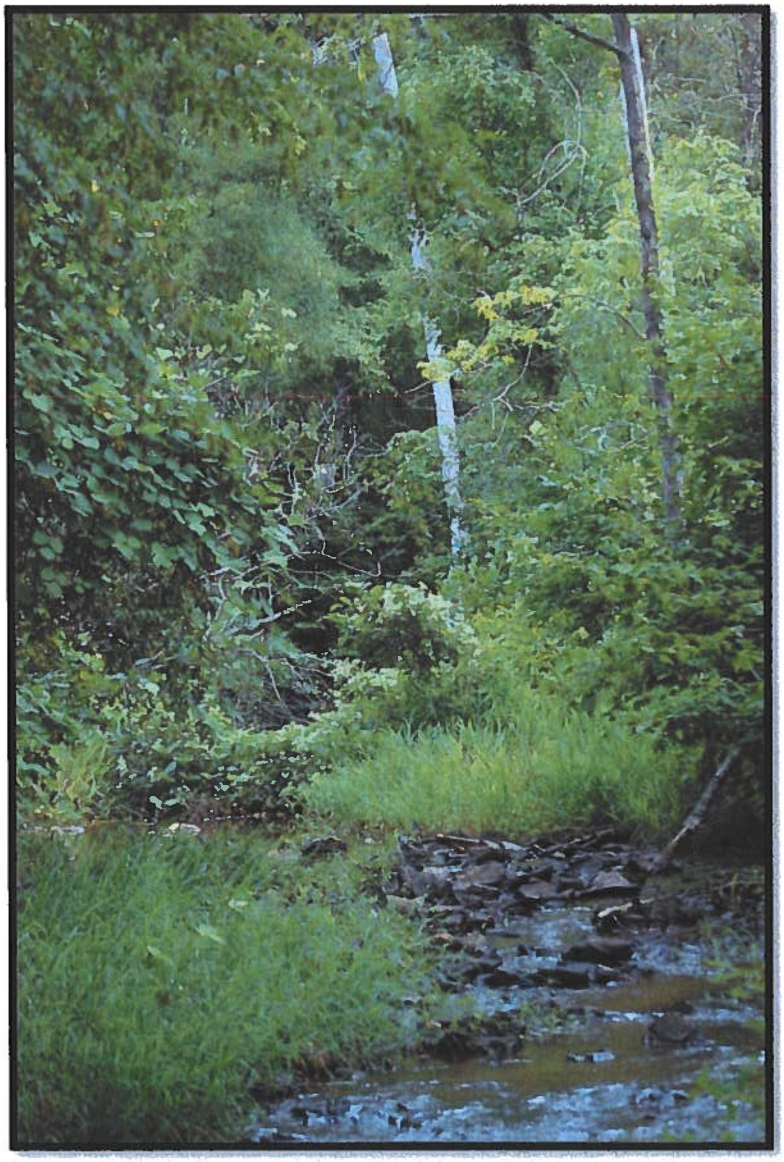
North Augusta
South Carolina's Riverfront

STORMWATER MANAGEMENT

NORTH AUGUSTA
WATER QUALITY & STREAM ASSESSMENT 2007 to 2020



April 2021

This report was prepared by
Tanya Strickland, Stormwater Superintendent
Michaela Canady, Editor
City of North Augusta, Stormwater Management Department

Questions or comments:
803-441-4246
Or email: stormwater@northaugusta.net

Waterqualityreport2020 FINAL Version 1.1

Table of Contents

List Tables & Figures

This page intentionally blank.

Acknowledgements:

This work could not have been accomplished without the assistance of many individuals and teams.

City Stormwater Team: Tom Zeaser, P.E., Michaela Canady, Thomas Meteraud, Brian Maleck, P.E., Lamar Harvey, Bill Fokes, David Caddell & his staff in Streets & Drains. In conjunction with all Public Utilities and additional Public Services staff that are involved in this program in many aspects within their own programs and continue to be critical to the success of this effort. Thanks to each and every one that works to improve our public systems and ultimately water quality of streams.

The following interns were key to the program goals and achievements, the list includes their last known positions:

Stormwater Interns:	What are they doing now?
Erin Jones, USCA	SCDHEC Water Quality Program
Daniel Atkins, USC	Mortgage Banker
Heather Mentrup, USCA	Graduate school
Daniel Harmon, USCA	Unknown
Alex Baker, College of Charleston	Manager, Half Moon Outfitters
Michael Nakama, Augusta University	Biology Instructor, Augusta University
Christina Tran Mayers, Augusta University	High School Science Teacher, Evans, GA
Tripp Swicord, USC	Engineer, Charlotte, NC
Matt Murphy, Citadel	Police Officer, Aiken
Devay Dandy, Augusta University	Stormwater Environmental Educator, Mt. Pleasant, SC
April Miles, USCA	Water Quality Technician, Orangeburg DPU
Clark Mullins, Lander University	High School Teacher, Gilbert, SC
Patrick Bagwell, Georgia Southern	Water Contractor, Austin, TX
Paul Jackson, USC	Unknown

And two stormwater staff members including our current Environmental Technician:

Sarah Montero, (former)SW Environmental Technician	Stormwater Manager, Joint Base Lewis-McChord AF, Washington
Michaela D. Canady, (Present) SW Environmental Technician	City of North Augusta

Thank you!

This page intentionally blank.

Water Quality & Stream Monitoring Program Report 2021

1.0 Overview with background

In 2003, North Augusta was designated by the state as a city required to acquire a small municipal separate storm sewer system (sMS4) permit as part of the federally mandated Phase II program of the Clean Water Act. In response to and in anticipation of these requirements, a stormwater utility program was created through city ordinance. The goal of the stormwater management department (SWMD) is to meet the requirements of small MS4 permit, thereby reducing pollutants entering streams and the Savannah River. The requirements include implementation of an illicit discharge detection and elimination program (IDDE). As part of that, the city created a stream monitoring program.

The permit also requires that the city identify the watershed through system wide mapping of storm water infrastructure with pipe outfalls to streams. With that information, we work to eliminate found impacts to the storm system and implement programs that will continue to improve and minimize impacts from non-point source pollution. Ultimately, the city storm system and its local streams empty to the city's drinking water source, Savannah River.

As a tool to determine if the programs are effective at reducing pollution, a baseline assessment of water quality within streams was conducted from 2005 to 2007 (a copy of that report is available on the city website). The initial assessment studied nine sub-basins that led to a ranking using physical properties and water quality information. Since then, we have continued monitoring the basins in North Augusta.

Also in the interim time, a complete MS4 program was implemented in the city that tackles the problem of nonpoint source pollution through six (6) state required best management practices (BMPs). They are:

1) Public education and outreach (all age groups),
2) Public participation with programs,
3) New and redevelopment construction permitting and inspection,
4) Illicit discharge to city storm systems and streams identification, detection and elimination,
5) Post construction inspection and maintenance of infrastructure and
6) Municipal operations at facilities and employee training

Through these BMPs, the SWMD continues to educate the public and involve them in our activities. We have a dedicated team to oversee maintenance of our storm drainage system and we strive to protect the system and streams from impacts from community

2.0 Understanding the Watershed

2.1 Drainage Basins & Sub-Basins - Why they matter.

All of North Augusta's drainage basins are part of the larger drainage basin, the Savannah River Basin that ultimately flows to the Savannah River. It is a major basin that is identified and numbered through nationwide assessments by federal and state government agencies. We are located specifically in the Middle Savannah part of the basin. Drainage areas within the city are actually sub-basins to the larger system. They do have numeric identifiers assigned to them, but for this report, we will just use the *city named* sub-basins. Throughout this report we will refer to the city sub-basins simply as "basins" for clarity.

The city drainage areas are divided into these basins using hydrology, topography, and flow information through GIS mapping tools (see Figure 2.1). Each basin contains various types of streams within them to move water through the system to the Savannah River. Some streams are flowing continuously, others are flowing intermittently based on water tables and rainfall and some are flowing only during rainfall. Each are important and have a role to play when it comes to pollution sources and potential transport to the river and they are considered for protection in each development plan submitted.

Many of our city drainage basins are located within the "source water protection area" (SWPA), or waters that drain to the river above the city drinking water intakes (see Figure 2.4). SWPA's are land areas that contribute water to the drinking water supply and where pollution from human activities or natural sources poses the greatest threat to source water quality. Buffers to these areas are important aspects of protecting our drinking water. In many instances, those buffers are already developed since the buffer ordinance was implemented in 2010, so education and outreach to those areas of the city are important tools we use to protect them from pollution.

Maps: A revised map of the North Augusta drainage basins was developed in 2014 and is provided as Figure 2.1. It shows the basins and the larger stream channels. Figure 2.2 is a map of the basins with the Priority Rankings shown. Figure 2.3 shows the sampling locations within the basins (some have been omitted for clarity). All basin sampling locations are provided in Appendix C.

The source water protection area map (Figure 2.2) shows the state recommended 100-foot protective buffer area to prevent impacts to these source waters. With this map, you can clearly see how important each tributary can be to the larger watershed. Impacts to streams in these areas could directly affect every resident on the city drinking water system, through higher treatment costs and potential health risks from contaminants. It is important to the community as a whole that the city considers actions within the watershed source water protection areas. We should all pay attention to our streams and creeks and what goes into them.

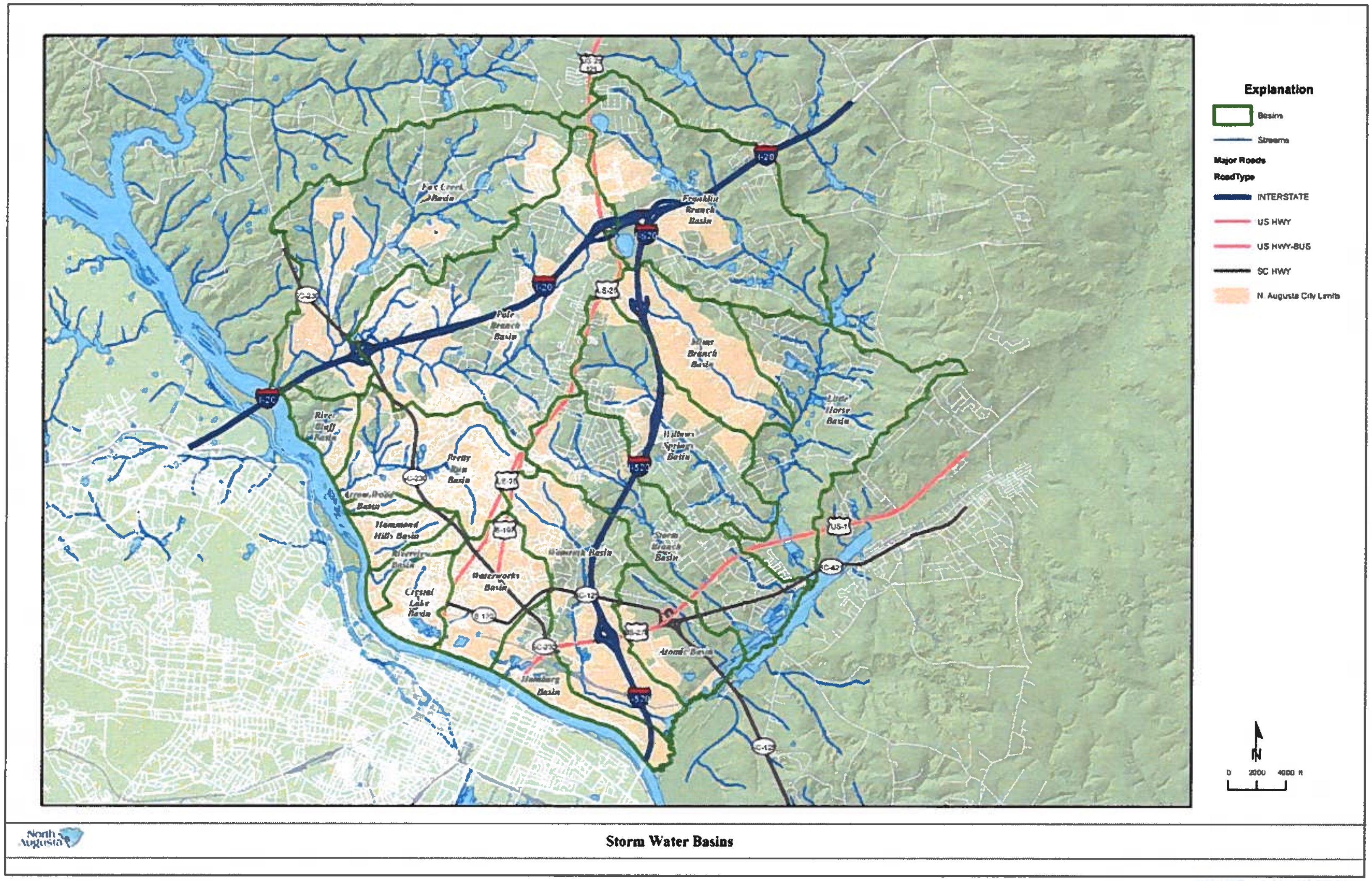


Figure 2.1: North Augusta Watershed Basins Map

This page intentionally blank.

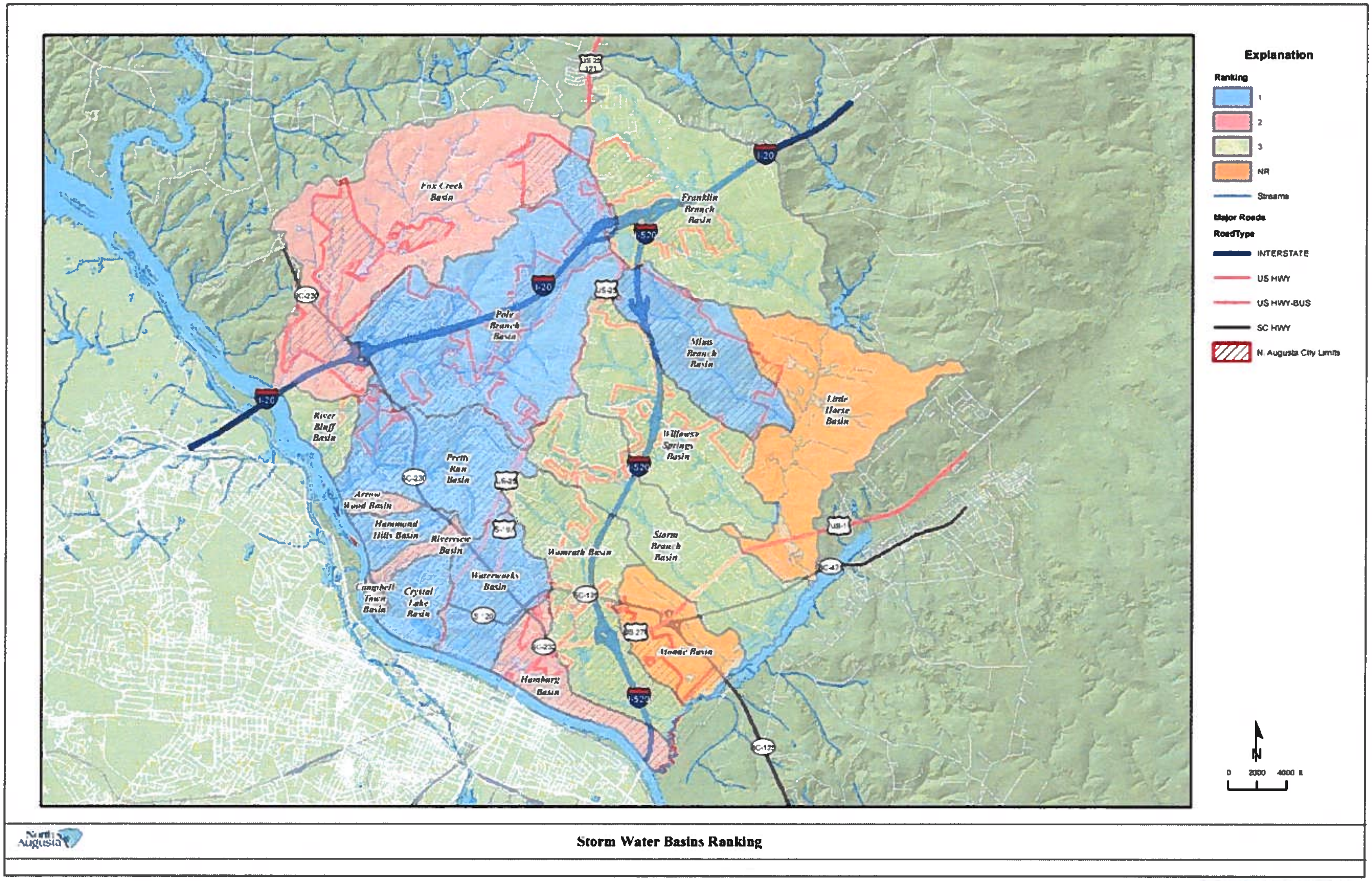


Figure 2.2: North Augusta Basin - Priority Map

This page intentionally blank.

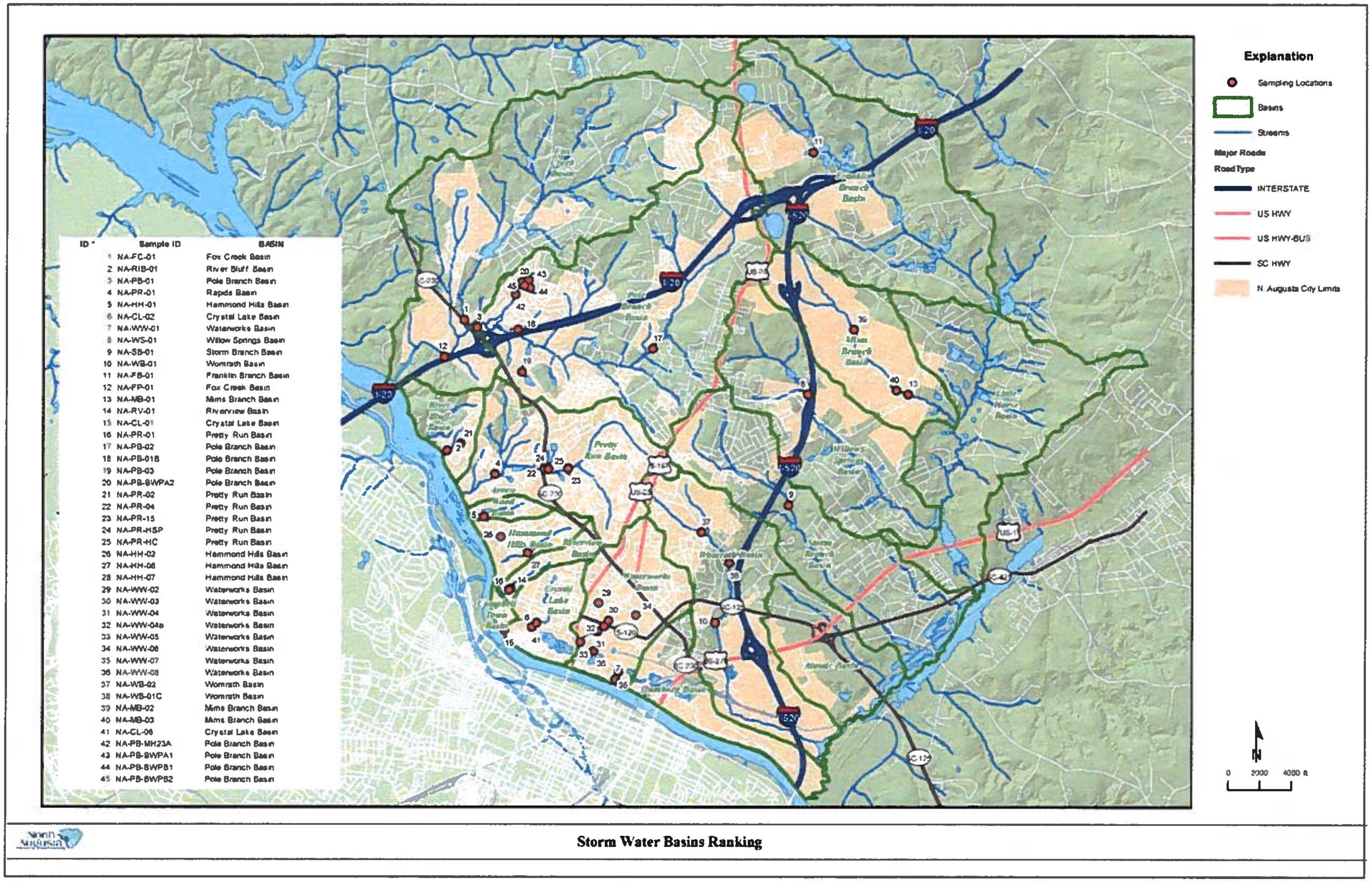


Figure 2.3: North Augusta Stream Sampling Locations Map (some not shown, see Appendix C for complete list).

This page intentionally blank.

North Augusta Source Water Protection Areas (SCDHEC Watershed Atlas)

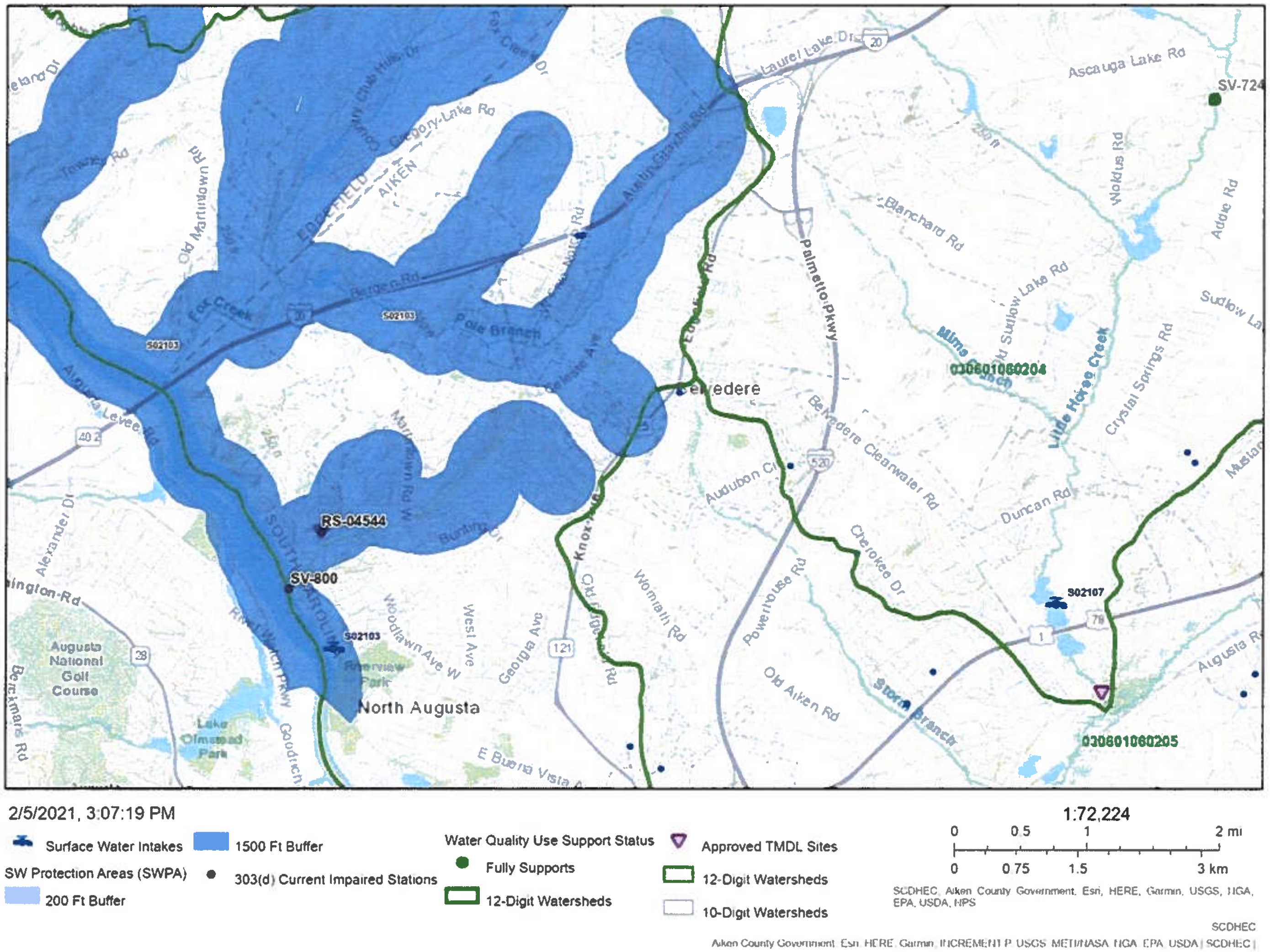


Figure 2.4: City of North Augusta Source Water Protection Area Map (source: SCDHEC GIS MAP)

This page intentionally blank.

2.2 Prioritizing basins, assessment, inspection & maintenance.

As part of the requirements and commitments of the small MS4 permit, basins within the city were prioritized. An ongoing schedule was developed to visit, inspect, clean and/or repair all storm sewer infrastructure by priority within the basin. The priority map (Figure 2.2) was created based on development density, human activity, and/or water or stream integrity impairments already known. Sub-basins are ranked Priority 1, Priority 2 or Priority 3. Priorities diminish as population or activity within the basin decreases.

A **Priority 1** basin is deemed to be a critical basin that is highly developed with a lot of impervious surface and human activity. It is assumed that this type of basin activity has a higher likelihood of impacting waterways. Some "Priority 1" sub-basins were determined by using existing water quality information according to SCDHEC's 303d list or if a TMDL is in effect. Priority 2 & 3 basins are less impacted due to less density of residential and commercial facilities, more open space and less human impact. Infrastructure is still monitored, inspected, cleaned or repaired but less frequently than higher priority basins.

The Streets & Drains and Stormwater Management Department Staff are using the priority map to assign work tasks within the city. All Priority 1 basin infrastructures are inspected, repaired or cleaned annually. **Priority 2 & 3** basins will all be inspected & maintained in the same manner during the first round of assessments to verify 100% of the system is mapped accurately, and or in need of repair. After that, these basins will undergo the same process but on a rotational basis, Priority 2 biannually and Priority 3 basins as needed, or if a citizen reports issues.

If a complaint is received by the community regardless of the priority or its location, the infrastructure is inspected for issues and maintained immediately if required. Citizen complaints alert us to many problems and we always welcome phone calls. The public play an important role in our ability to identify and solve issues in the watershed.

All developed basins are being assessed and monitored for illicit discharges through stream sampling and infrastructure integrity assessments. Stream physical integrity "assessments" have been updated along several stream segments throughout the city but not comprehensively to date. Basins with little or no flow and basins that are less impacted by residential, commercial, or industrial uses within the city are not being monitored for water quality on a routine basis.

2.3 Continued Mapping & Maintaining SW Infrastructure

In addition to the assessment protocols and subdivision of the basins in North Augusta, a basin-wide survey of stormwater infrastructure was initiated in 2004 and continues to today. The full survey of the system from 2004-2010 resulted in a map of all stormwater infrastructure. The map is part of the GIS program and is available on our city website under "advanced" map. An inspection maintenance program is ongoing and is now fully implemented. As storm boxes are encountered, they are cleaned of debris (removing pollutants from the system). The amount of pollutants removed from stormwater infrastructure and city streets (street sweeping program) is logged and reported annually to SCDHEC.

In 2020, staff were equipped with tablets and the stormwater team and the city GIS department developed a method to electronically update information from infrastructure inspections. Staff can add or correct misinformation within the map using the tablets within the existing GIS stormwater map. This is providing a full review of the original mapping and will improve accuracy of the map. Staff also log observed condition of the system and the type maintenance required. If a box needs cleaning, it is taken care of within that week. Work orders are generated and prioritized for the crew based on the inspections.

There are currently 4,057 storm boxes documented within the city system along with associated conveyances and piping. To date, we are confident that 99% of the mapping is complete and we are in a maintenance and correction mode with field data collection by staff. New construction of stormwater infrastructure is added electronically through the engineering department. Beginning in 2020 and running through 2022, the entire storm system is scheduled for inspection (~20% inspected annually is required by our permit). The inspectors are following the priority maps.

2.4 Water quality sampling

Water quality within the streams is important to understand so we can determine human impacts to them. We conduct stream monitoring to determine if they are polluted and if so, where we can look to correct the situation. We pull samples within each basin at the lowest point as a routine point (see Figure 2.3). We also have incorporated locations for sampling higher up within the basins if needed. Water samples are pulled either as grab samples (just like it sounds, grabbed for instant assessments of water quality at that moment) or during rain events as composite samples (pulled over-time and mixed) to see the concentration of pollutant as they may wash into the system over a day.

There are three to four distinct areas of sampling analysis we consider. One is to assess field conditions such as pH, dissolved oxygen, temperature, odor, and color. Another area is bacteria and nutrient concentrations in the water, *Fecal coliform*s or *E. coli* and also the contaminants that may be present if sewer overflow is occurring like ammonia, nitrogen, phosphorus, and a measure of them called total Kjeldahl nitrogen (TKN). By definition, TKN, a component of total nitrogen, is the sum of organic nitrogen and ammonia. This information will help determine what the overall picture is. High bacteria could indicate animal wastes in some instances. So, testing to see if there are also high nutrient levels along with the high bacteria level, would tell us more than just one or the other. For instance, when both are high, we should consider illicit discharge. We then look at more physical aspects of the system including walking the line, observing conditions, or if necessary, smoke testing, dye testing or televising to determine if sewer lines or septic tanks may be leaking into storm drains or nearby ditches leading to streams.

We also consider concentration of metals in the water to determine if pollutants are entering the storm system from either industrial or commercial locations where a lot of equipment, heavy traffic or parking areas could impact the system. Periodically, we run other tests to determine if other things may be going on in the watershed. Such as pesticides and herbicides during summertime when yards and gardens are being maintained with them. We also look at optical brighteners (found in detergents). This will tell us if residential wash waters are entering streams. Testing chlorine levels and using other detergent tests to analyze the water for the presence of residential water or commercial impacts to our system.

If you want more specific information about these tests, information is provided at the end of this report as Appendix A. Appendix C is where you will find a comprehensive list of sample locations within the city.

Reading the result tables in this report: the results data are compared to known average concentrations in streams, state standards, federal standards, or regulatory guidelines. Since many pollutants don't have a standard, we have to look at other information. For those samples, we look at the 2004 National Ambient Stormwater Quality Database 1.1 (NASQD) by Robert Pitt and his team. They have compiled thousands of sampling data across the country from stormwater departments to analyze what you can expect to see (normal range) during a stormwater event in streams. They have provided a valuable real-life example based on the type of land use involved (residential, industrial, commercial, highways, or mixed uses). With these sources of information, we can determine if the results we get are indicating a problem or not. As for the data tables in this report, any sample result for a pollutant that is higher than any standard is highlighted yellow in the data tables provided. Since there are several that have no standard, we look at the NASQD and if the sample is higher than the range that they give, then it is highlighted yellow. All non-highlighted sample results are in the normal range for streams.

2.5 Sub-basins not Presented in this Report

Several basins have not been fully assessed for reasons described earlier in the report. Basins with least impacts from the city and that are omitted are listed below with a brief overview explaining why they were excluded.

- **Horse Creek Basin** is monitored by SCDHEC year-round so ample data is being compiled. The reach of Horse Creek within the city limits is minimal and no impacts from the city stormwater system exist. Stormwater enters from Aiken County and then is filtered through a vast wetland prior to reaching the stream.
- **Arrow Wood Basin** is a small basin (138 acres) located in the Pretty Run Drive & River Oak Drive area of the city located near Hammond Hills S/D. A very small number of homes drain to this basin into a pond located near the Hammond Hills swimming pool. Once water leaves the pond (where water quality treatment is provided), the water travels down to the Savannah River directly beyond River Oak Drive. We have eliminated it from our monitoring plan unless required due to the water quality provided by the pond.
- **Franklin Branch Basin** is located along the edge of the city limits near I-20 at Highway 25. Within the city limits, residential and commercial development has occurred over the past 10 years. All of these projects were designed with water quality treatment components for the

stormwater systems. Random sampling will take place if problems are encountered or reported. The bulk of this basin is outside the city's MS4 permit area (city limits).

- **Willow Springs Basin** has little to no impact from the city of North Augusta. The stream channel bypasses all stormwater systems in the city portions of its reach.
- **Storm Branch Basin** is dry within the City limits of North Augusta. Storm Branch basin encompasses 870 acres. The location along Powerhouse Road where water from this basin would enter the stream system is checked routinely during sampling and has been dry during each event.
- **Hamburg Basin** also traverses the edge of the city limits. This basin has 915 acres within it, a vast majority of that is wetlands. Once the water enters the city, it encounters the wetland in the lower reach of the sub-basin that provide a water quality filter prior to impacts to Horse Creek sub-basin. This basin is in stable condition at this time.
- **Little Horse Creek Basin** is located outside of the city limits, drainage can occur to the basin through Mims Branch Basin and a small area in the Lakes and Streams S/D that has a small portion located within the city limits. The regional sewer line does run through this basin. Due to the very low number of city parcels within this basin, it is not studied at this time.
- **Atomic Basin** is located below the Storm Branch basin along Atomic Road and has minimal impact from property within the city limits. It is a sub-basin of the Horse Creek basin that is studied by Aiken County's MS4. It is not being studied by the city at this time.
- **Campbell Town Basin** is located near along the riverfront adjacent to the North Augusta Water Plant of Hammonds Ferry Road. This small basin is approximately 60 acres of drainage area. There are minimal impacts within this basin so it is not studied unless suspected illicit discharge is reported. The storm drainage for the soccer complex and the one street neighborhood, Campbell Towne Landing drain through the storm system and empty into the river from two different outfalls.
- **Riverbluff Basin** is located within the Savannah Barony Subdivision. Samples are taken at the bottom of the basin. This basin is 440 acres and is located in an area primarily with large lot residential homes. This basin is in stable condition.

3.0 Mims Branch Basin

3.1 Description

The Mims Branch basin drains a large undeveloped basin (1,595 acres) located off of Highway 25 from Ascauga Lake Road to Blanchard Road and is bordered by Old Sudlow Lake Road. It is the only basin in the city that is nearly completely undeveloped. It is a Priority 1 basin. The preliminary physical stream assessments at Mims Branch indicated that it is a healthy stream channel that effectively transports the current load of stormwater. Each segment assessed scored higher than other streams in the city. There have been little changes to that condition.

Construction of the final reach of Interstate-520 took place within the basin from 2008-2010 bringing the highway through Mims Branch basin as you can see in the photo above. The basin is depicted by the slightly shaded area. The resulting roadway now drains into several locations throughout the property. The basin is bordered by Willow Springs Basin.

The basin contains a perennial stream that is fed by groundwater percolation from an area located within the large tract of land. There is a suspected underground hydrologic connection to the large Carolina Bay known as Mathis Lake upstream of Mims Branch. Studies to confirm that connection have not been done. The basin is routinely sampled at the lowest point where it crosses Old Sudlow Lake Road as it leaves the city limits. In addition to this location, other sample locations higher up in the basin were assessed during the earlier basin study to get an overall indication of stream and habitat quality during the baseline study. Those locations have not been sampled for information in this report.

Due to the almost pristine condition of this basin water quality and stream integrity, it is considered a *"representative basin"* for comparison with other basins within the city. It is in a primarily undeveloped area and is not impacted by industrial, commercial or residential use. Based on results overall to date, **data collected from location (NAMB01) could be considered "a natural background condition"** for most types of samples we collect. The water quality of Mims Branch is a target or goal for other streams located in the city's watershed. A comprehensive discussion of the water quality in comparison to other basins can be found in the conclusions part of this report.

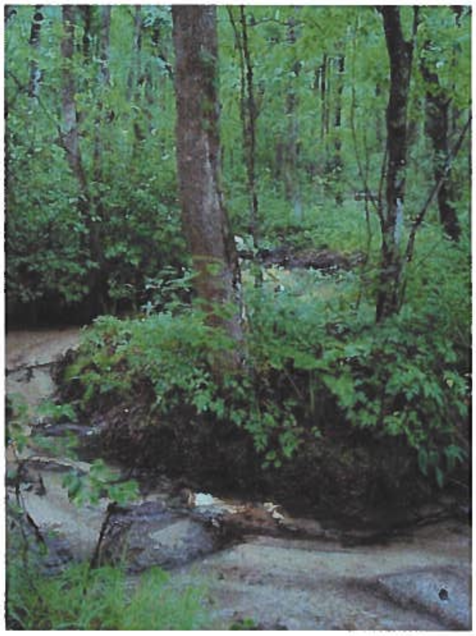
3.2 Mims Branch Sampling Results & Discussion: GOOD TO EXCELLENT

Continued water quality sampling results indicate that pollutant loads entering the stream channel are minimal. The water quality for this sub-basin remains excellent. The results are provided in Table 3.1 "Post Baseline Water Sample Results for Mims Branch". Since the baseline assessment, the Mims Branch sub-basin has been sampled on numerous occasions. The data generated suggests that the water quality at Mims Branch remains healthy. There was an exception for only one TKN sample collected in August 2011 (highlighted yellow). Even though it is higher than expected, it is in line with stormwater sampling by Pitt, et.al. All other samples analyzed were well below regulatory standards if they exist, or below the average for the state. If no standard exists, they were compared and found at or below averages for storm sampling within open space or residential areas by Pitt, et.al. Averaging all samples collected during this period also indicate that the basin water quality and pollutant concentrations are below standards or observed averages across the state during dry or wet weather (Figure 3.1, Mims Branch Dry Vs Wet Weather Sampling Averages Graph). Thus, the data indicates that basin water quality remains in excellent condition when compared to the baseline assessment.

3.3 Development in the basin - LOW

Mims Branch has undergone some development during the time period, changing the basin in some ways. Three projects were completed, they are the I-520 road construction, Mims Branch Sewer Line construction, and installation of a new North Augusta Water Tank. I-520 roadways and its interchanges total approximately 45.0 linear acres of impervious area that has been constructed in Mims Branch since the baseline assessment. During construction, BMPs to prevent impacts to the watershed were used and monitored closely. Permanent BMPs are managed by SCDOT (drainage pathways, storm drain outfalls, etc.). Since the project was completed, failures of individual drainage BMPs were observed and reported to SCDOT for repairs. None have ultimately impacted the stream channel due to the distance of travel. In addition, there have been two small projects within the basin resulting in less than an acre of disturbance and 0.4 acres of additional impervious area.

Future development in Mims Branch is in the early planning stages. The property was timbered in 2018 to remove undergrowth that could be a fire hazard in response to a 100-acre brush fire triggered by a blown tire on I-520 in late 2016. The owners left substantial buffer along the stream reach (from 300' in the upper reach and up to 800' in the lower reach). The city will work with developers to ensure that the stream and its integrity will be protected during and after development. The best available BMPs should be utilized on all projects that occur there to preserve the existing water quality in Mims Branch basin.



3.4 Stream channel integrity: - EXCELLENT

The stream running through the Mims Branch basin is mostly pristine. There are a few areas where four wheelers have impacted by crossing but it is minimal. The headwaters are located at the top of the basin and percolate up from the ground in several locations. Flow begins there and picks up throughout the upper reach as other seeps are located as it travels down gradient toward the middle of the basin.

The stream is braided and meandering with much vegetative cover along the banks and within the meanders. Sand and pebbles are evident as well. The tree canopy keeps the stream shaded for most of its reach and it widens until it becomes a wide shallow wetland stream. Where it crosses Old Sudlow Lake road, it is also wide with clear to tea colored water and has tremendous flow. It travels down and eventually connects with larger streams in Aiken County that are outside of the city limits.

This page intentionally blank.

Table 3.1. Post Baseline Water Sampling Results for Mims Branch 2007-2020 (highlighted results are above normal observed concentrations), *table continued on next page*

Parameter Tested	05/14/07 NAMB01	05/15/08 NAMB01	08/19/09 NAMB01	08/11/11 NAMB02	09/22/11 NAMB02	04/13/18 NAMB02	05/06/20 NAMB02	06/25/20 NAMB01 Wet	State Avg[1]	EPA or State STD or Guideline[2,3]
pH (su)	5.69	6.14	5.40	5.77	4.30	-	6.99	-	7-8	6.5-8.5 (su)
DO (mg/l)	9.08	9.65	8.40	9.10	8.44	-	8.3	-		Temp dependent
Temp (°C)	20.2	20.9	20.9	21.9	20.0	-	21.9	-		Weather dependent
Turbidity (ntu)	10	-	-	-		-		-	<16	mcl 50.0 ntu
Total Phos (mg/l)	0.021	n/d	n/d	0.012	0.018	0.014	n/d	n/d	<0.14	(lakes mcl 0.06 mg/l) (use Pitt storm data = 0.18-0.31 mg/l)
Hardness										n/a,(use Pitt, storm data 32-150 mg/l CaCo3)
COD (mg/l)										(n/a, use Pitt, storm data 34.0-100.0 mg/l)
TKN (mg/l)	0.61	0.034	n/d	1.50	0.32	0.47	n/d	1.1	<0.58	n/a use Pitt, storm data: 0.74 to 2.0 mg/l)
Ammonia (mg/l)	n/d	n/d	n/d	n/d	0.12	0.37	n/d	n/d	<0.2	CCC 0.99-4.0 mg/l, CMC 7.3-24 mg/l) Pitt, storm data 0.18-1.07 mg/l
Nitrite/Nitrate (mg/l)	0.76	0.47	0.69	0.81	0.50	0.7	0.56	0.19	<0.62	(n/a, use Pitt, storm data 0.28-0.73 mg/l)
Fecal coliform (col/100 ml)	183	-	-	-	-	-	-	-		(state now looks at E. coli) (Pitt, storm data 730-11,000 mpn/100ml)
E. coli (col/100 ml)	-	-	-	-	-	54*	-	-		(state now looks at E. coli*)(Pitt, storm data 700-1900 mpn/100ml)
Copper (mg/l)	0.15	-	n/d	n/d	n/d	-	-n/d		<0.01	CMC 0.0038 mg/l, CCC 0.0029 mg/l, HH 1.3 mg/l (H2O/Org) Pitt, storm data 0.006-0.024 mg/l
Iron (mg/l)	0.19	-	n/d	n/d	1.2	-	0.15	1.4	<1.17	Aquatic life criteria 1.0 mg/l
Manganese (mg/l)	n/d	-	n/d	n/d	0.041	-	n/d	0.032	<0.084	0.05-mg/L SMCL drinking water, none for streams

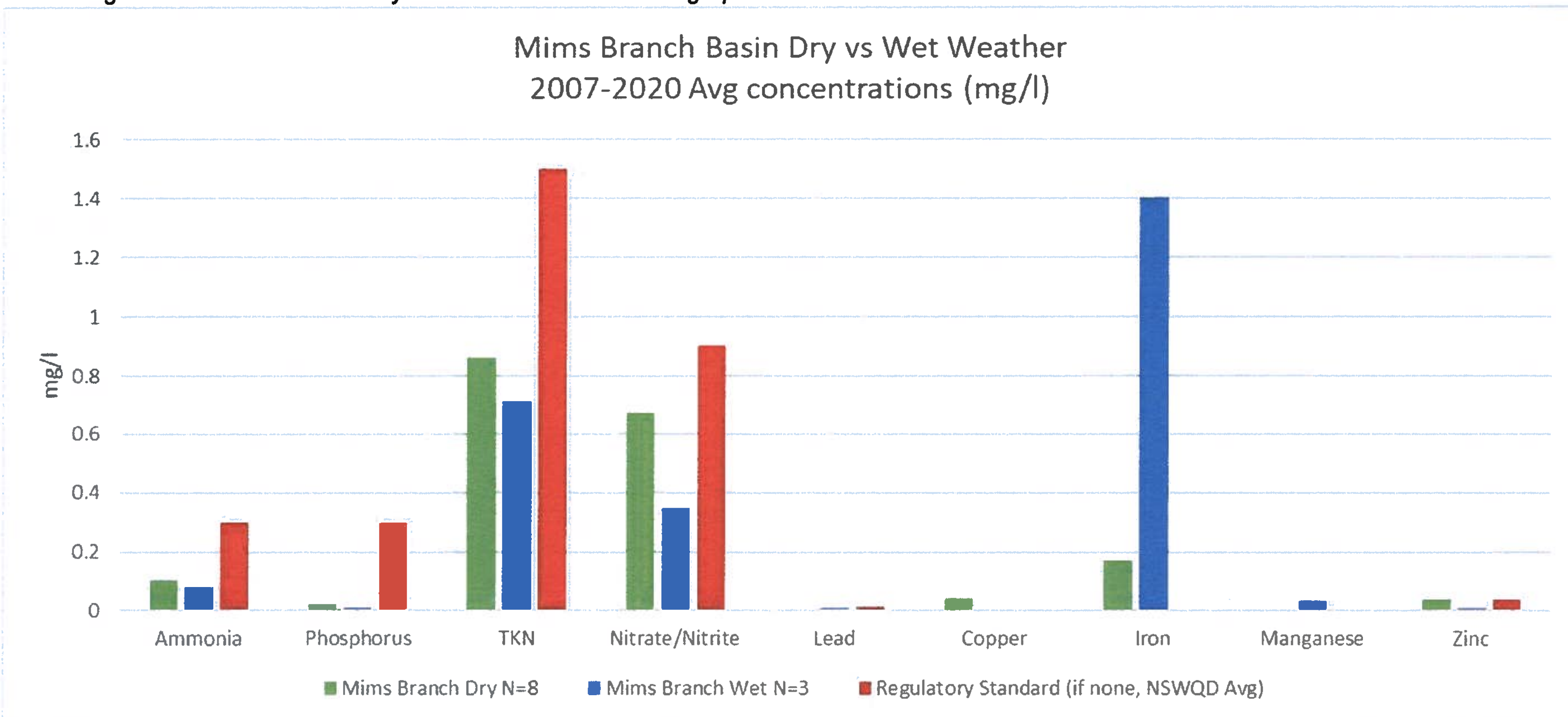
Parameter Tested	05/14/07 NAMB01	05/15/08 NAMB01	08/19/09 NAMB01	08/11/11 NAMB02	09/22/11 NAMB02	04/13/18 NAMB02	05/06/20 NAMB02	06/25/20 NAMB01 Wet	State Avg[1]	EPA or State STD or Guideline[2,3]
Lead (mg/l)	0.0046	-	n/d	n/d	n/d	-	n/d	n/d		0.014 mg/l (CMC Aq), 0.0005 mg/l CCC aq (0.0007 mg/l state), Pitt, storm data 0.001-0.031 mg/l stormwater
Zinc (mg/l)	0.12	-	n/d	n/d	n/d	-	n/d	n/d	<0.04	7.4 (HH) 0.037 (CMC & CCC Aq) Pitt storm data 0.01-0.13 mg/l

(1) State average is used from an unpublished draft document compiling all ambient stream monitoring sampling across South Carolina during a five-year period (1993-1997).

(2) Data retrieved from SC DHEC Water Classification & Standards Regulation 61-68 published June 26, 2020.

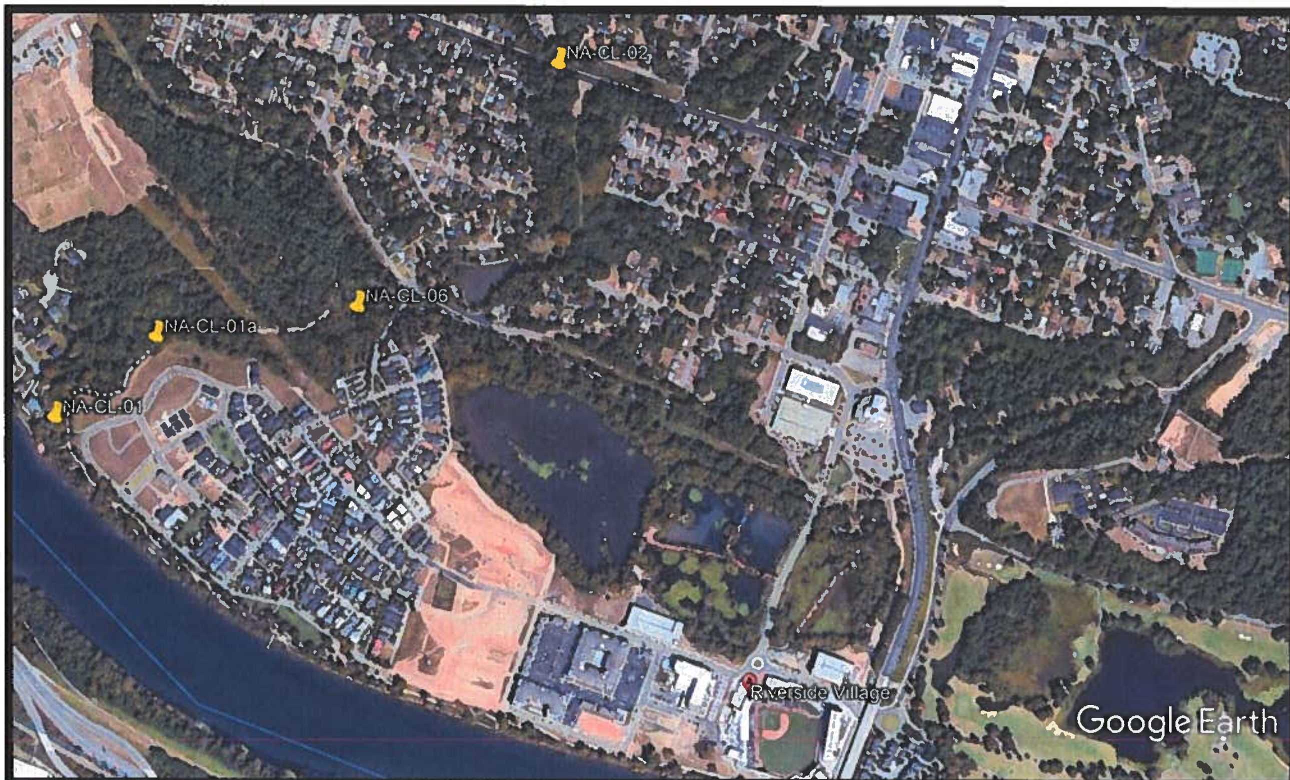
(3) Pitt, National Stormwater Quality Database 2004, wet weather sampling base on land use (range is Open Space, Residential, Commercial, Industrial and Freeway Mixed, etc): Notes: Aq = aquatic life, HH = human health, CMC Aq = Criteria Maximum Concentration for aquatic life, CCC Aq = Criterion Continuous Concentration for aquatic life, I = instantaneous result, Avg = average **(Highlighted=high result) and (- indicates tests were not conducted)**

Figure 3.1: Mims Branch Dry Vs Wet Weather Results graph



This page intentionally blank.

4.0 Crystal Lake Basin



4.1 Description

The Crystal Lake basin is a smaller basin (564 acres) within the older sections of North Augusta. This is a Priority 1 basin. The basin drainage areas are actually depicted on the original Boeckh Plat as undeveloped wooded areas for drainage. These features have not changed much since that publication. The city has purchased several of the tracts shown on the plat to maintain the original drainage features. The Crystal Lake basin's primary perennial stream is called Crystal Creek (unofficially). A second drainage way within the basin transports stormwater through the storm system as it flows down the Georgia & Bluff Avenues to Brick Pond Park.

Crystal Creek drains the largest part of the basin which encompasses the developed area. The entire basin is a high-density residential area where approximately 81% (475 acres) is fully developed with residential and light commercial uses. Of the 584-acre basin, only 19% (109 acres) remains undeveloped. That is primarily the wooded areas adjacent to the stream reaches (drainage features), parks, ponds or undeveloped buffer areas near Brick Pond Park. The commercial areas include the city's older downtown section and the newly developed Riverfront Village.

The basin encompasses parts of Jackson Avenue, Mokateen, Crystal Lake Drive, Forest and Lake Avenues, lower West Avenue from Sno-Cap and below, Bluff and Cumberland Avenues, parts of Georgia Avenue downtown and Crystal Lake Drive. The large drainage depression located near Woodlawn Avenue accepts stormwater pipes that discharge to it from the upper areas of the basin. The water flows down through the basin until it crosses Buena Vista Avenue at Crystal Lake Drive. Crystal Creek transports stormwater around the Crystal Lake Pond and then travels under Alta Vista

Avenue and through the lower basin until it reaches the Savannah River at the end of Savannah Point Drive. The stream you cross over at the North Augusta Greeneway Trail railcar bridge is Crystal Creek just before it empties into the river.

The downtown portion of the system is mostly storm pipes or ditches that ultimately empty into Brick Pond Park for stormwater treatment prior to discharging through the pond overflow to the Savannah River. The primary sample point NA-CL-01 is at the Savannah Point location. Samples are also collected higher up in the basin at NA-CL-06 and also at Brick Pond Park. Since the storm water treatment system at Brick Pond Park is a separate system, the results of its sampling are to be presented in the Brick Pond Park Water Quality Report.

The Crystal Creek stream channel is routinely inundated with stormwater flows that challenge its banks and erosion is evident in many sections along the route. This indicates that sediment loads are higher during storms and evidence of that is seen at the end of the creek as a "sediment island" where it enters Savannah River. Channel erosion is evident upstream above the Mokateen pond where a ravine has formed over the years. Sediment deposits and slope failures are also observed mid and lower reach of the basin after it crosses Buena Vista Avenue and below the North Augusta Greeneway. Middle and up-stream locations of the stream channel have historical trash and debris that has been lodged there over the years. Storm events move debris down the channel and most of it is captured on the upstream side of Buena Vista Avenue. Some sewer service lines cross the creek in several areas and have been found broken in the past. When this occurs, we immediately notify the owners to repair failures. Trash and sewage pollutants can tremendously impair the stream water quality when they are present. City utilities will eliminate the discharges as soon as they are observed.

4.2 Crystal Lake Sampling Results & Discussion: GOOD TO FAIR

In Crystal Lake basin, the residential areas and some of the commercial areas have been in existence for quite a long time and as for land use, residential is the highest in the upper part of the basin. The older neighborhoods and older commercial facilities located there do not have a stormwater treatment component to their storm systems. Since 2005, most new residential subdivisions or new commercial facilities are required to treat the 1st inch of rainfall prior to releasing it to the storm system, creeks or the river. The storm pipes dumping stormwater to the creeks within the upper part of the basin do not provide treatment.

The primary sampling point for this area of the basin is NA-CL-01. It is located at the creek at the end of Savannah Point Drive. A secondary point that with easier access is located upstream approximately 2000 feet at the entrance to Hammonds Ferry, NA-CL-06. Generally, the sample is taken at the second point but NA-CL-01 is still sampled when needed. Other points are located within the basin and are used primarily if we need to conduct investigations for a source of a pollutant or illicit discharge.

Data generated during the study period indicate that the water quality in the main Crystal Lake basin stream is generally good during dry weather (see Table 4.1). During rain events, pollutants are washed into the stream from residential areas and the streets. Elevated levels of nitrogen have been observed during the study period. None are high enough to indicate a point source. Most are still within the expected ranges routinely seen in stormwater within this type of land use. An average of the results during dry and wet weather sampling are shown in Figure 4.2. With the exception of Ammonia and Nitrate/nitrite concentrations, the routine water quality sample results comparison indicate that the averaged concentrations are within the state standards or within the ranges to be expected in stormwater sampling for this type of land use. During wet weather we see ammonia is elevated but not high enough to indicate a particular problem. And during dry weather nitrate/nitrite concentrations are elevated, we commonly see higher concentrations during dry weather. They are elevated, but not high enough to indicate a specific source. Based on the results to date, the data do not indicate a significant problem or a point source occurring.

4.3 Development in the basin: HIGH

Crystal Lake basin has been under quite a lot of development during the past 10 years. Overall 106 acres was disturbed during construction within the basin over the time period. Along with the proposed completion of Hammonds Ferry Subdivision and the Riverfront Village projects, and some redevelopment projects higher in the basin, a total of 35 acres of impervious surface will have been added. Hammonds Ferry Development continues to develop at an accelerated rate. The entire Hammonds Ferry Subdivision area has been permitted and the remaining construction of homes is ongoing. The Riverfront Village project is adding commercial and recreation areas along the Savannah River as well.

Newer projects require a water quality treatment features. This includes the Brick Pond Park stormwater treatment system for the upper reaches of the basin and also underground treatment units have been added along the riverfront to capture and treat stormwater runoff to reduce pollutant loads entering the Savannah River from the riverfront development. Brick Pond Park treats stormwater from for projects located above Railroad Avenue. As for the development below Railroad Avenue, individual underground treatment units are installed at the final point in the stormwater system before water is discharged to the river (see Figure 4.1 below). Each blue dot is an individual treatment unit at the end of the stormwater system. The underground units' capture and collect sediment, oils and trash that enters the storm drains during storms.

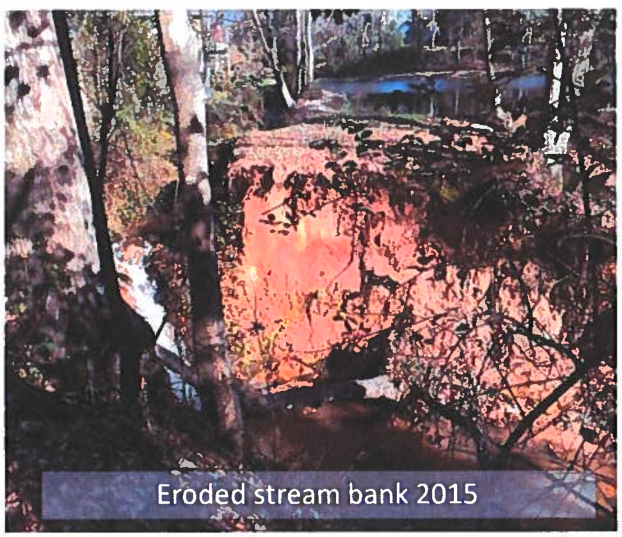
Figure: 4.1 North Augusta Riverfront development underground stormwater treatment unit locations.

4.4 Stream channel integrity in the basin – FAIR TO POOR

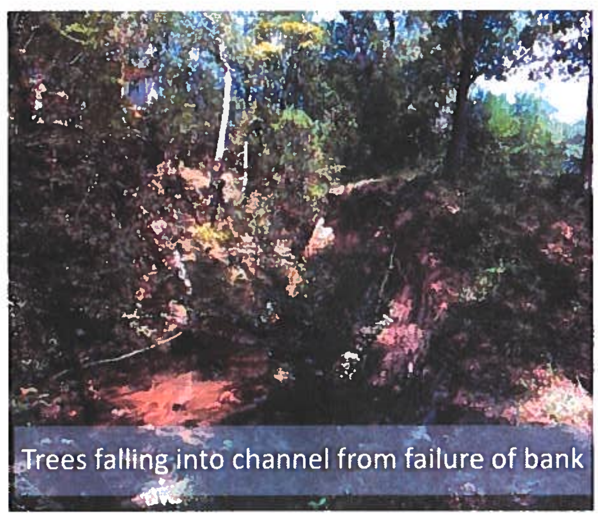
The top of the basin has a stream reach that has all been piped over the years. Water from the residential areas at the top of the basin above W. Woodlawn, drain into the system and is channeled through pipes the outfall into the Mokateen Pond drainage way (at W. Woodlawn by Lake Ave). The stream channel of the middle reach of Crystal Lake basin (from W. Woodlawn down to Buena Vista) are highly vegetated, meandering and braided creating wetland habitats on private property along the reach. These areas provide adequate habitat for aquatic insects and plants. We have witnessed that several sewer line taps cross the stream and have malfunctioned at times releasing sewage into the channel. Channel erosion is evident upstream above the Mokateen pond where a ravine has formed over the years. Sediment deposits and slope failures are also observed mid and lower reach of the basin after it crosses Buena Vista Avenue and below the North Augusta Greeneway.

Middle and up-stream locations of the stream channel have historical trash and debris that has been lodged there over the years. Additionally, there is trash and debris trapped in the channels in certain locations on city and private property. Stream reaches within appear to be holding up well in the middle of the basin.

Below this area, the integrity of the stream channel is mostly failing (from Buena Vista through to the Savannah River). Considerable rain events have made the problem worse over the past few years. Channel integrity is failing from the end of the reach next to Crystal Lake Pond and below. The pictures here show some of the issues at and below Alta Vista Avenue. The upper reaches appear meandering, wide and braided in some areas. With the exception of the ravine above the Mokateen/Jackson pond.



Eroded stream bank 2015



Trees falling into channel from failure of bank

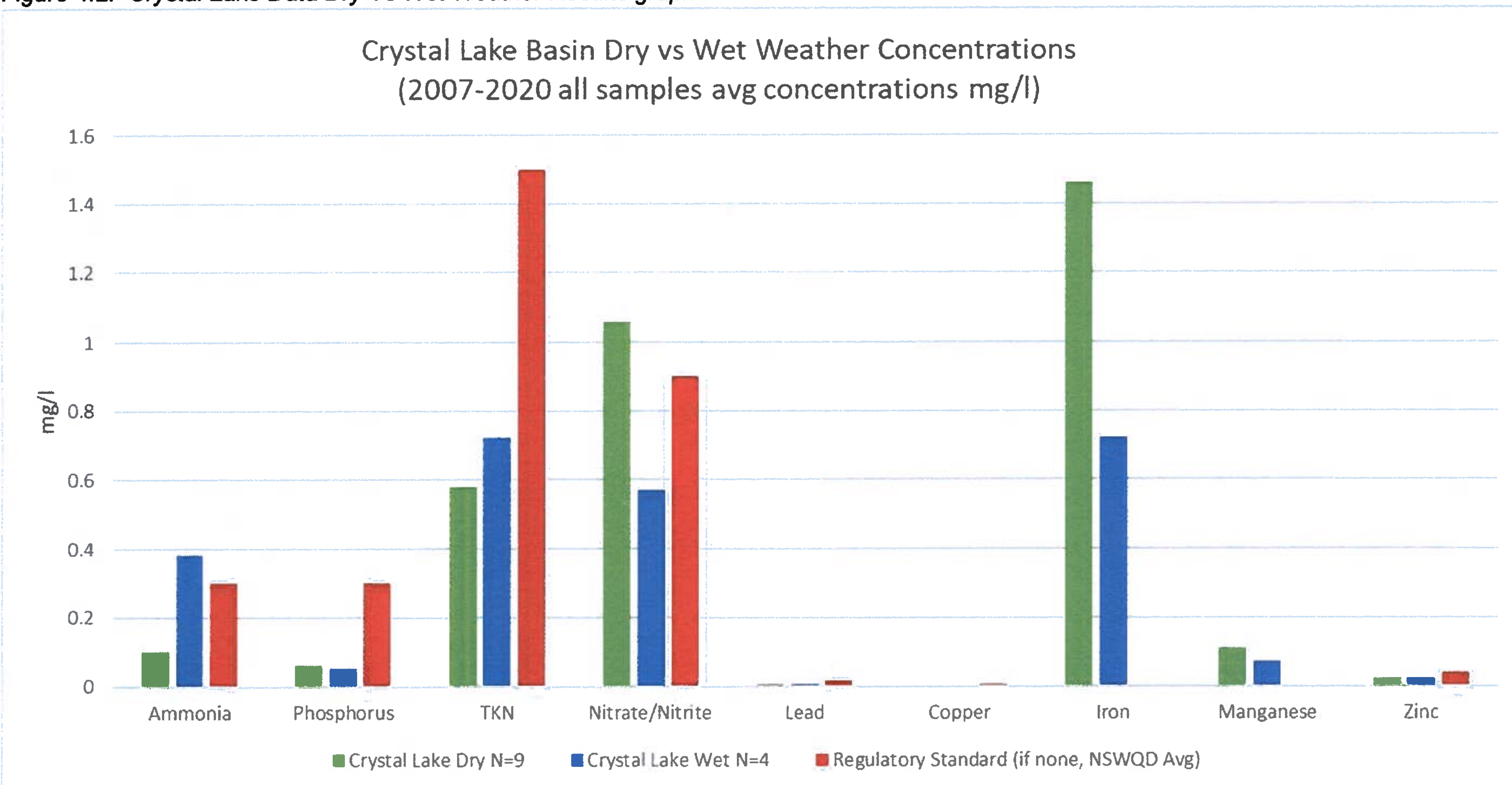
Table 4.1. 2007-2020 Water Quality Sampling Results for Crystal Lake Basin

Parameter Tested	Date 05/14/07	Date 09/13/07W	Date 05/15/08	Date 08/19/09	Date 08/10/11	Date 08/11/11	Date 09/22/11W	Date 05/09/12W	Date 12/18/12W	Date 04/03/18	Date 12/11/18	Date 05/03/20	State Avg1	EPA or State STD or Guideline2,3
pH (su)	6.7	7.1	6.82	6.79	7.07		6.64	7.15	7.43		7.23	6.69		6.5-8.5 (su)
DO (mg/l)	7.6	7.14	9.3	7.86	6.78		7.8	7.2	7.42		9.36	8.57		Temp dependent
Temp (oC)	21.5	25.3	19.6	25.4	27.1		23.2	24	15.2		12.2	19.3		Weather dependent
Turbidity (ntu)								11					<16	mcl 50.0 ntu
Total Phos (mg/l)	0.04	0.035	0.058	0.212	0.015		0.047	0.12	0.01		0.029	n/d	<0.14	(lakes mcl 0.06 mg/l) (use Pitt storm data = 0.18-0.31 mg/l)
Hardness					36			16	48					n/a
COD											10			(n/a, use Pitt, storm data 34-100 mg/l)
TKN (mg/l)	n/d		n/d	1.2	0.74						0.24	0.15	<0.58	n/a use Pitt, storm data: 0.74 to 2.0 mg/l)
Ammonia (mg/l)	0.1	0.15	n/d	0.147	n/d		n/d	0.64	0.36		0.19	n/d	<0.2	CCC 0.99-4.0 mg/l, CMC 7.3-24 mg/l) Pitt, storm data 0.18-1.07 mg/l
Nitrite/Nitrate (mg/l)	1.3	0.8	0.58	0.4	1.5		0.34	0.15	1.0		1.2	1.4	<0.62	(n/a, use Pitt, storm data 0.28-0.73 mg/l)
Fecal coliform (col/100 ml)										866				(state now looks at E. coli) (Pitt, storm data 700-1900 mpn/100ml)
Copper (mg/l)	n/d	n/d	n/d	n/d	n/d			0.0051	n/d		n/d	n/d	<0.01	CMC 0.0038 mg/l, CCC 0.0029 mg/l, HH 1.3 mg/l (H2O/Org) Pitt, storm data 0.006-0.024 mg/l
Iron (mg/l)	0.98	0.054	0.69	4.36	0.32			1.3	0.8		1.8	0.6	<1.17	Aquatic life criteria 1.0 mg/l
Manganese (mg/l)	0.13	0.052	0.16	0.0825	0.048			0.097	0.069		0.18	0.065	<0.084	0.05-mg/L SMCL drinking water, none for streams
Lead (mg/l)	0.0032	n/d	0.0031	0.0082	n/d			n/d	n/d		n/d	n/d		0.014 mg/l (CMC Aq), 0.0005 mg/l CCC aq (0.0007 mg/l state), Pitt, storm data 0.005-0.08 mg/l stormwater
Zinc (mg/l)	n/d	0.039	n/d	0.0757	n/d			0.025	n/d		n/d	n/d	<0.04	7.4 (HH) 0.037 (CMC & CCC Aq) Pitt storm data 0.04-0.30 mg/l
Pest/Herbicide						N/D								

(1) State average is used from an unpublished draft document compiling all ambient stream monitoring sampling across South Carolina during a five-year period (1993-1997).
(2) Data retrieved from SC DHEC Water Classification & Standards Regulation 61-68 published June 26, 2020. Pb addendum 303D list, 0.0007 mg/l aquatic life
Notes: Aq = aquatic life, HH = human health, CMC Aq = Criteria Maximum Concentration for aquatic life, CCC Aq = Criterion Continuous Concentration for aquatic life, I = instantaneous result, Avg = average
(3) Pitt, National Stormwater Quality Database 2004, wet weather sampling base on land use (range is Open Space, Residential, Commercial, Industrial and Freeway concentrations)

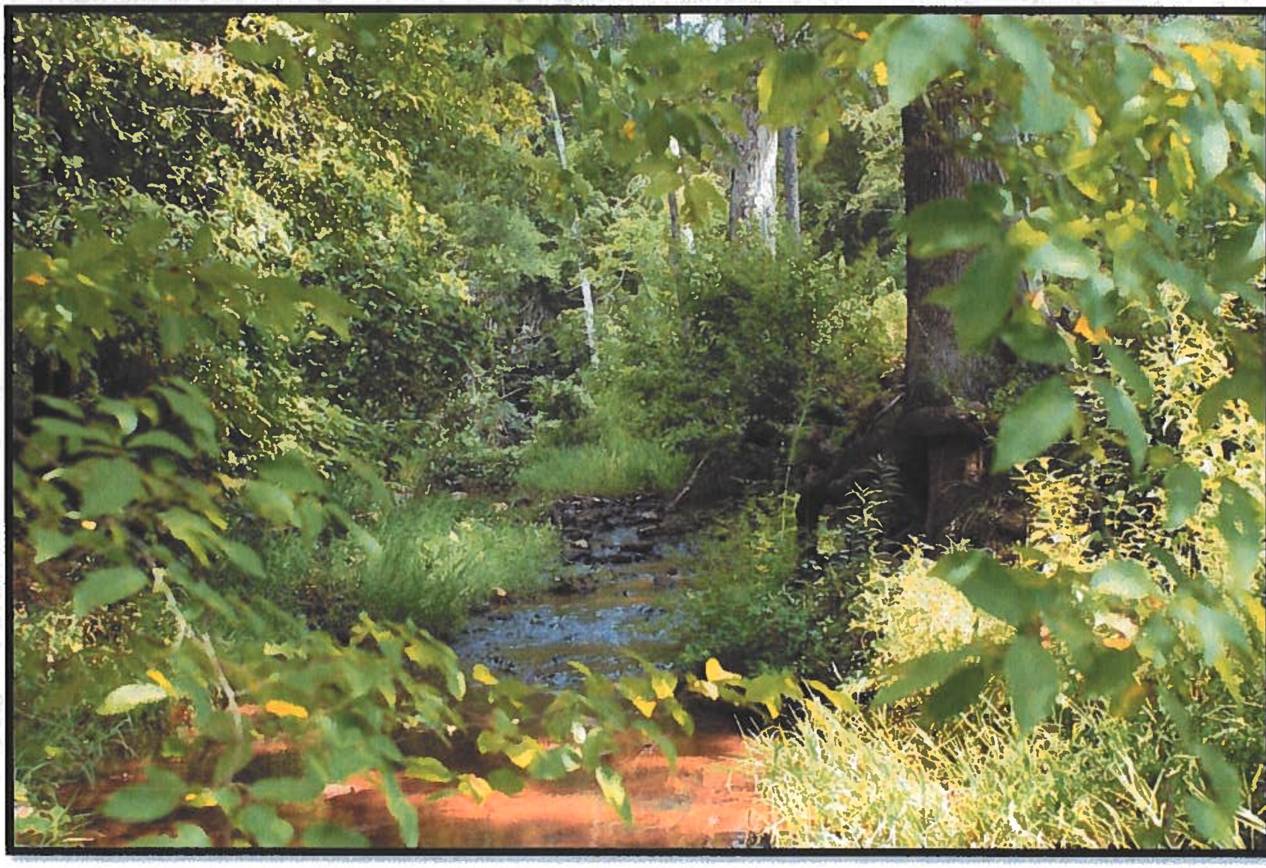
This page intentionally blank.

Figure 4.2: Crystal Lake Data Dry Vs Wet Weather Results graph



This page intentionally blank.

5.0 Fox Creek Basin



5.1 Description

Fox Creek basin is a large 4,700-acre drainage area located at the edge of the city near the Edgefield County line. This is a priority 2 basin. It is mostly still wooded (approximately 71%) with creeks and streams that flow into Gregory Lake located on Gregory Lake Road and into smaller tributaries below it, all that are part of the Fox Creek Basin. The basin is located within the source water protection area of North Augusta. The city annexed over 500 acres within this basin over the past few years due to development requests or city purchases of the abandoned railway for North Augusta Greeneway connectors and the North Augusta Country Club.

Fox Creek converges with Pole Branch basin at the bottom of the reach and both basins discharge into Savannah River upstream of the I-20 overpass. Even though this is true, we consider them separately due to the size of the two basins. The basin is sampled at the location just prior to its convergence with Pole Branch at NA-FC-01. The development adjacent to and within this basin is substantial and increasing.

Water quality sample stations in Fox Creek:

Water quality samples are pulled below the Greg's Gas Plus at sample point NA-FC-01 located on Martintown Road near Gregory Lake Road (pictured above and shown below). This is the bottom reach of the basin. A secondary sample point at Gregory Lake Road is NA-FC-02. Much of the basin is outside of the city limits of North Augusta and tributaries that are completely outside of the city limits are not sampled.

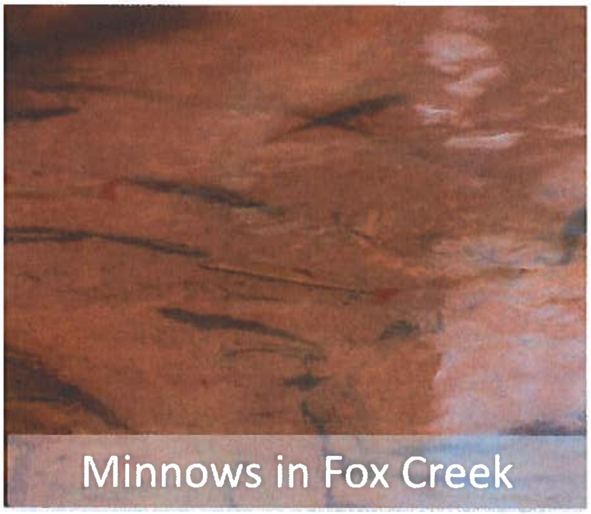
5.2 Fox Creek Sampling Results & Discussion – GOOD to EXCELLENT

The sampling conducted at Fox Creek basin to date has not indicated any serious issues or impairments. One wet weather sample event did show elevated levels of phosphorus and TKN, but they were on the borderline and can be expected during storms (Table 5.1). Much higher levels would be required to indicate infrastructure or illicit discharge impacts to the stream. This location is also sampled by the Adopt a Stream Program of Georgia. They have reported elevated *fecal coliform* concentrations from the volunteers sampling there. Those numbers were provided to the city as well and reviewed and discussed among researchers. From experience sampling our city streams for this constituent, the numbers were not alarming and did not indicate a sanitary sewer overflow or a clear septic tank malfunction impact (several septic tanks have been installed along Gregory Lake Road with individual building lots outside of the city limits). The concentrations reported more likely indicate a wildlife induced elevated level. City infrastructure was checked and no problems were observed.

A comparison of average concentrations of pollutants wet vs dry weather indicate a slight elevation of nutrients, but none that are outside of the expected concentrations during wet weather events according to Pitt, et.al. (Figure 5.1)

With careful consideration of buffers and prevention of impacts to the stream channel, Fox Creek Basin can remain healthy.

The stream reach at the sample location appears healthy with many areas of cover for aquatic insects, the substrate of the stream is rocky, sandy and contains pebbles as well. Overhanging vegetation is present throughout the reach all of which indicate a good habitat.



Minnows in Fox Creek

The native minnow, the dusky shiner (*Notropis cummingsae*) is routinely seen swimming in the stream. The photo to the left is of breeding male shiners (color on fin tips). It was taken at Fox Creek in 2009. Fish of this description were collected in 2008 from Pole Branch for professional identification by researchers at USC-Aiken. These appear to be the same species.

5.3 Development in the basin - Moderate

Fox Creek Basin is currently under increased development pressures along the Gregory Lake Road corridor. Over 50 acres have been or will be disturbed during construction during the past 10 years with approximately 19 acres of impervious surfaces added or planned within the portions that are within the city limits. Additional development along the corridor have occurred but records for areas outside of the city limits are not available.

5.4 Stream channel integrity in the basin: GOOD to EXCELLENT

Stream integrity within Fox Creek Basin is good until the lower reach of the channel after the convergence with Pole Branch. There we see deep excision on the banks, trees with roots open to the air. Heavy rains create excessive flows especially in this lowest reach of the basin. Otherwise the Fox Creek channels within the City limits have been observed, and appear to be in good condition.

This page intentionally blank.

Table 5.1. 2007-2020 Water Quality Sampling Results for Fox Creek Basin

Parameter Tested	Date 10/18/07	Date 05/15/08	Date 08/19/09	Date 09/30/10	Date 09/22/11W	Date 04/03/18	Date 05/06/20	State Avg[1]	EPA or State STD or Guideline[2,3]
pH (su)	7.51	7.53	7.28	7.38	6.67	-	7.2		6.5-8.5 (su)
DO (mg/l)	8.09	9.2	7.2	7.25	4.24	-	8.5		Temp dependent
Temp (°C)	23.7	21.5	26.7	23.1	23.1	-	23.8		Weather dependent
Turbidity (ntu)								<16	mcl 50.0 ntu
Total Phos (mg/l)	0.025	0.029	nd	0.059	0.15	0.016	nd	<0.14	(lakes mcl 0.06 mg/l) (use Pitt storm data = 0.07-0.156 mg/l)
Hardness									n/a,(use Pitt, storm data 32-150 mg/l CaCo3)
E coli.						86*			(state now looks at E. coli*) (Pitt, storm data 700-1900 mpn/100ml)
COD						18			(n/a, use Pitt, storm data 34.0-100.0 mg/l)
TKN (mg/l)	nd	0.61	0.8	0.36	1.6	0.48	0.17	<0.58	n/a use Pitt, storm data: 0.74 to 2.0 mg/l)
Ammonia (mg/l)	nd	nd	0.122	nd	0.14	0.4		<0.2	CCC 0.99-4.0 mg/l, CMC 7.3-24 mg/l) Pitt, storm data 0.18-1.07 mg/l
Nitrite/Nitrate (mg/l)	1.2	0.14	0.176	0.051	0.097	0.13	0.097	<0.62	(n/a, use Pitt, storm data 0.6-1.2 mg/l)
Fecal coliform (col/100 ml)									(state now looks at E. coli) (Pitt, storm data 730-11,000 mpn/100ml)
Copper (mg/l)	nd		nd	nd			nd	<0.01	0.0038 mg/l CMC, 0.0029 mg/l CCC, HH 1.3 mg/l (H2O/Org) Pitt, storm data 0.006-0.024 mg/l
Iron (mg/l)	0.61		0.438	0.272			0.85	<1.17	Aquatic life criteria 1.0 mg/l
Manganese (mg/l)	0.029		0.0685	0.0152			0.069	<0.084	0.05-mg/L SMCL drinking water, none for streams
Lead (mg/l)	nd		nd	nd			nd		0.014 mg/l (CMC Aq), 0.0005 mg/l CCC aq (0.0007 mg/l state), Pitt, storm data 0.005-0.08 mg/l stormwater
Zinc (mg/l)	nd		nd	nd			nd	<0.04	7.4 (HH) 0.037 (CMC & CCC Aq) Pitt storm data 0.04-0.30 mg/l

(1) State average is used from an unpublished draft document compiling all ambient stream monitoring sampling across South Carolina during a five-year period (1993-1997).

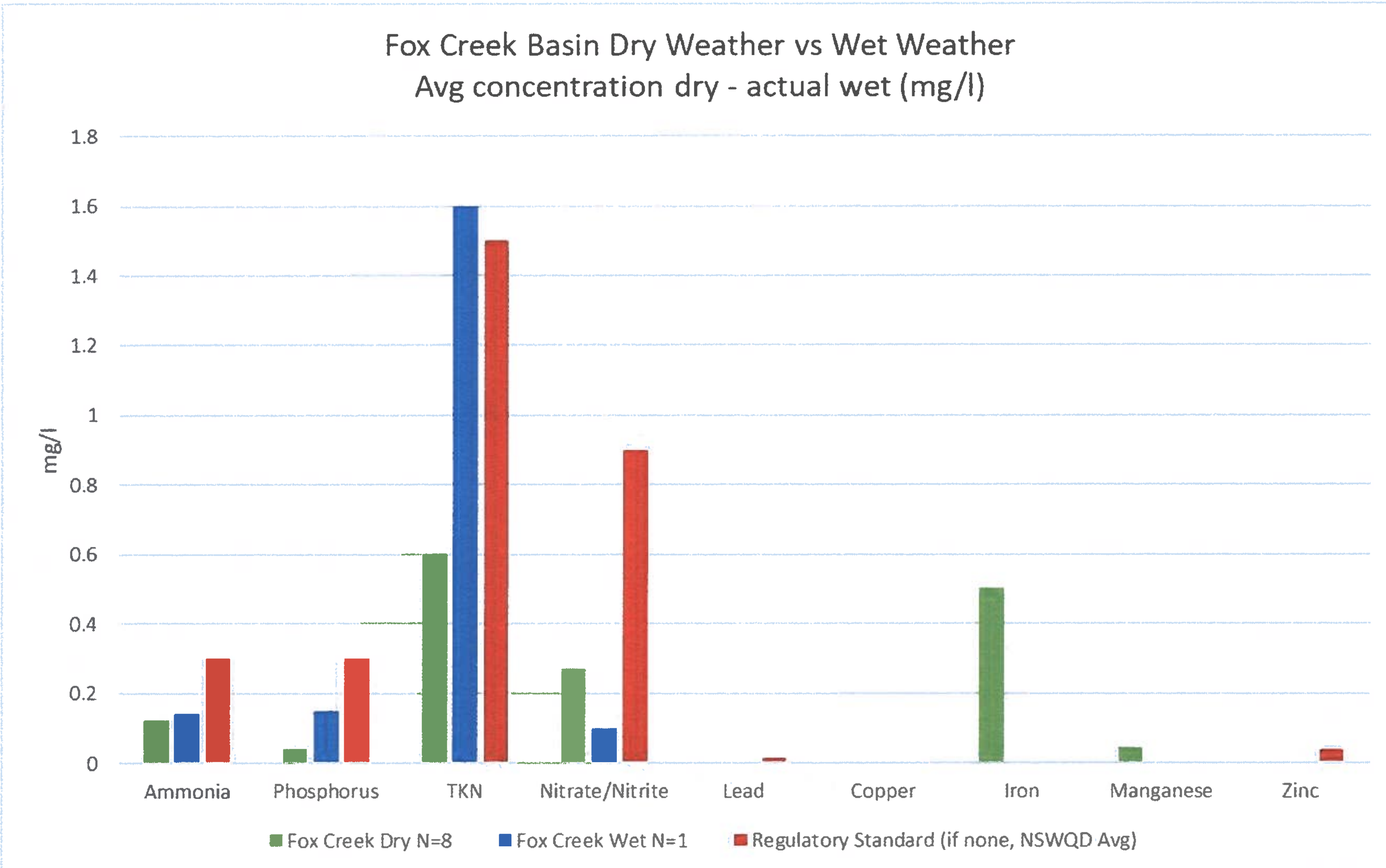
(2) Data retrieved from SC DHEC Water Classification & Standards Regulation 61-68 published June 26, 2020.

Notes: Aq = aquatic life, HH = human health, CMC Aq = Criteria Maximum Concentration for aquatic life, CCC Aq = Criterion Continuous Concentration for aquatic life, I = instantaneous result, Avg = average

(3) Pitt, National Stormwater Quality Database 2004, wet weather sampling base on land use (range is Open Space, Residential, Commercial, Industrial and Freeway concentrations)

This page intentionally blank.

Figure 5.1: Fox Creek Data Dry Vs Wet Weather Results graph



This page intentionally blank.

6.0 Pole Branch Basin

6.1 Description

Pole Branch basin is one of the city's largest basins with 4,567 acres of drainage area. It is located within the city's source water protection area. The basin is under development pressure with approximately 76% of the basin developed to date (estimated). For these reasons it is a Priority 1 basin. To accommodate study of such a large basin, we look at it in two sections, the upper Pole Branch and the Lower Pole Branch areas. The upper basin borders along Highway 25 at I-20 to Arbor Place off of Walnut Lane and then encompasses Austin Heights and Bergen Road businesses and communities. The lower basin collects rainfall from Belvedere to Five Notch road at I-520 and also Knobcone Avenue. It includes a large area bordering Edgewood Heights Subdivision and the shops that border it at Highway 25 and areas near the North Augusta High School, Paul Knox Middle School through and along Five Notch Road leading to I-20. All creeks and streams located in the area converge into Pole Branch. The Upper Pole Branch crosses I-20 at Bergen Road and at Austin Graybill Road. Lower Pole Branch converges with Fox Creek just below Martintown Road and then the confluence stream empties to the Savannah River.

The Pole Branch watershed includes a mix of high and medium density residential, high density commercial, and some light industrial areas. Major traffic corridors including Highway 25, I-20, I-520, Five Notch Road, areas to the west of Martintown Road and all their neighboring communities impact this watershed. In addition, a main sanitary sewer trunk line winds through the watershed and includes lift stations and older sewer lines. The storm system includes a maze of stormwater pipes and ditches draining to creeks and streams throughout the basin.

Water quality samples are pulled at Willow Wick Apartments at sample point NA-PB-01. There are many other sample points within Pole Branch Basin that are sampled as well. NA-PB-01 is the lowest point at the bottom reach of the basin before it converges with Fox Creek drainage. Special studies were conducted along tributaries from Bergen West and Wando Woodland subdivisions and are provided in Appendix A. Sampling was conducted in the upper reaches of the basin as well for comparison to lower reaches. NA-PB-01 is the routine station. Basin data is comprehensively evaluated.

6.2 Pole Branch Sampling Results & Discussion – GOOD

Water quality sampling results within the basin are promising. Due to the high nutrient concentrations identified during the baseline sampling period, Pole Branch has been a focus of the city monitoring program. As part of the baseline assessment, the city conducted routine grab, composite, and first flush sampling during rain events. Overall, sampling results indicated that this basin water quality was in poor condition. Nitrate loads were significant during rain events and high during non-rain events. Special studies have been conducting since that time to identify sources and to evaluate newer stormwater treatment methods that are being implemented with newer developments.

Routine sampling results and rainfall event sampling since the baseline assessment suggest that the water quality has improved since the earlier sampling (Table 6.1). The data indicate that most concentrations of nutrients (nitrate/nitrites, ammonia, phosphorus & TKN) are testing below standards or are within the range expected based on land use and weather condition. Metals are also within the ranges we want to see. Looking at the average of the data on wet sample days versus dry sample days (Figure 6.1), the data indicate no significant problems and pollutant's present are still within the averages we see in stormwater sampling with this type of land use (Pitt et.al). This basin has improved.

In late 2020, a failing sewer trunk line was identified in the upper reach of the basin. It is unknown exactly when the condition deteriorated to the point that infiltration was occurring, and samples within that reach may not have been conducted after that occurred. Sediment infiltration within the lift station and a high increase in water going to the sewer treatment plant alerted Public Utilities staff of an ongoing problem that needed to be identified. During a walk down of the basin to evaluate a new subdivision, it was discovered that there was a problem with the integrity of the line. Once discovered, quick action was taken and the sewer line repair was completed in April 2021. A vast wetland is located downstream of the location and it is likely that it acted as a treatment system removing contaminants that may have escaped the line. Infiltration into the line appeared to be the biggest problem, rather than sewage leaving the line, although that is suspected to have occurred.

Also within the basin, there are several features that could result in increased nutrient levels. These include; a tract of land upstream of the sample point where annual crop farming occurs, new developments within the basin, large older residential areas with well-maintained lawns and gardens, and also commercial areas. Belvedere is an unincorporated community located within the basin. This community has had little maintenance of storm sewers in the past. The city will be partnering with Aiken County to assess this basin when funds are attained.

Pole Branch will continue to be monitored for improvements. As problems are identified, solutions will be implemented in conjunction with increased public education and outreach about the problems in this basin.

6.3 Development in the Basin – HEAVY

Pole Branch basin is highly developed with many older neighborhoods, schools and businesses. Along Bergen Road, Austin Graybill, and Highway 25 above I-20, new developments are growing by the day. Over the past ten years 507 acres have been disturbed by construction resulting in additional 186.6 acres of impervious surfaces mostly within that area. The continued growth is evident with permit applications still being submitted for the new commercial and residential areas.

6.4 Stream channel integrity in the basin - POOR

Pole Branch basin is the largest basin in North Augusta and is also a critical Priority 1 basin due to its size and customer impact, population (commercial and residential), is in the source water protection zone of the city, and due to the age of a majority of the infrastructure. It receives water from a large part of the city along with a large portion of non-city residential and commercially developed land in Belvedere, SC. The preliminary physical stream assessments at Pole Branch indicate that this stream channel was not effective at transporting current loads of stormwater during heavy storm events. The two assessments that were conducted along the stream channel resulted in poor and fair conditions scoring less than 6.0 and just above at 6.3 in the baseline assessment (0-6.0 is poor condition; 6.1-7.4 is fair condition).

Currently both upper and lower reaches of the basin are showing signs of physical stress. Failing banks and sediment deposition is increasing in the upper reaches of the basin and also at the lower reach near Willow Wick apartments and beyond. The banks are scoured and growing deeper where possible (lower reach has shale creek bottom) during large rain events at and below the sample location at Bergen Road. Several tributaries within the basin are showing signs of stress as well. Excessive flows are observed and causing failures of infrastructure within the basin.

