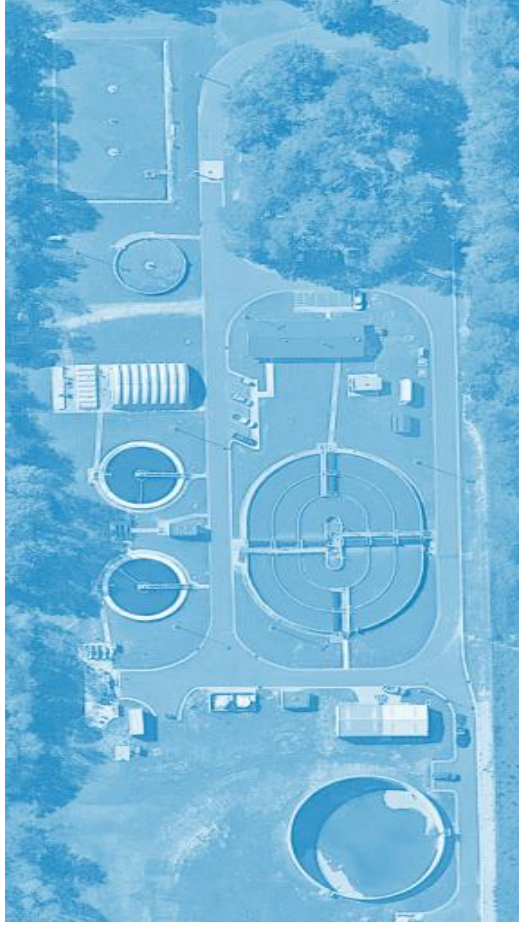




30 July & 1 August 2019

Balancing Future Growth and Nitrogen Discharge Limitations:
Wastewater Master Planning for the City of Raleigh

LNBA WORKSHOP 2019
RALEIGH | KINSTON

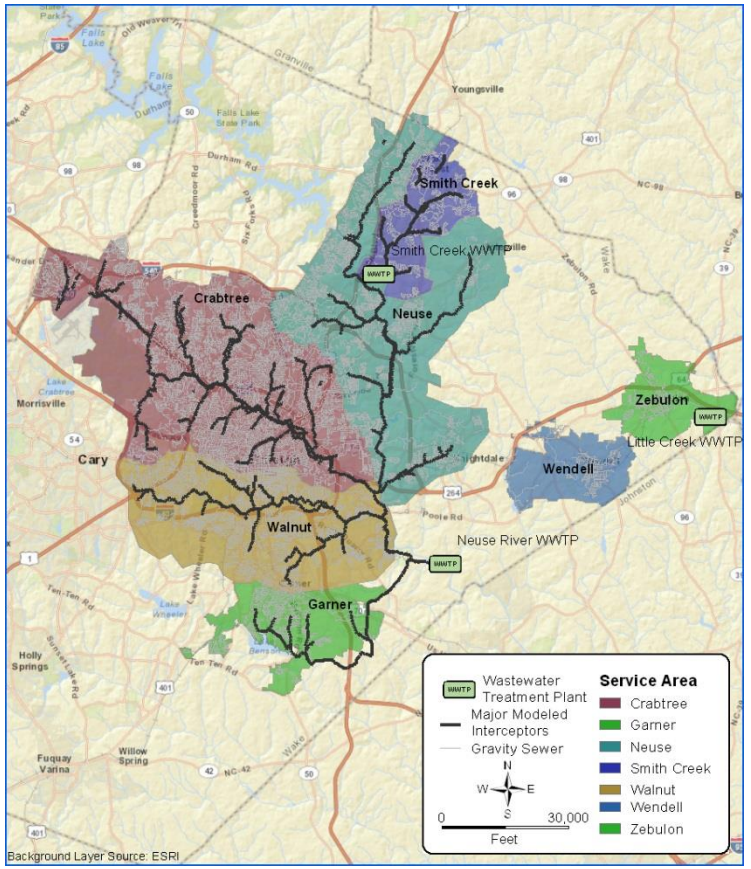
BLACK & VEATCH

Wastewater Treatment Master Plan: Development

- Background
- Methodology
- System-Wide Flow Alternatives
- Treatment Process Options
- Recommended Wastewater Treatment Solution

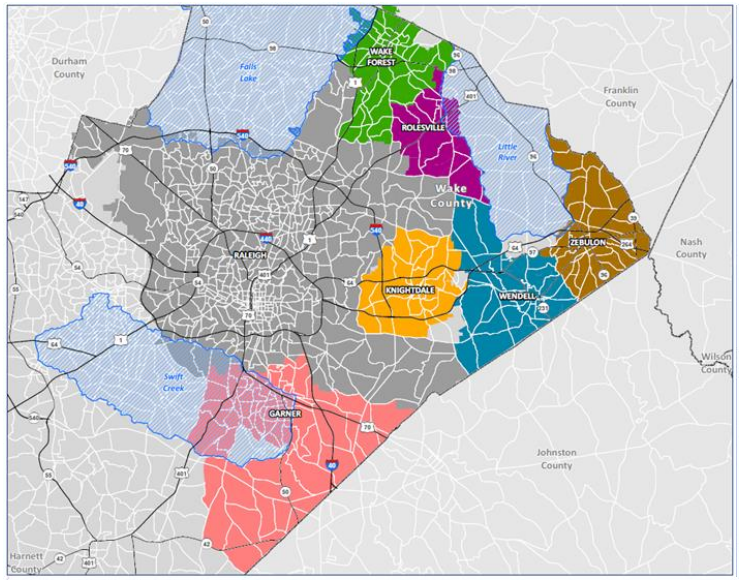
Existing Wastewater System

- CORPUD provides sanitary sewer service to 195,000 customers and a service population of 570,000 people.
- Wastewater collection system consists of 2,500 miles of pipeline and 114 pump stations.
- CORPUD owns and operates three WWTPs:
  - Neuse River RRF (75 mgd)
  - Smith Creek WWTP (3 mgd)
  - Little Creek WWTP (2.2 mgd)



Key Planning Drivers

Capacity

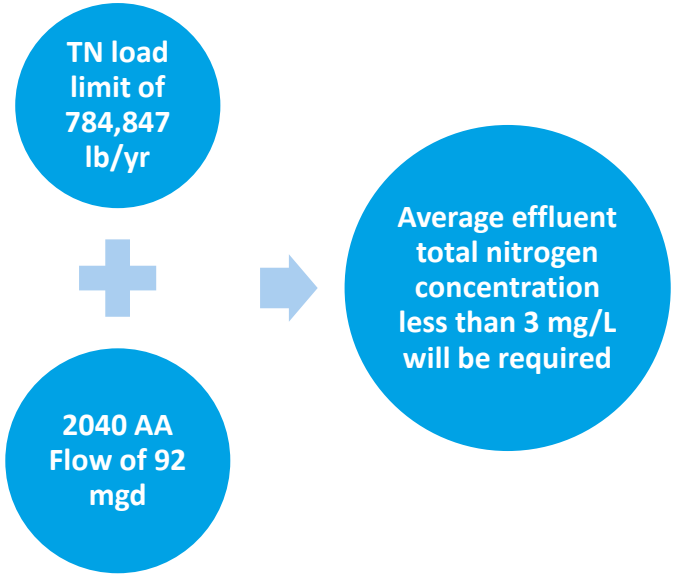


AA flows are expected to double from 48 mgd in 2015 to more than 92 mgd by 2040 to meet the growing service area.

Sustainability

CORPUD has a long term vision to be a leader in the use of wastewater as a beneficial resource.

