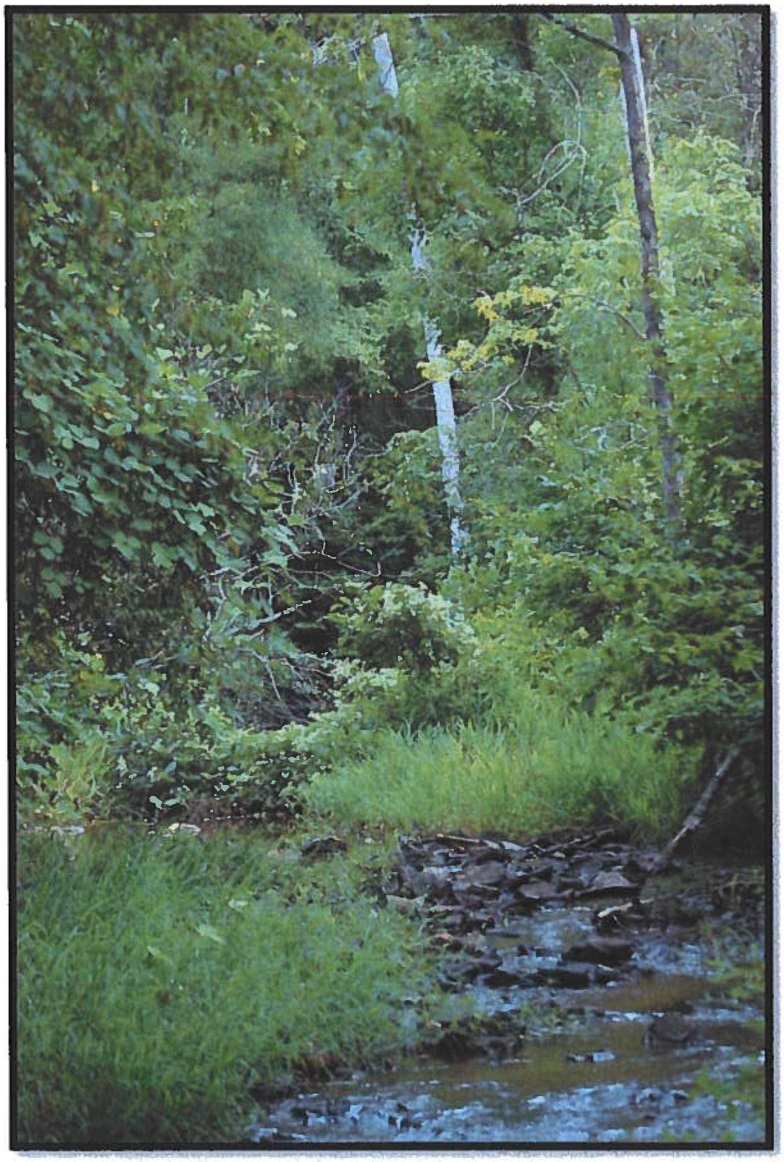
North Augusta
South Carolina's Riverfront

STORMWATER MANAGEMENT

NORTH AUGUSTA
WATER QUALITY & STREAM ASSESSMENT 2007 to 2020



April 2021

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Acknowledgements:

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

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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?
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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
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Tripp Swicord, USC	Engineer, Charlotte, NC
Matt Murphy, Citadel	Police Officer, Aiken
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Clark Mullins, Lander University	High School Teacher, Gilbert, SC
Patrick Bagwell, Georgia Southern	Water Contractor, Austin, TX
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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!

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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.

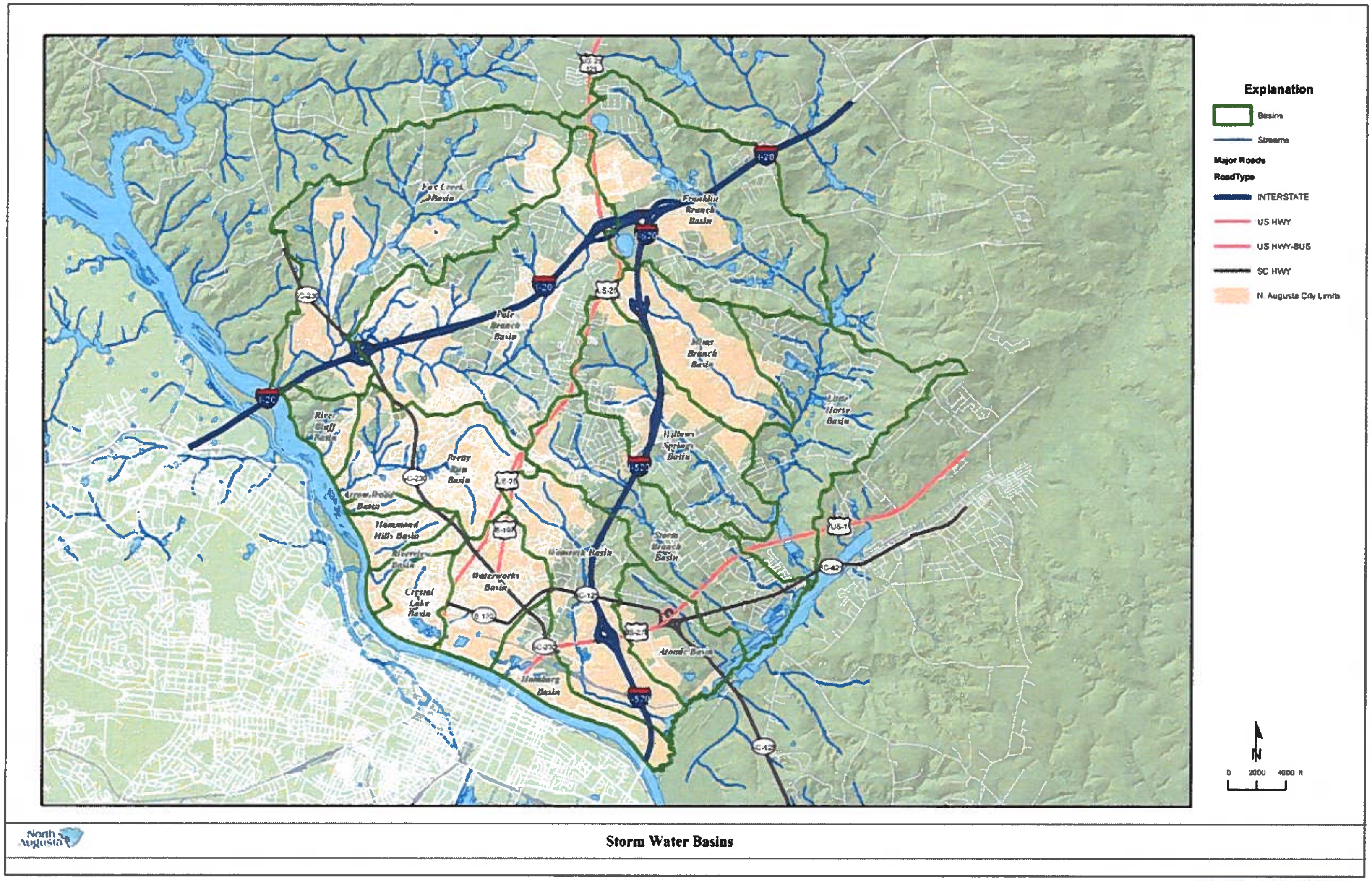

Figure 2.1: North Augusta Watershed Basins Map

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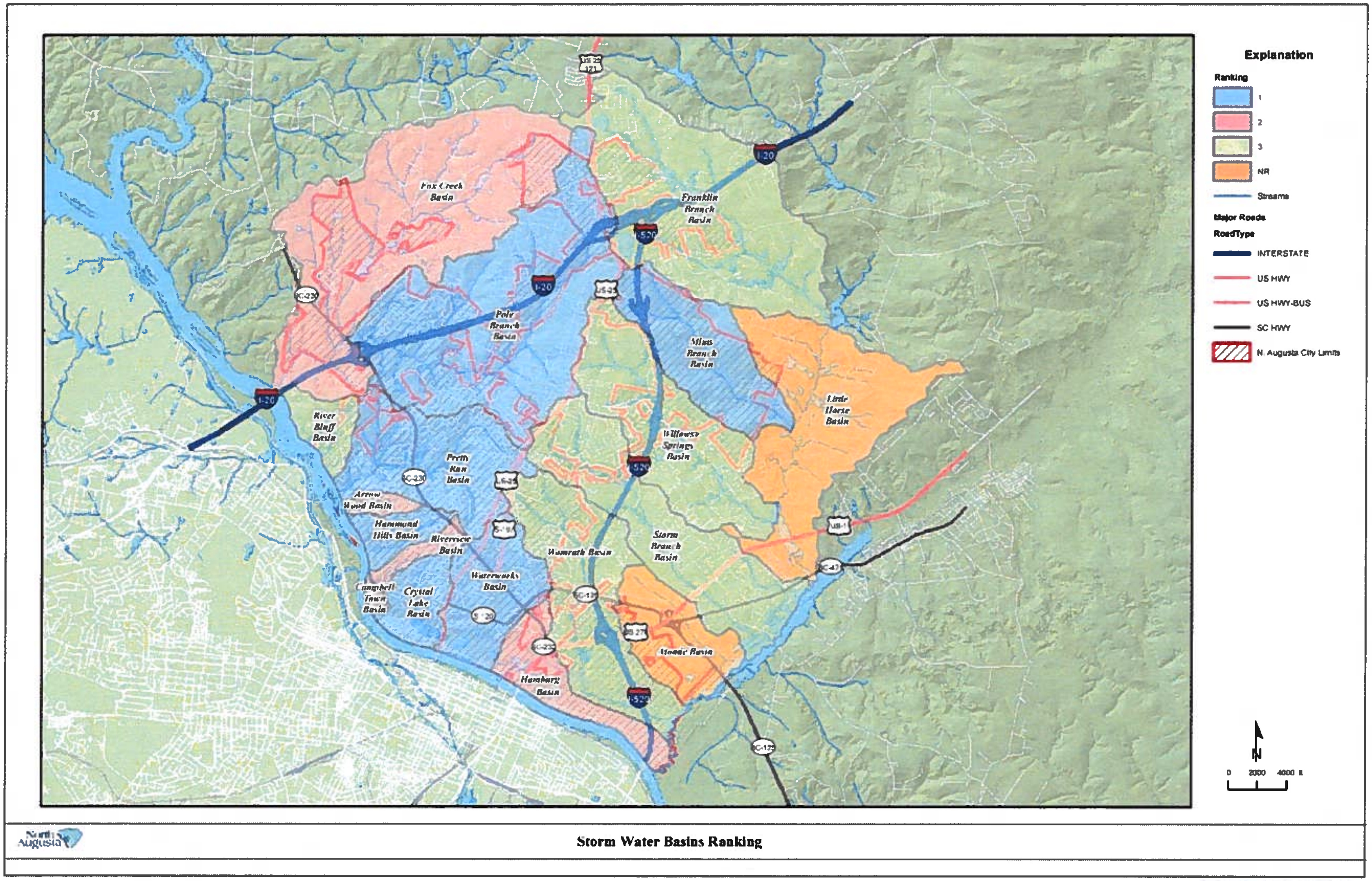