Certain areas are severe, including the upper reach below I-20. Scour and impacts to sewer lines have occurred as recently as 2020. In addition, bank flooding has been reported and observed at the lower reaches of the channel below Bergen Road. Sediment deposition and bank instability is evident causing hydrologic alteration and channel widening. This basin is considerably impaired due to excessive flows and inadequate conveyance and detention. As the basin develops further, these problems will become more evident. Currently, the city is trying to acquire funds to address the biggest issues within the basin.

This page intentionally blank.

Table 6.1. 2007-2020 Water Quality Sampling Results for Pole Branch Basin

Parameter Tested (W=wet weather)	Date 05/14/07	Date 09/13/07 W	Date 05/15/08	Date 08/19/09	Date 09/30/10	Date 09/30/10	Date 09/30/10	Date 02/18/11	Date 08/11/11	Date 09/22/11 W	Date 05/09/12 W	Date 04/03/18	Date 05/06/20	State Avg[1]	EPA or State STD or Guideline[2,3]
pH (su)	6.82	7.32	7.26	6.98	7.70	7.82	7.26	7.85	7.03	6.63	6.62	-	7.09		6.5-8.5 (su)
DO (mg/l)	8.64	7.7	8.85	7.06	8.2	7.7	7.91	11.8	7.7	9.43	8.00	-	8.38		Temp dependent
Temp (°C)	22.3	24.7	20.0	25.0	22.1	20.0	23.6	13.7	26.4	22.5	22.3	-	22.0		Weather dependent
Turbidity (ntu)	27							4.7			6.7			<16	mcl 50.0 ntu
Total Phos (mg/l)	0.57	0.028	0.048	nd	nd	nd	nd	0.018	0.022	0.052	0.038	0.012	nd	<0.14	(lakes mcl 0.06 mg/l) (use Pitt storm data = 0.18-0.31 mg/l)
Hardness									48		14				n/a,(use Pitt, storm data 32-150 mg/l CaCo3)
COD (mg/l)												13			(n/a, use Pitt, storm data 34.0-100.0 mg/l)
TKN (mg/l)	0.56	nd	nd	0.8	0.59	0.46	0.50	0.25	0.74	1.7	0.97	0.48	nd	<0.58	n/a use Pitt, storm data: 0.74 to 2.0 mg/l)
Ammonia (mg/l)	0.13	0.12	0.13	0.123	nd	nd	nd	0.13	nd	0.13	0.19	0.39	nd	<0.2	CCC 0.99-4.0 mg/l, CMC 7.3-24 mg/l) Pitt, storm data 0.18-1.07 mg/l
Nitrite/Nitrate (mg/l)	0.48	0.33	0.31	0.46	0.32	0.27	0.251	0.28	0.29	0.18	nd	0.26	0.29	<0.62	(n/a, use Pitt, storm data 0.28-0.73 mg/l)
Fecal coliform (col/100 ml)	697											345*			(state now looks at E. coli*)(Pitt, storm data 700-1900 mpn/100ml)
Copper (mg/l)	0.0007	nd	nd	0.005	nd	nd	nd	nd	nd	-	nd	nd	0.029	<0.01	CMC 0.0038 mg/l, CCC 0.0029 mg/l, HH 1.3 mg/l (H2O/Org) Pitt, storm data 0.006-0.024 mg/l
Iron (mg/l)	1.7	0.77	1.5	0.952	0.952	0.495	1.17	0.33	0.067	-	1.2	-	1.1	<1.17	Aquatic life criteria 1.0 mg/l
Manganese (mg/l)	0.059	0.029	0.056	0.023	0.0238	0.022	0.04	0.024	0.034	-	0.041	-	0.062	<0.084	0.05-mg/L SMCL drinking water, none for streams
Lead (mg/l)	nd	nd	0.0042	nd	nd	nd	nd	nd	nd	-	nd	-	nd		0.014 mg/l (CMC Aq), 0.0005 mg/l CCC aq (0.0007 mg/l state), Pitt, storm data 0.005-0.08 mg/l stormwater
Zinc (mg/l)	nd	0.043	nd	0.010	0.013	nd	0.0108	0.025	nd	-	nd	-	nd	<0.04	7.4 (HH) 0.037 (CMC & CCC Aq) Pitt storm data 0.04-0.30 mg/l

(1) State average is used from an unpublished draft document compiling all ambient stream monitoring sampling across South Carolina during a five-year period (1993-1997).

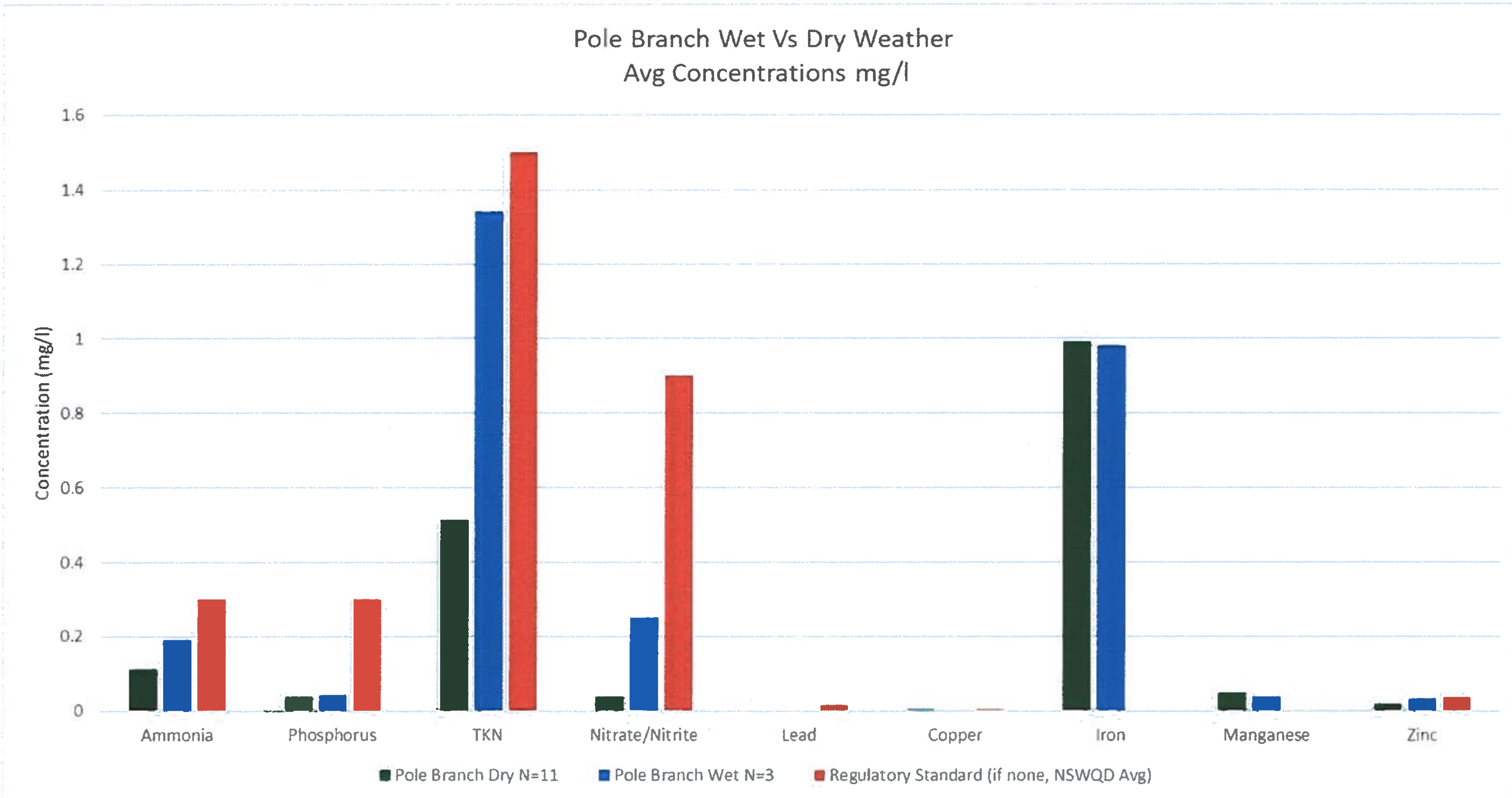
(2) Data retrieved from SC DHEC Water Classification & Standards Regulation 61-68 published June 26, 2020.

Notes: Aq = aquatic life, HH = human health, CMC Aq = Criteria Maximum Concentration for aquatic life, CCC Aq = Criterion Continuous Concentration for aquatic life, I = instantaneous result, Avg = average

(3) Pitt, National Stormwater Quality Database 2004, wet weather sampling based on land use (range is Open Space, Residential, Commercial, Industrial and Freeway concentrations)

This page intentionally blank.

Figure 6.1: Pole Branch Data Dry Vs Wet Weather Results graph



This page intentionally blank.

7.0 Hammond Hills Basin

7.1 Description

The Hammond Hills basin is located in a residential neighborhood with some mixed use. The basin drainage area is 410 acres with 76% of that area developed. This is a Priority 1 basin. The infrastructure is older in this area with stormwater systems that consist of pipes and ditches. There is minimal stormwater piping in the basin, only where necessary to cross roadways. The original neighborhood was developed in the 1950s. This creates issues in areas that are not obvious. During development easements were not obtained for many of the ditches that are located there. The basin is sampled at two locations lower in the basin, prior to crossing into the final reach where they discharge to the Savannah River.

7.2 Hammond Hills Sampling Results & Discussion – GOOD

The data from sampling events indicate that Hammond Hills basin is good. As shown in the data results in Table 7.1, none of the samples were higher than what is normally observed in streams. During wet weather, phosphorus and nitrate/nitrite levels are higher than the standards or average for streams, but they are not above the average concentrations seen in stormwater samples within residential locations. Comparing the wet weather sampling averages with dry weather averages, again nutrient levels are higher than state averages, but are within the ranges that are seen during stormwater sampling (Figure 7.1).

Habitat within the stream channels were good in several locations where excessive erosion is not seen. We will continue to monitor the channels and look for issues that need to be addressed.

7.3 Development in the basin - Moderate

During the past 10 years, 35 acres within Hammond Hills basin have been disturbed due to construction. Over 17 additional acres were developed as impervious surfaces. While this is not a lot, the basin is highly developed already. Development opportunities are mostly limited to the commercial corridor and individual lots that may be available within the existing residential areas.

7.4 Stream channel integrity in the basin: POOR

Overall, the channels within the basin are in poor shape. The lower reach of the basin has shown signs of stress with degrading channels and excessive debris collection within them. Eroding banks have increased channel size and created unstable banks. Ditches located within the basin appear to be failing. Many have been lined with concrete or rock and cement, but that has not held up in many over time. There have been incidents reported of property damage from the eroding conveyances that have become larger due to the excessive flows during heavy rainfalls. As mentioned earlier, easements for many of these features are not established and individual property owners must maintain them. Existing pipes made from corrugated metal have failed within the basin as well. The city has repaired many of these over the past few years. More are slated for repair.

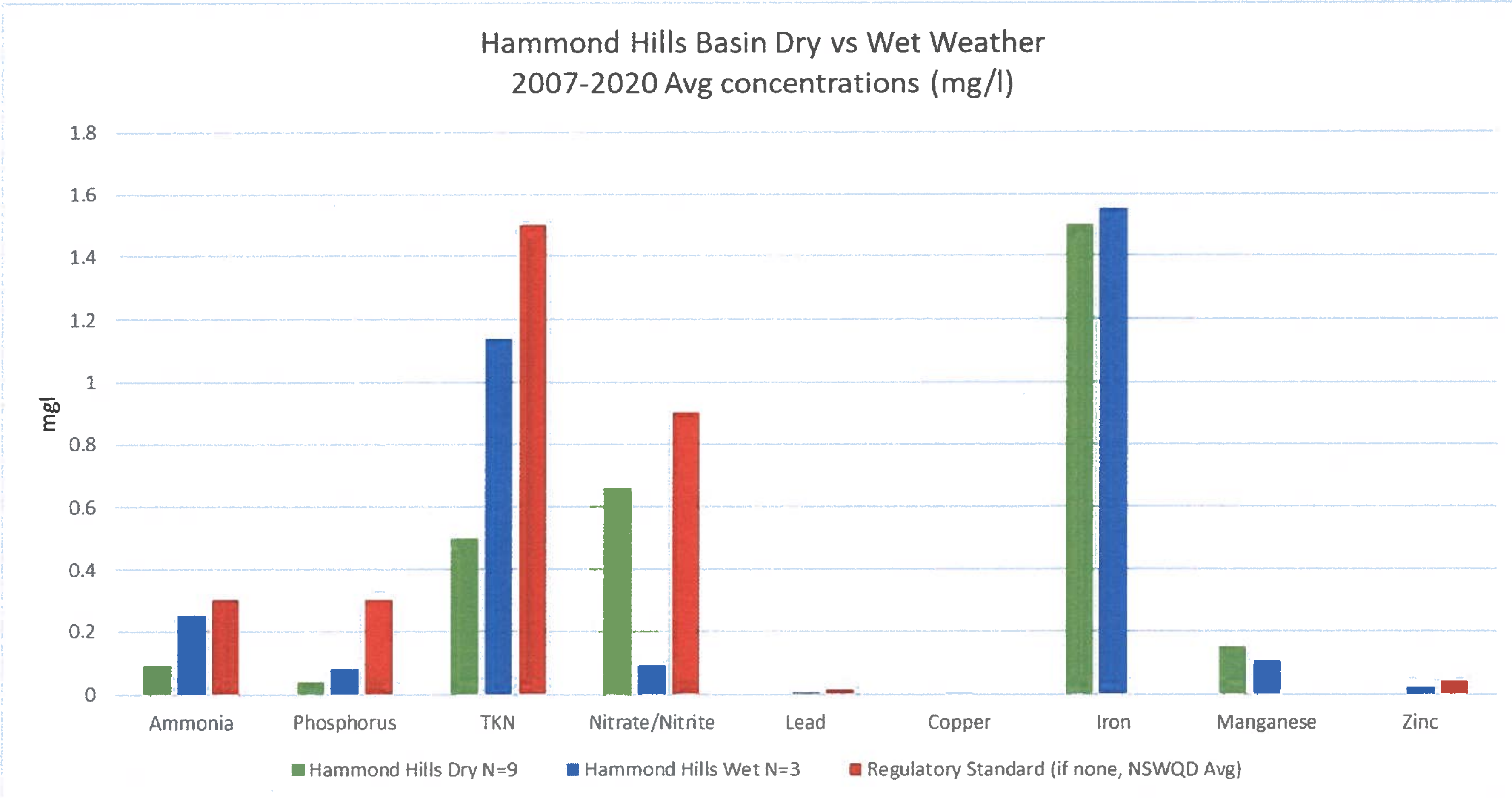
Table 7.1. 2007-2020 Water Quality Sampling Results for Hammond Hills

Parameter Tested	Date 08/19/09	Date 08/19/09	Date 08/11/11	Date 09/22/11w	Date 05/09/12w	Date 12/18/12w	Date 04/13/18	Date 12/11/18	Date 12/12/12	Date 12/12/12	Date 05/06/20	State Avg[1]	EPA or State STD or Guideline[2,3]
pH (su)	6.4	6.9	7.03	6.76	-	6.22	-	7.12	6.56	7.04	7.06		6.5-8.5 (su)
DO (mg/l)	6.08	7.18	5.75	6.8	-	7.2	-	9.54	5.05	8.3	8.57		Temp dependent
Temp (°C)	25.5	24.7	27.34	22.9	-	14.3	-	12.6	12.7	11.6	20.3		Weather dependent
Turbidity (ntu)					2.1							<16	mcl 50.0 ntu
Total Phos (mg/l)	nd	nd	0.035	0.006	0.13	0.059	0.018	0.01	0.21	0.016	nd	<0.14	(lakes mcl 0.06 mg/l) (use Pitt storm data = 0.18-0.31 mg/l)
Hardness			42			54							n/a,(use Pitt, storm data 32-150 mg/l CaCo3)
E coli.							1987*						(state now looks at E. coli*)(Pitt, storm data 700-1900 mpn/100ml)
COD							13	10	26	10			(n/a, use Pitt, storm data 34.0-100.0 mg/l)
TKN (mg/l)	0.8	0.6	0.44	0.63	2.1	0.7	0.45	0.13	0.94	nd	0.12	<0.58	n/a use Pitt, storm data: 0.74 to 2.0 mg/l)
Ammonia (mg/l)	0.136	0.112	nd	0.11	0.33	0.3	0.18	nd	nd	nd	nd	<0.2	CCC 0.99-4.0 mg/l, CMC 7.3-24 mg/l) Pitt, storm data 0.18-1.07 mg/l
Nitrite/Nitrate (mg/l)	1.55	0.676	0.32	0.12	0.065	0.088	0.29	0.88	0.025	1.2	0.37	<0.62	(n/a, use Pitt, storm data 0.28-0.73 mg/l)
Copper (mg/l)	-	nd	nd	-	0.0072	nd	-	nd	nd	nd	nd	<0.01	CMC 0.0038 mg/l, CCC 0.0029 mg/l, HH 1.3 mg/l (H2O/Org) Pitt, storm data 0.006-0.024 mg/l
Iron (mg/l)	-	0.241	0.34	-	1.9	1.2	-	0.74	6.5	0.71	0.51	<1.17	Aquatic life criteria 1.0 mg/l
Manganese (mg/l)	-	0.011	nd	-	0.11	0.1	-	0.091	0.65	0.95	0.046	<0.084	0.05-mg/L SMCL drinking water, none for streams
Lead (mg/l)	-	nd	nd	-	nd	nd	-	nd	nd	nd	nd		0.014 mg/l (CMC Aq), 0.0005 mg/l CCC aq (0.0007 mg/l state), Pitt, storm data 0.005-0.08 mg/l stormwater
Zinc (mg/l)	-	nd	nd	-	0.034	nd	-	nd	nd	nd	nd	<0.04	7.4 (HH) 0.037 (CMC & CCC Aq) Pitt storm data 0.04-0.30 mg/l

(1) State average is used from an unpublished draft document compiling all ambient stream monitoring sampling across South Carolina during a five-year period (1993-1997).
(2) Data retrieved from SC DHEC Water Classification & Standards Regulation 61-68 published June 26, 2020.
Notes: Aq = aquatic life, HH = human health, CMC Aq = Criteria Maximum Concentration for aquatic life, CCC Aq = Criterion Continuous Concentration for aquatic life, I = instantaneous result, Avg = average
(3) Pitt, National Stormwater Quality Database 2004, wet weather sampling base on land use (range is Open Space, Residential, Commercial, Industrial and Freeway concentrations)

This page intentionally blank.

Figure 7.1: Hammond Hills - Data Dry Vs Wet Weather Results graph



This page intentionally blank.

8.0 Pretty Run Basin

8.1 Description

Pretty Run basin is a large basin (1,811 acres) located entirely within the city's source water protection area. It is approximately 68% developed as mixed residential with about 8% of that commercial. The remaining 34% is wooded corridors and open space areas. Pretty Run is a priority 1 basin. Pretty Run creek is considered an impaired stream by the state for *fecal coliform* bacteria from a year of monthly samples in 2005 and also has been listed as impaired for biological condition (macroinvertebrates) from a sample that was collected by the state in 2004. These issues require the city to conduct regulated sampling events and studies to try and identify if sewer lines or septic tank leakages that may contain bacterial pollutants are causing the impairments. The city has conducted extensive studies within Pretty Run basin since 2005. The latest study was a sampling study conducted from 2014-2016. The data generated has been analyzed and a report was submitted to DHEC with the annual report in 2016.

The basin drains older neighborhoods such as Lyndhurst, areas adjacent to the North Augusta Greeneway Trail, Bolin Road, Knollwood, Hammond Pond and other private pond drainage areas. Marion Avenue and portions of Georgia Avenue at McDonald's restaurant. Most of the area located east of Five Notch Road is included. In addition, residential areas across Martintown Road are also drained to the Pretty Run basin including; the Rapids, Herron Cove, Overlook IV. The main branch of this basin is Pretty Run Creek. This primary sample point is NA-PR-01 and is located in the Rapids subdivision on Riverbluff Drive at the utility maintenance right-of-way just before the stream enters the Savannah River.

8.2 Pretty Run Sampling Results & Discussion - GOOD

There are two sampling regimes in Pretty Run basin. One is routine sampling that is done along with all of the other basin sampling events. These tests are the ones we run for all creeks and streams that we monitor in the city. Additionally, there is a regulatory TMDL sampling regime that was required by the state in the small MS4 Permit. As part of the TMDL process, the state looked at the data and suspected sources and set the TMDL standard for *E. coli* in Pretty Run basin as "at or below 349 col/100 ml" of stream water. This is to explain why there are two different sets of data that we maintain for Pretty Run Basin. We look at the data together and use it together for reporting, but since there is routine and regulatory, we have to look at it separately as well. The city's routine monitoring is for informational purposes that we use to see how well our program is working, it is less formal. Regulatory sampling is very rigid and requires more oversight and input by the state for it to be deemed valid.

During routine sampling (monitoring) in Pretty Run we generally pull field parameters, *E. coli*, nutrients and metals. Sometimes we pull other tests that we are specifically using to investigate an illicit discharge or we want to capture the data for another reason. In Pretty Run basin we also have conducted special studies looking macroinvertebrates. That data is provided in Appendix D. The data for the routine monitoring is presented below in Table 8.1.

As you can see the data indicate that Pretty Run has become a fairly healthy watershed. Only one sample for TKN (nutrient) pulled during the period was outside of what we would normally see for this type of monitoring. No other data that day indicated a problem. The results of our routine monitoring since the baseline are actually better than before. The wet Vs dry sampling data also indicate a healthy watershed (Figure 7.1) where both types of weather events sampled, the averaged data is lower than the standards or other measures. So, although the bacteria testing does show higher levels than the standard, the results are considered in detail within the regulatory sampling discussion below and also in further detail within the Pretty Run Monitoring reports that are provided in Appendix B. The reports were required and submitted to the state in 2016 & 2018. Raw data is also provided in Appendix B.

The TMDL regulatory sampling required us to prepare a sampling plan and look at the bacterial data specifically. The TMDL Monitoring and Assessment Plan was prepared in January 2015 and is available on the City of North Augusta website. The sampling plan was sent to the state for approval prior to implementation. Once we were allowed to proceed, we then began implementing the plan's sampling regime. The plan including sampling studies along the main branch and all tributaries leading to Pretty Run Creek DHEC sampling point. Maps and details are in the plan.

We conducted *E. coli* testing, nutrients and metals, optical brightener tests, detergent chemical testing, and source tracking studies (bacterial DNA markers) to determine if animal or human sources were to blame for the higher levels of bacteria. The full data set for this project is presented in Appendix B. Based on the data generated and studies conducted throughout the basin, it is most likely that the higher bacterial levels are a product of the concentration of wildlife in the wooded corridors and green spaces that have remained after development. Data generated at the same time the bacteria tests are conducted do not indicate a manmade source. For example, when a sanitary sewer source is suspected, you will see high bacteria levels but also much higher nutrient levels and/or indications of the presence of optical brighteners and detergents. None of our data show that. We have higher bacteria, but none of the other tests show a problem or any indication of a human source (in most instances). Random hits of a human source can be expected also due to human activity and stormwater bringing that into the stream, but if it were a significant impact all or several of the tests would point to that.

In addition to the testing, we have conducted numerous physical assessments of the basin that included aerial infrared surveys during the winter looking for warmer discharges that could be detected that way. A flight crew flew over the basin on an extremely cold night and used infrared cameras to photograph all spots that lit up as "hot spots". We then went to each and every one identified during the flight to assess if they were in fact, illicit discharges from sewer lines, residential washing machines, septic tank discharges or something else. None of those items were found. The culprits in that study turned out to be groundwater seeps that percolate up from below ground where the temperature is warmer than the cold winter atmosphere. The utilities department has conducted smoke testing and dye testing looking for breaches in the systems in the basin as well. We continue to look for issues by walking sewer lines near streams and inspecting storm systems looking for illicit discharges. While some issues are found, none have been significant and all are corrected. So, no smoking gun has ever been found that would indicate that the Pretty Run bacteria problem is solely a manmade source.

Through DNA analysis source tracking methods and further research, the data and research suggests that the bacteria are likely from wildlife sources. Results of DNA analysis support that assumption. Three rounds of bacterial source tracking with DNA were conducted. The first two rounds of testing were through the use of an EPA certified laboratory. Each test is expensive so we had to be considerate of that. The laboratory offered different types of tests for communities depending on suspected sources. The city chose human and ruminant (cattle, sheep, goats, buffalo, deer, elk, giraffes and camels). We know that pets would contribute as a source so we did not opt for the domesticated animals testing (dogs, pigs, horses, and chickens). If the two tests we chose were inconclusive, we then could change the scheme on the next round. The results showed that ruminants were positive on nearly all samples, where humans were not. We did get two samples that actually indicated a human source, but both were on bacteria samples that had the lowest numbers (75 & 187 col/100 ml respectively) well below the TMDL standard of 349 col/100 ml of *E. coli*, not high numbers.

A third DNA source tracking event took place with a student from USC-Aiken working on her degree in Biology. Staff worked with the student to pull samples in Pretty Run basin to analyze for whether the sources were animal or human. The test was not as specific as the EPA certified test. But the information was interesting. In her study, none of the samples indicated a human source, and all indicated an animal sources. The information she gathered, was in line the earlier testing.

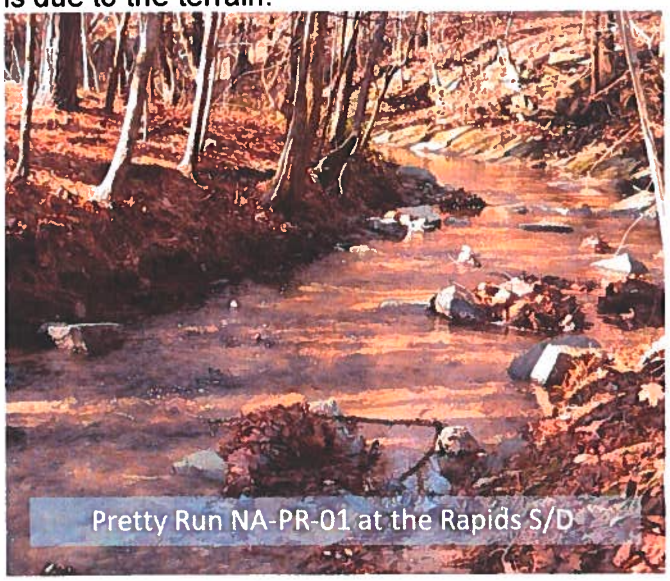
We continue to conduct routine monitoring of Pretty Run basin. We also look for ways to reduce human or pet sources to Pretty Run Creek. We see a lot of opportunity for improvement and we will implement projects to reduce our impacts to it. As for wildlife concentrating within the wooded and stream corridors in Pretty Run basin and across the city, that is ultimately a manmade problem as well. As we continue to develop within Pretty Run basin and throughout the city, we need to be aware of the fact that the benefits of open space not only give us a place to enjoy nature nearby, but also a place for animals to congregate and live. The water quality impairments their presence may cause, are not easily eliminated.

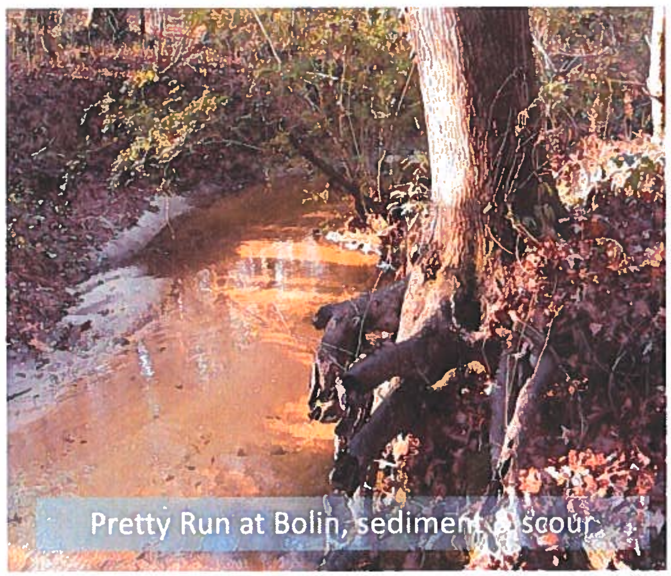
8.3 Development in the Basin - Low

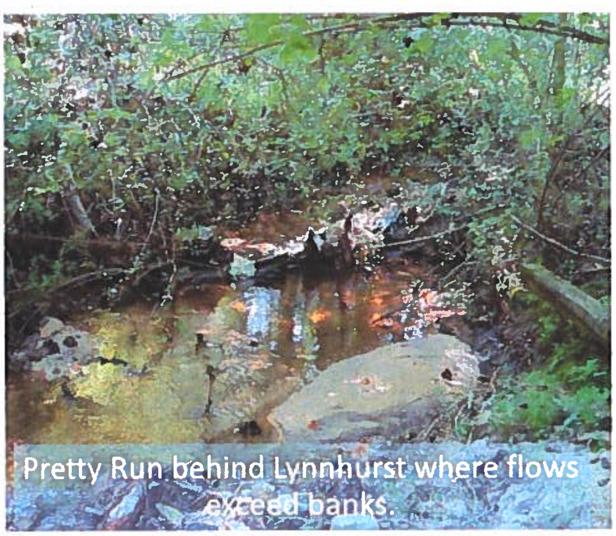
The development within Pretty Run basin was significant since the 1950's and the basin is reaching about 68% developed with only a few larger tracts of land still undeveloped and in private ownership. Over the past 10 years, we have seen about 48 acres of disturbances from construction within the basin and 30 acres of impervious surfaces added. This is less than several other basins, but it is heavily developed already.

8.4 Stream channel integrity in the basin – POOR to GOOD

The Pretty Run creek stream channel is in fairly good condition in the lower reach. Pretty Run creek originates higher in the basin along Five Notch road as storm drainage from the commercial areas of Knox and Georgia Avenues just before the intersection of the Highway 25 corridor. Drainage from that upper end of the basin comes through a ditch beside the Pizza Hut delivery and winds its way down and around behind Dove Street before it crosses Green Acres and Knollwood. The upper reach of the basin is in poor condition with scour and channel degradation from excessive flows. As it passes through below Knollwood, it slows and passes through natural wetlands where permanent flow is established year round. This is the middle channel where the stream channel picks up water from many groundwater seeps that are in that area and it meanders through as a single stream behind Lyndhurst Subdivision. This is where the stream becomes less stable. During heavy storms it is inundated with flow and has caused flooding and problems with property damage on parcels located adjacent. We have received numerous complaints and found damage caused by the high flows in that area. The stream channel then goes under the Greeneway Trail near Bolin & Martintown Road where it also shows signs of stream channel stress. As it passes through under Martintown and through the Rapids Subdivision, the substrate changes to rocky outcroppings and shale and the channel is stabilized at that point. Even excessive flows at this point do not seem to be causing channel degradation, and that is due to the terrain.


Pretty Run NA-PR-01 at the Rapids S/D


Pretty Run at Bolin, sediment & scour.


Pretty Run behind Lynnhurst where flows exceed banks.

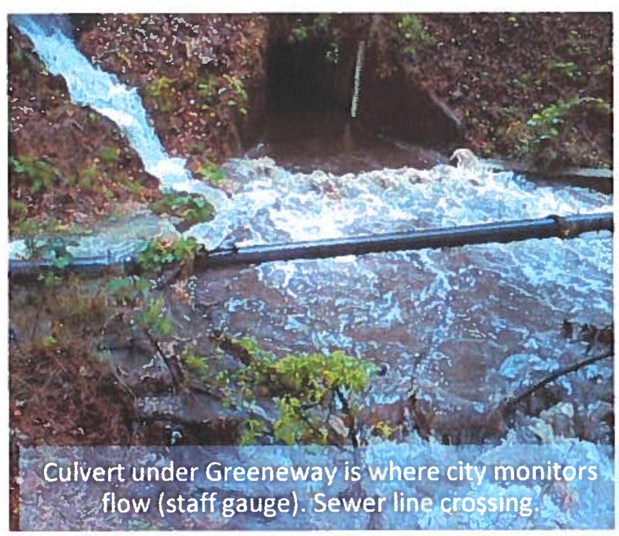

Culvert under Greeneway is where city monitors flow (staff gauge). Sewer line crossing.

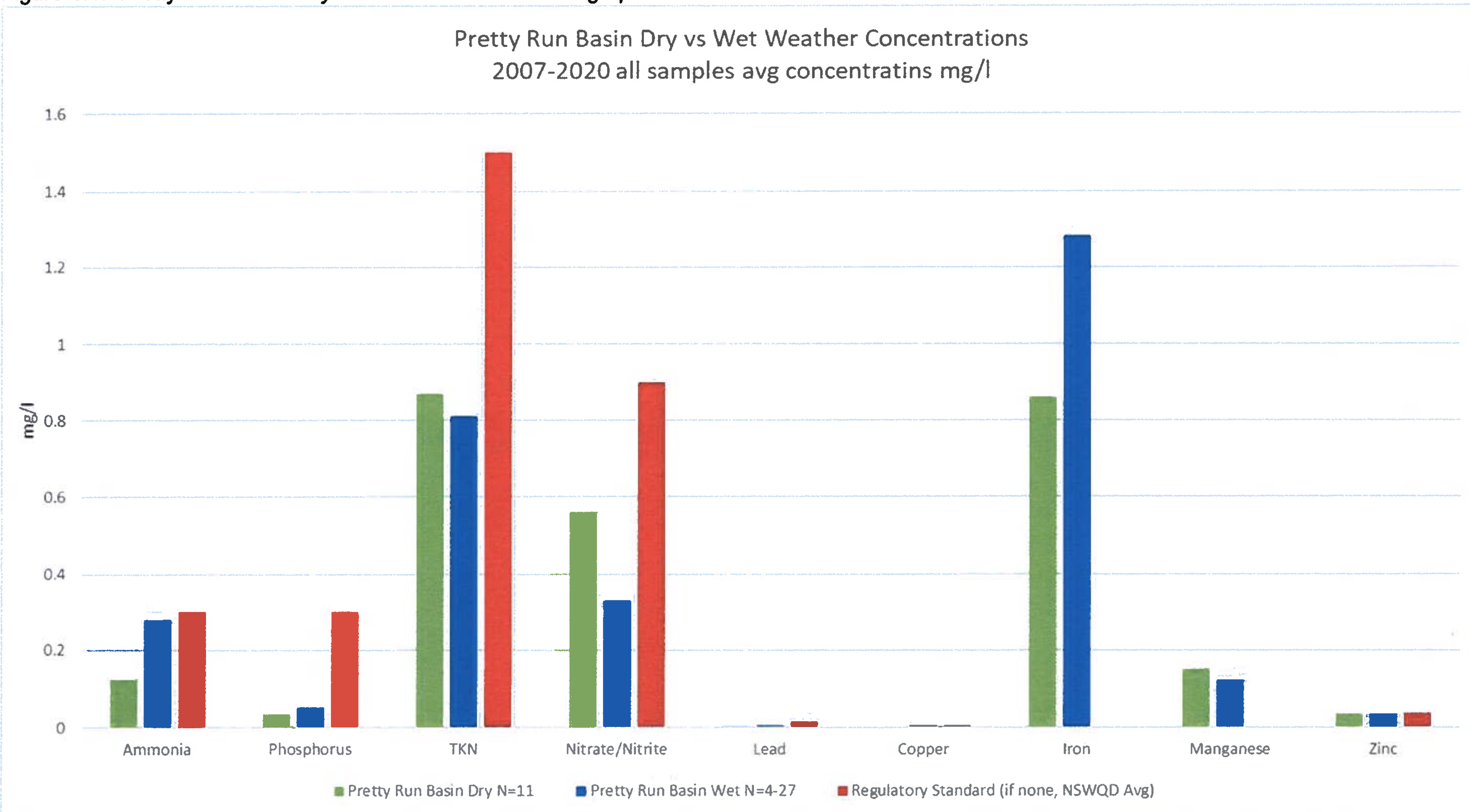
Table 8.1. 2007-2020 Water Quality Sampling Results for Pretty Run Basin

Parameter Tested	Date 05/14/07	Date 09/13/07W	Date 05/15/08	Date 08/07/08	Date 08/11/11	Date 09/22/11W	Date 12/18/12W	Date 2/08/18	Date 2/08/18	Date 2/08/18	Date 2/08/18	Date 12/11/18	Date 05/06/20	Date 05/06/20	State Avg[1]	EPA or State STD or Guideline[2,3]
pH (su)	7.05	7.29	-	6.48	7.52	6.6	7.08	7.80	6.80	7.01	6.97	6.2	6.98	7.46		6.5-8.5 (su)
DO (mg/l)	9.0	7.79	-	8.71	7.85	8.53	7.57	8.10	7.5	9.09	9.42	10.76	8.77	8.74		Temp dependent
Temp (°C)	19.8	25.0	-	26.5	26.7	22.4	14.9					10.9	20.4	19.5		Weather dependent
Turbidity (ntu)	5														<16	mcl 50.0 ntu
Total Phos (mg/l)	0.29	0.018	0.03	0.025	0.033	0.03	nd	0.028	0.015	0.043	0.012	0.19	nd	0.12	<0.14	(lakes mcl 0.06 mg/l) (use Pitt storm data = 0.18-0.31 mg/l)
Hardness					39							46				n/a,(use Pitt, storm data 32-150 mg/l CaCo3)
COD								12	16	16	0	nd				(n/a, use Pitt, storm data 34.0-100.0 mg/l)
TKN (mg/l)	nd	nd	0.51	nd	4.1	0.28	0.69	0.53	0.47	0.6	0.95	0.13	0.29	0.28	<0.58	n/a use Pitt, storm data: 0.74 to 2.0 mg/l)
Ammonia (mg/l)	nd	0.14	nd	nd	nd	0.12	0.33	0.22	0.11	0.24	0.43	nd	nd	nd	<0.2	CCC 0.99-4.0 mg/l, CMC 7.3-24 mg/l) Pitt, storm data 0.18-1.07 mg/l
Nitrite/Nitrate (mg/l)	0.67	0.47	0.32	0.99	0.55	0.34	0.64	0.59	0.72	0.10	0.12	0.77	0.65	0.65	<0.62	(n/a, use Pitt, storm data 0.28-0.73 mg/l)
Fecal coliform (col/100 ml) *(sampled multiple locations 08/11/11)*	426		490		416 140 264 252 119								227.4*	88*		(state now looks at E. coli) (Pitt, storm data FC 730-11,000 mpn/100ml) (EC 700-1900)
Copper (mg/l)	nd	nd	nd	nd	nd	nd	nd	-	-	-	-	nd	nd	nd	<0.01	CMC 0.0038 mg/l, CCC 0.0029 mg/l, HH 1.3 mg/l (H2O/Org) Pitt, storm data 0.006-0.024 mg/l
Iron (mg/l)	0.75	0.76	0.72	0.28	0.37	-	0.58	-	-	-	-	0.52	0.51	0.86	<1.17	Aquatic life criteria 1.0 mg/l
Manganese (mg/l)	0.15	0.24	0.015	0.19	0.018	-	0.24	-	-	-	-	0.044	0.021	0.028	<0.084	0.05-mg/L SMCL drinking water, none for streams
Lead (mg/l)	nd	nd	0.003	nd	nd	-	nd	-	-	-	-	nd	nd	nd		0.014 mg/l (CMC Aq), 0.0005 mg/l CCC aq (0.0007 mg/l state), Pitt, storm data 0.005-0.08 mg/l stormwater
Zinc (mg/l)	nd	0.05	nd	0.34	nd	-	nd	-	-	-	-	nd	nd	nd	<0.04	7.4 (HH) 0.037 (CMC & CCC Aq) Pitt storm data 0.01-0.13 mg/l
Pest/Herbicide				nd				-	-	-	-					

(1) State average is used from an unpublished draft document compiling all ambient stream monitoring sampling across South Carolina during a five-year period (1993-1997).
(2) Data retrieved from SC DHEC Water Classification & Standards Regulation 61-68 published June 26, 2020.
Notes: Aq = aquatic life, HH = human health, CMC Aq = Criteria Maximum Concentration for aquatic life, CCC Aq = Criterion Continuous Concentration for aquatic life, I = instantaneous result, Avg = average
(3) Pitt, National Stormwater Quality Database 2004, wet weather sampling base on land use (range is Open Space, Residential, Commercial, Industrial and Freeway concentrations)

This page intentionally blank.

Figure 8.1: Pretty Run Data - Dry Vs Wet Weather Results graph



This page intentionally blank.

9.0 Waterworks Basin

9.1 Description

The Waterworks basin is a large basin (1,208 acres) that handles tremendous flows during rain events. Waterworks basin is a Priority 1 basin. Flows from this basin incorporate stormwater from extensively developed residential and higher density commercial businesses along Knox, Martintown, and Buena Vista Avenue. Approximately 87% of the basin is developed, and that number is growing. The basin enters the river through two separate channels within the River Golf Club.

The upper reach of the basin drains the areas from Knox Avenue near the Channel 12 television station and below including Lowes, Walmart, North Augusta and Kroger Shopping Centers, and along Martintown Road. Drainage from parts of downtown Georgia Avenue, West Spring Grove and North Augusta Elementary flow into the main channel through the Community Center and Maude Edenfield Park. The communities along Old Edgefield Road are part of this basin as well, including Edgefield Heights, Summerfield Park and the area below them down to Atomic Road. Stormwater from these areas flow through and along Atomic Road to pipes that send the stormwater across Atomic Road and eventually is piped down to Buena Vista Avenue. They all converge near Mealing Avenue and then on to stream next to the Public Safety complex. Stormwater enters the stream and travels along Riverside Boulevard and then through River Golf Club and its pond systems before emptying into the Savannah River at Shoreline Drive. That is the location of NA-WW-01, the primary sampling point.

Stormwater that originates from the west side of the Business & Technology Center, Philpot and Gentry Lanes, Old Martintown and Fleetwood Drive flows through the basin behind Barton Road and into River Golf Club under the railroad tracks. This stormwater converges in the ponds of the River Golf Club and eventually merges and empties at the same location.

9.2 Waterworks Basin Sampling Results & Discussion - GOOD to FAIR

Waterworks basin sampling result show TKN and Nitrate/nitrite levels are above averages or standards (Table 9.1). These numbers could indicate pollutants entering the system. The principle sources of nitrate contamination in water are fertilizers, animal waste and septic wastes. We have all three concerns in this part of the basin. Comparison between dry and wet sample events also show some elevated levels of TKN but overall the numbers are still within range of what we normally see in stormwater sampling (Figure 9.1).

Wetlands remove pollutants, and that is observed during dry and wet weather sampling. During one dry weather sample event we pulled a sample upstream near the Greeneway Trail entrance on Riverside Boulevard NA-WW-05, (Nitrate = 1.4 mg/l, high) and then one downstream before the water leaves River Club Golf Course area NA-WW-01, (Nitrates = 0.75 mg/l) at the stream entrance to Savannah River. Also, during a wet weather sample event we pulled a sample upstream at NA-WW-05, (TKN=8.3 mg/l, extremely high) and then one downstream again NA-WW-01, (TKN=0.92 mg/l) at Savannah River. This is an example of how well wetlands in that area remove pollutants in Waterworks Basin. We know that the water leaving the basin to the Savannah River is less polluted than samples taken upstream of the wetlands. Many of the samples are pulled upstream, samples pulled at the outfall, NA-WW-01 confirm that.

Interestingly, sampling at a groundwater spring behind Maude Edenfield Park that contributes to the Waterworks drainage, we found it had higher levels of nitrite/nitrate than normally observed in groundwater. So we conducted a review of data across the nation looking at nitrates in groundwater. Based on that information, it was determined that these levels are not normal in the groundwater. Reviewing old Sandborn maps from the 1923, we noted that the map shows a fertilizer plant, North Augusta Warehouse and Fertilizer Company was located in this vicinity. Nitrates would be involved in that operation. There could be long buried stockpile of materials contributing to the groundwater nitrite/nitrate levels located here. No fertilizer or impacts to groundwater have been observed in that secluded location. The historical information is not conclusive as we don't know of any buried materials and may never know due to the development within the area.

What we do know though, is that the elevated nutrients are consistent with several sewer line failures that were discovered within the area of the sample location. A breach of the system located near the Public Safety complex was discovered after reports of sewage odors along Riverside Boulevard, the main channel of the stream. Several other reports and failures were observed along the reach as well. Sewer overflow or line failures are known to have occurred at least four times over this reporting period. Certain sections of the system were closely examined upon notification of problems and major repairs to the system were done during that time and again after the realignment of Buena Vista Avenue. Since the numbers are still elevated in the latest sampling, there may be cause to look at this system in its entirety.

9.3 Development in the Basin: Moderate

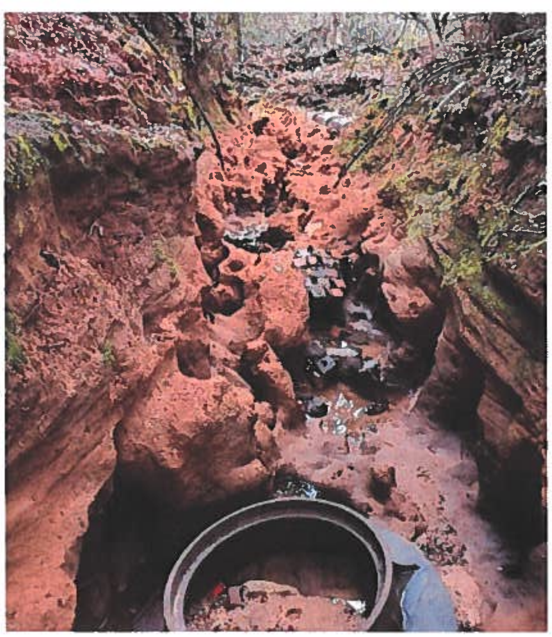
Development within the basin includes the disturbance of and 39 acres resulting in 28 acres of new impervious surface in the downtown commercial shopping areas.

9.4 Stream channel integrity in the basin: POOR

The basin has been affected by excessive flows. Channel integrity is degraded with erosion and incision occurring in channels within the entire basin. Newer developments within the upper basin flows through detention ponds to reduce the release rate. Older shopping centers development within that same area do not. Lowes, River Commons, Shoppes at North Augusta and Walmart are new projects that provided detention. Other older shopping areas on Martintown Road, Knox and along Atomic Road do not. The combination of unretained from these locations along with SCDOT roadways entering the same pipe infrastructure as the newer detained flows has the system at its maximum capacity. At the outfalls of the system, it is obvious there is a problem. The flow is creating deep ravines, failing slopes on channels, sediment loads within the channels, impacted storm system and sanitary infrastructure, and flooding.

In addition to storm conveyances failing, stormwater pipes in streets have failed, ponds have failed, and commercial infrastructure has failed in the area. The city has relined many feet of pipes that were causing road failure in Woodlawn Place over the past few years. A pond and its piping failed adjacent to that location from a condominium complex. An additional failure occurred along the length of the entire complex at one apartment complex. These failures have also impacted existing infrastructure downstream.

This area would benefit from a comprehensive review to identify areas where regional detention could be accomplished. Unfortunately, there is not a lot of available locations for that to work. For this reason, all redevelopment within this area on larger tracts that don't currently provide some sort of detention, should consider it. The city must consider this as well, and work toward processing development proposals within the basin that will not create more problems, but could solve existing ones.



This page intentionally blank.

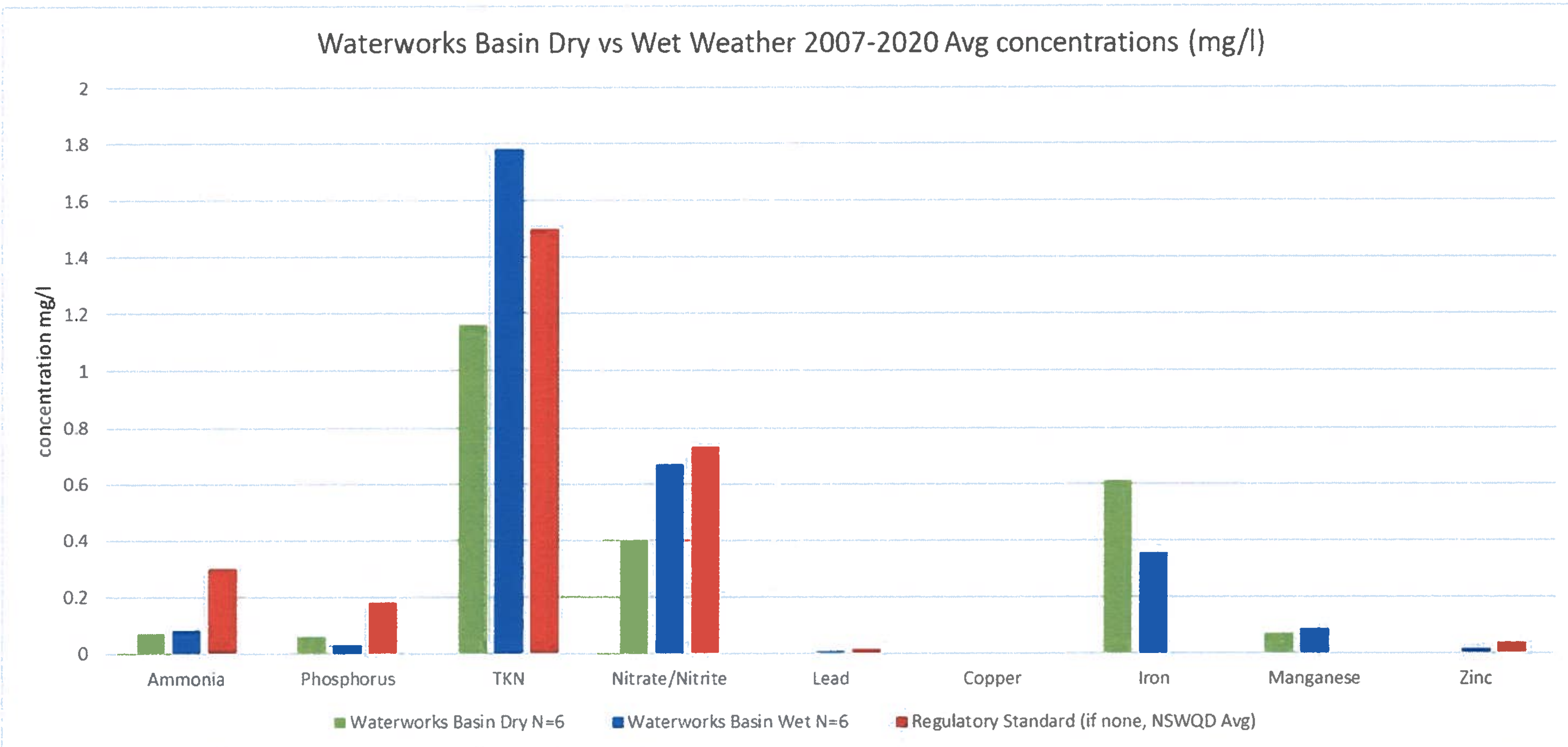
Table 9.1. 2007-2020 Water Quality Sampling Results for Water Works Basin

Parameter Tested	Date 10/18/07	Date 05/15/08	Date 08/19/09	Date 08/10/11	Date 09/22/11W	Date 09/22/11W	Date 05/09/12W	Date 12/12/18W	Date 12/12/18W	Date NAWW01 05/06/20	Date NAWW05 05/06/20	State Avg[1]	EPA or State STD or Guideline[2,3]
pH (su)	7.22	6.93	8.37	6.60	7.80	6.53	6.75	6.99	6.99	7.16	7.39		6.5-8.5 (su)
DO (mg/l)	8.02	7.76	7.35	4.65	6.50	7.74	7.34	7.38	10.11	7.23	8.60		Temp dependent
Temp (°C)	24.07	22.6	29.1	31.69	23.5	24.9	28.4	15.0	12.5	23.0	21.3		Weather dependent
Turbidity (ntu)							9.6					<16	mcl 50.0 ntu
Total Phos (mg/l)	0.032	0.082	nd	0.038	0.045	0.044	0.84	nd	nd	0.14	0.062	<0.14	(lakes mcl 0.06 mg/l) (use Pitt storm data = 0.18-0.31 mg/l)
Hardness				51			18						n/a,(use Pitt, storm data 32-150 mg/l CaCo3)
COD								nd	nd				(n/a, use Pitt, storm data 34.0-100.0 mg/l)
TKN (mg/l)	nd	2.2	1.1	0.79	8.30	0.92	0.89	nd	0.11	0.54	nd	<0.58	n/a use Pitt, storm data: 0.74 to 2.0 mg/l)
Ammonia (mg/l)	nd	0.13	0.106	nd	0.16	nd	0.29	nd	nd	nd	nd	<0.2	CCC 0.99-4.0 mg/l, CMC 7.3-24 mg/l) Pitt, storm data 0.18-1.07 mg/l
Nitrite/Nitrate (mg/l)	0.33	0.12	nd	0.065	0.40	0.82	nd	1.8	1.7	0.075	1.4	<0.62	(n/a, use Pitt, storm data 0.28-0.73 mg/l)
Fecal coliform (col/100 ml)											615.2*		(state now looks at E. coli) (Pitt, storm data Fc730-11,000 mpn/100ml, Ec: 700-1900 mpn/100ml
Copper (mg/l)	nd	-	nd	nd	-	-	nd	nd	nd	nd	nd	<0.01	CMC 0.0038 mg/l, CCC 0.0029 mg/l, HH 1.3 mg/l (H2O/Org) Pitt, storm data 0.006-0.024 mg/l
Iron (mg/l)	0.34	-	0.894	0.38	-	-	0.81	0.43	0.10	1.1	0.35	<1.17	Aquatic life criteria 1.0 mg/l
Manganese (mg/l)	0.052	-	0.717	0.09	-	-	0.18	0.049	0.11	0.11	0.041	<0.084	0.05-mg/L SMCL drinking water, none for streams
Lead (mg/l)	nd	-	nd	nd	-	-	nd	nd	nd	nd	nd		0.014 mg/l (CMC Aq), 0.0005 mg/l CCC aq (0.0007 mg/l state), Pitt, storm data 0.005-0.08 mg/l stormwater
Zinc (mg/l)	nd	-	nd	nd	-	-	nd	nd	nd	nd	nd	<0.04	7.4 (HH) 0.037 (CMC & CCC Aq) Pitt storm data 0.04-0.30 mg/l
Pest/Herb								nd	nd				

(1) State average is used from an unpublished draft document compiling all ambient stream monitoring sampling across South Carolina during a five-year period (1993-1997).
(2) Data retrieved from SC DHEC Water Classification & Standards Regulation 61-68 published June 26, 2020.
Notes: Aq = aquatic life, HH = human health, CMC Aq = Criteria Maximum Concentration for aquatic life, CCC Aq = Criterion Continuous Concentration for aquatic life, I = instantaneous result, Avg = average
(3) Pitt, National Stormwater Quality Database 2004, wet weather sampling base on land use (range is Open Space, Residential, Commercial, Industrial and Freeway concentrations)

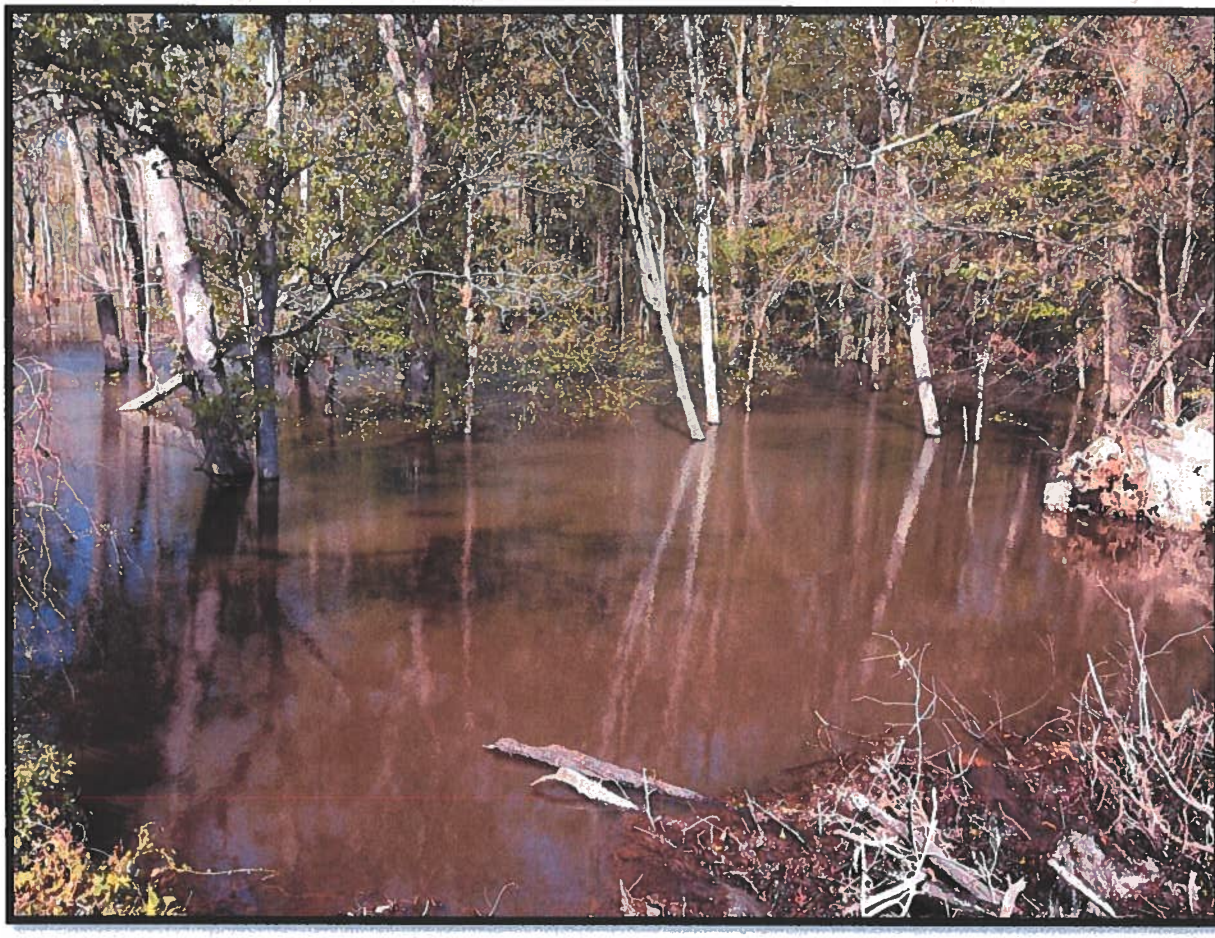
This page intentionally blank.

Figure 9.1: Waterworks Data Dry Vs Wet Weather Results graph



This page intentionally blank.

10.0 Womrath Basin



10.1 Description

This basin includes the area located from the junction of Knox Avenue and Old Edgefield Road back to Carolina Springs/Womrath Road. It is a Priority 3 basin. The water flows from these areas and crosses Atomic Road near the I-520 overpass. It then travels along through more wetlands until it flows under Highway 1 (Aiken/Augusta Highway). From there the unnamed creek empties into wetlands located adjacent to Horse Creek. This basin is sampled at the TTX Plant located off of Hamburg Road.

The basin has three distinct sections, the upper basin that drains toward Euclid Avenue from the Knox Avenue storm system. The large shopping center (the old Food Lion) and the Bowling Alley are the top locations of the basin. Once flow converges and flows into the system at Euclid, deep ravines have formed over the years that run all the way through until the drainage ditch reaches Womrath Road across from the closed golf practice facility. This area is considered the Middle basin area. The channel is deep and drops many feet below the road surface. Erosion and sediment deposition is a big problem in this part of the basin. Flows entering the channel erode anything in its path. As it flows down beyond Clay Pit Road, the channel evens out and the channel branches and intersects in a wooded area with other drainage features. This area seems to mitigate for the earlier erosion. The water flows through the area and appears to be in good condition. Slopes along the highway corridor at Highway 1 are failing and falling into the wetlands below. SC DOT has been trying to resolve this issue recently. The third part of the basin is mostly wetlands and all located below the TTX Hamburg Facility where the flow is piped under part of the facility until it daylights back to the swamps below.

10.2 Womrath Basin Sampling Results & Discussion - Good

Sampling results for this basin are good. Most of the data indicate no substantial pollutants of concern (see Table 10.1). During heavy rainfall, there is a potential for increased levels of pollutants entering the stream channel due to surcharging of sewer lines. This has been reported to staff by citizens from the sewer lines that run down Womrath Road. Data from wet vs dry weather sampling is shown in Figure 10.1. While there are some indications of higher nutrient levels in individual samples, none are over the average seen in stormwater sampling.

10.3 Development in the Basin – Moderate

Womrath basin has experienced quite of bit of development in the past 10 years. Approximately 66 acres of disturbance has been permitted, and several have not started. Once they are completed, these projects will result in 45.3 acre of additional impervious surface being added within the drainage area.

10.4 Stream channel integrity in the basin - POOR

The upper basin has significant gulley formation and continued erosive velocities at the head of the system through to the Womrath Road crossing. The ravines and gulleys that have formed over the years are unstable. Development plans for a residential subdivision is under review and another has been submitted. Both plans are reviewed with the ravine below them in mind. Once the water leaves the ravine, it continues to erode channels across Womrath Road. The flow of water is slowed after it reaches the middle part of the basin below Clay Pit Road. During non-rain events, the ravine has little to no flow. The lower reach of the basin is flat with braided channels and vast wetlands to remove pollutants prior to the discharge into either Horse Creek of the Savannah River.

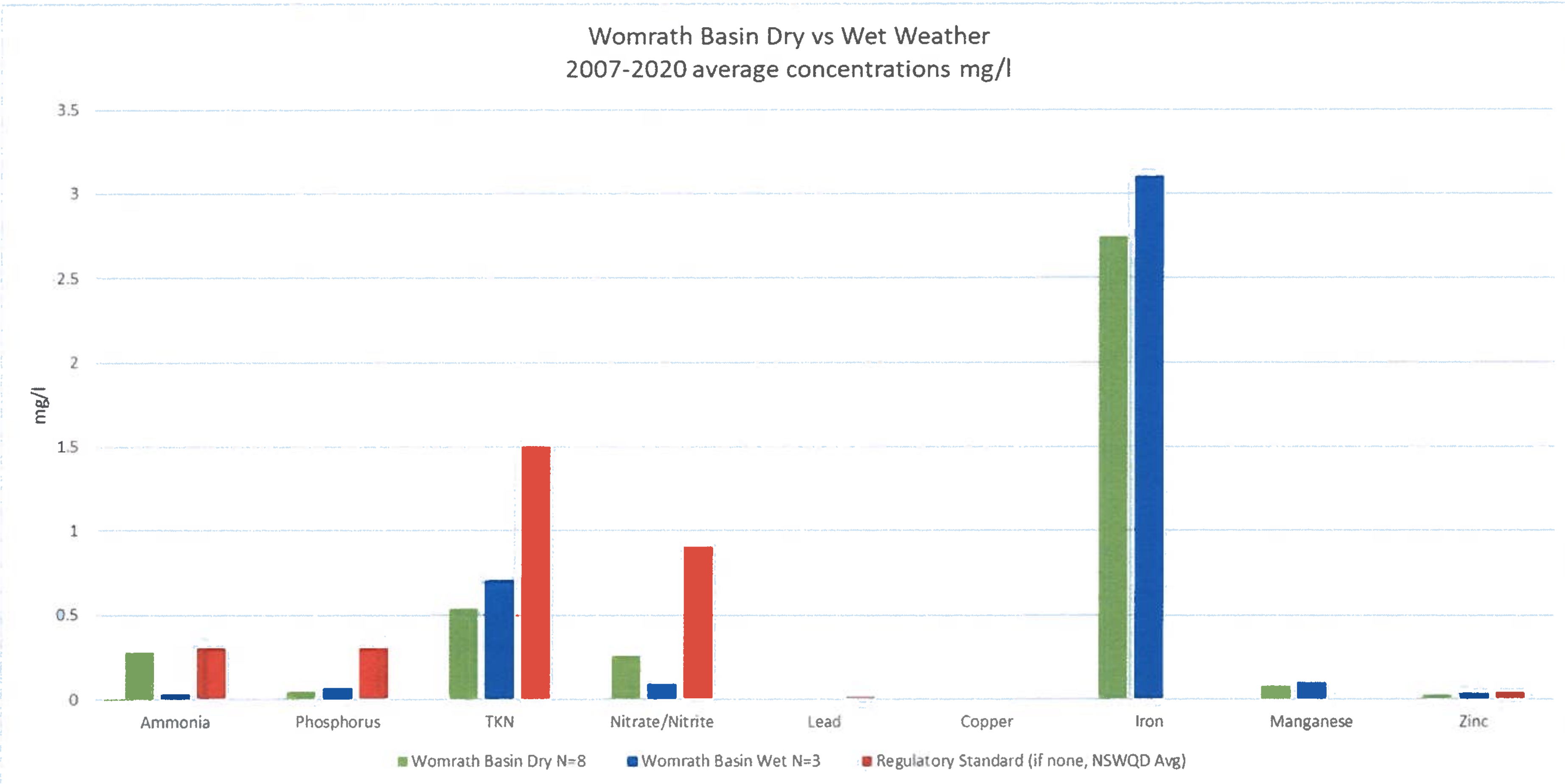
Table 10.1. 2007-2020 Water Quality Sampling Results for Womrath Basin

Parameter Tested	Date 10/18/07	Date 10/18/07	Date 05/15/08	Date 08/07/08	Date 08/11/11	Date 09/22/11W	Date 05/09/12W	Date 04/03/18	Date 05/06/20	State Avg[1]	EPA or State STD or Guideline[2,3]
pH (su)	6.94	7.15	6.64	6.48	5.94	7.2	6.58	-	6.32		6.5-8.5 (su)
DO (mg/l)	7.98	8.45	8.57	8.4	6.3	6.33	7.32	-	8.27		Temp dependent
Temp (°C)	23.2	22.9	23.5	26.8	23.0	22.0	22.8	-	19.1		Weather dependent
Turbidity (ntu)							35			<16	mcl 50.0 ntu
Total Phos (mg/l)	0.024	0.40	0.16	0.011	0.15	0.048	0.083	0.031	nd	<0.14	(lakes mcl 0.06 mg/l) (use Pitt storm data = 0.18-0.31 mg/l)
Hardness					45		23				n/a,(use Pitt, storm data 32-150 mg/l CaCo3)
COD								19.0			(n/a, use Pitt, storm data 34.0-100.0 mg/l)
TKN (mg/l)	nd	0.57	0.70	0.61	0.46	0.41	1.0	0.69	0.18	<0.58	n/a use Pitt, storm data: 0.74 to 2.0 mg/l)
Ammonia (mg/l)	nd	0.15	0.16	0.3	0.11	0.10	0.49	0.76	0.19	<0.2	CCC 0.99-4.0 mg/l, CMC 7.3-24 mg/l) Pitt, storm data 0.18-1.07 mg/l
Nitrite/Nitrate (mg/l)	0.44	0.48	0.12	0.31	0.84	0.11	0.065	0.19	0.16	<0.62	(n/a, use Pitt, storm data 0.28-0.73 mg/l)
Fecal coliform (col/100 ml)					132.0			12*			(state now looks at E. coli) (Pitt, storm data 730-11,000 mpn/100ml, Ec: 700-1900 mpn/100ml)
Copper (mg/l)	nd	nd	-	nd	nd	-	0.0058	-	nd	<0.01	CMC 0.0038 mg/l, CCC 0.0029 mg/l, HH 1.3 mg/l (H2O/Org) Pitt, storm data 0.006-0.024 mg/l
Iron (mg/l)	1.8	2.3	-	4.1	2.3	-	3.1	-	3.2	<1.17	Aquatic life criteria 1.0 mg/l (naturally occurring)
Manganese (mg/l)	0.057	0.086	-	0.12	0.044	-	0.96	-	0.077	<0.084	0.05-mg/L SMCL drinking water, none for streams
Lead (mg/l)	nd	nd	-	nd	nd	-	nd	-	nd		0.014 mg/l (CMC Aq), 0.0005 mg/l CCC aq (0.0007 mg/l state), Pitt, storm data 0.005-0.08 mg/l stormwater
Zinc (mg/l)	nd	0.05	-	0.27	nd	-	0.036	-	nd	<0.04	7.4 (HH) 0.037 (CMC & CCC Aq) Pitt storm data 0.04-0.30 mg/l
Pest/Herbicide				nd							

(1) State average is used from an unpublished draft document compiling all ambient stream monitoring sampling across South Carolina during a five-year period (1993-1997).
(2) Data retrieved from SC DHEC Water Classification & Standards Regulation 61-68 published June 26, 2020.
Notes: Aq = aquatic life, HH = human health, CMC Aq = Criteria Maximum Concentration for aquatic life, CCC Aq = Criterion Continuous Concentration for aquatic life, I = instantaneous result, Avg = average
(3) Pitt, National Stormwater Quality Database 2004, wet weather sampling base on land use (range is Open Space, Residential, Commercial, Industrial and Freeway concentrations)

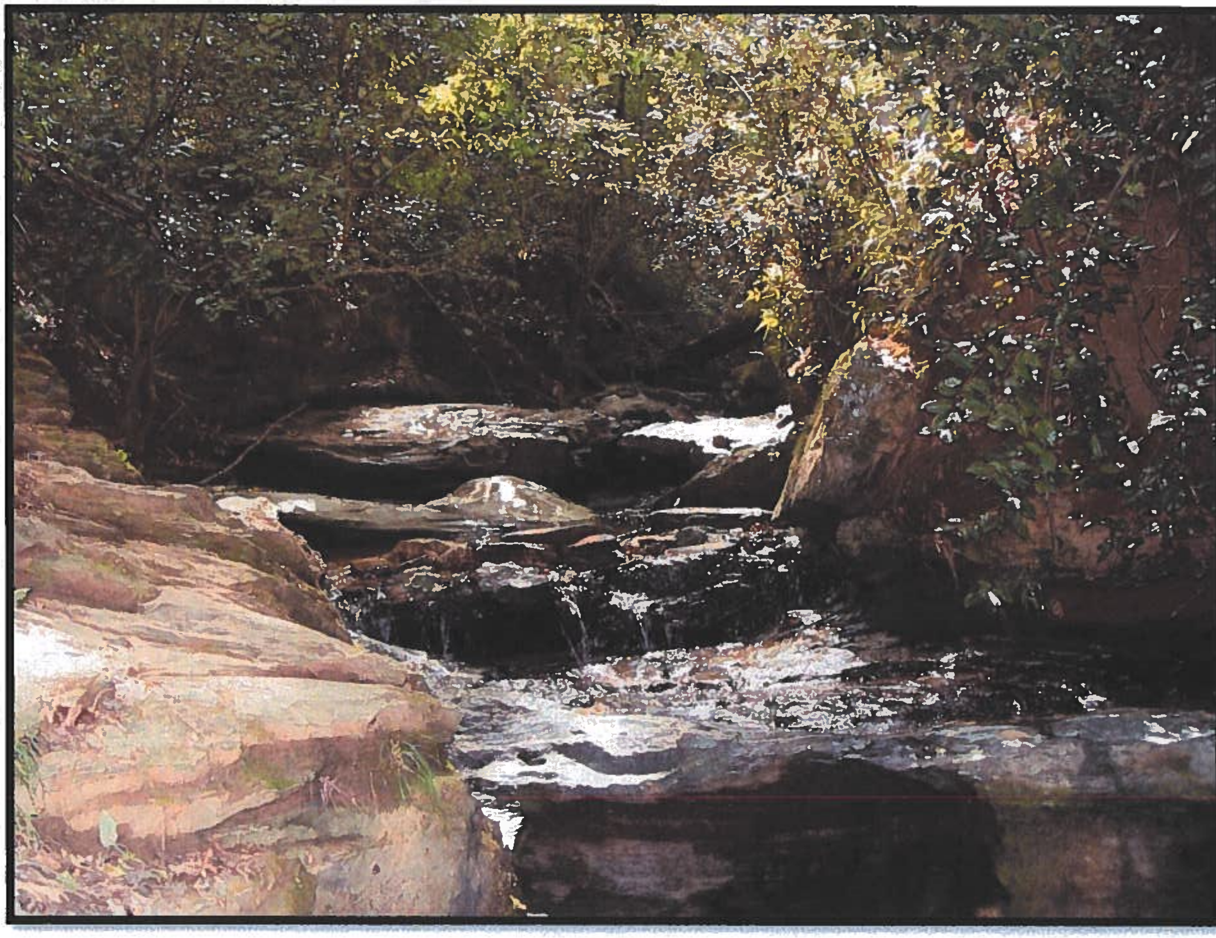
This page intentionally blank.

Figure 10.1: Womrath Basin Data - Dry Vs Wet Weather Results graph



This page intentionally blank.

11.0 Riverview Basin



11.1 Description

This small basin is the located near Riverview Park Activities Center with drainage coming in from of Hammond Hills development areas near the entrance to the park. Riverview Basin is a Priority 2 basin and is within the Source Water Protection Area. The outfall from this basin into Savannah River is very close to the North Augusta Water Plant raw water intake pumps so it is monitored routinely. Hammond Hills basin is approximately 220 acres. It is significantly developed with older residential homes. Approximately 80% of the basin (175 acres) is developed with residential and public uses. The remaining portions of the basin are wooded or open grassed areas.

11.2 River View Sampling Results & Discussion - GOOD

Data suggest that the stream is in fairly good condition. One sample indicates that the nitrate/nitrite level in the stream exceeded the average levels for streams, all others were within normal range (Table 11.1). Wet weather vs dry weather sampling averages also suggest that Riverview basin has little water quality issues (Figure 11.1)

11.3 Development in the basin - Low

Development within Riverview basin has been minimal over the last 10 years. In that time, development within the basin totaled 2.4 acres of disturbance and 1.1 acres of new impervious acreage.

11.4 Stream channel integrity in the basin – Good to Fair

The stream channel that takes flow to the Savannah River within this basin is in fair condition. As it leaves the residential area, wetlands and wooded areas protect the stream channel. It is shaded and shallow. Once it passes through the Riverview Park, there are areas where excessive erosion is occurring. A disc golf course traverses this reach and some of the infrastructure for the course is causing problems during excessive rain events. The city is working with the Disc Golf managers to resolve these issues. An area of preservation for the endangered relict trillium is located along the lower reach of the basin below the City of North Augusta Water Plant water tank.

Table 11.1. 2007-2020 Water Quality Sampling Results for Riverview Basin

Parameter Tested	Date 08/19/09	Date (FF) 05/09/12	Date 12/18/12W	Date 04/03/18	Date 12/11/18	Date 05/06/20W	State Avg[1]	EPA or State STD or Guideline[2,3]
pH (su)	6.4	7.08	6.39		7.12	7.06		6.5-8.5 (su)
DO (mg/l)	6.08	7.08	6.40		9.06	8.57		Temp dependent
Temp (°C)	25.5	24.0	14.9		12.2	19.7		Weather dependent
Turbidity (ntu)		900					<16	mcl 50.0 ntu
Total Phos (mg/l)	nd	0.99	nd	0.11	nd	nd	<0.14	((lakes mcl 0.06 mg/l) (use Pitt storm data = 0.18-0.31 mg/l)
Hardness		390	22					n/a,(use Pitt, storm data 32-150 mg/l CaCo3)
COD				10		nd		(n/a, use Pitt, storm data 34.0-100.0 mg/l)
TKN (mg/l)	0.80	4.9	1.1	0.45	0.11	nd	<0.58	n/a use Pitt, storm data: 0.74 to 2.0 mg/l) (FF=first flush)
Ammonia (mg/l)	0.136	2.2	0.63	0.25	nd	nd	<0.2	CCC 0.99-4.0 mg/l, CMC 7.3-24 mg/l) Pitt, storm data 0.18-1.07 mg/l
Nitrite/Nitrate (mg/l)	1.55	ND	0.58	0.93	1.8	1.2	<0.62	(n/a, use Pitt, storm data 0.28-0.73 mg/l)
Fecal coliform (col/100 ml)				435*				(state now looks at E. coli) (Pitt, storm data Fc: 730-11,000 mpn/100ml, Ec: 700-1900 mpn/100ml)
Copper (mg/l)		0.027	nd		nd	nd	<0.01	CMC 0.0038 mg/l, CCC 0.0029 mg/l, HH 1.3 mg/l (H2O/Org) Pitt, storm data 0.006-0.024 mg/l
Iron (mg/l)		11.0	0.34		0.24	0.22	<1.17	Aquatic life criteria 1.0 mg/l
Manganese (mg/l)		0.72	0.070		0.052	0.037	<0.084	0.05-mg/L SMCL drinking water, none for streams
Lead (mg/l)		0.032	nd		nd	nd		0.014 mg/l (CMC Aq), 0.0005 mg/l CCC aq (0.0007 mg/l state), Pitt, storm data 0.005-0.08 mg/l stormwater
Zinc (mg/l)		0.14	nd		nd	nd	<0.04	7.4 (HH) 0.037 (CMC & CCC Aq) Pitt storm data 0.04-0.30 mg/l
Pest/Herbicide								

(1) State average is used from an unpublished draft document compiling all ambient stream monitoring sampling across South Carolina during a five-year period (1993-1997).

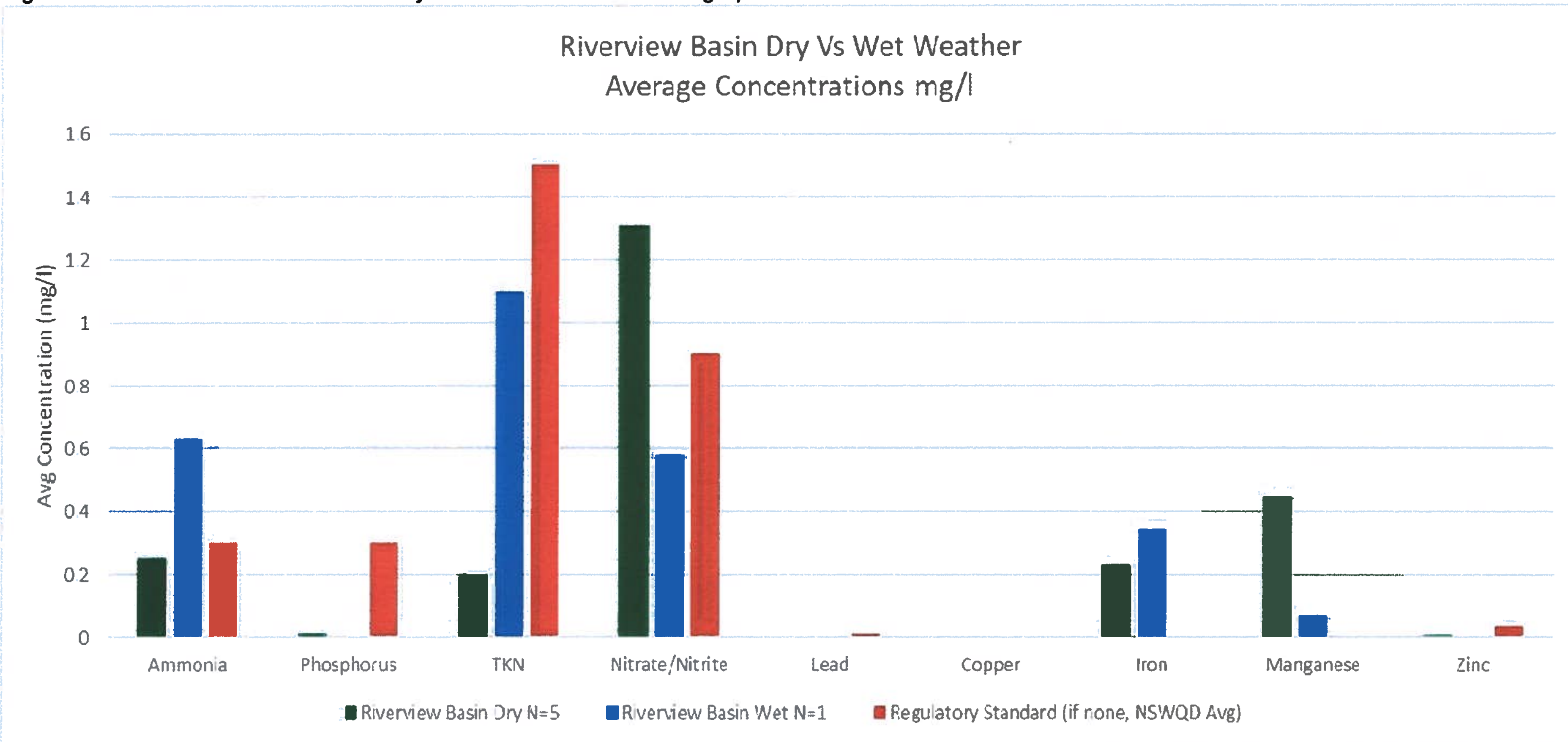
(2) Data retrieved from SC DHEC Water Classification & Standards Regulation 61-68 published June 26, 2020.

Notes: Aq = aquatic life, HH = human health, CMC Aq = Criteria Maximum Concentration for aquatic life, CCC Aq = Criterion Continuous Concentration for aquatic life, I = instantaneous result, Avg = average

(3) Pitt, National Stormwater Quality Database 2004, wet weather sampling base on land use (range is Open Space, Residential, Commercial, Industrial and Freeway concentrations)

This page intentionally blank.

Figure 11.1: Riverview Basin Data - Dry Vs Wet Weather Results graph



This page intentionally blank.

12.0 Conclusions & Path Forward:

12.1 Water quality

Based on the water quality sampling results overall for the North Augusta watershed, the data indicate an improvement in water quality as compared to earlier data. Statistical analysis of the data is complicated by the fact that there are a small number of samples per basin and the gap in time between sample events. This report is to share the basic information that has been gathered and is an overview of the results. Further studies of the data generated from the stormwater monitoring program will be compiled in subsequent reports that are more technical than we present here.

Based on the amount of pollutant loads physically being removed from the storm sewer system throughout the city's drainage area, we sense that it is the most likely reason the water quality within the city has improved from the baseline assessment. Overall we have removed nearly 4,700 tons of materials from storm drains, drainage ways, streets, and ponds. Table 12.1 is provided so that you can see exactly what the community and city has accomplished in pollutant reduction during the study period. This information shows the significant progress that the city has made in removing pollutants from the streets, drains and streams since the program was fully developed. We have also accomplished great strides in reaching out to the public to participate in our activities to remove potential sources from the community in a safe way. We have stayed on top of our construction projects to prevent sediment, chemicals and trash from those areas from reaching the streams or storm systems in the city. And most importantly, we have used our limited resources to reach out and educate citizens of every age to join us in improving water quality in North Augusta and beyond.

Table 12.1 Activities by the SWMD to reduce pollution in the watershed 2007-2020

2007-2020 North Augusta Water Quailty Activiites	**Total**	
Storm drain cleaning (tons removed)	544.62	Tons
Number of drains cleaned	5444	Drains
Street Sweeping (tons removed)	3929.58	Tons
Hazardous Waste Collection	112.13	Tons
Hazardous Waste Participants (cars only)	1630	Cars
Litter pick up program (streets) tons	134.65	Tons
Pipes repaired (linear feet)	6559	Linear Ft
Ponds cleaned (records from 2019, tons removed)		
Construction	**Total**	
SW Construction Permits Issued	233	Permits
Construction Inspections	6188	Inspections
Percent Pass	82%	Passed
Percent Fail	18%	Failed
Education and Outreach	**Total**	
In-person Public Outreach Totals (Brick Pond Park)	22711	participants
Stormwater Newsletters to all residents	362100	newsletters
Public Participation Totals	15898	participants

Going forward, water quality sampling will continue. Over the next 10 years, the sampling will be conducted to collecting stronger information about storm events versus dry weather events during seasons. That information it will be used to look at the bigger picture. The first round of sampling started earlier this year. All of the data generated will provide a clearer picture of the concentration of pollutants that enter our storm system during rain events and that are there naturally.

In addition to that, our storm system monitoring program is stronger than ever with electronic tracking capabilities to verify every box is observed, cleaned or repaired on a schedule. Our education program will continue with exciting new changes and ideas for citizen involvement. The stormwater program is planning and gearing up for an adopt a stream program in the community to get volunteers to join us on sampling event days. A training event is being scheduled to bring citizens closer into the process in this program. We are excited to be working closely with citizens.

12.2 Stream integrity:

Excessive flows of rainfall after long periods of drought wreak havoc on our stream channels mostly because of the topography we enjoy. Most of our drainage has a significant fall to reach the Savannah River. But some situations are manmade due development that took place long ago when detention was not considered. SC DOT roadways have little detention and those conveyances are all involved in the transport of the storm water in our community. We also have stormwater connections that we are not in control of located within Aiken County's jurisdiction. As the city has grown, so have the problems associated with these mixed systems. We are working together to discuss the bigger issues such as Pole Branch and some of the downtown problems. But like the city, all agencies are struggling for funds to address the problems. This report is to open up that conversation to the citizens as well. We have problems with our drainage ways and several streams. The solutions to these problems are expensive and are costly to the citizens of this community.

But, we have made progress across the city. We continue to monitor, map, inspect and repair our infrastructure. We continue to respond immediately to citizen notifications of problems and fix them as soon as possible. We also have concentrated on finding solutions and resolving stormwater infrastructure issues. We have a list of projects that we have prioritized and tackle as funds become available. In 2020, we were finally able to resolve a large project in Lynnhurst Subdivision to alleviate flooding from undersized pipes along Bunting Drive. We have been relining or replacing failing storm pipes throughout the community. We have shored up drainage ways that were failing and threatening sewer or water lines located nearby.

There are solutions, but they are expensive and involve private property owners, different agencies and in some cases counties, as well as the public. As the city continues to grow, it is important that we take the time to look at the problems, put them higher on our priority lists. The projects are many and we tackle them as the funding becomes available. We are looking at the information we have gathered on basin integrity and are going to focus more efforts on identifying what problems can be resolved and what will it take to resolve others and plan to make that happen. We intend to form strong alliances and partnerships where necessary to work toward that goal and acquiring coalitions and funding to achieve it.

