Preliminary Lower Catawba Nutrient TMDLs: Modeling Results

April 2016

Background

Phosphorus and nitrogen are essential nutrients for aquatic life. In surface waters, they control algal growth, typically measured by chlorophyll-*a*. Excessive nutrient levels can lead to water quality problems such as algal blooms, hypoxia (low dissolved oxygen), and elevated pH.

Within the Catawba River Basin of South Carolina (SC), the following reservoirs are impaired as a result of excessive nutrients (phosphorus and nitrogen) and/or microscopic algal growth (chlorophyll-*a*):

- Cedar Creek Reservoir
- Fishing Creek Reservoir
- Great Falls Reservoir
- Lake Wateree Reservoir

More than 30 ambient monitoring locations within the Catawba reservoir system are currently included on the state's 2014 303 (d) List of Impaired Waters (the most recent biennial list submitted to and approved by the EPA).

Many of these monitoring locations have also been included on the 303(d) list for total phosphorus, total nitrogen or chlorophyll-*a* since SC adopted water quality standards for these pollutants in 2001.

Elevated pH has also been observed at monitoring locations within the system. Long-term monitoring data have demonstrated these conditions existed prior to 2001, although more recent data are demonstrating some improvement as nutrient reductions have been implemented by utilities upstream of the impaired reservoirs.

In accordance with the Clean Water Act and 40 CFR Part 130, Total Maximum Daily Loads (TMDLs) are required to address impaired locations included on a state's 303(d) list. South Carolina is developing TMDLs to address these impairments in the Lower Catawba River Basin.

Once these TMDLs are implemented through permits and voluntary measures, the reservoir system should continue to respond and, over time, achieve the water quality standards as outlined in Regulation 61-68, SC's Water Classifications & Standards.

Water Quality Standards

During each biennial 303(d) listing cycle, ambient data collected at each monitoring location in the Catawba system are assessed against these water quality criteria to evaluate the impairment status.

South Carolina R. 61-68 E.11.a-e. includes narrative and numeric criteria that are applicable to lakes/reservoirs. Eco-regional-based numeric criteria are only applicable for all SC lakes greater than 40 acres in surface area. For each of the four reservoirs in the Catawba system in SC, which is located completely within the piedmont ecoregion, the applicable nutrient criteria targets for aquatic life use are a total phosphorus concentration of 0.06 mg/l, a total nitrogen concentration of 1.5 mg/l and a Chlorophyll-*a* concentration of 40 μg/l.

As the Catawba River Basin headwaters and contributing waters extend well upstream of the four SC reservoirs and into North Carolina (NC), it is also important to consider relevant NC water quality standards as nutrient levels are evaluated in the system as a whole. As outlined in Title 15A of the NCAC subchapter 02B, NC currently has a numeric Chlorophyll-a criterion of 40 μg/l applicable for aquatic life use in freshwater lakes/reservoirs greater than 10 acres. In addition, NC may designate "nutrient sensitive waters" in specific cases; there are currently no nutrient sensitive waters in the NC Catawba River Basin.

Reservoirs and Nutrient Loading

The reservoirs, shown in Figure 1, (Fishing Creek Reservoir, Great Falls Reservoir, Cedar Creek Reservoir, and Lake Wateree) are downstream of the large and fast growing Charlotte-Rock Hill metropolitan area and more than a dozen major wastewater treatment facilities. In 1999 SCDHEC determined that a reduction in phosphorus loading to the basin was necessary to protect water quality. SCDHEC began imposing total phosphorus limits on SC industrial facilities with phosphorus in their effluent and larger SC domestic wastewater treatment facilities. Since then, phosphorus loads have been held constant even as facilities have expanded. So that for example, Rock Hill Manchester Creek WWTP (SC0020443) currently is permitted to discharge TP at 56.8 kg/day (125 lbs/day) as a 12-month running average. This load is based on the previous flow of 15 mgd; though the facility is now at a design flow of 20 mgd.

Considerable progress has been made in reducing phosphorus loading and in lake phosphorus concentrations since 1999. The average loading of phosphorus to Fishing Creek Reservoir (FCR) for 1998-1999 from the major point sources was 1121 kg/day. The load from these sources had declined to 359 kg/day for 2011-10/2012, a decrease of 68 %. Monthly total phosphorus loads, summed by state, as reported by the dischargers are shown in Figure 2. This decline came about primarily through implementation of phosphorus treatment by wastewater facilities and also the loss of two industrial facilities in SC (Hoechst-Celanese and Springs Industries) that had a total permitted load of 50.5 kg/day and perhaps other factors. The single most significant change was the installation and operation of phosphorus treatment at Charlotte Water's (Formerly Charlotte-Mecklenburg Utilities and CMUD) McAlpine Creek WWTP, which decreased its load from 452 kg/day (2002-2003) to 94.7 kg/day (2007-2008), a decline of 79%, as the result of updated permits.

This substantial decrease in phosphorus loading from these point sources has resulted in lower concentrations of total phosphorus in all of the reservoirs. Figure 3 shows this as a plot of the 5-year running 75th percentile TP concentration and Figure 4 shows the 5-year running 90th percentile TP concentration. The percentiles are calculated for the 5-year period ending in the year on the x-axis. For example, the period 1998-2002 was used to calculate the percentiles for 2002. The 75th and 90th percentiles were chosen because they are comparable to the assessment methodology that SCDHEC uses to evaluate water quality data for 303(d) purposes. The 75th percentile is analogous to the threshold used to list a lake due to nutrient impairment for the 303(d) list. The 90th percentile is analogous to a threshold used to determine if a waterbody is threatened or beginning to demonstrate elevated nutrient levels.

Figure 1 is a map of the lower Catawba lakes that shows the locations of the long term water quality monitoring sites displayed in Figures 3, 4, 7, and 8.

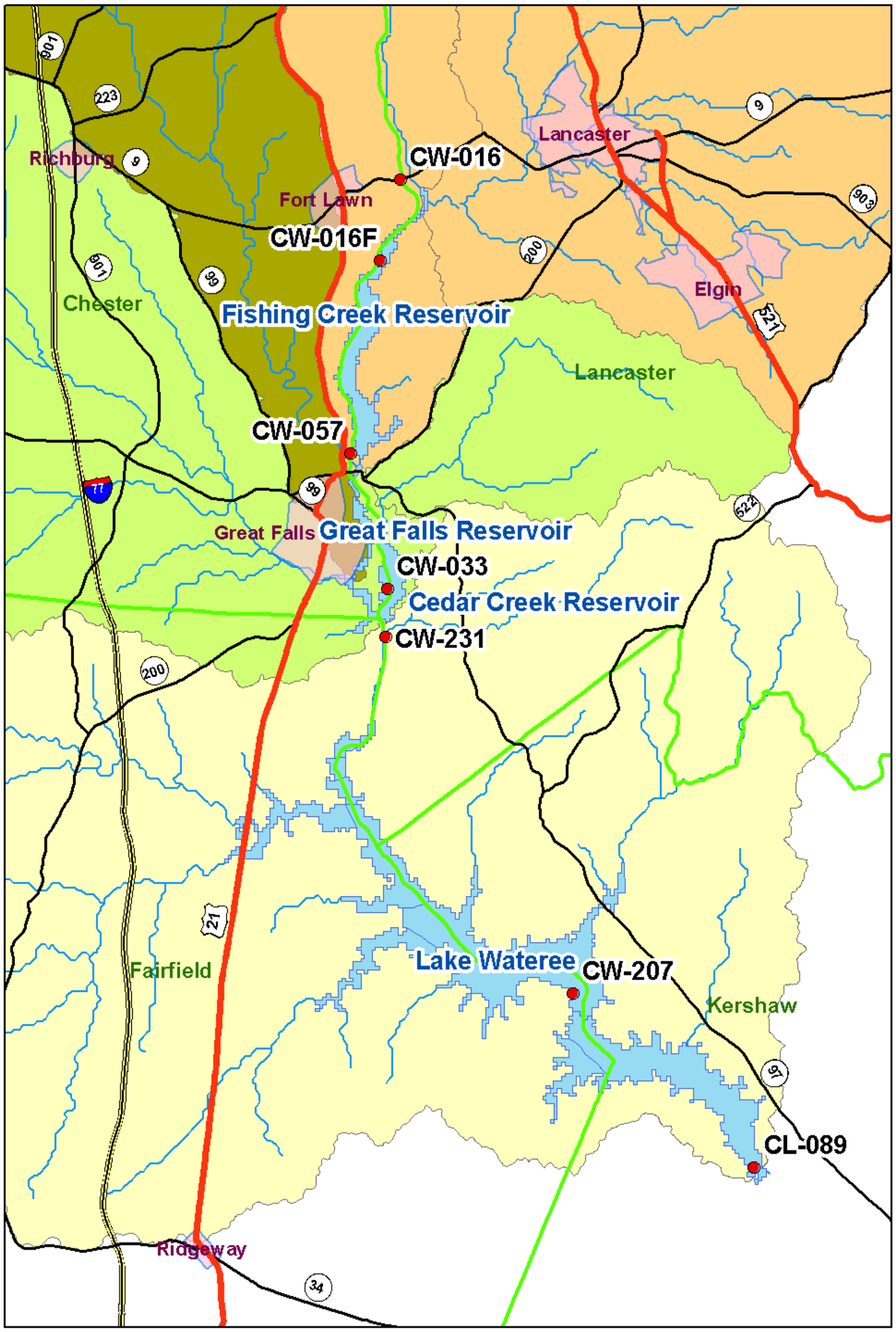


Figure 1. Map of the lower Catawba Basin lakes with long term nutrient impaired SCDHEC water quality monitoring sites.

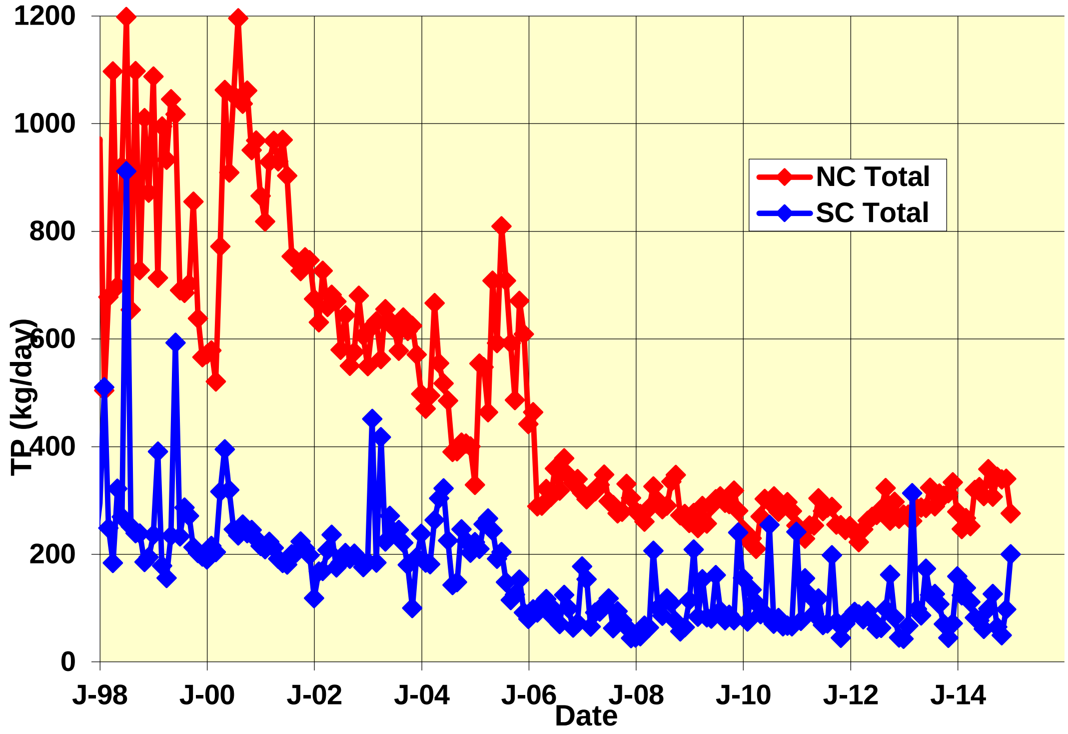


Figure 2a. Monthly phosphorus loads to Fishing Creek Reservoir from major point sources by state.

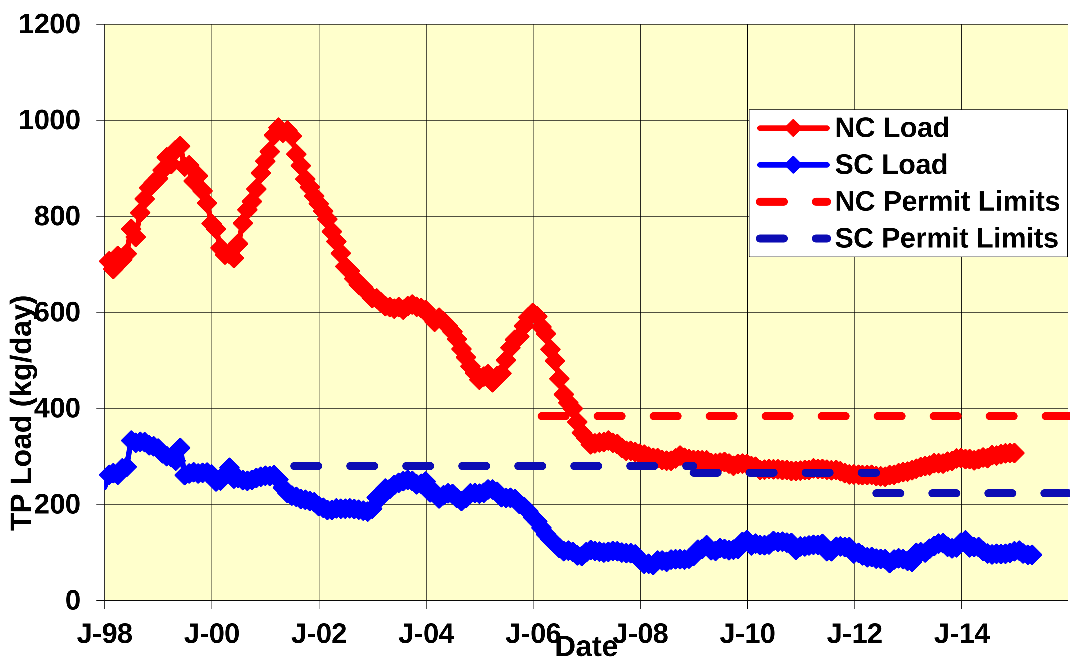


Figure 2b. 12-Month running average phosphorus loads to Fishing Creek Reservoir from major point sources with total permitted load limit by state.

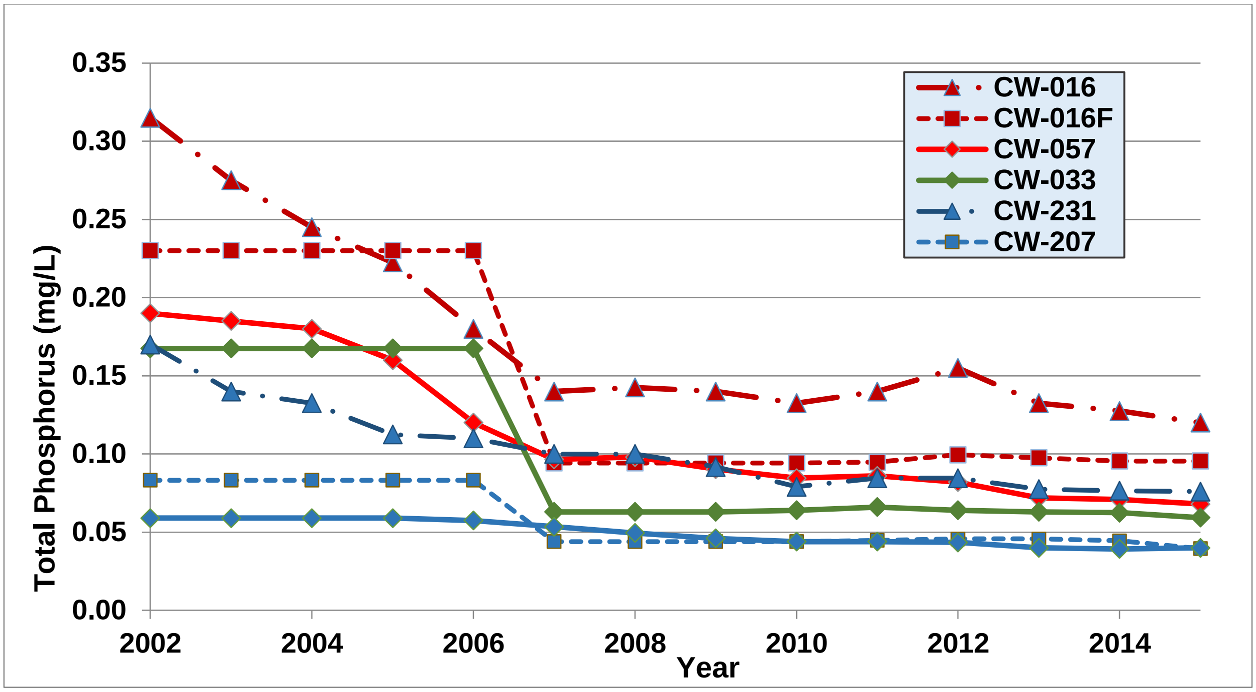


Figure 3. 5-Year running 75th percentile Total Phosphorus concentrations in the Lower Catawba Reservoirs. Diamonds and solids lines are lower lake stations; triangles and dotted lines are upper lake stations; remaining station (CW-207) is mid-lake Lake Wateree.

