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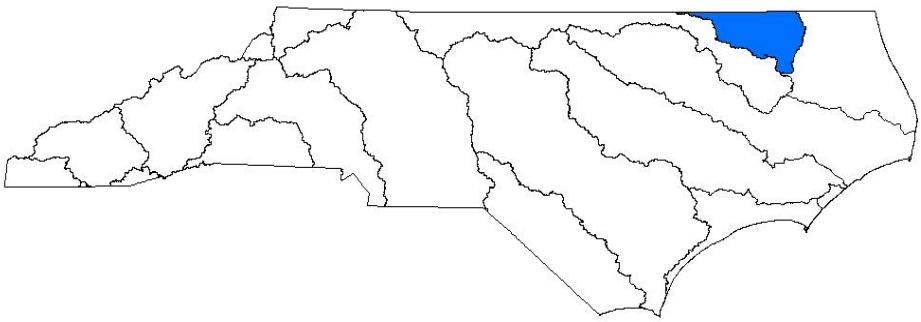
Chapter 1 Chowan Basin Overview



1.1 General Description

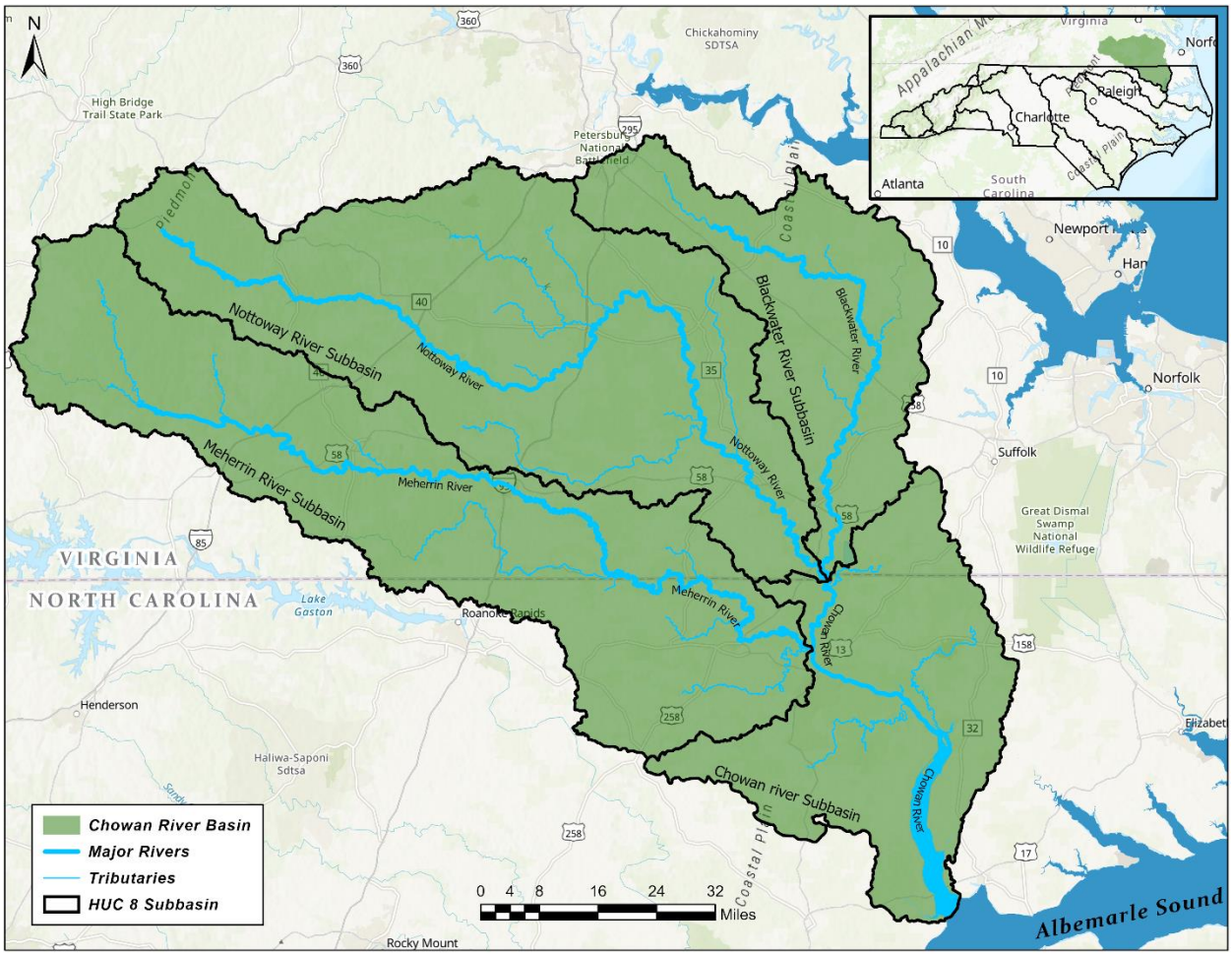
The North Carolina portion of the Chowan River basin is in the northeastern coastal plain, but its headwaters begin in Virginia (VA). Three major rivers – the Blackwater, Nottoway and Meherrin – begin in VA and flow south-southeast to form the Chowan River near the Virginia-North Carolina state line. Nearly 1,300 square miles of land is included in the North Carolina (NC) portion of the basin, but most of the drainage area (3,600 square miles) lies in VA (Figure 1-1). Major tributaries to the Chowan River in NC include Potecasi Creek, Wiccacon River, and Ahoskie Creek. All or portions of Northampton, Hertford, Gates, Bertie and Chowan counties are located in the basin along with several local municipalities including Ahoskie, Colerain, Conway, Gatesville, Powellsville and Rich Square (Figure 1-2). Most of the water used in the basin for public or private use comes from groundwater sources. Projected use estimates indicate that there will be a small increase in water use over the next several years.

Important natural resources in the basin include wetlands, anadromous fish spawning areas and Merchant's Millpond State Park. The North Carolina Natural Heritage Program (NHP) considers 100 miles of the Chowan River and its tributaries significant aquatic habitat because of diverse, rare, and vulnerable populations of freshwater mussels. Five mussel species are listed as threatened by the Wildlife Resources Commission (WRC). These include the triangle and alewife floaters, the eastern lampmussel, the eastern pondmussel and the tidewater mucket. No species in this basin have been listed as endangered.

The basin is part of the larger Albemarle-Chowan River basin (HUC 030102), which includes southeastern VA and NC's Pasquotank River basin. The Chowan River is the second-largest tributary to the Albemarle Sound, one the country's largest estuaries. The Albemarle Sound, in turn, is part of the Albemarle-Pamlico Estuarine System. It is the second largest estuarine system in the United States and includes portions of or all of the Chowan, Pasquotank, Roanoke, Tar-Pamlico, Neuse, and White Oak river basins. In recognition of the numerous benefits provided by the Albemarle and Pamlico Sounds, the United States Congress designated the Albemarle-Pamlico Estuarine System an "estuary of national significance" in 1987. That same year, the Albemarle-Pamlico Estuarine Study (APES) was among the first of 28 National Estuary Programs established by the EPA through amendments to the Clean Water Act (CWA). Upon adoption of its first Comprehensive Conservation Management Plan (CCMP) in 1994, the program became known as the Albemarle-Pamlico National Estuary Program (APNEP) and it broadened its mission to include applied conservation, management and engagement initiatives to protect natural resources within the region. In

2012, the program was formally renamed and identified as a Partnership, reflecting the importance of coordinated and integrated efforts for protecting and restoring the estuarine ecosystem in the region.

