Executive Summary

Chowan River Basin Plan

Basinwide planning is a watershed-based approach to identify areas across the state where water resource concerns should be addressed. The planning process also identifies areas that need additional protection, restoration, or preservation to ensure waters of the state are meeting their designated use. The 2020 Chowan River Basin Water Resources Plan is a reflection of this planning process and serves as a summary document for this river basin.

Basinwide water quality management plans are required under General Statute 143-215.8B and are approved by the Environmental Management Commission (EMC) every 10 years (Session Law 2012-200). Updates are provided throughout the 10-year period to address changes in water resources and modeling methodology, to report changes to wastewater permits, and to share advances in scientific knowledge. While these plans are prepared by the Division of Water Resources (DWR), their implementation and the protection of water resources entail the coordinated efforts of many agencies, local governments, and stakeholder groups in the state. These plans are not a rule; however,

> "Any water quality standard or classification and any requirement or limitation of general applicability that implements a basinwide water quality management plan is a rule and must be adopted as provided in Article 2A of Chapter 150B of the General Statutes (G.S. 143-215.8B[e])."

The Chowan River basin begins in the foothills of Virginia (VA). The VA headwater streams include the Blackwater, Nottaway and Meherrin rivers. These three rivers converge to form the Chowan River near the Virginia-North Carolina state line. The North Carolina (NC) portion of the basin is located in the Middle Atlantic Coastal Plain and Southeastern Plains ecoregions with the Roanoke River basin to the west and south and the Pasquotank River basin to the east. The river flows south-southeast and drains to the Albemarle Sound where it eventually flows into the Atlantic Ocean. The nearest connection to the Atlantic Ocean, however, is through Oregon Inlet, which is beyond the Croatan and Roanoke sounds. Consequently, the mixing of water in the Chowan River is typically driven by meteorological, wind and storm, tide rather than astronomical tides. Nearly 1,300 square miles of land is included in the NC portion of the basin, but approximately 75% of the drainage area (3,600 square miles) lies in VA. Nearly 36 percent of land use in the NC portion of the basin is identified as forest. An additional 29 percent is identified as agriculture with wetlands comprising just over 20 percent of the remaining land cover. All or portions of Bertie, Chowan, Gates, Herford and Northampton counties are located in the NC portion of the basin. Sixteen municipalities are also in the basin including Ahoskie, Cofield, Gatesville, Murfreesboro, Seaboard, and Winton. Population has remained relatively constant with some areas seeing a decline in population. Based on the 2010 census, an estimated 95,000 people live in the North Carolina portion of the basin. Major tributaries to the Chowan River in NC include Potecasi Creek, Wiccacon River, and Meherrin River.

The Chowan River is an attractive area for recreational and commercial fishing with fish species that include striped bass, Atlantic sturgeon, American shad, hickory shad and alewife and blueback herring, collectively known as "river herring". Areas for boating and kayaking can be found throughout the basin

including Bennett's Millpond, Edenton Town Harbor, and publicly accessible wetlands, like the Chowan Swamp Game Land, and Merchants Millpond State Park. The natural areas of the Chowan River basin include: Chowan Swamp/Bennetts Creek/Catherine Creek Swamps, Colerain/Cow Island Swamp and Slopes, Rocky Hock Swamp Forest, Chinkapin Creek Hardwood Forest, Wiccacon River Bluffs and Swamp, Meherrin River/Banks Creek Natural Area, and Chowan River/Bartonsville Natural Area. The Chowan River basin contains 909 stream miles throughout two 8-digit hydrologic unit codes (HUC). Most of the watersheds are made up of low-gradient swamp streams that can support a variety of habitats (terrestrial and aquatic) and biodiversity.

The 2020 Chowan River Basinwide Water Resources Plan is the fourth document to be developed for the Chowan River basin by the North Carolina Department of Environmental Quality's (NCDEQ) - DWR. The plan includes eight chapters covering water quality and quantity issues in the basin. Because a hydrologic (or water supply) model has not been developed for the Chowan River basin, national and local water use information reported by the public water supply (PWS) systems, through their local water supply plans (LWSP), and entities required to register with the state's Water Withdrawal and Transfer Registration (WWATR) program was used to provide an overview of water use in the basin. Water quantity information was also obtained from the 2018 Agricultural Water Use Survey published by the North Carolina Department of Agriculture & Consumer Services (NCDA&CS).

The 2020 Chowan River Basinwide Water Resources Plan includes the following information:

Chapter 1: Overview

Provides basic information about land use and population, nonpoint source pollution (agriculture, forestry, stormwater) and basin characteristics (aquatic habitats, wetland functions, etc.).

Chapter 2: Monitoring Data and Water Quality

Reviews how chemical, physical and biological parameters are used to assess water quality in North Carolina and overall results for the Chowan River basin.

Chapter 3, 4, and 5: Watershed Chapters and Nutrient Sensitive Waters Summary

Provides detailed information at the watershed scale. Individual stream assessments, special studies, information related to water use, specific projects in the watershed are included.

Chapter 6: Water Quality Initiatives and Funding

Explores various options for protecting water resources and includes information as it relates to local initiatives, watershed planning and funding opportunities.

Chapter 7: Permitted and Registered Activities in the Chowan River Basin

Contains general information about existing programs that protect water resources. Examples include National Pollutant Discharge Elimination System (NPDES) and non-discharge wastewater management, stormwater programs, public water supply systems, and animal feeding operations.

Chapter 8: Water Use and Availability in the Chowan River Basin

Provides a summary of water use in the basin. Information related to water use was obtained from LWSPs, information housed in the WWATR database, and the Ground Water Management Branch (GWMB).

Information related to agricultural water use was obtained from the Agricultural Water Use Survey published by NCDA&CS.

Story Map

The plan also includes interactive components. Using online tools available through ESRI, a StoryMap and a Web Application were developed specifically for the Chowan River basin. Because the interactive components provide a better view of where monitoring locations, permits and streams are located in the basin, only a few locational maps are included in this basin plan.

Water Quality Monitoring

This report covers biological monitoring data and water quality data collected between 2005 and 2019. A summary of the freshwater miles that were assessed found to be impaired (Table 1). It does not include all waterbodies in the basin. Most of the water quality standards are being met at the ambient monitoring stations sampled within the Chowan River basin. There are 31 freshwater miles that are impaired in this river basin (Table 2).

Table 1: Summary of Use Support in the Chowan River Basin

Total Freshwater Miles	Assessed Freshwater Miles	Impaired Freshwater Miles
909	306 (33.7%)	31 (10.0%)

Table 2: The 2018 Impaired Waters (303(d)) List in the Chowan River Basin and the Cause for the Impairment.

Stream Name	AU #	Classification	Subbasin #	Stream Miles	Parameter of Interest	Reason for Rating
Wiccacon River (Hoggard Swamp)	25-14	C;NSW	03010203	23	Benthos	Fair
Cricket Swamp	25-24-2	C;NSW	03010203	8	Low pH (6)	>10 % & >90 % confidence

Biological Sampling

The Water Sciences Section (WSS) Biological Assessment Branch (BAB) collects information on benthic macroinvertebrate community, stream habitats, fish communities, and fish tissue data for DWR. A total of 12 benthic macroinvertebrate community sites were sampled during the 2010 cycle and nine sites were sampled during the 2015 cycle. Most of the sites sampled rated Moderate bioclassification with only one site receiving Not Rated in 2015. Chinkapin Swamp (DB3) was the only site that declined in bioclassification rating and the Chowan River (DB14) declined based on provisional bioclassification criterion. This provision criterion is for unwadeable stream which require sampling by boat similar to the stations in the Chowan River. Overall trends for the basin indicate water quality is meeting criteria for benthic macroinvertebrates. Several additional sites were also sampled as part of special studies (Table 3).

Fish Communities use the North Carolina Index of Biological Integrity (NCIBI) which incorporates information about species richness and composition, trophic composition, fish abundance, and fish condition. The NCIBI summarizes the effects of all classes of factors influencing aquatic faunal communities such as water quality, energy source, habitat quality, flow regime, and biotic interactions.

