2022 Status of the Work of the Upper Neuse River Basin Association to Support Implementation and Re-examination of the Falls Lake Rules

November 2022

The Upper Neuse River Basin Association (UNRBA) was formed in 1996 to examine water quality conditions and regulatory controls within the Falls Lake watershed. Seven municipalities, six counties, and local Soil and Water Conservation Districts voluntarily formed the UNRBA. In 2011, the Association began to focus on re-examination of the Falls Lake Nutrient Management Strategy passed by the NC Environmental Management Commission (EMC) in 2011. Its members have invested approximately $10 million in monitoring and modeling studies to improve the understanding of nutrient loading, processing, and resulting water quality in Falls Lake. The UNRBA is also working with other stakeholders in the watershed to ensure the revised strategy incorporates the latest science and provides a feasible framework for nutrient management.

Background

The Falls Lake project was authorized by Congress as part of the Flood Control Act in 1965. The reservoir began filling in January 1983. The designated uses of Falls Lake include drinking water supply, recreation, fishing, aquatic life, and wildlife. Design and construction of the impoundment were conducted by the USACE, which continues to manage the reservoir today.

Pre-impoundment studies predicted that Falls Lake would be highly eutrophic, especially in the upper end of the lake (DNER 19731, USACE 19742, NCDEM 19833). These studies predicted that that dissolved oxygen would be depleted in deeper portions of the lake during thermally stratified conditions. Despite the predicted high chlorophyll-a concentrations and the low dissolved oxygen concentrations in deep waters, each study indicated that the uses of Falls Lake would be met. Conditions in the lake today based on monitoring by the NC Division of Water Resources (DWR) are much better than predicted. For example, the earlier studies predicted summer average chlorophyll-a concentrations of 110 µg/L while data collected from August 2014 to October 2018 show a summer average concentration of 41 µg/L in the upper part of the lake. These data are summarized in the UNRBA 2019 Monitoring Report.

Falls Lake was listed on the NC 303(d) list for exceedances of the 40 µg/L chlorophyll-a criterion in 2008. In 2011 the EMC passed the Falls Lake Nutrient Management Strategy (the Rules) which requires two stages of nutrient reductions for Falls Lake. The Stage I goal is to achieve compliance with the chlorophyll-a standard in the lower half of the lake (below Highway 50). The Stage II goal is to always comply with the chlorophyll-a standard everywhere in the lake. The current Management Strategy dictates load reduction requirements for local governments and other entities based on a lake nutrient response model developed by the DWR. Based on DWR's fiscal analysis of the Management Strategy completed at time the rules were developed, the cost of Stage I is expected to exceed $500 million and implementation costs for Stage II are expected to approach $1 billion or more.

The UNRBA is in the process of its re-examination of Stage II of the Rules. The UNRBA began planning for the re-examination in 2011 in accordance with the procedures and requirements outlined in the Rules (15A NCAC 02B.0275 Section (5)(f)). This section of the rules is generally referred to as the adaptative management provision. The UNRBA supports its members in the implementation of Stage I of the Management Strategy; however, the UNRBA believes that the reduction goals for Stage II are infeasible and beyond the limits of technology. This conclusion is supported based on a technical review of the Stage II provisions (see Section 3 of Framework for Reexamination of Stage II).

Stage I Implementation Support

UNRBA Stage I efforts to reduce nutrient loading have already contributed to water quality improvements in Falls Lake. Based on DWR's 2021 Status Report for Falls Lake, agriculture, wastewater treatment plants exceeding 1 million gallons per day, and NC Department of Transportation have all met or exceeded Stage I load reduction targets.

The three major wastewater treatment plants have reduced total nitrogen loads by 57 percent and total phosphorus loads by 73 percent since the Falls Lake Rules were enacted. Agriculture has reduced total nitrogen losses by 77 percent.

