Water Quality Monitoring Support Packet:

What's Monitored & What's Changing in North Carolina NSW Waters

Water Quality Standards and Monitoring Background:

Water quality standards are science-based regulations that consist of three main components:

- the **designated uses** of water bodies;
- the **chemical, physical and biological criteria** used to assess whether water bodies are meeting their designated uses; and
- **antidegradation requirements** to protect the integrity of water bodies so that designated uses can be maintained or expanded.

Common designated uses include:

- protection and propagation of aquatic life (fish, insects, etc.)
- recreation (swimming, fishing, etc.)
- public drinking water supply, and
- agricultural, industrial, and navigational uses.

Water quality standards are set at both the state and federal level. The Environmental Protection Agency (EPA) sets minimum national requirements for drinking water and surface waters. States and authorized tribes then adopt, update, and enforce standards to tailor them to their localities. The state of North Carolina has designated uses for surface waters – known as "surface water classifications" – as well as water quality standards for waters in Title 15A of the North Carolina Administrative Code (NCAC) subchapter 02B. Additionally, states are required under the federal Clean Water Act to continuously review and revise water uses and standards to protect resources. This review and modification process is known as a Triennial Review because it occurs every three years.

Water quality monitoring is fundamentally assessing whether surface waters are meeting their designated uses. Monitoring is conducted by states to ensure compliance with the Clean Water Act, develop basin water resources plans, and identify and quantify maximum pollution limits for surface waters. Water quality standards are enforced in NC through the issuance of permit limits to facilities with National Pollutant Discharge Elimination (NPDES) permits, the establishment of water quality benchmarks for Stormwater Permitting, and the development of Total Maximum Daily Loads (TMDLs), which includes state Nutrient Sensitive Waters (NSW) strategies (the Neuse, Tar-Pamlico, Falls Lake and Jordan Lake strategies). If surface waters are found to not be meeting set chemical, physical, and biological criteria they are considered "impaired", and the state is required to take action to address the impairment(s) so that waters can once again meet their designated uses.

North Carolina has over 2.2 million acres of estuarine waters and around 38,000 miles of freshwater creeks, streams and rivers. Only a fraction of these waters can be monitored given currently available funding and staffing. Since the 1960s, the state's Ambient Monitoring System (AMS) has collected water quality data through a relatively static network of 300+ stations located in all 17 major river basins in NC. These stations provide site specific, long-term water quality information. Stations are visited at least quarterly year-round for collection of chemical, physical and bacterial pathogen characteristics, but most are monitored monthly. The following core suite of indicators is measured at all stations.

Temperature	Total Suspended Solids/Residue (TSS)
Specific conductance	Dissolved Oxygen (DO)
pH	Fecal coliform
Turbidity	

The following additional indicators may be measured depending on site-specific concerns:

Salinity	Fluoride	Oil and grease
Secchi depth	Sulfate	Chlorophyll-a
Flow	Total hardness	
Nutrients (NH3, NO2+, NO3, TKN, TP),	Color	

In addition to the long-running AMS program, in 2007 the state initiated a Random AMS program to randomly select and sample thirty freshwater stream locations in NC every two years. Randomly selected locations are sampled once per month for the following parameters:

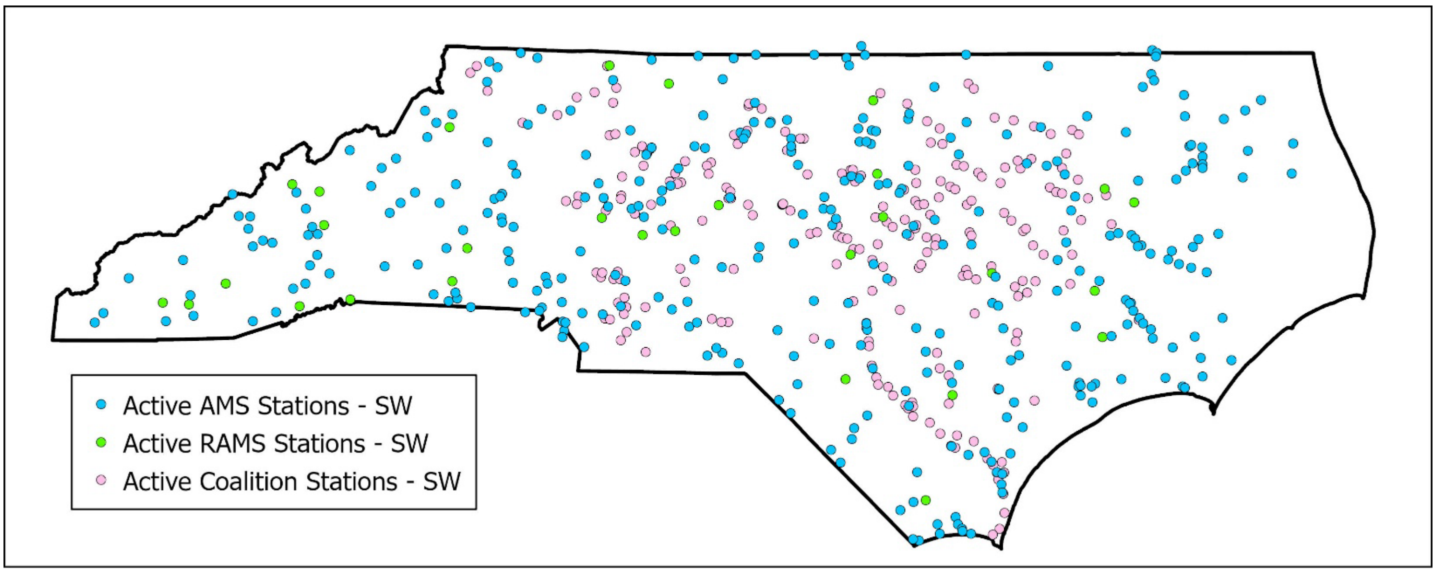
DO	Alkalinity	Turbidity
Specific conductance	Chloride	Total and dissolved metals
Temperature	Fluoride	Mercury
pH	Sulfate	Volatile organics

Every other month, these locations are also tested for cyanide, sulfide, semi-volatile organics, pesticides, and PCBs. The state has chosen to undertake a Random AMS program to:

- supplement the existing AMS program which has largely focused on large rivers and areas with known water quality problems;

- collect data on parameters that are rarely examined; and
- answer broad questions about water quality in NC streams with greater statistical rigor.

Lastly, North Carolina also has a monitoring coalition program, which is a voluntary ambient monitoring program designed to assess water quality in a watershed context. These coalitions largely consist of wastewater dischargers who partner together to collect water quality data to meet monitoring requirements set in their NPDES permits. There are currently seven monitoring coalitions in five of the state's river basins: New, Yadkin- Pee Dee, Cape Fear, Neuse, and Tar-Pamlico. Collectively these coalitions sample 270 stations monthly for a variety of physical, chemical, and bacteriological parameters.



In addition to the monitoring described above which largely focuses on chemical and physical water quality criteria, the state also conducts biological monitoring (fish and benthic macroinvertebrates) and lake monitoring on a five-year cycle.

In the last several years, lack of sufficient funding in both the biological monitoring and AMS programs have created many challenges for water monitoring in North Carolina. Biological sampling, in particular, has experienced significant declines. For example, in the Broad River Basin, biological sampling occurred at 56 stations in 2015, but in 2021 only four stations were assessed. Water quality monitoring data is critical to many stakeholders and underpins many important programs across the state. Just within the soil and water conservation partnership, 303(d) data – which is determined from water quality monitoring results – is used by the Division of Soil and Water Conservation to present funding allocation recommendations to the Soil and Water Conservation Commission (SWCC) for the Agriculture Cost Share Program and the Community Conservation Assistance Program. And many Soil and Water Conservation Districts use 303(d) data to rank conservation projects and make local funding and planning decisions.

