



# NEUSE RIVER BASIN MODELING - DATA COLLECTION

---

## DRAFT REPORT

Prepared for Hydrologics Inc.

5/7/2009

MOFFATT & NICHOL



## Table of Contents

1. Introduction.....	1
2. Agriculture .....	1
2.1. Data Sources .....	1
2.1.1. National Agricultural Statistics Service.....	1
2.1.2. North Carolina Agriculture Statistics.....	1
2.1.3. Consultation with Agriculture Extension Agents .....	2
2.1.4. Consultation with Dr. Ronald Sneed .....	2
2.1.5. Golf Course Irrigation.....	2
2.2. Methods.....	2
2.2.1. Determining Crop Acreage and Livestock Head.....	2
2.2.2. Determining Agricultural Water Use.....	4
2.2.3. Rainfall.....	6
2.3. Data Distribution.....	6
3. Municipal and Industrial Withdrawals.....	6
3.1. Data Sources .....	6
3.2. Methodology .....	6
4. Municipal and Industrial Discharges .....	7
4.1. Data Sources .....	7
4.2. Methods.....	7
5. References.....	8

## List of Tables

Table 1. Summary of Neuse River Basin - Distribution by County .....	9
Table 2. Basis of County Rainfall Statistics .....	10
Table 3. Summary of Agriculture Distribution.....	11
Table 4. Summary Water Withdrawal Data.....	13
Table 5. Summary of Wastewater Discharges.....	14



## List of Figures

Figure 1. Neuse River Basin .....	17
Figure 2. Rain Gages.....	18
Figure 3. Distribution of Agriculture .....	19
Figure 4. Water withdrawals.....	20
Figure 5. Wastewater discharges .....	21

## Introduction

On behalf of North Carolina Division of Water Resources (NCDWR), Hydrologics Inc. is developing a basin-wide water use model, OASIS, for the Neuse River Basin (Figure 1). Table 1 summarizes the portion of area contained within the limits of the model domain by County.

In support of the model development, Moffatt & Nichol (M&N) was tasked with gathering and processing water use and discharge data by agriculture, industrial, and municipal sources. The objective of the data collection effort was to develop a time series for water withdrawal and discharge for the past 78 years (1930-2008). Data was gathered from private industry as well as the following governmental agencies:

- NC Division of Water Resources (DWR)
- NC Division of Water Quality (DWQ)
- National Climactic Data Center (NCDC)
- National Agricultural Statistics Service (NASS)
- United States Department of Agriculture (USDA)
- North Carolina Department of Agriculture (NCDA)
- North Carolina Cooperative Extension Service (NCCES)
- United States Geological Survey (USGS)
- Municipal and Local Government Bodies

Methods used and sources of data acquired to develop the water use time series in support of model development are discussed below.

## 1. Agriculture

### 1.1. *Data Sources*

#### 1.1.1. National Agricultural Statistics Service

Approximately every 5 years, the NASS requests agriculture data from farmers and land owners. Responses to the survey yields extensive data regarding land acreage, crop type grown, livestock counts, and other information. M&N contacted the NASS to obtain all records for counties within the Neuse River basin back to 1930. Data included irrigated and non-irrigated acreage on tobacco, cotton, soybeans, corn peanuts, and head counts for livestock. Agriculture Census data was obtained for the following years: 1930, 1935, 1940, 1945, 1950, 1954, 1959, 1964, 1969, 1974, 1978, 1982, 1987, 1992, 1997, 2002, and 2007.

#### 1.1.2. North Carolina Agriculture Statistics

Incomplete statistics data from the NC Department of Agriculture back to 1930. The NCDA began collecting information for some crops prior to 1930, and others around

1975. Prior to 1975, only crop acreage for corn, cotton, tobacco and peanuts was available. After 1975, wheat, corn, oats, barley, sorghum, cotton, tobacco, peanuts, potatoes, and hay acreage was available. Also beginning in 1975, information regarding cattle, hogs and pigs, chickens, and turkeys is available.

The NCDA Plant Division maintains a database with up-to-date information regarding container and field nurseries in the State. Included in the database is nursery type and acreage. All nurseries less than 5 acres were considered to be container nurseries.

### **1.1.3. Consultation with Agriculture Extension Agents**

After compiling all data, during October 2008, M&N contacted agriculture extension agents of counties within the Neuse Basin with a questionnaire requesting verification of the most up-to-date values for their county, and for an estimate of the county's distribution. For example, if the majority of the agriculture is located in the north of the county, but only the southern portion of the county is located within the basin, then less water will be allotted for agriculture. The same methodology is applied for subbasins within the county.

Based on input from the extension agents, with the exception of Wake and Durham Counties, the distribution of Agriculture within the Neuse Basin was assumed to be uniform.

### **1.1.4. Consultation with Dr. Ronald Sneed**

Dr. Ronald Sneed, retired professor from North Carolina State University and former State extension irrigation specialist was consulted to verify that the values received and calculated were appropriate for the given locations. Dr. Sneed was able to provide insight into typical irrigation practices in use in the areas as well as to further delineate the distribution of the agriculture within each county.

### **1.1.5. Golf Course Irrigation**

The extent of golf courses was determined based on a combination of available geographic information for Wake and Johnston County as well as the statistics published by the USGS (USGS, 2005).

## **1.2. Methods**

### **1.2.1. Determining Crop Acreage and Livestock Head**

Raw data was obtained from the sources listed above. Data gaps were filled using the following methods.

#### **1.2.1.1. Tobacco**

No significant irrigation of tobacco existed prior to 1950 and was therefore assumed to be 0. A ratio between irrigated and total acres of tobacco was computed for years where both values were known. Half of this acreage was assumed to be the percentage of irrigated tobacco in 1955. A linear interpolation between the closest years with values using the percent irrigated was done for all data gaps.

#### 1.2.1.2. Turf

No significant irrigated turf producers existed prior to 1970. 1969 irrigated turf acreage was assumed to be 0. Linear interpolation was done for all missing turf acreage between 1970 and 2007.

#### 1.2.1.3. Golf Courses

An estimate of water use for golf courses was made based on the total acreage of each course. The total rate of water irrigation was assumed to be on average 1.5 in/week during (1 Apr-31 Oct); it is assumed that rate is applied over tees, greens and fairways which comprise 40% of the total golf course area; i.e. the estimate irrigation is 0.57 in/week x (total acreage). For the remainder of the year (Nov 1 – Mar 31) is assumed that only tees and greens are irrigated; tees and greens are assumed to comprise 2.9% of total acres at 1.5in/week. Data from 2006 and 2007 provided by City of Raleigh and Johnston County was used to validate the assumptions on golf course irrigation use.

Golf course acreage in 1969 was assumed to be 35% of the total acreage in 1998. In 1930, the total acreage was assumed to be 10% of the total acreage of 2008. Linear interpolation was performed for all years in between. The water demand curve for golf courses was also adjusted for the years 1930 up to 1968.

#### 1.2.1.4. Nurseries

Both field and container nursery acreage in 1969 was assumed to be 30% of the total acreage of 2002. Field nursery acreage was assumed to be 0 in 1930. Linear interpolation was done for years in between. Container nurseries began in 1960. Therefore, container nursery acreage was assumed to be 0 in 1959. NCDA database values were used for the years 2006-2008. Linear interpolation was done for all unknown values.