12.3 New Basin Rankings based on Water Quality and Basin Integrity

Table 12.2 2021 Stream Water Quality and Physical Assessment Rankings

Basin	Priority	Previous Ranking (baseline 2007)	Water Quality (Rating 2021 overall)	Stream/Channel Integrity (Upper to lower Reach)	Improvement Yes / No or Same	Overall Rating 2021 (based on water quality and integrity)
Mims Branch	1	Excellent	Excellent	Excellent	Same	Excellent
Crystal Lake	1	Poor	Good to Fair	Fair to Poor	Yes (WQ)	Fair
Fox Creek	2	Good	Good to Excellent	Excellent to Good	Same	High to Good
Pole Branch	1	Poor	Good	Poor	Yes (WQ)	Fair
Hammond Hills	1	None	Good	Poor	N/A	Fair
Pretty Run	1	Poor	Good	Poor to Good	Yes (WQ)	Fair
Waterworks	1	Poor	Good to Fair	Poor	Yes (some WQ)	Poor
Womrath	3	Poor	Good	Poor	Yes (WQ)	Poor
Riverview	2	Fair	Good	Good to Fair	Same	Fair
River Bluff	3	Good	Good	Excellent	Same	Good
Franklin Branch	3	N/R	Good (limited data)	Wetland seeps at headwaters, Good	None	Good
Arrow Wood	2	N/R	Good	Good	None	Good
Horse Creek *(99% of basin outside city)*	3	N/R	SCDHEC TMDL/303D	Good: lower margins in city limits	None	NR
Willow Springs *Mostly outside city*	3	N/R	Not sampled	No problems observed	None	Good
Storm Branch	3	N/R	Storm water only	Dry	None	NR
Hamburg	2	N/R	Not sampled - wetlands	Good to excellent – wetlands	None	Good to Excellent
Atomic	NR	N/R	Not sampled - wetlands	Good to excellent	None	Good to Excellent
Campbell Town	2	N/R	Not sampled – storm water only	Good, mostly pipes from one street & soccer field	None	No problems observed
Little Horse Creek *(outside City)*	NR	N/R	Not sampled –	Good to Excellent observed full reach	None	Good to Excellent

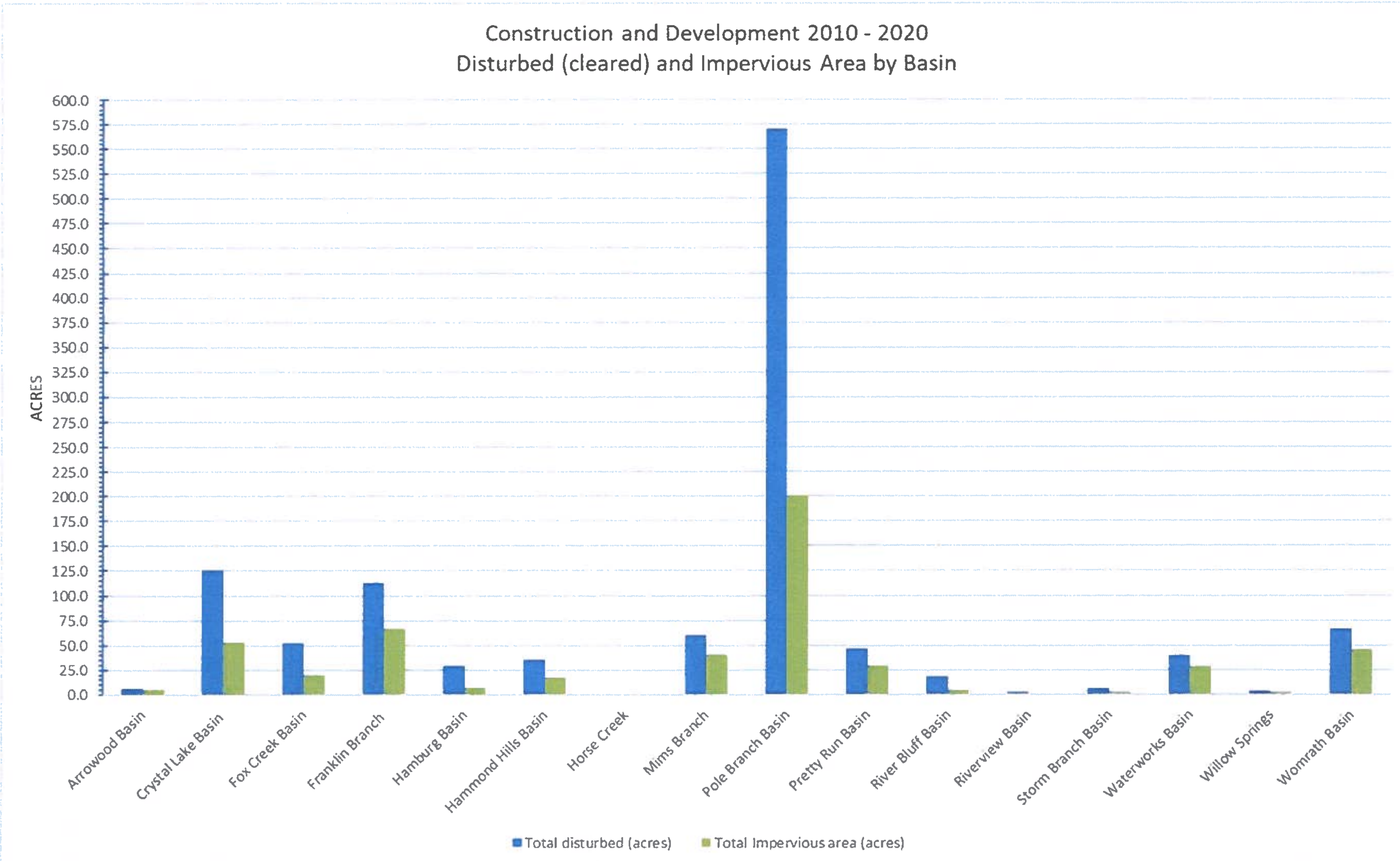
12.4 Land Use & Development within the Basin

Land Use Estimates developed vs undeveloped by basin (very ruff estimates, google earth only)

Basin	type	Pct	ac
Pole Branch	woods	24%	1100
	develp mix	76%	3467
	Total	100%	4567
Ham Hills	woods	22%	90
	devel res	78%	320
	Total	100%	410
Fox Creek	woods	71%	3358
	dev res	29%	1341
	Total	100%	4699
Waterworks	woods	13%	152
	developed res mix	63%	767
	commercial	24%	289
	total	100%	1208
Womrath	woods	55%	1182
	developed mix	45%	961
	total	100%	2143
Riverview	woods	20%	45
	developed res	80%	175
	total	100%	220
Riverbluff	woods	50%	219
	devel resid	50%	221
		100%	440

Pretty Run	woods	34%	619
	develop mixed	58%	1056
	commercial	8%	136
		100%	1811
Crystal LAKE	woods	19%	109
	develop mixed	81%	475
	Total	100%	564

Figure 12.1 Construction & Development – Estimated Disturbed and Impervious Acres by Basin 2010-2020



Intentionally left blank.

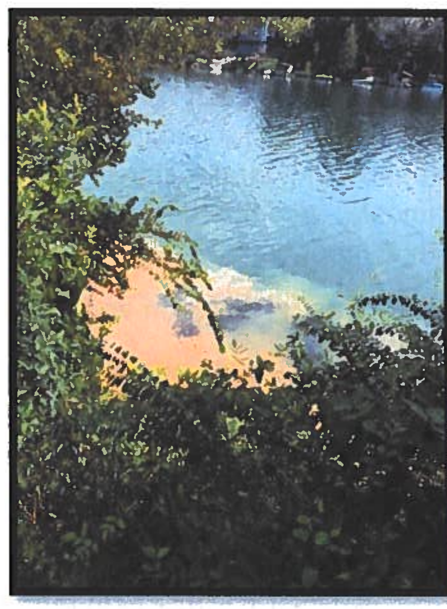
Appendix A: Water Quality Sampling Methods & Specifics:

Field parameters (instant measurements)

- **pH**: A measure of acidity of the water. Seven (7) is neutral. Concentrations less than seven (7) are acidic and numbers over seven (7) are alkaline. Water is generally neutral (6.0-7.5) but black water streams are commonly more acidic (4.5 to 5.9).

- **Temperature**: is taken as a measure due to its relationship dissolved oxygen (the solubility of oxygen decreases as water temperature increases).

- **Dissolved oxygen (DO)**: The concentration of molecular oxygen (O_2) dissolved in water. The DO level represents one of the most important measurements of water quality and is a critical indicator of a water body's ability to support healthy ecosystems. DO gets in water by diffusion from the surrounding air; aeration of water that has tumbled over falls and rapids; and as a waste product of photosynthesis. Levels above 5 mg/L are considered optimal, and most fish cannot survive for prolonged periods at levels below 3 mg/L.



- **Turbidity**: Turbidity of water (the opaqueness) is caused by suspended matter such as clay, silt, finely divided organic and inorganic matter, soluble organic compounds, and plankton or other microscopic organisms. The test measures the light that can pass through the solution, the less light, the higher the turbidity. In streams, a major cause of elevated turbidity is disturbed and eroding soils carried by storm run-off to streams. Other causes can be high concentrations of nutrients that lead to algal blooms, where algae are the source of the problem. Once in the stream system, elevated turbidity reduces the depth of photosynthesis and the feeding ability of aquatic organisms.

- **Residual chlorine (Cl_2)**: Chlorine is used to clean water (disinfect) for human use. Residual chlorine tests help to indicate whether drinking water, wastewater or other chlorine containing water is discharging into a stream. If found, it is most likely coming from a human source (home or commercial facility leaks or discharges).

The remaining samples are analyzed by independent laboratories for concentrations of a variety of constituents. The city uses the same routine sampling methods and analyzes for the same parameters as the South Carolina Department of Health and Environmental Control (SCDHEC) ambient stream monitoring program.

- **Total Suspended Solids (TSS)**: Like turbidity, the causes of high TSS are generally from disturbed soils, erosion from construction sites or other work areas during rainfall or embankment failures along a stream due to high velocity storm flows. The TSS test measures the actual concentration of suspended solids within the water. We conduct TSS tests after heavy storms to determine what background concentrations are (general concentrations during a storm) so we have that information if needed. There are other times when we may have a large impact and need this information during our investigations to determine specific impacts from a source. We can do this test in the water lab or send it off for analysis.

Nutrient concentrations analyzed.

Nutrients are substances that provide food or nourishment, such as usable proteins, vitamins, minerals or carbohydrates and can be studied by looking at nitrogen compounds in a water body. Too many nutrients in streams can case health and environmental problems including increased algae and depletion of oxygen due to the upset in the ecosystem balance.

Understanding Total Nitrogen:

There are three forms of nitrogen that are commonly measured in water bodies: *ammonia*, nitrates and *nitrites*. Total nitrogen is the sum of total Kjeldahl nitrogen TKN (ammonia, organic and reduced nitrogen) and nitrate/nitrite. It can be derived by monitoring for organic nitrogen compounds, free - ammonia, and nitrate - nitrite individually and adding the components together. An acceptable range of total nitrogen is 2 mg/L to 6 mg/L although standard vary geographically. (US EPA, Fact Sheet).

In other words, Nitrogen and other constituents have the following relationship;

Total Nitrogen is defined as the sum of organic nitrogen, nitrate, nitrite, and ammonia:

Total N = Organic (N + NO_3^- - N) + (NO_2^- - N + NH_3 - N)

N = Nitrogen

NO_3^- -N = Nitrate nitrogen,

NO_2^- -N = Nitrite nitrogen, and

NH_3 -N = Ammonia nitrogen

By definition, TKN, a component of total nitrogen, is the sum of organic nitrogen and ammonia. Therefore, the above equation may be re-written as:

Total N = TKN + NO_3^- - N + NO_2^- - N

Nutrient Tests:

- **Ammonia (NH_3)**: Natural ammonia gas is formed by the action of bacteria on proteins and urea (animal and human urine components). Manmade ammonia is made from hydrogen and nitrogen. Ammonia is used as a cleaning agent in many homes and businesses. It is also rich in nitrogen, so it makes an excellent fertilizer. Ammonium salts are a major source of nitrogen for fertilizers. Ammonia levels greater than approximately 1 mg/L usually indicate polluted waters. Sustained levels higher than 2.0 will kill most fish. Ammonia in waters with a higher pH and with warmer temperature makes it more toxic. It is much more toxic to fish and aquatic life when water contains very little dissolved oxygen and carbon dioxide.

- **Phosphorus**: Phosphorus is the most abundant mineral in the world and is required for life for most organisms (plant and animal). Generally, normal levels are less than about 0.03 mg/l. Higher levels in freshwater systems can cause an imbalance (more nitrates) that could lead to algal blooms, eutrophication, and lower dissolved oxygen concentrations, ultimately creating an inhospitable environment for many living organisms. There are many natural sources of phosphorus including phosphate rocks and disturbance of bottom sediments that hold phosphorus. High phosphorus levels could be a result of sewage, wash-water (detergents) or other illicit discharges to a stream.

- **Nitrate/nitrite (N)**: Nitrite and Nitrate are forms of the element Nitrogen, which makes up about 80 percent of the air we breathe. Inorganic nitrogen may exist in the free-state as a gas, as *ammonia* (when combined with hydrogen), or as nitrite or nitrate (when combined with oxygen). Nitrites are relatively short-lived because they are quickly converted to nitrates by bacteria. Nitrites produce a serious illness (brown blood disease) in fish, even though they don't exist for very long in the environment. Nitrate is a major ingredient of fertilizer and is necessary for crop production. When it rains, varying nitrate amounts wash from the landscape as lawn fertilizer run-off, leaking septic tanks, manure from animals (including fish and birds) and discharges from car exhausts.

  Together with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream. This, in turn, affects dissolved oxygen, temperature, and other indicators. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L) or higher) under certain conditions. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L) (EPA).

- **Total Kjeldahl Nitrogen (TKN)**: TKN measures the organic portions of total nitrogen in the water. High measurements of TKN typically can indicate sources such as sewage or manure discharges to water bodies. The Kjeldahl method of nitrogen analysis is the worldwide standard for calculating the protein content in a wide variety of materials ranging from human and animal food, fertilizer, waste water and fossil fuels.

- **Biological Oxygen Demand (BOD)** BOD is a laboratory measure of the amount of dissolved oxygen that is demanded by aerobic biological organisms (bacteria). It measures biological organic material that is present that utilizes the oxygen that is there. The amount of oxygen consumed by these organisms in breaking down the waste is known as the BOD of the sample. Aeration of stream water by rapids and waterfalls, for example will accelerate the decomposition of organic and inorganic material. Therefore, BOD levels at a sampling site with slower, deeper waters might be higher for a given volume of organic and inorganic material than the levels for a similar site in highly aerated waters. BOD directly affects the amount of dissolved oxygen in rivers and streams. The rate of oxygen consumption in a stream is affected by a number of variables: temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low dissolved oxygen: aquatic organisms become stressed, suffocate, and die (information from USEPA).

- **Chemical Oxygen Demand (COD)** COD is a measure of soluble organic matter present in the water. This tests looks at all compounds that can be chemically oxidized, not just biological. This test is more useful in stormwater sampling. Results of this test can provide additional information about stormwater influences on a waterbody. Sources that create higher COD in streams can include residual food wastes in bottles and cans, emulsified oils, antifreeze and others. For instance, COD concentrations in beer can be as high as 100,000 mg/l.

Hardness & Metal concentration sampling with pollutant sources:

- **Hardness**: Natural freshwaters are characterized as being "hard" and "soft". Extremely soft water is almost like distilled water with low concentrations of dissolved chemicals. You might find such water in a high mountain lake or stream. Extremely hard water – typical in arid regions – is full of minerals due to high evaporation rates that concentrate chemicals in the water (M. Pace, 2018). As rainfall levels decrease over time, hardness levels increase due to the slowing of the stream's flow and the dissolved metals in the water being allowed to settle in place. Stream flow and hardness levels have an indirect relationship (USEPA 2000). Other studies across the world have found the similar results also.

- **Copper:** copper occurs naturally, but it can also found in waste dumps, waste water, combustion of fossil fuels and wastes, plumbing and brass water fixtures, fungicides, wood production, phosphate fertilizer production, and natural sources (for example, windblown dust, from native soils or decaying vegetation). The concentration of copper in lakes and rivers ranges from 0.5 to 1,000 ppb (0.0005 to 1 mg/l) with an average concentration of 10.0 ppb (0.01 mg/l). The average copper concentration in groundwater 5.0 ppb (0.05 mg/l) is similar to that in lakes and rivers; however, monitoring data indicate that some groundwater contains levels of copper up to 2,783 ppb (2.783 mg/l) that are well above the standard of 1,300 ppb (1.3 mg/l) for drinking water. (2015 Agency for Toxic Substances and Disease Registry ATSDR, CDC Atlanta).

- **Manganese:** can occur in municipal wastewater discharges, pesticides, sewage sludge, mining and mineral processing, emissions from alloy, steel, and iron production, combustion of fossil fuels, and, to a much lesser extent, emissions from the combustion of fuel additives

- **Iron:** Iron is the fourth most abundant element, by weight, in the earth's crust. Natural waters contain variable amounts of iron depending on the geological area and other chemical components of the waterway. Iron in groundwater is normally present in the ferrous or bivalent form [Fe++] which is soluble. It is easily oxidized to ferric iron [Fe+++] or insoluble iron upon exposure to air. This precipitate is orange-colored and often turns streams orange. Iron bacteria undergoes an oxidation process (change their compound structure) to fulfill its energy requirements. This involves changing ferrous iron (Fe^{2+}) into ferric iron (Fe^{3+}). This process makes the iron insoluble and produces the rust-colored slimy deposit in stream beds. The current aquatic life standard is less than 1.0 mg/L based on toxic effects. (It is not calculated based on hardness). (Brian Oram, PG).

- **Lead:** Lead can be found naturally in the environment especially within our area near the fall line (SCDHEC, Lead in Surface Waters) but also can be released by: industrial sources and/or contaminated sites, deteriorating lead-based paint on the walls, doors and windows of a home, paint (pre-1978), used car batteries; open burning of waste, lead-containing pipes, faucets, and welding/soldering materials frequently found in the plumbing of older buildings, past use of lead gasoline (contaminated soils), second hand smoke, candles (leaded wick). The level considered protective for aquatic life at a hardness of 100 is less than 0.003 mg/L. Use as a domestic water source requires less than 0.05 mg/L. Drinking water must contain less than 0.015 mg/L (Brian Oram, PG).

- **Zinc:** Three important sources of zinc input into surface water are metal manufacturing, domestic waste water, and atmospheric fallout. Urban runoff, mine drainage, and municipal and industrial effluents are smaller but more concentrated sources of zinc in water. Davis et al. (2001) estimated the zinc loadings in urban storm water runoff. Buildings and automobiles (tires with zinc construction) were found to contribute 95% of loadings (0.646 kg/ha/year) to storm water runoff in urban environments. Researchers report a frequency of detection for zinc of 95%, with a concentration range of 0.01–2.4 mg/L (Cole et al. 1984). Agency for Toxic Substances and Disease Registry ATSDR, CDC Atlanta. Criteria for aquatic life has been set at less than 0.106 mg/L based on hardness of 100 mg/L.

- **Other heavy metals**: Mercury, nickel and cadmium sampling is only being conducted as needed. In earlier sampling events, the city tested for nickel and cadmium. These metal tests were discontinued since none was ever observed. They will be used if necessary during an illicit discharge investigation in a stream where they could be possible.

Additional Tests; Pesticides/Herbicides and Volatile Organics:

Several sample events were conducted to identify if other pollutants that may be present in streams. These tests are run on 24-hour composite samples at least once in a sub-basin and are also run when suspected:

- **Pesticides**: Chemicals used to kill or deter insects.
- **Herbicides**: Chemicals used to kill or deter plants.
- **Volatile organic compounds (VOCs).** These compounds are commonly found in gasoline and solvents. They are harmful to aquatic life.

Investigations of illicit discharges can require additional tests depending on the source of the illicit discharge.

Understanding terms within the tables:
Within various tables throughout the document, several terms or acronyms are given regarding standards. A brief overview of these terms or acronyms is given below as described in SCDHEC's Water Classification & Standards R-61-69, July 2004.

Criteria Maximum Concentrations – (CMC) The criteria maximum concentration is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect.

Criterion Continuous Concentration – (CCC) The criterion continuous concentration is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect.

The CMC and CCC are just two of the six parts of aquatic life criterion; the other four parts are the acute averaging period, chronic averaging period, acute frequency of allowed exceedance, and chronic frequency of allowed exceedance.

Physical Stream Assessments

In 2021, this report looks at physical stream assessments based on known problems and issues only. We did not conduct the same level of testing as described below for the basins. During the next 10 year cycle, many more basin assessments are planned that will look at this issue using the methods described below.

In 2003, initial strategies were developed to investigate the physical integrity of streams located in North Augusta. Several protocols for conducting stream assessments were investigated. They are listed below:

- The National Resource Conservation Service (NRCS) - Stream Visual Assessment Protocol, 1998 NWCC Technical Note 99-1
- The Rapid Stream Assessment Technique (RSAT) Evaluation Method
- EPA Rapid Bio-assessment Protocols Habitat Assessment

Using these techniques as a guide, the SWMD developed a simplified form for use in the field to conduct these investigations. The form includes a section to describe the drainage area, owner, land uses of the area, and physical conditions at the site. A site diagram is included through a GIS mapping system to identify the location of the investigation and the part of the stream assessed (reach). The site is scored on physical conditions including channel condition, hydrologic alteration, riparian zone, bank stability, water appearance, nutrient enrichment, barriers, and fish cover. The resulting overall score can determine if the conditions at the stream segment are Poor, Fair, Good, or Excellent. A more comprehensive assessment that includes a habitat assessment (macro-invertebrate) was conducted at several locations. The protocols for these assessments are included when questions pertaining to the simplified form arise. All assessments include photographs of the site at the time of the evaluation and at subsequent visits to the sites.

Streams are rated on the following criteria:

Features	Scoring Range
Channel Condition	10 – 1 (10 being best)
Bank Stability	10 – 1 (10 being best)
Barriers to Fish Movement	10 – 1 (10 being best)
Riffle Embeddedness (fine sediments in riffle habitat)	10 – 1 (10 being best)
Hydrologic Alteration	10 – 1 (10 being best)
Water Appearance	10 – 1 (10 being best)
In-stream Fish Cover	10 – 1 (10 being best)
Macro-invertebrates Observed	10 – 1 (10 being best)
Riparian Zone Condition	10 – 1 (10 being best)
Nutrient Enrichment	10 – 1 (10 being best)
Insect/invertebrate habitat	15 – -3 (-3 being worst)

Once these conditions are scored, the overall resulting score is calculated. Ratings for stream condition are determined by the following overall scores:

Overall Score	Rating
0 – 6.0	Poor
6.1 – 7.4	Fair
7.5 - 8.9	Good
9.0 and up	Excellent

Data collected is logged into a database and printed in a binder in the SWMD records department. The data is also stored in the Alchemy information management system that the city maintains.

This page is intentionally left blank.

Calculation of Metrics

1. Density- Is the relative abundance of animals in a sample.

Calculation: Number of animals in subsample / proportion of sample processed.

Example : 300 animals picked / 0.25 (or one quarter of sample picked) = 1200 animals/sample

2. Richness- Species richness is the number of species in a sample unit.

Calculation: Richness is the total number of distinct taxa identified in a sample. Note immature larva identified to family or genus are not considered a distinct new taxa if a genus or species identification is determined within its group.

Example :

Taxon	# orgs Rep 1	# orgs Rep 2
Ephemerellidae Ephemerella sp	2	0
Ephemerellidae Ephemerella dorothea	3	4
Ephemerellidae Ephemerella invaria	0	2
Richness =	1	2
Mean Richness =	1.5	

3. EPT Index- The EPT index is a subset of the above richness measure. It is the number of species in the sample in the generally more environmentally sensitive orders Ephemeroptera, Plecoptera, and Trichoptera.

Calculation: The number of distinct taxa identified in a sample from the insect orders Ephemeroptera, Plecoptera, Trichoptera. Note same rules apply as above for richness in determining number of distinct taxa.

4. EPT/EPT & Chironomidae - Is a measure of the ratio of the abundance of the intolerant EPT orders to the generally tolerant Diptera family Chironomidae.

Calculation: The number (abundance) of animals from the orders Ephemeroptera, Trichoptera and Plecoptera, divided by the above plus the number of Chironomidae.

5. % Oligochaeta - Is a measure of the percent of the macroinvertebrate community made up of the Order Oligochaeta.

Calculation: The number (abundance) of Oligochaeta divided by the total number of animals in sample.

6. Percent Model Affinity of Orders - (PMA-O) Is a measure of order level similarity to a model based on the reference streams Novak and Bode (1992).

Calculation: Determine the percent composition for each major group - Coleoptera, Diptera, Ephemeroptera, Plecoptera, Trichoptera, Oligochaeta, Other. Compare to the "Model" for the appropriate stream community (see below), then add up the lower of the two values for each of the groups (assessment site vs Model), this is the PMA-O for the assessment site.

PMA-O = • •min (X_a or X_r)

Where: X_a = the percent composition of order X from the assessment site;

X_r = the percent composition of order X from the appropriate reference condition;

Example:

Percent Composition Major Grps	Assessment Site % Comp	Model for MMC (Medium Mt)
Coleoptera	20	**6**
Diptera	55	**18**
Ephemeroptera	**10**	34
Plecoptera	**2**	8
Trichoptera	**3**	33
Oligocheata	10	**0.5**
Other	**0**	0.5
PMA-Orders =	39.5 rounded = 40.0	

7. Hilsenhoff Biotic Index- BI (0-10) - Is a measure of the macroinvertebrate assemblage tolerance toward organic (nutrient) enrichment Hilsenhoff (1987). In many ways this index is both an indicator taxa metric and functional group metric, since those taxa which become more dominant in moderately enriched streams are those which are taking advantage of shifts in the available food base in the stream.

Calculation : Multiply the number of individuals of a taxon by its assigned tolerance value, see VTDEC BI values, modified from Hilsenhoff 1987, and Bode 1996. Total all these products, and divide by the total number of individuals <u>of each taxon assigned a tolerance value</u>. This is the Bio Index value.

$$HBI = \bullet \bullet \frac{n_i a_i}{N}$$

Where:"n" is the number of individuals of the "i"th taxon;

"a" is the index value of that taxon;

N is the total number of individuals in the sample assigned a Bio Index Value

Example :

Taxon	Count	BI Tolerance Value	Subtotal Ct × BI
Ephemerllidae imm	(10)	NA	NA
Ephemerella sp	**10**	4	**40**
Ephemerella needhami	**10**	1	**10**
Plecoptera Leuctridae imm	**20**	0	**0**
Diptera Cricotopus bisinctus	**5**	6	**30**
Trichoptera Symphitopsyche alhedra	**10**	3	**30**
Trichoptera Symphitopsyche sp	**5**	5	**25**
Totals	***60***		***145***
Site Bio Index Value	145 ÷ 60 = ***<u>2.42</u>***		

8. Pinkham-Pearson Coefficient of Similarity - Functional Groups - (PPCS-F) - Is a measure of functional feeding group similarity to a model based on the reference streams. It is similar in concept to the **PMA-O** in that a site is compared to a model of the composition of the functional feeding groups as opposed to order level taxonomic changes. Also the Pinkham Pearson Coefficient of Similarity (Pinkham1976) was used as the similarity index.

Calculation: At the assessment site determine the percent composition of the six major functional groups (Collector Gatherer, Collector Filterer, Predator, Shredder-Detritus, Shredder-Herbivore, Scraper) as assigned by VTDEC after Merrit and Cummins 1996, Bode 1996. For each functional group determine the product (min/max) between the assessment site vs the Model for the stream community sampled. Add these products and divide by six (# of functional grps). This is the PPCS-F.

$$PPCS\text{-}F = 1/k \cdot \sum_{I=1}^{K} \text{minimum}(xia, xib)/\text{maximum}(xia, xib)$$

Where: k = the number of comparisons between stations (6)

xi = the number of individuals in functional group I

a, b = site a, site b

Example :

Functional Group	Assessment Site % Comp	"Model" for MMC	Product (min/max)
Collector .Gatherer	68	32	0.47
Collector Filterer	10	30	0.33
Predator	2	13	0.15
Shredder - Detritus	0	4	0.00
Shredder - Herbaceous	16	1	0.06
Scraper	2	13	0.15
PPCS-F =			**0.19**

Appendix B: Data & Analysis

Table B.2.: Pretty Run Raw Data - 2015-2020 REGULATORY SAMPLING FOR BACTERIA (*E. COLI*)

Date (order)	Grab Time	pH	DO	Temp	Detergent Test (chemetrics)	E. Coli 100ml	DNA Source Tracking	Optical Brightener Test (black light)	Turb/tss	Ammonia	Nitrite/ Nitrate	Lead	TKN	Phosphorus
7/20/2015	11:30	4.21	8.25	25.8	Low Level Detergent = 0	261								
7/20/2015	11:30	-	-	-	-	0								
7/20/2015	12:07	6.68	9.07	24.6	Low Level Detergent = 0	517								
7/20/2015	12:15	6.56	9.6	24.7	Low Level Detergent not tested	387								
7/20/2015	12:40	6.44	7.37	23.4	Low Level Detergent = 0	172								
7/20/2015	12:40	6.44	7.37	23.4	Low Level Detergent = 0	185								
7/20/2015	12:50	-	-	-	-	-								
7/21/2015	11:28	7.28	7.51	26.1	Low Level Detergent = >0 and < 0.25	1120								
7/21/2015	12:05	7.16	6.04	24.8	Low Level Detergent = 0	179								
10/27/2015	12:25	7.3	7.65	13.3		>2419								
10/27/2015	12:50	7.4	9.61	15.7		>2419				ND	0.13		0.94	0.14
10/27/2015	12:59					>2419								
10/27/2015	12:55	6.86	10.35	16.3		>2419				0.13	0.088		1.2	0.18
10/27/2015	13:25	8.3	10.9	16		>2419								
10/27/2015	13:25					0								
10/27/2015	13:25					>2419								
10/27/2015	14:18	7.53	10.3	16.5		>2419				0.22	0.1		0.52	0.053
10/27/2015	14:50					>2419				ND	0.21		0.72	0.032

Table B.2.: Pretty Run Raw Data - 2015-2020 REGULATORY SAMPLING FOR BACTERIA (*E. COLI*)

Date (order)	Grab Time	pH	DO	Temp	Detergent Test (chemetrics)	E. Coli 100ml	DNA Source Tracking	Optical Brightener Test (black light)	Turb/tss	Ammonia	Nitrite/ Nitrate	Lead	TKN	Phosphorus
10/27/2015	15:20	6.87	9.2	16.9		>2419								
11/3/2015	14:50	6.99	9.36	19.2	0	1300								
11/3/2015	15:40	6.51	9.4	19.3	0	816								
11/3/2015	15:59	-	-	-		488								
2/16/2016	11:22 a.m.	8.5	9.1	12.1		689								
2/16/2016	12:02	-	-	-		81								
2/16/2016	12:05	-	-	-		75	Human - Pos Ruminant - Pos							
2/16/2016	12:05	-	-	-		187	Human - Pos Ruminant - Pos							
2/16/2016	12:35	7.26	10.3	12.2		211								
2/16/2016	12:38	7.26	9.46	13.4		534	Human - Neg Ruminant - Pos							
2/16/2016	12:38					0								
06/28/2016 -07/02/16	12:10							NEG						
06/28/2016 -07/02/16	12:25							NEG						
06/28/2016 -07/02/16	13:40							NEG						
06/28/2016 -07/02/16	14:10							NEG						
06/28/2016 -07/02/16	14:40							NEG						
06/28/2016 -07/02/16	15:10							NEG						

Table B.2.: Pretty Run Raw Data - 2015-2020 REGULATORY SAMPLING FOR BACTERIA (*E. COLI*)

Date (order)	Grab Time	pH	DO	Temp	Detergent Test (chemetrics)	E. Coli 100ml	DNA Source Tracking	Optical Brightener Test (black light)	Turb/tss	Ammonia	Nitrite/ Nitrate	Lead	TKN	Phosphorus
8/2/2016	11:00	7.22	6.93	24.4	Low level Deterg. = 0.0	1046								
8/2/2016	11:20	7.41	7.17	25.7	Low level Deterg. = 0.0	148				0.11	0.67		0.65	0.023
8/2/2016	11:25	7.15	7.17	25.7	Low level Deterg. = 0.0	921				nd	0.61		0.54	0.024
8/2/2016	11:25	-	-	-		0								
8/2/2016	11:50	6.4	7.21	26.8	Low level Deterg. = 0.0	2419				1.1	0.17		1.5	0.017
8/2/2016	12:21	7.28	7.17	27	Low level Deterg. = 0.0	1300				0.11	0.53		0.57	0.029
8/2/2016	12:21	7.28	7.17	27		1046								
8/2/2016	12:45	6.2	7.2	25.5	Low level Deterg. = 0.0	770				1.8	0.67		2.5	0.02
9/1/2016	15:30					461								
9/2/2016	15:30					816								
9/2/2016	13:15							NEG						
9/2/2016	12:53							NEG						
9/2/2016	10:05					>2419		NEG		0.16	0.25		0.71	0.16
9/2/2016	10:30					>2419		NEG		0.21	0.26		0.35	0.067
9/2/2016	10:50					>2419				nd	0.16		0.49	0.1
9/2/2016	10:50					>2419		NEG						
9/2/2016	12:10				COD=94.0 mg/l	>2419		NEG		0.17	0.44		1.6	0.19
9/2/2016	12:10					0								
9/2/2016	12:10					-				0.18	0.55		0.35	0.036
9/2/2016	12:53					>2419		NEG		nd	0.2		0.57	0.16
9/2/2016	13:15					308		NEG		nd	0.1		0.32	0.068

Table B.2.: Pretty Run Raw Data - 2015-2020 REGULATORY SAMPLING FOR BACTERIA (*E. COLI*)

Date (order)	Grab Time	pH	DO	Temp	Detergent Test (chemetrics)	E. Coli 100ml	DNA Source Tracking	Optical Brightener Test (black light)	Turb/tss	Ammonia	Nitrite/ Nitrate	Lead	TKN	Phosphorus
9/2/2016	13:25					1987								
9/2/2016	14:00					816				nd	0.27		0.44	0.11
2/23/2017	11:10					166.4								
2/23/2017	12:22					16	Hum - Rum -							
2/23/2017	12:40					137.6								
2/23/2017	12:40					0								
2/23/2017	12:45					150								
2/23/2017	12:49					101.4								
2/23/2017	13:10					770.1	Hum - Rum +							
2/23/2017	13:10					547.5								
2/23/2017	14:00					365.4	Hum - Rum -							
2/23/2017	14:22					150								
2/23/2017	14:25					325.5								
4/3/2017	13:09													
5/25/2017	10:57	6.6		19.3		574								
5/25/2017	11:00					0								
5/25/2017	11:39	5.7		20.4		23								
5/25/2017	12:00	6		19.8		488								
5/25/2017	12:16	6.51		20.6		517								
5/25/2017	12:49	6.86	7.6	20.4		411								
5/25/2017	13:25	7.02	10	20.7		449								
5/25/2017	13:46	7.06	7.6	20.3		866				0.36	0.34		0.64	0.025
5/25/2017	13:46	"	"	"		548								
2/8/2018	14:34	7.8	8.1		COD=16		Hum-, Anim+			0.11	0.72		0.47	0.015
2/8/2018	13:55	6.8	7.5		COD=12		Hum-, Anim+			0.22	0.59		0.53	0.028
2/13/2018	14:56	6.97	9.42		COD=ND	>2419	Hum-, Anim+			0.43	0.12		0.95	0.012

Table B.2.: Pretty Run Raw Data - 2015-2020 REGULATORY SAMPLING FOR BACTERIA (*E. COLI*)

Date (order)	Grab Time	pH	DO	Temp	Detergent Test (chemetrics)	E. Coli 100ml	DNA Source Tracking	Optical Brightener Test (black light)	Turb/tss	Ammonia	Nitrite/ Nitrate	Lead	TKN	Phosphorus
2/13/2018	15:30	7.01	9.09		COD=16	411	Hum-, Anim+			0.24	0.1		0.6	0.043
2/20/2018	15:23	7.11	8.68			222								
2/20/2018	15:10	7.11	8.9			84								
2/20/2018	15:20					158								
2/20/2018	15:24				dup	166								
2/26/2018	10:49	6.29	8.48			>2429								
2/26/2018	10:50	dup				>2419								
2/26/2018	11:35		7.73			>2419								
2/26/2018	13:38	7.26	9.67	100%		>2419								
2/26/2018	13:40	7.26	9.67	25%		4184								
2/26/2018	13:43	7.26	9.67	10%		3650								
5/6/2020	14:40	6.98	8.77	20.4		227.4								
5/6/2020	14:40	6.98	8.77	20.4		0								
5/6/2020	15:15	7.46	8.74	19.5		88								
5/6/2020	15:15	7.46	8.74	19.5		76.8								

Appendix C: Sample locations:

City of North Augusta Watershed Basin Sampling Stations

(all primary stations are numbered *01* are at the lowest point in that Basin, generally numbers move up as we go higher)

BASIN	**ID Name**	**Location Description**	**Coordinates (Lat)**	**Coordinates (Long)**
Arrow Wood Basin	NA-AW-01	Below Hammond Hill pond outfall, Greeneway, and River Oak Dr		
Crystal Lake Basin	NA-CL-01	End of Savannah Point Dr in Campbletown Landing	Lat 33°29'23.0309'N	Long 81°59'14.3328'W
Crystal Lake Basin	NA-CL-01a	Below railcar bridge Greeneway		
Crystal Lake Basin	NA-CL-02	At Buena Vista where stream crosses low side (Hannah Property)		
Crystal Lake Basin	NA-CL-06	Off Crystal Lake Drive in Hammonds Ferry below both outfalls near entrance (09/22/09)	Lat 33°29'24.86"N	Long 81°58'53.85"W
Crystal Lake Basin (in Brick Pond Park)	NA-HF-01	creek from natural spring to perched wetland	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-02	creek from natural springs above GW	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-03	West Pond Center of dam	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-04	East pond center of dam	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-05	SW collection area	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-05a	Storm pipe from GA Ave.	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-06	East pond south	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-07	East pond north	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-08	west pond south	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-09	west pond north	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-10	storm ditch to perched wetland	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-10b	outfallof perched sw box	North Augusta Brick Pond Park Sample Locations – Post Construction map	

BASIN	**ID Name**	**Location Description**	**Coordinates (Lat)**	**Coordinates (Long)**
Crystal Lake Basin (in Brick Pond Park)	NA-HF-11	perched storm pipe	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-12	pump area	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-13	perched	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-14	storm pipe from MB	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-15	small pond below CW	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-16	CW near dam	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-17	outlet to CW	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-18	Brick Pond Park outfall/ 280 Railroad Ave.	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-19	storm drain on GA	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-20	storm drain on Bluff	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-21	outfall to west pond north (culverts from HF)	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-22	outfall to west pond south (culverts from HF)	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-23	East Pond T	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Crystal Lake Basin (in Brick Pond Park)	NA-HF-24	East pond pavilion	North Augusta Brick Pond Park Sample Locations – Post Construction map	
Fox Creek Basin	NA-FC-01	Below Fireworks stand (Now Gregs Gas Plus) driveway off Martintown Rd. Parcel #106-00- 00-021	Lat 33°32'15.5594'N	Long 82°00'02.3130'W
Fox Creek Basin	NA-FP-01	At convergence of Fox Creek and Pole Branch Basins		
Hammond Hills Basin	NA-HH-01	HH Pool on left, turn right on Greeneway, 2 ponds on right	Lat 33°30'34.9339'N	Long 81°59'30.9520'W
Hammond Hills Basin	NA-HH-02	Merriwether & Stanton (next to Zeaser home)	Lat 33°30'22.31"N	Long 81°59'17.95"W
Hammond Hills Basin	NA-HH-03	Stanton Drive		

BASIN	ID Name	Location Description	Coordinates (Lat)	Coordinates (Long)
Hammond Hills Basin	NA-HH-06	Stream to river below Riverview Park behind Property Maint. Storage bldgs.	Lat 33 ° 30'12.05"N	Long 81o58'57.54"W
Hammond Hills Basin	NA-HH-06a	creek crossing at 629 Stanton Dr.		
Horse Creek Basin	NA-HC-01	Bridge at AikenPSA/Mayson Turf (aprox. 800 ft from Sav. River)	Lat 33°31'54.3591'N	Long 81°54'12.0144'W
Mims Branch Basin	NA-MB-01	Old Sudlow Lake Rd (creek)	Lat 33°30'26.05'N	Long 82°00'02.3130'W
Mims Branch Basin	NA-MB-02	At Road Crossing (4x4 wheelers dirt crossing) inside Blanchard Tract	Lat 33°32'35.48"N	Long 81°54'53.49"W
Mims Branch Basin	NA-MB-03	At power line crossing off of Old Sudlow Lake Rd near MB-01	Lat 33°31'56.80"N	Long 81°54'21.01"W
Pole Branch Basin	NA-PB-01	Bergen Road at Willow Wick	Lat 33°32'34.5374'N	Long 81°59'37.8097'W
Pole Branch Basin	NA-PB-01B	Bergen Road bridge next to Brighton Place	Lat 33°32'33.52'N	Long 81°59'06'95"W
Pole Branch Basin	NA-PB-02	Behind home at 418 Madison St. (behind Mossy Creek Elem)	Lat 33°32'22.02'N	Long 81°57'25.25'W
Pole Branch Basin	NA-PB-03	Below Knobcone Avenue across from Mckie property Farm	Lat 33°32'06.35'N	Long 81°59'03.68'W
Pole Branch Basin	NA-PB-5a	Downstream of PB01B as creek turns (below Wando Woodlands PH2a outfall)	On map	
Pole Branch Basin	NA-PB-BWPA1	NA Bergen West Pond A (Largest Pond built Ph I) Upstream (manhole in common area)	Lat 33°33'03.42"N	Long 81°59'04.74"W
Pole Branch Basin	NA-PB-BWPA2	NA Bergen West Pond A (Largest Pond built PH 1) downstream (at headwall outfall)	On map	
Pole Branch Basin	NA-PB-BWPB1	NA Bergen West Pond B (2nd Pond built Ph I) upstream as stream enters fence to pond	On map	
Pole Branch Basin	NA-PB-BWPB2	NA Bergen West Pond B (2nd Pond built Ph I) downstream prior to crossing access road to creek)	On map	
Pole Branch Basin	NA-PB-MH23A	Unnamed trib to Pole Branch where BWPA and BWPB discharge (below streams convergence at power line)	On map	
Pole Branch Basin	NA-PB-MP	Mckie Pond off Martintown	Not mapping this one	
Pole Branch Basin	NAPBWW	Below Willow Wick bridge at entrance to apartments (2011)	Lat 33°32'34.49"N	Long 81°59'36.91"W
Pretty Run Basin	NA-PR-02B	See Pretty Run Monitoring Plan	Final point before NAPR02 discharges with main channel.	
Pretty Run Basin	NA-PR-02SD	Storm Box on street above NAPR02		
Pretty Run Basin	NA-PR-03 HC	Channel upstream of NAPRHSP (Bolin Rd) (2011)	Lat 33°31'05.09"N	Long 81°58'42.84"W
Pretty Run Basin	NA-PR-04	Downstream of Halloweens (Bolin Rd, 1st house by Martintown)	Lat 33°31'05.27"N	Long 81°58'45.80"W
Pretty Run Basin	NA-PR-13	Creek behind Dove Street Dead end		
Pretty Run Basin	NA-PR-13SD1	Storm drain Dove Street (first on rt)		

BASIN	ID Name	Location Description	Coordinates (Lat)	Coordinates (Long)
Pretty Run Basin	NA-PR-13SD2	Storm drain Dove Street (second on rt)		
Pretty Run Basin	NA-PR-13SD3	Storm drain Dove Street (end of street)		
Pretty Run Basin	NA-PR-14	Siskin Circle behind house (dogs next door)		
Pretty Run Basin	NA-PR-14 KW	Sewer access road from Knollwood at Cascade Drive, where stream crosses access rd., rocks (57 stone) (2011)	On map	
Pretty Run Basin	NA-PR-14B	Siskin Circle storm box to creek		
Pretty Run Basin	NA-PR-14SD	Storm drain on Siskin Cir		
Pretty Run Basin	NA-PR-15	Pretty Run Creek behind home at 1800 Flamingo Road (Williamson)	Lat 33°31'05.92"N	Long 81°58'27.80"W
Pretty Run Basin	NA-PR-16	Off Robin Road		
Pretty Run Basin	NA-PR-16Di	Ditch leading to NAPR16		
Pretty Run Basin	NA-PR-16SB	Storm Box leading to NAPR16		
Pretty Run Basin	NA-PR-GA	behind Pizza Hut at Georgia Ave, and Five Notch Rd.		
Pretty Run Basin	NA-PR-HBP	Stream below Hammond Pond before trib with NAPRHP2 intersects		
Pretty Run Basin	NA-PR-HP	Stream below Hammond Pond		
Pretty Run Basin	NA-PR-HP2	Stream below Overlook IV behind homes		
Pretty Run Basin	NAPRHSP	Storm Pipe at Halloween's House (end of driveway) Bolin Road 1st house on right (2011)	Lat 33°31'05.62"N	Long 81°58'43.16"W
Pretty Run Basin	NA-PR-HSPpipe	Pretty Run storm pipe at Bolin near Martintown Rd		
Pretty Run Basin (formerly Rapids Basin)	NA-PR-01	Pretty Run Creek, Riverbluff Drive, service Rd on left by creek aka DHEC sample point RS-04544	Lat 33°31'01.7116'N	Long 81°59'22.9954'W
River Bluff Basin	NA-PR-RiB-02	By Overlook IV, ck behind house on 203 Blue Heron Lane	Lat 33°31'20.78"N	Long 81°59'49.13"W
River Bluff Basin	NA-RiB-01	Shoals Way at end (steps lead to creek) off of Barony Drive	Lat 33°31'16.1208'N	Long 81°59'59.4716'W
Riverview Basin	NA-RiV-01	Low side of stream to river at Riverview Park entrance near Hammonds Ferry Rd	Lat 33°29'48.31"N	Long 81°59'11.40"W
Riverview Basin (formerly Woodlawn Basin 1988)	NA-RiV-06 (not)Or HH-06 correct	Stream to river below Riverview Park behind Property Maint. Storage bldgs	Lat 33°30'12.05"N	Long 81°58'57.54"W
Storm Branch Basin	NA-SB-01	Power House Road crossing Storm Branch	Lat 33°30'43.8856'N	Long 81°55'41.4954'W
Waterworks Basin	NA-WW-02	Upstream of Golf Course in the creek at JL VFW	Lat 33°29'40.89"N	Long 81°58'03.72"W
Waterworks Basin	NA-WW-03	Upstream of golf course at spring in Maude Edenfield Park	Lat 33°29'29.60"N	Long 81°57'55.85"W
Waterworks Basin	NA-WW-04	Greeneway Bridge by Public Safety	Lat 33°29'22.62 N	Long 81°58'04.18"W
Waterworks Basin	NA-WW-04a	At pipe below parking lot of old Municipal Bldg.	Lat 33°29'26.01"N	Long 81°57'59.32"W

BASIN	ID Name	Location Description	Coordinates (Lat)	Coordinates (Long)
Waterworks Basin	NA-WW-05	Upstream of Golf Course at culvert by GW trail parking lot	Lat 33°29'15.97"N	Long 81°58'16.95"W
Waterworks Basin	NA-WW-06	Channel behind residence behind Wife Saver	Lat 33°29'33.37"N	Long 81°57'35.46"W
Waterworks Basin	NA-WW-07	Flow at spillway from golf course pond to ditch off Riverclub Lane	Lat 33°28'57.13"N	Long 81°57'47.88"W
Waterworks Basin	NA-WW-08	Sample taken from golf cart bridge that goes over the area that separates the wetland from the pond.	Lat 33°29'10.04"N	Long 81°58'07.05"W
Waterworks Basin (formerly City Hall 1988)	NA-WW-01	At Ditch on Shoreline Dr.	Lat 33°28'52.5332'N	Long 81°57'50.3401'W
Womrath Basin	NAWB01C	Aiken Road where stream crosses (close to Womrath) (2011)	Lat 33°30'06.82"N	Long 81°56'25.47"W
Womrath Basin	NA-WB-02	At Womrath Rd and Golf T-practice field	Lat 33°30'26.05"N	Long 81°56'46.70"W
Womrath Basin (Formerly Carolina Springs Basin 1988)	NA-WB-01	At TTX Bridge in front of plant	Lat 33°29'28.7978'N	Long 81°56'35.4559'W

This page is intentionally blank.

Appendix D: Special Studies & Additional Data

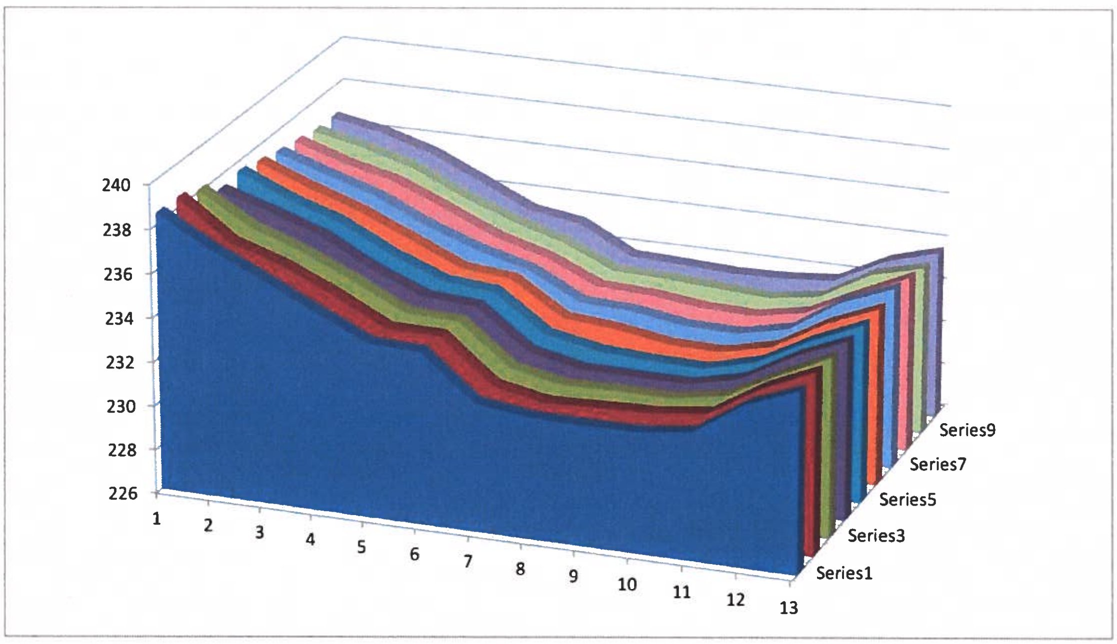
Pole Branch Basin

MH 21	MH Elev	244.48
	Rdg+	2.34
	Total	246.82

Segment B - Pole Branch Trib Study Survey

		a	b	c	d	e	f	g	h	i	j	k	l	m
upstream	**B1**	8.29	9.63	10.72	11.85	12.93	13.04	15.01	15.32	15.36	15.35	15.05	13.5	12.58
	B2	8.33	10.06	10.82	11.86	13.04	13.08	15.01	15.47	15.38	15.3	15	13.55	12.52
	B3	8.7	10.07	10.89	11.93	13.08	13.16	14.98	15.45	15.39	15.41	15	13.75	12.65
	B4	9.41	10.11	10.91	12.13	13.1	13.25	15	15.51	15.53	15.55	15.01	13.68	12.69
	B5	9.28	10.27	11.02	12.2	13.13	13.34	15	15.44	15.59	15.64	15.01	13.76	12.73
	B6	9.51	10.41	11.2	12.21	13.28	13.5	15	15.2	15.59	15.64	15.08	13.74	12.75
	B7	9.76	10.52	11.24	12.35	13.2	13.81	15.01	15.12	15.5	15.55	15.03	13.52	12.56
	B8	9.94	10.7	11.26	12.27	13.3	13.96	15	15.11	15.4	15.48	15.04	13.9	12.8
	B9	10.15	10.63	11.31	12.41	13.28	13.98	15.01	15.09	15.24	15.39	15.04	13.71	13.11
downstream	**B10**	10.19	10.6	11.32	12.38	13.46	13.81	15.06	15.16	15.28	15.22	15.01	13.8	13.14

B1	238.53	237.19	236.1	234.97	233.89	233.78	231.81	231.5	231.46	231.47	231.77	233.32	234.24
B2	238.49	236.76	236	234.96	233.78	233.74	231.81	231.35	231.44	231.52	231.82	233.27	234.3
B3	238.12	236.75	235.93	234.89	233.74	233.66	231.84	231.37	231.43	231.41	231.82	233.07	234.17
B4	237.41	236.71	235.91	234.69	233.72	233.57	231.82	231.31	231.29	231.27	231.81	233.14	234.13
B5	237.54	236.55	235.8	234.62	233.69	233.48	231.82	231.38	231.23	231.18	231.81	233.06	234.09
B6	237.31	236.41	235.62	234.61	233.54	233.32	231.82	231.62	231.23	231.18	231.74	233.08	234.07
B7	237.06	236.3	235.58	234.47	233.62	233.01	231.81	231.7	231.32	231.27	231.79	233.3	234.26
B8	236.88	236.12	235.56	234.55	233.52	232.86	231.82	231.71	231.42	231.34	231.78	232.92	234.02
B9	236.67	236.19	235.51	234.41	233.54	232.84	231.81	231.73	231.58	231.43	231.78	233.11	233.71
B10	236.63	236.22	235.5	234.44	233.36	233.01	231.76	231.66	231.54	231.6	231.81	233.02	233.68



MH 24	Elev	248.00	
	Rdg	1.98	
		249.98	actual elevation of point

Section-segment A Pole Branch Tributary Study Survey 3/4/2011

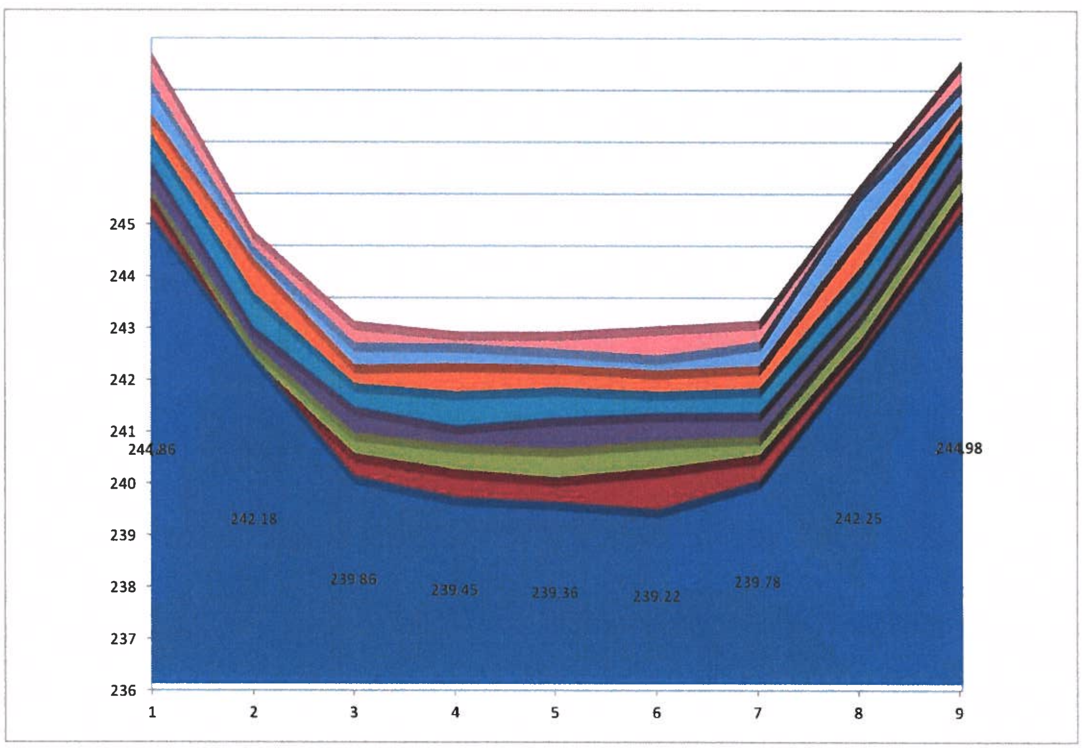
Readings

	mh	*mh*	*mh*	*mh*	*center*						
	a	h	g	f	e	d	c	b	i	Channel	
pts	1	2	3	4	5	6	7	8	9	Width	Top Width
A1	5.12	7.8	10.12	10.53	10.62	10.76	10.2	7.73	5	6'6"	11'1"
A2	5.2	8.32	10.15	10.46	10.61	10.43	10.17	7.94	5.09	6'2.5"	11'1"
A3	5.49	8.48	10.19	10.41	10.49	10.34	10.25	7.92	5.09	6'3.5"	11"
A4	5.44	8.61	10.14	10.51	10.35	10.26	10.25	8	5.04	7'	10'11"
A5	5.35	8.4	10.15	10.3	10.22	10.3	10.23	7.9	5.04	5'4"	21'8"
A6	5.42	8.19	10.24	10.21	10.24	10.34	10.25	7.65	5.19	5'3"	17"7"
A7	5.24	8.41	10.27	10.28	10.38	10.51	10.24	7.35	5.25	5'3"	19'4"
A8	5.12	8.56	10.3	10.5	10.5	10.39	10.28	7.65	5.26	5'4"	19'7"

Conv

A1	244.86	242.18	239.86	239.45	239.36	239.22	239.78	242.25	244.98
A2	244.78	241.66	239.83	239.52	239.37	239.55	239.81	242.04	244.89
A3	244.49	241.5	239.79	239.57	239.49	239.64	239.73	242.06	244.89
A4	244.54	241.37	239.84	239.47	239.63	239.72	239.73	241.98	244.94
A5	244.63	241.58	239.83	239.68	239.76	239.68	239.75	242.08	244.94
A6	244.56	241.79	239.74	239.77	239.74	239.64	239.73	242.33	244.79
A7	244.74	241.57	239.71	239.7	239.6	239.47	239.74	242.63	244.73
A8	244.86	241.42	239.68	239.48	239.48	239.59	239.7	242.33	244.72

road MH



Forest

MH 24	Elev	248.00
	Rdg	1.98
		249.98 actual elevation of point

Section-segment A Pole Branch Tributary Study Survey 3/4/2011

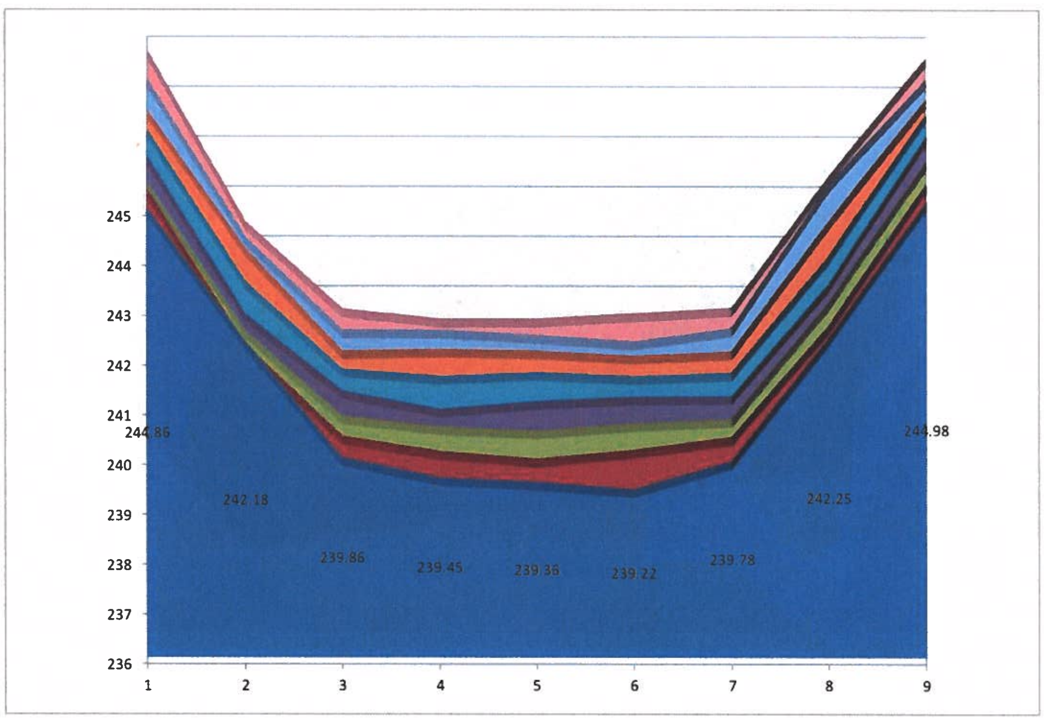
Readings

	mh	*mh*	*mh*	*mh*	*center*						
	a	h	g	f	e	d	c	b	i	Channel	
pts	1	2	3	4	5	6	7	8	9	Width	Top Width
A1	5.12	7.8	10.12	10.53	10.62	10.76	10.2	7.73	5	6'6"	11'1"
A2	5.2	8.32	10.15	10.46	10.61	10.43	10.17	7.94	5.09	6'2.5"	11'1"
A3	5.49	8.48	10.19	10.41	10.49	10.34	10.25	7.92	5.09	6'3.5"	11"
A4	5.44	8.61	10.14	10.51	10.35	10.26	10.25	8	5.04	7'	10'11"
A5	5.35	8.4	10.15	10.3	10.22	10.3	10.23	7.9	5.04	5'4"	21'8"
A6	5.42	8.19	10.24	10.21	10.24	10.34	10.25	7.65	5.19	5'3"	17"7"
A7	5.24	8.41	10.27	10.28	10.38	10.51	10.24	7.35	5.25	5'3"	19'4"
A8	5.12	8.56	10.3	10.5	10.5	10.39	10.28	7.65	5.26	5'4"	19'7"

Conv

A1	244.86	242.18	239.86	239.45	239.36	239.22	239.78	242.25	244.98
A2	244.78	241.66	239.83	239.52	239.37	239.55	239.81	242.04	244.89
A3	244.49	241.5	239.79	239.57	239.49	239.64	239.73	242.06	244.89
A4	244.54	241.37	239.84	239.47	239.63	239.72	239.73	241.98	244.94
A5	244.63	241.58	239.83	239.68	239.76	239.68	239.75	242.08	244.94
A6	244.56	241.79	239.74	239.77	239.74	239.64	239.73	242.33	244.79
A7	244.74	241.57	239.71	239.7	239.6	239.47	239.74	242.63	244.73
A8	244.86	241.42	239.68	239.48	239.48	239.59	239.7	242.33	244.72

road MH

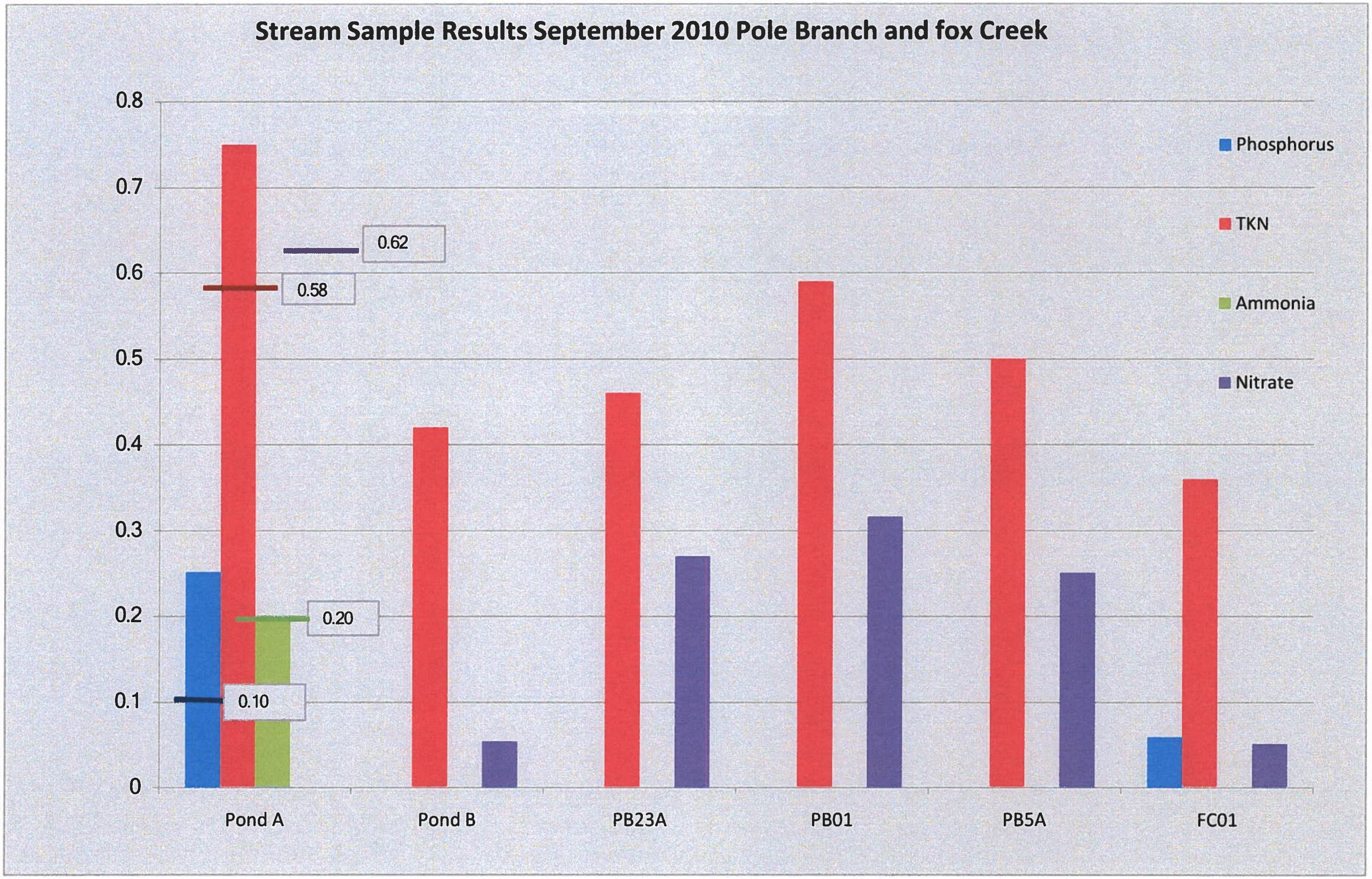


Forest

Storm Water Sampling

A Comparison of Storm Water Ponds with and without Water Quality Features

Site	H20 Quality	Basin	ID	Date	Grab Time	pH	DO	Temp	Notes	TSS	Nutrients: Nitrate/Nitrite	Nutrients: Ammonia	Nutrients: Phosphorus	Nutrients: TKN	Metals: Zinc	Metals: Lead	Metals: Manganese	Metals: Iron	Metals: Copper
Church Lot Pond	N	Pretty Run	SW1	10/5/09	10:10	6.1	6.8	18.8	Rain	3	0.813	ND	0.102	0.9	0.047	0.00383	0.044	0.241	ND
Brighton Place	Y	Pole Branch	SW2	10/5/09	11:40	7.01	6.89	18.7	Drizzle	4	ND	ND	ND	0.6	0.0291	ND	0.0239	1.34	ND
Woodstone	Y	Pole Branch	SW3	10/5/09	12:30	7.03	6.65	19.5	Not Raining	22	ND	ND	0.127	0.7	0.0262	ND	0.15	2.05	ND
Village @ Bergen	N	Pole Branch	SW4	10/5/09	13:05	6.99	7.5	18.7	Drizzle	9	0.081	ND	0.06	0.6	0.0787	ND	0.0181	1.13	ND
Residential Average's										48	0.6	0.31	0.3	1.4	0.073	0.012			0.012
										Differences									
Church Lot Pond	N	Pretty Run	SW1	10/5/09	10:10	6.1	6.8	18.8	Rain	45	-0.213		0.198	0.5	0.026	0.00817	-0.044	-0.24	
Brighton Place	Y	Pole Branch	SW2	10/5/09	11:40	7.01	6.89	18.7	Drizzle	44				0.8	0.0439		-0.0239	-1.34	
Woodstone	Y	Pole Branch	SW3	10/5/09	12:30	7.03	6.65	19.5	Not Raining	26			0.173	0.7	0.0468		-0.15	-2.05	
Village @ Bergen	N	Pole Branch	SW4	10/5/09	13:05	6.99	7.5	18.7	Drizzle	39	0.519		0.24	0.8	-0.006		-0.0181	-1.13	


Stream Sample Results September 2010 Pole Branch and fox Creek
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.62
0.58
0.20
0.10
Phosphorus
TKN
Ammonia
Nitrate
Pond A
Pond B
PB23A
PB01
PB5A
FC01

Dry Weather Sampling

BASIN	ID	Identifier	Date	Grab Time	pH	DO	Temp	Cl2 or Notes	Fecal Coliform col/100 ml	Turb	Cadmium	Total Nitrogen (Calc)	Total Org Nit (Calc)	Ammonia	Nickel	Nitrite/Nitrate	Lead	TKN	Phosphorus	Copper	Iron	Manganese	Zinc
Pole Branch Basin	BW Pond A1	BW Pond A1	2/18/2011	14:13	7.5	10.6	15.6	turb hold time exceeded		3.6				nd		0.81	nd	0.25	0.22	nd	0.74	0.13	0.076
Pole Branch Basin	BW Pond A2	BW Pond A2	2/18/2011	13:22	7.25	11.1	13.2	turb hold time exceeded		3				0.12		0.45	nd	0.32	0.034	nd	0.31	0.028	0.042
Pole Branch Basin	BW Pond B1	BW Pond B1	2/18/2011	11:51	6.87	8.5	15	turb hold time exceeded		6.1				0.15		0.29	nd	0.25	0.017	nd	0.45	0.41	0.027
Pole Branch Basin	BW Pond B2	BW Pond B2	2/18/2011	12:38	7.11	9.5	13.2	turb hold time exceeded		4.7				0.11		0.24	nd	0.26	0.035	nd	0.45	0.19	0.024
Pole Branch Basin	PB-01	PB-01	9/30/2010	14:15	7.7	8.2	22.1							nd		0.317	nd	0.59	nd	nd	1.26	0.0238	0.013
Pole Branch Basin	PB-23A	TPB-01	9/30/2010	11:30	7.82	7.7	20							nd		0.27	nd	0.46	nd	nd	0.495	0.0222	nd
Pole Branch Basin	TPB-01	TPB-01	2/18/2011	13:00	7.85	11.6	13.7	turb hold time exceeded		4.7				0.13		0.28	nd	0.25	0.018	nd	0.33	0.024	0.025
Pole Branch Basin	Pond A-BW	BW Pond A2	9/30/2010	11:00	7	3.8	22					0.77	0.552	0.198		0.02	nd	0.75	0.252	nd	5.77	1.15	0.0137
Pole Branch Basin	Pond B-BW	BW Pond B2	9/30/2010	10:57	7.73	5.2	20.5							nd		0.054	nd	0.42	nd	nd	1.01	0.439	nd
Pole Branch Basin																							
Pole Branch Basin																							
Pole Branch Basin																							
Pole Branch Basin																							
Pole Branch Basin																							

Wet Weather Sampling

BASIN		Date	Grab Time	pH	DO	Temp	Cl2 or Notes	Fecal Coliform col/100 ml	Turb	Cadmium	Total Nitrogen (Calc)	Total Org Nit (Calc)	Ammonia	Nickel	Nitrite/Nitrate	Lead	TKN	Phosphorus	Copper	Iron	Manganese	Zinc
Pole Branch Basin																						
Pole Branch Basin																						
Pole Branch Basin																						
Pole Branch Basin																						
Pole Branch Basin																						
Pole Branch Basin																						
Pole Branch Basin																						
Pole Branch Basin																						
Pole Branch Basin																						
Pole Branch Basin																						
Pole Branch Basin																						
Pole Branch Basin																						

~Walnut Lane Neighborhood Park~
North Augusta's own Carolina Bay!

North Augusta
South Carolina's Riverfront
Stormwater Management Department

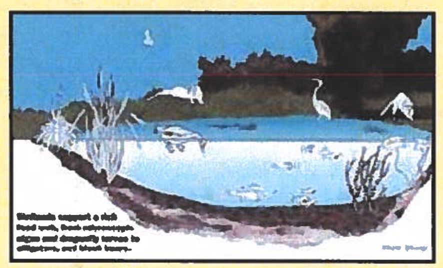
What are Wetlands?

Wetlands are a vital link between land and water. They are transition zones where the flow of water, the cycling of nutrients, and the energy of the sun meet to create a unique ecosystem.

Pictures of different wetlands found in the United States. Wetlands can be wet or dry.

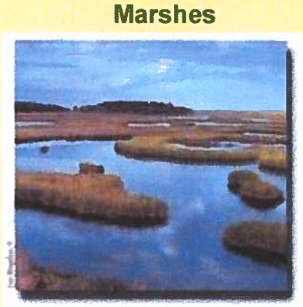
Wetlands also help improve water quality by removing unwanted pollutants from stormwater. This process occurs when water entering the wetland slows down. This allows pollutants in the water to become trapped by the vegetation, and the pollutants are filtered out. Plants and soil also help improve the global atmosphere by storing carbon.

Wetlands are among the most productive ecosystems in the world. Their level of productivity is similar to the rainforest or the coral reef. Wetlands are able to support a large variety of plants, insects, amphibians, birds, fish and mammals. The relationships between these organisms in the wetland is known as a food web.



Wetlands in the United States fall into 4 general categories:

Marshes



Marshes are composed of soft-stem vegetation. They are supported by groundwater, and can be fresh or salt water marshes.

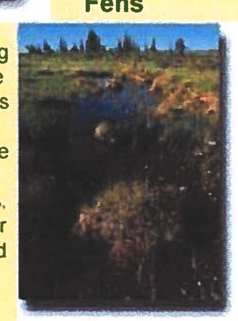
Swamps

Swamps are mainly composed of woody plants. They are saturated with water during the growing season, and have standing water at other times.

Bogs

Bogs are composed of spongy peat deposits, acidic water, and the ground is covered by moss.

Fens



Fens are peat-forming wetlands that receive nutrients from sources other than precipitation. Because there are higher nutrient levels in fens, this supports a higher diversity of plants and animals.

Carolina Bays are Unique Wetlands

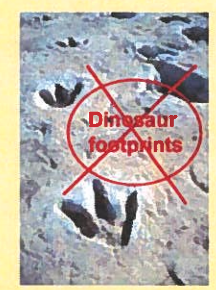
Carolina bays, which were first discovered in the 18th century, are isolated wetlands in natural shallow depressions. These bays have an elliptical shape and usually contain water. Water found in these bays is supplied through precipitation and shallow groundwater. Most Carolina bays are not naturally connected with streams or any other bodies of water. This is one characteristic of Carolina bays that make them unique.

Aerial view of a Carolina bay in Minnesota

Carolina bays have an elliptical or tear drop shape and are oriented northwest to southwest (NW/SW). Nearly 20,000 of these shallow basins exist up and down the coast ranging from Florida to New Jersey; however, many occur in the Carolinas, which accounts for the name.

Of the 20,000 bays that exist, 97% of the Carolina bays located in South Carolina have been destroyed or severely altered.

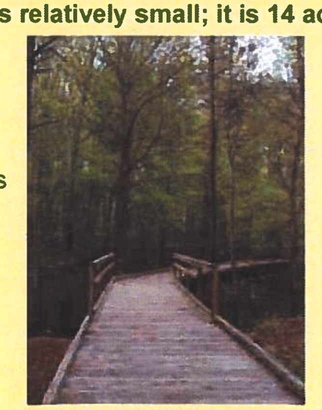
Researchers believe that Carolina bays are 30,000 to 100,000 years or older, however this is not a general concenus. One theory of the origin of Carolina bays suggests that a meteor hit Earth thousands of years ago, breaking into tiny pieces, making dents as they skipped across the Earth's surface. One legend even suggested that these wetlands were dinosaur footprints, however, this is not true.



Habitat Description

Carolina bays vary in size. They can range from less than an acre to thousands of acres. **Walnut Lane is relatively small; it is 14 acres in size.**

Carolina bays can be wet all year or they can fill with water and dry up depending on the season. Generally water levels are lowest in autumn and highest in early spring. Water levels in Carolina bays fluctuate depending on the amount of rainfall from year to year.



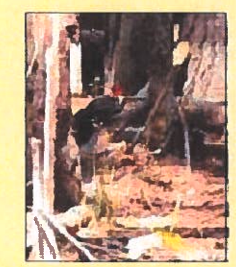
Walnut Lane walkway

Carolina Bay Critters & Plants

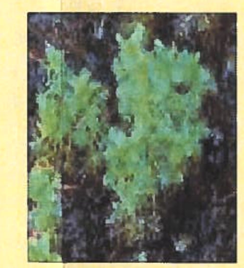
Though water might only exist in these basins part of the year, these wetlands still support a variety of wildlife. These undisturbed wetlands are reported to have the greatest diversity of species compared to other wetlands. Carolina bays provide habitat for animals such as frogs, salamanders, turtles, snakes and alligators. Many birds, such as herons and egrets, live in Carolina bays. These wetlands also support mammals such as deer, raccoons, skunks and opossums. Microscopic organisms called zooplankton also live in Carolina bays. Salamanders and frogs are the most abundant organism to live in Carolina bays. These areas are critical breeding habitats for them.

Water depth and soil type play a significant role in determining the types of plants a specific bay can support. The majority of bays support trees such as black gum, sweet gum, magnolia, bald cypress and maple. The shrubs sumac, button bush, gallberry and red bay are commonly found in these bays. Water lilies, sedges and various grasses can also be found.

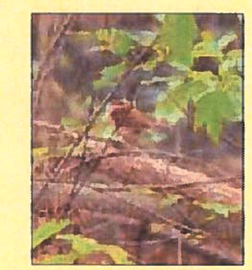
The following pictures are plants and animals that have been found in the Walnut Lane Carolina Bay.



Pileated Woodpecker



Watermilfoil



Carolina Wren

Summary

Carolina bays are isolated wetlands that are elliptically shaped, and have a NW/SW orientation. They also support the most diverse variety of plants, animals and mammals compared to other wetlands.

Since they are wetlands, they aid in purifying our water by processing nutrients, suspended materials and other pollutants. They also control flooding and erosion. Carolina bays offer a habitat for wildlife and recreation for humans.

Beginning in the 1970s, the government passed federal wetland regulations supporting the protection of these bays. However, in 2001, the Supreme Court removed these isolated wetlands from protection under the Clean Water Act.

Because these wetlands promote vast diversity, aid in improving the environment, and the quality of living for others around, it is vital to protect these anomalies. The City of North Augusta requires 25 foot buffers (restrictions) around Carolina bays and all other water bodies in its limits.

For additional information contact the North Augusta Stormwater Management Department at (803) 441-4246 or visit our website at www.northaugusta.net

Poster developed by Heather Mentrup, NA SWMD Intern from USC-Aiken

Pretty Run Basin

City of North Augusta TMDL Monitoring and Assessment Plan Implementation Summary

Submitted with 2016 Annual Report

The data collected and presented as follows are the summary information gathered through four (4) sampling events prescribed in the City of North Augusta TMDL Monitoring and Assessment Plan. They constitute preliminary information and are from the first completed rounds of our Summer, Fall, Winter sampling along with one follow-up investigative sampling event. The sampling plan is as follows:

SEASON	MONTHS	DATES (24 mos):
• Summer Sampling 2016	(June – August)	June 2015 and July
• Fall Sampling	(September – October)	TBD 2015 and 2016
• Winter Sampling or 2017	(November – February)	TBD 2015 and 2016
• Spring Sampling	(March – May)	TBD 2016 and 2017

To date the Summer dry weather, Fall wet weather and first Winter Wet weather samples have been completed and on schedule. This report summarizes the results of the sampling events and follow-up sampling based on those results. There is one remaining sample event for this first year implementation. All samples analyzed for *E. coli* were processed via IDEXX Quantitray enumeration procedures.

Samples taken at prescribed sample locations within the Pretty Run Basin during a representative wet weather event in the Fall on October 27, 2015 all exceeded the high range of the testing method at >2419.2 mpn/100 ml. That data was inconclusive since it was all above the testing range. Subsequent rounds of sampling were conducted as the result of elevated *E. coli* levels observed in previously taken background samples. Dry weather background samples were taken on July 07, 2015. One sample at a downstream location, NA-PR-02 resulted in 1120 mpn/100 ml. This is above the standard 349 mpn/100 ml and also is the highest result of all the background samples. Therefore, three sample points were added to the sampling plan upstream of NA-PR-02 along two branches of an unnamed tributary of Pretty Run

Creek. A third branch on that tributary was not sampled. One point was chosen along the western branch, NA-PR-HP2 and two points along the eastern branch, NA-PR-HP and NA-PR-HPb respectively. Please refer to illustrations provided. The NA-PR-HP2 (western branch) upstream location is an area within the basin where the sole source of impact is from urban animal activity. The two eastern branch samples NA-PR-HP and NA-PR-HPb are on a stream segment that is adjacent to a sanitary sewer line.

NA-PR-02 is located downstream of the confluence of these two branches. When the elevated *E. coli* level of 1120 mpn/100 ml was seen at NA-PR-02 during a dry weather event, it was suspected that illicit discharge from nearby sanitary sewer lines along the eastern branch could be the cause. This nearby sewer line services neighborhoods located above the 171 sq. acre wooded area surrounding the three branches in question. Follow-up sampling was conducted on November 3, 2015 to potentially identify if the source of *E. coli* was the sewer service line. This set of samples, which was not a representative wet or dry weather sampling event, showed highest *E. coli* levels (1300 mpn/ 100ml) were from NA-PR-HP2. Lower levels were shown from NA-PR-HP and NA-PR-HPb (816 mpn/ 100 ml, and 488 mpn/ 100 ml respectively). Since NA-PR-HP2 does not run adjacent to any waste water sewer lines and has no impact from human activity, we suspect the cause of elevated levels is not the nearby waste water line that was impacting this unnamed tributary.

Research found involving similar situations with elevated *E. coli* levels suggested that elevated levels such as these during rain events can arise from urban animal sources alone. To further elucidate potential wastewater sources we also conducted nutrient testing (Phosphorus, TKN, Ammonia, and Nitrite/Nitrate) concurrently with the *E. coli* samples during October 27, 2015. The results imply that sanitary sewer leakages are unlikely to be the cause of the elevated *E. coli* levels. Subsequent to those samples, we conducted DNA source tracking analysis at NA-PR-HP2 during the February 16, 2016. It revealed the *E. coli* and other bacteria found in NA-PR-HP2 samples were of ruminant, not human, origin. Based on this information, it is our belief that these results show no cause for concern of illicit discharge impact upon the Pretty Run Basin from waste water lines. To further our understanding of this reach of Pretty Run, the city will conduct smoke testing of these wastewater lines prior to our Spring wet weather sample event.

Previous research conducted by Pitt and Shergill of the University of Alabama have shown similar levels of *E. coli* in a study conducted on a section of Cribbs Mill Creek in Tuscaloosa, Alabama. These levels were observed in wet weather samples collected from areas where sanitary sewage contamination was not possible. In their samples taken during a wet weather event on 25-Sep-02, areas that were both prone and not prone to use by urban animal life and where contamination from sanitary sewage was not a possibility, levels of *E. coli* regularly exceeded 2419.2 mpn/100 ml. In areas prone to urban animal use alone, all but one of Pitt and Shergill's samples exceeded 2419.2 mpn/100 ml. The one sample that was lowest was measured at 344.8 mpn/100 ml, only 4.2 mpn/100 ml below the SCDHEC TMDL standard of 349. Animals that live in the surrounding area frequently seek refuge in this location. While conducting sampling, visible evidence of ruminant in habitation was seen throughout the area. This included deer scat and tracks. Therefore, it is reasonable to assume that this increased animal activity has led to the elevated levels of *E. coli* observed in the unnamed tributary affecting the downstream locations including RS-04544 (aka NA-PR-01).

At the time that the *E. coli* samples were gathered on the 27-Oct-15 wet weather event, nutrient samples were also taken. The results of these test can be seen in the chart below. Also in the chart are average levels of nutrients observed in the National Stormwater Quality Database (NSQD) in residential areas as well as the average levels of nutrients of all samples taken within North Augusta from 2005 until 2013. All nutrient levels reported in the 27-Oct-15 sampling event were below the city average as well as those observed in the NSQD. Having nutrient levels within accepted ranges reinforces our belief that sanitary sewage is not impacting these branches in question.

	27-Oct-15 Event	NSQD Observed Residential (Avg. Conc)	City of North Augusta (Avg. for all streams N=88) (2005-2013)
Ammonia (mg/L)	0.22	0.31	0.38
Nitrate (mg/L)	0.1	0.6	0.7
Phosphorus (mg/L)	0.053	0.3	0.19
TKN (mg/L)	0.52	1.4	0.89

Further tests were conducted on samples gathered on 16-Feb-2016. In addition to the IDEXX Quantitray analysis for *E. coli*, two DNA source tracking test were performed by SourceMolecular Laboratories to determine if (1) human or (2) ruminant sources could be identified. Observed *E. coli* levels in the February 16, 2016 wet weather sample at NA-PR-HP2 were 534 mpn/100ml, however, the DNA source tracking analyses showed that in this sample, none of the bacterial contamination had human origins. The contaminating bacteria that was present in the sample originated from ruminant sources.

Despite our reported *E. coli* levels exceeding the standard 349 mpn/100ml in the Pretty Run Basin we believe we have provided ample evidence that these levels potentially arise from natural sources, not from city wastewater infrastructure or illicit discharges to stormwater systems. This elevation in *E. coli* levels are most likely the result of large amounts of animal activity and not deficiencies in local infrastructure. This is concurrent with the current TMDL for Pretty Run Creek in the City of North Augusta.

DNA testing for human or animal markers, conducting field investigations including land use; the resulting data indicate strongly that human impacts are not the cause of the wet weather concentrations of *E. coli* in the watershed. Only one DNA sample taken along with a duplicate for quality assurance during winter wet weather sample event indicated human DNA marker, and in that sample the *E. coli* concentration was 75 col/100 ml and a duplicate for quality assurance indicated 187 col/100 ml. The concentration of *E. coli* was well below the TMDL for the stream and does not indicate a bigger problem such as a sewer overflow or system malfunction. Stormwater sources are impacting the stream but those sources, in all likelihood, are animal sources such as deer, raccoon and birds (birds sources were not tested since it is a known source). Animals that live in the surrounding area frequently seek refuge in this location. While conducting sampling, visible evidence of ruminant in habitation was seen throughout the area. This included deer scat and tracks. Therefore, it is reasonable to assume that this increased animal activity has led to the elevated levels of *E. coli* observed in the unnamed tributary affecting the downstream locations including RS-04544 (aka NA-PR-01).

We will continue to target these neighborhoods with outreach and education to limit pet impacts to the watershed. It is also our intention to apply for funding through various grant programs to acquire additional information about the watershed, to find unique ways to address contributions of bacteria within the watershed and hopefully to implement techniques to limit the impacts. There are stormwater devices such as concrete ditches and other conveyances within these old neighborhoods that offer opportunities for improvement and we want to pursue implementing water quality treatment techniques where possible to improve water quality.

4) Are the sMS4's stormwater discharges impacting the stream with the POCs?

Based on sampling of storm drains for *E. coli*, Optical Brighteners, detergent sampling, nutrient sampling and field surveys of the watershed stream water quality, the evidence suggests that stormwater discharges are not impacting the stream with the POC, *E. coli.*, that the overland flow of water is bringing bacteria across the landscape from animal activity that is occurring in smaller and more compact areas of our city.

The development of our community has concentrated animals along our stream corridors where we provide buffers and development is less likely.

5) How do the POC concentrations from storm events in North Augusta compare regionally to storms of similar land use and precipitation?

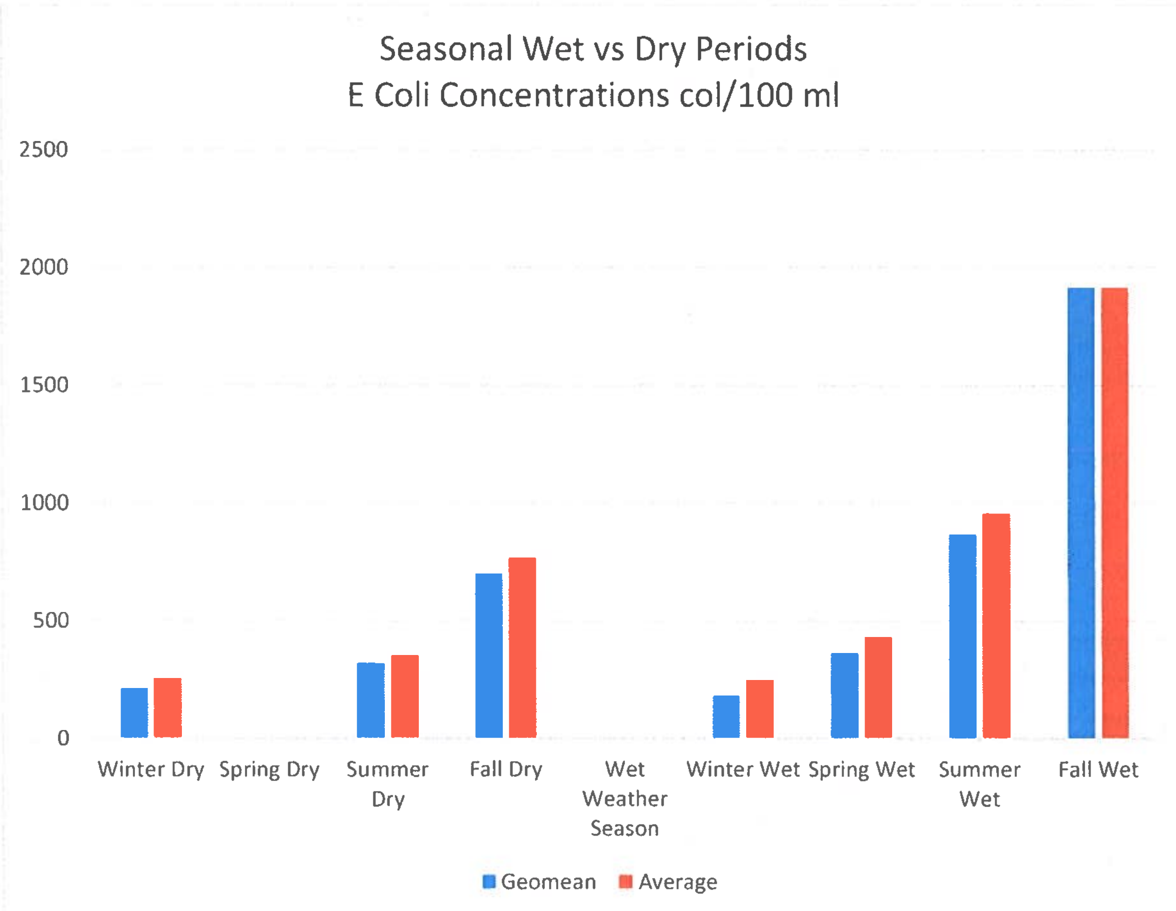
Through a comparison of regional stormwater data and other evidenced based studies of stormwater concentrations of *E. coli*, the Pretty Run sub watershed is within the average range or less of *E. coli* concentrations during certain seasons and weather conditions. Data suggest that the cause of the elevated *E. coli* within the sub watershed are more than likely concentrated areas of animal populations along the stream reaches due to increased development pressure on habitat that within the open space that all development in North Augusta must provide as part of the city development code.