<u>Resource Citations:</u>

North Carolina Department of Environmental Quality, Division of Water Resources. (n.d.). Ambient Monitoring System (AMS) [Web page]. https://www.deq.nc.gov/about/divisions/water-resources/water-sciences-section/ecosystems-branch/ambient-monitoring-system-ams

North Carolina Department of Environmental Quality, Division of Water Resources. (n.d.). Monitoring Coalition Program [Web page]. https://www.deq.nc.gov/about/divisions/water-resources/water-sciences/ecosystems-branch/monitoring-coalition-program

North Carolina Department of Environmental Quality, Division of Water Resources. (n.d.). Random Ambient Monitoring System (RAMS) [Web page]. https://www.deq.nc.gov/about/divisions/water-resources/water-sciences-section/ecosystems-branch/random-ambient-monitoring-system-rams

North Carolina Department of Environmental Quality, Division of Water Resources. (n.d.). Surface Water Standards [Web page]. https://www.deq.nc.gov/about/divisions/water-resources/water-planning/classification-standards/surface-water-standards

Water Quality Changes in NSW Waters:

The following sections provide a high-level reference for SWCC members to better understand how water quality has changed over time in the Neuse and Tar-Pamlico estuaries and the Falls Lake and Jordan Lake reservoirs. Given time constraints, Allie Dinwiddie is not able to cover this information in her annual update presentation to the SWCC on Agriculture Rule implementation in NSW watersheds. More information about these water quality changes can be found in the linked resource citations.

Neuse Estuary:

Neuse Nutrient Strategy *Strategy effective 1997, Readopted in April 2020* *Baseline: 1991 – 1995* *Sets a 30% N loss reduction*

- Between baseline and 2010 Total Nitrogen (TN) loading from all sources to the Neuse Estuary was reduced (Figure 12).
- Since 2002, TN levels have risen and are slightly above baseline levels, due to larger Total Kjeldahl Nitrogen (TKN) – ammonia and organic nitrogen – contributions (Figure 12).

- Intense storm activity – “high flow events” – have mobilized materials that have increased nutrient productivity in estuaries and is likely the main contributor to increased TKN.
- Phosphorus loading has reduced by 15 – 20% below baseline and has been holding steady despite increases in flow (management activities may be having impact) (Figure 13).
- Chlorophyll-*a* exceedance rates tend to be consistently lower in the lower estuary and moderately higher in the upper estuary. The middle estuary is more sensitive and variable (Figure 21).
- There has been an overall decline in the frequency of reported fish kill events, but two large mortality events occurred between 2008 and 2009 and in 2013 (Figure 25).
- There has been an overall decline in the frequency of reported algal bloom events as well (Figure 25).

FIGURE 12. NITROGEN REDUCTION FOR AVERAGE FLOW CONDITION COMPARED TO 1991-1995 (FORT BARNWELL)

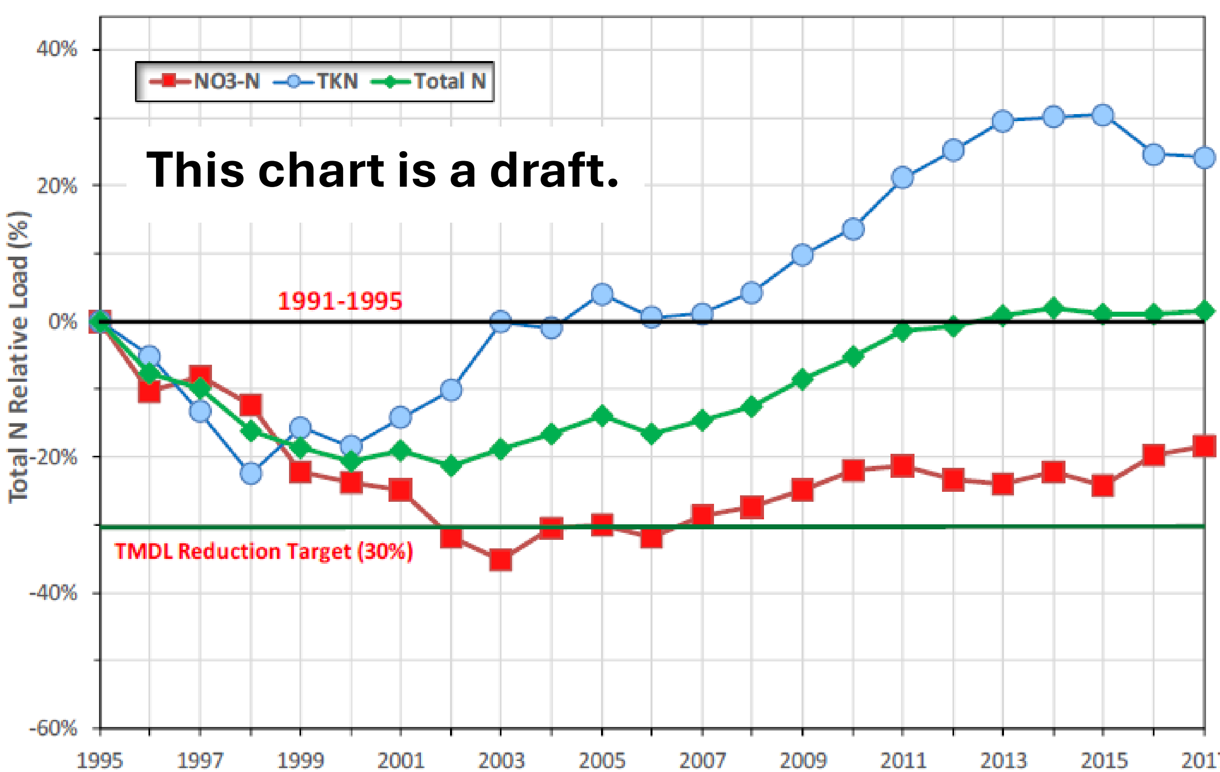


FIGURE 13. PHOSPHORUS REDUCTION FOR AVERAGE FLOW CONDITION COMPARED TO 1991-1995 (FORT BARNWELL)

