Lower Ouachita-Smackover HUC-8 Watershed Management Plan

Developed for the
Arkansas Department of Agriculture Natural Resources Division

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Alliance Technical Group

South West Arkansas Planning & Development District

United States Environmental Protection Agency

Lower Ouachita-Smackover HUC-8 Watershed Management Plan

Acknowledgements:

Ouachita Couty

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Equilibrium, Inc

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United States Geological Survey

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EXECUTIVE SUMMARY

Section 319(h) of the Clean Water Act was added in 1987 to create a national program to address nonpoint source pollution (pollution that enters our waters primarily through stormwater run-off). Section 319(h) provides funding and has encouraged states and territories to manage their waters using a watershed approach. The watershed approach provides a flexible but comprehensive framework to assess and manage water quality and quantity. Using this approach, the attention is focused on not only point source discharges but also stream disturbances in riparian corridors and how anthropogenic land use changes impact stormwater runoff.

Arkansas Department of Agriculture, Natural Resources Division designated the Lower Ouachita-Smackover Creek Watershed (LOSW) as a priority watershed in the Nonpoint Source (NPS) Pollution Management Plan during the review processes for the 2011-2016 Plan. In the 2018-2023 Plan the LOSW continued to score as a priority watershed. However, in the 2024-2029 ranking matrix, the watershed no longer ranked as a priority. The Natural Resources Division manages 319 grant project funding and is the primary agency in Arkansas that initiates NPS pollution control.

Since nonpoint source pollution is connected to land use, and most land is privately owned, landowner involvement is critical to approach watershed issues holistically.

The objective of this project is to develop a nine-element watershed management plan (WMP) for the LOSW. One key component of the assessment portion of this project will be the development of the soil and water assessment tool (SWAT) model to predict NPS contributions in the watershed. A ranking matrix was developed to incorporate key assessment efforts that have been collected over the last couple of decades and to prioritize the LOSW HUC-12 sub-watersheds just as Natural Resources Division does with the state’s HUC-8 watersheds.

Preparation of this plan was funded partially by an EPA 319 Grant through the Arkansas Natural Resources Division. The Southwest Arkansas Planning and Development District (SWAPDD), the grantee, has spearheaded efforts in the expansive LOSW, partnering with Cities of El Dorado, Smackover, Norphlet, Camden, and East Camden, along with Ouachita and Union counties, Arkansas Division of Environmental Quality (DEQ), Alliance Technical Group (ATG) and the Union County Water Conservation Board.

The LOSW (HUC 08040201) is approximately 1,804 mi2 in size with 48 HUC- 12 sub-watersheds (Figure A). The LOSW spans over multiple counties in Arkansas including Bradely, Calhoun, Cleveland, Columbia, Dallas, Nevada, Ouachita, and Union.

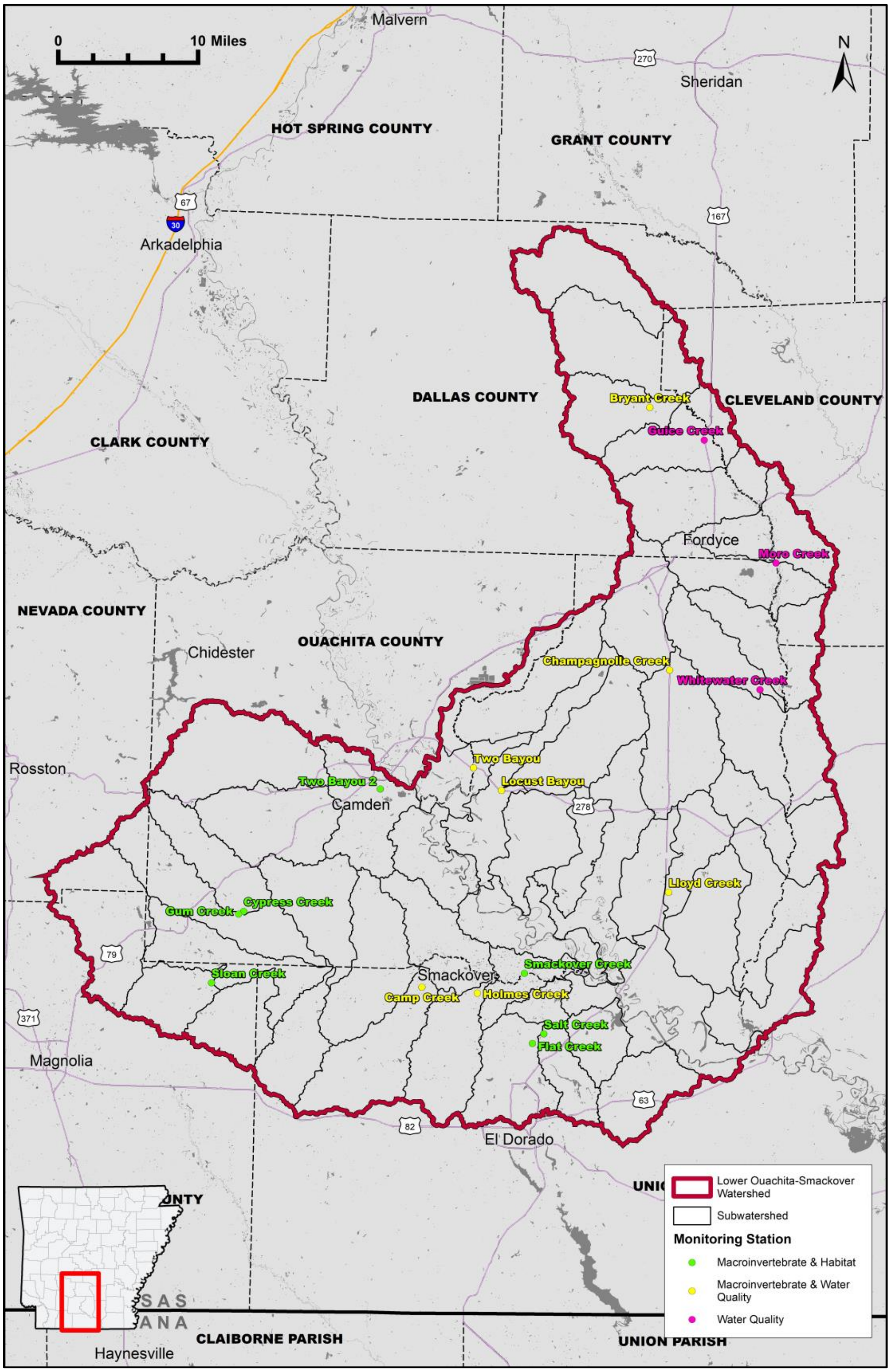


Figure A. Lower Ouachita-Smackover HUC-8 watershed.

Overall, the watershed is dominated by forest land uses (53%). Silviculture is the dominant land use as represented by the amount of evergreen forests in the watershed, which comprise the majority of the forest land uses, averaging 50% overall. Emergent and woody wetland land uses comprise a large percentage (27%), while developed areas only make up approximately 6% of the watershed (NLCD, 2019).

A comprehensive assessment was completed on the LOSW to evaluate its physical, chemical, and hydrologic condition. In total there are 48 HUC-12 sub-watersheds in the larger HUC-8 LOSW. Data evaluated from the watershed spans from 2011-2023. All data were considered for use in this assessment. Assessment efforts included:

- Desktop/GIS analysis
- Water quality monitoring
- SWAT modeling
- Bioassessment
- Flow gauging
- Unified Stream Assessments

Of the 48 sub-watersheds, 29 form the basis for how the findings from the assessment phase will be utilized to identify and prioritize pollutant sources for management. Using the results of the assessment work completed in the watershed, the following is a summary of the results and recommendations.

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 oil and gas well numbers, developed and hay/pasture land use percent, monitored total nitrogen, and TSS loads, concentration of cattle, slope of the watershed, amount of impacted riparian buffers, miles of unpaved roads, SWAT model load predictions for sediment and nitrogen, percent of reach eroded and amount of streambank erosion.

According to the matrix ranking, the five key sub-watersheds in most need of land use management and source reductions in the LOSW are Haynes Creek-Smackover Creek, Sandy Creek, Little Two Bayou- Two Bayou, Taylor Creek -Champagnolle Creek, and Sloan Creek. A visualization of the matrix rankings in each of the sub-watersheds is provided below in Figure B.

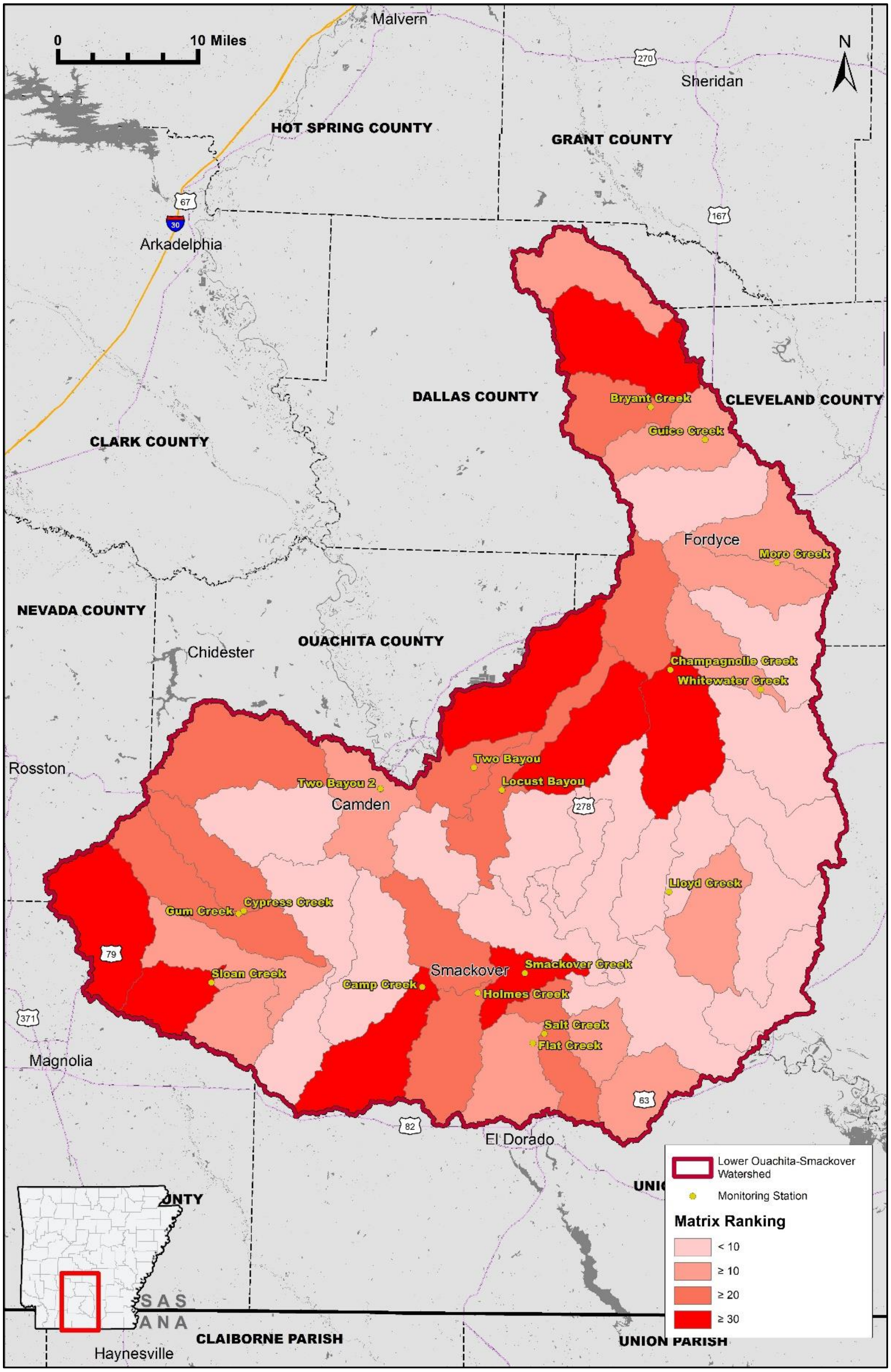


Figure B. Visualization of matrix ranking scores by priority sub-watershed.

Once the watershed priorities are established then a series of best management practices (BMP) are recommended to reduce pollutants in stormwater run-off in these priority sub-watersheds. The primary BMPs recommended are:

- Vegetated Filter Strips/Riparian Buffers in pasture/hay/urban/agricultural land uses
- A sweet of detention oriented BMPs in urban/development land uses
- A sweet of stormwater BMPs in oil/gas field land uses
- Eroding streambank stabilization
- Unpaved road BMPs

To encourage progress towards attainment of the goals of the WMP a series of measurable milestones has been established (Table A).

Table A. Interim Measurable Milestones.

Milestone	Measurement method
Stakeholder group success	Meetings at least 2/year and attendance of at least 40% of group on average
Monitoring program initiated	First round of routine samples collected
Unpaved road BMP meeting	Meeting occurred on schedule
Grant applications submitted	At least two applications completed
Eroded streambank stabilization	Stabilization completed on schedule Length of stream completed as planned
Oil and Gas field stormwater management practices implemented	Completed on schedule and attaining percentage goals
Unpaved Road BMPs implemented	Completed on schedule and attaining percentage goals
Urban areas stormwater management practices implemented	Completed on schedule and attaining percentage goals
Monitoring shows TSS and TN loading is stable or decreasing	Data analysis (per Section 7.0) of first three-year monitoring cycle (2025-2027)
WMP reviewed and updated every five years	Plan review is completed in 2029 and needed updates included

Implementation of the recommended management measures in this WMP are strictly voluntary. In areas where the Arkansas Department of Energy and Environments Division of Environmental Quality (DEQ) has designated waters not in attainment of the state water quality standards a total maximum daily load (TMDL) may dictate required reductions, but this WMP does not have similar regulatory authority nor require any entity to abide by its recommendations, which simply serve as a guide to improve water quality in the watershed.

1.0 INTRODUCTION

Section 319(h) of the Clean Water Act was added in 1987 to create a national program to address nonpoint source pollution. Section 319(h) provides funding and has encouraged states and territories to manage their waters using a watershed approach. The watershed approach provides a flexible but comprehensive framework to assess and manage water quality and quantity. Using this approach, the attention is focused on not only point source discharges but also stream disturbances in riparian corridors and how anthropogenic land use changes impact stormwater runoff.

In 2008 the EPA released a guide, Handbook for Developing Watershed Plans to Restore and Protect Our Waters (EPA, 2008). This Watershed Management Plan (WMP) has been developed largely on the 2008 Environmental Protection Agency (EPA) guidance along with the 2013 Quick Guide to Developing Watershed Plans to Restore and Protect Our Waters (EPA, 2008 & 2013). Both guides discuss the complexity and difficulty of identifying and resolving nonpoint source pollution. Since nonpoint source pollution is connected to land use, and most land is privately owned, landowner involvement is critical to approach watershed issues holistically. The EPA has found success with involvement from stakeholders. Establishing a stakeholder group that lives in the watershed is the best way to approach watershed planning as they have a vested interest. Further, the EPA manuals provide guidance on how to incorporate the nine minimum elements from the Clean Water Act Section 319 Nonpoint Source Program's funding guidelines into the watershed development process (Table 1.1).

Preparation of this plan was funded partially by an EPA 319 Grant through the Arkansas Department of Agriculture, Natural Resources Division. The Southwest Arkansas Planning and Development District (SWAPDD), the grantee, has spearheaded efforts in the expansive Lower Ouachita -Smackover Watershed (LOSW), partnering with Cities of El Dorado, Smackover, Norphlet, Camden, and East Camden, along with Ouachita and Union counties, Arkansas Division of Environmental Quality (DEQ), Alliance Technical Group (ATG) and the Union County Water Conservation Board.

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 that need to be controlled	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 reduction goals	Section 6.0
Element 4 - Estimate technical and financial resources needed to implement the plan	Section 9.0
Element 5 - Develop information and education component	Section 8.0
Element 6 – Develop an implementation schedule	Section 6.0
Element 7 - Develop interim measurable milestones to track management implementation	Section 6.0
Element 8 - Criteria to measure success of watershed goals	Section 7.0
Element 9 - Monitoring component to evaluate progress of watershed goals	Section 7.0

Arkansas Department of Agriculture, Natural Resources Division designated the Lower Ouachita-Smackover Creek Watershed (LOSW) as a priority watershed in the Nonpoint Source (NPS) Pollution Management Plan during the review processes for the 2011-2016 Plan. In the 2018-2023 Plan the LOSW continued to score as a priority watershed. However, in the 2024-2029 ranking matrix, the watershed no longer ranked as a priority. The Natural Resources Division manages 319 grant project funding and is the primary agency in Arkansas that initiates NPS pollution control.

The approved Arkansas 2018 303(d) list contains 22 assessment units in the LOSW. Nutrients, metals, and sediment (turbidity) appear to be the principal concern in the watershed today. Several sources are believed to be contributors to these elevated levels including industrial and municipal NPDES discharges and NPS pollution.

Over the past couple of decades, data has been collected in the LOSW. In 2011 the University of Arkansas's Water Resource Center received a Section 319 grant to collect water quality data in the LOSW. Equilibrium, Inc. has completed two water quality and flow studies as part of 319 projects, that have been completed in the watershed (Equilibrium, 2020). Alliance Technical Group (ATG) completed macroinvertebrate community assessments and stream physical habitat assessment in the spring of 2023 as part of this 319 project. These projects along with other key studies will be discussed in Section 3 of this WMP. The objective of this project is to develop a nine-element WMP for the LOSW. One key component of the assessment portion of this project will be the development of the soil and water assessment tool (SWAT) model to predict NPS contributions in the watershed. A ranking matrix was developed to incorporate key assessment efforts that have been collected over the last couple of decades and to prioritize the HUC-12 subwatersheds just as Natural Resources Division does with the state’s HUC-8 watersheds.

2.0 WATERSHED DESCRIPTION

The LOSW is a priority watershed for the Arkansas Nonpoint Management Plan and has listed streams on the Arkansas DEQ's (EPA approved) 2018 303(d) list. The LOSW (HUC 08040201) is approximately 1,804 mi2 in size with 48 HUC- 12 subwatersheds (Figure 2.1). The LOSW spans over multiple counties in Arkansas including Bradely, Calhoun, Cleveland, Columbia, Dallas, Nevada, Ouachita, and Union. The HUC-12 subwatersheds range in size from 17.8 mi2 to 60.4 mi2. The watershed is encompassed by the Gulf Coastal Plain ecoregion (Omernick, 1987).

Overall, the watershed is dominated by forest land uses (53%) (Figure 2.2). Silviculture is the dominant forest land use as represented by the amount of evergreen forests in the watershed, which comprise the majority of the forest land uses, averaging 50% overall. Emergent and woody wetland land uses comprise a large percentage (27%), while developed areas only make up approximately 6% of the watershed (NLCD, 2019). Haynes Creek and Mill Creek -Smackover Creek have the highest amount of development within their watersheds at 20% and 23%, respectively. Soils on the land surface in the watershed (Figure 2.3) are primarily dominated by the Guyton soils that frequently flood. The second most common soil type is Smithton's fine sandy loam with 0-2% slopes. The third largest soil type within the watershed was Amy silt loam with 0-1% slopes that frequently floods. Soil types present in the LOSW are displayed in Figure 2.3. Slopes are fairly flat overall (3.7% on average) with averages for the HUC-12s ranged from 1.3%-7.5% (Figure 2.4.)

All waters in the state of Arkansas have Designated Uses applied to them that dictate the level of water quality that must be maintained. The drainages in the LOSW are designated for the following uses by the Arkansas' Division of Environmental Quality (ADEQ):

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

*Except for those waters with designated use variations supported by Use Attainability Analysis or other investigations. Figure 2.5 contains the streams that use attainability studies, streams on the 303(d) list, and which streams have extraordinary resource waters.

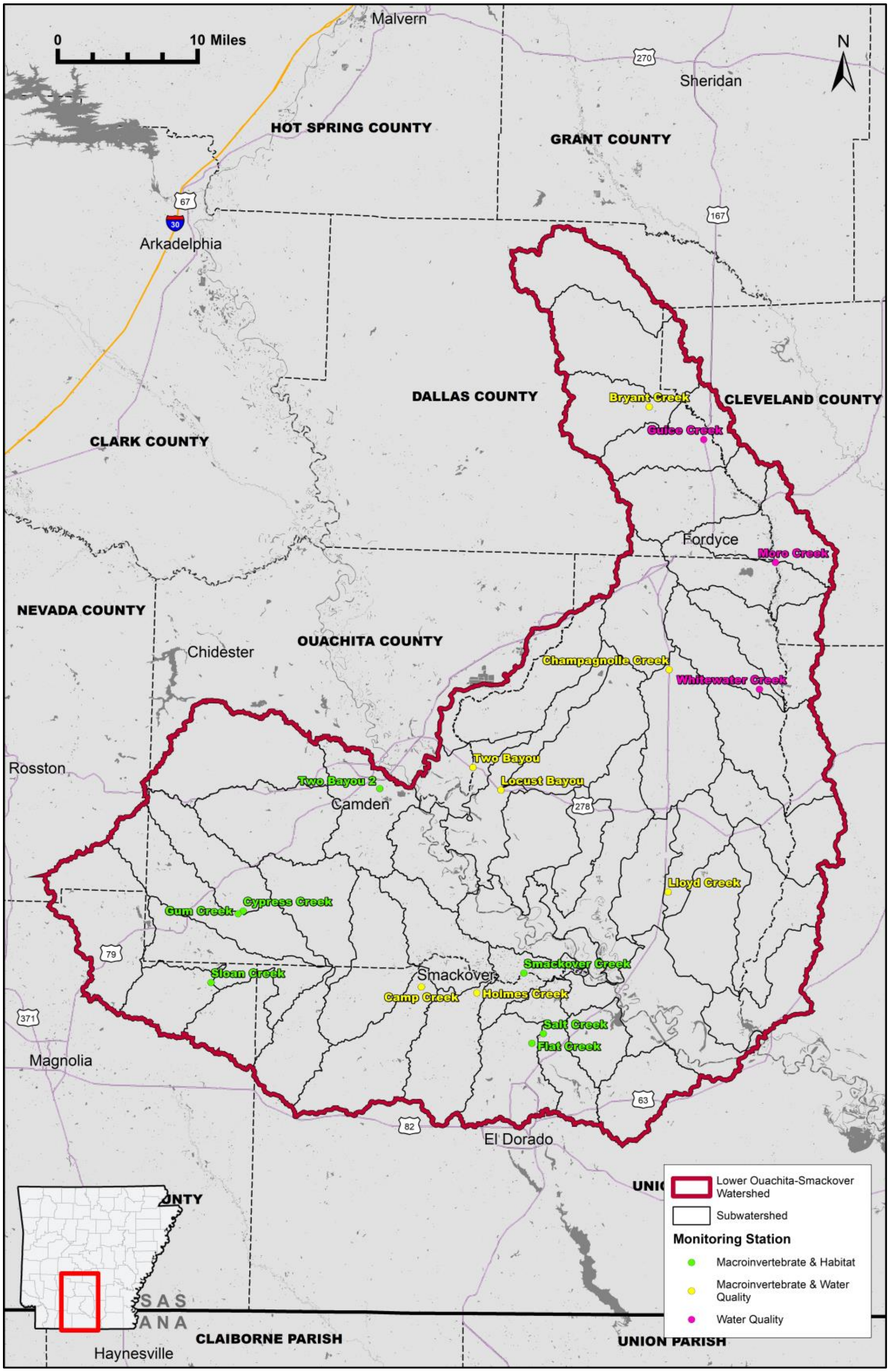


Figure 2.1. General overview of LOSW showing subwatersheds and the equilibrium Monitoring locations.

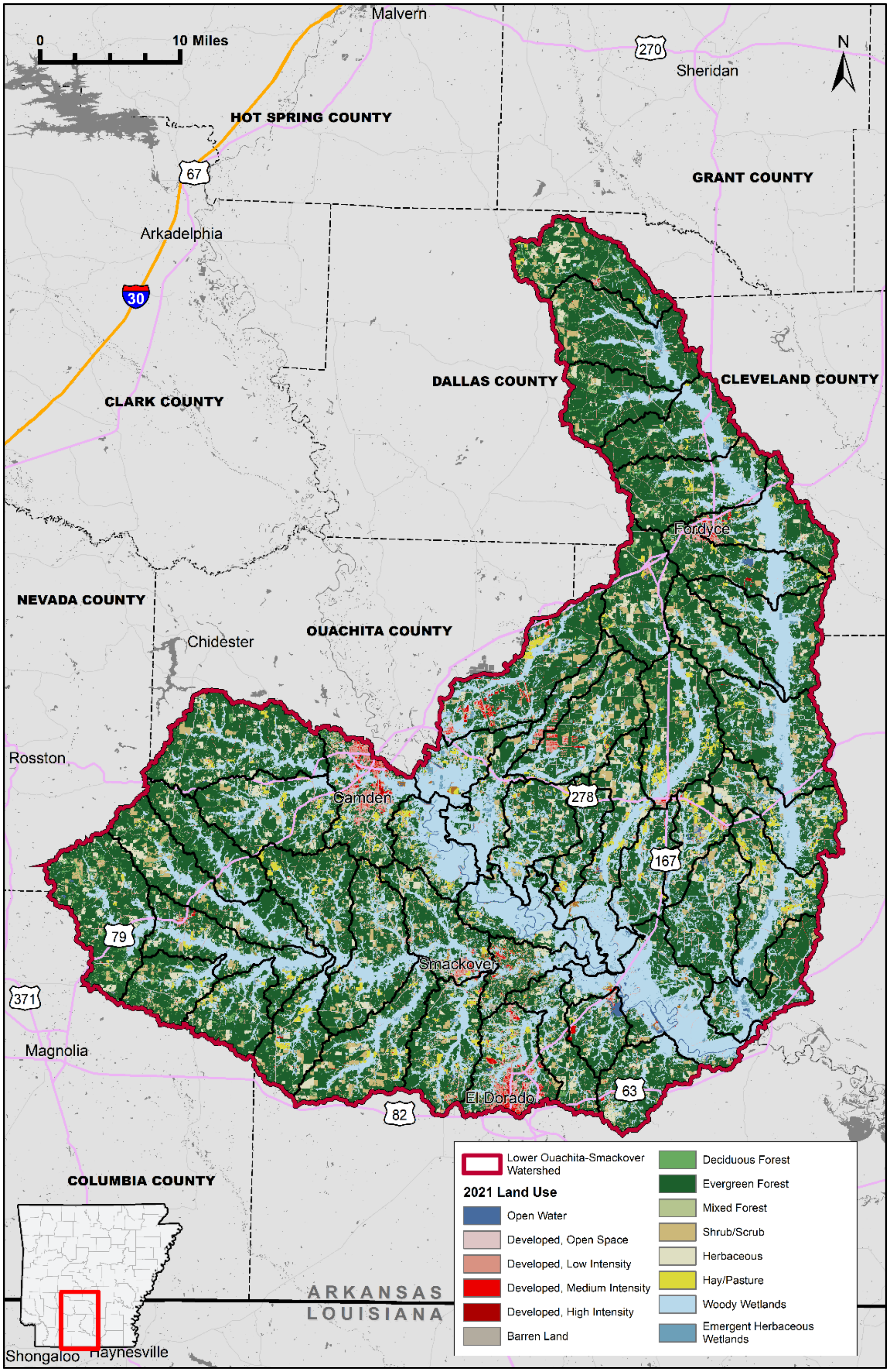


Figure 2.2. LOSW land uses using the NLCD 2021 dataset.

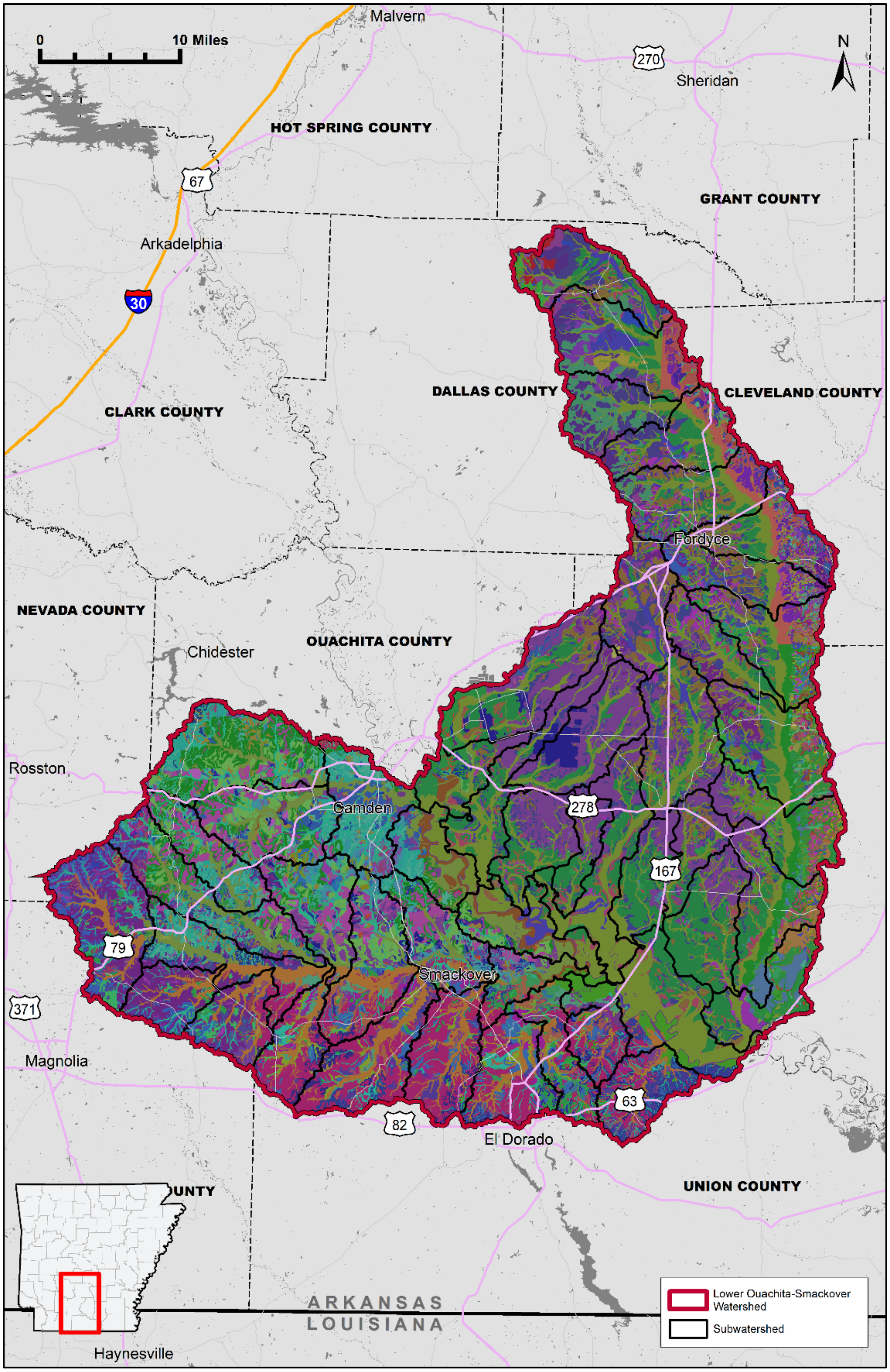


Figure 2.3. Map of soils in the LOSW.

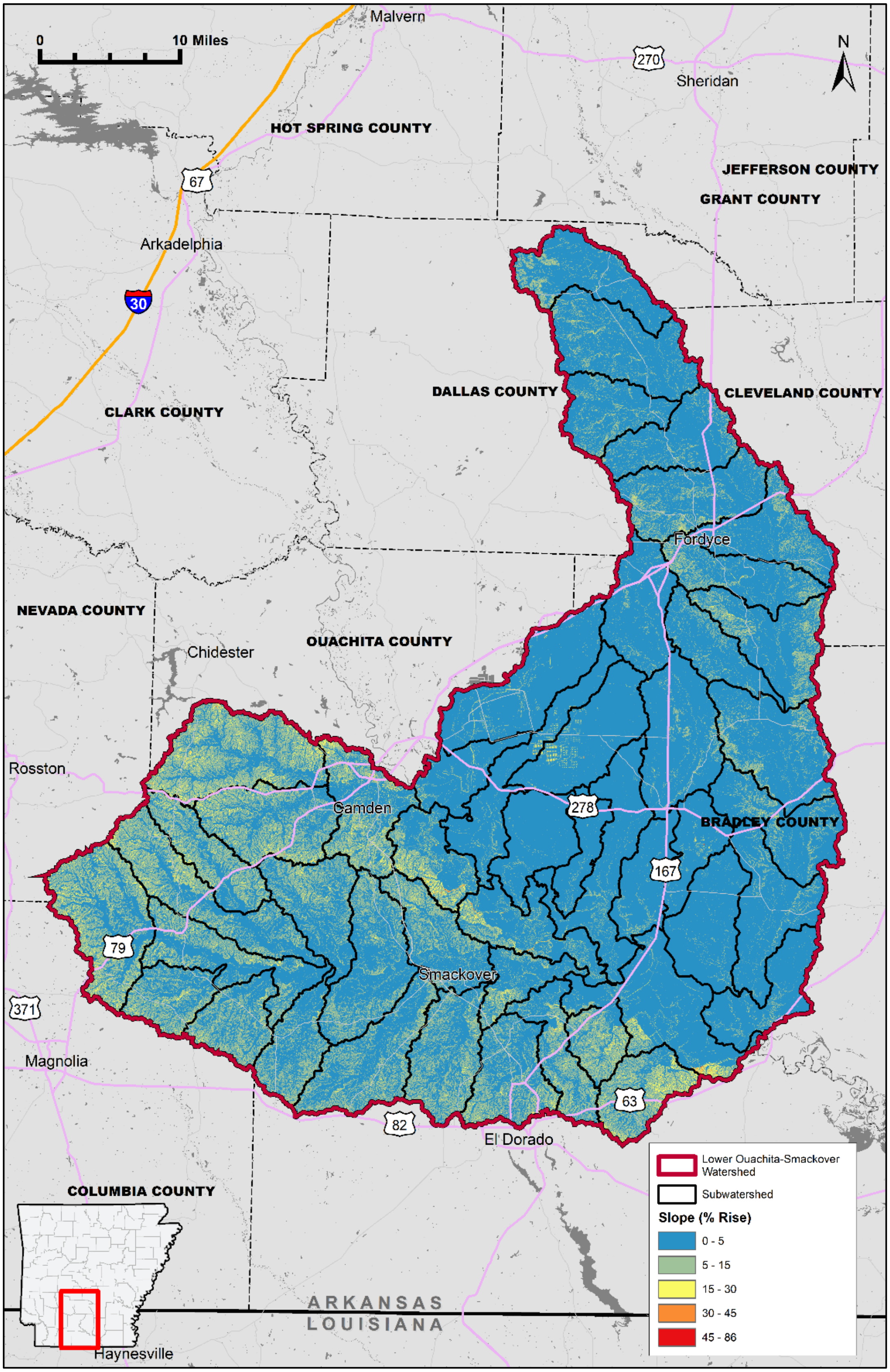


Figure 2.4. Land surface slope in the LOSW.

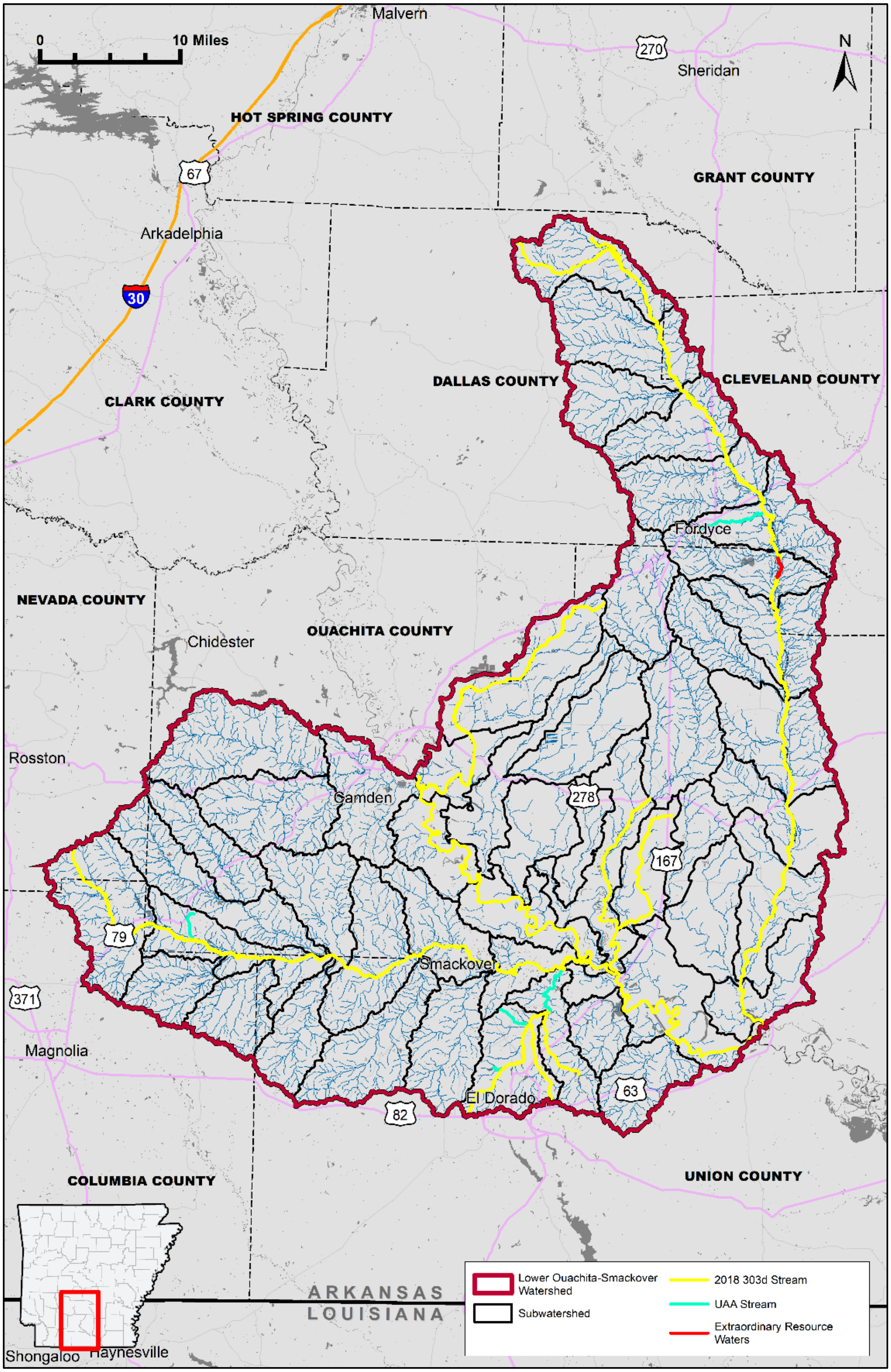


Figure 2.5. Map of extraordinary resource waters, use attainability analyses, and streams on the 303 (d) list.

3.0 WATERSHED ASSESSMENT

A comprehensive assessment was completed on the LOSW to evaluate its physical, chemical, and hydrologic condition. In total there are 48 HUC-12 subwatersheds in the HUC-8 LOSW. Data evaluated from the watershed spans from 2011-2023. All data were considered for use in this assessment. Completed studies are listed below:

1. In 2011, the Arkansas Water Resources Center at the University of Arkansas was awarded a Section 319 grant to monitor and assess 21 sites from November 2013 to September 2014. The study yielded a report titled "Constituent Load Estimation in the Lower Ouachita-Smackover Watershed" (Simpson, et al., 2015).
2. The University of Arkansas's Department of Agriculture was awarded a Section 319 grant project, No. 13-600. The objective was to look at water quality in priority watersheds in LOSW to develop a calibrated and validated SWAT model. The SWAT model created for this grant was not available for use in this WMP.
3. In 2018 the Arkansas Department of Agriculture's Forestry Division partnered with the Arkansas Timber Producers Association and others to identify educational needs and develop educational materials. The partnership included a best management practices (BMP) handbook and brochure. The group also held multiple outreach and training programs. The project also included writing and addressing recommendations for silviculture BMPs through a management plan. When the 2022 Arkansas Annual Report was written there were 38 Forest Stewardship Management Plans approved and provided to landowners.
4. In 2017, funding for a "Calhoun County Arkansas Unpaved Roads Program Support" project No. 17-1300 was able to reduce sediment runoff and future maintenance costs.
5. In 2021, Equilibrium was awarded Project 21-1000 to monitor water quality in the Lower Ouachita-Smackover Creek Watershed. There were 10 subwatersheds monitored to estimate HUC-12 subwatershed loads.
6. In 2021, Southwest Arkansas Planning and Development District was awarded a Section 319 grant for a project titled, "Lower Ouachita-Smackover HUC-8 Watershed Modeling and Management Planning." Objectives of the project were to develop a soil and water assessment tool (SWAT) and prepare a WMP.

A description of each assessment component is contained in the following sections. Water quality samples were collected on a routine basis over two years at 10 sites, totaling 2,401 samples. Unified stream assessments and macroinvertebrates were collected to represent 14 subwatersheds as there were two monitoring locations in one of the HUC-12 subwatersheds. The subwatersheds that have been evaluated by Equilibrium and ATG represent a cross-section of the 48 HUC- 12 subwatersheds of LOSW. For this WMP we focused the overall assessment on 32 subwatersheds (defined at approximately a 12-digit HUC level) that were believed to be reasonable and of manageable size, and similar groupings. Approximately 67% of the LOSW subwatersheds were assessed. Table 3.1 provides a summary of data type collected in each assessed subwatershed with monitoring locations provided in Figure 3.1.

Table 3.1. Assessed HUC-12 subwatersheds and type of assessment completed.

Creek Name	Water Quality	Macroinvertebrate and Habitat	Water Quality and Macroinvertebrate and Habitat	Upstream of a Monitored Subwatershed**
1. Caney Creek - Moro Creek	*			
2. Guice Creek - Moro Creek	*			
3. Whitewater Creek	*			
4. Mill Creek - Two Bayou 2		*		
5. Haynes Creek - Smackover Creek		*		
6. Salt Creek		*		
7. Cypress Creek - Gum Creek		*		
8. Gum Creek		*		
9. Sloan Creek		*		
10. Haynes Creek		*		
11. Sandy Creek - Camp Creek			*	
12. Dogwood Creek - Two Bayou			*	
13. Lost Creek - Champagnolle Creek			*	
14. Locust Bayou			*	
15. Headwaters of Lloyd Creek			*	
16. Holmes Creek			*	
17. Bryant Creek			*	

Creek Name	Water Quality	Macroinvertebrate and Habitat	Water Quality and Macroinvertebrate and Habitat	Upstream of a Monitored Subwatershed
18. North Bayou				*
19. South Bayou				*
20. Cypress Creek - Smackover Creek				*
21. Little Two Bayou - Two Bayou				*
22. Taylor Creek - Champagnolle Creek				*
23. Cooke Creek - Moro Creek				*
24. Mill Creek Smackover				*
25. Brushy Creek - Smackover Creek				*
26. Holly Creek - Smackover Creek				*
27. Beech Creek - Smackover Creek				*
28. Wolf Creek - Smackover Creek				*
29. Fife Creek-Moro Creek				*
30. Pickett Creek - Moro Creek				*
31. Holcomb Creek				*
32. Cordell Creek - Caney Creek				*

**Indicates a subwatershed is monitored as a component of a monitoring station on a downstream water.

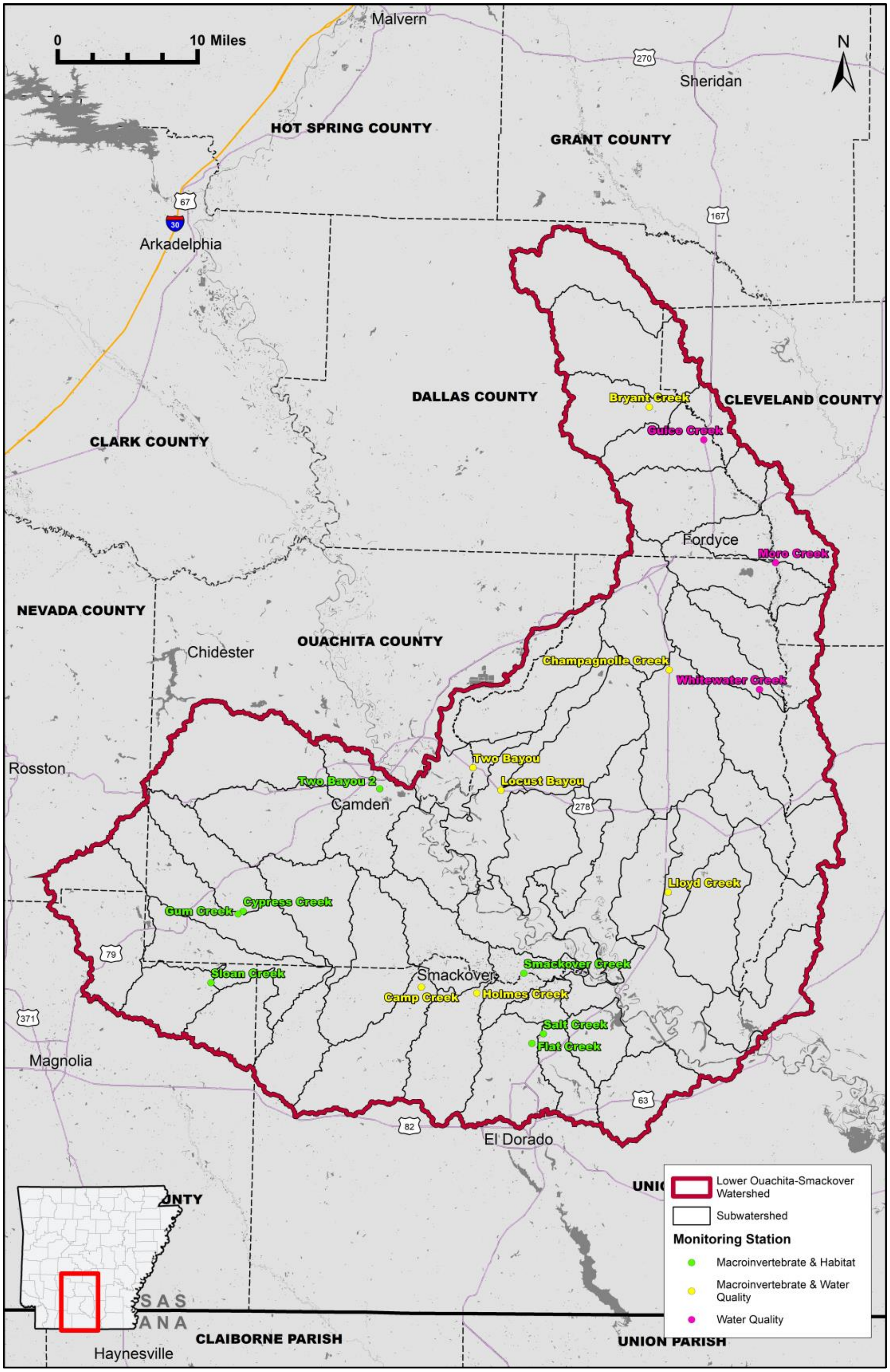


Figure 3.1. Equilibrium and Alliance Technical Group sampling locations within respective subwatersheds assessed.

3.1 GIS Non-point Source Assessment

A desktop assessment of the LOSW was completed using GIS resources including soil 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 the 32 subwatersheds noted above.

3.1.1 Land Use by Subwatershed

Historically, the LOSW has had a large number of commercial loblolly pine plantations. Lumber and pulpwood production has been a large driver in the economy along with oil and gas drilling and mineral mining.

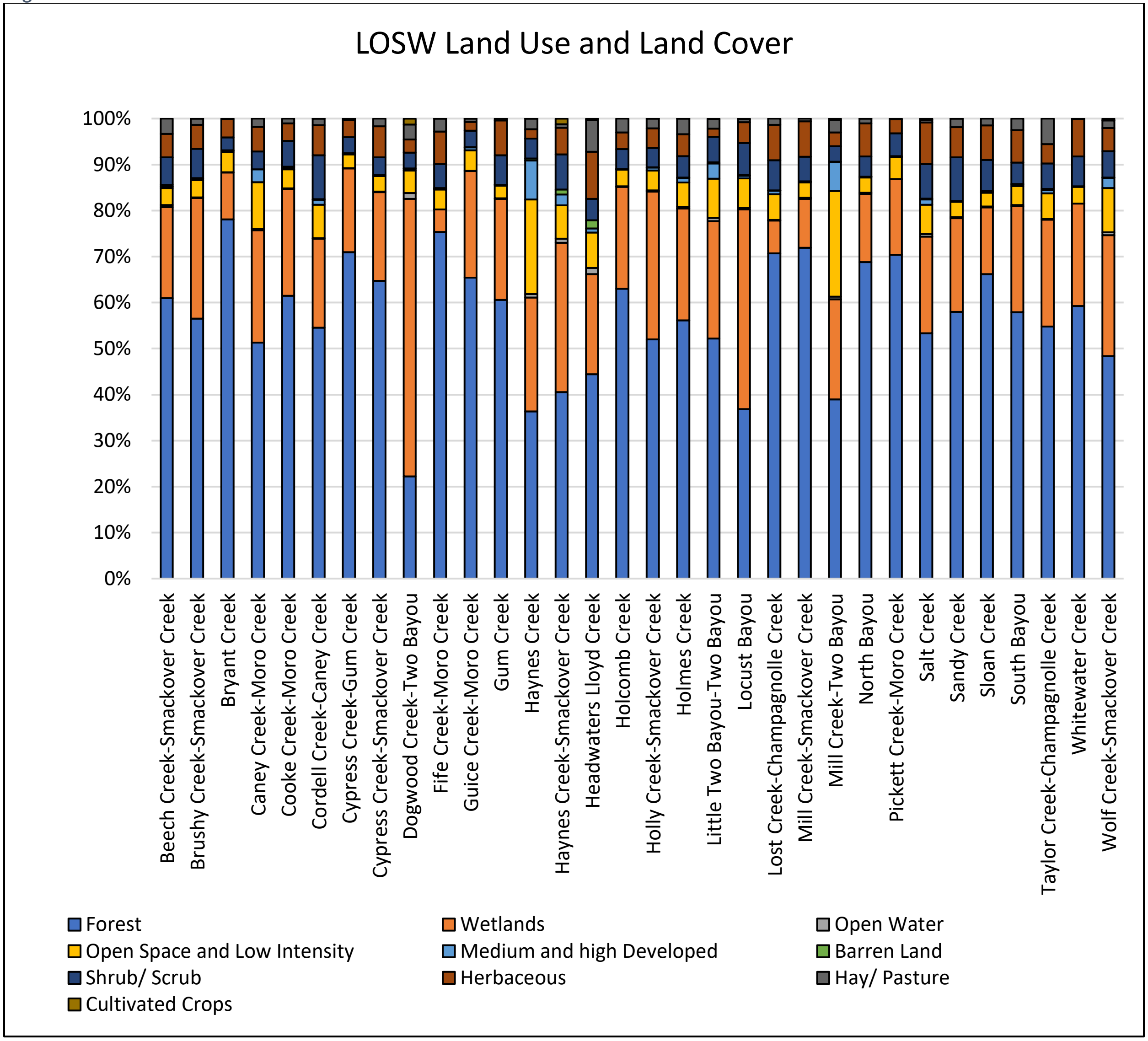
Land use was evaluated using 2021 NLCD land use land cover data from the Multi-Resolution Land Characteristics Consortium. A summary of the land use assessment is provided in Table 3.1.1.1. The LOSW dominant land use is forest, averaging 53% with a range from 22-78%. Evergreen forest is the dominant forest type and is primarily used for silviculture in the south, including in Arkansas. Evergreen forest composition ranges from 21-74% of the assessed sub-watersheds. The second dominant type of land use is wetlands which mostly occur in the larger river floodplains. Both emergent and woody wetlands were combined, however, woody wetlands percentages were an order of magnitude larger than the emergent wetland percentages. Wetlands on average comprise 27% of the LOSW, ranging from 5-65%. The Champagnolle Creek – Ouachita River subwatershed has the largest percentage of wetlands with 65.5%, and Dogwood Creek – Two Bayou had the second most wetlands within its subwatershed at 61.1%. Figure 3.1.1.1 below are a visual representation of each sub-watershed's land use. Due to the prevalence of evergreen (pine) forest, which are typically used for silviculture, and the potential for large sediment loads from these land uses during timber harvest events, the percentage of pine forest will be used in the ranking matrix.

Table 3.1.1.1. Percent land use for all 32 watersheds in the LOSW using NLCD 2021 data.

Name of Subwatershed	Forest	Wetlands	Open Water	Open Space and Low Intensity	Medium and High Developed	Barren Land	Shrub/ Scrub	Herbaceous	Hay/ Pasture	Cultivated Crops
Beech Creek-Smackover Creek	61.2	19.9	0.4	3.7	0.4	0.3	6.0	5.1	3.4	0.0
Brushy Creek-Smackover Creek	56.6	26.3	0.1	3.8	0.3	0.1	6.4	5.3	1.3	0.0
Bryant Creek	78.2	10.2	0.1	4.4	0.3	0.0	2.8	4.0	0.1	0.0
Caney Creek-Moro Creek	51.5	24.5	0.3	10.2	2.8	0.0	3.9	5.4	1.8	0.0
Cooke Creek-Moro Creek	61.6	23.2	0.2	4.1	0.4	0.2	5.6	3.9	1.0	0.0
Cordell Creek-Caney Creek	54.6	19.4	0.1	7.3	1.1	0.1	9.5	6.6	1.4	0.0
Cypress Creek-Gum Creek	71.0	18.3	0.1	3.0	0.2	0.0	3.5	3.7	0.4	0.0
Cypress Creek-Smackover Creek	64.8	19.3	0.1	3.4	0.1	0.0	3.9	6.8	1.7	0.0
Dogwood Creek-Two Bayou	22.5	61.1	1.3	5.0	0.4	0.1	3.5	2.9	3.3	1.3
Fife Creek-Moro Creek	75.4	4.9	0.0	4.3	0.3	0.0	5.3	7.1	2.8	0.0
Guice Creek-Moro Creek	65.4	23.2	0.1	4.5	0.7	0.1	3.6	1.9	0.7	0.0
Gum Creek	60.7	22.0	0.1	2.8	0.2	0.0	6.4	7.6	0.4	0.0
Haynes Creek	36.6	24.9	0.8	20.8	8.5	0.4	4.4	2.1	2.3	0.0
Haynes Creek-Smackover Creek	40.9	32.7	0.9	7.3	2.4	1.1	7.8	5.9	0.7	1.3
Headwaters Lloyd Creek	45.0	22.1	1.4	7.8	0.9	1.8	4.7	10.4	7.0	0.3
Holcomb Creek	63.0	22.2	0.1	3.6	0.1	0.0	4.3	3.7	3.0	0.0

Name of Subwatershed	Forest	Wetlands	Open Water	Open Space and Low Intensity	Medium and High Developed	Barren Land	Shrub/ Scrub	Herbaceous	Hay/ Pasture	Cultivated Crops
Holly Creek-Smackover Creek	52.2	32.2	0.3	4.4	0.6	0.0	4.2	4.3	2.1	0.0
Holmes Creek	56.4	24.4	0.5	5.3	1.0	0.1	4.7	4.8	3.4	0.0
Little Two Bayou-Two Bayou	52.6	25.7	0.7	8.6	3.4	0.2	5.6	1.8	2.1	0.1
Locust Bayou	37.0	43.6	0.4	6.4	0.6	0.1	7.1	4.5	0.7	0.2
Lost Creek-Champagnolle Creek	70.8	7.1	0.2	5.6	0.7	0.1	6.6	7.7	1.3	0.0
Mill Creek-Smackover Creek	72.1	10.7	0.3	3.3	0.2	0.1	5.4	7.7	0.6	0.0
Mill Creek-Two Bayou	39.2	21.9	0.6	23.1	6.3	0.1	3.3	3.0	2.7	0.4
North Bayou	69.0	14.9	0.2	3.3	0.2	0.1	4.4	7.2	1.0	0.0
Pickett Creek-Moro Creek	70.4	16.4	0.0	4.7	0.2	0.0	5.0	3.1	0.1	0.0
Salt Creek	53.6	21.1	0.5	6.4	1.2	0.2	7.6	9.1	0.6	0.3
Sandy Creek	58.1	20.5	0.3	3.3	0.2	0.0	9.5	6.6	1.9	0.0
Sloan Creek	66.3	14.5	0.2	3.0	0.2	0.2	6.8	7.5	1.5	0.0
South Bayou	58.0	23.1	0.2	4.2	0.4	0.1	4.6	7.1	2.5	0.0
Taylor Creek-Champagnolle Creek	54.9	23.2	0.1	5.7	0.7	0.2	5.6	4.2	5.6	0.0
Whitewater Creek	59.3	22.3	0.0	3.6	0.1		6.5	8.2	0.1	0.0
Wolf Creek-Smackover Creek	48.7	26.5	0.6	9.6	2.2	0.1	5.8	5.1	1.6	0.4

Figure 3.1.1.1 Land use land cover for the 32 assessed LOSW subwatersheds from the 2021 NLCD data set.



3.1.2 Oil and Gas Well Density

The Smackover formation spans approximately 7,000 square miles within southern Arkansas and has produced 500+ million barrels of oil and 500 billion cubic feet of natural gas. A study was published on the history of petroleum extraction in southern Arkansas that estimated 134,610,902 barrels had been extracted by 1950 (Figure 3.1.2.1) (Vestal, 1950). During the early boom days, wildcat wells were drilled, and blowouts were common as there was no way to pressurize the gas and oil wells. During this time, oil was flowing at a staggering rate which caused abundant spills and contamination of soils in the watershed (Figure 3.1.2.2.). In total, there have been 8,063 gas and oil wells drilled in the LOSW (Figures 3.1.2.3 and 3.1.2.4.). Because of this history in the watershed and its potential impact on water quality, both active, total gas and oil wells will be included in the ranking matrix for the subwatersheds assessed.

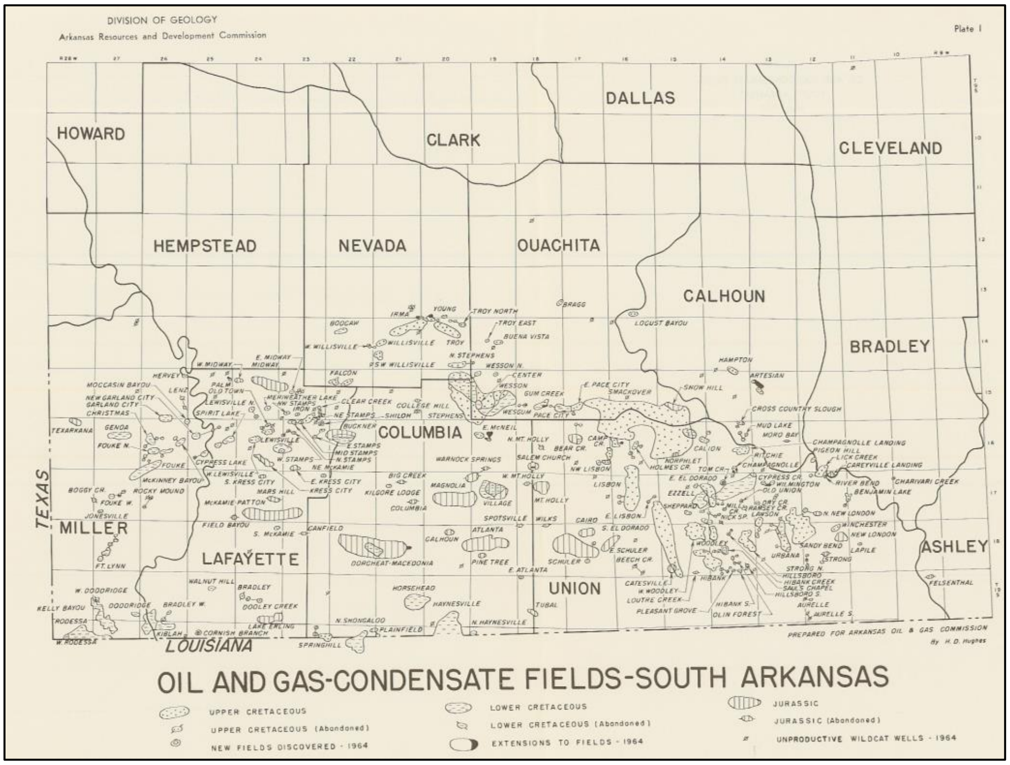


Figure 3.1.2.1. Plate I taken from the State of Arkansas Geological Commission Information Circular 14 titled, "Petroleum Geology of the Smackover Formation in Southern Arkansas" by Jack H. Vestal in 1950.

Figure 3.1.2.2. Large outcropping of a historic oil seep that has turned into asphalt in Smackover Creek.

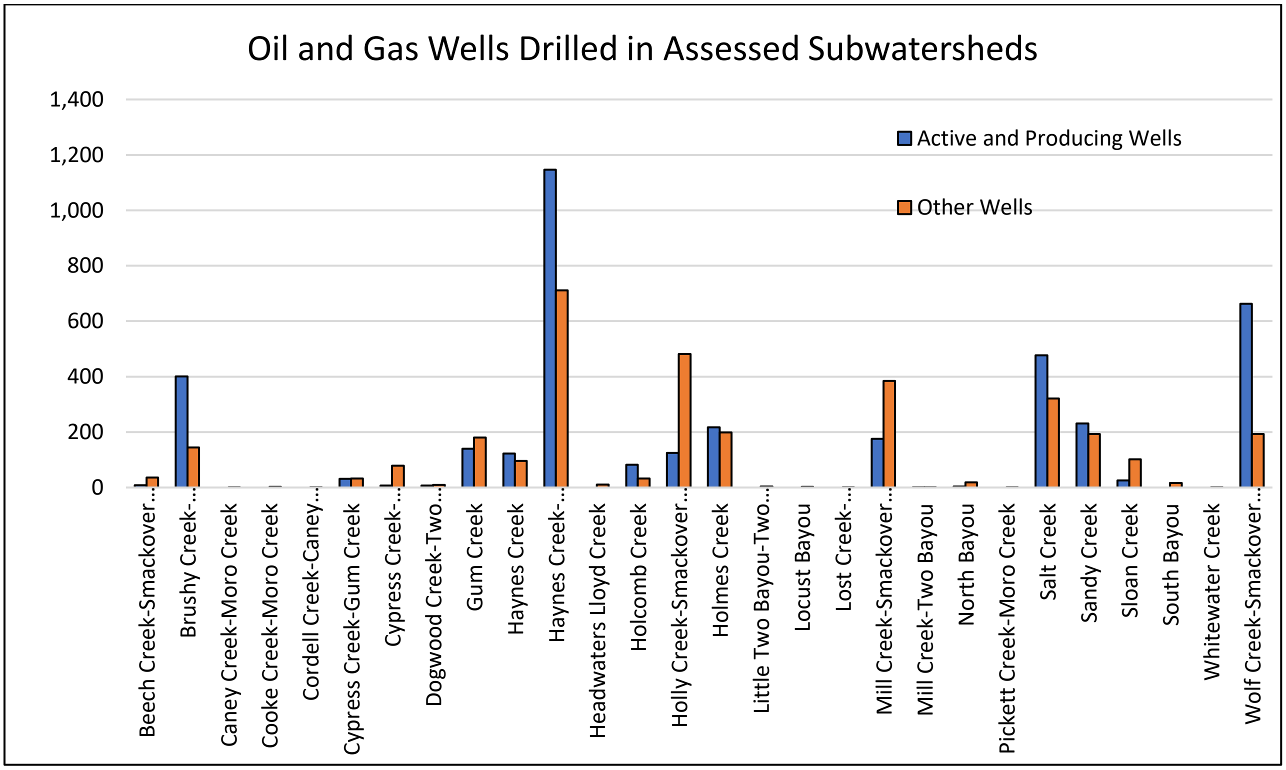


Figure 3.1.2.3. All active & Producing gas wells and grand total of gas wells per watershed.

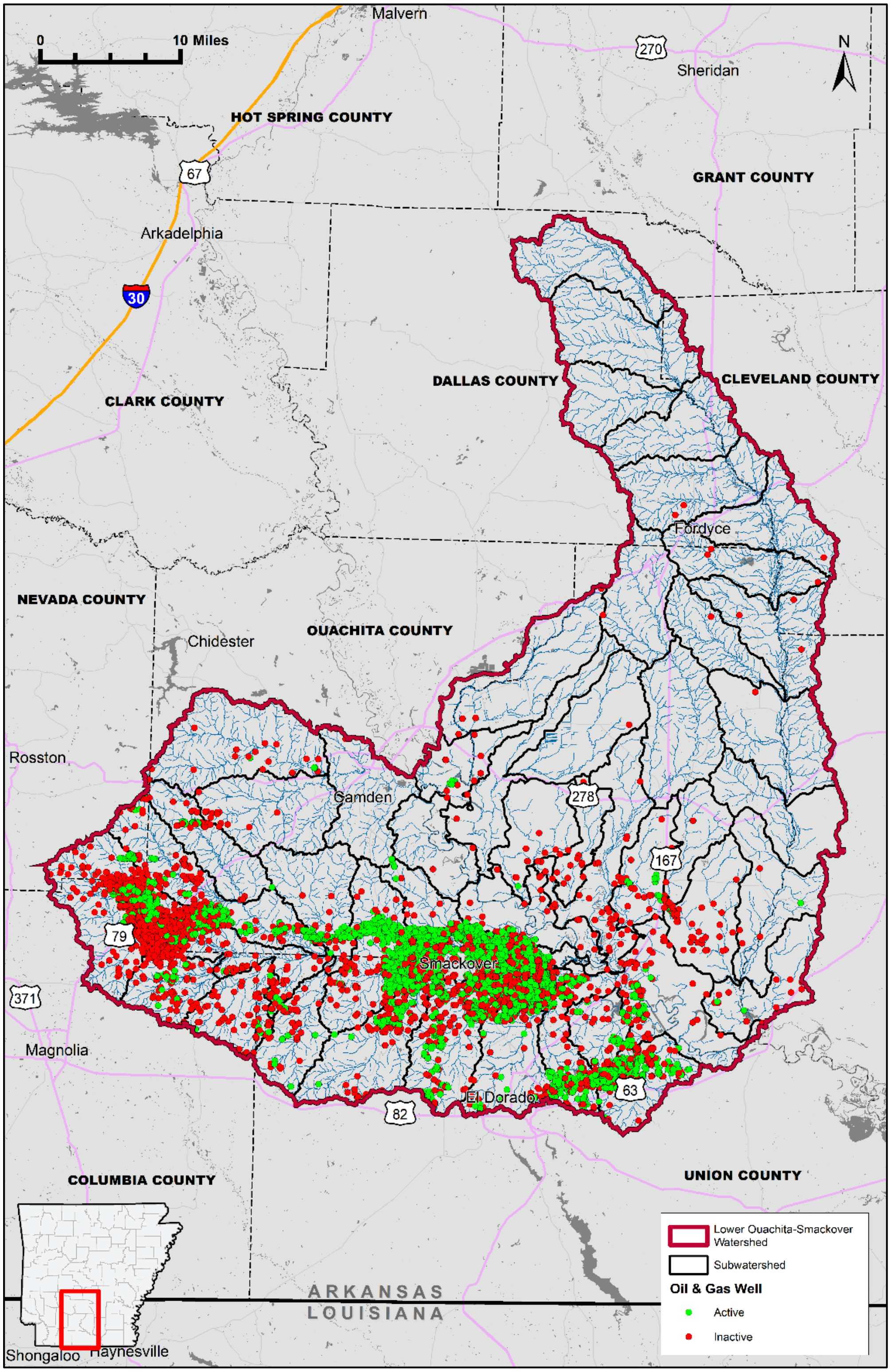


Figure 3.1.2.4. Oil and gas well density in the LOSW (Arkansas Oil and Gas commission, 2022).

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 14 subwatersheds. 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 are provided in Table 3.2.1 below. A 1,500-foot (minimum) representative section in each of the 14 subwatersheds were assessed following the USA protocol. The impacts observed and their frequency of occurrence is assumed to be consistent with comparable stream reaches in that subwatershed. That is, stream reaches not assessed on that stream that have similar channel size to the assessed reach and are directly upstream of the reach assessed are anticipated to have similar characteristics and issues at a similar frequency to those of the reach assessed.

Sediment deposition, bank erosion/failure, and bank stability were noted as the biggest impacts on the reach at several areas in the subwatersheds. Sediment deposition was noted most frequently and varied in severity from low to moderate.

Table 3.2.1. Summary of biggest impacts on each reach that was identified during USAs.

Site Name	**HUC 12 Sub-Watershed(s) the site represents**	**Biggest Impacts on Reach**
Bryant Creek	Bryant Creek	Bank failure, sediment deposition, & bank erosion
Cypress Creek	Cypress Creek- Gum Creek	Some bank erosion
Two Bayou	Little Two Bayou - Two Bayou, & Dogwood Creek-Two Bayou	Homemade boat ramp
Gum Creek	Gum Creek	Bank failure & bank erosion
Flat Creek	Haynes Creek	Trash, & sediment deposition
Smackover Creek	Haynes, Beech, Cypress, Mill, Holly, Brushy, &Wolf Creek-Creek-Smackover Creek, Gum Creek, Cypress-Gum Creek, Sloan Creek Holmes Creek, Sandy Creek, & Holcomb Creek	Oil is seeping creating oil outcrops, and bank failure
Holmes Creek	Holmes Creek	Oil seep, bank scour, & bank failure
Lloyd Creek	Headwaters of Lloyd Creek	Sediment deposition, bank failure, channelized
Locust Bayou	Locust Bayou & Cordell Creek-Caney Creek	Recent clearing, bank failure, & bank widening
Two Bayou 2	Mill Creek - Two Bayou, North Bayou, & South Bayou	Bank erosion and outfalls
Salt Creek	Salt Creek	none
Camp Creek	Sandy Creek	Bank scour, bank failure, and sediment deposition
Sloan Creek	Sloan Creek	Bank scour
Champagnolle Creek	Lost Creek - Champagnolle Creek	Bank failure, sediment deposition, & bank erosion

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 high-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 subwatershed was beyond the scope of this project. However, several geomorphic attributes were estimated during the USAs, and are helpful in assessing channel stability (Rosgen, 1996). Table 3.3.1 provides a summary of the channel dimensions estimated (and some measured) during the 14 USAs as well as key stability issues noted.

Table 3.3.1. Summary of geomorphic characteristics observed during the USAs, calculated from observed data or obtained through desktop analysis.

Parameter (estimated)	**Lower Ouachita-Smackover**													
	Bryant Creek	**Cypress Creek**	**Two Bayou**	**Gum Creek**	**Flat Creek**	**Smackover Creek**	**Holmes Creek**	**Lloyd Creek**	**Locust Bayou**	**Two Bayou 2**	**Salt Creek**	**Camp Creek**	**Sloan Creek**	**Champagnolle Creek**
Watershed size (mi^2)	30.4	14.2	22.1	22.1	11.5	305.8	38.5	21.5	61.9	128.4	17.3	43.7	22.4	37.8
Bankfull depth (ft)	2.5	2.5	4.5	2.0	2.5	3.0	4.5	2.0	5.3	5.0	2.5	3	3.5	5
Bankfull width (ft)	32	15	55	25	20	60	55	20	50	50	15	40	40	40
Substrate size class	silt/clay	silt/clay	silt/clay	silt/clay	silt/clay and sand	silt/clay	silt/clay	silt/clay	silt/clay	silt/clay	silt/clay	silt/clay	silt/clay	Sand and Gravel
Width: Depth ratio	13	6	12	13	8	20	12	10	10	10	6	13	11	8
Entrenchment Ratio	0.90	0.88	0.96	0.92	0.83	0.93	0.92	0.95	0.92	0.92	0.94	0.92	0.94	0.89
Overall streambank erosion hazard	Moderate	High	Moderate	High	Very low	High	Moderate	Moderate	Moderate	Moderate	Very low	High	High	High
Channel stability issues	Bank failure and sediment deposition	Bank failure	None	Bank failure	Sediment deposition	Bank scour	Bank failure, and bank scour	Channelized, bank failure, and sediment deposition	Bank failure and widening	None	None	Bank failure, bank scour, and sediment deposition	Bank scour	Bank failure and sediment deposition

Width: Depth Ratio = bankfull width (ft) / bankfull depth (ft) Entrenchment Ratio= Width of flood prone area (ft) / Width of bankfull (ft).

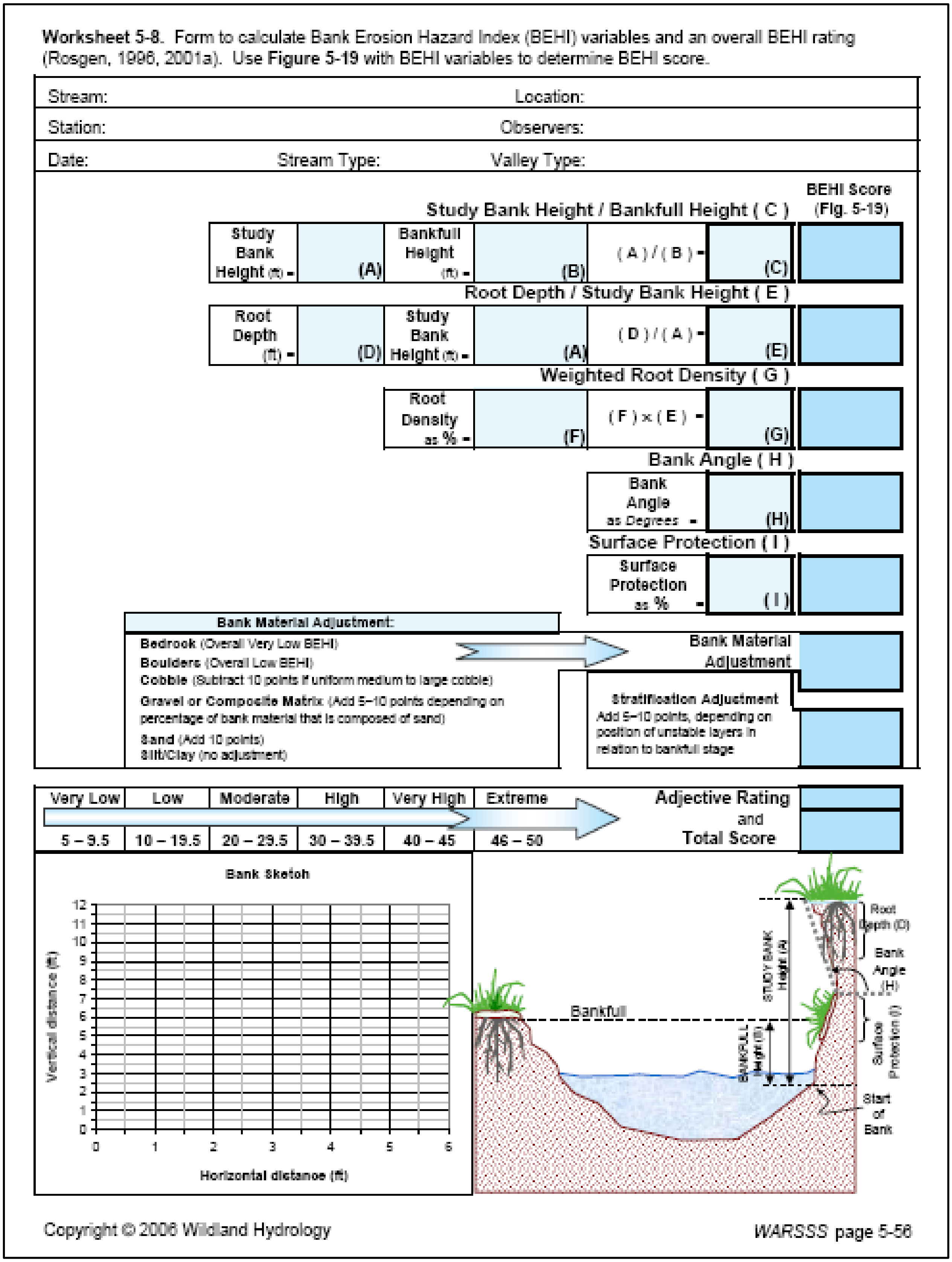
[1] Includes upstream subwatersheds area.

Bank erosion was noted in several areas, particularly in Sandy and Sloan Creek subwatersheds (Figure 3.3.1.) The severity of bank erosion was 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 a level of erosion hazard (Figure 3.3.2.) The possible erosion levels are low, moderate, high, very high, and extremely high. The BEHI calculated in the LOSW watershed ranged from low active erosion to high active erosion (Figure 3.3.3.). Silt/clay were the dominant stream substrates of these sub-watersheds and the associated land surface slopes were fairly low. Silt/clay substrate is the least susceptible to erosion. The soils in the overall LOSW are mostly composed of Guyton silt loam and Smithton sandy loam, which have moderate potential for erosion. In comparison to other Arkansas watersheds, the 14 LOSW subwatersheds had a lower bank erosion hazard percentages than both Lake Conway-Point Remove Watershed and the Poteau River Watershed, both of which have higher gravel content in their bank soils and higher land slopes. Land slope is half as high in the LOSW at 3.7%, compared to the other two Arkansas watersheds that average 6.5%.

Figure 3.3.1. Comparison of bank erosion (Sloan Creek) to a unimpacted bank (Salt Creek).

Streambank erosion can add hundreds of tons of sediment (and nutrients) 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 subwatershed. The main tributary stream length, the percent of USA reach affected by bank erosion, average bank height, dominant substrate and an erosion rate coefficient was used to determine pounds of sediment/foot of eroded bank (Table 3.3.2.) There were 14 USAs completed in the LOSW. The USA data that was collected was used in the other subwatersheds upstream of the assessed. That is, the reach erosion percentages from USA locations were used to calculate erosion rates in unassessed upstream subwatersheds based on the assessed characteristic (i.e. area NHD stream length, etc.). If an assessed stream was used to estimate an unassessed stream, it is indicated in the table below in the second column. Data used in calculating upstream streambank erosion (lb/yr) is also in Table 3.3.2.

Streambank erosion (lb/yr) and BEHI scores are a key attribute used in the ranking matrix. Using the BEHI for the 14 reaches observed, a process was completed to integrate multiple variables that are related to combine erosional processes leading to a comprehensive measurement of erosion potential. All 14 reaches had entrenchment ratios less than 1.4, classifying the streams as entrenched or vertically contained. For all 14 reaches, the high width/depth ratios indicate the watershed is experiencing accelerated streambank erosion rates, excess deposition/aggradation, and over-widening. (Rosgen et al., 2016). Scores from the BEHI were included in the matrix. The two subwatersheds with the highest stream BEHI scores were Smackover and Sloan Creek (Figure 3.3.3.)



Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream: Location:

Station: Observers:

Date: Stream Type: Valley Type:

BEHI Score (Fig. 5-19)

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) = (A) **Bankfull Height** (ft) = (B) (A) / (B) = (C)

Root Depth / Study Bank Height (E)

Root Depth (ft) = (D) **Study Bank Height** (ft) = (A) (D) / (A) = (E)

Weighted Root Density (G)

Root Density as % = (F) (F) × (E) = (G)

Bank Angle (H)

Bank Angle as *Degrees* = (H)

Surface Protection (I)

Surface Protection as % = (I)

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

Very Low	Low	Moderate	High	Very High	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50

Adjective Rating and Total Score

Bank Sketch

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Figure 3.3.2. Bank erosion hazard index form from Rosgen's 2014, Watershed Assessment of River Stability and Sediment Supply. Image from Watershed Assessment of River Stability and Sediment Supply (Rosgen, 2014)

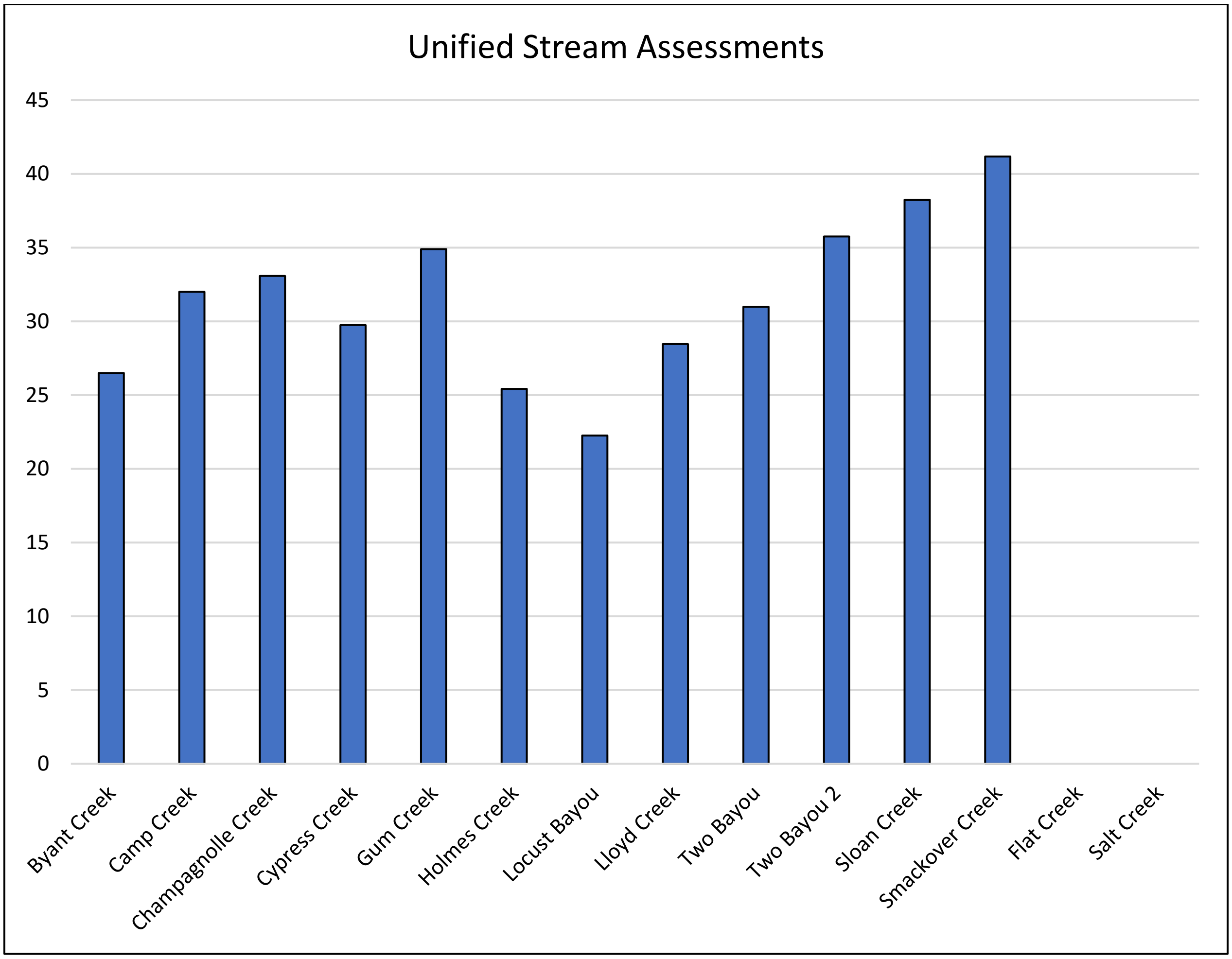

Figure 3.3.3 Bank erosion hazard indices for the 14 subwatersheds assessed.

Table 3.3.2. Estimated bank erosion rates for each sub watershed.