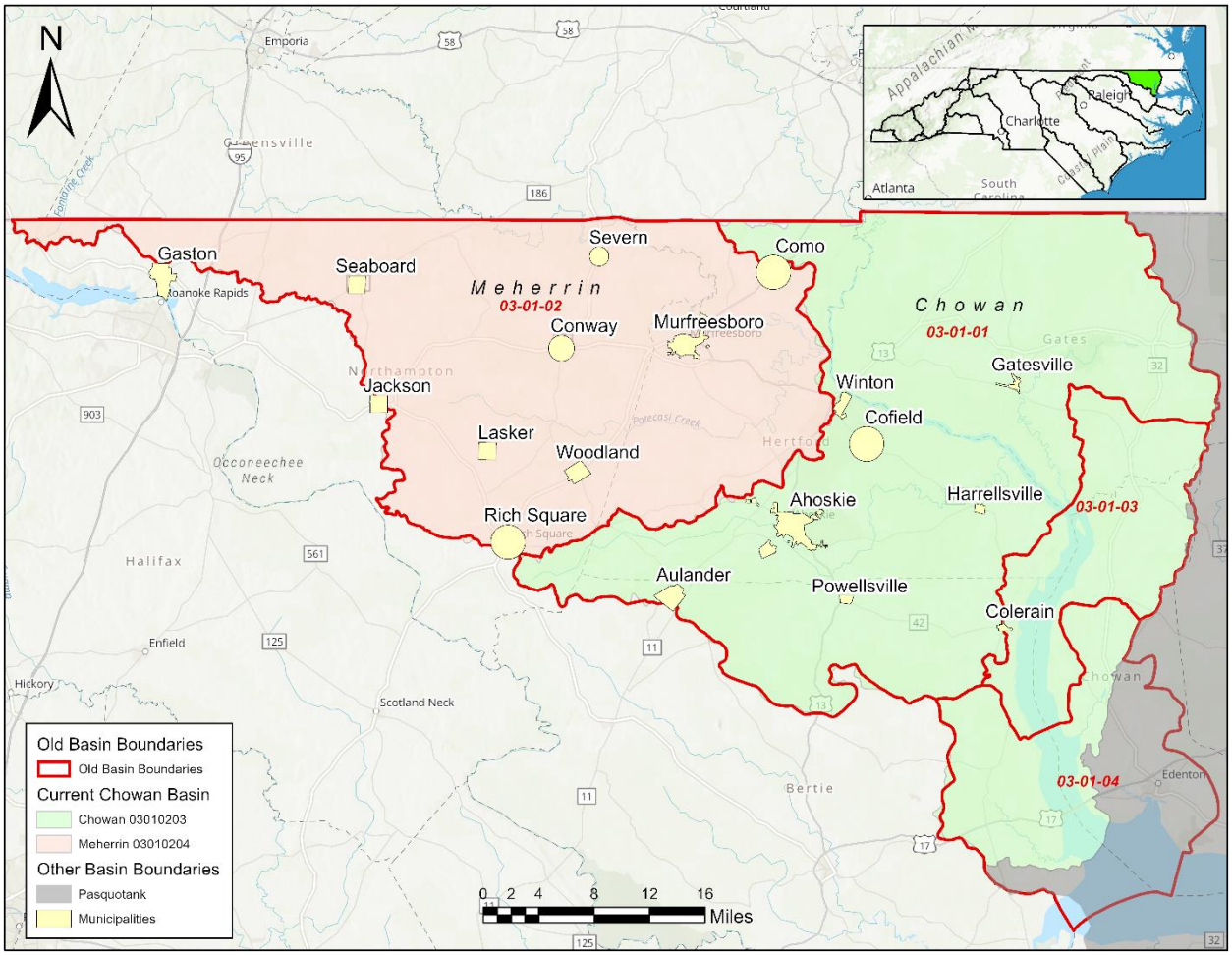
Figure 1-1 General Map of the Entire Chowan River Basin



1.2 Watershed Boundaries in the Chowan River Basin

The Division of Water Resources' (DWR) previous basin plans used subbasin boundaries that were numbered based on the river basin and location within the river basin. DWR has changed how these subbasins are grouped to conform to the federal cataloging unit known as hydrologic unit codes (HUCs). Each hydrologic unit is identified by a unique number. The largest HUC is two digits (region). Two additional digits can be added to the HUC to sub-divide it into smaller areas, or watersheds. The HUCs are nested within each other from the largest geographic area (region) to the smallest geographic area (cataloging unit) (USGS, 2020). Each HUC represents the area of the landscape that drains to a portion of the stream network (USGS, 2020). This report is organized by chapters at the HUC 8. The conversion from DWR subbasins to HUC 8 is illustrated in Figure 1-2. Note that a portion of the Chowan River basin near Edenton is now in the Pasquotank River basin based on the USGS Watershed Boundary Dataset (WBD) (USGS, 2020).

Figure 1-2 General Map of the Chowan River Basin in North Carolina with the old DWR Subbasins and 8-Digit Hydrologic Units



1.3 Aquatic Habitats

The areas where rivers and sounds meet are described as "drowned river estuaries" (Riggs and Ames 2003). Due to the retreat of the last glacial maximum, the old river channels were submerged over the past 17,000 years due to sea-level rise. The transition zone from river to estuary occurs in a broad zone where riverine processes become estuarine. The Chowan River, like the Roanoke River, is a mainstem or trunk river, discharging large volumes of fresh water into the Albemarle Sound estuary. The erosion of upland clay soils is the source of significant loads of sediment deposited in the sound following storms.

1.3.1 Types of Aquatic Habitats

The Fisheries Reform Act was passed in 1997 by the NC General Assembly in recognition that protecting habitat is as important as preventing overfishing. The act established the requirement to develop a Coastal Habitat Protection Plan (CHPP) to protect and enhance important coastal fisheries habitats. The CHPP lists six distinguishable habitat types along the state's coast: water column, submerged aquatic vegetation, shell, soft and hard bottom habitats, and wetlands (NCDMF, 2016).

1.3.1.1 Water Column

The water column is a unique, dynamic habitat with changing physical and chemical properties that links all the various habitats and provides the means of transport of organisms from one habitat type to

another. Water depth and direction of flow can vary depending on meteorological events, such as precipitation and wind direction, tidal events, and proximity to inflow from inland rivers and outflow through the coastal inlets. These factors also influence mixing of the water column's dissolved gases and ions, suspended particles, and temperature.

1.3.1.2 Submerged Aquatic Vegetation (SAV)

The submerged aquatic vegetation (SAV) habitat is populated with various species of plants that are not able to support themselves out of the water. The plant composition is dependent upon factors such as depth, salinity, wave action and water clarity. The SAV provide surface area for organism residency and egg deposition, refuge from predation, and food matter for grazers and detritivores.

1.3.1.3 Shell Bottom Habitat

Shell bottom habitat is comprised of, as the name suggests, both living oysters, clams and other shellfish and the shell remnants of these organisms. Some of these habitats are called beds, rocks, or reefs while others may be layers of heavily weathered and broken shell fragments upon finer, underlying sediments. Established mollusks beds can function as "living shorelines," defusing wave action and reducing the rate of shoreline erosion.

1.3.1.4 Soft Bottom Habitat

The unconsolidated, unvegetated soft bottom habitat is not unique to the marine, or brackish-water environments, but extends up to the headwaters of freshwater channel networks. Soft bottom habitat is nourished and maintained by shoreline erosion and stormwater runoff throughout the basin and by transport from the headwaters to the estuaries and sounds. The composition of the bottom can vary from organic detrital material to fine silt, clay and sand to coarse sands.

1.3.1.5 Hard Bottom Habitat

The hard bottom habitat is typically located offshore, beyond the breakers. Hard bottom is colonized by sessile organisms and provides vertical relief, which attracts and sustains economically important species and their prey. The establishment of artificial reefs, both in the sounds and the ocean, as well as shipwrecks helps to supplement hard bottom habitat. Near shore and in the estuaries, this habitat can be negatively impacted by degraded water quality.

Hard and shell bottom habitats are less abundant in the Chowan River basin due to the low salinity levels. Low salinity limits the distribution of oysters, clams and other marine mollusks, and sediment load deposited on the estuary bottom. The sole artificial reef built in the Albemarle Sound is at the mouth of the Chowan River, named Black Walnut Point Reef (AR-191). The reef was established in the mid-1980's to create additional hard bottom habitat, attract sport fish and provide a recreational opportunity accessible for small vessels.

1.3.1.6 Wetlands

Wetlands provide a transition zone between terrestrial and aquatic habitats. The extent to which wetlands are inundated depends on the elevation of the bottom materials and the height, or stage, of the water column. The species diversity and distribution of wetlands is influenced by the factors mentioned above and determines whether the wetlands are periodically inundated (intertidal) or always submerged (subtidal) (NCDMF, 2016). Wetland habitat types are identified by the depth and duration of the hydrology, the landscape position, the soil type, and the dominant vegetation (Carolina Wetland Association, 2016).

Wetlands also provide critical habitat for waterfowl, certain mammals and amphibians, reptiles, aquatic insects, fish and birds (ASWM, 2019b). Many migratory bird species, like tundra swans, egrets, herons, and various duck and songbird species, use wetlands to rest, forage for food, and seek shelter from predators and inclement weather. These safe-haven patches in the landscape are essential for the survival of migratory birds (Wisconsin Wetland Association, 2016). Geographically isolated wetlands are particularly important for amphibians, as many frogs and salamander species require a network of fish-free small wetlands to survive and prosper (Leibowitz, 2003). There are also many rare and at-risk species that require wetlands to survive. Approximately 70 percent of the NC endangered species depend on wetlands (NCDWR, 2018). Estuarine wetlands serve as nursery habitat for clams, oysters and crayfish. They are also an important source of fish and shellfish food production for striped bass, pike, sunfish, crappie, crab, clams, oysters, crayfish, and shrimps. Besides providing ecosystem services, wetlands are great places for recreation, such as fishing, boating, hunting, birdwatching, hiking, and enjoying nature (NCDWR, 2018). Examples of publicly accessible wetlands found in the Chowan River basin in Gates County include the Chowan Swamp Game Land and Merchant Mill Pond State Park. More information about these and other publicly accessible wetlands can be found on DWR's ncwetlands.org website.

1.3.2 Fisheries in the Chowan River Basin

The Chowan River basin has historically been a significant fisheries resource. Some of the species that have been sought include striped bass (*Morone saxatilis*), Atlantic sturgeon (*Acipenser oxyrinchus*), American shad (*Alosa sapidissima*), hickory shad (*Alosa mediocris*), and alewife (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*), collectively known as "river herring". All of these species are anadromous meaning they migrate from the ocean as adults through inlets into the coastal bays and sounds and ascend the freshwater rivers and creeks to spawn. They typically return to the waters in which they were spawned. Some will return for several years to spawn again while some will die after spawning only once. The region where the Chowan and Roanoke rivers discharge into the western Albemarle Sound is an important nursery area for the anadromous larval fish transported downstream where they mature before moving to the ocean. Cues that trigger spawning runs are warming temperatures and high-water flows.

