FLORIDA ONSITE SEWAGE NITROGEN REDUCTION STRATEGIES (FOSNRS) STUDY: Overview and Status

Presentation to the FDOH Technical Review and Advisory Panel (TRAP)

September 25, 2014

by

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PROJECT TEAM ACKNOWLEDGEMENTS

Florida HEALTH

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And many support firms and staff!

Presentation Outline

- Nitrogen Impacts to Water Quality
- Nitrogen reducing OSTDS
- FOSNRS Background
- Passive Nitrogen Reduction System (PNRS) Pilot Studies
- Passive Nitrogen Reduction System (PNRS): Full Scale Implementation
- Overview of Tasks C and D, N Fate & Transport
- Summary & Questions

Nitrogen Impacts to Water Quality

Adverse effects of nitrogen

Human Health

- SDWA Limit of 10 mg/L NO_3 – N
- Harmful algal blooms (HABs)

Ecosystem Health

- Nitrogen is the limiting nutrient for eutrophication of many coastal waters and some freshwater systems
- Increased watershed N loading can be linked to:
  - Algal blooms
  - Loss of seagrass and shellfish habitat
  - Hypoxia

Nitrogen impacts to water quality

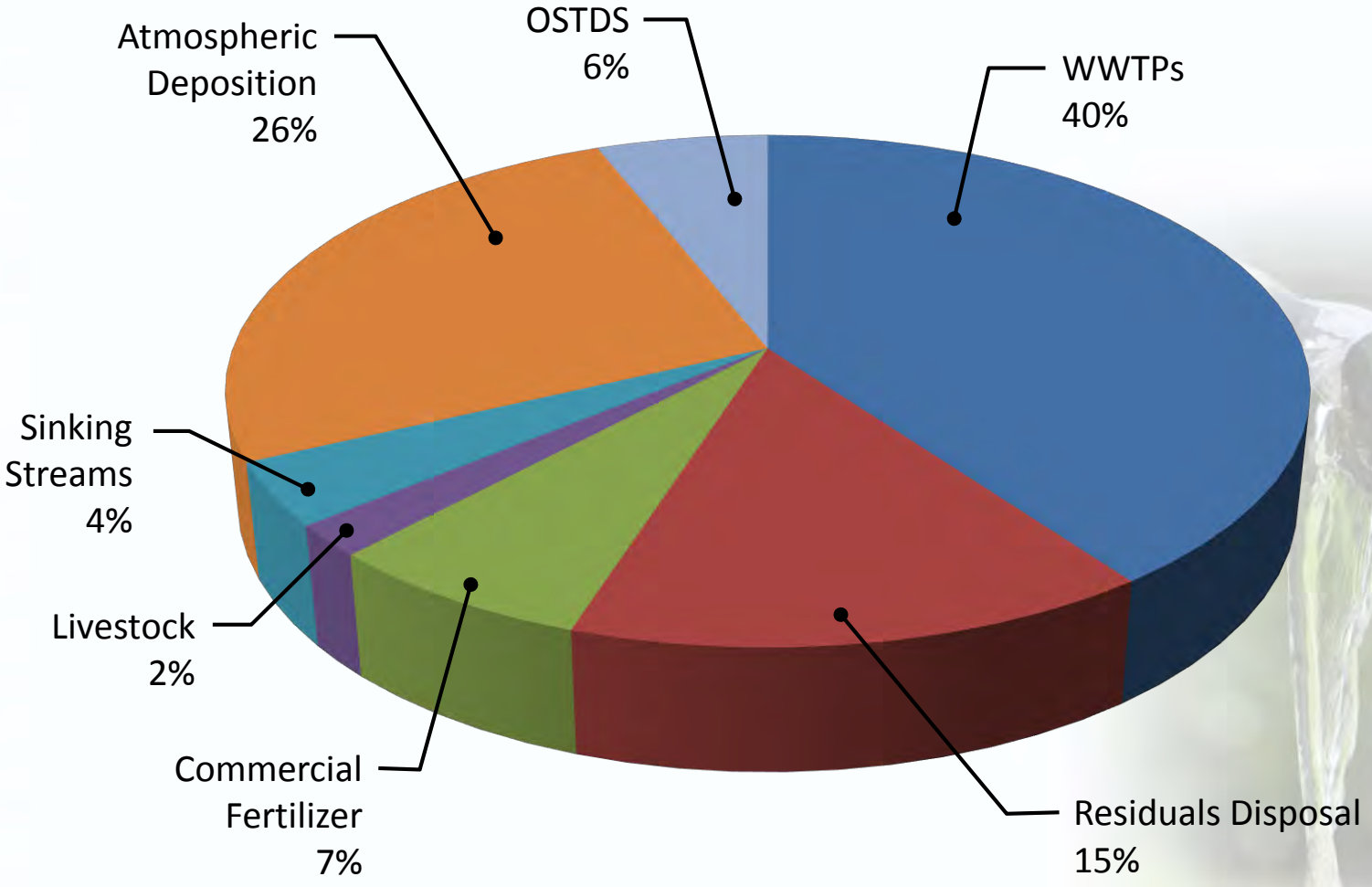
- Impacts of excess nitrogen on water quality have been documented in many areas of Florida and nationwide:
  - Tampa Bay, Sarasota Bay
  - Florida Keys
  - Wekiva Study Area
  - Wakulla County
  - Florida's Freshwater Springs
  - Chesapeake Bay
  - Cape Cod

In Florida, nitrogen loading has resulted in water quality problems for our freshwater springs…

