Niantic Data Synthesis Project

10/7/19 update to the Niantic Nitrogen Working Group

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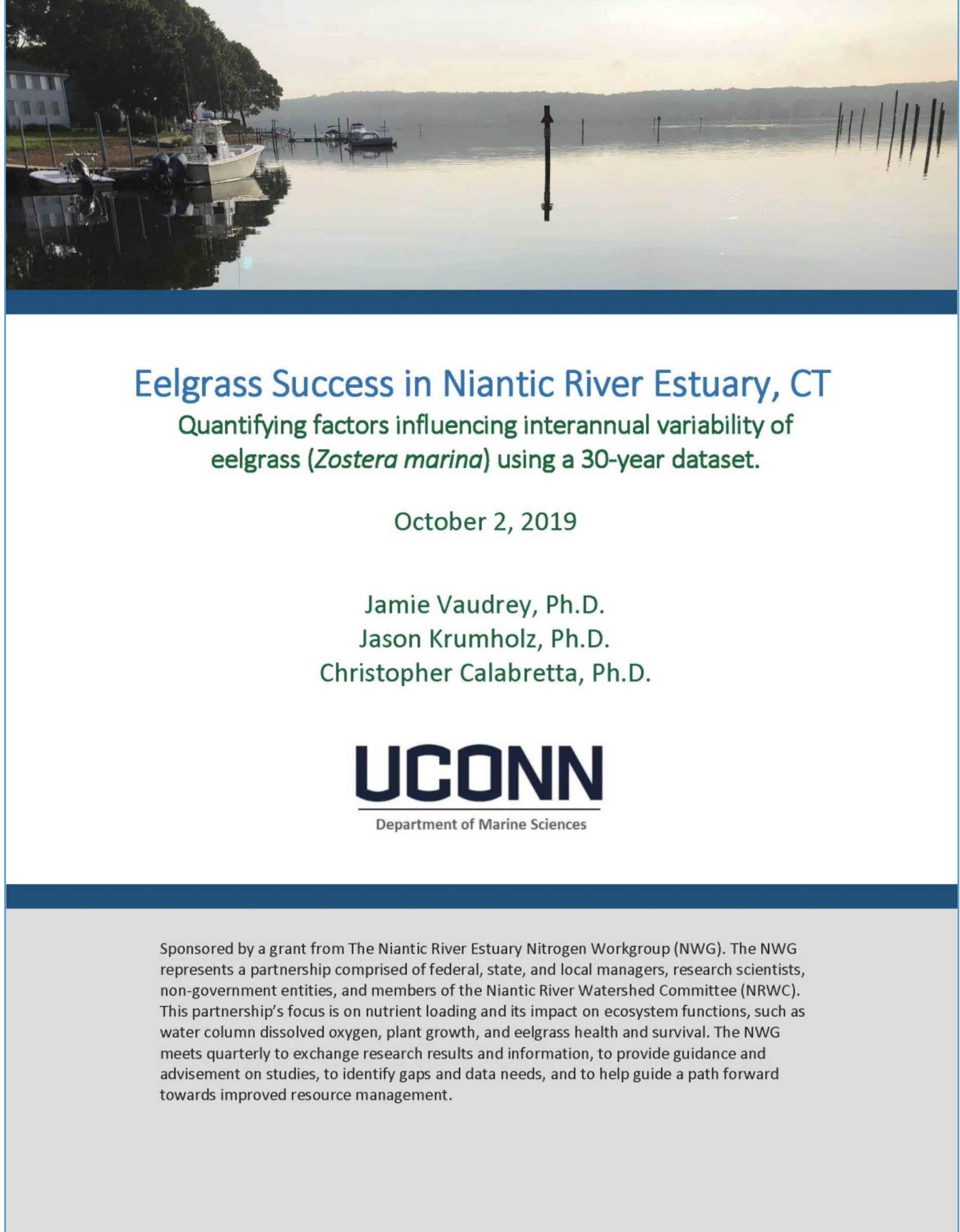
a) Data Synthesis Report

- final version of report – checking on acknowledgements, then available on website
- added in a "List of Tables" and a "List of Figures" to the Table of Contents
- added in a new section at the beginning, "Introduction to Niantic River and the Goals of this Report"



Eelgrass Success in Niantic River Estuary, CT

Quantifying factors influencing interannual variability of eelgrass (*Zostera marina*) using a 30-year dataset.

October 2, 2019

Jamie Vaudrey, Ph.D.
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Christopher Calabretta, Ph.D.

UCONN
Department of Marine Sciences

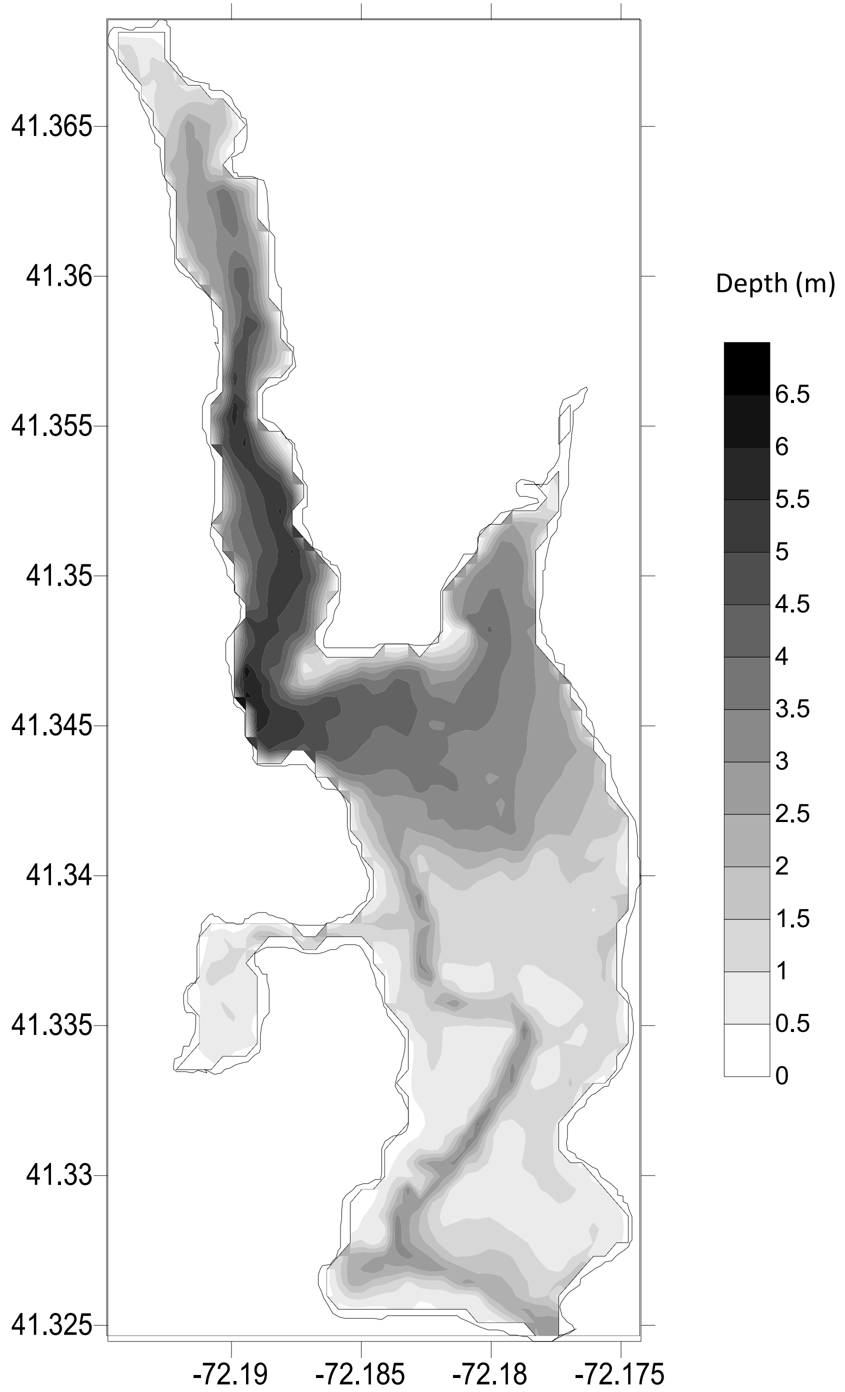
Sponsored by a grant from The Niantic River Estuary Nitrogen Workgroup (NWG). The NWG represents a partnership comprised of federal, state, and local managers, research scientists, non-government entities, and members of the Niantic River Watershed Committee (NRWC). This partnership's focus is on nutrient loading and its impact on ecosystem functions, such as water column dissolved oxygen, plant growth, and eelgrass health and survival. The NWG meets quarterly to exchange research results and information, to provide guidance and advisement on studies, to identify gaps and data needs, and to help guide a path forward towards improved resource management.

Introduction to Niantic River and the Goals of this Report

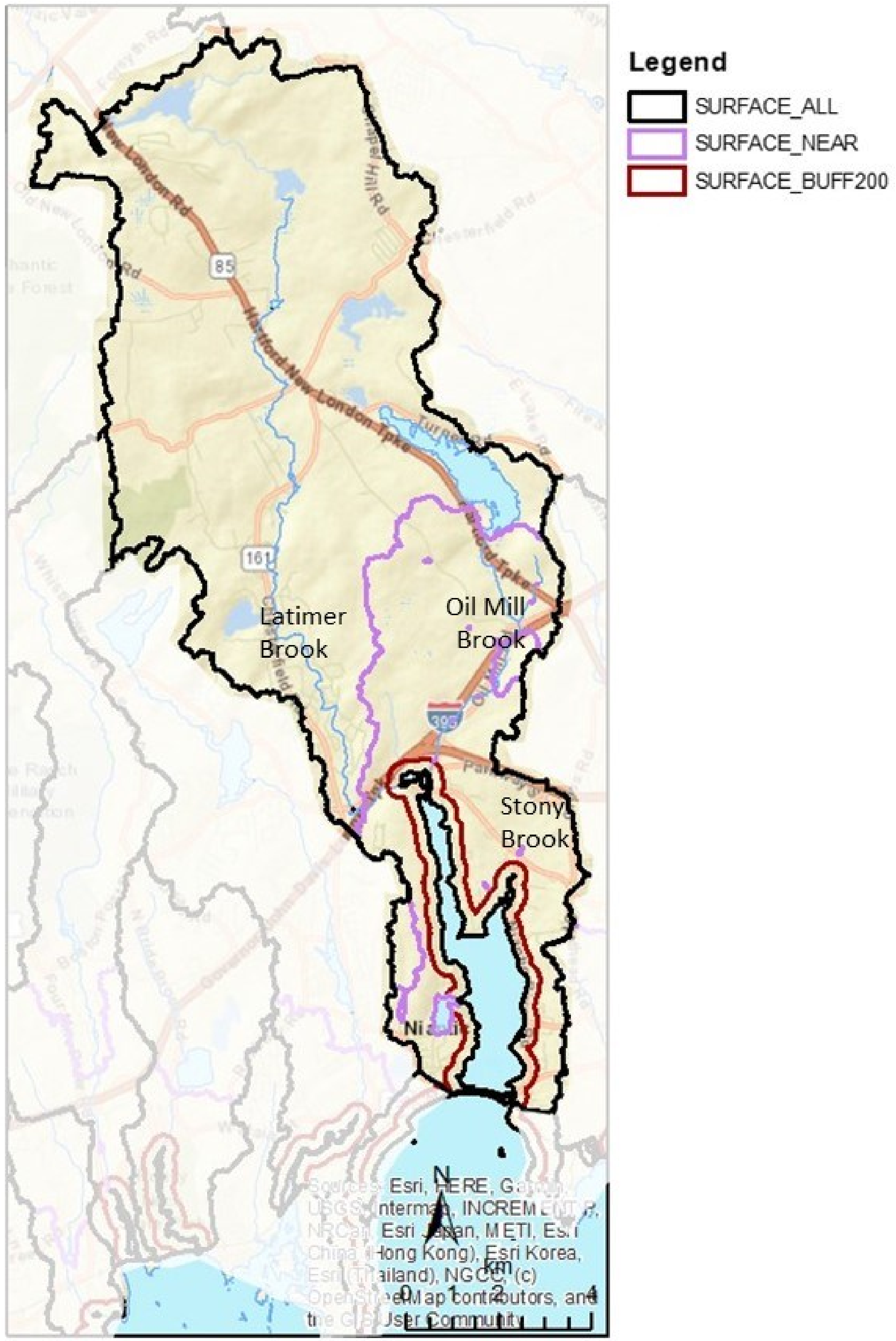
- background, pulled from proposal text
  - vibrant system, multiple habitats
  - interannual fluctuations in eelgrass
  - LIS CCMP – has eelgrass goals
- general statement on long history of data
- Site Information
  - Southeastern Connecticut, U.S.A. (GPS coordinates: 41.339188°, -72.179531°)
  - average depth of 2.6 m and a maximum depth of 7 m
  - The estuarine area north of the train bridge is 270 ha[1] .
  - Three freshwater streams drain to Niantic River Estuary: Latimer Brook, Oil Mill Brook, and Stony Brook.
  - The watershed is 7310 ha or 28.2 square miles, as calculated by Vaudrey et al. (2016)[2] using ArcHydro to identify which stream reaches drained to the embayment.

[1] Vaudrey, J.M.P. 2007. Estimating total ecosystem metabolism (TEM) from the oxygen rate of change: a comparison of two Connecticut estuaries. Doctoral Dissertation, University of Connecticut Groton. 424pp.

[2] Vaudrey, J.M.P., J.K. Kim, C. Yarish, L. Brousseau, C. Pickerell, and J. Eddings. 2016. Comparative analysis and model development for determining the susceptibility to eutrophication of Long Island Sound embayments. University of Connecticut and Cornell Cooperative Extension of Suffolk County. Final report prepared for Connecticut Sea Grant College Program, New York Sea Grant College Program, and the Long Island Sound Study. Project number R-CE-34-CTNY. 46 pp. contact: jamie.vaudrey@uconn.edu.



Depth (m)
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
41.365
41.36
41.355
41.35
41.345
41.34
41.335
41.33
41.325
-72.19
-72.185
-72.18
-72.175



Legend
SURFACE_ALL
SURFACE_NEAR
SURFACE_BUFF200
Latimer Brook
Oil Mill Brook
Stony Brook

b) Modeling

- on hold
- that portion of the project has taken much more time than we anticipated and budgeted for
- switching to focus on the remainder of the project

Other Deliverables

c) develop recommendations for a target nitrogen load from the watershed which is supportive of CCMP targets for eelgrass and ecosystem integrity, taking into account the predicted changes in climate (e.g. rising temperatures and sea levels);

d) utilize a land-use based nitrogen loading model recently developed by Vaudrey for many embayments, including Niantic River, to evaluate nitrogen mitigation strategies;

e) assess the applicability of this study to other embayments of Long Island Sound by suggesting approach and data requirements for various assessments; and

f) identify any data gaps and suggest monitoring protocol to fill these gaps.

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c) Target N-Load Supportive of Eelgrass

Latimer, J.S., and S.A. Rego. 2010. Empirical relationship between eelgrass extent and predicted watershed-derived nitrogen loading for shallow New England estuaries. *Estuarine, Coastal and Shelf Science* 90: 231-240.

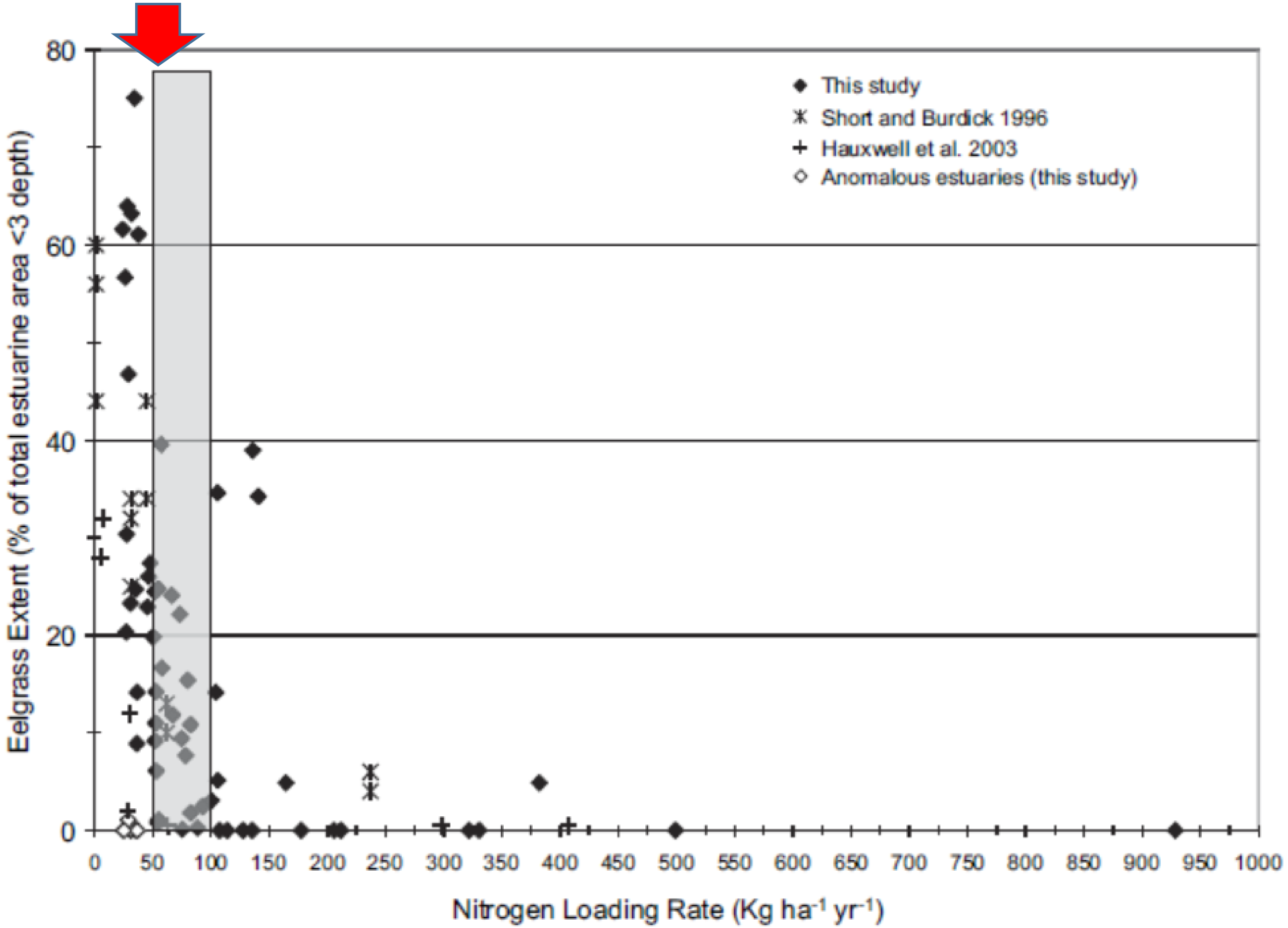

Fig. 2. Plot of eelgrass extent (percent of available habitat) vs. nitrogen loading rate (Kg N ha^{-1} yr^{-1}) (including other published values); gray bar is the nitrogen loading threshold range from the literature 50 - 100 Kg ha^{-1} yr^{-1}).

$18{,}033 \pm 4{,}023$ kg N y^{-1}

area = 321 ha

56 ± 12 kg ha^{-1} y^{-1}

Vaudrey, J.M.P., J.K. Kim, C. Yarish, L. Brousseau, C. Pickerell, and J. Eddings. 2016. Comparative analysis and model development for determining the susceptibility to eutrophication of Long Island Sound embayments. University of Connecticut and Cornell Cooperative Extension of Suffolk County. Final report prepared for Connecticut Sea Grant College Program, New York Sea Grant College Program, and the Long Island Sound Study. Project number R-CE-34-CTNY. 46 pp. contact: jamie.vaudrey@uconn.edu.