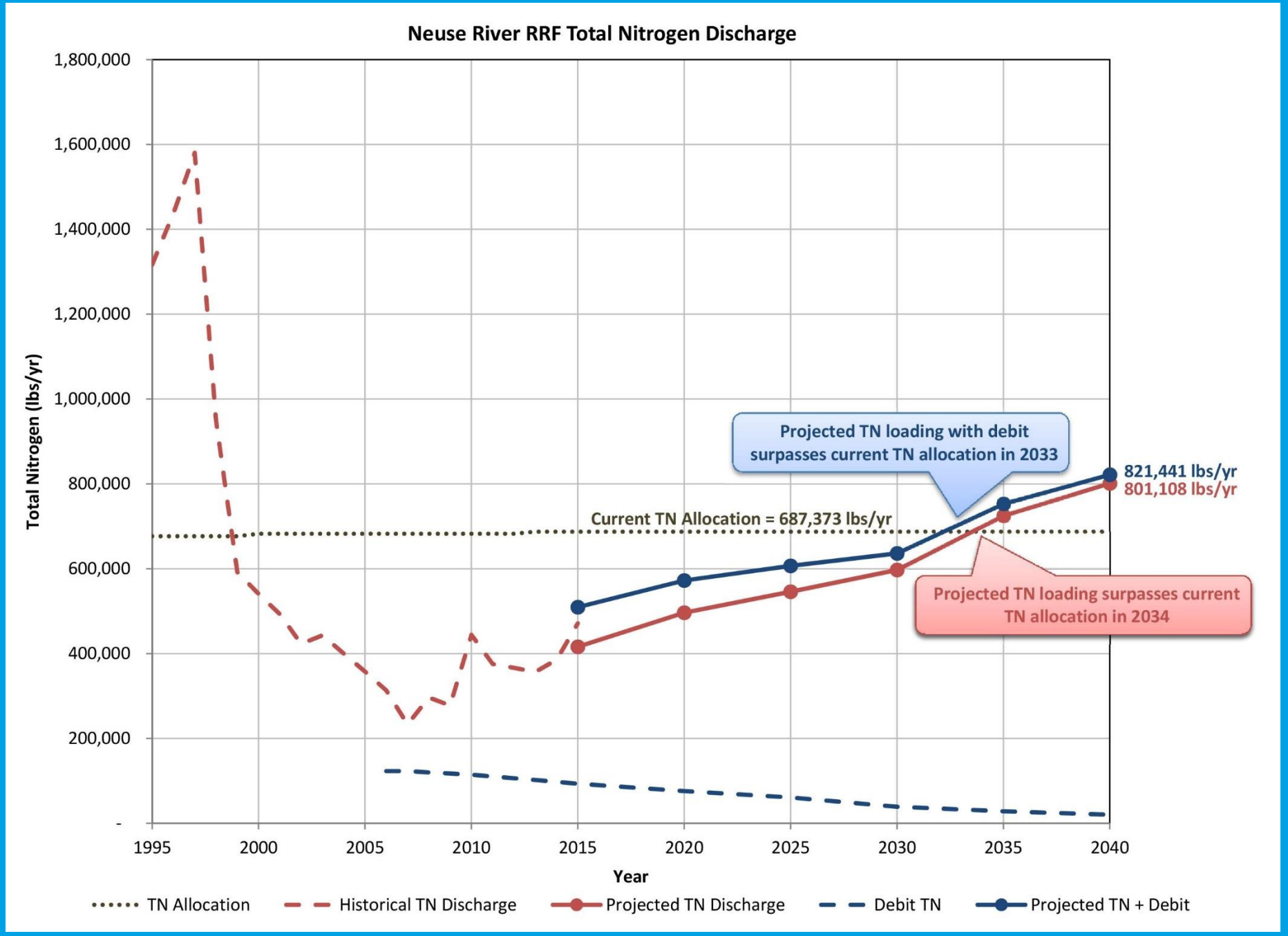
Regulatory



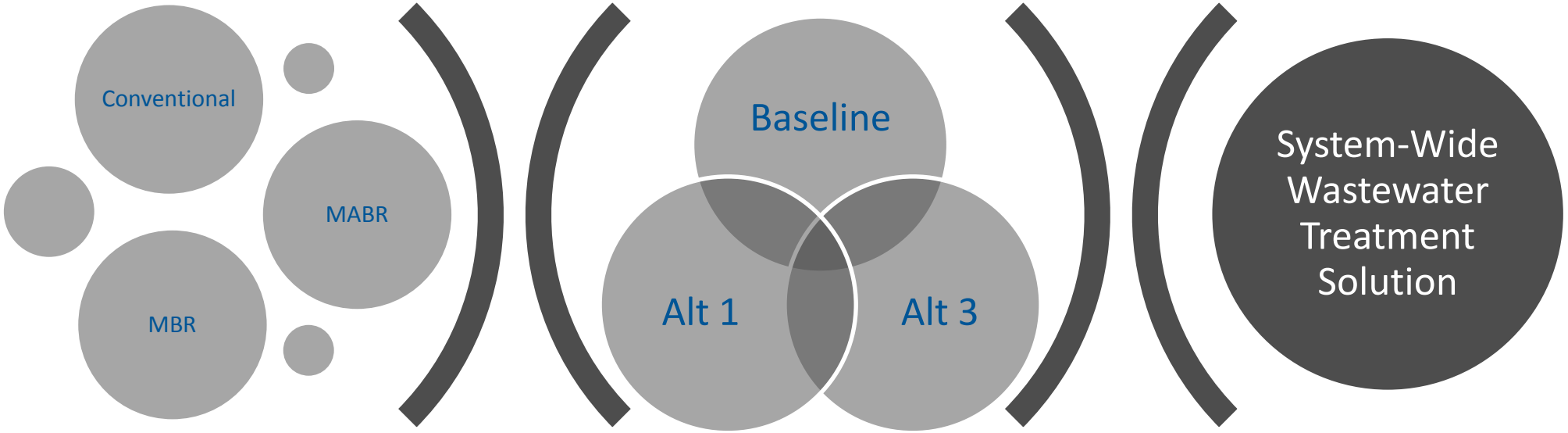
Existing nitrogen regulations will play a critical role in future wastewater treatment.

Drivers will shape the landscape of future wastewater treatment in CORPUD service area.

Nitrogen Limitations



Methodology:
Determination of System-Wide Treatment Solution



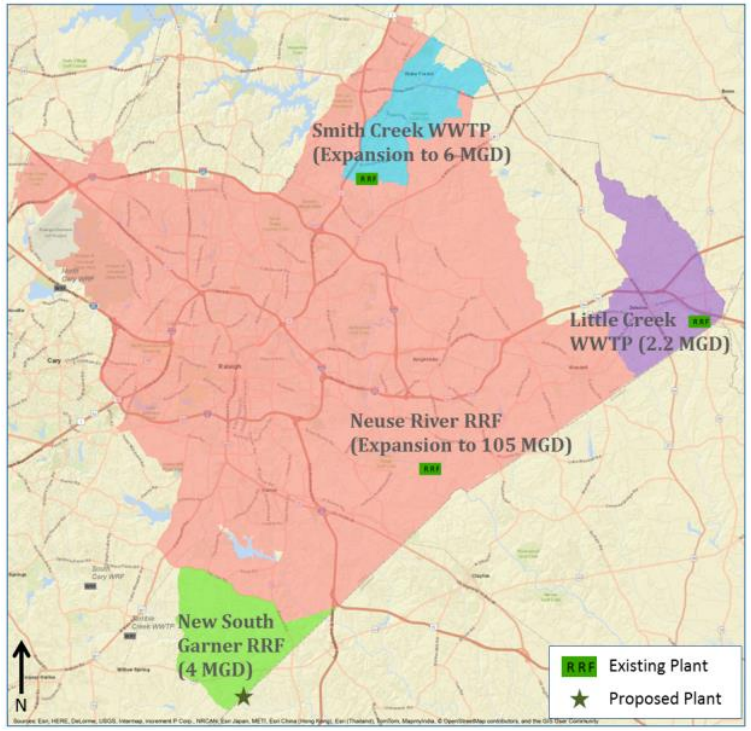
Treatment Process Options

System-Wide Flow Alternatives

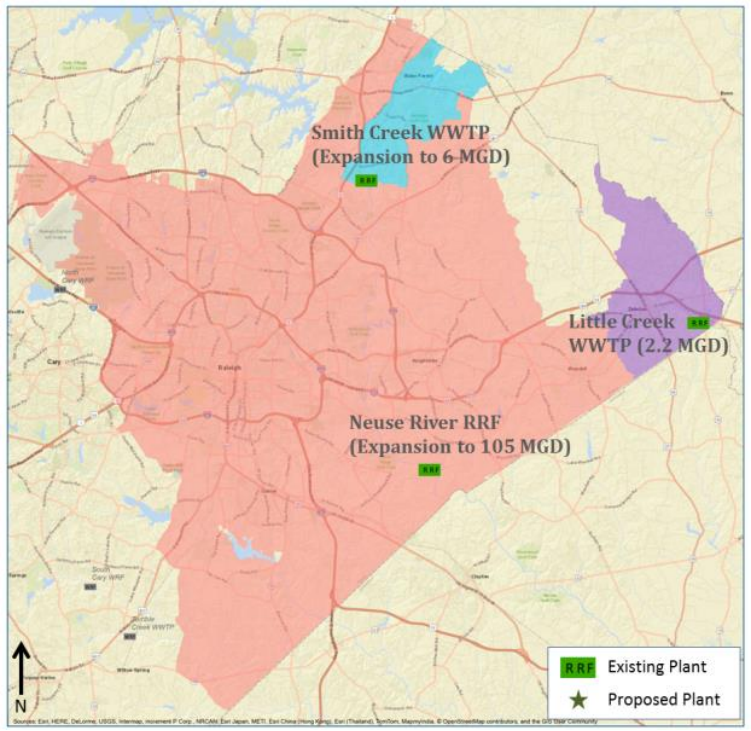
Final Selection

System-Wide Flow Alternatives:
Expand Existing or Build New?

