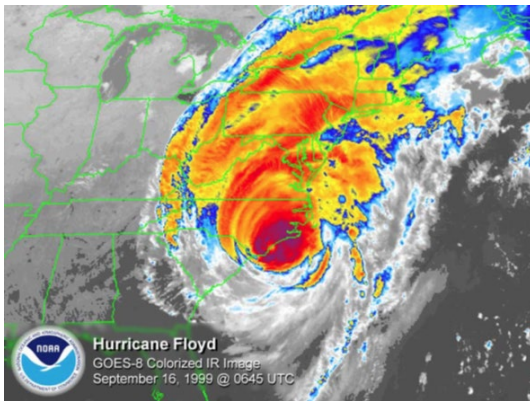


# Evaluating Nature Based Solutions for Mitigating Riverine Flooding in Eastern North Carolina

B.A. Doll<sup>1,2</sup>, D. Line<sup>2</sup> and J. Kurki-Fox<sup>2</sup>

<sup>1</sup> NC Sea Grant, Box 8605, NC State University, Raleigh NC 27695, [bdoll@ncsu.edu](mailto:bdoll@ncsu.edu)

<sup>2</sup> Biological and Agricultural Engineering Department, Box 7625, NC State University, Raleigh NC 27695, [dline@ncsu.edu](mailto:dline@ncsu.edu), [jjkurkif@ncsu.edu](mailto:jjkurkif@ncsu.edu)



# Natural Infrastructure (Nature-based solutions)

**Research Question:** How can natural Infrastructure mitigate flooding during extreme rainfall events? And what are the cost and benefits environmental & damage reduction?



Reforestation



Wetland restoration



Stream restoration



Water Farming

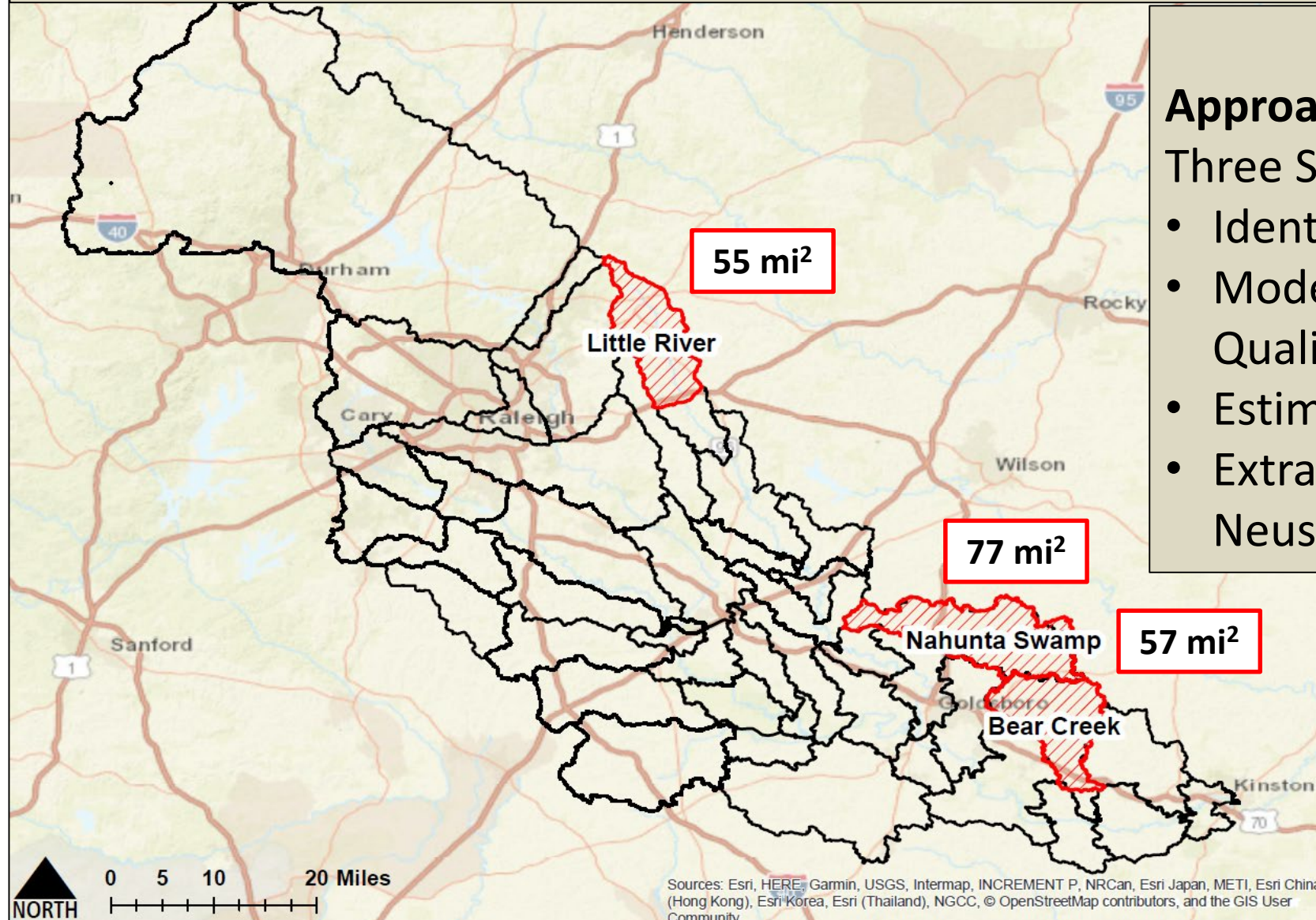
## Approach:

1. Identify Opportunity
2. Model watershed hydrology to determine flow reduction
3. Model river hydraulics to estimate the associated flood reduction
4. Model water quality benefit
5. Estimate costs and benefits



## Research Question:

How can natural Infrastructure mitigate flooding during extreme rainfall events? And what are the cost and benefits (environmental & damage reduction)?



## Neuse Basin Focus:

### Approach:

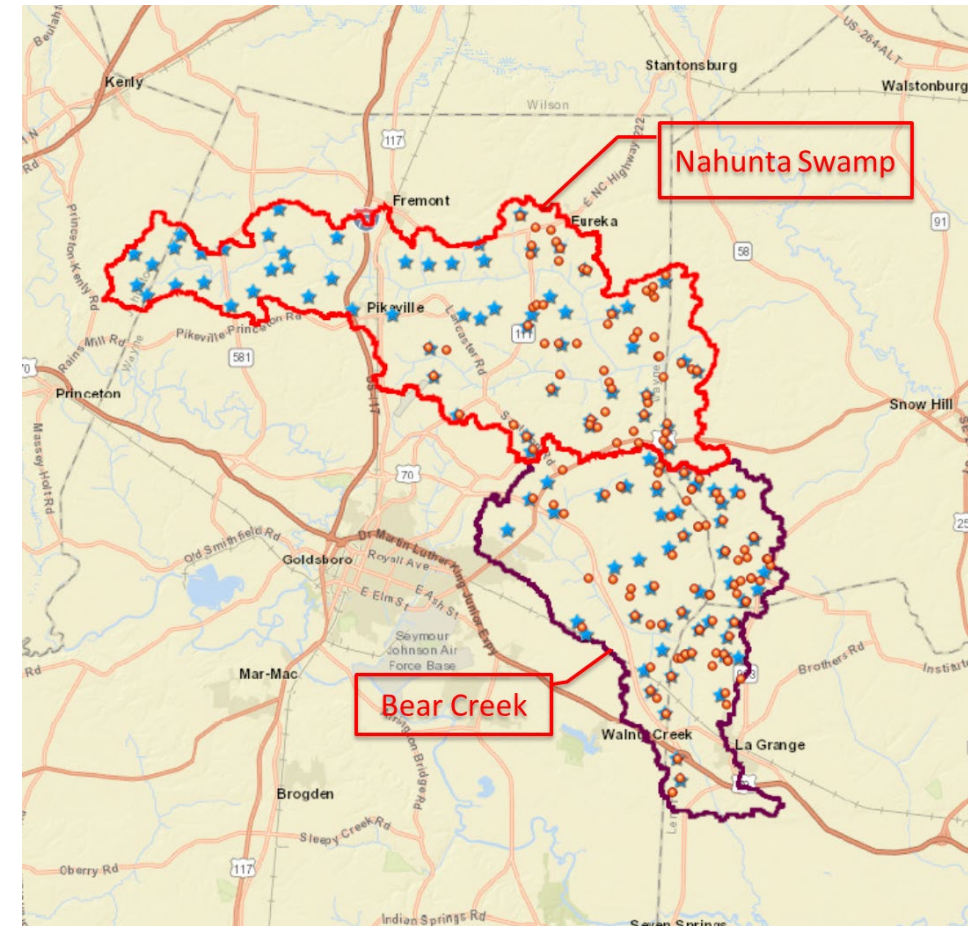
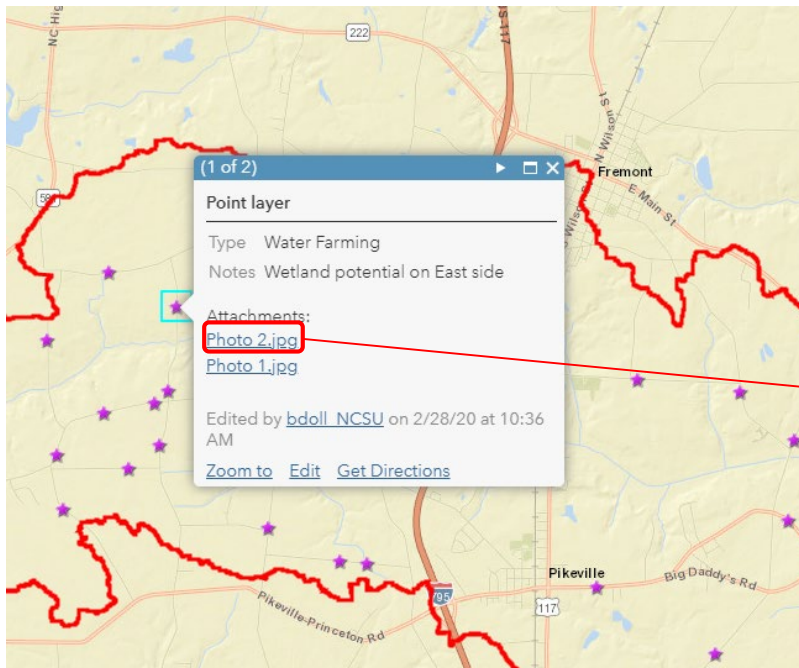
Three Study Subbasins (USGS gauges)

- Identified NI Opportunity
- Modeled Hydrology & Water Quality Before & After
- Estimate Reductions
- Extrapolate Results to the Full Neuse Basin



# Identifying Potential Sites for Natural Infrastructure

- Map Identification (GIS)
- Ground Truth
  - 241 potential sites in the three sub-basins (Collect photos & data)
- Refine GIS analyses





# Water Farming

- Engineered system designed to retain and slowly release water
  - Reduce downstream flooding
  - Reduce downstream water quality impacts
- Berm/terrace (<5ft high) around the downslope edge of field(s)
- Outlet structure (e.g. flashboard riser, weir, culvert, tile outlet, riser pipe)