[1]North Carolina Department of Natural and Economic Resources (DNER) Office of Water and Air Resources. 1973. North Carolina Water Plan – Progress Report Chapter 34 – Neuse River Basin Special Annex. Special Analysis of the Falls of the Neuse Project.
[2]United States Army Corps of Engineers (USACE). 1974. Final Environmental Impact Statement (Revised) Falls Lake Neuse River Basin North Carolina. U.S. Army Corps of Engineers Wilmington District. March 1974.
[3]North Carolina Division of Environmental Management (NCDEM). 1983. Water Quality Discussions of Falls of the Neuse and B. Everett Jordan Lakes. North Carolina Department of Natural Resources and Community Development, Division of Environmental Management, Water Quality Section. 94 pp.

New development regulations were adopted in 2012 by all local governments in the watershed to reduce loading from development activities to background levels. Though the Stage I load reduction targets for existing development were not set by DWR and the EMC, the UNRBA worked to develop actions and program proposals to reduce loading from existing development. This effort involves two initiatives: the Nutrient Credit Development Project and the Stage I existing development Interim Alternative Implementation Approach (IAIA). These two initiatives are summarized below.

Nutrient Credit Development Project

In 2014, the UNRBA invested approximately $310,000 on a Nutrient Credit Development Project to expand the list of state-approved nutrient-reducing practices in North Carolina. DWR contributed an additional $70,000 through a 319 grant. More information about these practices and their nutrient crediting is available online at https://www.unrba.org/nutrient-credit-program.

Stage I Existing Development Interim Alternative Implementation Approach (IAIA)

Since 2018, the UNRBA has been exploring an alternative option for achieving compliance with Stage I existing development nutrient load reductions requirements to overcome some of the obstacles present in the current Rules. This concept was originally suggested by environmental advocacy groups active in the watershed. The UNRBA worked with its members, representatives from environmental groups, conservation organizations, staff at DWR, other interest groups and regulated entities to develop an alternative approach for complying with the Rules that uses financial investment in eligible projects and activities that benefit water quality and quantity. This approach does not rely on counting pounds of nutrient reductions associated with individual projects, rather this innovative approach promotes actions that reduce nutrients from developed land and provide benefits to the watershed and lake. The IAIA Program Document (approved by the EMC in January 2021) and other materials are available here.

The IAIA is a voluntary program that allows jurisdictions to use a joint compliance approach. The program is also a pilot study to inform the development of a revised nutrient management strategy for Falls Lake. This program is interim because it only applies until the Falls Lake Rules are readopted as required by the NC General Assembly (expected in 2025 or later).

Year 1 of the IAIA was hugely successful. Participants were required to commit $1.5 million to eligible projects and actions. Annual compliance reporting shows that $5.5 million were committed in the first year!

> This voluntary, innovative approach promotes actions that reduce nutrients from developed land and provide benefits to the watershed and lake.

Re-examination of Stage II

The DWR predictive modeling used to develop the Falls Rules and set the Stage I and Stage II nutrient reduction requirements was developed on a compressed time schedule with limited data. There is significant uncertainty in the nutrient load reduction targets and the ability of the lake to meet chlorophyll-a water quality standards regardless of the load reductions achieved. For these reasons, the Rules allow for a “re-examination” of the required nutrient load reductions (adaptive management provision). The UNRBA developed a framework for conducting the re-examination in 2013 that included a review of historic data and models, recommendations for additional monitoring, and development of a watershed model and three lake water quality models.

The primary purpose of the UNRBA monitoring was to provide the necessary data and information to support development of models to allow for the evaluation of updated management approaches. Prior to collecting data, all necessary approvals from DWR were obtained (documents provided on the UNRBA monitoring website). As required by the Rules, DWR approved the Description of the Modeling Framework and the Modeling QAPP that specifies how the models should be developed and assessed for performance.

By the end of this process, the UNRBA membership will have spent approximately $10 million to support this re-examination effort.

The UNRBA also coordinated with researchers through the NC Policy Collaboratory on additional studies to inform water quality simulation models. The NC Policy Collaboratory is also providing third party review of the UNRBA modeling efforts. This invaluable contribution is occurring while the models are being developed to provide input and feedback on the model development processes being used by the UNRBA. Third party reviews increase transparency and provide an extra layer of assurance that the models can be relied upon to support regulatory and policy decisions.