The Index is undergoing revisions for the Upper Coastal Plain (Chowan, Neuse, Pasquotank, Roanoke, Tar, and White Oak River basins) as such the fish community sites in the Chowan River basin have not been sampled since 2000.

Table 3: Biological Monitoring Cycles and Special Studies in the Chowan River basin

Monitoring Cycle Number	Dates	Benthic Samples Collected
4	September 2005 – August 2010	12
5	September 2010 – August 2015	9
Special Study (county)	**Dates**	**Benthic Samples Collected**
Ivy Creek (Northampton)	March 14, 2011	1
Unnamed Tributary Corduroy Swamp (Northampton)	March 14, 2011	1
Cricket Swamp (Bertie)	March 6, 2012	1

Ambient Sampling

The WSS Ecosystems Branch (EB) coordinates the Ambient Monitoring System (AMS) and Random Ambient Monitoring System (RAMS) which collects water quality data to measure chemical and physical parameters (Figure 1, Table 4). Nine AMS stations were monitored for dissolved oxygen, pH, specific conductivity, turbidity, nutrients, and fecal coliform bacteria between 2005 and 2019. These stations are used to obtain long-term local trends in water quality.

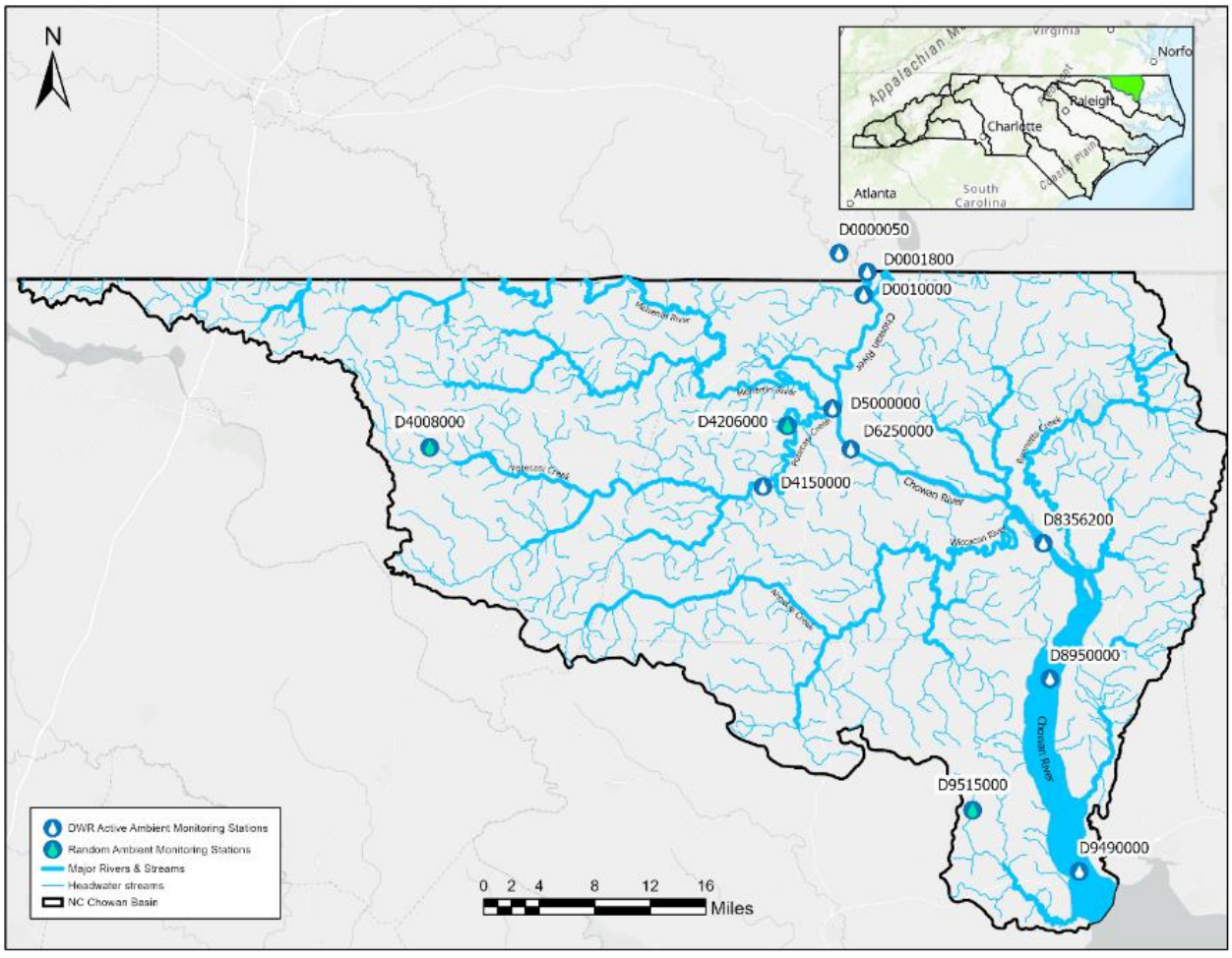
Three RAMS stations were sampled between 2009 and 2014 (Figure 1, Table 4). This program creates new temporary monitoring stations that measure a wider range of parameters than AMS stations in order to obtain a broader understanding of water quality throughout the entire state. Every RAMS station is scheduled to be visited once per month for the duration of the two years of monitoring totaling 24 sampling events.

Table 4: DWR Ambient and Random Ambient Monitoring Stations in the Chowan River Basin, 2005 - 2019

Station ID	Station Location	Active Date	County	State	Stream Classification
Ambient Monitoring Stations					
D0000050	NOTTAWAY RIVER AT US 258 NEAR RIVERDALE VA	1/1981-Present	SOUTHAMPTON	VA	II Estuarine
D0001800	BLACKWATER RIVER .5 MI UPS MOUTH NEAR WYANOKE	1/1981-Present	GATES	NC	B NSW
D0010000	CHOWAN RIVER NEAR RIDDICKSVILLE	3/1974-Present	HERTFORD	NC	B NSW
D4150000	POTECASI CREEK AT NC 11 NEAR UNION	1/1981-10/2019	HERTFORD	NC	C NSW
D5000000	MEHERRIN RIVER AT SECONDARY ROAD 1175 PARKERS FERRY NEAR COMO	1/1974-Present	HERTFORD	NC	B NSW

Station ID	Station Location	Active Date	County	State	Stream Classification
D6250000	CHOWAN RIVER AT US 13 AT WINTON	4/1969-Present	HERTFORD	NC	B NSW
D8356200	CHOWAN RIVER AT CHANNEL MARKER 16 NEAR GATESVILLE	1/1981-Present	GATES	NC	B NSW
D8950000	CHOWAN RIVER AT CHANNEL MARKER 7 AT COLERAIN	5/1969-Present	CHOWAN	NC	B NSW
D9490000	CHOWAN RIVER AT US 17 AT EDENHOUSE	5/1969-Present	BERTIE	NC	B NSW
Random Ambient Monitoring Stations					
D4008000	WICCACANEE SWAMP AT SR 1500 NEAR JACKSON	1/2009-12/2010	NORTHAMPTON	NC	C NSW
D9515000	CRICKET SWAMP OFF SECONDARY RAOD 1346 NEAR ASHLAND	1/2011-12/2012	BERTIE	NC	C NSW
D4206000	POTECASI CREEK OFF NC 158 NEAR MAPLETON	1/2013-12/2014	HERTFORD	NC	C NSW

Figure 1: Ambient Monitoring System and Random Ambient Monitoring System Stations in the Chowan Basin.



Lakes Assessment

The WSS Intensive Survey Branch (ISB) tests and reports on the water quality of lakes and reservoirs. Merchants Millpond was sampled May-September 2010 and again in May and August 2015. It is a shallow lake with a maximum depth of five feet and has characteristics of swamp waters. This lake has consistently exhibited elevated biological productivity since it was first monitored by DWR in 1981.