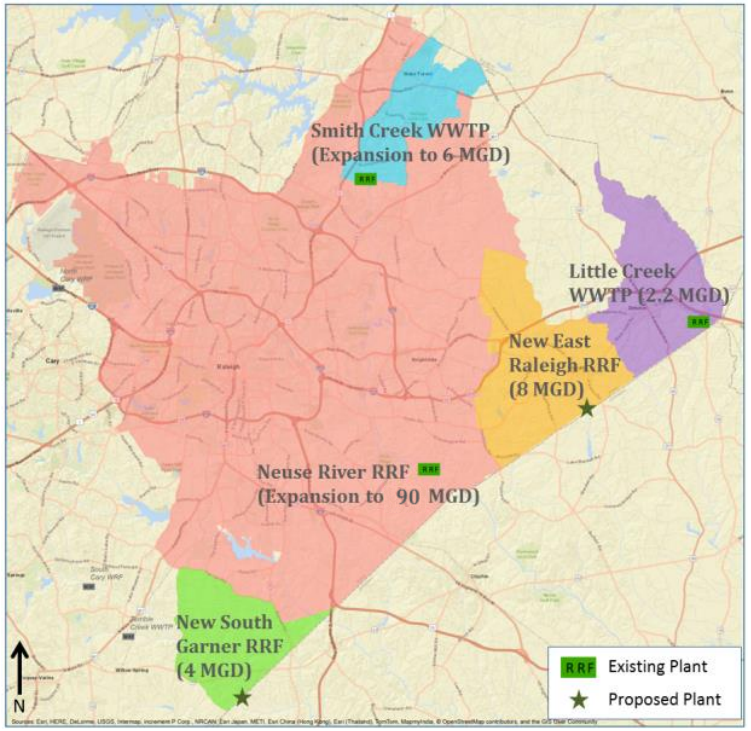
Baseline



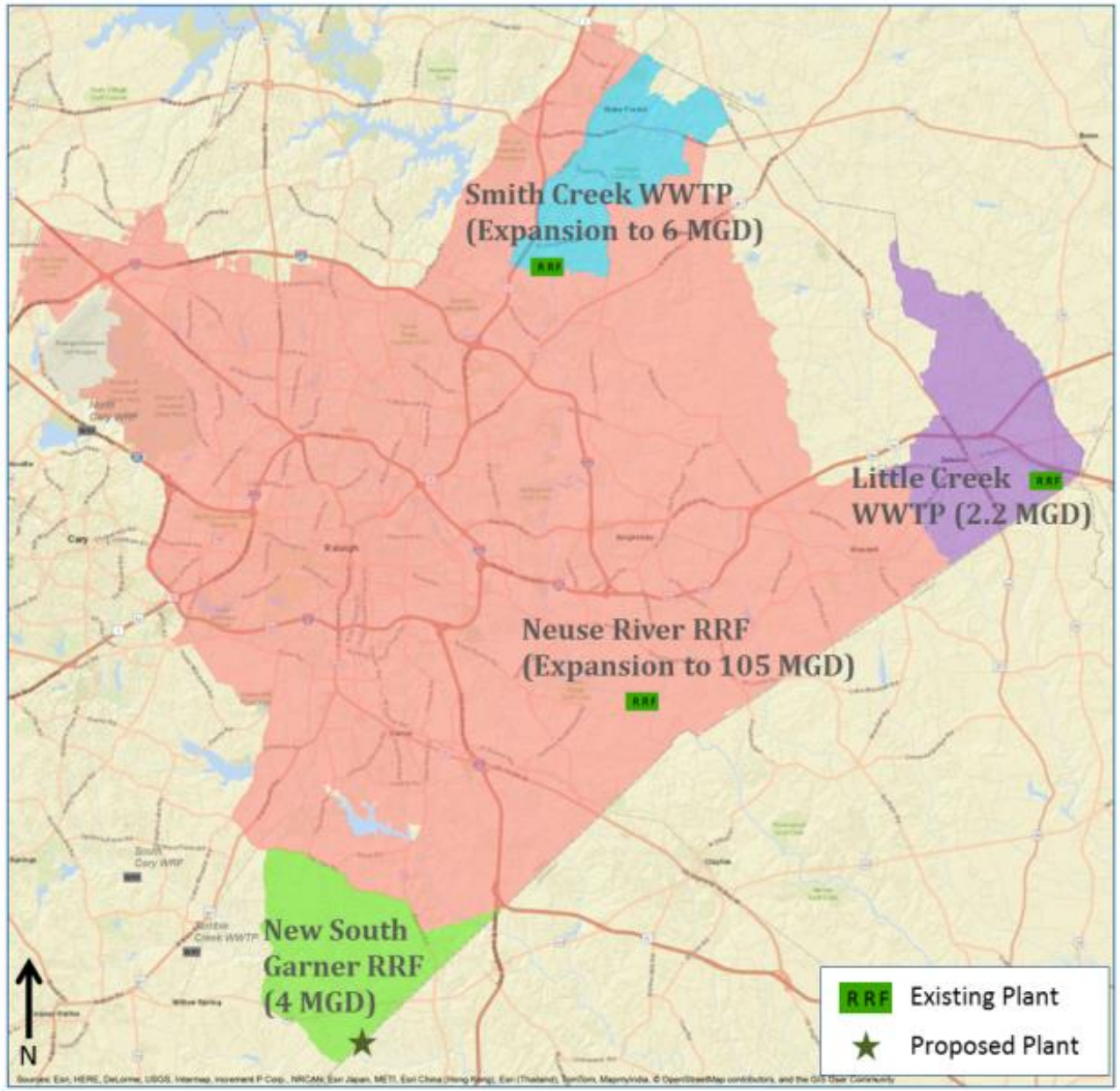
Alternative 1



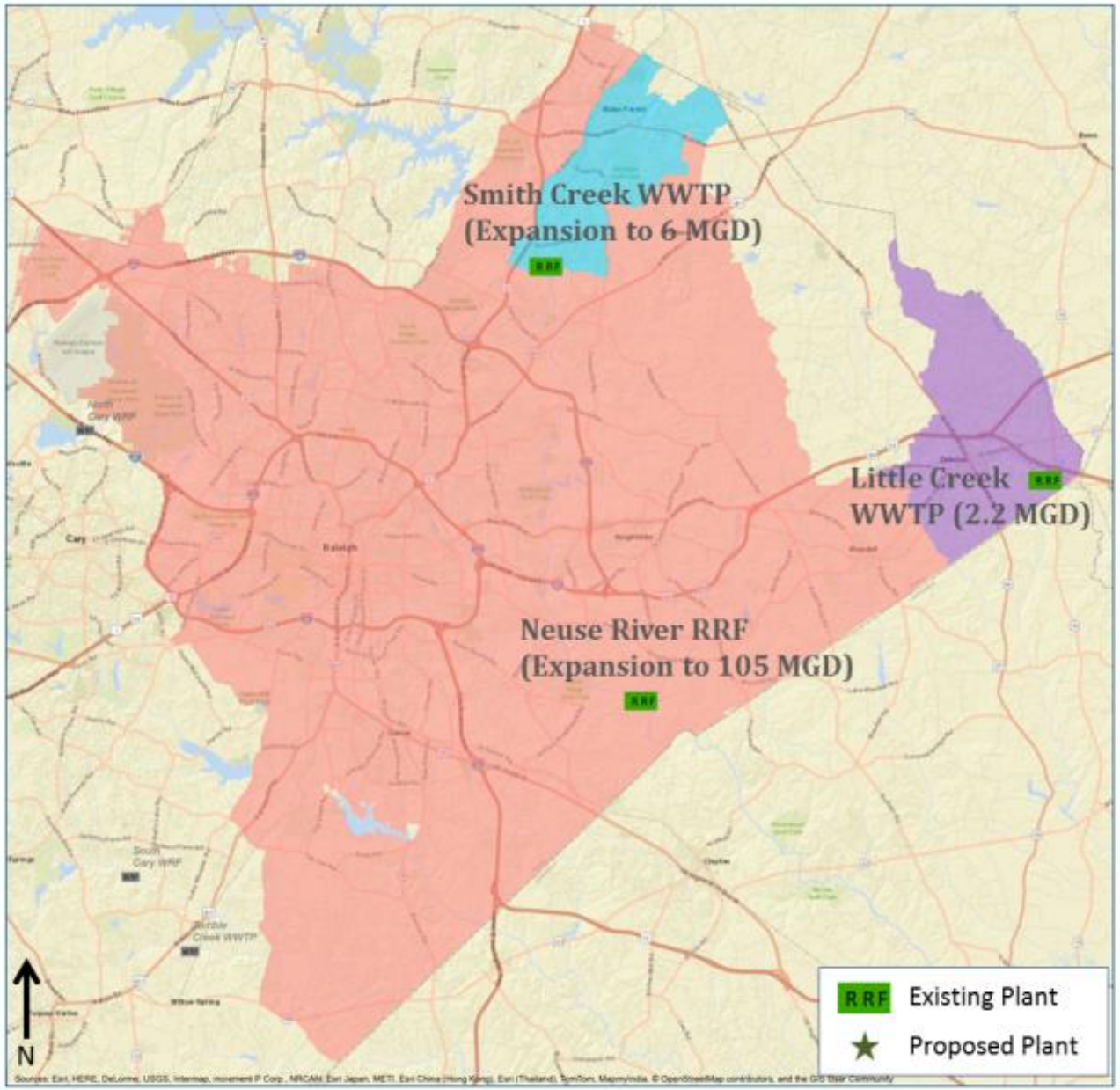
Alternative 3



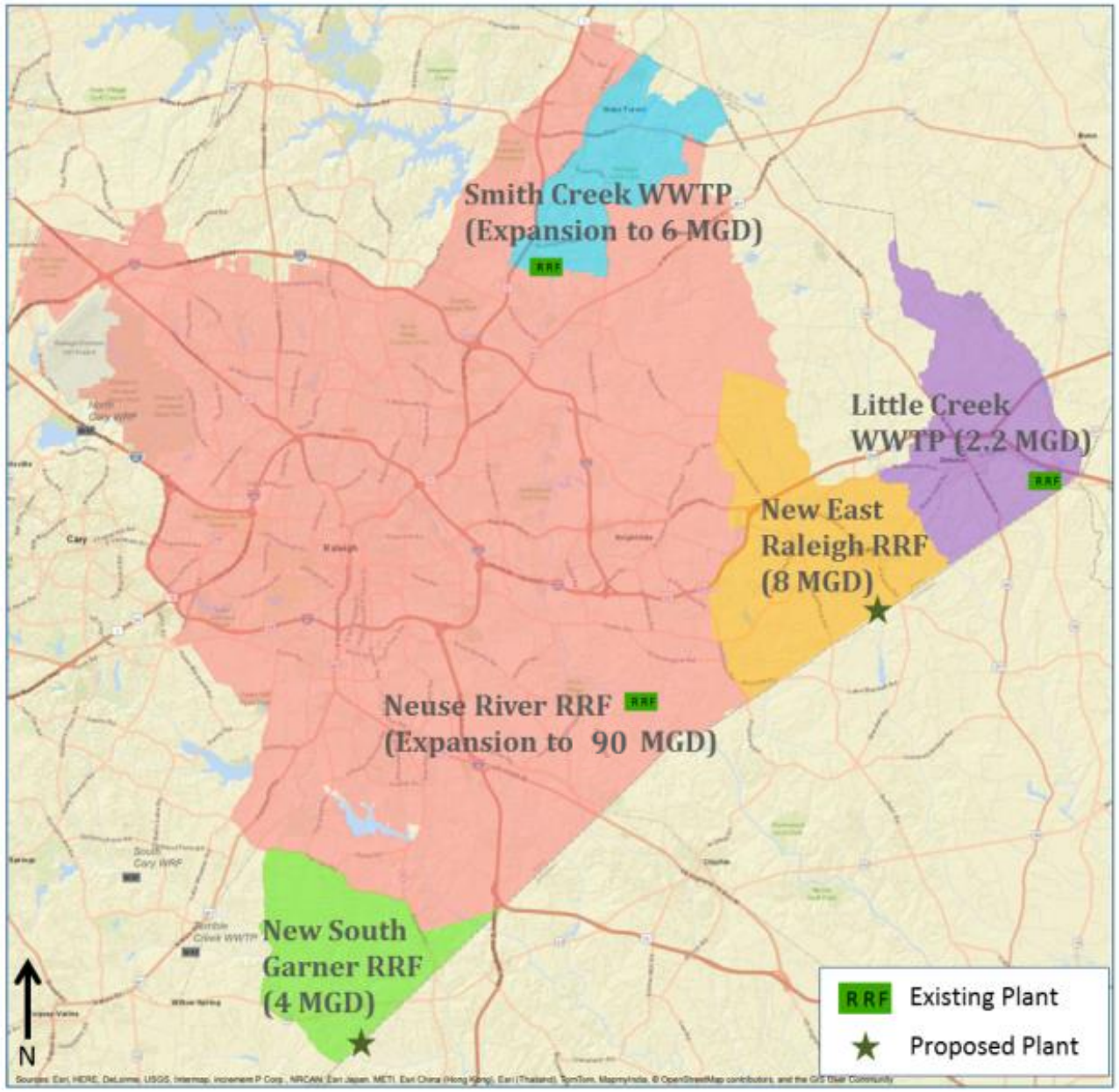
Baseline


Smith Creek WWTP
(Expansion to 6 MGD)
Little Creek
WWTP (2.2 MGD)
Neuse River RRF
(Expansion to 105 MGD)
New South
Garner RRF
(4 MGD)
N
RRF Existing Plant
Proposed Plant

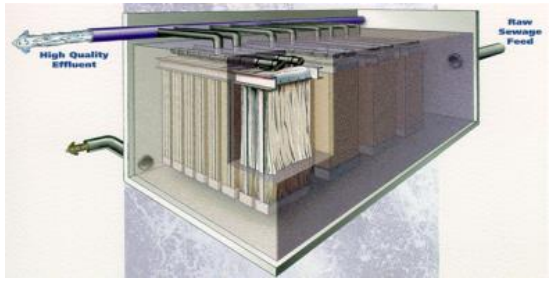
Alternative 1



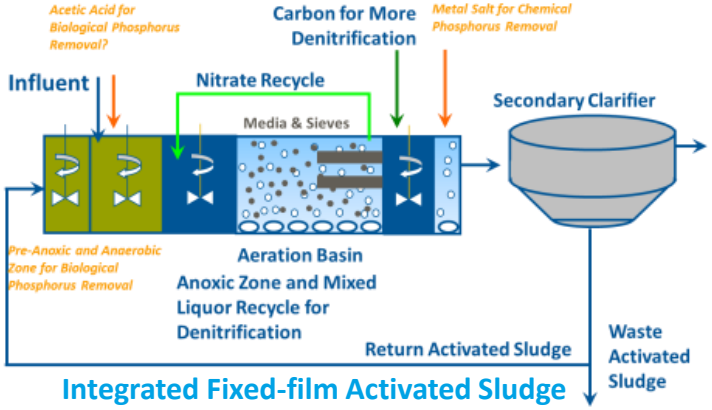
Alternative 3



Treatment Process Options:
Conventional or Innovative Treatment?