> By the end of this process, the UNRBA membership will have spent approximately $10 million to support this re-examination effort.

UNRBA Monitoring

Routine Monitoring began in August 2014 and continued through October 2018. The Routine Monitoring obtained monthly samples on 20 water quality parameters from 38 tributary stations resulting in more than 38,000 measurements. Special studies were also conducted to provide a detailed understanding of the functions of the watershed and Falls Lake's physical, chemical, biological, and geological characteristics. These special studies included storm event sampling, high flow event sampling, lake sediment depth and quality, lake bathymetry, constriction point monitoring of water movement and water quality, and light extinction data. The UNRBA invested approximately $3.5 million in the monitoring effort to fill data gaps and improve the understanding of the lake and the watershed.

The UNRBA developed a comprehensive monitoring report in 2019 that summarizes the monitoring data, provides nutrient loading summaries by source and through time, and evaluates lake residence time, dissolved oxygen concentrations, and algal toxin data. This monitoring data, along with data collected by other organizations (DWR, NC State University Center for Applied Aquatic Ecology, and the cities of Durham and Raleigh), has been used to calibrate watershed loading and lake water quality simulation models.

A key finding of the UNRBA monitoring study is that nutrient loading is not the only driver of algal growth in the lake. It is clear that during some periods that other influences such as lake sediment nutrient release, hydrology, and hydraulics in the lake and watershed are more important in determining the trophic conditions in the lake than nutrient concentrations or loading. Chlorophyll-a concentrations in Falls Lake were highest in 2017 (especially below Highway 50) compared to other UNRBA monitoring years (Figure 1), but nutrient loads that year were approximately half (Figure 3). High nutrient loading corresponds with high precipitation and streamflows that increase flushing and reduce residence times. Periods of low loading correspond to small inflows and longer residence times when algae are provided longer periods for growth. The hydrology, morphology, retention time, depth, and characteristics of the different areas of the lake are just as important as nutrient loading. While the UNRBA aims to manage nutrient loading in the watershed, it recognizes it is not the only factor to consider in developing a revised nutrient management strategy.

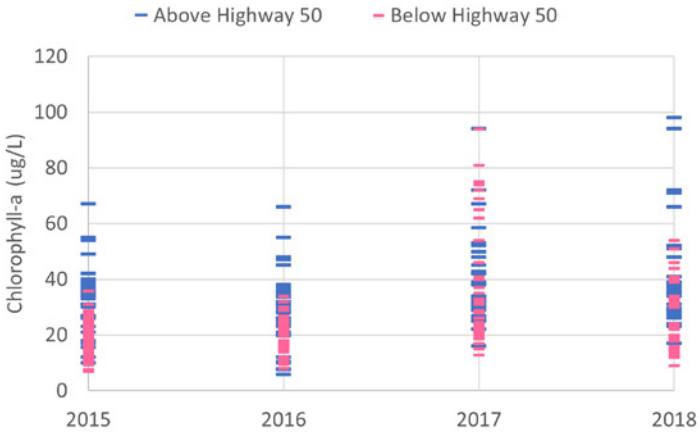


Figure 1. Chlorophyll-a Measurements in Upper Falls Lake (above Highway 50) and Lower Falls Lake (below Highway 50)

Watershed Modeling

The UNRBA worked extensively with local governments, researchers, state and federal agencies, and utilities to obtain data to develop a revised watershed model for Falls Lake. Data summaries and discussions are documented in Modeling and Regulatory Support Workgroup (MRSW) meeting materials.