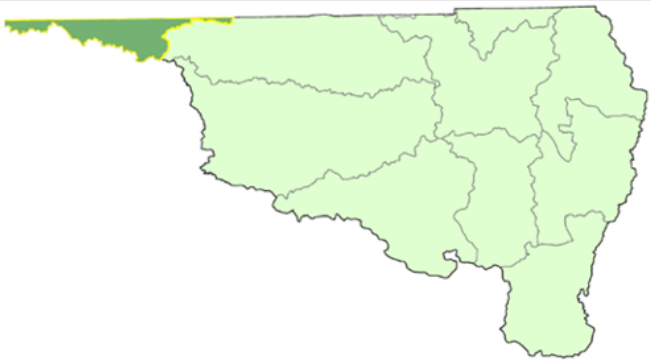
Algae and Aquatic Plants

The WSS Algae and Aquatic Plants Assessment Program that provides two types of evaluations: episodic and routine. Samples for episodic evaluations are collected in response to specific events such as fish kills, algal blooms, and nuisance aquatic plant and algal growth. Routine evaluations are targeted studies of specific waterbodies of interest and are generally performed in cooperation with other DWR programs. Routine evaluations are conducted to assess changes in algal assemblages over time and are often focused on estuarine systems where there are known issues of nutrient enrichment and have had frequent algal blooms or fish kills. This program also maintains the NC DWR Algal Bloom Map which displays locations analyzed by DWR for algal bloom activity.

Watersheds in the Chowan River Basin

Fontaine Creek Watershed (HUC: 0301020407)

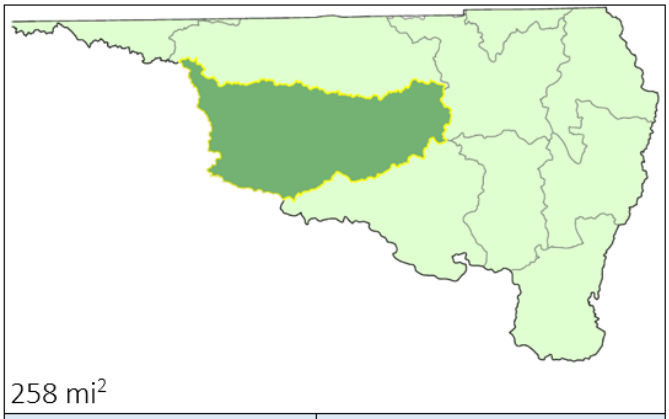
The Fontaine Creek watershed drains approximately 48 square miles of primarily forest and agriculture land cover. The watershed drains north into VA which eventually flows into the Meherrin River. Beaverpond Creek and Jacks Swamp are the main waterbodies on the NC side of the border. Currently, there are three permitted swine operations and no permitted NPDES wastewater dischargers, non-discharge permitted facilities, ambient monitoring stations or benthic macroinvertebrate sites in the NC portion of this watershed. Overall, water quality in this watershed remains unassessed in NC due to the lack of ambient monitoring stations and benthic macroinvertebrate community sites.



48 mi^2

Land Cover		NCDEQ Sampling Sites	
Forest	46.2%	Benthic Cycle 4	0
Agriculture	27.9%	Benthic Cycle 5	0
Developed	4.8%	AMS Stations	0
Wetland	12.4%		
Permits		**Water Supply**	
NPDES Wastewater	0	Public Water Supply System	0
Non-Discharge	0	Local Water Supply Plans	0
Permitted Swine Ops.	3	WWATR	0

Potecasi Creek Watershed (HUC: 0301020408)



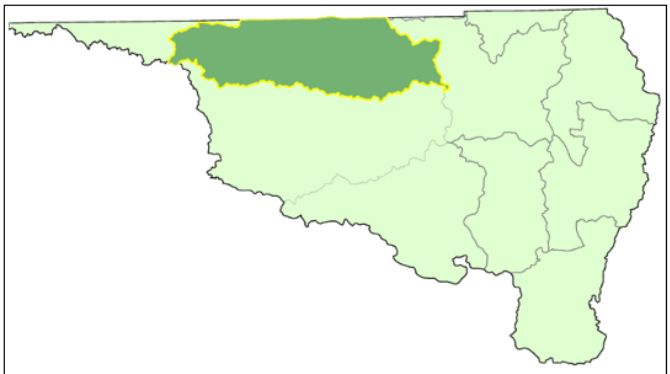
258 mi^2

Land Cover		NCDEQ Sampling Sites	
Forest	39.3%	Benthic Cycle 4	3
Agriculture	32.3%	Benthic Cycle 5	2
Developed	4.4%	AMS Stations	1
Wetland	17.3%	RAMS Stations	2
Permits		Water Supply	
NPDES Wastewater	0	Public Water Supply System	3
Non-Discharge	3	Local Water Supply Plans	3
Permitted Swine Ops.	16	WWATR	0

The Potecasi Creek watershed drains approximately 258 square miles of primarily forest and agriculture land cover. The main stream in this watershed is Potecasi Creek. This stream exhibits low velocity, with swamps and heavy tree canopy throughout the watershed. Potecasi Creek was removed from the impaired water list in 2008 after the listing was determined to be inconsistent with the assessment methodology. A natural conditions assessment was conducted in Potecasi Creek in 2009 that determined the low dissolved oxygen and pH were the result of natural conditions. Nitrate and organic nitrogen have been increasing in this stream since 2000. Total phosphorus has remained relatively stable since 2012 after relatively historical high annual mean concentrations. Turbidity and fecal coliform readings were higher in Potecasi Creek relative to the other monitored streams in the Chowan River basin. Two tributaries (Bells Branch and Painter Swamp) of Potecasi Creek were previously listed on the impaired waters list but all have been delisted since 2008. These two tributaries were delisted after identifying flaws in the original analysis. The biological integrity in Urahaw Swamp, a tributary of Potecasi Creek maintained moderate benthic macroinvertebrate community ratings during the 2010 and 2015 sampling cycles. During 2010 sampling of Urahaw Swamp, the entire right bank (looking upstream), including some trees within some of the side channels had been recently logged. Other areas around the swamp were regenerating from earlier logging events. There was little to no extensive riparian vegetation, the water was very turbid from the recent activities and some large silty pools were present in the backwater areas. The Potecasi Creek watershed has the greatest number of permitted swine operations of all the Chowan River basin watersheds. Overall, water quality in the Potecasi Creek watershed remains good with a need to continue monitoring nutrients, turbidity, and fecal coliform.

Tarrara Creek-Meherrin River Watershed (HUC: 0301020409)

Tarrara Creek – Meherrin River watershed drains approximately 192 square miles of primarily agriculture and forest land cover. Overall, the benthic community in the Meherrin River had indicated a moderate decline in water quality since it was first sampled in 1983. In 2015, the river was "Not Rated" although biologists noted that the benthic community had improved since it was last sampled in 2010. The Meherrin River was previously on the impaired waters list for dissolved oxygen but has been removed since 2014 as a result of changes in the assessment methodology. Overall, water quality in this watershed is good with a need to continue to monitor the dissolved oxygen. Kirbys Creek, a tributary to the Meherrin River, continues to represent some of the best water quality in the Chowan River basin.