#### 1.2.1.5. Secondary Crops (Soybeans, Cotton, Corn, Peanuts, Irrigated Pasture and Hay)

Irrigation for secondary crops was assumed to be 0 before 1976 unless otherwise noted in the Agriculture Census. Linear interpolation was performed for any unknown values.

#### 1.2.1.6. Vegetables

Irrigated acreage in 1975 was assumed to be 20% of the total acreage of 2002. It was assumed to be 0 in 1950. Linear interpolation was performed for irrigated vegetable acreage in all other years where data was not available.

#### 1.2.1.7. Blueberries and Strawberries.

Irrigated blueberry and strawberry acreage was assumed to be constant between 1975 and 2001 and from 2002 to 2008. Prior to 1975, it was assumed there was no irrigation on either crop.

#### 1.2.1.8. Other Fruits - Orchards

Irrigated fruit acreage was assumed to be 50% of the total acreage in 2002. It was assumed to be 0 in 1950. Linear interpolation was performed for years in between.

### 1.2.1.9. Livestock

Linear interpolations were performed for years where no Census or Agricultural Statistics data exists.

### 1.2.2. Determining Agricultural Water Use

The methodology for determining water use by agriculture in the basin mirrored that of the Cape Fear River Basin Model. Evapotranspiration (ET) demand for tobacco, soybeans, peanuts, cotton, and corn was estimated based on the moisture curves provided by Dr. Sneed. The plant dates (start dates) were staggered based on geographical location of the county in which they are planted. The corresponding counties fell into the following classifications: upper – Person, Orange, Durham, Granville, Wake, Franklin; middle – Johnston, Nash, Wilson; and lower – Wayne, Greene, Pitt, Lenoir, Craven, and Jones. Crop requirements for turfgrass, golf courses, nursery crops, vegetables, blueberries, strawberries, and other fruit were estimated seasonally. The general breakdown for these crops incorporated a warm and cool season with special consideration for frost/freeze protection where applicable. USGS water use daily requirements from the 1995 Water Use Report were used for livestock water use requirements, per the Cape Fear Model Report (Moffatt & Nichol, 1999).

To summarize,

**Table 1-1. Crop Water Requirements**

Crop	Start Date			Evapotranspiration
	High	Mid	Low	
Tobacco	20 May	10 May	30 April	By Curve
Early Soybeans	20 May	28 May	1 May	By Curve
Late Soybeans	20 June	20 June	20 June	By Curve
Peanuts	N/A	7 May	7 May	By Curve
Cotton	N/A	7 May	7 May	By Curve
Corn	23 April	14 April	7 April	By Curve

Pasture and Hay: 1 May – 30 September, 1”/week; Rest of year = none

Turfgrass: 15 April – 15 October, 1.25”/ week; Rest of year = none

Golf Courses: 1 April – 31 October, 0.57”/week; Rest of year = Tees and greens 2.9% of total acres, 2”/week

Nursery (container): 1 June – 31 August, 0.75”/day; 1 April -31 May and 1 September – 31 October, 0.5”/day; Rest of year = 0.2”/day

Nursery (field): 1 May – 31 October, 1.25”/week; Rest of year = none

Vegetables: 1 April – 15 August, 1.25”/week; 16 August – 31 October, 1”/week; Rest of year = none



Blueberries: 15 April -15 June, 1.25"/week (production); 16 June – 30 September, 1.25"/week (protection); 28 February – 14 April, 1"/day for frost/freeze protection, highly variable

Strawberries: 1 April – 1 June, 1.25"/week (production); 15 September – 31 October, 1.25"/week (establishment); 1 October – 15 November, 1"/day (establishment); 28 February – 1 April, 1"/day for frost/freeze protection, highly variable

Other fruit: (Peaches, pecans, Apples, etc.): 15 April – 31 August, 1.25"/week (production); 1 March – 14 April, 0.16"/hr = 3.84"/day for frost/freeze protection

**Table 1-2: Livestock Water Requirements**

Livestock	Water Requirement	Duration
Beef Cattle	12 gal/day/head	All Year
Dairy Cattle	40 gal/day/head	All Year
Horses	12 gal/day/head	All Year
Pigs	4 gal/day/head	All Year
Chickens	9 gal/day/100 head	All Year
Turkeys	9 gal/day/100 head	All Year
Other animals (mainly goats, sheep)	2 gal/day/head	All Year

With the data above, a total agricultural water use demand curve consisting of daily values was computed for the time period between 1930 and 2008. For tobacco, soybeans, peanuts, cotton, and corn, irrigation is directly related to crop stress and rainfall. Therefore, each crops' weekly ET demand was compared to weekly rainfall totals. Where shortfalls of rainfall occurred, we assumed irrigation started to make up the demand. The shortfall amount was then evenly distributed over the next week. All other crops and livestock had fairly constant irrigation and water usage and were therefore not related to rainfall. Completing these calculations for the each year gives a daily total agricultural water use for the model.

When reviewing this information, it is important to be aware of the overall history of irrigation in North Carolina. Prior to the 1950's, little irrigation was done in North Carolina. Up until that time, only steel pipe was used for irrigation, and the war effort was consuming most available steel supplies. However, during the 1950's, three catalysts spurred the initial growth of irrigation in NC: the ending of WWII, the advent of aluminum pipe, and the drought of the 1950's. Aluminum pipe was especially important because its weight allowed fixed systems to be moved with relative ease. The next important advance in irrigation came in the late 1960's and early 1970's with the birth of automated irrigation and hard hose reel systems. These systems allowed irrigation of secondary crops like corn and soybeans to become economically feasible. Of course, other factors such as changes in leisure time and affluence have also had effects on irrigation since commercial turf and golf courses rely heavily on irrigation.



The system used for determining total water use used for irrigation and watering of livestock is described in Section 2.2.1.

### **1.2.3. Rainfall**

Rainfall data was used in determining frequency of irrigation. As described above, a weekly irrigation amount was assigned to each crop. If the rainfall total in that week did not reach the minimum value, irrigation was used to supplement. Rainfall for 1930-2008 was gathered from the National Climactic Data Center. The location of gages is illustrated in Figure 2 and summarized in Table 2.

### **1.3. Data Distribution**

The distribution of Ag water use was developed based input from NC Agriculture Extension Agents from each county. The Agents were asked to verify the values and note the distribution of those crops within the county based on the model nodes. Figure 3 and Table 3 summarize the distribution of Agriculture with respect to the location of the calibration gages used in the model.

The verified distributions were then applied to the water use for each county by assigning an estimated portion of the crop/livestock to the drainage area of the node. These values were then used to formulate an overall time series for historical water use.

## **2. Municipal and Industrial Withdrawals**

### **2.1. Data Sources**

Data was requested from multiple private and municipal entities. A significant collection effort was undertaken by Moffatt & Nichol and Hydrologics. Only entities who use more than 100,000 gallons per day were considered. Table 4 summarizes the withdrawal data compiled and the record of data available. Figure 4 illustrates the distribution of water withdrawals.