Anadromous fish spawning runs have supported important commercial harvest industries and recreational fishing, have provided families sustenance and been the focus of cultural events throughout the region. Commercial fishery still exists but not at the harvest levels of the past. The cumulative impacts of unregulated fishing offshore and inland, habitat and water quality degradation, and limited access to historical spawning habitat by dam and culvert construction have contributed to the decline of anadromous fish populations in the basin. With the implementation of fishing moratoria, seasons, and limits for commercial and other harvests, some species populations have recovered. Striped bass has recovered, but river herring stocks have not despite harvest restrictions (NCDMF, 2016).

Three fish species found in the Chowan River basin are designated as endangered: the Atlantic sturgeon, the shortnose sturgeon (*Acipenser brevirostrum*), and the Roanoke logperch (*Percina rex*). The shortnose sturgeon is uncommon in the basin and easily confused with its more common relative, the Atlantic sturgeon. The primary threats to sturgeons are habitat degradation, water pollution, dredging, water withdrawals, fishing net entanglement, and habitat access impediments (NOAA, 2020a; b). The logperch in the basin is only found in Virginia in the upper reaches of the Nottoway River and its tributaries. A survey of the North Carolina portion of the Meherrin River has been recommended to determine if populations of logperch live in that watershed (NCDWR, 2014). Some of the threats to Roanoke logperch

populations are siltation and hydrologic alteration from changes in land use, channelization, water withdrawal, toxic spills, and disrupted gene flow and habitat loss from damming (NCDWR, 2014).

The upper reach of the Chowan River is globally significant due to its overall freshwater mussel diversity according to Alderman and Alderman (2009). This area provides habitat for six state-listed mussel species. Additionally, the yellow lance (Elliptio lanceolata), a federally designated threatened species, and the Atlantic pigtoe (Fusconaia masoni), a candidate for threatened designation, are found in the upper reaches of the Nottoway River. Mussels are particularly sensitive to siltation as well as hydrologic alteration from changes in land use, channelization and disrupted gene flow and habitat loss from dam and culvert construction. Mussels are also dependent on sustainable populations of the host fish species for the successful maturation of their young, or glochidia.

1.4 Population and Land Cover

1.4.1 Population

Population and density data help identify the watersheds likely to have the most impacts from urban growth. Increases in population often result in more impervious surface cover which often increases the amount of nonpoint source pollution and stormwater runoff. Increases in stormwater runoff can impact aquatic habitats, stream flow and downstream flooding. Population data can also be used to project future water demand and assist with local water supply planning efforts. Population information presented here is intended to estimate expected population growth in the counties and municipalities located wholly or partially in the Chowan River basin. Information presented here is available on North Carolina's Office of State Budget and Management (OSBM) website.

Based on the 2010 census, the estimated population for the basin is just over 95,000. Most of the population growth is occurring in Gates and Hertford counties. County population projections for 2020 and 2030 indicate that populations in all counties are expected to decrease. Bertie and Northampton counties are expected to see the largest decreases (Table 1-1).

Table 1-1 Population Growth and Projections by County

County	% of County in Basin	Population 2000	Population 2010	Percent Growth 2000-2010	Population Projection 2020	Percent Growth 2010-2020	Population Projection 2030	Percent Growth 2010-2030
Bertie	30%	19,773	21,282	7.6	19,058	-10.5	16,454	-22.7
Chowan	67%	14,526	14,793	1.8	14,668	-0.8	14,670	-0.8
Gates	80%	10,516	12,197	16.0	11,915	-2.3	11,914	-2.3
Hertford	100%	22,601	24,669	9.2	24,121	-2.2	23,360	-5.3
Northampton	65%	22,086	22,099	0.1	20,416	-7.6	19,057	-13.8
Totals		89,520	95,040	6.2	90,178	-5.1	85,455	-10.1
Note: The numbers reported here reflect county population. The county is not entirely within the basin. The intent is to demonstrate growth for counties located wholly or partially in the basin.								

Municipal populations in the Chowan River basin are relatively small, ranging from 91 in Como to 4,855 in Ahoskie (2017) (Table 1-2). Growth in municipal areas was modest between 2000 and 2010. There were slight declines in most of the municipalities between 2010 and 2015. Murfreesboro was the only

municipality with an increase in population between 2010 and 2015. The largest municipalities, Ahoskie and Murfreesboro, grew by 7.3 percent and 33.2 percent, respectively, between 2000 and 2015.

Table 1-2 Population Growth by Municipality

Municipality	Population 2000	Population 2010	Population 2015	Percent Growth 2000-2010	Percent Growth 2010-2015	Percent Growth 2000-2015
Ahoskie	4,523	5,039	4,855	11.4	-3.7	7.3
Aulander	922	895	850	-2.9	-5.0	-7.8
Cofield	347	413	407	19.0	-1.5	17.3
Como	78	91	91	16.7	0.0	16.7
Conway	734	836	835	13.9	-0.1	13.8
Gatesville	281	321	313	14.2	-2.5	11.4
Jackson	695	513	487	-26.2	-5.1	-29.9
Lasker	103	122	121	18.4	-0.8	17.5
Murfreesboro	2,421	2,835	3,225	17.1	13.8	33.2
Rich Square	931	958	943	2.9	-1.6	1.3
Seaboard	695	632	604	-9.1	-4.4	-13.1
Severn	263	276	270	4.9	-2.2	2.7
Winton	956	769	734	-19.6	-4.6	-23.2
Woodland	833	809	767	-2.9	-5.2	-7.9
Note: The numbers reported reflect municipality population. The intent is to demonstrate growth for municipalities located wholly or partially within the basin.						

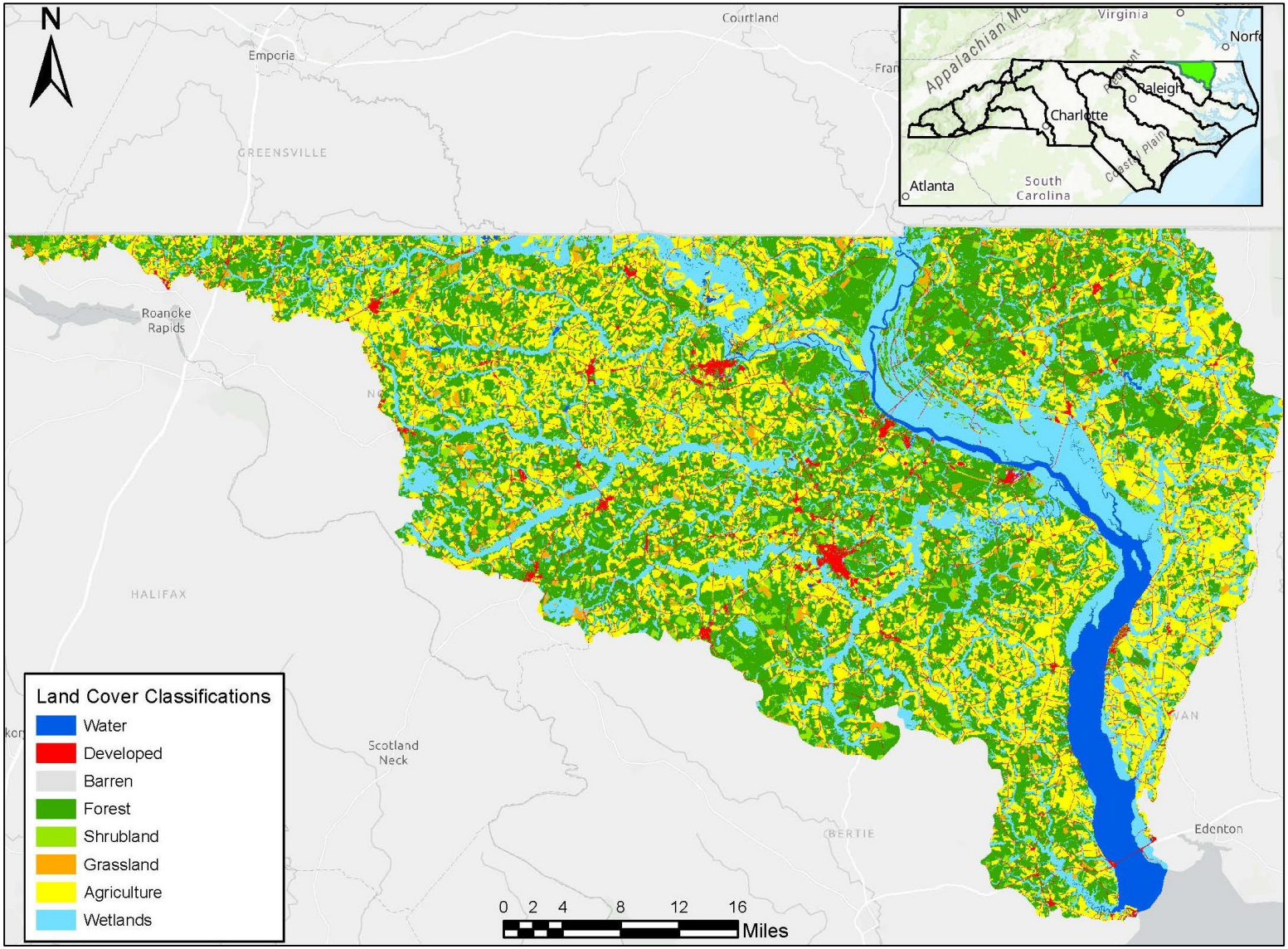
1.4.2 Land Cover – National Land Cover Data (NLCD)

Land cover assists with developing land use management policies, modeling nutrient and pesticide runoff, understanding spatial patterns in biodiversity, ecosystem status and health, and evaluating the effects of land use changes on water quality over time (Homer et al., 2012). North Carolina uses land cover datasets available from the National Land Cover Database (NLCD). In the Chowan River basin, changes in land use mirrors population with a greater percentage of impervious surface near population centers. Land cover types and percent coverage are included in Table 1-3. Spatial distribution is shown in Figure 1-3.

