

Task 1: Framework for a Re-examination of Stage II of the Falls Nutrient Strategy



Executive Summary

ES.1 Introduction

Falls Lake was constructed by the US Army Corps of Engineers in the late 1970s. The Congressionally authorized uses of the project were flood control, water supply, recreation, fish and wildlife enhancement, and augmentation of low flows for purposes of pollution abatement and water-quality control in the Neuse River Basin. P.L. 89-298 (Oct. 27, 1965). The NCDWQ designated uses of Falls Lake under the Clean Water Act are drinking water supply, recreation, fishing, aquatic life including propagation and survival, and wildlife.

The North Carolina General Assembly's 2005 "Clean Lakes Act" (S.L. 2005-190) generated intensive data collection in water supply reservoirs across the State, including Falls Lake. Based on water quality monitoring conducted primarily in 2006, a portion of Falls Lake, from the confluence of the Eno and Flat River arms to the Interstate 85 Bridge (I-85), was identified as impaired due to exceedances of the turbidity and chlorophyll *a* water quality criteria (NCDENR 2012a). Another portion of Falls Lake, from the I-85 Bridge downstream to the dam also exceeds the chlorophyll *a* water quality criterion (NCDENR 2012a). The water quality criteria for chlorophyll *a* and turbidity are 40 µg/L and 25 nephelometric turbidity units (NTU), respectively. Under the Use Support guidance employed for the referenced review period, NCDWQ identified waterbodies as impaired if ten percent or more of the data (minimum of ten samples) exceeded the water quality criteria. The impairment determinations for Falls Lake were based on data collected between 2002 and 2006. Based on feedback from the Upper Neuse River Basin Association (UNRBA), the Association is, in addition to the specific re-examination process for Falls Lake, evaluating the State's chlorophyll *a* standard and is planning on entering into discussions with the Division of Water Quality (NCDWQ) and the Environmental Management Commission (EMC) to review the State's interpretation and application of the chlorophyll *a* standard. As reflected in UNRBA discussions, there are a number of alternatives relative to the standard including the standard value itself, application of the standard over the growing season as an average, and the use of several trophic measurements rather than one to define eutrophication level.

Table ES-1 summarizes the impairments for Falls Lake segments. The impairment status is specified by assessment unit number, which is a unique identifier that NCDENR uses to define specific segments of a waterbody. The UNRBA may recommend revisions to this segmentation in the future based on collection of additional data or to pursue specific regulatory options. The designated use associated with these water quality standards violations is the Aquatic Life use. However, there is no existing biological evidence to support an impaired status for this use; i.e., the lake does not have issues with fish kills due to eutrophication or low DO and supports a healthy sports fishery, etc. Although a fish kill occurred in 2008 near Highway 50, it was limited primarily to one species, channel catfish, and water quality measurements, total algal counts, and algal speciation during the event were within normal ranges (NCDWQ 2008). A North Carolina Wildlife Resources commission representative considered it a natural event likely "caused by a combination of spawning activities and high water temperature which may have allowed a bacterial infection to sicken weakened fish" (NCDWQ 2008). However, the lake is considered impaired by NCDWQ because it does not meet all of the applicable water quality criteria assigned to the aquatic life use.

Table ES-1 Falls Lake Water Quality Attainment and Impairment Status

Listing Year	Water Body	Assessment Unit Number	Cause of Impairment	Use Support Category	Use Support Rating
2008	Flat River (incl. Flat R. Arm of Falls Lake)	27-3-(9)	Low Dissolved Oxygen	Aquatic Life	Impaired
	Neuse River (From Source to I-85 Bridge)	27-(1)	Turbidity; Chlorophyll a	Aquatic Life	Impaired
	Neuse River (From I-85 Bridge to Dam)	27-(5.5)	Chlorophyll a	Aquatic Life	Impaired
2010	Flat River (incl. Flat R. Arm of Falls Lake)	27-3-(9)	Low Dissolved Oxygen	Aquatic Life	Impaired
	Neuse River (From Source to I-85 Bridge)	27-(1)	Turbidity; Chlorophyll a	Aquatic Life	Impaired
	Neuse River (From I-85 Bridge to Panther Creek)	27-(5.5)a	Turbidity; Chlorophyll a	Aquatic Life	Impaired
	Neuse River (From Panther Creek to Falls Dam)	27-(5.5)b	Chlorophyll a	Aquatic Life	Impaired
2012	Flat River (incl. Flat R. Arm of Falls Lake)	27-3-(9)	Low Dissolved Oxygen	Aquatic Life	Impaired
	Neuse River (From Source to I-85 Bridge)	27-(1)	Turbidity ¹	Aquatic Life	Impaired
	Neuse River (From I-85 Bridge to Panther Creek)	27-(5.5)a	Turbidity ¹	Aquatic Life	Impaired

In 2010 the Environmental Management Commission (EMC) passed the Falls Lake Nutrient Management Strategy, requiring two stages of nutrient reductions (N.C. Rules Review Commission 2010). The Rules establish a Nutrient Management Strategy for Falls of the Neuse Reservoir aimed at attaining:

"...the classified uses of Falls of the Neuse Reservoir set out in 15A NCAC 02B .0211 from current impaired conditions related to excess nutrient inputs; protect its classified uses as set out in 15A NCAC 02B .0216, including use as a source of water supply for drinking water; and maintain and enhance protections currently implemented by local governments in existing water supply watersheds encompassed by the watershed of Falls of the Neuse Reservoir." (15NCAC 02B .0275)

Stage I of the Nutrient Management Strategy requires "intermediate or currently achievable controls throughout the Falls watershed with the objective of reducing nitrogen and phosphorus loading, and attaining nutrient-related water quality standards in the Lower Falls Reservoir as soon as possible but no later than January 15, 2021, while also improving water quality in the Upper Falls Reservoir...." (15NCAC 02B .0275 (4) (a)). Based on modeling and evaluation by the NC Division of Water Quality (NCDWQ), Stage I will require a 20 percent and 40 percent reduction in total nitrogen and total phosphorus loading, respectively, for point sources and agriculture. For development based sources, the rules require that loading be reduced to the levels of the baseline year (2006) established by NCDWQ. Stage I requires local jurisdictions to establish requirements to control nutrient input from new development sources.

Stage II requires that all areas of Falls Lake achieve the nutrient-related water quality standards. Based on NCDWQ modeling and evaluation, the additional loading reductions required to achieve this goal are

40 percent and 77 percent for total nitrogen and total phosphorus, respectively, relative to the baseline year. NCDWQ reservoir monitoring data will be used to assess compliance with the goals of the Strategy and determine if additional load reductions to a particular lake segment are needed. As stated in the Rules:

"Stage II requires implementation of additional controls in the Upper Falls Watershed beginning no later than January 15, 2021 to achieve nutrient-related water quality standards throughout Falls Reservoir by 2041 to the maximum extent technically and economically feasible..." (15NCAC 02B .0275 (4) (b))

The NCDWQ believes that the Stage II nutrient reductions are needed for all of Falls Reservoir to achieve compliance with water quality standards. The rules identify the parties (municipalities, counties, agriculture, and state and federal entities) responsible for implementing the nutrient reductions. The nutrient reductions are to be achieved by requiring stormwater controls and implementation of best management practices (BMPs) for new and existing development, point source discharges, and agricultural non-point sources.