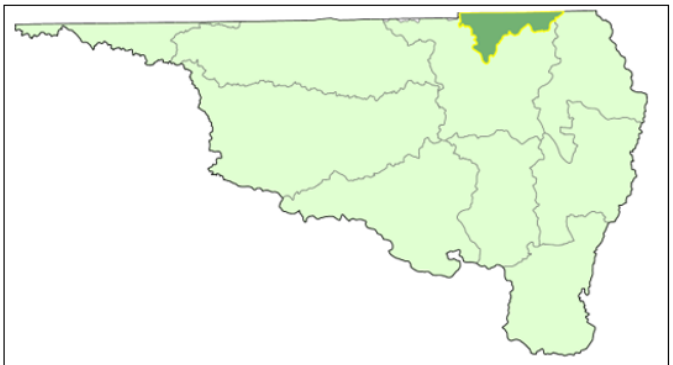


192 mi^2

Land Cover		NCDEQ Sampling Sites	
Forest	32.1%	Benthic Cycle 4	2
Agriculture	35.9%	Benthic Cycle 5	2
Developed	4.5%	AMS Stations	1
Wetland	20.2%		
Permits		**Water Supply**	
NPDES Wastewater	0	Public Water Supply System	6
Non-Discharge	5	Local Water Supply Plans	6
Permitted Swine Ops.	3	WWATR	1

Somerton Creek Watershed (HUC: 0301020301)

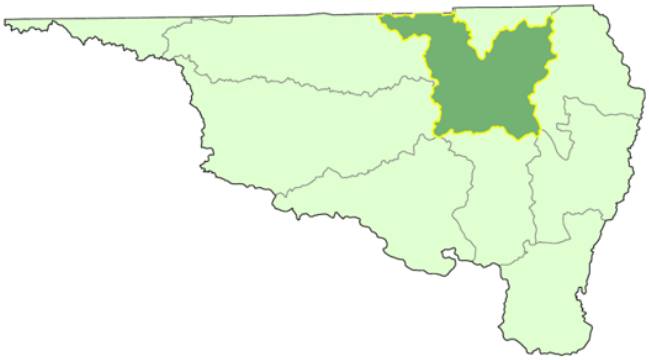
Somerton Creek watershed encompasses approximately 30 square miles and has the greatest percentage of forest and relatively low agriculture land cover compared to the rest of the Chowan River basin watersheds. Somerton Creek originates in VA and drains to the Chowan River near the VA/NC. The VA portion of Somerton Creek is impaired for aquatic life use based on benthic macroinvertebrate bioassessments and for recreation use based on *Escherichia coli*. The VA portion was previously impaired for dissolved oxygen, but was delisted as a result of a natural conditions report confirming the cuase of the impairment was natural sources. Overall, water quality in this watershed remains unassessed in NC due to the lack of ambient monitoring stations and benthic macroinvertebrate community stations.



30 mi^2

Land Cover		NCDEQ Sampling Sites	
Forest	55.5%	Benthic Cycle 4	0
Agriculture	18.5%	Benthic Cycle 5	0
Developed	4.5%	AMS Stations	0
Wetland	11.4%		
Permits		**Water Supply**	
NPDES Wastewater	0	Public Water Supply System	0
Non-Discharge	0	Local Water Supply Plans	0
Permitted Swine Ops.	0	WWATR	0

Sarem Creek-Chowan River Watershed (HUC: 0301020302)



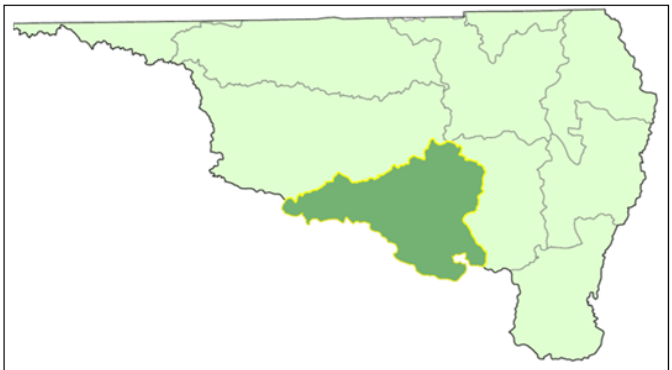
152 mi^2

Land Cover		NCDEQ Sampling Sites	
Forest	37.2%	Benthic Cycle 4	3
Agriculture	15.6%	Benthic Cycle 5	1
Developed	4.3%	AMS Stations	2
Wetland	32.2%		
Permits		**Water Supply**	
NPDES Wastewater	2	Public Water Supply System	3
Non-Discharge	1	Local Water Supply Plans	3
Permitted Swine Ops.	3	WWATR	2

The Sarem Creek – Chowan River watershed drains approximately 152 square miles of primarily forest and wetland land cover in North Carolina. This watershed is where the Nottoway and Blackwater Rivers from VA meet to form the Chowan River. These two VA rivers are on the impaired waters list for dissolved oxygen impairments and mercury. It was determined, however, all six Blackwater segments are impaired due to natural conditions and were moved to category 4C based on EPA approval letter dated April 8, 2010. The Nottoway River is also impaired for *Escherichia coli*. The Chowan River flows southeast from the NC/VA border meeting the Meherrin River, Cole Creek, and Wiccacon River in this watershed. The low dissolved oxygen concentrations observed in the Blackwater River influence the Chowan River. The upper reaches of the Chowan River were historically on the impaired waters list for a pH and dissolved oxygen impairment until 2010 when it was removed as the cause of the impairment was determined to natural conditions. A segment of the Chowan River was also delisted for Cadmium based on the approved dissolved metals water quality standards for NC approved by the EPA on April 2016. In 2010, the biological community in the mainstem of the Chowan River was determined to be Not Impaired. Overall, water quality in this watershed is good with a need to continue to monitor the dissolved oxygen and benthic macroinvertebrate communities.

Ahoskie Creek Watershed (HUC: 0301020303)

The Ahoskie Creek watershed drains approximately 170 square miles of primarily forested land with the largest percentage of developed land in the Chowan River basin (5.5%). The Town of Ahoskie has grown by 11 percent since 2000. There are no ambient monitoring or benthic macroinvertebrate community sampling in this watershed. This watershed has the only major NPDES wastewater permit in the Chowan River basin. Overall, water quality in this watershed remains unassessed due to the lack of ambient monitoring stations and benthic macroinvertebrate community sites.

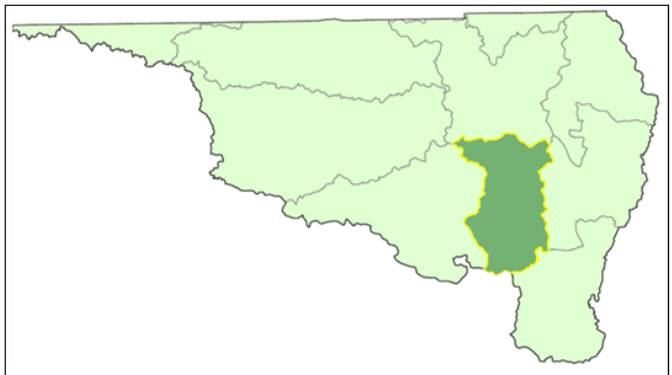


170 mi^2

Land Cover		NCDEQ Sampling Sites	
Forest	43.0%	Benthic Cycle 4	0
Agriculture	25.4%	Benthic Cycle 5	0
Developed	5.5%	AMS Stations	0
Wetland	17.7%		
Permits		**Water Supply**	
NPDES Wastewater	1	Public Water Supply System	3
Non-Discharge	3	Local Water Supply Plans	3
Permitted Swine Ops.	3	WWATR	9

Wiccacon River Watershed (HUC: 0301020304)

The Wiccacon River watershed drains approximately 106 square miles of primarily forest and agriculture land. The Wiccacon River is the main stream flowing through this watershed. The Wiccacon River has remained on the impaired waters list since 1998 due to biological impairment. The Wiccacon has historically had generally low dissolved oxygen and fair or poor benthic macroinvertebrate communities without a potential source identified. Chinkapin Swamp is a tributary that meets with other tributaries to eventually flow into the Wiccacon River. This swamp area is wooded with agricultural use in the headwaters of the drainage area. The 2015 biological community assessment showed a decline in the community possibly as a result of a declining amount of forest in the watershed. Overall, water quality monitoring efforts should be focused in this watershed to determine the cause of the Wiccacon River impairment and encourage the use of nonpoint source BMPs.