Sampling Site Name	HUC 12 Sub-Watershed(s) the site represents1	Reach Observed Length (ft)	Bank Erosion Length (LB+RB,ft)	% Reach Eroded	NHD Stream Length (ft)	Stream Length Eroded (ft)	Average Bank Height (ft)	Erosion Hazard Low (ft)	Erosion Hazard Medium (ft)	Erosion Rate (ft/yr)	Volume Sediment Eroded (ft3/yr)	Sediment Eroded (lbs/yr)	P (lbs/yr)	N (lbs/yr)	Sediment Eroded (lb./mi)
Bryant Creek	Bryant Creek	1,462	240	16%	72,831	11,955.8	9.0	240.0	0.0	0.25	26,900.6	2,470,286.0	723.8	1,375.9	179,087.3
Cypress Creek	Cypress Creek- Gum Creek	1,240	264	21%	94,394	20,096.8	3.9	214.0	50.0	0.5	38,686.3	3,552,564.3	1,040.9	1,978.8	198,715.4
Two Bayou	Little Two Bayou - Two Bayou, & Dogwood Creek-Two Bayou	1,780	50	3%	161,016	4,522.9	7.0	50.0	0.0	0.25	7,915.1	726,844.8	213.0	404.9	23,834.5
Gum Creek	Gum Creek	3,800	423	11%	101,283	11,274.4	3.0	423.0	0.0	0.25	8,455.8	776,495.9	227.5	432.5	40,479.6
Flat Creek	Haynes Creek	1,300	0	0%	35,384	0.0	5.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0
Smackover Creek	Beech, Cypress, Holly, Brushy, Wolf Creek, Haynes Creek-Smackover Creek, Gum Creek, Sandy Creek, & Holcomb Creek	2,928	1,128	39%	378,146	145,679.2	12.4	1,128.0	0.0	0.5	901,390.0	82,774,646.4	24,253.0	46,105.5	1,155,770.9
Holmes Creek	Holmes Creek	2,320	429	18%	78,313	14,481.2	4.0	429.0	0.0	0.25	14,481.2	1,329,804.4	389.6	740.7	89,657.7
Lloyd Creek	Headwaters of Lloyd Creek	2,760	780	28%	28,866	8,157.8	3.6	660.0	120.0	0.5	14,480.1	1,329,704.3	389.6	740.6	243,221.7
Locust Bayou	Locust Bayou & Cordell Creek-Caney Creek	3,340	345	10%	142,259	14,694.4	4.7	216.0	129.0	0.25	17,265.9	1,585,531.3	464.6	883.1	58,847.6
Two Bayou 2	Mill Creek - Two Bayou, North Bayou, & South Bayou	2,150	132	6%	67,671	4,154.7	10.0	132.0	0.0	0.25	10,386.7	953,811.7	279.5	531.3	74,420.7
Salt Creek	Salt Creek	1,740	0	0%	49,355	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0
Camp Creek	Sandy Creek	2,246	2,246	100%	103,332	103,332.0	3.5	0.0	2,246.0	0.75	271,246.5	24,908,566.1	7,298.2	13,874.1	1,272,763.8
Sloan Creek	Sloan Creek	2,152	2,152	100%	63,783	63,783.0	6.5	0.0	2,152.0	0.75	310,942.1	28,553,815.3	8,366.3	15,904.5	2,363,704.2
Champagnolle Creek	Lost Creek - Champagnolle Creek	3,080	906	29%	203,332	59,811.3	9.0	906.0	0.0	0.5	269,150.8	24,716,120.9	7,241.8	13,766.9	641,813.0

3.3.1 Riparian Buffer Impacts

Riparian buffers are the vegetated land areas directly adjacent to the streambank. When riparian buffers are impacted (reduced buffer width and/or quality), it typically results in a more direct pathway for NPS pollution to enter streams. Riparian buffers were assessed during the USAs and are a part of the desktop assessment (Table 3.3.1.1).

Impacted riparian buffers are often associated with higher streambank erosion. When trees and shrubs are removed from along a stream bank, an increasing amount of unfiltered stormwater can enter the stream. Without sufficient riparian buffer, infiltration into the riparian is not readily occurring. The roots of the riparian buffer, which usually help secure soil, are insufficient to secure the banks to mitigate erosion. Since USAs were not conducted on all subwatersheds and to account for more than just reach scale (USA based) riparian buffer condition, each main stem perennial stream (identified per aerial imagery from Google Earth) in each associated subwatershed 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 perennial stream in that subwatershed to represent percent of stream with impacted riparian buffers to help identify and assess where significant problems might exist (Table 3.2.2).

According to Table 3.3.1.1, Locust Bayou, Lloyd Creek, and Caney-Moro Creek are the subwatersheds have the largest percentages of impacted riparian buffer at 12.1%, 11.2%, 11%, respectively. The desktop analysis of impacted riparian buffers are a key attribute included in the ranking matrix.

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

Waterbody	Left Bank affected	Right Bank affected	Stream Total	sum of affected	sum of evaluated	% affected
Beech Creek-Smackover Creek	2,485	2,259	80,770	4,744	161,540	2.9%
Brushy Creek-Smackover Creek	54	54	45,472	108	90,944	0.1%
Bryant Creek	4,828	1,780	67,187	6,608	134,374	4.9%
Camp Creek-Sandy Creek	5,154	4,692	108,089	9,846	216,178	4.6%
Caney Creek-Moro Creek	5,470	5,806	51,041	11,276	102,082	11.0%
Cooke Creek-Moro Creek	1,129	1,509	81,785	2,638	163,570	1.6%
Cordell Creek-Caney Creek	8,262	11,788	117,363	20,050	234,726	8.5%
Cypress Creek-Gum Creek	1,489	1,489	76,787	2,978	153,574	1.9%
Cypress Creek-Smackover Creek	2,782	2,782	47,745	5,564	95,490	5.8%
Dogwood Creek-Two Bayou	328	328	52,430	656	52,430	1.3%
Fife Creek-Moro Creek	3157	2811	101,222	5968	202444	2.9%
Guice Creek-Moro Creek	445	357	56,556	802	113,112	0.7%
Gum Creek	8,615	5,582	80,448	14,197	160,896	8.8%
Haynes Creek (Flat)	1,257	1,133	46,616	2,390	93,232	2.6%
Haynes Creek-Smackover Creek	70	2,168	61,416	2,238	122,832	1.8%
Holcomb Creek	1,395	1,461	65,512	2,856	131,024	2.2%
Holly Creek-Smackover Creek	3,073	3,073	109,213	6,146	218,426	2.8%
Holmes Creek	6,167	5,688	80,590	11,855	161,180	7.4%
Little Two Bayou	2,676	2,724	96,315	5,400	192,630	2.8%
Lloyd Creek	3,466	2,903	28,371	6,369	56,742	11.2%
Locust Bayou	14,520	17,432	132,289	31,952	264,578	12.1%
Lost Creek-Champagnolle Creek	4,404	4,346	80,830	8,750	161,660	5.4%
Mill Creek-Smackover Creek	1,220	1,226	76,010	2,446	152,020	1.6%
Mill Creek-Two Bayou 2	2,098	3,334	63,811	5,432	127,622	4.3%
North Bayou	1,814	2,005	97,429	3,819	194,858	2.0%
Pickett Creek-Moro Creek	5978	5543	80630	11521	161260	7.1%
Salt Creek	1,941	1,941	75,291	3,882	150,582	2.6%
Sloan Creek	3,104	5,147	67,865	8,251	135,730	6.1%
South Bayou	3,642	1,109	69,010	4,751	138,020	3.4%
Taylor Creek-Champagnolle Creek	1,977	1,725	103,167	3,702	206,334	1.8%
White Water Creek	521	521	100710	1042	201420	0.5%
Wolf Creek-Smackover Creek	671	556	50,747	1,227	101,494	1.2%

3.3.2 Unpaved Roads

Unpaved roads are common in rural Arkansas. According to ARDOT approximately 72% of Arkansas county roads are unpaved. There are over 1,800 miles of unpaved roads in the watershed. Approximately 1,200 miles of unpaved roads are in the 32 assessed subwatersheds. During storm events these roads can transport significant loads of sediment into adjacent streams. The magnitude of the sediment load varies dependent on many factors including proximity to streams, condition of the road, slope and the design of the road. 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.

The unpaved road assessment was completed using GIS road layers for each subwatershed in the LOSW. 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 Sheets, 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 LOSW 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 lbs of sediment per mile of road (Table 3.3.2.1) (Bloser and Sheets, 2012). The calculated load of sediment from unpaved roads is a key attribute used in the ranking matrix.

Table 3.3.2.1. Summary of unpaved roads in the LOSW and estimates of sediment loads from unpaved roads in the LOSW.

Name	Unpaved Roads (miles)	TSS load per rain event (lbs)	Annual Loads (12 rain events) (lbs)
Beech Creek-Smackover Creek	30.5	14,792.9	177,515.3
Brushy Creek-Smackover Creek	33.9	16,433.4	197,201.2
Bryant Creek	37.9	18,369.2	220,430.5
Caney Creek-Moro Creek	28.5	13,816.8	165,801.2
Cooke Creek-Moro Creek	40.0	19,422.3	233,067.5
Cordell Creek-Caney Creek	100.3	48,635.8	583,629.7
Cypress Creek-Gum Creek	14.2	6,880.6	82,567.2
Cypress Creek-Smackover Creek	12.9	6,243.2	74,918.4
Dogwood Creek-Two Bayou	16.5	8,004.7	96,056.8
Fife Creek-Moro Creek	22.9	11,095.9	133,151.0
Guice Creek-Moro Creek	59.7	28,960.3	347,523.1
Gum Creek	22.1	10,730.5	128,765.4
Haynes Creek	39.2	18,991.5	227,897.4
Haynes Creek-Smackover Creek	33.7	16,353.5	196,242.5
Headwaters Lloyd Creek	33.8	16,407.2	196,886.6
Holcomb Creek	11.3	5,466.1	65,592.8
Holly Creek-Smackover Creek	27.8	13,495.8	161,949.1
Holmes Creek	42.4	20,548.8	246,585.7
Little Two Bayou-Two Bayou	82.3	39,915.9	478,990.6
Locust Bayou	65.8	31,934.4	383,213.2
Lost Creek-Champagnolle Creek	53.2	25,801.7	309,620.7
Mill Creek-Ouachita River	23.9	11,605.8	139,270.0
Mill Creek-Two Bayou	10.2	4,935.5	59,225.6
North Bayou	31.9	15,480.3	185,763.7
Pickett Creek-Moro Creek	77.5	37,583.2	450,998.1
Salt Creek	36.0	17,475.2	209,702.3
Sandy Creek	38.5	18,670.9	224,050.7
Sloan Creek	1.9	925.9	11,111.2
South Bayou	21.7	10,530.3	126,363.6
Taylor Creek-Champagnolle Creek	73.6	35,709.9	428,519.3
Whitewater Creek	41.6	20,191.7	242,299.9
Wolf Creek-Smackover Creek	28.4	13,769.5	165,233.6

3.3.3 Land Slope

A land slope analysis was completed for each of the 32 subwatersheds and are provided in Table 3.3.3.1. Slopes are generally homogenous between subwatersheds. On average the slope was low (3.7%) for the assessed subwatersheds and ranged from 1.3% to 7.5%. Lower slope (flat) areas have a lower potential for erosion (lower velocity = less erosive factors) and higher potential for flooding as it takes longer for runoff to enter the streams in the watershed. High-volume rain events combined with poorly filtrating soil allows more water to runoff into the stream channels. This along with carrying a large sediment load, can lead to increased streambank erosion and channel scour, compounding the issue. Land slope is less of concern in the LOSW as the majority of the LOSW is less than 4%.

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

Name	Mean Slope (percent rise)
Beech Creek-Smackover Creek	4.5
Brushy Creek-Smackover Creek	3.9
Bryant Creek	3.1
Caney Creek-Moro Creek	3.1
Cooke Creek-Moro Creek	3.4
Cordell Creek-Caney Creek	1.6
Cypress Creek-Gum Creek	5.9
Cypress Creek-Smackover Creek	5.2
Dogwood Creek-Two Bayou	1.9
Fife Creek-Moro Creek	2.8
Guice Creek-Moro Creek	2.8
Gum Creek	5.6
Haynes Creek	4.9
Haynes Creek-Smackover Creek	3.9
Headwaters Lloyd Creek	1.7
Holcomb Creek	4.3
Holly Creek-Smackover Creek	4.6
Holmes Creek	4.8
Little Two Bayou-Two Bayou	1.6
Locust Bayou	1.7
Lost Creek-Champagnolle Creek	2.3
Mill Creek-Smackover Creek	7.5
Mill Creek-Two Bayou	6.0
North Bayou	7.0
Pickett Creek-Moro Creek	2.8
Salt Creek	5.0
Sandy Creek	4.5
Sloan Creek	5.4
South Bayou	6.0
Taylor Creek-Champagnolle Creek	2.2
Whitewater Creek	2.8
Wolf Creek-Smackover Creek	4.5

3.3.4 Soils

Soils on the land surface in the overall LOSW are mostly composed of Guyton silt loam soils that frequently flood. The second most common soil type is Smithton's fine sandy loam with 0-2% slopes. The third largest soil type within the watershed was Amy silt loam with 0-1% slopes that frequently floods. Soil types present in the LOSW are displayed in the figure below (Figure 3.3.4.1.)

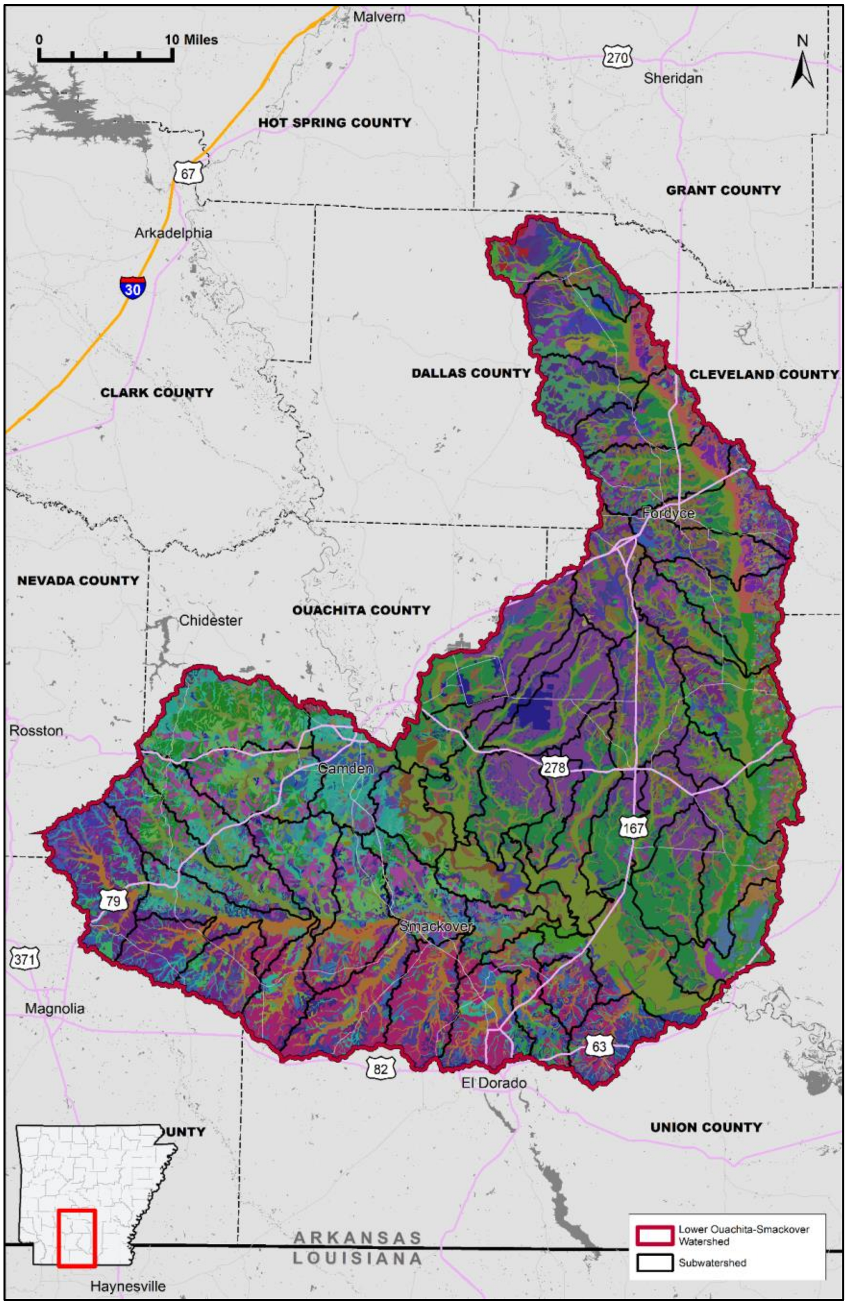

Figure 3.3.4.1 Map of soils in the LOSW.

3.3.5 Agricultural Animal Numbers

Numbers of agricultural animals were estimated in the watershed using 2017 county USDA data. For cattle and chickens, the numbers from USDA published county data and the number of acres of pasture in each county were used to calculate number of cattle or chickens per acre pasture to determine the amount of animals in each subwatershed. A desktop analysis was completed to determine which or how much of each of the 32 subwatersheds are in the 7 counties and how many square miles of pasture land use is present in the LOSW. Cattle and chickens were assumed to be evenly spread out over the pastures in the assessed counties. An amount of cattle or chickens per mi^2 was then assigned to each subwatershed using the number of square miles of pasture determined through the desktop analysis. A summary of the agricultural animal estimates is provided in Table 3.3.5.1. Number of chickens in the LOSW is believed to be decreasing as some poultry processing facilities in the watershed have closed. Therefore, number of cattle will be the only agricultural animal parameter used in the ranking matrix.

Table 3.3.5.1. Agricultural animal estimates per subwatershed.

HUC Number	Name	Cattle (#/mi^2) of that subwatershed	Chicken (#/mi^2) of that subwatershed	Hay/ Pasture (mi^2)	Cattle (#/pasture land use mi^2)	Chickens (#/pasture land use mi^2)
80402010101	Fife Creek-Moro Creek	4.2	0.2	1.1	4.6	0.2
80402010102	Bryant Creek	0.1	0.0	0.0	0.0	0.0
80402010103	Pickett Creek-Moro Creek	0.4	311.2	0.1	0.0	22.7
80402010104	Guice Creek-Moro Creek	1.5	1,059.6	0.3	0.4	289.0
80402010105	Cooke Creek-Moro Creek	1.8	51.3	0.5	0.9	24.0
80402010106	Caney Creek-Moro Creek	4.8	4,994.7	0.6	3.1	3,216.1
80402010201	White Water Creek	0.1	2.8	0.0	0.0	0.0
80402010205	Headwaters Lloyd Creek	8.3	241.9	1.6	13.2	383.3
80402010301	Mill Creek-Smackover Creek	6.8	970.5	0.3	2.2	308.9
80402010302	Cypress Creek-Gum Creek	0.6	74.8	0.1	0.1	8.2
80402010303	Sloan Creek	5.3	921.7	0.4	1.9	328.6
80402010304	Cypress Creek-Smackover Creek	6.1	1,050.2	0.5	2.8	480.6
80402010305	Gum Creek	3.2	380.2	0.2	0.7	78.4

Table 3.3.5.1 continued.

HUC Number	Name	Cattle (#/mi^2) of that subwatershed	Chicken (#/mi^2) of that subwatershed	Hay/ Pasture (mi^2)	Cattle (#/pasture land use mi^2)	Chickens (#/pasture land use mi^2)
80402010306	Holly Creek-Smackover Creek	4.9	656.8	0.8	4.1	546.2
80402010401	Beech Creek-Smackover Creek	5.6	720.1	0.9	5.1	664.4
80402010402	Holcomb Creek	5.8	762.5	1.1	6.4	845.0
80402010403	Sandy Creek	5.2	677.0	0.9	4.5	587.2
80402010404	Brushy Creek-Smackover Creek	3.5	458.1	0.6	2.1	279.5
80402010405	Holmes Creek	8.1	1,042.9	1.3	10.8	1,393.5
80402010406	Wolf Creek-Smackover Creek	3.0	395.3	0.6	1.7	219.9
80402010407	Haynes Creek	5.1	654.8	0.8	4.2	549.3
80402010408	Salt Creek	1.0	125.6	0.2	0.2	20.2
80402010409	Haynes Creek-Smackover Creek	0.8	107.3	0.1	0.1	15.0
80402010501	South Bayou	6.1	801.1	1.2	7.1	938.7
80402010502	North Bayou	3.2	418.4	0.6	1.9	256.0
80402010503	Mill Creek-Two Bayou	5.5	725.8	1.1	5.8	770.5
80402010601	Lost Creek-Champagnolle Creek	2.6	75.3	0.5	1.3	37.1
80402010602	Taylor Creek-Champagnolle Creek	14.8	430.0	2.8	41.7	1,211.4
80402010701	Little Two Bayou-Two Bayou	6.1	698.1	1.2	7.1	817.7
80402010702	Dogwood Creek-Two Bayou	4.0	363.1	0.8	3.0	275.9
80402010703	Cordell Creek-Caney Creek	3.2	93.8	0.6	2.0	57.7
80402010704	Locust Bayou	1.3	38.6	0.3	0.3	9.7

3.4 Water Quality

3.4.1 Previous 319 Grant Efforts

The LOSW has had ongoing water quality monitoring for the last decade. In 2011, the Arkansas Water Resources Center at the University of Arkansas was awarded a Section 319 grant to monitor and assess 21 sites in the LOSW from November 2013 to September 2014. The study yielded a report titled "Constituent Load Estimation in the Lower Ouachita-Smackover Watershed" (Simpson, et al., 2015). The study report focused on 2 stream sites with United States Geological Survey (USGS) streamflow gages; Moro Creek and Smackover Creek. Table 3.4.1.1 shows the annual loads of nutrients at the Smackover and Moro Creek stream sites for the years 2013 and 2014.

Table 3.4.1.1. The summary of calculated annual discharge and loads for Smackover Creek (USGS 07362100) and Moro Creek (USGS 07362500) in 2013 and 2014.

Site	Year	Annual Q (ft^3)	NO_3-N (lbs.)	TN (lbs.)	SRP (lbs.)	TP (lbs.)	TSS (lbs.)
Moro Creek	2013	7,483,891,224	29,762	307,104	4,299	30,203	5,410,137
	2014	5,647,526,824	33,069	249,122	3,880	26,015	5,255,814
Smackover Creek	2013	6,539,576,146	28,881	254,634	4,630	33,731	9,687,100
	2014	6,813,618,218	40,124	285,719	5,181	39,242	12,151,865

3.4.2 Water Quality Data Collected Specifically for the WMP

Equilibrium, LLC was awarded a Section 319 grant, Grant # 13-600. The 13-600 grant project was awarded to collect water quality samples in the LOSW. Equilibrium began collecting samples in October 2016 and continued to collect samples every 7 days at all ten stream sites until October 2020 (Figure 3.4.2.1.). Data is provided in Appendix B.

All water quality samples collected and focused on in this WMP were handled according to a Quality Assurance Project Plan (QAPP) approved by the Natural Resources Division and EPA Region 6. In brief, grab samples were collected in clean, labeled containers from within the main area of flow in the channel and delivered to the laboratory for analysis following all chain of custody procedures (see QAPP for project).

Water quality samples were collected every 7 days. Large storm concentrations can be indicative of a major source of NPS since stormwater is how most NPS pollution reaches the streams. Because the samples were completed on a rotating basis instead of event based, stormwater or rising limb samples were not a focus nor were they indicated in the data report.

Therefore, most of the samples can be considered at normal seasonal water levels. The highest sediment levels were recorded from Champagnolle Creek, Whitewater Creek and Bryant Creek. For phosphorus, Two Bayou had the highest concentration followed by Whitewater Creek and Champagnolle Creek. (Table 3.4.2.1.) For total kjeldahl nitrogen, the Sandy Creek, Champagnolle Creek, and Whitewater Creek sampling stations had the highest concentrations. The three highest ammonia concentrations were at the Guice Creek, Champagnolle Creek, and Lloyd Creek stream sites.

Table 3.4.2.1. Water quality results from data collected by Equilibrium.

Stream Sampled	HUC-12 Watershed that the Sampling Point Represents	Average of Total Phosphorus (mg/L)	Average of Total Kjeldahl Nitrogen (mg/L)	Average of Ammonia (mg/L)	Average of TSS (mg/L)	Average of Sulfate (mg/L)	Average of Chloride (mg/L)
Bryant Creek	Bryant Creek	0.052	0.814	0.074	18.8	5.5	5.3
	Fife Creek - Moro Creek						
	Pickett Creek - Moro Creek						
Sandy Creek	Sandy Creek	0.067	1.021	0.044	9.1	3.5	91.3
Champagnolle Creek	Lost Creek - Champagnolle Creek	0.073	0.997	0.083	26.1	3.2	3.0
	Taylor Creek - Champagnolle Creek						
Guice Creek	Guice Creek - Moro Creek	0.064	0.866	0.092	17.1	3.8	5.1
Holmes Creek	Holmes Creek	0.060	0.714	0.051	9.6	3.8	57.1
Lloyd Creek	Headwaters of Lloyd Creek	0.065	0.885	0.079	10.6	2.2	3.8
Locust Bayou	Cordell Creek - Caney Creek	0.046	0.808	0.057	9.6	1.5	3.3
	Locust Bayou						
Moro Creek	Caney Creek - Moro Creek	0.071	0.810	0.050	14.7	3.7	4.5
	Cooke Creek - Moro Creek						
Two Bayou	Dogwood Creek - Two Bayou	0.093	0.811	0.078	9.6	2.8	9.9
	Little Two Bayou - Two Bayou						
Whitewater Creek	White Water Creek	0.074	0.940	0.067	20.2	3.2	4.1

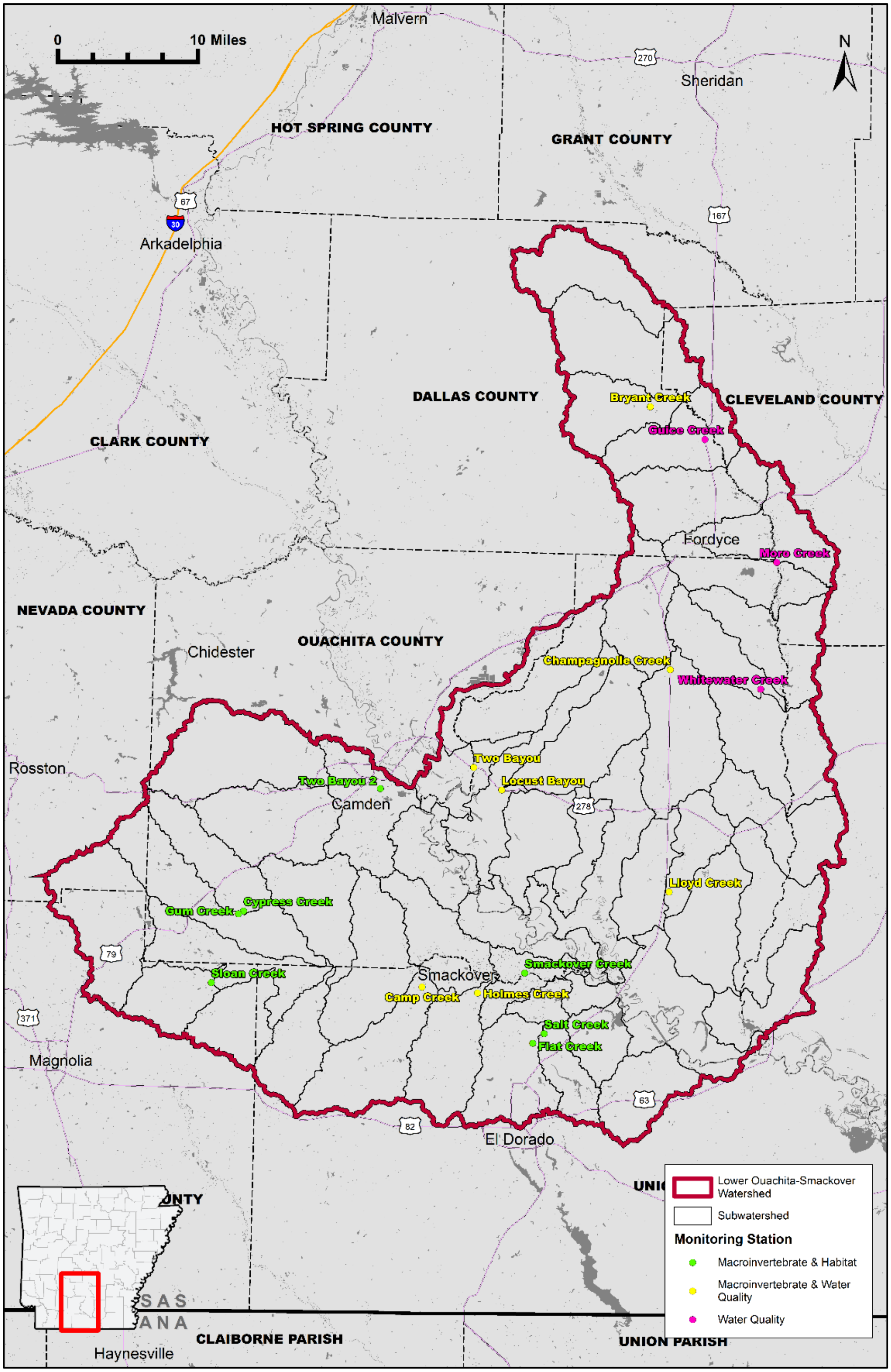

Figure 3.4.2.1. Sample stations in each subwatershed utilized for the assessment portion of the WMP.

3.4.3 Macroinvertebrate Assessments

Benthic macroinvertebrates inhabit the sediment or live on the bottom substrates of streams, rivers and lakes. The presence of these organisms and their diversity and tolerance to environmental perturbation at an expected level reflects the maintenance of a systems biological integrity. Monitoring these assemblages is useful in assessing the aquatic life status of the water body and detecting trends in water quality and overall ecological condition. Macroinvertebrate communities were sampled by ATG at 14 site locations in June of 2023. Collection and analysis methods generally followed Standard Operating Procedures for Macroinvertebrate Monitoring in Wadable Streams, Version 1 - 2021 (RBA) protocols (DEQ, 2021) and the QAP for the project (QAP, 2022). All habitats present at a site were sampled instream. The sample distribution guide (DEQ, 2021) was used to determine the number of samples from each habitat type. Macroinvertebrates from each sample were identified and enumerated (Appendix C.).

Several macroinvertebrate metrics used by DEQ were calculated for the collections completed. These metrics include: taxa richness, Hilsenhoff biotic index, ratio of Ephemeroptera, Plecoptera and Trichoptera (EPT) to Chironomidae abundances, percent contribution of dominant taxa, EPT index and ratio of scraper to filterer collector feeding groups (Table 3.4.3.1).

Table 3.4.3.1. Macroinvertebrate metrics calculated based on collections in the LOSW.

Macroinvertebrate Metric	Taxa Richness	Hilsenhoff Biotic Index	Ratio of EPT to Chironomid Abundances	% Contribution of Dominant Taxa	% EPT	Ratio of Scrapers to filterer collectors
Bryant Creek	16	7.21	0:1	67.0%	4.4%	1.6
Camp Creek	13	7.47	0:1	51.3%	2.7%	1.8
Champagnolle Creek	14	6.66	1:2	37.5%	25.8%	75.0
Cypress Creek	6	5.64	2:1	38.2%	51.0%	38.5
Flat Creek	10	6.97	13:9	50.6%	15.3%	0.0
Gum Creek	11	5.38	10:7	30.7%	44.0%	95.7
Holmes Creek	11	7.04	3:8	39.7%	15.1%	18.2
Lloyd Creek	16	5.89	1:1	23.6%	23.6%	30.8
Locust Bayou	16	6.85	3:7	45.8%	26.1%	48.7
Salt Creek	15	7.33	3:8	21.7%	13.0%	33.3
Sloane Creek	13	7.13	1:2	41.0%	28.0%	76.9
Smackover Creek	8	7.58	0:1	75.4%	1.4%	0.0
Two Bayou	17	7.47	0:1	21.6%	1.7%	4.2
Two Bayou 2	15	6.69	1:8	49.0%	6.1%	4.2

These metrics were modeled after the guidelines provided by Arkansas Division of Environmental Quality Assessment Methodology (DEQ, 2024). Taxa richness was highest at Two Bayou, ranged from 6-17 and averaged 13. Gum Creek had the lowest or most sensitive community according to the Hilsenoff biotic index that ranged from 5.38-7.58 and averaged 6.81. Percent dominant taxa was lowest at Two Bayou and highest at Smackover Creek. A high percent contribution of dominant taxa would be indicative of a more tolerant community. Lower percent dominant would indicate that the community is more sensitive to environmental perturbations. A high percentage EPT taxa would indicate a sensitive macroinvertebrate community. The highest percentage of EPT taxa for the LOSW was found at Cypress Creek. Overall, the macroinvertebrate community seems to be as expected, abundant, fairly diverse, but generally tolerant. Gum Creek and Loyd Creek had the highest overall scores, while Smackover Creek, Holmes Creek and Camp Creek had the lowest overall scores. Two key metrics, Hilsenhoff biotic index and species Richness will be used in the ranking matrix.

3.4.4 Designated Use Assessment Criteria

The approved Arkansas 2018 303(d) list contains 22 assessment units of the LOSW. There are 13 assessment units of the Lower Ouachita - Smackover that are on the 4a list. The 4a list indicates that water quality criteria are not being met but a TMDL has been written for the listed parameters. The parameters not in attainment are mercury, total dissolved solids, turbidity, chloride, sulfate, and temperature. The other 9 assessment units of the LOSW are on the category 5 list. The category 5 list indicates the waterbody was impaired, or more than one water quality standards are not attained. The parameters not in attainment are dissolved oxygen, lead, pH, turbidity, copper, pathogens, and nitrate.

Water quality data collected for this plan was compared to the Arkansas Assessment Criteria for the Gulf Coastal Plains Ecoregion. Table 3.4.4.1 provides a summary of the assessment criteria that are pertinent to this WMP study’s focus. Constituents analyzed for this study that have water quality criteria were compared to those criteria. Turbidity was the only constituent that was measured with consistency, 291 occurrences. According to the assessment criteria, when turbidity measurements exceed 20% of the base flow or 25% of storm flow measurements (minimum of 24 measurements) the stream is listed as impaired. Because there was no indication of which samples were storm samples, turbidity exceedances cannot be calculated accurately. The turbidity exclusions will be assumed to be addressed by TSS reduction goals in this WMP.

Table 3.4.4.1. Water quality standards assessment criteria.

Parameter	Standard		Support	Non-Support
Gulf Coastal Temperature[1]	30°C		≤10 %	>10 %
Gulf Coastal Dissolved Oxygen[1] (mg/L)	Primary	Critical		
<10 mi^2	5	2		
10-150 mi^2	5	3		
pH	6.0-9.0 S.U.			
Gulf Coastal Cl/SO_4/TDS	250/250/500			
Gulf Coastal Ammonia				
Acute (Salmonids absent, pH=6.5)	48.8 mg/L		I-hour average not exceeded more than once every 3 years	
Chronic (using 14°C and pH=6.5)	6.5 mg/L		Monthly average shall not exceed	
Gulf Coastal Turbidity				
Base flows	21 NTU		≤20 %	>20 %
All flows	32 NTU		≤25%	>25 %

[1] Except for site specific standards approved in water quality standards.

3.5 Hydrologic Analysis

The hydrologic regime of a stream (magnitude and frequency of flow levels) influences the shape of the stream channel, the type and abundance of habitat available to biota, and the type and load of pollutants transported in the system. Geology, land use, weather patterns and seasons affect the hydrologic regime of a stream. In recent years, there has been a trend of increasing intensity in rainfall (i.e. more rain in a short period of time). During high intensity events there is less time for infiltration resulting in increased runoff (EPA, 2016). Understanding a stream's hydrology, including regional climatic shifts, is integral to the assessment of stream stability, ecology, and water quality.

For the 13-600 Equilibrium study, automated level measuring loggers were installed at the monitoring locations. Each level logger was maintained, and data was downloaded throughout the year. These automatic level measuring gages continuously measured stream level (stage) every 15 minutes. Rating curves were developed from measured flow. The equation for the best fit rating curve line is then used to extrapolate the stream level data collected and convert it into flow. Smackover Creek has a United States Geological Survey (USGS) gage (No. 07362100) installed with a rating curve developed and real-time data can be extrapolated to estimate discharge over time (Figure 3.5.1).

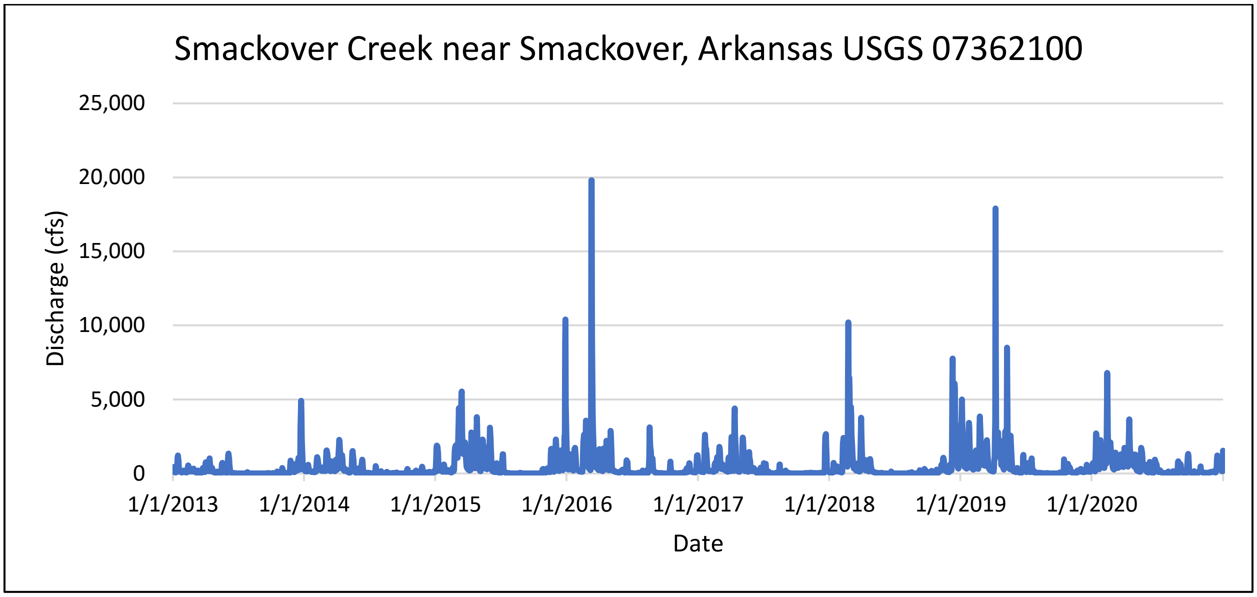

Figure 3.5.1. The USGS discharge data from the Smackover Creek near Smackover, Arkansas.

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, their transport, and their effect on water quality. SWAT was used in this report to calculate baseline (existing/current conditions) subwatershed loading and to evaluate potential BMP removal rates from various practices and land uses in the LOSW. 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 Natural Resources Division recommends evaluating pollutant loading and implementing mitigation efforts on the subwatershed 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 LOSW 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 conditions. The HUC-12 NHD layer was used to delineate the LOSW into 48 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 2010 through 2022. Eleven different weather stations were used for temperature and/or precipitation including Camden, Eldorado, Moro Bay, Hampton, Warren, Prescott, 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 LOSW between 2012 and 2022 included 17 dischargers with sustained annual flow, all of which were included in the SWAT model (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 LOWR using cattle counts from census data and sub-watershed pasture land use area.

The model was run from 2012 to 2022, with the first 3 years as warm-up, and then was calibrated to flow using R-SWAT. Flow data between 2017 and 2022 from the Smackover Creek gage near Smackover was primarily used for the calibration. Once calibrated flows produced from the model were compared back to actual Smackover Creek flows and also to Champagnolle Creek flows. The model calibration produces an R2 value of 0.61 for Smackover Creek and 0.43 for Champagnolle Creek, which is considered an acceptable relationship for modeling. The model calibration also produced NSE values greater than 0.33 but less than 1.0 for both gauges. Values for NSE between 0.0 and 1.0 are generally considered acceptable model performance (Moriasi, et.al, 2007). The peaks and valleys match up well to flows predicted by the model. Calibration to sediment was more problematic as there was believed to be 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 HUC-12 sub-watersheds. Annual average loading from 2017-2020 (four years) was used for the assessment. 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 HUC-12 sub-watersheds within the larger LOSW watershed.

The highest priority sub-watersheds based on sediment and nitrogen loads washed off of each land use area (lbs./mi2) were Amason Creek-Ouachita, Sandy Creek, Haynes Creek-Smackover, Sloan Creek, Haynes Creek, and Mill Creek-Two Bayou (Figure 3.6.1 and 3.6.2). Note, basin 47 is the overall outlet and is anomalous in regard to its actual sub-watershed based loading (i.e. it is not figured into the ranking analysis). Total watershed loading for use in Section 6.1 and in evaluation of BMP effectiveness was calculated at each sub-watershed outlet, which is a combination of wash off of land uses plus channel scour & re-suspension. The sub-basin based loading as depicted in Figures 3.6.1 and 3.6.2 will be used in the ranking matrix.

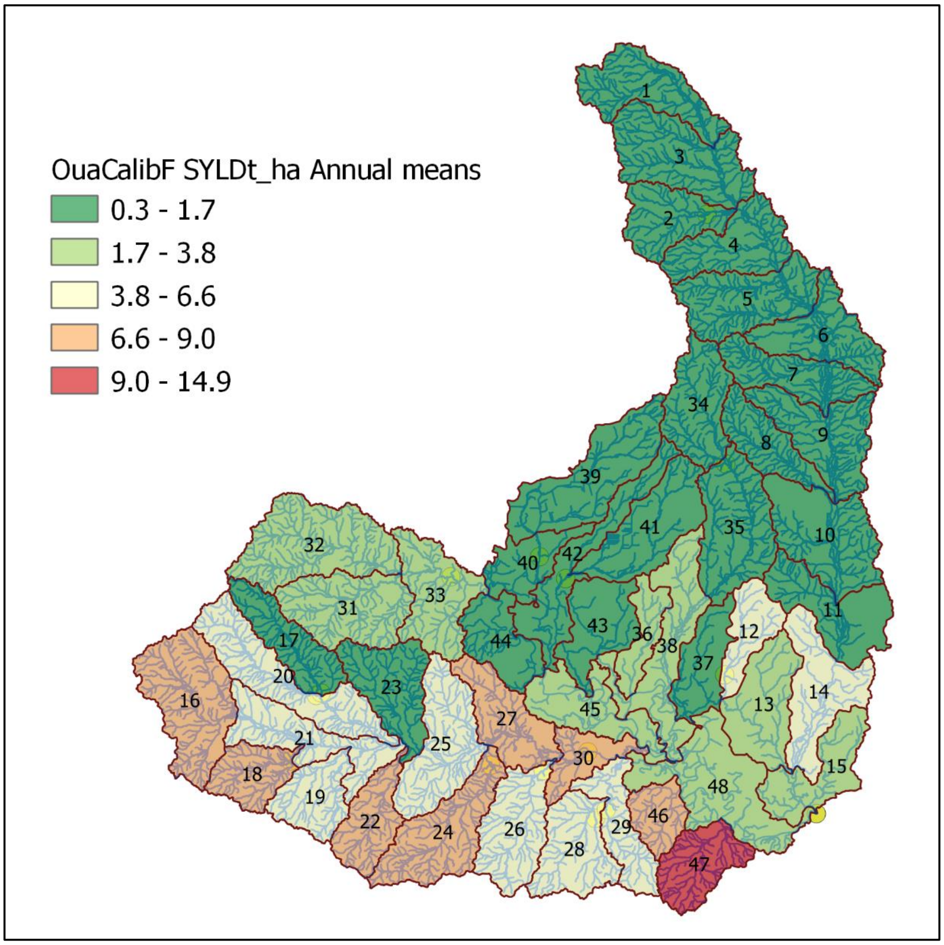

Figure 3.6.1. Sediment loading off of each sub-watershed (metric tons/ha).

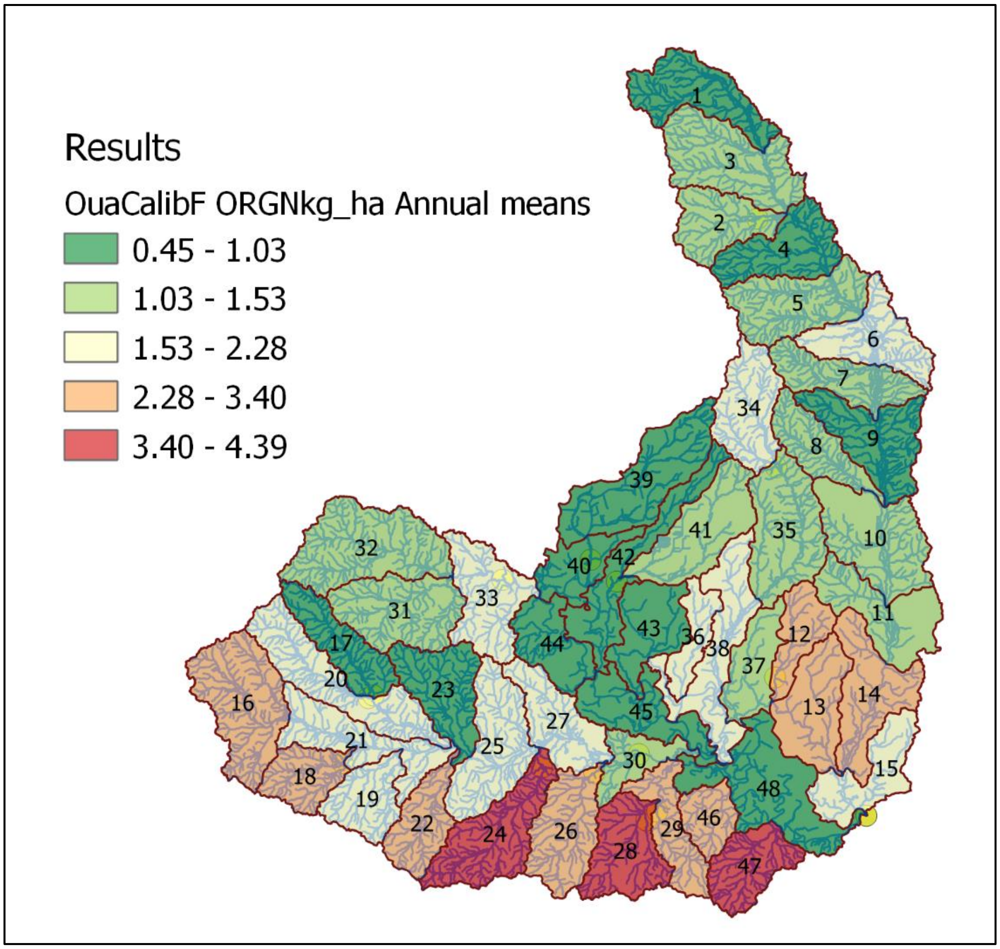

Figure 3.6.2. Nitrogen loading off of each sub-watershed (kg/ha)

4.0 LOADING ANALYSIS

4.1 Pollutant Loading From Key Recent Monitoring Studies

Water quality data used in this section were collected by Equilibrium (Grant # 13-300) during 2016-2020. Loading of pollutants in the LOSW was calculated from collected data and the flow estimations from the rating curves and USGS gages. A summary of the loading for key constituents is provided in Table 4.1.1.

Automated level measuring loggers were installed at the monitoring locations. The stage measurements were used to develop a rating curve, using the equation to extrapolate flow data from the level loggers. Flows were used with concentration data to calculator loading. The purpose of the monitoring was to identify key subwatersheds with the highest sediment and nutrient loading.

To account for varying watershed sizes and the impact it has on the loading calculation, loading data was divided by watershed size to normalize it and to achieve pounds per square mile (mi2) for each constituent (Figures 4.1.1 – 4.1.4.). Loading should have the watershed size incorporated into the loading calculation as some of the subwatersheds are much larger than others and thus will have greater flows and loads due only to their size, if not normalized.

For sub-watersheds upstream of the sampling reach calculations were completed by using the sampled streams' load divided by the area as a constant. Once the constant was developed, it was multiplied by each subwatersheds area to arrive at a load that has taken area into account.

Table 4.1.1. Loading of key storm flow constituents normalized on a per mi2 basis.

Name of Stream Sampled	HUC-12 Watershed Name	Average of TP (lb/mi2)	Average of Total Nitrogen (lb/mi2)	Average of Ammonium (lb/mi2)	Average of TSS (lb/mi2)
Bryant Creek	Bryant Creek	22.5	368.5	14.1	4,219.6
	Fife Creek - Moro Creek	29.2	478.6	18.3	5,479.9
	Pickett Creek - Moro Creek	38.7	633.7	24.2	7,255.7
Camp Creek	Sandy Creek	2.9	46.7	1.8	534.6
Champagnolle Creek	Lost Creek - Champagnolle Creek	41.2	675.4	25.8	7,733.6
	Taylor Creek - Champagnolle Creek	56.1	918.1	35.0	10,512.9
Guice Creek		25.3	413.6	15.8	4,735.7
Holmes Creek		28.9	472.5	18.0	5,410.8
Lloyd Creek		13.0	212.5	8.1	2,433.1
Locust Bayou	Cordell Creek - Caney Creek	46.5	760.9	29.0	8,712.1
	Locust Bayou	40.8	668.7	17.9	7,656.5
Moro Creek	Caney Creek - Moro Creek	44.7	732.7	28.0	8,389.4
	Cooke Creek - Moro Creek	26.3	430.4	16.4	4,928.5
Two Bayou	Dogwood Creek - Two Bayou	50.3	823.9	31.4	9,433.6
	Little Two Bayou - Two Bayou	120.7	1,975.9	75.4	22,624.4
Whitewater Creek		29.1	476.9	18.2	5,461.0

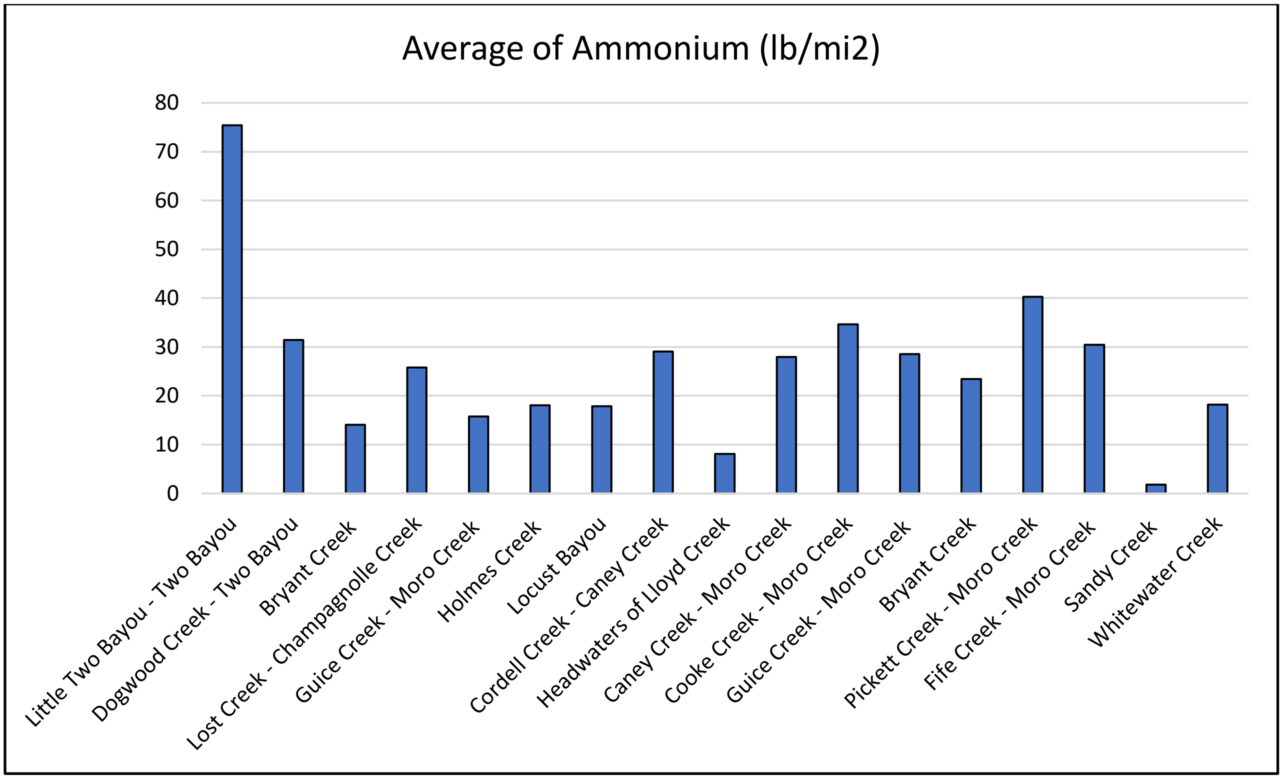

Figure 4.1.1. Average ammonium results (lb/mi2) from each subwatershed sampled or directly upstream watershed of a reach sampled.

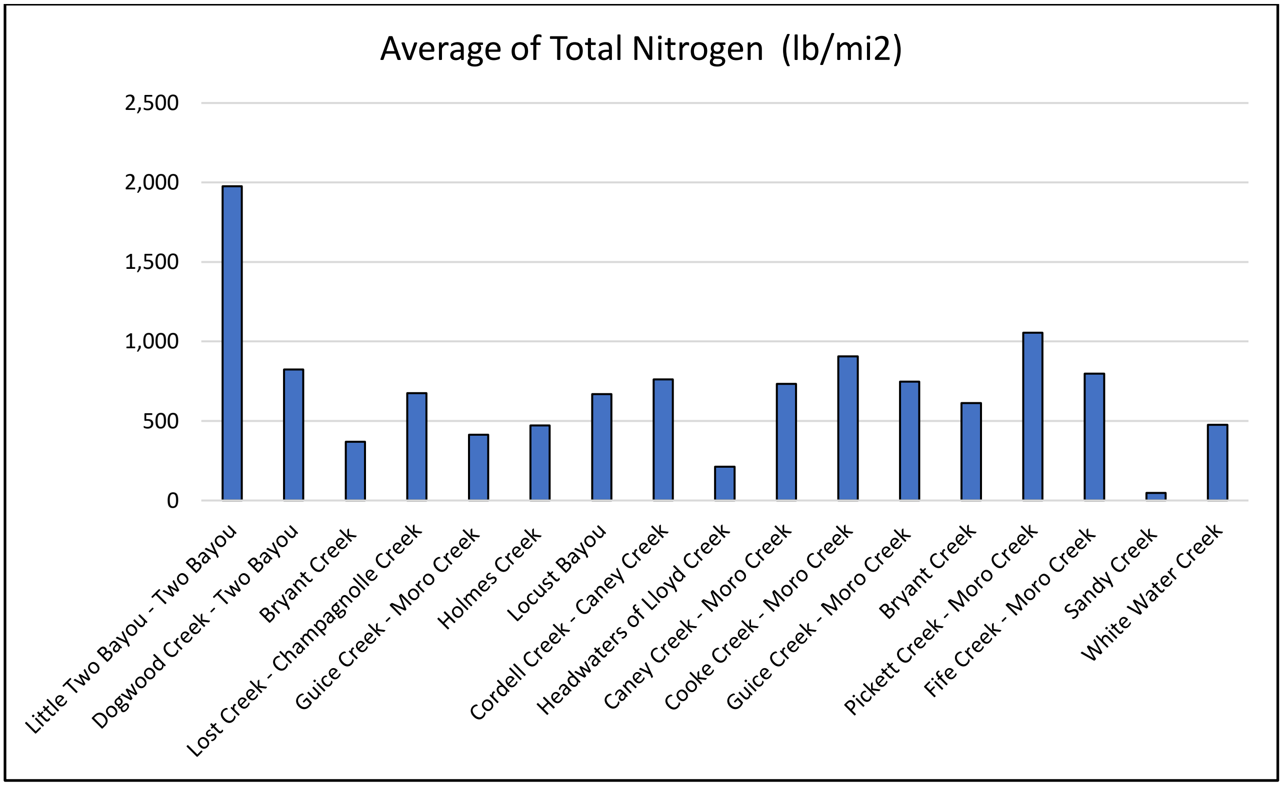

Figure 4.1.2. Average total nitrogen results (lb/mi2) from each subwatershed sampled or directly upstream watershed of a reach sampled.

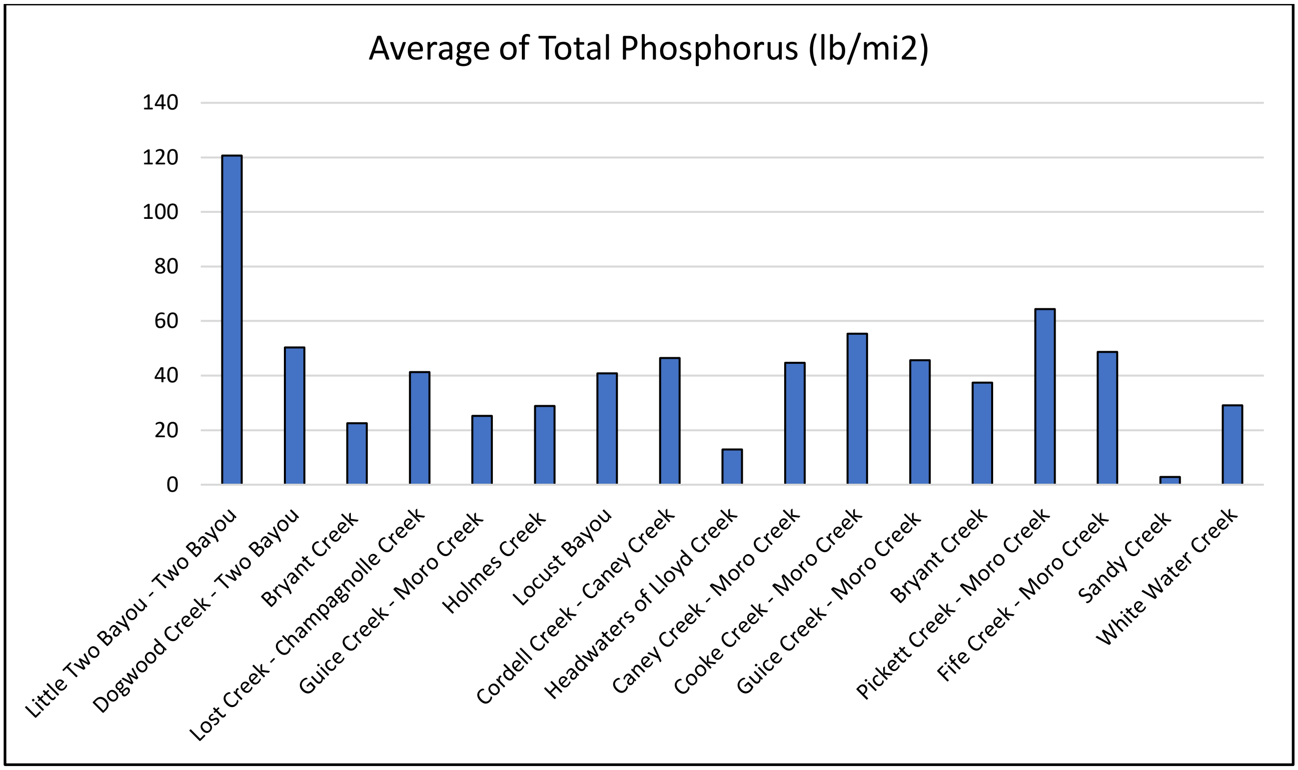

Figure 4.1.3. Average phosphorus results (lb/mi2) from each sub-watershed sampled or directly upstream watershed of a reach sampled.

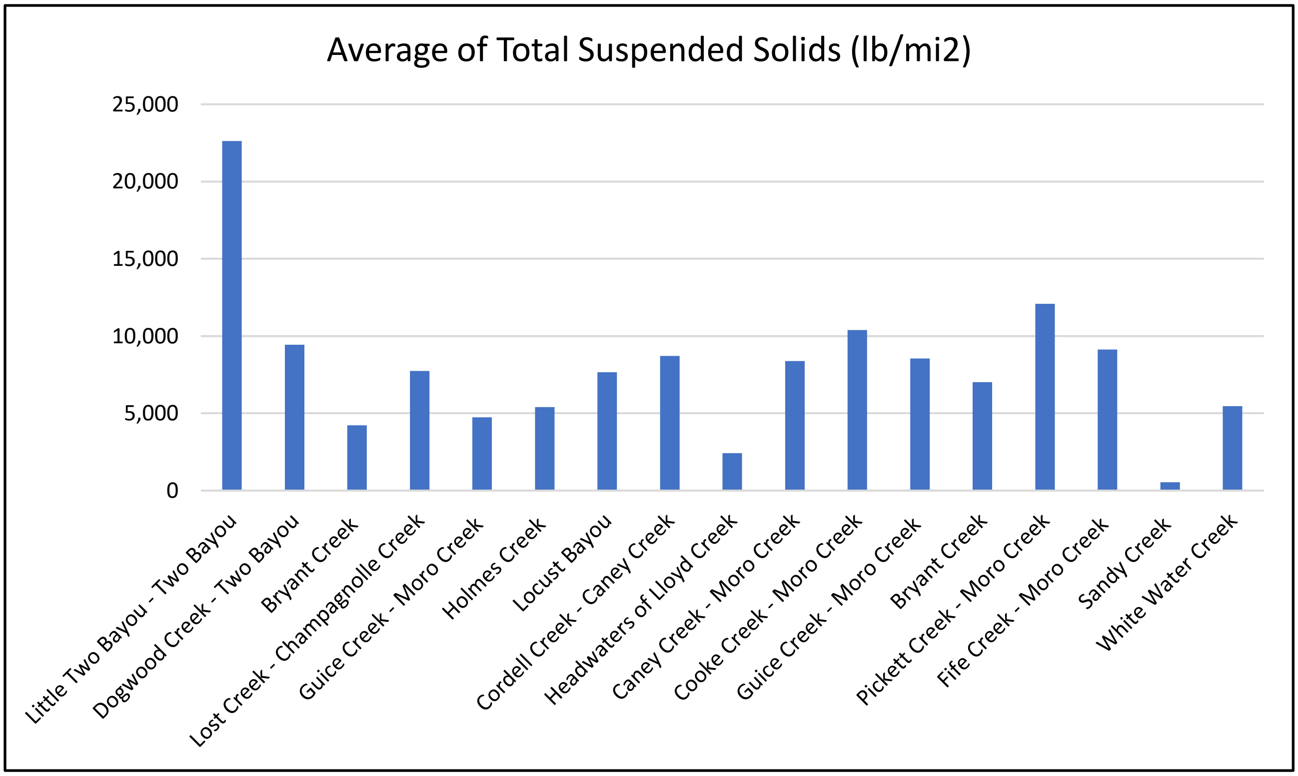

Figure 4.1.4. Average total suspended solids results (lb/mi2) from each subwatershed sampled or directly upstream watershed of a reach sampled.

5.0 POLLUTION SOURCE ASSESSMENT

The LOSW has 48 HUC-12 subwatersheds. The HUC-12 watershed sizes were ideal for watershed assessment, planning, and implementation. Of the 48 subwatersheds, 29 form the basis for how the findings from the assessment phase will be utilized to identify and prioritize pollutant sources for management.

5.1 Point Sources

Figure 5.1.1 depicts where all the NPDES permits are within the LOSW and list can be found in Appendix D. Within the LOSW there are 66 active NPDES permits. There are 5 major permitees (design flow > 1.0 MGD) and 138 minor permitees (design flow < 1.0 MGD).

Water quality data has been collected in the Lower Ouachita-Smackover (HUC 8040201) watershed by various state and federal agencies for some time. There have been two total maximum daily load (TMDL) reports completed in the watershed. One was completed in 2002 for mercury in fish tissue for the Ouachita River and Bayou Bartholomew. The other approved TMDL was written in 2003 and focused on chloride, sulfate, and TDS in Flat and Salt Creek. More recent data have been collected (2017-2018) to assess TMDL status in Flat and Salt Creeks, but that data has not yet been approved by the Arkansas DEQ. Preliminary results indicate that significant reductions in the TMDL pollutant levels have been achieved and further implementation efforts may not be necessary to meet the TMDL objectives.

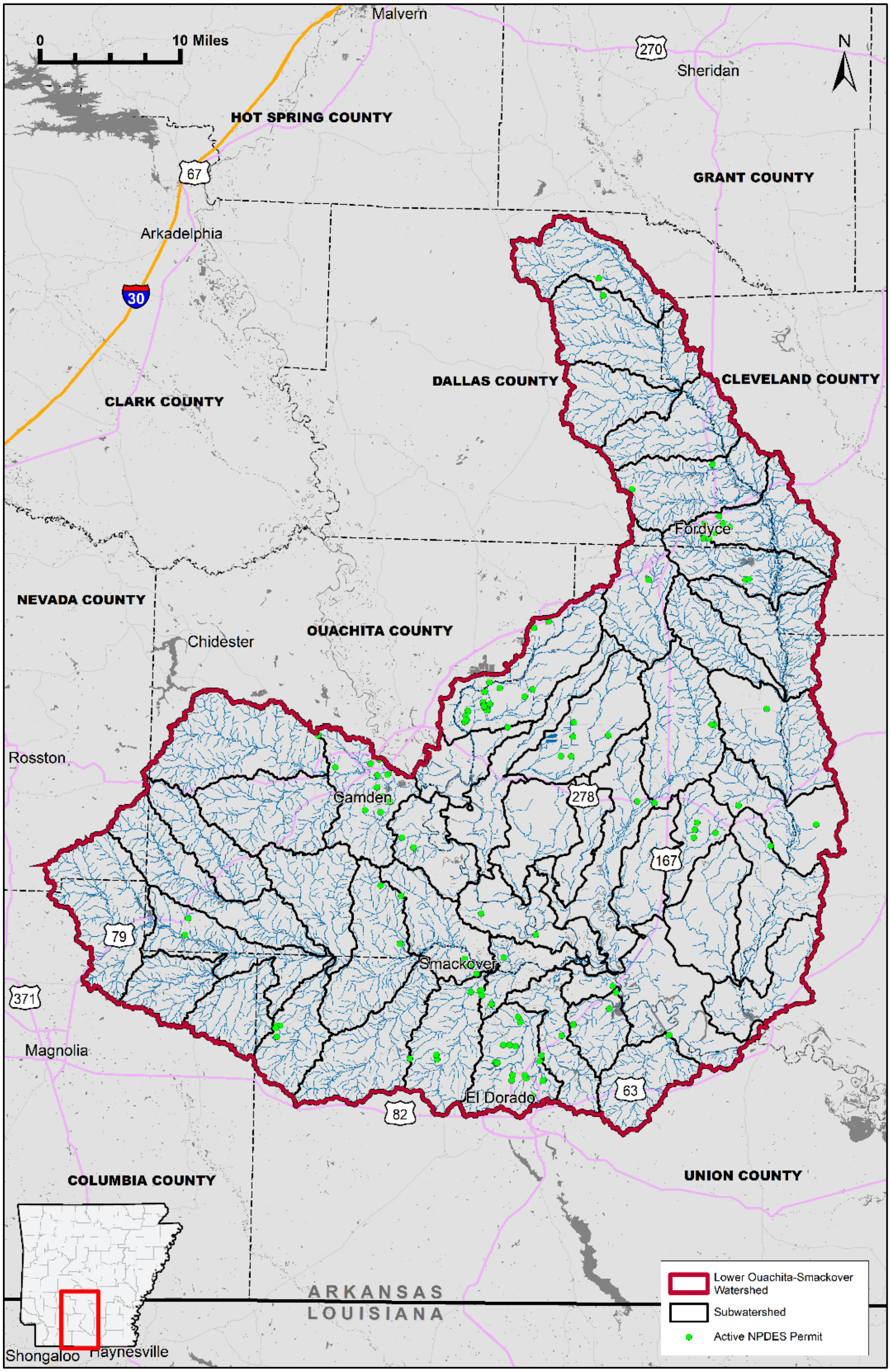

Figure 5.1.1. Active NPDES permits in the LOSW.

5.2 Priority Subwatershed Ranking

Using the results of the assessment work completed in the watershed, the following is a summary of what are believed to be key impact factors and the top subwatershed based sources of pollutants (Table 5.2.1).

Many factors play into determining which subwatersheds 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 oil and gas well numbers, developed and hay/pasture land use percent, total nitrogen, total phosphorus and TSS loads, concentration of agricultural animals, slope of the watershed, amount of impacted riparian buffers, miles of unpaved roads, SWAT model load predictions, percent of reach eroded and amount of bank erosion, if available. There were two water quality loading parameters that were included in the matrix giving water quality more weight in the ranking. Scores were assigned to subwatersheds that ranked either first (10 points), second (9 points), third (8 points), fourth (7 points), fifth (6 point), sixth (5 point), seventh (4 point), eighth (3 point), nineth (2 point), and ten (1 point) worst in a given impact category. Maximum possible score was 120. The higher the score the higher the priority. Table 5.3.1 provides a summary of the score totals for each subwatershed. As noted previously, not all subwatersheds had monitoring stations or were the focus of assessment efforts. The unmonitored HUC-12 sub-basins are represented in this assessment by other subwatersheds with similar land use.

Table 5.2.1 Ranking of each impact category for each subwatershed.

Watershed Names	Active & Producing Oil and Gas Wells	Mean Land Slope (percent rise)	Unpaved Roads (miles)	TSS load per rain event (lbs)	Macro. Hilsenhoff Biotic Index	Macro. Taxa Richness	% of Impacted Riparian Buffer (< 50 ft)	Streambank Erosion (ft3/mi)	Average of TSS (lb/mi2)	SWAT modeled sediment Loads (total/ha)	SWAT modeled Organic Nitrogen + Nitrate (total/ha)	Silviculture % Land Use	Total
Haynes Creek-Smackover Creek	10				10	9		8		8			45
Sandy Creek	6				8	5		9		9	4		41
Little Two Bayou-Two Bayou			9	9	2		9		10				39
Taylor Creek-Champagnolle Creek			7	7		3			9		10		36
Sloan Creek		4			5	4	3	10		7		1	34
Cordell Creek-Caney Creek			10	10			6		7				33
Pickett Creek-Moro Creek			8	8			4		3			8	31
Mill Creek-Smackover Creek	4	10								10	2	4	30
Cypress Creek-Gum Creek		6				10		5				7	28
Salt Creek	8	2			7	2				3	5		27
Locust Bayou			6	6			10	1	4				27
Lost Creek-Champagnolle Creek			4	4			1	7	5			6	27
Holmes Creek	5		3	3	4	7		3					25
Gum Creek	3	5				6	7			1	3		25
Wolf Creek-Smackover Creek	9									6	9		24
Dogwood Creek-Two Bayou					9				8		6		23
North Bayou		9									8	5	22
Bryant Creek					6			4				10	20
Haynes Creek	1	1			3	8				2			15
Caney Creek-Moro Creek							8		6				14
Cypress Creek-Smackover Creek		3					2				7	2	14
Guice Creek-Moro Creek			5	5								3	13
Mill Creek-Two Bayou		8			1	1		2					12
Fife Creek-Moro Creek									2			9	11
Holly Creek-Smackover Creek	2						5			4			11
Brushy Creek-Smackover Creek	7										1		8
South Bayou		7											7
Headwaters Lloyd Creek								6					6
Beech Creek-Smackover Creek										5			5
Whitewater Creek			2	2					1				5
Cooke Creek-Moro Creek			1	1									2
Holcomb Creek													0

According to the matrix ranking, the five key sub-watersheds in most need of land use management and source reductions in the LOSW are Haynes Creek-Smackover Creek, Sandy Creek, Little Two Bayou- Two Bayou, Taylor Creek -Champagnolle Creek, and Sloan Creek. A visualization of the matrix rankings in each of the watersheds is provided below in Figure 5.2.1.

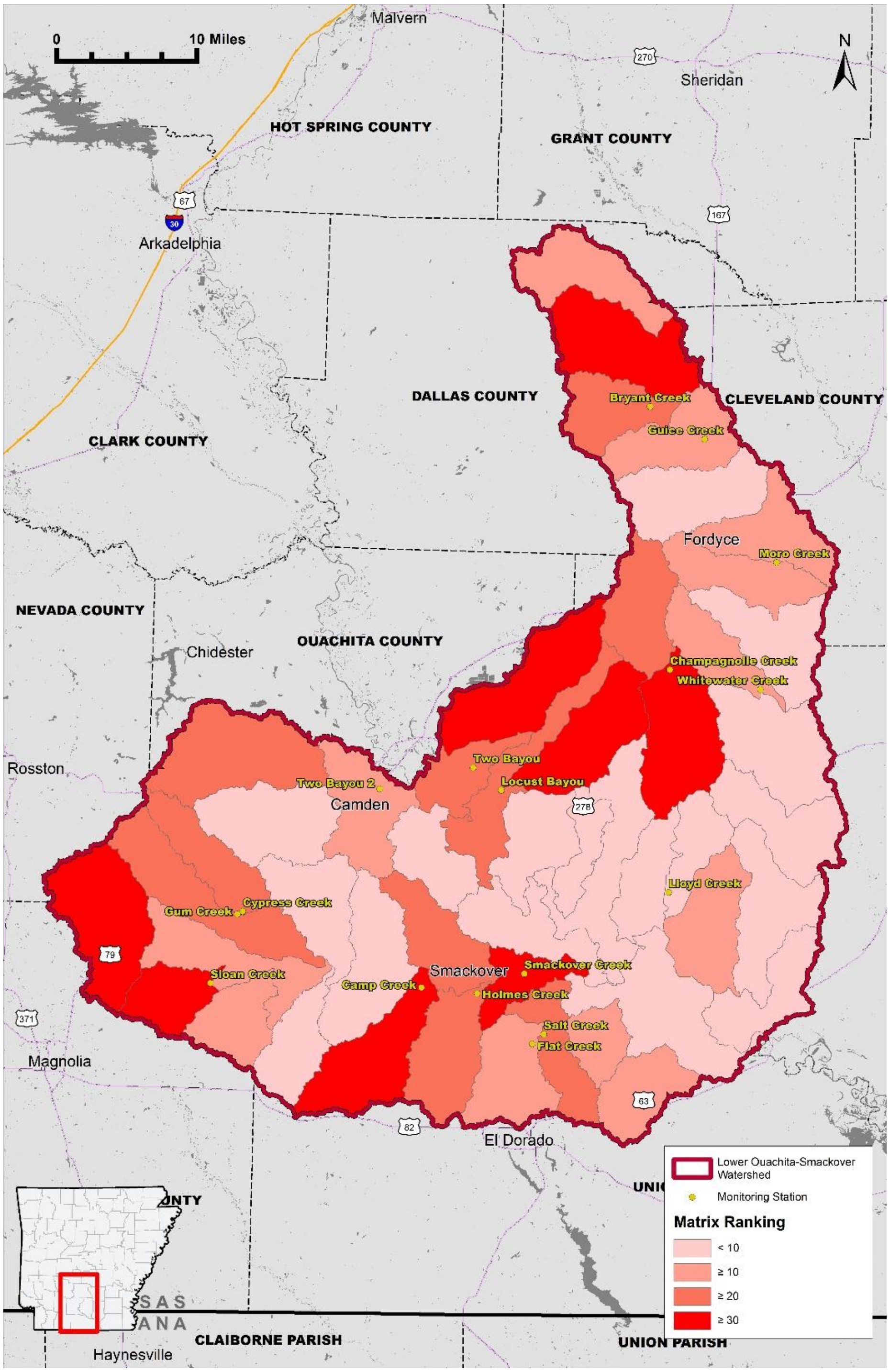

Figure 5.2.1. Matrix rankings of top watershed concerns in the LOSW.

6.0 RECOMMENDATIONS FOR WATERSHED MANAGEMENT

The following sections provide recommendations for management of the LOSW through voluntary BMP implementation, 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). Even the practice of preserving or restoring natural lands, such as riparian buffers, can help attenuate flood waters.

6.1 Recommended Load Reductions

Based on the assessment data presented in this plan and the history of 303d listing and TMDL's, load reductions of key pollutants are needed.

A reduction of 35% for TSS loading (and an associated 35% for N) will be targeted for the LOSW. This is a reasonable reduction target for water quality in the watershed. Any reductions in sediment are expected to return similar proportional load reductions to nitrogen based on correlation analysis completed on SWAT model outputs. The three key sub-watersheds in most need of land use management and source reductions in the LOSW are Haynes Creek-Smackover Creek, Sandy Creek and Little Two Bayou-Two Bayou.

Annual loading for each of the assessed subwatersheds was evaluated using the SWAT model and compared to loading from the monitoring data described in Section 4.1. Annual loading predictions from SWAT were used to assess load reduction targets for this study as they were most relatable to BMP reduction potential. The resulting annual loads for TSS and nitrogen (Table 6.1.1) were then used to establish a load reduction target for each constituent, based on the 35% reduction goal. Targeting reduction of these two pollutants is anticipated to carry comparable (proportional) reductions to other pollutants of concern in the watershed, including BOD, phosphorus, metals, etc.

Table 6.1.1. Comparison of annual loading calculated by modeling and from monitoring.

Loading Source	**TSS (lb/yr)**	**N (lb/yr)**
Monitoring data	62,217,885	8,322,934
SWAT	467,233,928	1,078,616
A 35% reduction in the load based on SWAT data		
Target Load Reduction	163,531,875	377,516
Loading Goal	303,702,053	701,100

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 (HRUs) 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 (based on HRU's) that it is applied to.

To assess and manage NPS pollution, the Natural Resources Division recommends evaluating pollutant loading and implementing mitigation efforts on the subwatershed 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 land uses for a particular BMP and loadings of sediments (and nitrogen) were compared to the base model to assess changes. The BMPs simulated in SWAT include:

1. A 50 foot buffer on 25% of pasture/hay, row crops and urban land uses watershed wide.

2. Detention/bioretention on 25% of urban/developed land uses.
3. Oil field land management on 25% of these land uses using BMPs including, bioretention, wet swales, filter strips, infiltration trenches, stormwater ponds, and stormwater wetlands.

Based on the results of the modeling, the most effective BMP applied to the watershed was a filter strips and widened riparian buffers. Riparian buffers protect the streambanks from erosion and provides a filtration mechanism for sediments and pollutants in runoff. The next most effective BMP was oil field land use management using a variety of stormwater controls. Oil field land use reductions were modeled using a combination of BMPs with at least one at each site.

6.2 Land Use and Runoff Management

The following sections provide best management practices recommended to protect water quality and/or the hydrologic regime of the key subwatersheds of the LOSW. 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. Appendix E provides a synoptic list of BMPs

6.2.1 Agricultural Land Use

Farmers 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 Natural Resources Division, the University of Arkansas Cooperative Extension Service and others. Frequently farmers can enter cost share agreements with one of these federal or state entities that provide the majority of funds to accomplish some of these 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 subwatershed, and particularly in subwatersheds Headwaters of Lloyd Creek, Taylor Creek – Champagnolle Creek, and Holmes Creek where pasture is the most prevalent, 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 subwatersheds:

- Riparian buffers along stream corridors. Minimum of 25 feet forest and 25 feet native grasses (50 ft. total). 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 subwatersheds 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 top soil erosion and utilizes remaining nutrients.

6.2.2 Developed - Commercial and Industrial Land Uses

Overall, the LOSW is not a highly developed area of the state. However, there are over 140 NPDES permits (mostly stormwater) in this watershed. Many of the NPDES permits are concentrated in the southern portion of the watershed near the urban areas of El Dorado, Arkansas. Although the subwatershed urban land use percentages range from 0.12-8.5%, recommendations in this section are still applicable to that area. Ensuring these entities are in compliance with their permits is an important component of managing the water quality and quantity in those subwatersheds. Besides the industry, these areas also contain more commercial development.

Several subwatersheds, particularly in the Mill Creek-Two Bayou, Haynes Creek, and Caney Creek-Moro Creek contain the most open space and low intensity land use. Well pads and their associated infrastructure can be a significant source of sediments during construction, but this risk diminishes dramatically after soil stabilization with vegetation. The Beech Creek and Brushy Creek should be the target subwatersheds for the BMPs listed below.

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.
- Enforce construction stormwater management plans.
- 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. buffer zones, wetlands, etc.) and maintain these as green areas.

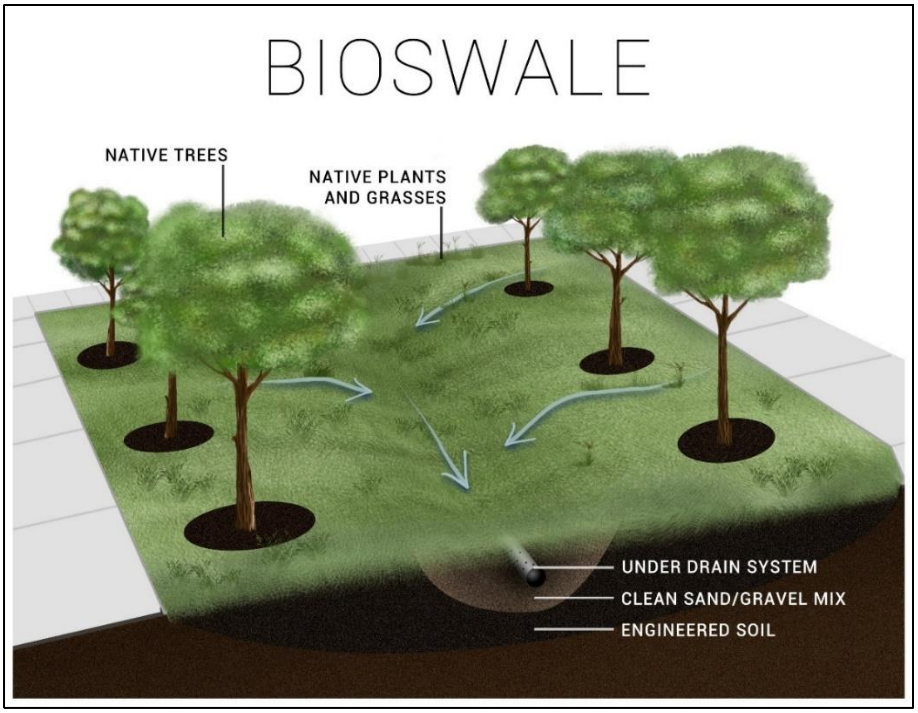

Figure 6.2.1. A bioswale (bioretention) that is effective in reducing pollutant load in stormwater run-off from commercial and institutional areas.

6.2.3 Developed - Residential Land Uses

As mentioned, overall LOSW is not highly developed but rural residential areas occur throughout the watershed with a higher concentration near El Dorado and Camden. Therefore, in subwatersheds Mill Creek-Two Bayou, Haynes Creek, and Caney Creek-Moro Creek recommended implementation of best management practices by developers and residents should be encouraged and in some areas required.

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 construction stormwater management plans.
- 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.

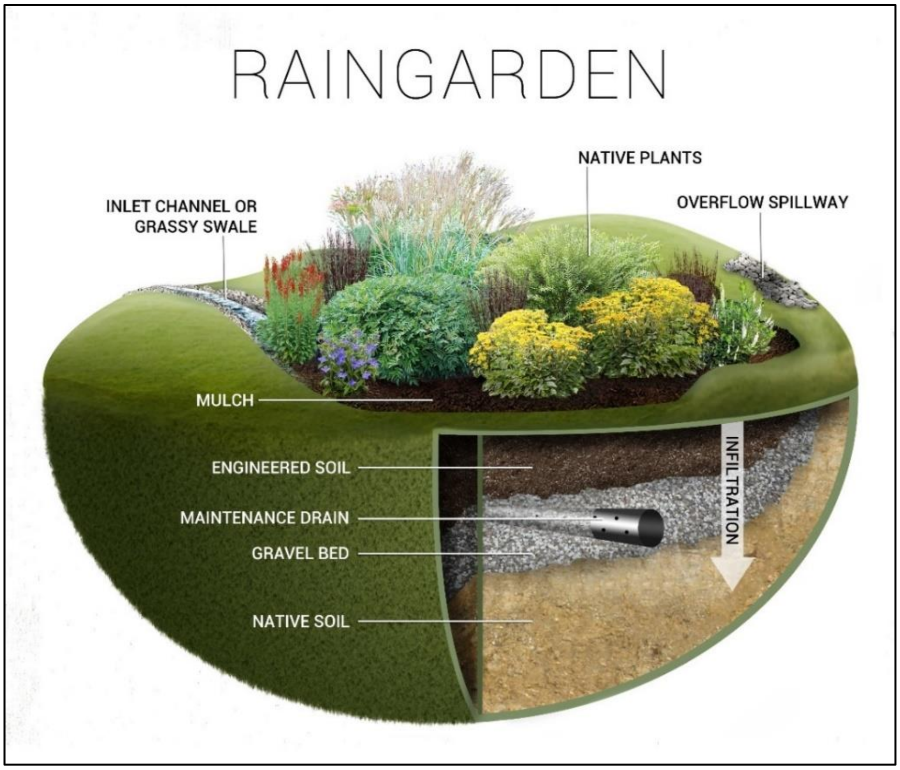

Figure 6.2.2. Example of a raingarden that can be easily and inexpensively installed in most yards and/or commercial areas to improve stormwater quality.