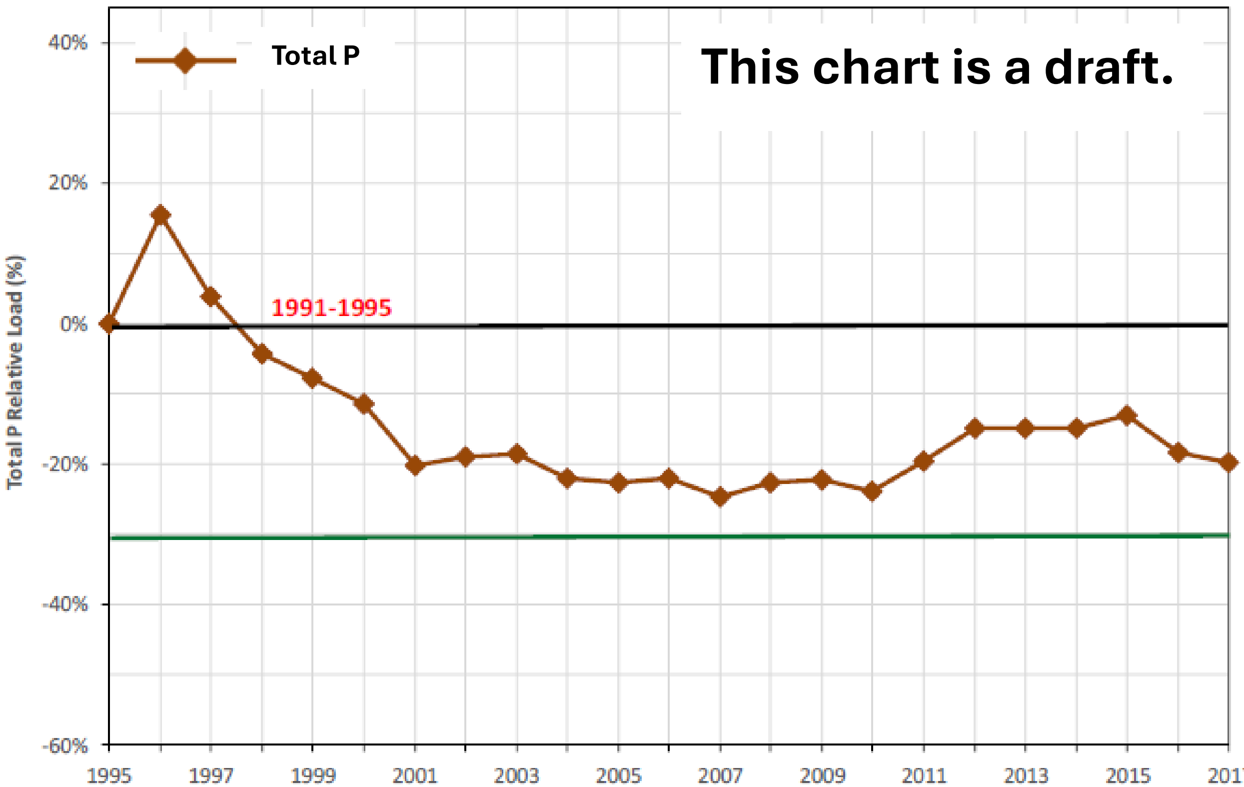


FIGURE 25. REPORTED FISH KILL EVENTS - NEUSE ESTUARY

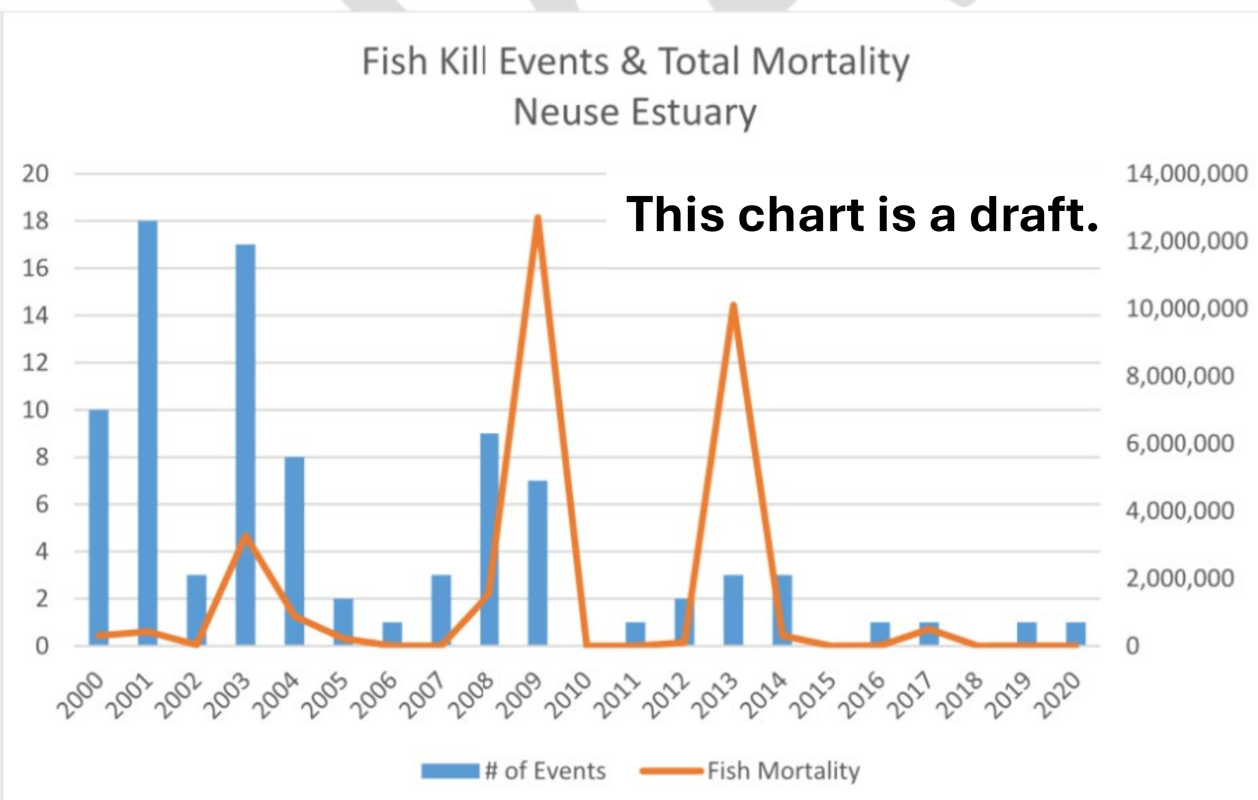
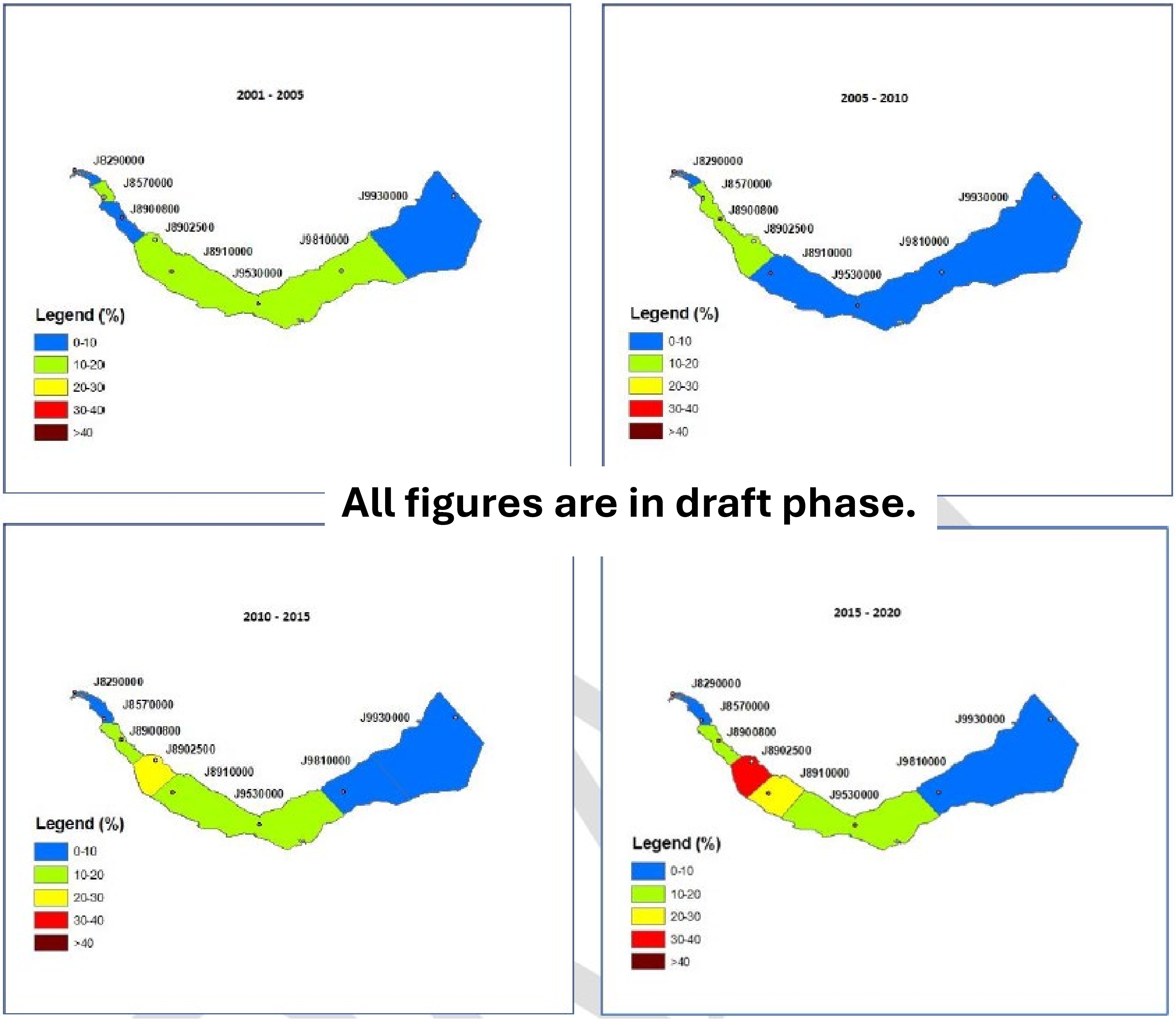