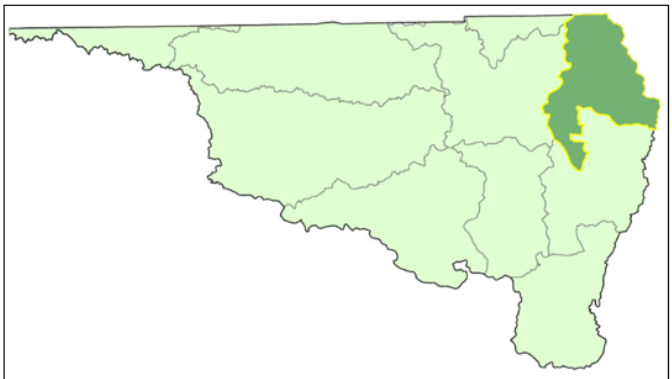


106 mi^2

Land Cover		NCDEQ Sampling Sites	
Forest	40.3%	Benthic Cycle 4	1
Agriculture	31.7%	Benthic Cycle 5	1
Developed	3.3%	AMS Stations	0
Wetland	18.7%		
Permits		**Water Supply**	
NPDES Wastewater	0	Public Water Supply System	2
Non-Discharge	1	Local Water Supply Plans	2
Permitted Swine Ops.	1	WWATR	5

Bennetts Creek Watershed (HUC: 0301020305)

Bennetts Creek watershed drains approximately 107 square miles of primarily forest land cover with agriculture found along the headwater streams and swamps in the upper region of the watershed. Merchants Millpond is 1.2 square mile natural heritage site composed of swamp and hardwood forest which support a diverse assemblage of aquatic plants including several rare species. The shallow millpond exhibits many characteristics associated with a Swamp Water designation, such as tannic waters and buttressed trees. Duck weed and watermeal are present on the surface of Merchants Millpond while submerged aquatic macrophytes occur throughout the lake. Overall, Merchants Millpond was eutrophic (nutrient rich) in 2015 and has historically exhibited elevated biologic productivity since it was first monitored in 1981. Agricultural best management practices should continue to be promoted in this watershed.

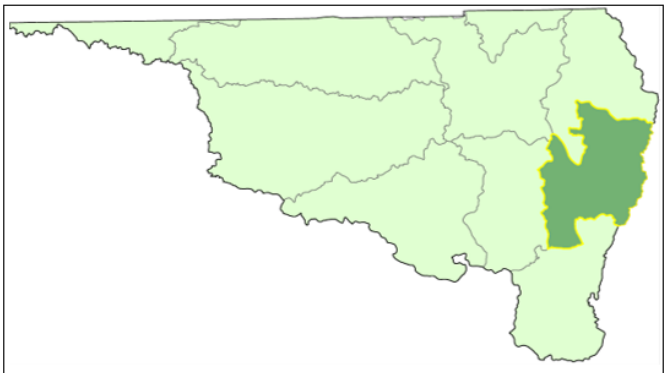


107 mi^2

Land Cover		NCDEQ Sampling Sites	
Forest	37.5%	Benthic Cycle 4	1
Agriculture	27.2%	Benthic Cycle 5	0
Developed	3.5%	Lakes Monitoring Cycle 4	3
Wetlands	25.0%	Lakes Monitoring Cycle 5	2
Permits		Water Supply	
NPDES Wastewater	3	Public Water Supply System	0
Non-Discharge	1	Local Water Supply Plans	0
Permitted Swine Ops.	4	WWATR	0

Holiday Island-Chowan River Watershed (HUC: 0301020306)

This watershed drains approximately 120 square miles of primarily agriculture land. The watershed has the highest percentage of agricultural land and the second greatest amount of permitted swine operations relative to the rest of the Chowan River basin watersheds. The mainstem of the Chowan River flows through this watershed receiving streamflow from the Wiccacon River, Bennetts Creek, and Indian Creek. Relatively high chlorophyll *a* concentrations, that exceeded the 40 µg/L standard, were observed at the ambient water quality monitoring stations near the mid and lower sections of the Chowan River in this watershed. The lower Chowan River has also experienced multiple severe algal blooms in the last few years. Visit the Algal Bloom Map to view where the blooms have been



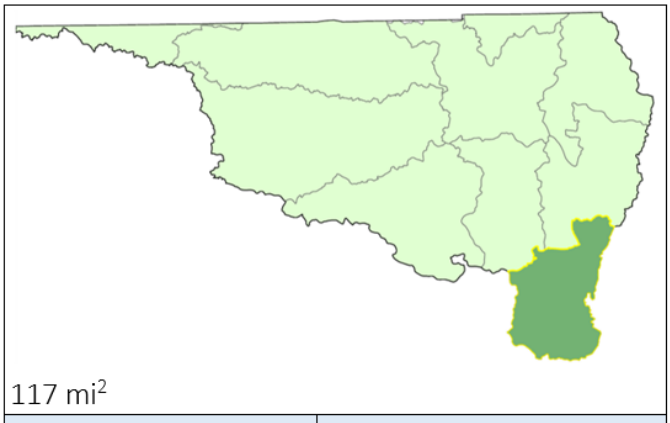
120 mi^2

Land Cover		NCDEQ Sampling Sites	
Forest	19.3%	Benthic Cycle 4	0
Agriculture	38.4%	Benthic Cycle 5	0
Developed	3.5%	AMS Stations	2
Wetland	22.6%		
Permits		Water Supply	
NPDES Wastewater	0	Public Water Supply System	0
Non-Discharge	1	Local Water Supply Plans	0
Permitted Swine Ops.	6	WWATR	5

observed. Overall, water use in this watershed has been impacted by severe algal blooms. Additional monitoring resources should be focused in this section of the Chowan River.

Chowan River Watershed (HUC: 0301020307)

This watershed drains approximately 117 square miles of primarily agriculture, forest and wetland land covers. The mouth of the Chowan River meets the Albemarle Sound in this watershed. This section of the Chowan River also experienced severe algal blooms since 2015 with relatively high chlorophyll *a* concentrations, that exceeded the 40 µg/L standard. Visit the Algal Bloom Map to view where the blooms have been observed. In 2015, the biological community in the mainstem Chowan River showed a decline and a shift to more pollution tolerant taxa compared to the 2010 sampling effort. The presence of many estuarine or freshwater-tolerant crustaceans indicates saltwater intrusions into this area of the river. Rockyhock Creek, Eastmost Swamp, and Cricket Swamp are tributaries of the Chowan River. Cricket Swamp has been on the impaired waters list for pH since it was sampled in 2012, although the cause could be natural conditions. Cricket Swamp and Eastmost Swamp both received moderate ratings for their benthic macroinvertebrate communities. Overall, water use in this watershed has been impacted by severe algal blooms. Additional monitoring resources should be focused in this section of the Chowan River.



117 mi^2

Land Cover		NCDEQ Sampling Sites	
Forest	25.2%	Benthic Cycle 4	2
Agriculture	29.8%	Benthic Cycle 5	2
Developed	3.8%	AMS Stations	1
Wetland	16.2%	RAMS Stations	1
Permits		**Water Supply**	
NPDES Wastewater	1	Public Water Supply System	1
Non-Discharge	1	Local Water Supply Plans	1
Permitted Swine Ops.	1	WWATR	2

Impacts to Water Quality

Pollutant sources fall into two general categories: point sources and nonpoint sources. Most often the source is based on the predominant land use in a watershed. Many point sources were removed from the Chowan River due to the Nutrient Sensitive Water (NSW) management strategy that was implemented in 1982. The NSW management strategy also resulted in municipal wastewater treatment plants (WWTP) converting to land application. Many unknown sources can impact water quality. However, agriculture, forestry, failing septic systems, altered hydrology, and runoff from land application of wastewater sites have all been identified as potential sources of nutrients impacting water quality in the basin.

Agriculture

In NC, approximately 29 percent of the land use in the Chowan River basin is identified as agriculture. Excess nutrients, pesticides, herbicides, bacteria and sediment are often associated with agricultural activities. In the Chowan River basin, significant efforts have been made to reduce nitrogen and phosphorus loads originating from agricultural land through the installation of best management practices (BMPs). Between July 2010 and June 2020, more than $1.2 million of state cost share funds has

been spent in the basin on both agriculture and urban BMPs to protect water quality. Several practices have also been installed using funds available through programs managed by the USDA Natural Resource Conservation Service (NRCS).

