March 25, 2013

Mr. John Huisman
NC Department of Environment and Natural Resources
Division of Water Quality
Nonpoint Source Planning Unit
1601 Mail Service Center
Raleigh, North Carolina 27699-1601

Re: REVISIONS to City of Durham Submission of Falls Lake Inventory and Characterization of Load Reduction Potential – Revision 1, March 25, 2013

Dear Mr. Huisman:
The initial submittal of the City of Durham Falls Lake Inventory and Characterization of Load Reduction Potential (dated January 31, 2013) has been revised based on new data. The Division of Water Quality’s Raleigh Regional Office provided additional information regarding condition and proportion of discharging sand filter systems. These sources were used to revise information in sections 2 - Introduction, 2.2 - Discharging Sand Filter Systems, Including Availability of or Potential for Central Sewer Connection, and 2.3 - Properly Functioning and Malfunctioning Septic Systems; Figures 2-2 and 2-3 were revised to reflect the updated information; an Appendix E was added to the report.

Load reductions at edge of field were differentiated from the load to the lake for sand filter systems and septic systems based on data in the 2013 Hazen and Sawyer reported prepared for the City of Raleigh, A Review of Onsite Wastewater System Performance and Nutrient Trading Policy to Support Falls Lake Nutrient Strategy Development. This report provides a range of estimated nutrient loads from the source to the lake assuming soil and instream attenuation and WARMF modeling based calculations. An excerpt of the report has been included as Appendix E.

The accompanying geodatabase was revised by removing private property owner names for septic systems and sand filter systems.

As stated in our initial submittal, the potential load reductions are estimates developed by the City in conjunction with the County and Brown and Caldwell to provide a preliminary approximation of the potential reductions. These values are not an estimate of potential credits and should not be interpreted to represent actual expected nutrient removals.

If you have any questions, comments or need additional information, please contact Sandra Wilbur at (919) 560-4326 ext. 30286 or by e-mail at Sandra.Wilbur@DurhamNC.Gov.

Sincerely,

Paul Wiebke, PE
Assistant Director of Public Works
Stormwater and GIS Services

cc: John Cox
    Sandra Wilbur
    Lance Fontaine
The initial submittal of this report (dated January 31, 2013) has been revised by the City of Durham based on new information from the Raleigh Regional Office of the Division of Water Quality and on the report, *A Review of Onsite Wastewater System Performance and Nutrient Trading Policy to Support Falls Lake Nutrient Strategy Development*, by Hazen and Sawyer for the City of Raleigh Public Utilities Department (January 2013). These sources were used to revise information in sections 2 - Introduction, 2.2 - Discharging Sand Filter Systems, Including Availability of or Potential for Central Sewer Connection, and 2.3 - Properly Functioning and Malfunctioning Septic Systems; Figures 2-2 and 2-3 were revised to reflect the updated information; an Appendix E was added to the report.

**Limitations:**

*This document was prepared solely for City of Durham in accordance with professional standards at the time the services were performed and in accordance with the contract between City of Durham and Brown and Caldwell dated March 1, 2011. This document is governed by the specific scope of work authorized by City of Durham; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by City of Durham and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.*
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1. Introduction

The North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality (DWQ) Falls Lake Rules were developed to address the water quality issues in Falls Lake by reducing pollution being contributed by upstream sources. The final Falls Lake Rules were adopted by the Environmental Management Commission on November 18, 2010; the N.C. Rules Review Commission approved the Falls Lake Rules on December 16, 2010, and the effective date of the Falls Lake Rules was established on January 15, 2011. In accordance with 15A NCAC 02B.0278 (4)(d), local governments shall develop inventories and characterize load reduction potential, to the extent that accounting methods allow, for the following by January, 2013:

- wastewater collection systems
- discharging sand filter systems, including availability of or potential for central sewer connection
- properly functioning and malfunctioning septic systems
- restoration opportunities in utility corridors
- fertilizer management plans for local government-owned lands
- structural stormwater practices, including intended purpose, condition, potential for greater nutrient control
- wetlands and riparian buffers including potential for restoration opportunities

Brown and Caldwell performed an inventory and load reduction characterization of the above categories for the watersheds that drain to Falls Lake and are located within the City of Durham’s municipal corporate limits. As part of this inventory, the data presented in this memo were compiled into a geospatially-referenced geodatabase. Additionally, maps were generated to facilitate comparison of watershed-specific inventories and potential load reductions. The watersheds include: Lick Creek; Little Lick Creek; Panther Creek; Ellerbe Creek; Eno River; Little River; and Flat River.

2. Inventory and Potential Load Reduction Assumptions

The inventory and load reduction characterization was primarily completed as a desktop analysis using ESRI ArcGIS software. The GIS analysis was based on existing information Brown and Caldwell previously collected for the Ellerbe Creek Watershed Management Implementation Plan (City of Durham and Brown and Caldwell, 2010) and the Northeast and Crooked Creek Watershed Improvement Plan (City of Durham and Brown and Caldwell, in progress), data collected by the County of Durham regarding septic systems and sand filters, City-wide existing Stormwater Control Measure (SCM) data, and supporting GIS data layers as described in each section below. Local watershed plans and other local supporting documents, as listed below, were used to assist with the inventory and load reduction potential within each watershed:

- Ellerbe Creek Local Watershed Plan (NC Ecosystem Enhancement Program, 2003)
- Lick Creek Watershed Restoration Plan (Upper Neuse River Basin Association, 2009)
- Little Lick Creek Local Watershed Plan (Upper Neuse River Basin Association, 2006)
- UNRBA Technical Memorandum: Lick Creek Watershed Restoration Priorities (UNRBA, 2007)
- Upper Neuse Phase IV Restoration Implementation: Project Atlases (NCEEP, 2010)
- Priorities for Watershed Restoration in Little Lick Creek Memorandum (UNRBA, 2005)
The local watershed plans primarily presented recommendations to improve water quality and areas to focus preservation and improvement efforts. The project atlases and technical memoranda identified individual projects that were reviewed and, when appropriate, were included in this inventory. The load reductions assigned in this document are estimates developed by the City of Durham (City) and Brown and Caldwell to provide a preliminary approximation of the potential reductions. Generally, the reduction estimates are based on simplifying assumptions that differ from one category to the next. Unless otherwise noted, the estimates represent edge of field reductions or the functional equivalent. Values reported as edge-of-field are not an estimate of potential credits and should not be interpreted to represent actual expected nutrient removals. Moreover, the combined load from all generating sources is higher than the load delivered to the lake because of in-stream nutrient processing. The estimates provided in this technical memorandum generally represent potential load reductions at each site rather than at the lake, and potential load reductions measured at the lake would be less than those presented in this technical memorandum.

For sand filter systems and septic systems, loadings to Falls Lake were generated based on data from the report, “A Review of Onsite Wastewater System Performance and Nutrient Trading Policy to Support Falls Lake Nutrient Strategy Development” (prepared by Hazen and Sawyer for the City of Raleigh, 2013). This report provides estimates for nutrient reductions as measured from the edge of field to the load at the lake assuming some soil and instream attenuation occurs. The report provides similar reduction estimates based on the evaluation of the WARMF model developed for the Fall Lake watershed. In both cases the reduction estimate is made in two steps, soil attenuation, and in-stream attenuation.

The following sections describe the inventory process and assumptions made for load reductions for each category listed under 15A NCAC 02B.0278 (4)(d) of the Falls Lake Rules. Each section will explain how the inventory was completed, discuss the method to estimate the load reductions, and present tabular data showing the load reduction potential in each watershed. Each section also has a corresponding geodatabase component that provides geospatial data to support the inventory and load reduction potential, as shown on the attached figures. The geodatabase components have been designed to allow for updates to be easily made as additional research and data become available.

### 2.1 Wastewater Collection Systems

Wastewater collection systems can contribute total nitrogen (TN) and total phosphorus (TP) to surface waters as a result of sanitary sewer overflows (SSOs) and leaking sanitary sewer pipes. To reduce the frequency and scale of these occurrences, the City’s Department of Water Management (DWM) has implemented an inspection, maintenance, rehabilitation and replacement program for wastewater collection and conveyance assets.

**Inventory** – To perform the inventory of wastewater collection system assets, Brown and Caldwell coordinated with the City to obtain the database of SSOs and spills within the City. Given the Falls Lake Rules base year of 2006, this analysis was based on the spills and overflows that occurred in 2006, and each of these occurrences was grouped according to which watershed they occurred in to complete the inventory. The data source for the SSO data discharges for City owned systems was provided as a Microsoft Excel spreadsheet (Titled: Sewerspillsreportedfrompublicsystem-Falls Watershed.xlsx, provided on November 11, 2012), and the associated latitude and longitude fields were used to map the locations of each of the 19 occurrences, as shown on Figure 2-1. The spills and overflows shown on Figure 2-1, and included in the geodatabase as SSO_2006.shp, are those that occurred in 2006. They are presented as a baseline from which to estimate watershed-wide load reductions.

**Load Reduction Assumption** – The 80:20 rule was used in assuming the TN and TP reduction potential for wastewater collection systems. The 80:20 rule is a generally accepted industry rule that assumes that 80 percent of the nutrient loadings will be removed from each watershed by repairing or replacing 20 percent of the pipes. This rule presumes that the 20 percent of pipes that are repaired or replaced are those pipe sections that have been identified as leaking or failing. A comprehensive assessment of the sanitary sewer system existing conditions would need to be completed before these pipe sections could be identified; thus, this report does not identify which particular pipes will be repaired or replaced. Since the Falls Lake Rules...
used the year 2006 as a baseline year for water quality, the total volume of leaks or spills that occurred in each watershed are shown as 2006 totals.

