Onsite wastewater treatment systems in southern New England:

Nitrogen removal performance, greenhouse gas emissions and climate change woes

Alissa Cox

Bianca Ross

Sara Wigginton

THE UNIVERSITY OF RHODE ISLAND

Disclaimer

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Special thanks to:

RI DEM

TOWN OF CHARLESTOWN

MASSTC The Massachusetts Alternative Septic System Test Center

NEIWPCC New England Interstate Water Pollution Control Commission

BCDHE Barnstable County Department of Health and Environment Promote - Protect - Support 90 YEARS OF SERVICE 1926 - 2016

THE UNIVERSITY OF RHODE ISLAND

Who are we?

Laboratory of Soil Ecology & Microbiology @ URI

- **Jose Amador**, Principal Investigator
- **George Loomis**, Director of New England Onsite Wastewater Training Program
- PhD Students:
  - **Alissa Cox**
  - **Bianca Ross**
  - **Sara Wigginton**

L S E M

Laboratory of Soil Ecology & Microbiology
University of Rhode Island

Protecting Southern New England's Coasts

Protecting humans and the environment from OWTS

Narragansett, RI algal blooms
Caused by N pollution

N-removal I&A Technologies

N-removal Soil Treatment Areas

Monitoring N Removal

Protecting Southern New England's Coasts

Protecting OWTS from Coastal Hazards

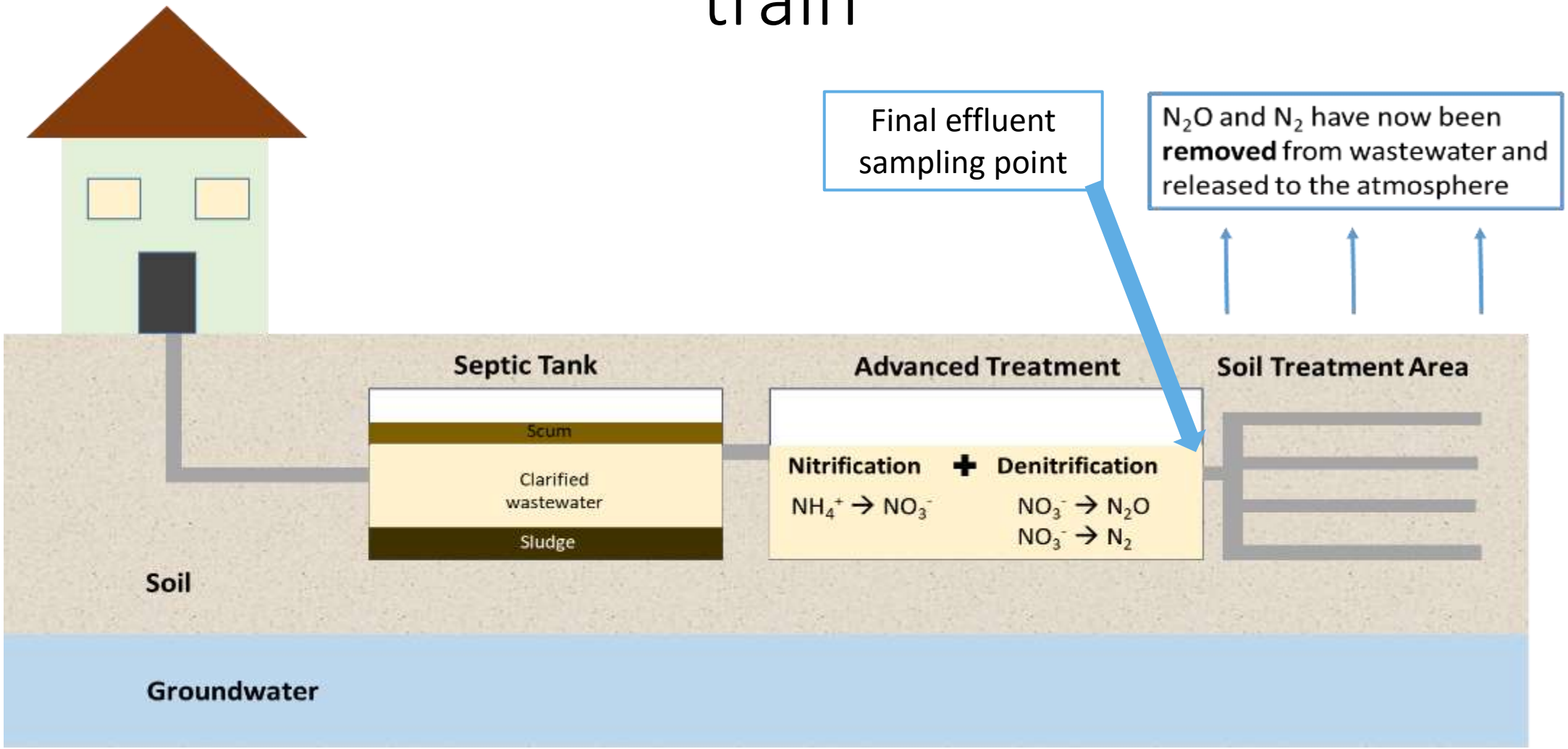
Rising Groundwater

Coastal Storms

Assessing Nitrogen-removal performance of Advanced Onsite Wastewater Treatment Systems in Charlestown

Bianca Ross

Advanced OWTS: Nitrogen removal treatment train



Project Description

- **46 study sites** in Charlestown, RI
  - **27 seasonally-occupied** – sampled 4 times throughout the summer
  - **23 year-round** – sampled quarterly throughout the year
- Field and lab analyses on final effluent to assess **system performance and N-removing effectiveness**
- **Optimize N removal**

Technologies

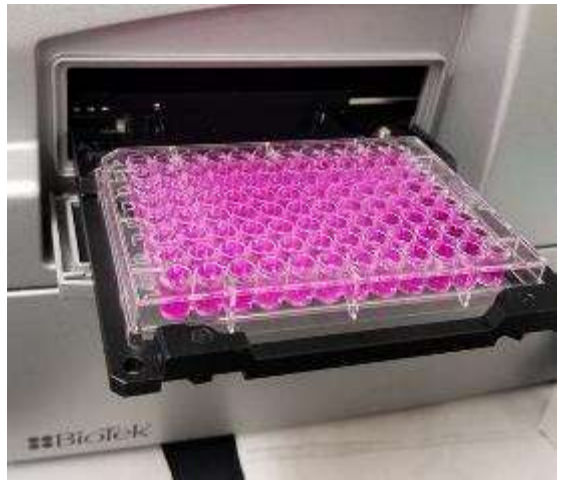
- Orenco Advantex® AX20 and RX30
- Biomicrobics MicroFAST®
- Norweco Singulair® models TNT, 960, and DN
  - Grouped all Norweco systems for statistical analyses

Sample Collection and Processing

Arrive at field site

Collect final effluent sample

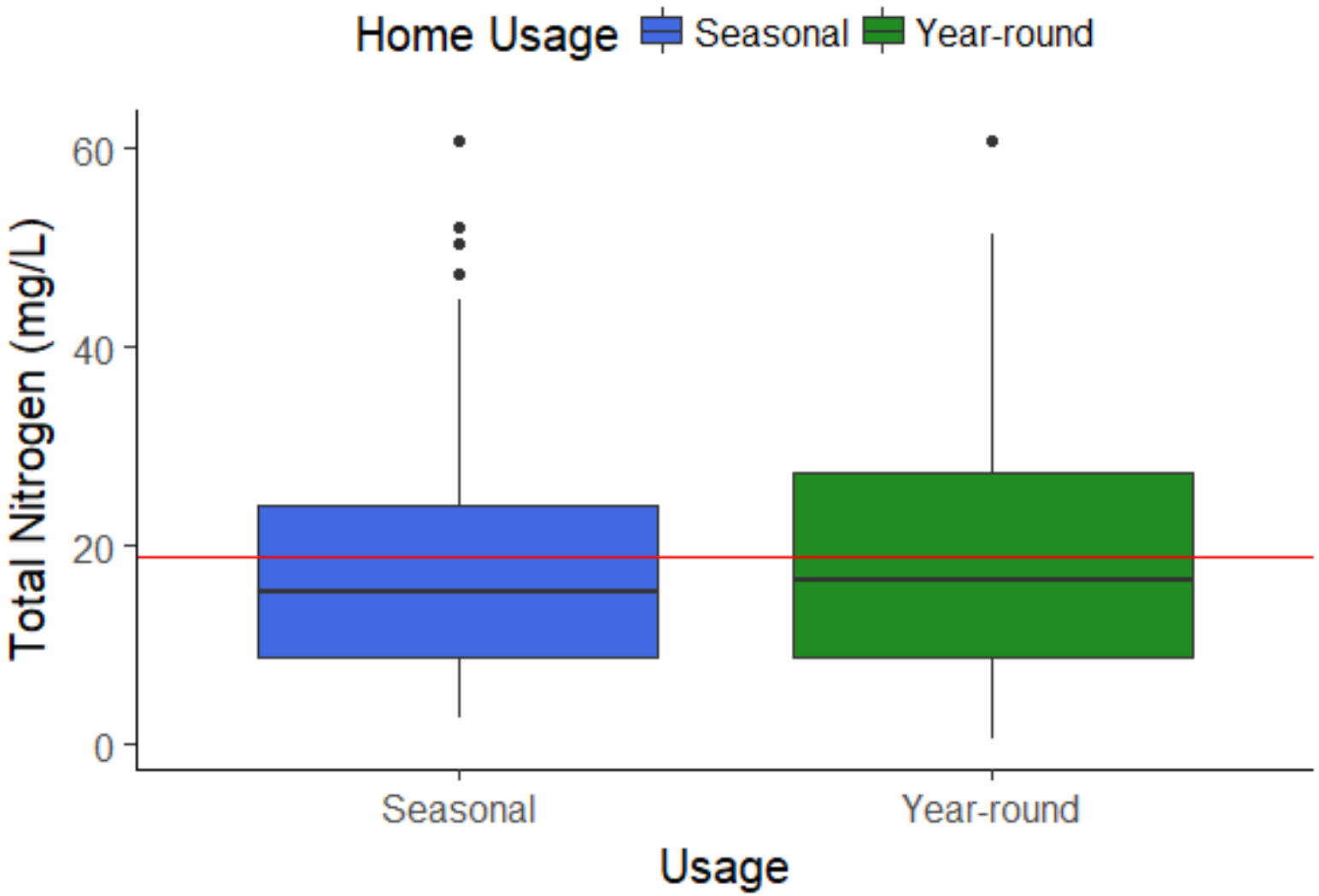
Field analysis (pH, DO, temperature, NH_4^+, and NO_3^-)



Standard lab analysis (BOD, pH, alkalinity, TN, NH_4^+, and NO_3^-)

Total Nitrogen Analysis

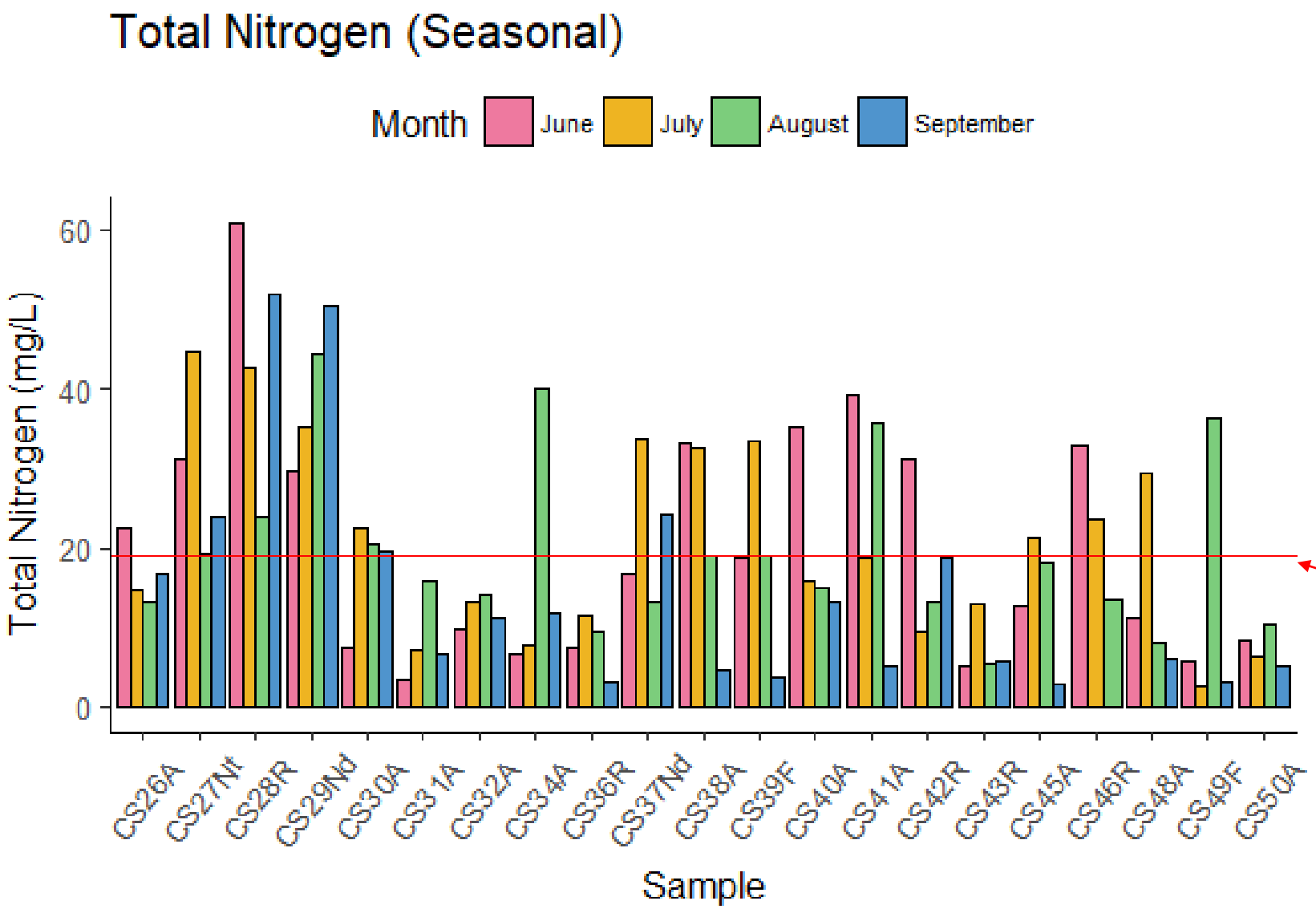
Total Nitrogen vs. Home Usage



Home usage: not significant

19 mg/L RIDEM standard

Total Nitrogen: Seasonal Start-up Time?