The Consensus Principles were adopted in February 2010 to guide the Falls Lake Nutrient Management Strategy. The Consensus Principles call for a review of the attainability of the designated uses for the Upper Lake, and the feasibility of achieving Stage II reduction goals and meeting the water quality standard for chlorophyll *a*. The principles also propose an examination of whether existing uses of the Upper Lake can be protected with alternative water quality standards.

Cardno ENTRIX is assisting the Upper Neuse River Basin Association (UNRBA) in determining the best approach to address the nutrient management rule requirements and the Consensus Principles regarding the re-examination of Stage II of the Falls Lake Nutrient Management Strategy. The re-examination should consider existing data, models, nutrient management strategies, the Consensus Principles, water quality standards (including designated uses and water quality criteria), implementation costs, and regulatory flexibility (Figure ES-1).

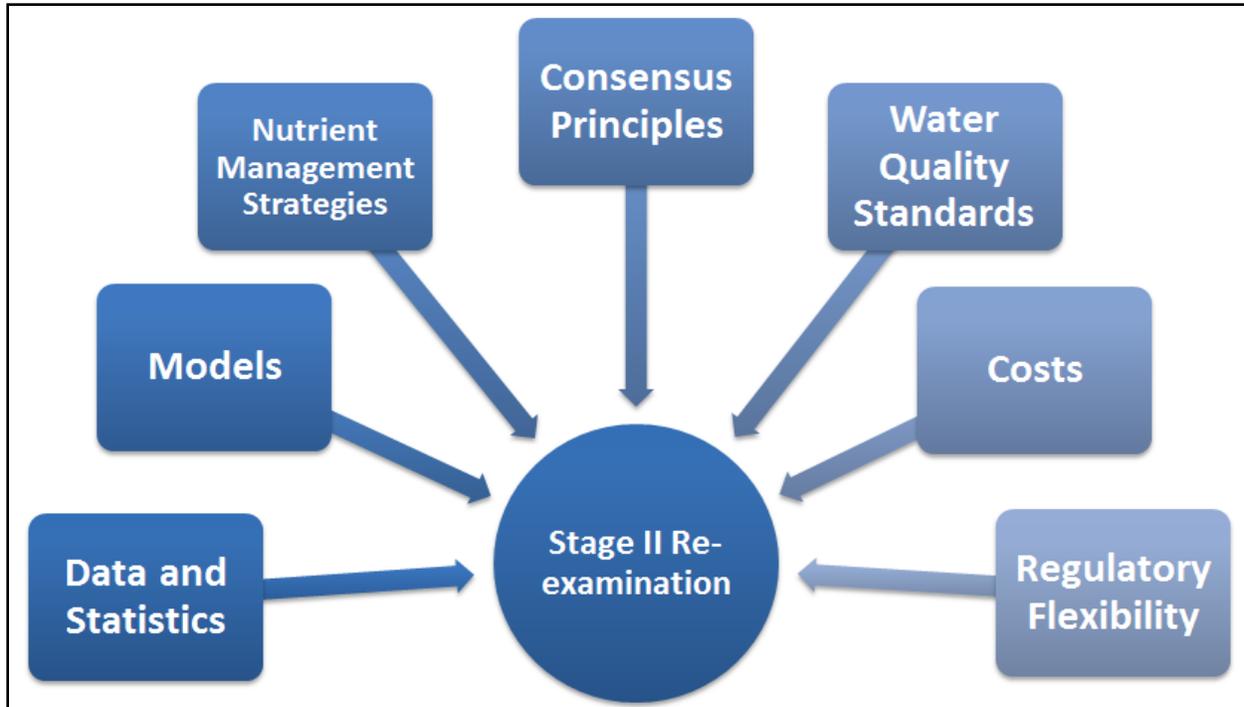


Figure ES- 1 Stage II Re-examination Components

Four project tasks were designed to provide the UNRBA with the information needed to make informed decisions regarding the next steps to implementation of the re-examination and to develop jurisdictional loads for regulatory and program implementation purposes:

- > Task 1. Develop a Framework for a Re-examination of Stage II of the Falls Lake Nutrient Management Strategy (described in this TM)
- > Task 2. Review Existing Data and Reports to Summarize Knowledge of Falls Lake and the Falls Lake Watershed (Cardno ENTRIX 2012)
- > Task 3. Review Methods for Delivered and Jurisdictional Nutrient Loads (Cardno ENTRIX 2013a)
- > Task 4. Recommend Future Monitoring and Modeling (Cardno ENTRIX 2013b)

The objective of Task 1 is to integrate the findings from Tasks 2, 3, and 4 into a recommended path forward for the re-examination of the Stage II rules. This task also includes development of a spreadsheet tool that predicts the impacts of various nutrient reduction scenarios on lake water quality. The Falls Lake Framework Tool has been set up using existing information and models to link water quality to designated uses. The output of the Tool is intended to provide planning level information with the understanding that the results of future monitoring and modeling studies will be used to refine the Tool when necessary.

ES.2 Summary of the Physical, Chemical, and Biological Conditions of Falls Lake

Cardno ENTRIX compiled existing data and reports on Falls Lake and its watershed from 1999 to 2011. The resulting database was used to summarize spatial and temporal trends in lake water quality and to identify gaps in monitoring data (Cardno ENTRIX 2012). Figure ES-2 is a map of the monitoring stations in the watershed along with the jurisdictional boundaries. Summary statistics and box plots were used to assess spatial and temporal trends in water quality data.

The water quality database was also used to calculate tributary nutrient loading to the lake and to describe how data gaps may affect watershed and lake response modeling results (Cardno ENTRIX 2013a). Cardno ENTRIX recommended future monitoring and modeling studies to fill monitoring gaps and reduce the uncertainty associated with the watershed and lake response modeling conducted by the State (Cardno ENTRIX 2013b).