Figure 2.2: North Augusta Basin - Priority Map

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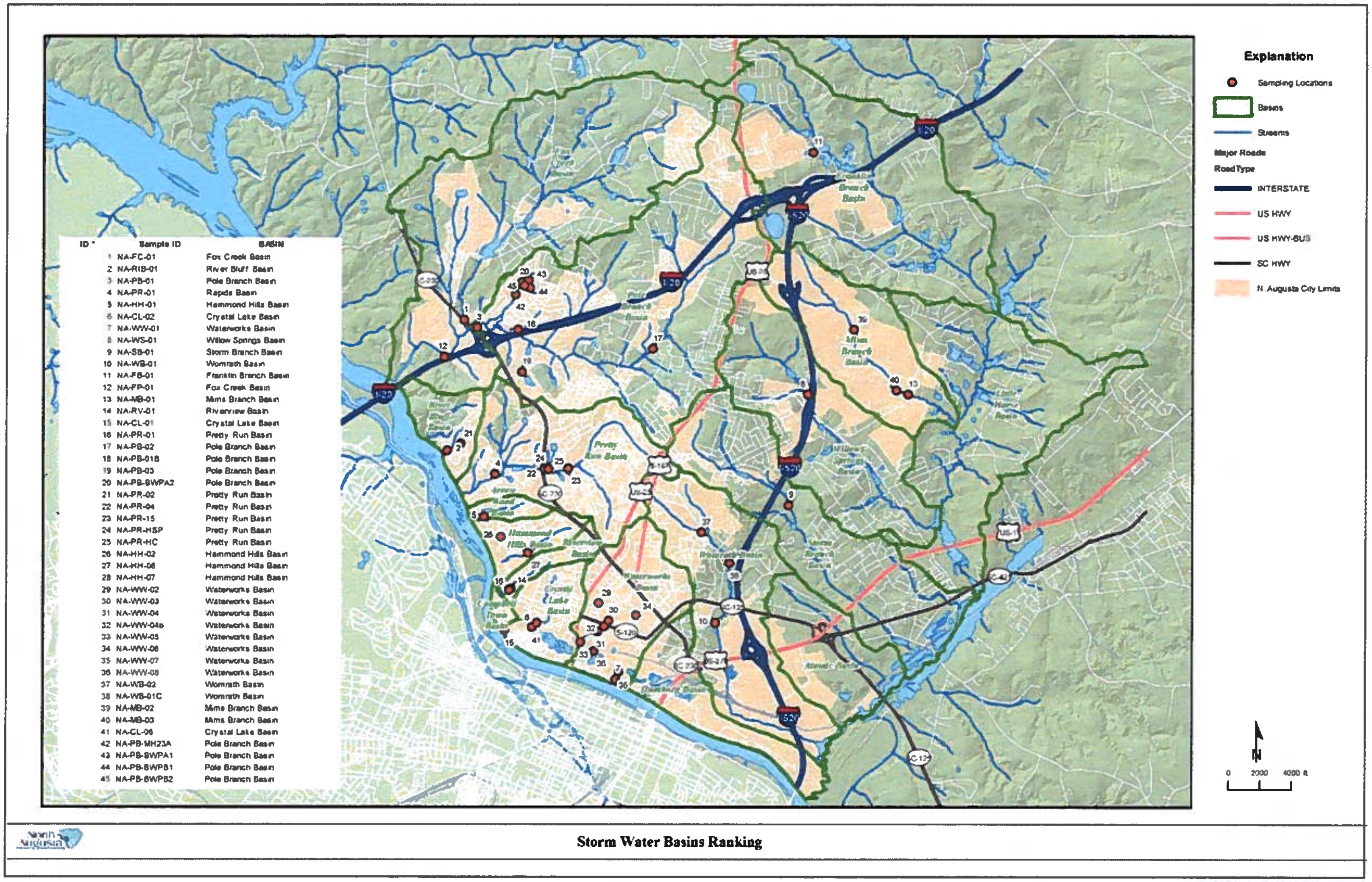

Figure 2.3: North Augusta Stream Sampling Locations Map (some not shown, see Appendix C for complete list).

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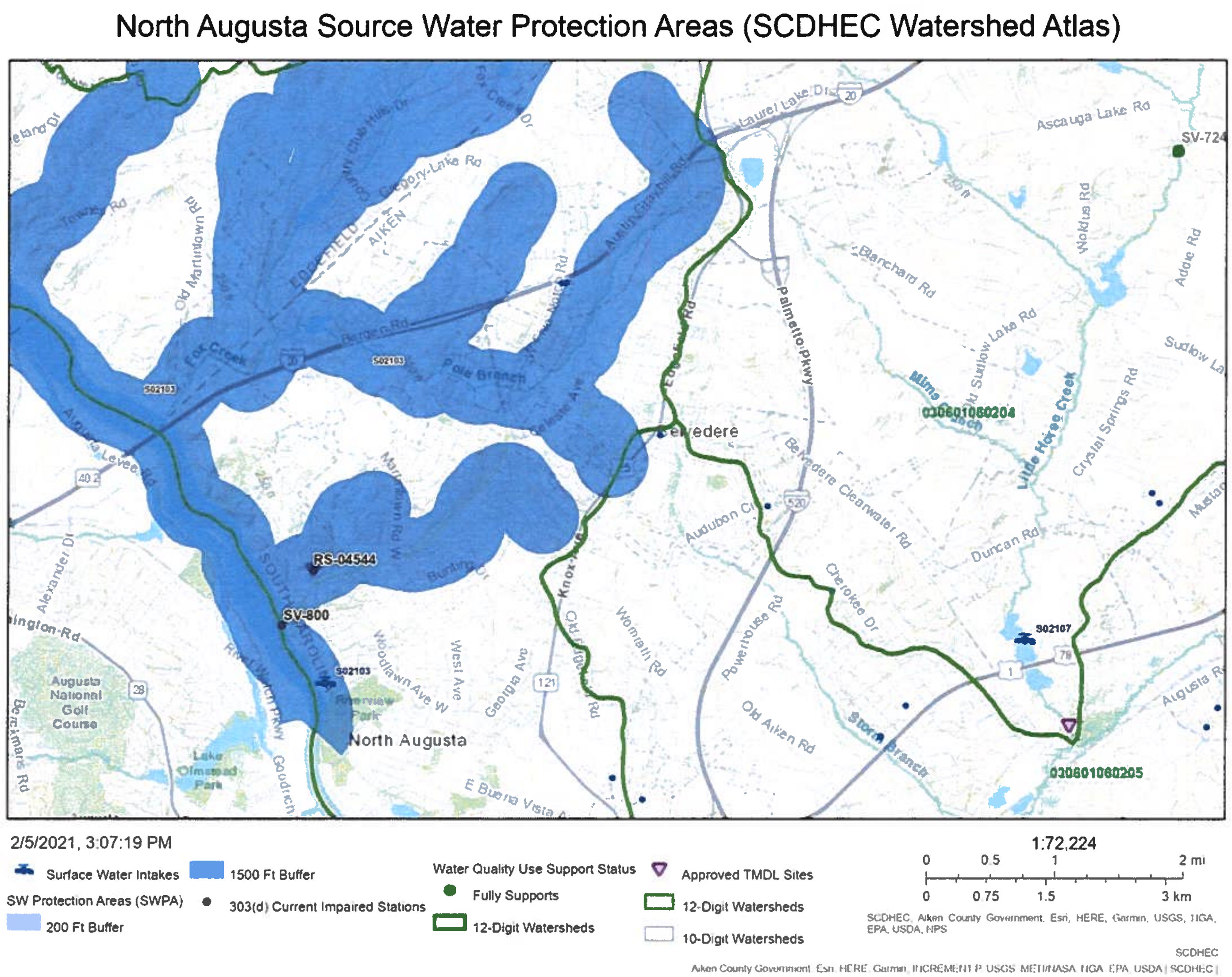

Figure 2.4: City of North Augusta Source Water Protection Area Map (source: SCDHEC GIS MAP)

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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.

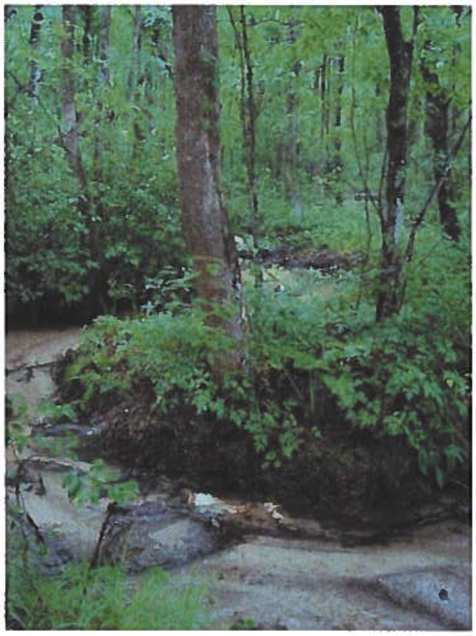
3.2 Mims Branch Sampling Results & Discussion: GOOD TO EXCELLENT

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.