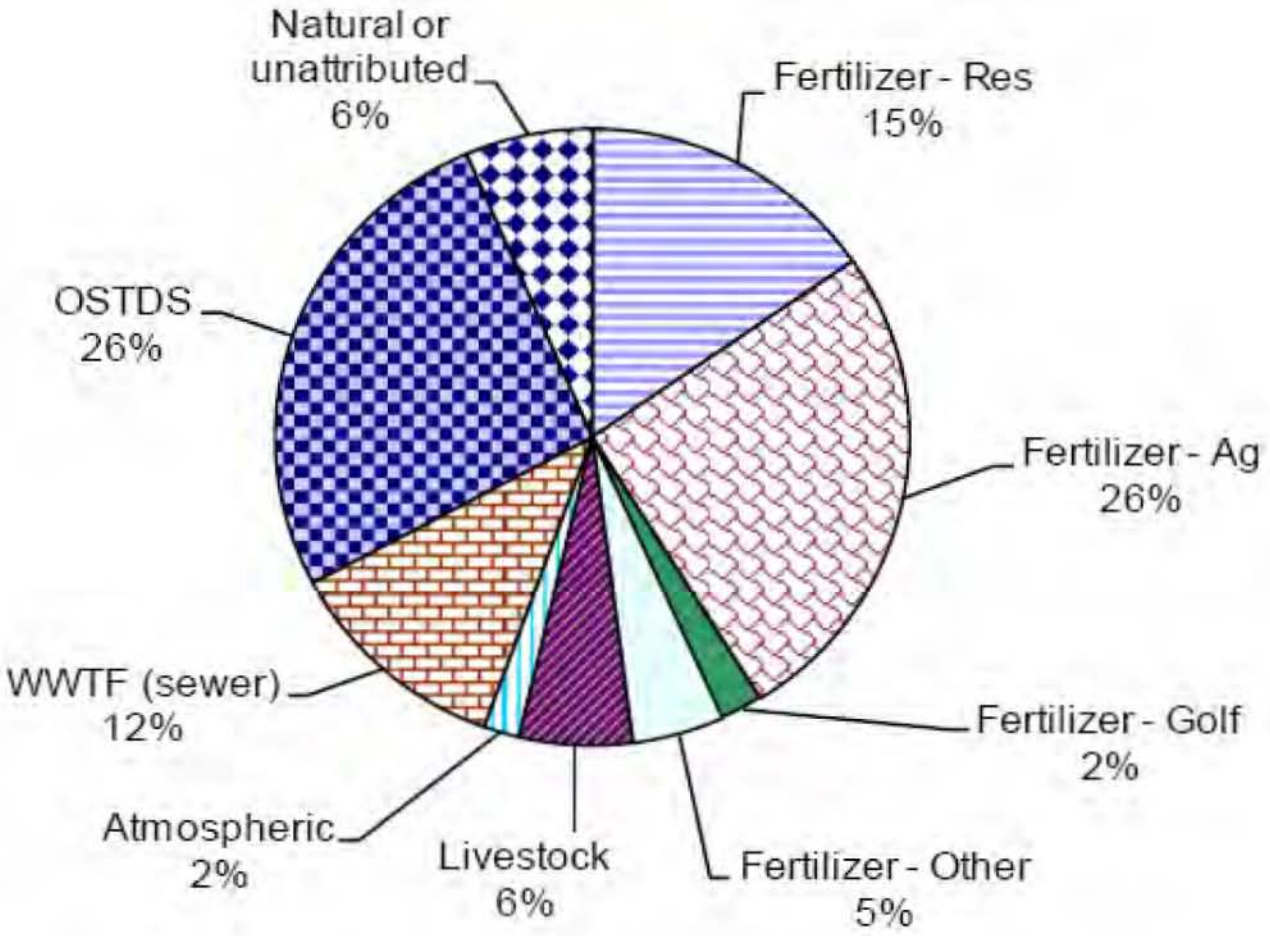
Photos courtesy of John Moran - SpringsEternalProject.org

Photos courtesy of John Moran - SpringsEternalProject.org

In some watersheds OSTDS nitrogen loading is relatively low (Wakulla Springs 1990-1999)



In other watersheds OSTDS nitrogen loading is relatively high (Wekiva Study Area)



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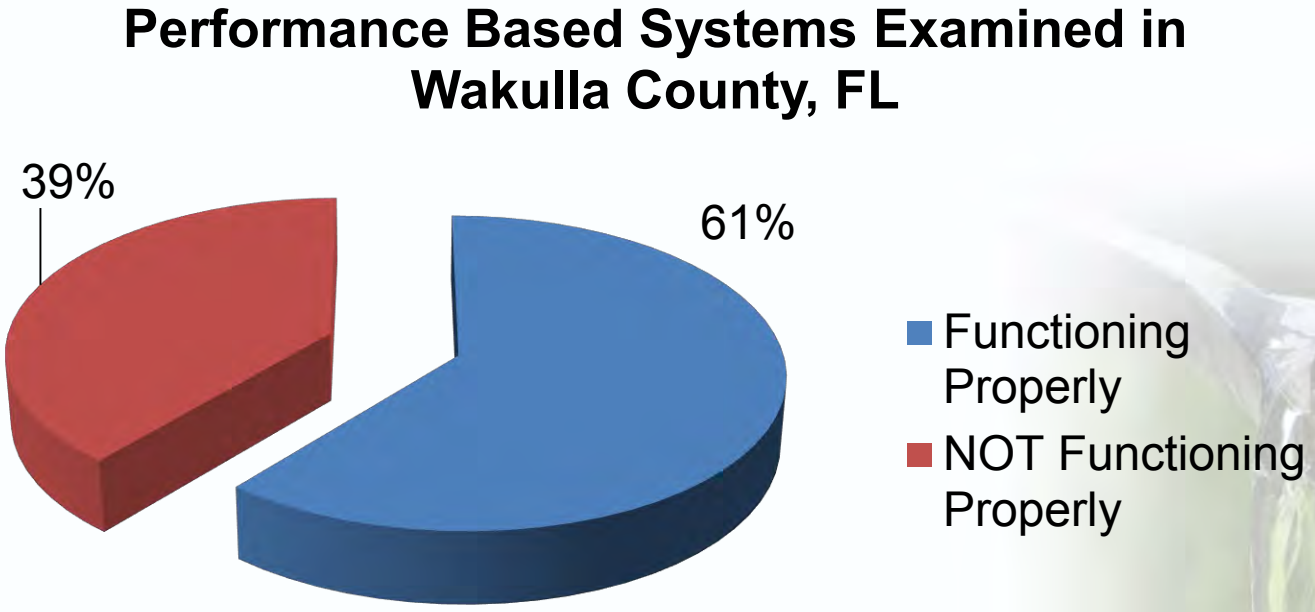
Nitrogen reducing OSTDS

Nitrogen reducing OSTDS

- Concerns over nitrogen loading have led to requirements for OSTDS designed to reduce nitrogen, typically to 10 mg/L total nitrogen, prior to discharge to the soil
- Currently, most are mechanical treatment units utilizing an activated sludge biological (BNR) process, similar to a municipal treatment plant
- Two step process:
  1. Aeration to “nitrify” nitrogen compounds to NO_3 (nitrification)
  2. Anoxic conditions to “denitrify” NO_3 to nitrogen gas (denitrification)

Recent evaluation in Florida showed inconsistent results for these performance based treatment (PBTS) systems…



"Of a total of 59 performance based treatment systems (PBTS) inspected in Wakulla County, 23 (39%) of these systems were not functioning properly at the time of inspection" Harden et al. (2010)