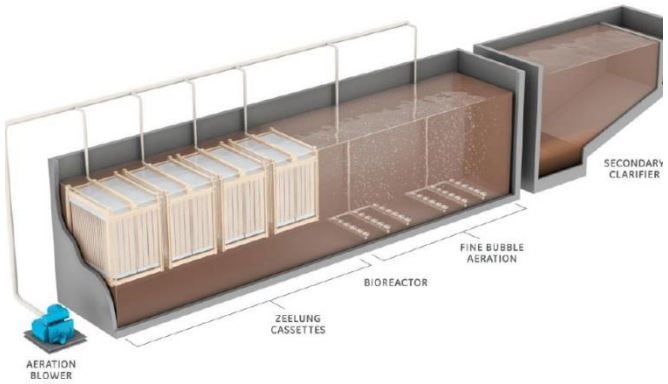


Membrane Bioreactor

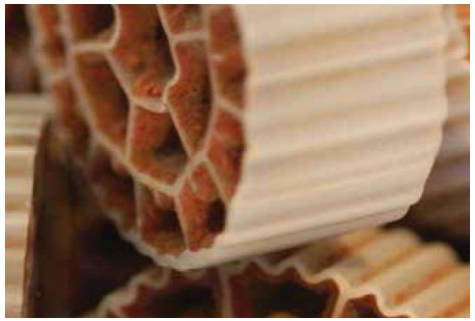


Integrated Fixed-film Activated Sludge

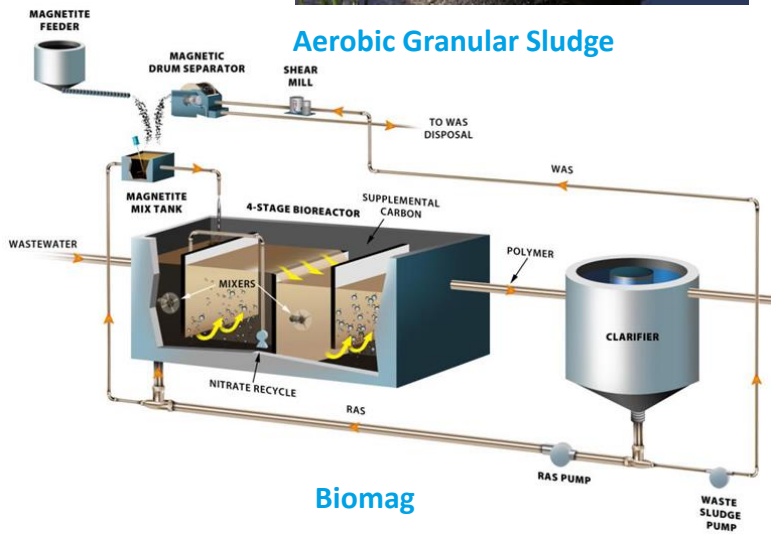
Aerobic Granular Sludge



Membrane Biofilm Reactor



Mainstream Deammonification



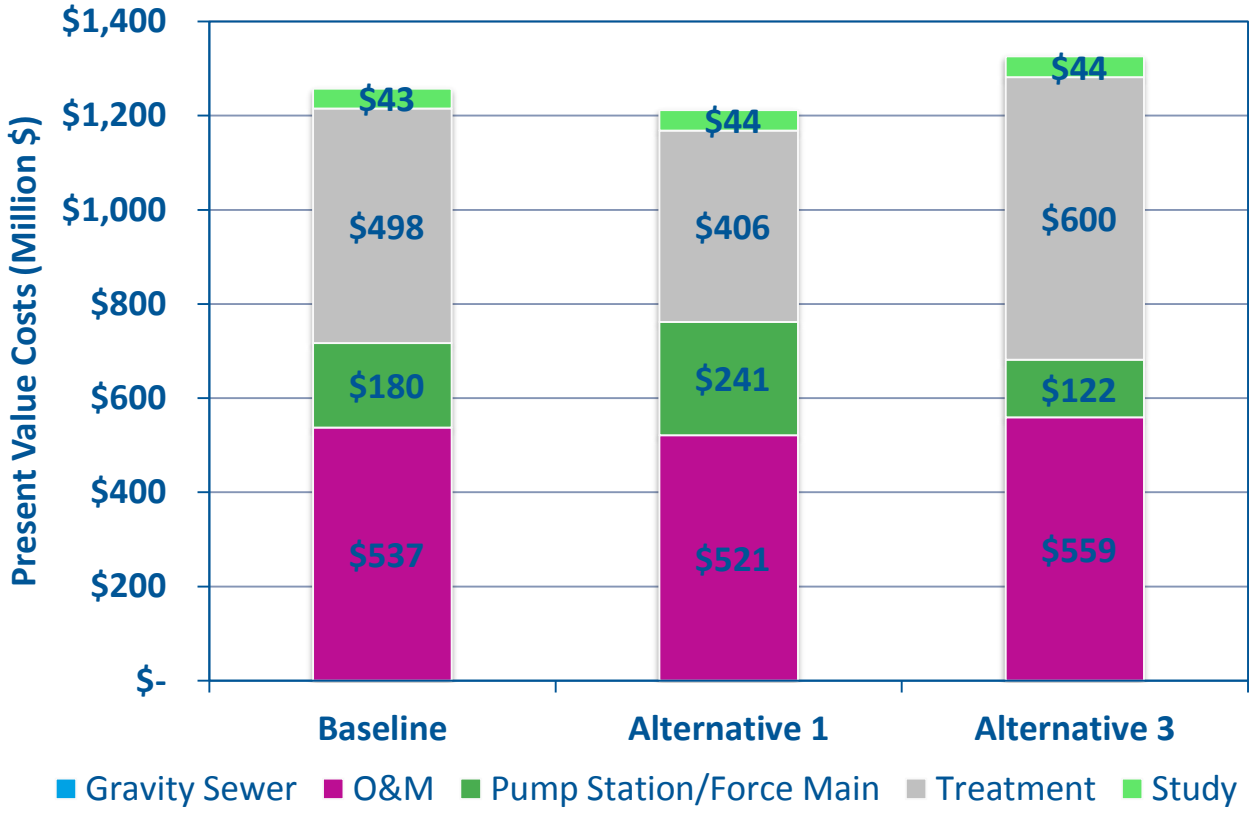
Biomag

Key criteria in screening process options was ability to achieve low total nitrogen concentrations in plant effluent and potential for water reuse.

Treatment Process Options:
Conventional or Innovative Treatment?

System-Wide Wastewater Treatment Solution:
Present Worth Cost Analysis

	BASELINE	ALTERNATIVE 1	ALTERNATIVE 3
Total	$1,258 M	$ 1,212 M	$ 1,326 M



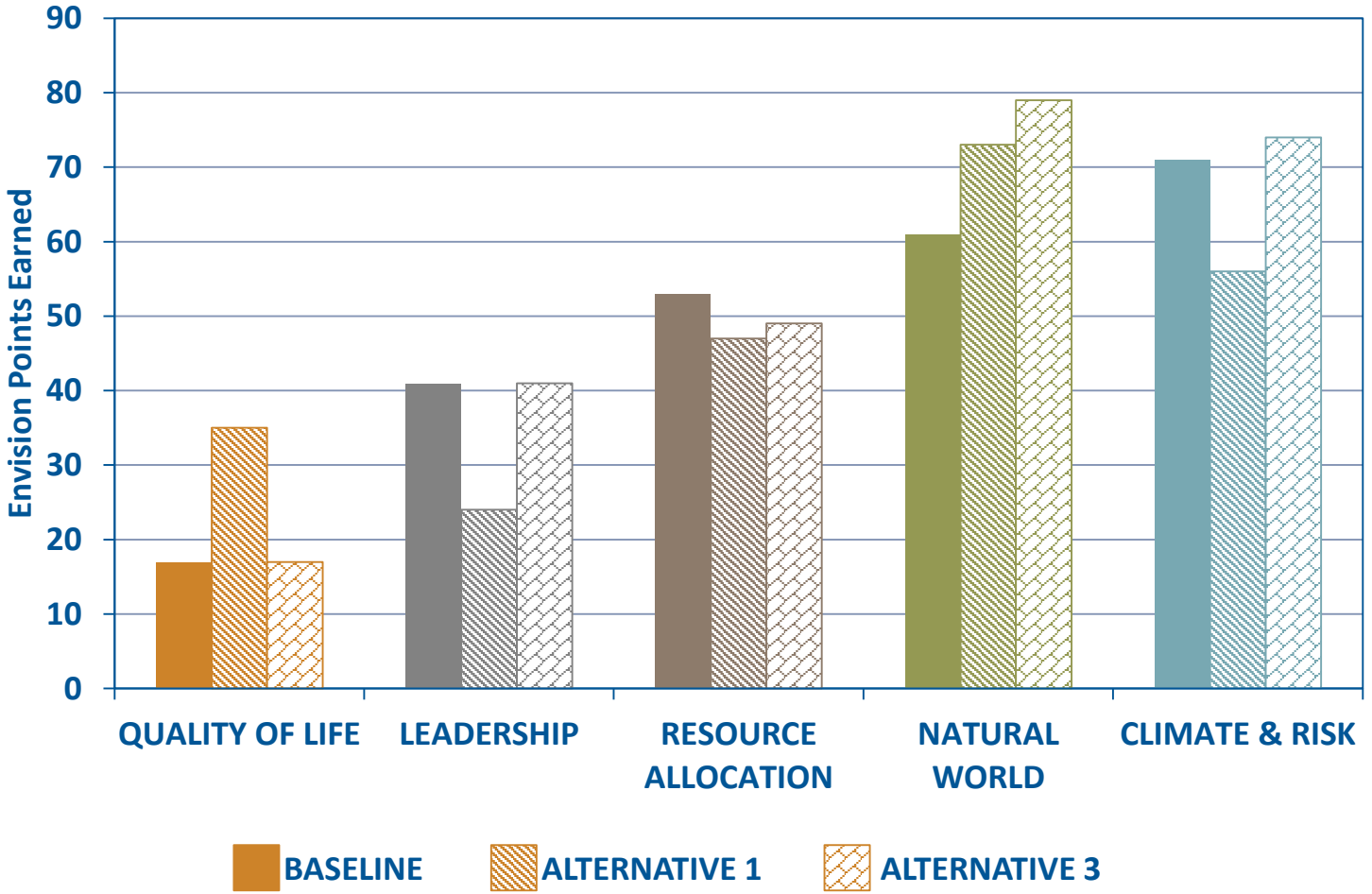
- Alternative 1 only includes upgrades to existing treatment facilities.
- Baseline and Alternative 1 include an additional expansion at the Neuse River RRF that is not required in Alternative 3 over planning horizon.
- Alternative 3 includes the construction of two plants and upgrades at the existing plants.

System-Wide Wastewater Treatment Solution:
Envision Sustainability Analysis

Quality of Life
Fewer plants = reduced impacts to surrounding community.

Leadership
More plants = more opportunities for water reuse and collaboration with stakeholders.