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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

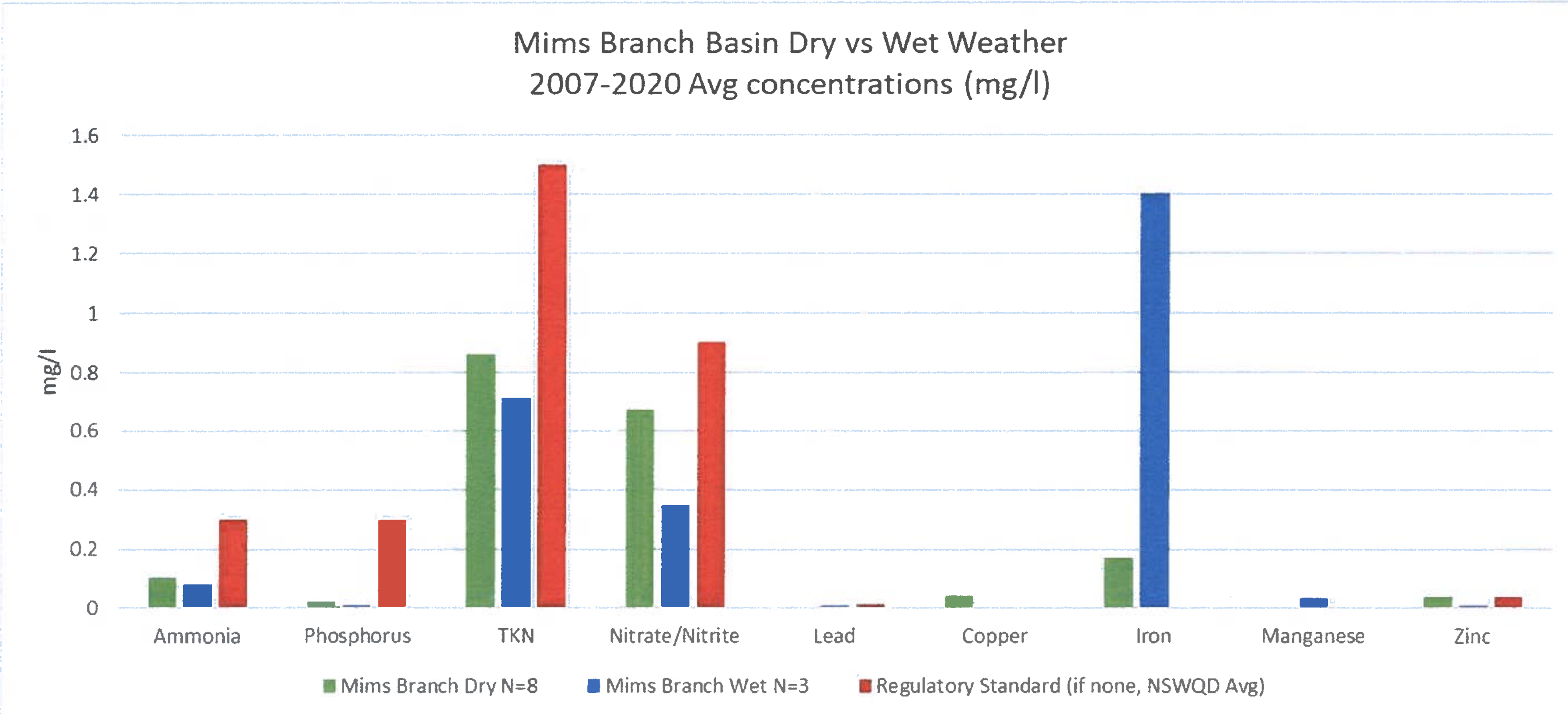
Parameter Tested	05/14/07 NAMB01	05/15/08 NAMB01	08/19/09 NAMB01	08/11/11 NAMB02	09/22/11 NAMB02	04/13/18 NAMB02	05/06/20 NAMB02	06/25/20 NAMB01 Wet	State Avg[1]	EPA or State STD or Guideline[2,3]
Lead (mg/l)	0.0046	-	n/d	n/d	n/d	-	n/d	n/d		0.014 mg/l (CMC Aq), 0.0005 mg/l CCC aq (0.0007 mg/l state), 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



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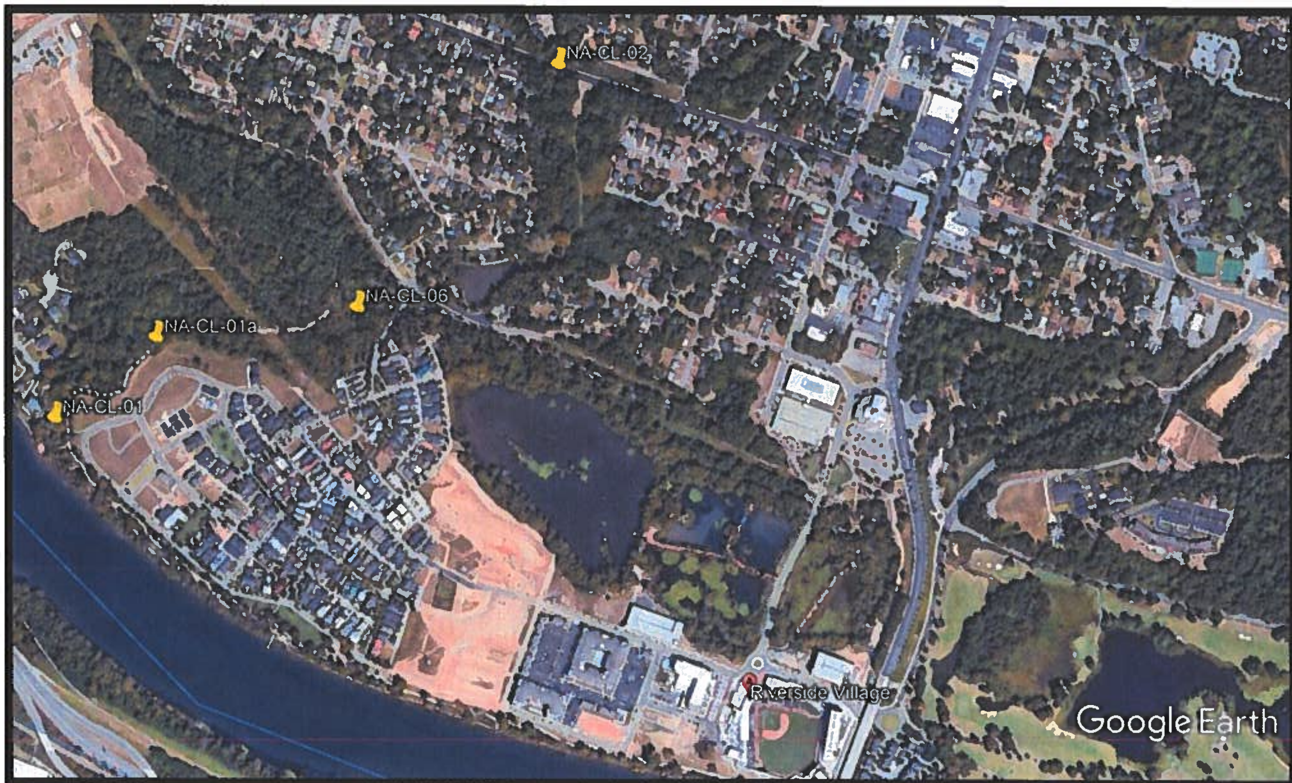
4.0 Crystal Lake Basin



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.

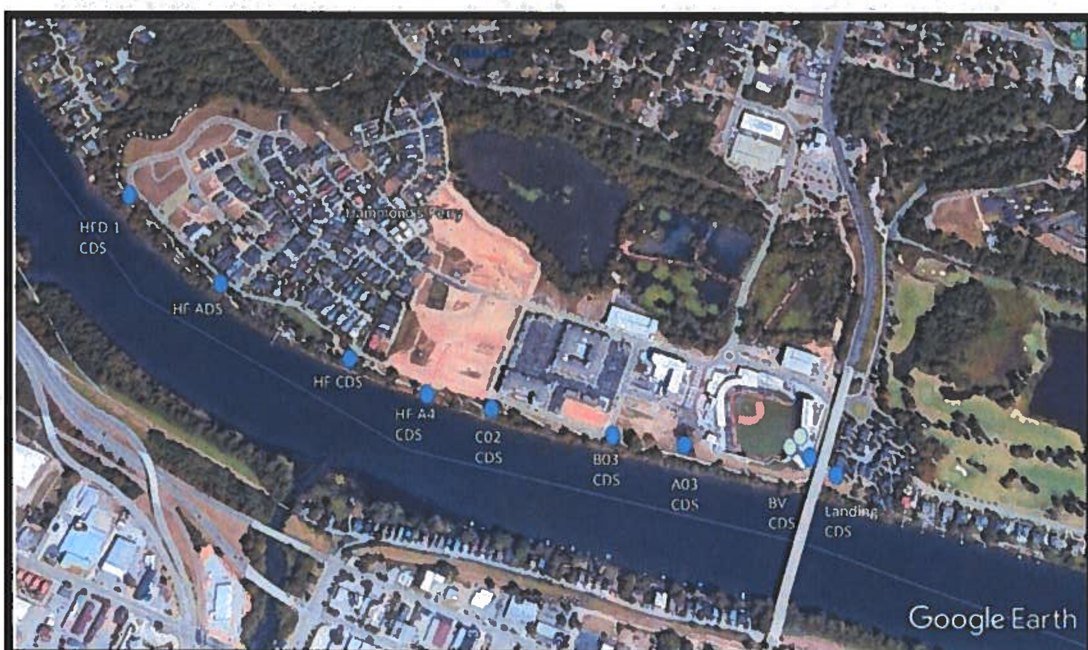


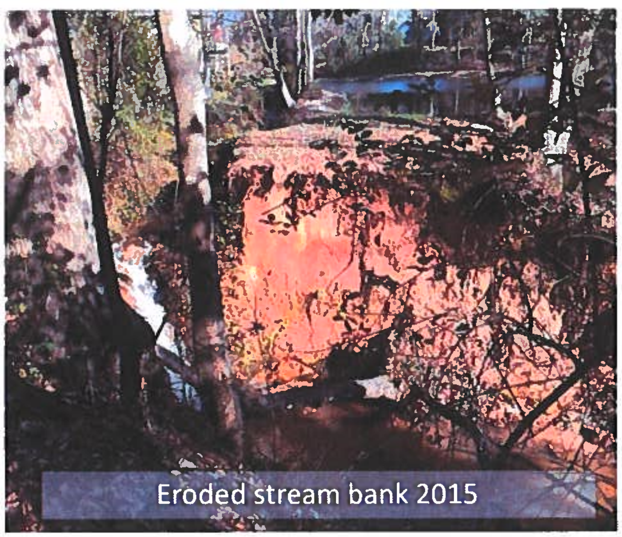
Figure: 4.1 North Augusta Riverfront development underground stormwater treatment unit locations.