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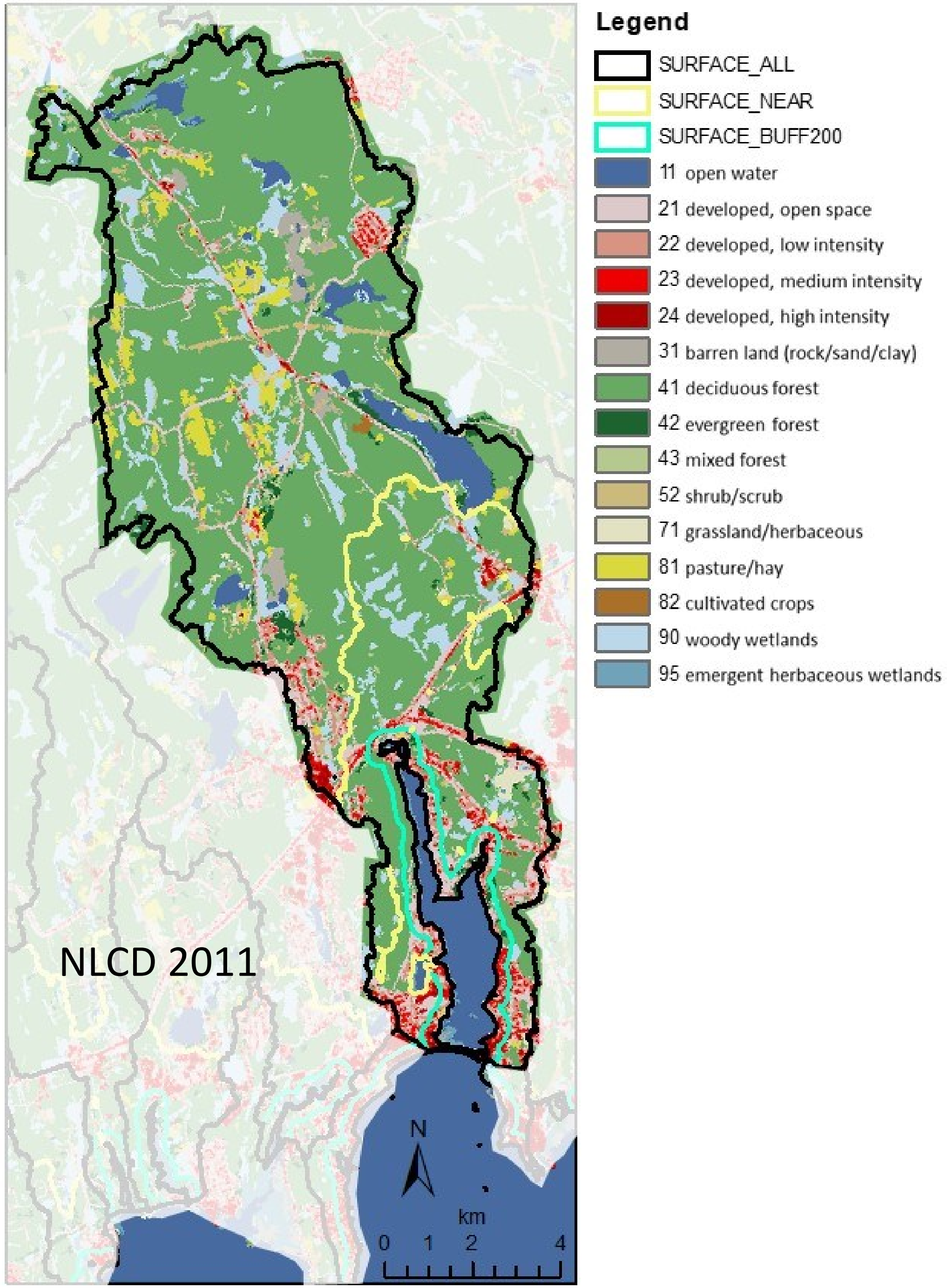
d) N Load model & mitigation strategies

- watershed characteristics
- identifying the sources
- identifying the solutions



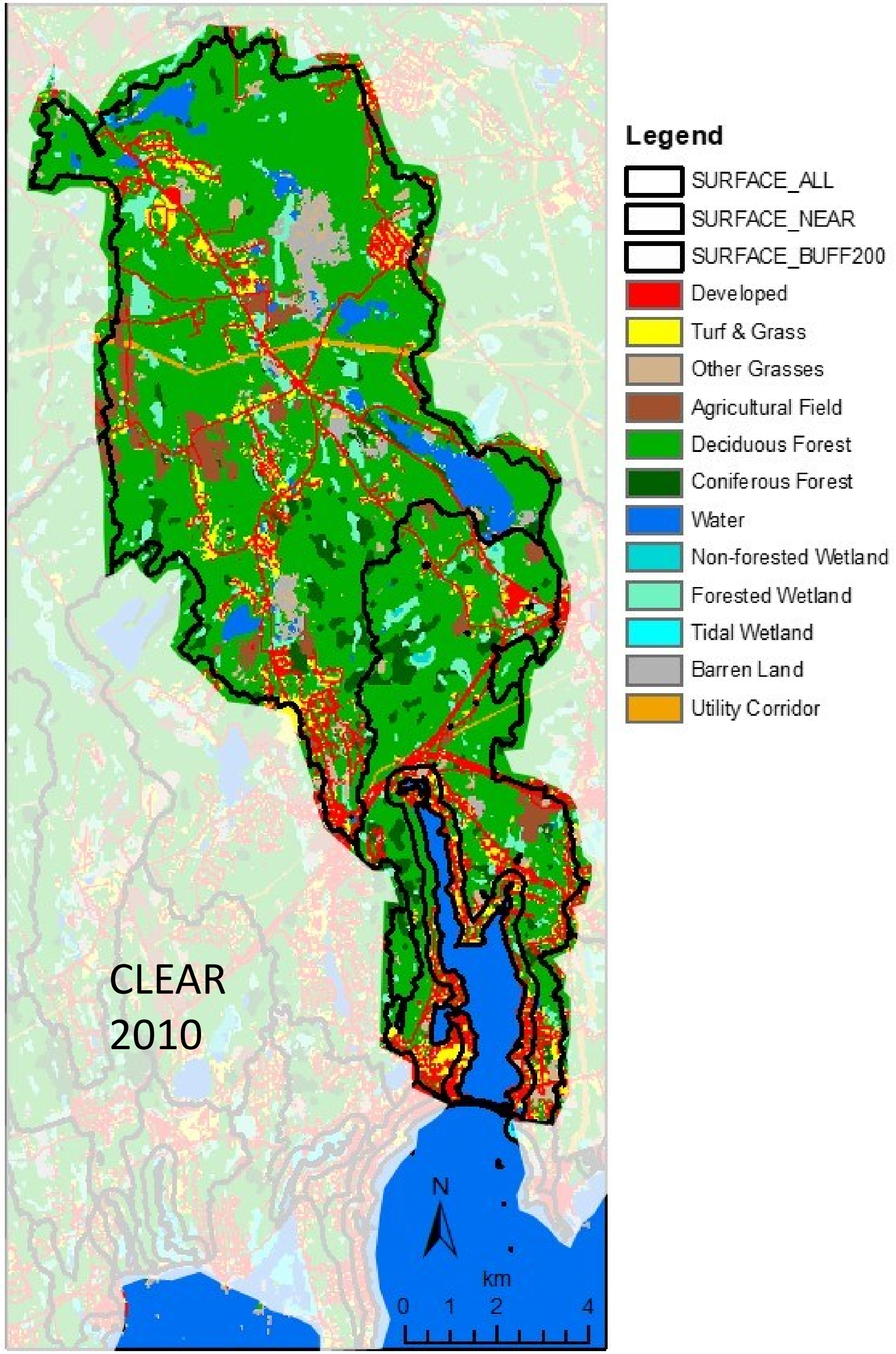
Land Use

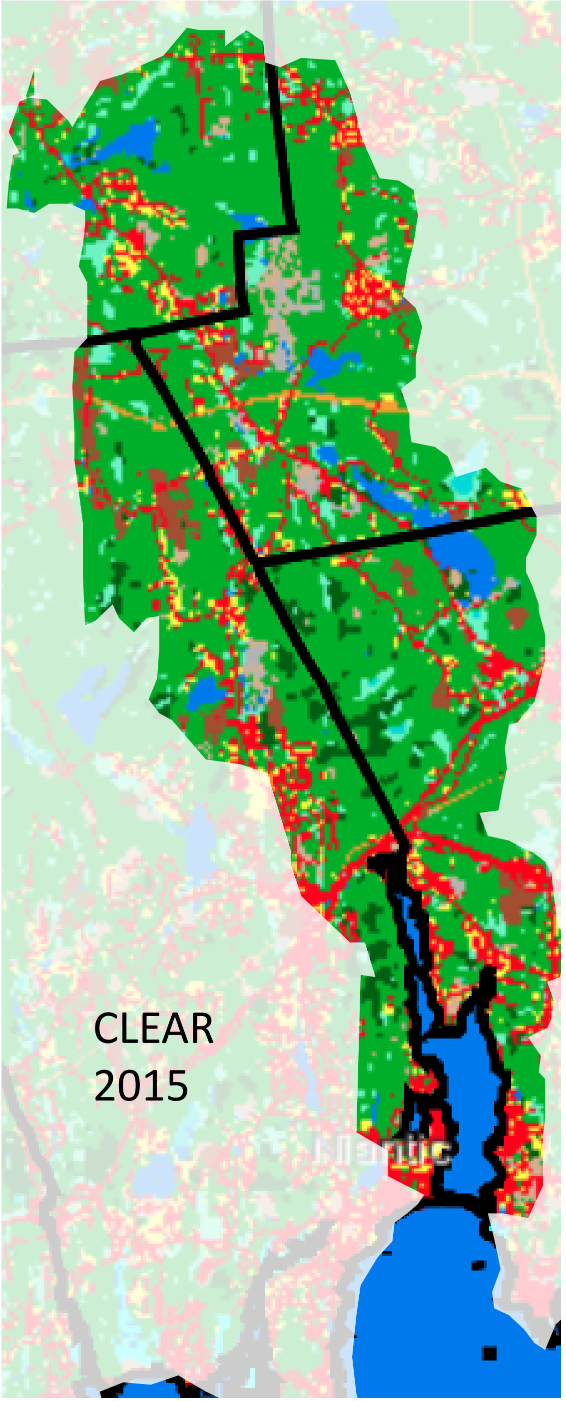
NLCD land cover dataset, 2011

2001, 2003, 2006, 2008, 2011, 2013, 2016

CLEAR land cover dataset, 2010

1985, 1990, 1995, 2002, 2006, 2010

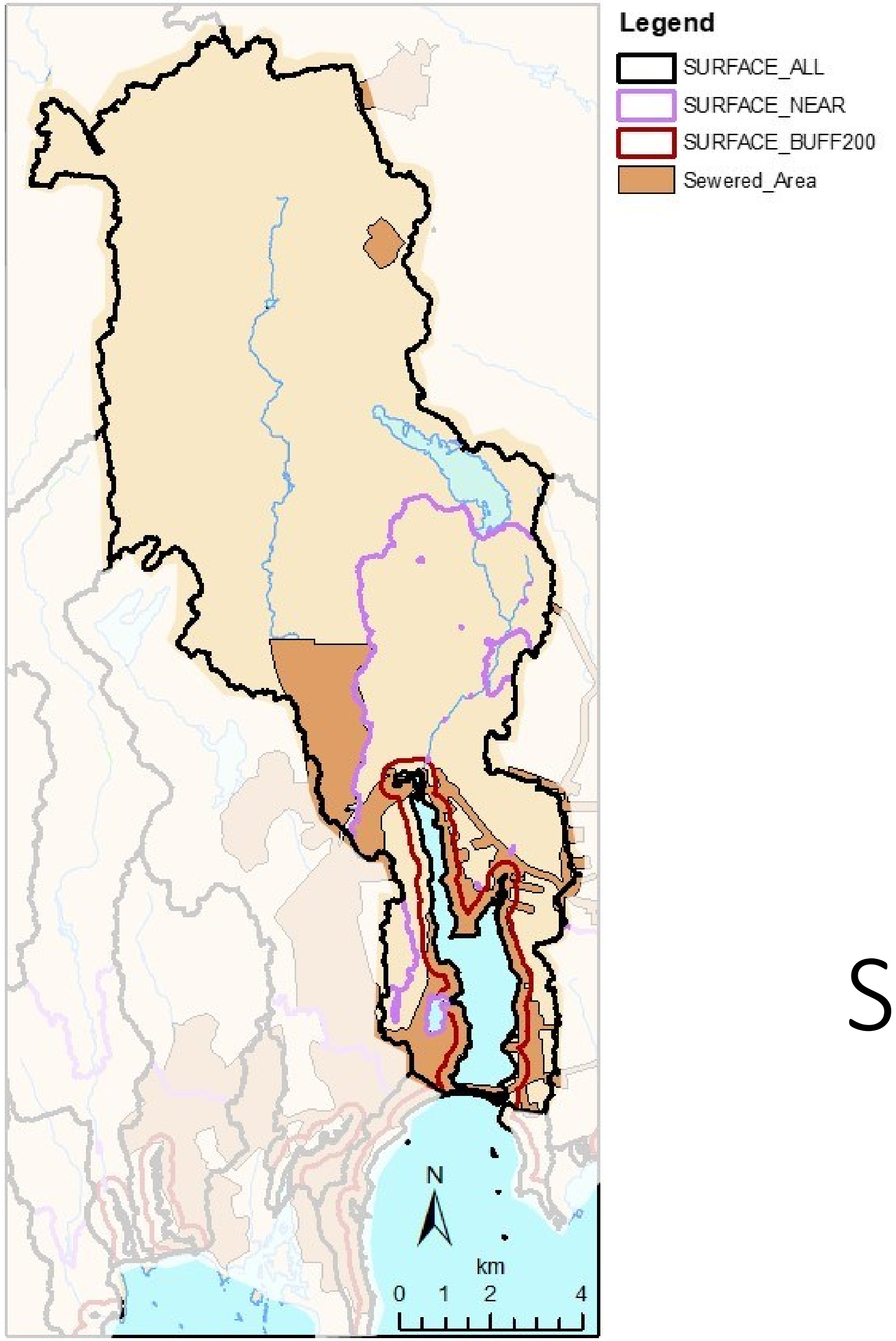




https://clear.uconn.edu/projects/landscape/CT/landcoverviewer.htm

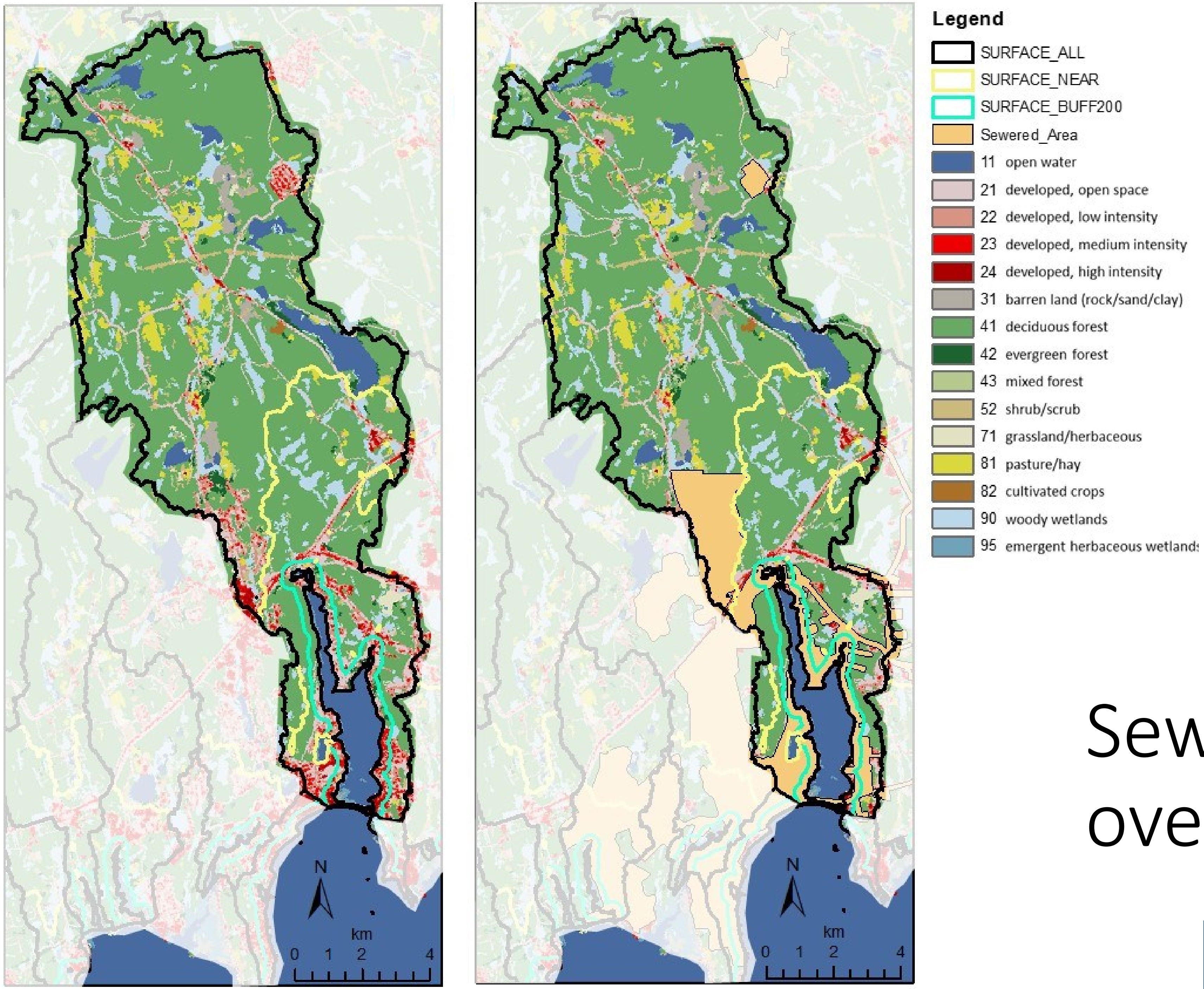
- Used CLEAR online viewer to approximate the NIR watershed for 2015.
- Not much change in land-use from 2010 to 2015.
- Some “other grasses” converted to “deciduous forest”

