Field Evaluation of Layered Nitrogen-reducing Soil Treatment Areas in Coastal Rhode Island

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TOWN OF CHARLESTOWN

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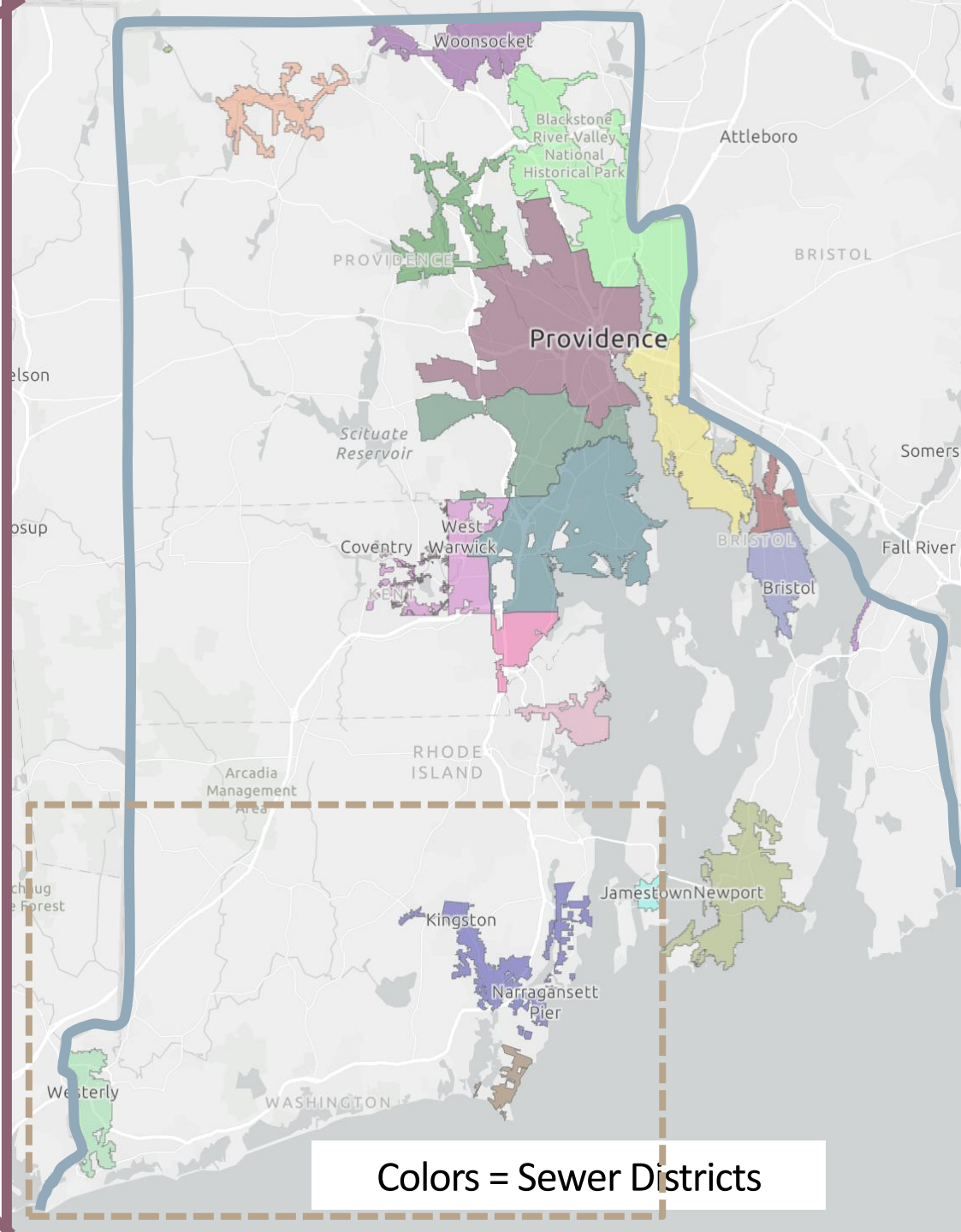THE UNIVERSITY OF RHODE ISLAND

Roadmap for today's talk

- Context - RI

- Layered Nitrogen-Reducing Soil Treatment Area Overview

- LNSTA Site info, Sampling & Analysis Methods

- Performance Data

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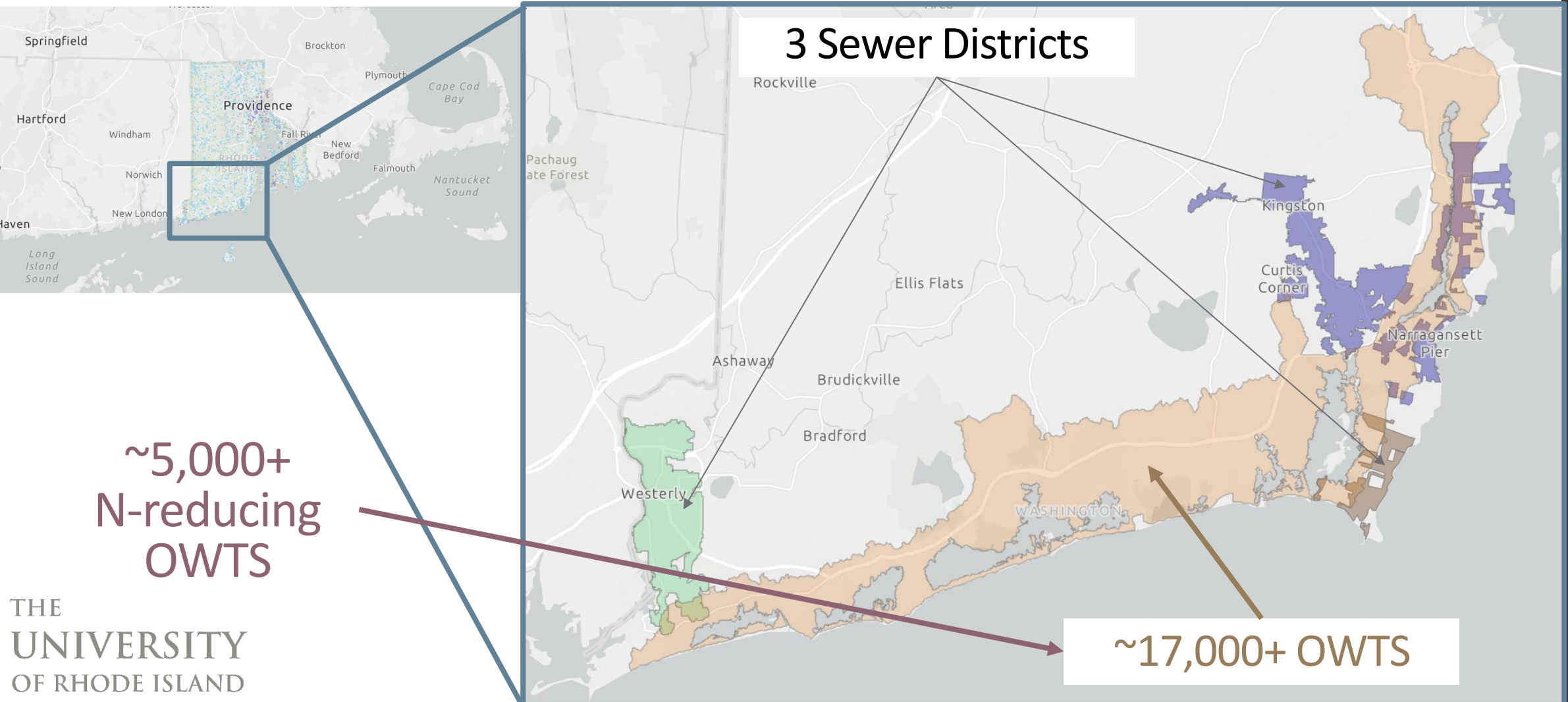
Septic systems everywhere!

Rhode Island, USA

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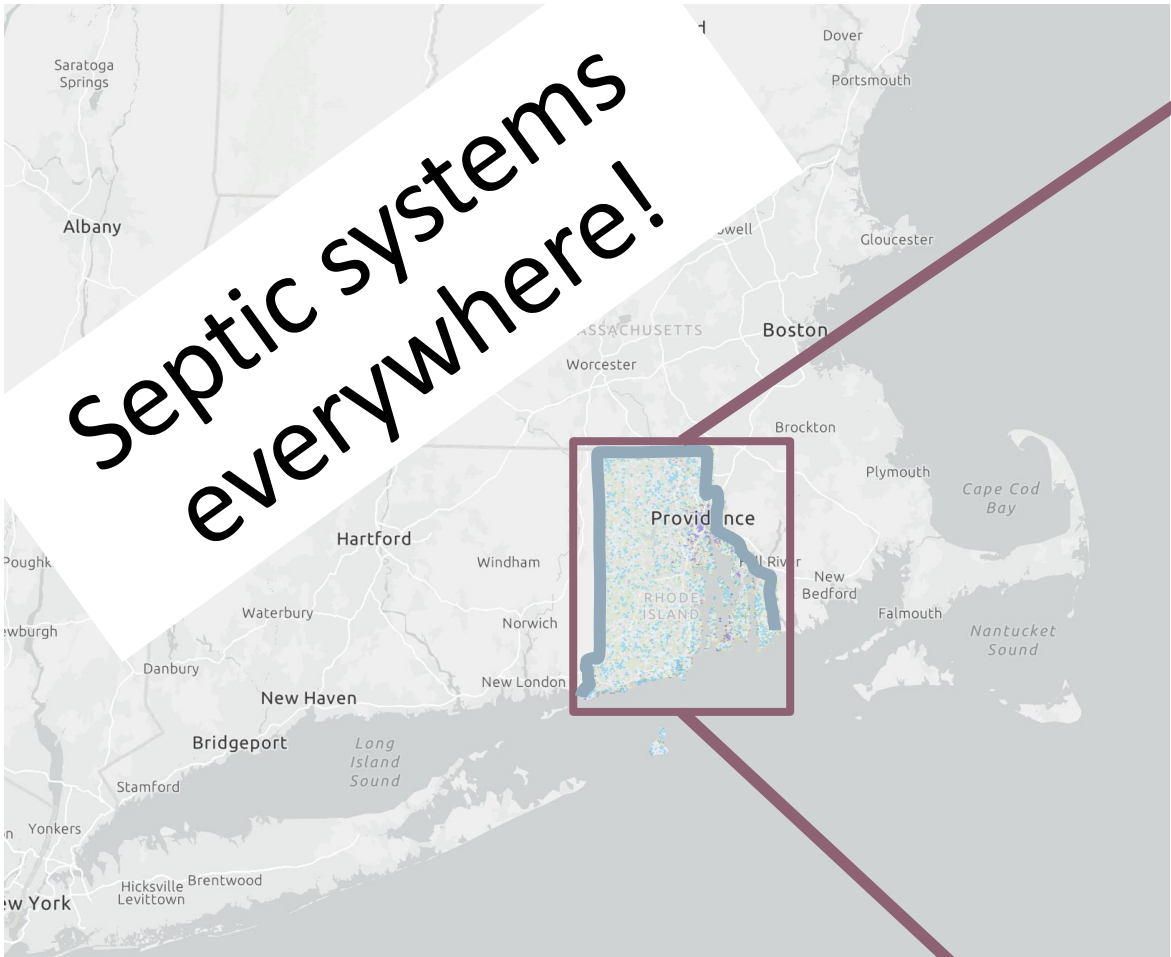
Colors = Sewer Districts