4.4 Stream channel integrity in the basin – FAIR TO POOR

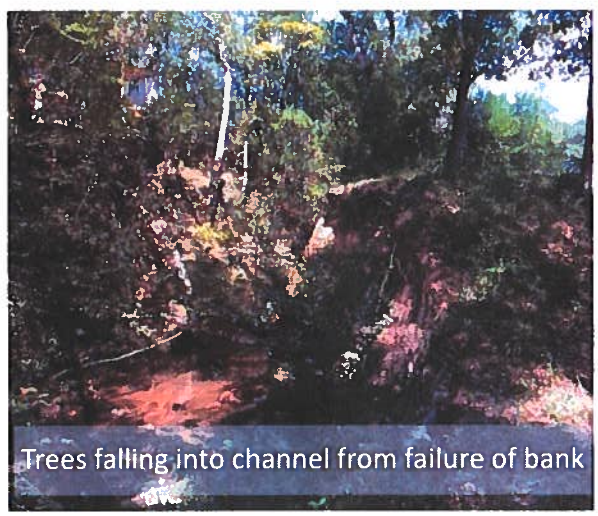
The top of the basin has a stream reach that has all been piped over the years. Water from the residential areas at the top of the basin above W. Woodlawn, drain into the system and is channeled through pipes the outfall into the Mokateen Pond drainage way (at W. Woodlawn by Lake Ave). The stream channel 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)

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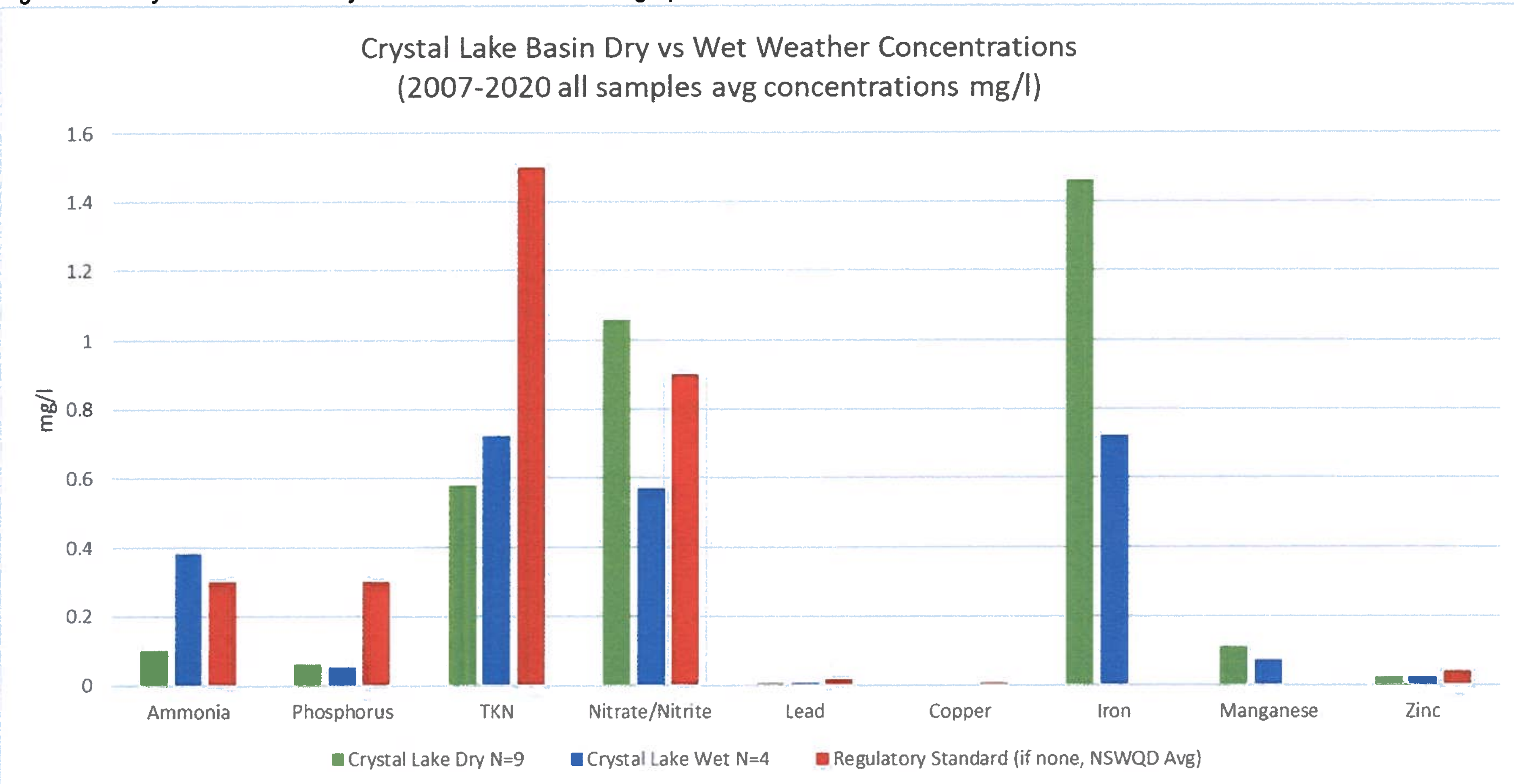
Figure 4.2: Crystal Lake Data Dry Vs Wet Weather Results graph



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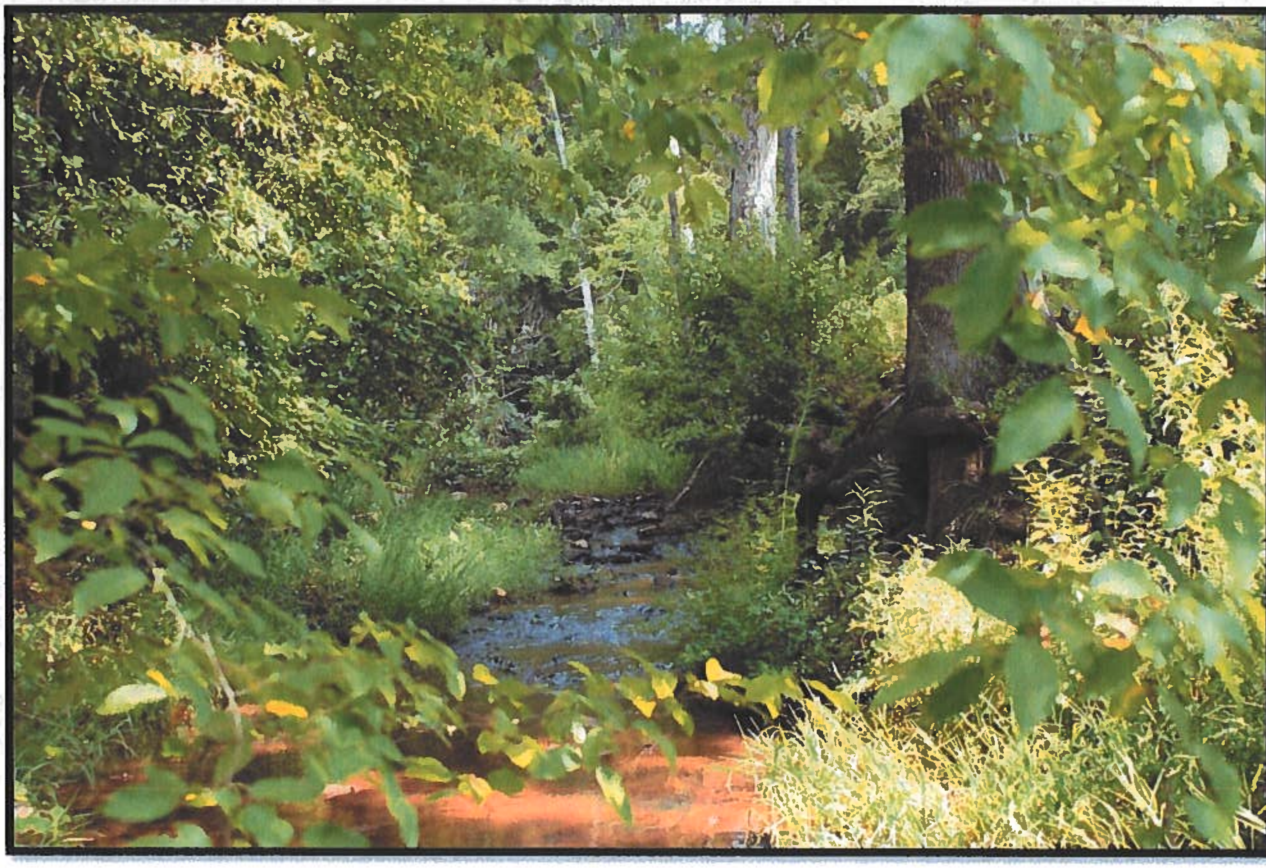
5.0 Fox Creek Basin



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.

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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)

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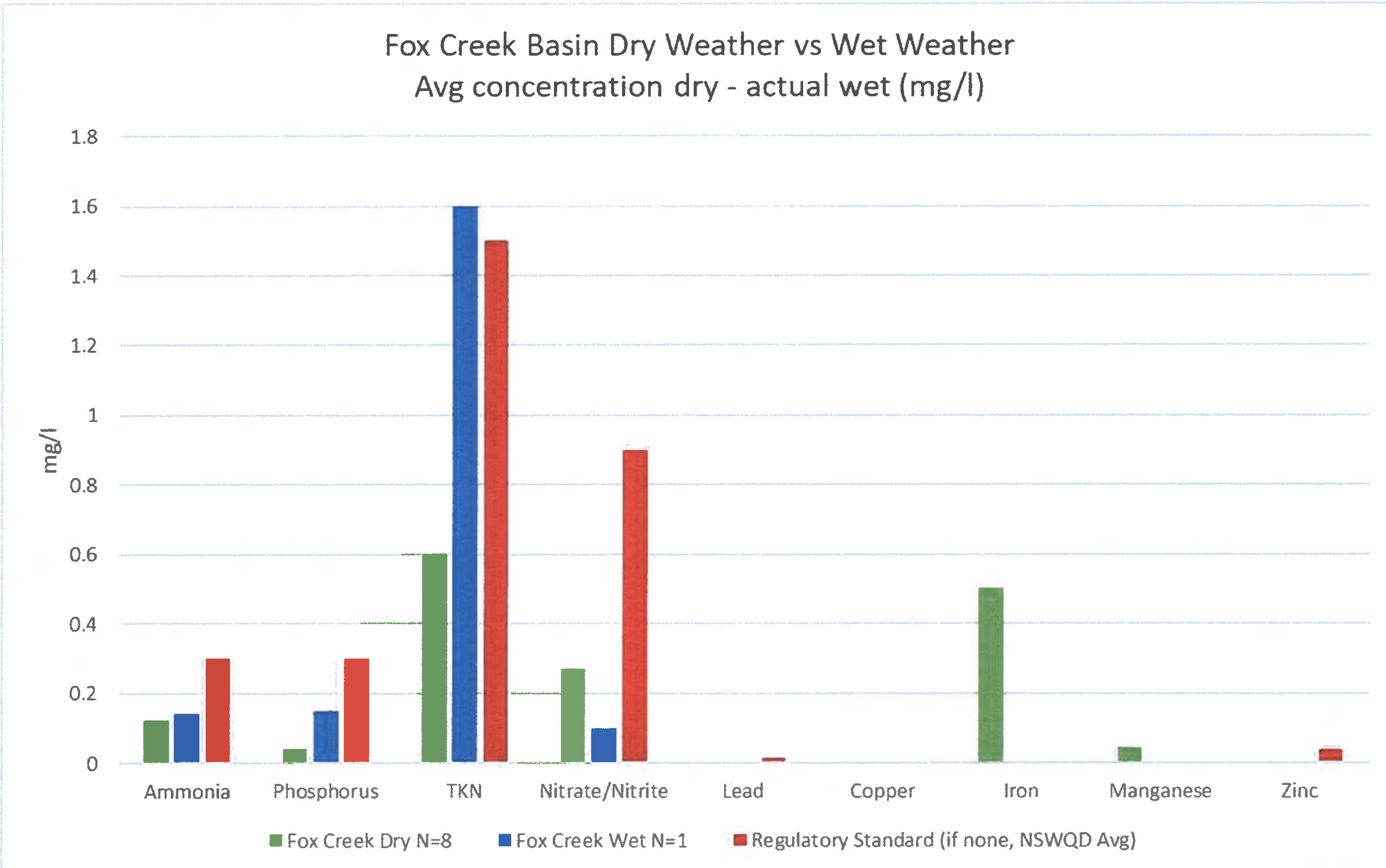
Figure 5.1: Fox Creek Data Dry Vs Wet Weather Results graph



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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.