WATERSHED CHARACTERISTICS

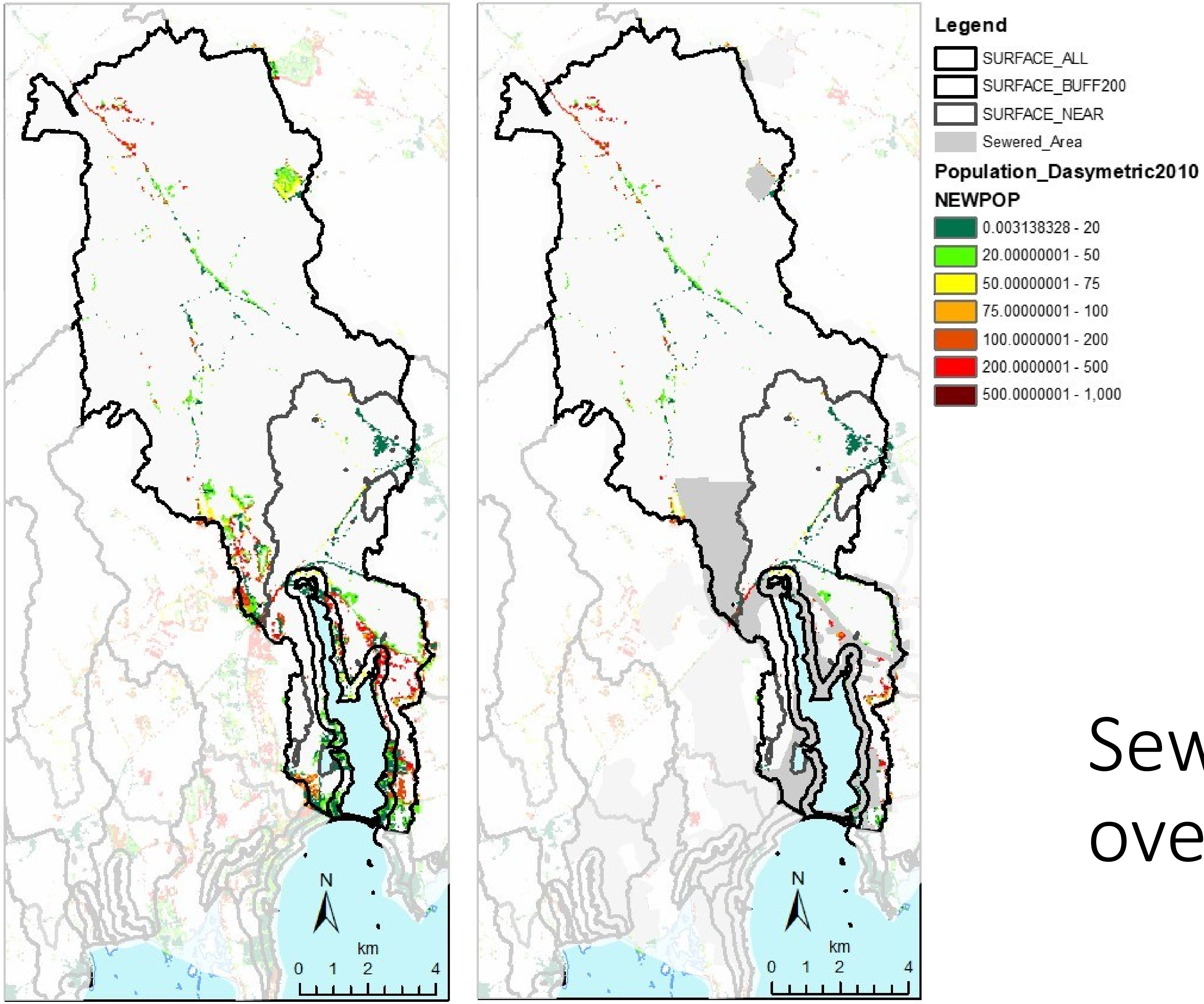


Sewered Areas

WATERSHED CHARACTERISTICS



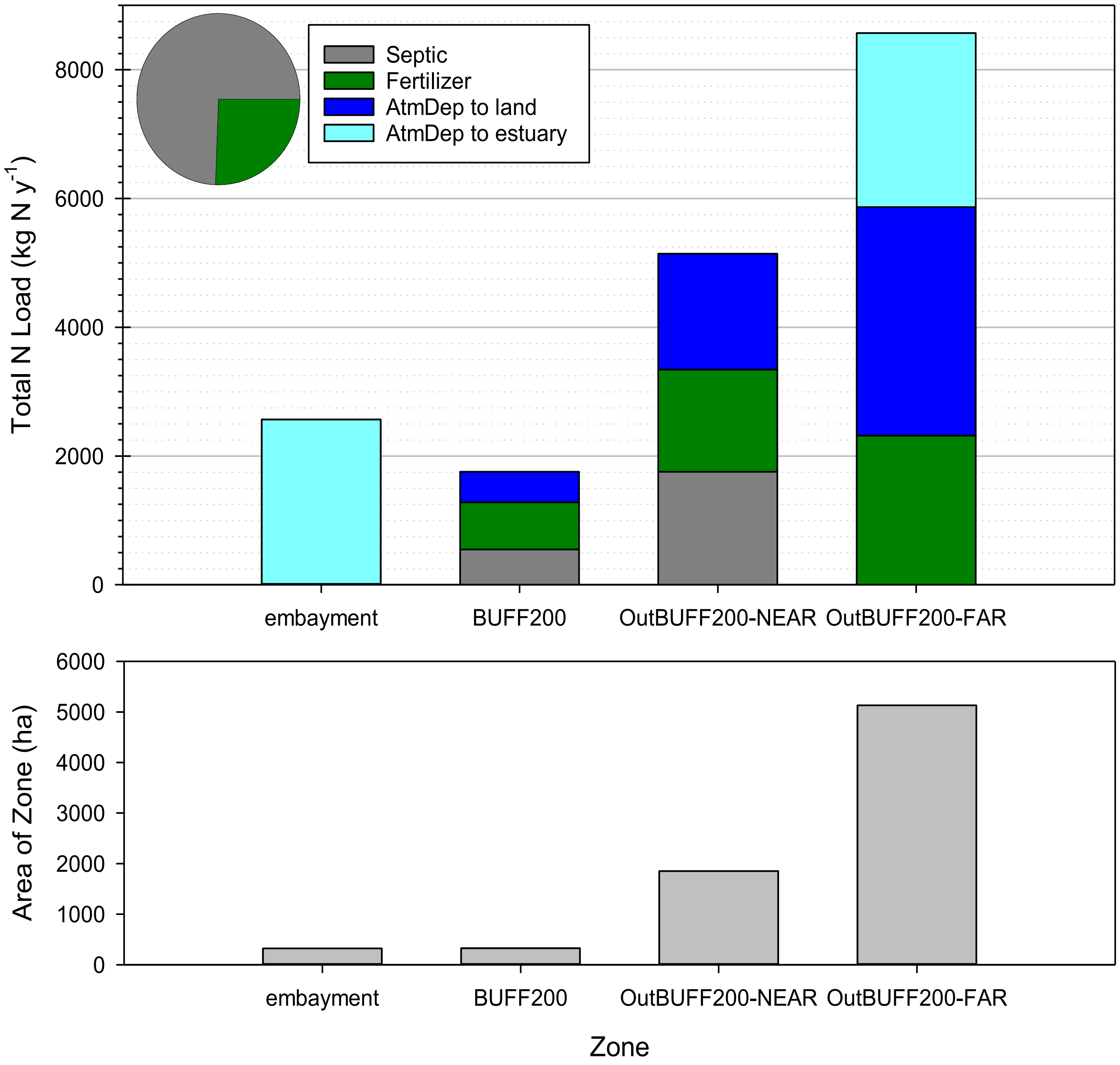
Sewered Areas over Land Cover

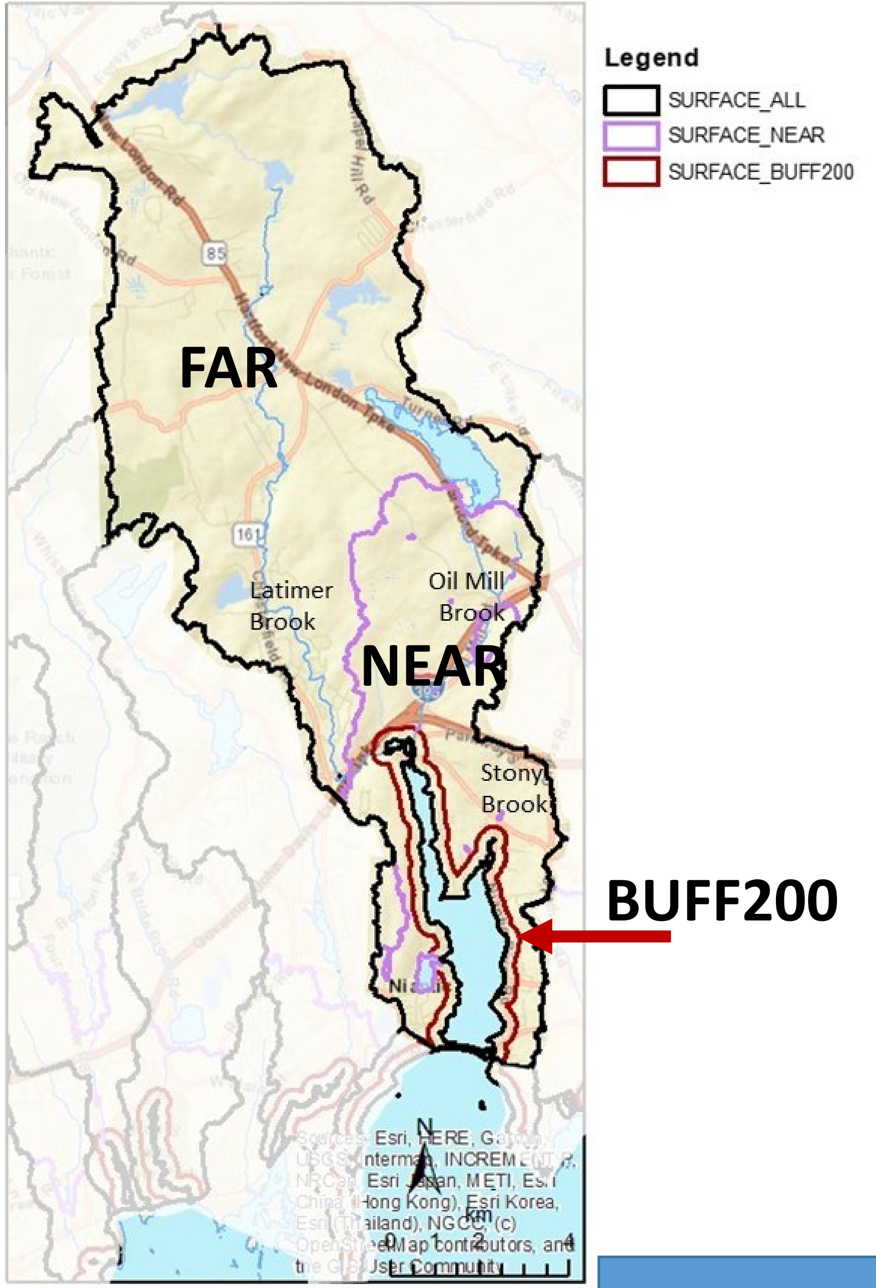


Sewered Areas over Population

Total N Load

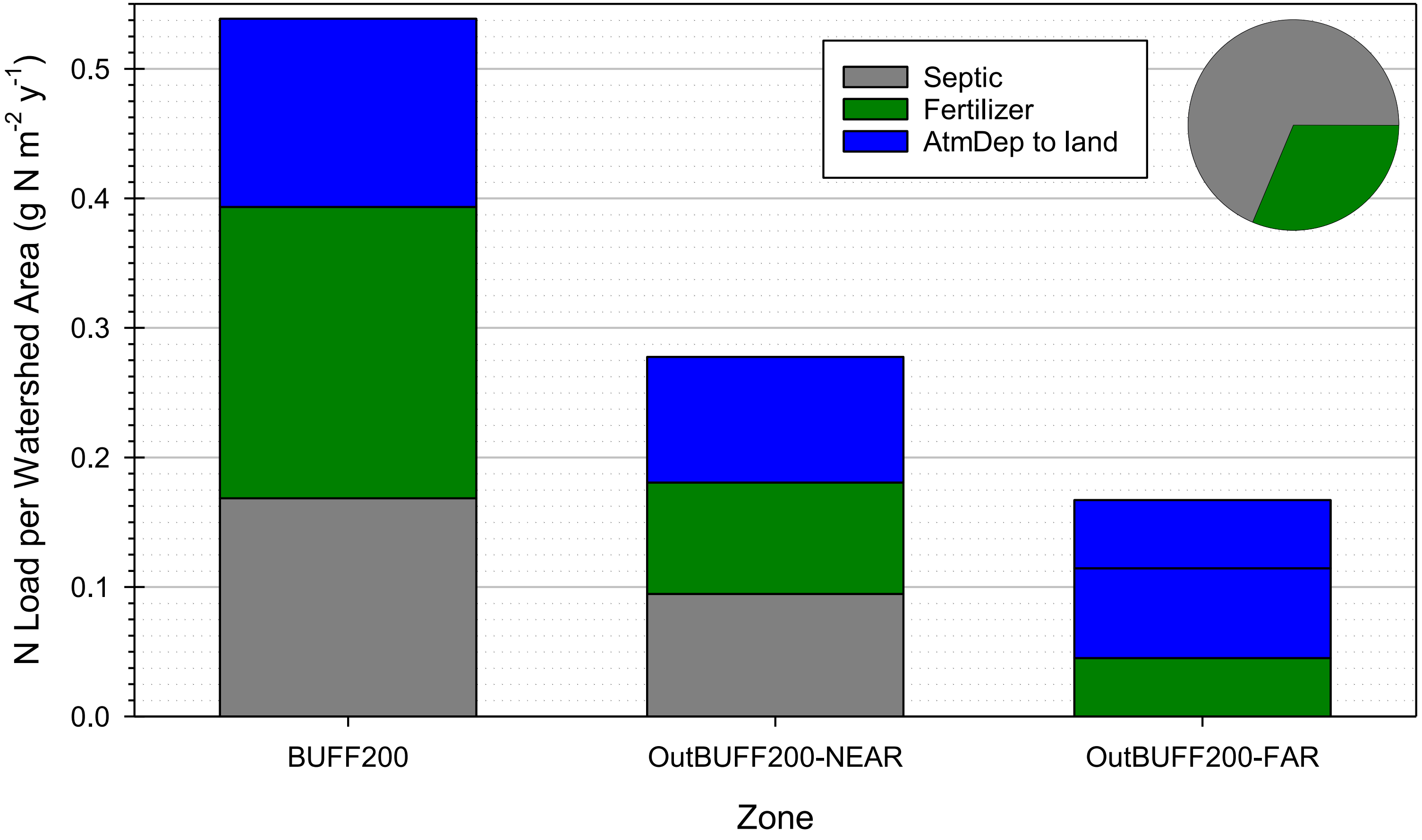
Area

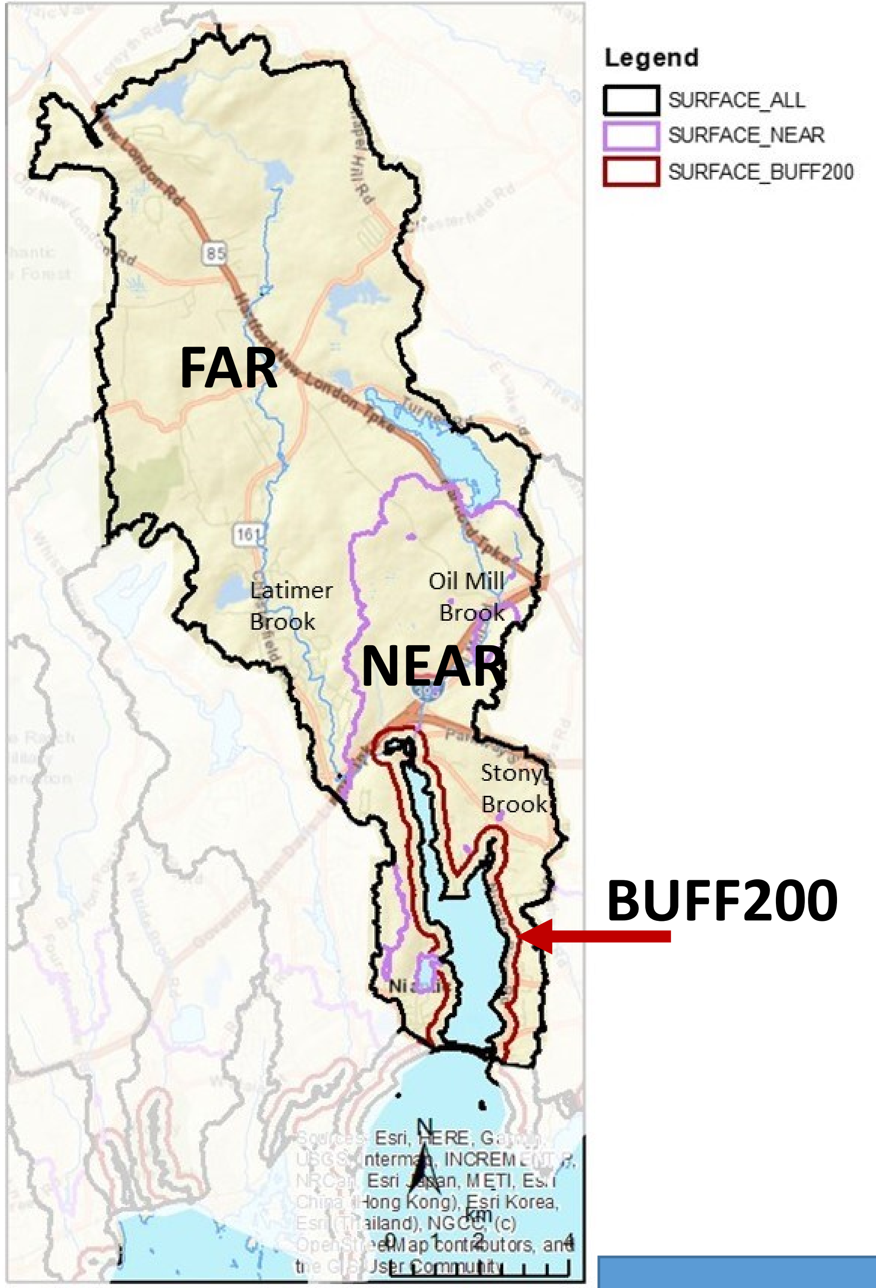




SOURCES

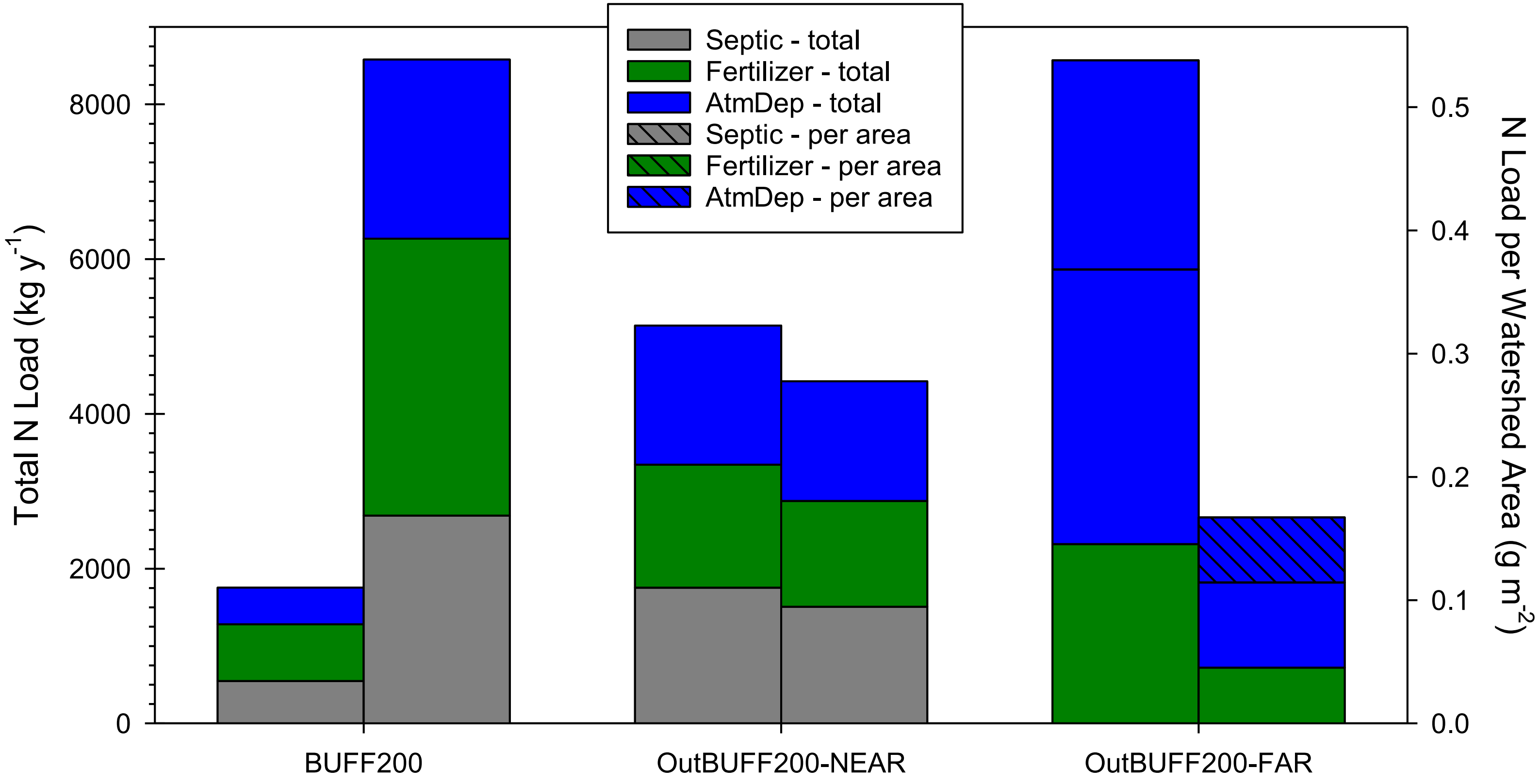
N Load per Watershed Area

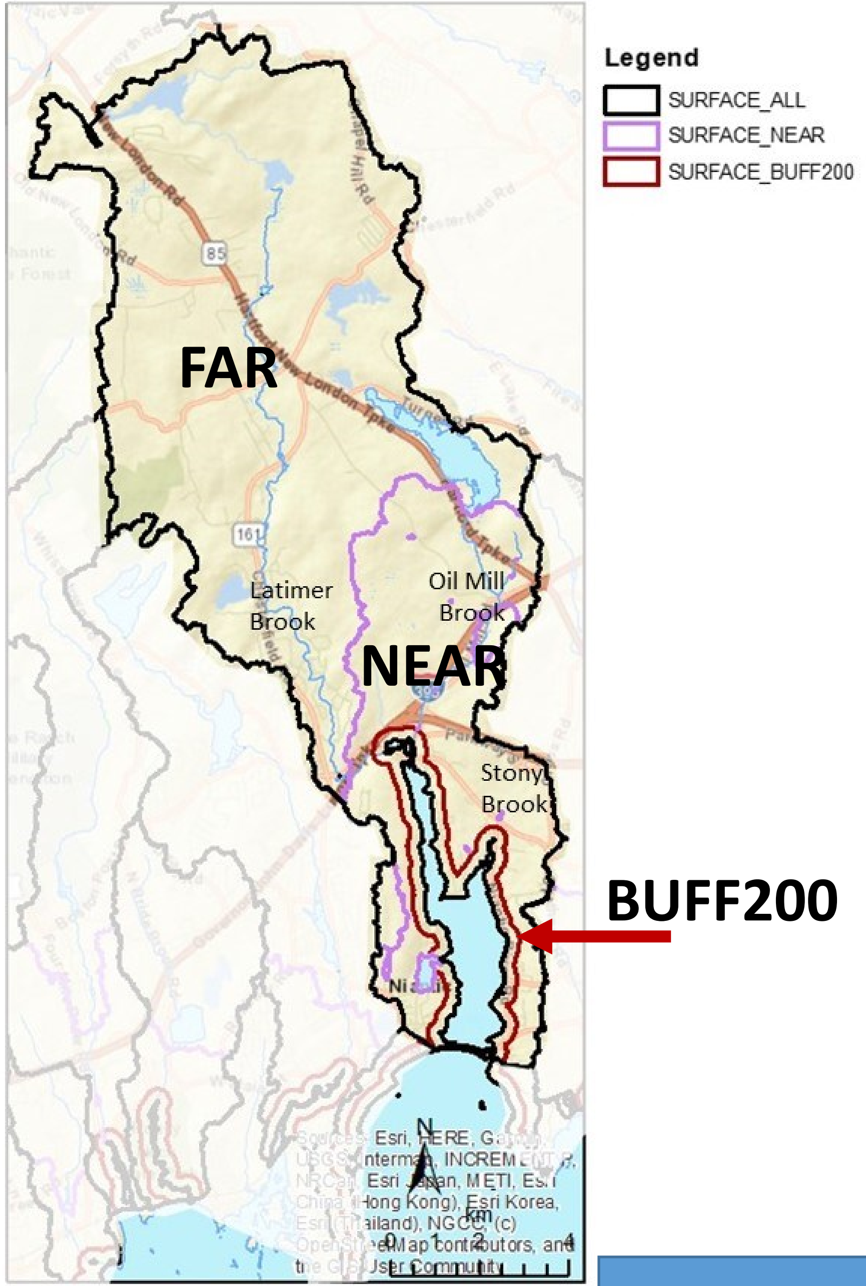




SOURCES