Advanced N-reducing treatment required near the coast since 2008

3 Sewer Districts

~5,000+ N-reducing OWTS

~17,000+ OWTS

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Most advanced N-reducing systems are proprietary technology

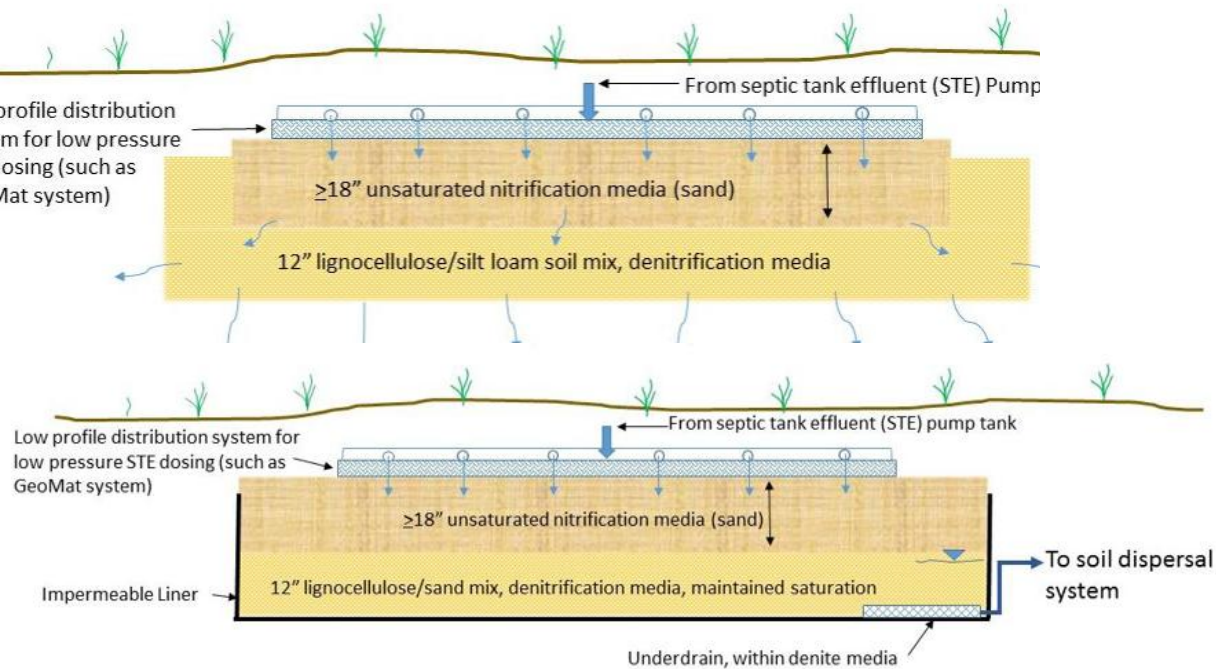Advanced treatment systems include (extra) specially engineered components

Controls

Primary Treatment

Advanced / Secondary Treatment

Bottomless Sand Filter

Soil

Groundw...

Pond / Stream

N from incoming wastewater reduced!
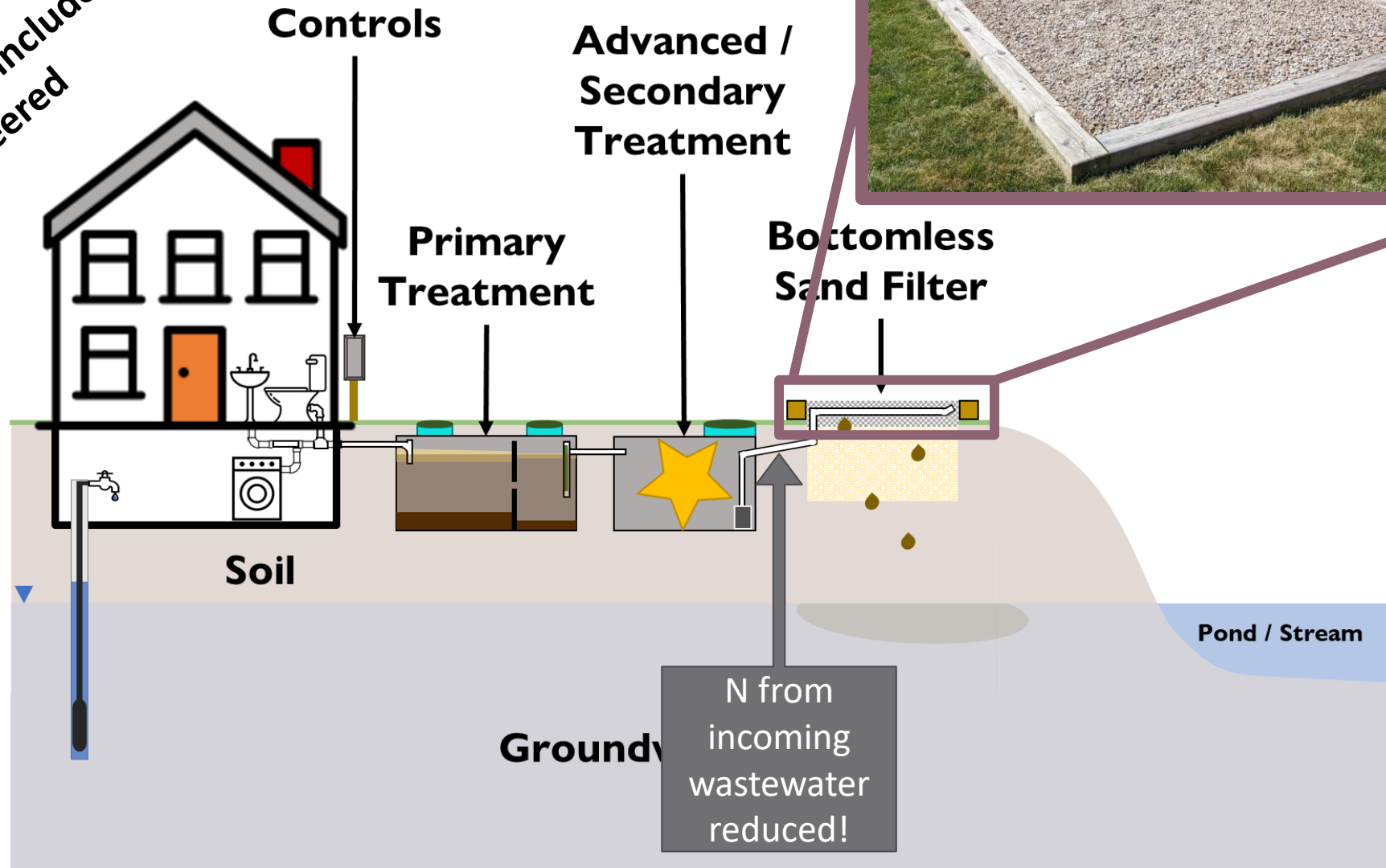
Current [2024] cost (southern RI):
~$33–42k (+)

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Quest: Non-proprietary, lower-cost N-reducing technology options?