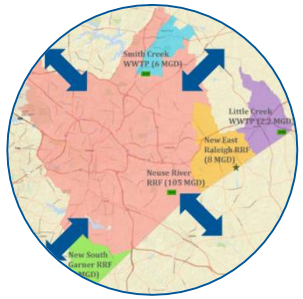
Resource Allocation
Fewer plants = reduced materials.
More plants = more opportunities for reuse.

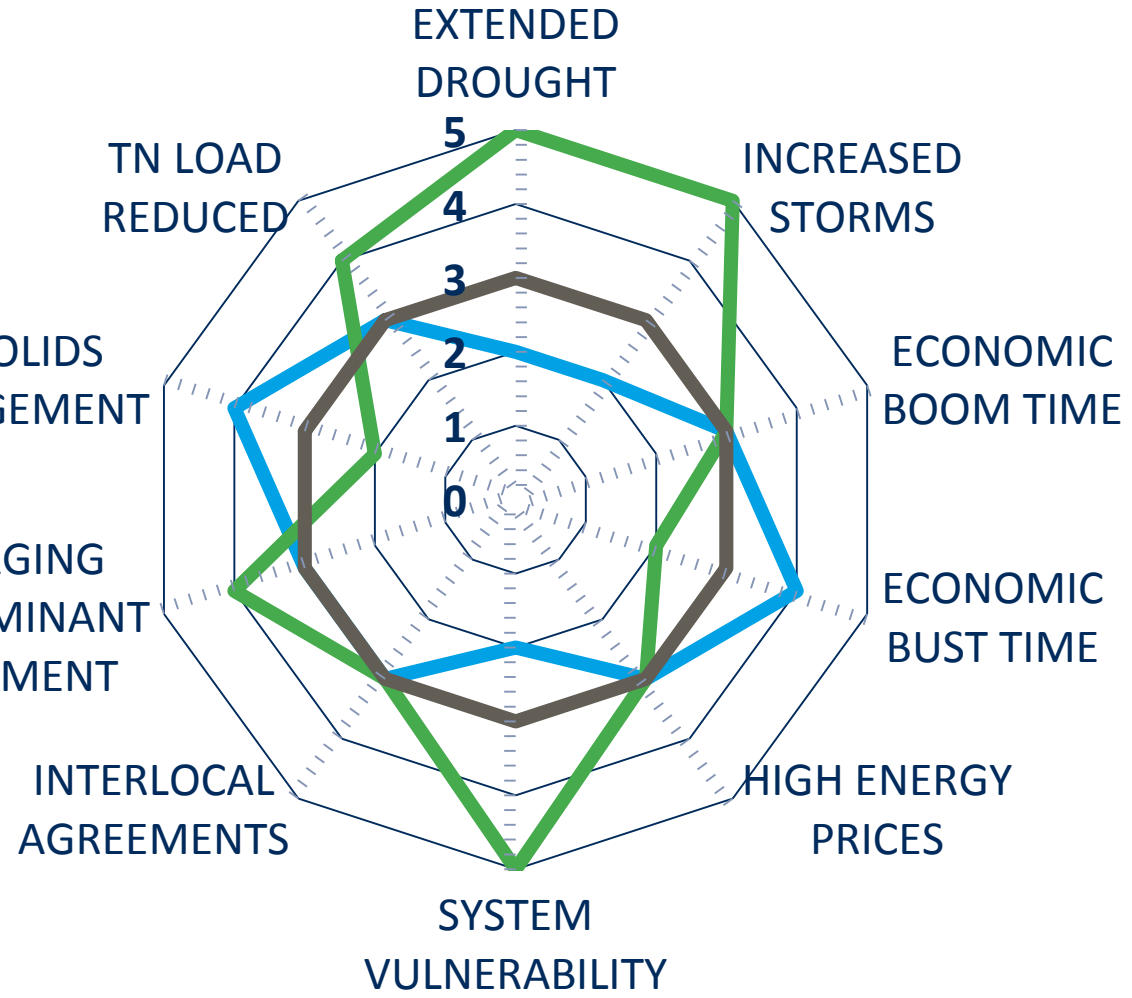


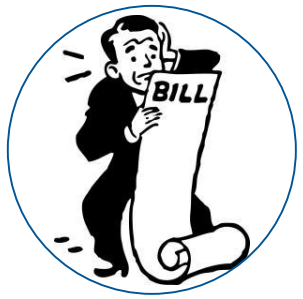
Natural World
Fewer plants = reduced impacts on habitats, greenfields, etc.

Climate & Risk
More plants = more resiliency and opportunities for reuse.
Fewer plants = longer force mains and potential for methane emissions.

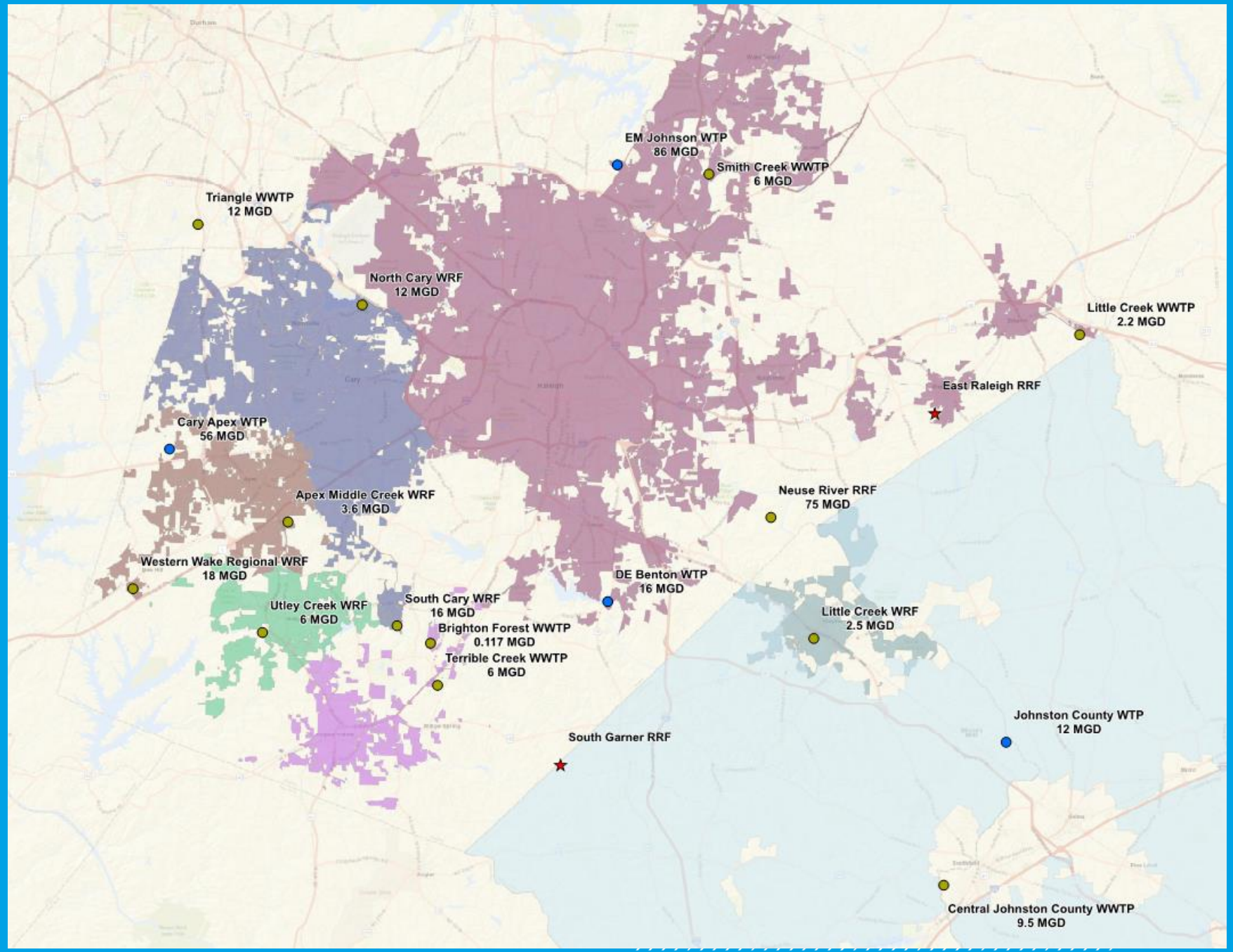
System-Wide Wastewater Treatment Solution:
Resiliency Analysis