A combination of detention related BMPs (bioretention, extended dry detention and stormwater ponds) were modeled in SWAT and shown to have potential to reduce pollutants in developed land uses. Sediment reduction predicted from implementation of these BMPs on 25% of urban/developed land uses is:

- 3,063,790 lbs.

6.2.4 Unpaved Roads Management

Several BMPs are available to decrease sediment transport from unpaved roads and many of these are in use in the LOSW. However, current funding only allows a fraction to be addressed adequately. Key subwatersheds where there is a high concentration of unpaved roads are Cordell Creek-Caney Creek, Little Two Bayou-Two Bayou, and Pickett Creek-Moro Creek. 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 subwatersheds is provided in Table 6.2.4. These estimates are based on info from Bloser, S.M. and Sheets B.E., 2012. 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)	173,678,191	86,839,096
N load	50,888	25,444
P Load	96,739	48,369

Sediment reduction predicted from implementation of these BMPs on 50% of unpaved roads is:

- 86,839,096 lbs.

6.2.5 Oil and Gas Land Management

Southern Arkansas has a long history of oil extraction with an estimated 134,610,902 barrels of oil having been extracted by 1950. Smackover field was one of the top producing fields in the United States. Today, the oil fields span a 10-county area and still produce oil. In total, there have been 8,063 gas and oil wells drilled in the LOSW with 3,947 still producing. Best management practices have been in place on the majority of oil well pads and tank farms for years. These BMPs commonly include:

- Secondary containment for storage tanks
- Soil berming of active pumping areas to detain/contain or divert stormwater run-off
- Run-off collection ponds
- Soil stabilization and planting

These oil and gas land use areas (both active and un-restored inactive) could benefit from additional BMP’s including implementation of one or several of the following:

- Bioretention
- wet swales
- vegetated filter/buffer strips
- infiltration trenches
- stormwater ponds
- stormwater wetlands

Sediment reduction predicted from implementation of these BMPs on 25% of oil field land uses:

- 3,761,681 lbs.

6.2.6 Silviculture Management

The Agriculture Department's Arkansas Forestry Commission (AFC) is the lead agency responsible for the Forestry BMP Program (AFC, 2021). The BMP Program relies on voluntary implementation of BMPs based on the training and education of forest landowners, foresters, and loggers. In 1996, Arkansas adopted the BMP implementation survey procedures developed by the Southern Group of State Foresters. The last survey available online was conducted and published in 2017. The survey found that in the region of the LOSW there is a 93% implementation rate for BMPs. Silviculture BMPs are documented to achieve 77-83% reduction in sediment loads (Hawks, et al., 2022). The top 4 categories of BMPs implemented in the survey were regeneration, harvesting, road surface management and streamside management zones.

Based on SWAT modeling, potential sediment loads off of silviculture operations could exceed 75 million pounds annually if not for these BMPS which generally reduce those level by at least 77%.

Due to the high adoption rate of silviculture BMPs in Arkansas, no additional reduction targets will be assessed for silviculture land use in this plan. However, common deficiencies in stormwater BMPs based on survey results include lack of water bars on skid trails, fire lanes, and inactive roads, absence of streamside management zones, inadequate stabilization of stream crossings, and poor utilization of seeding and mulch to stabilize loose soil. It is recommended that all silviculture operations either improve use of or begin use of these BMPs. Historically, based on survey results, the largest room for improvement is with the private individual or family forest landowners as they have been the least compliant with silviculture BMPs.

6.3 Stream Corridor Restoration/Enhancement

6.3.1 Riparian Buffers

Riparian vegetated buffers are lacking or limited in several reaches in the LOSW. 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: Locust Bayou, Lloyd Creek, and Caney-Moro Creek.

Buffer widths should be planted as wide as possible on each side of the stream. A minimum width of at least 25 ft (50 ft preferred) on each side of the stream should be targeted. 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 typically designed.

Sediment reduction achieved from implementation of 50 ft. vegetated strips/buffers on 25% of impacted stream buffers in agriculture, hay and urban land uses:

- 11,164,294 lbs.

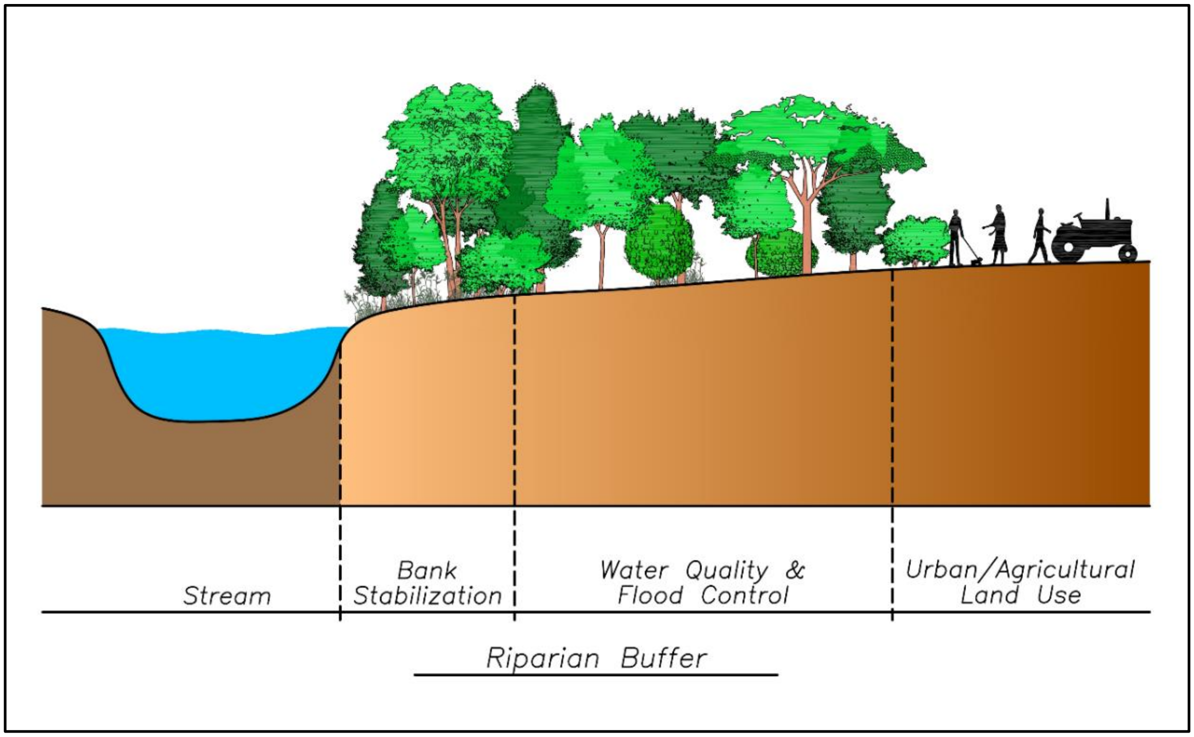

Figure 6.3.1. Generic Representation of the ideal Riparian Buffer Zone.

6.3.2 Streambank and Channel Stabilization

Several of the streams in the LOSW are exhibiting significant streambank erosion at several locations (Table 6.3.2.1). 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. Primary/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 and nutrient 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.)
- 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 state (AGFC) or federal (NRCS) agencies or contract engineering companies who have additional experience with streambank stabilization.

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

Stream Name	HUC 12 Sub-Watershed(s) the site represents	Sediment Eroded (lbs/yr)	P (lbs/yr)	N (lbs/yr)
Bryant Creek	Bryant Creek	2,470,286	724	1,376
Cypress Creek	Cypress Creek- Gum Creek	3,552,564	1,041	1,979
Two Bayou	Little Two Bayou - Two Bayou, & Dogwood Creek-Two Bayou	726,845	213	405
Gum Creek	Gum Creek	776,496	228	433
Flat Creek	Haynes Creek	0	0	0
Smackover Creek	Beech, Cypress, Holly, Brushy, Wolf Creek, Haynes Creek-Smackover Creek, Gum Creek, Sandy Creek, & Holcomb Creek	82,774,646	24,253	46,106
Holmes Creek	Holmes Creek	1,329,804	390	741
Lloyd Creek	Headwaters of Lloyd Creek	1,329,704	390	741
Locust Bayou	Locust Bayou & Cordell Creek-Caney Creek	1,585,531	465	883
Two Bayou 2	Mill Creek - Two Bayou, North Bayou, & South Bayou	953,812	280	531
Salt Creek	Salt Creek	0	0	0
Camp Creek	Sandy Creek	24,908,566	7,298	13,874
Sloan Creek	Sloan Creek	28,553,815	8,366	15,905
Champagnolle Creek	Lost Creek - Champagnolle Creek	24,716,121	7,242	13,767
	Total Load	173,678,191	50,888	96,739
	Reduction Potential if 50% of Banks Stabilized	86,839,096	25,444	48,369

Sediment reduction estimated from implementation of streambank stabilization projects on 50% of impacted stream banks:

- 86,839,096 lbs.

6.3.3 Critical Area Conservation

Land conservation should become a priority. Where possible, attainment of land and/or establishment of conservation easements should be considered in areas critical to the stream and wetlands to maintain these as green areas. This practice typically helps to reduce localized flooding as well as serving to improve water quality. First place to begin this effort is typically in developed land use areas where support from the local municipality may be garnered. Any improvements or conservation to wetlands should be considered as wetlands filter pollutants and the watershed has on average 27% of its area as wetlands. 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 and wetland conservation	Preserve wetland areas where possible, including limiting logging in bottom land hardwood stands. Minimize all clearing to that essential for commercial and residential activities to maintain as much forest as possible.
Riparian Buffers	Riparian vegetated buffers should be encouraged along all stream corridors and be protected by local ordinance or easement where possible.
Beaver dam analogues	Allow beaver dams to remain in place as they frequently create viable wetland habitats. Consider post-assisted log structures as low-tech tools to process-based restoration.

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, unpaved road BMPs and vegetated filters rips/riparian buffers (Figure 6.4.1). The most effective for N removal appear to be stormwater BMPs in developed areas, streambank stabilization and stormwater BMPs in oil field land (Figures 6.4.2).

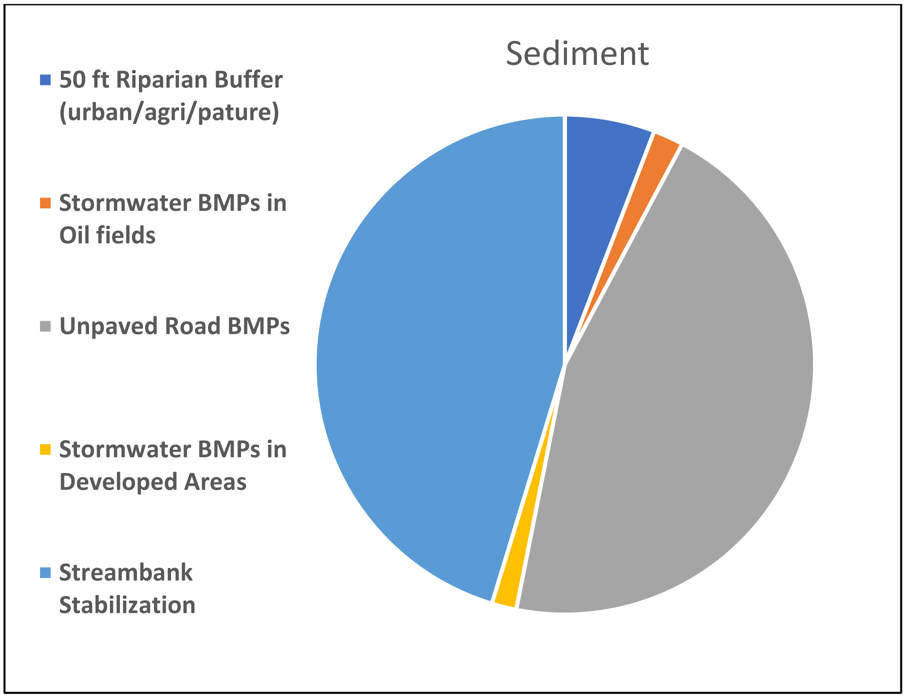

Figure 6.4.1. Source and scale of Total Suspended Solids (TSS) load reductions.

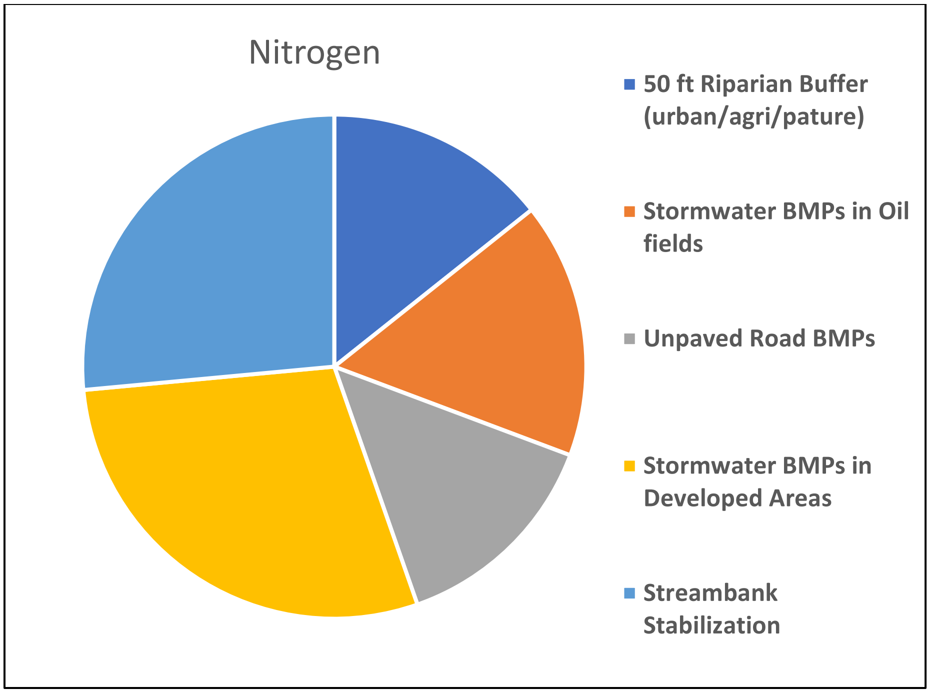

Figure 6.4.2. Source and scale of Nitrogen (N) load reductions.

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 reduction goals expressed.

Table 6.4.1. Prioritization of recommended Watershed Management Practices.

Count	Watershed Names	Implementation
1	Haynes Creek-Smackover Creek	A 50 foot buffer on 25% of pasture/hay and urban land use watershed wide. Barren land management including bioretention, wet swales, filter strips, infiltration trenches, stormwater ponds, and stormwater wetlands.
2	Sandy Creek	A 50 foot buffer on 25% of pasture/hay and urban land use watershed wide. Barren land management including bioretention, wet swales, filter strips, infiltration trenches, stormwater ponds, and stormwater wetlands.
3	Little Two Bayou-Two Bayou	Detention/bioretention on 25% of urban/developed land.
4	Taylor Creek-Champagnolle Creek	Detention/bioretention on 25% of urban/developed land.
5	Sloan Creek	A 50 foot buffer on 25% of pasture/hay and urban land use watershed wide.
6	Cordell Creek-Caney Creek	Detention/bioretention on 25% of urban/developed land.
7	Pickett Creek-Moro Creek	Detention/bioretention on 25% of urban/developed land. Silviculture BMPs were not modeled, however, if BMPs are used in operations there is a 77-83% reduction in sediment loads
8	Mill Creek-Smackover Creek	Detention/bioretention on 25% of urban/developed land.

Count	Watershed Names	Implementation
9	Smackover (and all associated subbasin)	Complete streambank stabilization on primary and accessible eroded banks
10	Sloan Creek, Camp Creek and Champagnolle Creek and associates subbasins	Complete streambank stabilization on primary and accessible eroded banks
11	Cordell Creek-Canney Creek and Little Two Bayou-Two Bayou	Install unpaved road BMPs
12	Picket Creek-Moro Creek and Taylor Creek-Champagnolle Creek	Install unpaved road BMPs
13	Smackover creek and all associated subbasins	Install additional stormwater BMPs in oil field land uses
14	Cypress Creek-Gum Creek	A 50 foot buffer on 25% of pasture/hay and urban land use watershed wide. Barren land management including bioretention, wet swales, filter strips, infiltration trenches, stormwater ponds, and stormwater wetlands.
15	Salt Creek	A 50 foot buffer on 25% of pasture/hay and urban land use watershed wide. Barren land management including bioretention, wet swales, filter strips, infiltration trenches, stormwater ponds, and stormwater wetlands.
16	Locust Bayou	Detention/bioretention on 25% of urban/developed land.

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 (Table 6.4.2.). The schedule provides ten years for actions to be accomplished that will result in a 35% reduction of sediment, nitrogen and other associated pollutants in the watershed.

Table 6.4.2. Implementation Schedule[1].

Action Item	Target Date for completion
Establish a permanent watershed management/stakeholder group to oversee implementation.	Feb 1, 2025
Meet with stakeholder group to coordinate implementation projects and monitoring and plan for future funding	March 1, 2025
Apply for grants to fund future monitoring and implementation projects	October 1, 2025
Implement riparian buffers and filter strips in key sub-watersheds	December 1, 2027
Meet with county judges and US Forest Service to discuss unpaved road maintenance	October 1, 2025
See 25% of unpaved roads in key sub-watersheds receive new BMP application	December 1, 2028
Implement stormwater BMPs on 15% of key urban/developed and oil/gas well land uses	December 1, 2029
Bank stabilization of 20% of eroded banks in in sub-watersheds	December 1, 2027
Implement riparian buffers and filter strips in remaining key sub-watersheds	December 1, 2029
Bank stabilization of 20% of eroded banks in remaining key sub-watersheds	December 1, 2031
Implement stormwater BMPs on remaining 10% of key urban/developed and oil/gas well land uses	December 1, 2032
See 25% of remaining unpaved roads in key sub-watersheds receive new BMP application	December 1, 2033
See remaining 10% of streambanks stabilized in key subwatersheds	December 1, 2034

[1] 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 group success	Meetings at least 2/year and attendance of at least 40% of group on average
Monitoring program initiated	First round of routine samples collected

Milestone	Measurement method
Unpaved road BMP meeting	Meeting occurred on schedule
Grant applications submitted	At least two applications completed
Eroded streambank stabilization	Stabilization completed on schedule Length of stream completed as planned
Oil and Gas field stormwater management practices implemented	Completed on schedule and attaining percentage goals
Unpaved Road BMPs implemented	Completed on schedule and attaining percentage goals
Urban areas stormwater management practices implemented	Completed on schedule and attaining percentage goals
Monitoring shows TSS and TN loading is stable or decreasing	Data analysis (per Section 7.0) of first three-year monitoring cycle (2027-2029)
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.

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 10 years the WMP will be updated. The update will include goals, revisions to key components that have changed over time as well as revisions needed to improve accomplishment of its goals.

7.0 WATER QUALITY TARGETS (SUCCESS CRITERIA) AND MONITORING

A load reduction target of 35% (Section 6.1) for sediment and nitrogen has been established to ensure continued maintenance of the water quality criteria and the overall integrity of these waters and reduce loading of these pollutants and others associated with sediment. In preparation for this WMP, a LOSW WMP stakeholder group has been in the works and spearheaded by the Southwest Arkansas Planning and Development District (SWAPDD). The LOSW WMP stakeholders group once formalized will lead efforts in the watershed. Once BMPs begin to be implemented, a watershed monitoring program should be implemented to track reductions within the LOSW. Any new monitoring data collected will be compared to historical data collected.

The first year and possibly even the second year of WMP implementation (2025 and 2026) 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 2027 and continue for 3 years until 2029. 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 three ways:

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

The 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

The LOSW stakeholder group is being created out of a series of meetings and conversations concerning this WMP. The stakeholder group began working during grant planning in 2021 but became more active at the first formal meeting held on September 19th, 2023. The stakeholders should meet at a minimum, once per year (2/year is the goal), to discuss new concerns, coordinate watershed efforts and work on the WMP.

8.2 Educational Outreach

The LOSW and the SWAPDD would benefit from educating the public concerning relevant environmental and watershed issues. Public informational meetings were held on September 19,2023 and May 28, 2024. Meetings included key stakeholders and citizens living in the watershed potentially impacted by activities in the watershed and allowed stakeholders to express issues concerning the watershed and to ask questions about the draft WMP. Through these meetings, and other communications with stakeholders plans can be formulated to address these issues. Key stakeholders were given the opportunity to provide feedback on the WMP and suggestions concerning sources of pollutants in the watershed. This information was evaluated and used to set priorities in the action plan. The final draft of the watershed management plan will be made available electronically to all the key stakeholders for review and comment. Future proposed revisions of the watershed management plan and schedules will be sent to all key stakeholders that are involved in the stakeholder group. Key issues or needs identified in the past stakeholder meeting(s) are in the Table 8.2.1 below.

Table 8.2.1. Stakeholder feedback on nonpoint source issues in the LOSW.

Drainage issues	Silviculture
Flooding	Clear cutting
Streambank erosion	Post-cut land management
Road crossing/culvert erosion	Unpaved roads

Key details pertaining to this WMP have been transferred to an educational brochure that will be posted online and made available at SWAPDD for interested public to learn more about this important effort.

8.3 Continuing Education

The stakeholders should continue educating the residents of the LOSW on implementation of BMPs and what programs can assist residents financially to implement BMPs. A series of meetings will be held in the first 2 years post WMP approval to educate landowners on a series of BMP related activities and how to fund such efforts. Once every 3 years, and during years the WMP is reviewed a public meeting will be held to receive comment in regard to issues that still need to be addressed and success of programs.

9.0 TECHNICAL AND FINANCIAL ASSISTANCE

The projected costs to accomplish a 35% reduction in sediment in the LOSW is summarized in the table below.

Table 9.0.1. Sediment load reductions for the LOSW.

Management Measure	TSS Reduced (lbs)	Cost per lb reduced ($)	Cost Estimate ($)
Filter strips/Riparian buffers	11,164,294	0.35	3,907,503
Oil Field Stormwater mgmt. BMPs	3,761,681	18	67,710,258
Unpaved Road BMPs	86,939,096	3.8	330,368,565
Detention BMPs in urban/developed land	3,063,790	18	55,148,220
Streambank stabilization	86,839,096	0.6	52,103,458

A vast array of federal funding opportunities exists for developing and implementing effective watershed management activities. A number of incentives and grants are available for landowners to implement BMPs; and grants are available to communities to install stormwater treatment practices and replant riparian areas. Some grants will be more easily obtained by local governments (city/county), non-profits or community groups, such as the SWAPDD, 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 9.0.3. require matching funds from the applicant (Table 9.0.2.). 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 1/3 of the funding will come from a combination of these programs. The cost-share programs in Arkansas that are managed by the USDA/NRS and the Natural Resources Division are anticipated to be a good and readily available source to fund agriculture 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
Union County (Unpaved roads)
Ouachita County (Unpaved roads)
SWAPDD
City of Camden
City of Smackover
City of El Dorado
State Conservation Districts in each county
AGFC
Local Land Owners

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	National Fish and Wildlife Foundation	Fish, wildlife, habitat conservation
Native Plant Conservation Initiative	National Fish and Wildlife Foundation	Protect/enhance/restore native plant communities
Non-point Source Implementation Grants (319 Program)	USDA (NRCS) EPA (National resources Division or OCC)	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

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Appendix A

USA Forms

Unified Stream Assessment (USA)

REACH ID: Bryant Creek
STREAM: BCI
DATE/TIME: 6/8/23
INITIALS: JLL / ENJ

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - [✓ Pool] (circle)
☒Riffle 2.5 % ☒ Run 2.5 % ☒ Pool 95 % ☐ Steps ______%

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

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

Land use
☒ Forest 85 % ☐ Pasture _____% ☐ Urban _____%
☒ Commercial 15 % ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

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

Riparian Buffer
Vegetation Type: ☒ Forest 80 % ☒Shrub/Sapling 20 % ☐ 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) ☒Unshared (<25% coverage)

Water Quality Observations

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

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

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

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Bryant Creek	**Date:** 6/8/23	**Initials:**

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER 1	2527 Right-Downstream	[✓ L] M H VH EX (circle one)	186	1	Bank: Height 10 ft, Angle 80 Deg Protection: Roots 75 %, Root Depth 4 ft Vegetation 60 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 2	2528 Left-upstream	[✓ L] M H VH EX (circle one)	54	1	Bank: Height 8 ft, Angle 90 Deg Protection: Roots 60 %, Root Depth 3 ft Vegetation 30 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ____ft, Angle ____Deg Protection: Roots____%, Root Depth ____ft Vegetation ____% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ____ft, Angle ____Deg Protection: Roots____%, Root Depth ____ft Vegetation ____% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ____ft, Angle ____Deg Protection: Roots____%, Root Depth ____ft Vegetation ____% [4]Material: Silt/Clay Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: Bryant Creek	**STREAM:** BC1	**DATE/TIME:** 6/8/23	**INITIALS:** JLC/ENT
OTHER INFO:			

Average Conditions (check applicable)

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

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

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

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

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

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

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

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

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

Channel Dimensions (facing downstream): See erosion hazard Index
Lt bank Ht:_____(ft) Bankfull Depth _____(ft) Wetted Width:_____(ft) Riffle/Run Depth_____(ft)
Rt bank Ht:_____(ft) Bankfull Width _____(ft)) TOB Width:_____(ft) Pool Depth _____(ft)

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

Reach Accessibility For Restoration

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

5 4 3 2 [✓ 1]

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

Place sketch of reach on back of page.

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

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

Unified Stream Assessment (USA)

REACH ID: Camp Creek	**STREAM:**	**DATE/TIME:** 6/6/23	**INITIALS:** ENJ/DZC

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - Pool (circle)
☐ Riffle ______% ☑ Run 15 % ☑ Pool 85 % ☐ Steps ______%

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

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

Land use
☑ Forest 100 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

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

Riparian Buffer
Vegetation Type: ☑ Forest 100 % ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations

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

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

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

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Camp Creek	**Date:**	**Initials:**

Impact I.D.[1]	**Coordinates (Lat / Long) or Waypoint**	**Severity (1-3)**[2]	**Restoration Opportunity (1-3)**[3]	**Description**

BEHI I.D.	**Coordinates (Lat / Long) or Waypoint**	**Bank Erosion Hazard**	**Bank Lth. (ft)**	**Rest. Opp. (1-3)**[3]	**Bank information for BEHI**
ER	entire reach	L [✓ M] H VH EX (circle one)		1	Bank: Height 3.5 ft, Angle 85 Deg Protection: Roots 55 %, Root Depth 2.5 ft Vegetation 20 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle _________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle _________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle _________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle _________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID:

STREAM: Camp Creek

DATE/TIME: 6/6/23

INITIALS:

OTHER INFO:

Average Conditions (check applicable)

Flood Plain Dynamics

Connection: ☐ Poor ☑ Fair ☐ Good

Habitat: ☐ Poor ☑ Fair ☐ Good

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

Encroachment: ☐ Poor ☑ Fair ☐ Good

Periphyton (attached algae):

Filamentous: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant

Prostrate: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant

Floating: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant

Suspended Algae (phytoplankton) abundance:

☑ None noticeable (water basically clear)

☐ Moderate (water slightly green tinted)

☐ Abundant (water appears green)

Aquatic Plants In Stream:

Submerged: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant

Emergent: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant

Floating: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant

Aquatic Life Observed:

☑ Fish ☐ Snails ☐ Crawfish ☑ Macroinvertebrates

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

☐ Cattle ☐ Beaver ☐ Deer ☐ Other________

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

☐ Outfalls(OT): 1 2 3 Wpt________

☐ Stream Crossing(SC): 1 2 3 Wpt________

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

☐ Channel Modification(CM) : 1 2 3 Wpt________

☐ Impacted Buffers(IB): 1 2 3 Wpt________

☐ Trash(TR): 1 2 3 Wpt________

☐ Utilities(UT): 1 2 3 Wpt________

☐ Other________: 1 2 3 Wpt________

Notes:

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

Channel Dynamics:

☐ Incised (degrading) ☐ Widening ☐ Headcutting

☐ Channelized ☐ Aggrading ☑ Bank scour

☐ Bed Scour ☑ Bank Failure ☐ Slope failure

☑ Sediment Deposition ☐ Culvert Scour (upstream / downstream / top) ☐ None (natural stabile channel)

Channel Dimensions (facing downstream):

Lt bank Ht: 3.5 (ft) Bankfull Depth 0.75 (ft) Wetted Width: 45 (ft) Riffle/Run Depth 0.5 (ft)

Rt bank Ht: 4.5 (ft) Bankfull Width 55 (ft)) TOB Width: 65 (ft) Pool Depth 1.5 (ft)

Channel Stability:

Lt Bank: Angle 90 degrees

LtBank Vegetation protection: 10 % cover

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

Length Lt Bank Affected:________

Wpt(s):________

Rt Bank: Angle 85 degrees

RtBank Vegetation protection 5 % cover

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

Length Rt Bank Affected:________

Wpt(s):________

Reach Accessibility For Restoration

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

5 4 3 2 [✓ 1]

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

Place sketch of reach on back of page.

Restoration Potential:

☐ Riparian reforestation ☑ Bank stabilization

☐ Stormwater retrofit ☐ Outfall stabilization

☐ Channel modification ☐ PS investigation

☐ Culvert rehab. ☐ Other________

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

Unified Stream Assessment (USA)

REACH ID: Champagnolle Creek	**STREAM:** CC1	**DATE/TIME:** 6/8/23	**INITIALS:** JLC / ENS

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - [✓ Riffle/Pool] - Pool (circle)
☒ Riffle 5 % ☒ Run 30 % ☒ Pool 65 % ☐ Steps ______%

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

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

Land use
☒ Forest 100 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

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

Riparian Buffer
Vegetation Type: ☒ Forest 80 % ☒Shrub/Sapling 10 % ☒ Herbs/Grasses 10 % ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations

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

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

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

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Champonelle Creek	Date: 6/8/23	Initials: ENT/JLC

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI L/R
ER 1	2522 Right Downstream JLC	[✓ L] M H VH EX (circle one)	126	1	Bank: Height 7 ft, Angle 90 Deg Protection: Roots 35 %, Root Depth 2 ft Vegetation 55 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 2	2523-2524 Right Upstream	[✓ L] M H VH EX (circle one)	160	1	Bank: Height 10 ft, Angle 110 Deg Protection: Roots 70 %, Root Depth 6 ft Vegetation 50 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 3	2525-2526 Right + Left Upstream	[✓ L] M H VH EX (circle one)	310	1	Bank: Height 8-12 ft, Angle 90/110 Deg Protection: Roots 40/60 %, Root Depth 3/4 ft Vegetation 20/60% [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ~~8-12~~ ft, Angle ~~90/110~~ Deg Protection: Roots ~~40/60~~ %, Root Depth ~~3/4~~ ft Vegetation ~~20/60%~~ ~~40/60~~ [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ____ ft, Angle ____ Deg Protection: Roots ____ %, Root Depth ____ ft Vegetation ____ % [4]Material: Silt/Clay Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: Chayonelle Creek
STREAM:
DATE/TIME: 6/8/23
INITIALS: ENJRC
OTHER INFO:

Average Conditions (check applicable)

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

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

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

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

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

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

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

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

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

Channel Dimensions (facing downstream): - See bank erosion index
Lt bank Ht: ~12 (ft) Bankfull Depth 5 (ft) Wetted Width:________(ft) Riffle/Run Depth 0.5 (ft)
Rt bank Ht: ~12 (ft) Bankfull Width 46 (ft)) TOB Width:________(ft) Pool Depth 5-8 (ft)

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

Reach Accessibility For Restoration

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

5 4 3 2 [✓ 1]

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

Place sketch of reach on back of page.

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

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

Unified Stream Assessment (USA)

REACH ID: Cypress Creek	**STREAM:** CC-1	**DATE/TIME:** 6/6/23 900	**INITIALS:** EN JT JL

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - Pool (circle)
☑ Riffle ______% ☑ Run ______% ☑ Pool ______% ☐ Steps ______%

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

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

Land use
☑ Forest 100 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

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

Riparian Buffer
Vegetation Type: ☑ Forest 85 % ☑ Shrub/Sapling 15 % ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations
Odors Noted:
☑ Normal/None ☐ Sewage ☐ Anaerobic
☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other____________

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

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

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Cypress Creek	**Date:** 6/6/23	**Initials:** ENJ JLC

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER 1	wypt left bank 490 ENJ d/s	[✓ L] M H VH EX (circle one)	36ft	1	Bank: Height 4 ft, Angle 95 Deg Protection: Roots 75 %, Root Depth 3.5 ft Vegetation 10 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 2	ENJ right bank wypt 491 d/s	[✓ L] M H VH EX (circle one)	48	1	Bank: Height 3.75 ft, Angle 85 Deg Protection: Roots 60 %, Root Depth 3.5 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 3	ENJ A bank wypt 492 u/s	[✓ L] [✓ M] H VH EX (circle one)	90	1	Bank: Height 3.5 ft, Angle 95 Deg Protection: Roots 70 %, Root Depth 3.5 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 4	JLC wpt 2499 d/s left bank	L [✓ M] H VH EX (circle one)	58ft	1	Bank: Height 5 ft, Angle 105 Deg Protection: Roots 45 %, Root Depth 45 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER	JLC wp 2489 right bank u/s	[✓ L] M H VH EX (circle one)	40	1	Bank: Height 3 ft, Angle 95 Deg Protection: Roots 45 %, Root Depth 3 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: Cypress
STREAM: CC-1
DATE/TIME: 6/6/23
INITIALS: ENJJLC
OTHER INFO:

Average Conditions (check applicable)

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

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

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

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

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

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

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

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

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

Channel Dimensions (facing downstream):
Lt bank Ht: 3.5 (ft) Bankfull Depth ________(ft) Wetted Width: 12 (ft) Riffle/Run Depth 0.5 (ft)
Rt bank Ht: 4 (ft) Bankfull Width 15 (ft)) TOB Width: 20 (ft) Pool Depth 2.5 (ft)

Channel Stability:
Lt Bank: Angle 85 degrees
LtBank Vegetation protection: 5 % cover
LtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Lt Bank Affected:________
Wpt(s):________
Rt Bank: Angle 85 degrees
RtBank Vegetation protection 5 % cover
RtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Rt Bank Affected:________
Wpt(s):________

Reach Accessibility For Restoration

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

5 4 3 [✓ 2] 1

Notes: (biggest problem(s) you see in survey reach)
Some bank erosion but looks pretty natural

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

Place sketch of reach on back of page.

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

Unified Stream Assessment (USA)

REACH ID: JLLgps

STREAM: Flat Creek

DATE/TIME: 6/5/23 1500

INITIALS: ENJJLC

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

Weather – Antecedent (24-h) Rain in past 72-h: y / n

☐Heavy rain ☐Steady rain ☐Showers ☑Clear/sunny
☐Mostly cloudy ☐Partly cloudy

Weather – Current conditions

☐Heavy rain ☐Steady rain ☐Showers ☑Clear/sunny
☐Mostly cloudy ☐Partly cloudy

Stream Classification

☑ Perennial ☐ Intermittent ☐ Ephemeral ☐ Tidal
☐ Coldwater ☐ Coolwater ☑ Warmwater Order_____

Stream Origin

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

Hydrology

Flow: ☐ High ☐ Moderate ☑ Low ☐ None

Base Flow as %Channel Width: ☑0-25% ☐50-75% ☐25-50% ☐75-100% **Flows Measured:** Yes / [✓ No]

Stream Gradient: ☐ High (≥25ft/mi) ☐ Moderate (10-24 ft/mi) ☑ Low (<10 ft/mi) ~Slope: ________ft/mi

Sinuosity: ☐ High ☐ Moderate ☑ Low

Channel Morphology **System:** Step/Pool - Riffle/Pool - Pool (circle)

☑ Riffle 5 % ☐ Run 10 % ☐ Pool 85 % ☐ Steps ______%

Dominant Substrate

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

Dominant In-Stream Habitats

☑Woody Debris ☑Root Wads ☐Leaf Packs
☐Deposition ☐Undercut Bank
☐Aquatic Plants ☐Overhanging Vegetation
Habitat Quality: ☑Poor ☐Fair ☐Good ☐ Optimal

Land use

☑ Forest >90% ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

Local Watershed NPS Pollution

☐ Industrial Storm Water
☐ Urban/Sub-Urban Storm Water ☐ Row crops
☐ Cattle ☑ Other local dumping ☐ No evidence

Riparian Buffer

Vegetation Type: ☑ Forest 60 % ☑ Shrub/Sapling 40 % ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations

Odors Noted:

☑ Normal/None ☐ Sewage ☐ Anaerobic
☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other____________

Water Surface Appearance:

☐ Slick ☑ Sheen ☐ Globs
☐ Flecks ☐ None ☐ Other___________

Turbidity/Water Clarity:

☐ Clear ☑ Slightly turbid ☐ Turbid
☐ Opaque ☑ Stained ☐ Other______________

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Flat Creek	**Date:**	**Initials:**

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
FC- 1)	wypt 2488 JLC	2,5	2	Lots of trash dumping

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER	None even low hazard	L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth _____ft Vegetation ______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth _____ft Vegetation ______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth _____ft Vegetation ______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth _____ft Vegetation ______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth _____ft Vegetation ______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: FC-1
STREAM: Flat
DATE/TIME:
INITIALS:
OTHER INFO:

Average Conditions (check applicable)

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

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

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

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

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

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

Reach Impacts: (circle impact level 1=minor, 2=moderate, 3=major, and tag with a GPS waypoint(s) (Wpt) ID)
☐ Outfalls(OT): 1 2 3 Wpt________
☐ Stream Crossing(SC): 1 2 3 Wpt________
☐ Bank Erosion(ER): 1 2 3 Wpt________
☐ Channel Modification(CM): 1 2 3 Wpt________
☐ Impacted Buffers(IB): 1 2 3 Wpt________
☑ Trash(TR): 1 2 [✓ 3] Wpt 2478-3L
☐ Utilities(UT): 1 2 3 Wpt________
☐ Other________: 1 2 3 Wpt________
Notes:

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

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

Channel Dimensions (facing downstream):
Lt bank Ht: 5 (ft) Bankfull Depth 2.5 (ft) Wetted Width: 10-15 (ft) Riffle/Run Depth 0.5 (ft)
Rt bank Ht: 5 (ft) Bankfull Width 20 (ft)) TOB Width: 30 (ft) Pool Depth 1.5 (ft)

Channel Stability:
Lt Bank: Angle 130 degrees
LtBank Vegetation protection: 45 % cover
LtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Lt Bank Affected:________
Wpt(s):________
Rt Bank: Angle ~~70~~ 120 degrees
RtBank Vegetation protection 50 % cover
RtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Rt Bank Affected:________
Wpt(s):________

Reach Accessibility For Restoration

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

5 4 [✓ 3] 2 1

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

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

Place sketch of reach on back of page.

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

Unified Stream Assessment (USA)

REACH ID: Gum Creek	**STREAM:** GC 1	**DATE/TIME:** 6/6/23 1230	**INITIALS:** JLC

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - Pool (circle)
☐ Riffle ______% ☒ Run ______% ☒ Pool ______% ☐ Steps ______%

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

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

Land use
☒ Forest 100 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

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

Riparian Buffer
Vegetation Type: ☒ Forest 80 % ☒ Shrub/Sapling 10 % ☒ Herbs/Grasses 10 % ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations

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

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

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

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Gum Creek	**Date:** 6/6/23	**Initials:** JLC

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER 1	WP: 2491 -Left bank (Up.S.) JLC	[✓ L] M H VH EX (circle one)	63	1	Bank: Height 3 ft, Angle 120 Deg Protection: Roots 15 %, Root Depth 2 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 2	WP: 2492 -Left bank (Up.S.) JLC	[✓ L] M H VH EX (circle one)	180	1	Bank: Height 3.5 ft, Angle 95 Deg Protection: Roots 60 %, Root Depth 2.5 ft Vegetation 25 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 3	WP: 2493 -Left bank (Down.S.) JLC	[✓ L] M H VH EX (circle one)	60ft	1	Bank: Height 3 ft, Angle 95 Deg Protection: Roots 60 %, Root Depth 2 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 4	WP: 2494 -Left bank (UP.S.) JLC	[✓ L] M H VH EX (circle one)	40ft	1	Bank: Height 3 ft, Angle 95 Deg Protection: Roots 50 %, Root Depth 2 ft Vegetation 15 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 5	WP: 2495 -Left bank (UP.S.) JLC	[✓ L] M H VH EX (circle one)	80 ft	1	Bank: Height 2.5 ft, Angle 110 Deg Protection: Roots 30 %, Root Depth 1.5 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: Gum Creek
STREAM: GC1
DATE/TIME: 6/6/23 1230
INITIALS: JLC
OTHER INFO:

Average Conditions (check applicable)

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

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

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

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

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

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

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

Notes:

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

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

Channel Dimensions (facing downstream):
Lt bank Ht: 3 (ft) Bankfull Depth ________(ft) Wetted Width: 12 (ft) Riffle/Run Depth________(ft)
Rt bank Ht: 3.5 (ft) Bankfull Width 25 (ft)) TOB Width: 30 (ft) Pool Depth 3 (ft)

Channel Stability:
Lt Bank: Angle 95 degrees
LtBank Vegetation protection: 5 % cover
LtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Lt Bank Affected:________________
Wpt(s):________________
Rt Bank: Angle 115 degrees
RtBank Vegetation protection 5 % cover
RtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Rt Bank Affected:________________
Wpt(s):________________

Reach Accessibility For Restoration

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

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

Place sketch of reach on back of page.

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

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

Unified Stream Assessment (USA)

REACH ID: Holmes Creek
STREAM:
DATE/TIME: 6/8/23
INITIALS: ENJ/JLC

REACH START
LAT:
LONG:

REACH END
LAT:
LONG:

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - Pool (circle)
☑ Riffle 10 % ☐ Run _____% ☑ Pool 90 % ☐ Steps _____%

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

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

Land use
☑ Forest 100 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

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

Riparian Buffer
Vegetation Type: ☑ Forest 100 % ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations

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

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

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

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

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

V 1.4 October 2011

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Holmes Creek	**Date:** 6/8/23	**Initials:** JLC/ENJ

Impact I.D.[1]	Coordinates (Lat / Long) or ~~Waypoint~~	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
1	2516	1	1	Oil seep

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER 1	WP: 2513 Left - Up Stream JLC	[✓ L] M H VH EX (circle one)	210	1	Bank: Height 3 ft, Angle 110 Deg Protection: Roots 50 %, Root Depth 3 ft Vegetation 10 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 2	WP: 2514 Right - Down Stream	L M H VH EX (circle one)	129	1	Bank: Height 5 ft, Angle 105 Deg Protection: Roots 80 %, Root Depth 4 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 3	WP: 2515 Left bank Down-Stream	[✓ L] M H VH EX (circle one)	90	1	Bank: Height 4 ft, Angle 100 Deg Protection: Roots 35 %, Root Depth 2 ft Vegetation 40 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ____ft, Angle ____Deg Protection: Roots____%, Root Depth ____ft Vegetation ____% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ____ft, Angle ____Deg Protection: Roots____%, Root Depth ____ft Vegetation ____% [4]Material: Silt/Clay Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: Holmes Creek **STREAM:**
DATE/TIME: 6/8/23
INITIALS:
OTHER INFO:

Average Conditions (check applicable)

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

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

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

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

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

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

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

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

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

Channel Dimensions (facing downstream):
Lt bank Ht: 3.5 (ft) Bankfull Depth 4.5 (ft) Wetted Width: 45 (ft) Riffle/Run Depth <0.5 (ft)
Rt bank Ht: 4 (ft) Bankfull Width 55 (ft)) TOB Width: 65 (ft) Pool Depth 1.5 (ft)

Channel Stability:
Lt Bank: Angle 110 degrees
LtBank Vegetation protection: 10 % cover
LtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Lt Bank Affected:________
Wpt(s):________

Rt Bank: Angle 105 degrees
RtBank Vegetation protection 5 % cover
RtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Rt Bank Affected:________
Wpt(s):________

Reach Accessibility For Restoration

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

5 4 3 2 [✓ 1]

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

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

Place sketch of reach on back of page.

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

Unified Stream Assessment (USA)

REACH ID: Locust Lloyd Bayou	**STREAM:**	**DATE/TIME:** 6/7/22	**INITIALS:** ENJ / JLC

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - Pool (circle)
☑ Riffle 7 % ☑ Run 3 % ☑ Pool 90 % ☐ Steps ______%

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

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

Land use
☑ Forest 100 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

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

Riparian Buffer
Vegetation Type: ☑ Forest 100 % ☐ 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) ☐ Unshared (<25% coverage)

Water Quality Observations

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

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

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

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Locust Bayou	**Date:** 6/7/23	**Initials:** EMJ/JLC

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
1	WP:2504	1	1	Appears to be a crossing area; Stream crossing
2	WP:2505	2	1	Cypress tress cut and left inhibiting stream channel.

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER 1	JLC WP:2504 Left - Down S.	[✓ L] M H VH EX (circle one)	30	1	Bank: Height 3.5 ft, Angle 110 Deg Protection: Roots 75 %, Root Depth 3.5 ft Vegetation 10 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 2	JLC WP:2504 Right - Down S.	[✓ L] M H VH EX (circle one)	78	1	Bank: Height 4.5 ft, Angle 100 Deg Protection: Roots 70 %, Root Depth 4.5 ft Vegetation 10 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 3	JLC WP:2506 Left - Upstream	[✓ L] M H VH EX (circle one)	108	1	Bank: Height 4.5 ft, Angle 110 Deg Protection: Roots 70 %, Root Depth 4 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 4	JLC Left - Down. WP:2507	L [✓ M] H VH EX (circle one)	60	1	Bank: Height 6 ft, Angle 65 Deg Protection: Roots 40 %, Root Depth 5 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 5	JL Left- WP:2508	L [✓ M] H VH EX (circle one)	60	1	Bank: Height 5 ft, Angle 60 Deg Protection: Roots 70 %, Root Depth 5 ft Vegetation 5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____

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

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

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

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

1

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

Locust

[redacted] USA, Cont.

REACH ID: [redacted] Creek
STREAM: LC-1
DATE/TIME: 6/7/23
INITIALS: ENJ / JLC
OTHER INFO:

Average Conditions (check applicable)

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

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

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

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

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

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

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

Notes:

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

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

Channel Dimensions (facing downstream):
Lt bank Ht: 4.5 (ft) Bankfull Depth 5-5.5 (ft) Wetted Width: 40 (ft) Riffle/Run Depth <0.5 (ft)
Rt bank Ht: 4 (ft) Bankfull Width 50 (ft)) TOB Width: 40 (ft) Pool Depth 1.5 (ft)

Channel Stability:
Lt Bank: Angle 40 degrees
LtBank Vegetation protection 10 % cover
LtBank Erosion Hazard: L [✓ M] H VH EX (circle one)
Length Lt Bank Affected:________
Wpt(s):________
Rt Bank: Angle 95 degrees
RtBank Vegetation protection 5 % cover
RtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Rt Bank Affected:________
Wpt(s):________

Reach Accessibility For Restoration

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

5 4 3 2 [✓ 1]

Notes: (biggest problem(s) you see in survey reach)
Looks like clearing is occuring within the watershed
Lots of down trees & remenants of trees

Place sketch of reach on back of page.

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

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

Unified Stream Assessment (USA)

REACH ID: Lloyd Creek	**STREAM:** LC-1	**DATE/TIME:** 6/7/23	**INITIALS:** ENJ/JLC

REACH START JLC wypt	**REACH END**
LAT: "	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - Pool (circle)
☑ Riffle 2 % ☑ Run 3 % ☑ Pool 95 % ☐ Steps ______%

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

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

Land use
☑ Forest 100 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

Local Watershed NPS Pollution
☐ Industrial Storm Water
☐ Urban/Sub-Urban Storm Water ☐ Row crops
☐ Cattle ☑ Other pond outfall ☐ No evidence

Riparian Buffer
Vegetation Type: ☑ Forest 100 % ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations

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

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

Turbidity/Water Clarity:
☐ Clear ☑ Slightly turbid ☐ Turbid
☐ Opaque ☑ Stained ☐ Other________________

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Lloyd Creek	**Date:** 6/7/23	**Initials:** JLC

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
	wypt 2502	1	1	Outfall from Pond that is on the western side of Lloyd Creek

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	R/L* Bank information for BEHI Right/left
ER 1	WP: 2497 Both banks Up.St. / JLC	[✓ L] M H VH EX (circle one)	105 ft.	1	Bank: Height 4/3* ft, Angle 95/125 Deg Protection: Roots 75/40*%, Root Depth 4/1* ft Vegetation 10/5*% [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 2	WP: 2498 Left B (Up.St.) JLC	~~L~~ [✓ M] H VH EX (circle one)	120	1	Bank: Height 3.5 ft, Angle 80 Deg Protection: Roots 80 %, Root Depth 3.5 ft Vegetation 15 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 3	WP: 2499 Right (Up.St)	[✓ L] M H VH EX (circle one)	150	1	Bank: Height 3.5 ft, Angle 90 Deg Protection: Roots 90 %, Root Depth 3.5 ft Vegetation 10 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 4	WP: 2500 LB & R* (Up.St) JLC	[✓ L] M H VH EX (circle one)	150	1	Bank: Height 3.5/3* ft, Angle 120/90* Deg Protection: Roots 50/60%, Root Depth 3.5/3* ft Vegetation 15/10*% [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER 5	WYPT 2501-2502-JLC 3 Both	[✓ L] M H VH EX (circle one)	See 5[illegible]	1	Bank: Height 3 ft, Angle 100 Deg Protection: Roots 65 %, Root Depth 3 ft Vegetation 10 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: Lloyd Creek	STREAM:	DATE/TIME: 6/7/23	INITIALS: JLC/ENS
OTHER INFO:			

Average Conditions (check applicable)

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

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

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

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

Aquatic Life Observed:
☑ Fish ☑ Snails ☑ Crawfish ☑ Macroinvertebrates

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

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

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

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

Channel Dimensions (facing downstream):
Lt bank Ht: 3 (ft) Bankfull Depth ~2 (ft) Wetted Width: 15 (ft) Riffle/Run Depth <0.5 (ft)
Rt bank Ht: 3.5 (ft) Bankfull Width 20 (ft)) TOB Width: 22 (ft) Pool Depth 2 (ft)

Channel Stability:
Lt Bank: Angle 90 degrees
LtBank Vegetation protection: 10 % cover
LtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Lt Bank Affected: See GPS
Wpt(s):________
Rt Bank: Angle 100 degrees
RtBank Vegetation protection 10 % cover
RtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Rt Bank Affected:________
Wpt(s): See JLC GPS

Reach Accessibility For Restoration

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

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

sediment deposits have created several bars + disconnected Pools in <2 week

Place sketch of reach on back of page.

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

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

Unified Stream Assessment (USA)

REACH ID: Two Bayou 0	**STREAM:** TB0-1	**DATE/TIME:** 6/7/23	**INITIALS:** ENT/RL

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - Pool (circle)
☐ Riffle ______% ☑ Run 5 % ☑ Pool 95 % ☐ Steps ______%

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

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

Land use
☑ Forest 100 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

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

Riparian Buffer
Vegetation Type: ☑ Forest 100 % ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations

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

Water Surface Appearance:
☐ Slick ☐ Sheen ☐ Globs
☐ Flecks ☑ None ☐ Other____________

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

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: two bayou	**Date:**	**Initials:**

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
1	2512	1	1	Homemade boat ramp

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER 1	WP: 2512 Right/DS. JLC	L M H VH EX (circle one)	50	1	Bank: Height 7 ft, Angle 95 Deg Protection: Roots 50 %, Root Depth 2 ft Vegetation 40 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: Two Bayou
STREAM:
DATE/TIME: 6/7/23
INITIALS:
OTHER INFO:

Average Conditions (check applicable)

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

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

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

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

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

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

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

Notes:

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

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

Channel Dimensions (facing downstream):
Lt bank Ht: 3.5 (ft)
Rt bank Ht: 9 (ft)
Bankfull Depth 4.5 (ft)
Bankfull Width 55 (ft))
Wetted Width: 30 (ft)
TOB Width: 60 (ft)
Riffle/Run Depth N/A (ft)
Pool Depth (ft)

Channel Stability:
Lt Bank: Angle 125 degrees
LtBank Vegetation protection: 40 % cover
LtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Lt Bank Affected:
Wpt(s):

Rt Bank: Angle 130 degrees
RtBank Vegetation protection 35 % cover
RtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Rt Bank Affected:
Wpt(s):

Reach Accessibility For Restoration

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

5 4 3 2 1

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

Place sketch of reach on back of page.

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

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

Unified Stream Assessment (USA)

REACH ID: Two Bayou 2	**STREAM:**	**DATE/TIME:** 6/7/23	**INITIALS:** EN / JLC

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - Pool (circle)
☐ Riffle ______% ☑ Run 15 % ☑ Pool 75 % ☐ Steps ______%

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

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

Land use
☑ Forest 100 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

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

Riparian Buffer
Vegetation Type: ☑ Forest 100 % ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations

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

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

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

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream:	Date:	Initials:

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
1	2509	1	1	Outfall

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER 1	Right - down Stream 2510 JC	[✓ L] M H VH EX (circle one)	132	1	Bank: Height 10 ft, Angle 110 Deg Protection: Roots 40 %, Root Depth 4 ft Vegetation <5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: Two Bayou 2	STREAM:	DATE/TIME: 6/7/23	INITIALS:
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

Periphyton (attached algae):

Filamentous: ☐ None ☑ Sparse ☐ Moderate ☐ Abundant

Prostrate: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant

Floating: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant

Suspended Algae (phytoplankton) abundance:

☐ None noticeable (water basically clear)

☐ Moderate (water slightly green tinted)

☐ Abundant (water appears green)

Aquatic Plants In Stream:

Submerged: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant

Emergent: ☐ None ☑ Sparse ☐ Moderate ☐ Abundant

Floating: ☐ None ☑ Sparse ☐ Moderate ☐ Abundant

Aquatic Life Observed:

☑ Fish ☐ Snails ☐ Crawfish ☑ Macroinvertebrates

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

☐ Cattle ☐ Beaver ☑ Deer ☐ Other____________

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

☑ Outfalls(OT): [✓ 1] 2 3 Wpt________

☐ Stream Crossing(SC): 1 2 3 Wpt________

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

☐ Channel Modification(CM): 1 2 3 Wpt________

☐ Impacted Buffers(IB): 1 2 3 Wpt________

☐ Trash(TR): 1 2 3 Wpt________

☐ Utilities(UT): 1 2 3 Wpt________

☐ Other____________: 1 2 3 Wpt________

Notes:

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

Channel Dynamics:

☐ Incised (degrading) ☐ Channelized ☐ Bed Scour ☐ Sediment Deposition

☐ Widening ☐ Aggrading ☐ Bank Failure ☐ Culvert Scour (upstream / downstream / top)

☐ Headcutting ☐ Bank scour ☐ Slope failure ☑ None (natural stabile channel)

Channel Dimensions (facing downstream):

Lt bank Ht: 8 (ft) Bankfull Depth 5 (ft) Wetted Width: 35 (ft) Riffle/Run Depth N/A (ft)

Rt bank Ht: 10 (ft) Bankfull Width 50 (ft)) TOB Width: 60 (ft) Pool Depth ________(ft)

Channel Stability:

Lt Bank: Angle 130 degrees

LtBank Vegetation protection: 40 % cover

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

Length Lt Bank Affected:____________

Wpt(s):____________

Rt Bank: Angle 170 degrees

RtBank Vegetation protection 35 % cover

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

Length Rt Bank Affected:____________

Wpt(s):____________

Reach Accessibility For Restoration

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

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

Place sketch of reach on back of page.

Restoration Potential:

☐ Riparian reforestation ☐ Bank stabilization

☐ Stormwater retrofit ☐ Outfall stabilization

☐ Channel modification ☐ PS investigation

☐ Culvert rehab. ☐ Other____________

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

Unified Stream Assessment (USA)

REACH ID: Salt Creek	**STREAM:**	**DATE/TIME:** 6/5/23	**INITIALS:** 1530

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - [✓ Pool] (circle)
☐ Riffle ______% ☑ Run 10 % ☑ Pool 90 % ☐ Steps ______%

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

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

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

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

Riparian Buffer
Vegetation Type: ☐ Forest ____% ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations
Odors Noted:
☑ Normal/None ☐ Sewage ☐ Anaerobic
☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other____________

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

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

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

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

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USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Salt	**Date:**	**Initials:**

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
None				

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI
ER	None	L M H VH EX (circle one)			Bank: Height _________ft, Angle _________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height _________ft, Angle _________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height _________ft, Angle _________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height _________ft, Angle _________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height _________ft, Angle _________Deg Protection: Roots_______%, Root Depth ______ft Vegetation _______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: Salt Creek
STREAM: SC-1
DATE/TIME: 6/6/23
5
INITIALS: ENJ/JLC
OTHER INFO:

Average Conditions (check applicable)

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

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

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

Aquatic Plants In Stream:
Submerged: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant
Emergent: ☐ None ☐ Sparse ☐ Moderate ☑ Abundant – all grasses along both banks
Floating: ☑ None ☐ Sparse ☐ Moderate ☐ Abundant

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

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

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

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

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

Channel Dimensions (facing downstream):
Lt bank Ht: 0.5 (ft) Bankfull Depth 2.5 (ft) Wetted Width: 12 (ft) Riffle/Run Depth N/A (ft)
Rt bank Ht: 0.5 (ft) Bankfull Width 15 (ft)) TOB Width: 17 (ft) Pool Depth 1-3ft (ft)

Channel Stability:
Lt Bank: Angle even w/ water 90 degrees
LtBank Vegetation protection: 95 % cover
LtBank Erosion Hazard: L M H VH EX (circle one)
Length Lt Bank Affected: 0
Wpt(s):__________

Rt Bank: Angle 90 0.5 ft degrees
RtBank Vegetation protection 0 95 % cover
RtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Rt Bank Affected:__________
Wpt(s):__________

Reach Accessibility For Restoration

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

5 4 3 2 1

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

looks really natural

Place sketch of reach on back of page.

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

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

Unified Stream Assessment (USA)

REACH ID: SC-1	**STREAM:** Sloan Creek	**DATE/TIME:** 6/6/23	**INITIALS:** ENJ/JLC

REACH START	**REACH END**
LAT:	**LAT:**
LONG:	**LONG:**

Average Conditions (check applicable)

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

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

Stream Classification
☑ Perennial ☑ Intermittent ☐ Ephemeral ☐ Tidal
☐ Coldwater ☐ Coolwater ☐ Warmwater Order______

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

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

Channel Morphology **System:** Step/Pool - Riffle/Pool - Pool (circle)
☑ Riffle 10 % ☑ Run 10 % ☑ Pool 80 % ☐ Steps ______%

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

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

Land use
☑ Forest 100 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ Industrial_____% ☐ Sub-Urban____%

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

Riparian Buffer
Vegetation Type: ☑ Forest 100 % ☐ 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) ☐Unshared (<25% coverage)

Water Quality Observations

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

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

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

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Sloan	**Date:** 6/6/23	**Initials:** ENJ/JLC

Impact I.D.[1]	**Coordinates (Lat / Long) or Waypoint**	**Severity (1-3)**[2]	**Restoration Opportunity (1-3)**[3]	**Description**

BEHI I.D.	**Coordinates (Lat / Long) or Waypoint**	**Bank Erosion Hazard**	**Bank Lth. (ft)**	**Rest. Opp. (1-3)**[3]	**Bank information for BEHI**
ER	Whole reach JLC gps	L [✓ M] H VH EX (circle one)		2	Bank: Height 6-7 ft, Angle 85-95 Deg Protection: Roots 30-40 %, Root Depth 2 ft Vegetation 15 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth ______ft Vegetation ______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth ______ft Vegetation ______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth ______ft Vegetation ______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____
ER		L M H VH EX (circle one)			Bank: Height ________ft, Angle ________Deg Protection: Roots______%, Root Depth ______ft Vegetation ______% [4]Material: Silt/Clay Sand / Gravel Cobble - %____

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

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

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

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

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

USA, Cont.

REACH ID: Sloan
STREAM: SC-1
DATE/TIME: 6/6/23 1315
INITIALS: ENT/JLC
OTHER INFO:

Average Conditions (check applicable)

Flood Plain Dynamics
Connection: ☑ Poor ☐ Fair ☐ Good
Habitat: ☐ Poor ☑ Fair ☐ Good

Vegetation: ☑ Forest ☐ Shrub/Sapling ☑ Tall grasses ☑ Turf/crops
Encroachment: ☐ Poor ☐ Fair ☑ Good

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

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

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

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

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

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

Notes:

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

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

Channel Dimensions (facing downstream):
Lt bank Ht: 6 (ft) Bankfull Depth 3.5 (ft) Wetted Width: 20 (ft) Riffle/Run Depth 0.5 (ft)
Rt bank Ht: 6.5 (ft) Bankfull Width 40 (ft)) TOB Width: 45 (ft) Pool Depth 1.5 (ft)

Channel Stability:
Lt Bank: Angle 115 degrees
LtBank Vegetation protection: 20 % cover
LtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Lt Bank Affected:__________
Wpt(s):__________

Rt Bank: Angle 110 degrees
RtBank Vegetation protection 15 % cover
RtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Rt Bank Affected:__________
Wpt(s):__________

Reach Accessibility For Restoration

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

5 4 3 [✓ 2] 1

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

lots of bank erosion

too much water?

Place sketch of reach on back of page.

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

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

0

Unified Stream Assessment (USA)

REACH ID: SmackOver
STREAM:
DATE/TIME: 6/8/23
INITIALS: ENT/JLC

REACH START
LAT:
LONG:

REACH END
LAT:
LONG:

Average Conditions (check applicable)

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

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

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

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

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

Channel Morphology
System: Step/Pool - Riffle/Pool - Pool (circle)
☐ Riffle ______% ☑ Run 15 % ☑ Pool 85 % ☐ Steps ______%

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

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

Land use
☐ Forest 50 % ☐ Pasture _____% ☐ Urban _____%
☐ Commercial_____% ☐ Row Crops _____%
☐ Hay_____% ☐ ~~Industrial~~ 50 % ☐ Sub-Urban____%
oil field

Local Watershed NPS Pollution
☐ Industrial Storm Water
☐ Urban/Sub-Urban Storm Water ☐ Row crops
☐ Cattle ☑ Other oil feld ☐ No evidence

Riparian Buffer
Vegetation Type: ☑ Forest 15 % ☑ Shrub/Sapling 15 % ☐ 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) ☑Unshared (<25% coverage)

Water Quality Observations

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

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

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

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

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

USA Reach Impact Data Detail Sheet (optional)

Reach ID/Stream: Smashovers Creek	**Date:** 6/8/23	**Initials:** JLC / ENJ

Impact I.D.[1]	Coordinates (Lat / Long) or Waypoint	Severity (1-3)[2]	Restoration Opportunity (1-3)[3]	Description
1	2519	1	1	Dried Oil remnants

BEHI I.D.	Coordinates (Lat / Long) or Waypoint	Bank Erosion Hazard	Bank Lth. (ft)	Rest. Opp. (1-3)[3]	Bank information for BEHI L/R
ER 1	2517 JLC Upstream - Right & Left	[✓ L] M H VH EX (circle one)	51	1	Bank: Height 8/10 ft, Angle 95/90 Deg Protection: Roots 20/30 %, Root Depth 2/4 ft Vegetation 15 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %
ER 2	2518 JLC Upstream - Left & Right	[✓ L] M H VH EX (circle one)	111	1	Bank: Height 15/13 ft, Angle 100 Deg Protection: Roots 30/15 %, Root Depth 6/6 ft Vegetation 30 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %
ER 3	2520 JLC Upstream - L+R	[✓ L] M H VH EX (circle one)	135	1	Bank: Height 13/12 ft, Angle 95/105 Deg Protection: Roots 40/60 %, Root Depth 4/6 ft Vegetation 15/5 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %
ER 4	2521 JLC Downstream - L+R	[✓ L] M H VH EX (circle one)	267	1	Bank: Height 12/1.5 ft, Angle 110/120 Deg Protection: Roots 10/30 %, Root Depth 1/4 ft Vegetation 5/10 % [4]Material: [✓ Silt/Clay] Sand / Gravel Cobble - %
ER		L M H VH EX (circle one)			Bank: Height ____ ft, Angle ____ Deg Protection: Roots ____ %, Root Depth ____ ft Vegetation ____ % [4]Material: Silt/Clay Sand / Gravel Cobble - % ____

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

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

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

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

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

USA, Cont.

REACH ID: Smackover Creek	**STREAM:**	**DATE/TIME:** 6/8/23	**INITIALS:**
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

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

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

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

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

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

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

Notes:

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

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

Channel Dimensions (facing downstream):
Lt bank Ht: 13 (ft) Bankfull Depth ? (ft) Wetted Width: 40 (ft) Riffle/Run Depth ____(ft)
Rt bank Ht: 10 (ft) Bankfull Width 40 (ft)) TOB Width: ~~40~~ 70 (ft) Pool Depth ____(ft)

Channel Stability:
Lt Bank: Angle 100 degrees
LtBank Vegetation protection: 75 % cover
LtBank Erosion Hazard: [✓ L] M H VH EX (circle one)
Length Lt Bank Affected:____________
Wpt(s):____________

Rt Bank: Angle 110 degrees
RtBank Vegetation protection 35 % cover
RtBank Erosion Hazard: L [✓ M] H VH EX (circle one)
Length Rt Bank Affected:____________
Wpt(s):____________

Reach Accessibility For Restoration

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

5 4 3 2 1

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

Seeping oil

Place sketch of reach on back of page.

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

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

Appendix B

WQ Data and Substation Identification

HUC12	Name	ToHUC	PolygonID	WSNO	Subbasin
80402010101	Fife Creek-Moro Creek	80402010103	0	0	1
80402010102	Bryant Creek	80402010103	1	1	2
80402010103	Pickett Creek-Moro Creek	80402010104	2	2	3
80402010104	Guice Creek-Moro Creek	80402010105	3	3	4
80402010105	Cooke Creek-Moro Creek	80402010106	4	4	5
80402010106	Caney Creek-Moro Creek	80402010107	5	5	6
80402010107	Smith Creek-Caney Creek	80402010202	6	6	7
80402010201	White Water Creek	80402010202	7	7	8
80402010202	Clear Creek-Caney Creek	80402010203	8	8	9
80402010203	Jacks Creek-Caney Creek	80402010204	9	9	10
80402010204	Wahl Branch-Caney Creek	80402010207	10	10	11
80402010205	Headwaters Lloyd Creek	80402010206	11	11	12
80402010206	Outlet Lloyd Creek	80402010207	12	12	13
80402010207	Wolf Branch	80402010208	13	13	14
80402010208	La Baum Creek	80402010803	14	14	15
80402010301	Mill Creek-Smackover Creek	80402010306	15	15	16
80402010302	Cypress Creek-Gum Creek	80402010305	16	16	17
80402010303	Sloan Creek	80402010306	17	17	18
80402010304	Cypress Creek-Smackover Creek	80402010306	18	18	19
80402010305	Gum Creek	80402010306	19	19	20
80402010306	Holly Creek-Smackover Creek	80402010402	20	20	21
80402010401	Beech Creek-Smackover Creek	80402010402	21	21	22
80402010402	Holcomb Creek	80402010404	22	22	23
80402010403	Sandy Creek	80402010404	23	23	24
80402010404	Brushy Creek-Smackover Creek	80402010406	24	24	25
80402010405	Holmes Creek	80402010406	25	25	26
80402010406	Wolf Creek-Smackover Creek	80402010409	26	26	27
80402010407	Haynes Creek	80402010408	27	27	28
80402010408	Salt Creek	80402010409	28	28	29
80402010409	Haynes Creek-Smackover Creek	80402010707	29	29	30
80402010501	South Bayou	80402010502	30	30	31
80402010502	North Bayou	80402010503	31	31	32
80402010503	Mill Creek-Two Bayou	80402010706	32	32	33
80402010601	Lost Creek-Champagnolle Creek	80402010602	33	33	34
80402010602	Taylor Creek-Champagnolle Creek	80402010605	34	34	35
80402010603	Black Lake	80402010605	35	35	36
80402010604	Dry Branch-Champagnolle Creek	80402010605	36	36	37
80402010605	Dunn Creek-Champagnolle Creek	80402010707	37	37	38
80402010701	Little Two Bayou-Two Bayou	80402010702	38	38	39
80402010702	Dogwood Creek-Two Bayou	80402010706	39	39	40
80402010703	Cordell Creek-Caney Creek	80402010704	40	40	41
80402010704	Locust Bayou	80402010706	41	41	42
80402010705	Blackwater Creek	80402010707	42	42	43
80402010706	Doris Creek-Ouachita River	80402010707	43	43	44
80402010707	Champagnolle Creek-Ouachita River	80402010803	44	44	45
80402010801	Amason Creek-Ouachita Creek	80402010803	45	45	46
80402010802	Mill Creek-Ouachita River	80402010803	46	46	47
80402010803	Crooked Creek-Ouachita River	80402020202	47	47	48

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
9/8/2020	7.0	38.6102	HC	0.06	0.90	0.06	10.6	8.0	2.70	205.20	0.17	1.07
8/1/2018	0.0	43.2434	SC	0.04	0.82	0.03	10.6	8.0	3.40	201.30	0.02	0.82
1/30/2018	1.8	43.2434	SC	0.05	0.85	0.02	2.8	5.0	9.80	197.40	0.02	0.85
7/18/2018	0.0	43.2434	SC	0.04	0.62	0.04	4.3	1.0	4.00	197.30	0.02	0.62
7/25/2018	0.0	43.2434	SC	0.05	0.69	0.03	6.3	5.0	2.40	195.20	0.02	0.69
8/8/2018	0.0	43.2434	SC	0.05	0.91	0.03	7.7	7.0	4.40	195.10	0.02	0.91
7/5/2018	0.0	43.2434	SC	0.04	0.65	0.03	5.8	3.0	3.40	193.70	0.02	0.65
6/27/2018	0.0	43.2434	SC	0.02	0.51	0.02	4.8	6.0	2.50	191.50	0.02	0.51
1/8/2020	3.9	43.2434	SC	0.07	0.96	0.03	5.2	4.0	3.60	187.60	0.02	0.96
8/22/2018	0.0	43.2434	SC	0.03	0.71	0.06	6.0	5.0	3.70	187.60	0.02	0.71
7/11/2018	0.0	43.2434	SC	0.04	0.63	0.03	6.1	5.0	5.80	187.00	0.02	0.63
8/15/2018	0.0	43.2434	SC	0.02	0.63	0.02	4.7	5.0	3.70	180.10	0.02	0.63
12/13/2017	0.0	43.2434	SC	0.05	0.72	0.08	5.5	6.0	4.00	178.40	0.03	0.75
9/15/2020	4.5	38.6102	HC	0.05	0.71	0.05	10.8	8.0	2.60	175.60	0.03	0.74
6/28/2017	4.7	43.2434	SC	0.04	0.93	0.04	4.3	8.0	3.40	172.00	0.02	0.93
12/18/2019	5.4	43.2434	SC	0.05	0.79	0.02	4.4	7.0	5.50	171.80	0.02	0.79
9/22/2020	13.8	38.6102	HC	0.05	0.60	0.04	18.0	24.0	2.30	171.20	0.25	0.85
9/5/2018	0.0	43.2434	SC	0.03	0.79	0.09	6.3	4.0	3.70	166.60	0.02	0.81
3/28/2018	7.9	43.2434	SC	0.07	0.81	0.02	12.8	14.0	3.00	165.50	0.02	0.81
12/4/2019	4.2	43.2434	SC	0.05	0.90	0.02	4.7	8.0	6.30	163.40	0.02	0.90
1/2/2020	6.2	43.2434	SC	0.08	1.29	0.02	5.2	8.0	3.70	162.60	0.02	1.29
11/14/2018	7.7	43.2434	SC	0.03	0.90	0.03	5.1	6.0	5.40	162.40	0.02	0.90
9/19/2018	0.0	43.2434	SC	0.04	0.71	0.06	5.7	4.0	5.00	159.60	0.02	0.71
12/11/2019	7.0	43.2434	SC	0.05	1.33	0.03	4.5	7.0	5.30	159.00	0.02	1.33
11/28/2018	6.8	43.2434	SC	0.03	0.87	0.04	4.2	3.0	5.30	157.80	0.02	0.87
1/24/2018	5.1	43.2434	SC	0.05	0.89	0.02	3.5	5.0	8.70	157.20	0.02	0.89
3/29/2017	5.2	43.2434	SC	0.06	1.04	0.04	3.0	4.0	3.40	156.90	0.02	1.04
9/13/2017	4.7	43.2434	SC	0.05	0.79	0.04	12.5	8.0	4.20	156.40	0.02	0.79
3/22/2017	5.0	43.2434	SC	0.05	0.81	0.02	2.6	3.0	4.10	156.30	0.02	0.81
12/5/2018	7.2	43.2434	SC	0.04	0.84	0.06	3.7	4.0	9.80	156.00	0.02	0.84
9/12/2018	0.0	43.2434	SC	0.05	0.95	0.13	11.1	7.0	4.80	155.00	0.02	0.95
10/10/2018	3.5	43.2434	SC	0.04	0.77	0.02	3.7	6.0	8.30	154.60	0.02	0.77
8/23/2017	3.8	43.2434	SC	0.05	0.92	0.04	4.0	7.0	2.70	153.50	0.02	0.92
9/27/2017	2.8	43.2434	SC	0.05	0.93	0.06	5.1	5.0	3.90	153.00	0.02	0.93
11/29/2017	0.0	43.2434	SC	0.03	0.70	0.08	5.4	5.0	4.10	153.00	0.02	0.70
11/25/2019	3.5	43.2434	SC	0.06	0.98	0.02	4.9	8.0	7.50	152.60	0.02	0.98
10/4/2017	1.6	43.2434	SC	0.04	0.77	0.05	5.0	6.0	3.80	152.60	0.02	0.77
10/25/2017	0.0	43.2434	SC	0.04	0.83	0.05	20.0	8.0	2.60	152.30	0.02	0.83
11/13/2019	3.0	43.2434	SC	0.05	0.90	0.03	6.9	7.0	8.50	151.20	0.02	0.90
11/6/2019	2.5	43.2434	SC	0.06	1.07	0.02	6.4	7.0	9.10	150.60	0.02	1.07
3/15/2017	5.2	43.2434	SC	0.07	0.91	0.05	8.7	10.0	4.70	150.10	0.02	0.91
10/8/2019	8.9	38.6102	HC	0.05	0.60	0.04	9.7	5.0	8.30	149.40	0.23	0.83
12/6/2017	0.0	43.2434	SC	0.03	0.75	0.08	5.6	5.0	0.00	148.60	0.02	0.77
11/20/2018	7.1	43.2434	SC	0.03	0.96	0.05	5.0	2.0	5.40	148.40	0.02	0.96
10/17/2018	3.8	43.2434	SC	0.05	0.78	0.08	5.4	7.0	7.60	147.40	0.02	0.78
9/20/2017	3.8	43.2434	SC	0.03	0.77	0.05	2.4	2.0	3.90	147.40	0.02	0.77
11/20/2019	2.3	43.2434	SC	0.05	0.96	0.02	5.5	6.0	7.20	145.80	0.02	0.98
9/26/2018	4.5	43.2434	SC	0.18	2.13	0.04	11.0	25.0	9.10	145.60	0.10	2.23
10/24/2018	4.3	43.2434	SC	0.04	0.98	0.05	5.2	6.0	7.30	145.20	0.13	1.11
3/13/2019	7.9	43.2434	SC	0.04	0.75	0.03	6.8	5.0	5.10	144.80	0.02	0.75
11/8/2017	0.0	43.2434	SC	0.05	0.89	0.02	5.8	7.0	3.10	143.60	0.02	0.89
12/27/2017	2.1	38.6102	HC	0.05	0.69	0.10	9.9	5.0	6.60	142.60	0.09	0.78
10/18/2017	0.0	43.2434	SC	0.05	1.05	0.09	43.4	14.0	2.80	142.50	0.02	1.05
11/1/2017	0.0	43.2434	SC	0.04	0.83	0.04	12.4	9.0	2.60	142.30	0.02	0.83
8/23/2017	8.1	38.6102	HC	0.06	0.79	0.08	7.8	5.0	1.80	141.50	0.12	0.91
11/15/2017	0.0	43.2434	SC	0.04	0.85	0.04	7.4	6.0	3.40	141.50	0.02	0.85
11/21/2017	0.0	43.2434	SC	0.04	0.77	0.03	8.2	8.0	3.30	141.40	0.02	0.77
11/7/2018	6.3	43.2434	SC	0.08	1.23	0.03	7.3	11.0	5.00	139.40	0.02	1.23
10/31/2018	4.8	43.2434	SC	0.10	1.55	0.02	6.6	14.0	7.00	138.80	0.02	1.55
2/6/2019	6.8	43.2434	SC	0.04	0.76	0.02	6.5	4.0	3.00	137.00	0.09	0.85

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
9/6/2017	6.0	43.2434	SC	0.04	0.89	0.03	7.7	9.0	4.70	136.60	0.02	0.89
9/22/2020	4.1	43.2434	SC	0.10	0.92	0.08	11.9	9.0	5.20	135.40	0.20	1.12
2/22/2017	6.4	43.2434	SC	0.07	1.06	0.02	5.8	7.0	4.20	133.70	0.02	1.08
10/30/2019	3.9	43.2434	SC	0.08	1.26	0.02	8.2	10.0	7.10	131.80	0.02	1.26
9/15/2020	2.5	43.2434	SC	0.07	0.94	0.02	3.9	5.0	5.40	130.60	0.09	1.03
2/21/2018	11.5	43.2434	SC	0.05	0.69	0.02	8.2	6.0	6.80	128.70	0.02	0.69
9/8/2020	3.1	43.2434	SC	0.09	1.01	0.02	5.8	9.0	7.20	126.80	0.10	1.11
3/14/2018	5.4	43.2434	SC	0.04	0.74	0.02	7.9	5.0	4.10	125.40	0.02	0.74
10/26/2016	0.1	38.6102	HC	0.04	0.39	0.03	6.4	4.0	3.16	124.30	0.06	0.45
7/19/2017	3.3	43.2434	SC	0.07	1.21	0.03	5.6	11.0	2.10	124.30	0.02	1.21
3/8/2017	5.4	43.2434	SC	0.07	1.02	0.06	7.9	7.0	4.80	123.00	0.02	1.04
5/3/2017	6.7	43.2434	SC	0.06	1.09	0.03	5.0	9.0	1.80	120.70	0.02	1.09
8/29/2018	0.0	43.2434	SC	0.06	0.65	0.03	10.0	11.0	1.70	119.20	0.02	0.65
3/21/2018	5.7	43.2434	SC	0.06	0.83	0.03	10.3	9.0	4.30	119.00	0.02	0.83
2/7/2018	10.6	43.2434	SC	0.05	0.66	0.03	8.1	6.0	6.80	118.30	0.03	0.69
9/6/2017	22.6	38.6102	HC	0.05	0.78	0.06	12.0	9.0	3.00	117.70	0.08	0.86
8/2/2017	2.4	43.2434	SC	0.06	1.84	0.04	5.9	9.0	1.80	116.00	0.02	1.84
6/21/2017	3.8	43.2434	SC	0.03	1.03	0.03	3.1	5.0	1.00	115.30	0.02	1.05
7/26/2017	3.5	43.2434	SC	0.05	0.91	0.02	3.7	7.0	1.80	114.90	0.02	0.91
10/16/2019	10.5	43.2434	SC	0.05	0.87	0.02	11.9	8.0	10.10	114.60	0.18	1.05
10/23/2019	2.9	43.2434	SC	0.06	1.01	0.02	10.9	14.0	9.50	114.00	0.02	1.01
12/6/2017	6.2	38.6102	HC	0.05	0.55	0.04	5.6	5.0	3.70	113.10	0.02	0.55
7/19/2017	10.4	38.6102	HC	0.06	0.77	0.05	10.3	5.0	2.20	112.80	0.10	0.87
10/6/2020	0.6	38.6102	HC	0.04	0.45	0.02	9.2	5.0	3.90	111.40	0.08	0.53
8/9/2017	2.3	43.2434	SC	0.04	0.86	0.06	4.8	6.0	2.10	111.10	0.02	0.86
6/14/2017	4.7	43.2434	SC	0.07	0.99	0.02	4.2	13.0	1.60	111.00	0.02	1.01
1/30/2018	2.4	38.6102	HC	0.04	0.49	0.03	8.0	2.0	7.20	110.10	0.04	0.53
11/21/2016	1.0	38.6102	HC	0.07	0.58	0.03	9.2	7.0	5.60	109.90	0.04	0.62
3/18/2020	6.2	43.2434	SC	0.05	0.84	0.02	5.4	7.0	3.30	108.60	0.15	0.99
11/21/2017	1.5	38.6102	HC	0.04	0.48	0.03	3.4	52.0	3.30	107.90	0.02	0.50
8/16/2017	4.8	43.2434	SC	0.04	0.94	0.04	4.4	6.0	2.90	107.80	0.02	0.94
11/29/2017	1.9	38.6102	HC	0.03	0.38	0.05	4.0	2.0	3.70	107.60	0.02	0.38
7/21/2020	0.0	43.2434	SC	0.09	1.19	0.02	5.1	9.0	0.50	106.80	0.20	1.39
6/7/2017	5.0	43.2434	SC	0.08	1.75	0.09	8.0	15.0	2.40	106.30	0.02	1.77
11/2/2016	0.0	43.2434	SC	0.21	2.29	0.04	15.0	27.0	1.70	105.10	0.02	2.29
8/4/2020	0.0	38.6102	HC	0.05	0.50	0.02	12.7	5.0	3.40	104.40	0.24	0.74
7/28/2020	0.8	43.2434	SC	0.06	1.04	0.02	4.8	8.0	0.60	103.90	0.21	1.25
8/30/2017	3.4	43.2434	SC	0.05	0.81	0.05	5.0	5.0	2.80	103.60	0.02	0.81
11/16/2016	0.3	38.6102	HC	0.06	0.46	0.04	6.5	3.0	3.30	103.50	0.04	0.50
11/15/2017	0.7	38.6102	HC	0.03	0.45	0.04	3.9	1.0	4.20	103.40	0.02	0.45
11/9/2016	0.0	43.2434	SC	0.08	1.20	0.03	16.9	12.0	1.10	103.40	0.02	1.20
11/9/2016	0.3	38.6102	HC	0.06	0.47	0.04	6.9	4.0	2.80	102.90	0.05	0.52
11/8/2017	0.7	38.6102	HC	0.05	0.45	0.02	3.4	2.0	3.90	102.80	0.02	0.45
7/7/2020	1.7	43.2434	SC	0.07	1.01	0.02	4.0	8.0	0.80	101.90	0.14	1.15
10/3/2018	0.0	38.6102	HC	0.04	0.71	0.05	8.2	3.0	3.00	101.20	0.13	0.84
7/14/2020	0.6	43.2434	SC	0.17	1.83	0.02	8.1	17.0	1.00	100.60	0.22	2.05
9/19/2018	0.9	38.6102	HC	0.05	0.71	0.08	5.4	3.0	2.90	100.50	0.14	0.85
11/16/2016	0.0	43.2434	SC	0.07	1.04	0.11	17.4	9.0	1.70	100.30	0.02	1.04
7/17/2019	2.2	43.2434	SC	0.08	1.06	0.06	6.2	9.0	1.70	99.60	0.03	1.09
10/26/2016	0.0	43.2434	SC	0.08	1.31	0.05	18.7	15.0	2.01	98.10	0.02	1.31
11/21/2016	0.0	43.2434	SC	0.07	1.18	0.18	19.4	11.0	0.80	97.90	0.02	1.18
9/12/2018	0.0	38.6102	HC	0.06	0.81	0.07	7.9	3.0	4.90	97.50	0.11	0.92
7/11/2018	0.7	38.6102	HC	0.04	0.57	0.06	8.5	2.0	3.60	97.50	0.13	0.70
10/17/2018	22.8	38.6102	HC	0.05	0.72	0.03	14.7	11.0	4.00	97.30	0.08	0.80
11/2/2016	0.0	38.6102	HC	0.06	0.47	0.06	7.1	4.0	3.30	96.60	0.05	0.52
7/1/2020	3.6	43.2434	SC	0.10	1.26	0.02	4.4	10.0	0.70	96.10	0.16	1.42
12/13/2017	1.7	38.6102	HC	0.04	0.32	0.04	5.3	4.0	4.30	95.50	0.03	0.35
12/14/2016	0.6	43.2434	SC	0.07	1.14	0.20	17.0	9.0	4.80	94.70	0.06	1.20
12/21/2016	0.4	43.2434	SC	0.09	1.30	0.16	18.5	13.0	5.40	94.50	0.06	1.36
12/21/2016	0.9	38.6102	HC	0.06	0.52	0.04	8.6	6.0	4.50	93.90	0.02	0.54