Gobler et al. 2021

Wigginton et al. 2021

Diagrams courtesy of S. Wigginton

Layered, unsaturated soil treatment system cross section (not to scale)

From septic tank effluent (STE) Pump

profile distribution
m for low pressure
osing (such as
Mat system)

≥18" unsaturated nitrification media (sand)

12" lignocellulose/silt loam soil mix, denitrification media

Low profile distribution system for low pressure STE dosing (such as GeoMat system)

From septic tank effluent (STE) pump tank

≥18" unsaturated nitrification media (sand)

Impermeable Liner

12" lignocellulose/sand mix, denitrification media, maintained saturation

To soil dispersal system

Underdrain, within denite media
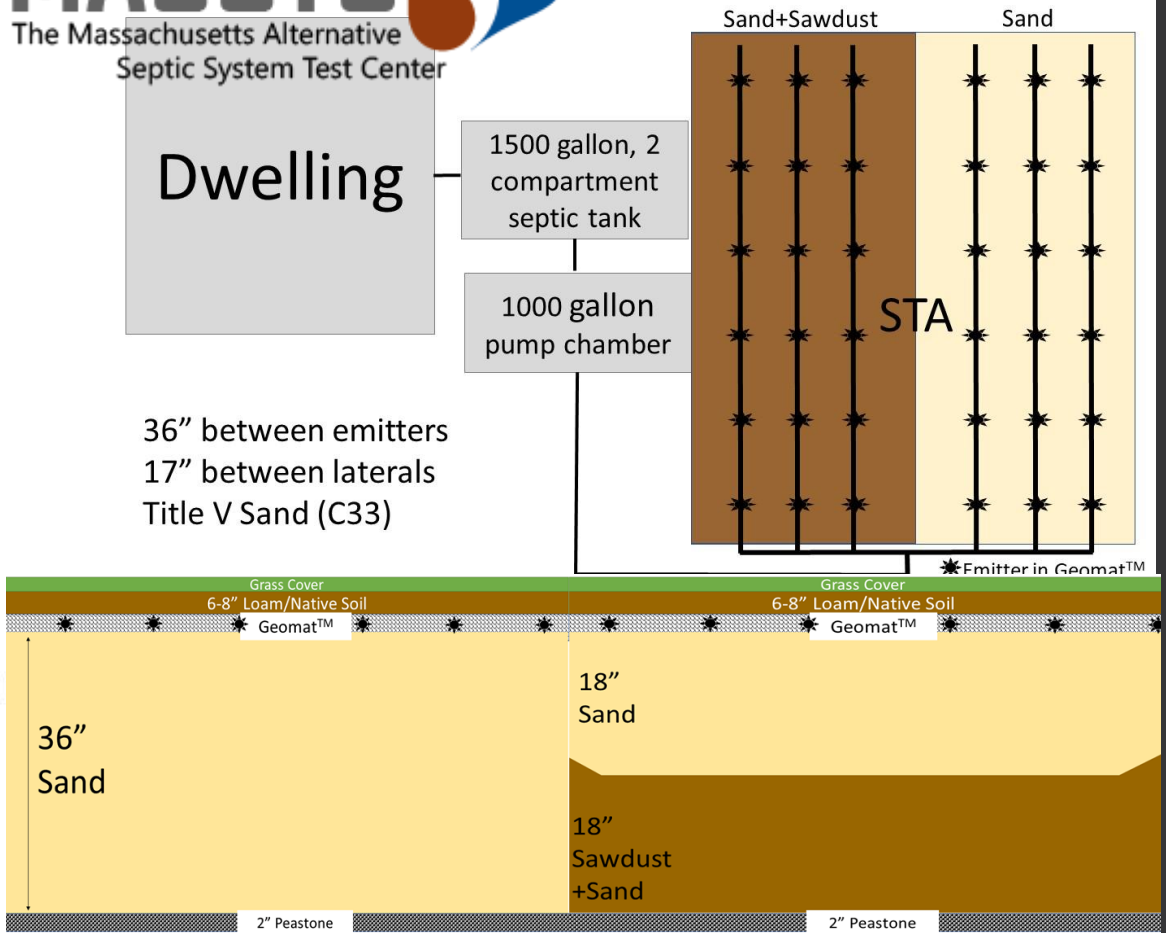
Diagrams courtesy of Suffolk County Dept. Health Services

Dwelling

1500 gallon, 2 compartment septic tank

1000 gallon pump chamber

36" between emitters
17" between laterals
Title V Sand (C33)

Sand+Sawdust | Sand

STA

Emitter in Geomat™

Grass Cover
6-8" Loam/Native Soil
Geomat™

36" Sand

18" Sand

18" Sawdust +Sand

2" Peastone

(Cross section)

Past woodproduct-amended layered drainfield performance is variable

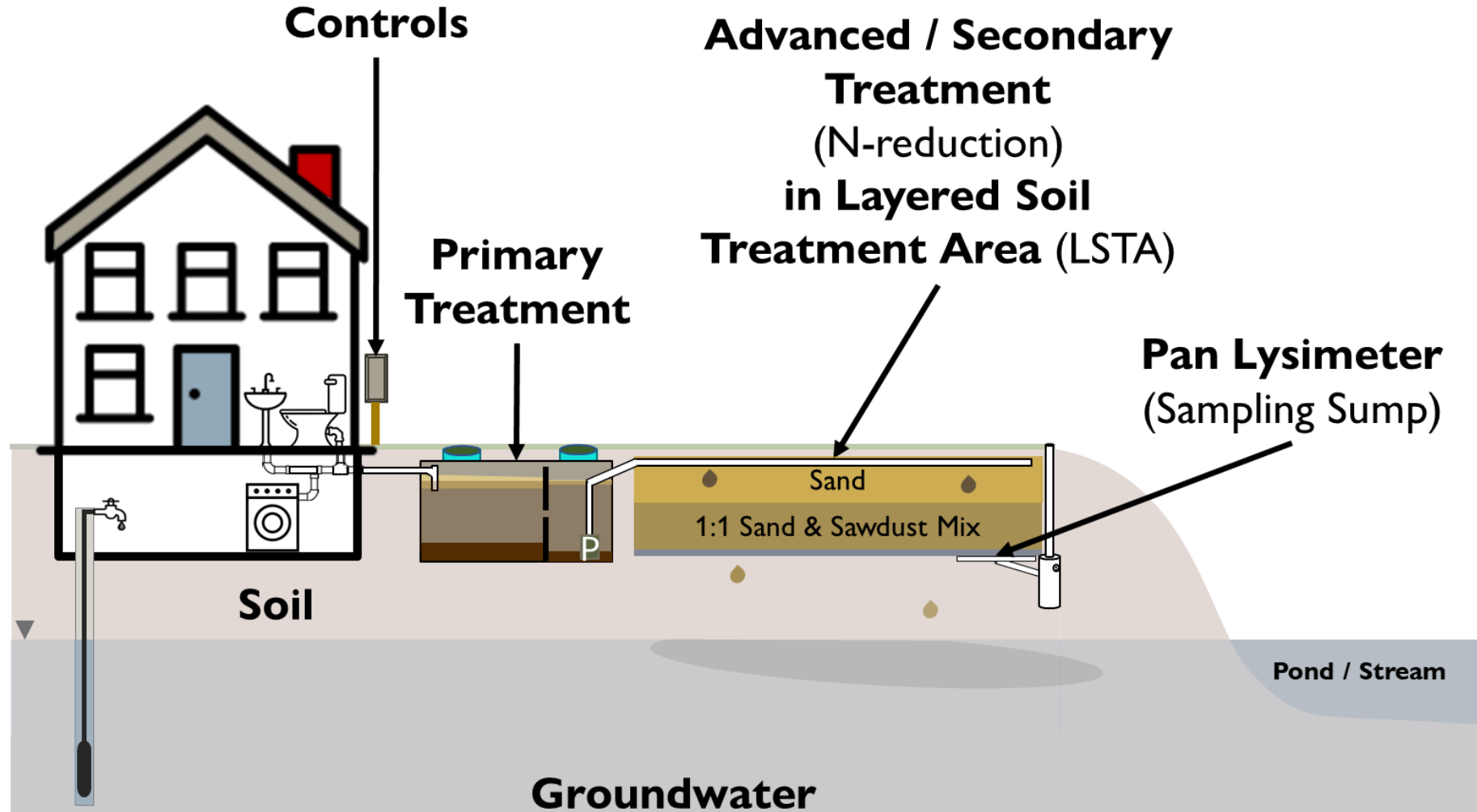**CANADA**
(Robertson et al. 1995, 2008)

- Real world performance: 60-100% N reduction (1995)

- Reliable N-reduction for up to 15 years
  - Within 50% performance value of Y1 (2008)

LI / MA
(Gobler et al. 2021 / Wigginton et al. 2021)

- Prototype N reduction:
  - 84% (G)
  - 93% (W)

- Real world N reduction (influent to effluent):
  - 88% (G)
  - 76% (W)

- Comparable to proprietary tech

- Unexplained variability

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RI Pilot: A non-proprietary N-reducing drainfield technology

Controls

Advanced / Secondary Treatment
(N-reduction)
in Layered Soil Treatment Area (LSTA)

Primary Treatment

Pan Lysimeter
(Sampling Sump)

Sand

1:1 Sand & Sawdust Mix

P

Soil

Pond / Stream

Actual 2021 cost:
~$24-27k

Groundwater

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RI LNSTA performance expectation

- Better long-term performance in RI LNSTAs than MA systems?
  - Better installation oversight
    - Better compaction
  - Better carbon source
    - MA: Wood Chips
    - RI: Local Hardwood Sawdust
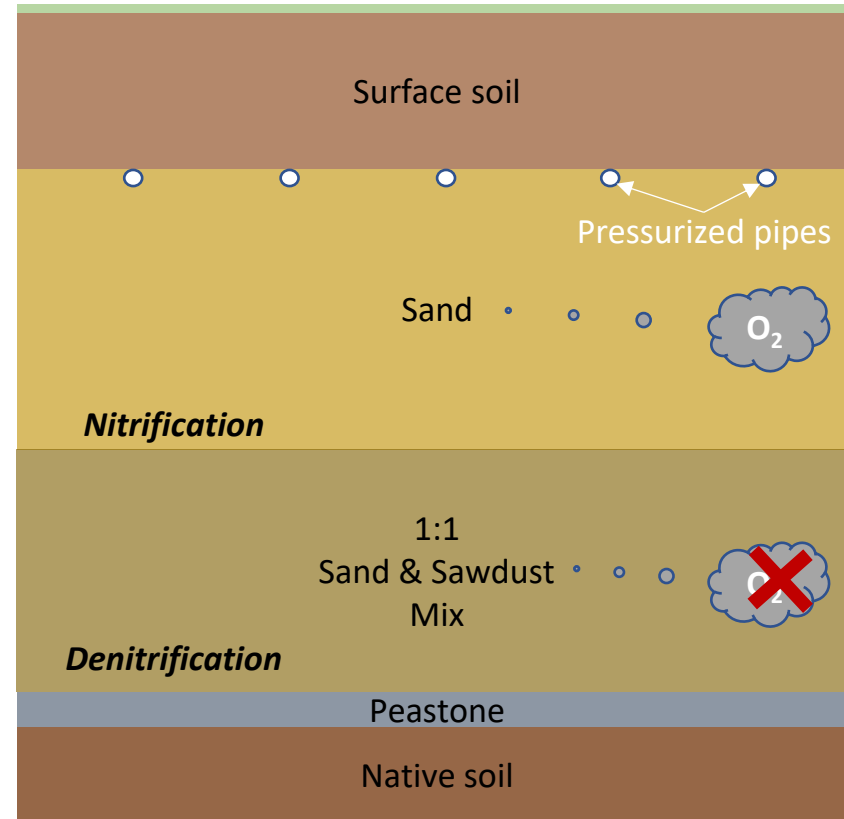 - Active ongoing maintenance
    - Especially lateral cleaning!