Section 2 of this TM provides a brief summary of the findings from these reports. Several key points are noted here in the executive summary:

- > The data summaries (Cardno ENTRIX 2012) confirm the trends reported by NCDENR and other researchers. In particular, several studies demonstrate that water quality improves in the lake from the upstream end to the downstream end near the dam.
- > The highest levels of chlorophyll *a* occur in the upstream segments of the lake, with stepwise improvements occurring downstream toward the dam. As described in Section 2.1.2.2, this longitudinal improvement in water quality was predicted in the studies that preceded construction of the dam (State of North Carolina Department of Natural and Economic Resources Office of Water and Air Resources 1973, USACE 1974).
- > The chlorophyll *a* criteria of 40 µg/L is exceeded in each of the three lake segments upstream of Highway 50.
- > The turbidity criteria of 25 NTU is exceeded in the upper lake.
- > Other than the Flat River arm, the lake is not impaired for dissolved oxygen or pH.
- > Water quality in the tributaries was relatively poor during the baseline year of 2006.
- > Chlorophyll *a* concentrations in the lake increased from 2003 to 2006. Since 2006, concentrations have generally leveled off in the Upper Lake and declined in the Lower Lake.
- > The Lower Lake has not exceeded the chlorophyll *a* standard in 10 percent or more of samples since 2009. None of the samples collected in the Lower Lake by NCDWQ exceeded the chlorophyll *a* criteria in 2010, 2011, or 2012 except for Station NEU019L where 8 percent of the samples exceeded the criteria in 2012 (Figure ES-3, NCDENR 2012b). NCDWQ may remove the Lower Lake from the list of impaired waters following attainment of water quality standards for two consecutive use support assessments, which occur every two years based on the previous five years of data.
- > The total organic carbon (TOC) concentrations in the Upper Lake were highest in 2008 and 2009 relative to the other six years monitored (2005 through 2012). The TOC concentrations in the Lower Lake fluctuate from year to year with the highest concentrations observed in 2002 and 2003. Concentrations decreased in 2004 followed by an increasing trend in 2005 and 2006, stable concentrations from 2006 to 2008, and a decreasing trend from 2008 to 2010.
- > Data gaps in the existing monitoring programs are a source of uncertainty in the lake response modeling conducted by NCDWQ. A specific concern with the existing modeling is that since chlorophyll *a* data was not collected in the tributaries upstream of Falls Lake, there was no data available to build the model input for this parameter. To fill this gap, NCDWQ assumed that tributary chlorophyll *a* concentrations were the same as those observed at nearby lake stations. This approach was also used to build the model inputs for TOC. Cardno ENTRIX (2013b) recommends collection of additional monitoring data to reduce uncertainty associated with these parameters.
- > The NCDWQ relied on a single year to set the nutrient load allocations, and this year (2006) was impacted by a large tropical storm. Because the UNRBA has identified the need for a more complete evaluation of Falls Lake beneficial uses and the effect of the Stage II requirements on the practical impact to established and classified uses, the ability to effectively and accurately simulate Falls Lake

water quality over a wider range of conditions is needed. In addition, there needs to be a mechanism that directly links lake water quality with attainment of designated uses.