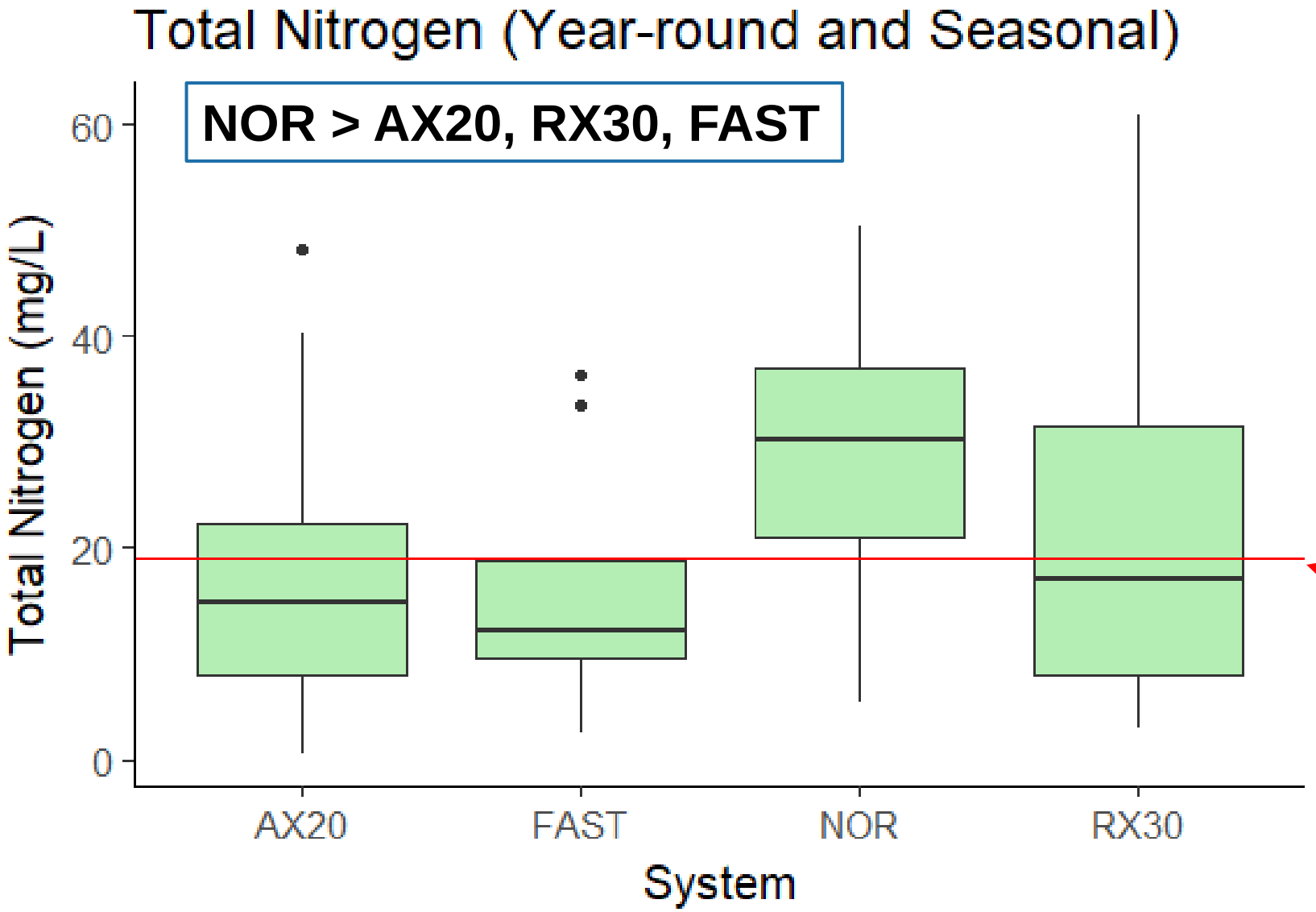


Home usage is **not** influencing performance

Sample Code Key:
A = AX20
R = RX30
F = FAST
Nt/Nd = Norweco

19 mg/L RIDEM standard

Total Nitrogen vs. Technology Type



Technology type: significant

19 mg/L RIDEM standard

So far…

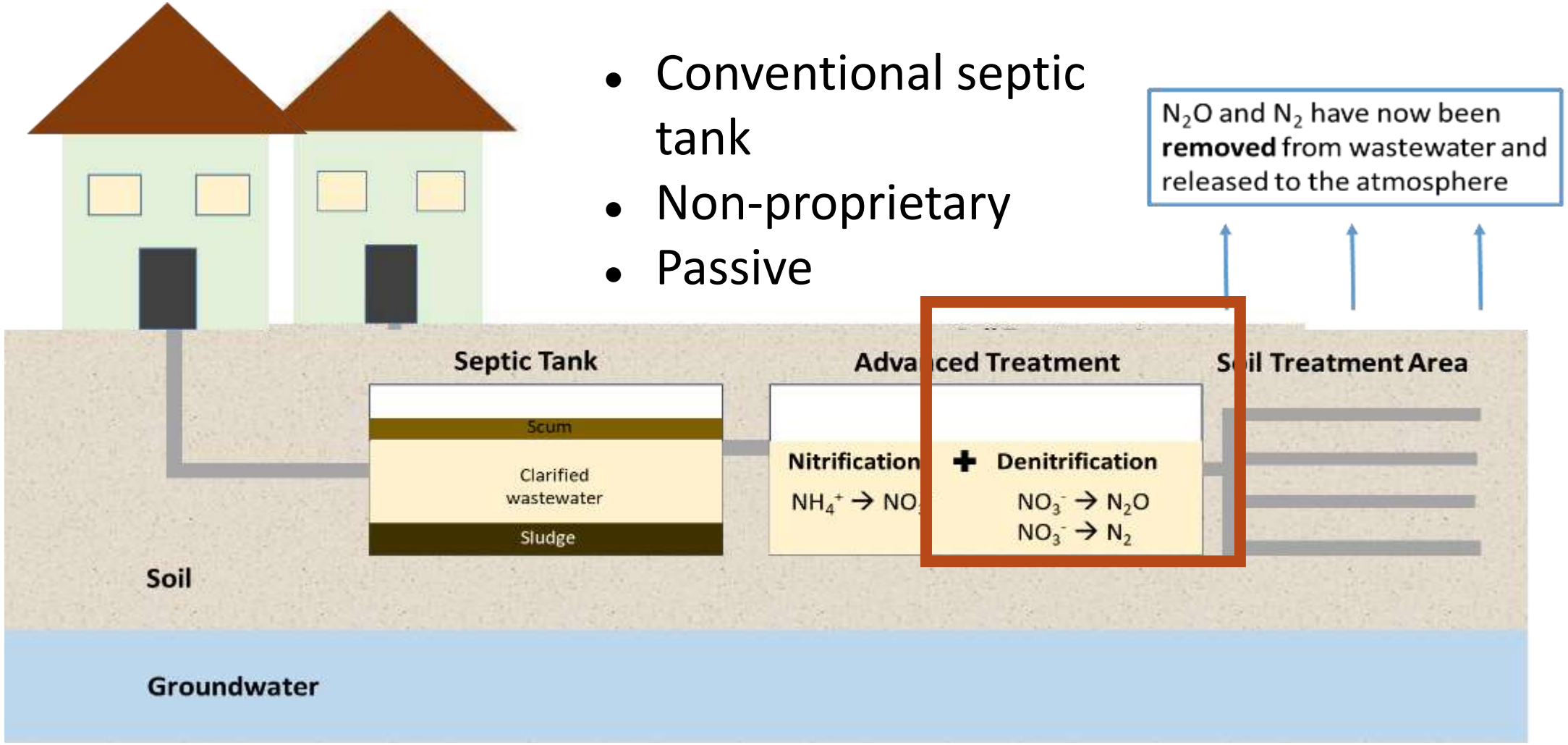
- Technology type does influence effluent total nitrogen concentrations
- BOD_5, alkalinity, ammonium, and total nitrogen data suggest that Norweco systems don't appear to be nitrifying sufficiently
- Home usage does not influence effluent nitrogen concentrations
  - No start-up time

Assessing performance and greenhouse gas emissions from a passive, nitrogen-removing septic system soil treatment area

Sara Wigginton

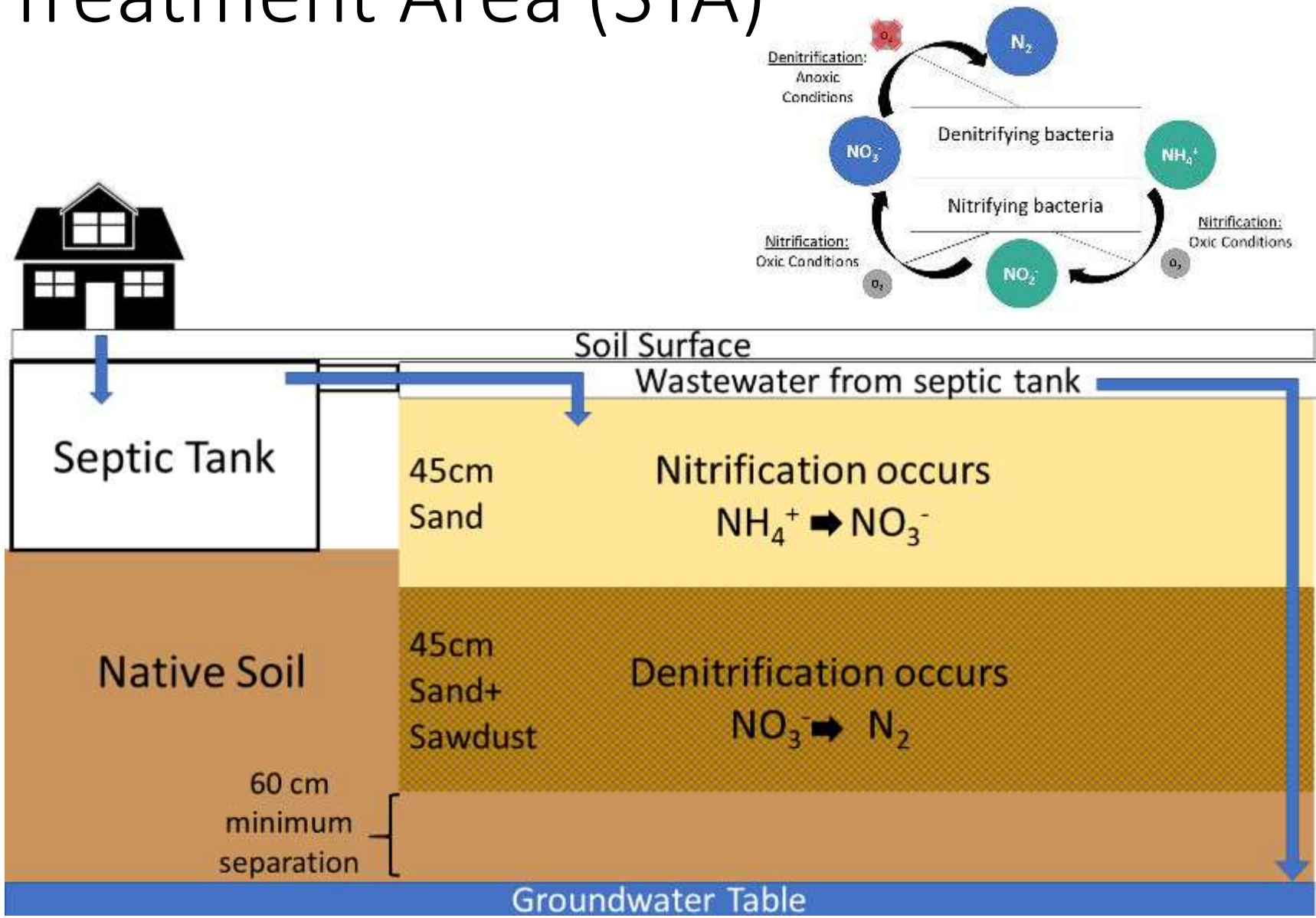
Advanced OWTS: Nitrogen removal treatment train in the STA