N-reducing
OWTS in RI

LNRSTA Overview

Site Info

Performance
Data

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Schematic of N-Removing Layered Soil Treatment Area (RI)

Plan View

Cross-section

Pressurized PVC pipes

[Hanging Pump Vault]

2-Compartment Septic Tank

Single Family Dwelling

Surface soil

Pressurized pipes

Sand

O_2

Nitrification

1:1 Sand & Sawdust Mix

Denitrification

Peastone

Native soil
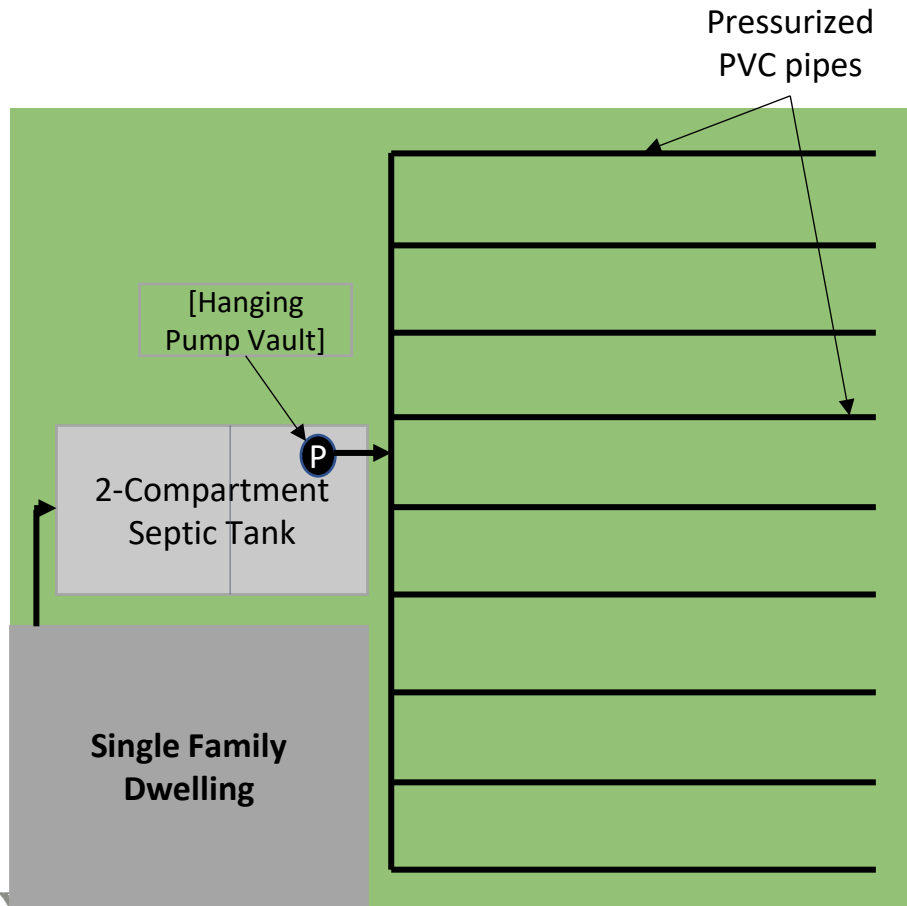
The layered soil treatment area

- Shallow pressurized drainfield infrastructure
  - Orifices sized to handle STE

- 18" ASTM C-33 Sand

- 18" Sand & Sawdust (1:1 by volume)

- 2" Peastone

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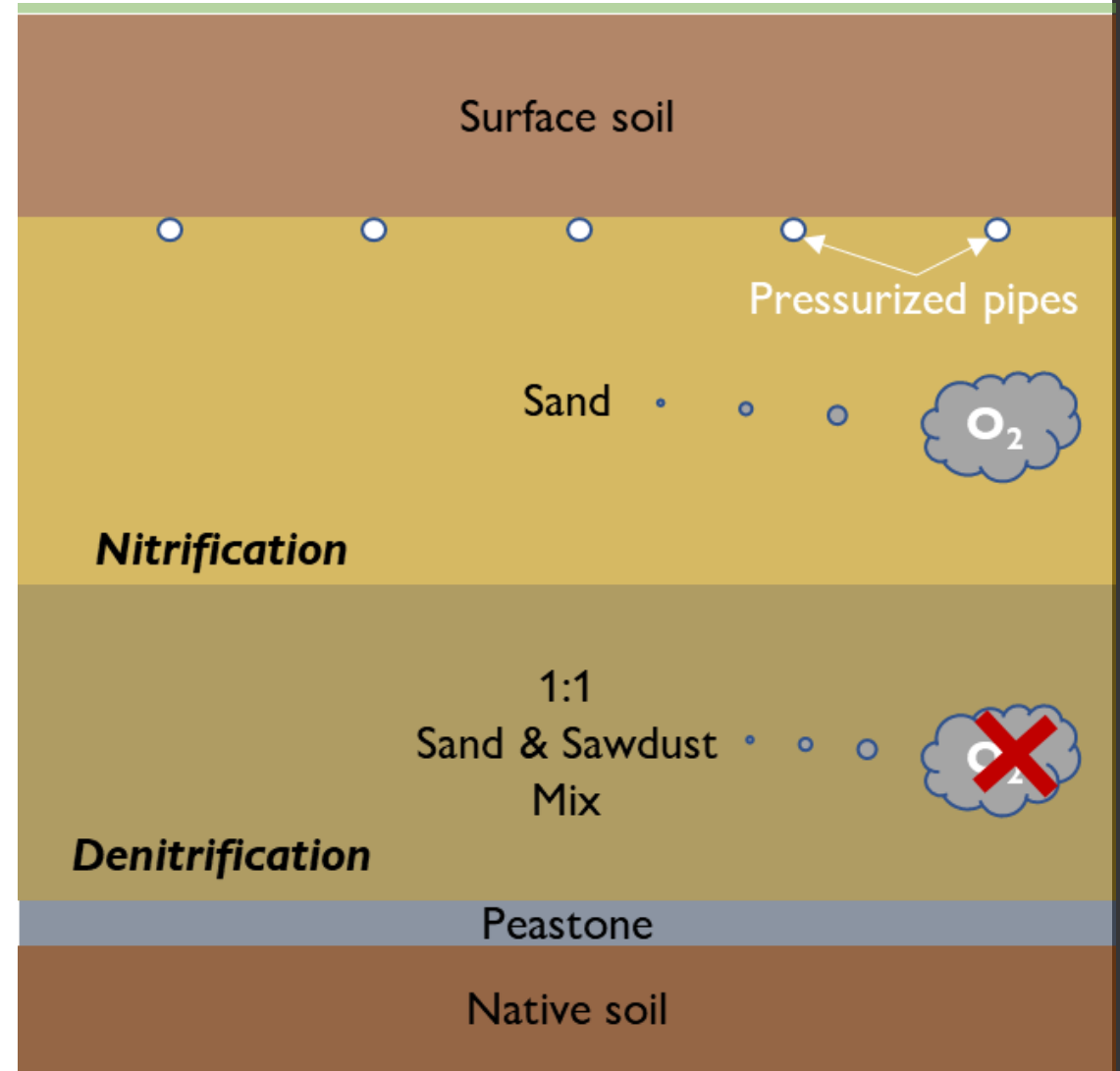
RI LNSTA Demo Systems

- All replaced existing systems

- 2-3 Bedroom; year-round occupancy

- Designed Fall/Winter 2021

- Installed June 2022

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RI LNSTA Demo Systems – Site 1 (2BR)

BEFORE

AFTER

Image source: RIGIS 2022 April & July Aerial Photography

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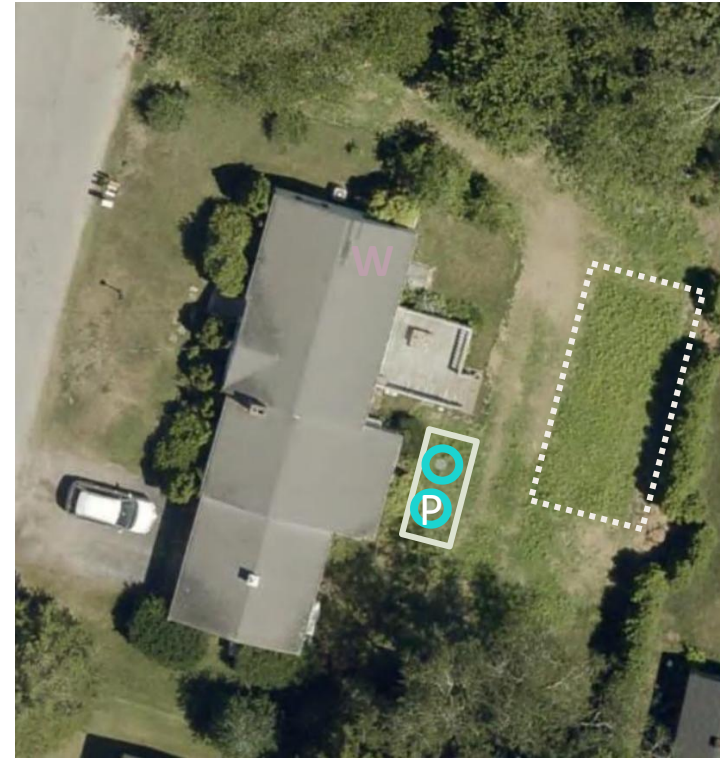
RI LNSTA Demo Systems – Site 2 (3BR)

