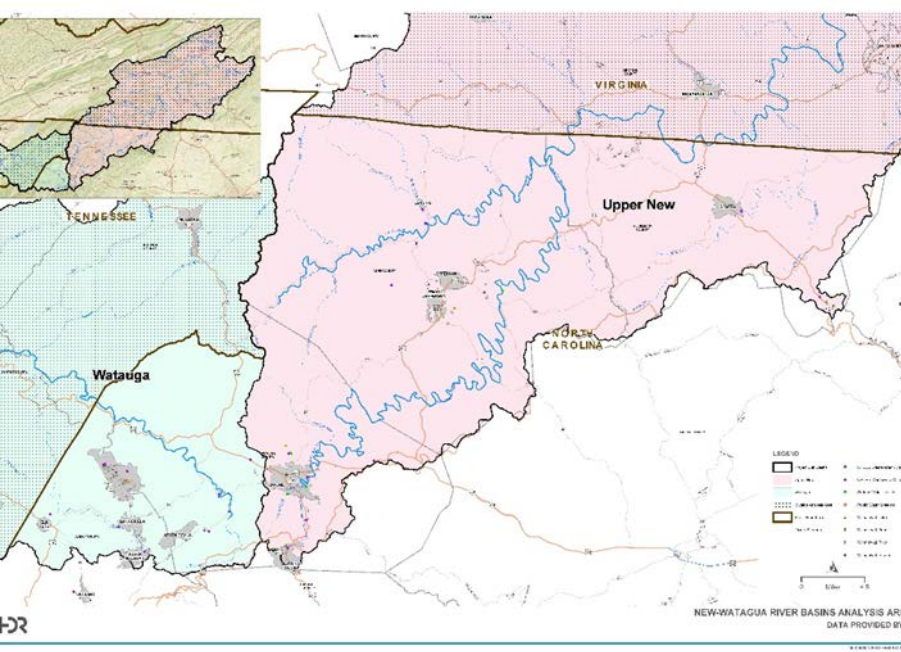


HDR






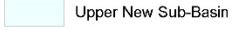

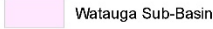


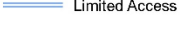

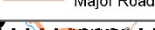
New and Watauga Hydrologic Model Stakeholder Meeting #2

Data Collection and Processing
Review

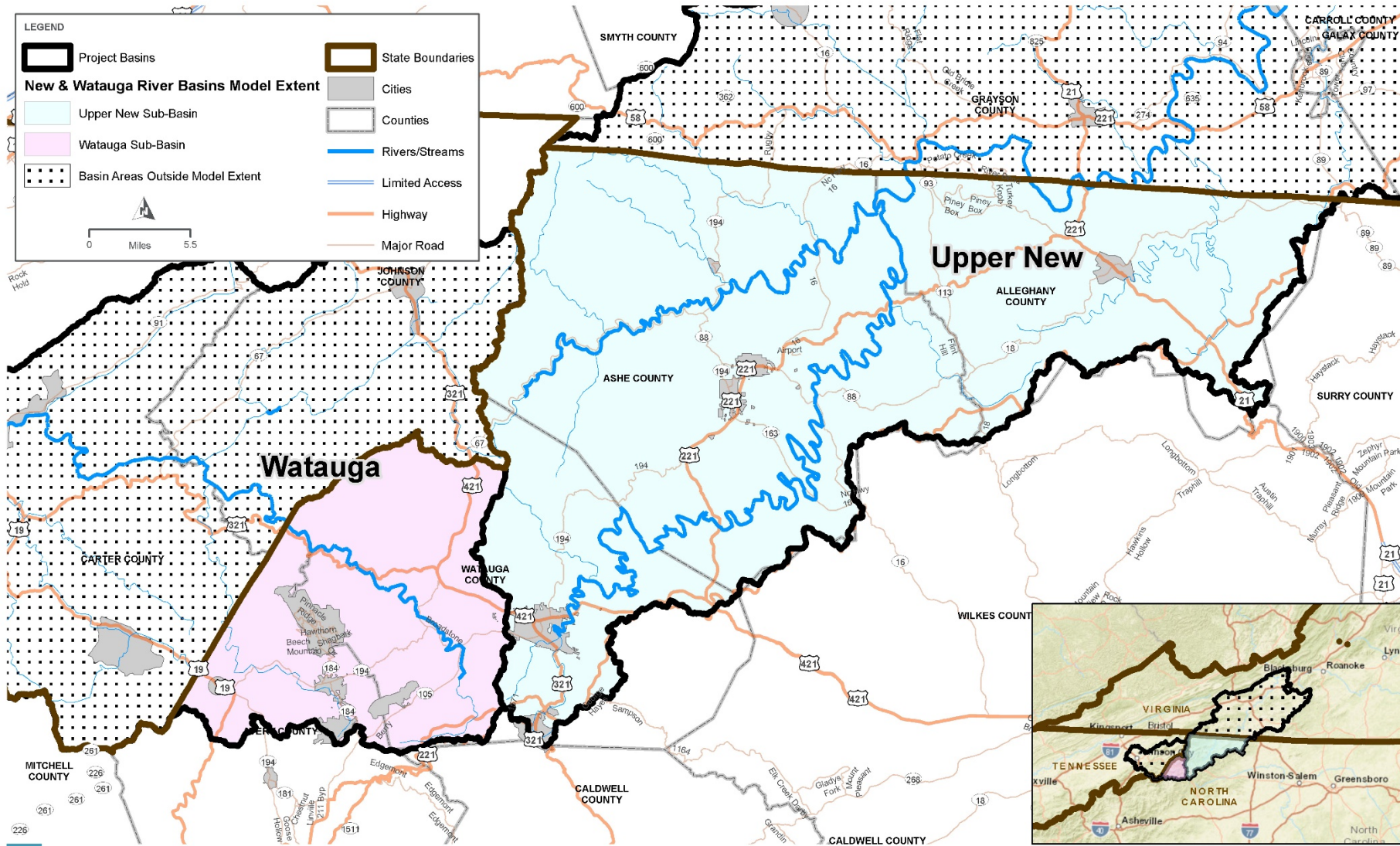


October 2, 2018

LEGEND

| | |
|---|--|
|  Project Basins |  State Boundaries |
| New & Watauga River Basins Model Extent |  Cities |
|  Upper New Sub-Basin |  Counties |
|  Watauga Sub-Basin |  Rivers/Streams |
|  Basin Areas Outside Model Extent |  Limited Access |
| |  Highway |
| |  Major Road |