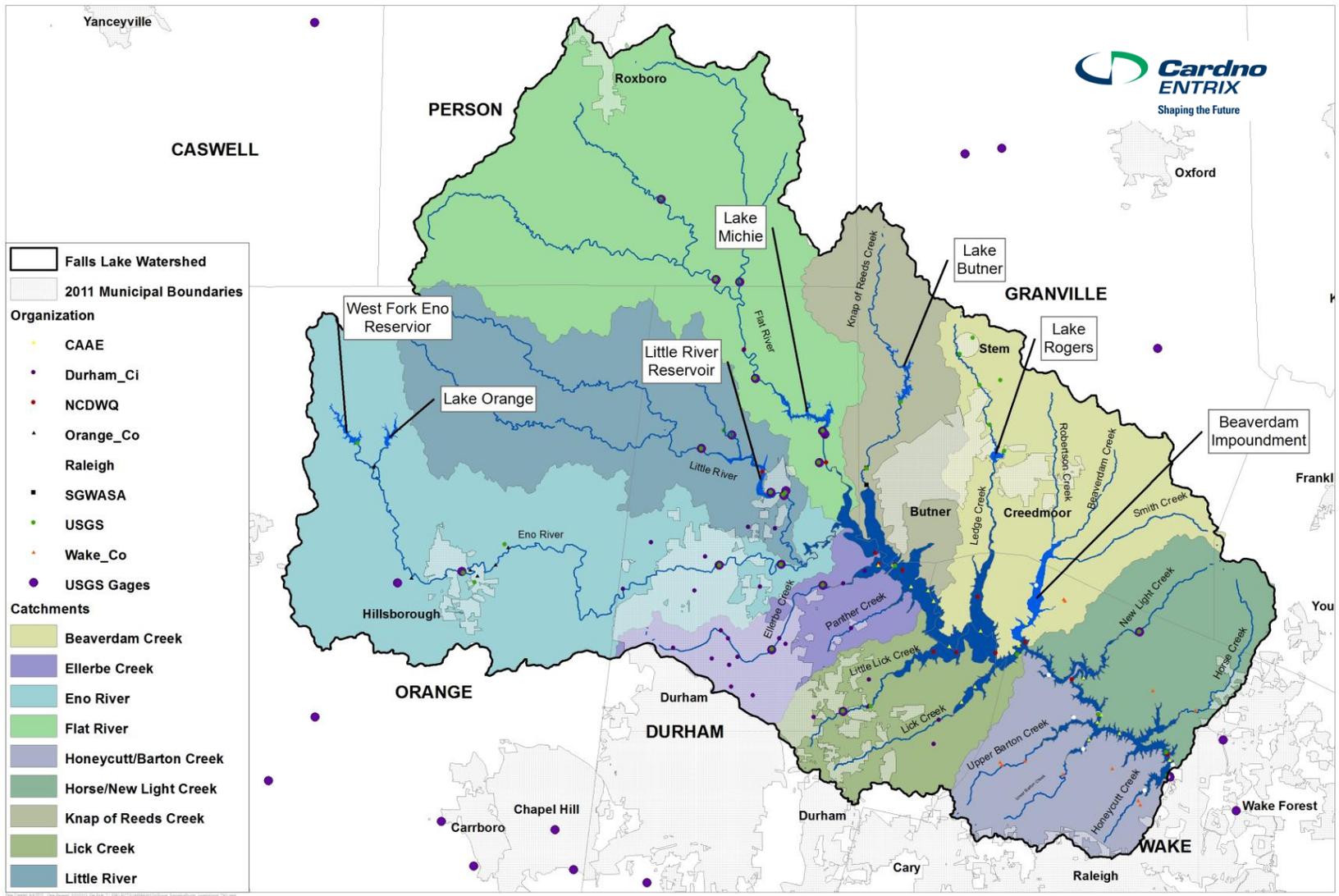


Figure ES-2 Water Quality and Flow Monitoring Stations in Falls Lake Watershed

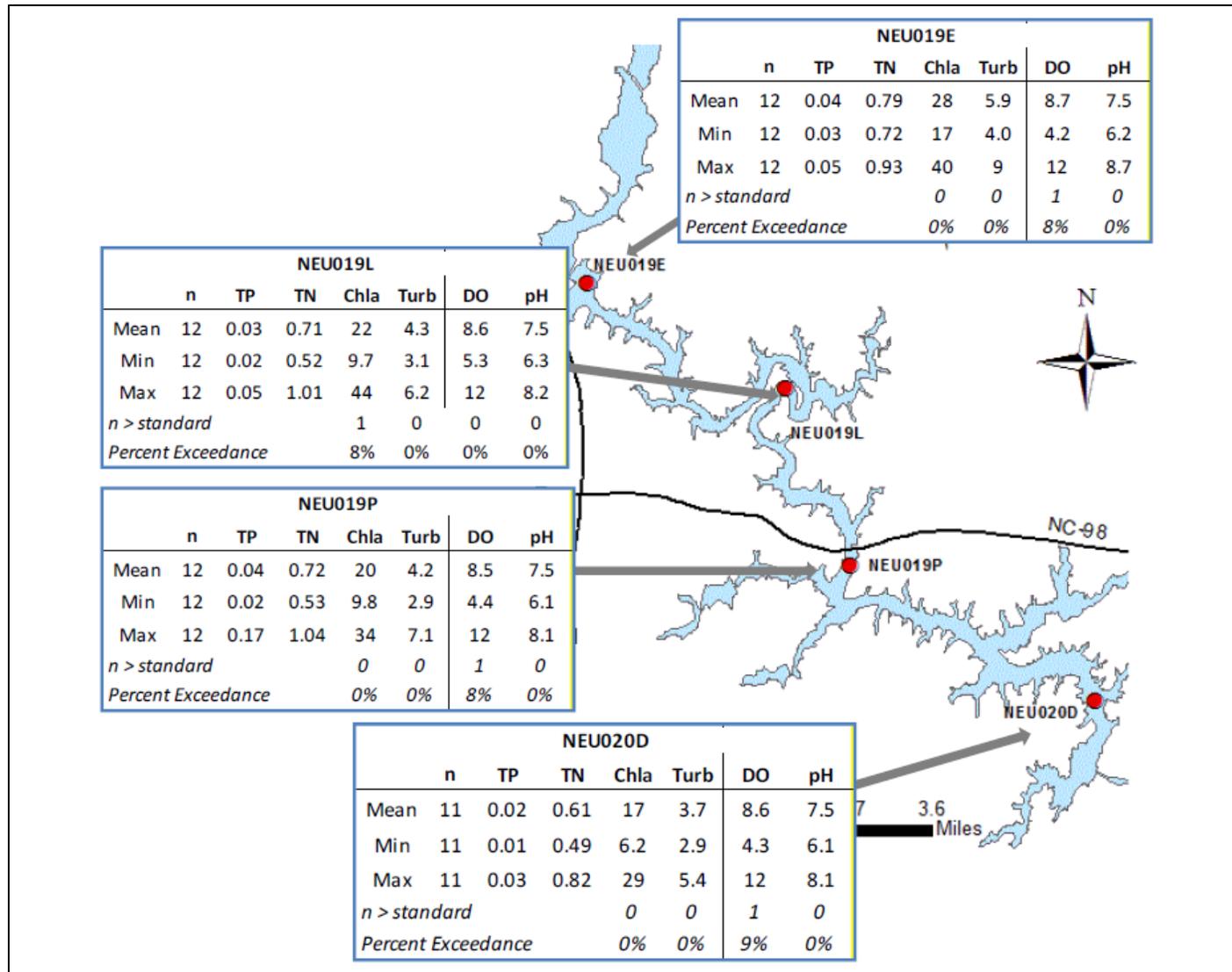


Figure ES-3 Results of NCDWQ 2012 Water Quality Sampling in the Lower Lake (NCDENR 2012b)

ES.3 Cost Assessment for Stage II

In 2010, NCDWQ published the fiscal analysis of the Falls Lake Nutrient Management Strategy which includes capital, permitting, operation, and maintenance costs (NCDWQ 2010). The report concluded that Stage I of the Strategy would cost approximately \$604 million (\$2010) in implementation costs and Stage II would cost approximately \$946 million (\$2010). Cardno ENTRIX reviewed the feasibility and cost estimates for the Stage II implementation based on the NCDWQ assumptions as well as additional sources of information. Based on the Cardno ENTRIX review, the Stage II loading targets are not technically, logistically, or financial feasible:

- > The Stage II phosphorus reduction goal of 77 percent is beyond the limits of current technology. Meeting the Stage II nitrogen reduction goal of 40 percent will require treating nearly every acre of existing development. Given site specific constraints (topography, soil type, etc.) treating every acre of existing development is not technically feasible. In addition, these percent reductions rely heavily on a limited number of BMPs.
- > Approximately 1,000 BMPs will need to be installed during each year to achieve compliance with Stage II nitrogen targets. Designing, permitting, and installing this number of BMPs in the watershed is not logistically feasible. Implementing this number of BMPs each year will likely cost more than the \$551 million projected in the fiscal analysis due to the high percent reduction requirements and site specific constraints.
- > Local studies conducted in North Carolina indicate that watersheds relying on retrofitting existing development to meet nutrient reduction goals will likely not be able to reduce nutrient loading by more than 20 percent for total nitrogen or 50 percent for total phosphorus. In an example watershed (Ellerbe Creek), cumulative nutrient reductions greater than 10 percent for nitrogen and 12 percent for phosphorus were not achievable given the constraints in the watershed including lack of space and high imperviousness (Hunt et al. 2012).
- > NCDWQ does not currently have approved nutrient load accounting methods for three of the most cost effective BMPs identified by Hunt et al. (2012).
- > The NCDWQ (2010) fiscal analysis acknowledges that cost effective practices for reducing nutrient loading from existing development may not be available today, but that new technologies and accounting procedures would likely be developed during the Stage I period that would help the local governments meet the Stage II requirements. If new technologies and credit accounting tools are not developed over the next several years, achieving the Stage II goals will not be technically feasible.
- > While agriculture is estimated to contribute the largest percentages of baseline nutrient loads according to the modeling performed by NCDWQ, they have the lowest expected implementation costs of any sector. The NCDWQ (2010) fiscal analysis limits the amount of reductions achievable by agriculture by assuming only one BMP system will be applied to pasture lands. While the fiscal analysis indicates that the Stage II nitrogen targets are attainable for agriculture, there are not enough stream miles available for implementation to meet this goal.
- > The NCDWQ (2010) fiscal analysis does not address the significant phosphorus reductions required of the agricultural community: "While the rule requires specific reductions in phosphorus as well, the current available accounting criteria are qualitative in nature and would not allow for meaningful cost estimation." Given that the stream protection BMPs on pastureland are not capable of achieving the Stage II nitrogen reductions, it is unlikely they will be able to achieve the Stage II phosphorus reductions which are nearly two times higher.
- > In other parts of the country, the agricultural community is able to earn nutrient credits using BMPs that are generally more cost effective than those implemented on existing development. In North

Carolina, many of these BMPs do not have accounting measures in place to allow agriculture to earn nutrient credits. Increasing the number and type of BMPs that the agricultural community can use to earn credits may reduce overall implementation costs in the watershed through a nutrient trading program.

- > The USEPA Municipal Preliminary Screener indicates that the Stage II loading targets will cause a “Large Impact” to the community in the Falls Lake watershed. The projected cost of \$945 million (\$2010) will require each household to contribute approximately \$1,400 per year to reduce nutrient loading from existing development and wastewater treatment plants. This preliminary ranking indicates that additional studies are needed to confirm that the rules are not financially feasible.