Total N Load & per Watershed Area

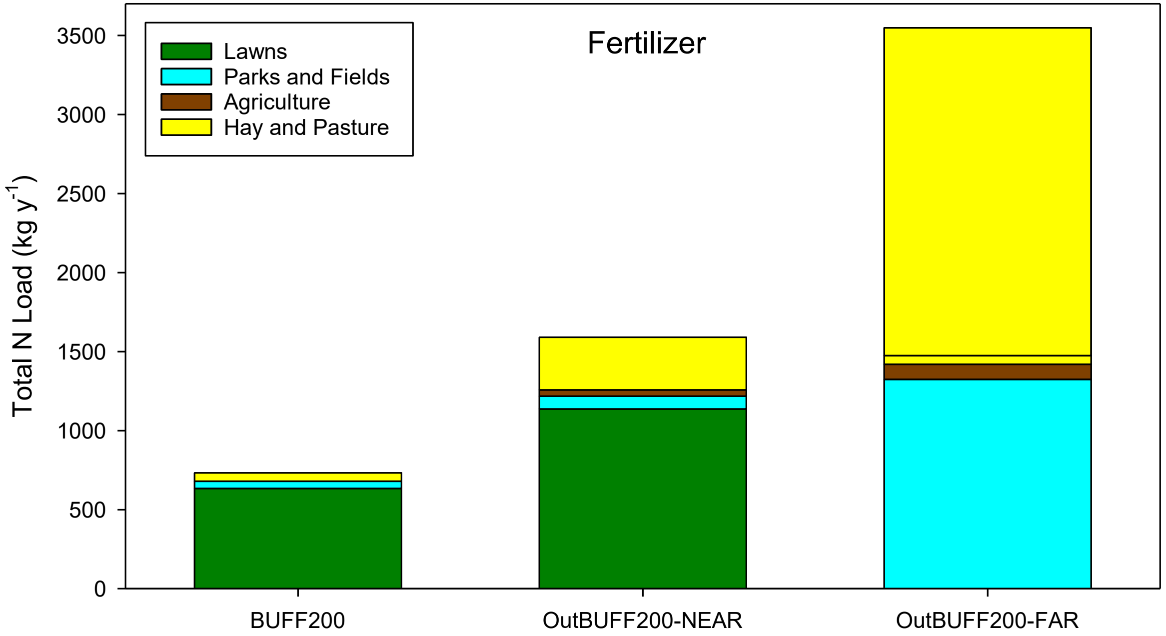


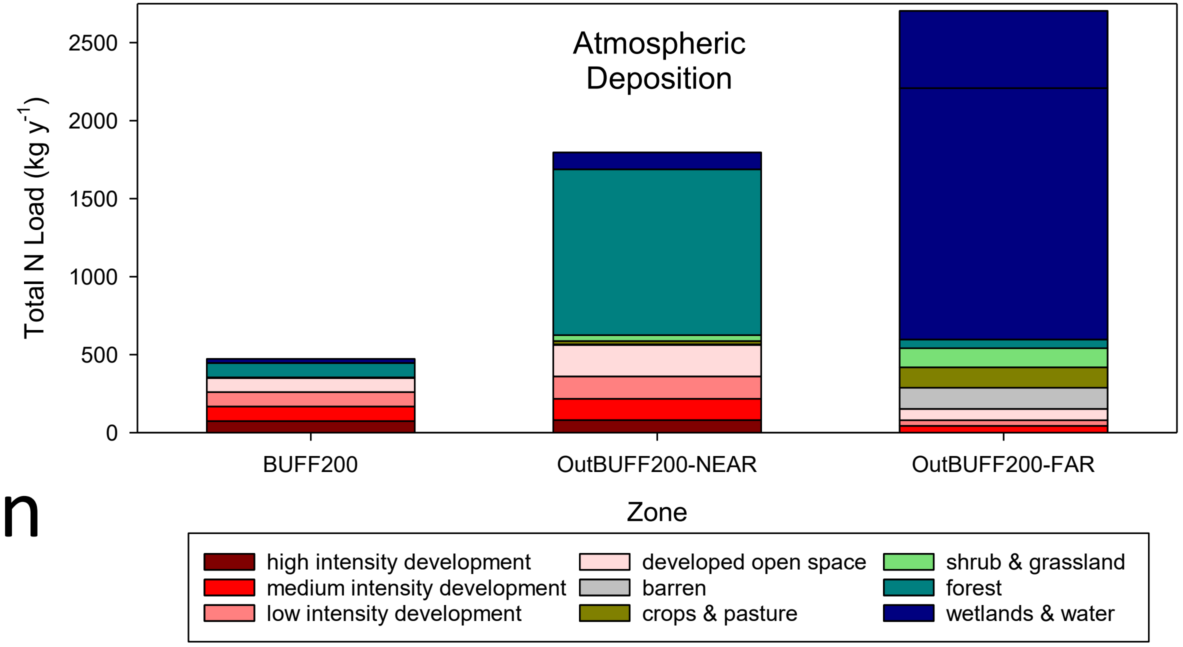


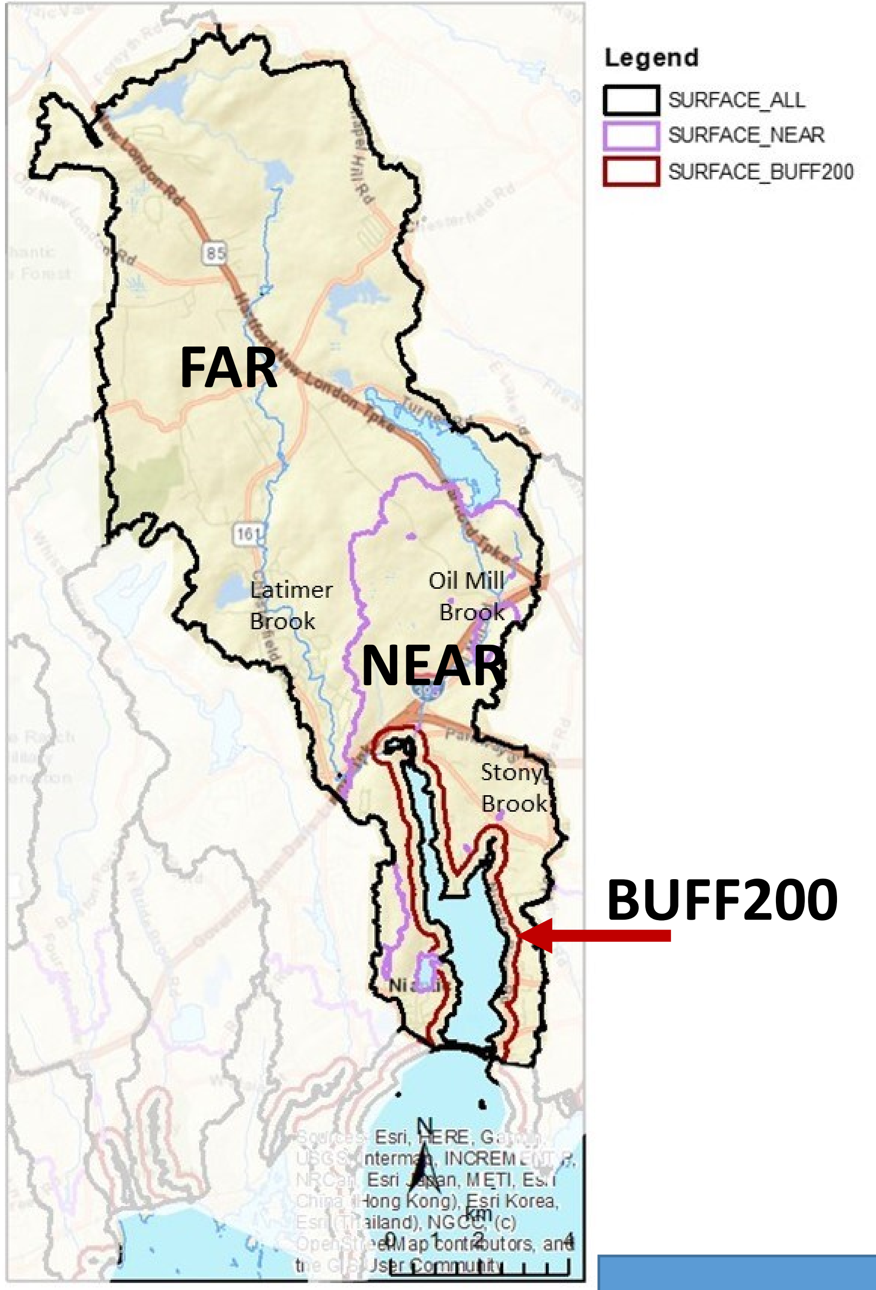
SOURCES

fertilizer

Total N Load



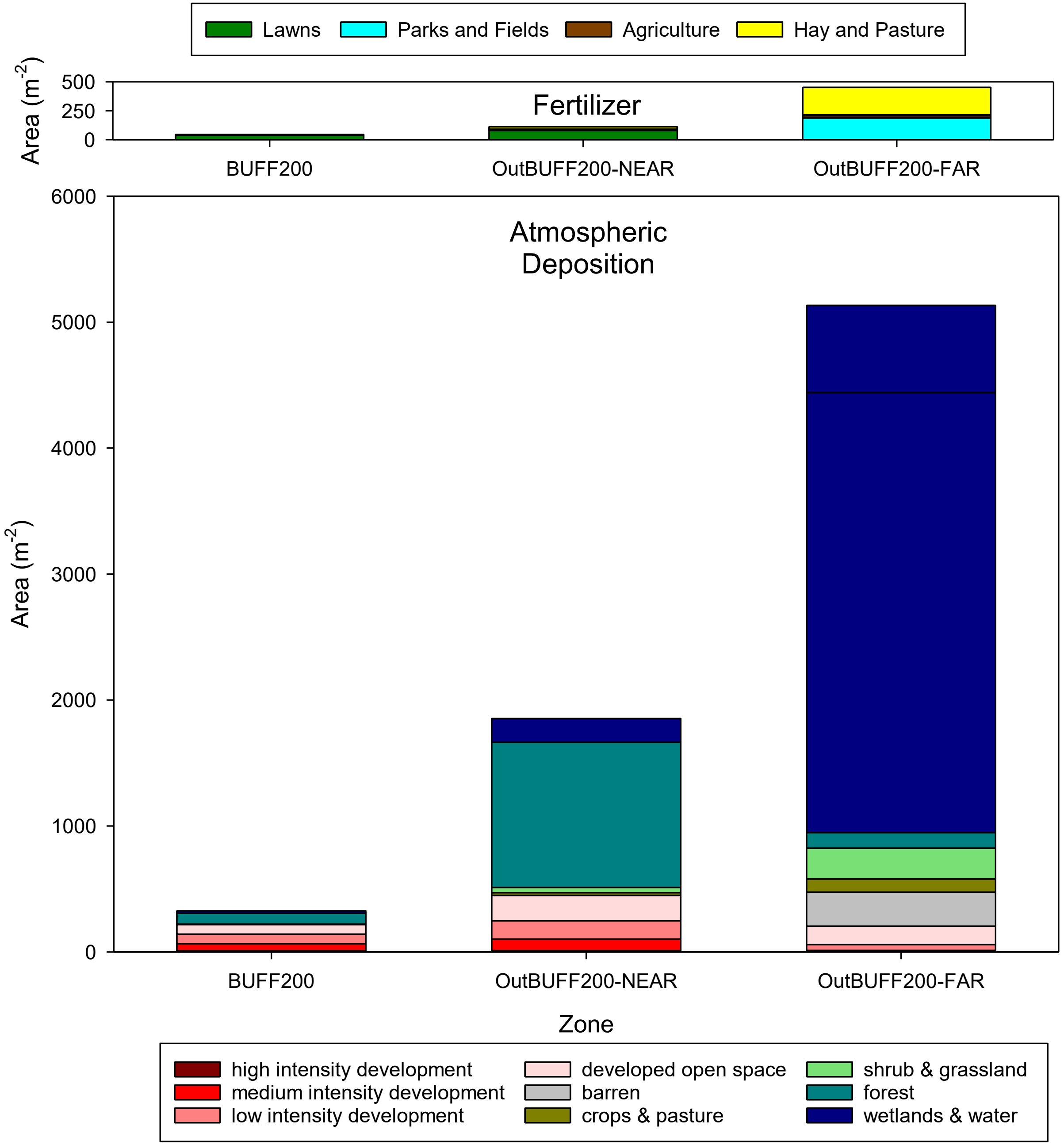


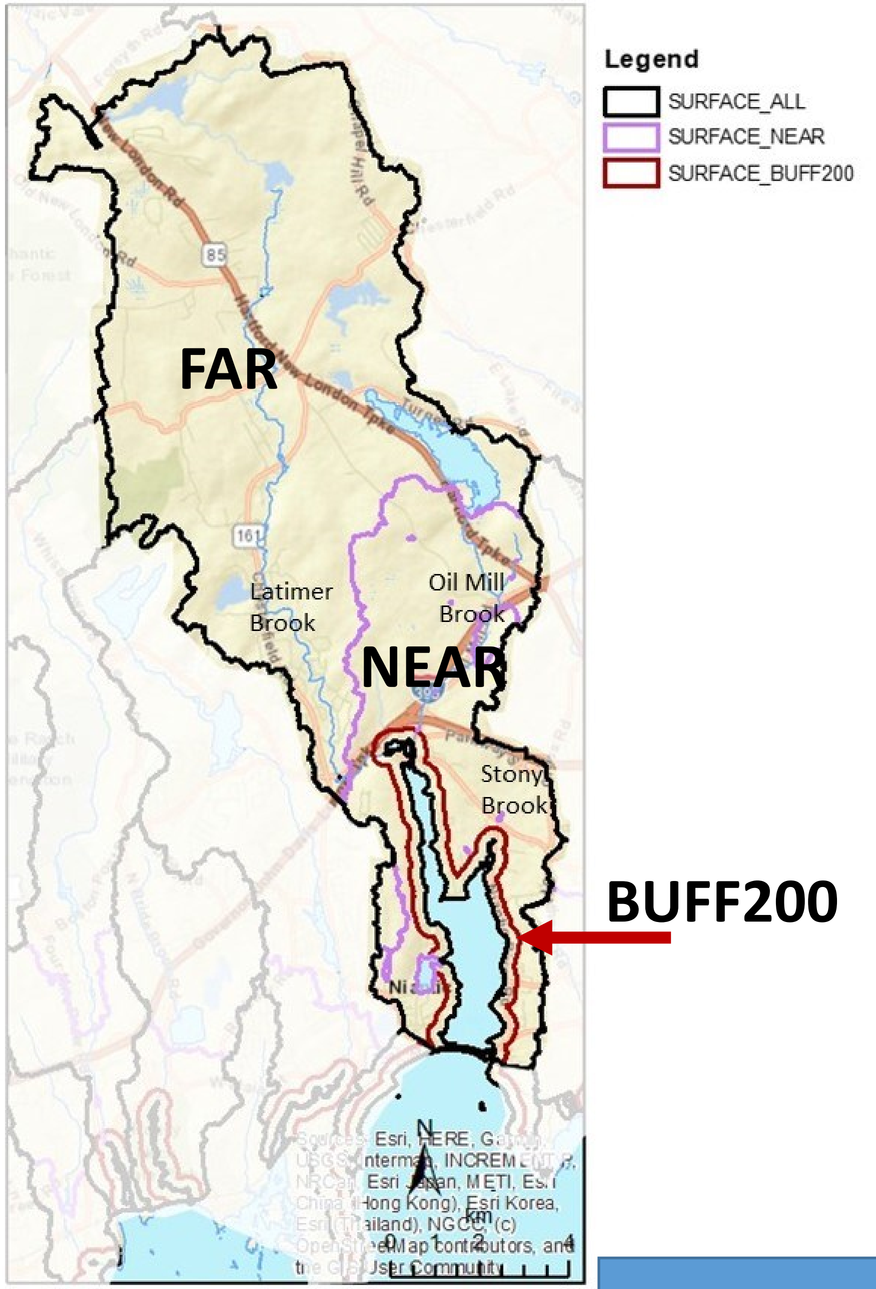


atmosph.
deposition

SOURCES

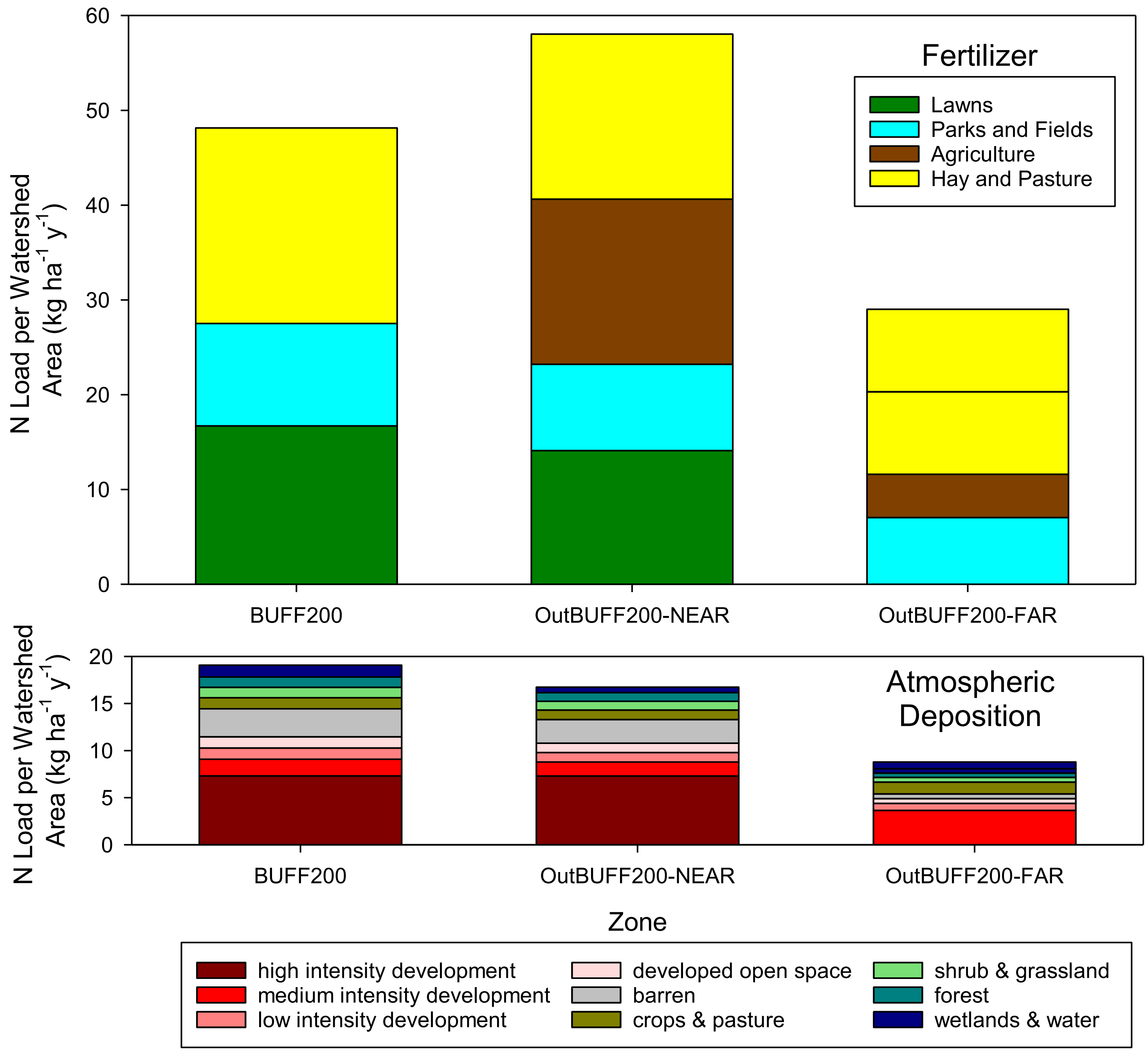
Area

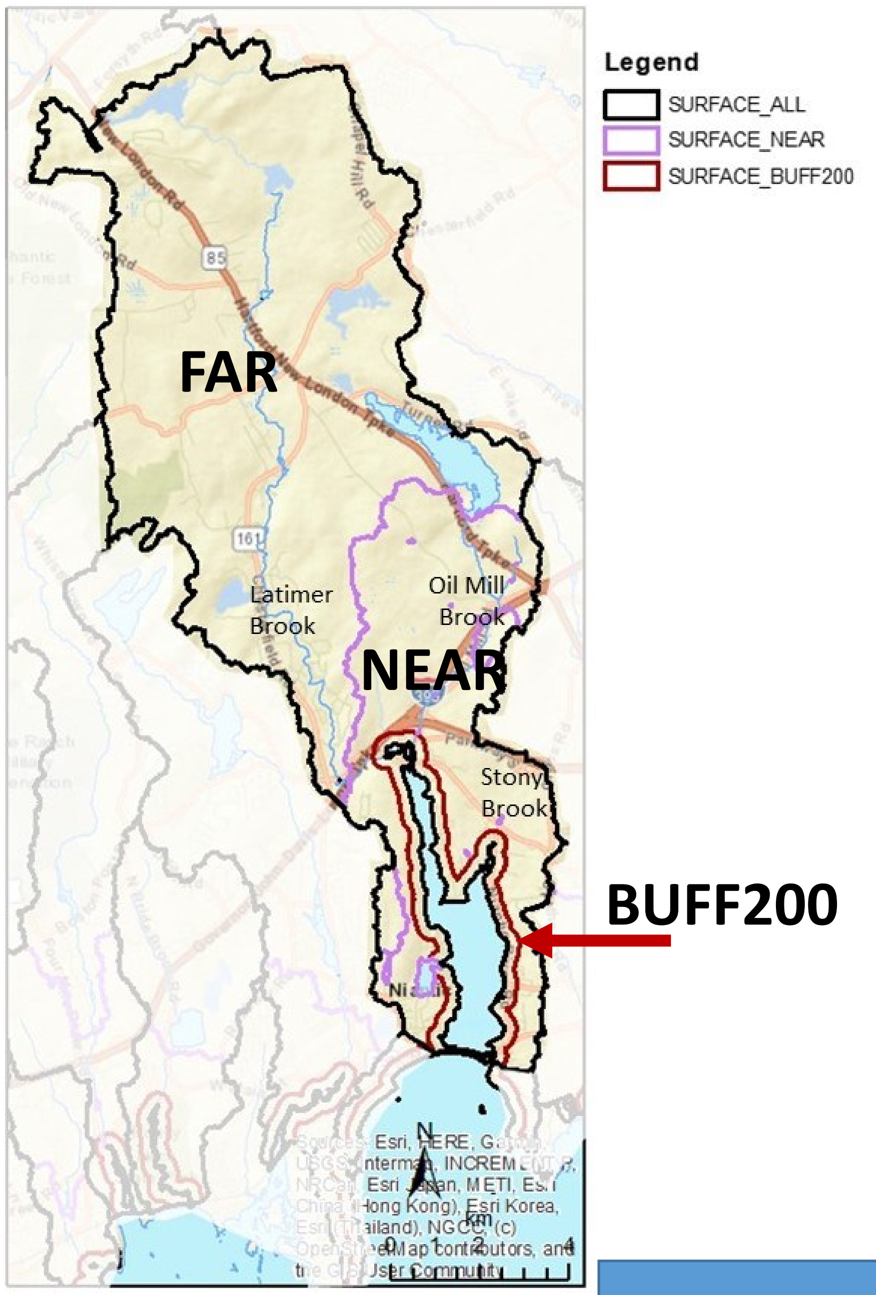




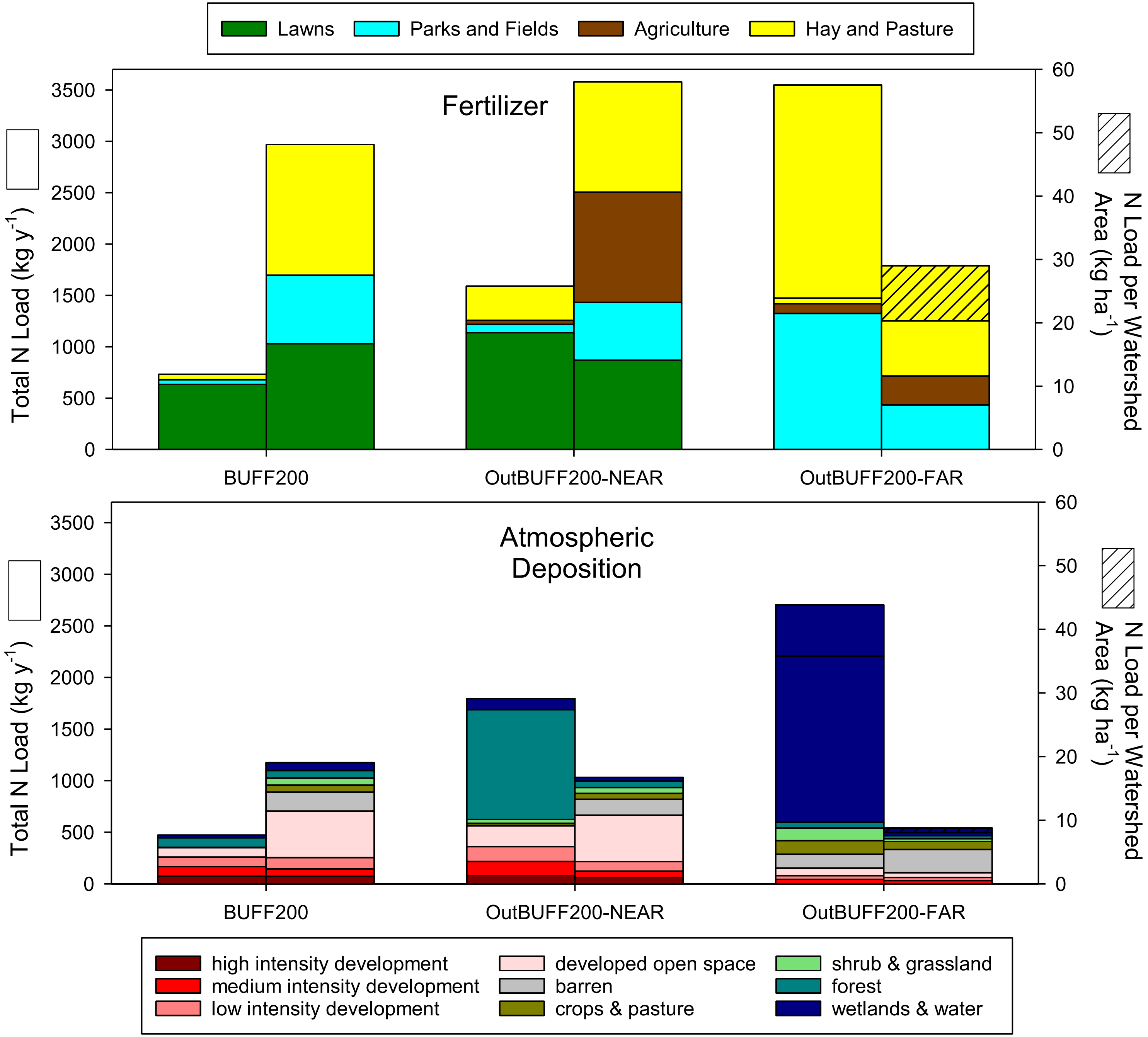
SOURCES

N Load per Watershed Area