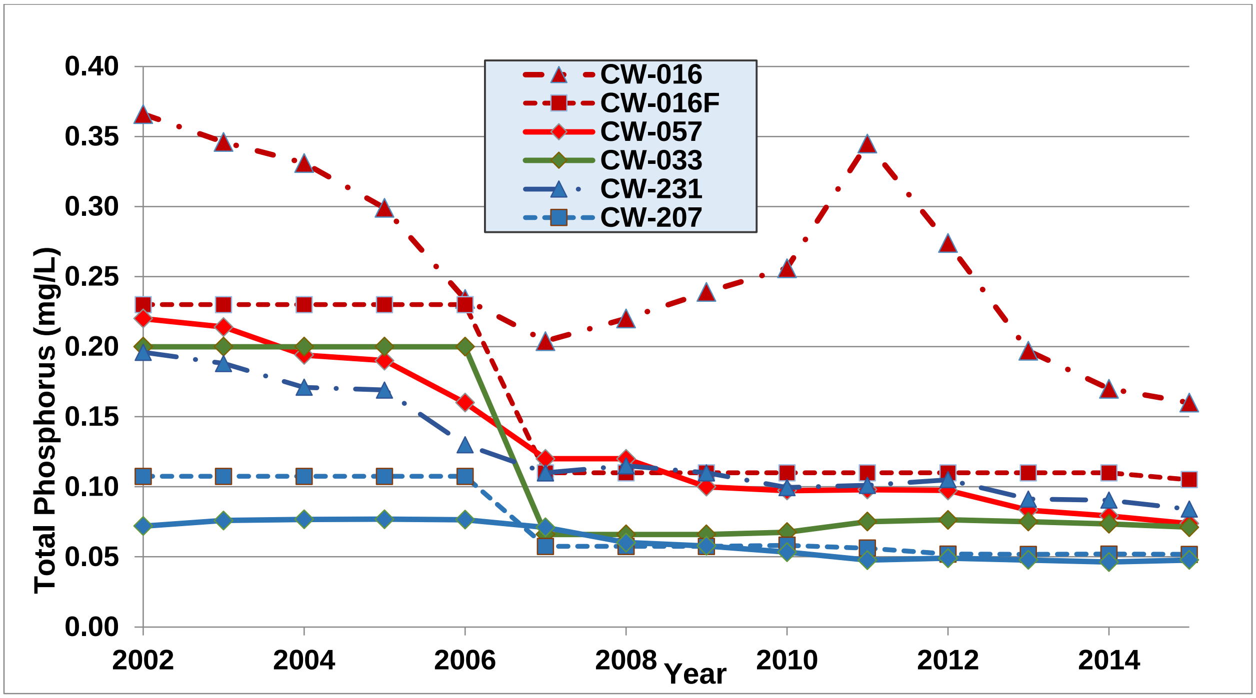


Figure 4. 5-Year running 90th percentile total phosphorus concentrations in the lower Catawba reservoirs. Diamonds and solids lines are lower lake stations; triangles and dotted lines are upper lake stations; remaining station (CW-207) is mid-lake Lake Wateree.

Unlike phosphorus however, the nitrogen load to the Catawba Basin from major domestic wastewater point sources has been increasing (Figure 5). Nitrogen loading has been much more variable for the SC industrial source. The NPDES permits for many facilities that discharge wastewater have numerical limits for ammonia; none currently limit nitrate or total nitrogen. For most domestic wastewater facilities nitrate is predominant form of nitrogen in their wastewater. Some evidence suggests that the focus by domestic wastewater treatment facilities on reducing phosphorus in their effluent has contributed to increase in nitrogen in their effluent as a trade-off for the lower phosphorus.

As nitrogen loads have increased, total nitrogen (TN) concentrations in the Catawba reservoirs have been increasing (Figures 6 and 7). These 5-year running 75th and 90th percentile plots show a gradual increase in the TN concentration for most locations. As in the case of decreasing TP trends the upward TN trends are more obvious in Fishing Creek Reservoir. The percentiles are calculated for the 5-year period ending in the year on the x-axis. The 75th and 90th percentiles were chosen because they are comparable to the assessment methodology that SCDHEC uses to evaluate water quality data for 303(d) purposes. The 75th percentile is analogous to the threshold used to list a lake due to nutrient impairment for the 303(d) list. The 90th percentile is analogous to a threshold used to determine if a waterbody is threatened or beginning to demonstrate elevated nutrient levels.

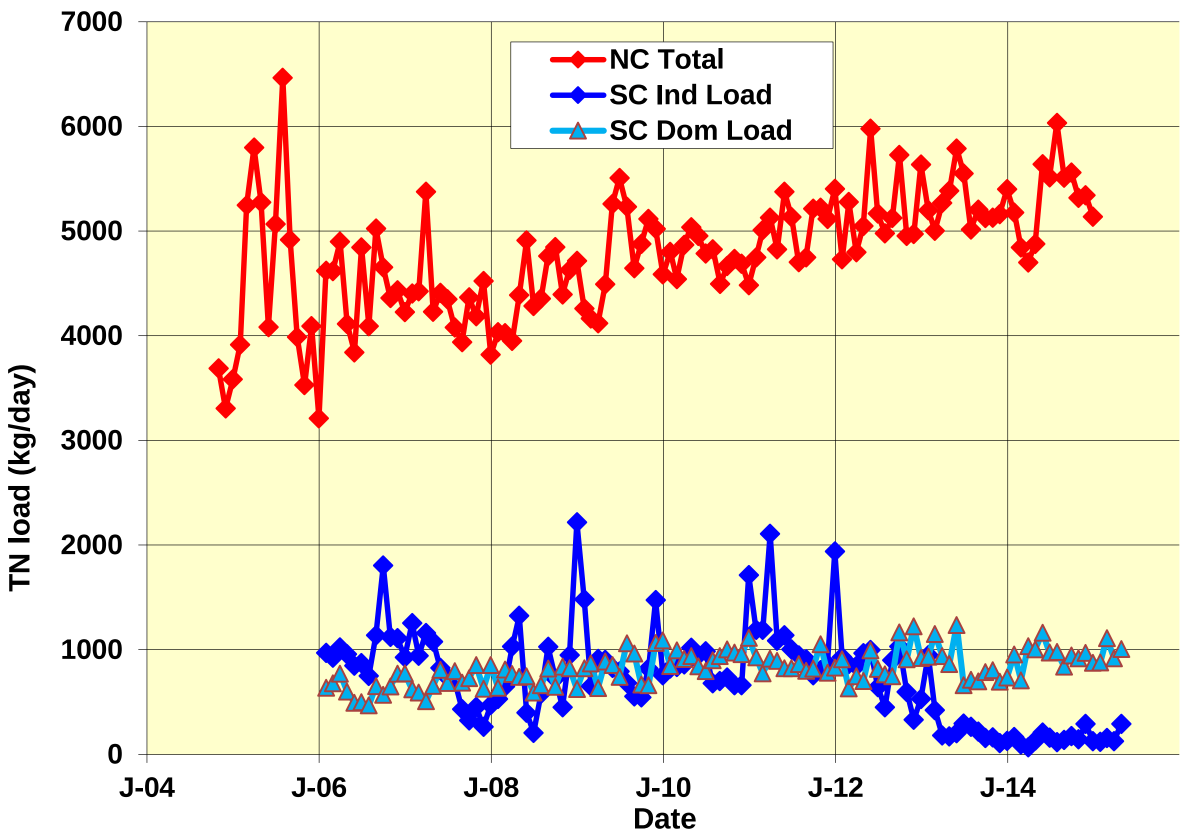


Figure 5a. Monthly nitrogen loads to Fishing Creek Reservoir from major point sources by state. SC load is broken down by industrial and domestic WWTP type.

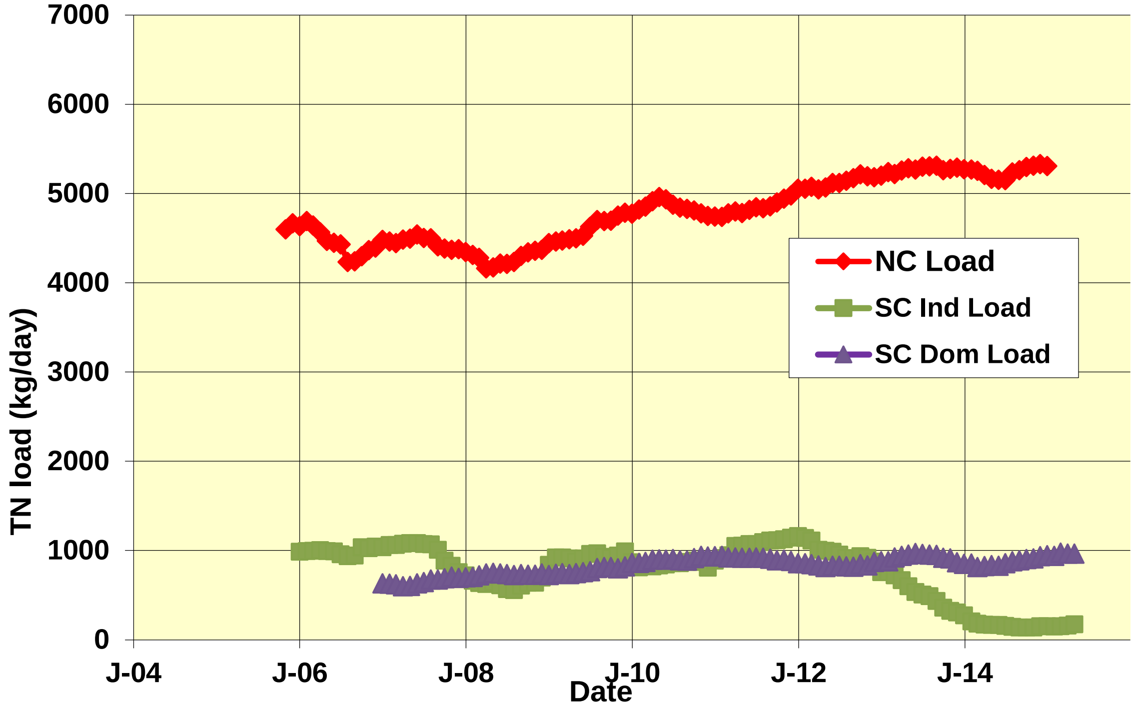


Figure 5b. 12-Month running average total nitrogen loads to Fishing Creek Reservoir from major point sources by state. SC load is broken down by industrial and domestic WWTP type.

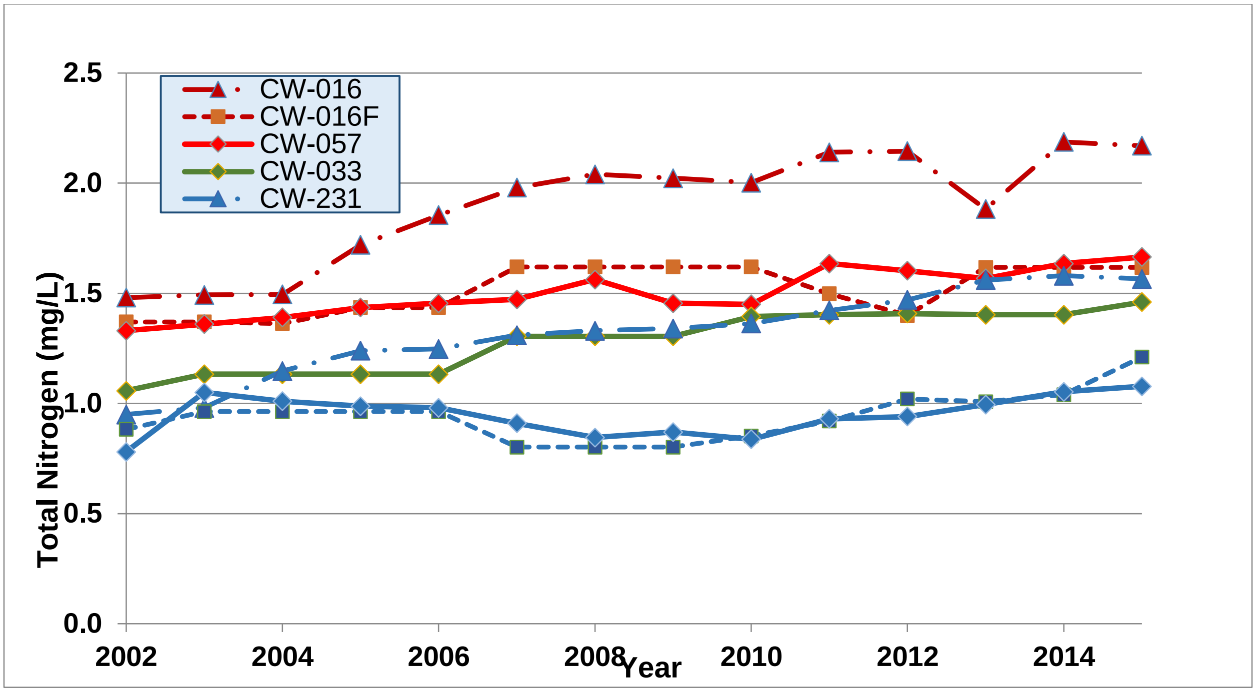


Figure 6. 5-Year running 75th percentile total nitrogen concentrations in the Lower Catawba Reservoirs. Diamonds and solids lines are lower lake stations; triangles and dotted lines are upper lake stations; remaining station (CW-207) is mid-lake Lake Wateree.

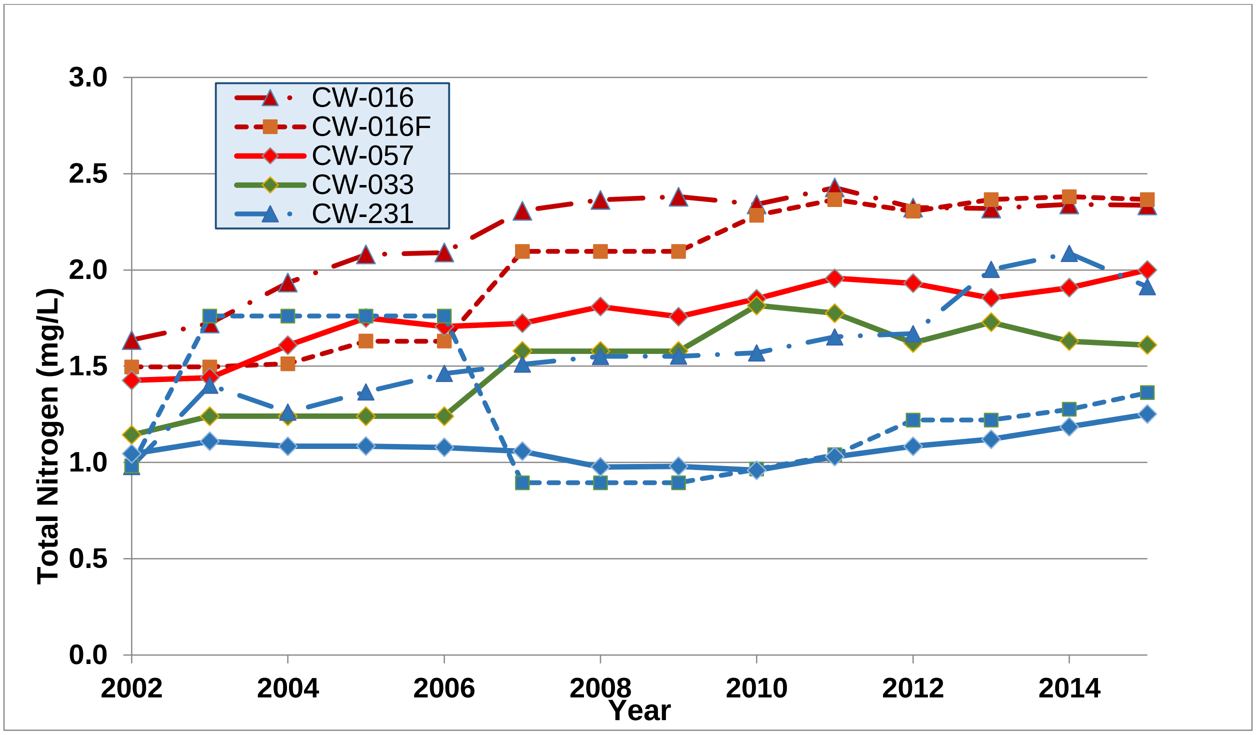


Figure 7. 5-Year running 90th percentile total nitrogen concentrations in the lower Catawba reservoirs. Diamonds and solids lines are lower lake stations; triangles and dotted lines are upper lake stations; remaining station (CW-207) is mid-lake Lake Wateree.