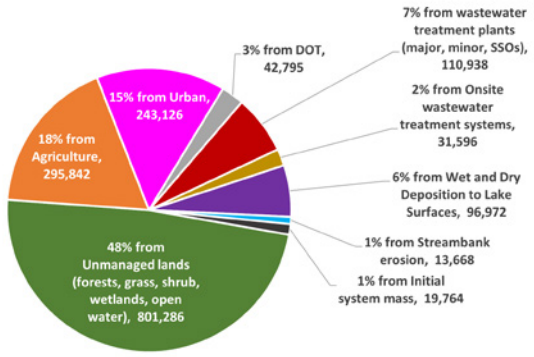
A primary input to watershed models is land use data. The Falls Lake watershed is comprised of mostly unmanaged lands (75 percent). Approximately 10 percent of the watershed is used for agriculture, the acreage of which has declined nearly 45 percent in the past 15 years. Approximately 10 percent of the land is classified as developed, most of which is low intensity. There are areas in the watershed like the City of Durham where development is denser, and the City has installed over 350 nutrient and flow reduction measures to improve water quality.

Soils data and precipitation data are also key drivers of hydrologic response and determine stream flows and nutrient loads delivered to Falls Lake. Soils data and soils chemistry data were obtained from US Department of Agriculture Natural Resources Conservation Service. Radar precipitation data for 78 locations in the watershed were provided by the NC State Climate Office (with support from NC Department of Transportation).

The watershed model evaluates the sources of nutrient loading to Falls Lake which will inform development of the revised nutrient management strategy.

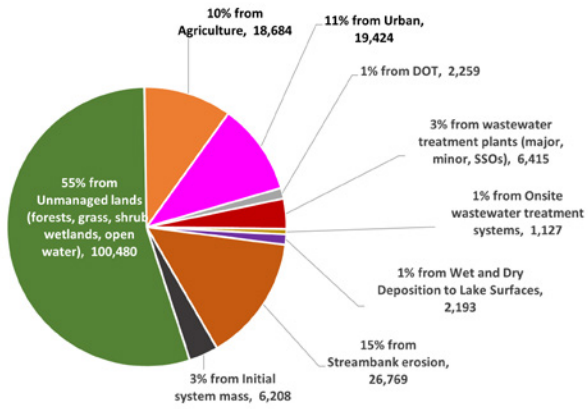
The modeling has resulted in improved understanding regarding the importance of soil chemistry on the transport, retention, and release of nutrients in the watershed. This understanding should be reflected in the revised strategy in a way that reflects the length of time that changes in watershed activities may take to realize changes in delivered loading to Falls Lake and resulting water quality. Similarly, the modeling demonstrates that the significant efforts in the watershed to reduce point and non-point source nutrient loading have had an important impact on delivered loads to Falls Lake. Because most of the land in the watershed is unmanaged (forests, wetlands, etc.), approximately half of the delivered nutrient and carbon load to Falls Lake originates from these unmanaged lands (Figure 2). These relatively natural areas that dominate the drainage are important to the health of the watershed and the lake. Multiple stakeholders and experts have expressed that conservation must be an important component of a revised nutrient management strategy. Achieving measurable load reductions to Falls Lake will require a systems approach directed at realistic and incremental change in the nutrient balance within this watershed and the lake.

Sources of Delivered Total Nitrogen Load
(1.65M pounds per year - average to wet hydrologic condition)



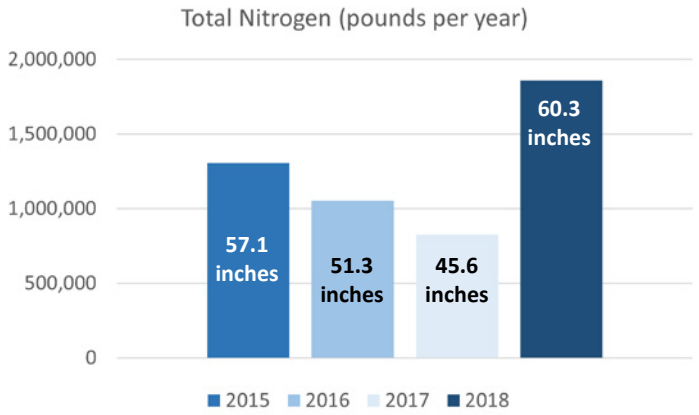
based on the UNRBA study period (2014-18)