Figure 21. Neuse - Percent of Samples Exceeding Chlorophyll a standard of 40 µg/L from 2001 – 2020



<u>Resource Citation:</u>

North Carolina Department of Environmental Quality, Division of Water Resources. (2023, May). *Draft 20-year Neuse and Tar-Pamlico Nutrient Management Strategy retrospective: An analysis of implementation and recommendations for adaptive management* [Draft report, PDF]. https://edocs.deq.nc.gov/WaterResources/DocView.aspx?dbid=0&id=4207441

Tar-Pamlico Estuary:

Tar-Pamlico Nutrient Strategy *Strategy effective 2001, Readopted in April 2020* *Baseline: 1991* *Sets a 30% N loss reduction & no P loss increase*

- Between baseline and mid-2000s, TN loading from all sources was reduced (Figure 17).
- Since 2008, TN levels have risen and are slightly above baseline levels, due to larger Total Kjeldahl Nitrogen (TKN) contributions (Figure 17).
- Intense storm activity and high flows flushing nutrients into the system are likely to responsible for these nitrogen changes as well.
- Phosphorus loading has decreased. A spike in loading from 2012 to 2015 was likely due to increases in high flow intervals and increases in P concentrations during the time frame (Figure 18).
- Chlorophyll-*a* exceedance rates are sensitive and variable throughout the Tar-Pamlico estuary (Figure 23). Up until around 2010 higher exceedance rates were limited to the upper and middle estuary. Higher exceedance rates now extend to the lower estuary.
- There has been an overall decline in the frequency of reported fish kill events; however, two large mortality events occurred between 2008 and 2009 and in 2013. There has also been an overall decline in frequency of reported algal bloom events as well (Figure 26).

FIGURE 17. NITROGEN REDUCTION FOR AVERAGE FLOW CONDITION COMPARED TO 1991-1995 (GRIMESLAND)

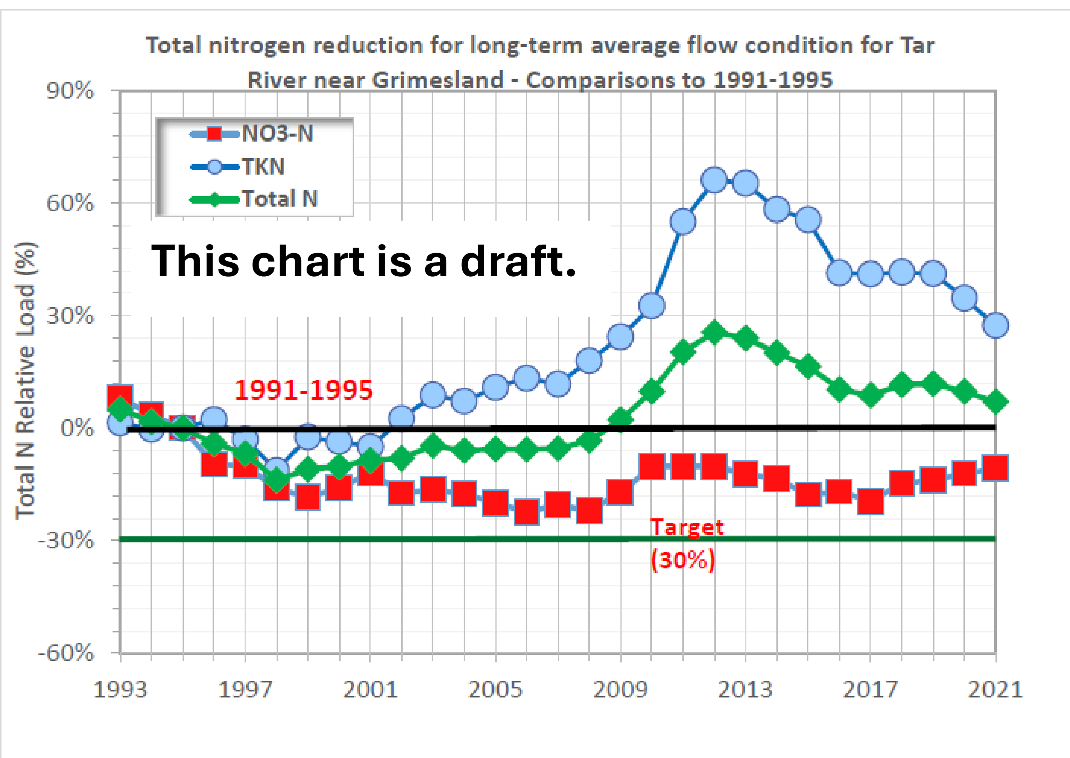


FIGURE 18. PHOSPHORUS REDUCTION FOR AVERAGE FLOW CONDITION COMPARED TO 1991-1995 (GRIMESLAND)