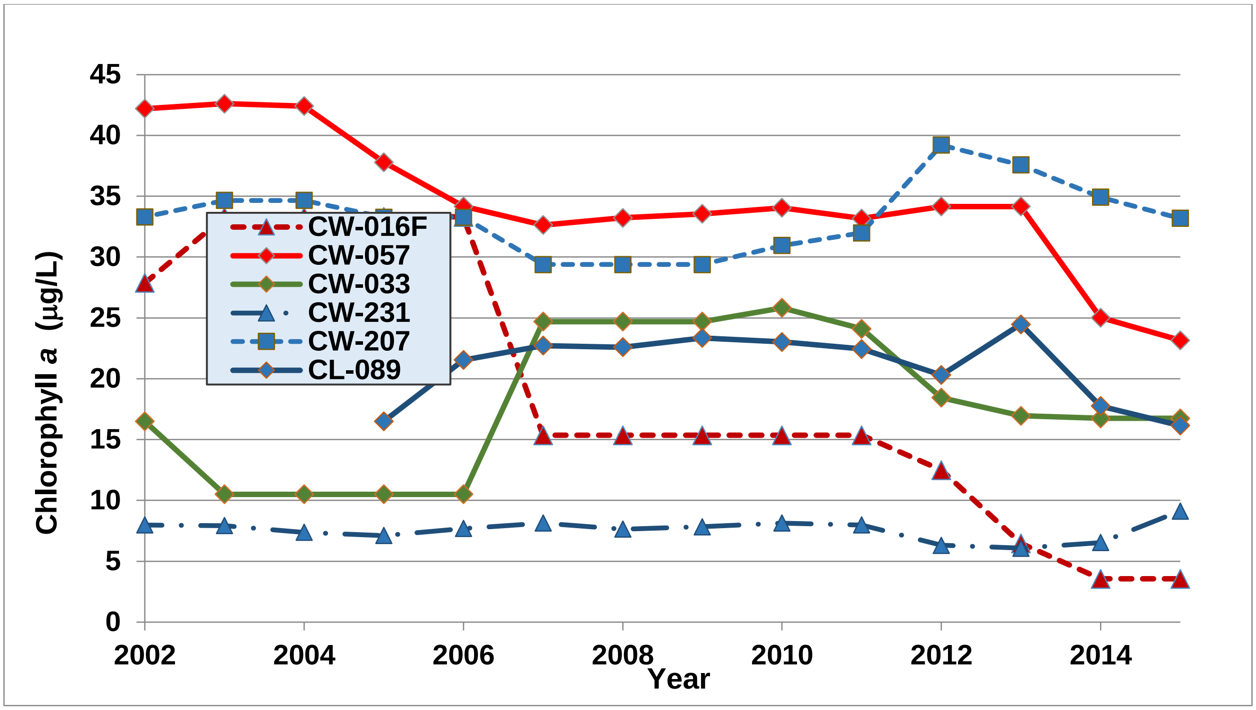


Figure 8. 5-Year running 75th percentile chlorophyll-*a* concentrations in the Lower Catawba Reservoirs. Diamonds and solids lines are lower lake stations; triangles and dotted lines are upper lake stations; remaining station (CW-207) is mid-lake Lake Wateree.

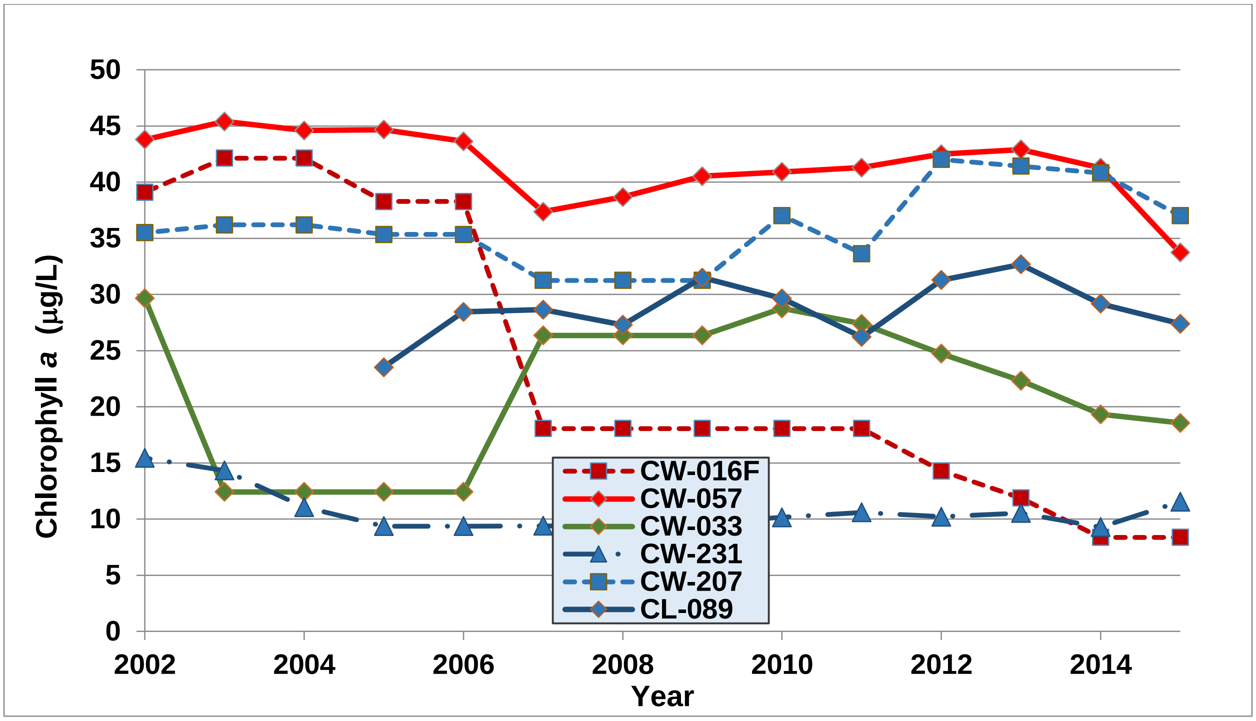


Figure 9. 5-Year running 90th percentile chlorophyll-*a* concentrations in the Lower Catawba Reservoirs. Diamonds and solids lines are lower lake stations; triangles and dotted lines are upper lake stations; remaining station (CW-207) is mid-lake Lake Wateree.

Despite the previous reductions in phosphorus loading to the Catawba, additional reductions are needed to achieve the 0.06 mg/l TP water quality target. Although Figures 3 and 4 showed a significant decline in TP concentrations, the 75th and 90th percentile TP concentrations for all but the two lower sites on Lake Wateree still exceed 0.06 mg/l in the lake in 2015. The 75th percentile TN concentration has been above the 1.5 mg/l water quality target most years since 2007 for both CW-016F and CW-057 in Fishing Creek Reservoir.

Fishing Creek Reservoir, Great Falls Reservoir, Cedar Creek Reservoir, and CW-231, the upper station on Lake Wateree, continue to be impaired due to TP. Fishing Creek, Great Falls, and Cedar Creek Reservoirs are impaired due excessive TN. Lake Wateree has a recent impairment due to chlorophyll-a and Fishing Creek Reservoir has a legacy site that remains on the 303(d) list. Fishing Creek and Cedar Creek Reservoirs, and Lake Wateree are impaired for pH, while Great Falls and Cedar Creek Reservoirs, and Lake Wateree are impaired for DO. These DO and pH impairments are probably due to nutrient enrichment. Tables 1, 2, and 3 illustrate the change in impairments and percentage of samples exceeding each standard by assessment period. These tables list only stations with long term data. Each of the lakes has been sampled at least one random monitoring site (random monitoring sites are generally sampled monthly for one year only). In addition, Cedar Creek Reservoir and Lake Wateree have each been sampled at two other stations that are sampled infrequently. Great Falls Reservoir has no permanent water quality monitoring sites but is and has been represented on previous 303(d) list by historical random monitoring stations. A map of all sites (current and legacy) included on the 2014 303(d) List related to nutrients is included as Appendix A, and a table of monitoring data is included as Appendix B.

Sites with more than 25% exceedance of nutrient standards are automatically placed on the 303(d) List as not supporting designated uses. In accordance with South Carolina's 303(d) listing methodology, sites with more than 10% and up to 25% exceedance are discretionary and may be considered impaired depending on site-specific factors. Sites with less than 10% exceedance are considered fully supporting. The modeling target for the reduction scenarios was less than 10% exceedance.

Table 1 shows TP impairments and percentage of samples exceeding the 0.06 mg/l standard for each 5-year assessment period. CW-016 is at the upper end of the lake and is not considered a lake station. The percentages of samples exceeding 0.06 mg/l TP has declined at all sites. It remains above the 25% exceedance threshold for sites upstream of CW-207 on Lake Wateree. These sites are likely to remain on the 2016 303(d) list due to excessive TP as well.

Table 2 shows the shows TN impairments and percentage of samples exceeding the 1.5 mg/l standard for each 5-year assessment period. CW-016 is at the upper end of the lake and, for assessment purposes, is considered riverine and therefore is not evaluated as a lake or reservoir. The percentages of samples exceeding the TN standard has generally increased at all sites upstream of CW-207 on Lake Wateree. Fishing Creek, Great Falls, and Cedar Creek Reservoirs are all considered impaired due to TN and included on the 2014 303(d) list. Results of the WARMF model simulation indicate that the simulated chlorophyll response is not affected by nitrogen constituents (ammonia, nitrate, and organic nitrogen) so that reducing TN in the system is not predicted to lower chlorophyll-a levels in the lakes.

Table 3 shows the chlorophyll-*a* impairments and percentage of samples exceeding the 40 μg/l standard for each 5-year assessment period. Chlorophyll-*a*, which is the response variable to the nutrients, does not follow the patterns of either TN or TP. Various factors influence the percentage of samples exceeding the standards. The upper three reservoirs have limited storage and short retention times, which does not provide algae (represented by Chlorophyll-*a*) with an opportunity to take up the nutrients and grow except in the low flow times as in the 1998-2002 drought years. Another factor may be the reduction in sampling, such that since 2010 many sites have only one or two samples a year.

Table 1. Percentage of samples for total phosphorus from long term stations that exceeded the standard by 303(d) assessment period. High-lighted cells were on 303(d) list.

303(d) Year	Assessment Period	Fishing Creek Reservoir			Cedar Creek Res	Lake Wateree		
		CW-016 *	CW-016F	CW-057	CW-033	CW-231	CW-207	CL-089
		Percent						
2004	1998 - 2002	96%	100%	100%	100%	88%	75%	16%
2006	2000 - 2004	78%	100%	92%	100%	78%	75%	19%
2008	2002 - 2006	77%	100%	84%	100%	81%	75%	21%
2010	2004 - 2008	82%	60%	75%	42%	80%	8%	11%
2012	2006 - 2010	85%	71%	56%	47%	65%	6%	6%
2014	2008 - 2012	85%	82%	62%	41%	67%	0%	5%
2016**	2010 - 2014	81%	77%	58%	31%	59%	4%	3%

* Note: CW-016 is not considered as a lake station.
** Note: 2016 assessments are draft until approved by EPA.

Table 2. Percentage of samples for total nitrogen from long term stations that exceeded the standard by 303(d) assessment period. High-lighted cells were on 303(d) list.

303(d) Year	Assessment Period	Fishing Creek Reservoir			Cedar Creek Res	Lake Wateree		
		CW-016 *	CW-016F	CW-057	CW-033	CW-231	CW-207	CL-089
		Percent						
2004	1998 - 2002	17%	9%	5%	0%	0%	6%	0%
2006	2000 - 2004	23%	10%	14%	0%	8%	17%	0%
2008	2002 - 2006	39%	18%	20%	0%	9%	17%	0%
2010	2004 - 2008	47%	40%	28%	14%	14%	0%	0%
2012	2006 - 2010	50%	36%	22%	14%	20%	0%	2%
2014	2008 - 2012	55%	23%	29%	11%	24%	0%	3%
2016**	2010 - 2014	58%	32%	33%	12%	33%	0%	3%

* Note: CW-016 is not considered as a lake station.

** Note: 2016 assessments are draft until approved by EPA.

Table 3. Percentage of samples for chlorophyll-*a* from long term stations that exceeded the standard by 303(d) assessment period. High-lighted cells were on 303(d) list.

303(d) Year	Assessment Period	Fishing Creek Reservoir		Cedar Creek Res	Lake Wateree		
		CW-016F	CW-057	CW-033	CW-231	CW-207	CL-089
2004	1998 - 2002	14%	29%	0%	0%	0%	0%
2006	2000 - 2004	22%	27%	0%	0%	0%	0%
2008	2002 - 2006	20%	17%	0%	0%	0%	4%
2010	2004 - 2008	0%	11%	0%	0%	0%	3%
2012	2006 - 2010	0%	17%	0%	0%	14%	7%
2014	2008 - 2012	0%	24%	0%	0%	29%	5%
2016*	2010 - 2014	0%	17%	0%	0%	19%	0%

* Note: 2016 assessments are draft until approved by EPA.

WARMF Model

The Watershed Analysis Risk Management Framework or WARMF Model which had been developed to facilitate TMDLs was used to create a watershed model of the Catawba-Wateree Basin upstream of the Lake Wateree dam by the Electric Power Research Institute and Duke Power Company (now Duke Energy Company). Beginning about 1999, Hank McKellar and Dan Tufford of the University of South Carolina, using a 319 grant from SCDHEC, refined and calibrated the model for the lower Catawba Basin. Since then SCDHEC and NCDEQ, formerly NCDENR, have both updated and further refined parts of the model. From 2012 – 2014, SCDHEC with help from NCDEQ under took a major update of the model bringing it current to September 2012. This effort updated major point sources, meteorology stations, managed flow, and air quality sites. Land use was updated to NLCD 2006. Minor point sources, water quality stations, and flow gaging stations in the basin downstream of the Lake Wylie dam were also updated. Finally representative gaging and water quality stations in the upper basin were also updated. Calibration of the model for the lower basin was also performed by Systech Water Resources, Inc.

TMDL Module

The TMDL Module in the final WARMF model previously provided to stakeholders was not functional. The module had no Designated Uses or Criteria and would not allow new ones to be added. A subsequent module executable had a functional TMDL module for Windows 7, but did not work on Windows XP systems. More recently Systech provided a model executable includes a functional TMDL module for the Windows XP platform.

Method

Following the completion of the model update and calibration by Systech Water Resources, SCDHEC began to apply the model for its intended use to develop nutrient TMDLs. A scenario that had the currently active major point source inputs at their 2014 permit limits for relevant wastewater constituents was a necessary first step. Facilities that no longer discharged wastewater into the basin were removed from the model.

Current Permit Scenario

Point source input files (NPDES#_Permit.pts) were created for all active point sources in the lower Catawba Basin with phosphorus limits (15 files). These facilities are listed in Table 4 which shows their design or permitted flow, as of September 2014, and permitted phosphorus load. The three Charlotte point sources are discussed in more detail below. Nineteen minor facilities that do not have TP limits and the two very small facilities on Lake Wateree which have 0.06 mg/l TP limits are listed in Table 5. The point source input files for these facilities, which contribute less than 5 % of the point source phosphorus load, were unchanged.

The calibrated model included many point sources that became inactive just prior to or during the period covered by the calibrated model (10/01/2003 – 09/30/2012) that were removed for this and the TMDL scenarios. Most of these were discharging treated effluent during part of the calibration period; some of these had been significant sources of phosphorus such as Hoechst-Celanese (SC0001783) and Springs Grace Complex (SC0003255).

The permit condition model input files were populated with permitted values for flow, DO, BOD, ammonia, and TP. If the permit provided alternative seasonal limits, these were reflected in the point source model input files. No facility currently has TN or nitrate numeric limits, most monitor and report TN loads or concentrations. Nitrate loads were calculated from the average concentration and the design or permitted flow for the SC facilities. In the model, organic nitrogen is a percentage of organic carbon (8.0%). The four major NC point sources include organic carbon as an input. For these facilities the permit condition load was calculated from the input concentration and the permitted flow.

Each of the three Charlotte Water (formerly Charlotte-Mecklenburg Utilities or CMUD) facilities were represented in the model for the permit scenario as having their phosphorus load based on a 1 mg/l TP concentration and the design flow. Their current permit has a bubble limit for TP for all three, but no specified limit for the individual plants. Charlotte Water has operated since 2006 by using a high level of phosphorus treatment at the McAlpine Creek WWTP (NC0024970). The Irwin Creek (NC0024945) and Sugar Creek (NC0024937) facilities typically discharge effluent at 2 to 3 mg/l TP. Distributing the loads based on equal concentrations is more conservative than apportioning the load distribution based on the current effluent distribution. The permits allow Charlotte Water to distribute the phosphorus load among the three facilities as they choose so long as they meet the overall limit.

The permitted condition scenario was run for the calibration period (10/01/2003 – 09/30/2012). The results were used to calculate exceedance percentages and to calculate reference loads by source for each reservoir or reservoir segment.

Reduction from Permitted Load Scenarios

Because the TMDL module was not initially available, the first TMDL scenarios were run from the WARMF Engineering Module using modified point source input (PTS) files to make reductions in point source loading. The phosphorus load in one or more pts files would be reduced by a pre-determined amount to assess the effect of a given reduction in the phosphorus load. For example, new PTS files would be created from Permit Limit PTS files for the three Charlotte Water facilities with phosphorus loads reduced by 50%.