Properly Functioning Systems Mean TN = 29 ± 19 mg N/L

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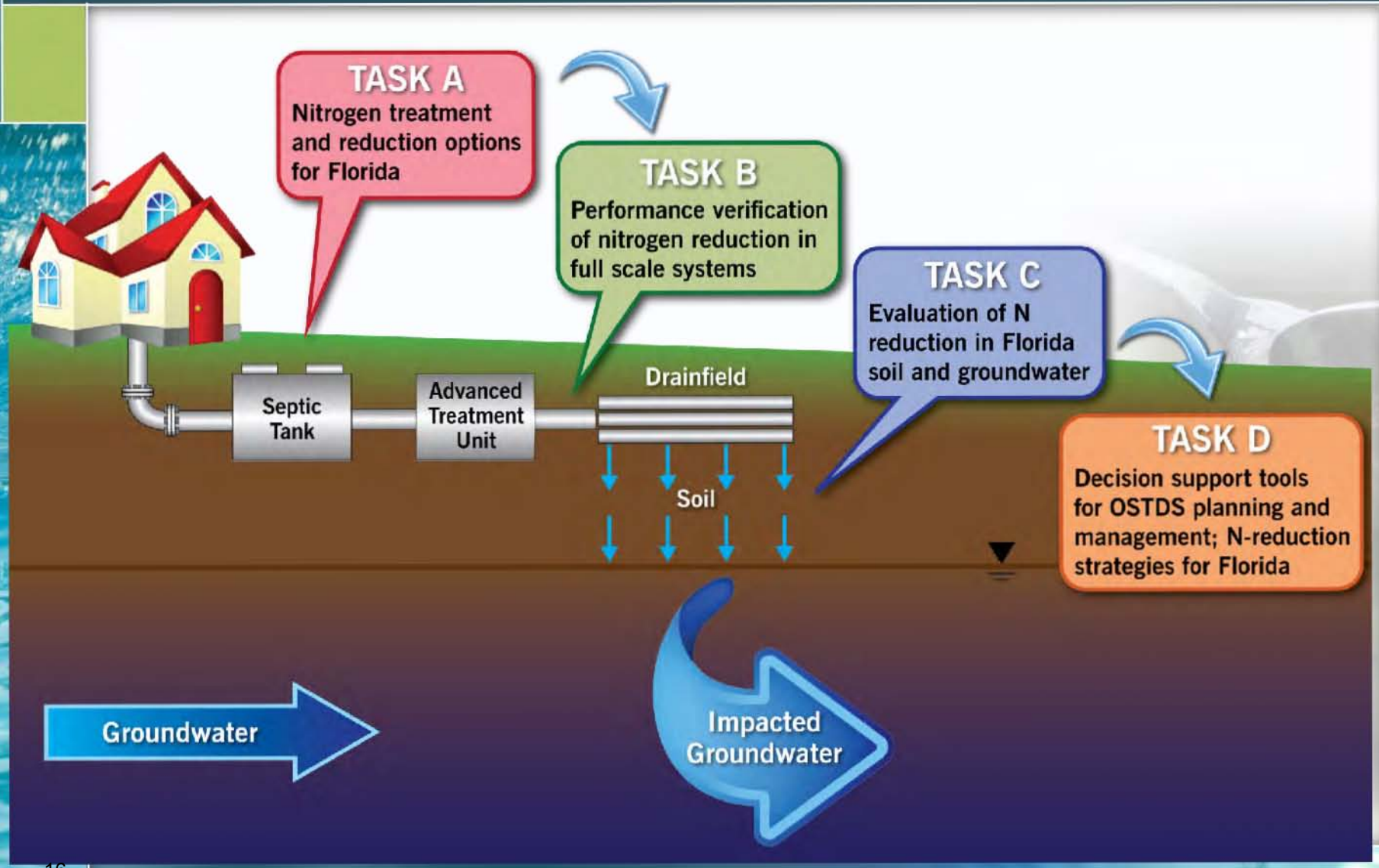
FOSNRS Background

FOSNRS project initiated by Florida legislature

- Laws of Florida, 2008-152, directed FDOH to conduct a study to further develop more “passive” & cost-effective nitrogen reduction strategies for OSTDS
- Initiated the Florida Onsite Sewage Nitrogen Reduction Strategies (FOSNRS) Project in 2009
- RFP identified four primary study areas

Four primary study areas



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Passive Nitrogen Reduction System (PNRS) Pilot Studies

What are “passive” nitrogen reduction systems?

- Passive nitrogen reduction systems (PNRS) are OSTDS that reduce effluent N using reactive media for denitrification and a single liquid pump, if necessary.
- Two stage process:
  - Stage 1: “nitrify” nitrogen compounds to NO_3 (nitrification)
  - Stage 2: “denitrify” NO_3 to nitrogen gas (denitrification)

