4	0.05	0.018	0.49	0.04	MRL	57	6	7.6	5.1	0.4
10/23/2018	NC-1	11.2	7.10	64.8	19.8	8.7	0.04	0.008	0.34	0.03	0.13	60	6	7.6	4.3	0
10/23/2018	Vestal	12.3	7.30	338	63.0	7.9	0.07	0.012	0.61	0.02	0.05	211	99	38.5	21.8	0
11/15/2018	Banaszak	3	7.68	192	19.6	11.33	0.09	0.023	0.60	0.08	0.26	126	11	27.7	19.0	0.6
11/15/2018	WOB-1	3.9	8.06	65.7	17.2	10.39	0.05	0.011	0.43	0.02	0.04	57	7	4.8	5.8	0
11/15/2018	Sharkey	4.2	7.62	174	17.2	11.34	0.05	0.010	0.43	0.03	0.11	105	9	22.5	13.9	0
11/15/2018	Henry	3.6	8.14	46.0	16.0	11.05	0.03	0.009	0.29	0.02	MRL	45	4	4.0	3.4	0
11/15/2018	Dog Pound	4.9	7.77	160.5	14.5	10.6	0.04	0.009	0.37	0.01	0.10	98	15	16.0	12.6	0
11/15/2018	Golf Course	4.8	8.2	120.7	21.4	9.4	0.05	0.015	0.51	0.03	0.14	68	8	8.4	9.8	0
11/15/2018	Ball Fields	4.4	8.3	165.3	19.0	8.91	0.10	0.044	1.38	0.05	0.56	122	4	5.9	6.4	0
11/15/2018	WOB-2	2.6	8.2	71.8	8.7	10.9	0.03	0.013	0.41	0.02	MRL	48	6	8.8	4.9	0.3
11/15/2018	NC-1	4.4	8.1	54.8	8.2	11.81	0.03	0.008	0.26	0.02	0.09	48	5	7.2	3.5	0.1
11/15/2018	Vestal	4.8	8.5	301	15.8	10.37	0.04	0.011	0.38	0.02	0.05	171	7	44.9	22.1	0.1
12/10/2018	Banaszak	4.9	6.64	58.2	15.8	11.69	0.04	0.008	0.38	0.04	0.11	49	5	5.9	5.8	0.3
12/10/2018	WOB-1	4.4	6.73	46.4	18.9	10.9	0.05	0.007	0.42	0.01	0.03	54	8	3.6	3.8	0
12/10/2018	Sharkey	5.2	6.59	116.8	20.9	11.95	0.05	0.015	0.42	0.02	0.20	49	7	17.4	9.1	0.1
12/10/2018	Henry	4.2	6.93	36.1	14.8	11.53	0.04	0.004	0.37	0.01	0.18	43	5	3.8	2.5	0
12/10/2018	Dog Pound	6.6	6.67	119.4	31.2	10.45	0.08	0.006	0.69	0.01	0.15	81	40	13.6	9.3	0
12/10/2018	Golf Course	5.2	6.84	86.0	73.0	9.78	0.12	0.019	0.74	0.03	0.08	69	28	2.7	2.6	0
12/10/2018	Ball Fields	3.6	6.65	126.4	126.4	9.32	0.36	0.274	1.62	0.05	0.78	128	50	5.1	4.0	0
12/10/2018	WOB-2	4.5	6.9	58.8	26.5	10.61	0.08	0.031	0.58	0.01	0.06	66	12	6.0	4.0	0.2
12/10/2018	NC-1	5.4	6.94	40.5	11.1	11.43	0.03	0.003	0.29	0.01	0.11	38	2	5.8	2.4	0.3
12/10/2018	Vestal	3.8	6.92	213.7	22.8	10.28	0.04	0.008	0.45	0.02	0.05	139	8	12.9	12.4	0
1/24/2019	Banaszak	3.5	7.17	50.4	20.1	12.25	0.04	0.007	0.36	0.03	0.11	54	9	5.8	4.5	0.4
1/24/2019	WOB-1	3.1	7.4	36.7	22.3	11.52	0.05	0.007	0.45	0.02	0.04	52	7	3.3	2.8	0
1/24/2019	Sharkey	3.4	7.03	103.7	31.1	12.13	0.06	0.010	0.41	0.03	0.15	88	19	7.3	6.3	0



0 1 2 Miles



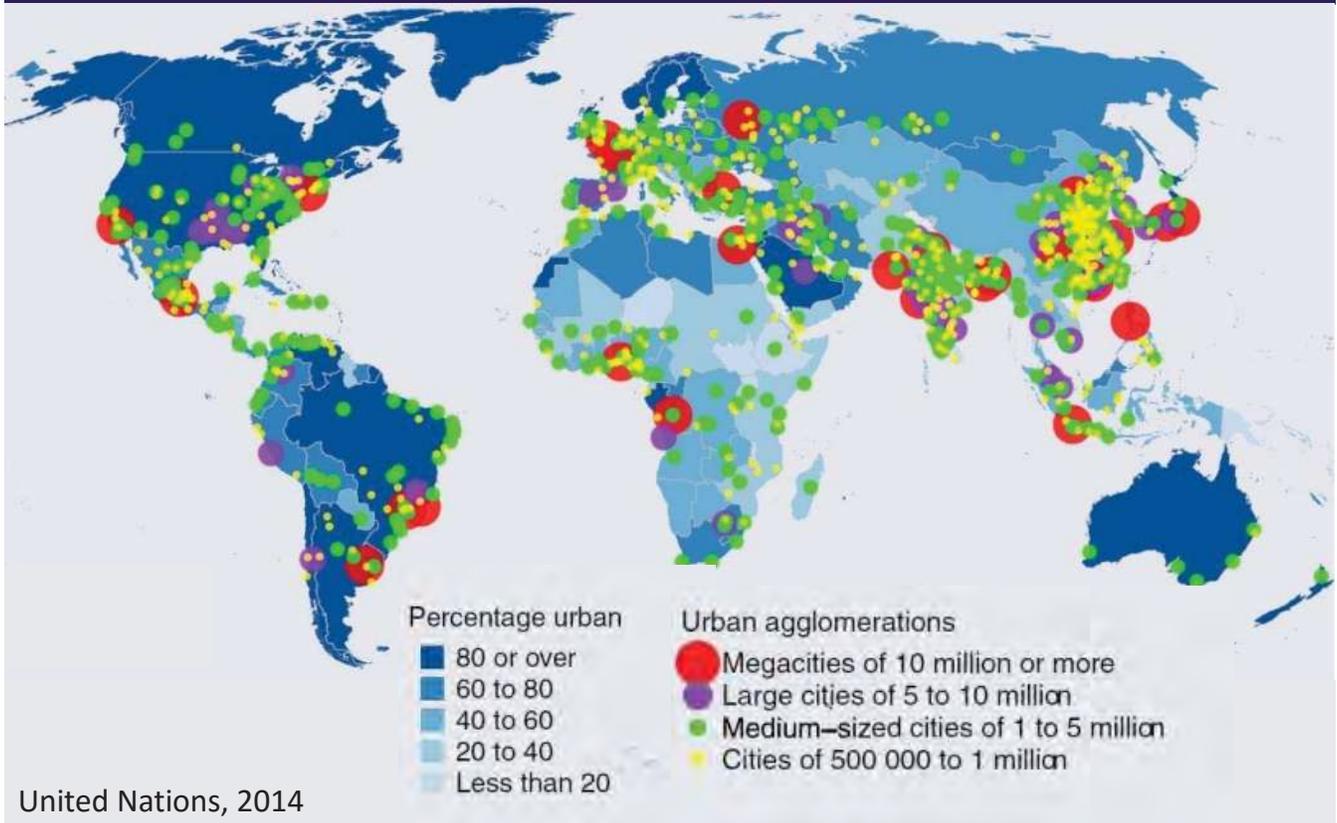
-  STREAM STATIONS
-  STREAMS
-  WHITE OAK BAYOU WATERSHED

# Does the Orientation of Urban Land Use Influence White Oak Bayou Stream Water Quality?

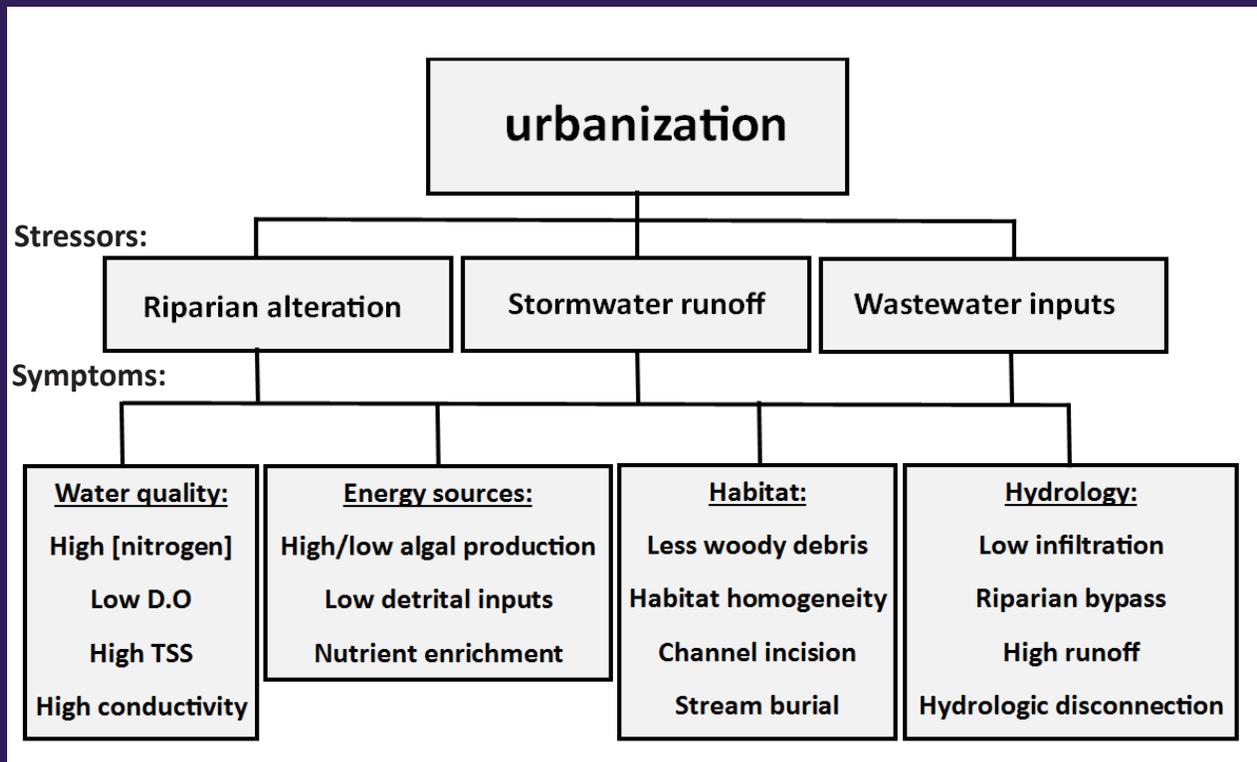


Stephanie Stoughton and Sally Entreklin  
University of Central Arkansas

## Global Urbanization

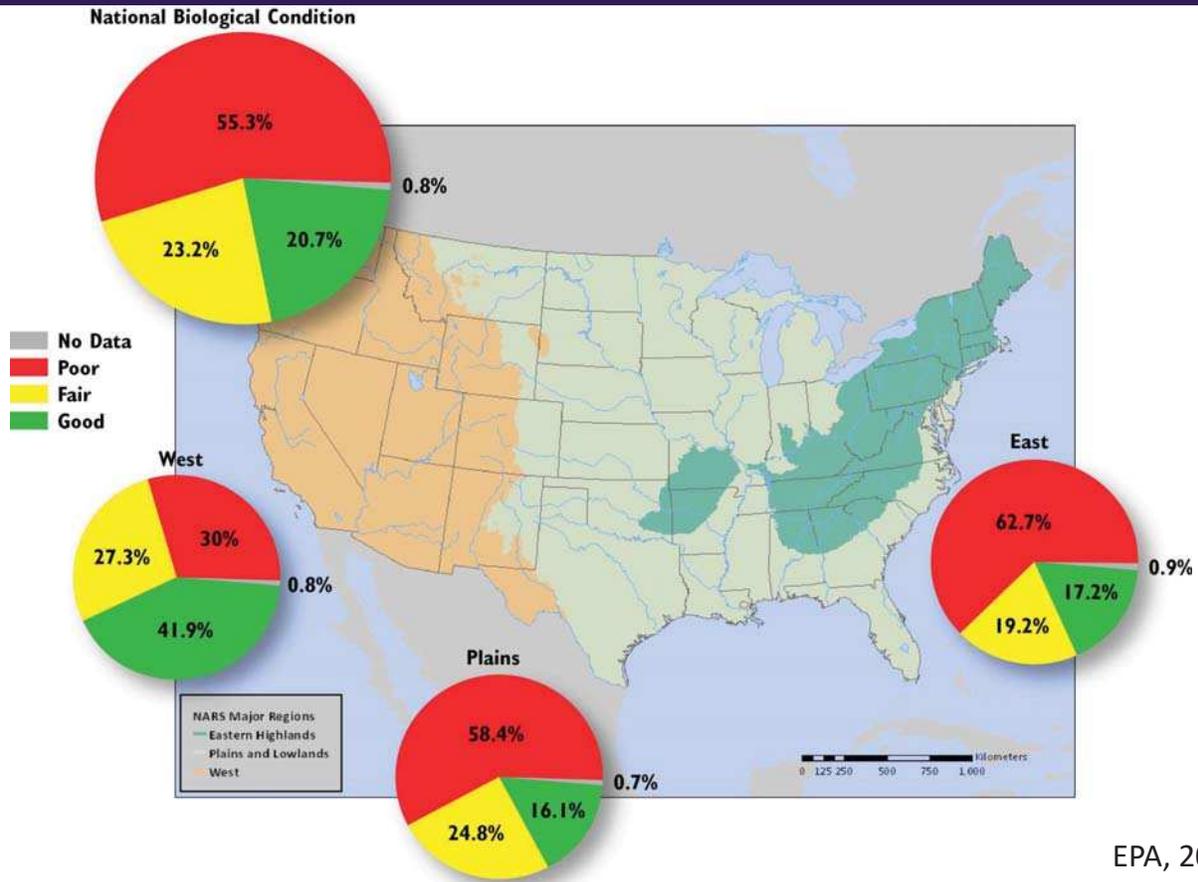


# Urban Stream Syndrome

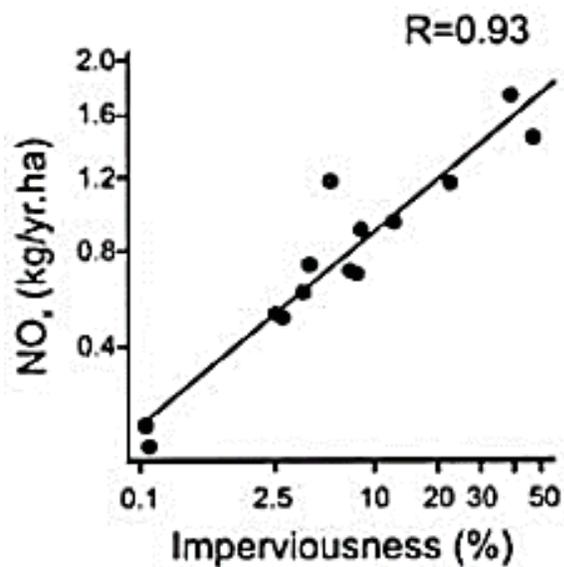


Walsh et al., 2005, Hale et al. 2016, Adapted from EPA CADDIS Model

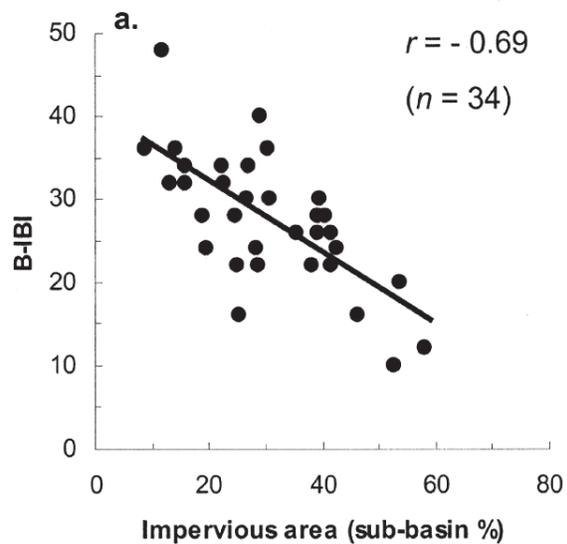
# U.S. stream impairment



# Catchment-level impacts to ecosystems

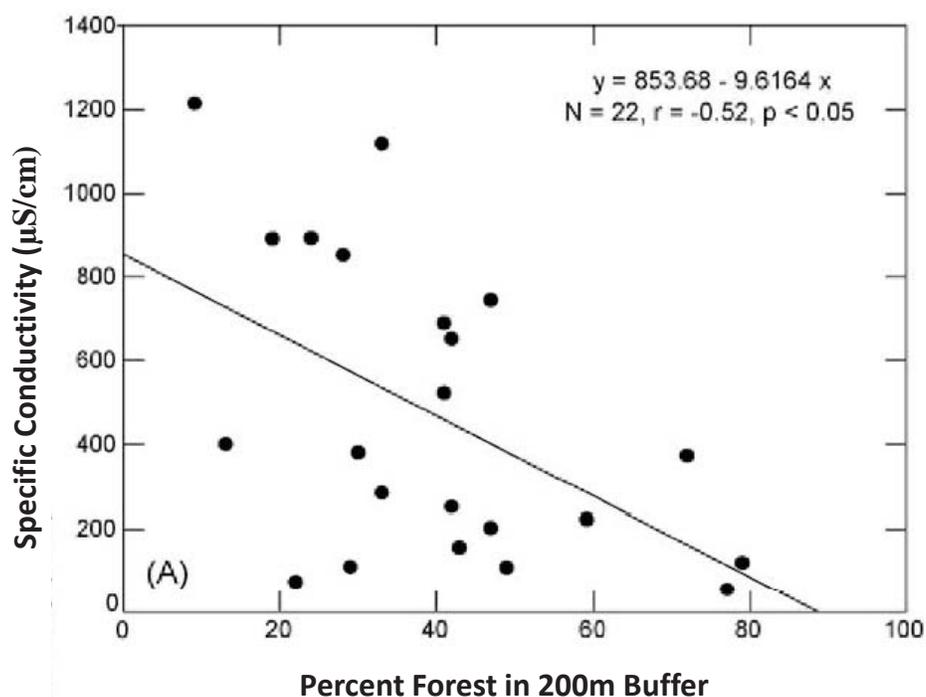


Hatt et al., 2004



Morley and Karr, 2002

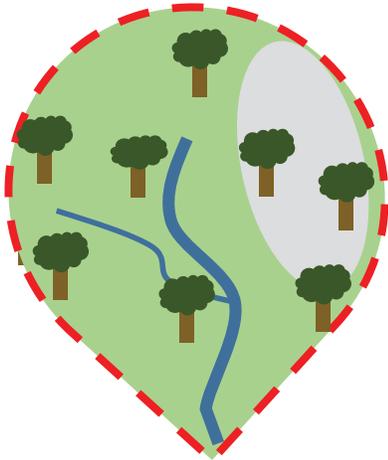
# Local-scale water quality improvements



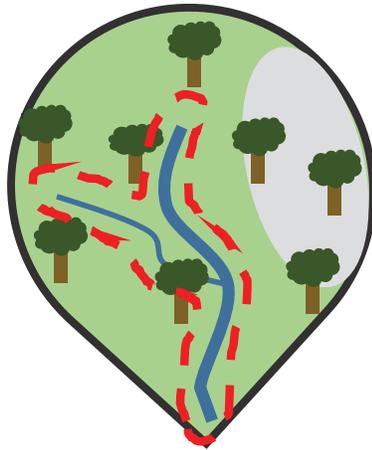
Tran et al., 2010

# Spatial arrangement

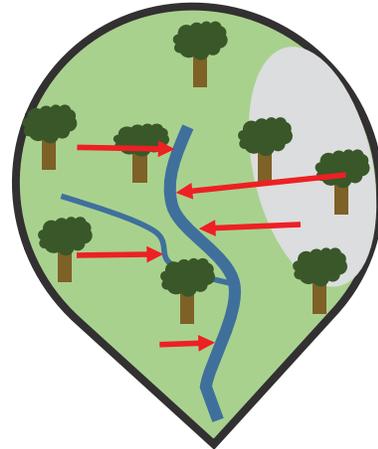
Catchment



200m buffer

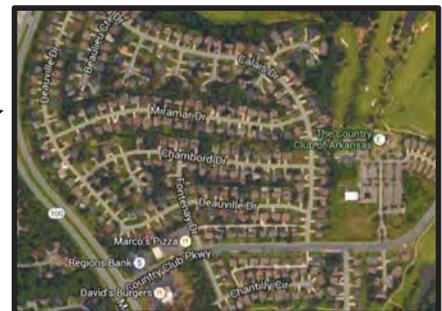
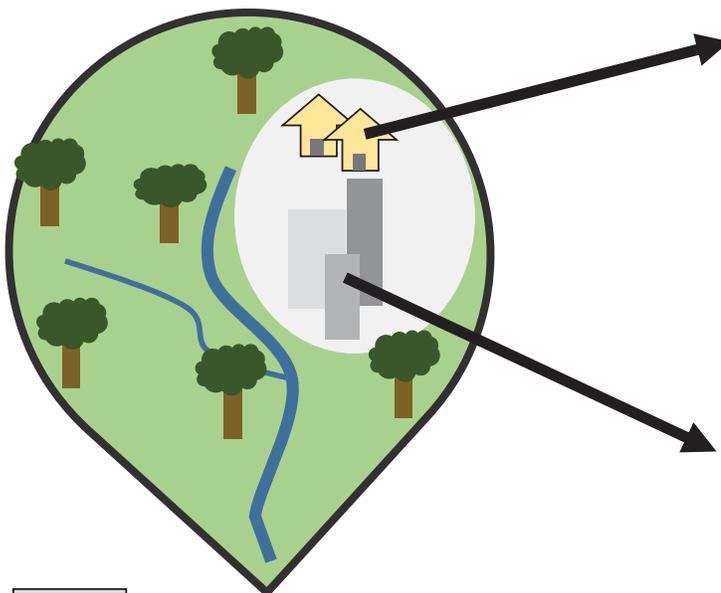


Inverse-distance weighted



Peterson et al., 2011,  
King et. al., 2005

# Urban categories



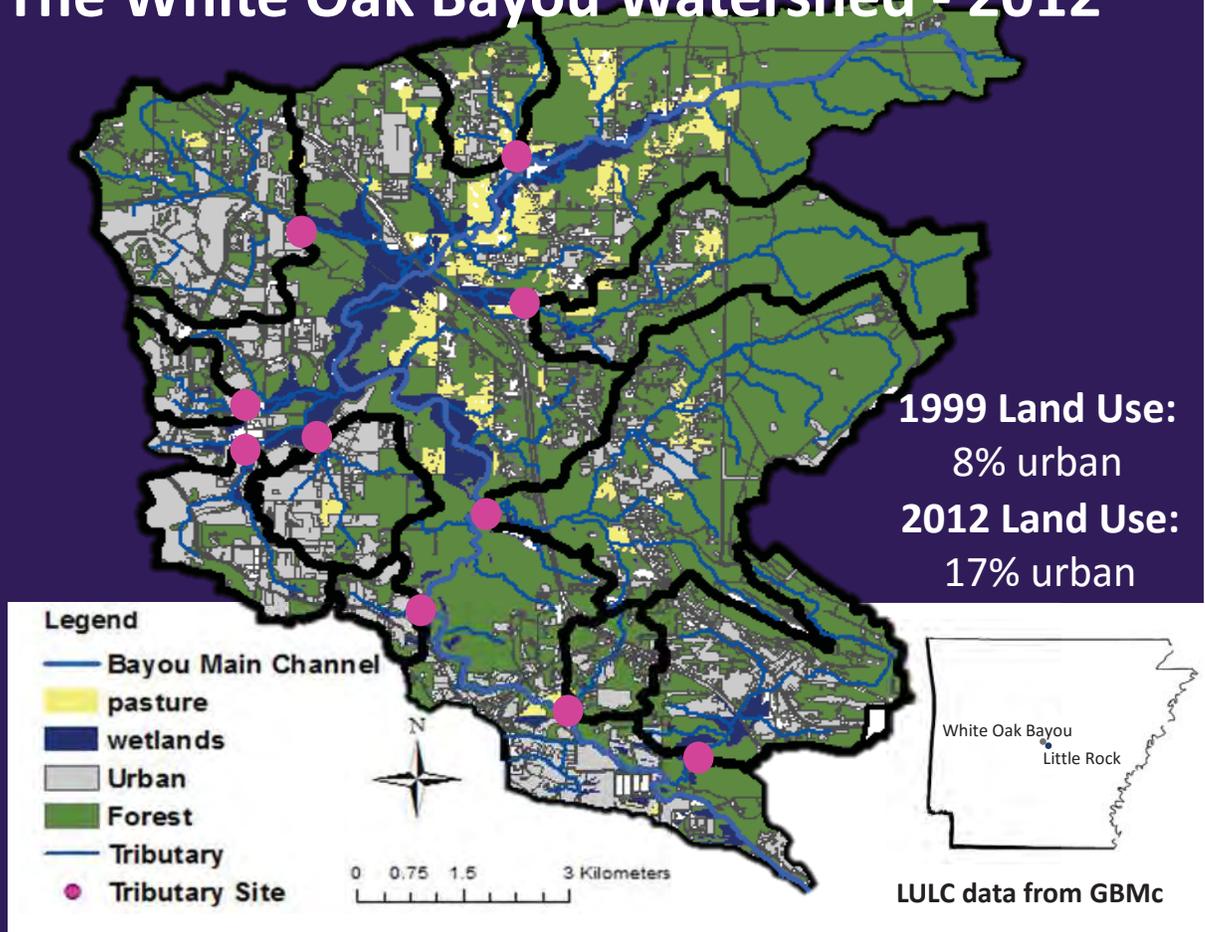
residential



commercial

Images from Google Maps

# The White Oak Bayou Watershed - 2012





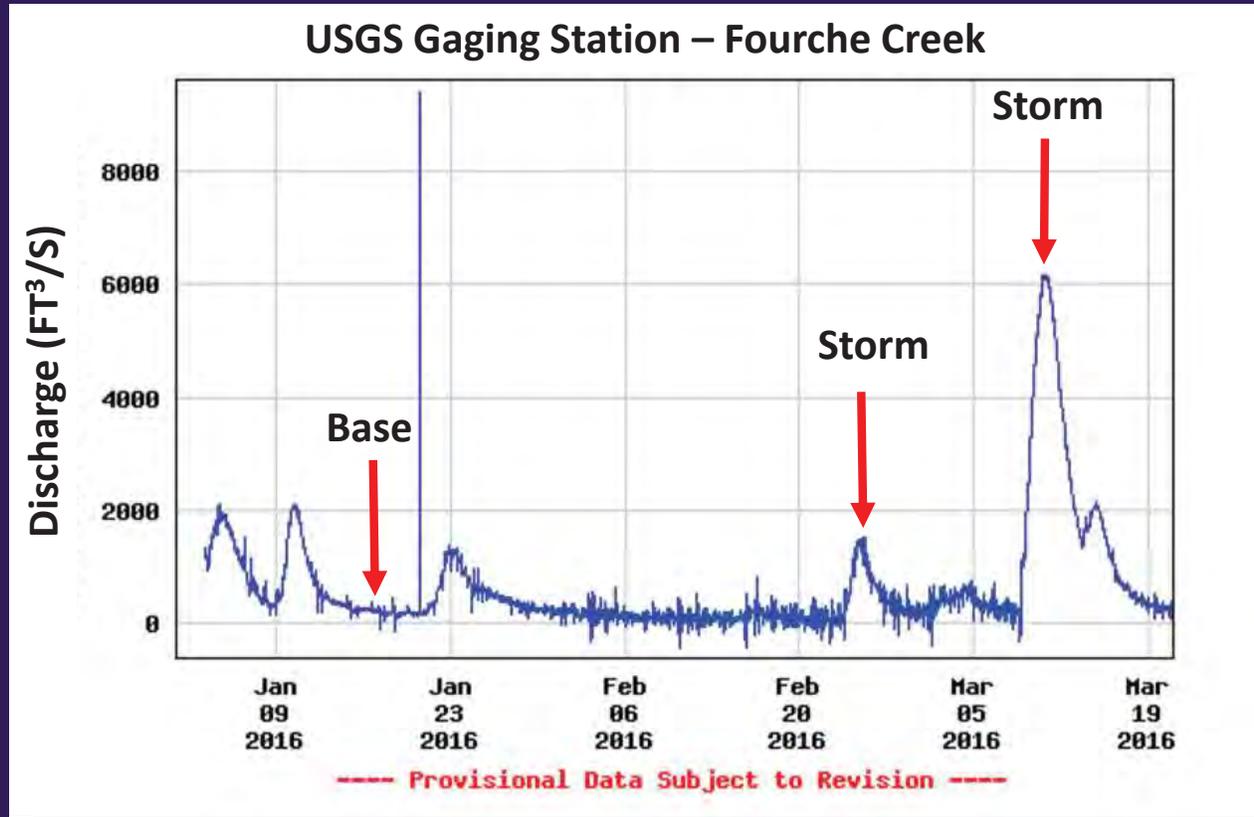
## Hypotheses

**Primary :** Water quality parameters will change as urban and pasture land cover increase among catchments.

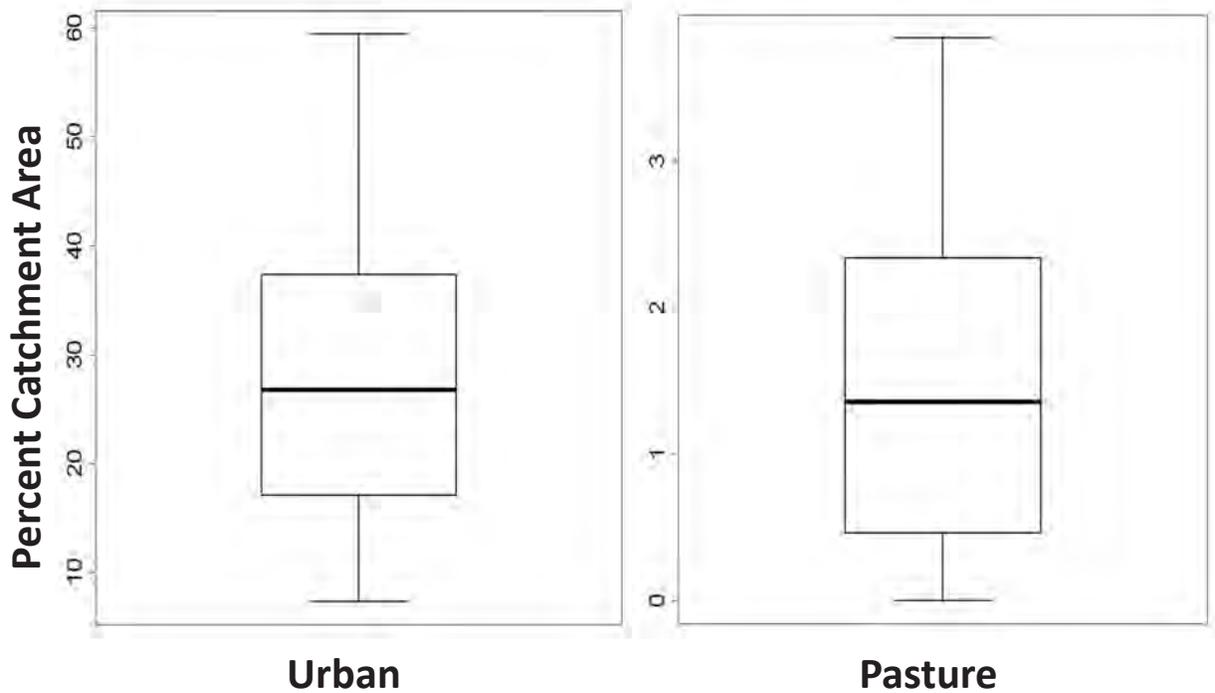
**Alternative 1:** Water quality parameters will change as urban and pasture land cover increase among 200m buffers.

**Alternative 2:** Water quality parameters will change as urban and pasture land cover is weighted by distance from stream channels.

# Sampled different flows



# Gradient of urban land use



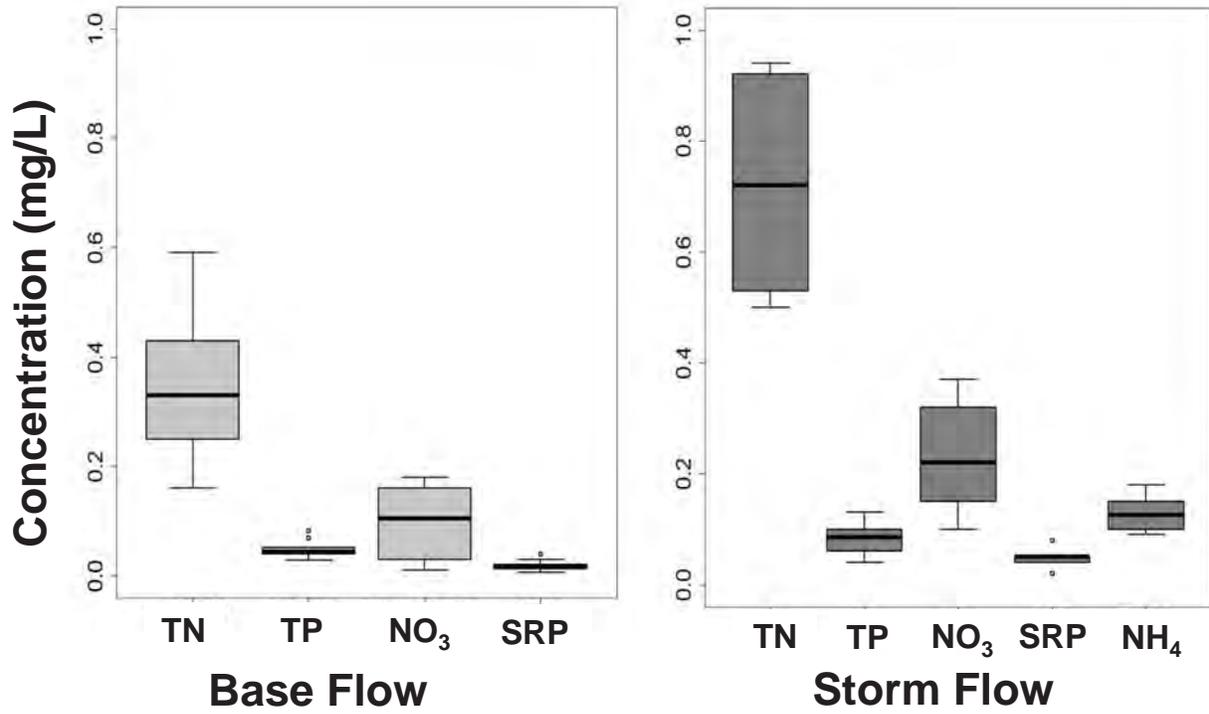
# Statistical analysis

**Response variable** = **factor** x **variable** x **variable**  
Total N (mg/L)      Catchment area (km<sup>2</sup>)      % urban catchment      % pasture catchment

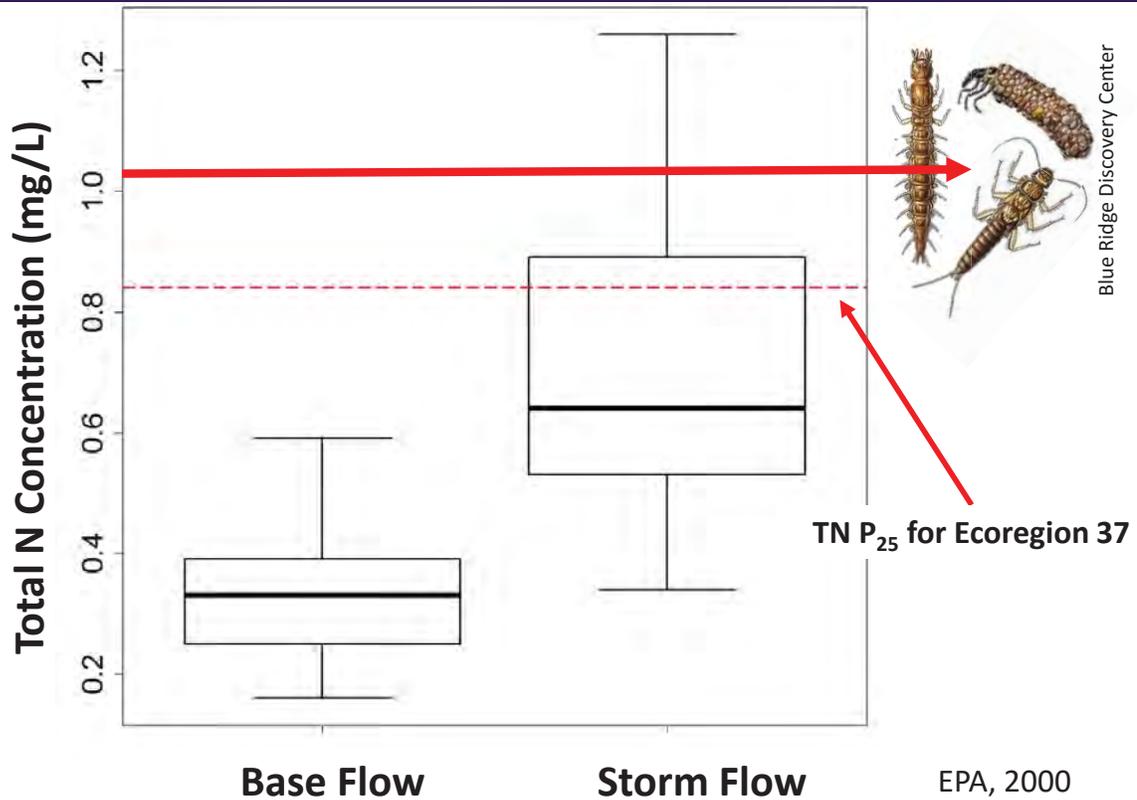
# Statistical analysis

**Response variable** = **variable** x **variable** x **variable**  
Total N (mg/L)      % residential catchment      % commercial catchment      % pasture catchment