BEFORE

AFTER

Image source: RIGIS 2022 April & July Aerial Photography

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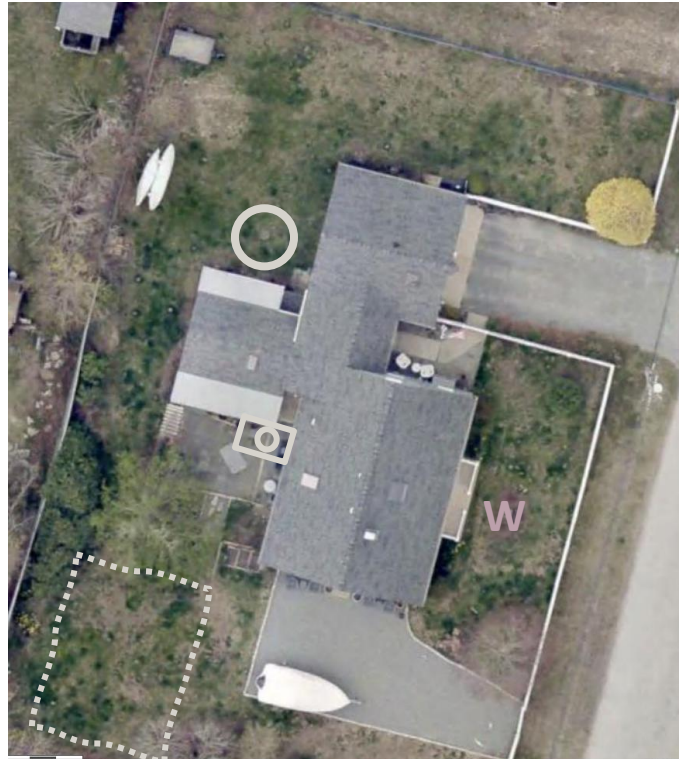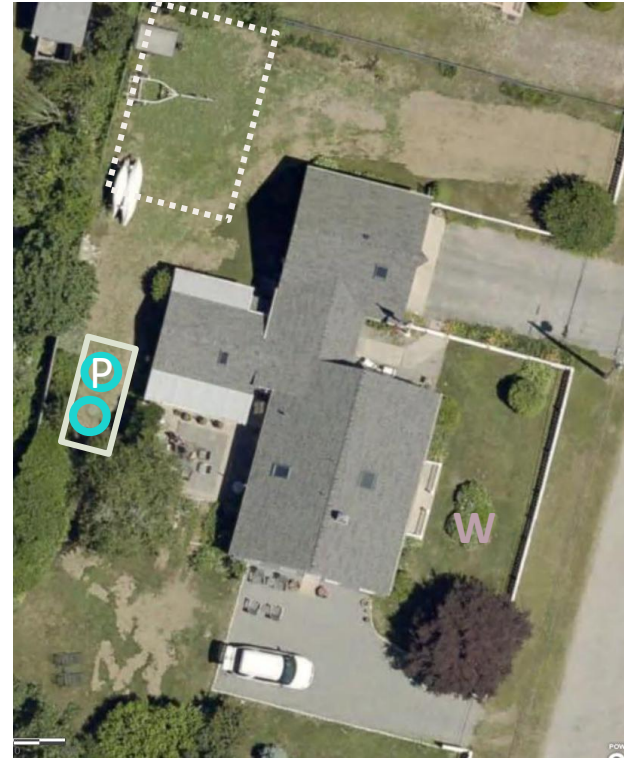
RI LNSTA Demo Systems – Site 3 (2BR)

BEFORE

AFTER

Image source: RIGIS 2022 April & July Aerial Photography

N-reducing
OwTS in RI

LNRSTA Overview

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Performance
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RI LNSTA Demo Systems – Site 4 (2BR)

BEFORE

AFTER

Image source: RIGIS 2022 April & July Aerial Photography

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Normal growth patterns on top of LNSTA

N-reducing
OWTS in RI

LNRSTA Overview

Site Info

Performance
Data

Operation & Maintenance needs for LNSTAs
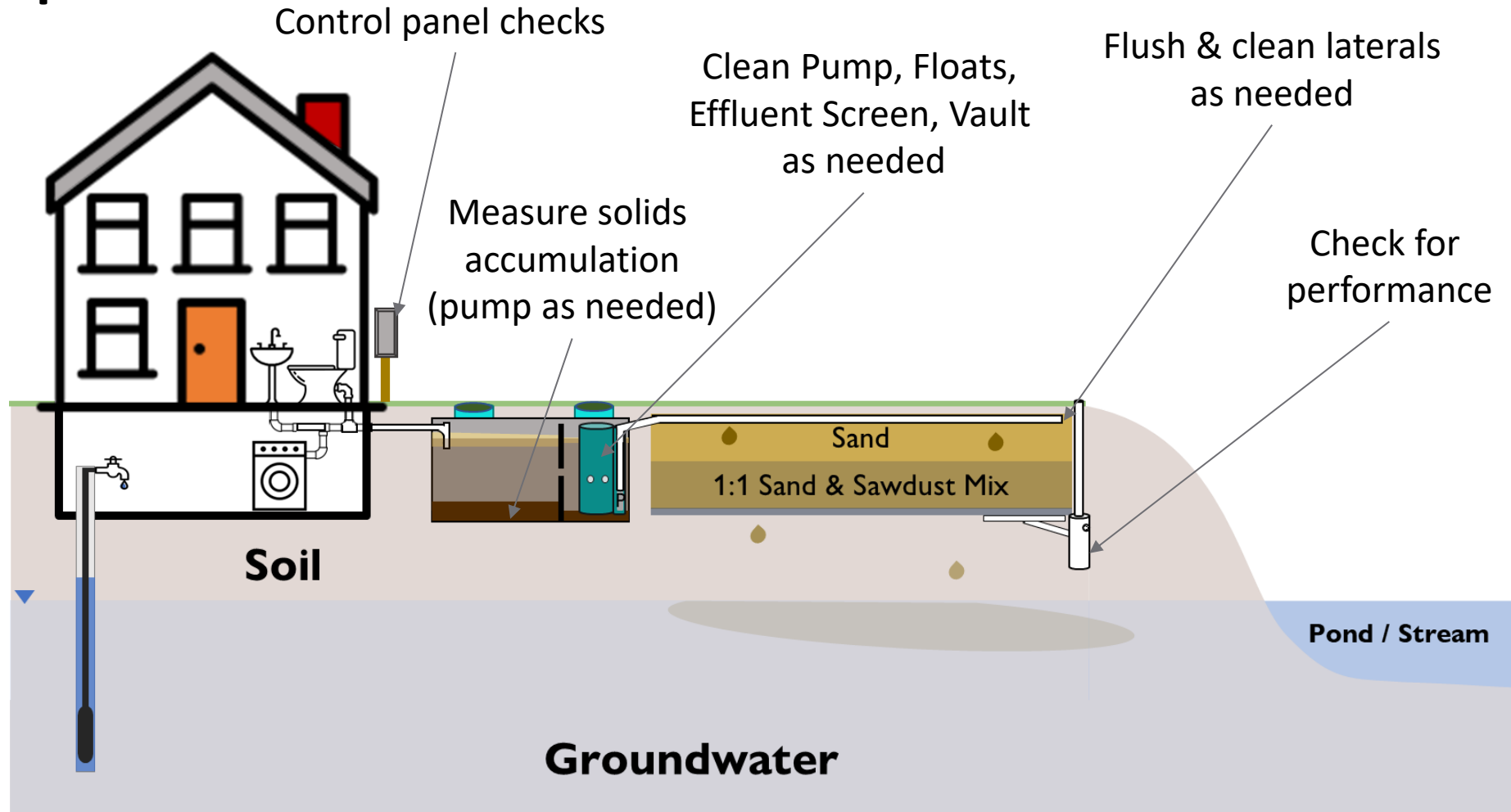
Cost comparisons (replacing existing failing/substandard system)

RI LNSTA

- 2022: **$27,525 AVG**
  - Design cost: $4,750
  - Installation cost: $22,775

$5k difference

$? difference

PROPRIETARY TECHNOLOGY

- Textile filter to Press. DF (2017-2018): **$27,169 AVG**
  - Range: $23,200 — $31,963

