Nine-Element Watershed Management Plan for the Augusta Canal (HUC-12 #030601060601) Butler Creek (HUC-12 #030601060602) and Beaverdam Ditch (HUC-12 #030601060607) Watersheds in Savannah River Basin

Augusta-Richmond County
Columbia County

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Introduction

Purpose of Watershed Management Plan

This Watershed Management Plan (WMP) addresses stream segments not supporting designated uses as listed on the 2014 Georgia 305(b)/303(d) List that are located the in Augusta Canal HUC# 030601060601, Butler Creek HUC# 030601060602, or Beaverdam Ditch HUC# 030601060607. The *goal of the WMP* is to restore water quality within the listed segments to meet the designated beneficial use of Fishing.

The WMP addresses the following specific listed stream segments and violated criteria:

Table 1: Summary of 2014 Integrated 305(b)/303(d) List

Waterbody Name	Criterion Violated	Segment Name	Segment Length (miles)	Potential Causes	Use	County
Butler Creek	FC	Boardman's Pond to Phinizy Ditch	9	NP, UR	Fishing	Richmond
Butler Creek	FC	Phinizy Ditch to Savannah River	3	UR	Fishing	Richmond
Rocky Creek	BioM, BioF	Headwaters to SR56	6	NP, UR	Fishing	Richmond
Rocky Creek	FC, BioM, BioF	SR56 to New Savannah Road	2	UR	Fishing	Richmond
Rae's Creek	BioF	Headwaters to Cranes Creek	4	UR	Fishing	Richmond
Reed Creek	FC	S1727 to Bowen Pond	8	UR	Fishing	Columbia

FC = Fecal Coliform, BioM = Macroinvertebrate Community Biota Impacted, BioF= Fish Biota Impacted, NP = Nonpoint/Unknown Sources, UR = Urban Runoff/Urban Effects

Georgia's freshwater fecal coliform (FC) criteria designated for Fishing use are: "for the months of May through October, when water contact recreation activities are expected to occur, fecal coliform not to exceed a geometric mean of 200 per 100 mL based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours. Should water quality and sanitary studies show fecal coliform levels from non-human sources exceed 200/100 mL (geometric mean) occasionally, then the allowable geometric mean fecal coliform shall not exceed 300 per 100 mL in lakes and reservoirs and 500 per 100 mL in free flowing freshwater streams. For the months of November through April, fecal coliform are not to exceed a geometric mean of 1,000 per 100 mL based on at least four samples collected from a given sampling site over a 30-day period at intervals not less than 24 hours and not to exceed a maximum of 4,000 per 100 mL for any sample. The State

does not encourage swimming in these surface waters since a number of factors which are beyond the control of any State regulatory agency contribute to elevated levels of bacteria."

Stream segments can be listed as supporting or not supporting the designated use of Fishing based on narrative scores of Very Good, Good, Fair, Poor or Very Poor. These scores are assigned from multi-metric indices of biological assessments for macroinvertebrates (BioM) or from an Index of Biotic Integrity (IBI) and/or Index of Well-Being (IWB) for fish (BioF) communities that are conducted by Georgia EPD or certified subcontractors. Streams are listed as not meeting the designated use of Fishing if BioM or BioF scores are rated as Poor or Very Poor. The pollutant of concern is sediment which is assumed to contribute to habitat degradation. A rating of Fair indicates that further assessment is required before qualifying the stream for a change of status. Streams are considered supporting the designated use if the narrative score is determined to be Good or Very Good.

1. Causes of impairment and pollutant sources to be addressed

1.1. Watershed characterizations and impairments

The most current land use data are for 2015 developed by the University of Georgia Natural Resources Spatial Analysis Laboratory (NARSAL) under contract to Georgia EPD. Land use/cover classification was based on satellite-derived spectral data at a 30 meter resolution. Drainage boundaries for each listed segment were based on HUC 12 contour lines as modified by flow accumulation models. These are consistent with the methodology used to derive land use/cover data in prior Georgia EPD water quality evaluations (Total Maximum Daily Load reports and implementation plans). Land use/cover data and impervious surface estimates for 2015 are summarized in Table 2 for the drainage area contributing to each listed segment. Maps showing drainage boundaries and detailed land use and impervious surface cover are provided in Appendix A.

With the exception of Lower Butler Creek (the segment from Phinizy Ditch to the Savannah River) all segments are dominated by urban land use (ranging from 43 to 81 percent) and have significant impervious surface cover (ranging from 19 to 39 percent). Land classified as agriculture is mostly pasture. Grass cover, present in open developed areas, cannot be distinguished from pasture that has similar spectral characteristics. Consequently, areas classified as pasture in urban watersheds are likely to be open fields that are not active in hay production or grazing. Little row crop agriculture exits within these urbanized watersheds.

Table 2: 2015 Land Cover/Use and Impervious Cover

	Lower Butler[1]		**Upper Butler[2]**		**Lower Rocky[3]**		**Upper Rocky[4]**		**Rae's Creek[5]**		**Reed Creek[6]**	
	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%
urban	**97**	17	**9330**	43	**4316**	70	**4992**	65	**2233**	70	**6397**	81
forest	**105**	19	**7958**	36	**509**	8	**396**	5	**736**	16	**1051**	13
agriculture	**71**	13	**1685**	8	**359**	6	**273**	4	**246**	5	**171**	2
quarries	**0**	0	**111**	1	**0**	0	**655**	9	**0**	0	**0**	0
wetland	**270**	48	**1518**	7	**773**	13	**2**	1	**169**	4	**165**	2

other	**19**	3	**1303**	6	**217**	4	**1287**	17	**216**	5	**158**	2
TOTAL	**562**	100	**21,906**	100	**6173**	100	**7537**	100	**4599**	100	**7942**	100
impervious area	**27**	5	**4093**	19	**2197**	36	**2950**	39	**1341**	29	**2243**	28
1 Butler Creek Phinizy Ditch to Savannah River (Appendix A Figures 1 and 2) 2 Butler Creek Headwaters to Phinizy Ditch (Appendix A Figures 3 and 4) 3 Rocky Creek HWY 56 to Phinizy Ditch (Appendix A Figures 5 and 6) 4 Rocky Creek Headwaters to HWY 56 (Appendix A Figures 7 and 8) 5 Rae's Creek Headwaters to Cranes Creek confluence (Appendix A Figure 9) 6 Reed Creek SR1727 to Bowens Pond (Appendix A Figures 10 and 11) Source: Data and maps prepared by University of Georgia Natural Resources Spatial Analysis Laboratory												

1.1.1. BUTLER CREEK

1.1.1.1. Watershed Description

The 3-mile reach of Lower Butler Creek from its intersection with Phinizy Ditch to the Savannah flows through emergent wetlands or forested wetlands with significant, intact riparian vegetation (Figure 1). A primary stream channel carries the majority of flow only during extended dry periods; flow is frequently carried through small distributaries or across flooded wetlands. The sub-watershed is mostly owned by Augusta-Richmond County and a portion is maintained as the Phinizy Swamp Nature Park by the Phinizy Center for Water Sciences (PCWS). The Georgia Department of Natural Resources Phinizy Swamp Wildlife Management Area lies immediately above the confluence of Butler Creek and Phinizy Ditch.

Constructed wetland cells receive tertiary-treated wastewater from the Augusta-Richmond Messerly Water Treatment Plant. These cells can be distinguished in the aerial photograph shown in Figure 1. Water flowing through the wetland cells collects in a final pond and is discharged via a short ditch into Butler Creek at a location 100 yards from its confluence with the Savannah River.

To the west of the nature park, the Augusta Regional Airport property is separated from the nature park by the paved Lock and Dam Road. There are no residences or building on Lock and Dam Road with the exception of the PCWS campus. The PCWS maintains three properly serviced septic systems on the campus. Other land cover includes grass-covered, open fields on the airport or adjacent to Lock and Dam Road. Agricultural use does not occur in the Lower Butler Creek sub-watershed. The presence of wildlife is encouraged in the protected nature park, the adjacent WMA, and by proximity to the Savannah River. Wildlife frequenting Butler Creek and associated wetlands include muskrats, river otter, coyote, deer, opossum, racoons, bobcat, and a diversity of waterfowl, reptiles and amphibians.

The Upper Butler Creek watershed above the confluence of Butler Creek with Phinizy Ditch is dominated by low-density urban land use. However, significant portions of riparian areas are vegetated in wetlands or conservation easements forming portions of a 12-mile riparian greenway. The riparian corridor above the Phinizy Ditch confluence also provides connectivity to the movement of wildlife through the WMA and Phinizy Nature Park.

Figure 1: Butler Creek (in blue) from its confluence with Phinizy Ditch (shown in red) to the Savannah River is listed as not meeting FC criterion.

1.1.1.2. TMDL Background- identification of impairment and potential pollutant sources

Two segments of Butler Creek are listed (Table 1) on Georgia's 2014 Integrated 305(b)/303(d) List. A FC TMDL for the 9-mile segment of Butler Creek from Boardman's Pond to Phinizy Ditch determined a 49% reduction in fecal loading was required (Georgia EPD 2016). However, 2013-2014 data from Augusta, GA taken at four locations (Old US Hwy 1, Windsor Spring Road, Mike Padgett Hwy, and Doug Bernard Pwy), indicated that the 9-mile segment met water quality standards for FC (FC 0/4 gm). GA EPD removed the FC violation from the Boardman's Pond to Phinizy Ditch segment in Upper Butler Creek for the DRAFT 2016 305(b)/303(d) List. Consequently, this WMP addresses only the Lower Butler Creek segment from Phinizy Ditch to the Savannah River that remains listed as violating the FC criterion. For purposes of this WMP, this segment is referred to as Lower Butler Creek.

The 2014 305(b)/303(d) List assigns the category of 4a to the segment of Phinizy Ditch to the Savannah River indicating that a TMDL has been completed for the parameter of fecal coliform. In 2000, the Georgia Environmental Protection Division (GAEPD) published a FC Total Maximum Daily Load (TMDL) for a 10-mile segment of Butler Creek (USEPA-Region 4 2000) that included the segment from Phinizy Ditch to the Savannah River (Lower Butler Creek). The TMDL determined that to achieve the water quality standard of 200 counts/100 mL as a 30-day geometric mean, fecal loading from the Butler Creek watershed would have to be reduced by 98%. The TMDL calculation was based on the results of the Stormwater

Management Model (SWMM) and the Water Quality Analysis Simulation Program (WASP5) model to determine the appropriate 30-day fecal coliform load that would achieve water quality standards. It was determined that the largest 30-day geometric fecal coliform concentration had a value of 2774 counts/100 mL. In 2005, GA EPD published a TMDL Implementation Plan for the Butler Creek segment of Phinizy Ditch to the Savannah River that used the 98% FC load reduction from the 2000 TMDL report as a target for water quality restoration (Georgia EPD 2005).

The 2014 305(b)/303(d) List identifies the potential cause for FC impairment in Lower Butler Creek to be UR (urban runoff/urban effects). The 2005 TMDL Implementation Plan states that potential loading into the reach could come from upstream sources, Phinizy Ditch, or point and nonpoint sources within the watershed. However, according to the DRAFT 2016 305(b)/303(d) List, the upstream segment of Butler Creek no longer violates the FC water quality standard and Phinizy Ditch is supporting a designated use of Fishing, making it unlikely that these segments contribute to excessive FC loads.

1.1.1.3. Monitoring Results

Augusta-Richmond County monitors FC on Butler Creek at the Doug Barnard Parkway Bridge a short distance above the confluence with Phinizy Ditch, and at the Phinizy Nature Park located below the Phinizy Ditch confluence. Monthly geometric mean FC concentrations over the 6-year period of 2012-2017 show no exceedances of the applicable FC criterion for the October-March of 1000 cfu/100ml, or the April-September criterion of 500 cfu/100ml where non-human sources such as wildlife are significant (Table 3).

Table 3: Butler Creek fecal coliform cfu/100 ml geometric means by month

Month Year	Butler Creek at D. Barnard Parkway Bridge	Butler Creek at Phinizy Nature Park Bridge
March 2012	106	79
June 2012	125	87
September 2012	21	52
December 2012	140	26
March 2013	33	14
June 2013	247	162
September 2013	82	30
December 2013	41	53
March 2014	51	22
June 2014	103	66
September 2014	201	98
December 2014	78	61
March 2015	32	26
June 2015	75	87
September 2015	129	168
December 2015	272	251
March 2016	41	56
June 2017	166	152
September 2017	116	158
December 2017	149	92

Source: Augusta Engineering Department

Monitoring data (Table 3) confirm that the potential sources identified in the 2005 TMDL Implementation Plan (Georgia EPD) from either upstream or Phinizy Ditch do not contribute excessive FC loading into Lower Butler Creek. There are no significant sources of urban point or nonpoint source runoff in this sub-watershed. Stormwater from Lock and Dam Road and the adjacent airport is infiltrated into swales or directed toward the Spirit Creek watershed (HUC-10 #0306010603).

Based upon these data, a course of action will be taken to remove the fecal coliform impairment from this lower section of Butler Creek relative to the 500 cfu/100 cfu water quality standard.

1.1.2. ROCKY CREEK

1.1.2.1. Watershed Description

The majority of the Rocky Creek watershed lies to the south of US-78 (Gordon Highway) and to the North and East of I-520 (Bobby Jones Expressway). With the exception of a very small area in the headwaters, Rocky Creek is fully within the Upper Coastal Plain Physiographic Province. Together, the two listed segments of Rocky Creek drain a watershed of 13,710 acres. Upper Rocky Creek (above SR-56) is dominated by urban land use (65%) with 39% of the watershed in impervious cover. Lower Rocky Creek (below SR-56) is also dominated by urban land (70%) but also has significant wetland cover (13%). Figures 5-8 in Appendix A show the mapped drainage boundaries, land use/cover or impervious surface distribution for the two listed segments of Rocky Creek.

1.1.2.2. TMDL Background- identification of impairment and potential pollutant sources

1.1.2.2.1. Fecal coliform

In 2000, Georgia EPD published a TMDL for FC loading to a 12-mile segment of Rocky Creek that included the 2-mile segment of SR56 to New Savannah Road (USEPA-Region 4 2000a). The TMDL model, which was not validated with measured FC concentrations or hydrologic flows, estimated that the largest, 30-day geometric fecal coliform concentration occurred in Segment 12 of Rocky Creek between 6/11/97 and 9/3/97 with a value of 1,016 counts/100 ml or 3.76E+14 counts/30 days. . The TMDL stated that an 80% reduction in FC loads from the Rocky Creek watershed was necessary to meet the FC criterion. The lower 2-mile segment of Rocky Creek from SR56 (Mike Padgett Road) to New Savannah Road (Doug Barnard Parkway) is the only segment listed as not meeting the FC criterion on the 2014 305(b)/303(d) List (Table 1).

In 2005, Georgia EPD published a TMDL Implementation Plan for the Rocky Creek segment of SR56 to New Savannah Road that stated that the listing of the segment was “based on modelling, not testing” and targeted an 80% reduction from the existing loading of 1016 cfu/100ml to a TMDL of 816 cfu/100ml. The Implementation Plan identified wildlife, stormwater runoff, leaking sanitary sewers, leaking septic tanks and illegally dumped septage as possible sources of FC loading.