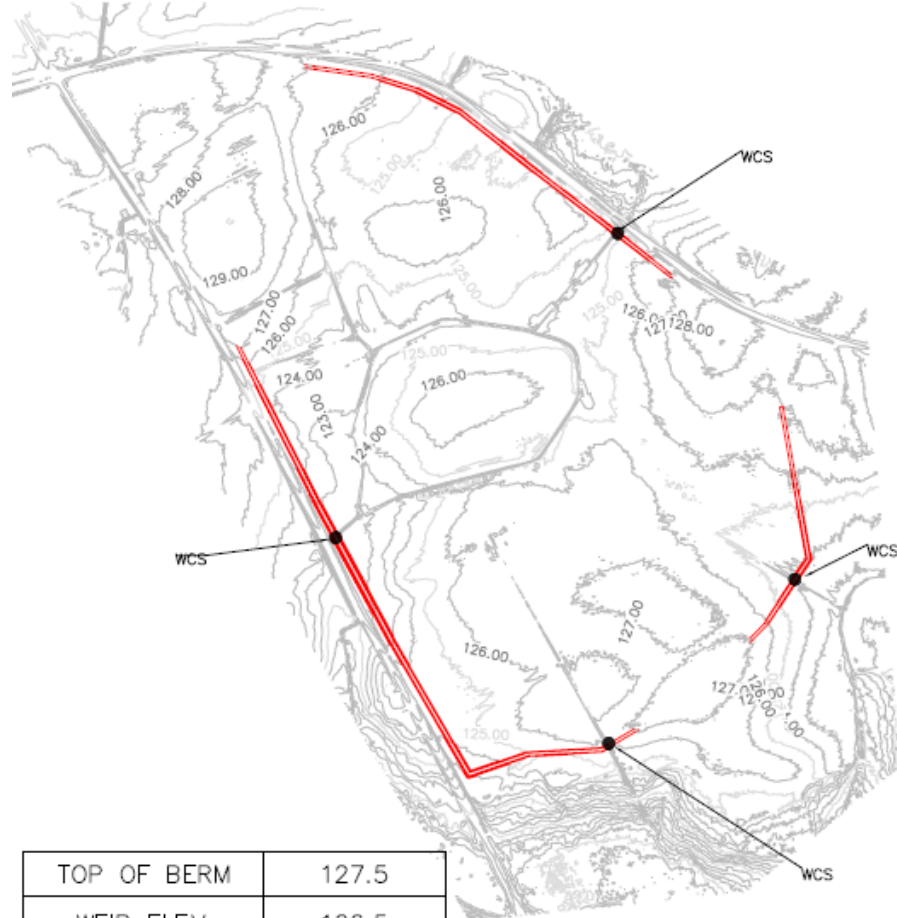


Caulkins Water Farm, South Florida

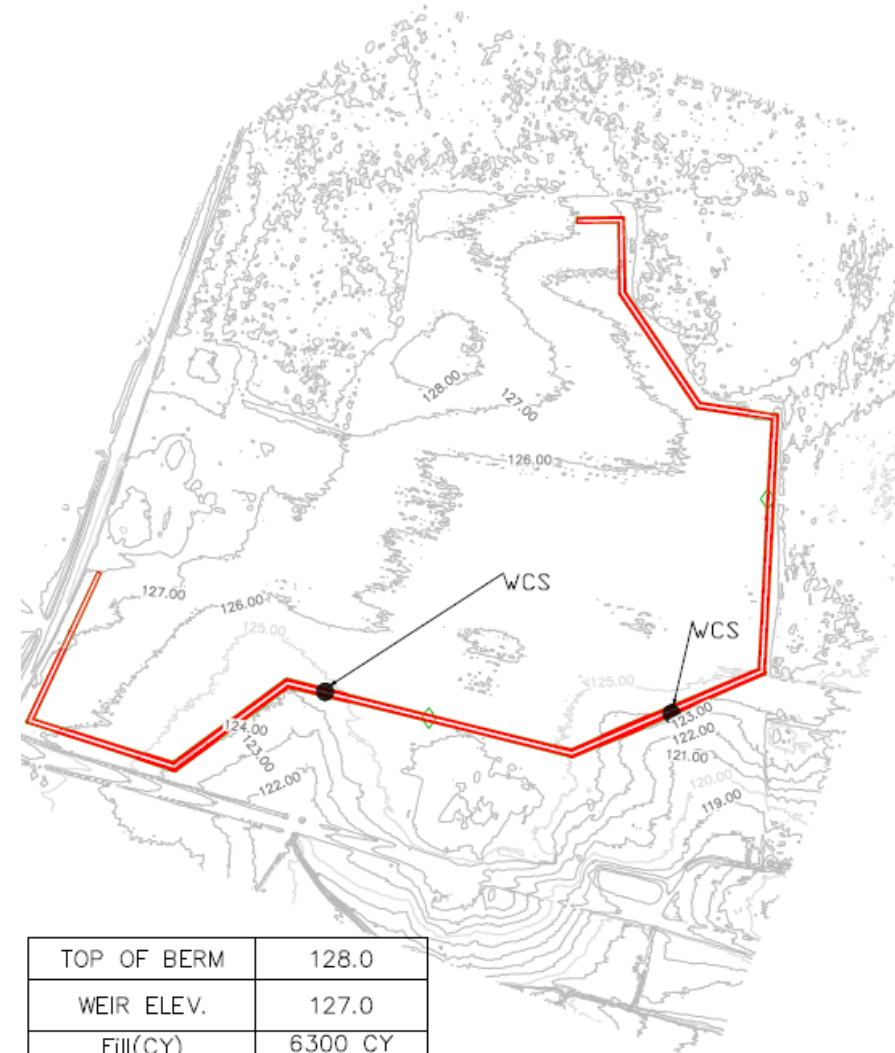
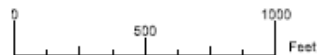
## Most appropriate locations:

- Agricultural land not in floodplain
- No structures or roads
- Mean slope < 1.1%
- Contiguous area >20 ac

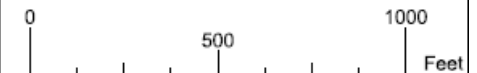
# Water Farming



TOP OF BERM	127.5
WEIR ELEV.	126.5
Fill(CY)	9000 CY
WCS	4
AREA (AC)	82
Storage (AC-FT)	77

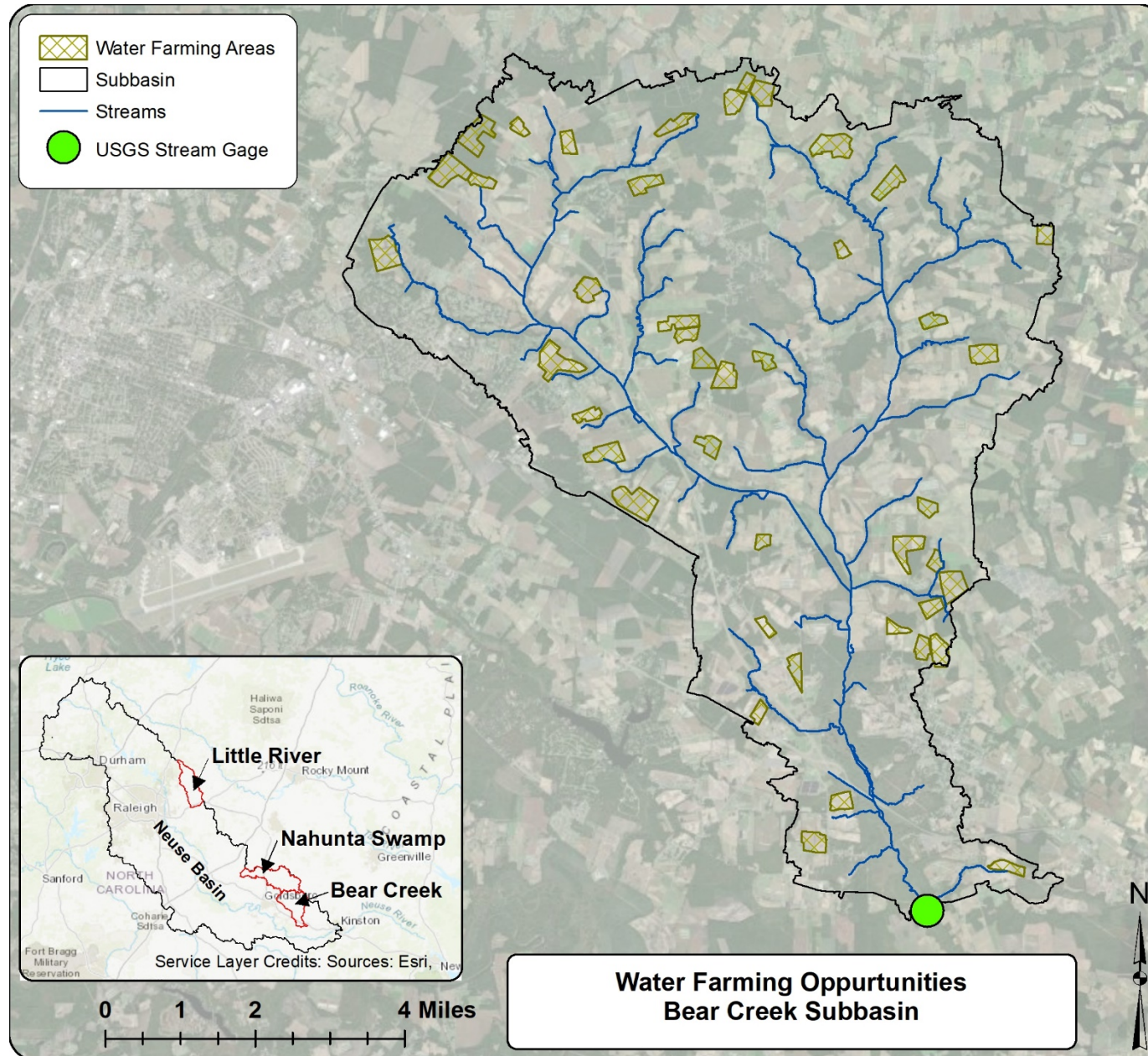


TOP OF BERM	128.0
WEIR ELEV.	127.0
Fill(CY)	6300 CY
WCS	2
AREA (AC)	37
Storage (AC-FT)	38



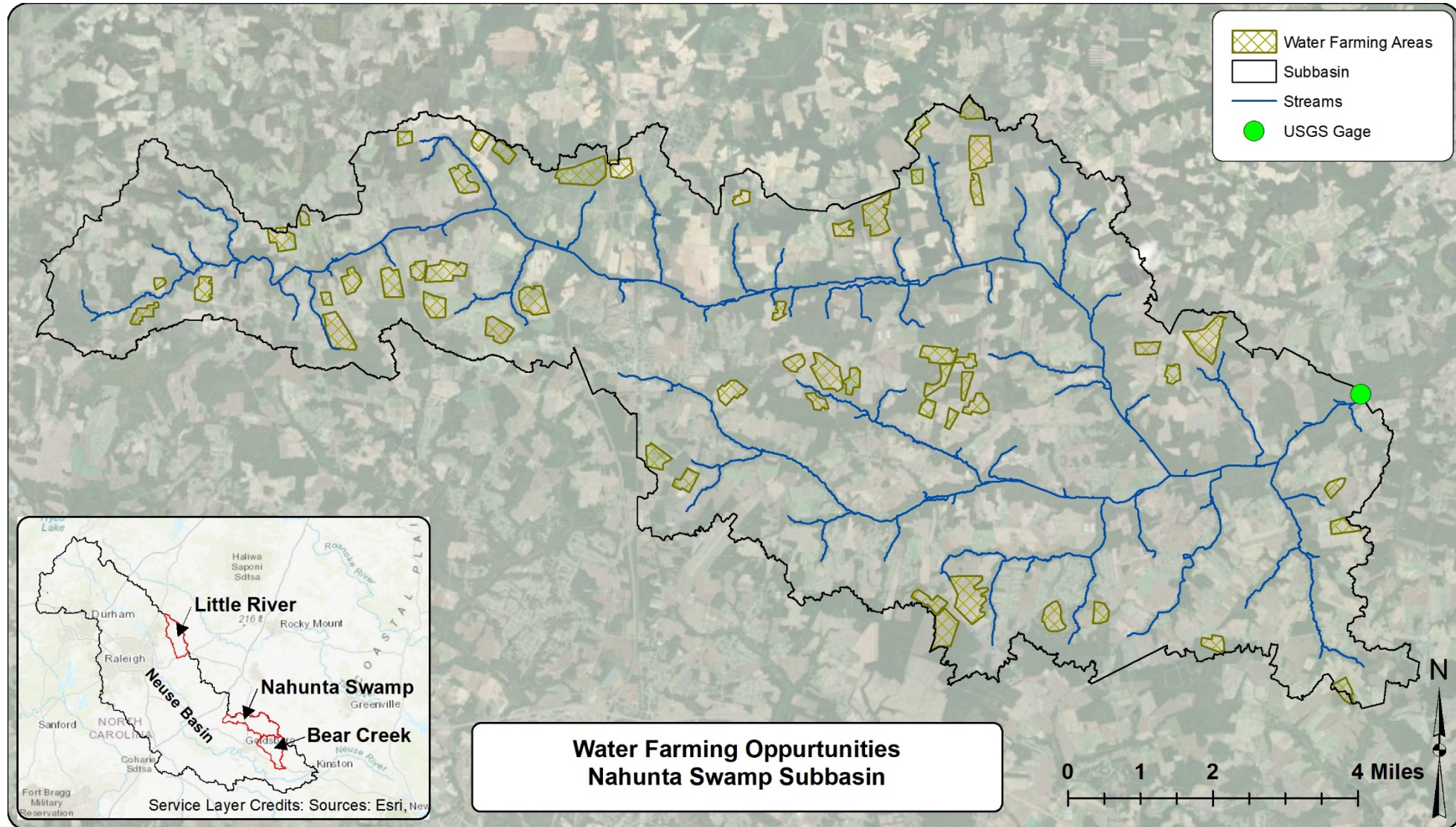


# Bear Creek Water Farming



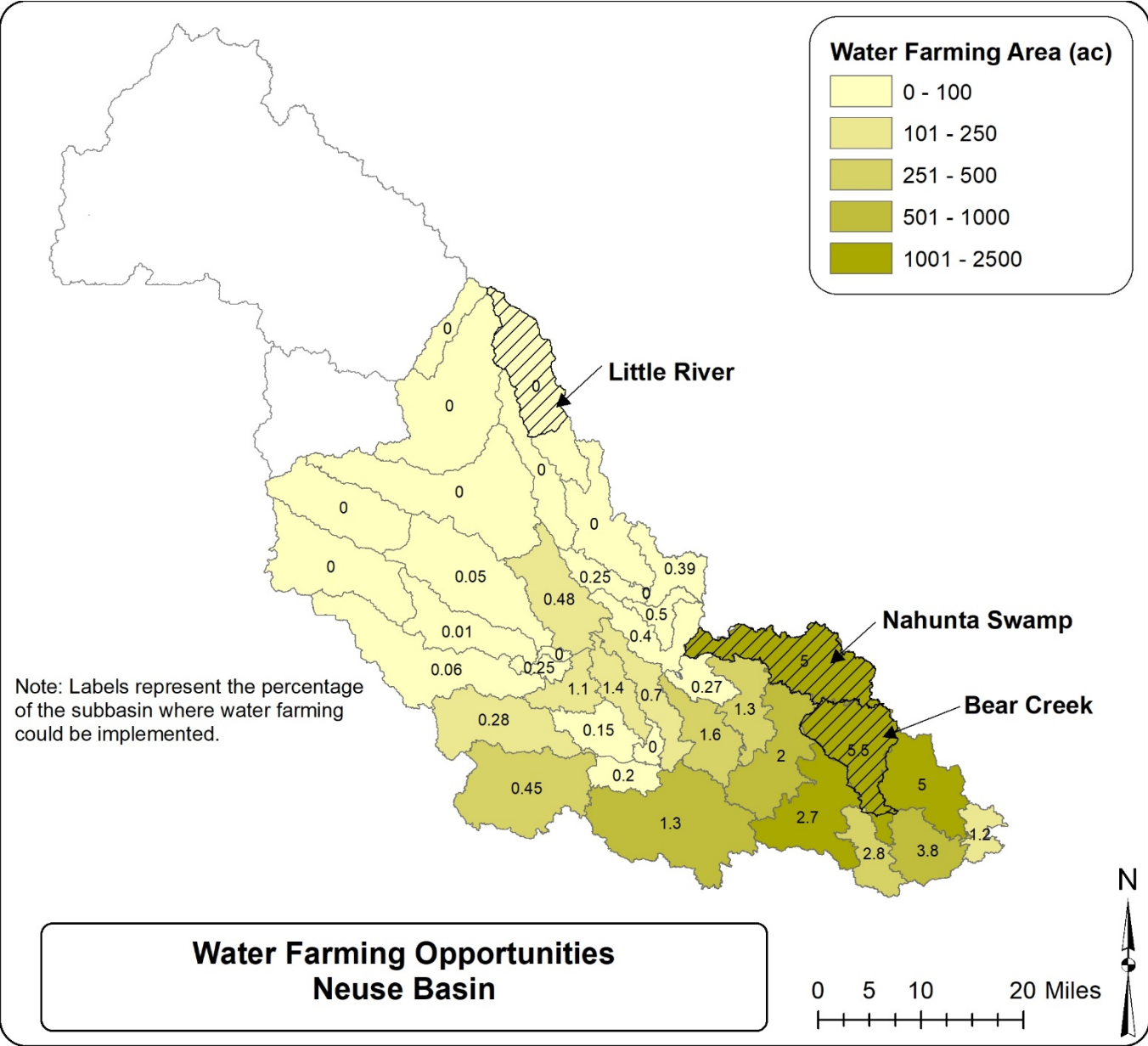


# Nahunta Water Farming





# Middle Neuse Water Farming



Study Watershed	Water Farming (acres)	Part of Watershed (%)
Little River	-	-
Nahunta Swamp	2,505 [55]	~5
Bear Creek	1,995 [43]	~5
Middle Neuse	13,047	1.1