To determine the annual load reduction for nutrients, Durham water reclamation facility raw sewage nutrient concentrations (Table 4 of “Evaluation of Pollutants in Wastewater Generated by Mobile Car Washing Operations in Durham, NC, August 2012”) were applied to the 2006 total spill volume to determine the amount of TN and TP potentially contributed to each watershed. These typical concentrations are 39 mg/L for TN and 6.3 mg/L for TP. The estimated load reductions presented in Table 2-1 are 80 percent of the total 2006 annual nutrient loadings, as specified by the 80:20 rule.

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Total Number of SSOs or Leaks in 2006</th>
<th>Total Volume Released in 2006 (gal)</th>
<th>TN Removed by 80% Reduction in Spills (lbs/yr)</th>
<th>TP Removed by 80% Reduction in Spills (lbs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lick Creek</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Little Lick Creek</td>
<td>1</td>
<td>40,000</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Ellerbe/Panther Creek</td>
<td>15</td>
<td>184,807</td>
<td>48</td>
<td>8</td>
</tr>
<tr>
<td>Eno River</td>
<td>3</td>
<td>7,072,000</td>
<td>1,841</td>
<td>297</td>
</tr>
<tr>
<td>Little River</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Flat River</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

### 2.2 Discharging Sand Filter Systems, Including Availability of or Potential for Central Sewer Connection

Discharging single-pass, sand filters are a form of onsite wastewater treatment systems. These systems pass septic tank effluent through a system of perforated distribution pipes, so that the effluent can percolate through 18-inches of sand; a second series of perforated pipes underneath the sand collects any filtered effluent that does not percolate into the surrounding soil. Discharging sand filter systems can be effective for removing total suspended solids (TSS) and TP, but may be less effective for TN. As with all onsite wastewater disposal systems, the effectiveness of a discharging sand filter is a function of the initial design and installation, site soil characteristics, and the subsequent operation, inspection, and maintenance practices. According to the Raleigh Regional Office of the Division of Water Quality, 7% of the systems they had visited have a problem, while only 31 to 32% show any evidence of a discharge, with many of these being a small trickle. Discharging sand filter systems in the City are regulated by the State, and are not under the jurisdiction of municipalities.

**Inventory** – To perform the inventory of discharging sand filter systems, Brown and Caldwell coordinated with the City to obtain data from Durham County to map the location of discharging sand filter systems within the City’s municipal corporate limits. The data source for this inventory was a Microsoft Excel file, received from Durham County on January 16, 2013 and titled DurhamFalls_Inv_2012Dec31.xls, which included all of the parcels treated by a sand filter. This file was then joined to the City of Durham 2012 parcel data based on the parcel PID number to spatially display and examine the sand filters, which were then grouped according to watershed, as shown in CitySandFilters.shp in the geodatabase. Appendix A presents the City On-Site Septic and Sandfilter Inventory, prepared by the Durham County Environmental Health Division and submitted on January 25, 2013. This document, as supported by the geodatabase shapefile, shows that there are 253 sand filter systems in the City, all of which are filter bed systems. The shapefile only shows 250 parcels because three of the sand filter systems were located on parcels that already had at least one sand filter. According to the inventory in Appendix A, 191 of these sites have public sewer available. Assuming that each of these parcels has 200 linear feet of road frontage, it would cost approximately $2.3
Use of contents on this sheet is subject to the limitations specified at the beginning of this document.
Revised_FinalFallsLakeInventory_March2013.docx

Revised_FinalFallsLakeInventory_March2013.docx

millions to connect all 191 lots to an existing sewer line, using the estimate presented in Appendix B at a cost of $12,015 per lot connection.

**Load Reduction Assumption** – To characterize the load reduction potential for discharging sand filter systems, Brown and Caldwell estimated the TN and TP reduction by assuming the parcels identified in the County’s sand filter inventory have public sewer available and would be connected to the public system with the sand filter being decommissioned. The City conducted a study of sand filters that had surface discharges and obtained average effluent concentrations in 1999-2000 and again in 2008 as presented in *Nutrient and Bacteria Characterization of Surface Discharging Sand Filter Systems* (City of Durham, Stormwater Services, 2008). The 2008 average TN effluent was 40.4 mg/L. It is important to note that these concentrations were measured from samples taken from sand filter discharge pipes and represent surface discharge. This report does not account for concentrations and associated potential load reductions that enter shallow groundwater. Limited TP data from this study indicated a concentration of 16 mg/L which seemed higher than usual. Because the TN average concentration of 40.4 mg/L is comparable to the value developed by Metcalf and Eddy of 40 mg/L, the Metcalf and Eddy value for TP (10 mg/L) will be used. It is assumed that these concentrations are representative of all systems that are actually discharging. If these systems are connected to sewer, there will be a significant reduction in the concentration discharged. If the wastewater treatment plant effluent concentration is 3 mg/L for TN and 0.2 mg/L for TP, then the net TN reduction will be 40.4 – 3 mg/L or a net reduction of 37.4 mg/L for TN and 9.8 mg/L for TP.

Wastewater flow to the septic tank was assumed to average 144 gallons per day per household, which is based on 2.4 persons per household and 60 gallons per capita per day. As previously mentioned, according to the Raleigh Regional Office of the Division of Water Quality, 7% of the systems they had visited have a problem, while only 31 to 32% of the systems show any evidence of a discharge. Therefore, 7% of the systems are discharging and poorly functioning and 25% (32%-7%) of the systems are discharging but not poorly performing.

For the 7% of systems that were poorly functioning, it was conservatively assumed that the soil media is clogged and that all of the effluent discharges from the tail pipe. For the 7% of systems that are poorly functioning, using TN effluent reduction of 36.4 mg/L with average effluent flow of 144 gpd results in a yield less than 16.4 pounds of TN per year per household. Assuming the same effluent flow, the TP yield per system would be less than 4.3 pounds per year for poorly performing systems. These reductions in TN and TP yield were used to calculate reduction in total load at edge-of-field based on connecting these systems to city sewer.

For the 25% of systems that are discharging but are not poorly performing it was assumed that these systems represent a range of discharge rates that varies linearly from 0 to 144 gpd. The 25% of systems that are operational but which are discharging, the average yield is 8.2 pounds of TN per year per system. For other discharging systems the average yield is 2.2 pounds TP per year. Thus, load reductions due to connecting parcels to public sewer and decommissioning sand filter systems is shown in Table 2-2.

Table 2-2 shows the total number of sand filter systems by watershed and the associated potential load reduction if systems that are discharging are connected to sanitary sewer lines. The table differentiates the TN and TP load at lake from the edge of field load and provides a range of reduction values assuming some instream attenuation occurs (Assumption 2, Appendix E) and on WARMF modeling based calculations (36% - 36% removal of TN and 41.5% - 42% removal of TP – see Appendix E). These estimates were based on the data included in Appendix E which were excerpted from the report, “A Review of Onsite Wastewater System Performance and Nutrient Trading Policy to Support Falls Lake Nutrient Strategy Development” (prepared by Hazen and Sawyer for the City of Raleigh, 2013).
Table 2-2. Inventory and Characterization: Sand Filter Systems

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Total Number of Sand Filter Systems</th>
<th>Total Number</th>
<th>Edge of Field TN Load Reduction (lbs/yr)</th>
<th>Estimated TN Load at Lake (lbs/yr)</th>
<th>Edge of Field TP Load Reduction (lbs/yr)</th>
<th>Estimated TP Load at Lake (lbs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls Lake</td>
<td>191 sewer available</td>
<td>61</td>
<td>611</td>
<td>220 - 220</td>
<td>162</td>
<td>67.2 - 68</td>
</tr>
</tbody>
</table>

1 – 253 total
2 – Range for estimated Load at Lake based on data from Hazen and Sawyer for the City of Raleigh, 2013 (36% - 36% removal of TN from edge of field load)
3 – Range for estimated Load at Lake based on data from Hazen and Sawyer for the City of Raleigh, 2013 (41.5% - 42% removal of TP from edge of field load)

2.3 Properly Functioning and Malfunctioning Septic Systems

Septic systems are a form of onsite wastewater treatment systems. If a septic system is properly planned, sized, designed, located, permitted, installed and maintained, then TN and TP discharges to surface water should be minimal. As with all onsite wastewater treatment systems, the effectiveness of a septic system is a function of the initial design and installation, and the subsequent operation, inspection, and maintenance practices. Septic systems in the City of Durham are regulated by the County and the State, and are not under the jurisdiction of municipalities.

Inventory – To perform the inventory of septic systems, Brown and Caldwell coordinated with the City to obtain GIS data from Durham County to map the location of parcels served by septic systems that are located within the City’s municipal corporate limits. The data source for this inventory is a Microsoft Excel file, titled DurhamFalls Inv_2012Dec31.xls, which includes all of the parcels that are treated by a septic system (unknown systems were assumed to be septic systems rather than sand filters). This excel file was provided by Durham County on January 16, 2013 and was joined to the City of Durham 2012 parcel data by the parcel PIN number to spatially display and examine the septic systems. The septic systems were then grouped according to watershed, as shown on Figure 2-3. Appendix A shows the inventory compiled by Durham County, where the first table shows the count of each type of septic system inside the City of Durham municipal corporate limits as well as the associated estimated failure rate for each type. Note that the inventory lists 1,017 septic systems in the City, but the shapefile only shows 1,009 parcels. This is because eight of the septic systems were located on parcels that already had at least one septic system. A definition of each of the septic system types shown can be found in Appendix C, Table V(a) of the North Carolina Administrative Code 18A.1961 (NCDENR, 1990).