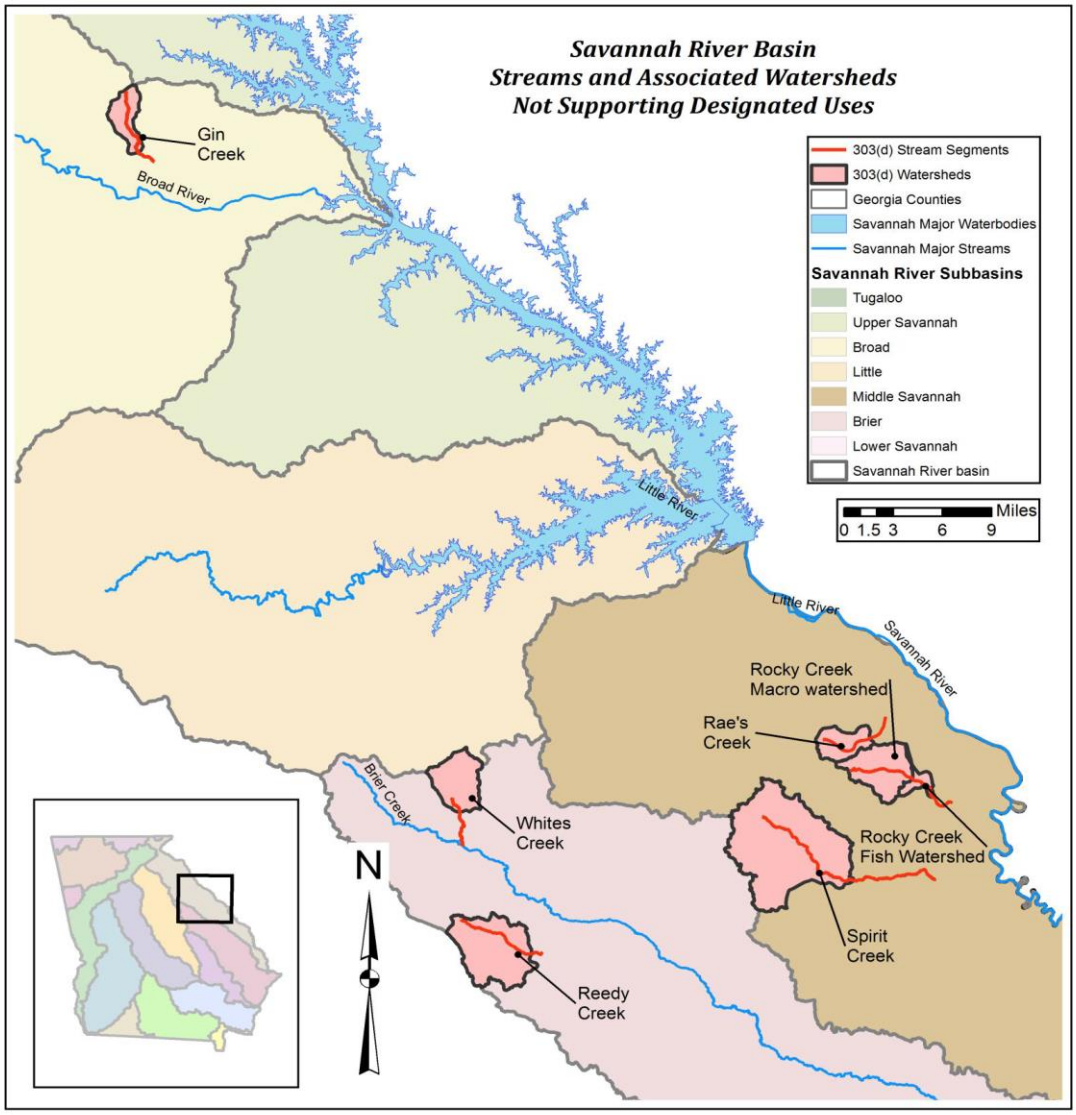
In 2007, the Augusta Engineering Department (AED) sponsored a Bacterial Source Tracking study conducted by MapTech Inc (Blacksburg, VA) in Rocky and Butler Creeks to quantify fecal coliform bacteria from human, pet, wildlife, and livestock sources. That study showed the lower portion of Rocky Creek (Mike Padgett Road to Doug Barnard Pkwy) had the highest fecal coliform loadings (>18E^{12} E. coli cfu/day) of all sites included in the study (5 sites in Butler Creek and 5 sites in Rocky Creek). The breakdown from human, wildlife, pet, and livestock sources for the Mike Padgett site was 34%, 31%, 23%, and 12% and from the Doug Barnard site was 30%, 27%, 24%, and 19%.

During the period 2012-2014, Augusta-Richmond County conducted an Implementation Program for the 2005 TMDL Implementation Plan including education, outreach, Lagrangian water sampling for E. coli from the water column, sediment E. coli sampling, and macroinvertebrate sampling within the Rocky Creek watershed (Augusta-Richmond County 2014). Outcomes of the Implementation Program, conducted with the cooperation and funding of USEPA and Georgia EPD, are highly relevant to this WMP and further discussed below.

1.1.2.2.2. Biotic impairment

Two adjoining segments of Rocky Creek are listed on the 2014 305(b)/303(d) as not meeting biotic narrative criteria for fish (BioF) and macroinvertebrate communities (BioM). The two segments are Headwaters to SR56, a 6-mile segment referred to herein as Upper Rocky Creek; and SR56 to New Savannah Road, a 2-mile segment referred to as Lower Rocky Creek and which is also listed for FC.

Both segments are listed for BioF and BioM. The listing of Lower Rocky Creek (see map below) results from one Fish IBI survey conducted in July 2008 at a sampling site above SR56 (Mike Padgett Highway) and located at the most downstream end of Upper Rocky Creek. Fish IBI scores were rated as Very Poor with an unfavourable habitat score of 78 out of 200. In addition, one macroinvertebrate survey, conducted in December 2001 on the Upper Rocky Creek reach at EPD macro site ID 65c-4 (GOMAS ID RV_01_264) 33.439711, -82.027779 upstream of access road to mall near US Hwy 278/US Hwy 78/ State Route 10, ranked as Very Poor for both habitat quality and macroinvertebrate IBI score.



Based on the 2001 and 2008 data, a TMDL for sediment loading in runoff to Rocky Creek was calculated (Georgia EPD 2016). The TMDL focused on sediment based on the assumption that biological communities are impaired by degradation of habitat *due to sedimentation from runoff*. However, the TMDL found that no reduction in current sediment loads was required to meet allowable loads consistent with those that support healthy biological communities. The 2016 TMDL states that the source of "sediment may be the result of past, legacy land use practices, and that it is believed that if sediment loads are maintained at acceptable levels streams will repair themselves over time."

*1.1.2.3. **Monitoring results***

1.1.2.3.1. Fecal coliform

Fecal coliform concentrations are monitored by the Augusta Engineering Department (AED) at two locations as indicated in the Augusta Stormwater Management Plan, Impaired Waterbodies Monitoring Plan (MS4 NPDES Permit No. GAS 000200). The two locations are at SR56 (Mike Padgett Road), (Latitude 33.420864, Longitude -

82.006886), and downstream at the New Savannah Road (Doug Barnard Parkway), (Latitude 33.415697, Longitude -81.993769). These two locations bracket the listed segment. AED also monitors a third location on an unnamed tributary above its confluence with Rocky Creek just below the SR56 bridge. This tributary drains a significant, urbanized portion of the sub-watershed below SR56 (see Appendix A, Figure 4).

Monthly FC geometric mean concentrations reported by AED are shown in Table 4. The TMDL Implementation Program estimated through bacterial source tracking that 25% of FC loading in Rocky Creek may be from wildlife sources (Augusta-Richmond County 2014). Given the significance of wildlife sources, the applicable criterion is to not exceed a geometric mean of 500 cfu/100ml during May through October, and 1000 cfu/100ml during November through April. For the reported 23 months period, FC concentrations exceeded the criterion 10 and 4 times, at SR56 and at New Savannah Road, respectively..

FC concentrations generally decrease in the 2-mile segment from SR56 to New Savannah Road. Within the segment's sub-watershed, there is no chronic pattern of elevated FC concentrations from urban runoff sources located in the sub-watershed. Although the unnamed tributary watershed is developed, tributary discharges into Rocky Creek directly below SR56 are only infrequently a significant source of loading when compared to upstream sources (above SR56).

Table 4: Rocky Creek fecal coliform cfu/100ml geometric means by month

Month Year	SR56 (Mike Padgett Highway)	Un-named tributary below SR56	New Savannah Road (Doug Barnard Parkway)
March 2012	233	56	140
June 2012	123	**556**	188
September 2012	247	38	46
December 2012	268	11	340
March 2013	238	16	144
June 2013	**600**	200	**502**
September 2013	244	14	226
December 2013	983	13	464
March 2014	226	9	193
June 2014	**2866**	107	**543**
September 2014	**959**	150	312
December 2014	602	65	866
March 2015	86	13	145
June 2015	**845**	**699**	413
September 2015	**1001**	228	**730**
December 2015	707	261	459
March 2016	213	12	184
June 2016	**519**	**657**	336
September 2016	**739**	361	**571**
December 2016	**1531**	343	784
March 2017	997	124	645
June 2017	**598**	335	214
September 2017	**771**	461	217

Source: Augusta Engineering Department, Bold red denotes criterion violation

1.1.2.3.2. Biotic impairment

As discussed, the TMDL for BioF and BioM point toward sediment as the cause for impairment with legacy sediment as the likely source material. A pedestrian survey was conducted to assess geomorphic characteristics of the stream.

1.1.2.3.2.1. Pedestrian survey

During July through September 2016, the PCWS conducted a visual survey of the main stem of Rocky Creek by walking downstream for 6.7 miles beginning near Noland Connector (33.44764 -82.07985) and ending below New Savannah Road (33.41592 -81.99339). The survey included a geomorphic assessment to measure channel stability and processes. Field measurements and visual scoring of aggradation, widening and degradation processes were measured at 2000- foot intervals. Within channel stormwater structures, pipes, and other features were documented, photographed and GPS coordinates documented.

Figure 2 summarizes in-channel processes documented at 2000-foot intervals during the Rocky Creek visual survey. At all cross-sections, processes of channel aggradation and widening scored higher than channel degradation indicating that Rocky Creek is in active channel evolution and adjustment characteristics of alluvial streams. Cross-section 15 had the lowest score indicating channel stability. Cross-section 15 is located at the reach within which BioF, BioM and habitat surveys were conducted. The stability of this reach is consistent with prior channelization and reduced geomorphic complexity. Cross-sections 6 to 9, near North Leg and Wheeless Road areas, had consistently low channel stability scores dominated by the erosive processes of widening and degradation. A high density of impervious cover and associated stormwater conveyed from significant arterial roads and commercial uses influences this reach, this information confirmed pedestrian survey observations.

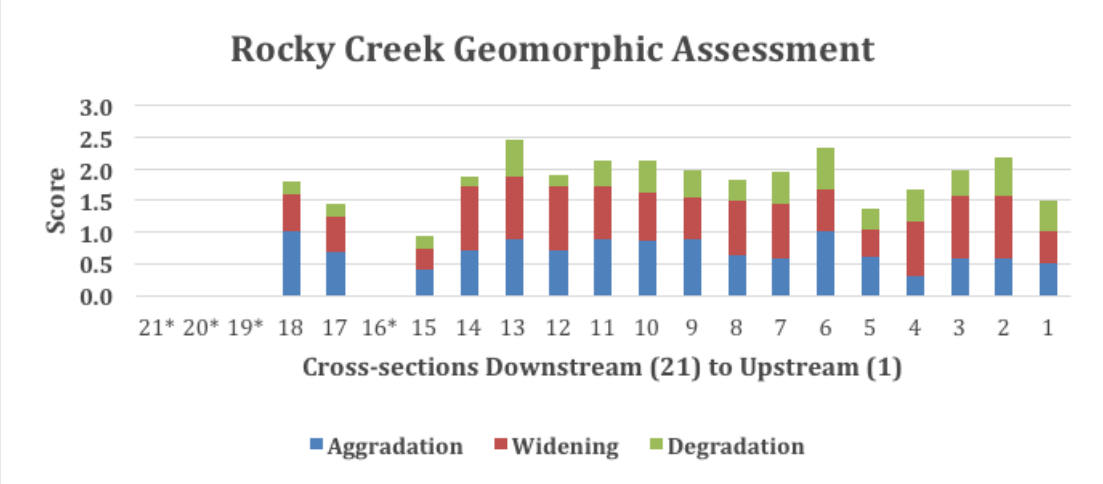


Figure 2: Rocky Creek channel aggradation, widening and degradation channel processes assessed at 2000-ft intervals. Cross-section 1 is the most upstream cross-section. Cross-sections denoted with asterisk (*) were not wadable. Source (PCWS 2017).

1.1.3. RAES CREEK

1.1.3.1. Watershed Description

Seventy percent of the sub-watershed from the headwaters of Rae's Creek to its confluence with Crane's Creek is in urban land uses with approximately 29% having impervious cover (Table 2, Appendix A Figures 5, 6). An area of agriculturally-zoned land lies in the uppermost headwater region of the listed segment.

Although a small area in the headwaters is in the Piedmont Physiographic Provence, the remainder of the watershed within the Southeastern Coastal Plain. The transition from the Piedmont to Coastal Plain results in large changes in slope as the listed segment from the headwaters to Cranes Creek drops from approximately 500 to 200 NAVD.

1.1.3.2. TMDL background - Identification of impairment and potential pollutant sources

A 4-mile segment of Rae's Creek mainstem from the Headwaters to Cranes Creek is listed on the 2014 305(d)/303(b) list for not meeting the BioF criterion for fish community assessment. This listing results from one fish community and habitat assessment conducted in July 2008 upstream of the bridge crossing on Jackson Road (33.47737 -82.07229). This assessment scored the Fish IBI as very poor, and assigned a low score of 58 out of a possible 200 points for habitat.

In 2016, a TMDL for sediment loads to Rae's Creek was published (Georgia EPD 2016). The TMDL focused on sediment as the pollutant of concern based on the assumption that biological communities are impaired by degraded habitat due to sedimentation. However, the TMDL found that no reduction in current sediment loads was required to meet allowable loads that would be consistent with those that support healthy biological communities. The 2016 TMDL states that the source of sediment may be the result of past, "legacy" land use practices, and that it is believed that if sediment loads are maintained at acceptable levels, streams will repair themselves over time.

1.1.3.3. Monitoring results

1.3.3.3.1. Pedestrian survey

A reconnaissance-level geomorphic assessment of Rae's Creek was conducted in March 2015 through November 2015. The objective of the assessment was to evaluate channel stability, locate areas prone to flooding or erosion, document water infrastructure associated with the creek, and collect a reference library of photographs and videos to document overall stream condition.

The creek begins in a low-density residential area, zoned for agriculture, along Wrightsboro Road, then transitions into commercial properties approaching and through I-520 (Bobby Jones Expressway). After I-520, the creek runs through low-density residential areas, interspersed with a few patches of high-density residential areas.

The creek runs through 3 major depositional zones; an instream detention pond creates a wetland above the Wrightsboro Road bridge beaver dams have created an impoundment below Wrightsboro Road, and Lake Aumond is an in-stream pond. Bed sediments associated with these features are unconsolidated fine particles including silts and clays. Outside of these depositional zones, bed sediments are dominated by unconsolidated sands with few larger materials such as pebbles.

With the exception of the reach associated with the concentration of commercial uses near I-520 and Wrightsboro Road, the listed segment has good bank and riparian vegetation. However, evidence of instream erosion is evident throughout the segment and increases in frequency approaching I-520. Erosional features noted include bank cutting, exposed roots, and lateral sand bar formation.