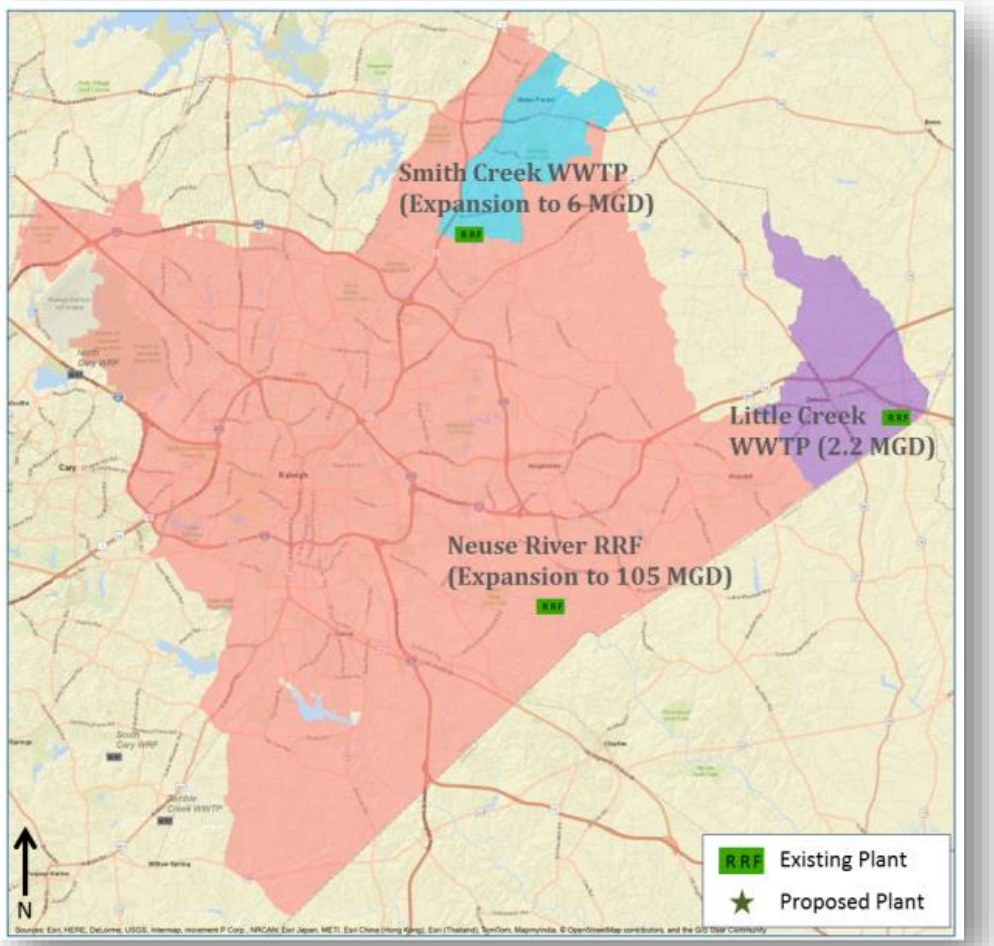




Regional Partnership Evaluation

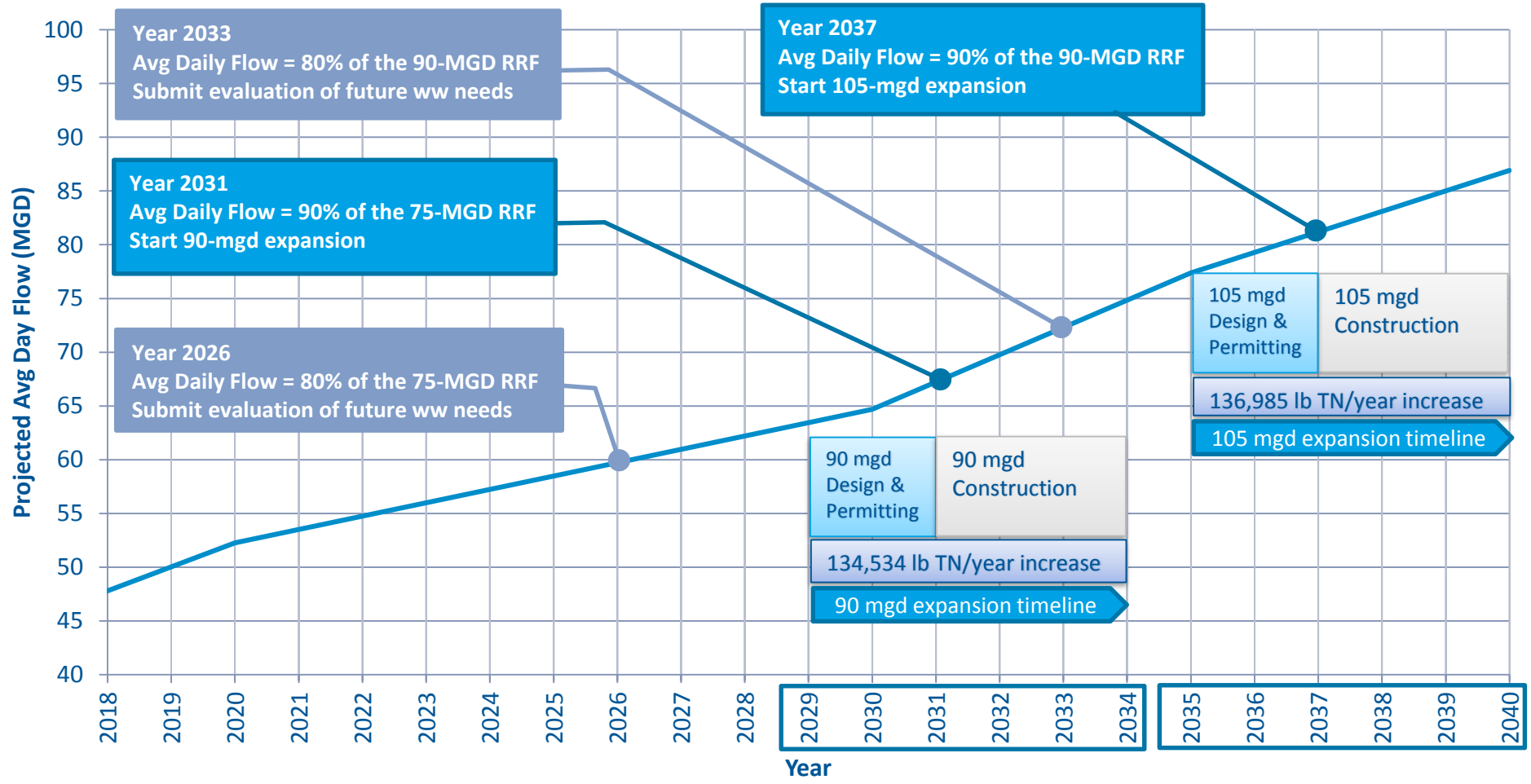


Recommended Wastewater Treatment Solution: Alternative 1



- Consists of upgrades and expansions at the Neuse River RRF.
- Recommended due to its cost and simpler environmental permitting process.
- Allows CORPUD to consolidate their wastewater treatment and operations at one primary facility.

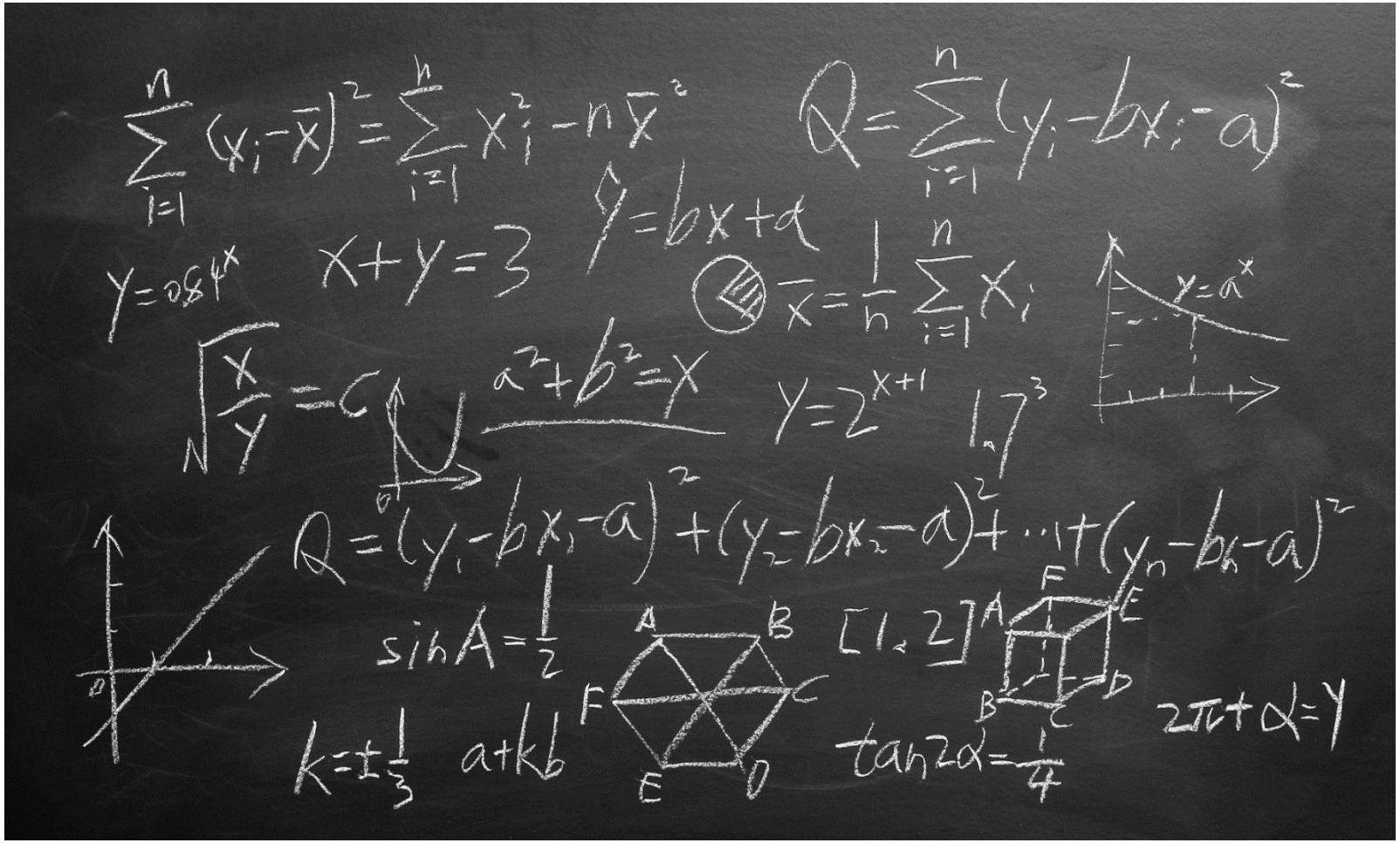
Recommended Wastewater Treatment Solution: Alternative 1



Wastewater Treatment Master Plan: Implementation

- 15 NCAC 02B.0234 Update
- NC House Bill 812
- Nutrient Trading Alternatives
- Modified Nutrient Offset Program


TIME TO SAY GOODBYE


$\sum_{i=1}^{n}(x_i-\bar{x})^2=\sum_{i=1}^{n}x_i^2-n\bar{x}^2$
$Q=\sum_{i=1}^{n}(y_i-bx_i-a)^2$
$y=0.8^x$
$x+y=3$
$\hat{y}=bx+a$
$\bar{x}=\frac{1}{n}\sum_{i=1}^{n}x_i$
$y=a^x$
$\sqrt[N]{\frac{x}{y}}=c$
$a^2+b^2=x$
$y=2^{x+1}$
1.7^3
$Q=(y_1-bx_1-a)^2+(y_2-bx_2-a)^2+\cdots+(y_n-bx_n-a)^2$
$\sin A=\frac{1}{2}$
$[1,2]$
$k=\pm\frac{1}{3}$
$a+kb$
$\tan 2\alpha=\frac{1}{4}$
$2\pi+\alpha=4$