- Conventional septic tank
- Non-proprietary
- Passive



N-removing Soil Treatment Area (STA)

- Promotes nitrification in the top layer and denitrification in the lower layer.
- Sawdust amended sand gives microbes a **carbon source** and keeps bottom layer **saturated**



Research objectives:

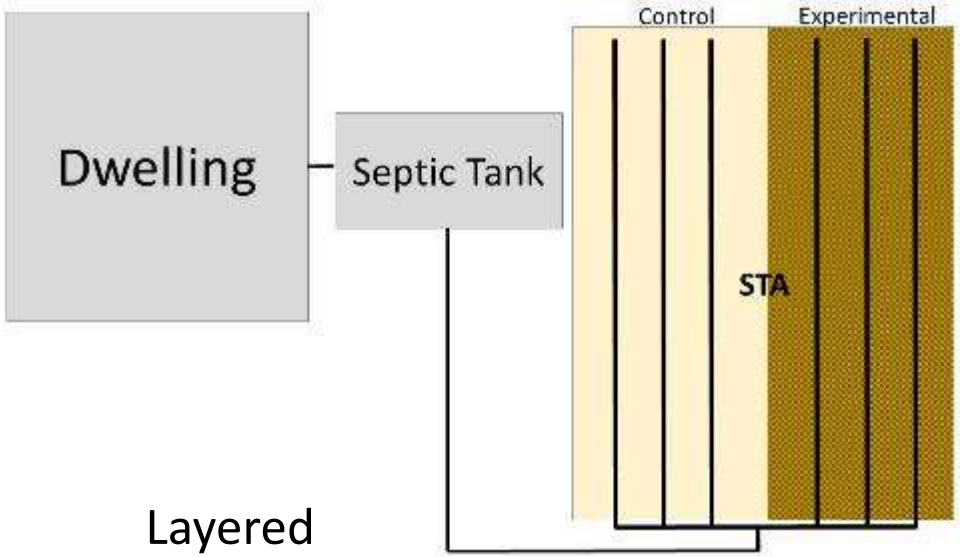
Assess N removal performance of layered soil treatment areas

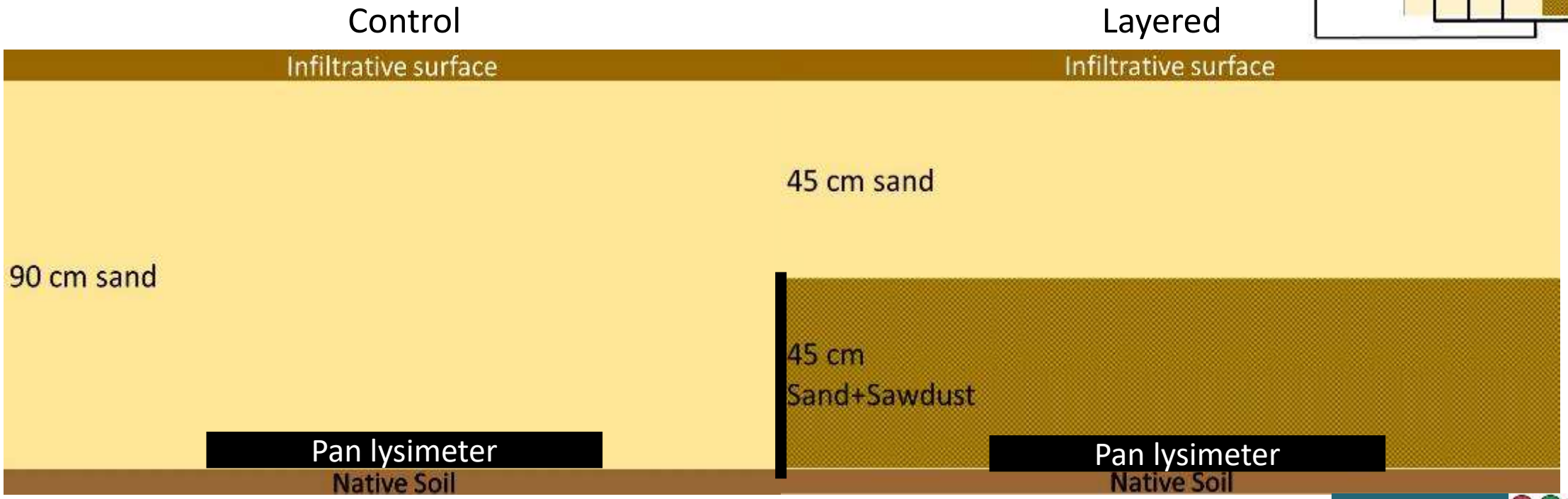
"Are layered systems meeting N removal regulation standards?"

Assess greenhouse gas emissions from layered soil treatment areas

"Are layered systems impacting air quality?"

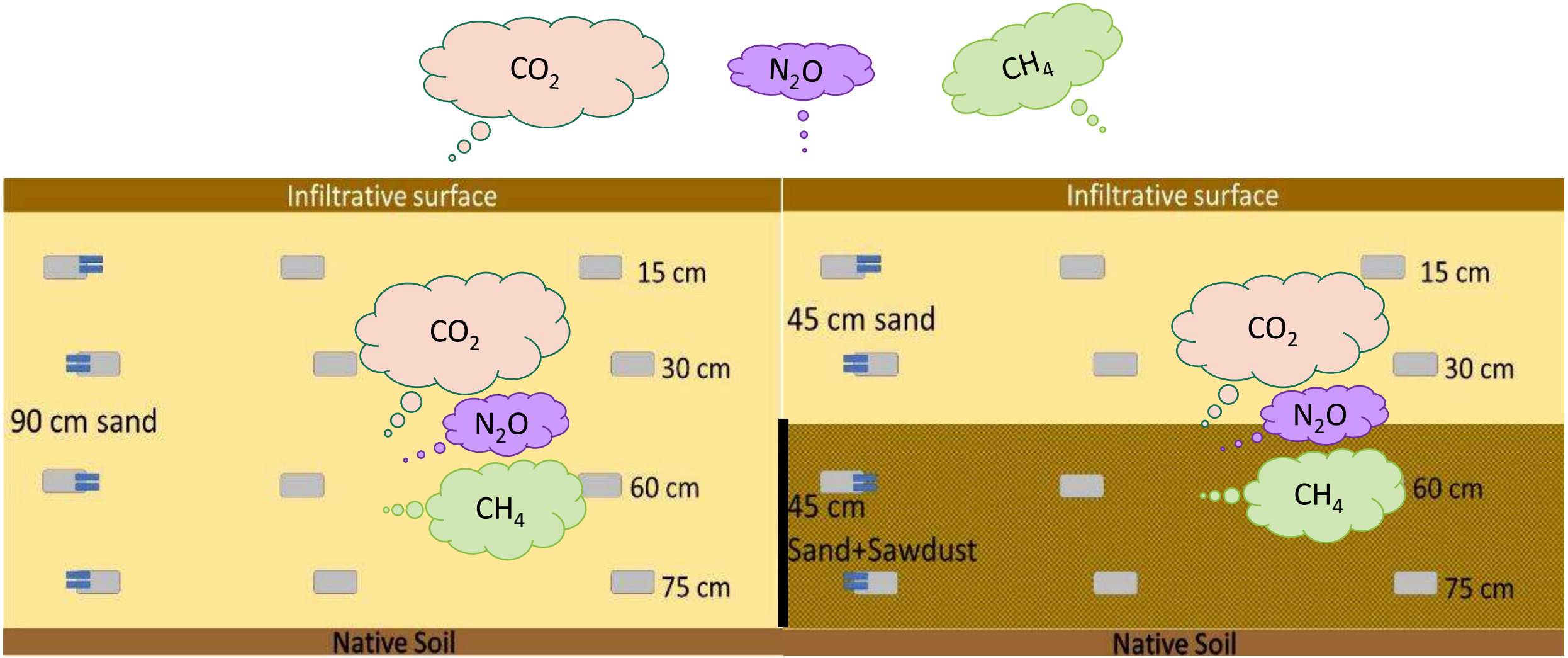
Layered Soil Treatment Areas:
Experimental Design

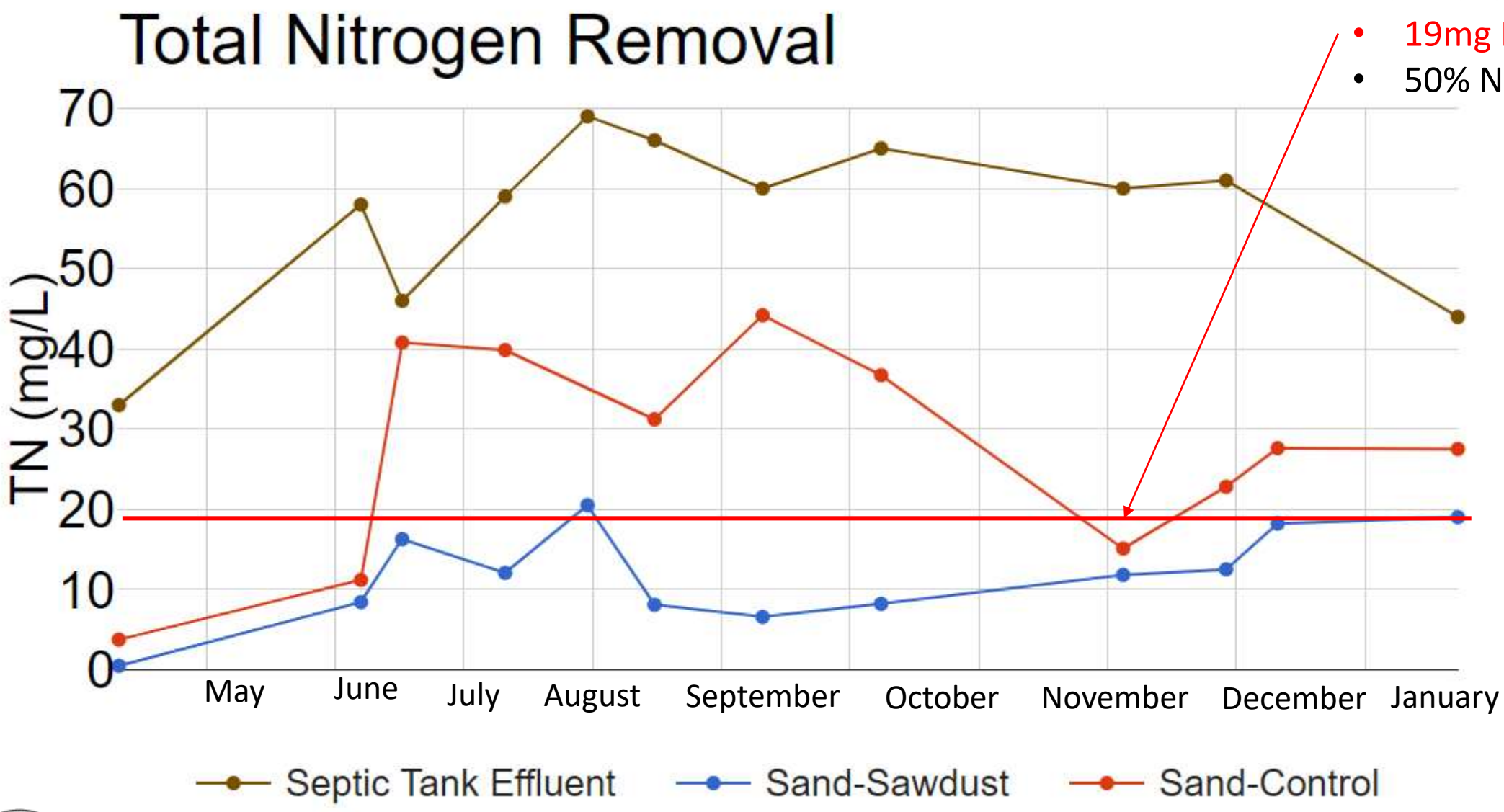




(Cross section)

Monitoring GHG emissions in Layered STAs: *Methods*





Massachusetts regulations:

- 19mg N/L in effluent
- 50% N removal

%N removal from Layered STA: 65-98%

%N removal from Control STA: 11-88%

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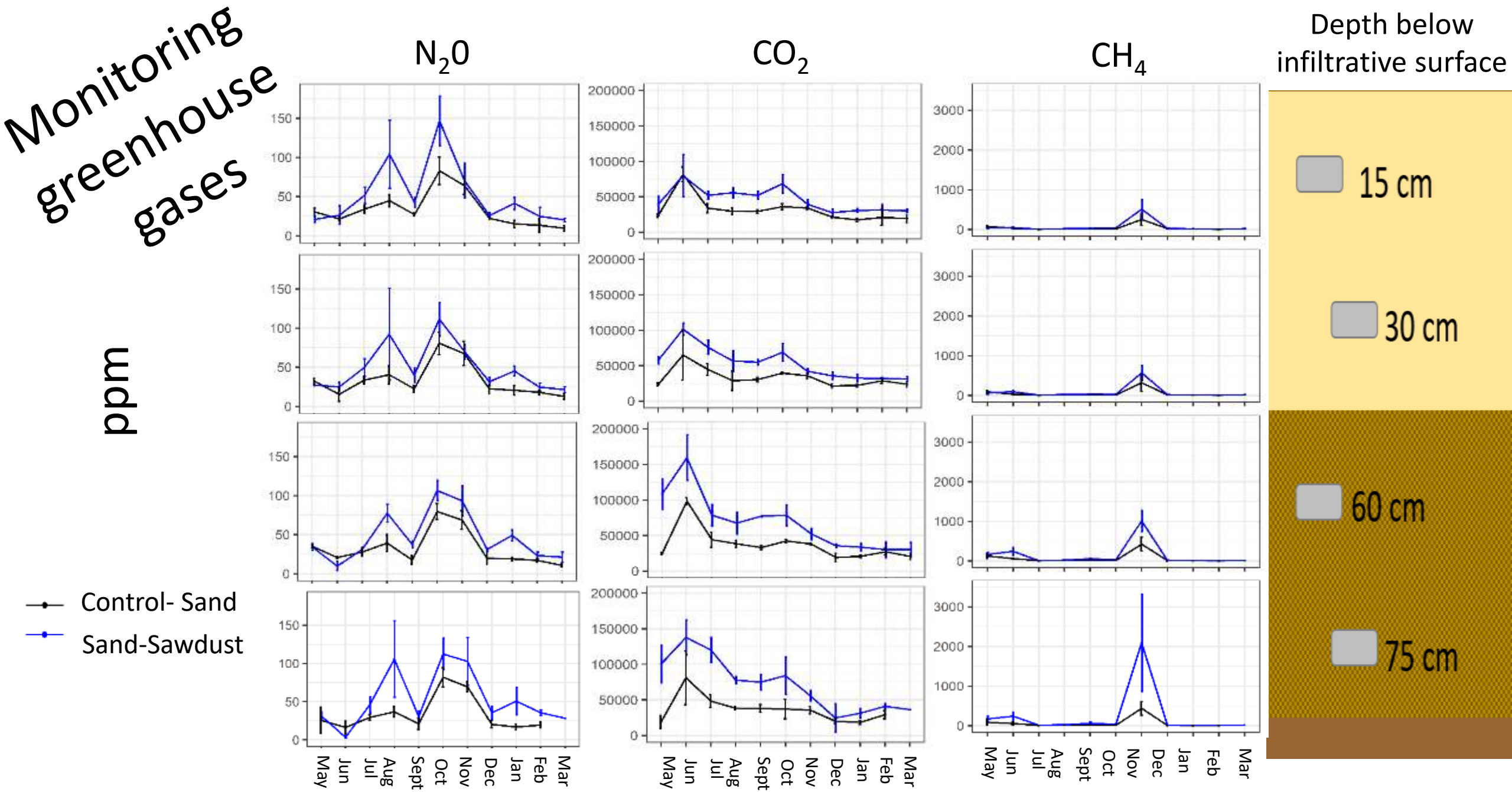
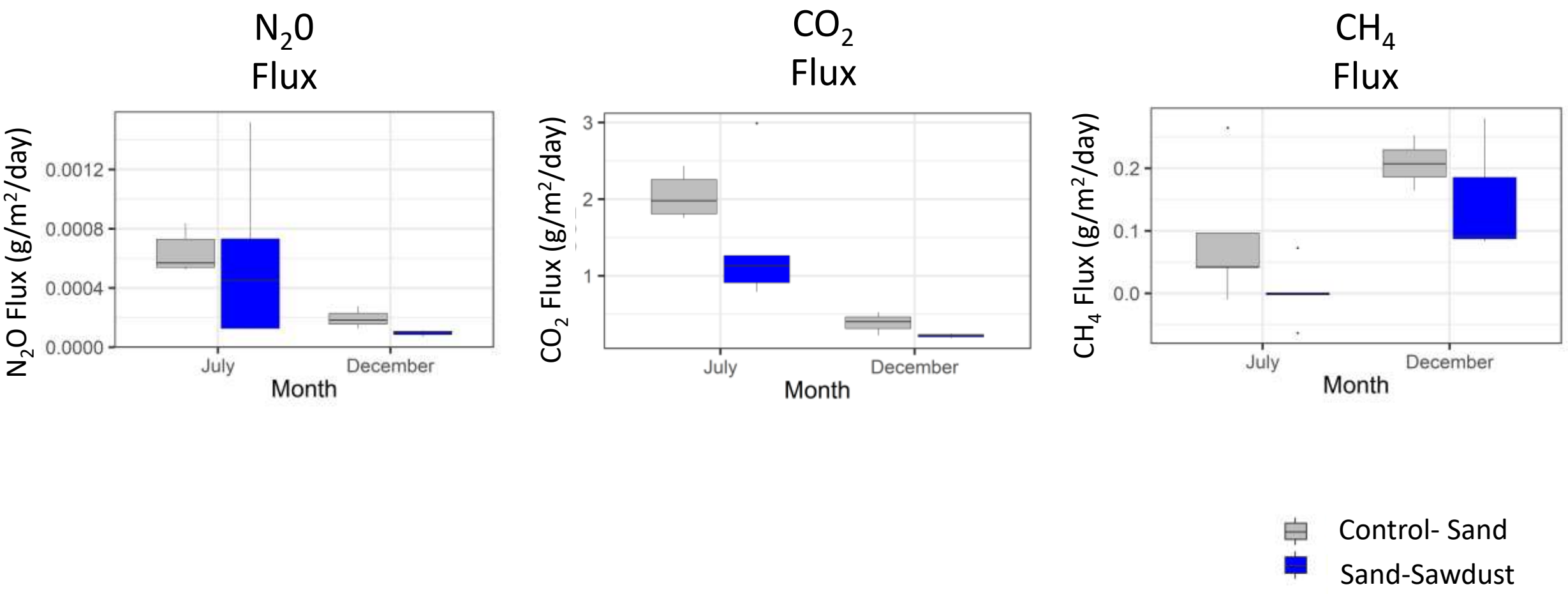
Monitoring greenhouse gases



Monitoring emissions at the soil surface



Layered Soil Treatment Areas: *Findings*

- Layered STA removes N more consistently than control
  - Layered STA meets Massachusetts regulations in 100% of samples
  - Control STA meeting standards in less than 40% of samples
- Layered STA produced more GHGs than control below the surface

BUT…

- Layered STA emitted less GHGs to the atmosphere

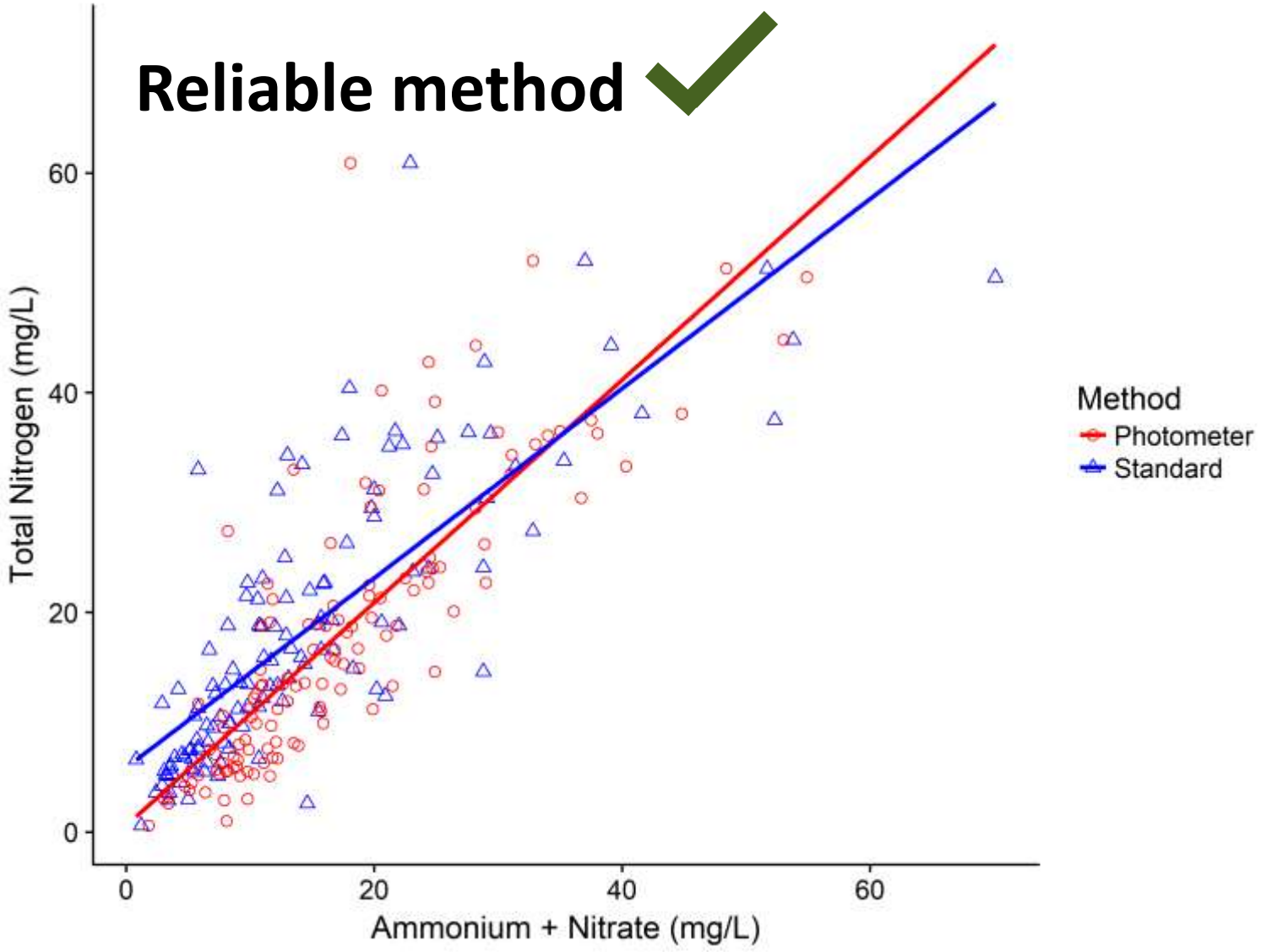
Monitoring OWTS: Photometer

Bianca Ross

Photometer

- Colorimetric reaction measures ammonium and nitrate concentrations
- Total Nitrogen = Ammonium + Nitrate + Organic Nitrogen
- Can the photometer estimate total nitrogen concentrations?
  - Photometer vs. Standard Methods

Sum of Ammonium and Nitrate vs. Total Nitrogen



Standard methods:

Slope = 0.86

Y-intercept = 5.7

$R^2 = 0.64$

$p < 0.001$

Photometer:

Slope = 1.01

Y-intercept = 0.62

$R^2 = 0.68$

$p < 0.001$

Summary

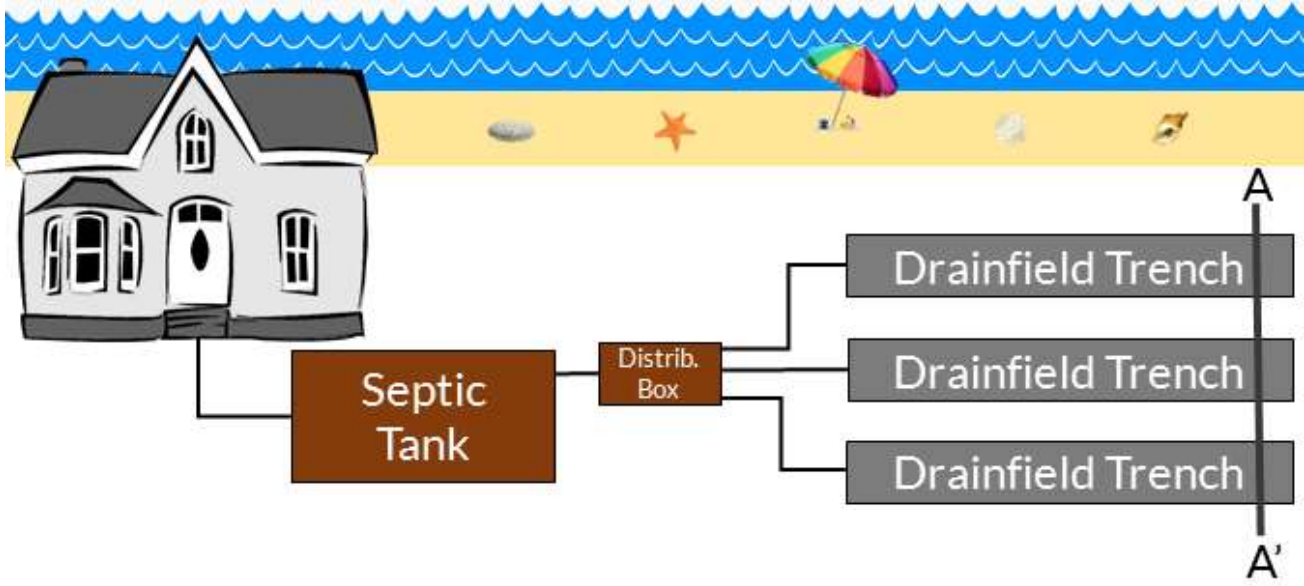
- Fast method that provides nearly immediate results
- Can be used in an outdoor and indoor setting
- Cost-effective
- Reliable “triage” method for identifying underperforming systems