We see through the research of Robert Pitt and others that North Augusta's data mirrors many other communities that are similar in size and rainfall patterns. Previous research conducted by Pitt and Shergill of the University of Alabama have shown similar levels of *E. coli* in a study conducted on a section of Cribbs Mill Creek in Tuscaloosa, Alabama. These levels were observed in wet weather samples collected from areas where sanitary sewage contamination was not possible. In their samples taken during a wet weather event on 2002, areas that were both prone and not prone to use by urban animal life and where contamination from sanitary sewage was not a possibility, levels of *E. coli* regularly exceeded 2419.2 mpn/100 ml. In areas prone to urban animal use alone, all but one of Pitt and Shergill's samples exceeded 2419.2 mpn/100 ml. The one sample that was lowest was measured at 344.8 mpn/100 ml, only 4.2 mpn/100 ml below the SCDHEC TMDL standard of 349.

City of North Augusta TMDL Monitoring and Assessment Plan Implementation Summary Submitted with 2018 Annual Report

The data collected and presented as follows are the summary information gathered through sampling events prescribed in the City of North Augusta TMDL Monitoring and Assessment Plan from July 2015 to May 2017.

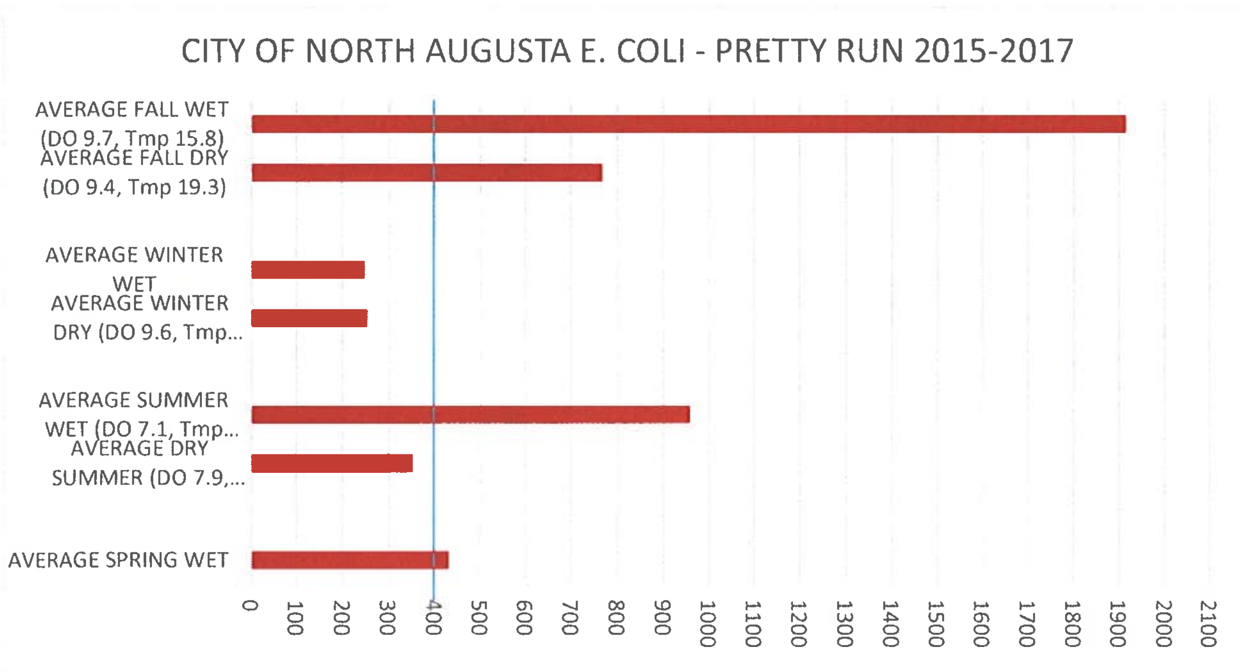
Results of the sampling are as follows:



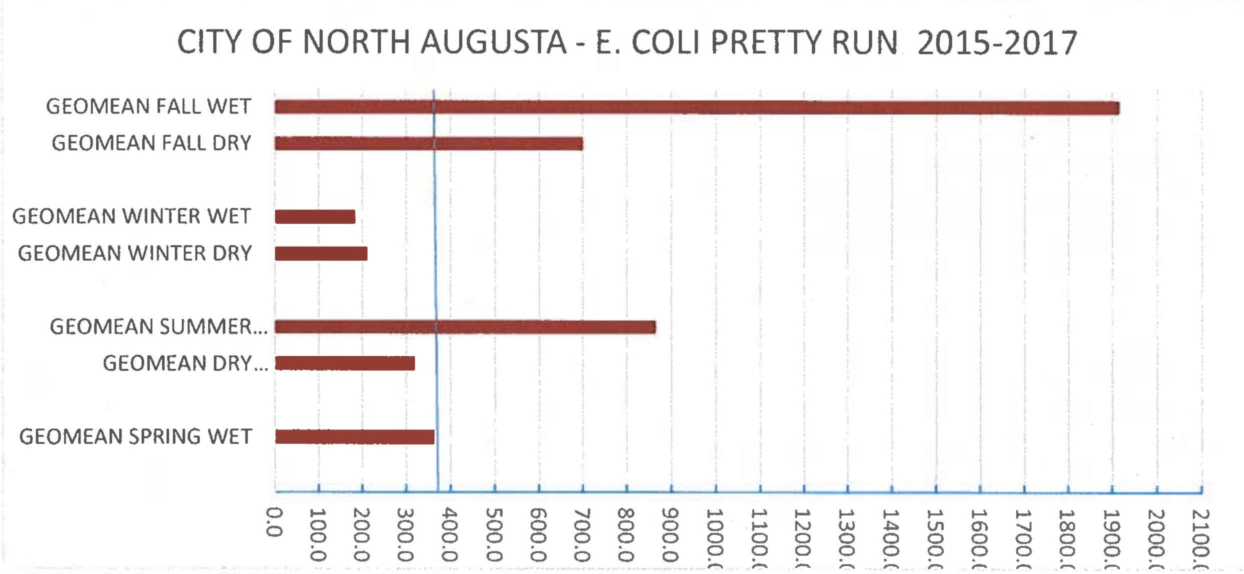
All samples analyzed for *E. coli* were processed via IDEXX Quantitray enumeration procedures.

Based on the results of the sampling the average concentrations of *E. coli* appear to be low except during Summer and Fall wet weather sample events. For *E. coli* sampling to be indicative of a true sources such as a leaking sewer line or overflowing septic system, the numbers would be in the 12,000 col/100 ml range according to data retrieved in *Quantification of E. coli & Enterococi Levels in Wet Weather and*

Dry Weather Flows, (Shergill & Pitt, 1989). Our testing methods was limited to an unknown number >2419 col/100 ml. much like theirs. Therefore, dilution was required to get a true number. Several samples toward the end of the sampling period were dilution samples. A true number was reached with that method. Further sampling within the Pretty Run watershed will use the dilution method.



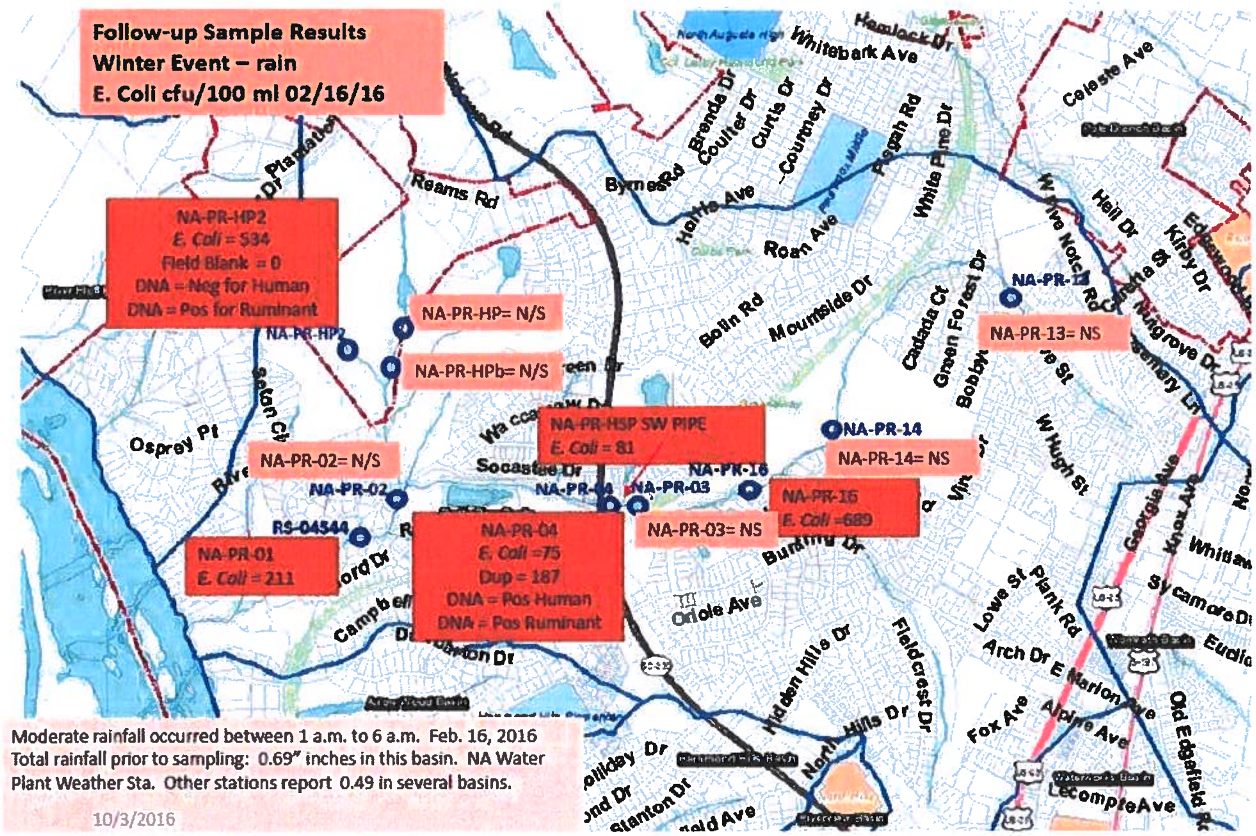
City of North Augusta Average Concentrations of E. Coli by Season	
AVERAGE SPRING WET	**430.7**
AVERAGE DRY SUMMER (DO 7.9, Tmp 24.7)	**352.6**
AVERAGE SUMMER WET (DO 7.1, Tmp 26.0)	**956.3**
AVERAGE WINTER DRY (DO 9.6, Tmp 12.6)	**253.9**
AVERAGE WINTER WET	**248.2**
AVERAGE FALL DRY (DO 9.4, Tmp 19.3)	**766.3**
AVERAGE FALL WET (DO 9.7, Tmp 15.8)	**1914.9**



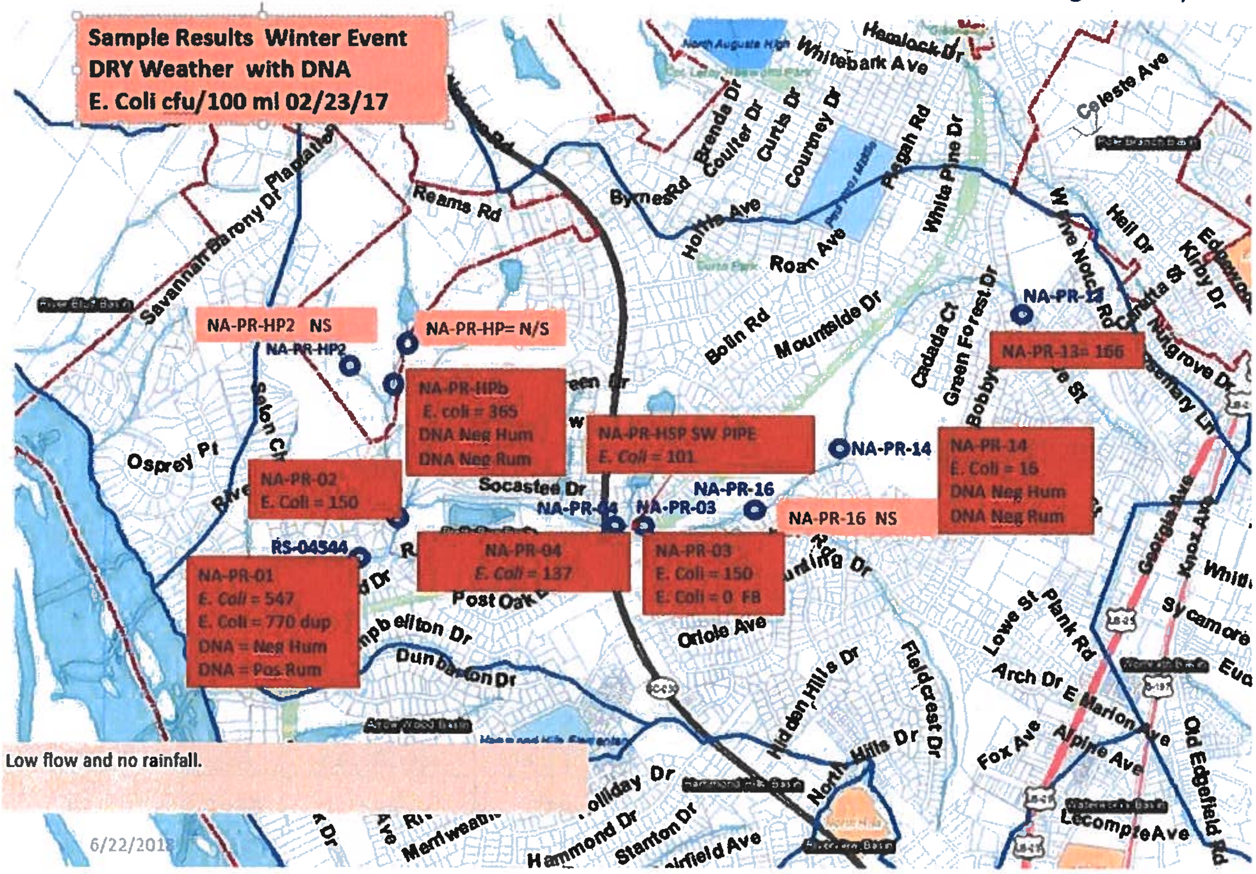
City of North Augusta Average Concentrations of E. Coli by Season						
GEOMEAN SPRING WET						**362.0**
GEOMEAN DRY SUMMER						**318.0**
GEOMEAN SUMMER WET						**865.0**
GEOMEAN WINTER DRY						**211.0**
GEOMEAN WINTER WET						**183.0**
GEOMEAN FALL DRY						**699.0**
GEOMEAN FALL WET						**1916.0**

To further identify the source of the *E. coli* in our sampling, DNA analysis was undertaken of samples within the sub-watershed. DNA source tracking test were performed by SourceMolecular Laboratories to determine if (1) human or (2) ruminant sources could be identified. DNA results are shown below, NS = not sampled.

During the Febrauary 16, 2016 wet weather sample we ran DNA. Note that high concentration of *E. coli* appears in NA-PR-HP2 location 534 col/100 ml., as you can see from the map, there are no homes, no stormwater or sanitary sewer infrastructure in that area. The DNA sample in that location was positive for ruminant, but not human sources. Interestingly, we did have a positive human source indicated at NA-PR-04 where the *E. coli* level was 75 col/100 ml.



Another sample event in February 2017 we looked at DNA in our samples. This was a dry weather event. The results are below. During this sample event we looked at a location below the unpopulated sample location NA-PR-HP2. We sampled just at the convergence of the stream. Our DNA results were negative for both human and ruminant sources. We also sampled RS-04544 (NA-PR-01 City ID). There we had *E. coli* indicated at 547 col/100 ml. That sample was negative for human, but positive for ruminant. Another sample in the upper reaches of the sub-watershed indicated low *E. coli*, with both DNA samples being negative.



Research found involving similar situations with elevated *E. coli* levels suggested that elevated levels such as these during rain events can arise from urban animal sources alone. To further elucidate potential wastewater sources we also conducted nutrient testing (Phosphorus, TKN, Ammonia, and Nitrite/Nitrate) concurrently with the *E. coli* samples during several sampling events. All of the data generated from nutrient samplings were within the average to low range for the constituents sampled based on SCDHEC Standard, Robert Pitt Stormwater Water Quality Database for residential stormwater sampling. The results imply that sanitary sewer leakages are unlikely to be the cause of the elevated *E. coli* levels. We have also conducted low-level detergent sampling and optical brightener sampling with all negative results from storm drains within the watershed. Based on this information, it is our belief that these results show no cause for concern of illicit discharge impact upon the Pretty Run Basin from sanitary wastewater lines or illicit discharges of wastewater to them.

Despite our reported *E. coli* levels exceeding the standard 349 mpn/100ml in the Pretty Run Basin we believe we have provided ample evidence that these levels potentially arise from natural sources, not from city wastewater infrastructure or illicit discharges to stormwater systems. This elevation in *E. coli* levels are most likely the result of large amounts of animal activity and not deficiencies in local infrastructure. This is concurrent with the current TMDL for Pretty Run Creek in the City of North Augusta.

Questions from our sampling plan:

1) What are the *Fecal coliform* or *E. coli* bacteria levels in the Pretty Run Creek Sub-basin receiving waters during dry or wet weather?

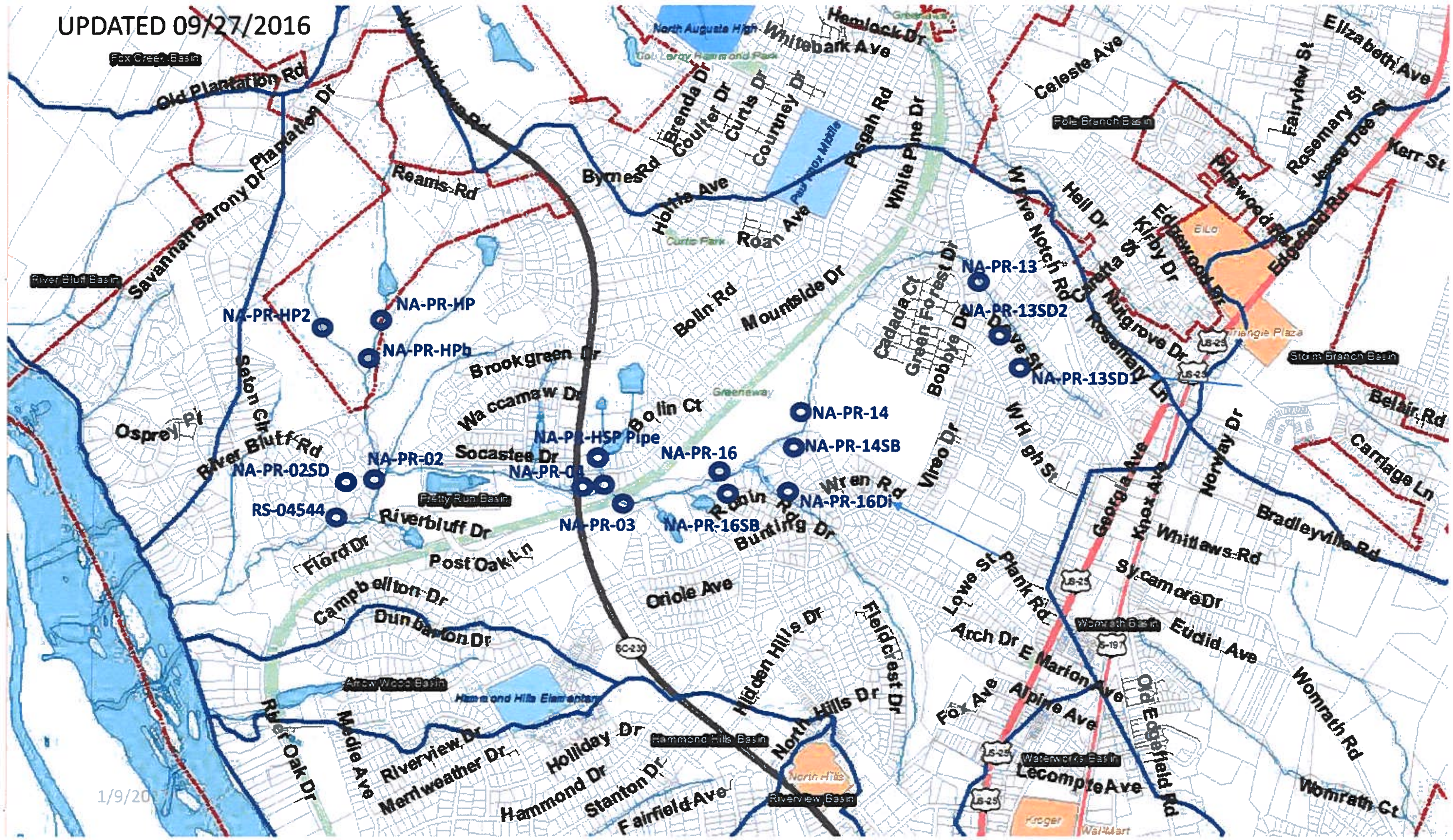
E. coli Results Wet vs Dry						
	N	Range		Median	Geomean	Avg
Wet	45	0-1120		816	464	1592
Dry	23	0-2419	Unsensored	261	174	375

2) What are the characteristics of the average storm event concentrations at monitoring sites?

Wet Weather Season	Geomean	Average
Winter Wet	183	248
Spring Wet	362	**431**
Summer Wet	**865**	**956**
Fall Wet	**1916**	**1915**

3) Are TMDL WLAs being met? And if not, assess, develop and implement a plan to control stormwater source discharges to the MEP.

TMDL WLAs are being met during winter and summer dry weather conditions. During summer and fall wet or dry weather conditions, evidenced based investigations (including sampling in stream and from storm drains throughout the watershed for *E. coli*, nutrients, optical brighteners, detergents, conducting


UPDATED 09/27/2016
Fox Creek Basin
Old Plantation Rd
Plantation Dr
Savannah Barony Dr
Reams Rd
River Bluff Basin
NA-PR-HP2
NA-PR-HP
NA-PR-HPb
Seaton Cir
Osprey Pl
River Bluff Rd
NA-PR-02SD
NA-PR-02
RS-04544
Pretty Run Basin
Riverbluff Dr
Fiord Dr
Post Oak Ln
Campbellton Dr
Dunbarton Dr
Arrowwood Basin
Hammond Hills Elementary
River Oak Dr
Madie Ave
Riverview Dr
Merriweather Dr
Holliday Dr
Hammond Dr
Stanton Dr
Fairfield Ave
Brookgreen Dr
Waccamaw Dr
Socastee Dr
NA-PR-HSP Pipe
NA-PR-03
Bolin Ct
Bolin Rd
Byrnes Rd
Hollie Ave
Curtis Park
Roan Ave
Mountside Dr
Greeneway
NA-PR-16
NA-PR-16SB
NA-PR-14
NA-PR-14SB
NA-PR-16Di
Robin Rd
Wren Rd
Bunting Dr
Oriole Ave
SC-230
Hidden Hills Dr
Fieldcrest Dr
North Hills Dr
Hammond Hills Basin
North Hills
Riverview Basin
North Augusta High
Col. Leroy Hammond Park
Whitebark Ave
Hemlock Dr
Brenda Dr
Coulter Dr
Curtis Dr
Courtney Dr
Paul Knox Middle
Pisgah Rd
White Pine Dr
Cadada Ct
Green Forest Dr
Bobbye Dr
NA-PR-13
NA-PR-13SD2
NA-PR-13SD1
Vireo Dr
W Hugh St
Five Notch Rd
Hell Dr
Kirby Dr
Edgewood Dr
Nutgrove Dr
Rosemary Ln
Celeste Ave
Pole Branch Basin
Fairview St
Rosemary St
Jessie Dee St
Elizabeth Ave
Kerr St
Pinewood Dr
Edgefield Rd
EiLo
Triangle Plaza
Storm Branch Basin
Belair Rd
Carriage Ln
Norway Dr
Georgia Ave
Knox Ave
Whitlaws Rd
Bradleyville Rd
Sycamore Dr
Lowe St
Plank Rd
Womrath Basin
Euclid Ave
Arch Dr
E Marion Ave
Old Edgefield Rd
Womrath Rd
Fox Ave
Alpine Ave
Waterworks Basin
Lecompte Ave
Womrath Ct
Kroger
Wal-Mart

				STANDARDS or Average for SC→										STD = 349 mpn/100 ml				<1.17 avg < 1.3 HH	<0.20 avg	<0.61 EPA/SC	<0.62 avg < 10.0 HH	<0.013 HH < 0.014 AQ	<0.58 avg	<0.14 avg < 1.3 HH	<0.01 avg < 1.3 HH <0.0038 AOCMC	<1.17 avg < 0.3 EPA/SC	<0.084 avg < 0.05 HH < 1.0 Aq	<0.04 avg < 7.4 HH <0.03 AQ
Code Code Key 1=Clear no rain, 2=Rainfall, 3=First Flush, 4=24 Hour, 5=Field data only, 6=fecal only, 7=Nuts only, 8=Pond	Est flow (mgd)	Water Elev Box Culvert - (230.1 stream with no rain)	Season	BASIN	ID	Field Notes from Log Books or sampler (1) Hard bound Rite in Rain pages 16 to end Book (2) Small pocket sized Rite in Rain spiral and one large bound Data Logbook in SW office Composite samplers chained and locked at each use location (3) Data LB logbook of all anlaytical results (4) Pretty Run small Rite in Rain logbook beginning 07202015	Log Bk # & Pg #	Date (order)	Grab Time	pH	DO	Temp	Detergent Test	F. Coli 100ml	DNA Source Tracking	Optical Brightener test	Turb/tss	Cadmium	Ammonia	Nickel	Nitrite/Nitrate	Lead	TKN	Phosphorus	Copper	Iron	Manganese	Zinc
1			summer	Pretty Run	NA-PR-01	Water lower than normal. Dry weather sample. Hot >100F later today and yesterday. Slightly tea colored water.	2015 PR pg 4	7/20/2015	11 30	4 21	8 25	25 8	Low Level Detergent = 0	261														
1			summer	Pretty Run	NA-PR-01 Blank	Field Blank - Water lower than normal. Dry weather sample. Hot >100F later today and yesterday. Deionized H20	2015 PR pg 4	7/20/2015	11 30	-	-	-	-	0														
1			summer	Pretty Run	NA-PR-04	Water lower than normal. A flow is coming from Bolin Storm Pipe upstream of sample location. Tea colored water.	2015 PR pg 5	7/20/2015	12 07	6.68	9 07	24.6	Low Level Detergent = 0	517														
1	2.26	230.1	summer	Pretty Run	NA-PR-03	Water lower than normal. Minimal flow, not registered on staff gauge. This is upstream of storm pipe. Tea colored water.	2015 PR pg 5	7/20/2015	12 15	6.56	9.6	24 7	Low Level Detergent not tested	387														
1			summer	Pretty Run	NA-PR-16	Water level lower than normal. Many fish and a couple of species were observed. Water was tea colored. This sample location was a narrow stream where water traverses over rocks and falls and is fast moving. This sample was erroneously labled NAPR13 on lab record and log book. Corrected 11/05/2015, NAPR13 was dry with no flow on sample day as indicated	2015 PR pg 5	7/20/2015	12:40	6.44	7 37	23 4	Low Level Detergent = 0	172														
1			summer	Pretty Run	NA-PR-16 DUP	Water level lower than normal. Many fish and a couple of species were observed. Water was tea colored. This sample location was a narrow stream where water traverses over rocks and falls and is fast moving. This sample was erroneously labled NAPR13 on lab record and log book. Corrected 11/05/2015, NAPR13 was dry with no flow on sample day as indicated	2015 PR pg 5	7/20/2015	12:40	6.44	7 37	23 4	Low Level Detergent = 0	185														
1			summer	Pretty Run	NA-PR-13	DRY - No Water	2015 PR Pg 5	7/20/2015	12 50	-	-	-	-	-														
1			summer	Pretty Run	NA-PR-02	Low flow. Dry weather. Sample pulled behind home at 8 Water Oak Drive This branch flows into Pretty Run.	2015 PR Pg 7	7/21/2015	11 28	7 28	7 51	26 1	Low Level Detergent = >0 and < 0 25	1120														
1			summer	Pretty Run	NA-PR-14b	Low flow, very low. Dry weather. Pulled at Greeneway Crossing at end of Cascade Court. This is a change in location due to difficulty at original location	2015 PR Pg 7	7/21/2015	12 05	7 16	6 04	24 8	Low Level Detergent = 0	179														
2			fall	Pretty Run	NA-PR-13 (KW)	Low flow, but it is flowing. Water is clear. Rainfall in last 24 hours =0 57", pouring rain during sample pull. EC only. (TS/DD)	2015 PR Pg 10-11	10/27/2015	12 25	7 3	7 65	13 3		>2419														
2			fall	Pretty Run	NA-PR-03	Behind Halloween's house. Flow is high, turbidity is noticible. Upstream of storm pipe at Halloweens. EC/Nuts pulled (TS/DD)	2015 Pr Pg 11	10/27/2015	12 50	7 4	9 61	15 7		>2419					ND		0.13		0.94	0.14				
2			fall	Pretty Run	NA-PR-Pipe	Pulled from storm pipe discharging into creek at Halloweens home. High flow, 1/4 of pipe. No odor. EC only. No field parameters. (TS/DD)	2015 Pr Pg 11	10/27/2015	12 59					>2419														
2			fall	Pretty Run	NA-PR-04	Behind Halloween's house. Flow is high, turbidity is noticible. Downstream of storm pipe at Halloweens. EC/Nuts pulled (TS/DD)	2015 PR Pg 11	10/27/2015	12 55	6 86	10.35	16 3		>2419					0 13		0 088		1 2	0.18				
2			fall	Pretty Run	NA-PR-01	Water level high, flow is high. Color is slightly turbid with no odor. TS/DD	2015 PR Pg 11	10/27/2015	13 25	8 3	10 9	16		>2419														
2			fall	Pretty Run	NA-PR-01 Blank	Field Blank Only - DI Water	2015 PR Pg 11	10/27/2015	13 25					0														
2			fall	Pretty Run	NA-PR-01 Dup	Duplicate Sample	2015 PR Pg 11	10/27/2015	13 25					>2419														
2			fall	Pretty Run	NA-PR-02	Arrived 14:01 p.m. Walked behind house and followed stormdrain path to find outfall of drain. Pulled sample upstream from this outfall pipe. (Behind Water Oak Culdesac) Pulled EC/Nuts TS/DD/JD	2015 PR Pg 12	10/27/2015	14 18	7 53	10 3	16 5		>2419					0 22		0 1		0 52	0.053				
2			fall	Pretty Run	NA-PR-16	Water high, flow moderately high, color is turbid, tannish but clear. No odor. Raining, did not pull field parameters. TS/DD EC/Nuts	2015 PR Pg 12	10/27/2015	14 50					>2419					ND		0.21		0.72	0 032				
2			fall	Pretty Run	NA-PR-14b	Had a hard time reaching this stream but asked a neighbor and they pointed us in the right direction. Walked into woods behind home and found the stream. Narrow here, but flow is strong. Water slightly turbid, no odor. Appears to be a bit of a jam upstream. Light rain. EC Only TS/DD	2015 PR Pg 12	10/27/2015	15 20	6 87	9 2	16 9		>2419														
1		230.2	fall	Pretty Run	NA-PR-HP2	Rained past two days, but not raining today. Unnamed trib to Pretty Run near Overlook, no pond headwater	2015 PR Pg 13	11/3/2015	14 50	6 99	9 36	19 2	0	1300														
1	4.2	230.2	fall	Pretty Run	NA-PR-HP	Rained past two days, but not raining today. Unnamed trib to Pretty Run from Hammond Pond.	2015 PR Pg 13	11/3/2015	15 40	6 51	9 4	19 3	0	816														
1		230.2	fall	Pretty Run	NA-PR-HP2	Rained past two days, but not raining today. Unnamed trib to Pretty Run from Hammond Pond, just a bit lower than NAPRHP. Smelled sewer, probably from Manhole located near NAPRHP	2015 PR Pg 13	11/3/2015	15 59	-	-	-		488														
2			winter	Pretty Run	NA-PR-16	Rained overnight. Storm came in around 12:58 a.m. and rained until early morning. Total rainfall is 0.69" at Pretty Run Basin, based on NA WTP station. Other basins 0.49"	2015 PR Pg 17-19	2/16/2016	11:22 a m	8 5	9 1	12 1		689														
2			winter	Pretty Run	NA-PR-HSP Pipe	Rained overnight. Storm came in around 12:58 a.m. and rained until early morning. Total rainfall is 0.69" at Pretty Run Basin, based on NA WTP station. Other basins 0.49"	2015 PR Pg 17-19	2/16/2016	12:02	-	-	-		81														
2			winter	Pretty Run	NA-PR-04	Rained overnight. Storm came in around 12:58 a.m. and rained until early morning. Total rainfall is 0.69" at Pretty Run Basin, based on NA WTP station. Other basins 0.49". Pulled source tracking sample	2015 PR Pg 17-19	2/16/2016	12:05	-	-	-		75	Human - Pos Ruminant - Pos													
2			winter	Pretty Run	NA-PR-04 (duplicate)	Rained overnight. Storm came in around 12:58 a.m. and rained until early morning. Total rainfall is 0.69" at Pretty Run Basin, based on NA WTP station. Other basins 0.49"	2015 PR Pg 17-19	2/16/2016	12:05	-	-	-		187	Human - Pos Ruminant - Pos													
2			winter	Pretty Run	NA-PR-01	Rained overnight. Storm came in around 12:58 a.m. and rained until early morning. Total rainfall is 0.69" at Pretty Run Basin, based on NA WTP station. Other basins 0.49"	2015 PR Pg 17-19	2/16/2016	12 35	7 26	10 3	12 2		211														
2			winter	Pretty Run	NA-PR-HP2	Rained overnight. Storm came in around 12:58 a.m. and rained until early morning. Total rainfall is 0.69" at Pretty Run Basin, based on NA WTP station. Other basins 0.49". Pulled source tracking sample	2015 PR Pg 17-19	2/16/2016	12 38	7 26	9 46	13 4		534	Human - Neg Ruminant - Pos													
2			winter	Pretty Run	NA-PR-16 Field Blank	Rained overnight. Storm came in around 12:58 a.m. and rained until early morning. Total rainfall is 0.69" at Pretty Run Basin, based on NA WTP station. Other basins 0.49"	2015 PR Pg 17-19	2/16/2016	12 38					0														
2			summer	Pretty Run		Box 1 Optical Brightener pulled 07/02/16 07 12 am	2015 PR Pg 22-23	06/28/2016 -07/02/16	12:10							NEG												
2			summer	Pretty Run		Box 2 total rainfall July 1= 0.77", pulled 07/02/16 07:55 a.m	2015 PR Pg 22-23	06/28/2016 -07/02/16	12 25							NEG												
2			summer	Pretty Run		Box 3 total rainfall July 1= 0.77", pulled 07/02/16 07 20 a.m	2015 PR Pg 22-23	06/28/2016 -07/02/16	13 40							NEG												

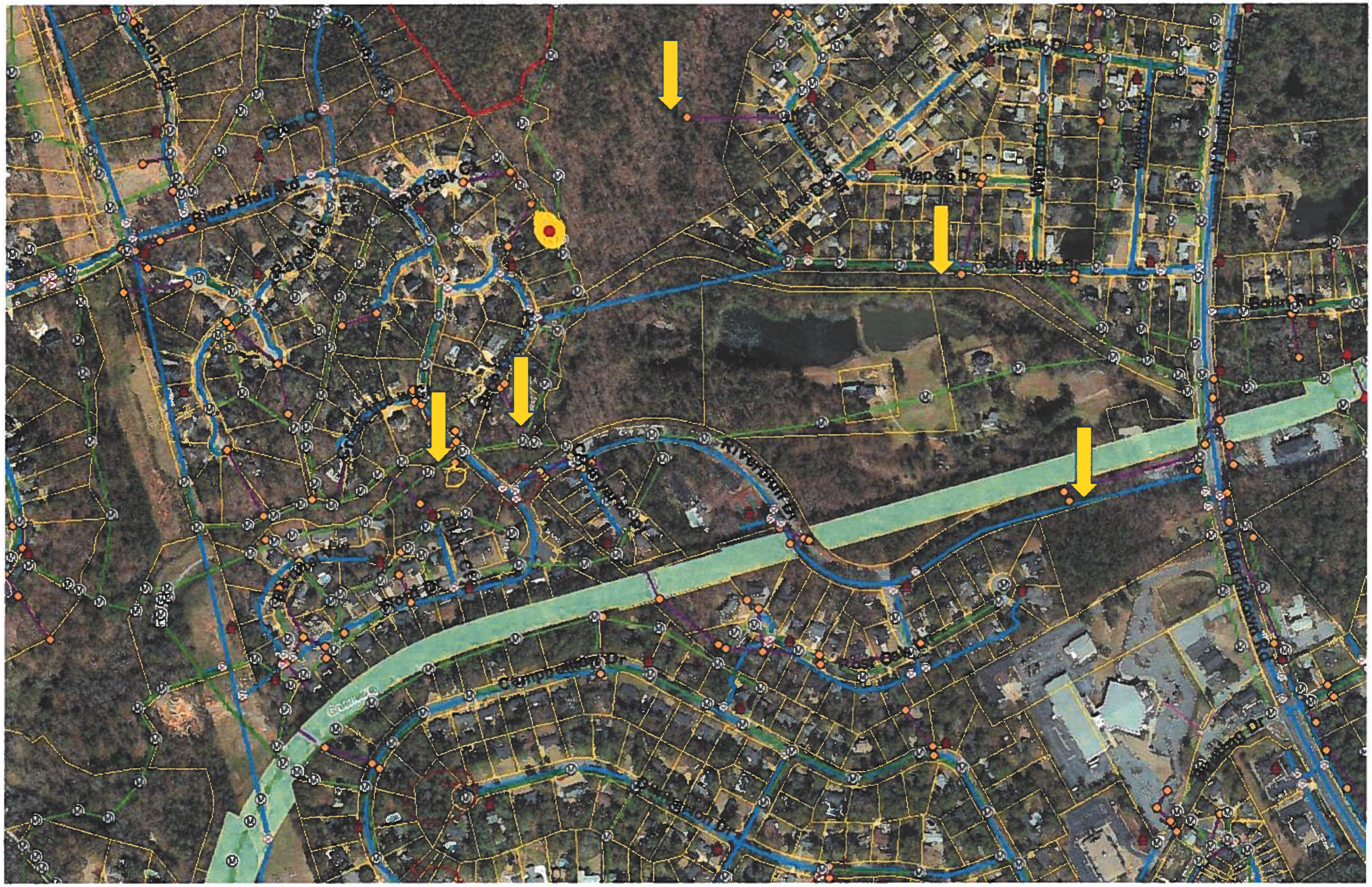
Code Code Key: 1=Clear no rain, 2=Rainfall, 3=First Flush, 4=24 Hour, 5=Field data only, 6=fecal only, 7=Nuts only, 8=Pond	Est flow (mgd)	Water Elev Box Culvert - (230.1 stream with no rain)	Season	BASIN	ID	Field Notes from Log Books or sampler (1) Hard bound Rite in Rain pages 16 to end Book (2) Small pocket sized Rite in Rain spiral and one large bound Data Logbook in SW office Composite samplers chained and locked at each use location (3) Data LB logbook of all anlaytical results (4) Pretty Run small Rite in Rain logbook beginning 07202015	Log Bk # & Pg #	Date (order)	Grab Time	pH	DO	Temp	Detergent Test	E. Coli 100ml	DNA Source Tracking	Optical Brightener test	Turb/tss	Cadmium	Ammonia	Nickel	Nitrite/Nitrate	Lead	TKN	Phosphorus	Copper	Iron	Manganese	Zinc
						STANDARDS or Average for SC→								STD = 349 mpn/100 ml				<1.17 avg < 1.3 HH	<0.20 avg	<0.61 EPA/SC	<0.62 avg < 10.0 HH	<0.013 HH < 0.014 AQ	<0.58 avg	<0.14 avg < 1.3 HH	<0.01 avg < 1.3 HH <0.0038 AQCMC	<1.17 avg < 0.3 EPA/SC	<0.084 avg < 0.05 HH < 1.0 Aq	<0.04 avg < 7.4 HH <0.03 AQ
2			summer	Pretty Run		Box 4 total rainfall July 1= 0.77", pulled 07/02/16 07:25 a.m.	2015 PR Pg 22-23	06/28/2016 -07/02/16	14:10							NEG												
2			summer	Pretty Run		Box 6 total rainfall July 1= 0.77", pulled 07/02/16 07:40 a.m.	2015 PR Pg 22-23	06/28/2016 -07/02/16	14:40							NEG												
2			summer	Pretty Run		Box 12 total rainfall July 1= 0.77", pulled 07/02/16 07:45 a.m.	2015 PR Pg 22-23	06/28/2016 -07/02/16	15:10							NEG												
2		230.5	summer	Pretty Run	NA-PR-13	Rained last night. Storm started around 7:30 p.m. and continued until 11:30 p.m. Total rainfall was 1.77" at Water Plant and 1.0" at Rapids Station (wunderground). Basins north rec'd 3.67"	2015 PR Pg 26-29	8/2/2016	11:00	7.22	6.93	24.4	Low level Deterg = 0.0	1046														
2		230.5	summer	Pretty Run	NA-HSP-Pipe	Rained last night. Storm started around 7:30 p.m. and continued until 11:30 p.m. Total rainfall was 1.77" at Water Plant and 1.0" at Rapids Station (wunderground). Basins north rec'd 3.67"	2015 PR Pg 26-29	8/2/2016	11:20	7.41	7.17	25.7	Low level Deterg = 0.0	148					0.11		0.67		0.65	0.023				
2	5.17	230.5	summer	Pretty Run	NA-PR-04	Rained last night. Storm started around 7:30 p.m. and continued until 11:30 p.m. Total rainfall was 1.77" at Water Plant and 1.0" at Rapids Station (wunderground). Basins north rec'd 3.67"	2015 PR Pg 26-29	8/2/2016	11:25	7.15	7.17	25.7	Low level Deterg = 0.0	921					nd		0.61		0.54	0.024				
2		230.5	summer	Pretty Run	NA-PR-04FB	Rained last night. Storm started around 7:30 p.m. and continued until 11:30 p.m. Total rainfall was 1.77" at Water Plant and 1.0" at Rapids Station (wunderground). Basins north rec'd 3.67"	2015 PR Pg 26-29	8/2/2016	11:25	-	-	-		0														
2		230.5	summer	Pretty Run	NA-PR-HP2	Rained last night. Storm started around 7:30 p.m. and continued until 11:30 p.m. Total rainfall was 1.77" at Water Plant and 1.0" at Rapids Station (wunderground). Basins north rec'd 3.67"	2015 PR Pg 26-29	8/2/2016	11:50	6.4	7.21	26.8	Low level Deterg = 0.0	2419					1.1		0.17		1.5	0.017				
2		230.5	summer	Pretty Run	NA-PR-01	Rained last night. Storm started around 7:30 p.m. and continued until 11:30 p.m. Total rainfall was 1.77" at Water Plant and 1.0" at Rapids Station (wunderground). Basins north rec'd 3.67"	2015 PR Pg 26-29	8/2/2016	12:21	7.28	7.17	27	Low level Deterg = 0.0	1300					0.11		0.53		0.57	0.029				
2		230.5	summer	Pretty Run	NA-PR-01Dup	Rained last night. Storm started around 7:30 p.m. and continued until 11:30 p.m. Total rainfall was 1.77" at Water Plant and 1.0" at Rapids Station (wunderground). Basins north rec'd 3.67"	2015 PR Pg 26-29	8/2/2016	12:21	7.28	7.17	27		1046														
2		230.5	summer	Pretty Run	NA-PR-16	Rained last night. Storm started around 7:30 p.m. and continued until 11:30 p.m. Total rainfall was 1.77" at Water Plant and 1.0" at Rapids Station (wunderground). Basins north rec'd 3.67"	2015 PR Pg 26-29	8/2/2016	12:45	6.2	7.2	25.5	Low level Deterg = 0.0	770					1.8		0.67		2.5	0.02				
1	10.98	230.6	fall	Pretty Run	NA-PR-03	Rain gauge set up at NA-PR-13. hot dry cloudy light breeze. BP = 29.93 in/hg. Set up Optical Brightner tests at Drain #1499 at 1:42 p.m. on Dove street, One at Knollwood at 2:10 p.m. Greenforest Drive.	2015 PR Pg 30-31	9/1/2016	15:30					461														
2		231.2	fall	Pretty Run	NA-PR-02SD	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80". Water discolored, taking a few photos and a grab sample for E. Coli	2015 PR Pg 32-34	9/2/2016	15:30					816														
2		231.2	fall	Pretty Run	NA-PR-13SD3 Drain #1499	Optical brightener, pulled 524 Dove Street (0.98" rain) (this may be repeated below. NAPR13sd1)	2015 PR Pg 32-34	9/2/2016	13:15							NEG												
2		231.2	fall	Pretty Run	NA-PR-13	Optical brightener, pulled (0.98" rain) this appears to be repeated below. Same sample will consider deleting once I review	2015 PR Pg 32-34	9/2/2016	12:53							NEG												
2		231.2	fall	Pretty Run	NA-PR-16di	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80" (Ditch behind Robin @ Siskin-Concrete Lined)	2015 PR Pg 32-34	9/2/2016	10:05					>2419		NEG			0.16		0.25		0.71	0.16				
2		231.2	fall	Pretty Run	NA-PR-14SD	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80" (Box next to 537 Siskin) Note: 2047 Wren lined ditch photo)	2015 PR Pg 32-34	9/2/2016	10:30					>2419		NEG			0.21		0.26		0.35	0.067				
2		231.2	fall	Pretty Run	NA-PR-16SB	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80" (1922 Robin Rd.)	2015 PR Pg 32-34	9/2/2016	10:50					>2419					nd		0.16		0.49	0.1				
2		231.2	fall	Pretty Run	NA-PR-16SBDUP	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80" (1922 Robin Rd.)	2015 PR Pg 32-34	9/2/2016	10:50					>2419		NEG												
2	20.35	231.2	fall	Pretty Run	NA-PR-03	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80"	2015 PR Pg 32-34	9/2/2016	12:10					>2419	COD=94.0 mg/l	NEG			0.17		0.44		1.6	0.19				
2		231.2	fall	Pretty Run	NA-PR-03FB	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80"	2015 PR Pg 32-34	9/2/2016	12:10					0														
2		231.2	fall	Pretty Run	NA-PR-03 Comp	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80"	2015 PR Pg 32-34	9/2/2016	12:10					-					0.18		0.55		0.35	0.036				
2		231.2	fall	Pretty Run	NA-PR-13	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80"	2015 PR Pg 32-34	9/2/2016	12:53					>2419		NEG			nd		0.2		0.57	0.16				
2		231.2	fall	Pretty Run	NA-PR-13-SD1	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80" (524 Dove)	2015 PR Pg 32-34	9/2/2016	13:15					308		NEG			nd		0.1		0.32	0.068				
2		231.2	fall	Pretty Run	NA-PR-13-SD2	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80"	2015 PR Pg 32-34	9/2/2016	13:25					1987														
2		231.2	fall	Pretty Run	NA-PR-02SD	Rainfall 0.98" this morning by 9 a.m. By 12:10 p.m. rain gage at NA-PR-13 1.80" (storm drain culdesac). All samples at lab at 15:30	2015 PR Pg 32-34	9/2/2016	14:00					816					nd		0.27		0.44	0.11				
1		230.1	winter	Pretty Run	NA-PR-13	Dry weather sampling event. Low flow. Pulled e. coli sample only	2015 PR Pg 36-37	2/23/2017	11:10					166.4														
1		230.1	winter	Pretty Run	NA-PR-14	Dry weather sampling event. Jack Burchalter location. New reach of stream. Lots of braided streams and potential area for more study	2015 PR Pg 36-37	2/23/2017	12:22					16	Hum - Rum -													
1		230.1	winter	Pretty Run	NA-PR-04	Dry weather sampling. No discoloration	2015 PR Pg 36-37	2/23/2017	12:40					137.6														
1		230.1	winter	Pretty Run	NA-PR-04FB	Dry weather sampling. Field blank	2015 PR Pg 36-37	2/23/2017	12:40					0														
1		230.1	winter	Pretty Run	NA-PR-03	Dry weather sampling. Upstream of pipe	2015 PR Pg 36-37	2/23/2017	12:45					150														
1		230.1	winter	Pretty Run	NA-PR-HSP Pipe	Dry weather sampling. Pipe discharging. Erosion happening at top of headwall area	2015 PR Pg 36-37	2/23/2017	12:49					101.4														
1		230.1	winter	Pretty Run	NA-PR-01	Dry weather sampling. No issues observed	2015 PR Pg 36-37	2/23/2017	13:10					770.1	Hum - Rum +													
1		230.1	winter	Pretty Run	NA-PR-01Dup	Dry weather samplinng. No issues observed.	2015 PR Pg 36-37	2/23/2017	13:10					547.5														
1		230.1	winter	Pretty Run	NA-PR-HPB	Dry weather sampling. Good flow. Walked up to sample point.	2015 PR Pg 36-37	2/23/2017	14:00					365.4	Hum - Rum -													
1		230.1	winter	Pretty Run	NA-PR-02	Dry weather sampling. Good flow. Walked up to sample point.	2015 PR Pg 36-37	2/23/2017	14:22					150														
1		230.1	winter	Pretty Run	NA-PR-02B	New sample location, third trib to NA-PR-02	2015 PR Pg 36-37	2/23/2017	14:25					325.5														
2	25.85	231.4				NOTED STORM EVENT - Water entering from 2 additional locations (down the trail) Photo		4/3/2017	13:09																			
2		230.4	Spring	Pretty Run	NA-PR-13	Wet weather sampling. OK flow. DO meter not working. Nuts collected, but not able to be tested (wrong container/preservative). 0.6" rainfall	2015 PR pg 38	5/25/2017	10:57	6.6		19.3		574														
2		230.4	Spring	Pretty Run	NA-PR-13 FB	Field Blank	2015 PR pg 38	5/25/2017	11:00					0														
2		230.4	Spring	Pretty Run	NA-PR-16 Di	Ditch off Siskin upstreams of NAPR16. Low flow	2015 PR pg 38	5/25/2017	11:39	5.7		20.4		23														
2		230.4	Spring	Pretty Run	NA-PR-16	Wooded area with more flow. Small fry spotted	2015 PR pg 38	5/25/2017	12:00	6		19.8		488														
2	4.9	230.4	Spring	Pretty Run	NA-PR-03	Wet weather sampling. No issues observed. Staff gage below 1. Nuts collected but not testable (wrong container/preservative)	2015 PR pg 38	5/25/2017	12:16	6.51		20.6		517														

				STANDARDS or Average for SC→										STD = 349 mpn/100 ml				<1.17 avg < 1.3 HH	<0.20 avg	<0.61 EPA/SC	<0.62 avg < 10.0 HH	<0.013 HH < 0.014 AQ	<0.58 avg	<0.14 avg < 1.3 HH	<0.01 avg < 1.3 HH <0.0038 AQCMC	<1.17 avg < 0.3 EPA/SC	<0.084 avg < 0.05 HH < 1.0 Aq	<0.04 avg < 7.4 HH <0.03 AQ
Code Code Key: 1= Clear no rain, 2=Rainfall, 3=First Flush, 4=24 Hour, 5=Field data only, 6=fecal only, 7=Nuts only, 8=Pond	Est flow (mgd)	Water Elev Box Culvert -(230.1 stream with no rain)	Season	BASIN	ID	Field Notes from Log Books or sampler (1) Hard bound Rite in Rain pages 16 to end Book (2) Small pocket sized Rite in Rain spiral and one large bound Data Logbook in SW office Composite samplers chained and locked at each use location (3) Data LB logbook of all anlaytical results (4) Pretty Run small Rite in Rain logbook beginning 07202015	Log Bk # & Pg #	Date (order)	Grab Time	pH	DO	Temp	Detergent Test	E. Coli 100ml	DNA Source Tracking	Optical Brightener test	Turb/tss	Cadmium	Ammonia	Nickel	Nitrite/Nitrate	Lead	TKN	Phosphorus	Copper	Iron	Manganese	Zinc
2		230.4	Spring	Pretty Run	NA-PR-04	Sample taken downstream from 04 on other side of bridge. Foamy water spotted downstream. DO meter now working	2015 PR pg 38	5/25/2017	12 49	6 86	7 6	20 4		411														
2		230.4	Spring	Pretty Run	NA-PR-02	Wet weather sample. Area looks good including branches meeting upstream of 02 sample point. Better address for 02 collection is 12 or 14 Brookview Ct	2015 PR pg 38	5/25/2017	13 25	7 02	10	20 7		449														
2		230.4	Spring	Pretty Run	NA-PR-01	Wet weather sampling. No issues observed. Dup taken with same scoop. Nuts taken here	2015 PR pg 38	5/25/2017	13 46	7 06	7 6	20 3		866					0.36		0 34		0 64	0.025				
2		230.4	Spring	Pretty Run	NA-PR-01 Dup	" " " "	2015 PR pg 38	5/25/2017	13 46	"	"	"		548														
1		230.4	Winter	Pretty Run	NA-PR-03	Dry weather sampling, nuts & bacteria, DNA Erin Spivey USCA	2015 PR pg 44	2/8/2018	14 34	6 8	7 5				-Hum +animal	COD=16			0.11		0 72		0 47	0.015				
1		230.4	Winter	Pretty Run	NA-PR-01	Dry weather sampling, nuts & bacteria, DNA Erin Spivey USCA	2015 PR pg 44	2/8/2018	14 34	7 8	8 1				-Hum +animal	COD=12			0.22		0 59		0 53	0.028				
1		230.4	Winter	Pretty Run	NA-PR-HP2	Dry weather sampling, nuts & bacteria, DNA Erin Spivey USCA	2015 PR pg 44	2/13/2018	14 56	6 97	9 42			>2419	-Hum +animal	COD=ND			0 43		0 12		0 95	0.012				
1		230.4	Winter	Pretty Run	NA-PR-HP	Dry weather sampling, nuts & bacteria, DNA Erin Spivey USCA	2015 PR pg 44	2/13/2018	15 30	7 01	9 69			411	-Hum +animal	COD=16			0 24		0 1		0 6	0.043				
1		230.4	Winter	Pretty Run	NA-PR-04	Dry weather sampling, E coli	2015 PR pg 45	2/20/2018	15 23	7 11	8 68			222														
1		230.4	Winter	Pretty Run	NA-PR-HSP Pipe	Dry weather sampling, E coli (50% dilution)	2015 PR pg 45	2/20/2018	15 10	7 11	8 9			84														
1		230.4	Winter	Pretty Run	NA-PR-FB	Dry weather sampling, E coli (50% dilution)	2015 PR pg 45	2/20/2018	15 06					0														
1		230.4	Winter	Pretty Run	NA-PR-04 dup	Dry weather sampling, E coli (50% dilution)	2015 PR pg 45	2/20/2018	15 24					166														
1		230.4	Winter	Pretty Run	NA-PR-04B	Dry weather sampling, E coli (50% dilution)	2015 PR pg 46	2/20/2018	15 20					158														
2		230.4	Winter	Pretty Run	NA-PR-16Di	Wet weather event (0.12" rainfall	2015 PR pg 46	2/26/2018	10 49	6 29																		
2		230.4	Winter	Pretty Run	NA-PR-16Di dup	Wet weather event (0.12" rainfall	2015 PR pg 46	2/26/2018	10 50																			
2		230.4	Winter	Pretty Run	NA-PR-FB	Wet weather event (0.12" rainfall	2015 PR pg 46	2/26/2018	10 52																			
2		230.4	Winter	Pretty Run	NA-PR-01	Wet weather event (0.12" rainfall	2015 PR pg 46	2/26/2018	13 38	7 26	9 67																	
2		230.4	Winter	Pretty Run	NA-PR-01 10%	Wet weather event (0.12" rainfall	2015 PR pg 46	2/26/2018	13 43																			
2		230.4	Winter	Pretty Run	NA-Pr-01 25%	Wet weather event (0.12" rainfall	2015 PR pg 46	2/26/2018	13 40																			
2020																												
1		230.4	Spring	Pretty Run	NA-PR-01	Dry weather sampling, last rain 6 day prior to grab sample. Nuts/Mets pulled also	book 1 of 2 pg 101	5/6/2020	14 40	6 98	8 77	20 4		227 4					nd		0.65	nd	0 24	nd	nd	0 51	0.021	nd
1		230.4	Spring	Pretty Run	NA-PR-01 FB	Dry weather sampling, last rain 6 day prior to grab sample. Nuts/Mets pulled also	book 1 of 2 pg 101	5/6/2020	14 40	6 98	8 77	20 4		0														
1		230.4	Spring	Pretty Run	NA-PR-04	Dry weather sampling, last rain 6 day prior to grab sample. Nuts/Mets pulled also	book 1 of 2 pg 101	5/6/2020	15 15	7 46	8 74	19 5		88					nd		0 65	nd	0 28	0 12	nd	0 86	0.028	nd
1		230.4	Spring	Pretty Run	NA-PR-04Dup	Dry weather sampling, last rain 6 day prior to grab sample. Nuts/Mets pulled also	book 1 of 2 pg 101	5/6/2020	15 15	7 46	8 74	19 5		76 8														

Optical Brightener Sampling – Pretty Run Basin (Map 2)

Optical Brightener Sampling – Pretty Run Basin (Map 1)

Optical Brightener Sampling – Pretty Run Basin (Map 3)



2013 Macroinvertebrate Study

(Pretty Run Creek, Mims Branch Creek, Waterworks Creek)

Summary

In 2010, SCDHEC presented information in the preliminary 303d listing that Pretty Run impairments will include "macroinvertebrates" as a listed impairment and would then require a TMDL for that impairment in the future. Macroinvertebrate sampling involves a team pulling samples of small aquatic and semi-aquatic insects from the stream over a few days. In some cases, a week of sampling is conducted. The information is then analyzed by species type and abundance to determine if the stream is healthy or impaired. A lack of certain species that should be abundant or a lack of species that are intolerant to pollutants is analyzed. Or an abundance of species that are hardy and withstand pollutant loads and lack of the others is assessed. The result of the sampling is tabulated and a "score" is achieved. That score determines if the stream is healthy or impaired.

The fact that the stream was sampled in the past for macroinvertebrates by the state raised a few questions. When did SCDHEC sample Pretty Run Creek for macroinvertebrates and where is that data and also what were the conditions at that time? We contacted the state and they provided us the information. The macroinvertebrate sampling that the state conducted was in 2004. It was only one sample event. We have provided it here. So in essence, that one sample event could lead to the city is facing another TMDL for Pretty Run Creek. We questioned the state on how or when would the revisit the site since many years had passed. They informed us that their budgets would not allow that at the time. We questioned whether we could sample the stream to verify or refute the status and have the impairment removed from the list. The answer was yes, but only if we could produce certified results by utilizing a certified lab or providing SCDHEC with a Quality Assurance Project Plan (QAPP) for approval. Once we had that, we would be able to certify the results and they would be considered as valid data for review for delisting.

We created a QAPP and it is attached in this section. The QAPP was in its third review by the state for final approval. Prior to final approvals, we ended the project due to the end of the students' internships. The team did a great job putting together the materials and equipment, writing the standard operating procedures, establishing a sampling regime and creating the QAPP.

As for the actual sampling and analysis of data, there is a method and a system to score each sample event in the watershed. The following is an explanation of how that is accomplished and will help you to understand the resulting data for our efforts, and from DHEC's. So here are what the scores mean:

Count: Number of insects collected.

TR: Taxa richness is the number of taxa present in a given area.

EPT Biotic Index: Some macroinvertebrate orders, such as *Diptera* (true flies), are generally tolerant to higher levels of pollutants in streams. Other orders, such as *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Tricoptera* (caddisflies), are very sensitive to many pollutants in the stream environment. EPT can be expressed as a percentage of the sensitive orders (E= *Ephemeroptera*, P= *Plecoptera*, T= *Tricoptera*) to the total taxa found. <u>A large percentage of EPT taxa indicates high water quality</u>. Calculated by the following:

$$\frac{\textbf{Total EPT Taxa}}{\textbf{Total Taxa Found}} \times 100\% = \%\ \textbf{Abundance}$$

BI Biotic Index: The biotic index (BI) is the average pollution tolerance of all organisms collected (based on assigned index values for taxa) and the calculation factors in relative abundances. The index is based on a scale of 0 to 10, with 10 representing the most impaired stream condition.

BI & EPT Scores (in general)

Excellent = 5   Good = 4   Good-Fair = 3   Fair=2   Poor = 1

Upstream vs downstream comparisons: By comparing final bioclassification scores, an assessment can be made. The following represents the levels of impairment and their associated change in bioclassification scores, or difference.

Unimpaired	0.4
Slightly impaired	0.6 – 1.4
Moderately impaired	1.6 – 2.4
Severely impaired	>2.6

Combined Score – overall score (EPT & BI)

Bioclass	**ALU**
Excellent and Good	Fully Supporting
Good-Fair and Fair	Partially Supporting
Poor	Not Supporting

During the process of getting approvals for the QAPP, the staff were training on the procedures and conducted preliminary sampling in the Pretty Run watershed. The results of those events are provided in this section. Samples collected are sorted and species are identified. Then based on numbers of each species, they are ranked either Rare (1-2 individuals), Common (3-9) individuals, or Abundant (>10 individuals). If there are less than 100 total organisms in a sample, the Biotic Index (BI) is not used. Instead, the EPT index is used along with other data to assign a bioclassification. Ecoregions influence macroinvertebrate distribution so different BI and EPT criteria are used based on that information. North Augusta sampled streams are located in the Piedmont ecoregion and that information was used for the data analysis.

Pretty Run Creek:

DHEC DATA Result July 28, 2004 Pretty Run at RS-04544 (Aka NA-PR-01)

Count:	TR:	EPT:	BI:	EPT Score:	BI Score:	Comb. Score:	Bioclass:	ALU
196	29	6	6.41	1.4	3	2.2	F	PS

The city data forward is preliminary and was part of the training process only.

North Augusta Preliminary Result June 24, 2013 Pretty Run at RS-04544 (not certified)

Count:	TR:	EPT:	BI:	EPT Score:	BI Score:	Comb. Score:	Bioclass:	ALU
108	16	5	6.45	1.0	3	2	F	PS

Another sample event farther upstream in Pretty Run was taken off of Socastee Road on July 15, 2013. For that sample event, the count was only 38. Scoring was not done on this sample, due to the small count.

Mims Branch: Macroinvertebrate sampling was also conducted at Mims Branch (a representative stream).

North Augusta Preliminary Result June 17, 2013 NA-MB-03, Mims Branch at Power line (not certified)
For that sample event, the count was only 15. Scoring was not done on this sample, due to the small count.

North Augusta Preliminary Result June 17, 2013 NA-MB-02, Mims Branch crossing by 4x4s (not certified)
For that sample event, the count was only 23. Scoring was not done on this sample, due to the small count.

North Augusta Preliminary Result July 22, 2013 NA-MB-02, Mims Branch crossing by 4x4s (not certified)
For that sample event, the count was only 37. Scoring was not done on this sample, due to the small count.

Finally, we also sampled at **Waterworks Basin** during the training period. Here we had the several legs of the stream sampled. First, upstream we sampled within the NA Community Center by the basketball courts, Second we sampled along Riverside Boulevard at the upper end but just below the foot bridge over the creek. Third we sampled where a repair had been made to the channel in 2011, we called that sample the old season. We also sampled a Forth location downstream from that area where we had repaired the stream channel with matting and boulders earlier in the year (2013) to reduce erosion.

Waterworks Basin: Macroinvertebrate sampling.

North Augusta Preliminary Result May 29, 2013 NA-WW-03A, Waterworks BB Court (not certified)
For that sample event, the count was only 15. Scoring was not done on this sample, due to the small count.

North Augusta Preliminary Result May 29, 2013 NA-WW-04, Waterworks below bridge (not certified)
For that sample event, the count was only 8. Scoring was not done on this sample, due to the small count.

North Augusta Preliminary Result May 29, 2013 NA-WW-OS1, Waterworks Old Season (not certified)

Count:	TR:	EPT:	BI:	EPT Score:	BI Score:	Comb. Score:	Bioclass:	ALU
321	16	3	6.15	1.0	3	2	F	PS

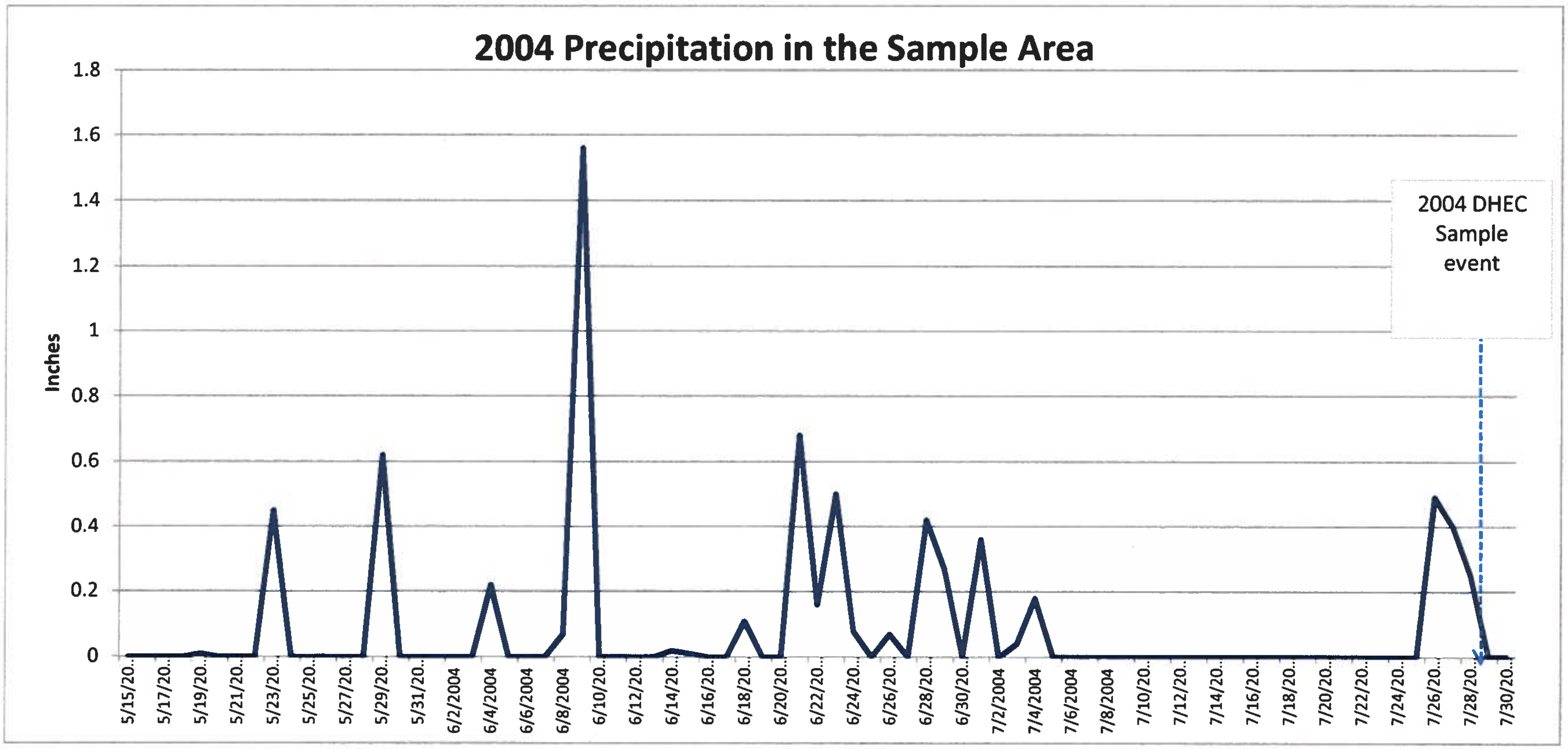
North Augusta Preliminary Result May 29, 2013 NA-WW-NS1, Waterworks New Season (not certified)

Count:	TR:	EPT:	BI:	EPT Score:	BI Score:	Comb. Score:	Bioclass:	ALU
122	8	2	5.38	1.0	5	3	G-F	PS

DATE	STATION	Count	TR	EPT	BI	EPT Score	BI Score	Comb. Score	Bioclas	ALU	Comments
07/28/04	RS-04544	194	29	6	6.41	1.4	3	2.2	F	PS	

STATION	DATE	STATE	COUNTY	STREAM
RS-04544	7/28/~~19~~04 2004	SC	Aiken	Tributary to Savanah River @ River Rapids Subdivisoon

STATION	DATE	PHYLUM	CLASS	ORDER	FAMILY	GENSPEC	NUMBER	TV
RS-04544	7/28/04	Arthropoda	Crustacea	Amphipoda	Talitridae	Hyallela azteca	1	7.75
RS-04544	7/28/04	Arthropoda	Hexapoda	Coleoptera	Dryopidae	Helichus sp.	1	4.63
RS-04544	7/28/04	Arthropoda	Hexapoda	Coleoptera	Elmidae	Ancyronyx variegatus	2	6.49
RS-04544	7/28/04	Arthropoda	Hexapoda	Coleoptera	Elmidae	Microcylloepus pusillus	6	2.11
RS-04544	7/28/04	Arthropoda	Hexapoda	Coleoptera	Elmidae	Stenelmis sp.	19	5.1
RS-04544	7/28/04	Arthropoda	Crustacea	Decapoda	Cambaridae	Cambaridae	3	7.5
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Chironomidae	Ablabesmyia mallochi	22	7.19
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Chironomidae	Ablabesmyia rhamphe GR	4	0
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Chironomidae	Paratanytarsus dissimilis	1	8.45
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Chironomidae	Pentaneura inconspicua	1	4.7
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Chironomidae	Polypedilum convictum	1	4.9
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Chironomidae	Polypedilum illinoense	1	9
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Chironomidae	Thienemannimyia GR	9	0
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Chironomidae	Tribelos fusicorne	1	6.31
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Ptychopteridae	Bittacomorpha clavipes	1	0
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Simuliidae	Simulium sp.	5	0
RS-04544	7/28/04	Arthropoda	Hexapoda	Diptera	Tipulidae	Tipula sp.	7	7.33
RS-04544	7/28/04	Arthropoda	Hexapoda	Ephemeroptera	Baetidae	Baetis pluto	1	4.28
RS-04544	7/28/04	Arthropoda	Hexapoda	Ephemeroptera	Baetidae	Pseudocloeon propinquum	1	5.8
RS-04544	7/28/04	Arthropoda	Hexapoda	Ephemeroptera	Heptageniidae	Maccaffertium modestum	11	5.5
RS-04544	7/28/04	Mollusca	Gastropoda	Mesogastropoda	Pleuroceridae	Elimia sp.	1	2.5
RS-04544	7/28/04	Mollusca	Gastropoda	Mesogastropoda	Viviparidae	Campeloma sp.	1	6.45
RS-04544	7/28/04	Annelida	Oligochaeta	NA	NA	Oligochaeta	6	0
RS-04544	7/28/04	Arthropoda	Hexapoda	Odonata	Aeshnidae	Boyeria vinosa	9	5.89
RS-04544	7/28/04	Arthropoda	Hexapoda	Odonata	Calopterygidae	Calopteryx sp.	26	7.78
RS-04544	7/28/04	Arthropoda	Hexapoda	Odonata	Gomphidae	Progomphus sp.	3	8.7
RS-04544	7/28/04	Arthropoda	Hexapoda	Trichoptera	Hydropsychidae	Cheumatopsyche sp.	1	6.22
RS-04544	7/28/04	Arthropoda	Hexapoda	Trichoptera	Hydropsychidae	Hydropsyche betteni	46	7.78
RS-04544	7/28/04	Arthropoda	Hexapoda	Trichoptera	Leptoceridae	Triaenodes ignitus	3	4.58


2004 Precipitation in the Sample Area
Inches
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
5/15/20…
5/17/20…
5/19/20…
5/21/20…
5/23/20…
5/25/20…
5/27/20…
5/29/20…
5/31/20…
6/2/2004
6/4/2004
6/6/2004
6/8/2004
6/10/20…
6/12/20…
6/14/20…
6/16/20…
6/18/20…
6/20/20…
6/22/20…
6/24/20…
6/26/20…
6/28/20…
6/30/20…
7/2/2004
7/4/2004
7/6/2004
7/8/2004
7/10/20…
7/12/20…
7/14/20…
7/16/20…
7/18/20…
7/20/20…
7/22/20…
7/24/20…
7/26/20…
7/28/20…
7/30/20…
2004 DHEC Sample event

07/28/2004 SCDHEC Sample Log – used to prepare photos & information from various internet sources

Hyalella azteca is found across Central America, the Caribbean and North America,[2] as far north as the Arctic tree line.[1] It lives among vegetation in permanent bodies of freshwater, including lakes and rivers,[1] extending into tidal fresh water, and freshwater barrier lagoons.[2] It is "the most abundant amphipod of lakes [in North America]". Hyalella azteca grows to a length of 3–8 millimetres (0.12–0.31 in), with males being larger than females.[1] Their colour is variable, but the most frequent hues are white, green and brown

Helichus sp.

AQUATIC DRYOPOID BEETLES (COLEOPTERA) OF THE UNITED STATES by
Harley P. Brown
Department of Zoology]
The University of Oklahoma
730 Van Vleet Oval, Room 222
Norman, Oklahoma 73069

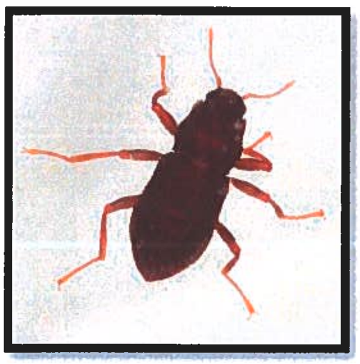
Helichus, of the family Dryopidae, is unique among insects in that the adults are aquatic, behaving rather like elmids, whereas the larvae are terrestrial, inhabiting soil or decaying wood. The adults are not permanently bound to the water once they return to it. They probably emerge and fly at night, at least upon occasion. The females have sharp-tipped ovipositors with which they probably insert their eggs into appropriate materials. The larvae of Dryops and Pelonomus are also soil-dwellers, the adults being terrestrial or, at most, riparian. Dryops frequents trash lodged in streams, but does not appear to enter the water.

Various parts of the legs and body, especially on the ventral side, are covered with a hydrofuge tomentum or pile which maintains a film of air when the beetle is submerged. This film, which is in contact with the air reservoir beneath the elytra, provides adequate gaseous exchange in the well-aerated lotic situations occupied by the beetles. Small bubbles of oxygen photosynthetically produced by algae and other aquatic plants provide an additional source of oxygen and can be incorporated into the plastron. Since the gaseous film is essential to these beetles, it is not difficult to understand why they cannot tolerate excessive pollution by such wetting agents as soaps and detergents.

07/28/2004 SCDHEC Sample Log – used to prepare photos & information from various internet sources

Ancyronyx variegatus

Microcylloepus pusillus (riffle beetle)

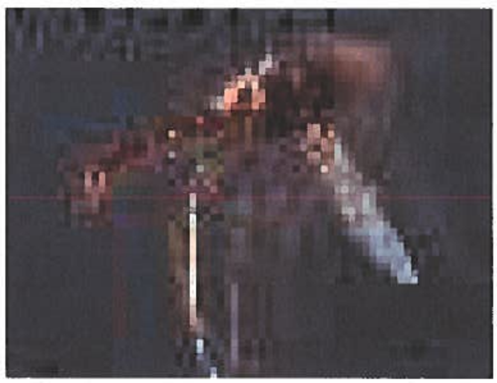


Stenelmis sp.(riffle beetle)

Cambaridae sp.

07/28/2004 SCDHEC Sample Log – used to prepare photos & information from various internet sources

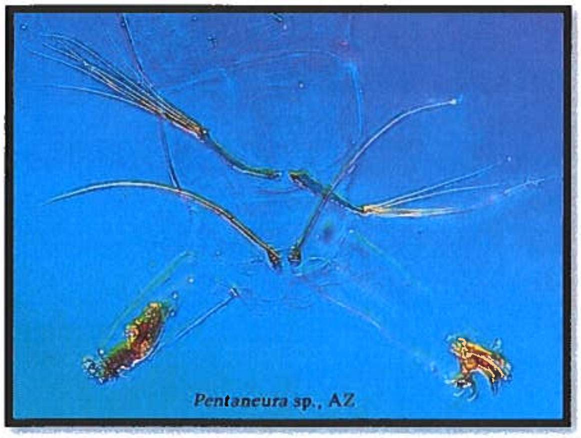
Ablabesmyia is a genus of non-biting midges in the subfamily Tanypodinae of the bloodworm family Chironomidae.



Paratanytarsus dissimilis

07/28/2004 SCDHEC Sample Log – used to prepare photos & information from various internet sources

Pentaneura inconspicua

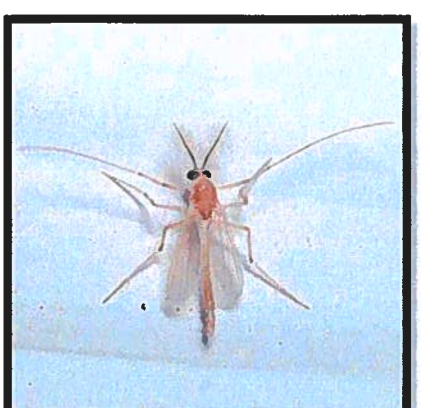


Pentaneura larvae are recognizable by very long anal tubules and large supraanal setae mounted on dark tubercles. The mandible has very large mola and inner teeth; in contrast to Trissopelopia, the ring organ is situated in the apical 1/3 of the basal maxillary palp segment. Unnamed material from North America with more weakly developed mola, and essentially straight inner teeth of the ligula extends the larval generic diagnosis (M. Bolton pers. comm.). Larvae of Pentaneura occur in small and large bodies of running water.

The known distribution of the genus is North and South America, with 2 species on each continent. Pentaneura inconspicua and P. inyoensis are quite common throughout the USA in rivers and streams.

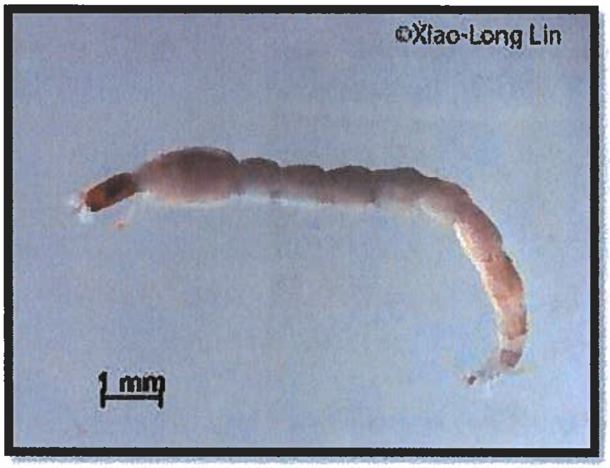
Polypedilum convictum

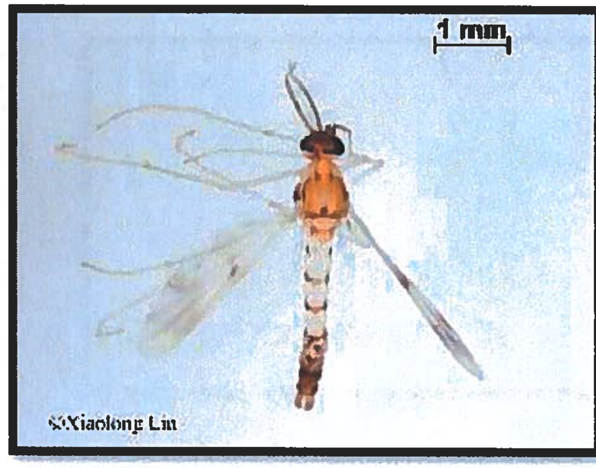
Polypedilum illinoense



07/28/2004 SCDHEC Sample Log – used to prepare photos & information from various internet sources

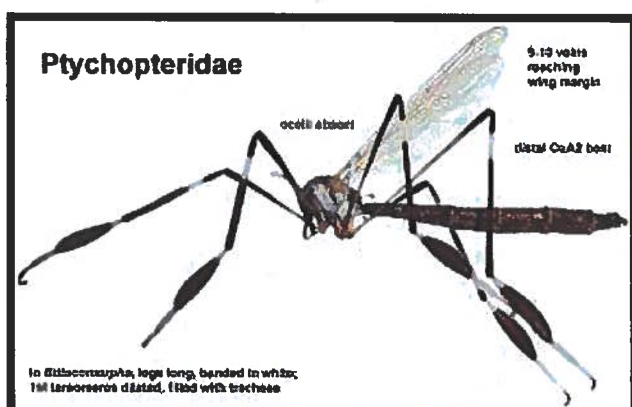
Thienemannimyia GR





Tribelos fusicorne

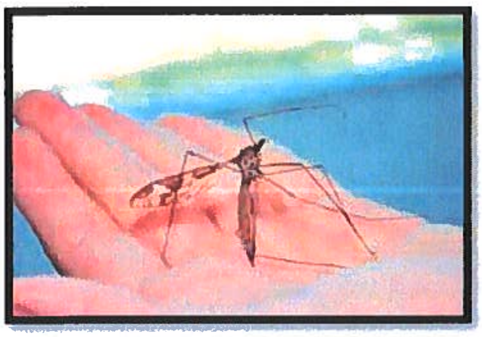
Bittacomorpha clavipes



07/28/2004 SCDHEC Sample Log – used to prepare photos & information from various internet sources

Simulium sp. (black fly black fly larvae)

Tipula sp. (crane fly)

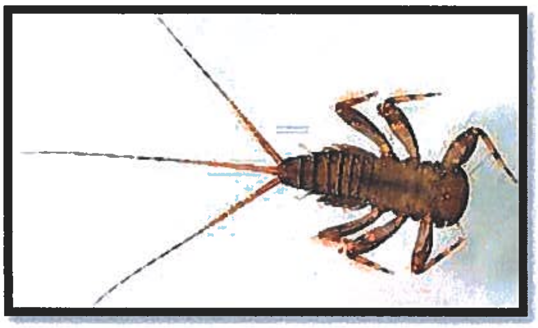


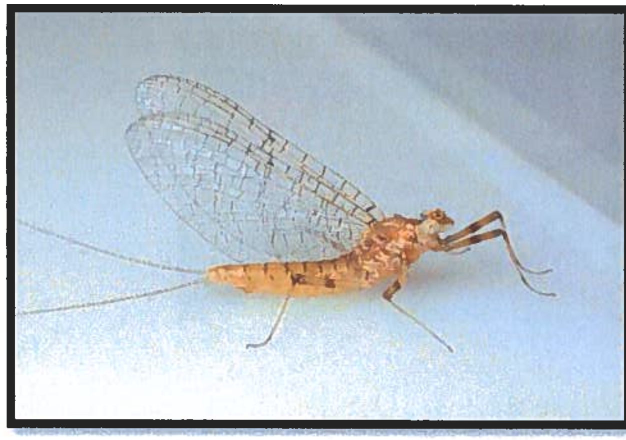
Baetis pluto (small minnow mayflies)

Pseudocloeon propinquum

07/28/2004 SCDHEC Sample Log – used to prepare photos & information from various internet sources

Maccaffertium modestum





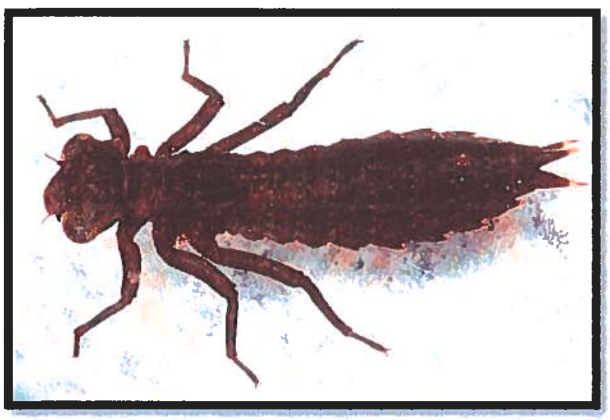
Elimia sp.

Campeloma sp.

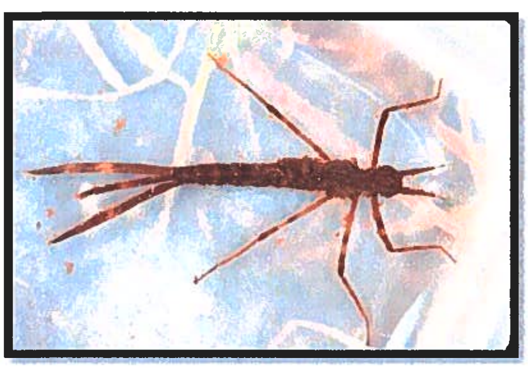
07/28/2004 SCDHEC Sample Log – used to prepare photos & information from various internet sources

Oligochaeta

Boyeria vinosa

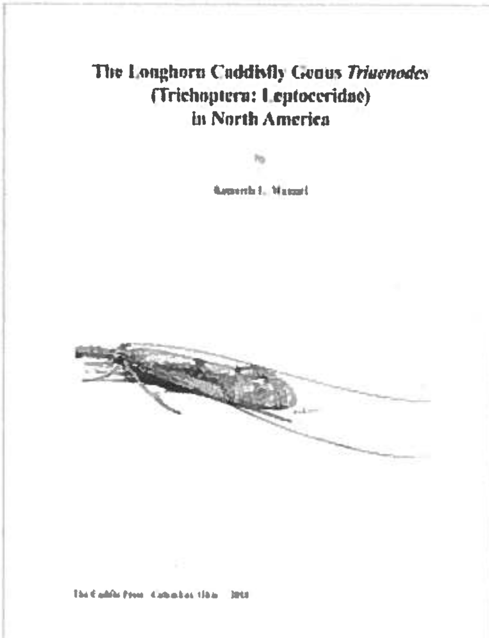


Calopteryx sp.



07/28/2004 SCDHEC Sample Log – used to prepare photos & information from various internet sources

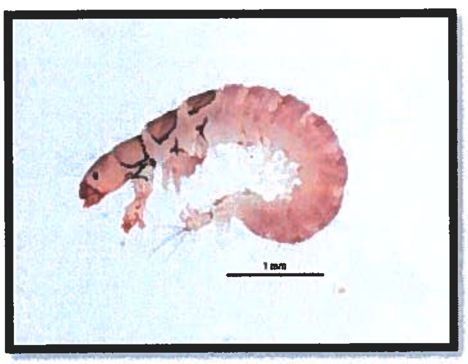
Triaenodes ignites


The Longhorn Caddisfly Genus *Triaenodes*
(Trichoptera: Leptoceridae)
in North America

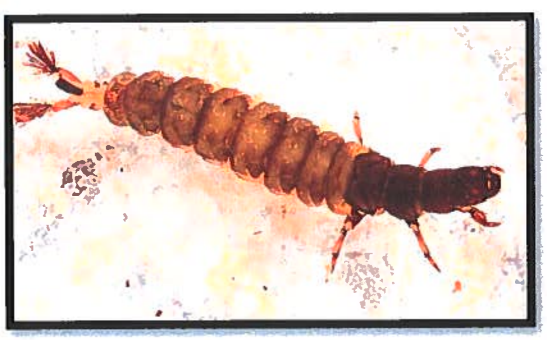
07/28/2004 SCDHEC Sample Log – used to prepare photos & information from various internet sources

Progomophus sp.

Cheumatopsyche sp.