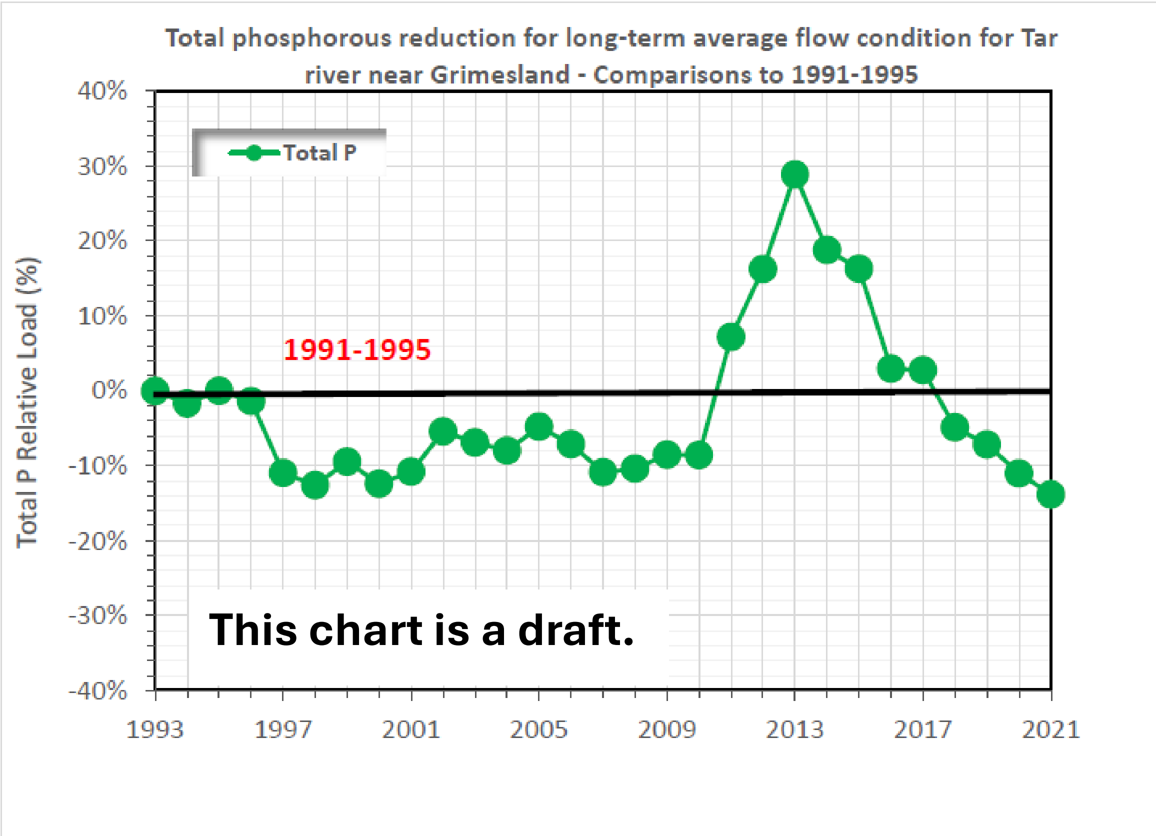


FIGURE 26. REPORTED FISH KILL EVENTS - TAR-PAMLICO ESTUARY

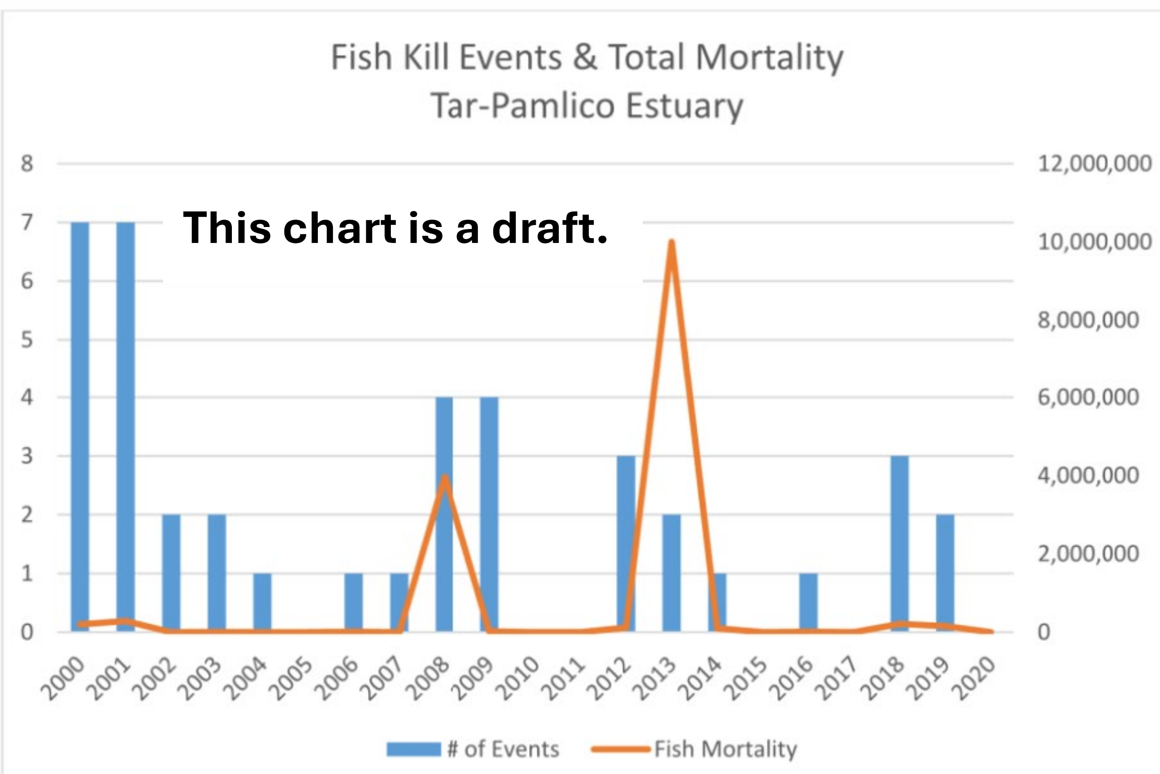
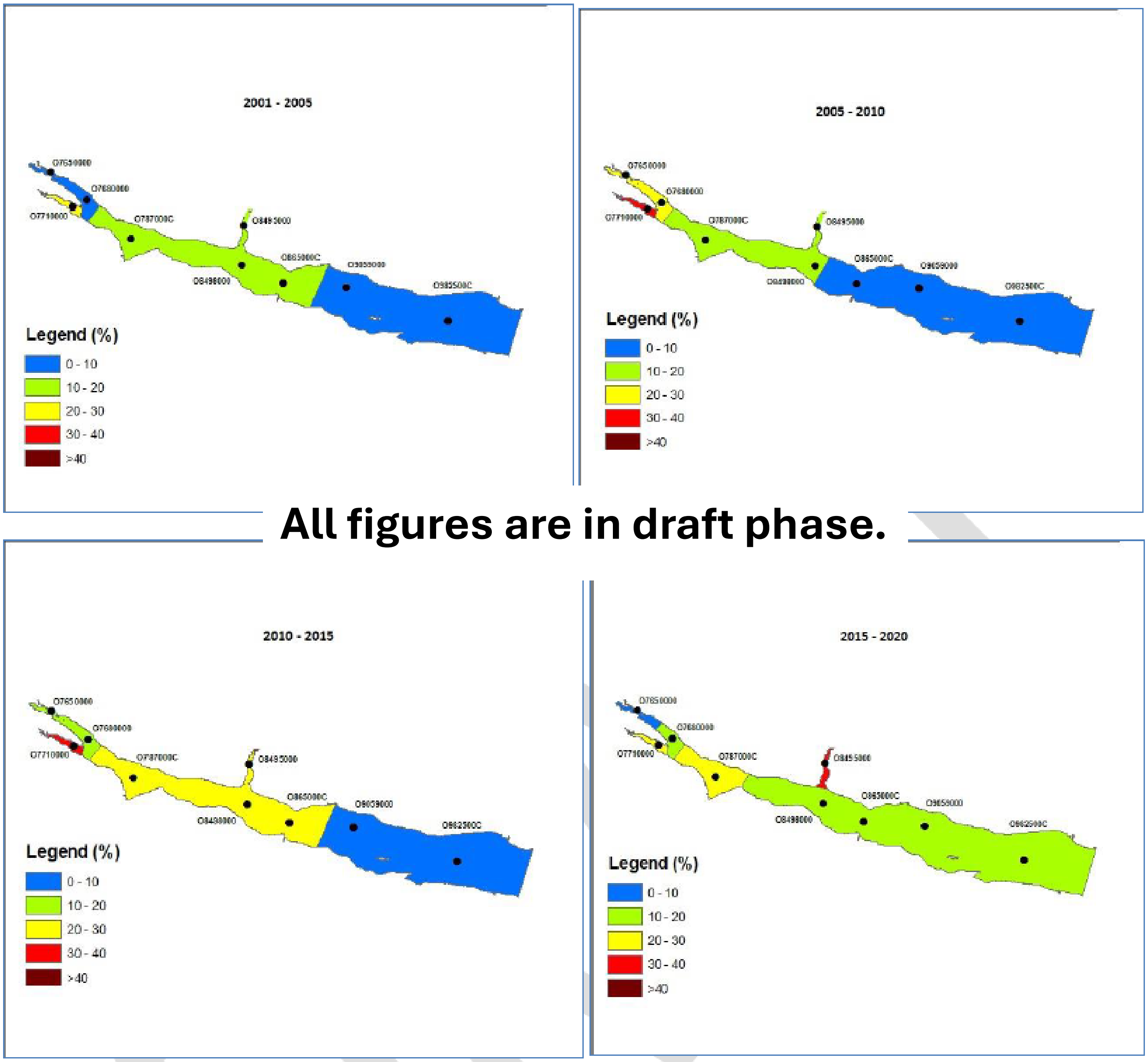


FIGURE 23. TAR-PAM - % OF SAMPLES EXCEEDING CHLOROPHYLL A STANDARD OF 40 μG/L FROM 2001 – 2020



Resource Citation:

North Carolina Department of Environmental Quality, Division of Water Resources. (2023, May). *Draft 20-year Neuse and Tar-Pamlico Nutrient Management Strategy retrospective: An analysis of implementation and recommendations for adaptive management* [Draft report, PDF]. https://edocs.deq.nc.gov/WaterResources/DocView.aspx?dbid=0&id=4207441

Falls Lake:

Falls Lake Nutrient Strategy
Strategy effective 2011, Undergoing readoption
Baseline: 2006
Set goals in time stages:

→ *Stage I (by 2020): 20% N loss and 40% P loss reduction*

→ *Stage II (by 2041): 40% N loss and 77% P loss reduction*

- Between baseline and 2019, there has been a reduction in TN, TP, TKN, and Nitrate-N losses from all sources (Tables 5 and 6).
- Falls Lake water quality has stabilized in the last several decades and today is largely meeting its designated uses (drinking water, fishing & swimming).
- Chlorophyll-*a* exceedance rates are higher in the upper, shallower end of the lake and decrease as the lake narrows and deepens (Figures 12 through 14)
- Eutrophic status may intensify cyanobacterial harmful algal blooms as climate and storm frequency/intensity continues to change.
- Legacy nutrients will continue to influence water quality and mute the impact of source reduction progress.
- Conserving remaining forestland and pervious land is critical and streambank stabilization may provide the most significant return for TP control.