Nitrogen Credits per the Neuse Rules

$$TN = 1.0\ MGD\ \times 3.0\ mg/L \times 8.34 \frac{lb/MG}{mg/L} \times 365\ day/year \times 30\ years \times \$42.68$$

$$TN = \$11{,}700{,}000$$

1.0 MGD = $11.7 M *Just for nitrogen credits*

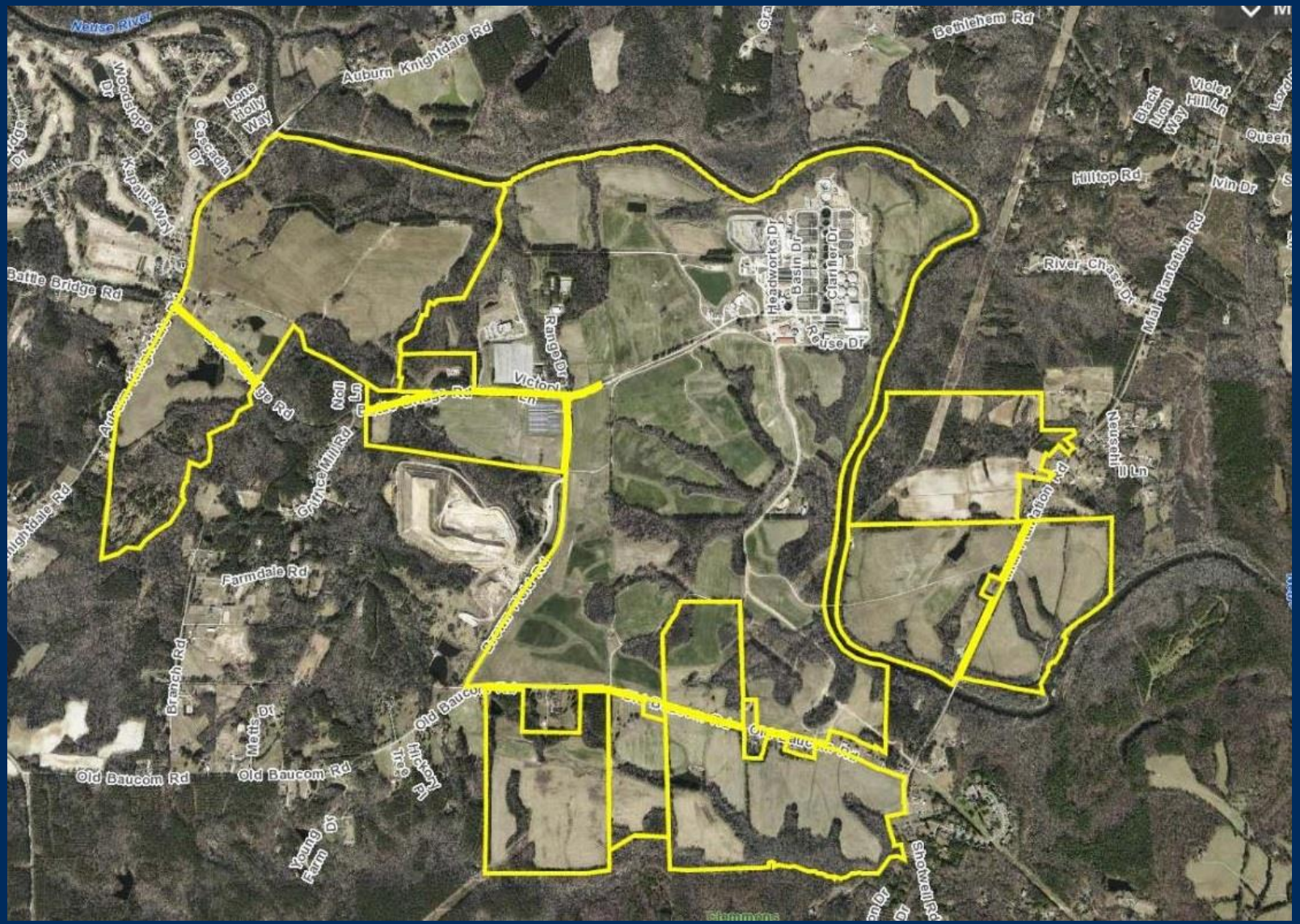
Assume ballpark $17/gal for construction cost, land, etc.
which adds an additional $17,000,000.

Offset Credit Management in Jordan Lake

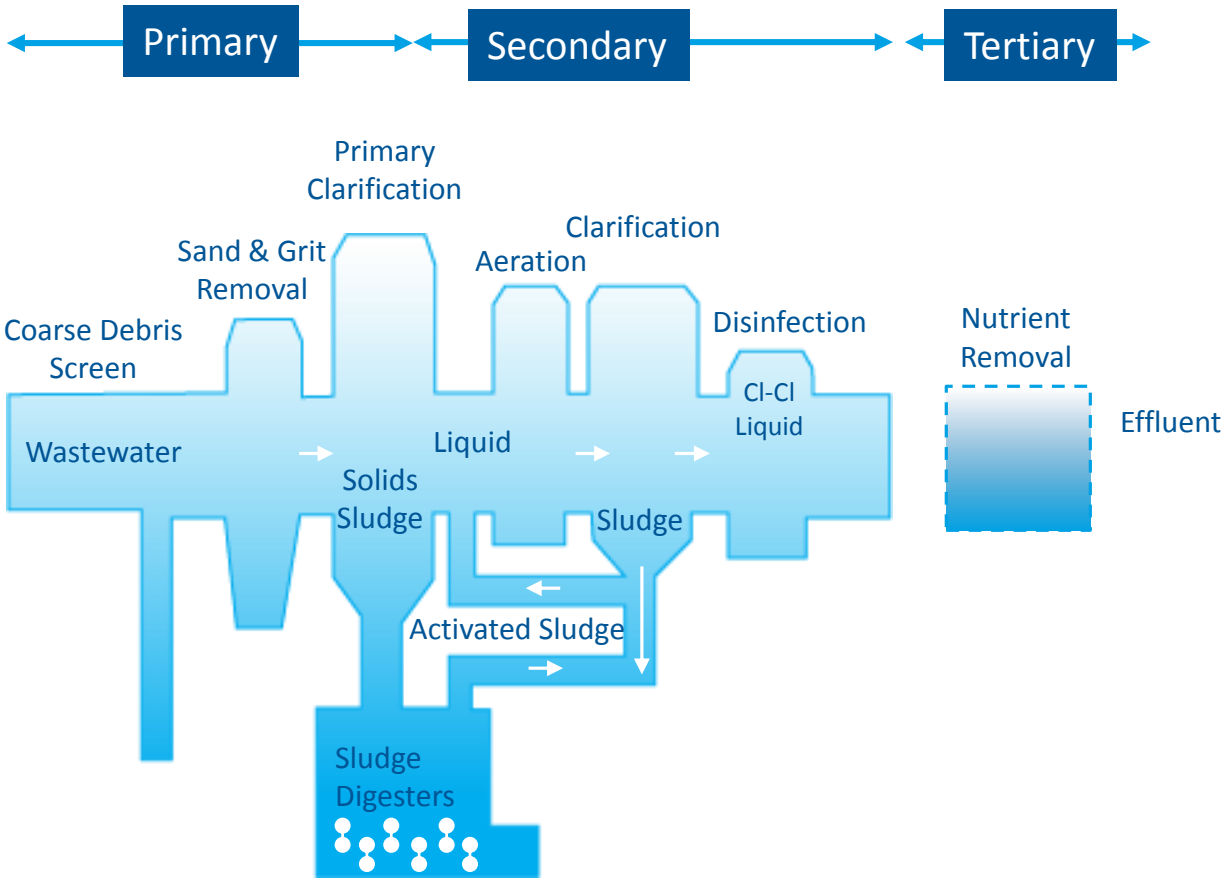
MGD Systems	Lbs P	Lbs N	Acres Required	Mitigation Services Cost	Restoration Cost
6	3,300	54,800	775	$250,965,000	$30,987,000
8	4,400	73,100	1033	$334,752,000	$41,334,000
10	5,500	91,400	1292	$418,539,000	$51,680,000
12	6,600	109,600	1549	$501,930,000	$61,974,000
14	7,700	127,900	1808	$585,717,000	$72,320,000
16	8,800	146,200	2067	$669,504,000	$82,667,000
18	9,900	164,400	2324	$752,895,000	$92,960,000
20	11,000	182,700	2583	$836,682,000	$103,307,000
26	14,300	237,500	3357	$1,087,647,000	$134,294,000

- **Mitigation Services Cost over 30 years based on:**
  - **Nitrogen at 3 mg/L and $132/lb**
  - **Phosphorus at 0.18 mg/L and $343/lb**
- **Restoration Cost based on $40,000 lb/ac**
- **Acres based on 75 lbs/ac/yr**

Nutrient Offset Credits on Existing CORPUD Property



Treatment vs. Offsets



VS

Nutrient Offsets
The Next Generation
Boldly go where no man has gone before.....

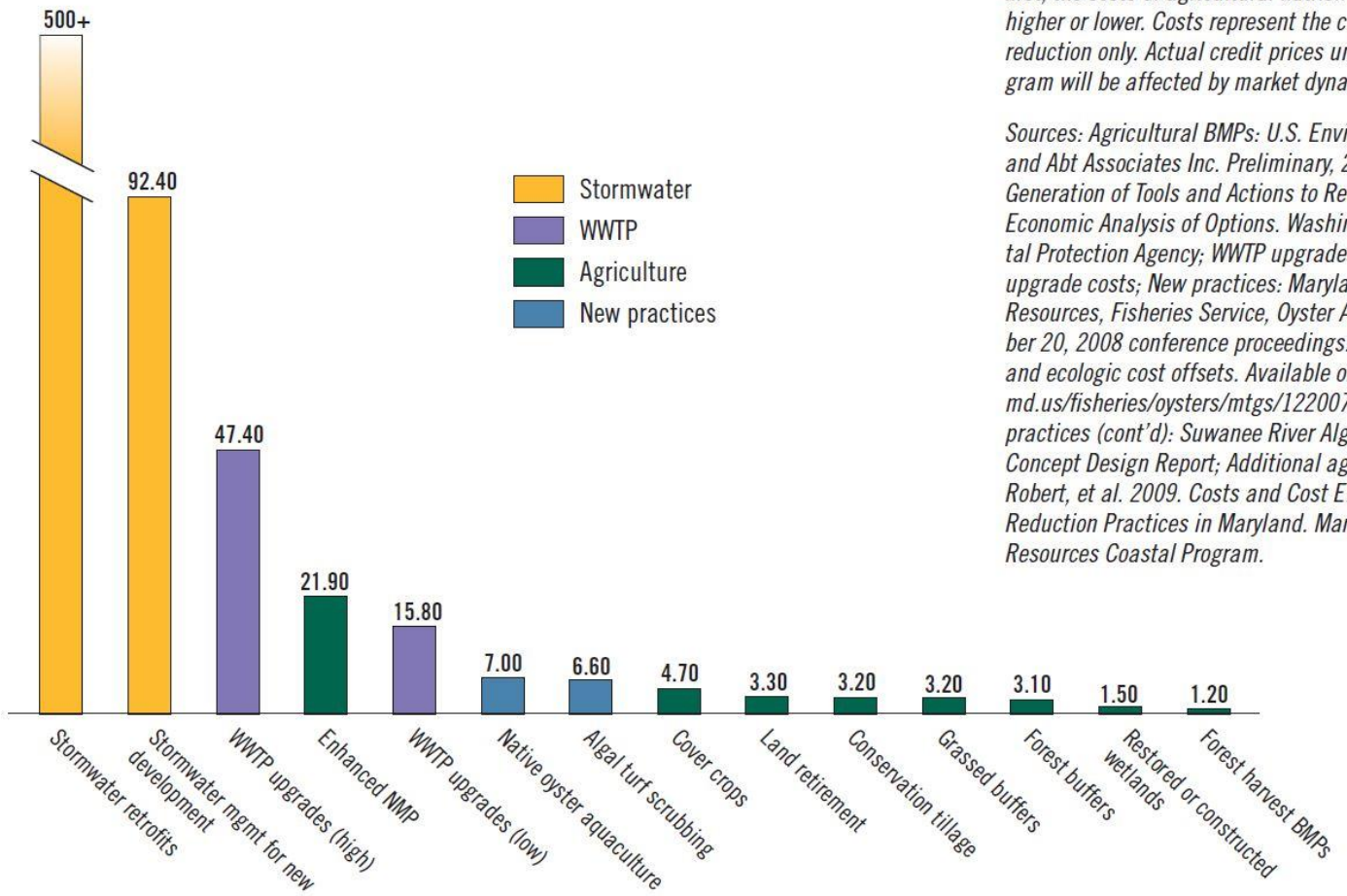
Riparian Buffers

Advantages

- Less costly compared to mitigation services
- Known end product
- Known cost
- Ability to negotiate agreements
- Ability to spread cost over several years
- Mitigation experts ensuring permanent credits

Riparian Buffer vs. Other Nitrogen Reduction Measures

FIGURE 1. **Average Cost of Selected Nitrogen Reduction Measures**
Dollars per pound of annual nitrogen reduction



Note: Cost estimates do not take into account the baseline or minimum practices that agriculture will have to implement prior to selling credits. Depending on which practices farmers implement first, the costs of agricultural nutrient reduction measures may be higher or lower. Costs represent the costs of achieving the nitrogen reduction only. Actual credit prices under a nutrient trading program will be affected by market dynamics of supply and demand.