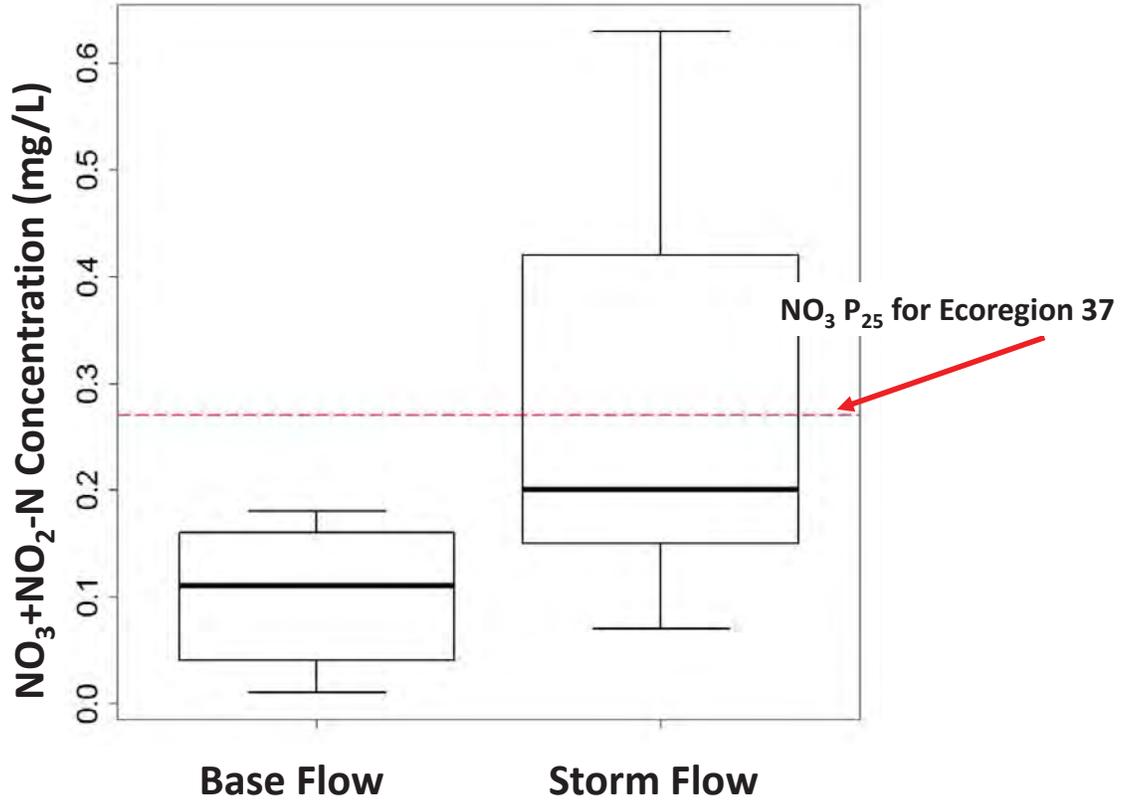
# White Oak Bayou nutrients



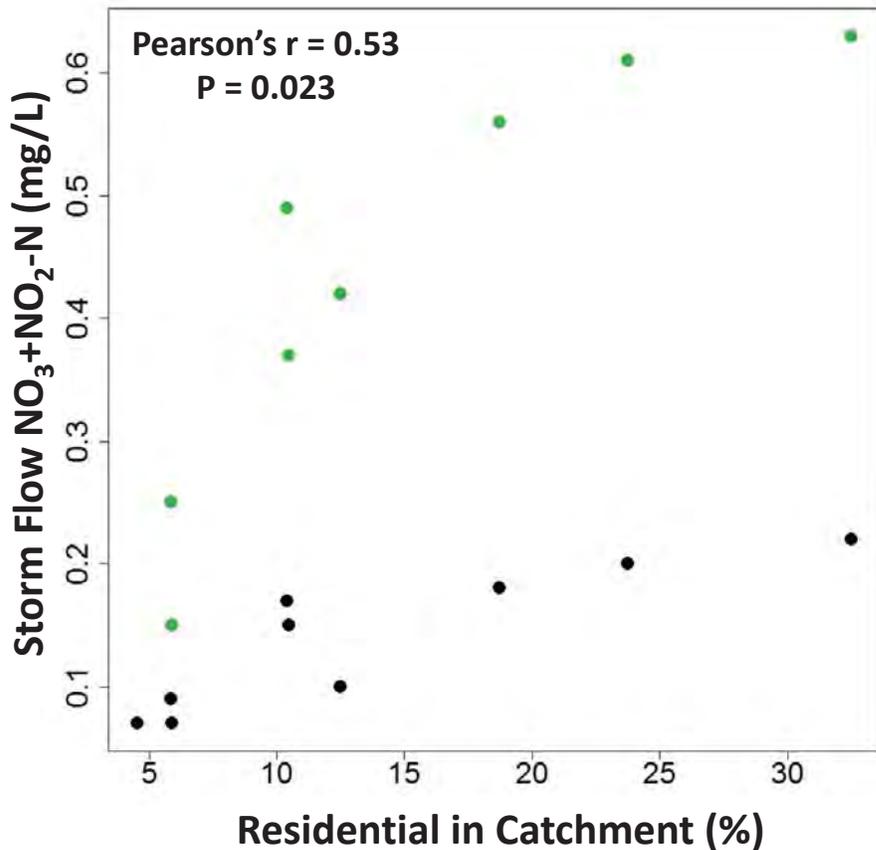
# Total nitrogen in the White Oak Bayou



# NO<sub>3</sub> in the White Oak Bayou



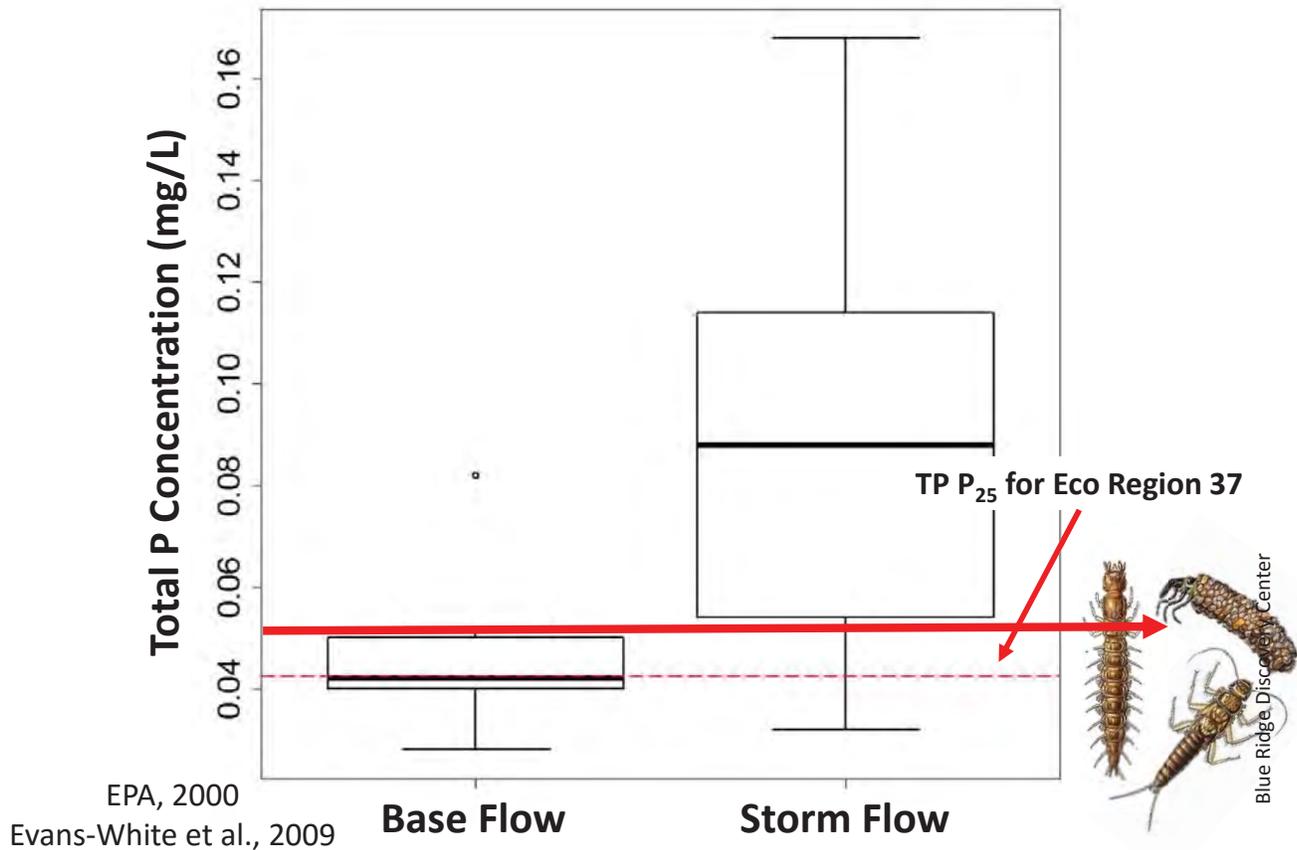
EPA, 2000



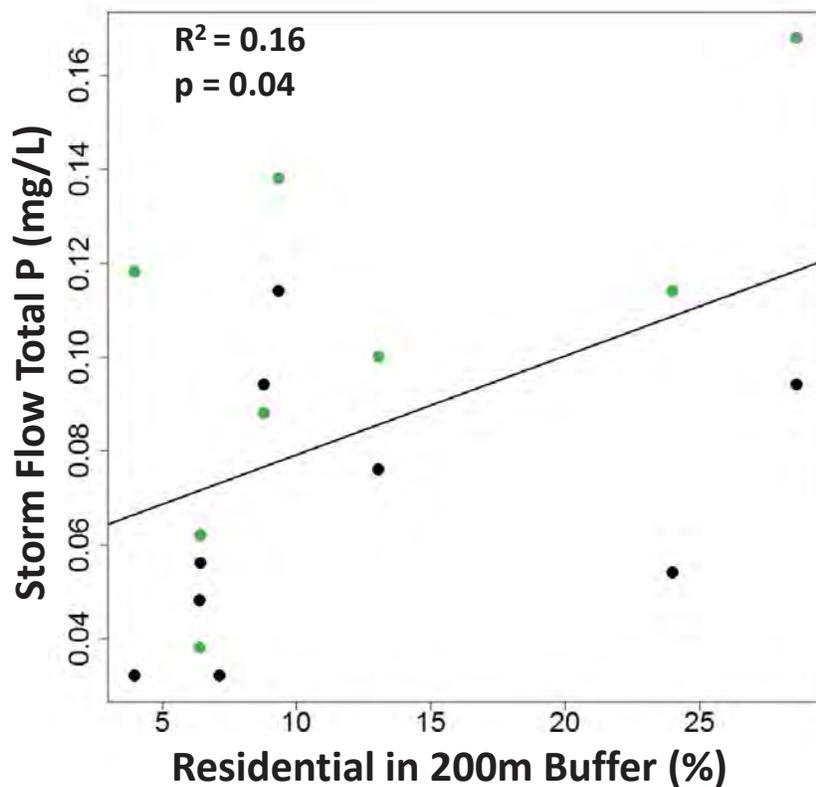
## Storms

- 24 February
- 10 March

# Total phosphorus in the White Oak Bayou



# Total phosphorus in the White Oak Bayou



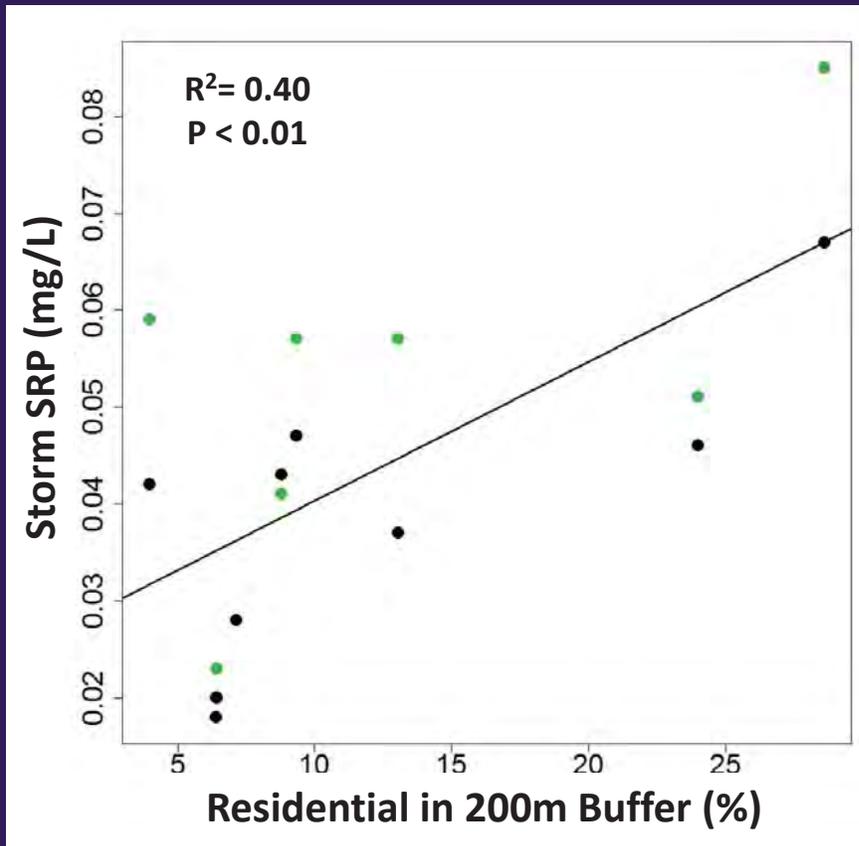
## Full Model Results

200m buffer  
residential & pasture  
 $R^2 = 0.30$   
 $P = 0.03$

## Storms

- 24 February
- 10 March

# SRP in the White Oak Bayou



## Full Model Results

200m buffer  
residential & pasture

$R^2 = 0.45$

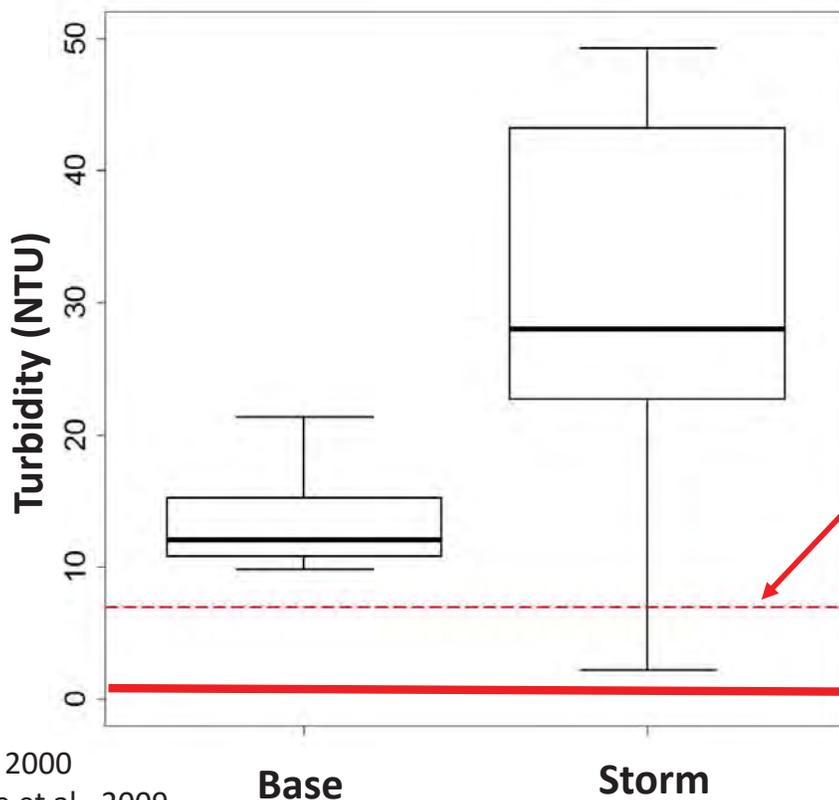
$P < 0.01$

## Storms

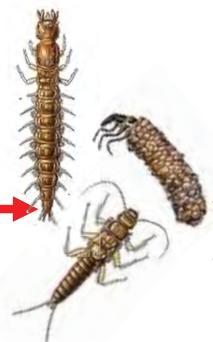
● 24 February

● 10 March

# Turbidity in the White Oak Bayou

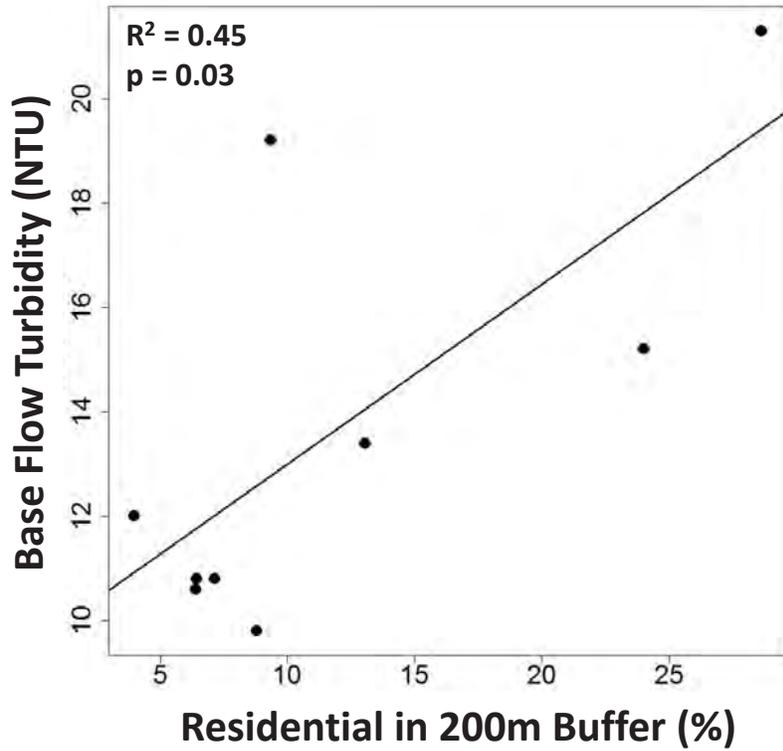


Turbidity  $P_{25}$   
Eco Region 37



Blue Ridge Discovery Center

# Turbidity in the White Oak Bayou

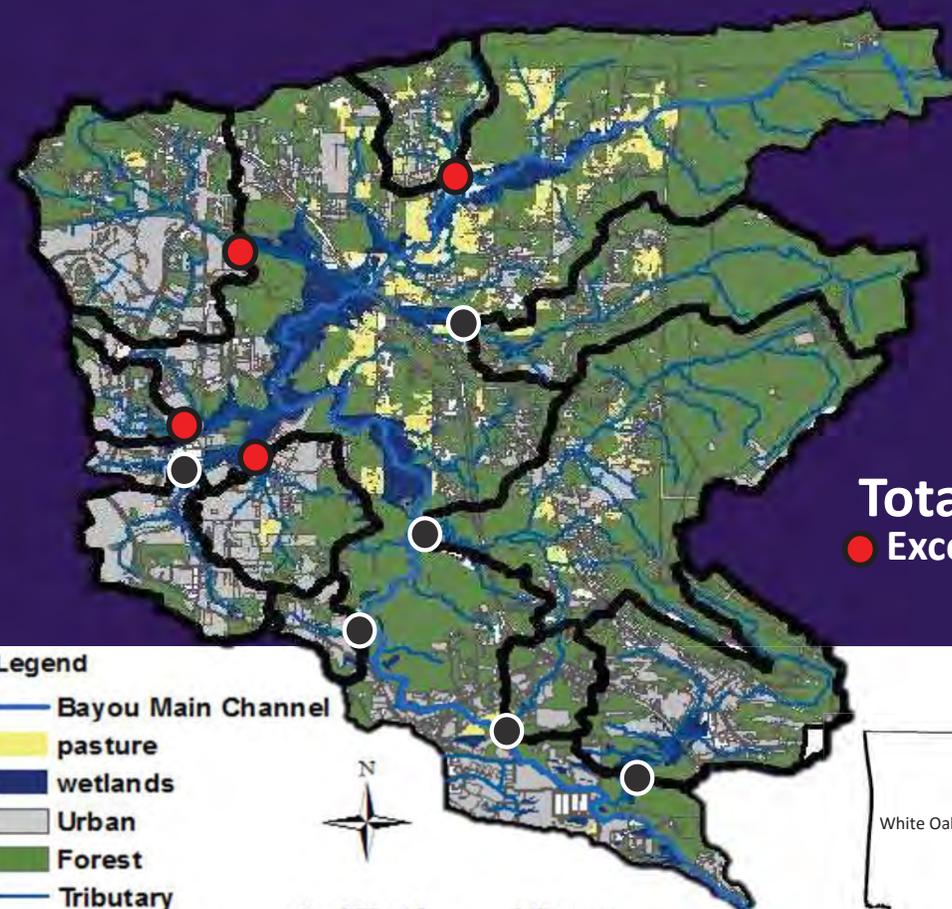


## Full Model Results

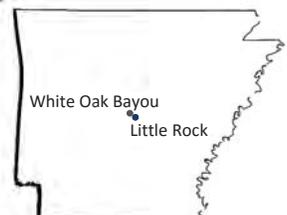
200m buffer  
residential, pasture,  
commercial

$R^2 = 0.88$

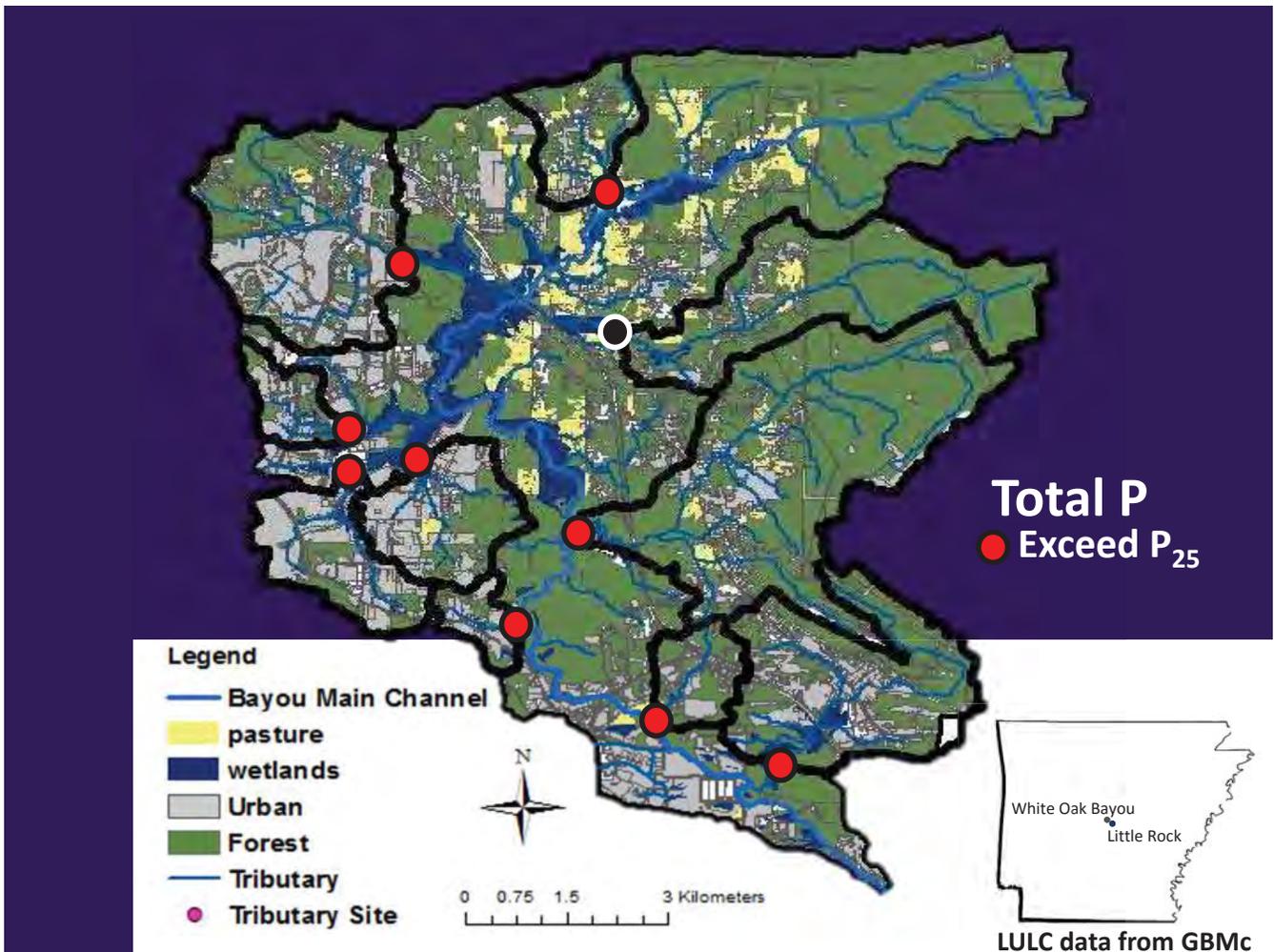
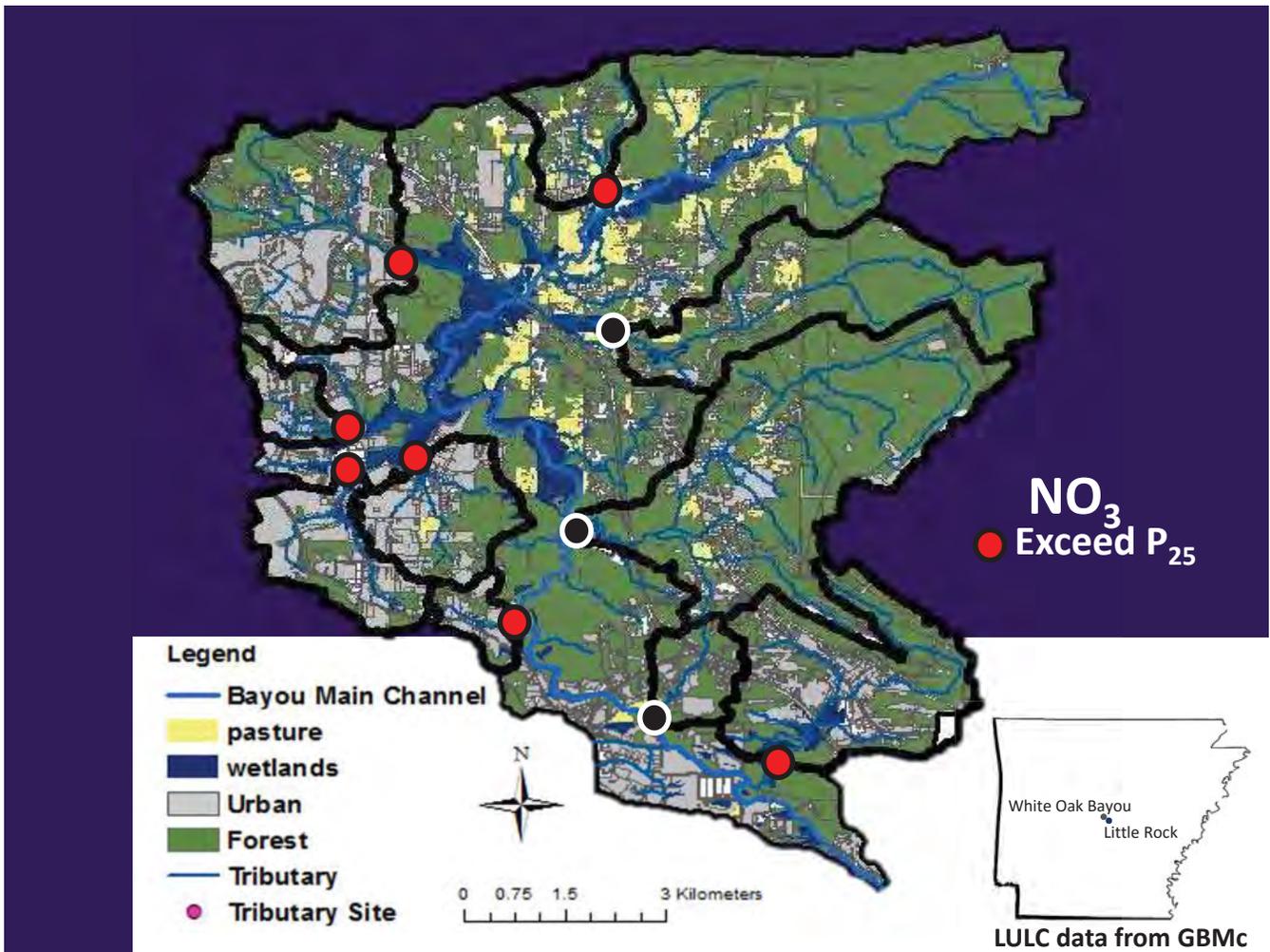
$P < 0.01$



Total N  
● Exceed  $P_{25}$



LULC data from GBMc



# Water quality predicted by models

Catchment	200m Buffer	IDW
Temperature	Turbidity	
Dissolved Oxygen	Total P	
Ammonium	SRP	

 Base flow

 Storm flow

## Residential development in White Oak Bayou



# Acknowledgements

Greg Phillips and Emily Edwards, GBMc

Anne Trainor, The Nature Conservancy

EPA Region 6 Grant: CD-00F-74101-1

UCA Biology Graduate Assistantship

Arkansas Water Resource Center

Mikayla Shaddon, Lucy Baker, Elise Coffelt, Tristan Odekirk,  
Chris Robinson, Derek Fillipek, Holly Wren, Nick Ledbetter

**Wetland Data Summary**

Site	Date	Waterbody	Lat	Long	Flow	Nitrate-nitrite		SRP	DOC	Ammonium	Mean Ash-			Temp (°C)	pH	ORP (mV)	SpCond (µS/cm)	Sal (ppt)	TurbSC (NTU)	LDO (% sat)	LDO (mg/L)	
						TN (mg/L)	TP (mg/L)				mg/L	mg/L	mg/L									mg/L
BallfieldsW	4-Dec-16	Wetland	34.846445	-92.381903	Base	3.17	0.024	2.42	0.007	2.15	2.45	5493.11	9.96	14.94	7.03	7.46	425	628	0.32	3.9	71.4	8.65
						0.37	0.118	0	0.031	14.96	0.07	199.20	38.26	54.51	20.18	7.32	417	59	0.02	27.5	104.7	9.55
						1.77	0.071	1.21	0.019	8.555	1.26	2846.155	24.10865	34.72582	13.605	7.39	421	343.5	0.17	15.7	88.05	9.10
						0.37	0.024	0	0.007	2.15	0.07	199.1968	9.958677	14.93802	7.03	7.32	417	59	0.02	3.9	71.4	8.65
						3.17	0.118	2.42	0.031	14.96	2.45	5493.113	38.25862	54.51362	20.18	7.46	425	628	0.32	27.5	104.7	9.55
Bank	5-Dec-16	Wetland	34.820633	-92.363237	Base	0.43	0.176	0	0.199	20.76	0.11	4374.28	55.63	84.68	13.85	5.06	396	90	0.03	15	39.6	4.10
						0.83	0.506	0.01	0.169	11.23	0.06	236.84	38.85	56.03	12.7	9.35	402	276	0.13	6.5	51	5.42
						0.63	0.341	0.005	0.184	15.995	0.085	2305.559	47.2412	70.35296	13.275	7.205	399	183	0.08	10.75	45.3	4.76
						0.43	0.176	0	0.169	11.23	0.06	236.8408	38.84853	56.02928	12.7	5.06	396	90	0.03	6.5	39.6	4.10
						0.83	0.506	0.01	0.199	20.76	0.11	4374.277	55.63387	84.67664	13.85	9.35	402	276	0.13	15	51	5.42
BurnsParkNorth	5-Dec-16	Wetland	34.807505	-92.328963	Base	0.42	0.184	0.03	0.052	9.7	0.16	4653.68	53.05	72.91	7.22	6.94	457	49	0.01	22	76.3	9.22
						1.11	0.315	0.01	0.026	7.57	0.11	144.82	63.22	92.69	12.39	7.59	378	42	0.01	6.3	69.2	7.41
						0.43	0.132	0	0.004	16.26	0.16	5812.63	12.60	33.25	7.11	6.47	460	19	-0.01	6.9	29.9	3.62
						0.61	0.164	0	0.11	14.26	0.02	97.45	17.93	21.73	9.94	8.98	418	75	0.02	10.1	25.1	2.84
						0.6425	0.19875	0.01	0.048	11.9475	0.1125	2677.144	36.70153	55.1427	9.165	7.495	428.25	46.25	0.0075	11.325	50.125	5.77
Carnahan	4-Dec-16	Wetland	34.856016	-92.380572	Base	0.23	0.056	0	0.018	8.14	0.09	4317.59	21.73	27.82	15.37	7.2	440	58	0.02	147.9	103.6	10.38
						0.55	0.068	0.01	0.023	12.2	0.07	81.21	21.69	41.88	22.89	7.68	402	42	0.01	17	106.7	9.20
						0.39	0.062	0.005	0.0205	10.17	0.08	2199.397	21.70806	34.85221	19.13	7.44	421	50	0.015	82.45	105.15	9.79
						0.23	0.056	0	0.018	8.14	0.07	81.20732	21.68918	27.82306	15.37	7.2	402	42	0.01	17	103.6	9.20
						0.55	0.068	0.01	0.023	12.2	0.09	4317.588	21.72693	41.88135	22.89	7.68	440	58	0.02	147.9	106.7	10.38
Chandler	5-Dec-16	Wetland	34.809729	-92.348867	Base	0.57	0.222	0.01	0.013	14.19	0.11	3546.51	35.24	65.42	11.47	7.07	417	426	0.21	3.1	33.2	3.62
						0.79	0.04	0.21	0.01	17.02	0.33	288.63	68.41	78.43	10.09	9.67	322	418	0.21	10	44.9	5.07
						0.68	0.131	0.11	0.0115	15.605	0.22	1917.573	51.82135	71.92481	10.78	8.37	369.5	422	0.21	6.55	39.05	4.35
						0.57	0.04	0.01	0.01	14.19	0.11	288.631	35.23649	65.42133	10.09	7.07	322	418	0.21	3.1	33.2	3.62
						0.79	0.222	0.21	0.013	17.02	0.33	3546.515	68.4062	78.42829	11.47	9.67	417	426	0.21	10	44.9	5.07
CountryClub	6-Dec-16	Wetland	34.850761	-92.366684	Base	0.22	0.042	0	0.017	8.4	0.11	10420.22	27.55	32.44	11.11	5.61	468	66	0.02	-2.2561	8.2	0.00
						0.55	0.088	0.04	0.027	9.84	0.07	81.49	21.91	30.51	17.96	7.3	377	53	0.01	16.7	42.1	4.00
						0.385	0.065	0.02	0.022	9.12	0.09	5250.856	24.72931	31.47401	14.535	6.455	422.5	59.5	0.015	7.22195	25.15	2.00
						0.22	0.042	0	0.017	8.4	0.07	81.49117	21.91032	30.50961	11.11	5.61	377	53	0.01	-2.2561	8.2	0.00
						0.55	0.088	0.04	0.027	9.84	0.11	10420.22	27.54831	32.43841	17.96	7.3	468	66	0.02	16.7	42.1	4.00
EastHighSchool	4-Dec-16	Wetland	34.859575	-92.381225	Base	0.22	0.06	0	0.048	7.94	0.08	4857.95	25.03	38.01	11.22	7.09	434	63	0.02	16.9	94.2	10.34
						0.56	0.075	0.02	0.022	12.29	0.07	122.67	26.79	38.58	17.66	5.93	344	50	0.01	20.5	36.8	3.51
						0.39	0.0675	0.01	0.035	10.115	0.075	2490.315	25.91213	38.29489	14.44	6.51	389	56.5	0.015	18.7	65.5	6.93
						0.22	0.06	0	0.022	7.94	0.07	122.675	25.03264	38.00691	11.22	5.93	344	50	0.01	16.9	36.8	3.51
						0.56	0.075	0.02	0.048	12.29	0.08	4857.955	26.79161	38.58286	17.66	7.09	434	63	0.02	20.5	94.2	10.34
EastPublicWorks	4-Dec-16	Wetland	34.851406	-92.381771	Base	0.44	0.1	0	0.03	12.17	0.07	4769.75	16.51	33.02	18.6	8.25	478	128	0.05	0.1	74.3	6.95
						0.93	0.138	0.02	0.047	13.08	0.09	152.90	17.22	24.73	17.42	7.88	384	98	0.04	11.7	35.3	3.39
						0.685	0.119	0.01	0.0385	12.625	0.08	2461.325	16.86516	28.87659	18.01	8.065	431	113	0.045	5.9	54.8	5.17
						0.44	0.1	0	0.03	12.17	0.07	152.9032	16.50964	24.7339	17.42	7.88	384	98	0.04	0.1	35.3	3.39
						0.93	0.138	0.02	0.047	13.08	0.09	4769.746	17.22069	33.01927	18.6	8.25	478	128	0.05	11.7	74.3	6.95
Gubanski	4-Dec-16	Wetland	34.866398	-92.365411	Base	0.34	0.086	0.01	0.019	14.08	0.12	5439.65	31.07	39.79	20	5.67	355	115	0.05	0.1	32.8	2.98
						1.18	0.18	0.09	0.024	12.72	0.05	158.49	23.36	30.61	17.9	7.15	414	70	0.02	10.3	32.5	3.09
						0.76	0.133	0.05	0.0215	13.4	0.085	2799.072	27.21783	35.2026	18.95	6.41	384.5	92.5	0.035	5.2	32.65	3.04
						0.34	0.086	0.01	0.019	12.72	0.05	158.4918	23.36334	30.61464	17.9	5.67	355	70	0.02	0.1	32.5	2.98
						1.18	0.18	0.09	0.024	14.08	0.12	5439.651	31.07233	39.79057	20	7.15	414	115	0.05	10.3	32.8	3.09
Harb	5-Dec-16	Wetland	34.84562	-92.361918	Base	0.26	0.056	0	0.018	8.68	0.12	3567.11	20.27	27.73	11.66	6	402	58	0.02	9.1	48.4	5.26
						0.74	0.126	0.02	0.047	12.25	0.09	105.52	23.02	29.00	17.92	7.33	409	51	0.01	19.1	35.8	3.40
						0.5	0.091	0.01	0.0325	10.465	0.105	1836.316	21.64674	28.36858	14.79	6.665	405.5	54.5	0.015	14.1	42.1	4.33