0 Miles 5.5



NEW AND WATAUGA RIVER BASINS

MODEL EXTENT

FIGURE 1B



Data Collection Overview

Withdrawals and Returns

Introduction

- Data focus:
 - Agriculture
 - Industrial
 - Municipal
 - 1930-2017
- Data Sources:
 - NC Division of Water Resources (NCDWR)
 - National Climatic 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 Governments
 - Stakeholder input from April, 2018 kickoff



Data Collection & Processing

- Collect Water Withdrawal and Discharge Data
 - Identify applicable water users
 - Collect withdrawal & return data for users
 - Enter data into MS Excel database
 - Collect geographic information on withdrawal and return points
 - Reservoir operations (HydroLogics)
 - Data timeline = 1930 to 2017
- Process Data
 - “Hindcasting” forecasts of historic water use for withdrawals and returns where historic information is not available.
 - Water / Wastewater Utilities
 - Industrial
 - Power Generation
 - Agriculture / Irrigation



Data Documentation

- Deliverables
 - Withdrawal and discharge database
 - **Summary report of water withdrawal & return data and hindcasting methodology**
- Use of Data:
 - Develop inflow dataset
 - » Historical record of unimpaired (natural) river flow
 - Establish model nodes
 - Determine drainage areas to each node
 - Document water use demand for individual users
 - Determine agricultural water use needs across the basin



Data Collection Draft Report

French Broad and New/Watauga River Basin
Models

Prepared for HydroLogics, Inc.

Western, North Carolina
September 19, 2018



Agricultural Data

Collection, Processing, & Results

Agriculture – Data Collection

- Quantify water use for:
 - Crop irrigation
 - Turf irrigation
 - Livestock watering
- Data Sources
 - National Agricultural Statistics Services (NASS)
 - Crops and Livestock Agricultural Survey (Ag Survey)
 - » Annual data
 - USDA Census of Agriculture (Census)
 - » Data every 5 years
 - NC Department of Agriculture (NCDA) Statistics
 - Agriculture Extension Agent Consultation
 - Dr. Ronald Sneed (retired professor NCSU)
 - US Geological Survey (USGS)



Agricultural Water Use Assumptions

- Crops evaluated
 - Tobacco
 - Turf
 - Golf courses
 - Nurseries (field and container/under cover)
 - Secondary crops (soybeans, cotton, corn, peanuts, irrigated pasture and hay)
 - Vegetables
 - Blueberries and Strawberries (no identified acreage from databases)
 - Orchards
- Livestock evaluated
 - Cattle (dairy and beef)
 - Chickens
 - Turkeys
 - Pigs
 - Horses
 - Other (alpacas, deer, duck, elk, goats, llamas, sheep, pheasants, etc.)

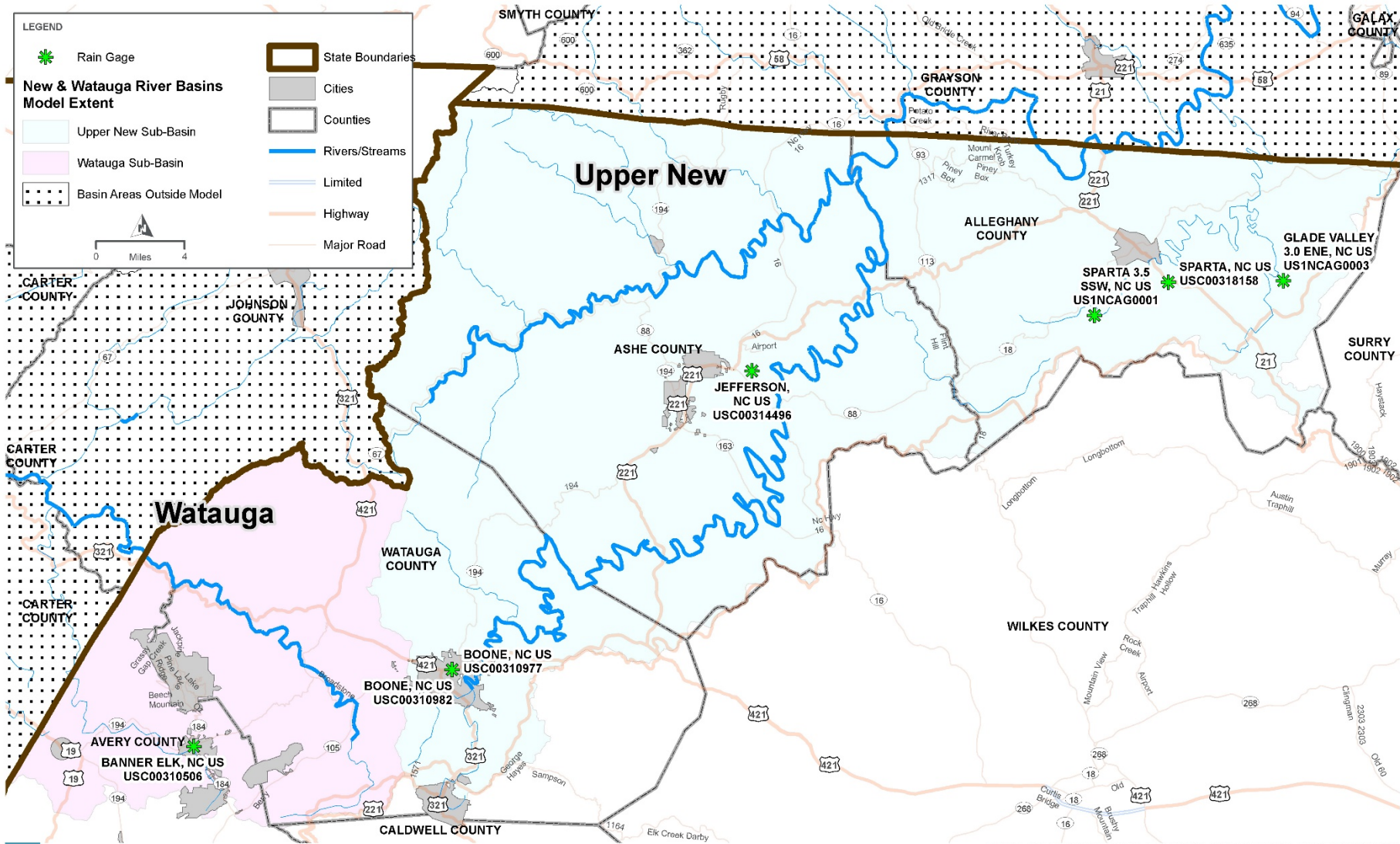
| Crop Water Requirements | | | | |
|---|-------------------|---|--|--------------------|
| Crop | Start Date | | | Evapotranspiration |
| | High | Mid | Low | |
| Tobacco | 6-Jul | 5-Jun | 15-May | By Curve |
| Early Soybeans | 14-Jun | 1-Jun | 16-May | By Curve |
| Late Soybeans | 1-Aug | 15-Jul | 1-Jul | By Curve |
| Peanuts | N/A | 1-Jun | 15-May | By Curve |
| Cotton | N/A | 1-Jun | 15-May | By Curve |
| Corn | 10-May | 1-May | 20-Apr | By Curve |
| | Dates | Amount | Rest of Year | |
| Pasture and Hay | 15 May – 14 Oct | 1"/week | none | |
| Turfgrass | 28 Apr – 30 Sep | 1.25"/week | none | |
| Golf Courses | 13 Apr – 17 Oct | 0.57"/week | Tees & Greens 2.9% of total ac., 2"/week | |
| Nursery (container) | 13 Jun – 12 Sep | 0.75"/day | 0.2"/day | |
| | 13 Sep – 31 Oct | 0.5"/day | | |
| Nursery (field) | 1 May – 14 Oct | 1.25"/week | none | |
| Vegetables | 15 April – 31 Aug | 1.25"/week | none | |
| | 1 Sep – 14 Oct | 1"/week | | |
| Blueberries | 15 Apr -15 Jun | 1.25"/week (production) | | |
| | 16 Jun – 30 Sep | 1.25"/week (protection) | | |
| | 28 Feb – 14 Apr | 1"/day for frost/freeze protection, highly variable | | |
| Strawberries | 2 Apr – 1 Jun | 1.25"/week (production) | | |
| | 15 Sep – 30 Sep | 1.25"/week (establishment) | | |
| | 1 Oct – 15 Nov | 1"/day (establishment) | | |
| | 28 Feb – 1 Apr | 1"/day for frost/freeze protection, highly variable | | |
| Other fruit (Peaches, pecans, Apples, etc.) | 15 Apr – 31 Aug | 1.25"/week (production) | | |
| | 1 Mar – 14 Apr | 0.16"/hr = 3.84"/day for frost/freeze protection | | |