nitrification media: expanded clay

denitrification media: lignocellulosics

denitrification media: elemental sulfur

Two stage single pass pilot-scale biofilters

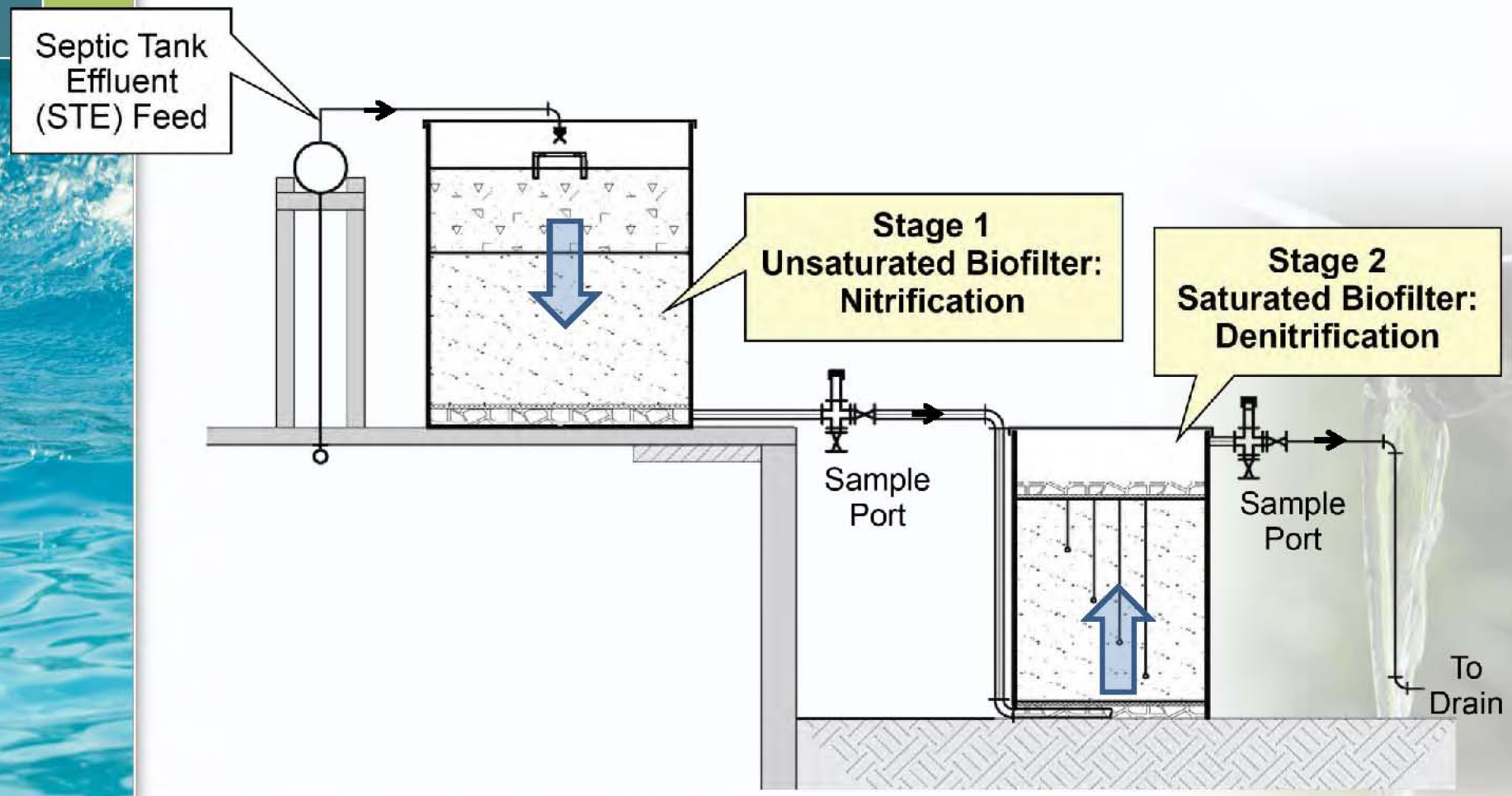
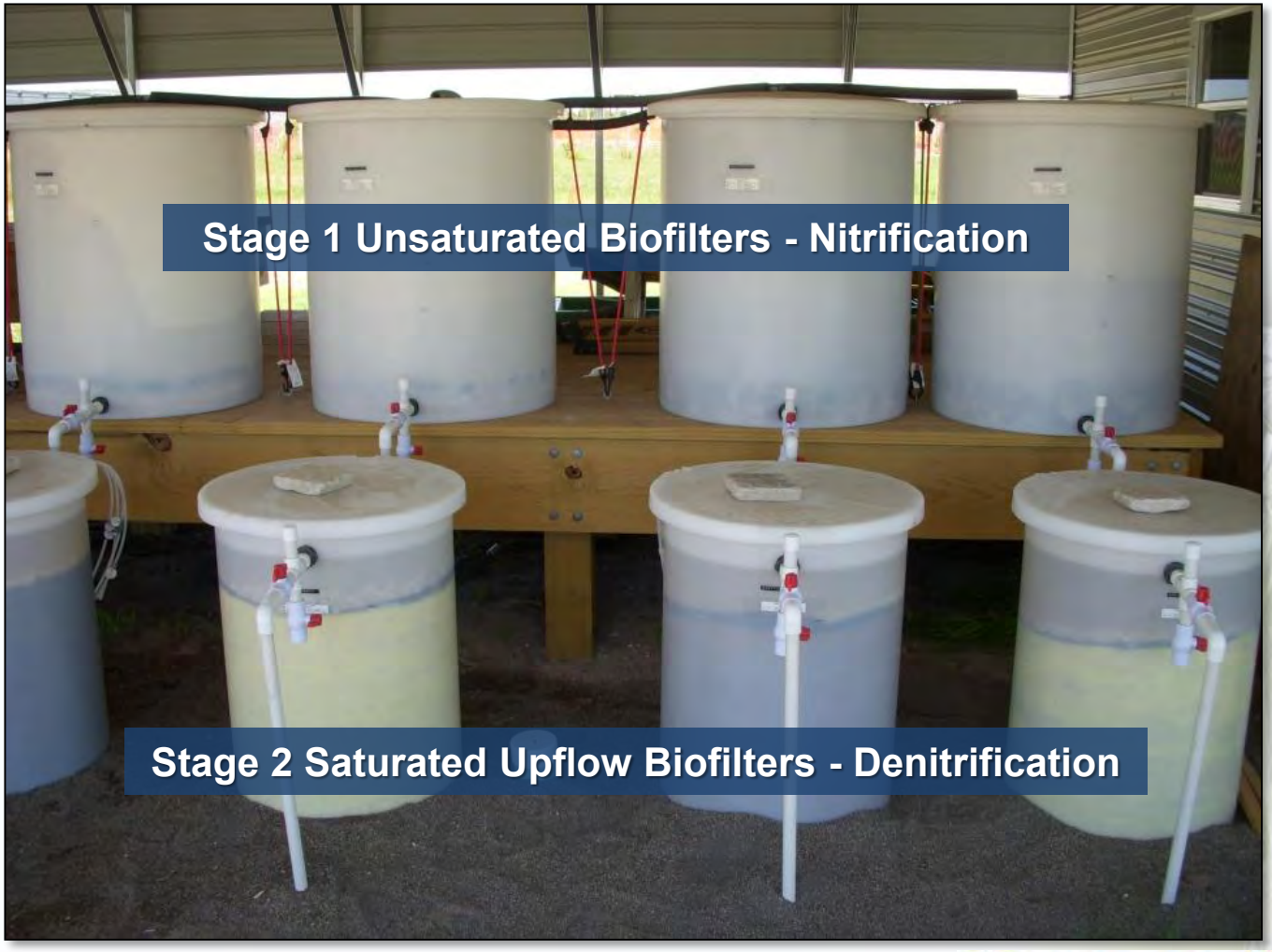