1.1.4. REED CREEK

1.1.4.1. Watershed Description

Reed Creek watershed is located in Columbia County. An 8-mile segment of Reed Creek from S-1727 to Bowen Pond is listed as violating the FC criterion. This segment drains a sub-watershed of 6,397 acres. Eighty-one percent of the sub-watershed is in urban land uses, with impervious surfaces covering 28% of the area.

1.1.4.2. TMDL background- Identification of impairment and potential pollutant sources

In 2000, a TMDL of 4.41 x 10^{10} counts/d was developed for the Reed Creek watershed (USEPA, Region 4) which included a wasteload allocation for 4.34 x 10^{10} counts/d from the Reed Creek wastewater plant and natural background conditions; this leaves a load allocation of 7.34 x 10^{8} counts/d. This TMDL identified failures in the sewer collection system as the suspected source as well as non-point sources in urban runoff.

In 2002, GAEPD (2002) developed a TMDL implementation plan for Reed Creek which generally identified urban surfaces and failing sewer systems as primary nonpoint sources.

In 2005, GAEPD revised the load allocation and established a 75% FC load reduction target for the listed segment (GAEPD 2005). This TMDL generally listed wildlife, leaking sanitary sewer lines, leaking septic tanks, land application systems, and landfills as possible nonpoint sources.

1.1.4.3. Monitoring results

Columbia County monitors fecal coliform concentrations at 4 locations on Reed Creek:

Location	**Latitude Longitude**	**Notes**
Reed Ck @ Holiday	33.520111 -82.119206	Located off Holiday Drive in Holiday Park Subdivision. This site was chosen because it represents the second major tributary in the upper reaches of Reed Creek.

Reed Ck @ Stonington	33.510436 -82.111966	Located off Stonington Drive in Heritage Hills Subdivision. This site was chosen because it represents one of the major tributaries in the upper reaches of Reed Creek.
Reed Ck @ The Pass	33.534932 -82.086955	Located where Reed Creek runs adjacent to The Pass. This site was chosen because it is below the confluence of three major tributaries.
Reed Ck @ Foxfire	33.539621 -82.068028	Located at the intersection of Reed Creek and Foxfire Place in West Lake subdivision. This site was chosen because it is as far downstream as possible in the urbanized area but is upstream of Bowen Pond.

Results from those monitoring efforts are shown in Table 5.

Table 5: Reed Creek fecal coliform cfu/100 ml geometric means by month

Month Year	Reed Ck @ Holiday	Reed Ck @ Stonington	Reed Ck @ The Pass	Reed Ck @ Foxfire
March 2015	142	**6463**	377	338
May 2015	**677**	**205**	**384**	**282**
September 2015	**1876**	**511**	**1876**	**851**
December 2015	688	225	571	558
March 2016	310	154	410	470
May 2016	**298**	100	**409**	**290**
September 2016	126	**512**	**350**	**752**
December 2016	190	59	225	181
March 2017	925	162	913	930
May 2017	**997**	**637**	**619**	**863**
September 2017	**442**	105	**358**	**288**
December 2017	319	134	479	443

Source: Columbia County Water Department
RED and bold denotes criterion violated

With the exception of March 2015, all violations of the FC criterion occur during the months of May and September, bracketing the summer season. Within the March 2015 to December 2017 period, the frequency of FC criterion violation does not remarkably differ among sites—upstream locations are as likely to violate the criterion during summer months as are downstream sites.

1.1.4.4. Visual assessment of creek

A visual stream assessment was conducted at locations along the mainstem of Reed Creek during January 22-29, 2017. The Georgia Adopt-A-Stream Habitat Survey protocol was conducted within each of ten stream reaches upstream of a bridge crossing at which access was provided (Table 6).

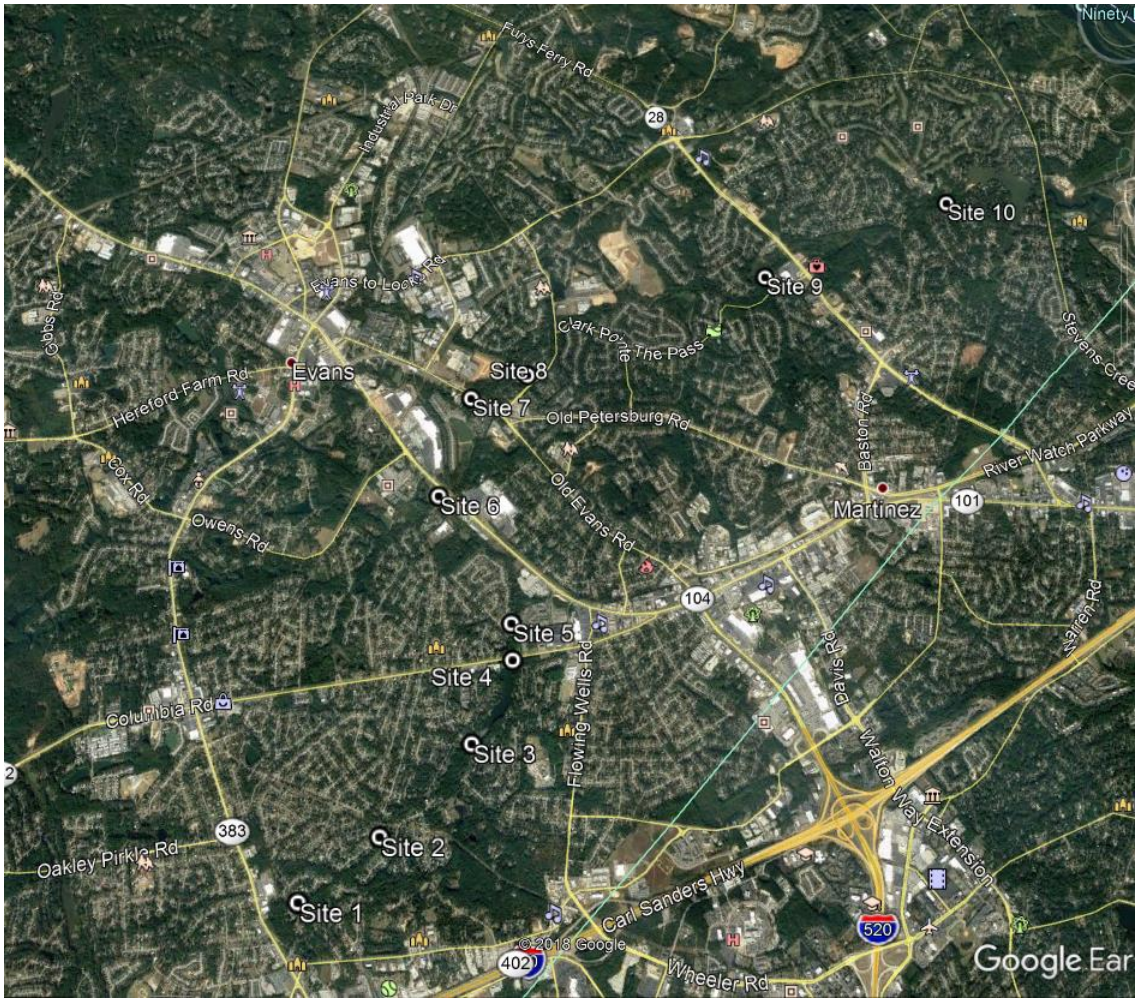


Figure 3: Map of survey site locations

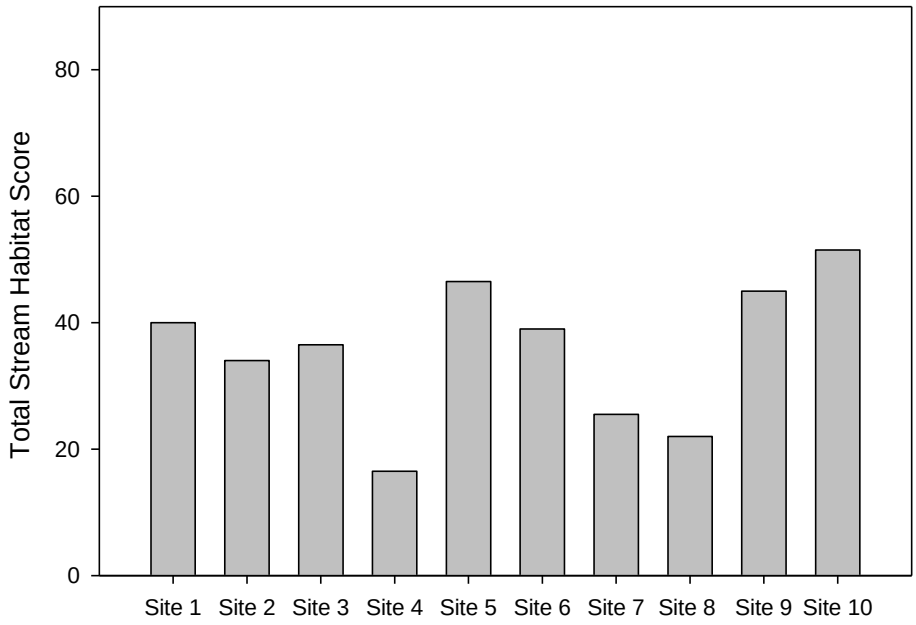


Figure 4: Total Stream Habitat Score based on Georgia Adopt-A-Stream: stream habitat survey. Excellent (69-90), Good (46-68), Fair (23-45) Poor (0-22).

The objective was to provide a consistent basis for reporting on the status and conditions of the stream and identify factors that might contribute to fecal coliform loading. Findings relevant to potential sources of fecal contamination are:

- Antecedent conditions were dry weather with low stream flows. Water clarity was turbid and opaque at all locations with the exception of Dowling Road. No unusual odors were noted. Trash, mostly plastics, was present at all sites
- A sewer easement runs the length of the mainstem. Repairs of a burst sewer line were being conducted at Kestwick Drive indicating the potential from sanitary sewer system
- Riparian vegetative cover, that could act to reduce and/or filter runoff, was absent or reduced in many locations. For example, homeowners were mowing to the edge of the stream banks
- Of the ten locations assessed, 8 ranked poor or fair, and two ranked good. Although these scores are not direct indicators of sources of fecal contamination, they are consistent with a stream impacted by urban hydrology with the high potential for fecal contamination from non-point sources such as pet wastes.

2. Estimated load reductions expected from management practices

2.1. Sediment TMDLs

Two Richmond County creeks addressed in this Plan have TMDLs developed in 2016 with 0% sediment load reduction requirements (Rocky and Rae's). Those TMDLs indicate "legacy sediments" are the cause for impairment and that compliance with the NPDES MS4 permit and continued implementation of stormwater BMPs will allow the creeks to equilibrate and stream habitat and water quality to improve over time (GAEPD 2016 pg 45).

2.2. Fecal coliform TMDLs

Two Richmond County creeks and one Columbia County creek addressed in this Plan have fecal coliform TMDLs. A 98% load reduction is required for Lower Butler Creek, an 80% load reduction is required for Rocky Creek, and a 75% reduction is required for Reed Creek.

3. Appropriate NPS best management practices and critical areas where BMPs are needed

3.1. Augusta-Richmond County

3.1.1. County-wide NPS stormwater controls through ordinances and regulations (addresses fecal coliform, Bio F and Bio M impairments)

Augusta's various ordinances, regulations, technical manuals, and land development documents provide needed legal authority to implement and enforce stormwater control measures that are designed to reduce sediment and fecal coliform transport to local creeks. Key ordinances are listed below:

> i) Land Subdivision Regulations; ii) Site Plan Regulations; iii) Grading Ordinance; iv) Stormwater Management Ordinance; v) Stormwater Management Plan Technical Manual; vi) Tree Ordinance; Flood Damage Prevention Ordinance; and vii) Soil Erosion, Sedimentation and Pollution Control Ordinance

The County's Soil Erosion and Sedimentation Control Ordinance was last amended in January 2018. This ordinance is beneficial to water quality because of the requirement of BMPs, silt traps, and sediment basins during land-disturbing activities. The ordinance also protects a 25-foot buffer of natural and undisturbed land along all state waters. This ordinance helps to slow stormwater flow to the creeks, thus reducing sedimentation of streams. Slower stormwater through buffers also results in less fecal coliform bacteria being carried and deposited into local creeks.

In addition to the above efforts, Augusta Engineering Department and Augusta Planning and Development Department ensure water quality protection and decreased erosion through construction site management controls. These controls include the appropriate legal authority through Augusta's ordinances mentioned above, a comprehensive site plan review process, construction site inspection process, and construction site enforcement processes.

Further effort to protect against sediment and fecal coliform transport to creeks is through Augusta-Richmond County's Community Greenspace Program which was adopted in November 2000. This plan focuses on preservation of natural, undisturbed areas of the county through grant money awarded by the State of Georgia. Many of the areas targeted for protection under this plan are downstream from the impaired portion of Rocky Creek. However, there is undeveloped land surrounding the impaired portion of the creek that may be considered in the future as part of the greenspace plan. These protected greenspaces will inherently protect water quality in their watersheds. Again, greenspaces will slow stormwater flow, allowing the fecal coliform concentration to be lower in Butler and Rocky Creeks. Augusta's comprehensive plan mentions that efforts are in place to eliminate CSOs, replace aging infrastructure, and replace septic with sewer which will decrease additional fecal loading to creeks.

Augusta and the U. S. Army Corps of Engineers have been working on a Regional Flood Control Feasibility Study. This study includes recommended structural and non-structural drainage improvement projects in Rocky Creek which will help decrease the power of stormwater flow thereby decreasing mobilization of legacy sediments in Rocky Creek (the stated sediment source in TMDL (GAEPD, 2016)). Furthermore, some areas within Rocky Creek area are slated as high priority for redevelopment including the former Regency Mall property where Rocky Creek crosses Dean's Bridge Road, Hyde Park, Aragon Park, and Dover-Lyman. Gordon Highway, which parallels Rocky Creek in some areas, has been noted as a critical gateway corridor in need of redevelopment as well. All of these efforts outline critical areas where new or updated BMPs would play an important role in sediment reduction and decreased fecal coliform runoff to

Rocky Creek as the area undergoes redevelopment. The Augusta Engineering Department's plan review processes will ensure these BMPs are incorporated.

GAEPD (2016) recommends implementation of the Georgia Stormwater Management Manual (GSMM) to facilitate prevention and mitigation of stream bank erosion due to increased stream flow and velocities caused by urban runoff through structural storm water BMP installation. The GSMM states, "Energy dissipaters are engineered devices such as rip-rap aprons or concrete baffles placed at the outlet of stormwater conveyances for the purpose of reducing the velocity, energy and turbulence of the discharged flow". Energy dissipating structures to reduce velocity, dissipate turbulence or flatten flow grades in ditches are often necessary. This approach can also be applied to in-stream systems which would also provide a variety of habitat types for aquatic insect and fish populations.

3.1.2. Basin specific NPS BMPs (addresses fecal coliform, Bio F and Bio M impairments)

This Plan outlines specific BMP implementation projects that focus on increasing in-stream habitat to address specific aquatic insect and fish impairments and decreasing stormwater runoff velocity and volume through installation of GI/LID BMPs. In addition, proposed monitoring activities will help determine the extent and degree of impairment due to sediment transport in watersheds that have recently undergone significant land use changes. These projects and activities will also address high fecal coliform loads which are, in part, due to minimal herbivory of bacterial populations in urban streams by aquatic insects and fish because those predator populations are impaired as well as transport of fecal coliform loads due to sediment-bound bacteria. This last point was shown to be a significant potential contributor of fecal coliform concentrations to Richmond County streams since fecal coliform concentrations were always higher in creek sediment samples than in overlying water samples during the Section 319(h) FY11 Grant, "*Implementation of Revised TMDL Education Programs for Rocky and Butler Creeks*".