Site	Date	Waterbody	Lat	Long	Flow	TN (mg/L)	TP (mg/L)	Nitrate-nitrite (mg/L)	SRP (mg/L)	DOC (mg/L)	Ammonium (mg/L)	Mean Ash-			Temp (°C)	pH	ORP (mV)	SpCond (µS/cm)	Sal (ppt)	TurbSC (NTU)	LDO (% sat)	LDO (mg/L)
												MeanTDS (mg/L)	Free TSS (mg/L)	MeanTSS (mg/L)								
					Min	0.26	0.056	0	0.018	8.68	0.09	105.5247	20.27401	27.73445	11.66	6	402	51	0.01	9.1	35.8	3.40
					Max	0.74	0.126	0.02	0.047	12.25	0.12	3567.108	23.01947	29.00271	17.92	7.33	409	58	0.02	19.1	48.4	5.26
Haas	2-Apr-16	Wetland	34.84562	-92.361918	Base	0.88	0.13	0.03	0.027	12.33	0.08	104.90	21.30	24.91	18.69	6.79	403	47	0.01	16	44.7	4.19
Hass	5-Dec-16	Wetland	34.844451	-92.359607	Base	0.51	0.228	0.02	0.037	9.29	0.15	4429.47	20.00	23.21	7.39	5.22	393	72	0.02	16.4	55.9	6.72
					Average	0.695	0.179	0.025	0.032	10.81	0.115	2267.185	20.6494	24.05959	13.04	6.005	398	59.5	0.015	16.2	50.3	5.46
					Min	0.51	0.13	0.02	0.027	9.29	0.08	104.8989	20	23.20794	7.39	5.22	393	47	0.01	16	44.7	4.19
					Max	0.88	0.228	0.03	0.037	12.33	0.15	4429.471	21.2988	24.91123	18.69	6.79	403	72	0.02	16.4	55.9	6.72
HenryW	5-Dec-16	Wetland	34.866677	-92.351875	Base	0.4	0.082	0	0.164	16.32	0.11	2589.29	23.71	45.79	8.89	3.74	460	31	0	11.7	30.9	3.59
HenryW	2-Apr-16	Wetland	34.866677	-92.351875	Base	0.61	0.098	0.02	0.02	7.2	0.06	144.31	16.73	23.52	17.66	6.79	396	32	0	15.5	81.1	7.75
					Average	0.505	0.09	0.01	0.092	11.76	0.085	1366.797	20.22306	34.6556	13.275	5.265	428	31.5	0	13.6	56	5.67
					Min	0.4	0.082	0	0.02	7.2	0.06	144.305	16.7335	23.52263	8.89	3.74	396	31	0	11.7	30.9	3.59
					Max	0.61	0.098	0.02	0.164	16.32	0.11	2589.29	23.71262	45.78857	17.66	6.79	460	32	0	15.5	81.1	7.75
LongFisher	6-Dec-16	Wetland	34.87254	-92.36913	Base	0.38	0.092	0	0.014	10.33	0.12	9553.26	38.26	48.27	12.71	6.4	426	88	0.03	-2.2568	3.22	0.10
LongFisher	2-Apr-16	Wetland	34.87254	-92.36913	Base	0.95	0.168	0.04	0.048	10.42	0.12	144.31	44.16	52.67	16.56	6.22	366	82	0.03	38.9	51.9	5.08
					Average	0.665	0.13	0.02	0.031	10.375	0.12	4848.785	41.20706	50.4739	14.635	6.31	396	85	0.03	18.3216	27.56	2.59
					Min	0.38	0.092	0	0.014	10.33	0.12	144.3081	38.25862	48.27447	12.71	6.22	366	82	0.03	-2.2568	3.22	0.10
					Max	0.95	0.168	0.04	0.048	10.42	0.12	9553.262	44.1555	52.67332	16.56	6.4	426	88	0.03	38.9	51.9	5.08
NorthHighSchool	4-Dec-16	Wetland	34.862955	-92.376551	Base	0.25	0.056	0	0.026	9.03	0.12	2536.36	20.00	26.57	18.07	7.67	470	182	0.08	0.1	50.6	4.78
NorthHighSchool	2-Apr-16	Wetland	34.862955	-92.376551	Base	0.58	0.082	0.02	0.031	12.13	0.07	132.33	23.21	30.00	19.86	7.34	398	56	0.01	21.4	78.5	7.18
					Average	0.415	0.069	0.01	0.0285	10.58	0.095	1334.346	21.60397	28.28323	18.965	7.505	434	119	0.045	10.75	64.55	5.98
					Min	0.25	0.056	0	0.026	9.03	0.07	132.3298	20	26.56646	18.07	7.34	398	56	0.01	0.1	50.6	4.78
					Max	0.58	0.082	0.02	0.031	12.13	0.12	2536.362	23.20794	30	19.86	7.67	470	182	0.08	21.4	78.5	7.18
NorthPublicWorks	4-Dec-16	Wetland	34.854651	-92.387619	Base	0.2	0.062	0	0.016	9.72	0.13	4343.96	9.71	12.72	16.36	7	454	72	0.02	426	103.4	10.14
NorthPublicWorks	2-Apr-16	Wetland	34.854651	-92.387619	Base	0.71	0.086	0	0.026	12.03	0	169.22	33.36	39.92	18.63	6.55	402	73	0.02	16.7	140.1	13.12
					Average	0.455	0.074	0	0.021	10.875	0.065	2256.589	21.53214	26.32109	17.495	6.775	428	72.5	0.02	221.35	121.75	11.63
					Min	0.2	0.062	0	0.016	9.72	0	169.2173	9.70571	12.71808	16.36	6.55	402	72	0.02	16.7	103.4	10.14
					Max	0.71	0.086	0	0.026	12.03	0.13	4343.961	33.35857	39.9241	18.63	7	454	73	0.02	426	140.1	13.12
VestalW	5-Dec-16	Wetland	34.824470	-92.363237	Base	0.3	0.084	0	0.059	13.02	0.12	3754.59	28.23	47.05	8.87	6.66	450	31	0	10.6	48.1	5.58
VestalW	2-Apr-16	Wetland	34.824470	-92.363237	Base	0.19	0.036	0	0.009	5.86	0	165.49	15.00	20.00	11.7	8.34	401	36	0	12.5	64.3	7.00
					Average	0.245	0.06	0	0.034	9.44	0.06	1960.043	21.61554	33.52276	10.285	7.5	425.5	33.5	0	11.55	56.2	6.29
					Min	0.19	0.036	0	0.009	5.86	0	165.4929	15	20	8.87	6.66	401	31	0	10.6	48.1	5.58
					Max	0.3	0.084	0	0.059	13.02	0.12	3754.593	28.23108	47.04553	11.7	8.34	450	36	0	12.5	64.3	7.00
Zajac	4-Dec-16	Wetland	34.86565	-92.37179	Base	0.24	0.064	0	0.023	11.39	0.13	4514.60	15.47	21.05	6.95	7.52	464	46	0.01	11.5	22.6	2.75
Zajac	2-Apr-16	Wetland	34.86565	-92.37179	Base	0.52	0.1	0	0.066	12.8	0.05	181.35	16.79	21.91	20.53	7.17	395	25	0	47.9	103.1	9.30
					Average	0.38	0.082	0	0.0445	12.095	0.09	2347.975	16.13117	21.48262	13.74	7.345	429.5	35.5	0.005	29.7	62.85	6.03
					Min	0.24	0.064	0	0.023	11.39	0.05	181.3499	15.47196	21.05453	6.95	7.17	395	25	0	11.5	22.6	2.75
					Max	0.52	0.1	0	0.066	12.8	0.13	4514.599	16.79038	21.9107	20.53	7.52	464	46	0.01	47.9	103.1	9.30
ZajacRoad	4-Dec-16	Wetland	34.85373	-92.36423	Base	0.19	0.048	0	0.067	8.01	0.08	3236.80	18.23	23.86	13.19	7.43	435	80	0.03	1618	102.1	10.82
ZajacRoad	2-Apr-16	Wetland	34.85373	-92.36423	Base	0.49	0.07	0.03	0.028	11.62	0.06	91.77	16.59	20.10	19.94	7.1	333	49	0.01	17.2	72.4	6.61
					Average	0.34	0.059	0.015	0.0475	9.815	0.07	1664.283	17.4126	21.97824	16.565	7.265	384	64.5	0.02	817.6	87.25	8.72
					Min	0.19	0.048	0	0.028	8.01	0.06	91.76922	16.59302	20.10101	13.19	7.1	333	49	0.01	17.2	72.4	6.61
					Max	0.49	0.07	0.03	0.067	11.62	0.08	3236.797	18.23218	23.85547	19.94	7.43	435	80	0.03	1618	102.1	10.82

**Stream Baseflow Summary**

Site	Date	Waterbody	Lat	Long	Flow	Nitrate-nitrite				Mean Ash-				pH	ORP (mV)	SpCond (µS/cm)	Sal (ppt)	TurbSC (NTU)	LDO (% sat)	LDO (mg/L)	
						TN (mg/L)	TP (mg/L)	(mg/L)	SRP (mg/L)	Ammonium (mg/L)	MeanTDS (mg/L)	Free TSS (mg/L)	MeanTSS (mg/L)								Temp (°C)
Ballfields	16-Jan-16	Stream	34.84611	-92.3804	base	0.55	0.07	0.03	0.03	NA	45.86	43.56	22.83	7.09	5.82	466	44	0.01	35.7	77.9	8.69
Ballfields	22-Oct-16	Stream	34.84611	-92.3804	base	0.51	0.06	0	0.013	0.04	481.4605	27.45315	30.99306	17.45	7.2	421	526	0.27	7.1	59.7	5.72
Ballfields	9-Jun-16	Stream	34.84611	-92.3804	base	1.47	0.132	0	0.023	0.1	290.94	38.1951	56.3684	26.19	6.45	387	118	0.05	18.3	18.3	1.48
Ballfields	9-Dec-16	Stream	34.84611	-92.3804	base	0.5	0.061	0.01	0.026	0.04	326.3586	4.219245	7.047299	6.11	8	NA	225	NA	7.4	84.4	10.44
					average	0.7575	0.08075	0.01	0.023	0.06	286.1548	28.35687	29.30969	14.21	6.8675	424.6667	228.25	0.11	17.125	60.075	6.5825
					min	0.5	0.06	0	0.013	0.04	45.86	4.219245	7.047299	6.11	5.82	387	44	0.01	7.1	18.3	1.48
					max	1.47	0.132	0.03	0.03	0.1	481.4605	43.56	56.3684	26.19	8	466	526	0.27	35.7	84.4	10.44
Banaszak	16-Jan-16	Stream	34.88532	-92.3517	base	0.43	0.052	0.17	0.02	NA	51.19	22.83	12.38	7.7	5.8	486	68	0.02	19.2	95.9	10.53
Banaszak	22-Oct-16	Stream	34.88532	-92.3517	base	1.15	0.232	0	0.024	0.04	97.13539	129.3518	145.1713	11.7	5.44	448	73	0.02	66.4	26.4	2.87
Banaszak	9-Jun-16	Stream	34.88532	-92.3517	base	1.07	0.152	0.28	0.063	0.23	149.285	60.4466	71.1863	20.25	6.4	464	80	0.03	60	43.8	3.96
Banaszak	9-Dec-16	Stream	34.88532	-92.3517	base	0.59	0.102	0.01	0.056	0.03	140.3752	4.79142	7.98957	4.13	6.6	NA	169	NA	8.4	22.1	2.88
					average	0.81	0.1345	0.115	0.04075	0.1	109.4964	54.35495	59.18178	10.945	6.06	466	97.5	0.023333	38.5	47.05	5.06
					min	0.43	0.052	0	0.02	0.03	51.19	4.79142	7.98957	4.13	5.44	448	68	0.02	8.4	22.1	2.87
					max	1.15	0.232	0.28	0.063	0.23	149.285	129.3518	145.1713	20.25	6.6	486	169	0.03	66.4	95.9	10.53
BurnsPark	16-Jan-16	Stream	34.80231	-92.3269	base	0.39	0.037	0.13	0.015	NA	89.26	12.38	43.56	9.35	6.4	471	125	0.05	9.8	95	10.02
BurnsPark	22-Oct-16	Stream	34.80231	-92.3269	base	0.94	0.077	0.35	0.039	0.05	115.2618	20.9746	29.4783	12.79	6.2	468	140	0.06	18.7	52.6	5.58
BurnsPark	9-Jun-16	Stream	34.80231	-92.3269	base	0.91	0.07	0.05	0.019	0.09	333.721	25	31.5818	29.32	8.16	380	211	0.1	13.2	107.5	8.22
BurnsPark	9-Dec-16	Stream	34.80231	-92.3269	base	1.36	0.061	0.52	0.036	0.15	144.6382	6.392716	8.545317	3.46	6.9	NA	184	NA	7.6	86.5	11.45
					average	0.9	0.06125	0.2625	0.02725	0.096667	170.7203	16.18683	28.29135	13.73	6.915	439.6667	165	0.07	12.325	85.4	8.8175
					min	0.39	0.037	0.05	0.015	0.05	89.26	6.392716	8.545317	3.46	6.2	380	125	0.05	7.6	52.6	5.58
					max	1.36	0.077	0.52	0.039	0.15	333.721	25	43.56	29.32	8.16	471	211	0.1	18.7	107.5	11.45
DogPark	16-Jan-16	Stream	34.85177	-92.3941	base	0.25	0.04	0.01	0.013	NA	158.62	14.08	34.76	7.5	6.46	462	177	0.08	13.4	95.4	10.52
DogPark	22-Oct-16	Stream	34.85177	-92.3941	base	0.32	0.046	0	0.013	0.03	235.8248	17.89242	24.27646	15.44	6.33	444	207	0.1	6	18	1.8
DogPark	9-Jun-16	Stream	34.85177	-92.3941	base	0.43	0.04	0	0.007	0.03	305.828	32.2548	37.2479	24.61	7.42	435	257	0.12	6.7	11.5	0.96
DogPark	9-Dec-16	Stream	34.85177	-92.3941	base	0.39	0.027	0.04	0.013	0.03	156.0812	1.44225	3.15818	5.88	7.8	NA	217	NA	5	58.8	7.35
					average	0.3475	0.03825	0.0125	0.0115	0.03	214.0885	16.41737	24.86064	13.3575	7.0025	447	214.5	0.1	7.775	45.925	5.1575
					min	0.25	0.027	0	0.007	0.03	156.0812	1.44225	3.15818	5.88	6.33	435	177	0.08	5	11.5	0.96
					max	0.43	0.046	0.04	0.013	0.03	305.828	32.2548	37.2479	24.61	7.8	462	257	0.12	13.4	95.4	10.52
GolfCourse	16-Jan-16	Stream	34.84334	-92.3941	base	0.59	0.082	0.18	0.04	NA	193.63	34.76	14.08	8.28	6.28	468	137	0.06	21.3	97.4	10.54
GolfCourse	22-Oct-16	Stream	34.84334	-92.3941	base	0.58	0.073	0	0.009	0.03	153.0111	11.65695	15.38978	17.84	6.25	422	179	0.08	9.4	48.3	4.59
GolfCourse	9-Jun-16	Stream	34.84334	-92.3941	base	0.84	0.094	0.03	0.042	0.19	156.629	21.0545	30	26.45	7.36	407	154	0.07	10.5	47.4	3.81
GolfCourse	9-Dec-16	Stream	34.84334	-92.3941	base	0.57	0.066	0.13	0.033	0.06	134.9914	4.424672	7.967315	5.3	7	NA	146	NA	6.3	62.7	7.94
					average	0.645	0.07875	0.085	0.031	0.093333	159.5654	17.97403	16.85927	14.4675	6.7225	432.3333	154	0.07	11.875	63.95	6.72
					min	0.57	0.066	0	0.009	0.03	134.9914	4.424672	7.967315	5.3	6.25	407	137	0.06	6.3	47.4	3.81
					max	0.84	0.094	0.18	0.042	0.19	193.63	34.76	30	26.45	7.36	468	179	0.08	21.3	97.4	10.54
Henry	16-Jan-16	Stream	34.8662	-92.351	base	0.16	0.04	0.04	0.006	NA	41.64	15.47	14.75	8.08	6.86	498	35	0	10.6	90	9.79
Henry	22-Oct-16	Stream	34.8662	-92.351	base	0.75	0.144	0	0.011	0	87.5446	29.67432	33.60788	15.03	5.54	432	74	0.02	22.5	2.6	0.26
Henry	9-Jun-16	Stream	34.8662	-92.351	base	1.01	0.108	0	0.025	0.07	190.765	18.8207	29.2402	21.62	7.64	474	66	0.02	17.9	47.8	4.21
Henry	9-Dec-16	Stream	34.8662	-92.351	base	0.61	0.08	0	0.05	0.03	111.6172	10.55526	20.26319	4.68	7.6	NA	73	NA	15.7	29	3.41
					average	0.6325	0.093	0.01	0.023	0.033333	107.8917	18.63007	24.46532	12.3525	6.91	468	62	0.013333	16.675	42.35	4.4175
					min	0.16	0.04	0	0.006	0	41.64	10.55526	14.75	4.68	5.54	432	35	0	10.6	2.6	0.26
					max	1.01	0.144	0.04	0.05	0.07	190.765	29.67432	33.60788	21.62	7.64	498	74	0.02	22.5	90	9.79
PumpStatic	16-Jan-16	Stream	34.81342	-92.3422	base	0.33	0.046	0.16	0.016	NA	284.32	12.33	14.66	7.3	6.94	449	193	0.09	12	92.3	10.23
PumpStatic	22-Oct-16	Stream	34.81342	-92.3422	base	0.41	0.079	0.08	0.044	0.02	147.9043	12.38834	14.43236	15.33	6.5	413	199	0.09	10.7	72	7.21
PumpStatic	9-Jun-16	Stream	34.81342	-92.3422	base	0.79	0.054	0.48	0.024	0.09	477.978	32.183	36.1025	24.34	7.67	388	438	0.22	13.8	90.5	7.56
PumpStatic	9-Dec-16	Stream	34.81342	-92.3422	base	0.28	0.053	0.06	0.026	0.03	148.2865	3.889939	6.036811	4.08	8	NA	228	NA	5.5	94	12.32

Site	Date	Waterbody	Lat	Long	Flow	Nitrate-nitrite					Mean Ash-			Temp (°C)	pH	ORP (mV)	SpCond (µS/cm)	Sal (ppt)	TurbSC (NTU)	LDO (% sat)	LDO (mg/L)
						TN (mg/L)	TP (mg/L)	(mg/L)	SRP (mg/L)	Ammonium (mg/L)	MeanTDS (mg/L)	Free TSS (mg/L)	MeanTSS (mg/L)								
					average	0.4525	0.058	0.195	0.0275	0.046667	264.6222	15.19782	17.80792	12.7625	7.2775	416.6667	264.5	0.133333	10.5	87.2	9.33
					min	0.28	0.046	0.06	0.016	0.02	147.9043	3.889939	6.036811	4.08	6.5	388	193	0.09	5.5	72	7.21
					max	0.79	0.079	0.48	0.044	0.09	477.978	32.183	36.1025	24.34	8	449	438	0.22	13.8	94	12.32
Sharkey	16-Jan-16	Stream	34.87735	-92.3871	base	0.33	0.042	0.11	0.013	NA	155.91	14.66	18.09	7.72	6.38	477	201	0.09	15.2	104.8	11.5
Sharkey	22-Oct-16	Stream	34.87735	-92.3871	base	0.46	0.212	0.24	0.136	0.03	448.6286	10.87205	11.52079	17.04	6.99	425	527	0.27	8.1	64.5	6.22
Sharkey	9-Jun-16	Stream	34.87735	-92.3871	base	0.68	0.046	0.12	0.011	0.08	303.147	20	25.5436	24.77	8.41	444	358	0.18	11.8	82.7	6.86
Sharkey	9-Dec-16	Stream	34.87735	-92.3871	base	0.37	0.133	0.12	0.088	0.02	285.0426	5.229322	7.488872	4.51	7.8	NA	408	NA	9	91	11.76
					average	0.46	0.10825	0.1475	0.062	0.043333	298.1821	12.69034	15.66081	13.51	7.395	448.6667	373.5	0.18	11.025	85.75	9.085
					min	0.33	0.042	0.11	0.011	0.02	155.91	5.229322	7.488872	4.51	6.38	425	201	0.09	8.1	64.5	6.22
					max	0.68	0.212	0.24	0.136	0.08	448.6286	20	25.5436	24.77	8.41	477	527	0.27	15.2	104.8	11.76
ShortMarcl	16-Jan-16	Stream	34.83819	-92.3551	base	0.24	0.028	0.1	0.01	NA	51.27	14.75	12.33	8.24	8.41	517	45	0.01	10.8	95.4	10.34
ShortMarcl	22-Oct-16	Stream	34.83819	-92.3551	base	0.73	0.09	0	0.02	0.15	100.8048	17.85924	21.9888	14.02	5.49	456	89	0.03	16.2	22.7	2.34
ShortMarcl	9-Jun-16	Stream	34.83819	-92.3551	base	0.6	0.08	0	0.03	0.22	331.411	13.1037	20	22.82	6.08	499	101	0.04	8.9	7.4	0.64
ShortMarcl	9-Dec-16	Stream	34.83819	-92.3551	base	0.6	0.086	0	0.029	0.03	94	4.04124	9.49122	4.92	6.8	NA	87	NA	7.1	20.6	2.63
					average	0.5425	0.071	0.025	0.02225	0.133333	144.3714	12.43855	15.95251	12.5	6.695	490.6667	80.5	0.026667	10.75	36.525	3.9875
					min	0.24	0.028	0	0.01	0.03	51.27	4.04124	9.49122	4.92	5.49	456	45	0.01	7.1	7.4	0.64
					max	0.73	0.09	0.1	0.03	0.22	331.411	17.85924	21.9888	22.82	8.41	517	101	0.04	16.2	95.4	10.34
Vestal	16-Jan-16	Stream	34.82485	-92.3675	base	0.29	0.05	0.01	0.02	NA	247.91	18.09	15.47	7.99	8.91	462	323	0.16	10.8	85.4	9.31
Vestal	22-Oct-16	Stream	34.82485	-92.3675	base	0.38	0.077	0.01	0.043	0.02	191.5973	13.97308	17.56089	14.62	6.46	422	279	0.13	11.7	60.3	6.13
Vestal	9-Jun-16	Stream	34.82485	-92.3675	base	0.45	0.038	0.11	0.01	0.08	374.885	66.6111	73.2828	24.1	7.4	389	571	0.29	12.7	92.2	7.73
Vestal	9-Dec-16	Stream	34.82485	-92.3675	base	0.44	0.064	0.05	0.03	0.03	206.0136	6.301704	8.663501	4.28	7	NA	304	NA	7.8	74.9	9.86
					average	0.39	0.05725	0.045	0.02575	0.043333	255.1015	26.24397	28.7443	12.7475	7.4425	424.3333	369.25	0.193333	10.75	78.2	8.2575
					min	0.29	0.038	0.01	0.01	0.02	191.5973	6.301704	8.663501	4.28	6.46	389	279	0.13	7.8	60.3	6.13
					max	0.45	0.077	0.11	0.043	0.08	374.885	66.6111	73.2828	24.1	8.91	462	571	0.29	12.7	92.2	9.86

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2015	Summer	17-Jul	Country Club	DET	1	>1	1/2	Coleoptera	Dytiscidae (adult)		1	2	P	
2015	Summer	17-Jul	Country Club	DET	1	>1	1/2	Coleoptera	Haliphilidae (larvae)		2	4	SH	
2015	Summer	17-Jul	Country Club	DET	1	>1	1/2	Diptera	Ceratopogonidae		2	4	P	
2015	Summer	17-Jul	Country Club	DET	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	11	22	P	
2015	Summer	17-Jul	Country Club	DET	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	22	44	CG	
2015	Summer	17-Jul	Country Club	DET	1	>1	1/2	Diptera	Culicidae		1	2	CG	
2015	Summer	17-Jul	Country Club	DET	1	>1	1/2	Hemiptera	Corixidae		20	40	P	
2015	Summer	17-Jul	Country Club	DET	1	>1	1/2	Hemiptera	Mesoveliidae (instar)		5	10	P	
2015	Summer	17-Jul	Country Club	DET	1	>1	1/2	Oligochaeta			12	24	CG	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Acariformes	Hydrachnida		3	6	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Amphipoda	Dogielinotidae	Hyaella	27	54	CG	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Coleoptera	Hydrophilidae (larvae)		1	2	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Coleoptera	Noteridae (adult)		1	2	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Coleoptera	Noteridae (larvae)		1	2	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Decapoda	Palaeonidae		3	6	SH	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Diptera	Ceratopogonidae		9	18	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Diptera	Chaoboridae		59	118	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	63	126	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	108	216	CG	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Hemiptera	Nepidae		1	2	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Hemiptera	Pleidae		1	2	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Odonata	Coenagrionidae		2	4	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Odonata	Odonata		5	10	P	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Oligochaeta			1	2	CG	
2015	Summer	15-Jul	Haas	DET	1	>1	1/2	Ostracoda			1	2	CF	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Acariformes	Hydrachnida		21	84	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Amphipoda	Talitridae		84	336	CG	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Coleoptera	Haliphilidae (adult)		1	4	SH	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Coleoptera	Noteridae (adult)		4	16	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Coleoptera	Hydrophilidae (adult)		2	8	CG	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Coleoptera	Hydrophilidae (larvae)		5	20	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Coleoptera	Noteridae (larvae)		3	12	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Decapoda	Palaeonidae		3	12	SH	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Diptera	Ceratopogonidae		25	100	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Diptera	Chironomidae	Tanypodinae	24	96	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Diptera	Chironomidae	Non-Tanypodinae	141	564	CG	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Diptera	Culicidae		2	8	CG	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Diptera	Stratiomyidae		4	16	CG	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Diptera	Tabanidae		2	8	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Hemiptera	Belostomatidae		2	8	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Hemiptera	Mesoveliidae (instar)		3	12	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Hemiptera	Notonectidae		11	44	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Hemiptera	Pleidae		1	4	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Odonata	Coenagrionidae		3	12	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Odonata	Odonata		1	4	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Odonata	Libellulidae		25	100	P	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Ostracoda			7	28	CF	
2015	Summer	15-Jul	Haas	SAV	1	>1	1/4	Rhynchobdellidae			8	32	P	
2015	Summer	15-Jul	Harb	DET	1	>1	1/2	Decapoda	Palaeonidae		3	6	SH	
2015	Summer	15-Jul	Harb	DET	1	>1	1/2	Diptera	Ceratopogonidae		35	70	P	
2015	Summer	15-Jul	Harb	DET	1	>1	1/2	Diptera	Chaoboridae		12	24	P	
2015	Summer	15-Jul	Harb	DET	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	66	132	P	
2015	Summer	15-Jul	Harb	DET	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	13	26	CG	
2015	Summer	15-Jul	Harb	DET	1	>1	1/2	Hemiptera	Corixidae		85	170	P	
2015	Summer	15-Jul	Harb	DET	1	>1	1/2	Hygrophila	Planorbidae	Ancylini	1	2	SC	
2015	Summer	15-Jul	Harb	DET	1	>1	1/2	Odonata	Libellulidae		1	2	P	
2015	Summer	15-Jul	Harb	DET	1	>1	1/2	Oligochaeta			5	10	CG	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Acariformes	Hydrachnida		17	17	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Amphipoda	Talitridae		25	25	CG	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Coleoptera	Dytiscidae (adult)		1	1	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Coleoptera	Haliphilidae (adult)		3	3	SH	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Coleoptera	Noteridae (adult)		1	1	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Coleoptera	Noteridae (larvae)		3	3	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Decapoda	Palaeonidae		2	2	SH	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Diptera	Ceratopogonidae		63	63	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	50	50	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	89	89	CG	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Diptera	Culicidae		2	2	CG	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Diptera	Stratiomyidae		13	13	CG	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Ephemeroptera	Baetidae		53	53	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Hemiptera	Belostomatidae		3	3	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Hemiptera	Corixidae		48	48	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Hemiptera	Notonectidae		3	3	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Hygrophila	Physidae		1	1	SC	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Hydrophila	Planorbidae		1	1	SC	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Odonata	Aeshnidae		1	1	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Odonata	Gomphidae		1	1	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Odonata	Libellulidae		15	15	P	
2015	Summer	15-Jul	Harb	SAV	1	>1	1	Oligochaeta			3	3	CG	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Amphipoda	Dogielinotidae	Hyaella	1	2	CG	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Coleoptera	Hydrophilidae (larvae)		1	2	P	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Diptera	Ceratopogonidae		3	6	P	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Diptera	Chaoboridae		1	2	P	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	29	58	P	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	100	200	CG	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Ephemeroptera	Baetidae		2	4	CG	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Hemiptera	Corixidae		90	180	P	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Hemiptera	Velidae		1	2	P	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Odonata	Aeshnidae		1	2	P	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Odonata	Corduliidae		1	2	P	
2015	Summer	17-Jul	Long Fisher	DET	1	>1	1/2	Oligochaeta			5	10	CG	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	2	2	CG	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyaella	5	5	CG	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Coleoptera	Hydrophilidae (larvae)		8	8	P	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Collembola			1	1	CG	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Decapoda	Palaeonidae		1	1	SH	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	37	37	P	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	27	27	CG	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Diptera	Tabanidae		1	1	P	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Hemiptera	Belostomatidae		1	1	P	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Hemiptera	Corixidae		5	5	P	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Hemiptera	Mesoveliidae (instar)		1	1	P	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Martodea			1	1	P	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Odonata			1	1	P	
2015	Summer	17-Jul	Long Fisher	SAV	1	>1	1	Oligochaeta			4	4	CG	
2015	Summer	15-Jul	Zajac	DET	1	>1	1	Diptera	Ceratopogonidae		4	4	P	
2015	Summer	15-Jul	Zajac	DET	1	>1	1	Diptera	Chaoboridae		2	2	P	
2015	Summer	15-Jul	Zajac	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	10	10	P	
2015	Summer	15-Jul	Zajac	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	21	21	CG	
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Acariformes	Hydrachnida		2	4	P	
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Amphipoda	Crangonyctidae	Crangonyx	15	30	CG	
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Amphipoda	Talitridae		125	250	CG	*Zajac Rd DET needed
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Coleoptera	Dytiscidae (adult)		1	2	P	
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Coleoptera	Hydrophilidae (larvae)		3	6	P	
2015														

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Hemiptera	Corixidae		17	34	P	P
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Hemiptera	Hydrometridae		1	2	P	P
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Hemiptera	Mesoveliidae (instar)		1	2	P	P
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Hemiptera	Nepidae		3	6	P	P
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Hemiptera	Pleidae		1	2	P	P
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Hydrophila	Physidae		1	2	SC	P
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Odonata	Gomphidae		1	2	P	P
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Odonata	Libellulidae		3	6	P	P
2015	Summer	15-Jul	Zajac	SAV	1	>1	1/2	Rhynchobdellidae	Glossiphoniidae		1	2	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Acariformes	Hydrachnida		1	2	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Amphipoda	Dogielinotidae	Hyaella	1	2	CG	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Coleoptera	Dytiscidae (adult)		1	2	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Coleoptera	Hydraenidae (adult)		1	2	SC	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Coleoptera	Hydrophilidae (adult)		2	4	CG	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Coleoptera	Hydrophilidae (larvae)		4	8	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Coleoptera	Noteridae (adult)		2	4	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Coleoptera	Noteridae (larvae)		1	2	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Diptera	Ceratopogonidae		9	18	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Diptera	Chaoboridae		1	2	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	97	194	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	118	236	CG	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Diptera	Tabanidae		1	2	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Hemiptera	Belostomatidae		4	8	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Hemiptera	Corixidae		2	4	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Hemiptera	Mesoveliidae		7	14	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Odonata	Coenagrionidae		2	4	P	P
2015	Summer	15-Jul	Zajac Road	SAV	1	>1	1/2	Ostracoda			9	18	CF	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Coleoptera	Dytiscidae (adult)		1	1	P	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Coleoptera	Dytiscidae (larvae)		4	4	P	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Coleoptera	Halpidae (adult)		7	7	SH	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Coleoptera	Halpidae (larvae)		2	2	SH	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Coleoptera	Noteridae (adult)		2	2	P	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Coleoptera	Noteridae (larvae)		3	3	P	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Decapoda	Palaeonidae		1	1	SH	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Hemiptera	Belostomatidae		1	1	P	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Hemiptera	Corixidae		10	10	P	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Hemiptera	Mesoveliidae (instar)		6	6	P	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Odonata	Coenagrionidae		7	7	P	P
2015	Summer	16-Jul	Ballfields	DET	1	>1	1	Oligochaeta			7	7	CG	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Acariformes	Hydrachnida		1	2	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Coleoptera	Curculionidae (adult)		1	2	SH	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Coleoptera	Dytiscidae (adult)		1	2	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Coleoptera	Dytiscidae (larvae)		16	32	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Coleoptera	Gyrinidae (larvae)		1	2	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Coleoptera	Hydrophilidae (adult)		3	6	CG	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Coleoptera	Hydrophilidae (larvae)		9	18	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Coleoptera	Noteridae (adult)		5	10	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Coleoptera	Noteridae (larvae)		10	20	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Diptera	Ceratopogonidae		31	62	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	5	10	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	14	28	CG	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Diptera	Culicidae		3	6	CG	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Diptera	Stratiomyidae		15	30	CG	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Diptera	Tabanidae		8	16	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Ephemeroptera	Baetidae		6	12	CG	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Hemiptera	Belostomatidae		9	18	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Hemiptera	Corixidae		1	2	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Hemiptera	Mesoveliidae (instar)		2	4	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Hemiptera	Velidae		1	2	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Hemiptera	Velidae		1	2	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Hydrophila	Lymnaeidae		12	24	SC	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Hydrophila	Physidae		5	10	SC	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Hydrophila	Planorbidae		2	4	SC	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Odonata	Coenagrionidae		33	66	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Odonata	Cordulidae		18	36	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Odonata	Gomphidae		1	2	P	P
2015	Summer	16-Jul	Ballfields	SAV	1	>1	1/2	Rhynchobdellidae	Glossiphoniidae		4	8	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Amphipoda	Crangonyctidae	Crangonyx	3	6	CG	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Coleoptera	Hydrophilidae (larvae)		3	6	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Diptera	Chaoboridae		2	4	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	49	98	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	137	274	CG	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Diptera	Tabanidae		3	6	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Hemiptera	Corixidae		6	12	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Hemiptera	Mesoveliidae (instar)		1	2	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Hemiptera	Velidae		1	2	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Odonata	Aeshnidae		1	2	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Odonata	Coenagrionidae		1	2	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Odonata	Cordulidae		5	10	P	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Oligochaeta			1	2	CG	P
2015	Summer	16-Jul	East H.S.	DET	1	>1	1/2	Ostracoda			1	2	CF	P
2015	Summer	16-Jul	East H.S.	SAV	1	>1	1/2	Amphipoda	Gammaridae		21	42	CG	P
2015	Summer	16-Jul	East H.S.	SAV	1	>1	1/2	Coleoptera	Dytiscidae (larvae)		1	2	P	P
2015	Summer	16-Jul	East H.S.	SAV	1	>1	1/2	Coleoptera	Noteridae (larvae)		1	2	P	P
2015	Summer	16-Jul	East H.S.	SAV	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	25	50	P	P
2015	Summer	16-Jul	East H.S.	SAV	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	41	82	CG	P
2015	Summer	16-Jul	East H.S.	SAV	1	>1	1/2	Hemiptera	Gerridae		1	2	P	P
2015	Summer	16-Jul	East H.S.	SAV	1	>1	1/2	Odonata	Libellulidae		17	34	P	P
2015	Summer	16-Jul	East H.S.	SAV	1	>1	1/2	Oligochaeta			1	2	CG	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Amphipoda	Crangonyctidae	Crangonyx	16	32	CG	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Coleoptera	Dytiscidae (larvae)		3	6	P	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Coleoptera	Hydrophilidae (adult)		8	16	CG	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Coleoptera	Hydrophilidae (larvae)		3	6	P	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Coleoptera	Noteridae (larvae)		2	4	P	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Decapoda	Cambaridae		3	6	CG	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Diptera	Ceratopogonidae		1	2	P	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	30	60	P	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	50	100	CG	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Diptera	Culicidae		1	2	CG	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Hemiptera	Belostomatidae		2	4	P	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Hemiptera	Corixidae		2	4	P	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Hemiptera	Hydrometridae		1	2	P	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Hemiptera	Mesoveliidae (instar)		4	8	P	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Hydrophila	Planorbidae		3	6	SC	P
2015	Summer	16-Jul	North H.S.	DET	1	>1	1/2	Odonata	Cordulidae		5	10	P	P
2015	Summer	16-Jul	North H.S.	SAV	1	>1	3/4	Amphipoda	Crangonyctidae	Crangonyx	10	12.5	CG	P
2015	Summer	16-Jul	North H.S.	SAV	1	>1	3/4	Coleoptera	Dytiscidae (adult)		1	1.25	P	P
2015	Summer	16-Jul	North H.S.	SAV	1	>1	3/4	Coleoptera	Dytiscidae (larvae)		4	5	P	P
2015	Summer	16-Jul	North H.S.	SAV	1	>1	3/4	Coleoptera	Noteridae (adult)		1	1.25	P	P
2015	Summer	16-Jul	North H.S.	SAV	1	>1	3/4	Coleoptera	Noteridae (larvae)		6	7.5	P	P
2015	Summer	16-Jul	North H.S.	SAV	1	>1	3/4	Diptera	Chironomidae	Tanypodinae	62	77.5	P	P
2015	Summer	16-Jul	North H.S.	SAV	1	>1	3/4	Diptera	Chironomidae	Non-Tanypodinae	12	15		

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2015	Summer	16-Jul	North H.S.	SAV	1	>1	3/4	Odonata	Gomphidae		2	2.5	P	P
2015	Summer	16-Jul	North H.S.	SAV	1	>1	3/4	Odonata	Libellulidae		6	7.5	P	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Acariformes	Hydrachnida		1	1	P	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	2	2	CG	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Coleoptera	Noteridae (larvae)		1	1	P	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Decapoda	Palaemonidae		33	33	SH	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Diptera	Ceratopogonidae		5	5	P	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	74	74	P	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Ephemeroptera	Baetidae	Non-Tanypodinae	189	189	CG	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Ephemeroptera	Caenidae		1	1	CG	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Hemiptera	Corixidae		14	14	CF	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Hemiptera	Nepidae		84	84	P	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Hemiptera	Nepidae		2	2	P	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Odonata	Cordulidae		2	2	P	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Oligochaeta			17	17	CG	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Trichoptera	Leptoceridae	Nectopsyche	1	1	SH	P
2015	Summer	16-Jul	Carubahn	DET	1	>1	1	Veneroida	Sphaeriidae		4	4	F	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Acariformes	Hydrachnida		2	2	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	6	6	CG	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	182	182	CG	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Coleoptera	Dytiscidae (adult)		7	7	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Coleoptera	Dytiscidae (larvae)		14	14	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Coleoptera	Hydrophilidae (adult)		1	1	CG	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Coleoptera	Hydrophilidae (larvae)		3	3	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Coleoptera	Noteridae (adult)		6	6	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Coleoptera	Noteridae (larvae)		8	8	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Coleoptera	Staphylinidae		6	6	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Collembola			1	1	CG	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	78	78	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	32	32	CG	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Diptera	Culicidae		16	16	CG	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Diptera	Tabanidae		2	2	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Ephemeroptera	Baetidae		35	35	CG	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Ephemeroptera	Caenidae		28	28	CF	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Hemiptera	Belostomatidae		6	6	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Hemiptera	Corixidae		27	27	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Hemiptera	Hydrometridae		4	4	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Hemiptera	Mesoveliidae (instar)		5	5	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Hemiptera	Nepidae		1	1	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Hemiptera	Notonectidae		21	21	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Hemiptera	Nepidae		1	1	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Hygrophila	Lymnaeidae		2	2	SC	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Hygrophila	Physidae		7	7	SC	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Hygrophila	Planorbidae		5	5	SC	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Megaloptera	Corydalidae	Chauliodes	1	1	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Odonata	Coenagrionidae		16	16	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Odonata	Cordulidae		67	67	P	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Oligochaeta			3	3	CG	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Ostracoda			4	4	CF	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Trichoptera	Leptoceridae	Nectopsyche	2	2	SH	P
2015	Summer	16-Jul	Carubahn	SAV	1	>1	1	Veneroida	Sphaeriidae		4	4	F	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Acariformes	Hydrachnida		3	12	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Amphipoda	Dogielinotidae	Hyalella	1	4	CG	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Coleoptera	Dytiscidae (larvae)		1	4	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Coleoptera	Halplidae (adult)		1	4	SH	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Coleoptera	Hydrophilidae (larvae)		1	4	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Diptera	Ceratopogonidae		6	24	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Diptera	Chironomidae	Tanypodinae	65	260	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Diptera	Chironomidae	Non-Tanypodinae	14	56	CG	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Diptera	Culicidae		1	4	CG	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Diptera	Tabanidae		2	8	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Ephemeroptera	Baetidae		12	48	CG	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Hemiptera	Belostomatidae		1	4	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Hemiptera	Corixidae		68	272	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Hemiptera	Gerridae		2	8	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Hemiptera	Mesoveliidae (instar)		1	4	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Hemiptera	Nepidae		1	4	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Hygrophila	Physidae		1	4	SC	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Hygrophila	Planorbidae	Ancylini	1	4	SC	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Odonata	Coenagrionidae		5	20	P	P
2015	Summer	16-Jul	East P.W.	DET	1	>1	1/4	Odonata	Cordulidae		12	48	P	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Amphipoda	Talitridae		2	4	CG	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Decapoda	Cambaridae		2	4	CG	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	41	82	P	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	17	34	CG	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Diptera	Chironomidae		1	2	CG	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Ephemeroptera	Baetidae		5	10	CG	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Hemiptera	Corixidae		28	56	P	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Hemiptera	Nepidae		1	2	P	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Hemiptera	Notonectidae		1	2	P	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Hygrophila	Planorbidae		1	2	SC	P
2015	Summer	16-Jul	East P.W.	SAV	1	>1	1/2	Odonata	Libellulidae		7	14	P	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Acariformes	Hydrachnida		1	1	P	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	4	4	CG	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Coleoptera	Dytiscidae (larvae)		10	10	P	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Coleoptera	Gyrinidae (larvae)		1	1	P	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Coleoptera	Halplidae (adult)		1	1	SH	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Decapoda	Palaemonidae		1	1	SH	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Diptera	Chaoboridae		1	1	P	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	29	29	P	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	121	121	CG	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Diptera	Culicidae		1	1	CG	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Hemiptera	Corixidae		227	227	P	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Odonata	Cordulidae		10	10	P	P
2015	Summer	15-Jul	Gubanski	DET	1	>1	1	Oligochaeta			45	45	CG	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Acariformes	Hydrachnida		1	1	P	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	12	12	CG	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Amphipoda	Talitridae		13	13	CG	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Chrysomelidae (adult)		5	5	SH	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Chrysomelidae (larvae)		1	1	SH	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Curculionidae (adult)		3	3	SH	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Dytiscidae (adult)		3	3	P	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Dytiscidae (larvae)		33	33	P	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Gyrinidae (larvae)		1	1	P	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Halplidae (adult)		3	3	SH	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Hydrophilidae (adult)		2	2	CG	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Hydrophilidae (larvae)		1	1	P	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Noteridae (adult)		3	3	P	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Coleoptera	Noteridae (larvae)		7	7	P	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	3	3	P	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	39	39	CG	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Diptera	Culicidae		12	12	CG	P
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Diptera	Tabanidae					