Sources of Delivered Total Phosphorus Load
(184,000 pounds per year - average to wet hydrologic condition)



based on the UNRBA study period (2014-18)

Figure 2. Sources of Delivered Nutrient Loads to Falls Lake Based on the Watershed Model



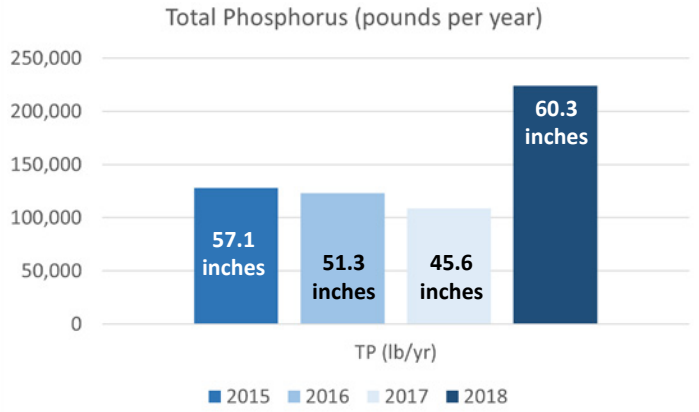


Figure 3. Annual Percipitation and Nutrient Loads Delivered to Falls Lake

Another important finding is the importance of precipitation on delivered loading to Falls Lake. During an average rainfall year like 2017, loads of total phosphorus and total nitrogen are approximately half that of a wet rainfall year like 2018.

The watershed modeling report has been drafted and reviewed by the MRSW. The report will be finalized and submitted to DWR along with the modeling files in early 2023.

Lake Water Quality Modeling

Two lake water quality models are being developed that use the information from the watershed model to simulate nutrient, carbon, and chlorophyll-a concentrations in Falls Lake. Both of these models are in the process of being finalized and draft reports will be submitted to the MRSW in spring 2023.

The UNRBA re-examination also includes the development of a model to evaluate how designated uses are affected by lake water quality. This statistical model will be primarily data driven and will incorporate Bayesian techniques that allow expert opinion to be considered when relationships between parameters and uses are difficult to quantify or costly to measure. The UNRBA has identified experts in the fields of water chemistry, lake processes, drinking water treatability, and evaluation of impacts to recreational uses to provide this expertise.

The initial findings of the lake models are consistent with the evaluations presented in the 2019 comprehensive monitoring report:

- Concentrations of nutrients in Falls Lake are relatively low
- Ammonia releases from lake sediments are higher in the deeper areas of the lake.
- Chlorophyll-a can reach high concentrations even when nutrient concentrations remain low (Figure 4).
- The two lake models are configured to simulate three groups of algae and corresponding chlorophyll-a concentrations. Diatoms and blue green algae have their own specific groups. A dominant group of algae present in Falls Lake is Prymnesiophytes. These are grouped into “other algae” along with several other types.
- DWR measures the biovolume of algae at three locations in Falls Lake. Chlorophyll-a can reach high concentrations even when total biovolume is low (Figure 5). This complicates simulation of chlorophyll-a because the models are designed to predict more chlorophyll-a when more algae are present.