3.1.2.1. Rocky Creek biota improvement project

Rocky Creek is a typical Coastal Plain urban stream characterized by vertical banks, shallow depths during baseflow, and homogenous habitat, mostly consisting of unconsolidated coarse sand with no depth variability. The 2016 TMDL for BioF and BioM impairment calls for a 0% reduction in sediment and states that recovery will occur naturally. The TMDL suggests that continuing to comply with the NPDES MS4 permit requirements and BMP implementations will provide the required sediment management strategy to alleviate biotic impacts from legacy sediment sources. ***However, this Plan recommends going above and beyond the TMDL in an effort to speed recovery of aquatic insect and fish populations by improving habitat quality and availability.***

Ecosystem diversity and stability is generally driven by habitat availability and diversity. Our intention is to restore healthy macroinvertebrate and fish communities in two ways. First, habitat will be restored by directly providing habitat through adding new structures to the stream. Secondly, habitat will be restored by adding

structures that will encourage the stream to develop a more natural riffle-pool geomorphology over time that supports habitat diversity. We also intend to use these management practices, via restoration of a healthy biological community, to decrease fecal coliform concentrations based on a food web theory that is well-supported by existing science. We do not, however, intend to conduct a traditional "stream restoration" project as our approach will be done almost entirely by hand and will not involve the use of heavy equipment or earth moving at any significant level. We intend to use structures that can be installed by hand and use the power of the stream to provide sustained and advantageous geomorphology. The primary purpose of installed BMPs will be habitat restoration as the TMDL does not call for further reduction in sediment. However, since urban areas still create elevated sedimentation, and since stream bank erosion has been observed, further reduction may improve biotic health and will be pursued as an ancillary benefit of habitat BMP installation. This will be achieved through reducing in-stream bank erosion as several of the BMP options have the ability to protect banks from further erosion caused by extended durations of elevated flows characteristic of urban hydrology.

3.1.2.2. Rocky Creek GI/LID BMP proof of concept project

Since the TMDL identifies legacy sediments as the sediment source causing the impairment in this creek, developing watershed BMPs that could ultimately reduce the stream flow volume and velocity mobilizing these legacy sediments may be an important restoration approach to stabilizing this creek too. Richmond County is located on the fall line and these creeks have a unique mix of Piedmont and Coastal Plain soil characteristics, so determination of appropriate BMPs for this county is challenging. Another challenge for BMPs in this county is that most of the county is considered to be a source of groundwater recharge for the Cretaceous Tertiary aquifer system (GADNR, 1992a), with much of that considered to be "high susceptibility" groundwater recharge area (GADNR, 1992b). Within such a designated area, it is against the groundwater protection ordinances of both the State of Georgia and Richmond County, until updated, to allow infiltration of stormwater into the ground through stormwater infiltration basins. ***Within these constraints, this Plan proposes to go above and beyond the TMDL in an effort to increase the rate of habitat stability to more quickly meet the biotic recovery goals of Rocky Creek by proposing to develop a Low Impact Development/Green Infrastructure (LID/GI) proof of concept program within the Rocky Creek watershed.***

Within Augusta-Richmond County, the schools comprise 320 total acres of impervious surface. This project will develop a pilot program to address impervious surface/stormwater issues from schools by installing a series of BMPs on-site at one Richmond County School within the impaired Rocky Creek watershed with the long-term goal of replicating the BMP implementation/education program at school sites throughout the county. The BMPs will be fully functional and will include both conventional (e.g. stormwater retention, detention, and infiltration basins, etc.) and low-impact development (LID)/green infrastructure (GI) (e.g. filter strips, pocket and constructed wetlands, rain barrels, rain gardens, vegetated swales, and various infiltration practices). Stormwater management performance will be measured by comparing pre/post-BMP installation parameters that focus on reducing water volume in runoff, increasing infiltration, and decreasing sediment/ fecal coliform transport to Rocky Creek.

To engage the public and conduct high visibility projects are ways to bring attention to important issues and to educate the general public. To that end, a STEM curriculum that uses the BMP installation as the focus will be developed and implemented. This curriculum will be used throughout Augusta-Richmond County; but, could also be expanded regionally. The STEM curriculum will include development of an Arduino-based data collection platform (www.arduino.cc) and sensors for measuring water quantity (e.g. rain gauges, ground and surface water level loggers, lysimeters, etc.) and water quality (e.g. temperature, specific conductance, etc.). This system will allow students to develop and program their own instrumentation which will be fitted to each BMP. Data from the instruments will be the foundation of the STEM curriculum, and analyses from pre/post testing metrics will be used to compare effectiveness among both conventional and LID/GI-based BMPs.

LID/GI management strategies provide a more natural way of replicating the pre-development drainage characteristics to protect urban streams. However, one approach will not fit all sites, and an assessment to determine which BMPs will have the best results in Augusta-Richmond County needs to be done to identify those practices that will optimize the ecological and economic benefits. All partners in this proposal, including the students in the STEM curriculum, will play a role in assessing the design, installation, and effectiveness of the installed BMPs with emphasis on the comparison of LID/GI versus conventional practices. The effectiveness of BMPs will be measured by, but not be limited to, the following: attenuation of stormwater volume and velocity, retention of coliforms/sediment, sustaining of aquatic ecosystems both within the BMPs and within Rocky Creek, and the impacts of BMPs on Rocky Creek, downstream of the school site.

3.1.2.3. Rae's Creek

Rae's Creek is a mix of Piedmont and Coastal Plain habitats with bedrock outcrops in parts of the watershed and unconsolidated sand and clay material in others. Rae's Creek TMDL identifies legacy sediments as the cause of impairment and does not call for load reductions, so the intent of this Plan is to speed up the recovery process to meet habitat stability and diversity necessary for expected aquatic insect and fish metrics. The listed section of Rae's Creek is at the uppermost portion of the watershed which was forested approximately 15 years ago and developed over that time period. ***Since the TMDL identifies legacy sediments as the source of sediment for this impairment and since land use changed from forest to high density urban occurred within the past 15 years, for this watershed this Plan proposes to implement a monitoring program that helps characterize the hydrology and sediment dynamics that lead to decreased habitat quality and availability for this sub-watershed.*** This effort will lead to identifying potential hydrologic stressors that decrease habitat quality and availability due to transport of legacy sediments. Once identified, watershed and in-stream BMPs previously learned from the Rocky Creek efforts could be implemented that will repair the hydrologic conditions leading to legacy sediment transport and habitat degradation, if needed.

The 2005 Total Maximum Daily Load Evaluation for Thirty-Two Stream Segments in the Savannah River Basin for Fecal Coliform (Reed Creek), the 2000 Total Maximum

Daily Load (TMDL) Development for Fecal Coliform in the Butler Creek Watershed, and the 2000 Total Maximum Daily Load (TMDL) Development for Fecal Coliform in the Rocky Creek Watershed identify multiple potential nonpoint fecal coliform sources, the most relevant being wildlife, leaking sanitary sewers, leaking septic tanks, and impervious surface runoff.

To go above and beyond the activities to reduce sediment transport, this Plan proposes to integrate fecal coliform monitoring of in-stream BMP activities proposed for the sediment TMDL. For in-stream BMPs, improving aquatic habitat will increase the abundance of macroinvertebrates and fish. It is expected that increased aquatic insect and fish populations will result in decrease concentrations of fecal coliform bacteria through increased predation pressure, which is currently lacking. This Plan proposes to monitor and calculate the load reductions of fecal coliform concentrations as a result of installed BMPs during the LID/GI proof of concept project described in section 2.1.1. Preferred BMPs will be installed at locations within the watershed that have impairments.

3.1.2.4. Lower Butler Creek

There are no significant sources of urban point or nonpoint source runoff in this sub-watershed. Stormwater from Lock and Dam Road and the adjacent airport is infiltrated into swales. ***Based upon these data, a course of action will be taken to remove the fecal coliform impairment from this lower section of Butler Creek relative to the 500 cfu/100 cfu water quality standard***.

3.1.2.5. Rocky Creek

While leaky sewer systems are not considered a non-point source of fecal coliform in streams, high concentrations for the listed section of Rocky Creek are associated with known and reported sewer overflow events (data not shown). In 2018, Augusta Utilities Department will install a force main and pump stations within the listed section of Rocky Creek. It is likely that this will significantly decrease the total load of fecal coliform to this section of creek. ***This Plan proposes to monitor the pre- and post-force-main installation for fecal coliform concentrations to quantify progress toward the 80% reduction goal. Samples will be collected at existing MS4 and non-MS4 sites at the current quarterly frequency and will be collected so that geometric means can be calculated for each sample event.***

3.2. Columbia County

3.2.1. County-wide NPS stormwater controls through ordinances and regulations (addresses fecal coliform impairments)

Columbia County has ordinances and technical manuals that provide legal authority to regulate stormwater management and reduce pollutants. Key ordinances are listed below:

i) Chapter 34, Article I, Grading; (ii) Chapter 34, Article II, Nuisances; (iii) Chapter 34, Article III, Soil Erosion, Sedimentation and Pollution Control; (iv) Chapter 34, Article IV, Stormwater Management; (v) Columbia County Supplement to the Georgia Stormwater Management Manual; (vi) Chapter 42, Floods; (vii) Chapter 90, Article III, Buffers and Screening; (viii)

Chapter 90, Article III, Tree Protection; (ix) Chapter 90, Article III, Landscaping.

Chapter 34, Article III

The County's Soil Erosion, Sedimentation and Pollution Control Ordinance was last amended in February 2018. This Ordinance is largely adopted from the Georgia State Model Ordinance but goes above and beyond in many aspects. The Ordinance requires best management practices (BMPs) employed on all projects and strict adherence to approved plans, sediment storage throughout all phases of construction, control of construction waste, and penalties for violations. Chapter 34 Article III Section of the Ordinance also protects a 25-foot natural, undisturbed vegetative buffer along state waters and a 100-foot undisturbed vegetative buffer along the Savannah River. These Ordinance requirements are instrumental and effective in reducing sedimentation into state waters and other sensitive areas.

The Columbia County Stormwater Utility Department has an erosion, sedimentation and pollution control (ES&PC) plan reviewer, floodplain plan reviewer, and stormwater management reviewer that oversee and ensure proposed projects adhere to state and local regulations. During construction, four stormwater inspectors oversee infrastructure installation. Seven erosion and sedimentation (E&S) inspectors and one E&S supervisor oversee all land disturbing activities throughout the County to ensure preservation of our aquatic resources. When warranted, Notices of Violation and Stop Work Orders are issued, with accompanying fees.

Chapter 90, Article III, Section 139. The Buffers and Screening section of Columbia County code provides for standards for both natural buffers and structural buffers. A natural buffer is an area left in its natural state with supplemental plantings as needed. Buffers are required for any new project whether commercial, residential, or one of the planned unit districts. One of the hallmarks of this section is the requirement for a 50-foot natural buffer along public or private roads or rights-of-way, as well as buffering between similar zoning districts.

Chapter 90, Article III, Section 141. The Tree Protection section provides for the preservation of trees during the development process, especially specimen trees. A tree survey is required for new development. If replanting of a site is required, this section does have requirements for tree density through a Tree Density Unit calculation for both commercial and residential projects.

Chapter 90, Article III, Section 140. Columbia County also has a robust landscape ordinance. This section of the ordinance requires landscape strips on commercial projects, as well as landscaping per every 2,000 square feet of pavement. Additionally, this section does permit the use of an alternative landscape plan that typically takes advantage of green infrastructure such as bioswales.

3.2.2. Basin specific NPS BMPs (addresses fecal coliform impairment)

3.2.2.1. Reed Creek

This Plan proposes to implement a monitoring program that helps characterize the hydrology and fecal coliform dynamics that lead to increased loading within the Reed Creek watershed. We propose to install 5 rain gauge/water level loggers along the 8-mile listed section of Reed Creek to subdivide the reach into six separate sections. These loggers will allow for the development of stage discharge curves at each location so volumetric analyses can be conducted. In addition to volume, quarterly fecal coliform samples will be collected at three of the five stations; samples will be collected so that geometric means can be calculated for each quarterly sampling event. Combining the fecal coliform and volume data will allow for development of fecal loading information so source assessments can be developed and so a baseline can be set to measure progress toward load reduction. ***This effort will be conducted "above and beyond" MS4 sampling requirements.***

4. Estimated amounts of technical and financial assistance, associated costs, and identification of sources/authorities committed to implement the plan

Over the years, the city of Augusta has worked with a variety of stakeholders to identify and protect environmentally sensitive areas. Examples of environmentally sensitive areas in the community include the Savannah River and its tributaries, including the associated floodplains, wetlands, prime farmland and groundwater recharge areas. Some of the organizations that the city partners with to protect these resources include Phinizy Center for Water Sciences (formerly Southeastern Natural Sciences Academy), Augusta University's College of Science and Mathematics, Georgia Forestry Commission, Briar Creek Soil and Water Conservation District, Central Savannah River Area (CSRA) Land Trust, Savannah Riverkeeper, local engineering consultants, and Georgia Department of Natural Resources. Along with Augusta's in-house expertise, these organizations have the technical capability needed to implement the plan to resolve nonpoint source pollution issues within Augusta's watersheds.

Ability of the responsible parties to successfully implement the management practices identified in this plan depends on the availability of funding. It is essential that funding mechanisms be identified through a combination of Federal, State and local sources to comply with the Clean Water Act, support the long-term goals of the Regional Water Plan, and address the impairments currently outlined in this Plan. There are currently several funding sources available to both Richmond and Columbia County for implementation of this plan. In 2000 and 2016 respectively, Columbia County and Richmond County implemented stormwater utilities which provide for monitoring efforts in creeks throughout each county as well as for educational outreach to promote public involvement activities. Under the competitive Section 319(h) grant program, funds may be available for BMP implementation projects outlined in this Plan.

Other matching grant opportunities may be available through the Environmental Protection Agency's Office of Water for both non-point source mitigation and water quality testing. Both county's personnel and the stakeholder group should continually conduct research into possible future funding sources.

In July 2018, a Section 319(h) grant will be executed and will provide an opportunity to go above and beyond the natural recovery rate in Rocky Creek by installing and improving available aquatic insect and fish habitat. This grant includes four project partners (Augusta Engineering Department, Savannah State University, Phinizy Center for Water Sciences, and Augusta University.

Another Section 319(h) grant is projected to begin in the Fall 2018 and is a stormwater BMP pilot and STEM education project designed to identify the most efficient stormwater BMPs for Augusta and to provide students with a real-world problem set for STEM education. The project has four project partners: Augusta Engineering Department, Richmond county School District, Phinizy center for Water Sciences, and Augusta University.

5. Education and Outreach to Encourage Public Participation in Plan Implementation

5.1. Augusta-Richmond County

The Augusta Engineering and Augusta Utilities Departments provide funding annually to support various educational activities through several non-profit organizations throughout the CSRA. Those organizations, Brier Creek Soil and Water Conservation District, Savannah Riverkeeper, and Phinizy Center for Water Sciences, provide education to a wide range of audiences on topics related to the impairments of creeks addressed in this Plan. With regular funding, Brier Creek Soil and Water Conservation District will continue to educate stakeholders on sediment best management practices. Savannah Riverkeeper will continue to provide education on sediment and fecal coliform contamination and other water quality issues within Richmond County to a wide-ranging audience. Phinizy Center will continue to provide education on fecal coliform pollution, sedimentation, and other stormwater issues through K-College field trips. Annual summaries of these activities are provided to Augusta by these organizations. Status and updates to this Plan will be provided through those organizations.