Each water user was requested to provide water withdrawal data for as far back as possible. Supplemental information was provided by the Division of Water Resources, thanks to the Local Water Supply Plans submitted annually to the State.

Data was provided in several formats and time periods. The majority of the water withdrawal information was provided up through April 2008.

### **2.2. Methodology**

The water withdrawal data was collected into a monthly time series for input into the model. The start dates provided by the withdrawal entities was used, if available. For the City water users, back calculations were done based on the city's population data to determine the historical water withdrawals. Note that the Progress Energy and Weyerhaeuser water usage data was only available since 2004 and 1991, respectively, but water has been withdrawn from both locations prior to those dates. The most historical recorded values were considered to be constant back to the beginning of the withdrawal.

The withdrawal location of each user was grouped into appropriate nodes. The time series reports as far back as 1930, if the withdrawal existed. If there was no withdrawal at that



location prior to a certain year, the time series value for withdrawal is 0 up until the corresponding start month.

### **3. Municipal and Industrial Discharges**

#### **3.1. Data Sources**

The primary source for the total municipal and industrial discharges into the basin is from the NC Division of Water Quality. All permitted discharges were compiled as identified in Table 5 and the location is illustrated in Figure 5. A file for each discharger in the basin was created. The records dated back to 1994. Additional sources include municipal waste water treatment plant records and private companies. Facilities that are currently in use, as well as closed facilities were taken into consideration.

#### **3.2. Methods**

For municipal facilities' records were used where available. Historical records were linearly interpolated based on the city's population. To fill in any data gaps for private facilities, the earliest recorded discharges were assumed to be constant back until the facility opened.

All entities that discharge greater than 100,000 gallons per day were considered. A time series of the monthly discharges along each reach was calculated using the assumed discharges from the facilities within that reach. The monthly time series was applied at the node in the model.

Extensive interpolation was performed to fill in any data gaps prior to 1994. Although there was little data to be had, we feel that the discharge data set is representative of the discharges in the Neuse River Basin.

## 4. References

- Moffatt & Nichol, 1999. Data Summary and Methodology for Estimation of Water Use in Support of Development of the Cape Fear River Basin Model.
- North Carolina Department of Agriculture and Consumer Services, January 2009. "NCDA&CS Certified Nursery Database" <http://www.agr.state.nc.us/plantindustry/NurseryBook/search.asp>
- North Carolina Department of Agriculture, Agricultural Statistics Division. Water Use Studies: 2007 Central Coastal Plain. <<http://www.agr.state.nc.us/stats/release/WU2007 Central.pdf>>
- North Carolina Department of Environment and Natural Resources, Division of Water Resources. Annual Water Use Reporting. Local Water Supply Planning and Water Withdrawal Registration. < <http://www.ncwater.org/whichsystem.php> > November 2008.
- National Climatic Data Center. Rainfall Data. <<http://lwf.ncdc.noaa.gov/oa/ncdc.html>> November 2008.
- Sneed, Dr. Ronald. Personal Communication, October 2008.
- United States Department of Agriculture: National Agricultural Statistics Service. The Census of Agriculture. 1930, 1950, 1992, 1997, 2002, 2007. Washington: GPO, publication date varies. <<http://www.agcensus.usda.gov/Publications/2007/index.asp>>
- United States Department of Agriculture: National Agricultural Statistics Service. The Census of Agriculture. 1940, 1945, 1950, 1954, 1959, 1964, 199, 1974, 1978, 1982, 1987. Washington: GPO, publication date varies.
- United States Department of Agriculture: National Agricultural Statistics Service. Quick Stats – State and County Data. North Carolina Livestock and Crop Statistics. 1975-2004.
- United States Census Bureau. Population. < <http://www.census.gov/prod/www/abs/decennial/index.htm>> January 2009.
- USGS, 2005. [http://nc.water.usgs.gov/infodata/wateruse/data/Data\\_Tables\\_2005.html](http://nc.water.usgs.gov/infodata/wateruse/data/Data_Tables_2005.html). Water use data tables.

## Referenced Tables

**Table 1. Summary of Neuse River Basin - Distribution by County**

<b>County</b>	<b>Total County Area (acreage)</b>	<b>Area within the Neuse River Basin (acreage)</b>	<b>Percentage of the County within the Neuse River Basin</b>
CRAVEN	451395	427941	95%
DURHAM	191089	141229	74%
FRANKLIN	316685	35458	11%
GRANVILLE	343236	84012	24%
GREENE	170454	170454	100%
JOHNSTON	509250	497268	98%
JONES	302981	233427	77%
LENOIR	257210	257186	100%
NASH	347339	69983	20%
ORANGE	256969	133630	52%
PAMLICO	217857	194124	89%
PERSON	258586	82419	32%
PITT	418727	167540	40%
WAKE	547995	465145	85%
WAYNE	356469	327971	92%
WILSON	239491	194818	81%



**Table 2. Basis of County Rainfall Statistics**

<b>County Name</b>	<b>Rain Gages Used</b>
Person	Durham 1930-2008; Durham CO Data from Cape Fear model used to fill the gaps.
Orange	Durham 1930-2008; Durham CO Data from Cape Fear model used to fill the gaps.
Durham	Durham 1930-2008; Durham CO Data from Cape Fear model used to fill the gaps.
Granville	Durham 1930-2008; Durham CO Data from Cape Fear model used to fill the gaps.
Wake	RDU 1973-2008; Cape Fear Model Wake CO 1933-1972; Durham 1930-1932
Franklin	Louisburg 1930-2008
Johnston	Clayton 1955-2008; Wake 1930-1936; averaged Wake & Wilson 3 SW to fill the gaps
Nash	Wilson 3 SW 1936-2008; gaps filled with Louisburg data
Wayne	Seymour-Johnson AFB 2000-2008; gaps filled with averaged Wilson 3 SW & Kinston 7 SE data
Wilson	Wilson 3 SW 1936-2008; gaps filled with Greenville data
Greene	Averaged Wilson 3 SW, Greenville & Kinston 7 SE
Lenoir	Kinston 7 SE 1930-2008; gaps filled with Kinston AG RSCH data
Pitt	Greenville 1930-2008; gaps filled with averaged Wilson 3 SW & Kinston 7 SE data