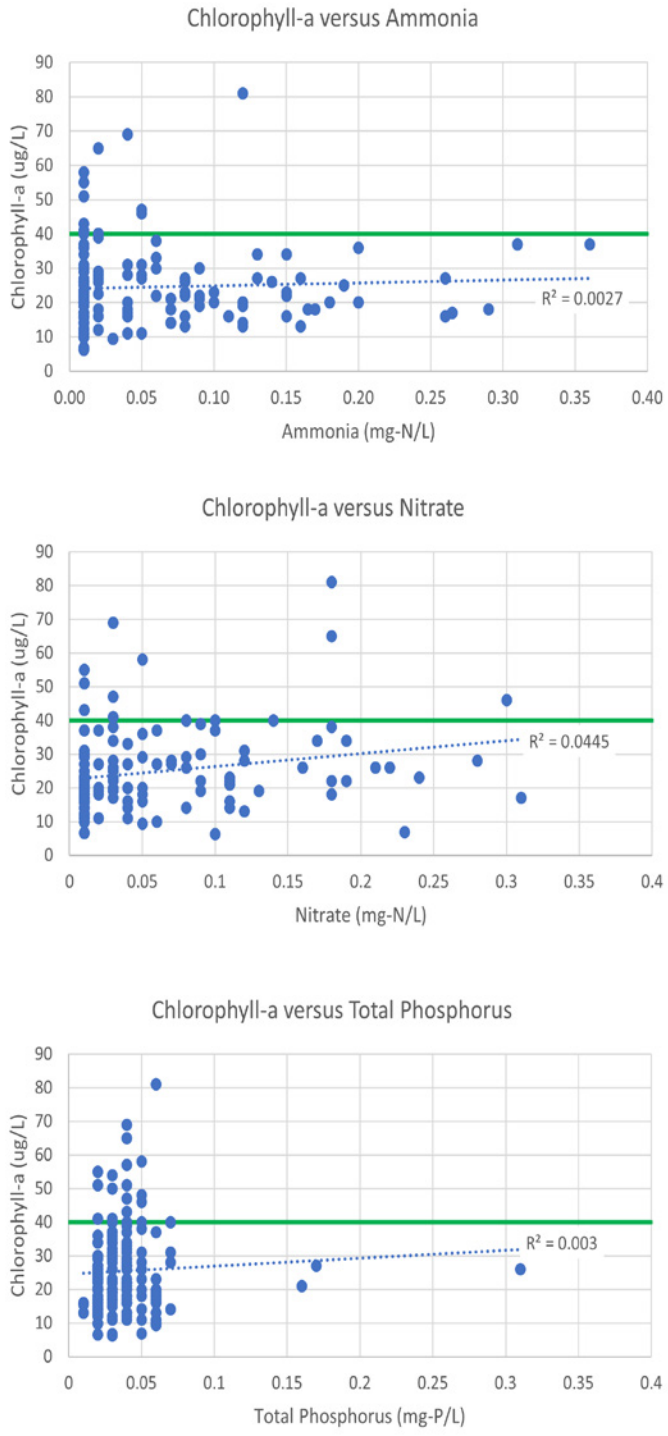


Figure 4. Nutrient and Chlorophyll-a Concentrations Observed in the Lower Lake (Station NEU019P)

After the predictive models are developed, they will be used to evaluate the impacts of different management options on lake water quality and designated uses. The UNRBA convened a Scenario Screening Workgroup comprised of UNRBA members and representatives from agriculture, US Forest Service, and NC DOT to prioritize scenarios for evaluation. One of the scenarios selected will be an "all forest or wetlands" scenario. This scenario will simulate all lands as forests and leave wetlands in place. It will also remove point sources, fertilizer application, and onsite wastewater treatment systems. This scenario will determine the lowest hypothetical loading to Falls Lake and predict resulting lake water quality. Another scenario will evaluate loads and lake water quality when feasible actions are taken to reduce loading from controllable sources.

A cost benefit analysis will also be conducted to assess the technical and financial feasibility of the various management options. The re-examination will integrate the model results of various management options and cost benefit information to develop recommendations for a revised nutrient management strategy for Falls Lake. This approach may also include the evaluation of regulatory options such as site-specific chlorophyll-a criteria, sub-classifications of designated uses, or other regulatory options. Given the vast amount of data collected in the watershed and lake, and the constraints on further reductions in nutrient loading, a more reasonable pathway is needed to ensure long-term protection of this important resource.