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Hemiptera	Hydrometridae		1	1	P	7
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Hemiptera	Mesoveliidae		1	1	P	6
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Hemiptera	Mesoveliidae (instar)		8	8	P	4
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Hemiptera	Nepidae		4	4	P	6
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Hemiptera	Notonectidae		1	1	P	4
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Hygrophila	Lymnaeidae		1	1	SC	4
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Hygrophila	Physidae		1	1	SC	4
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Hydrophila	Planorbidae		2	2	SC	4
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Odonata	Coenagrionidae		23	23	P	4
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Odonata	Corduliidae		113	113	P	4
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Odonata	Gomphidae		1	1	P	4
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Odonata	Libellulidae		67	67	P	4
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Oligochaeta			25	25	CG	4
2015	Summer	15-Jul	Gubanski	SAV	1	>1	1	Rhynchobdellidae	Glossiphoniidae		1	1	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Acariformes	Hydrachnida		2	4	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Amphipoda	Dogielinotidae	Hyalella	26	52	CG	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Coleoptera	Dytiscidae (adult)		3	6	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Coleoptera	Dytiscidae (larvae)		2	4	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Coleoptera	Hydrophilidae (adult)		4	8	CG	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Coleoptera	Noteridae (adult)		3	6	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Diptera	Ceratopogonidae		23	46	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	23	46	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	3	6	CG	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Diptera	Tabanidae		8	8	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Hemiptera	Belostomatidae		1	2	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Hemiptera	Corixidae		40	80	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Hemiptera	Nepidae		1	2	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Odonata	Coenagrionidae		2	4	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Odonata	Corduliidae		2	4	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Oligochaeta			5	10	CG	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Rhynchobdellidae	Glossiphoniidae		1	2	P	4
2015	Summer	16-Jul	North P.W.	DET	1	>1	1/2	Veneroida	Sphaeriidae		2	4	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Acariformes	Hydrachnida		4	8	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Amphipoda	Dogielinotidae	Hyalella	51	102	CG	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Coleoptera	Curculionidae (adult)		2	4	SH	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Coleoptera	Dytiscidae (adult)		2	4	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Coleoptera	Dytiscidae (larvae)		5	10	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Coleoptera	Noteridae (adult)		4	8	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Coleoptera	Noteridae (larvae)		1	2	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Diptera	Ceratopogonidae		3	6	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Diptera	Chironomidae	Tanypodinae	5	16	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Diptera	Chironomidae	Non-Tanypodinae	5	10	CG	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Diptera	Siraomyiidae		1	2	CG	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Diptera	Tabanidae		2	4	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Ephemeroptera	Caenidae		2	4	CF	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Hemiptera	Corixidae		13	26	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Odonata	Coenagrionidae		3	6	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Odonata	Corduliidae		11	22	P	4
2015	Summer	16-Jul	North P.W.	SAV	1	>1	1/2	Oligochaeta			1	2	CG	4
2017	Summer	22-May	Country Club	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1			7
2017	Summer	22-May	Country Club	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1			6
2017	Summer	22-May	Country Club	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2			4
2017	Summer	22-May	Country Club	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	1			6
2017	Summer	22-May	Country Club	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	1			4
2017	Summer	22-May	Country Club	DET	1	>1	1	Ephemeroptera	Caenidae		1			5
2017	Summer	22-May	Country Club	DET	1	>1	1	Hemiptera	Corixidae		2			5
2017	Summer	22-May	Country Club	DET	1	>1	1	Hemiptera	Corixidae		2			5
2017	Summer	22-May	Country Club	DET	1	>1	1	Oligochaeta			1			5
2017	Summer	22-May	Country Club	DET	1	>1	1	Veneroida	Sphaeriidae		1			4
2017	Summer	22-May	Country Club	DET	1	>1	1	Veneroida	Sphaeriidae		1			6
2017	Summer	22-May	Country Club	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2			4
2017	Summer	22-May	Country Club	DET	2	>1	1	Hemiptera	Corixidae		1			3
2017	Summer	22-May	Country Club	DET	2	>1	1	Oligochaeta			1			3
2017	Summer	22-May	Country Club	DET	3	>1	1	Amphipoda	Dogielinotidae	Hyalella	1			2
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Ceratopogonidae		1			12
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Ceratopogonidae		1			10
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Ceratopogonidae		1			8
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Ceratopogonidae		1			6
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Non-Tanypodinae		1			7
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Non-Tanypodinae		2			5
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Non-Tanypodinae		9			4
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Tanypodinae		1			5
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Tanypodinae		2			6
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Tanypodinae		2			4
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Tipulidae		2			14
2017	Summer	22-May	Country Club	DET	3	>1	1	Diptera	Tipulidae		2			10
2017	Summer	22-May	Country Club	DET	3	>1	1	Hemiptera	Corixidae		1			2
2017	Summer	22-May	Country Club	DET	3	>1	1	Oligochaeta			2			5
2017	Summer	22-May	Country Club	DET	3	>1	1	Ostracoda			1			2
2017	Summer	22-May	Country Club	DET	3	>1	1	Veneroida	Sphaeriidae		1			3
2017	Summer	22-May	Country Club	SAV	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	2			6
2017	Summer	22-May	Country Club	SAV	1	>1	1	Coleoptera	Hydrophilidae (larvae)		1			7
2017	Summer	22-May	Country Club	SAV	1	>1	1	Decapoda	Cambaridae	Cambarinae	1			12
2017	Summer	22-May	Country Club	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1			2
2017	Summer	22-May	Country Club	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2			3
2017	Summer	22-May	Country Club	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3			5
2017	Summer	22-May	Country Club	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	1			4
2017	Summer	22-May	Country Club	SAV	1	>1	1	Hemiptera	Corixidae		8			3
2017	Summer	22-May	Country Club	SAV	1	>1	1	Odonata	Coenagrionidae		1			6
2017	Summer	22-May	Country Club	SAV	1	>1	1	Trichoptera	Hydroptilidae		1			2
2017	Summer	22-May	Country Club	SAV	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	1			4
2017	Summer	22-May	Country Club	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1			8
2017	Summer	22-May	Country Club	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1			5
2017	Summer	22-May	Country Club	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3			6
2017	Summer	22-May	Country Club	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	4			5
2017	Summer	22-May	Country Club	SAV	2	>1	1	Diptera	Tipulidae		2			10
2017	Summer	22-May	Country Club	SAV	2	>1	1	Ephemeroptera	Caenidae		1			4
2017	Summer	22-May	Country Club	SAV	2	>1	1	Hemiptera	Belostomatidae		1			19
2017	Summer	22-May	Country Club	SAV	2	>1	1	Hemiptera	Belostomatidae		1			7
2017	Summer	22-May	Country Club	SAV	2	>1	1	Hemiptera	Belostomatidae		1			5
2017	Summer	22-May	Country Club	SAV	2	>1	1	Hemiptera	Corixidae		1			4
2017	Summer	22-May	Country Club	SAV	2	>1	1	Hemiptera	Corixidae		3			3
2017	Summer	22-May	Country Club	SAV	2	>1	1	Hydrophila	Physidae		1			5
2017	Summer	22-May	Country Club	SAV	2	>1	1	Isopoda	Asellidae	Caecidotea	2			4
2017	Summer	22-May	Country Club	SAV	3	>1	1	Acariformes	Hydrachnida		1			4
2017	Summer	22-May	Country Club	SAV	3	>1	1	Amphipoda	Dogielinotidae	Hyalella	2			5
2017	Summer	22-May	Country Club	SAV	3	>1	1	Coleoptera	Dytiscidae (larvae)		1			4
2017	Summer	22-May	Country Club	SAV	3	>1	1	Coleoptera	Hydrophilidae (larvae)		1			5
2017	Summer	22-May	Country Club	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2			6
2017	Summer	22-May	Country Club	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3			3
2017	Summer	22-May	Country Club	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	18			6
2017	Summer	22-May	Country Club	SAV	3	>1	1	Diptera	Tabanidae		1			4
2017	Summer	22-May	Country Club	SAV	3	>1	1	Hemiptera	Corixidae		2			3
2017	Summer	22-May	Country Club	SAV	3	>1	1	Isopoda	Asellidae	Caecidotea	8			4
2017	Summer	22-May	Country Club	SAV	3	>1	1							

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2017	Summer	22-May	Zajac	DET	1	>1	1	Amphipoda	Dogielinotidae	Hyaella	1	3		3
2017	Summer	22-May	Zajac	DET	1	>1	1	Diptera	Ceratopogonidae		5	6		6
2017	Summer	22-May	Zajac	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	4		4
2017	Summer	22-May	Zajac	DET	1	>1	1	Oligochaeta			1	5		5
2017	Summer	22-May	Zajac	DET	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	3	4		4
2017	Summer	22-May	Zajac	DET	2	>1	1	Coleoptera	Dytiscidae (larvae)		1	4		4
2017	Summer	22-May	Zajac	DET	2	>1	1	Decapoda	Cambaridae	Cambarinae	1	14		14
2017	Summer	22-May	Zajac	DET	2	>1	1	Diptera	Ceratopogonidae		14	8		8
2017	Summer	22-May	Zajac	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	4		4
2017	Summer	22-May	Zajac	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	8	6		6
2017	Summer	22-May	Zajac	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	19	8		8
2017	Summer	22-May	Zajac	DET	2	>1	1	Diptera	Chironomidae	Tanypodinae	5	6		6
2017	Summer	22-May	Zajac	DET	2	>1	1	Hemiptera	Corixidae		1	3		3
2017	Summer	22-May	Zajac	DET	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	6		6
2017	Summer	22-May	Zajac	DET	3	>1	1	Hemiptera	Corixidae		1	4		4
2017	Summer	22-May	Zajac	SAV	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	16	4		4
2017	Summer	22-May	Zajac	SAV	1	>1	1	Coleoptera	Dytiscidae (adult)		1	5		5
2017	Summer	22-May	Zajac	SAV	1	>1	1	Coleoptera	Dytiscidae (larvae)		10	4		4
2017	Summer	22-May	Zajac	SAV	1	>1	1	Decapoda	Cambaridae	Cambarinae	1	12		12
2017	Summer	22-May	Zajac	SAV	1	>1	1	Decapoda	Cambaridae	Cambarinae	1	15		15
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Ceratopogonidae		1	10		10
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Ceratopogonidae		2	6		6
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	6		6
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	4		4
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	8		8
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	7		7
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	4	10		10
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	9	5		5
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	1	8		8
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	4	7		7
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	4	4		4
2017	Summer	22-May	Zajac	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	6	5		5
2017	Summer	22-May	Zajac	SAV	1	>1	1	Hemiptera	Corixidae		1	4		4
2017	Summer	22-May	Zajac	SAV	1	>1	1	Hemiptera	Corixidae		1	3		3
2017	Summer	22-May	Zajac	SAV	1	>1	1	Hemiptera	Corixidae		2	2		2
2017	Summer	22-May	Zajac	SAV	1	>1	1	Hygrophila	Physidae		9	4		4
2017	Summer	22-May	Zajac	SAV	1	>1	1	Hygrophila	Planorbidae		6	2		2
2017	Summer	22-May	Zajac	SAV	1	>1	1	Isopoda	Asellidae	Caecidotea	1	5		5
2017	Summer	22-May	Zajac	SAV	1	>1	1	Odonata	Coenagrionidae		4	6		6
2017	Summer	22-May	Zajac	SAV	1	>1	1	Odonata	Cordulidae		1	28		28
2017	Summer	22-May	Zajac	SAV	1	>1	1	Odonata	Cordulidae		2	3		3
2017	Summer	22-May	Zajac	SAV	1	>1	1	Veneroida	Sphaeriidae		1	3		3
2017	Summer	22-May	Zajac	SAV	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	1	2		2
2017	Summer	22-May	Zajac	SAV	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	15	4		4
2017	Summer	22-May	Zajac	SAV	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	15	3		3
2017	Summer	22-May	Zajac	SAV	2	>1	1	Coleoptera	Dytiscidae (larvae)		1	3		3
2017	Summer	22-May	Zajac	SAV	2	>1	1	Coleoptera	Dytiscidae (larvae)		10	4		4
2017	Summer	22-May	Zajac	SAV	2	>1	1	Decapoda	Cambaridae	Cambarinae	1	18		18
2017	Summer	22-May	Zajac	SAV	2	>1	1	Decapoda	Cambaridae	Cambarinae	1	16		16
2017	Summer	22-May	Zajac	SAV	2	>1	1	Decapoda	Cambaridae	Cambarinae	1	12		12
2017	Summer	22-May	Zajac	SAV	2	>1	1	Diptera	Ceratopogonidae		1	7		7
2017	Summer	22-May	Zajac	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	5	5		5
2017	Summer	22-May	Zajac	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	5	4		4
2017	Summer	22-May	Zajac	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	7	9		9
2017	Summer	22-May	Zajac	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	8	3		3
2017	Summer	22-May	Zajac	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	40	6		6
2017	Summer	22-May	Zajac	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	40	5		5
2017	Summer	22-May	Zajac	SAV	2	>1	1	Hydrophila	Physidae		73	3		3
2017	Summer	22-May	Zajac	SAV	2	>1	1	Hydrophila	Planorbidae		13	2		2
2017	Summer	22-May	Zajac	SAV	2	>1	1	Isopoda	Asellidae	Caecidotea	1	4		4
2017	Summer	22-May	Zajac	SAV	2	>1	1	Odonata	Coenagrionidae		2	5		5
2017	Summer	22-May	Zajac	SAV	2	>1	1	Veneroida	Sphaeriidae		1	6		6
2017	Summer	22-May	Zajac	SAV	2	>1	1	Veneroida	Sphaeriidae		1	5		5
2017	Summer	22-May	Zajac	SAV	2	>1	1	Veneroida	Sphaeriidae		2	3		3
2017	Summer	22-May	Zajac	SAV	3	>1	1	Amphipoda	Dogielinotidae	Hyaella	127	3		3
2017	Summer	22-May	Zajac	SAV	3	>1	1	Coleoptera	Dytiscidae (adult)		1	3		3
2017	Summer	22-May	Zajac	SAV	3	>1	1	Coleoptera	Dytiscidae (larvae)		1	3		3
2017	Summer	22-May	Zajac	SAV	3	>1	1	Coleoptera	Hydrophilidae (larvae)		2	5		5
2017	Summer	22-May	Zajac	SAV	3	>1	1	Coleoptera	Staphylinidae		1	6		6
2017	Summer	22-May	Zajac	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	8	4		4
2017	Summer	22-May	Zajac	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	8	6		6
2016	Summer	22-May	Zajac	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	26	6		6
2017	Summer	22-May	Zajac	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	26	5		5
2017	Summer	22-May	Zajac	SAV	3	>1	1	Hemiptera	Corixidae		2	2		2
2017	Summer	22-May	Zajac	SAV	3	>1	1	Hemiptera	Mesocelididae		2	2		2
2017	Summer	22-May	Zajac	SAV	3	>1	1	Hemiptera	Corixidae		1	19		19
2017	Summer	22-May	Zajac	SAV	3	>1	1	Hydrophila	Physidae		66	3		3
2017	Summer	22-May	Zajac	SAV	3	>1	1	Hydrophila	Planorbidae		27	3		3
2017	Summer	22-May	Zajac	SAV	3	>1	1	Isopoda	Asellidae	Caecidotea	2	3		3
2017	Summer	22-May	Zajac	SAV	3	>1	1	Megaloptera	Corydalidae		1	6		6
2017	Summer	22-May	Zajac	SAV	3	>1	1	Odonata	Coenagrionidae		5	6		6
2017	Summer	22-May	Ballfields	DET	1	>1	1	Decapoda	Palaeomonetes		5	6		6
2017	Summer	22-May	Ballfields	DET	1	>1	1	Diptera	Ceratopogonidae		1	7		7
2017	Summer	22-May	Ballfields	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	4		4
2017	Summer	22-May	Ballfields	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	2	5		5
2017	Summer	22-May	Ballfields	DET	1	>1	1	Hemiptera	Corixidae		1	2		2
2017	Summer	22-May	Ballfields	DET	1	>1	1	Hemiptera	Corixidae		1	5		5
2017	Summer	22-May	Ballfields	DET	1	>1	1	Hemiptera	Corixidae		2	3		3
2017	Summer	22-May	Ballfields	DET	1	>1	1	Veneroida	Sphaeriidae		1	2		2
2017	Summer	22-May	Ballfields	DET	2	>1	1	Diptera	Ceratopogonidae		1	5		5
2017	Summer	22-May	Ballfields	DET	2	>1	1	Diptera	Chironomidae	Tanypodinae	1	5		5
2017	Summer	22-May	Ballfields	DET	2	>1	1	Ephemeroptera	Baetidae		13	6		6
2017	Summer	22-May	Ballfields	DET	2	>1	1	Hemiptera	Corixidae		1	2		2
2017	Summer	22-May	Ballfields	DET	3	>1	1	Diptera	Ceratopogonidae		13	5		5
2017	Summer	22-May	Ballfields	DET	3	>1	1	Diptera	Chironomidae	Tanypodinae	3	6		6
2017	Summer	22-May	Ballfields	DET	3	>1	1	Hemiptera	Corixidae		1	6		6
2017	Summer	22-May	Ballfields	DET	3	>1	1	Hemiptera	Corixidae		1	2		2
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Oligochaeta			6	12		12
2017	Summer	22-May	Ballfields	SAV	1	>1	1	Acariformes	Hydrachnida		1	2		2
2017	Summer	22-May	Ballfields	SAV	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	1	4		4
2017	Summer	22-May	Ballfields	SAV	1	>1	1	Coleoptera	Dytiscidae (adult)		1	2		2
2017	Summer	22-May	Ballfields	SAV	1	>1	1	Collembola			1	3		3
2017	Summer	22-May	Ballfields	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	1	5		5
2017	Summer	22-May	Ballfields	SAV	1	>1	1	Hydrophila	Lymnaeidae		1	3		3
2017	Summer	22-May	Ballfields	SAV	1	>1	1	Veneroida	Sphaeriidae		1	3		3
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	1	2		2
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Coleoptera	Hydrophilidae (adult)		1	4		4
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Coleoptera	Hydrophilidae (larvae)		1	5		5
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Decapoda	Cambaridae		1	16		16
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Decapoda	Cambaridae		1	8		8
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	2		2
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	5		5
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Diptera	Tabanidae		1	6		6
2017	Summer	22-May	Ballfields	SAV	2	>1								

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Hygrophila	Lymnaeidae		5	5		4
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Hygrophila	Lymnaeidae		9	9		2
2017	Summer	22-May	Ballfields	SAV	2	>1	1	Hygrophila	Physidae		1	1		4
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Coleoptera	Hydrophilidae (adult)		3	3		4
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Coleoptera	Hydrophilidae (larvae)		1	1		4
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Decapoda	Cambaridae		1	1		11
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		5
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	3	3		5
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Hemiptera	Corixidae		1	1		5
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Hemiptera	Corixidae		1	1		3
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Hygrophila	Lymnaeidae		1	1		7
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Hygrophila	Lymnaeidae		1	1		4
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Hygrophila	Lymnaeidae		1	1		2
2017	Summer	22-May	Ballfields	SAV	3	>1	1	Hygrophila	Lymnaeidae		2	2		3
2017	Summer	22-May	East H.S.	DET	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	3	3		4
2017	Summer	22-May	East H.S.	DET	1	>1	1	Amphipoda	Dogielinotidae		1	1		4
2017	Summer	22-May	East H.S.	DET	1	>1	1	Decapoda	Palaeonetes		2	2		5
2017	Summer	22-May	East H.S.	DET	1	>1	1	Diptera	Ceratopogonidae		3	3		6
2017	Summer	22-May	East H.S.	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		5
2017	Summer	22-May	East H.S.	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		6
2017	Summer	22-May	East H.S.	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	5	5		4
2017	Summer	22-May	East H.S.	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	6	6		6
2017	Summer	22-May	East H.S.	DET	1	>1	1	Ephemeroptera	Caenidae		1	1		3
2017	Summer	22-May	East H.S.	DET	1	>1	1	Hemiptera	Corixidae		4	4		5
2017	Summer	22-May	East H.S.	DET	1	>1	1	Hemiptera	Corixidae		23	23		2
2017	Summer	22-May	East H.S.	DET	1	>1	1	Odonata	Aeschnidae		1	1		2
2017	Summer	22-May	East H.S.	DET	1	>1	1	Oligochaete			2	2		12
2017	Summer	22-May	East H.S.	DET	2	>1	1	Diptera	Ceratopogonidae		1	1		5
2017	Summer	22-May	East H.S.	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		14
2017	Summer	22-May	East H.S.	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		10
2017	Summer	22-May	East H.S.	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		5
2017	Summer	22-May	East H.S.	DET	2	>1	1	Diptera	Chironomidae	Tanypodinae	3	3		5
2017	Summer	22-May	East H.S.	DET	2	>1	1	Hemiptera	Corixidae		2	2		3
2017	Summer	22-May	East H.S.	DET	2	>1	1	Hemiptera	Corixidae		7	7		5
2017	Summer	22-May	East H.S.	DET	2	>1	1	Oligochaete			2	2		7
2017	Summer	22-May	East H.S.	DET	2	>1	1	Oligochaete			3	3		10
2017	Summer	22-May	East H.S.	DET	3	>1	1	Amphipoda	Dogielinotidae	Hyalella	1	1		5
2017	Summer	22-May	East H.S.	DET	3	>1	1	Diptera	Ceratopogonidae		7	7		6
2017	Summer	22-May	East H.S.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		8
2017	Summer	22-May	East H.S.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		5
2017	Summer	22-May	East H.S.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		7
2017	Summer	22-May	East H.S.	DET	3	>1	1	Diptera	Chironomidae	Tanypodinae	9	9		6
2017	Summer	22-May	East H.S.	DET	3	>1	1	Diptera	Chironomidae	Tanypodinae	10	10		5
2017	Summer	22-May	East H.S.	DET	3	>1	1	Diptera	Coenagrionidae		1	1		10
2017	Summer	22-May	East H.S.	DET	3	>1	1	Hemiptera	Corixidae		1	1		4
2018	Summer	23-May	East H.S.	DET	3	>1	1	Hemiptera	Corixidae		3	3		5
2017	Summer	22-May	East H.S.	DET	3	>1	1	Oligochaete			2	2		13
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	12	12		4
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	39	39		2
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Amphipoda	Dogielinotidae		4	4		4
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	12	12		3
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Coleoptera	Dytiscidae (adult)		1	1		5
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Coleoptera	Noteridae (adult)		3	3		2
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Decapoda	Cambaridae	Cambarinae	1	1		16
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Decapoda	Cambaridae	Cambarinae	1	1		10
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Decapoda	Palaeonetes		1	1		5
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		4
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		3
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		8
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	1	1		9
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	2	2		6
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Ephemeroptera	Caenidae		2	2		5
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Hemiptera	Corixidae		2	2		3
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Hemiptera	Corixidae		5	5		4
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Hygrophila	Physidae		3	3		3
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Hygrophila	Physidae		4	4		2
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Hygrophila	Planorbidae		22	22		2
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Odonata	Coenagrionidae		4	4		10
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Odonata	Coenagrionidae		4	4		8
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Odonata	Corduliidae		1	1		24
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Oligochaete			1	1		6
2017	Summer	22-May	East H.S.	SAV	1	>1	1	Veneroida	Sphaeriidae		2	2		2
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	6	6		5
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	8	8		3
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Amphipoda	Dogielinotidae	Hyalella	2	2		5
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Decapoda	Cambaridae		2	2		15
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Decapoda	Palaeonetes		1	1		8
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Diptera	Ceratopogonidae		1	1		5
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		8
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	16	16		5
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	3	3		7
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Ephemeroptera	Baetidae		3	3		6
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Ephemeroptera	Caenidae		2	2		5
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Hemiptera	Corixidae		5	5		3
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Isopoda	Asellidae	Caecidotea	1	1		5
2017	Summer	22-May	East H.S.	SAV	2	>1	1	Odonata	Corduliidae		5	5		10
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Amphipoda	Crangonyctidae	Crangonyx	3	3		4
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Amphipoda	Crangonyctidae	Crangonyx	8	8		2
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Decapoda	Cambaridae		1	1		18
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		6
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		5
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		8
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	2	2		5
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	4	4		8
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Ephemeroptera	Baetidae		2	2		6
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Ephemeroptera	Caenidae		4	4		5
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Hemiptera	Corixidae		1	1		4
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Hemiptera	Corixidae		2	2		3
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Hemiptera	Corixidae		2	2		2
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Hygrophila	Planorbidae		2	2		2
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Isopoda	Caecidotea	Asellidae	1	1		3
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Odonata	Coenagrionidae		1	1		7
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Odonata	Coenagrionidae		1	1		4
2017	Summer	22-May	East H.S.	SAV	3	>1	1	Odonata	Corduliidae		2	2		20
2017	Summer	22-May	North H.S.	DET	1	>1	1	Diptera	Ceratopogonidae		2	2		6
2017	Summer	22-May	North H.S.	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		5
2017	Summer	22-May	North H.S.	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	2	2		7
2017	Summer	22-May	North H.S.	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	1	1		5
2017	Summer	22-May	North H.S.	DET	1	>1	1	Hemiptera	Corixidae		2	2		2
2017	Summer	22-May	North H.S.	DET	1	>1	1	Hemiptera	Corixidae		5	5		2
2017	Summer	22-May	North H.S.	DET	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	1	1		3
2017	Summer	22-May	North H.S.	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		11
2017	Summer	22-May	North H.S.	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		5

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2017	Summer	22-May	North H.S.	DET	2	>1	1	Diptera	Coenagrionidae		1			6
2017	Summer	22-May	North H.S.	DET	2	>1	1	Hemiptera	Corixidae		1			5
2017	Summer	22-May	North H.S.	DET	2	>1	1	Hemiptera	Corixidae		1			3
2017	Summer	22-May	North H.S.	DET	2	>1	1	Hemiptera	Corixidae		1			2
2017	Summer	22-May	North H.S.	DET	3	>1	1	Acariformes	Hydrachnida		1			1
2017	Summer	22-May	North H.S.	DET	3	>1	1	Amphipoda	Crangonyctidae	Crangonyx	1			3
2017	Summer	22-May	North H.S.	DET	3	>1	1	Amphipoda	Crangonyctidae	Crangonyx	1			5
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Ceratopogonidae		1			11
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			4
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			5
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			8
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			9
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			10
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	3			6
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	3			7
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Tanyptodinae	1			3
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Tanyptodinae	1			4
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Tanyptodinae	1			5
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Tanyptodinae	1			8
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Tanyptodinae	2			7
2017	Summer	22-May	North H.S.	DET	3	>1	1	Diptera	Chironomidae	Tanyptodinae	4			6
2017	Summer	22-May	North H.S.	DET	3	>1	1	Ephemeroptera	Baetidae		1			6
2017	Summer	22-May	North H.S.	DET	3	>1	1	Hemiptera	Corixidae		3			5
2017	Summer	22-May	North H.S.	DET	3	>1	1	Odonata	Corduliidae		1			3
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	1			2
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Collembola	Hydrophilidae (larvae)		1			3
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			8
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	5			6
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Diptera	Chironomidae	Tanyptodinae	5			4
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Diptera	Chironomidae	Tanyptodinae	11			8
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Diptera	Culicidae	Wycomyia	1			5
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Ephemeroptera	Baetidae		1			6
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Ephemeroptera	Caenidae		1			5
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Hemiptera	Corixidae		2			4
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Hemiptera	Corixidae		9			2
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Hemiptera	Corixidae		19			5
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Hygrophila	Physidae		1			2
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Hygrophila	Planorbidae		1			2
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Odonata	Coenagrionidae		2			10
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Odonata	Coenagrionidae		8			5
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Oligochaete			1			6
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Rhynchobdellidae	Glossiphoniidae		1			2
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Trichoptera	Leptoceridae	Nectopsyche	2			5
2017	Summer	22-May	North H.S.	SAV	1	>1	1	Veneroida	Sphaeriidae		1			8
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	2			3
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	10			5
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Amphipoda	Crangonyctidae	Crangonyx	10			4
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Decapoda	Cambaridae		1			14
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			9
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			8
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	3			5
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Diptera	Chironomidae	Tanyptodinae	1			10
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Diptera	Chironomidae	Tanyptodinae	4			8
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Diptera	Chironomidae	Tanyptodinae	5			4
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Diptera	Chironomidae	Tanyptodinae	7			5
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Ephemeroptera	Baetidae		1			5
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Ephemeroptera	Caenidae		2			3
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Hemiptera	Corixidae		1			1
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Hemiptera	Corixidae		5			2
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Hemiptera	Corixidae		8			5
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Hygrophila	Planorbidae		8			2
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Hygrophila	Planorbidae		2			2
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Odonata	Coenagrionidae		3			7
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Odonata	Coenagrionidae		8			5
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Oligochaete			6			4
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Odonata	Libellulidae		1			16
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Ostracoda			27			1
2017	Summer	22-May	North H.S.	SAV	2	>1	1	Veneroida	Sphaeriidae		3			2
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Amphipoda	Crangonyctidae	Crangonyx	2			4
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Amphipoda	Crangonyctidae	Crangonyx	10			2
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			9
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			7
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	17			5
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Diptera	Chironomidae	Tanyptodinae	8			6
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Ephemeroptera	Baetidae		1			6
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Hemiptera	Corixidae		3			5
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Hemiptera	Corixidae		8			3
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Hemiptera	Corixidae		1			1
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Hygrophila	Planorbidae		2			2
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Odonata	Coenagrionidae		3			7
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Odonata	Coenagrionidae		8			5
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Oligochaete			2			5
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Ostracoda			10			1
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Rhynchobdellidae	Glossiphoniidae		1			2
2017	Summer	22-May	North H.S.	SAV	3	>1	1	Veneroida	Sphaeriidae		4			2
2017	Summer	22-May	Carubhan	DET	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	1			4
2017	Summer	22-May	Carubhan	DET	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	1			2
2017	Summer	22-May	Carubhan	DET	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	2			3
2017	Summer	22-May	Carubhan	DET	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	2			1
2017	Summer	22-May	Carubhan	DET	1	>1	1	Collembola	Halplidae (adult)		1			4
2017	Summer	22-May	Carubhan	DET	1	>1	1	Diptera	Ceratopogonidae		1			14
2017	Summer	22-May	Carubhan	DET	1	>1	1	Diptera	Ceratopogonidae		1			6
2017	Summer	22-May	Carubhan	DET	1	>1	1	Diptera	Chaoboridae		2			8
2017	Summer	22-May	Carubhan	DET	1	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			8
2017	Summer	22-May	Carubhan	DET	1	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			5
2017	Summer	22-May	Carubhan	DET	1	>1	1	Diptera	Chironomidae	Tanyptodinae	1			8
2017	Summer	22-May	Carubhan	DET	1	>1	1	Ephemeroptera	Caenidae		1			5
2017	Summer	22-May	Carubhan	DET	1	>1	1	Ephemeroptera	Caenidae		1			3
2017	Summer	22-May	Carubhan	DET	1	>1	1	Ephemeroptera	Caenidae		4			7
2017	Summer	22-May	Carubhan	DET	1	>1	1	Hemiptera	Corixidae		2			1
2017	Summer	22-May	Carubhan	DET	1	>1	1	Hemiptera	Corixidae		5			3
2017	Summer	22-May	Carubhan	DET	1	>1	1	Odonata	Corduliidae		1			19
2017	Summer	22-May	Carubhan	DET	1	>1	1	Oligochaete			2			8
2017	Summer	22-May	Carubhan	DET	1	>1	1	Oligochaete			10			18
2017	Summer	22-May	Carubhan	DET	1	>1	1	Oligochaete			10			14
2017	Summer	22-May	Carubhan	DET	2	>1	1	Acariformes	Hydrachnida		2			1
2017	Summer	22-May	Carubhan	DET	2	>1	1	Amphipoda	Dogielinotidae	Hyalella	3			3
2017	Summer	22-May	Carubhan	DET	2	>1	1	Diptera	Chironomidae	Non-Tanyptodinae	1			5
2017	Summer	22-May	Carubhan	DET	2	>1	1	Ephemeroptera	Caenidae		1			5
2017	Summer	22-May	Carubhan	DET	2	>1	1	Ephemeroptera	Caenidae		1			5
2017	Summer	22-May	Carubhan	DET	2	>1	1	Ephemeroptera	Caenidae		1			3
2017	Summer	22-May	Carubhan	DET	2	>1	1	Ephemeroptera	Caenidae		1			2
2017	Summer	22-May	Carubhan	DET	2	>1	1	Hemiptera	Corixidae		1			3
2017	Summer	22-May	Carubhan	DET	2	>1	1	Hemiptera	Corixidae		3			5
2017	Summer	22-May	Carubhan	DET	2	>1	1	Hemiptera	Corixidae		4			2
2017	Summer	22-May												

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2017	Summer	22-May	Carubahn	DET	3	>1	1	Diptera	Ceratopogonidae		1	1		12
2017	Summer	22-May	Carubahn	DET	3	>1	1	Diptera	Chaoboridae		1	1		5
2017	Summer	22-May	Carubahn	DET	3	>2	2	Diptera	Chironomidae	Non-Tanypodinae	2	2		4
2017	Summer	22-May	Carubahn	DET	3	>1	1	Diptera	Chironomidae	Tanypodinae	2	2		6
2017	Summer	22-May	Carubahn	DET	3	>1	1	Ephemeroptera	Caenidae		1	1		4
2017	Summer	22-May	Carubahn	DET	3	>1	1	Hemiptera	Corixidae		1	1		4
2017	Summer	22-May	Carubahn	DET	3	>1	1	Hemiptera	Corixidae		3	3		2
2017	Summer	22-May	Carubahn	DET	3	>1	1	Oligochaete			2	2		5
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Acariformes	Hydrachnida		1	1		4
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Acariformes	Hydrachnida		1	1		1
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyaella	2	2		1
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyaella	2	2		1
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyaella	3	3		3
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyaella	3	3		2
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyaella	3	3		3
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyaella	3	3		2
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Decapoda	Palaeonetes		1	1		8
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Decapoda	Palaeonetes		1	1		8
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Diptera	Ceratopogonidae		1	1		5
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Diptera	Ceratopogonidae		1	1		5
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Diptera	Ceratopogonidae		2	2		10
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Diptera	Ceratopogonidae		2	2		10
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		8
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	1	1		6
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Diptera	Non-Tanypodinae		1	1		8
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Diptera	Tanypodinae		2	2		6
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ephemeroptera	Baetidae		4	4		8
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ephemeroptera	Baetidae		4	4		8
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ephemeroptera	Baetidae		4	4		8
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ephemeroptera	Caenidae		8	8		3
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ephemeroptera	Caenidae		8	8		3
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ephemeroptera	Caenidae		13	13		6
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ephemeroptera	Caenidae		13	13		6
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ephemeroptera	Caenidae		21	21		5
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ephemeroptera	Caenidae		21	21		5
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Hemiptera	Corixidae		4	4		4
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Hemiptera	Corixidae		4	4		4
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Hemiptera	Corixidae		5	5		6
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Hemiptera	Corixidae		5	5		6
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Hemiptera	Corixidae		7	7		2
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Odonata	Coenagrionidae		1	1		4
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Odonata	Coenagrionidae		1	1		4
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Oligochaete			4	4		6
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Oligochaete			4	4		6
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ostracoda			4	4		1
2017	Summer	22-May	Carubahn	SAV	1	>1	1	Ostracoda			4	4		1
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Acariformes	Hydrachnida		1	1		1
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Amphipoda	Dogielinotidae	Hyaella	3	3		4
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Coleoptera	Halplidae (larvae)		1	1		4
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Decapoda	Palaeonetes		1	1		6
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		3
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	1	1		8
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Ephemeroptera	Baetidae		2	2		6
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Ephemeroptera	Caenidae		2	2		2
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Ephemeroptera	Caenidae		4	4		8
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Ephemeroptera	Caenidae		9	9		6
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Ephemeroptera	Caenidae		11	11		5
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Odonata	Coenagrionidae		1	1		4
2017	Summer	22-May	Carubahn	SAV	2	>1	1	Odonata	Coenagrionidae		5	5		11
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Oligochaete			4	4		6
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Oligochaete			4	4		6
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Acariformes	Hydrachnida		7	7		1
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Amphipoda	Dogielinotidae	Hyaella	65	65		3
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Coleoptera	Dytiscidae (larvae)		1	1		3
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Coleoptera	Halplidae (larvae)		2	2		4
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Diptera	Ceratopogonidae		32	32		6
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		6
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	9	9		7
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Ephemeroptera	Baetidae		2	2		3
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Ephemeroptera	Caenidae		150	150		4
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Hemiptera	Corixidae		5	5		3
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Hydrophila	Planorbidae		4	4		2
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Odonata	Coenagrionidae		4	4		7
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Odonata	Cordulidae		3	3		5
2017	Summer	22-May	Carubahn	SAV	3	>1	1	Ostracoda			1	1		1
2017	Summer	22-May	East P.W.	DET	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	1	1		3
2017	Summer	22-May	East P.W.	DET	1	>1	1	Coleoptera	Hydrophilidae (larvae)		1	1		4
2017	Summer	22-May	East P.W.	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		4
2017	Summer	22-May	East P.W.	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		9
2017	Summer	22-May	East P.W.	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		7
2017	Summer	22-May	East P.W.	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		5
2017	Summer	22-May	East P.W.	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	2	2		8
2017	Summer	22-May	East P.W.	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	3	3		6
2017	Summer	22-May	East P.W.	DET	1	>1	1	Hemiptera	Corixidae		1	1		5
2017	Summer	22-May	East P.W.	DET	1	>1	1	Oligochaete			3	3		5
2017	Summer	22-May	East P.W.	DET	1	>1	1	Ostracoda			2	2		2
2017	Summer	22-May	East P.W.	DET	1	>1	1	Veneroida	Sphaeriidae		5	5		4
2017	Summer	22-May	East P.W.	DET	1	>1	1	Veneroida	Sphaeriidae		7	7		5
2017	Summer	22-May	East P.W.	DET	2	>1	1	Decapoda	Cambaridae	Cambarinae	1	1		33
2017	Summer	22-May	East P.W.	DET	2	>1	1	Decapoda	Cambaridae	Cambarinae	1	1		20
2017	Summer	22-May	East P.W.	DET	2	>1	1	Diptera	Chaoboridae		1	1		9
2017	Summer	22-May	East P.W.	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		12
2017	Summer	22-May	East P.W.	DET	2	>1	1	Diptera	Chironomidae	Tanypodinae	7	7		7
2017	Summer	22-May	East P.W.	DET	2	>1	1	Hemiptera	Corixidae		4	4		4
2017	Summer	22-May	East P.W.	DET	2	>1	1	Hemiptera	Corixidae		2	2		5
2017	Summer	22-May	East P.W.	DET	2	>1	1	Hydrophila	Physidae		1	1		2
2017	Summer	22-May	East P.W.	DET	2	>1	1	Hydrophila	Planorbidae		1	1		2
2017	Summer	22-May	East P.W.	DET	2	>1	1	Veneroida	Sphaeriidae		2	2		7
2017	Summer	22-May	East P.W.	DET	2	>1	1	Veneroida	Sphaeriidae		4	4		3
2017	Summer	22-May	East P.W.	DET	2	>1	1	Veneroida	Sphaeriidae		10	10		5
2017	Summer	22-May	East P.W.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		7
2017	Summer	22-May	East P.W.	DET	3	>1	1	Hemiptera	Belostomatidae		1	1		6
2017	Summer	22-May	East P.W.	DET	3	>1	1	Hemiptera	Corixidae		1	1		6
2017	Summer	22-May	East P.W.	DET	3	>1	1	Hemiptera	Corixidae		1	1		4
2017	Summer	22-May	East P.W.	DET	3	>1	1	Hemiptera	Corixidae		1	1		2
2017	Summer	22-May	East P.W.	DET	3	>1	1	Oligochaete			2	2		5
2017	Summer	22-May	East P.W.	DET	3	>1	1	Veneroida	Sphaeriidae		4	4		5
2017	Summer	22-May	East P.W.	DET	3	>1	1	Veneroida	Sphaeriidae		5	5		3
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	2	2		5
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Amphipoda	Crangonyctidae	Crangonyx	7	7		2
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Coleoptera	Hydrophilidae (adult)		1	1		4
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Decapoda	Cambaridae	Cambarinae	1	1		15
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Diptera	Ceratopogonidae		1	1		9
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		9
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Diptera	Chironomidae					