| 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/50 head | All Year |
| Other animals (mainly goats, sheep) | 2 gal/day/head | All Year |

Agricultural Water Use Methodology

- Calculated to produce water use demand curve (daily values) from 1930-2017.
- Evapotranspiration curves
 - Used for movable irrigation (tobacco, soybeans, peanuts, cotton, corn, and nurseries in the open)
 - Irrigation level directly related to crop stress
 - Insufficient rainfall = irrigation
 - Rainfall data (1930-2017) from National Climactic Data Center (by county)
- Surface vs. Groundwater Use
 - USGS irrigation withdrawal data used (1995, 2000, 2005, 2010)
 - Surface vs. groundwater ratio to total irrigation developed
- Data Distribution
 - Assumed even distribution across counties, EXCEPT:
 - Cropped out Federal and State owned lands (national forests, state parks, etc.)
 - Where consultation with Ag. Extensions indicated an exception
 - Water use prorated to each OASIS node, based on drainage area



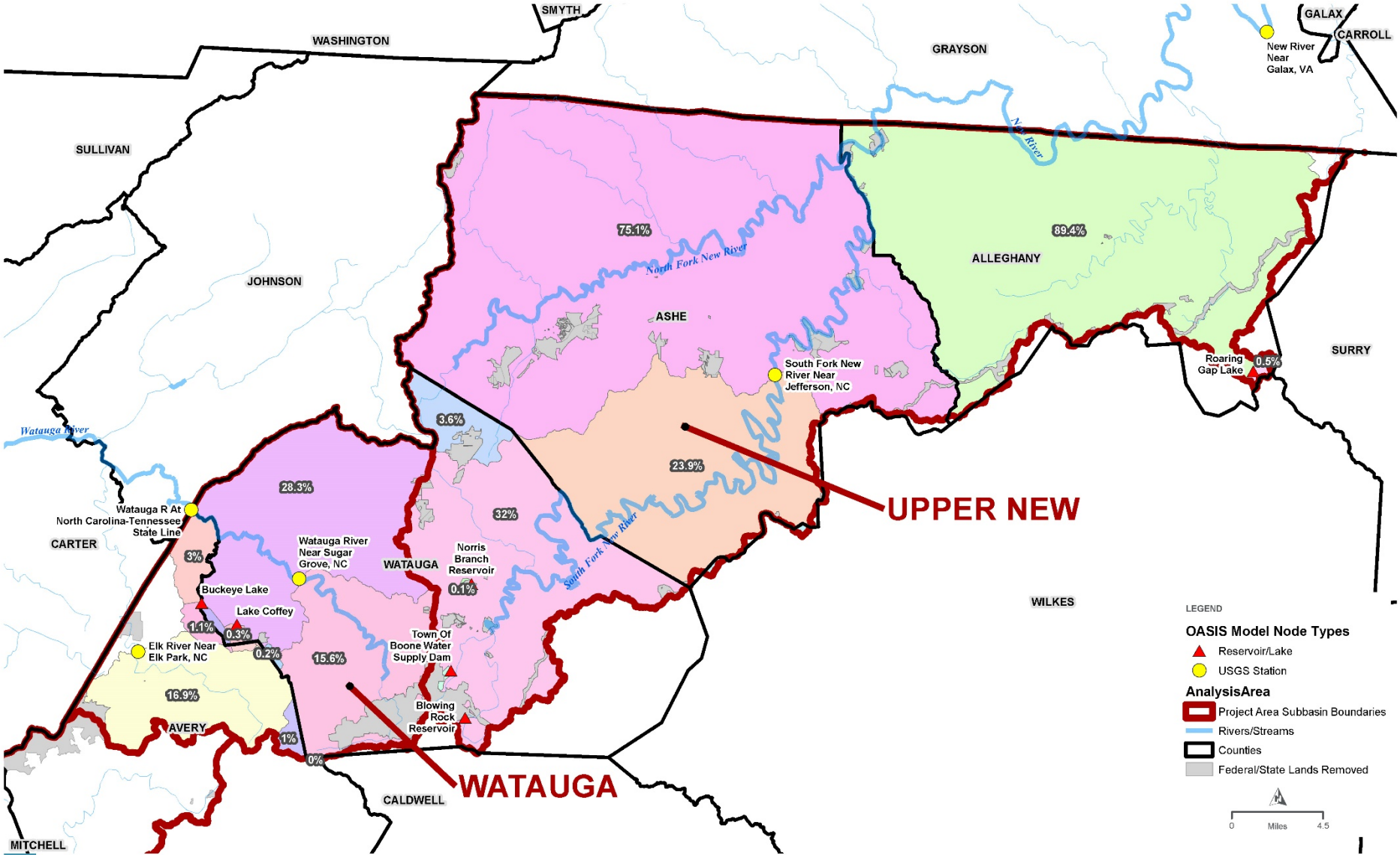


RAIN GAGES USED IN NEW AND WATAUGA RIVER BASINS

NCDC STATIONS

FIGURE 2B





LEGEND

OASIS Model Node Types

- ▲ Reservoir/Lake
- USGS Station

Analysis Area

- Project Area Subbasin Boundaries
- Rivers/Streams
- Counties
- Federal/State Lands Removed