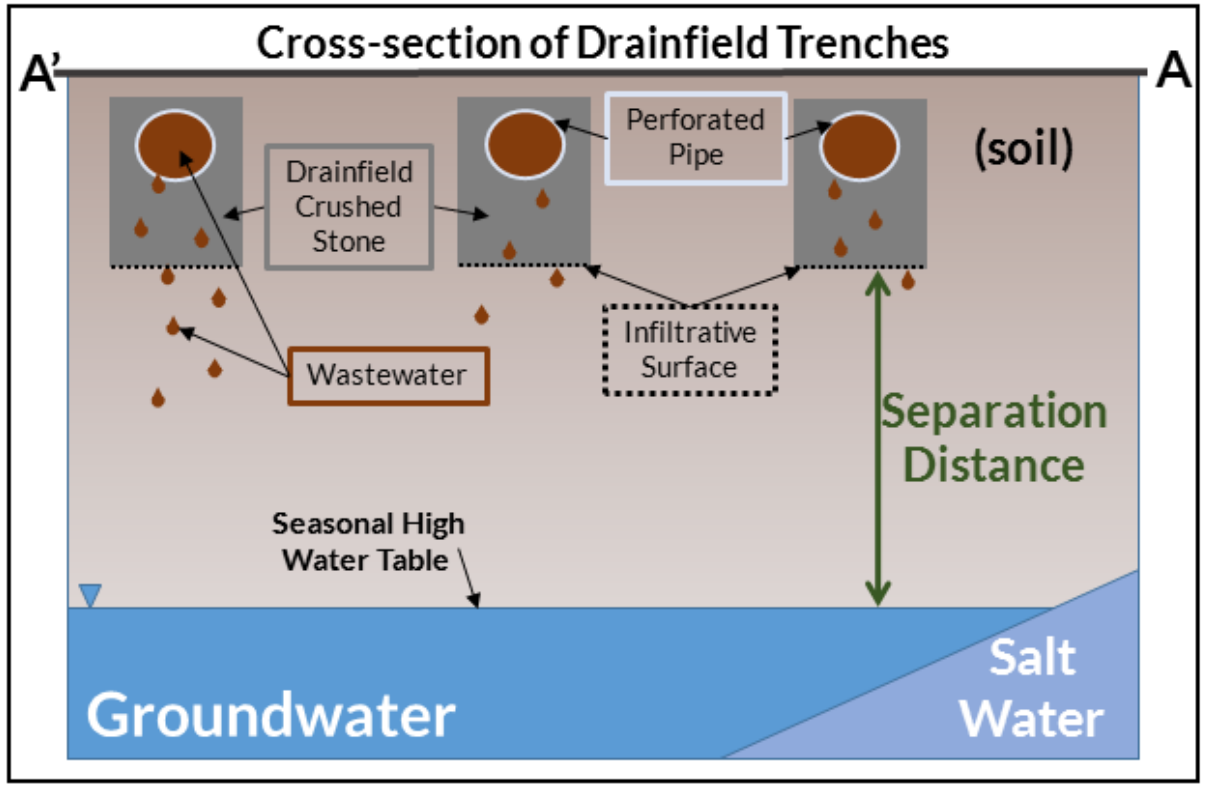
Dual threats to systems along the coast…

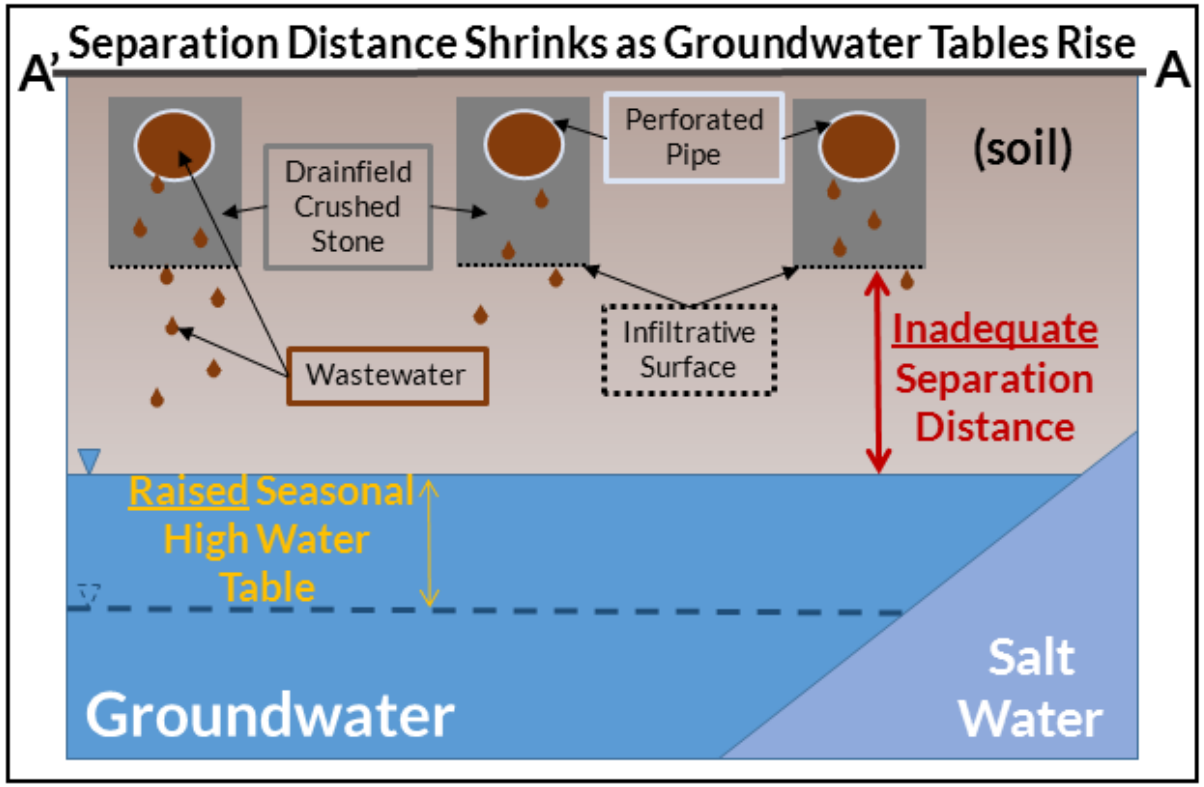
Alissa Cox

Coastal OWTS
Rising groundwater tables
Coastal storms

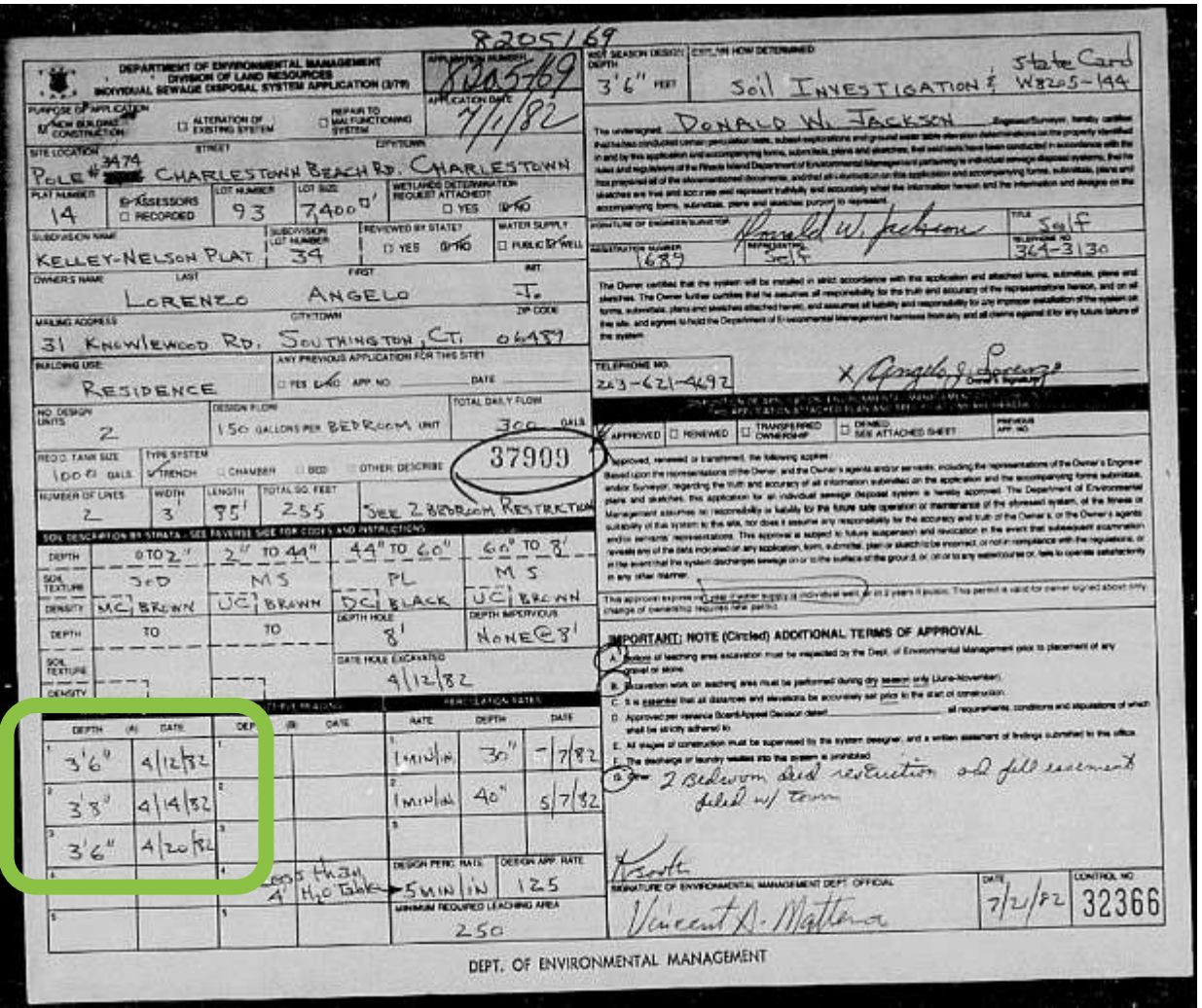
Coastal OWTS







Coastal groundwater tables in southern RI


DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
DIVISION OF LAND RESOURCES
INDIVIDUAL SEWAGE DISPOSAL SYSTEM APPLICATION (3/79)

APPLICATION NUMBER 8205169
APPLICATION DATE 7/1/82
PURPOSE OF APPLICATION: NEW BUILDING CONSTRUCTION; ALTERATION OF EXISTING SYSTEM; REPAIR TO MALFUNCTIONING SYSTEM
SITE LOCATION: POLE # [redacted] CHARLESTOWN BEACH RD. CHARLESTOWN
PLAT NUMBER 14; ASSESSORS / RECORDED; LOT NUMBER 93; LOT SIZE 7400 ft²; WETLANDS DETERMINATION REQUEST ATTACHED: YES / NO
SUBDIVISION NAME: KELLEY-NELSON PLAT; SUBDIVISION LOT NUMBER 34; REVIEWED BY STATE? YES / NO; WATER SUPPLY: PUBLIC / WELL
OWNER'S NAME: LORENZO ANGELO J.
MAILING ADDRESS: 31 KNOLLWOOD RD. SOUTHINGTON, CT. 06489
BUILDING USE: RESIDENCE; ANY PREVIOUS APPLICATION FOR THIS SITE? YES / NO
NO. DESIGN UNITS 2; DESIGN FLOW 150 GALLONS PER BEDROOM UNIT; TOTAL DAILY FLOW 300 GALS
REQ'D. TANK SIZE 1000 GALS; TYPE SYSTEM: TRENCH / CHAMBER / BED / OTHER, DESCRIBE
NUMBER OF LINES 2; WIDTH 3'; LENGTH 85'; TOTAL SQ. FEET 255
SEE 2 BEDROOM RESTRICTION
37909

DEPTH	0 TO 2"	2" TO 44"	44" TO 60"	60" TO 8'
SOIL TEXTURE	SCD	MS	PL	MS
DENSITY	MC BROWN	UC BROWN	DC BLACK	UC BROWN
DEPTH	TO	TO		
SOIL TEXTURE				
DENSITY				