Table 1-3 Land Cover – North Carolina Portion of the Chowan River Basin HUC 030102 from NCLD 2016

Land Cover Type	2001		2011		2016	
	Square Miles	Percent of Total	Square Miles	Percent of Total	Square Miles	Percent of Total
Agriculture	387.5	29.9%	381.1	29.4%	381.3	29.4%
Barren	0.4	0.0%	0.4	0.0%	0.4	0.0%
Developed	53.7	4.1%	54.5	4.2%	55.4	4.3%
Forest	445.4	34.3%	436.3	33.6%	466.3	35.9%
Grassland/Shrubland	94.1	7.3%	108.5	8.4%	77.5	6.0%
Open Water	52.6	4.1%	53.2	4.1%	53.1	4.1%
Wetland	264.4	20.4%	264.2	20.4%	264.3	20.4%
Total	1,298		1,298		1,298	

Figure 1-3 Chowan River Basin Land Cover[1] (Source: NLCD 2016, https://www.mrlc.gov/data)



Developed, Forest, Grassland/Shrubland, Agriculture, and Wetland classes were created by aggregating two or more 2016 NLCD classifications. Developed is a combination of Developed, Open Space, Developed, Low Intensity, Developed, Medium Intensity, and Developed High Intensity. Forest represents deciduous, evergreen, and mixed forest classes. Grassland/Shrubland is Grassland/Herbaceous and Shrub/Scrub. Agriculture is Pasture/Hay and Cultivated Crops. Wetland is Woody Wetlands and Emergent Herbaceous Wetlands. 2016 NLCD definitions of classifications are found at https://www.mrlc.gov/data/legends/national-land-cover-database-2016-nlcd2016-legend.

1.5 Point Source Pollution

Point source pollution refers to pollution that enters surface waters through "any discernable, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container" (US EPA, 2019). Point source pollutants are primarily associated with wastewater and stormwater discharges from municipal (city and county) and industrial wastewater treatment facilities. They can also originate from small, domestic wastewater systems that serve schools, commercial properties, residential subdivisions, and individual homes. To ensure that point source pollution does not negatively impact water quality or human health, wastewater, and stormwater point source pollutants are regulated through the National Pollutant Discharge Elimination System (NPDES) Program. The NPDES permitting program sets monitoring and treatment requirements for facilities discharging wastes directly to surface waters (US EPA, 2019). The program also keeps records of the spatial location of point sources of pollution. This information from the NPDES program can be assessed alongside ambient water quality data to ensure that both permit requirements are being met and are sufficient to protect the water quality of receiving streams and rivers. More information about permitted programs can be found in Permitted and Registered Activities chapter (Chapter 7).

1.6 Nonpoint Source Pollution

Nonpoint source pollution (NPS) is defined to mean "any source of water pollution that does not meet the legal definition of "point source" in Section 502(14) of the Clean Water Act (CWA)" (US EPA, 2020). NPS can result from any number of activities and land uses. Construction and land clearing activities, agriculture, golf courses, mining operations, solid waste disposal sites, urban landscapes, and on-site wastewater treatment systems (septic systems) all contribute to NPS and can add sediment, nutrients, bacteria, heavy metals, oil, and grease to a waterbody. NPS is difficult to monitor and account for. DWR works with several state and local agencies to identify potential NPS and the types of activities that may be impacting water quality in the area, but data gaps exist. These unknowns include, but are not limited to, the amount of fertilizers, pesticides, herbicides, and dry-litter animal waste applied to land, as well as the level at which these same pollutants may be impacting groundwater and air quantity and eventually reaching surface waters through baseflow or atmospheric deposition.

There are several programs in place through various organizations that protect water resources from NPS. Many include funding for best management practices (BMPs) that can reduce the amount of sediment, nutrients, and bacteria entering a waterbody as well as protect streambanks, reduce erosion, and manage waste. More information about these programs can be found in the Statewide, Regional and Local Initiatives chapter (Chapter 6).

> ***Best management practice (BMP)*** *is defined as "a structural or nonstructural management-based practice used to singularly or in combination to reduce point source or nonpoint source inputs to receiving waters in order to achieve water quality protection goals" (15A NCAC 02B .0202).*

1.6.1 Agriculture

Approximately 29 percent of the land use in the North Carolina portion of the Chowan River basin is identified as agriculture (Table 1-3). Excess nutrients, pesticides, herbicides, bacteria, and sediment are often associated with agricultural activities. To understand how agriculture has changed over the past 10 to 15 years, the USDA, National Agricultural Statistic Service's (NASS) Census of Agriculture was reviewed. The USDA publishes the Census of Agriculture every five years. The data collected by and reported in the

census provide an overview of agricultural operations on a national, state, county, or county equivalent scale to show the importance and value of agriculture to a particular region. It also helps evaluate historic agricultural trends to formulate policies, develop programs, and identify and allocate local and national funds for agricultural programs (USDA, 2017). The data can be queried at the state, county, or watershed scale. Because the watershed scale includes portions of VA, agriculture data was queried at the county scale for counties located entirely or partially within the Chowan River basin. This includes Bertie, Chowan, Gates, Hertford, and Northampton counties.

Per the 2017 Census of Agriculture, a total of 959 farm operations are operating on a total of 510,698 acres (798 mi^2) in Bertie, Chowan, Gates, Hertford, and Northampton counties. This is a decrease from what was reported in the 2007 Census of Agriculture when 1,153 total farms were operating on a total of 532,071 acres (831 mi^2). The total number of acres identified as cropland has increased from approximately 355,000 acres in 2007 to just over 372,000 acres in 2017 while pastureland and woodland has declined (Table 1-4).

Livestock inventory numbers have also changed over time. Per the 2017 Census of Agriculture, the poultry inventory increased between 2007 and 2012 from 9.5 million birds (chickens, broilers) on 114 farms to 11.4 million birds (chickens, broilers) on 132 farms. In 2017, the total number of birds decreased by 400,000 birds (11 million chickens, broilers) on a total of 133 farms (Table 1-5). Bertie County had the highest inventory followed by Hertford (Table 1-5). The livestock inventory for cattle and hogs decreased between 2007 and 2017, but in the case of hogs, information was withheld from one or more counties to avoid disclosing data from individual farms (Table 1-4) (USDA, 2017). Information that is obtained through the Census of Agriculture cannot be used for statistical purposes. It can only be used to compare changes over time. This makes it difficult to assess the extent of potential impacts animal operations and animal waste may have on water quality.

As of May 2020, there were 40 permitted animal operations in the Chowan River basin (Figure 1-4). All are permitted swine operations. Animal operations are defined under General Statute 143.215.10B as feedlots that have more than 250 swine, 100 confined cattle, 75 horses, 1,000 sheep, or 30,000 confined poultry with a liquid waste management system. All permitted animal operations are required to have a Certified Animal Waste Management Plan (CAWMP). The CAWMP is incorporated into the animal permit issued by DWR by reference and defines the fields to which waste is land applied, the crops to be grown, and other details about the operation. All waste must be applied at no greater than agronomic rates (an amount that can be used productively by the crops that are planted) (General Statute 143-215.10C). These permitted animal facilities are inspected annually.

Most poultry operations in North Carolina use a dry waste management system and are referred to as dry litter poultry operations. Such operations are deemed permitted under administrative code (NCAC) 15A NCAC 02T .1303. Owners or operators of dry litter poultry operations with 30,000 or more birds are required to adhere to rules set forth under 15A NCAC 02T .1303 and General Statute 143-215.10C. These requirements include minimum stream setbacks, land application rates, soil and waste analysis, and recordkeeping. This information is included in a waste utilization plan (WUP) (also known as a nutrient management plan (NMP)). Producers are required to keep WUPs (NMPs) on file at the farm and do not have to submit the plan to DWR for review.

To better understand where potential nutrient sources may be contributing to the increases in organic nitrogen or the resurgence of harmful algal blooms in the basin, information on the location of potential

nutrient sources (including dry litter poultry operations and manure hauling) could help DWR adapt the basinwide stream monitoring program, identify new water quality monitoring stations, and help create a mass balance of nitrogen and phosphorus for the basin. Stream monitoring data has historically been valuable in understanding and addressing nutrient related impacts to recreational use, the economic well-being, and overall ecological integrity of the basin (Deerhake, personal communication). DEQ will continue to work collaboratively with federal, state, and local agencies as well as stakeholders in the basin to identify information sharing opportunities to target water quality monitoring and BMP implementation throughout the basin.

A table of permitted animal feeding operations as well as a general overview of animal feeding operations (AFO) can be found in the Permitted and Registered Activities chapter (Chapter 7). More information can also be found on the Animal Feeding Operations (AFO) Program's website. A more detailed review of how the number of animals has changed over time can be found in Appendix V-III. It includes a review of animal inventory numbers for counties located entirely or partially in the basin in Virginia as well as North Carolina.