Photo of Two-stage single pass biofilter pilot units



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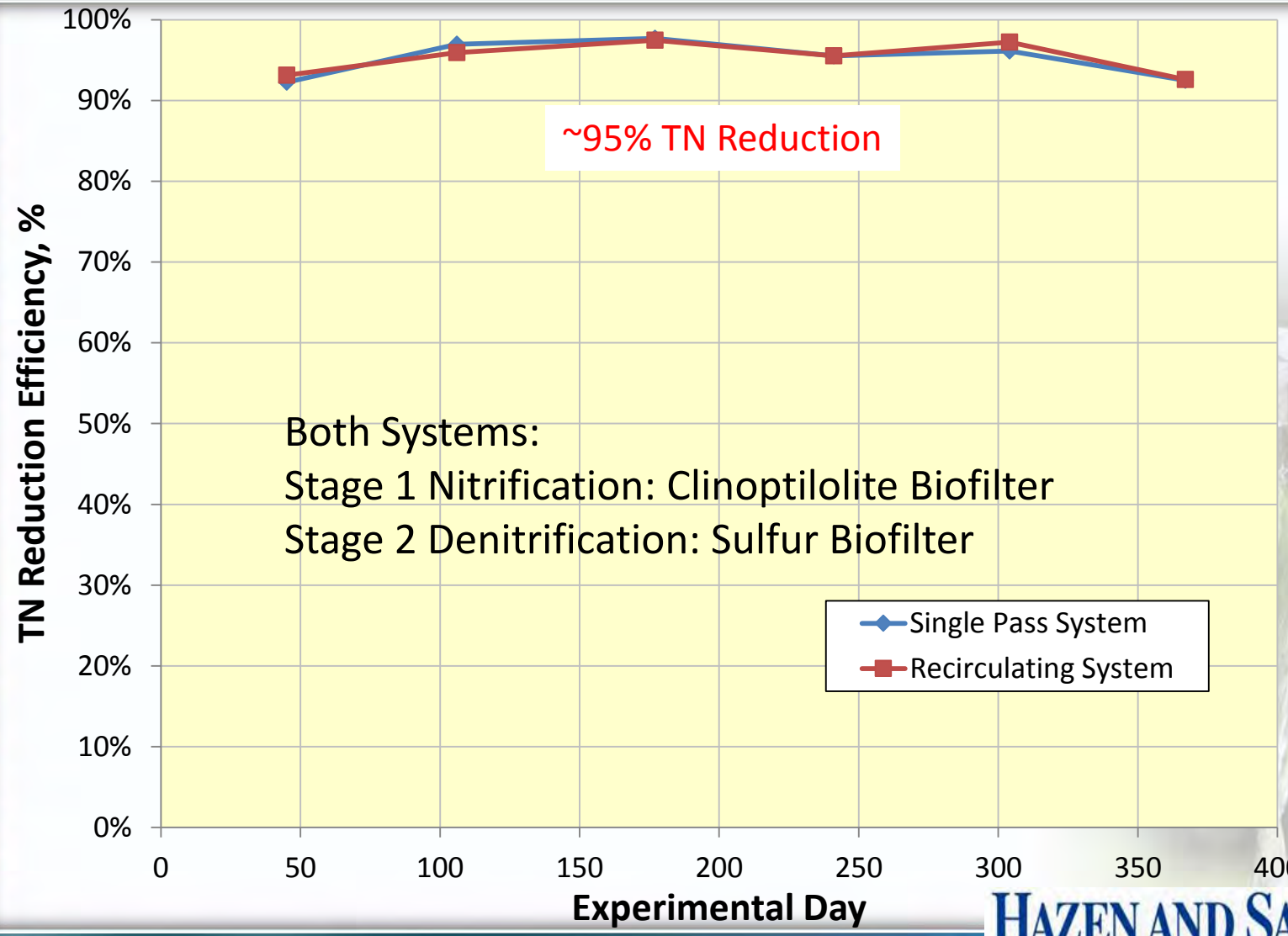
PNRS pilot-scale test results



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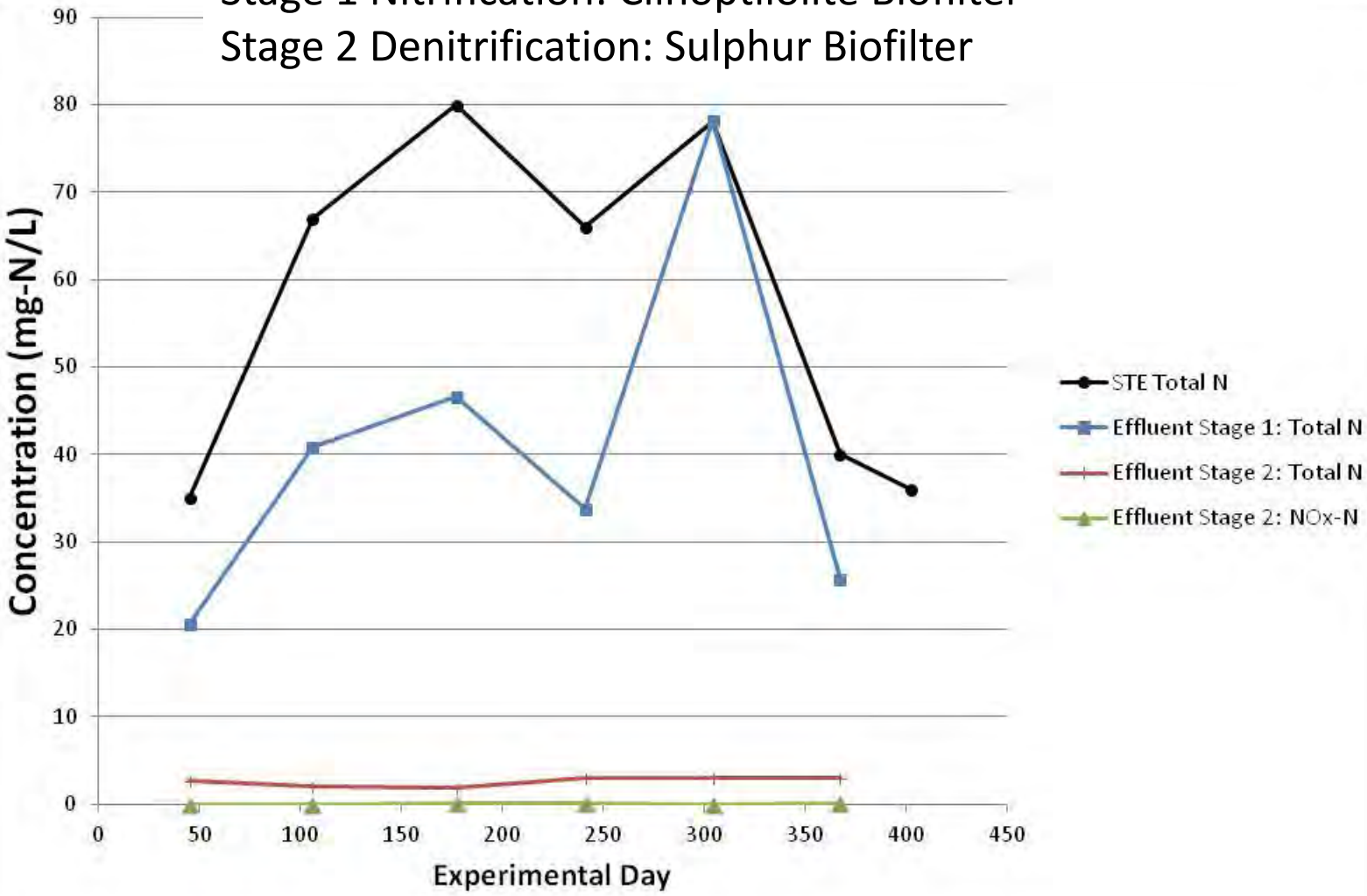
Single Pass System

Stage 1 Nitrification: Clinoptilolite Biofilter
Stage 2 Denitrification: Sulphur Biofilter