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	1	1		4
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Hemiptera	Belostomatidae		1	1		14
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Hemiptera	Belostomatidae		1	1		8
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Hemiptera	Corixidae		4	4		3
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Hygrophila	Lymnaeidae		2	2		4
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Odonata	Aeshnidae		1	1		15
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Odonata	Coenagrionidae		1	1		11
2017	Summer	22-May	East P.W.	SAV	1	>1	1	Veneroida	Sphaeriidae		1	1		5
2017	Summer	22-May	East P.W.	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		5
2017	Summer	22-May	East P.W.	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	4	4		3
2017	Summer	22-May	East P.W.	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	1	1		7
2017	Summer	22-May	East P.W.	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	2	2		4
2017	Summer	22-May	East P.W.	SAV	2	>1	1	Hygrophila	Physidae		1	1		2
2017	Summer	22-May	East P.W.	SAV	2	>1	1	Odonata	Coenagrionidae		1	1		15
2017	Summer	22-May	East P.W.	SAV	2	>1	1	Oligochaete			2	2		5
2017	Summer	22-May	East P.W.	SAV	2	>1	3	Ostracoda			3	3		2
2017	Summer	22-May	East P.W.	SAV	2	>1	1	Veneroida	Sphaeriidae		1	1		7
2017	Summer	22-May	East P.W.	SAV	2	>1	1	Veneroida	Sphaeriidae		2	2		5
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Amphipoda	Crangonyctidae	Crangonyx	1	1		4
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Coleoptera	Dytiscidae (adult)		1	1		2
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Decapoda	Palaeonetes		1	1		11
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		8
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		6
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	1	1		8
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	3	3		6
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Hemiptera	Corixidae		1	1		4
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Hemiptera	Corixidae		1	1		2
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Hemiptera	Corixidae		2	2		3
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Hemiptera	Corixidae		4	4		5
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Ostracoda			1	1		2
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Veneroida	Sphaeriidae		1	1		8
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Veneroida	Sphaeriidae		1	1		3
2017	Summer	22-May	East P.W.	SAV	3	>1	1	Veneroida	Sphaeriidae		4	4		4
2017	Summer	22-May	Gubanski	DET	1	>1	1	Coleoptera	Dytiscidae (larvae)		1	1		4
2017	Summer	22-May	Gubanski	DET	1	>1	1	Decapoda	Cambaridae	Cambarinae	1	1		19
2017	Summer	22-May	Gubanski	DET	1	>1	1	Decapoda	Palaeonetes		1	1		9
2017	Summer	22-May	Gubanski	DET	1	>1	1	Diptera	Ceratopogonidae		1	1		6
2017	Summer	22-May	Gubanski	DET	1	>1	1	Diptera	Ceratopogonidae		2	2		5
2017	Summer	22-May	Gubanski	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		5
2017	Summer	22-May	Gubanski	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	1	1		13
2017	Summer	22-May	Gubanski	DET	1	>1	1	Diptera	Chironomidae		2	2		4
2017	Summer	22-May	Gubanski	DET	1	>1	1	Diptera	Chironomidae		5	5		8
2017	Summer	22-May	Gubanski	DET	1	>1	1	Hemiptera	Corixidae		1	1		4
2017	Summer	22-May	Gubanski	DET	1	>1	1	Hemiptera	Corixidae		1	1		3
2017	Summer	22-May	Gubanski	DET	1	>1	1	Hemiptera	Corixidae		7	7		5
2017	Summer	22-May	Gubanski	DET	1	>1	1	Hygrophila	Lymnaeidae		2	2		3
2017	Summer	22-May	Gubanski	DET	1	>1	1	Odonata	Corduliidae		1	1		16
2017	Summer	22-May	Gubanski	DET	1	>1	1	Oligochaete			3	3		15
2017	Summer	22-May	Gubanski	DET	1	>1	1	Rhynchobdellida	Glossiphoniidae		1	1		7
2017	Summer	22-May	Gubanski	DET	2	>1	1	Amphipoda	Dogielnotidae	Hyalella	10	10		15
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Ceratopogonidae		1	1		8
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Ceratopogonidae		2	2		12
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Ceratopogonidae		2	2		6
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Ceratopogonidae		6	6		5
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		3
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	4	4		7
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	8	8		5
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Chironomidae	Tanypodinae	8	8		3
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Chironomidae	Tanypodinae	8	8		8
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Coenagrionidae		1	1		10
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Coenagrionidae		1	1		9
2017	Summer	22-May	Gubanski	DET	2	>1	1	Diptera	Coenagrionidae		1	1		8
2017	Summer	22-May	Gubanski	DET	2	>1	1	Hemiptera	Corixidae		1	1		4
2017	Summer	22-May	Gubanski	DET	2	>1	1	Hemiptera	Corixidae		1	1		3
2017	Summer	22-May	Gubanski	DET	2	>1	1	Hemiptera	Corixidae		5	5		5
2017	Summer	22-May	Gubanski	DET	2	>1	1	Hygrophila	Physidae		1	1		5
2017	Summer	22-May	Gubanski	DET	2	>1	1	Hygrophila	Physidae		1	1		4
2017	Summer	22-May	Gubanski	DET	2	>1	1	Hygrophila	Physidae		1	1		3
2017	Summer	22-May	Gubanski	DET	2	>1	1	Hygrophila	Planorbidae		2	2		2
2017	Summer	22-May	Gubanski	DET	2	>1	1	Oligochaete			3	3		5
2017	Summer	22-May	Gubanski	DET	2	>1	1	Oligochaete			8	8		8
2017	Summer	22-May	Gubanski	DET	2	>1	1	Oligochaete			10	10		15
2017	Summer	22-May	Gubanski	DET	2	>1	1	Oligochaete			11	11		12
2017	Summer	22-May	Gubanski	DET	2	>1	1	Veneroida	Sphaeriidae		3	3		3
2017	Summer	22-May	Gubanski	DET	2	>1	1	Coleoptera	Chrysomelidae (adult)		3	3		3
2017	Summer	22-May	Gubanski	DET	3	>1	1	Coleoptera	Dytiscidae (larvae)		3	3		3
2017	Summer	22-May	Gubanski	DET	3	>1	1	Decapoda	Palaeonetes		3	3		5
2017	Summer	22-May	Gubanski	DET	3	>1	1	Diptera	Ceratopogonidae		1	1		10
2017	Summer	22-May	Gubanski	DET	3	>1	1	Diptera	Ceratopogonidae		1	1		8
2017	Summer	22-May	Gubanski	DET	3	>1	1	Diptera	Ceratopogonidae		2	2		12
2017	Summer	22-May	Gubanski	DET	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	12	12		6
2017	Summer	22-May	Gubanski	DET	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	13	13		7
2017	Summer	22-May	Gubanski	DET	3	>1	1	Diptera	Chironomidae	Tanypodinae	2	2		8
2017	Summer	22-May	Gubanski	DET	3	>1	1	Diptera	Chironomidae	Tanypodinae	3	3		4
2017	Summer	22-May	Gubanski	DET	3	>1	1	Ephemeroptera	Baetidae		1	1		8
2017	Summer	22-May	Gubanski	DET	3	>1	1	Hemiptera	Corixidae		1	1		2
2017	Summer	22-May	Gubanski	DET	3	>1	1	Odonata	Coenagrionidae		1	1		6
2017	Summer	22-May	Gubanski	DET	3	>1	1	Oligochaete			1	1		6
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Coleoptera	Dytiscidae (larvae)		1	1		3
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Decapoda	Palaeonetes		2	2		9
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Ceratopogonidae		2	2		10
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Ceratopogonidae		3	3		5
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		3
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1	1		2
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		9
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		8
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		7
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		5
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	4	4		4
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	1	1		7
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	7	7		5
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Hemiptera	Belostomatidae		1	1		5
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Hemiptera	Corixidae		1	1		2
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Hygrophila	Planorbidae		1	1		2
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Isopoda	Asellidae	Caecidota	2	2		4
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Odonata	Coenagrionidae		2	2		10
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Odonata	Coenagrionidae		3	3		9
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Oligochaete			1	1		9
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Oligochaete			1	1		8
2017	Summer	22-May	Gubanski	SAV	1	>1	1	Oligochaete			1	1		5
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Acariformes	Hydrachnida		3	3		1
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Amphipoda	Dogielnotidae	Hyalella	2	2		3
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Coleoptera	Dytiscidae (larvae)		1	1		3
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Coleoptera	Dytiscidae (larvae)		3	3		4
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Coleoptera	Hydrophilidae	Berosus (larvae)	1	1		

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Ceratopogonidae		2	2		8
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Ceratopogonidae		3	3		9
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Ceratopogonidae		3	3		7
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Ceratopogonidae		3	3		6
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Ceratopogonidae		4	4		11
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Ceratopogonidae		6	6		10
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	2	2		3
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		9
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	5	5		4
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	9	9		5
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	9	9		7
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	10	10		6
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	12	12		8
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	2	2		3
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	3	3		7
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	6	6		5
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	11	11		6
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	12	12		4
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Ephemeroptera	Baetidae		2	2		8
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Ephemeroptera	Caenidae		6	6		5
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Hemiptera	Mesoveliidae		1	1		5
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Hygrophila	Physidae		4	4		3
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Hygrophila	Planorbidae		1	1		3
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Hydrophila	Planorbidae		3	3		2
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Odonata	Coenagrionidae		1	1		10
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Odonata	Odonata		1	1		4
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Odonata	Coenagrionidae		2	2		7
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Odonata	Coenagrionidae		4	4		8
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Odonata	Corduliidae		1	1		19
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Odonata	Corduliidae		1	1		2
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Odonata	Corduliidae		2	2		3
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Oligochaeta			2	2		8
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Ostracoda			2	2		1
2017	Summer	22-May	Gubanski	SAV	2	>1	1	Trichoptera	Leptoceridae	Oecetis	1	1		3
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Amphipoda	Dogielinotidae	Hyalella	44	44		3
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Coleoptera	Dytiscidae (larvae)		3	3		5
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Coleoptera	Dytiscidae (larvae)		3	3		4
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Ceratopogonidae		5	5		6
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Ceratopogonidae		8	8		9
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Ceratopogonidae		12	12		10
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Ceratopogonidae		7	7		7
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	9	9		10
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	20	20		7
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	20	20		5
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	20	20		4
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	30	30		6
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	2	2		8
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	18	18		6
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	22	22		5
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Ephemeroptera	Baetidae		2	2		7
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Ephemeroptera	Caenidae		3	3		5
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Hemiptera	Pleidae		1	1		2
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Hydrophila	Physidae		3	3		3
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Hydrophila	Planorbidae		6	6		2
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Isopoda	Asellidae	Caecidota	2	2		4
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Odonata	Coenagrionidae		5	5		8
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Odonata	Corduliidae		2	2		5
2017	Summer	22-May	Gubanski	SAV	3	>1	1	Odonata	Corduliidae		2	2		18
2017	Summer	22-May	North P.W.	DET	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	68	68		3
2017	Summer	22-May	North P.W.	DET	1	>1	1	Coleoptera	Chrysomelidae (larvae)		2	2		15
2017	Summer	22-May	North P.W.	DET	1	>1	1	Decapoda	Palaemonetes		2	2		8
2017	Summer	22-May	North P.W.	DET	1	>1	1	Diptera	Ceratopogonidae		12	12		4
2017	Summer	22-May	North P.W.	DET	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	10	10		8
2017	Summer	22-May	North P.W.	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	9	9		6
2017	Summer	22-May	North P.W.	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	10	10		10
2017	Summer	22-May	North P.W.	DET	1	>1	1	Diptera	Chironomidae	Tanypodinae	10	10		8
2017	Summer	22-May	North P.W.	DET	1	>1	1	Ephemeroptera	Caenidae		1	1		6
2017	Summer	22-May	North P.W.	DET	1	>1	1	Neuroptera	Sisyridae	Sisyra	1	1		4
2017	Summer	22-May	North P.W.	DET	2	>1	1	Amphipoda	Dogielinotidae	Hyalella	16	16		4
2017	Summer	22-May	North P.W.	DET	2	>1	1	Coleoptera	Chrysomelidae (larvae)		1	1		23
2017	Summer	22-May	North P.W.	DET	2	>1	1	Coleoptera	Chrysomelidae (larvae)		2	2		15
2017	Summer	22-May	North P.W.	DET	2	>1	1	Coleoptera	Chrysomelidae (larvae)		3	3		6
2017	Summer	22-May	North P.W.	DET	2	>1	1	Diptera	Ceratopogonidae		1	1		8
2017	Summer	22-May	North P.W.	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		7
2017	Summer	22-May	North P.W.	DET	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	7	7		12
2017	Summer	22-May	North P.W.	DET	2	>1	1	Diptera	Chironomidae	Tanypodinae	6	6		8
2017	Summer	22-May	North P.W.	DET	2	>1	1	Diptera	Chironomidae	Tanypodinae	10	10		4
2017	Summer	22-May	North P.W.	DET	2	>1	1	Hirudinea			1	1		4
2017	Summer	22-May	North P.W.	DET	2	>1	1	Hirudinea			3	3		11
2017	Summer	22-May	North P.W.	DET	3	>1	1	Amphipoda	Dogielinotidae	Hyalella	8	8		4
2017	Summer	22-May	North P.W.	DET	3	>1	1	Amphipoda	Dogielinotidae	Hyalella	46	46		3
2017	Summer	22-May	North P.W.	DET	3	>1	1	Coleoptera	Chrysomelidae (larvae)		1	1		10
2017	Summer	22-May	North P.W.	DET	3	>1	1	Coleoptera	Chrysomelidae (larvae)		3	3		6
2017	Summer	22-May	North P.W.	DET	3	>1	1	Decapoda	Palaemonetes		1	1		5
2017	Summer	22-May	North P.W.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	15	15		8
2017	Summer	22-May	North P.W.	DET	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	19	19		13
2017	Summer	22-May	North P.W.	DET	3	>1	1	Diptera	Chironomidae	Tanypodinae	12	12		10
2017	Summer	22-May	North P.W.	DET	3	>1	1	Diptera	Chironomidae	Tanypodinae	20	20		8
2017	Summer	22-May	North P.W.	DET	3	>1	1	Ephemeroptera	Caenidae		5	5		4
2017	Summer	22-May	North P.W.	DET	3	>1	1	Ephemeroptera	Caenidae		6	6		5
2017	Summer	22-May	North P.W.	DET	3	>1	1	Hemiptera	Corixidae		1	1		3
2017	Summer	22-May	North P.W.	DET	3	>1	1	Hirudinea			4	4		14
2017	Summer	22-May	North P.W.	DET	3	>1	1	Trichoptera	Hydroptilinae	Oxyethira	1	1		2
2017	Summer	22-May	North P.W.	DET	3	>1	1	Trichoptera	Leptoceridae	Oecetis	1	1		3
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	2	2		5
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	9	9		4
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Amphipoda	Dogielinotidae	Hyalella	10	10		3
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Coleoptera	Dytiscidae (adult)		1	1		5
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Coleoptera	Dytiscidae (adult)		2	2		4
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Diptera	Ceratopogonidae		1	1		10
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Diptera	Ceratopogonidae		1	1		9
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Diptera	Ceratopogonidae		1	1		8
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3	3		8
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Diptera	Chironomidae	Non-Tanypodinae	7	7		5
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	8	8		8
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Diptera	Chironomidae	Tanypodinae	8	8		5
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Ephemeroptera	Baetidae		3	3		4
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Ephemeroptera	Caenidae		9	9		5
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Ephemeroptera	Caenidae		9	9		3
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Hemiptera	Pleidae		1	1		3
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Hydrophila	Physidae		1	1		2
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Odonata	Coenagrionidae		1	1		6
2017	Summer	22-May	North P.W.	SAV	1	>1	1	Odonata	Corduliidae		1	1		

WOB Macroinvertebrate Data														
Year	Season	Date	Site	Habitat	Replication	Subfraction (> or < 1)	Subsample (fraction)	Order	Family	Genus	Abundance	Fixed Abundance (accounts for subsampling)	FFG	Size Class*
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Coleoptera	Dytiscidae (adult)		4			3
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Coleoptera	Dytiscidae (larvae)		2			4
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Coleoptera	Noteridae (larvae)		1			4
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Decapoda	Palaeomonetes		1			3
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Diptera	Ceratopogonidae		2			12
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Diptera	Ceratopogonidae		2			6
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Diptera	Chironomidae	Non-Tanypodinae	4			8
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Diptera	Chironomidae	Tanypodinae	49			8
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Ephemeroptera	Baetidae		5			6
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Ephemeroptera	Caenidae		50			5
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Ephemeroptera	Caenidae		53			3
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Hirudinea			1			13
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Hygrophila	Physidae		2			4
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Hygrophila	Planorbidae		2			5
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Odonata	Coenagrionidae		1			16
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Odonata	Coenagrionidae		5			9
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Odonata	Corduliidae		1			16
2017	Summer	22-May	North P.W.	SAV	2	>1	1	Veneroida	Sphaeriidae		2			3
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Amphipoda	Dogielinotidae	Hyaella	6			3
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Amphipoda	Dogielinotidae	Hyaella	8			4
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Coleoptera	Dytiscidae (larvae)		1			3
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Coleoptera	Noteridae (larvae)		1			3
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Diptera	Ceratopogonidae		1			12
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Diptera	Ceratopogonidae		1			9
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1			8
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	1			5
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Diptera	Chironomidae	Non-Tanypodinae	3			4
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	3			5
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Diptera	Chironomidae	Tanypodinae	4			8
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Ephemeroptera	Baetidae		6			6
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Ephemeroptera	Caenidae		2			3
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Ephemeroptera	Caenidae		40			5
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Ephemeroptera	Caenidae		40			4
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Hirudinea			1			11
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Hygrophila	Physidae		1			4
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Hygrophila	Physidae		1			2
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Odonata	Coenagrionidae		1			8
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Odonata	Coenagrionidae		1			4
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Odonata	Coenagrionidae		4			5
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Odonata	Corduliidae		1			3
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Ostracoda			1			2
2017	Summer	22-May	North P.W.	SAV	3	>1	1	Veneroida	Sphaeriidae		11			2

**Stream Storm Flow Summary**

Site	Date	Waterbody	Lat	Long	Flow	Nitrate-nitrite					Mean Ash-					Temp (°C)	pH (s.u.)	ORP (mV)	SpCond (µS/cm)	Sal (ppt)	TurbSC (NTU)	LDO (% sat)	LDO (mg/L)
						TN (mg/L)	TP (mg/L)	(mg/L)	(mg/L)	Ammoniu m (mg/L)	MeanTDS (mg/L)	Free TSS (mg/L)	MeanTSS (mg/L)										
Ballfields	24-Feb-16	Stream	34.84611	-92.38044	storm	1.25	0.282	0.32	0.091	0.21	181.23	231.1	257.26	14.8	4.06	559	188	0.09	64.7	82.7	8.32		
Ballfields	10-Mar-16	Stream	34.84611	-92.38044	storm	0.7	0.136	0.08	0.025	0.11	181.23	257.26	47.16	14.74	6.71	449	41	0.01	139.2	53.5	5.43		
Ballfields	28-Nov-16	Stream	34.84611	-92.38044	storm	1.51	0.402	0.68	0.182	0.08	64.784841	47.6412417	56.134495	12.01	6.89	484	134	0.06	1218	NA	NA		
Ballfields	23-Nov-16	Stream	34.84611	-92.38044	storm	1.14	0.235	0.26	0.033	0.03	436.86605	32.268733	36.652331	13.96	5.92	422	122	0.05	33.5	70.4	7.27		
Ballfields	22-Jan-17	Stream	34.84611	-92.38044	storm	0.9	0.166	0.14	0.03	0.06	94.806958	44.6359517	98.475339	12.92	5.93	385	87	NA	95.3	NA	NA		
					average	1.1	0.2442	0.296	0.0722	0.098	191.78357	122.581185	99.136433	13.686	5.902	459.8	114.4	0.0525	310.14	68.86667	7.006667		
					min	0.7	0.136	0.08	0.025	0.03	64.784841	32.268733	36.652331	12.01	4.06	385	41	0.01	33.5	53.5	5.43		
					max	1.51	0.402	0.68	0.182	0.21	436.86605	257.26	257.26	14.8	6.89	559	188	0.09	1218	82.7	8.32		
Banaszak	24-Feb-16	Stream	34.88532	-92.35166	storm	1.26	0.138	0.42	0.057	0.23	108.18	37.43	47.16	8.42	4.12	512	177	0.08	24.1	84.7	9.92		
Banaszak	10-Mar-16	Stream	34.88532	-92.35166	storm	0.67	0.114	0.1	0.047	0.14	108.18	47.16	34.59	14.56	6.6	420	35	0	49.2	70.4	7.17		
Banaszak	28-Nov-16	Stream	34.88532	-92.35166	storm	1.66	0.349	0.57	0.17	0.3	68.283705	49.1153744	62.045665	11.97	5.56	507	59	0.02	NA	NA	NA		
Banaszak	23-Nov-16	Stream	34.88532	-92.35166	storm	1.94	0.475	1.19	0.411	0.03	152.48134	28.4757632	34.765078	14	5.64	431	126	0.05	36.9	81.8	8.44		
Banaszak	22-Jan-17	Stream	34.88532	-92.35166	storm	1.12	0.159	0.27	0.045	0.15	80.816329	81.4365497	55.807173	12.43	5.51	489	100	NA	34.5	68	7.26		
					average	1.33	0.247	0.51	0.146	0.17	103.58827	48.7235375	46.873583	12.276	5.486	471.8	99.4	0.0375	36.175	76.225	8.1975		
					min	0.67	0.114	0.1	0.045	0.03	68.283705	28.4757632	34.59	8.42	4.12	420	35	0	24.1	68	7.17		
					max	1.94	0.475	1.19	0.411	0.3	152.48134	81.4365497	62.045665	14.56	6.6	512	177	0.08	49.2	84.7	9.92		
BurnsPark	24-Feb-16	Stream	34.80231	-92.32689	storm	0.89	0.088	0.37	0.041	0.1	124.06	30.92	34.59	10.3	4.15	489	179	0.08	47.2	84.9	9.51		
BurnsPark	10-Mar-16	Stream	34.80231	-92.32689	storm	0.53	0.094	0.15	0.043	0.1	124.06	34.59	257.26	14.68	7.57	420	61	0.02	42.3	75.7	7.69		
BurnsPark	28-Nov-16	Stream	34.80231	-92.32689	storm	1.62	0.327	0.87	0.138	0.13	88.493376	71.493096	81.115367	12.36	6.23	466	91	0.03	NA	NA	NA		
BurnsPark	23-Nov-16	Stream	34.80231	-92.32689	storm	0.95	0.074	0	0.012	0.05	188.19359	13.2477153	17.985843	11.26	6.53	510	162	0.07	11.3	83.6	9.17		
BurnsPark	22-Jan-17	Stream	34.80231	-92.32689	storm	0.95	0.086	0.29	0.024	0.08	145.61309	14.6099451	43.794496	12.8	6.2	484	205	NA	46.5	79.5	8.42		
					average	0.988	0.1338	0.336	0.0516	0.092	134.08401	32.9721513	86.949141	12.28	6.136	473.8	139.6	0.05	36.825	80.925	8.6975		
					min	0.53	0.074	0	0.012	0.05	88.493376	13.2477153	17.985843	10.3	4.15	420	61	0.02	11.3	75.7	7.69		
					max	1.62	0.327	0.87	0.138	0.13	188.19359	71.493096	257.26	14.68	7.57	510	205	0.08	47.2	84.9	9.51		
DogPark	24-Feb-16	Stream	34.85177	-92.39407	storm	1.14	0.1	0.56	0.057	0.14	155.59	22.48	25.5	11.56	4.36	550	185	0.08	18.2	81.5	8.87		
DogPark	10-Mar-16	Stream	34.85177	-92.39407	storm	0.6	0.076	0.18	0.037	0.17	155.59	25.5	103.09	15.21	7.23	430	54	0.01	28	72.8	7.31		
DogPark	28-Nov-16	Stream	34.85177	-92.39407	storm	0.72	0.137	0.33	0.08	0.06	84.303712	24.3237384	29.355126	12.82	6.02	483	54	0.01	59.4	NA	NA		
DogPark	23-Nov-16	Stream	34.85177	-92.39407	storm	0.69	0.079	0.31	0.035	0.03	117.8246	13.7506887	17.155437	14.89	6.06	406	131	0.05	17.8	74.7	7.55		
DogPark	22-Jan-17	Stream	34.85177	-92.39407	storm	0.83	0.117	0.29	0.033	0.05	87.156849	55.3823904	41.820664	13.07	6	445	102	NA	17.2	NA	NA		
					average	0.796	0.1018	0.334	0.0484	0.09	120.09303	28.2873635	43.384245	13.51	5.934	462.8	105.2	0.0375	28.12	76.33333	7.91		
					min	0.6	0.076	0.18	0.033	0.03	84.303712	13.7506887	17.155437	11.56	4.36	406	54	0.01	17.2	72.8	7.31		
					max	1.14	0.137	0.56	0.08	0.17	155.59	55.3823904	103.09	15.21	7.23	550	185	0.08	59.4	81.5	8.87		
GolfCourse	24-Feb-16	Stream	34.84334	-92.39408	storm	0.34	0.168	0.63	0.085	0.18	171.21	41.55	47.85	20.53	4.2	623	96	0.04	2.2	84.2	9.23		
GolfCourse	10-Mar-16	Stream	34.84334	-92.39408	storm	0.83	0.094	0.22	0.067	0.16	368.86	103.09	25.5	14.84	6.95	435	64	0.02	43.2	67.3	6.81		
GolfCourse	28-Nov-16	Stream	34.84334	-92.39408	storm	0.84	0.197	0.25	0.108	0.11	81.154028	28.3061639	35.956932	11.71	6.02	494	90	0.03	1199	NA	NA		
GolfCourse	23-Nov-16	Stream	34.84334	-92.39408	storm	0.84	0.176	0.32	0.089	0.05	101.97657	25.9486165	32.777816	14.66	5.79	417	144	0.06	46.1	67.9	6.9		
GolfCourse	22-Jan-17	Stream	34.84334	-92.39408	storm	0.95	0.12	0.22	0.04	0.08	116.97991	36.4513645	35.593617	13.13	5.96	419	168	NA	40.5	NA	NA		
					average	0.76	0.151	0.328	0.0778	0.116	168.0361	47.069229	35.535673	14.974	5.784	477.6	112.4	0.0375	266.2	73.13333	7.646667		
					min	0.34	0.094	0.22	0.04	0.05	81.154028	25.9486165	25.5	11.71	4.2	417	64	0.02	2.2	67.3	6.81		
					max	0.95	0.197	0.63	0.108	0.18	368.86	103.09	47.85	20.53	6.95	623	168	0.06	1199	84.2	9.23		
Henry	24-Feb-16	Stream	34.8662	-92.35101	storm	0.6	0.038	0.15	0.02	0.11	90.18	21.11	23.62	8.36	5.68	469	44	0.01	21.9	73.9	8.68		
Henry	10-Mar-16	Stream	34.8662	-92.35101	storm	0.41	0.048	0.07	0.018	0.08	90.18	23.62	23.76	13.95	7	423	24	0	23.5	75.8	7.82		
Henry	28-Nov-16	Stream	34.8662	-92.35101	storm	0.85	0.226	0	0.033	0.02	71.318889	48.5925889	66.882815	NA	NA	NA	NA	NA	NA	NA	NA		
Henry	23-Nov-16	Stream	34.8662	-92.35101	storm	0.91	0.24	0	0.04	0.02	127.43308	78.929703	95.817443	11.57	5.55	471	62	0.02	82.7	16.8	1.83		
Henry	22-Jan-17	Stream	34.8662	-92.35101	storm	0.36	0.053	0	0.008	0.02	58.595869	33.3070515	15.438011	11.51	5.32	504	76	NA	12.2	40.5	4.42		
					average	0.626	0.121	0.044	0.0238	0.05	87.541568	41.1118687	45.103654	11.3475	5.8875	466.75	51.5	0.01	35.075	51.75	5.6875		
					min	0.36	0.038	0	0.008	0.02	58.595869	21.11	15.438011	8.36	5.32	423	24	0	12.2	16.8	1.83		
					max	0.91	0.24	0.15	0.04	0.11	127.43308	78.929703	95.817443	13.95	7	504	76	0.02	82.7	75.8	8.68		
PumpStatic	24-Feb-16	Stream	34.81342	-92.34218	storm	0.98	0.118	0.49	0.059	0.11	176.13	29.95	34.94	7.84	4.06	503	179	0.08	131.4	85	10.11		
PumpStatic	10-Mar-16	Stream	34.81342	-92.34218	storm	0.58	0.032	0.17	0.042	0.09	176.13	34.94	38.26	14.85	7.49	422	58	0.02	34.7	76.4	7.73		

PumpStatic	28-Nov-16	Stream	34.81342	-92.34218	storm	1.3	0.329	0.73	0.198	0.04	68.32559	53.4402045	61.449095	12.54	5.53	539	70	0.02	152.1	NA	NA
PumpStatic	23-Nov-16	Stream	34.81342	-92.34218	storm	2.16	0.402	1.49	0.247	0.04	126.2645	66.1575666	68.646745	19.68	6.54	427	107	0.04	58.9	99	9.07
PumpStatic	22-Jan-17	Stream	34.81342	-92.34218	storm	1.13	0.186	0.38	0.065	0.05	141.15119	58.196913	67.905705	12.94	6.31	422	208	NA	115.5	NA	NA
					average	1.23	0.2134	0.652	0.1222	0.066	137.60026	48.5369368	54.240309	13.57	5.986	462.6	124.4	0.04	98.52	86.8	8.97
					min	0.58	0.032	0.17	0.042	0.04	68.32559	29.95	34.94	7.84	4.06	422	58	0.02	34.7	76.4	7.73
					max	2.16	0.402	1.49	0.247	0.11	176.13	66.1575666	68.646745	19.68	7.49	539	208	0.08	152.1	99	10.11
Sharkey	24-Feb-16	Stream	34.87735	-92.38705	storm	1.21	0.114	0.61	0.051	0.19	170.94	33.25	38.26	9.38	4.27	533	184	0.08	22.7	77.1	8.83
Sharkey	10-Mar-16	Stream	34.87735	-92.38705	storm	0.72	0.054	0.2	0.046	0.11	170.94	38.26	36.59	14.72	7.36	423	56	0.01	43.6	74.1	7.51
Sharkey	28-Nov-16	Stream	34.87735	-92.38705	storm	1.06	0.473	0.47	0.123	0.28	66.847653	197.547832	219.4255	12.5	5.96	489	68	0.02	444	NA	NA
Sharkey	23-Nov-16	Stream	34.87735	-92.38705	storm	1.18	0.206	0.66	0.121	0.05	108.44003	35.4723384	42.315091	14.63	5.84	424	121	0.05	41.8	72.9	7.41
Sharkey	22-Jan-17	Stream	34.87735	-92.38705	storm	0.94	0.154	0.34	0.038	0.06	94.499118	10.0859262	68.890896	12.65	5.98	448	117	NA	4.4	NA	NA
					average	1.022	0.2002	0.456	0.0758	0.138	122.33336	62.9232194	81.096297	12.776	5.882	463.4	109.2	0.04	111.3	74.7	7.916667
					min	0.72	0.054	0.2	0.038	0.05	66.847653	10.0859262	36.59	9.38	4.27	423	56	0.01	4.4	72.9	7.41
					max	1.21	0.473	0.66	0.123	0.28	170.94	197.547832	219.4255	14.72	7.36	533	184	0.08	444	77.1	8.83
ShortMarcl	24-Feb-16	Stream	34.83819	-92.35514	storm	0.64	0.062	0.25	0.023	0.13	123.77	20.95	23.76	7.8	4.13	509	183	0.08	26.5	82.3	9.79
ShortMarcl	10-Mar-16	Stream	34.83819	-92.35514	storm	0.41	0.056	0.09	0.02	0.09	123.77	23.76	34.94	13.71	7.03	435	27	0	21.6	73	7.57
ShortMarcl	28-Nov-16	Stream	34.83819	-92.35514	storm	0.92	0.189	0.07	0.085	0.03	95.301673	28.3207172	38.798545	10.44	5.73	518	106	0.04	130.3	NA	NA
ShortMarcl	23-Nov-16	Stream	34.83819	-92.35514	storm	0.83	0.142	0.03	0.019	0	144.68821	28.7734528	38.592066	17.31	5.79	383	134	0.06	252.2	100	9.61
ShortMarcl	22-Jan-17	Stream	34.83819	-92.35514	storm	0.41	0.057	0.08	0.012	0.04	70.136426	84.0227168	19.314927	12.76	5.48	481	90	NA	5.8	NA	NA
					average	0.642	0.1012	0.104	0.0318	0.058	111.53326	37.1653774	31.081108	12.404	5.632	465.2	108	0.045	87.28	85.1	8.99
					min	0.41	0.056	0.03	0.012	0	70.136426	20.95	19.314927	7.8	4.13	383	27	0	5.8	73	7.57
					max	0.92	0.189	0.25	0.085	0.13	144.68821	84.0227168	38.798545	17.31	7.03	518	183	0.08	252.2	100	9.79
Vestal	24-Feb-16	Stream	34.82485	-92.36754	storm	0.72	0.094	0.15	0.051	0.11	126.33	33.02	36.59	9.31	6.32	428	122	0.01	32.7	78	8.95
Vestal	10-Mar-16	Stream	34.82485	-92.36754	storm	0.48	0.032	0.07	0.028	0.11	126.33	36.59	23.62	14.94	6.78	429	62	0.02	33	62.9	6.35
Vestal	28-Nov-16	Stream	34.82485	-92.36754	storm	0.84	0.305	0.3	0.131	0.05	54.128637	106.957971	119.57181	12.33	5.95	529	52	0.01	249.5	NA	NA
Vestal	23-Nov-16	Stream	34.82485	-92.36754	storm	0.95	0.194	0.4	0.095	0.03	110.47945	47.1071946	52.331219	17.51	6.46	414	118	0.05	8.7	99.6	9.53
Vestal	22-Jan-17	Stream	34.82485	-92.36754	storm	1.24	0.216	0.47	0.045	0.13	93.767837	26.9505267	95.422037	12.98	5.92	419	119	NA	92.6	NA	NA
					average	0.846	0.1682	0.278	0.07	0.086	102.20718	50.1251385	65.507013	13.414	6.286	443.8	94.6	0.0225	83.3	80.16667	8.276667
					min	0.48	0.032	0.07	0.028	0.03	54.128637	26.9505267	23.62	9.31	5.92	414	52	0.01	8.7	62.9	6.35
					max	1.24	0.305	0.47	0.131	0.13	126.33	106.957971	119.57181	17.51	6.78	529	122	0.05	249.5	99.6	9.53

# Appendix D

Possible BMPs

<b>ST-1</b>	Stormwater Treatment Options	
	<b>EXTENDED DETENTION</b>	

This option relies on 12 to 24 hour detention of stormwater runoff after each rain event. An under-sized outlet structure restricts stormwater flow so it backs up and is stored within a pond or wetland. The temporary ponding enables particulate pollutants to settle out and reduces the effective shear stress on downstream banks. Extended Detention (ED) differs from stormwater detention, which is used for peak discharge or flood control purposes and often detains flows for just a few minutes or hours. ED is normally combined with other stormwater treatment options such as wet ponds and constructed wetlands to enhance retrofit performance and appearance (Figure 1). The most common design variations for ED retrofits include:

- Micropool Extended Detention (Water Quality)
- Micropool Extended Detention (Channel Protection)

- Wet Extended Detention Pond
- ED Wetlands

Schematics of each ED retrofit design variation are provided in Figure 2. ED is an ideal stormwater treatment option because it is cost-effective, versatile and safe, and is also the preferred stormwater treatment option for providing downstream channel protection.

#### Typical ED Retrofit Applications

ED is an attractive option to retrofit existing ponds (SR-1), and can also be utilized for other storage retrofits with the possible exception of the conveyance system (SR-4). ED is generally not suited for on-site retrofit applications. Dry ED ponds should seldom be considered as a standalone retrofit strategy, unless downstream channel protection is a priority.