Augusta will continue to provide information on the status and other updates to this Plan through annual Earth Day and Rivers Alive Clean-up events. These events generally attract thousands of people and provide an opportunity to reach large, general audiences. Augusta will also provide status and updates of this Plan through the municipal website and social media outlets.

Augusta will raise public awareness of fecal coliform, sediment, and other water quality issues by encouraging public participation in Adopt-A-Stream activities within affected creek basins. These efforts will also allow for additional data to be collected so that implementation and success of BMPs recommended in the Plan can be

documented. Augusta will partner with Adopt-A-Stream volunteers throughout the CSRA to facilitate development of stations within affected creeks.

Augusta will partner with organizations such as Phinizy Center, Savannah Riverkeeper, Augusta University (and other universities), local engineering firms, and others to develop Section 319(h) grant applications to implement best management practice activities outlined within this Plan. Progress on all projects will be distributed through collaborator outlets (websites, social media, public presentations, etc.) during and after project activities.

5.2. Columbia County

Columbia County provides education and outreach activities through Reed Creek Nature Park and Interpretive Center, a county-owned and operated facility. Kindergarten through 12th grade, home school, and after school field trips are conducted throughout the school year as well as field trips and outreach for all ages. Topics range from botany to zoology and include ecology and nonpoint source water pollution.

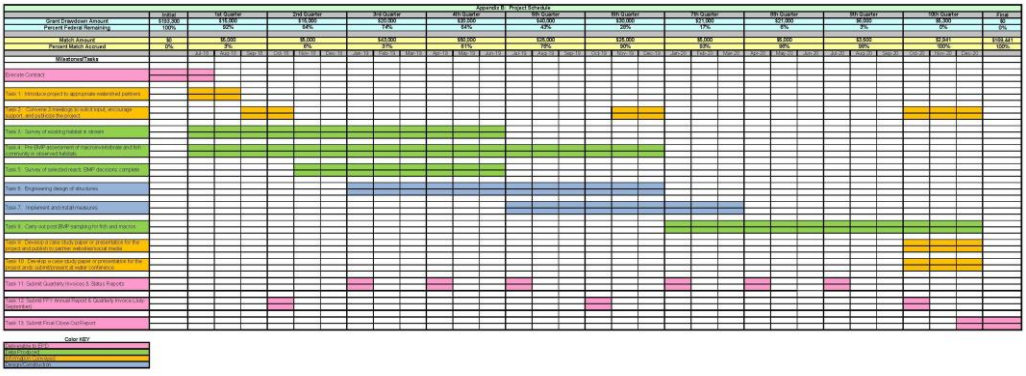
6. Schedule for expeditious implementation of BMPs

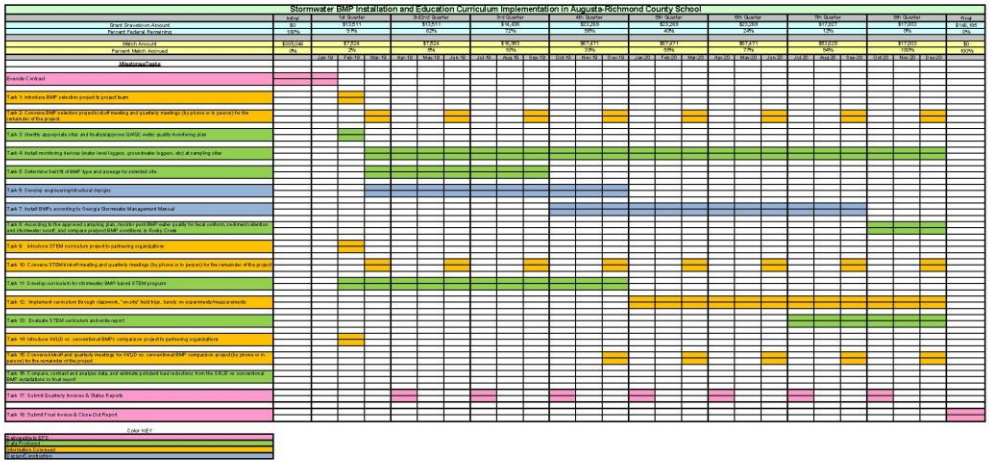
6.1. Augusta-Richmond County

In order to establish an effective TMDL implementation plan, an implementation schedule must be carefully adhered to. A stakeholder group for the drainage basin of the impaired portion of Rocky Creek has been established. This group has been instrumental in the identification of potential sources of fecal coliform in the Rocky Creek area and in the development of potential measures to reduce or eliminate the excessive levels of fecal coliform present in the creek. A stakeholder group of Rocky Creek TMDL Implementation Plan – Fecal Coliform Bacteria 19 landowners, government officials, environmental activists, and other concerned citizens has been identified to help pinpoint the problem and to help implement identified solutions and monitoring schedules.

The implementation schedules for both Section 319(h) Grants awarded to implement this Plan follow and can also be found in Appendix A:

Biota Improvement in an Urban Stream through Aquatic Habitat Restoration





This group of stakeholders will actively work together to continue to identify remedial measures and potential funding sources necessary to implement these remedial measures. Initial management controls and any necessary best management practices or environmental protection measures will be established and adapted once initial implementation has been analysed. Monitoring and status reports of any improvement or worsening of the fecal coliform levels will be strictly adhered to so that goals for bacteria load reductions can be met.

After the stakeholders and community leaders have a firm grasp on current fecal coliform levels based on the water quality monitoring schedule outlined in this Plan, the rest of the community can get involved. The educational programs in the schools and throughout the community must be implemented as soon as possible during the second year of the Plan. Management programs, best management practices, monitoring and evaluation of data, and periodic status reports must continue throughout the five-year implementation schedule. Continuous evaluation, analysis, and reporting results are all imperative to the success of the implementation of the TMDL. If the fecal coliform levels do not fall below the target TMDL, a more rigorous implementation plan should be developed in the final year of this five-year implementation period.

Since planning documents indicate that destruction of aquatic habitat is causing the impairment of instream biota, additional habitat should be provided. Regarding the installation of instream aquatic habitat restoration, as sediment loads are confirmed to not be continuing to exceed TMDL, aquatic habitat restoration management practices will be installed as soon as possible to provide habitat where sediment has eliminated suitable habitat. Ideally this should happen before the next GAEPD 5-year monitoring cycle for the watersheds addressed in this Plan.

6.2. Columbia County

Implementation of monitoring efforts for fecal coliform loading assessment in Reed Creek will commence in the 4th Quarter of 2018. Data will be collected and analysed over a minimum of 1 year to encompass a full hydrologic regime and to establish a seasonal baseline.

7. Measurable milestones to determine implementation success of management practices

Measurable milestone 1: Annual review of data relative to impairments-
As part of the MS4 program, Augusta collects water quality data on all 303(d) listed creeks in the county. Augusta will analyse these data annually in order to determine success of non-point source management measures and BMP implementation projects relative to each stream's impairment. Data, analyses, and findings will be compiled into a summary document and will be reviewed by the stakeholder group. Results will be posted across all education and information outlets discussed in Section 5 of this plan.

Measurable milestone 2: 5-year review of Watershed Management Plan implementation and success–
Every 5-years, all Plan activities and annual datasets will be reviewed within the context of progress toward bringing each listed stream into compliance with State water quality standards. Data, analyses, and findings will be compiled into a summary document and will be reviewed by the stakeholder group. Results will be posted across all education and information outlets discussed in Section 5 of this plan.

Measurable milestone 3: Implementation of Section 319(h) grant, "*Biota Improvement in an Urban Stream through Aquatic Habitat Restoration* ***The grant's timeline requires quarterly and final reporting*** and includes meetings, surveys of existing habitat, habitat improvements selection and design, and pre- and post-habitat sampling. The grant period will end in December 2020. The measureable milestone is to complete all grant deliverables.

Measurable milestone 4: Implementation of Section 319 (h) grant, "*Stormwater and its best management practices (BMPs): BMP installation and education curriculum implementation at a school in Augusta-Richmond County*". ***The grant's timeline requires quarterly and final reporting***, The grant is projected to run through December 2020. The measureable milestone is to complete all grant deliverables.

Measurable milestone 5: Implementation of intensive, above and beyond monitoring program for fecal coliform dynamics in Reed Creek in the 4th Quarter of 2018. Water level and rainfall data will be collected continuously from 5 sites and analyzed for a minimum of one year to set a baseline for hydrologic analyses. Fecal coliform samples will be collected quarterly from three of the five sites. Loading calculations will be developed and analyzed. In subsequent years, monitoring sites may either be moved or new sites added in order to identify potential problem areas and sources. Appropriate BMPs will be evaluated and implemented based upon these findings. Monitoring will continue through post BMP implementation in order to evaluate effectiveness.

8. Criteria to determine BMP success and progress toward attainable water quality standards

8.1. Augusta-Richmond County

The 303(d) listed impairments within this plan are BioF and BioM (due to legacy sediment) and fecal coliform bacteria. The timeline and measurable milestones outlined in Sections 6 and 7, respectively, allow for measurement of progress toward BMP implementation. The following criteria are intended to help define BMP effectiveness toward achieving incremental load reductions .

Water quality monitoring is the most critical component in determining the success of the BMPs. Monitoring also helps determine compliance with regulations, major sources of loading, and quantitative evidence of the success or failure of the regulatory and voluntary actions implemented in the drainage basin. No two watersheds are alike; therefore, the actual monitoring of the particular watershed through water sampling and analysis, rather than relying on computer model data, is critical to determining effectiveness of implementing efforts outlined in this Plan.

Levels of fecal coliform in Rocky Creek will be monitored by standard periodic grab sampling. Augusta-Richmond County has a definitive sampling schedule, including sampling points and dates, as well as dedicated funding through the newly developed stormwater utility. Sampling is scheduled, at a minimum, biannually and at a frequency to ensure 30-day geometric means are calculated. Samples are obtained at least once during the summer season (May through October) and once during the winter season (November through April) each year to provide a complete inventory of the conditions in the impaired segment of Rocky Creek. Additional supplementary sampling points may be utilized by voluntary water quality monitoring organizations. Total suspended sediment (TSS) concentrations in Rocky Creek and Rae's Creek will be measured, at a minimum, according to the approved Impaired Waterbody Plans for those creeks (https://www.augustaga.gov/2672/Water-Quality-Programs).

To support sediment sampling, one rain gauge/water level logger system will be installed in each impaired reach so precipitation and water level in each creek can be measured. For each station, a water level/discharge relationship will be developed through stream gauging techniques. Water volume and TSS concentrations will allow for sediment load calculations to be developed in order to more effectively measure the effectiveness of management practices over time.

Each of the BMP implementation projects described in Section 2. have specific monitoring elements that will be GAEPD approved and will be required to determine the effectiveness of BMPs toward decreasing fecal coliform and sediment transport.

Fecal coliform load reductions

Load reductions of 10% per year are anticipated as a result of BMP implementation and other activities recommended in this nonpoint source Watershed Management Plan. Reductions will be evaluated through an annual monitoring program outlined below. While progress will be tracked annually, more emphasis will be placed on results 2-3 year's post-BMP implementation. This "lag" period is important based on the hypothesis that high fecal loads are,

in part, due to minimal herbivory of bacterial populations in urban streams by aquatic insects and fish because those predator populations are impaired.

Bio F and Bio M improvements

Improvements in Fish Index of Biotic Integrity (IBI) (16; very poor) and Macroinvertebrate Multimeric Index (MMI) (5; very poor) in the BMP-installed, impaired sections of Rocky Creek are anticipated to increase at a rate of 2.5 IBI units per year and 5 MMI units over a 5-year period as a result of BMP and nonpoint source management plan implementation activities. While progress will be tracked annually, more emphasis will be placed on results 2-3 years post-BMP implementation. This "lag" period is important based on the hypothesis that it will take time for aquatic insect populations to become established within the newly improved habitat, and the fish populations to increase as a result of increased aquatic insect populations.

8.2. Columbia County

Since source identification has yet to be developed for Reed Creek, efforts toward attaining BMP effectiveness have to include source identification as well.

9. Methods to Evaluate and Revise Plan Implementation

Since Augusta's Municipal Separate Storm Sewer System (MS4) responsibilities fall to the Augusta Engineering Department, it makes sense that evaluating and revising Plan implementation falls under that department too, with input and assistance from other departments as needed. As a result, review of this Watershed Management Plan's implementation progress will run parallel to annual MS4 short term (1 year) and long term (5 year) activity timelines, where annual review of data and Plan progress will run concurrently with annual MS4 review/reporting, and in-depth Plan progress and reviews will run concurrently with 5-year permit cycle timelines.

Columbia County MS4 reporting requirements have the same timeline so Columbia County will adopt the same method to evaluate and revise this plan.

References

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GADNR, 1992b. https://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/HA-20.pdf

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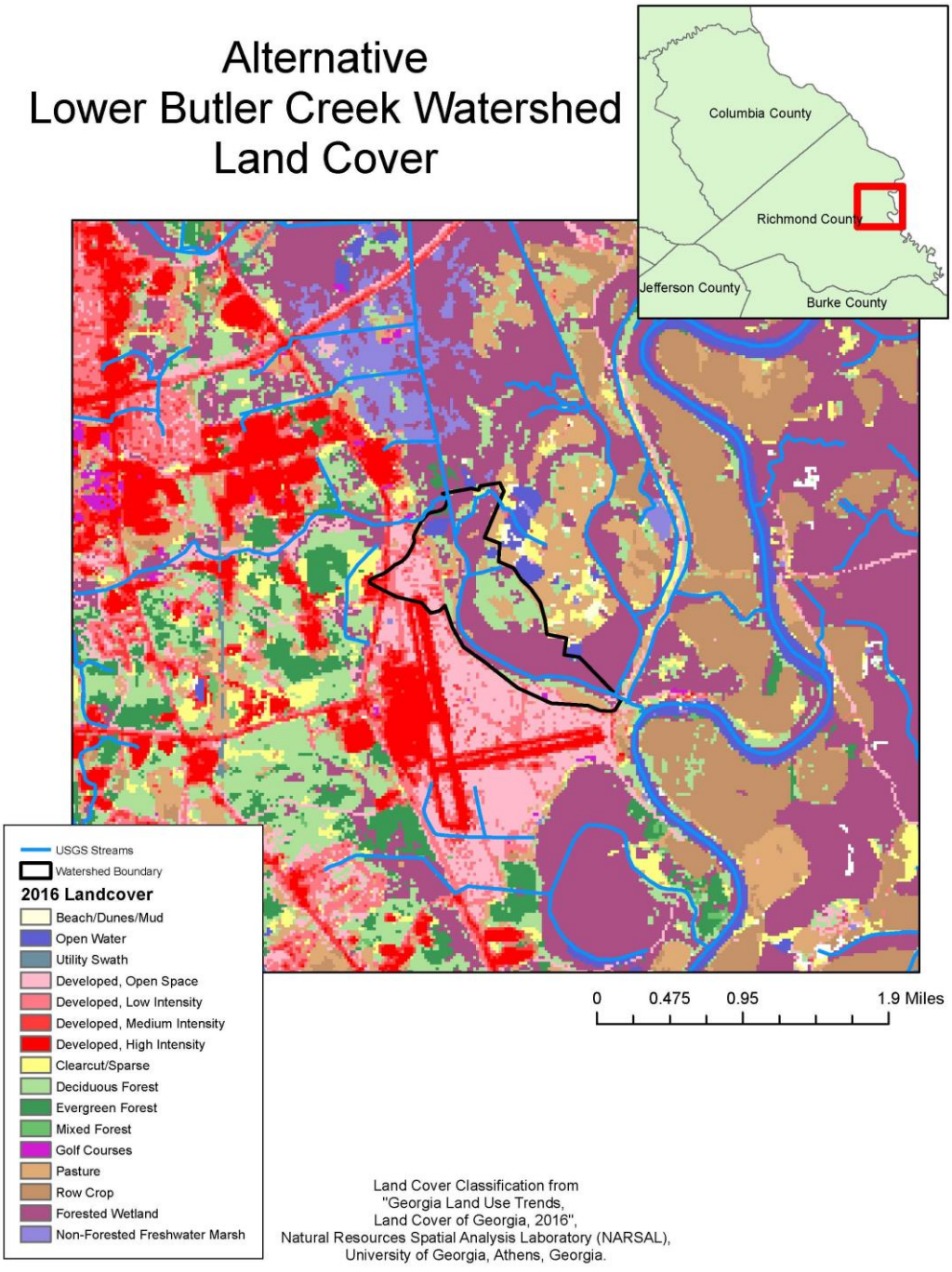
Georgia EPD 2016.
(http://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/Savannah%20Fecal%20Coliform%20TMDL%20Report%20%5B2016%5D.pdf).