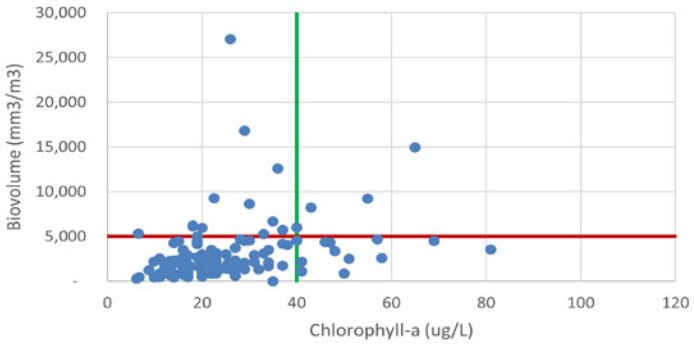


Figure 5. Scatter plot of algal biovolume and chlorophyll-a at a station below Highway 50 (red line is the DWR-determined "threshold" for an algal bloom, green line is the water quality criterion for chlorophyll-a). At this station, nearly 80 percent of the exceedances of the chlorophyll-a criterion occur when the biovolume is less than the threshold for a bloom.

Working to Achieve a Broadly Supported Set of Recommendations for a Revised Management Strategy

The efforts of the UNRBA and other organizations including the NC Policy Collaboratory have greatly improved the scientific understanding of nutrient processing in the watershed and Falls Lake. Revised policies must consider the science and realities of the system. Significant load reductions have occurred since the Rules were passed, and further reductions will be limited by technological and logistical constraints. The UNRBA recognizes the importance of protecting Falls Lake and seeks to establish a revised nutrient management strategy that will meet these challenges.

During 2022, the UNRBA moved into the discussion of concepts and principles for a revised strategy. This is a critical process that must begin before the modeling is finalized. The work completed by the UNRBA and the NC Policy Collaboratory, discussions that have occurred over the last several years, and the process followed to develop the IAIA, have established some clear guidelines for managing the lake and watershed.

Falls Lake is the most thoroughly studied reservoir in NC and among the most studied in the country. The 2014 to 2018 UNRBA monitoring program provided fundamental data and information that was previously not available. The 2019 comprehensive report along with the preliminary results of the Collaboratory research provides an informed picture of the system. The modeling provides further clarification as well as tools to test scenarios, management actions, and their impacts on lake water quality.

In September and October 2022, the PFC and the UNRBA Board were briefed on the need to intensify discussions of a new strategy. In November and December 2022, the PFC used most of its meeting time to look at concepts and principles that should be considered. This process will dominate the work of the UNRBA in 2023. These preliminary discussions will be shared with the larger set of stakeholders, leading to broader discussions ahead of finalizing recommendations.

The UNRBA recognizes the importance of protecting Falls Lake and seeks to establish a revised nutrient management strategy that will meet these challenges.

Stakeholder Involvement

The UNRBA membership has consistently used consensus to reach its decisions based on input from its members and representatives. External stakeholders participate through attendance and participation at UNRBA meetings which are open to the public. External stakeholders also have access to review UNRBA project activities, materials developed to describe and present its work, and documents generated by the UNRBA and its contractors in support of its objectives. Stakeholders are invited to comment on these materials during meetings and in writing to provide input to the work of the UNRBA. The UNRBA has and will continue to provide and enhance input opportunities during stakeholder meetings and workshops. The UNRBA encourages timely input from external stakeholders as this input is critical to the success of implementing a revised nutrient management strategy for Stage II. Input from the NC Department of Environmental Quality, including specifically the DWR, as the regulatory agency is especially important for successful development and adoption of a revised strategy.

Schedule

The UNRBA completed its four-year monitoring program in 2018 and is currently focused on development of models to evaluate nutrient loading from the watershed and water quality in the lake. These models were calibrated in 2022 and now will be used to test nutrient management scenarios. The UNRBA will work internally and with external stakeholders including the NC Policy Collaboratory to evaluate the predictions for nutrient management actions and to consider feasibility and costs in the revised strategy. The UNRBA will propose a revised strategy in 2023, considering the work of the Collaboratory. The Collaboratory's final report on Falls Lake is due later in 2023. Figure 6 provides an overview of the UNRBA re-examination schedule.