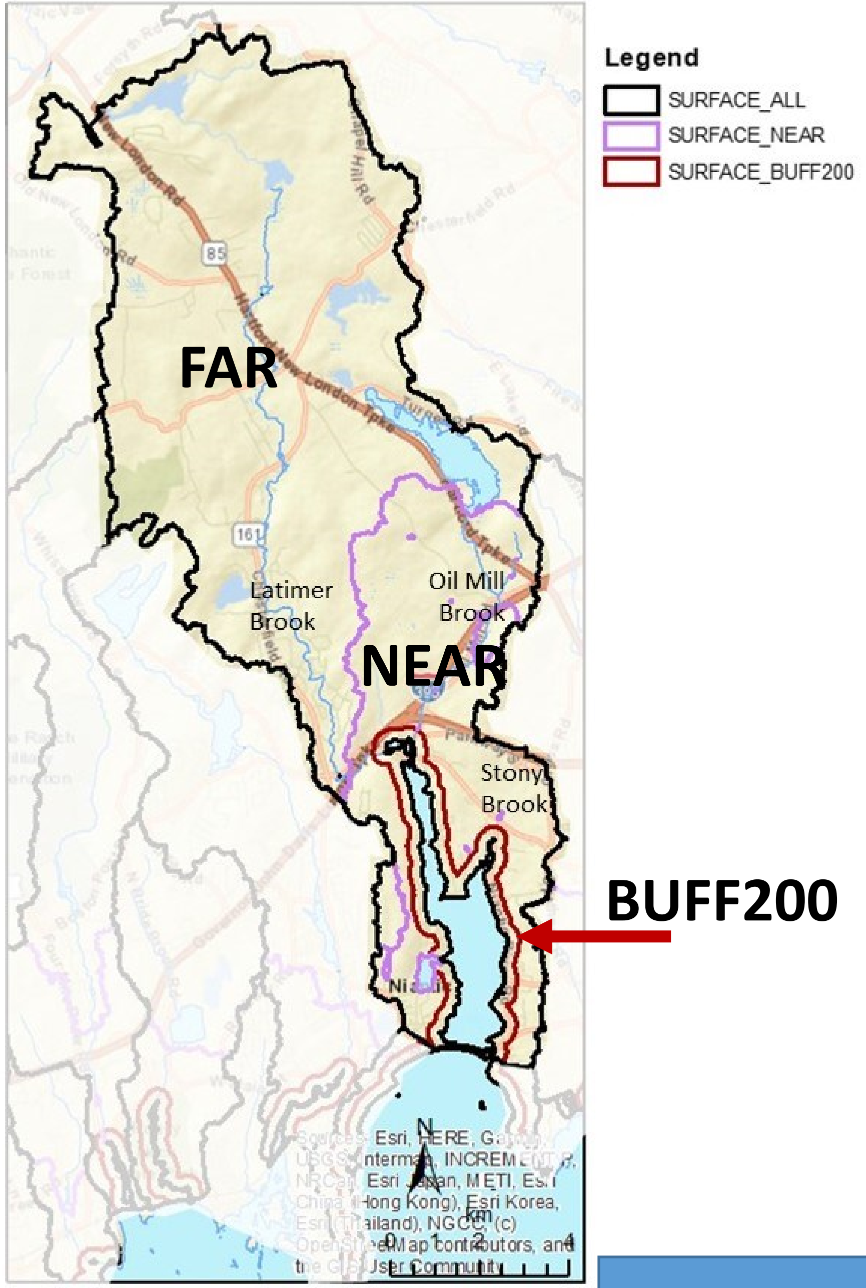




SOURCES

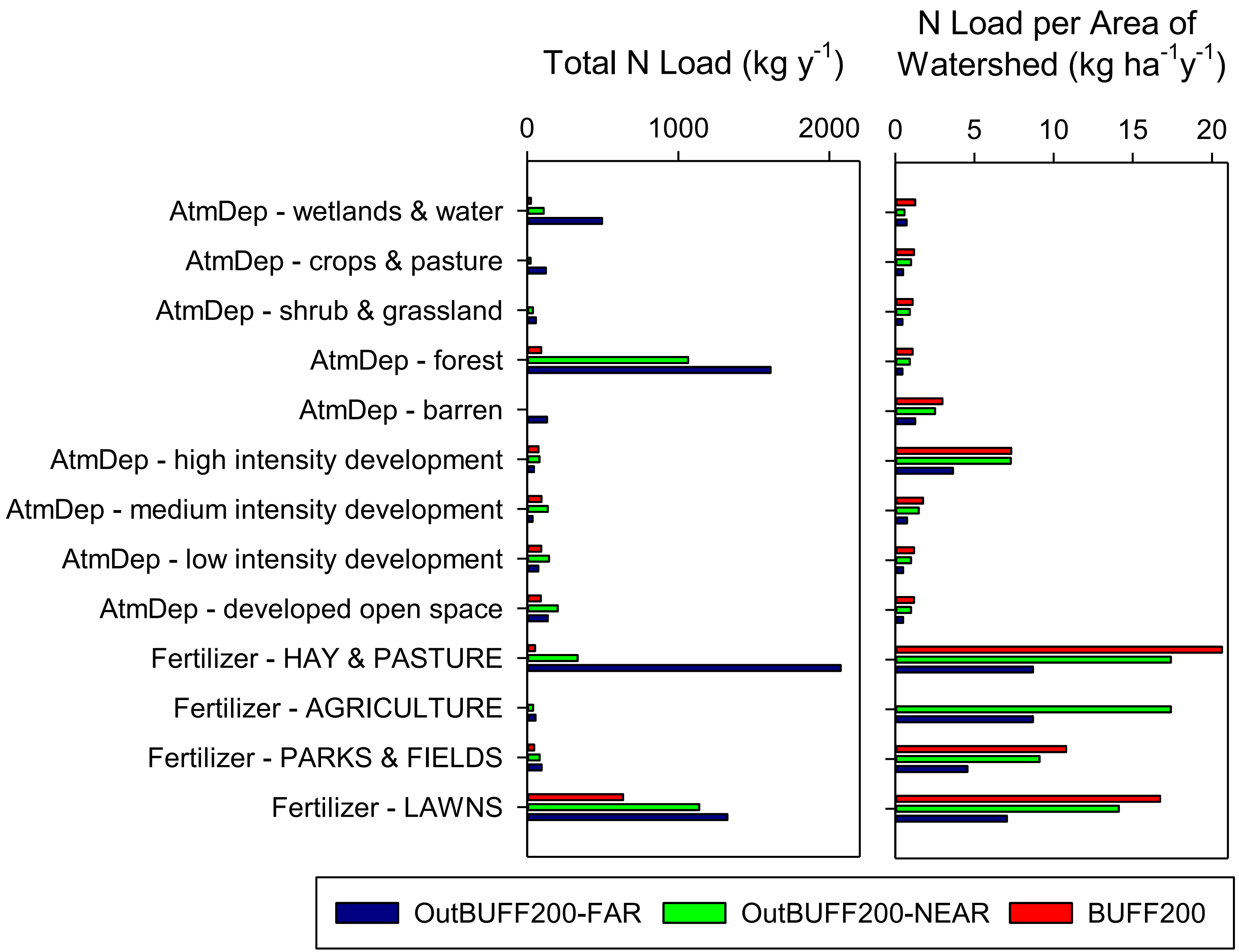


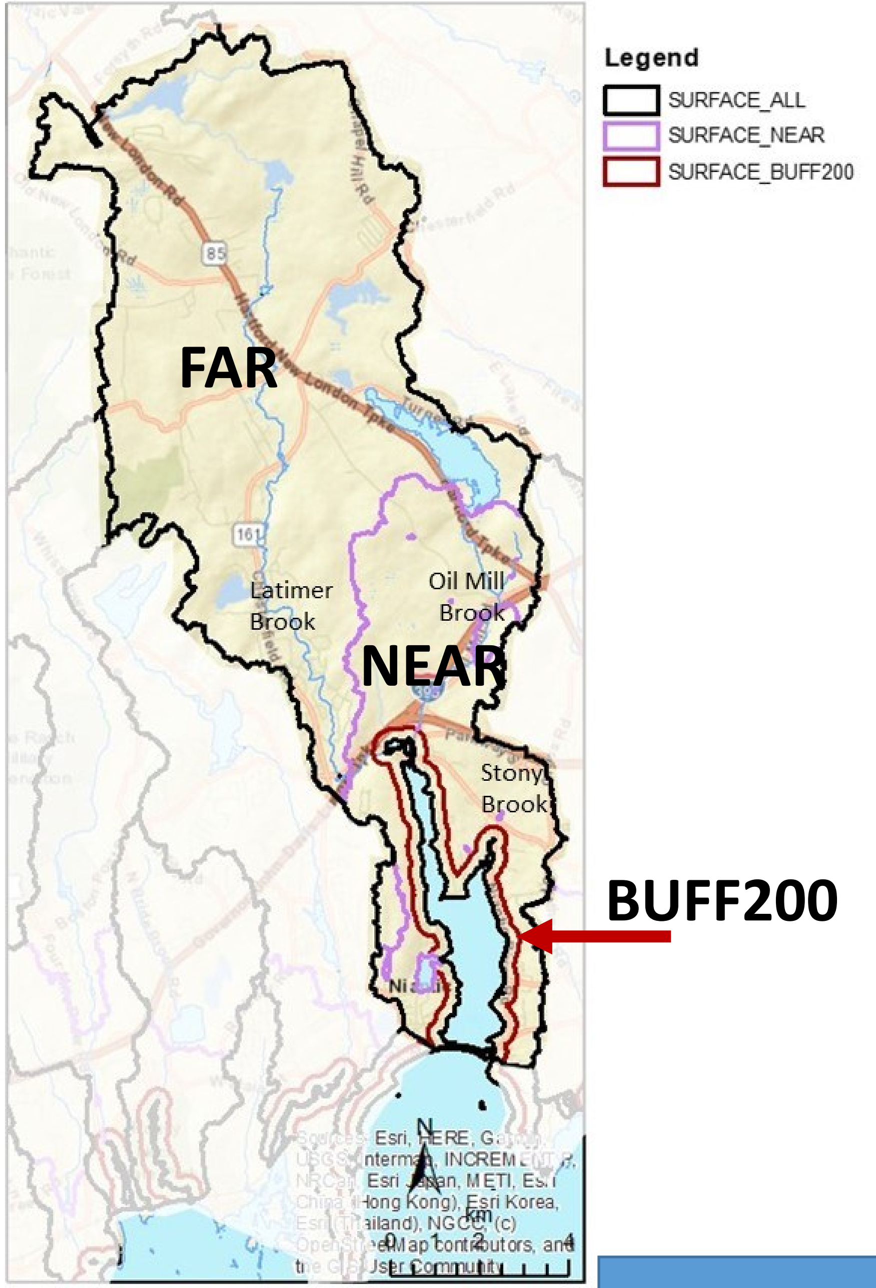
Lawns
Parks and Fields
Agriculture
Hay and Pasture
Fertilizer
Total N Load (kg y^{-1})
N Load per Watershed Area (kg ha^{-1})
BUFF200
OutBUFF200-NEAR
OutBUFF200-FAR
Atmospheric Deposition
high intensity development
medium intensity development
low intensity development
developed open space
barren
crops & pasture
shrub & grassland
forest
wetlands & water