These initial scenarios showed that significant phosphorus load reductions from the major point sources on the order of 60 – 70 % from the permitted loads would allow Fishing Creek Reservoir to meet the TP target

When the TMDL Module became available, scenarios including reductions in the NPS load were possible. The TMDL Module allows the user to enter a multiplier for either the point or nonpoint sources and the model varies the other multiplier to attempt to attain the standard. (The multipliers may also be entered directly into the scenario control file (*.coe). Care must be used to ensure that values are entered in the correct columns.) The multipliers apply to all point or nonpoint sources equally. That is a model limitation for NPS, because any reduction strategy would apply only to controllable sources such as developed, pasture and cultivated land uses and loads from failing septic systems. To work around this problem, spreadsheets were created that calculated for each of the upper reservoirs (Not for Lake Wateree) an adjusted multipliers that takes into account the % of background or non-reducible NPS load to achieve a given percent reduction from the reducible or anthropogenic NPS load for each simulation period. For example a 40% reduction in the NPS TP load from the Fishing Creek sub-watershed for the 10/2003 – 9/2012 simulation period requires a multiplier of 0.77 (40 % of anthropogenic load of 96.2 kg/day = 38.48 which is 23% of the total NPS load or 1 – 0.23 = 0.77). All point source files were affected by these multipliers, not just the major point sources.

Existing Condition Scenario

The existing condition scenario was based on the calibrated scenario. Inactive point source input files were removed so that only active point sources remained, as in the permitted condition scenario. As for the permitted condition scenario there are 15 point sources with phosphorus limits (13 Majors and 2 Minors) (Table 4). For this scenario flows and loads are actual flows and loads from the calibrated model, which were based on Discharge Monitoring Reports (DMRs). Nineteen minor facilities that do not have TP limits and the two very small facilities on Lake Wateree which have 0.06 mg/l TP limits are

Table 4. Lower Catawba River Basin Major NPDES Discharger Design Flows and Phosphorus Limits for Permit Limit and TMDL Scenarios as of September 2014.

NPDES ID	Name	Design or Long Term Avg Flow		TP Limits		Comments
				Permit	Model	
		mgd	m^3/s	lbs/day	kg/day	
Fishing Creek Reservoir						
North Carolina						
NC0024937	CMUD-Sugar Crk WWTP	20	0.88	826	75.7	For the model individual limits based on TP of 1 mg/L were calculated for each WWTP.
NC0024945	CMUD-Irwin Crk WWTP	15	0.66		56.8	
NC0024970	CMUD-McAlpine Crk WWTP	64	2.80		242.2	
NC0085359	Union Cnty/ Twelvemile Crk WWTP	6	0.26	20.85	9.46	New permit allows expansion to 12 mgd. No change in TP limit.
South Carolina						
SC0001015	Resolute Forest Products	25	1.10	292	132	
SC0020371	Fort Mill WWTP	3	0.13	12.5	5.67	
SC0020443	Rock Hill WWTP	20	0.88	124.7	56.6	
SC0027146	Foxwood SD/Blue Ribbon Util	0.12	0.0053	1.0	0.454	
SC0030112	Lamplighter Village SD/CWS	0.63	0.028	10.5	4.76	
SC0046892	City of Lancaster WWTP	7.5	0.33	48.0	21.8	
SC0047864	Lancaster Cnty/Indianland WWTP	1.2	0.05	16.7	7.57	Permit allows expansion to 15 mgd. No change in TP limit.
Great Falls Reservoir						
SC0038156	York-Fishing Crk WWTP	2	0.09	17.0	7.71	Permit allows expansion to 4 mgd. No change in TP limit.
SC0001741	Chester-Lando/Manetta WWTP	0.8	0.04	4.14	1.88	Permit allows expansion to 1.2 mgd. No change in TP limit.
Cedar Creek Reservoir						
SC0036056	Chester-Rocky Crk WWTP	1.36	0.06	11.3	5.13	New permit rerated design flow as 1.6 mgd and allows expansion to 4 mgd. No change in TP limit.
SC0021211	Great Falls WWTP	1.4	0.06	12.0	5.44	
Lake Wateree						
None						
Total Flow & Phosphorus Load		**168**	**7.36**	**1397**	**634**	

listed in Table 5. The simulated flows and loads from this scenario are slightly smaller than for the calibration scenario, because the inactive point sources are not included in this scenario.

The existing condition analysis was focused on the 2007-2012 period rather than the entire modeling period. The phosphorus load to the basin was significantly larger in 2004 and 2005 and decreased substantially in 2006. Therefore, we chose to compare reductions to loading from the recent period 2007-2012. The model period 10/2003 – 12/2006 was run as a warm start scenario for the 1/2007 – 9/2012 period, which was used for the subsequent analyses.

Table 5. Active Minor Point Sources without Phosphorus Limits in Lower Catawba Basin Model for Permitted Scenario.

NPDES ID	Facility Name	Flow		PO_4 Load	
		(mgd)	(cms)	lbs/day	(kg/day)
Fishing Creek Reservoir					
North Carolina					
NC0028274	Shaw Industries	DMR Flow		None	
NC0056669	Industrial Fire Protection	DMR Flow		None	
NC0063789	Heater Utilities Inc - Mint Hill Festival WWTP	DMR Flow		None	
South Carolina					
SC0027189	Utilities SC - Shandon SD	DMR Flow		DMR Loads	
SC0028622	Quail Meadow Park	DMR Flow		DMR Loads	
SC0032417	Cedar Valley Mobile Home Park	DMR Flow		DMR Loads	
SC0035360	Nation Ford Chemical (R-M Industries)*	DMR Flow		None	
SC0038113	Util Services SC Carowoods SD	DMR Flow		None	
SC0041807	Rebound Behavorial Health	DMR Flow		DMR Loads	
Great Falls Reservoir					
SC0027111	McAfee Trailer Park	DMR Flow		DMR Loads	
SC0041670	Adnah Hills Mobile Home Park	DMR Flow		DMR Loads	
SC0039217	Util Services SC Country Oaks SD	DMR Flow		DMR Loads	
SC0027341	Jack Nelson Enterprises	DMR Flow		DMR Loads	
SC0042129	Kentucky-Cumberland Coal Co.	DMR Flow		None	
SC0047538	Carolawn, Inc NPL Site	DMR Flow		None	
SC0046248	Plains LPG Services LP (formerly Suburban Propane)	DMR Flow		None	
Cedar Creek Reservoir					
None					
Lake Wateree					
SC0035980	White Oak Conf Center	DMR Flow		DMR Loads	
SC0033651	Carolinas 7th Day Adventist-NOSOA *	DMR Flow		DMR Loads	
SC0044440	USAF Wateree Recreation *	DMR Flow		DMR Loads	

Reduction from Existing Load Scenarios

For these scenarios the TMDL module was used only to change the PS and NPS multipliers. Results of the reductions from Permit Loads were used to guide the selection of reductions to simulate. The reduction multipliers for TP are applied to PO4 in both PS and NPS inputs. The reduction multipliers for TN are applied to NH3, NO3, and Organic Carbon (In WARMF organic nitrogen is represented as a fixed percentage of organic carbon.) in both PS and NPS inputs.

As for the Permitted Condition scenarios the multipliers for NPS loads were adjusted so that the selected reduction percentage applied to the anthropogenic NPS sources: developed, pasture and cultivated land uses and loads from failing septic systems. For example a 40% reduction in the NPS TN load from the Fishing Creek sub-watershed requires a multiplier of 0.763 for the 1/2007 -9/2012 period. For the 10/2003 – 12/2006 warm start period the multiplier would be 0.753.

Guidelines for Load Reduction Scenarios

These guidelines were followed in developing and evaluating load reduction scenarios for the Catawba Basin. They are offered not as rules but as means but to clarify the process that was used to develop these results.

For these scenarios the goal is meeting the targets (TP $\leq$ 0.060, TN $\leq$ 1.50, chlorophyll-a $\leq$ 40.0) in 90 % of days during the simulation period.

Simulation period for the permit and reduction from permit scenarios was 1/1/2004 – 9/30/2012, which includes dry and average rainfall years, with a 3 month model spin-up period. The scenarios were also evaluated for each calendar year.

Simulation period for the existing and reduction from existing scenarios was 1/1/2007 – 9/30/2012, with a 'Warm Start' period of 10/01/2003 – 12/31/2006. Scenarios were evaluated for the 2007-12 period and each calendar year.

Anthropogenic phosphorus NPS Reduction limited to 40% where possible based on (1) preliminary runs indicating an equal 40% reduction from current actual loading from point and anthropogenic nonpoint sources would meet the target and (2) larger reductions were believed to have less assurance of achievement.

Attempt to maintain consistency in reduction percentages among reservoirs.

Target attainment assessed for the simulation period using Excel Spreadsheet not WARMF Designated Use/Criterion.

Assessment is made on surface layer of each reservoir.

Reduction percentages presented for phosphorus are from (1) permitted loads and (2) existing or actual loads.

Reduction percentages presented for nitrogen are from (1) ramped up loads based on historical concentrations and permitted flows and (2) existing or actual loads.

Chlorophyll-*a* is assessed for the Growing Season, which is defined as May 1 – October31. Samples for chlorophyll-*a* are not typically collected during the winter.

The TMDL Module also proved to be useful to modify the multipliers for specific TMDL Reduction scenarios. One can change both PS and NPS multipliers with the TMDL Module, save the scenario file, and then run it in the Engineering Module.

Two approaches were identified for achieving the TN and the TP water quality targets in the lower Catawba Basin. In Approach 1 the goal was to determine the load that would just meet the targets in the surface layer of Fishing Creek Reservoir with additional reductions to meet the targets if possible in the lower reservoirs. Water quality assessments are generally based on surface water samples. For Approach 2, the goal was to determine the load in Fishing Creek Reservoir that also allows Great Falls Reservoir and the other downstream reservoir meet the targets with additional load reduction in each reservoir's drainage basin. That is the discharge from Fishing Creek Reservoir would also meet the target. This approach is necessary because 90% of the loads to reservoirs downstream of Fishing Creek Reservoir are from the upstream reservoir and the surface layer of the upstream reservoir may meet the target while the water passed downstream, which comes from the lower layers of the reservoir, does not meet the target.

WARMF simulates both the loss of phosphorus from the water column to the sediments and also the diffusion of phosphorus from the sediments back into the water column when the concentration of phosphate is higher in the sediment than in the water. In stream segments sediment scour and resuspension are simulated. Phosphorus loading to the Fishing Creek Reservoir from point sources declined by about 50% around the end of 2005 and has remained at about 400 kg/day since. The Catawba Model simulates surface TP concentrations adequately in the reservoir during the calibration period which includes both high and lower phosphorus loading. Fishing Creek Reservoir sediments during the calibration period include both higher and lower water column phosphorus levels. Despite limited profile data for the reservoirs, the model processes are adequately simulating total phosphorus throughout the water column of Fishing Creek Reservoir, which is indicated by the calibration of Great Falls Reservoir, which is essentially the outflow from Fishing Creek Reservoir.

For the scenarios presented in this document, phosphorus reductions and nitrogen reductions were performed separately. Scenarios that combined reductions for both phosphorus and nitrogen were also simulated. Results of combining the phosphorus and nitrogen reductions showed no difference in chlorophyll-*a* and a small difference in total nitrogen, compared to the phosphorus only reduction.

There was no significant difference in chlorophyll-*a* concentrations in the lakes between phosphorus only reductions and combined phosphorus and nitrogen reductions. For the combined reduction scenarios, the reductions for phosphorus and nitrogen were the same as the Approach 2 reductions from permit provided in this document.

There was a small but significant increase in the total nitrogen concentrations in the lakes for scenarios with combined phosphorus and nitrogen reductions compared to nitrogen reduction only scenarios. This increase in nitrogen appears to be greater when algal activity is higher.

Results and Discussion

Reductions from Permitted Flow and Permitted Load (TP) and Extrapolated Load (TN)

Tables 6 - 9 provide possible reductions and target exceedances for the two approaches from scenarios based on permitted flow, as of September 2014, and load for total phosphorus and permitted flow and load extrapolated to permitted flow for total nitrogen as described above. Figure 10 shows locations of model segment IDs in tables.

These scenarios are presented as examples of possible load reductions that achieve the appropriate targets in these impaired lakes. Though these loads may be useful in determining future TMDLs, actual allocations for source categories and individual sources are to be determined later.

Approach 1

The results for Approach 1 estimate that an overall reduction of 58% (PS: 62%; NPS: 40%) in the TP load to Fishing Creek Reservoir (FCR) would meet the TP target in the surface layer of the lake (Table 1). This scenario meets SC target of 40.0 µg/L for chlorophyll-*a* in the growing season. This level of reduction in FCR and similar in Great Falls and Cedar Creek Reservoir does not allow the TP target to be met in either of these two reservoirs or the upper segments of Lake Wateree. Over 90 % of the TP load to these reservoirs is from the upstream reservoir. It is not possible to reduce the load from their respective sub-watersheds enough to meet the target, without additional reductions in the load upstream of Fishing Creek Reservoir.

Reductions required to meet the TN target in the surface layer of the lake) in Fishing Creek Reservoir are smaller than for TP: overall 41% (PS: 43%; NPS: 19%). As was the case for this approach for TP, just meeting the target in Fishing Creek Reservoir does not allow the downstream reservoirs meet the TN target.

Pie charts showing the phosphorus loads to Fishing Creek Reservoir by source categories are provided in Figure 11 for the permitted flow and load scenario and in Figure 12 for the Approach 1 reduction from permit scenario. The percentage of the phosphorus load from point source load decreases from 61 % to 40 % respectively for the two scenarios according to the model.

Table 6. Phosphorus load reductions and resulting phosphorus and Chlorophyll-*a* exceedances for Approach 1.

Reservoir	Segment ID		Total Phosphorus Reduction from Permit Scenario (%)				Exceedance (%)		
			PS	NPS - Human	Reducibl e Load		TP *		Chlorophyll-*a* **
FCR	L1562		62%	40%	58%		10.0%		1.6%
GFR	L1563		57%	40%	47%		18.6%		0.0%
CCR	L1567		65%	40%	53%		14.3%		0.0%
LWat	R0624		0%	0%	0%		20.0%		0.0%
	L0584		0%	0%	0%		16.1%		2.8%
	L0002		0%	0%	0%		4.1%		0.0%
	L2292		0%	0%	0%		0.0%		0.0%

Note: * - Exceedences of total phosphorus are assessed on all data.

** - Exceedances of Chlorophyll-*a* are assessed on Growing Season (May - October) only

Table 7. Nitrogen load reductions and resulting total nitrogen exceedances for Approach 1.

Reservoir	Segment ID		N Reduction from Permit Scenario (%)				Exceedance (%)
			PS	NPS - Human	Reducible Load		
FCR	L1562		43%	19%	41%		9.7%
GFR	L1563		81%	48%	76%		16.3%
CCR	L1567		87%	99%	92%		9.0%
LWat	R0624		0%	0%	0%		13.3%
	L0584		0%	0%	0%		12.5%
	L0002		0%	0%	0%		5.6%
	L2292		0%	0%	0%		0.0%

Approach 2

The results for Approach 2 estimate that an overall reduction of 64% (PS: 70%; NPS: 39%) in the TP load to FCR would more than meet the TP target in the surface layer of the lake. This scenario meets the SC criterion of 40.0 μg/L for chlorophyll- in the growing season. At this level of reduction in FCR, Great Falls and Cedar Creek Reservoir and all segments of Lake Wateree also meet the target for TP.

Reductions to meet the TN target in Fishing Creek Reservoir following Approach 2 are smaller than reductions for TP: overall 48% (PS: 50%; NPS: 29%). Using this approach, meeting the target in both Fishing Creek Reservoir and Great Falls Reservoir allows the two downstream reservoirs meet the target with no additional reduction required from these watersheds.

Table 8. Phosphorus load reductions and resulting total phosphorus and chlorophyll-*a* exceedances for Approach 2.

Reservoir	Segment ID	Total Phosphorus Reduction from Permit Scenario (%)			Exceedance (%)	
		PS	NPS - Human	Reducible Load	TP *	Chlorophyll-*a* **
FCR	L1562	70%	39%	65%	5.1%	0.1%
GFR	L1563	64%	51%	57%	9.9%	0.0%
CCR	L1567	64%	30%	48%	8.6%	0.0%
LWat	R0624	0%	0%	0%	10.5%	0.0%
	L0584	0%	0%	0%	7.7%	1.8%
	L0002	0%	0%	0%	1.0%	0.0%
	L2292	0%	0%	0%	0.0%	0.0%

Note: * - Exceedances of total phosphorus are assessed on all data.

** - Exceedences of Chlorophyll-*a* are assessed on Growing Season (May - October) only

Table 9. Nitrogen load reductions and resulting total nitrogen exceedances for Approach 2.

Reservoir	Segment ID	N Reduction from Permit Scenario (%)			Exceedance (%)
		PS	NPS - Human	Reducible Load	
FCR	L1562	50%	29%	48%	5.7%
GFR	L1563	48%	32%	46%	9.5%
CCR	L1567	0%	0%	0%	5.9%
LWat	R0624	0%	0%	0%	7.6%
	L0584	0%	0%	0%	7.5%
	L0002	0%	0%	0%	6.2%
	L2292	0%	0%	0%	0.0%

Reductions from DMR Flow and DMR Load (TP and TN)

Tables 10 - 13 provide possible reductions and target exceedances for the two approaches from scenarios based on actual DMR flows and loads for total phosphorus and total nitrogen as described above.