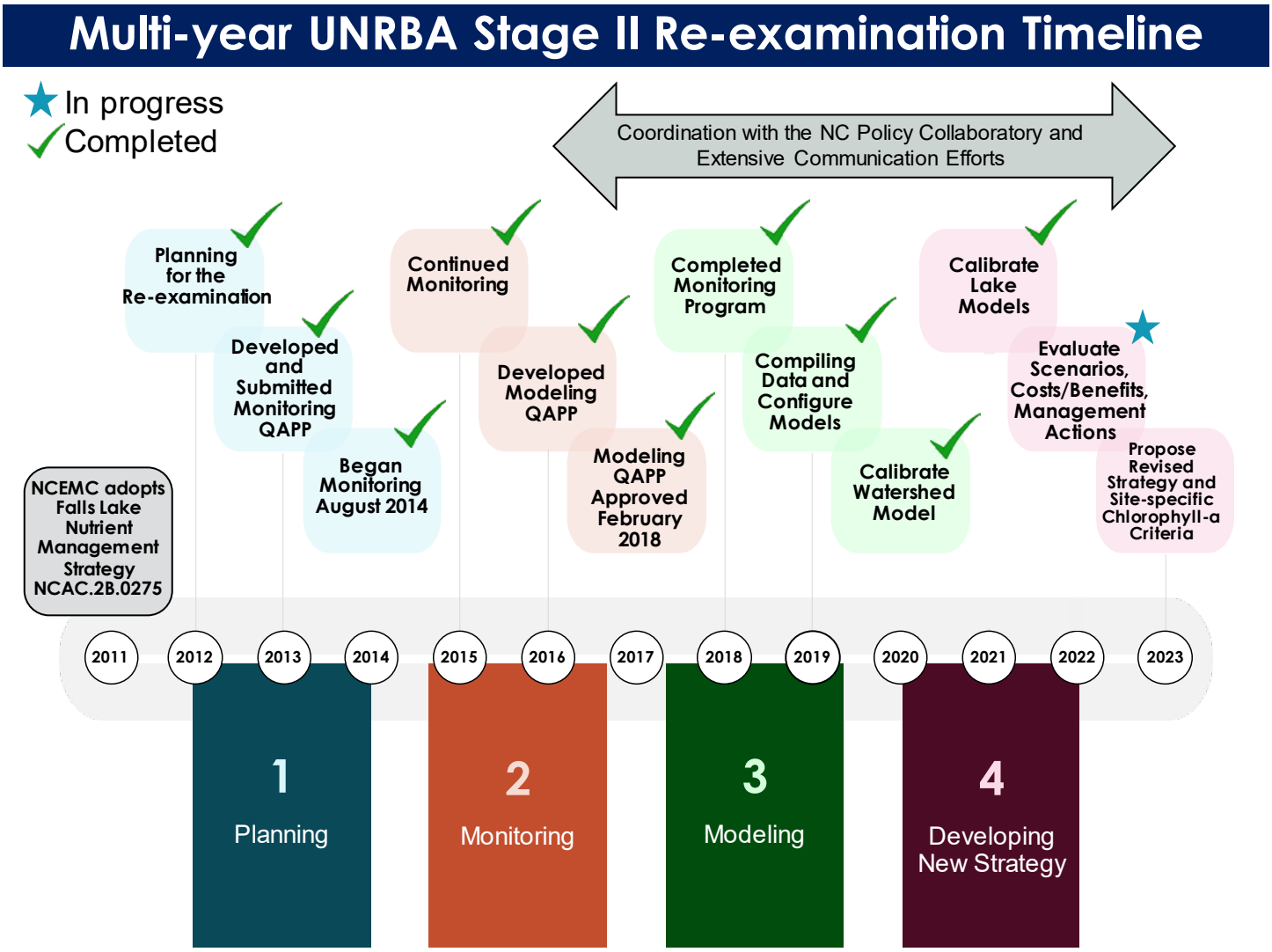


Figure 6. Schedule for the UNRBA Re-examination of Stage II Requirements