As of May 2020, there are 40 permitted animal feeding operations (AFOs) in the Chowan River basin. All are permitted swine operations. Waste treatment from these operations typically includes a liquid waste treatment lagoon and application of liquid to vegetated spray fields. If not effectively utilized by vegetation (i.e., applied at agronomic rates), nutrients produced by animals can enter surface waters by atmospheric deposition, groundwater and stormwater runoff. NCDEQ has regulatory authority over swine and cattle operations that use dry or liquid manure waste management systems and poultry operations that use a liquid waste management system (i.e., spray irrigation). These permitted animal facilities are inspected annually.

Most poultry operations, however, produce dry-litter poultry waste that typically falls under the deemed permitted category (NCAC 02T .1303) and do not require an NPDES or state permit. Operations that fall into this category are only inspected if a complaint is filed. Because information about the location, number of birds, amount of dry-litter poultry waste produced, and the location, surface area and application rate on which the dry-litter poultry waste is applied is unknown, determining the extent of potential impacts from dry-litter poultry waste to water quality is difficult to assess. Additional information is needed about the location of deemed permitted poultry operations and land application sites (both on-farm and off-farm) to assist DWR in establishing new monitoring stations to access potential nutrient impacts to aquatic ecosystems and water quality. Based on data available through the USDA Census of Agriculture, the overall number of farms and the land area utilized for farming operations in Bertie, Chowan, Gates, Hertford and Northampton counties has declined since 2007, but the number of birds has increased in Bertie, Gates, and Hertford counties.

Forestry

Nearly 36 percent of the land use in the Chowan River basin in NC is identified as forested. Forests often play a significant role in protecting water quality by absorbing and filtering precipitation, anchoring soil, intercepting particulate matter, and reducing instream water temperatures.

Special attention is needed to ensure that water quality is protected while timber is being harvested in the basin. Inappropriate management practices can impact water quality by altering instream habitat and increasing sediment load. These impacts can also alter the interface of the aquatic and terrestrial ecosystem and change watershed functions. Without appropriate best management practices in place during and after harvests, sediment entering a waterbody can have a negative impact on water quality. Sediment can stem from exposed cuts for skid trails, slopes with bare soil, and improperly constructed stream crossings, forest roads, and log decks. As a result, the majority of regulations and erosion control recommendations pertaining to forestry focus on preventing debris and sediment from entering waterbodies. Properly planned and executed forest management plans facilitate the sustainable harvest of forest products while protecting water quality.

Between July 2007 and June 2017, the North Carolina Forest Service (NCFS) inspected 1,303 timber harvesting operations on 82,064 acres. Eighteen were found to be out of compliance with the Forest Practice Guidelines (FPG). The most common violations were related to streamside management zones (SMZ), debris entering streams, stream crossings, or rehabilitation of the project area. Because

landowners are not required to notify NCFS of timber harvesting or related forestry activities, the numbers reported may not be a full representation of the timber harvests in the basin.

There has been growing concern in recent years over forest management and its influence on algal blooms in the Chowan River basin. In August 2016, NCFS personnel conducted an aerial assessment via aircraft along the Chowan River to see if algal blooms were emanating from timber harvests. At that time, the NCFS found no visible algal growth originating from past timber harvests of varying ages. NCFS met with stakeholders in the basin, including the Soil and Water Conservation Districts (SWCD) and the Albemarle Resource Conservation and Development Council, Inc. (ARCD), to discuss riparian buffer incentives for landowners wanting to harvest timber adjacent to known nutrient-sensitive waters. Working collaboratively with landowners, state and federal agencies, and researchers, NCFS continues to explore how forest management may influence water quality in the Albemarle region.

Non-Discharge Wastewater Treatment Systems

Due to the nutrient sensitivity of the waters in the Chowan River basin and the strict effluent limits on discharges, non-discharge wastewater treatment systems are more common than municipal surface wastewater dischargers. This transition occurred in the 1980's to help prevent eutrophication in the nutrient sensitive waters of the Chowan River basin. In many groundwater monitoring wells around the non-discharge wastewater treatment system, nitrate and ammonia concentrations are below the 15A NCAC 02L and Interim Maximum Allowable Concentrations for groundwater of 10 mg/L and 1.5 mg/L, respectively. Although groundwater concentrations below many of these facilities adhere to groundwater standards, a few facilities have observed concentrations above these standards in groundwater around the facilities. Investigations indicate the elevated nutrient concentrations are the result of surrounding land use. All of the facilities in the Chowan River basin have the potential to cause impacts to surface or groundwater. Although potential may exist for groundwater and surface water impacts to occur from non-discharge operations, there are few facilities where routine run-off occurs from the spray fields, no routine cases of nutrient over-application occurring based on monitoring data, nor widespread groundwater impacts attributable to wastewater management operations.

Parameters of Concern in the Chowan River Basin

Algal Blooms and Nutrients

The Chowan River was the first coastal river in NC recognized to experience problems with nutrient enrichment or eutrophication in 1972 and 1978. Nutrient enrichment resulting from excess nitrogen and phosphorous in waterbodies can cause algal blooms that deplete oxygen, kill fish, and create taste and odor problems in drinking water. The Chowan NSW Water Quality Management Plan nutrient reduction goals of 20 percent for nitrogen and 35 percent for phosphorus were documented in the 1990's, but since 2000 the Chowan river and tributaries have seen a steady increase in organic nitrogen levels. Additional research and analytical tools are needed to better understand the source of increasing organic nitrogen and how to properly manage this load.

Over the last several years a resurgence of algal bloom and potentially harmful algal bloom (pHAB) activity has occurred in the Chowan River. There is a need to better understand the different nutrient contributions in the VA and NC watersheds which form the Chowan River which flows into the Albemarle Sound. One of the goals of this assessment is to better understand the changes that have occurred over time and if there is a specific turning point or shift in environmental conditions which have resulted in the

Chowan River becoming increasingly susceptible to the development of algal blooms and/or pHABs. Reviewing the changes in nutrient concentrations and loading is just the first step in understanding possible changes in the watershed. This report will present the nitrogen species [nitrate, ammonia, and organic nitrogen], total phosphorus, and chlorophyll *a* data over time throughout the Chowan River basin in an effort to communicate the changes in the instream nutrient concentrations and loads relating those changes to the management strategy, land use and other watershed implementation efforts that have taken place since the early 1980's. Nutrient levels were analyzed at nine ambient stations throughout the basin. Increasing instream concentration levels of organic nitrogen were observed at all nine sites, with the highest amounts found in the Potecasi River. Total phosphorus instream concentration levels were only found to be increasing at one site in the Potecasi River. The source of the increased nutrients has not been identified.

Low pH

The standard for pH in freshwater is 6 su and 9 su. One river, Cricket Swamp, has water quality with a pH less than this standard. This was determined by monitoring at a RAMS station D9515000 between 2011-2012. Cricket Swamp drains to Salmon Creek then flow to the Chowan River near the Albemarle Sound. The source of the low pH has not been determined but could be the result of natural conditions. The natural conditions contributing to the low pH could be reactions with acid soils and drainage of swamp-like water.

Dioxins

Dioxins have been identified as an impairment for the Albemarle Sound to the mouths of the Chowan and Roanoke rivers. Dioxins are the byproducts of industrial processes and are formed during the chlorine bleaching process at pulp and paper mills. The current dioxins advisory was issued by the Department of Health and Human Services (DHHS) in 2001. The advisory is for the consumption of catfish and carp in the Albemarle Sound from Bull Bay to Harvey Point; West to the mouth of the Roanoke River and to the mouth of the Chowan River to the U.S. Highway 17 Bridge (Perquimans, Chowan, Bertie, Washington, and Tyrrell counties). Women of childbearing age and children should not eat any catfish or carp from this area until further notice. All other persons should eat no more than one meal per month of catfish and carp from this area. For more information on this advisory please visit the DHHS website https://epi.dph.ncdhhs.gov/oee/fish/advisories.html.