Figure 1-4 Animal Operation Permits Map

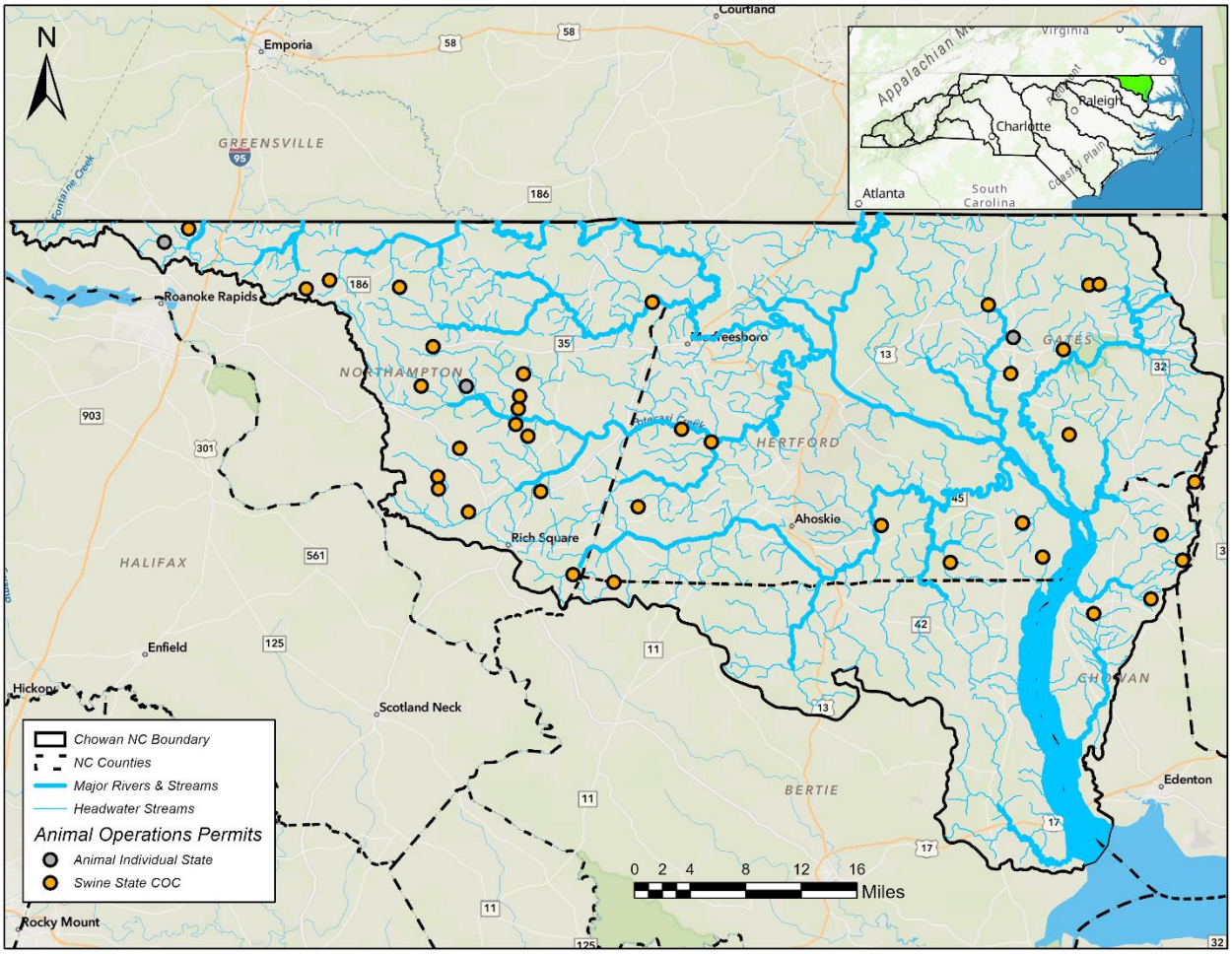


Table 1-4 USDA Census of Agriculture Data – Bertie, Chowan, Gates, Hertford and Northampton counties (2007, 2012, 2017)

	2007	2012	2017	2007	2012	2017
	Number of Operations			Number of Acres/Animals		
Number of Farms & Land Area	1,153	1,129	959	532,071	513,991	510,698
Land Use						
Total Cropland	849	870	722	354,632	351,288	372,265
Total Pastureland	324	243	193	13,625	12,738	10,331
Total Woodland	694	652	506	153,280	140,508	123,356
Harvested Cropland	704	710	589	341,186	338,520	341,036
Land in irrigated farms	145	115	79	166,909	142,720	119,587
Irrigated land	145	115	79	26,361	21,688	15,947
Livestock Inventory						
Cattle (including calves)	115	96	114	4,100	4,142	3,798
Hogs	46	45	57	292,637**	130,480**	133,084**
Chickens*	114	131	132	9,496,888	11,396,089	10,993,282
Crops						
Corn, Grain	366	263	240	64,711	35,961	40,192
Soybeans	495	525	466	100,189	119,854	131,062
Cotton	317	289	225	117,573	116,848	98,143
Tobacco	59	44	32	4,442	5,997**	6,910**
Peanuts	242	171	159	31,557	29,101	29,188
Wheat	178	287	162	22,505	47,864	30,860
Forage (hay, haylage, silage, greenchop)	61	48	45	4,855	2,520	2,636**
Fertilizers and Chemicals						
Cropland fertilized, except cropland pastured	616	585	495	305,945	289,554	244,064
Pastureland and rangeland fertilized	71	38	46	1,669	830	1,165
Manure	161	158	145	21,475	16,524	21,424
Organic fertilizer***	(NA)	(NA)	18	(NA)	(NA)	480
Acres treated with chemicals to control:						
Insects	476	490	393	249,455	241,083	300,818
Weeds, grass or brush	504	654	514	279,184	320,746	341,188
Nematodes	141	190	138	49,996	81,275	56,737
Diseases in crops and orchards	129	214	177	36,523	78,639	87,243
Growth, thin fruit, ripen or defoliate	256	213	221	96,981	94,841	102,629

*Broilers and other meat-type chickens.

**(D) Information withheld from one or more counties to avoid disclosing data for individual farms (USDA, 2017).

(NA) Information not available (USDA, 2017).

***This is a new item for 2017. These are the number of cropland or pastureland on which approved organic fertilizers were applied (USDA, 2017).

Table 1-5 USDA Census of Agriculture Data – Poultry Inventory 2007, 2012, 2017

County	2007	2012	2017	2007	2012	2017
	Number of Farms			Number of Animals (Poultry)*		
Bertie	51	63	67	5,251,485	6,083,898	5,863,743
Chowan	8	6	2	259,495	250,475	**(D)
Gates	12	17	20	826,791	1,125,530	1,474,245
Hertford	21	31	25	1,623,690	2,116,632	2,140,814
Northampton	22	14	18	1,535,427	1,819,554	1,514,480
Totals	114	131	132	9,496,888	11,396,089	10,993,282

*Broilers and other meat-type chickens.

**(D) Information withheld from one or more counties to avoid disclosing data for individual farms (USDA,2017)

Soil and water technicians along with the Albemarle Resource Conservation and Development Council, Inc. (ARCD) are continually working with agricultural operations to identify areas to implement nutrient and sediment reducing BMPs as well as identifying how best to redesign drainage from agricultural fields to reduce the amount and speed at which stormwater runoff enters a waterbody. For nearly four decades, significant efforts have been made to reduce nitrogen and phosphorus loads originating from agricultural land through the installation of best management practices (BMPs). Over the past decade (July 2010 and June 2020) alone, more than $1.2 million was spent by the Soil and Water Conservation Districts (SWCDs) through various cost share programs managed by the North Carolina Department of Agriculture & Consumer Services (NCDA&CS) Division of Soil and Water Conservation (DSWC) to install BMPs throughout the basin. Several practices have also been installed using funds available through programs managed by the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS). A list of practices that have been installed in the basin can be found in the Statewide, Regional and Local Initiatives chapter (Chapter 6). BMPs that target nutrient reduction and sediment removal should continue to be prioritized and implemented throughout the Chowan River basin.

1.6.2 Forestry

Special attention is needed to ensure that water quality is protected while timber is being harvested. Inappropriate management practices can impact water quality by altering in-stream habitat, increasing sediment load, and increasing stream temperature. These impacts can also alter the interface of the aquatic and terrestrial ecosystem and change watershed functions. Without appropriate 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.

1.6.2.1 Forest Practices Guidelines (FPG) Related to Water Quality

The North Carolina Forestry Service (NCFS) is delegated the authority to monitor and evaluate forestry operations in North Carolina. NCFS staff regularly inspect timber harvests for compliance with the Forest Practice Guidelines (FPG) for Water Quality. The FPGs are a set of results-based guidelines meant to protect water quality and are mandatory, statewide requirements defined by North Carolina Administrative Code (02 NCAC 60C .0100-.0209). All forestry-related, site-disturbing activities must comply with the FPGs if the activity is to remain exempt from permitting and other requirements specified in the North Carolina Sedimentation Pollution Control Act (SPCA) of 1973 (NCFS, 2017). Inspections often involve NCFS staff visiting the same site multiple times to provide forest operators and landowners technical assistance for BMPs to minimize impacts of forestry on water quality.