TABLE 5. COMBINED TRIBUTARY FLOW-NORMALIZED ANNUAL NUTRIENT LOAD ESTIMATES AND PERCENT CHANGE FROM BASELINE YEAR OF 2006

	Flow-normalized load in Pounds per Year						Percent Change
Parameter (lbs./year)	2006	2006 LCL	2006 UCL	2019	2019 LCL	2019 UCL	From 2006
TN	1,024,488	877,297	1,158,094	821,222	709,358	914,072	-20%
TP	152,736	118,445	199,642	72,863	56,147	93,700	-52%
Nitrate-N	553,140	393,526	698,047	350,094	262,051	454,367	-37%
TKN	527,125	441,351	608,356	516,984	418,316	594,867	-2%

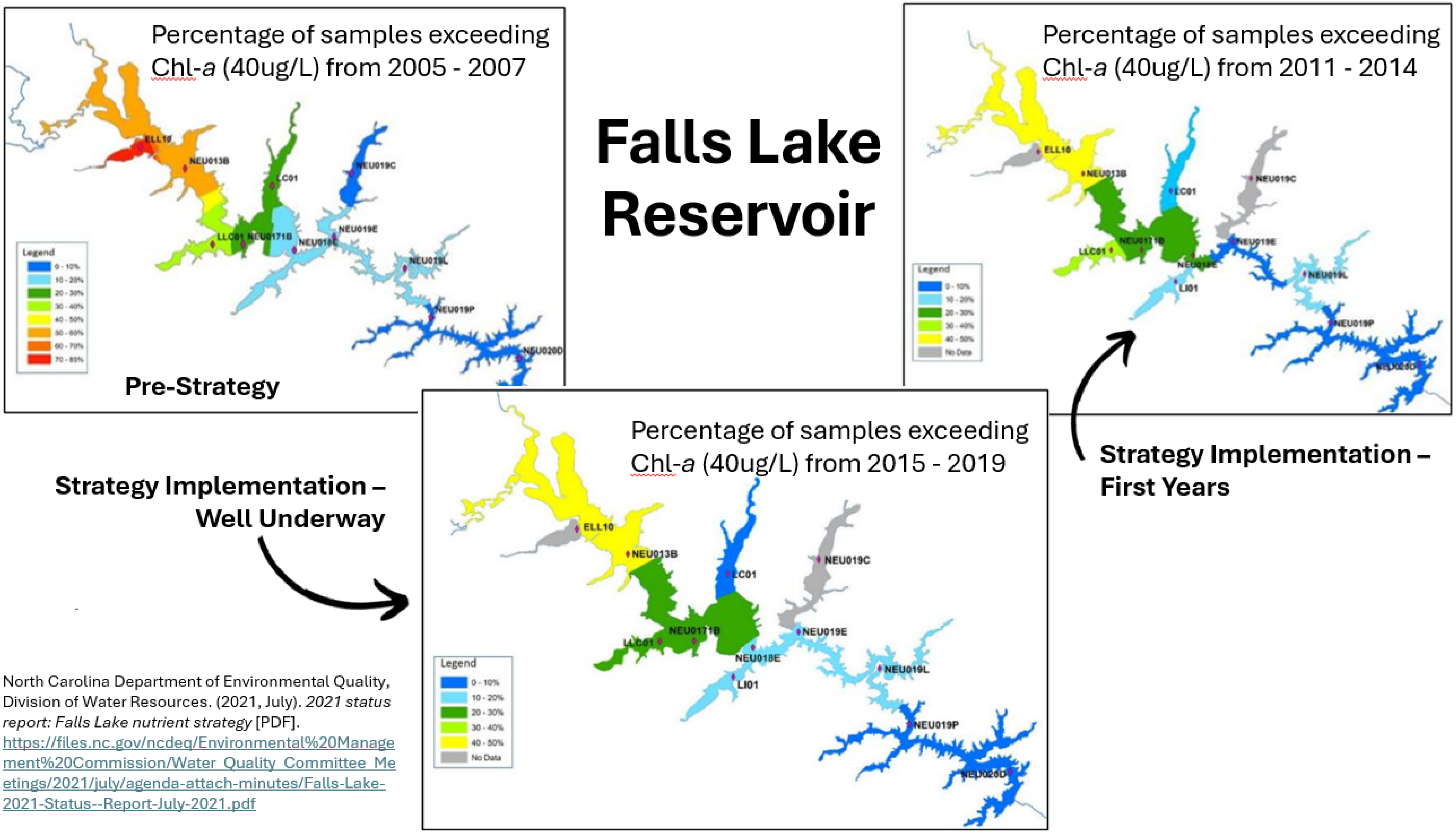
LCL = 90% LOWER CONFIDENCE LIMIT
UCL = 90% UPPER CONFIDENCE LIMIT

TABLE 6. COMBINED TRIBUTARY FLOW-NORMALIZED ANNUAL NUTRIENT LOAD ESTIMATES AND PERCENT CHANGE FROM 2006-2010 AVERAGE (PRE-MANAGEMENT STRATEGY PERIOD)

	Flow-normalized load in Pounds per Year						Percent Change
Parameter (lbs./year	2006-2010	2006-2010 LCL	2006-2010 UCL	2011-2019	2011-2019 LCL	2011-2019 UCL	From 2006-2010
TN	986,040	861,378	1,104,290	875,480	773,766	965,362	-11%
TP	130,302	103,318	167,047	85,691	67,666	108,136	-34%
Nitrate-N	505,401	375,338	624759	393,542	307,568	490,986	-22%
TKN	529,374	449,179	607,857	524,382	438,154	593,700	-1%

LCL = 90% LOWER CONFIDENCE LIMIT
UCL = 90% UPPER CONFIDENCE LIMIT

Figures 12 through 14. Percent of Samples Exceeding Chlorophyll-*a* Standard (40 µg/L)



Resource Citation:

North Carolina Department of Environmental Quality, Division of Water Resources. (2021, July). *2021 status report: Falls Lake nutrient strategy* [PDF]. https://files.nc.gov/ncdeq/Environmental%20Management%20Commission/Water_Quality_Committee_Meetings/2021/july/agenda-attach-minutes/Falls-Lake-2021-Status--Report-July-2021.pdf

Jordan Lake:

Jordan Lake Nutrient Strategy
Strategy effective 2009, Undergoing readoption
Baseline: 1997-2001
Set goals by subwatershed:

- → *Haw: 8% N loss and 5% P loss reduction*
- → *Upper New Hope: 35% N loss and 5% P loss reduction*
- → *Lower New Hope: No N loss and P loss increase*

- Between baseline and 2020, there has been a 1% reduction in flow-normalized TN and a 39% reduction in flow normalized TP from all sources (Table 1).
- Flow normalized TP changes in and around Jordan Lake from 2016 to 2020 show downward trends (Figure 1)). In the Haw subwatershed flow normalized TP changes show largely downward trends (Figure 2).
- Flow normalized TN changes in and around Jordan Lake from 2016 to 2020 show inconsistent trends (Figure 3). In the Haw subwatershed flow normalized TN trends show that TN loads to the lake are increasing (Figure 4).
- Legacy nutrients also play a large role in influencing water quality and mute the impact of source reduction progress.
- Reducing nutrient loads to the New Hope arm will produce greater water quality benefits.
- Conserving remaining forestland and pervious land is critical.