In summary, a review of the available information indicates that meeting the Stage II load reduction targets is not technically, logistically, or financial feasible. Additional sources of information including local and regional studies indicate that treatment costs are highly variable and are generally more expensive on existing development compared to agriculture. The analyses presented in this section support the need for a re-examination of the Stage II rules as described in Section 6.

ES.4 Linking Water Quality in Falls Lake to Designated Uses

An essential component of the framework for re-examining Stage II of the Falls Lake Nutrient Management Strategy is a tool that links nutrient loads to lake water quality, designated uses, implementation costs, water treatment costs, and recreational value. Cardno ENTRIX used the available physical, chemical, and biological data to develop a spreadsheet based tool (the Falls Lake Framework Tool) that establishes these linkages using existing data.

Figure ES-4 illustrates how the various components of the Falls Lake Framework Tool (the Tool) link nutrient inputs and predicted lake water quality to designated uses, attainment of water quality criteria, and implementation costs. The Falls Lake Framework Tool uses baseline (2006) nutrient loads and user-selected management scenarios to calculate nutrient loading to the lake. These loads are input to the US Army Corps of Engineers (USACE) BATHTUB model (Section 4.1.1) to estimate total nitrogen (TN), total phosphorus (TP), and chlorophyll *a* concentrations in Falls Lake. Regression equations based on data collected in Falls Lake (Section 4.1.3) are then used to estimate concentrations of total organic carbon (TOC), total suspended sediment (TSS), turbidity, and dissolved oxygen (DO) in Falls Lake. Finally, the Tool uses existing information to link water quality with attainment of water quality criteria and status of designated uses (Section 4.2). The output from the Tool includes implementation costs for the selected management scenarios as well as impacts to designated uses.

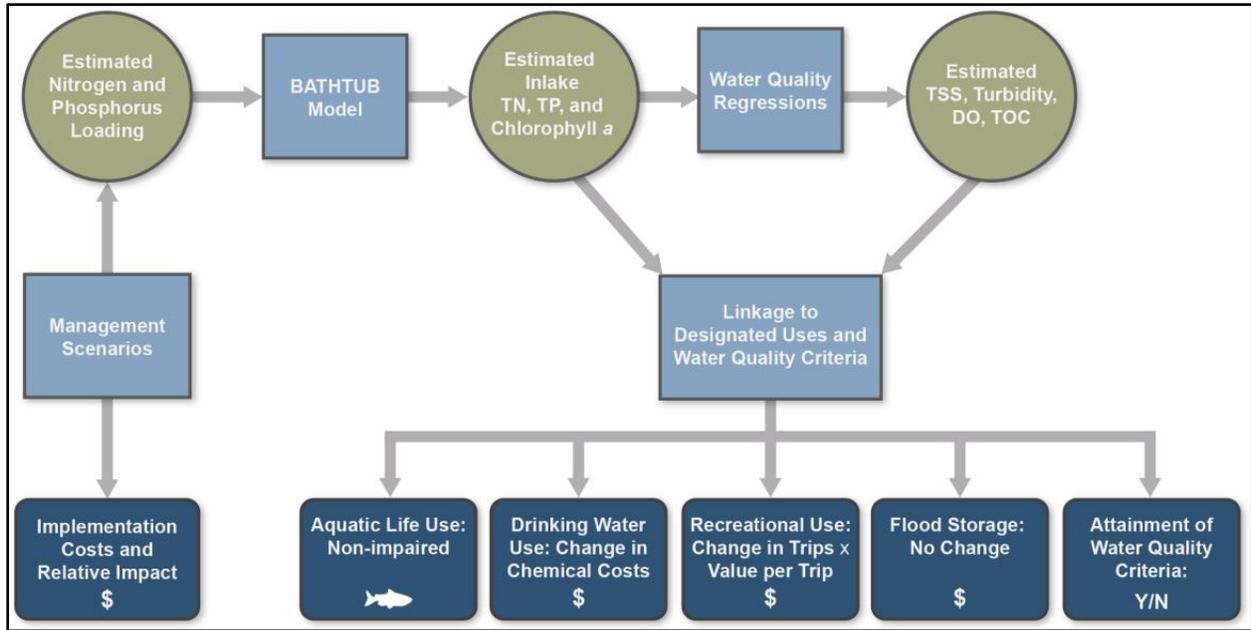


Figure ES-4 Graphical Illustration of the Falls Lake Framework Tool

ES 4.1 Linkage of Nutrient Loading, Water Quality, and Designated Uses

The Tool allows the user to select from two options to calculate baseline loading to the lake. The user may also select from various nutrient reduction scenarios to test the impacts on water quality (nutrients, chlorophyll a, TOC, etc.). The Tool uses multiple calculations to link changes in water quality, resulting from implementation of nutrient management scenarios, to changes in designated uses and attainment of water quality criteria.

The Tool provides a comparison of predicted lake water quality to water quality criteria. Under existing conditions, the lake attains the DO and pH criteria. Nutrient management scenarios are not expected to shift the lakes status from Attainment to Non-Attainment for these criteria, so these parameters are categorized as Attainment for the baseline and nutrient management scenarios. The Tool predicts changes in the lake chlorophyll a concentrations and turbidity levels and provides an assessment of whether or not these criteria will be met.

Falls Lake is on the 303(d) list due to violations of the turbidity and chlorophyll a values. The Aquatic Life beneficial use is not considered “Not Impaired” based on existing biological data. No fish kills due to eutrophication or low DO have been reported in Falls Lake, and the lake supports a healthy sports fishery. Future studies are recommended to further assess the aquatic life use. Based on existing information, the Falls Lake Framework Tool categorizes the Aquatic Life use as “Not Impaired” based on the biology of the lake. Nutrient management strategies are not expected to cause biological impairments in the lake, so the Falls Lake Framework Tool categorizes the Aquatic Life use as “Not Impaired” for the baseline and nutrient management scenarios. The Tool addresses non-attainment of the water quality criteria separately.

To provide a linkage between water quality and the drinking water supply use, the Tool estimates the cost of chemical usage at the City of Raleigh’s water treatment plant based on Falls Lake water quality. The Tool uses TOC concentrations in the raw water supply to estimate the pounds of ferric sulfate needed to treat the water. The output from the Tool is a change in annual cost to treat an average of 50 MGD of water.

The Tool also estimates the annual change in the value of the recreational use of Falls Lake based on total phosphorus, turbidity, and dissolved oxygen concentrations. The Tool uses a recreational model developed by researchers at North Carolina State University to link water quality with the monetary value of associated ecosystem services including recreational use (Phaneuf et al. 2008). The Tool outputs the change in the annual value of recreation for Falls Lake.