These scenarios are presented as examples of possible load reductions that achieve the appropriate targets in these impaired lakes. Though these loads may be useful in determining future TMDLs, actual allocations for source categories and individual sources are to be determined later.

Approach 1

The results for Approach 1 from the existing condition scenario estimate that an overall reduction of 48% (PS: 50%; NPS: 40%) in the TP load to FCR would meet the TP target in the surface layer of the lake (Table 10). This scenario meets SC target of 40 µg/L for chlorophyll-*a* in the growing season. These results are similar to those for the reductions from permitted condition scenario. This level of reduction in FCR and similar reductions from the Great Falls and Cedar Creek Reservoir watersheds do not meet the TP target in either GFR or CCR or the upper segments of Lake Wateree. Because over 90 % of the TP load to these reservoirs is from the upstream reservoir, it is not possible to meet the TP target without additional load reduction from Fishing Creek Reservoir.

Reductions to meet the TN target in Fishing Creek Reservoir are smaller than for TP: overall 19% (PS: 20%; NPS: 14%) (Table 11). As was the case for this approach for TP, just meeting the target in Fishing Creek Reservoir does not allow the downstream reservoirs meet the TN target.

Pie charts showing the phosphorus loads to Fishing Creek Reservoir by source categories are provided in Figure 13 for the DMR (existing) flow and load scenario and in Figure 14 for the Approach 1 reduction from DMR flow and load scenario. The percentage of the phosphorus load from point source load decreases from 48 % to 35 % respectively for the two scenarios according to the model.

Table 10. Phosphorus load reductions from existing loads and resulting phosphorus and Chlorophyll-*a* exceedances for Approach 1 for 2007 - 2012.

Reservoir	Segment ID		Total Phosphorus Reduction from Permit Scenario (%)				Exceedance (%)		
							TP *		Chlorophyll-*a* **
			PS	NPS - Human	Reducible Load				
FCR	L1562		50%	40%	48%		10.0%		0.4%
GFR	L1563		47%	40%	41%		16.7%		0.0%
CCR	L1567		49%	40%	42%		13.8%		0.0%
LWat	R0624		NA	NA	NA		17.4%		0.0%
	L0584		NA	NA	NA		12.8%		4.3%
	L0002		NA	NA	NA		1.7%		0.0%
	L2292		NA	NA	NA		0.1%		0.0%

Note: * - Exceedances of total phosphorus are assessed on all data.
** - Exceedances of Chlorophyll-*a* are assessed on Growing Season (May - October) only

Table 11. Nitrogen load reductions from existing loads and resulting total nitrogen exceedances for Approach 1 for 2007 - 2012.

Reservoir	Segment ID		N Reduction from Permit Scenario (%)				Exceedance (%)
			PS	NPS - Human	Reducible Load		
FCR	L1562		20%	14%	19%		10.4%
GFR	L1563		19%	14%	17%		16.0%
CCR	L1567		19%	15%	16%		9.6%
LWat	R0624		NA	NA	NA		13.8%
	L0584		NA	NA	NA		8.7%
	L0002		NA	NA	NA		0.0%
	L2292		NA	NA	NA		0.0%

Approach 2

The results for Approach 2 from the existing condition scenario estimate that an overall reduction of 51% (PS: 55%; NPS: 39%) in the TP load to FCR would meet the TP target in the surface layer of the lake (Table 12). This scenario meets SC target of 40 µg/l for chlorophyll-*a* in the growing season. These results are somewhat smaller than those for the reductions from the permitted condition scenario. This level of reduction in FCR and somewhat smaller in the Great Falls and Cedar Creek Reservoir watersheds allow the TP target to be met in all reservoirs including all segments of Lake Wateree. Over 90 % of the TP load to these reservoirs is from the upstream reservoir. It is not possible to reduce the load from their respective sub-watersheds enough to meet the target, without additional reductions in the load upstream of Fishing Creek Reservoir.

Reductions required to meet the TN target in Fishing Creek Reservoir are smaller than for TP: overall 21% (PS: 22%; NPS: 19%) (Table 13). As was the case for this approach for TP, similar reductions from the Great Falls and Cedar Creek Reservoir watersheds, allow the downstream reservoirs to meet the TN target.

Table 12. Phosphorus load reductions from existing loads and resulting total phosphorus and chlorophyll-*a* exceedances for Approach 2 for 2007 - 2012.

Reservoir	Segment ID		Total Phosphorus Reduction from Permit Scenario (%)				Exceedance (%)		
			PS	NPS - Human	Reducible Load		TP *		Chlorophyll-*a* **
FCR	L1562		55%	39%	51%		5.9%		0.1%
GFR	L1563		52%	50%	50%		10.6%		0.0%
CCR	L1567		49%	40%	42%		7.2%		0.0%
LWat	R0624		NA	NA	NA		9.1%		0.0%
	L0584		NA	NA	NA		8.1%		2.7%
	L0002		NA	NA	NA		0.0%		0.0%
	L2292		NA	NA	NA		0.0%		0.0%

Note: * - Exceedances of total phosphorus are assessed on all data.
** - Exceedances of Chlorophyll-*a* are assessed on Growing Season (May - October) only

Table 13. Nitrogen load reductions from existing loads and resulting total nitrogen exceedances for Approach 2 for 2007 - 2012.

Reservoir	Segment ID		N Reduction from Permit Scenario (%)				Exceedance (%)
			PS	NPS - Human	Reducible Load		
FCR	L1562		22%	19%	22%		7.4%
GFR	L1563		21%	22%	22%		10.3%
CCR	L1567		21%	20%	20%		5.0%
LWat	R0624		NA	NA	NA		6.5%
	L0584		NA	NA	NA		6.0%
	L0002		NA	NA	NA		6.0%
	L2292		NA	NA	NA		0.0%

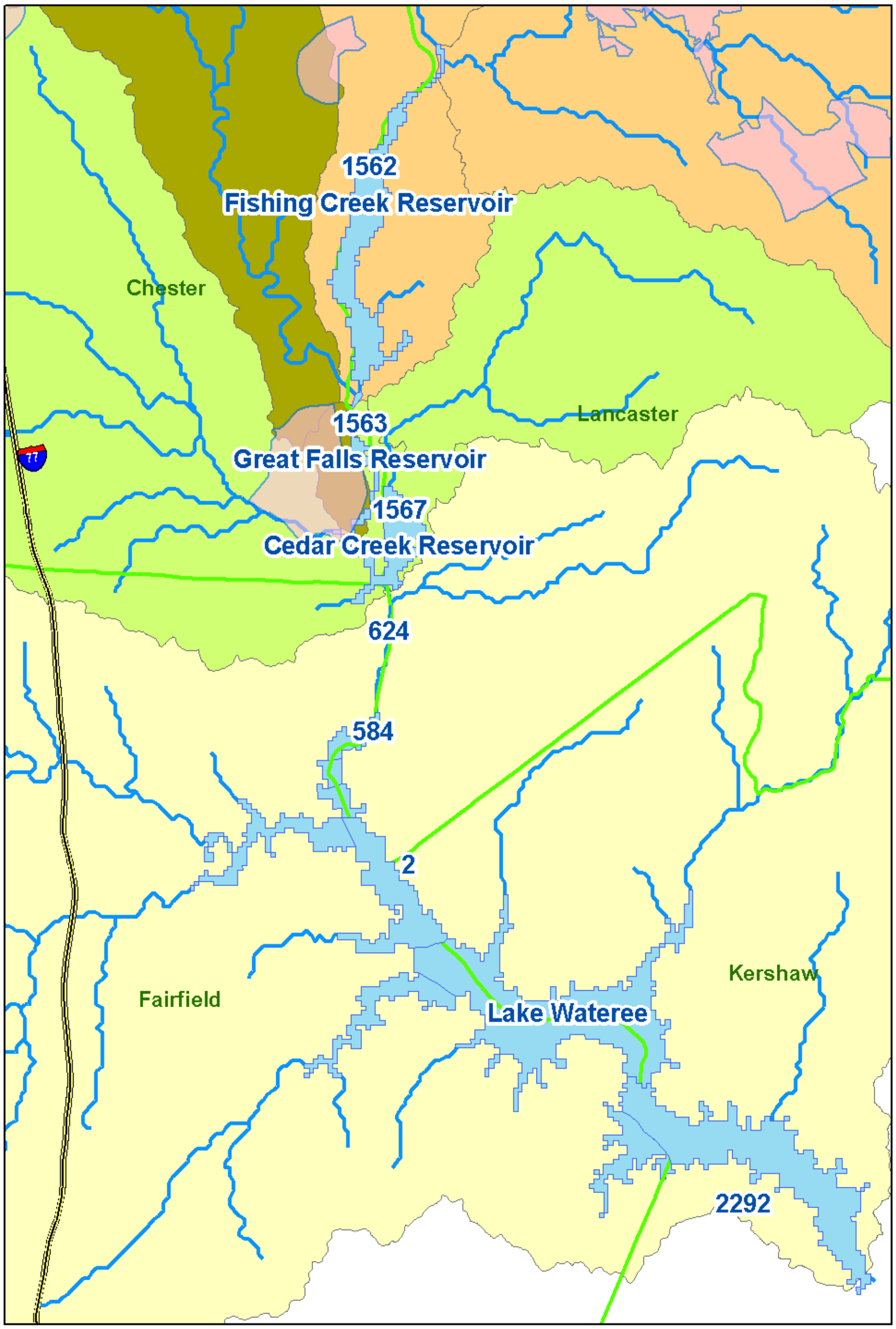


Figure 10. Map of lower Catawba lakes showing model segment IDs.

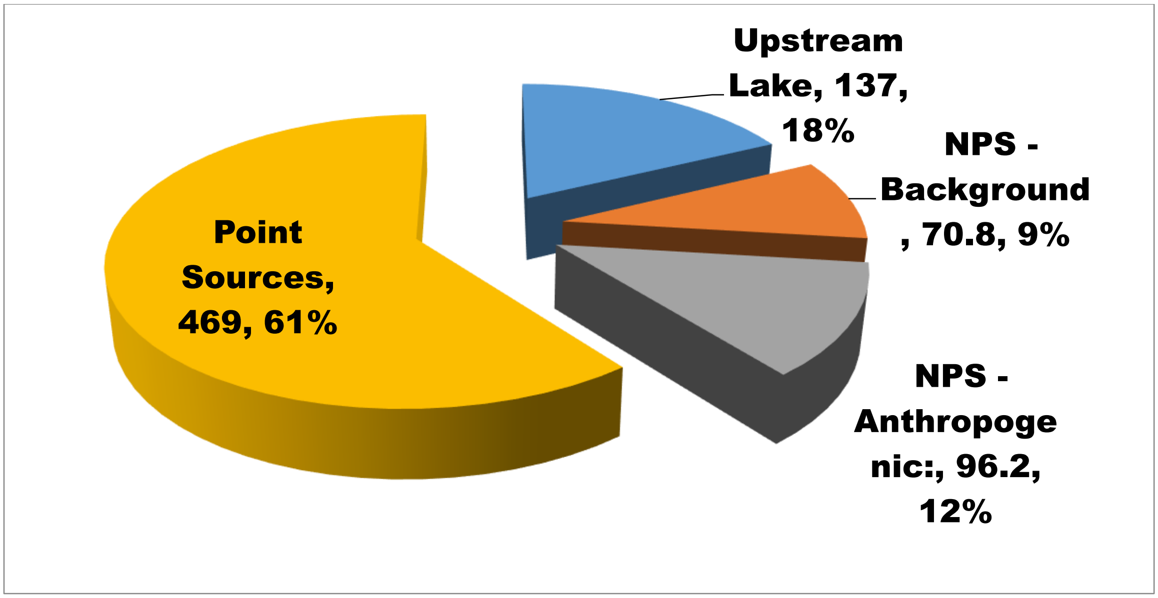


Figure 11. Pie chart of sources of phosphorus to Fishing Creek Reservoir from Permit Limits Scenario for 10/2003 - 09/2012 (Load in kg/day).

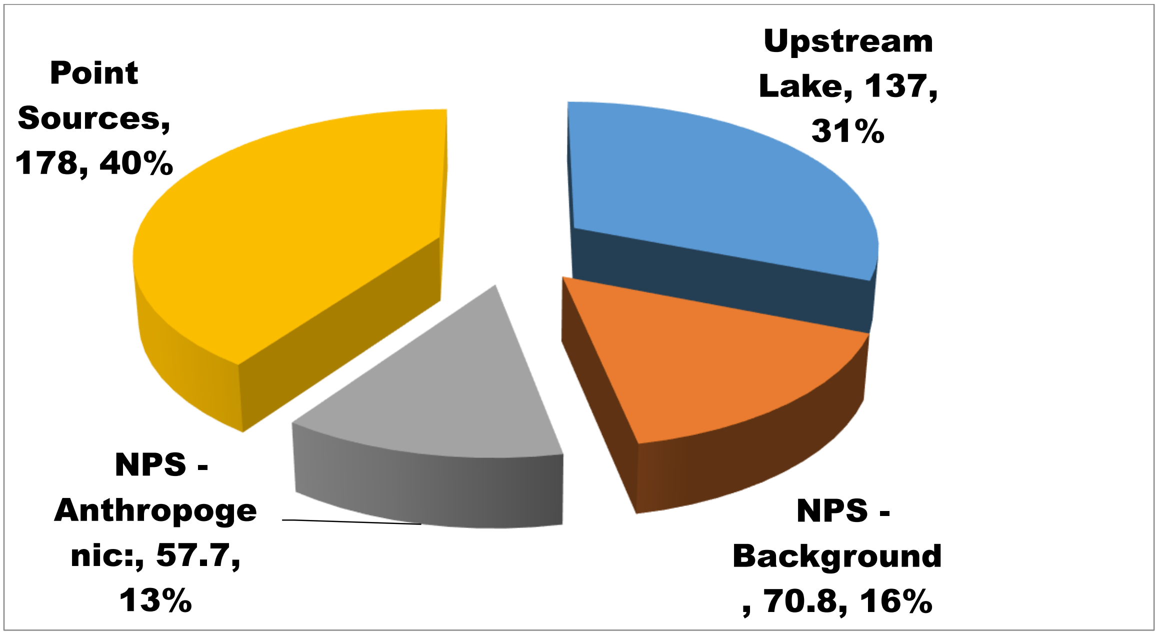


Figure 12. Pie chart of sources of phosphorus to Fishing Creek Reservoir from Reduction to Permit Limits Scenario for 10/2003 - 09/2012 (Load in kg/day).

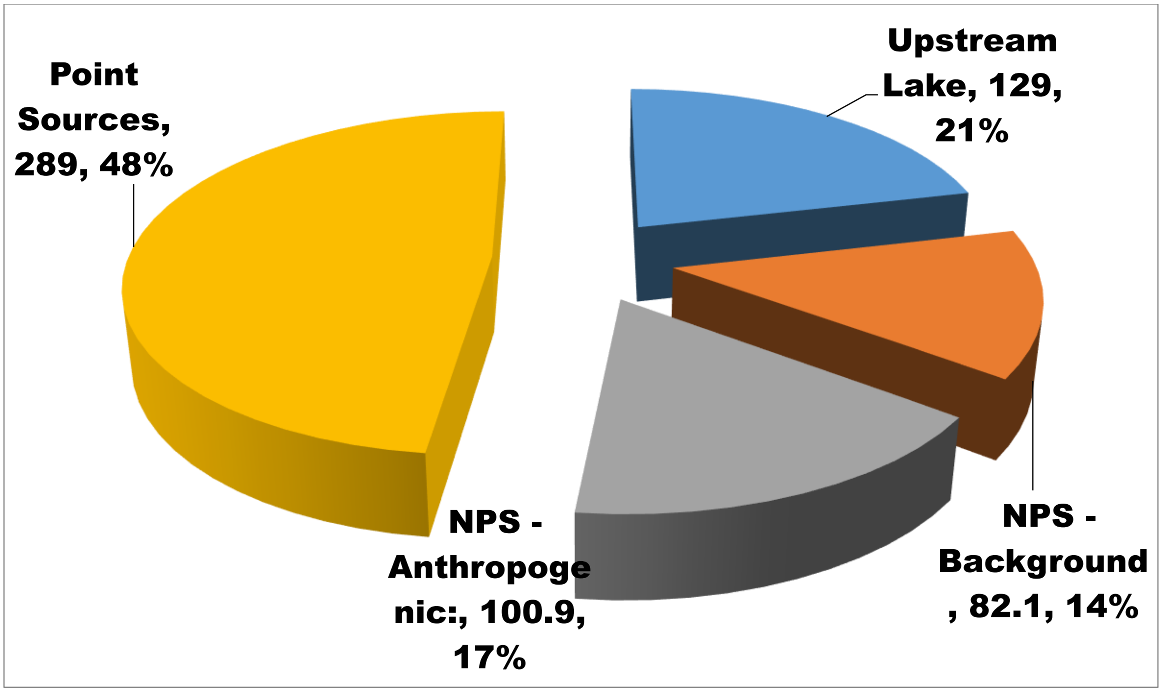


Figure 13. Pie chart of sources of phosphorus to Fishing Creek Reservoir from Existing Scenario for 01/2007 - 09/2012 (Load in kg/day).