Table 1. Combined 2020 Tributary Flow-Normalized (FN) Nutrient Load Estimates and Percent Changes from Baseline (1997 – 2001)

Parameter	Baseline FN Load (lbs/yr)	2020 FN Load (lbs/yr)	Percent Change in FN Load
Total Nitrogen (TN)	7,971,907	7,898,052	-1%
Total Phosphorus (TP)	1,164,547	710,262	-39%

Figure 1. Flow Normalized (FN) Total Phosphorus (TP) Loading Trends around Jordan Lake (2016 to 2020)

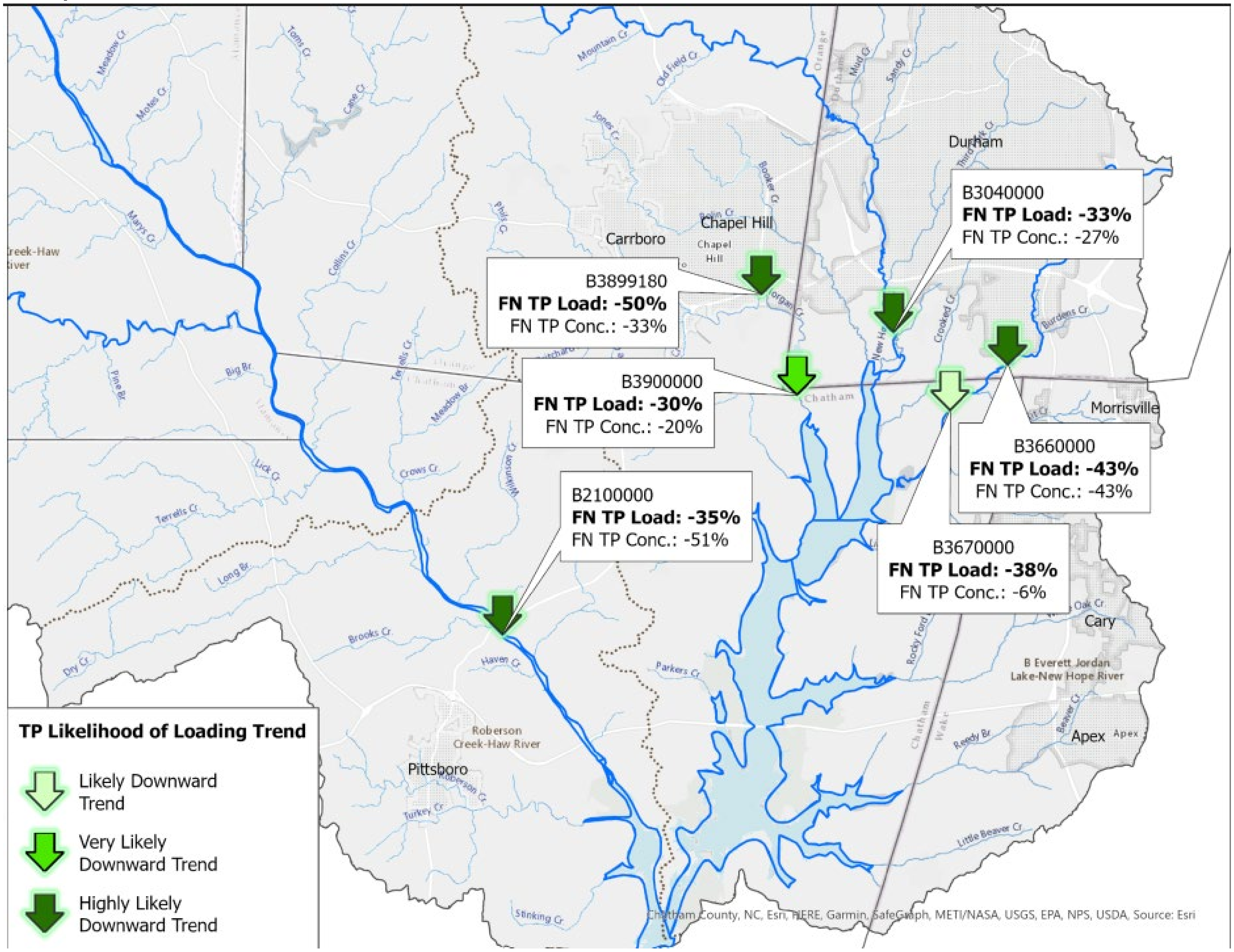


Figure 2. Flow Normalized (FN) Total Phosphorus (TP) Loading Trends in Haw Subwatershed (2016 to 2020)

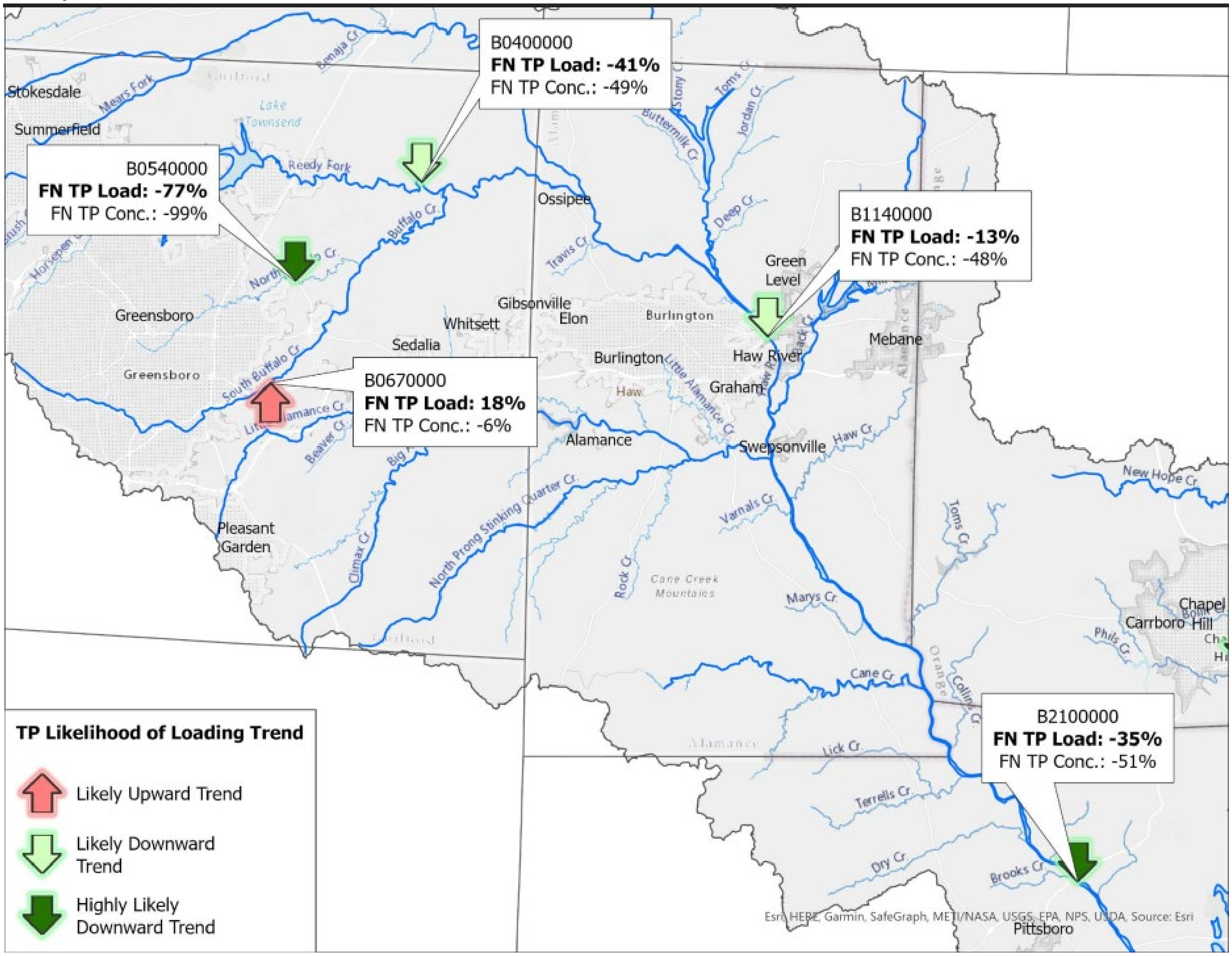


Figure 3. Flow Normalized (FN) Total Nitrogen (TN) Loading Trends in Haw Subwatershed (2016 to 2020)