1.6.2.2 Locations of Harvests

Over the last ten years, timber harvests were scattered throughout the entire basin. Compared to other counties, however, there have been relatively fewer harvests in portions of Bertie and Chowan counties, particularly in the Cypress Swamp, Edenhouse Point-Chowan River, and Mount Gould Landing-Chowan River watersheds (Figure 1-5; Figure 1-6). Because landowners are not required to notify NCFS of timber harvesting or related forestry activities, the numbers reported here are not a full representation of the timber harvests in the basin (Coats, 2017).

Between July 2007 and June 2012, the NCFS inspected 569 timber harvests in the Chowan River basin, totaling 37,395 acres (Figure 1-5). NCFS found 12 harvests to be out of compliance, resulting in a compliance rate of 97.9% (Table 1-6). The most common violations were related to streamside management zones (SMZ), debris entering streams, stream crossings, or rehabilitation of the project site.

Between July 2012 and June 2017, the NCFS inspected 734 timber harvests, totaling 44,669 acres (Figure 1-6). Six harvests were out of compliance, resulting in a compliance rate of 99.2% (Table 1-6). The most common violations were related to debris entering streams.

Between July 2017 and June 2020, the NCFS inspected 440 timber harvests, totaling 28,452 acres. Fifteen harvests were out of compliance, resulting in a compliance rate of 96.6% (Table 1-6). The most common violations were related to stream crossings. More information about the NCFS water quality inspection process can be found online on NCFS's website.

Table 1-6 Number of Inspections Conducted by NCFS in the Chowan River Basin

Time Period	# Inspected Timber Harvests	Total Acres	# Out of Compliance
07/2007-06/2012	569	37,395	12
07/2012-06/2017	734	44,669	6
07/2017-06/2020	440	28,452	15

1.6.2.3 Forestry Best Management Practices (BMPs)

Knowledge of the soils and hydrology of a site can help address harvest schedules, equipment types, flooding potential, and reforestation options. Silvicultural or forestry activities in wetlands, regardless of size, should be conducted in a manner that minimizes adverse impacts on the unique hydrologic and ecological functions of those ecosystems. Implementing forestry BMPs is strongly encouraged to protect the water resources of North Carolina efficiently and effectively.

The NC Forestry BMP Manual details specific tools and methods which can be used during forestry operations to reach compliance with the FPGs. From 2013 to 2016, the NCFS carried out surveys across the state to assess the implementation of BMPs on timber harvests. These surveys gave a snapshot of practices used in different areas of the state and helped to understand where additional recommendations may be needed. In the Chowan River basin, the NCFS conducted surveys on seven sites, assessing 542 total BMPs. Seventy-nine percent of the BMPs assessed were implemented successfully. NCFS found that when BMPs were properly implemented, there was no risk to water quality (Coats, 2017).

To protect the waters of NC and promote the use of bridgemats, the NCFS allows loggers and timber buyers to borrow the NCFS's bridgemats for use during forestry-related operations. A bridgemat consists of a panel that establishes a temporary crossing over streams, ditches, or small water channels. Temporary bridges can be a very effective solution for stream crossings since the equipment and logs stay out of the water channel. When installed and removed correctly, bridgemats cause very little soil disturbance. Bridgemats are free to borrow from the NCFS for forestry use in the Chowan River basin and have been for several years. More information about bridgemats is available on the NCFS website.

Figure 1-5 Water Quality Inspections in the Chowan River Basin July 2007 - June 2012 (NCFS, 2020)

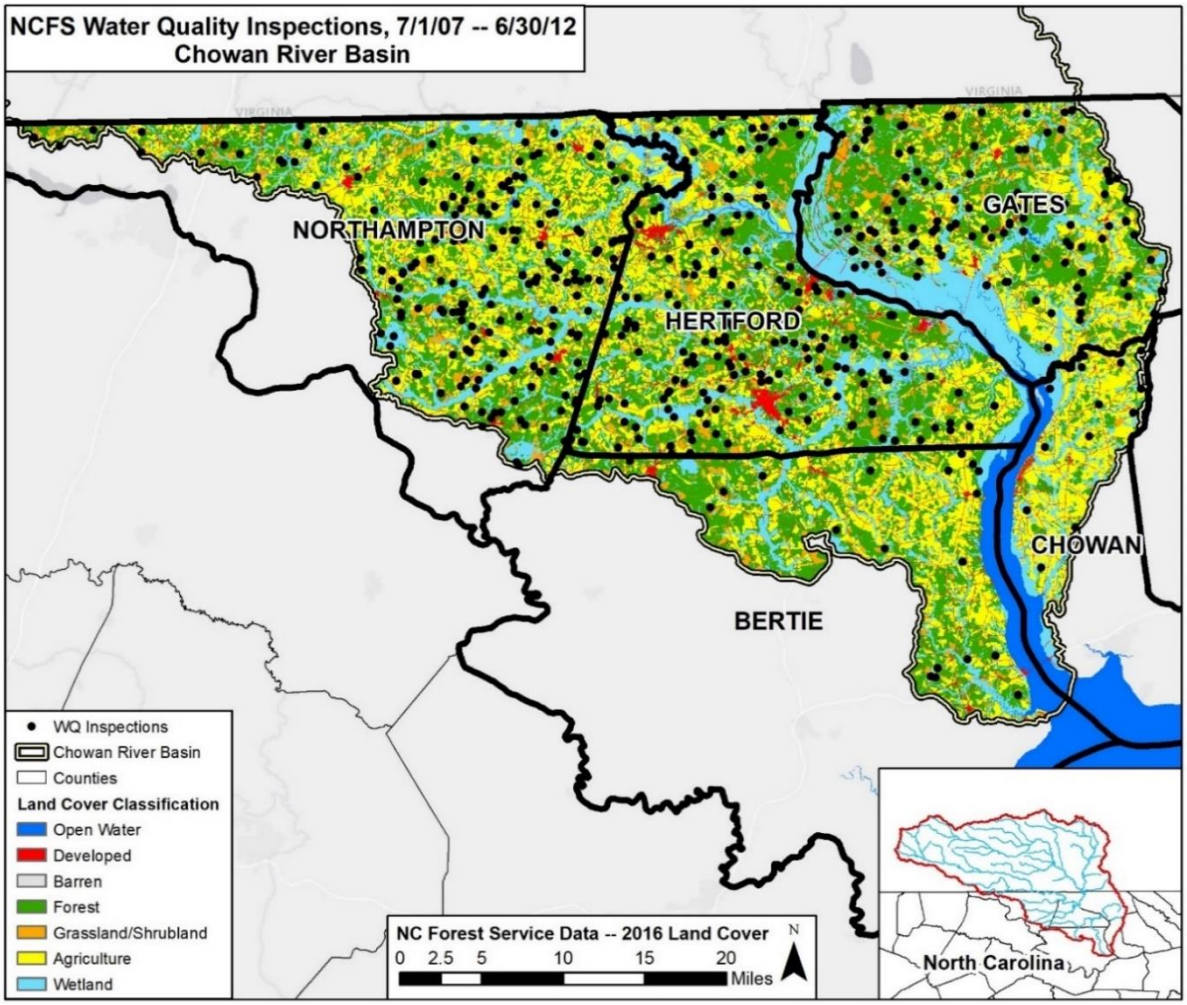
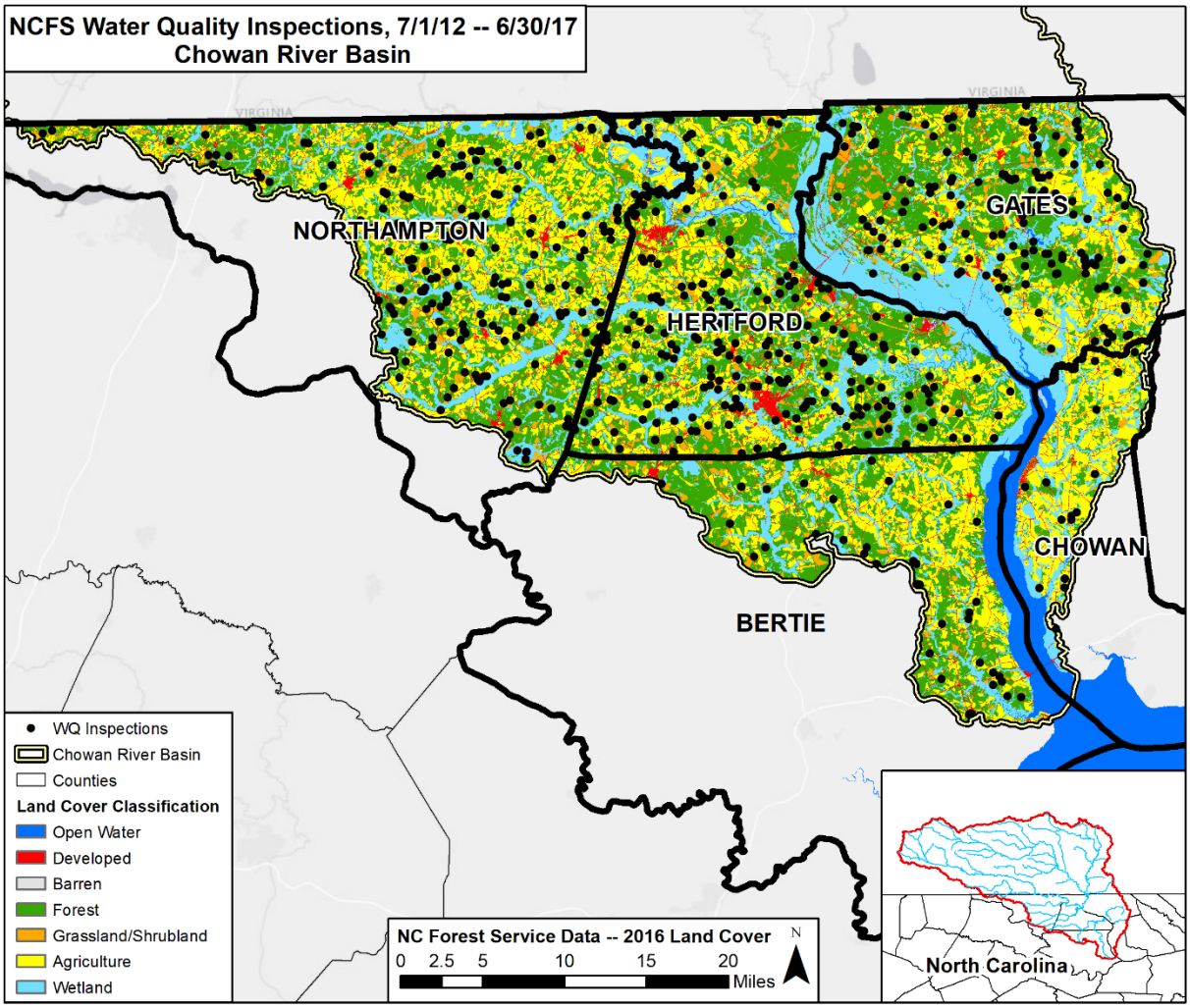