Figure 1: This shallow wetland was designed with extended detention. (Rolling Stone retrofit, Montgomery County, MD)

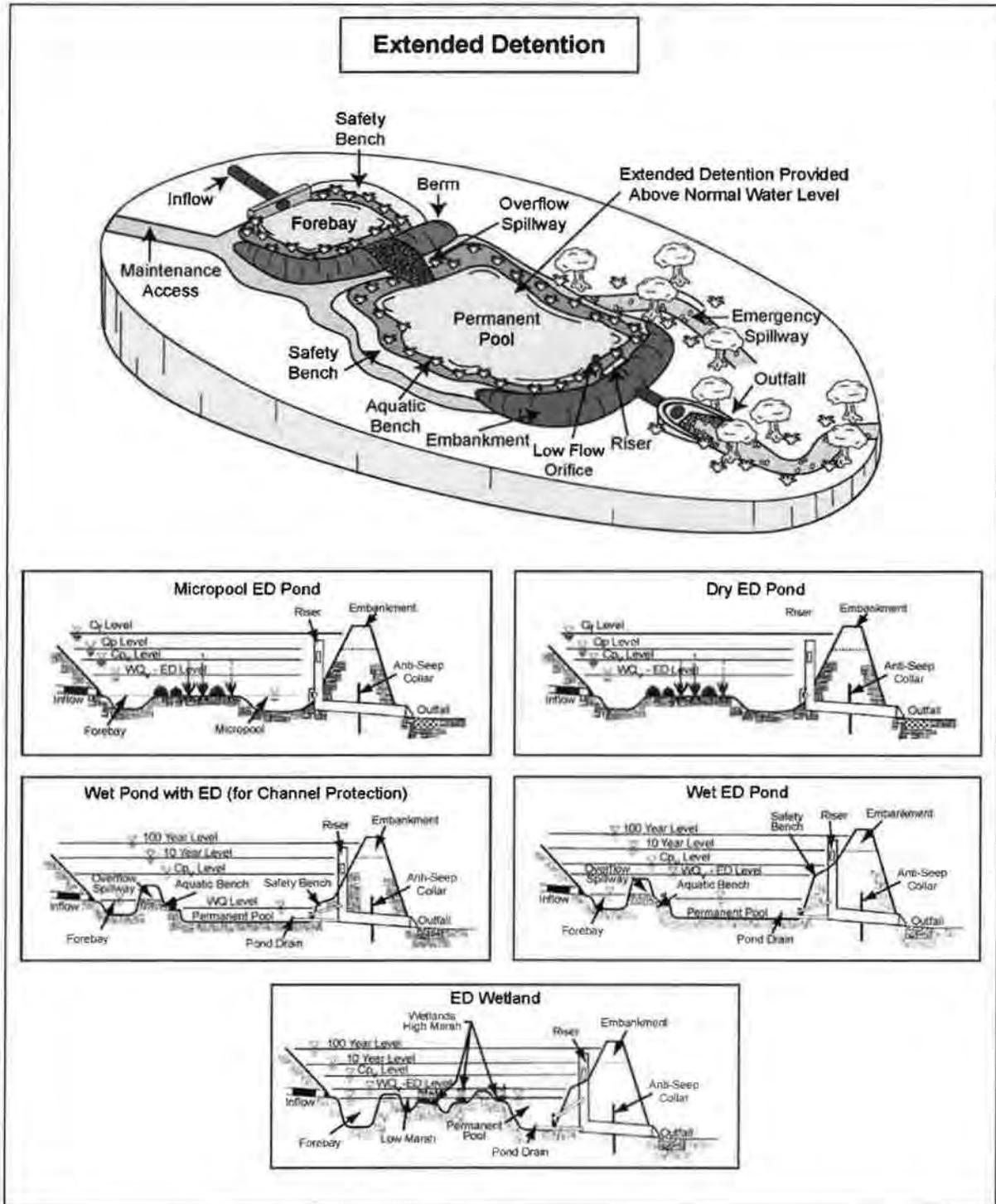


Figure 2: Extended Detention Schematics

### ED Pollutant Removal Capability

ED ponds rely on gravitational settling as their primary pollutant removal mechanism. Consequently, they generally provide fair to good removal for particulate pollutants but low or negligible removal for soluble pollutants, such as nitrate and soluble phosphorus (Table 1). ED generally has the lowest overall pollutant removal rate of any stormwater treatment option. As a result, ED

is normally combined with wet ponds or constructed wetlands to maximize pollutant removal rates.

Several site-specific factors can have a strong influence on ED pollutant removal rates. Designers should review the design factors in Table 2 to compute the expected pollutant removal rates for the individual retrofit using the design point method.

Pollutant	Low End	Median	High End
Total Suspended Solids	50	70	80
Total Phosphorus	15	20	30
Soluble Phosphorus	-10	-10	40
Total Nitrogen	25	25	35
Organic Carbon	15	25	35
Total Zinc	25	30	60
Total Copper	30	30	50
Bacteria	0	40	90
Hydrocarbons	40	70	80
Chloride	0	0	0
Trash/Debris	65	80	85

See Appendix D for data sources and assumptions used to derive these removal rates  
Low End and High End are the 25<sup>th</sup> and 75<sup>th</sup> quartiles

Design Factors	X	Points
Wet ED or Multiple Cell Design		+ 2
Exceeds target WQv by more than 25%		+ 1
Exceeds target WQv by more than 50%		+ 2
Off-line design		+ 1
Flow path greater than 1.5 to 1		+ 1
Sediment forebay		+ 1
Constructed wetland elements included in design		+ 1
On-line design		- 1
Flow path less than 1:1		- 1
Pond SA/CDA ratio less than 2%		- 2
Does not provide full WQv volume		- 2
Pond intersects with groundwater		- 2
<b>NET DESIGN SCORE (max. of 5 points)</b>		

An important factor influencing pollutant removal rates is whether ED is combined with another treatment option, such as a wet pond or stormwater wetland. As a general rule, if more than 50% of the target WQv is provided by a wet pond or constructed wetland, then the higher pollutant removal rate for the treatment option should be applied (see Profile Sheets ST-2 and ST-3).

#### **Other Stormwater Benefits Provided by ED**

ED retrofits can provide other stormwater benefits to address other restoration objectives:

*Recharge:* Dry ED pond retrofits can provide modest groundwater recharge benefits. Strecker *et al.* (2004) reported up to 30% runoff reduction for a large population of monitored dry ED ponds,

presumably due to infiltration through the bottom soils of the basin. Recharge benefits will be reduced if the ED pond has impermeable or compacted soils, a liner, or a permanent pool of water.

*Channel Protection:* ED ponds are the primary means to protect downstream channels if full channel protection storage can be provided at the retrofit site. It should be noted, however, that channel protection normally requires about 20-40% more storage volume than that needed for water quality treatment (see Figure 1.3 in Chapter 1). Consequently, designers may have difficulty finding adequate space to retrofit channel protection storage at tight sites. Guidance on estimating channel protection storage volume for individual retrofit sites can be found in Appendix C.

<b>ST-2</b>	<b>Stormwater Treatment Options</b>	
	<b>WET PONDS</b>	

Wet ponds consist of a permanent pool of standing water that promotes a better environment for gravitational settling, biological uptake and microbial activity (Figure 1). Runoff from each new storm enters the pond and partially displaces pool water from previous storms. The pool also acts as a barrier to re-suspension of sediments and other pollutants deposited during prior storms. When sized properly, wet ponds have a residence time that ranges from many days to several weeks, which allows numerous pollutant removal mechanisms to operate.

Wet pond retrofits can be employed in several different design configurations:

- Wet Pond
- Wet ED Pond
- Wet Pond with ED for Channel Protection
- Pond Wetland System

Figure 2 illustrates each wet pond design variation. Wet ponds are an ideal retrofit treatment option due to their high and reliable pollutant removal performance, community acceptance and amenity value. Wet ponds can also provide channel protection above the permanent pool in some retrofit situations.



**Figure 1: Wet ponds can provide additional pollutant removal through settling**

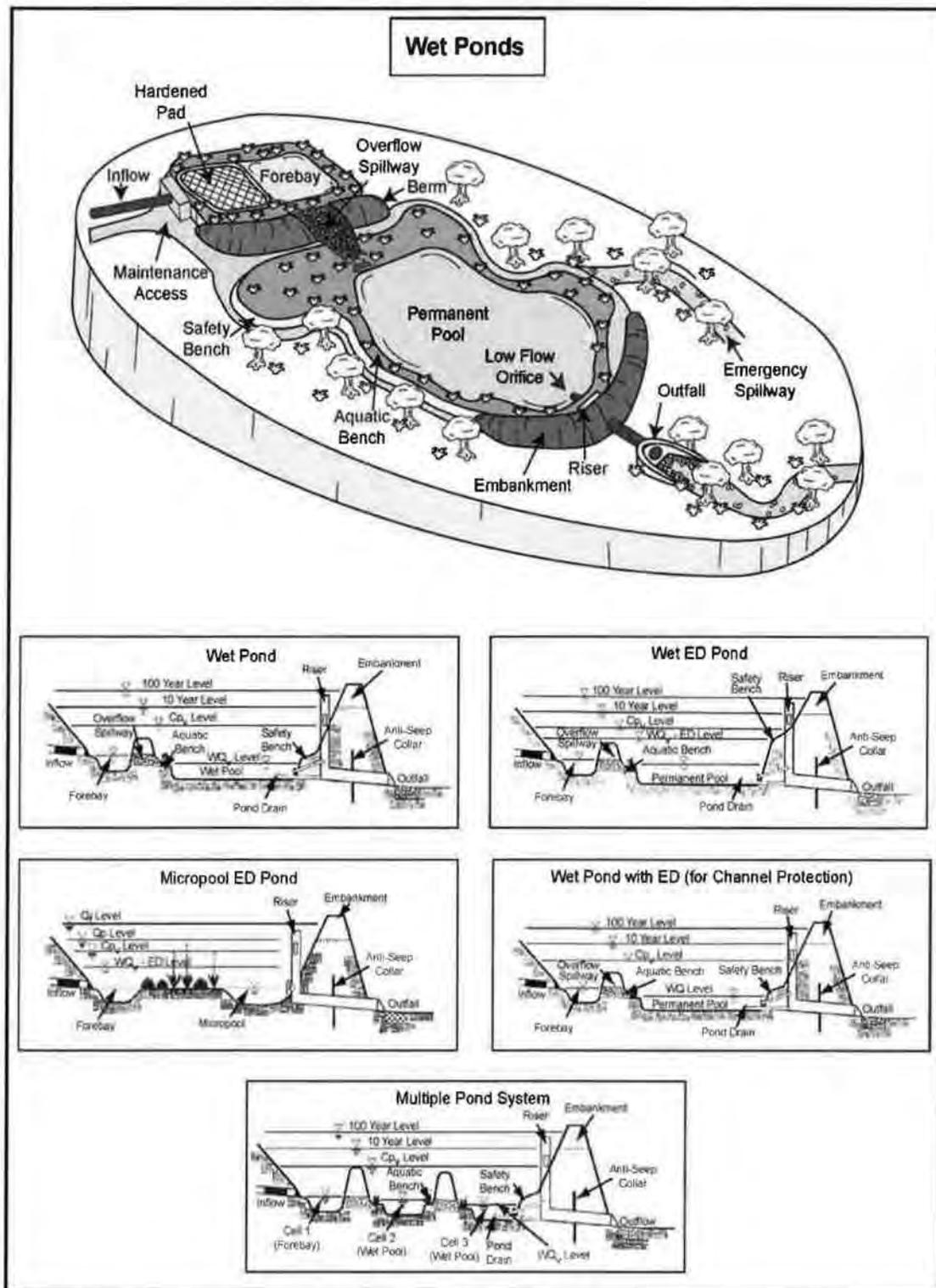


Figure 2: Schematics for various wet pond variations

### Typical Retrofit Applications

Wet ponds can be used as either a primary or secondary treatment option in most storage retrofit situations. Wet ponds are not recommended for conveyance retrofits (SR-4) and most on-site retrofit applications.

### Wet Pond Pollutant Removal Capability

Many pollutant removal mechanisms operate in the water column and bottom sediments of wet ponds including gravitational settling, algal uptake, adsorption, ultra-violet radiation and microbial processes. Many wet ponds have been intensively monitored in the past three decades and researchers consistently report moderate to high removal rates across the full range of stormwater pollutants (Table 1). Wet ponds generally have higher pollutant removal rates than other stormwater treatment options reviewed in this chapter.

Wet pond research has revealed many site-specific conditions and design factors that can enhance or detract from the median removal rates (Table 2). In general, the walkaway volume of a retrofit is when it cannot provide at least 35% of the target WQv. In addition, if more than 50% of the target water quality volume is provided by ED, the lower removal rates outlined in Profile Sheet ST-1 should be applied. Designers can review the design factors and site conditions in Table 2 to evaluate

whether their individual retrofit design will perform better or worse than normal, using the design point method.

### Other Stormwater Benefits Provided by Wet Ponds

Wet pond retrofits have limited potential to provide other stormwater benefits:

*Groundwater Recharge:* Due to their standing water and sealed bottoms, wet ponds do not offer much benefit in terms of groundwater recharge.

According to Strecker *et al.* (2004), wet ponds reduce incoming runoff volumes by less than 5%, most of which is accomplished by evaporation rather than soil infiltration.

*Channel Protection:* When site topography permits, extended detention can be stacked above the permanent pool to provide downstream channel protection. Designers should note that the CPv storage is typically 20 to 40% greater than the WQv storage so it is often hard to provide full channel protection at tight retrofit sites. Guidance on estimating the channel protection volume needed at individual retrofit sites can be found in Appendix C.

<b>Pollutant</b>	<b>Low End</b>	<b>Median</b>	<b>High End</b>
Total Suspended Solids	60	80	90
Total Phosphorus	40	50	75
Soluble Phosphorus	40	65	75
Total Nitrogen	15	30	40
Organic Carbon	25	45	65
Total Zinc	40	65	70
Total Copper	45	60	75
Bacteria	50	70	95
Hydrocarbons	60	80	90
Chloride	0	0	0
Trash/Debris	75	90	95

See Appendix D for data sources and assumptions used to derive these removal rates  
 Low End and High End are the 25<sup>th</sup> and 75<sup>th</sup> quartiles

<b>Design Factors</b>	<b>X</b>	<b>Points</b>
Wet ED or Multiple Pond Design		+ 2
Exceeds target WQv by more than 50%		+ 2
Exceeds target WQv by more than 25%		+ 1
Off-line design		+ 1
Flow path greater than 1.5 to 1		+ 1
Sediment forebay at major outfalls		+ 1
Wetland elements cover at least 10% of surface area		+ 1
Single cell pond		- 1
Flow path less than 1:1		- 1
On-line design		- 1
Pond SA/CDA ratio less than 2%		- 2
Does not provide full WQv volume		- 2
Pond intersects with groundwater		- 2
<b>NET DESIGN SCORE (max of 5 points)</b>		

<b>ST-3</b>	Stormwater Treatment Options	
	<b>CONSTRUCTED WETLANDS</b>	

**How Constructed Wetlands Work**

Constructed wetlands are shallow depressions that receive stormwater inputs for treatment. Wetlands are typically less than one foot deep (although they have deeper pools at the forebay and micropool) and possess variable microtopography to promote dense and diverse wetland cover (Figure 1). Runoff from each new storm displaces runoff from previous storms, and the long residence time allows multiple pollutant removal processes to operate. The wetland environment provides an ideal environment for gravitational settling, biological uptake, and microbial activity.

Constructed wetlands can be a stand-alone treatment option, or be combined with other stormwater treatment options in several configurations:

- Shallow Marsh
- ED Wetland
- Pond Wetland
- Wet Swales

Each constructed wetland design variation is illustrated in Figure 2.

Constructed wetlands are ideal because they replicate natural wetland ecosystems, provide efficient and reliable pollutant removal and have low construction costs (if ample space is available at the retrofit site). Well-designed stormwater wetlands enjoy widespread community acceptance, and possess high amenity and habitat value. Depending on site topography, constructed wetlands can also provide downstream channel protection when ED storage is stacked above the normal water level of the wetland.



**Figure 1: This wetland was constructed to treat stormwater from a nearby commercial area.**

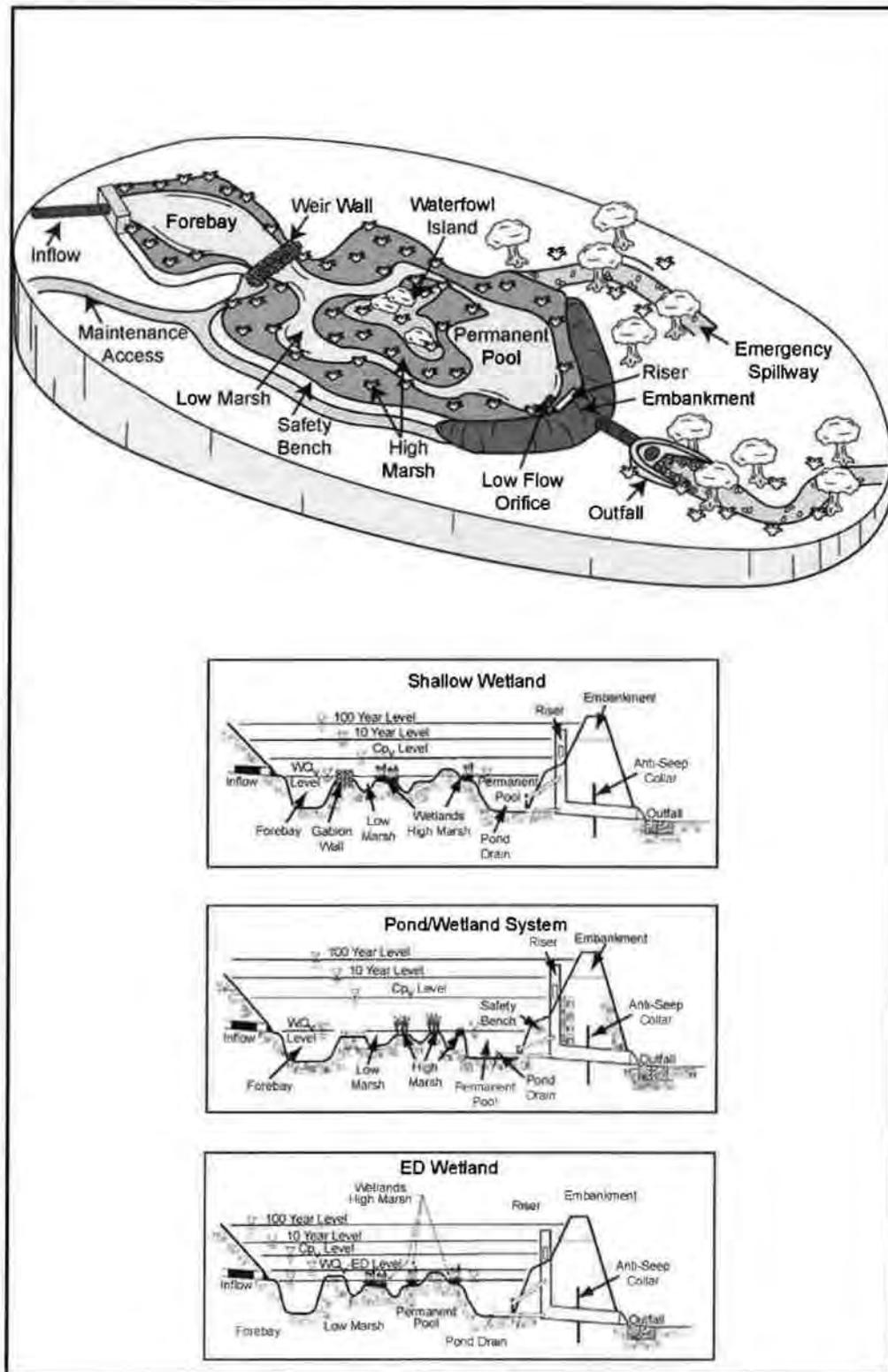


Figure 2: Schematics of three wetland variations

### Typical Retrofit Applications for Constructed Wetlands

Constructed wetlands can be the primary or secondary form of stormwater treatment in the following storage retrofit applications:

- **SR-1** Excavate shallow wetland in bottom of pond or add aquatic benches to wet pond
- **SR-2** Create wooded wetlands above road crossings (often with ED)
- **SR-3** Divert runoff from pipe to shallow wetland treatment cells in floodplain
- **SR-4** Install offline shallow wetland cells or in-line wet swales in the conveyance system
- **SR-5** Install wetland cells in highway cloverleaf or create wet swales in highway right of way
- **SR-6** Create wetland treatment cell adjacent to large parking lots

Constructed wetlands are seldom used for on-site retrofit applications, although several may incorporate some wetland elements.

### Pollutant Removal Capability of Constructed Wetlands

Constructed wetlands utilize a range of physical, chemical, microbial and biological mechanisms to remove pollutants. Wetland vegetation and sediments provide a growth media for microbes and filter and settle pollutants attached to sediments. Researchers have studied a large population of stormwater wetlands, and have concluded their removal rates are similar to wet ponds, but are somewhat more variable, especially for nutrients and organic carbon (Table 1).

Key design factors and site conditions that increase or decrease pollutant removal rates within constructed wetland retrofits are outlined in Table 2. The recommended walkaway volume for wetland retrofits is when they provide less than 35% of the target WQv. Constructed wetlands that allocate more than 50% of their storage for ED should use the lower removal rates for ED ponds shown in Profile Sheet ST-1. The median pollutant removal rates at individual retrofit sites can be adjusted to account for runoff capture volume and other site factors using the design point method (Table 2).

### Other Stormwater Benefits Provided by Constructed Wetlands

Constructed wetlands can offer additional stormwater benefits:

*Runoff Reduction:* Constructed wetlands are capable of reducing 5 to 10% of the incoming runoff volume through evaporation and seepage losses, according to Strecker *et al* (2004). This minor reduction is not likely to provide a meaningful groundwater recharge benefit.

*Channel Protection:* Designers can stack ED above constructed wetlands to provide channel protection storage, although the frequent changes in water levels will degrade the quality and density of wetland cover. Designers can avoid the “bounce” problem by limiting the vertical depth of extended detention. Guidance on estimating the channel protection volume needed at an individual retrofit site is provided in Appendix C.

<b>Table 1: Range of Reported Removal Rates for Constructed Wetlands</b>			
<b>Pollutant</b>	<b>Low End</b>	<b>Median</b>	<b>High End</b>
Total Suspended Solids	45	70	85
Total Phosphorus	15	50	75
Soluble Phosphorus	5	25	55
Total Nitrogen	0	25	55
Organic Carbon	0	20	45
Total Zinc	30	40	70
Total Copper	20	50	65
Bacteria	40	60	85
Hydrocarbons	50	75	90
Chloride	0	0	0
Trash/Debris	75	90	95

See Appendix D for data sources and assumptions used to derive these removal rates  
 Low End and High End are the 25<sup>th</sup> and 75<sup>th</sup> quartiles

<b>Table 2: Design Point Calculation to Estimate Pollutant Removal for Wetland Retrofits</b>		
<b>Design Factors</b>	<b>X</b>	<b>Points</b>
Pond-Wetland or Multiple Cell Design		+ 2
Pond-Wetland or Multiple Cell Design		+ 2
Exceeds target WQv by more than 50%		+ 2
Complex wetland microtopography		+ 2
Exceeds target WQv by more than 25%		+ 1
Flow path greater than 1.5 to 1		+ 1
Wooded wetland design		+ 1
Off-line design		+ 1
No forebay or pretreatment features		- 1
Wetland intersects with groundwater		- 1
Flow path is less than 1:1		- 1
No wetland planting plan specified		- 2
Wetland SA to CDA ratio is less than 1.5%		- 2
Does not provide full WQv volume		- 2
<b>NET DESIGN SCORE (max of 5 points)</b>		

<b>ST-4</b>	Stormwater Treatment Options	
	<b>BIORETENTION</b>	

Bioretention is a landscaping feature adapted to treat stormwater runoff at retrofit sites (Figure 1). Individual bioretention areas serve drainage areas of one acre or less. Surface runoff is directed into a shallow landscaped depression that incorporates many of the pollutant removal mechanisms that operate in forested ecosystems. The filter is composed of an 18 to 48 inch deep sand/soil bed with a surface mulch layer. During storms, runoff temporarily ponds six to nine inches above the mulch layer and then rapidly filters through the bed. Normally, the filtered runoff is collected in an underdrain and returned to the storm drain system (Figure 2). The underdrain consists of a perforated

pipe in a gravel jacket installed along the bottom of the filter bed.

In other cases, bioretention can be designed to infiltrate runoff into native soils. This can occur at sites with highly permeable soils, a low groundwater table, and a low risk of groundwater contamination. This design features the use of a “partial exfiltration” system that promotes greater groundwater recharge. Underdrains are only installed beneath a portion of the filter bed or are eliminated altogether, thereby increasing stormwater infiltration.



Figure 1: Bioretention created in a parking lot turn-around

Bioretention creates an ideal environment for filtration, biological uptake, and microbial activity, and provides moderate to high pollutant removal. Bioretention can become an attractive landscaping feature

with high amenity value and community acceptance. In the right landscape setting, bioretention can be a cost effective and flexible retrofit option.

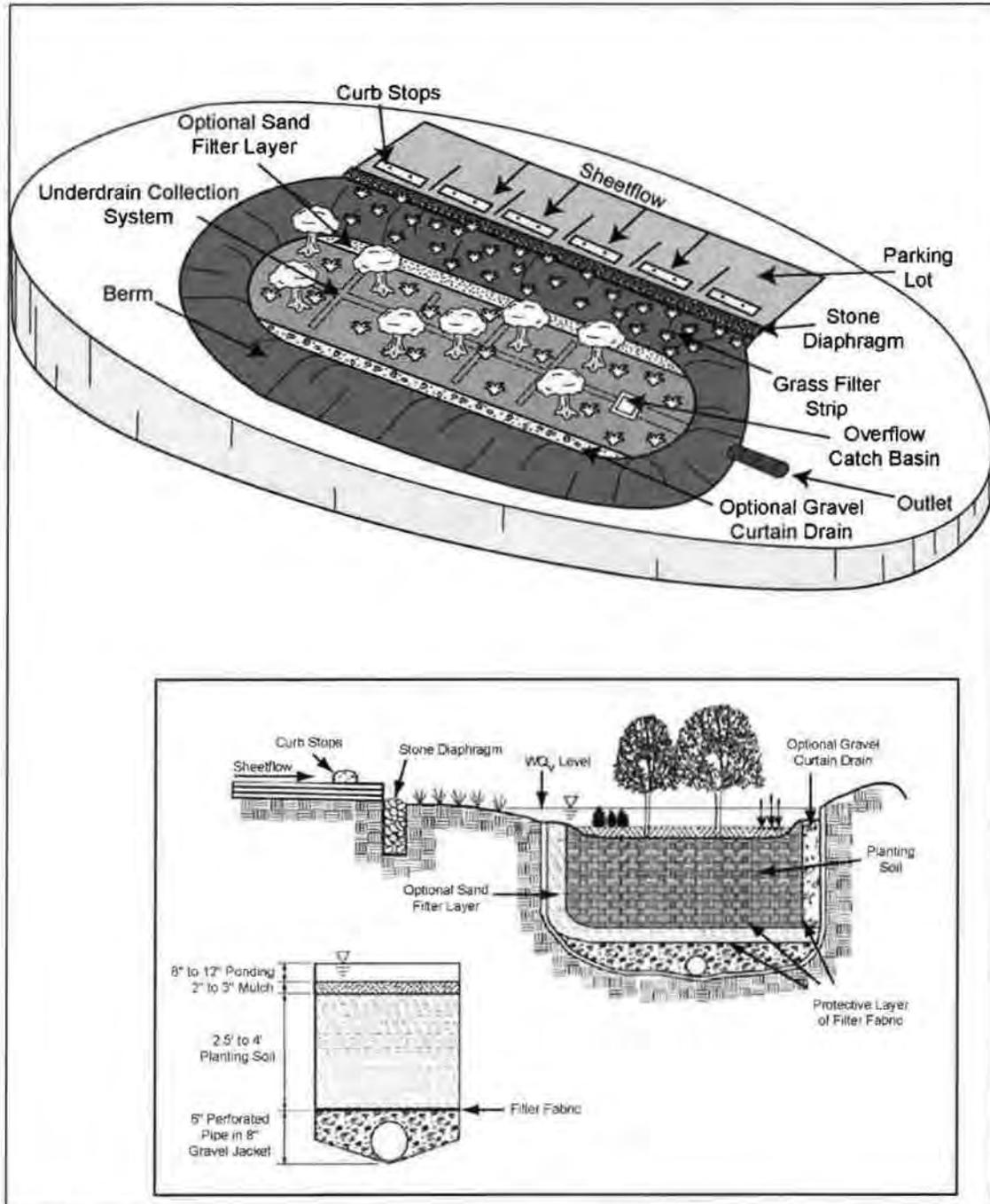


Figure 2: Bioretention schematic with underdrain

### Typical Retrofit Applications for Bioretention

Bioretention is an extremely versatile stormwater treatment option for both storage and on-site retrofits that can fit within unused land at a variety of different sites. Common bioretention retrofit opportunities include:

- **SR-1** Install bioretention in bottom of dry pond
- **SR-3** Split flows from smaller pipes to a large bioretention area
- **SR-4** Create series of on-line or off-line bioretention cells
- **SR-5** Install two-cell bioretention area
- **SR-6** Divert flow to two-cell bioretention area
- **OS-7** Install bioretention w/ underdrain to treat hotspot
- **OS-8** Install bioretention within parking lot islands or perimeter
- **OS-9** Incorporate bioretention in streetscapes, tree pits, cul-de-sacs or traffic calming measures
- **OS-10** Install rain-garden to treat residential or commercial rooftop runoff
- **OS-12** Utilize bioretention as a landscape feature

### Estimated Pollutant Removal by Bioretention

Until recently, only a handful of monitoring studies had measured the pollutant removal performance of bioretention areas. The most recent studies indicate that bioretention provides effective pollutant removal for many pollutants as a result of sedimentation, filtering, plant uptake, soil adsorption, and microbial processes. Table 1 summarizes bioretention pollutant removal rates for a variety of common stormwater pollutants.

The recommended walkaway volume for bioretention is about 50% of the target water quality volume. Another notable factor is whether the underlying soils have enough permeability to dispense with an underdrain. If an underdrain is not needed, pollutant removal will be enhanced by the greater infiltration of runoff into the soil and may approach the higher pollutant removal rates achieved by infiltration practices (see Profile Sheet ST-6). From the standpoint of nutrient removal, it is strongly recommended that the phosphorus index of topsoil mixed into the bioretention media be tested.

Table 2 can be used to adjust the median removal rates for individual retrofit projects by using the design point method.

### Other Stormwater Benefits Provided by Bioretention

Bioretention retrofits can provide important stormwater benefits under certain site conditions.

*Recharge:* Bioretention has been shown to reduce runoff volume by 35 to 50% through evapotranspiration and infiltration of runoff, according to Hunt *et al.* (2006) and Traver (2006). Runoff reduction exceeding 90% has been reported for deeper filter beds that lack underdrains and are situated on permeable soils (Horner *et al.*, 2003).

*Channel Protection:* The feasibility of storing the channel protection volume within bioretention areas has not yet been demonstrated, although the impressive runoff reduction rates suggests that widespread use of bioretention could be an effective element of a larger strategy to protect downstream channels from erosion.

<b>Pollutant</b>	<b>Low End</b>	<b>Median</b>	<b>High End</b>
Total Suspended Solids	15*	60*	75*
Total Phosphorus	-75	5	30
Soluble Phosphorus	-10	0	50
Total Nitrogen	40	45	55
Total Zinc	40	80	95
Total Copper	40	80	100
Bacteria	20	50	80
Hydrocarbons	80	90	95
Chloride	0	0	0
Trash/Debris	80*	90*	95*

\* Adequate pretreatment must be provided to reduce sediment loads to bioretention areas or clogging and practice failure may result  
 See Appendix D for data sources and assumptions used to derive these removal rates  
 Low End and High End are the 25<sup>th</sup> and 75<sup>th</sup> quartiles

<b>Design Factors</b>	<b>X</b>	<b>Points</b>
Exceeds target WQv by more than 50%		+ 3
Exceeds target WQv by more than 25%		+ 2
Tested filter media soil P Index less than 30 (phosphorus only)		+ 3
Filter bed deeper than 30 inches		+ 1
Two cell design with pretreatment		+ 1
Permeable soils; no underdrain needed		+ 2
Upflow pipe on underdrain		+1
Impermeable soils; underdrain needed		- 1
Filter bed less than 18 inches deep		- 1
Single cell design		- 1
Bioretention cell is less than 5% of CDA		-1
Does not provide full water quality storage volume		- 2
Filter media not tested for P Index (phosphorus only)		- 3
<b>NET DESIGN SCORE ( max of 5 points)</b>		
<b>NET PHOSPHORUS SCORE (max of 5 points)</b>		

<b>ST-6</b>	Stormwater Treatment Options	
	<b>INFILTRATION</b>	

Infiltration practices capture and temporarily store stormwater runoff before infiltrating it into underlying soils where most pollutants are trapped. Infiltration can be an ideal on-site retrofit to treat stormwater runoff as long as minimum geotechnical requirements are met. Infiltration retrofits consists of a rock-filled chamber with no outlet. Stormwater runoff must first pass through some form of pretreatment, such as a swale or sediment basin. Runoff is then stored in the voids between the stones, where it slowly infiltrates into the soil matrix over a few days (Figure 1). Alternatively,

proprietary materials such as perforated corrugated metal pipe, plastic arch pipe, or plastic lattice trays can be substituted for stone to increase storage capacity. A schematic of a typical infiltration trench is provided in Figure 2.

Where favorable soil conditions exist, infiltration can improve water quality, increase groundwater recharge and reduce runoff volumes. Infiltration practices are particularly desirable in subwatersheds that seek to reduce runoff volumes to prevent combined sewer overflows.



Figure 1: Infiltration Trench

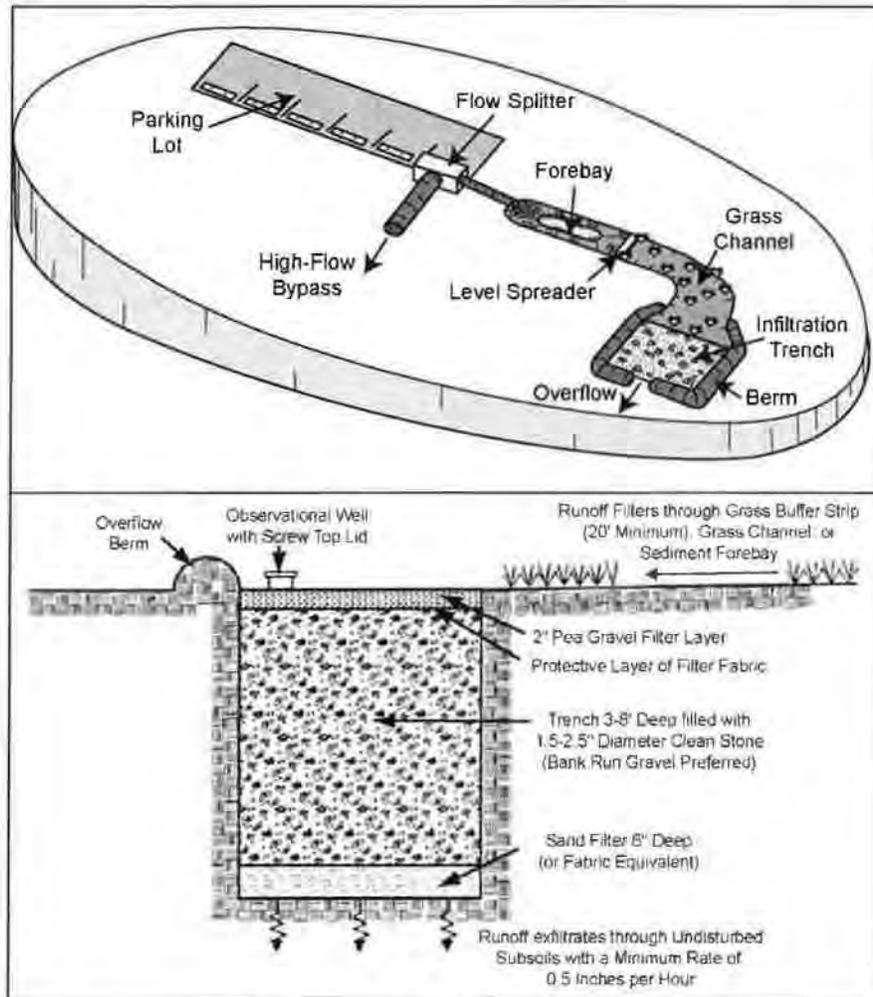


Figure 2: Schematic of an infiltration trench

### Other Stormwater Benefits Provided by Stormwater Filters

Stormwater filter retrofits can seldom address other stormwater management objectives beyond water quality treatment. Since they have an impermeable liner and underdrain, they cannot recharge groundwater. They usually lack enough storage capacity to provide meaningful channel protection.

### Typical Retrofit Application

Infiltration retrofits can be located on small, unused portions of a site and consume as

little as 2-5% of site area. They are effectively used in narrow linear areas along setbacks or property boundaries. Where soils are acceptable, infiltration can treat runoff in the following retrofit locations:

- **OS-8** Infiltration trenches along margins of small parking lot or use of permeable pavers
- **OS-9** Perforated storm drain pipes to infiltrate street runoff
- **OS-10** Simple disconnection of roof leaders over appropriate soils or use of french drains/dry wells to infiltrate rooftop runoff

- **OS-11** Disconnection of small impervious surfaces
- **OS-12** Permeable pavers in urban hardscapes
- **OS-13** Underground infiltration galleries

Infiltration is seldom used for storage retrofits unless underlying soils have exceptional infiltration capability. It is important to confirm that retrofit soils can support adequate infiltration, since past grading, filling, disturbance, and compaction can greatly alter original soil infiltration qualities. The greatest opportunity for infiltration retrofits exists in sensitive or impacted subwatersheds, where some of the original soil structure may still exist. By contrast, most soils in non-supporting subwatersheds are not likely to be suitable for infiltration. Some regions of the country still have excellent soils that allow for widespread implementation of infiltration retrofits (e.g., glacial tills, sand).

#### **Pollutant Removal by Infiltration Retrofits**

Infiltration retrofits utilize several pollutant removal mechanisms including filtering, soil adsorption and transfer to groundwater. Theoretically, nearly all the pollutants that enter an infiltration practice should be removed except for soluble pollutants that travel through groundwater and return downstream. It is important to note that infiltration retrofits **are not** intended to treat sites with high sediment or trash/debris loads, as they will cause the practice to clog and fail.

Very few infiltration practices have been monitored, so only limited pollutant removal

data has been published. Designers should therefore regard the infiltration pollutant removal rates shown in Table 1 as an initial estimate until more performance monitoring data becomes available.

Several site-specific and design factors can have a strong influence on infiltration pollutant removal rates (Table 2). As always, removal rates for individual retrofit projects should be adjusted to account for site-specific design factors that can enhance or diminish pollutant removal using the design point method. The most important design factor is the size of the individual retrofit in relation to the target WQv treatment. Pollutant removal rates diminish for under-sized infiltration retrofits; the recommended walkaway volume is about 50% of the target WQv.

#### **Other Stormwater Benefits Provided by Infiltration**

Infiltration retrofits are desirable because they confer other stormwater benefits:

*Groundwater Recharge:* Infiltration of stormwater runoff is the preferred means to provide groundwater recharge within a subwatershed. When designed properly, they can infiltrate the entire runoff reduction or WQv to keep stormwater runoff out of combined sewers.

*Channel Protection:* While infiltration practices are not specifically designed to store the channel protection volume, their ability to reduce runoff volumes should help protect downstream channels from erosion. If suitable soils are present across a subwatershed, infiltration may be an effective channel protection strategy.

<b>Table 1: Range of Reported Removal Rates for Infiltration Practices</b>			
<b>Pollutant</b>	<b>Low End</b>	<b>Median</b>	<b>High End</b>
Total Suspended Solids	60*	90*	95*
Total Phosphorus	50	65	95
Soluble Phosphorus	55	85	100
Total Nitrogen	0	40	65
Organic Carbon	80	90	95
Total Zinc	65	65	85
Total Copper	60	85	90
Bacteria	25	90	95
Hydrocarbons	85	90	95
Chloride	0	0	0
Trash/Debris	90*	95*	99*

\* Adequate pretreatment must be provided to reduce sediment loads to infiltration practices or clogging and practice failure may result  
 See Appendix D for data sources and assumptions used to derive these removal rates  
 Low End and High End are the 25<sup>th</sup> and 75<sup>th</sup> quartiles

<b>Table 2: Design Point Calculation to Estimate Pollutant Removal for Infiltration Retrofits</b>		
<b>Design Factors</b>	<b>X</b>	<b>Points</b>
Exceeds target WQv by more than 50%		+ 3
Exceeds target WQv by more than 25%		+ 2
Tested infiltration rates between 1.0 and 4.0 in/hr		+ 2
At least two forms of pretreatment prior to infiltration		+ 2
CDA is nearly 100% impervious		+ 1
Off-line design w/ cleanout pipe		+ 1
Underdrain utilized		- 1
Filter fabric used on trench bottom		- 1
CDA more than 1.0 acre		- 1
Soil infiltration rates < 1.0 in/hr or > 4.0 in/hr		- 2
Pervious areas or construction clearing in CDA		- 2
Does not provide full WQv volume		- 3
<b>NET DESIGN SCORE (max of 5 points)</b>		

<b>ST-7</b>	Stormwater Treatment Options	
	<b>SWALES</b>	

Swales utilize the stormwater conveyance system to provide treatment in either storage or on-site retrofit applications. Swales have moderate pollutant removal capability, can reduce runoff volume and increase groundwater recharge. Swales are designed to treat the WQv within an open channel. The three design variants are the dry swale, wet swale, and grass channel.