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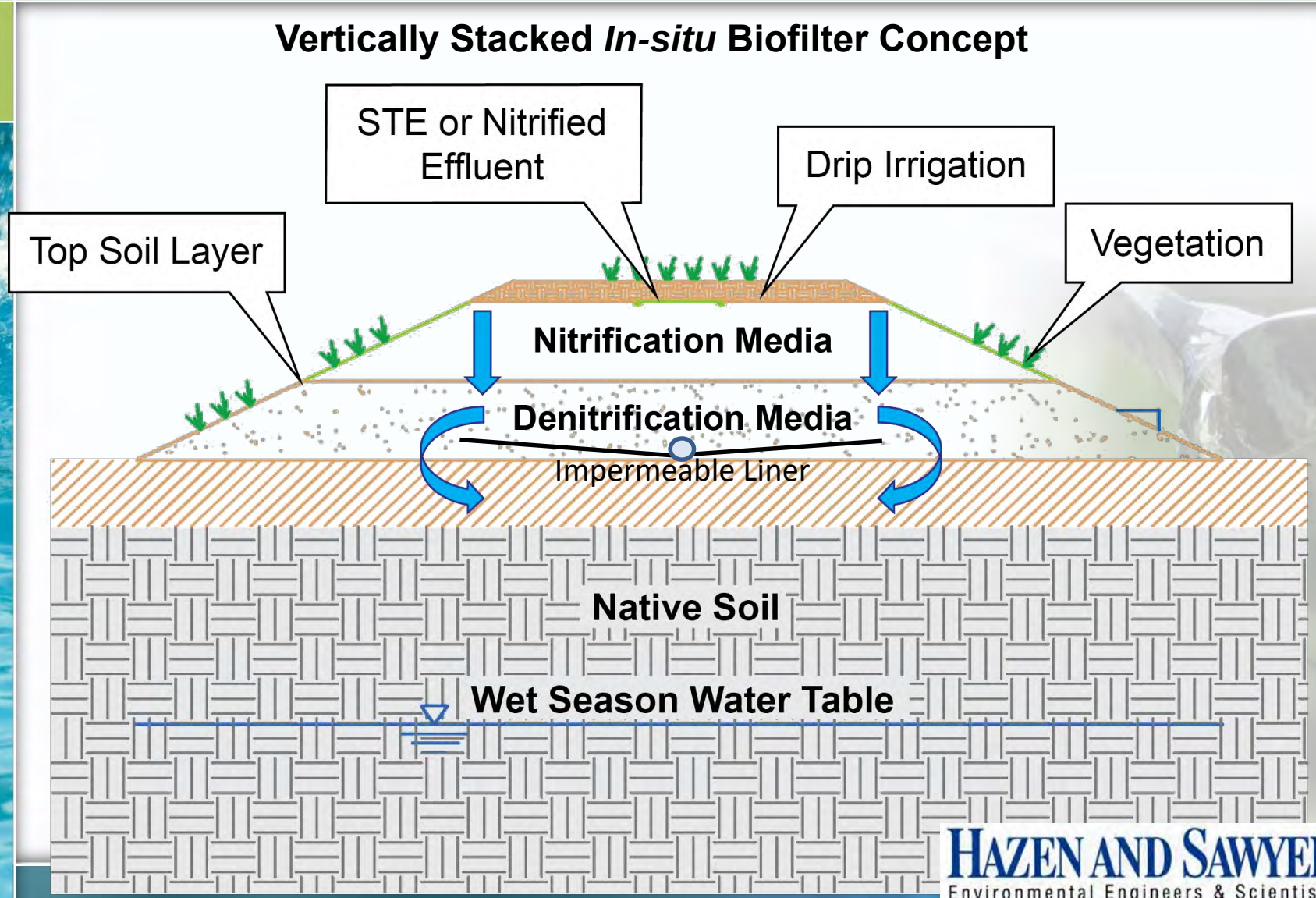
Also investigating *in-situ* stacked biofilters



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In situ Stacked Biofilter Construction

Pilot vertically stacked biofilter system performance

Mean results over 8 sample events, 523 days of operation

	n	TKN mg N/L	NH_3 mg N/L	NO_x mg N/L	TN mg N/L	Sulfate mg/L	Fecal Coliform (Ct/100 mL)	% TN Reduction
		mean	mean	mean	mean	mean	geomean	
STE Drip	8	65.1	55.60	0.29	65.4	40.6	13,273	
Stage 1 18" Sand	8	3.2	0.03	33.13	36.3	49.4	Non-detect	44%
Stage 2a ligno/sand	9	3.0	0.36	3.55	6.5	115.7	2.3	90%
Stage 2b sulfur tank	8	3.4	0.95	0.06	3.5	292.9	6.5	94%

Lessons learned from pilot test

- Encouraging results from pilot PNRS; several system configurations capable of ≥ 95% N reduction
- Sulfate production vs nitrate reduction
- Highly reactive elemental sulfur media
- Lignocellulosic retention time issues
- Recommended evaluation of combination lignocellulosic and elemental sulfur denitrification systems for full-scale treatment units

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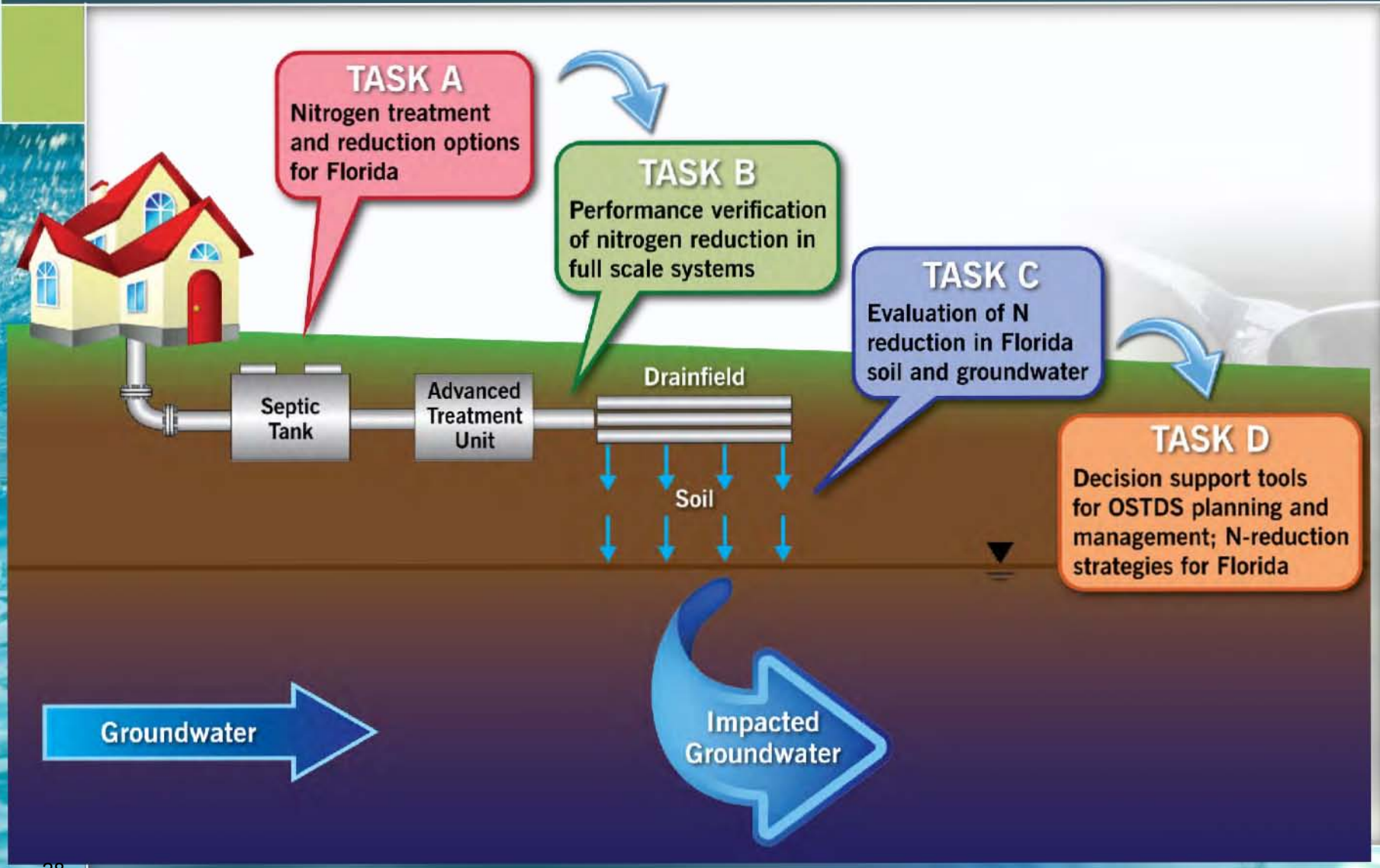
Passive Nitrogen Reduction Systems (PNRS): Full-scale Implementation