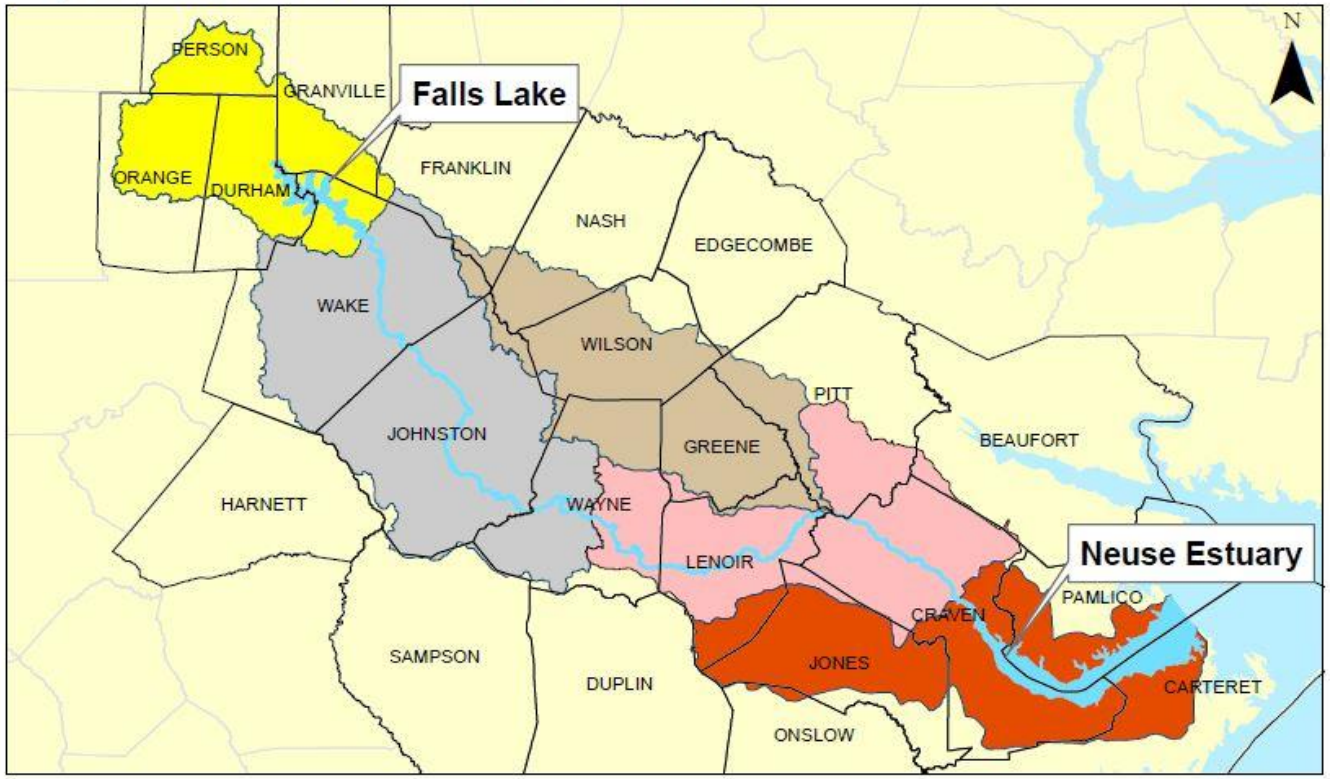
Sources: Agricultural BMPs: U.S. Environmental Protection Agency and Abt Associates Inc. Preliminary, 2009. Chesapeake Bay: Next Generation of Tools and Actions to Restore the Bay: Preliminary Economic Analysis of Options. Washington, D.C.: U.S. Environmental Protection Agency; WWTP upgrades: WRI analysis using plant upgrade costs; New practices: Maryland Department of Natural Resources, Fisheries Service, Oyster Advisory Commission. December 20, 2008 conference proceedings: Oyster restoration economic and ecologic cost offsets. Available online at: http://www.dnr.state.md.us/fisheries/oysters/mtgs/122007/meeting122007.html; New practices (cont'd): Suwanee River Algal Turf Scrubbing System Concept Design Report; Additional agricultural BMPs from Wieland, Robert, et al. 2009. Costs and Cost Efficiencies for Some Nutrient Reduction Practices in Maryland. Maryland Department of Natural Resources Coastal Program.

Neuse Mitigation Strategies

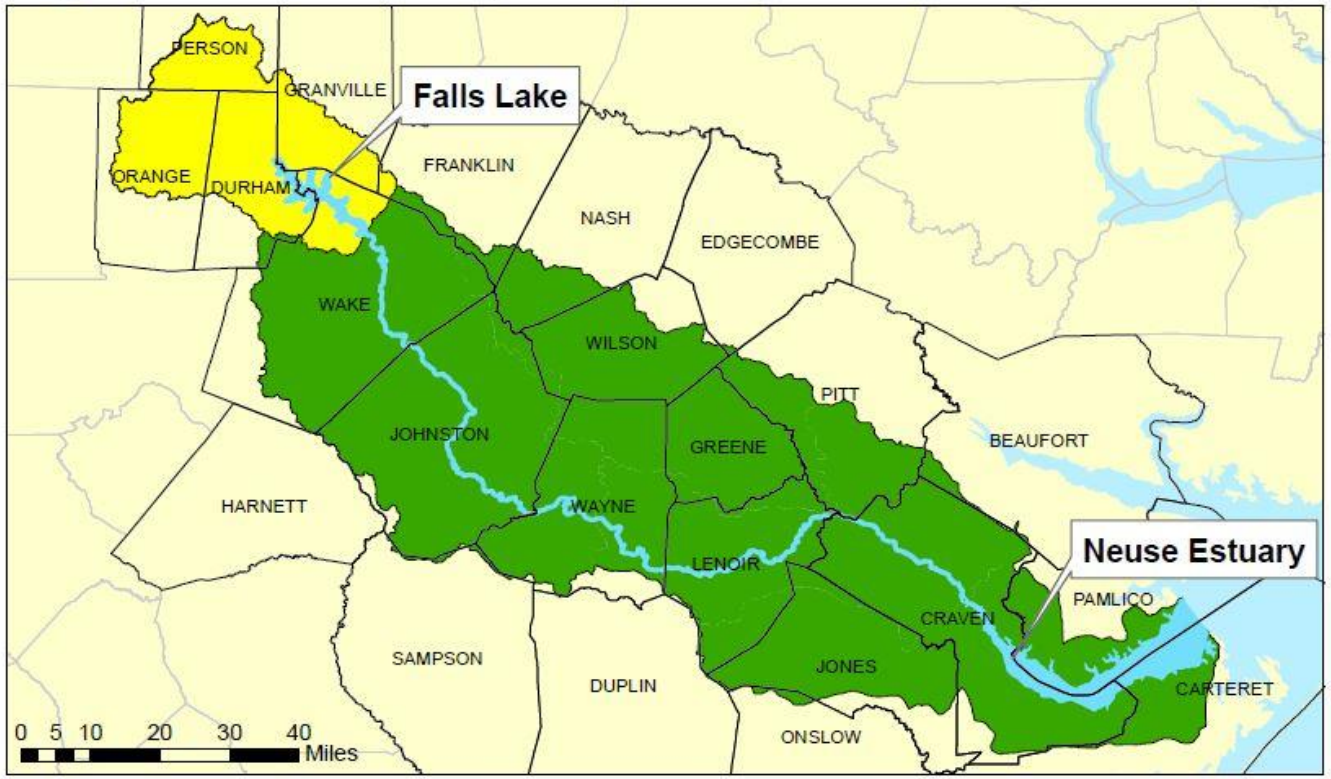
Mitigation Services	$63,259,000	Δ
RS Private Mitigation Bank	$44,282,000	-30%
HUC Legislation H812	$26,570,000	-40%
1.1 Ratio (Rules)	$13,285,000	-50%
Transport Factor Applied	$6,643,000	-50%

Savings by potential future regulatory actions for 49,405 lbs nitrogen

Map 1: Neuse River Basin - Current Service Areas

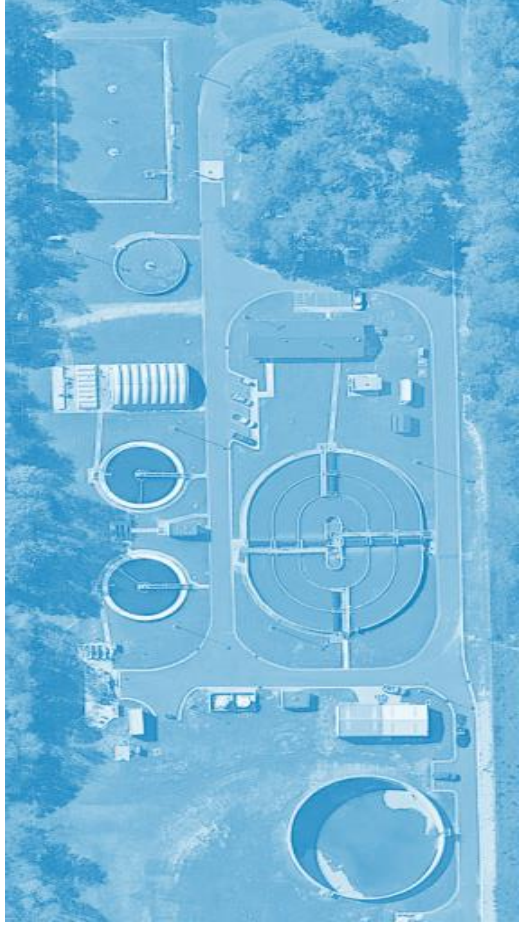


Map 2: Neuse River Basin - Expanded Service Areas




12
3
9
6





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