Load Reduction Assumption – To characterize the load reduction potential for discharging septic systems, Brown and Caldwell estimated the edge of field TN and TP reduction by assuming: 1) the property of a malfunctioning septic system would be connected to existing sanitary sewer lines where available (within 100 feet of an existing line), or 2) malfunctioning septic systems would be replaced with functioning septic systems to a degree that results in less than 10 percent of systems failing.

Connecting septic systems to existing public sanitary sewer lines is an alternate way to achieve load reductions. Thus, the spatial septic system data was analyzed to locate those septic systems within 100 feet of an existing sanitary sewer line and are identified in the geodatabase as CitySeptic.shp. Approximately 775 of these systems were within 100 feet of a force main, gravity main, or lateral line and recognized as being able to be removed from service as the parcel could be served by public sanitary sewers. With this information, Brown and Caldwell estimated the load reduction potential of removing these systems. The EPA Model Program for the Chesapeake Bay Watershed estimates the average septic tank effluent to contain approximately 9 lbs per person per year of TN, with the average person using 75 gallons of water per day (EPA, 2012). Assuming that each septic system serves a household, and the average household size is about 2.4 persons, the average septic tank effluent is 21.6 lbs of TN per year. This is the amount entering
shallow groundwater; a significant fraction of this nitrogen will undergo denitrification in the hyporheic zone as the groundwater enters surface waters. This average TN effluent is equivalent to approximately 39.4 mg/L, which is comparable to the Metcalf and Eddy estimated value of 40 mg/L. Since there is no data available on TP from this model program, the Metcalf and Eddy value of 10 mg/L is applied. Load reductions are reported as an average of 21.6 lbs of TN per year and 5.5 lbs of TP per year per septic system for edge of field results. The table differentiates the TN and TP load at lake from the edge of field load and provides a range of reduction values assuming some soil and instream attenuation occurs (Assumption 3, Appendix E) and on WARMF modeling based calculations (86% - 92.4% removal of TN and 90.3% - 90.4% removal of TP – see Appendix E). These estimates were based on the data included Appendix E from the report, “A Review of Onsite Wastewater System Performance and Nutrient Trading Policy to Support Falls Lake Nutrient Strategy Development” (prepared by Hazen and Sawyer for the City of Raleigh, 2013). Table 2-3 presents these estimated potential load reductions, as well as the estimated cost to connect the systems to public sanitary sewer lines, using the estimate of $12,015 per parcel as shown in Appendix B.

As mentioned in Section 2.2, septic system failure surveys reviewed by USEPA cite septic system failure rates ranging from 10 to 20 percent (USEPA, 2000). Thus, failure rates below 10 percent were not directly assessed in this report and are assumed to be addressed and corrected through the mandatory ongoing inspections. The average weighted failure rate is shown on the attached Durham County septic system inventory to be 5.48 percent. Since this is below the lower range of the EPA expected failure rate of 10 percent, no further load reductions are anticipated due to repairing or replacing failing systems. Note that Type 4 (LPP distribution or more than 1 pump or siphon) septic systems have a higher estimated failure rate of 15.8 percent. Type 4 systems represent only 4.6 percent of the septic systems in the municipal City limits. Mandated periodic inspections of Type 4 septic systems will continue to be conducted, which are expected to address this higher failure rate, and no further reductions from Type 4 systems are anticipated.

### Table 2-3. Inventory and Characterization: Septic Systems

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Total Number of Septic Systems</th>
<th>Total Number</th>
<th>Edge of Field TN Load Reduction (lbs/yr)</th>
<th>Estimated TN Load at Lake (lbs/yr)</th>
<th>Edge of Field TP Load Reduction (lbs/yr)</th>
<th>Estimated TP Load at Lake (lbs/yr)</th>
<th>Estimated Cost to Connect to Public Lines ($)</th>
<th>Existing Percent of Remaining Septic Systems Failing (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lick Creek</td>
<td>13</td>
<td>3</td>
<td>65</td>
<td>4.9 - 9.1</td>
<td>17</td>
<td>1.6 - 1.6</td>
<td>36,045</td>
<td>5.48</td>
</tr>
<tr>
<td>Little Lick Creek</td>
<td>123</td>
<td>94</td>
<td>2,030</td>
<td>154.3 - 284.2</td>
<td>517</td>
<td>49.6 - 50.1</td>
<td>1,129,410</td>
<td>5.48</td>
</tr>
<tr>
<td>Ellerbe/Panther Creek</td>
<td>227</td>
<td>198</td>
<td>4,277</td>
<td>325.1 - 598.8</td>
<td>1,089</td>
<td>104.5 - 105.6</td>
<td>2,378,970</td>
<td>5.48</td>
</tr>
<tr>
<td>Eno River</td>
<td>618</td>
<td>487</td>
<td>10,519</td>
<td>799.4 - 1472.7</td>
<td>2,679</td>
<td>257.2 - 259.9</td>
<td>5,851,305</td>
<td>5.48</td>
</tr>
<tr>
<td>Little River</td>
<td>28</td>
<td>11</td>
<td>238</td>
<td>18.1 - 33.3</td>
<td>61</td>
<td>5.9 - 5.9</td>
<td>132,165</td>
<td>5.48</td>
</tr>
<tr>
<td>Flat River</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

1 – Range for estimated Load at Lake based on data from Hazen and Sawyer for the City of Raleigh, 2013 (86% - 92.4% removal of TN from Edge of Field load)

2 – Range for estimated Load at Lake based on data from Hazen and Sawyer for the City of Raleigh, 2013 (90.3% - 90.4% removal of TP from Edge of Field load)

### 2.4 Restoration Opportunities in Utility Corridors

Utility corridors were defined as locations where City-owned wastewater collection system assets are located. The average cleared easement is approximately 40 feet wide, with some easements wider or narrower than others. Restoration opportunities were identified as those cleared areas that had the potential to be revegetated to improve bank stability and remove pollutants.
Inventory – To perform the inventory of restoration opportunities in utility corridors, Brown and Caldwell performed a GIS spatial analysis using the City’s GIS data for the wastewater collection system and GIS data for streams within the City’s municipal corporate limits. The streams were buffered by 50 feet to meet the Neuse River Basin Buffer Rules (NCDENR, 2000) and the utility corridors were buffered by 20 feet to create a 40-foot wide easement typical of the City. These two buffered areas were then intersected to locate areas of potential restoration opportunities where the utility corridor either crossed or paralleled a stream. Brown and Caldwell used 2012 aerial imagery to identify opportunities for riparian buffer restoration projects where the City’s wastewater collection system is located adjacent to (within 50 feet) or crossing a stream, resulting in a significant absence of vegetation. Each identified buffer restoration opportunity in City-managed utility corridors is included in the geodatabase in the shapefile Riparian_Buffer_Restoration.shp. The data sources for this inventory were the 2012 City of Durham sanitary sewer gravity mains (snGravityMain.shp, 2011), force mains (snForceMain.shp, 2011), lateral lines (snLateralLine.shp, 2011), the 2012 City of Durham stormwater channels layer (SWChannels, 2012), and 2012 aerial imagery.

Load Reduction Assumption – To characterize TN and TP load reduction potential for restoration opportunities, Brown and Caldwell assumed that a 15-foot corridor, centered over the utility, would be maintained and cleared of tall or dense vegetation. The remainder of the existing cleared utility corridor within 50 feet of the stream bank was assumed to be restored. The assumed load reduction for these restored areas was calculated using the NCDWQ nutrient reductions associated with riparian buffer establishment of 75.77 lbs/ac/yr for TN and 4.88 lbs/ac/yr for TP, as shown in Appendix D (NCDWQ, 2012). Each buffer restoration opportunity area is included in the geodatabase as Riparian_Buffer_Restoration.shp and includes the assumed load reduction for that area. Table 2-4 shows a summary of the potential load reduction within each watershed.

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Total Number of Opportunities</th>
<th>Total Area Available for Restoration (ac)</th>
<th>Potential TN Removal (lbs/yr)</th>
<th>Potential TP Removal (lbs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lick Creek</td>
<td>2</td>
<td>0.3</td>
<td>23</td>
<td>1.5</td>
</tr>
<tr>
<td>Little Lick Creek</td>
<td>8</td>
<td>5.0</td>
<td>377</td>
<td>24.3</td>
</tr>
<tr>
<td>Ellerbe/Panther Creek</td>
<td>49</td>
<td>37.6</td>
<td>2,849</td>
<td>183.5</td>
</tr>
<tr>
<td>Eno River</td>
<td>49</td>
<td>40.6</td>
<td>3,075</td>
<td>198.0</td>
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<tr>
<td>Little River</td>
<td>10</td>
<td>3.7</td>
<td>282</td>
<td>18.1</td>
</tr>
<tr>
<td>Flat River</td>
<td>1</td>
<td>0.1</td>
<td>8</td>
<td>0.5</td>
</tr>
</tbody>
</table>

2.5 Fertilizer Management Plans for Local Government-Owned Lands

Inventory – To perform the inventory of fertilizer management plans for City-owned lands, Brown and Caldwell coordinated with the City to obtain GIS data to map the location of City-owned parcels that require landscaping services such as parks, City offices, etc. The number of City-owned parcels and the acreage of the City-owned parcels for each watershed are included in the geodatabase as Fertilizer_Management_Plan.shp. A total of 71 City-owned parcels were identified and each parcel was assigned an estimated percentage of maintained area based on a desktop visual examination. The data source for this inventory was the City of Durham 2012 parcel data (Parcels.shp, 2012) and 2012 aerial imagery to estimate percentages of maintained area.