Figure 1-6 Water Quality Inspections in the Chowan River Basin July 2012 - June 2017 (NCFS, 2020)



1.6.2.4 *Forestry and Algal Blooms*

In recent years, there has been growing concern 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 SWCD and the ARCD, to discuss riparian buffer incentives for landowners wanting to harvest timber adjacent to known nutrient-sensitive waters. NCFS continues to explore how forest management may influence water quality by collaborating with landowners, state and federal agencies, and researchers (Coats, 2017).

1.6.2.5 Forestry: Next Steps

Several state and local entities are working together to understand forestry's impacts on water quality in the Chowan River basin. SMZs are "an area along both sides of intermittent streams and perennial streams and along the margins of perennial waterbodies where extra precaution is used in carrying out forestry-related, land-disturbing activities to protect water quality" (02 NCAC 60C .0102). Per administrative code, the SMZ shall be of sufficient width to "confine visible sediment resulting from accelerated erosion" (02

NCAC 60C .0201). Chapter 4 of the North Carolina Forestry BMP Manual includes information about SMZs and riparian buffers, and it states the general recommendation for SMZ width is "50 feet along each side of intermittent streams, perennial streams and perennial waterbodies" (NCFS, 2006). The width of the SMZ may vary depending on the purpose of the SMZ and the site's conditions. Wider SMZs may be needed for sites that exhibit highly erodible soils, soil areas with little or minimal groundcover near the waterbody, and special waters such as trout, water supply watersheds, nutrient-sensitive waters, and shellfish waters (NCFS, 2006). Because waters in the Chowan River basin have been designated as nutrient-sensitive waters (NSW), a wider SMZ may be needed to protect water quality during timber harvests. A wider SMZ could also minimize the amount of woody debris entering a waterbody after heavy rainfall or extreme storm events.

Forestry-related, land-disturbing activities can alter hydrologic processes and influence water quality. It can take months to years for water quality to return to pre-harvest conditions (Ensign and Mallin, 2001), but forestry research studies also demonstrate that properly implemented BMPs effectively protect aquatic and riparian ecosystems (Cristian et al., 2016). More research specific to the Chowan River basin and silviculture in forested swamps is needed to understand the relationship between forestry-related operations, groundwater, nutrients, and algal blooms within the basin. Stakeholders throughout the watershed have acknowledged that there is no one clear source, or cause, of the algal blooms, however, this also does not rule out forestry practices as a significant contributing source. Continued monitoring could help pinpoint some of the point and nonpoint sources of nutrients entering the basin. In addition, NCFS has recommended a "comprehensive water quality study" of forestry-related activities in coastal bottomland swamp forests to help understand the relationship of silviculture and algal blooms. The study would require substantial new funding for five or more years, landowner commitment, and experienced foresters and researchers to conduct the study. “Although not in a position to fund such a project, 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” (Brogan, 2018).

Local stakeholders have been working with local foresters to identify ways to protect forested areas in the basin. One recommendation is to 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.

More information and frequently asked questions about logging in North Carolina can be found on NCFS’s website.

1.6.3 Golf Courses

Golf courses utilize intensive turf management practices that often rely heavily on the use of fertilizers and chemical pesticides. Stormwater runoff then carries these pollutants to nearby streams, impacting aquatic life and habitat. The construction of golf courses can also introduce sediment into streams and destabilize streams that are straightened or altered to meet the design of the golf course. Because there is little information on stormwater management and the amount of commercial fertilizers or pesticides used for turf management on golf courses, it is difficult to assess the impact they may be having on water quality in the Chowan River basin.

1.6.4 Stormwater

Stormwater runoff is rainfall or snowmelt that flows across the ground and impervious surfaces (e.g., buildings, roads, parking lots, etc.). In urbanized areas, stormwater systems often concentrate stormwater runoff into smooth, straight conduits. The runoff gathers speed and volume as it travels through the system before it is released. The outfall is often directed to a surface waterbody where the high velocity can scour streambeds, damage streambanks and vegetation, and destroy aquatic habitat. The volume can cause flooding, damage infrastructure, and cause unnaturally high fluctuations in stream flow.

Many daily activities have the potential to cause stormwater pollution, and in an area where activities (e.g., construction, land clearing, etc.) have the potential to contribute more pollutants through stormwater runoff, measures should be taken to minimize impacts from runoff. One major component in reducing impacts from stormwater runoff involves planning up front during the design process. New construction designs should include plans to prevent or minimize the amount of runoff leaving the site. Wide streets, large cul-de-sacs, long driveways, and sidewalks lining both sides of the street are all features of urbanizing areas that create excess impervious cover and consume natural areas. Green infrastructure (GI) can be used to minimize the impact from runoff. GI has several definitions but generally involves the use of natural landscape features (e.g., soil, vegetation, forests, wetlands, etc.) to help maintain ecological processes, sustain natural resources, and contribute to community and individual health and quality of life (Firehock, 2013).

The presence of intact riparian buffers, floodplains and/or wetlands in urban areas can also reduce the impacts of development. These porous, natural landscapes hold rainwater and snowmelt and allow the water to infiltrate slowly. This slow infiltration also helps recharge groundwater supplies. Where feasible, establishing and protecting existing buffers, floodplains and wetlands should be considered, and the amount of impervious cover should be limited as much as possible. Preserving the natural streamside vegetation or riparian buffer is one of the most economical and efficient BMPs for reducing the amount of stormwater reaching surface waters. In addition, riparian buffers provide a variety of benefits including: moderation of water temperature by providing shade, holding water and decreasing the high temperatures often measured in stormwater runoff; preventing erosion and lose of land; providing flood control; moderating streamflow; and providing food and habitat to aquatic and terrestrial life (Burgess, 2004). For more information on stormwater and how to manage it, refer to the Division of Energy, Mineral and Land Resources (DEMLR) Stormwater website: https://deq.nc.gov/about/divisions/energy-mineral-land-resources/stormwater.

1.7 Projects Requiring Water Quality Certifications (WQCs)

Although federal and state regulations have slowed the loss of wetlands since the mid-1980s, approximately one-third of the wetland alterations in the coastal plain have occurred since the 1950s, primarily due to agricultural and managed forests conversion (USGS, 1996). Currently, under Section 404 of the Clean Water Act (CWA), administered by the US Army Corps of Engineers (ACOE), it is unlawful to discharge dredged or fill material into waters of the United States without federal approval, unless the discharge is covered under an exemption. Most routine farming, ranching, or silviculture activities that are part of an “on-going” farming or forestry operation and do not convert a wetland area to an upland are considered exempt and do not require a Section 404 permit or DWR water quality certification. Routine activities include cultivation, plowing, harvesting, minor drainage, seeding, and bedding (US EPA, 1990; USGS, 1996). The “Swampbuster” provision of the 1985 Food Security Act and amendments to the

1990 Food, Agriculture, Conservation, and Trade Act discourages (through financial disincentives) the draining, filling, or other alteration of wetlands for agricultural use. In some situations, farmers use the USDA Wetlands Reserve Program (WRP) to restore previously converted or altered wetlands and avoid penalties for new wetland conversions.

In addition to the federal authorization of the CWA's Section 404, Section 401 authorizes states to issue Water Quality Certifications (WQCs) for any federally permitted or licensed activity that results in dredged or fill material discharging to waters of the United States in the state where that discharge occurs (US EPA, 2017a; US EPA, 2017b). Wetland fill is the most common type of permanent impact approved under NC's 401 wetland certification program administered by DWR. Wetlands filled during construction activities (e.g. road construction, commercial and domestic development) generally lose all wetland functions. Other types of permanent impacts include excavation, grading, flooding, and vegetation clearing (in certain circumstances). Permitted projects must take steps to avoid and minimize impacts to wetlands, streams, and other aquatic resources and provide Compensatory Mitigation for unavoidable permanent losses as required by the federal permit (Individual or Nationwide) or state water WQC (US EPA, 2017b).