Table 3. Summary of Agriculture Distribution

FID_1	CO_NAME	ACRES	BASIN_PART	Ag_Distrib
30	CRAVEN	13475	Lower	3.0
31	CRAVEN	649	Lower	0.0
35	CRAVEN	9	Lower	0.0
22	CRAVEN	20167		4.0
47	CRAVEN	226002		46.0
42	DURHAM	8308	Upper	4.0
58	DURHAM	8176	Upper	7.8
62	DURHAM	9511	Upper	9.7
69	DURHAM	12450	Upper	13.7
72	DURHAM	24047	Upper	7.6
74	DURHAM	47335	Upper	48.8
77	DURHAM	31403	Upper	9.4
44	FRANKLIN	4303	Upper	1.0
54	FRANKLIN	9356	Upper	3.0
79	FRANKLIN	5127	Upper	2.0
15	FRANKLIN	16681		5.0
73	GRANVILLE	7715	Upper	2.0
76	GRANVILLE	23767	Upper	7.0
80	GRANVILLE	52530	Upper	15.0
8	GREENE	97035	Middle	57.0
88	GREENE	7754	Middle	5.0
37	GREENE	65665		39.0
10	JOHNSTON	18189	Middle	4.0
34	JOHNSTON	41686	Middle	8.0
41	JOHNSTON	18312	Middle	4.0
52	JOHNSTON	89780	Middle	18.0
55	JOHNSTON	5516	Middle	1.0
90	JOHNSTON	68115	Middle	13.0
3	JOHNSTON	52122		10.0
6	JOHNSTON	3639		1.0
84	JOHNSTON	199909		39.0
33	JONES	215366	Lower	71.0
45	JONES	5437	Lower	2.0
46	JONES	1631	Lower	1.0
18	JONES	9734		3.0
5	LENOIR	364	Middle	0.0
20	LENOIR	2	Middle	0.0
23	LENOIR	99710	Middle	39.0
32	LENOIR	44090	Middle	17.0
87	LENOIR	89283	Middle	35.0
36	LENOIR	23791		9.0
12	NASH	23901	Upper	7.0
50	NASH	3	Upper	0.0
13	NASH	46082		13.0
61	ORANGE	0	Upper	0.0



NEUSE BASIN MODELING -  
DATA COLLECTION DRAFT REPORT

63	ORANGE	37238	Upper	14.0
66	ORANGE	48743	Upper	19.0
70	ORANGE	40190	Upper	16.0
59	ORANGE	7458		3.0
65	ORANGE	0		0.0
60	PERSON	79119	Upper	31.0
64	PERSON	295	Upper	0.0
68	PERSON	83	Upper	0.0
75	PERSON	2922		1.0
19	PITT	1	Middle	0.0
21	PITT	0	Middle	0.0
38	PITT	71259	Middle	17.0
49	PITT	96323	Middle	23.0
14	WAKE	13333	Upper	3.5
43	WAKE	216758	Upper	20.0
53	WAKE	47323	Upper	15.8
56	WAKE	49530	Upper	15.8
71	WAKE	857	Upper	0.0
91	WAKE	45181	Upper	14.1
92	WAKE	13041	Upper	3.5
4	WAKE	15903		5.3
78	WAKE	63220		5.0
83	WAYNE	150384	Middle	42.0
7	WAYNE	80537		23.0
89	WAYNE	97050		27.0
51	WILSON	4284	Middle	2.0
85	WILSON	264	Middle	0.0
9	WILSON	11458		5.0
11	WILSON	167760		70.0
40	WILSON	11052		5.0



**Table 4. Summary Water Withdrawal Data**

PWSS		Plants	SW Sources	Historical Assumptions	Data Available	Projected Withdrawal Period
1	Creedmoor	Creedmoor WTP	Lake Rogers	using Creedmoor City's population data to populate the historical water withdrawals	1992/1997/2006 data	1935-2008
2	Durham	Brown WTP, Williams WTP	Lake Michie, Little River Reservoir, Eno River	using City of Durham's population data; Raw water is assumed to be 10% more than Finished water	Finished water from 1990-2008	1930-2008
3	Goldsboro	Goldsboro WTP	Neuse River, Little River Reservoir	Goldsboro City population data used.	1997/2002 data from DWR	1931-1973, 1974-2008
4	Hillsborough	Hillsborough WTP	Eno River/LBJ	Hillsborough Town population data used.	Daily data from 1996-2008; same file as Piedmont Minerals	1936-2008
5	Johnston County	Johnston County WTP	Neuse River	start August 1996	Raw water from 1997-2008; Monthly Total	1996-2008
6	City of Raleigh	E. M. Johnson WTP, GG Hill WTP	Falls Lake, Wake Forest	for EMJ, if finished water available, 5% added to obtain raw water, otherwise Raleigh City population used; For GGHill, Wake Forest Town population used.	Raw water from 1969-1980 & 1990-2008 EMJ; 2005-2008 GGHill; Golf Course #1/2/3	1930-2008
7	S Granville	Butner WTP	R.D. Holt	Butner Town population used.	Raw water from 1996-2008; Monthly average provided	1966-2008
8	Smithfield	Smithfield Water Plant	Neuse River	Smithfield Town population data used.	Raw water from 1998-2008; Monthly average provided	1918-1970 (no data available), 1998-2008
9	Wilson	Wiggins Mill WTP, Toisnot WTP	Wiggins Mill Reservoir, Toisnot Rservoir	Wilson City population data used.	1997/2002 data from DWR	1930-2008
13	Orange-Alamance	Orange-Alamance Water Treatment Plant	Eno River	note: in 1969, 300 customers to 3200 customers today	Daily data from 1996-2008	1969-2008
<b>Industrial Users</b>						
10	Piedmont Minerals		Eno River		Daily data from 1996-2008	1996-2008
11	Progress Energy	H. F. Lee Steam Electric Plant	Neuse River	prior to 2004, assumed to be the same as 2004.	Raw Water from 2002-2007; 2002/2003 data incorrect; Monthly average provided	1951-2008
12	Weyerhaeuser	NBCelluloseFiber Raw Water Intake	Neuse River	start Dec-1969; prior to 1991, assumed to be the same as 1991.	Raw Water from 1991-2008; Monthly average provided	1969-2008