Load Reduction Assumption – To characterize the load reduction potential for fertilizer management plans, a baseline of current fertilizer application rates are needed. The City is working on a Fertilizer Management Plan with the three departments that use fertilizer (General Services, Parks and Recreation, and Water Management) to maintain City-owned land. Phosphorus-free fertilizers are used except when establishing turf on newly-graded land. Brown and Caldwell assumed fertilization rates listed by the NC Cooperative Extension, which lists a high application rate of nitrogen (N) as 4 pounds of N per 1,000 square feet per year.
and a basic application rate of N as 2 pounds of N per 1,000 square feet per year. Brown and Caldwell assumed the City uses a 16-0-8 ratio of N-P-K (Nitrogen-Phosphorus-Potassium) as a typical ratio for fertilizer application on City-owned land. This fertilizer ratio implies that, to apply 1-pound of N, 6.25 pounds of a 16-0-8 fertilizer would need to be applied per 1,000 square feet. Thus, to achieve the high application rate of 4 lbs per 1,000 square feet per year, 25 pounds per 1,000 square feet of 16-0-8 fertilizer would need to be applied annually. To achieve the basic application rate of 2 lbs of N per 1,000 square feet per year, 12.5 pounds per 1,000 square feet of 16-0-8 fertilizer would need to be applied annually. The estimated load reduction for fertilizer management will be based on the difference between the high and basic application rates, which is 2 lbs per 1,000 square feet and area of maintained land on City-owned parcels. The Fertilizer_Management_Plan.shp file in the geodatabase includes the acreage of each parcel, the estimated percent maintained, the load reduction potential of 2 lbs of TN per 1,000 square feet per year, and the total estimated load reduction for each identified City-maintained parcel. Table 2-5 shows a summary of the potential load reduction within each watershed.

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Total Number of Parcels</th>
<th>Total Area Managed (ac)</th>
<th>Potential Reduction in TN Applied (lbs/yr)</th>
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<tr>
<td>Lick Creek</td>
<td>0</td>
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<td>--</td>
</tr>
<tr>
<td>Little Lick Creek</td>
<td>7</td>
<td>9.2</td>
<td>802</td>
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<tr>
<td>Ellerbe/Panther Creek</td>
<td>52</td>
<td>51.7</td>
<td>4,505</td>
</tr>
<tr>
<td>Eno River</td>
<td>10</td>
<td>28.5</td>
<td>2,485</td>
</tr>
<tr>
<td>Little River</td>
<td>2</td>
<td>2.1</td>
<td>187</td>
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<tr>
<td>Flat River</td>
<td>0</td>
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</tr>
</tbody>
</table>

2.6 Structural Stormwater Practices, Including Intended Purpose, Condition, and Potential for Greater Nutrient Control

Structural stormwater practices were defined as those structural facilities intended to capture and treat stormwater. Examples of such facilities are wet ponds, dry ponds, constructed wetlands, bioretention areas, and sand fillers, often referred to as Stormwater Control Measures (SCM). The City has provided Brown and Caldwell with GIS data documenting the location of existing structural stormwater practices within the City’s municipal corporate limits (swBMP.shp, received 10 December, 2012).

Inventory – To perform the inventory of structural stormwater practices, Brown and Caldwell performed a spatial analysis using GIS data for the location of structural stormwater practices and GIS data for the watershed boundaries to report the number of structural stormwater practices located within each watershed and within the City’s existing municipal corporate limits. In addition, Brown and Caldwell reviewed eight local watershed plans and supporting documents, as referenced in the introduction to Section 2 above, to include in the inventory other specific existing structural stormwater practices identified as candidates for greater nutrient reduction. These existing structural stormwater practices were included in the text of the document with accompanying location information and pictures. One example is the Summary of Field Work Activities in Little Lick Creek Memorandum (NC Center for Watershed Protection, 2005), which identified two dry ponds serving Pendleton Apartments as good candidates for retrofit to improve water quality treatment by addressing any needed repair issues and performing regular maintenance activities. This inventory was further broken down by type of SCM and by watershed, as shown on Figure 2-6 and in the geodatabase file StructuralStormwaterPractices.shp.

Load Reduction Assumption – To characterize the load reduction potential for structural stormwater practices recorded in the geodatabase, Brown and Caldwell used the findings from two previously completed watershed studies - Ellerbe Creek Watershed Improvement Plan (ECWIP) and Northeast and Crooked Creek Watershed Improvement Plan (NECWIP). The SCMs from the ECWIP and NECWIP were summarized based
on two primary categories: (1) the percent of SCMs of each type that had less than 100-percent existing functionality and the associated estimate of average reduction in existing functionality, and (2) the percent of each type of SCM that was recommended for a retrofit that would convert the SCM to a different type of SCM with a higher pollutant removal efficiency.

Each watershed within the Falls Lake basin was evaluated to determine if the watershed characteristics such as impervious cover, development type, and density were more similar to Ellerbe Creek or to Northeast Creek. This evaluation revealed that every watershed, other than Ellerbe Creek, was more similar to Northeast Creek. However, since the Northeast Creek watershed is located in the Jordan Lake basin and must comply with Jordan Lake Rules, the methodology behind designing and implementing SCMs in Northeast Creek will differ from that used in the Falls Lake watershed. Therefore, the numbers developed for each watershed were reviewed and adjusted, based on knowledge of the watersheds and the inventory of existing SCMs, to develop a set of numbers that better represents the Falls Lake watersheds. Table 2-6 shows, by watershed, the estimated number of each type of SCM that would be converted to a more efficient type of SCM. The table also presents the estimated number of SCMs with a reduced existing functionality and the resulting increase in nutrient removal at each SCM by improving the SCM to 100-percent functionality. Unless identified in an existing watershed management plan, specific SCMs were not identified for conversion as a part of this inventory. The nutrient removal at each SCM is dependent upon the size and land use of the drainage area; thus, the load reduction potential in this section is reported as a potential increase in efficiency at each SCM rather than in pounds of TN and TP. As an example, the average drainage area size for dry ponds recommended for retrofit in the Ellerbe Creek Watershed is approximately 5 acres, with an average associated potential load reduction of 6 lbs/ac/yr for TN and 1 lbs/ac/yr for TP. Similarly, these potential load reductions associated with retrofits of other types of SCMs are as follows: 97 lbs/ac/yr of TN and 20 lbs/ac/yr of TP for wet ponds with an average drainage area of approximately 77 acres; 2 lbs/ac/yr of TN and 1 lbs/ac/yr of TP for sand filters with an average drainage area of approximately 1 acre; and 8 lbs/ac/yr of TN and 1 lbs/ac/yr of TP for constructed wetlands with an average drainage area of approximately 8 acres. The numbers presented in Table 2-6 are estimates developed by the City and Brown and Caldwell and may change upon a more detailed watershed study.

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Type of Existing SCM (Intended Purpose)</th>
<th>Total Count</th>
<th>Number to Convert to Wet Pond*</th>
<th>Number to Convert to Constructed Wetland**</th>
<th>SCMs with Reduced Existing Functionality</th>
<th>Average Existing Functionality/Condition (% Efficient)</th>
<th>Potential Increase in TN Removal at each SCM (%)</th>
<th>Potential Increase in TP Removal at each SCM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lick Creek</td>
<td>Wet Pond</td>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dry Pond</td>
<td>26</td>
<td>7</td>
<td>10</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Bioretention</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Sand Filter</td>
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<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
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<td>0</td>
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</tr>
<tr>
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<td>Bioretention</td>
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</tr>
<tr>
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<td>0</td>
<td>2</td>
<td>0.66</td>
<td>12</td>
<td>15</td>
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Use of contents on this sheet is subject to the limitations specified at the beginning of this document.
Revised_FinalFallsLakeInventory_March2013.docx
### Table 2-6. Inventory and Characterization: Structural Stormwater Practices

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Type of Existing SCM (Intended Purpose)</th>
<th>Total Count</th>
<th>Number to Convert to Wet Pond*</th>
<th>Number to Convert to Constructed Wetland**</th>
<th>SCMs with Reduced Existing Functionality</th>
<th>Average Existing Functionality/Condition (% Efficient)</th>
<th>Potential Increase in TN Removal at each SCM (%)</th>
<th>Potential Increase in TP Removal at each SCM (%)</th>
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<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Constructed Wetland</td>
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<td>0</td>
<td>0</td>
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<td>--</td>
<td>--</td>
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</tr>
<tr>
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<td>Wet Pond</td>
<td>22</td>
<td>0</td>
<td>0</td>
<td>13</td>
<td>0.53</td>
<td>12</td>
<td>19</td>
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<tr>
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<td>Dry Pond</td>
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<td>17</td>
<td>0.66</td>
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<td>15</td>
</tr>
<tr>
<td></td>
<td>Constructed Wetland</td>
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<td>--</td>
<td>--</td>
<td>--</td>
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<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Little River</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wet Pond</td>
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<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
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<td></td>
<td>Dry Pond</td>
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<td>1</td>
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<td>0</td>
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<td>0.5</td>
<td>20</td>
<td>30</td>
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<td>Sand Filter</td>
<td>0</td>
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<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Constructed Wetland</td>
<td>0</td>
<td>--</td>
<td>--</td>
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<td>--</td>
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<tr>
<td>Flat River</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Conversion of a dry pond to a wet pond results in a potential increase in removal efficiency at each SCM of 10% for TN and 20% for TP.

**Conversion of a dry pond to a constructed wetland results in a potential increase in removal efficiency at each SCM of 20% for TN and 20% for TP. Conversion of a wet pond to a constructed wetland results in a potential increase in removal efficiency and each SCM of 10% for TN, with no increase for TP.