DEPTH HOLE 8'; DEPTH IMPERVIOUS NONE @ 8'; DATE HOLE EXCAVATED 4/12/82

DEPTH	DATE	DEPTH	DATE	RATE	DEPTH	DATE
3'6"	4/12/82			1 MIN/IN	30"	7/7/82
3'8"	4/14/82			1 MIN/IN	40"	5/7/82
3'6"	4/20/82					

DESIGN PERC. RATE 5 MIN/IN; DESIGN APP. RATE 125; MINIMUM REQUIRED LEACHING AREA 250

WET SEASON DESIGN DEPTH 3'6" FEET; DETERMINED BY: SOIL INVESTIGATION & State Card W8205-144
The undersigned DONALD W. JACKSON, Engineer/Surveyor, hereby certifies that he has conducted certain percolation tests, subsoil exploration and ground water table elevation determinations on the property identified in and by the application and accompanying forms, submittals, plans and sketches, that said tests have been conducted in accordance with the rules and regulations of the Rhode Island Department of Environmental Management pertaining to individual sewage disposal systems, that he has prepared all of the aforementioned documents, and that all information on this application and accompanying forms, submittals, plans and sketches are true and accurate and represent truthfully and accurately what the information hereon and the information and designs on the accompanying forms, submittals, plans and sketches purport to represent.
SIGNATURE OF ENGINEER/SURVEYOR: Donald W. Jackson; TITLE: Self; REGISTRATION NUMBER 1685; REGISTRATION SEAL; TELEPHONE NO. 364-3130
The Owner certifies that the system will be installed in strict accordance with this application and attached forms, submittals, plans and sketches. The Owner further certifies that he assumes all responsibility for the truth and accuracy of the representations hereon, and on all forms, submittals, plans and sketches attached hereto, and assumes all liability and responsibility for any improper installation of the system on the site, and agrees to hold the Department of Environmental Management harmless from any and all claims against it for any future failure of the system.
TELEPHONE NO. 263-621-4692; Owner's Signature: X Angelo J. Lorenzo

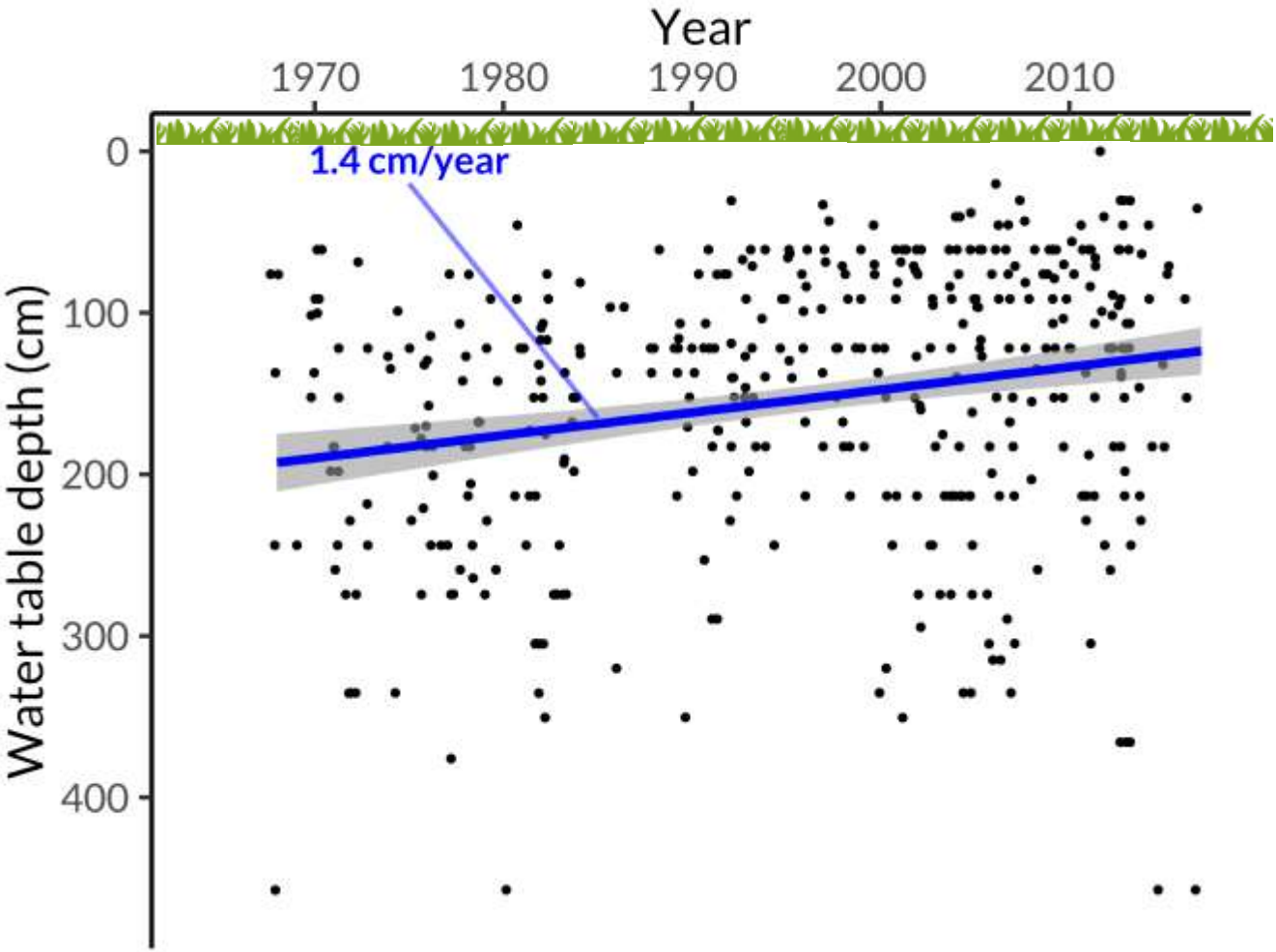
APPROVED / RENEWED / TRANSFERRED OWNERSHIP / DENIED SEE ATTACHED SHEET; PREVIOUS APP. NO.
Approved, renewed or transferred, the following applies:
Based upon the representations of the Owner and the Owner's agents and/or servants, including the representations of the Owner's Engineer and/or Surveyor, regarding the truth and accuracy of all information submitted on the application and the accompanying forms submittals, plans and sketches, this application for an individual sewage disposal system is hereby approved. The Department of Environmental Management assumes no responsibility or liability for the future safe operation or maintenance of the aforesaid system, of the fitness or suitability of this system to this site, nor does it assume any responsibility for the accuracy and truth of the Owner's or the Owner's agents and/or servants' representations. This approval is subject to future suspension and revocation in the event that subsequent examination reveals any of the data indicated on any application, form, submittal, plan or sketch to be incorrect, or not in compliance with the regulations, or in the event that the system discharges sewage on or to the surface of the ground, or on or to any watercourse or, fails to operate satisfactorily in any other manner.
This approval expires on ____ if not under supply is installed within 2 years it public. This permit is valid for owner signed above only. Change of ownership requires new permit.

IMPORTANT: NOTE (Circled) ADDITIONAL TERMS OF APPROVAL
A. Notice of leaching area excavation must be inspected by the Dept. of Environmental Management prior to placement of any gravel or stone.
B. Excavation work on leaching area must be performed during dry season only (June-November).
C. It is essential that all distances and elevations be accurately set prior to the start of construction.
D. Approved per variance Board/Appeal Decision dated _____ all requirements, conditions and stipulations of which shall be strictly adhered to.
E. All stages of construction must be supervised by the system designer, and a written assessment of findings submitted to this office.
F. The discharge of laundry wastes into the system is prohibited.
G. 2 Bedroom deed restriction and fill requirement filed w/ town

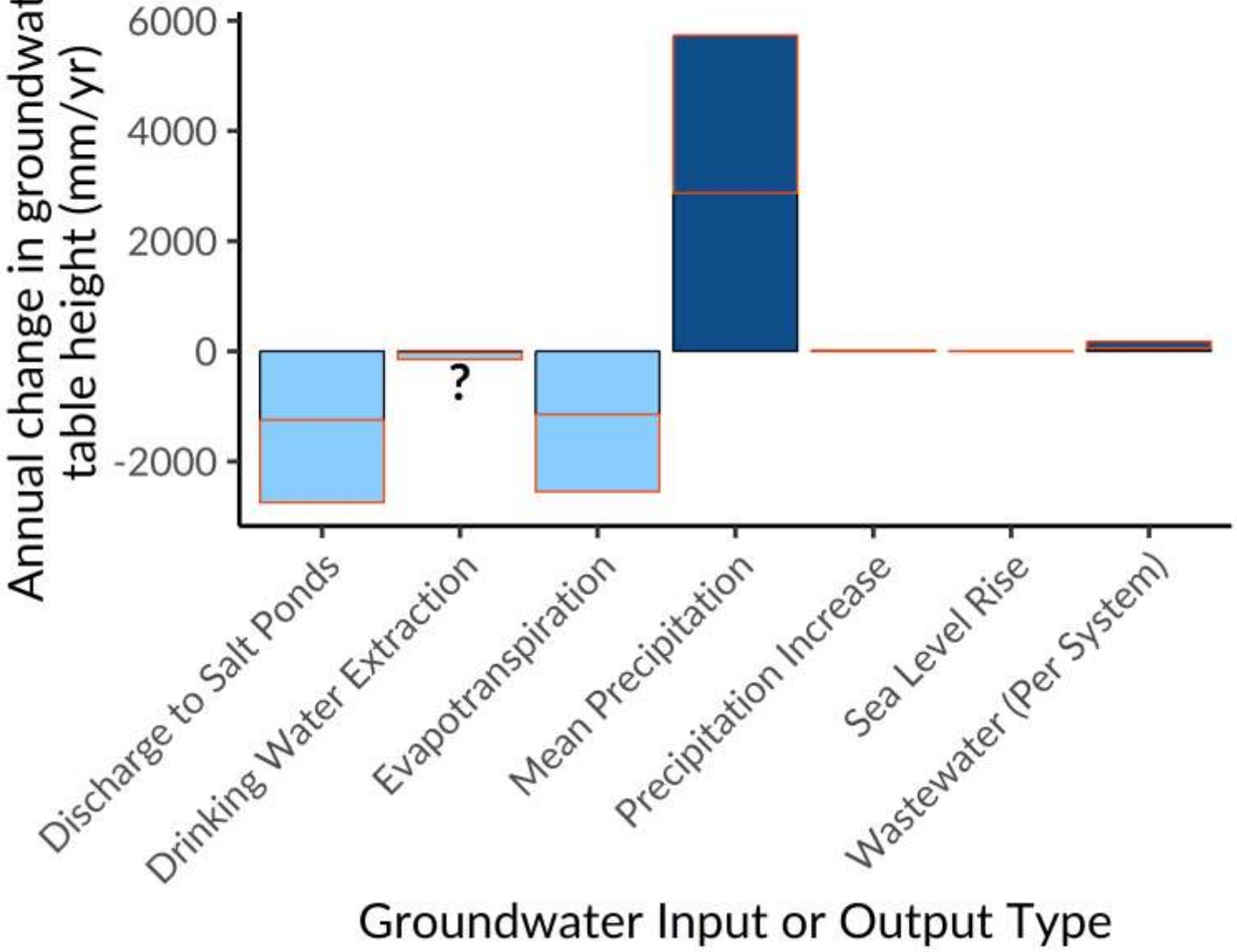
SIGNATURE OF ENVIRONMENTAL MANAGEMENT DEPT. OFFICIAL: Vincent A. Mattera; DATE 7/21/82; CONTROL NO. 32366

DEPT. OF ENVIRONMENTAL MANAGEMENT

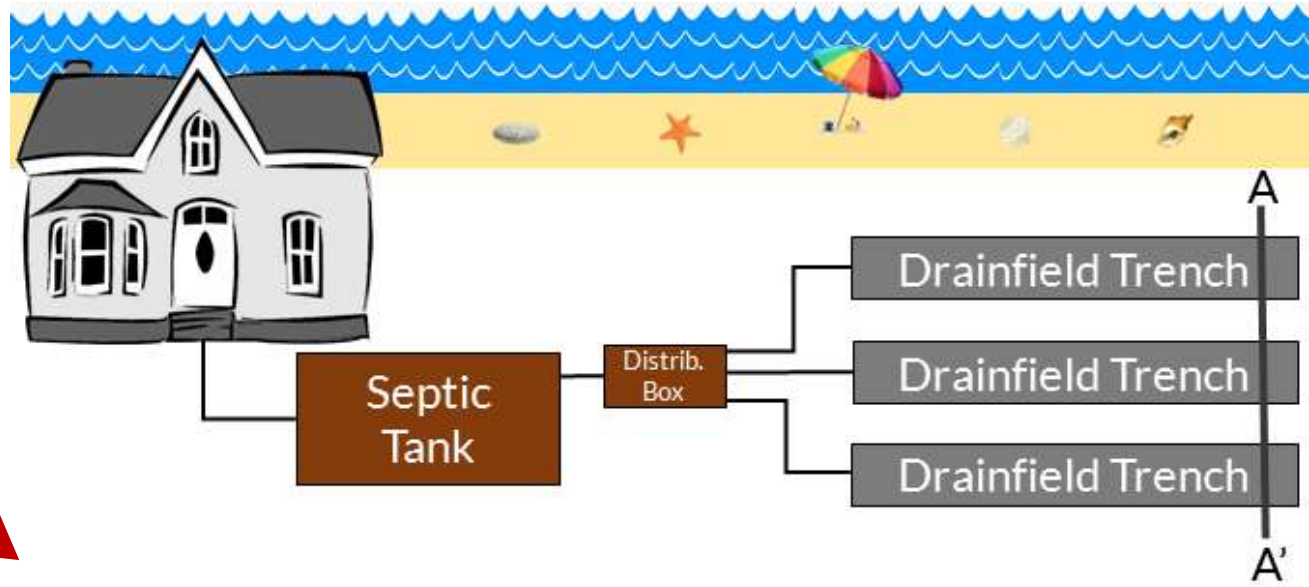
Near-shore groundwater tables along southern RI coast are rising