Hydropsyche betteni



Preliminary CNA Samples

Stream name: Pretty Run Creek
Location: RS-04544
River Basin:
Collected by: A. Baker and C. Tran
Date Collected: 6/24/2013
Taxonomist: A. Baker and C. Tran
Dates Identified: 6/25/13, 7/1/13, 7/8/13

Phylum	Class	Order	Organism Family	Subfamily	Genspec	Number	Life Stage	Taxonimist Initials	TCR	TV	FFG	AV	TV		
Annelida	Oligochaeta	N/A	N/A	N/A	Oligochaeta	1	Adult	CT	1	-	7		-		
Arthropoda	Hexapoda	Trichoptera	Hydropsychidae	N/A	Hydropsyche betteni	47	Immature	AB/CT	2	7.78	3	10	7.78	77.8	
Arthropoda	Hexapoda	Trichoptera	Hydropsychidae	N/A	Cheumatopsyche sp.	15	Immature	AB/CT	2	6.22	7	10	6.22	62.2	
Arthropoda	Hexapoda	Trichoptera	Hydropsychidae	N/A	Ceratopsyche sp.	8	Immature	AB/CT	2	-	1		-		
Arthropoda	Hexapoda	Coleoptera	Elmidae	N/A	Optioservus sp.	1	Immature	CT	2	2.36	5	1	2.36	2.36	
Arthropoda	Hexapoda	Coleoptera	Elmidae	N/A	Macronychus sp.	1	Adult	CT	2	4.58	5	1	4.58	4.58	
Arthropoda	Hexapoda	Collembola	Isotomidae	N/A	Isotomurus sp.	2	Immature	CT	2	-	0		-		
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Chironomus sp.	1	Pupa	CT	3	9.63	4	1	9.63	9.63	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Chironomus sp.	2	Immature	CT	3	9.63	4	1	9.63	9.63	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Polypedilum flavum	4	Immature	CT	3	4.93	4	3	4.93	14.79	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Polypedilum sp.	2	Immature	CT	3	-	4		-		
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Clinotanypus sp.	1	Immature	CT	3	-	6		-		
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Larsia sp.	1	Immature	CT	3	9.3	6	1	9.3	9.3	
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Natarsia sp.	1	Immature	CT	3	9.95	6	1	9.95	9.95	
Arthropoda	Hexapoda	Ephemeroptera	Baetidae	N/A	Baetis sp.	14	Immature	CT	3	5.4	4	10	5.4	54	
Arthropoda	Hexapoda	Ephemeroptera	Heptageniidae	N/A	Maccaffertium sp.	7	Immature	CT	3	5.5	4	3	5.5	16.5	
						108						42		270.74	6.44619

Date Sampled	Station	Count	TR	EPT	BI	EPT Score	BI Score	Comb. Score	Bioclass	ALU
6/24/2013	RS-04544	108	16	5	6.45	1	3	2	F	PS

Benthic Macroinvertebrate Sample Log-in Sheet

Date Collected	Callected By	Number of Containers	Preservation	Station Number	Stream Name and Location	Date Received by Lab	Lot Number	Date of Completion: Sorting	Date of Completion: Mounting	Date of Completion: Identification
7/15/2013	Baker/Tran	1	91% EtOH	N/A	Pretty Run Creek - Socastee Road	7/15/2013	N/A	7/15/2013	7/15/2013	7/19/2013

Benthic Macroinvertebrate Sample Log-in Sheet

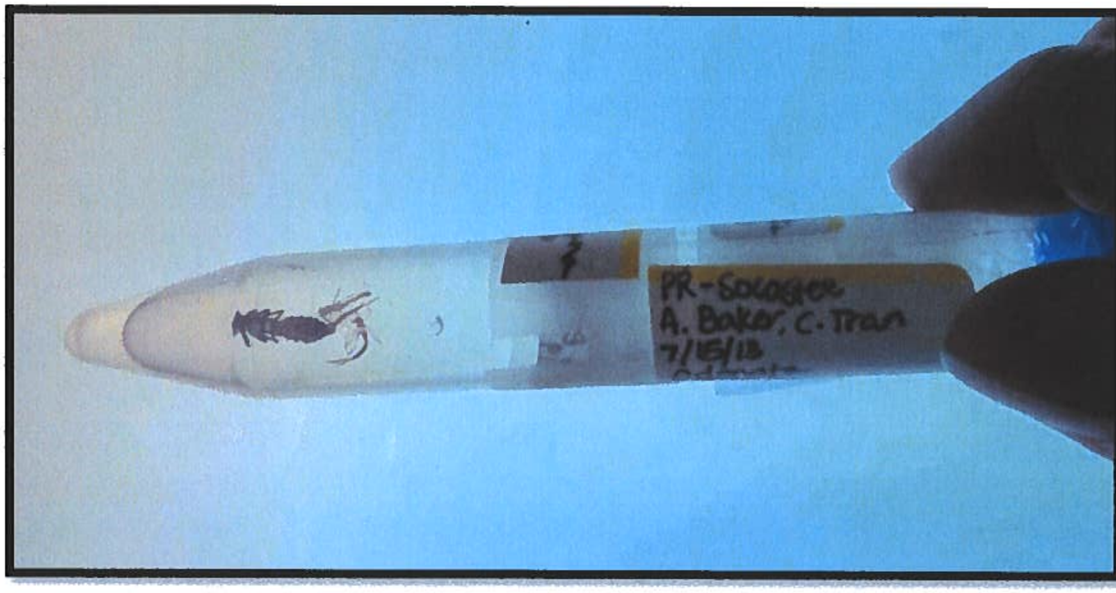
Date Collected	Callected By	Number of Containers	Preservation	Station Number	Stream Name and Location	Date Received by Lab	Lot Number	Date of Completion: Sorting	Date of Completion: Mounting	Date of Completion: Identification
6/24/2013	Baker/Tran	1	91% EtOH	N/A	Pretty Run Creek - RS-04544	6/24/2013	N/A	6/24/2013	6/24/2013	7/8/2013

Stream name: Pretty Run Creek
Location: Socastee Road
River Basin:
Collected by: A. Baker and C. Tran
Date Collected: 7/15/2013
Taxonomist: A. Baker and C. Tran
Dates Identified: 7/19/2013

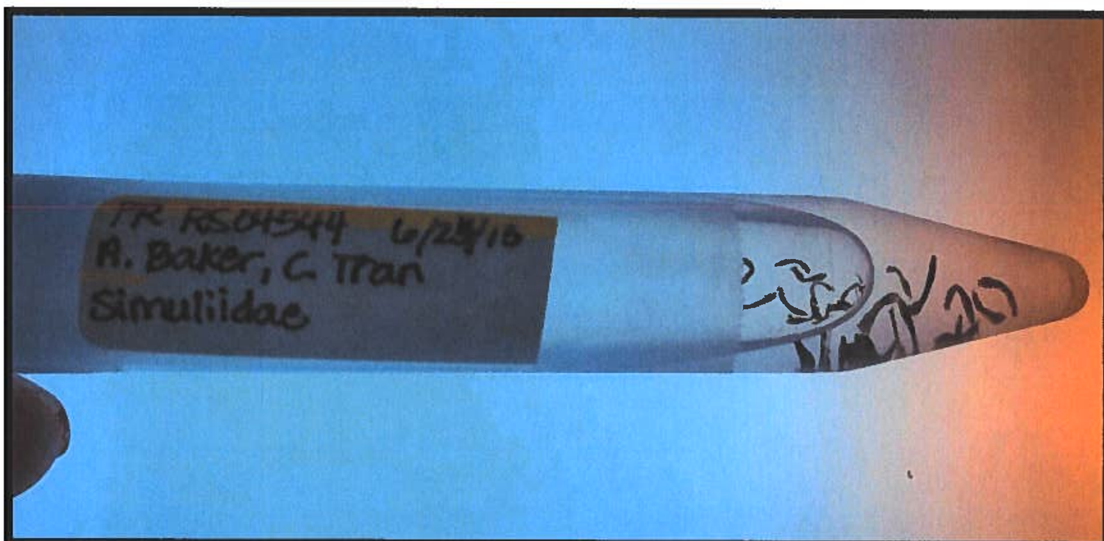
Phylum	Class	Order	Organism Family	Subfamily	Genspec	Number	Life Stage	Taxonimist Initials	TCR	TV
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Polypedilum flavum	3	Immature	CT	3	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Polypedilum sp.	2	Immature	CT	3	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Chironomus sp.	3	Immature	CT	3	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Cryptochironomus sp.	1	Immature	CT	3	
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Thienemannimyia sp.	2	Immature	CT	3	
Arthropoda	Hexapoda	Odonata	Gomphidae	N/A	Boyeria vinosa	1	Immature	AB	1	
Arthropoda	Hexapoda	Odonata	Gomphidae	N/A	Calopteryx maculata	4	Immature	AB	2	
Arthropoda	Hexapoda	Odonata	Gomphidae	N/A	Hetaerina americana	5	Immature	AB	4	
Arthropoda	Hexapoda	Trichoptera	Hydropsychidae	N/A	Cheumatopsyche sp.	8	Immature	AB	2	
Arthropoda	Hexapoda	Ephemeroptera	Heptageniidae	N/A	Heptagenia sp.	2	Immature	AB	2	
Arthropoda	Hexapoda	Ephemeroptera	Baetidae	N/A	Callibaetis sp.	5	Immature	AB	3	
Arthropoda	Hexapoda	Collembola	Isotomidae	N/A	Isotomurus sp.	1	Immature	CT	2	
Arthropoda	Crustacea	Amphipoda	Talitridae	N/A	Hyallela azteca	1	Immature	CT	2	
						38				

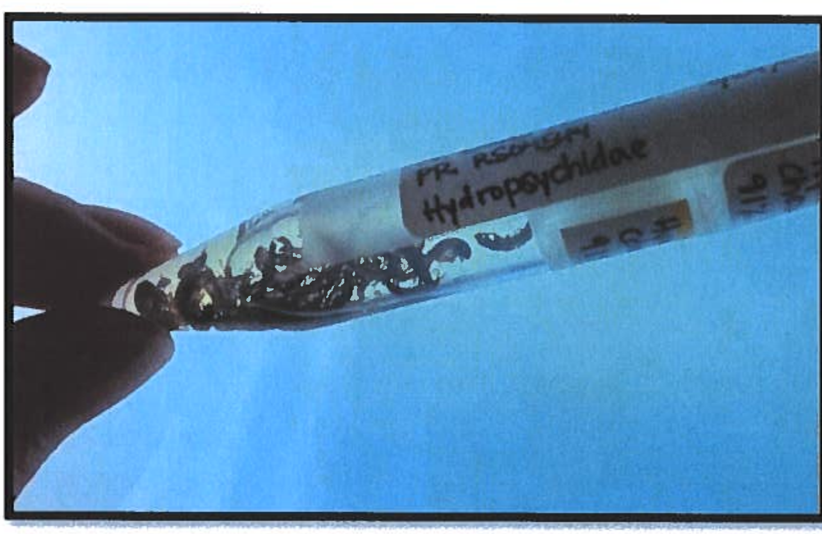
— NOT ENOUGH Collected to SCORE —

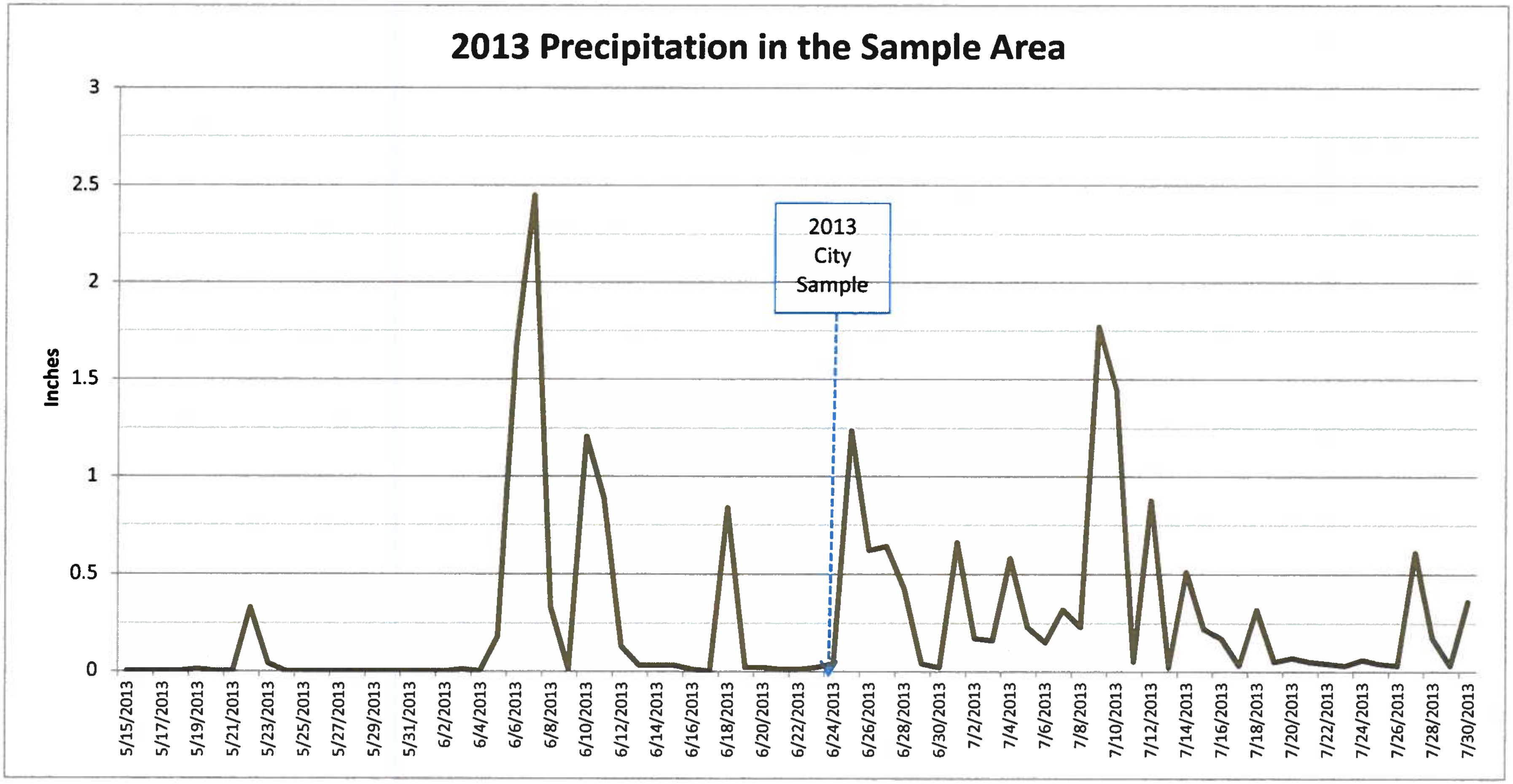
Pretty Run Macro Sampling Photos 2013



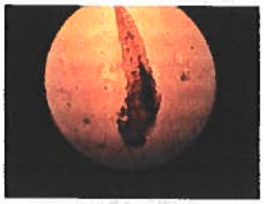
ODONATA



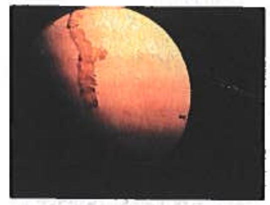



2013 Precipitation in the Sample Area
Inches
3
2.5
2
1.5
1
0.5
0
2013
City
Sample
5/15/2013
5/17/2013
5/19/2013
5/21/2013
5/23/2013
5/25/2013
5/27/2013
5/29/2013
5/31/2013
6/2/2013
6/4/2013
6/6/2013
6/8/2013
6/10/2013
6/12/2013
6/14/2013
6/16/2013
6/18/2013
6/20/2013
6/22/2013
6/24/2013
6/26/2013
6/28/2013
6/30/2013
7/2/2013
7/4/2013
7/6/2013
7/8/2013
7/10/2013
7/12/2013
7/14/2013
7/16/2013
7/18/2013
7/20/2013
7/22/2013
7/24/2013
7/26/2013
7/28/2013
7/30/2013


08162013 012


08162013 050


07152013 pr socastee slide 4 a


07152013 pr socastee slide 4 a (1)

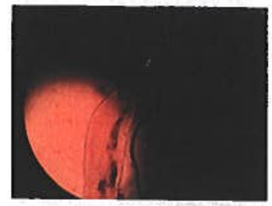

07152013 pr socastee slide 4b


07152013 pr socastee slide 4b (1)


07152013 pr socastee slide 4b (2)


07152013 pr socastee slide 4b (3)


07152013 pr socastee slide 3a


07152013 pr socastee slide 3a (1)


07152013 pr socastee slide 3a (2)

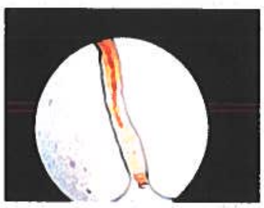

07152013 pr socastee slide 3a (3)

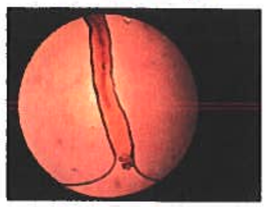

07152013 pr socastee slide 2 b 3


07152013 pr socastee slide 2 b (1) 3


07152013 pr socastee slide 2 c 3


07152013 pr socastee slide 2 c (1) 3


07152013 pr socastee slide 2 c (2) 3


07152013 pr socastee slide 2 c (3) 3


07152013 pr socastee slide 2 c (4) 3


07152013 pr socastee slide 2 c (5) 3


07152013 socastee slide 2d 3


07152013 socastee slide 2d (1) 3

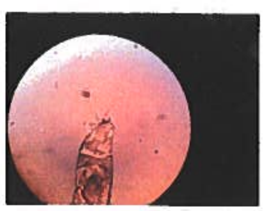

07152013 pr socastee slide 2 a


07152013 pr socastee slide 2 a (1)

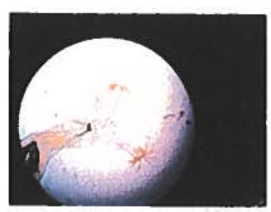

07152013 pr socastee slide 2 a (2)


07152013 pr socastee slide 2 a (3)

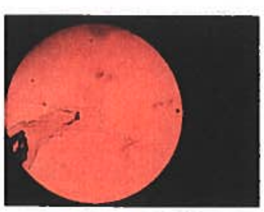

07152013 pr socastee slide 2 a (4)


07152013 pr socastee slide 2 a (5)


07152013 pr socastee slide 1 b


07152013 pr socastee slide 1 b (1)


07152013 pr socastee slide 1 b (2)


07152013 pr socastee slide 1 b (3)

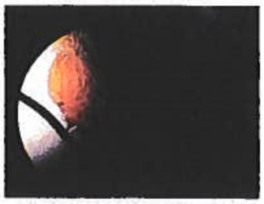

07152013 pr socastee slide 1 b (4)


07152013 pr socastee slide 1 b (5)


07152013 pr socastee slide 1 b (6)

Double Check these Photos


07152013 pr socastee slide 1 b (7)


07152013 pr socastee slide 1 b (8)

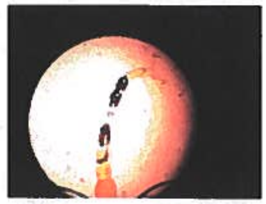

07152013 pr socastee slide 1 b (9)


07152013 pr socastee slide 1 b (10)

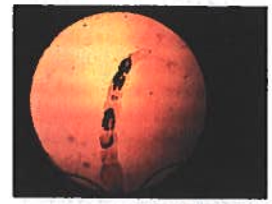

07152013 pr socastee slide 1 b (11)


07152013 pr socastee slide 1 b (12)


07152013 pr socastee slide 1 b (13)


07152013 pr socastee slide 1 b (14)


07152013 pr socastee slide 1 b (15)

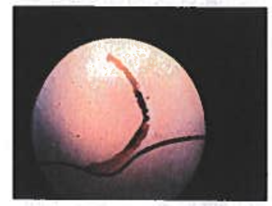

07152013 pr socastee slide 1 b (16)

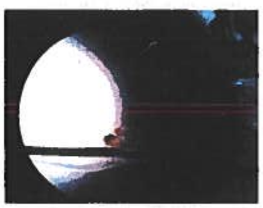

07152013 pr socastee slide 1 b (17)

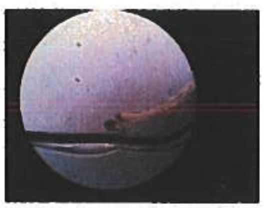

07152013 pr socastee slide 1 b (18)


07152013 pr socastee slide 1 b (19)


07152013 pr socastee slide 1 b (20)

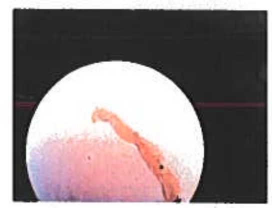

07152013 pr socastee slide 1 a


07152013 pr socastee slide 1 a (1)


07152013 pr socastee slide 1 a (2)


07152013 pr socastee slide 1 a (3)


07152013 pr socastee slide 1 a (4)


07152013 pr socastee slide 1 a (5)


07152013 pr socastee slide 1 a (6)


07152013 pr socastee slide 1 a (7)

Strickland, Tanya

From: Glover, James <gloverjb@dhec.sc.gov>
Sent: Friday, January 10, 2014 3:31 PM
To: Strickland, Tanya
Cc: Burdick, Nydia; Glenn Trofatter
Subject: Macro QAPP
Attachments: North Augusta QAPP for Macroinvertebrate Sampling Rev 1 Dec 2013 jbg.pdf

Tonya,

Nydia suggested I send my comments directly to you. The QAPP is very well done. I included some comments, most of which are technical. I have less experience with QAPP format so if any of my comments conflict with Nydia's you should default to hers. If you have not done so already I would start with Nydia first and then go to mine after. Please let me know if you have questions.

Jim

--

James B. Glover, PhD
Aquatic Biology Section, Manager
SC Department of Health And Environmental Control
2600 Bull Street
Columbia SC 29201
803-898-4081
Gloverjb@dhec.sc.gov

Strickland, Tanya

From: Burdick, Nydia <burdicnf@dhec.sc.gov>
Sent: Thursday, January 02, 2014 1:53 PM
To: Strickland, Tanya
Subject: Fwd: QAPP for a project in North Augusta

Here are James' comments.

---------- Forwarded message ----------
From: **Glover, James** <gloverjb@dhec.sc.gov>
Date: Fri, Jul 19, 2013 at 9:53 AM
Subject: Re: QAPP for a project in North Augusta
To: "Burdick, Nydia" <burdicnf@dhec.sc.gov>

Nydia,

This is a well written QAPP and I have no major changes. Here are a few general comments:

It appears that macroinvertebrate samples will be collected for 3 weeks at 3 sites: 1. The original RS station 2. An "upstream" station 3. and a "representative" station. While I have no problem with sampling numerous sites it should be made clear that the decision of impairment is based on the criteria listed in DHEC's Macroinvertebrate SOP, regardless of the results of the "upstream" station or the "representative" station. Additionally, since 3 samples will be taken at the original RS station it should be stated how the decision of impairment will be made. For example if the bioclassification scores are 3.3 (impaired), 3.9 (unimpaired), and 3.4 (impaired) how will these results be interpreted?; Mean= 3.5 (Unimpaired), Median= 3.4 (Impaired) We have not provided guidance on this situation. The median I think seems the best option for 3 sampling events.

Hester-Dendy sampling is mentioned. Additional sampling techniques and analysis is acceptable for information purposes, such as source identification, but should not be used for impairment decisions.

If the above issues are clarified then it should be approved. Could this be inserted at number 6 at the top of page 10 "Analytical approach/Decision rule"? Currently N/A is given.

On Wed, Jun 12, 2013 at 8:44 AM, Burdick, Nydia <burdicnf@dhec.sc.gov> wrote:

Here's a QAPP that came in yesterday concerning Macroinvertebrates. I have not had a chance to look at it. It will be a couple of weeks before I can get to this one, but I thought I'd send it to you now.

Nydia

---------- Forwarded message ----------
From: **Strickland, Tanya** <TStrickland@northaugusta.net>

Date: Tue, Jun 11, 2013 at 9:23 AM
Subject: RE: QAPP for a project in North Augusta
To: "Burdick, Nydia" <burdicnf@dhec.sc.gov>

Nydia:

Good morning. I have attached our draft QAPP and the SOP for our project for your review. I would appreciate any feedback you can provide so that we can finalize this documentation and get started on our project. We have chosen a certified lab at this time to assist us with the project. We may still submit a certification request for our lab, but would like to get this project underway as soon as possible.

Let us know what else we may need to provide for approval.

Attachments: City of North Augusta QAPP

City of North Augusta Macro SOP

Tanya

Tanya Strickland

Environmental Coordinator

Stormwater Management Department

Office 803.441.4246

Cell 803.474.2910

Fax 803.441.4208

City of North Augusta

100 Georgia Avenue

North Augusta, SC 29841

PO Box 6400

North Augusta, SC 29861-6400

www.northaugusta.net

From: Burdick, Nydia [mailto:burdicnf@dhec.sc.gov]
Sent: Thursday, May 30, 2013 2:57 PM
To: Strickland, Tanya
Cc: Graves, David; Smith, Carol F.
Subject: Re: QAPP for a project in North Augusta

Hi Tanya,

For the QAPP you will need to have a certified lab chosen. You can go ahead and submit the QAPP but you must have a certified lab chosen before any sampling can begin. You can leave that blank until you find a certified lab or become certified, but the QAPP cannot be approved until the lab is selected.

As far as getting certified, please be aware that there is specialized training for Macroinvertebrates which must be completed before a lab can go through the certification process. For more information on that please contact Bennie Cockerel in the EQC Office of Environmental Laboratory Certification at 803-896-0974.

A Class 3 QAPP is for a project that is limited in scope by either 2 parameters or less or is a not more than a year in length. However, there is a caveat that if the project is regulatory in nature you may be required to submit a full QAPP. I originally try to have 4 types of QAPPs, but a Class 2 is so much like a full QAPP that I don't give out that classification any more. Eventually when our QAPP Guide is updated the Class 2 will be dropped.

I hope this helps!

Nydia

On Tue, May 28, 2013 at 4:53 PM, Strickland, Tanya <TStrickland@northaugusta.net> wrote:

Nydia:

We are working on a QAPP for macro sampling we are going to be conducting at RS-04544 this summer. I wanted to touch base with you about it. We have begun drafting the document and are near finishing. We also are considering getting our lab certified for macroinvertebrate sampling. We are working on that application as well.

First things first, will a QAPP for the project be required to be submitted along with an application for certification of the lab?

We are working to determine if our QAPP is a Class 3 or possibly a Class 2.

We will be conducting a macroinvertebrate study of the regulated site on Pretty Run Creek, RS-04544.

We will compare this site to another site in the community that we feel is in the best condition of streams in our area. The 2nd location is in an undeveloped location with very little impact from human activity. We call it our representative stream.

Pretty Run Creek is a TMDL stream and the pollutant of concern is fecal coliform. Since the stormwater program was developed in North Augusta, the department has continually conducted studies and implemented BMPs to improve the conditions there (since 2005). We would like to assess the macro community as part of our efforts to determine how the BMPs implemented have or have not improved the conditions and water quality in Pretty Run. Pretty Run has also been listed by the state on the 303D list form aquatic life for Bio, based on macroinvertebrate sampling conducted prior to implementation of the BMPS and the TMDL. We would like to determine if the stream is impaired for bio at this time.

If you could help us determine the Class (2 or 3) of this small project, it would be greatly appreciated. If you are not the correct person, can you forward this to that person? Also, if we do submit an application for laboratory certification, would we need to submit a QAPP with that form?

Sincerely,

Strickland, Tanya

From:	Burdick, Nydia <burdicnf@dhec.sc.gov>
Sent:	Thursday, January 02, 2014 1:51 PM
To:	Strickland, Tanya
Subject:	Re: City of North Augusta QAPP for Macro Sampling

Tanya,
I have been told to just go ahead and send you a letter with my comments. I will also be forwarding Jim Glover's comments (via email) from your first submission. I assume I sent those, but since I was not sure--I am sending them now. The major issue you have is that you are not certified under the Clean Water Act to perform field analysis for pH, turbidity, and macroinvertebrates. You need to apply for this as well as update the QAPP in order to get approval.

Nydia Burdick

On Mon, Dec 30, 2013 at 9:30 AM, Burdick, Nydia <burdicnf@dhec.sc.gov> wrote:

Tanya,
I am about halfway through your QAPP and I do have a good many comments. We probably could stand to have a phone call and let me help you through it. We do have one major issue and that's your certification. You are certified for pH and Turbidity under the Safe Drinking Water Act and that does not work for streams. I'd like to see you keep the field analyses but you will have to apply to add these under the Clean Water Act (WP) and run a PT sample on both. At the same time you could apply for DO which does not have a PT.

Nydia

On Wed, Dec 18, 2013 at 2:57 PM, Strickland, Tanya <TStrickland@northaugusta.net> wrote:

Nydia:

I am trying to complete a few projects here at the end of the year. One is to get the revised QAPP to you for review. We have adjusted the information to conduct sampling with Jeff next summer (so no rush on this). The attached QAPP is Revision 1, with all attached appendices included.

Take care and Happy Holidays!
Tanya

Tanya Strickland

Environmental Coordinator

Stormwater Management Department

Office 803.441.4246

Cell 803.474.2910

Fax 803.441.4208

City of North Augusta

100 Georgia Avenue

North Augusta, SC 29841

PO Box 6400

North Augusta, SC 29861-6400

www.northaugusta.net

--

Nydia F. Burdick, M.S.
Office of Environmental Laboratory Certification
803-896-0862 Fax 803-896-0850

--

Nydia F. Burdick, M.S.
Office of Environmental Laboratory Certification
803-896-0862 Fax 803-896-0850

Jan 2014 Final DHEC Review – comments Summarized

Section A Project Management

A1. Title Page

A Macroinvertebrate Assessment of Pretty Run Creek
Prepared by Tanya Strickland
City of North Augusta, SC
May 30, 2013

Project Manager: David Caddell
Stormwater Manager, North Augusta, SC

Lead Organization: City of North Augusta

Project Locations: Pretty Run Creek and Mims Branch

Project Manager: ______________________ Date:__________
David Caddell

Project QA/QC: ______________________ Date:__________
Jeff Wollis, Normandeau Associates, Inc. *(Certified Lab)*

SC DHEC BOW: ______________________ Date:__________
Carol Roberts, Watershed Manager

SC DHEC[1] ______________________ Date:__________
[2]James Glover, Aquatic Biology Section Manger

SCDHEC Env. Lab. Cert.:______________________ Date:__________
Nydia Burdick, Cert. Officer

Summary of Comments on North Augusta QAPP for Macroinvertebrate Sampling Rev 1 Dec 2013 jbg.pdf

Page: 1

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 2:21:33 PM -05'00'
BOW

Number: 2 Author: gloverjb Subject: Highlight Date: 1/10/2014 3:20:26 PM -05'00'
Since my name is included here my role should probably be included in section A. i.e communication only in the flow chart. Include in distribution list table.

A2. Table of Contents

Contents

A3. Distribution List

Table 1. Distribution List

Name	Title	Organization	Phone	Fax
David Caddell dcaddell@northaugusta.net	Project Manager	North Augusta, SC	803-441-4295	803-441-4243
Tanya Strickland tstrickland@northaugusta.net	Environmental Coordinator	North Augusta, SC	803-441-4246	803-441-4208
Jeff Wollis jwollis@normandeau.com	Data Q/A Q/C Project	Normandeau Associates, Aiken	803-644-6262	803-644-6965
Hannah Procter hprocter@normandeau.com	Project Validator	Normandeau Corporate, NH	603-472-5191	603-472-7052
Carol Roberts robertck@dhec.sc.gov	Watershed Basin Manager	SCDHEC	803-898-4035	803-898-4215
Nydia Burdick burdicnf@dhec.sc.gov	QA Manager	SCDHEC-OQA Columbia	803-896-0862	803-898-4215

A4. Project/ Task Organization

David Caddell is the Project Manager and will manage personnel in this study.

Tanya Strickland will be the City Laboratory and Field manager and will oversee collection of samples and laboratory activities. Ms. Strickland is also responsible for developing and maintaining the QAPP, generating reports, training and maintaining quality assurance and quality control (QA/QC) for the study.

Jeff Wollis of Normandeau Associates, a macroinvertebrate Certified Laboratory, will be the Data Collector for the project. Mr. Wollis will also conduct site visits and conduct further QA/QC in the North Augusta Laboratory.

Normandeau Associates in Bedford, NH verifies lab data as Data Validator.

Tanya Strickland and David Caddell are the Field Investigators and will assist in basin surveys for sampling sites, determination of land use near the sites, conduct site assessments, assist with field sampling work, and laboratory analysis for the project under the oversight of Jeff Wollis of Normandeau Associates.

Carol Roberts will provide expertise from the SCDHEC Bureau of Water DHEC-BOW ~~Watershed management program~~. Carol is the Salkehatchie and Savannah Watershed Manager.

Nydia Burdick will review and approve the QAPP.

Carol Smith is the SCDHEC Lab Director. Under her authority, samples will be analyzed and the results verified.

Page: 4

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 3:20:29 PM -05'00'

Number: 2 Author: gloverjb Subject: Highlight Date: 1/10/2014 3:12:36 PM -05'00'
Carol Roberts and James Glover, both of the Bureau of Water (BOW), will provide expertise...

Number: 3 Author: gloverjb Subject: Cross-Out Date: 1/10/2014 2:32:51 PM -05'00'

Number: 4 Author: gloverjb Subject: Highlight Date: 1/10/2014 2:33:21 PM -05'00'
to informal. Use Carol Roberts or Ms. Roberts

Number: 5 Author: gloverjb Subject: Highlight Date: 1/10/2014 3:13:17 PM -05'00'
and James Glover is the manager of the Aquatic Biology Section.

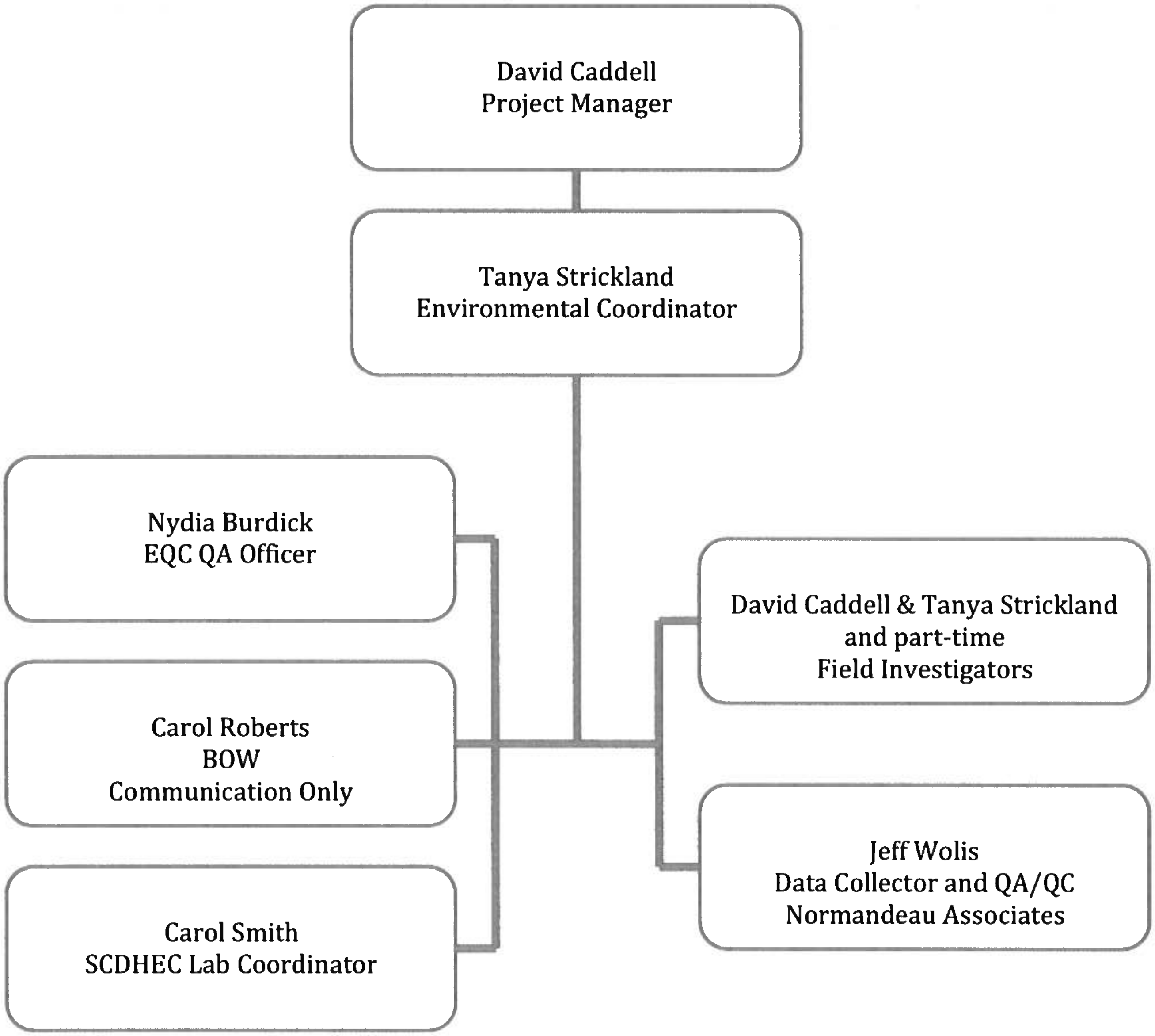


Figure 1. Project Organization Chart

A5. Problem Definition/ Background

The basin called the Pretty Run basin (formerly known as the Rapids basin) in North Augusta contains a stream system named Pretty Run Creek. Pretty Run Creek is located in a highly dense residential part of North Augusta (Aiken County). Pretty Run Creek is a small urban stream. This area is in the Southeastern Plains Ecoregion of western South Carolina. Figure 2 shows the location of the watershed within Aiken County and South Carolina. Most of the watershed is in the City of North Augusta and is developed. Approximately 5,100 people live in the watershed in 2,200 households (2000 US Census).

Page: 5

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 9:38:36 AM -05'00'

After sentence (see Omernik 1989). Place Omernik 1989 in literature cited section.

Number: 2 Author: gloverjb Subject: Cross-Out Date: 1/10/2014 9:40:31 AM -05'00'

Number: 3 Author: gloverjb Subject: Cross-Out Date: 1/10/2014 9:40:45 AM -05'00'

Number: 4 Author: gloverjb Subject: Highlight Date: 1/10/2014 9:44:03 AM -05'00'

A total maximum daily load (TMDL) was developed by SCDHEC in 2006 and approved by EPA in 2007 for Pretty Run Creek at water quality monitoring site, RS-04544. Prior to the TMDL implementation, RS-04544 was on the §303(d) list for fecal coliform contamination. Probable sources of fecal coliform bacteria identified in the watershed are sanitary sewers, illicit discharges, failing septic systems, wildlife and urban runoff. Currently, the TMDL requires a 31% reduction in fecal coliform loads to Pretty Run Creek.

Since the implementation of the TMDL for Pretty Run Creek, many activities and Best Management Practices (BMPs) implementation projects have been undertaken in the watershed. Projects undertaken include:

- Using §319 grant funds, the area has been extensively surveyed for illicit discharges, leaking sewer lines, failing septic tanks or any other impact. All problems found have been investigated and repaired.
- A winter-time night infrared aerial survey was conducted to determine if illicit discharges existed. All issues identified in the survey have been investigated and eliminated as a source of pollutants.
- Septic tank surveys were conducted and several were found to be located within the watershed. Those septic tank owners were contacted regarding 319 funds being available for assisting in the financing of tying onto the city sewer system. While none did tie on, the septic tanks were inspected for leaks or malfunction.
- The city conducts Capacity, Management, Operation, and Maintenance (CMOM) activities all along the Pretty Run Creek watershed (and throughout the city) to find and repair any problems within the city sanitary sewer system. Included in the project is smoke testing to determine if any sanitary sewer is potentially impacting a stormsewer, dye testing, remote TV inspections, stormsewer mapping and inspections, and attending to all customer complaints that alert personnel to problems unknown. All locations where problems have been found in these systems have been repaired.
- Several other projects maintaining or installing better infrastructure along the stream reach has been accomplished as well.
- Development projects that are proposed in the basin are scrutinized more critically and developers work with the city to provide wider buffers from the stream to infrastructure and lots. On all new projects, the first one inch of stormwater now must be treated during storm events through BMPs placed within the development (wetland ponds, forebays, proprietary treatment devices, etc.).
- A public education campaign has been on-going for seven (7) years as well as informing all citizens of the problems and solutions to prevent impacts to the watershed.
- A comprehensive survey of the entire stormwater infrastructure has been conducted.

All of these BMP projects have hopefully improved the conditions at Pretty Run Creek.

In 2010 and 2012, the state listed Pretty Run Creek on the §303d list for aquatic life (AL) BIO – macroinvertebrate.[1] After consulting with state officials, it was learned that a

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:12:55 PM -05'00'

The macroinvertebrate survey of Pretty Run Creek that indicated impairement was conducted in 2004. No further macroinvertebrate bioassessments has been conducted by SCDHEC since that time.

macroinvertebrate survey of Pretty Run Creek was conducted in 2004 and that one sample event caused the stream to be placed on the §303d list. No further sampling by the state has been conducted to verify if the BMPs' implemented for this stream since the 2004 sample event, have provided better water quality and habitats for macroinvertebrates.

The purpose of this study is to assess Pretty Run Creek at RS-04544 to determine if the water quality has improved sufficiently to support a healthy aquatic invertebrate community. By assessing benthic macroinvertebrates, conducting site assessments and field water quality sampling, the city can use the results to determine if the creek is currently impaired. In addition, a site at Mims Branch will be used as a representative study area to compare the results of the data from RS-04544. Mims Branch is located in an undeveloped area of the city and the highly buffered stream has very little impacts from urbanization including commercial or industrial facilities, roads and traffic, human, pet or agricultural activity and is considered in pristine condition based on surveys of the stream conducted by the city.

A6. Project/ Task Description

~~As stated previousl~~y, the purpose of this proposed project is to identify problem areas as well as their probable sources and to bolster existing knowledge concerning Pretty Run Creek's ambient water quality baseline. SCDHEC conducted a study that determined Pretty Run Creek as impaired in 2004. The results of the 2004 survey conducted by SCDHEC were used as a basis for targeting RS-04544 as a sampling location to determine if it is still impaired ~~due to urbanization~~ by assessing benthic macroinvertebrates. The project will utilize a timed, qualitative, multi-habitat sampling protocol through a variety of biometrics to establish a baseline. Field parameters pH and turbidity will be measured and recorded at each site every time a sample is collected.

Page: 7

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:10:04 PM -05'00'

Number: 2 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:16:51 PM -05'00'

if the aquatic macroinvertebrate community has changed since 2004 and, if improved, to determine if listing the stream as impaired for aquatic life is still warrented.

Number: 3 Author: gloverjb Subject: Highlight Date: 1/10/2014 2:03:08 PM -05'00'

This is appropriate. Keep in mind however that macroinvertebrate criteria are based on a reference condition for various ecoregions in the Carolina's. So while comparing data from Pretty Run Creek to Mims Branch may provide insight to the communty structure, Mims Branch should not be considered a "reference site". If Pretty Run Creek's bioassessment score remains significantly below 3.5 delisting the stream should not be done, regardless of the condition of Mims Branch. Even if these two creeks are similar much more information would be needed on an ecoregion scale to imply that SCDHEC's criteia is overly restrictive for Pretty Run Creek.

Number: 4 Author: gloverjb Subject: Cross-Out Date: 1/10/2014 12:17:13 PM -05'00'

Number: 5 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:17:50 PM -05'00'

The

Number: 6 Author: gloverjb Subject: Cross-Out Date: 1/10/2014 12:17:20 PM -05'00'

Number: 7 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:18:14 PM -05'00'

Creek

Number: 8 Author: gloverjb Subject: Cross-Out Date: 1/10/2014 12:18:40 PM -05'00'

Number: 9 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:18:28 PM -05'00'

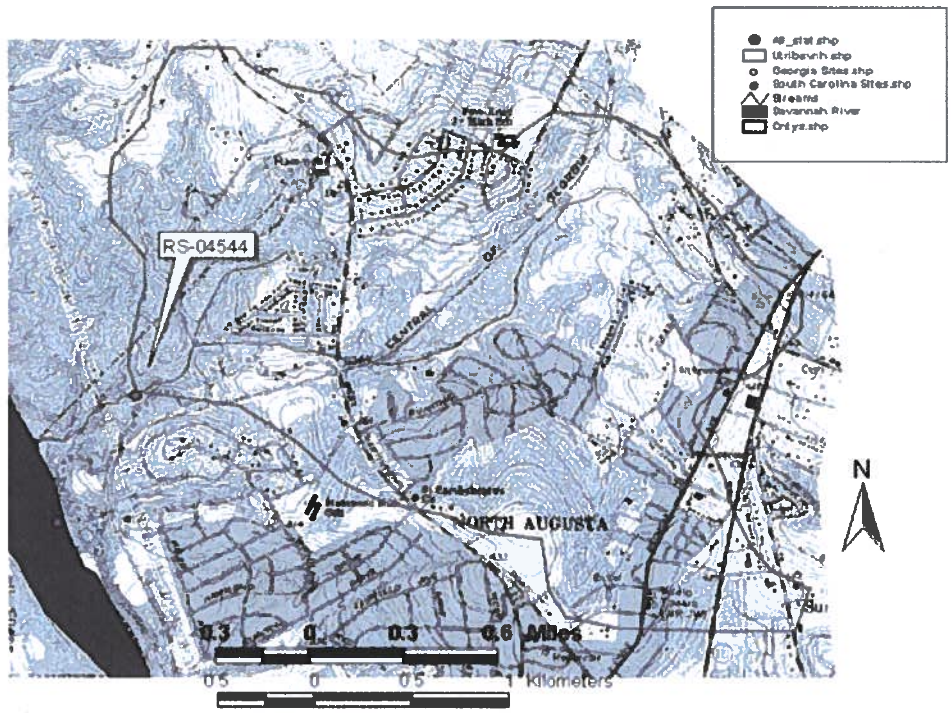


Figure 2. Map of Sampling Site (The map above is used as an illustration only.)

The following table gives Project activities and their anticipated date of initiation and completion.

Table 2. Project Schedule

Activity	**Name/Group**	**Anticipated date of initiation**	**Anticipated date of completion**	**Comments**
Visual Reconnaissance	Field Investigators	01/2012	08/30/2014	
Site Determination	Field Investigators	05/01/2013	05/30/2013	
QAPP Approval	T. Strickland & Jeff Wollis & Field investigators	06/11/2013	01/30/2014	
Project Training	Jeff Wollis with T. Strickland,	05/01/2013	08/30/2014	
Sampling Begins	Field Investigators	07/01/2014	08/15/2014	Sampling occurs Wednesday and Thursday of each week within this time period
Normandeau Associates Lab Cert Audit Internal	Hannah Proctor	TBD	08/30/2014	
Data Verification	Jeff Wollis/ T. Strickland	07/10/2014	08/30/2014	
Final Lab Report	T. Strickland and David Caddell	08/30/2014	09/30/2014	

Data Validation	Hannah Proctor, Normandeau Assoc.	As soon as verification is complete	08/30/2014	

The dates shown in the table above are estimates only. Because rain events can impact the results of the data, it is important to associate rain data with the collected samples. Wet weather or rain events are defined as rainfall that exceeds 0.10 inches (as determined by a rain gauge located 213 Lake Murray Drive, North Augusta, SC). Sampling events may be delayed in the case of serious droughts or rain events if rainfall that exceeds 0.50 inches.

A7. Data Quality Objectives (DQOs) and Data Quality Indicators (DQIs)

Macroinvertebrate samples will be collected using D-frame dip net, kick net, hand sieves (#10 and #30), and a fine mesh sampler. The samples will then be placed into plastic vials and glass jars containing 91% ethanol solution.[1] Samples will be brought to the lab at the end of the day and reconstituted with fresh 91% ethanol solution and logged into the Project Logbook.[2] Before the sorting and identification of a macroinvertebrate samples begin, the field investigators assume continued custody of the sample by signing for it in the Project Logbook. Custody remains with the field investigators until the sample has been sorted and identified in the city laboratory. Once the initial identification and paperwork is complete, the sample will be shipped to the QA/QC Laboratory, Normandeau Associates in Aiken SC. There the taxonomist will assume custody of the sample and will validate the data generated by the field staff or invalidate it based on QA/QC protocols by the certified laboratory. Once the data has been verified and validated, the official data become official results and are recorded as such in the Project Logbook. Sample completion is noted for each sample in the Project Logbook that has undergone in-house sorting and identification, as well as Certified Laboratory verification and validation. All samples will be returned to the City Lab and placed in the Voucher Collection.

The voucher collection will serve to determine if the results collected were accurate for future samples. Jeff Wollis will ensure the accuracy of identified macroinvertebrates given the experience of the taxonomist and by using appropriate and approved resources. The Taxonomist's Certainty Rating (TCR) will be marked on the Laboratory Bench Sheets. To ensure that the sample collected is representative of the stream, a 100 m reach (that is representative of the characteristics of the stream) will be selected. Whenever possible, the area will be approximately 100 m upstream from any road or bridge crossing to minimize its effect on stream velocity, depth and overall habitat quality. There will be no major tributaries discharging to the stream in the study area. A small number of samples can be lost, but if more than 100 organisms are lost from a sample then no conclusions can be made using the Biotic Indices. The same SOP used by SCDHEC in the 2004 study will be used when collecting samples from the representative stream (Mims Branch).

Page: 9

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:20:59 PM -05'00'
Mention visual collection procedures of logs and other substrate. See SCDHEC SOP.

Number: 2 Author: gloverjb Subject: Cross-Out Date: 1/10/2014 12:19:50 PM -05'00'

DQOs

1. State the Problem- To determine if the quality of water in Pretty Run Creek has improved due to BMP implementation, and if not, to help identify what types of sources of pollution is still indicated by the macroinvertebrate study results.

2. Identify the decision- Is the stream improved or not? The results from this study will be used to determine if the stream water quality has improved. Assessment of macroinvertebrates is a common technique to determine if impairments are potentially present. The results will be compared to current EPA metrics that indicate (by the presence, absence, or ratios of certain species) whether it is likely that the stream is healthy or potentially impaired. Along with the EPA protocols and metrics, the data will also be compared to the results of the sample event that occurred on July 28, 2004 by SCDHEC. Other factors will be considered during the assessment including stream physical condition and weather prior to the sampling event.

3. Identify inputs to the study- macroinvertebrate samples collected and identified, analysis of the results, and what they indicate (EPA protocol). Weather conditions and physical stream condition will be considered.

4. Define the Study Boundaries- RS-04544 at Pretty Run Creek and as a representative stream, Mims Branch at location off of Old Sudlow Lake Road in North Augusta, SC.

5. Limits on Decision Error- A team of two or three biologists (never less than two) will spend two man hours sampling at the site. At some impacted sites it may be impractical to sample for two man-hours due to the severity of the impact. For instance, a sediment discharge may greatly reduce aquatic habitat such that macroinvertebrates are scarce, and in these situations it is reasonable to reduce sampling effort. Therefore, whenever 40 or fewer total macroinvertebrates are collected at the first site during the first man-hour, sampling may be terminated and the collection may become a one man-hour sampling effort instead of a two man-hour effort (at least 100 organisms are necessary for the biotic index to be reliable). Sampling should always begin at the farthest downstream site in the study area and then upstream locations. When a sampling event is reduced to one man-hour, the reference site and other study sites should likewise be sampled for one man-hour. Although it may be obvious that a site has been adversely impacted, it is important to document the degree of impact so that restoration efforts and their results can be later verified. A small number of samples can be lost, but if more than 100 organisms are lost from a sample then no conclusions can be made using the Biotic Indices.

   To alleviate bias, this project will utilize a timed, qualitative, multi-habitat sampling protocol. Samples collected will represent various habitats and locations within the sample reach.

Page: 10

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:24:17 PM -05'00'

Using aquatic macroinvertebrates as a bioindicator, to assess aquatic life condition of Pretty Run Creek and identify conditions that may account for for the community structure. To indentify possible stressors that could account for the biotic condition of the stream.

Number: 2 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:24:36 PM -05'00'

Climatic

Number: 3 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:29:23 PM -05'00'

physical condition of the stream and its watershed

6. Analytical approach/Decision rule- N/A

7. Optimize the design for obtaining the data- A sample from RS-04544 once a week over a three-week period producing a variable number of samples, and a secondary site will be sampled upstream of the RS-04544 site on three occasions. Results from both sites will help determine the approximate location of the non-point sources.

A8. Training

City of North Augusta Training and Experience:

The City of North Augusta employees two trained biologists full-time and will employ biologist part-time to assist with this study:

David Caddell holds a Bachelor's Degree in Biology from Clemson University in 1993. He has also completed the course requirements for a Master's Degree in Ecotoxicology from the University of Georgia in 2004.

Tanya Strickland holds a Bachelor's Degree in Biology from University of South Carolina Aiken in 1999. She has conducted research in wetlands ecology for over 20 years at streams, ponds, and other water bodies in Aiken County. She has also managed numerous projects observing water quality impairments. Tanya has incorporated and developed the standard operating procedures for the City regarding this project and has trained staff on utilizing them to obtain quality data.

Part-time assistant to the study: Christina Tran holds a Bachelor's Degree in Biology from Georgia Regents University in 2013. During her studies, she took part in an investigation of benthic macroinvertebrate diversity and water quality at Raes Creek in Augusta, Georgia under Dr. Jessica Reichmuth at which time she:

- Created a baseline benthic macroinvertebrate study for Raes Creek to observe water quality and macroinvertebrate diversity
- Collected macroinvertebrates and identified them to lowest practical taxonomic level
- Collected macroinvertebrates from three sampling sites within Raes Creek using a Surber sampler as an active sampling method, and Hester Dendy plates as a passive sampling technique
- Performed data analysis using benthic metrics (Shannon Weaver, Richness, Evenness) of collected samples
- Measured physiochemical parameters including: nitrate, phosphate, dissolved oxygen, pH, depth, and velocity.

Part-time assistant to the study: Alex Baker is a rising senior at College of Charleston in Marine Biology with a minor in Environmental Studies.

Page: 11

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:37:05 PM -05'00'

This is a bit confusing. It implies there may be up to 3 samples per site. Later I see only 2 samples will be collected from each site. Reword. Also I suggest your time frame be extended from July 1 to the end of August in case of flooding or drought. Idealy I would give the stream 2 weeks between sampling events to recover. One week is probably OK but if diversity is low and habitat limited the first sampling event itself may bias the second event. Because the window of opportunity is rather small one week is OK just pay attention to the long term weather forcast and make the call accordingly.

While working for the City, Christina and Alex have been instrumental in:

- Helping devise sampling procedure for the assessment of benthic macroinvertebrates in North Augusta, South Carolina watersheds
- Assisting with the design of a standard operating procedure and Quality Assurance Project Plan for benthic macroinvertebrate sampling and analysis
- Performing multi-habitat sampling protocol for macroinvertebrates using a D-frame dip net, kick net, hand sieves, and mesh sampler on various creeks in North Augusta, South Carolina
- Testing physiochemical parameters (pH, dissolved oxygen, and temperature) along with macroinvertebrate sampling at various creeks in North Augusta, South Carolina
- Identifying collected macroinvertebrates to lowest practical taxonomic level
- Performing data analysis using benthic metrics of collected samples.

A resume is attached for each of City of North Augusta's employees in Appendix A.

Normandeau Associates' Training and Experience:

Jeff Wollis holds a Bachelor's degree in wildlife and fisheries science from the University of Tennessee in 1986. He has over 27 years of experience in fisheries, macroinvertebrate and water quality field research and report writing. The concentration of his projects is in the southeastern U.S. while many other projects have been done across the U.S.

The field staff for this project will be assisted in the field by Jeff Wollis to verify proper procedures and methods of collection, preservation, sorting, identification, documentation, reference and voucher collection maintenance, and quality control (City's Standard Operating Procedures for Assessing Freshwater Benthic Macroinvertebrate Appendix B) and also the Normandeau Associates' SOP (Appendix C).

Additional measures to verify that training is adequate for City staff will be implemented during this project. Jeff Wollis (QA/QC Officer) will observe and verify sampling techniques conducted by field staff. Mr. Wollis will produce a report verifying or identifying correct procedures are used, and if not, a corrective action plan. [1] The plan will be discussed with the project management team and implemented immediately. Tanya Strickland will assure that any additional training required through the corrective action plan is provided to staff. All documentation will be archived in the stormwater management department of North Augusta.

A9. Documentation and Record

Tanya Strickland is responsible for writing, maintaining, and distributing the QAPP. Other persons on the Distribution List will receive the QAPP via mail or email in PDF format.

Page: 12

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 12:37:38 PM -05'00'

The

Data Report Package:
The data report package from the lab will include the following items:

1. The data in a printed Excel Spreadsheet and also on CD. Each Spreadsheet submitted will provide the data for the entire sampling period of the RS-04544 site.

2. A MS Word file on RS-04544 (both hardcopy and CD) will give a narrative for each sample collected detailing any problems associated with the chain of custody, sampling, analysis, and QA/QC for each.

Table 3. Project Documents and Archive

Item	Produced by:	Hardcopy/Electronic
Field Logs*	Field Staff	Hardcopy
Chain of Custody+	Field Staff	Hardcopy
Reports+*	City Lab & QA/QC Lab	Hardcopy
Lab QC records+	City Lab & QA/QC Lab	Both
Internal Audit reports+	Lab	Both
Training Records*	Field (City Lab and QA/QC Lab)	Both
Training Records+	Lab (City Lab and QA/QC Lab)	Both
Corrective Action Reports*	Field (City Lab and QA/QC Lab)	Hardcopy
Corrective Action Reports+	Lab (City Lab and QA/QC Lab	Electronic
Voucher Collection and Maintenance Records	City Lab (includes COC comments from field)	Both

*These records will be filed in the North Augusta, SC city files for 2 years and archived to North Augusta Record warehouse for 5 years.

+These records will be filed at the Stormwater Management Department Lab for 2 years, and then archived for 8 more years. Electronic records are backed up nightly. At the end of the project all files will be backed up separately (on DVDs) and stored with the hard copies.

Section B Measurements/Data Acquisition

B1. Sampling Process/Experimental Design

<u>Sampling strategy</u>: Sampling will begin on or about July 1, 2014 and will end on or about August 15, 2014. Samples will be collected on Wednesday and Thursday's during that time period. The goal is to collect two valid samples from each of the sample locations during the sampling period. Pretty Run Creek will be sampled in two separate locations or "reaches". The representative stream will also be sampled in two separate reaches. A total of four valid samples is the goal of the study. All sample events that occur may not produce a valid sample due to finding less than 100 individual macroinvertebrates during a sampling event. Regardless of the validity of a sample, the organisms will be sorted, identified and logged for future reference and studies. All valid samples (collections of more than 100 organisms per sample event) will be sorted, identified and logged into the data set. Further analysis will be completed and EPA protocols and metrics will be used to indicate the condition of the sample point. Habitat assessments, rainfall, and other weather data will also be considered to determine if any bias is indicated due to lack of rainfall or excessive rainfall (rainfall exceeds 0.50 inches) just prior to or during the

sampling periods that could have had an impact on the habitat during the study. All rain events will be measured and documented using a simple manual rain gauge that is currently in use and located near the project area.

Sample locations: SCDHEC previously listed Pretty Run Creek on the §303(d) List for fecal coliform contamination and has since produced a TMDL (approved by EPA) for the stream. Probable sources of fecal coliform bacteria that were identified in the TMDL are sanitary sewer, illicit discharge, failing septic systems, and urban runoff. RS-04544 is a random location selected for sampling by the state as part of its random sampling program. RS-04544 will be used in this study as well. In addition, a second upstream location on Pretty Run Creek will be sampled for comparison. The second location will be given an identifier or NA-PR-25SS. A third location will be sampled as a representative stream. That sample location will be given the identifier of NA-MB-01. The representative stream is located where no development has occurred, and where the stream has no human influences other than hikers and light four wheeling activities. The property is privately owned and is not open to the public. Data collected by SCDHEC in 2004 will be compared to current data in order to determine[2] ~~if BMPs implemented throughout the watershed of Pretty Run Creek (since the TMDL) has or has not created improved habitats or water quality.~~

Sampling procedures: At each site, a team of two or three biologists (never less than two) will collect samples for aquatic macroinvertebrates for approximately three man-hours (three man-hours represent three biologists sampling for one hour, or two biologists sampling for one and one half hours). With the aid of a D-frame dip net, kick net, hand sieve, white plastic pan and a fine mesh sampler, all the available natural habitats are sampled within the reach. Macroinvertebrates are also to be collected directly from the habitat with forceps.

All macroinvertebrates collected are to be placed in jars or vials filled with 91% ethanol (EtOH) and labeled with the station number, collector, and collection date. If a sampling site becomes inaccessible, then sampling at that site will be delayed. If the inaccessibility will last for more than two weeks, a new nearby site will be located. This site must be sampled along with the original sample (when the site becomes accessible) for the rest of the project. If no site can be located, the remaining sites will be included in the study without the inaccessible site.

Sample handling: Samples will be transported back the stormwater lab in iced coolers immediately after a sample event. Samples will be sorted and reconstituted with 91% EtOH. Once all the samples have been sorted, they will be identified to the lowest practical taxonomic level. All data will be recorded in the Log Book and a spreadsheet. Samples along with spreadsheets will be sent to the certified lab to be verified and validated (see Table 4).

B2. Sampling Methods

Detailed listings of all sampling methods (QA and QC) are listed in Table 4.

Page: 14

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 1:06:03 PM -05'00'

While restoration practices designed to reduce human pathogen indicator levels may also contribute to improvement in environmental conditions this is not always the case. An extreme example is a highly chlorinated swimming pool. Fecal coliform bacteria are controled, but aquatic invertebrates and fish would not find the conditions hospitable. The assessments in 2004 and 2010 should be compared but the conclusions as to why things look worse, better, or the same is a matter for inductive reasoning. Landuse changes in the watershed (good and bad), instream habitat changes, climatic conditions, BMP impliminatation or some other event that may not be known until after field work is conducted and may account for a portion or all of the change. While the 303d list and BMP installation is driving this study, and which you have appropriately acknowledge, I would remove this from the primary objective of the study. The macroinvertebrate bioassessment results in 2004 and 2010 will be what they will be. Providing hypothesis as to why comes with the analysis of the data and supporting information and knowledge of the stream, the watershed, and climatic conditions in during this time span. I suggest ending this particular sentence with the word "trends".

Number: 2 Author: gloverjb Subject: Cross-Out Date: 1/10/2014 12:38:54 PM -05'00'

Normandeau Associates in Aiken, SC is a macroinvertebrate certified state lab (Lab Cert number: 0210100). Please see attached SOPs for further information on this lab protocol.

Normandeau Associates in Bedford, NH is a South Carolina macroinvertebrate certified lab (Lab Cert number: 80003001).

North Augusta Water Plant Lab is certified for pH and turbidity (Lab Cert number: 02005001). North Augusta is not currently certified for dissolved oxygen (DO), but will be applying for certification in the near future. During this study, DO will be measured but will not be logged in the Log Book. If we find an abnormally low (< 3ppm) measurement of DO, we will seek a certified lab to confirm if a problem exists.

a) Chironomidae and Small Macroinvertebrate Collection Procedure

Collection Steps:

1. Fill a 19.0 liter bucket approximate one half full with water.

2. Collect two or three samples of all the habitat types present at a stream site by hand (rocks, sticks, leaf packs, root banks, etc.) and rinse in the bucket to remove midges and other macroinvertebrates. Attached root banks (wads) and vegetation may be rinsed directly in the bucket without detachment.

3. Since some midge taxa are sand dwellers, select a sandy bottom site in the stream and collect midges by placing the small mesh bag on the bottom with the open end facing upstream. Disturb approximately a 1.0 m^2 area of the sand upstream of the bag and let the sand and midges drift into the bag. Collect three sand samples from three different areas of the stream. The bag is only used when there are sandy bottom areas available.

4. Empty the contents of the bag into the same bucket of water that contains the other habitat washes and rinse the bag up and down in the bucket to remove the attached midges.

5. Rinse and remove by hand as much of the larger debris as possible from the bucket and discard. Stir the water in the bucket and strain through the Nytex covered pipe.

6. Remove small portions of the detritus left in the bottom of the Nytex pipe and place in a white pan 1/4 filled with water. Spread the detritus evenly in the pan by hand so that the macroinvertebrates can be seen against the white background. With the aid of forceps and an eyedropper, collect the midges and other small macroinvertebrates and preserve them in a jar filled with 91% EtOH.

7. Repeat step 6 until all the detritus in the Nytex pipe has been examined.

b) D-frame Dip Net Collection Procedure

Collection steps:

1. Root banks are sampled by repeatedly jabbing a D-frame dip net (500 μm mesh size) into the root wads along a stretch of bank until the net is about 1/4 full of detritus and root debris. Several root wads are washed down by hand into the dip net to remove firmly attached macroinvertebrates. Aquatic vegetation is sampled by sweeping the dip net through the vegetation two or three times.

2. Rinse the bottom of the dip net in the stream to remove excess mud and silt. Remove small portions of the detritus left in the net and spread them evenly in a white pan 1/4 filled with water. Do not attempt to sort through so much detritus that the bottom of the pan is obscured.

3. Using forceps remove macroinvertebrates from the pan and place in jar of 91% EtOH.

c) Kick Net Collection Procedure

Collection Steps:

1. Place the kick net slightly downstream of the area to be sampled (snags/leaf packs and/or rock/gravel riffle). Disturb about 1.0 m^2 of the habitat and catch the debris and macroinvertebrates that drift into the net.

2. Spread the kick net out on a sand bar or a flat area on the bank and collect macroinvertebrates from the net with forceps and preserve them in a jar of 91% EtOH.

d) Hand Sieve Collection Procedure

Collection Steps:

1. Visually inspect the sand and mud for signs of macroinvertebrate activity. For example, the movement of burrowing odonates and mussels leaves trails in the sand. Small holes can be seen in the mud, clay, or sand in areas where burrowing mayflies are found. The tubes of *Phylocentropus* sp. larvae can be seen extending above the substrate when they are present.

2. With either the #10 or #30 sieves, sample the mud or sand where there are signs of macroinvertebrate activity (use #10 sieve primarily for sand substrates). Sift the excess sand, mud, silt, and detritus in the stream to trap macroinvertebrates in the sieve.

3. Collect macroinvertebrates from the sieve and place them in jar of 91% EtOH.

4. With the #30 sieve, sample root bank and snag sites and process as above.

A source of variability for this study includes rainfall. Because rain events can impact the results of the data, it is important to associate rain data with the collected samples. Wet weather or rain events are defined as rainfall that exceeds 0.10 inches (as determined by rain gauges). Sampling events may be delayed in the case of serious droughts or rain events if rainfall exceeds 0.50 inches. Another source of variability for this study includes accessibility of sites. If a sampling site becomes inaccessible, then sampling at that site will be delayed. If the inaccessibility will last for more than two weeks, a new nearby site will be located. This site must be sampled along with the original sample (when the site becomes accessible) for the rest of the project. If no site can be located, the remaining sites will be included in the study without the inaccessible site.

B3. Sampling Handling and Custody

Each sampling event will begin on Wednesday of each week for three week after the approval of this QAPP. All field parameters will be recorded in the field Log Book and on all COC forms. All holding times will be required by EPA approved sampling methods will be strictly adhered to. All macroinvertebrate will be preserved in the field at time of collection with 91% EtOH. For specific details of each sampling procedure, see Table 4 below. For each event the following will take place:

Table 4. Sampling and COC Events

Item	When	Staff	Duration	Comments
Daily calibration of DO and pH meters. Monthly calibration of thermometers (will be conducted by the city's currently Certified Lab Personnel)	Prior to leaving the lab, and once in the field prior to measuring. If more than three samples collected, another calibration completed prior to measuring. Lab checks meters upon return.	Certified Lab Staff and Field Investigators	~10 minutes	All calibration results, date, and time will be recorded in Project Logbook. Air temperature will be recorded from local weather station.
Q/C In the Field	Upon Arriving at Site	Field Investigators	20 minutes	Sample labels will be properly completed, including the sample identification code, date, stream name, sampling location, and collector's name and placed into the sample container. The outside of the container should be labeled with the same information.
Measure DO, pH, and water	Within 15 minutes of pulling a sample.	Certified Lab Staff and Field	5-20 minutes	Documented in Project Logbook with date and time of

Page: 17

Number: 1 Author: gloverjb Subject: Highlight Date: 1/10/2014 1:22:21 PM -05'00'

Include visual collection procedures, see SCDHEC macro SOP

Number: 2 Author: gloverjb Subject: Highlight Date: 1/10/2014 1:06:08 PM -05'00'

Item	When	Staff	Duration	Comments
temperature at sample site		Investigators		sample. Indicate if sample is "in-stream" or pulled and then measured.
Collect turbidity sample	Upon arriving at site	Certified Lab Staff and Field Investigators	~1 minute	Sample container will be labeled with same information as the other sample labels.
Assess habitat	±20 minutes of arrival at site	Field Investigators	5-10 minutes	Documented in Project Logbook (use *EPA Form A-1 Stream Characterization*)
Collecting samples	After measuring DO, pH, air temperature, and water temperature and habitat assessment. Samples will be placed in 91% EtOH immediately after collection	Field Investigators	~3 man hours	Samples preserved in 91% EtOH solution. Place all samples in cooler on ice for transport. Log all sample locations, date, time and vial number in log-book using *EPA-Form A-14* Field Data Sheet.
Q/C in the Field	After Sampling is complete	Field Investigators	15 minutes	After sampling is completed at a site, all nets, pans, etc. that came into contact with the sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris. Any additional organisms found will be placed into the sample containers. The equipment will be examined again prior to use at the next sampling site.
Q/C in the Field	At completion of sample event, at upstream location 50 yards from sample site. (once per sample event week)	Field Investigators	~3 man hours	We will conduct one sample replicate (1 duplicate sample) per week when a valid sample is collected.
Return to lab	After the last site collected and placed in cooler	Field Investigators	~10-30 minutes	Calibration check on meters upon return. Log results.
Measure turbidity	As soon as returned to lab	Certified Lab Staff	~3 minutes	Documented in Project Logbook with date and time of sample.
Chain of Custody	When needed.	Field Investigators	5 minutes.	All samples collected will have a COC generated and placed in the iced cooler with the samples. Samples will be delivered to Normandeau Assoc. in Aiken, SC for shipment to Bedford, NH. (see Normandeau SOP).

Each sample location is identified by an identifying number. All samples collected at each location are labeled with this identifying number, date and time of collection, initials, and then placed on ice in a cooler. A COC is generated for each sample event day and remains with the samples to the lab. If any shipping is required, a COC remains with the sample.

After the measurement of DO and pH, the instruments will be rinsed with deionized water to avoid contamination and will be re-calibrated prior to reuse by City's certified staff to conduct these field parameters.

Since there is no field analysis being done, continuous monitoring is N/A for this project.

It is important to obtain at least 75% valid data from this project. If this is not achieved at the end of the expected sampling date, sampling will be extended in order to obtain 75% valid data. If the problems occur with broken samples or invalid samples due to temperature on receipt, the hold time was exceeded or other problems, the lab will notify David Caddell who will determine any needed corrective action and if resampling is needed. This corrective action and the result of these actions will be documented on a project corrective action form and stored in the project file at North Augusta, SC city Stormwater Department files.

Macroinvertebrates are placed in jars or vials filled with 91% ethanol (EtOH) and labeled with the station number, collector, and collection date. Habitat assessments and measurements of DO, pH, air and water temperature will be recorded in the Project Logbook. The Project Logbook serves to track sample processing, document progress through initial log in, sorting, taxonomic identification, and data recording. The number of jars and/or vials containing the samples at each phase of sample processing, identification, and storage is recorded in the Project Logbook. The identification data are recorded on a macroinvertebrate bench sheet (EPA Form A16). Completed bench sheets along with habitat assessment forms (EPA Form A-1) field data sheets (EPA Form A-14), preliminary assessment sheets (EPA Form A-18) and any other hard copy document related to a sample are kept on permanent file. Using the completed bench sheet, the data are then entered into the most recent version of Microsoft Excel for Windows program where the data are stored for later analysis. After data are entered into the Excel for Windows database, the data are printed out on spreadsheets. These spreadsheets are compared to the original bench sheets and corrections are made if needed. The taxa list, physiochemical data, and habitat information will be entered into a Microsoft Excel Spreadsheet.

B4. Analytical Methods

The samples will be analyzed and verified by a certified lab. The samples will be identified using reference books and taxonomic keys with the assistance of a stereo microscope and a compound light microscope.

Macroinvertebrate samples collected will be processed in the laboratory under controlled conditions. Aspects of laboratory processing include sorting and identification of organisms.

B5. Quality Control Requirements in the Lab

Table 5. Sampling Methods

Parameter	Method	Citation
pH	4500HB (2011)	SC Environmental Lab Certification Methods Update Rule II
Turbidity	2130B (18th)	Analytical Method for Turbidity Measurement : Nephelometric Method (June 2003) EPA-600/R/93/100
Macroinvertebrate	Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish - Second Edition	EPA 841-B-99-002

Table 6. Laboratory Receiving and Processing

Item	When	Staff	Duration	Comments
Log samples in	Upon arrival at Lab	Field Investigators	~10 minutes	All samples will be dated and recorded in the sample log form (EPA Form A-2) in the Project Log Book upon arrival in the lab. All information from the sample container label will be included on the sample log sheet. If more than one container was used, the number of containers will be indicated. All samples should be sorted in a single laboratory to enhance quality control. Verify that all samples have arrived at the laboratory, and are in proper condition for processing.
Q/C In the Lab	Note - Laboratory	Field Investigators	1 minute	All samples will be sorted in the sorting/identification laboratory to enhance quality control.
Prepare samples for sorting	After logging samples in log book at laboratory	Field Investigators	15-30 minutes	Thoroughly rinse sample in a 500 μm-mesh sieve to remove preservative and fine sediment. Large organic material (whole leaves, twigs, algal or macrophyte mats, etc.) not removed in the field will be rinsed, visually inspected, and discarded. Samples that have been preserved in alcohol will be soaked in water for about 15 minutes to hydrate the benthic organisms, to prevent them from floating on the water surface during sorting. If the sample was stored in more than one container, the contents **of all containers for a given sample** will be combined at this time. The sample will be gently mixed by hand while rinsing to make it homogeneous.
Q/C in the Lab	After processing samples for sorting	Field Inspectors	10 minutes	After laboratory processing is complete for a given sample, all sieves, pans, trays, etc., that have come in contact with the sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris; organisms found will be added to the sample residue.

Item	When	Staff	Duration	Comments
Sorting	After the final processing step	Field Inspectors	40 minutes	Spread the sample evenly across a pan marked with grids approximately 6 cm x 6 cm. On the laboratory bench sheet (EPA Form A-16), note the presence of large or obviously abundant organisms; do not remove them from the pan.
Subsampling Step *(this step will not be used in this study, listed only to indicate the omission of the step)*	After large organisms are counted in pan	N/A	N/A	Use a random numbers table to select 4 numbers corresponding to squares (grids) within the gridded pan. Remove all material (organisms and debris) from the four grid squares, and place the material into a shallow white pan and add a small amount of water to facilitate sorting. If there appear (through a cursory count or observation) to be 200 organisms ± 20% (cumulative of 4 grids), then subsampling is complete.
Q/C in the Lab	Once per week during study period	QA/QC Inspector Normandeau	15 minutes	Ten percent of the sorted samples in each lot will be examined by laboratory QC person. (A lot is defined as a sample event.) The QC worker will examine the grids chosen and tray used for sorting and will look for organisms missed by the sorter. Organisms found will be added to the sample vials. If the QC person finds less than 10 organisms (or 10% in larger subsamples) remaining in the grids or sorting tray, the sample passes; if more than 10 (or 10%) are found, the sample fails. If the first 10% of the sample lot fails, a second 10% of the sample lot will be checked by the QC observer.
Identification	After sorting is complete	Field Investigators	3 hours	Each specimen will be prepared and mounted when necessary or observed under the appropriate magnification to make identification. All bench sheets will be filled out properly, results will be listed in the lab project notebook and will be entered into an excel spreadsheet. Once completed, all samples will be preserved as required in the SOP. Samples will be prepared for the QA/QC lab along with all COC paperwork. Each sample will be packaged along with the COC form and taken to the QA/QC Certified laboratory in Aiken, SC.
Verification/ Validation	After sample identification is completed, properly logged, preserved, and packaged for shipment with COC.	QA/QC Lab	(undetermin ed)	The lab will conduct verification and validation of sample data generated by field investigators.

Item	When	Staff	Duration	Comments
Chain of Custody	When samples have been collected, labeled and put into cooler, a COC will be generated.	Field Investigators	5 minutes	All collected samples will require the generation of a COC once labeled and put into the cooler.. The COC procedures will be followed or the sample will be invalidated.

The Project Manager is responsible for any analytical problems or failures. These problems, corrective actions and results (of the corrective action) are logged in an electronic Corrective Action Log. For specific details, please see:

- Appendix B (North Augusta SOP for Assessing Benthic Macroinvertebrates)
- Appendix C (Normandeau Assoc. Inc. Procedure No. EA6)
- Appendix D (City of North Augusta Drinking Water Lab Turbidity SOP)
- Appendix E (City of North Augusta Drinking Water Lab pH SOP)

B6. Instrument/Equipment Testing, Inspection and Maintenance

1. D-frame dip net (500 Φm)
2. 1.0m^2 Kick net (500 Φm)
3. Hand sieves (U.S. #=s 10 and 30)
4. 13.0 cm long by 10.0 cm (dia.) PVC fine mesh sampler (300 Φm)
5. 0.5m by 1.0m Fine mesh bag (300 Φm)
6. Bucket
7. White pan
8. Forceps
9. Collection vials and jars filled with 91% EtOH
10. pH meter (inspected and calibrated before every initial use)
11. Turbidity meter
12. Temperature meter
13. Cooler for transport

Lab Instrumentation needed:

1. Stereo microscope (20x to 40x magnification)
2. Compound light microscope (10x to 1000x magnification)
3. 91% EtOH
4. CMC-10 mounting media
5. Forceps
6. Probe
7. Petri dishes

B7. Instrument Calibration and Frequency

The city currently has certifications for pH and turbidity measurements. The City does not currently have certifications for DO; however, DO measurements will still be taken but will not be logged into the Log Book. The pH and DO meters will be calibrated before each sampling event. Calibration is completed in the lab prior to leaving and once in the field prior to measuring and will be documented in the Project Logbook and signed by certified personnel to conduct the tests. If more than three samples are collected in the field on a given sample day, another calibration is completed prior to measuring. The measurements will be taken within 15 minutes of pulling a sample at the sample site. There is no hold time if the measurement is taken directly in stream. The meters will then be checked in the lab upon return. If there is a deficiency with either meter, the data will be invalidated and noted in the project logbook. A sample for turbidity will be collected at the sample site and measured at the City's lab as soon as possible. If the sample cannot be measured as soon as possible, the sample should be cooled to 4°C to minimize microbiological decomposition of solids. If storage is necessary, the hold time should probably not exceed a few hours.

B8. Inspection/Acceptance Requirements for Supplies and Consumables

All supplies needed by the City of North Augusta for this study will be ordered through the stormwater management department. Materials must meet guidelines or regulatory standards for the method being used.

Item	Required for:	Type	Comments
Sample Containers	macroinvertebrate collection in field	Amber glass	
Sample Vials and Labels	Storage of sorted and identified specimens	15 mL-50 mL conical tubes	
91% EtOH	Preservation	Denatured alcohol	MSDS sheet in lab
pH Buffers	Calibration of pH meter	4.00, 7.00, 10.00 standards	See pH SOP (Appendix C)
Slides and Coverslips	Mounting of midges and Baetidae	Glass	
CMC-10 Mounting Media	Mounting of midges and Baetidae	Masters Co., Inc.	May be purchased from Fisher Scientific

Table 7. Required Supplies and Consumables

B9. Data Acquisition Requirements (Non-Direct Measurements)

The non-direct measurements used are from the 2004 SCDHEC sample event at RS-04544. SCDHEC is the source of non-direct measurements for this project. The sample event of 2004 indicated that the water quality was impaired. All data collected during this study will also be used to determine if water quality has improved or is impaired. The study of direct measurements will be compared to the non-direct measurements only to determine species diversity changes, specifically observing species richness and evenness. Using this information will help us determine if other factors may have impacted the macroinvertebrate diversity of the stream compared to the 2004 sample event.

The other data that will be used during the study will be reference materials outlined in the SOPs attached, but most specifically to determine biotic indices we will use the EPA's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish - Second Edition. This protocol is the standard method accepted by the EPA.

B10. Data Management

All data acquired throughout this project will be the responsibility of the Project Manager. The Field Inspectors count and compile the data. Microsoft Excel is used to record and store the data collected in the City's Electronic Data Management System (EDMS) which includes storage, permanent archiving, and retrieval capabilities. All data acquired by third parties (e.g. lab analyses, QA/QC documentations and reports, training records, etc.) will be stored within the stormwater management department records in paper format and scanned electronically to be stored in the EDMS.

The standard record keeping practices the City uses is that all data generated in the field is logged in a log book (Field Log Book). Staff then transfers this data to the Excel spreadsheets once back into the office. All data are verified to be accurately transferred to the spreadsheets by a second person who initials and dates both the raw data and the electronic data as being accurate. If inconsistencies are found they are corrected on the electronic record and notes are made in the Field Log Book or on the lab analysis sheet. All electronic data are backed up on external media for safe keeping and kept for 3 years.

All archived data will be available for retrieval by contacting the City's IT department. The IT department is also responsible for maintaining all hardware and software configurations for the City.

All checklists and forms that will be used during the study are outlined, identified, and attached in the SOPs within the appendices of this document.

Section C Assessment and Oversight

C1. Assessment and Response Actions

Type	Frequency & Expected Date	Organization Responsible	Individual who is notified of deficiencies	Time frame of notification	Person responsible for Corrective Action	Corrective Action effectiveness documented where?	Individuals receiving Corrective Action Response
Internal Lab Audit	09/2013	Stormwater Management Department	David Caddell	Immediately	Tanya Strickland	Laboratory Electronic Corrective Action file	David Caddell
Internal Lab Auidt – Normandeau	TBD	Normandeau Associates	David Caddell	Immediately	Normandeau Associates	See Normandeau's SOP	David Caddell

Assoc.							
Internal Audit- Field	3 weeks- July 2014	Stormwater Management Department	David Caddell	Immediately	Tanya Strickland	Corrective Action file folder	David Caddell and Jeff Wollis
Check of Cert Status	End and beginning of project		David Caddell	Immediately	Tanya Strickland	Corrective Action file folder	David Caddell and Jeff Wollis
External Certification Audit	TBD by SCDHEC	Normandeau Associates	Jeff Wollis	SCDHEC	Jeff Wollis et al.	See Normandeau's SOP	David Caddell and Jeff Wollis
External Proficiency Test	TBD by SCDHEC	Normandeau Associates	Jeff Wollis	SCDHEC	Jeff Wollis et al.	See Normandeau's SOP	David Caddell and Jeff Wollis

Table 8. Project Assessments and Corrective Actions

C2. Reports to Management

N/A

Section D Data Validation and Usability

D1. Data Review, Verification and Validation

No attempt is made to collect all specimens encountered. If a taxon can be reliably identified in the field, only 10-15 specimens are collected, other taxa are collected in approximate proportion to their abundance in each sampling method (net, pan, sieve, etc.). Since the emphasis of the MHSP method is to collect different taxa, abundance is considered only in a relative sense. Some taxa are not collected including: Nematoda, Collembola, semiaquatic Coleoptera, and all Hemiptera except Naucoridae, Belostomatidae, Corixidae, and Nepidae. These are not collected because they are most often found on the water surface or on the banks, and are not truly benthic. Whenever 40 or fewer total macroinvertebrates are collected at the first site during the first man-hour, sampling may be terminated and the collection may become a one man-hour sampling effort instead of a two man-hour effort (at least 100 organisms are necessary for the biotic index to be reliable).

If the organism collected is missing identifiable parts, the organism will not be used in the analysis.

D2. Validation and Verification Methods

The data collection/verification analyst (Jeff Wollis) will verify that City staff records contain all samples that were collected correctly. He will also verify that they were analyzed and data are generated and logged correctly. A second analyst (Hannah Proctor) will check data (validate) generated by Jeff Wollis to determine if the correct results are being reported. If any inconsistencies are found within the data, the validator will research and determine why and report the results to the Project Manager.

The Project Manager will be responsible for ensuring that for every sample sent to the City laboratory, a result was received. Normandeau Associates in Aiken, SC will be sent the data and samples for follow-up QA/QC. This check will ensure that the sample data are complete and accurate. All reports from Normandeau and the data validator will be sent to the Project Manager. Any discrepancies within the data will be assessed by the Project Manager to determine if the sample is valid. A report will be generated for each sample and kept in the log book.

David Caddell will notify staff on the distribution list that sampling will be extended and for how long.

Ten percent of all identified samples are selected at random to be evaluated for taxonomic accuracy. The quality assurance (QA)/quality control (QC) reviewer records the findings in the permanently bound Macroinvertebrate QA/QC Logbook (Appendix 6). Count accuracy is also checked and similar QA/QC measures (checking counts of other samples identified by errant taxonomist) are taken if average count error (all taxa) exceeds 10%. A sample is chosen for QA/QC after 10 samples have been identified. Each set of 10 completed samples is numbered. A single sample is randomly chosen by picking a coin from a jar of coins numbered one through ten. Each taxonomist is assigned a number and is chosen to perform QA/QC by random picking from numbered coins. The taxonomist that conducted the initial identifications is not eligible to conduct QA/QC on that sample. Disagreements are resolved between the QA/QC taxonomist and the original taxonomist, and the results are recorded in the QA/QC logbook.

Taxonomists use current, accepted taxonomic references in making identifications as well as in interpreting the results (see references in attached SOP). In addition, primary literature is kept on file and used when the above keys are not appropriate. Taxonomists also attend workshops and in-service training sessions to expand their knowledge and competence.

Verification will also include an overlook of field data to make sure documentation was complete and accurate. Problems seen will be noted by the verifier. Data will be examined and ensured that sample results match what was expected at the site. The data will be compared at all locations. After these assessments, the Validator researches the data and/or documentation that are inconsistent for any anomalies in the research. This is done by contacting Lab and Field Personnel to try and correct and/or explain inconsistencies. After all of the validation steps have been completed, the Validator submits a report to the Project Manager who will include this report as appendix to the final report.

D3. Reconciliation with User Requirements

N/A

Appendix A

City of North Augusta Training and Experience

J. David Caddell
195 Stag Run
Edgefield, SC 29824
(803) 215-3931
caddell_david@yahoo.com

EDUCATION

1989-1993 *BS* Aquaculture, Fisheries, and Wildlife Biology
Emphasis in Wildlife Biology
Minor in Forest Resource Management

EMPLOYMENT

2002-Present Stormwater Manager and Superintendent Streets and Drains, City of North Augusta

- Directs compliance with the SCDHEC NPDES General Permit for Small MS4s
- Monitors community compliance with all City Environmental ordinances
- Ensures maintenance and repair of City roads, signage, and storm drainage infrastructure
- Maintenance of traffic signals

1998-Present Owner, Storage Solutions of Edgefield

2004-Present Owner, Environmental Solutions of Edgefield, LLC

- Industrial Stormwater Permit Compliance
- Construction Stormwater Inspections
- Pre-construction Property Assessments
- Wildlife Management Property Enhancement
- Drainage and Erosion Control Improvements

1999-2002 Environmental Health Manager II, SCDHEC

- Directed Operations of the stormwater, wastewater, NPS pollution, agriculture, ambient stream monitoring, and dams / reservoir safety programs for the Lower Savannah EQC District
- Provided technical assistance to homeowners, contractors, and local governments

1995-1999 Natural Resource Technician and Environmental Health Manager I, SCDHEC

- Underground storage tank inspections
- Nonpoint source pollution and construction site inspections

PROFESSIONAL CERTIFICATIONS

Associate Public Manager
Certified Professional in Erosion and Sediment Control
Certified Professional in Storm Water Quality
Certified Erosion Protection and Sediment Control Inspector
Certified Stormwater Plan Reviewer
Traffic Signal Technician Level II

Listing of Entomology Classes and Classes Covering Aquatic Invertebrates

Clemson University 1989-1993

BIOSC 441, H441, 641 Ecology 3(3,0) Study of basic ecological principles underlying the relationships between organisms and their biotic and abiotic environments. Includes physiological, population, and community ecology, with applications of each to human ecological concerns.
ENT 200 Six-Legged Science 3(3,0) Introduction to insects, their various relationships with humans, other animals, and plants. The general nature of this course makes it beneficial to all students regardless of specialty.
ENT 201 Selected Topics 1(1,0) Discussion course covering topics dealing with insects and related arthropods. Subjects are chosen to reflect issues of current interest as well as those having significance in human history. May be repeated for a maximum of three credits.
ENT (BIOSC) 301 Insect Biology and Diversity 4(3,3) Introduction to the study of insects, with emphasis on their structure, function, ecology, and behavior. Identification of commonly encountered species is highlighted. Relationships between insect and human populations are discussed. Control technologies are introduced, with emphasis on environmentally responsible tactics
W F B 350 Principles of Fish and Wildlife Biology 3(3,0) Introduction to principles of fisheries and wildlife biology on which sound management practices are based. Interrelationships of vertebrate and invertebrate biology, habitat, and population dynamics are covered.
W F B 462, H462, 662 Wetland Wildlife Biology 3(3,0) Study of wetland wildlife habitats, emphasizing classification by physical, chemical, and biological characteristics; importance of wetland habitat for management and production of wetland wildlife species.

Iowa State 1998

ENT 590 Ecology and Pest Management

North Augusta
South Carolina's Riverfront

North Augusta Standard Operating Procedure for Assessing Benthic Macroinvertebrates

Section 1 Aquatic Macroinvertebrates

1.0 Introduction

Aquatic macroinvertebrates are insects and other invertebrates associated with streams, rivers, lakes, and estuaries. Aquatic macroinvertebrate communities can be useful indicators of water quality because they respond to integrated stresses over time, and reflect fluctuating environmental conditions. Community response to various pollutants (e.g. organic, toxic, and sediment) may be assessed through interpretation of diversity, known organism tolerances, and, in some cases, relative abundance and feeding behavior types.