Mercury

In 1997 a statewide fish consumption advisory was issued due to mercury levels found throughout the state. Mercury levels in fish have been found at unsafe levels especially in larger fish due to bioaccumulation. The major source of the mercury has been determined to be atmospheric deposition. For more information on this advisory please visit the DHHS website https://epi.dph.ncdhhs.gov/oee/fish/advisories.html.

Recommendations

Balancing economic growth with water resources protection is challenging. Point source impacts on surface waters can be measured and addressed through voluntary and regulatory actions, but the cumulative effects of nonpoint source pollution are diffuse. Nonpoint source pollution is the primary threat to water quality and habitat degradation in the Chowan River basin. While streams impacted by

nonpoint source pollution can be identified through the basin planning process, actions to address the issues are needed at the local level. Recommendations below are categorized by sector and include agencies, stakeholders, and other entities as potential participants needed to participate in the recommendation. Recommendations in **bold type** are ones that have been identified as priorities by the Basin Planning Branch.

Agriculture Best Management Practices (BMPs) and Waste Management Recommendations:	Participants
State and local agencies, as well as individual cooperators and landowners, should invest in nutrient reducing activities including: ▪ ***Identify and expand educational opportunities to work with private landowners on nutrient management and the benefits of implementing BMPs, maintaining riparian buffers and conducting soil tests.*** ▪ ***Provide new funding to hire additional personnel (DSWC) to promote BMPs in the region and work with landowners on new and innovative practices that can reduce nutrients, manage water levels in the field, and explore the benefits of forested buffers and wetlands to reduce nutrients and mitigate flood damage.*** ▪ ***Identify how best to capture water quality data and BMP benefits to model nutrient loads throughout the entire basin (Virginia and North Carolina).*** ▪ ***Promote BMPs to reduce the loading of phosphorus into the whole Chowan River system, with a focus on reducing phosphorus bound to sediments that can increase instream total phosphorus concentrations during runoff events.*** ▪ ***Encourage the use of nutrient management plans to ensure efficient use of fertilizers.***	**NC Department of Agriculture & Consumer Services, Division of Soil and Water Conservation (DSWC)** **Universities and Colleges** **DWR - Nonpoint Source Planning Branch** **DWR - Basin Planning Branch** **DWR - Modeling and Assessment Branch** **DWR - Water Quality Regional Operations Section** **Albemarle-Pamlico National Estuary Partnership** **DWR - 401 & Buffer Transportation Permitting Branch** **USDA Natural Resources Conservation Service**

Identify and evaluate opportunities to continue promoting and implementing nutrient reducing BMPs throughout the basin including: ▪ ***Review and reevaluate existing policies that may limit a BMP's use in the basin.*** ▪ ***Enroll the support of academic researchers to identify new, cost-effective nutrient reducing BMPs for the region based on soil type, current and future crop rotations and specialty crops, organic and inorganic fertilizer management, etc.***	**NC Department of Agriculture & Consumer Services, DSWC** **USDA Natural Resources Conservation Service** **Universities and Colleges** **DWR - Nonpoint Source Planning Branch** **DWR - Basin Planning Branch**
Current rules and regulations do not require poultry operations that produce dry-litter poultry waste to obtain an NPDES or state general permit. Because information about the location, number of animals, amount of dry-litter poultry waste produced, or fields on which the dry-litter poultry waste is applied is unknown, determining the extent of potential impacts from dry-litter poultry waste to water quality is difficult to assess. Additional information is needed about the location of poultry operations and land application sites statewide in order for DWR to establish new monitoring stations to assess potential nutrient impacts to aquatic ecosystems and water quality. To obtain additional information about the location of poultry operations and land application sites, NCDEQ should evaluate existing regulatory requirements for poultry operations that includes a possible registration program.	**General Assembly** **NC Department of Environmental Quality** **DWR - Animal Feeding Operations Branch** **Public Stakeholders and Non-Profits**
Developed Areas Recommendations:	**Participants**
Characterize locations, extent, and age of septic systems in the basin. Consider financial incentives and/or regulatory options to address failing septic systems.	NC Department of Health and Human Services County Health Departments

Coordinate with local governments and community residents to: ▪ *Voluntarily increase tree canopy cover, reduce fertilized landscaping, and minimize impervious surfaces with a primary focus on waterfront communities in areas with bloom activity (e.g., Arrowhead Beach).* ▪ *Allow economic growth to occur but maintain water quality through a comprehensive stormwater management program.* ▪ *Encourage Green infrastructure to minimize the impact from runoff.* ▪ *Work with local governments to identify and fund cost-effective stormwater retrofit projects, with a focus on local flood resiliency (maximize co-benefits).*	Public Stakeholders and Non-Profits Local County and City Governments Universities and Colleges NC Association of Regional Councils of Governments Division of Energy, Mineral, and Land Resources Stormwater Program
Nutrients in the Chowan Basin and Albemarle Sound Recommendations:	**Participants**
Continue to work with the Nutrient Criteria Development Plan (NCDP) Scientific Advisory Council (SAC) to develop appropriate protective criteria recommendations for the Chowan River and Albemarle Sound. This may include modification of current criteria such as chlorophyll *a* and/or the development of an instream nitrogen and/or phosphorus criteria.	**NC Department of Environmental Quality, DWR** **Universities and Colleges** **Public Stakeholders and Non-Profits**
The current monitoring schema and resource allocation does not appear to appropriately capture the magnitude, frequency or the geographic extent of the ongoing water quality problems in the region. There is a need to provide new financial support and additional staff to state agencies and review the Chowan River basin Ambient Monitoring System program to ensure the program is capturing the algal blooms, algal toxin production, nutrients and physical characteristics needed to understand current water quality conditions and algal bloom development (e.g., dissolved fractions of	**NC Department of Environmental Quality, DWR**

N and P, algal limiting constituents, sediment recycling, nutrient source identification, river flow, etc.).	
Local monitoring of algal blooms, research needs, and education: ▪ *Develop and expand local capacity to monitor for algal blooms and algal toxins.* ▪ *Expand local education and outreach on algal blooms and improve local stakeholder digital reporting of blooms.* ▪ *Support research and use of new monitoring techniques and technology to improve understanding of algal blooms in the hard to reach sections of the Chowan River and Albemarle Sound region (e.g. remote sensing/satellite imagery, drones, etc.).* ▪ *There is a critical need for technology that can distinguish a specific nitrogen signature in order to identify a specific source such as agricultural animal types, domestic waste or a background forest/sediment signature. DWR encourages researchers to continue to work toward a method viable to use on a large-scale system. This would assist in the development of appropriate best management practices to reduce the load of organic nitrogen into the system.* ▪ *Track health-related algal events, including closures and advisories.*	County Health Department Local Special Monitoring Groups Public Stakeholders, Non-Profits, and citizen scientist organizations NC Department of Agriculture & Consumer Services DSWC NC Department of Environmental Quality, Division of Water Resources Albemarle-Pamlico National Estuary Partnership Universities and Colleges DWR - Ecosystems Branch DWR - Education and Outreach NC Department of Health and Human Services
When practicable, the NCDEQ Regional Offices should split groundwater samples at designated non-discharge facilities during a compliance visit and analyze the samples for total phosphorous, total nitrogen, nitrate, ammonia, and total Kjeldahl nitrogen. These samples will help better establish an understanding of nutrients in groundwater surrounding these facilities capturing both the ambient groundwater and downgradient groundwater.	Universities and Colleges DWR - Basin Planning Branch DWR – Non-Discharge Permitting and Regional Offices