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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	<0.08 4	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)

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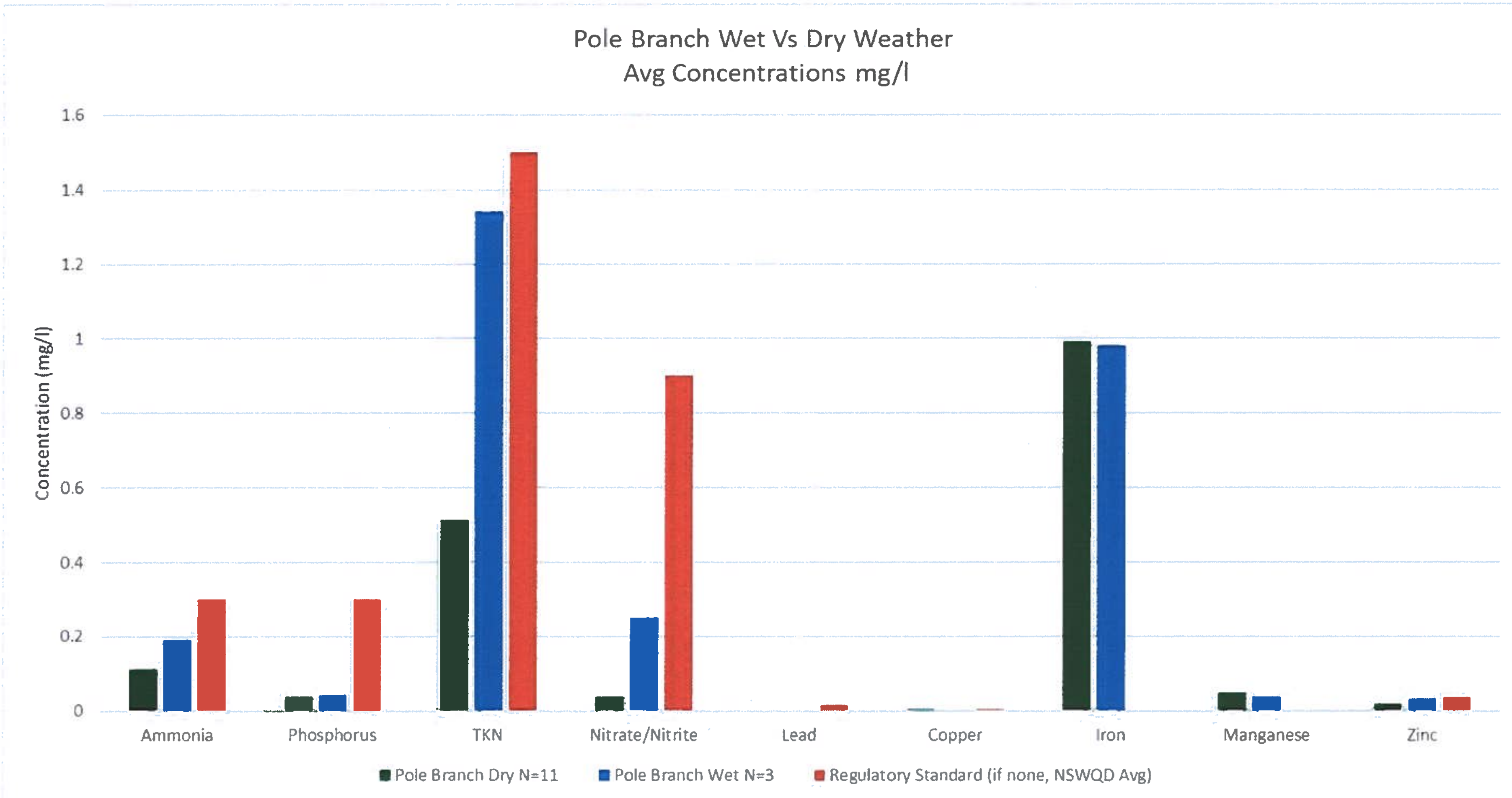
Figure 6.1: Pole Branch Data Dry Vs Wet Weather Results graph



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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)

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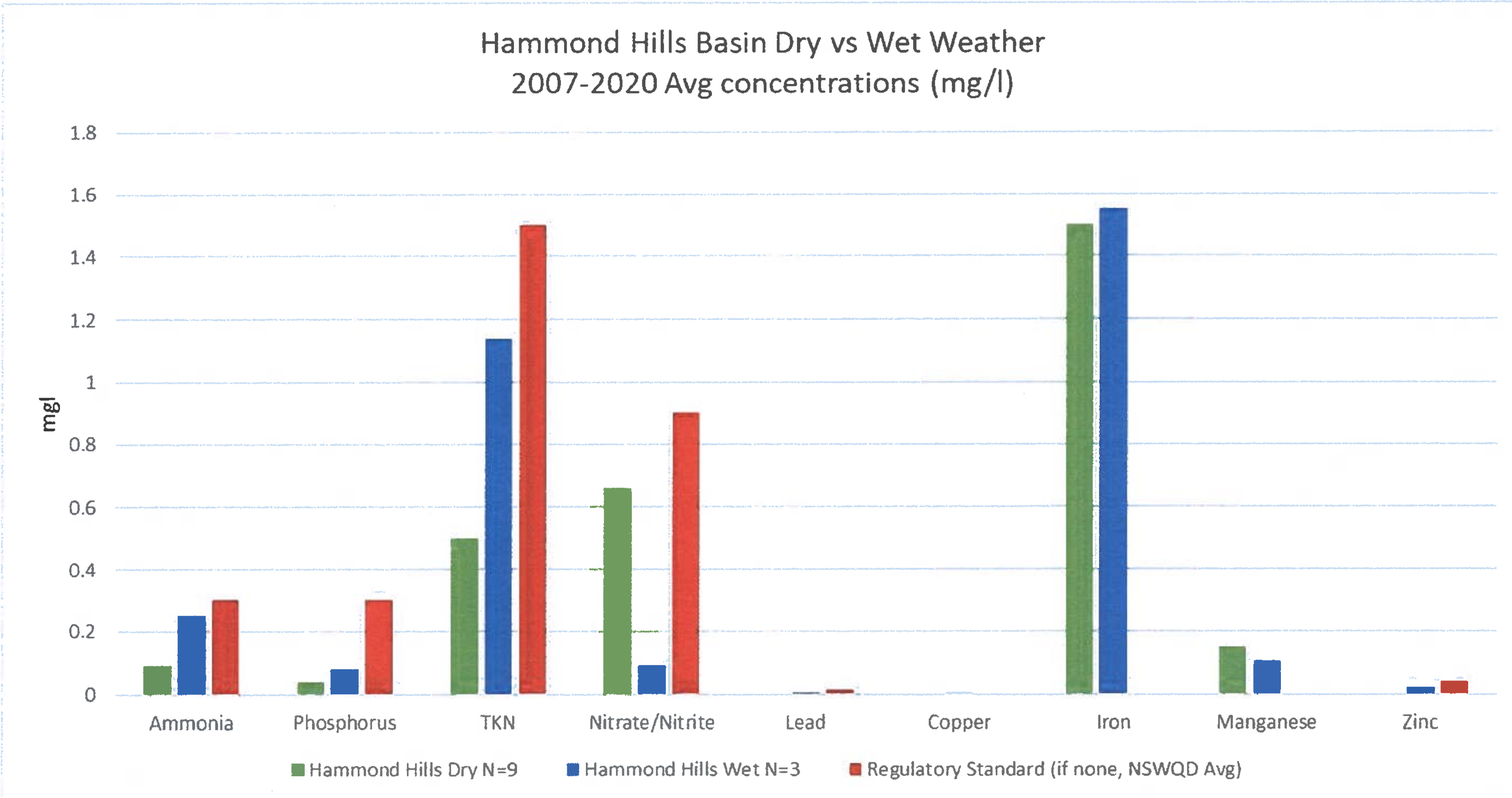
Figure 7.1: Hammond Hills - Data Dry Vs Wet Weather Results graph



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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.

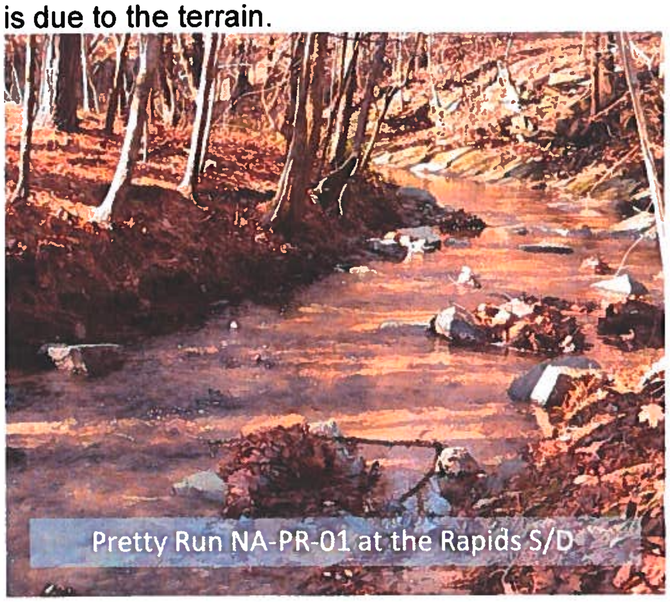
We continue to conduct routine monitoring of Pretty Run basin. We also look for ways to reduce human or pet sources to Pretty Run Creek. We see a lot of opportunity for improvement and we will implement projects to reduce our impacts to it. As for wildlife concentrating within the wooded and stream corridors 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

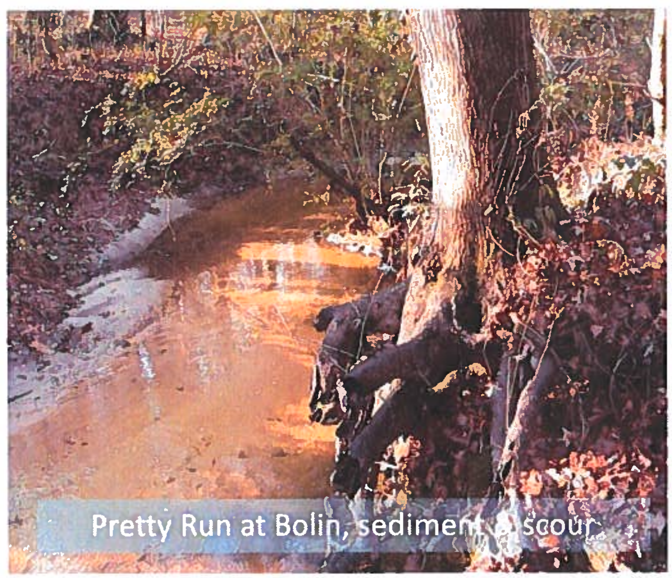
The development within Pretty Run basin was significant since the 1950's and the basin is reaching about 68% developed with only a few larger tracts of land still undeveloped and in private ownership. Over the past 10 years, we have seen about 48 acres of disturbances from construction within the basin 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.