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
9/20/2017	6.0	38.6102	HC	0.04	0.52	0.07	3.1	2.0	2.30	93.50	0.07	0.59
10/10/2018	37.1	38.6102	HC	0.07	0.94	0.03	27.0	26.0	3.20	93.40	0.09	1.03
11/30/2016	0.0	43.2434	SC	0.07	1.06	0.25	19.4	10.0	4.90	92.70	0.03	1.09
2/15/2017	5.1	43.2434	SC	0.04	0.82	0.02	7.9	8.0	5.40	92.40	0.02	0.82
6/21/2017	0.1	38.6102	HC	0.08	0.66	0.05	11.8	5.0	1.60	89.00	0.19	0.85
2/15/2017	52.4	38.6102	HC	0.08	0.76	0.05	19.5	19.0	3.70	88.80	0.07	0.83
12/7/2016	0.4	43.2434	SC	0.08	1.00	0.25	19.9	9.0	3.90	88.50	0.05	1.05
1/10/2017	4.7	43.2434	SC	0.08	1.15	0.09	10.3	8.0	6.50	88.00	0.02	1.15
6/17/2020	1.1	43.2434	SC	0.22	2.46	0.02	10.7	11.0	1.90	87.80	0.17	2.63
2/19/2020	11.2	43.2434	SC	0.04	0.79	0.02	11.7	4.0	4.50	87.60	0.02	0.79
6/3/2020	2.4	43.2434	SC	0.43	6.07	0.05	17.5	29.0	0.50	87.20	0.08	6.15
12/14/2016	0.8	38.6102	HC	0.07	0.53	0.04	7.5	4.0	5.80	86.90	0.02	0.55
10/20/2020	5.1	38.6102	HC	0.04	0.45	0.02	7.8	5.0	2.70	86.60	0.26	0.71
7/28/2020	0.7	38.6102	HC	0.06	0.55	0.03	11.3	5.0	3.00	85.90	0.34	0.89
7/12/2017	4.4	43.2434	SC	0.07	1.14	0.04	4.9	9.0	2.40	85.80	0.02	1.14
9/5/2018	0.1	38.6102	HC	0.03	0.59	0.07	5.0	3.0	2.20	85.70	0.10	0.69
10/31/2018	0.1	38.6102	HC	0.05	0.67	0.03	6.6	3.0	4.70	85.60	0.12	0.79
3/22/2017	0.8	38.6102	HC	0.07	0.70	0.05	10.5	7.0	3.70	85.40	0.04	0.74
6/24/2020	7.2	43.2434	SC	0.13	1.60	0.02	6.8	15.0	0.50	84.70	0.18	1.78
1/10/2018	2.1	43.2434	SC	0.05	1.00	0.03	6.4	5.0	6.50	84.70	0.02	1.02
1/17/2017	6.4	43.2434	SC	0.10	1.35	0.08	12.9	13.0	5.10	84.50	0.02	1.37
8/8/2018	1.0	38.6102	HC	0.03	0.58	0.05	6.6	2.0	6.60	84.00	0.09	0.67
1/22/2020	4.7	43.2434	SC	0.07	0.93	0.05	10.4	10.0	4.20	83.90	0.02	0.93
9/13/2017	8.1	38.6102	HC	0.06	0.58	0.05	7.2	2.0	2.80	83.20	0.09	0.67
8/2/2017	6.0	38.6102	HC	0.05	1.01	0.05	7.8	6.0	2.10	82.10	0.03	1.04
4/29/2020	9.0	43.2434	SC	0.08	0.90	0.08	10.3	12.0	1.60	81.70	0.15	1.05
7/25/2018	3.5	38.6102	HC	0.06	0.61	0.04	6.5	4.0	1.80	81.50	0.06	0.67
9/27/2017	4.3	38.6102	HC	0.04	0.55	0.06	5.0	1.0	1.50	81.20	0.06	0.61
11/13/2019	6.7	38.6102	HC	0.04	0.45	0.03	7.0	2.0	5.20	81.10	0.04	0.49
2/5/2020	8.5	43.2434	SC	0.05	0.83	0.03	10.9	4.0	5.40	80.90	0.02	0.83
8/22/2018	0.3	38.6102	HC	0.05	0.64	0.08	7.9	4.0	6.50	80.40	0.21	0.85
3/7/2018	5.7	43.2434	SC	0.06	0.81	0.05	15.4	6.0	4.30	80.40	0.02	0.81
11/1/2017	0.5	38.6102	HC	0.04	0.41	0.04	7.2	5.0	3.80	80.30	0.06	0.47
9/26/2018	0.6	38.6102	HC	0.06	0.86	0.06	6.8	5.0	6.20	79.70	0.16	1.02
6/14/2017	0.5	38.6102	HC	0.05	0.71	0.07	10.8	9.0	3.50	79.40	0.16	0.87
1/10/2018	3.0	38.6102	HC	0.04	0.40	0.02	7.9	2.0	6.10	79.10	0.06	0.46
8/9/2017	13.0	38.6102	HC	0.08	0.60	0.05	11.3	7.0	4.30	78.80	0.08	0.68
8/29/2018	2.0	38.6102	HC	0.04	0.65	0.04	5.2	4.0	3.40	78.80	0.10	0.75
3/4/2020	6.2	43.2434	SC	0.04	0.78	0.05	10.0	6.0	4.00	78.40	0.11	0.89
4/3/2019	6.0	43.2434	SC	0.04	0.86	0.03	5.0	8.0	3.20	78.20	0.02	0.86
8/30/2017	10.4	38.6102	HC	0.09	0.75	0.07	9.4	5.0	1.90	78.00	0.12	0.87
7/5/2018	1.2	38.6102	HC	0.06	0.63	0.06	8.9	2.0	4.00	77.70	0.02	0.63
2/8/2017	4.9	43.2434	SC	0.07	0.90	0.03	11.3	9.0	4.90	77.00	0.02	0.90
7/12/2017	10.4	38.6102	HC	0.08	0.98	0.09	13.7	7.0	8.00	76.30	0.17	1.15
10/24/2018	0.0	38.6102	HC	0.04	0.76	0.03	10.3	5.0	4.70	76.30	0.16	0.92
12/27/2017	5.4	43.2434	SC	0.05	0.95	0.08	8.7	7.0	6.70	76.30	0.03	0.98
10/6/2020	0.8	43.2434	SC	0.07	0.85	0.07	9.4	7.0	2.90	76.10	0.04	0.89
5/27/2020	7.4	43.2434	SC	0.12	1.26	0.02	9.6	16.0	1.70	76.00	0.06	1.32
10/27/2020	3.8	43.2434	SC	0.10	0.99	0.05	7.5	8.0	2.40	75.70	0.02	0.99
7/26/2017	10.4	38.6102	HC	0.06	0.57	0.05	10.0	6.0	3.60	75.20	0.08	0.65
5/19/2017	4.8	43.2434	SC	0.10	1.21	0.05	8.5	13.0	1.80	75.00	0.02	1.21
11/20/2019	3.7	38.6102	HC	0.04	0.49	0.02	5.7	3.0	5.20	74.90	0.07	0.56
7/18/2018	1.4	38.6102	HC	0.07	0.69	0.06	7.3	3.0	2.40	74.70	0.07	0.76
10/20/2020	2.7	43.2434	SC	0.08	0.96	0.02	5.9	7.0	2.80	74.70	0.02	0.96
2/20/2019	7.1	43.2434	SC	0.04	0.90	0.05	14.3	11.0	3.80	74.70	0.02	0.92
10/4/2017	4.3	38.6102	HC	0.06	0.59	0.06	5.8	4.0	2.00	74.60	0.08	0.67
7/5/2017	5.5	43.2434	SC	0.07	1.09	0.07	10.6	13.0	3.00	74.60	0.06	1.15
12/5/2018	2.5	38.6102	HC	0.04	0.86	0.07	7.2	3.0	6.20	73.70	0.02	0.86
3/29/2017	1.1	38.6102	HC	0.08	0.50	0.10	10.8	9.0	2.80	73.30	0.07	0.57
9/18/2019	0.0	43.2434	SC	0.08	1.25	0.03	8.0	10.0	0.90	72.70	0.02	1.25

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
11/28/2018	1.4	38.6102	HC	0.04	0.58	0.04	6.1	3.0	5.20	72.60	0.05	0.63
10/13/2020	4.3	43.2434	SC	0.07	0.89	0.06	6.1	4.0	2.80	72.30	0.02	0.89
6/10/2020	8.8	43.2434	SC	0.16	1.70	0.03	18.1	26.0	1.40	72.00	0.06	1.76
9/11/2019	0.0	43.2434	SC	0.06	1.05	0.04	5.4	8.0	0.60	71.50	0.02	1.05
1/10/2017	2.5	38.6102	HC	0.05	0.55	0.07	11.5	7.0	4.60	71.10	0.06	0.61
9/4/2019	0.0	43.2434	SC	0.09	1.16	0.02	5.6	8.0	0.50	70.80	0.02	1.16
10/8/2019	3.4	43.2434	SC	0.08	1.13	0.03	12.4	14.0	3.30	69.80	0.09	1.22
8/21/2019	0.0	43.2434	SC	0.09	1.10	0.02	8.1	13.0	0.90	69.60	0.03	1.13
8/28/2019	0.0	43.2434	SC	0.08	1.16	0.07	7.5	10.0	0.80	69.60	0.02	1.16
1/16/2019	7.1	43.2434	SC	0.03	0.70	0.04	11.7	4.0	3.90	69.00	0.02	0.72
9/25/2019	0.0	43.2434	SC	0.07	0.95	0.02	5.6	8.0	1.70	68.90	0.02	0.97
8/14/2019	0.0	43.2434	SC	0.15	1.55	0.02	10.6	20.0	0.90	68.70	0.02	1.57
6/27/2018	0.1	38.6102	HC	0.07	0.77	0.08	8.7	8.0	4.20	67.80	0.16	0.93
10/18/2017	0.3	38.6102	HC	0.05	0.49	0.04	6.6	2.0	2.20	67.80	0.07	0.56
8/7/2019	0.0	43.2434	SC	0.13	1.44	0.05	11.4	18.0	1.30	67.10	0.02	1.46
3/11/2020	6.3	43.2434	SC	0.05	0.81	0.02	15.3	8.0	4.30	67.10	0.09	0.90
1/17/2017	102.6	38.6102	HC	0.11	1.10	0.07	30.2	32.0	4.00	66.80	0.08	1.18
1/4/2017	5.3	43.2434	SC	0.08	1.20	0.05	9.4	7.0	6.80	66.60	0.02	1.22
12/4/2019	14.2	38.6102	HC	0.04	0.64	0.02	9.6	3.0	5.30	66.00	0.06	0.70
11/25/2019	9.6	38.6102	HC	0.04	0.41	0.02	5.8	3.0	5.70	65.90	0.02	0.41
11/6/2019	4.4	38.6102	HC	0.05	0.58	0.04	12.5	5.0	6.50	64.40	0.11	0.69
9/29/2020	2.3	43.2434	SC	0.06	0.92	0.05	12.4	10.0	4.30	64.10	0.02	0.94
4/26/2017	2.2	38.6102	HC	0.07	0.83	0.10	13.2	8.0	2.20	63.80	0.11	0.94
11/7/2018	19.9	38.6102	HC	0.05	0.85	0.03	11.6	9.0	4.50	63.80	0.02	0.85
7/31/2019	0.0	43.2434	SC	0.14	1.49	0.03	8.6	13.0	1.50	63.60	0.03	1.52
6/19/2019	0.1	38.6102	HC	0.07	0.52	0.03	15.8	10.0	2.70	63.50	0.17	0.69
3/15/2017	7.6	38.6102	HC	0.07	0.63	0.03	13.8	9.0	4.50	62.90	0.06	0.69
5/31/2017	5.0	43.2434	SC	0.08	1.14	0.04	9.6	16.0	2.10	62.70	0.02	1.16
4/26/2017	4.8	43.2434	SC	0.16	2.00	0.03	9.0	17.0	1.80	62.60	0.02	2.02
11/20/2018	5.5	38.6102	HC	0.04	0.74	0.03	9.2	3.0	5.40	62.50	0.04	0.78
9/29/2020	3.7	38.6102	HC	0.06	0.67	0.03	12.7	4.0	3.30	62.40	0.08	0.75
5/10/2017	4.9	43.2434	SC	0.07	1.12	0.03	10.5	14.0	3.60	61.90	0.02	1.14
8/18/2020	1.3	38.6102	HC	0.05	0.51	0.03	8.2	3.0	2.70	61.60	0.05	0.56
10/27/2020	11.7	38.6102	HC	0.05	0.55	0.02	13.4	4.0	3.10	61.60	0.02	0.55
1/31/2017	4.9	43.2434	SC	0.06	0.81	0.05	16.7	7.0	5.40	61.60	0.02	0.81
1/24/2018	24.2	38.6102	HC	0.06	0.74	0.03	20.9	10.0	7.70	60.60	0.08	0.82
5/1/2019	0.0	43.2434	SC	0.07	0.85	0.05	8.3	7.0	2.50	59.50	0.02	0.87
10/13/2020	15.9	38.6102	HC	0.05	0.68	0.03	12.6	6.0	3.70	58.30	0.11	0.79
6/17/2020	1.0	38.6102	HC	0.07	0.69	0.05	17.9	9.0	3.10	57.70	0.36	1.05
1/2/2020	41.4	38.6102	HC	0.05	0.75	0.04	13.5	5.0	6.10	57.20	0.08	0.83
7/24/2019	0.0	43.2434	SC	0.07	0.89	0.03	8.4	8.0	2.20	57.20	0.03	0.92
5/13/2020	3.3	38.6102	HC	0.06	0.74	0.07	20.6	11.0	3.30	57.00	0.14	0.88
6/5/2019	0.7	38.6102	HC	0.07	0.72	0.17	16.4	9.0	2.70	56.70	0.19	0.91
1/31/2017	3.2	38.6102	HC	0.07	0.69	0.06	14.4	6.0	5.50	56.50	0.07	0.76
10/30/2019	12.5	38.6102	HC	0.05	0.70	0.08	15.1	5.0	6.80	56.00	0.14	0.84
2/7/2018	270.2	38.6102	HC	0.06	0.98	0.07	30.2	28.0	4.20	55.50	0.14	1.12
6/3/2020	4.3	38.6102	HC	0.06	0.81	0.06	21.4	13.0	3.20	55.40	0.34	1.15
11/30/2016	20.3	38.6102	HC	0.08	0.67	0.02	16.7	12.0	1.50	55.20	0.08	0.75
12/11/2019	60.5	38.6102	HC	0.05	0.71	0.03	12.9	5.0	4.80	54.90	0.05	0.76
4/3/2019	3.4	38.6102	HC	0.04	0.67	0.04	9.1	7.0	4.10	54.20	0.07	0.74
9/18/2019	1.8	38.6102	HC	0.04	0.39	0.03	6.3	2.0	2.60	54.20	0.08	0.47
2/26/2020	6.5	43.2434	SC	0.04	0.68	0.02	16.9	5.0	4.20	54.10	0.08	0.76
2/8/2017	10.7	38.6102	HC	0.08	0.66	0.04	14.1	8.0	5.40	54.00	0.06	0.72
10/23/2019	6.2	38.6102	HC	0.06	0.76	0.04	14.9	4.0	9.00	53.90	0.11	0.87
1/23/2019	11.9	43.2434	SC	0.04	0.73	0.05	21.2	12.0	3.20	53.70	0.02	0.75
6/7/2017	2.6	38.6102	HC	0.06	1.01	0.11	18.8	12.0	3.50	53.60	0.14	1.15
3/14/2018	7.5	38.6102	HC	0.05	0.76	0.04	13.8	5.0	5.30	53.50	0.05	0.81
3/27/2019	6.2	43.2434	SC	0.05	1.15	0.05	9.7	8.0	2.80	53.50	0.02	1.15
3/18/2020	42.1	38.6102	HC	0.05	0.71	0.04	16.7	10.0	3.70	53.40	0.13	0.84
5/6/2020	7.9	38.6102	HC	0.06	0.75	0.08	18.2	14.0	3.00	53.10	0.24	0.99

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
3/28/2018	188.1	38.6102	HC	0.07	1.08	0.02	36.7	53.0	2.70	52.80	0.05	1.13
7/14/2020	0.4	38.6102	HC	0.07	0.60	0.04	14.2	6.0	2.80	52.80	0.32	0.92
9/25/2019	1.1	38.6102	HC	0.06	0.70	0.05	6.7	5.0	14.60	52.80	0.10	0.80
8/11/2020	0.0	38.6102	HC	0.05	0.46	0.03	10.0	7.0	3.10	52.70	0.18	0.64
1/8/2020	11.8	38.6102	HC	0.04	0.63	0.03	13.4	3.0	6.20	52.70	0.08	0.71
7/7/2020	2.1	38.6102	HC	0.08	0.64	0.04	17.6	10.0	2.80	52.60	0.08	0.72
3/8/2017	30.2	38.6102	HC	0.07	0.98	0.06	18.8	15.0	4.10	52.60	0.06	1.04
10/25/2017	0.1	38.6102	HC	0.06	0.56	0.04	6.1	2.0	4.20	52.50	0.02	0.58
4/4/2018	13.4	38.6102	HC	0.07	0.78	0.08	15.3	8.0	4.10	52.20	0.07	0.85
6/19/2019	0.0	43.2434	SC	0.07	1.01	0.03	6.5	10.0	1.30	52.10	0.02	1.03
8/7/2019	0.9	38.6102	HC	0.06	0.82	0.07	12.7	7.0	2.80	51.80	0.14	0.96
6/12/2019	0.1	38.6102	HC	0.06	0.71	0.08	15.3	7.0	2.80	51.60	0.18	0.89
7/10/2019	0.0	43.2434	SC	0.15	1.87	0.05	9.3	13.0	2.00	51.50	0.02	1.89
2/14/2018	7.8	43.2434	SC	0.05	0.72	0.02	21.6	7.0	6.50	50.90	0.04	0.76
6/28/2017	10.4	38.6102	HC	0.06	0.90	0.07	15.1	8.0	1.90	50.80	0.13	1.03
12/18/2019	27.8	38.6102	HC	0.04	0.55	0.03	11.1	3.0	5.40	50.50	0.07	0.62
2/28/2018	8.2	43.2434	SC	0.04	0.78	0.03	15.2	5.0	4.30	50.50	0.02	0.78
1/22/2020	18.9	38.6102	HC	0.05	0.68	0.05	14.6	4.0	5.90	50.10	0.10	0.78
2/6/2019	14.7	38.6102	HC	0.04	0.59	0.05	11.2	3.0	5.60	50.10	0.09	0.68
5/13/2020	2.1	43.2434	SC	0.09	1.05	0.02	7.9	8.0	1.70	50.00	0.05	1.10
2/14/2018	87.7	38.6102	HC	0.03	0.69	0.06	23.3	8.0	6.80	49.90	0.12	0.81
2/21/2018	130.8	38.6102	HC	0.07	0.69	0.03	23.3	25.0	6.10	49.50	0.06	0.75
8/25/2020	0.1	38.6102	HC	0.05	0.38	0.02	7.7	5.0	2.80	49.40	0.16	0.54
8/14/2019	0.5	38.6102	HC	0.06	0.51	0.04	7.2	2.0	2.60	49.30	0.14	0.65
9/11/2019	1.9	38.6102	HC	0.05	0.51	0.04	6.3	8.0	2.70	49.20	0.07	0.58
5/19/2017	0.6	38.6102	HC	0.08	0.78	0.06	17.1	9.0	2.10	48.50	0.13	0.91
5/10/2017	1.3	38.6102	HC	0.08	0.77	0.08	19.3	10.0	3.90	47.90	0.15	0.92
8/16/2017	19.1	38.6102	HC	0.08	0.96	0.06	16.5	14.0	4.10	47.50	0.09	1.05
9/1/2020	8.1	38.6102	HC	0.07	0.75	0.04	11.3	4.0	4.20	47.50	0.08	0.83
3/4/2020	41.4	38.6102	HC	0.05	0.61	0.04	17.0	7.0	4.90	47.50	0.12	0.73
6/12/2019	0.0	43.2434	SC	0.09	1.17	0.05	6.5	12.0	1.30	47.00	0.03	1.20
1/16/2019	14.2	38.6102	HC	0.06	0.60	0.05	13.0	3.0	5.20	46.80	0.09	0.69
7/5/2017	26.4	38.6102	HC	0.09	0.92	0.10	19.6	12.0	3.10	46.70	0.10	1.02
7/31/2019	0.0	38.6102	HC	0.10	0.52	0.03	13.2	3.0	3.00	46.60	0.17	0.69
12/7/2016	80.5	38.6102	HC	0.08	0.71	0.03	17.7	13.0	6.00	46.40	0.12	0.83
5/31/2017	1.6	38.6102	HC	0.07	0.79	0.08	15.8	8.0	2.70	46.40	0.13	0.92
7/21/2020	0.0	38.6102	HC	0.08	0.62	0.05	13.8	6.0	2.00	46.20	0.11	0.73
5/29/2019	1.0	38.6102	HC	0.07	0.74	0.09	17.1	5.0	3.10	46.20	0.19	0.93
5/1/2019	7.4	38.6102	HC	0.07	0.72	0.09	16.8	10.0	3.30	46.10	0.14	0.86
5/3/2017	49.0	38.6102	HC	0.08	0.98	0.07	21.0	14.0	3.30	46.00	0.10	1.08
3/27/2019	5.2	38.6102	HC	0.06	0.77	0.06	12.6	5.0	4.10	46.00	0.06	0.83
8/1/2018	0.0	38.6102	HC	0.07	0.79	0.06	14.2	6.0	7.20	45.60	0.16	0.95
5/8/2019	0.2	43.2434	SC	0.09	1.23	0.05	9.8	11.0	2.40	45.20	0.02	1.25
6/5/2019	0.0	43.2434	SC	0.12	1.35	0.04	6.5	9.0	1.20	44.60	0.02	1.37
7/2/2019	0.0	43.2434	SC	0.11	1.51	0.03	8.4	16.0	2.90	44.60	0.02	1.53
4/29/2020	144.9	38.6102	HC	0.10	1.25	0.07	67.7	80.0	2.30	44.20	0.14	1.39
4/4/2018	5.7	43.2434	SC	0.06	1.05	0.05	15.0	11.0	3.00	44.10	0.02	1.05
9/4/2019	1.7	38.6102	HC	0.05	0.46	0.03	7.0	5.0	2.70	44.00	0.10	0.56
8/15/2018	0.3	38.6102	HC	0.05	0.58	0.04	7.4	3.0	3.30	43.90	0.11	0.69
3/21/2018	15.2	38.6102	HC	0.07	0.82	0.04	18.4	13.0	4.30	43.50	0.05	0.87
7/1/2020	9.9	38.6102	HC	0.07	0.91	0.05	19.8	11.0	2.00	43.40	0.22	1.13
10/16/2019	261.4	38.6102	HC	0.09	0.99	0.04	43.0	21.0	8.10	43.10	0.48	1.47
5/29/2019	0.0	43.2434	SC	0.10	1.26	0.04	6.0	9.0	1.60	43.00	0.02	1.28
7/10/2019	2.0	38.6102	HC	0.07	0.90	0.07	20.2	10.0	2.70	42.60	0.15	1.05
1/4/2017	51.1	38.6102	HC	0.08	0.96	0.06	20.1	12.0	4.60	42.20	0.07	1.03
4/22/2020	6.3	43.2434	SC	0.06	0.95	0.05	21.1	10.0	3.30	41.70	0.07	1.02
1/15/2020	6.7	43.2434	SC	0.05	0.88	0.04	15.0	5.0	4.40	41.50	0.03	0.91
3/1/2017	7.9	43.2434	SC	0.08	0.99	0.06	29.6	17.0	5.00	41.40	0.02	1.01
8/21/2019	1.0	38.6102	HC	0.06	0.51	0.04	7.8	4.0	2.80	41.20	0.12	0.63
3/11/2020	44.0	38.6102	HC	0.05	0.63	0.03	20.5	8.0	4.60	39.50	0.02	0.65

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
1/29/2020	9.4	43.2434	SC	0.04	0.71	0.03	13.7	7.0	3.70	38.00	0.02	0.73
11/9/2016	2.1	62.5485	2B	0.16	0.62	0.06	1.9	2.0	2.10	37.90	1.88	2.50
7/2/2019	3.9	38.6102	HC	0.06	0.79	0.06	19.0	4.0	2.90	37.30	0.10	0.89
5/8/2019	19.5	38.6102	HC	0.08	0.98	0.09	22.5	13.0	3.00	37.20	0.14	1.12
2/22/2017	160.6	38.6102	HC	0.07	0.97	0.03	29.4	22.0	5.10	37.20	0.07	1.04
3/20/2019	19.2	38.6102	HC	0.05	0.89	0.04	17.5	7.0	4.60	35.50	0.08	0.97
3/7/2018	18.7	38.6102	HC	0.04	0.71	0.05	18.9	6.0	5.10	35.50	0.06	0.77
1/30/2019	6.8	43.2434	SC	0.04	0.74	0.03	18.4	4.0	3.60	35.50	0.02	0.76
11/2/2016	1.2	62.5485	2B	0.18	0.58	0.05	2.6	4.0	7.10	35.40	2.81	3.39
11/16/2016	1.8	62.5485	2B	0.15	0.57	0.04	2.4	3.0	1.70	34.90	2.36	2.93
4/24/2019	0.0	43.2434	SC	0.06	0.95	0.08	12.3	7.0	2.20	34.40	0.02	0.97
5/15/2019	10.5	38.6102	HC	0.08	0.86	0.09	17.5	9.0	3.50	34.20	0.13	0.99
5/6/2020	3.3	43.2434	SC	0.08	1.31	0.04	13.2	13.0	2.10	33.90	0.06	1.37
1/9/2019	7.2	43.2434	SC	0.04	0.69	0.05	18.6	2.0	3.50	33.70	0.02	0.69
1/29/2020	168.0	38.6102	HC	0.05	0.62	0.03	35.2	30.0	4.70	33.60	0.09	0.71
5/24/2017	94.7	38.6102	HC	0.10	0.97	0.07	27.7	27.0	3.30	33.40	0.11	1.08
4/24/2019	14.1	38.6102	HC	0.07	0.72	0.06	17.1	8.0	3.60	33.40	0.11	0.83
1/30/2019	31.5	38.6102	HC	0.04	0.53	0.03	14.4	4.0	5.60	32.60	0.07	0.60
4/8/2020	6.5	43.2434	SC	0.06	0.96	0.09	17.2	10.0	3.10	32.60	0.04	1.00
12/12/2018	34.8	38.6102	HC	0.04	0.79	0.05	17.1	7.0	6.50	32.40	0.11	0.90
11/14/2018	70.9	38.6102	HC	0.05	0.86	0.02	19.6	8.0	5.30	32.10	0.17	1.03
10/26/2016	2.9	62.5485	2B	0.16	0.57	0.05	2.5	4.0	6.02	32.00	3.32	3.89
11/21/2016	1.3	62.5485	2B	0.19	0.74	0.05	2.8	4.0	5.10	31.90	2.30	3.04
1/9/2019	28.8	38.6102	HC	0.03	0.63	0.04	15.5	3.0	4.90	31.90	0.07	0.70
12/13/2017	9.1	62.5485	2B	0.22	0.54	0.04	3.8	5.0	5.00	31.80	2.89	3.43
4/5/2017	34.3	38.6102	HC	0.09	0.99	0.09	25.1	20.0	4.30	31.80	0.09	1.08
8/28/2019	0.6	38.6102	HC	0.05	0.60	0.05	7.4	4.0	2.50	31.30	0.13	0.73
1/15/2020	52.4	38.6102	HC	0.05	0.73	0.03	20.0	7.0	6.00	31.30	0.13	0.86
5/27/2020	71.8	38.6102	HC	0.09	0.87	0.05	27.6	31.0	2.60	31.10	0.12	0.99
5/15/2019	0.0	43.2434	SC	0.07	1.16	0.06	10.0	11.0	2.30	30.50	0.02	1.18
10/8/2019	0.8	62.5485	2B	0.26	0.59	0.04	5.8	3.0	5.80	29.80	3.52	4.11
2/26/2020	49.5	38.6102	HC	0.04	0.55	0.03	17.1	6.0	5.40	29.70	0.09	0.64
5/22/2019	13.7	38.6102	HC	0.08	0.93	0.10	24.0	14.0	3.00	29.60	0.12	1.05
12/19/2018	34.0	38.6102	HC	0.05	0.74	0.05	15.5	6.0	5.40	29.60	0.12	0.86
6/26/2019	16.6	38.6102	HC	0.05	0.89	0.05	29.9	13.0	5.40	29.50	0.16	1.05
4/8/2020	49.0	38.6102	HC	0.07	0.94	0.06	24.1	16.0	3.60	29.30	0.07	1.01
4/22/2020	43.2	38.6102	HC	0.06	0.87	0.02	24.1	12.0	3.60	29.20	0.08	0.95
5/22/2019	0.1	43.2434	SC	0.06	1.09	0.10	14.3	11.0	2.30	28.80	0.03	1.12
3/13/2019	98.9	38.6102	HC	0.05	0.85	0.05	21.7	8.0	4.60	28.10	0.06	0.91
4/19/2017	5.0	43.2434	SC	0.08	1.29	0.05	9.9	11.0	4.40	27.80	0.02	1.29
2/27/2019	38.5	38.6102	HC	0.04	0.68	0.04	17.7	8.0	4.60	27.70	0.07	0.75
10/25/2017	11.3	62.5485	2B	0.13	0.47	0.04	2.8	1.0	5.20	27.60	2.94	3.41
12/6/2017	23.9	62.5485	2B	0.17	0.61	0.04	3.9	3.0	4.50	27.30	2.73	3.34
4/19/2017	23.9	38.6102	HC	0.08	1.09	0.07	19.4	16.0	2.50	27.30	0.09	1.18
12/20/2017	13.1	43.2434	SC	0.07	0.70	0.02	15.6	9.0	3.50	26.70	0.04	0.74
5/24/2017	7.1	43.2434	SC	0.08	0.87	0.07	23.1	17.0	1.90	26.60	0.02	0.89
6/26/2019	0.4	43.2434	SC	0.06	0.91	0.04	22.2	14.0	3.60	26.50	0.04	0.95
5/20/2020	32.3	38.6102	HC	0.08	0.77	0.05	20.7	20.0	3.20	26.40	0.08	0.85
2/20/2019	150.0	38.6102	HC	0.05	0.66	0.04	30.7	21.0	4.70	26.40	0.08	0.74
7/24/2019	8.1	38.6102	HC	0.07	0.75	0.09	21.7	12.0	3.20	25.90	0.11	0.86
12/20/2017	489.8	38.6102	HC	0.07	0.83	0.02	23.8	12.0	3.50	25.80	0.16	0.99
12/28/2016	267.3	38.6102	HC	0.12	1.10	0.03	33.5	26.0	4.30	25.70	0.09	1.19
1/23/2019	351.0	38.6102	HC	0.05	0.76	0.05	37.8	22.0	2.10	25.50	0.04	0.80
7/25/2018	28.5	62.5485	2B	0.14	0.66	0.04	6.6	6.0	3.50	25.20	0.53	1.19
10/18/2017	6.1	62.5485	2B	0.11	0.49	0.07	3.7	2.0	4.80	25.20	1.63	2.12
9/18/2019	36.1	62.5485	2B	0.11	0.67	0.09	3.3	3.0	4.90	25.20	1.39	2.06
6/24/2020	67.0	38.6102	HC	0.08	0.82	0.03	35.2	26.0	4.20	25.20	0.02	0.82
3/6/2019	6.8	43.2434	SC	0.05	0.80	0.02	28.0	10.0	4.50	25.20	0.02	0.82
11/29/2017	10.7	62.5485	2B	0.15	0.63	0.05	3.1	5.0	3.90	25.10	1.05	1.68
3/20/2019	6.5	43.2434	SC	0.05	0.85	0.02	19.3	7.0	2.90	24.90	0.02	0.85

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
6/10/2020	130.6	38.6102	HC	0.09	1.03	0.04	32.3	32.0	3.00	24.70	0.07	1.10
9/25/2019	38.4	62.5485	2B	0.13	0.54	0.08	4.2	5.0	5.40	24.50	1.78	2.32
1/24/2017	65.4	38.6102	HC	0.08	0.78	0.05	25.5	13.0	4.60	24.50	0.09	0.87
2/5/2020	114.7	38.6102	HC	0.06	0.80	0.03	36.9	22.0	5.10	24.00	0.11	0.91
3/1/2017	149.4	38.6102	HC	0.08	0.98	0.07	32.7	20.0	4.20	23.80	0.08	1.06
12/19/2018	7.3	43.2434	SC	0.05	0.94	0.04	20.2	8.0	3.60	23.80	0.02	0.94
4/17/2019	0.3	43.2434	SC	0.06	0.98	0.06	17.4	8.0	2.90	23.60	0.02	1.00
9/11/2019	42.9	62.5485	2B	0.10	0.74	0.08	2.5	4.0	4.00	23.10	0.91	1.65
9/4/2019	19.9	62.5485	2B	0.12	0.60	0.06	3.1	3.0	4.40	23.00	1.85	2.45
4/15/2020	57.4	38.6102	HC	0.07	0.83	0.05	28.6	17.0	3.30	23.00	0.11	0.94
3/6/2019	58.2	38.6102	HC	0.04	0.65	0.05	20.5	9.0	4.90	22.90	0.08	0.73
3/25/2020	128.1	38.6102	HC	0.06	0.85	0.05	25.8	15.0	4.00	22.60	0.02	0.85
7/11/2018	3.1	62.5485	2B	0.15	0.66	0.08	9.6	6.0	3.20	22.30	1.04	1.70
11/1/2017	13.8	62.5485	2B	0.17	0.53	0.05	4.0	4.0	5.20	22.20	3.74	4.27
11/20/2019	10.2	62.5485	2B	0.11	0.79	0.06	4.2	3.0	4.50	22.20	1.18	1.97
12/28/2016	9.0	43.2434	SC	0.15	0.97	0.03	35.1	27.0	3.90	22.20	0.02	0.99
2/27/2019	6.8	43.2434	SC	0.06	0.84	0.02	20.1	7.0	3.70	21.30	0.02	0.84
7/5/2018	4.3	62.5485	2B	0.17	0.83	0.06	7.6	6.0	3.50	21.10	0.91	1.74
4/5/2017	7.2	43.2434	SC	0.07	1.08	0.07	19.1	14.0	3.40	21.10	0.03	1.11
10/4/2017	6.9	62.5485	2B	0.14	0.61	0.07	3.2	5.0	4.50	20.50	1.74	2.35
4/17/2019	37.4	38.6102	HC	0.07	0.81	0.06	22.6	9.0	3.70	20.50	0.08	0.89
9/20/2017	7.8	62.5485	2B	0.12	0.53	0.06	2.8	6.0	4.00	18.90	2.23	2.76
11/15/2017	8.5	62.5485	2B	0.21	1.12	0.35	3.5	3.0	4.90	18.80	0.78	1.90
8/28/2019	25.9	62.5485	2B	0.11	0.66	0.07	4.2	5.0	4.20	18.80	2.19	2.85
11/21/2017	12.2	62.5485	2B	0.24	1.19	0.04	5.2	6.0	3.80	18.70	0.56	1.75
9/5/2018	38.3	62.5485	2B	0.12	0.89	0.10	6.2	7.0	4.70	18.60	0.96	1.85
9/27/2017	5.8	62.5485	2B	0.11	0.71	0.08	3.5	2.0	4.20	18.60	1.63	2.34
7/17/2019	228.7	38.6102	HC	0.08	1.05	0.05	36.6	25.0	2.80	18.40	0.10	1.15
3/25/2020	8.7	43.2434	SC	0.07	0.93	0.02	32.8	15.0	4.20	18.30	0.02	0.93
8/25/2020	7.2	62.5485	2B	0.14	0.62	0.06	8.7	10.0	4.10	18.20	2.06	2.68
1/24/2017	7.1	43.2434	SC	0.08	1.00	0.04	34.2	15.0	4.40	18.10	0.02	1.00
12/4/2019	30.1	62.5485	2B	0.08	0.71	0.09	8.0	2.0	3.90	18.00	0.28	0.99
12/12/2018	7.4	43.2434	SC	0.05	0.97	0.03	25.2	11.0	6.80	17.70	0.02	0.97
2/28/2018	319.7	38.6102	HC	0.06	0.80	0.02	30.9	12.0	3.70	17.20	0.04	0.84
8/11/2020	11.7	62.5485	2B	0.11	0.69	0.26	4.6	4.0	3.80	17.10	1.56	2.25
7/18/2018	19.6	62.5485	2B	0.18	1.21	0.06	6.7	5.0	2.90	16.90	0.78	1.99
5/20/2020	5.7	43.2434	SC	0.06	0.93	0.05	16.5	17.0	2.70	16.90	0.02	0.95
8/2/2017	8.5	62.5485	2B	0.12	1.12	0.05	6.4	5.0	2.50	16.80	0.74	1.86
9/13/2017	6.0	62.5485	2B	0.11	0.70	0.06	5.9	3.0	3.50	16.70	1.25	1.95
2/21/2018	916.6	62.5485	2B	0.07	0.87	0.03	36.6	57.0	2.60	16.70	0.03	0.90
8/1/2018	0.0	62.5485	2B	0.15	1.20	0.20	16.6	9.0	2.80	16.60	0.73	1.93
8/21/2019	20.0	62.5485	2B	0.09	0.50	0.05	4.5	5.0	3.90	16.60	2.20	2.70
10/31/2018	0.5	62.5485	2B	0.08	0.94	0.03	8.1	4.0	2.10	16.40	0.32	1.26
11/7/2018	427.1	62.5485	2B	0.10	1.31	0.04	72.6	79.0	1.60	16.30	0.07	1.38
11/8/2017	10.0	62.5485	2B	0.20	0.80	0.02	9.0	7.0	3.80	16.10	0.57	1.37
7/21/2020	6.8	62.5485	2B	0.12	0.59	0.03	9.3	9.0	3.20	15.90	1.26	1.85
1/2/2019	161.2	38.6102	HC	0.05	0.79	0.02	27.5	10.0	3.70	15.90	0.06	0.85
2/13/2019	12.6	43.2434	SC	0.07	0.94	0.04	42.6	16.0	3.60	15.80	0.02	0.94
9/19/2018	30.5	62.5485	2B	0.18	0.93	0.09	7.9	6.0	2.90	15.50	0.91	1.84
8/29/2018	34.4	62.5485	2B	0.14	1.13	0.15	7.5	9.0	7.90	15.00	0.87	2.00
8/23/2017	10.4	62.5485	2B	0.13	0.68	0.07	7.4	6.0	2.20	14.80	0.59	1.27
12/21/2016	8.6	62.5485	2B	0.15	0.70	0.10	5.0	4.0	4.80	14.50	0.98	1.68
9/5/2018	0.6	25.8688	BC	0.04	0.77	0.11	12.3	9.0	9.40	14.40	0.03	0.80
8/30/2017	8.6	62.5485	2B	0.14	0.74	0.07	6.7	5.0	3.10	14.20	1.52	2.26
4/15/2020	6.9	43.2434	SC	0.07	0.93	0.05	29.5	13.0	3.40	14.20	0.08	1.01
10/24/2018	4.2	62.5485	2B	0.13	0.74	0.04	7.8	6.0	2.90	14.10	0.86	1.60
9/6/2017	18.3	62.5485	2B	0.17	0.72	0.07	12.0	11.0	3.00	13.90	1.41	2.13
10/27/2020	17.1	62.5485	2B	0.16	0.51	0.05	5.4	4.0	3.40	13.90	1.79	2.30
12/14/2016	9.1	62.5485	2B	0.14	0.79	0.07	6.0	4.0	4.60	13.60	0.73	1.52
1/2/2020	7.2	25.8688	BC	0.04	0.67	0.02	10.8	2.0	13.50	13.60	0.02	0.69

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
7/26/2017	11.5	62.5485	2B	0.11	0.57	0.04	5.5	6.0	2.70	13.40	0.57	1.14
8/29/2018	3.7	25.8688	BC	0.04	0.68	0.08	11.6	13.0	12.40	13.40	0.05	0.73
7/28/2020	0.0	62.5485	2B	0.12	0.62	0.04	7.6	6.0	3.40	13.30	1.09	1.71
9/26/2018	29.3	62.5485	2B	0.11	1.05	0.14	14.2	17.0	2.80	13.30	0.37	1.42
10/20/2020	4.0	62.5485	2B	0.11	0.71	0.05	6.3	7.0	2.60	13.30	1.14	1.85
12/18/2019	100.6	62.5485	2B	0.05	0.82	0.04	14.6	3.0	3.10	13.30	0.09	0.91
2/13/2019	308.0	38.6102	HC	0.07	0.93	0.03	34.6	9.0	3.30	13.30	0.04	0.97
2/12/2020	12.4	43.2434	SC	0.06	0.81	0.03	34.7	12.0	2.90	13.30	0.04	0.85
10/3/2018	7.1	62.5485	2B	0.17	1.14	0.09	10.8	10.0	2.30	13.20	0.90	2.04
1/4/2017	48.0	62.5485	2B	0.06	0.82	0.04	6.3	3.0	3.60	12.90	0.17	0.99
10/30/2019	5.8	25.8688	BC	0.03	0.43	0.05	6.0	2.0	22.60	12.80	0.02	0.43
9/12/2018	1.7	62.5485	LB	0.03	0.71	0.04	10.3	4.0	2.20	12.80	0.02	0.73
6/7/2017	193.8	62.5485	2B	0.06	1.12	0.11	14.3	12.0	0.90	12.70	0.13	1.25
1/30/2018	91.0	62.5485	2B	0.05	0.54	0.05	5.8	2.0	4.40	12.70	0.12	0.66
4/10/2019	136.2	38.6102	HC	0.08	1.29	0.10	28.8	12.0	3.40	12.70	0.06	1.35
8/22/2018	8.0	25.8688	BC	0.04	0.71	0.11	10.1	7.0	12.30	12.50	0.02	0.71
9/22/2020	13.7	62.5485	2B	0.24	0.82	0.20	12.3	13.0	2.80	12.30	1.45	2.27
8/14/2019	16.4	62.5485	2B	0.12	0.53	0.04	6.5	5.0	3.30	12.30	1.03	1.56
6/27/2018	3.2	62.5485	2B	0.12	0.83	0.12	8.3	11.0	2.90	12.20	0.41	1.24
11/25/2019	66.9	241.314	MC	0.09	0.75	0.02	10.1	10.0	4.10	12.20	0.02	0.75
10/30/2019	15.5	62.5485	2B	0.10	0.79	0.10	11.3	6.0	3.80	12.10	0.35	1.14
3/13/2019	625.9	62.5485	2B	0.06	1.16	0.05	14.7	10.0	1.80	12.10	0.02	1.18
9/15/2020	13.5	62.5485	2B	0.16	0.74	0.05	8.9	9.0	2.70	11.70	0.99	1.73
10/23/2019	2.3	62.5485	2B	0.16	0.73	0.06	9.9	7.0	3.90	11.60	0.93	1.66
8/8/2018	33.9	62.5485	2B	0.14	0.79	0.05	7.3	6.0	2.60	11.60	0.33	1.12
10/6/2020	3.6	62.5485	2B	0.11	0.64	0.04	7.9	6.0	2.80	11.60	0.64	1.28
1/22/2020	64.1	62.5485	2B	0.05	0.75	0.08	8.9	4.0	2.90	11.60	0.14	0.89
8/7/2019	31.7	62.5485	2B	0.11	0.62	0.06	8.5	5.0	3.10	11.50	0.97	1.59
3/22/2017	0.8	17.7607	GC	0.05	0.51	0.03	11.2	9.0	8.40	11.40	0.02	0.51
1/10/2018	18.9	62.5485	2B	0.10	0.79	0.28	4.7	2.0	4.60	11.20	0.61	1.40
11/28/2018	19.6	62.5485	2B	0.07	0.80	0.16	6.8	4.0	2.70	11.10	0.35	1.15
7/5/2018	0.0	241.314	MC	0.11	1.00	0.06	14.9	12.0	5.50	11.10	0.02	1.00
2/15/2017	1.7	17.7607	GC	0.04	0.50	0.03	13.8	9.0	9.10	11.00	0.02	0.50
1/10/2017	20.3	62.5485	2B	0.07	0.67	0.09	3.9	2.0	3.70	10.90	0.44	1.11
6/19/2019	24.4	62.5485	2B	0.11	0.68	0.08	10.2	8.0	2.90	10.80	0.64	1.32
4/1/2020	379.7	38.6102	HC	0.06	1.01	0.03	33.4	19.0	2.80	10.80	0.06	1.07
7/11/2018	0.0	241.314	MC	0.09	1.02	0.04	14.5	11.0	4.30	10.80	0.02	1.02
3/29/2017	0.9	17.7607	GC	0.06	0.62	0.05	13.8	12.0	6.90	10.70	0.02	0.62
2/8/2017	33.8	62.5485	2B	0.09	0.52	0.06	4.7	5.0	4.00	10.60	0.37	0.89
12/5/2018	225.0	62.5485	2B	0.05	1.11	0.08	10.9	6.0	3.10	10.50	0.09	1.20
11/20/2018	63.6	62.5485	2B	0.06	0.99	0.08	8.7	3.0	2.80	10.40	0.19	1.18
1/24/2018	373.9	62.5485	2B	0.04	0.79	0.04	11.4	4.0	3.70	10.40	0.08	0.87
1/8/2020	6.5	25.8688	BC	0.02	0.55	0.02	11.7	1.0	11.40	10.40	0.02	0.55
6/21/2017	14.9	62.5485	2B	0.10	0.77	0.11	8.7	6.0	3.00	10.30	0.60	1.37
9/8/2020	14.6	62.5485	2B	0.13	0.69	0.07	10.1	10.0	2.20	10.20	0.45	1.14
3/15/2017	2.2	17.7607	GC	0.05	0.51	0.03	18.1	11.0	8.50	10.20	0.02	0.51
3/21/2018	0.9	17.7607	GC	0.05	0.49	0.03	13.6	19.0	8.80	10.20	0.02	0.49
5/3/2017	581.5	62.5485	2B	0.06	0.99	0.07	15.3	18.0	1.40	10.10	0.12	1.11
3/22/2017	8.1	25.8688	BC	0.05	0.59	0.03	13.6	12.0	9.10	10.10	0.02	0.59
8/22/2018	7.5	62.5485	2B	0.13	0.95	0.10	14.8	13.0	1.90	9.90	0.08	1.03
5/19/2017	74.1	62.5485	2B	0.07	0.89	0.08	10.7	10.0	2.10	9.90	0.33	1.22
8/18/2020	0.9	62.5485	2B	0.12	0.88	0.11	14.7	12.0	3.00	9.80	0.41	1.29
12/27/2017	44.8	62.5485	2B	0.08	0.72	0.13	6.2	5.0	4.50	9.80	0.13	0.85
2/19/2020	338.6	38.6102	HC	0.07	0.89	0.02	55.4	24.0	3.30	9.80	0.09	0.98
11/25/2019	34.1	62.5485	2B	0.08	0.72	0.05	7.6	5.0	3.90	9.70	0.16	0.88
11/13/2019	20.6	62.5485	2B	0.14	0.61	0.10	4.4	3.0	4.20	9.60	0.86	1.47
12/28/2016	86.8	62.5485	2B	0.07	0.71	0.06	6.5	3.0	3.80	9.50	0.11	0.82
2/15/2017	31.2	25.8688	BC	0.04	0.55	0.02	13.0	7.0	9.00	9.50	0.02	0.57
1/30/2018	12.3	25.8688	BC	0.03	0.51	0.02	11.1	3.0	11.70	9.50	0.02	0.51
7/5/2018	0.0	25.8688	BC	0.06	0.91	0.12	11.3	8.0	2.20	9.40	0.02	0.91

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
4/1/2020	11.5	43.2434	SC	0.08	1.13	0.04	40.3	18.0	2.90	9.30	0.02	1.13
2/8/2017	1.0	17.7607	GC	0.05	0.48	0.03	12.6	8.0	7.40	9.20	0.02	0.48
11/16/2016	2.2	241.314	MC	0.08	0.66	0.03	6.9	5.0	2.40	9.20	0.02	0.66
1/30/2018	44.1	25.8688	WW	0.04	0.60	0.02	21.3	5.0	9.30	9.20	0.02	0.62
7/14/2020	0.4	62.5485	2B	0.11	0.71	0.06	9.9	6.0	2.10	9.00	0.48	1.19
11/6/2019	11.3	62.5485	2B	0.10	0.72	0.11	5.9	5.0	4.50	9.00	0.52	1.24
9/29/2020	24.9	62.5485	2B	0.08	0.72	0.04	10.3	7.0	23.00	9.00	0.32	1.04
3/15/2017	15.6	25.8688	BC	0.05	0.54	0.03	13.9	8.0	8.60	9.00	0.02	0.54
10/31/2018	10.3	25.8688	BC	0.04	0.91	0.02	12.0	7.0	8.70	9.00	0.02	0.91
1/10/2017	1.3	17.7607	GC	0.04	0.43	0.04	11.8	4.0	7.90	9.00	0.02	0.45
3/4/2020	1.0	17.7607	GC	0.04	0.45	0.03	17.9	7.0	8.10	9.00	0.03	0.48
8/1/2018	0.1	241.314	MC	0.07	0.95	0.04	11.3	9.0	2.50	9.00	0.02	0.95
11/14/2018	458.1	62.5485	2B	0.05	1.09	0.03	12.3	10.0	2.40	8.90	0.06	1.15
1/31/2017	1.0	17.7607	GC	0.06	0.80	0.05	13.5	4.0	7.20	8.90	0.02	0.80
5/13/2020	0.3	17.7607	GC	0.05	0.86	0.17	19.2	11.0	6.70	8.90	0.05	0.91
1/2/2019	10.8	43.2434	SC	0.06	0.77	0.02	33.5	10.0	2.50	8.90	0.02	0.77
1/31/2017	27.5	62.5485	2B	0.07	0.68	0.04	4.6	2.0	4.40	8.80	0.34	1.02
1/2/2020	0.9	17.7607	GC	0.04	0.64	0.03	14.6	4.0	8.20	8.80	0.02	0.64
8/8/2018	1.8	241.314	MC	0.07	1.01	0.04	13.6	10.0	2.00	8.80	0.02	1.01
11/29/2017	2.3	25.8688	BC	0.09	1.07	0.13	27.9	10.0	8.60	8.70	0.10	1.17
2/8/2017	25.6	25.8688	BC	0.04	0.46	0.03	12.0	7.0	8.20	8.70	0.02	0.48
7/18/2018	4.8	241.314	MC	0.12	1.17	0.04	20.8	25.0	3.90	8.70	0.02	1.17
1/24/2018	372.7	241.314	MC	0.07	0.73	0.02	39.0	16.0	6.70	8.70	0.03	0.76
6/27/2018	0.3	25.8688	BC	0.05	0.85	0.13	7.5	9.0	2.40	8.60	0.03	0.88
12/18/2019	10.4	25.8688	BC	0.04	0.70	0.02	16.9	5.0	9.30	8.60	0.06	0.76
7/7/2020	3.0	62.5485	LB	0.04	0.62	0.02	9.5	8.0	0.80	8.60	0.03	0.65
1/30/2018	83.1	241.314	MC	0.03	0.58	0.03	16.5	2.0	9.50	8.60	0.02	0.58
1/30/2018	1.7	17.7607	GC	0.04	0.60	0.04	13.3	3.0	14.90	8.50	0.03	0.63
3/14/2018	1.5	17.7607	GC	0.03	0.51	0.03	14.4	11.0	8.20	8.50	0.02	0.53
7/25/2018	0.7	241.314	MC	0.10	1.09	0.04	11.3	11.0	3.00	8.50	0.02	1.09
11/9/2016	0.7	241.314	MC	0.09	0.73	0.03	6.7	7.0	2.60	8.50	0.02	0.73
11/2/2016	0.7	241.314	MC	0.10	0.75	0.04	10.7	7.0	3.80	8.40	0.02	0.75
3/22/2017	63.1	241.314	MC	0.08	0.60	0.03	17.6	9.0	6.70	8.40	0.02	0.60
3/22/2017	44.6	62.5485	2B	0.10	0.72	0.07	9.0	8.0	2.80	8.30	0.43	1.15
3/29/2017	55.5	62.5485	2B	0.09	1.27	0.11	7.5	7.0	2.30	8.30	0.25	1.52
1/4/2017	8.3	20.0773	LC	0.04	0.83	0.04	6.5	2.0	5.60	8.30	0.02	0.83
1/10/2017	7.4	25.8688	BC	0.03	0.46	0.05	11.6	6.0	7.40	8.20	0.02	0.46
3/11/2020	2.7	17.7607	GC	0.04	0.59	0.02	24.7	9.0	7.00	8.20	0.03	0.62
12/20/2017	335.6	241.314	MC	0.17	0.93	0.05	32.2	25.0	6.30	8.20	0.43	1.36
2/8/2017	37.5	241.314	MC	0.06	0.65	0.03	16.6	9.0	7.30	8.20	0.02	0.67
10/26/2016	1.8	241.314	MC	0.08	0.64	0.05	13.9	9.0	3.69	8.17	0.03	0.67
1/17/2017	153.4	62.5485	2B	0.15	1.13	0.12	21.3	14.0	3.30	8.10	0.36	1.49
7/31/2019	40.9	62.5485	2B	0.12	0.63	0.08	8.4	5.0	6.00	8.10	0.48	1.11
3/15/2017	110.0	62.5485	2B	0.06	0.70	0.04	9.1	5.0	3.10	8.10	0.12	0.82
5/10/2017	637.2	62.5485	2B	0.06	1.04	0.09	9.9	11.0	3.00	8.10	0.16	1.20
2/22/2017	607.0	62.5485	2B	0.04	0.91	0.04	13.8	11.0	2.80	8.10	0.05	0.96
3/11/2020	12.4	25.8688	BC	0.04	0.56	0.02	19.0	7.0	9.30	8.10	0.02	0.56
1/10/2018	8.8	25.8688	BC	0.03	0.48	0.02	7.8	2.0	13.00	8.10	0.08	0.56
1/24/2018	18.5	25.8688	BC	0.03	0.75	0.02	25.9	10.0	10.30	8.10	0.05	0.80
2/6/2019	0.6	17.7607	GC	0.04	0.46	0.04	12.6	4.0	8.10	8.10	0.02	0.48
11/13/2019	6.5	62.5485	LB	0.02	0.40	0.03	7.7	2.0	2.80	8.10	0.02	0.40
1/2/2020	351.0	241.314	MC	0.04	0.65	0.02	16.7	4.0	7.50	8.10	0.02	0.65
6/5/2019	36.2	62.5485	2B	0.11	0.81	0.17	10.0	9.0	2.80	8.00	0.59	1.40
1/24/2017	107.8	62.5485	2B	0.07	0.86	0.05	7.9	3.0	4.40	8.00	0.15	1.01
10/27/2020	9.5	25.8688	BC	0.04	0.57	0.03	10.8	3.0	6.80	8.00	0.02	0.57
2/12/2020	534.4	38.6102	HC	0.05	0.90	0.03	31.5	13.0	2.90	8.00	0.04	0.94
8/4/2020	10.7	241.314	MC	0.10	0.70	0.03	30.7	10.0	2.50	8.00	0.11	0.81
3/21/2018	77.9	62.5485	2B	0.08	0.58	0.02	9.5	10.0	2.40	7.90	0.25	0.83
2/15/2017	867.4	62.5485	2B	0.06	0.99	0.02	15.1	22.0	2.70	7.90	0.06	1.05
3/21/2018	12.2	25.8688	BC	0.04	0.49	0.03	11.2	12.0	9.80	7.90	0.12	0.61

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
12/21/2016	48.3	241.314	MC	0.06	0.55	0.03	11.0	5.0	8.40	7.90	0.05	0.60
8/4/2020	0.3	62.5485	2B	0.12	0.66	0.04	14.7	11.0	2.50	7.80	0.39	1.05
10/16/2019	57.8	62.5485	2B	0.11	0.75	0.08	22.1	9.0	3.30	7.80	0.35	1.10
11/16/2016	2.3	25.8688	BC	0.17	1.35	0.21	51.1	30.0	3.10	7.80	0.26	1.61
11/21/2016	4.2	241.314	MC	0.06	0.63	0.03	5.6	5.0	2.20	7.80	0.03	0.66
10/18/2017	0.3	25.8688	BC	0.08	1.38	0.25	23.4	14.0	2.60	7.70	0.08	1.46
12/21/2016	8.4	25.8688	BC	0.05	0.80	0.03	12.9	7.0	8.30	7.70	0.02	0.80
2/21/2018	84.1	17.7607	GC	0.05	0.86	0.03	28.9	28.0	7.80	7.70	0.05	0.91
10/27/2020	0.2	17.7607	GC	0.05	0.61	0.05	11.9	5.0	3.80	7.70	0.02	0.61
1/16/2019	1.1	17.7607	GC	0.04	0.76	0.05	17.1	4.0	8.30	7.70	0.03	0.79
1/8/2020	0.6	17.7607	GC	0.04	0.65	0.03	16.9	2.0	6.80	7.70	0.02	0.65
3/22/2017	13.8	25.8688	WW	0.06	0.66	0.03	17.9	14.0	5.80	7.70	0.02	0.66
2/5/2020	176.7	62.5485	2B	0.05	0.79	0.06	15.2	8.0	2.50	7.60	0.09	0.88
1/31/2017	8.4	25.8688	BC	0.05	0.59	0.04	12.9	5.0	7.90	7.60	0.02	0.59
1/22/2020	1.6	17.7607	GC	0.03	0.71	0.02	18.7	6.0	7.50	7.60	0.07	0.78
4/12/2017	540.4	38.6102	HC	0.08	1.05	0.02	38.1	22.0	2.40	7.60	0.04	1.09
1/10/2017	5.6	20.0773	LC	0.04	0.63	0.04	6.7	2.0	4.60	7.60	0.02	0.63
1/2/2020	52.2	62.5485	2B	0.07	0.71	0.24	11.2	3.0	3.00	7.50	0.20	0.91
8/11/2020	2.7	25.8688	BC	0.05	0.63	0.04	14.9	11.0	5.50	7.50	0.02	0.63
4/4/2018	2.1	17.7607	GC	0.04	0.58	0.05	15.4	10.0	6.70	7.50	0.02	0.58
3/21/2018	57.0	241.314	MC	0.07	1.06	0.02	19.8	21.0	2.60	7.50	0.16	1.22
11/9/2016	0.9	25.8688	BC	0.13	1.45	0.34	35.6	12.0	2.90	7.40	0.13	1.58
1/24/2017	3.6	17.7607	GC	0.05	0.83	0.05	19.5	9.0	6.80	7.40	0.02	0.85
9/15/2020	5.1	62.5485	LB	0.04	0.56	0.02	8.9	7.0	1.10	7.40	0.03	0.59
3/21/2018	26.9	25.8688	WW	0.04	0.58	0.02	16.0	7.0	5.80	7.40	0.02	0.58
6/28/2017	33.2	62.5485	2B	0.06	0.83	0.09	10.2	10.0	2.60	7.30	0.40	1.23
2/6/2019	248.9	62.5485	2B	0.04	0.74	0.09	11.3	6.0	2.00	7.30	0.08	0.82
11/2/2016	0.4	25.8688	BC	0.10	1.20	0.27	29.6	11.0	2.20	7.30	0.06	1.26
11/21/2017	1.1	25.8688	BC	0.09	1.11	0.10	35.5	28.0	5.80	7.30	0.36	1.47
3/4/2020	10.1	25.8688	BC	0.03	0.41	0.03	17.4	7.0	8.50	7.30	0.02	0.41
11/25/2019	9.4	37.838	CH	0.05	0.68	0.02	11.3	9.0	4.40	7.30	0.02	0.68
6/27/2018	0.1	17.7607	GC	0.09	1.20	0.16	23.1	26.0	1.10	7.30	0.02	1.20
9/15/2020	0.1	17.7607	GC	0.06	0.70	0.04	16.6	12.0	3.70	7.30	0.11	0.81
2/26/2020	3.6	17.7607	GC	0.03	0.46	0.02	17.6	6.0	7.50	7.30	0.03	0.49
2/8/2017	8.3	20.0773	LC	0.04	0.53	0.03	5.1	3.0	3.90	7.30	0.04	0.57
2/15/2017	10.6	20.0773	LC	0.04	0.59	0.02	5.8	4.0	3.20	7.30	0.03	0.62
1/30/2018	6.7	20.0773	LC	0.04	0.55	0.04	22.9	2.0	4.50	7.30	0.19	0.74
1/24/2018	28.7	25.8688	WW	0.06	0.66	0.02	24.2	9.0	8.80	7.30	0.13	0.79
5/13/2020	9.9	62.5485	2B	0.08	0.90	0.11	11.1	8.0	2.30	7.20	0.29	1.19
3/29/2017	10.1	25.8688	BC	0.06	0.79	0.04	15.5	13.0	6.00	7.20	0.02	0.79
12/13/2017	2.1	25.8688	BC	0.06	0.74	0.06	12.4	4.0	10.90	7.20	0.45	1.19
1/19/2017	106.0	17.7607	GC	0.06	0.93	0.08	29.1	23.0	5.10	7.20	0.03	0.96
10/20/2020	0.2	17.7607	GC	0.06	0.63	0.02	19.5	14.0	4.50	7.20	0.04	0.67
2/5/2020	23.5	17.7607	GC	0.05	0.89	0.03	30.9	21.0	6.50	7.20	0.06	0.95
9/29/2020	14.4	20.0773	LC	0.07	1.00	0.03	13.5	7.0	4.10	7.20	0.75	1.75
3/11/2020	126.1	241.314	MC	0.06	0.63	0.04	28.2	9.0	6.80	7.20	0.06	0.69
4/10/2019	2.3	43.2434	SC	0.06	1.01	0.06	29.0	10.0	3.00	7.20	0.02	1.03
3/11/2020	7.7	25.8688	WW	0.04	0.69	0.04	16.5	14.0	6.10	7.20	0.03	0.72
4/19/2017	9.3	25.8688	BC	0.04	0.68	0.06	23.1	17.0	6.40	7.10	0.03	0.71
7/5/2018	0.1	17.7607	GC	0.09	1.19	0.20	15.6	8.0	1.30	7.10	0.02	1.19
11/29/2017	1.7	241.314	MC	0.04	0.68	0.05	4.5	4.0	0.90	7.10	0.02	0.68
3/4/2020	3.3	25.8688	WW	0.05	0.67	0.05	25.5	8.0	5.60	7.10	0.03	0.70
10/13/2020	18.5	62.5485	2B	0.09	0.68	0.03	9.0	6.0	2.30	7.00	0.21	0.89
8/16/2017	90.8	62.5485	2B	0.07	1.06	0.06	10.4	10.0	1.70	7.00	0.15	1.21
1/8/2020	42.5	62.5485	2B	0.06	0.75	0.08	9.4	2.0	3.30	7.00	0.23	0.98
10/25/2017	0.7	25.8688	BC	0.08	1.32	0.28	34.1	22.0	3.70	7.00	0.26	1.58
11/15/2017	0.3	25.8688	BC	0.08	1.13	0.21	32.0	17.0	6.90	7.00	0.45	1.58
10/20/2020	5.7	25.8688	BC	0.04	0.50	0.02	16.4	8.0	6.20	7.00	0.04	0.54
10/10/2018	23.1	37.838	CH	0.12	1.40	0.04	309.0	128.0	39.00	7.00	0.28	1.68
12/6/2017	1.0	17.7607	GC	0.09	1.10	0.07	27.1	15.0	2.70	7.00	0.02	1.12

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
2/20/2019	35.1	17.7607	GC	0.04	0.67	0.04	29.5	28.0	6.70	7.00	0.04	0.71
6/17/2020	4.1	62.5485	2B	0.10	0.72	0.09	11.6	8.0	2.30	6.90	0.53	1.25
10/17/2018	39.0	62.5485	2B	0.09	1.13	0.14	16.2	11.0	2.10	6.90	0.32	1.45
10/4/2017	0.9	25.8688	BC	0.08	1.18	0.12	19.3	17.0	2.00	6.90	0.02	1.18
2/22/2017	52.1	25.8688	BC	0.06	0.98	0.15	35.7	27.0	6.10	6.90	0.03	1.01
11/1/2017	0.0	25.8688	BC	0.06	1.28	0.25	37.6	33.0	4.00	6.90	0.27	1.55
8/4/2020	3.2	25.8688	BC	0.06	0.65	0.07	21.9	12.0	5.60	6.90	0.05	0.70
3/14/2018	15.7	25.8688	BC	0.02	0.41	0.03	11.6	5.0	8.60	6.90	0.02	0.41
3/28/2018	230.0	17.7607	GC	0.11	1.22	0.02	78.5	198.0	5.10	6.90	0.04	1.26
4/26/2017	0.8	17.7607	GC	0.05	0.85	0.08	23.2	15.0	3.90	6.90	0.03	0.88
11/28/2018	1.6	17.7607	GC	0.03	0.60	0.02	10.9	3.0	5.40	6.90	0.02	0.60
3/15/2017	22.6	25.8688	WW	0.07	0.61	0.03	21.4	12.0	6.30	6.90	0.03	0.64
2/6/2019	2.2	25.8688	WW	0.02	0.50	0.04	22.3	6.0	7.20	6.90	0.02	0.52
10/10/2018	221.6	62.5485	2B	0.12	1.22	0.07	20.7	18.0	2.00	6.80	0.16	1.38
11/8/2017	0.0	25.8688	BC	0.08	1.47	0.35	42.2	25.0	4.70	6.80	0.26	1.73
9/20/2017	2.2	25.8688	BC	0.07	1.21	0.10	9.5	10.0	2.40	6.80	0.02	1.21
7/21/2020	0.1	17.7607	GC	0.07	0.77	0.07	21.0	5.0	2.80	6.80	0.14	0.91
1/24/2018	5.0	17.7607	GC	0.05	0.79	0.03	30.4	20.0	6.90	6.80	0.07	0.86
10/6/2020	0.2	17.7607	GC	0.05	0.59	0.03	21.3	9.0	4.70	6.80	0.06	0.65
10/13/2020	0.9	17.7607	GC	0.05	0.66	0.02	21.4	14.0	4.30	6.80	0.02	0.66
4/3/2019	0.4	17.7607	GC	0.03	0.55	0.04	11.0	8.0	7.10	6.80	0.02	0.55
3/22/2017	7.0	20.0773	LC	0.04	0.70	0.02	5.5	4.0	2.40	6.80	0.02	0.70
1/10/2018	5.4	20.0773	LC	0.04	0.55	0.02	9.5	1.0	5.20	6.80	0.45	1.00
3/29/2017	203.9	241.314	MC	0.08	0.67	0.06	18.3	17.0	5.40	6.80	0.02	0.69
1/2/2020	2.2	25.8688	WW	0.04	0.70	0.03	21.4	6.0	5.80	6.80	0.05	0.75
3/8/2017	366.6	62.5485	2B	0.06	0.99	0.05	14.1	9.0	3.00	6.70	0.06	1.05
9/27/2017	1.5	25.8688	BC	0.07	1.20	0.08	14.2	14.0	4.10	6.70	0.02	1.20
6/21/2017	0.1	17.7607	GC	0.08	1.31	0.33	31.5	26.0	2.40	6.70	0.03	1.34
7/28/2020	0.1	17.7607	GC	0.07	0.68	0.04	22.6	5.0	2.10	6.70	0.13	0.81
4/8/2020	2.8	17.7607	GC	0.06	0.63	0.04	21.9	12.0	5.40	6.70	0.04	0.67
3/25/2020	6.8	17.7607	GC	0.04	0.74	0.02	28.1	12.0	5.90	6.70	0.02	0.76
1/17/2017	10.4	20.0773	LC	0.04	0.72	0.06	8.4	6.0	3.90	6.70	0.02	0.74
1/31/2017	7.2	20.0773	LC	0.04	0.57	0.03	5.6	1.0	3.90	6.70	0.12	0.69
3/15/2017	211.9	241.314	MC	0.05	0.62	0.04	22.3	13.0	7.00	6.70	0.03	0.65
2/8/2017	13.8	25.8688	WW	0.06	0.61	0.03	15.6	11.0	3.70	6.70	0.02	0.61
8/15/2018	23.5	62.5485	2B	0.12	0.73	0.08	9.2	8.0	2.00	6.60	0.36	1.09
5/1/2019	206.4	62.5485	2B	0.09	1.11	0.27	16.7	20.0	1.90	6.60	0.17	1.28
12/6/2017	0.4	25.8688	BC	0.09	1.13	0.13	23.2	16.0	11.50	6.60	1.12	2.25
1/22/2020	9.8	25.8688	BC	0.04	0.94	0.05	17.0	7.0	8.80	6.60	0.09	1.03
11/28/2018	10.4	25.8688	BC	0.03	0.59	0.03	8.7	3.0	6.50	6.60	0.02	0.59
1/24/2018	44.2	37.838	CH	0.07	0.88	0.02	29.8	16.0	5.30	6.60	0.11	0.99
7/11/2018	0.1	17.7607	GC	0.08	1.16	0.11	18.4	11.0	1.20	6.60	0.02	1.16
3/8/2017	42.6	17.7607	GC	0.07	1.12	0.05	36.9	37.0	4.90	6.60	0.03	1.15
12/4/2019	8.5	62.5485	LB	0.03	0.71	0.02	9.9	2.0	2.20	6.60	0.02	0.71
12/11/2019	11.1	62.5485	LB	0.03	0.48	0.02	8.5	2.0	1.80	6.60	0.02	0.48
10/27/2020	185.5	241.314	MC	0.07	0.53	0.02	17.6	8.0	4.80	6.60	0.02	0.53
10/18/2017	0.2	241.314	MC	0.06	0.64	0.05	11.6	7.0	1.40	6.60	0.02	0.66
10/25/2017	0.5	241.314	MC	0.05	0.61	0.03	10.0	6.0	1.40	6.60	0.02	0.61
11/20/2019	30.9	241.314	MC	0.05	0.62	0.03	10.3	4.0	8.20	6.60	0.02	0.62
1/8/2020	55.1	241.314	MC	0.04	0.65	0.02	14.9	3.0	7.50	6.60	0.02	0.65
11/15/2017	1.1	241.314	MC	0.03	0.66	0.07	4.3	4.0	1.60	6.60	0.02	0.66
1/10/2018	62.8	25.8688	WW	0.05	0.63	0.02	21.6	5.0	7.60	6.60	0.08	0.71
6/3/2020	13.4	62.5485	2B	0.08	0.78	0.16	11.3	11.0	2.00	6.50	0.26	1.04
12/20/2017	26.6	25.8688	BC	0.10	1.03	0.02	26.7	19.0	3.10	6.50	0.02	1.05
9/13/2017	3.0	25.8688	BC	0.08	1.13	0.11	14.4	15.0	2.50	6.50	0.02	1.13
2/7/2018	163.8	25.8688	BC	0.08	0.96	0.03	118.0	255.0	8.40	6.50	0.08	1.04
9/6/2017	4.7	25.8688	BC	0.06	1.11	0.13	16.6	14.0	3.20	6.50	0.03	1.14
2/6/2019	6.1	25.8688	BC	0.02	0.44	0.02	11.4	5.0	8.50	6.50	0.02	0.44
8/4/2020	0.1	17.7607	GC	0.07	0.74	0.03	28.9	12.0	1.80	6.50	0.12	0.86
5/19/2017	0.3	17.7607	GC	0.06	1.00	0.14	31.6	23.0	4.10	6.50	0.06	1.06

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
6/3/2020	0.4	17.7607	GC	0.06	0.86	0.16	24.5	16.0	4.70	6.50	0.08	0.94
8/11/2020	0.1	17.7607	GC	0.06	0.72	0.03	25.6	14.0	1.70	6.50	0.06	0.78
10/13/2020	18.6	20.0773	LC	0.05	0.69	0.02	16.2	7.0	2.50	6.50	0.22	0.91
8/11/2020	25.1	241.314	MC	0.10	0.72	0.03	27.3	17.0	2.80	6.50	0.09	0.81
6/21/2017	31.1	241.314	MC	0.09	0.95	0.06	39.0	22.0	3.00	6.50	0.22	1.17
3/8/2017	489.5	241.314	MC	0.08	0.87	0.05	28.4	22.0	5.90	6.50	0.05	0.92
12/13/2017	2.3	241.314	MC	0.05	0.62	0.03	3.7	4.0	1.30	6.50	0.02	0.64
1/10/2017	84.5	241.314	MC	0.04	0.66	0.04	14.4	6.0	6.00	6.50	0.02	0.68
11/21/2017	1.1	241.314	MC	0.04	0.69	0.04	4.6	7.0	0.00	6.50	0.02	0.69
1/10/2018	36.1	241.314	MC	0.04	0.43	0.02	13.1	2.0	10.70	6.50	0.08	0.51
4/3/2019	92.2	62.5485	2B	0.07	0.83	0.18	7.7	7.0	2.80	6.40	0.21	1.04
7/11/2018	1.1	25.8688	BC	0.08	0.85	0.07	32.2	20.0	3.20	6.40	0.24	1.09
4/4/2018	15.9	25.8688	BC	0.04	0.54	0.04	12.0	6.0	7.50	6.40	0.02	0.56
10/13/2020	7.6	25.8688	BC	0.04	0.66	0.02	16.5	8.0	59.00	6.40	0.02	0.68
11/16/2016	0.1	17.7607	GC	0.16	1.28	0.06	52.7	13.0	0.00	6.40	0.03	1.31
5/24/2017	0.9	17.7607	GC	0.10	0.98	0.11	29.6	21.0	5.10	6.40	0.05	1.03
7/14/2020	0.2	17.7607	GC	0.07	0.77	0.11	23.5	10.0	3.60	6.40	0.16	0.93
1/4/2017	3.9	17.7607	GC	0.05	0.68	0.06	17.4	10.0	6.60	6.40	0.02	0.70
5/6/2020	0.4	17.7607	GC	0.05	0.99	0.22	15.8	14.0	4.40	6.40	0.05	1.04
1/30/2019	1.1	17.7607	GC	0.03	0.42	0.03	14.5	5.0	7.50	6.40	0.03	0.45
11/8/2017	0.8	241.314	MC	0.05	0.65	0.02	5.4	7.0	1.20	6.40	0.02	0.67
12/6/2017	2.5	241.314	MC	0.05	0.68	0.04	6.1	5.0	1.00	6.40	0.02	0.70
1/22/2020	1.0	25.8688	WW	0.04	0.69	0.04	24.7	7.0	6.70	6.40	0.07	0.76
6/12/2019	42.4	62.5485	2B	0.14	0.86	0.22	9.1	9.0	2.30	6.30	0.49	1.35
5/29/2019	54.1	62.5485	2B	0.11	0.89	0.18	12.1	7.0	2.40	6.30	0.39	1.28
6/14/2017	33.2	62.5485	2B	0.08	0.90	0.11	9.3	10.0	2.10	6.30	0.62	1.52
4/29/2020	268.9	62.5485	2B	0.06	0.77	0.08	36.9	38.0	1.20	6.30	0.06	0.83
10/26/2016	0.3	25.8688	BC	0.09	0.92	0.12	25.5	13.0	1.87	6.30	0.02	0.94
12/14/2016	15.2	25.8688	BC	0.06	0.79	0.02	12.2	6.0	5.50	6.30	0.02	0.79
10/6/2020	4.7	25.8688	BC	0.04	0.50	0.03	13.9	7.0	7.30	6.30	0.07	0.57
1/16/2019	11.8	25.8688	BC	0.03	0.37	0.03	14.4	3.0	7.40	6.30	0.02	0.37
11/21/2016	0.5	17.7607	GC	0.26	1.97	0.04	77.4	49.0	1.50	6.30	0.03	2.00
2/7/2018	149.1	17.7607	GC	0.09	0.96	0.04	49.0	106.0	5.00	6.30	0.07	1.03
9/22/2020	0.3	17.7607	GC	0.08	0.73	0.03	28.3	28.0	2.70	6.30	0.07	0.80
3/15/2017	12.3	20.0773	LC	0.03	0.65	0.04	10.2	5.0	2.70	6.30	0.14	0.79
2/21/2018	126.6	25.8688	WW	0.05	0.56	0.03	33.4	20.0	7.20	6.30	0.04	0.60
12/7/2016	44.0	62.5485	2B	0.09	0.74	0.06	12.5	5.0	3.60	6.20	0.28	1.02
3/28/2018	1003.0	62.5485	2B	0.09	1.02	0.02	35.4	49.0	1.70	6.20	0.04	1.06
2/7/2018	1456.3	62.5485	2B	0.06	0.83	0.04	32.3	49.0	2.40	6.20	0.08	0.91
7/17/2019	1243.8	62.5485	2B	0.05	0.97	0.04	16.3	16.0	1.10	6.20	0.03	1.00
11/20/2018	11.2	25.8688	BC	0.03	0.73	0.04	13.0	5.0	7.30	6.20	0.02	0.73
7/26/2017	0.1	17.7607	GC	0.11	1.28	0.24	26.4	30.0	1.90	6.20	0.02	1.28
11/20/2019	4.4	62.5485	LB	0.03	0.39	0.02	7.4	2.0	2.60	6.20	0.08	0.47
1/24/2018	11.9	20.0773	LC	0.07	0.80	0.03	74.7	14.0	4.20	6.20	0.18	0.98
10/4/2017	0.3	241.314	MC	0.07	0.76	0.06	8.5	10.0	1.50	6.20	0.02	0.76
1/31/2017	57.6	241.314	MC	0.05	0.56	0.04	17.5	5.0	7.10	6.20	0.02	0.58
11/1/2017	0.7	241.314	MC	0.03	0.53	0.03	7.8	5.0	1.50	6.20	0.02	0.55
10/31/2018	20.0	25.8688	WW	0.06	0.86	0.03	13.1	4.0	4.10	6.20	0.07	0.93
12/11/2019	0.7	25.8688	WW	0.05	0.67	0.03	17.7	5.0	4.30	6.20	0.02	0.67
11/30/2016	12.3	62.5485	2B	0.11	0.68	0.07	22.9	11.0	2.80	6.10	0.24	0.92
7/5/2017	113.5	62.5485	2B	0.09	1.17	0.08	10.1	11.0	1.00	6.10	0.13	1.30
7/1/2020	11.8	62.5485	2B	0.09	0.70	0.07	12.1	8.0	1.80	6.10	0.33	1.03
12/7/2016	9.5	25.8688	BC	0.06	0.87	0.03	15.3	9.0	15.50	6.10	0.02	0.87
7/28/2020	3.5	25.8688	BC	0.06	0.75	0.09	17.8	15.0	3.60	6.10	0.04	0.79
9/22/2020	6.6	25.8688	BC	0.06	0.61	0.03	17.1	15.0	4.80	6.10	0.07	0.68
2/26/2020	15.6	25.8688	BC	0.03	0.44	0.02	15.4	5.0	8.00	6.10	0.03	0.47
5/10/2017	0.6	17.7607	GC	0.06	0.65	0.07	25.3	16.0	6.20	6.10	0.06	0.71
2/19/2020	24.2	17.7607	GC	0.04	0.67	0.03	30.0	18.0	6.00	6.10	0.06	0.73
3/20/2019	0.8	17.7607	GC	0.03	0.58	0.03	15.9	7.0	7.20	6.10	0.02	0.58
12/7/2016	1.0	20.0773	LC	0.09	0.93	0.03	16.0	12.0	8.20	6.10	0.15	1.08

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
3/8/2017	14.4	20.0773	LC	0.06	0.74	0.05	8.9	6.0	3.00	6.10	0.08	0.82
10/20/2020	22.9	241.314	MC	0.07	0.56	0.02	18.9	10.0	4.70	6.10	0.02	0.58
12/14/2016	31.6	241.314	MC	0.06	0.66	0.04	11.5	3.0	6.80	6.10	0.12	0.78
3/4/2020	409.1	241.314	MC	0.04	0.52	0.03	21.3	7.0	7.20	6.10	0.04	0.56
1/17/2017	25.5	25.8688	WW	0.08	0.72	0.04	19.2	12.0	4.50	6.10	0.02	0.74
1/4/2017	24.3	25.8688	WW	0.06	0.74	0.03	18.8	10.0	6.60	6.10	0.02	0.76
1/10/2017	14.4	25.8688	WW	0.04	0.69	0.03	14.4	5.0	4.90	6.10	0.02	0.69
11/28/2018	18.6	25.8688	WW	0.04	0.81	0.03	13.3	3.0	4.90	6.10	0.02	0.81
10/24/2018	16.8	25.8688	WW	0.03	0.79	0.04	13.4	6.0	2.30	6.10	0.05	0.84
4/4/2018	237.0	62.5485	2B	0.06	0.95	0.07	10.8	7.0	2.00	6.00	0.09	1.04
3/8/2017	53.4	25.8688	BC	0.06	0.90	0.04	41.2	38.0	6.30	6.00	0.02	0.92
12/4/2019	7.0	25.8688	BC	0.04	0.69	0.02	14.4	4.0	5.90	6.00	0.02	0.69
2/5/2020	26.6	25.8688	BC	0.04	0.65	0.03	26.7	16.0	8.60	6.00	0.05	0.70
9/15/2020	4.9	25.8688	BC	0.04	0.69	0.04	15.0	9.0	5.20	6.00	0.07	0.76
7/18/2018	0.1	17.7607	GC	0.10	1.33	0.20	20.1	13.0	1.20	6.00	0.02	1.33
2/22/2017	70.7	17.7607	GC	0.05	1.01	0.03	37.9	33.0	4.00	6.00	0.05	1.06
9/8/2020	0.4	17.7607	GC	0.05	0.68	0.03	19.1	12.0	4.00	6.00	0.09	0.77
1/30/2018	21.2	62.5485	LB	0.02	0.60	0.02	8.2	1.0	4.10	6.00	0.02	0.62
2/5/2020	1008.3	241.314	MC	0.06	0.93	0.07	29.0	16.0	6.40	6.00	0.10	1.03
4/26/2017	16.3	25.8688	WW	0.06	0.90	0.10	30.8	19.0	2.80	6.00	0.06	0.96
12/18/2019	4.9	25.8688	WW	0.06	0.76	0.03	33.6	11.0	5.40	6.00	0.07	0.83
12/21/2016	12.5	25.8688	WW	0.05	0.75	0.02	8.8	5.0	5.80	6.00	0.02	0.75
9/1/2020	9.9	62.5485	2B	0.12	0.88	0.10	12.7	12.0	2.30	5.90	0.31	1.19
12/11/2019	41.3	62.5485	2B	0.09	0.85	0.16	14.1	4.0	3.40	5.90	0.31	1.16
4/26/2017	10.7	25.8688	BC	0.04	0.84	0.06	22.9	19.0	4.60	5.90	0.02	0.86
10/17/2018	13.8	25.8688	BC	0.04	1.02	0.04	23.9	11.0	6.00	5.90	0.04	1.06
1/17/2017	44.8	17.7607	GC	0.14	1.05	0.05	47.7	62.0	4.30	5.90	0.03	1.08
1/10/2017	14.1	62.5485	LB	0.03	0.58	0.03	9.4	3.0	2.30	5.90	0.06	0.64
12/27/2017	6.8	20.0773	LC	0.05	0.59	0.02	23.0	5.0	6.00	5.90	0.36	0.95
9/27/2017	2.2	241.314	MC	0.07	0.77	0.07	9.8	7.0	2.50	5.90	0.02	0.79
11/13/2019	22.5	241.314	MC	0.06	0.70	0.03	14.9	5.0	7.50	5.90	0.02	0.70
1/22/2020	901.0	241.314	MC	0.04	0.61	0.02	21.4	7.0	6.90	5.90	0.05	0.66
4/19/2017	22.3	25.8688	WW	0.05	0.95	0.08	25.8	14.0	5.70	5.90	0.05	1.00
12/4/2019	0.5	25.8688	WW	0.04	0.69	0.02	18.4	8.0	5.60	5.90	0.03	0.72
2/19/2020	2.1	25.8688	WW	0.03	0.55	0.04	23.6	6.0	5.80	5.90	0.06	0.61
7/10/2019	84.6	62.5485	2B	0.09	0.80	0.05	9.2	11.0	1.40	5.80	0.20	1.00
3/4/2020	55.8	62.5485	2B	0.08	0.83	0.05	11.6	6.0	2.80	5.80	0.17	1.00
7/21/2020	3.0	25.8688	BC	0.07	0.97	0.16	23.6	19.0	4.10	5.80	0.02	0.99
11/25/2019	7.7	25.8688	BC	0.05	0.74	0.02	11.1	10.0	5.80	5.80	0.02	0.74
5/13/2020	4.9	25.8688	BC	0.04	0.68	0.09	20.2	12.0	5.10	5.80	0.02	0.70
12/27/2017	10.5	25.8688	BC	0.03	0.69	0.02	14.8	6.0	9.20	5.80	0.16	0.85
2/20/2019	55.7	25.8688	BC	0.02	0.59	0.04	29.1	39.0	7.50	5.80	0.03	0.62
2/8/2017	19.0	37.838	CH	0.05	0.44	0.03	9.9	6.0	4.80	5.80	0.02	0.44
11/9/2016	0.2	17.7607	GC	0.14	1.08	0.08	36.8	14.0	0.80	5.80	0.02	1.10
7/5/2017	0.2	17.7607	GC	0.09	0.98	0.17	27.6	18.0	3.80	5.80	0.05	1.03
9/6/2017	0.4	17.7607	GC	0.08	1.16	0.23	15.9	16.0	2.30	5.80	0.02	1.18
8/8/2018	0.1	17.7607	GC	0.06	1.32	0.26	17.7	11.0	0.80	5.80	0.02	1.34
9/29/2020	12.7	17.7607	GC	0.05	0.83	0.02	28.1	27.0	6.20	5.80	0.03	0.86
1/24/2018	99.9	62.5485	LB	0.02	0.70	0.03	10.8	2.0	4.20	5.80	0.04	0.74
8/22/2018	13.1	241.314	MC	0.14	1.10	0.10	15.7	11.0	3.20	5.80	0.12	1.22
12/28/2016	34.9	25.8688	WW	0.09	0.72	0.03	26.5	19.0	5.30	5.80	0.02	0.74
2/26/2020	4.2	25.8688	WW	0.04	0.56	0.04	23.9	9.0	6.10	5.80	0.04	0.60
4/19/2017	80.7	62.5485	2B	0.10	1.01	0.22	14.2	12.0	1.80	5.70	0.30	1.31
1/17/2017	60.1	25.8688	BC	0.15	0.80	0.05	67.1	104.0	6.60	5.70	0.04	0.84
1/15/2020	16.6	25.8688	BC	0.04	0.72	0.03	17.3	6.0	8.30	5.70	0.12	0.84
11/2/2016	0.2	17.7607	GC	0.12	1.05	0.08	25.4	15.0	1.30	5.70	0.02	1.07
6/5/2019	0.1	17.7607	GC	0.09	1.28	0.40	26.6	14.0	2.50	5.70	0.05	1.33
7/25/2018	0.1	17.7607	GC	0.08	1.22	0.24	17.7	15.0	1.00	5.70	0.02	1.22
7/1/2020	0.3	17.7607	GC	0.07	0.86	0.10	36.6	25.0	3.40	5.70	0.14	1.00
8/25/2020	0.1	17.7607	GC	0.05	0.55	0.03	19.6	9.0	4.30	5.70	0.15	0.70