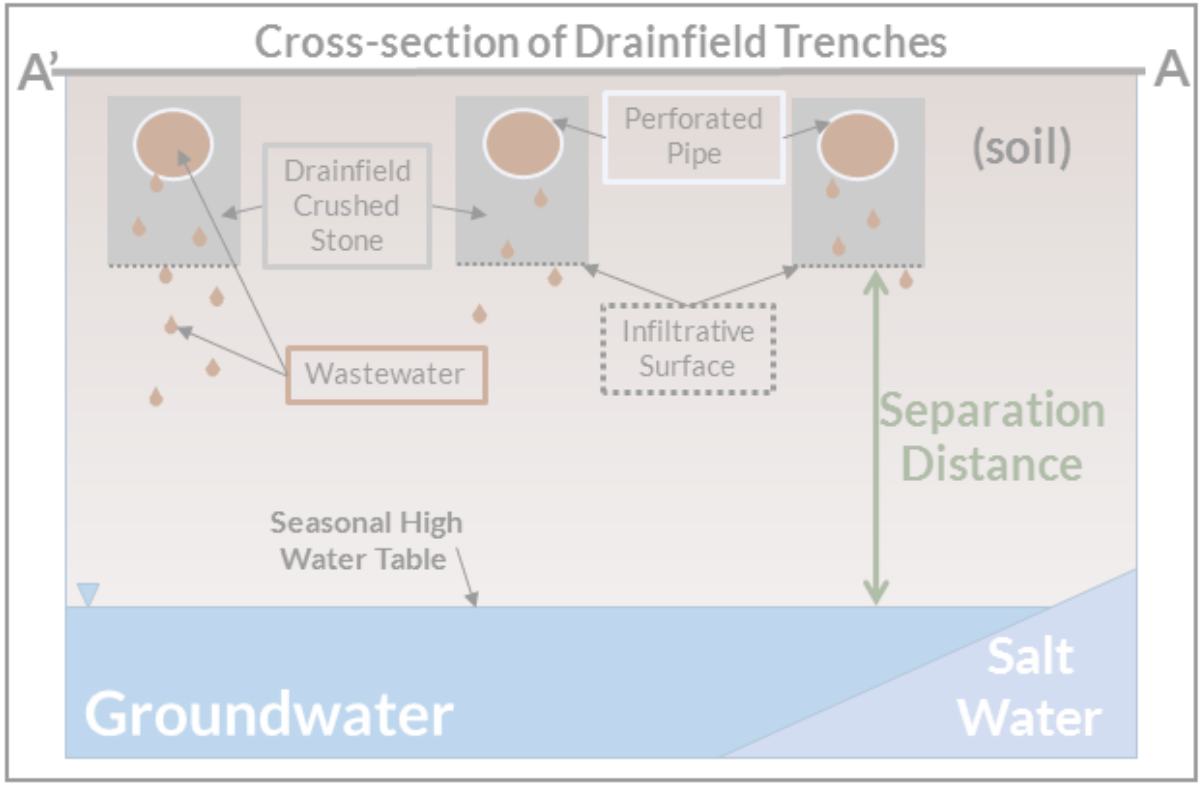


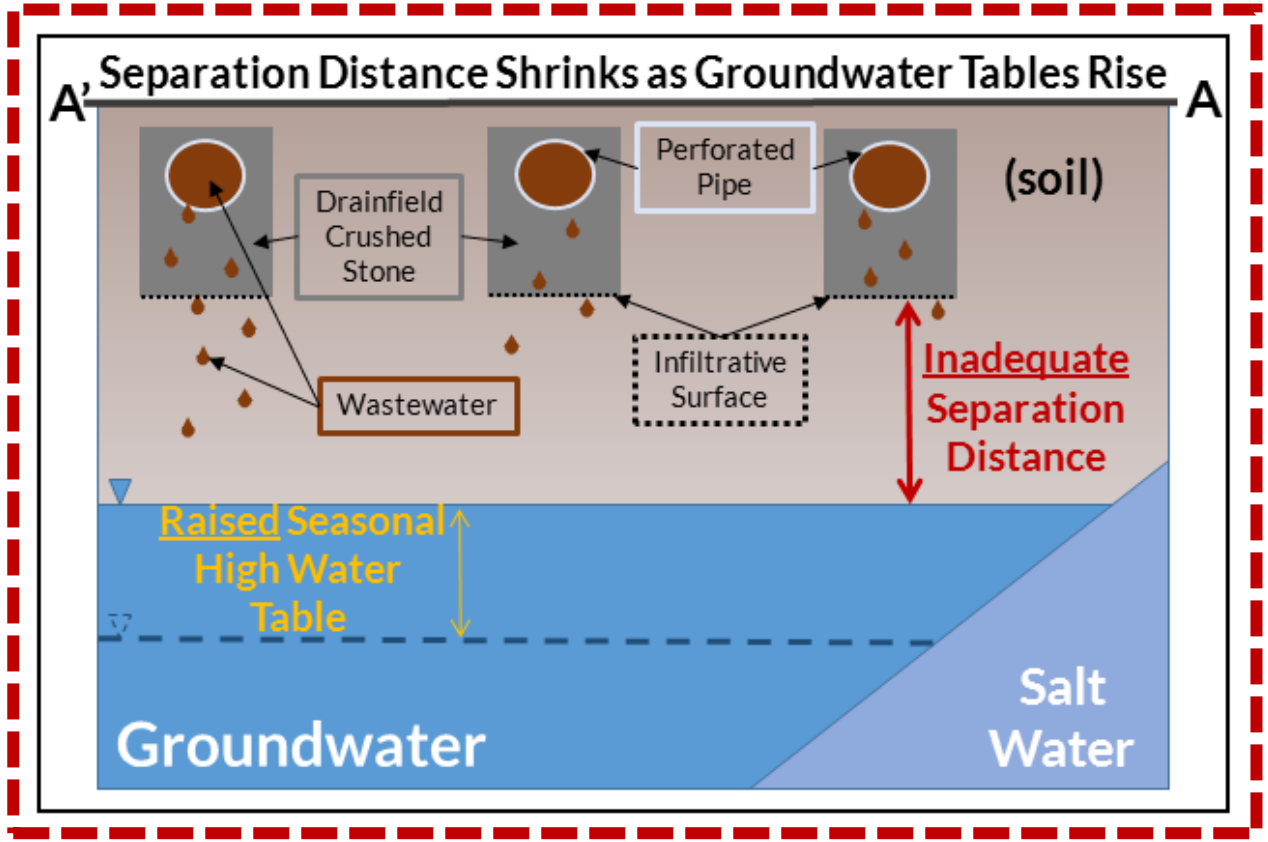
Near-shore groundwater inputs and outputs along southern RI coast



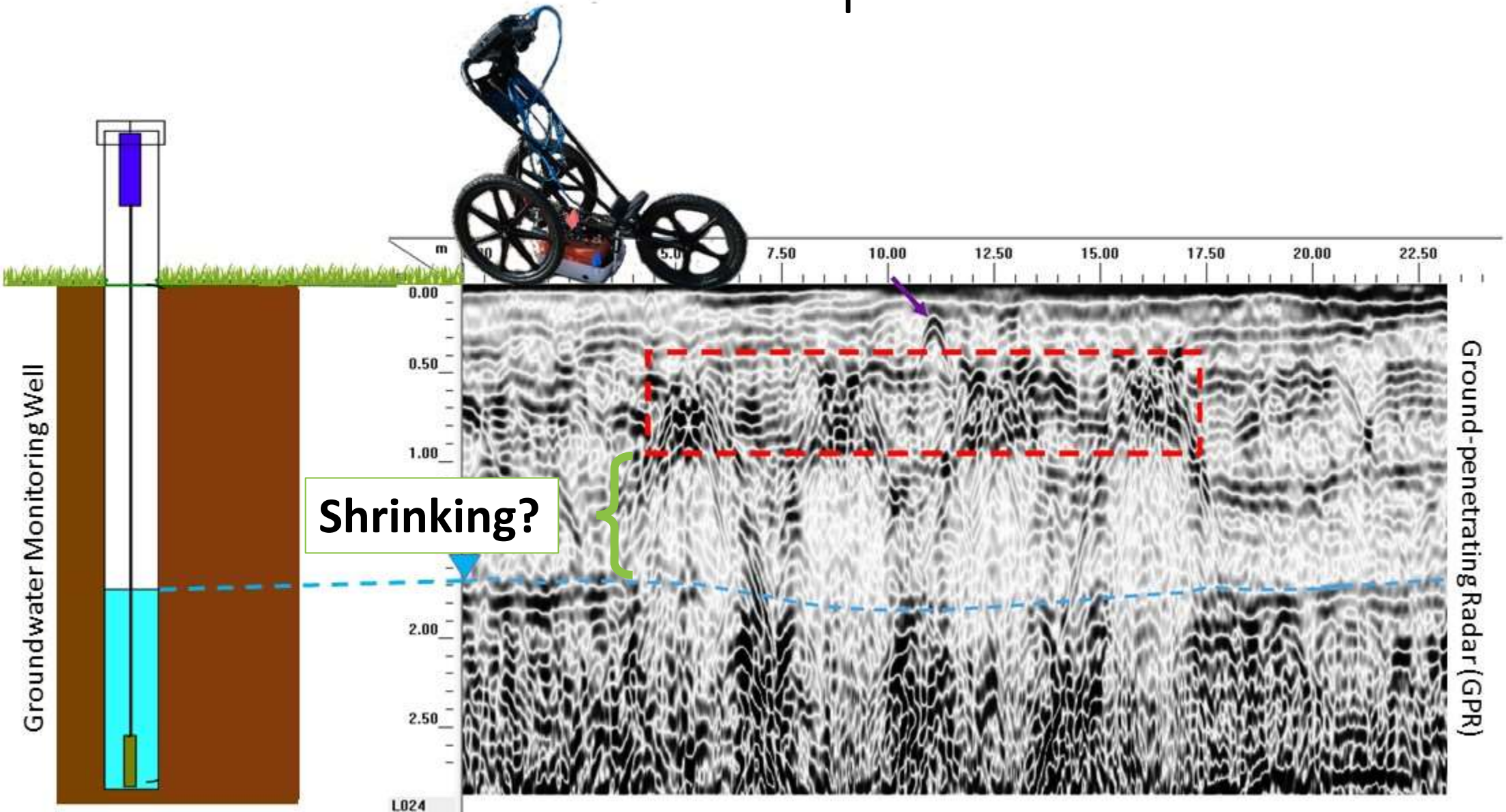
Septic systems along coast are losing separation distance







Groundwater tables: Next Steps

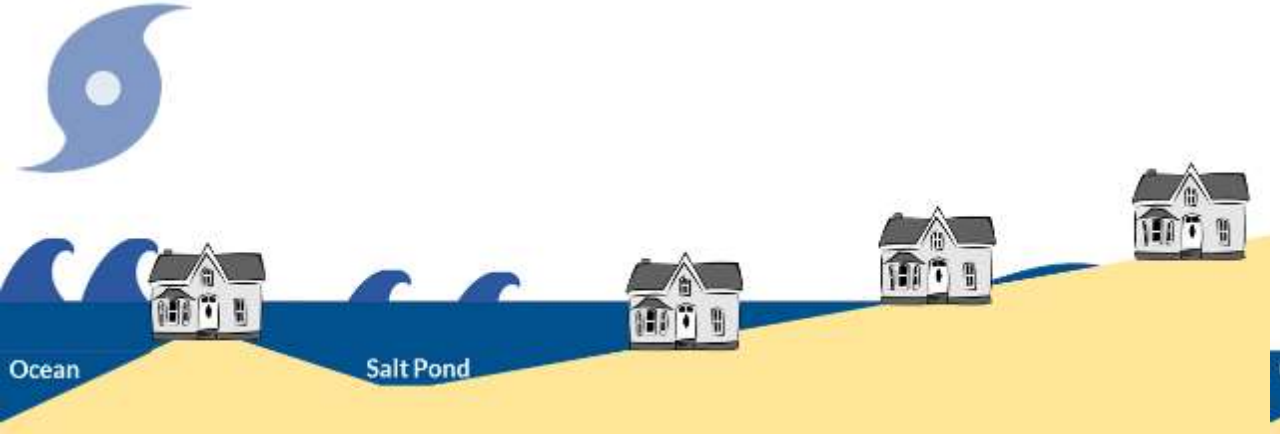


Coastal OWTS
Rising groundwater tables
Coastal storms

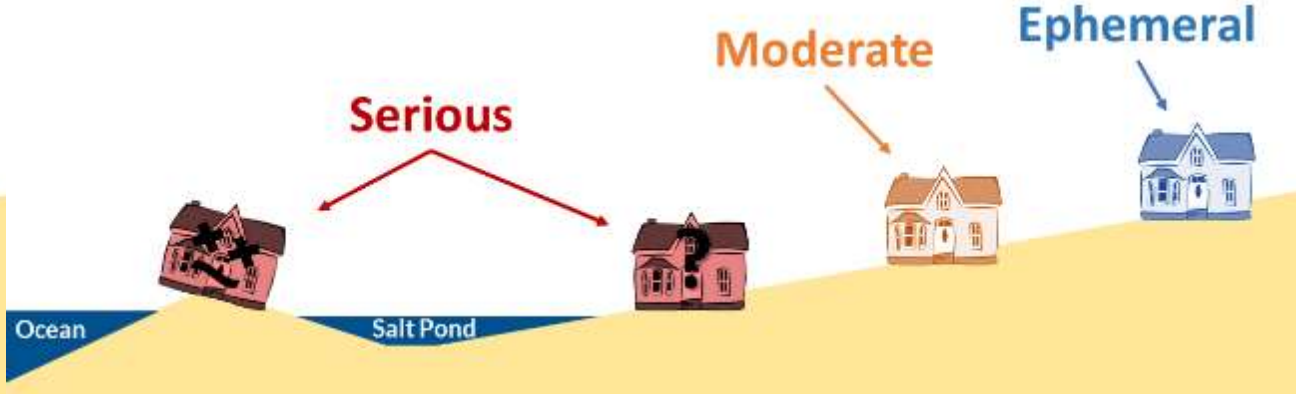
Army Corps proposes raising homes

Modeling storm impacts…

During a Storm:
Flooding and fast-moving water inundates septic systems (especially low-lying and near-shore systems)