0 Miles 4.5

NEW AND WATAUGA RIVER BASIN AREAS DRAINING TO OASIS MODEL NODES BY COUNTY
 AGRICULTURE AND IRRIGATION AREA
 FIGURE 2B



Agricultural Water Use - Example

- Step 1: Identify Annual Irrigated Acreage and Livestock (by county and year)

| COUNTY: | | Yancey | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|--|--------------|----------------------------|-------------------|---------|---------|-------------------|---------------|-----------------------|----------------------------|------------------|---------------------|--------------------|---------------|----------------|---------------------|-------------------------|
| STEP 1 : IDENTIFY ANNUAL IRRIGATED ACREAGE AND LIVESTOCK COUNT | | | | | | | | | | | | | | | | |
| YEAR | COUNTY TOTAL | COUNTY AREA WITHIN PROJECT | IRRIGATED TOBACCO | TURF | GOLF | CONTAINER NURSERY | FIELD NURSERY | NURSERY - IN THE OPEN | NURSERY - UNDER PROTECTION | IRRIGATED COTTON | IRRIGATED EARLY SOY | IRRIGATED LATE SOY | IRRIGATED SOY | IRRIGATED CORN | IRRIGATED VEGETIBLE | IRRIGATED PASTURE & HAY |
| | | | (Moveable) | (Fixed) | (Fixed) | (Fixed) | (Fixed) | (Moveable) | (Fixed) | (Moveable) | (Moveable) | (Moveable) | (Moveable) | (Moveable) | (Fixed) | (Fixed) |
| | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) | (acres) |
| 2000 | 200,345 | 200,276 | 15.20 | ND | 150.00 | ND | ND | 140.80 | 0.13 | ND | ND | ND | ND | ND | 5.64 | 10.19 |
| 2001 | 200,345 | 200,276 | 14.60 | ND | 150.00 | ND | ND | 160.40 | 0.14 | ND | ND | ND | ND | ND | 5.82 | 10.59 |
| 2002 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 180.00 | 0.14 | ND | ND | ND | ND | ND | 6.00 | 11.00 |
| 2003 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 178.60 | 0.42 | ND | ND | ND | ND | ND | 8.80 | 11.00 |
| 2004 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 177.20 | 0.70 | ND | ND | ND | ND | ND | 11.60 | 11.00 |
| 2005 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 175.80 | 0.98 | ND | ND | ND | ND | ND | 14.40 | 11.00 |
| 2006 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 174.40 | 1.26 | ND | ND | ND | ND | ND | 17.20 | 11.00 |
| 2007 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 173.00 | 1.54 | ND | ND | ND | ND | ND | 20.00 | 11.00 |
| 2008 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 191.80 | 1.45 | ND | ND | ND | ND | ND | 18.60 | 11.00 |
| 2009 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 210.60 | 1.37 | ND | ND | ND | ND | ND | 17.20 | 11.00 |
| 2010 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 229.40 | 1.28 | ND | ND | ND | ND | ND | 15.80 | 11.00 |
| 2011 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 248.20 | 1.20 | ND | ND | ND | ND | ND | 14.40 | 11.00 |
| 2012 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 267.00 | 1.11 | ND | ND | ND | ND | ND | 13.00 | 11.00 |
| 2013 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 267.00 | 1.11 | ND | ND | ND | ND | ND | 13.00 | 11.00 |
| 2014 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 267.00 | 1.11 | ND | ND | ND | ND | ND | 13.00 | 11.00 |
| 2015 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 267.00 | 1.11 | ND | ND | ND | ND | ND | 13.00 | 11.00 |
| 2016 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 267.00 | 1.11 | ND | ND | ND | ND | ND | 13.00 | 11.00 |
| 2017 | 200,345 | 200,276 | 14.00 | ND | 150.00 | ND | ND | 267.00 | 1.11 | ND | ND | ND | ND | ND | 13.00 | 11.00 |

Agricultural Water Use - Example

- Step 2: Annual Pattern of Daily Water Demand Rates (by crop and livestock type; by month and day)