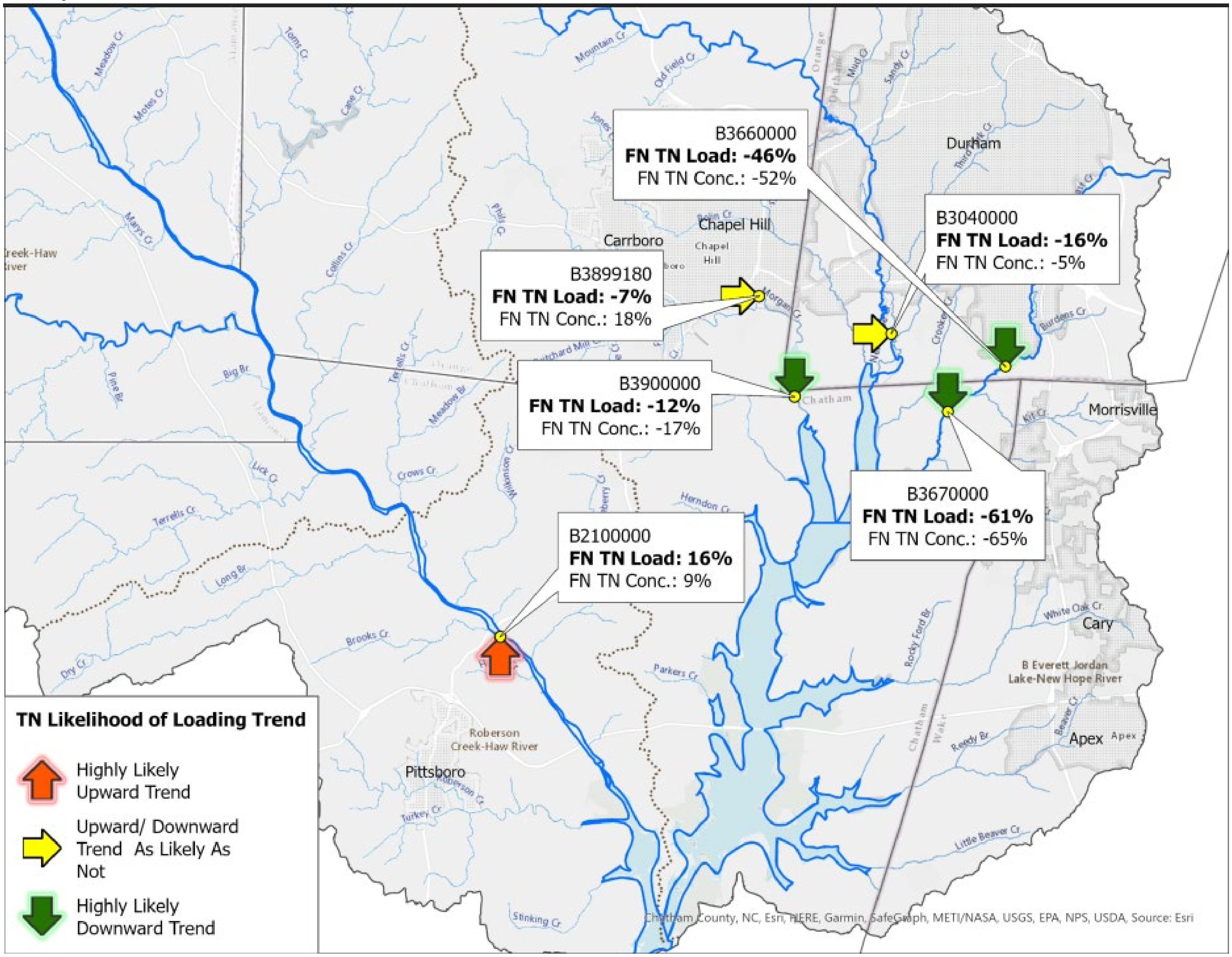
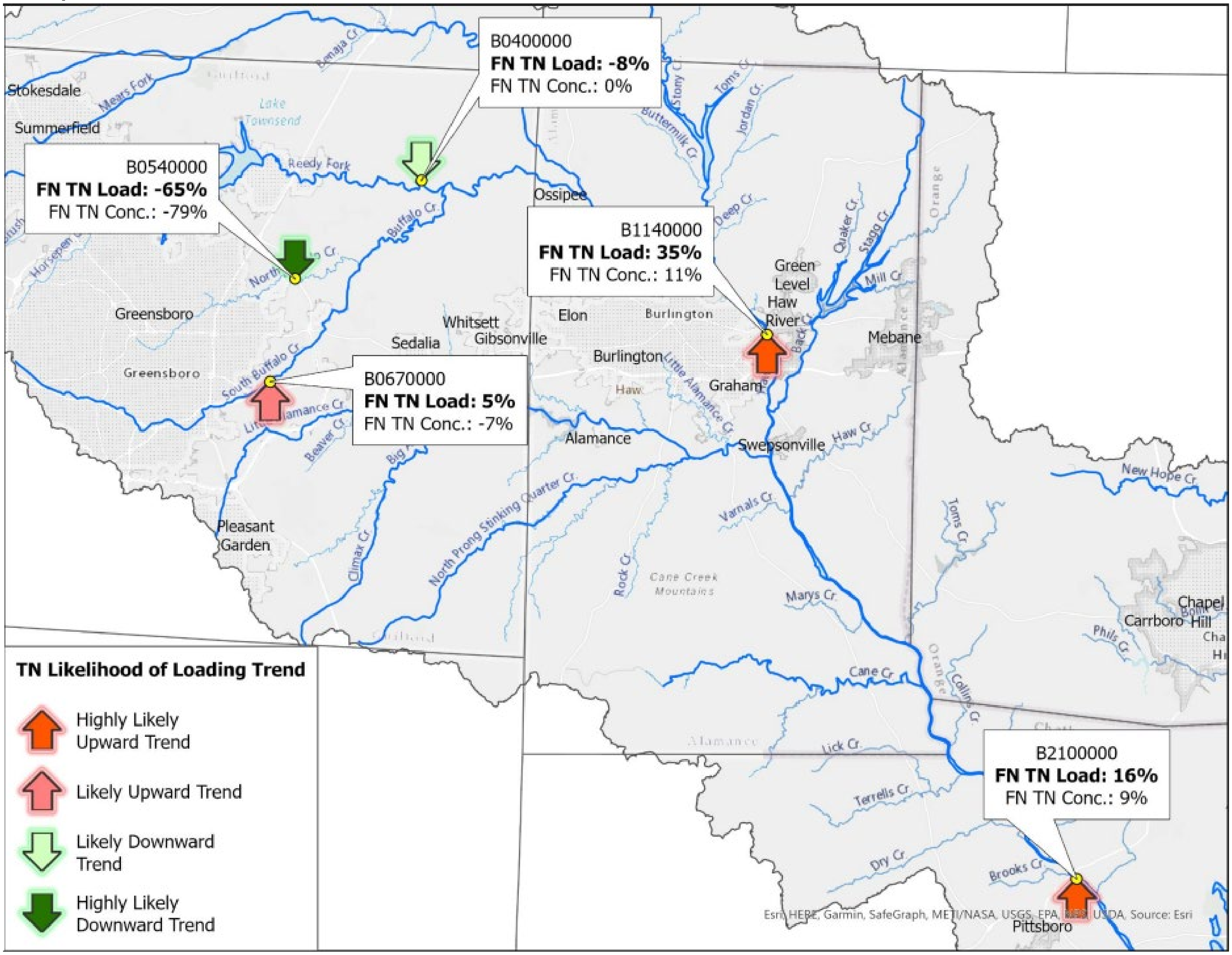


Figure 4. Flow Normalized (FN) Total Nitrogen (TN) Loading Trends in Haw Subwatershed (2016 to 2020)



<u>Resource Citations:</u>

North Carolina Department of Environmental Quality, Division of Water Resources. (2023, November). *Jordan Lake stakeholder meeting — presentation by A. Painter* [PDF]. https://www.deq.nc.gov/water-resources/planning-section/nonpoint/jlmtg1nov2023apainter/download?attachment

North Carolina Department of Environmental Quality, Division of Water Resources, Modeling and Assessment Branch. (2022, March 3). Nutrient Loadings and Trends in the Jordan Lake Watershed [ArcGIS StoryMap]. https://storymaps.arcgis.com/stories/541f3db7be394839af6d172d24d884de