Table 5. Summary of Wastewater Discharges

Permit	Owner	Facility	County	Type	Class	Flow	Subbasin	Receiving Stream	Lat	Lon	Current?	Original permit issuance	Processed
Active Discharges													
NC0001376	Riverplace II LLC	Riverplace II LLC	Wake	Industrial Process & Commercial	Minor	5000000	30402	NEUSE RIVER	35.908333	-78.551389	01/1994-11/2006	8/30/1979	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 1/1980)
NC0003191	Weyerhaeuser Company	New Bern Mill	Craven	Industrial Process & Commercial	Major	32000000	30408	NEUSE RIVER	35.198889	-77.1125	01/1994-06/2008	12/31/1973	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 1/1974)
NC0003417	Progress Energy Carolinas Inc	Lee Steam Electric Plant	Wayne	Industrial Process & Commercial	Major	not limited	30412	NEUSE RIVER	35.377778	-78.070278	01/1994-05/2008	6/30/1977	
NC0003549	TransMontaigne Operating Company, LP	Selma South terminal	Johnston	Industrial Process & Commercial	Minor	not limited	30402	Mill Creek (at Selma)	35.551667	-78.303889	01/1994-04/2008	11/10/1981	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 1/1982)
NC0003760	Unifi-Kinston LLC	Unifi-Kinston LLC	Lenoir	Industrial Process & Commercial	Major	3600000	30405	NEUSE RIVER	35.324722	-77.466389	01/1994-05/2008	12/29/1978	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 1/1979)
NC0007536	Town of Stantonsburg	Stantonsburg WTP	Wilson	Water Treatment Plant	Minor	not limited	30407	Contentnea Creek	35.605833	-77.819722	01/1994-05/2008		Excluded (most of time < 0.1MGD)
NC0020389	Town of Benson	Benson WWTP	Johnston	Municipal, Large	Major	1900000	30404	Hannah Creek	35.389444	-78.508333	01/1994-04/2008	12/1/1982	Yes (Benson town population)
NC0020842	Town of Snow Hill	Snow Hill WWTP	Greene	Municipal, < 1MGD	Minor	500000	30407	Contentnea Creek	35.456389	-77.661944	01/1994-05/2008	2/28/1979	Yes (Snow Hill town population)
NC0021644	Town of La Grange	La Grange WWTP	Lenoir	Municipal, < 1MGD	Minor	750000	30405	Mosely Creek	35.309444	-77.776111	01/1994-05/2008	1/13/1981	Yes (La Grange town population)
NC0022217	Motiva Enterprises LLC	Apex terminal	Wake	Industrial Process & Commercial	Minor	not limited	30403	Middle Creek	35.718889	-78.814722	01/1994-05/2008	12/31/1979	?
NC0023841	City of Durham	North Durham WRF	Durham	Municipal, Large	Major	20000000	30401	Ellerbe Creek	36.030278	-78.863333	01/1994-04/2008		Yes (1944-1993 USGS; 1933-1943 Durham city population)
NC0023906	City of Wilson	Wilson WWTP	Wilson	Municipal, Large	Major	14000000	30407	Contentnea Creek	35.676944	-77.914167	01/1994-05/2008	12/31/1974	Yes (Wilson city population)
NC0023949	City of Goldsboro	Goldsboro WWTP	Wayne	Municipal, Large	Major	17600000	30405	NEUSE RIVER	35.336111	-77.999722	01/1994-05/2008	6/5/1978	Yes (Goldsboro city population)
NC0024236	City of Kinston	Kinston Regional Water Reclamation Facility	Lenoir	Municipal, Large	Major	11850000	30405	NEUSE RIVER	35.287778	-77.501944	01/1994-05/2008	4/30/1979	Yes (Kinston city population)
NC0025453	Town of Clayton	Little Creek WWTP	Johnston	Municipal, Large	Major	2500000	30402	NEUSE RIVER	35.641111	-78.464722	01/1994-05/2008	4/13/1982	Yes (Clayton town population)
NC0026433	Town of Hillsborough	Hillsborough WWTP	Orange	Municipal, Large	Major	3000000	30401	Eno River	36.073611	-79.090278	01/1994-04/2008	5/17/1982	Yes (Hillsborough town population)
NC0026662	Town of Princeton	Princeton WWTP	Johnston	Municipal, < 1MGD	Minor	275000	30406	Little River	35.482222	-78.144444	01/1994-05/2008	4/6/1981	Yes (Princeton town population)
NC0026824	South Granville Water & Sewer Authority (SGWASA)	SGWASA WWTP	Granville	Municipal, Large	Major	5500000	30401	Knap of Reeds Creek	36.1275	-78.798889	01/1994-05/2008		Yes (Butner town population 1950-)
NC0029033	City of Raleigh	Neuse River WWTP	Wake	Municipal, Large	Major	75000000	30402	NEUSE RIVER	35.723333	-78.477778	01/1994-05/2008		Yes (Raleigh city population)
NC0029572	Town of Farmville	Farmville WWTP	Pitt	Municipal, Large	Major	3500000	30407	Little Contentnea Creek	35.5875	-77.5461	01/1994-05/2008	1/13/1981	Yes (Farmville town population)
NC0030716	Johnston County Department of Public Utilities	Central Johnston County WWTP	Johnston	Municipal, Large	Major	13500000	30402	NEUSE RIVER	35.501111	-78.375556	01/1994-04/2008	2/17/1981	Yes (Johnston county population)



Permit	Owner	Facility	County	Type	Class	Flow	Subbasin	Receiving Stream	Lat	Lon	Current?	Original permit issuance	Processed
NC0030759	City of Raleigh	Smith Creek WWTP	Wake	Municipal, Large	Major	6000000	30402	NEUSE RIVER	35.907778	-78.538333	01/1994-05/2008		Yes (Wake Forest town population)
NC0031828	Town of Vanceboro	Vanceboro WWTP	Craven	Municipal, < 1MGD	Minor	300000	30409	Swift Creek	35.295	-77.148333	01/1994-05/2008	12/31/1981	Yes (Vanceboro town population)
NC0032077	Contentnea Metropolitan Sewerage District	Contentnea Sewerage District WWTP	Pitt	Municipal, Large	Major	2850000	30407	Contentnea Creek	35.351944	-77.416389	01/1994-05/2008	11/30/1981	Yes (Ayden+Grifton+Winterville town population)
NC0048879	Town of Cary	North Cary WRF	Wake	Municipal, Large	Major	12000000	30402	Crabtree Creek (Crabtree Lake)			01/1994-05/2008		Yes (Cary town population)
NC0049662	Aqua North Carolina, Inc.	Hawthorne Subdivision WWTP	Wake	100% Domestic < 1MGD	Minor	250000	30401	Upper Barton Creek	35.935556	-78.727222	01/1994-05/2008	11/30/1981	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 1/1982)
NC0051322	Carolina Water Service, Inc. of North Carolina	Ashley Hills WWTP	Wake	100% Domestic < 1MGD	Minor	495000	30402	Poplar Creek			01/1994-05/2008	9/30/1982	Excluded (prior to 2004, < 0.1 MGD)
NC0052311	Magellan Terminals Holdings L P	Selma Terminal	Johnston	Industrial Process & Commercial	Minor	not limited	30402	Mill Creek (at Selma)	35.555556	-78.295833	01/1994-05/2008	8/3/1983	
NC0057606	Town of Stantonsburg	Stantonsburg WWTP	Wilson	Municipal, < 1MGD	Minor	375000	30407	Contentnea Creek	35.582778	-77.800556	01/1994-05/2008	2/7/1984	Yes (Stantonsburg town population)
NC0058416	South Granville Water & Sewer Authority (SGWASA)	SGWASA WTP	Granville	Water Treatment Plant	Minor	not limited	30401	Knap of Reeds Creek	36.141111	-78.769722	01/1994-05/2008		Yes (prior to 1994, discharges = 0.06*withdaws)
NC0061492	Maury Sanitary Land District	Maury Sanitary Land District WWTP	Greene	Municipal, < 1MGD	Minor	225000	30407	Contentnea Creek	35.428611	-77.5825	01/1994-05/2008	7/19/1985	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 1/1986)
NC0064050	Town of Apex	Apex Water Reclamation Facility	Wake	Municipal, Large	Major	3600000	30403	Middle Creek	35.709167	-78.834722	01/1994-05/2008		Yes (Apex town population)
NC0064564	Aqua North Carolina, Inc.	Neuse Colony WWTP	Johnston	100% Domestic < 1MGD	Minor	750000	30402	NEUSE RIVER	35.645556	-78.406111	06/1997-05/2008	2/7/1986	Excluded (prior to 2006, < 0.1 MGD)
NC0064891	Town of Kenly	Kenly Regional WWTP	Johnston	Municipal, < 1MGD	Minor	630000	30406	Little River (Tarpleys Pond)	35.582222	-78.159167	01/1994-05/2008	4/1/1986	Yes (Kenly town population)
NC0065102	Town of Cary	South Cary WRF	Wake	Municipal, Large	Major	16000000	30403	Middle Creek	35.645833	-78.757222	01/1994-05/2008		Yes (Cary town population)
NC0066516	Town of Fuquay-Varina	Terrible Creek WWTP	Wake	Municipal, Large	Major	6000000	30403	Terrible Creek	35.6136	-78.7258	07/1997-04/2008	7/1/1996	Yes (Fuquay-Varina town population)
NC0073229	Weyerhaeuser Company	Greenville Lumber Facility	Pitt	Industrial Process & Commercial	Minor	not limited	30409	Swift Creek	35.415556	-77.422222	01/1994-06/2008	5/16/1988	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 6/1988)
NC0075281	Craven County Wood Energy, LP	Craven County Wood Energy	Craven	Industrial Process & Commercial	Minor	200000	30408	Bachelor Creek	35.140278	-77.178889	01/1994-05/2008	1/10/1989	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 1/1989)
NC0079316	City of Raleigh (Town of Zebulon)	Little Creek WWTP	Wake	Municipal, Large	Major	2200000	30407	Little Creek	35.813056	-78.272222	01/1994-05/2008		Yes (Zebulon town population)
NC0080519	Lampe & Malphrus Lumber	10th Street Wet-Decking site	Johnston	Industrial Process & Commercial	Minor	not limited	30402	Buffalo Creek			07/1999-11/2007	3/23/1992	
NC0082376	City of Raleigh	E.M. Johnson WTP	Wake	Water Treatment Plant	Minor	not limited	30402	NEUSE RIVER	35.910556	-78.591111	01/1994-01/2007		Yes (Raleigh city population)
NC0083348	Town of Smithfield	Smithfield WTP	Johnston	WTP	Minor	300000	30402	Buffalo Creek	35.518333	-78.345833	04/1994-05/2008		Excluded (most of time < 0.1MGD)