COUNTY: Yancey

| STEP 2: ANNUAL PATTERN OF DAILY WATER USE COEFFICIENTS BY CROP AND LIVESTOCK | | | | | | | | | | | | | | | | | |
|--|-------|-----|-----------|-------------------|----------|----------|-------------------|---------------|-----------------------|----------------------------|------------------|---------------------|--------------------|---------------|----------------|---------------------|-------------------------|
| TABLE ROW | MONTH | DAY | MONTH-DAY | IRRIGATED TOBACCO | TURF | GOLF | CONTAINER NURSERY | FIELD NURSERY | NURSERY - IN THE OPEN | NURSERY - UNDER PROTECTION | IRRIGATED COTTON | IRRIGATED EARLY SOY | IRRIGATED LATE SOY | IRRIGATED SOY | IRRIGATED CORN | IRRIGATED VEGETABLE | IRRIGATED PASTURE & HAY |
| | | | | (Moveable) | (Fixed) | (Fixed) | (Fixed) | (Fixed) | (Moveable) | (Fixed) | (Moveable) | (Moveable) | (Moveable) | (Moveable) | (Moveable) | (Fixed) | (Fixed) |
| | | | | (in/day) | (in/day) | (in/day) | (in/day) | (in/day) | (in/day) | (in/day) | (in/day) | (in/day) | (in/day) | (in/day) | (in/day) | (in/day) | (in/day) |
| 183 | 7 | 1 | 7-1 | 0.1669 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0706 | 0.0995 | 0.0010 | 0.0503 | 0.2330 | 0.1786 | 0.1429 |
| 184 | 7 | 2 | 7-2 | 0.1725 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0723 | 0.1030 | 0.0020 | 0.0525 | 0.2370 | 0.1786 | 0.1429 |
| 185 | 7 | 3 | 7-3 | 0.1800 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0740 | 0.1065 | 0.0030 | 0.0548 | 0.2410 | 0.1786 | 0.1429 |
| 186 | 7 | 4 | 7-4 | 0.1875 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0764 | 0.1100 | 0.0040 | 0.0570 | 0.2450 | 0.1786 | 0.1429 |
| 187 | 7 | 5 | 7-5 | 0.1950 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0788 | 0.1150 | 0.0050 | 0.0600 | 0.2470 | 0.1786 | 0.1429 |
| 188 | 7 | 6 | 7-6 | 0.2006 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0812 | 0.1200 | 0.0060 | 0.0630 | 0.2490 | 0.1786 | 0.1429 |
| 189 | 7 | 7 | 7-7 | 0.2063 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0836 | 0.1250 | 0.0070 | 0.0660 | 0.2510 | 0.1786 | 0.1429 |
| 190 | 7 | 8 | 7-8 | 0.2119 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0860 | 0.1300 | 0.0080 | 0.0690 | 0.2530 | 0.1786 | 0.1429 |
| 191 | 7 | 9 | 7-9 | 0.2175 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0884 | 0.1350 | 0.0090 | 0.0720 | 0.2550 | 0.1786 | 0.1429 |
| 192 | 7 | 10 | 7-10 | 0.2225 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0908 | 0.1400 | 0.0100 | 0.0750 | 0.2565 | 0.1786 | 0.1429 |
| 193 | 7 | 11 | 7-11 | 0.2275 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0932 | 0.1450 | 0.0120 | 0.0785 | 0.2580 | 0.1786 | 0.1429 |
| 194 | 7 | 12 | 7-12 | 0.2325 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0956 | 0.1500 | 0.0140 | 0.0820 | 0.2595 | 0.1786 | 0.1429 |
| 195 | 7 | 13 | 7-13 | 0.2340 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.0980 | 0.1550 | 0.0160 | 0.0855 | 0.2610 | 0.1786 | 0.1429 |
| 196 | 7 | 14 | 7-14 | 0.2355 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1009 | 0.1600 | 0.0180 | 0.0890 | 0.2625 | 0.1786 | 0.1429 |
| 197 | 7 | 15 | 7-15 | 0.2370 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1038 | 0.1643 | 0.0200 | 0.0921 | 0.2610 | 0.1786 | 0.1429 |
| 198 | 7 | 16 | 7-16 | 0.2385 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1067 | 0.1685 | 0.0220 | 0.0953 | 0.2595 | 0.1786 | 0.1429 |
| 199 | 7 | 17 | 7-17 | 0.2400 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1096 | 0.1728 | 0.0240 | 0.0984 | 0.2580 | 0.1786 | 0.1429 |
| 200 | 7 | 18 | 7-18 | 0.2417 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1125 | 0.1770 | 0.0260 | 0.1015 | 0.2565 | 0.1786 | 0.1429 |
| 201 | 7 | 19 | 7-19 | 0.2433 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1175 | 0.1813 | 0.0280 | 0.1046 | 0.2550 | 0.1786 | 0.1429 |
| 202 | 7 | 20 | 7-20 | 0.2450 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1225 | 0.1855 | 0.0300 | 0.1078 | 0.2533 | 0.1786 | 0.1429 |
| 203 | 7 | 21 | 7-21 | 0.2438 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1275 | 0.1898 | 0.0320 | 0.1109 | 0.2515 | 0.1786 | 0.1429 |
| 204 | 7 | 22 | 7-22 | 0.2425 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1325 | 0.1940 | 0.0340 | 0.1140 | 0.2498 | 0.1786 | 0.1429 |
| 205 | 7 | 23 | 7-23 | 0.2413 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1375 | 0.1983 | 0.0360 | 0.1171 | 0.2480 | 0.1786 | 0.1429 |
| 206 | 7 | 24 | 7-24 | 0.2400 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1450 | 0.2025 | 0.0380 | 0.1203 | 0.2463 | 0.1786 | 0.1429 |
| 207 | 7 | 25 | 7-25 | 0.2350 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1525 | 0.2060 | 0.0400 | 0.1230 | 0.2445 | 0.1786 | 0.1429 |
| 208 | 7 | 26 | 7-26 | 0.2300 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1600 | 0.2095 | 0.0420 | 0.1258 | 0.2428 | 0.1786 | 0.1429 |
| 209 | 7 | 27 | 7-27 | 0.2250 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1675 | 0.2130 | 0.0440 | 0.1285 | 0.2410 | 0.1786 | 0.1429 |
| 210 | 7 | 28 | 7-28 | 0.2194 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1750 | 0.2165 | 0.0460 | 0.1313 | 0.2393 | 0.1786 | 0.1429 |
| 211 | 7 | 29 | 7-29 | 0.2138 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1825 | 0.2200 | 0.0480 | 0.1340 | 0.2375 | 0.1786 | 0.1429 |
| 212 | 7 | 30 | 7-30 | 0.2081 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1900 | 0.2235 | 0.0500 | 0.1368 | 0.2340 | 0.1786 | 0.1429 |
| 213 | 7 | 31 | 7-31 | 0.2025 | 0.1786 | 0.0814 | 0.7500 | 0.1786 | 0.1786 | 0.7500 | 0.1975 | 0.2270 | 0.0525 | 0.1398 | 0.2305 | 0.1786 | 0.1429 |

Agricultural Water Use - Example

- Step 3: Unadjusted Total Water Demand (unadjusted for precipitation and groundwater use)

COUNTY: Yancey

STEP 3: UNADJUSTED TOTAL WATER DEMAND (UNADJUSTED FOR PRECIPITATION and GROUNDWATER USE)

| YEAR | STEP 1 ROW | STEP 2 ROW | IRRIGATED TOBACCO | TURF | GOLF | CONTAINER NURSERY | FIELD NURSERY | NURSERY - IN THE OPEN | NURSERY - UNDER PROTECTION | IRRIGATED COTTON | IRRIGATED EARLY SOY | IRRIGATED LATE SOY | IRRIGATED SOY | IRRIGATED CORN | IRRIGATED VEGETIBLE | IRRIGATED PASTURE & HAY |
|-----------|------------|------------|-------------------|---------|---------|-------------------|---------------|-----------------------|----------------------------|------------------|---------------------|--------------------|---------------|----------------|---------------------|-------------------------|
| | | | (Moveable) | (Fixed) | (Fixed) | (Fixed) | (Fixed) | (Moveable) | (Fixed) | (Moveable) | (Moveable) | (Moveable) | (Moveable) | (Moveable) | (Fixed) | (Fixed) |
| | | | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) |
| 7/1/2000 | 71 | 183 | 0.0689 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/2/2000 | 71 | 184 | 0.0712 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/3/2000 | 71 | 185 | 0.0743 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/4/2000 | 71 | 186 | 0.0774 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/5/2000 | 71 | 187 | 0.0805 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/6/2000 | 71 | 188 | 0.0828 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/7/2000 | 71 | 189 | 0.0851 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/8/2000 | 71 | 190 | 0.0874 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/9/2000 | 71 | 191 | 0.0898 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/10/2000 | 71 | 192 | 0.0918 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/11/2000 | 71 | 193 | 0.0939 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/12/2000 | 71 | 194 | 0.0960 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/13/2000 | 71 | 195 | 0.0966 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/14/2000 | 71 | 196 | 0.0972 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/15/2000 | 71 | 197 | 0.0978 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/16/2000 | 71 | 198 | 0.0984 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/17/2000 | 71 | 199 | 0.0991 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/18/2000 | 71 | 200 | 0.0997 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/19/2000 | 71 | 201 | 0.1004 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/20/2000 | 71 | 202 | 0.1011 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/21/2000 | 71 | 203 | 0.1006 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/22/2000 | 71 | 204 | 0.1001 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/23/2000 | 71 | 205 | 0.0996 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/24/2000 | 71 | 206 | 0.0991 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/25/2000 | 71 | 207 | 0.0970 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/26/2000 | 71 | 208 | 0.0949 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/27/2000 | 71 | 209 | 0.0929 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/28/2000 | 71 | 210 | 0.0905 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/29/2000 | 71 | 211 | 0.0882 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/30/2000 | 71 | 212 | 0.0859 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |
| 7/31/2000 | 71 | 213 | 0.0836 | NA | 0.3316 | NA | NA | 0.6827 | 0.0027 | NA | NA | NA | NA | NA | 0.0274 | 0.0395 |