http://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/EPA_Butler_Creek_Fecal_TMDL.pdf

http://epd.georgia.gov/sites/epd.georgia.gov/files/related_files/site_page/Savannah%20Biota%20Impacted%20TMDL%20Report%20%5B2016%5D.pdf

Appendix A

Alternative
Lower Butler Creek Watershed
Land Cover



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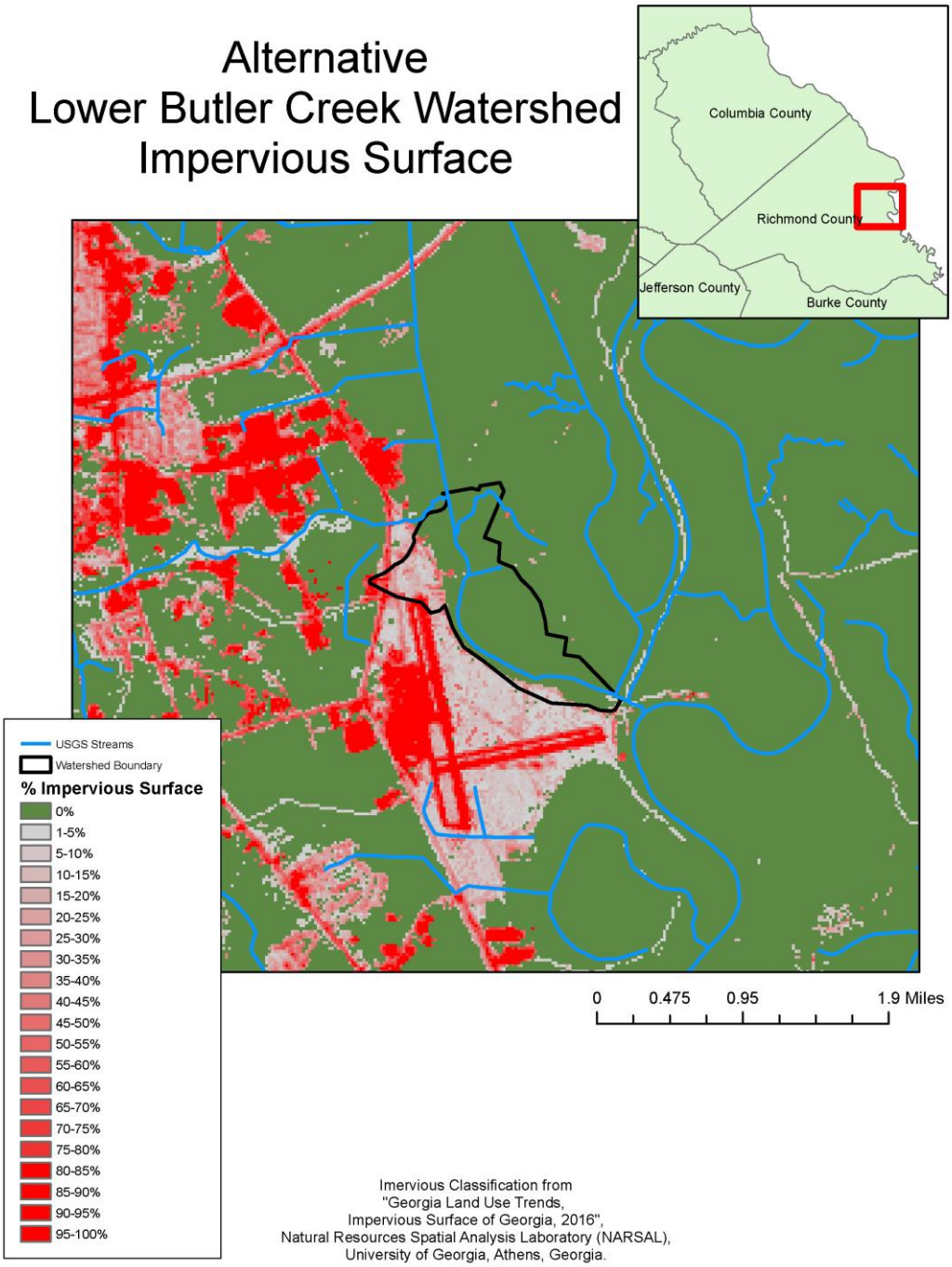
University of Georgia, Athens, Georgia.