Legend
SURFACE_ALL
SURFACE_NEAR
SURFACE_BUFF200
FAR
NEAR
BUFF200
Latimer Brook
Oil Mill Brook
Stony Brook

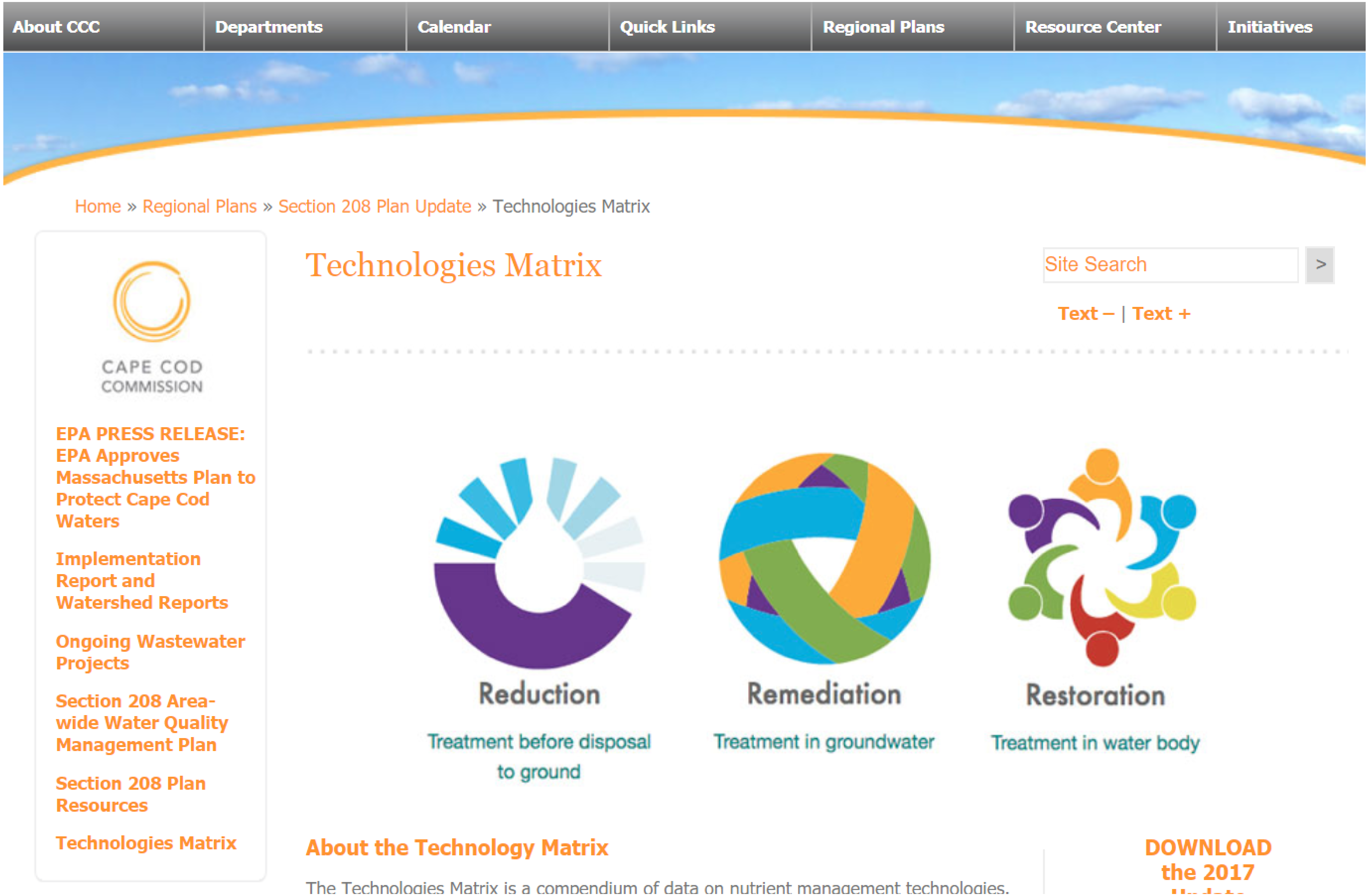
SOURCES


Total N Load (kg y^{-1})
N Load per Area of Watershed (kg $ha^{-1}y^{-1}$)
0
1000
2000
0
5
10
15
20
AtmDep - wetlands & water
AtmDep - crops & pasture
AtmDep - shrub & grassland
AtmDep - forest
AtmDep - barren
AtmDep - high intensity development
AtmDep - medium intensity development
AtmDep - low intensity development
AtmDep - developed open space
Fertilizer - HAY & PASTURE
Fertilizer - AGRICULTURE
Fertilizer - PARKS & FIELDS
Fertilizer - LAWNS
OutBUFF200-FAR
OutBUFF200-NEAR
BUFF200


Legend
SURFACE_ALL
SURFACE_NEAR
SURFACE_BUFF200
FAR
NEAR
BUFF200
Latimer Brook
Oil Mill Brook
Stony Brook

SOURCES

Solutions

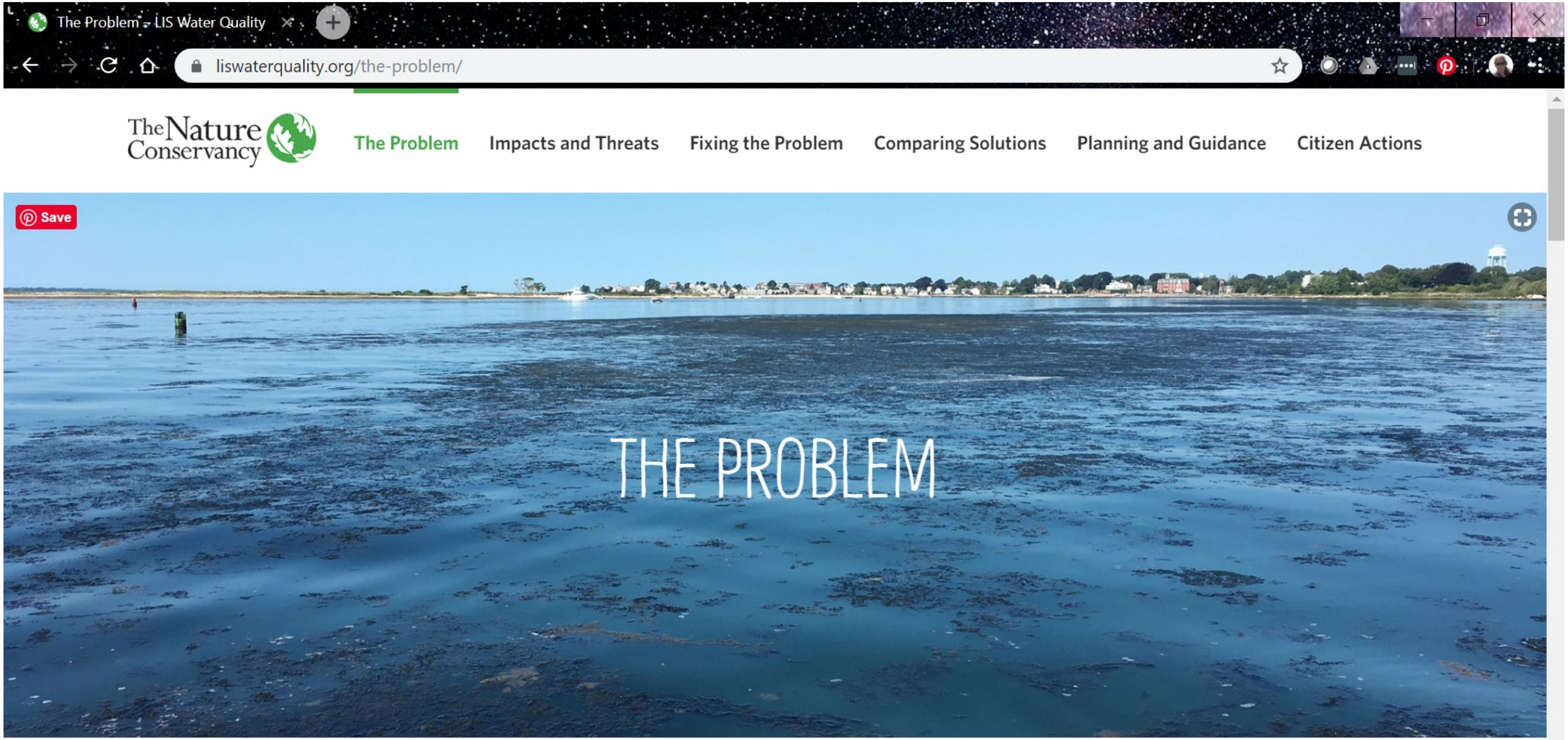


http://www.capecodcommission.org/index.php?id=656

Excel file with lots of information.

Solutions

https://www.liswaterquality.org/the-problem/



Solutions

https://www.liswaterquality.org/the-problem/

overview

efficiency & costs

strengths & weaknesses

The Nature Conservancy | The Problem | Impacts and Threats | Fixing the Problem | Comparing Solutions | Planning and Guidance | Citizen Actions

Upgrade Septic System Technology

Septic system technology has greatly advanced in recent years, improving the potential of onsite wastewater treatment systems to treat nitrogen. There are a wide variety of options currently in use and more in development – including commercial proprietary systems and non-proprietary systems – both capable of controlling pathogens and removing significantly more nitrogen than conventional septic systems.

Proprietary nitrogen reducing septic systems – sometimes known as alternative treatment – include a septic tank to settle solids. Effluent flows from the tank to a treatment unit where aeration triggers beneficial bacteria to consume nitrogen in the form of ammonia, convert it to nitrate and then harmless, inert nitrogen gas. In Connecticut, the Department of Energy and Environmental Protection (DEEP) is responsible for oversight of alternative treatment systems. Currently, they are only approved for use in large volume applications and are not permitted for use in residential settings. However, alternative treatment systems have been used in neighboring states of Massachusetts and Rhode Island for many years to reduce nitrogen pollution before it enters groundwater. In 2015, Suffolk County, New York began a comprehensive pilot project to install and monitor performance of nitrogen reducing systems as part of a septic system improvement program to address degraded water quality.

Additionally, promising new wastewater system designs are being tested in Florida, Massachusetts and on Long Island. These non-proprietary systems use gravity and low-pressure dosing pumps to filter effluent through layers of sand and denitrifying carbon media – for example, wood chips or sawdust. This approach is often referred to as passive nitrogen removal (PNR) and does not require an additional treatment unit between the septic tank and drainfield. Use of this technology is limited to existing highly polluted ground and surface waters in Connecticut and will require significant monitoring and fine-tuning of implementation before being approved for widespread use.

Nitrogen Removal

- *50-75%*

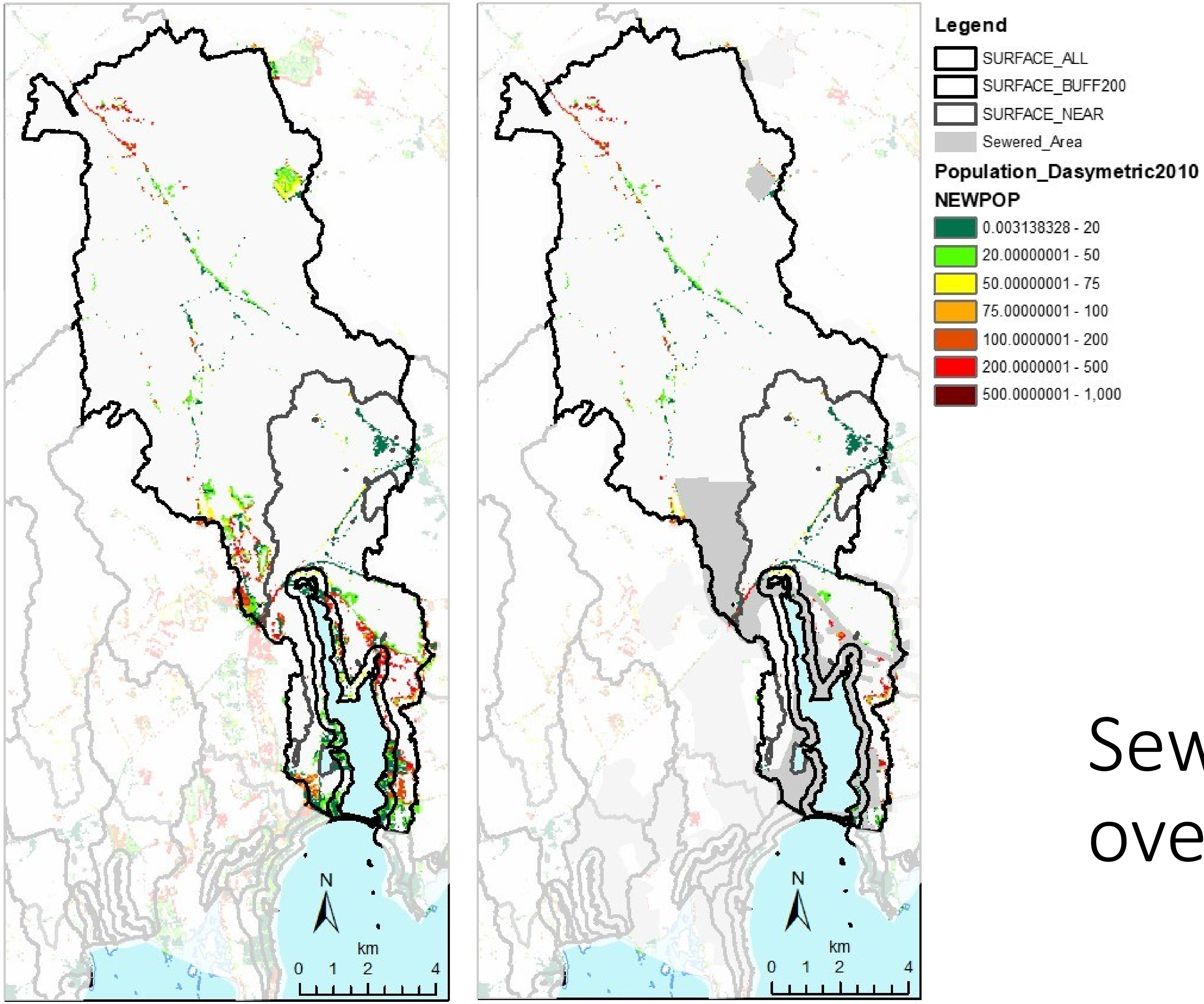
Cost Efficiency

- *$580-$770 per pound of nitrogen removed*

Project Costs

- *System Cost Range: $10,000-$30,000,*
- *Operations and Maintenance: $2,000-$3,200 per year*
- *Monitoring: $200-$300 per year*

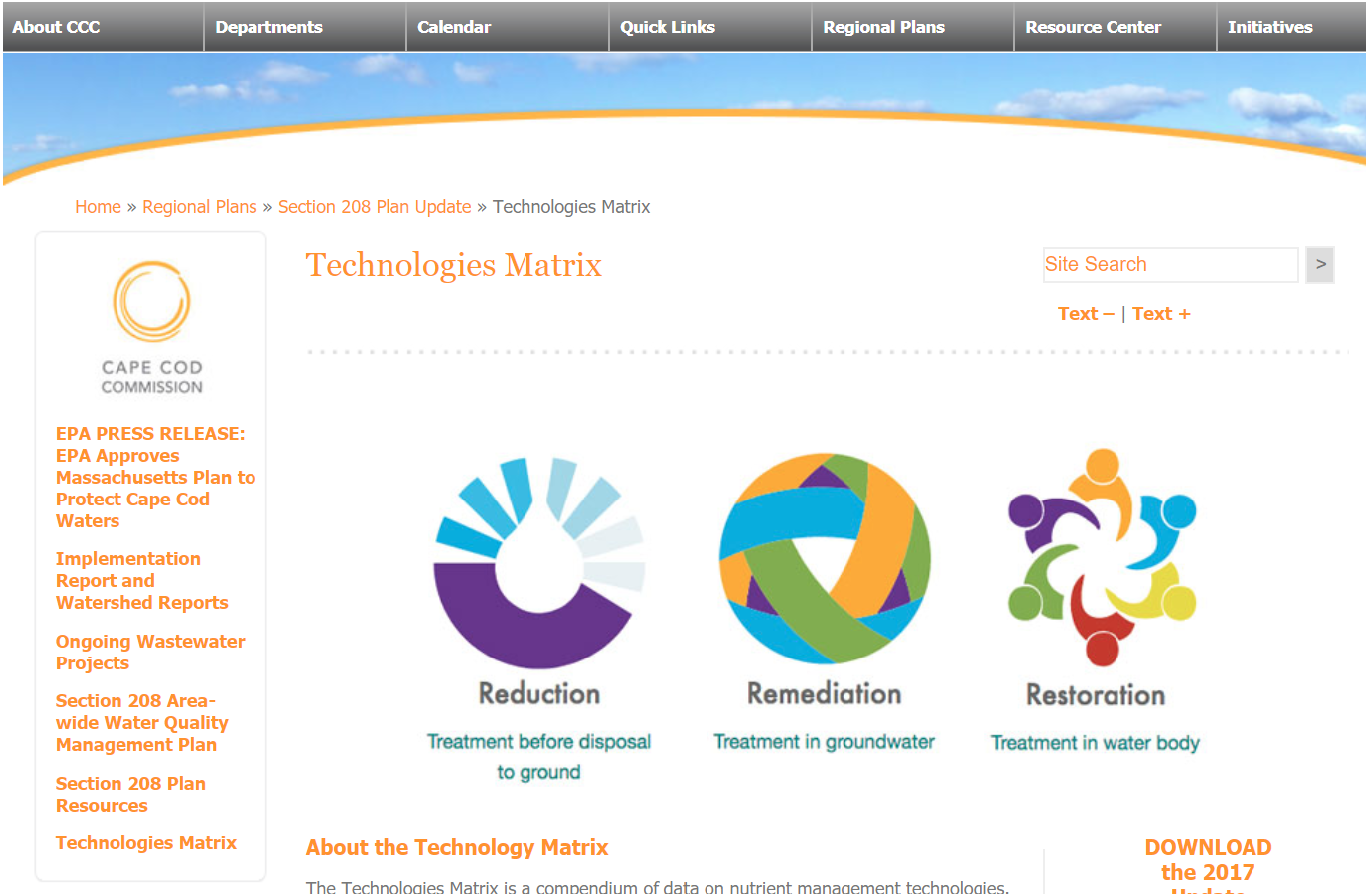
Strengths	Weaknesses
• Removes nitrogen at the source, before it reaches groundwater • More effective at removing nitrogen than conventional systems • Long-lasting • Some proprietary models include service/maintenance	• Systems often require specific lot sizes and setbacks • Pumps/blowers/mixer technologies require energy and homeowner of service provider maintenance • High cost per homeowner for proprietary technologies or drainfield construction • Systems range in effectiveness (50-85% nitrogen removal)



Sewered Areas over Population

WATERSHED CHARACTERISTICS

Solutions



http://www.capecodcommission.org/index.php?id=656

Excel file with lots of information.