Between 2007 to 2017, DWR approved certifications for over 36.5 acres of permanent wetland and 4,500 linear feet of permanent stream impacts in the Chowan River basin. The North Carolina Department of Transportation's (DOT) transportation improvement projects (TIPs) resulted in the largest permitted impacts of wetland acreage in the basin during this time period.

- The 2011 TIP for US 158 (NC DWR Project Number 20111075 / DOT TIP R-2583), in Hertford County, had 10.5 acres of permanent wetland impacts and 3,786 linear feet of permanent stream impacts.
- The 2012 TIP for road widening over seven miles of US 13/US 158 (NC DWR Project Number 20120296 / NC DOT TIP R-2507), from NC 45/US 158 near Winton in Hertford County to US158 in Tarheel in Gates County, resulted in over 21.7 acres of permanent wetland impacts. Both projects met all compensatory mitigation requirements through purchasing credits from NC's in-lieu Fee program through the Division of Mitigation Services.

1.8 Climate Risk and Resiliency

In October of 2018, Governor Roy Cooper signed Executive Order 80 (EO80), "North Carolina's commitment to address climate change and transition to a clean energy economy". Section 9 of EO80 was a directive to the cabinet agencies to integrate climate adaptation and resilience planning into cabinet agency policies, programs, and operations (DEQ, 2020).

In June 2020, the North Carolina Climate Risk Assessment and Resiliency Plan (2020 Resiliency Plan) was published by DEQ. It defined a resilient North Carolina as "a state where our communities, economics, and ecosystems are better able to rebound, positively adapt to, and thrive amid changing conditions and challenges, including disasters and climate change; to maintain quality of life, healthy growth, and durable systems; and to conserve resources for present and future generations" (DEQ, 2020). The 2020 Resiliency plan includes the recommendations of the agencies involved with executing EO80, as well as stakeholders throughout the state, on how to integrate climate adaptation and resiliency planning into their policies, programs, and operations. It provides the state's best understanding of projected change in climate; considers climate justice issues; evaluates state infrastructure, assets, programs, and services that are vulnerable and at risk to climate and non-climate stressors; and includes preliminary actions currently

underway or which can be taken to reduce risk. It also includes nature-based solutions and recommendations to enhance ecosystem resiliency and sequester carbon through natural and working lands (NWL). The plan concludes by describing next steps for implementing and updating the 2020 Resiliency Plan as well as strategic resilience initiatives (DEQ, 2020).

One of the first steps in developing the 2020 Resiliency Plan was for DEQ to work with the North Carolina Institute for Climate Studies (North Carolina State University), representatives from many major higher education institutions, and subject matter experts to develop the North Carolina Climate Science Report (NCCSR). Key findings were categorized by percent probability and, except where noted, referred to future changes through the end of the century. Definitions for virtually certain, very likely, likely, unlikely, etc. are included in the NCCSR as well as Chapter 3 and Appendix A of the 2020 Resiliency Plan. Key findings of the NCCSR include:

- Sea level: It is ***virtually certain*** that sea level will continue to rise along North Carolina's coast due to the expansion of ocean water from warming and melting of ice in Greenland and the Antarctic ice sheets.
- Flooding: It is ***virtually certain*** that rising sea level and increasing storm intensity will lead to an increase in storm surge flooding in coastal North Carolina. Inland flooding is also ***likely*** to increase due to extreme precipitation events.
- Temperature: It is ***very likely*** that temperatures in North Carolina will increase substantially in all seasons and that the number of warm and very warm nights will increase and that the summer heat index will increase due to increases in absolute humidity.
- Precipitation: It is ***very likely*** that extreme precipitation frequency and intensity will increase statewide due to increases in atmospheric water vapor content, and it is ***likely*** that total annual precipitation will increase.
- Drought and wildfires: It is ***likely*** there will be more frequent and intense droughts across the state and that this increase will ***likely*** increase wildfires.
- Ecosystem and habitat loss: Sea level rise will result in a loss of wetlands and the habitats associated with them. The loss of wetlands will impact not only commercial and recreational fisheries, but also adversely impact water quality, decrease a buffers capacity to attenuate nonpoint source pollution runoff, and reduce the resilience of coastal communities. Due to warmer temperatures, harmful algal blooms may increase impacting aquatic organisms and human health.
- Public health: Saltwater intrusion due to climate change will impact both groundwater and surface water drinking water sources and impact the amount of freshwater available to irrigate agricultural crops. Extreme weather events will put more stress on emergency management, public services, and institutions, and require more resources to address the impacts. Poor air quality, injuries, and loss due to flooding, heat-related illnesses, and increased areas where disease-carrying vectors, such as mosquitoes, will all impact human health.
- Non-climate stressors: Many of these impacts will be compounded by non-climate stressors such as population growth, urbanization, and economic inequality. Climate-related impacts will likely have greater effects on vulnerable populations, exacerbating disparities that already exist (Kunkel, et al., 2020; DEQ, 2020).

Programs with DEQ's DWR that may be impacted by climate change include:

- Water Quality: Increases to temperature and the length of the warm season can result in increased algal production, lower dissolved oxygen concentrations, degraded aquatic communities, and impacts to commercial and recreational fisheries (i.e., fish kills, trout reproduction, shellfish harvesting).
- Water Supply Planning: Water supply planning will be affected by decreased water availability from more frequent drought conditions.
- Water and Wastewater Facilities: More frequent and intense rain events increase the flood risk to many facilities that DWR regulates such as wastewater treatment plants and animal operations. Discharges permitted through NPDES are currently based on low-flow statistics calculated with historical stream flow data. Variable precipitation in the future could affect typical low flows, changing the capacity of receiving streams to assimilate pollutant loads.
- Non-Point Source Pollution: More frequent and severe precipitation events can increase the delivery of nonpoint source pollution loads to surface waters impacting aquatic habitats, water supply intakes, dam maintenance (i.e., sediment build up and removal), etc.

Basinwide planning can contribute to climate resilience by identifying natural resources that may be affected by climate change, providing recommendations for adaptive management, and recognizing nature-based solutions to climate impacts. Basin plans frequently 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 (GI), low-impact development and living shorelines (Atkins, 2015; US EPA, 2016; DEQ 2020). Many of these same strategies fall in line with those identified in the 2020 Resiliency Plan.

Many of the recommendations presented in basins plans have also been identified as means to mitigate impacts from increased precipitation and flood events caused by climate change. One example, found in Chapter 5 of the 2020 Resiliency Plan, is land use guidance which includes protecting riparian buffers. This is also one of several strategies identified in basin plans to increase North Carolina's resilience to water quality impacts from flooding. Chapter 5 in the 2020 Resiliency Plan notes that several watersheds have rules in place that protect riparian buffers. Many of these rules were put into place to reduce the amount of nutrients entering waterways from point and nonpoint sources of pollution, but they can also help alleviate impacts from flooding. In addition to rules to protect riparian buffers, the NC Flood Act of 2000 required that communities regulating land use "prohibit certain uses in the 100-year floodplain". Prohibited uses include new solid waste disposal facilities, hazardous waste management facilities, salvage yards, and chemical storage facilities. By expanding and enforcing these protections statewide, state and local governments increase the capacity of the natural landscape to assimilate pollutants before they enter a waterbody (DEQ, 2020). Since inland flooding is projected to increase, it is critical to adopt practices that reduce storm-driven nonpoint point source pollution.

Basin plans also encourage the collection of more data for many different DWR programs to garner a deeper understanding of current conditions and changes over time and encourage the use of natural and working lands (NWL). The basin plans will continue to be a source of this information and will increasingly analyze NC's major river basins with a lens towards climate resiliency. More information about the global impacts of climate change can be found on the Fourth National Climate Assessment website (https://nca2018.globalchange.gov/). For more information on North Carolina's efforts to address climate

change, visit https://deq.nc.gov/energy-climate/climate-change. More information about NWL can be found here: https://nicholasinstitute.duke.edu/project/north-carolina-natural-and-working-lands.

1.9 Contaminants of Emerging Concern

Contaminants of emerging concern (CECs) are increasingly being detected in surface and groundwater across the state. They come from a wide range of sources including pesticides, lawn and agricultural products, disinfection by-products, wood preservatives, pharmaceutical and personal care products (PPCPs), and industrial chemicals as well as their by-products (US EPA, 2019). Potential sources include conventional wastewater treatments plants, individual on-site wastewater collection systems, and industrial and chemical manufacturing facilities. GenX and 1,4-dioxane are examples of CECs recently identified in North Carolina surface waters. These compounds often go undetected and untreated because facilities do not have the analytical tools, methods or treatment systems in place that can detect, eliminate or treat them.

While a compound may be unique to a specific source or river basin, many are widespread. The effects of CECs on aquatic ecosystems and on human health are mostly unknown, and the lack of appropriate analytical methods and monitoring techniques makes identification and management a challenge. The uncertainty of whether these emerging compounds are present, their effects on human health and their impacts to aquatic ecosystems is a growing public concern. Because CECs are not fully understood, state agencies and EPA are working on analytical methods to identify the compounds in a variety of media (water, wastewater, biosolids, soils, sediment, agricultural products) and identify treatment options for public water supply systems to provide safe drinking water to the public and ensure that aquatic ecosystems are protected.

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