One of the main reasons for constructing Falls Lake was to provide flood control benefits to communities downstream. Data provided by the USACE suggests that Falls Lake provides annual average flood control benefits of \$21 million, and the lake prevented an estimated \$259 million dollars in damages in 1996 associated with Hurricane Fran. The Tool assumes nutrient management practices will not impact flood control benefits. Revisions to the Tool in the future may add a linkage between nutrient reductions and the flood control use to account for practices that reduce storm volumes and peak flows, increase infiltration in the watershed, disconnect impervious surfaces, etc. For the current version, the change in flood control storage resulting from nutrient management is assumed to be zero.

ES 4.2 Estimation of Implementation Costs and Fiscal Impact

The Falls Lake Framework Tool also estimates annual nutrient management implementation cost based on the cost per pound of phosphorus reduction. The Tool assumes that the relative proportions of nitrogen and phosphorus reductions are similar to those required by Stage I and Stage II of the Falls Lake Nutrient Management Strategy. Implementation costs are calculated based on the simulated phosphorus reduction only and do not include additional costs to achieve nitrogen reductions. The user can either select the NCDWQ fiscal analysis as the basis of the cost estimate, or use the “user-specified \$/lb-P” to run the calculation.

The Tool also includes the USEPA Municipal Preliminary Screener (described in Section 4.3) that USEPA uses to rank the relative social and economic impact of pollution controls. This Municipal Preliminary Screener calculates economic impacts based on USEPA’s “Interim Economic Guidance for Water Quality Standards,” EPA-823-B-95-002 (1995) (hereinafter WQS Economic Guidance). The Municipal Preliminary Screener uses median household income (MHI) and number of households affected by the pollution controls to estimate the financial impacts to the regulated communities. If the cost per household of achieving compliance is over 2 percent of MHI, the cost is considered a “Large” financial impact. Costs between 1 and 2 percent of MHI are a “Mid-range Impact.” If the costs are less than 1 percent, the impact is assumed to be “Little.”

The output from the USEPA Municipal Preliminary Screener may be used to support various regulatory options such as use attainability analyses and variances, and the USEPA recommends that impacts in the “Mid-range” or “Large” category undergo further analysis. Figure ES-5 shows an example of the annual implementation costs associated with changing the percent reductions of nitrogen and phosphorus loading using the Falls Lake Framework Tool. The relative proportions of nitrogen and phosphorus reductions are similar to those required by Stage I and Stage II of the Falls Lake Nutrient Management Strategy. The categories on the x-axis are the percent reductions of total nitrogen and total phosphorus, respectively. The category (40, 77) represents the Stage II scenario. Percent reductions and implementation costs that cause a “Large” impact according to the USEPA Municipal Preliminary Screener are shaded orange. “Mid-range” impacts are shaded purple, and “Little” impacts are shaded green.

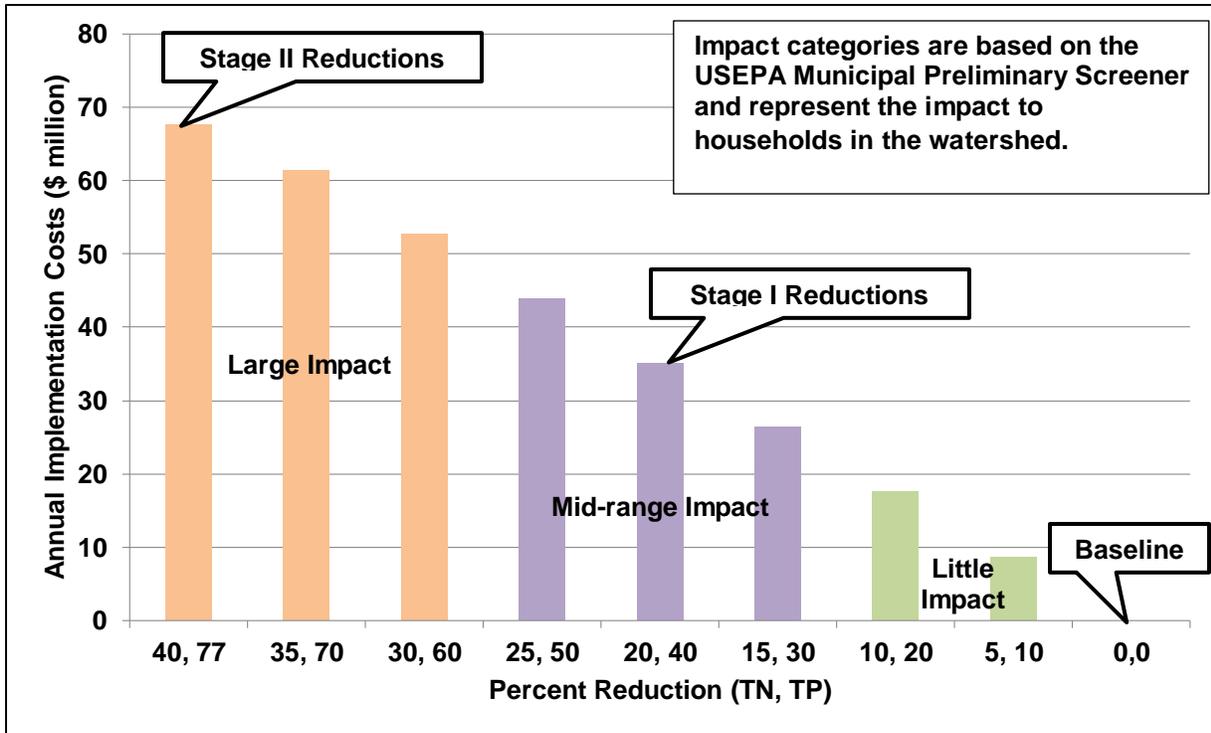


Figure ES-5 Annual Implementation Costs Associated with Varying Percent Reductions in Nitrogen and Phosphorus Loading

ES 4.3 Example Application of the Falls Lake Framework Tool—Stage II Reduction Scenario

An example application of the Falls Lake Framework Tool, which assumed Stage II nutrient reductions, is presented below. The values presented in the NCDWQ fiscal analysis are used to calculate costs. For this example, the Falls Lake Framework Tool estimates the following:

- > Nutrient reductions of 658,000 pounds of nitrogen and 35,000 pounds of phosphorus are required for the upper five tributaries draining to Falls Lake to meet the Stage II reductions of 40 percent for nitrogen and 77 percent for phosphorus.
- > Falls Lake will continue to attain DO and pH criteria under the Stage II scenario.
- > Mean chlorophyll *a* concentrations in the lake will not exceed 20 µg/L, and the standard of 40 µg/L is not likely to be exceeded.
- > Mean turbidity will remain less than 10 NTU (the water quality standard is 25 NTU).
- > Mean TOC concentrations near the dam will decrease by approximately 0.9 mg/L.
- > The Aquatic Life use is categorized as “Not Impaired” under the Stage II scenario based on compliance with biological indices even under the baseline scenario.
- > Full implementation of the Stage II scenario may decrease the drinking water treatment costs for the City of Raleigh by approximately \$194,000 per year. The City is studying the need for advanced technologies at the water treatment plant that may cost approximately \$125 million if TOC concentrations increase over the next several years (Hazen and Sawyer 2012).
- > The Tool estimates that full implementation of the Stage II scenario may increase the value of the recreational designated use by approximately \$168,000 per year based on local studies.