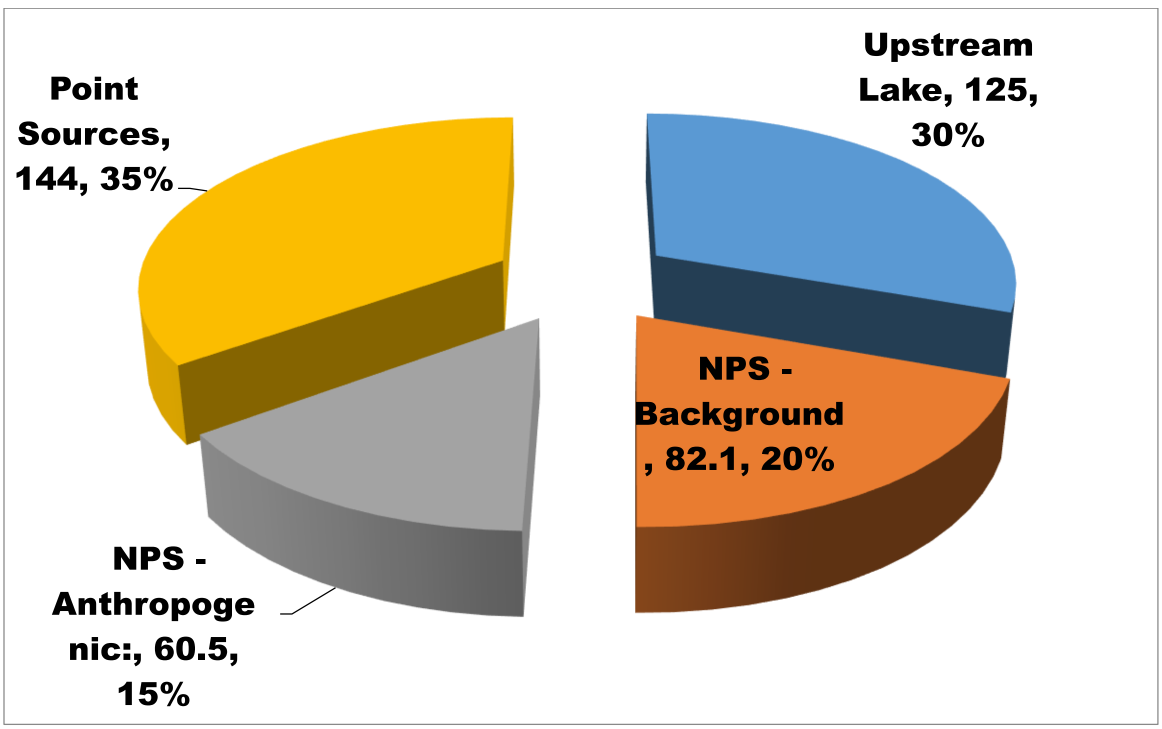
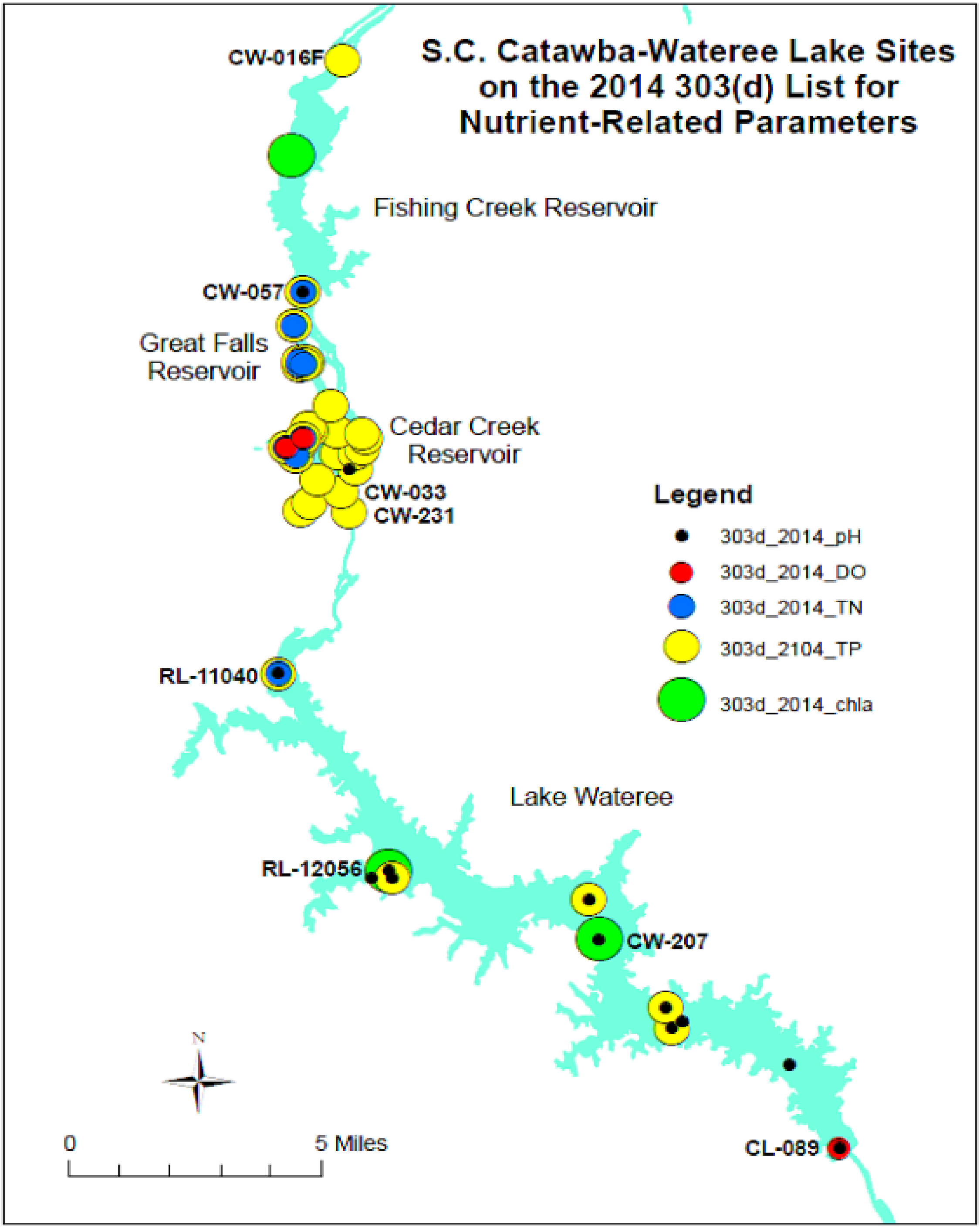


Figure 14. Pie chart of sources of phosphorus to Fishing Creek Reservoir from Reduction to Existing Scenario for 01/2007 - 09/2012 (Load in kg/day).

References

SCDHEC 2015. http://www.scdhec.gov/HomeAndEnvironment/Docs/tmdl_14-303d.pdf

Appendix A Map of nutrient-related impairments in Lower Catawba Basin.



Appendix B Water Quality Data

Total Phosphorus

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
CW-016			**CW-016F**			**CW-057**			**CW-033**			**CW-231**			**CW-207**			**CL-089**		
Date	**c**	**TP**	**Date**	**c**	**TP**	**Date**	**c**	**TP**	**Date**	**c**	**TP**	**Date**	**c**	**TP**	**Date**	**c**	**TP**	**Date**	**c**	**TP**
		mg/L			**mg/L**			**mg/L**			**mg/L**			**mg/L**			**mg/L**			**mg/L**
No phosphorus data available for period January 1998 - May 2001.																				
06/28/01		0.33				06/28/01		0.210				06/28/01		0.18				06/21/01		0.037
07/19/01		0.23				07/19/01		0.180				07/26/01		0.17				07/23/01	<	0.02
08/23/01		0.4				08/23/01		0.190				08/09/01		0.17				08/15/01		0.031
09/19/01		0.39				09/19/01		0.180				09/06/01		0.071				09/11/01		0.059
10/18/01		0.26				10/18/01		0.220				10/25/01		0.22				10/18/01		0.06
11/01/01		0.22				11/01/01		0.190				11/29/01		0.099				11/14/01		0.052
12/10/01		0.36				12/10/01		0.260				12/11/01		0.24				12/06/01		0.044
01/31/02		0.18	01/31/02		0.14	01/31/02		0.14	01/31/02		0.13	01/31/02		0.099	01/10/02		0.11	01/10/02		0.059
02/28/02		0.22	02/28/02		0.2	02/28/02		0.19	02/28/02		0.14	02/28/02		0.098	02/14/02		0.13	02/14/02		0.11
03/14/02		0.34	03/14/02		0.23	03/14/02		0.18	03/14/02		0.2	03/14/02		0.14	03/14/02		0.079	03/14/02		0.076
04/25/02		0.26	04/25/02		0.23	04/25/02		0.12	04/25/02		0.13	04/25/02		0.14	04/04/02		0.073	04/04/02		0.047
05/30/02		0.3	05/30/02		0.26	05/30/02		0.16	05/30/02		0.2	05/30/02		0.068	05/02/02		0.055	05/02/02		0.031
06/13/02		0.18	06/13/02		0.18	06/13/02		0.180	06/13/02		0.17	06/13/02		0.1	06/20/02		0.054	06/20/02		0.029
07/31/02		0.22	07/31/02		0.2	07/31/02		0.130	07/31/02		0.16	07/31/02		0.16	07/02/02		0.037	07/02/02		0.021
08/22/02		0.27	08/22/02		0.23	08/22/02		0.220							08/22/02		0.071	08/22/02		0.034
09/30/02		0.29				09/30/02		0.160							09/04/02		0.084	09/04/02		0.057
10/31/02		0.24	10/31/02		0.23	10/31/02		0.150	10/31/02		0.13	10/31/02		0.084	10/23/02		0.072	10/23/02		0.047
11/21/02		0.11	11/21/02		0.14	11/21/02		0.110	11/21/02		0.13	11/21/02		0.023	11/14/02		0.083	11/14/02		0.038
12/17/02		0.06	12/17/02		0.096	12/17/02		0.088	12/17/02		0.1	12/17/02	<	0.02	12/17/02		0.083	12/17/02		0.071
												01/29/03		0.025				01/07/03		0.077
02/20/03		0.056				02/20/03		0.058				02/13/03	<	0.02				02/20/03		0.053
												03/31/03		0.11				03/26/03		0.093
04/17/03		0.074				04/17/03		0.085				04/17/03		0.25				04/10/03		0.073
05/29/03		0.063				05/29/03		0.057				05/15/03		0.039				05/15/03		0.021
06/23/03		0.031				06/23/03	<	0.020				06/30/03		0.048				06/05/03		0.053
07/31/03		0.07				07/31/03		0.069				07/17/03		0.06				07/01/03		0.022
08/28/03		0.039										08/14/03		0.044				08/05/03		0.025
09/29/03		0.16				09/29/03		0.086				09/29/03		0.097				09/02/03		0.022
10/30/03		0.16				10/30/03		0.093				10/29/03		0.11				10/09/03		0.024
11/20/03		0.087				11/20/03		0.085				11/13/03		0.1				11/06/03		0.024
												12/18/03		0.1				12/03/03		0.05

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
01/21/04		0.044				01/21/04		0.072										01/08/04		0.048
02/24/04		0.13				02/24/04		0.088				02/24/04		0.086				02/12/04		0.041
03/10/04		0.06				03/10/04		0.084				03/25/04		0.095				03/02/04		0.038
04/08/04		0.087				04/08/04		0.099				04/28/04		0.13				04/08/04		0.021
05/27/04		0.16				05/27/04		0.12				05/18/04		0.13				05/20/04		0.057
06/10/04		0.21				06/10/04		0.170				06/17/04		0.16				06/10/04		0.047
07/19/04		0.22				07/19/04		0.089				07/29/04		0.1				07/29/04		0.059
08/19/04		0.11				08/10/04		0.160				08/26/04		0.094				08/05/04		0.041
09/02/04		0.14				09/20/04		0.120				09/15/04		0.078				09/16/04		0.084
10/20/04		0.057				10/21/04		0.080				10/18/04		0.1				10/20/04		0.1
11/15/04		0.034				11/04/04		0.100				11/18/04		0.11				11/04/04		0.046
12/13/04	<	0.02				12/09/04		0.069				12/16/04		0.059				12/02/04		0.055
01/26/05		0.066				01/11/05		0.069				01/11/05		0.069						
02/09/05		0.053				02/22/05		0.13				02/22/05		0.11				02/03/05		0.069
03/09/05		0.16				03/15/05		0.069				03/14/05		0.091				03/30/05		0.065
04/21/05		0.06				04/26/05		0.095				04/20/05		0.1				04/07/05		0.078
05/10/05		0.094				05/12/05		0.1				05/19/05		0.12				05/26/05		0.036
06/02/05		0.23				06/16/05		0.083				06/21/05		0.066				06/30/05		0.045
07/13/05		0.085				07/13/05		0.068				07/27/05		0.075				07/28/05		0.04
08/16/05		0.097				08/30/05		0.060				08/11/05		0.097				08/30/05		0.051
09/22/05		0.13				09/12/05		0.100				09/07/05		0.089						
10/31/05		0.15				10/05/05		0.120				10/03/05		0.1				10/06/05		0.042
11/15/05		0.17				11/08/05		0.100				11/03/05		0.11				11/14/05		0.056
12/07/05		0.22				12/14/05		0.075				12/01/05		0.11						
01/03/06		0.074				01/26/06		0.052				01/11/06		0.051				01/18/06		0.044
02/08/06		0.04				02/06/06		0.073				02/07/06		0.071				02/02/06		0.04
03/01/06		0.043				03/28/06		0.064				03/29/06		0.057				03/23/06		0.025
04/12/06		0.061				04/27/06		0.096				04/17/06		0.079				04/27/06		0.057
05/24/06		0.093				05/30/06		0.028				05/23/06		0.074				05/25/06		0.029
06/07/06		0.13										06/06/06		0.074				06/28/06		0.041
07/06/06		0.12				07/17/06		0.053				07/17/06		0.074				07/06/06	<	0.02
08/08/06		0.098				08/03/06		0.080				08/23/06		0.099				08/24/06	<	0.02
09/20/06		0.084				09/07/06		0.082				09/27/06		0.07				09/21/06		0.046
10/10/06		0.2				10/05/06		0.028				10/12/06		0.11				10/30/06		0.051
11/02/06		0.067				11/28/06		0.059				11/29/06		0.066				11/29/06		0.061
12/07/06		0.074				12/28/06		0.097				12/05/06		0.069						
01/03/07		0.046	01/04/07		0.036	01/04/07		0.04	01/31/07		0.038	01/31/07		0.041	01/25/07		0.059	01/25/07		0.047
02/14/07		0.061	02/08/07		0.057	02/08/07		0.05	02/22/07		0.061	02/22/07		0.051	02/15/07		0.029	02/15/07		0.036
03/07/07		0.073	03/15/07		0.067	03/15/07		0.075	03/29/07		0.059	03/29/07		0.056	03/15/07		0.029	03/15/07		0.046

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
04/04/07		0.052	04/12/07		0.053	04/12/07		0.051	04/19/07		0.066	04/19/07		0.066	04/12/07		0.044	04/12/07		0.035
05/08/07		0.12	05/17/07		0.11	05/17/07		0.33	05/31/07		0.04	05/31/07		0.069	05/17/07	<	0.02	05/17/07	<	0.02
06/12/07		0.11	06/26/07		0.11	06/13/07		0.034	06/26/07		0.066	06/26/07		0.078	06/14/07		0.038	06/14/07	<	0.02
07/11/07		0.087	07/12/07		0.091	07/12/07		0.044	07/19/07		0.024	07/19/07		0.1	07/12/07		0.25	07/12/07		0.024
08/08/07		0.34	08/09/07		0.092	08/09/07		0.083	08/23/07		0.07	08/23/07		0.037	08/01/07	<	0.02	08/01/07	<	0.02
09/18/07		0.14				09/13/07		0.059	09/20/07		0.051	09/20/07		0.071	09/04/07		0.035	09/04/07		0.03
10/02/07		0.095				10/11/07		0.035	10/29/07		0.056	10/29/07		*	10/04/07		0.037	10/04/07		0.033
11/13/07		0.35	11/08/07	<	0.02	11/08/07		0.083	11/19/07		0.05	11/19/07		0.05	11/27/07		0.044	11/27/07		0.032
12/03/07		0.082	12/27/07		0.095	12/27/07		0.100	12/27/07		0.062	12/27/07		0.055	12/10/07		0.027	12/10/07		0.037
01/15/08		0.5				01/23/08		0.089				01/23/08		0.044				01/16/08	<	0.02
02/13/08		0.064				02/27/08		0.055				02/26/08		0.078				02/07/08		0.022
03/18/08		0.21				03/26/08		0.098				03/26/08		0.092				03/06/08		0.044
04/15/08		0.47				04/28/08		0.054				04/29/08	<	0.02				04/24/08		0.053
05/06/08		0.12				05/14/08		0.069				05/14/08		0.091				05/27/08		0.034
06/04/08		0.14				06/12/08		0.094				06/12/08		0.069				06/19/08		0.044
07/08/08		0.22				07/24/08		0.080				07/24/08		0.86				07/10/08	<	0.02
08/12/08		0.14				08/14/08		0.078				08/14/08		0.082				08/27/08		0.038
09/10/08		0.13				09/29/08		0.089				09/29/08		0.086				09/25/08		0.034
10/23/08		0.098				10/09/08		0.080				10/09/08		0.15				10/23/08		0.033
11/19/08		0.094				11/06/08		0.099												
12/18/08		0.064				12/29/08		0.098										12/04/08		0.045
01/06/09		0.84				01/28/09		0.063				01/26/09	<	0.02				01/15/09		0.068
02/11/09		0.12				02/19/09		0.072										02/26/09	<	0.02
03/04/09	<	0.02				03/30/09		0.042				03/31/09		0.059				03/12/09		0.04
04/21/09		0.037				04/21/09	<	0.02				04/23/09		0.038				04/08/09		0.025
05/13/09		0.052				05/12/09		0.06				05/12/09		0.061				05/07/09		0.03
06/16/09	<	0.02										06/04/09		0.061				06/04/09		0.035
07/16/09		0.11				07/23/09		0.063				07/23/09		0.049				07/23/09		0.026
08/12/09		0.12				08/27/09		0.051				08/27/09		0.065				08/12/09		0.026
09/02/09		0.1				09/30/09		0.089				09/30/09		0.092				09/10/09		0.046
11/02/09		0.26				11/16/09		0.058				11/16/09		0.079						
																		12/03/09		0.058
01/07/10		0.066	02/04/10		0.11										01/07/10		0.052			
						02/04/10		0.042	02/25/10		0.085							02/03/10		0.07
03/01/10		0.065													03/25/10		0.058			
																		04/01/10		0.039
05/18/10		0.12	05/26/10		0.079	05/26/10		0.062	05/12/10		0.064	05/12/10		0.059	05/20/10		0.042			
																		06/17/10		0.029
07/08/10		0.096							07/27/10		0.031	07/27/10		0.051	07/15/10		0.042			