- Aerobic Treatment unit to Press. DF (2021-2023): **$32,362 AVG**
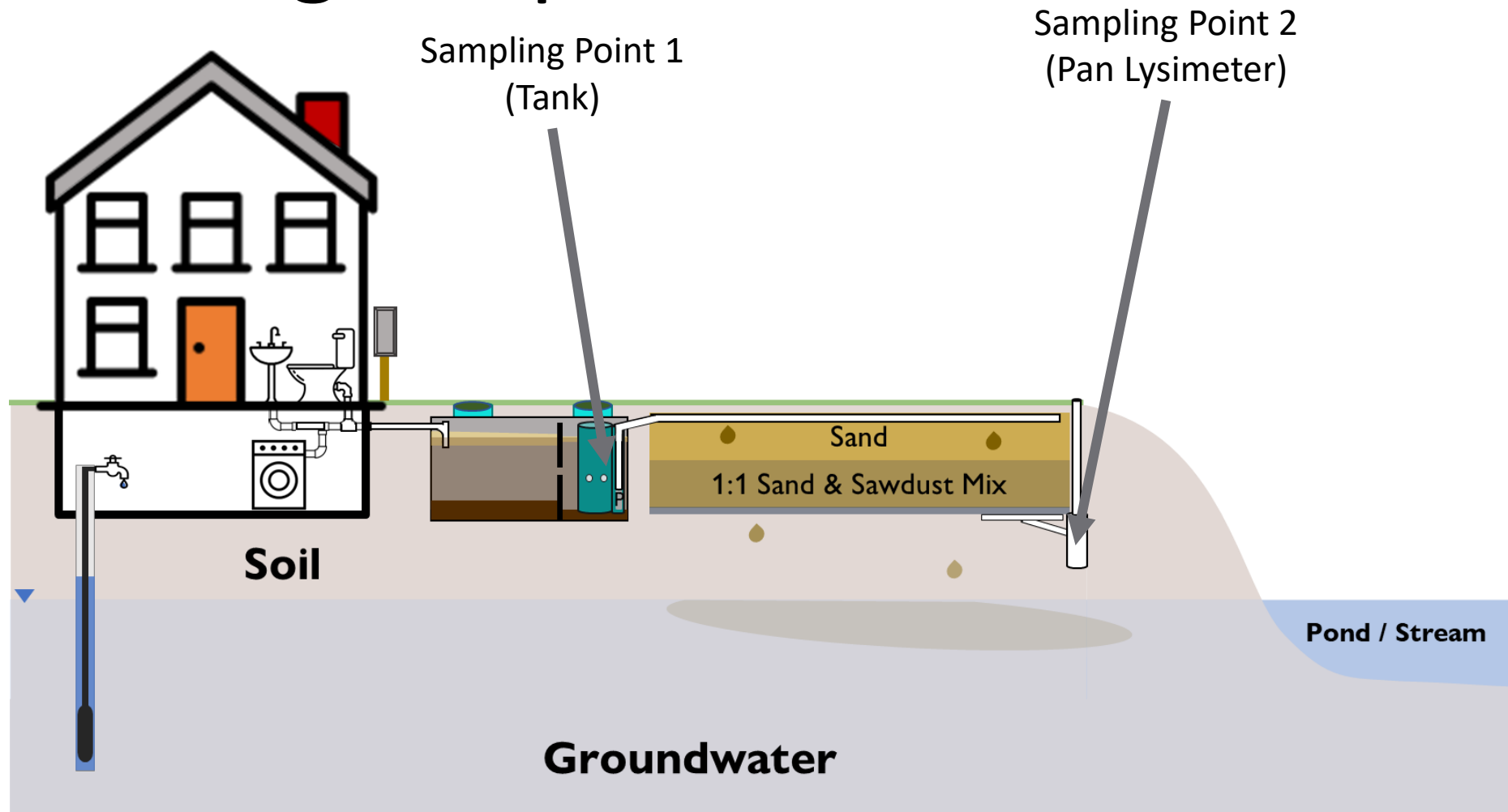 - Range: $25,413 — $36,680
  - 2024 Range: $33 – 42k

These values are based on final cost of grant-funded installations of systems in Charlestown, RI

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LNSTA Sampling & Analysis

Are LNSTAs doing what they're supposed to?

How do they compare to proprietary technology performance?

N-reducing
OWTS in RI

LNRSTA Overview

Site Info

Performance
Data

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Collecting samples from LNSTAs

Sampling Point 1
(Tank)

Sampling Point 2
(Pan Lysimeter)

Sand

1:1 Sand & Sawdust Mix

Soil

Pond / Stream

Groundwater

N-reducing
OWTS in RI

LNRSTA Overview

Site Info

Performance
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Collecting samples from LNSTAs

N-reducing
OWTS in RI

LNRSTA Overview

Site Info

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Data

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Collecting samples from systems

N-reducing
OWTS in RI

LNRSTA Overview

Site Info

Performance
Data

Measuring Field Parameters

- Temperature

- pH

- Salinity

- Conductivity

- Dissolved Oxygen

N-reducing
OWTS in RI

LNRSTA Overview

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Data

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Analyzing wastewater samples

Samples collected in the field are processed & analyzed in the lab
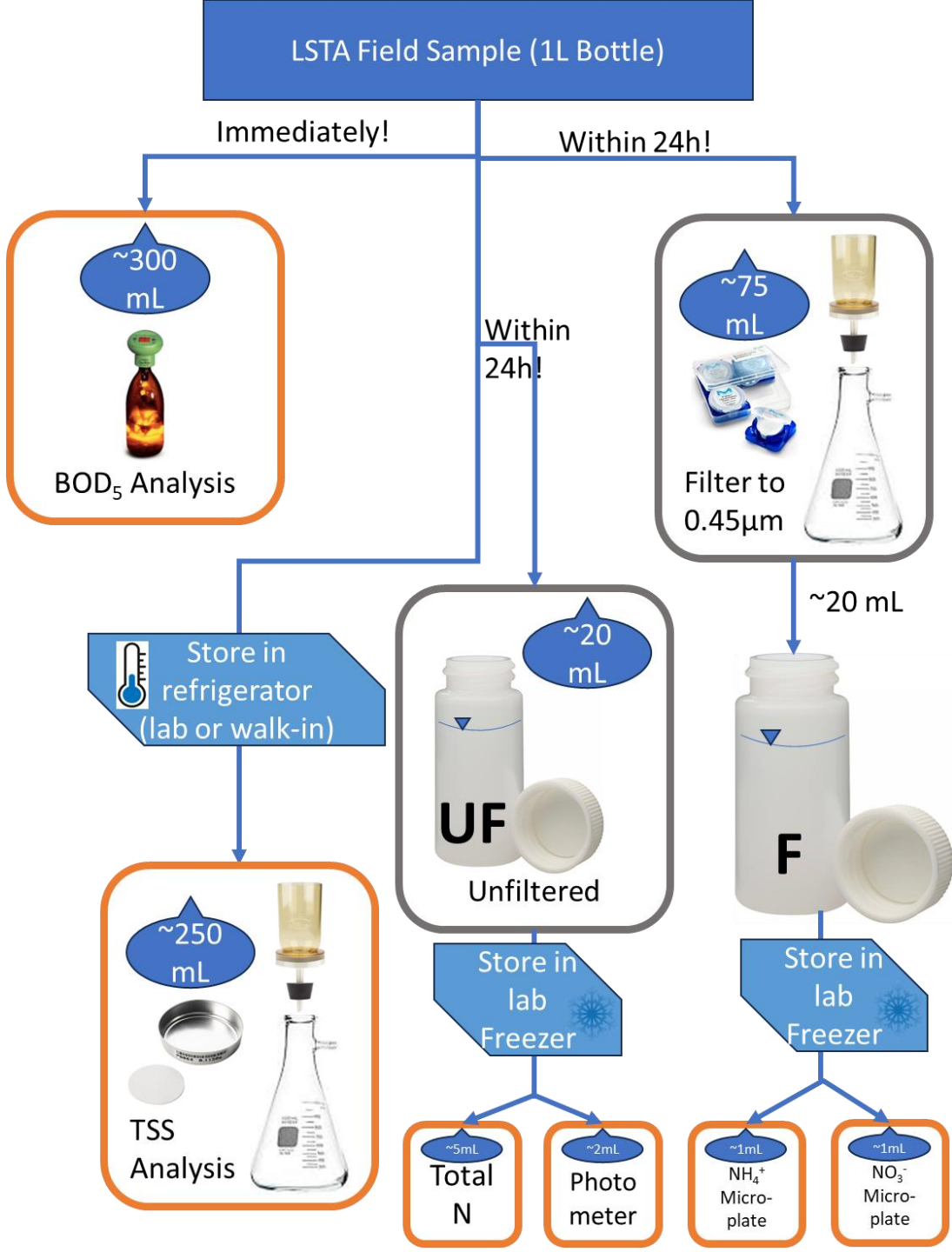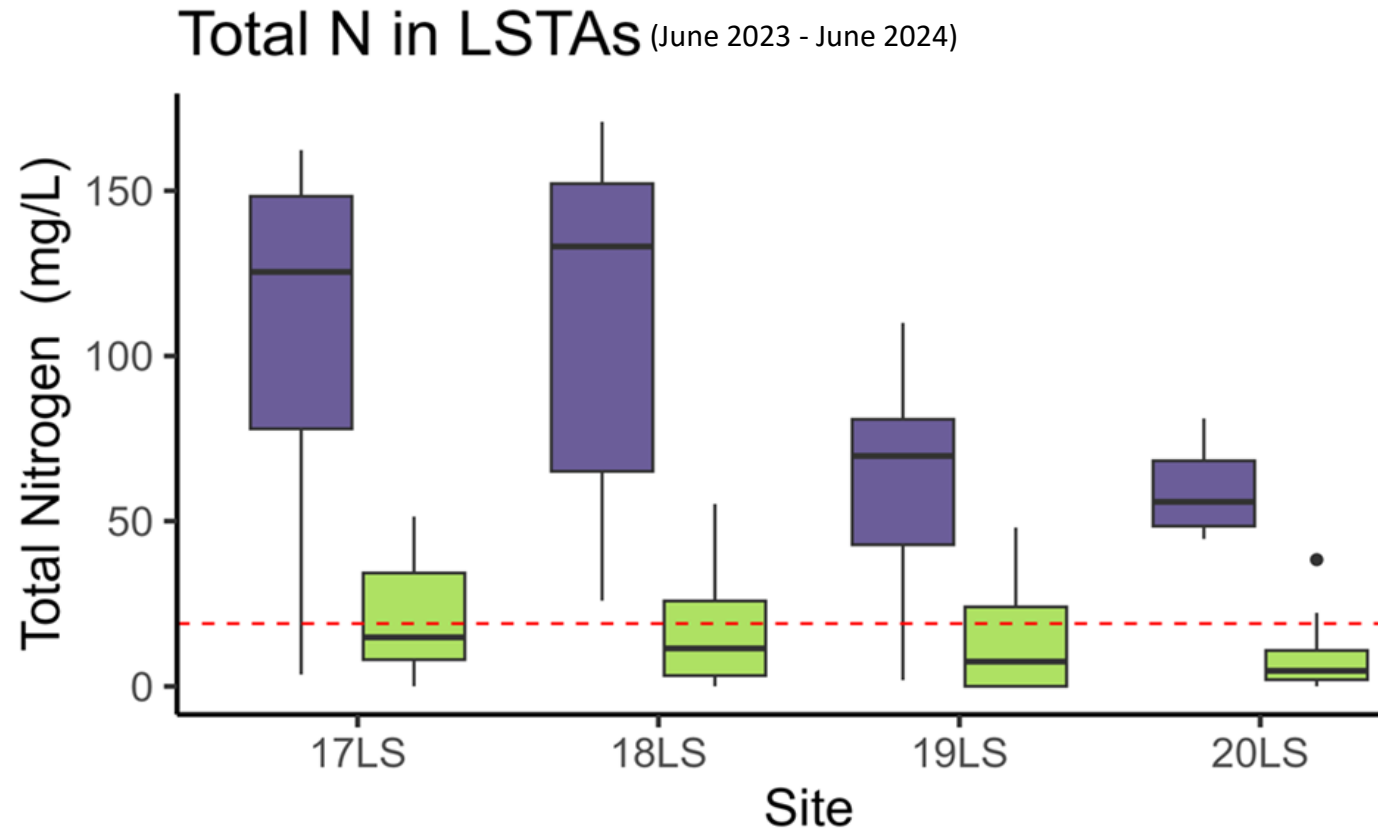
LNSTA Performance