- > For the current version, the change in flood control storage resulting from nutrient management is assumed to be zero.
- > Implementation costs for the Stage II scenario are approximately \$67.5 million per year with total projected costs of \$945 million (NCDWQ 2010). However, it is unlikely that this expenditure will actually achieve the Stage II phosphorus reductions given the current limits of technology and limited number of NCDWQ-approved BMPs.
- > Based on the USEPA Municipal Preliminary Screener, the financial impact of the Stage II rules is “Large.”

Cardno ENTRIX (2013b) recommends future monitoring and modeling studies that will provide additional information to link water quality to designated uses. The data will also provide an indication of the lake response to the nutrient load reductions that have already been achieved. Following collection of the additional data and development of future models such as the empirical model linking water quality to designated uses, the Falls Lake Framework Tool may be updated to refine the predicted impacts on water quality and designated uses.

ES.5 Regulatory Options for Falls Lake

Section 5 of this TM provides an overview of the regulatory options for Falls Lake including a discussion of Use Attainability Analyses, variances, and site-specific criteria. The options are described in relation to the State and Federal laws, Falls Lake designated uses, water quality criteria, existing water quality impairments, the Falls Lake Nutrient Management Strategy, and the Consensus Principles. A discussion of the applicability of each option and examples of its use elsewhere in the country are provided. The section provides a foundation for the recommended path forward that is described in Section 6.

ES.6 Recommendations for the Re-examination of the Stage II Rules

Cardno ENTRIX and Barnes and Thornburg have developed a set of recommendations for the UNRBA in moving forward with the re-examination of the Stage II rules. These recommendations include a multi-part process including monitoring, modeling, and regulatory actions for moving forward with the re-examination of the Stage II rules. The following recommendations are presented briefly below with more detailed information provided in Section 6:

- > Conduct monitoring studies for a minimum of four to five years (the rules require a minimum of three years) to support revised lake response modeling (tributary load estimation, inflake water quality, and inflake processes) and support the regulatory options. These studies are needed to support the re-examination process described below. Full monitoring years are anticipated as 2014 through 2017, and monitoring may continue into 2018 depending on weather patterns or unforeseen events. These monitoring studies are discussed in detail in the Task 4 TM and are summarized in Section 6.1 of this memorandum.
- > In the near term, immediate regulatory relief may be sought through the legislative or administrative process (Section 6.2). For example, the UNRBA may petition NCDWQ to delay implementation of the Stage I rules until a more complete set of nutrient reduction accounting procedures are in place. Additionally, the UNRBA may want to press NCDWQ to account for delivery factors in the estimation of nutrient loading to the lake. This would likely reduce the implementation costs for nutrient load reductions by accounting for fate and transport in the watershed. These options should be pursued in 2013.

Part 1 of the re-examination process is to revise and recalibrate the lake response modeling following data collection, and use the recalibrated model to estimate the nutrient loading reductions needed to comply with the chlorophyll *a* standard throughout the lake (Section 6.3). This part of the process is required by the Falls Lake Nutrient Management Strategy and is an integral component of the overall

plan. After this analysis, the preliminary screening factor for the fiscal impact of pollution control should be recalculated to determine if the impact is little, mid-range, or large.

Part 1 requires collection of data to support tributary load estimation, lake water quality, and lake processes to revise the lake nutrient response modeling and recalculate the nutrient reduction targets. Model revisions and recalculation of loading targets may occur in 2018 depending on the duration of the monitoring period, which may need to be extended if abnormal weather patterns occur. Cardno ENTRIX recommends preliminary model updates following the first one or two years of monitoring to provide planning level results. The results of the modeling will be used to reassess the technical and financial feasibility of the revised load allocations and provide the modeling platform for the other parts of the re-examination process.

Part 2 of the re-examination process is to petition NCDWQ to develop a new designated use category that would represent the existing functions of the upper lake (recreational use, aquatic life use, water supply protection) recognizing the limitations imposed by the authorized purposes of the lake as a Corps of Engineers project (i.e. flood protection) (Section 6.4). This is a two-step process. The first step is the creation of the new sub-category of the Class C use. The second step is to change the use classification for the Upper Lake from its current classification to the newly created sub-classification. That change will require a sub-classification use attainability analysis (SC-UAA) which is not a removal of a designated use and will still maintain the fishable, swimmable classification of the lake. This option will use the data and revised lake nutrient response modeling conducted for Part 1. Collection of additional supporting data to demonstrate that the lake is meeting the existing and revised designated uses should occur simultaneously with the other monitoring studies (2013 through 2017). In addition to the revised lake nutrient response model, a supporting empirical lake model (Cardno ENTRIX 2013b) should be used to ensure that the water quality in the Lower Lake is protected as a drinking water supply. In addition, modeling may be needed to demonstrate that the chlorophyll *a* levels are not achievable due to either natural conditions or hydrologic modification, if either or both of these justifications are used for the SC-UAA. If the SC-UAA is to be justified based on economic and social impacts, then an economic analysis must be performed. Part 2 may be controversial because it entails a permanent change in the designated use of the upper lake.

Part 3 of the re-examination process is development of a site specific chlorophyll *a* criterion for the upper lake. This part of the overall plan requires the same data sets and models used for parts 1 and 2 with additional analyses to determine the site-specific chlorophyll *a* criteria for the upper lake that continues to meet the aquatic life, recreation, and water supply designated uses. Demonstration that a site-specific chlorophyll *a* criterion in the upper lake continues to protect the existing use classifications for the Upper Lake and drinking water supply use in the Lower Lake will be required. If the future monitoring studies demonstrate that the lake is meeting its designated uses (as appears the case based on existing biological indicators), a site specific criteria based on current conditions may be a favorable option to all parties.

It is likely that the revised lake nutrient response model will still result in nutrient load allocations that are financially burdensome to the regulated community and beyond the limits of technology. Development, approval, and regulatory change associated with an SC-UAA or a site-specific chlorophyll *a* criteria may take several years in addition to the monitoring and modeling studies that are required for the process. While these more permanent paths are being considered, the UNRBA may need to apply for a variance (**Part 4**). The State's fiscal analysis (NCDWQ 2010) states repeatedly that "We expect more cost-effective measures than structural stormwater BMP retrofits to emerge even during the course of Stage I" and that "one reason to expect that more cost-effective solutions will emerge is that both this rule and federal regulatory changes will drive innovation to address loading contributions from existing developed lands." If new technologies do not emerge over the next seven years and the re-examination process cannot be completed before implementation of Stage II begins in 2021, a variance would allow for

additional time to complete the process. While this would not be a permanent solution, and would likely need to be reissued periodically, it would provide financial relief to the local governments. A variance must be supported by the same types of analyses that support a SC-UAA. This part of the plan is less controversial than the SC-UAA or site specific criteria because variances are temporary and do not involve permanent changes in designated uses or criteria.