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
																		08/26/10		0.033
09/07/10		0.071	09/20/10		0.077	09/20/10		0.034	09/15/10		0.046	09/15/10		0.11	09/16/10		0.031			
																		10/28/10		0.031
11/09/10		0.2	11/17/10		0.079	11/17/10		0.097	11/18/10		0.062	11/18/10		0.068	11/18/10		0.033			
																		12/09/10		0.038
			01/27/11		0.059										01/20/11		0.047	01/20/11		0.048
02/22/11		0.077	02/09/11		0.072	02/09/11		0.082	02/24/11		0.06	02/09/11		0.1						
			03/15/11		0.078										03/24/11		0.052	03/24/11		0.047
04/12/11		0.11	04/07/11		0.053	04/07/11		0.063	04/21/11		0.049	04/21/11		0.065						
			05/18/11		0.094										05/26/11		0.039	05/26/11		0.04
06/09/11		0.17	06/13/11		0.16	06/13/11		0.120	06/16/11		0.072	06/13/11		0.12						
			07/07/11		0.12										07/28/11		0.026	07/28/11		0.026
08/03/11		0.14	08/10/11		0.082	08/10/11		0.052	08/18/11		0.064	08/25/11		0.076						
			09/08/11		0.089										09/27/11		0.038	09/27/11		0.03
10/05/11		0.4	10/13/11		0.08	10/13/11		0.074	10/27/11		0.077	10/27/11		0.084						
			11/30/11		0.11										11/14/11		0.041	11/14/11		0.033
12/15/11		0.052	12/12/11		0.06	12/12/11		0.075	12/07/11		0.076	12/12/11		0.084						
			01/18/12		0.04	01/18/12		0.052				01/25/12		0.072	01/19/12		0.05	01/19/12		0.043
02/02/12		0.059							02/22/12		0.038	02/22/12		0.045						
			03/20/12		0.1	03/20/12		0.032							03/22/12		0.023	03/22/12	<	0.02
04/04/12		0.13							04/26/12		0.057	04/26/12		0.059						
			05/17/12		0.096	05/17/12		0.048							05/17/12		0.022	05/17/12	<	0.02
06/14/12		0.15							06/14/12		0.022	06/14/12		0.046						
			07/23/12		0.1	07/23/12		0.054							07/19/12		0.039	07/19/12		0.03
08/08/12		0.17							08/16/12		0.028	08/16/12		0.061						
			09/12/12		0.098	09/12/12		0.073							09/27/12		0.025	09/27/12	<	0.02
10/08/12		0.12							10/23/12		0.036	10/23/12		0.047						
			11/14/12		0.089	11/14/12		0.065							11/15/12		0.036	11/15/12		0.033
12/05/12		0.091							12/05/12		0.052	12/05/12		0.066						
01/08/13		0.063	01/08/13		0.061	01/08/13		0.071							01/17/13		0.028	01/17/13	<	0.02
									02/27/13		0.053	02/27/13		0.077						
03/27/13		0.049	03/27/13		0.035	03/27/13		0.068							03/21/13		0.047	03/21/13		0.039
									04/17/13		0.027	04/17/13		0.044						
05/23/13		0.028	05/23/13		0.072	05/23/13		0.029							05/16/13		0.027	05/16/13	<	0.02
									06/20/13		0.034	06/20/13		0.046						
															07/18/13		0.035	07/18/13		0.03
									08/08/13		0.024	08/08/13		0.082						
															09/12/13		0.02	09/12/13	<	0.02
									10/10/13		0.038	10/10/13		0.048						

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
11/19/13		0.086	11/19/13		0.069	11/19/13		0.053												
									12/12/13		0.036	12/12/13		0.039						
									01/08/14		0.063	01/08/14		0.042						
02/06/14		0.056	02/06/14		0.055	02/06/14		0.061							02/20/14		0.03	02/20/14		0.044
									03/19/14		0.038	03/19/14		0.071						
															04/17/14		0.029	04/17/14		0.026
									05/22/14		0.032	05/22/14		0.067						
06/11/14		0.079	06/11/14		0.074	06/11/14		0.028							06/12/14		0.026	06/12/14		0.024
									07/16/14		0.02	07/16/14		0.035						
															08/14/14		0.025	08/14/14	<	0.02
10/20/14		0.066	10/20/14		0.062	10/20/14		0.061							12/11/14		0.07	12/11/14		0.046
12/18/14		0.083	12/18/14		0.059	12/18/14		0.068												
01/20/15		0.034				01/20/15		0.04	01/21/15		0.043				01/22/15		0.052	01/22/15		0.05
						03/03/15		0.061	02/25/15		0.059	02/19/15		0.055	02/19/15		0.034	02/19/15		0.036
03/25/15		0.12				03/25/15		0.042							03/18/15		0.032	03/18/15		0.052
						04/13/15		0.033	04/13/15		0.026	04/16/15		0.076	04/16/15	<	0.02	04/16/15	<	0.02
05/14/15		0.064				05/14/15		0.032	05/27/15	<	0.02				05/21/15	<	0.02	05/21/15	<	0.02
						06/23/15		0.028				06/08/15		0.044	06/18/15	<	0.02	06/18/15	<	0.02
07/14/15		.081				07/14/15		0.040							07/23/15	<	0.02	07/23/15	<	0.02
						08/20/15		0.046				08/13/15		0.053	08/13/15	<	0.02	08/13/15	<	0.02
09/29/15		.098				09/29/15		0.053							09/17/15		0.028	09/17/15	<	0.02
						10/20/15		0.073							10/22/15		0.037	10/22/15	<	0.02
11/17/15		.044				11/17/15		0.053							11/19/15		0.055	11/19/15		0.063
						12/09/15		0.032												

Total Nitrogen

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
CW-016			CW-016F			CW-057			CW-033			CW-231			CW-207			CL-089		
Date	c	TN	Date	c	TN	Date	c	TN	Date	c	TN	Date	c	TN	Date	c	TN	Date	c	TN
		mg/L			mg/L			mg/L			mg/L			mg/L			mg/L			mg/L
1/26/98		0.78	1/26/98		0.78	1/26/98		0.88							1/14/98		0.89			
2/12/98		0.98	2/12/98		1.04	2/12/98		0.97							2/18/98		0.9			
3/26/98		0.74										3/26/98		0.74	3/5/98		0.76			
4/16/98		0.90	4/16/98		0.83	4/16/98		0.86				4/16/98		0.97	4/15/98		0.86			
5/7/98		0.62	5/7/98		1.02	5/7/98		0.85	5/14/98		0.66	5/14/98		0.82	5/7/98		0.66			
6/9/98		1.42	6/9/98		1.33	6/9/98		1.23	6/23/98		0.95	6/23/98		0.78	6/10/98		0.63			
7/1/98		0.75	7/1/98		1.12	7/1/98		0.59	7/30/98		0.80	7/30/98	<	0.57	7/16/98	<	0.57			
8/6/98		1.03	8/6/98		0.79	8/6/98		0.93	8/27/98		0.91	8/27/98		1.08	8/6/98		0.69			
9/15/98		0.65	9/15/98		1.22	9/15/98	<	0.95	9/17/98		1.00	9/17/98		0.87	9/14/98	<	0.79			
10/1/98		0.83	10/1/98		1.21	10/1/98		0.92	10/5/98		0.80	10/5/98		0.95	10/8/98		0.86			
11/5/98		1.73	11/5/98		1.87	11/5/98		1.23							11/19/98		0.97			
12/3/98		0.67	12/3/98		1.25	12/3/98		1.27							12/3/98		0.85			
1/7/99		1.26	1/7/99		1.19	1/7/99		1.24												
2/4/99		0.84	2/4/99		0.97	2/4/99		0.77												
3/18/99		1.16	3/18/99		1.20	3/18/99		1.29												
4/5/99		0.91	4/5/99		1.21	4/5/99		1.14												
5/20/99		1.60	5/20/99		1.60	5/20/99		1.51												
6/2/99		0.91	6/2/99		0.70	6/2/99														
7/1/99		0.74	7/1/99		1.16	7/1/99		1.10												
8/3/99		2.01	8/3/99		1.46	8/3/99		0.75												
9/1/99		1.02	9/1/99		1.37	9/1/99		1.10												
10/27/99		1.09	10/27/99		1.19	10/27/99		1.26												
11/4/99		1.66	11/4/99		0.94	11/4/99		1.08												
12/29/99		1.47	12/29/99		1.44	12/29/99		1.37												
2/17/00		0.83	2/17/00		0.85	2/17/00		0.96												
3/9/00		1.38	3/9/00		1.38	3/9/00		1.37												
4/27/00		0.79	4/27/00		1.06	4/27/00		1.25												
5/4/00		1.18	5/4/00		1.07	5/4/00		1.15												
6/1/00		1.28	6/1/00		1.00	6/1/00		1.12												
7/20/00		1.07	7/20/00		1.27	7/20/00		1.03												
8/17/00		1.50	8/17/00		1.18	8/17/00		1.09												
9/21/00		0.97																		
11/30/00		1.03	11/30/00		1.36	11/30/00		1.44												
12/27/00		1.47	12/27/00		1.20	12/27/00		1.22												

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
1/4/01		1.06				1/4/01		1.33												
3/1/01		0.99				3/1/01		1.33												
5/3/01		1.30				5/3/01		1.14												
7/19/01		1.23				7/19/01		0.98				7/26/01		0.9						
8/23/01						8/23/01												8/15/01	<	0.69
9/19/01		1.17				9/19/01		0.76				9/6/01		0.35						
10/18/01						10/18/01												10/18/01		0.81
11/1/01		0.93				11/1/01		1.15				11/29/01	<	0.41						
1/31/02		1.49	1/31/02		1.22	1/31/02		1.31	1/31/02		1.08	1/31/02		0.58	1/10/02		0.8	1/10/02	<	0.4
2/28/02		1.35	2/28/02		1.50	2/28/02		1.44	2/28/02		1.15	2/28/02		0.97						
3/14/02	>	1.70	3/14/02		0.96	3/14/02			3/14/02						3/14/02		1.01	3/14/02		1.04
4/25/02		1.57	4/25/02		1.37	4/25/02		1.02	4/25/02		1.05	4/25/02		0.99						
5/30/02			5/30/02		0.82	5/30/02			5/30/02						5/2/02		0.52	5/2/02		0.38
6/13/02			6/13/02		1.13	6/13/02		1.15	6/13/02		0.88	6/13/02		0.74						
7/31/02			7/31/02		0.25	7/31/02			7/31/02						7/2/02		0.806	7/2/02	<	0.47
8/22/02		2.08	8/22/02		2.00	8/22/02		2.32												
9/30/02						9/30/02									9/4/02	<	0.82	9/4/02		0.6
10/31/02		1.55	10/31/02		1.63	10/31/02		1.36	10/31/02		1.33	10/31/02		0.86						
11/21/02			11/21/02		0.83	11/21/02			11/21/02						11/14/02		2.51	11/14/02		1.09
12/17/02		0.89	12/17/02		1.17	12/17/02		1.04	12/17/02		0.99	12/17/02		0.378						
																		1/7/03		0.98
2/20/03		1.92				2/20/03		1.40				2/13/03		0.52						
4/17/03		1.00				4/17/03		1.39				4/17/03		1.238				4/10/03		0.92
6/23/03		1.20				6/23/03		0.96				6/30/03		0.74				6/5/03		1.08
8/28/03		0.85										8/14/03		0.93				8/5/03		0.64
10/30/03		1.99				10/30/03		1.48				10/29/03		1.53				10/9/03		1.13
												12/18/03		1.51				12/3/03		1.38
1/21/04		1.01				1/21/04		1.10										1/8/04		1.07
3/10/04		1.37				3/10/04		1.83				3/25/04		1.24				3/2/04		1.05
4/8/04		1.72				4/8/04		1.32				4/28/04		1.2				4/8/04		0.84
5/27/04		2.10				5/27/04		1.58				5/18/04		1.27				5/20/04	<	0.81
6/10/04		2.14				6/10/04		1.86				6/17/04		1.13				6/10/04	<	0.57
7/19/04		0.95				7/19/04		0.93										7/29/04		0.464
8/19/04		1.22				8/10/04		1.65				8/26/04		0.74				8/5/04	<	0.75
9/2/04		1.05				9/20/04		0.96				9/15/04		0.65				9/16/04		0.75
10/20/04		0.71				10/21/04		0.81				10/18/04		0.89				10/20/04		0.61
11/15/04		0.55				11/4/04		0.98				11/18/04		1.04				11/4/04		0.56
12/13/04		0.93				12/9/04		1.02				12/16/04		0.8				12/2/04		0.78
1/26/05		1.22				1/11/05		1.06				1/11/05		1.08						
2/9/05		0.85				2/22/05		1.43				2/22/05		1.33				2/3/05		1.01
3/9/05		2.04				3/15/05						4/20/05		1				3/30/05		0.8

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
4/21/05		1.20				4/26/05		1.73				5/19/05		1.28				4/7/05		0.98
5/10/05		0.89				5/12/05		1.28				6/21/05	<	0.27				5/26/05		0.9
6/2/05		2.00				6/16/05		1.01				7/27/05		0.97				6/30/05	<	0.54
7/13/05		0.99				7/13/05		0.60				8/11/05		0.87				7/28/05	<	0.78
8/16/05		1.46				8/30/05		0.50				9/7/05		0.78				8/30/05		0.47
9/22/05		2.46				9/12/05		1.95				10/3/05		1.29				10/6/05		0.229
10/31/05		2.03				10/5/05		1.23				11/3/05		1.39				11/14/05		1.1
11/15/05		2.61				11/8/05		1.51				12/1/05		1.42						
12/7/05		1.11				12/14/05		0.68												
1/3/06		1.25				1/26/06		0.86				1/11/06		0.92				1/18/06		0.89
2/8/06		0.90				2/6/06		0.85				2/7/06		0.78				2/2/06		0.58
3/1/06		1.30				3/28/06		1.47				3/29/06		1.51				3/23/06		0.79
4/12/06		1.31				4/27/06		1.61				4/17/06		1.56				4/27/06		0.73
5/24/06		1.23				5/30/06		1.28				5/23/06		1.18				5/25/06		0.73
6/7/06		2.69				6/19/06		1.45				6/6/06		0.88				6/28/06	<	0.12
7/6/06		1.38				7/17/06		1.03				7/17/06		0.97				7/6/06		0.439
8/8/06		1.01				8/3/06		1.03				8/23/06		1.14				8/24/06	<	0.12
9/20/06						9/7/06		1.40				9/27/06		1.2				9/21/06		0.88
10/10/06	>	1.90				10/5/06		0.96				10/12/06		1.48				10/30/06		0.8
11/2/06		1.59				11/28/06						11/29/06		0.81				11/29/06		0.98
12/7/06		1.53				12/28/06		1.00				12/5/06		0.93						
1/3/07		0.62	1/4/07		0.72	1/4/07		0.66	1/31/07		0.94	1/31/07		0.97	1/25/07		0.91	1/25/07		0.77
2/14/07		0.92	2/8/07		1.65	2/8/07		1.12	2/22/07		1.04	2/22/07		1.16	2/15/07		0.89	2/15/07		0.76
3/7/07		1.36	3/15/07		1.53	3/15/07		1.00	3/29/07			3/29/07		0.95	3/15/07		0.63	3/15/07		0.67
4/4/07		0.73	4/12/07		0.66	4/12/07			4/19/07											
5/8/07			5/17/07		1.10	5/17/07		1.42	5/31/07											
6/12/07		2.29	6/26/07		0.54	6/13/07		1.33	6/26/07		1.22	6/26/07		1.55	6/14/07		0.73	6/14/07		0.629
7/11/07		1.41	1/0/00		1.38	7/12/07		1.72	7/19/07		1.06	7/19/07		1.33	7/12/07	<	0.56	7/12/07	<	0.93
8/8/07		1.79	8/9/07		1.36	8/9/07		0.75	8/23/07		0.86	8/23/07		0.99	8/1/07	<	0.3	8/1/07	<	0.44
9/18/07		2.02				9/13/07		1.15	9/20/07			9/20/07		1	9/4/07		0.802	9/4/07	<	0.6
10/2/07		1.95				10/11/07		1.37	10/29/07						10/4/07		0.38	10/4/07		0.389
11/13/07		3.20	11/8/07		2.42	11/8/07		1.66	11/19/07		1.39	11/19/07		1.57	11/27/07		0.35	11/27/07		0.39
12/3/07		2.93	12/27/07		2.06	12/27/07		2.19	12/27/07		1.86	12/27/07		1.34				12/10/07		0.48
1/15/08		2.28				1/23/08		2.21				1/23/08		0.52				1/16/08		0.73
2/13/08		2.17				2/27/08						2/26/08		1.61				2/7/08		0.95
3/18/08		1.40				3/26/08		1.37				3/26/08		1.33				3/6/08		0.93
4/15/08		0.95				4/28/08		1.14				4/29/08	<	0.13				4/24/08		0.73
5/6/08		1.86				5/14/08		1.14				5/14/08		1.19				5/27/08		0.49
6/4/08	>	2.30				6/12/08		0.94				6/12/08		1.37				6/19/08	<	0.35
7/8/08		2.13				7/24/08		0.98				7/24/08		1.16				7/10/08	<	0.24