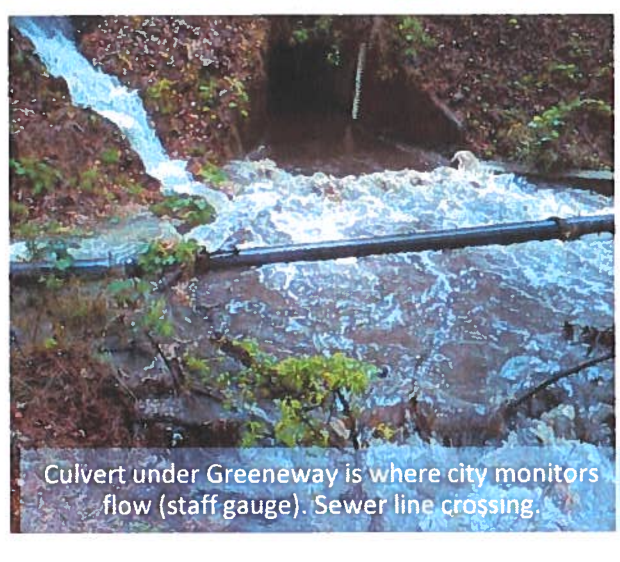


Pretty Run NA-PR-01 at the Rapids S/D



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)

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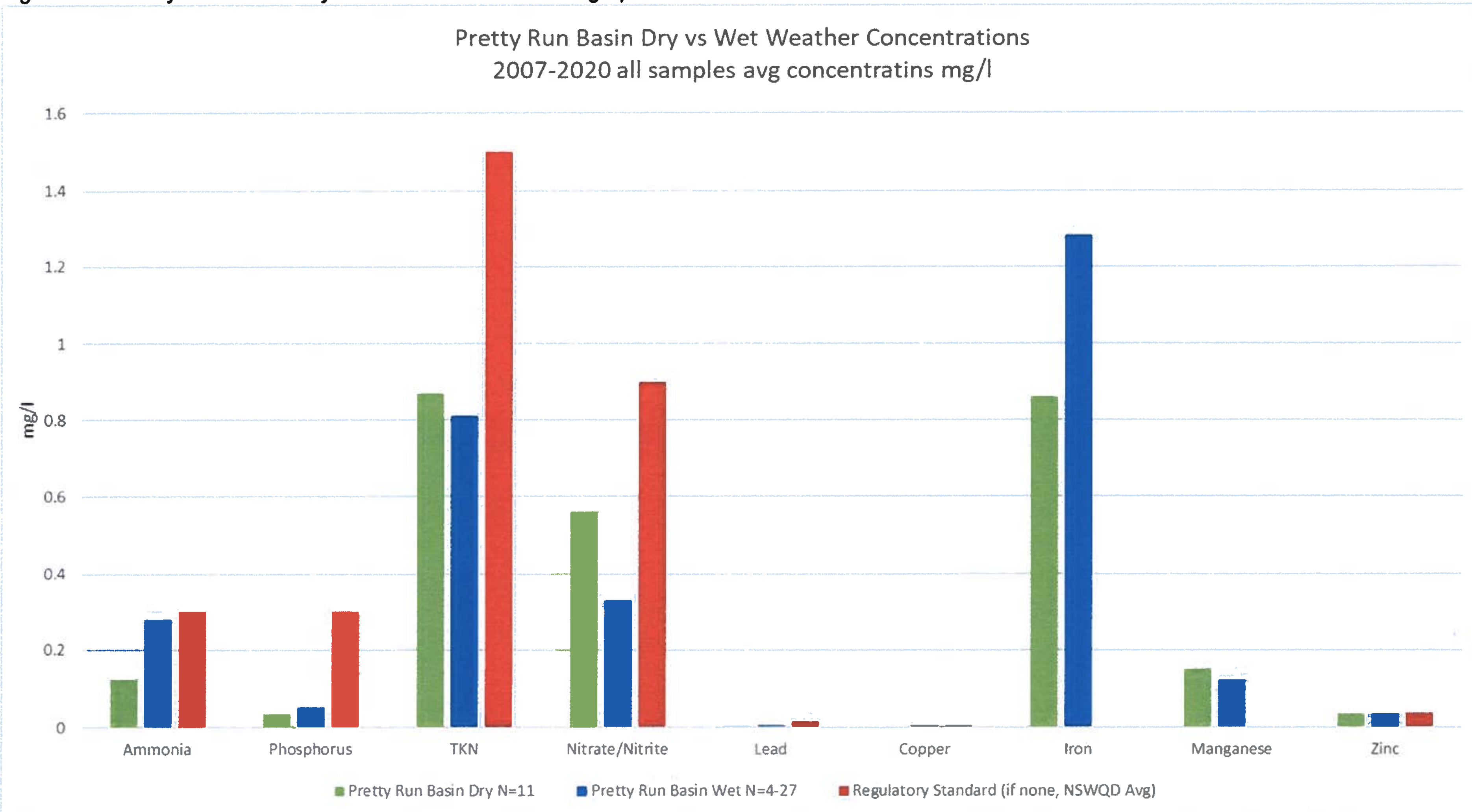
Figure 8.1: Pretty Run Data - Dry Vs Wet Weather Results graph



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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.

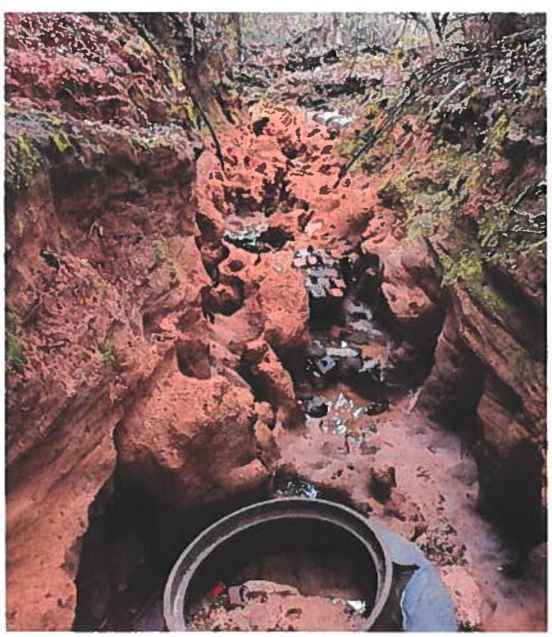

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Table 9.1. 2007-2020 Water Quality Sampling Results for Water Works Basin

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)

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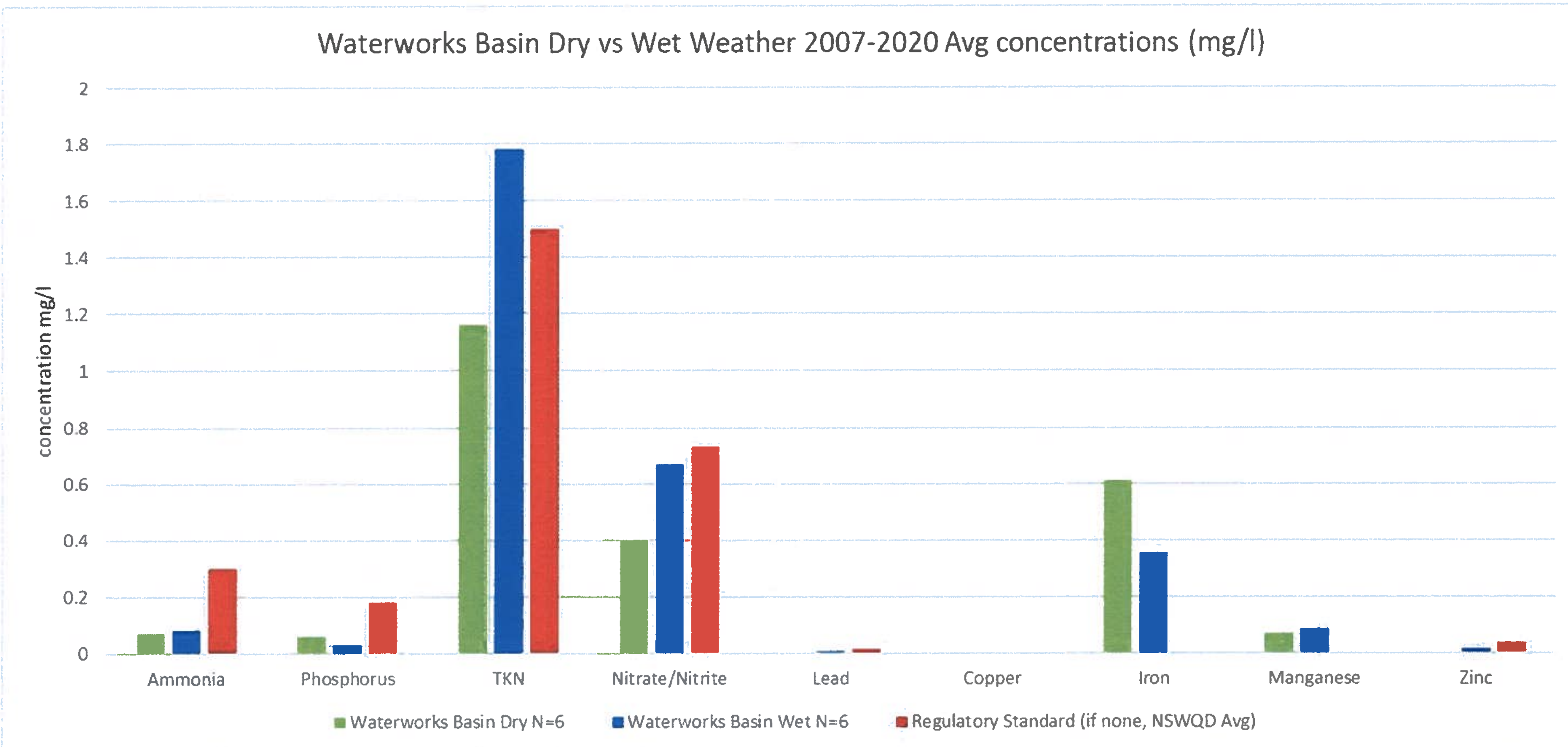
Figure 9.1: Waterworks Data Dry Vs Wet Weather Results graph