Agricultural Water Use - Example

- Step 5: Adjusted Total Ag Water Demand (adjusted for precipitation and irrigation (ET curves))

COUNTY: Yancey

STEP 5: ADJUSTED TOTAL WATER DEMAND (ADJUSTED FOR PRECIPITATION and GROUNDWATER USE)

| YEAR | IRRIGATED TOBACCO | TURF | GOLF | CONTAINER NURSERY | FIELD NURSERY | NURSERY - IN THE OPEN | NURSERY - UNDER PROTECTION | IRRIGATED COTTON | IRRIGATED EARLY SOY | IRRIGATED LATE SOY | IRRIGATED SOY | IRRIGATED CORN | IRRIGATED VEGETABLE | IRRIGATED PASTURE & HAY |
|-----------|-------------------|---------|---------|-------------------|---------------|-----------------------|----------------------------|------------------|---------------------|--------------------|---------------|----------------|---------------------|-------------------------|
| | (Moveable) | (Fixed) | (Fixed) | (Fixed) | (Fixed) | (Moveable) | (Fixed) | (Moveable) | (Moveable) | (Moveable) | (Moveable) | (Moveable) | (Fixed) | (Fixed) |
| | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) | (MGD) |
| 7/1/2000 | -- | NA | 0.3316 | NA | NA | 0.0392 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/2/2000 | -- | NA | 0.3316 | NA | NA | -- | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/3/2000 | -- | NA | 0.3316 | NA | NA | -- | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/4/2000 | -- | NA | 0.3316 | NA | NA | -- | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/5/2000 | -- | NA | 0.3316 | NA | NA | -- | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/6/2000 | -- | NA | 0.3316 | NA | NA | -- | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/7/2000 | -- | NA | 0.3316 | NA | NA | -- | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/8/2000 | -- | NA | 0.3316 | NA | NA | -- | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/9/2000 | 0.0470 | NA | 0.3316 | NA | NA | 0.3767 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/10/2000 | 0.0470 | NA | 0.3316 | NA | NA | 0.3767 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/11/2000 | 0.0470 | NA | 0.3316 | NA | NA | 0.3767 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/12/2000 | 0.0470 | NA | 0.3316 | NA | NA | 0.3767 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/13/2000 | 0.0470 | NA | 0.3316 | NA | NA | 0.3767 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/14/2000 | 0.0470 | NA | 0.3316 | NA | NA | 0.3767 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/15/2000 | 0.0470 | NA | 0.3316 | NA | NA | 0.3767 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/16/2000 | 0.0196 | NA | 0.3316 | NA | NA | 0.0334 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/17/2000 | 0.0196 | NA | 0.3316 | NA | NA | 0.0334 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/18/2000 | 0.0196 | NA | 0.3316 | NA | NA | 0.0334 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/19/2000 | 0.0196 | NA | 0.3316 | NA | NA | 0.0334 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/20/2000 | 0.0196 | NA | 0.3316 | NA | NA | 0.0334 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/21/2000 | 0.0196 | NA | 0.3316 | NA | NA | 0.0334 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/22/2000 | 0.0196 | NA | 0.3316 | NA | NA | 0.0334 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/23/2000 | 0.0639 | NA | 0.3316 | NA | NA | 0.4159 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/24/2000 | 0.0639 | NA | 0.3316 | NA | NA | 0.4159 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/25/2000 | 0.0639 | NA | 0.3316 | NA | NA | 0.4159 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/26/2000 | 0.0639 | NA | 0.3316 | NA | NA | 0.4159 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/27/2000 | 0.0639 | NA | 0.3316 | NA | NA | 0.4159 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/28/2000 | 0.0639 | NA | 0.3316 | NA | NA | 0.4159 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/29/2000 | 0.0639 | NA | 0.3316 | NA | NA | 0.4159 | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/30/2000 | -- | NA | 0.3316 | NA | NA | -- | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |
| 7/31/2000 | -- | NA | 0.3316 | NA | NA | -- | 0.0020 | NA | NA | NA | NA | NA | 0.0197 | 0.0284 |