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
3/6/2019	2.4	17.7607	GC	0.03	0.57	0.03	20.6	6.0	10.50	5.70	0.03	0.60
8/4/2020	2.1	62.5485	LB	0.04	0.61	0.02	8.4	8.0	0.90	5.70	0.03	0.64
2/26/2020	43.7	62.5485	LB	0.03	0.71	0.05	14.8	6.0	2.20	5.70	0.02	0.73
11/28/2018	9.0	20.0773	LC	0.05	0.63	0.04	17.9	6.0	2.90	5.70	0.14	0.77
11/25/2019	18.0	20.0773	LC	0.03	0.59	0.02	9.7	4.0	3.30	5.70	0.02	0.59
4/4/2018	44.1	25.8688	WW	0.06	0.73	0.04	26.1	15.0	4.90	5.70	0.02	0.75
11/25/2019	0.5	25.8688	WW	0.05	0.69	0.02	16.1	6.0	4.90	5.70	0.02	0.69
7/5/2017	9.0	25.8688	BC	0.08	0.91	0.10	32.2	22.0	5.60	5.60	0.10	1.01
2/21/2018	280.6	25.8688	BC	0.07	0.67	0.02	58.4	101.0	6.60	5.60	0.03	0.70
12/11/2019	6.4	25.8688	BC	0.04	0.66	0.04	10.5	2.0	5.80	5.60	0.02	0.66
2/19/2020	52.1	25.8688	BC	0.04	0.67	0.02	34.4	31.0	7.40	5.60	0.02	0.69
10/24/2018	7.8	25.8688	BC	0.03	1.02	0.04	17.9	5.0	4.40	5.60	0.03	1.05
1/30/2018	35.4	37.838	CH	0.03	0.56	0.02	13.4	5.0	5.90	5.60	0.02	0.58
8/1/2018	0.1	17.7607	GC	0.06	1.33	0.44	16.5	8.0	2.60	5.60	0.02	1.33
6/19/2019	8.6	62.5485	LB	0.06	0.93	0.04	17.8	15.0	0.70	5.60	0.02	0.93
11/28/2018	16.0	62.5485	LB	0.03	0.57	0.02	9.2	3.0	1.60	5.60	0.03	0.60
8/25/2020	0.6	20.0773	LC	0.09	1.02	0.11	9.8	5.0	0.50	5.60	0.03	1.05
10/6/2020	6.1	20.0773	LC	0.06	0.61	0.03	24.6	10.0	3.90	5.60	0.08	0.69
1/24/2017	17.1	20.0773	LC	0.05	0.82	0.04	8.5	4.0	3.90	5.60	0.16	0.98
10/20/2020	7.8	20.0773	LC	0.05	0.59	0.02	11.1	6.0	2.40	5.60	0.04	0.63
11/30/2016	62.1	241.314	MC	0.13	0.68	0.03	18.5	13.0	4.80	5.60	0.02	0.68
12/7/2016	78.3	241.314	MC	0.09	0.61	0.02	15.3	5.0	7.10	5.60	0.32	0.93
12/11/2019	46.4	241.314	MC	0.04	0.51	0.03	11.5	3.0	8.30	5.60	0.02	0.51
11/9/2016	3.0	25.8688	WW	0.56	2.60	0.06	323.0	175.0	3.50	5.60	0.10	2.70
8/30/2017	15.1	25.8688	WW	0.07	1.09	0.10	13.9	10.0	2.30	5.60	0.02	1.09
6/21/2017	12.8	25.8688	WW	0.06	1.10	0.07	33.7	14.0	1.80	5.60	0.10	1.20
10/20/2020	3.5	25.8688	WW	0.06	0.72	0.03	17.8	11.0	3.00	5.60	0.02	0.72
1/31/2017	14.0	25.8688	WW	0.05	0.73	0.03	19.3	6.0	5.80	5.60	0.02	0.73
4/3/2019	0.9	25.8688	WW	0.05	0.69	0.04	17.6	11.0	5.80	5.60	0.02	0.69
4/26/2017	133.2	62.5485	2B	0.07	0.95	0.11	8.7	7.0	1.40	5.50	0.16	1.11
3/14/2018	169.1	62.5485	2B	0.06	0.66	0.03	9.3	9.0	2.30	5.50	0.11	0.77
11/30/2016	3.8	25.8688	BC	0.07	0.79	0.03	20.7	13.0	5.50	5.50	0.06	0.85
4/8/2020	13.6	25.8688	BC	0.06	0.60	0.02	20.5	11.0	5.80	5.50	0.02	0.60
5/19/2017	6.0	25.8688	BC	0.05	0.71	0.08	21.8	14.0	4.40	5.50	0.04	0.75
9/4/2019	0.4	25.8688	BC	0.05	0.77	0.06	9.3	9.0	2.30	5.50	0.02	0.77
8/25/2020	3.4	25.8688	BC	0.05	0.58	0.05	19.1	13.0	5.90	5.50	0.06	0.64
12/5/2018	14.2	25.8688	BC	0.03	0.79	0.13	16.3	5.0	6.80	5.50	0.03	0.82
11/29/2017	0.9	17.7607	GC	0.09	0.92	0.10	17.4	7.0	1.10	5.50	0.02	0.92
6/14/2017	0.1	17.7607	GC	0.08	1.18	0.23	27.1	20.0	2.40	5.50	0.07	1.25
1/10/2018	1.4	17.7607	GC	0.06	0.73	0.04	18.4	5.0	7.50	5.50	0.04	0.77
10/17/2018	0.5	17.7607	GC	0.06	1.27	0.06	32.8	9.0	4.30	5.50	0.04	1.31
6/17/2020	0.3	17.7607	GC	0.06	0.86	0.14	33.3	21.0	3.90	5.50	0.10	0.96
12/5/2018	4.8	17.7607	GC	0.04	1.15	0.22	17.5	5.0	5.50	5.50	0.03	1.18
1/15/2020	10.3	17.7607	GC	0.04	0.70	0.03	20.9	8.0	6.90	5.50	0.16	0.86
11/6/2019	4.6	62.5485	LB	0.02	0.49	0.02	8.6	7.0	3.40	5.50	0.02	0.49
10/31/2018	4.9	20.0773	LC	0.08	0.89	0.03	20.6	5.0	2.70	5.50	0.40	1.29
2/15/2017	671.3	241.314	MC	0.12	0.81	0.02	29.3	24.0	4.90	5.50	0.12	0.93
10/17/2018	123.9	241.314	MC	0.08	0.93	0.03	22.4	10.0	3.00	5.50	0.08	1.01
11/16/2016	2.9	25.8688	WW	0.54	2.58	0.07	253.0	76.0	3.80	5.50	0.05	2.63
3/8/2017	79.2	25.8688	WW	0.08	1.03	0.06	46.3	59.0	3.90	5.50	0.03	1.06
6/3/2020	5.0	25.8688	WW	0.08	0.88	0.08	32.2	16.0	3.40	5.50	0.20	1.08
10/27/2020	4.3	25.8688	WW	0.06	0.77	0.04	25.1	11.0	4.10	5.50	0.06	0.83
1/29/2020	49.4	25.8688	WW	0.04	0.64	0.02	32.7	20.0	6.00	5.50	0.07	0.71
12/20/2017	1104.3	62.5485	2B	0.08	0.97	0.03	29.1	38.0	2.60	5.40	0.14	1.11
3/11/2020	91.3	62.5485	2B	0.05	0.79	0.07	17.3	8.0	2.20	5.40	0.08	0.87
5/10/2017	9.1	25.8688	BC	0.04	0.58	0.07	20.5	12.0	4.80	5.40	0.04	0.62
4/3/2019	5.4	25.8688	BC	0.03	0.64	0.04	10.5	6.0	7.30	5.40	0.02	0.64
1/30/2019	12.2	25.8688	BC	0.02	0.42	0.04	11.8	3.0	7.60	5.40	0.07	0.49
4/5/2017	5.9	17.7607	GC	0.05	0.77	0.07	25.7	20.0	5.90	5.40	0.04	0.81
5/3/2017	17.1	17.7607	GC	0.05	0.82	0.06	28.6	20.0	6.30	5.40	0.05	0.87

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
12/11/2019	0.5	17.7607	GC	0.05	0.68	0.07	12.8	1.0	5.00	5.40	0.02	0.68
1/29/2020	50.5	17.7607	GC	0.03	0.72	0.03	27.8	11.0	5.60	5.40	0.07	0.79
12/21/2016	11.8	62.5485	LB	0.05	0.50	0.02	19.1	4.0	3.50	5.40	0.07	0.57
1/2/2020	13.8	62.5485	LB	0.03	0.59	0.02	11.7	3.0	2.00	5.40	0.02	0.59
10/24/2018	4.6	20.0773	LC	0.11	0.96	0.03	21.0	4.0	2.70	5.40	1.34	2.30
8/18/2020	0.1	20.0773	LC	0.09	1.08	0.03	12.7	12.0	0.50	5.40	0.03	1.11
7/26/2017	10.1	241.314	MC	0.12	0.85	0.05	27.3	21.0	2.40	5.40	0.13	0.98
11/28/2018	41.9	241.314	MC	0.05	0.52	0.03	11.5	3.0	5.60	5.40	0.02	0.52
1/16/2019	11.1	25.8688	WW	0.04	0.71	0.04	20.1	3.0	4.90	5.40	0.02	0.71
7/26/2017	14.6	25.8688	BC	0.08	1.12	0.18	29.0	31.0	3.30	5.30	0.02	1.12
7/14/2020	4.1	25.8688	BC	0.06	0.87	0.15	21.2	13.0	5.50	5.30	0.06	0.93
1/24/2017	21.3	25.8688	BC	0.05	0.65	0.04	23.4	11.0	6.00	5.30	0.02	0.65
5/6/2020	6.8	25.8688	BC	0.05	0.82	0.09	13.6	15.0	5.30	5.30	0.06	0.88
3/25/2020	22.4	25.8688	BC	0.03	0.65	0.02	24.2	10.0	5.80	5.30	0.02	0.65
1/31/2017	19.2	37.838	CH	0.05	0.56	0.04	13.0	5.0	5.10	5.30	0.03	0.59
8/30/2017	0.1	17.7607	GC	0.12	1.30	0.24	26.7	30.0	2.70	5.30	0.02	1.30
9/13/2017	0.1	17.7607	GC	0.09	0.97	0.21	26.2	15.0	2.40	5.30	0.04	1.01
1/10/2018	7.5	62.5485	LB	0.02	0.40	0.02	8.9	2.0	4.10	5.30	0.12	0.52
8/11/2020	0.0	20.0773	LC	0.10	0.87	0.05	10.4	9.0	0.50	5.30	0.02	0.87
6/28/2017	1.9	20.0773	LC	0.05	0.91	0.07	47.3	16.0	1.90	5.30	0.07	0.98
1/17/2017	154.7	241.314	MC	0.10	0.83	0.05	36.8	32.0	6.90	5.30	0.05	0.88
3/14/2018	141.5	241.314	MC	0.06	0.99	0.02	14.1	8.0	2.80	5.30	0.02	0.99
12/4/2019	49.2	241.314	MC	0.06	0.75	0.02	15.3	3.0	7.10	5.30	0.02	0.75
12/18/2019	266.3	241.314	MC	0.06	0.74	0.03	26.7	11.0	6.30	5.30	0.02	0.76
10/13/2020	104.6	241.314	MC	0.06	0.68	0.02	28.1	16.0	4.30	5.30	0.02	0.70
3/25/2020	416.2	241.314	MC	0.05	0.61	0.03	26.4	11.0	5.60	5.30	0.05	0.66
2/6/2019	75.6	241.314	MC	0.04	0.54	0.06	15.3	5.0	6.90	5.30	0.04	0.58
11/2/2016	3.2	25.8688	WW	0.40	2.15	0.05	217.0	47.0	2.50	5.30	0.05	2.20
5/13/2020	6.8	25.8688	WW	0.07	0.92	0.12	28.0	12.0	2.60	5.30	0.12	1.04
12/7/2016	19.4	25.8688	WW	0.06	0.65	0.02	13.7	6.0	5.20	5.30	0.10	0.75
3/14/2018	16.5	25.8688	WW	0.05	0.71	0.03	25.0	7.0	5.10	5.30	0.02	0.73
2/5/2020	15.3	25.8688	WW	0.05	0.82	0.03	35.2	18.0	4.10	5.30	0.04	0.86
1/8/2020	0.5	25.8688	WW	0.04	0.67	0.03	24.3	5.0	5.30	5.30	0.06	0.73
10/26/2016	0.2	17.7607	GC	0.14	0.89	0.07	36.9	35.0	0.87	5.27	0.02	0.89
5/24/2017	22.1	25.8688	BC	0.06	0.75	0.13	37.3	30.0	4.70	5.20	0.05	0.80
3/1/2017	29.9	25.8688	BC	0.05	0.74	0.04	26.8	15.0	5.70	5.20	0.02	0.76
8/21/2019	1.5	25.8688	BC	0.05	0.66	0.04	8.2	8.0	2.90	5.20	0.02	0.66
6/3/2020	5.9	25.8688	BC	0.05	1.09	0.11	22.0	17.0	5.00	5.20	0.03	1.12
9/8/2020	6.8	25.8688	BC	0.04	0.71	0.04	14.8	10.0	5.00	5.20	0.08	0.79
1/29/2020	93.3	25.8688	BC	0.03	0.57	0.06	23.8	12.0	7.10	5.20	0.05	0.62
1/2/2020	13.1	37.838	CH	0.05	0.76	0.02	17.8	7.0	5.30	5.20	0.02	0.76
11/15/2017	1.4	17.7607	GC	0.14	1.32	0.06	23.4	22.0	0.90	5.20	0.02	1.32
8/14/2019	0.1	17.7607	GC	0.08	0.82	0.10	15.6	5.0	2.00	5.20	0.07	0.89
5/29/2019	0.1	17.7607	GC	0.07	1.11	0.26	26.7	13.0	4.00	5.20	0.05	1.16
12/18/2019	3.2	17.7607	GC	0.05	0.64	0.03	30.7	6.0	6.10	5.20	0.03	0.67
6/28/2017	0.7	17.7607	GC	0.04	0.78	0.09	30.9	27.0	4.00	5.20	0.08	0.86
10/27/2020	5.8	62.5485	LB	0.04	0.74	0.03	8.8	4.0	1.20	5.20	0.02	0.74
2/8/2017	16.9	62.5485	LB	0.03	0.46	0.04	8.0	4.0	2.90	5.20	0.02	0.46
11/16/2016	6.3	20.0773	LC	0.12	1.07	0.06	22.4	10.0	2.00	5.20	0.29	1.36
8/30/2017	7.7	241.314	MC	0.11	0.83	0.05	17.8	11.0	2.60	5.20	0.07	0.90
6/24/2020	239.7	241.314	MC	0.09	0.76	0.02	38.8	23.0	3.90	5.20	0.16	0.92
3/1/2017	625.3	241.314	MC	0.08	0.82	0.06	29.9	16.0	4.70	5.20	0.03	0.85
9/20/2017	8.5	241.314	MC	0.08	0.77	0.05	16.4	12.0	2.60	5.20	0.04	0.81
1/16/2019	177.7	241.314	MC	0.04	0.50	0.04	17.5	3.0	5.70	5.20	0.03	0.53
4/3/2019	251.8	241.314	MC	0.04	0.64	0.07	19.1	13.0	5.80	5.20	0.04	0.68
12/20/2017	160.0	25.8688	WW	0.29	1.28	0.03	142.0	161.0	3.10	5.20	0.34	1.62
3/28/2018	114.1	25.8688	WW	0.09	1.05	0.02	48.9	61.0	2.80	5.20	0.03	1.08
7/10/2019	9.9	25.8688	WW	0.08	1.14	0.12	39.6	54.0	2.40	5.20	0.10	1.24
8/4/2020	5.6	25.8688	WW	0.06	0.72	0.06	20.6	6.0	0.80	5.20	0.04	0.76
2/14/2018	866.4	62.5485	2B	0.05	0.74	0.03	24.3	27.0	2.80	5.10	0.05	0.79

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
11/21/2016	1.1	25.8688	BC	0.11	1.44	0.16	29.1	11.0	6.20	5.10	1.20	2.64
6/19/2019	2.4	25.8688	BC	0.07	0.96	0.18	37.7	17.0	3.80	5.10	0.02	0.96
8/28/2019	1.6	25.8688	BC	0.05	0.76	0.07	9.4	9.0	2.40	5.10	0.04	0.80
3/20/2019	7.5	25.8688	BC	0.02	0.67	0.04	15.0	8.0	7.20	5.10	0.02	0.67
1/10/2017	19.8	37.838	CH	0.04	0.66	0.05	12.7	6.0	4.60	5.10	0.03	0.69
3/11/2020	20.3	37.838	CH	0.03	0.51	0.02	22.3	7.0	5.00	5.10	0.03	0.54
11/21/2017	0.9	17.7607	GC	0.11	1.23	0.09	14.0	11.0	0.00	5.10	0.02	1.25
3/1/2017	15.9	17.7607	GC	0.06	0.75	0.06	28.2	18.0	2.80	5.10	0.04	0.79
10/25/2017	0.8	17.7607	GC	0.06	0.71	0.07	14.2	8.0	1.50	5.10	0.02	0.73
5/15/2019	0.8	17.7607	GC	0.05	0.72	0.11	18.4	13.0	5.60	5.10	0.03	0.75
11/9/2016	5.6	20.0773	LC	0.10	0.93	0.10	24.1	13.0	1.80	5.10	0.23	1.16
8/4/2020	0.1	20.0773	LC	0.08	1.05	0.19	13.4	9.0	0.70	5.10	0.02	1.05
9/1/2020	8.0	20.0773	LC	0.06	0.84	0.02	13.8	10.0	3.80	5.10	0.05	0.89
9/8/2020	7.9	20.0773	LC	0.06	2.48	1.49	11.4	8.0	2.60	5.10	1.29	3.77
4/19/2017	10.2	20.0773	LC	0.05	0.88	0.08	16.2	10.0	3.10	5.10	0.12	1.00
7/5/2017	40.3	241.314	MC	0.09	0.75	0.08	38.0	20.0	4.10	5.10	0.17	0.92
1/24/2017	546.4	241.314	MC	0.06	0.68	0.04	20.9	7.0	5.70	5.10	0.02	0.68
10/13/2020	4.2	25.8688	WW	0.06	0.84	0.02	24.9	16.0	3.90	5.10	0.04	0.88
12/27/2017	51.8	25.8688	WW	0.05	0.69	0.03	25.8	9.0	7.50	5.10	0.28	0.97
9/12/2018	3.9	62.5485	2B	0.13	0.91	0.09	12.5	8.0	2.60	5.00	0.24	1.15
8/23/2017	5.1	25.8688	BC	0.08	1.15	0.09	26.9	30.0	2.90	5.00	0.02	1.15
6/17/2020	4.3	25.8688	BC	0.06	0.88	0.14	23.7	15.0	4.40	5.00	0.06	0.94
8/16/2017	7.7	25.8688	BC	0.05	1.12	0.05	24.8	23.0	3.70	5.00	0.05	1.17
7/1/2020	5.3	25.8688	BC	0.05	0.86	0.09	25.9	12.0	3.90	5.00	0.07	0.93
3/15/2017	31.9	37.838	CH	0.05	0.66	0.03	22.4	9.0	2.80	5.00	0.03	0.69
3/22/2017	19.0	37.838	CH	0.05	0.54	0.02	11.9	10.0	4.70	5.00	0.02	0.56
1/10/2018	37.5	37.838	CH	0.05	0.69	0.02	10.9	2.0	7.10	5.00	0.03	0.72
11/8/2017	1.0	17.7607	GC	0.12	1.21	0.02	21.6	19.0	0.70	5.00	0.02	1.21
8/21/2019	0.0	17.7607	GC	0.08	0.80	0.08	15.7	8.0	1.20	5.00	0.05	0.85
10/18/2017	0.7	17.7607	GC	0.07	0.81	0.11	14.2	6.0	1.20	5.00	0.03	0.84
5/31/2017	4.0	17.7607	GC	0.06	1.12	0.16	37.2	22.0	3.90	5.00	0.08	1.20
8/16/2017	0.4	17.7607	GC	0.06	0.99	0.07	31.2	24.0	4.20	5.00	0.06	1.05
12/4/2019	0.8	17.7607	GC	0.04	0.76	0.02	19.8	4.0	4.80	5.00	0.02	0.76
1/9/2019	2.3	17.7607	GC	0.03	0.45	0.03	15.2	7.0	6.30	5.00	0.43	0.88
1/4/2017	29.9	62.5485	LB	0.04	0.76	0.03	11.8	4.0	3.70	5.00	0.02	0.76
10/20/2020	3.1	62.5485	LB	0.03	0.45	0.02	7.7	8.0	1.20	5.00	0.09	0.54
7/25/2018	0.4	20.0773	LC	0.17	1.70	0.06	111.0	27.0	4.00	5.00	0.02	1.70
11/2/2016	4.8	20.0773	LC	0.11	1.09	0.11	28.3	22.0	1.40	5.00	0.21	1.30
10/18/2017	1.6	20.0773	LC	0.10	1.00	0.13	14.0	11.0	1.40	5.00	0.04	1.04
7/26/2017	0.1	20.0773	LC	0.08	0.99	0.03	8.3	8.0	1.10	5.00	0.02	0.99
10/25/2017	2.0	20.0773	LC	0.08	1.04	0.10	15.9	13.0	1.50	5.00	0.05	1.09
11/15/2017	2.5	20.0773	LC	0.07	1.08	0.09	12.5	10.0	3.00	5.00	0.04	1.12
11/29/2017	3.2	20.0773	LC	0.07	0.97	0.12	10.9	5.0	2.00	5.00	0.06	1.03
6/27/2018	2.1	241.314	MC	0.10	0.87	0.07	24.3	16.0	5.20	5.00	0.10	0.97
9/18/2019	4.5	241.314	MC	0.09	1.06	0.14	23.3	11.0	1.00	5.00	0.03	1.09
11/7/2018	516.7	241.314	MC	0.08	0.90	0.03	31.7	17.0	4.10	5.00	0.03	0.93
10/23/2019	11.2	241.314	MC	0.07	0.73	0.03	23.9	8.0	9.00	5.00	0.05	0.78
1/4/2017	362.6	241.314	MC	0.05	0.62	0.03	19.6	7.0	7.50	5.00	0.03	0.65
9/18/2019	6.0	25.8688	WW	0.09	1.30	0.08	44.8	35.0	1.00	5.00	0.02	1.30
3/25/2020	12.1	25.8688	WW	0.04	0.77	0.02	32.2	15.0	4.30	5.00	0.02	0.79
3/1/2017	489.1	62.5485	2B	0.06	1.04	0.07	12.4	8.0	2.60	4.90	0.06	1.10
8/30/2017	4.5	25.8688	BC	0.06	1.12	0.12	10.4	11.0	2.30	4.90	0.02	1.12
1/4/2017	20.8	25.8688	BC	0.05	0.73	0.04	21.5	12.0	5.50	4.90	0.02	0.75
4/5/2017	21.4	25.8688	BC	0.05	0.82	0.05	21.9	16.0	4.80	4.90	0.02	0.84
7/19/2017	5.8	25.8688	BC	0.05	0.90	0.12	31.0	19.0	18.00	4.90	0.08	0.98
8/7/2019	1.8	25.8688	BC	0.05	0.79	0.07	17.4	12.0	4.00	4.90	0.02	0.79
9/27/2017	0.2	17.7607	GC	0.11	1.20	0.16	19.8	17.0	1.40	4.90	0.02	1.20
10/4/2017	0.8	17.7607	GC	0.09	0.96	0.12	12.2	13.0	1.40	4.90	0.02	0.96
11/1/2017	1.1	17.7607	GC	0.07	0.82	0.13	33.8	21.0	1.90	4.90	0.07	0.89
8/7/2019	0.1	17.7607	GC	0.06	0.79	0.08	19.7	6.0	2.30	4.90	0.08	0.87

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
8/18/2020	0.5	17.7607	GC	0.05	0.69	0.05	26.1	14.0	5.10	4.90	0.16	0.85
12/27/2017	1.6	17.7607	GC	0.04	0.90	0.05	16.8	8.0	5.90	4.90	0.05	0.95
12/19/2018	5.3	17.7607	GC	0.04	0.60	0.03	15.1	8.0	7.40	4.90	0.05	0.65
7/21/2020	1.0	20.0773	LC	0.09	0.99	0.09	12.1	8.0	1.30	4.90	0.03	1.02
7/28/2020	0.2	20.0773	LC	0.09	0.96	0.08	11.9	11.0	0.60	4.90	0.02	0.96
3/1/2017	29.0	20.0773	LC	0.08	0.97	0.13	12.2	7.0	3.30	4.90	0.12	1.09
12/13/2017	3.1	20.0773	LC	0.08	0.82	0.08	13.3	6.0	2.30	4.90	0.08	0.90
11/21/2017	2.8	20.0773	LC	0.07	1.03	0.07	12.0	10.0	1.90	4.90	0.04	1.07
4/26/2017	5.3	20.0773	LC	0.05	0.87	0.11	19.0	7.0	1.70	4.90	0.10	0.97
9/6/2017	17.7	241.314	MC	0.10	0.92	0.12	27.4	21.0	2.50	4.90	0.08	1.00
9/22/2020	865.1	241.314	MC	0.09	0.70	0.03	26.6	25.0	3.40	4.90	0.09	0.79
4/26/2017	269.0	241.314	MC	0.06	0.94	0.09	31.6	25.0	3.40	4.90	0.05	0.99
2/13/2019	916.2	241.314	MC	0.06	0.88	0.04	32.3	12.0	5.30	4.90	0.03	0.91
2/21/2018	4777.0	241.314	MC	0.05	0.63	0.02	21.0	9.0	6.00	4.90	0.02	0.65
4/8/2020	261.6	241.314	MC	0.05	0.71	0.05	23.4	14.0	4.50	4.90	0.05	0.76
7/21/2020	4.2	25.8688	WW	0.08	0.88	0.07	16.4	11.0	1.10	4.90	0.02	0.90
3/29/2017	16.5	25.8688	WW	0.07	0.95	0.03	25.2	16.0	4.80	4.90	0.02	0.97
9/4/2019	3.3	25.8688	WW	0.07	1.11	0.08	11.4	8.0	0.70	4.90	0.02	1.11
5/6/2020	5.5	25.8688	WW	0.07	1.05	0.20	20.2	16.0	3.10	4.90	0.09	1.14
8/11/2020	3.9	25.8688	WW	0.07	0.82	0.03	23.1	14.0	0.80	4.90	0.02	0.84
12/14/2016	13.8	25.8688	WW	0.06	0.72	0.02	10.5	5.0	5.20	4.90	0.09	0.81
9/26/2018	19.9	25.8688	WW	0.05	1.23	0.07	12.8	11.0	3.50	4.90	0.79	2.02
8/14/2019	2.1	25.8688	BC	0.07	0.70	0.05	17.5	10.0	3.30	4.80	0.02	0.70
6/14/2017	15.2	25.8688	BC	0.06	0.60	0.07	28.0	36.0	6.00	4.80	0.04	0.64
6/21/2017	14.0	25.8688	BC	0.06	0.83	0.12	28.9	20.0	4.00	4.80	0.04	0.87
8/8/2018	0.1	25.8688	BC	0.06	1.02	0.11	17.3	9.0	2.10	4.80	0.02	1.02
7/31/2019	2.0	25.8688	BC	0.06	0.83	0.10	18.4	15.0	4.50	4.80	0.04	0.87
11/7/2018	75.0	25.8688	BC	0.04	0.92	0.02	24.6	17.0	3.10	4.80	0.04	0.96
1/24/2017	32.2	37.838	CH	0.05	0.70	0.04	21.5	8.0	5.40	4.80	0.03	0.73
9/20/2017	0.1	17.7607	GC	0.09	0.94	0.16	15.2	14.0	1.70	4.80	0.02	0.94
6/12/2019	0.1	17.7607	GC	0.08	0.93	0.17	29.8	11.0	3.30	4.80	0.12	1.05
2/28/2018	156.9	17.7607	GC	0.04	0.68	0.02	31.1	38.0	5.60	4.80	0.03	0.71
12/28/2016	21.0	62.5485	LB	0.05	0.62	0.03	23.2	7.0	3.10	4.80	0.04	0.66
11/8/2017	2.6	20.0773	LC	0.09	1.20	0.05	17.1	16.0	1.70	4.80	0.02	1.20
12/14/2016	1.4	20.0773	LC	0.08	0.76	0.04	15.6	10.0	6.60	4.80	0.06	0.82
9/20/2017	0.1	20.0773	LC	0.07	0.95	0.03	10.6	7.0	1.50	4.80	0.02	0.95
12/6/2017	2.9	20.0773	LC	0.07	0.97	0.10	17.7	12.0	2.20	4.80	0.07	1.04
3/29/2017	8.9	20.0773	LC	0.06	0.53	0.06	8.2	5.0	2.20	4.80	0.02	0.55
12/4/2019	21.8	20.0773	LC	0.04	0.59	0.02	12.2	2.0	3.00	4.80	0.03	0.62
9/11/2019	3.3	241.314	MC	0.09	1.09	0.10	24.6	16.0	1.00	4.80	0.03	1.12
4/5/2017	694.3	241.314	MC	0.08	0.90	0.07	20.8	16.0	3.90	4.80	0.03	0.93
2/20/2019	590.6	241.314	MC	0.06	0.71	0.06	26.5	14.0	8.40	4.80	0.10	0.81
5/10/2017	15.2	25.8688	WW	0.08	0.81	0.08	35.4	20.0	3.90	4.80	0.07	0.88
7/28/2020	2.8	25.8688	WW	0.07	0.88	0.05	19.6	16.0	1.00	4.80	0.04	0.92
10/6/2020	2.7	25.8688	WW	0.07	0.77	0.03	25.4	11.0	3.50	4.80	0.05	0.82
11/20/2019	0.1	25.8688	WW	0.04	0.85	0.03	11.8	5.0	4.20	4.80	0.02	0.85
7/19/2017	34.5	62.5485	2B	0.08	0.71	0.06	8.3	7.0	1.90	4.70	0.42	1.13
5/8/2019	538.1	62.5485	2B	0.05	1.09	0.14	15.3	17.0	2.40	4.70	0.06	1.15
7/10/2019	2.1	25.8688	BC	0.05	0.82	0.15	23.9	14.0	3.90	4.70	0.06	0.88
2/28/2018	123.4	25.8688	BC	0.03	0.58	0.03	24.4	36.0	6.50	4.70	0.02	0.60
6/19/2019	0.1	17.7607	GC	0.09	1.09	0.20	25.8	11.0	2.30	4.70	0.09	1.18
7/10/2019	0.1	17.7607	GC	0.09	0.79	0.13	21.2	13.0	2.50	4.70	0.08	0.87
9/4/2019	0.0	17.7607	GC	0.08	0.79	0.07	16.3	7.0	0.90	4.70	0.04	0.83
12/7/2016	1.3	17.7607	GC	0.07	0.78	0.02	16.9	11.0	6.00	4.70	0.02	0.78
5/1/2019	1.1	17.7607	GC	0.05	0.70	0.11	18.4	9.0	4.70	4.70	0.03	0.73
6/12/2019	11.8	62.5485	LB	0.06	0.69	0.06	12.3	8.0	0.90	4.70	0.06	0.75
10/23/2019	2.7	62.5485	LB	0.03	0.69	0.03	10.3	6.0	3.10	4.70	0.02	0.69
7/14/2020	3.2	20.0773	LC	0.07	0.79	0.07	13.0	13.0	1.20	4.70	0.05	0.84
9/15/2020	4.6	20.0773	LC	0.06	0.93	0.12	10.1	10.0	2.70	4.70	0.51	1.44
10/23/2019	9.4	20.0773	LC	0.04	0.73	0.05	15.9	5.0	3.70	4.70	0.03	0.76

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
11/13/2019	13.1	20.0773	LC	0.04	0.54	0.03	7.6	1.0	3.20	4.70	0.02	0.56
12/18/2019	32.5	20.0773	LC	0.04	0.72	0.05	13.6	3.0	2.70	4.70	0.13	0.85
7/28/2020	14.8	241.314	MC	0.12	0.82	0.02	45.1	21.0	2.20	4.70	0.17	0.99
7/10/2019	11.2	241.314	MC	0.09	0.99	0.05	25.7	10.0	2.80	4.70	0.15	1.14
8/28/2019	4.9	241.314	MC	0.08	1.25	0.18	16.3	15.0	1.00	4.70	0.04	1.29
9/25/2019	4.1	241.314	MC	0.06	0.77	0.07	6.8	5.0	0.80	4.70	0.02	0.77
10/6/2020	25.3	241.314	MC	0.06	0.57	0.02	27.8	12.0	3.90	4.70	0.06	0.63
12/13/2017	3.5	25.8688	WW	0.12	1.21	0.06	58.1	13.0	1.10	4.70	0.02	1.23
9/11/2019	6.8	25.8688	WW	0.07	1.20	0.09	25.2	26.0	1.00	4.70	0.02	1.20
2/14/2018	78.7	25.8688	WW	0.06	0.58	0.02	29.5	16.0	6.00	4.70	0.12	0.70
10/17/2018	23.7	25.8688	WW	0.05	0.86	0.05	19.7	8.0	1.80	4.70	0.07	0.93
11/20/2018	16.6	25.8688	WW	0.04	0.91	0.03	25.7	5.0	4.90	4.70	0.07	0.98
3/25/2020	244.4	62.5485	2B	0.04	0.82	0.03	14.7	9.0	1.90	4.60	0.04	0.86
3/28/2018	291.7	25.8688	BC	0.10	1.11	0.02	84.5	212.0	4.20	4.60	0.02	1.11
8/2/2017	14.6	25.8688	BC	0.06	2.12	0.21	21.5	25.0	2.50	4.60	0.02	2.12
8/1/2018	0.8	25.8688	BC	0.06	0.85	0.08	14.4	5.0	1.90	4.60	0.02	0.85
1/9/2019	13.1	25.8688	BC	0.03	0.54	0.05	13.7	6.0	6.40	4.60	0.02	0.54
10/8/2019	5.6	37.838	CH	0.24	1.93	0.29	44.0	120.0	12.50	4.60	1.01	2.94
10/6/2020	7.1	37.838	CH	0.05	0.51	0.03	13.6	6.0	3.30	4.60	0.04	0.55
12/13/2017	1.0	17.7607	GC	0.11	1.02	0.04	34.4	14.0	0.00	4.60	0.02	1.02
7/31/2019	0.1	17.7607	GC	0.09	0.77	0.11	20.7	7.0	3.10	4.60	0.09	0.86
7/7/2020	1.6	17.7607	GC	0.05	0.82	0.07	35.6	26.0	3.80	4.60	0.10	0.92
4/24/2019	0.7	17.7607	GC	0.04	0.61	0.05	16.1	8.0	5.70	4.60	0.03	0.64
9/1/2020	2.2	17.7607	GC	0.04	0.56	0.04	22.1	18.0	4.40	4.60	0.13	0.69
3/18/2020	40.5	17.7607	GC	0.03	0.60	0.03	27.5	9.0	5.00	4.60	0.07	0.67
6/28/2017	9.7	62.5485	LB	0.07	0.79	0.05	11.4	8.0	1.20	4.60	0.05	0.84
11/16/2016	3.9	62.5485	LB	0.06	0.79	0.04	8.2	10.0	0.00	4.60	0.04	0.83
3/28/2018	410.5	62.5485	LB	0.05	0.76	0.02	19.6	27.0	1.40	4.60	0.02	0.78
3/22/2017	17.0	62.5485	LB	0.04	0.57	0.03	8.5	5.0	1.60	4.60	0.02	0.57
12/18/2019	27.9	62.5485	LB	0.04	0.71	0.02	15.3	2.0	2.00	4.60	0.02	0.71
8/9/2017	0.1	20.0773	LC	0.09	1.32	0.40	13.9	7.0	0.80	4.60	0.03	1.35
9/6/2017	1.9	20.0773	LC	0.07	1.12	0.10	18.8	9.0	2.30	4.60	0.05	1.17
10/4/2017	0.3	20.0773	LC	0.07	0.98	0.11	8.5	8.0	1.10	4.60	0.02	0.98
11/1/2017	2.4	20.0773	LC	0.07	0.94	0.07	15.4	9.0	1.60	4.60	0.07	1.01
10/17/2018	11.1	20.0773	LC	0.07	1.11	0.04	29.4	6.0	2.10	4.60	0.66	1.77
7/7/2020	4.9	20.0773	LC	0.07	0.72	0.06	15.3	10.0	1.40	4.60	0.12	0.84
5/19/2017	4.2	20.0773	LC	0.06	0.82	0.09	33.6	13.0	1.30	4.60	0.11	0.93
7/1/2020	9.5	20.0773	LC	0.06	0.83	0.07	18.3	9.0	2.00	4.60	0.26	1.09
10/27/2020	20.7	20.0773	LC	0.05	0.66	0.03	11.7	3.0	2.20	4.60	0.12	0.78
10/10/2018	47.9	241.314	MC	0.11	1.04	0.02	40.3	24.0	13.40	4.60	0.11	1.15
3/28/2018	1683.6	241.314	MC	0.10	0.93	0.02	60.6	128.0	5.30	4.60	0.02	0.95
8/21/2019	4.7	241.314	MC	0.10	0.74	0.05	12.3	13.0	1.70	4.60	0.05	0.79
8/23/2017	14.7	241.314	MC	0.09	0.88	0.05	21.3	12.0	3.20	4.60	0.10	0.98
9/4/2019	3.8	241.314	MC	0.06	0.70	0.04	5.8	7.0	1.10	4.60	0.02	0.70
7/14/2020	5.1	25.8688	WW	0.09	0.84	0.06	23.7	14.0	1.40	4.60	0.02	0.86
6/14/2017	11.8	25.8688	WW	0.08	1.14	0.14	28.9	17.0	2.90	4.60	0.13	1.27
9/6/2017	14.0	25.8688	WW	0.07	0.95	0.12	20.6	17.0	1.90	4.60	0.19	1.14
8/7/2019	0.1	25.8688	WW	0.07	1.58	0.16	25.1	18.0	1.50	4.60	0.03	1.61
11/13/2019	5.8	25.8688	WW	0.05	0.67	0.02	18.6	5.0	4.20	4.60	0.04	0.71
1/30/2019	5.8	25.8688	WW	0.03	0.59	0.03	24.0	5.0	5.90	4.60	0.04	0.63
10/26/2016	3.4	25.8688	WW	0.35	1.97	0.07	179.0	77.0	2.82	4.55	0.12	2.09
5/31/2017	202.2	62.5485	2B	0.06	0.94	0.07	12.7	11.0	1.60	4.50	0.13	1.07
4/5/2017	302.2	62.5485	2B	0.05	0.95	0.05	11.1	12.0	2.50	4.50	0.08	1.03
6/24/2020	163.0	62.5485	2B	0.05	0.76	0.02	12.8	14.0	1.20	4.50	0.04	0.80
3/7/2018	1151.8	62.5485	2B	0.04	0.68	0.03	10.2	4.0	2.20	4.50	0.03	0.71
7/18/2018	9.7	25.8688	BC	0.07	0.99	0.12	24.6	14.0	1.60	4.50	0.02	0.99
6/5/2019	3.2	25.8688	BC	0.07	1.11	0.22	35.4	22.0	4.30	4.50	0.05	1.16
9/25/2019	0.0	25.8688	BC	0.06	0.97	0.10	16.6	8.0	1.40	4.50	0.03	1.00
8/18/2020	5.3	25.8688	BC	0.04	0.69	0.06	24.9	12.0	6.10	4.50	0.09	0.78
1/17/2017	36.0	37.838	CH	0.06	0.80	0.05	15.9	18.0	4.80	4.50	0.03	0.83

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
2/21/2018	313.4	37.838	CH	0.06	0.76	0.02	38.9	56.0	5.40	4.50	0.04	0.80
12/11/2019	9.7	37.838	CH	0.05	0.68	0.04	13.0	4.0	4.60	4.50	0.02	0.68
12/21/2016	1.5	17.7607	GC	0.07	0.66	0.03	14.2	8.0	4.40	4.50	0.02	0.66
8/28/2019	0.0	17.7607	GC	0.07	0.86	0.08	19.2	8.0	1.30	4.50	0.10	0.96
7/24/2019	0.2	17.7607	GC	0.05	0.74	0.10	23.8	9.0	4.00	4.50	0.10	0.84
11/25/2019	0.9	17.7607	GC	0.05	0.72	0.02	15.5	10.0	4.80	4.50	0.02	0.72
2/27/2019	6.3	17.7607	GC	0.02	0.50	0.03	18.6	9.0	6.10	4.50	0.03	0.53
10/24/2018	5.0	62.5485	LB	0.03	0.63	0.03	11.0	5.0	1.10	4.50	0.02	0.65
7/18/2018	1.2	20.0773	LC	0.14	1.17	0.09	131.0	15.0	4.80	4.50	0.13	1.30
9/13/2017	0.6	20.0773	LC	0.09	1.04	0.08	15.3	10.0	1.80	4.50	0.02	1.04
9/27/2017	0.0	20.0773	LC	0.07	1.00	0.06	8.4	5.0	1.30	4.50	0.02	1.00
6/24/2020	19.6	20.0773	LC	0.06	0.87	0.03	15.5	14.0	1.90	4.50	0.09	0.96
12/5/2018	11.9	20.0773	LC	0.04	0.76	0.05	16.7	2.0	2.40	4.50	0.06	0.82
12/11/2019	32.7	20.0773	LC	0.04	0.78	0.10	13.7	4.0	2.50	4.50	0.13	0.91
11/20/2019	9.5	20.0773	LC	0.03	0.47	0.02	11.4	3.0	3.30	4.50	0.03	0.50
10/16/2019	35.2	241.314	MC	0.14	1.08	0.03	33.6	21.0	7.10	4.50	0.27	1.35
7/21/2020	11.1	241.314	MC	0.11	0.85	0.04	37.9	13.0	2.20	4.50	0.20	1.05
8/14/2019	6.7	241.314	MC	0.09	0.83	0.05	15.0	7.0	2.00	4.50	0.09	0.92
11/6/2019	14.0	241.314	MC	0.05	0.65	0.03	18.3	6.0	7.10	4.50	0.04	0.69
2/15/2017	311.6	25.8688	WW	0.17	0.97	0.03	52.2	108.0	4.60	4.50	0.14	1.11
11/29/2017	4.8	25.8688	WW	0.10	1.16	0.05	40.0	11.0	0.70	4.50	0.02	1.16
10/25/2017	11.4	25.8688	WW	0.08	0.90	0.14	24.6	12.0	0.90	4.50	0.02	0.92
6/17/2020	4.8	25.8688	WW	0.08	1.00	0.10	31.8	16.0	2.70	4.50	0.12	1.12
9/13/2017	11.4	25.8688	WW	0.07	0.79	0.12	14.8	11.0	1.80	4.50	0.02	0.81
5/31/2017	13.1	25.8688	BC	0.06	0.86	0.07	34.6	23.0	3.90	4.40	0.04	0.90
6/12/2019	2.4	25.8688	BC	0.05	0.80	0.13	28.0	12.0	4.00	4.40	0.04	0.84
12/19/2018	16.8	25.8688	BC	0.04	0.47	0.03	14.7	4.0	6.10	4.40	0.04	0.51
2/14/2018	305.3	37.838	CH	0.07	0.73	0.02	73.8	117.0	5.10	4.40	0.07	0.80
2/5/2020	51.0	37.838	CH	0.05	0.67	0.06	31.2	42.0	5.10	4.40	0.09	0.76
4/29/2020	27.5	17.7607	GC	0.09	1.34	0.32	51.9	48.0	3.00	4.40	0.07	1.41
8/23/2017	0.1	17.7607	GC	0.07	1.04	0.19	18.7	15.0	6.40	4.40	0.03	1.07
10/31/2018	0.1	17.7607	GC	0.05	0.98	0.04	11.6	6.0	1.90	4.40	0.03	1.01
3/7/2018	26.7	17.7607	GC	0.04	0.55	0.03	20.9	6.0	4.70	4.40	0.02	0.57
10/13/2020	6.1	62.5485	LB	0.05	0.71	0.02	13.0	7.0	1.20	4.40	0.02	0.71
12/14/2016	11.0	62.5485	LB	0.04	0.42	0.02	10.0	4.0	3.60	4.40	0.04	0.46
11/25/2019	9.4	62.5485	LB	0.03	0.59	0.02	9.9	6.0	2.50	4.40	0.02	0.59
1/8/2020	11.4	62.5485	LB	0.03	0.63	0.02	10.8	2.0	2.50	4.40	0.02	0.65
5/31/2017	7.6	20.0773	LC	0.07	0.89	0.10	24.9	11.0	1.90	4.40	0.20	1.09
2/21/2018	45.1	20.0773	LC	0.07	0.65	0.06	25.8	8.0	3.20	4.40	0.26	0.91
2/22/2017	55.8	20.0773	LC	0.06	0.84	0.03	16.3	12.0	2.60	4.40	0.14	0.98
11/20/2018	16.1	20.0773	LC	0.05	0.78	0.03	16.4	3.0	2.60	4.40	0.15	0.93
10/30/2019	13.3	20.0773	LC	0.05	0.74	0.04	12.6	4.0	3.70	4.40	0.09	0.83
3/21/2018	7.9	20.0773	LC	0.04	0.74	0.03	23.9	7.0	2.50	4.40	0.13	0.87
8/7/2019	7.4	241.314	MC	0.10	0.97	0.06	25.0	12.0	2.50	4.40	0.12	1.09
2/22/2017	1110.2	241.314	MC	0.08	0.89	0.03	32.8	20.0	4.50	4.40	0.04	0.93
4/1/2020	1430.2	241.314	MC	0.05	0.90	0.03	28.2	17.0	4.00	4.40	0.03	0.93
4/12/2017	18.9	43.2434	SC	0.07	0.93	0.02	33.8	14.0	1.60	4.40	0.02	0.95
12/6/2017	4.5	25.8688	WW	0.11	1.28	0.03	47.7	8.0	0.00	4.40	0.02	1.28
11/8/2017	8.4	25.8688	WW	0.10	1.35	0.08	59.8	39.0	1.60	4.40	0.02	1.35
5/19/2017	11.7	25.8688	WW	0.09	1.03	0.09	39.3	22.0	2.90	4.40	0.08	1.11
6/5/2019	0.3	25.8688	WW	0.09	1.46	0.40	32.9	19.0	1.30	4.40	0.04	1.50
9/22/2020	4.8	25.8688	WW	0.08	0.94	0.04	20.0	17.0	1.90	4.40	0.08	1.02
11/1/2017	9.5	25.8688	WW	0.07	1.17	0.22	37.9	16.0	3.90	4.40	0.05	1.22
9/29/2020	4.1	25.8688	WW	0.06	0.81	0.03	26.9	14.0	3.90	4.40	0.09	0.90
12/5/2018	18.4	25.8688	WW	0.05	0.99	0.05	27.9	8.0	4.60	4.40	0.08	1.07
3/20/2019	1.5	25.8688	WW	0.04	0.70	0.04	30.6	11.0	5.70	4.40	0.02	0.70
10/26/2016	4.0	20.0773	LC	0.09	0.83	0.07	19.8	13.0	1.14	4.39	0.11	0.94
8/9/2017	39.6	62.5485	2B	0.08	0.73	0.06	14.1	10.0	2.40	4.30	0.21	0.94
5/6/2020	22.5	62.5485	2B	0.07	0.80	0.14	14.2	17.0	1.90	4.30	0.16	0.96
9/18/2019	0.9	25.8688	BC	0.06	0.84	0.06	15.4	13.0	1.50	4.30	0.02	0.84

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
10/23/2019	5.1	25.8688	BC	0.05	0.72	0.03	19.3	10.0	2.70	4.30	0.02	0.72
6/28/2017	10.9	25.8688	BC	0.02	0.68	0.08	32.5	27.0	5.20	4.30	0.10	0.78
12/12/2018	24.0	25.8688	BC	0.02	0.58	0.03	16.5	4.0	5.90	4.30	0.09	0.67
6/24/2020	2.7	17.7607	GC	0.07	0.80	0.11	43.7	29.0	2.80	4.30	0.13	0.93
12/12/2018	12.6	17.7607	GC	0.02	0.67	0.03	16.4	5.0	5.50	4.30	0.09	0.76
1/17/2017	45.7	62.5485	LB	0.08	0.92	0.05	34.2	22.0	0.90	4.30	0.08	1.00
11/2/2016	3.8	62.5485	LB	0.06	0.81	0.04	10.7	14.0	1.30	4.30	0.04	0.85
10/31/2018	8.9	62.5485	LB	0.05	0.79	0.02	9.4	5.0	1.10	4.30	0.02	0.79
3/15/2017	31.2	62.5485	LB	0.04	0.69	0.03	12.3	7.0	2.60	4.30	0.03	0.72
9/6/2017	3.2	62.5485	LB	0.04	0.82	0.08	10.2	9.0	1.20	4.30	0.15	0.97
7/1/2020	4.7	62.5485	LB	0.04	0.71	0.03	10.6	8.0	0.90	4.30	0.07	0.78
9/29/2020	7.4	62.5485	LB	0.03	0.64	0.02	9.1	7.0	1.40	4.30	0.02	0.66
11/21/2016	6.2	20.0773	LC	0.11	0.99	0.05	27.2	15.0	1.80	4.30	0.22	1.21
8/30/2017	0.6	20.0773	LC	0.09	1.18	0.15	12.3	10.0	1.30	4.30	0.02	1.20
6/21/2017	1.3	20.0773	LC	0.05	1.08	0.07	13.5	12.0	0.80	4.30	0.05	1.13
1/2/2020	35.3	20.0773	LC	0.04	0.75	0.04	12.4	4.0	2.40	4.30	0.12	0.87
9/12/2018	26.2	241.314	MC	0.09	0.95	0.05	15.9	7.0	2.10	4.30	0.10	1.05
5/13/2020	37.3	241.314	MC	0.06	0.81	0.06	38.6	25.0	3.50	4.30	0.12	0.93
2/26/2020	358.7	241.314	MC	0.04	0.52	0.03	18.8	6.0	5.30	4.30	0.05	0.57
11/21/2017	6.0	25.8688	WW	0.11	1.22	0.04	44.7	20.0	0.70	4.30	0.02	1.22
11/15/2017	7.4	25.8688	WW	0.09	1.15	0.15	51.6	19.0	1.00	4.30	0.02	1.15
7/26/2017	10.7	25.8688	WW	0.08	0.89	0.10	23.5	19.0	1.50	4.30	0.02	0.89
9/15/2020	5.0	25.8688	WW	0.08	0.98	0.07	17.1	17.0	2.50	4.30	0.05	1.03
10/18/2017	13.6	25.8688	WW	0.07	0.85	0.10	17.0	8.0	1.00	4.30	0.02	0.87
3/18/2020	13.0	25.8688	WW	0.04	0.61	0.04	32.4	13.0	4.40	4.30	0.06	0.67
2/20/2019	487.5	62.5485	2B	0.05	0.87	0.05	17.5	13.0	1.90	4.20	0.05	0.92
1/29/2020	359.1	62.5485	2B	0.04	0.76	0.04	27.8	23.0	2.00	4.20	0.05	0.81
9/11/2019	2.9	25.8688	BC	0.07	0.90	0.03	35.9	33.0	1.80	4.20	0.04	0.94
5/3/2017	50.8	25.8688	BC	0.04	0.78	0.05	27.2	15.0	5.10	4.20	0.06	0.84
7/24/2019	3.1	25.8688	BC	0.04	0.69	0.09	22.9	7.0	5.40	4.20	0.06	0.75
3/6/2019	16.7	25.8688	BC	0.03	0.58	0.03	18.3	7.0	6.50	4.20	0.02	0.58
5/1/2019	15.1	25.8688	BC	0.03	0.52	0.07	0.4	9.0	8.00	4.20	0.02	0.52
11/28/2018	34.6	37.838	CH	0.04	0.63	0.02	11.2	7.0	3.70	4.20	0.02	0.63
6/7/2017	4.0	17.7607	GC	0.05	1.30	0.14	41.8	32.0	2.00	4.20	0.06	1.36
9/27/2017	5.0	62.5485	LB	0.11	1.39	0.09	13.7	16.0	1.00	4.20	0.06	1.45
11/21/2016	3.8	62.5485	LB	0.06	0.70	0.05	9.3	13.0	0.80	4.20	0.07	0.77
9/20/2017	5.4	62.5485	LB	0.06	0.90	0.04	9.8	12.0	1.00	4.20	0.13	1.03
7/12/2017	21.2	62.5485	LB	0.04	1.05	0.06	13.9	11.0	1.20	4.20	0.08	1.13
9/22/2020	3.9	20.0773	LC	0.07	0.84	0.07	11.1	12.0	1.90	4.20	0.09	0.93
4/4/2018	11.4	20.0773	LC	0.06	0.81	0.13	22.5	9.0	3.00	4.20	0.08	0.89
11/6/2019	11.4	20.0773	LC	0.05	0.65	0.03	10.4	6.0	3.60	4.20	0.10	0.75
6/14/2017	40.7	241.314	MC	0.10	1.33	0.22	10.6	10.0	1.00	4.20	0.02	1.35
9/29/2020	437.1	241.314	MC	0.06	0.70	0.02	25.2	20.0	5.00	4.20	0.07	0.77
10/31/2018	106.8	241.314	MC	0.03	0.80	0.02	20.7	9.0	3.10	4.20	0.06	0.86
11/21/2016	2.9	25.8688	WW	0.26	2.13	0.06	325.0	110.0	4.70	4.20	0.14	2.27
8/28/2019	3.6	25.8688	WW	0.09	1.21	0.11	11.7	9.0	0.70	4.20	0.02	1.21
8/23/2017	18.0	25.8688	WW	0.07	0.85	0.06	16.6	11.0	2.60	4.20	0.04	0.89
9/20/2017	9.7	25.8688	WW	0.05	0.80	0.08	11.2	6.0	2.40	4.20	0.03	0.83
10/3/2018	11.9	25.8688	WW	0.05	1.44	0.11	13.5	13.0	3.00	4.20	0.25	1.69
7/7/2020	3.5	62.5485	2B	0.08	0.76	0.05	17.5	12.0	1.40	4.10	0.19	0.95
3/27/2019	511.7	62.5485	2B	0.05	1.02	0.05	15.5	10.0	1.60	4.10	0.03	1.05
1/16/2019	258.2	62.5485	2B	0.04	0.72	0.07	10.7	4.0	2.30	4.10	0.07	0.79
7/25/2018	2.9	25.8688	BC	0.10	1.12	0.13	19.6	10.0	1.20	4.10	0.03	1.15
5/15/2019	6.2	25.8688	BC	0.04	0.77	0.15	17.5	12.0	5.60	4.10	0.02	0.77
3/29/2017	22.8	37.838	CH	0.06	0.45	0.05	16.2	13.0	3.90	4.10	0.02	0.47
3/21/2018	31.0	37.838	CH	0.04	0.44	0.02	9.3	9.0	5.00	4.10	0.02	0.44
3/14/2018	38.3	37.838	CH	0.02	0.58	0.03	15.0	7.0	4.80	4.10	0.02	0.60
12/14/2016	1.1	17.7607	GC	0.08	0.70	0.03	20.1	11.0	4.70	4.10	0.02	0.70
8/2/2017	0.1	17.7607	GC	0.08	2.62	0.25	43.5	38.0	1.30	4.10	0.02	2.62
7/2/2019	0.1	17.7607	GC	0.05	0.91	0.11	23.7	7.0	3.60	4.10	0.09	1.00

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
10/17/2018	17.7	62.5485	LB	0.05	0.79	0.03	32.0	7.0	1.40	4.10	0.04	0.83
9/8/2020	5.3	62.5485	LB	0.04	0.70	0.03	9.3	8.0	1.40	4.10	0.03	0.73
9/22/2020	5.1	62.5485	LB	0.04	0.51	0.02	10.8	9.0	0.90	4.10	0.07	0.58
1/31/2017	18.3	62.5485	LB	0.03	0.56	0.02	9.1	2.0	2.70	4.10	0.03	0.59
8/16/2017	23.3	62.5485	LB	0.03	0.88	0.04	14.0	10.0	1.90	4.10	0.02	0.90
2/19/2020	33.6	62.5485	LB	0.03	0.64	0.03	14.9	6.0	1.80	4.10	0.02	0.66
6/7/2017	7.6	20.0773	LC	0.07	1.11	0.11	22.3	13.0	1.50	4.10	0.11	1.22
7/5/2017	4.0	20.0773	LC	0.07	0.98	0.08	25.3	10.0	1.70	4.10	0.07	1.05
5/10/2017	7.2	20.0773	LC	0.06	0.61	0.06	25.9	9.0	2.60	4.10	0.11	0.72
4/19/2017	361.9	241.314	MC	0.18	1.53	0.13	46.8	57.0	4.10	4.10	0.11	1.64
8/25/2020	10.4	241.314	MC	0.09	0.70	0.02	26.1	14.0	3.50	4.10	0.10	0.80
2/14/2018	2306.1	241.314	MC	0.07	0.71	0.06	43.6	59.0	5.50	4.10	0.05	0.76
3/13/2019	2131.3	241.314	MC	0.06	0.82	0.05	30.1	11.0	5.40	4.10	0.02	0.84
8/16/2017	19.3	25.8688	WW	0.07	0.90	0.05	35.5	23.0	2.50	4.10	0.14	1.04
5/15/2019	1.0	25.8688	WW	0.05	0.79	0.12	27.0	18.0	4.90	4.10	0.05	0.84
1/9/2019	11.6	25.8688	WW	0.04	0.60	0.04	25.0	1.0	5.10	4.10	0.04	0.64
10/8/2019	1.5	25.8688	BC	0.06	0.98	0.10	13.3	10.0	1.40	4.00	0.04	1.02
4/29/2020	62.8	25.8688	BC	0.06	0.81	0.08	41.8	36.0	3.90	4.00	0.04	0.85
7/12/2017	6.7	25.8688	BC	0.05	0.93	0.08	30.3	25.0	5.70	4.00	0.09	1.02
5/29/2019	3.5	25.8688	BC	0.05	0.80	0.14	30.8	22.0	4.60	4.00	0.04	0.84
11/16/2016	3.5	37.838	CH	0.23	2.00	0.49	68.7	35.0	0.50	4.00	0.02	2.00
9/18/2019	7.8	37.838	CH	0.16	2.24	0.18	29.1	6.0	1.60	4.00	0.02	2.24
4/19/2017	31.4	37.838	CH	0.03	0.64	0.06	17.7	13.0	4.40	4.00	0.07	0.71
5/20/2020	12.7	17.7607	GC	0.05	0.78	0.08	23.5	20.0	4.10	4.00	0.09	0.87
5/8/2019	3.2	17.7607	GC	0.04	0.72	0.07	23.8	14.0	4.90	4.00	0.03	0.75
11/9/2016	4.0	62.5485	LB	0.06	0.84	0.08	11.0	11.0	1.20	4.00	0.03	0.87
9/13/2017	1.2	62.5485	LB	0.06	0.78	0.04	12.0	11.0	1.10	4.00	0.05	0.83
7/21/2020	1.2	62.5485	LB	0.06	0.96	0.02	10.4	11.0	0.50	4.00	0.02	0.96
7/14/2020	2.1	62.5485	LB	0.04	0.56	0.02	8.5	8.0	0.60	4.00	0.03	0.59
9/1/2020	4.3	62.5485	LB	0.03	0.64	0.02	7.1	7.0	2.00	4.00	0.04	0.68
10/6/2020	3.0	62.5485	LB	0.03	0.44	0.02	9.4	6.0	1.20	4.00	0.02	0.46
9/18/2019	2.9	20.0773	LC	0.13	1.62	0.56	24.5	9.0	0.50	4.00	0.02	1.62
8/16/2017	8.0	20.0773	LC	0.07	1.06	0.05	12.9	7.0	2.20	4.00	0.13	1.19
6/17/2020	4.7	20.0773	LC	0.07	0.85	0.09	18.7	11.0	1.70	4.00	0.09	0.94
11/7/2018	28.7	20.0773	LC	0.05	1.05	0.03	21.5	10.0	1.70	4.00	0.10	1.15
6/3/2020	34.5	241.314	MC	0.08	0.85	0.07	42.3	28.0	3.40	4.00	0.16	1.01
5/19/2017	96.6	241.314	MC	0.07	0.86	0.07	37.1	26.0	4.10	4.00	0.11	0.97
5/29/2019	0.3	25.8688	WW	0.10	1.62	0.26	39.2	23.0	2.00	4.00	0.06	1.68
7/31/2019	0.2	25.8688	WW	0.09	1.13	0.11	22.6	12.0	2.10	4.00	0.09	1.22
7/7/2020	7.0	25.8688	WW	0.09	0.78	0.05	27.3	14.0	1.70	4.00	0.08	0.86
8/21/2019	3.9	25.8688	WW	0.08	1.09	0.12	11.4	12.0	0.80	4.00	0.02	1.09
5/3/2017	38.7	25.8688	WW	0.05	0.82	0.05	40.0	27.0	3.70	4.00	0.07	0.89
7/24/2019	266.9	62.5485	2B	0.08	0.85	0.11	13.5	13.0	1.80	3.90	0.28	1.13
12/28/2016	47.8	25.8688	BC	0.06	1.00	0.06	23.4	19.0	4.70	3.90	0.07	1.07
9/1/2020	15.1	25.8688	BC	0.05	0.70	0.03	30.7	24.0	4.60	3.90	0.08	0.78
3/18/2020	49.4	25.8688	BC	0.03	0.51	0.02	24.7	8.0	5.40	3.90	0.03	0.54
11/29/2017	3.9	37.838	CH	0.21	3.09	0.35	104.0	72.0	0.00	3.90	0.02	3.09
12/6/2017	3.8	37.838	CH	0.21	2.82	0.40	119.0	85.0	0.00	3.90	0.02	2.84
11/15/2017	4.6	37.838	CH	0.17	2.56	0.39	97.2	68.0	0.00	3.90	0.02	2.58
9/11/2019	8.8	37.838	CH	0.12	2.18	0.34	33.4	13.0	3.00	3.90	0.04	2.22
12/14/2016	18.9	37.838	CH	0.08	0.78	0.06	15.8	9.0	3.60	3.90	0.02	0.80
7/26/2017	14.5	37.838	CH	0.06	0.81	0.02	12.9	14.0	2.30	3.90	0.02	0.81
9/4/2019	4.1	37.838	CH	0.06	1.03	0.17	30.3	11.0	3.10	3.90	0.02	1.03
3/13/2019	33.5	17.7607	GC	0.04	0.80	0.03	25.1	10.0	5.50	3.90	0.02	0.80
4/22/2020	12.9	17.7607	GC	0.04	0.70	0.05	28.3	13.0	4.20	3.90	0.05	0.75
7/5/2018	1.6	62.5485	LB	0.06	0.98	0.03	22.7	14.0	1.40	3.90	0.02	0.98
4/29/2020	103.9	62.5485	LB	0.05	0.75	0.07	14.2	12.0	1.00	3.90	0.03	0.78
3/18/2020	112.3	62.5485	LB	0.03	0.72	0.03	15.4	7.0	1.60	3.90	0.02	0.72
8/2/2017	0.1	20.0773	LC	0.08	2.16	0.14	14.9	10.0	0.60	3.90	0.02	2.16
10/16/2019	39.6	20.0773	LC	0.08	0.96	0.04	33.6	18.0	3.00	3.90	0.21	1.17

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
3/14/2018	13.0	20.0773	LC	0.06	0.66	0.03	63.2	9.0	2.90	3.90	0.10	0.76
7/24/2019	8.3	20.0773	LC	0.06	0.89	0.06	11.2	7.0	1.40	3.90	0.04	0.93
1/8/2020	21.7	20.0773	LC	0.06	0.80	0.18	13.1	5.0	2.60	3.90	0.16	0.96
6/10/2020	22.7	20.0773	LC	0.06	0.85	0.03	19.1	19.0	1.60	3.90	0.11	0.96
10/3/2018	3.3	20.0773	LC	0.05	1.05	0.06	17.6	4.0	2.10	3.90	1.06	2.11
5/13/2020	7.8	20.0773	LC	0.05	0.89	0.09	17.0	9.0	2.10	3.90	0.09	0.98
4/3/2019	7.1	20.0773	LC	0.04	0.66	0.04	9.7	7.0	2.70	3.90	0.02	0.68
7/31/2019	11.5	241.314	MC	0.10	0.79	0.06	26.1	10.0	3.10	3.90	0.16	0.95
4/12/2017	774.5	241.314	MC	0.08	1.00	0.03	31.8	24.0	3.60	3.90	0.04	1.04
8/16/2017	111.7	241.314	MC	0.08	1.03	0.11	23.4	15.0	2.20	3.90	0.02	1.03
10/30/2019	171.9	241.314	MC	0.07	0.79	0.05	25.9	8.0	5.90	3.90	0.08	0.87
4/4/2018	196.3	241.314	MC	0.06	0.99	0.05	14.1	10.0	3.50	3.90	0.02	0.99
3/6/2019	486.9	241.314	MC	0.06	0.69	0.03	22.6	10.0	3.50	3.90	0.02	0.69
6/24/2020	7.1	25.8688	WW	0.09	0.90	0.07	35.8	20.0	1.70	3.90	0.17	1.07
7/1/2020	6.4	25.8688	WW	0.09	0.94	0.06	32.8	13.0	2.10	3.90	0.14	1.08
6/19/2019	0.2	25.8688	WW	0.08	1.17	0.16	29.3	26.0	1.30	3.90	0.04	1.21
9/27/2017	7.8	25.8688	WW	0.06	0.85	0.09	8.8	5.0	1.10	3.90	0.02	0.85
10/10/2018	12.5	25.8688	WW	0.06	1.13	0.07	16.7	19.0	2.30	3.90	0.04	1.17
10/4/2017	6.3	25.8688	WW	0.05	0.83	0.08	7.5	9.0	0.80	3.90	0.02	0.83
10/26/2016	4.3	62.5485	LB	0.07	0.70	0.05	13.5	14.0	0.90	3.84	0.04	0.74
8/15/2018	6.5	25.8688	BC	0.06	0.88	0.09	18.7	12.0	2.40	3.80	0.02	0.88
7/2/2019	2.7	25.8688	BC	0.04	0.82	0.11	24.3	5.0	4.00	3.80	0.04	0.86
4/24/2019	6.3	25.8688	BC	0.03	0.52	0.04	15.7	7.0	5.60	3.80	0.02	0.52
4/22/2020	18.9	25.8688	BC	0.03	1.12	0.12	23.5	12.0	4.50	3.80	0.04	1.16
12/13/2017	3.7	37.838	CH	0.25	2.34	0.40	97.9	66.0	0.00	3.80	0.04	2.38
11/21/2016	3.5	37.838	CH	0.24	2.17	0.49	87.9	57.0	0.80	3.80	0.04	2.21
11/9/2016	3.7	37.838	CH	0.19	1.70	0.33	53.7	32.0	1.00	3.80	0.02	1.72
10/25/2017	5.9	37.838	CH	0.14	1.88	0.25	89.9	79.0	0.70	3.80	0.02	1.90
7/5/2017	13.6	37.838	CH	0.08	0.92	0.11	25.9	18.0	2.70	3.80	0.05	0.97
5/19/2017	15.9	37.838	CH	0.05	0.80	0.09	22.9	14.0	3.90	3.80	0.06	0.86
11/20/2018	27.6	37.838	CH	0.05	0.73	0.04	14.5	5.0	4.60	3.80	0.09	0.82
2/20/2019	54.0	37.838	CH	0.04	0.67	0.04	44.1	43.0	9.30	3.80	0.07	0.74
9/5/2018	0.1	17.7607	GC	0.06	0.99	0.22	12.3	10.0	1.20	3.80	0.04	1.03
11/7/2018	22.6	17.7607	GC	0.05	1.13	0.04	14.8	13.0	2.50	3.80	0.36	1.49
11/20/2019	0.2	17.7607	GC	0.05	0.67	0.02	9.6	4.0	3.00	3.80	0.02	0.67
8/30/2017	2.0	62.5485	LB	0.06	0.96	0.07	10.2	11.0	1.00	3.80	0.05	1.01
11/7/2018	79.2	62.5485	LB	0.05	1.01	0.03	22.2	15.0	1.50	3.80	0.05	1.06
6/5/2019	10.7	62.5485	LB	0.05	0.75	0.10	11.0	6.0	0.80	3.80	0.06	0.81
4/19/2017	23.7	62.5485	LB	0.04	0.81	0.08	12.5	8.0	2.00	3.80	0.04	0.85
7/26/2017	6.5	62.5485	LB	0.04	0.81	0.02	8.4	10.0	1.00	3.80	0.06	0.87
11/20/2018	24.1	62.5485	LB	0.03	0.75	0.03	10.8	4.0	2.20	3.80	0.04	0.79
8/18/2020	2.3	62.5485	LB	0.03	0.52	0.02	7.5	7.0	1.50	3.80	0.02	0.54
9/11/2019	1.8	20.0773	LC	0.13	2.36	0.22	43.8	27.0	0.60	3.80	0.02	2.36
8/29/2018	4.5	241.314	MC	0.11	1.02	0.06	16.2	11.0	2.30	3.80	0.11	1.13
5/6/2020	44.3	241.314	MC	0.07	0.86	0.10	23.2	25.0	3.40	3.80	0.15	1.01
9/8/2020	66.1	241.314	MC	0.06	0.83	0.03	23.1	19.0	2.90	3.80	0.03	0.86
1/29/2020	1122.6	241.314	MC	0.03	0.60	0.02	19.0	6.0	6.40	3.80	0.04	0.64
11/7/2018	44.2	25.8688	WW	0.10	1.29	0.03	56.9	59.0	2.20	3.80	0.07	1.36
4/5/2017	30.5	25.8688	WW	0.07	0.79	0.05	28.3	22.0	4.90	3.80	0.07	0.86
10/16/2019	5.6	25.8688	WW	0.07	1.13	0.12	52.5	6.0	4.50	3.80	0.59	1.72
9/8/2020	5.0	25.8688	WW	0.07	0.91	0.05	23.6	17.0	3.00	3.80	0.10	1.01
10/26/2016	4.2	37.838	CH	0.13	1.38	0.21	35.8	29.0	1.06	3.74	0.02	1.40
9/12/2018	9.1	25.8688	BC	0.05	0.82	0.12	18.1	9.0	2.50	3.70	0.02	0.82
7/7/2020	11.1	25.8688	BC	0.05	0.87	0.03	30.9	28.0	4.30	3.70	0.05	0.92
2/27/2019	16.7	25.8688	BC	0.03	0.51	0.04	14.4	8.0	5.70	3.70	0.02	0.53
11/2/2016	3.9	37.838	CH	0.18	1.97	0.16	41.5	22.0	2.20	3.70	0.02	1.99
10/18/2017	6.5	37.838	CH	0.14	1.77	0.21	70.0	58.0	0.40	3.70	0.02	1.77
8/30/2017	20.8	37.838	CH	0.12	1.43	0.29	35.4	31.0	1.30	3.70	0.02	1.43
3/8/2017	116.0	37.838	CH	0.07	0.89	0.04	36.4	36.0	2.20	3.70	0.03	0.92
3/28/2018	181.4	37.838	CH	0.06	0.83	0.02	45.4	67.0	3.30	3.70	0.03	0.86

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
8/4/2020	5.7	37.838	CH	0.06	0.96	0.10	12.1	11.0	1.20	3.70	0.02	0.96
6/14/2017	16.0	37.838	CH	0.05	0.66	0.09	18.1	16.0	4.30	3.70	0.07	0.73
3/4/2020	12.2	37.838	CH	0.04	0.61	0.06	19.6	10.0	4.70	3.70	0.07	0.68
10/20/2020	6.9	37.838	CH	0.04	0.61	0.02	12.1	8.0	2.70	3.70	0.03	0.64
1/8/2020	12.1	37.838	CH	0.03	0.57	0.03	15.6	2.0	4.60	3.70	0.04	0.61
9/11/2019	0.1	17.7607	GC	0.09	0.78	0.07	14.4	12.0	1.60	3.70	0.07	0.85
9/18/2019	0.0	17.7607	GC	0.09	0.98	0.08	14.4	12.0	0.90	3.70	0.02	0.98
7/19/2017	0.1	17.7607	GC	0.08	1.05	0.20	26.2	15.0	2.00	3.70	0.04	1.09
4/15/2020	28.6	17.7607	GC	0.04	0.64	0.03	27.4	11.0	4.20	3.70	0.08	0.72
9/26/2018	7.8	62.5485	LB	0.05	1.01	0.06	19.3	13.0	3.30	3.70	0.16	1.17
8/14/2019	7.1	62.5485	LB	0.05	0.81	0.02	10.7	10.0	0.60	3.70	0.02	0.81
12/27/2017	12.3	62.5485	LB	0.04	0.61	0.02	10.8	5.0	4.80	3.70	0.23	0.84
3/11/2020	24.9	62.5485	LB	0.03	0.72	0.02	17.3	7.0	1.50	3.70	0.04	0.76
9/4/2019	0.9	20.0773	LC	0.09	1.17	0.26	13.8	8.0	0.80	3.70	0.03	1.20
4/5/2017	24.8	20.0773	LC	0.08	1.00	0.08	58.7	19.0	2.70	3.70	0.11	1.11
7/11/2018	3.2	20.0773	LC	0.08	0.85	0.05	85.1	9.0	4.20	3.70	0.09	0.94
9/26/2018	9.7	20.0773	LC	0.06	1.45	0.25	19.4	7.0	3.00	3.70	0.91	2.36
10/10/2018	12.4	20.0773	LC	0.06	0.94	0.03	17.2	11.0	2.10	3.70	0.09	1.03
1/22/2020	18.5	20.0773	LC	0.06	0.75	0.20	20.4	8.0	4.20	3.70	0.16	0.91
6/3/2020	7.3	20.0773	LC	0.06	0.70	0.07	16.0	11.0	1.80	3.70	0.12	0.82
4/8/2020	22.8	20.0773	LC	0.05	0.88	0.06	20.6	17.0	1.70	3.70	0.09	0.97
5/1/2019	0.9	25.8688	WW	0.07	0.86	0.14	28.5	13.0	3.30	3.70	0.05	0.91
3/20/2019	183.4	62.5485	2B	0.05	0.79	0.11	11.3	5.0	1.90	3.60	0.13	0.92
12/12/2018	482.0	62.5485	2B	0.04	0.73	0.04	11.8	6.0	2.40	3.60	0.06	0.79
1/30/2019	462.7	62.5485	2B	0.04	0.72	0.03	13.1	5.0	2.00	3.60	0.05	0.77
2/14/2018	374.6	25.8688	BC	0.07	0.85	0.03	85.4	138.0	4.70	3.60	0.05	0.90
11/20/2019	5.4	25.8688	BC	0.05	0.76	0.02	13.9	8.0	4.40	3.60	0.02	0.76
3/7/2018	38.6	25.8688	BC	0.03	0.60	0.02	20.1	5.0	4.90	3.60	0.02	0.62
11/21/2017	4.2	37.838	CH	0.17	2.37	0.43	116.0	83.0	0.00	3.60	0.02	2.37
11/1/2017	5.1	37.838	CH	0.16	2.38	0.32	92.2	71.0	0.70	3.60	0.03	2.41
11/8/2017	5.0	37.838	CH	0.15	2.13	0.25	77.5	61.0	0.50	3.60	0.02	2.13
7/28/2020	6.0	37.838	CH	0.07	0.93	0.03	9.6	11.0	1.30	3.60	0.02	0.93
12/5/2018	34.3	37.838	CH	0.05	0.96	0.07	18.1	8.0	4.10	3.60	0.09	1.05
1/16/2019	10.6	37.838	CH	0.04	0.53	0.04	18.5	4.0	4.50	3.60	0.04	0.57
12/12/2018	18.8	37.838	CH	0.03	0.68	0.05	17.5	7.0	4.40	3.60	0.11	0.79
12/20/2017	48.9	17.7607	GC	0.13	1.01	0.03	48.0	53.0	5.90	3.60	0.09	1.10
9/25/2019	0.0	17.7607	GC	0.10	0.94	0.10	14.1	8.0	0.80	3.60	0.06	1.00
11/30/2016	0.9	17.7607	GC	0.09	0.73	0.03	22.7	18.0	2.80	3.60	0.02	0.73
9/12/2018	0.2	17.7607	GC	0.07	0.75	0.13	11.8	6.0	1.40	3.60	0.05	0.80
5/22/2019	9.4	17.7607	GC	0.05	1.04	0.17	31.2	23.0	4.30	3.60	0.08	1.12
3/27/2019	13.7	17.7607	GC	0.04	0.89	0.05	23.9	12.0	5.70	3.60	0.03	0.92
4/17/2019	5.8	17.7607	GC	0.04	0.58	0.04	17.9	7.0	4.90	3.60	0.02	0.58
8/28/2019	8.8	62.5485	LB	0.14	2.53	0.44	25.7	24.0	0.70	3.60	0.05	2.58
10/10/2018	20.8	62.5485	LB	0.06	0.87	0.02	27.7	15.0	1.80	3.60	0.06	0.93
3/8/2017	105.3	62.5485	LB	0.04	0.77	0.02	13.6	10.0	2.30	3.60	0.02	0.79
10/3/2018	4.4	62.5485	LB	0.04	0.76	0.03	12.3	7.0	1.20	3.60	0.05	0.81
8/1/2018	1.3	20.0773	LC	0.10	1.05	0.02	70.3	22.0	2.80	3.60	0.04	1.09
11/30/2016	2.5	20.0773	LC	0.09	0.77	0.03	21.8	12.0	4.90	3.60	0.38	1.15
3/28/2018	54.3	20.0773	LC	0.08	0.93	0.02	26.8	57.0	1.70	3.60	0.04	0.97
6/14/2017	2.5	20.0773	LC	0.06	0.91	0.11	15.7	12.0	1.40	3.60	0.12	1.03
2/14/2018	41.4	20.0773	LC	0.04	0.70	0.12	24.7	10.0	3.60	3.60	0.28	0.98
1/16/2019	13.6	20.0773	LC	0.04	0.65	0.06	39.7	6.0	3.00	3.60	0.14	0.79
3/11/2020	20.3	20.0773	LC	0.04	0.69	0.03	14.6	8.0	1.90	3.60	0.11	0.80
6/5/2019	21.4	241.314	MC	0.09	0.95	0.14	38.3	20.0	3.80	3.60	0.22	1.17
5/27/2020	655.8	241.314	MC	0.07	0.81	0.04	22.8	22.0	3.10	3.60	0.07	0.88
5/10/2017	563.0	241.314	MC	0.06	0.75	0.05	22.3	14.0	3.60	3.60	0.05	0.80
10/24/2018	143.5	241.314	MC	0.05	0.90	0.02	28.5	13.0	2.60	3.60	0.05	0.95
11/20/2018	154.4	241.314	MC	0.05	0.77	0.04	17.4	8.0	4.50	3.60	0.05	0.82
8/18/2020	6.6	25.8688	WW	0.09	0.79	0.05	30.4	17.0	2.40	3.60	0.12	0.91
6/12/2019	0.3	25.8688	WW	0.08	1.07	0.12	30.3	13.0	1.60	3.60	0.23	1.30