Task B Overview



7 PNRS systems installed

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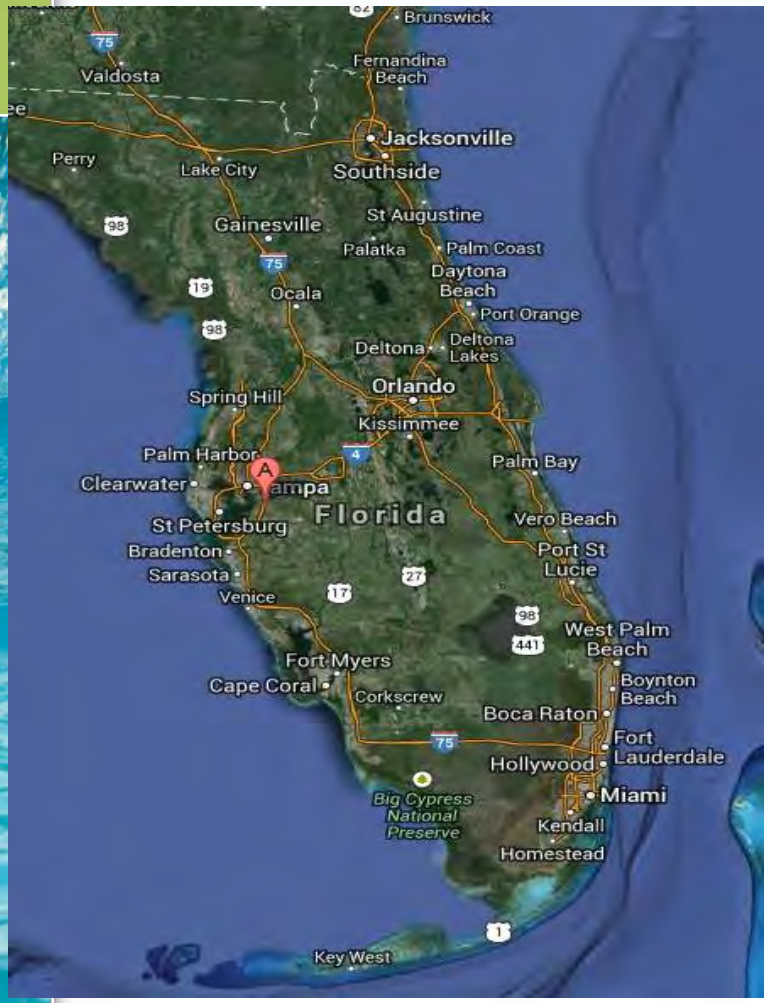
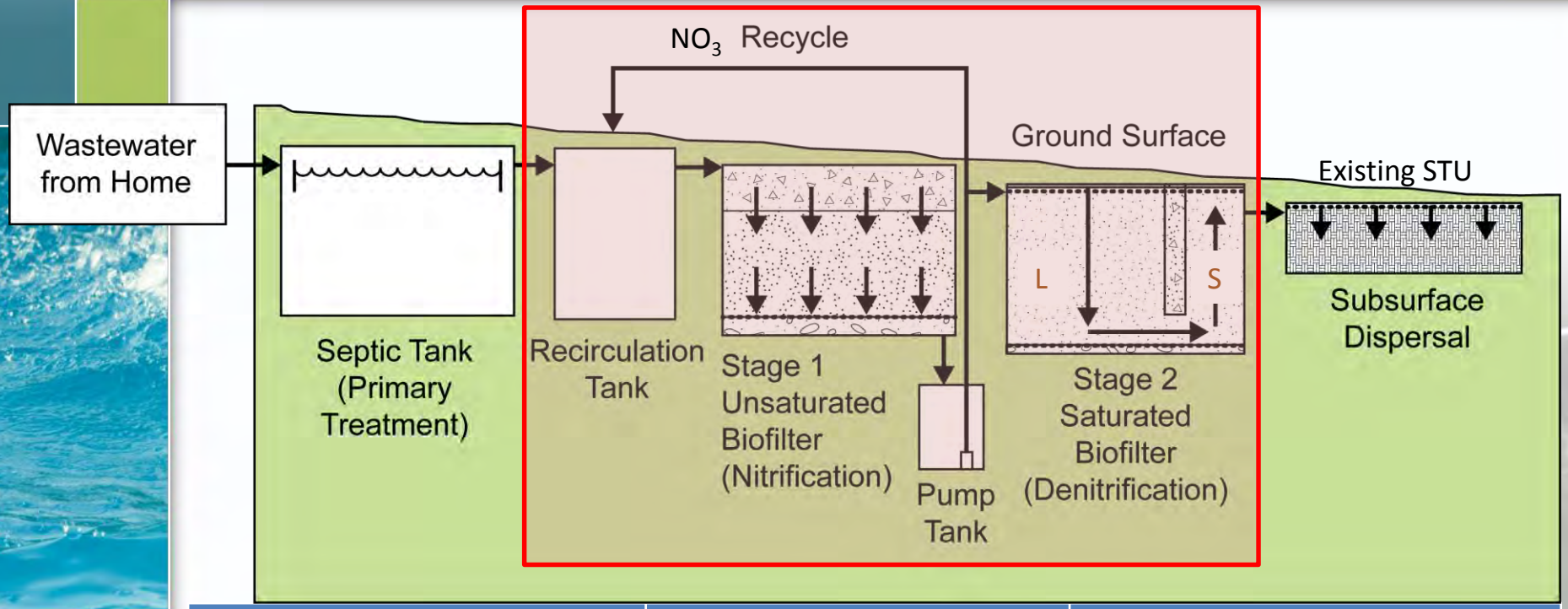
Hillsborough County PNRS: Tank System with Recirculation