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
8/12/08		2.59				8/14/08												8/27/08		0.42
9/10/08		2.16				9/29/08		1.65				9/29/08		1.61				9/25/08		0.64
10/23/08		1.89				10/9/08		1.76				10/9/08		1.67				10/23/08		0.62
11/19/08		1.62				11/6/08		2.08												
12/18/08		1.12				12/29/08		1.32										12/4/08		0.86
1/6/09		1.65				1/28/09		1.17				1/26/09		0.225				1/15/09		0.99
2/11/09		1.79				2/19/09		1.91										2/26/09		0.83
3/4/09		0.61				3/30/09		1.26				4/23/09		0.61				3/12/09		1.13
4/21/09		1.42				4/21/09		0.64				5/12/09		1.21				4/8/09		0.94
5/13/09		0.91				5/12/09		0.91				6/4/09		0.64				5/7/09		0.41
6/16/09		0.55										7/23/09		0.98				6/4/09		0.68
7/16/09		1.46				7/23/09		1.26				8/27/09		0.96				7/23/09		0.277
8/12/09		1.81				8/27/09		0.53										8/12/09	<	0.17
9/2/09		1.38				9/30/09		1.39				9/30/09		1.44				9/10/09	<	0.52
11/2/09		1.45				11/16/09		0.61				11/16/09		0.64						
																		12/3/09		0.79
1/7/10		0.97													1/7/10		0.84			
			2/4/10		0.76	2/4/10		0.97										2/3/10		0.58
3/1/10		1.02													3/25/10		1.22			
																	0.64	4/1/10		0.73
5/18/10		2.32	5/26/10		1.04	5/26/10		0.84				5/12/10		1.09	5/20/10		0.525			
												7/27/10		0.9				6/17/10		0.66
7/8/10		1.81										7/27/10		0.9	7/15/10	<	0.38			
												11/18/10		2.17				8/26/10	<	0.51
9/7/10		1.20	9/20/10		1.35	9/20/10		0.99				9/15/10		1.33	9/16/10		0.81			
															11/18/10		1.02	10/28/10		7.75
11/9/10		2.52	11/17/10		2.38	11/17/10		1.94				11/18/10		2.17						
																		12/9/10		1
			1/27/11		1.40															
2/22/11		2.14	2/9/11		0.98	2/9/11		0.80	2/24/11		1.4	2/9/11		0.88						
			3/15/11		1.30										3/24/11		1.02	3/24/11		1.03
4/12/11		0.98	4/7/11		0.63				4/21/11											
			5/18/11		1.20															
6/9/11		1.30	6/13/11		1.37	6/13/11		0.78	6/16/11			6/13/11		1.13						
			7/7/11		1.29										7/28/11	<	0.121	7/28/11	<	0.12
8/3/11		1.07	8/10/11		1.00	8/10/11		0.94	8/18/11		0.84	8/25/11		1.96						
			9/8/11		1.40										9/27/11		0.95	9/27/11		1.06
10/5/11		2.50	10/13/11		2.35	10/13/11		2.02	10/27/11		1.26	10/27/11		1.8						
			11/30/11		2.49										11/14/11		1.39	11/14/11		1.12

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
12/15/11		0.97	12/12/11		0.88	12/12/11		1.62	12/7/11		1.69									
			1/18/12		1.09	1/18/12		1.23				1/25/12		1.04	1/19/12		1.22	1/19/12		1.25
2/2/12		1.89							2/22/12		1.35	2/22/12		1.4						
			3/20/12		1.52	3/20/12		1.69							3/22/12		0.97	3/22/12		0.79
4/4/12		1.48							4/26/12			4/26/12		0.93						
			5/17/12		1.37	5/17/12		1.35							5/17/12		0.7	5/17/12		0.67
6/14/12		2.36							6/14/12		0.82	6/14/12		1						
			7/23/12		1.27	7/23/12		0.95							7/19/12		0.913	7/19/12	<	0.18
8/8/12		1.85							8/16/12		1.00	8/16/12		1.22						
			9/12/12		1.14	9/12/12		1.09							9/27/12		0.68	9/27/12		0.37
10/8/12		1.88							10/23/12		1.16	10/23/12		1.56						
			11/14/12		1.90	11/14/12		1.55							11/15/12		0.79	11/15/12		0.76
12/5/12		2.23							12/5/12		1.46	12/5/12		1.66						
1/8/13		1.74	1/8/13		2.07	1/8/13		1.68							1/17/13		1.38	1/17/13		1.07
									2/27/13		1.33	2/27/13		1.29						
3/27/13		1.18	3/27/13		0.68	3/27/13		1.40	4/17/13		1.29				3/21/13		0.88	3/21/13		0.99
									6/20/13		0.82	4/17/13		1.43						
5/23/13		1.11	5/23/13		1.65	5/23/13		1.33							5/16/13		0.9	5/16/13		0.9
									8/8/13		0.95	6/20/13		0.85						
															7/18/13		0.3	7/18/13	<	0.24
									10/10/13		1.33	8/8/13		2.63						
															9/12/13		0.443	9/12/13		0.44
									12/12/13		12.70	10/10/13		1.58						
11/19/13		2.31	11/19/13		2.38	11/21/13		1.83												
												12/12/13		12.75						
									1/8/14		1.49	1/8/14		1.02						
2/6/14		2.18	2/6/14		2.43	2/6/14		2.12							2/20/14		1.36	2/20/14		1.27
									3/19/14		1	3/19/14		0.98						
															4/17/14		1.06	4/17/14		0.9
									5/22/14		1.17	5/22/14		1.4						
6/11/14		1.73	6/11/14		1.25	6/11/14		1.24							6/12/14		0.35	6/12/14		0.461
									7/16/14		0.80	7/16/14		1.11						
															8/14/14		0.43	8/14/14		0.36
10/20/14		1.44	10/20/14		0.97	10/20/14		1.31												
12/18/14		2.19	12/18/14		1.22	12/18/14		1.16							12/11/14		1.13	12/11/14		1.08
1/20/15	<	0.72				1/20/15	<	0.87	1/21/15		1.11	1/22/15			1/22/15		0.92	1/22/15		0.78
						3/3/15		1.43	2/25/15		1.46	2/19/15		1.56	2/19/15		0.92	2/19/15		0.81
3/25/15		1.59				3/25/15		1.92				3/18/15			3/18/15		1.33	3/18/15		1.26

Fishing Creek Reservoir									Cedar Creek Res			Lake Wateree								
						4/13/15		1.30	4/13/15		1.41	4/16/15		1.51	4/16/15		1.22	4/16/15		1.06
5/14/15		2.65				5/14/15		1.65	5/27/15		1.24	5/21/15			5/21/15		1.24	5/21/15		1.1
07/14/15		1.47				07/14/15		1.51	07/15/15		1.59				07/23/15	<	0.39	07/23/15	<	0.40
						08/20/15		1.44	08/20/15		1.33	08/13/15		1.4	08/13/15		0.49	08/13/15	<	0.47
09/29/15		2.06				09/29/15		2.00	09/30/15		1.50				09/17/15		0.66	09/17/15		0.60
						10/20/15		2.04	10/15/15		1.76				10/22/15		1.41	10/22/15		1.23
11/17/15		1.56				11/17/15		1.24	11/30/15		1.15				11/19/15		1.18	11/19/15		1.28
						12/09/15		1.19	12/09/15		1.47									

Chlorophyll-*a*

Fishing Creek Reservoir				Cedar Creek Res		Lake Wateree					
CW-016F		**CW-057**		**CW-033**		**CW-231**		**CW-207**		**CL-089**	
Date	**Chlor *a***	**Date**	**Chlor *a***	**Date**	**Chlor a**	**Date**	**Chlor *a***	**Date**	**Chlor *a***	**Date**	**Chlor *a***
	mg/L		**mg/L**		**mg/L**		**mg/L**		**mg/L**		**mg/L**
05/07/98	2.3	05/07/98	11.2	05/14/98	13.1	05/14/98	5.2	05/07/98	12.9		
06/09/98	3.8	06/09/98	16.4	06/23/98	7.0	06/23/98	24.3	06/10/98	23.6		
07/01/98	1.9	07/01/98	30.6	07/30/98	34.7	07/30/98	8.5	07/16/98	27.8		
08/06/98	7.6	08/06/98	15.9	08/27/98	16.5	08/27/98	5.9	08/06/98	31.4		
09/15/98	8.0	09/15/98	34.0	09/17/98	28.4	09/17/98	3.0	09/14/98	23.6		
05/04/00	3.8	05/04/00	24.2					05/09/00	23.9		
06/01/00	6.9	06/01/00	42.6					07/13/00	32.2		
07/20/00	44.3	07/20/00	34.6					08/03/00	32.9		
08/17/00	29.3	08/17/00	28.0					09/21/00	36.2		
								10/19/00	34.8		
		05/03/01	29.6			05/17/01	0.5				
		06/28/01	14.4			06/28/01	7.5			06/21/01	14.9
		07/19/01	42.2			07/26/01	4.6			07/23/01	15.4
		08/23/01	47.8			08/09/01	7.0			08/15/01	23.6
		09/19/01	26.0			09/06/01	1.8			09/11/01	18.3
		10/18/01	15.3			10/25/01	6.4			10/18/01	15.7
05/30/02	6.3	05/30/02	43.0	05/30/02	13.7	05/30/02	5.0	05/02/02	29.6	05/02/02	9.9
06/13/02	33.3	06/13/02	75.7	06/13/02	9.4	06/13/02	14.9	06/20/02	34.5	06/20/02	26.0
07/31/02	41.6	07/31/02	43.8	07/31/02	9.3	07/31/02	15.8	07/02/02	22.6	07/02/02	13.5
08/22/02	23.6	08/22/02	28.6			10/31/02	1.1	08/22/02	26.1	08/22/02	13.9
10/31/02	2.2	09/30/02	21.4			11/21/02		09/04/02	36.2	09/04/02	6.8
		10/31/02	6.5	10/31/02	2.8	12/17/02		10/23/02	28.7	10/23/02	11.0
						09/29/03	9.2			09/02/03	15.9
		10/30/03	4.5			10/29/03	2.3			10/09/03	6.0
						09/29/03	9.2			09/02/03	15.9
		10/30/03	4.5			10/29/03	2.3			10/09/03	6.0
						05/19/05	5.1			03/30/05	
		05/12/05	27.2			06/21/05	7.2			04/07/05	
		06/16/05	44.9			07/27/05	4.6			05/26/05	13.0

Fishing Creek Reservoir				Cedar Creek Res		Lake Wateree					
		07/13/05	10.4			08/11/05	4.7			06/30/05	30.9
		08/30/05	16.3			09/07/05	4.2			07/28/05	10.4
		09/12/05	13.3			10/03/05				08/30/05	6.8
		05/30/06	22.9			05/23/06	9.1			05/25/06	7.5
		06/19/06	34.4			06/06/06	6.8			06/28/06	32.9
		07/17/06	38.1			07/17/06	5.7			07/06/06	18.4
		08/03/06	30.2			08/23/06	8.2			08/24/06	22.8
		09/07/06	17.0			09/27/06	3.2			09/05/06	3.5
		10/05/06	33.9			10/12/06	4.9			09/21/06	41.0
						11/29/06				10/30/06	5.7
										01/08/07	20.5
				03/29/07		03/29/07				04/09/07	13.6
				04/19/07		04/19/07				04/10/07	8.6
05/17/07	6.3	05/17/07	15.4	05/31/07	22.9	05/31/07				05/17/07	23.1
06/26/07	7.9	06/13/07	23.7	06/26/07	10.1	06/26/07	8.1	06/14/07	24.0	06/14/07	26.4
07/12/07	13.8			07/19/07	25.3	07/19/07	9.7	07/12/07	32.5	07/12/07	
08/09/07	19.9			08/23/07	27.4	08/23/07	12.0	08/01/07	16.9	08/01/07	20.5
		09/08/07	31.6	09/20/07	13.0	09/20/07		09/04/07	22.9	09/04/07	13.6
		09/13/07	17.6	10/29/07	9.1	10/29/07		10/04/07	29.4	10/04/07	8.6
		11/10/07	41.3			11/19/07				11/27/07	
		12/07/07	25.4			12/27/07				12/07/07	13.7
		05/14/08	20.6			05/14/08				05/27/08	
		06/12/08	33.2			06/12/08				06/19/08	14.7
		07/24/08	40.0			07/24/08				07/10/08	11.9
		08/14/08	9.8			08/14/08	3.7			08/27/08	13.7
		09/29/08	11.2			09/29/08	3.4			09/25/08	7.5
		10/09/08	14.6			10/09/08	6.4			10/23/08	8.0
						05/12/09	11.2			05/06/09	13.4
		05/12/09	5.3			06/04/09	4.5			06/04/09	24.5
		07/23/09	15.8			07/23/09	4.3			07/23/09	9.2
		08/27/09	64.8			08/27/09	5.5			08/12/09	24.1
		09/30/09	23.5			09/30/09	2.6			09/10/09	40.4
		05/26/10	22.0	05/12/10	5.0						
										06/17/10	8.1

Fishing Creek Reservoir				Cedar Creek Res		Lake Wateree					
				07/27/10	31.9			07/15/10	21.8		
		09/20/10	43.1							08/26/10	16.5
				09/15/10		09/15/10	6.1	09/16/10	43.8		
										10/28/10	10.6
								05/26/11	31.0	05/26/11	35.0
		06/13/11	17.2	06/16/11	17.0	06/13/11	7.9				
								07/28/11	32.3	07/28/11	12.2
		08/10/11	34.2	08/18/11	19.9	08/25/11	5.0				
								09/27/11	31.2	09/27/11	11.1
		10/13/11	4.2	10/27/11	5.8	10/27/11	2.3				
								05/17/12	37.6	05/17/12	30.4
07/23/12	15.5	07/23/12	42.1							07/19/12	14.8
				08/16/12	3.6	08/16/12	12.1				
09/12/12	3.5	09/12/12	13.8					09/27/12	40.8	09/27/12	8.3
				10/23/12	3.5	10/23/12	1.1				
05/23/13	0.7	05/23/13	7.5					05/15/13	20.6	05/15/13	24.5
				06/20/13	9.7	06/20/13	5.6				
07/17/13	2.0	07/17/13	17.5					07/18/13	9.6	07/18/13	13.0
				08/08/13	12.1	08/08/13	2.3				
				05/22/14	7.6	05/22/14	2.1				
								06/12/14	14.5		
				07/16/14	16.8	07/16/14	9.4				
08/06/14	2.6	08/06/14	16.3							08/14/14	17.8
				09/18/14	8.8	09/18/14	4.4				
10/20/14	2.0	10/20/14	15.4					10/16/14	22.4	10/16/14	9.0
				11/06/14	7.1	11/06/14	2.6				
		05/14/15	33.3	05/27/15	16.3			05/21/15	15.1	05/21/15	11.0
		06/23/15	17.5	06/25/15	8.9	06/18/15	15.5	06/18/15	19.6	06/18/15	14.1
		07/14/15	28.9	07/15/15	18.8			07/23/15	34.1	07/23/15	15.6
		08/20/15	21.3	08/20/15	18.4	08/13/15	9.1	08/13/15	23.1	08/13/15	9.5
		09/29/15	20.2	09/30/15	11.9			09/17/15	36.2	09/17/15	8.4
		10/20/15	4.9	10/15/15	3.5			10/22/15	11.0	10/22/15	12.5