### 2.7 Wetlands and Riparian Buffers Including Potential for Restoration Opportunities

For the purposes of this section, riparian buffers were defined as areas adjacent to a stream, but not those areas that were previously identified in section 2.4 as utility corridors. This prevents any areas from being accounted for more than once in the inventory. The Ellerbe Creek Local Watershed Plan (NCEEP, 2003) recommends restoring riparian buffers along parks, golf courses, and other areas as a key component to improve water quality. This local watershed plan points out that often the cost and maintenance is lower than mowing to the top of the bank, with only periodic removal of invasives required.
Inventory – To perform the inventory of wetlands and riparian buffers, Brown and Caldwell coordinated with the City to obtain GIS data to map the location of wetlands and riparian buffers within the City’s municipal corporate limits. Brown and Caldwell used National Wetlands Inventory (NWI) GIS data (nwi_poly.shp, 2012) and 2012 aerial imagery to identify the location of candidate wetlands and stream data (SWChannels, 2012) to identify the location of candidate riparian buffers. There were 243 areas of NWI wetlands within the City’s municipal corporate limits, many of which were along stream corridors or are now developed, as well as several other locations identified as potential wetlands using aerial imagery. Each of these wetlands was examined using aerial imagery to determine if the wetland has potential for a restoration opportunity. During the inventory, none of the wetlands inside the City’s municipal corporate limits were identified for potential restoration opportunities. The City will continue the ongoing effort to identify and preserve natural existing wetlands.

The riparian buffers were identified as a 50-foot buffer around streams, using 2012 aerial imagery to determine if the buffer has minimal vegetation and thus potential for restoration opportunities. The Ellerbe Creek Local Watershed Plan recommends that the focus for buffer restoration projects be in the headwaters. The Little Lick Creek Watershed Restoration Priorities Technical Memo (UNRBA, 2007) identified a total of nearly 2,000 linear feet of potential stream buffer restoration in Falls Village Golf Course, located in the northern part of the Lick Creek Watershed on City owned property just north of NC-98. The individual locations with minimal buffers on the golf course were identified using 2012 aerial imagery, as shown on Figure 2-7. Another riparian buffer restoration opportunity previously identified is just south of Butler Road, and was identified in the Upper Neuse Project Atlas: Little Lick Creek (NCEEP, 2010) and in the Priorities for Watershed Restoration in Little Lick Creek Memorandum (UNRBA, 2005). These two documents, along with the Lick Creek and Ellerbe Creek Upper Neuse Project Atlases (UNRBA, 2010), also identify other potential riparian buffer areas within the City’s municipal corporate limits, all of which are included in this inventory. The location of riparian buffers identified for restoration for each watershed are included in the geodatabase as the file Riparian_Buffer_Restoration.shp.

Load Reduction Assumption – The TN and TP load reduction for riparian buffers with restoration potential will use the same methodology presented in Section 2.4 for restoration opportunities in utility corridors – the NCDWQ nutrient reductions associated with riparian buffer establishments (NCDWQ, 2012), appended to this report as Appendix D. The Riparian_Buffer_Restoration.shp file includes each area of potential restoration, the associated acreage, the removal of TN and TP per acre, and the resulting TN and TP removal associated with each identified area. A summary of the areas with restoration potential and the associated load reductions are presented in Table 2-7.

### Table 2-7. Inventory and Characterization: Wetlands and Riparian Buffers

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Total Number of Wetland Restoration Opportunities</th>
<th>Total Number of Riparian Buffer Opportunities</th>
<th>Total Area Available for Riparian Buffer Restoration (ac)</th>
<th>Potential TN Removal (lbs/yr)</th>
<th>Potential TP Removal (lbs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lick Creek</td>
<td>0</td>
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<td>3.1</td>
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<td>Little Lick Creek</td>
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<td>12.2</td>
<td>927</td>
<td>59.7</td>
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<tr>
<td>Ellerbe/Panther Creek</td>
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<td>27</td>
<td>34.6</td>
<td>2,620</td>
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<td>Eno River</td>
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<td>22</td>
<td>18.3</td>
<td>1,390</td>
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<td>Little River</td>
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<td>57.1</td>
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<tr>
<td>Flat River</td>
<td>0</td>
<td>0</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

3. Summary

This technical memorandum and the geodatabase represent an inventory and characterization of the load reduction potential of seven categories for the Falls Lake watersheds within the City in accordance to 15A NCAC 02B.0278 (4)(d). This regulation states that local governments shall develop inventories and
characterize load reduction potential, to the extent that accounting methods allow, for the following by January, 2013:

- wastewater collection systems
- discharging sand filter systems, including availability of or potential for central sewer connection
- properly functioning and malfunctioning septic systems
- restoration opportunities in utility corridors
- fertilizer management plans for local government-owned lands
- structural stormwater practices, including intended purpose, condition, potential for greater nutrient control
- wetlands and riparian buffers including potential for restoration opportunities

The inventory and load reductions presented in this memo represent a summary of potential opportunities from the categories listed above only to reduce nutrient pollutant contributions from the City into Falls Lake. Load reductions characterized in this memo were listed as either mass removal in pounds of TN and TP or as percent reductions from existing conditions. These potential load reductions are estimates developed by the City and Brown and Caldwell to provide a preliminary approximation of the potential reductions. These values are not an estimate of potential credits and should not be interpreted to represent actual expected nutrient removals. A geodatabase has been submitted as an attachment to this memo, and includes the data presented in this memo in geospatial form. The inventory files within this geodatabase are set up to be changed, updated, and/or refined as time and new information becomes available allowing refinement to the inventory areas in the Falls Lake Watershed with nutrient load reduction potential.
References


List of Figures

Figure 2-1. Wastewater Collection System
Figure 2-2. Discharging Sand Filter Systems – REVISED MARCH 2013
Figure 2-3. Discharging Septic Systems – REVISED MARCH 2013
Figure 2-4. Restoration Opportunities in Utility Corridors
Figure 2-5. Fertilizer Management Plans
Figure 2-6. Structural Stormwater Control Measures
Figure 2-7. Wetlands and Riparian Buffers
Figure 2-1
Wastewater Collection System

Falls Lake Inventory and Load Reduction Potential

Legend
- 2006 SSOs
- Force Main
- Gravity Main
- Streams
- Watershed Boundary
- City of Durham

Ellerbe/Panther Creek:
- Number of Occurrences: 15
- 2006 Volume Released: 214,807 gal
- 80% Reduction in TN: 57 lbs/yr
- 80% Reduction in TP: 14 lbs/yr

Eno River:
- Number of Occurrences: 3
- 2006 Volume Released: 7,072,000 gal
- 80% Reduction in TN: 1,888 lbs/yr
- 80% Reduction in TP: 472 lbs/yr

Flat River:
- Number of Occurrences: 0

Little Lick Creek:
- Number of Occurrences: 1
- 2006 Volume Released: 40,000 gal
- 80% Reduction in TN: 11 lbs/yr
- 80% Reduction in TP: 3 lbs/yr

Little River:
- Number of Occurrences: 0

Lick Creek:
- Number of Occurrences: 0

Eno River:
- Number of Occurrences: 3
- 2006 Volume Released: 7,072,000 gal
- 80% Reduction in TN: 1,888 lbs/yr
- 80% Reduction in TP: 472 lbs/yr

Flat River:
- Number of Occurrences: 0

Little Lick Creek:
- Number of Occurrences: 1
- 2006 Volume Released: 40,000 gal
- 80% Reduction in TN: 11 lbs/yr
- 80% Reduction in TP: 3 lbs/yr

Lick Creek:
- Number of Occurrences: 0

Ellerbe/Panther Creek:
- Number of Occurrences: 15
- 2006 Volume Released: 214,807 gal
- 80% Reduction in TN: 57 lbs/yr
- 80% Reduction in TP: 14 lbs/yr

Legend
- 2006 SSOs
- Force Main
- Gravity Main
- Streams
- Watershed Boundary
- City of Durham
Figure 2-2
Discharging Sand Filter Systems

Falls Lake Watershed:
Number of Sand Filter Systems: 253
Number with sewer available: 191
Potential Number to Remove: 61
Resulting Edge of Field TN Removal: 611 lbs/yr
Resulting Load at Lake TN Removal: 220 - 220 lbs/yr
Resulting Edge of Field TP Removal: 162 lbs/yr
Resulting Load at Lake TP Removal: 67.2 - 68 lbs/yr
Figure 2-3

Discharging Septic Systems

Falls Lake Inventory and Load Reduction Potential

Legend

- Streams
- Watershed Boundary
- Septic Systems
- City of Durham

Eno River:
Number of Septic Systems: 618
Potential Number to Remove: 487
Resulting Edge of Field TN Removal: 10,519 lbs/yr
Resulting Load at Lake TN Removal: 799.4 - 1472.7 lbs/yr
Resulting Edge of Field TP Removal: 2,679 lbs/yr
Resulting Load at Lake TP Removal: 5.9 - 5.9 lbs/yr

Flat River:
Number of Septic Systems: 0

Little River:
Number of Septic Systems: 28
Potential Number to Remove: 11
Resulting Edge of Field TN Removal: 238 lbs/yr
Resulting Load at Lake TN Removal: 18.1 - 33.3 lbs/yr
Resulting Edge of Field TP Removal: 61 lbs/yr
Resulting Load at Lake TP Removal: 5.9 - 5.9 lbs/yr

Ellerbe/Panther Creek:
Number of Septic Systems: 227
Potential Number to Remove: 198
Resulting Edge of Field TN Removal: 4,277 lbs/yr
Resulting Load at Lake TN Removal: 325.1 - 598.8 lbs/yr
Resulting Edge of Field TP Removal: 1,089 lbs/yr
Resulting Load at Lake TP Removal: 104.5 - 105.6 lbs/yr