N species

Sampling Location — Septic Tank, Final Effluent

Sand
1:1 Sand & Sawdust Mix

(July 2022 - July 2024)

Ammonium Nitrogen (mg/L) vs Site (17LS, 18LS, 19LS, 20LS)

(July 2022 - July 2024)

Nitrite + Nitrate Nitrogen (mg/L) vs Site (17LS, 18LS, 19LS, 20LS)

Total N in LSTAs (June 2023 - June 2024)

Note **Influent N much higher** than in some past experiments!

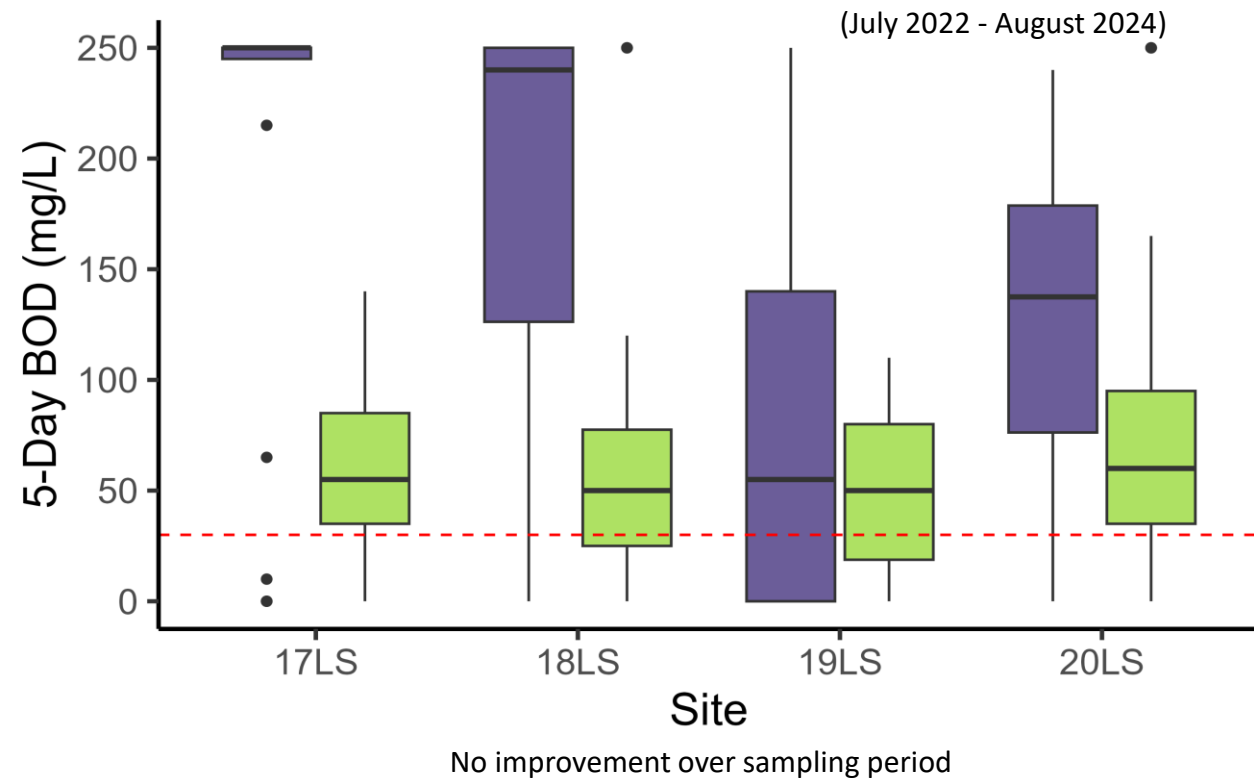THE UNIVERSITY OF RHODE ISLAND
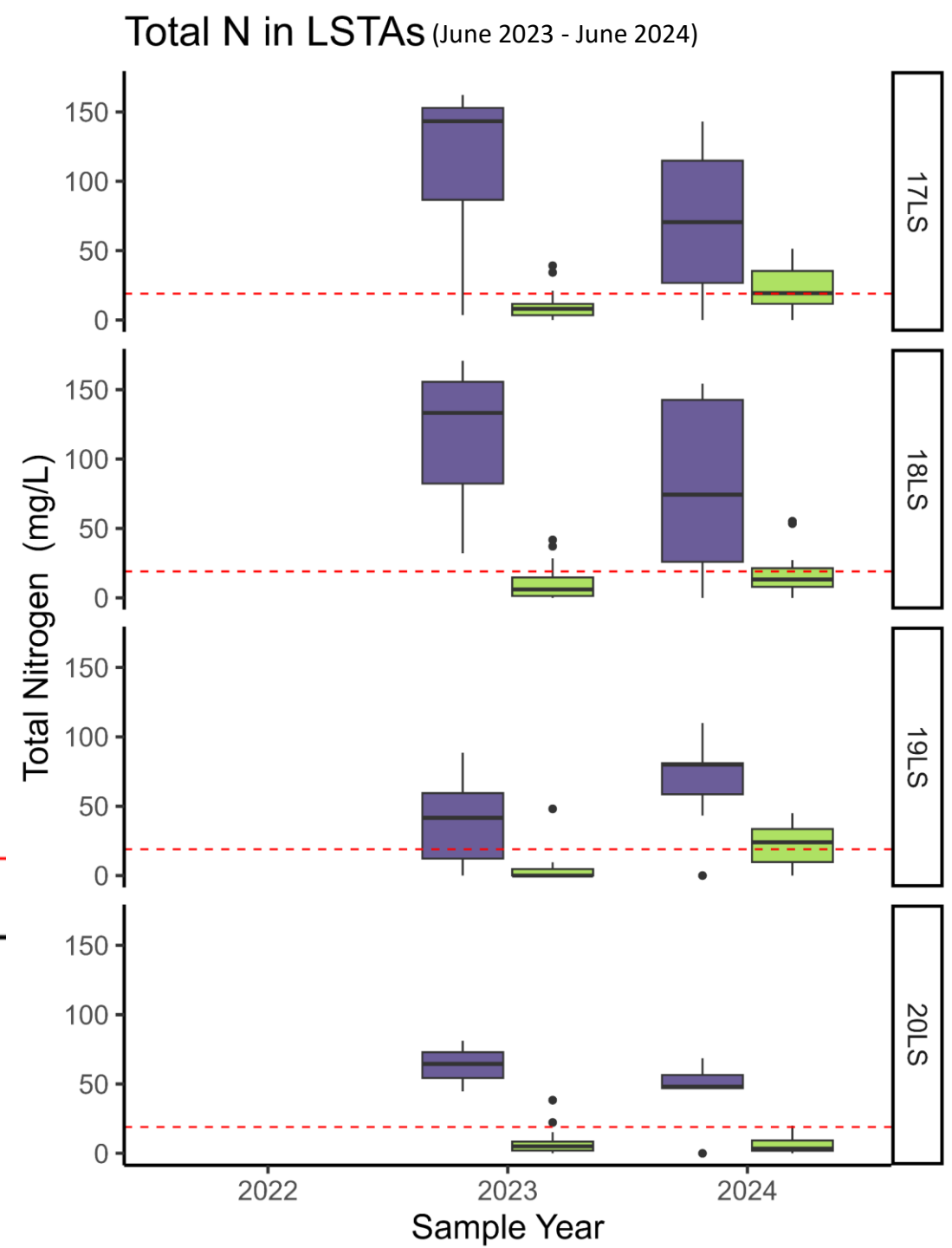
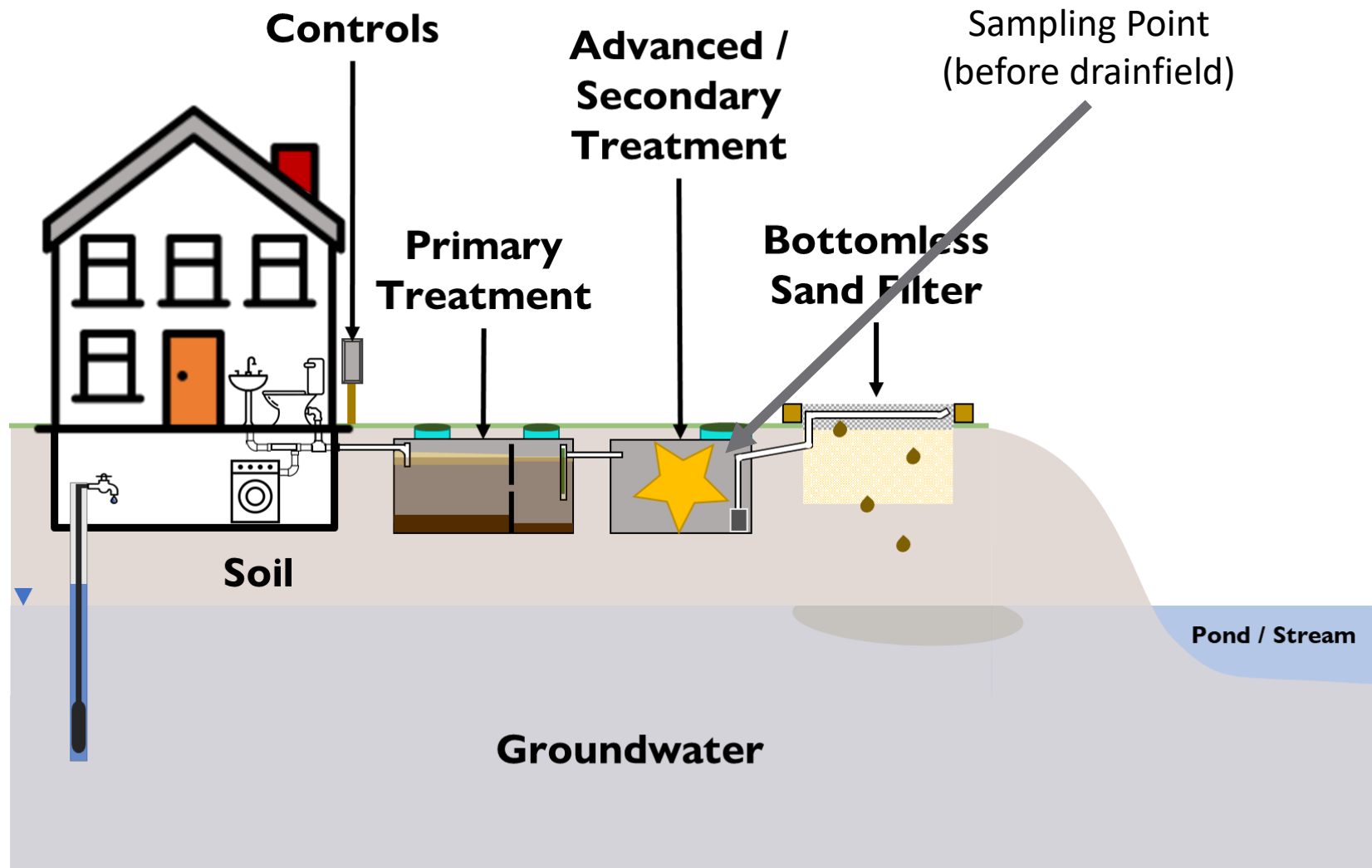# Maintenance is key