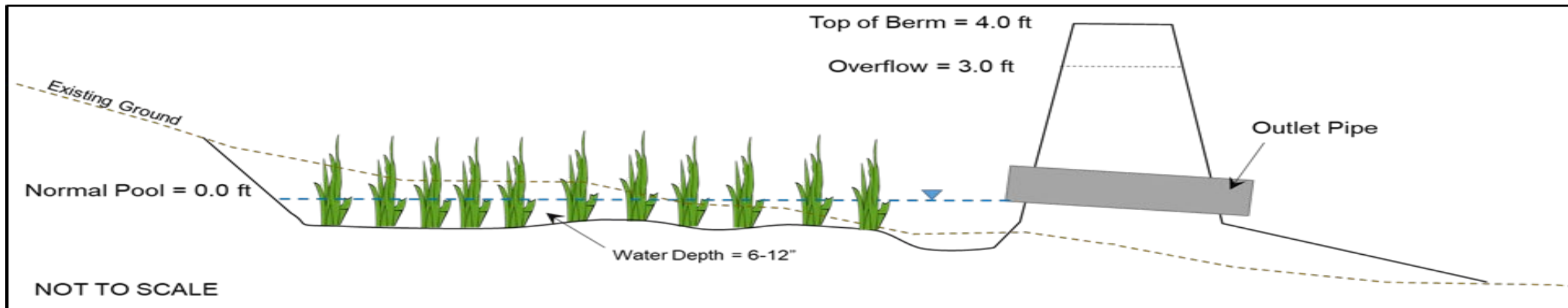
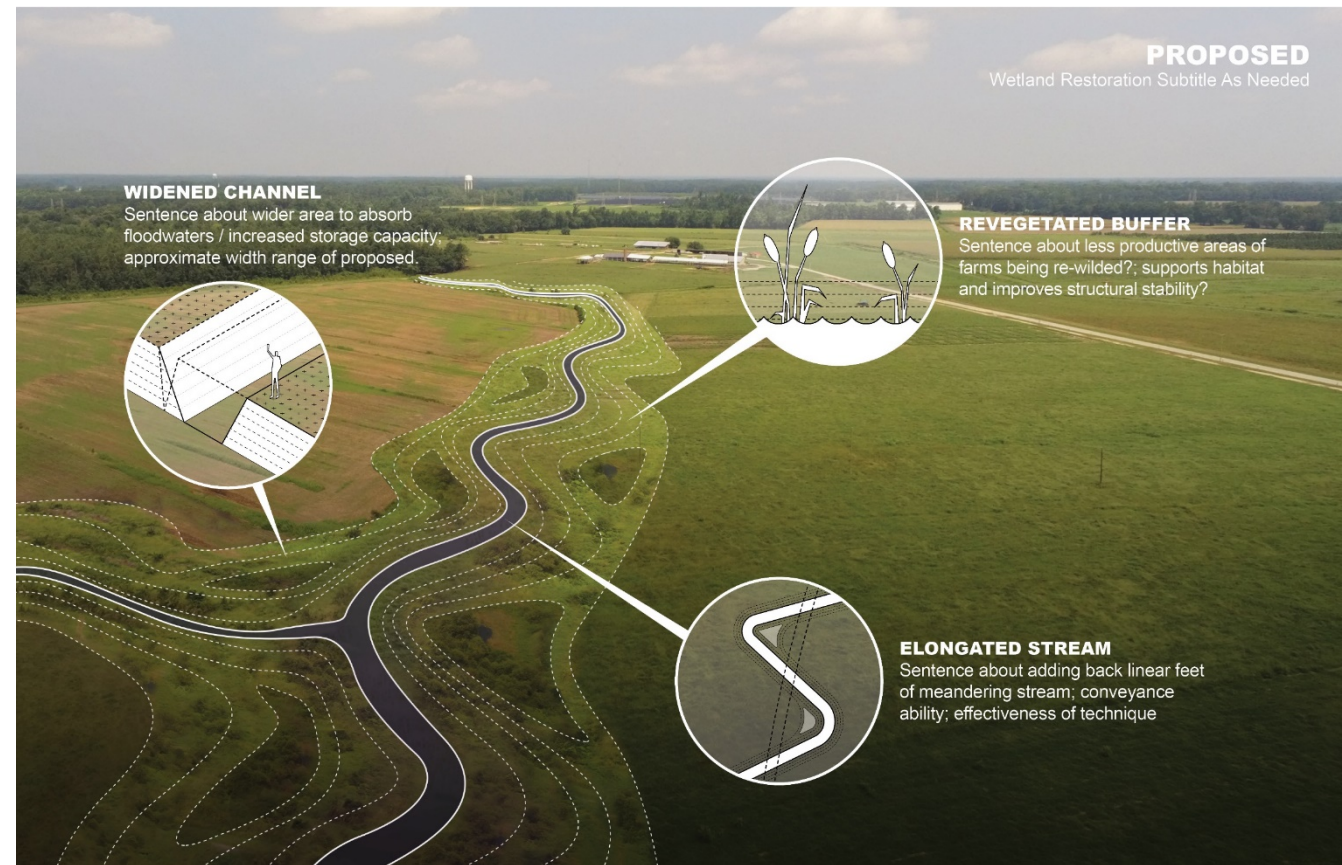
# Flood Storage Wetlands

- Retain and slowly release runoff from upstream area (cropland)
- Construct on small drainage features (i.e. ag ditches and small streams)
- Earthen berm and outlet structure (e.g. flashboard riser, weir, culvert) required
- Enhance current wetlands to temporarily retain upstream runoff





# Flood Storage Wetlands

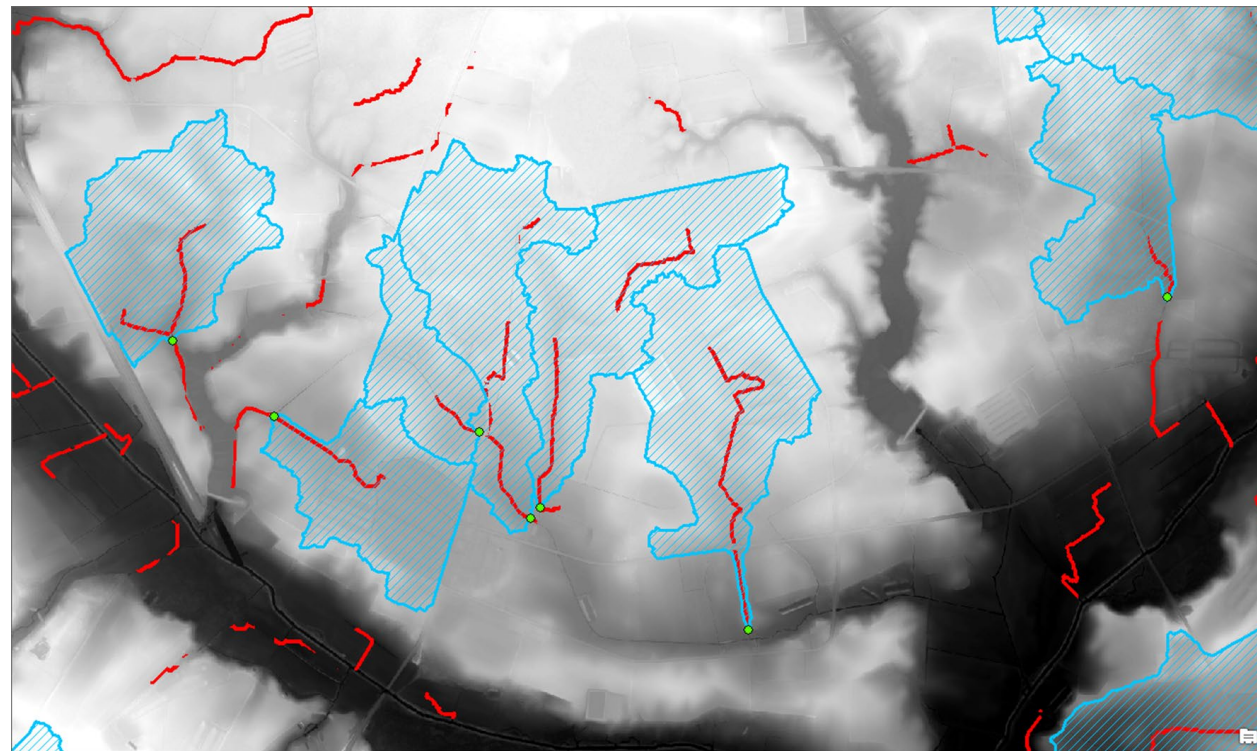




# Flood Storage Wetlands

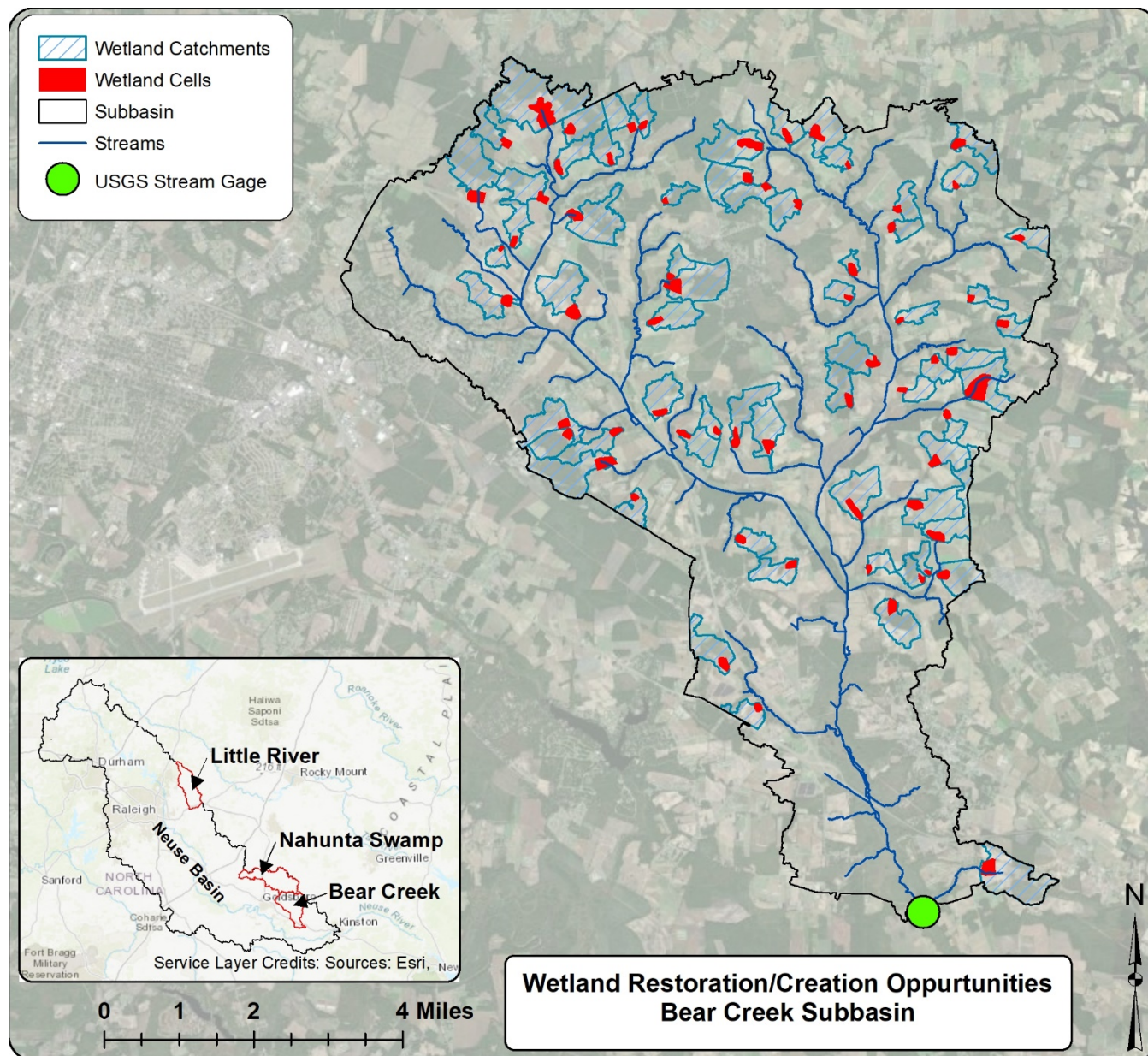
Characteristics:

- Drain at least 35 acres of land
- Sized to 10% of the drainage area



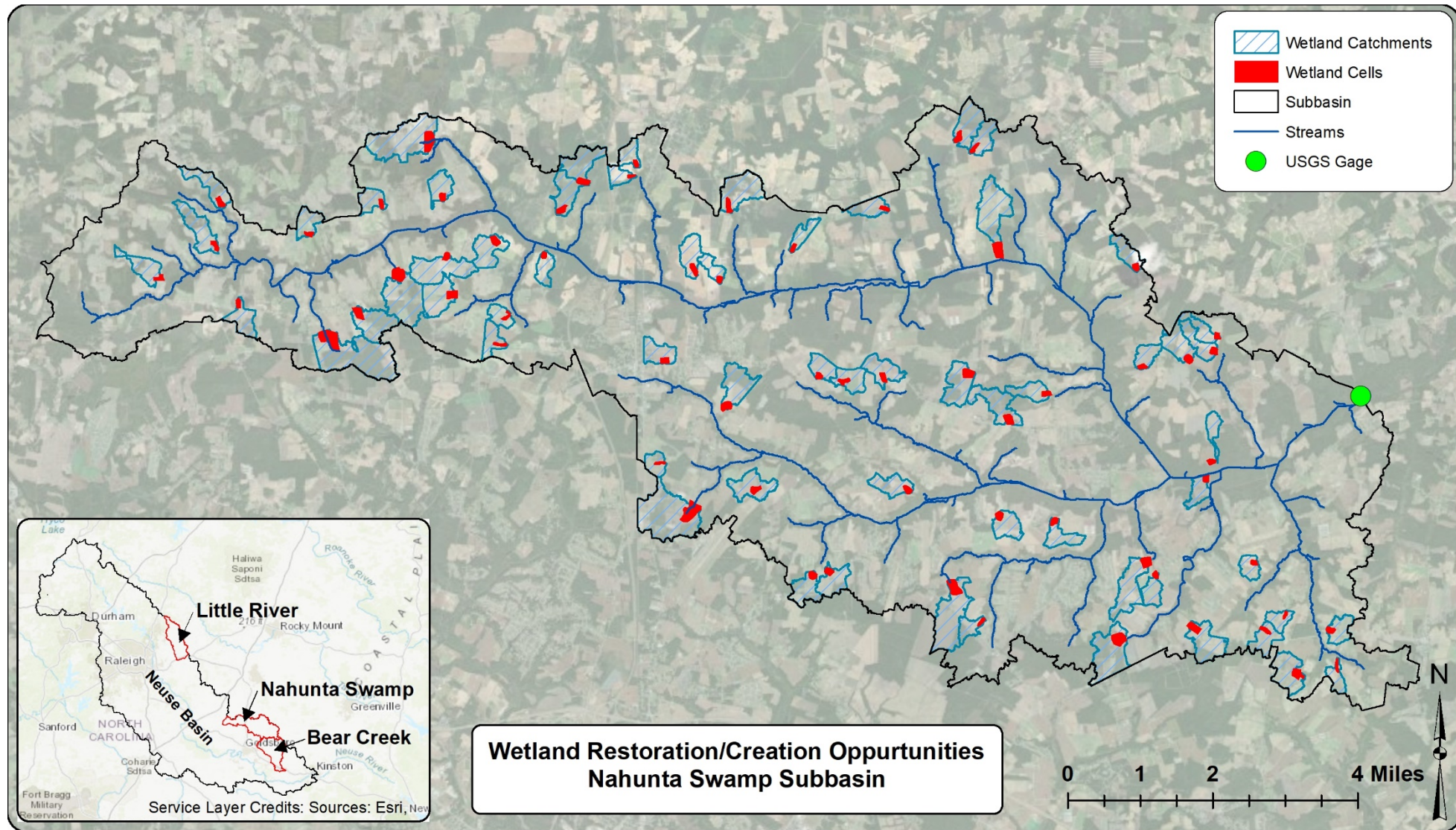


# Bear Creek Flood Storage Wetlands



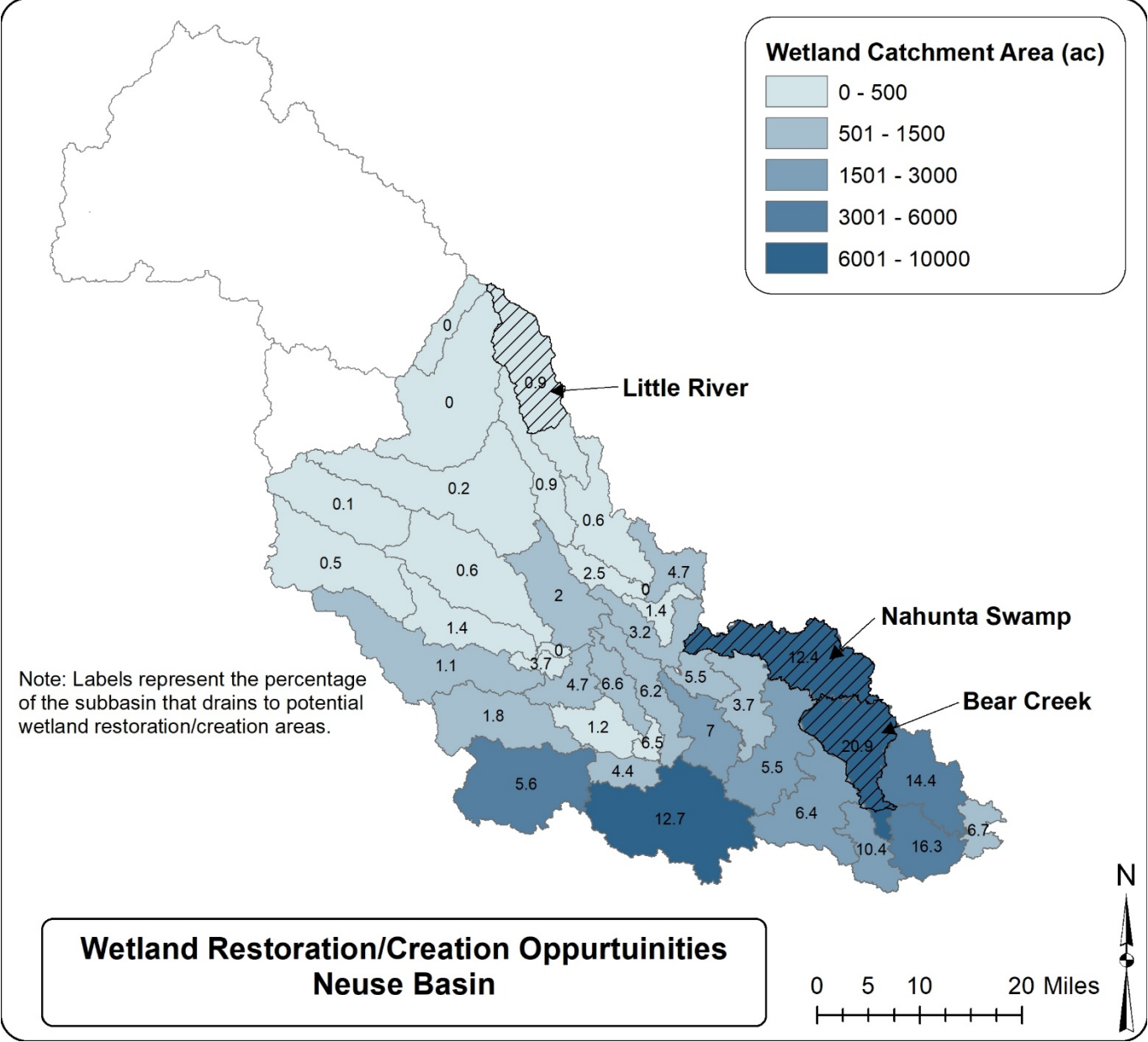


# Nahunta Swamp Flood Storage Wetlands





# Wetland Restoration/Creation



Study Watershed	Wetland DA (acres)	Part of Watershed (%)
Little River	544 [10]	1.5
Nahunta Swamp	6,035 [64]	12
Bear Creek	8,105 [66]	21
Middle Neuse	68,461	5.7

# Reforestation

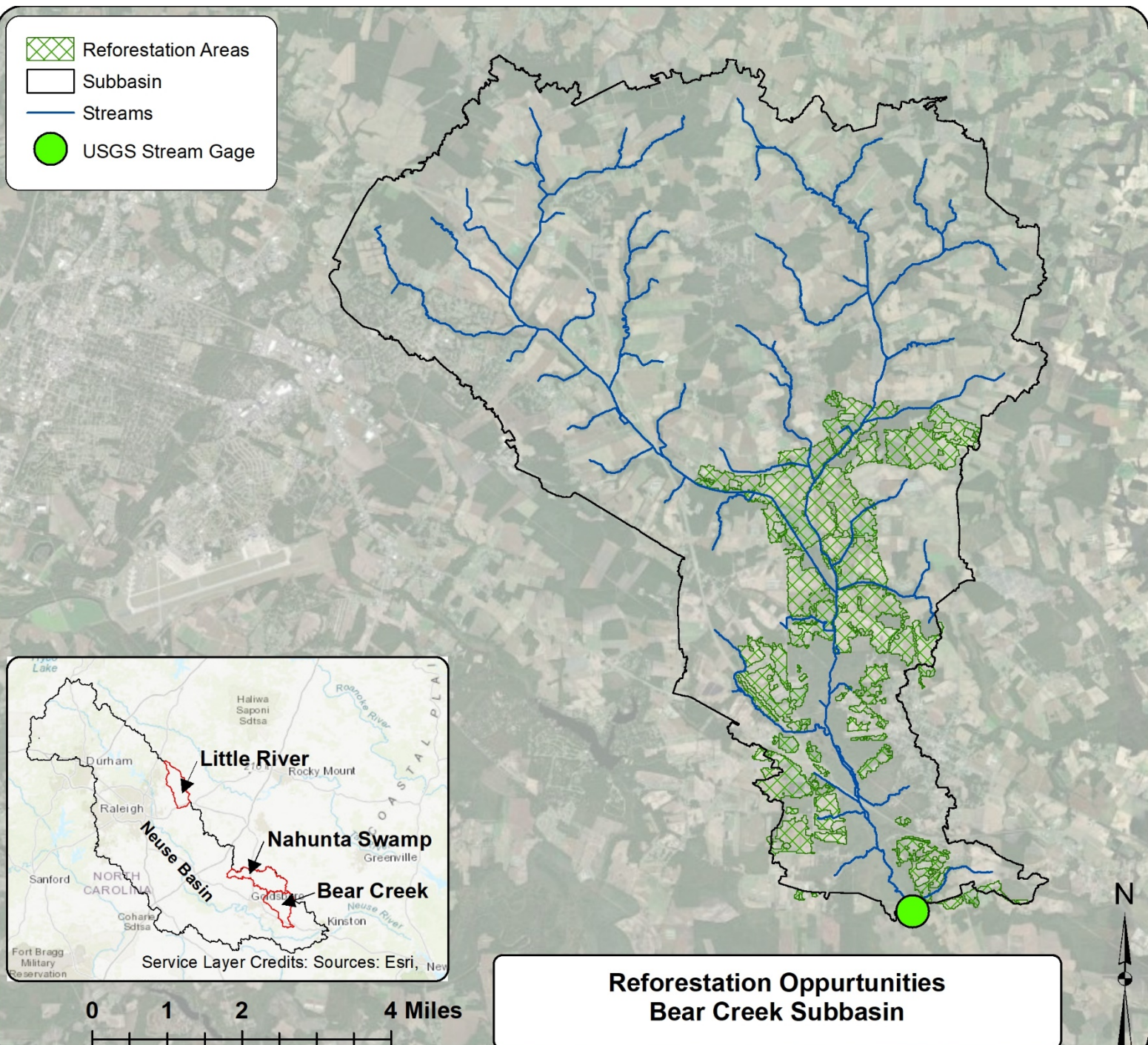
- Reduce runoff
- Convert cropland on low productivity soil to forest
- Potentially convert other land to forest (We only analyzed Ag land conversion)