*Dry swales* are a linear soil filter system that temporarily stores and then filters the desired WQv (Figure 1). Dry swales are similar to bioretention areas in that they rely on a fabricated soil bed on the bottom of the channel. Existing soils are replaced with a sand/soil mix that meets minimum permeability requirements. Dry swales provide a good environment for filtration, biological uptake, and microbial activity. Stormwater treated by the soil bed flows into an underdrain, which conveys treated runoff back to the conveyance system further downstream. The underdrain system is typically created by encasing a perforated pipe

within a gravel layer on the bottom of the swale.

*Wet swales* are linear wetland cells that intercept shallow groundwater to maintain a wetland plant community (Figure 2). Saturated soils support wetland vegetation, which provides an ideal environment for gravitational settling, biological uptake, and microbial activity.

*Grass channels* are open channels that provide limited water quality treatment using rate-based design criteria. Grass channels reduce flow velocities and increase filtration capacity. Grass channels generally cannot provide the same degree of pollutant removal as dry or wet swales.

All three swale designs provide significantly better water quality treatment than the conventional roadside ditch. Schematics of the dry and wet swale designs are illustrated in Figure 3.



Figure 1: Dry Swale



Figure 2: Wet Swale

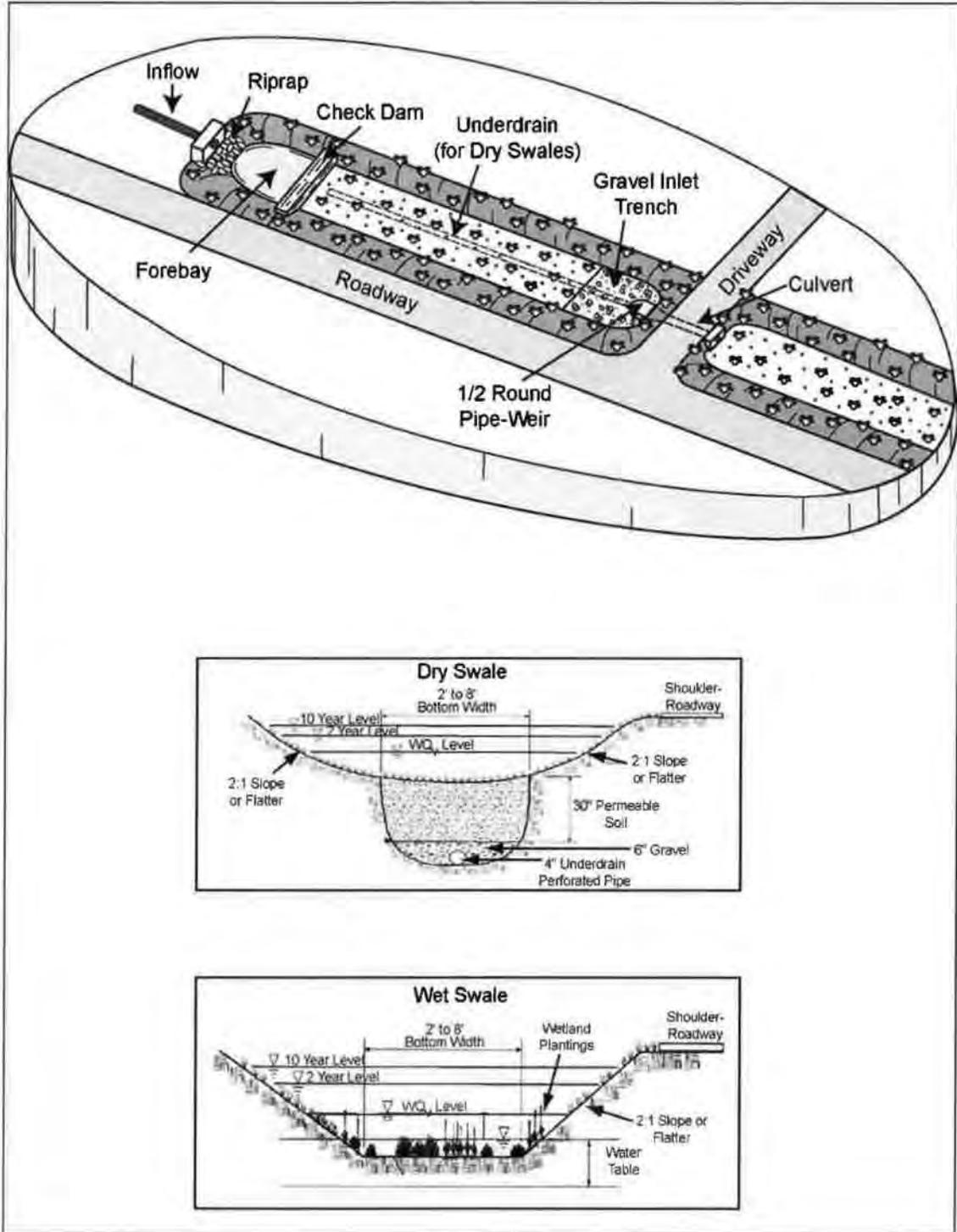


Figure 3: Schematic of a dry and wet swale

### Typical Swale Retrofit Application

Most swale retrofits require that an existing open channel be widened, deepened, reduced in gradient, or some combination of all three. Swales are particularly well suited to treat runoff from low and medium density residential streets and small parking lots.

Typical retrofit situations where swales can be applied include:

- **SR-4** Install dry swale or grass channel within existing conveyance system
- **OS-8** Install swales along margins of small parking lots
- **OS-9** Install swale retrofit along open section street or convert closed section street into dry swale
- **OS-11** Direct runoff to swale as means to disconnect a small impervious area

### Estimating Pollutant Removal Capability of Swale Retrofits

The primary pollutant removal mechanisms operating in swales are settling, filtering

infiltration and plant uptake. The reported pollutant removal rates for swales are highly variable. Table 1 shows the range in removal rates for swales that have been specifically designed for stormwater treatment (e.g., dry swales, wet swales and biofilters). Please note that the median removal rates should be cut in half if the proposed retrofit is a grass channel.

Designers may find it difficult to define the expected removal rate for a swale retrofit. Many site conditions and design factors can enhance or diminish their pollutant removal rates (Table 2). A reasonable estimate for each individual swale retrofit can be developed using the design point method. A primary factor influencing swale removal rates is the proportion of the WQv that is actually infiltrated or stored within retrofit treatment cells. A second influential factor is how the retrofit is sized in relation to the target WQv-- the recommended walkaway volume is about 50% of the target WQv.

**Table 1: Range of Reported Removal Rates for Swales**

Pollutant	Low End	Median	High End
Total Suspended Solids	70	80	90
Total Phosphorus	-15	25	45
Soluble Phosphorus	-95	-40	25
Total Nitrogen	40	55	75
Organic Carbon	55	70	85
Total Zinc	60	70	80
Total Copper	45	65	80
Bacteria	-65	0	25
Hydrocarbons	70	80	90
Chloride	0	0	0
Trash/Debris	0	0	50

See Appendix D for data sources and assumptions used to derive these removal rates  
 Low End and High End are the 25<sup>th</sup> and 75<sup>th</sup> quartiles

<b>Table 2: Design Point Calculation to Estimate Pollutant Removal for Swale Retrofits</b>		
<b>Design Factors</b>	<b>X</b>	<b>Points</b>
Exceeds target WQv by more than 50%		+ 3
Dry or wet swale design		+ 2
Exceeds target WQv by more than 25%		+ 2
Longitudinal swale slope between 0.5 to 2.0%		+ 1
Velocity within swale < 1 fps during WQ storm		+ 1
Measured soil infiltration rates exceed 1.0 in/hr		+ 1
Multiple cells with pretreatment		+ 1
Off-line design w/ storm bypass		+ 1
Longitudinal swale slope < 0.5% or > 2%		- 1
Measured soil infiltration rates less than 1.0 in/hr		- 1
Swale sideslopes more than 5:1 h:v		- 1
Swale intersects groundwater (except wet swale)		- 1
No pretreatment to the swale or channel		- 1
Swales conveys stormflows up to 10 year storm		- 2
Does not provide full WQv volume		- 2
Grass channel		- 3
<b>NET DESIGN SCORE (max of 5 points)</b>		

**Other Stormwater Benefits Provided by Swales**

Swales retrofits can provide other stormwater benefits, including:

*Groundwater Recharge:* Swales can reduce runoff volumes by an average of 40% through infiltration on the swale bottom and across side-slopes, according to Strecker *et al.* (2004). Some research studies have reported as much as 80 to 90% runoff reduction for dry swales that are heavily landscaped with trees and shrubs to promote greater evapotranspiration (Horner *et al.*, 2003).

*Channel Protection:* While most swales are not designed to provide channel protection storage, the high degree of runoff reduction suggests that they have some potential to protect downstream channels from erosion. It may be possible to capture and detain the entire channel protection volume at small sites.

<b>ST-8</b>	Stormwater Treatment Options	
	<b>Other Retrofit Treatment</b>	

This stormwater treatment option includes a diverse group of on-site techniques that capture, store and partially treat rooftop runoff in residential areas and highly urban landscapes, including:

**Residential Rooftops**

- Rainbarrels
- Rain Gardens
- French Drains/Drywells

**Non-Residential Settings**

- Cisterns
- Green Rooftops
- Permeable Pavers
- Stormwater Planters

Each rooftop technique has a unique ability to reduce runoff, remove pollutants or recharge groundwater and differs greatly in its design, installation cost and maintenance needs. A full description of each treatment option is provided in the series of fact sheets provided in Appendix F.

**Typical Retrofit Applications**

Many of these practices are primarily used to treat runoff from individual rooftops (OS-10), but stormwater planters and permeable pavers can also be applied to retrofit small

parking lots (OS-8) and urban landscapes/hardscapes (OS-12).

**Pollutant Removal Capability**

These techniques can provide partial or full treatment of the target WQv, depending on site conditions. The pollutant removal rate for each technique varies greatly, so designers should consult the appropriate fact sheet in Appendix F to get an accurate estimate.

**Benefits, Constraints, Concerns and Design, Construction and Maintenance Issues**

Taken as a group, these stormwater treatment techniques are suitable for use in small, on-site retrofits and have few site constraints. Individually, each technique has numerous siting, design, and maintenance issues which are described in Appendix F.

**Installation Costs for Other Stormwater Retrofits**

The installation costs for this group of retrofits are compared in Table 1.

<b>Table 1: Installation Costs for Other Stormwater Retrofits (per cubic foot treated)</b>		
<b>Retrofit Type</b>	<b>Median Cost</b>	<b>Cost Range</b>
<b>Residential Settings</b>		
Rain Barrels	\$ 25.00	\$ 12.50 to \$ 40.00
Rain Gardens:		
Volunteer Installation	\$ 4.00	\$ 3.00 to \$ 5.00
Professional Installation	\$ 7.00	\$ 5.00 to \$ 10.00
Professional Landscaping	\$ 12.00	\$ 10.00 to \$ 15.00
French Drains/Drywells	\$ 12.00	\$ 10.50 to \$ 13.50
<b>Non-Residential Settings</b>		
Cisterns	\$ 15.00	\$ 6.00 to \$ 25.00
Intensive Green Rooftops	\$ 360.00	\$ 300.00 to \$ 420.00
Extensive Green Rooftops	\$ 225.00	\$ 144.00 to \$ 300.00
Permeable Pavers	\$ 120.00	\$ 96.00 to \$ 144.00
Stormwater Planters	\$ 27.00	\$ 18.00 to \$ 36.00
Rain Gardens	\$ 12.00	\$ 10.00 to \$ 15.00
<i>Note: See Appendix E for documentation and cost assumptions</i>		

<b>MO-4</b>	<b>Municipal Operation</b>	
	<b>STREET SWEEPING</b>	

### Description

Public streets and roadways can comprise as much as 10 to 20% of total impervious cover in suburban subwatersheds and as much as 20 to 40% in highly urban subwatersheds. Particulate matter or “street dirt” tends to accumulate along the curbs of streets and roadways in between rainfall events. Sources of pollutants include run-on, atmospheric deposition, vehicle emissions and wear and tear, breakup of street surface, littering, leaves and other organic material and sanding. This results in the accumulation of stormwater pollutants such as sediment, nutrients, metals, hydrocarbons, bacteria, pesticides, trash and other toxic chemicals.

In many communities, these pollutants remain on public streets and roadways until they are washed into the storm drain system during a rainfall event. However, some communities use street sweeping (Figure 1) to remove some of these pollutants and prevent them from being conveyed into the storm drain system.

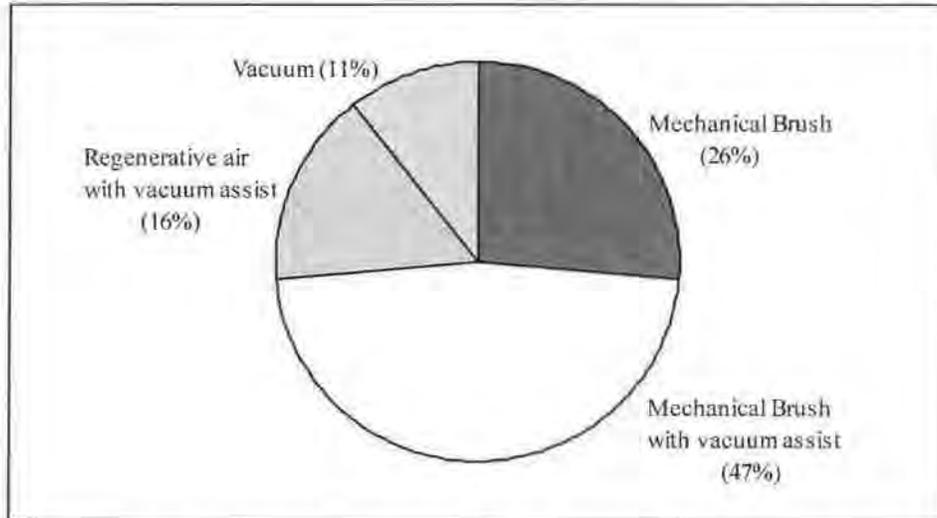
The ability of street sweepers to remove common stormwater pollutants varies depending on sweeper technology, sweeper operation and frequency, street conditions and the chemical and physical characteristics of the pollutants that have accumulated on the pavement. Although newer street sweeping technology can remove more than 90% of street dirt under ideal conditions, street sweeping does not necessarily guarantee water quality improvements (CWP, 2006a). Street sweepers are typically more effective at removing larger-sized particles than fine-grained particles and nutrients, although newer technology such as small-micron surface cleaning technologies may be capable of picking up smaller particles (Sutherland and Jelen, 1997). However, as illustrated in Figure 2, only 27% of Chesapeake Bay communities rely on this modern sweeping technology. The street sweepers most commonly used by Chesapeake Bay communities are mechanical brush and mechanical brush with vacuum assist sweepers (CWP, 2006b), which tend to have lower pollutant removal capabilities than newer air or vacuum assist technologies.

Table 1 provides expected pollutant removal rates for street sweeping. These pollutant removal rates are lower than reported “pick-up” efficiencies of street sweepers, due to a number of discount factors that impact the effectiveness of street sweeping (CWP



**Figure 1.** This broom sweeper is assisted by a following vacuum sweeper for increased removal.

2006a). In general, street sweeping is usually more effective in arid and semi-arid climates where pollutants can accumulate over longer intervals on street and curb surfaces.



**Figure 2. Most common street sweeping technology used by Chesapeake Bay communities**

Frequency	Technology	Total Suspended Solids	Total Phosphorus	Total Nitrogen
Monthly	Mechanical	9%	3%	3%
	Regenerative Air/Vacuum	22%	4%	4%
Weekly	Mechanical	13%	5%	6%
	Regenerative Air/Vacuum	31%	8%	7%

**Investigating and Improving the Operation**

Improving or initiating street sweeping activities in your community can reduce the amount of stormwater pollution that is conveyed into local aquatic resources. It requires you to examine your existing street sweeping operations, if they exist, and identify where improvements can be made to reduce the amount of pollution that has accumulated on public streets and roadways. This can be accomplished within the context of the seven-step program planning and development process (Chapter 2), as described below.

**Step 1: Identify Existing Municipal Operations**

Recall that the first step in the process is to identify the municipal operations that are conducted within your community. In terms of street sweeping, this means determining whether or not your community currently sweeps any public streets and roadways. If it does, the next step in the process is to collect some basic information about how the way those activities are conducted. If not, you should consider developing a street sweeping program or begin investigating the other municipal operations that are conducted within your community.

### ***Step 2: Collect Information About Each Operation***

Once you have determined that your community currently conducts street sweeping operations, the next step in the process is to collect some basic information about how those operations are carried out. Basic information to collect about the street sweeping activities conducted in your community includes:

- Narrative description of the street sweeping activities
- Locations of active and planned street sweeping activities
  - Street address
  - Watershed and subwatershed address
  - Geospatial coordinates (e.g. latitude, longitude)
- Map showing locations of active and planned street sweeping activities
- Operation manager name
- Operation manager contact information

This information should be added to the simple database or binder that contains the information about all of the municipal operations conducted in your community.

As you collect some basic information about the street sweeping operations conducted in your community, you should begin communicating with the individual who oversees or manages these activities. This is an ideal time to inform this individual about the community's pollution prevention/good housekeeping efforts and the purpose of the community's municipal pollution prevention/good housekeeping program. It is also a good time to educate them about the influence that street sweeping can have on water quality and how it can be used to reduce the amount of pollution that has accumulated on public streets and roadways.

### ***Step 3: Complete the Municipal Operations Analysis (MOA)***

The next step in the process is to use the basic information that you have collected about the street sweeping activities conducted in your community to complete Section 4 of the MOA. This section of the MOA asks a series of questions about the nature, scope and distribution of the street sweeping operations conducted within your community. In some cases, you will be able to answer all of the questions using only the information that you have already collected about the street sweeping activities. In most cases, however, answering the questions will require additional input from the individual who manages or oversees your community's street sweeping operation.

Once you have answered all of the questions presented within Section 4 of the MOA, you should calculate your score to determine how well your community is currently conducting its street sweeping activities. When you have completed the entire MOA, you should also compare the score that you received in Section 4 with the scores you received in each of the other sections of the analysis. This will help you focus your pollution prevention/good housekeeping efforts on the municipal operations that have the greatest influence on water quality in your community.

#### ***Step 4: Focus Pollution Prevention/Good Housekeeping Efforts***

The next step in the process is to use the results of the MOA, as well as information about local subwatershed restoration goals and objectives, to develop a list of the municipal operations in the order in which they will be further investigated and improved. This list, known as the prioritized municipal operations list, can be used to guide your local pollution prevention/good housekeeping efforts and ensure that you are using your resources on improving the operations that have the greatest influence on water quality in your community. The operations at the top of the prioritized municipal operations list should be those that you will address first, while those at the bottom should be those that you will address over time.

If street sweeping comes out on top of your prioritized municipal operations list, the next step in the process is to further investigate the way that street sweeping activities are conducted in your community and determine the improvements that can be used to reduce the amount of pollution that has accumulated on public streets and roadways. If it does not, you should begin investigating the operation that is located at the top of your list. The other profile sheets presented in this chapter provide additional information about investigating each of the other municipal operations.

#### ***Step 5: Investigate Municipal Operations and Select Pollution Prevention/Good Housekeeping Practices***

##### Step 5.1: Collect Additional Information About Street Sweeping Activities

Once you have determined that street sweeping will be the focus of your pollution prevention/good housekeeping efforts, the next step in the process is to collect some additional information about these activities to determine how they can be improved to reduce the amount of stormwater pollution that has accumulated on public streets and roadways. To collect this additional information, you should coordinate with the individual who manages or oversees these activities. This individual will be able to answer questions about the street sweeping activities and help you determine where improvements can be made. It is also a good opportunity for them to learn more about how street sweeping can influence stormwater quality. Table 2 provides a list of example questions that can be used to collect additional information from the individual who manages or oversees the street sweeping activities conducted in your community.

**Table 2: Sample Discussion Questions**

- Are you familiar with our pollution prevention/good housekeeping efforts and the purpose of our municipal pollution prevention/good housekeeping program?
- What pollutants are most commonly associated with street dirt?
- What areas or streets in the community are dirtier than others (e.g. have higher street particulate matter loadings compared to others)?
- What proportion of streets in the community is swept?
- Do sweepers pick up leaf piles?
- How is sweeping frequency defined?
- Is sweeping coordinated with fall leaf pickup?
- Is tandem sweeping used?
- Are no-parking zones used to increase pick up efficiency?
- What technology is being used and what is the size of the street sweeper fleet?

**Table 2: Sample Discussion Questions**

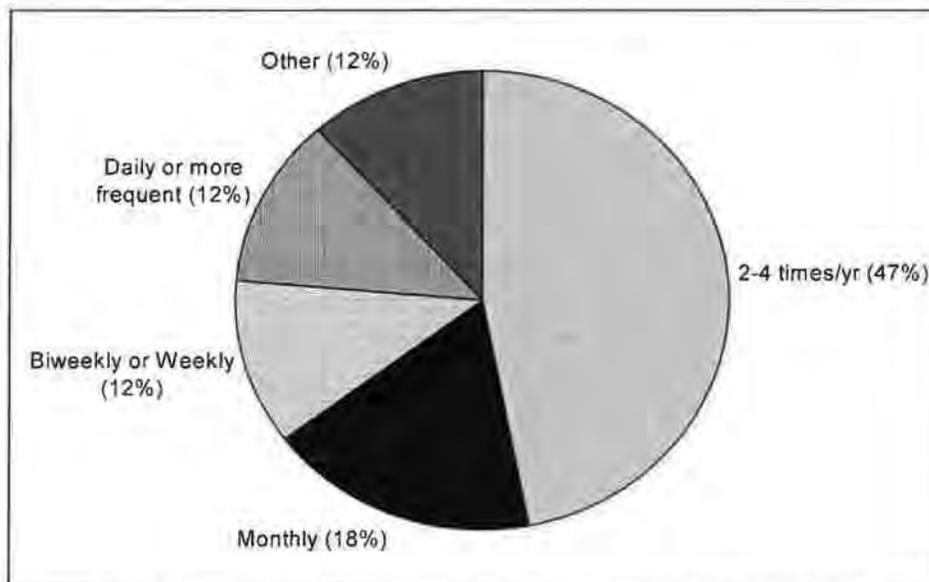
- What is the frequency of street sweeping for public streets?
- Do you have a training program for street sweeper operators?
- How do you dispose of material collected from the street sweepers?
- What problems affect the performance of street sweeping (e.g., on-street parking, inadequate budget, untrained operators)

When collecting additional information about the street sweeping activities conducted in your community, you should strive to determine what streets are being swept (if any), how frequently they are swept (e.g. twice a month) and the technology that is used to sweep them. The basic idea is to determine if the street sweeping program is operating at a level where measurable pollutant reductions can be achieved. In particular, you should evaluate:

- *Sweeper frequency* - should be defined based on local rainfall statistics, where the optimal frequency is about twice the interstorm period (runoff producing event) based on national rainfall statistics (i.e., approximately once a week, if the storm frequency is once every two weeks). At a minimum, sweeping should occur during periods of heavy accumulation. For example before the rain or wet season in drier, arid climates or in the fall and early spring in temperate climate. In the fall, sweepers should pick up leaves (and not avoid them) as they can contribute 25% of nutrient loadings in catch basins. If more substantial piles of leaves are found in your community during the fall, street sweeping activities should be coordinated with leaf pickup. Equally important is an early spring sweeping before rains begin to pick up sand, de-icing material and winter debris, to include municipally owned parking lots. More frequent sweeping may reduce the need for catch basin cleaning (see Profile Sheet MO-5). Figure 3 illustrates the percent of Chesapeake Bay communities that sweep more than once per year and the associated street sweeping frequency.
- *Sweeper technology and operations* – the ability of street sweeping to impact water quality is dependent on the sweeper’s pick-up efficiency of fine-grained sediment. There are three main types of sweepers: mechanical, regenerative air, and vacuum sweepers. Mechanical sweepers (broom-type) are typically the least expensive and are better suited to pick up large-grained sediment particles. Vacuum and regenerative air sweepers are better at removing fine grained sediment particles and are more effective as part of a NPDES plan (Partland, 2001), but are less effective on wet surfaces and are more expensive. Removal efficiency can be improved through tandem sweeping (two sweepers sweeping the same route, with one following the other to pick up missed material) or if the street sweeper makes multiple passes on a street.
- *Conditions* – access to the curb is paramount to street sweeping efficiency, as the majority of pollutants on streets are closest to the curb. Parked cars can restrict access; a regional survey conducted for Concord, CA revealed that appropriately enforced no-parking zones overwhelmingly achieved adequate compliance to allow street sweeping (Berryman and Henigar, 2003).
- *Distance to storage and disposal facilities* - street sweepers do not travel very quickly so the distance to the storage and disposal facilities can significantly reduce the number of hours that operators actually spend sweeping streets.

- *Staff training* - street sweepers are a major investment and operators must be specially trained on how to properly drive and maintain them. Training should be held at least once a year for all staff to provide them with a thorough understanding of the proper implementation of sweeping and other pollution prevention/good housekeeping practices, and safety procedures. Also see Profile Sheet MO-10.

The most common purposes for street sweeping in the Chesapeake Bay area are aesthetics, followed by residential demand. Keeping material out of the storm drains and street safety were also common responses. Public health, safety, permit requirements, and water quality were not among the most frequently cited reasons for street sweeping, but are considered important by a significant proportion of communities (CWP 2006b).



**Figure 3. Percentage of communities that sweep more than once per year and the associated sweeping frequency**

### Step 5.2: Conduct Field Investigations

Once you have collected some additional information about the street sweeping activities conducted in your community, the next task is to conduct some field work to determine where street sweeping can be most effective in improving water quality your community. The Street and Storm Drains (SSD) investigation measures the average pollutant accumulation in the streets, curbs and catch basins of a subwatershed. It is a visual inspection of pollutant accumulation along streets curb and gutters, and storm drain inlets. This information should be used to identify the dirtiest streets and quantify the impact of current maintenance practices on urban streams and identify changes to current street sweeping program. For example, a high accumulation rate may suggest that more regularly scheduled street sweeping is needed. The SSD is time intensive and probably cannot be completed for all streets in a community; however,

the stormwater manager should consider conducting the SSD in subwatersheds with impaired waters or sensitive aquatic resources. This information is particularly useful for communities with limited resources who may not be able to increase street sweeping in all areas. For more information on the SSD, see Manual 11.

### Step 5.3: Prescribe Pollution Prevention/Good Housekeeping Practices

Once existing operations have been assessed, the next step in the process is to develop a targeted street sweeping program that can help improve water quality by removing and properly disposing of the street dirt that has accumulated on public streets and roadways. In order to observe water quality improvements, most communities will need to invest in better street sweeping technologies and increase sweeping frequency. Depending on the results of Step 1, a variety of improvements can be made to the way that street sweeping operations currently occur (Table 3). If resources are limited, street sweeping should be concentrated on the dirtiest streets in sensitive subwatersheds at the right times of year (fall and early spring).

**Table 3: Good Housekeeping Techniques for Street and Parking Lot Sweeping**

- Analyze sweeper wastes for hazardous waste content and dispose of properly at the landfill
- Sweep prior to rainstorms so pollutants are not washed into storm drain system
- Sweep as soon as possible following application of deicers or other applied chemicals
- Properly maintain sweepers and operate according to manufacturers directions
- Store swept material in a covered and contained site until it can be disposed of at a landfill
- Implement parking controls to improve street sweeper efficiency by maximizing sweepable street edges where dirt tends to collect
- Routinely inspect street curbs for sediment and debris and schedule dirtiest streets for regular sweeping
- Coordinate seasonal sweeping schedules to coincide with important pollution prevention events during the subwatershed year. These include the end of curbside leaf collection, winter sanding operations, and peak pollen production in the spring
- Select the most effective combination of street sweeper technology that is consistent with municipal budget resources
- Sweep streets at the optimal frequency to remove the greatest pollutant removal, given local rainfall, street density, curb access and traffic safety
- Post permanent signs to notify vehicle owners and residents about forthcoming sweeping operations and associated parking restrictions
- Work with local police department to patrol designated routes to ticket illegally parked cars

### Step 5.4: Develop Implementation Plan

Once there is a targeted street sweeping program, a brief implementation plan should be created. The plan should summarize the results of the assessment and the street sweeping effort that will be used to reduce the amount of pollution that has accumulated on public streets and roadways. The plan should also include a schedule that describes when the street sweeping program will be implemented. The implementation plan can be used to guide the implementation of the prescribed street sweeping program.

### ***Step 6: Implement Pollution Prevention/Good Housekeeping Practices***

Once an implementation plan has been created, the next step in the process is implementing the prescribed street sweeping program. Although it may be tempting to hand the responsibility for implementation over to the individual who manages or oversees the community's street

sweeping activities, it is important to work with this individual during the implementation phase to get the prescribed street sweeping program up and running. Simple techniques that can be used to do this include providing additional education and information about the prescribed street sweeping program and providing assistance in securing funding for the program.

**Step 7: Evaluate Progress in Implementation**

The last step in the process involves evaluating the progress made in implementing the prescribed pollution prevention/good housekeeping practices. Measurable performance goals and implementation milestones will be needed to evaluate progress in implementation and track success in addressing local water quality issues and subwatershed restoration goals and objectives. Some example measurable goals and implementation milestones are presented in Table 4.

<b>Table 4: Measurable Goals and Implementation Milestones for Improving Municipal Street Sweeping Activities<sup>1</sup></b>		
<b>Example Measurable Goals</b>	<b>Timeframe</b>	<b>Priority</b>
<b>Goals related to program startup</b>		
Identify and collect basic information about municipal street sweeping activities	Complete shortly after program startup; update regularly after that	●
Add the information about street sweeping activities to the simple database or binder that contains basic information about each municipal operation		●
Develop a digital GIS or hard copy map showing the location of all municipal street sweeping activities		◎
Complete Section 4 of the Municipal Operations Analysis (MOA)	Year 1; repeat every 5 years	●
Prioritize local pollution prevention/good housekeeping efforts based on the results of the MOA and other factors, such as local pollutants of concern		●
<b>Goals related to preventing or reducing stormwater pollution</b>		
Collect additional information about the way that street sweeping activities are conducted within your community	Year 1	●
Prescribe pollution prevention/good housekeeping practices to improve the way that municipal street sweeping activities are conducted within your community		●
Develop implementation plan for prescribed street sweeping program		●
Secure funding and resources to implement prescribed street sweeping program	Begin in Year 1	●
Implement prescribed street sweeping program	Begin in Year 2	●
<b>Goals related to program evaluation</b>		
Develop measurable performance goals and implementation milestones	Complete shortly after program startup; update regularly after that	●
Evaluate progress in meeting measurable goals and implementation milestones		●
Evaluate progress in implementing prescribed pollution prevention/good housekeeping practices	End of Year 1 and each year after that	●

**Table 4: Measurable Goals and Implementation Milestones for Improving Municipal Street Sweeping Activities<sup>1</sup>**

Example Measurable Goals	Timeframe	Priority
<i>Notes</i> 1) Assumes that street sweeping is as the top of your prioritized municipal operations list. <i>Key</i> ● = Essential ◎ = Optional but Recommended		

The methods used to evaluate success in meeting these measurable performance goals and implementation milestones can be as simple as a semi-annual or annual inspections used to identify the improvements that have been put in place and the improvements that still need to be made.

### Scoping the Required Level of Effort

The level of effort required to develop an effective street sweeping program varies greatly from one community to the next. Basic guidance on scoping the level of effort required to develop a street sweeping program is provided in Table 5. Communities can use this information to estimate the level of effort required to develop their own street sweeping programs.

**Table 5: Scoping the Level of Effort Required to Improve Street Sweeping Operations**

Step	Staff Hours
Step 1: Identify Existing Municipal Operations	4-8 <sup>1</sup>
Step 2: Collect Information About Street Sweeping Activities	4-8
Step 3: Complete Section 4 of the Municipal Operations Analysis (MOA)	10-20
Step 4: Focus Pollution Prevention/Good Housekeeping Efforts	4-8 <sup>1</sup>
Step 5: Investigate Municipal Operations and Select Pollution Prevention/Good Housekeeping Practices	80-200
Step 5.1: Collect Additional Information About Street Sweeping Activities	20-40
Step 5.2: Conduct Field Investigations	20-80
Step 5.3: Prescribe Pollution Prevention/Good Housekeeping Practices	20-40
Step 5.4: Develop Implementation Plan	20-40
Step 6: Implement Pollution Prevention/Good Housekeeping Practices	Varies <sup>2</sup>
Step 7: Evaluate Progress in Implementation	20-40/evaluation <sup>1</sup>
<i>Notes</i> 1: Represents total level of effort required to complete step for all municipal operations. 2: Varies according to the extent and type of improvements required.	

### Resources

Urban Subwatershed Restoration Manual II: Unified Subwatershed and Site Reconnaissance: A User's Manual. <http://www.cwp.org/PublicationStore/USRM.htm>

The Smart Watershed Benchmarking Tool.

[http://cwp.org.master.com/tehis/master/search/+/form/Smart\\_Watershed.html](http://cwp.org.master.com/tehis/master/search/+/form/Smart_Watershed.html)

City Madison Street Sweeping Study

[http://www.ci.madison.wi.us/engineering/stormwater/street\\_sweeping.htm](http://www.ci.madison.wi.us/engineering/stormwater/street_sweeping.htm)

Stormwater Effects Handbook: Chapter 5

<http://www.epa.gov/ednrmrl/publications/books/handbook/index.htm>

Sutherland, R.C., and Jelen, S.L. (1997). Contrary to Conventional Wisdom: Street Sweeping can be an Effective BMP. In James, W. *Advances in Modeling the Management of Stormwater Impacts* – Vol. 5. Published by CHI, Guelph, Canada. pp 179-190.

US Department of Transportation, Federal Highway Administration's Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring: Street Sweeping Fact Sheet <http://www.fhwa.dot.gov/environment/ultraurb/3fs16.htm>

Walker, T. and Wong, T. (1999). Effectiveness of Street Sweeping for Stormwater Pollution Control. Technical Report 99/08. Cooperative Research Centre for Catchment Hydrology, Melbourne, AUS. <http://www.catchment.crc.org.au/archive/pubs/1000009.html>

Waschbusch, Robert J.; Selbig, W. R.; Bannerman, Roger T. 1999. WRI 99-4021. Sources of phosphorus in stormwater and street dirt from two urban residential basins in Madison, Wisconsin, 1994-95. <http://wi.water.usgs.gov/pubs/WRIR-99-4021/>

World Sweeper Website <http://www.worldsweeper.com/Street/Studies/index.html>

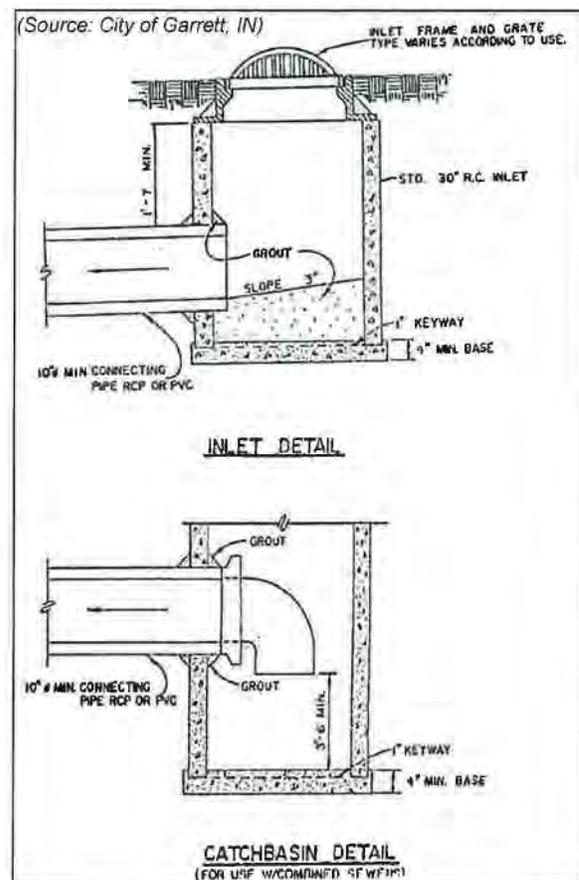
<b>MO-5</b>	<b>Municipal Operation</b>	
	<b>STORM DRAIN MAINTENANCE</b>	

**Description**

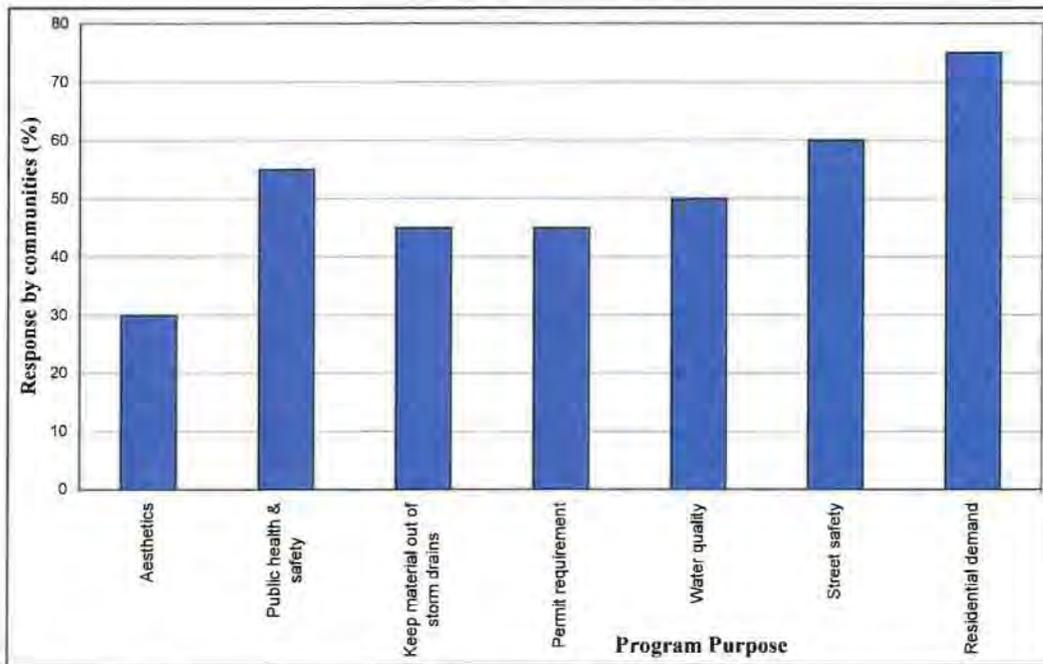
Public streets and roadways can comprise as much as 10 to 20% of total impervious cover in suburban subwatersheds and from 20 to 40% of highly urban subwatersheds. Fine particles and pollutants naturally tend to accumulate along the curbs of roads in between rainfall events. Sources of pollutants include run-on, atmospheric deposition, vehicle emissions, breakup of street surface, littering, and sanding. This results in the accumulation of stormwater pollutants such as sediment, nutrients, metals, hydrocarbons, bacteria, pesticides, trash and other toxic chemicals.