Alternative
Lower Butler Creek Watershed
Impervious Surface
Columbia County
Richmond County
Jefferson County
Burke County
USGS Streams
Watershed Boundary
% Impervious Surface
0%
1-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30-35%
35-40%
40-45%
45-50%
50-55%
55-60%
60-65%
65-70%
70-75%
75-80%
80-85%
85-90%
90-95%
95-100%
0
0.475
0.95
1.9 Miles
Imervious Classification from
"Georgia Land Use Trends,
Impervious Surface of Georgia, 2016",
Natural Resources Spatial Analysis Laboratory (NARSAL),
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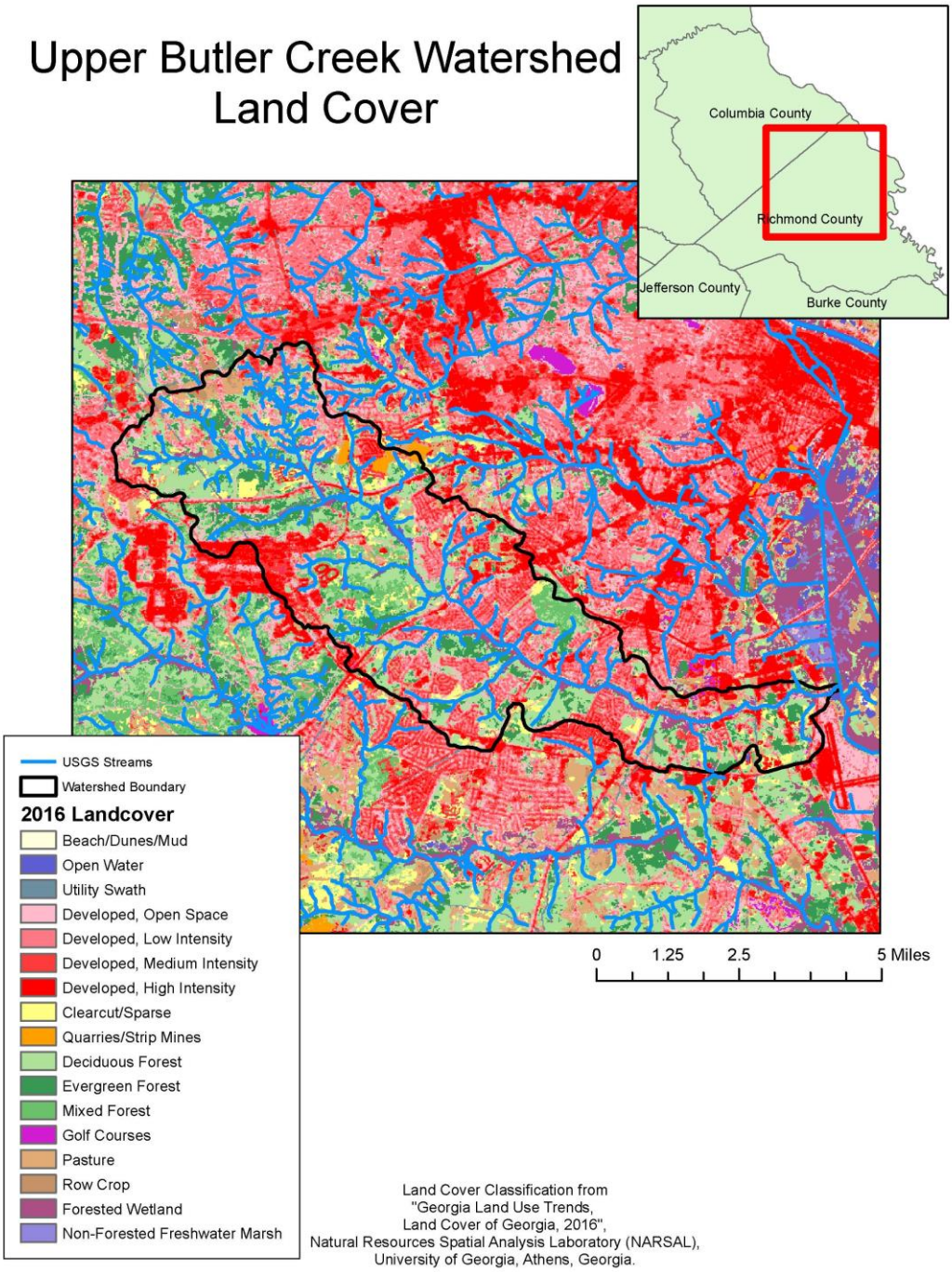
Upper Butler Creek Watershed
Land Cover
Columbia County
Richmond County
Jefferson County
Burke County
USGS Streams
Watershed Boundary
2016 Landcover
Beach/Dunes/Mud
Open Water
Utility Swath
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Clearcut/Sparse
Quarries/Strip Mines
Deciduous Forest
Evergreen Forest
Mixed Forest
Golf Courses
Pasture
Row Crop
Forested Wetland
Non-Forested Freshwater Marsh
0
1.25
2.5
5 Miles
Land Cover Classification from
"Georgia Land Use Trends,
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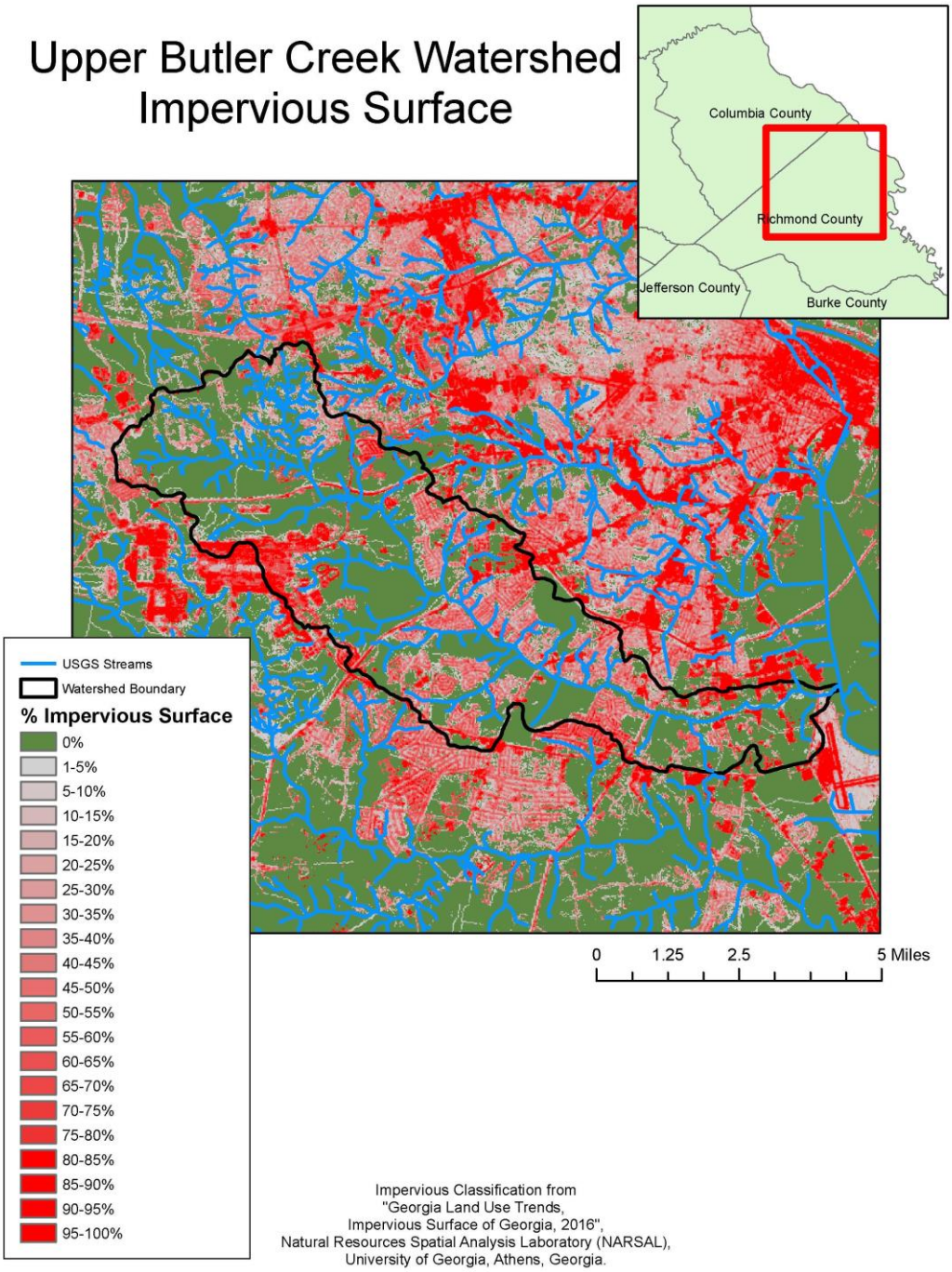
Upper Butler Creek Watershed
Impervious Surface
Columbia County
Richmond County
Jefferson County
Burke County
USGS Streams
Watershed Boundary
% Impervious Surface
0%
1-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30-35%
35-40%
40-45%
45-50%
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75-80%
80-85%
85-90%
90-95%
95-100%
0
1.25
2.5
5 Miles
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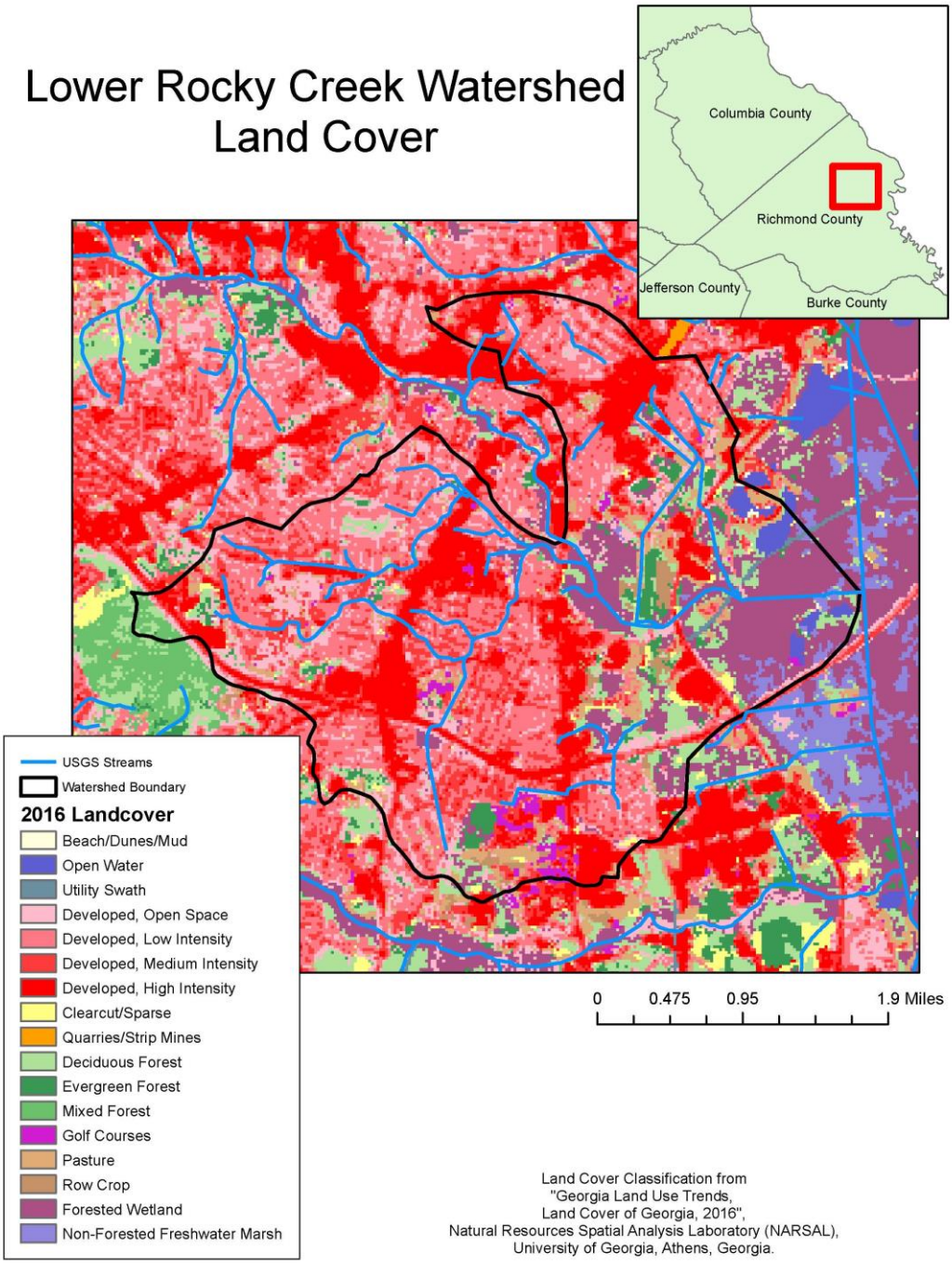
Lower Rocky Creek Watershed
Land Cover
Columbia County
Richmond County
Jefferson County
Burke County
USGS Streams
Watershed Boundary
2016 Landcover
Beach/Dunes/Mud
Open Water
Utility Swath
Developed, Open Space
Developed, Low Intensity
Developed, Medium Intensity
Developed, High Intensity
Clearcut/Sparse
Quarries/Strip Mines
Deciduous Forest
Evergreen Forest
Mixed Forest
Golf Courses
Pasture
Row Crop
Forested Wetland
Non-Forested Freshwater Marsh
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0.475
0.95
1.9 Miles
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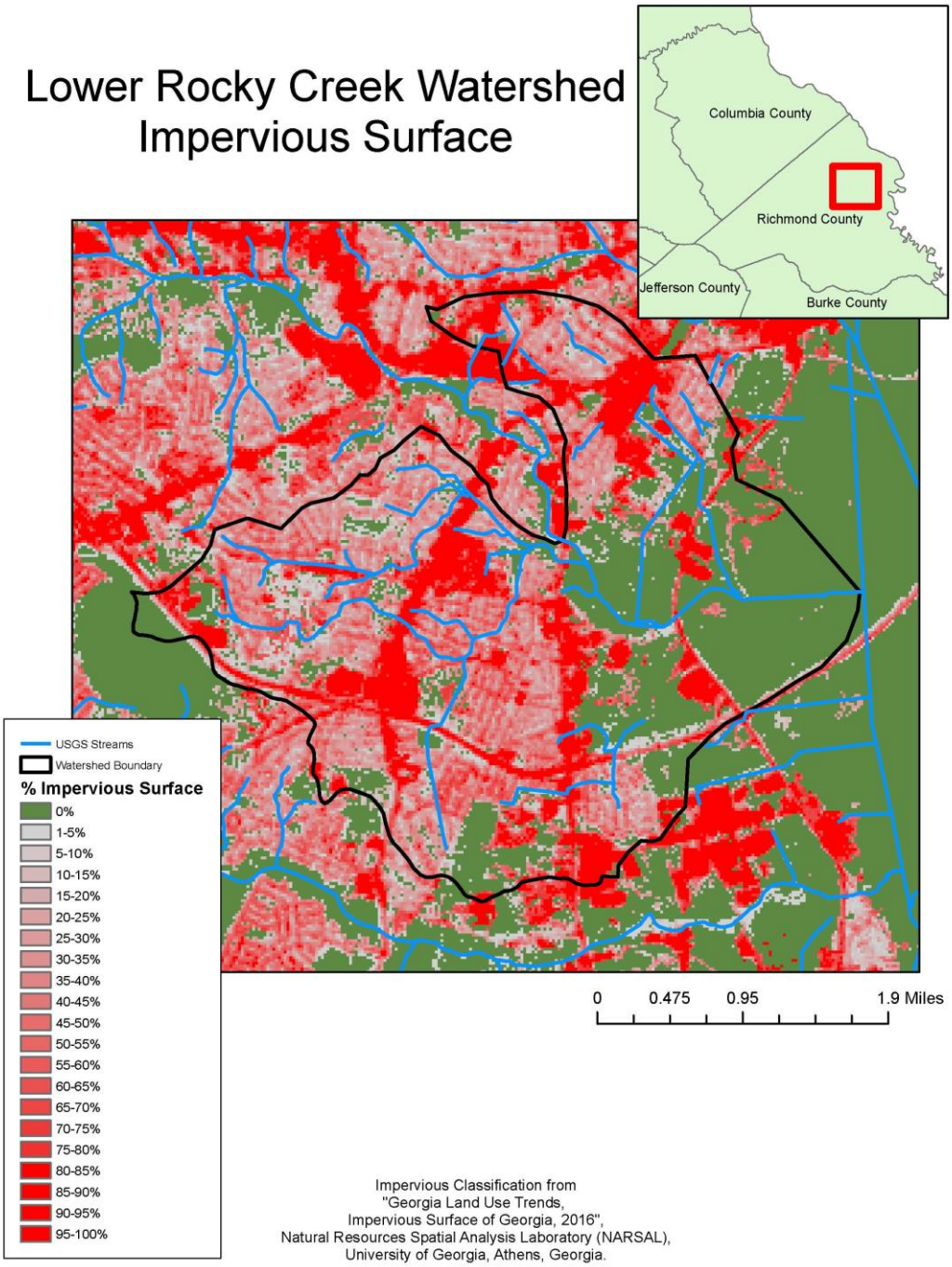
Lower Rocky Creek Watershed
Impervious Surface
Columbia County
Richmond County
Jefferson County
Burke County
USGS Streams
Watershed Boundary
% Impervious Surface
0%
1-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30-35%
35-40%
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0.475
0.95
1.9 Miles
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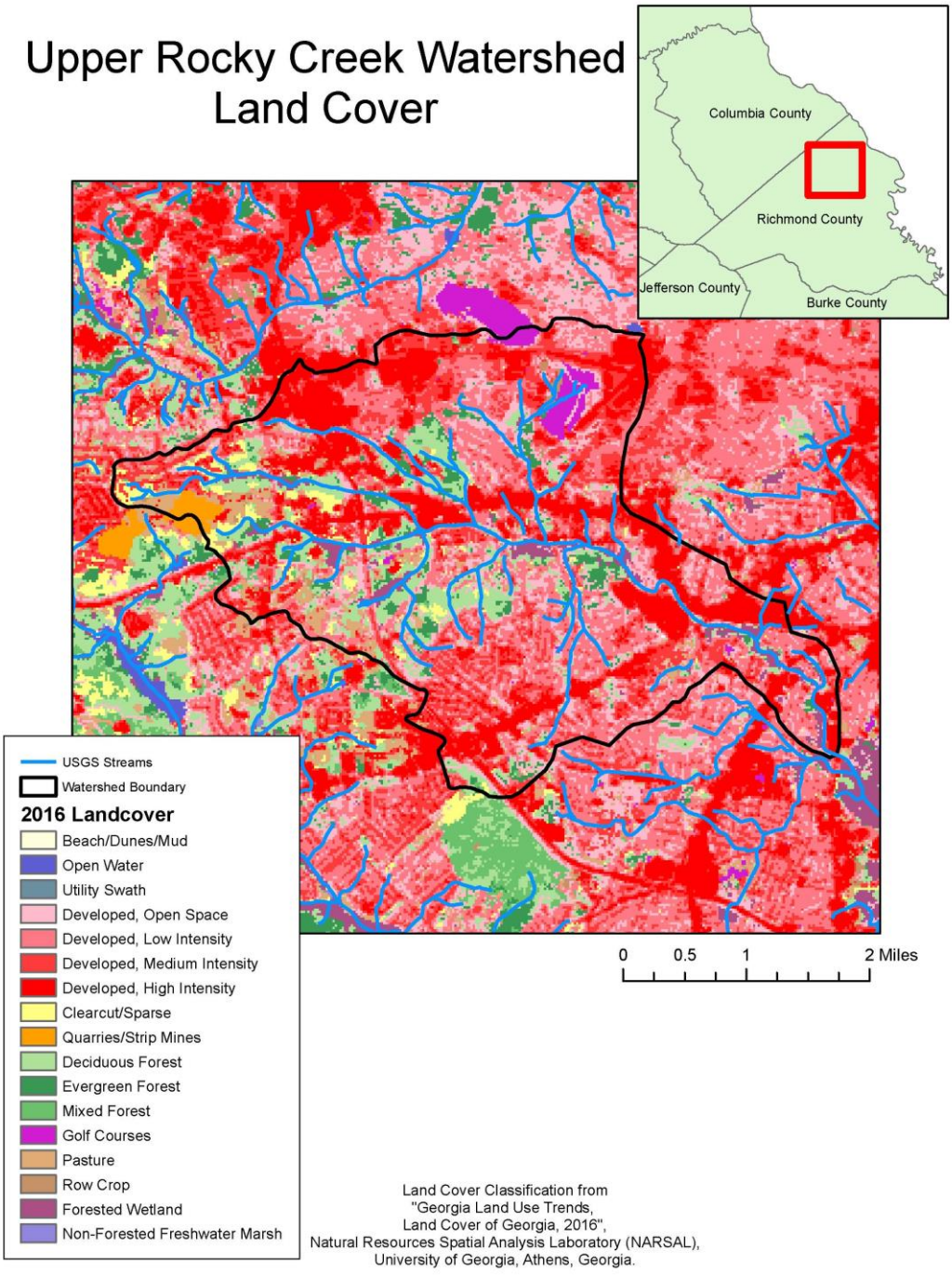
Upper Rocky Creek Watershed Land Cover



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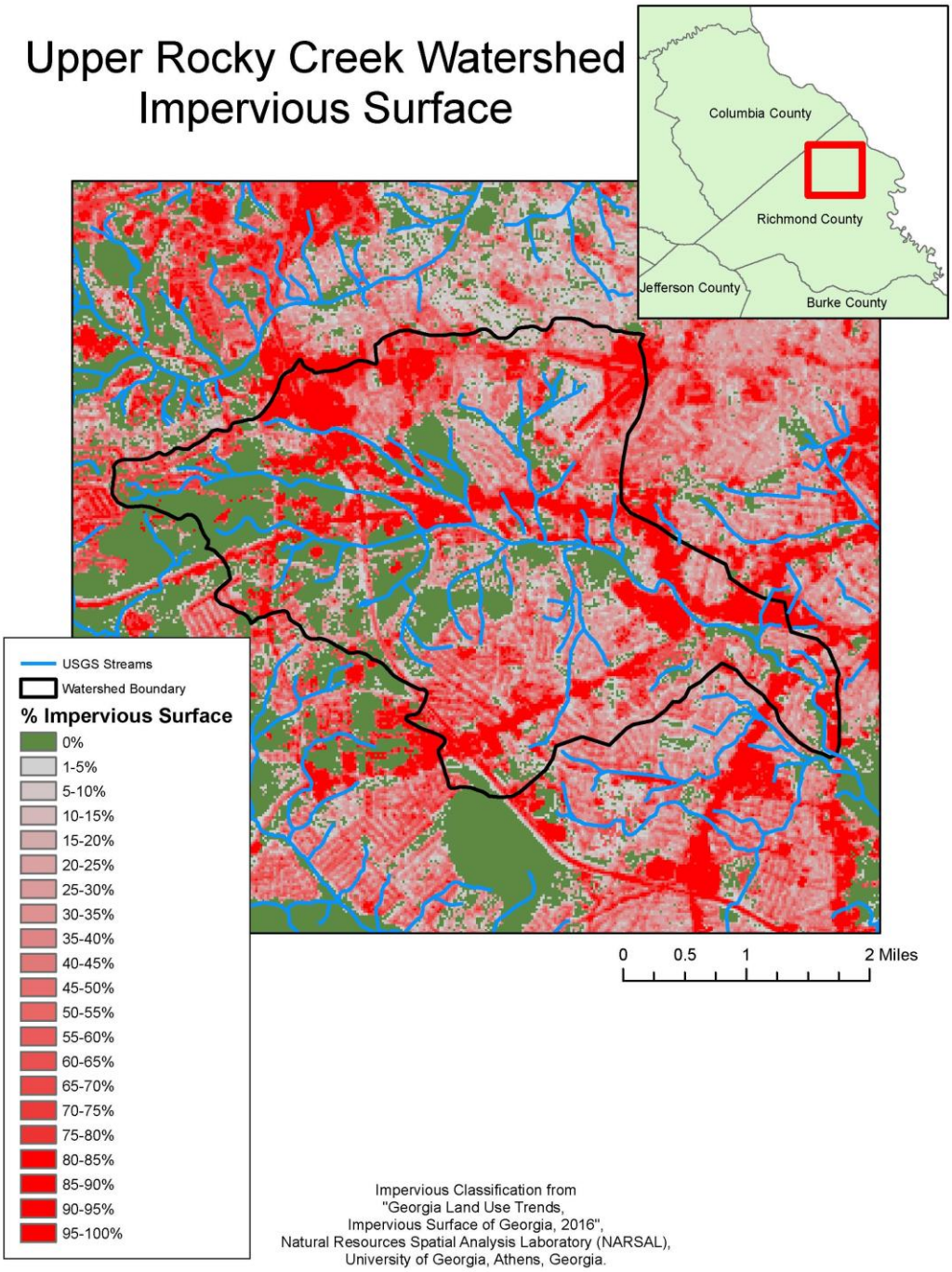
Upper Rocky Creek Watershed
Impervious Surface
Columbia County
Richmond County
Jefferson County
Burke County
USGS Streams
Watershed Boundary
% Impervious Surface
0%
1-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30-35%
35-40%
40-45%
45-50%
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95-100%
0
0.5
1
2 Miles
Impervious Classification from
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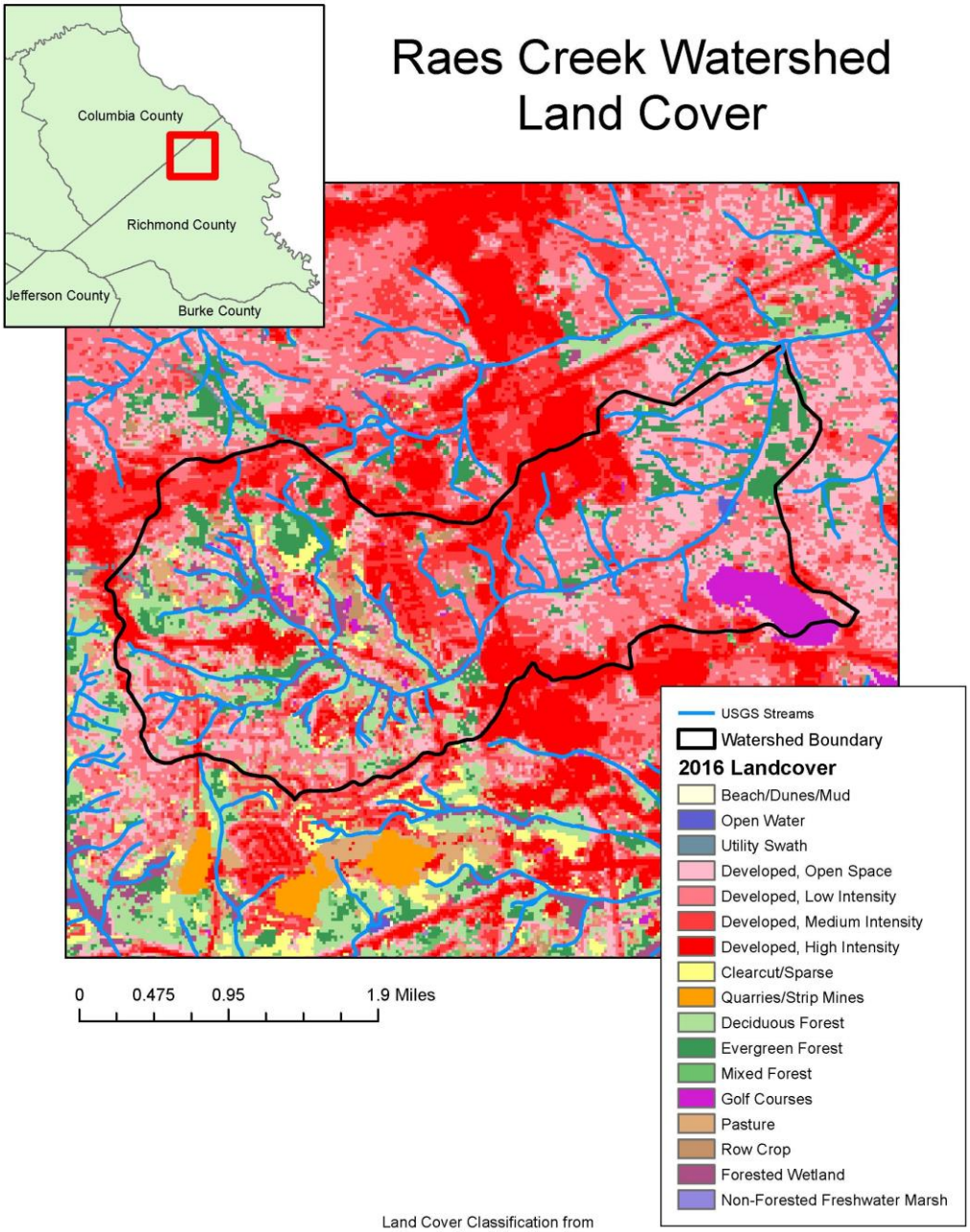