- National Commodity Crop Productivity Index (NCCPI)  $< 0.33$

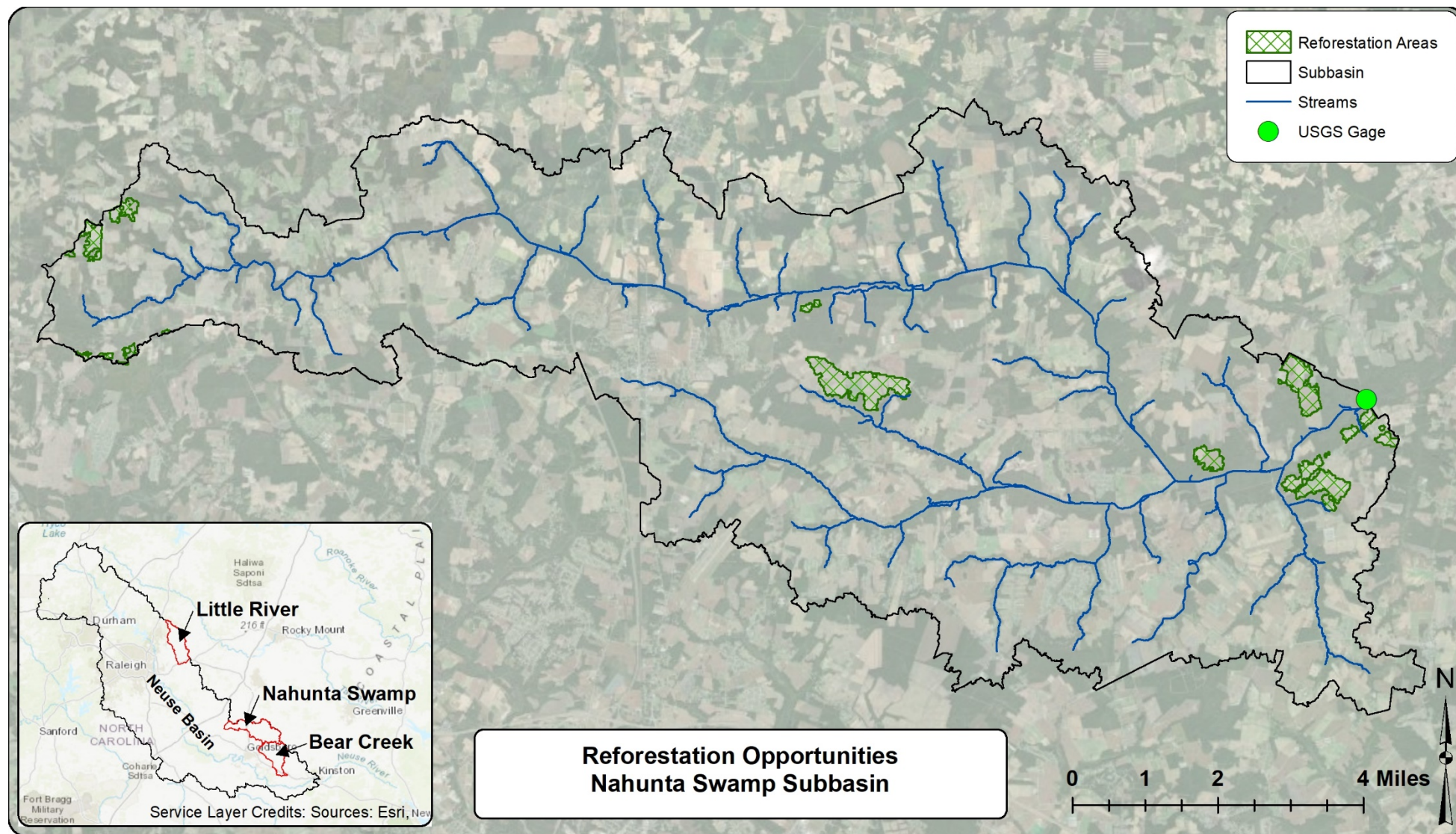


# Bear Creek Reforestation



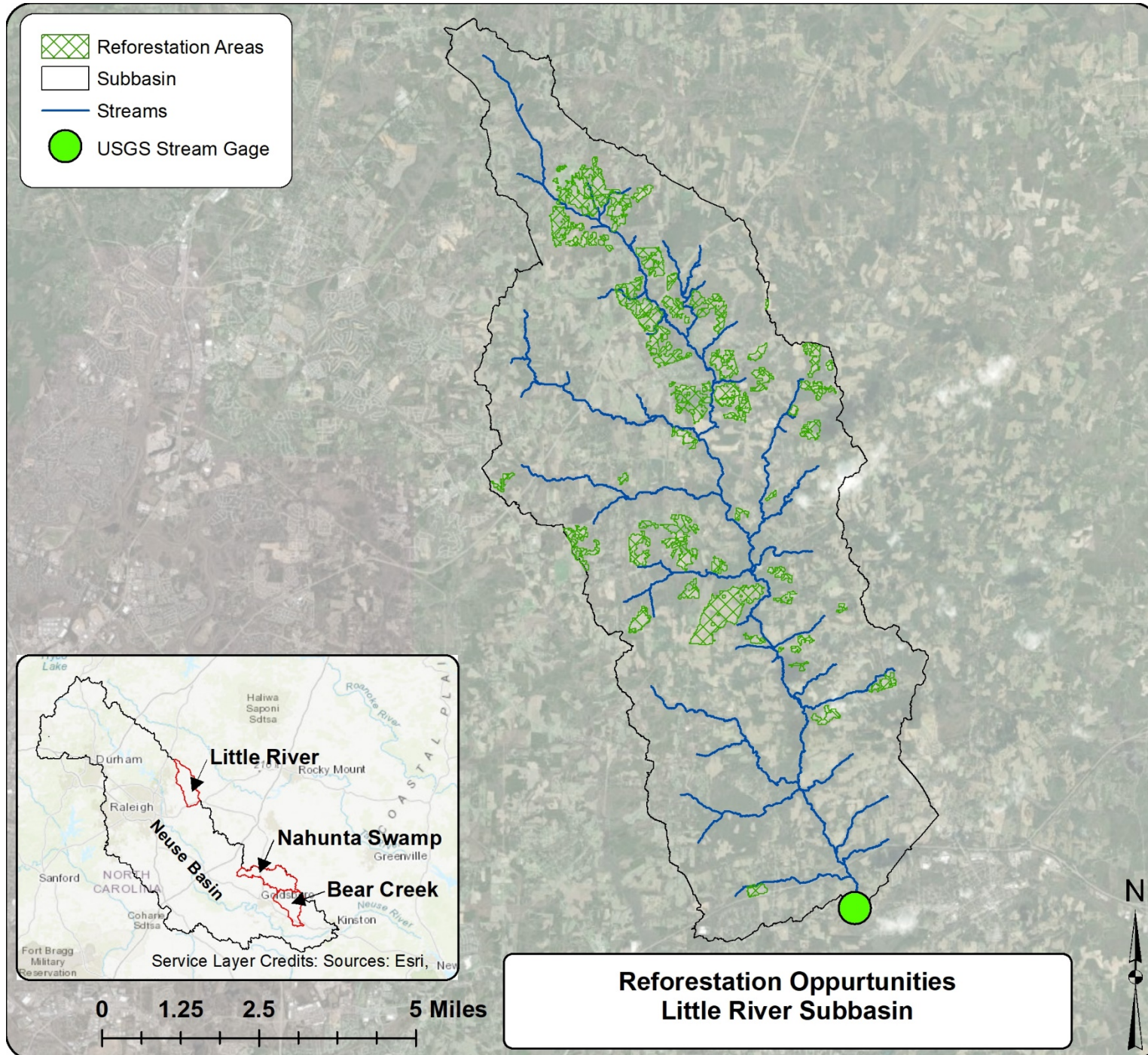


# Nahunta Swamp Reforestation

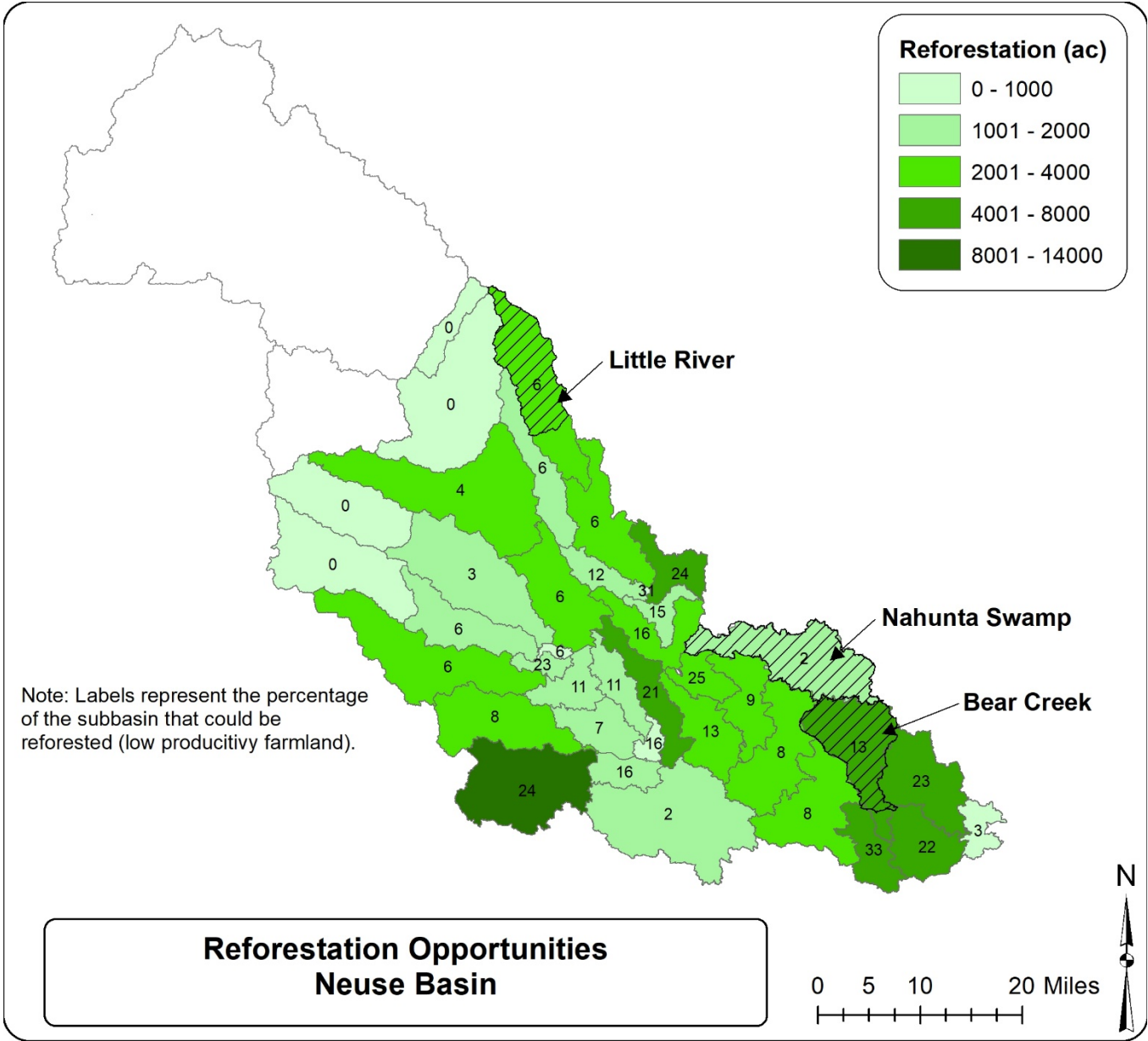




# Little River Reforestation



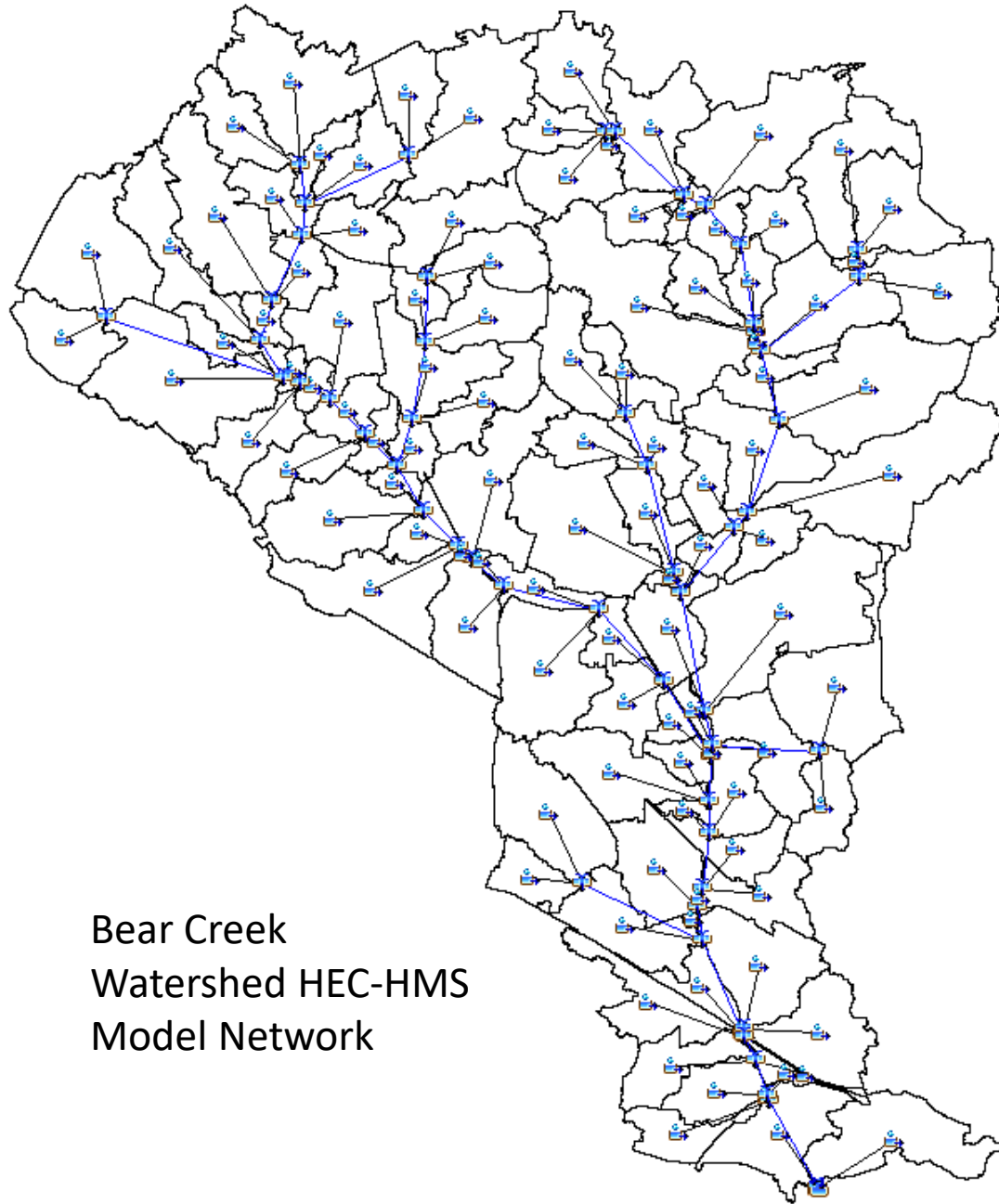
# Reforestation



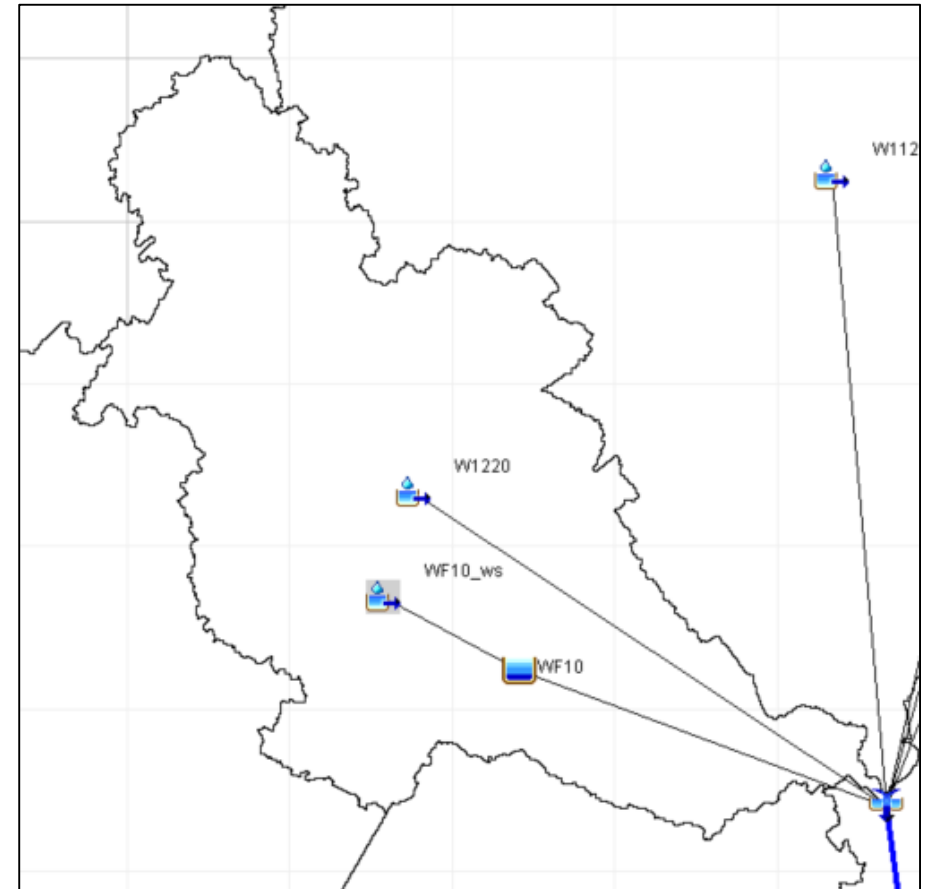
Study Watershed	Reforestation (acres)	Part of Watershed (%)
Little River	2,327	6.5
Nahunta Swamp	885	1.8
Bear Creek	3,975	10.6
Middle Neuse	102,000	8.4