After a Storm:
Septic systems may be damaged from long-term flooding or scouring action of fast-moving water

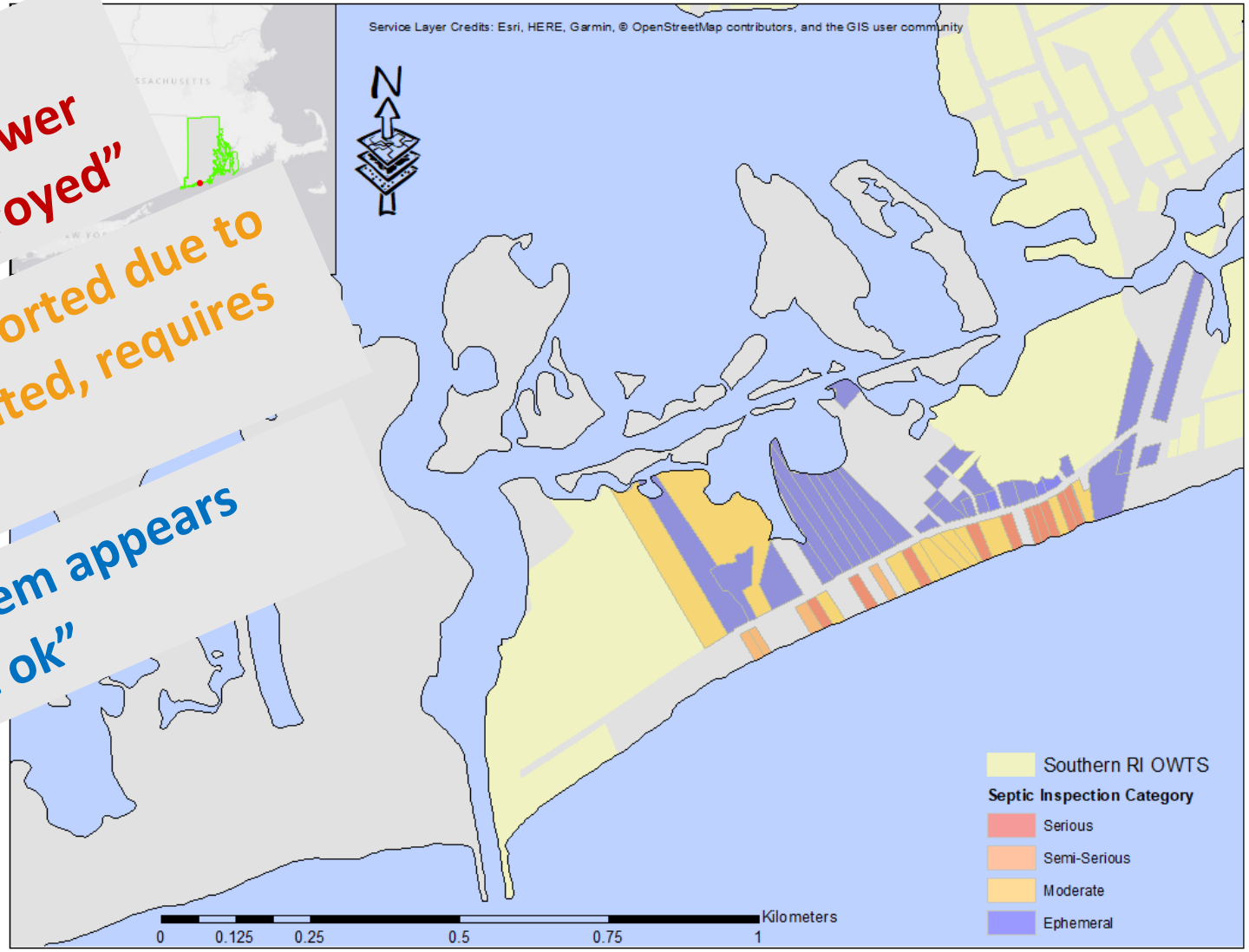


Damage post-Sandy (2012) – Observations from Town Officials

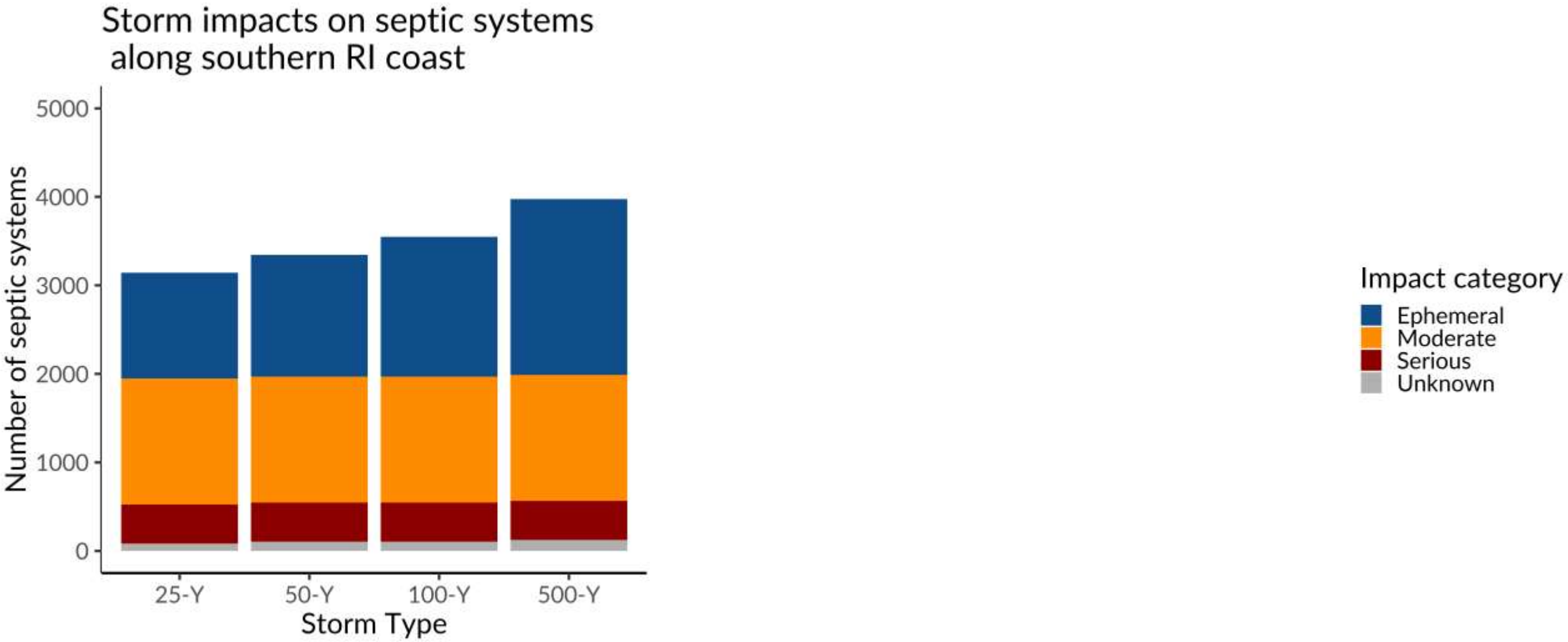
"fully exposed septic tank ocean side undermined, no outlet pipe, building sewer broken, covers off, tank full, likely destroyed"

"system in front, building sewer un-supported due to erosion, appears intact, system inundated, requires assessment"

"building sewer ok, system appears inundated but ok"



Coastal Storms



Why storm damage is concerning for OWTS

- Septic System Repairs & Replacements…
  - Take weeks – months!
  - Expensive!
    - Repairs: $1k – $15k
    - Installing Advanced Treatment Tech: $23k – $30k

…PER SYSTEM!

<u>…what happens to wastewater in the meantime?</u>

→ **???**

Why worry?

Rising Groundwater Tables

Coastal septic systems

Coastal Storms

Failing / failed septic systems

Nutrient & Pathogen Pollution

Contaminated Coastal Waters

Environmental Health Problems

Algal Blooms

Contaminated wells

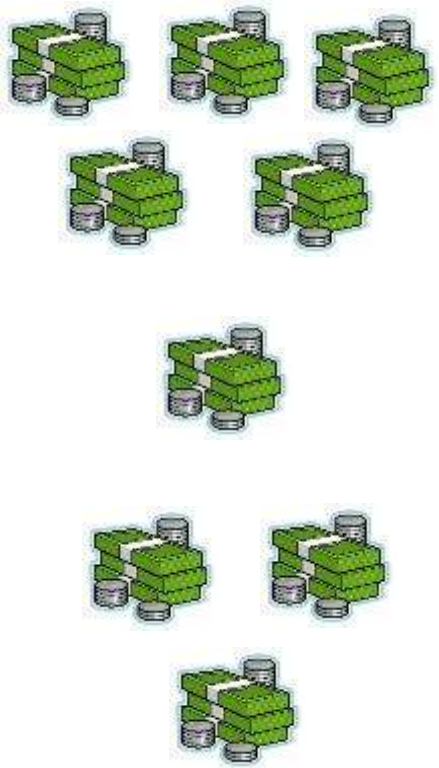
Human Health Problems

Protecting Southern New England's Coasts

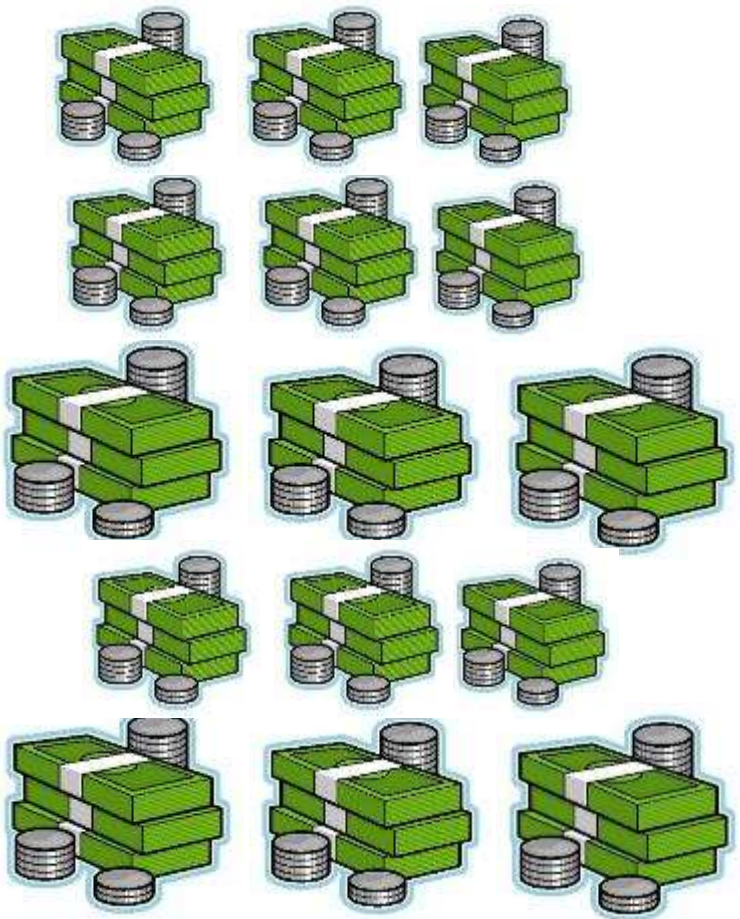
Multi faceted approach:

- Replace Conventional OWTS:
  - I & A Proprietary Tech
  - I & A Non Proprietary Tech
- Monitor and Adjust
- Prepare for climate change:
  - Rising groundwater
  - Storms

Investment



Return



Thank you!

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- Sara Wigginton – sarawigginton@uri.edu

Lab website:
https://sites.google.com/site/soilecologyandmicrobiology/home

LSEM
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