1.1 Field Collection Methods

1.1.2 Timed-qualitative Multiple Habitat Sampling Protocol

The city will use a timed-qualitative, multiple habitat sampling protocol (MHSP) to collect macroinvertebrates. Multiple habitat sampling of some type is widely used by many regulatory and non-regulatory agencies both in the United States and abroad (Barbour, et al., 1997; USEPA, 1997; Marchant, et al., 1997). The greatest benefit from using the MHSP is that it enables benthic biologists to collect representative macroinvertebrate taxa from the wide variety of natural habitats in a stream. Since macroinvertebrates occupy all habitat types, many taxa may not be collected when selected habitats are sampled by specific sampling devices (e.g. Surber net, Ponar dredge, etc.). This can lead to exclusion of a variety of taxa and inaccurate water quality assessments.

At locations within the city that will be targeted for sampling, a team of two or three biologists (never less than two) samples for aquatic macroinvertebrates for approximately three man-hours (three man-hours represent three biologists sampling for one hour, or two biologists sampling for one and one half hours). With the aid of a D-frame dip net, kick net, hand sieve, white plastic pan and a fine mesh sampler, all the available natural habitats are sampled. Macroinvertebrates are also collected directly from the habitat with forceps. All macroinvertebrates are placed in jars or vials filled with 85% ethanol (EtOH) and labeled with the station number, collector, and collection date.

The goal of the sampling team is to collect as many different macroinvertebrate taxa as possible during the allotted time. Although the MHSP is a qualitative method, the actual collection of samples is a disciplined procedure designed to ensure that all the habitats present at a site are thoroughly sampled, irrespective of what type habitat is available or where the sample is collected. Rivers and streams vary in habitat type and amount available for colonization by macroinvertebrates. For example, mountain sites are dominated by rock/gravel riffle stream substrate, woody debris, and root banks, while coastal sites are dominated by aquatic vegetation, root banks, woody debris, and sandy to muddy stream substrate. Between the mountains and coastal plain lies the piedmont which has a combination of some or all of the above habitats. North Augusta is located in the Piedmont region of the state. Using the MHSP method insures that a good representation of the macroinvertebrate community will be obtained. The following is a discussion of the MHSP with detailed steps on how to properly collect macroinvertebrate samples from the variety of stream habitats.

Field Sampling Procedures:

1. A 100 m reach that is representative of the characteristics of the stream should be selected. Whenever possible, the area should be at least 100 m upstream from any road or bridge crossing to minimize its effect on stream velocity, depth and overall habitat quality. There should be no major tributaries discharging to the stream in the study area.
2. The physical/chemical field sheet should be completed to document site description, weather conditions, and land use. After sampling, review this information for accuracy and completeness.
3. Draw a map of the sampling reach. This map should include in-stream attributes (e.g., riffles, falls, fallen trees, pools, bends, etc.) and important structures, plants, and attributes of the bank and near stream areas. Use an arrow to indicate the direction of flow. Indicate the areas that were sampled for macroinvertebrates on the map. If available, use hand-held GPS for latitude and longitude determination taken at the furthest downstream point of the sampling reach. If not available, mark on the data sheet the nearest intersections with street names and closest addresses to the sample location.
4. Different types of habitat are to be sampled in approximate proportion to their representation of surface area of the total macroinvertebrate habitat in the reach. For example, if snags comprise 50% of the habitat in a reach and riffles comprise 20%, then 10 jabs should be taken in snag material and 4 jabs should be take in riffle areas. The remainder of the jabs (6) would be taken in any remaining habitat type. Habitat types contributing less than 5% of the stable habitat in the stream reach should not be sampled. In this case, allocate the remaining jabs proportionately among the predominant substrates. The number of jabs taken in each habitat type should be recorded on the field data sheet.
5. Sampling begins at the downstream end of the reach and proceeds upstream. A total of 20 jabs or kicks will be taken over the length of the reach; a single jab consists of forcefully thrusting the net into a productive habitat for a linear distance of 0.5 m. A kick is a stationary sampling accomplished by positioning the net and disturbing the substrate for a distance of 0.5 m upstream of the net.
6. The jabs or kicks collected from the multiple habitats will be composited to obtain a single homogeneous sample. Every 3 jabs, more often if necessary, wash the collected material by running clean stream water through the net two to three times. If clogging does occur that may hinder obtaining an appropriate sample, discard the material in the net and redo that portion of the sample in the same

habitat type but in a different location. Remove large debris after rinsing and inspecting it for organisms; place any organisms found into the sample container. Do not spend time inspecting small debris in the field.

7. Complete the top portion of the "Benthic Macroinvertebrate Field Data Sheet", which duplicates the "header" information on the physical/chemical field sheet.
8. Record the percentage of each habitat type in the reach. Note the sampling gear used, and comment on conditions of the sampling, e.g., high flows, treacherous rocks, difficult access to stream, or anything that would indicate adverse sampling conditions.
9. Document observations of aquatic flora and fauna. Make qualitative estimates of macroinvertebrate composition and relative abundance as a cursory estimate of ecosystem health and to check adequacy of sampling.
10. Perform habitat assessment after sampling has been completed. Having sampled the various microhabitats and walked the reach helps ensure a more accurate assessment. Conduct the habitat assessment with another team member, if possible.
11. Return samples to laboratory and complete log-in forms. All samples should be dated and recorded in the "Sample Log" notebook or on sample log forms.

A. Chironomidae and Small Macroinvertebrate Collection Procedure

A very important component of the macroinvertebrate community is the midge family Chironomidae. Midges generally account for at least 50% of the total species diversity in most systems (Merritt and Cummins, 1996). Since midges are relatively small, they are collected with fine mesh samplers. The fine mesh samplers are made with Nytex (micro-screen cloth material) that has a mesh size of 300 Fm. One sampler is a mesh bag, 0.5 m by 1.0 m, made from a folded sheet of Nytex sewn together on two sides. This bag is used to collect midges from the sand. The other sampler is a 13.0 cm long by 10.0 cm diameter piece of PVC pipe with a Nytex covering on one end. This is used to strain water from the bucket in which midges are washed from the habitats. Although the objective of the fine mesh net is to collect midges, it can also collect other small macroinvertebrates.

Collection Steps:

1. Fill a 19.0 liter bucket approximate one half full with water.

2. Collect two or three samples of all the habitat types present at a stream site by hand (rocks, sticks, leaf packs, root banks, etc.) and rinse in the bucket to remove midges and other macroinvertebrates. Attached root banks (wads) and vegetation may be rinsed directly in the bucket without detachment.

3. Since some midge taxa are sand dwellers, select a sandy bottom site in the stream and collect midges by placing the small mesh bag on the bottom with the open end facing upstream. Disturb approximately a 1.0 m^2 area of the sand upstream of the bag and let the sand and midges drift into the bag. Collect three sand samples from

three different areas of the stream. The bag is only used when there are sandy bottom areas available.

4. Empty the contents of the bag into the same bucket of water that contains the other habitat washes and rinse the bag up and down in the bucket to remove the attached midges.

5. Rinse and remove by hand as much of the larger debris as possible from the bucket and discard. Stir the water in the bucket and strain through the Nytex covered pipe.

6. Remove small portions of the detritus left in the bottom of the Nytex pipe and place in a white pan 1/4 filled with water. Spread the detritus evenly in the pan by hand so that the macroinvertebrates can be seen against the white background. With the aid of forceps and an eye dropper, collect the midges and other small macroinvertebrates and preserve them in a jar filled with 85% EtOH.

7. Repeat step 6 until all the detritus in the Nytex pipe has been examined.

Do not collect more than 100 midges, but collect them in relative proportion to the size classes present. Other macroinvertebrates are sampled proportional to the relative abundance in each pan picked. Although the emphasis of the fine mesh sampler is to collect small macroinvertebrates, larger macroinvertebrates are collected as they are encountered.

B. D-frame Dip Net Collection Procedure

The habitat type most often sampled with the dip net is root bank habitat. Root banks are usually present at all stream sites and they support a variety of small caddisflies and other taxa. Aquatic vegetation, when present, is also sampled with the dip net.

Collection Steps:

1. Root banks are sampled by repeatedly jabbing a D-frame dip net (500 Fm mesh size) into the root wads along a stretch of bank until the net is about 1/4 full of detritus and root debris. Several root wads are washed down by hand into the dip net to remove firmly attached macroinvertebrates. Aquatic vegetation is sampled by sweeping the dip net through the vegetation two or three times.

2. Rinse the bottom of the dip net in the stream to remove excess mud and silt. Remove small portions of the detritis left in the net and spread them evenly in a white pan 1/4 filled with water. Do not attempt to sort through so much detritus that the bottom of the pan is obscured.

3. Using forceps, remove macroinvertebrates from the pan and place in jar of 85% EtOH.

Based on the quality of the root banks and/or aquatic vegetation, collect one or two dip net samples in the root banks and two or three samples in the aquatic vegetation.

C. Kick Net Collection Procedure

The kick net is a 1.0 m^2 sheet of Nytex (500 Fm mesh size) attached on two sides to 1.5 m long poles. The kick net is used to sample rock/gravel riffles and snags/leaf packs.

Collection Steps:

1. Place the kick net slightly downstream of the area to be sampled (snags/leaf packs and/or rock/gravel riffle). Disturb about 1.0 m^2 of the habitat and catch the debris and macroinvertebrates that drift into the net.

2. Spread the kick net out on a sand bar or a flat area on the bank and collect macroinvertebrates from the net with forceps and preserve them in a jar of 85% EtOH.

If the habitat is mostly snags/leaf packs, a minimum of two kick net samples are taken. If the habitat is a mix of both rock/gravel riffle and snags/leaf packs, a minimum of one kick net sample is taken from each habitat. In streams that are mostly rock/gravel riffle, a minimum of two kick net samples are taken in the riffle areas. One kick net sample is taken from a high velocity riffle area and the other is taken from a low velocity riffle area.

D. Hand Sieve Collection Procedure

Hand sieves are used to sample all habitat types and are also used during visual collections. Hand sieve sizes used are the U.S. #30 (0.6 mm openings) and the U.S. #10 (2.0 mm openings). The #10 sieve is used primarily in the sand while the #30 is used on all habitat types. The hand sieve enables the biologist to sample large amounts of habitat quickly and is invaluable for collecting sediment-dwelling taxa such as: Odonata (dragonflies), Gastropoda (snails), Pelecypoda (clams, mussels), Polycentropodidae (burrowing caddisflies), sand case building and burrowing caddisflies (Molannidae, Sericostomadidae, Dipseudopsidae, Odontoceridae), and Ephemeridae (burrowing mayflies). The hand sieve can be used effectively in the same habitat types that are sampled with the dip net and kick net.

Collection Steps:

1. Visually inspect the sand and mud for signs of macroinvertebrate activity. For

example, the movement of burrowing odonates and mussels leaves trails in the sand. Small holes can be seen in the mud, clay, or sand in areas where burrowing mayflies are found. The tubes of *Phylocentropus* sp. larvae can be seen extending above the substrate when they are present.

2. With either the #10 or #30 sieves, sample the mud or sand where there are signs of macroinvertebrate activity (use #10 sieve primarily for sand substrates). Sift the excess sand, mud, silt, and detritus in the stream to trap macroinvertebrates in the sieve.

3. Collect macroinvertebrates from the sieve and place them in jar of 85% EtOH.

4. With the #30 sieve, sample root bank and snag sites and process as above.

F. Visual Collection Procedure

The collection procedure described above is the minimum sampling effort conducted at each stream site. For an additional 1.5 man-hours, stream habitats are visually searched for macroinvertebrates, and collected directly from the habitat with forceps and placed in jars filled with 85% EtOH. For example, rocks and logs are searched for taxa such as the retreat building *Psychomyia* sp. (caddisfly) and for retreat building Hydropsychidae. The undersides of rocks are examined for macroinvertebrates such as Ephemeroptera (mayflies), Plecoptera (stoneflies), Gastropoda (snails), Psephenidae (water pennies) and Megaloptera (hellgrammites). The crevices in rocks and logs are searched for caddisflies such as *Nyctiophylax* sp., *Pycnopsyche* sp., and *Ceraclea* sp. Decaying logs are picked apart to reveal midges and other taxa. Aquatic vegetation, sticks, and limbs are visually searched for small caddisflies (Hydroptilidae and Brachycentridae) and other macroinvertebrates. Mature leaf packs, snags, and root banks are sampled with a #30 sieve to collect a variety of other macroinvertebrates.

G. Collection Procedures Summary

No attempt is made to collect all specimens encountered. If a taxon can be reliably identified in the field, only 10-15 specimens are collected, other taxa are collected in approximate proportion to their abundance in each sampling method (net, pan, sieve, etc.). Since the emphasis of the MHSP method is to collect different taxa, abundance is considered only in a relative sense (see Data Analysis). Some taxa are not collected including: Nematoda, Collembola, semiaquatic Coleoptera, and all Hemiptera except Naucoridae, Belostomatidae, Corixidae, and Nepidae. These are not collected because they are most often found on the water surface or on the banks, and are not truly benthic.

There is no established distance of stream reach sampled at any particular site. If there is good, fairly evenly distributed natural habitat, approximately 100 m of stream (both sides) is routinely sampled. In streams where there is sparse habitat, the distance covered may be more than 100 m. Most sites are accessed at road bridges and are sampled upstream of the bridge, however, some situations may warrant sampling downstream (e.g. access and/or habitat limitations).

As previously noted, the MHSP is a three man-hour sampling effort. Approximately one hour is devoted to use of the kick net and dip net, while about one half hour is devoted to the fine mesh samplers. The rest of the time (one and one half hours) is spent using hand sieves and forceps to make visual collections of all habitat types present.

As a general rule, when a team of biologists sample a site, each one independently uses one of the three sampling devices (dip net, kick net, fine mesh nets) to sample the appropriate habitat. Upon completion, visual collections are begun and the hand sieve is used extensively. It is helpful for the sampling team to discuss the kinds and numbers of taxa present and absent at a site. This results in more efficient sampling.

The sampling methodology described above requires that freshwater streams and rivers be wadeable for efficient sample collection. High water conditions can impair sampling efficiency by making some critical habitats inaccessible due to water depth and clarity. An underestimate of taxa richness may lead to an incorrect assessment of water quality. If high water levels and turbid conditions make sampling difficult, it is better to return to the site under more amenable sampling conditions.

Generally, nonwadeable rivers are not sampled for macroinvertebrates. The city will not be sampling in nonwadeable conditions.

1.1.3 Instrument/Equipment Testing, Inspection and Maintenance

Field Instrumentation needed:

1. D-frame dip net (500 Φm)
2. 1.0m^2 Kick net (500 Φm)
3. Hand sieves (U.S. #=s 10 and 30)
4. 13.0 cm long by 10.0 cm (dia.) PVC fine mesh sampler (300 Φm)
5. 0.5m by 1.0m Fine mesh bag (300 Φm)
6. Bucket
7. White pan
8. Forceps
9. Collection vials and jars filled with 91% EtOH
10. pH meter
11. DO meter
12. Temperature meter
13. Cooler for transport (no ice)

Sorting Procedures:

1. Prior to processing any samples in a lot (i.e., samples within a collection date, specific watershed, or project), complete the sample log-in sheet to verify that all samples have arrived at the laboratory, and are in proper condition for processing.
2. Thoroughly rinse sample in a 500 μm-mesh sieve to remove preservative and fine sediment. Large organic material (whole leaves, twigs, algal or macrophyte mats, etc.) not removed in the field should be rinsed, visually inspected, and discarded. If the samples have been preserved in alcohol, it will be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms, which will prevent them from floating on the water surface during sorting. If the sample was stored in more than one container, the contents of all containers for a given sample should be combined at this time. Gently mix the sample by hand while rinsing to make homogeneous.
3. Save the sorted debris residue in a separate container. Add a label that includes the words "sorted residue" in addition to all prior sample label information and preserve in 91% ethanol. Save the remaining unsorted sample debris residue in a separate container labeled "sample residue"; this container should include the original sample label. Length of storage and archival is determined by the laboratory or benthic section supervisor.
4. Place the sorted organisms in vials, and preserve in 91% ethanol. Label the vials inside with the sample identifier or lot number, date, stream name, sampling location and taxonomic group. If more than one vial is needed, each should be labeled separately and numbered (e.g., 1 of 2, 2 of 2). If identification is to occur immediately after sorting, a petri dish or watch glass can be used instead of vials.
5. Midge (Chironomidae) larvae and pupae should be mounted on slides in an appropriate medium (CMS-10); slides should be labeled with the site identifier, date collected, and the first initial and last name of the collector. As with midges, worms (Oligochaeta) must also be mounted on slides and should be appropriately labeled.
6. Fill out header information on Laboratory Bench Sheet as in field sheets. Also check subsample target number. Complete back of sheet for subsampling/sorting information. Note number of grids picked, time expenditure, and number of organisms. If QC check was performed on a particular sample, person conducting QC should note findings on the back of the Laboratory Bench Sheet. Calculate sorting efficiency to determine whether sorting effort passes or fails.
7. Record date of sorting and slide monitoring, if applicable, on Log-In Sheet as documentation of progress and status of completion of sample lot.

Identification Procedures:

1. Most organisms are identified to the lowest practical level (generally genus or species) by a qualified taxonomist using a dissecting microscope. Taxonomy can be at any level, but should be done consistently among samples. In the original RBPs, two levels of identification were suggested – family (RBP II) and genus/species (RBP

III). Midges (Diptera: Chironomidae) are mounted on slides in an appropriate medium and identified using a compound microscope. Each taxon found in a sample is recorded and enumerated in a laboratory bench notebook and then transcribed to the laboratory bench sheet for subsequent reports. Any difficulties encountered during identification (e.g., missing gills) are noted on these sheets.

2. Labels with specific taxa names (and the taxonomist's initials) are added to the vials of specimens by the taxonomist. (Note that individual specimens may be extracted from the sample to be included in a reference collection or to be verified by a second taxonomist.) Slides are initialed by the identifying taxonomist. A separate label may be added to slides to include the taxon (taxa) name(s) for use in a voucher or reference collection.
3. Record the identity and number of organisms on the Laboratory Bench Sheet. Either a tally counter or "slash" marks on the bench sheet can be used to keep track of the cumulative count. Also, record the life stage of the organisms, the taxonomist's initials and the Taxonomic Certainty Rating (TCR) as a measure of confidence.
4. Use the back of the bench sheet to explain certain TCR ratings or condition of organisms. Other comments can be included to provide additional insights for data interpretation. If QC was performed, record on the back of the bench sheet.
5. For archiving samples, specimen vials, (grouped by station and date), are placed in jars with a small amount of 91% ethanol and tightly capped. The ethanol level in these jars must be examined periodically and replenished as needed, before ethanol loss from the specimen vials takes place. A stick-on label is placed on the outside of the jar indicating sample identifier, date, and preservative (91% ethanol)

Lab Instrumentation needed:

1. Stereo microscope (20x to 40x magnification)
2. Compound light microscope (10x to 1000x magnification)
3. 91% EtOH
4. CMC-10 mounting media
5. Forceps
6. Probe
7. Petri dishes

1.1.4 <u>Abbreviated Timed-Qualitative Multiple Habitat Sampling Protocol</u>

In situations where the full three man-hour sampling effort is not warranted, the abbreviated MHSP is used. This method is used to determine to what extent an effluent or a nonpoint source impact has affected a stream. This method generally works well because of the upstream-downstream comparison that can be made using the macroinvertebrate data. The abbreviated MHSP is very similar to the ambient MHSP, except that the time spent sampling is reduced to two man-hours by a team of two or three biologists (never less than two).

At some impacted sites it may be impractical to sample for two man-hours due to the severity of the impact. For instance, a sediment discharge may greatly reduce aquatic habitat such that macroinvertebrates are scarce, and in these situations it is reasonable to reduce sampling effort. Therefore, whenever 40 or fewer total macroinvertebrates are collected at the first site during the first man-hour, sampling may be terminated and the collection may become a one man-hour sampling effort instead of a two man-hour effort (at least 100 organisms are necessary for the biotic index to be reliable (see Data Analysis Section)). Sampling should always begin at the farthest downstream site in the study area. When sampling effort is reduced to one man-hour, the reference site and other study sites should likewise be sampled for one man-hour. Although it may be obvious that a site has been adversely impacted, it is important to document the degree of impact so that restoration efforts can be later verified.

1.1.5 Equipment

1. D-frame dip net
2. Kick net
3. Hand sieves (U.S. #=s 10 and 30)
4. 13.0 cm long by 10.0 cm (dia.) PVC fine mesh sampler
5. Fine mesh bag
6. 19 liter bucket
7. White pan
8. Forceps
9. Collection vials and jars filled with 85% EtOH
10. Collection labels and EtOH-proof pen or pencil
11. Physicochemical parameter equipment (pH meter, dissolved oxygen/temperature meter, conductivity meter, and stick thermometer)

1.2 Habitat Assessment

Habitat assessment is an important step towards understanding the effects of pollution on macroinvertebrate communities. The city conducts two kinds of habitat assessments at each sampling site. The first is a comprehensive assessment adopted from the Environmental Protection Agency=s (EPA) ARevisions to Rapid Bioassessment Protocols for Use in Streams and Rivers@ (Appendix 1), and the second is a simplified form developed to meet specific needs of the city (Appendix 2). Instructions are included on the forms explaining how to evaluate each of the habitat metrics. Habitat metrics are independently evaluated by each biologist and averaged for a final score (on a single form) which represents a consensus by the assessment team.

The EPA habitat assessment (EPA-HA) provides a thorough evaluation of several conditions at a stream site that could affect stream habitat quality. It provides clues to why certain habitat types may be present or absent, and information about the general stream condition at the assessment site. Since the EPA-HA is a standardized form, it is very useful for reporting purposes and sharing data among the Southeastern states.

The simplified habitat assessment form (ABS-HA) provides more detailed information about instream macroinvertebrate habitat. It enables ABS biologists to make better assessments on the role of stream habitat in situations where pollution is involved. The form classifies the habitat into five categories and rates them from Aexcellent@ to Anon-existent@. This permits visualization of the habitats when the data are being analyzed, and helps to explain the presence or absence of certain taxa. In addition, the ABS-HA helps ABS biologists to cluster stations according to shared habitats when comparisons are made among stations.

1.3 Physicochemical Sampling Procedures

The stream dissolved oxygen, pH, temperature, and conductivity are measured at the time of macroinvertebrate sampling. Results are recorded in the Field Quality Control Logbook (Appendix 3). Specific operation and calibration procedures are followed as documented in the Environmental Investigations Standard Operating Procedures and Quality Assurance Manual (SCDHEC, 1997).

1.4 Laboratory Methods

1.4.1 Sample Handling and Identification

At the end of each sampling day, the samples are reconstituted with fresh 85% EtOH. After returning to the laboratory the samples are logged into the Macroinvertebrate Receiving Logbook (MCRL) (Appendix 4) and stored for further processing.

Before the sorting and identification of a macroinvertebrate sample begins, the taxonomist assumes custody of the sample by signing for it in the MCRL. Custody remains with the taxonomist until the sample has been identified and these data are recorded. Sample completion is noted in the MCRL.

Macroinvertebrates are sorted by taxonomic order and placed into separate vials or petri dishes for further identification. Specimens not requiring slide mounting are identified using a stereo dissecting scope capable of at least 40x magnification. Midges and some baetid mayflies are mounted on labeled (date and locality) slides with CMC-10 mounting media and identified with a compound microscope capable of 1000x magnification. Identifications are made to the lowest practical taxonomic level using the appropriate taxonomic references.

Midges are transferred to water and allowed to settle before mounting. A drop of CMC-10 mounting media is placed on a labeled slide, and the specimen(s) is oriented in the media so that the ventral side of the head capsule is up. To get the head arranged properly, it may be necessary to separate it from the body. A cover slip is placed over the specimen and gentle pressure is applied to spread the mouthparts. Several midges may be mounted on one slide. Slides are allowed to dry at least two days before identification.

Baetidae that require slide mounting are set aside in a petri dish and the entire body or body parts are mounted, as necessary, for identification. A drop of CMC 10 mounting media is placed on a labeled slide. Baetidae (or parts) are placed in the drop of CMC 10 and, with forceps, a cover slip is placed over the specimen. Gentle pressure is applied to the cover slip to reveal the structures necessary for identification. Several Baetidae may be mounted on one slide. Slides are placed on a drying rack for two days before identification.

After the sorted macroinvertebrates (except Chironomidae and some Baetidae) from a station have been identified and these data recorded on bench sheets, they are placed together in a single jar of 85% EtOH. This jar is labeled with station, date collected, and person who identified the sample, and is stored at least five years in the city voucher collection in the lab. If a new taxa record (i.e. one not previously collected from South Carolina) is identified from a site, it is removed from the voucher collection and stored separately in the a reference collection located in a second drawer. A note is made on a bench sheet (form used to record the number of taxa and specimens identified) when a specimen is relocated to the reference collection. Slide mounted specimens are stored separately in cabinets according to sample date and station. If mounted Chironomidae or Baetidae are transferred to the reference collection, this is noted on the bench sheet.

1.4.2 <u>Data Analysis</u>

The taxa list, physicochemical data, and habitat information are entered into a Microsoft Excel for Windows spreadsheet database. This program is used for data management and reporting purposes. The data is then stored in the city Alchemy Tracking System in the Stormwater Management department folders locaed in Public Works section of the computer system. A folder entitled "Monitoring" is located in the Illicit Discharge folder. All data will be stored in this folder. The system is backedup nightly.

Because the MHSP is a timed-qualitative method, metrics that require quantitative collection methods are not used. Two metrics that have proven to be very effective in evaluating macroinvertebrate data collected by qualitative methods are the EPT and biotic indices (Lenat, 1993; Wallace, 1996; Barbour, 1997). The EPT index is the total number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa collected at a site. Most EPT taxa are very intolerant of pollution and, in general, a high EPT count indicates excellent water quality.

The biotic index (BI) is the average pollution tolerance of all organisms collected (based on assigned index values for taxa) and the calculation factors in relative abundances. The index is based on a scale from 0 to 10, with 10 representing the most impaired stream conditions.

Biotic Index (BI) =3(TvÆ)(nÆ)/N

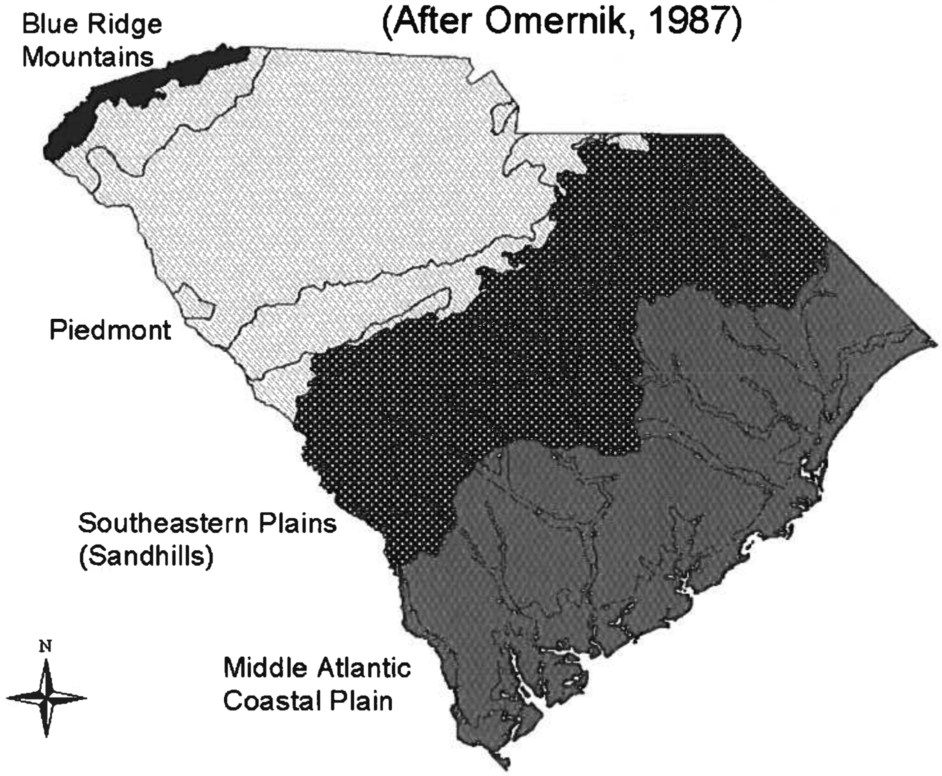
TVÆ = Æth taxon tolerance value
nÆ = Æth taxon abundance value
N = sum of all abundance values

Assigned tolerance values developed in North Carolina (NCDEHNR, 1997) are used in these calculations (Appendix 5). Taxa with no assigned tolerance value are excluded from the calculation.

The calculation of the BI does not include all specimens collected in a sample but rather a maximum of 10 specimens per taxon. This is done to ensure that the BI for a site will not be biased because some taxa are more successfully collected than others. Since most taxa cannot be accurately identified in the field, it is common for some taxa to be more abundant in a sample. Taxa collected from freshwater streams are designated as Rare (1-2 individuals), Common (3-9 individuals) or Abundant (>10 individuals) and are assigned a 1, 3, and 10, respectively, for the calculation of the BI. If there are less than 100 total organisms in a sample, the BI is not used. Instead, the EPT index is used along with other data to assign a bioclassification.

Since ecoregions influence macroinvertebrate distribution, different BI and EPT criteria are used to establish bioclassifications for streams based on the ecoregion in which they occur.
Figure 1 shows the ecoregions in South Carolina (after Omernik 1987). Carlson (1981) recognized similar aquabiotic provinces: Mountain, Piedmont, Sandhills and Coastal plain. The City of North Augusta is situated in the Piedmont and partly in the Sandhills ecoregions (in the lower reaches of the community). All sample locations are located in the Piedmont part of the city at this time. Currently there are no criteria for swamps and slow-flowing streams in the Coastal Plain region in South Carolina.

Figure 1. Ecoregions of South Carolina
(After Omernik, 1987)



Bioclassification of streams in South Carolina is based on the combination of equally weighted BI and EPT scores, and parallels North Carolina=s criteria range:

Excellent = 5 Good = 4 Good-Fair = 3 Fair = 2 Poor = 1

Since North Carolina and South Carolina share similar ecoregions, the North Carolina bioclassification criteria are applied to South Carolina streams. The following tables are used to determine the scores for the EPT taxa richness values and BI values.

Score	BI Values			EPT Values		
	M	P	S/CA	M	P	S/CA
5	<4.00	<5.14	<5.42	>43	>33	>29
4.6	4.00-4.04	5.14-5.18	5.42-5.46	42-43	32-33	28
4.4	4.05-4.09	5.19-5.23	5.47-5.51	40-41	30-31	27
4	4.10-4.83	5.24-5.73	5.52-6.00	34-39	26-29	22-26
3.6	4.84-4.88	5.74-5.78	6.01-6.05	32-33	24-25	21
3.4	4.89-4.93	5.79-5.83	6.06-6.10	30-31	22-23	20
3	4.94-5.69	5.84-6.43	6.11-6.67	24-29	18-21	15-19
2.6	5.70-5.74	6.44-6.48	6.68-6.72	22-23	16-17	14
2.4	5.75-5.79	6.49-6.53	6.73-6.77	20-21	14-15	13
2	5.80-6.95	6.54-7.43	6.78-7.68	14-19	10-13	8-12
1.6	6.96-7.00	7.44-7.48	7.69-7.73	12-13	8-9	7
1.4	7.01-7.05	7.49-7.53	7.74-7.79	10-11	6-7	6
1	>7.05	>7.53	>7.79	0-9	0-5	0-5

(M = Mountain, P = Piedmont, S = Sandhills, CA = Coastal Plain)

Borderline classifications are assigned near half-step values (1.4, 2.6, etc.) and are defined as boundary EPT and BI values. The two ratings are averaged together to produce a combined score which determines the final bioclassification. When the combined score falls between two bioclassifications, it is either rounded up or down based on whether the decimal fraction is larger or smaller than 0.5.

In cases where the decimal fraction is exactly 0.5, other metrics are considered to determine which bioclassification to assign. Metrics considered are: taxa richness, EPT abundance, feeding groups (i.e. filter feeders, predators, etc.) and habitat information. Three biologists independently evaluate the information from a stream site and form a majority consensus on which bioclassification to assign.

Bioclassification of streams is important because it helps state and federal officials prioritize cleanup and protection efforts. This information is reported in the 305b report to the United States Evironmental Protection Agency. The Clean Water Act (Section 305b) requires that each year the States report the conditions of their waters to congress. In the 305b report, macroinvertebrates are used to make a determination on a stream=s aquatic life use support (ALUS). The criteria used to measure ALUS are summarized in three categories: Fully Supporting, Partially Supporting and Not Supporting.

Fully Supporting: Reliable data indicate functioning, sustainable biological assemblages (e.g. fish, macroinvertebrates, or algae) none of which has been modified significantly beyond the natural range of the reference condition.

Partially Supporting: At least one assemblage indicates moderate modification of the biological community as compared to the reference condition.

Not Supporting: At least one assemblage indicates a severely impacted macroinvertebrate community. Data clearly indicate severe modification of the biological community compared to the reference condition.

The Aquatic Biology Section determines the ALUS based on the bioclassification of the stream:

Bioclassification	ALUS
Excellent and Good	Fully Supporting
Good-Fair and Fair	Partially Supporting
Poor	Not Supporting

This method is also used to make stream impairment judgements for South Carolina=s Watershed Water Quality Management Strategy and for point/nonpoint source impact assessments.

1.4.3 Data Analysis for Special Studies

Special studies often involve using sites upstream from a point source discharge or a non-point source area as a control. The site downstream from the potential impact can then be compared with this upstream reference station for assessment purposes. By comparing final bioclassification scores an assessment can be made. The following represents the levels of impairment and their associated change in bioclassification scores.

Level of Impairment	Decrease in Bioclassification Score
Unimpaired	#0.4
Slightly Impaired	0.6-1.4
Moderately Impaired	1.6-2.4
Severely Impaired	$2.6

If the decrease is 0.5, 1.5, or 2.5, professional judgement is used to decide whether to move up or down on the scale. Taxa Richness, Total Count and other metrics may be consulted to help determine the level of impairment in this situation.

The above scale is used as a general guide and there are situations where professional judgment may override the assessment. A common example is when the control is also impaired. If the control is Good-Fair, Fair, or Poor, a proper assessment may not be possible using the above scale. If the control is Poor (1), for example, the downstream site will be assessed as nonimpaired. In such a situation the data is said to be inconclusive. Because the upstream site is already impaired it would be impossible to determine the relative contribution of the discharge to the water quality of the stream. In this situation, water chemistry, toxicity tests, or other means may be the only way of determining impact. Another possibility is if the downstream site is almost devoid of life. An assessment of severe impairment may be warranted even if the control site is suboptimal.

In situations where a bioclassification cannot be calculated for a downstream site due to a paucity of organisms, an assessment of impact will be based on professional judgement. Metrics such as EPT taxa richness, total taxa richness, and abundance of organisms will be used to compare the control site with the study site.

1.5 Quality Assurance

All macroinvertebrate samples are logged into the City's Macroinvertebrate Receiving Logbook upon delivery to the lab. Entries on the Macroinvertebrate Sampling Form are checked for agreement as to the number of jars and vials of samples collected from each station. The logbook serves to track sample possession and to document progress through initial log in, sorting, taxonomic identification, and data recording. The number of jars and/or vials containing the samples at each phase of sample processing, identification, and storage is recorded in the logbook. The identification data are recorded on a macroinvertebrate bench sheet. Completed bench sheets along with habitat assessment forms and any other hard copy related to a sample are kept on permanent file. Using the completed bench sheet, the data are then entered into the most recent version of Microsoft Excel for Windows program where the data are stored for later analysis. After data are entered into Excel for Windows database, the data are printed out on spreadsheets. These spreadsheets are compared to the original bench sheets and corrections made if needed.

Ten percent of all identified samples are selected at random to be evaluated for taxonomic accuracy. The quality assurance (QA)/quality control (QC) reviewer records the findings in the permanently bound Macroinvertebrate QA/QC Logbook (Appendix 6). Count accuracy is also checked and similar QA/QC measures (checking counts of other samples identified by errant taxonomist) are taken if average count error (all taxa) exceeds 10%. A sample is chosen for QA/QC after 10 samples have been identified. Each set of 10 completed samples is numbered. A single sample is randomly chosen by picking a coin from a jar of coins numbered one through ten. Each taxonomist is assigned a number and is chosen to perform QA/QC by random picking from numbered coins. The taxonomist that conducted the initial identifications is not eligible to conduct QA/QC on that sample. Disagreements are resolved between the QA/QC taxonomist and the original taxonomist, and the results are recorded in the QA/QC logbook.

Taxonomists use current, accepted taxonomic references in making identifications as well as in interpreting the results (see References). In addition, primary literature is kept on file and used when the above keys are not appropriate. Certified Laboratory Taxonomists also attend workshops and in-service training sessions to expand their knowledge and competence.

1.6 References

Barbour, M. T., J. Gerritsen, B. D. Snyder, J. B. Stribling. 1997. Revision to rapid bioassessment protocols for use in streams and rivers: Periphyton, benthic macroinvertebrates and fish. EPA 841-D-97-002, Washington, D.C.

Bode, R. W. 1983. Larvae of North American *Eukiefferiella* and *Tvetenia* (Diptera: Chironomidae). New York State Museum Bulletin No. 452. The New York State Education Dept., Albany, NY. 40 pp.

Brigham, A. R., W. U. Brigham, and A. Gnilka. 1982. Aquatic insects and Oligochaeta of North and South Carolina. Midwest Aquatic Enterprises, Mahomet, IL. 800 pp.

Brinkhurst, R. O. 1986. Guide to the freshwater aquatic microdrile oligochaetes of North America. Can. Spec. Publ. Fish. Aquat. Sci. 84. 259 pp.

Burch, J. B. 1972. Freshwater unionacean clams (Mollusca: Pelecypoda) of North America. EPA Proj. No. 18050 ELD. U.S. Govt. Print. Off., Washington, D. C. 176 pp.

Burch, J. B. 1982. Freshwater snails (Mollusca: Gastropoda) of North America. EPA-600/3-82-026. 294 pp.

Carlson, P. C. 1981. Aquatic insects as indicators of environmental alteration. A dissertation presented to the graduate school of Clemson University. 99 pp.

Epler, J. H. 1992. Identification manual for the larval Chironomidae (Diptera) of Florida. Contract No. SP251 State of Florida Dept. of Environmental Regulation, Orlando FL.

Hobbs, H. H. 1981. The crayfishes of Georgia. Smithsonian contributions to zoology; no. 318. Smithsonian Institution Press, Washington, D. C. 549 pp.

Holsinger, J. R. 1972. The freshwater amphipod crustaceans (Gammaridae of North America). EPA Project No. 18050. U.S. Govt. Print. Off., Washington, D. C. 89 pp.

Hudson, P. L., D. R. Lenat, B. A. Caldwell, and D. Smith 1990. Chironomidae of the southeastern United States: A checklist of species and notes on biology, distribution, and habitat. U.S. Fish Wildl. Serv., Fish Wildl. Res. 7 46 pp.

Klemm, D. J. 1972. Freshwater leeches (Annelida: Hirudinae) of North America. EPA Project No. 18050, U.S. Govt. Print. Off., Washington, DC. 53 pp.

Klemm, D. J. 1982. Leeches (Annelida: Hirudinea) of North America. EPA 600/3-32-025. 177 pp.

Lenat, D. R. 1993. A biotic index for the southeastern United States: Derivation and list of tolerance values, with criteria for assigning water-quality ratings. In: J. N. Am Benthol. Soc., 12(3):279-290.

Marchant, R., A. Hirst, R. H. Norris, R. Butcher, L. Metzeling, and D. Tiller. 1997. Classification and prediction of macroinvertebrate assemblages from running waters in Victoria, Australia. In: J. N. Am Benthol. Soc., 1997, 16(3): 664-681.

Merritt, R. W., and K. W. Cummins. 1996. An Introduction the Aquatic Insects of North America, 3rd. Ed. Kendall/Hunt Publ. Co., Dubuque, IA. 862 pp.

Needham, J. G., and J. J. Westfall, Jr. 1964. A Manual of the dragonflies of North America (Anisoptera). Univ. Calif. Press, Los Angeles, CA. 615 pp.

North Carolina Department of Environment, Health and Natural Resources (NCDEHNR). 1997. Standard operating procedures: Biological monitoring. Division of Environmental Management, Water Quality Section, Raleigh, NC.

Omernik, J.M. 1987. Ecoregions of the conterminous United States (map supplement). Annals of the Association of American Geographers. 77(1): 118-125.

Pennak, R. W. 1989. Freshwater invertebrates of the United States. 3rd Ed. John Wiley and Sons, NY. 628 pp.

Ross, H. H. 1944. The caddisflies or Trichoptera of Illinois. Entomol. Reprint Specialists, Los Angeles. CA. 326 pp.

South Carolina Department of Health and Environmental Control. 1997. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Environmental Quality Control. Columbia, S.C.

Stewart, K. W. and B. P. Stark. 1988. Nymphs of North American stonefly genera (Plecoptera). The Thomas Say Foundation., Vol. 12. 460 pp.

United States Environmental Protection Agency. 1997. Field and laboratory methods for macroinvertebrate and habitat assessment of low gradient nontidal streams. Mid-Atlantic Coastal Streams Workgroup, Environmental Services Division, Region 3, Wheeling, WV. 23 pp.

Usinger, R. L. 1971. Aquatic insects of California. Univ. Calif. Press, Berkeley, CA. 608 pp.

Wallace, J. B., J. W. Grubaugh and M.R. Whiles. 1996. Biotic indices and stream ecosystem processes: Results from an experimental study. In: Ecological Applications, 6(1), 1996, pp. 140-151. by the Ecological Society of America.

Wiederholm, T. (ed.). 1983. Chironomidae of the Holartic Region. Keys and Diagnoses. Part 1. Larvae. Entomologica Scandinavica. Supplement No. 19. 457 pp.

Wiggins, G. B. 1996. Larvae of the North American caddisfly genera (Trichoptera). 2nd Ed. Univ. Toronto Press, Toronto, Canada. 457 pp.

Williams, W. D. 1972. Freshwater isopods (Asellidae) of North America. EPA Project No. 18050. U.S. Govt. Print. Off., Washington, D. C. 45 pp.

Appendix 1

Environmental Protection Agency
Habitat Assessment Forms (low and high gradient)

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION
STATION # ________ RIVERMILE ________	STREAM CLASS
LAT ________ LONG ________	RIVER BASIN
STORET #	AGENCY
INVESTIGATORS	
FORM COMPLETED BY	DATE ________ TIME ________ AM PM ; REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% <20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score __________

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION	
STATION #________ RIVERMILE________	STREAM CLASS	
LAT ____________ LONG ____________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ______ TIME ______ AM PM	REASON FOR SURVEY

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are <u>not</u> new fall and <u>not</u> transient).	40-70% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment. Layering of cobble provides diversity of niche space.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regime	All four velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (Slow is < 0.3 m/s, deep is > 0.5 m.)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity/ depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (<20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—HIGH GRADIENT STREAMS (BACK)

Parameters to be evaluated broader than sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream <7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of >25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

Total Score ___

Appendix 2

Habitat Assessment- Short Form

Macroinvertebrate Habitat Assessment - Short Form

Station __________ Date __________ Time __________ #Jars ____ #Vials _____

Stream Name __________________ Location ________________ County ________

Collectors Names ________________________ Field QC Logbook ______Page# ____

Air Temp (C) _____ pH (SU)_____ DO (mg/l)_____ H20 Temp (C)_____ Cond (umhos/cm)______

Aquatic Habitat Score: Excellent = 5 Good = 4 Good - Fair = 3 Fair = 2 Poor = 1 Nonexistent = 0

*Habitat	Score						Comments
Root Banks	5	4	3	2	1	0	
Logs, Sticks, Snags	5	4	3	2	1	0	
Rock/Gravel Riffle	5	4	3	2	1	0	
Mature Leaf Pack	5	4	3	2	1	0	
Aquatic Vegetation	5	4	3	2	1	0	
Total							

*If aufwuchs and/or sediment on the habitats appear to adversely affect colonization by macroinvertebrates, this impact is noted in the comments section; however, the habitat score does not change.

**Velocity/Flow: Fully Supporting Partially Supporting Not Supporting

Sedimentation: Little or no Moderate Severe

**The degree to which there is diversity of flow supportive of macroinvertebrate colonization of the variety of habitats.

Appendix 3

Forms and Worksheets used for Projects

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME	LOCATION	
STATION # ______ RIVERMILE ______	STREAM CLASS	
LAT ______ LONG ______	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE ______ TIME ______ AM PM	REASON FOR SURVEY

WEATHER CONDITIONS	Now / Past 24 hours ☐ storm (heavy rain) ☐ ☐ rain (steady rain) ☐ ☐ showers (intermittent) ☐ ____%☐ %cloud cover ☐____% ☐ clear/sunny ☐ Has there been a heavy rain in the last 7 days? ☐ Yes ☐ No Air Temperature ____° C Other ______________
SITE LOCATION/MAP	Draw a map of the site and indicate the areas sampled (or attach a photograph)
STREAM CHARACTERIZATION	Stream Subsystem ☐ Perennial ☐ Intermittent ☐ Tidal Stream Origin ☐ Glacial ☐ Spring-fed ☐ Non-glacial montane ☐ Mixture of origins ☐ Swamp and bog ☐ Other ______ Stream Type ☐ Coldwater ☐ Warmwater Catchment Area ________ km^2

Form A-01 Stream Characterization Front

PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (BACK)

WATERSHED FEATURES	**Predominant Surrounding Landuse** ☐ Forest ☐ Commercial ☐ Field/Pasture ☐ Industrial ☐ Agricultural ☐ Other ______ ☐ Residential **Local Watershed NPS Pollution** ☐ No evidence ☐ Some potential sources ☐ Obvious sources **Local Watershed Erosion** ☐ None ☐ Moderate ☐ Heavy
RIPARIAN VEGETATION (18 meter buffer)	Indicate the dominant type and record the dominant species present ☐ Trees ☐ Shrubs ☐ Grasses ☐ Herbaceous dominant species present ______
INSTREAM FEATURES	Estimated Reach Length ______ m Estimated Stream Width ______ m Sampling Reach Area ______ m² Area in km² (m²x1000) ______ km² Estimated Stream Depth ______ m Surface Velocity ______ m/sec (at thalweg) **Canopy Cover** ☐ Partly open ☐ Partly shaded ☐ Shaded **High Water Mark** ______ m **Proportion of Reach Represented by Stream Morphology Types** ☐ Riffle ______ % ☐ Run ______ % ☐ Pool ______ % Channelized ☐ Yes ☐ No Dam Present ☐ Yes ☐ No
LARGE WOODY DEBRIS	LWD ______ m² Density of LWD ______ m²/km² (LWD/ reach area)
AQUATIC VEGETATION	Indicate the dominant type and record the dominant species present ☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free floating ☐ Floating Algae ☐ Attached Algae dominant species present ______ Portion of the reach with aquatic vegetation ______ %
WATER QUALITY	Temperature ______ °C Specific Conductance ______ Dissolved Oxygen ______ pH ______ Turbidity ______ WQ Instrument Used ______ **Water Odors** ☐ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other ______ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ None ☐ Other ______ **Turbidity (if not measured)** ☐ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Stained ☐ Other
SEDIMENT/ SUBSTRATE	**Odors** ☐ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other ______ **Oils** ☐ Absent ☐ Slight ☐ Moderate ☐ Profuse **Deposits** ☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand ☐ Relict shells ☐ Other ______ **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No

INORGANIC SUBSTRATE COMPONENTS (should add up to 100%)			ORGANIC SUBSTRATE COMPONENTS (does not necessarily add up to 100%)		
Substrate Type	Diameter	% Composition in Sampling Reach	Substrate Type	Characteristic	% Composition in Sampling Area
Bedrock			Detritus	sticks, wood, coarse plant materials (CPOM)	
Boulder	> 256 mm (10")				
Cobble	64-256 mm (2.5"-10")		Muck-Mud	black, very fine organic (FPOM)	
Gravel	2-64 mm (0.1"-2.5")				
Sand	0.06-2mm (gritty)		Marl	grey, shell fragments	
Silt	0.004-0.06 mm				
Clay	< 0.004 mm (slick)				

Form A-02 Stream Characterization BACK

BENTHIC MACROINVERTEBRATE FIELD DATA SHEET

STREAM NAME	LOCATION	
STATION # ________ RIVERMILE ________	STREAM CLASS	
LAT ________ LONG ________	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		LOT NUMBER
FORM COMPLETED BY	DATE ________ TIME ________ AM PM	REASON FOR SURVEY

HABITAT TYPES	Indicate the percentage of each habitat type present ☐ Cobble ____% ☐ Snags ____% ☐ Vegetated Banks ____% ☐ Sand ____% ☐ Submerged Macrophytes ____% ☐ Other ( ) ____%
SAMPLE COLLECTION	Gear used ☐ D-frame ☐ kick-net ☐ Other ________ How were the samples collected? ☐ wading ☐ from bank ☐ from boat Indicate the number of jabs/kicks taken in each habitat type. ☐ Cobble ____ ☐ Snags ____ ☐ Vegetated Banks ____ ☐ Sand ____ ☐ Submerged Macrophytes ____ ☐ Other ( ) ____
GENERAL COMMENTS	

QUALITATIVE LISTING OF AQUATIC BIOTA
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare, 2 = Common, 3 = Abundant, 4 = Dominant

Periphyton	0	1	2	3	4	Slimes	0	1	2	3	4
Filamentous Algae	0	1	2	3	4	Macroinvertebrates	0	1	2	3	4
Macrophytes	0	1	2	3	4	Fish	0	1	2	3	4

FIELD OBSERVATIONS OF MACROBENTHOS
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare (1-3 organisms), 2 = Common (3-9 organisms), 3 = Abundant (>10 organisms), 4 = Dominant (>50 organisms)

Porifera	0	1	2	3	4	Anisoptera	0	1	2	3	4	Chironomidae	0	1	2	3	4
Hydrozoa	0	1	2	3	4	Zygoptera	0	1	2	3	4	Ephemeroptera	0	1	2	3	4
Platyhelminthes	0	1	2	3	4	Hemiptera	0	1	2	3	4	Trichoptera	0	1	2	3	4
Turbellaria	0	1	2	3	4	Coleoptera	0	1	2	3	4	Other	0	1	2	3	4
Hirudinea	0	1	2	3	4	Lepidoptera	0	1	2	3	4						
Oligochaeta	0	1	2	3	4	Sialidae	0	1	2	3	4						
Isopoda	0	1	2	3	4	Corydalidae	0	1	2	3	4						
Amphipoda	0	1	2	3	4	Tipulidae	0	1	2	3	4						
Decapoda	0	1	2	3	4	Empididae	0	1	2	3	4						
Gastropoda	0	1	2	3	4	Simuliidae	0	1	2	3	4						
Bivalvia	0	1	2	3	4	Tabanidae	0	1	2	3	4						
						Culicidae	0	1	2	3	4						

Form A14-Field Data Sheet

page ___ of ___

BENTHIC MACROINVERTEBRATE SAMPLE LOG-IN SHEET

Date Collected	Collected By	Number of Containers	Preservation	Station #	Stream Name and Location	Date Received by Lab	Lot Number	Date of Completion		
								sorting	mounting	identification

Serial Code Example: [illegible]
B = Benthic, F = Fish, P = Periphyton ■ [illegible] = project number ■ [illegible] = sample number ■ [illegible] = lot number [illegible]

A-15 Sample Log-In Sheet

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (FRONT)

page ____ of ____

STREAM NAME	LOCATION
STATION # ________ RIVERMILE ________	STREAM CLASS
LAT ____________ LONG ____________	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE ________	LOT #
TAXONOMIST DATE	SUBSAMPLE TARGET ☐ 100 ☐ 200 ☐ 300 ☐ Other

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
Hemiptera											

Taxonomic certainty rating (TCR) 1-5 1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials

Total No. Organisms ____________ Total No. Taxa ____________

A-16 Front of Lab Bench Sheet

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (BACK)

SUBSAMPLING/SORTING INFORMATION

Sorter ____________

Date ____________

Number of grids picked ________

Time expenditure ________ No. of organisms ________

Indicate the presence of large or obviously abundant organisms:

QC: ❑ YES ❑ NO **QC Checker** ____________

organisms originally sorted [ ] – (# organisms recovered by checker [ ] + # organisms originally sorted [ ]) = % sorting efficiency [ ]

≥90%, sample passes ________

<90%, sample fails, action taken ____________

TAXONOMY

ID ____________

Date ____________

Explain TCR ratings of 1-3:

Other Comments (e.g. condition of specimens):

QC: ❑ YES ❑ NO **QC Checker** ____________

Organism recognition ❑ pass ❑ fail

Verification complete ❑ YES ❑ NO

General Comments (use this space to add additional comments):

A-17 Back of Lab Bench Sheet

PRELIMINARY ASSESSMENT SCORE SHEET
(PASS)

page ____ of ____

STREAM NAME	LOCATION
STATION # RIVERMILE	STREAM CLASS
LAT ____________ LONG	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE	LOT # NUMBER OF SWEEPS
HABITATS ☐COBBLE ☐SHOREZONE ☐SNAGS ☐VEGETATION	

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
						Taxonomic certainty rating (TCR) 1-5: [illegible] LS = life stage: I = immature, P = pupa, A = adult TI = Tolerance index					
Hemiptera											

	Site Value	Target Threshold	
			If 2 or more [illegible] are [illegible] target threshold [illegible] is **HEALTHY**
Total No. Taxa			
EPT Taxa			If less than 2 metrics [illegible] this target range, site is **SUSPECTED IMPAIRED**
Tolerance Index			

Form A-18 Preliminary Assessment Score Sheet

Appenix 4

Macroinverebrate Receiving Logbook (LOG-IN) Sheet

page __ of __

BENTHIC MACROINVERTEBRATE SAMPLE LOG-IN SHEET

Date Collected	Collected By	Number of Containers	Preservation	Station #	Stream Name and Location	Date Received by Lab	Lot Number	Date of Completion		
								sorting	mounting	identification

Serial Code Example: B0754001(1)
B = Benthos (F = Fish, P = Periphyton)# 0754 = project number# 001 = sample number# (1) = lot number (e.g., winter 1996 = 1, summer 1996 = 2)

Appendix 5
South Carolina Tolerance Values for Biotic Index

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

Appendix 5
South Carolina Tolerance Values for Biotic Index

TAXA	TV	FFG
ANNELIDA		
Aeolosoma sp.	---	8
Amphichaeta	---	0
Batracobdella sp.	7.61	6
Branchiobdellida	---	0
Branchiura sowerbyi	8.28	8
Cambarincolidae	---	0
Chaetogaster diastrophus	---	6
Chaetogaster sp.	---	7
Dero digitata	---	5
Eclipidrilus sp.	---	8
Enchytraeidae	9.84	8
Glossiphoniidae	9	6
Haplotaxida	---	0
Helobdella sp.	9	6
Helobdella triserialis	9	6
Hirudinea	---	0
Hirudinidae	5	6
Ilyodrilus templetoni	---	8
Limnodrilus hoffmeisteri	9.47	8
Lumbriculidae	7.03	8
Macrobdella decora	---	0
Megasolecidae	---	8
Moorebdella tetregon	9.43	6
Naididae	---	7
Nais communis	8.81	8
Nais sp.	8.9	8
Nais variabilis	8.9	8
Oligochaeta	---	7
Opistocystidae	9.04	8
Peloscolex sp.	5.4	8
Philodella sp.	5	6
Placobdella nuchalis	9	6
Placobdella papillata	9	6
Placobdella papillifera	9	

TAXA	TV	FFG
ANNELIDA cont.		
Placobdella sp.	9	6
Pristina longisoma	---	5
Pristina sp.	---	7
Quistadrilus c.f. multisetosu	---	8
Quistadrilus sp.	7.11	8
Slavina appendiculata	7.06	8
Stylaria lacustrus	---	7
Stylodrilus sp.	7.03	8
Tubifex tubifex	10	8
Tubificidae	7.11	8
Vejdovskyella comata	---	8
HYDRACARINA	5.53	6
ARACHNOIDA	---	0
CRUSTACEA		
Amphipoda	---	0
Caecidotea forbesi	9.11	4
Caecidotea sp.	9.11	4
Cambaridae	7.5	7
Cambarus sp.	7.62	7
Copepoda	---	0
Crangonyx serratus	7.87	4
Crangonyx sp.	7.87	4
Gammaridae	---	4
Gammarus fasciatus	9.1	4
Gammarus sp.	9.1	4
Hyallela azteca	7.75	4
Lirceus lineatus	7.85	4
Lirceus sp.	7.85	4
Palaemonetes paludosus	7.07	7
Palaemonetes sp.	7.07	7
Procambarus sp.	9.46	7
Synurella sp.	---	4

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

SC Master List of Benthic Macroinvertebrates

TAXA	TV	FFG
COLEOPTERA		
Acilius sp.	---	6
Agabetes acuductus	---	6
Agabetes sp.	---	6
Agabus sp.	8.3	6
Agasicles hygrophila	---	0
Anacaena sp.	---	3
Anchytarsus bicolor	3.64	2
Ancyronyx variegatus	6.49	6
Anodocheilus exiguus	---	6
Bagous sp.	---	6
Berosus sp.	8.43	4
Bidessonotus sp.	---	6
Bidessus fuscatus	---	6
Carabidae	---	
Celina sp.	8.04	6
Chrysomelidae	---	1
Coleoptera	---	0
Collembola	---	0
Copelatus glyphicus	---	6
Copelatus sp.	---	6
Coptotomus interrogatus	---	6
Coptotomus sp.	9.26	6
Curculionidae	---	6
Cybister sp.	---	6
Cymbiodyta sp.	---	4
Cyphon sp.	---	0
Derallus altus	---	4
Deronectes griseostriatus	4	6
Deronectes sp.	4	1
Desmopachria grana	---	6
Dineutus carolinus	5.54	6
Dineutus discolor	5.54	6
Dineutus robertsi	5.54	6
Dineutus sp.	6	6
Disonycha sp.	---	0

TAXA	TV	FFG
COLEOPTERA cont.		
Dobolocellus ovatus	---	4
Donacia sp.	---	1
Dryopidae	---	1
Dubiraphia bivittata	5.93	5
Dubiraphia quadrinotata	---	5
Dubiraphia sp.	5.93	5
Dubiraphia vittatata	4.05	5
Dytiscidae	---	0
Dytiscus fasciventris	---	6
Dytiscus hybridus	---	6
Dytiscus sp.	---	6
Ectopria nervosa	4.16	5
Ectopria sp.	---	5
Elmidae	---	5
Elodes sp.	---	0
Enochrus sayi	8.75	4
Enochrus sp.	8.75	4
Enochrus sublongus	8.75	4
Entomobryidae	---	0
Eretes sp.	---	6
Falloporus sp.	2.96	6
Gonielmis dietrichi	---	5
Graphoderus liberus	---	6
Gyrinidae	---	0
Gyrinus sp.	6.17	6
Haliplidae	---	1
Haliplus fasciatus	---	1
Haliplus sp. 8.71	1	
Helichus basalis	5.4	5
Helichus lithophilus	---	5
Helichus sp.	4.63	5
Helobata striata	---	2
Helochares maculicollis	---	4
Helocombus sp.	---	1
Helodidae	---	0

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

TAXA	TV	FFG	TAXA	TV	FFG
COLEOPTERA cont.			**COLEOPTERA cont.**		
Helophorus sp.	7.57	4	*Paracymus confusus*	---	4
Hoperius planatus	---	6	*Paracymus sp.*	---	4
Hydaticus bimarginatus	9.1	6	*Pelonomus obscurus*	---	5
Hydaticus sp.	9.1	6	*Peltodytes dunavani*	---	1
Hydraena sp.	---	6	*Peltodytes duodicimpunctatus*	---	1
Hydraenidae---	0		*Peltodytes muticus*	---	1
Hydrobiomorpha casta	0	0	*Peltodytes oppositus*	8.73	1
Hydrobius sp.	---	4	*Peltodytes sexmaculatus*	---	1
Hydrocanthus sp.	7.14	7	*Peltodytes shermani*	---	1
Hydrochara obtusa	---	4	*Peltodytes sp.*	8.73	1
Hydrochara sp.	---	4	*Prionocyphon sp.*	---	0
Hydrochus sp.	6.55	4	*Promoresia elegans*	2.15	5
Hydrophilidae	---	0	*Promoresia sp.*	2.35	5
Hydrophillus triangularis	---	4	*Promoresia tardella*	0	5
Hydroporus mellitus	4	6	*Psephenidae*	---	0
Hydroporus sp.	8.62	6	*Psephenus herricki*	2.35	5
Hydroporus undulatus	8.62	6	*Ptilodactyla augustata*	---	2
Hydroporus vittatipennis	8.62	6	*Ptilodactyla serricollis*	---	2
Hydroporus/Hygrotus sp.	---	0	*Ptilodactyla sp.*	---	2
Hydrovatus sp.	---	6	*Ptilodactylidae*	---	0
Hygrotus farctus	---	6	*Pyrrhalta nymphaeae*	---	1
Hygrotus sp.	---	6	*Rhantus sp.*	3.61	6
Ilybius sp.	---	6	*Scirtes sp.*	---	1
Laccobius agilis	---	4	*Spanglerogyrus sp.*	---	0
Laccobius sp.	7.32	4	*Sperchopsis tessellatus*	6.13	4
Laccophilus sp.	---	6	*Staphylinidae*	---	0
Laccornis diformis	---	6	*Stenelmis hungerfordi*	5.1	5
Liodesus sp.	---	6	*Stenelmis sp.*	5.1	5
Macronychus glabratus	4.58	5	*Stenus sp.*	---	0
Matus ovatus	---	6	*Suphis inflatus*	---	7
Microcylloepus pusillus	2.11	5	*Suphisellus sp.*	---	7
Noteridae	---	0	*Thermonectus sp.*	---	6
Optioservus ovalis	2.36	5	*Tropisternus collaris*	---	4
Optioservus sp.	2.36	5	*Tropisternus glaber*	9.68	4
Optioservus trivittatus	---	5	*Tropisternus limbatus*	9.68	4
Oulimnius latiusculus	1.78	5	*Tropisternus sp.*	9.68	4
Oulimnius sp.	1.8	5	*Uvarus sp.*	---	0

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

TAXA	TV	FFG
DIPTERA:CHIRONOMIDAE		
Ablabesmyia annulata	2.04	6
Ablabesmyia cinctipes	---	6
Ablabesmyia hauberi	---	6
Ablabesmyia janata	7.40	6
Ablabesmyia mallochi	7.19	6
Ablabesmyia monilis	---	6
Ablabesmyia parajanta/janata	7.37	6
Ablabesmyia peleensis	9.67	6
Ablabesmyia philosphagnos	---	6
Ablabesmyia rhamphe GR	---	6
Ablabesmyia sp.	7.20	6
Ablabesmyia tarella	7.20	6
Alotanypus sp.	---	0
Apedilum sp.	---	4
Apsectrotanypus johnsoni	0.10	6
Axarus sp.	---	6
Bethbilbeckia floridensis	---	0
Brillia sp.	5.18	2
Brundiniella eumorpha	1.71	6
Bryophaenocladius sp.	---	4
Cardiocladius sp.	---	4
Chaetocladius sp.	---	4
Chernovskia orbicus	9.63	4
Chironomidae	---	0
Chironominae	---	0
Chironomini---	4.00	
Chironomus riparius	---	2
Chironomus attenuatus	---	4
Chironomus crassicaudatus	---	4
Chironomus decorus (Complex)	---	0
Chironomus sp.	9.63	4
Cladopelma sp.	4.09	4
Cladotanytarsus sp.	---	4
Clinotanypus pinguis	---	0
Clinotanypus sp.	---	6

TAXA	TV	FFG
DIPTERA:CHIRONOMIDAE cont.		
Clunia marshalli	8.00	6
Coelotanypus scapularis	---	6
Coelotanypus tricolor	---	6
Coelotanypus concinnus	---	6
Coelotanypus sp.	8.00	6
Conchapelopia Group	---	6
Constempellina sp.	---	4
Cordites sp.	6.01	4
Corynoneura sp.	---	4
Cricotopus bicinctus	---	6
Cricotopus sp.	---	6
Cricotopus/Orthocladius	---	5
Cryptochironomus NR macropodus	---	6
Cryptochironomus NR ponderosus	---	6
Cryptochironomus NR rolli	---	6
Cryptochironomus blarina GR.	7.41	6
Cryptochironomus digitatus	---	6
Cryptochironomus fulvus	6.38	6
Cryptochironomus sorex	---	6
Cryptochironomus sp.	6.40	6
Cryptotendipes sp.	6.19	4
Crytotendipes emorsa	---	4
Demelierea brachialis	---	1
Demicryptochironomus sp.	2.12	6
Diamesa sp.	---	5
Diamesinae	---	0
Dicrotendipes fumidus	---	4
Dicrotendipes lucifer	7.95	5
Dicrotendipes modestus	8.73	4
Dicrotendipes neomodestus	8.10	4
Dicrotendipes nervosus	9.76	4
Dicrotendipes simpsoni	9.95	5
Dicrotendipes sp.	8.10	4
Diplocladius cultriger	7.41	4
Diplocladius sp.	7.41	4
Djalmabatista pulcher	---	6
Einfeldia sp.	7.08	4

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

TAXA	TV	FFG
DIPTERA:CHIRONOMIDAE cont.		
Endochironomus nigricans	7.79	4
Endochironomus signaticornis GR	---	4
Endochironomus sp.	---	4
Epoicocladius sp.	0.00	1
Eukiefferiella brehmi GR	2.72	5
Eukiefferiella brevicalcar GR	2.23	5
Eukiefferiella claripennis GR	5.58	5
Eukiefferiella devonica GR	2.59	5
Eukiefferiella gracei GR	3.44	5
Euiefferiella pseudomontana GR	4.00	5
Eukiefferiella similis GR	---	6
Eukiefferiella sp.		5
Genus P (Epler 1992)		0
Glyptotendipes		4
Goeldechironomus divineyae	9.47	4
Goeldechironomus holoprasinus	---	4
Guttipelopia currani	---	6
Gymnometriocnemus sp.	---	4
Harnischia curtilamelata	9.07	4
Harnischia sp.	---	4
Heleniella sp.	0.00	4
Heterotrissocladius marcidus GR	---	4
Heterotrissocladius sp.	5.23	4
Hudsonimyia karelena	---	6
Hudsonimyia sp.	---	6
Hydrobaenus pilipes	---	5
Hydrobaenus sp.	9.54	5
Hyporhygma quadripuncatum	---	1
Kiefferulus dux	---	1
Krenosmittia sp.	0.00	4

TAXA	TV	FFG
DIPTERA:CHIRONOMIDAE cont.		
Labrundinia NR virescens	---	6
Labrundinia beckae	---	6
Labrundinia floridana	---	6
Labrundinia johanseni	---	6
Labrundinia neopilosella	5.97	6
Labrundinia pilosella	5.91	6
Labrundinia sp.	5.90	6
Labrundinia virescens	4.33	6
Larsia sp.	9.30	6
Lauterborniella agrayloides	---	1
Limnophyes sp.	7.43	4
Lipiniella sp.	---	4
Lopescladius sp.	1.67	4
Macropelopia sp.	---	6
Meropelopia sp.	---	1
Metriocnemus NR fuscipes	---	4
Metriocnemus sp.	---	4
Microchironomus sp.	---	4
Micropsectra sp.	---	4
Microtendipes pedellus GR	5.50	7
Microtendipes rydalensis GR	6.20	0
Microtendipes sp.	---	7
Monopelopia sp.	---	7
Nanocladius NR balticus	---	4
Nanocladius alternantherae	---	6
Nanocladius balticus	---	4
Nanocladius distinctus	---	4
Nanocladius downesi	2.45	4
Nanocladius minimus	---	4
Nanocladius paravulus	---	4
Nanocladius sp.	7.07	4
Natarsia sp.	9.95	6
Nilodorium sp.	---	4
Nilotanypus americanus	---	6
Nilotanypus fimbriatus	---	6
Nilotanypus sp.	3.90	6
Nilothauma sp.	5.03	4

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

TAXA	TV	FFG
DIPTERA:CHIRONOMIDAE cont.		
Odontomesa fulva	5.89	4
Oliveridia sp.	3.19	5
Omisus pica	---	4
Orthocladiinae	---	0
Orthocladius annectens	---	4
Orthocladius lignicola	---	4
Orthocladius oliveri	---	5
Orthocladius sp.	---	4
Pagastia sp.	1.77	5
Pagastiella ostansa	2.50	4
Parachaetocladius abnobasus	0.00	4
Parachaetocladius sp.	0.00	4
Parachironomus abortivus	8.32	6
Parachironomus carinatus	---	6
Parachironomus frequens	---	6
Parachironomus monochromus	9.56	6
Parachironomus pectinatellae	6.45	6
Parachironomus potamogetti	---	6
Parachironomus schneideri	---	6
Parachironomus sp.	9.42	6
Parachironomus subletti	---	6
Paracladopelma doris	---	6
Paracladopelma loganea	---	6
Paracladopelma nereis	0.94	6
Paracladopelma sp.	5.51	6
Paracladopelma undine	4.93	6
Paracricotopus sp.	---	4
Parakiefferiella sp.	5.40	4
Parakiefferiella triqueta	5.15	4
Paralauterborniella nigrohalteralis	4.77	4
Paralimnophyes sp.	---	4
Paramerina NR anomala	---	6
Paramerina smithae	---	6
Paramerina sp.	4.29	6

TAXA	TV	FFG
DIPTERA:CHIRONOMIDAE cont.		
Parametriocnemus lundbecki	3.65	4
Parametriocnemus sp.	3.65	4
Parapsectra sp.	---	4
Paratanytarsus sp.	8.45	4
Paratendipes connectens (Group)	4.00	0
Paratendipes sp.	5.11	4
Paratrichocladius	---	4
Pedionomus beckae	---	4
Pentaneura inculta	---	6
Pentaneura sp.	4.70	6
Phaenopsectra flavipes	7.94	5
Phaenopsectra sp.	6.50	4
Polypedilum angulum	5.20	4
Polypedilum aviceps	3.65	4
Polypedilum branseniae	---	1
Polypedilum flavum	4.93	4
Polypedilum digitifer	---	4
Polypedilum fallax	6.39	4
Polypedilum halterale	7.31	4
Polypedilum illinoense	9.00	4
Polypedilum laetum	1.37	4
Polypedilum nubeculosum	---	4
Polypedilum ontario	---	4
Polypedilum scalaenum	8.40	4
Polypedilum sordens	---	4
Polypedilum sp.	---	4
Polypedilum sp. C (Epler 1992)	---	4
Polypedilum trigonum	---	4
Polypedilum tritum	---	4
Polypedilum tuberculum	---	4
Potthastria gaedi	1.98	5
Potthastria longimanus	6.46	5
Potthastria sp.	1.98	5
Procladius bellus	---	6
Procladius sp.	9.10	6
Prodiamesa olivacea	9.50	4
Psectracladius NR elatus	---	4

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

TAXA	TV	FFG
DIPTERA:CHIRONOMIDAE cont.		
Psectracladius simulans	---	4
Psectracladius sp.	3.59	4
Psectrotanypus dyari	---	6
Psectrotanypus sp.	---	6
Pseudochironomus fulviventris	---	4
Pseudochironomus middlekauffi	---	4
Pseudochironomus richardsoni	---	4
Pseudochironomus sp.	5.36	4
Pseudorthocladius sp.	1.51	4
Pseudosmittia sp.	---	2
Psilometriocnemus sp.	---	6
Rheocricotopus robacki	7.28	4
Rheocricotopus sp.	7.30	4
Rheocricotopus tuberculatus	5.40	4
Rheopelopia acra	---	6
Rheopelopia sp.	---	6
Rheosmittia sp.	7.00	4
Rheotanytarsus sp.	5.89	3
Robackia claviger	2.16	6
Robackia demeijereia	3.74	6
Robackia sp.	2.16	6
Saetheria hirta	---	6
Saetheria sp.	---	6
Saetheria tylus	7.07	4
Smittia sp.	---	4
Stelechomyia perpulchra	5.02	2
Stempellina sp.	0.00	4
Stempellinella sp.	4.62	1
Stenochironomus sp.	6.45	1
Stictochironomus divinctus	6.52	4
Stictochironomus sp.	6.52	4
Stilocladius clinopecten	0.98	4

TAXA	TV	FFG
DIPTERA:CHIRONOMIDAE cont.		
Sublettea coffmani	1.60	4
Symbiocladius sp.	---	1
Symposiocladius lignicola	5.34	5
Sympotthastia sp.	5.09	5
Sympotthastia zavreli	---	4
Synorthocladius sp.	4.36	5
Tanypodinae	---	0
Tanypus carinatus	---	7
Tanypus concavus	---	6
Tanypus neopunctipennis	---	7
Tanypus punctipennis	---	7
Tanypus sp.	9.19	7
Tanypus stellatus	---	7
Tanytarsus guerlus	---	7
Tanytarsus sp.	6.76	7
Thienemaniella sp.	5.86	4
Thienemannimyia GR	---	6
Tokunagaia sp.	---	4
Tribelos atrum	6.31	1
Tribelos fusicorne	6.31	1
Tribelos jucundus	6.30	4
Tribelos sp.	6.31	1
Trissopelopia	---	6
Tvetenia bavarica GR	3.65	5
Tvetenia discoloripes GR	3.61	5
Tvetenia sp.	---	5
Unniella multivirga	---	4
Xenochironomus sp.	---	6
Xenochironomus sublettei	---	2
Xenochironomus xenolabis	7.10	6
Xestochironomus sp.	5.99	1
Xylotopus par	5.99	1
Zalutschia sp.	---	4
Zavrelia sp.	5.30	4
Zavreliella varipennis	---	4
Zavrelimyia sp.	---	6

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

TAXA	TV	FFG
DIPTERA:OTHER		
Aedes sp.	---	6
Alluaudomyia sp.	5.99	6
Anopheles excrucians	3.00	3
Anopheles punctipennis	---	3
Anopheles sp.	8.58	3
Antocha sp.	4.25	5
Atherix lantha	2.07	6
Atherix sp.	2.10	6
Atrichopogon sp.	6.49	5
Bessia	---	6
Bittacomorpha clavipes	---	4
Bittacomorpha sp.	---	4
Bittacomorphella sp.	---	4
Blephariceras sp.	0.00	5
Brachypremna sp.	---	2
Ceratopogonidae	---	0
Ceratopogoniinae	---	6
Chaoboridae	---	0
Chaoborus albatus	---	6
Chaoborus americanus	---	6
Chaoborus flavicans	---	6
Chaoborus punctipennis	8.50	6
Chaoborus sp.	8.50	6
Chelifera sp.	7.57	6
Chrysogaster	---	4
Chrysops sp.	6.73	4
Cnephia mutata	---	3
Cnephia pecuarium	---	3
Cnephia sp.	---	3
Culex atratus	---	3
Culex erraticus	---	3
Culex restuans	---	3
Culex sp.	---	3
Culex territans	---	3
Culicidae	---	0
Culicoides sp.	7.70	6
Culiseta sp.	---	4
Dasyhelea sp.	5.00	6

TAXA	TV	FFG
DIPTERA:OTHER cont.		
Dilophus sp.	---	0
Diptera	---	0
Dixa sp.	2.55	4
Dixella indiana	---	1
Dixella sp.	---	1
Dixidae	---	0
Dolichopodidae	---	4
Ectemnia invenmusta	---	6
Ectemnia sp.	---	6
Empididae	7.57	6
Ephydra	---	5
Ephydridae	---	5
Erioptera	4.62	2
Eristalis sp.	9.69	8
Forcipomyia sp.	---	6
Forcipomyiinae	---	6
Gonomyia (Group)	---	4
Helius sp.	---	4
Hemerodromia sp.	---	6
Hexatoma sp.	4.31	6
Holorusia sp.	---	2
Leptoconops sp.	---	5
Limnophila sp.	---	2
Limonia sp.	9.64	2
Liriopespp	---	2
Mansonia perturbani	---	4
Mansonia sp.	---	3
Mansonia titilans	---	4
Maruina sp.	---	4
Molophilus sp.	---	2
Muscidae	---	6
Nemotelus sp.	---	5
Odontomyia	---	4
Oxycera sp.	---	5
Palpomyia (Complex)	6.86	6
Pedicia sp.	---	2
Pericoma sp.	---	4
Phoridae	---	0

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

SC Master List of Benthic Macroinvertebrates

TAXA	TV	FFG
DIPTERA:OTHER cont.		
Pilaria sp.	---	2
Polymeda/Ormosia sp.	6.27	4
Probezzia sp.	---	6
Prosimulium magnum	---	3
Prosimulium mixtum	4.00	3
Prosimulium rhizophorum	---	3
Prosimulium sp.	4.01	3
Protoplasa fitchii	4.33	4
Pseudolimnophila sp.	7.22	4
Psorophora	---	6
Psychoda sp.	9.64	4
Psychodidae	---	0
Ptychoptera sp.	---	4
Ptychopteridae	---	0
Rhabdomastix sp.	---	4
Rhagionidae	---	0
Roederoides sp.	7.57	6
Sciaridae	---	0
Sepedon	---	1
Simuliidae	---	0
Simulium clarkei	---	3
Simulium congareenarum	4.87	3
Simulium decorium	---	3
Simulium jonesi	---	3
Simulium meridionale	---	3
Simulium NR johannseni	---	3
Simulium nyssa	---	3
Simulium parnassum	---	3
Simulium pictipes	---	3
Simulium podostemi	---	3
Simulium snowi	---	3
Simulium sp.	---	3
Simulium tuberosum	4.42	3
Simulium venustum	7.06	3
Simulium verecundum	---	3
Simulium vittatum	8.65	3

TAXA	TV	FFG
DIPTERA:OTHER cont.		
Stegoterna mutata	---	3
Stilobezzia sp.	---	6
Stratiomyidae	---	5
Stratiomys sp.	8.08	4
Syrphidae	---	4
Tabanidae	---	0
Tabanus sp.	9.22	6
Tanyderidae	---	0
Telmatoscopus sp.	---	4
Tipula sp.	7.33	2
Tipulidae	---	0
Toxorhynchites septentrionalis	---	6
Ulomorpha sp.	---	6
Uranotaenia sp.	---	3
EPHEMEROPTERA		
Acentrella ampla	3.61	1
Acentrella carolina	---	1
Acentrella sp.	---	1
Acerpenna macdunnoughi	---	1
Acerpenna pygmaeus	3.88	1
Acerpenna sp.	3.88	1
Ameletus lineatus	2.38	4
Amercaenis sp.	1.00	0
Attenella attenuata	1.56	4
Baetidae	---	5
Plauditus sp.	5.40	4
Baetis armillatus	5.40	4
Baetis brunneicolor	---	5
Baetis dubium	5.40	4
Baetis flavistriga	6.58	5
Baetis hageni	1.62	5
Baetis intercalaris	4.99	5
Baetis pluto	4.28	5
Baetis punctiventris	5.40	4
Baetis sp.	5.40	4
Baetis tricaudatus	1.63	5

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

SC Master List of Benthic Macroinvertebrates

TAXA	TV	FFG
EPHEMEROPTERA cont.		
Baetisca becki	---	1
Baetisca berneri	2.02	4
Baetisca carolina	3.47	4
Baetisca gibbera	1.43	4
Baetisca lacustris	---	4
Baetisca laurentina	---	4
Baetisca obesa	---	4
Baetisca rogersi	---	4
Baetisca sp.	3.40	4
Baetiscidae	---	0
Barbaetis benfieldi	---	1
Brachycercus sp.	3.01	4
Caenis amica	---	4
Caenis anceps	---	4
Caenis diminuta	---	4
Caenis diminuta/punctata	---	4
Caenis hilaris	7.41	4
Caenis latipennis	7.41	4
Caenis maccaferti	---	4
Caenis punctata	---	4
Caenis sp.	7.41	4
Callibaetis sp.	9.84	1
Centroptilum alamance	6.60	5
Centroptilum sp.	6.60	5
Cercobrachys sp.	---	0
Choroterpes sp.	---	4
Cinygmula subaequalis	0.00	5
Cloeon sp.	6.60	4
Dannella lita	0.00	4
Dannella simplex	3.61	4
Dannella sp.	---	4
Drunella allegheniensis	0.83	5
Leucrocuta aphrodite	2.42	5
Leucrocuta hebe	---	5
Leucrocuta sp.	2.40	5
Litobrancha recurvata	0.00	4
Macdunnoa brunnea	0.58	1

TAXA	TV	FFG
EPHEMEROPTERA cont.		
Metretopodidae	---	0
Neoephemera bicolor	---	4
Neoephemera coompressa	0.00	4
Neoephemera purpurea	1.57	4
Neoephemera sp.	---	4
Neoephemera youngi	0.86	4
Nixie sp.	0.00	1
Paracloeodes	---	4
Paraleptophlebia sp.	0.94	4
Potamanthus distinctus	---	1
Potamanthus myops	---	4
Potamanthus sp.	1.53	4
Procloeon sp.	5.00	5
Pseudiron centralis	---	6
Pseudocloeon sp.	4.02	5
Rhithrogena amica	0.30	5
Rhithrogena exilis	0.30	1
Rhithrogena fuscifrons	0.30	5
Rhithrogena sp.	0.30	5
Serratella carolina	0.00	4
Serratella dificiens	2.75	4
Serratella serrata	1.88	4
Serratella serratoides	1.66	4
Serratella sordida	1.70	4
Serratella sp.	1.70	4
Serratella speculosa	---	4
Siphlonuridae	---	0
Siphlonurus mirus	5.81	4
Siphlonurus quebecensis	5.81	4
Siphlonurus sp.	5.81	4
Siphloplecton sp.	3.31	6
Siphloplecton speciosum	---	6
Stenacron carolina	1.14	5
Stenacron gilderslevi	---	5
Stenacron interpunctatum	6.87	5
Stenacron pallidum	2.72	5
Stenacron sp.	---	5

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

SC Master List of Benthic Macroinvertebrates

TAXA	TV	FFG
EPHEMEROPTERA cont.		
Stenonema bipunctatum	---	4
Stenonema carlsoni	2.08	4
Stenonema exiguum	3.83	4
Stenonema femoratum	7.18	4
Stenonema integrum	5.75	4
Stenonema ithaca	3.58	4
Stenonema lenati	2.26	1
Stenonema mediopunctatum	3.77	4
Stenonema meririvulanum	0.13	4
Stenonema modestum	5.50	4
Stenonema nepotellum	---	4
Stenonema pudicum	2.01	1
Stenonema pulchellum	---	4
Stenonema sp.	---	4
Stenonema terminatum	4.10	4
Stenonema vicarium	1.26	4
Tortorpus incertus	---	4
Tricorythidae	---	0
Tricorythidae sp.	5.06	1
HETEROPTERA		
Belostoma sp.	9.80	6
Belostoma/Abedus	---	6
Belostomatidae	---	0
Benacus griseus	---	6
Buenoa sp.	---	6
Corixidae	9.00	0
Gelastocoridae	---	0
Gelastocoris oculatus	---	6
Gerridae	---	0
Gerris conformis	---	6
Gerris sp.	---	6
Hebrus sp.	---	6
Herbridae	---	0
Hesperocoridae sp.	---	6
Heteroptera	---	6
Hydrometra australis	---	6
Hydrometra martini	---	6

TAXA	TV	FFG
HETEROPTERA cont.		
Hydrometra sp.	---	6
Lethocerus americanus	---	6
Lethocerus sp.	---	6
Limnogonus hesione	---	6
Limnoporus sp.	---	6
Merragata herbriodes	---	7
Mesovelia mulsanti	---	6
Mesovelia sp.	---	6
Mesovelliidae	---	0
Metrobates hesperus	---	6
Metrobates sp.	---	6
Microvelia sp.	---	6
Naucoridae	---	6
Neogerris hesione	---	6
Nepa apiculata	---	6
Nepidae	---	0
Notonecta sp.	8.71	6
Notonectidae	---	0
Palmocorixa sp.	---	7
Paravelia sp.	---	
Pelocoris sp.	7.01	
Ramphocorixa sp.	---	6
Ranatra buenoi	7.82	6
Rhagovelia obesa	---	6
Rheumatobates sp.	---	6
Sigara sp.	9.06	1
Trepobates sp.	---	6
Trichocorixa sp.	---	6
Vellidae	---	0
LEPIDOPTERA		
Helophorous linearis	---	1
Lepidoptera	---	7
Neargyractis slossonalis	---	7
Noctuidae	---	7
Parapoynx sp.	---	7
Petrophila sp.	---	7
Pyralidae	---	7

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

SC Master List of Benthic Macroinvertebrates

TAXA	TV	FFG
MEGALOPTERA		
Chauliodes pectinicornis	9.55	6
Chauliodes rastricornis	8.42	6
Chauliodes sp.	---	6
Corydalidae	---	0
Corydalus cornutus	5.16	6
Megaloptera	---	6
Nigronia fasciatus	5.55	6
Nigronia serricornis	4.95	6
Nigronia sp.	---	6
Sialidae	---	0
Sialis aequalis	7.17	6
Sialis sp.	7.17	6
NEUROPTERA		
Climacia areolaris	---	6
Sisyra vicaria	---	6
ODONATA		
Aeschnidae	---	6
Aeshna sp.	---	6
Aeshna umbrosa	---	6
Aeshna verticalas	---	6
Anax junius	---	6
Anax longipes	---	6
Anax sp.	---	6
Archilestes grandis	---	6
Argia apicalis	---	6
Argia bipunctulata	8.17	6
Argia fumipennis	8.17	6
Argia sedula	8.46	6
Argia sp.	8.17	6
Argia tibialis	---	6
Argia translata	8.17	6
Arigomphus sp.	5.80	6
Basiaeschna janata	7.35	6
Boyeria grafiana	6.05	6
Boyeria sp.	---	6
Boyeria vinosa	5.89	6
Brachymesia gravida	---	6

TAXA	TV	FFG
ODONATA cont.		
Calopterygidae	---	6
Calopteryx dimidiata	7.78	6
Calopteryx maculata	8.30	6
Calopteryx sp.	7.78	6
Celithemis eponina	---	6
Celithemis sp.	---	6
Chromagrion conditum	---	6
Coenagrionidae	---	0
Cordulegaster diasatops	5.73	6
Cordulegaster erroneous	---	6
Cordulegaster fasciatus	---	6
Cordulegaster maculata	5.70	6
Cordulegaster sayi	---	6
Cordulegaster sp.	5.73	6
Cordulegasteridae	---	0
Corduliidae	---	0
Corduliidae/Libellulidae	---	0
Didymops transversa	2.36	6
Dromogomphus armatus	---	6
Dromogomphus sp.	5.92	6
Dromogomphus spinosus	---	6
Dromogomphus spoiliatus	---	6
Enallagma divigens	---	6
Enallagma durum	---	6
Enallagma signatum	8.90	6
Enallagma sp.	8.91	6
Epiaeschna sp.	---	6
Epiaeschna sp.	---	6
Epicordulia princeps	5.60	6
Epicordulia sp.	5.60	6
Epitheca cynosura	---	6
Epitheca princeps	---	6
Epitheca semiaquea	---	6
Epitheca sp.	---	6
Erpetogomphus designatus	---	6
Erythemis simplicicollis	9.72	6

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

TAXA	TV	FFG
ODONATA cont.		
Erythemis sp.	---	6
Erythrodiplax bernice	---	6
Erythrodiplax connata	---	6
Erythrodiplax sp.	---	6
Gomphaeshna sp.	6.00	6
Gomphidae	---	0
Gomphus sp.	5.80	6
Gomphus spiniceps	5.10	6
Gomphus villosipes	---	6
Hagenius brevistylus	3.99	6
Helocordulia shelysi	---	6
Helocordulia sp.	4.83	6
Helocordulia uhleri	4.86	6
Hetaerina americana	---	1
Hetaerina sp.	5.61	6
Hetaerina tittia	---	6
Ischnura sp.	9.52	6
Ischnura/Anomalagrion	---	6
Ladona deplanata	---	6
Lanthus parvulus	1.80	6
Lanthus sp.	1.77	6
Lanthus vernalis	1.80	6
Lestes sp.	9.42	6
Lestidae	---	0
Libellula auripennis	---	6
Libellula forensie	---	6
Libellula lydia	---	6
Libellula sp.	9.64	6
Libellulidae	---	6
Macromia alleganiensis	---	6
Macromia gborgiana	6.20	
Macromia illinoense	---	6
Macromia sp.	6.16	6
Macromia taeniolata	6.16	6
Nannothemis sp.	---	6
Nasiaeschna pentacantha	8.14	6
Nasiaeshna sp.	---	6
Nehalennia sp.	---	6