- **Laterals in LNSTA must be cleaned every 6 months**
  - Significant build up of materials
  - Uneven distribution
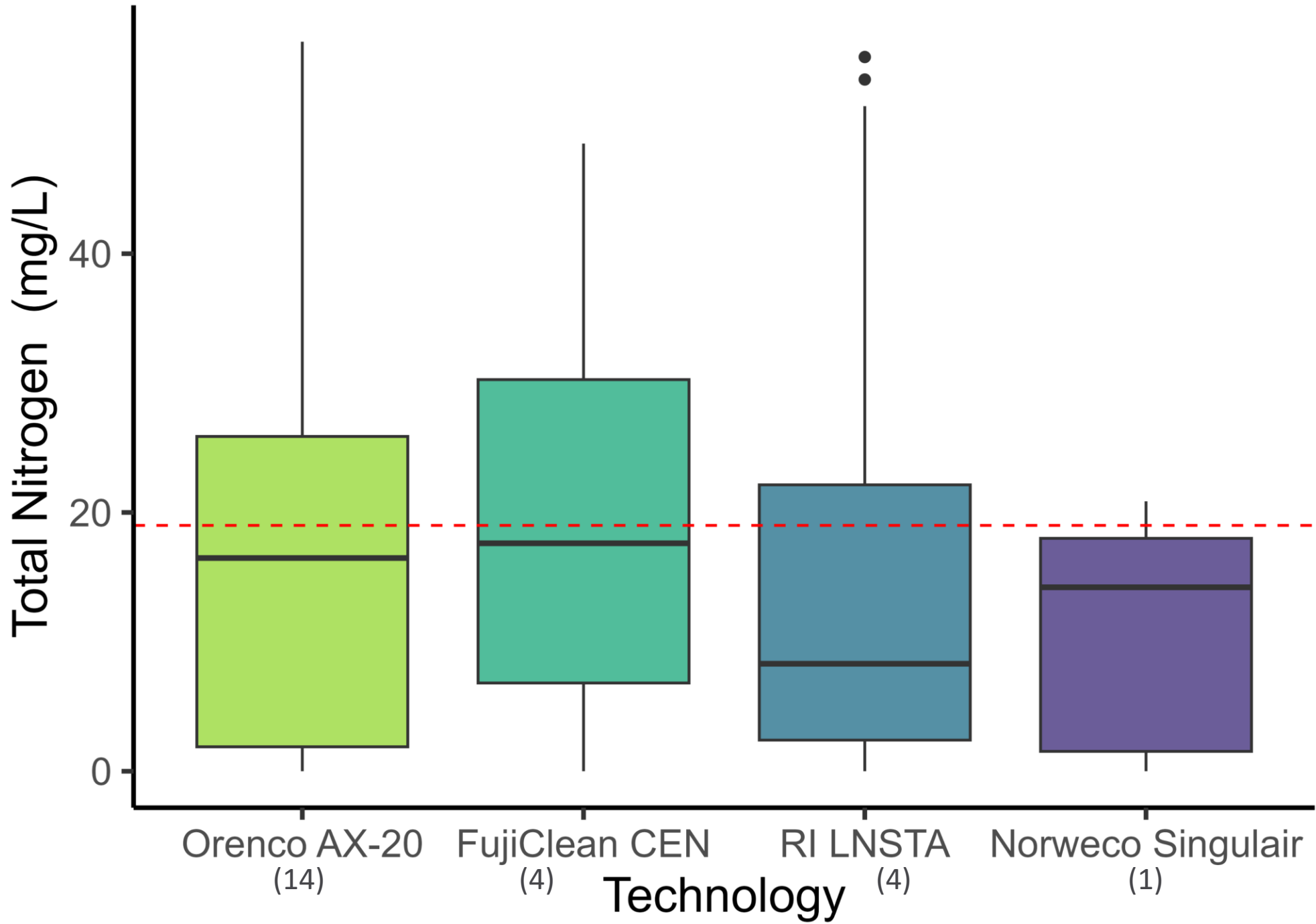   - ? Poor/uneven saturated conditions in bottom layer?

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BOD & TSS
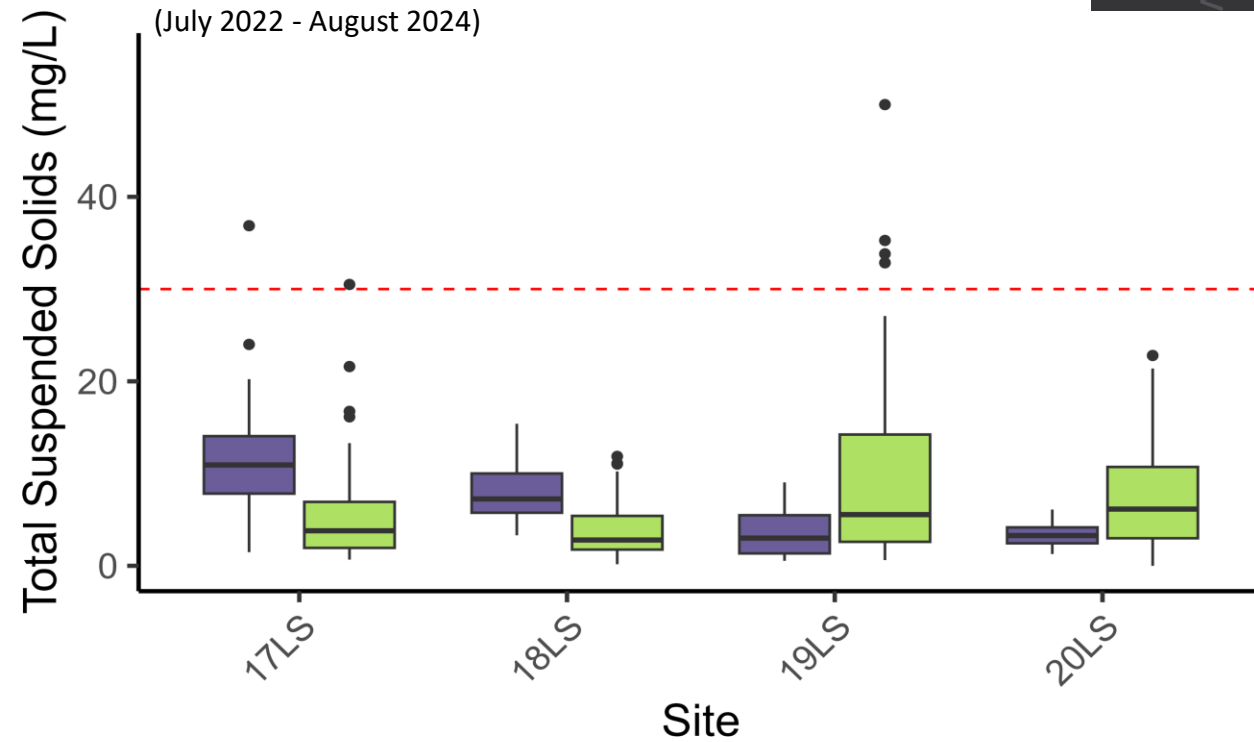
Advanced system performance

Comparison to proprietary OWTS

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Summary

- RI LNSTAs perform comparably to advanced systems for N reduction
  - over first 2 years
  - 4 systems studied
  - Similar to 2021 results from Wigginton & Gobler et al.

- A promising addition to N-reduction options in RI

- Cost of LNSTA significantly lower than proprietary options
  - $~27k (*vs* $~32k)
    - 2024 costs ~33-42k

- Installation best practices very important
  - + impacts from system use

- Maintenance = critical!

Wigginton et al. 2021, Gobler et al. 2021

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Thank you!

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