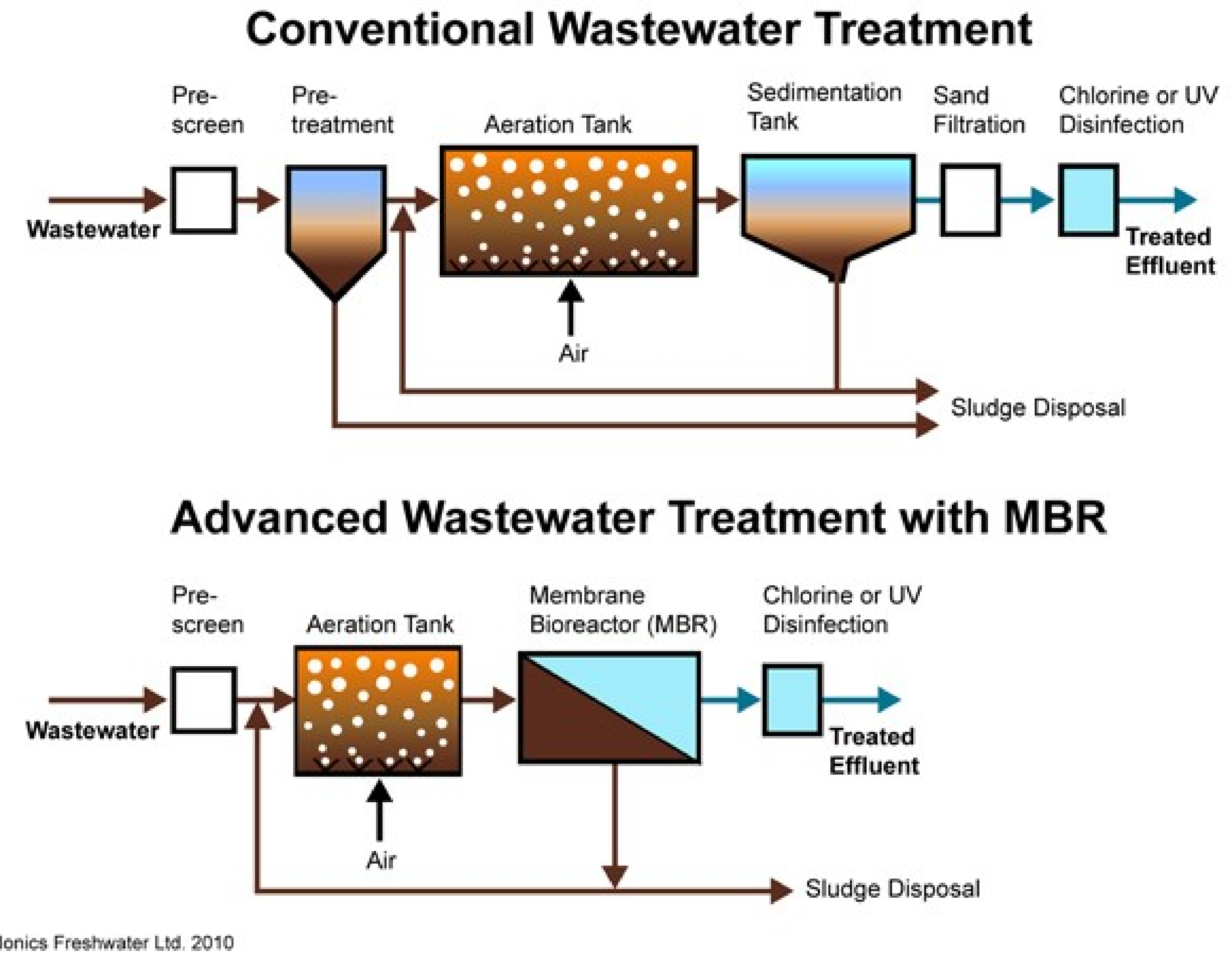
Wastewater Treatment Systems

Conventional Treatment (~10mg/L)
Advanced Treatment (~5mg/L)
Cluster Treatment System - Single-stage (<15mg/L)
Cluster Treatment System - Two-stage (<8mg/L)
Satellite Treatment (~10mg/L)
Satellite Treatment - Enhanced (<8mg/L)
Innovative/Alternative (I/A) Systems (<19mg/L)
Innovative/Alternative (I/A) Enhanced Systems (10-13mg/L)

Wastewater Treatment Systems – "sewer systems"

Conventional Treatment (~10mg/L)

Advanced Treatment (~5mg/L)

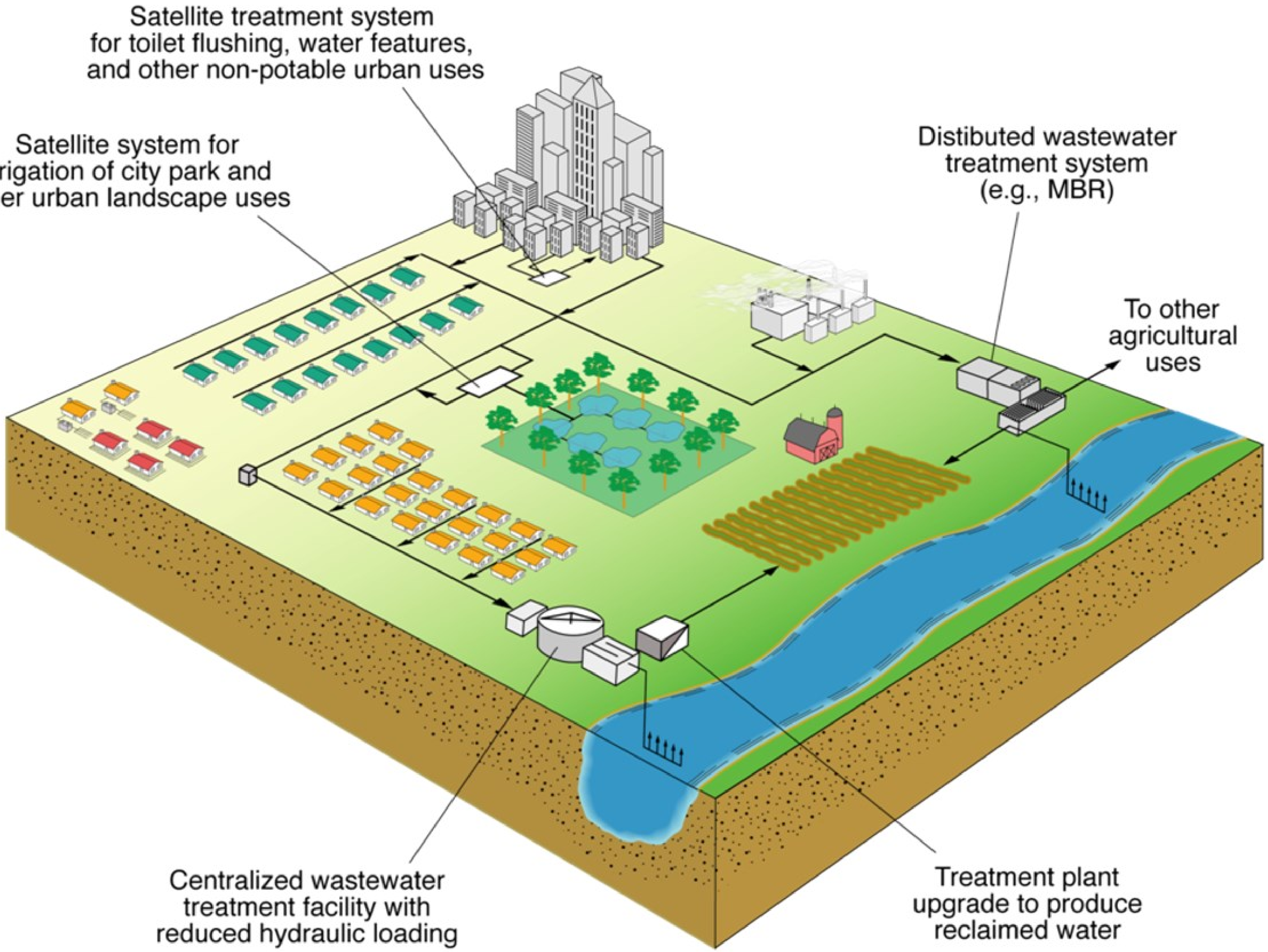


http://www.ionicsfreshwater.com/index.php/wastewater-treatment

On-Site Treatment Systems

Satellite Treatment (~10mg/L)

Satellite Treatment - Enhanced (<8mg/L)

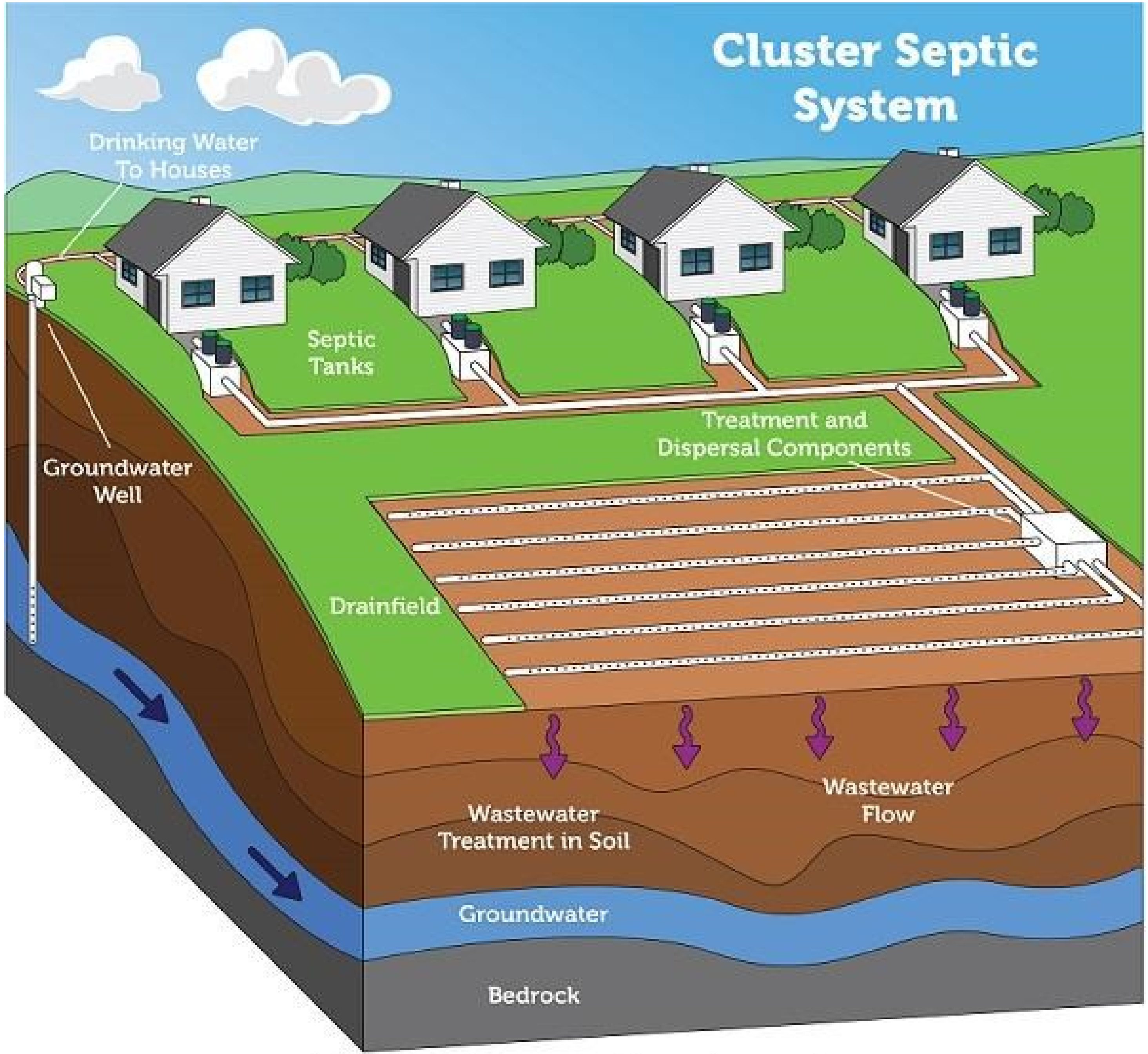


https://www.semanticscholar.org/paper/Water-reuse-%3A-Overview-of-current-practices-and-in-Angelakis-Gikas/510418e8c0ba45079124a0c8f28e6186fd017d38

On-Site Treatment Systems

Cluster Treatment System - Single-stage (<15mg/L)

Cluster Treatment System - Two-stage (<8mg/L)

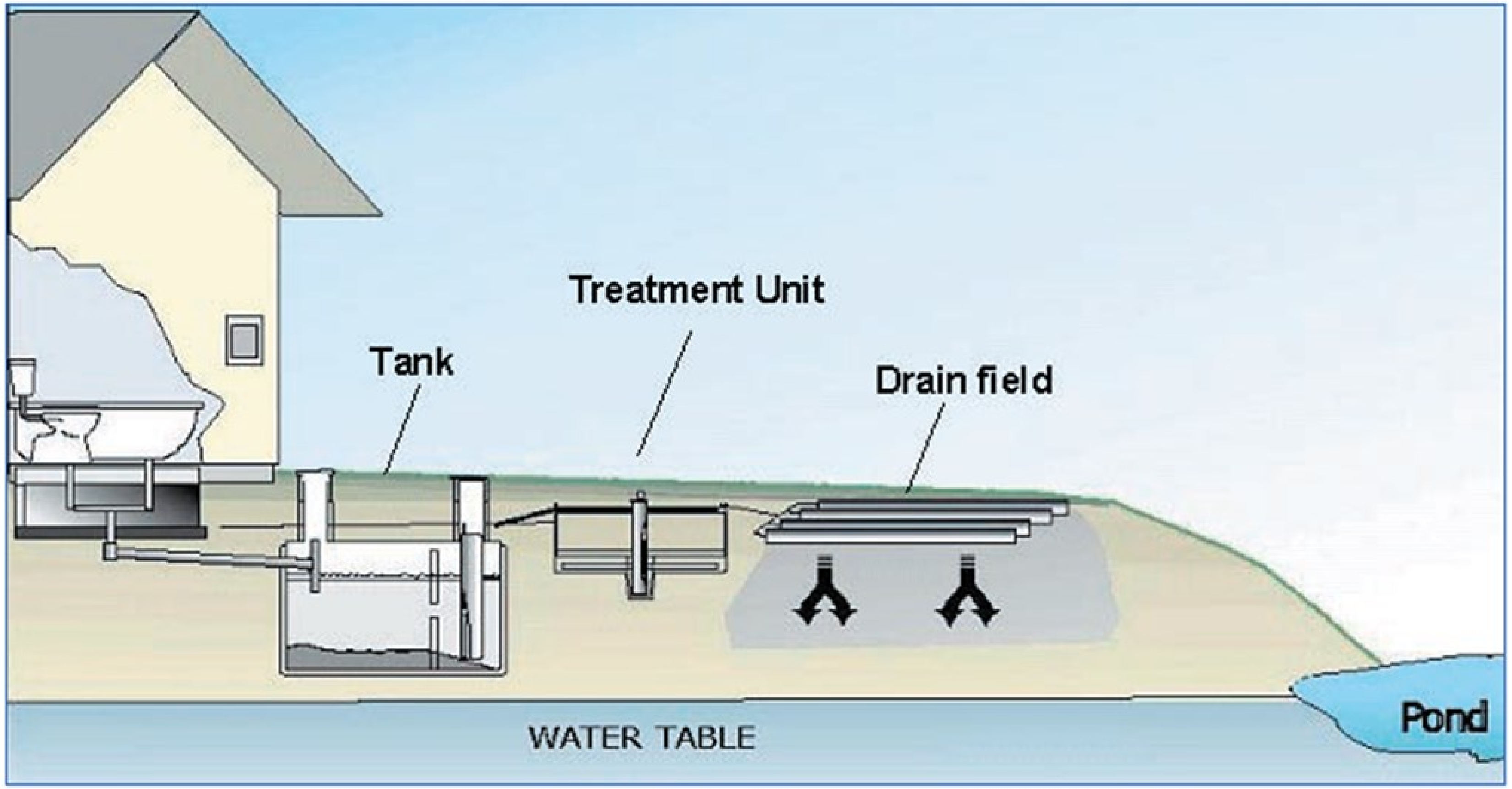


Please note: Septic systems vary. Diagram is not to scale.

https://integritysepticdrain.com/companies-that-pump-out-septic-tanks-benton-tn

On-Site Treatment Systems

Innovative/Alternative (I/A) Systems (<19mg/L)
Innovative/Alternative (I/A) Enhanced Systems (10-13mg/L)



Alternative and innovative systems add a component between the septic tank and drainfield.

Waste Reduction Toilets

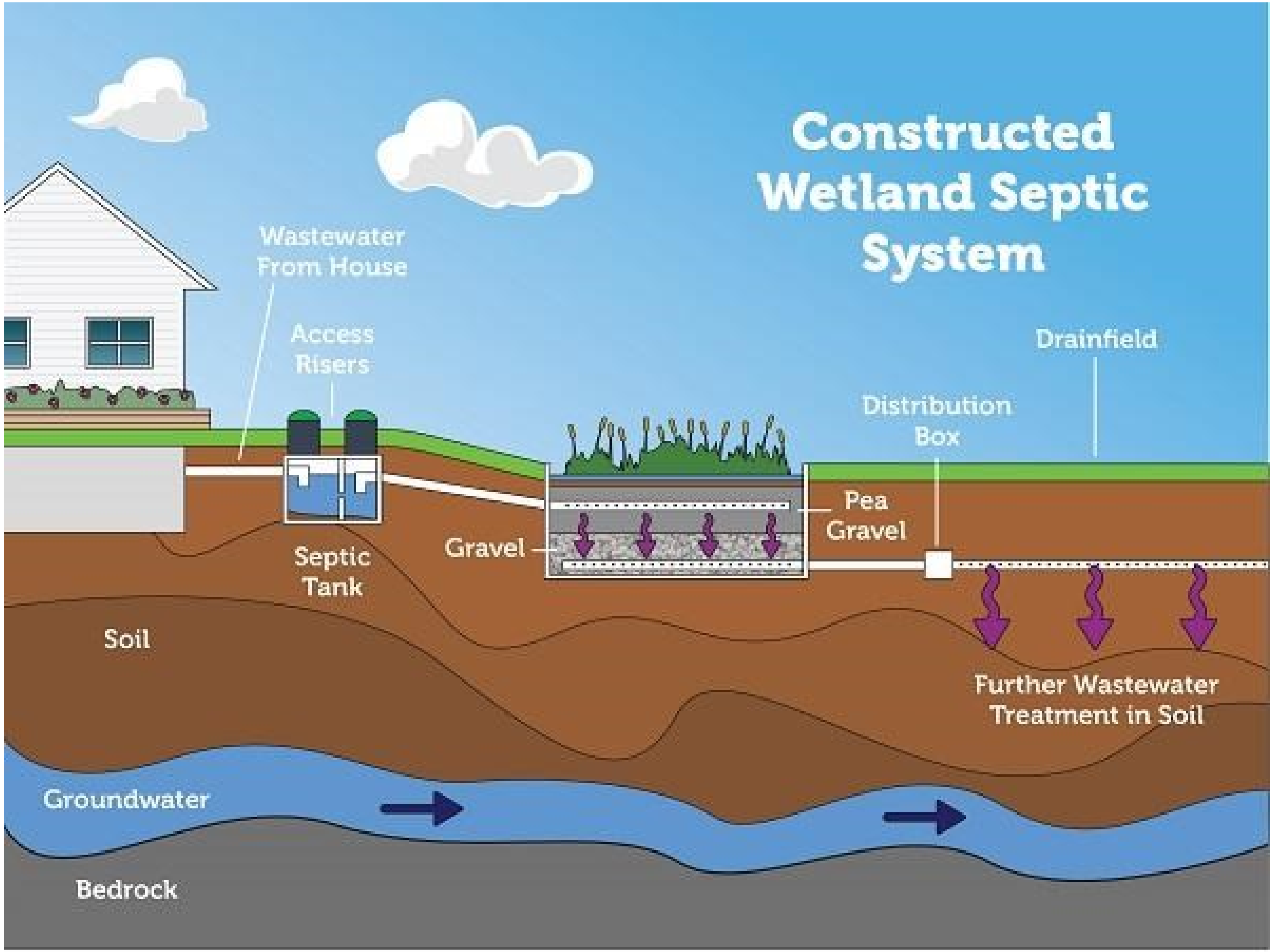
Toilets: Composting
Toilets: Incinerating
Toilets: Packaging
Toilets: Urine Diverting
Public Facility: Urine Diverting