The current schedule described in the Falls Lake Nutrient Management Strategy provides little time to conduct the necessary monitoring and modeling studies, analyses, negotiations, and regulatory changes that are required of the re-examination process. Figure ES-6 illustrates the recommended schedule for this process which includes seeking immediate regulatory relief, conducting monitoring studies, revising the lake modeling, and exploring each part of the re-examination process concurrently.

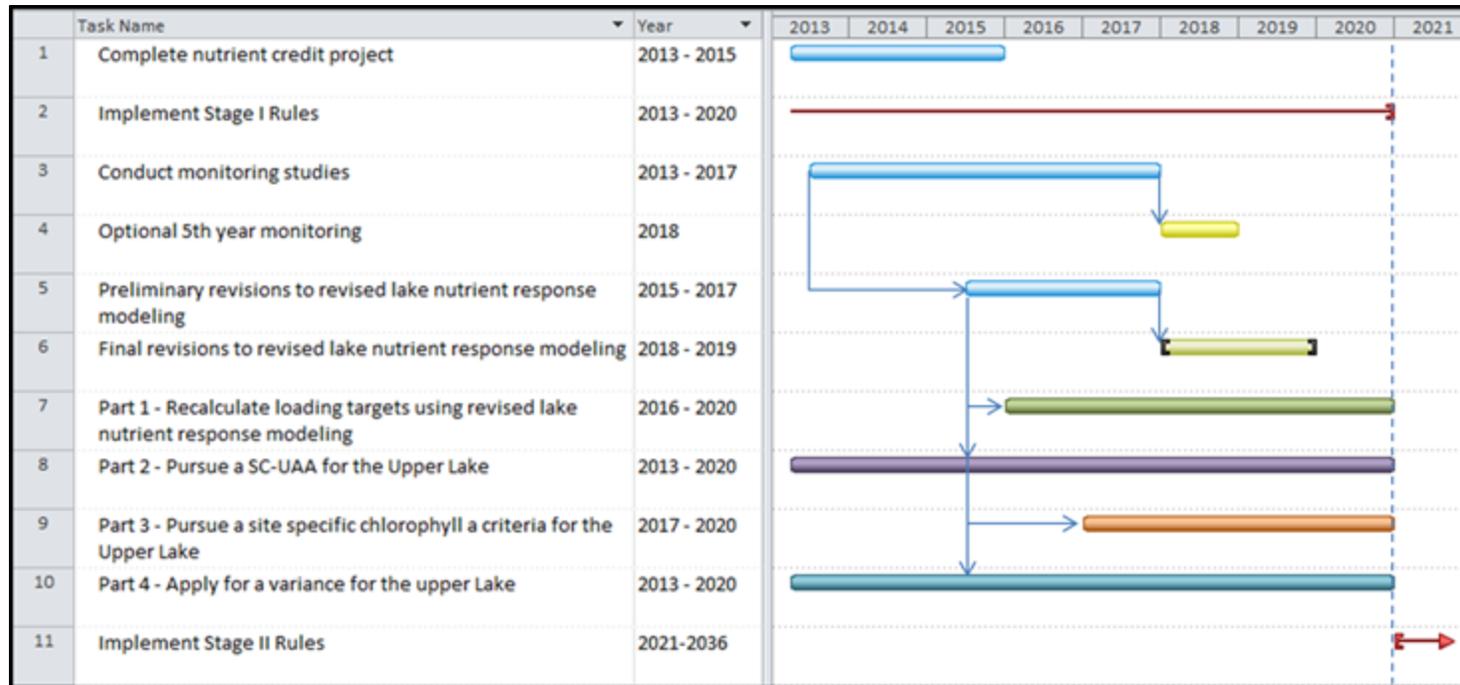


Figure ES-6 Potential Schedule for the Re-examination of Stage II

ES. 7 Conclusions

The Falls Lake Nutrient Management Strategy presents technical and financial challenges to the regulated community in the watershed. While the State estimated that Stage II of the Strategy would cost approximately \$945 million to implement, a review of the analysis (Section 3) indicates that these expenditures are not likely to achieve the Stage II nitrogen or phosphorus reductions. Achieving the nitrogen reductions from the upper watershed would require 1) treating every acre of existing development (which is not technically feasible) 2) use of a limited set of BMPs, and 3) installation of approximately 1,000 BMPs each year (which is not logistically feasible). The Stage II phosphorus reduction goals for existing development are beyond the limits of technology. In agricultural areas, the Stage II goals are not feasible for nitrogen or phosphorus given the assumption of one BMP type applied to pasture land only.

The Falls Lake Framework Tool provides an estimation of the monetary impact of the Stage II reductions on the designated uses of Falls Lake. Benefits to the lake from enhanced recreation and reduced chemical cost are approximately \$354 thousand per year, based on local information. The Tool compares simulated water quality to water quality criteria and categorizes the aquatic life use as “Not Impaired” based on current observations of biological indices. The current version of the Tool assumes there is no change to the flood control use. Implementation costs associated with these benefits are approximately \$67.5 million per year, or \$945 million total based on the NCDWQ (2010) fiscal analysis. Based on the Cardno ENTRIX review of the fiscal analysis, it is unlikely that these expenditures will achieve the Stage II reduction goals.

Given the high cost of implementing Stage II and the uncertainty with respect to the outcome, Cardno ENTRIX and Barnes and Thornburg recommend a multi-part process for moving forward with the re-examination process which includes four main components. The overall process relies on collection of additional monitoring and modeling studies to provide a scientific basis for the re-examination. These studies will support revised lake response modeling and support the various regulatory options that comprise the overall plan for the re-examination process.

Under the current schedule for the Falls Lake Nutrient Management Strategy, the UNRBA has less than eight years to move through the re-examination process. The Consensus Principles require a minimum of three years of data collection followed by revised modeling studies to provide a basis for altering Stage II of the rules. The UNRBA Path Forward Committee has recommended at least four years of monitoring to incorporate variations in weather and environmental conditions, with an optional fifth year as needed. Following monitoring, modeling studies may take one to two years to complete and negotiations with State and Federal agencies may take several years. Cardno ENTRIX recommends that the UNRBA conduct preliminary updates to the lake nutrient response modeling and begin exploring each part of the re-examination process as soon as appropriate for each part of the process. In addition, Cardno ENTRIX recommends that the UNRBA petition the State for a delay in the implementation of the Strategy to allow more time for 1) the re-examination process and 2) development of credits for additional BMPs that may be useful for the Stage I and Stage II local programs.

The re-examination process is likely to cost somewhere between \$5 million to \$10 million in monitoring, modeling, negotiation, and potential litigation costs. Relative to the Stage II implementation costs that are estimated to cost approximately \$67.5 million per year beginning in 2021, the costs of moving forward with the re-examination process is relatively small.