Conduct preliminary assessment of nutrient modeling needs in the basin including: ▪ *If warranted, finance external nutrient model for the Chowan River basin to characterize the degree of nutrient reductions needed to achieve water quality goals.* ▪ *Conduct bioassays throughout the Chowan River and Albemarle Sound region to understand response of algae to nitrogen and phosphorus and determine if these systems are nitrogen or phosphorus limited.*	Universities and Colleges Public Stakeholders and Non-Profits DWR - Modeling and Assessment Branch DWR - Nonpoint Source Planning Branch
Interstate Cooperation Recommendations:	**Participants**
Establish better communication between Virginia DEQ, North Carolina DEQ and the Albemarle-Pamlico National Estuary Partnership to better understand changes that have occurred over time and steps that each state has taken and can continue to take to control nutrients, ensure proportionate nutrient-reduction measures are in place, and improve water quality flowing to the Albemarle Sound.	**Albemarle-Pamlico National Estuary Partnership** **Virginia DEQ** **North Carolina DEQ** **Local elected officials, public stakeholders and interest groups**
Streamflow Research Recommendations:	**Participants**
Investigate possible temporal relationships between stream flow and chlorophyll *a* concentrations. Understanding the correlation between stream flow and chlorophyll *a* concentrations could assist local agencies with forecasting the intensity of algal bloom that may occur.	DWR - Modeling and Assessment Branch DWR - Basin Planning Branch Universities and Colleges Public Stakeholders and Non-Profits
Identify new and innovative modeling approaches for coastal watersheds to adequately replicate the interactions of surface and groundwater withdrawals, modified land use and drainage patterns, adequate flow for the protection of aquatic habitats, changes in	DWR - Modeling and Assessment Branch DWR - Ground Water Management Branch

weather patterns, and stage-flow relationships. Data gaps in stream flow and the tidal influence in coastal waters complicates efforts to model stream flow.	DWR - Water Supply Planning Branch Wildlife Resources Commission Universities and Colleges Public Stakeholders and Non-Profits
Consider utilizing a prioritization tool for federal, state and local resources agencies to collectively identify dams suitable for removal, rate and map habitat for target species, identify impediments in the basin, and assess the miles of stream network or the area of habitat made available to migrating fish by removal or modification of each structure. Some of the other considerations associated with a dam removal proposal is the amount of accumulated sediment stored behind the dam, the amount, value and potential impact to established wetlands that may surround the impoundment, and the potential expansion of the range of any existing exotic species in the basin.	Universities and Colleges Wildlife Resources Commission Division of Marine Fisheries NC Aquatic Connectivity Team Southeast Aquatic Resources Partnership Division of Mitigation Services NC Division of Environmental Quality, Division of Water Resources Public Stakeholders and Non-Profits US Fish and Wildlife Service
Administrative, Communication and Public Relations Recommendations:	**Participants**
Establish a Chowan Strategy web page on Nonpoint Source website with key historical documents, summary of historical issues, and summary of current conditions and ongoing work.	Department of Environmental Quality, Division of Water Resources
Consider accepting third-party algal reporting as a separate data source on the NC algal bloom map. Activities already underway at county level (Pasquotank) with active community participation.	Local County, City Governments, Public Stakeholders Department of Environmental Quality, Division of Water Resources

Contribute to community forums related to water resources protection and algal blooms	Department of Environmental Quality, Division of Water Resources
Prioritize advancing Chowan issues in 2020-2021 NC Department of Environmental Quality Division of Water Resources staff work plan development	Department of Environmental Quality, Division of Water Resources
Coordinate and facilitate bi-annual meetings between stakeholders, APNEP and local stakeholders interested in discussing water quality and quantity concerns.	DWR - Basin Planning Branch
Climate Change Recommendations:	**Participants**
Continue developing basin plans that recommend protecting wetlands and floodplains, installing stormwater BMPs, identifying and retrofitting high-risk infrastructure, projecting and planning for changes in water use and availability, identifying areas that are disproportionately burdened with environmental hazards, and implementing green infrastructure, low-impact development and living shorelines. All these strategies can protect water quality and promote water resource sustainability. They have also been identified as means to mitigate impacts from increased precipitation and flood events caused by climate change.	NC Department of Environmental Quality Albemarle-Pamlico National Estuary Partnership Public Stakeholders and Local Interest Groups
Forestry and Water Quality Recommendations:	**Participants**
Continue working with landowners and consulting foresters to promote site appropriate BMPs. Continue monitoring sites for compliance with the Forest Practice Guidelines Related to Water Quality. Collaborate in opportunities to study the effects of forest management.	North Carolina Department of Agriculture and Consumer Services (NCDA&CS), NC Forest Service (NCFS) Regional and Consulting Foresters Universities and Colleges to study the regional SMZ widths

Identify research needs specific to the Chowan River basin. ▪ *More research is needed on the transport of legacy sediments within the basin.* ▪ *Research examining silvicultural practices in forested swamps is needed to better understand the relationship among forestry-related operations and water quality parameters within the basin. Continued monitoring could help identify nonpoint sources of nutrients entering the basin.* ▪ *Develop a designed study to evaluate water quality parameters stemming from managed forest land and provide recommendations for improving harvesting techniques and/or practices. The study would require substantial new funding for five or more years, landowner commitment, and experienced foresters and researchers to conduct the study. NCFS has offered to assist with project scoping, selecting foresters and researchers willing to participate in such a project, provide technical expertise on forestry practices, provide applicable references for literature review and general review and oversight.*	North Carolina Department of Agriculture and Consumer Services (NCDA&CS), NC Forest Service (NCFS) Universities and Colleges to study silviculture in forested swamps NC Department of Environmental Quality
Establish a conservation program for swamp forest buffers similar to existing federal and state cost share programs for agricultural lands. The program could provide an economic incentive to landowners to conserve and manage swamp forest buffers. Conserving and managing the swamp forest buffers, in turn, could protect critical drainage areas, protect water quality and provide aquatic and terrestrial habitat throughout the basin.	NC Forest Service (NCFS) County Tax Offices
Characterize the nature and extent of riparian and wetland forestry activities in the basin.	NC Forest Service (NCFS) NC Department of Environmental Quality

Characterize the existing and potential use of forestry lands for waste application.	NC Forest Service (NCFS) NC Department of Environmental Quality
Water Use and Demand Recommendations:	**Participants**
To ensure that future water supply needs can be met and to identify conflicts or problems that need to be resolved, information about water use needs to be collected from all water users.	**DWR - Water Supply Planning Branch** **NC DEQ – Public Water Supply Section** **DWR - Basin Planning Branch** **NC Department of Agriculture & Consumer Services** **NC Farm Bureau** **United States Department of Agriculture**
Establish a statewide water withdrawal permitting program. A statewide water withdrawal permitting program would allow DWR the ability to better manage water resources in the state.	General Assembly NC Department of Environmental Quality Water Supply Planning Branch
North Carolina Department of Environmental Quality Recommendations:	**Participants**
As funding, personnel, and/or laboratory capacity resources become available, it is recommended that the RAMS program incorporate collection of nutrients, and where appropriate, chlorophyll *a* samples.	NC Department of Environmental Quality, Division of Water Resources

Consider implementation of nonpoint source management strategies (e.g. buffer rules) analogous to those in other nutrient-impaired watersheds.	**DWR - Nonpoint Source Planning Branch** **DWR - Water Quality Regional Operations Section**
Consider financial incentives (i.e. grants or tax credits) to promote strategic preservation or restoration of riparian areas.	**Council of Governments (COG)** **County Tax Offices** **NC Department of Agriculture & Consumer Services (NC Forest Service, Agricultural Development and Farmland Preservation Trust Fund)**
Continue to support and expand the monitoring of groundwater through the Ground Water Management Branch. Consideration should be given to locate wells in strategic locations in proximity to surface waterbodies. Such locations may provide a method to improve predictive modeling efforts related to groundwater discharges to surface waters and could provide for more accurate assessment of surface water impairments resulting from groundwater discharges enabling the state to make sound permitting judgments and recommendations to better protect ground and surface water quality.	**DWR - Ground Water Management Branch** **DWR - Animal Feeding Operation** **NCDA&CS Division of Soil and Water Conservation** **DWR - Water Quality Regional Operations Section** **DWR - Non-Discharge Branch**