Permit	Owner	Facility	County	Type	Class	Flow	Subbasin	Receiving Stream	Lat	Lon	Current?	Original permit issuance	Processed
NC0084514	Raleigh Durham Airport Authority	RDU International Airport-WWTP	Wake	Industrial Process & Commercial	Minor	not limited	30402	Brier Creek	35.859444	-78.807222	04/1995-02/2008	3/16/1994	Yes
NC0084735	Johnston County Department of Public Utilities	Johnston County WTP	Johnston	Water Treatment Plant	Minor	4000000	30402	NEUSE RIVER	35.580556	-78.327778	09/1996-04/2008		Yes
NC0085936	Jerry G Williams & Sons, Inc.	Wet Log Deck Storage site	Johnston	Industrial Process & Commercial	Minor	not limited	30402	NEUSE RIVER	35.491111	-78.353889	02/1998-12/2007	11/18/1997	Yes
<b>Historical</b>													
NC0003379	Eaton Corporation	Roxboro plant	Person	Industrial Process & Commercial	Minor	22000	30401	North Flat River			01/1994-05/2008	3/1/1982	Excluded (permitted discharge < 0.1MGD)
NC0007528	City of Raleigh	G.G. Hill WTP	Wake	Water Treatment Plant	Minor	70000	30402	Smith Creek	35.969444	-78.488889	01/1994-04/2008		Yes (Wake Forest town population)
NC0003859	Piedmont Minerals Co Inc	Piedmont Minerals Co., Inc.					03-04-01				01/1994-10/1998	2/17/1981	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 3/1981)
NC0020541	City of Kinston	Peachtree WWTP					03-04-05		35.245833	-77.566667	01/1994-09/2006		Yes (Kinston city population)
NC0021563	Town of Middlesex	Middlesex WWTP, Town Of					03-04-07		35.7825	-78.206111	01/1994-04/1998		Yes (Middlesex town population, end on 4/1998)
NC0025020	Town of Wendell	Wendell WWTP, Town Of					03-04-06		35.77	-78.377778	01/1994-04/1994		Yes (Wendell town population using 1997 waterwater monthly discharges from DWR, end on 4/1994)
NC0026310	City of Durham	Durham (Little Lick Crk WW					03-04-01		35.970278	-78.805278	01/1994-11/1994	3/19/1982	Assume included in North Durham WRF flows documented by USGS
NC0026336	City of Durham	Durham (Eno WWTP)					03-04-01		36.076111	-78.8875	01/1994-06/1994	9/28/1977	Assume included in North Durham WRF flows documented by USGS
NC0030392	Wayne County	Genoa Industrial WWTP					03-04-12		35.338889	-78.024167	01/1994-04/2001	11/30/1981	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 1/1982)
NC0050041	Town of Morrisville	Morrisville WWTP, Town Of					03-04-02		35.821944	-78.821667	01/1994-07/1997		Yes (Morrisville town population, end on 7/1997)
NC0050938	Town of Morrisville	Morrisville WTP, Town Of					03-04-02				01/1994-09/1997		Excluded (previous to 1996, discharge < 0.1MGD)
NC0063177	U S Air Force	Seymour Johnson Air Force Base					03-04-05		35.336111	-77.962222	01/1994-05/2002	9/29/1986	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 1/1987); some numbers aren't quite reasonable!
NC0064149	Jones Dairy Farm Utilities Inc	Jones Dairy Farm WWTP					03-04-02				01/1994-10/2005	3/5/1986	Excluded (prior to 2003, discharges <0.1MGD)
NC0064408	Whitewood Properties Inc D	Neuse Crossing WWTP					03-04-02		35.876389	-78.531944	01/1994-05/2007	2/12/1986	Yes (assumed for years prior to 1994, same as 1994 discharges; began on 3/1986)
NC0072583	Webbers Hatchery	Webbers Hatchery					03-04-12		35	-80	01/1994-01/1996	2/28/1988	Excluded
NC0076724	Coastal Lumber Co	Kinston lumber yard					03-04-05		35.272222	-77.623611	01/1994-08/2001	6/30/1989	