# Evaluate Flood Reduction Potential of NI using Hydrology Model (HEC- HMS)



Bear Creek  
Watershed HEC-HMS  
Model Network



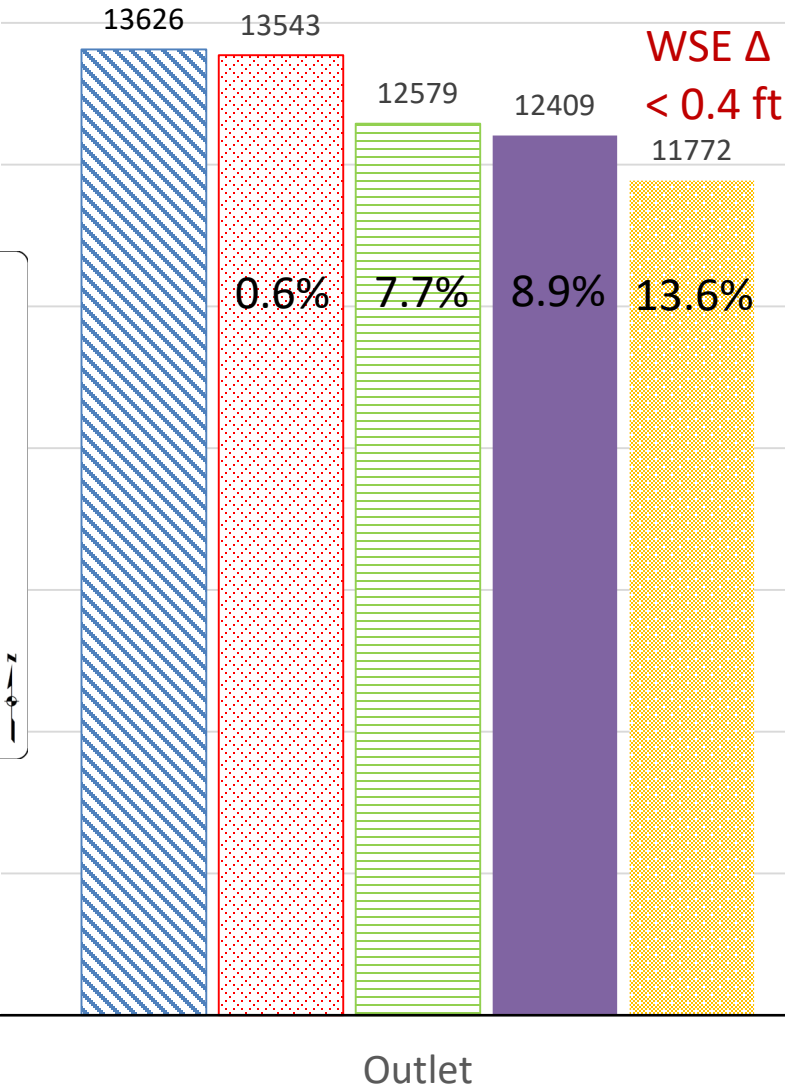
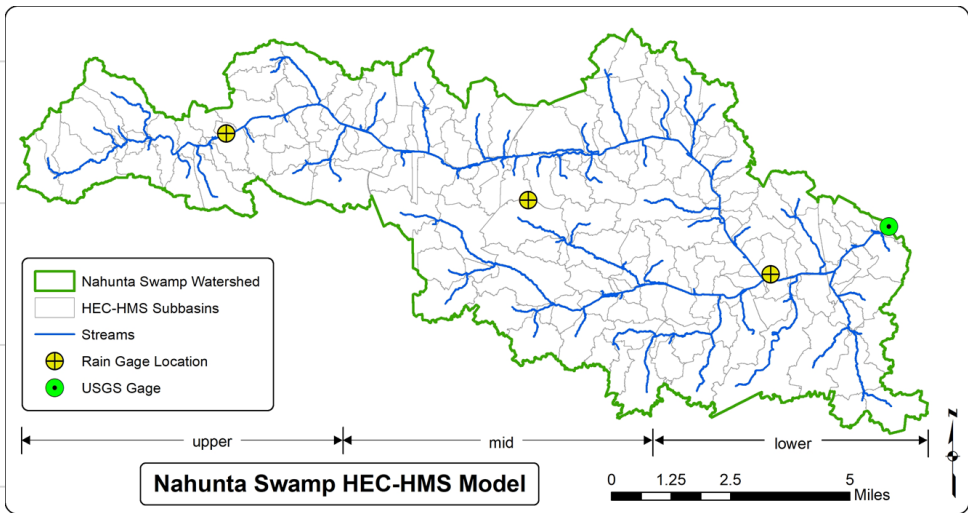
# Nahunta Swamp: Peak Q for Matthew

Water Farming - **5.1%**

Wetland - **12.2%**

Reforestation - **1.8**

Peak Discharge (cfs)



Calibrate Reforest WF Wetland WF+Wetland

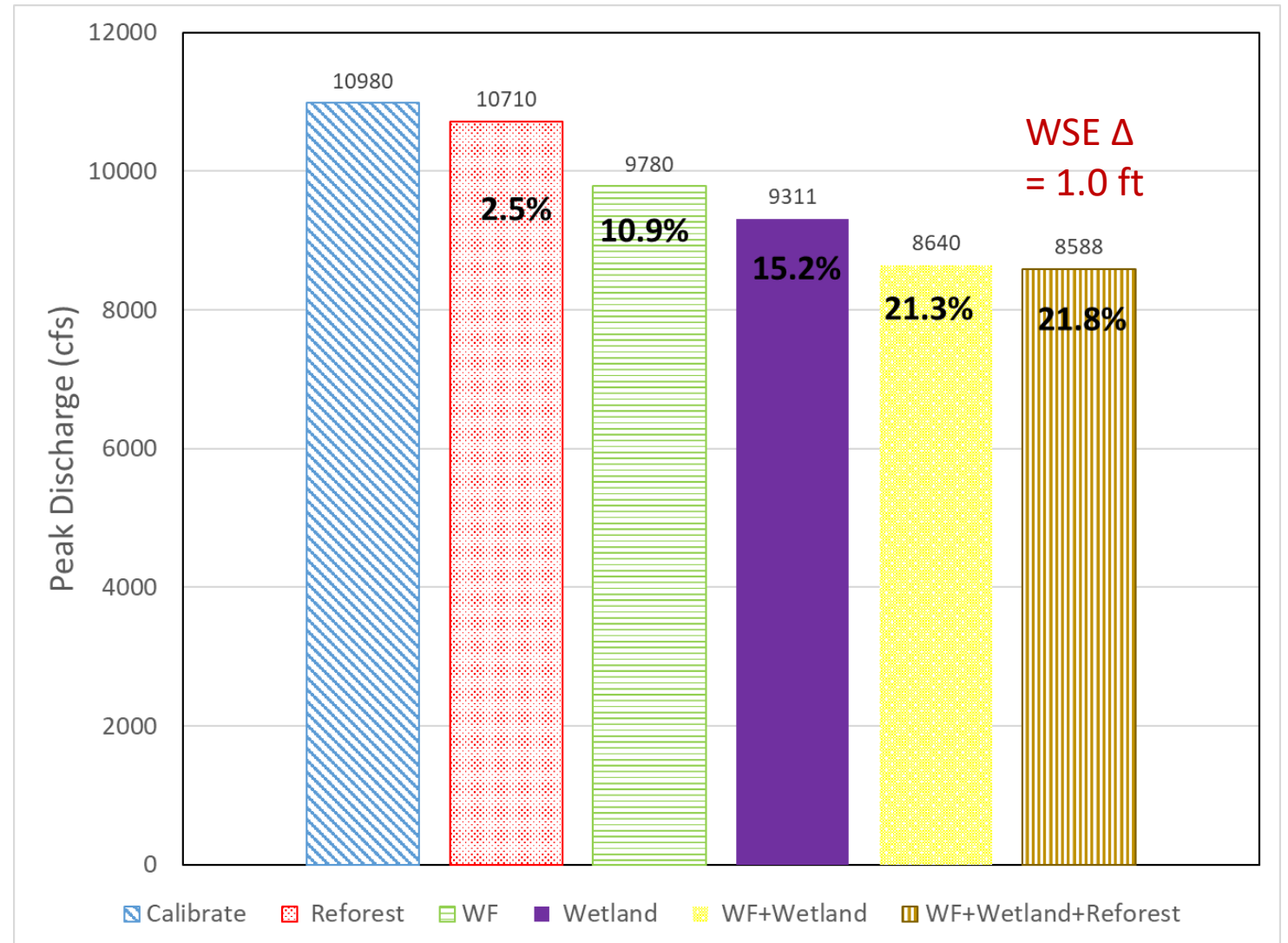
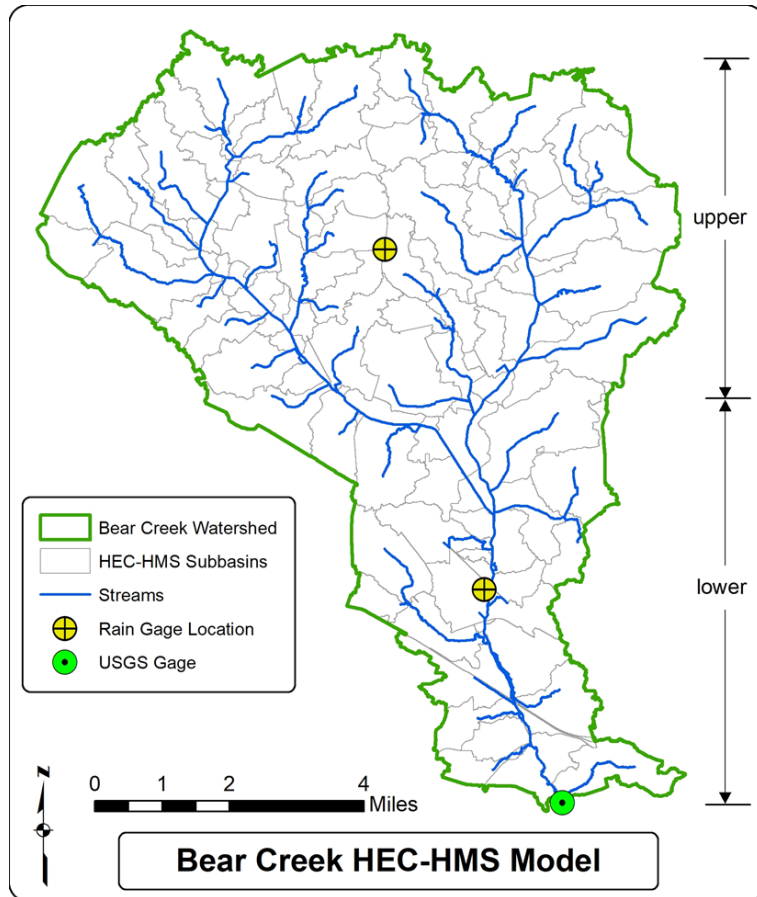