Little Lick Creek:
Number of Septic Systems: 123
Potential Number to Remove: 94
Resulting Edge of Field TN Removal: 2,030 lbs/yr
Resulting Load at Lake TN Removal: 154.3 - 284.2 lbs/yr
Resulting Edge of Field TP Removal: 517 lbs/yr
Resulting Load at Lake TP Removal: 49.6 - 50.1 lbs/yr

Lick Creek:
Number of Septic Systems: 13
Potential Number to Remove: 3
Resulting Edge of Field TN Removal: 65 lbs/yr
Resulting Load at Lake TN Removal: 4.9 - 9.1 lbs/yr
Resulting Edge of Field TP Removal: 17 lbs/yr
Resulting Load at Lake TP Removal: 1.6 - 1.6 lbs/yr
Figure 2-4

Restoration Opportunities in Utility Corridors

Legend
- Streams
- Force Main
- Gravity Main
- Watershed Boundary
- Restoration Opportunities in Utility Corridors
- City of Durham

<table>
<thead>
<tr>
<th>Creek</th>
<th>Number of Opportunities</th>
<th>Area Available for Restoration</th>
<th>Potential TN Removal</th>
<th>Potential TP Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eno River</td>
<td>49</td>
<td>40.6 ac</td>
<td>3,075 lbs/yr</td>
<td>198.0 lbs/yr</td>
</tr>
<tr>
<td>Ellerbe/Panther Creek</td>
<td>49</td>
<td>37.6 ac</td>
<td>2,849 lbs/yr</td>
<td>183.5 lbs/yr</td>
</tr>
<tr>
<td>Little Lick Creek</td>
<td>8</td>
<td>5.0 ac</td>
<td>377 lbs/yr</td>
<td>24.3 lbs/yr</td>
</tr>
<tr>
<td>Lick Creek</td>
<td>2</td>
<td>0.3 ac</td>
<td>23 lbs/yr</td>
<td>1.5 lbs/yr</td>
</tr>
<tr>
<td>Flat River</td>
<td>1</td>
<td>0.1 ac</td>
<td>8 lbs/yr</td>
<td>0.5 lbs/yr</td>
</tr>
<tr>
<td>Little River</td>
<td>10</td>
<td>3.7 ac</td>
<td>282 lbs/yr</td>
<td>18.1 lbs/yr</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Figure 2-5
Fertilizer Management Plans
Falls Lake Inventory and Load Reduction Potential

Legend
- Streams
- Watershed Boundary
- Fertilizer Management Areas
- City of Durham

Little River:
Number of Parcels: 2
Estimated Maintained Area: 2.1 ac
Reduction in TN Applied: 187 lbs/yr

Little Lick Creek:
Number of Parcels: 7
Estimated Maintained Area: 9.2 ac
Reduction in TN Applied: 802 lbs/yr

Lick Creek:
Number of Parcels: 0

Eno River:
Number of Parcels: 10
Estimated Maintained Area: 28.5 ac
Reduction in TN Applied: 2,485 lbs/yr

Ellerbe/Panther Creek:
Number of Parcels: 52
Estimated Maintained Area: 51.7 ac
Reduction in TN Applied: 4,505 lbs/yr

Flat River:
Number of Parcels: 0
Figure 2-6
Structural Stormwater Control Measures
Falls Lake Inventory and Load Reduction Potential

Legend
Existing Structural SCMs
- Dry pond
- Wet Pond
- Constructed Wetland
- Pocket Wetland
- Level Spreader
- Bioretention
- Sand Filter
- Underground Storage

Streams
- Watershed Boundary
- City of Durham

Flat River:
Number of Existing SCMs: 0
Convert 1 Dry Ponds to Wet Ponds
Convert 2 Dry Ponds to Constructed Wetland

Lick Creek:
Number of Existing SCMs: 31
Convert 7 Dry Ponds to Wet Ponds
Convert 10 Dry Ponds to Constructed Wetland

Ellerbe/Panther Creek:
Number of Existing SCMs: 76
Convert 2 Dry Ponds to Wet Ponds
Convert 3 Dry Ponds to Constructed Wetland

Little Lick Creek:
Number of Existing SCMs: 61
Convert 5 Dry Ponds to Wet Ponds
Convert 7 Dry Ponds to Constructed Wetland

Eno River:
Number of Existing SCMs: 93
Convert 6 Dry Ponds to Wet Ponds
Convert 8 Dry Ponds to Constructed Wetland

Little River:
Number of Existing SCMs: 10
Convert 1 Dry Ponds to Wet Ponds
Convert 2 Dry Ponds to Constructed Wetland

City of Durham
Public Works Department
101 City Hall Plaza
Durham, NC 27701

JANUARY 2013
Figure 2-7
Wetlands and Riparian Buffers

Legend
- Streams
- Watershed Boundary
- Riparian Buffer Restoration Opportunities
- Existing NWI Wetlands
- City of Durham

Little River:
Number of Opportunities: 13
Area Available for Restoration: 11.7 ac
Potential TN Removal: 887 lbs/yr
Potential TP Removal: 57.1 lbs/yr

Eno River:
Number of Opportunities: 22
Area Available for Restoration: 18.3 ac
Potential TN Removal: 1,390 lbs/yr
Potential TP Removal: 89.5 lbs/yr

Ellerbe/Panther Creek:
Number of Opportunities: 27
Area Available for Restoration: 34.6 ac
Potential TN Removal: 2,620 lbs/yr
Potential TP Removal: 168.7 lbs/yr

Little Lick Creek:
Number of Opportunities: 11
Area Available for Restoration: 12.2 ac
Potential TN Removal: 927 lbs/yr
Potential TP Removal: 59.7 lbs/yr

Lick Creek:
Number of Opportunities: 2
Area Available for Restoration: 0.6 ac
Potential TN Removal: 48 lbs/yr
Potential TP Removal: 3.1 lbs/yr
Appendix A: City of Durham Falls Lake On-Site Septic and Sandfilter Inventory
City of Durham Falls Lake On-Site Septic and Sandfilter Inventory
submitted by
Durham County Environmental Health Division
Robert S. Jordan
Environmental Health Supervisor
January 25, 2013

Table 1. Health Department Jurisdiction

<table>
<thead>
<tr>
<th>System Type</th>
<th>Total Systems</th>
<th>Failure Rate %</th>
<th>% of Total Systems</th>
<th>Weighted Failure %</th>
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</thead>
<tbody>
<tr>
<td>1 Pit Privies</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2 Gravity Conv.</td>
<td>943</td>
<td>3.4</td>
<td>92.72</td>
<td>3.15</td>
</tr>
<tr>
<td>3 Pump Conv.</td>
<td>27</td>
<td>6.1</td>
<td>2.66</td>
<td>1.60</td>
</tr>
<tr>
<td>4 LPP</td>
<td>47</td>
<td>15.8</td>
<td>4.62</td>
<td>.73</td>
</tr>
<tr>
<td>5 Pre-Treatment</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6 &gt;3000 GPD</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>City Totals</td>
<td>1017</td>
<td>100%</td>
<td>5.48%</td>
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</table>

Table 2. DWQ Jurisdiction

<table>
<thead>
<tr>
<th>System Type</th>
<th>Total Systems</th>
<th>Public Sewer Available</th>
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<tbody>
<tr>
<td>Filter Beds</td>
<td>253</td>
<td>191</td>
</tr>
<tr>
<td>Subsurface Drip</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spray</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>253</td>
<td>191</td>
</tr>
</tbody>
</table>
Summary Notes on the Durham Falls Lake Septic/Filter Bed Inventory

1) Any system under Health Department jurisdiction with surfacing effluent is deemed a failure by virtue of the definition of system failure in 15A NCAC 18A .1961.

2) Failures are caused by hydraulic overload or maintenance failures caused by broken piping or other broken components.

3) Properties known to be served by Health Department systems and those suspected to be served by Health Department systems were combined for the purpose of this inventory.

4) Properties known to be served by DWQ systems and those suspected to be served by DWQ systems were combined for the purpose of this inventory.

5) One hundred forty-four properties within the city limits are served by systems unknown as to type. These are included in the Type 2 totals in Table 1. The age of these systems would indicate this to be the most likely category for the majority of these systems.

6) A complete list of system types and management schedules for Table 1 is found in 15A NCAC 18A .1961 Table 5(a).

7) The failure rate for Type 2 systems shown in Table 1 was based upon a field survey conducted in Durham during April of 2012 by DHHS OSWP staff, DWQ staff, and Durham, Orange and Wake County Environmental Health staff. One hundred forty-seven of the 1237 systems with public sewer available were surveyed. This constituted an 11.88% sample of these systems. Approximately 25% of the systems assessed were on sites mapped as soils generally acceptable for system installations under the current rules. Approximately 75% of the systems assessed were on sites mapped as soils generally unacceptable for system installations under the current rules. Five of the one hundred forty-seven systems surveyed were failing for a failure rate of 3.4%.

8) The failure rate for Type 3 systems in Table 1 was calculated using mandated periodic inspections findings by Environmental Health as required in 15A NCAC 18A .1961. Six hundred and eight systems are currently managed with thirty-seven experiencing failure during the current inspection cycle for a failure rate of 6.1%.