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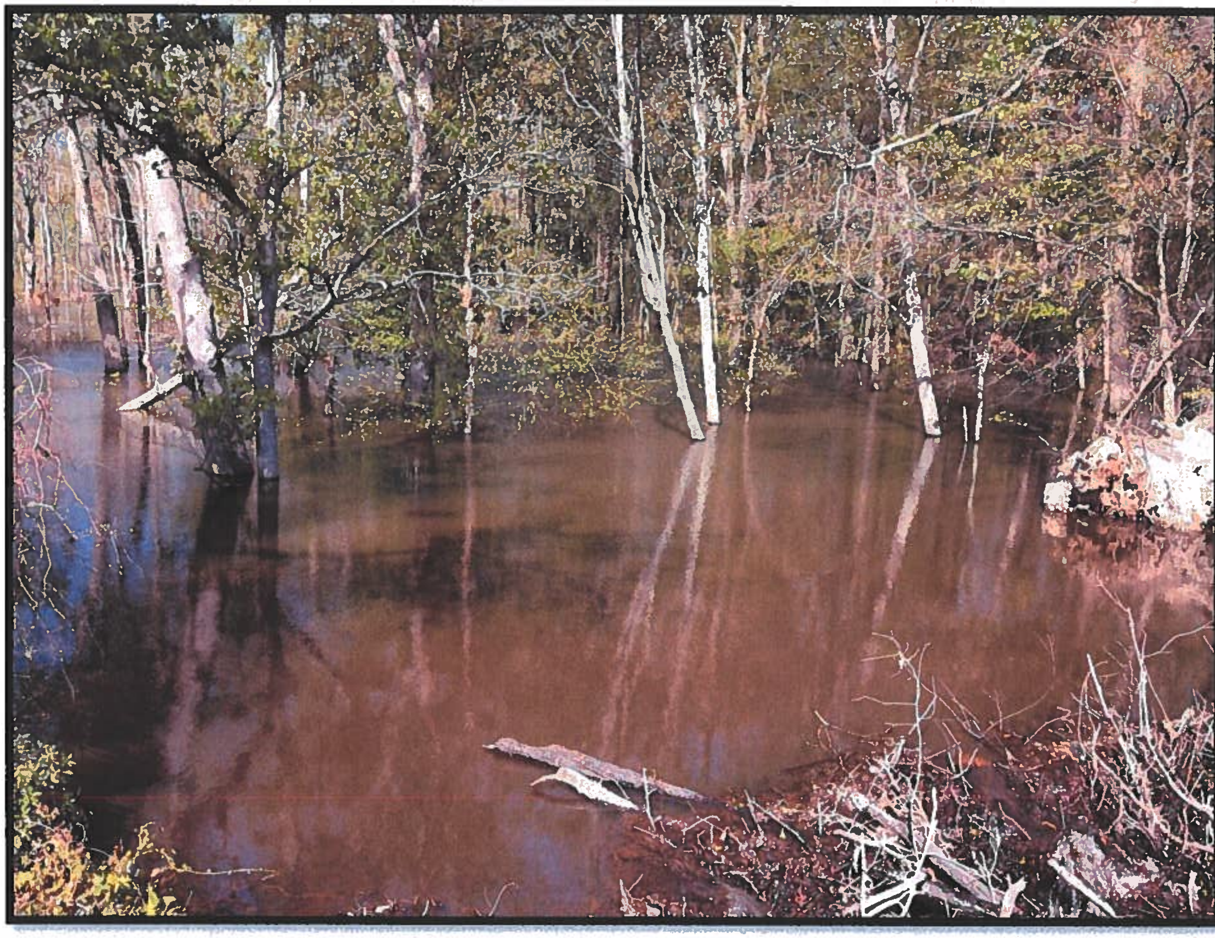
10.0 Womrath Basin



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)

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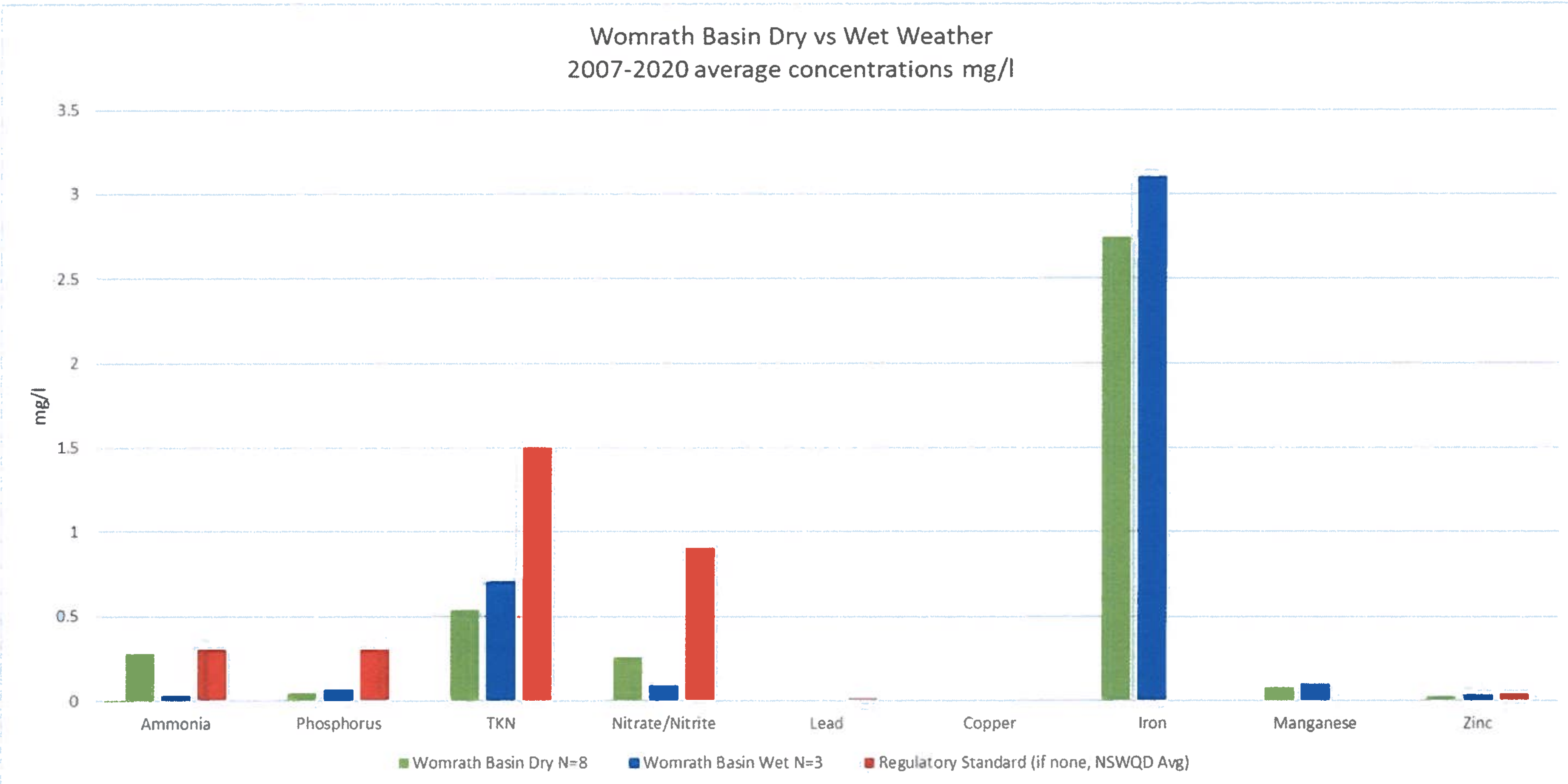
Figure 10.1: Womrath Basin Data - Dry Vs Wet Weather Results graph



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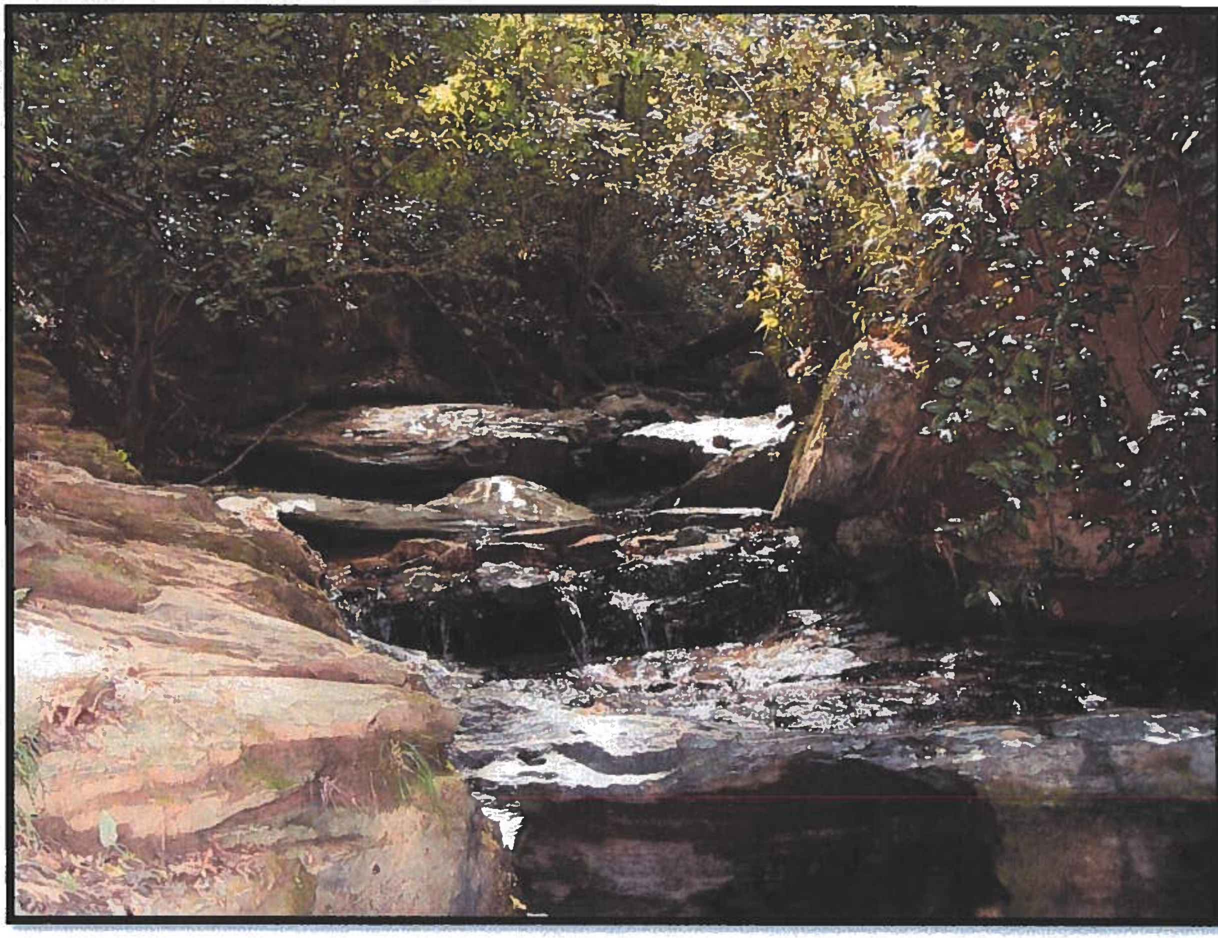
11.0 Riverview Basin