## Referenced Figures

Figure 1. Neuse River Basin

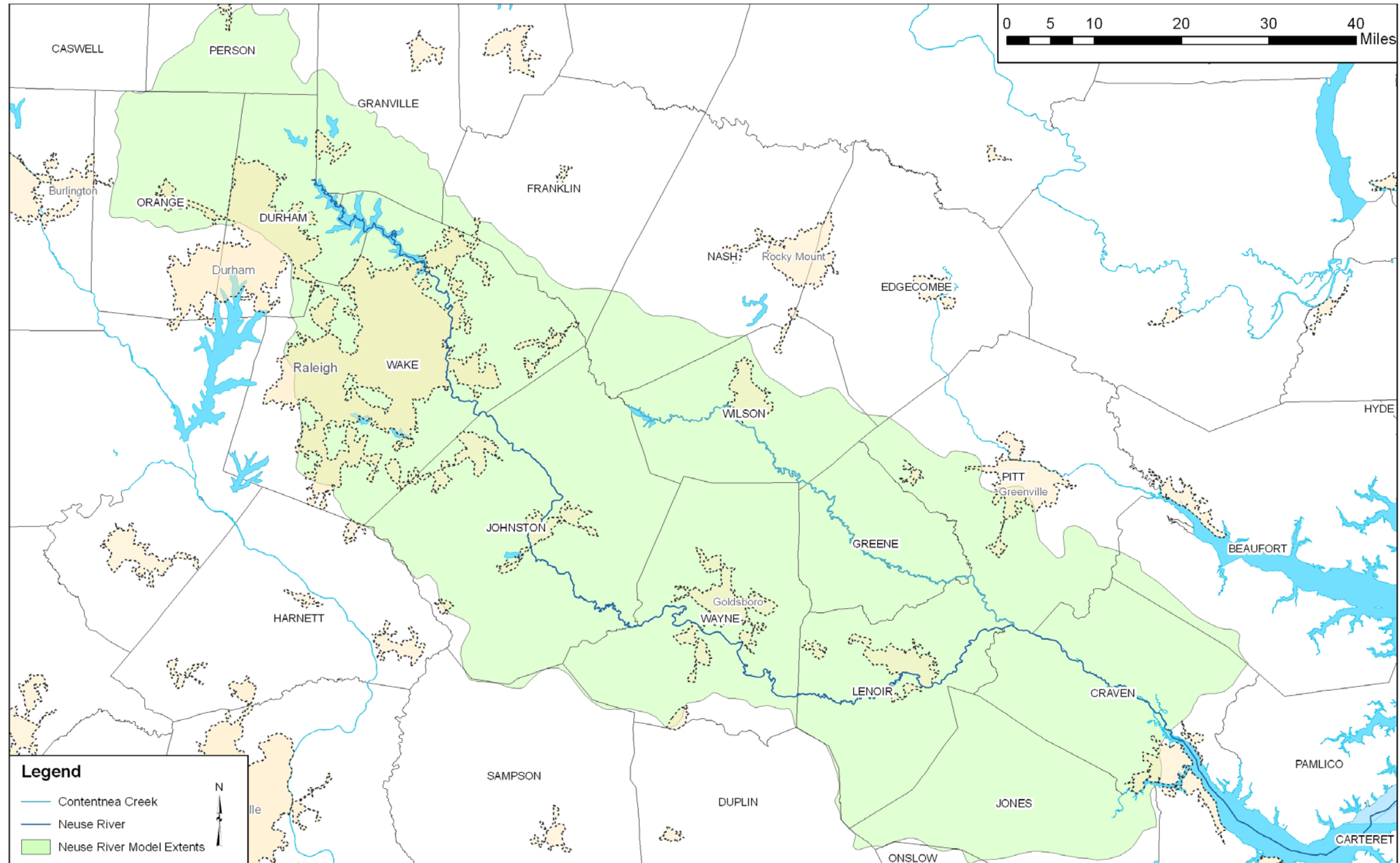


Figure 2. Rain Gages

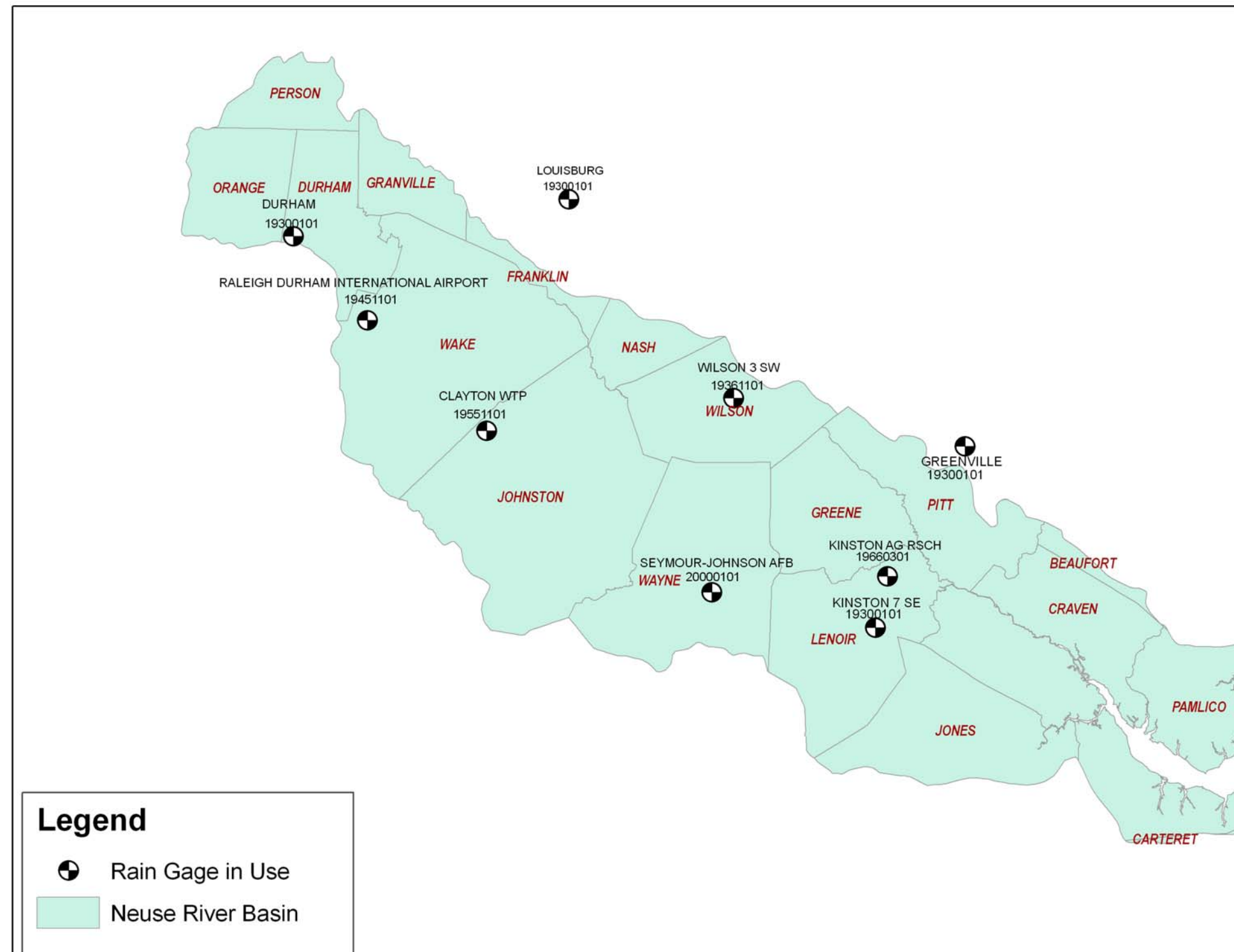