TAXA	TV	FFG
ODONATA cont.		
Neurocordulia alabamensis	---	6
Neurocordulia molesta	1.80	6
Neurocordulia obsoleta	5.15	6
Neurocordulia sp.	5.03	6
Neurocordulia virginiensis	2.05	6
Odonata	---	6
Ophiogomphus anomalus	---	6
Ophiogomphus carolinus	---	6
Ophiogomphus mainensis	5.54	6
Ophiogomphus sp.	5.54	6
Pachydiplax longipennis	9.86	6
Pantala flavescens	---	6
Pantala sp.	---	6
Perithemis sp.	9.85	6
Perithemis tenera	9.85	6
Plathemis lydia	---	6
Progomphus obscurus	8.22	6
Progomphus sp.	8.70	6
Somatochlora provocans	---	6
Somatochlora sp.	9.15	6
Stylogomphus albistylus	4.72	6
Stylurus sp.	5.80	6
Sympetrum sp.	7.29	6
Sympetrum vicinum	---	6
Telebasis byersi	---	6
Tetragoneuria cynosura	8.50	6
Tetragoneuria semiaquea	---	6
Tetragoneuria sp.	8.57	6
Tramea sp.	---	6
PLECOPTERA		
Acroneuria abnormis	2.06	6
Acroneuria arenosa	2.30	6
Acroneuria arida	---	6
Acroneuria carolinensis	0.00	6
Acroneuria evoluta	---	6
Acroneuria internata	---	6
Acroneuria lycorias	2.12	6
Acroneuria mela	0.89	6
Acroneuria sp.	---	6

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

TAXA	TV	FFG
PLECOPTERA cont.		
Acroneuria/Eccoptura.	---	6
Agnetina annulipes	0.00	6
Agnetina capitata	0.00	6
Agnetina flavescens	0.00	6
Agnetina sp.	0.00	6
Allocapnia sp.	2.52	2
Alloperla sp.	1.22	6
Amphinemura delosa	---	2
Amphinemura sp.	3.33	2
Attaneuria ruralis	---	6
Beloneuria sp.	0.00	6
Bolotoperla rossi	---	2
Capniidae	---	2
Chloroperla sp.	---	6
Chloroperlidae	---	0
Clioperla clio	4.72	1
Cultus descisus	1.57	6
Diploperla duplicata	2.68	6
Diploperla morgani	1.44	6
Diploperla sp.	---	6
Eccoptura xanthenes	3.74	6
Haploperla brevis	0.98	6
Helopicus bogaloosa	0.00	6
Helopicus sp.	0.81	6
Helopicus subvarians	0.81	6
Hydroperla sp.	---	6
Isogenoides hansoni	0.54	6
Isogenoides NR hastatus	---	6
Isogenus crosbyi	---	6
Isogenus sp.	---	6
Isoperla bilineata	5.44	6
Isoperla clio	---	6
Isoperla dicala	2.10	6
Isoperla holochlora	0.00	6
Isoperla marlynia	---	6
Isoperla near frisoni	---	6
Isoperla similis	---	6
Isoperla sp.	---	6

TAXA	TV	FFG
PLECOPTERA cont.		
Isoperla transmarina	5.23	6
Leuctra sp.	0.67	2
Leuctridae	---	0
Malirekus hastatus	1.15	6
Nemocapnia carolina	---	2
Nemoura sp.	---	2
Nemoura venosa	---	2
Nemouridae	---	0
Neoperla sp.	1.49	6
Oemopteryx contorta	---	2
Paracapnia angulata	0.12	2
Paragnetina fumosa	3.36	6
Paragnetina ichusa	0.00	6
Paragnetina immarginata	1.38	6
Paragnetina kansensis	1.99	6
Paragnetina media	3.36	6
Paragnetina sp.	1.54	6
Paranemoura sp.	---	0
Peltoperlidae	---	0
Perlesta placida	4.72	6
Perlesta sp.	4.70	6
Perlidae	---	0
Perlinella drymo	0.00	6
Perlinella ephyre	1.26	6
Perlinella sp.	---	6
Perlodidae	---	0
Plecoptera	---	0
Prostoia sp.	5.78	2
Pteronarcidae	1.64	2
Pteronarcys biloba	---	2
Pteronarcys dorsata	1.76	2
Pteronarcys proteus	---	2
Pteronarcys sp.	1.67	2
Remenus bilobatus	0.28	6
Shipsa rotunda	0.33	2
Soyedina sp.	0.00	2
Strophopteryx sp.	2.70	2
Suwallia sp.	1.18	1

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

SC Master List of Benthic Macroinvertebrates

TAXA	TV	FFG
PLECOPTERA cont.		
Sweltsa sp.	0.00	6
Taenionema atlanticum	---	0
Taeniopterygidae	---	0
Taeniopteryx atlanticum	---	1
Taeniopterygidae	---	0
Taeniopteryx atlanticum	---	1
Taeniopteryx burksi	6.12	2
Taeniopteryx lita	---	2
Taeniopteryx maura	---	2
Taeniopteryx maura	5.37	2
Taeniopteryx metequi	1.42	2
Taeniopteryx paravulus	---	2
Taeniopteryx sp.	5.37	2
Taeniopteryx ugola	---	2
Tallaperla sp.	1.20	2
Viehoperla sp.	1.18	2
Yugus arinus	0.00	6
Yugus bulbosus	0.00	6
Yugus sp.	0.00	6
Zapada chila	---	2
Zealeutra sp.	---	2
TRICHOPTERA		
Agapetus sp.	0.00	5
Agarodes georgius	---	2
Agarodes griseus	---	2
Agarodes libalis	---	2
Agarodes sp.	0.69	2
Agarodes wallacei	---	2
Agraylea multipunctata	---	1
Agraylea sp.	---	1
Agrypnia sp.	---	2
Agrypnia vestita	---	2
Anabolia consocia	---	2
Anisocentropus pyraloides	0.85	2
Apatania sp.	0.64	5
Arctopsyche irrorata	0.00	6
Brachycentridae	---	0
Brachycentrus appalachia	0.63	3

TAXA	TV	FFG
PLECOPTERA cont.		
Brachycentrus chelatus	0.60	3
Brachycentrus incanus	---	5
Brachycentrus lateralus	0.60	3
Brachycentrus nigrosoma	2.33	3
Brachycentrus numerosus	1.74	3
Brachycentrus sp.	2.08	3
Brachycentrus spinae	0.00	6
Calamoceratidae	---	0
Ceraclea alces	---	6
Ceraclea ancylus	2.29	5
Ceraclea ancylus/flavus	2.01	4
Ceraclea cancellata	---	4
Ceraclea diluta	---	4
Ceraclea enodis	2.01	4
Ceraclea excisa	0.00	5
Ceraclea flava	0.00	5
Ceraclea maculata	6.50	4
Ceraclea mentiea	0.00	4
Ceraclea misca	2.01	4
Ceraclea near transversa	2.54	6
Ceraclea neffi	---	4
Ceraclea nepha	---	5
Ceraclea ophioderus	2.38	2
Ceraclea punctata	---	4
Ceraclea resurgens	2.87	6
Ceraclea slossonae	---	4
Ceraclea sp.	2.01	4
Ceraclea tarsipunctata	---	4
Ceraclea transversa	2.54	6
Ceratopsyche alhedra	0.02	1
Ceratopsyche bifida	2.18	1
Ceratopsyche bronta	2.47	1
Ceratopsyche etnieri	---	1
Ceratopsyche macleodi	0.62	1
Ceratopsyche morosa	2.63	1
Ceratopsyche slossonae	0.00	1
Ceratopsyche sp.	---	1
Ceratopsyche sparna	2.72	1
Ceratopsyche ventura	0.00	1

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

SC Master List of Benthic Macroinvertebrates

TAXA	TV	FFG
PLECOPTERA cont.		
Cernotina sp.	---	6
Cernotina spicata	---	6
Cheumatopsyche sp.	6.22	7
Chimarra aterrima	2.76	3
Chimarra obscura	2.76	3
Chimarra socia	2.76	3
Chimarra sp.	2.76	3
Culoptila sp.	---	5
Cyrnellus fraternus	7.34	6
Dibusa angata	---	1
Diplectrona metaqui	---	3
Diplectrona modesta	2.21	3
Dolophilodes sp.	0.81	3
Fattigia pele	0.88	2
Glossosoma sp.	1.55	5
Glossosomatidae	---	0
Goeria calcarata	---	5
Goeria fuscula	---	5
Goeria sp.	0.13	5
Goeria stylata	---	5
Goerita sp.	---	5
Helicopsyche borealis	0.00	5
Helicopsyche paralimnella	0.00	5
Helicopychidae	---	0
Hesperophylax sp.	---	2
Heteroplectron americanum	3.23	2
Hydatophylax argus	2.17	2
Hydatophylax sp.	---	2
Hydropsyche betteni	7.78	3
Hydropsyche bidens	---	3
Hydropsyche carolina	---	1
Hydropsyche decalda	4.30	3
Hydropsyche demora	2.06	3
Hydropsyche elissoma	---	3
Hydropsyche frisoni	---	3
Hydropsyche hageni	---	3
Hydropsyche incommoda	4.77	3
Hydropsyche leonardi	---	3
PLECOPTERA cont.		
Hydropsyche malcleodi	---	6
Hydropsyche mississippiensis	---	3
Hydropsyche phalerata	3.62	3
Hydropsyche rossi	4.77	3
Hydropsyche scalaris	2.10	3
Hydropsyche simulans	---	3
Hydropsyche sp.	---	3
Hydropsyche venularis	4.96	3
Hydropsychidae	---	0
Hydroptila sp.	6.22	1
Hydroptilidae	---	0
Ironoquia punctatissima	7.78	2
Ironoquia sp.	7.30	2
Lepidostoma sp.	0.90	2
Lepidostomatidae	---	1
Leptoceridae	---	0
Leptocerus americanus	---	1
Leucotrichia pictipes	4.06	5
Limnephilidae	---	0
Limnephilus sp.	---	2
Limnephilus submonilifer	---	2
Lype diversa	4.05	2
Macrostemum carolina	3.52	1
Macrostemum sp.	3.52	1
Matrioptila jeanae	0.00	5
Mayatrichia ayama	---	1
Micrasema bennetti	0.00	1
Micrasema burksi	0.00	1
Micrasema charonis	0.75	1
Micrasema rickeri	0.00	1
Micrasema rusticum	0.00	1
Micrasema sp.	---	1
Micrasema sprulesi	---	1
Micrasema wataga	2.63	1
Molanna blenda	6.09	4
Molanna sp.	---	4
Molanna tryphena	2.45	4
Molanna uniophila	---	4

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

TAXA	TV	FFG
PLECOPTERA cont.		
Molannidae	---	0
Mystacides sepulchralus	2.69	4
Nectopsyche candida	5.46	4
Nectopsyche exquisita	4.10	4
Nectopsyche pavida	4.14	4
Nectopsyche sp.	2.94	4
Neophylax antiqua	---	1
Neophylax concinnus	1.45	5
Neophylax consimilis	1.46	5
Neophylax fuscus	0.00	5
Neophylax mitchelli	0.00	5
Neophylax oligius	2.23	5
Neophylax ornatus	1.53	5
Neophylax sp.	2.20	5
Neotrichia collata	---	1
Neotrichia sp.	---	1
Neureclipsis sp.	4.19	3
Nyctiophylax celta	0.69	6
Nyctiophylax moestus	3.31	6
Nyctiophylax nephphilus	0.83	6
Nyctiophylax nr. sp. B (Flint)	0.85	6
Nyctiophylax sp.	0.85	6
Nyctiophylax uncus	---	6
Ochrotrichia sp.	3.95	1
Odontoceridae	---	0
Oecetis avara	---	6
Oecetis cinerascens	---	6
Oecetis georgia	3.00	6
Oecetis inconspicua Complex	---	6
Oecetis morsei/sphyra	---	6
Oecetis nocturna	4.10	6
Oecetis osteni	---	6
Oecetis persimillis	4.70	6
Oecetis scala GR	---	6
Oecetis sp.	4.70	6
"Oecetis Sp. A (Floyd, 95)"	4.70	6

TAXA	TV	FFG
PLECOPTERA cont.		
"Oecetis Sp. E (Floyd, 95)"	4.70	6
"Oecetis Sp. F (Floyd, 95)"	4.70	6
Oligostomis pardalis	1.42	6
Orthotrichia sp.	8.29	1
Oxyethira sp.	2.22	1
Palaeagapetus celsus	---	1
Parapsyche apicalis	---	6
Parapsyche cardis	0.00	6
Parapsyche sp.	---	6
Philopotamidae	---	0
Phylocentropus carolinus	6.20	3
Phylocentropus lucidus	6.20	3
Phylocentropus placidus	6.20	3
Phylocentropus sp.	6.20	3
Phyrganeidae	---	0
Phyryganea sayi	---	2
Platycentropus	---	2
Platycentropus radiatus	---	2
Platycentropus uniformis	---	2
Polycentropodidae	---	0
Polycentropus sp.	3.53	6
Polycentropus/Cernotina	3.53	6
Potamyia flava	---	3
Protoptila sp.	2.55	5
Pseudogoera singularis	---	6
Psilotreta frontalis	0.00	5
Psilotreta labida	0.00	5
Psilotreta sp.	0.00	5
Psychmyiidae	---	0
Psychomyia flavida	2.91	4
Psychomyia nomada	1.97	4
Psychomyia sp.	---	4
Ptilostomis sp.	6.37	2
Pycnopsyche antica	2.50	2
Pycnopsyche antica/guttifer	2.52	2
Pycnopsyche divergens	2.50	2
Pycnopsyche gentilis	0.57	2

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

TAXA	TV	FFG
PLECOPTERA cont.		
Pycnopsyche guttifer	2.58	2
Pycnopsyche lepida	2.68	2
Pycnopsyche luculenta	2.50	2
Pycnopsyche sp.	2.52	2
Rhyacophila acutiloba	0.00	6
Rhyacophila amicus	---	6
Rhyacophila atrata	0.00	6
Rhyacophila banksi	---	6
Rhyacophila carolina	0.00	6
Rhyacophila carpenteri	---	6
Rhyacophila fuscula	1.88	6
Rhyacophila glaberrima	---	6
Rhyacophila invaria	---	6
Rhyacophila ledra	3.86	6
Rhyacophila lobifera	---	6
Rhyacophila manistte	---	6
Rhyacophila melita	0.00	6
Rhyacophila minor	0.00	6
Rhyacophila mycta	---	6
Rhyacophila nigrita	0.00	6
Rhyacophila sp.	---	6
Rhyacophila torva	1.59	6
Rhyacophila vibox	---	6
Rhyacophila vuphipes	0.00	6
Sericostomatidae	---	2
Setodes sp.	0.00	4
Stactobiella sp.	1.29	1
Theliopsyche sp.	---	2
Triaenodes cumberlandensis	4.46	1
Triaenodes ignitus	4.58	1
Triaenodes injusta	2.47	1
Triaenodes marginatus	---	1
Triaenodes melaca	---	1
Triaenodes ochraceus	4.46	1
Triaenodes perna	4.06	1
Triaenodes sp.	4.46	1
Trichoptera	---	0
Wormaldia sp.	0.65	3

TAXA	TV	FFG
Molluska		
Amnicola sp.	5.20	5
Ancylidae	---	0
Campeloma decisum	6.45	4
Campeloma sp.	6.45	4
Corbicula fluminea	6.12	3
Elimia	2.46	5
Ferrissia sp.	6.55	5
Gastropoda	---	0
Gillia altilis	---	5
Goniobasis sp.	---	5
Gyraulus sp.	4.23	5
Helisoma anceps	6.23	5
Hydrobiidae	---	5
Laevapex sp.	7.49	5
Lymnaea sp.	---	4
Menetus dilitatus	8.23	5
Menetus sp.	8.23	5
Pelecypoda	---	3
Physella sp.	8.84	5
Pisidium sp.	6.48	3
Planorbella sp.	6.82	5
Planorbidae	---	5
Pleuroceridae	---	5
Pseudosuccinea columella	7.65	4
Sphaeriidae	---	3
Sphaerium sp.	7.58	3
Unionidae	---	3
Valvata sp.	---	5
Viviparidae	---	5
Viviparus sp.	---	5
Nematoda	4.80	0
Nematomorpha	---	0
Platyhelminthes		
Dugesia sp.	7.50	0
Dugesia tigrina	7.50	0
Planariidae	7.50	0
Turbellaria	---	0

TV= Tolerance Value
FFG= Functional Feeding Groups (1=Herbivore, 2=Shredder, 3=Filter Feeder, 4=Collector, 5=Scraper, 6=Predator, 7=Omnivore, 8=Deposit Feeder)

Appendix 6

Macroinvertebrate QA/QC Logbook Sheet

Macroinvertebrate QA/QC Logbook

Original Taxonomy					QA/QC Taxonomy					
Station	Date Coll	Date ID	Taxonomist	# Taxa	QA/QC Taxonomist	Date	# Taxa	# Taxa/agree	# Taxa/disagree	% Difference

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (BACK)

SUBSAMPLING/SORTING INFORMATION Sorter __________ Date __________	Numbers of grids picked ________ Time expenditure ________ No. of organisms ________ Indicate the presence of large or obviously abundant organisms: **QC:** ☐ YES ☐ NO **QC Checker** __________ # organisms originally sorted [ ] – (# organisms recovered by checker [ ] ÷ # organisms originally sorted [ ]) = % sorting efficiency [ ] ≥90%, sample passes ________ <90%, sample fails, action taken __________
TAXONOMY ID __________ Date __________	Explain TCR ratings of 1-3: Other Comments (e.g. condition of specimens): **QC:** ☐ YES ☐ NO **QC Checker** __________ Organism recognition ☐ pass ☐ fail Verification complete ☐ YES ☐ NO

General Comments (use this space to add additional comments):

Appendix C

Normandeau Associates Inc. Procedure No. EA6

PROCEDURE NO. EA6

REQUEST FOR REVIEW AND APPROVAL OF PROCEDURE NO. EA6 (Rev. 8):

"Identification and Enumeration of Macroinvertebrates"

Reviewed and Approved By:

______________________________ ____________
George M. Christian — Date
Laboratory Supervisor, Stowe

______________________________ ____________
Hanna Proctor — Date
Laboratory Supervisor, Bedford

______________________________ ____________
Robert Hasevlat — Date
QA Manager

______________________________ ____________
Paul L. Harmon — Date
Vice President

NORMANDEAU ASSOCIATES INC.

PROCEDURE NO. EA6
Rev. 8 (March 2009)

IDENTIFICATION AND ENUMERATION OF MACROINVERTEBRATES

Approved By: ______________________________ __________
Paul L. Harmon Date
Vice President

Distributed To: ______________________________

______ Controlled Copy

______ Uncontrolled Copy

REVISION SHEET

Rev. No.	Page	Section or Paragraph
5	Title page updated	
5	3	2.0; 3.1; 4.1; 5.0
5	4	6.7; 6.11; 6.12; 6.17; 7.1; 7.2
5	5	8.4; 11.0
5	Attachments 1 & 2 added	
6	Title page updated	
6	3	2.0; 4.1
6	4	6.11
6	5	11.0
6	Attachment II removed	
7	*Title page updated*	
*7**	*3**	*2.0*
*7**	*3*	*4.1*
*7**	*4*	*6.11*
*7**	*5*	*8.4*
*7**	*5*	*8.5*
*7**	*5*	*8.6*
*7**	*5*	*8.7*
*7**	*5*	*8.8*
*7**	*6*	*10.0*

* *Revised sections are shown in italics.*

IDENTIFICATION AND ENUMERATION OF MACROINVERTEBRATES

1.0 PURPOSE

This procedure is provided to ensure a high level of accuracy and consistency regarding identification and enumeration of macroinvertebrates.

2.0 SCOPE

This procedure is applicable to the identification and enumeration of macroinvertebrates and applies to personnel who identify macroinvertebrates.

3.0 DEFINITIONS

3.1 **Trained personnel** refers to biologists who have acquired experience in macroinvertebrate identification through academic study or training, and have demonstrated the ability to independently make accurate identifications.

3.2 **Taxonomic expert** refers to a recognized authority in identifying macroinvertebrates through description of species and/or publication of keys and other taxonomic literature.

4.0 REFERENCES

4.1 *Corporate Health & Safety document (current revision).*

4.2 USEPA. 1973. Biological field and laboratory methods. EPA-670/4-73-001.

5.0 SAFETY PRECAUTIONS

Observe appropriate laboratory safety precautions given per Reference 4.1. Handle noxious or toxic preservatives, mounting media, and clearing agents per precautions provided in MSDS sheets (e.g., wear personal eye and skin protective gear, and use these materials in well ventilated areas such as outside, under a fume hood, or with other ventilation system). Contact the Invertebrate Section Supervisor for MSDS's and required personal protective gear. **NOTE:** Formalin/formalin products normally are neither required, nor are they to be used in the conduct of this procedure. In the unlikely event formalin is required (client specified) or encountered, contact the Section Supervisor before proceeding with specimen identification and enumeration.

6.0 APPARATUS

The following equipment (or equivalent) as applicable is needed:

6.1 Dissecting microscope with 10-20x oculars and variable magnifications (at least 8-10x), stage micrometer, and ocular micrometer.
6.2 Tensor lamp.
6.3 Compound microscope (1000x and internal light source).
6.4 Forceps.
6.5 Dissecting needles.
6.6 Flat-bottomed Syracuse or petri dishes.

6.7 Preservatives (e.g., isopropanol and ethanol).
6.8 Clear plastic ruler (mm graduations).
6.9 Glass slides.
6.10 Cover slips.
6.11 *Hot plate*.
6.12 Clearing agents for chironomids and oligochaetes (e.g., Amman's lactophenol and 10% potassium hydroxide).
6.13 Euparol for permanent slide mounts.
6.14 Appropriate taxonomic keys.
6.15 Bench/data sheets (see Attachment I for example).
6.16 Mettler balance.
6.17 Air filtration system (e.g., Ecologizer) or hood, and personal protective gear.

7.0 INSTRUCTIONS

7.1 Identification requiring dissecting microscope only.

7.1.1 Pour vialed specimens into a petri or Syracuse dish, and examine with the dissecting microscope.

7.1.2 If necessary, segregate morphologically similar specimens into groups.

7.1.3 If any taxon or group contains too many individuals as to make identification of all of them impractical, randomly subsample each as allowed per study specifications.

7.1.4 Select the proper key and identify the specimen(s) to the lowest practicable taxonomic level (or per client specifications).

7.1.5 Record the identification of each taxon and number of specimens by taxon on the bench sheet. Additional information to be recorded on the bench sheet includes project name, sample location, date, identifying biologist, pertinent sub-sampling information, and applicable taxonomic notes.

7.1.6 Return specimens to the vial and add preservative. **NOTE: If specimens are to be weighed by individual taxon, be sure that each vial contains only one taxon. If necessary, add a label bearing the specimen(s) name.**

7.2 Identification requiring both dissecting and compound microscopes. **NOTE: Chironomid larvae and oligochaetes require special preparation for viewing with a compound microscope. Clear chironomid larvae by placing them in a 10% KOH solution until the head capsule is transparent. Clear oligochaetes in Amman's Lactophenol until the body is translucent. Gentle application of heat will aid the clearing process.**

7.2.1 Follow instructions 7.1.1 through 7.1.4 until key characters become too small to be observed clearly (e.g., mouthparts of Chironomidae spp.).

7.2.2 Using a glass slide, mounting media, and cover slip make a slide mount of the specimen(s) requiring further magnification.

7.2.3 Continue with the appropriate taxonomic key using the compound microscope, and identify the specimen to the lowest practicable level.

7.2.4 Follow instructions 7.1.5 and 7.1.6.

8.0 QUALITY CONTROL

8.1 Macroinvertebrate identification and enumeration shall be conducted only by personnel experienced or trained in appropriate techniques.

8.2 Maintain a reference collection of all taxa (if applicable) identified for a particular study. Taxa will be properly labeled with name, date, location of collection, reference number, life stage, taxonomic reference, and identifying biologist.

8.3 Current taxonomic literature will be used and keys updated as appropriate.

8.4 Interchange of taxonomic opinion among in-house biologists will ensure consistency and agreement in identification. QC checks of identification accuracy will be made by a second biologist who will re-identify 10% of the samples (minimum 1 sample) *from consecutive batches of 10. A sample will be re-identified from those analyzed by each biologist that worked on the project.* Samples selected for QC should represent a majority of the taxa identified for a particular collection. Each taxon from the selected sample will be either verified or rejected by the second identifier. In cases where identification is rejected, each biologist shall compare their respective criteria and attempt to *correct* the identity of the taxon. If this effort fails, the identification shall be moved to *the taxonomic level, where agreement is reached. By selecting QA/QC samples from consecutive batches, corrections made to the first batch can be more easily applied to subsequent ones.*

8.5 A data set is considered sufficiently accurate when 90.0 percent of the original identifications and taxa counts are confirmed by a second biologist. Original gross counts (the sample total) must be within 90 percent of the QA/QC count. If a sample fails either criterion, another (one containing a majority of the taxa) is selected from the same batch of 10 and re-identified. If the second sample passes, corrections can be limited to those taxa that were found to be in error (from both samples). If the second sample fails, all samples from that batch of 10 analyzed by the first biologist need to be re-examined.

8.6 Specimens representing state or federally "endangered", "threatened", or "species of special concern (e.g., freshwater mollusks)" taxa will be sent (as applicable) to taxonomic experts for verification.

8.7 Quality Control results will be logged on the respective Bench Sheets produced from the sample analysis and any taxonomic changes noted. All data tables and narrative reports produced for each study should be checked for transcriptions, spelling, and calculation errors by a second biologist.

8.8 Where project specific protocols provided to Normandeau differ from this in-house procedure, the analyses and Quality Assurance/Quality Control shall be conducted according to client specifications.

9.0 REPORTING

Report the completion of specimen identification as per study specifications.

10.0 RECORDS

Retain the following records in the laboratory per study specifications. In lieu of such, records shall be retained for a period of at least three (3) years following completion of a given study.

- Laboratory Bench sheets and Sample Processing forms (including QC identification records)
- Reference collection
- Copies of reports generated by Section 9.0
- Personnel training records
- *QA/QC log including sample numbers, biologist names, and results (as per study specifications)*

11.0 ATTACHMENTS

I Laboratory Identification Bench Sheet --- (Example, see Project Manager for current revision)

Appendix D

City of North Augusta Drinking Water Lab Turbidity SOP

Turbidity, Nephelometric with 2100AN & 2100N

Turbidity - SM2130B – 2011

SOP #: 313.0

February 5, 2013

City of North Augusta Drinking Water Laboratory

Approved By:

_______________________________________ _______________________
Water Production Supervisor Date

_______________________________________ _______________________
Water Production Superintendent Date

Reviewed By:

Initials:					
Date:					

Initials:					
Date:					

1. Scope:

The HACH 2100AN and 2100N Lab Turbidimeters are microprocessor-based nepholometers with the capability of measuring turbidity from 0 to 10,000 NTU with automatic range selection and decimal point placement. These units also display in units of % Transmittance, Absorbance or Color units. The procedures follow for using the 2100AN and 2100N for turbidity measurement.

2. Equipment and Glassware

HACH 2100AN or 2100N, sample cells (Hach #20849-00), filter assembly (USEPA Method 180.1), silicone oil & cloth, sample container

3. Turbidity Measurement

a. Close the cell cover and press the I/O switch on the back instrument panel to turn power on to the 2100AN or 2100N. Allow the instrument to warm up for 30 minutes before proceeding.

b. Collect a representative sample in a clean container. Fill the sample cell to the line (approximately 30 ml). Handle the sample cell by the top only. Cap the sample cell.

c. Hold the sample cell by the cap and wipe with a clean towel or tissue to remove water spots.

d. Apply a thin bead of silicone oil from the top to the bottom of the cell, just enough to coat the cell with a thin layer of oil. Use the spreading cloth to spread the oil evenly. Then wipe off the excess oil. The cell should be nearly dry with little or no visible oil.

e. Install the USEPA filter module.

f. Place the sample cell in the instrument cell compartment and close the lid.

g. Allow reading to stabilize (about 3 minutes) and record reading.

4. Measurement Hints

a. Always cap the sample cell to prevent spillage of sample into the compartment.

b. Always close the compartment lid during measurement.

c. Use the appropriate Filter Assembly. **The EPA Filter Assembly must be used for all samples requiring DHEC or EPA reporting.**

d. Do not leave the sample cell in the cell compartment for long periods of time.

e. Leave the instrument on 24 hours a day unless extended storage is necessary.

f. Always use clean and scratch-free sample cells.

g. Always apply silicone oil.

5. Cleaning Sample Cells

Cells must be meticulously clean and free from significant scratches. Clean the inside and outside of the cells by washing thoroughly with a non-abrasive laboratory detergent. Then continue cleaning with a 1: 1 HCl bath followed by multiple rinses with distilled or deionized water. Air dry the cells. Handle cells by the top only to minimize dirt and fingerprints.

6. Quality Control/ Quality Assurance

The HACH 2100AN and 2100N are calibrated with primary (Formazin) or StablCal standards) quarterly (within first 15 days of January, April, July and October). Primary calibrations are documented on the Lab Turbidimeter Calibration Record. The turbidimeters are also verified daily with Gelex secondary standards and a 0.50 NTU StablCal Formazin Standard and recorded in the Daily Turbidimeter Check Record. The Gelex standards have their values assigned at the time of calibration with primary standards in order to allow for aging of the Gelex.

Appendix E

City of North Augusta Drinking Water Lab pH SOP

pH, Hydrogen Ion Concentration

pH - SM4500H-B-2011

SOP #: 310.0

February 5, 2013

City of North Augusta Drinking Water Laboratory

Approved By:

_______________________________________ _______________________
Water Production Supervisor Date

_______________________________________ _______________________
Water Production Superintendent Date

Reviewed By:

Initials:					
Date:					

Initials:					
Date:					

1. **Description:**

The Accumet Model AR25 and Model XL25 pH / Ion Meters are state-of-the-art, microprocessor based meters. These Models include dual input channels, providing for the simultaneous analysis and display of two different parameters. In addition to pH and millivolt measurement, the units also perform analyses with ion selective electrodes by direct potentiometry.

Both Models will be used to perform pH and fluoride measurements at this facility. Specific procedures follow for pH analysis. It is assumed that properly functioning electrodes are connected to the Meter prior to conducting a standardization/ measurement series. It must also be noted that these Models require the use of the ATC probe supplied with the meter or an identical one from the manufacturer. No other ATC probe shall be used.

2. **Initial Setup:**

Refer to the instruction manual for the respective meter for detailed procedures for initial instrument assembly, setup, and electrode connections. The following procedures define the steps to perform each analysis. It is assumed the instrument has been properly assembled and setup in accordance with the instrument manual.

3. **Standardization:**

   a. Touch **STD** on the pH measure screen to access the standardize screen.

   b. Touch **CLEAR** to delete any previous standardization. All pH standardization values will be cleared.

   c. Rinse the electrode with distilled water and blot dry with a tissue. Immerse the electrode in a 7.00 pH buffer solution and stir gently. Allow the pH reading to stabilize and touch **STD** again to standardize the meter to the 7.00 buffer.

   d. Using the displayed keypad, input **7.00**, then press **ENTER.** The meter will accept the value once it recognizes the buffer value is stable. At this time, *Stable*, a beaker icon and the entered pH value will appear on the screen. Then the meter will return to the pH Measure screen.

   e. Touch **STD** on the pH measure screen to access the standardize screen.

   f. Rinse the electrodes with distilled water and blot dry with a tissue. Immerse the electrode in a 4.00 pH buffer solution and stir gently. Allow the pH to stabilize.

   g. Using the displayed keypad, input **4.00**, then press **ENTER**. The meter will accept the value once it recognizes the buffer value is stable. At this time, *Stable*, a beaker icon and the entered pH value will appear on the screen. Then the meter will return to the pH Measure screen.

   h. Touch **STD** on the pH measure screen to access the standardize screen.

   i. Rinse the electrodes with distilled water and blot dry with a tissue. Immerse the electrode in a 10.00 pH buffer solution and stir gently. Allow the pH to stabilize.

j. Using the displayed keypad, input **10.00**, then press **ENTER**. The meter will accept the value once it recognizes the buffer value is stable. At this time, *Stable*, a beaker icon and the entered pH value will appear on the screen. Then the meter will return to the pH Measure screen.

k. The slope efficiency value displayed must be recorded in the **pH Meter Calibration Record.**

l. With the electrode immersed in the 10.00 pH buffer solution touch **MEAS** to measure the pH of the 10.00 buffer. *Stable* will appear when the instrument recognizes the measurement is stable. The displayed value must be 10.00 $\pm$ 0.04 pH units. This value also must be recorded in the **pH Meter Calibration Record.**

4. To Measure pH of a Sample:

a. Rinse electrode and blot dry with a tissue.

b. Immerse the electrode into sample and stir gently.

c. Touch **MEAS** to begin measuring the sample.

d. When *Stable* is displayed, the pH value displayed may be recorded.

5. Electrode Storage:

The pH electrodes used for the Accumet 25 and Accumet AR25 must be stored in pH 4.00 buffer at all times.

6. Quality Control:

The Accumet XL25 and AR25 must be standardized with fresh pH buffers at least once per shift. The meter response to the pH 10.00 buffer and the electrode slope value must be recorded on the **pH Meter Calibration Record.**

The ATC probe must be checked monthly against an NIST traceable thermometer and the results recorded on the **Thermometer/ ATC Comparison Record**. In addition, the temperature deviation must be labeled on the XL25 and/or AR25.

Strickland, Tanya

From: Burdick, Nydia <BURDICNF@dhec.sc.gov>
Sent: Monday, June 16, 2014 11:01 AM
To: Strickland, Tanya
Subject: RE: Macro QAPP

I understand. I am in the same situation.

Nydia F. Burdick
Office of Environmental Laboratory Certification
Phone: 803-896-0862
Fax: 803-896-0850

From: Strickland, Tanya <TStrickland@northaugusta.net>
Sent: Monday, June 16, 2014 10:59 AM
To: Burdick, Nydia
Cc: Glover, James
Subject: RE: Macro QAPP

Hi Nydia:

Yes, we may. I have a ton of things that have gotten ahead of that, namely two new general permits that I have including our new MS4 permit that was issued in January. So I have a lot of information that I have to provide by July 1 for that effort. I will get back with that project in mid to late July. So much to do, just one of me.

Thanks,
Tanya
From: Burdick, Nydia [mailto:burdicnf@dhec.sc.gov]
Sent: Monday, June 16, 2014 10:07 AM
To: Strickland, Tanya
Cc: Glover, James
Subject: Re: Macro QAPP

Tonya,
I haven't heard from you in awhile. Are you still pursuing the macroinvertebrate project?

On Fri, Jan 10, 2014 at 3:30 PM, Glover, James <gloverjb@dhec.sc.gov> wrote:

> Tonya,
>
> Nydia suggested I send my comments directly to you. The QAPP is very well done. I included some comments, most of which are technical. I have less experience with QAPP format so if any of my comments conflict with Nydia's you should default to hers. If you have not done so already I would start with Nydia first and then go to mine after. Please let me know if you have questions.
>
> Jim
>
> --

James B. Glover, PhD
Aquatic Biology Section, Manager
SC Department of Health And Environmental Control
2600 Bull Street
Columbia SC 29201
803-898-4081
Gloverjb@dhec.sc.gov

--
Nydia F. Burdick, M.S.
Office of Environmental Laboratory Certification
803-896-0862 Fax 803-896-0850

Waterworks Basin

2013 Macroinvertebrate Study

(Pretty Run Creek, Mims Branch Creek, Waterworks Creek)

Summary

In 2010, SCDHEC presented information in the preliminary 303d listing that Pretty Run impairments will include "macroinvertebrates" as a listed impairment and would then require a TMDL for that impairment in the future. Macroinvertebrate sampling involves a team pulling samples of small aquatic and semi-aquatic insects from the stream over a few days. In some cases, a week of sampling is conducted. The information is then analyzed by species type and abundance to determine if the stream is healthy or impaired. A lack of certain species that should be abundant or a lack of species that are intolerant to pollutants is analyzed. Or an abundance of species that are hardy and withstand pollutant loads and lack of the others is assessed. The result of the sampling is tabulated and a "score" is achieved. That score determines if the stream is healthy or impaired.

The fact that the stream was sampled in the past for macroinvertebrates by the state raised a few questions. When did SCDHEC sample Pretty Run Creek for macroinvertebrates and where is that data and also what were the conditions at that time? We contacted the state and they provided us the information. The macroinvertebrate sampling that the state conducted was in 2004. It was only one sample event. We have provided it here. So in essence, that one sample event could lead to the city is facing another TMDL for Pretty Run Creek. We questioned the state on how or when would the revisit the site since many years had passed. They informed us that their budgets would not allow that at the time. We questioned whether we could sample the stream to verify or refute the status and have the impairment removed from the list. The answer was yes, but only if we could produce certified results by utilizing a certified lab or providing SCDHEC with a Quality Assurance Project Plan (QAPP) for approval. Once we had that, we would be able to certify the results and they would be considered as valid data for review for delisting.

We created a QAPP and it is attached in this section. The QAPP was in its third review by the state for final approval. Prior to final approvals, we ended the project due to the end of the students' internships. The team did a great job putting together the materials and equipment, writing the standard operating procedures, establishing a sampling regime and creating the QAPP.

As for the actual sampling and analysis of data, there is a method and a system to score each sample event in the watershed. The following is an explanation of how that is accomplished and will help you to understand the resulting data for our efforts, and from DHEC's. So here are what the scores mean:

Count: Number of insects collected.

TR: Taxa richness is the number of taxa present in a given area.

EPT Biotic Index: Some macroinvertebrate orders, such as *Diptera* (true flies), are generally tolerant to higher levels of pollutants in streams. Other orders, such as *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), and *Tricoptera* (caddisflies), are very sensitive to many pollutants in the stream environment. EPT can be expressed as a percentage of the sensitive orders (E= *Ephemeroptera*, P= *Plecoptera*, T= *Tricoptera*) to the total taxa found. <u>A large percentage of EPT taxa indicates high water quality</u>. Calculated by the following:

$$\frac{\textbf{Total EPT Taxa}}{\textbf{Total Taxa Found}} \times 100\% = \%\ \textbf{Abundance}$$

BI Biotic Index: The biotic index (BI) is the average pollution tolerance of all organisms collected (based on assigned index values for taxa) and the calculation factors in relative abundances. The index is based on a scale of 0 to 10, with 10 representing the most impaired stream condition.

BI & EPT Scores (in general)

Excellent = 5 Good = 4 Good-Fair = 3 Fair=2 Poor = 1

Upstream vs downstream comparisons: By comparing final bioclassification scores, an assessment can be made. The following represents the levels of impairment and their associated change in bioclassification scores, or difference.

Unimpaired	0.4
Slightly impaired	0.6 – 1.4
Moderately impaired	1.6 – 2.4
Severely impaired	>2.6

Combined Score – overall score (EPT & BI)

Bioclass	**ALU**
Excellent and Good	Fully Supporting
Good-Fair and Fair	Partially Supporting
Poor	Not Supporting

During the process of getting approvals for the QAPP, the staff were training on the procedures and conducted preliminary sampling in the Pretty Run watershed. The results of those events are provided in this section. Samples collected are sorted and species are identified. Then based on numbers of each species, they are ranked either Rare (1-2 individuals), Common (3-9) individuals, or Abundant (>10 individuals). If there are less than 100 total organisms in a sample, the Biotic Index (BI) is not used. Instead, the EPT index is used along with other data to assign a bioclassification. Ecoregions influence macroinvertebrate distribution so different BI and EPT criteria are used based on that information. North Augusta sampled streams are located in the Piedmont ecoregion and that information was used for the data analysis.

Pretty Run Creek:

DHEC DATA Result July 28, 2004 Pretty Run at RS-04544 (Aka NA-PR-01)

Count:	TR:	EPT:	BI:	EPT Score:	BI Score:	Comb. Score:	Bioclass:	ALU
196	29	6	6.41	1.4	3	2.2	F	PS

The city data forward is preliminary and was part of the training process only.

North Augusta Preliminary Result June 24, 2013 Pretty Run at RS-04544 (not certified)

Count:	TR:	EPT:	BI:	EPT Score:	BI Score:	Comb. Score:	Bioclass:	ALU
108	16	5	6.45	1.0	3	2	F	PS

Another sample event farther upstream in Pretty Run was taken off of Socastee Road on July 15, 2013. For that sample event, the count was only 38. Scoring was not done on this sample, due to the small count.

Mims Branch: Macroinvertebrate sampling was also conducted at Mims Branch (a representative stream).

North Augusta Preliminary Result June 17, 2013 NA-MB-03, Mims Branch at Power line (not certified)
For that sample event, the count was only 15. Scoring was not done on this sample, due to the small count.

North Augusta Preliminary Result June 17, 2013 NA-MB-02, Mims Branch crossing by 4x4s (not certified)
For that sample event, the count was only 23. Scoring was not done on this sample, due to the small count.

North Augusta Preliminary Result July 22, 2013 NA-MB-02, Mims Branch crossing by 4x4s (not certified)
For that sample event, the count was only 37. Scoring was not done on this sample, due to the small count.

Finally, we also sampled at **Waterworks Basin** during the training period. Here we had the several legs of the stream sampled. First, upstream we sampled within the NA Community Center by the basketball courts, Second we sampled along Riverside Boulevard at the upper end but just below the foot bridge over the creek. Third we sampled where a repair had been made to the channel in 2011, we called that sample the old season. We also sampled a Forth location downstream from that area where we had repaired the stream channel with matting and boulders earlier in the year (2013) to reduce erosion.

Waterworks Basin: Macroinvertebrate sampling.

North Augusta Preliminary Result May 29, 2013 NA-WW-03A, Waterworks BB Court (not certified)
For that sample event, the count was only 15. Scoring was not done on this sample, due to the small count.

North Augusta Preliminary Result May 29, 2013 NA-WW-04, Waterworks below bridge (not certified)
For that sample event, the count was only 8. Scoring was not done on this sample, due to the small count.

North Augusta Preliminary Result May 29, 2013 NA-WW-OS1, Waterworks Old Season (not certified)

Count:	TR:	EPT:	BI:	EPT Score:	BI Score:	Comb. Score:	Bioclass:	ALU
321	16	3	6.15	1.0	3	2	F	PS

North Augusta Preliminary Result May 29, 2013 NA-WW-NS1, Waterworks New Season (not certified)

Count:	TR:	EPT:	BI:	EPT Score:	BI Score:	Comb. Score:	Bioclass:	ALU
122	8	2	5.38	1.0	5	3	G-F	PS

Benthic Macroinvertebrate Sample Log-in Sheet

Date Collected	Callected By	Number of Containers	Preservation	Station Number	Stream Name and Location	Date Received by Lab	Lot Number	Date of Completion: Sorting	Date of Completion: Mounting	Date of Completion: Identification
5/29/2013	Baker/Tran	1	91% EtOH	N/A	Riverside Blvd -- Basketball Courts	5/29/2013	N/A	5/30/2013	5/30/2013	6/20/2013
5/29/2013	Baker/Tran	1	91% EtOH	N/A	Riverside Blvd -- Below Bridge	5/29/2013	N/A	5/30/2013	5/30/2013	6/20/2013
5/29/2013	Baker/Tran	1	91% EtOH	N/A	Riverside Blvd -- New Season (2013)	5/29/2013	N/A	5/31/2013	5/31/2013	7/9/2013
5/30/2013	Baker/Tran	1	91% EtOH	N/A	Riverside Blvd -- Old Season (2011)	5/30/2013	N/A	5/31/2013	5/31/2013	7/9/2013

Stream name: Riverside Blvd.
Location: Basketball Courts
River Basin: Waterworks Basin
Collected by: A. Baker and C. Tran
Date Collected: 5/29/13
Taxonomist: Tran
Dates Identified: 6/4/13, 6/20/13

Phylum	Class	Order	Organism Family	Subfamily	Genspec	Number	Life Stage	Taxonimist Initials	TCR	TV	FFG	AV	TV		
Arthropoda	Hexapoda	Diptera	Sumliidae	N/A	Simulium sp.	8	Immature	CT	1	4.4 (epa)	3	3	4.4	13.2	
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Ablabesmyia sp.	2	Immature	CT	2	7.2	6	1	7.2	7.2	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Polypedilum flavum	1	Immature	CT	2	4.93	4	1	4.93	4.93	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Tanytarsus sp.	3	Immature	CT	2	6.76	7	3	6.76	20.28	
Arthropoda	Hexapoda	Diptera	Chironomidae	Orthocladiinae	Thienemanniella sp.	1	Immature	CT	2	6	6	1	6	6	
						15						9		51.61	5.734444

Stream name: Riverside Blvd.
Location: Below Bridge
River Basin: Waterworks Basin
Collected by: A. Baker and C. Tran
Date Collected: 5/29/13
Taxonomist: Tran
Dates Identified: 6/10/13, 6/20/13

		Organism											
Phylum	**Class**	**Order**	**Family**	**Subfamily**	**Genspec**	**Number**	**Life Stage**	**Taxonomist Initials**	**TCR**	**TV**	**FFG**	**AV**	**TV**
Arthropoda	Hexapoda	Diptera	Simuliidae		Simulium sp.	1	Immature	CT	1	4.4 (epa)	3	1	4.4
Annelida	Oligochaeta	N/A	N/A	N/A	Oligochaeta	7	Adult	CT	1	-	7		
						8							

Stream name: Riverside Blvd.
Location: Old Season (2011)
River Basin: Waterworks Basin
Collected by: A. Baker and C. Tran
Date Collected: 5/30/13
Taxonomist: A. Baker and C. Tran
Dates Identified: 6/5/13, 6/6/13, 6/7/13, 6/10/13, 6/21/13, 6/27/13, 6/28/13, 7/9/13

Phylum	Class	Order	Organism Family	Subfamily	Genspec	Number	Life Stage	Taxonomist Initials	TCR	TV	FFG	AV	TV		
Arthropoda	Hexapoda	Trichoptera	Hydropsychidae	N/A	Hydropsyche sp.	83	Immature	CT & AB	2	-	3		-		
Arthropoda	Hexapoda	Trichoptera	Hydropsychidae	N/A	Ceratopsyche sp.	2	Immature	CT	2	-	1		-		
Arthropoda	Hexapoda	Diptera	Simuliidae	N/A	Simulium sp.	172	Immature	CT	1	4.4 (epa)	3	10	4.4	44	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Chironomus sp.	2	Pupa	CT	2	9.63	4	1	9.63	9.63	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Chironomus sp.	3	Immature	CT	3	9.63	4	3	9.63	28.89	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Tribelos fuscicorne	1	Immature	CT	3	6.31	1	1	6.31	6.31	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Polypedilum flavum	5	Immature	CT	3	-	4		-		
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Cladotanytarsus sp.	1	Immature	CT	3	-	4		-		
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Cryptochironomous sp.	1	Immature	CT	3	6.4	6	1	6.4	6.4	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Pseudochironomous sp.	1	Immature	CT	3	5.36	4	1	5.36	5.36	
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Thienemannimyia GR	2	Pupa	CT	2	8.7 (epa)	6	1	8.7	8.7	
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Thienemannimyia GR	1	Immature	CT	3	8.7 (epa)	6	1	8.7	8.7	
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Ablabesmyia sp.	11	Immature	CT	3	7.2	6	10	7.2	72	
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Pentaneura inconspicua	4	Immature	CT	3	4.7	6	3	4.7	14.1	
Mollusca	Gastropoda	Basommatophora	Physidae	N/A	Physa sp.	1	Adult	CT	2	-	5		-		
Arthropoda	Hexapoda	Ephemeroptera	Baetidae	N/A	Baetis sp.	31	Immature	CT	4	5.4	4	10	5.4	54	
						321						42		258.09	6.145

Date Samplec	Station	Count	TR	EPT	BI	EPT Score	BI Score	Comb. Score	Bioclass	ALU
5/30/2013	Old Season	321	16	3	6.15	1	3	2	F	PS

Stream name: Riverside Blvd.
Location: New Season (2013)
River Basin: Waterworks Basin
Collected by: A. Baker and C. Tran
Date Collected: 5/29/13
Taxonomist: A. Baker and C. Tran
Dates Identified: 6/7/13, 6/10/13, 6/11/13, 6/12/13, 6/13/13, 6/28/13, 7/9/13

Phylum	Class	Order	Organism Family	Subfamily	Genspec	Number	Life Stage	Taxonomist Initials	TCR	TV	FFG	AV	TV		
Annelida	Oligochaeta	N/A	N/A	N/A	Oligochaeta	2	Juvenile	CT	2	-	7		-		
Arthropoda	Hexapoda	Trichoptera	Hydropsychidae	N/A	Hydropsyche sp.	24	Immature	CT	2	-	3		-		
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Thienemannimyia GR	2	Pupa	AB	3	-	6		-		
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Thienemannimyia GR	6	Immature	CT	3	-	6		-		
Arthropoda	Hexapoda	Diptera	Chironomidae	Tanypodinae	Ablabesmyia sp.	4	Immature	CT	3	7.2	6	3	7.2	21.6	
Arthropoda	Hexapoda	Diptera	Chironomidae	Chironominae	Chironomus sp.	1	Immature	CT	3	9.63	4	1	9.63	9.63	
Arthropoda	Hexapoda	Diptera	Simuliidae	N/A	Simulium sp.	49	Immature	CT	1	4.4 (epa)	3	10	4.4	44	
Arthropoda	Hexapoda	Ephemeroptera	Baetidae	N/A	Baetis sp.	34	Immature	CT	4	5.4	4	10	5.4	54	
						122						24		129.23	5.384583

Date Sampled	Station	Count	TR	EPT	BI	EPT Score	BI Score	Comb. Score	Bioclass	ALU
5/29/2013	New Season	122	8	2	5.38	1	5	3	G-F	PS

Date Sampled	Station	Count	TR	EPT	BI	EPT Score	BI Score	Comb. Score	Bioclass	ALU
5/29/2013	New construction (new season)	122	8	2	5.38	1	5	3	G-F	PS

Date Sampled	Station	Count	TR	EPT	BI	EPT Score	BI Score	Comb. Score	Bioclass	ALU
5/30/2013	Old Season (repaired original study area)	321	16	3	6.15	1	3	2	F	PS

Chronic Toxicity Tests on Runoff from a North Augusta Watershed

UNIVERSITY OF SOUTH CAROLINA AIKEN

Brandon Hall and S. Michele Harmon, PhD — Department of Biology and Geology,
The University of South Carolina-Aiken, Aiken, South Carolina 29801

Abstract

This project assessed the extent of nonpoint source pollution in water samples collected from a wetland area located in North Augusta, SC, by performing chronic toxicity tests using *Ceriodaphnia dubia*. Nonpoint sources of water pollution are those that cannot be traced to any single, specific point of discharge. Examples of nonpoint source pollution include: oil and gasoline, fertilizers, and pesticides. The watershed of interest feeds into the Savannah River and includes a large commercial area, several housing developments, and a large wetland associated with the River Club golf course located in the floodplain. The stream was sampled both upstream and downstream of the golf course, in fair weather and during a rainstorm, to determine if the levels of pollutants in the water were toxic to aquatic organisms. The chronic toxicity tests involved exposing *Ceriodaphnia dubia* to water collected from the wetland for one full week and subsequent examination of their mortality and reproductive rates. There were three fair-weather tests and one rainstorm event test. Anion analysis was also conducted via ion chromatography to quantify the amounts of nutrients present. The samples were also measured for pH and dissolved oxygen. Results of the fair-weather tests suggest that the golf course wetland filters and removes harmful nonpoint source pollutants from the runoff feeding into the Savannah River. Data from rain samples indicate that the wetland may not be as effective during periods of heavy rain.

Introduction

Sources of water pollution that cannot be traced to any single, specific point of discharge are classified as nonpoint sources of pollution[1]. The types of pollutants found in nonpoint source water pollution include: gasoline and petroleum wastes from city streets, inorganic fertilizers used on agricultural farms and golf courses, pesticides, manure, salts from water used for irrigation, and chemicals from livestock feedlots[1].

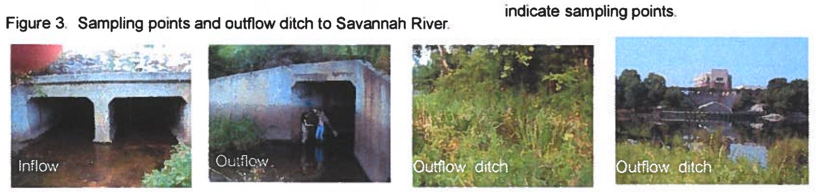
Figure 1. Potential sources of nonpoint source pollution include lawns, golf courses, roads and parking lots.

This project assessed the effect of nonpoint source pollution in water collected from a wetland area located in North Augusta, SC, by performing chronic toxicity tests using *Ceriodaphia dubia*. Samples were collected during fair weather and after a rain event.

The wetland of interest (Figure 2) is located in the Savannah River Floodplain, and is fed by a small stream that runs through a large commercial area, several housing developments, and the River Club golf course[2]. This stream collects large volumes of runoff from these areas during rain events. Samples were collected as the stream flowed into the golf course and as it flowed from the golf course into the river (Figure 3).

Figure 2. Arial view of the golf course and associated wetland. Yellow "X"s indicate sampling points.

Figure 3. Sampling points and outflow ditch to Savannah River.



Methods

Standard three-brood chronic toxicity tests were performed using *Ceriodaphnia dubia* (Figure 4) following methods prescribed by the ASTM[3] and US EPA[4].

Figure 4. *Ceriodaphnia dubia*, a common aquatic toxicity indicator species.

C. dubia neonates (< 24 hours old) from in-house cultures were exposed to a laboratory control and the upstream and downstream samples. Twenty replicates, each containing one neonate, were prepared for each concentration; replicates consisted of 30-ml vials containing 20 ml of test solution (Figure 5). Moderately hard reconstituted water[4] served as the control solution for these tests. Test solutions were renewed daily, and test organisms were fed at a rate of 250 µl feeding solution/replicate/day (Figure 6).

Tests were conducted in an environmental chamber under controlled photoperiod (16:8 LD) at 23 ± 2°C. Mortality and reproductive rates of the test organisms were analyzed and compared to a laboratory control group. Three samples were collected during fair-weather conditions and one sample collected during a rainstorm event. Samples were also analyzed for nutrients and basic water quality parameters (dissolved oxygen and pH).

Figure 5. Replicate exposures. Each vial contains one individual.

Basic Experimental Design:

- **3 "treatments": control, upstream, downstream**
- 20 test subjects per treatment
- 20 ml aliquots for each test subject
- 7-day exposure period
- Endpoint: reproductive effects
- 4 separate tests: three during dry weather and one immediately after large rainfall event

Figure 6. Feeding test organisms.

Results

Anion analyses indicate that that the wetland reduces the concentration of nitrate (probably from fertilizers) in the stream as it runs through toward the Savannah River (Figure 7). This was true for samples taken during fair weather and immediately after a large storm event.

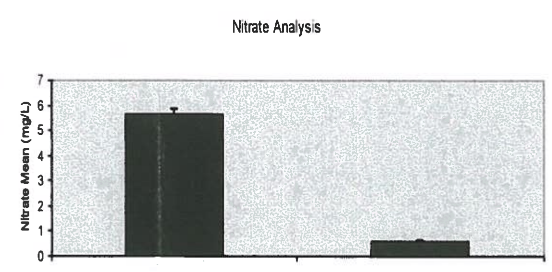


Figure 7. Nitrate concentrations of the samples. The graph is presented as a mean concentration of all samples taken upstream and downstream of the wetland.

The results of chronic 3-brood toxicity tests with *C. dubia* indicated no significant differences in reproduction between samples collected both upstream and downstream of the golf course wetland (Figure 8). There was, however, a difference between the laboratory control and the samples that were taken immediately after a heavy rain event (Figure 8). Data from rain samples indicate that the wetland may not be as effective at toxicant removal during periods of heavy rain. It is of significance to point out that samples taken for Test 3 were taken subsequent to a major weekend storm. Therefore, data from week 3 are representative of storm conditions.

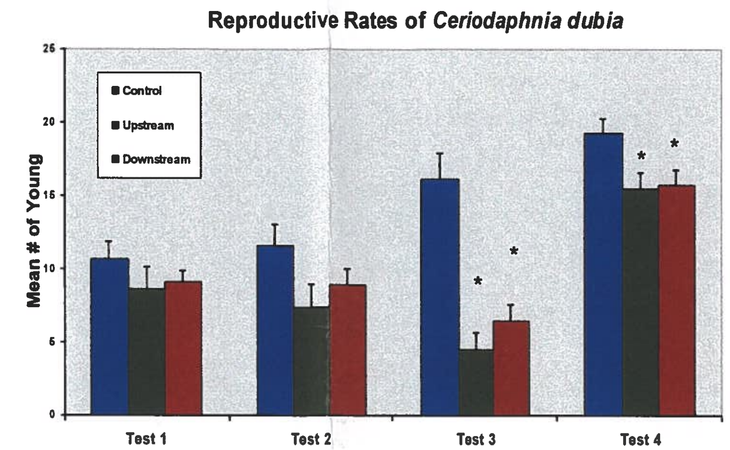


Figure 8. Results of chronic toxicity tests with *C. dubia*. Tests 1, 2 and 4 were conducted with samples taken during dry periods. Test 3 was conducted with samples taken after a major rain event. Asterisks indicate statistical significance.

Conclusions

While this wetland was preserved to add an aesthetic element to the golf course, it also provides a natural filtering system for the water that flows through on its way to the Savannah River. Results from chronic *C. dubia* tests initially indicate that the River Club golf course wetland successfully filters out harmful nonpoint source runoff pollution during fair weather. However, during rainstorm events, there seems to be a **"short circuit"** of the system owing to the sudden rush of stormwater feeding into the wetland. The wetland is unable to effectively remove nonpoint source runoff pollution from these surges of water as they flow into river. Possible solutions to this problem could be a re-routing of the system, or the construction of a detention pond to slow the movement of runoff through the wetland.

Literature cited

1. Miller, G Tyler. Living in the Environment: Principles, Connections, and Solutions, 12th ed. Belmont, CA: Thomas Learning, Inc.; 2002. 758 p.
2. Watersheds, Basins, Streams, Creeks, Rivers & Ponds. [Internet]. North Augusta, SC: North Augusta Stormwater Management Department.; c2006 [cited 2007 Mar 14]. Available from http://www.northaugusta.net/Dept_Serv/Engin_PublicWorks/stormwater/naturalnew.htm
3. ASTM 1993. Standard Guide for Conducting Three-Brood, Renewal Toxicity Tests with Ceriodaphnia dubia. ASTM Standards on Aquatic Toxicology and Hazard Evaluation. Designation E-1295-89. American Society for Testing and Materials, Philadelphia, PA
4. EPA 2002. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Fourth Edition. EPA-821-R-02-013. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Acknowledgments

This work was funded by USC Aiken and the City of North Augusta, SC. Special thanks to Erin Jones, Tanya Strickland, and David Caddell of the City of North Augusta, and to Dr. Gary Mills of Savannah River Ecology Laboratory.

Crystal Lake Basin

Hammonds Ferry Constructed Wetland Design

Southeastern Natural Sciences Academy

April 18, 2007

Introduction

We are pleased to present the Hammonds Ferry Wetland Design (Figure 1). This design allows a functional wetland to be constructed with minimal clearing and filling of the existing ponds and surrounding area. The wetland will treat stormwater runoff, provide wildlife habitat, and contribute to the aesthetics of the development. The wetland will be constructed in the small pond closest to the Georgia Avenue Bridge and will be approximately 1.5 acres. Upon completion the wetland will be planted with a suite of wetland plant species adapted to a range of hydrologic conditions.

Existing depressions

The wetland will receive the majority of its influent from the existing area consisting of numerous interconnected depressions (Figure 2). This area currently receives stormwater runoff from most of the area surrounding lower Georgia Avenue and the bridge. In addition it will also receive inflows from the proposed Municipal Complex. During times of intense rainfall the velocity of water from this stormwater pipe can be quite high (Figure 3). However, the existing depressions facilitate slowing and storage of stormwater which is then distributed to the larger ponds. Therefore, we feel that it is best to leave this area intact. However, the depressions area collects significant amounts of trash and woody debris. Thus we suggest it be thoroughly cleaned of trash and debris. We also suggest the installation of stormwater trash traps to help prevent the deposition of additional trash.

Constructed wetland

We propose that three wetland influent weir boxes be installed to facilitate flow from the depressions area into the constructed wetland (Figure 1). Based on water level data collected over the past few months we suggest that "full pool" of the wetland be 126 feet above mean sea level (AMSL) (Figure 4). To minimize flooding during periods of intense precipitation we suggest that an emergency overflow to the river be constructed at an elevation of 128 feet AMSL. This will allow an additional two feet of water level rise above full pool which greatly increases the stormwater storage capacity. Brief periods of increased water level in the constructed wetland should not negatively impact the wetland.

Based on full pool of 126 AMSL we propose to create a shallow vegetated wetland by filling the existing pond and creating a bottom gradient elevation going from 126 to 123 feet AMSL with the shallow end on the Georgia Avenue side (Figure 1). The wetland will consist of three planting zones with water depths ranging from zero to three feet. Within each zone, wetland vegetation adapted to the water depths associated with each zone will be planted and/or seeded (Table 1). Beyond the third planting zone will be an area of open water approximately 10 to 12 feet wide. In this open area the bottom elevation will drop to approximately 119-120 feet AMSL.

We propose that three wetland effluent weir boxes or stop logs be installed on the narrow land bridge to allow water to freely flow into the adjacent open water pond. This design allows us to adjust the weir plates to hold water in the wetland during periods of drought. Alternatively, weirs could be installed on the proposed SCDOT Central Avenue Bridge. However, the ability to independently manage the wetland water level would be lost.

Additional suggestions

Further development will increase runoff from impervious surfaces. Thus, we suggest connecting East Pond and West Pond with a culvert through the existing land bridge. The water level data show that West Pond is approximately one foot lower than East Pond (Figure 4). Connecting the two ponds will slightly lower the water level in East Pond, but will significantly increase the overall stormwater storage capacity of the system.

We suggest constructing two waterfalls in the wetland complex (Figure 1). The waterfalls will greatly improve the aesthetics of the area, aerate the water, and serve as overflow during periods of high water. The first waterfall will be in the corner of the perched wetland near the large beaver dam and will flow into the open water pond (Figures 1 and 5). We suggest the elevation of this waterfall be approximately 1 foot higher than the elevation of the second proposed waterfall. This will allow flow over the second waterfall during normal flow conditions and flow over the first waterfall during times of high flows. Such a scenario will allow water to flow through the constructed wetland during most flow scenarios and will decrease the impact of high flows on the constructed wetland.

The second waterfall will flow from the small stream that currently flows from the North Augusta Greenway to the perched wetland, and into the depressions area (Figures 1 and 6). We propose rerouting this stream so that it is diverted to the waterfall instead of the perched wetland. The perched wetland will receive stormwater runoff from the proposed Central Avenue and Municipal Complex and should remain wet under normal conditions.

We propose the construction of an extension to the North Augusta Greenway that would provide access to the wetland complex. The extension would consist of a walking trail, boardwalk, and small bridge. It would loop from the small road adjacent to the Georgia Avenue

Bridge over the constructed wetland and into the flat area just below the perched wetland, then over the waterfall and back to the Greenway.

Finally, throughout the wetland design phase of this project we compiled ancillary data pertaining to the constructed wetlands and adjacent ponds. The first set of data collected was a list of fauna species observed throughout the initial design phase (Appendix A). It should be noted that this list resulted from a casual assessment and by no means constitutes a complete qualitative or quantitative species list. The second data set is a synoptic survey of sediment and water column chemistries taken within the proposed constructed wetland pond (Appendix B).

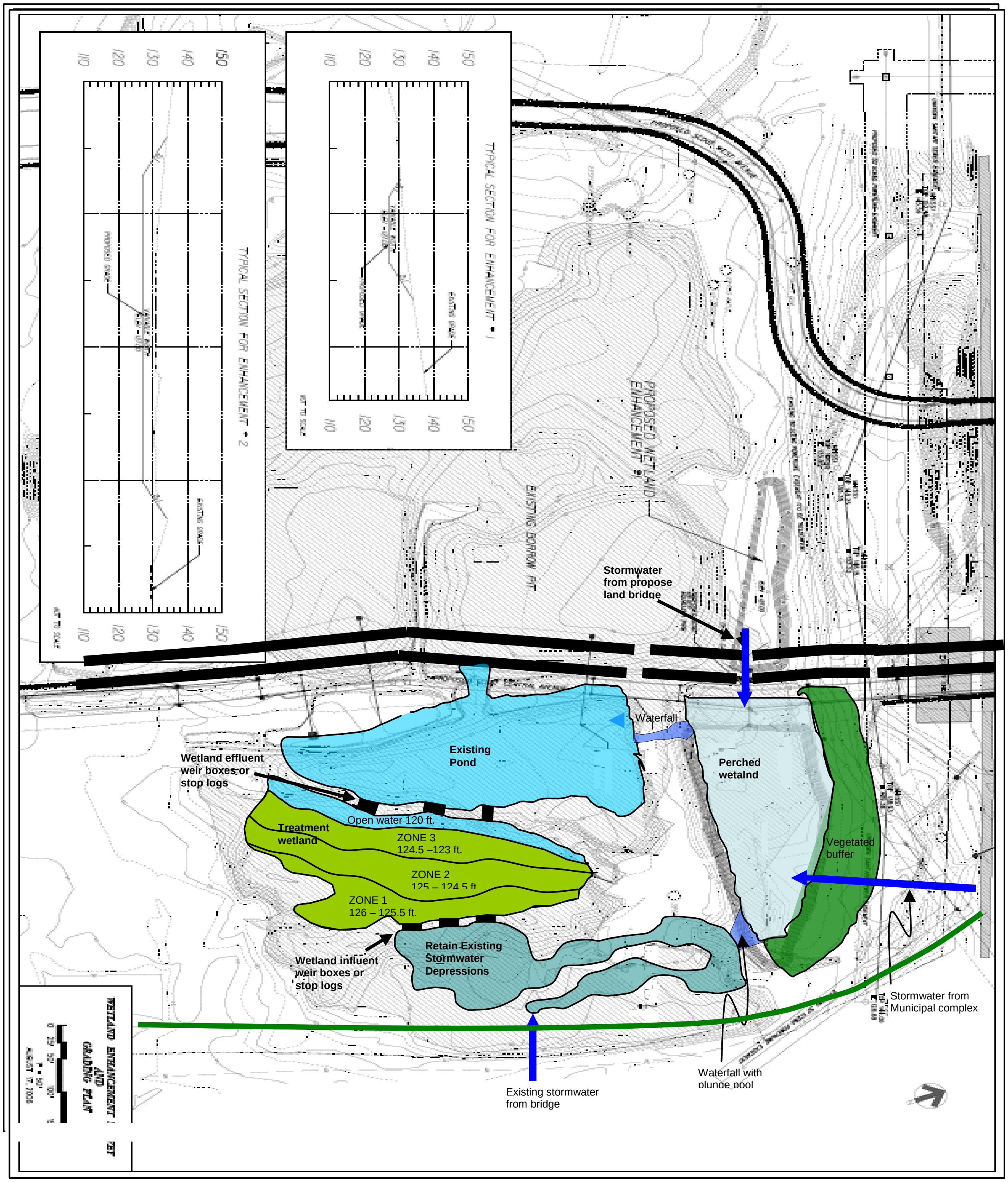


Figure 1. Conceptual wetland design.

Figure 2. Interconnected depression area serves to diminish stormwater velocity and feed wetland.

Figure 3. Velocity of stormwater from Georgia Avenue Bridge during heavy rain.

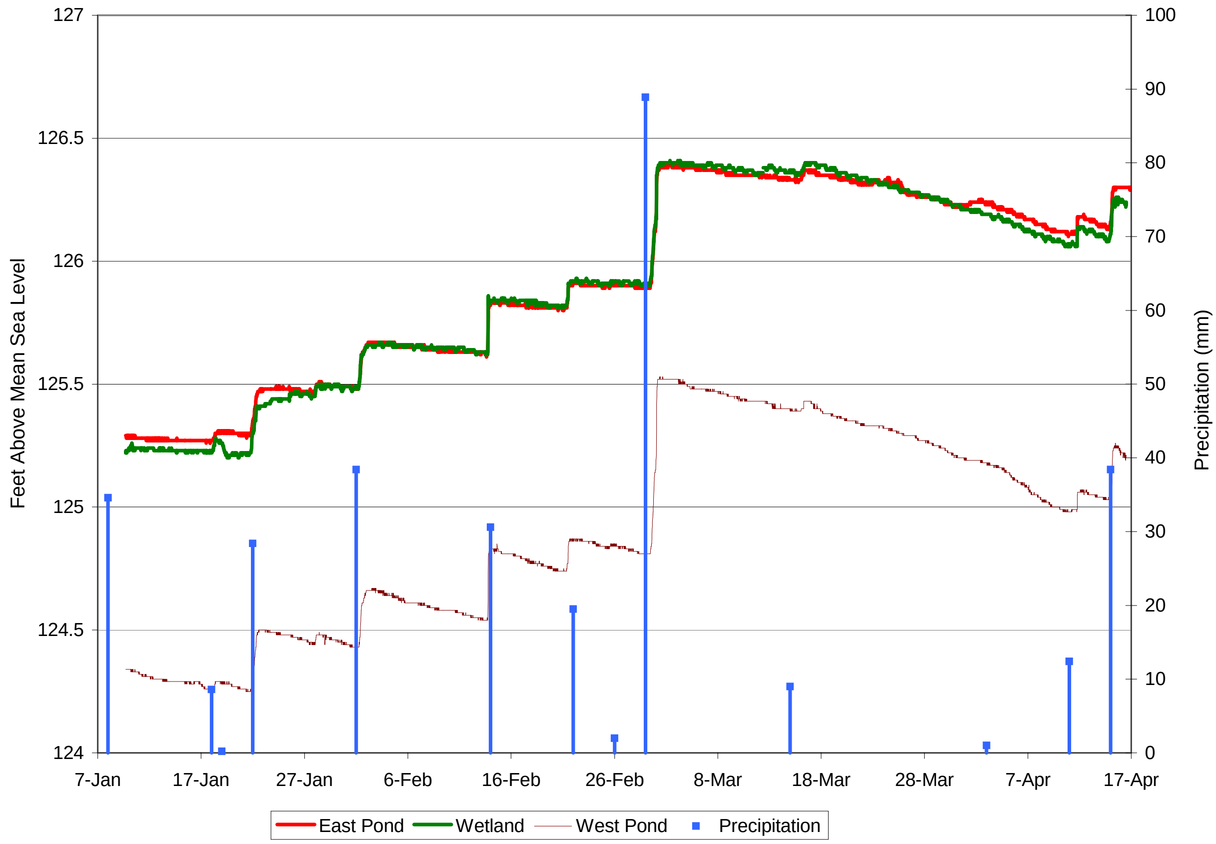


Figure 4. Water level elevation and precipitation at Hammonds Ferry wetland, East Pond, and West Pond.

Figure 5. Conceptual waterfall flowing from perched wetland to open water pond.

Biological Survey of Amphibians and Reptiles at Brick Pond Park

Kelley A. Jonske, April Martin, Department of Biology
Dr. Bran Cromer, Assistant Professor, Department of Biology

Amphibians and reptiles are an integral part of ecosystems along the Savannah River. A biological survey of the newly constructed Brick Pond Park in North Augusta, South Carolina was conducted to determine the diversity of the amphibious and reptilian species present. The nine-month study was conducted using various passive capture techniques such as; drift fences with pitfall traps, cover boards, and baited hoop nets (turtle traps). Some active capture techniques were employed as well, such as netting and hand-catching. Along with the biological survey, an efficacy study was conducted to determine which capture methods were most effective. Each specimen was identified, measurements recorded, and then released. Data was compiled as to which species were present and which method of capture was used for each. The species collected are consistent with a typical piedmont forest ecoregion.

Analysis of Turtle Population Characteristics at Brick Park Pond

Wuraola Animashaun, Department of Biology
Veneita Colclough, Department of Biology

Faculty Representative: Brandon Cromer, Ph.D, Department of Biology

The study involved data collection on species of freshwater turtles at Brick Pond Park in North Augusta, SC. The purpose of this study was to evaluate population demographics (population size, sex ratio, body size, and home range) of freshwater turtles. The techniques employed included: turtle trapping, weighing, tagging and radio tracking. Trapping occurred during the fall of 2009 using three hoop traps baited with sardines. The length and width of each turtle was measured to calculate the turtles' size; the gender of each turtle was also recorded. The size and weight of each turtle was then compared on a basis of species and gender. All turtles were immediately released at the site of capture. The turtles were then classified based on gender and species along with the average calculations of weight and size. A T-test was done to compare the size of the female turtles to the male turtles. Four turtles were tagged and their movements were monitored from August to mid December 2009. The movements may be correlated to the availability of food and the diversity of predators. Samples were collected from the turtle scutes and claws; future research will involve mercury analysis of turtles inhabiting Brick Park Pond. (Word count: 200)

Analysis of Turtle Population Characteristics at Brick Park Pond

Wuraola Animashaun, Department of Biology
Veneita Colclough, Department of Biology

Faculty Representative: Brandon Cromer, Ph.D, Department of Biology

The study involved data collection on species of freshwater turtles at Brick Pond Park in North Augusta, SC. The purpose of this study was to evaluate population demographics (population size, sex ratio, body size, and home range) of freshwater turtles. The techniques employed included: turtle trapping, weighing, tagging and radio tracking. Trapping occurred during the fall of 2009 using three hoop traps baited with sardines. The length and width of each turtle was measured to calculate the turtles' size; the gender of each turtle was also recorded. The size and weight of each turtle was then compared on a basis of species and gender. All turtles were immediately released at the site of capture. The turtles were then classified based on gender and species along with the average calculations of weight and size. A T-test was done to compare the size of the female turtles to the male turtles. Four turtles were tagged and their movements were monitored from August to mid December 2009. The movements may be correlated to the availability of food and the diversity of predators. Samples were collected from the turtle scutes and claws; future research will involve mercury analysis of turtles inhabiting Brick Park Pond. (Word count: 200)

PRECONSTRUCTION CHEMISTRY REPORT OF THE HAMMOND'S FERRY CONSTRUCTED WETLAND RESTORATION SITE IN NORTH AUGUSTA, SC

Conducted for the City of North Augusta, SC
by

Sarah Michele Harmon, PhD

October 2007

INTRODUCTION

The purpose of this report was to present a baseline of water quality and overall conditions in the area proposed for restoration through a conservation grant from the National Fish and Wildlife Foundation. Two sampling events occurred prior to construction: an initial waster and sediment sample taken in December 2006, and a more comprehensive water sample set taken in April 2007.

The area slated for restoration encompasses approximately 30 acres and is a former industrial site used for mining of clay and production of bricks. Clay mining activities left behind a series of small pools and quarry ponds that filled with water shortly after mining was complete in the 1930s and remain filled to this day. This site is located within the city limits of North Augusta, SC, in the floodplain adjacent to the Savannah River. The area immediately surrounding this site is being developed for mixed commercial and residential purposes. The former brick quarry that is to be restored is featured in Figure 1 along with some of the dominant features of this property.

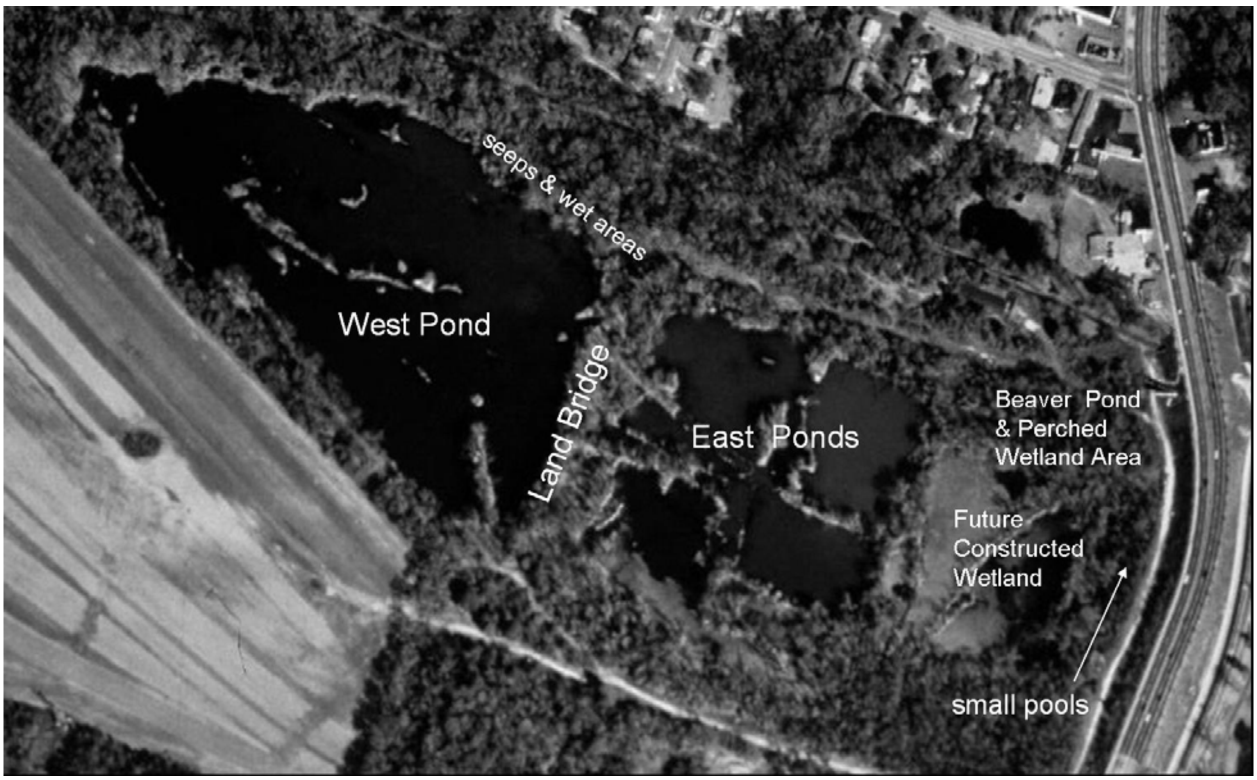
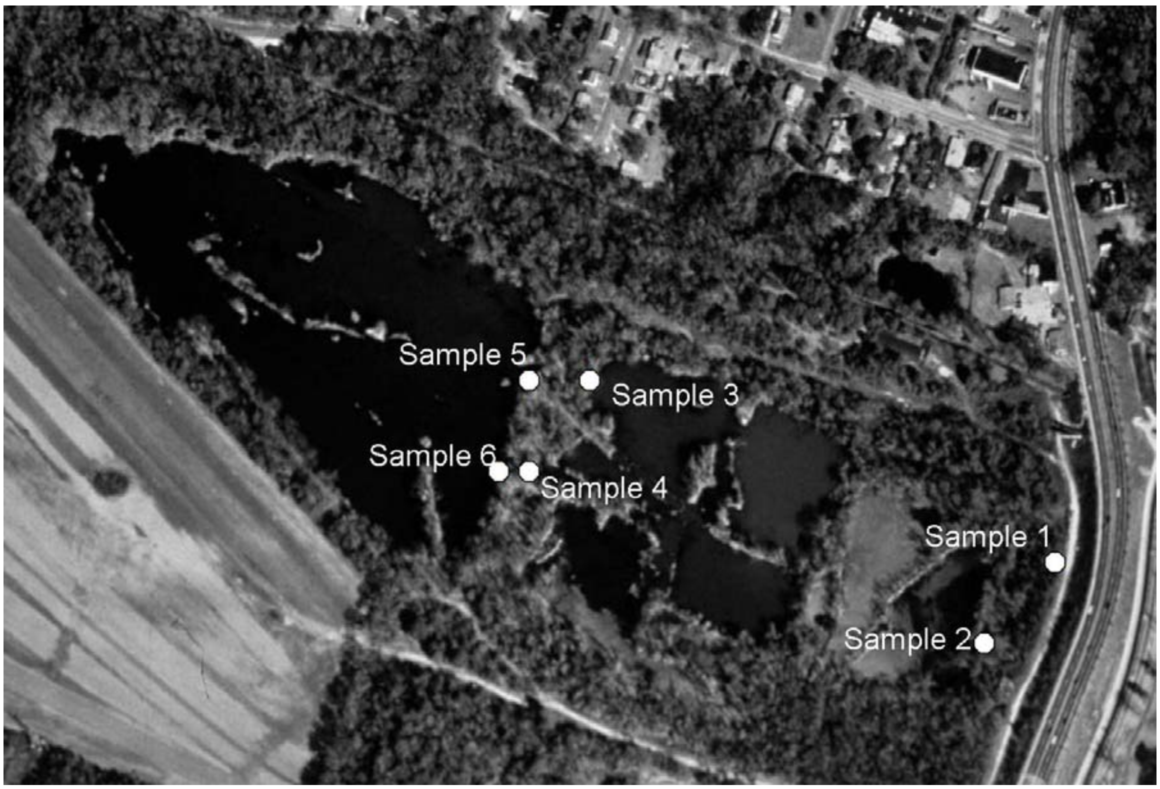


Figure 1. Aerial photograph of the area to be restored. The December 2006 chemistry sampling was conducted in the area labeled "Future Constructed Wetland."

METHODS

The initial sample set was taken in December 2006 from the area labeled "Future Constructed Wetland" featured in Figure 1 above. This sampling consisted of one aquatic grab sample and one sediment sample. The second series of preconstuction samples were taken April 2, 2007, from sampling locations noted in Figure 2. The April samples consisted of aquatic grab samples from each location. Both December 2006 and April 2007 sampling was conducted during clear weather. Sample containers with appropriate preservatives were provided by Shealy Environmental Services, Inc., Columbia, SC.



Water quality parameters (dissolved oxygen, pH, and temperature) were recorded at the time of sampling in April 2007. Dissolved oxygen and temperature were measured with a YSI Ecosense DO200 meter (Yellow Springs Instrument Company, Yellow Springs, OH); pH was measured with an Oakton Model 30 pH tester (Oakton Instruments, Vernon Hills, IL).

Analytical samples were preserved and shipped on ice to Shealy Environmental Services, Inc., Columbia, SC. All samples were analyzed within acceptable holding times. Standard trip and temperature blanks were included. A complete list of analytical methods is presented in Appendix 1.

RESULTS

Water Quality

The December 2006 sample included all basic inorganic water quality parameters listed in Table 1. Samples collected in April 2007 included only ammonia, 5-day BOD, phosphorus, and TKN. Dissolved oxygen ranged from 1.0 to 7.8 mg/L. Samples from locations 1-4 were below the standard 4.0 mg/L recommended by the state of South Carolina for freshwater (SC DHEC 2004). Biological oxygen demand (BOD) ranged from 2.2 to 13 mg/L. While there are no specific water quality criteria that pertain to BOD, values greater than 6 are usually indicative of a high organic load. Field-measured pH values ranged from 6.06 to 7.16, and all were within acceptable SC DHEC guidelines for a healthy freshwater system.

Table 1. Summary of water quality analyses conducted during December 2006 and April 2007. Blank spaces indicate that analyses were not conducted on a particular sample.

Parameter (mg/L)	December 2006	April 2007 Sample 1	April 2007 Sample 2	April 2007 Sample 3	April 2007 Sample 4	April 2007 Sample 5	April 2007 Sample 6
Alkalinity	17						
5-day BOD	2.2	6.2	2.6	13	4.1	2.9	2.2
5-day Carbonaceous BOD	2.0						
Chloride	3.7						
COD	46						
Dissolved chloride	4.8						
Dissolved ammonia N	<0.10	0.59	0.33	0.47	0.25	0.29	0.11
Dissolved nitrate-nitrite N	0.10						
Dissolved nitrite N	0.0076						
Dissolved oxygen[1]		3.5	1.0	1.5	1.5	5.8	7.8
Dissolved sulfate	1.2						
DOC	10						
Ortho-phosphorus	0.010						
Phosphorus	0.054	0.27	0.10	0.19	0.11	0.041	0.036
Sulfate	1.8						
TDS	31						
TIC	2.8						
TKN	0.49	2.6	1.2	2.6	1.3	0.69	0.98
TOC	7.6						
TSS	7.2						
TVSS	5.9						
pH[1] (no unit)		6.46	6.06	6.43	6.28	6.85	7.16

[1]Parameters measured in the field at the time of sample collection. Field temperatures for the April 2007 samples ranged from 17.8°C -23.1°C.

Water samples from December 2006 and April 2007 were also analyzed for metals and a number of organic contaminants including herbicides, PCBs, organochloine pesticides and volatile organic compounds (Table 2 and Appendix 2). Metals of concern that were detected in at least one sample over the two sampling periods included chromium, copper, lead, and zinc. While they were detected, all of these potential aquatic contaminants were at concentrations well below water quality limits set by the USEPA for freshwater (USEPA 2002). Other metals, such as iron, manganese, or sodium, were above detection, but are of no environmental concern because they are generally considered essential metals that are nontoxic in the environment at these concentrations. For organic compounds, there were only two positive detections: chloroform was detected at sample location 2, and toluene was detected at sample location 3. There are no water quality limits for either of these volatile organic compounds; however, both were detected in concentrations well below US EPA standards set for the protection of human health. Aqueous samples were analyzed for a number of organic contaminants that were below the detection limit and, therefore, not listed in Table 2. These include herbicides, organochlorine pesticides, and PCBs. Please refer to Appendix 2 for a comprehensive list of analytes that were below detection.

Table 2. Metals and organics measured in water samples during December 2006 and April 2007. Blank spaces indicate that analyses were not conducted on a particular sample.

	December 2006	April 2007 Sample 1	April 2007 Sample 2	April 2007 Sample 3	April 2007 Sample 4	April 2007 Sample 5	April 2007 Sample 6
Metals (µg/L)							
Arsenic	<1.0						
Cadmium	<0.10						
Calcium	4300						
Chromium	0.50						
Copper	1.1	8.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Iron	1200	3700	4200	3700	2800	560	480
Lead	0.44	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
Magnesium	1400						
Manganese	74	300	190	1700	550	62	52
Mercury	<0.10						
Nickel	0.48						
Potassium	2200						
Selenium	<1.0						
Silicon	660						
Sodium	2200						
Zinc	8.4	92	<20	<20	<20	<20	<20
Organics (µg/L)[1]							
Chloroform		2.7	<1.0	<1.0	<1.0	<1.0	<1.0
Toluene		<1.0	<1.0	1.4	<1.0	<1.0	<1.0

[1]Aqueous samples were analyzed for a number of organic contaminants that were below the detection limit for all samples and, therefore, not listed in this table. These include herbicides, organochlorine pesticides, and PCBs. Refer to Appendix 2 for a comprehensive list.

Sediment

A composite sediment sample from the proposed constructed wetland location was analyzed for metals and various organic contaminants in December 2006; results are summarized in Table 3. While South Carolina has no regulatory limits for sediment contamination, typical screening guidelines used by the USEPA and other federal agencies include the threshold effect concentration (TEC) and the probable effect concentration (PEC) in freshwater sediments (Jones et al. 1997). The TEC value is typically considered the value at which harmful effects on aquatic communities are rarely observed. The PEC concentrations are those at which harmful effects would frequently occur. Two metals, copper and zinc, exceeded the TEC but not the PEC values (Table 3). Other analytes listed in Table 3 (calcium, iron, magnesium, manganese, potassium, and selenium) are considered nontoxic at these concentrations.

Dalapon was the only organic contaminant detected. It is a herbicide used for used to control grasses in crops, lawns, drainage ditches, along railroad tracks, and in industrial areas (US EPA 2006). In the environment, Dalapon completely degrades to inorganic compounds through bacterial activity (Sternersen 2004).

Table 3. Summary of sediment analyses conducted in December 2006 in the location of the proposed constructed wetland.

	December 2006	TEC[1]	PEC[1]
Metals (mg/kg) [2]			
Arsenic	5.1	12.1	57
Cadmium	0.24	0.59	11.7
Calcium	2000		
Chromium	40	56	159
Copper	32	28	77.7
Iron	20,000		
Lead	43	34.2	396
Magnesium	2700		
Manganese	300		
Mercury	<0.47		
Nickel	22	39.6	38.5
Potassium	1800		
Selenium	1.2		
Zinc	210	159	1532
Herbicides (µg/kg)			
Dalapon	57		

[1]TEC= threshold effect concentration. PEC=probable effect concentration.
[2]Sediment samples were analyzed for a number of contaminants that were below the detection limit for all samples and, therefore, not listed in this table. These include sodium, herbicides, organochlorine pesticides, and PCBs. Refer to Appendix 2 for a comprehensive list.

Summary

Preconstruction chemical analyses indicated a moderately impaired system with low dissolved oxygen. This was probably due to the low-flow and high BOD conditions of this system prior to wetland construction. All other basic water quality parameters indicated the potential for a healthy system once restoration is complete and the wetland is given time to mature. Several potential contaminants were detected, but all were at concentrations that will not weaken the restoration effort nor present a risk to future ecological receptors in this constructed wetland.

References

Jones, D.S., G.W. Suter II, and R.N. Hull. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge TN.

SC DHEC. 2004. Water Classifications and Standards. Regulation 61-68. South Carolina Department of Health and Environmental Control. Bureau of Water. Columbia, SC.

Stenersen, J. 2004. Chemical Pesticides: Mode of Action and Toxicology. CRC Press. Boca Raton, FL.