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
5/27/2020	6.7	25.8688	WW	0.07	0.85	0.08	27.5	24.0	3.00	3.60	0.11	0.96
7/11/2018	9.2	25.8688	WW	0.06	1.06	0.04	16.7	9.0	2.30	3.60	0.02	1.06
1/15/2020	64.0	25.8688	WW	0.05	0.86	0.14	37.2	16.0	4.30	3.60	0.09	0.95
2/20/2019	124.8	25.8688	WW	0.04	0.77	0.05	34.5	27.0	3.40	3.60	0.04	0.81
5/20/2020	16.9	25.8688	BC	0.05	0.70	0.04	19.5	21.0	4.40	3.50	0.06	0.76
5/8/2019	14.4	25.8688	BC	0.04	0.63	0.05	20.5	12.0	5.00	3.50	0.02	0.65
8/11/2020	4.9	37.838	CH	0.07	0.96	0.15	25.1	9.0	1.00	3.50	0.02	0.96
8/28/2019	4.5	37.838	CH	0.06	1.03	0.12	18.9	18.0	3.10	3.50	0.02	1.03
7/21/2020	6.7	37.838	CH	0.06	0.88	0.02	13.2	13.0	1.70	3.50	0.02	0.88
9/29/2020	9.7	37.838	CH	0.05	0.59	0.03	16.9	9.0	3.20	3.50	0.07	0.66
4/4/2018	38.7	37.838	CH	0.04	0.55	0.03	17.2	10.0	4.20	3.50	0.02	0.57
8/9/2017	2.2	17.7607	GC	0.10	1.07	0.05	38.5	34.0	2.90	3.50	0.08	1.15
8/29/2018	0.1	17.7607	GC	0.08	1.07	0.11	12.1	17.0	1.40	3.50	0.02	1.09
12/28/2016	79.3	17.7607	GC	0.07	1.10	0.04	22.0	19.0	4.40	3.50	0.09	1.19
9/26/2018	0.2	17.7607	GC	0.05	1.01	0.08	13.8	9.0	2.70	3.50	0.05	1.06
11/14/2018	42.2	17.7607	GC	0.05	0.98	0.03	24.5	12.0	4.10	3.50	0.17	1.15
11/13/2019	0.3	17.7607	GC	0.04	0.71	0.03	12.2	3.0	3.40	3.50	0.02	0.71
8/11/2020	1.2	62.5485	LB	0.07	0.65	0.03	11.3	12.0	0.60	3.50	0.05	0.70
7/5/2017	12.5	62.5485	LB	0.05	0.75	0.06	14.9	9.0	2.10	3.50	0.03	0.78
12/5/2018	55.2	62.5485	LB	0.04	1.03	0.05	13.4	5.0	2.20	3.50	0.03	1.06
2/5/2020	57.2	62.5485	LB	0.04	0.83	0.13	26.8	12.0	1.80	3.50	0.05	0.88
10/30/2019	5.5	62.5485	LB	0.02	0.78	0.06	13.0	9.0	2.90	3.50	0.02	0.80
8/28/2019	0.2	20.0773	LC	0.10	1.43	0.24	10.9	9.0	0.60	3.50	0.02	1.43
7/19/2017	1.2	20.0773	LC	0.07	0.94	0.06	14.3	11.0	1.70	3.50	0.07	1.01
2/6/2019	11.2	20.0773	LC	0.03	0.56	0.05	23.2	6.0	2.80	3.50	0.11	0.67
9/5/2018	1.8	241.314	MC	0.11	1.04	0.07	13.1	15.0	1.90	3.50	0.03	1.07
12/27/2017	552.7	241.314	MC	0.09	0.97	0.02	21.3	13.0	4.90	3.50	0.06	1.03
6/19/2019	19.1	241.314	MC	0.09	0.90	0.05	41.2	14.0	2.60	3.50	0.20	1.10
7/19/2017	32.3	241.314	MC	0.08	1.04	0.06	36.3	24.0	3.30	3.50	0.16	1.20
12/5/2018	1154.0	241.314	MC	0.07	1.17	0.26	17.1	4.0	3.50	3.50	0.02	1.17
9/15/2020	80.8	241.314	MC	0.07	0.69	0.02	22.3	18.0	2.80	3.50	0.05	0.74
11/14/2018	1212.4	241.314	MC	0.06	0.93	0.03	20.6	9.0	3.50	3.50	0.02	0.95
7/2/2019	20.2	241.314	MC	0.06	0.87	0.07	29.5	10.0	3.90	3.50	0.13	1.00
4/29/2020	511.1	241.314	MC	0.06	0.87	0.11	30.3	25.0	3.30	3.50	0.08	0.95
2/19/2020	875.5	241.314	MC	0.04	0.48	0.02	18.7	5.0	5.50	3.50	0.05	0.53
4/29/2020	11.5	25.8688	WW	0.07	0.86	0.14	43.0	33.0	2.40	3.50	0.05	0.91
7/2/2019	0.5	25.8688	WW	0.06	0.86	0.07	27.0	11.0	2.70	3.50	0.07	0.93
2/28/2018	354.8	25.8688	WW	0.05	0.68	0.02	42.3	53.0	4.00	3.50	0.03	0.71
4/24/2019	1.1	25.8688	WW	0.05	0.81	0.10	26.6	11.0	4.40	3.50	0.04	0.85
5/24/2017	558.8	62.5485	2B	0.06	1.06	0.07	20.1	21.0	1.40	3.40	0.06	1.12
9/19/2018	4.1	25.8688	BC	0.07	0.95	0.09	19.1	16.0	3.40	3.40	0.03	0.98
6/24/2020	10.1	25.8688	BC	0.06	0.86	0.05	32.4	26.0	2.80	3.40	0.10	0.96
10/3/2018	2.7	25.8688	BC	0.05	1.38	0.10	12.8	8.0	3.50	3.40	0.07	1.45
9/29/2020	35.9	25.8688	BC	0.05	0.91	0.02	30.6	32.0	3.50	3.40	0.03	0.94
6/7/2017	26.0	25.8688	BC	0.04	1.02	0.07	35.3	27.0	6.10	3.40	0.04	1.06
9/26/2018	8.7	25.8688	BC	0.04	1.15	0.07	21.4	16.0	4.20	3.40	0.05	1.20
4/15/2020	24.1	25.8688	BC	0.03	0.51	0.02	24.1	15.0	4.60	3.40	0.03	0.54
9/13/2017	15.5	37.838	CH	0.09	1.35	0.33	35.6	15.0	1.30	3.40	0.02	1.35
8/16/2017	27.0	37.838	CH	0.06	0.78	0.10	20.3	14.0	1.50	3.40	0.02	0.80
7/14/2020	7.8	37.838	CH	0.06	0.79	0.09	18.8	13.0	2.20	3.40	0.05	0.84
10/24/2018	18.1	37.838	CH	0.05	0.98	0.07	27.0	14.0	1.30	3.40	0.07	1.05
6/28/2017	18.0	37.838	CH	0.04	0.72	0.06	28.9	19.0	2.90	3.40	0.06	0.78
1/22/2020	15.3	37.838	CH	0.03	0.60	0.04	18.2	7.0	4.70	3.40	0.06	0.66
2/19/2020	15.5	37.838	CH	0.03	0.44	0.07	15.2	6.0	4.80	3.40	0.09	0.53
2/6/2019	9.9	37.838	CH	0.02	0.43	0.03	15.1	7.0	5.10	3.40	0.04	0.47
10/24/2018	0.2	17.7607	GC	0.05	1.03	0.08	15.0	4.0	1.80	3.40	0.06	1.09
2/13/2019	45.1	17.7607	GC	0.05	0.93	0.03	33.6	17.0	4.60	3.40	0.04	0.97
4/10/2019	18.8	17.7607	GC	0.04	0.73	0.05	20.0	9.0	4.90	3.40	0.02	0.75
6/26/2019	2.8	17.7607	GC	0.04	0.83	0.08	43.8	28.0	4.20	3.40	0.12	0.95
8/25/2020	1.2	62.5485	LB	0.05	0.70	0.02	10.6	14.0	0.90	3.40	0.02	0.72

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
1/24/2017	94.9	62.5485	LB	0.04	0.86	0.05	11.0	5.0	3.40	3.40	0.10	0.96
4/26/2017	14.9	62.5485	LB	0.04	0.66	0.07	12.7	7.0	0.80	3.40	0.05	0.71
1/22/2020	16.9	62.5485	LB	0.03	0.68	0.03	12.8	5.0	2.10	3.40	0.04	0.72
8/8/2018	0.4	20.0773	LC	0.09	1.15	0.04	47.0	11.0	2.10	3.40	0.02	1.15
8/21/2019	0.0	20.0773	LC	0.09	1.03	0.06	8.5	12.0	0.70	3.40	0.02	1.03
8/14/2019	0.4	20.0773	LC	0.08	0.85	0.03	9.2	8.0	0.90	3.40	0.02	0.85
2/5/2020	27.4	20.0773	LC	0.04	0.74	0.05	27.3	9.0	3.40	3.40	0.15	0.89
8/2/2017	4.1	241.314	MC	0.12	2.38	0.03	24.4	26.0	0.90	3.40	0.02	2.40
6/10/2020	820.9	241.314	MC	0.09	0.90	0.03	45.0	43.0	3.10	3.40	0.12	1.02
6/17/2020	24.0	241.314	MC	0.08	0.76	0.05	42.0	22.0	3.20	3.40	0.19	0.95
7/14/2020	27.3	241.314	MC	0.08	0.79	0.04	33.9	17.0	2.40	3.40	0.17	0.96
6/10/2020	16.0	25.8688	WW	0.08	1.00	0.05	43.6	51.0	3.30	3.40	0.15	1.15
8/25/2020	3.7	25.8688	WW	0.08	0.73	0.03	24.5	17.0	1.70	3.40	0.03	0.76
2/13/2019	691.7	62.5485	2B	0.06	1.11	0.04	17.3	13.0	1.70	3.30	0.02	1.13
2/26/2020	144.4	62.5485	2B	0.05	0.65	0.02	13.2	11.0	2.30	3.30	0.07	0.72
1/15/2020	450.5	62.5485	2B	0.04	0.77	0.03	12.5	7.0	2.30	3.30	0.06	0.83
1/9/2019	627.7	62.5485	2B	0.03	0.69	0.04	11.6	4.0	1.70	3.30	0.05	0.74
1/23/2019	359.0	25.8688	BC	0.07	1.15	0.03	93.9	222.0	5.10	3.30	0.03	1.18
2/13/2019	39.0	25.8688	BC	0.04	0.92	0.03	29.3	12.0	4.50	3.30	0.02	0.94
11/14/2018	32.8	25.8688	BC	0.03	0.82	0.02	21.4	11.0	4.30	3.30	0.09	0.91
5/10/2017	20.9	37.838	CH	0.06	0.50	0.05	18.4	11.0	3.70	3.30	0.08	0.58
5/31/2017	34.5	37.838	CH	0.05	1.04	0.08	33.0	25.0	3.30	3.30	0.04	1.08
7/19/2017	12.9	37.838	CH	0.05	0.84	0.06	17.4	14.0	2.60	3.30	0.04	0.88
11/20/2019	7.3	37.838	CH	0.05	0.79	0.07	15.5	8.0	4.30	3.30	0.04	0.83
10/3/2018	0.1	17.7607	GC	0.06	1.14	0.19	11.5	10.0	1.80	3.30	0.02	1.16
10/30/2019	0.2	17.7607	GC	0.06	0.70	0.06	16.6	5.0	3.80	3.30	0.03	0.73
11/6/2019	0.2	17.7607	GC	0.05	0.76	0.04	17.5	4.0	4.20	3.30	0.02	0.76
3/29/2017	32.9	62.5485	LB	0.05	0.36	0.04	11.6	7.0	1.30	3.30	0.02	0.36
6/27/2018	9.8	62.5485	LB	0.05	0.83	0.06	10.3	7.0	1.80	3.30	0.04	0.87
12/7/2016	23.4	62.5485	LB	0.04	0.49	0.02	17.6	5.0	3.00	3.30	0.12	0.61
5/13/2020	4.3	62.5485	LB	0.04	0.67	0.07	12.8	8.0	0.90	3.30	0.04	0.71
6/3/2020	5.0	62.5485	LB	0.04	0.73	0.09	14.6	10.0	0.90	3.30	0.06	0.79
11/14/2018	276.2	62.5485	LB	0.03	0.92	0.02	14.2	9.0	2.00	3.30	0.07	0.99
3/4/2020	14.7	62.5485	LB	0.03	0.59	0.04	15.7	6.0	1.60	3.30	0.03	0.62
7/28/2020	1.8	62.5485	LB	0.03	0.58	0.02	7.4	8.0	0.70	3.30	0.05	0.63
8/15/2018	0.0	20.0773	LC	0.09	1.00	0.05	41.6	7.0	1.90	3.30	0.02	1.02
7/5/2018	3.5	20.0773	LC	0.07	0.73	0.06	80.0	10.0	3.70	3.30	0.06	0.79
8/7/2019	1.7	20.0773	LC	0.07	0.90	0.08	12.1	11.0	1.30	3.30	0.05	0.95
5/27/2020	15.6	20.0773	LC	0.07	0.81	0.04	12.5	13.0	1.50	3.30	0.04	0.85
3/27/2019	10.2	20.0773	LC	0.06	1.01	0.07	16.8	8.0	2.10	3.30	0.10	1.11
5/3/2017	27.6	20.0773	LC	0.05	0.82	0.10	24.1	10.0	2.20	3.30	0.16	0.98
12/19/2018	22.0	20.0773	LC	0.05	0.65	0.05	11.8	7.0	2.60	3.30	0.14	0.79
7/10/2019	4.1	20.0773	LC	0.05	0.90	0.06	9.4	7.0	1.20	3.30	0.06	0.96
3/4/2020	15.3	20.0773	LC	0.04	0.51	0.03	15.1	7.0	2.70	3.30	0.14	0.65
9/19/2018	5.0	241.314	MC	0.09	0.92	0.06	24.0	14.0	2.30	3.30	0.11	1.03
10/8/2019	10.8	241.314	MC	0.09	0.78	0.04	38.8	22.0	5.30	3.30	0.14	0.92
6/12/2019	21.0	241.314	MC	0.08	0.95	0.09	38.5	24.0	2.90	3.30	0.17	1.12
7/1/2020	180.2	241.314	MC	0.07	0.75	0.02	36.0	28.0	2.60	3.30	0.10	0.85
8/18/2020	22.0	241.314	MC	0.07	0.78	0.03	37.9	24.0	4.30	3.30	0.12	0.90
7/5/2018	12.6	25.8688	WW	0.08	1.16	0.09	16.6	9.0	4.10	3.30	0.02	1.16
1/24/2017	22.9	25.8688	WW	0.05	0.78	0.04	15.9	6.0	5.10	3.30	0.04	0.82
3/13/2019	58.9	25.8688	WW	0.05	0.83	0.03	40.5	18.0	4.00	3.30	0.03	0.86
3/7/2018	33.7	25.8688	WW	0.04	0.65	0.03	27.9	11.0	4.20	3.30	0.04	0.69
2/27/2019	5.3	25.8688	WW	0.04	0.56	0.02	25.8	9.0	4.70	3.30	0.03	0.59
3/6/2019	7.4	25.8688	WW	0.04	0.73	0.04	28.1	10.0	4.70	3.30	0.04	0.77
12/19/2018	657.8	62.5485	2B	0.04	0.77	0.04	10.9	8.0	1.90	3.20	0.07	0.84
3/18/2020	283.5	62.5485	2B	0.04	0.69	0.03	17.8	11.0	1.80	3.20	0.04	0.73
3/13/2019	50.1	25.8688	BC	0.05	0.85	0.04	24.4	10.0	4.80	3.20	0.02	0.85
3/27/2019	18.0	25.8688	BC	0.05	0.93	0.07	24.9	9.0	4.70	3.20	0.02	0.93
4/10/2019	18.7	25.8688	BC	0.04	0.85	0.04	20.4	8.0	5.10	3.20	0.02	0.85

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
9/27/2017	10.3	37.838	CH	0.16	2.52	0.05	53.4	48.0	0.50	3.20	0.02	2.52
10/23/2019	7.0	37.838	CH	0.14	1.12	0.08	121.0	24.0	11.40	3.20	0.41	1.53
10/4/2017	8.2	37.838	CH	0.13	1.85	0.11	49.5	39.0	0.50	3.20	0.02	1.85
12/28/2016	49.8	37.838	CH	0.07	0.96	0.02	22.5	14.0	4.00	3.20	0.03	0.99
1/4/2017	34.3	37.838	CH	0.06	0.89	0.04	22.5	11.0	4.00	3.20	0.03	0.92
8/21/2019	4.9	37.838	CH	0.06	0.87	0.13	6.5	13.0	3.10	3.20	0.02	0.87
6/24/2020	18.7	37.838	CH	0.06	0.76	0.03	32.8	28.0	2.70	3.20	0.19	0.95
5/3/2017	55.5	37.838	CH	0.05	0.75	0.04	25.9	19.0	3.80	3.20	0.07	0.82
12/19/2018	15.1	37.838	CH	0.04	0.55	0.04	16.3	6.0	4.00	3.20	0.07	0.62
5/13/2020	8.4	37.838	CH	0.04	0.63	0.11	16.4	10.0	2.80	3.20	0.05	0.68
1/30/2019	13.4	37.838	CH	0.03	0.44	0.03	15.2	5.0	5.00	3.20	0.07	0.51
1/23/2019	171.6	17.7607	GC	0.07	1.26	0.04	70.9	137.0	2.90	3.20	0.02	1.28
8/22/2018	0.1	17.7607	GC	0.06	0.91	0.19	9.5	8.0	1.60	3.20	0.02	0.91
8/9/2017	1.3	62.5485	LB	0.07	1.13	0.08	9.3	12.0	0.80	3.20	0.02	1.15
6/10/2020	56.0	62.5485	LB	0.05	0.91	0.03	15.6	16.0	1.00	3.20	0.06	0.97
3/21/2018	18.6	62.5485	LB	0.03	0.58	0.02	11.6	6.0	1.50	3.20	0.02	0.58
2/6/2019	60.2	62.5485	LB	0.03	0.59	0.05	15.4	5.0	1.50	3.20	0.03	0.62
5/6/2020	10.0	20.0773	LC	0.05	0.96	0.09	16.2	12.0	2.00	3.20	0.09	1.05
9/13/2017	9.0	241.314	MC	0.11	0.91	0.09	24.8	17.0	1.70	3.20	0.02	0.93
4/22/2020	1028.1	241.314	MC	0.06	0.75	0.03	26.4	12.0	3.30	3.20	0.03	0.78
8/2/2017	15.4	25.8688	WW	0.11	2.28	0.04	26.2	31.0	1.40	3.20	0.02	2.30
5/24/2017	293.4	25.8688	WW	0.08	1.13	0.08	74.2	91.0	3.00	3.20	0.07	1.20
8/9/2017	16.5	25.8688	WW	0.07	1.07	0.21	37.0	20.0	1.60	3.20	0.23	1.30
5/8/2019	1.7	25.8688	WW	0.07	0.91	0.10	38.2	21.0	4.50	3.20	0.04	0.95
5/20/2020	8.0	25.8688	WW	0.07	0.90	0.07	31.8	34.0	3.40	3.20	0.06	0.96
8/1/2018	6.7	25.8688	WW	0.05	1.05	0.15	19.5	10.0	1.10	3.20	0.02	1.05
10/30/2019	6.4	25.8688	WW	0.04	1.00	0.07	19.6	6.0	4.50	3.20	0.74	1.74
8/9/2017	10.7	25.8688	BC	0.06	1.07	0.05	66.7	47.0	3.60	3.10	0.40	1.47
4/17/2019	12.5	25.8688	BC	0.04	0.60	0.03	17.1	8.0	4.90	3.10	0.02	0.60
9/20/2017	13.0	37.838	CH	0.12	2.03	0.14	38.2	26.0	0.80	3.10	0.02	2.03
12/21/2016	17.1	37.838	CH	0.08	0.83	0.04	26.6	17.0	3.30	3.10	0.04	0.87
8/2/2017	21.3	37.838	CH	0.08	2.28	0.05	36.5	38.0	1.80	3.10	0.02	2.28
6/21/2017	17.5	37.838	CH	0.07	0.87	0.09	19.2	17.0	3.80	3.10	0.04	0.91
9/6/2017	19.2	37.838	CH	0.07	1.30	0.42	33.6	15.0	0.90	3.10	0.02	1.30
12/18/2019	25.6	37.838	CH	0.06	0.93	0.03	30.7	14.0	3.70	3.10	0.07	1.00
9/8/2020	8.2	37.838	CH	0.06	0.78	0.04	20.2	16.0	2.30	3.10	0.05	0.83
4/5/2017	43.5	37.838	CH	0.05	0.66	0.05	21.5	17.0	4.00	3.10	0.08	0.74
12/4/2019	11.4	37.838	CH	0.05	0.63	0.02	19.3	4.0	3.80	3.10	0.02	0.63
1/29/2020	82.4	37.838	CH	0.04	0.62	0.03	28.0	11.0	4.50	3.10	0.07	0.69
4/3/2019	9.2	37.838	CH	0.03	0.66	0.06	12.4	9.0	4.70	3.10	0.02	0.66
2/26/2020	19.4	37.838	CH	0.03	0.55	0.04	19.2	7.0	4.20	3.10	0.05	0.60
9/19/2018	0.1	17.7607	GC	0.08	0.95	0.14	10.9	10.0	2.30	3.10	0.02	0.95
10/10/2018	1.0	17.7607	GC	0.08	1.01	0.02	24.8	26.0	3.70	3.10	0.04	1.05
6/10/2020	43.8	17.7607	GC	0.06	0.87	0.05	36.7	38.0	2.70	3.10	0.14	1.01
10/23/2019	0.2	17.7607	GC	0.05	0.70	0.05	19.4	5.0	3.30	3.10	0.05	0.75
5/10/2017	25.4	62.5485	LB	0.05	0.74	0.08	15.3	9.0	1.60	3.10	0.05	0.79
6/21/2017	6.8	62.5485	LB	0.05	0.96	0.06	11.3	11.0	1.80	3.10	0.03	0.99
7/31/2019	2.4	20.0773	LC	0.07	0.75	0.07	9.8	6.0	1.40	3.10	0.05	0.80
11/14/2018	35.7	20.0773	LC	0.05	0.79	0.04	17.1	10.0	3.00	3.10	0.14	0.93
3/18/2020	22.8	20.0773	LC	0.04	0.74	0.04	20.4	9.0	2.20	3.10	0.10	0.84
5/31/2017	580.9	241.314	MC	0.08	0.83	0.06	32.0	22.0	2.50	3.10	0.06	0.89
7/24/2019	36.8	241.314	MC	0.07	0.77	0.07	35.0	19.0	4.20	3.10	0.11	0.88
3/7/2018	1074.4	241.314	MC	0.04	0.55	0.03	15.6	4.0	3.60	3.10	0.02	0.55
7/25/2018	7.9	25.8688	WW	0.07	1.00	0.06	15.1	10.0	0.80	3.10	0.02	1.00
8/8/2018	8.1	25.8688	WW	0.05	0.92	0.10	13.1	8.0	0.80	3.10	0.02	0.92
11/6/2019	5.7	25.8688	WW	0.04	0.80	0.04	21.6	6.0	4.20	3.10	0.27	1.07
5/22/2019	247.3	62.5485	2B	0.06	1.09	0.14	14.1	13.0	1.50	3.00	0.08	1.17
10/10/2018	23.9	25.8688	BC	0.07	1.19	0.03	30.9	38.0	2.70	3.00	0.03	1.22
5/22/2019	295.2	25.8688	BC	0.06	1.11	0.14	49.9	63.0	3.60	3.00	0.05	1.16
1/2/2019	41.6	25.8688	BC	0.03	0.73	0.03	21.2	12.0	4.20	3.00	0.03	0.76

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
8/9/2017	22.8	37.838	CH	0.08	1.11	0.15	30.4	26.0	1.50	3.00	0.08	1.19
9/22/2020	7.7	37.838	CH	0.07	0.72	0.05	14.9	18.0	3.20	3.00	0.23	0.95
7/10/2019	7.2	37.838	CH	0.06	0.93	0.09	15.7	11.0	2.70	3.00	0.04	0.97
10/13/2020	9.9	37.838	CH	0.06	0.82	0.02	23.6	13.0	2.30	3.00	0.03	0.85
12/27/2017	35.2	37.838	CH	0.05	0.79	0.02	13.2	7.0	4.80	3.00	0.24	1.03
10/27/2020	6.9	37.838	CH	0.05	0.68	0.04	11.5	8.0	2.30	3.00	0.02	0.68
4/26/2017	22.6	37.838	CH	0.04	0.66	0.06	25.0	16.0	3.00	3.00	0.06	0.72
1/15/2020	36.3	37.838	CH	0.04	0.74	0.04	21.8	9.0	4.50	3.00	0.13	0.87
6/7/2017	25.8	62.5485	LB	0.07	1.29	0.13	20.3	12.0	0.50	3.00	0.05	1.34
4/4/2018	56.8	62.5485	LB	0.04	0.89	0.05	13.3	9.0	1.70	3.00	0.02	0.91
8/15/2018	17.4	241.314	MC	0.08	1.01	0.07	28.9	19.0	4.90	3.00	0.12	1.13
7/5/2017	10.1	25.8688	WW	0.10	1.38	0.12	35.7	20.0	2.00	3.00	0.08	1.46
7/24/2019	3.4	25.8688	WW	0.10	0.99	0.08	39.3	38.0	2.50	3.00	0.14	1.13
5/22/2019	0.9	25.8688	WW	0.07	1.00	0.14	41.5	27.0	2.90	3.00	0.08	1.08
4/8/2020	276.7	25.8688	WW	0.07	1.01	0.04	45.2	62.0	2.00	3.00	0.05	1.06
7/18/2018	15.5	25.8688	WW	0.06	1.04	0.09	14.3	8.0	1.40	3.00	0.02	1.04
4/22/2020	24.4	25.8688	WW	0.04	0.66	0.04	30.5	19.0	3.40	3.00	0.07	0.73
5/27/2020	375.8	62.5485	2B	0.08	0.88	0.02	11.6	22.0	1.00	2.90	0.02	0.90
4/12/2017	975.2	62.5485	2B	0.06	1.04	0.03	17.0	18.0	1.00	2.90	0.03	1.07
4/24/2019	649.2	62.5485	2B	0.06	0.97	0.12	15.2	36.0	1.70	2.90	0.10	1.07
7/2/2019	170.6	62.5485	2B	0.06	0.87	0.05	11.9	11.0	1.20	2.90	0.11	0.98
2/19/2020	117.6	62.5485	2B	0.03	0.64	0.04	11.0	5.0	2.30	2.90	0.08	0.72
11/6/2019	5.1	25.8688	BC	0.05	0.82	0.06	18.8	6.0	3.60	2.90	0.02	0.82
6/26/2019	7.6	25.8688	BC	0.04	0.76	0.04	41.6	26.0	3.70	2.90	0.07	0.83
2/15/2017	466.5	37.838	CH	0.15	0.91	0.03	45.4	74.0	3.90	2.90	0.10	1.01
9/15/2020	9.8	37.838	CH	0.06	0.83	0.04	13.5	12.0	1.90	2.90	0.02	0.85
5/6/2020	9.5	37.838	CH	0.05	0.70	0.13	13.5	13.0	3.10	2.90	0.06	0.76
6/3/2020	8.7	37.838	CH	0.05	0.73	0.11	20.3	16.0	2.90	2.90	0.06	0.79
11/13/2019	7.5	37.838	CH	0.04	0.72	0.05	21.0	6.0	5.40	2.90	0.09	0.81
3/25/2020	23.4	37.838	CH	0.04	0.72	0.04	22.2	9.0	3.40	2.90	0.04	0.76
7/12/2017	0.2	17.7607	GC	0.09	1.15	0.09	38.1	26.0	2.30	2.90	0.05	1.20
2/14/2018	369.7	17.7607	GC	0.07	0.90	0.04	71.0	124.0	3.00	2.90	0.05	0.95
1/2/2019	54.0	17.7607	GC	0.03	0.62	0.02	22.0	19.0	4.10	2.90	0.05	0.67
7/31/2019	11.6	62.5485	LB	0.06	0.58	0.03	9.7	3.0	1.10	2.90	0.15	0.73
3/1/2017	234.0	62.5485	LB	0.05	0.74	0.05	11.8	6.0	3.00	2.90	0.03	0.77
5/19/2017	18.0	62.5485	LB	0.05	1.02	0.09	14.4	8.0	0.70	2.90	0.05	1.07
8/23/2017	7.4	62.5485	LB	0.05	0.65	0.03	12.0	12.0	1.20	2.90	0.06	0.71
2/22/2017	455.5	62.5485	LB	0.04	0.91	0.04	18.3	12.0	2.90	2.90	0.07	0.98
4/8/2020	358.8	62.5485	LB	0.04	0.92	0.02	17.3	16.0	0.90	2.90	0.02	0.92
1/16/2019	62.8	62.5485	LB	0.03	0.65	0.04	16.4	3.0	1.80	2.90	0.03	0.68
10/8/2019	0.1	20.0773	LC	0.11	1.49	0.55	33.8	19.0	5.00	2.90	0.54	2.03
12/21/2016	1.8	20.0773	LC	0.06	0.72	0.03	17.7	7.0	2.80	2.90	0.03	0.75
1/9/2019	18.3	20.0773	LC	0.05	0.62	0.05	31.6	6.0	2.20	2.90	0.13	0.75
2/19/2020	21.7	20.0773	LC	0.05	0.62	0.04	31.4	8.0	2.50	2.90	0.16	0.78
2/26/2020	19.6	20.0773	LC	0.04	0.56	0.04	12.2	6.0	2.20	2.90	0.16	0.72
12/12/2018	26.9	20.0773	LC	0.03	0.60	0.04	15.3	6.0	2.40	2.90	0.12	0.72
1/30/2019	14.7	20.0773	LC	0.03	0.51	0.03	18.1	5.0	2.60	2.90	0.14	0.65
5/31/2017	24.5	25.8688	WW	0.08	0.94	0.11	29.0	21.0	2.00	2.90	0.02	0.96
2/7/2018	630.1	25.8688	WW	0.08	0.92	0.04	76.2	135.0	3.30	2.90	0.11	1.03
3/1/2017	58.3	25.8688	WW	0.06	0.86	0.07	21.1	10.0	2.00	2.90	0.02	0.88
6/7/2017	22.1	25.8688	WW	0.06	1.14	0.10	43.4	35.0	2.40	2.90	0.04	1.18
12/12/2018	17.7	25.8688	WW	0.04	0.73	0.04	22.8	6.0	3.60	2.90	0.05	0.78
12/19/2018	14.2	25.8688	WW	0.04	0.78	0.04	20.0	7.0	3.40	2.90	0.03	0.81
3/6/2019	428.5	62.5485	2B	0.04	0.73	0.04	11.4	5.0	2.20	2.80	0.04	0.77
6/10/2020	28.4	25.8688	BC	0.05	0.82	0.04	35.5	35.0	3.00	2.80	0.13	0.95
10/3/2018	16.7	37.838	CH	0.07	1.53	0.08	27.6	20.0	2.00	2.80	0.23	1.76
10/17/2018	23.5	37.838	CH	0.06	1.25	0.08	68.2	33.0	1.80	2.80	0.34	1.59
3/1/2017	84.7	37.838	CH	0.05	0.73	0.07	27.1	17.0	4.00	2.80	0.06	0.79
11/30/2016	11.2	62.5485	LB	0.04	0.55	0.03	13.3	5.0	2.40	2.80	0.02	0.57
8/7/2019	9.9	62.5485	LB	0.04	0.58	0.03	9.0	7.0	0.90	2.80	0.03	0.61

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
3/25/2020	90.3	62.5485	LB	0.03	0.81	0.03	14.9	9.0	1.40	2.80	0.02	0.81
5/29/2019	5.7	20.0773	LC	0.08	0.89	0.09	48.9	10.0	2.20	2.80	0.09	0.98
8/23/2017	1.1	20.0773	LC	0.07	1.07	0.04	11.1	9.0	1.70	2.80	0.02	1.07
9/5/2018	0.0	20.0773	LC	0.07	1.12	0.10	14.3	6.0	1.00	2.80	0.02	1.12
6/27/2018	14.4	20.0773	LC	0.06	0.92	0.08	35.0	16.0	2.10	2.80	0.17	1.09
5/1/2019	193.7	241.314	MC	0.07	0.79	0.10	20.5	14.0	4.90	2.80	0.04	0.83
5/29/2019	51.3	241.314	MC	0.07	0.91	0.14	31.7	25.0	2.70	2.80	0.13	1.04
6/7/2017	942.3	241.314	MC	0.06	1.03	0.10	22.9	17.0	4.80	2.80	0.05	1.08
3/20/2019	188.5	241.314	MC	0.06	0.99	0.02	20.5	9.0	2.70	2.80	0.02	0.99
1/30/2019	229.2	241.314	MC	0.05	0.67	0.02	19.0	3.0	3.00	2.80	0.02	0.67
10/23/2019	5.4	25.8688	WW	0.06	1.07	0.04	21.9	8.0	4.30	2.80	0.74	1.81
9/1/2020	5.8	25.8688	WW	0.06	0.90	0.04	30.9	18.0	3.80	2.80	0.13	1.03
6/28/2017	13.2	25.8688	WW	0.05	1.02	0.06	42.6	25.0	2.50	2.80	0.09	1.11
6/27/2018	19.4	25.8688	WW	0.04	0.99	0.06	26.8	18.0	3.30	2.80	0.08	1.07
5/20/2020	165.1	62.5485	2B	0.06	0.80	0.04	10.7	16.0	1.30	2.70	0.06	0.86
2/27/2019	794.5	62.5485	2B	0.05	0.71	0.04	11.7	7.0	1.80	2.70	0.05	0.76
11/13/2019	5.6	25.8688	BC	0.04	0.67	0.03	15.5	4.0	3.90	2.70	0.02	0.67
8/7/2019	5.6	37.838	CH	0.08	0.92	0.10	75.8	64.0	3.10	2.70	0.02	0.92
6/7/2017	31.0	37.838	CH	0.07	0.89	0.10	28.2	24.0	8.00	2.70	0.05	0.94
8/14/2019	5.2	37.838	CH	0.07	0.73	0.03	12.3	14.0	2.30	2.70	0.02	0.73
6/17/2020	8.2	37.838	CH	0.06	0.83	0.10	20.5	16.0	2.60	2.70	0.05	0.88
3/18/2020	34.1	37.838	CH	0.03	0.53	0.04	21.0	7.0	3.60	2.70	0.06	0.59
10/8/2019	0.3	17.7607	GC	0.09	0.79	0.07	21.7	12.0	1.50	2.70	0.07	0.86
8/15/2018	0.2	17.7607	GC	0.07	0.90	0.13	24.8	13.0	2.00	2.70	0.04	0.94
2/21/2018	357.4	62.5485	LB	0.05	0.60	0.02	16.1	14.0	2.40	2.70	0.04	0.64
2/20/2019	142.6	62.5485	LB	0.03	0.72	0.05	22.4	12.0	1.90	2.70	0.04	0.76
4/3/2019	21.5	62.5485	LB	0.03	0.72	0.04	14.0	7.0	1.80	2.70	0.02	0.74
3/13/2019	38.6	20.0773	LC	0.05	0.85	0.03	23.1	11.0	3.30	2.70	0.08	0.93
4/29/2020	32.4	20.0773	LC	0.05	0.86	0.07	21.2	18.0	1.20	2.70	0.06	0.92
3/27/2019	1301.9	241.314	MC	0.06	1.05	0.06	27.4	9.0	3.60	2.70	0.02	1.05
4/12/2017	598.8	25.8688	WW	0.09	1.02	0.04	39.4	45.0	2.40	2.70	0.04	1.06
4/17/2019	4.8	25.8688	WW	0.05	0.66	0.05	30.5	13.0	4.10	2.70	0.03	0.69
4/22/2020	491.6	62.5485	2B	0.04	0.73	0.02	14.1	12.0	1.50	2.60	0.03	0.76
7/11/2018	12.7	37.838	CH	0.15	1.58	0.04	138.0	68.0	1.50	2.60	0.02	1.58
11/7/2018	68.2	37.838	CH	0.07	1.26	0.02	61.9	39.0	2.50	2.60	0.11	1.37
7/31/2019	6.6	37.838	CH	0.07	0.65	0.06	14.2	8.0	3.20	2.60	0.07	0.72
5/27/2020	29.2	37.838	CH	0.07	0.95	0.04	28.2	38.0	2.20	2.60	0.08	1.03
5/15/2019	11.8	37.838	CH	0.05	0.63	0.08	17.3	12.0	3.80	2.60	0.04	0.67
9/1/2020	9.3	37.838	CH	0.05	0.70	0.03	19.9	15.0	3.00	2.60	0.09	0.79
3/7/2018	63.4	37.838	CH	0.02	0.49	0.03	14.9	5.0	3.90	2.60	0.03	0.52
10/16/2019	1.0	17.7607	GC	0.07	0.96	0.05	26.7	11.0	1.80	2.60	0.04	1.00
5/27/2020	101.3	17.7607	GC	0.06	0.97	0.06	25.2	37.0	2.10	2.60	0.07	1.04
4/1/2020	156.2	17.7607	GC	0.04	0.84	0.02	29.9	22.0	2.80	2.60	0.05	0.89
5/31/2017	56.2	62.5485	LB	0.05	0.89	0.08	21.0	13.0	1.40	2.60	0.04	0.93
7/19/2017	15.5	62.5485	LB	0.04	0.78	0.04	9.9	9.0	1.00	2.60	0.05	0.83
2/14/2018	328.1	62.5485	LB	0.03	0.61	0.04	12.5	5.0	2.50	2.60	0.05	0.66
12/20/2017	158.8	20.0773	LC	0.09	0.98	0.06	34.8	23.0	2.20	2.60	0.20	1.18
3/7/2018	39.1	20.0773	LC	0.07	0.87	0.02	37.2	11.0	2.40	2.60	0.09	0.96
8/22/2018	1.5	20.0773	LC	0.07	0.83	0.04	24.9	24.0	1.30	2.60	0.02	0.83
5/8/2019	10.1	20.0773	LC	0.07	0.95	0.08	18.6	9.0	1.60	2.60	0.11	1.06
8/29/2018	0.3	20.0773	LC	0.06	0.95	0.04	21.2	9.0	1.10	2.60	0.02	0.97
5/20/2020	18.9	20.0773	LC	0.06	0.77	0.04	11.6	13.0	1.40	2.60	0.06	0.83
6/12/2019	3.9	20.0773	LC	0.05	0.78	0.09	13.2	7.0	2.00	2.60	0.47	1.25
4/22/2020	23.5	20.0773	LC	0.05	0.74	0.03	13.1	11.0	1.40	2.60	0.06	0.80
3/6/2019	16.0	20.0773	LC	0.04	0.64	0.03	18.7	7.0	2.60	2.60	0.10	0.74
7/2/2019	5.0	20.0773	LC	0.04	0.65	0.05	14.5	4.0	2.20	2.60	0.03	0.68
3/25/2020	37.4	20.0773	LC	0.04	0.83	0.04	29.1	10.0	1.90	2.60	0.10	0.93
12/28/2016	2076.0	241.314	MC	0.09	0.93	0.03	14.3	8.0	3.90	2.60	0.02	0.93
7/17/2019	1770.5	241.314	MC	0.07	0.87	0.04	32.4	19.0	3.70	2.60	0.04	0.91
4/10/2019	29.7	25.8688	WW	0.07	0.97	0.06	30.3	23.0	3.80	2.60	0.03	1.00

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
2/22/2017	448.7	25.8688	WW	0.06	1.01	0.02	32.0	26.0	2.80	2.60	0.03	1.04
3/27/2019	32.2	25.8688	WW	0.06	0.94	0.05	41.6	20.0	3.40	2.60	0.05	0.99
4/15/2020	42.2	25.8688	WW	0.05	0.66	0.04	36.0	19.0	3.20	2.60	0.07	0.73
7/18/2018	12.0	37.838	CH	0.23	2.63	0.05	263.0	106.0	1.90	2.50	0.02	2.65
8/8/2018	11.6	37.838	CH	0.12	1.98	0.03	214.0	39.0	1.70	2.50	0.02	2.00
10/16/2019	7.2	37.838	CH	0.12	1.15	0.08	99.6	26.0	7.90	2.50	0.51	1.66
6/5/2019	7.0	37.838	CH	0.09	1.04	0.21	22.4	17.0	2.40	2.50	0.02	1.04
8/23/2017	25.0	37.838	CH	0.06	1.06	0.16	34.7	20.0	1.50	2.50	0.02	1.06
11/14/2018	55.0	37.838	CH	0.04	0.82	0.03	25.4	13.0	2.90	2.50	0.20	1.02
3/6/2019	15.4	37.838	CH	0.03	0.58	0.03	21.2	9.0	4.00	2.50	0.04	0.62
5/24/2017	110.9	62.5485	LB	0.06	0.97	0.08	22.3	21.0	1.00	2.50	0.04	1.01
5/27/2020	172.7	62.5485	LB	0.05	0.80	0.02	10.9	12.0	0.90	2.50	0.02	0.82
6/24/2020	51.3	62.5485	LB	0.04	0.69	0.02	12.3	12.0	1.20	2.50	0.04	0.73
1/29/2020	160.9	62.5485	LB	0.03	0.57	0.02	11.8	4.0	2.10	2.50	0.04	0.61
9/12/2018	0.9	20.0773	LC	0.09	1.00	0.12	20.4	8.0	1.00	2.50	0.04	1.04
9/19/2018	0.3	20.0773	LC	0.07	0.89	0.08	12.7	5.0	1.00	2.50	0.02	0.89
6/5/2019	2.9	20.0773	LC	0.07	0.97	0.18	17.6	12.0	1.30	2.50	0.06	1.03
3/20/2019	13.6	20.0773	LC	0.05	0.60	0.03	47.8	8.0	3.20	2.50	0.09	0.69
6/26/2019	17.9	20.0773	LC	0.04	0.85	0.02	29.3	13.0	2.10	2.50	0.05	0.90
10/3/2018	22.7	241.314	MC	0.09	1.11	0.10	18.3	3.0	1.70	2.50	0.05	1.16
8/9/2017	459.1	241.314	MC	0.08	0.57	0.16	26.1	24.0	2.70	2.50	0.08	0.65
6/28/2017	912.4	241.314	MC	0.06	1.00	0.05	17.9	11.0	1.80	2.50	0.02	1.02
9/26/2018	207.7	241.314	MC	0.06	1.02	0.04	19.1	20.0	3.10	2.50	0.10	1.12
5/3/2017	2082.2	241.314	MC	0.05	0.92	0.03	19.3	10.0	2.00	2.50	0.02	0.94
1/2/2019	2152.1	241.314	MC	0.04	0.67	0.02	20.3	3.0	3.10	2.50	0.02	0.67
4/1/2020	326.6	25.8688	WW	0.06	1.04	0.03	38.0	28.0	2.30	2.50	0.03	1.07
4/1/2020	663.1	62.5485	2B	0.05	0.91	0.02	18.1	14.0	1.30	2.40	0.02	0.93
10/16/2019	6.7	25.8688	BC	0.07	0.96	0.09	51.9	25.0	1.50	2.40	0.03	0.99
5/27/2020	53.7	25.8688	BC	0.05	0.92	0.05	29.2	33.0	2.50	2.40	0.06	0.98
4/1/2020	113.9	25.8688	BC	0.03	0.76	0.02	28.7	26.0	3.20	2.40	0.04	0.80
12/7/2016	27.1	37.838	CH	0.09	0.81	0.02	14.5	13.0	2.90	2.40	0.02	0.81
3/13/2019	56.9	37.838	CH	0.06	0.80	0.03	25.9	11.0	4.70	2.40	0.14	0.94
2/28/2018	837.6	37.838	CH	0.05	0.69	0.03	28.5	40.0	2.40	2.40	0.03	0.72
2/27/2019	16.1	37.838	CH	0.03	0.49	0.03	19.5	19.0	4.10	2.40	0.05	0.54
8/2/2017	1.4	62.5485	LB	0.09	2.42	0.02	12.4	18.0	0.60	2.40	0.02	2.42
5/6/2020	6.9	62.5485	LB	0.04	0.79	0.12	12.4	10.0	1.00	2.40	0.05	0.84
7/12/2017	1.4	20.0773	LC	0.07	1.20	0.08	21.1	10.0	3.10	2.40	0.51	1.71
5/1/2019	8.6	20.0773	LC	0.07	0.78	0.11	20.6	8.0	2.80	2.40	0.12	0.90
5/24/2017	58.9	20.0773	LC	0.06	0.89	0.08	40.0	43.0	1.70	2.40	0.10	0.99
1/29/2020	91.1	20.0773	LC	0.04	0.66	0.05	20.8	19.0	1.70	2.40	0.13	0.79
5/15/2019	374.2	241.314	MC	0.05	0.83	0.13	15.2	13.0	4.20	2.40	0.06	0.89
9/1/2020	368.4	241.314	MC	0.05	0.69	0.02	16.7	12.0	2.40	2.40	0.04	0.73
3/18/2020	1580.2	241.314	MC	0.04	0.69	0.02	25.0	6.0	2.90	2.40	0.02	0.69
11/30/2016	9.1	25.8688	WW	0.17	1.05	0.03	41.3	36.0	5.10	2.40	0.02	1.05
7/19/2017	9.6	25.8688	WW	0.07	0.98	0.07	37.1	15.0	1.70	2.40	0.15	1.13
2/13/2019	373.0	25.8688	WW	0.06	1.00	0.04	42.0	19.0	3.30	2.40	0.03	1.03
6/10/2020	174.0	62.5485	2B	0.06	0.77	0.02	17.3	21.0	1.20	2.30	0.03	0.80
1/23/2019	1316.1	62.5485	2B	0.04	0.98	0.04	17.4	18.0	0.60	2.30	0.02	0.98
7/25/2018	9.3	37.838	CH	0.18	2.32	0.05	174.0	86.0	1.20	2.30	0.02	2.34
9/26/2018	25.1	37.838	CH	0.05	1.33	0.06	12.1	9.0	2.00	2.30	0.69	2.02
4/29/2020	39.9	37.838	CH	0.05	0.65	0.07	41.9	38.0	2.90	2.30	0.06	0.71
7/2/2019	8.6	37.838	CH	0.04	0.65	0.06	17.7	8.0	3.20	2.30	0.04	0.69
2/15/2017	194.5	62.5485	LB	0.07	0.85	0.02	26.7	19.0	2.80	2.30	0.17	1.02
5/29/2019	14.0	62.5485	LB	0.05	0.94	0.17	12.6	7.0	1.00	2.30	0.08	1.02
3/13/2019	202.9	62.5485	LB	0.04	0.96	0.04	21.2	9.0	1.70	2.30	0.02	0.98
7/10/2019	19.9	62.5485	LB	0.04	0.90	0.05	10.3	10.0	0.90	2.30	0.03	0.93
3/14/2018	38.9	62.5485	LB	0.03	0.78	0.03	15.9	5.0	1.70	2.30	0.02	0.78
12/19/2018	218.0	62.5485	LB	0.03	0.67	0.03	15.3	11.0	1.70	2.30	0.03	0.70
12/12/2018	140.5	62.5485	LB	0.02	0.72	0.02	13.8	6.0	2.40	2.30	0.03	0.75
6/19/2019	3.3	20.0773	LC	0.06	0.76	0.06	13.9	9.0	1.30	2.30	0.05	0.81

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
2/27/2019	18.6	20.0773	LC	0.04	0.58	0.04	24.0	9.0	2.10	2.30	0.10	0.68
5/22/2019	820.1	241.314	MC	0.07	0.99	0.14	25.5	18.0	2.50	2.30	0.09	1.08
9/5/2018	10.8	25.8688	WW	0.04	0.87	0.07	16.3	12.0	0.90	2.30	0.02	0.87
6/26/2019	482.6	62.5485	2B	0.05	0.92	0.04	14.8	13.0	1.50	2.20	0.05	0.97
4/8/2020	592.3	62.5485	2B	0.05	0.85	0.04	20.3	21.0	1.00	2.20	0.03	0.88
1/2/2019	777.2	62.5485	2B	0.03	0.85	0.02	12.8	9.0	1.80	2.20	0.02	0.87
8/15/2018	18.1	37.838	CH	0.05	1.45	0.05	27.6	23.0	2.00	2.20	0.25	1.70
11/6/2019	7.4	37.838	CH	0.05	0.91	0.06	19.6	8.0	3.50	2.20	0.13	1.04
5/20/2020	18.0	37.838	CH	0.05	0.61	0.03	16.7	21.0	3.10	2.20	0.05	0.66
5/1/2019	9.4	37.838	CH	0.04	0.57	0.07	16.3	11.0	3.40	2.20	0.03	0.60
7/24/2019	9.2	37.838	CH	0.04	0.67	0.07	29.0	18.0	3.00	2.20	0.08	0.75
4/22/2020	23.7	37.838	CH	0.03	0.57	0.02	20.3	11.0	3.10	2.20	0.05	0.62
6/26/2019	140.7	62.5485	LB	0.03	0.91	0.02	12.5	9.0	1.70	2.20	0.04	0.95
1/15/2020	229.9	62.5485	LB	0.03	0.83	0.03	12.3	5.0	2.00	2.20	0.05	0.88
2/7/2018	105.5	20.0773	LC	0.08	0.96	0.06	49.9	59.0	3.20	2.20	0.15	1.11
2/20/2019	108.6	20.0773	LC	0.06	0.86	0.06	29.6	24.0	2.10	2.20	0.12	0.98
5/15/2019	11.3	20.0773	LC	0.06	0.77	0.07	34.5	12.0	2.10	2.20	0.12	0.89
1/15/2020	70.4	20.0773	LC	0.06	0.79	0.02	24.3	11.0	2.40	2.20	0.11	0.90
12/28/2016	2.5	20.0773	LC	0.05	0.66	0.04	18.1	9.0	1.70	2.20	0.03	0.69
4/12/2017	136.6	20.0773	LC	0.05	0.92	0.03	16.4	13.0	1.60	2.20	0.05	0.97
4/1/2020	78.0	20.0773	LC	0.05	0.90	0.02	16.7	14.0	1.40	2.20	0.07	0.97
1/2/2019	44.2	20.0773	LC	0.04	0.73	0.07	27.4	8.0	2.00	2.20	0.07	0.80
1/15/2020	1512.1	241.314	MC	0.06	0.86	0.02	22.4	9.0	4.20	2.20	0.03	0.89
8/15/2018	22.9	25.8688	WW	0.06	0.94	0.10	20.8	10.0	1.30	2.20	0.06	1.00
8/22/2018	12.1	25.8688	WW	0.06	0.94	0.13	17.7	11.0	1.40	2.20	0.04	0.98
8/29/2018	6.1	25.8688	WW	0.05	1.07	0.05	13.9	13.0	1.20	2.20	0.02	1.09
5/15/2019	840.5	62.5485	2B	0.05	0.94	0.09	17.0	14.0	1.60	2.10	0.04	0.98
8/1/2018	14.1	37.838	CH	0.25	2.45	0.11	604.0	262.0	2.00	2.10	0.15	2.60
11/30/2016	12.1	37.838	CH	0.12	1.06	0.07	37.6	28.0	2.10	2.10	0.30	1.36
8/25/2020	5.9	37.838	CH	0.08	1.03	0.03	19.7	18.0	1.60	2.10	0.02	1.05
2/22/2017	674.2	37.838	CH	0.06	0.95	0.02	45.5	38.0	3.30	2.10	0.06	1.01
3/27/2019	22.7	37.838	CH	0.05	0.83	0.04	26.2	16.0	3.20	2.10	0.05	0.88
5/8/2019	14.0	37.838	CH	0.05	0.64	0.06	23.0	13.0	3.40	2.10	0.04	0.68
4/15/2020	32.9	37.838	CH	0.04	0.57	0.03	22.3	11.0	3.20	2.10	0.08	0.65
4/24/2019	10.9	37.838	CH	0.03	0.38	0.04	15.4	8.0	3.90	2.10	0.03	0.41
4/12/2017	278.7	17.7607	GC	0.09	1.12	0.02	34.9	36.0	2.20	2.10	0.03	1.15
4/5/2017	312.9	62.5485	LB	0.04	0.88	0.06	11.9	8.0	1.70	2.10	0.03	0.91
10/16/2019	15.2	62.5485	LB	0.04	0.66	0.02	16.6	7.0	2.30	2.10	0.15	0.81
5/3/2017	137.9	62.5485	LB	0.03	0.92	0.07	16.6	13.0	1.00	2.10	0.03	0.95
1/9/2019	203.7	62.5485	LB	0.03	0.65	0.03	16.6	3.0	1.60	2.10	0.02	0.67
1/30/2019	132.8	62.5485	LB	0.03	0.64	0.04	16.7	5.0	1.90	2.10	0.03	0.67
4/1/2020	433.0	62.5485	LB	0.03	0.94	0.02	18.0	12.0	1.10	2.10	0.03	0.97
7/17/2019	101.7	20.0773	LC	0.07	0.99	0.07	13.7	11.0	1.30	2.10	0.02	1.01
5/22/2019	15.4	20.0773	LC	0.06	0.81	0.09	17.2	11.0	1.70	2.10	0.07	0.88
4/15/2020	26.3	20.0773	LC	0.05	0.77	0.03	20.3	13.0	1.50	2.10	0.07	0.84
1/9/2019	878.1	241.314	MC	0.03	0.56	0.03	16.4	8.0	2.90	2.10	0.07	0.63
7/12/2017	11.4	25.8688	WW	0.07	1.02	0.09	36.0	17.0	4.10	2.10	0.17	1.19
7/12/2017	79.4	62.5485	2B	0.08	0.98	0.09	11.2	9.0	1.70	2.00	0.28	1.26
4/17/2019	499.1	62.5485	2B	0.04	0.90	0.05	13.3	9.0	1.50	2.00	0.04	0.94
2/12/2020	1337.3	62.5485	2B	0.04	0.77	0.03	12.4	11.0	1.30	2.00	0.05	0.82
6/19/2019	8.0	37.838	CH	0.09	1.13	0.03	20.4	16.0	2.00	2.00	0.02	1.13
6/12/2019	7.1	37.838	CH	0.08	1.04	0.09	26.4	18.0	2.30	2.00	0.08	1.12
4/8/2020	39.5	37.838	CH	0.06	0.83	0.04	28.2	26.0	2.20	2.00	0.05	0.88
6/10/2020	27.0	37.838	CH	0.06	0.92	0.03	34.9	32.0	2.00	2.00	0.12	1.04
8/18/2020	7.0	37.838	CH	0.06	0.93	0.06	26.6	18.0	2.10	2.00	0.06	0.99
7/7/2020	13.4	37.838	CH	0.05	0.82	0.04	27.0	22.0	1.80	2.00	0.07	0.89
6/26/2019	24.7	37.838	CH	0.04	0.78	0.04	34.6	25.0	3.00	2.00	0.08	0.86
4/1/2020	227.4	37.838	CH	0.04	0.86	0.02	26.9	19.0	2.20	2.00	0.06	0.92
2/13/2019	234.5	62.5485	LB	0.05	0.98	0.03	24.1	9.0	1.70	2.00	0.06	1.04
5/1/2019	48.4	62.5485	LB	0.05	1.02	0.20	16.8	15.0	1.30	2.00	0.03	1.05

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
6/14/2017	11.2	62.5485	LB	0.04	0.87	0.10	12.4	10.0	1.10	2.00	0.08	0.95
3/7/2018	509.5	62.5485	LB	0.03	0.73	0.03	13.1	4.0	1.90	2.00	0.02	0.73
3/20/2019	42.5	62.5485	LB	0.03	0.77	0.04	18.1	7.0	1.40	2.00	0.02	0.79
7/24/2019	65.4	62.5485	LB	0.03	0.67	0.04	11.4	6.0	1.20	2.00	0.04	0.71
4/24/2019	11.9	20.0773	LC	0.06	0.75	0.09	20.7	10.0	1.90	2.00	0.10	0.85
1/23/2019	2097.0	241.314	MC	0.08	0.94	0.03	70.9	107.0	2.70	2.00	0.04	0.98
7/7/2020	943.7	241.314	MC	0.05	0.74	0.02	20.4	16.0	1.80	2.00	0.04	0.78
4/24/2019	580.2	241.314	MC	0.04	0.67	0.06	15.9	10.0	3.00	2.00	0.02	0.67
2/12/2020	3912.0	241.314	MC	0.04	0.70	0.02	33.2	13.0	2.30	2.00	0.02	0.70
1/23/2019	397.7	25.8688	WW	0.06	0.87	0.04	47.8	57.0	1.80	2.00	0.02	0.89
7/17/2019	443.3	25.8688	WW	0.06	1.07	0.05	33.4	31.0	3.10	2.00	0.03	1.10
9/19/2018	6.6	25.8688	WW	0.05	0.85	0.12	11.5	10.0	0.80	2.00	0.03	0.88
1/2/2019	131.5	25.8688	WW	0.05	0.83	0.02	29.9	9.0	2.60	2.00	0.03	0.86
4/10/2019	675.3	62.5485	2B	0.06	0.95	0.05	14.8	13.0	1.60	1.90	0.04	0.99
7/5/2018	13.7	37.838	CH	0.15	1.50	0.04	95.3	62.0	1.80	1.90	0.02	1.50
7/12/2017	15.5	37.838	CH	0.06	0.76	0.06	25.1	16.0	3.20	1.90	0.06	0.82
4/10/2019	28.2	37.838	CH	0.05	0.81	0.05	20.1	11.0	3.50	1.90	0.03	0.84
4/17/2019	16.3	37.838	CH	0.04	0.65	0.05	18.8	10.0	3.70	1.90	0.04	0.69
1/2/2019	49.9	37.838	CH	0.03	0.71	0.03	23.5	11.0	3.10	1.90	0.06	0.77
4/12/2017	1048.7	62.5485	LB	0.05	0.85	0.02	14.2	11.0	0.90	1.90	0.03	0.88
2/7/2018	741.2	62.5485	LB	0.03	0.81	0.03	19.4	19.0	0.50	1.90	0.05	0.86
2/28/2018	124.9	20.0773	LC	0.06	0.78	0.02	25.7	18.0	1.60	1.90	0.08	0.86
2/28/2018	3777.5	241.314	MC	0.03	0.47	0.02	16.2	4.0	2.60	1.90	0.02	0.49
9/12/2018	12.4	25.8688	WW	0.04	0.97	0.09	13.6	12.0	0.80	1.90	0.02	0.97
4/12/2017	299.7	25.8688	BC	0.07	1.08	0.03	33.1	31.0	2.60	1.80	0.03	1.11
2/12/2020	683.4	25.8688	BC	0.04	0.65	0.02	33.1	31.0	3.40	1.80	0.03	0.68
8/22/2018	17.4	37.838	CH	0.16	1.52	0.08	313.0	44.0	2.40	1.80	0.08	1.60
2/13/2019	129.7	37.838	CH	0.05	0.97	0.03	34.9	19.0	2.90	1.80	0.05	1.02
3/27/2019	152.5	62.5485	LB	0.06	1.00	0.05	21.2	11.0	1.20	1.80	0.03	1.03
5/20/2020	52.1	62.5485	LB	0.05	0.75	0.04	9.5	13.0	1.10	1.80	0.02	0.75
5/8/2019	163.6	62.5485	LB	0.04	1.02	0.12	20.0	13.0	1.00	1.80	0.03	1.05
3/6/2019	119.7	62.5485	LB	0.03	0.77	0.04	18.8	6.0	2.00	1.80	0.03	0.80
7/2/2019	39.2	62.5485	LB	0.03	0.81	0.04	10.7	7.0	1.30	1.80	0.02	0.81
2/13/2019	83.3	20.0773	LC	0.06	1.00	0.05	27.2	10.0	2.00	1.80	0.05	1.05
4/10/2019	31.6	20.0773	LC	0.06	0.95	0.07	37.4	16.0	2.20	1.80	0.06	1.01
4/17/2019	21.3	20.0773	LC	0.06	0.68	0.05	76.1	12.0	2.40	1.80	0.08	0.76
5/24/2017	329.1	241.314	MC	0.08	0.95	0.04	56.9	81.0	2.50	1.80	0.12	1.07
7/12/2017	102.5	241.314	MC	0.08	0.86	0.04	40.7	28.0	2.50	1.80	0.12	0.98
2/7/2018	1321.9	241.314	MC	0.08	0.68	0.05	33.7	37.0	2.70	1.80	0.10	0.78
12/19/2018	1311.0	241.314	MC	0.05	0.53	0.03	16.1	4.0	2.40	1.80	0.02	0.53
5/8/2019	2371.7	241.314	MC	0.05	0.87	0.04	18.8	8.0	2.00	1.80	0.02	0.87
12/12/2018	1779.7	241.314	MC	0.04	0.66	0.02	18.7	5.0	3.00	1.80	0.02	0.66
4/10/2019	1653.6	241.314	MC	0.04	0.93	0.04	17.9	5.0	2.60	1.80	0.02	0.93
4/12/2017	902.0	37.838	CH	0.08	1.11	0.02	32.8	36.0	1.60	1.70	0.02	1.13
11/20/2018	2.4	17.7607	GC	0.05	0.97	0.05	16.5	6.0	1.60	1.70	0.02	0.97
4/22/2020	264.6	62.5485	LB	0.04	0.75	0.04	12.3	8.0	1.20	1.70	0.03	0.78
2/28/2018	794.5	62.5485	LB	0.03	0.60	0.02	9.9	5.0	1.80	1.70	0.02	0.60
2/27/2019	287.9	62.5485	LB	0.03	0.70	0.03	16.2	6.0	1.60	1.70	0.02	0.72
1/23/2019	135.8	20.0773	LC	0.05	0.85	0.05	30.9	31.0	0.90	1.70	0.04	0.89
2/27/2019	1393.1	241.314	MC	0.04	0.63	0.02	20.3	5.0	2.60	1.70	0.02	0.63
2/12/2020	726.7	25.8688	WW	0.04	0.78	0.03	26.2	9.0	2.10	1.70	0.02	0.78
4/15/2020	629.8	62.5485	2B	0.05	0.65	0.02	14.6	10.0	1.50	1.60	0.02	0.67
9/12/2018	14.3	37.838	CH	0.12	1.56	0.23	212.0	39.0	2.70	1.60	0.13	1.69
6/27/2018	16.0	37.838	CH	0.11	1.19	0.07	83.4	53.0	2.10	1.60	0.02	1.21
1/23/2019	597.1	37.838	CH	0.07	0.96	0.04	64.9	100.0	1.60	1.60	0.04	1.00
2/12/2020	482.6	17.7607	GC	0.03	0.59	0.02	24.8	17.0	2.20	1.60	0.03	0.62
5/22/2019	59.7	62.5485	LB	0.04	0.84	0.09	19.0	12.0	1.10	1.60	0.03	0.87
4/15/2020	397.4	62.5485	LB	0.04	0.72	0.02	13.3	7.0	1.20	1.60	0.02	0.74
1/2/2019	278.6	62.5485	LB	0.03	0.92	0.02	18.0	9.0	1.50	1.60	0.02	0.92
4/24/2019	213.8	62.5485	LB	0.03	0.77	0.06	18.0	16.0	1.50	1.60	0.03	0.80

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
6/26/2019	979.8	241.314	MC	0.05	0.82	0.03	28.3	15.0	2.30	1.60	0.04	0.86
4/17/2019	1648.1	241.314	MC	0.04	0.67	0.03	14.5	4.0	2.30	1.60	0.02	0.67
6/26/2019	31.3	25.8688	WW	0.05	0.88	0.03	35.4	31.0	2.20	1.60	0.05	0.93
2/7/2018	1439.7	37.838	CH	0.07	0.80	0.04	44.0	83.0	2.00	1.50	0.09	0.89
2/12/2020	1265.7	37.838	CH	0.04	0.82	0.09	26.2	14.0	2.30	1.50	0.05	0.87
12/20/2017	476.9	62.5485	LB	0.04	0.71	0.03	12.3	9.0	1.50	1.50	0.11	0.82
1/23/2019	629.7	62.5485	LB	0.04	0.79	0.03	23.1	21.0	0.90	1.50	0.02	0.81
5/15/2019	313.3	62.5485	LB	0.03	0.95	0.14	15.1	11.0	1.40	1.50	0.03	0.98
2/12/2020	1454.9	62.5485	LB	0.03	0.64	0.02	12.8	8.0	1.30	1.50	0.02	0.66
2/12/2020	196.6	20.0773	LC	0.04	0.67	0.03	15.7	8.0	1.40	1.50	0.06	0.73
4/15/2020	1976.2	241.314	MC	0.05	0.72	0.02	25.3	10.0	1.70	1.50	0.02	0.72
7/17/2019	364.6	25.8688	BC	0.06	0.92	0.04	24.8	35.0	3.80	1.40	0.03	0.95
5/24/2017	438.9	37.838	CH	0.09	1.17	0.05	80.8	144.0	2.10	1.40	0.03	1.20
10/30/2019	8.3	37.838	CH	0.07	1.37	0.10	31.0	17.0	3.70	1.40	1.32	2.69
4/17/2019	147.4	62.5485	LB	0.04	0.77	0.05	16.5	9.0	1.60	1.40	0.03	0.80
7/17/2019	575.4	62.5485	LB	0.04	0.89	0.04	10.9	9.0	0.90	1.40	0.02	0.91
4/10/2019	226.5	62.5485	LB	0.04	0.94	0.04	12.8	5.0	1.80	1.20	0.02	0.94
5/20/2020	1706.8	241.314	MC	0.05	0.65	0.02	11.3	8.0	1.20	1.20	0.02	0.65
12/20/2017	141.5	37.838	CH	0.13	0.91	0.02	65.8	76.0	2.00	1.00	0.21	1.12
7/17/2019	323.5	17.7607	GC	0.05	0.93	0.04	21.8	11.0	1.30	1.00	0.02	0.93
7/17/2019	843.2	37.838	CH	0.06	1.14	0.03	23.9	22.0	1.20	0.90	0.02	1.14
2/28/2018	1520.1	62.5485	2B	0.02	0.81	0.02	6.3	5.0	1.40	0.70	0.02	0.81
11/14/2018	50.0	25.8688	WW	0.05	0.76	0.02	29.3	16.0	0.50	0.60	0.03	0.79
5/16/2018	20.6	62.5485	2B	0.15	1.18	0.50	9.2	8.0	0.00	0.00	0.00	0.00
6/20/2018	8.0	62.5485	2B	0.12	0.79	0.05	5.3	8.0	0.00	0.00	0.00	0.00
5/30/2018	0.4	62.5485	2B	0.11	0.60	0.08	5.9	6.0	0.00	0.00	0.00	0.00
6/6/2018	3.4	62.5485	2B	0.11	1.32	0.12	7.0	8.0	0.00	0.00	0.00	0.00
5/23/2018	2.6	62.5485	2B	0.10	0.75	0.07	10.6	9.0	0.00	0.00	0.00	0.00
6/13/2018	6.6	62.5485	2B	0.10	0.62	0.04	6.4	6.0	0.00	0.00	0.00	0.00
5/9/2018	29.9	62.5485	2B	0.09	0.89	0.31	8.1	9.0	0.00	0.00	0.00	0.00
5/2/2018	63.6	62.5485	2B	0.06	0.63	0.10	12.8	7.0	0.00	0.00	0.00	0.00
4/11/2018	254.7	62.5485	2B	0.04	0.73	0.08	10.2	4.0	0.00	0.00	0.00	0.00
4/18/2018	223.0	62.5485	2B	0.04	0.72	0.07	9.8	7.0	0.00	0.00	0.00	0.00
4/25/2018	356.3	62.5485	2B	0.04	0.78	0.06	12.6	6.0	0.00	0.00	0.00	0.00
6/20/2018	0.5	25.8688	BC	0.07	0.96	0.14	11.1	9.0	0.00	0.00	0.00	0.00
5/30/2018	7.2	25.8688	BC	0.06	0.94	0.22	19.0	9.0	0.00	0.00	0.00	0.00
6/6/2018	4.0	25.8688	BC	0.06	1.04	0.15	17.4	9.0	0.00	0.00	0.00	0.00
4/25/2018	25.8	25.8688	BC	0.05	0.78	0.10	19.2	6.0	0.00	0.00	0.00	0.00
5/16/2018	10.0	25.8688	BC	0.05	0.75	0.06	11.6	15.0	0.00	0.00	0.00	0.00
6/13/2018	1.3	25.8688	BC	0.05	0.98	0.13	12.7	7.0	0.00	0.00	0.00	0.00
5/9/2018	8.6	25.8688	BC	0.04	0.60	0.07	9.7	6.0	0.00	0.00	0.00	0.00
5/23/2018	10.6	25.8688	BC	0.04	0.77	0.12	16.7	12.0	0.00	0.00	0.00	0.00
4/18/2018	19.6	25.8688	BC	0.03	0.36	0.04	14.4	6.0	0.00	0.00	0.00	0.00
4/11/2018	21.2	25.8688	BC	0.02	0.50	0.05	15.1	5.0	0.00	0.00	0.00	0.00
5/2/2018	10.8	25.8688	BC	0.02	0.51	0.07	13.6	8.0	0.00	0.00	0.00	0.00
6/20/2018	3.9	37.838	CH	0.09	1.74	0.18	72.7	45.0	0.00	0.00	0.00	0.00
5/16/2018	18.7	37.838	CH	0.07	0.74	0.04	15.1	15.0	0.00	0.00	0.00	0.00
5/30/2018	15.5	37.838	CH	0.07	0.85	0.02	13.1	11.0	0.00	0.00	0.00	0.00
6/13/2018	6.0	37.838	CH	0.07	1.15	0.03	42.3	28.0	0.00	0.00	0.00	0.00
6/6/2018	15.5	37.838	CH	0.06	1.10	0.04	24.9	22.0	0.00	0.00	0.00	0.00
4/25/2018	47.3	37.838	CH	0.04	0.55	0.04	18.7	7.0	0.00	0.00	0.00	0.00
4/11/2018	39.5	37.838	CH	0.03	0.51	0.07	12.8	6.0	0.00	0.00	0.00	0.00
4/18/2018	40.0	37.838	CH	0.03	0.50	0.07	12.8	7.0	0.00	0.00	0.00	0.00
5/9/2018	21.7	37.838	CH	0.03	0.57	0.05	12.9	7.0	0.00	0.00	0.00	0.00
5/2/2018	26.5	37.838	CH	0.02	0.41	0.04	16.5	8.0	0.00	0.00	0.00	0.00
5/23/2018	17.5	37.838	CH	0.02	0.72	0.02	14.8	12.0	0.00	0.00	0.00	0.00
6/20/2018	0.1	17.7607	GC	0.12	1.31	1.20	21.8	20.0	0.00	0.00	0.00	0.00
6/13/2018	0.1	17.7607	GC	0.09	1.25	0.24	26.3	17.0	0.00	0.00	0.00	0.00
5/30/2018	0.1	17.7607	GC	0.07	1.04	0.31	18.8	11.0	0.00	0.00	0.00	0.00
6/6/2018	0.1	17.7607	GC	0.07	1.35	0.30	24.4	16.0	0.00	0.00	0.00	0.00

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
4/25/2018	7.4	17.7607	GC	0.06	0.74	0.05	22.6	10.0	0.00	0.00	0.00	0.00
5/16/2018	0.2	17.7607	GC	0.06	0.97	0.18	20.4	21.0	0.00	0.00	0.00	0.00
4/18/2018	4.1	17.7607	GC	0.03	0.58	0.05	15.8	7.0	0.00	0.00	0.00	0.00
5/2/2018	0.7	17.7607	GC	0.03	0.50	0.08	18.0	11.0	0.00	0.00	0.00	0.00
5/9/2018	0.4	17.7607	GC	0.03	0.68	0.11	11.9	10.0	0.00	0.00	0.00	0.00
4/11/2018	4.1	17.7607	GC	0.02	0.50	0.06	16.4	7.0	0.00	0.00	0.00	0.00
5/23/2018	0.2	17.7607	GC	0.02	0.94	0.15	24.7	21.0	0.00	0.00	0.00	0.00
4/25/2018	16.2	38.6102	HC	0.10	0.85	0.07	24.8	7.0	0.00	0.00	0.00	0.00
5/16/2018	0.1	38.6102	HC	0.07	0.67	0.08	10.3	7.0	0.00	0.00	0.00	0.00
4/18/2018	14.0	38.6102	HC	0.06	0.72	0.06	18.3	6.0	0.00	0.00	0.00	0.00
5/9/2018	0.5	38.6102	HC	0.06	0.69	0.10	10.8	6.0	0.00	0.00	0.00	0.00
6/20/2018	0.6	38.6102	HC	0.06	0.54	0.06	8.6	4.0	0.00	0.00	0.00	0.00
4/11/2018	6.0	38.6102	HC	0.05	0.78	0.09	12.7	9.0	0.00	0.00	0.00	0.00
5/23/2018	0.0	38.6102	HC	0.05	0.61	0.05	10.2	9.0	0.00	0.00	0.00	0.00
5/30/2018	0.2	38.6102	HC	0.05	0.49	0.06	9.6	4.0	0.00	0.00	0.00	0.00
6/13/2018	0.3	38.6102	HC	0.05	0.59	0.06	9.1	4.0	0.00	0.00	0.00	0.00
5/2/2018	1.3	38.6102	HC	0.04	0.64	0.09	15.6	4.0	0.00	0.00	0.00	0.00
6/6/2018	0.6	38.6102	HC	0.04	0.84	0.06	10.1	7.0	0.00	0.00	0.00	0.00
6/20/2018	1.3	62.5485	LB	0.68	7.16	2.03	255.0	120.0	0.00	0.00	0.00	0.00
6/6/2018	1.4	62.5485	LB	0.14	1.78	0.05	64.7	49.0	0.00	0.00	0.00	0.00
5/16/2018	7.9	62.5485	LB	0.06	0.88	0.07	55.3	25.0	0.00	0.00	0.00	0.00
4/25/2018	93.9	62.5485	LB	0.05	0.75	0.04	16.4	6.0	0.00	0.00	0.00	0.00
4/11/2018	61.8	62.5485	LB	0.03	0.83	0.07	13.4	6.0	0.00	0.00	0.00	0.00
4/18/2018	52.9	62.5485	LB	0.03	0.68	0.04	13.5	6.0	0.00	0.00	0.00	0.00
5/9/2018	9.6	62.5485	LB	0.03	0.61	0.10	19.3	9.0	0.00	0.00	0.00	0.00
5/23/2018	7.4	62.5485	LB	0.03	0.74	0.07	15.5	9.0	0.00	0.00	0.00	0.00
5/30/2018	4.4	62.5485	LB	0.03	0.56	0.05	10.0	6.0	0.00	0.00	0.00	0.00
5/2/2018	15.8	62.5485	LB	0.02	0.59	0.06	12.5	5.0	0.00	0.00	0.00	0.00
4/25/2018	17.7	20.0773	LC	0.12	0.82	0.06	336.0	40.0	0.00	0.00	0.00	0.00
6/20/2018	0.0	20.0773	LC	0.11	1.50	0.03	35.3	26.0	0.00	0.00	0.00	0.00
5/16/2018	2.2	20.0773	LC	0.10	1.18	0.17	57.1	22.0	0.00	0.00	0.00	0.00
5/23/2018	4.8	20.0773	LC	0.10	1.18	0.17	74.1	14.0	0.00	0.00	0.00	0.00
6/6/2018	0.6	20.0773	LC	0.09	1.32	0.09	37.8	20.0	0.00	0.00	0.00	0.00
5/30/2018	3.0	20.0773	LC	0.08	0.87	0.09	46.3	9.0	0.00	0.00	0.00	0.00
6/13/2018	0.0	20.0773	LC	0.08	1.16	0.02	28.3	19.0	0.00	0.00	0.00	0.00
5/9/2018	5.4	20.0773	LC	0.06	0.75	0.08	46.4	9.0	0.00	0.00	0.00	0.00
4/11/2018	12.8	20.0773	LC	0.05	0.62	0.06	23.3	8.0	0.00	0.00	0.00	0.00
4/18/2018	15.4	20.0773	LC	0.05	0.62	0.06	36.6	9.0	0.00	0.00	0.00	0.00
5/2/2018	7.6	20.0773	LC	0.04	0.75	0.08	20.0	8.0	0.00	0.00	0.00	0.00
5/23/2018	81.8	241.314	MC	0.12	1.02	0.08	29.8	32.0	0.00	0.00	0.00	0.00
6/6/2018	4.2	241.314	MC	0.11	1.39	0.08	39.9	24.0	0.00	0.00	0.00	0.00
6/13/2018	1.0	241.314	MC	0.11	1.15	0.09	24.3	15.0	0.00	0.00	0.00	0.00
6/20/2018	0.4	241.314	MC	0.10	1.25	0.05	33.1	17.0	0.00	0.00	0.00	0.00
5/16/2018	13.5	241.314	MC	0.08	0.83	0.09	22.0	14.0	0.00	0.00	0.00	0.00
5/30/2018	21.5	241.314	MC	0.08	0.89	0.07	34.2	19.0	0.00	0.00	0.00	0.00
4/25/2018	930.0	241.314	MC	0.07	0.85	0.07	22.3	6.0	0.00	0.00	0.00	0.00
5/9/2018	23.9	241.314	MC	0.06	0.76	0.09	20.2	13.0	0.00	0.00	0.00	0.00
4/18/2018	903.6	241.314	MC	0.05	0.63	0.04	14.3	4.0	0.00	0.00	0.00	0.00
5/2/2018	55.2	241.314	MC	0.05	0.57	0.09	25.1	13.0	0.00	0.00	0.00	0.00
4/11/2018	805.5	241.314	MC	0.04	0.65	0.07	15.7	6.0	0.00	0.00	0.00	0.00
4/18/2018	5.5	43.2434	SC	0.05	0.83	0.04	6.4	5.0	0.00	0.00	0.00	0.00
4/25/2018	5.6	43.2434	SC	0.05	0.85	0.04	7.8	7.0	0.00	0.00	0.00	0.00
5/9/2018	4.5	43.2434	SC	0.05	0.70	0.04	2.2	2.0	0.00	0.00	0.00	0.00
6/13/2018	0.0	43.2434	SC	0.05	0.62	0.02	6.5	7.0	0.00	0.00	0.00	0.00
4/11/2018	5.5	43.2434	SC	0.04	0.78	0.06	4.4	5.0	0.00	0.00	0.00	0.00
5/16/2018	3.4	43.2434	SC	0.04	0.71	0.03	3.2	4.0	0.00	0.00	0.00	0.00
6/6/2018	0.0	43.2434	SC	0.04	1.00	0.04	6.8	6.0	0.00	0.00	0.00	0.00
6/20/2018	0.0	43.2434	SC	0.04	0.57	0.02	3.9	4.0	0.00	0.00	0.00	0.00
5/23/2018	2.4	43.2434	SC	0.03	0.63	0.02	4.0	4.0	0.00	0.00	0.00	0.00
5/2/2018	5.0	43.2434	SC	0.02	0.60	0.04	2.5	4.0	0.00	0.00	0.00	0.00

Date	Q	Watershed Area (mi2)	Site	TP (mg/L)	TKN (mg/L)	NH4-N (mg/L)	Turbidity (NTU)	TSS (mg/L)	SO4 (mg/L)	Cl- (mg/L)	NO3+NO2-N (mg/L)	TN (mg/L)
5/30/2018	1.1	43.2434	SC	0.02	0.56	0.02	5.4	4.0	0.00	0.00	0.00	0.00
6/6/2018	7.5	25.8688	WW	0.11	1.50	0.03	33.0	30.0	0.00	0.00	0.00	0.00
6/20/2018	2.2	25.8688	WW	0.08	1.13	0.05	24.7	13.0	0.00	0.00	0.00	0.00
5/30/2018	14.5	25.8688	WW	0.07	1.18	0.18	24.5	6.0	0.00	0.00	0.00	0.00
5/23/2018	23.7	25.8688	WW	0.06	1.06	0.16	16.2	15.0	0.00	0.00	0.00	0.00
6/13/2018	3.7	25.8688	WW	0.06	1.11	0.06	27.7	14.0	0.00	0.00	0.00	0.00
4/11/2018	24.0	25.8688	WW	0.05	0.59	0.07	20.5	6.0	0.00	0.00	0.00	0.00
4/18/2018	23.9	25.8688	WW	0.05	0.60	0.06	26.4	10.0	0.00	0.00	0.00	0.00
4/25/2018	29.2	25.8688	WW	0.05	0.79	0.06	23.6	10.0	0.00	0.00	0.00	0.00
5/2/2018	26.3	25.8688	WW	0.05	0.74	0.08	23.0	9.0	0.00	0.00	0.00	0.00
5/9/2018	25.9	25.8688	WW	0.05	0.80	0.11	17.1	10.0	0.00	0.00	0.00	0.00
5/16/2018	22.0	25.8688	WW	0.02	1.02	0.15	17.6	12.0	0.00	0.00	0.00	0.00