9) The failure rate for Type 4 systems shown in Table 1 was calculated using mandated periodic inspections findings by Environmental Health as required in 15A NCAC 18A .1961. Sixty-three systems are currently managed with ten experiencing failure during the current inspection cycle for a failure rate of 15.8%.
10) The zeros in Tables 1 and 2 indicates there are no Type 5 or 6 systems within the Durham City limits.
11) In the future, further field surveys will better refine this inventory.
12) Failure Rates are not reported for the DWQ systems as these systems are not under County Health Department jurisdiction.
13) All structures within 60’ of existing public sewer gravity lines currently served by DWQ systems are deemed as having connection available.
14) Loading from this inventory has not been calculated due to the lack of adequate scientific data.
Appendix B: City of Durham Sewer Connection Fees
CITY OF DURHAM POTENTIAL SEWER FEES FOR SAMPLE SCENARIOS

City Sewer existing adjacent to property to be served*

No Sewer frontage due (Inside or Outside City – sewer main previously assessed)

- $1,100.00 4” Lateral
- 915.00 Sewer Capital facility fee
- $2,015.00

100 ft Lot, with Sewer frontage due (Inside City)  
- $5,000.00 frontage charge (100’ @ $50.00/FF)
- 2,015.00 4” Lateral & Capital facility fee
- $7,015.00

200 ft Lot, with Sewer frontage due (Outside City)*

- $11,200.00 frontage charge (200’ @ $56.00/FF)
- 2,015.00 4” Lateral & Capital facility fee
- $13,125.00

100 ft Lot, (Inside City)  
- $5,000.00 maximum sewer main assessment
- 2,015.00 4” Lateral & Capital facility fee
- $7,015.00

200 ft Lot, (Outside City)*

- $11,200.00 maximum sewer main assessment
- 2,015.00 4” Lateral & Capital facility fee
- $13,215.00

200 ft Lot, (Inside City)  
- $10,000.00 maximum sewer main assessment
- 2,015.00 4” Lateral & Capital facility fee
- $12,015.00

City Sewer NOT existing; Owners Petition City to make necessary Sewer Main Extensions in existing public rights-of-way to serve property *

Sewer mains installed by the City as a result of a sufficient petition are assessed against abutting properties at actual cost, not to exceed the maximum rate set by City Council and in effect at the time the sewer extension is ordered, currently $50.00 per front foot (FF) for properties inside the City and $112.00/FF for properties outside the City.

100 ft Lot, (Inside City)  
- $5,000.00 maximum sewer main assessment
- 2,015.00 4” Lateral & Capital facility fee
- $7,015.00

200 ft Lot, (Outside City)*

- $11,200.00 maximum sewer main assessment
- 2,015.00 4” Lateral & Capital facility fee
- $13,215.00

Connection requires Council approval

City Sewer NOT existing; Owners Petition City to make necessary Sewer Extensions to serve property via Outfalls (i.e. cross country sewer mains)*

In addition to the maximum sewer main assessment of $112.00/FF, properties outside the City are assessed for sewer outfalls at actual cost, with no maximum rate. For illustrative purposes, $80.00/FF is used for the sewer outfall rate in the examples below. It is important to note that cost of construction varies significantly depending on length of improvements, depth, topography, rock encountered, size of main, amount of labor, material costs, etc.

100 ft Lot, (Outside City)  
- $11,200.00 maximum sewer main assessment
- 8,000.00 estimated outfall assessment (see above)
- 2,015.00 4” Lateral & Capital facility fee
- $21,215.00

200 ft Lot, (Outside City)*

- $22,400.00 maximum sewer main assessment
- 16,000.00 estimated outfall assessment (see above)
- 2,015.00 4” Lateral & Capital facility fee
- $40,415.00

NOTES
The above examples represent some scenarios that may occur. This document is not intended to represent all scenarios.

City Council may approve or disapprove sewer mains and sewer service connections in its discretion to property outside the city limits as established by Section 70-129 of the City of Durham Codes of Ordinances.

Connection to City sewer where no sewer lines exist typically requires a petition to City Council for approval of extension of City sewer to those areas. Over 50% of affected property owners, representing over 50% of the total road frontage, must sign the petition. Approval by City Council is not automatic. If approved by City Council, installation can take 2 to 3 years or longer.
There are areas of Durham County that cannot be served by city sewer without the installation of a regional pump station. These can be very expensive and often prove to be cost-prohibitive. None of the examples above reflect this scenario.

*In addition to the fees quoted for each scenario, the owner would incur private plumbing costs for having the sewer service installed on their property from the house to the lateral installed by the City, as well as abandonment of the septic system. Plumbing costs can vary from $3,000 to $10,000, depending on the length and depth of the ditch required, the amount of rock and obstacles (such as an irrigation system or landscaping) encountered in the path of the service line, etc.
Appendix C: Septic System Classification Definitions
authorized agent has observed and documented one or more of the malfunctioning conditions and has issued a notice of violation.

(2) Ground absorption sewage treatment and disposal systems shall be checked, and the contents of the septic tank removed, periodically from all compartments, to ensure proper operation of the system. The contents shall be pumped whenever the solids level is found to be more than 1/3 of the liquid depth in any compartment.

(b) System management in accordance with Tables V(a) and V(b) of this Rule shall be required for all systems installed or repaired after July 1, 1992. After July 1, 1992, system management in accordance with Tables V(a) and V(b) shall be required for all existing Type V and Type VI systems.

(c) No Improvement Permit or Construction Authorization shall be issued for Type IV, Type V, or Type VI systems, unless a management entity of the type specified in Table V(b) is specifically authorized, funded, and operational to carry out this management program in the service area where the proposed system is to be located.

(d) A local health department may be the public management entity only for systems classified Type IV, V(a) and V(b) and only when specifically authorized by resolution of the local board of health.

(e) A contract shall be executed between the system owner and a management entity prior to the issuance of an Operation Permit for a system required to be maintained by a public or private management entity, unless the system owner and certified operator are the same. The contract shall include the specific requirements for maintenance and operation, responsibilities of the owner and system operator, provisions that the contract shall be in effect for as long as the system is in use, and other requirements for the continued proper performance of the system. It shall also be a condition of the Operation Permit that subsequent owners of the system execute such a contract.

(f) Inspections of the system shall be performed by a management entity at the frequency specified in Table V(b). The management entity shall report the results of their inspections to the local health department at the specified reporting frequency. However, where inspections indicate the need for system repairs, the management entity shall notify the local health department within 48 hours in order to obtain a Construction Authorization for the repairs.

(g) The management entity shall be responsible for assuring routine maintenance procedures and monitoring requirements in accordance with the conditions of the Operation Permit and the contract.

(h) Sewage systems with multiple components shall be classified by their highest or most complex system type in accordance with Table V to determine local health department and management entity responsibilities.

(i) Sewage systems not identified in this Rule shall be classified by the Division of Environmental Health after consultation with the appropriate commission governing operators of pollution control facilities.

(j) The local health department shall routinely review the performance and operation reports submitted in accordance with Table V(b) of this Rule and shall perform an on-site inspection of the systems as required in Table V(a).

(k) The certified operator shall hold a valid and current certificate from the appropriate commission, and nothing in this Section shall preclude any requirements for system operators, in accordance with Article 3 of G.S. 90A.

<p>| TABLE V(a) |
| LOCAL HEALTH DEPARTMENT RESPONSIBILITIES |</p>
<table>
<thead>
<tr>
<th>System Classification</th>
<th>System Description</th>
<th>Permits Required</th>
<th>Minimum System Review Frequency</th>
</tr>
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<tbody>
<tr>
<td>Type I</td>
<td>a. Privy</td>
<td>Improvement</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>b. Chemical toilet</td>
<td>Permit, Construction Authorization, and Operation Permit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Incinerating toilet</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>d. Other toilet system</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>e. Grease trap</td>
<td>Operation Permit</td>
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</tr>
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<td></td>
</tr>
<tr>
<td>Type II</td>
<td>a. Conventional septic system (single-family or 480 GPD or less)</td>
<td>Improvement Permit, Construction Authorization, and Operation Permit</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>b. Conventional septic system with 750 linear feet of</td>
<td></td>
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</tr>
</tbody>
</table>
nitrification line or less
  c. Conventional system with shallow placement

<table>
<thead>
<tr>
<th>Type III</th>
<th>a. Conventional septic system &gt; 480 GPD (excluding single-family residence)</th>
<th>Improvement Permit, Construction Authorization, and Operation Permit</th>
<th>5 yrs. (Illinois only)</th>
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<tbody>
<tr>
<td></td>
<td>b. Septic system with single effluent pump or siphon</td>
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<tr>
<td></td>
<td>c. Gravity fill system</td>
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</tr>
<tr>
<td></td>
<td>d. Dual gravity field system</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>e. PPBPS system, gravity dosed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>f. Large diameter pipe system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>g. Other non-conventional trench systems</td>
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</tr>
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</table>

<table>
<thead>
<tr>
<th>Type IV</th>
<th>a. Any system with LPP distribution</th>
<th>Improvement Permit, Construction Authorization, and Operation Permit</th>
<th>3 yrs.</th>
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<tbody>
<tr>
<td></td>
<td>b. System with more than 1 pump or siphon</td>
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</table>

<table>
<thead>
<tr>
<th>Type V</th>
<th>a. Sand filter pretreatment system</th>
<th>Improvement Permit, Construction Authorization, and Operation Permit</th>
<th>12 mos.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b. Any &gt; 3,000-GPD septic tank system with a nitrification field designed for &gt; 1500 GPD</td>
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<tr>
<td></td>
<td>c. Aerobic Treatment Unit (ATU)</td>
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<tr>
<td></td>
<td>d. Other mechanical, biological, or chemical pretreatment plant (&lt; 3000 GPD)</td>
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</table>