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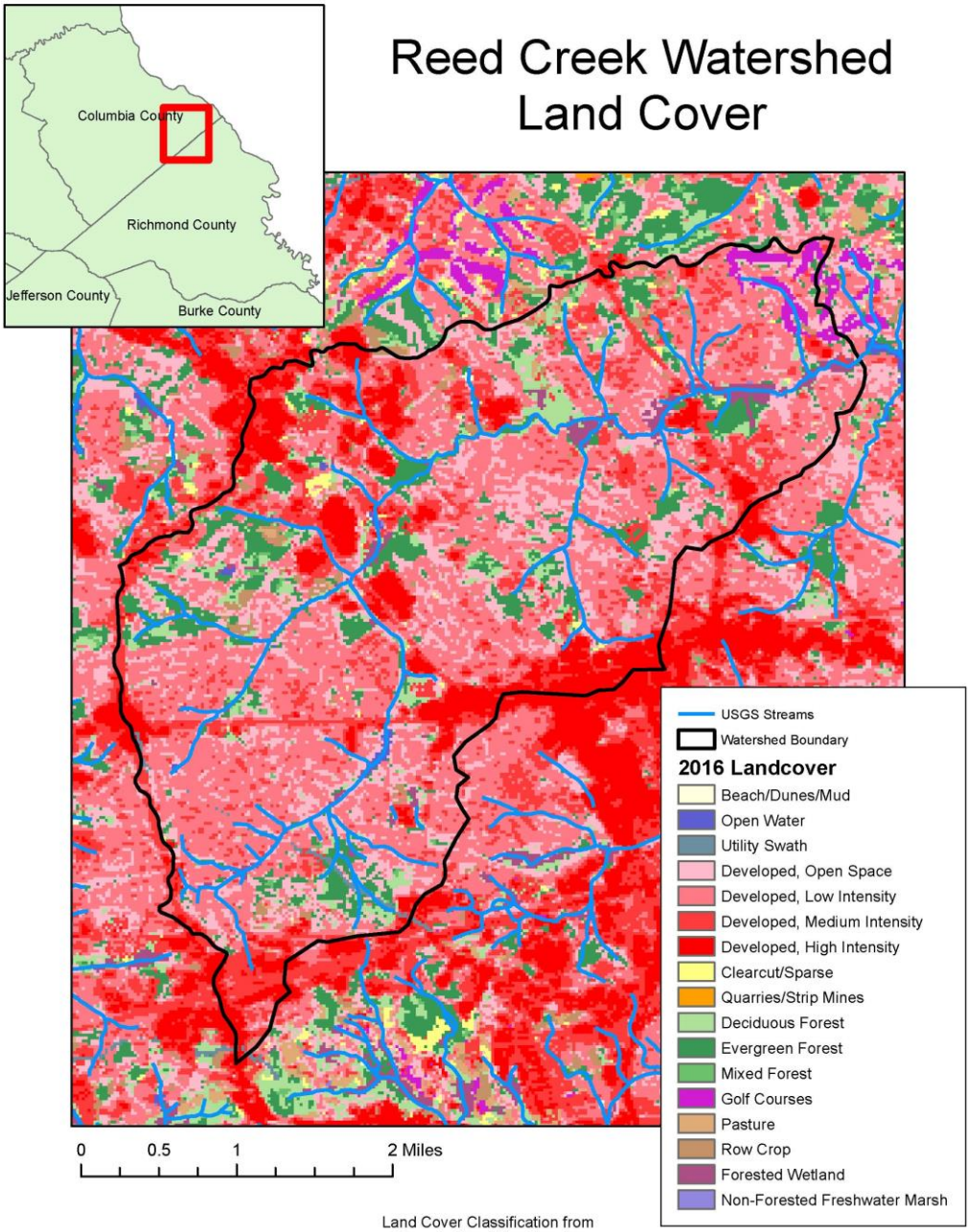

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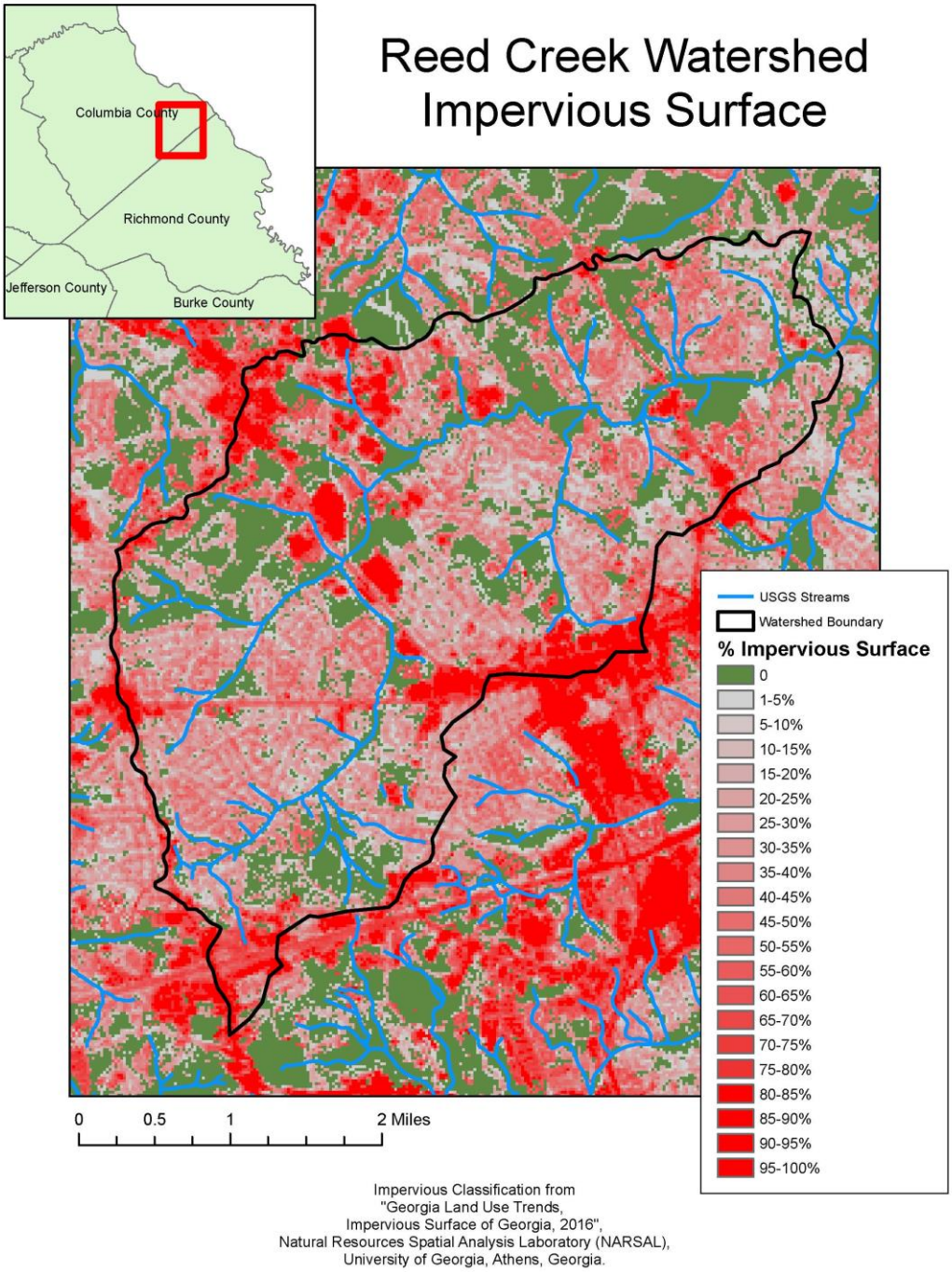

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Biota Improvement in an Urban Stream through Aquatic Habitat Restoration

Appendix B: Project Schedule

	Initial	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			5th Quarter			6th Quarter			7th Quarter			8th Quarter			9th Quarter			10th Quarter			Final
Grant Drawdown Amount	$193,300	$15,000			$15,000			$20,000			$20,000			$40,000			$30,000			$21,000			$21,000			$6,000			$5,300			$0
Percent Federal Remaining	100%	92%			84%			74%			64%			43%			28%			17%			6%			3%			0%			0%
Match Amount	$0	$5,000			$5,000			$43,000			$50,000			$25,000			$25,000			$5,000			$5,000			$3,500			$2,941			$169,441
Percent Match Accrued	0%	3%			6%			31%			61%			76%			90%			93%			96%			98%			100%			100%
		Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	
Milestones/Tasks																																
Execute Contract																																
Task 1: Introduce project to appropriate watershed partners																																
Task 2: Convene 3 meetings to solicit input, encourage support, and publicize the project																																
Task 3: Survey of existing habitat in stream																																
Task 4: Pre BMP assessment of macroinvertebrate and fish community in observed habitats																																
Task 5: Survey of selected reach; BMP decisions complete																																
Task 6: Engineering design of structures																																
Task 7: Implement and install measures																																
Task 8: Carry out post BMP sampling for fish and macros																																
Task 9: Develop a case study paper or presentation for the project and publish to partner websites/social media																																
Task 10: Develop a case study paper or presentation for the project ands submit/present at water conference																																
Task 11: Submit Quarterly Invoices & Status Reports																																
Task 12: Submit FFY Annual Report & Quarterly Invoice (July-September)																																
Task 13: Submit Final Close-Out Report																																

Color KEY

Deliverable to EPD
Data Produced
Information Conveyed
Design/Construction

Stormwater BMP Installation and Education Curriculum Implementation in Augusta-Richmond County School

	Initial	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			5th Quarter			6th Quarter			7th Quarter			8th Quarter			Final
Grant Drawdown Amount	$0	$13,511			$13,511			$14,436			$23,269			$23,269			$23,269			$17,927			$17,003			$146,195
Percent Federal Remaining	100%	91%			82%			72%			56%			40%			24%			12%			0%			0%
Match Amount	$305,046	$7,524			$7,524			$16,953			$67,471			$67,471			$67,471			$53,629			$17,003			$0
Percent Match Accrued	0%	2%			5%			10%			33%			55%			77%			94%			100%			100%
		Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Nov-20	Dec-20	
Milestones/Tasks																										
Execute Contract																										
Task 1: Introduce BMP selection project to project team																										
Task 2: Convene BMP selection project kickoff meeting and quarterly meetings (by phone or in person) for the remainder of the project																										
Task 3: Identify appropriate sites and finalize/approve QA/QC water quality monitoring plan																										
Task 4: Install monitoring devices (water level loggers, groundwater loggers, etc) at sampling sites																										
Task 5: Determine best fit of BMP type and acreage for selected site																										
Task 6: Develop engineering/structural designs																										
Task 7: Install BMPs according to Georgia Stormwater Management Manual																										
Task 8: According to the approved sampling plan, monitor post-BMP water quality for fecal coliform, sediment retention and stormwater runoff, and compare pre/post BMP conditions in Rocky Creek																										
Task 9: Introduce STEM curriculum project to partnering organizations																										
Task 10: Convene STEM kickoff meeting and quarterly meetings (by phone or in person) for the remainder of the project																										
Task 11: Develop curriculum for stormwater BMP-based STEM program																										
Task 12: Implement curriculum through classwork, "on-site" field trips, hands on experiments/measurements																										
Task 13: Evaluate STEM curriculum and write report																										
Task 14: Introduce GI/LID vs. conventional BMPs comparison project to partnering organizations																										
Task 15: Convene kickoff and quarterly meetings for GI/LID vs. conventional BMP comparison project (by phone or in person) for the remainder of the project																										
Task 16: Compare, contrast and analyze data, and estimate pollutant load reductions from the GI/LID vs conventional BMP installations in final report																										
Task 17: Submit Quarterly Invoices & Status Reports																										
Task 18: Submit Final Invoice & Close-Out Report																										

Color KEY

Deliverable to EPD
Data Produced
Information Conveyed
Design/Construction