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)

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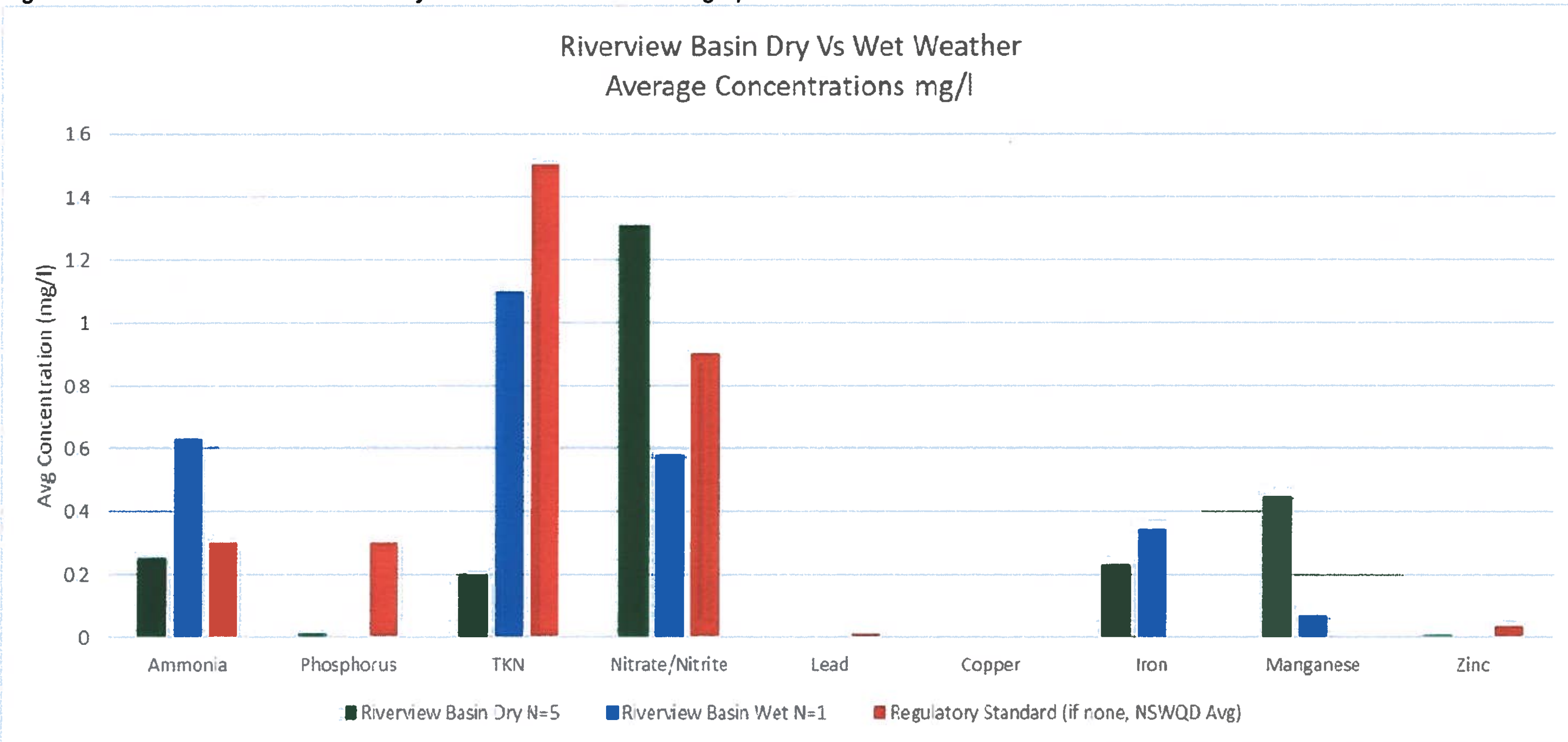
Figure 11.1: Riverview Basin Data - Dry Vs Wet Weather Results graph



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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

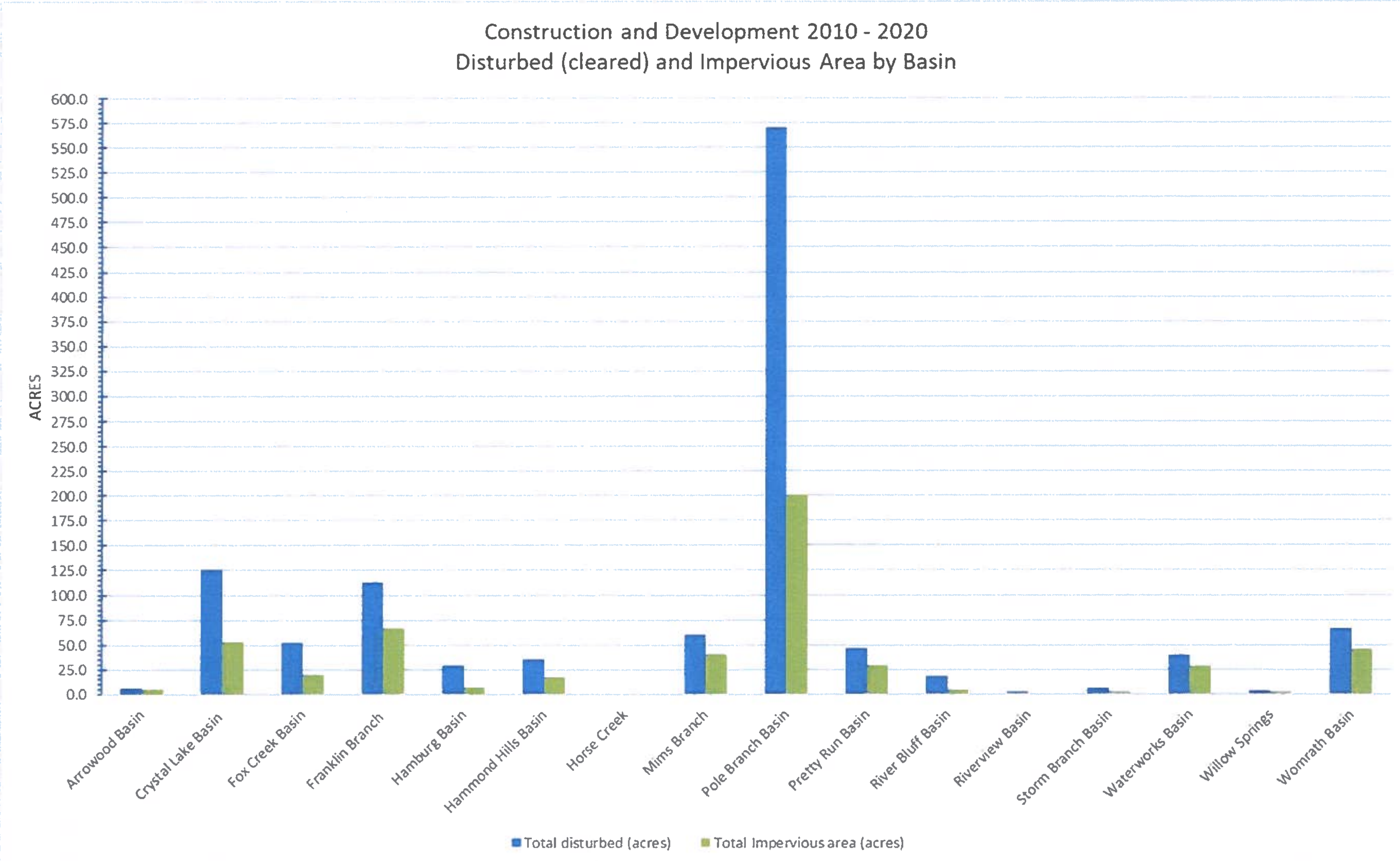
Basin	**Priority**	**Previous Ranking (baseline 2007)**	**Water Quality (Rating 2021 overall)**	**Stream/Channel Integrity (Upper to lower Reach)**	**Improvement Yes / No or Same**	**Overall Rating 2021 (based on water quality and integrity)**
Mims Branch	1	Excellent	Excellent	Excellent	Same	Excellent
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



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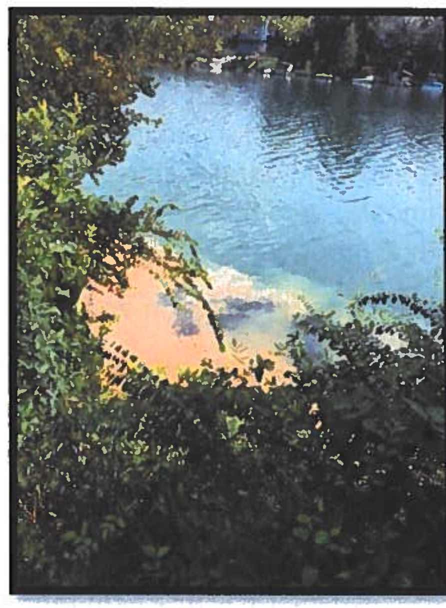
Appendix A: Water Quality Sampling Methods & Specifics:

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.

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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 of each taxon assigned a tolerance value. 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 = ***2.42***		

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

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Appendix D: Special Studies & Additional Data