Appendix C

Macroinvertebrate Data

Stream	Site abbreviation	Date	Season	Sample type	Order	Family	Genera	Functional Feeding Group	Number of individuals
Bryant Creek		6/21/2023	Spring	1	Amphipoda	Talitridae	Hyalella	Collector	4
Bryant Creek		6/21/2023	Spring	1	Coleoptera	Dytiscidae	Dytiscus	Predator	3
Bryant Creek		6/21/2023	Spring	1	Coleoptera	Dytiscidae	Uvarus	Predator	3
Bryant Creek		6/21/2023	Spring	1	Coleoptera	Elmidae	Microcylloepus	Collector Gatherer	4
Bryant Creek		6/21/2023	Spring	1	Decapoda	Cambaridae	Orconectes lancifer	Collector Gatherer	1
Bryant Creek		6/21/2023	Spring	1	Decapoda	Palaemonidae	Palaenonetes kadiakensis	Predator	2
Bryant Creek		6/21/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Filterer	61
Bryant Creek		6/21/2023	Spring	1	Ephemeroptera	Ephemerillidae	Antenella	Collector Gatherer	2
Bryant Creek		6/21/2023	Spring	1	Ephemeroptera	Heptageniidae	Stenonema	Scraper	1
Bryant Creek		6/21/2023	Spring	1	Ephemeroptera	Leptophlebiidae	Tricorythodes	Collector Gatherer	1
Bryant Creek		6/21/2023	Spring	1	Hemiptera	Corixidae	Micronecta	Predator	1
Bryant Creek		6/21/2023	Spring	1	Isopoda	Assellidae	Lirceus	Collector Gatherer	1
Bryant Creek		6/21/2023	Spring	1	Megaloptera	Corydalidae	Chauliodes	Predator	2
Bryant Creek		6/21/2023	Spring	1	Odonata	Aeshnidae	Boyeria	Predator	2
Bryant Creek		6/21/2023	Spring	1	Odonata	Libellulidae	Pachydiplax	Predator	1
Bryant Creek		6/21/2023	Spring	1	Oligochaeta	Lumbriculidae	Rhyncholmis	Collector Gatherer	2
Camp Creek		6/6/2023	Spring	1	Amphipoda	Talitridae	Hyalella	Collector	24
Camp Creek		6/6/2023	Spring	1	Coleoptera	Haliplidae	Peltodytes	Predator	2
Camp Creek		6/6/2023	Spring	1	Coleoptera	Hydrophilidae	Laccobius	Piercer-herbivore	1
Camp Creek		6/6/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Filterer	54
Camp Creek		6/6/2023	Spring	1	Diptera	Culicidae	Anopheles	Collector Filterer	1
Camp Creek		6/6/2023	Spring	1	Diptera	Culicidae	Uranotaenia	Collector Filterer	2
Camp Creek		6/6/2023	Spring	1	Diptera	Tipulidae	Tipula	Shredder	1
Camp Creek		6/6/2023	Spring	1	Ephemeroptera	Baetidae	Callibaetis	Collector Gatherer	3
Camp Creek		6/6/2023	Spring	1	Hemiptera	(possibly terrestrial)	--		1
Camp Creek		6/6/2023	Spring	1	Hemiptera	Corixidae	Centrocorisa	Predator	20
Camp Creek		6/6/2023	Spring	1	Hemiptera	Macroveliidae	Notomicrus	Predator	2
Camp Creek		6/6/2023	Spring	1	Isopoda	Asselidae	Lirceus	Collector Gatherer	1
Camp Creek		6/6/2023	Spring	1	Odonata	Gomphidae	Lanthus	Predator	1
Champanelle Creek		6/6/2023	Spring	1	Coleoptera	Elmidae	Rhizelmis	Collector Gatherer	9
Champanelle Creek		6/6/2023	Spring	1	Coleoptera	Gyrinidae	Gyretes	Predator	6
Champanelle Creek		6/6/2023	Spring	1	Decapoda	Cambaridae	Procambarus	Scraper	2
Champanelle Creek		6/6/2023	Spring	1	Diptera	Ceratopogonidae	Bezzia	Predator	1
Champanelle Creek		6/6/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Gatherer	45
Champanelle Creek		6/6/2023	Spring	1	Diptera	Chironomidae	Orthocladiinae	Collector Gatherer	4
Champanelle Creek		6/6/2023	Spring	1	Diptera	Chironomidae	Tanypodinae	Predator	19
Champanelle Creek		6/6/2023	Spring	1	Diptera	Simuliidae	Twinnia	Scraper	2
Champanelle Creek		6/6/2023	Spring	1	Ephemeroptera	Baetidae	Centroptilum	Collector Gatherer	10
Champanelle Creek		6/6/2023	Spring	1	Ephemeroptera	Ephemeridae	Hexagenia	Collector Gatherer	10
Champanelle Creek		6/6/2023	Spring	1	Ephemeroptera	Heptageniidae	Stenonema	Scraper	2
Champanelle Creek		6/6/2023	Spring	1	Ephemeroptera	Leptophlebiidae	Neochoroterpes	Collector Gatherer	1
Champanelle Creek		6/6/2023	Spring	1	Odonata	Libellulidae	Libellula	Predator	1
Champanelle Creek		6/6/2023	Spring	1	Trichoptera	Hydropsychidae	Cheumatopsyche	Collector Filterer	8
Cypress		6/6/2023	Spring	1	Amphipoda	Hyalellidae	Hyalella	Collector	1
Cypress		6/6/2023	Spring	1	Coleoptera	Elmidae	Rhizelmis	Collector Gatherer	11
Cypress		6/6/2023	Spring	1	Coleoptera	Haliplidae	Peltodytes	Predator	1
Cypress		6/6/2023	Spring	1	Coleoptera	Lampyridae	Photuris	Collector Gatherer	1
Cypress		6/6/2023	Spring	1	Decapoda	Cambaridae	Procambarus	Scraper	1
Cypress		6/6/2023	Spring	1	Decapoda	Palaemonidae	Palaemonetes	Predator	2
Cypress		6/6/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Gatherer	22
Cypress		6/6/2023	Spring	1	Diptera	Chironomidae	Tanypodinae	Predator	5
Cypress		6/6/2023	Spring	1	Diptera	Simuliidae	Twinnia	Scraper	2
Cypress		6/6/2023	Spring	1	Ephemeroptera	Baetidae	Centroptilum	Collector Gatherer	37
Cypress		6/6/2023	Spring	1	Ephemeroptera	Heptageniidae	Maccaffertium	Scraper	2
Cypress		6/6/2023	Spring	1	Hemiptera	Corixidae	Cymatia	Predator	1
Cypress		6/6/2023	Spring	1	Isopoda	Asellidae	Caecidotea	Collector Gatherer	2
Cypress		6/6/2023	Spring	1	Odonata	Aeshnidae	Boyeria	Predator	1
Cypress		6/6/2023	Spring	1	Trichoptera	Hydropsychidae	Cheumatopsyche	Collector Filterer	13
Flat Creek		6/22/2023	Spring	1	Amphipoda	Talitridae	Hyalella	Collector	43
Flat Creek		6/22/2023	Spring	1	Coleoptera	Dytiscidae	Dytiscus	Predator	3
Flat Creek		6/22/2023	Spring	1	Coleoptera	Gyrinidae	Dineutus	Predator	4
Flat Creek		6/22/2023	Spring	1	Decapoda	Palaemonidae	Palaemonetes	Predator	1
Flat Creek		6/22/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Filterer	9
Flat Creek		6/22/2023	Spring	1	Diptera	Tipulidae	Tipula	Shredder	1
Flat Creek		6/22/2023	Spring	1	Hemiptera	Corixidae	Centrocorisa	Predator	4
Flat Creek		6/22/2023	Spring	1	Odonata	Coenagrionidae	Argia	Predator	4
Flat Creek		6/22/2023	Spring	1	Oligochaeta	Lumbriculidae	Rhyncholmis	Collector Gatherer	3
Flat Creek		6/22/2023	Spring	1	Trichoptera	Hydropsychidae	Ceratopsyche	Collector Filterer	13
Gum Creek		6/21/2023	Spring	1	Amphipoda	Talitridae	Hyalella	Collector	8
Gum Creek		6/21/2023	Spring	1	Coleoptera	Elmidae	Microcylloepus	Collector Gatherer	1
Gum Creek		6/21/2023	Spring	1	Decapoda	Palaemonidae	Palaenonetes kadiakensis	Predator	1
Gum Creek		6/21/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Filterer	23
Gum Creek		6/21/2023	Spring	1	Diptera	Tipulidae	Tipula	Shredder	1
Gum Creek		6/21/2023	Spring	1	Ephemeroptera	Ephemerillidae	Antenella	Collector Gatherer	1
Gum Creek		6/21/2023	Spring	1	Ephemeroptera	Ephemerillidae	Ephemerella	Collector Gatherer	10
Gum Creek		6/21/2023	Spring	1	Ephemeroptera	Heptageniidae	Stenonema	Scraper	22
Gum Creek		6/21/2023	Spring	1	Hemiptera	Corixidae	Micronecta	Predator	2
Gum Creek		6/21/2023	Spring	1	Isopoda	Assellidae	Lirceus	Collector Gatherer	3
Gum Creek		6/21/2023	Spring	1	Megaloptera	Corydalidae	Chauliodes	Predator	3
Gum Creek		6/21/2023	Spring	1	Oligochaeta	Lumbriculidae	Rhyncholmis	Collector Gatherer	2
Holmes Creek		6/8/2023	Spring	1	Amphipoda	Talitridae	Hyalella	Collector	11
Holmes Creek		6/8/2023	Spring	1	Coleoptera	Gyrinidae	Dineutus	Predator	4
Holmes Creek		6/8/2023	Spring	1	Decapoda	Palaemonidae	Palaemonetes	Predator	1
Holmes Creek		6/8/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Filterer	29
Holmes Creek		6/8/2023	Spring	1	Ephemeroptera	Heptageniidae	Stenonema	Scraper	6
Holmes Creek		6/8/2023	Spring	1	Ephemeroptera	Leptophlebiidae	Hydrosmilodon	Collector Gatherer	1
Holmes Creek		6/8/2023	Spring	1	Isopoda	Assellidae	Lirceus	Collector Gatherer	11
Holmes Creek		6/8/2023	Spring	1	Odonata	Coenagrionidae	Argia	Predator	1
Holmes Creek		6/8/2023	Spring	1	Odonata	Gomphidae	Lanthus	Predator	4
Holmes Creek		6/8/2023	Spring	1	Oligochaeta	Lumbriculidae	Rhyncholmis	Collector Gatherer	1
Holmes Creek		6/8/2023	Spring	1	Trichoptera	Hydropsychidae	Ceratopsyche	Collector Filterer	4
Lloyd Creek		6/22/2023	Spring	1	Amphipoda	Talitridae	Hyalella	Collector	6
Lloyd Creek		6/22/2023	Spring	1	Coleoptera	Carabidae	--	Collector Gatherer	1
Lloyd Creek		6/22/2023	Spring	1	Coleoptera	Dytiscidae	Dytiscus	Predator	10
Lloyd Creek		6/22/2023	Spring	1	Coleoptera	Gyrinidae	Dineutus	Predator	1
Lloyd Creek		6/22/2023	Spring	1	Decapoda	Cambaridae	Orconectes lancifer	Collector Gatherer	1
Lloyd Creek		6/22/2023	Spring	1	Decapoda	Palaemonidae	Palaemonetes	Predator	6
Lloyd Creek		6/22/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Filterer	21
Lloyd Creek		6/22/2023	Spring	1	Ephemeroptera	Baetiscidae	Baetisca	Collector Gatherer	1
Lloyd Creek		6/22/2023	Spring	1	Ephemeroptera	Heptageniidae	Stenonema	Scraper	8
Lloyd Creek		6/22/2023	Spring	1	Ephemeroptera	Leptophlebiidae	Hydrosmilodon	Collector Gatherer	7
Lloyd Creek		6/22/2023	Spring	1	Hemiptera	Corixidae	Centrocorisa	Predator	2
Lloyd Creek		6/22/2023	Spring	1	Isopoda	Assellidae	Lirceus	Collector Gatherer	5
Lloyd Creek		6/22/2023	Spring	1	Odonata	Coenagrionidae	Argia	Predator	1

Stream	Site abbreviation	Date	Season	Sample type	Order	Family	Genera	Functional Feeding Group	Number of individuals
Lloyd Creek		6/22/2023	Spring	1	Odonata	Cordulegastridae	Cordulegaster	Predator	3
Lloyd Creek		6/22/2023	Spring	1	Oligochaeta	Lumbriculidae	Rhyncholmis	Collector Gatherer	11
Lloyd Creek		6/22/2023	Spring	1	Trichoptera	Hydropsychidae	Ceratopsyche	Collector Filterer	5
Locust Bayou		6/6/2023	Spring	1	Amphipoda	Hyalellidae	Hyalella	Collector	14
Locust Bayou		6/6/2023	Spring	1	Cladocera	Daphniidae	Daphnia	Collector Filterer	3
Locust Bayou		6/6/2023	Spring	1	Coleoptera	Dytiscidae	Uvarus	Predator	3
Locust Bayou		6/6/2023	Spring	1	Coleoptera	Elmidae	Rhizelmis	Collector Gatherer	13
Locust Bayou		6/6/2023	Spring	1	Diptera	Ceratopogonidae	Probezzia	Predator	1
Locust Bayou		6/6/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Gatherer	130
Locust Bayou		6/6/2023	Spring	1	Diptera	Chironomidae	Orthocladiinae	Collector Gatherer	19
Locust Bayou		6/6/2023	Spring	1	Diptera	Chironomidae	Tanypodinae	Predator	21
Locust Bayou		6/6/2023	Spring	1	Ephemeroptera	Baetidae	Centroptilum	Collector Gatherer	8
Locust Bayou		6/6/2023	Spring	1	Ephemeroptera	Heptageniidae	Stenonema	Scraper	7
Locust Bayou		6/6/2023	Spring	1	Isopoda	Asellidae	Caecidotea	Collector Gatherer	3
Locust Bayou		6/6/2023	Spring	1	Odonata	Coenagrionidae	Ischnura	Predator	3
Locust Bayou		6/6/2023	Spring	1	Plecoptera	Perlidae	Perlesta	Predator	3
Locust Bayou		6/6/2023	Spring	1	Trichoptera	Hydropsychidae	Cheumatopsyche	Collector Filterer	36
Locust Bayou		6/6/2023	Spring	1	Trichoptera	Hydroptilidae	Neotrichia	Scraper	12
Locust Bayou		6/6/2023	Spring	1	Trichoptera	Leptoceridae	Nectopsyche	Shredder	8
Salt Creek		6/6/2023	Spring	1	Amphipoda	Hyalellidae	Hyalella	Collector	19
Salt Creek		6/6/2023	Spring	1	Annelida	Lumbriculidae	Oligochaeta	Collector Gatherer	3
Salt Creek		6/6/2023	Spring	1	Coleoptera	Elmidae	Rhizelmis	Collector Gatherer	3
Salt Creek		6/6/2023	Spring	1	Coleoptera	Gyrinidae	Gyrinus	Predator	6
Salt Creek		6/6/2023	Spring	1	Coleoptera	Hydrophilidae	Berosus	Collector Gatherer	1
Salt Creek		6/6/2023	Spring	1	Diptera	Ceratopogonidae	Probezzia	Predator	1
Salt Creek		6/6/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Gatherer	20
Salt Creek		6/6/2023	Spring	1	Diptera	Chironomidae	Tanypodinae	Predator	10
Salt Creek		6/6/2023	Spring	1	Diptera	Tipulidae	Tipula	Shredder	6
Salt Creek		6/6/2023	Spring	1	Ephemeroptera	Baetidae	Centroptilum	Collector Gatherer	4
Salt Creek		6/6/2023	Spring	1	Hemiptera	Corixidae	Hesperocorixa	Predator	1
Salt Creek		6/6/2023	Spring	1	Isopoda	Asellidae	Caecidotea	Collector Gatherer	10
Salt Creek		6/6/2023	Spring	1	Trichoptera	Hydropsychidae	Cheumatopsyche	Collector Filterer	6
Salt Creek		6/6/2023	Spring	1	Trichoptera	Psychomyiidae	Lype	Scraper	2
Sloane Creek		6/6/2023	Spring	1	Annelida	Lumbriculidae	Oligochaeta	Collector Gatherer	1
Sloane Creek		6/6/2023	Spring	1	Coleoptera	Elmidae	Rhizelmis	Collector Gatherer	3
Sloane Creek		6/6/2023	Spring	1	Coleoptera	Haliplidae	Peltodytes	Predator	2
Sloane Creek		6/6/2023	Spring	1	Decapoda	Palaemonidae	Palaemonetes	Predator	1
Sloane Creek		6/6/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Gatherer	41
Sloane Creek		6/6/2023	Spring	1	Diptera	Chironomidae	Orthocladiinae	Collector Gatherer	4
Sloane Creek		6/6/2023	Spring	1	Diptera	Chironomidae	Tanypodinae	Predator	10
Sloane Creek		6/6/2023	Spring	1	Diptera	Simuliidae	Twinnia	Scraper	1
Sloane Creek		6/6/2023	Spring	1	Ephemeroptera	Baetidae	Centroptilum	Collector Gatherer	12
Sloane Creek		6/6/2023	Spring	1	Ephemeroptera	Heptageniidae	Stenacron	Scraper	3
Sloane Creek		6/6/2023	Spring	1	Hemiptera	Veliidae	Rhagovelia	Scraper	6
Sloane Creek		6/6/2023	Spring	1	Odonata	Gomphidae	Progomphus	Predator	3
Sloane Creek		6/6/2023	Spring	1	Trichoptera	Hydropsychidae	Cheumatopsyche	Collector Filterer	13
Smackover Creek		6/8/2023	Spring	1	Amphipoda	Talitridae	Hyalella	Collector	7
Smackover Creek		6/8/2023	Spring	1	Decapoda	Cambaridae	Orconectes lancifer	Collector Gatherer	1
Smackover Creek		6/8/2023	Spring	1	Decapoda	Palaemonidae	Palaemonetes	Predator	5
Smackover Creek		6/8/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Filterer	52
Smackover Creek		6/8/2023	Spring	1	Odonata	Coenagrionidae	Argia	Predator	1
Smackover Creek		6/8/2023	Spring	1	Oligochaeta	Lumbriculidae	Rhyncholmis	Collector Gatherer	1
Smackover Creek		6/8/2023	Spring	1	Orthoptera	Tettigoniidae	Conoephalus	Shredder	1
Smackover Creek		6/8/2023	Spring	1	Trichoptera	Hydropsychidae	Ceratopsyche	Collector Filterer	1
Two Bayou		6/6/2023	Spring	1	Amphipoda	Hyalellidae	Hyalella	Collector	12
Two Bayou		6/6/2023	Spring	1	Annelida	Lumbriculidae	Oligochaeta	Collector Gatherer	8
Two Bayou		6/6/2023	Spring	1	Arhynchobdellida	Hirudidae	Hirudo	Parasite	3
Two Bayou		6/6/2023	Spring	1	Coleoptera	Curculionidae	Brachycerus	Collector Gatherer	1
Two Bayou		6/6/2023	Spring	1	Coleoptera	Dytiscidae	Derovetellus	Predator	7
Two Bayou		6/6/2023	Spring	1	Coleoptera	Gyrinidae	Gyretes	Predator	1
Two Bayou		6/6/2023	Spring	1	Coleoptera	Haliplidae	Peltodytes	Predator	4
Two Bayou		6/6/2023	Spring	1	Decapoda	Cambaridae	Procambarus	Scraper	25
Two Bayou		6/6/2023	Spring	1	Decapoda	Palaemonidae	Palaemonetes	Predator	4
Two Bayou		6/6/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Gatherer	25
Two Bayou		6/6/2023	Spring	1	Diptera	Chironomidae	Orthocladiinae	Collector Gatherer	1
Two Bayou		6/6/2023	Spring	1	Diptera	Chironomidae	Tanypodinae	Predator	14
Two Bayou		6/6/2023	Spring	1	Ephemeroptera	Heptageniidae	Stenacron	Scraper	1
Two Bayou		6/6/2023	Spring	1	Odonata	Aeshnidae	Boyeria	Predator	2
Two Bayou		6/6/2023	Spring	1	Odonata	Coenagrionidae	Ischnura	Predator	4
Two Bayou		6/6/2023	Spring	1	Odonata	Libellulidae	Libellula	Predator	3
Two Bayou		6/6/2023	Spring	1	Trichoptera	Leptoceridae	Oecetis	Predator	1
Two Bayou 2		6/21/2023	Spring	1	Coleoptera	Dyticidae	Laccophilus	Predator	2
Two Bayou 2		6/21/2023	Spring	1	Coleoptera	Dytiscidae	Uvarus	Predator	3
Two Bayou 2		6/21/2023	Spring	1	Coleoptera	Elmidae	Microcylloepus	Collector Gatherer	1
Two Bayou 2		6/21/2023	Spring	1	Coleoptera	Lampyridae	Photuris	Collector Gatherer	1
Two Bayou 2		6/21/2023	Spring	1	Decapoda	Cambaridae	Orconectes lancifer	Collector Gatherer	10
Two Bayou 2		6/21/2023	Spring	1	Decapoda	Palaemonidae	Palaemon Kadiakensis	Predator	17
Two Bayou 2		6/21/2023	Spring	1	Diptera	Chironomidae	Chironomini	Collector Filterer	48
Two Bayou 2		6/21/2023	Spring	1	Ephemeroptera	Bactidae	Baetis	Collector Gatherer	1
Two Bayou 2		6/21/2023	Spring	1	Ephemeroptera	Heptageniidae	Stenonema	Scraper	2
Two Bayou 2		6/21/2023	Spring	1	Ephemeroptera	Siphlonuridae	Siphlonurus	Collector Gatherer	3
Two Bayou 2		6/21/2023	Spring	1	Hemiptera	Gerridae	Trepobates	Predator	3
Two Bayou 2		6/21/2023	Spring	1	Odonata	Cordulegastridae	Cordulegaster	Predator	1
Two Bayou 2		6/21/2023	Spring	1	Odonata	Gomphidae	Dromogomphus	Predator	2
Two Bayou 2		6/21/2023	Spring	1	Oligochaeta	Lumbriculidae	Rhyncholmis	Collector Gatherer	3
Two Bayou 2		6/21/2023	Spring	1	Oligochaeta	Tubificidae	--	Collector Gatherer	1

Appendix D

Active NPDES Dischargers

NPDES Permit N	Facility Name	City	HUC 12 Code	Watershed Name	Facility Latitu	Facility Longit	Pollutant Name
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	Chemical oxygen
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	Solids, total susp
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	Oil and grease
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	BOD, carbonace
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	Total Organic Ca
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	Ammonia as N
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	Total phenols
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	Sulfide
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	Chromium
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	Chromium, Hexa
AR0000591	SMACKOVER REFINERY/LUBE FACILITY (CAMERON EA	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364143	-92.716924	Lead
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Solids, total diss
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Nitrogen, nitrate
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Ammonia as N
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Sulfate
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Chloride
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Solids, total susp
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Oil and grease
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	BOD, carbonace
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Zinc
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Phosphorus
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Copper
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Cyanide
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Chromium, Triva
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Chromium, Hexa
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Nickel
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Selenium
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Lead
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Silver
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Cadmium
AR0000752	EL DORADO CHEMICAL COMPANY	EL DORADO	80402010407	Haynes Creek	33.26584	-92.688678	Mercury
AR0020168	STEPHENS, CITY OF	STEPHENS	80402010306	Holly Creek-Smackover Creek	33.397925	-93.0624	Solids, total susp
AR0020168	STEPHENS, CITY OF	STEPHENS	80402010306	Holly Creek-Smackover Creek	33.397925	-93.0624	BOD, carbonace
AR0020168	STEPHENS, CITY OF	STEPHENS	80402010306	Holly Creek-Smackover Creek	33.397925	-93.0624	Ammonia as N
AR0020168	STEPHENS, CITY OF	STEPHENS	80402010306	Holly Creek-Smackover Creek	33.397925	-93.0624	Total Residual Cl
AR0021440	SMACKOVER WWTP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.371111	-92.719167	Solids, total susp
AR0021440	SMACKOVER WWTP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.371111	-92.719167	Ammonia as N
AR0021440	SMACKOVER WWTP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.371111	-92.719167	Total Residual Cl
AR0021440	SMACKOVER WWTP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.371111	-92.719167	Mercury
AR0021440	SMACKOVER WWTP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.371111	-92.719167	BOD, carbonace
AR0021440	SMACKOVER WWTP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.371111	-92.719167	BOD, 5-day, 20 d
AR0021474	BEARDEN WWTP	BEARDEN	80402010701	Little Two Bayou-Two Bayou	33.715084	-92.635222	Solids, total susp
AR0021474	BEARDEN WWTP	BEARDEN	80402010701	Little Two Bayou-Two Bayou	33.715084	-92.635222	BOD, 5-day, 20 d
AR0021474	BEARDEN WWTP	BEARDEN	80402010701	Little Two Bayou-Two Bayou	33.715084	-92.635222	Total Residual Cl
AR0021873	HAMPTON, CITY OF	HAMPTON	80402010605	Dunn Creek-Champagnolle Creek	33.532667	-92.486528	Solids, total susp
AR0021873	HAMPTON, CITY OF	HAMPTON	80402010605	Dunn Creek-Champagnolle Creek	33.532667	-92.486528	BOD, carbonace
AR0021873	HAMPTON, CITY OF	HAMPTON	80402010605	Dunn Creek-Champagnolle Creek	33.532667	-92.486528	Ammonia as N
AR0021873	HAMPTON, CITY OF	HAMPTON	80402010605	Dunn Creek-Champagnolle Creek	33.532667	-92.486528	Total Residual Cl
AR0033715	CARTHAGE WWTP	CARTHAGE	80402010103	Pickett Creek-Moro Creek	34.058056	-92.549278	Solids, total susp
AR0033715	CARTHAGE WWTP	CARTHAGE	80402010103	Pickett Creek-Moro Creek	34.058056	-92.549278	BOD, carbonace
AR0033715	CARTHAGE WWTP	CARTHAGE	80402010103	Pickett Creek-Moro Creek	34.058056	-92.549278	Ammonia as N
AR0033758	FORDYCE, CITY OF	FORDYCE	80402010106	Caney Creek-Moro Creek	33.822085	-92.399271	Solids, total susp
AR0033758	FORDYCE, CITY OF	FORDYCE	80402010106	Caney Creek-Moro Creek	33.822085	-92.399271	BOD, carbonace
AR0033758	FORDYCE, CITY OF	FORDYCE	80402010106	Caney Creek-Moro Creek	33.822085	-92.399271	Ammonia as N
AR0033758	FORDYCE, CITY OF	FORDYCE	80402010106	Caney Creek-Moro Creek	33.822085	-92.399271	Copper
AR0033758	FORDYCE, CITY OF	FORDYCE	80402010106	Caney Creek-Moro Creek	33.822085	-92.399271	Lead
AR0033758	FORDYCE, CITY OF	FORDYCE	80402010106	Caney Creek-Moro Creek	33.822085	-92.399271	Total Residual Cl
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Solids, total diss
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Sulfate
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Chloride
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Ammonia as N
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Solids, total susp
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Oil and grease
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Phosphorus
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Zinc
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Nickel
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Copper
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Cadmium
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Chromium, Hexa
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Cyanide
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Selenium
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Mercury
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Chromium, Triva
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Silver
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Inorganic Nitrog
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	BOD, carbonace
AR0033936	EL DORADO NORTH WWTP	EL DORADO	80402010407	Haynes Creek	33.2472	-92.6463	Lead
AR0034363	SHUMAKER PUBLIC SERVICE CORP.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.6175	-92.721389	Solids, total susp
AR0034363	SHUMAKER PUBLIC SERVICE CORP.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.6175	-92.721389	BOD, carbonace
AR0034363	SHUMAKER PUBLIC SERVICE CORP.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.6175	-92.721389	Ammonia as N
AR0034363	SHUMAKER PUBLIC SERVICE CORP.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.6175	-92.721389	Total Residual Cl
AR0034363	SHUMAKER PUBLIC SERVICE CORP.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.6175	-92.721389	Zinc

NPDES Permit N	Facility Name	City	HUC 12 Code	Watershed Name	Facility Latitu	Facility Longit	Pollutant Name
AR0034363	SHUMAKER PUBLIC SERVICE CORP.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.6175	-92.721389	Mercury
AR0035653	NORPHLET WWTP	NORPHLET	80402010408	Salt Creek	33.291667	-92.625	Solids, total diss
AR0035653	NORPHLET WWTP	NORPHLET	80402010408	Salt Creek	33.291667	-92.625	Chloride
AR0035653	NORPHLET WWTP	NORPHLET	80402010408	Salt Creek	33.291667	-92.625	Solids, total susp
AR0035653	NORPHLET WWTP	NORPHLET	80402010408	Salt Creek	33.291667	-92.625	Ammonia as N
AR0035653	NORPHLET WWTP	NORPHLET	80402010408	Salt Creek	33.291667	-92.625	Sulfate
AR0035653	NORPHLET WWTP	NORPHLET	80402010408	Salt Creek	33.291667	-92.625	BOD, carbonace
AR0035653	NORPHLET WWTP	NORPHLET	80402010408	Salt Creek	33.291667	-92.625	Total Residual Cl
AR0035653	NORPHLET WWTP	NORPHLET	80402010408	Salt Creek	33.291667	-92.625	Lead
AR0035653	NORPHLET WWTP	NORPHLET	80402010408	Salt Creek	33.291667	-92.625	BOD, 5-day, 20 d
AR0035661	THORNTON, CITY OF	THORNTON	80402010601	Lost Creek-Champagnolle Creek	33.7644	-92.4925	Ammonia as N
AR0035661	THORNTON, CITY OF	THORNTON	80402010601	Lost Creek-Champagnolle Creek	33.7644	-92.4925	Solids, total susp
AR0035661	THORNTON, CITY OF	THORNTON	80402010601	Lost Creek-Champagnolle Creek	33.7644	-92.4925	BOD, carbonace
AR0037761	BEECH SPRINGS BAPTIST CAMP	LOUANN	80402010707	Champagnolle Creek-Ouachita Rive	33.424167	-92.702222	Ammonia as N
AR0037761	BEECH SPRINGS BAPTIST CAMP	LOUANN	80402010707	Champagnolle Creek-Ouachita Rive	33.424167	-92.702222	Total Residual Cl
AR0037761	BEECH SPRINGS BAPTIST CAMP	LOUANN	80402010707	Champagnolle Creek-Ouachita Rive	33.424167	-92.702222	BOD, carbonace
AR0037761	BEECH SPRINGS BAPTIST CAMP	LOUANN	80402010707	Champagnolle Creek-Ouachita Rive	33.424167	-92.702222	Oil and grease
AR0037761	BEECH SPRINGS BAPTIST CAMP	LOUANN	80402010707	Champagnolle Creek-Ouachita Rive	33.424167	-92.702222	Solids, total susp
AR0038211	CALION WWTP	CALION	80402010801	Amason Creek-Ouachita Creek	33.331284	-92.541389	Total Residual Cl
AR0038211	CALION WWTP	CALION	80402010801	Amason Creek-Ouachita Creek	33.331284	-92.541389	Solids, total susp
AR0038211	CALION WWTP	CALION	80402010801	Amason Creek-Ouachita Creek	33.331284	-92.541389	Ammonia as N
AR0038211	CALION WWTP	CALION	80402010801	Amason Creek-Ouachita Creek	33.331284	-92.541389	BOD, carbonace
AR0040517	LOUANN, CITY OF	LOUANN	80402010404	Brushy Creek-Smackover Creek	33.387806	-92.799861	Ammonia as N
AR0040517	LOUANN, CITY OF	LOUANN	80402010404	Brushy Creek-Smackover Creek	33.387806	-92.799861	Solids, total susp
AR0040517	LOUANN, CITY OF	LOUANN	80402010404	Brushy Creek-Smackover Creek	33.387806	-92.799861	BOD, carbonace
AR0042609	HARRELL WWTP	HARRELL	80402010205	Headwaters Lloyd Creek	33.5011	-92.4111	BOD, carbonace
AR0042609	HARRELL WWTP	HARRELL	80402010205	Headwaters Lloyd Creek	33.5011	-92.4111	Solids, total susp
AR0042609	HARRELL WWTP	HARRELL	80402010205	Headwaters Lloyd Creek	33.5011	-92.4111	Ammonia as N
AR0044733	CEDARWOOD LEISURE PARK, LLC	ELDORADO	80402010407	Haynes Creek	33.281667	-92.6725	Solids, total diss
AR0044733	CEDARWOOD LEISURE PARK, LLC	ELDORADO	80402010407	Haynes Creek	33.281667	-92.6725	Chloride
AR0044733	CEDARWOOD LEISURE PARK, LLC	ELDORADO	80402010407	Haynes Creek	33.281667	-92.6725	Sulfate
AR0044733	CEDARWOOD LEISURE PARK, LLC	ELDORADO	80402010407	Haynes Creek	33.281667	-92.6725	Solids, total susp
AR0044733	CEDARWOOD LEISURE PARK, LLC	ELDORADO	80402010407	Haynes Creek	33.281667	-92.6725	BOD, carbonace
AR0044733	CEDARWOOD LEISURE PARK, LLC	ELDORADO	80402010407	Haynes Creek	33.281667	-92.6725	Ammonia as N
AR0047503	IDAHO TIMBER OF CARTHAGE, LLC	CARTHAGE	80402010101	Fife Creek-Moro Creek	34.077556	-92.552806	Chemical oxygen
AR0047503	IDAHO TIMBER OF CARTHAGE, LLC	CARTHAGE	80402010101	Fife Creek-Moro Creek	34.077556	-92.552806	Solids, total susp
AR0047503	IDAHO TIMBER OF CARTHAGE, LLC	CARTHAGE	80402010101	Fife Creek-Moro Creek	34.077556	-92.552806	Oil and grease
AR0048381	ANTHONY TIMBERLANDS, INC.	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.293889	-92.947222	Chemical oxygen
AR0048381	ANTHONY TIMBERLANDS, INC.	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.293889	-92.947222	Solids, total susp
AR0048381	ANTHONY TIMBERLANDS, INC.	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.293889	-92.947222	Oil and grease
AR0049123	JIM YEAGER - D/B/A YEAGER APARTMENTS	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.301092	-92.95096	Ammonia as N
AR0049123	JIM YEAGER - D/B/A YEAGER APARTMENTS	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.301092	-92.95096	BOD, 5-day, 20 d
AR0049123	JIM YEAGER - D/B/A YEAGER APARTMENTS	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.301092	-92.95096	BOD, carbonace
AR0049123	JIM YEAGER - D/B/A YEAGER APARTMENTS	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.301092	-92.95096	Solids, total susp
AR0049140	ENTERGY ARKANSAS, LLC. - UNION POWER STATION	EL DORADO	80402010801	Amason Creek-Ouachita Creek	33.303028	-92.588111	Oil and grease
AR0049204	GEORGIA-PACIFIC WOOD PRODUCTS, LLC (FORDYCE C	FORDYCE	80402010107	Smith Creek-Caney Creek	33.7646	-92.3672	Solids, total susp
AR0049204	GEORGIA-PACIFIC WOOD PRODUCTS, LLC (FORDYCE C	FORDYCE	80402010107	Smith Creek-Caney Creek	33.7646	-92.3672	Ammonia as N
AR0049204	GEORGIA-PACIFIC WOOD PRODUCTS, LLC (FORDYCE C	FORDYCE	80402010107	Smith Creek-Caney Creek	33.7646	-92.3672	BOD, carbonace
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Solids, total diss
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Sulfate
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Chloride
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Solids, total susp
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Oil and grease
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	BOD, carbonace
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Phosphorus
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Zinc
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Selenium
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Copper
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Nickel
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Lead
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Cadmium
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Mercury
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Cyanide
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Chromium, Hexa
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Silver
AR0050296	EI DORADO, CITY OF-OUACHITA RIVER JOINT PIPELIN	EL DORADO	80402010803	Crooked Creek-Ouachita River	33.291528	-92.469694	Chromium, Triva
AR0050482	VICTORY LUMBER, LLC	CAMDEN	80402010503	Mill Creek-Two Bayou	33.535083	-92.814361	Chemical oxygen
AR0050482	VICTORY LUMBER, LLC	CAMDEN	80402010503	Mill Creek-Two Bayou	33.535083	-92.814361	Solids, total susp
AR0050482	VICTORY LUMBER, LLC	CAMDEN	80402010503	Mill Creek-Two Bayou	33.535083	-92.814361	Oil and grease
AR0050661	TINSMAN, AR WASTEWATER TREATMENT FACILITY	HAMPTON	80402010203	Jacks Creek-Caney Creek	33.624444	-92.330278	Solids, total susp
AR0050661	TINSMAN, AR WASTEWATER TREATMENT FACILITY	HAMPTON	80402010203	Jacks Creek-Caney Creek	33.624444	-92.330278	BOD, carbonace
AR0050661	TINSMAN, AR WASTEWATER TREATMENT FACILITY	HAMPTON	80402010203	Jacks Creek-Caney Creek	33.624444	-92.330278	Ammonia as N
AR0051071	AEROJET ROCKETDYNE, INC.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.625354	-92.689987	Chemical oxygen
AR0051071	AEROJET ROCKETDYNE, INC.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.625354	-92.689987	Solids, total susp
AR0051071	AEROJET ROCKETDYNE, INC.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.625354	-92.689987	Perchlorate (ClO
AR0051071	AEROJET ROCKETDYNE, INC.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.625354	-92.689987	1,3,5,7-Tetranitr
AR0051071	AEROJET ROCKETDYNE, INC.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.625354	-92.689987	Cyclonite
AR0051071	AEROJET ROCKETDYNE, INC.	EAST CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.625354	-92.689987	Oil and grease
AR0051811	EL DORADO SCHOOLS-UNION	EL DORADO	80402010802	Mill Creek-Ouachita River	33.23375	-92.53951	Oil and grease
AR0051811	EL DORADO SCHOOLS-UNION	EL DORADO	80402010802	Mill Creek-Ouachita River	33.23375	-92.53951	Solids, total susp
AR0051811	EL DORADO SCHOOLS-UNION	EL DORADO	80402010802	Mill Creek-Ouachita River	33.23375	-92.53951	Ammonia as N
AR0051811	EL DORADO SCHOOLS-UNION	EL DORADO	80402010802	Mill Creek-Ouachita River	33.23375	-92.53951	Total Residual Cl

NPDES Permit N	Facility Name	City	HUC 12 Code	Watershed Name	Facility Latituc	Facility Longitu	Pollutant Name
AR0051811	EL DORADO SCHOOLS-UNION	EL DORADO	80402010802	Mill Creek-Ouachita River	33.23375	-92.53951	BOD, carbonace
AR0052205	TRIPLE B WOOD DEALERS	FORDYCE	80402010106	Caney Creek-Moro Creek	33.818689	-92.386853	Solids, total susp
AR0052205	TRIPLE B WOOD DEALERS	FORDYCE	80402010106	Caney Creek-Moro Creek	33.818689	-92.386853	Chemical oxygen
AR0052205	TRIPLE B WOOD DEALERS	FORDYCE	80402010106	Caney Creek-Moro Creek	33.818689	-92.386853	Oil and grease
AR0052485	CALION, CITY OF -SOUTH ADDITION	CALION	80402010801	Amason Creek-Ouachita Creek	33.317417	-92.541444	Ammonia as N
AR0052485	CALION, CITY OF -SOUTH ADDITION	CALION	80402010801	Amason Creek-Ouachita Creek	33.317417	-92.541444	Solids, total susp
AR0052485	CALION, CITY OF -SOUTH ADDITION	CALION	80402010801	Amason Creek-Ouachita Creek	33.317417	-92.541444	Phosphorus
AR0052485	CALION, CITY OF -SOUTH ADDITION	CALION	80402010801	Amason Creek-Ouachita Creek	33.317417	-92.541444	Total Residual Cl
AR0052485	CALION, CITY OF -SOUTH ADDITION	CALION	80402010801	Amason Creek-Ouachita Creek	33.317417	-92.541444	BOD, carbonace
AR0053236	ANTHONY TIMBERLANDS INC	BEARDEN	80402010701	Little Two Bayou-Two Bayou	33.720776	-92.618066	Chemical oxygen
AR0053236	ANTHONY TIMBERLANDS INC	BEARDEN	80402010701	Little Two Bayou-Two Bayou	33.720776	-92.618066	Solids, total susp
AR0053236	ANTHONY TIMBERLANDS INC	BEARDEN	80402010701	Little Two Bayou-Two Bayou	33.720776	-92.618066	Oil and grease
ARG160026	WASTE CORPORATION OF ARKANSAS, LLC - UNION CC	EL DORADO	80402010409	Haynes Creek-Smackover Creek	33.32236	-92.69605	Solids, total susp
ARG160026	WASTE CORPORATION OF ARKANSAS, LLC - UNION CC	EL DORADO	80402010409	Haynes Creek-Smackover Creek	33.32236	-92.69605	Chemical oxygen
ARG160026	WASTE CORPORATION OF ARKANSAS, LLC - UNION CC	EL DORADO	80402010409	Haynes Creek-Smackover Creek	33.32236	-92.69605	Iron
ARG160026	WASTE CORPORATION OF ARKANSAS, LLC - UNION CC	EL DORADO	80402010409	Haynes Creek-Smackover Creek	33.32236	-92.69605	Oil and grease
ARG160052	CALHOUN COUNTY CLASS 4 LANDFILL	HAMPTON	80402010602	Taylor Creek-Champagnolle Creek	33.611306	-92.412722	Chemical oxygen
ARG160052	CALHOUN COUNTY CLASS 4 LANDFILL	HAMPTON	80402010602	Taylor Creek-Champagnolle Creek	33.611306	-92.412722	Iron
ARG160052	CALHOUN COUNTY CLASS 4 LANDFILL	HAMPTON	80402010602	Taylor Creek-Champagnolle Creek	33.611306	-92.412722	Solids, total susp
ARG160052	CALHOUN COUNTY CLASS 4 LANDFILL	HAMPTON	80402010602	Taylor Creek-Champagnolle Creek	33.611306	-92.412722	Oil and grease
ARG500029	ARK GRAVEL CO-BRADSHAW MINE	HAMPTON	80402010205	Headwaters Lloyd Creek	33.501195	-92.438442	Solids, total susp
ARG500029	ARK GRAVEL CO-BRADSHAW MINE	HAMPTON	80402010205	Headwaters Lloyd Creek	33.501195	-92.438442	Solids, total diss
ARG500029	ARK GRAVEL CO-BRADSHAW MINE	HAMPTON	80402010205	Headwaters Lloyd Creek	33.501195	-92.438442	Oil and grease
ARG500114	ROCK ISLAND SAND & GRAVEL LLC	HAMPTON	80402010204	Wahl Branch-Caney Creek	33.565194	-92.383111	Oil and grease
ARG500114	ROCK ISLAND SAND & GRAVEL LLC	HAMPTON	80402010204	Wahl Branch-Caney Creek	33.565194	-92.383111	Solids, total diss
ARG500114	ROCK ISLAND SAND & GRAVEL LLC	HAMPTON	80402010204	Wahl Branch-Caney Creek	33.565194	-92.383111	Solids, total susp
ARG550326	MARK AND JENNY TOOMBS	EL DORADO	80402010408	Salt Creek	33.27166	-92.627	BOD, 5-day, 20 d
ARG550326	MARK AND JENNY TOOMBS	EL DORADO	80402010408	Salt Creek	33.27166	-92.627	Solids, total susp
ARG550361	TURNER RESIDENCE	CAMDEN	80402010706	Doris Creek-Ouachita River	33.43899	-92.75476	Solids, total susp
ARG550361	TURNER RESIDENCE	CAMDEN	80402010706	Doris Creek-Ouachita River	33.43899	-92.75476	BOD, 5-day, 20 d
ARG550421	JASON OLIVE	EL DORADO	80402010407	Haynes Creek	33.22813	-92.63734	Solids, total susp
ARG550421	JASON OLIVE	EL DORADO	80402010407	Haynes Creek	33.22813	-92.63734	BOD, 5-day, 20 d
ARG550450	AMY MACHEN	EL DORADO	80402010407	Haynes Creek	33.261861	-92.641083	BOD, 5-day, 20 d
ARG550450	AMY MACHEN	EL DORADO	80402010407	Haynes Creek	33.261861	-92.641083	Solids, total susp
ARG550460	DR. MARK CRUMP	CAMDEN	80402010503	Mill Creek-Two Bayou	33.613722	-92.890694	BOD, 5-day, 20 d
ARG550460	DR. MARK CRUMP	CAMDEN	80402010503	Mill Creek-Two Bayou	33.613722	-92.890694	Solids, total susp
ARG550544	SAMMIE ANDREWS	CAMDEN	80402010404	Brushy Creek-Smackover Creek	33.448277	-92.824955	BOD, 5-day, 20 d
ARG550544	SAMMIE ANDREWS	CAMDEN	80402010404	Brushy Creek-Smackover Creek	33.448277	-92.824955	Solids, total susp
ARG550549	CHARLES BRANDON	HAMPTON	80402010605	Dunn Creek-Champagnolle Creek	33.534278	-92.507917	BOD, 5-day, 20 d
ARG550549	CHARLES BRANDON	HAMPTON	80402010605	Dunn Creek-Champagnolle Creek	33.534278	-92.507917	Solids, total susp
ARG550550	MATTHEW TROSCLAIR RESIDENCE	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.303322	-92.956505	BOD, 5-day, 20 d
ARG550550	MATTHEW TROSCLAIR RESIDENCE	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.303322	-92.956505	Solids, total susp
ARG550561	GOOD HOME BAPTIST CHURCH	LOUANN	80402010404	Brushy Creek-Smackover Creek	33.436444	-92.800667	Solids, total susp
ARG550561	GOOD HOME BAPTIST CHURCH	LOUANN	80402010404	Brushy Creek-Smackover Creek	33.436444	-92.800667	BOD, 5-day, 20 d
ARG550572	DAVID SUTHERLIN	EL DORADO	80402010408	Salt Creek	33.292046	-92.60145	BOD, 5-day, 20 d
ARG550572	DAVID SUTHERLIN	EL DORADO	80402010408	Salt Creek	33.292046	-92.60145	Solids, total susp
ARG550573	JASON WILSON	CAMDEN	80402010503	Mill Creek-Two Bayou	33.524167	-92.826667	Solids, total susp
ARG550573	JASON WILSON	CAMDEN	80402010503	Mill Creek-Two Bayou	33.524167	-92.826667	BOD, 5-day, 20 d
ARG550575	AR MUSEUM OF NATURAL RESOURCES	SMACKOVER	80402010405	Holmes Creek	33.33643	-92.71477	Solids, total susp
ARG550575	AR MUSEUM OF NATURAL RESOURCES	SMACKOVER	80402010405	Holmes Creek	33.33643	-92.71477	BOD, 5-day, 20 d
ARG550579	TREVOR CROSS	CAMDEN	80402010503	Mill Creek-Two Bayou	33.518192	-92.850875	Solids, total susp
ARG550579	TREVOR CROSS	CAMDEN	80402010503	Mill Creek-Two Bayou	33.518192	-92.850875	BOD, 5-day, 20 d
ARG550581	HENRY PURIFOY	CAMDEN	80402010502	North Bayou	33.599217	-92.89761	Solids, total susp
ARG550581	HENRY PURIFOY	CAMDEN	80402010502	North Bayou	33.599217	-92.89761	BOD, 5-day, 20 d
ARG550586	JOHN JAMESON	EL DORADO	80402010405	Holmes Creek	33.267222	-92.759722	BOD, 5-day, 20 d
ARG550586	JOHN JAMESON	EL DORADO	80402010405	Holmes Creek	33.267222	-92.759722	Solids, total susp
ARG550629	JASON BAKER	EL DORADO	80402010405	Holmes Creek	33.275578	-92.758829	BOD, 5-day, 20 d
ARG550629	JASON BAKER	EL DORADO	80402010405	Holmes Creek	33.275578	-92.758829	Solids, total susp
ARG550630	STEVE SLAUGHTER	EL DORADO	80402010405	Holmes Creek	33.268333	-92.790278	BOD, 5-day, 20 d
ARG550630	STEVE SLAUGHTER	EL DORADO	80402010405	Holmes Creek	33.268333	-92.790278	Solids, total susp
ARG550635	BRIAN RAMOS	HAMPTON	80402010205	Headwaters Lloyd Creek	33.496004	-92.438509	Solids, total susp
ARG550635	BRIAN RAMOS	HAMPTON	80402010205	Headwaters Lloyd Creek	33.496004	-92.438509	BOD, 5-day, 20 d
ARG550646	CHANCE NASH	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.299861	-92.95575	BOD, 5-day, 20 d
ARG550646	CHANCE NASH	MOUNT HOLLY	80402010401	Beech Creek-Smackover Creek	33.299861	-92.95575	Solids, total susp
ARG550650	JEREMY HARRIS	EL DORADO	80402010407	Haynes Creek	33.282111	-92.666667	BOD, 5-day, 20 d
ARG550650	JEREMY HARRIS	EL DORADO	80402010407	Haynes Creek	33.282111	-92.666667	Solids, total susp
ARG550744	GENERAL DYNAMICS OTS, INC. (CAMDEN OPERATION	HAMPTON	80402010703	Cordell Creek-Caney Creek	33.601889	-92.585944	BOD, 5-day, 20 d
ARG550744	GENERAL DYNAMICS OTS, INC. (CAMDEN OPERATION	HAMPTON	80402010703	Cordell Creek-Caney Creek	33.601889	-92.585944	Solids, total susp
ARG550780	SMACKOVER PAVING ATU	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.350611	-92.725056	Solids, total susp
ARG550780	SMACKOVER PAVING ATU	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.350611	-92.725056	BOD, 5-day, 20 d
ARG640052	SHUMAKER PUBLIC SERVICE CO-WTP #1	CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.648583	-92.696389	Solids, total susp
ARG640052	SHUMAKER PUBLIC SERVICE CO-WTP #1	CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.648583	-92.696389	Manganese
ARG640052	SHUMAKER PUBLIC SERVICE CO-WTP #1	CAMDEN	80402010701	Little Two Bayou-Two Bayou	33.648583	-92.696389	Iron
ARG670714	EL DORADO TERMINAL- TANK & PIPING HYDROSTATIC	EL DORADO	80402010407	Haynes Creek	33.2652	-92.62968	Total Organic Ca
ARG670714	EL DORADO TERMINAL- TANK & PIPING HYDROSTATIC	EL DORADO	80402010407	Haynes Creek	33.2652	-92.62968	Oil and grease
ARG670714	EL DORADO TERMINAL- TANK & PIPING HYDROSTATIC	EL DORADO	80402010407	Haynes Creek	33.2652	-92.62968	Benzene
ARG670714	EL DORADO TERMINAL- TANK & PIPING HYDROSTATIC	EL DORADO	80402010407	Haynes Creek	33.2652	-92.62968	Benzene, ethylbe
ARG670714	EL DORADO TERMINAL- TANK & PIPING HYDROSTATIC	EL DORADO	80402010407	Haynes Creek	33.2652	-92.62968	Solids, total susp
ARG670787	DELEK LOGISTICS OPERATING, LLC - MAGNOLIA STATI	MAGNOLIA	80402010407	Haynes Creek	33.21947	-92.66675	Total Organic Ca
ARG670787	DELEK LOGISTICS OPERATING, LLC - MAGNOLIA STATI	MAGNOLIA	80402010407	Haynes Creek	33.21947	-92.66675	Benzene
ARG670787	DELEK LOGISTICS OPERATING, LLC - MAGNOLIA STATI	MAGNOLIA	80402010407	Haynes Creek	33.21947	-92.66675	Oil and grease
ARG670787	DELEK LOGISTICS OPERATING, LLC - MAGNOLIA STATI	MAGNOLIA	80402010407	Haynes Creek	33.21947	-92.66675	Solids, total susp

NPDES Permit N	Facility Name	City	HUC 12 Code	Watershed Name	Facility Latituc	Facility Longitu	Pollutant Name
ARG670787	DELEK LOGISTICS OPERATING, LLC - MAGNOLIA STATI	MAGNOLIA	80402010407	Haynes Creek	33.21947	-92.66675	Total Residual Cl
ARG670787	DELEK LOGISTICS OPERATING, LLC - MAGNOLIA STATI	MAGNOLIA	80402010407	Haynes Creek	33.21947	-92.66675	Benzene, ethylbe
ARG670792	MULTIPLE TANK HYDROSTATIC TESTING PROJECT	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.362222	-92.711806	Oil and grease
ARG670792	MULTIPLE TANK HYDROSTATIC TESTING PROJECT	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.362222	-92.711806	Solids, total susp
ARG670792	MULTIPLE TANK HYDROSTATIC TESTING PROJECT	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.362222	-92.711806	Benzene, ethylbe
ARG670792	MULTIPLE TANK HYDROSTATIC TESTING PROJECT	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.362222	-92.711806	Total Organic Ca
ARG670792	MULTIPLE TANK HYDROSTATIC TESTING PROJECT	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.362222	-92.711806	Benzene
ARG670792	MULTIPLE TANK HYDROSTATIC TESTING PROJECT	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.362222	-92.711806	Total Residual Cl
ARG670813	MARTIN OPERATING PARTNERSHIP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364139	-92.716917	Total Residual Cl
ARG670813	MARTIN OPERATING PARTNERSHIP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364139	-92.716917	Oil and grease
ARG670813	MARTIN OPERATING PARTNERSHIP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364139	-92.716917	Total Organic Ca
ARG670813	MARTIN OPERATING PARTNERSHIP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364139	-92.716917	Benzene, ethylbe
ARG670813	MARTIN OPERATING PARTNERSHIP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364139	-92.716917	Benzene
ARG670813	MARTIN OPERATING PARTNERSHIP	SMACKOVER	80402010406	Wolf Creek-Smackover Creek	33.364139	-92.716917	Solids, total susp

Appendix E

BMPs

ST-1

Stormwater Treatment Options

EXTENDED DETENTION

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)

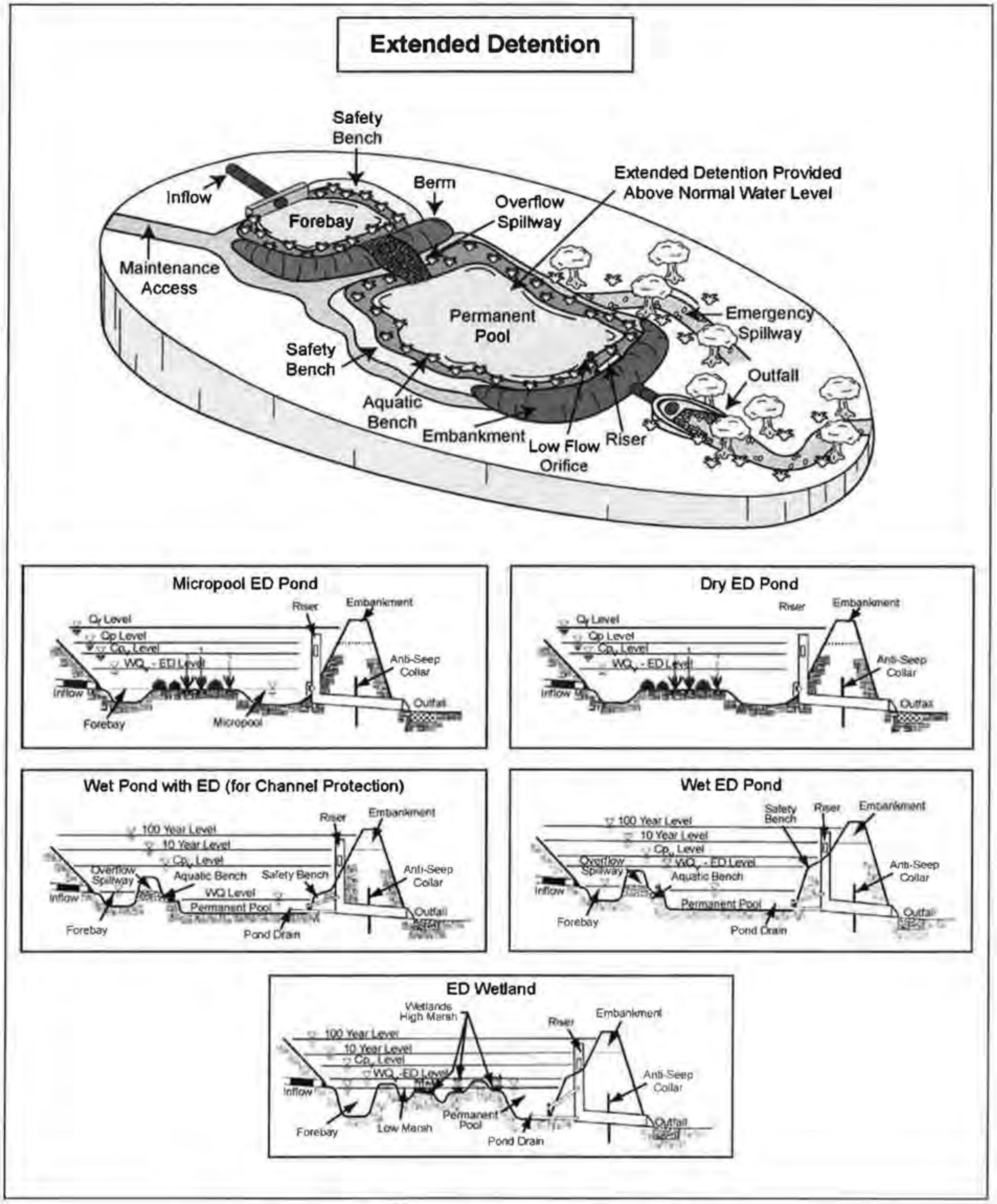


Figure 2: Extended Detention Schematics

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.

Table 1: Range of Reported Removal Rates for Dry Extended Detention Ponds

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 25th and 75th quartiles

Table 2: Design Point Calculation to Estimate Pollutant Removal for ED Retrofits

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
NET DESIGN SCORE (max. of 5 points)		

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.

ST-2

Stormwater Treatment Options

WET PONDS

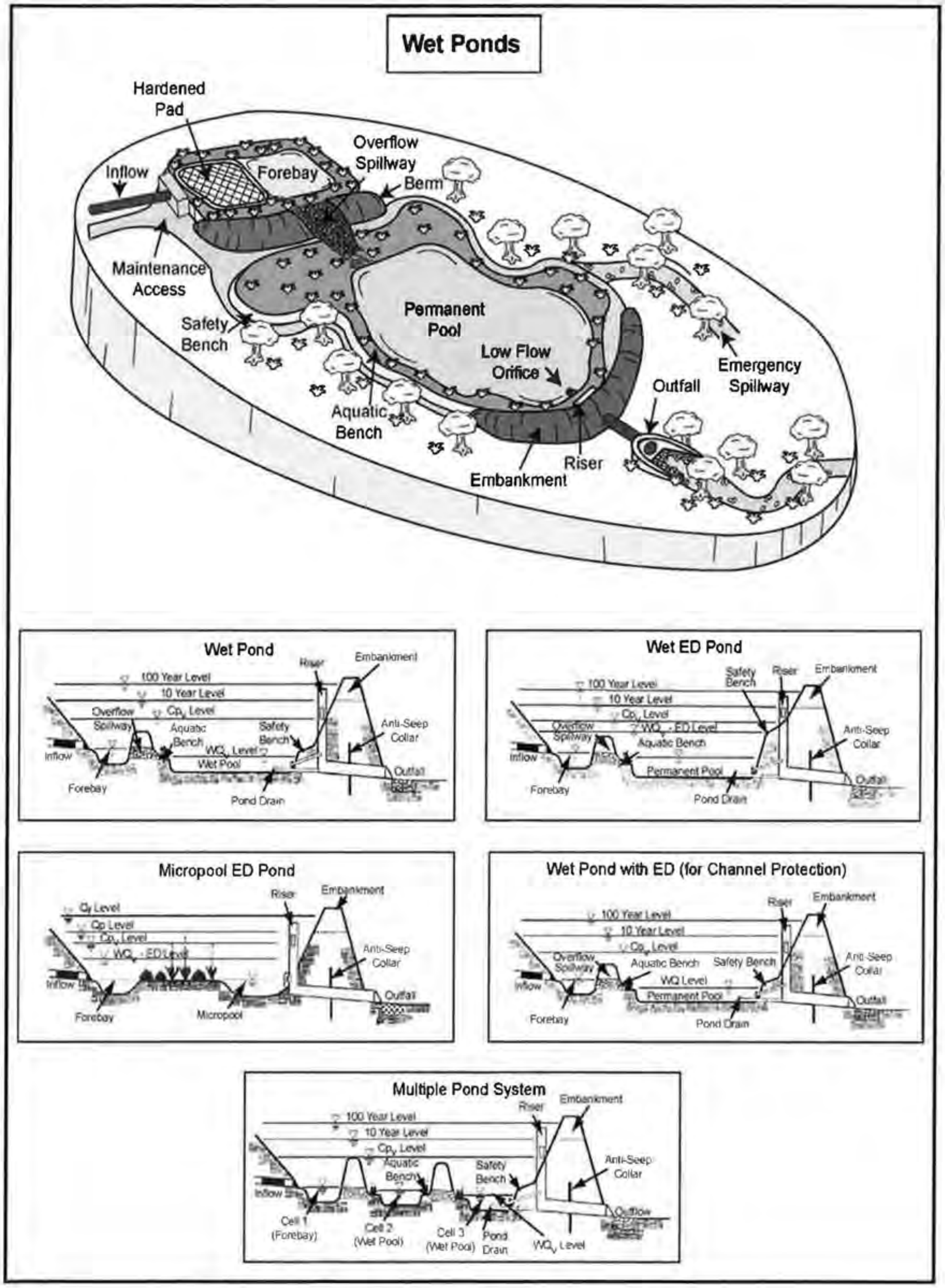
Wet ponds consist of a permanent pool of standing water that promotes a better environment for gravitational settling, biological uptake and microbial activity (Figure 1). Runoff from each new storm enters the pond and partially displaces pool water from previous storms. The pool also acts as a barrier 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


Wet Ponds

Wet Pond

Wet ED Pond

Micropool ED Pond

Wet Pond with ED (for Channel Protection)

Multiple Pond System

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 than 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.

Table 1: Range of Reported Removal Rates for Wet Ponds

Pollutant	Low End	Median	High End
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 25th and 75th quartiles

Table 2: Design Point Calculation to Estimate Pollutant Removal for Wet Pond Retrofits

Design Factors	X	Points
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
NET DESIGN SCORE (max of 5 points)		

ST-3

Stormwater Treatment Options

CONSTRUCTED WETLANDS

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.

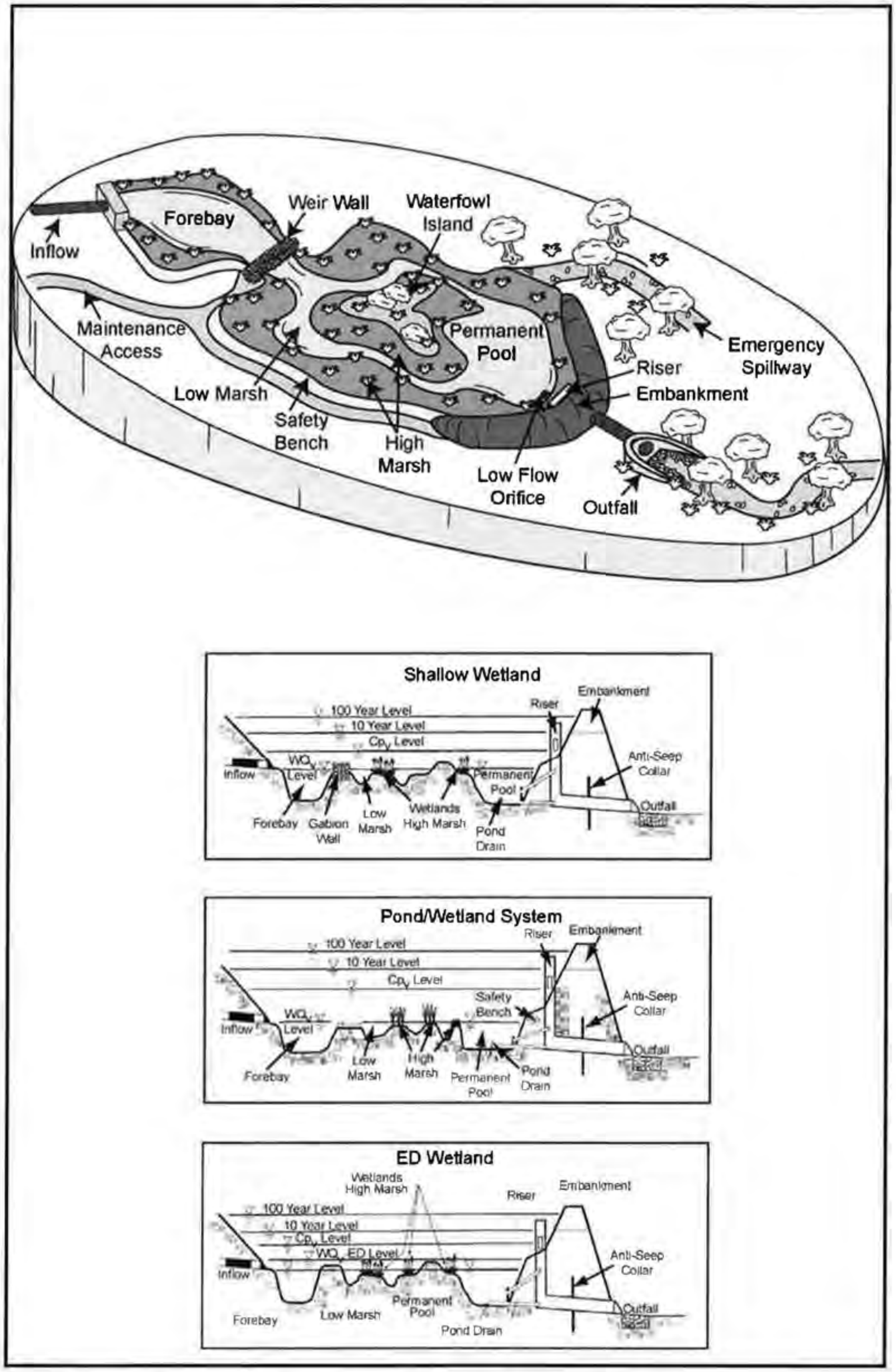


Figure 2: Schematics of three wetland variations

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.

Table 1: Range of Reported Removal Rates for Constructed Wetlands

Pollutant	Low End	Median	High End
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 25th and 75th quartiles

Table 2: Design Point Calculation to Estimate Pollutant Removal for Wetland Retrofits

Design Factors	X	***Points***
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
NET DESIGN SCORE (max of 5 points)		

ST-4

Stormwater Treatment Options

BIORETENTION

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.

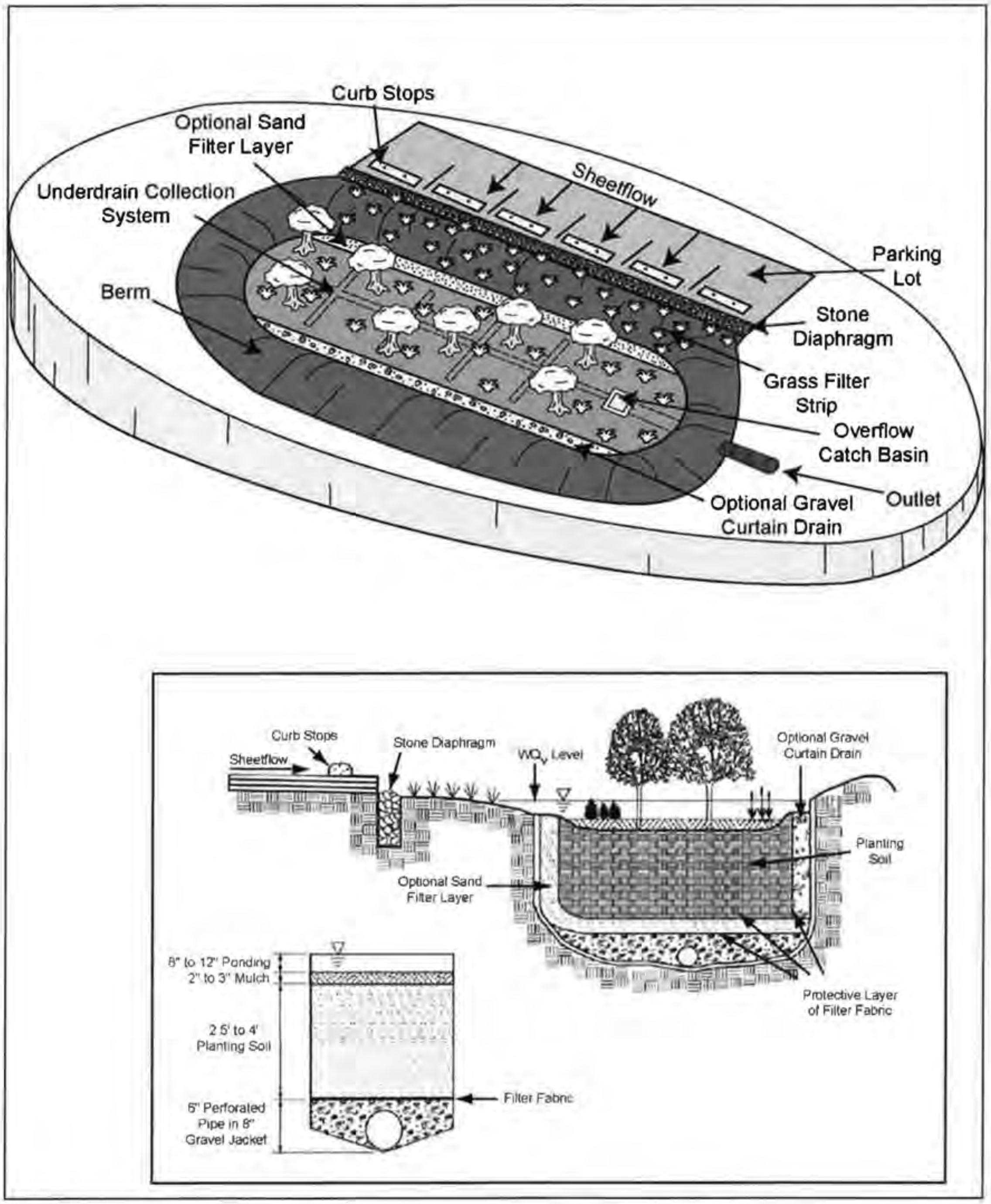


Figure 2: Bioretention schematic with underdrain

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.

Table 1: Range of Reported Removal Rates for Bioretention Areas

Pollutant	Low End	Median	High End
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 25th and 75th quartiles

Table 2: Design Point Calculation to Estimate Pollutant Removal for Bioretention Retrofits

Design Factors	X	Points
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
NET DESIGN SCORE (max of 5 points)		
NET PHOSPHORUS SCORE (max of 5 points)		

ST-6

Stormwater Treatment Options

INFILTRATION

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

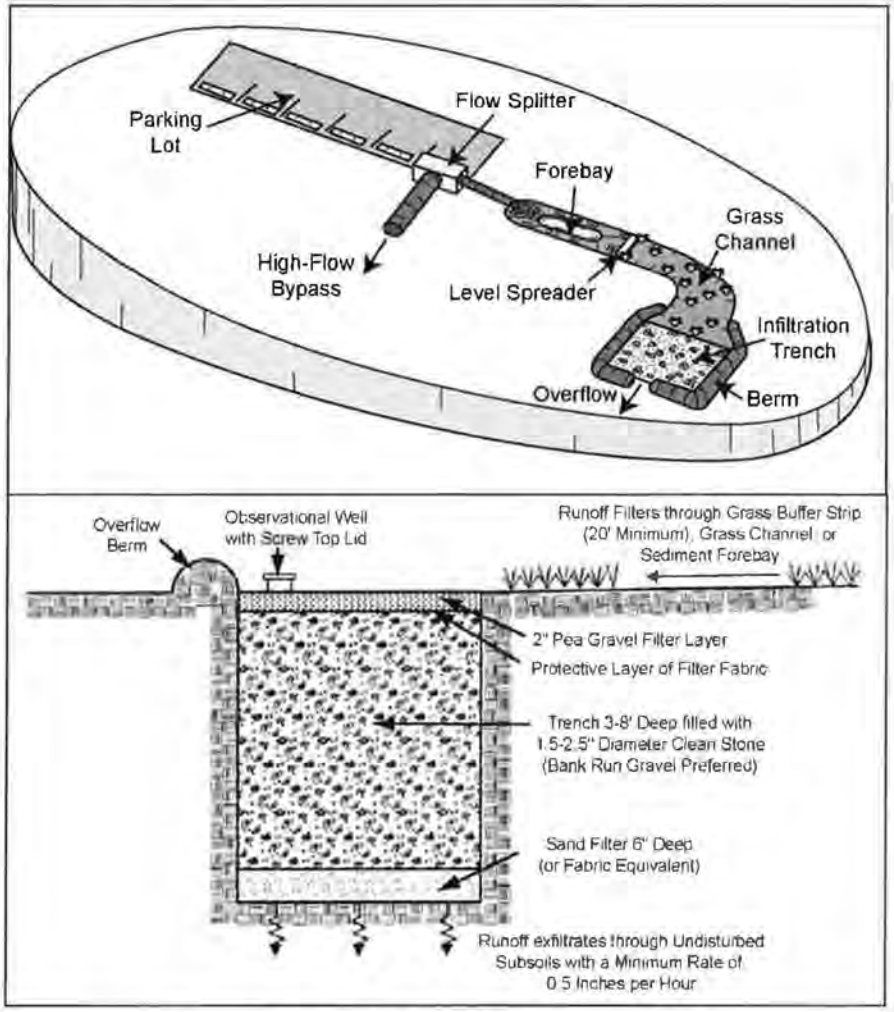


Figure 2: Schematic of an infiltration trench

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.

Table 1: Range of Reported Removal Rates for Infiltration Practices

Pollutant	Low End	Median	High End
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 25th and 75th quartiles

Table 2: Design Point Calculation to Estimate Pollutant Removal for Infiltration Retrofits

Design Factors	X	Points
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
NET DESIGN SCORE (max of 5 points)		

ST-7

Stormwater Treatment Options

SWALES

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

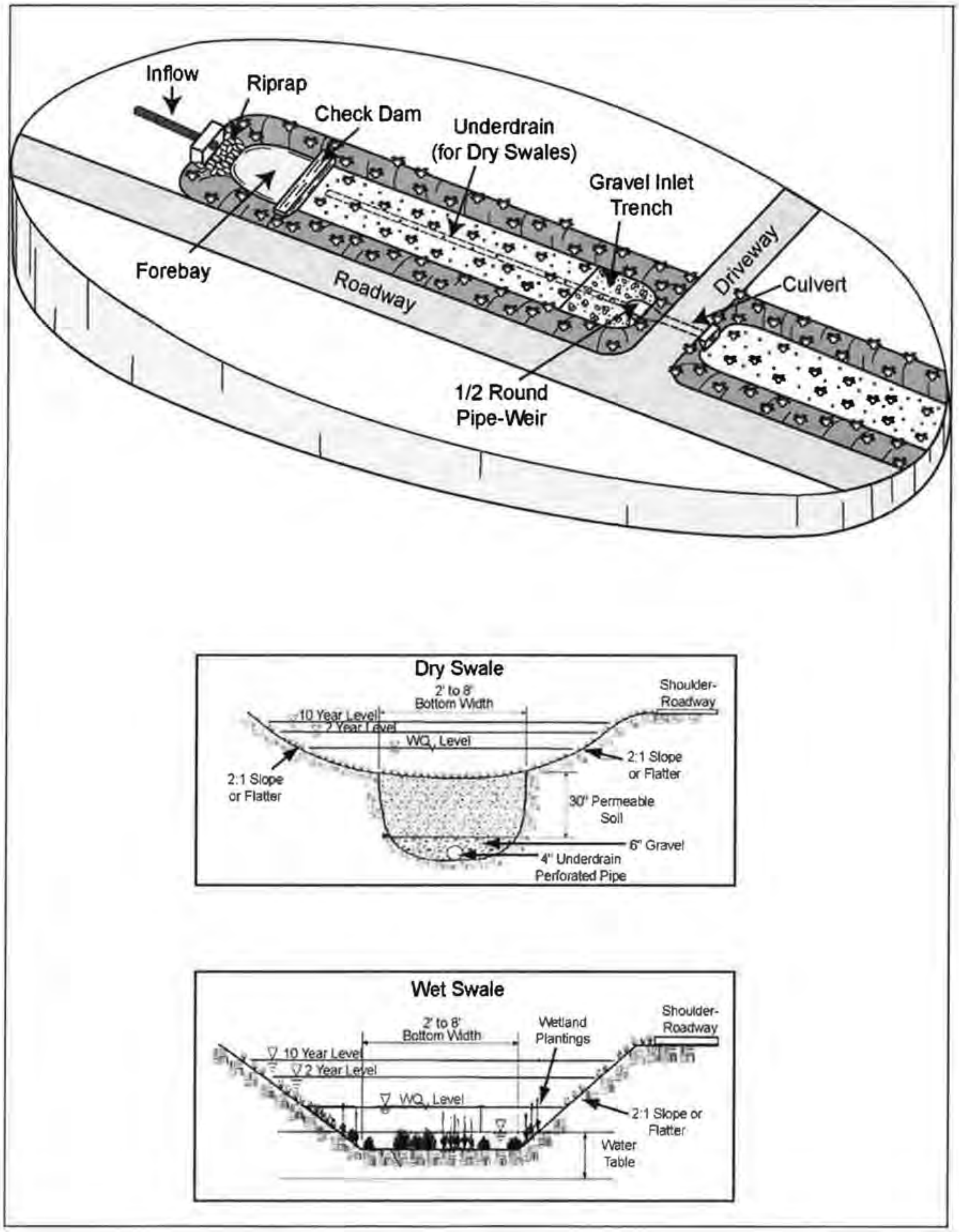


Figure 3: Schematic of a dry and wet swale

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 25th and 75th quartiles

Table 2: Design Point Calculation to Estimate Pollutant Removal for Swale Retrofits		
Design Factors	**X**	**Points**
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
NET DESIGN SCORE (max of 5 points)		

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.

ST-8

Stormwater Treatment Options

Other Retrofit Treatment

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.

Table 1: Installation Costs for Other Stormwater Retrofits (per cubic foot treated)

Retrofit Type	Median Cost	Cost Range
Residential Settings		
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
Non-Residential Settings		
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
Note: See Appendix E for documentation and cost assumptions		

MO-4

Municipal Operation

STREET SWEEPING

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.

Figure 1. This broom sweeper is assisted by a following vacuum sweeper for increased removal.

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

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.

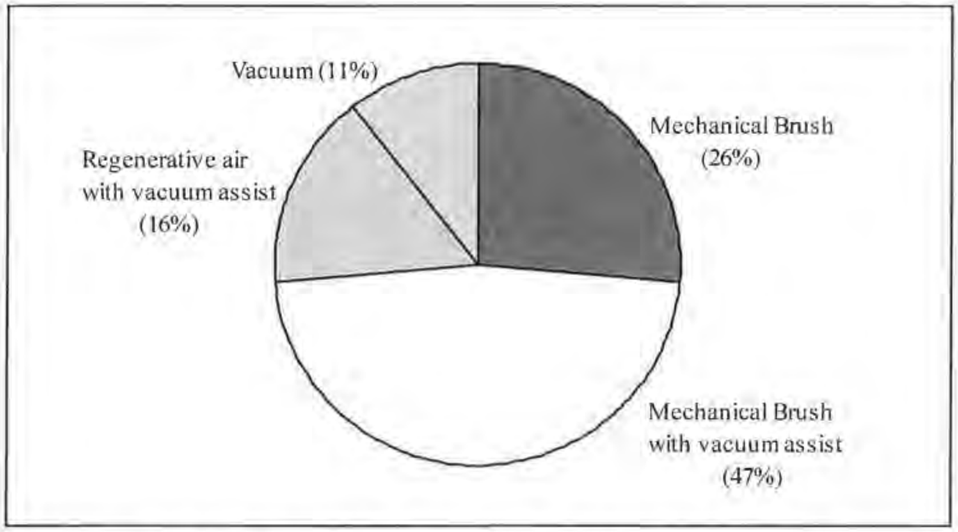


Figure 2. Most common street sweeping technology used by Chesapeake Bay communities

Table 1: Expected Pollutant Removal Rates for Street Sweeping (Law et al., 2008)

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 improve 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 addition 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 overwhelming 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).

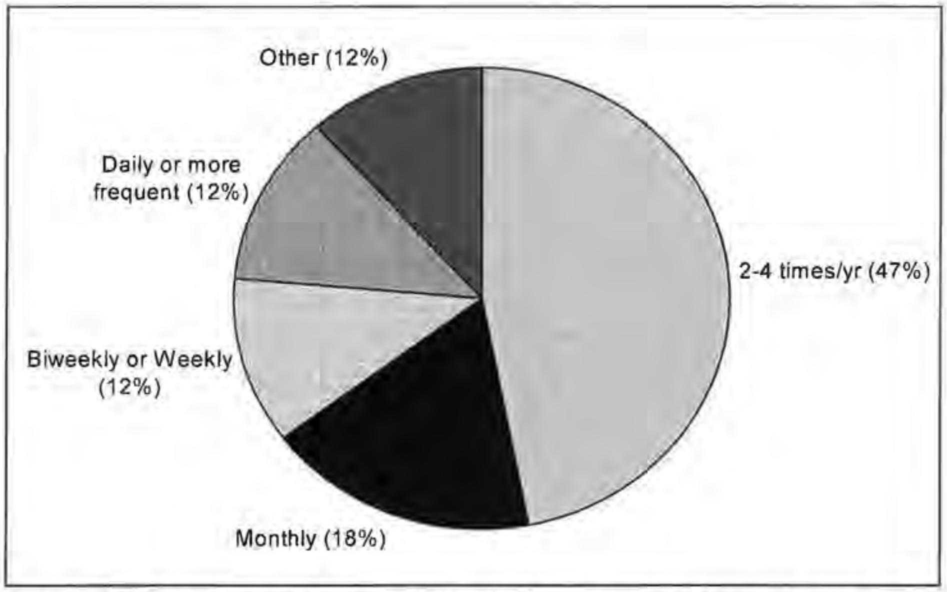


Figure 3. Percentage of communities that sweep more than once per year and the associated sweeping frequency

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.

Table 4: Measurable Goals and Implementation Milestones for Improving Municipal Street Sweeping Activities[1]

Example Measurable Goals	Timeframe	Priority
Goals related to program startup		
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		●
Goals related to preventing or reducing stormwater pollution		
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	●
Goals related to program evaluation		
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[1]

Example Measurable Goals	Timeframe	Priority

Notes
1) Assumes that street sweeping is as the top of your prioritized municipal operations list.
Key
● = 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[1]
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[1]
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[2]
Step 7: Evaluate Progress in Implementation	20-40/evaluation[1]

Notes
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

City Madison Street Sweeping Study
http://www.ci.madison.wi.us/engineering/stormwater/street_sweeping.htm

Stormwater Effects Handbook: Chapter 5
http://www.epa.gov/ednnrmrl/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

MO-5

Municipal Operation

STORM DRAIN MAINTENANCE

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 eras, 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.

(Source: City of Garrett, IN)

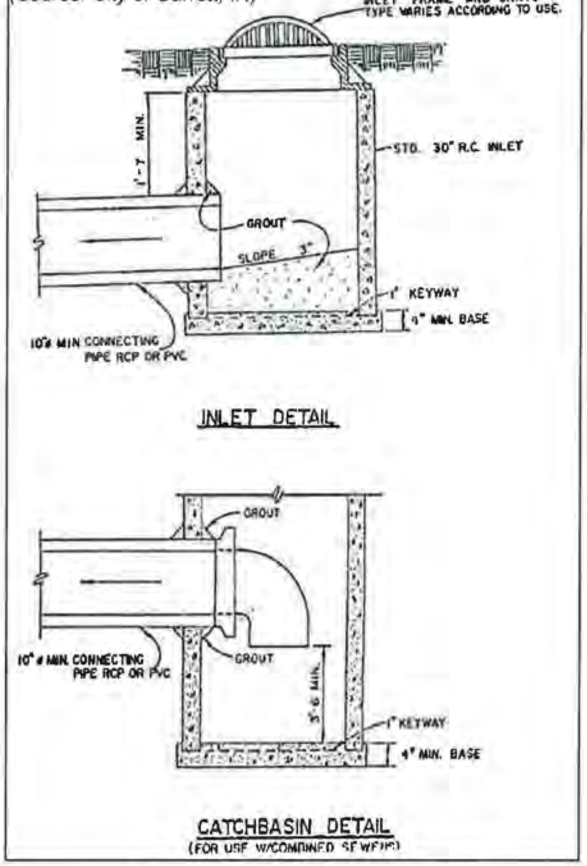


Figure 1. Catch Basin Detail

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.

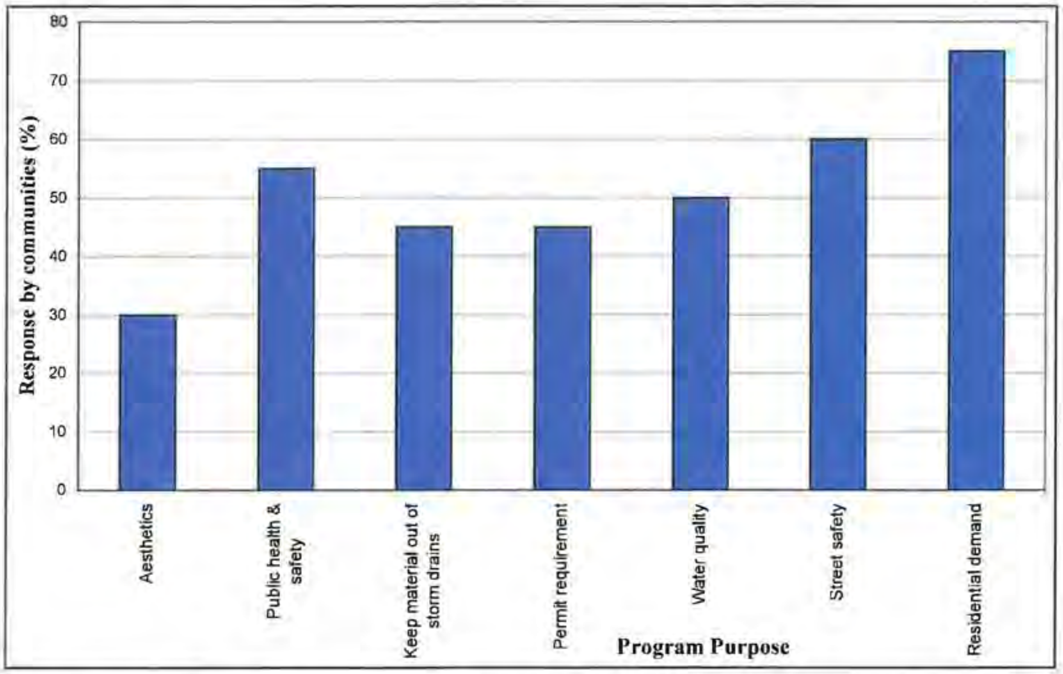


Figure 2: Purpose of storm drain cleanout programs in the Chesapeake Bay watershed

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.

Table 1: Expected Pollutant Removal Rates for Catch Basin Cleanouts (Law et al., 2008)

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 improve 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 suctions 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.

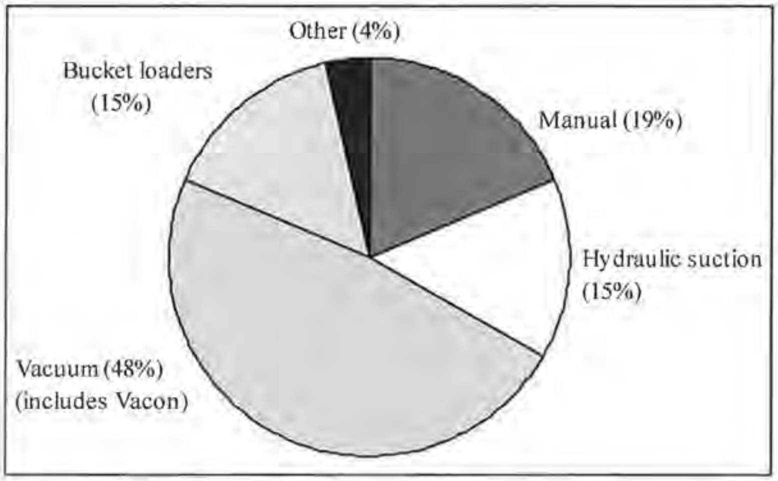


Figure 3. Most common storm drain cleanout technology used in NPDES Phase I and II Chesapeake Bay communities

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.

Figure 4. Conducting the SSD in Watershed 263, Baltimore, MD

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).

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.

Table 5: Measurable Goals and Implementation Milestones for Improving Municipal Storm Drain Maintenance Operations[1]

Example Measurable Goals	Timeframe	Priority
Goals related to program startup		
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		●
Goals related to preventing or reducing stormwater pollution		
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[1]

Example Measurable Goals	Timeframe	Priority
Goals related to program evaluation		
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	●

Notes

1) Assumes that storm drain maintenance is as the top of your prioritized municipal operations list.