US EPA. 2002. National Recommended Water Quality Criteria. EPA-822-R-02-047. U.S. Environmental Protection Agency Office of Water and Office of Science and Technology. Washington, DC.

US EPA. 2006. Consumer Factsheet on: DALAPON. [Internet]. Washington, DC: US Environmental Protection Agency.; *c*2006 [cited 2007 Nov 9]. Available from http://www.noaanews.noaa.gov/stories/s1119.htm.

APPENDIX 1: METHODS FOR ANALYSES

Parameter	Sample Date	Matrix	Method
Alkalinity	Dec. 2006	Aqueous	Titration US EPA Method 310.1[1]
Ammonia	Apr. 2007	Aqueous	Colorimetry US EPA Method 350.1[2]
BOD (5-day)	Dec. 2006 Apr. 2007	Aqueous	Probe Method at 20ºC US EPA Method 405.1[3]
Chloride	Dec. 2006	Aqueous	Ion Chromatography US EPA Method 300.0[4]
COD (low-level)	Dec. 2006	Aqueous	Colorimetry US EPA Method 410.4[5]
Herbicides[a]	Dec. 2006	Aqueous Sediment	Capillary GC-ECD US EPA Method 8151A[6]
Mercury	Dec. 2006	Aqueous	Manual CVAA US EPA Method 245.1[7]
Mercury	Dec. 2006	Sediment	CVAA US EPA Method 7471A[8]
Metals (As, Cd, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Na, Zn)	Dec. 2006	Sediment	ICP-AES US EPA Method 6010B[9]
Metals (As, Cd, Ca, Cr, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Si, Na, Zn)	Dec. 2006	Aqueous	ICP-MS US EPA Method 200.8[10]
Metals (Cu, Fe, Pb, Mn, Zn)	Apr. 2007	Aqueous	ICP-AES USEPA Method 200.7[11]
Nitrate	Dec. 2006	Aqueous	Colorimetry US EPA Method 353.2[12]
Nitrite	Dec. 2006	Aqueous	Spectrophotometry US EPA Method 354.1[13]
Organochlorine Pesticides[a]	Dec. 2006	Aqueous Sediment	GC US EPA Method 8081A[14]
PCBs[a]	Dec. 2006	Aqueous Sediment	GC US EPA Method 8082[15]
pH	Dec. 2006	Aqueous	US EPA Method 150.1[16]
Phosphorus	Apr. 2007	Aqueous	Colorimetry US EPA Method 365.11[17]
Sulfate	Dec. 2006	Aqueous	Ion Chromatography US EPA Method 300.0[4]
TIC	Dec. 2006	Aqueous	US EPA Method 415.1[18]
TKN	Apr. 2007 Dec. 2006	Aqueous	Colorimetry US EPA Method 351.2[19]
TOC / DOC	Dec. 2006	Aqueous	US EPA Method 415.1[18]

Parameter	Sample Date	Matrix	Method
TSS / TDS	Dec. 2006	Aqueous	Filterable Residue US EPA Method 160.1[20]
Volatile Organic Compounds[a]	Apr. 2007	Aqueous	Purge and Trap GC/MS US EPA Method 8260B[21]

[a]See Appendix A for a complete list of individual constituents and/or congeners that were included in the analysis

METHODOLOGY REFERENCES

1. US EPA 1978. Alkalinity by Titration. USEPA Method 310.1. In: Methods for the Chemical Analysis of Water and Wastes (MCAWW). EPA/600/4-79/020. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

2. US EPA 1993. Ammonia by Automated Colorimetry. USEPA Method 350.1. In: Methods for the Determination of Inorganic Substances in Environmental Samples EPA/600/R-93/100. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

3. US EPA 1974. Biochemical Oxygen Demand (5 days, 20ºC). USEPA Method 405.1. In: Methods for the Chemical Analysis of Water and Wastes (MCAWW). EPA/600/4-79/020. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

4. US EPA 1993. Inorganic Ions by Ion Chromatography. USEPA Method 300.0. In: Methods for the Determination of Inorganic Substances in Environmental Samples EPA/600/R-93/100. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

5. US EPA 1978.Chemical Oxygen Demand by Colorimetry. USEPA Method 410.4. In: Methods for the Chemical Analysis of Water and Wastes (MCAWW). EPA/600/4-79/020. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

6. US EPA 1996. Chlorinated Herbicides and Related Compounds in Water, Soil, and Waste Samples by Capillary GC-ECD. USEPA Method 8151A. In: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. EPA SW-846. United States Environmental Protection Agency. Office of Solid Waste. Washington, DC.

7. US EPA 1994. Determination of Mercury in Water by Cold Vapor Atomic Absorption Spectrometry. USEPA Method 245.1. Methods for the Determination of Metals in Environmental Samples, Supplement 1. EPA/600/R-94/111. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

8. US EPA 1993. Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique). US EPA Method 7471a. In: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. EPA SW-846. United States Environmental Protection Agency. Office of Solid Waste. Washington, DC.

9. US EPA 1996. Inductively Coupled Plasma-Atomic Emission Spectrometry. US EPA Method 6010B Revision 2. In: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. EPA SW-846. United States Environmental Protection Agency. Office of Solid Waste. Washington, DC.

10. US EPA 1994. Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma-Mass Spectrometry. USEPA Method 200.8. Methods for the Determination of Metals in Environmental Samples, Supplement 1. EPA/600/R-94/111. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

11. US EPA 1994. Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectrometry. USEPA Method 200.7. Methods for the Determination of Metals in Environmental Samples, Supplement 1. EPA/600/R-94/111. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

12. US EPA 1993. Nitrate-Nitrite Nitrogen by Colorimetry. USEPA Method 353.2. In: Methods for the Determination of Inorganic Substances in Environmental Samples EPA/600/R-93/100. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

13. US EPA 1971. Nitrite by Spectrophotometry. USEPA Method 354.1. In: Methods for the Chemical Analysis of Water and Wastes (MCAWW). EPA/600/4-79/020. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

14. US EPA 2000. Organochlorine Pesticides by Gas Chromatography. USEPA Method 8081A. In: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. EPA SW-846. United States Environmental Protection Agency. Office of Solid Waste. Washington, DC.

15. US EPA 2000. Polychlorinated Biphenyls (PCBs) by Gas Chromatography. USEPA Method 8082. In: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. EPA SW-846. United States Environmental Protection Agency. Office of Solid Waste. Washington, DC.

16. US EPA 1971. pH in Water by Electrometric Method. USEPA Method 150.1. In: Methods for the Chemical Analysis of Water and Wastes (MCAWW). EPA/600/4-79/020. U.S.EPA

National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

17. US EPA 1993. Phosphorus (all forms) by Semi-Automated Colorimetry. USEPA Method 365.1. In: Methods for the Determination of Inorganic Substances in Environmental Samples EPA/600/R-93/100. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

18. US EPA 1974. Total Organic Carbon. USEPA Method 415.1. In: Methods for the Chemical Analysis of Water and Wastes (MCAWW). EPA/600/4-79/020. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

19. US EPA 1993. TKN by Semi-Automated Block Digestion and Colorimetry. US EPA Method 351.2. In: Methods for the Determination of Inorganic Substances in Environmental Samples EPA/600/R-93/100. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD).Cincinnati, OH.

20. US EPA 1971. Filterable Residue by Drying Oven. USEPA Method 160.1. In: Methods for the Chemical Analysis of Water and Wastes (MCAWW). EPA/600/4-79/020. U.S.EPA National Exposure Research Laboratory (NERL). Microbiological and Chemical Exposure Assessment Research Division (MCEARD). Cincinnati, OH.

21. US EPA 1996. Volatile Organic Compounds By Gas Chromatography/Mass Spectrometry (GC/MS). US EPA Method 8260B Revision 2. In: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. EPA SW-846. United States Environmental Protection Agency. Office of Solid Waste. Washington, DC.

APPENDIX 2: COMPLETE ANALYTE LIST

December 2006 sediment and water samples were analyzed for all of the following contaminants, with results of less than detection:

Herbicides
2,4,5-T; 2,4-D; dalapon; 2,4-DB; dicamba; dichloroprop; dinoseb; MCPA; MCPP; 2,4,5-TP (Silvex).

PCBs
arochlor 1016, arochlor 1221, arochlor 1232, arochlor 1242, arochlor 1248, arochlor 1254, arochlor 1260

Oganochlorine Pesticides
aldrin; alpha-BHC; beta-BHC; delta-BHC; gamma-BHC (lindane); alpha-chlordane; gamma-chlordane; 4,4'-DDD; 4,4'-DDE; 4,4'-DDT; dieldrin; endosulfan I; endosulfan II; endosulfan sulfate, endrin, endrin aldehyde; endrin ketone; heptachlor; heptachlor epoxide; methoxychlor; toxaphene

April 2007 water samples were analyzed for all of the following contaminants, with results of less than detection:

Volatile Organic Compounds
acrolein; acrylonitrile; benzene; bromodichloromethane; bromoform; bromomethane; carbon disulfide; carbon tetrachloride; chlorobenzene; chloroethane; 2-chloroethylvinylether; chloromethane; dibromochloromethane; 1,2-dichlorobenzene; 1,3-dichlorobenzene; 1,4-dichlorobenzene; dichlorodifluoromethane; 1,1-dichloroethane; 1,1-dichloroethene; 1,2-dichloroethane; trans-1,2-dichloroethene; 1,2-dichloropropane; cis-1,3-dichloropropene; trans-1,3-dichloropropene; ethylbenzene; methylene chloride; 1,1,2,2-tetrachloroethane; tetrachloroethene; 1,2,4-trichlorobenzene; 1,1,1-trichloroethane; 1,1,2-trichloroethane; trichloroethene; trichlorofluoromethane; vinyl chloride

Figure 6. Conceptual waterfall flowing from rerouted feeder stream to depression area.

Table 1. Proposed wetland plant species (water depth) for planting or seeding into vegetation zones.

Zone 1 (0”-6”)
Juncus sp. (rushes) <2”-10”
Carex sp. (sedges) <2”-10”
Canna sp. (canna) <2”-10”
Polygonum aviculare (smartweed) <2”-10”
Spartina ambiguus (cordgrass) <2”-10”
Phragmites sp. (Common reed) <2”-20”
Cyperus flavescens (sedges) <2”-20”
Panicum sp. (panic grass) <2”-20”
Eleocharus (spike rush) <2”-20”
Arundo donax (Giant reed) <2”-20”
Glyceria striata (Manna grass) <2”-12”

Zone 2 (1”-18”)
Cyperus flavescens (sedges) <2”-20”
Panicum sp. (panic grass) <2”-20”
Eleocharus (spike rush) <2”-20”
Arundo donax (Giant reed) <2”-20”
Pontederia cordata (Pickerelweed) 4”-10”
Typha sp. (cattails) 4”-30”
Ludwigia leptocarpa (water primrose) 4”-20”
Zizania aquatica (Wild rice) 4”-40”
Scirpus cyperinus (Bullrush) 4”-48”
Sagittaria latifolia (Arrowheads) 10”-20”
Nelumbo lutea (American lotus) 10”-60”

Zone 3 (18”-36”)
Typha sp. (Cattails) 4”-30”
Zizania aquatica (Wild rice) 4”-40”
Scirpus cyperinus (Bullrush) 4”-48”
Sagittaria latifolia (Arrowheads) 10”-20”
Brasenia sp. (Watershield) 10”-24”
Nelumbo lutea (American lotus) 10”-60”
Nymphacae odorate (Waterlily) 20”-120”

Appendix A

Species list of observed animals.

Amphibians
Spotted salamanders
Eastern narrowmouth toad
Southern cricket frog
Leopard frog
Bronze frog

Reptiles
Eastern box turtle
Yellowbelly sliders
Eastern painted turtle
Eastern river cooter
Mud turtle
Musk turtle
Ground skink
Five-lined skink
Green anole
Rat snake
American alligator

Birds
Belted kingfisher
Wood duck
Mallard duck
Green heron
Great blue heron
Great egret

Mammals
Beaver
Deer

Appendix B

Chemistry Data

Report of Analysis

Southeastern Natural Sciences Academy
1858 Lock & Dam Road
Augusta, GA 30906
Attention: Oscar Flite

Project Name: **Hammonds Ferry**

Lot Number: **HL08045**
Date Completed: **12/26/2006**

Kelly M. Maberry
Project Manager

This report shall not be reproduced, except in its entirety, without the written approval of Shealy Environmental Services, Inc.

The following non-paginated documents are considered part of this report: Chain of Custody Record and Sample Receipt Checklist.

HL08045

Case Narrative

Southeastern Natural Sciences Academy

Lot Number: HL08045

This Report of Analysis contains the analytical result(s) for the sample(s) listed on the Sample Summary following this Case Narrative. The sample receiving date is documented in the header information associated with each sample.

Sample receipt, sample analysis, and data review have been performed in accordance with the most current approved NELAC standards, the Shealy Environmental Services, Inc. ("Shealy") Quality Assurance Management Plan (QAMP), standard operating procedures (SOPs), and Shealy policies. Any exceptions to the NELAC standards, the QAMP, SOPs or policies are qualified on the results page or discussed below.

If you have any questions regarding this report please contact the Shealy Project Manager listed on the cover page.

Pesticides

Sample -002 was diluted 10x due to matrix interference. The PQLs have been elevated as a result of this dilution.

SHEALY ENVIRONMENTAL SERVICES, INC.

Sample Summary

Southeastern Natural Sciences Academy

Lot Number: HL08045

Sample Number	Sample ID	Matrix	Date Sampled	Date Received
001	Hammond's Ferry	Aqueous	12/08/2006 1040	12/08/2006
002	Hammond's Ferry	Solid	12/08/2006 1100	12/08/2006

(2 samples)

Executive Summary
Southeastern Natural Sciences Academy
Lot Number: HL08045

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
001	Hammond's Ferry	Aqueous	Alkalinity	310.1	17		mg/L	6
001	Hammond's Ferry	Aqueous	BOD, 5 day	405.1	2.2		mg/L	6
001	Hammond's Ferry	Aqueous	Carbonaceous BOD, 5 day	405.1	2.0	7	mg/L	6
001	Hammond's Ferry	Aqueous	Chloride	300.0	3.7		mg/L	6
001	Hammond's Ferry	Aqueous	COD (low-level)	410.4	46		mg/L	6
001	Hammond's Ferry	Aqueous	Dissolved Chloride	300.0	4.8		mg/L	6
001	Hammond's Ferry	Aqueous	Dissolved Nitrate-Nitrite - N	353.2	0.10		mg/L	6
001	Hammond's Ferry	Aqueous	Dissolved Nitrite - N	354.1	0.0076	J	mg/L	6
001	Hammond's Ferry	Aqueous	Dissolved Sulfate	300.0	1.2		mg/L	6
001	Hammond's Ferry	Aqueous	DOC	415.1	10		mg/L	6
001	Hammond's Ferry	Aqueous	Ortho-phosphorus	365.2	0.010		mg/L	6
001	Hammond's Ferry	Aqueous	Phosphorus	365.1	0.054		mg/L	6
001	Hammond's Ferry	Aqueous	Sulfate	300.0	1.8		mg/L	6
001	Hammond's Ferry	Aqueous	TDS	160.1	31		mg/L	6
001	Hammond's Ferry	Aqueous	TIC	415.1	2.8		mg/L	6
001	Hammond's Ferry	Aqueous	TKN	351.2	0.49	J	mg/L	6
001	Hammond's Ferry	Aqueous	TOC	415.1	7.6		mg/L	6
001	Hammond's Ferry	Aqueous	TSS	160.2	7.2		mg/L	6
001	Hammond's Ferry	Aqueous	TVSS	160.2/160.4	5.9	J	mg/L	6
001	Hammond's Ferry	Aqueous	Calcium	200.8	4300	B	ug/L	10
001	Hammond's Ferry	Aqueous	Chromium	200.8	0.50	J	ug/L	10
001	Hammond's Ferry	Aqueous	Copper	200.8	1.1		ug/L	10
001	Hammond's Ferry	Aqueous	Iron	200.8	1200		ug/L	10
001	Hammond's Ferry	Aqueous	Lead	200.8	0.44	BJ	ug/L	10
001	Hammond's Ferry	Aqueous	Magnesium	200.8	1400		ug/L	10
001	Hammond's Ferry	Aqueous	Manganese	200.8	74	B	ug/L	10
001	Hammond's Ferry	Aqueous	Nickel	200.8	0.48	J	ug/L	10
001	Hammond's Ferry	Aqueous	Potassium	200.8	2200	B	ug/L	10
001	Hammond's Ferry	Aqueous	Silicon	200.8	660	B	ug/L	10
001	Hammond's Ferry	Aqueous	Sodium	200.8	2200		ug/L	10
001	Hammond's Ferry	Aqueous	Zinc	200.8	8.4	BJ	ug/L	10
002	Hammond's Ferry	Solid	Dalapon	8151A	57	JP	ug/kg	12
002	Hammond's Ferry	Solid	Arsenic	6010B	5.1		mg/kg	15
002	Hammond's Ferry	Solid	Cadmium	6010B	0.24	BJ	mg/kg	15
002	Hammond's Ferry	Solid	Calcium	6010B	2000		mg/kg	15
002	Hammond's Ferry	Solid	Chromium	6010B	40		mg/kg	15
002	Hammond's Ferry	Solid	Copper	6010B	32		mg/kg	15
002	Hammond's Ferry	Solid	Iron	6010B	20000		mg/kg	15
002	Hammond's Ferry	Solid	Lead	6010B	43		mg/kg	15
002	Hammond's Ferry	Solid	Magnesium	6010B	2700		mg/kg	15
002	Hammond's Ferry	Solid	Manganese	6010B	300		mg/kg	15
002	Hammond's Ferry	Solid	Nickel	6010B	22	B	mg/kg	15
002	Hammond's Ferry	Solid	Potassium	6010B	1800		mg/kg	15
002	Hammond's Ferry	Solid	Selenium	6010B	1.2	J	mg/kg	15

Executive Summary (Continued)

Lot Number: HL08045

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
002	Hammond's Ferry	Solid	Zinc	6010B	210		mg/kg	15

(45 detections)

Inorganic non-metals

Client: **Southeastern Natural Sciences Academy**
Laboratory ID: **HL08045-001**
Description: **Hammond's Ferry**
Matrix: **Aqueous**
Date Sampled: **12/08/2006 1040**
Date Received: **12/08/2006**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		(Alkalinity) 310.1	1	12/20/2006 2128	IVC		50225
1		(BOD, 5 day) 405.1	1	12/14/2006 1256	RLM	12/09/2006 0927	3401
1		(Carbonaceous) 405.1	1	12/14/2006 1603	IVC	12/09/2006 1356	3402
1		(Chloride) 300.0	1	12/12/2006 1418	DAS		49817
1		(COD (low-lev) 410.4	1	12/18/2006 1330	WD		
1	350.2	(Dissolved Am) 350.1	1	12/21/2006 1203	BMG	12/20/2006 1533	50187
1		(Dissolved Ch) 300.0	1	12/15/2006 1842	DAS		50037
1		(Dissolved Ni) 353.2	1	12/08/2006 1719	MML		49724
1		(Dissolved Ni) 354.1	1	12/08/2006 1719	MML		49722
1		(Dissolved Su) 300.0	1	12/15/2006 1842	DAS		50038
1		(DOC) 415.1	1	12/15/2006 0219	MML		50091
1		(Ortho-phosph) 365.2	1	12/09/2006 1030	NMS		
1		(pH) 150.1	1	12/08/2006 1700	PBC		49666
1		(Phosphorus) 365.1	1	12/22/2006 1116	BMG	12/20/2006 1530	50192
1		(Sulfate) 300.0	1	12/12/2006 1418	DAS		49813
1		(TDS) 160.1	1	12/14/2006 1440	NMS		711
1		(TIC) 415.1	1	12/18/2006 2153	MML		
1	351.4	(TKN) 351.2	1	12/23/2006 1037	DAS	12/19/2006 1200	50144
1		(TOC) 415.1	1	12/18/2006 2153	MML		50153
1		(TSS) 160.2	1	12/11/2006 1115	NMS		49687
1		(TVSS) 160.2/160.4	1	12/11/2006 1115	NMS		257

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
Alkalinity		**310.1**	**17**		**10**	**3.9**	**mg/L**	**1**
BOD, 5 day		**405.1**	**2.2**		**2.0**	**0.18**	**mg/L**	**1**
Carbonaceous BOD, 5 day		**405.1**	**2.0**	**7**	**2.0**	**0.21**	**mg/L**	**1**
Chloride		**300.0**	**3.7**		**1.0**	**0.033**	**mg/L**	**1**
COD (low-level)		**410.4**	**46**		**10**	**5.5**	**mg/L**	**1**
Dissolved Ammonia - N (phenate)		350.1	ND		0.10	0.050	mg/L	1
Dissolved Chloride		**300.0**	**4.8**		**1.0**	**0.033**	**mg/L**	**1**
Dissolved Nitrate-Nitrite - N		**353.2**	**0.10**		**0.020**	**0.0013**	**mg/L**	**1**
Dissolved Nitrite - N		**354.1**	**0.0076**	**J**	**0.020**	**0.0034**	**mg/L**	**1**
Dissolved Sulfate		**300.0**	**1.2**		**1.0**	**0.13**	**mg/L**	**1**
DOC		**415.1**	**10**		**1.0**	**0.19**	**mg/L**	**1**
Ortho-phosphorus		**365.2**	**0.010**		**0.010**	**0.0049**	**mg/L**	**1**
pH		**150.1**	**6.68**	*****			**su**	**1**
Phosphorus		**365.1**	**0.054**		**0.010**	**0.0048**	**mg/L**	**1**
Sulfate		**300.0**	**1.8**		**1.0**	**0.13**	**mg/L**	**1**
TDS		**160.1**	**31**		**10**	**3.4**	**mg/L**	**1**
TIC		**415.1**	**2.8**		**1.0**	**0.24**	**mg/L**	**1**
TKN		**351.2**	**0.49**	**J**	**0.50**	**0.084**	**mg/L**	**1**
TOC		**415.1**	**7.6**		**1.0**	**0.048**	**mg/L**	**1**
TSS		**160.2**	**7.2**		**4.0**	**0.34**	**mg/L**	**1**
TVSS		**160.2/160.4**	**5.9**	**J**	**10**	**2.0**	**mg/L**	**1**

Footnote(s): * Analyzed outside the 15 minute holding time. 7-SCF Out of range

PQL = Practical quantitation limit
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
ND = Not detected at or above the MDL
J = Estimated result < PQL and ≥ MDL
P = The RPD between two GC columns exceeds 40%
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
N = Recovery is out of criteria

Herbicides by GC

Client:	**Southeastern Natural Sciences Academy**	Laboratory ID:	**HL08045-001**
Description:	**Hammond's Ferry**	Matrix:	**Aqueous**
Date Sampled:	**12/08/2006 1040**		
Date Received:	**12/08/2006**		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	8151A	8151A	1	12/15/2006 1908	SRW	12/14/2006 1930	49946

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
2,4,5-T	93-76-5	8151A	ND		0.50	0.10	ug/L	1
2,4-D	94-75-7	8151A	ND		2.0	0.40	ug/L	1
Dalapon	75-99-0	8151A	ND		5.0	0.90	ug/L	1
2,4-DB	94-82-6	8151A	ND		4.0	0.81	ug/L	1
Dicamba	1918-00-9	8151A	ND		1.0	0.20	ug/L	1
Dichloroprop	120-36-5	8151A	ND		2.0	0.41	ug/L	1
Dinoseb	88-85-7	8151A	ND		2.0	0.44	ug/L	1
MCPA	94-74-6	8151A	ND		200	40	ug/L	1
MCPP	93-65-2	8151A	ND		200	46	ug/L	1
2,4,5-TP (Silvex)	93-72-1	8151A	ND		0.50	0.10	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
DCAA		84	50-130

Footnote(s): * Analyzed outside the 15 minute holding time. 7-SCF Out of range

PQL = Practical quantitation limit
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
ND = Not detected at or above the MDL
J = Estimated result < PQL and ≥ MDL
P = The RPD between two GC columns exceeds 40%
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
N = Recovery is out of criteria

PCBs by GC

Client:	**Southeastern Natural Sciences Academy**	Laboratory ID:	**HL08045-001**
Description:	**Hammond's Ferry**	Matrix:	**Aqueous**
Date Sampled:	**12/08/2006 1040**		
Date Received:	**12/08/2006**		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8082	1	12/11/2006 2054	NWD	12/10/2006 1232	49674

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
Aroclor 1016	12674-11-2	8082	ND		0.25	0.050	ug/L	1
Aroclor 1221	11104-28-2	8082	ND		0.25	0.14	ug/L	1
Aroclor 1232	11141-16-5	8082	ND		0.25	0.20	ug/L	1
Aroclor 1242	53469-21-9	8082	ND		0.25	0.14	ug/L	1
Aroclor 1248	12672-29-6	8082	ND		0.25	0.15	ug/L	1
Aroclor 1254	11097-69-1	8082	ND		0.25	0.11	ug/L	1
Aroclor 1260	11096-82-5	8082	ND		0.25	0.060	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
Decachlorobiphenyl		41	10-156
Tetrachloro-m-xylene		83	48-133

Footnote(s): * Analyzed outside the 15 minute holding time. 7-SCF Out of range

PQL = Practical quantitation limit
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
ND = Not detected at or above the MDL
J = Estimated result < PQL and ≥ MDL
P = The RPD between two GC columns exceeds 40%
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
N = Recovery is out of criteria

Organochlorine Pesticides by GC

Client:	**Southeastern Natural Sciences Academy**	Laboratory ID:	**HL08045-001**
Description:	**Hammond's Ferry**	Matrix:	**Aqueous**
Date Sampled:	**12/08/2006 1040**		
Date Received:	**12/08/2006**		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3520C	8081A	1	12/12/2006 1139	SRW	12/10/2006 1232	49675

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
Aldrin	309-00-2	8081A	ND		0.025	0.0020	ug/L	1
alpha-BHC	319-84-6	8081A	ND		0.025	0.0030	ug/L	1
beta-BHC	319-85-7	8081A	ND		0.025	0.019	ug/L	1
delta-BHC	319-86-8	8081A	ND		0.025	0.0080	ug/L	1
gamma-BHC (Lindane)	58-89-9	8081A	ND		0.025	0.0050	ug/L	1
alpha-Chlordane	5103-71-9	8081A	ND		0.025	0.0030	ug/L	1
gamma-Chlordane	5103-74-2	8081A	ND		0.025	0.0030	ug/L	1
4,4'-DDD	72-54-8	8081A	ND		0.025	0.0060	ug/L	1
4,4'-DDE	72-55-9	8081A	ND		0.025	0.0060	ug/L	1
4,4'-DDT	50-29-3	8081A	ND		0.025	0.0030	ug/L	1
Dieldrin	60-57-1	8081A	ND		0.025	0.0040	ug/L	1
Endosulfan I	959-98-8	8081A	ND		0.025	0.0060	ug/L	1
Endosulfan II	33213-65-9	8081A	ND		0.025	0.024	ug/L	1
Endosulfan sulfate	1031-07-8	8081A	ND		0.025	0.0030	ug/L	1
Endrin	72-20-8	8081A	ND		0.025	0.0050	ug/L	1
Endrin aldehyde	7421-93-4	8081A	ND		0.025	0.0030	ug/L	1
Endrin ketone	53494-70-5	8081A	ND		0.025	0.0040	ug/L	1
Heptachlor	76-44-8	8081A	ND		0.025	0.020	ug/L	1
Heptachlor epoxide	1024-57-3	8081A	ND		0.025	0.0030	ug/L	1
Methoxychlor	72-43-5	8081A	ND		0.10	0.014	ug/L	1
Toxaphene	8001-35-2	8081A	ND		0.25	0.030	ug/L	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
Decachlorobiphenyl		43	10-156
Tetrachloro-m-xylene		90	48-133

Footnote(s): * Analyzed outside the 15 minute holding time. 7-SCF Out of range

PQL = Practical quantitation limit
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
ND = Not detected at or above the MDL
J = Estimated result < PQL and ≥ MDL
P = The RPD between two GC columns exceeds 40%
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
N = Recovery is out of criteria

ICP-MS

Client: **Southeastern Natural Sciences Academy** Laboratory ID: **HL08045-001**

Description: **Hammond's Ferry** Matrix: **Aqueous**

Date Sampled: **12/08/2006 1040**

Date Received: **12/08/2006**

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	200.2	200.8	1	12/14/2006 2237	FTS	12/11/2006 1840	49749
2	200.2	200.8	1	12/20/2006 1610	FTS	12/11/2006 1840	49749

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
Arsenic	7440-38-2	200.8	ND		1.0	0.66	ug/L	1
Cadmium	7440-43-9	200.8	ND		0.10	0.042	ug/L	1
Calcium	**7440-70-2**	**200.8**	**4300**	**B**	**200**	**13**	**ug/L**	**1**
Chromium	**7440-47-3**	**200.8**	**0.50**	**J**	**5.0**	**0.35**	**ug/L**	**1**
Copper	**7440-50-8**	**200.8**	**1.1**		**1.0**	**0.15**	**ug/L**	**1**
Iron	**7439-89-6**	**200.8**	**1200**		**20**	**5.9**	**ug/L**	**1**
Lead	**7439-92-1**	**200.8**	**0.44**	**BJ**	**1.0**	**0.012**	**ug/L**	**1**
Magnesium	**7439-95-4**	**200.8**	**1400**		**50**	**0.94**	**ug/L**	**1**
Manganese	**7439-96-5**	**200.8**	**74**	**B**	**5.0**	**0.20**	**ug/L**	**1**
Nickel	**7440-02-0**	**200.8**	**0.48**	**J**	**5.0**	**0.28**	**ug/L**	**1**
Potassium	**7440-09-7**	**200.8**	**2200**	**B**	**200**	**6.0**	**ug/L**	**1**
Selenium	7782-49-2	200.8	ND		1.0	0.25	ug/L	1
Silicon	**7440-21-3**	**200.8**	**660**	**B**	**100**	**5.3**	**ug/L**	**2**
Sodium	**7440-23-5**	**200.8**	**2200**		**200**	**4.0**	**ug/L**	**2**
Zinc	**7440-66-6**	**200.8**	**8.4**	**BJ**	**10**	**1.4**	**ug/L**	**1**

Footnote(s): * Analyzed outside the 15 minute holding time. 7-SCF Out of range

PQL = Practical quantitation limit
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
ND = Not detected at or above the MDL
J = Estimated result < PQL and $\geq$ MDL
P = The RPD between two GC columns exceeds 40%
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
N = Recovery is out of criteria

CVAA

Client:	**Southeastern Natural Sciences Academy**	Laboratory ID:	**HL08045-001**
Description:	**Hammond's Ferry**	Matrix:	**Aqueous**
Date Sampled:	**12/08/2006 1040**		
Date Received:	**12/08/2006**		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		245.1	1	12/14/2006 1708	FLW	12/13/2006 1932	49878

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
Mercury	7439-97-6	245.1	ND		0.00010	0.000060	mg/L	1

Footnote(s): * Analyzed outside the 15 minute holding time. 7-SCF Out of range

PQL = Practical quantitation limit
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
ND = Not detected at or above the MDL
J = Estimated result < PQL and ≥ MDL
P = The RPD between two GC columns exceeds 40%
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
N = Recovery is out of criteria

Herbicides by GC

Client:	**Southeastern Natural Sciences Academy**	Laboratory ID:	**HL08045-002**
Description:	**Hammond's Ferry**	Matrix:	**Solid**
Date Sampled:	**12/08/2006 1100**	% Solids:	**17.5 12/11/2006 2012**
Date Received:	**12/08/2006**		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	8151A	8151A	1	12/15/2006 2110	SRW	12/13/2006 0945	49819
2	8151A	8151A	1	12/15/2006 2134	SRW	12/13/2006 0945	49819

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
2,4,5-T	93-76-5	8151A	ND		57	8.2	ug/kg	1
2,4-D	94-75-7	8151A	ND		230	96	ug/kg	1
Dalapon	**75-99-0**	**8151A**	**57**	**JP**	**570**	**50**	**ug/kg**	**2**
2,4-DB	94-82-6	8151A	ND		460	73	ug/kg	1
Dicamba	1918-00-9	8151A	ND		110	31	ug/kg	1
Dichloroprop	120-36-5	8151A	ND		230	47	ug/kg	1
Dinoseb	88-85-7	8151A	ND		230	110	ug/kg	1
MCPA	94-74-6	8151A	ND		23000	15000	ug/kg	1
MCPP	93-65-2	8151A	ND		23000	12000	ug/kg	1
2,4,5-TP (Silvex)	93-72-1	8151A	ND		57	24	ug/kg	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits	Q	Run 2 % Recovery	Acceptance Limits
DCAA		84	50-130		80	50-130

PQL = Practical quantitation limit
ND = Not detected at or above the MDL
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
B = Detected in the method blank
J = Estimated result < PQL and ≥ MDL
E = Quantitation of compound exceeded the calibration range
P = The RPD between two GC columns exceeds 40%
N = Recovery is out of criteria

PCBs by GC

Client:	**Southeastern Natural Sciences Academy**	Laboratory ID:	**HL08045-002**
Description:	**Hammond's Ferry**	Matrix:	**Solid**
Date Sampled:	**12/08/2006 1100**	% Solids:	**17.5 12/11/2006 2012**
Date Received:	**12/08/2006**		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3550B	8082	1	12/13/2006 1903	NWD	12/11/2006 1815	49700

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
Aroclor 1016	12674-11-2	8082	ND		97	15	ug/kg	1
Aroclor 1221	11104-28-2	8082	ND		97	28	ug/kg	1
Aroclor 1232	11141-16-5	8082	ND		97	17	ug/kg	1
Aroclor 1242	53469-21-9	8082	ND		97	17	ug/kg	1
Aroclor 1248	12672-29-6	8082	ND		97	17	ug/kg	1
Aroclor 1254	11097-69-1	8082	ND		97	5.7	ug/kg	1
Aroclor 1260	11096-82-5	8082	ND		97	3.5	ug/kg	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
Decachlorobiphenyl		92	50-130
Tetrachloro-m-xylene		110	50-130

PQL = Practical quantitation limit
ND = Not detected at or above the MDL
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
B = Detected in the method blank
J = Estimated result < PQL and ≥ MDL
E = Quantitation of compound exceeded the calibration range
P = The RPD between two GC columns exceeds 40%
N = Recovery is out of criteria

Organochlorine Pesticides by GC

Client:	**Southeastern Natural Sciences Academy**	Laboratory ID:	**HL08045-002**
Description:	**Hammond's Ferry**	Matrix:	**Solid**
Date Sampled:	**12/08/2006 1100**	% Solids:	**17.5 12/11/2006 2012**
Date Received:	**12/08/2006**		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3550B	8081A	10	12/15/2006 1429	SRW	12/11/2006 1815	49699

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
Aldrin	309-00-2	8081A	ND		97	19	ug/kg	1
alpha-BHC	319-84-6	8081A	ND		97	22	ug/kg	1
beta-BHC	319-85-7	8081A	ND		97	17	ug/kg	1
delta-BHC	319-86-8	8081A	ND		97	18	ug/kg	1
gamma-BHC (Lindane)	58-89-9	8081A	ND		97	20	ug/kg	1
alpha-Chlordane	5103-71-9	8081A	ND		97	16	ug/kg	1
gamma-Chlordane	5103-74-2	8081A	ND		97	14	ug/kg	1
4,4'-DDD	72-54-8	8081A	ND		97	14	ug/kg	1
4,4'-DDE	72-55-9	8081A	ND		97	18	ug/kg	1
4,4'-DDT	50-29-3	8081A	ND		97	16	ug/kg	1
Dieldrin	60-57-1	8081A	ND		97	19	ug/kg	1
Endosulfan I	959-98-8	8081A	ND		97	19	ug/kg	1
Endosulfan II	33213-65-9	8081A	ND		97	14	ug/kg	1
Endosulfan sulfate	1031-07-8	8081A	ND		97	13	ug/kg	1
Endrin	72-20-8	8081A	ND		97	19	ug/kg	1
Endrin aldehyde	7421-93-4	8081A	ND		97	17	ug/kg	1
Endrin ketone	53494-70-5	8081A	ND		97	12	ug/kg	1
Heptachlor	76-44-8	8081A	ND		97	22	ug/kg	1
Heptachlor epoxide	1024-57-3	8081A	ND		97	18	ug/kg	1
Methoxychlor	72-43-5	8081A	ND		380	77	ug/kg	1
Toxaphene	8001-35-2	8081A	ND		4700	520	ug/kg	1

Surrogate	Q	Run 1 % Recovery	Acceptance Limits
Decachlorobiphenyl		125	50-130
Tetrachloro-m-xylene		72	50-130

PQL = Practical quantitation limit
ND = Not detected at or above the MDL
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
B = Detected in the method blank
J = Estimated result < PQL and ≥ MDL
E = Quantitation of compound exceeded the calibration range
P = The RPD between two GC columns exceeds 40%
N = Recovery is out of criteria

ICP-AES

Client:	**Southeastern Natural Sciences Academy**	Laboratory ID:	**HL08045-002**
Description:	**Hammond's Ferry**	Matrix:	**Solid**
Date Sampled:	**12/08/2006 1100**	% Solids:	**17.5 12/11/2006 2012**
Date Received:	**12/08/2006**		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1	3050B	6010B	1	12/13/2006 1232	MNM	12/11/2006 1430	49727
2	3050B	6010B	1	12/13/2006 1730	MNM	12/11/2006 1430	49727

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
Arsenic	**7440-38-2**	**6010B**	**5.1**		**1.4**	**1.1**	**mg/kg**	**1**
Cadmium	**7440-43-9**	**6010B**	**0.24**	**BJ**	**0.57**	**0.060**	**mg/kg**	**1**
Calcium	**7440-70-2**	**6010B**	**2000**		**1400**	**100**	**mg/kg**	**1**
Chromium	**7440-47-3**	**6010B**	**40**		**1.4**	**0.29**	**mg/kg**	**1**
Copper	**7440-50-8**	**6010B**	**32**		**1.4**	**0.28**	**mg/kg**	**1**
Iron	**7439-89-6**	**6010B**	**20000**		**28**	**9.4**	**mg/kg**	**1**
Lead	**7439-92-1**	**6010B**	**43**		**1.4**	**0.53**	**mg/kg**	**1**
Magnesium	**7439-95-4**	**6010B**	**2700**		**1400**	**100**	**mg/kg**	**1**
Manganese	**7439-96-5**	**6010B**	**300**		**4.3**	**0.33**	**mg/kg**	**1**
Nickel	**7440-02-0**	**6010B**	**22**	**B**	**11**	**0.86**	**mg/kg**	**1**
Potassium	**7440-09-7**	**6010B**	**1800**		**1400**	**63**	**mg/kg**	**1**
Selenium	**7782-49-2**	**6010B**	**1.2**	**J**	**1.4**	**0.99**	**mg/kg**	**2**
Sodium	7440-23-5	6010B	ND		1400	98	mg/kg	1
Zinc	**7440-66-6**	**6010B**	**210**		**14**	**1.9**	**mg/kg**	**1**

PQL = Practical quantitation limit
B = Detected in the method blank
E = Quantitation of compound exceeded the calibration range
ND = Not detected at or above the MDL
J = Estimated result < PQL and ≥ MDL
P = The RPD between two GC columns exceeds 40%
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
N = Recovery is out of criteria

CVAA

Client:	**Southeastern Natural Sciences Academy**	Laboratory ID:	**HL08045-002**
Description:	**Hammond's Ferry**	Matrix:	**Solid**
Date Sampled:	**12/08/2006 1100**	% Solids:	**17.5 12/11/2006 2012**
Date Received:	**12/08/2006**		

Run	Prep Method	Analytical Method	Dilution	Analysis Date	Analyst	Prep Date	Batch
1		7471A	1	12/12/2006 1929	FLW	12/11/2006 2130	49805

Parameter	CAS Number	Analytical Method	Result	Q	PQL	MDL	Units	Run
Mercury	7439-97-6	7471A	ND		0.47	0.078	mg/kg	1

PQL = Practical quantitation limit
ND = Not detected at or above the MDL
Where applicable, all soil sample analysis are reported on a dry weight basis unless flagged with a "W"
B = Detected in the method blank
J = Estimated result < PQL and ≥ MDL
E = Quantitation of compound exceeded the calibration range
P = The RPD between two GC columns exceeds 40%
N = Recovery is out of criteria

SHEALY ENVIRONMENTAL SERVICES, INC.
106 Vantage Point Drive
Cayce, South Carolina 29033
Telephone No. (803) 791-9700 Fax No. (803) 791-9111

SHEALY Chain of Custody Record

Number 64413

Client: SNSA	Report to Contact:	Telephone No. / Fax No. / E-mail:	Quote No.:
Address: 1858 Cock and Dam Rd.	Sampler's Signature: x [signature]	Waybill No.:	Page 1 of 1
City: Augusta / State: GA / Zip Code: 30906	Printed Name: Brian Metts	Analysis (Attach list if more space is needed.)	
Project Name: Hammonds Ferry			
Project No.:	P.O. No.:		Lot No.: [illegible]03045

Sample ID / Description (Containers for each sample may be combined on one line.)	Date	Time	G=Grab C=Composite	Aqueous	Solid	Non-Aqueous	Unpres.	H_2SO_4	HNO_3	HCl	NaOH	NaOH/ZnAc	Metals Hg	OH II [illegible]	BOD TSS [illegible]	[crossed out]	Thal TOC [illegible]	Pest Herb PCB					Remarks / Cooler I.D.
Hammonds Ferry	12/8/06	10:40	G	X			6	1	1				1	1	2		1	3					
Hammonds Ferry	12/8/06	11:00	G		X		2						1					1					

Possible Hazard Identification: ☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison ☐ Unknown

Sample Disposal: ☐ Return to Client ☐ Disposal by Lab

Note: All samples are retained for six weeks from receipt unless other arrangements are made.

Turn Around Time Required (Prior lab approval required for expedited TAT.): ☐ Standard ☐ Rush (Specify)

QC Requirements (Specify):

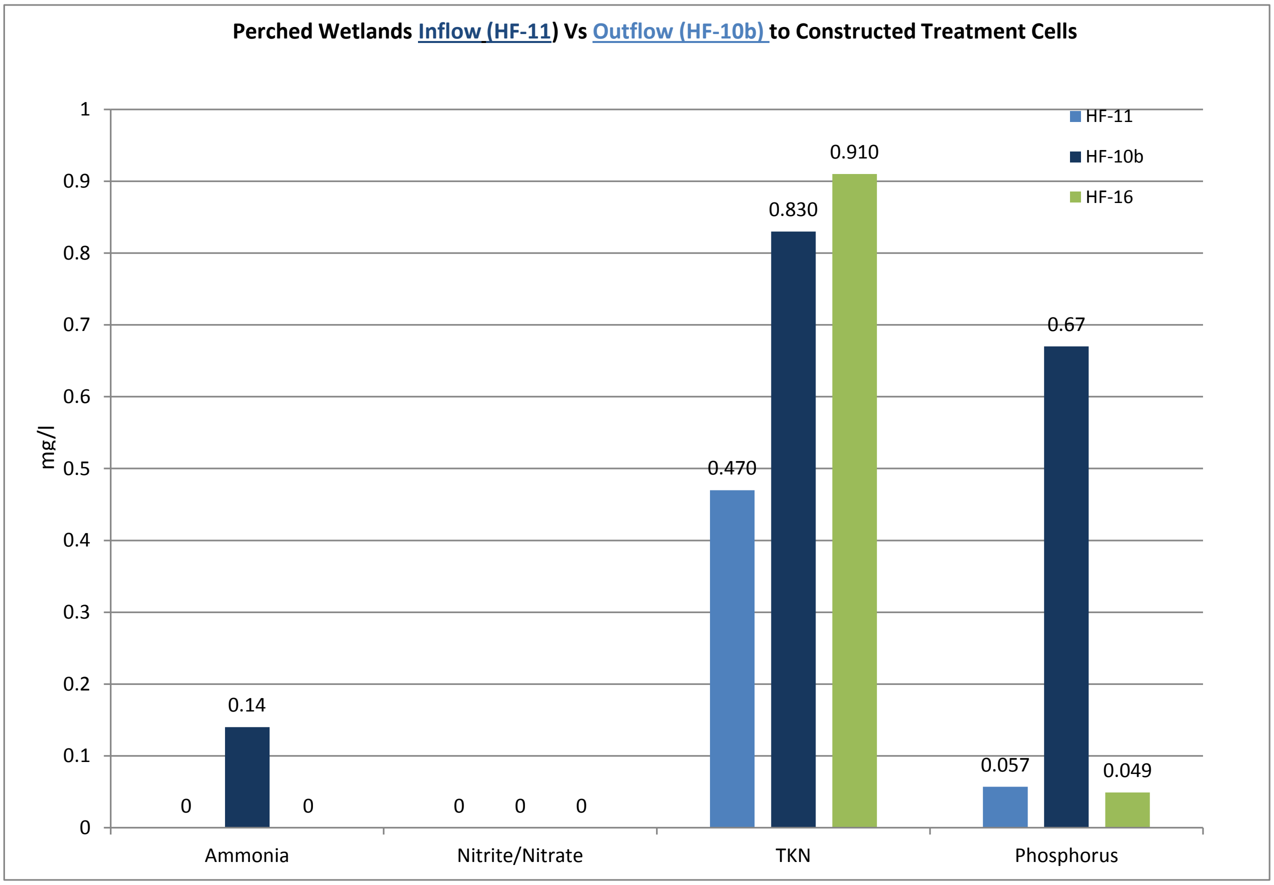
	Date	Time		Date	Time
1. Relinquished by: [signature]	12/8/06	1600	1. Received by:		
2. Relinquished by:			2. Received by:		
3. Relinquished by:			3. Laboratory received by: [signature]	12/8/06	1600
Comments:			LAB USE ONLY — Received on ice (Circle): (Yes) No Ice Pack	Receipt Temp. 0.4 °C	

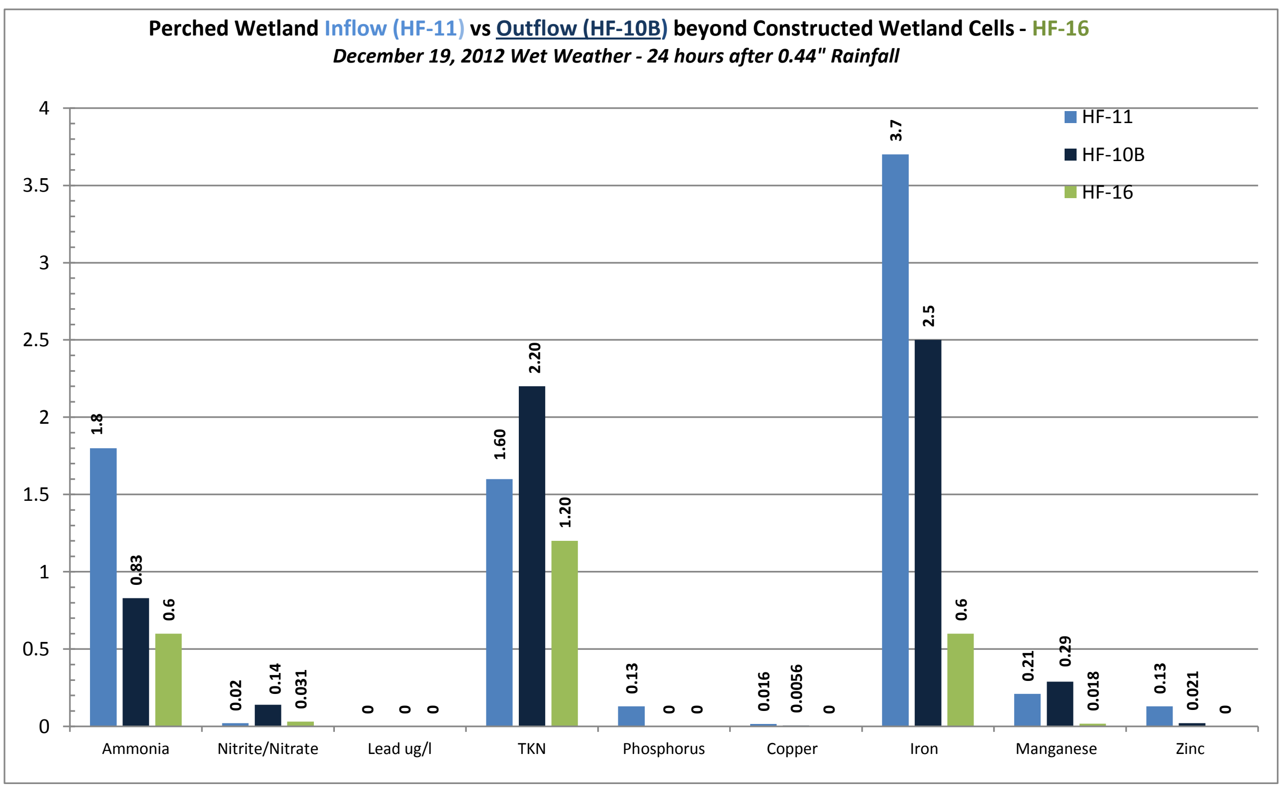
DISTRIBUTION: WHITE & YELLOW-Return to laboratory with Sample(s); PINK-Field/Client Copy

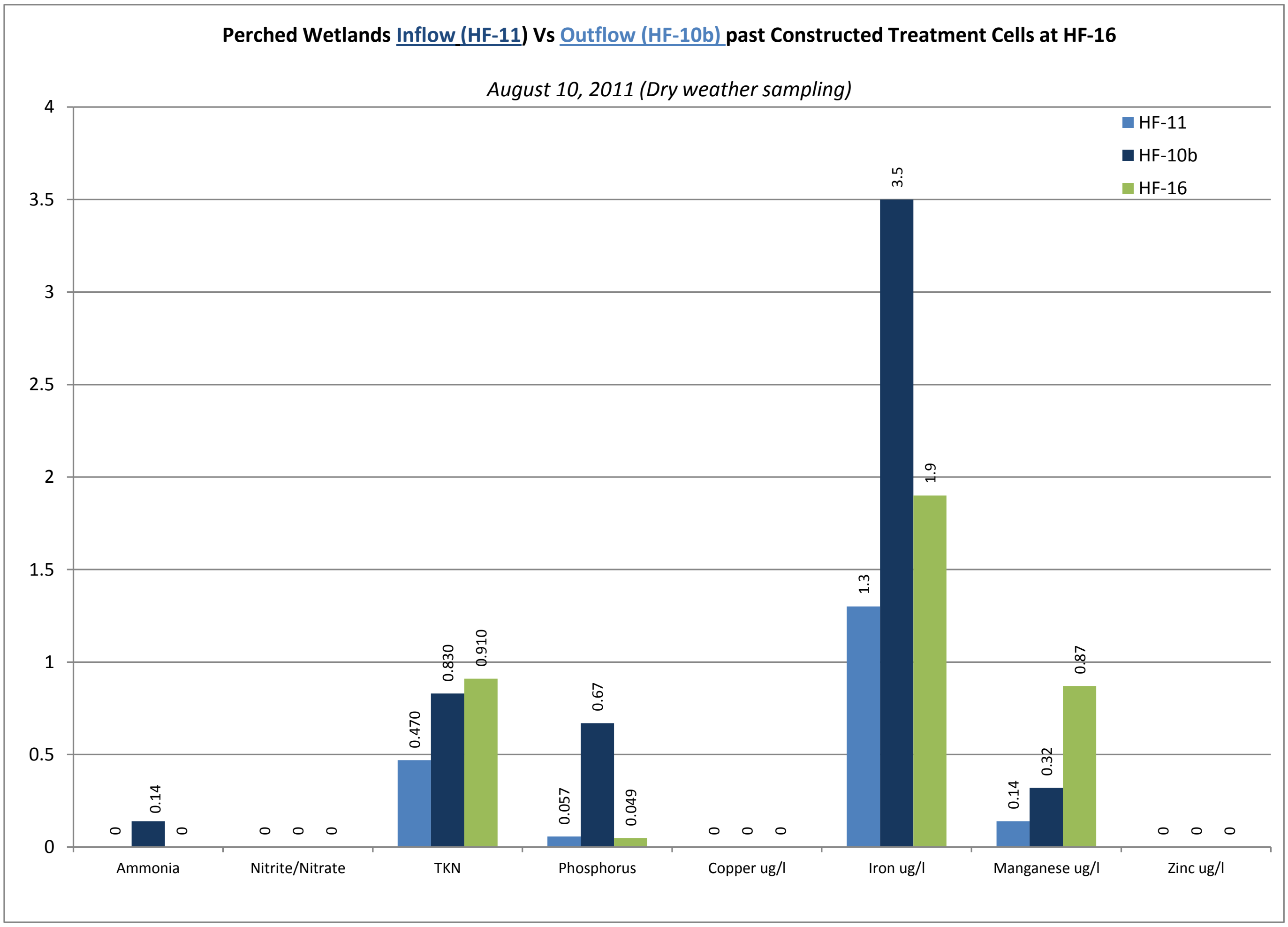
Document Number: F-AD-012 Effective Date: 08-04-02

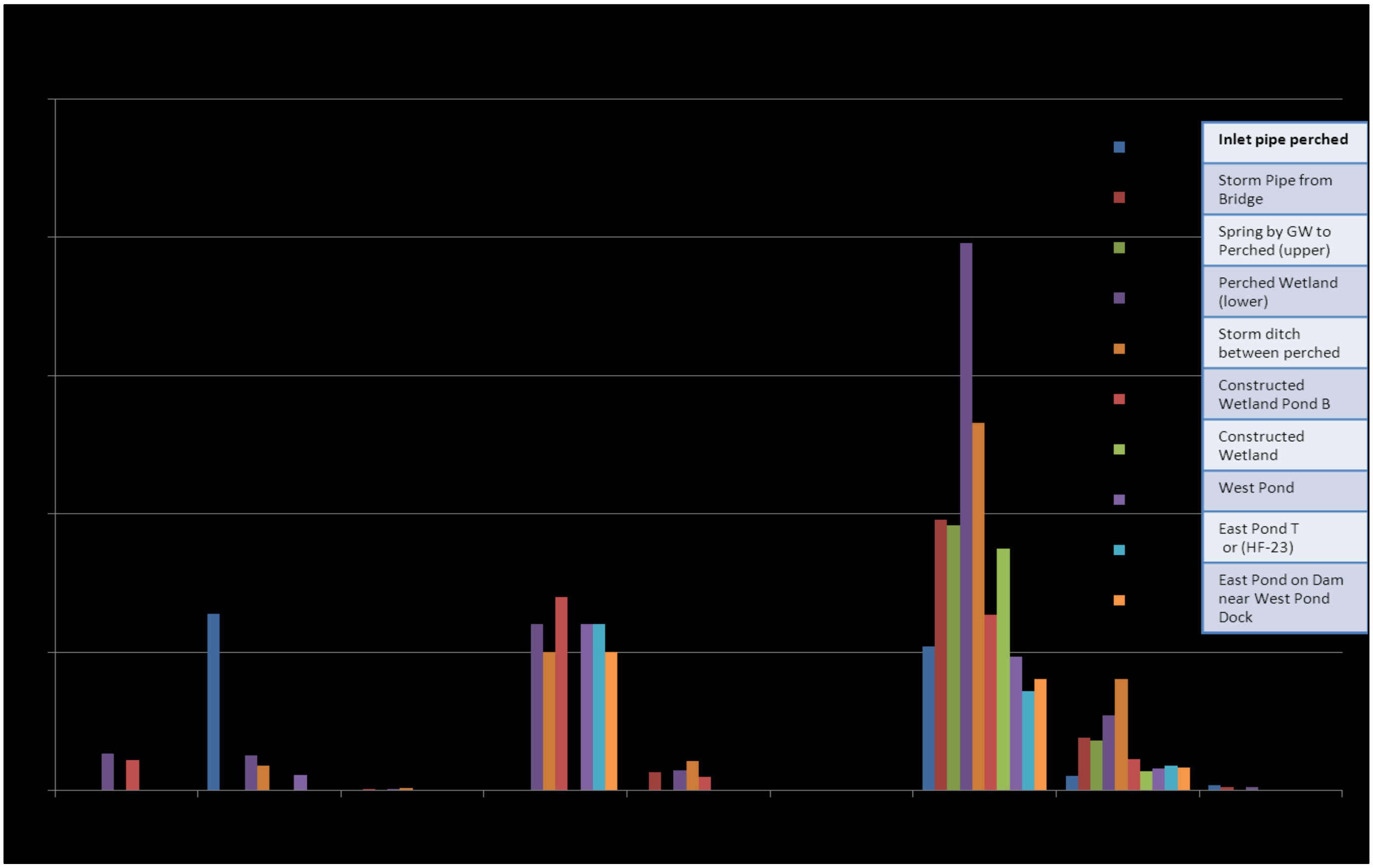
North Augusta Brick Pond Park Sample Locations – Post Construction

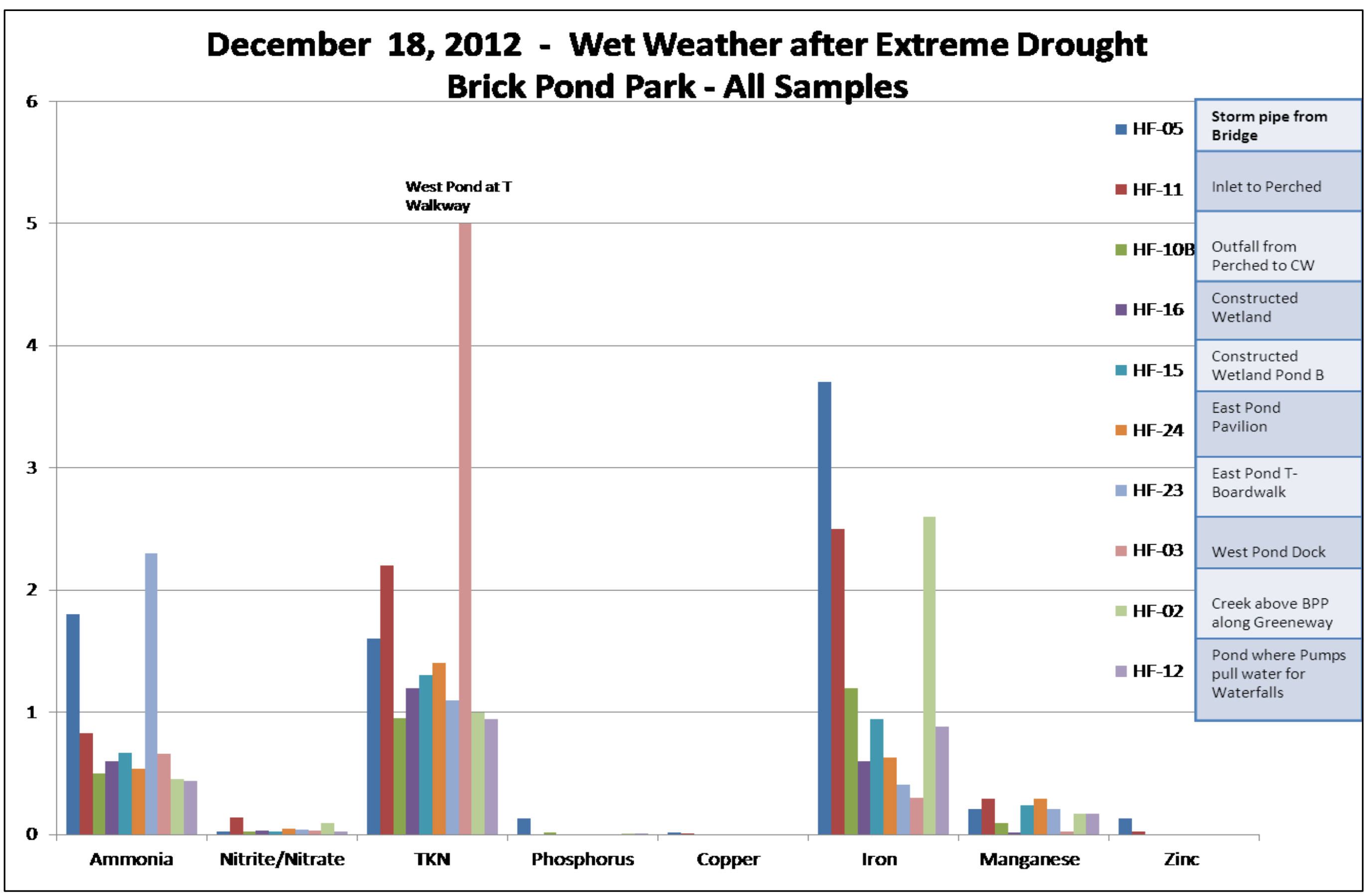
HF-01 Crk from Natural Springs to Perched **HF-02** Crk from Natural Springs Above GW **HF-03** West Pond Center of Dam **HF-04** East Pond Center of Dam **HF-05** SW Collection Area **HF-05a** Storm Pipe from GA **HF-06** East Pond South **HF-07** East Pond North **HF-08** West Pond South **HF-09** West Pond North **HF-10** Storm Ditch to Perched **HF-10b** Outfall of Perched SW Box, **HF-11** Perched Storm Pipe **HF-12** Pump Area **HF-13** Perched **HF-14** Storm Pipe from MB **HF-15** Small Pond below CW **HF-16** CW Near Dam **HF-17** Outlet to CW **HF-18** Overflow from Brick Pond Wetlands **HF-19** Storm Drain on GA **HF-20** Storm Drain on Bluff (not specifically shown **HF-21** Outfall to West Pond North **HF-22** Outfall to West Pond South these are two culverts from HF)**HF-23** East Pond T, **HF-24** East Pond Pavilion


Perched Wetlands Inflow (HF-11) Vs Outflow (HF-10b) to Constructed Treatment Cells
mg/l
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
HF-11
HF-10b
HF-16
0
0.14
0
0
0
0
0.470
0.830
0.910
0.057
0.67
0.049
Ammonia
Nitrite/Nitrate
TKN
Phosphorus


Perched Wetland Inflow (HF-11) vs Outflow (HF-10B) beyond Constructed Wetland Cells - HF-16
December 19, 2012 Wet Weather - 24 hours after 0.44" Rainfall
4
3.5
3
2.5
2
1.5
1
0.5
0
HF-11
HF-10B
HF-16
1.8
0.83
0.6
0.02
0.14
0.031
0
0
0
1.60
2.20
1.20
0.13
0
0
0.016
0.0056
0
3.7
2.5
0.6
0.21
0.29
0.018
0.13
0.021
0
Ammonia
Nitrite/Nitrate
Lead ug/l
TKN
Phosphorus
Copper
Iron
Manganese
Zinc


Perched Wetlands Inflow (HF-11) Vs Outflow (HF-10b) past Constructed Treatment Cells at HF-16
August 10, 2011 (Dry weather sampling)
HF-11
HF-10b
HF-16
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.14
0
0
0
0
0.470
0.830
0.910
0.057
0.67
0.049
0
0
0
1.3
3.5
1.9
0.14
0.32
0.87
0
0
0
Ammonia
Nitrite/Nitrate
TKN
Phosphorus
Copper ug/l
Iron ug/l
Manganese ug/l
Zinc ug/l


Inlet pipe perched
Storm Pipe from Bridge
Spring by GW to Perched (upper)
Perched Wetland (lower)
Storm ditch between perched
Constructed Wetland Pond B
Constructed Wetland
West Pond
East Pond T or (HF-23)
East Pond on Dam near West Pond Dock


December 18, 2012 - Wet Weather after Extreme Drought
Brick Pond Park - All Samples
6
5
4
3
2
1
0
West Pond at T Walkway
HF-05
HF-11
HF-10B
HF-16
HF-15
HF-24
HF-23
HF-03
HF-02
HF-12
Storm pipe from Bridge
Inlet to Perched
Outfall from Perched to CW
Constructed Wetland
Constructed Wetland Pond B
East Pond Pavilion
East Pond T-Boardwalk
West Pond Dock
Creek above BPP along Greeneway
Pond where Pumps pull water for Waterfalls
Ammonia
Nitrite/Nitrate
TKN
Phosphorus
Copper
Iron
Manganese
Zinc

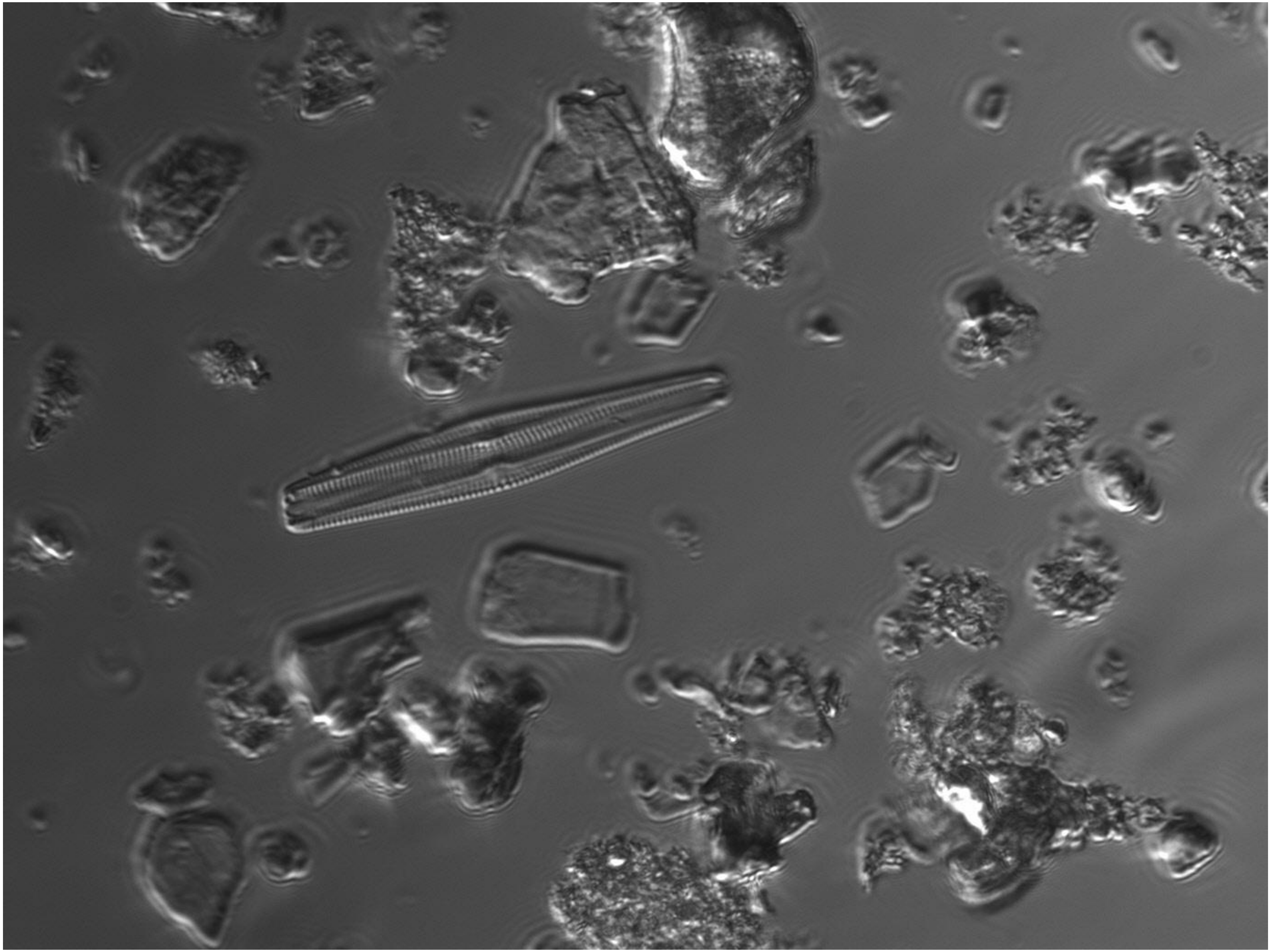
Diatoms of Brick Pond Park

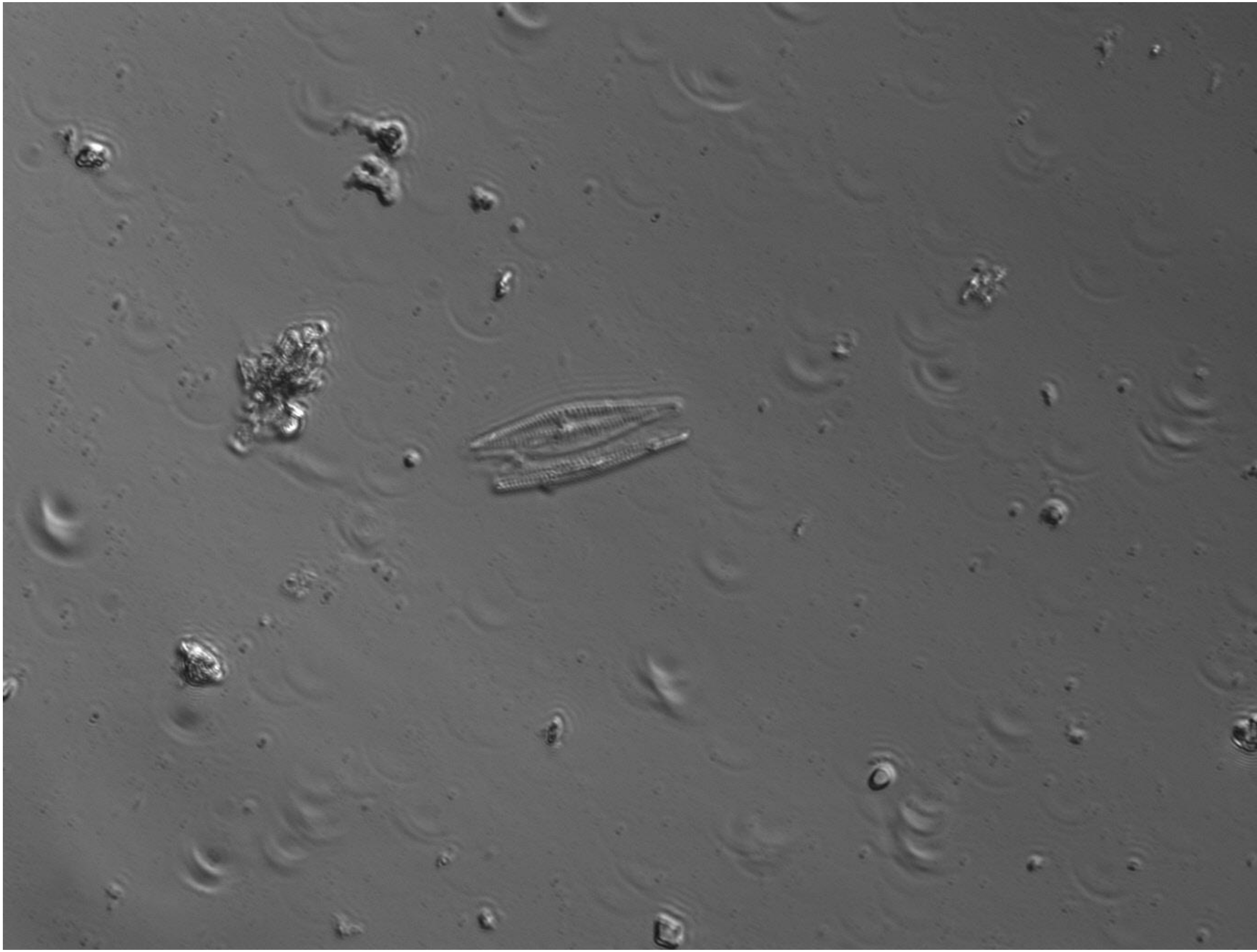
Electron-Microscopic Photos

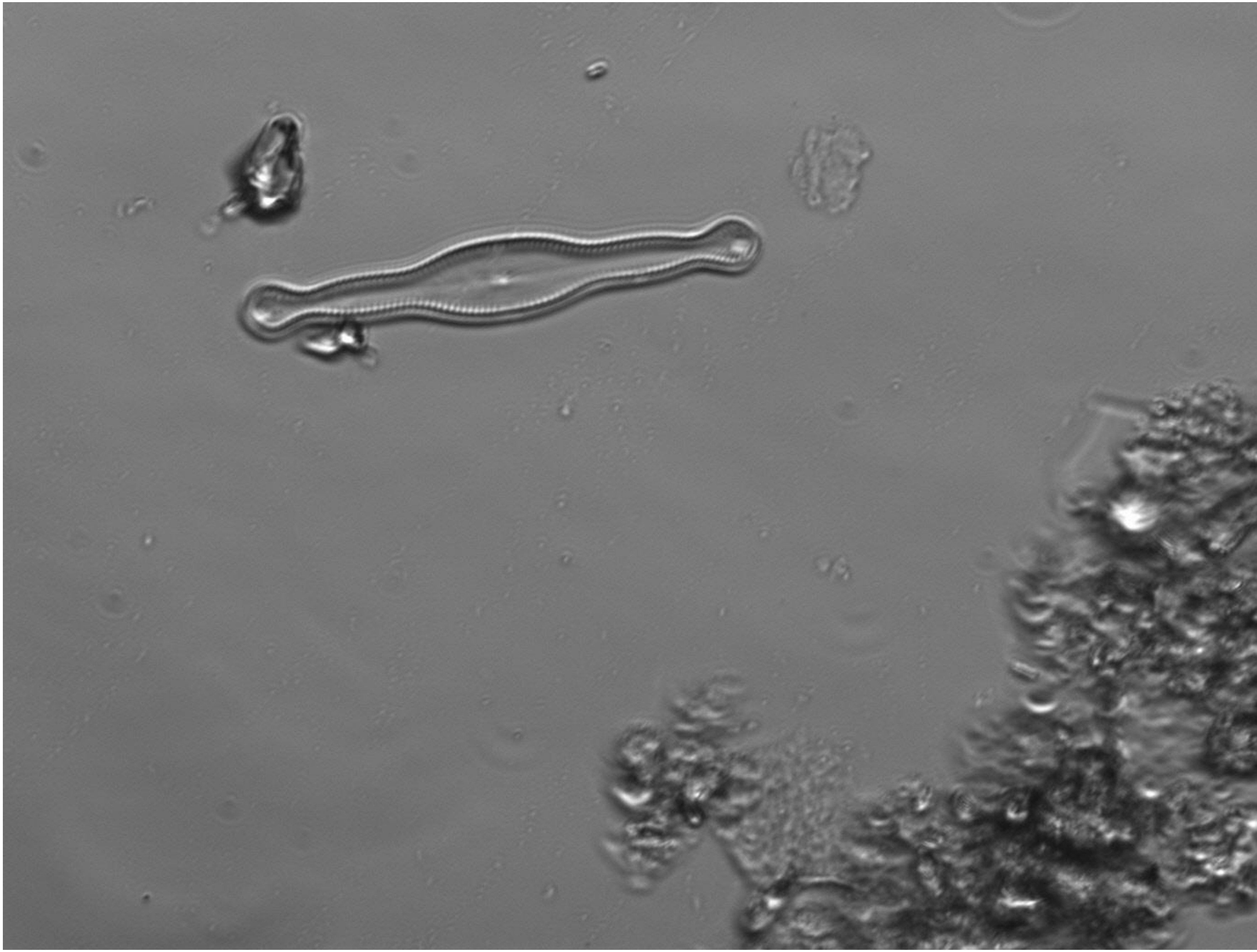
Augusta State University

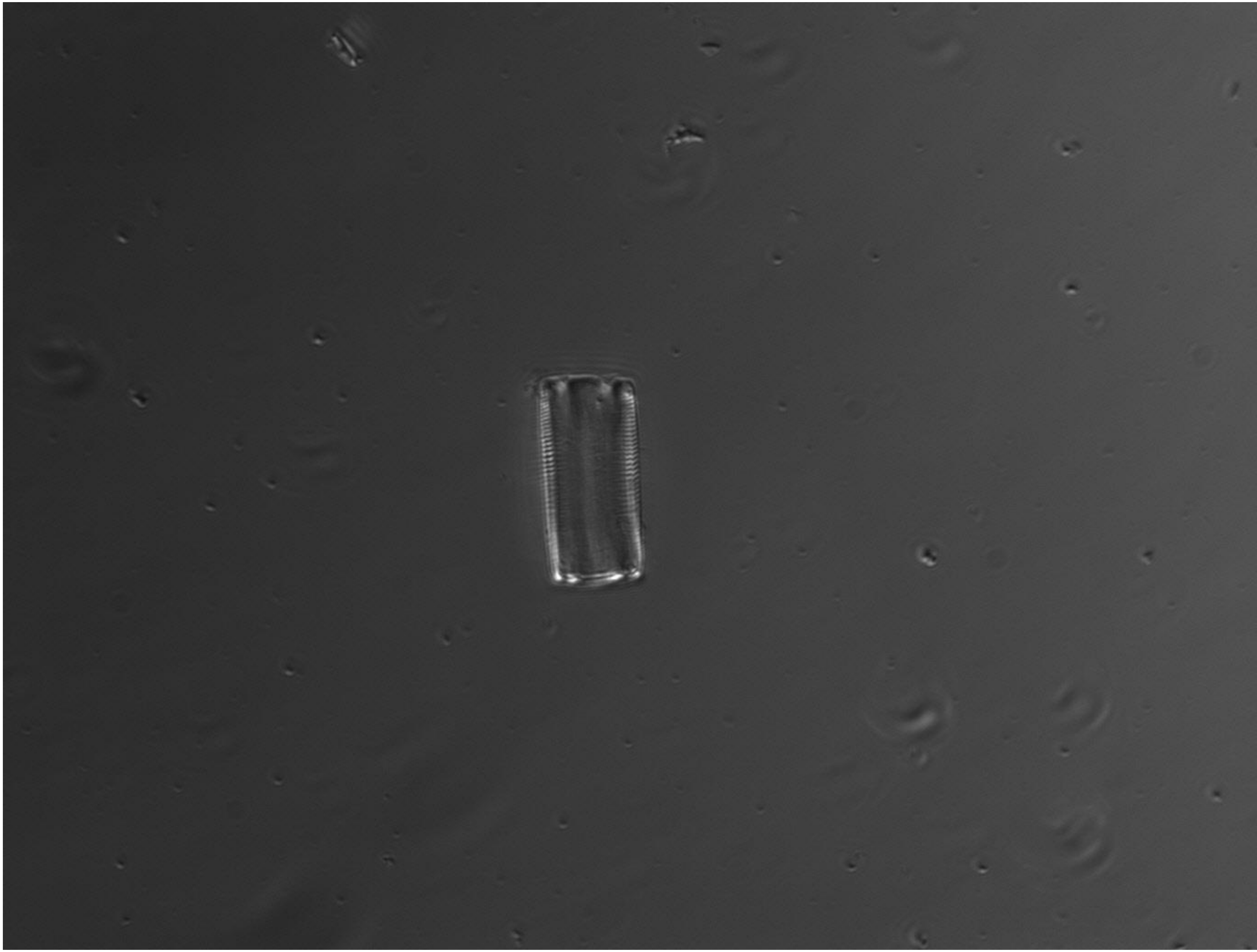
February 2012

Dr. Bran Cromer









Toxicity of Dieldrin to *Ceriodaphnia dubia* Acclimated to Water from a Potentially-Contaminated Constructed Wetland

UNIVERSITY OF SOUTH CAROLINA AIKEN

Heather Mentrup and S. Michele Harmon, PhD — Department of Biology and Geology,
The University of South Carolina-Aiken, Aiken, South Carolina 29801

Abstract

Dieldrin is classified as a highly toxic synthetic organochlorine pesticide that was used on U.S. crops from the 1950s until 1970 and for termite control until 1987. Concentrations of dieldrin persist in the environment because of the low volatility, chemical stability and lipophilic properties of the compound. Dieldrin degrades very slowly in both soil and water resulting in high bioaccumulation. It binds to the soil and can remain unchanged for decades. Dieldrin is highly toxic to humans, mammals and aquatic life. This pesticide was recently detected in the soil of a newly constructed stormwater treatment wetland. Because of the toxic properties of this pesticide, it has the potential to be detrimental to aquatic life as this wetland develops. This study demonstrates the toxic effects of dieldrin to a population of *Ceriodaphnia dubia* acclimated to water collected from this particular constructed wetland. The LC_{50} values for dieldrin in reconstituted laboratory water and water from the newly constructed wetland were 66.6 and 75.3 ppb, respectively.

Introduction

Constructed wetlands are artificial wastewater treatment systems that rely heavily on natural microbial, biological, physical, and chemical processes to treat wastewaters and improve water quality[1]. Constructed wetlands are generally shallow ponds or channels lined with impervious clay or synthetic liners. They are also planted with aquatic vegetation. Implementation of engineered structures enables control of flow direction, liquid detention time and water level.

Fig. 1. Pre-constructed wetland.

Fig. 2. Inundation of wetland after grading has occurred.

Constructed wetlands have been used to treat various types of wastewaters including urban runoff, municipal, industrial, agricultural, and acid mine drainage[1]. They treat various wastewaters by removing suspended solids, organic matter, pathogens, nutrients, and heavy metals. Constructed wetlands offer a cost-effective and low-maintenance solution to enhance water quality[2]. In addition, they promote habitat restoration and mitigate flooding.

Recently, 30 acres of upland and wetland habitat along the Savannah River was retrofitted to treat stormwater from a small municipality. On this site, 23 acres of ponds (borrow pits) exist from an abandoned brick-manufacturing facility. One of the existing ponds was engineered into a constructed wetland and will receive stormwater. The remaining ponds and the last 7 acres of uplands are also being enhanced to improve the ascetic appeal to the community enabling this site to function as an educational ecological park.

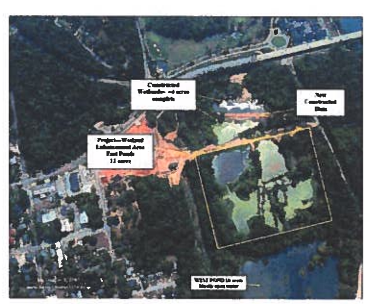


Fig. 3. Arial view of 30 acres of wetland and upland along Savannah River that is being retrofitted.

Fig. 4. Planting of constructed wetland.

Fig. 5. American Bullfrog found in wetland.

Fig. 6. Flow of municipal stormwater during a normal rain event.

Pesticide Under Study

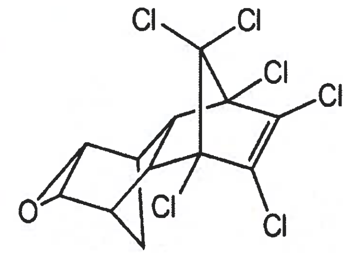


Fig. 7. Structure of Dieldrin (Courtesy of Wikapedia)

Dieldrin is classified as an organochlorine cyclodiene, and is highly persistent in the environment[3]. Concentrations of dieldrin persist in the environment because of the low volatility, chemical stability and lipophilic properties of this compound[4]. Dieldrin degrades very slowly in both soil and water resulting in high bioaccumulation[3].

Dieldrin is highly toxic to humans, mammals and aquatic life[5]. This pesticide is highly toxic because of its ability to first enhance, followed by suppression of gamma- aminobutyric acid (GABA)[6]. The suppression of GABA affects induced chloride currents resulting in hyperexcitation of the central nervous system followed by convulsions, which potentially results in paralysis[7].

In this case, dieldrin is of concern because it was detected in the soil of the newly constructed wetland previously described.

Test Organism

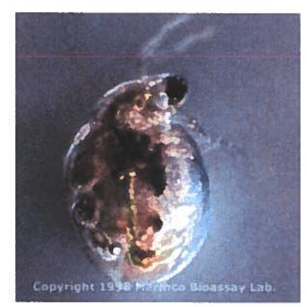


Fig. 8. *Ceriodaphnia dubia*

Ceriodaphnia dubia are small crustaceans that are in the littoral area of lakes, ponds and marshes throughout the world. According to the Environmental Protection Agency (EPA), *Ceriodaphnia dubia* is the recommenced freshwater invertebrate for both acute and chronic toxicity tests. In acute toxicity tests, less than 24-hour old *Ceriodaphnia* (neonates) are used to measure the lethal effects of contaminants.

Methods

Ceriodaphnia dubia neonates were exposed to dieldrin in a standard 48-hour static acute toxicity test following methods prescribed by USEPA[8]. Dieldrin was added in an ascending series of six concentrations (50, 75, 100, 150, 200, and 400 ppb) to water collected from the wetland along with a control. A second side-by-side test using laboratory reconstituted water was conducted as a comparison.

Fig. 9. Setting up toxicity test.

There were three replicate exposures per treatment with each replicate containing ten *Ceriodapnia dubia*. Mortality data was observed after a 48-hour period. These data were then analyzed using the Trimmed Spearman Karber method of median determination to identify the concentration that was lethal to 50% of the test organisms (i.e., the LC_{50}).

Basic Experimental Design

- ➢2 mediums: water from constructed wetland
  moderately hard reconstituted water
- ➢ 7 treatments: control, 50, 75, 100, 150, 200, and 400 ppb of dieldrin
- ➢3 replicates per treatment
- ➢10 test organisms per replicate
- ➢48-hour exposure period

Endpoint: mortality

Results & Conclusion

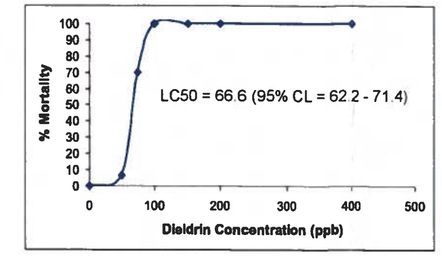


Fig. 10. Analytical graph of *C. dubia* mortality data acclimated in moderately hard reconstituted water.

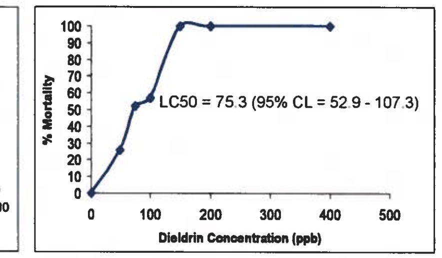


Fig. 11. Analytical graph of *C. dubia* mortality data acclimated in water from newly constructed stormwater wetland.

After analyzing the data, it was determined that the LC_{50} of dieldrin in moderately hard reconstituted water was 66.6 ppb, and for the water from the newly constructed wetland, the LC_{50} was 75.3 ppb. The 95% confidence intervals overlap.

Dieldrin was detected in the soil at 6.9 µg/kg soil before inundation, and 4.5 µg/kg soil after inundation. Thus far, this pesticide has not migrated to the water column.

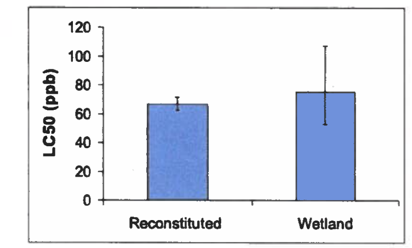


Fig. 12. Comparison of LC_{50} between moderately hard reconstituted water and water from the constructed wetland.

Literature cited

1. USEPA. 2000. Constructed wetlands treatment of municipal wastewaters. US Environmental Protection Agency, Office of Research and Development. EPA/625/R-99/010. Cincinnati, OH.
2. Knight RL, Payne, Jr. VW, Borer RE, Clarke, Jr., Pries JH. RA. 2000. Constructed wetlands for livestock wastewater management. Ecological Engineering 15:41-55.
3. ATSDR. 2002. Public health statement for aldrin/dieldrin. [Internet]. Atlanta, GA: Agency for Toxic Substances & Disease Registry (ATSDR).; c2002 [cited 2008 Jan 29]. Available from http://www.atsdr.cdc.gov/toxprofiles/phs1.html.
4. Jorgenson JL. 2001. Aldrin and dieldrin: A review of research on their production, environmental disposition and fate, bioaccumulation, toxicology, and epidemiology in the United States. Environmental Health Perspectives 109:113-139.
5. Dieldrin- identification, toxicity, use, water pollution potential, ecological toxicity and regulatory information. [Internet]. San Francisco, CA:Kegley S, Hill B, Orme S;c2007 [cited 2008 Jan 29]. Available from http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC33416.
6. Nagata K, Narahashi T. 1995. Multiple actions of dieldrin and lindane on the GABA(A) receptor-chloride channel complex of rat dorsal root ganglion neurons. Pesticide Science 44:1-7.
7. Narahashi T, Frey JM, Ginsburg, KS, Roy, ML. 1992. Sodium and GABA-activated channels as the targets of pyrethroids and cyclodienes. Toxicology Letters 64-65:429-436.
8. USEPA. 2002. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms. 5th ed. Washington, D.C

Acknowledgment

This work was funded by the USC Aiken Department of Biology and Geology.

Brick Pond Park
Sample Event
October 29, 2015

HF-02 is the groundwater sample from Parking Deck

HF-11 is the same water as it enters the Brick Pond Park perched wetland

HF-10b is the location where the water drops down into the stormwater treatment wetland

HF-16 is the location on the other side of the treatment wetland (presumably – water that has been treated)

Based on this data and the historical data, it appears that the water quality from the groundwater seep has improved since the parking deck was built due to removal of tons of debris and trash. The TCE plume, is still present but the treatment system cleans it and other problems.