Figure 3. Distribution of Agriculture

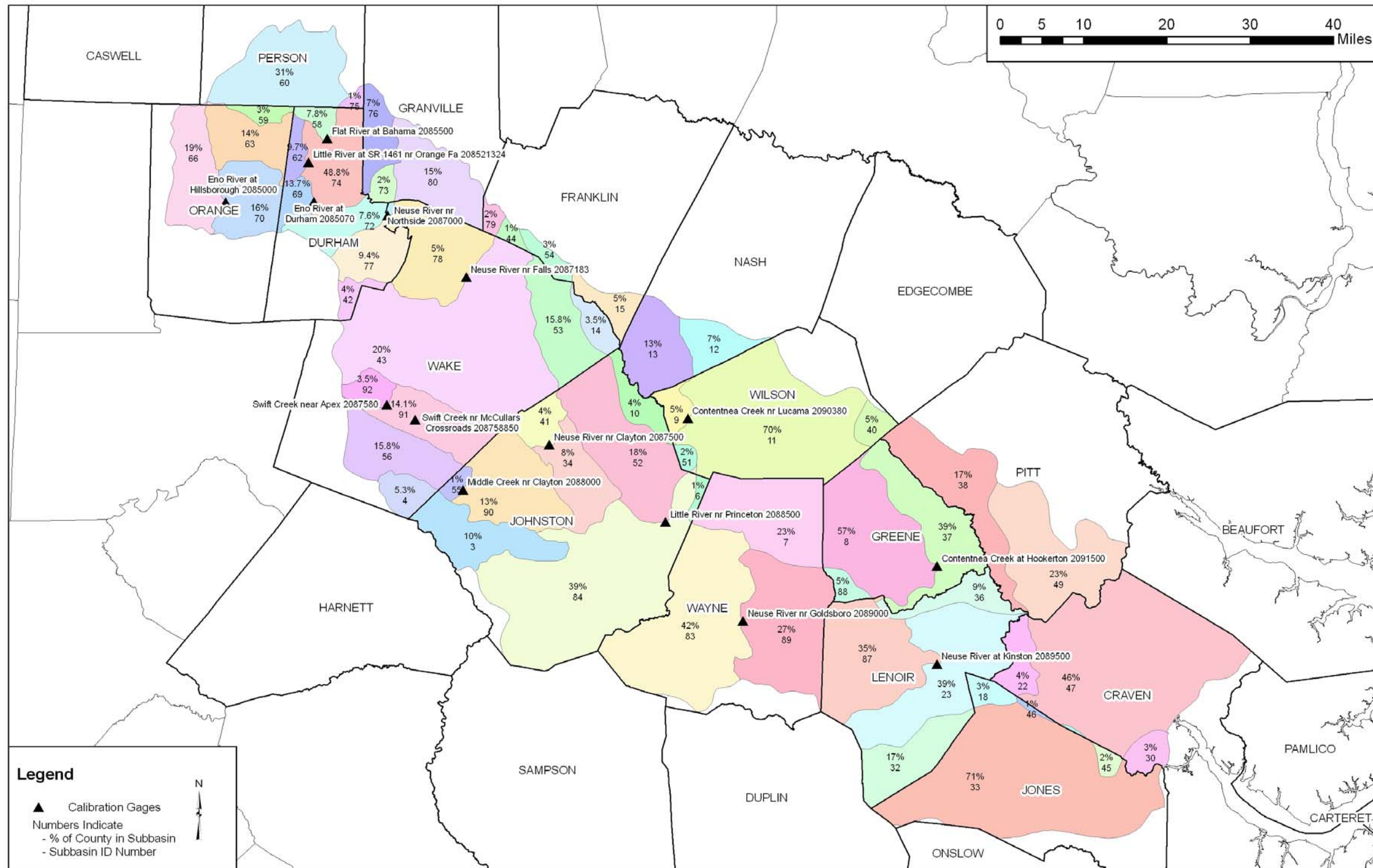


Figure 4. Water withdrawals

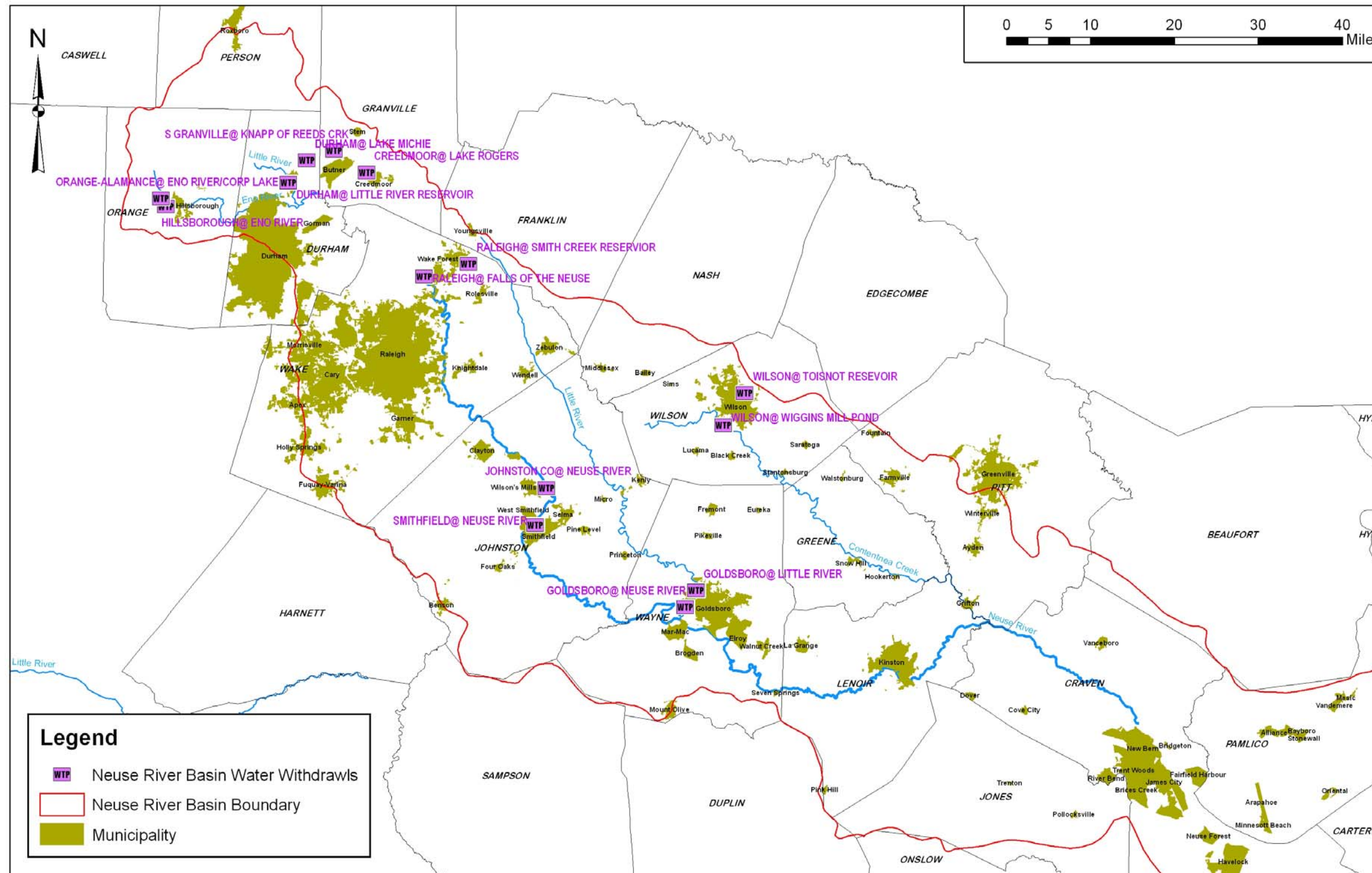


Figure 5. Wastewater discharges