# Bear Creek: Peak Q for Floyd

Water Farming -**5.3%**

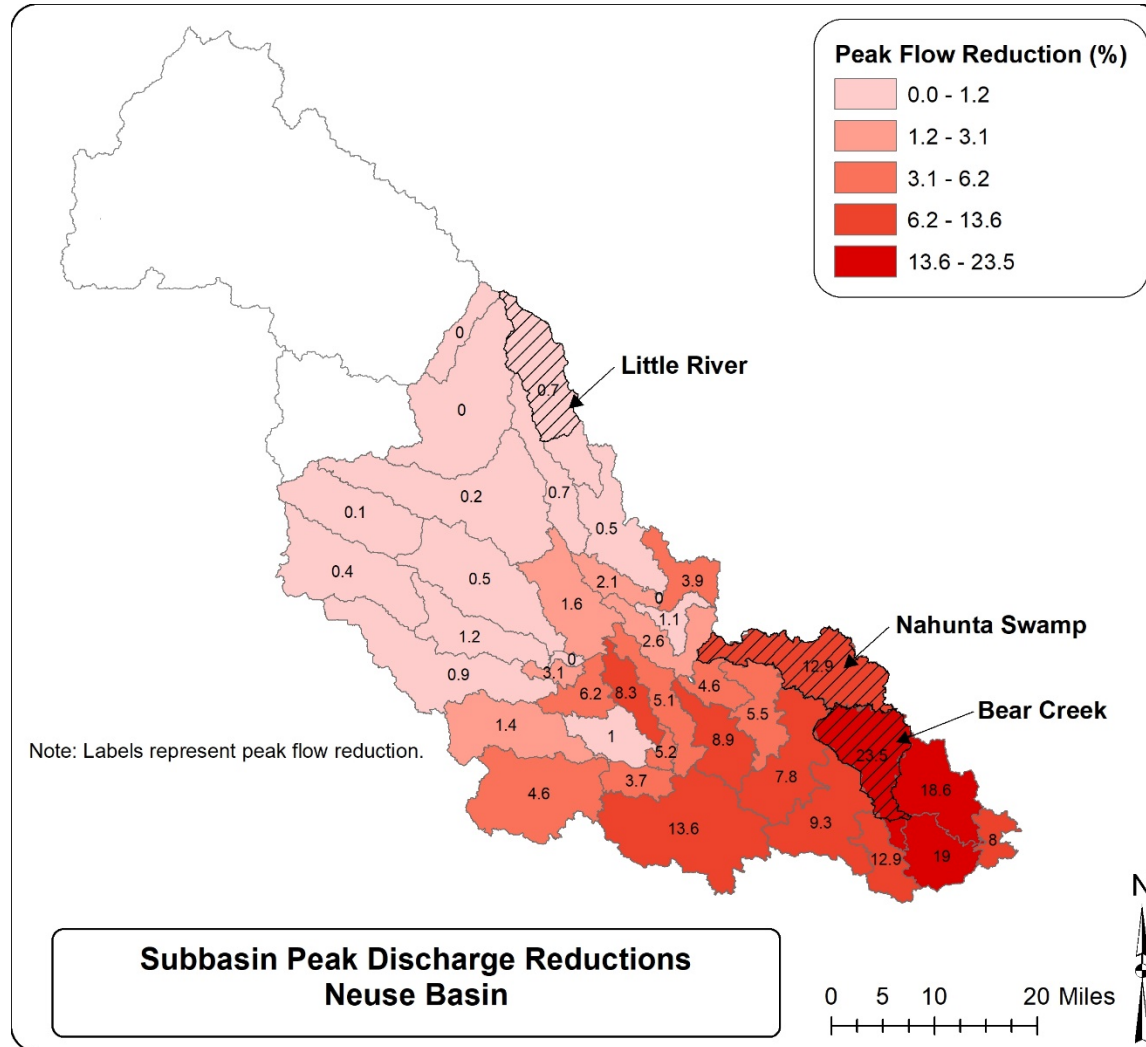
Wetland - **20%**

Reforestation -**10.6%**



# Extrapolate to Middle Neuse River Basin

- Water Farming (WF) + Wetland + Reforestation



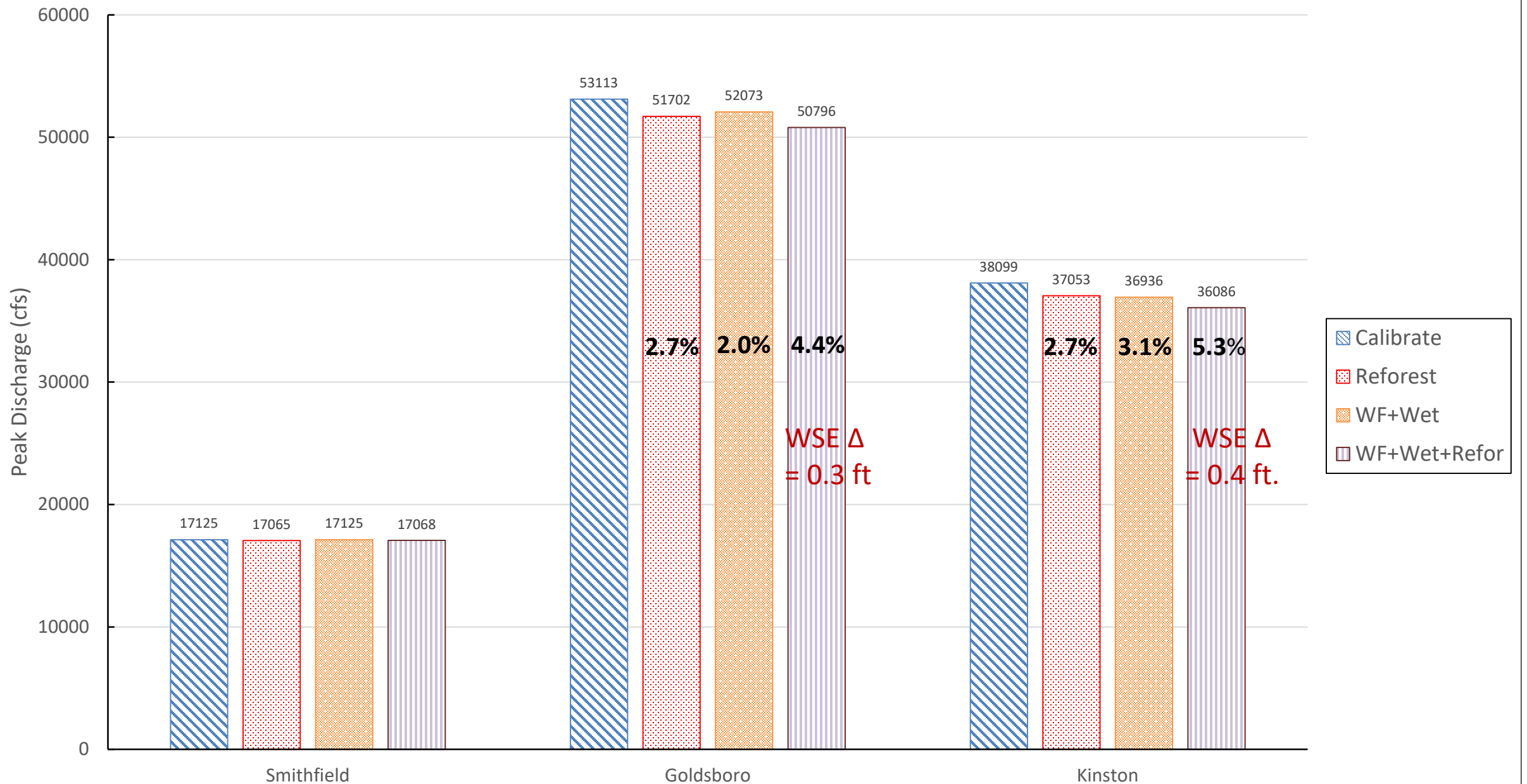
Water Farming -**1.1%**

Wetland – **5.7%**

Reforestation -**8.4%**

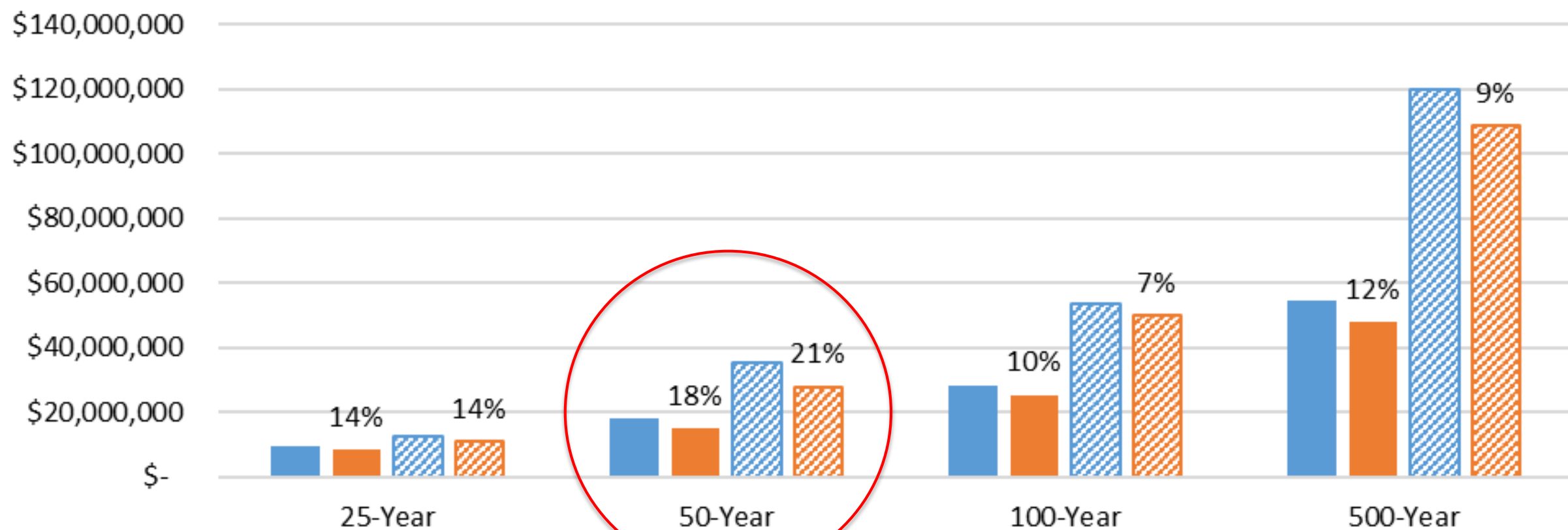


# Neuse River: Peak Discharge (Hurricane Matthew)



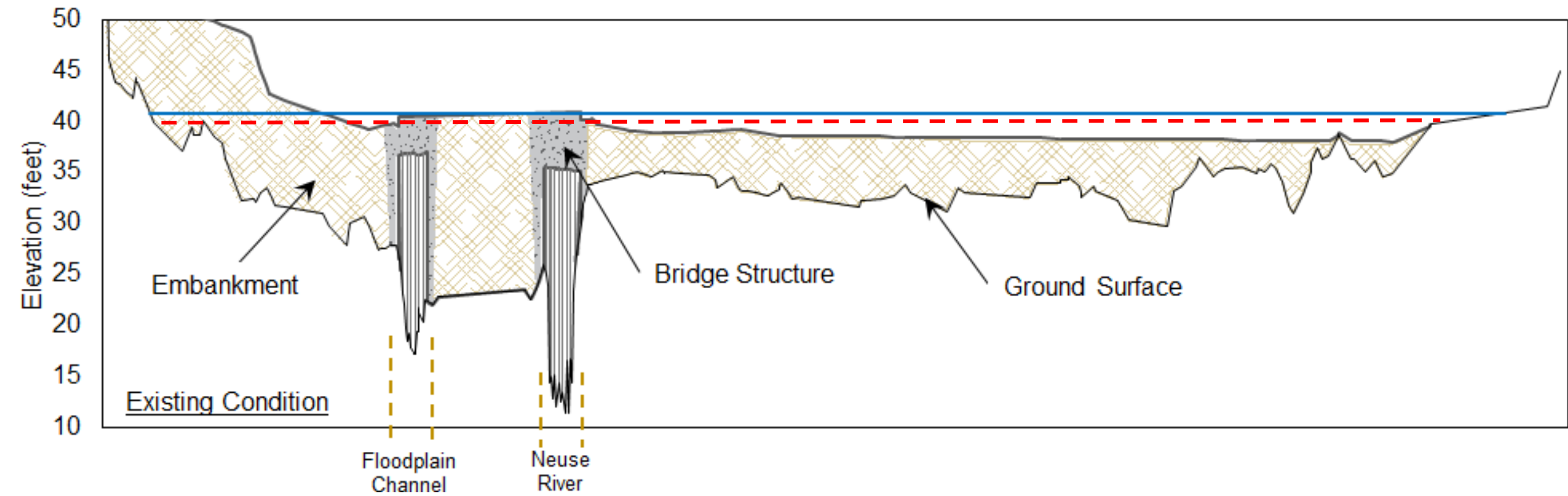
## Damage Reductions

■ Kinston Existing   ■ Kinston NI   ■ Gldsboro Existing   ■ Gldsboro NI

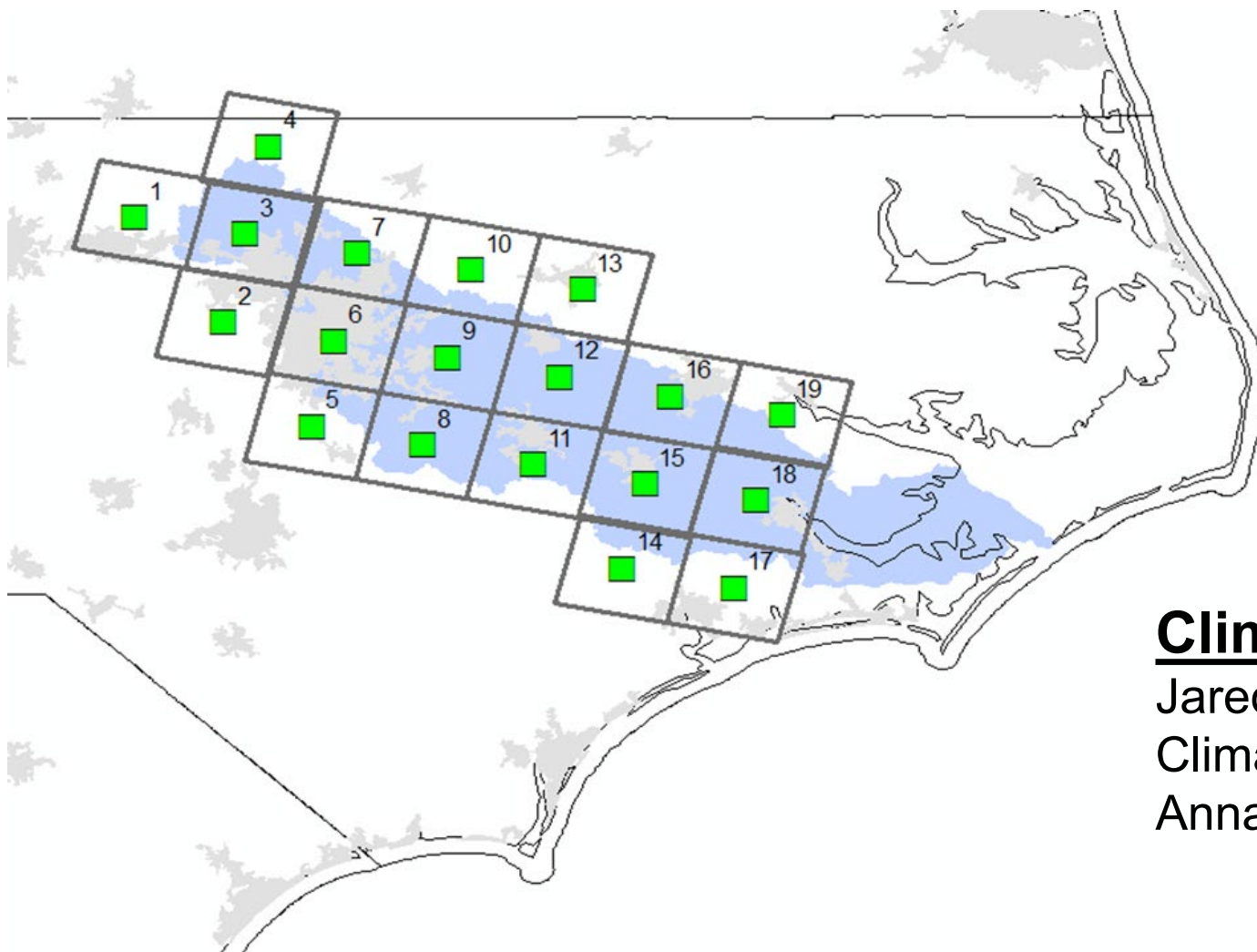




# US 70 in Kinston



# Climate Change – Impact on Extreme Storms

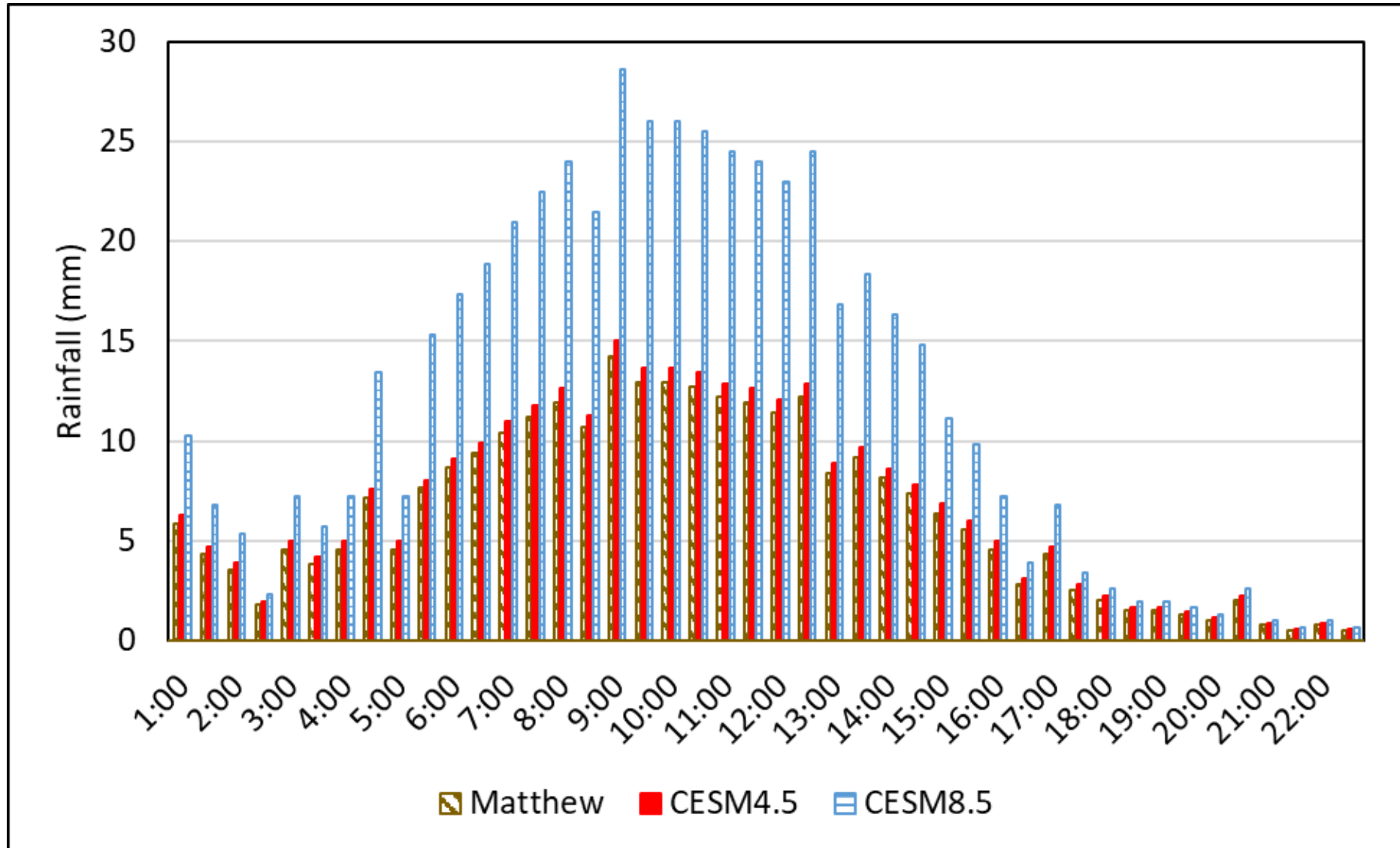


## Climate Modeling

Jared Bowden, NCSU, Southeast  
Climate Adaptation Science Center  
Anna Jalowska, NCSU, EPA