<table>
<thead>
<tr>
<th>Type VI</th>
<th>a. Any &gt; 3,000 GPD system with mechanical, biological, or chemical pretreatment system plant</th>
<th>Improvement Permit, Construction Authorization, and Operation Permit</th>
<th>6 mos.</th>
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<tbody>
<tr>
<td></td>
<td>b. Wastewater reuse/recycle</td>
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### TABLE V(b)

**MANAGEMENT ENTITY RESPONSIBILITIES**

<table>
<thead>
<tr>
<th>System Classification</th>
<th>Management Entity</th>
<th>Minimum System Inspection/Maintenance Frequency</th>
<th>Reporting Frequency</th>
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<tbody>
<tr>
<td>Type I</td>
<td>Owner</td>
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<td>N/A</td>
</tr>
<tr>
<td>Type II</td>
<td>Owner</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Type III</td>
<td>Owner</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Type IV</td>
<td>Public Management</td>
<td>2/yr.</td>
<td>12 mos.</td>
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Appendix D: NCDWQ Methodology and Calculations for determining Nutrient Reductions associated with Riparian Buffer Establishment
NC Division of Water Quality - Methodology and Calculations for determining Nutrient Reductions associated with Riparian Buffer Establishment

Nitrogen Water Quality Benefits for Riparian Buffer Restoration

1. Benefit of Land Use Change
2. Benefit of Nutrient Removal from Nonpoint Source Runoff
3. Benefit of Nutrient Removal from Periodic Overbank Flood

Nitrogen General Assumptions:

1. Life expectancy of Riparian Buffer is assumed to be 30 years. (Life expectancy for stormwater detention pond is 20 - 30 yrs)
2. Restored Riparian Buffer is assumed to be natural.

<table>
<thead>
<tr>
<th>Benefit (1)</th>
<th>Benefit (2)</th>
<th>Benefit (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Effectiveness (kg/ha/yr)</td>
<td>Annual Effectiveness (lb/ac/yr)</td>
<td>Effectiveness in 30 yrs (lb/ac)</td>
</tr>
<tr>
<td>11.08</td>
<td>9.89</td>
<td>296.6</td>
</tr>
<tr>
<td>70.09</td>
<td>62.54</td>
<td>1876.1</td>
</tr>
<tr>
<td>3.75</td>
<td>3.35</td>
<td>100.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>84.92</strong></td>
<td><strong>75.77</strong></td>
</tr>
</tbody>
</table>

Nitrogen Benefit Descriptions and Assumptions:

1) Benefit is due to change land use.
   Assume existing land use export coefficient is a composite export coefficient with a value of 12.98 kg/ha (agriculture and urban).
   Wetland export coefficient is 1.9 kg/ha.
   The annual nutrient output is decreased by 11.08 kg/ha annually by land use changing.
2) Benefit is due to nitrogen removal from nonpoint source runoff.
   Nutrient contribution/buffer treatment area ratio is approximately 10.8 (based on studies examined by Gannon 1997).
   In flow loading is calculated by nutrient contribution area x composite export coefficient.
   In flow loading is 10.8 ha x 12.98 kg/ha = 140 kg/ha/yr.
   Nutrient removal due to this benefit is calculated by in flow loading x removal efficiency
   *Gannon, Richard. 1997. Effectiveness of Wetland Riparian Areas for Treatment of Agricultural Pollution Sources: A Literature Review. (Draft)
   The nitrogen removal efficiency is 50% based on various literature.
   * Kadlec, Robert H. and Robert L. Knight. 1996. Treatment Wetland
3) Benefit is due to nitrogen removal from overbank flooding
   Nutrient concentration is assumed to be 2.5 mg/L. Assume overboard is 1 ft. Flood frequency is assumed to be once every year.
   Nutrient removal due to this benefit is estimated by in flow concentration x area (1 ha) x overboard height x removal efficiency.

Formula for Calculating Nitrogen Offset Reductions on Riparian Buffer Restoration Sites:

\[ \text{Size (Acres)} \times 75.77(\text{lbs/Acre/Year}) \times 30 \text{ Years} = \text{Total Pounds of Nitrogen Removed from Riparian Buffer Project} \]
Phosphorus Water Quality Benefits for Riparian Buffer Restoration

1). Benefit of Land Use Change
2). Benefit of Nutrient Removal from Nonpoint Source Runoff

Phosphorus General Assumptions:

1. Life expectancy of Riparian Buffer is assumed to be 30 years.

<table>
<thead>
<tr>
<th>Effectiveness of Riparian Buffer</th>
<th>Annual Effectiveness (lb/ac/yr)</th>
<th>Effectiveness in 30 yrs (lb/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benefit (1)</td>
<td>1.73</td>
<td>51.90</td>
</tr>
<tr>
<td>Benefit (2)</td>
<td>3.15</td>
<td>94.50</td>
</tr>
<tr>
<td>Total</td>
<td>4.88</td>
<td>146.40</td>
</tr>
</tbody>
</table>

Phosphorus Benefit Descriptions and Assumptions:

1) Benefit is due to change land use\(^1,2\)
   - Export coefficient for agricultural land is 2.15 (lb/ac/yr).
   - Export coefficient for riparian buffer is 0.42 (lb/ac/yr).
   - The annual total phosphorus (TP) output is decreased by 1.73 lb/ac annually by land use changing.

2) Benefit is due to TP removal from nonpoint source runoff\(^3,4\)
   - Mass load for TP reductions for buffer is estimated to be 3.15 lb/ac/yr.

Assumptions:

Riparian buffer restorations only occur on agricultural lands.
Width of restored riparian buffer is 50 feet, and with mixture of grass and forest.

References:

1 NC Division of Water Quality memo 'Export Coefficients Revisited' (1996)
2 Comparison of Selected TP Loading Coefficients (Jim Blose, 2001)
3 Cost-Effectiveness Study of Selected Agricultural Best Management Practices in the Neuse and Tar-Pamlico River Basins (Todd Kennedy, 2001)
4 A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation. (Seth Wenger, 1999)

Formula for Calculating Phosphorus Offset Reductions on Riparian Buffer Restoration Sites:

\[
\text{Size (Acres)} \times 4.88(\text{lbs/Acre/Year}) \times 30 \text{ Years} = \text{Total Pounds of Total Phosphorus Removed from Riparian Buffer Project}
\]
Appendix E: Excerpt from Report by Hazen and Sawyer for the City of Raleigh - A Review of Onsite Wastewater System Performance and Nutrient Trading Policy Report to Support Falls Lake Nutrient Strategy Development
A Review of
Onsite Wastewater System Performance and
Nutrient Trading Policy to
Support Falls Lake Nutrient Strategy Development

City of Raleigh Public Utilities Department
January 2013
model, nitrogen contributes 14 percent of the total load to Falls Lake and phosphorus accounts for 9.6 percent of the load. However, the load could be as high as 56 percent for nitrogen from OWTS and 45 percent for phosphorus from OWTS if no attenuation were to occur in soils or groundwater. It is important to note that because the total annual delivered loads to Falls Lake are calibrated to monitoring data, the total load would not increase. Instead, other nutrient sources would have to be modified in the model to deliver a smaller load, further increasing the relative proportion of nitrogen and phosphorus originating from OWTS. Thus, the potential impacts from OWTS could be severely over or under-estimated depending on the modeled assumptions and rate constants. It is suggested that follow-up work evaluate and justify the parameters chosen to calculate nutrient loading to Falls Lake from OWTS.

### WARMF Model Nitrogen and Phosphorus Load Outputs Applied to Nutrient Impact Options

<table>
<thead>
<tr>
<th>Assumption 1: No Soil Attenuation</th>
<th>Assumption 2: No Soil Attenuation, Some In-Stream Attenuation</th>
<th>Assumption 3: Some Soil and Instream Attenuation Occurs</th>
<th>WARMF-Calculated % Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>From OWTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TN (kg/day)</td>
<td>TP (kg/day)</td>
<td>TN (kg/day)</td>
<td>TP (kg/day)</td>
</tr>
<tr>
<td>872</td>
<td>53</td>
<td>872</td>
<td>53</td>
</tr>
<tr>
<td>OWTS Load to Streams</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>872</td>
<td>53</td>
<td>872</td>
<td>53</td>
</tr>
<tr>
<td>OWTS Load to Lake</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>872</td>
<td>53</td>
<td>314</td>
<td>22</td>
</tr>
<tr>
<td>Total Load Delivered to Falls Lake From All Nutrient Sources</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,560</td>
<td>117</td>
<td>1,000</td>
<td>86</td>
</tr>
<tr>
<td>Percent Contribution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>56%</td>
<td>45%</td>
<td>31%</td>
<td>26%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>9.6%</td>
</tr>
</tbody>
</table>

Note: WARMF-calculated TN load to lake = 802 kg/day; WARMF calculated TP load to lake = 71 kg/day; Loss through seepage to deep groundwater is not considered in Assumptions 1 or 2 but is included in Assumption 3. The calculated values could be further refined by inclusion of seepage loss in all three assumptions.

1 The total load to Falls Lake was adjusted for illustrative purposes to compare the relative impact of modeling assumptions per each nutrient load option. The annual delivered to Falls Lake are calibrated to monitoring data, so the total nutrient load would not increase. Rather, other nutrient load sources would be modified.

### Approaches to Assess Nutrient Load Contribution

A significant challenge in the evaluation of OWTS with respect to the TMDL is the development of a load calculation tool for nitrogen and phosphorus contributions and associated nutrient reduction measures. The WARMF model is a load allocation tool, utilizing the geographic location of a catchment within a watershed and general characteristics of activities within that catchment. WARMF is not effective at examining the detailed effect of individual pollutant sources within a catchment. However, the model does distinguish between the contribution from all of the sources in the catchment area, e.g., agriculture, onsite systems,