Agricultural Water Use - Example

- Step 6: County Ag Water Use Summary Total

COUNTY: Yancey

STEP 6: COUNTY SUMMARY TOTALS

| YEAR | TOTAL FIXED CROP WATER USE | TOTAL LIVESTOCK | TOTAL MOVABLE IRRIGATION | TOTAL AGRICULTURAL WATER USE |
|-----------|----------------------------|-----------------|--------------------------|------------------------------|
| | (Fixed) | (Livestock) | (Moveable) | |
| | (MGD) | (MGD) | (MGD) | (MGD) |
| 7/1/2000 | 0.44 | 0.06 | 0.04 | 0.54 |
| 7/2/2000 | 0.44 | 0.06 | -- | 0.50 |
| 7/3/2000 | 0.44 | 0.06 | -- | 0.50 |
| 7/4/2000 | 0.44 | 0.06 | -- | 0.50 |
| 7/5/2000 | 0.44 | 0.06 | -- | 0.50 |
| 7/6/2000 | 0.44 | 0.06 | -- | 0.50 |
| 7/7/2000 | 0.44 | 0.06 | -- | 0.50 |
| 7/8/2000 | 0.44 | 0.06 | -- | 0.50 |
| 7/9/2000 | 0.44 | 0.06 | 0.42 | 0.92 |
| 7/10/2000 | 0.44 | 0.06 | 0.42 | 0.92 |
| 7/11/2000 | 0.44 | 0.06 | 0.42 | 0.92 |
| 7/12/2000 | 0.44 | 0.06 | 0.42 | 0.92 |
| 7/13/2000 | 0.44 | 0.06 | 0.42 | 0.92 |
| 7/14/2000 | 0.44 | 0.06 | 0.42 | 0.92 |
| 7/15/2000 | 0.44 | 0.06 | 0.42 | 0.92 |
| 7/16/2000 | 0.44 | 0.06 | 0.05 | 0.55 |
| 7/17/2000 | 0.44 | 0.06 | 0.05 | 0.55 |
| 7/18/2000 | 0.44 | 0.06 | 0.05 | 0.55 |
| 7/19/2000 | 0.44 | 0.06 | 0.05 | 0.55 |
| 7/20/2000 | 0.44 | 0.06 | 0.05 | 0.55 |
| 7/21/2000 | 0.44 | 0.06 | 0.05 | 0.55 |
| 7/22/2000 | 0.44 | 0.06 | 0.05 | 0.55 |
| 7/23/2000 | 0.44 | 0.06 | 0.48 | 0.98 |
| 7/24/2000 | 0.44 | 0.06 | 0.48 | 0.98 |
| 7/25/2000 | 0.44 | 0.06 | 0.48 | 0.98 |
| 7/26/2000 | 0.44 | 0.06 | 0.48 | 0.98 |
| 7/27/2000 | 0.44 | 0.06 | 0.48 | 0.98 |
| 7/28/2000 | 0.44 | 0.06 | 0.48 | 0.98 |
| 7/29/2000 | 0.44 | 0.06 | 0.48 | 0.98 |
| 7/30/2000 | 0.44 | 0.06 | -- | 0.50 |
| 7/31/2000 | 0.44 | 0.06 | -- | 0.50 |



Municipal and Industrial Data

Collection, Processing, & Results

Municipal and Industrial Withdrawals – Data Collection

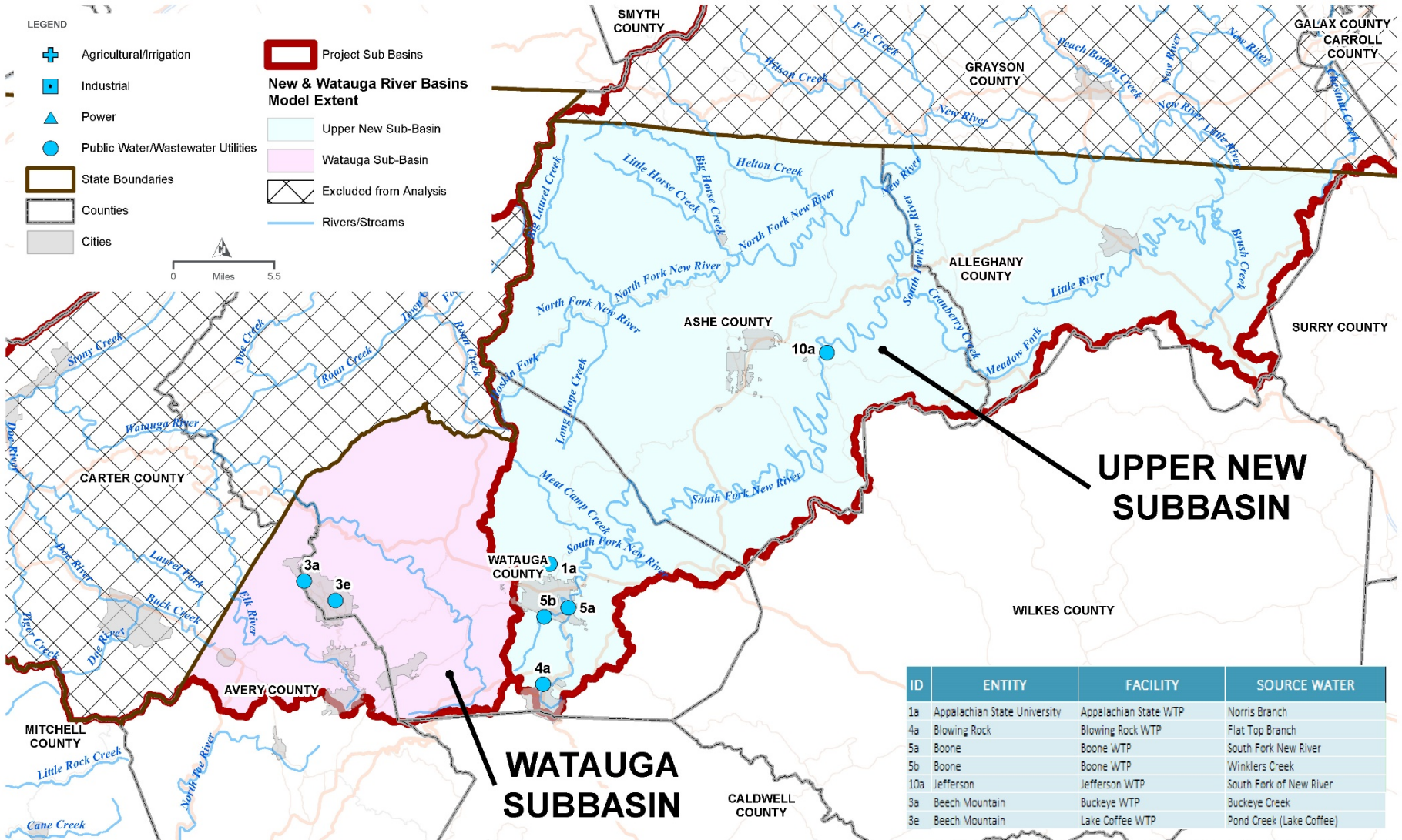
- Quantify water use for:
 - Municipal (public & private) water systems
 - Industries
 - Manufacturing
 - Mining
 - Power
 - Recreational*
- Data Sources
 - NCDWR Local Water Supply Plans (Public Water Utilities)
 - Data for 1997, 2002, and 2006-2017
 - NCDWR Water Withdrawal and Transfer Registration (Private Water Utilities and Industries)
 - Data for 1999, 2001-2006, & 2007-2017*
 - Individual Water Users
 - Fill in data gaps
 - Focus on 1930-1997 prior to NCDWR records
 - Provide anecdotal information (facility start and end dates)