Key

● = 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[1]
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[1]
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[2]
Step 7: Evaluate Progress in Implementation	20-40/evaluation[1]

Notes

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

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.scvurppp.org/

N-9

Neighborhood Source Area: Yard

SEPTIC SYSTEM MAINTENANCE

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.

Figure 1: Septic System Inspection/Cleaning Truck

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).

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

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

National Small Flows Clearinghouse
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_Onsite Education.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

N-1

Neighborhood Source Area: Yard

REDUCED FERTILIZER USE

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, rooftops, driveways or parking lots (Bannerman *et al.*, 1993; Steuer *et al.*, 1997; Waschbusch *et al.*, 2000; Garn, 2002).

Figure 1: Lawn Care Company Truck

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

North Carolina Department of Agriculture Free Residential Lawn Soil Testing. Residents can get a free soil test to determine the exact fertilizer and lime needs for their lawn, as well as for the garden, landscape plants and fruit trees. Information sheets and soil boxes are available from various government agencies, or local garden shops and other businesses. For more information, consult:
http://www.ncagr.com/agronomi/stfaqs.htm

Minnesota Department of Agriculture Phosphorus Lawn Fertilizer Use Restrictions. Starting in 2004, these restrictions limit the concentration of phosphorus in lawn care products and restrict its application at higher rates to specific situations based on need.
http://www.mda.state.mn.us/appd/ace/lawncwaterq.htm

Top Resources

Cornell Cooperative Extension. The Homeowner's Lawn Care Water Quality Almanac.
http://www.gardening.cornell.edu/lawn/almanac/index.html

University of Rhode Island Cooperative Extension Home*A*Syst Healthy Landscapes Program
http://www.healthylandscapes.org/

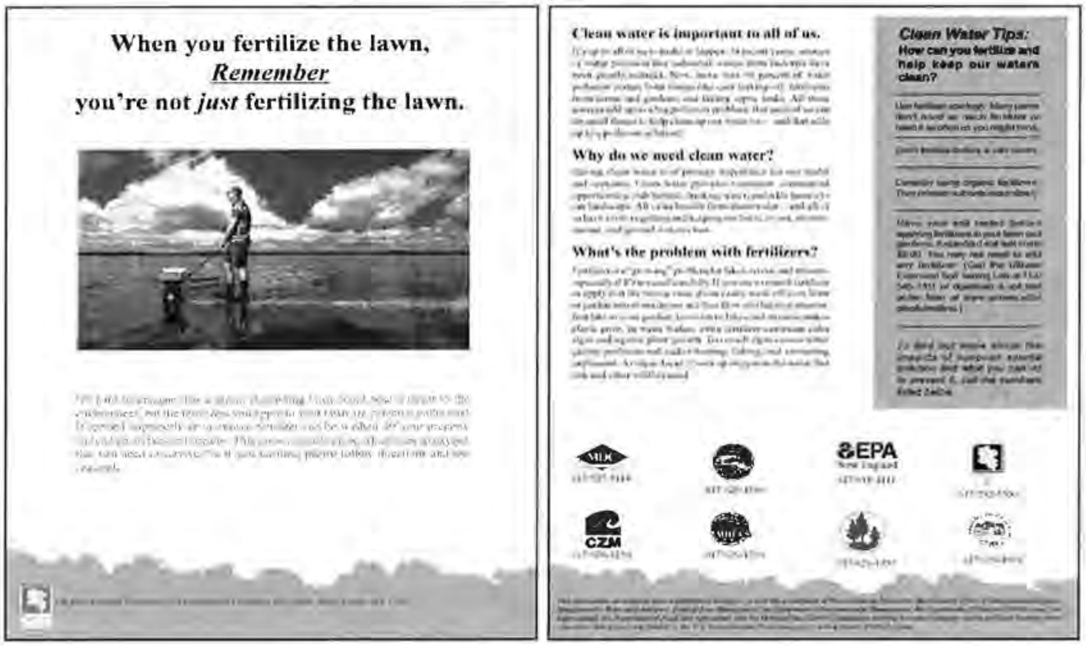
University of Maryland Cooperative Extension - Home and Garden Information Center.
http://www.agnr.umd.edu/users/hgic/

Turf and Landscape Best Management Practices. South Florida Water Management District and the Broward County Extension Education Division
http://www.sfwmd.gov/org/exo/broward/c11bmp/fertmgt.html

Florida Yards and Neighborhoods Handbook: A Guide to Environmentally Friendly Landscaping
http://hort.ufl.edu/fyn/hand.htm

University of Minnesota Extension Service Low-Input Lawn Care (LILaC)
http://www.extension.umn.edu/distribution/horticulture/DG7552.html

Austin TX, Stillhouse Spring Cleaning
http://www.ci.austin.tx.us/growgreen/stillhouse.htm



When you fertilize the lawn,
Remember
you're not *just* fertilizing the lawn.

Clean water is important to all of us.

Why do we need clean water?

What's the problem with fertilizers?

Clean Water Tips:
How can you fertilize and help keep our waters clean?

Figure 2: Educational Brochure on Fertilizer
Source: http://www.state.ma.us/dep/brp/wm/files/fertiliz.pdf

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.

Dirt and Gravel Road Best Management Practice Guide

Landowner's Handbook to Building and Maintaining Private Roadways

Published by the Culpeper Soil and Water Conservation District with funding from the Chesapeake Bay Restoration Fund. January 2019

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Table of Contents

Dirt and Gravel Road BMP Guide

Introduction

There are close to 400 miles of dirt and gravel roads in the Culpeper District. Dirt and gravel roads are low-volume roads that have relatively low use and provide service to residences and agricultural, logging and recreational areas. Most dirt and gravel roads are privately maintained and serve individual lots or small subdivisions. Maintaining and improving these roads can be a major responsibility for landowners.

Over time many roads and driveways deteriorate for a variety of reasons: poor construction, improper maintenance, excessive weather events, heavy traffic loads, and others. In addition to the high and frequent repair costs, many of these roads and roadside ditches drain directly into our waterways. The transport of both sediment and gravel into stream channels has a destructive impact to the stream ecosystem resulting in the smothering of aquatic habitat and reduction of the channel's capacity to carry water. Sedimentation of the channel causes increased frequency of flooding and streambank erosion. Competent construction and maintenance of dirt and gravel roads can save the landowner money and better protect local waterways.

The goal of this BMP guide is to help you plan and manage dirt and gravel roads to minimize the environmental impacts of uncontrolled runoff on local waterways. Our objective is to provide landowners with low cost solutions to common problems associated with building and maintaining dirt and gravel roads.

The following sections will discuss Site Assessment, Road Assessment, Common Problems, Troubleshooting, and Maintenance. The guide will also provide an Inspection Checklist, Maintenance Schedule, and Practice Specifications.

Figure 1

Figure 2

Figure 1: Gravel driveway directing runoff to stream crossing.

Figure 2: Well-maintained gravel driveway

Site Assessment

Whether your road is already built or you are planning to build, the existing site conditions should influence the location and design. A poorly designed road in a good location can always be improved. A well designed road in a poor location will need more maintenance. The topography, soils and land cover play a part in the alignment and stability of the road.

Ideally, the topography or slope of the land determines the location of the road. The steeper the terrain the longer the road should be as it traverses a series of switchbacks. Careful selection of road location can also help to minimize the need for culverts and drainage structures. Unfortunately most road right-of-ways are arbitrarily placed on deeds and plats. Costs also determine the location and length of the road. Shorter roads are not always less expensive in mountainous terrains.


Figure 3

Figure 3: A sinuous road can be better than the straight path.

Stable soils are needed to provide a solid base for the road. Soils are stable when the structure is suitable for compaction and the soil particles are slip resistant. The base soils should not have any organic matter that can decompose. The soil should have a low shrink-swell potential and be relatively dry. Soils with a high water table may need subsurface drainage.

Vegetation should be preserved on critical areas such as steep slopes and along waterways. Land cover affects the flow of runoff and can prevent erosion. Tree canopy can intercept rainfall and protect the understory from heavy rains. Good understory with groundcover can prevent erosion and further slow runoff. Forest cover can impact how the road banks are stabilized. The groundcover will need to be shade tolerant.


Figure 4

Figure 4: A road that follows close to the stream will erode.

Design and Construction Considerations

The Best Management Practices or BMPs in the Practice Specifications of this guide will aid in the design and construction of dirt and gravel roads. These BMPs help minimize problems associated with runoff and ensure the dirt and gravel road will be functional and easier to maintain. Below are suggestions for incorporating the BMPs listed in this guide and describe basic erosion control practices for construction.

The shape and grade of the road affects how well it drains. The roadside ditches transport runoff from the roadway, side slopes and adjacent areas. The ditches should minimize stream connection by using turnouts. The ditch outlets need to dissipate and disperse runoff flows. Conveying runoff safely off the road can be done over the road using dips and diversions or under the road using cross culverts. Controlling runoff is critical to long term maintenance.

Ditches are functional as soon as they are constructed so immediate stabilization is critical. During construction the ditches should be seeded, mulched and matted as soon as possible. Temporary matting that is staked in place is important to prevent mulch and seed washing. In some cases adding rock check dams will help slow runoff.

The side slopes need to be mulched and seeded after grading is complete. Temporary stabilization matting or other surface roughing techniques can be used on steep slopes to keep the seed and mulch in place.

Soil testing should be done to determine application rates for lime and fertilizers. This will help with vegetation establishment.

Minimize stream crossings and encroachments whenever possible. These areas can funnel sediments into waterways and each crossing will be a maintenance burden. Utilize the stream crossing BMPs in this guide to reduce the road's impact and maintenance.


Figure 5


Figure 6


Figure 7

Figure 5: Elevated (In-slope) Gravel Driveway to inside ditch.

Figure 6: Open top Culvert; Figure 7: Temporary stabilization matting in ditch

Road Assessment

Once the road is installed, routine inspection and maintenance should be performed to maintain the road. The surface condition of dirt and gravel roads can change rapidly. Heavy rains and traffic accelerate changes to the surface characteristics. Inspecting the road after unusually heavy rains and at least once a year is a good practice. Divide the roadway into segments with similar conditions. Common segments include the intersections, stream crossings, changes in shape (i.e. out-sloping / in-sloping), changes in slopes, and changes in surface aggregate. Document the condition of the road to set realistic maintenance goals to make timely repairs and stay on budget.


Figure 8


Figure 9

The inspections should assess the crown and roadway cross section; thickness and condition of the surface aggregate; and all drainage structures and flow paths.

- The crown height should be at least 6 inches higher than the shoulder and the cross slope of the roadway should be unrestricted and at least 4 percent; see the practice specifications on road surface shaping. The cut and fill slopes should be stable with a good stand of vegetation and little or no erosion or slumping.
- The depth of the gravel surface should be a minimum of 6 inches. The gravel surface should not show signs of loose gravel. Culverts and geotextile fabrics should have at least 12 inches of cover to prevent damage.
- Surface runoff should not be flowing laterally across or down the roadbed. The side ditches should be deep enough to contain surface runoff. The cross culverts should be clean and sized to prevent frequent impoundment of water. Stream crossings should be clean of debris, stable and show little signs of scour upstream or downstream. Groundwater seeps should be identified and should not contribute to the deformation of the roadbed or increase surface flows across or down the roadbed.

Figure 8: The shape of the road and the surface aggregates should be visibility evaluated for deficiencies.

Figure 9: When rills or other drainage problems exist, determine the source of the water. Is the shape or surface materials of the roadbed contributing to the drainage problem?

Common Problems

Below are five of the most common problems found on dirt and gravel roads. Make note of locations with these problems and measure the depth of damage. When these problems are severe, regrading and shaping of the road will be necessary to improve drainage and to reinforce the roadbed.

1. Erosion down the roadbed occurs when the crown is lost and thereby a flat road is created; or when the ditches are obstructed or non-existent and the runoff then create a u-shaped road.

2. Lateral erosion across the roadbed occurs at low spots in the road or where a ditch or cross culvert has been clogged with debris.

Figure 10: Erosion down the roadbed, see #1.

Figure 11: Lateral erosion across the roadbed, see #2.

3. Washboarding is a rough road with a series of ridges and depressions (or corrugations) across the road that is caused by fast or heavy traffic over poor surface material.

4. Rutting occurs where tire wear has created channels in the roadbed due to poor base material and high groundwater. Minor ruts are less than 3 inches and major ruts are over 9 inches deep.

5. Potholes are holes in the roadbed caused by poor drainage and traffic. Minor holes are isolated shallow depressions. Major holes are widespread and deeper than 6 inches.

Figure 12: Common pothole in tire wear tracks. Formation can be due to poor soils or freeze/thaw action or shade prevents the area from drying out, see #5.

Troubleshooting

Surface distress such as washboarding, ruts and potholes indicate loss of roadbed strength. The three primary causes of distress are poor subgrade, improper drainage or inadequate gravel cover.

- The subgrade is the foundation of the road base, usually made of native soil and rock. The subgrade becomes a problem when the native soil is poorly compacted, has too much organic matter or has groundwater seepage. Regrading and shaping the roadway to remove undesirable materials and compacting the soil will improve the subgrade. The use of a Geotextile fabric will reinforce the base materials and protect from over saturation. A subsurface practice such as a French Mattress or underdrain may also be needed to improve the road base.
- Surface drainage over or across the roadway washes the gravel cover and weakens the road. Runoff from the side slopes and uphill sources needs to be conveyed safely around the roadway. Cross Culverts and Dips are the primary tool to convey runoff under or over the road surface to minimize dirt and gravel erosion. Diversions and grade breaks intercept runoff down the road and diverts to a safe location.
- The surface aggregate should use 6 inches of fine gravel like VDOT #21A.Coarse gravel like VDOT #57s can be used as a base aggregate for strength and drainage. Maintaining the shape of the road will reduce the loss of gravel. Proper compaction of the gravel surface and routine blading and smoothing of the road surface will ensure uniform distribution. See Penn State's Center for Dirt and Gravel Road Studies Driving Surface Aggregate technical bulletin for specifications.


Figure 13

Figure 13: Massive ruts formed in a dirt road. The soils are soft and should be reinforced with Geotextile and need additional surface aggregate.


Figure 14

Figure 14: Runoff is conveyed down the driveway. The runoff needs to be diverted to a side ditch. A Dip or Diversion can be used; see the practice specifications.

Stream crossings are vulnerable to damage from major storms. Crossings can have localized scour, become overtopped or can be washed out.

- Scour is the erosion of the stream bank due to direct and vortex flows at individual locations in the stream channel. Scour primarily occurs when there are blockages of the stream channel or when the crossing itself restricts flow and causes backwater eddies. To reduce scour potential the upstream end of a culvert crossing could be reinforced with a solid headwall, wingwall or riprap lining. The culvert pipe can also be sized to pass more flows or the stream channel could be reconnected with the floodplain to dissipate erosive flows.

Figure 15

Figure 15: Inadequate culvert bedding combined with high flow depths causes piping; which is the loss of fill material. A headwall or riprap lining is needed.

Figure 16

Figure 16: Frequent high flows that can clog and overtop the roadbed need a high water bypass; see practice specifications.

- Overtopping occurs when the stream crossing is flooded during high water events. Low Water crossings are designed to overtop. Culvert crossings may need a high water bypass or secondary high flow pipe. The crossing could be enlarged to pass larger events.

- Washing out occurs when the crossing material is either overcome with erosive flows or there may have been a structural problem. Structural problems include piping along the culvert pipe; pipe buoyancy or floatation; or undermining of the crossing base material.

Figure 17: Poor placement of culvert resulted in buoyancy failure during high flow event. Culverts need 1 foot of cover and plastic pipes need to be weighted down.

Figure 17- photo credit Va. DCR

Maintenance

Annually the dirt and gravel road needs to be inspected and maintained. There are four maintenance components to consider for dirt and gravel roads. The roadway includes the road surface (shape and surface aggregate), side slopes (cut and fill banks), drainage system (ditches and culvert), and riparian buffers (vegetative area along waterways for dispersion of runoff).

There are three main functions involved with maintaining the road surface:

1. Blading and Smoothing to remove high spots and redistribute materials. Blading and Smoothing is an annual task for the spring to clear accumulated materials left by the snowplows.
2. Grading and Reshaping repairs the road shape and improves road drainage. Grading and Reshaping is a repair task performed every couple of years to maintain the crown of the road.
3. Adding Materials to resurface the roadbed or stabilizing gravel with binding agents for dust control and strength. Adding Materials can be annual or as needed depending on the quality of the base materials, traffic and weather.

Figure 18

Figure 19

Figure 18: Accumulation of loose materials along the shoulder or in the ditch does not allow runoff to sheet off the roadbed.

Figure 19: Placement of rock lining should not comprise the capacity of the side ditch.

The side slopes are very important for transitioning the roadway to the adjacent natural grades. Cut slopes can be steep and difficult to mow or maintain vegetation. Fill slopes are vulnerable to rill and gully erosion. Mowing high (4-6 inches), over seeding and taking soil samples to amend in accordance with a soil test will keep a mature and uniform stand of vegetation on these slopes. Repair eroding areas by maintaining erosion control measures such as surface diversions, subsurface drains, stabilization matting, rock linings or terraces.

The drainage system includes ditches, cross-culverts and stream crossings. These structures take the runoff from uphill and the roadway and convey it to a stable outlet. Debris removal may be needed multiple times a year to keep the structures free flowing. Mowing grass channels to maintain uniform and mature vegetation will be needed during the growing season. Woody vegetation should not be allowed to impede channel and culvert flows. Repair erosion as needed, with stabilization matting, check dams and rock lining.

Riparian Buffers are vegetative areas adjacent to streams that protect stream banks and shorelines. Ideally the roadway should be located at least 50-feet from the top of stream bank or shoreline so that runoff can be dispersed and filtered by vegetation prior to reaching the waterway. Grass buffers will need to be mowed no shorter than 6 inches and no more than 2 times a year. Where ditches or cross culverts are dispersed with a level spreader or turnout, these areas will need annual removal of debris and periodic erosion repair. Forested buffers may need trees cut when they fall into the stream channel.

Maintenance Schedule

Maintenance is generally done as needed for most gravel roads. Regular inspections and maintenance will protect a good road from becoming degraded. The following maintenance schedule table was adapted from: Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads; Kennebec County Soil and Water Conservation District and Maine Department of Environmental Protection, Bureau of Land and Water Quality; April 2010.

Task	Spring	Fall	Major Storms	Inspection Date & Condition
ROADWAYS				
Clear accumulated winter sand along the roadway and remove false berms	X			
Maintain the crown of the road surface and shoulder, as needed at least once per year.	X		X	
Clean out sediment within Diversions; Dips; Fords; or High Water Bypass.	X	X	X	
SIDE SLOPES				
[1]Replant bare areas or areas with sparse growth. Seed or plant at appropriate time.	X	X		
[2]Collect Soil Sample and Test, every 3 years	X			
Eroding Areas: armor with riprap or stabilization matting; or divert erosive flows to a stable area.			X	
DITCHES AND CULVERTS				
Remove obstruction and accumulated sediments, leaves, or debris.	X	X	X	
Stabilize any erosion			X	
Mow grass ditches		X		
Remove woody vegetation		X		
Repair slumping side slopes			X	
Replace stone lining where underlying geotextile fabric is showing or where stones have dislodged.			X	
Repair any erosion damage at the culvert's inlet			X	
OUTLETS AND RIPARIAN BUFFERS				
Mow vegetation in non-wooded buffer no shorter than 6 inches and no more than 2 times per year.		X		
Repair erosion below culverts and turnouts	X		X	
Install more level spreaders or ditch turnouts if needed for better distribution of flow		X		
Clean out accumulation of sediment within the level spreader or turnout.	X	X	X	

[1] Consider a drought or shade tolerant seed mix or plugs for problematic areas. www.mgnv.org/plants/ground-cover

[2] Soil Sampling refer to VCE Publication 452-129. www.pubs.ext.vt.edu/452/452-129/452-129.html

Inspection Checklists

Photocopy this page to use it, and keep it for your records.

If you observe 'yes' for any of these conditions on your road, promptly take action to resolve the problem.

Road Segment Inspected: _______________________________ Date: __________________

Roadway

Yes No

__ __ Erosion of the road surface; or sediment washed into streams, ditches or waterways

__ __ Washboarding, potholes, or rutting of the surface

__ __ Displacement of surfacing gravel

__ __ Spots in the road that remain soft and wet throughout the year

__ __ Soil is being tracked or washed out onto the public roadway

__ __ Over-hanging trees and limbs that cast abundant shade onto the road surface

__ __ Tree limbs and shrubs that obscure a driver's vision at the public road entrance

Side Slopes

__ __ Soil slumping or eroding down the face of cut banks and fill slopes

__ __ Bare areas or areas with sparse growth

__ __ Groundwater seepage coming out from cut bank

Ditches and Culverts

__ __ Clogged culverts or obstructions in ditches

__ __ Erosion in the ditch or scour around culverts

__ __ Rust, corrosion or deformation of metal pipes

__ __ Caving-in atop of a culvert pipe

__ __ Stream flow undermining culvert

__ __ Ruts in the stream bottom at a ford crossing; or stream flow dammed up at the ford

Outlets and Riparian Buffers

__ __ Sediment being washed away into the woods or onto neighbor's property

__ __ Sediment build-up within dips, turnouts, diversions, or level spreaders

__ __ Bare areas or areas with sparse growth within 35-feet of outlet.

Definitions

Base Coarse or Surface Aggregate – Main surface of travelway, normally consisting of well graded crushed stone mixture.

Subbase or Base Aggregate – second layer underlying the base coarse, normally consisting of an open graded stone mixtures that provide load distribution and internal drainage for the road.

Subgrade – surface of roadbed under subbase, usually the native load bearing soils.

Cut Slope or Back Slope or Cut Bank – the slope cut into soil or rock along the inside edge of the road.

Fill Slope or Embankment Slope – The inclined slope extending from the outside edge of the road shoulder to the toe of the fill.

Roadway – Total horizontal width of land affected by construction of the road from top of cut slope to toe of fill slope.

Travelway – portion of road for use by moving vehicles.

Roadbed – the driving surface and underlying materials used in the travelway

Shoulder – unpaved strip along edge of travelway. Inside shoulder is adjacent to cut slope. Outside shoulder is adjacent to fill slope.

Side Slope or Slope Ratio – Expressing constructed slopes as a ratio of horizontal distance to vertical rise such as 3:1 is 3 feet horizontal for every 1 foot vertical.

Through Cut – A road cut through a hill slope or ridge in which there is a cut slope on both sides.

Through Fill – Road comprised of fill material, where fill slopes are on both sides.

Drainage Structure – structures installed to control, divert, or move water off or across road; includes ditches, culverts, fords, dips, etc.

Surface Flow – overland runoff that can be dispersed or concentrated.

Subsurface Flow – groundwater moving through the soil or base aggregate.

Unimproved Roads – are unpaved roadways with a dirt or gravel surface.

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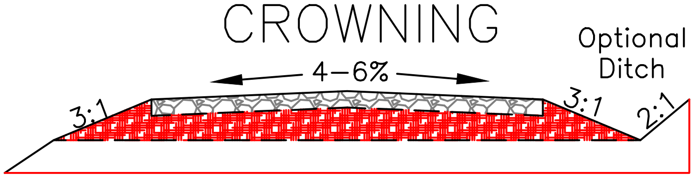
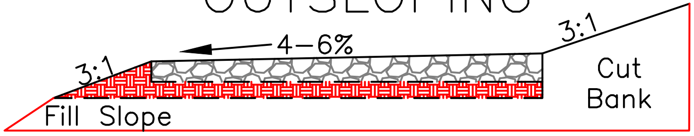
Section 2: Practice Specifications

2.1 ROAD SURFACE SHAPING

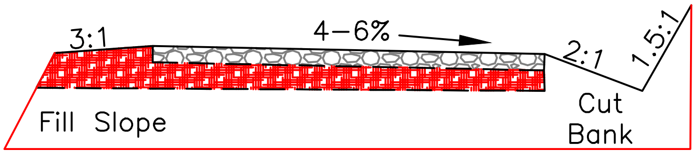
CROWNING



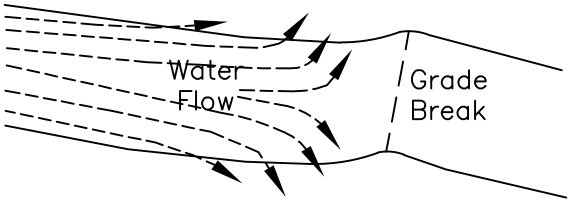
OUTSLOPING



INSLOPING WITH DITCH



GRADE BREAK



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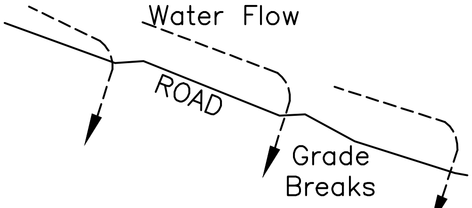


Profile

Description:
Road surface shaping is the grading of the roadbed to allow positive drainage and prevent erosion of the roadbed. Road shaping includes crowning, in–sloping, out–sloping and grade breaks. Crowning has an elevated center and continuous fall towards the shoulders. In–sloping grades the road to drain water towards the back slope or cut bank and away from the fill slope. Inslope road concentrates runoff against the backslope or inside ditch. Out–sloping grades the road to drain surface water to the downhill or fill slope side allowing sheet flow off of the road. Grade breaks are small intentional increases in road elevation on a downhill slope, which shorten flow paths and sheds runoff to one or both sides into ditches or dispersal areas.

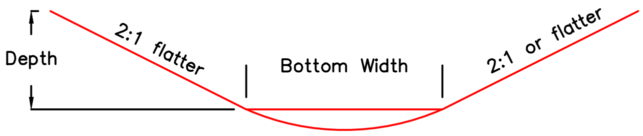
Limitations:
- Steep side slopes and unstable fill prevents use of out–sloping.
- Narrow right–of–ways prevents the use of in–sloping.
- Heavy loads and traffic speeds may disrupt grading.

Construction:
1. Crowning can be used where there is adequate drainage away from either side of the roadbed; such as ridges and floodplains. Effective for road slopes of 8% or greater. Remove berms from road shoulder that may trap water.
2. Out–sloping should be used on road slopes of 8% or less. Use on roads where side–slopes are gentle and where runoff is not concentrated and drainage area small.
3. In–sloping should be used on steep side slopes and where the fill–slope is unstable. The ditch shall have adequate capacity for the design flows. Consider frequent use of cross–culverts, road diversions and dips to disperse the concentrated ditch runoff at adequate turnouts. Requires more frequent maintenance.
4. Grade Breaks should be used on long road slopes where adequate space is available to safely shed runoff into ditches or dispersal areas. Located prior to gradient changes and stream crossings. Construct elevated berm perpendicular to roadway and taper the edges into the road grade.
5. Unpaved roads shall have a cross slope of 4 to 6 percent ($\frac{1}{2}$ to $\frac{3}{4}$ inch per 12 feet) to quickly shed runoff.

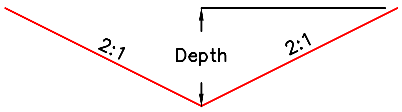
Maintenance:
- Maintain the cross slope during snow plowing and maintenance blading.
- Educate road crews to maintain these grading features, such as side ditches and grade breaks.
- Add materials to maintain cross slope and grade breaks as necessary.

Resources:
- Penn State Center for Dirt and Gravel Road Studies. Crown and Cross–Slope TB. 2005.
- Penn State Center for Dirt and Gravel Road Studies. Grade Breaks TB. 2004.
- Forestry Best Management Practices for Water Quality Technical Manual. March 2011. Virginia Department of Forestry. Forest Roads Specification 1.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC.Chapter 3 Road Surface Shape.

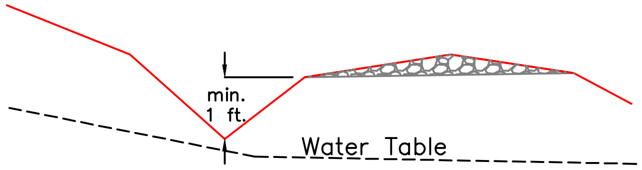
2.2 ROADSIDE DITCHES



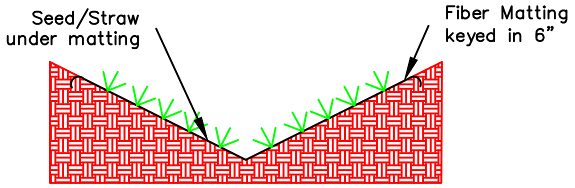
TRAPEZOIDAL/PARABOLIC



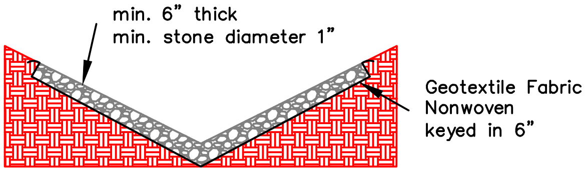
V–DITCH



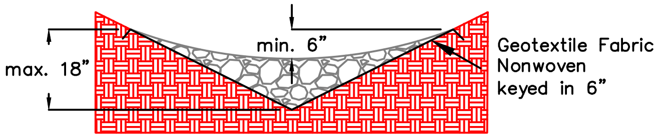
*Avoid the interception of ground water



Fiber Matting



Stone Lining



Rock Check Dam

*use 2" to 3" stone, combine with riprap for heavier flows.

Description:
Roadside ditches collect runoff from the road and abutting properties and drain it away from the road. Ditches can be on both sides of the road or one side. Typical ditches are v–shaped for ease of construction and maintenance. A trapezoidal or parabolic ditch are preferred to slow and disperse road runoff. Ditches should be vegetated or where needed lined with stone.

Limitations:
- Bedrock and narrow right–of–way can prevent the shaping of ditches.
- Entrenched or u–shaped roads have limited space for ditches.
- Steep Slopes increase erosion potential.

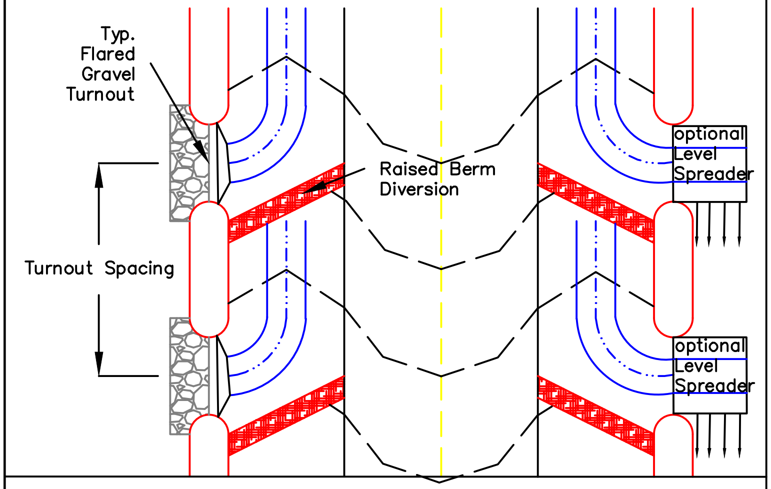
Construction:
1. Sizing is based on the volume of runoff and should be done by an experienced or qualified professional. Design flows should be based on the 10–year peak flow for channel capacity and velocity.
2. Avoid excavating the ditch below the water table if possible. Use subsurface drains to convey excess water away from ditch.
3. Ditches should be constructed on cut soils. If fill is used to create the ditch, the fill will need to be compacted and lined with fiber matting or stone.
4. A wide grass–lined trapezoidal or parabolic ditch is preferred. Bottom width of between 2 and 4 feet.
5. Ditch should have a shallow drop off from road surface. Side slopes of 2:1 or flatter; with a 3:1 side slope preferred.
6. Grass established with sod is preferred for immediate vegetated cover. The sod should be rolled out perpendicular to the flow of water and pegged. Temporary stabilization matting should be used if seeding the ditch. Ensure the matting is installed with continuous contact with the soil per manufacturer specifications.
7. Ditch Slopes greater than 2% should be lined with fiber matting and check dams.
8. Ditch Slopes greater than 5% should be lined with stone suitable for the flow velocity.
9. Disconnect ditches from stream channels, wetlands and ponds whenever possible, see Clearwater Crossing practice.
10. Avoid directing ditch flows toward wells, septic tanks, and drain fields.

Maintenance:
- Remove sediments and debris to maintain ditch capacity and vegetation.
- Ditches should be checked for erosion. Stabilize with matting or rock as needed. Consider the use of turnouts or cross culverts to minimize erosive flows.
- Remove unnecessary berms or debris windrows along the shoulder of the road to ensure sheet flow off the road surface.
- Reseed and mulch whenever soil is disturbed. Seed in fall for cool season lawn grass mix or spring for warm season grass mix. Maintain a cover density of 75%.

Resources:
- Virginia Erosion and Sediment Control Handbook, 3rd edition. 1992. Stormwater Conveyance Channel Spec. 3.17; RipRap Spec. 3.19; Rock Check Dams Spec. 3.20; and Stabilization Matting Spec. 3.36
- Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads. April 2010. Maine Department of Environmental Protection. Bureau of Land and Water Quality. Kennebec County Soil and Water Conservation District. Ditches Pg. 39.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 4 Low Maintenance Ditch and Berm Removal.

2.3 DITCH TURNOUTS

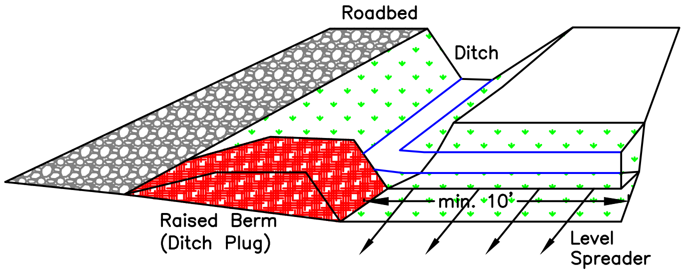
PLAN VIEW



DITCH TURNOUT SPACING:

Min. Spacing = 400/(Slope %) + 100 feet; Additional spacing may be needed based on site specific considerations.

When a road is within 25 feet of a stream and runs parallel to a stream for more than 300 feet, decrease the spacing by a minimum of 25%.



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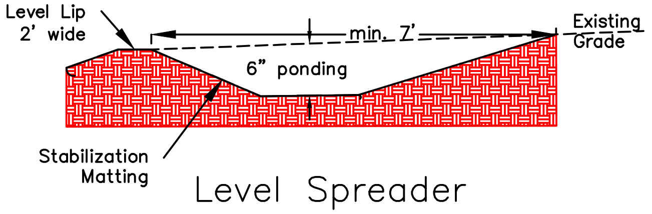


Level Spreader
CROSS SECTION

Description:
Ditch turnout or Wing Ditch is a diversion ditch constructed to disperse runoff away from the road and side ditches into adjacent undisturbed areas so that the volume and velocity of roadside ditch runoff is reduced on slopes. Turnouts properly disconnect concentrated ditch flow from streams, wetlands and ponds. The turnouts disperse runoff before erosion can occur. Typical turnouts use flared gravel aprons. Level spreaders can be used to aid in the dispersion of high runoff flows and provide additional sediment trapping.

Limitations:
- Narrow Roadways such as entrenched or u–shaped roads
- Steep or unstable fill slopes
- Wet and Flat areas without positive drainage
- Impacts to neighboring property

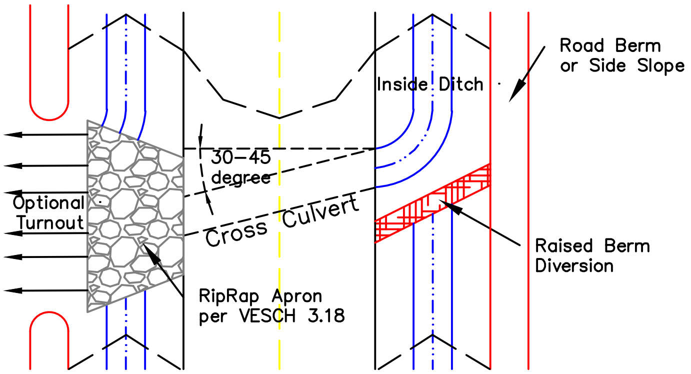
Construction:
1. Turnouts should be located so that they use the natural contour of the land.
2. Do not discharge directly into gullies or streams. Turnouts should discharge to vegetated buffers or filter strips.
3. Install multiple turnouts to minimize the accumulation of large volumes of runoff. Spacing guidelines are provided. Turnouts should be no more than 300 feet apart since erosion increases on ditches longer than 300 feet.
4. Turnouts with a slope less than 5% can be seeded and matted or sodded. Turnouts with slopes greater than 5% should be lined with 4" to 6" crushed angular stone over nonwoven geotextile fabric.
5. On sloping roads, the turnout should be angled at a 30 to 45 degree angle to the roadbed and downsloped less than 2% of the natural contour.
6. Level Spreader should be used with the turnout slopes greater than 10% or when the turnout is within 50 feet of a stream, pond, or other sensitive area.
7. Install Turnouts and Level Spreader on cut material and wide enough to allow for maintenance.
8. Turnouts can be a component of other water diversion structures such as dips, waterbars and cross culverts.

Maintenance:
- Inspect annually and after major storms.
- Clean out debris and sediments.
- Ensure runoff is dispersed into vegetation.
- Repair erosion in and downstream of flow dispersion structures.

Resources:
- Forestry Best Management Practices for Water Quality Technical Manual. March 2011. Virginia Department of Forestry. Specification 3 Wing Ditches.
- Virginia Erosion and Sediment Control Handbook. 3rd Edition 1992. Level Spreader specification 3.21.
- Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads. April 2010. Maine Department of Environmental Protection. Bureau of Land and Water Quality. Kennebec County Soil and Water Conservation District. Ditch Turnouts Section Pg. 49.

2.4 CROSS CULVERT

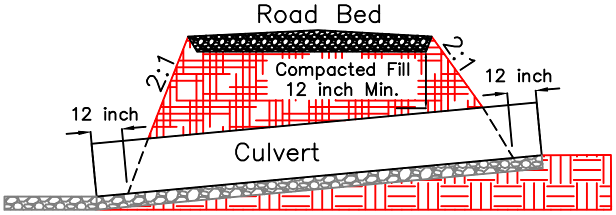
PLAN VIEW



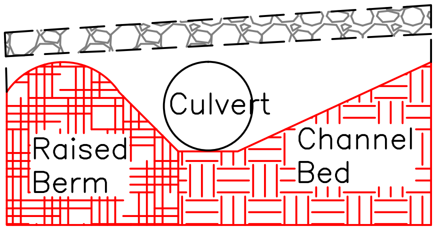
CROSS CULVERT SPACING:

Min. Spacing = 400/(Slope %) + 100 feet;
Additional spacing may be needed based on site specific considerations.

When a road is within 25 feet of a stream and runs parallel to a stream for more than 300 feet, decrease the spacing by a minimum of 25%.



PROFILE



CROSS SECTION

Description:
Cross Culvert is a pipe made of corrugated metal (CMP), high density plastic (HDPE), or reinforced concrete (RCP) installed under roads to convey water from an inside ditch to the outside edge of a road for dispersion.

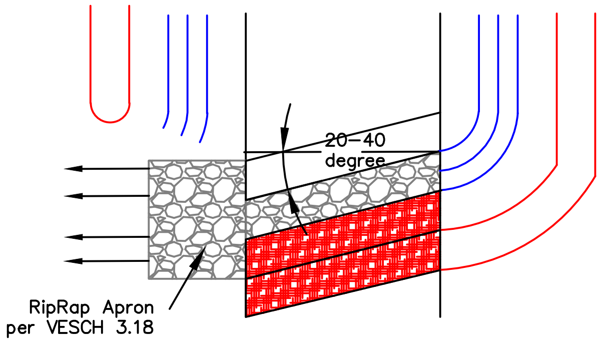
Limitations:
- Bedrock depth less than 2 feet prevent culvert placement.
- Fill cover greater than 1 foot is needed to prevent damage to the culvert from traffic and buoyancy protection.
- Adequate grade from inside ditch to culvert outlet.
- Not intended for springs/seeps or crossing live streams.

Construction:
1. Unless installed in a sag of the road, the cross culvert should be angled 30 to 45 degrees as measured from a line perpendicular to the road.
2. A raised berm diversion is installed in the ditch below the culvert inlet to direct water into the culvert. This berm should plug the ditch. The berm should be at least 4 feet wide.
3. The cross culvert should have a slope of 1-2% to prevent clogging and the bottom should be as close as possible to the natural grade of the outlet.
4. Cross culvert should be firmly seated and earth compacted at least halfway up the side of the pipe. Provide cover over the pipe that is equal to one foot per foot of culvert diameter. Never use less than one foot of cover.
5. The pipe should be long enough so both ends extend at least one foot beyond the side slope of the fill material.
6. Provide a stabilized outlet. Use riprap underlined with geotextile fabric or another structure such as a level spreader to disperse runoff and reduce flow velocities.
7. Provide inlet protection measures during construction to prevent clogging. Headwalls may be necessary to prevent erosion at the inlet.
8. Install multiple cross culverts to minimize the accumulation of large volumes of runoff. Spacing guidelines are provided above. Generally, cross culverts should be installed as needed.

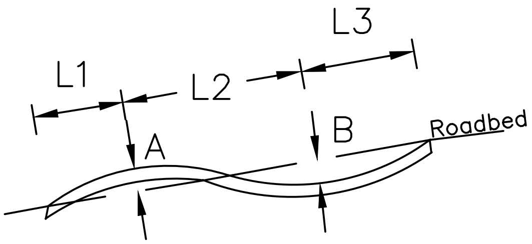
Maintenance:
- Inspect after each major runoff event and provide maintenance as needed.
- Annually remove debris and sediment at inlet and outlet of the culvert.
- Ensure outlets are stable, repair as necessary.
- Ensure inlets are stable, repair as necessary.
- Vegetated outlets shall be maintained with adequate cover. Amend the soil, reseed and mow as needed.

Resources:
- Penn State Center for Dirt and Gravel Road Studies, Crosspipe Installation TB. 2006.
- Forestry Best Management Practices for Water Quality Technical Manual. March 2011. Virginia Department of Forestry. Culvert Sizes for Cross Drainage of Roads specification 4.
- Virginia Engineering Design Note #1 Road Drainage Practices. 2008. USDA Natural Resource Conservation Service.

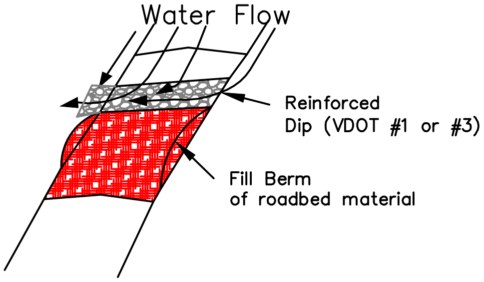
2.5 DIPS



PLAN VIEW



Dip Profile



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DIP SPACING:

Min. Spacing = 400/(Slope %) + 100 feet; Additional spacing may be needed based on site specific considerations.

When a road is within 25 feet of a stream and runs parallel to a stream for more than 300 feet, decrease the spacing by a minimum of 25%.

Description:
Dips are depressed grade breaks built across the road surface to convey ditch flows from one side to the other side of the road. The road profile (vertical alignment) is changed by simultaneously constructing a dip and raising the grade below the dip. The dip is skewed to one side to shed and disperse runoff. Used where cross culverts are not applicable or where the road is entrenched or u–shaped.

Limitations:
- Not intended to convey or divert springs or small streams.
- Use on low volume roads where traffic loads and speed is not a concern.
- Bedrock can impact the grading of Dips.
- Not to be used on roadbeds with slopes greater than 10 percent.

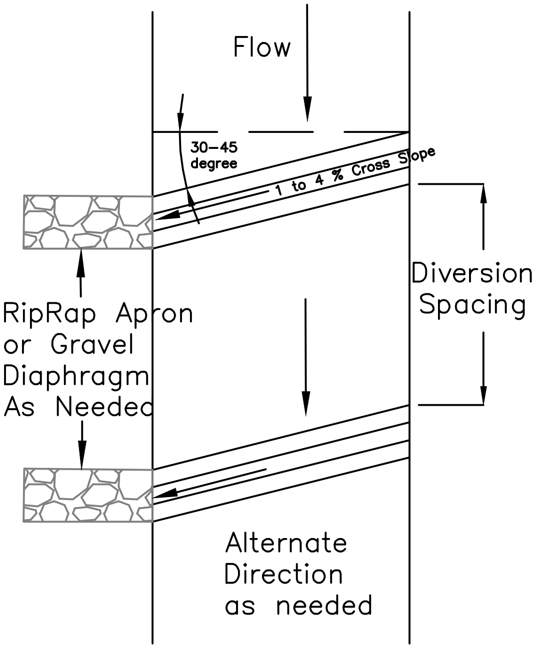
Construction:
1. The dip will be reinforced with VDOT #1 or #3 sized stones over nonwoven geotextile fabric.
2. Dip depth, B shall be a minimum of 6 inches. Approaching length, L3 shall be between 10 and 25 feet.
3. Angle the Dip across the road in the direction of flow between 20 and 40 degrees.
4. Maintain a cross–slope in the dip of 1 to 4 percent.
5. Reinforce the dip with stone and geotextile fabric to resist erosion.
6. The fill berm is part of the road and should be composed of roadbed material. The fill berm can tie into the roadbed or have a height, A, of less than 18 inches. The fill berm shall have a reverse grade of between 2 and 8 percent with a length, L2 of 10 to 15 feet.
7. Length, L1 should be 10 to 15 feet and tie into the roadbed grade.
8. The outlet shall be stabilized with stone apron in accordance with VESCH 3.18.
9. Use before stream crossings to direct water into vegetative filters and reduce hydrologic connectivity.

Maintenance:
- Inspect dips after each major runoff event and provide maintenance as needed
- Maintain the reverse grade.
- Remove debris and sediments from the dip.
- Ensure outlets are stable, repair as necessary.

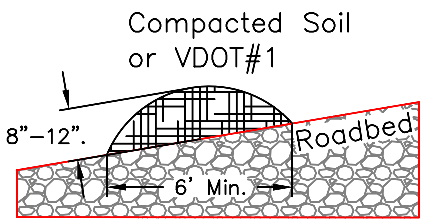
Resources:
- Penn State Center for Dirt and Gravel Road Studies, Broad Based Dips TB. 2008.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA Forest Service. Broad–Based DIp
- Forestry Best Management Practices for Water Quality Technical Manual. March 2011. Virginia Department of Forestry. Broad–Based Dip and Rolling Dip Specification 5 and 6.
- Virginia Erosion and Sediment Control Handbook. 3rd edition 1992. Outlet Protection Spec. 3.18.

2.6 ROAD DIVERSIONS

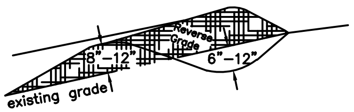
PLAN VIEW



WATERBAR DIVERSION



Typical Section



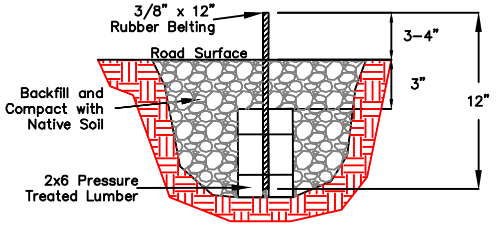
ISOMETRIC

DIVERSION SPACING:

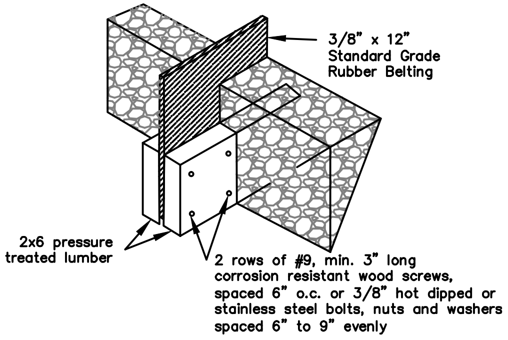
Min. Spacing = 400/(Slope %) + 100 feet; Additional spacing may be needed based on site specific considerations.

When a road is within 25 feet of a stream and runs parallel to a stream for more than 300 feet, decrease the spacing by a minimum of 25%.

RUBBER BELT DIVERSION

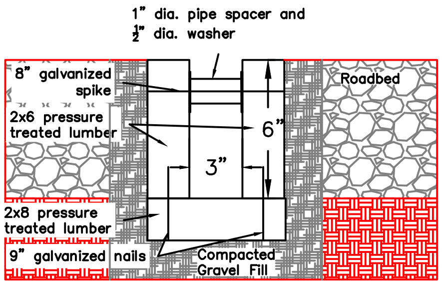


Typical Section

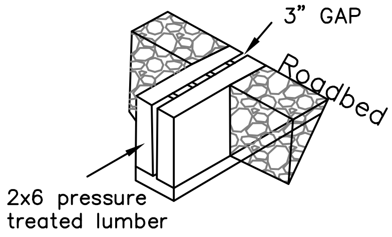


ISOMETRIC

OPEN TOP CULVERT



Typical Section



ISOMETRIC

Description:
Road Diversions are used to shed runoff from the roadbed to minimize erosion. These diversions must be resistant to erosion.
Diversions are ideal above or in entrenched roadbeds and at major grade breaks. Diversions include Water Bars; Rubber Belts; and Open Top Culverts.

Limitations:
- Water Bars and Rubber Belts are intended for low volume roads since they use above grade barriers. Frequent snow plowing can also damage these structures.
- Bedrock and groundwater intrusion can affect Open–Top Culverts and Rubber Belt installation.
- Do not use a diversion for live water flows.
- Do not use a diversion to convey ditch flows across the roadbed. Refer to the Cross Culvert or Dip practices.

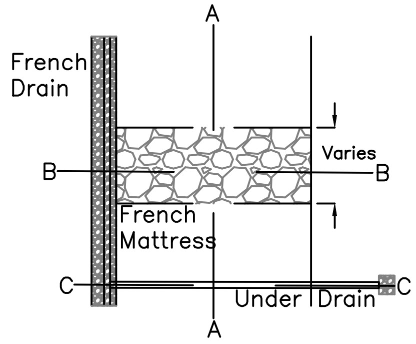
Construction:
1. Waterbar: dig a shallow trench 6" to 12" deep at an angle of approximately 30–45 degrees down slope to turn surface water off road; use the excavated material to form a 8" to 12" berm on the downhill side.
2. Rubber Belts: rubber belting is fastened to two pieces of treated lumber and buried in the road with at least 3 inches of the belting protruding.
3. Open Top Culvert: install timber flush with the roadbed; use 1" pipe spacers to reinforce the openings, spaced as needed.
4. The outlet end of the diversion should be fully open and extend far enough beyond the edge of the road to safely convey runoff away from the road surface. The outlet should drain into stable vegetated areas or be protected, as necessary, by a riprap apron or gravel diaphragm to capture sediments and prevent erosion.
5. Maintain a diversion cross slope of 1 to 4 percent.
6. Where no ditch is present on the uphill side, extend the diversion from the cut bank across full width of road.

Maintenance:
- Inspect diversion after each major runoff event and provide maintenance as needed to maintain proper drainage.
- Remove debris and sediment behind the diversion. Use a small hoe or trowel to clean out the Open Top Culvert.
- Ensure outlets are stable, repair as necessary.
- Plow and Grade carefully around diversions during routine maintenance of the roadbed. Flag locations to alert snow plows.
- Vegetated outlets shall be maintained with adequate cover. Amend the soil, reseed and mow as needed.

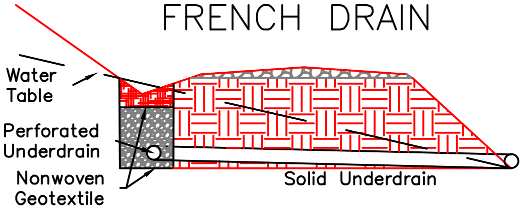
Resources:
- Virginia Erosion and Sediment Control Handbook 3rd edition 1992, Right–of–way Diversions Spec 3.11.
- Penn State Center for Dirt and Gravel Road Studies, Conveyor Belt Diversions TB. 2009.
- Forestry Best Management Practices for Water Quality Technical Manual. March 2011. Virginia Department of Forestry. Water Bar Specification 7.
- Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads. April 2010. Maine Department of Environmental Protection. Bureau of Land and Water Quality. Kennebec County Soil and Water Conservation District. Open–top Culverts Pg. 69.
- A Landowner's Guide to Building Forest Access Roads. July 1998. Wiest, Richard. USDA Forest Service. NA–TP–06–98. Road Construction: Open Top and Pole Culverts.
- Virginia Engineering Design Note #1 Road Drainage Practices. 2008. USDA Natural Resource Conservation Service (NRCS).

2.7 SUBSURFACE DRAINS

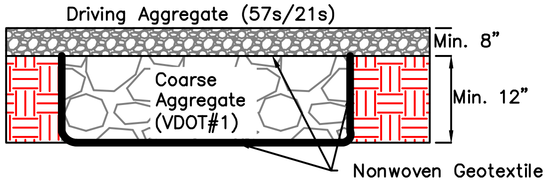
PLAN VIEW



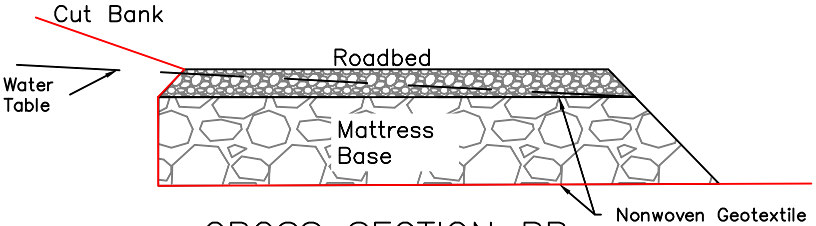
FRENCH DRAIN



FRENCH MATTRESS



CROSS SECTION AA



CROSS SECTION BB

Description:
Subsurface Drains allows the road cutslope, ditch and base to drain and separate groundwater from surface runoff. There are two types of drains, French Mattress and French Drains.

French Matress is a subsurface structure under a road consisting of clean coarse rock wrapped in geotextile fabric through which water can pass freely. French Mattresses are used in low–lying areas near streams and wetlands, areas where the road cuts off the natural subsurface flows or areas with high water table where concentrated outlet flows is undesirable.

French Drain is an under drain structure used to collect subsurface flows associated with springs and seeps at the edge of the cutslope, shoulder or below the ditch. French drains are composed of stones wrapped in geotextile fabric or can be combined with a perforated pipe.

Limitations:
- Should not be sized for the collection of surface flows.
- Not for concentrated flows associated with streams or ditches.

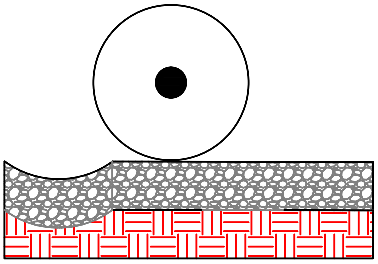
Construction:
French Mattress
1. Remove the road fill material to natural ground. This should be the width of wet area or seep.
2. Place non–woven geotextile on the bottom the full width of the area. Overlap multiple sheets at least 1–2 feet.
3. Place at least a foot of large, clean 3" to 6" rock.
4. Place a layer of geotextile fabric on top of the rock. Overlap joints by 12 inches.
5. Then place the road surface material to a minimum of 8" depth after compaction.
6. The mattress can daylight to natural grade or utilize a gravel diaphragm trench that percolates groundwater safely away.

French Drain:
1. The location of the drain should be placed at the toe of cut slope where groundwater is seeping out of the cut face. The trench should extend the length of the cut slope where the seepage is occurring. The gravel trench should be as wide and deep as necessary to convey the groundwater flow rate.
2. The under drain pipe diameter should be 4 to 6 inches and perforated. A solid pipe is used to daylight the under drain.
3. Install under drain pipe with a 1% minimum slope.
4. The under drain pipe should be wrapped with at least 3 inches of clean stones above and below the pipe with a non–woven geotextile fabric. Provide at least 6 inches of fill cover.
5. Outlet the under drain separately from ditch drainage when possible. Outlet in natural swales or stable filter areas.

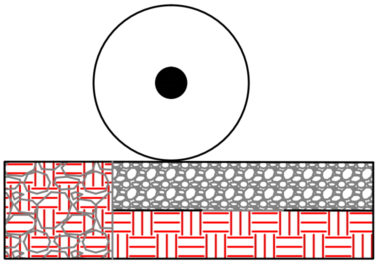
Maintenance:
- Remove debris and sediment from the outlet of the under drain pipe or french mattress.

Resources:
- Penn State Center for Dirt and Gravel Road Studies, French Mattress TB. 2013.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Grael Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 2 Subsurface Water
- Gravel Road Maintenance Manual: A Guide for Landowners on Camp and Other Gravel Roads. April 2010. Maine Department of Environmental Protection. Bureau of Land and Water Quality. Kennebec County Soil and Water Conservation District. Rock Sandwich Pg. 63.
- Kellar, G & Sherar, J. Low–Volume Roads Engineering: Best Management Practices Field Guide. July 2003. USDA Forest Service. Chapter 7 Drainage.

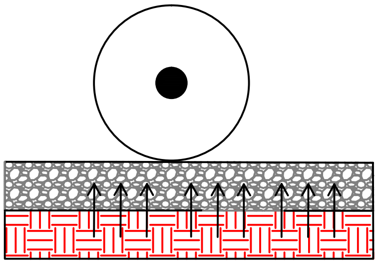
2.8 GEOTEXTILE FABRIC



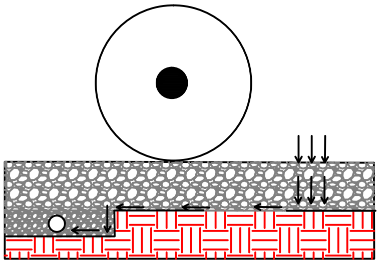
REINFORCEMENT



SEPARATION



FILTRATION



TRANSMISSION

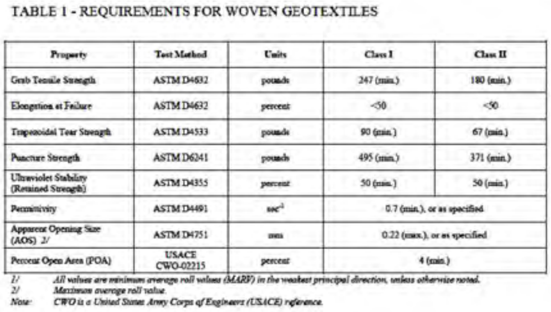


TABLE 1 - REQUIREMENTS FOR WOVEN GEOTEXTILES

Property	Test Method	Units	Class I	Class II
Grab Tensile Strength	ASTM D4632	pounds	247 (min.)	180 (min.)
Elongation at Failure	ASTM D4632	percent	<50	<50
Trapezoidal Tear Strength	ASTM D4533	pounds	90 (min.)	67 (min.)
Puncture Strength	ASTM D6241	pounds	495 (min.)	371 (min.)
Ultraviolet Stability (Retained Strength)	ASTM D4355	percent	50 (min.)	50 (min.)
Permittivity	ASTM D4491	sec^{-1}	0.7 (min.), or as specified	
Apparent Opening Size (AOS) 2/	ASTM D4751	mm	0.22 (max.), or as specified	
Percent Open Area (POA)	USACE CWO-02215	percent	4 (min.)	

1/ All values are minimum average roll values (MARV) in the weakest principal direction, unless otherwise noted.
2/ Maximum average roll value.
Note: CWO is a United States Army Corps of Engineers (USACE) reference.

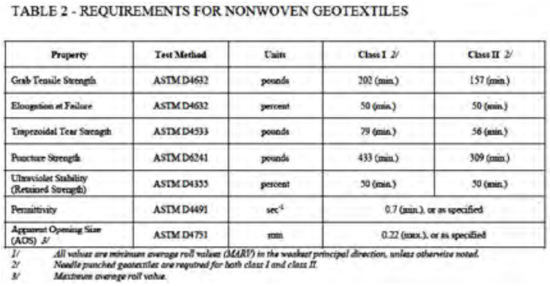


TABLE 2 - REQUIREMENTS FOR NONWOVEN GEOTEXTILES

Property	Test Method	Units	Class I 2/	Class II 2/
Grab Tensile Strength	ASTM D4632	pounds	202 (min.)	157 (min.)
Elongation at Failure	ASTM D4632	percent	50 (min.)	50 (min.)
Trapezoidal Tear Strength	ASTM D4533	pounds	79 (min.)	56 (min.)
Puncture Strength	ASTM D6241	pounds	433 (min.)	309 (min.)
Ultraviolet Stability (Retained Strength)	ASTM D4355	percent	50 (min.)	50 (min.)
Permittivity	ASTM D4491	sec^{-1}	0.7 (min.), or as specified	
Apparent Opening Size (AOS) 3/	ASTM D4751	mm	0.22 (max.), or as specified	

1/ All values are minimum average roll values (MARV) in the weakest principal direction, unless otherwise noted.
2/ Needle punched geotextiles are required for both class I and class II.
3/ Maximum average roll value.

Description:

Geotextile Fabric is a multi–purpose material common in road construction. The term geotextiles is used to describe a variety of manufactured products used to reinforce earthen structures. The type of Geotextiles described here are those fabrics made of synthetic polymer fibers which are either machine woven together (woven) or heat bonded (nonwoven). Geotextile fabrics have historically been used to enhance many erosion control practices. The discussion in this guide is for using geotextile fabric as a component of the road base layer and as a component of other Road BMPs.

Limitations:

- Geotextile fabrics must be placed by hand in most cases.
- Bedrock and angular rock intrusions can puncture geotextile fabrics
- The type and thickness of the road gravel may also stress the fabric.
- Depending on the type of geotextile fabric and subsoil materials, gravel on steep slopes may slip over the fabric.

Improving Road Strength:

- Reinforcement prevents rotational failure due to soft subsoil or frequent heavy or fast traffic. The geotextile fabric acts to disperse forces accross the failure plane to strengthen subgrade and gravel base material. A Woven fabric is used for its tensile strength.
- Separation prevents the intermixing of soil and gravel. The geotextile fabric reduces the thickness of the gravel base and disperses the applied loads to increase the life of the road. The frequency of adding gravel is reduced. Either a Woven or Nonwoven fabric can be used to separate road layers.

Improving Road Drainage:

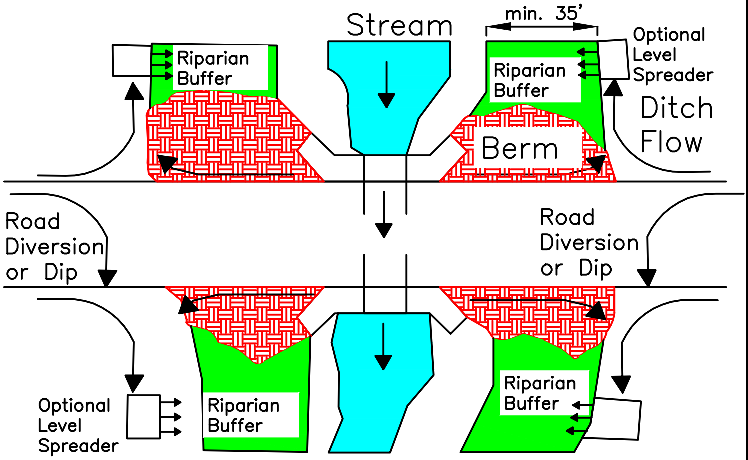
- Filtration helps retain soil particles while permitting water to pass through. Use to allow seeps or springs to drain through the gravel, thus reducing hydrostatic pressure associated with a high water table. The amount of water moving through the fabric determines design and selection of the geotextile. A nonwoven fabric is best for transmitting water.
- Transmission allows water and air to be conveyed along the geotextile plane to prevent flow accross the geotextile fabric. Typically used with a subsurface drainage structure to prevent over saturation of the gravel base or underlying subsoil. A woven fabric is usually used as a liner. A nonwoven fabric may be used around the subsurface drain.

Resources:

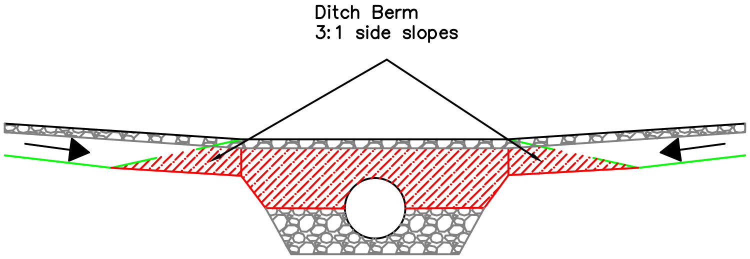
- Wisconsin Transportation Bulletin No 16. Geotextiles in Road Construction/Maintenance and Erosion Control. Wisconsin Transportation Information Center UW – Madison. 1997.
- A Landowner's Guide to Building Forest Access Roads. July 1998. Wiest, Richard. USDA Forest Service. NA–TP–06–98. Geotextiles.
- Va. Construction Specification VA–795 Geotextile. October 2015. USDA Natural Resource Conservation Service.

2.9 CLEARWATER CROSSINGS

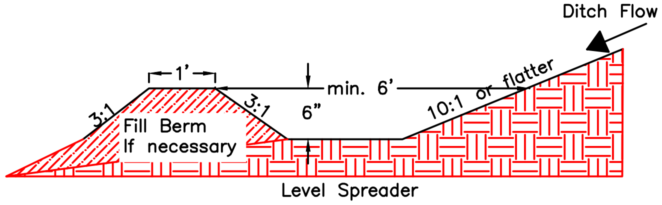
PLAN VIEW



*Use Level Spreader to dissipate and disperse ditch flows into riparian buffer area when slopes are steep or other site constraints.



CROSS SECTION



PROFILE

*Fill Berm should be compacted and stabilize for high flow situations. Otherwise the fill berm may be porous.

Description:
Clearwater Crossings are practices that minimize discharge of sediments and gravel into stream channels. Clearwater crossing disconnects ditches from the stream channel by diverting the ditch flow into a vegetated filter strip or riparian buffer. Disconnecting ditches combines ditch turn outs with vegetated filter strip and helps establish a functional riparian filter.

Limitations:
- Drainage areas greater than 1 acre per ditch outfall should be avoided.
- Riparian Buffer must be at least 35 feet of undisturbed vegetation.
- The slope of the receiving area must be less than 8 percent.
- When the slope or riparian buffer width cannot be met a modified dispersion measure (such as a gravel diaphragm or level spreader) may be needed.

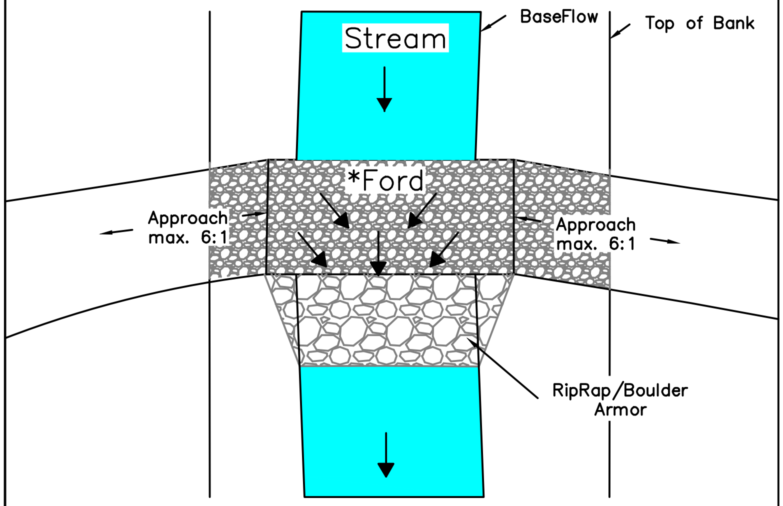
Construction:
1. Regrade ditches in wide flood plains to drain away from stream crossings.
2. Fill ditch outlets and divert ditch flows using turnouts away from the stream into stable vegetation.
3. Construct dips or diversions before the stream crossing to disperse surface and ditch flows before stream crossing.
4. Level spreaders should be used for erosive flows above steep slopes or when large volumes of runoff are concentrated to a single point.
5. Level spreader should be at least 10 feet long and typically no more than 40 feet. Larger level spreaders may be needed depending on the design flows, consult a professional engineer for sizing.
6. Level spreader should be built on contour and tied into the natural grade of the riparian buffer. In some cases, a fill berm may be necessary. The berm should not obstruct floodplain flows. The berms may be porous to promote better drainage. Berms must be compacted and stabilized with matting for erosive flows.

Maintenance:
- Inspect ditch turnouts for clogging or erosion.
- Inspect Level Spreader for ponding of water and erosion of the fill berm.
- Maintain the ditch and level spreader with grass cover by mowing at least once a year.

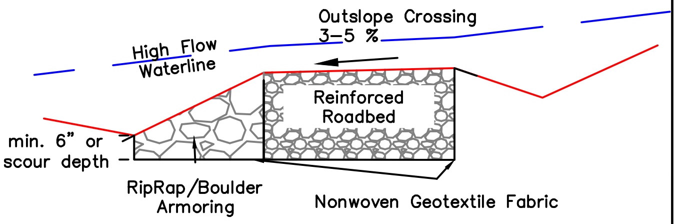
Resources:
- Penn State Center for Dirt and Gravel Road Studies, Croman Clearwater Crossing TB. 2006.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Grael Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 4 Disconnecting Ditches and Streams.

2.10 LOW WATER CROSSINGS

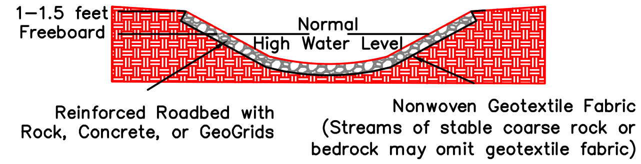
PLAN VIEW



*Grade crossing like a Dip. Crossing Width should be at least 12 feet.



PROFILE



CROSS SECTION

Description:
Low water crossing is a ford at or near stream bed elevation allowing stream flow over the road. Low water crossings are reinforced with stone aggregate or concrete to hold the channel grade.

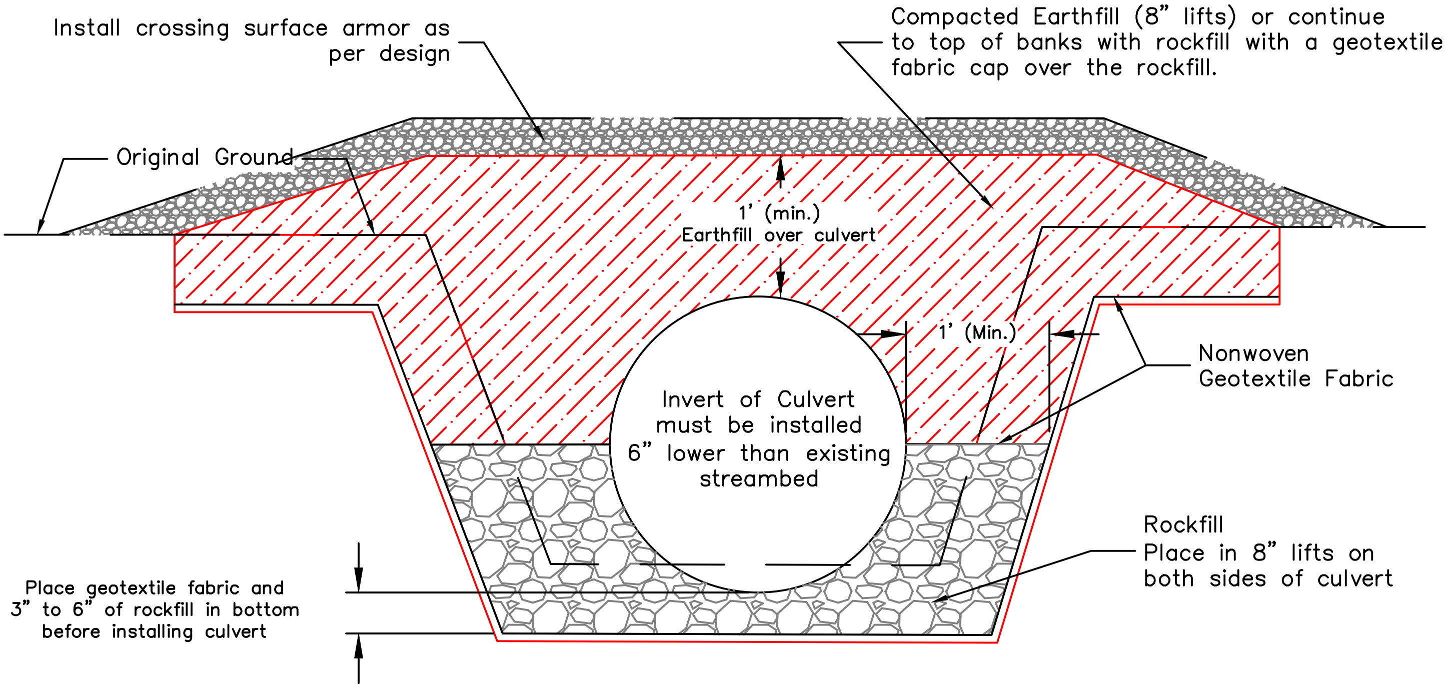
Limitations:
- High stream depth and flow velocity limit the use of low water crossings.
- Low Traffic Use only.
- Not appropriate for unconfined channels where cutoff channels are prevalent.
- Not for highly erodible channel materials.

Construction:
1. Contact the Army Corp of Engineers and Virginia Department of Environmental Quality for stream permits when installing a new crossing.
2. Perform the work in the dry whenever possible and divert the stream base flow with a diversion or pump around.
3. Excavate soft erodible materials from stream bed and approach. Excavate down to non-erodible materials or bedrock.
4. Provide a 3 to 5 percent outslope to the crossing to reduce debris accumulation. Shape of the low water crossing will be similar to a dip.
5. Key in large boulders at downstream edge of the crossing so that no more than 4 to 6 inches of each boulder is visible.
6. Backfill the crossing with non-erodible material. Use large rocks to build up to the desired road crossing elevation. Use smaller aggregate to fill voids and create a cohesive matrix.
7. Grade the approach to 6:1 (~15%) or flatter.
8. Create dips or grade breaks above approaches to reduce hydrologic connectivity. See Clearwater Crossing.
9. Install flood warning sign and flood stage in public view for incoming traffic.

Maintenance:
- Maintain flood warning sign and flood stage meter.
- Remove debris that collects in the crossing.
- Periodically maintain and replace smaller aggregate.
- Inspect downstream edge of the crossing and repair scour areas.

Resources:
- Kellar, G & Sherar, J. Low-Volume Roads Engineering: Best Management Practices Field Guide. July 2003. USDA Forest Service. Chapter 9 Fords and Low-water Crossings.
- Low-Water Crossing: Geomorphic, Biological, and Engineering Design Consideration. October 2006. USDA Forest Service. 0625 1808 SDTDC.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Grael Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC.Chapter 6 Imprvoed Fords and Low-Water Crossings.

2.11 CULVERT CROSSINGS



Description:
Stream Crossings have the greatest impact on water quality and aquatic habitat. Culvert crossings are used to pipe stream flow under the road. The pipe may be corrugated metal (CMP), high density plastic (HDPE) or reinforced concrete (RCP).

Limitations:
- Bedrock may affect culvert placement.
- Stream depth and flow may require more then one culvert or an alternative stream crossing such as a bridge or bottomless–arch culvert.

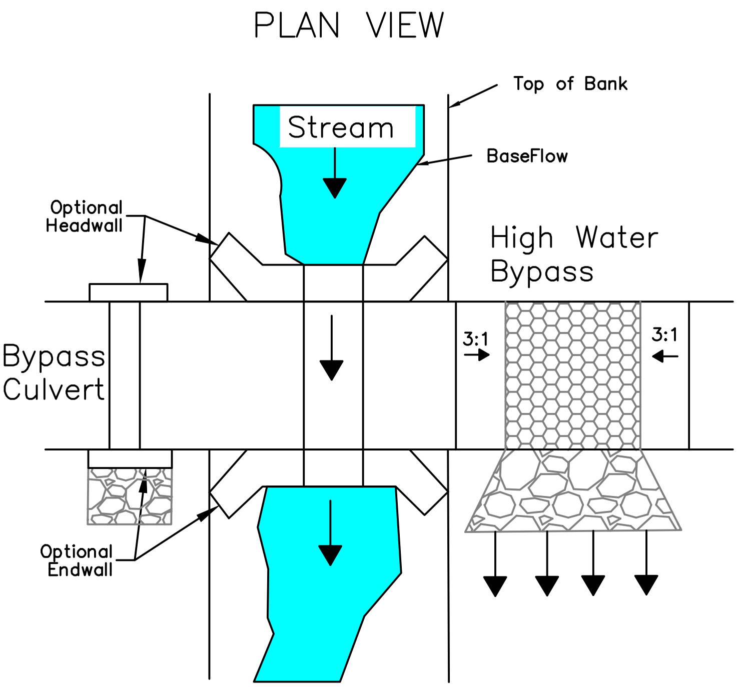
Construction:
1. Contact the Army Corp of Engineers and Virginia Department of Environmental Quality for stream permits when installing crossing.
2. Do not use culverts where large flows of sediments or large woody debris are expected or where the stream gradient is greater than 6 percent.
3. Stream crossing should be placed in an area where the stream bed is stable or where it can be stabilized. Preferably a riffle.
4. Place stream crossing perpendicular to the stream flow and not a bend in the stream channel.
5. Stream crossing must accommodate out–of–bank flows by safely bypassing without damaging the structure or eroding the stream bank or fill material.
6. Width of the stream crossing shall be at least 12 feet, but not more than 30 feet as measured from the upstream end to downstream end of the crossing, not including the side slopes.
7. The approach must be stable and no steeper than 6:1 (~15%).
8. Excavate soft material and backfill with suitable rock aggregate for a firm base.
9. The invert of at least one culvert must be installed at least 6 inches below the existing streambed to maintain stream baseflow and provide fish passage.
10. Place a minimum of one foot of backfill over the culvert. Make barrel length adequate to extend full width, including side slopes, plus one foot on each side.
11. Downstream side slope of fill shall be protected from erosion. In some cases this may require riprap armoring of the downstream side slope around the culvert outlet or an endwall.
12. Earthen fill side slopes shall be no steeper than 2:1. Rock fill side slopes shall be no steeper than 1.5:1.
13. Headwalls and endwalls should be provided for all culverts with diameter of 48 inches or larger or when more than one culvert is installed. Flared wingwalls should be used when the side slopes are steep and unstable.

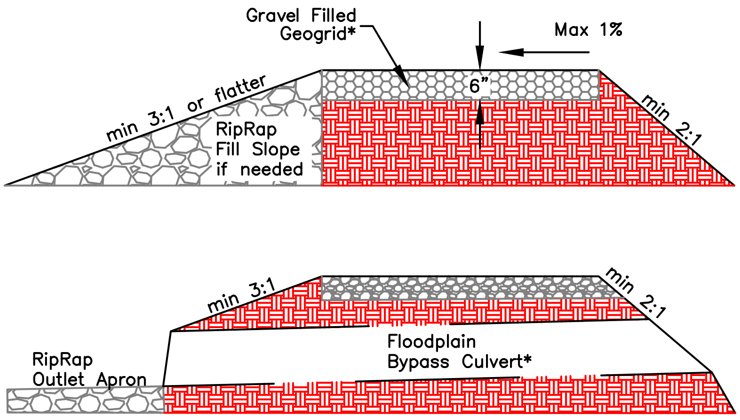
Maintenance:
- Remove debris and sediments clogging the culvert.
- Inspect for scour below the culvert outlet and at the upstream side slopes and stream banks.
- Inspect for sedimentation of the culvert inlet.
- For metal pipes ensure the pipe maintains an adequate coating of anti–corrosion sealant.
- Inspect pipes for damage and corrosion.

Resources:

- Environmentally Sensitive Road Maintenance Practices for Dirt and Grael Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 6 Improved Stream Crossings.
- Va. Conservation Practice Standard CODE 578: Stream Crossing 578. Natural Resource Conservation Service (NRCS). April 2012.
- A Landowner's Guide to Building Forest Access Roads. July 1998. USDA Forest Service. NA–TP–06–98. Stream Crossing Methods. Sizing Table 8&9.
- VDOT Road and Bridge Standards: Volume 1; section 100 Drainage. Endwall Treatments pg. 101.01 to 102.04. 2016 or latest edition. http://www.virginiadot.org/business/locdes/2016_road_and_bridge_standards.asp

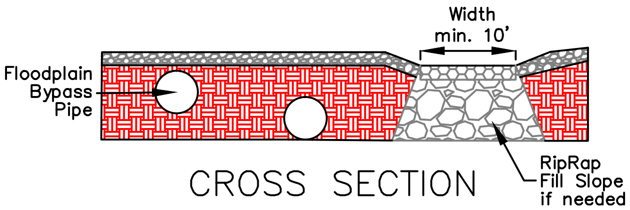
2.12 HIGH WATER BYPASS





PROFILE

*Geogrid may be replaced with concrete if flows are excessive.
Bypass Culvert is an option for elevated approaches.



Description:
High Water Bypass are intentionally designed flat, low–lying section of reinforced road bed that serves as an emergency spillway to allow high water to flow over the road with minimal damage to the road and stream crossing. High Water Bypass can also be provided within elevated bypass culvert set at the floodplain elevation. High Water Bypass can be provided by a stone–filled geogrid, concrete weir or culvert bypass pipe.

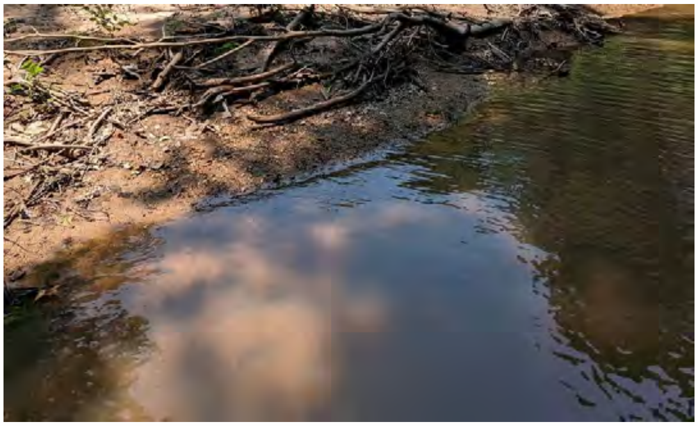
Limitations:
- Use for high flows not regular flows
- Used for low volume roads where periodic flooding of road will not impact emergency services.
- Bypass Culvert provides limited capacity compared to an overland bypass.

Construction:
1. High Water Bypass is to be the lowest point of a stream crossing approach, set at an elevation that connects to the floodplain.
2. All surface flows from road approaches should be diverted away from bypass area using dips, diversions or turnouts. See Clearwater Crossing practice.
3. Width should be at least $\frac{1}{3}$ width of floodplain or a minimum of 10 feet.
4. Excavate to a depth suitable for placement of a geotextile and geogrid. Backfill with 6 inches of 1"–3" stone and top dress with road aggregate.
5. Ensure that the bypass is level along width and the approaches are sloped at 3:1 or flatter.
6. Armor the downstream fill slope with rip rap if needed.
7. Headwalls and Endwalls on the stream culvert and bypass culvert should be considered when the high flows produce headwater elevation greater than 1.5 times the culvert diameter. Headwalls and Endwalls can be concrete, gabion baskets, or natural stones stacked. See Stream Crossing and resources for more details.
8. Install flood warning sign and flood stage in public view for incoming traffic.

Maintenance:
- Maintain flood warning sign and flood stage meter.
- Inspect High Water Bypass for erosion and vegetation blocking flow paths.
- Inpsect Geogrid for buoyancy uplift, scour or loss of material.
- Inspect bypass pipe for clogging, scour or uplift.
- Replace stone backfill as needed.

Resources:
- Penn State Center for Dirt and Gravel Road Studies, High Water Bypass TB. 2006.
- Penn State Center for Dirt and Gravel Road Studies, Headwalls & Endwalls TB. 2004.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 6 High Water Bypass.
- Environmentally Sensitive Road Maintenance Practices for Dirt and Gravel Roads. April 2012. USDA Forest Service. 1177 1802 SDTDC. Chapter 5 Headwalls and Endwalls.

Alliance
TECHNICAL GROUP



SOUTHWEST ARKANSAS PLANNING & DEVELOPMENT DISTRICT

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

ARKANSAS DEPARTMENT OF AGRICULTURE