Storm drain maintenance is often the last opportunity to remove pollutants before they enter the storm drain system. The effectiveness of this pollution prevention/good housekeeping practice depends on the basic design of the stormwater conveyance in a subwatershed. Most systems have a catch basin or sump pit located in the storm drain inlet to trap sediment and organic matter and prevent clogging (Figure 1). In some cases, however, conveyance systems were designed to be self-cleansing and thus have no storage. Each catch basin or sump pit tends to be unique in how quickly it fills up, and whether the trapped material is liquid, solid or organic. To this extent, each reflects the conditions and behaviors that occur within the few hundred feet of street it serves.

Storm drain maintenance can be an effective strategy in urban subwatersheds that have few other feasible options to remove pollutants. For many communities, storm drain maintenance is reactive and conducted in response to complaints from residents. Water quality is not a commonly cited reason for a storm drain cleanout program (see Figure 2). When performed properly, regular maintenance can improve water quality and prevent clogging and flooding.



**Figure 1. Catch Basin Detail**



**Figure 2: Purpose of storm drain cleanout programs in the Chesapeake Bay watershed**

The amount of pollution removed by storm drain maintenance is influenced by the amount of pollution removed by street sweeping (see profile sheet MO-4). The amount of dirt removed by street sweeping influences the quantity of dirt that can be trapped within storm drains, inlets or catch basins. Storm drain cleanout effectiveness is also impacted by both the frequency and method of cleanout. Table 1 provides estimated pollutant removal rates for catch basin cleanouts.

Frequency	Total Suspended Solids	Total Phosphorus	Total Nitrogen
Annual	18%	< 1%	3%
Semi-Annual	35%	2%	6%

**Investigating and Improving the Operation**

Improving or initiating storm drain maintenance your community can reduce the amount of stormwater pollution that is conveyed into local aquatic resources. It requires an examination of existing storm drain maintenance operations to identify where improvements can be made to reduce pollutant accumulation in catch basins, inlets and storm drain pipes. This can be accomplished within the context of the seven-step program planning and development process (Chapter 2), as described below.

### ***Step 1: Identify Existing Municipal Operations***

In this step, determine whether catch basin, inlet and storm drain cleanouts are currently conducted. If so, the next step in the process is to collect some basic information about how these activities are conducted. If not, you should consider developing a storm drain maintenance plan or investigating the other municipal operations that are conducted within the community.

### ***Step 2: Collect Information About Each Operation***

Once you have determined that your community currently conducts storm drain maintenance activities, the next step in the process is to collect some basic information about how those operations are conducted. Basic information to collect about the storm drain maintenance activities conducted in your community includes:

- Narrative description of the storm drain maintenance activities
- Locations of storm drain maintenance activities
  - Street address
  - Watershed and subwatershed address
  - Geospatial coordinates (e.g. latitude, longitude)
- Map showing locations of storm drain maintenance activities
- Operation manager name
- Operation manager contact information

This information should be added to the simple database or binder that contains the information about all of the municipal operations conducted in your community.

After collecting basic information about storm drain maintenance activities, begin communicating with the individual who oversees or manages these activities. This is an ideal time to inform this individual about the community's pollution prevention/good housekeeping efforts and its purpose. It is also a good time to educate them about the influence that storm drain maintenance can have on water quality and how it can be used to reduce the amount of pollution that has accumulated on public streets and roadways.

### ***Step 3: Complete the Municipal Operations Analysis (MOA)***

The next step in the process is to use the basic information that you have collected about the storm drain maintenance activities conducted in your community to complete Section 5 of the MOA. This section of the MOA asks a series of questions about the nature, scope and distribution of the storm drain maintenance operations. In some cases, you will be able to answer all of the questions using only the information that you have already collected about the street sweeping activities. In most cases, however, answering the questions will require additional input from the individual who manages or oversees your community's storm drain maintenance activities.

Once you have answered all of the questions presented within Section 5 of the MOA, you should calculate your score to determine how well your community is currently conducting its storm

drain maintenance activities. When you have completed the entire MOA, you should also compare the score that you received in Section 5 with the scores you received in each of the other sections of the analysis. This will help you focus your pollution prevention/good housekeeping efforts on the municipal operations that have the greatest influence on water quality in your community.

#### ***Step 4: Focus Pollution Prevention/Good Housekeeping Efforts***

The next step in the process is to use the results of the MOA, as well as information about local subwatershed restoration goals and objectives, to develop a list of the municipal operations in the order in which they will be further investigated and improved. This list, known as the prioritized municipal operations list, can be used to guide your local pollution prevention/good housekeeping efforts and ensure that you are using your resources on improving the operations that have the greatest influence on water quality in your community. The operations at the top of the prioritized municipal operations list should be those that you will address first, while those at the bottom should be those that you will address over time.

If storm drain maintenance comes out on top of your prioritized municipal operations list, the next step in the process is to further investigate the way that storm drain maintenance activities are conducted in your community and determine the improvements that can be used to reduce the amount of pollution that has accumulated in inlets, catch basins and storm drain pipes. If it does not, you should begin investigating the operation that is located at the top of your list. The other profile sheets presented in this chapter provide additional information about investigating each of the other municipal operations.

#### ***Step 5: Investigate Municipal Operations and Select Pollution Prevention/Good Housekeeping Practices***

##### **Step 5.1: Collect Additional Information About Storm Drain Maintenance Activities**

Once you have determined that storm drain maintenance will be the focus of your pollution prevention/good housekeeping efforts, the next step in the process is to collect some additional information about these activities to determine how they can be improved to reduce the amount of stormwater pollution that has accumulated in inlets, catch basins and storm drain pipes. To collect this additional information, you should coordinate with the individual who manages or oversees these activities. This individual will be able to answer questions about the storm drain maintenance activities and help you determine where improvements can be made. It is also a good opportunity for them to learn more about how street sweeping can influence stormwater quality. Table 2 provides a list of example questions that can be used to collect additional information from the individual who manages or oversees the storm drain maintenance activities conducted in your community.

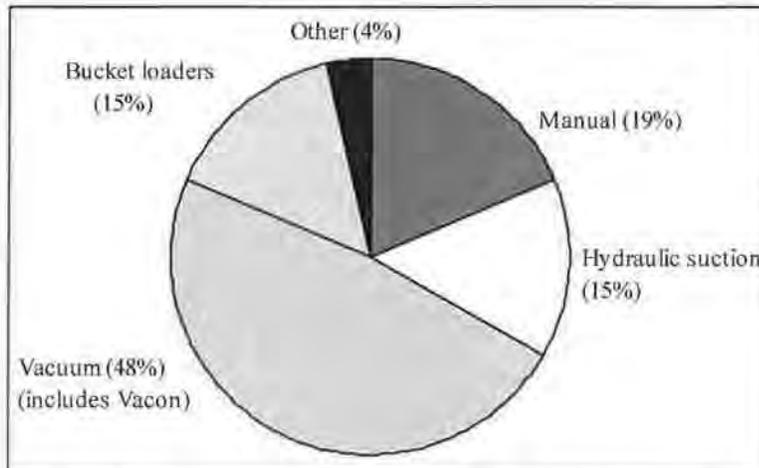
**Table 2: Sample Discussion Questions**

- Are you familiar with our pollution prevention/good housekeeping efforts and the purpose of our municipal pollution prevention/good housekeeping program?
- Do you understand how storm drain maintenance can impact stormwater quality?
- How frequently do you perform catch basin, inlet and storm drain cleanouts?
- How do you dispose of materials removed from the storm drain system?
- What additional resources would you need to improve the community's existing storm drain maintenance program?
- Do you provide regular stormwater pollution prevention training to employees who are involved with storm drain maintenance activities?

When collecting addition information about the storm drain maintenance activities conducted in your community, you should strive to determine how the storm drain system is currently being maintained, how frequently it is maintained and the technology that is used to maintain it. The basic idea is to determine if the storm drain maintenance program is operating at a level where measurable pollutant reductions can be achieved. In particular, you should evaluate:

- *Tracking* – the location and maintenance of storm drains should be tracked using a database and spatial referencing system (e.g., Global Positioning System, Geographic Information System). Additionally, knowing the type and era of the storm drain system may be of use since some inlets/catch basins are designed to be self-cleaning while others have some trapping capacity.
- *Frequency* – should be defined such that blockage of storm sewer outlet is prevented and it is recommended that the sump should not exceed 40 – 50 percent of its capacity. Semiannual cleanouts in residential streets and monthly cleanouts for industrial streets are suggested by Pitt and Bissonnett (1984) and Mineart and Singh (1994). More frequent cleanouts should be scheduled in the fall as leaves can contribute 25% of nutrient loadings in catch basins.
- *Technology* – the four common methods of cleaning catch basins are described in Table 3. Almost 65% of the Chesapeake Bay communities used vacuum-based technology or hydraulic suction to cleanout storm drains (Figure 3). The remaining communities use more basic technology such as manual removal or bucket loaders.
- *Staff training* - operators need to be properly trained in catch basin maintenance including waste collection and disposal methods. Staff should also be trained to report water quality problems and illicit discharges. See profile sheet MO-10 for more on employee training.
- *Material disposal* - since catch basin waste may contain hazardous material, it should be tested and disposed of accordingly. Maintenance personnel should keep a log of the amount of sediment collected and the removal date at the catch basin.

Table 3: Equipment Used for Catch Basin and Inlet Cleaning (from Lager et al. 1979)	
Equipment	Description
Manual cleaning	Bail out sediment-laden water and shovel into street then truck. Or crew enters catch basin and fill buckets with sediment that are then carried to a dump truck. Clean water is used to refill the catch basin.
Eductor cleaning	Eductor truck evacuates the catchment of the sediment-laden water into a settling tank.
Vacuum cleaning	Air blower of the vacuum truck is used to create a vacuum and the air-solid-liquid material is separated in the vacuum truck unit by gravity separation and baffles.
Vacuum combination jet cleaning (e.g. Vaccon)	A vacuum assisted truck that uses a combination of air, water and hydraulic suction. Suction is used to extract material from storm inlets. Water is used to clear material from storm drain pipes that is not removed by the vacuum. The material is stored in the truck holding tank and transported for disposal.



**Figure 3. Most common storm drain cleanout technology used in NPDES Phase I and II Chesapeake Bay communities**

**Step 5.2: Conduct Field Investigations**

After collecting some additional information about the storm drain maintenance activities in the community, it is time to conduct some field work to determine where storm drain maintenance can provide the most improvement to water quality (Figure 4). Conducting these field assessments is a key way to transform existing storm drain maintenance activities from reactive (response to resident complaints) to proactive activities. The Street and Storm Drains (SSD) investigation measures the average pollutant accumulation in the streets, curbs and catch basins of a subwatershed. The SSD can be used to characterize the current condition of storm drain infrastructure and the degree of pollutant accumulation in catch basins. This information should be used to quantify the impact of current maintenance practices on urban streams and identify changes to current storm drain maintenance program. For example, a high accumulation rate may suggest that more frequent and regular cleanouts are needed. The SSD is time intensive and

probably cannot be completed for all streets, but the stormwater manager should consider conducting the SSD in subwatersheds with impaired waters or sensitive aquatic resources. This information is particularly useful for communities with limited resources who may not be able to increase storm drain maintenance in all areas. For more information on the SSD, see Manual 11.

**Step 5.3: Prescribe Pollution Prevention/Good Housekeeping Practices**

Once existing operations have been assessed, the next step in the process is to select and implement the pollution prevention/good housekeeping practices that can help improve water quality through storm drain maintenance procedures and training. In order to observe water quality improvements, most communities will need to track maintenance activities and increase frequency. Depending on the results of Step 1, a variety of improvements can be made to the way that storm drain maintenance currently occurs (Table 4). If resources are limited, storm drain maintenance should be concentrated on the dirtiest streets in sensitive subwatersheds at the right times of year (just before and after rainy season).



**Figure 4. Conducting the SSD in Watershed 263, Baltimore, MD**

**Table 4: Good Housekeeping Techniques for Storm Drain Cleanout**

- Maintain a log of the amount of sediment collected and the date removed
- Analyze waste to determine the nature of disposal method
- Any liquids collected during cleanouts should be decanted and disposed of separately, depending on its hazard class
- Minimally clean once or twice per year (just before and just after the rainy season) or when the catch basin storage is one-third full, whichever happens first
- Plan cleaning to coincide with municipal street sweeping (MO-4)
- Locate and map all the catch basins within the community, and use these maps to promote widespread storm drain stenciling
- Keep records on accumulation rates within each individual catch basin using GIS or other tracking system
- Report all suspicious catch basins to appropriate local authorities for follow-up inspection and enforcement (e.g., inappropriate discharges and illegal dumping)

**Step 5.4: Develop Implementation Plan**

Once you have developed a targeted storm drain maintenance program, a brief implementation plan should be created. The plan should summarize the results of the assessment and the storm drain maintenance effort that will be used to reduce the amount of pollution that has accumulated in inlets, catch basins and storm drain pipes. The plan should also include a schedule that describes when the storm drain maintenance program will be implemented. The implementation plan can be used to guide the implementation of the prescribed storm drain maintenance program.

**Step 6: Implement Pollution Prevention/Good Housekeeping Practices**

Once an implementation plan has been created, the next step in the process is implementing the prescribed storm drain maintenance program. Although it may be tempting to hand the responsibility for implementation over to the individual who manages or oversees the community’s storm drain maintenance activities, it is important to work with this individual during the implementation phase to get the prescribed storm drain maintenance program up and running. Simple techniques that can be used to do this include providing additional education and information about the prescribed storm drain program and providing assistance in securing funding for the program.

**Step 7: Evaluate Progress in Implementation**

The last step in the process involves evaluating the progress made in implementing the prescribed pollution prevention/good housekeeping practices. Measurable performance goals and implementation milestones will be needed to evaluate progress in implementation and track success in addressing local water quality issues and subwatershed restoration goals and objectives. Some example measurable goals and implementation milestones are presented in Table 5.

<b>Table 5: Measurable Goals and Implementation Milestones for Improving Municipal Storm Drain Maintenance Operations<sup>1</sup></b>		
<b>Example Measurable Goals</b>	<b>Timeframe</b>	<b>Priority</b>
<b>Goals related to program startup</b>		
Identify and collect basic information about current municipal storm drain maintenance operations	Complete shortly after program startup; update regularly after that	●
Add the information about storm drain maintenance activities to the simple database or binder that contains basic information about each municipal operation		●
Develop a digital (e.g. GIS) or hard copy map showing the location of all storm drain maintenance activities		◎
Complete Section 5 of the Municipal Operations Analysis (MOA)	Year 1; repeat every 5 years	●
Prioritize local pollution prevention/good housekeeping efforts based on the results of the MOA and other factors, such as local pollutants of concern		●
<b>Goals related to preventing or reducing stormwater pollution</b>		
Collect additional information about the way that storm drain maintenance activities are conducted within your community	Year 1	●
Prescribe pollution prevention/good housekeeping practices to address deficiencies and improve the way that the municipal storm drain system is maintained within your community		●
Develop implementation plan for prescribed pollution prevention/good housekeeping practices		●
Secure funding and resources to implement prescribed pollution prevention/good housekeeping practices	Begin in Year 1	●
Implement prescribed pollution prevention/good housekeeping practices	Begin in Year 2	●

Table 5: Measurable Goals and Implementation Milestones for Improving Municipal Storm Drain Maintenance Operations <sup>1</sup>		
Example Measurable Goals	Timeframe	Priority
<i>Goals related to program evaluation</i>		
Develop measurable performance goals and implementation milestones	Complete shortly after program startup; update regularly after that	●
Evaluate progress in meeting measurable goals and implementation milestones		●
Evaluate progress in implementing prescribed pollution prevention/good housekeeping practices	End of Year 1 and each year after that	●
<i>Notes</i> 1) Assumes that storm drain maintenance is as the top of your prioritized municipal operations list. <i>Key</i> ● = Essential ⊙ = Optional but Recommended		

The methods used to evaluate success in meeting these measurable performance goals and implementation milestones can be as simple as a semi-annual or annual inspections used to identify the improvements that have been put in place and the improvements that still need to be made.

### Scoping the Required Level of Effort

The level of effort required to develop an effective storm drain maintenance program varies greatly from one community to the next. Basic guidance on scoping the level of effort required to improve storm drain maintenance operations is provided in Table 6. Communities can use this information to estimate the level of effort required to improve their own storm drain maintenance programs.

Table 6: Scoping the Level of Effort Required to Improve Storm Drain Maintenance Operations	
Step	Staff Hours
Step 1: Identify Existing Municipal Operations	4-8 <sup>1</sup>
Step 2: Collect Information About Street Sweeping Activities	4-8
Step 3: Complete Section 5 of the Municipal Operations Analysis (MOA)	10-20
Step 4: Focus Pollution Prevention/Good Housekeeping Efforts	4-8 <sup>1</sup>
Step 5: Investigate Municipal Operations and Select Pollution Prevention/Good Housekeeping Practices	80-200
Step 5.1: Collect Additional Information About Storm Drain Maintenance Activities	20-40
Step 5.2: Conduct Field Investigations	20-8
Step 5.3: Prescribe Pollution Prevention/Good Housekeeping Practices	20-40
Step 5.4: Develop Implementation Plan	20-40
Step 6: Implement Pollution Prevention/Good Housekeeping Practices	Varies <sup>2</sup>
Step 7: Evaluate Progress in Implementation	20-40/evaluation <sup>1</sup>
<i>Notes</i> 1: Represents total level of effort required to complete step for all municipal operations. 2: Varies according to the extent and type of improvements required.	

**Resources**

Urban Subwatershed Restoration Manual 11: Unified Subwatershed and Site Reconnaissance: A User's Manual. <http://www.cwp.org/PublicationStore/USRM.htm>

The Smart Watershed Benchmarking Tool.

[http://cwp.org.master.com/texis/master/search/+/form/Smart\\_Watershed.html](http://cwp.org.master.com/texis/master/search/+/form/Smart_Watershed.html)

U.S. EPA, Office of Water. Stormwater O&M Fact Sheet: Catch Basin Cleaning

<http://www.epa.gov/owm/mtb/catchbas.pdf>

Santa Clara Valley Urban Runoff Pollution Prevention Program

<http://www.sevurppp.org/>

<b>N-9</b>	<b>Neighborhood Source Area: Yard</b>	
	<b>SEPTIC SYSTEM MAINTENANCE</b>	

### Description

While most urban subwatersheds are served by sewers, some still rely on septic systems for sewage disposal, particularly in less developed subwatersheds that may lie outside of the sewer service envelope. The ideal watershed behavior is to regularly inspect and maintain septic systems, make repairs as needed, and prevent disposal of household chemicals through the leach field. The accepted practice is to inspect the tank and leach field once every two years to make sure it is working properly, and to pump out the tank (Ohrel, 1995; Figure 1). The negative watershed behavior is to ignore regular inspections and pumpouts to the point that the septic system becomes a subwatershed pollution source.

### How Septic Systems Influence Subwatershed Quality

Failing septic systems can be a major source of bacteria, nitrogen, and phosphorus, depending on the overall density of systems present in a subwatershed (Swann, 2001). Failure results in surface or subsurface movement of nutrients and

bacteria into the stream. According to the U.S. EPA (2002), more than half of all existing septic systems are more than 30 years old, which is well past their design life. The same study estimates that about 10% of all septic systems are not functioning properly at any given time, with even higher failure rates in some regions and soil conditions. It is extremely important to understand resident behavior in regard to inspection, pump out and repair, particularly if septic system density in a subwatershed is high.

### Percentage of Homeowners Engaging in Septic System Maintenance

Until recently, homeowner awareness about septic system maintenance was poorly understood. Swann (1999) conducted one of the first surveys to examine how frequently homeowners maintain their septic systems. Roughly half of the owners were classified as “septic slackers,” since they indicated that they had not inspected or cleaned out their systems in the past three years. A small, but significant, fraction (12%) of septic system owners had no idea where their septic system was located on their property. In addition, only 42% of septic system owners had ever requested advice on how to maintain their septic system, and they relied primarily on the private sector for advice (e.g., pumping service, contractors, and plumbers).



Figure 1: Septic System Inspection/Cleaning Truck

### **Variation in Septic System Maintenance**

Septic system failure rates appear to vary regionally, ranging from five to 40% (Swann, 2001). In most regions, failure rates are tied to current or past design, construction and maintenance regulations, which are set by local or state public health authorities. Failing systems are often clustered together. At the neighborhood level, many factors can influence septic system problems. Key factors linked to failure include small lot size, aging systems, poor soil or water table conditions, and close proximity to streams, lake fronts or ditches. In other cases, failure rates are tied to experimental septic system technologies, and seasonal use of properties.

### **Difficulty in Improving Septic System Maintenance**

Septic systems are a classic case of “out of sight, out of mind.” Many owners take their septic systems for granted, until they back up or break out on the surface of their lawn. Subsurface failures, which are the most common, go unnoticed. In addition, inspections, pump outs, and repair can be costly, so many homeowners tend to put off these expenditures until there is a real problem. Lastly, many septic system owners lack basic awareness about the link between septic systems and water quality at the subwatershed level.

### **Techniques to Increase Septic System Maintenance**

Many carrots and sticks have been developed in recent years to improve resident behaviors in regard to septic system maintenance, including:

- Media campaigns to increase awareness about septic system and water quality (e.g., billboards, radio, newspaper)
- Conventional outreach materials on maintenance (e.g., brochures, bill inserts, newsletters)
- Free or mandatory inspections

- Discount coupons for septic system maintenance
- Low interest loans for septic system repairs
- Performance certification upon property transfer
- Creation of septic management districts
- Certification and training of operation/maintenance professionals
- Termination of public services for failing systems

### **Good Examples**

Swann (2001) describes a series of case studies of effective local programs to improve septic system maintenance. Some additional examples are provided below:

*Washtenaw County, Michigan Time-Of-Sale Program:* The County's septic system regulation requires the inspection of all residential septic systems by private evaluators at the time of sale of a property. Evaluations must be done by a certified inspector who has received a license after training and an exam.  
<http://www.rougeriver.com/pdfs/illicit/OSS-02.pdf>

*Yarmouth, Maine Free Pumpouts (Septic Tank Pumping Ordinance)* - The town offers free septic system pump-outs to residents once every three years.  
<http://www.yarmouth.me.us/vertical/Sites/%7B13958773-A779-4444-B6CF-0925DFE46122%7D/uploads/%7B363C4270-0879-43BC-8639-55BFA419AC12%7D.PDF>

*Cannon Township, MI Septic Inspections and Testing* - The township used school children to conduct dye tests to identify failing septic systems. This program doubled as an education campaign to increase awareness of septic system owners.  
[http://peer.tamu.edu/curriculum\\_modules/Water\\_Quality/module\\_1/Kids%20Dye%20Project.htm](http://peer.tamu.edu/curriculum_modules/Water_Quality/module_1/Kids%20Dye%20Project.htm)

## Top Resources

Many excellent resources are available to educate homeowners about septic systems and water quality. Some of the better reference websites are provided below, and many contain additional educational links.

*On-site Wastewater Treatment Systems Manual*  
<http://www.epa.gov/ord/NRMRL/Pubs/625R00008/html/625R00008.htm>

*A Homeowner's Guide to Septic Systems*  
[http://www.epa.gov/npdes/pubs/homeowner\\_guide\\_long.pdf](http://www.epa.gov/npdes/pubs/homeowner_guide_long.pdf)

*National Small Flows Clearinghouse*  
[http://www.nesc.wvu.edu/nsfc/nsfc\\_septicnews.htm](http://www.nesc.wvu.edu/nsfc/nsfc_septicnews.htm)

*On-site Septic Systems: Educating the Homeowner*  
[http://www.nesc.wvu.edu/nsfc/Articles/SFQ/SFQw02\\_web/SFQw02\\_OnsiteEducation.html](http://www.nesc.wvu.edu/nsfc/Articles/SFQ/SFQw02_web/SFQw02_OnsiteEducation.html)

*University of Minnesota Onsite Sewage Treatment Program*  
<http://septic.coafes.umn.edu/>

*North Carolina Coast\* A\* Syst*  
<http://www.soil.ncsu.edu/assist/cas/septic/index.htm>



<h1>N-18</h1>	<b>Neighborhood Source Area: Common Areas</b>	
	<h2>PET WASTE PICKUP</h2>	

**Description**

The ideal watershed behavior is to pick up and properly dispose of pet waste (Figure 1). The negative watershed behavior is to leave pet waste in common areas and the yard, where it can be washed off in storm water runoff.

residents for pet waste is the trash can, with toilets coming in distant second. Dog walkers that do not pick up after their dogs are highly resistant to change; nearly half would not pick up even if confronted with fines or complaints from neighbors (Swann, 1999). Men are also prone to pick up after their dogs less often than women (Swann, 1999).

**How Pet Waste Influences Subwatershed Quality**

Pet waste has been found to be a major source of fecal coliform bacteria and pathogens in many urban subwatersheds (Schueler, 1999). A typical dog poop contains more than three billion fecal coliform bacteria and as many as 10% of dogs are also infected with either *giardia* or salmonella, which is not surprising considering they drink urban creek water. Fecal coliform bacteria are frequently detected in urban streams and rivers after storms, with levels as high 5,000 fecal coliform per tablespoon. Thus, it is not uncommon for urban and suburban creeks to frequently violate bacteria standards for swimming and water contact recreation after larger rainstorms.

**Percentage of Residents that Pick Up After Pets**

Surveys indicate that about 40% of all households own one or more dogs (Swann, 1999). Not all dog owners, however, are dog walkers. Only about half of dogs are walked regularly. About 60% of dog walkers claim to pick up after their dog some or all of the time (Swann, 1999; HGIC, 1998; and Hardwick, 1997). The primary disposal method reported by



**Figure 1: Pet Waste Pickup Station**

### Techniques to Promote Pet Waste Pickup

The key technique is to educate residents on sanitary and convenient options for retrieving and disposing of pet waste. Several communities have used both carrots and sticks to get more owners to pick up after their pets, including:

- Mass media campaigns of the water quality impacts of pet waste
- Conventional outreach materials (brochures, flyers, posters)
- Pooper bag stations in parks, greenways and common areas
- Educational signs in same areas
- “Pooper scooper” ordinances and enforcement
- Banning dogs from beaches and waterfront areas
- Providing designated “dog parks”

### Good Examples

#### *Water Quality Consortium Nonpoint Source Education Materials*

The Water Quality Consortium implemented an ad campaign focused on four themes: a man pushing a fertilizer spreader, a car driving on water leaking oil, a man washing his car, and man walking his dog. Each ad explains how the behavior leads to water pollution and provides specific tips outlining what residents can do to protect water quality.

[http://www.psat.wa.gov/Programs/Pie\\_Ed/Water\\_Ed\\_Materials.htm](http://www.psat.wa.gov/Programs/Pie_Ed/Water_Ed_Materials.htm)

#### *Pick It Up - It's Your Doodle Campaign (Gwinnett County Parks & Recreation Department)*

The county park agency provides plastic grocery bags for pet owners to use to clean up after their pets as part of a pilot program. The baggies are attached to a wooden post at a local park. Underneath a sign explains their purpose. Pet owners are also encouraged to bring replacement bags when they visit the park. <http://www.gwinnettcitizen.com/0203/doodle.html>

### Top Resources

#### *Public Open Space and Dogs: A Design and Management Guide for Open Space Professionals and Government*

<http://www.petnet.com.au/openspace/frontis.html>

#### *Considerations for the Selection and Use of Pet Waste Collection Systems in Public Areas*

[http://www.ecy.wa.gov/programs/wq/nonpoint/pet\\_waste/petwaste\\_station.pdf](http://www.ecy.wa.gov/programs/wq/nonpoint/pet_waste/petwaste_station.pdf)

#### *Properly Disposing of Pet Waste*

[http://www.cleanwatercampaign.com/what\\_can\\_i\\_do/pet\\_waste\\_home.html](http://www.cleanwatercampaign.com/what_can_i_do/pet_waste_home.html)

#### *Managing Pet and Wildlife Waste to Prevent Contamination of Drinking Water*

U.S. EPA Source Water Protection Practices Bulletin.

<http://www.epa.gov/safewater/protect/pdfs/petwaste.pdf>

<b>N-1</b>	<b>Neighborhood Source Area: Yard</b>	
	<b>REDUCED FERTILIZER USE</b>	

**Description**

The ideal behavior is to not apply fertilizer to lawns. The next best thing for homeowners who feel they must fertilize is to practice natural lawn care: using low inputs of organic or slow release fertilizers that are based on actual needs as determined by a soil test. The obvious negative watershed behavior is improper fertilization, whether in terms of the timing, frequency or rate of fertilizer applications, or a combination of all three. The other important variable to define is who is applying fertilizer in the neighborhood. Nationally, about 75% of lawn fertilization is done by homeowners, with the remaining 25% applied by lawn care companies (Figure 1). This split, however, tends to be highly variable within individual neighborhoods, depending on its income and demographics.

**How Fertilizer Influences Water Quality**

Recent research has demonstrated that lawn over-fertilization produces nutrient runoff with the potential to cause downstream eutrophication in streams, lakes, and estuaries (Barth, 1995a and 1995b). Scientists have also discovered that nitrogen and phosphorus levels in lawn runoff are about two to 10 times higher than any other part of the urban landscape such as streets,



**Figure 1: Lawn Care Company Truck**

rooftops, driveways or parking lots (Bannerman *et al.*, 1993; Steuer *et al.*, 1997; Waschbusch *et al.*, 2000; Garn, 2002).

**Percentage of People Engaging in Fertilizer Use**

Lawn fertilization is among the most widespread watershed behaviors in which residents engage. A survey of lawn care practices in the Chesapeake Bay indicated that 89% of citizens owned a yard, and of these, 50% applied fertilizer every year (Swann, 1999). The average rate of fertilization in 10 other regional lawn care surveys was even higher (78%), although this may reflect the fact that these surveys were biased towards predominantly suburban neighborhoods and excluded non-lawn owners. Several studies have measured the frequency of lawn fertilization, and have found that lawns are fertilized about twice a year, with spring and fall being the most common season for applications (Swann, 1999).

A significant fraction of homeowners can be classified as “over-fertilizers” who apply fertilizers above recommended rates. Surveys indicate the number of over-fertilizers at 50% to 70% of all fertilizers (Morris and Traxler, 1996; Swann, 1999; Knox *et al.*, 1995). Clearly, many homeowners, in a quest for quick results or a bright green lawn, are applying more nutrients to their lawns than they actually need.

**Variation in Fertilization Behavior**

Many regional and neighborhood factors influence local fertilization behavior. From a regional standpoint, climate is a very important factor, as it determines the length of the growing season, type of grass, and the irrigation needed to maintain a lawn. A detailed discussion of the role these factors play in fertilization can be

found in Barth (1995a). A host of factors also comes into play at the individual neighborhood scale. Some of the more important variables include average income, market value of houses, soil quality, and the age of the development (Law *et al.*, 2004). Higher rates of fertilization appear to be very common in new suburban neighborhoods where residents seek to establish lawns and landscaping. Also, lawn irrigation systems and fertilization are strongly associated.

### Difficulty in Changing Behavior

Changing fertilization behaviors can be hard since the desire for green lawns is deeply rooted in our culture (Jenkins, 1994; Teyssott, 1999). For example, the primary fertilizer is a man in the 45 to 54 year age group (BHI, 1997) who feels that “a green attractive lawn is an important asset in a neighborhood” (De Young, 1997). According to surveys, less than 10% of lawn owners take the trouble to take soil tests to determine whether fertilization is even needed (Swann, 1999; Law *et al.*, 2004). Most lawn owners are ignorant of the phosphorus or nitrogen content of the fertilizer they apply (Morris and Traxler, 1996), and are unaware that grass-cycling can sharply reduce fertilizer needs.

Most residents rely on commercial sources of information when making their fertilization decisions. The average consumer relies on product labels, store attendants, and lawn care companies as their primary, and often exclusive, sources of lawn care information. Consumers are also influenced by direct mail and word of mouth when they choose a lawn care company (Swann, 1999 and AMR, 1997).

Two approaches have shown promise in changing fertilization behaviors within a neighborhood, and both involve direct contact with individual homeowners. The first relies on using neighbors to spread the message to other residents, through master gardening programs. Individuals tend to be very receptive to advice from their peers, particularly if it relates to a

common interest in healthy lawns. The second approach is similar in that it involves direct assistance to individuals at their homes (e.g., soil tests and lawn advice) or at the point of sale.

### Techniques to Change Behavior

Most communities have primarily relied on carrots to change fertilization behaviors, although sticks are occasionally used in phosphorus-sensitive areas. The following are some of the most common techniques for changing fertilization behaviors:

- Seasonal media awareness campaigns
- Distribution of lawn care outreach materials (brochures, newsletters, posters, etc.; Figure 2)
- Direct homeowner assistance and training
- Master gardener program
- Exhibits and demonstration at point-of-sale retail outlets
- Free or reduced cost for soil testing
- Training and/or certification of lawn care professionals
- Lawn and garden shows on radio
- Local restrictions on phosphorus content in fertilizer

### Good Examples

*King County, Washington- Northwest Natural Yard Days.* This month-long program offers discounts on natural yard care products and educational information about natural yard care in local stores throughout King County and Tacoma. Education specialists came to Saturday and Sunday events at some stores and spent time with buyers to help them make good choices and learn about natural yard care, including the use of organic fertilizers that don't wash off into streams and lakes as easily as "quick release" chemical fertilizers. For more details, consult: <http://dnr.metrokc.gov/swd/ResRecy/events/naturalyard.shtml>





**COVER CROP**  
(acre)  
CODE 340

**DEFINITION**

Grasses, legumes, forbs, or other herbaceous plants established for seasonal cover and conservation purposes.

**PURPOSES**

- Reduce erosion from wind and water
- Increase soil organic matter
- Manage excess nutrients in the soil profile
- Promote biological nitrogen fixation
- Increase biodiversity
- Weed suppression
- Provide supplemental forage
- Soil moisture management

**CONDITIONS WHERE PRACTICE APPLIES**

On all lands requiring vegetative cover for natural resource protection

**CRITERIA**

**General Criteria Applicable To All Purposes**

Plant species, seedbed preparation, seeding rates, seeding dates, seeding depths, and planting methods will be consistent with approved local criteria and site conditions.

The species selected will be compatible with the nutrient management and pest management provisions of the plan.

Cover crops will be terminated by harvest, frost, mowing, tillage, and/or herbicides in preparation for the following crop.

Herbicides used with cover crops will be compatible with the following crop

Cover crop residue will not be burned

**Additional Criteria to Reduce Erosion From Wind and Water**

Cover crop establishment, in conjunction with other practices, will be timed so that the soil will be adequately protected during the critical erosion period(s).

Plants selected for cover crops will have the physical characteristics necessary to provide adequate protection.

The amount of surface and/or canopy cover needed from the cover crop shall be determined using current erosion prediction technology.

# **NUTRIENT MANAGEMENT**

(Acre)  
CODE 590

## **DEFINITION**

Managing the amount, source, placement, form and timing of the application of nutrients and soil amendments.

## **PURPOSES**

- To budget and supply nutrients for plant production.
- To properly utilize manure or organic by-products as a plant nutrient source.
- To minimize agricultural nonpoint source pollution of surface and ground water resources.
- To maintain or improve the physical, chemical and biological condition of soil.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice applies to all lands where plant nutrients and soil amendments are applied.

## **CRITERIA**

### **General Criteria Applicable to All Purposes**

Plans for nutrient management shall comply with all applicable Federal, state, and local laws and regulations.

Plans for nutrient management shall be developed in accordance with policy requirements of the NRCS General Manual Title 450, Part 401.03 (Technical Guides, Policy and Responsibilities) and Title 190, Part 402 (Ecological Sciences, Nutrient Management, Policy); technical requirements of the NRCS Field Office Technical Guide (FOTG); procedures contained in the National Planning Procedures Handbook (NPPH), and the NRCS National Agronomy Manual (NAM) Section 503.

Persons who review or approve plans for nutrient management shall be certified through any certification program acceptable to NRCS within the state.

Plans for nutrient management that are elements of a more comprehensive conservation plan shall recognize other requirements of the conservation plan and be compatible with its other requirements.

A nutrient budget for nitrogen, phosphorus, and potassium shall be developed that considers all potential sources of nutrients including, but not limited to animal manure and organic by-products, waste water, commercial fertilizer, crop residues, legume credits, and irrigation water.

Realistic yield goals shall be established based on soil productivity information, historical yield data, climatic conditions, level of management and/or local research on similar soil, cropping systems, and soil and manure/organic by-products tests. For new crops or varieties, industry yield recommendations may be used until documented yield information is available.

**POND**  
**(No.)**  
**CODE 378**

**DEFINITION**

A water impoundment made by constructing a dam or an embankment or by excavating a pit or dugout.

In this standard, ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at spillway elevation is 3 ft or more.

**PURPOSE**

To provide water for livestock, fish and wildlife, recreation, fire control, crop and orchard spraying, and other related uses, and to maintain or improve water quality.

**SCOPE**

This standard establishes the minimum acceptable quality for the design and construction of ponds if:

1. Failure of the dam will not result in loss of life; in damage to homes, commercial or industrial buildings, main highways, or railroads; or in interruption of the use or service of public utilities.
2. The product of the storage times the effective height of the dam is less than 3,000. Storage is the volume, in acre-feet, in the reservoir below the elevation of the crest of the emergency spillway. The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point in the cross section taken along the centerline of the dam. If there is no emergency spillway, the top of the dam is the upper limit.
3. The effective height of the dam is 35 ft or less, and the dam is hazard class (a).

**CONDITIONS WHERE PRACTICE APPLIES**

**Site conditions.** Site conditions shall be such that runoff from the design storm can be safely passed through (1) a natural or constructed emergency spillway, (2) a combination of a principal spillway and an emergency spillway, or (3) a principal spillway.

**Drainage area.** The drainage area above the pond must be protected against erosion to the extent that expected sedimentation will not shorten the planned effective life of the structure. The drainage area shall be large enough so that surface runoff and groundwater flow will maintain an adequate supply of water in the pond. The quality shall be suitable for the water's intended use.

**Reservoir area.** The topography and soils of the site shall permit storage of water at a depth and volume that ensure a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. If surface runoff is the primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses or shall be of a type that sealing is practicable.

# **PRESCRIBED GRAZING**

(Acre)  
CODE 528A

## **DEFINITION**

The controlled harvest of vegetation with grazing or browsing animals, managed with the intent to achieve a specified objective.

## **PURPOSES**

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

- Improve or maintain the health and vigor of selected plant(s) and to maintain a stable and desired plant community.
- Provide or maintain food, cover and shelter for animals of concern.
- Improve or maintain animal health and productivity.
- Maintain or improve water quality and quantity.
- Reduce accelerated soil erosion and maintain or improve soil condition for sustainability of the resource.

## **CONDITIONS WHERE PRACTICE APPLIES**

This practice may be applied on all lands where grazing and/or browsing animals are managed.

## **CRITERIA**

### **General Criteria Applicable For All The Purposes Stated Above.**

Removal of herbage will be in accordance with production limitations, plant sensitivities and management goals using Sections I & II of the FOTG and other references as guidance.

Frequency of defoliations and season of grazing will be based on the rate and physiological conditions of plant growth.

Duration and intensity of grazing will be based on desired plant health and expected productivity of key forage species to meet management unit objectives.

Maintain enough vegetative cover to prevent accelerated soil erosion due to wind and water.

Application of this practice will manipulate the intensity, frequency, duration, and season of grazing to:

- Insure optimum water infiltration,
- Maintain or improve riparian and upland area vegetation,
- Protect stream banks from erosion,
- Manage for deposition of fecal material away from water bodies, and
- Promote ecological and economical stable plant communities on both upland and bottom land sites which meet landowner objectives.

### **Additional Criteria For Improved Animal Health And Productivity.**

# WHITE OAK BAYOU WATERSHED MANAGEMENT PLAN

---