Municipal and Industrial Withdrawals – Data Processing

- Data Compilation
 - 1930-1960: limited data
 - 1970-present: more available/accurate data
 - Only entities withdrawing $\geq 100,000$ gpd (annual average day basis)
 - Or projected (through NC Local Water Supply Plans) to withdraw $\geq 100,000$ gpd (through 2060)
- Data Processing
 - Monthly time series for OASIS model
 - Based on facility start and end dates
 - Hindcasting missing/non-reported data
 - Developed record for 1930-2017
 - Water suppliers: Population data (U.S. Census)
 - Industries: GDP for NC (U.S. Bureau of Economic Analysis)
 - Monthly demands
 - Most recent 5 years of data
 - Used for each unique model node





NEW AND WATAUGA RIVER BASIN WATER WITHDRAWAL NODES FLOW MODIFICATION POINTS

FIGURE 4B

Municipal and Industrial Discharges – Data Collection

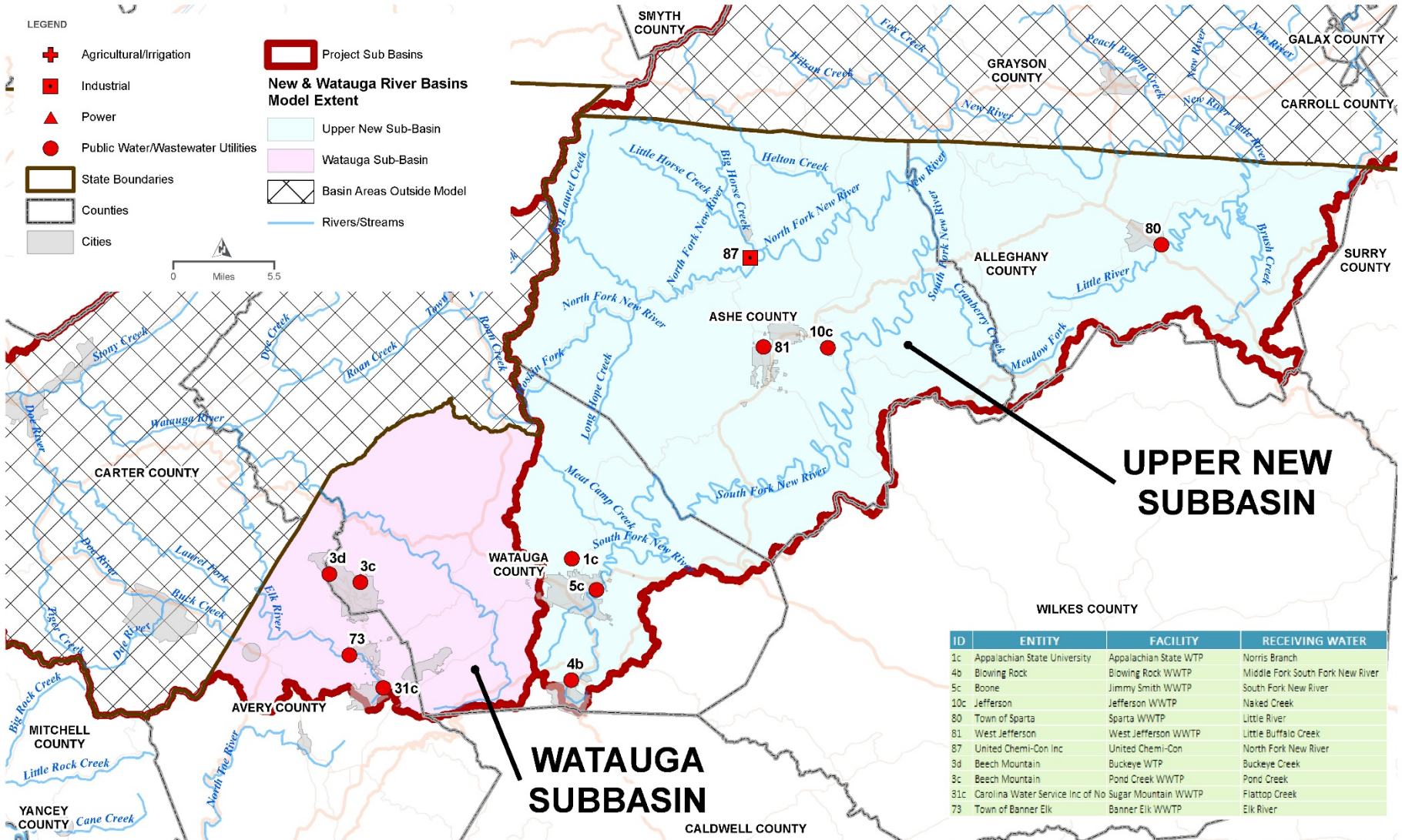
- Quantify water use for:
 - Municipal (public & private) water systems
 - Industries
 - Manufacturing
 - Mining
 - Power
 - Recreational
- Data Sources
 - NPDES records from NCDWR
 - 1994-2017
 - Individual dischargers
 - Fill in data gaps
 - Focus on 1930-1994 prior to NCDWR records
 - Provide anecdotal information (e.g. facility start and end dates, expansions, etc.)



Municipal and Industrial Discharges – Data Processing

- Data Compilation
 - 1994-present: more available/accurate
 - 1930-1993 data calculated/estimated if not provided
 - Only entities discharging $\geq 100,000$ gpd (annual average day basis)
- Data Processing
 - Monthly time series for OASIS model
 - Based on facility start and end dates
 - Hindcasting missing/non-reported data
 - Developed record for 1930-2017
 - Public wastewater discharges: Linear interpolation
 - Industries: GDP for NC (U.S. Bureau of Economic Analysis)
 - Monthly discharge patterns (similar to withdrawal approach)





| ID | ENTITY | FACILITY | RECEIVING WATER |
|-----|----------------------------------|-----------------------|----------------------------------|
| 1c | Appalachian State University | Appalachian State WTP | Norris Branch |
| 4b | Blowing Rock | Blowing Rock WWTP | Middle Fork South Fork New River |
| 5c | Boone | Jimmy Smith WWTP | South Fork New River |
| 10c | Jefferson | Jefferson WWTP | Naked Creek |
| 80 | Town of Sparta | Sparta WWTP | Little River |
| 81 | West Jefferson | West Jefferson WWTP | Little Buffalo Creek |
| 87 | United Chemi-Con Inc | United Chemi-Con | North Fork New River |
| 3d | Beech Mountain | Buckeye WTP | Buckeye Creek |
| 3c | Beech Mountain | Pond Creek WWTP | Pond Creek |
| 81c | Carolina Water Service Inc of No | Sugar Mountain WWTP | Flattop Creek |
| 73 | Town of Banner Elk | Banner Elk WWTP | Elk River |

NEW AND WATAUGA RIVER BASIN WATER DISCHARGE NODES FLOW MODIFICATION POINTS

FIGURE 6B

Questions???

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