Cinderella incinerating toilet

Sun-Mar composting toilet

Green Infrastructure

Constructed Wetlands
Hydroponic Treatments
Phytoirrigation
Stormwater BMPs



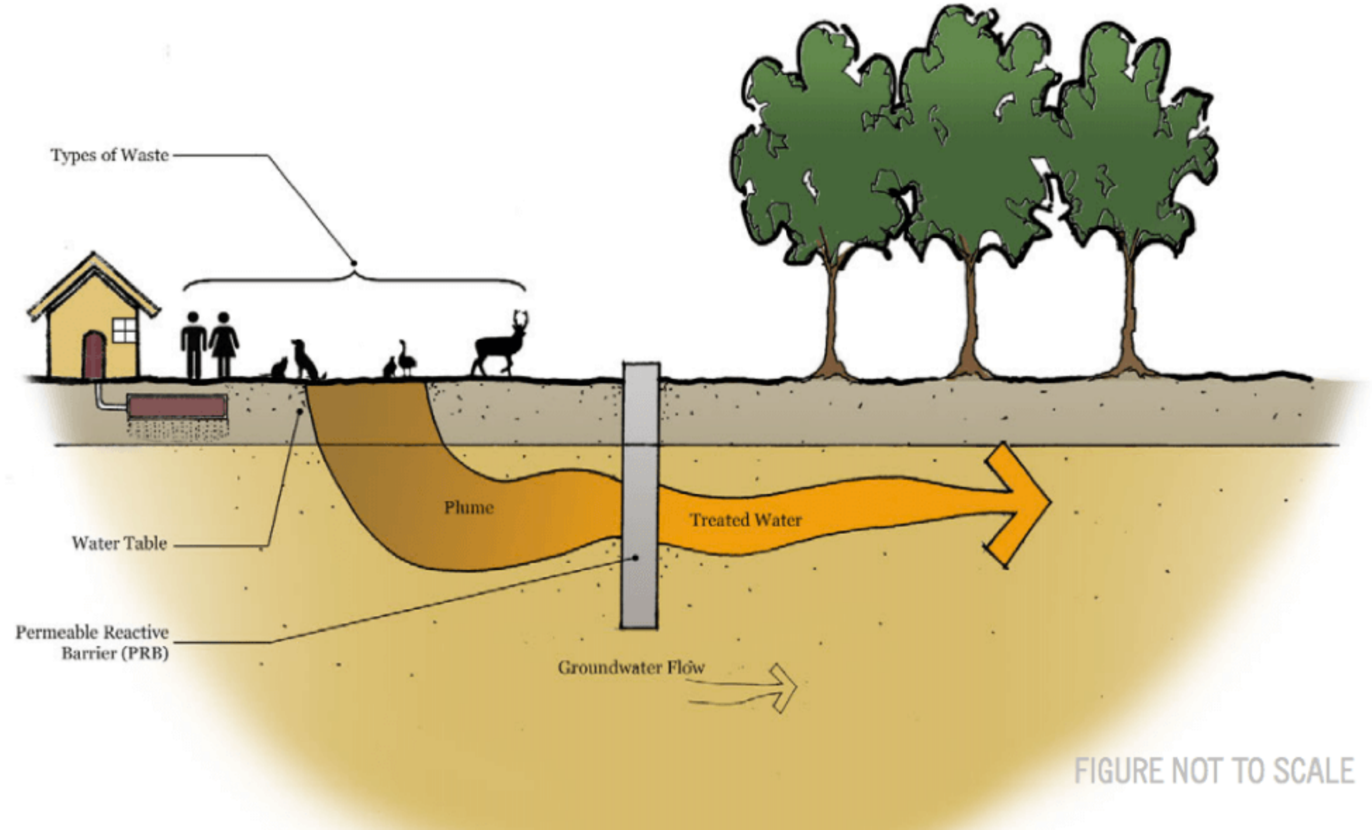
Please note: Septic systems vary. Diagram is not to scale.

https://integritysepticdrain.com/companies-that-pump-out-septic-tanks-benton-tn

Innovative & Resource Management

aquaculture
phytoremediation

fertigation wells
permeable reactive barriers



Non-Structural Technologies

fertilizer management
stormwater BMPs
remediation of existing development*
compact and open space development*
transfer of development rights*

System Alterations

Pond and Estuary Dredging
Inlet / Culvert Widening
Coastal Habitat Restoration

Floating Constructed Wetlands
Surface Water Remediation Wetlands
Wild Oyster Bed Maintenance

https://oceanservice.noaa.gov/facts/dredging.html

Categories of Solutions (Cape Cod Commission)

- on-site treatment systems (includes WWTFs)
- waste reduction toilets
- innovative & resource management
- non-structural technologies
- system alterations

MUNICIPALITY			
influent source	strategy	cost / kg-N, over lifetime of project ($)	reasonable?
bottom sediments	Pond and Estuary Dredging	$2	only navigational channel dredging, bk. eelgrass
estuary, surface waters	Floating Constructed Wetlands	$8	NA - no room
estuary	Inlet / Culvert Widening	$17	NA - Amtrak controlled
fertilizer	Fertilizer Management	$27	
raw sewage	Public Facility: Urine Diverting	$65	
estuary	Coastal Habitat Restoration	$74	NA - requires removing houses
primary & secondary WWTF, septic	Constructed Wetlands - Subsurface Flow	$90	
primary & secondary WWTF, septic	Constructed Wetlands - Surface Flow	$92	
raw sewage	Advanced Treatment (~5mg/L)	$118	NA - WWTF effluent does not discharge to NRE
raw sewage	Conventional Treatment (~10mg/L)	$130	NA - WWTF effluent does not discharge to NRE
stormwater	Stormwater BMP - Vegetated Swale	$140	
groundwater	Fertigation Wells - Turf	$149	
raw sewage	Toilets: Packaging	$213	
raw sewage	Toilets: Composting	$267	
raw sewage	Satellite Treatment (~10mg/L)	$301	
groundwater	PRBs - Trench Method (Aquifer Thickness - 30 feet)	$309	NA - rocky terrain
groundwater	Constructed Wetlands - Groundwater Treatment	$314	
raw sewage	Satellite Treatment - Enhanced (<8mg/L)	$325	
raw sewage	Toilets: Incinerating	$346	
groundwater	Phytoremediation	$354	NA - nothing to cut (very little Phragmites)
groundwater	PRBs - Injection Well Method	$450	NA - nothing to inject
raw sewage	Toilets: Urine Diverting	$584	
stormwater	Stormwater BMPs	$627	
stormwater	Stormwater BMP - Gravel Wetland	$684	
stormwater, groundwater	Stormwater: Constructed Wetlands	$708	
raw sewage	Cluster Treatment System - Two-stage (<8mg/L)	$872	
estuary, surface waters	Surface Water Remediation Wetlands	$942	NA - WWTF effluent does not discharge to NRE
stormwater	Stormwater BMP - Phytobuffers	$1,082	
raw sewage	Cluster Treatment System - Single-stage (<15mg/L)	$1,193	
raw sewage	Innovative/Alternative (I/A) Systems (<19mg/L)	$1,330	
raw sewage	Innovative/Alternative (I/A) Enhanced Systems (10-13mg/L)	$1,376	
raw sewage, primary WWTF, septic	Hydroponic Treatment	$1,691	NA - WWTF effluent does not discharge to NRE
stormwater, groundwater	Stormwater: Bioretention / Soil Media Filters	$1,923	
secondary & advanced WWTF	Phytoirrigation	$4,472	NA - WWTF effluent does not discharge to NRE

LAND CONSERVANCY			
influent source	strategy	cost / kg-N, over lifetime of project ($)	reasonable?
estuary, surface waters	Floating Constructed Wetlands	$8	NA - no room
fertilizer	Fertilizer Management	$27	
estuary	Coastal Habitat Restoration	$74	NA - requires removing houses
primary & secondary WWTF, septic	Constructed Wetlands - Subsurface Flow	$90	
primary & secondary WWTF, septic	Constructed Wetlands - Surface Flow	$92	
groundwater	PRBs - Trench Method (Aquifer Thickness - 30 feet)	$309	NA - rocky terrain
groundwater	Phytoremediation	$354	
groundwater	PRBs - Injection Well Method	$450	NA - nothing to inject
estuary, surface waters	Surface Water Remediation Wetlands	$942	

HOMEOWNER			
influent source	strategy	cost / kg-N, over lifetime of project ($)	reasonable?
fertilizer	Fertilizer Management	$27	
stormwater	Stormwater BMP - Vegetated Swale	$140	
raw sewage	Toilets: Packaging	$213	
raw sewage	Toilets: Composting	$267	
groundwater	PRBs - Trench Method (Aquifer Thickness - 30 feet)	$309	NA - rocky terrain
raw sewage	Toilets: Incinerating	$346	
groundwater	Phytoremediation	$354	NA - nothing to cut (very little Phragmites)
groundwater	PRBs - Injection Well Method	$450	
raw sewage	Toilets: Urine Diverting	$584	
stormwater	Stormwater BMPs	$627	
stormwater	Stormwater BMP - Gravel Wetland	$684	
stormwater	Stormwater BMP - Phytobuffers	$1,082	
raw sewage	Innovative/Alternative (I/A) Systems (<19mg/L)	$1,330	NA - not permitted for homeowner use in CT
raw sewage	Innovative/Alternative (I/A) Enhanced Systems (10-13mg/L)	$1,376	NA - not permitted for homeowner use in CT
stormwater, groundwater	Stormwater: Bioretention / Soil Media Filters	$1,923	

BUSINESS		
influent source	strategy	cost / kg-N, over lifetime of project ($)
estuary	Aquaculture - Shellfish Cultivated In Estuary Bed	$26
estuary	Aquaculture - Shellfish	$26
estuary	Aquaculture - Mariculture	$26

HOMEOWNER		
influent source	*strategy*	*cost / kg-N, over lifetime of project ($)*
fertilizer	Fertilizer Management	$27
stormwater	Stormwater BMP - Vegetated Swale	$140
raw sewage	Toilets: Packaging	$213
raw sewage	Toilets: Composting	$267
raw sewage	Toilets: Incinerating	$346
groundwater	PRBs - Injection Well Method	$450
raw sewage	Toilets: Urine Diverting	$584
stormwater	Stormwater BMPs	$627
stormwater	Stormwater BMP - Gravel Wetland	$684
stormwater	Stormwater BMP - Phytobuffers	$1,082
stormwater, groundwater	Stormwater: Bioretention / Soil Media Filters	$1,923

BUSINESS		
influent source	*strategy*	*cost / kg-N, over lifetime of project ($)*
estuary	Aquaculture	$26

LAND CONSERVANCY		
influent source	*strategy*	*cost / kg-N, over lifetime of project ($)*
fertilizer	Fertilizer Management	$27
primary & secondary WWTF, septic	Constructed Wetlands - Subsurface Flow	$90
primary & secondary WWTF, septic	Constructed Wetlands - Surface Flow	$92
groundwater	Phytoremediation	$354
estuary, surface waters	Surface Water Remediation Wetlands	$942

MUNICIPALITY

influent source	*strategy*	*cost / kg-N, over lifetime of project ($)*
bottom sediments	Pond and Estuary Dredging	$2
fertilizer	Fertilizer Management	$27
raw sewage	Public Facility: Urine Diverting	$65
primary & secondary WWTF, septic	Constructed Wetlands - Subsurface Flow	$90
primary & secondary WWTF, septic	Constructed Wetlands - Surface Flow	$92
stormwater	Stormwater BMP - Vegetated Swale	$140
groundwater	Fertigation Wells - Turf	$149
raw sewage	Toilets: Packaging	$213
raw sewage	Toilets: Composting	$267
raw sewage	Satellite Treatment (~10mg/L)	$301
groundwater	Constructed Wetlands - Groundwater Treatment	$314
raw sewage	Satellite Treatment - Enhanced (<8mg/L)	$325
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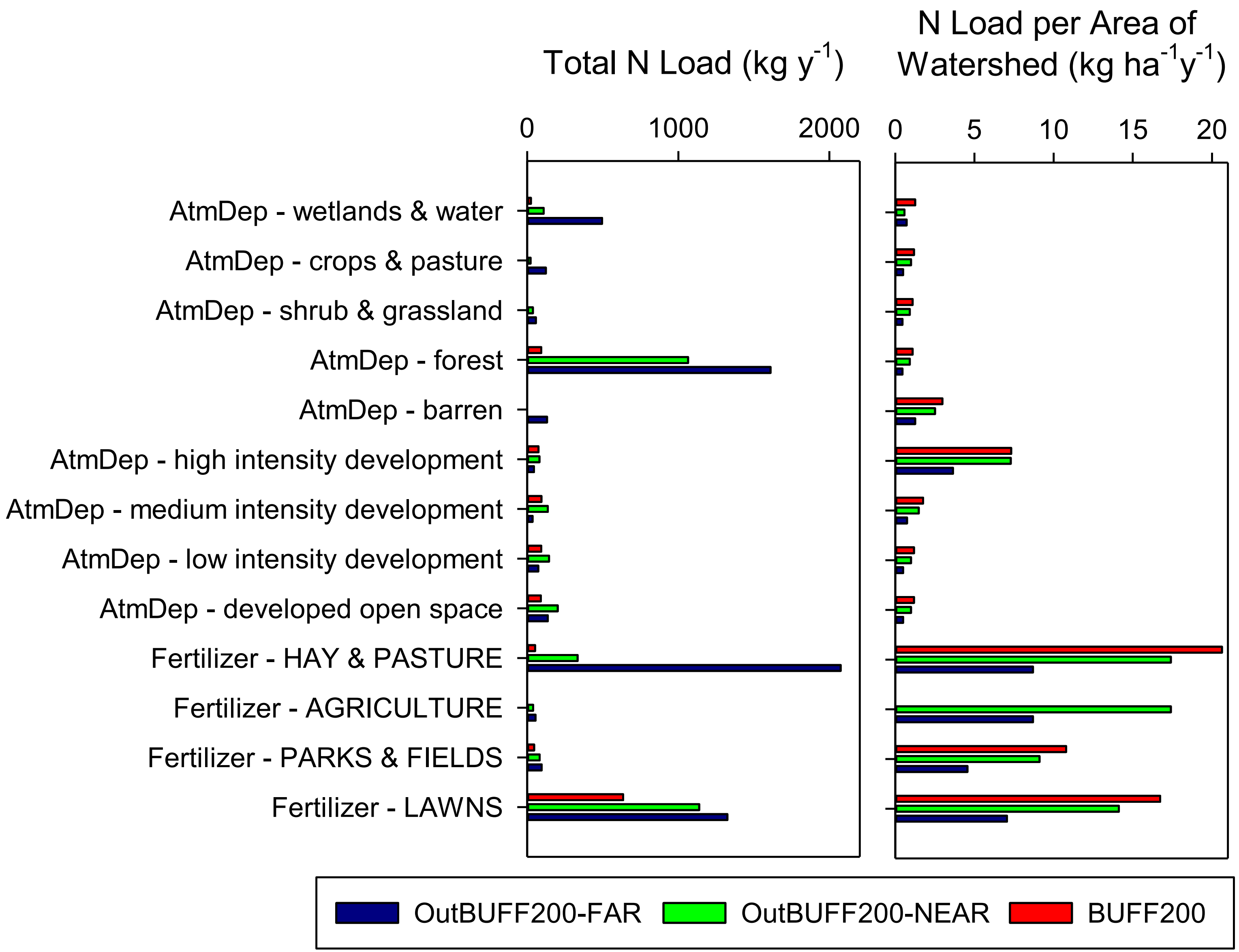
stormwater	Stormwater BMPs	$627
stormwater	Stormwater BMP - Gravel Wetland	$684
stormwater, groundwater	Stormwater: Constructed Wetlands	$708
raw sewage	Cluster Treatment System - Two-stage (<8mg/L)	$872
stormwater	Stormwater BMP - Phytobuffers	$1,082
raw sewage	Cluster Treatment System - Single-stage (<15mg/L)	$1,193
raw sewage	Innovative/Alternative (I/A) Systems (<19mg/L)	$1,330
raw sewage	Innovative/Alternative (I/A) Enhanced Systems (10-1	$1,376
stormwater, groundwater	Stormwater: Bioretention / Soil Media Filters	$1,923



Fertilizer Management

- $27 / kg N removed (Cape Cod Commission Tech Matrix)
- $15 / house for behavior change campaign (Chesapeake Bay numbers, as cited on TNC website)

Atmospheric Deposition in high intensity development areas.

- $92* / kg N removed for a surface water constructed wetland
- $140* / kg N removed for a vegetated swale
- $? / kg N removed for a rain garden servicing 1 inch of rainfall

(* data from Cape Cod Commission Tech matrix)

Other Deliverables

c) develop recommendations for a target nitrogen load from the watershed which is supportive of CCMP targets for eelgrass and ecosystem integrity, taking into account the predicted changes in climate (e.g. rising temperatures and sea levels);

d) utilize a land-use based nitrogen loading model recently developed by Vaudrey for many embayments, including Niantic River, to evaluate nitrogen mitigation strategies;

e) assess the applicability of this study to other embayments of Long Island Sound by suggesting approach and data requirements for various assessments; and

f) identify any data gaps and suggest monitoring protocol to fill these gaps.

Approach

- Literature review of similar efforts on seagrass in other systems
  - Identify common parameters and methods
  - Identify novel approaches/data gaps in this study if present
  - Other studies looking at multiple embayments across large estuaries
- Assess applicability of Niantic approach to other LIS Embayments
- Identify data requirements for broader implementation
- Recommend monitoring protocols based on what we have learned

Applicability

- Broader technique for multivariate data analysis used is highly applicable to other embayments throughout LIS
- However:
  - Parameters for each embayment may NOT be the same
    - FOR EXAMPLE: If sediment quality is consistently supportive of eelgrass throughout the Niantic, PRIMER will think that sediment quality doesn’t matter.
  - Conditions deemed “supportive” of eelgrass may vary between embayments (Buenau et al. 2018)

Buenau, K., Thurman, C., Vavrinec, J., Borde, A., & Thom, R. (2018). Is local adaptation a factor in planning eelgrass restoration? Initial assessment of responses to temperature by eelgrass growing across a stressor gradient.

Data Requirements

- Literature review suggests high degree of similarity in parameters:
  - Light
  - Temperature
  - Salinity
  - Sediment quality (grain size/organic %)
  - Water quality (oxygen, chlorophyll, nutrients, turbidity)
- Our analysis suggests Eelgrass Health Metrics are more responsive than simpler presence/abundance approaches
  - Index 1 (biomass*longest leaf) was the most responsive, but the additional work to calculate other indices is minimal

Monitoring Approach

- Target embayments can be identified using existing field efforts (e.g. UWS) and/or modeling work (e.g. Vaudrey et al.)
- Initial data survey can capture gradients across system
  - Sediment quality
  - Eelgrass metrics
  - Ranges of water quality
- Ongoing Annual survey effort necessary for some parameters (e.g. temperature), but episodic effort may be equally effective for others (e.g. nutrients, sediment quality)

Still to Do

- Write This Up…
- Look at impact of converting Oswegatchie Hills (O.H.) forested area to houses.
  - what numbers to use?
  - 236 acres (955,058 m^2)
  - 1/3 of forest to be developed?
    or all 236 acres?

Total N Load & N Load per Embayment Area	236 acres developed forest > med. intensity	79 acres developed forest > med. intensity
atmospheric deposition	+ 612 kg / y + 1.9 kg / ha / y	+ 576 kg / y + 1.8 kg / ha / y
fertilizer	+ 1,056 kg / y + 3.3 kg / ha / y	+ 697 kg / y + 2.2 kg / ha / y
TOTAL	+ 1,668 kg / y + 5.2 kg / ha / y	+ 1,273 kg / y + 4.0 kg / ha / y

current N Load estimate: 56 ± 12 Kg ha^{-1} y^{-1}

< 50 Kg ha^{-1} y^{-1} is protective of eelgrass

50-100 ha^{-1} y^{-1} eelgrass is stressed

> 100 Kg ha^{-1} y^{-1} results in eelgrass loss

new load if O.H. developed: 60 – 62 Kg ha^{-1} y^{-1}