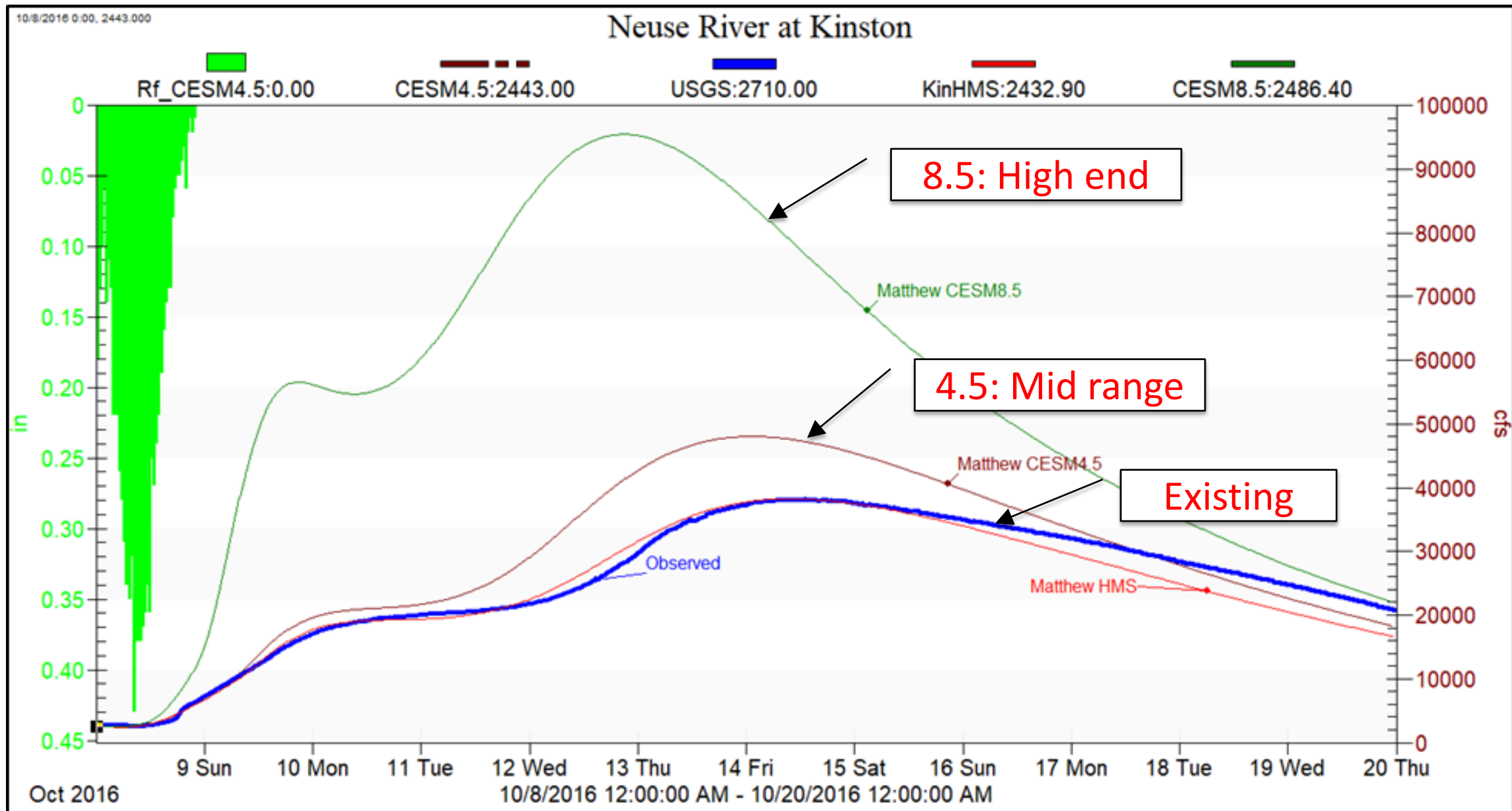


# Rainfall Distribution for Hurricane Matthew and Future Storms (Year 2100) for Kinston

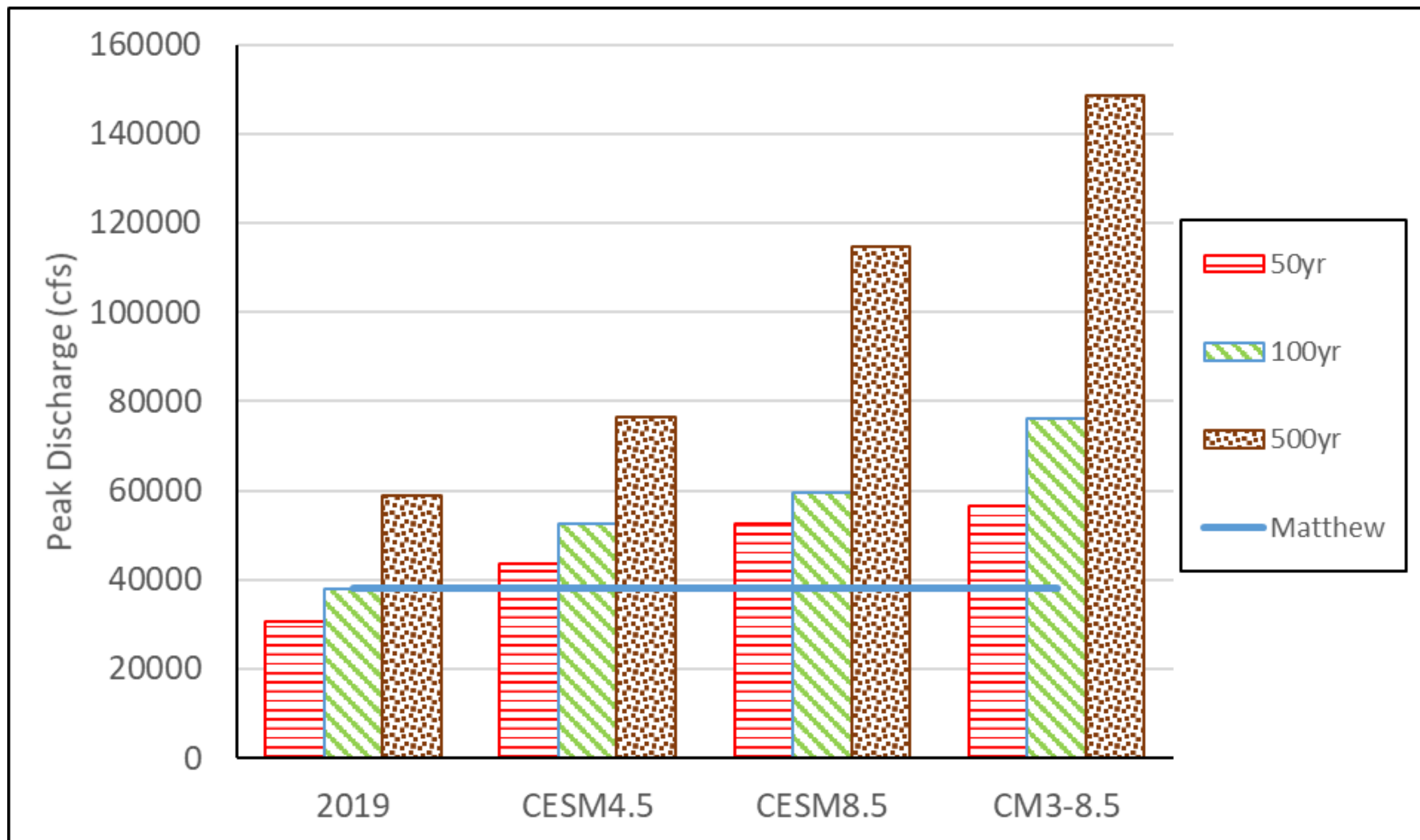


**CESM 4.5** – Some carbon reduction efforts made

**CESM 8.5** – No carbon reduction efforts made (Business as usual)







# Grand Forks, North Dakota (pop. 57,000)

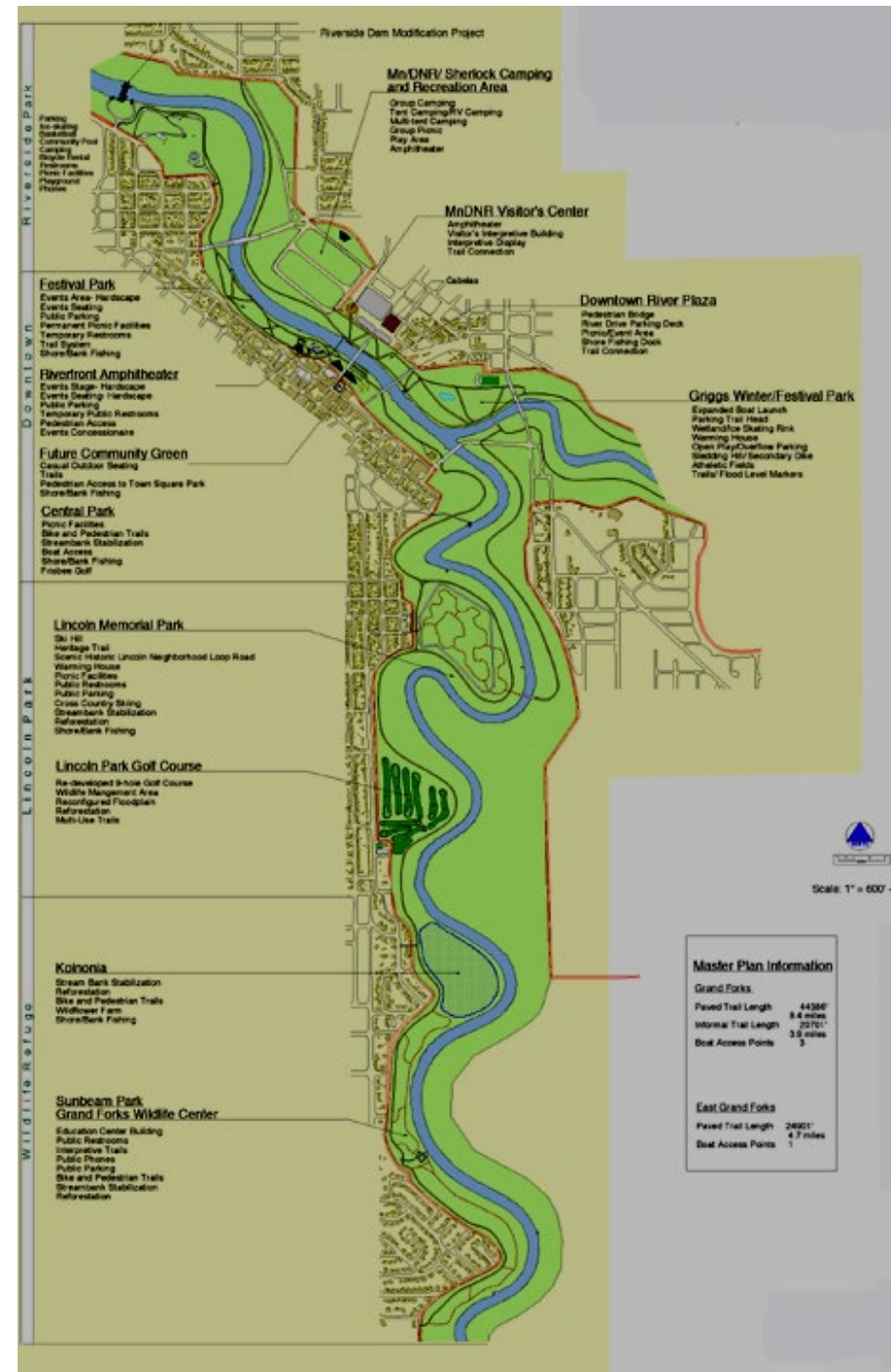


Source: Grand Forks Herald



# Greater Grand Forks Greenway Master Plan

- Buyout of repetitive flood loss properties (50 homes)
- Built a protective, flexible floodwall/levee system
- Implemented a 2,200-acre park and greenway system (20 miles of trails)





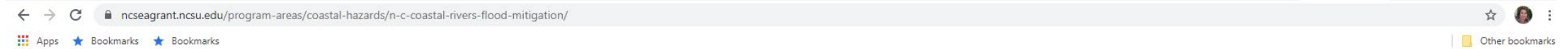




## Things to Consider:

- North Carolina **communities need financial and technical assistance** with flood mitigation (analysis, planning, design and implementation)
- **Innovative** multi-prong **approaches** are **needed**
- Need to better understand and **better communicate the risks** and uncertainty of future flood events
- **Relocate** repeat loss structures in the floodplain!
- Identify a place for water and **a safe place for people** – Water always wins!
- The most important use of **floodplains** is to **store floodwater**!
- Recovery of floodplains can **create beneficial opportunities** for communities (e.g. parks, greenways)

# http://go.ncsu.edu/flooding



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## N.C. Coastal Rivers Flood Mitigation

On this page:

[Major Floods](#) | [Transportation Impacts](#) | [Future Risks](#) | [Improving Resilience](#) | [Forecasting and Planning](#) | [References](#)

*The content below was prepared by J. Jack Kurki-Fox and edited by Barbara Doll, Julie Leibach, and Jonathan Page.*

**Major storms have exposed glaring vulnerabilities to riverine flooding in many N.C. Coastal Plain communities.**

Riverine flooding imperils life, health and livelihoods. It also threatens transportation infrastructure. Road closures and flooding can severely affect the movement of vital goods and services, with crippling effects on local economies and emergency response.