Hillsborough County PNRS Location



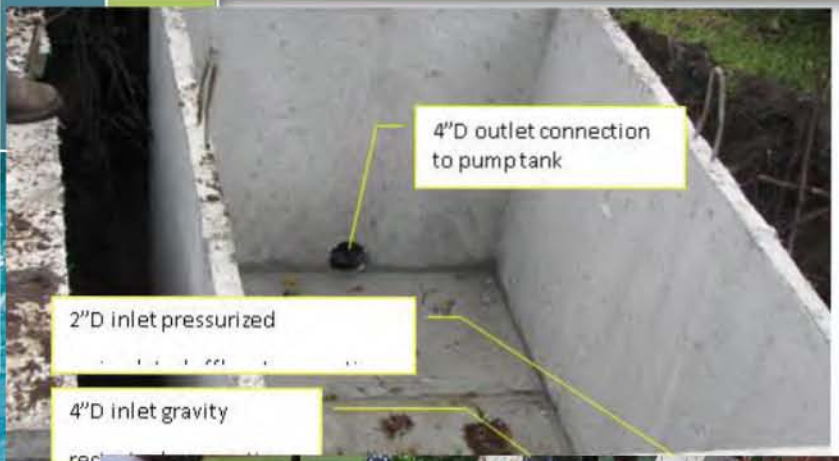
- Single family home
- 3 bedroom
- 2 residents
- Flow of 108 gpd

PNRS Flow Schematic and Basic Design Criteria

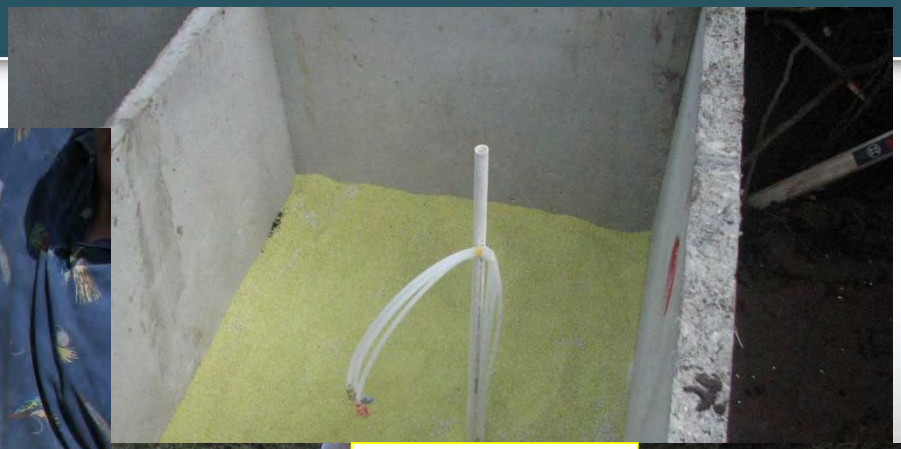


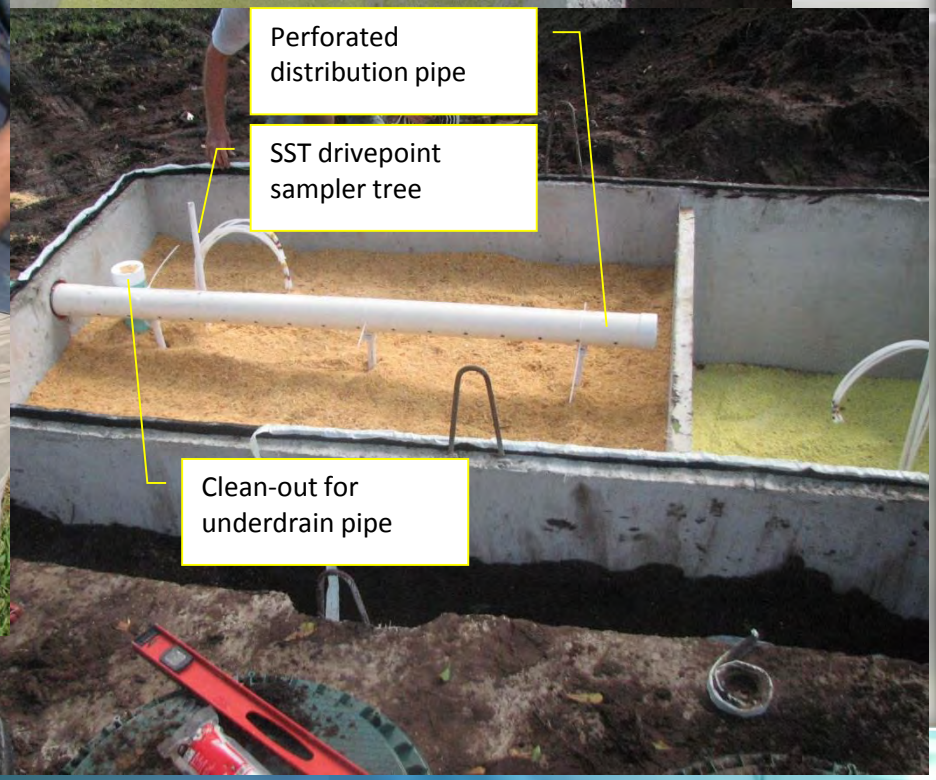
ID	HLR	Flow
Stage 1	3.0 gal/ft^2-d forward flow	108 gpd forward flow 450 gpd total w recycle (3.2:1 recycle ratio R/Q)
Stage 2, lignocellulosic	3.0 gal/ft^2-d	108 gpd
Stage 2, sulfur	6.1 gal/ft^2-d	108 gpd

Stage 1 Recirculating Biofilter Construction



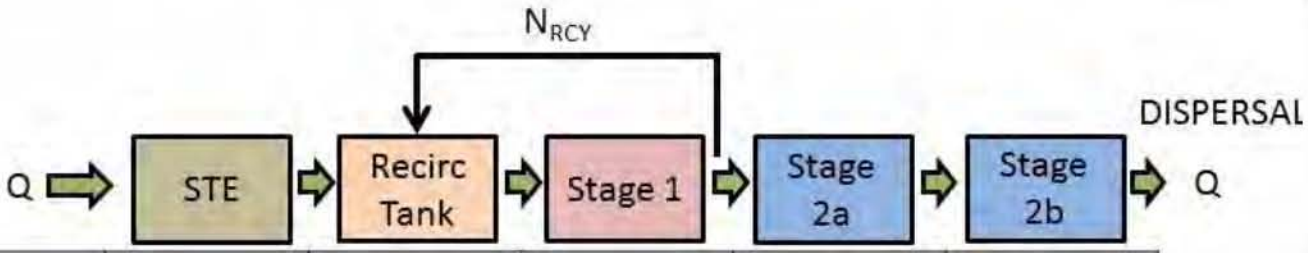
Stage 2 Denite Biofilter Construction





Completed Two-stage PNRS

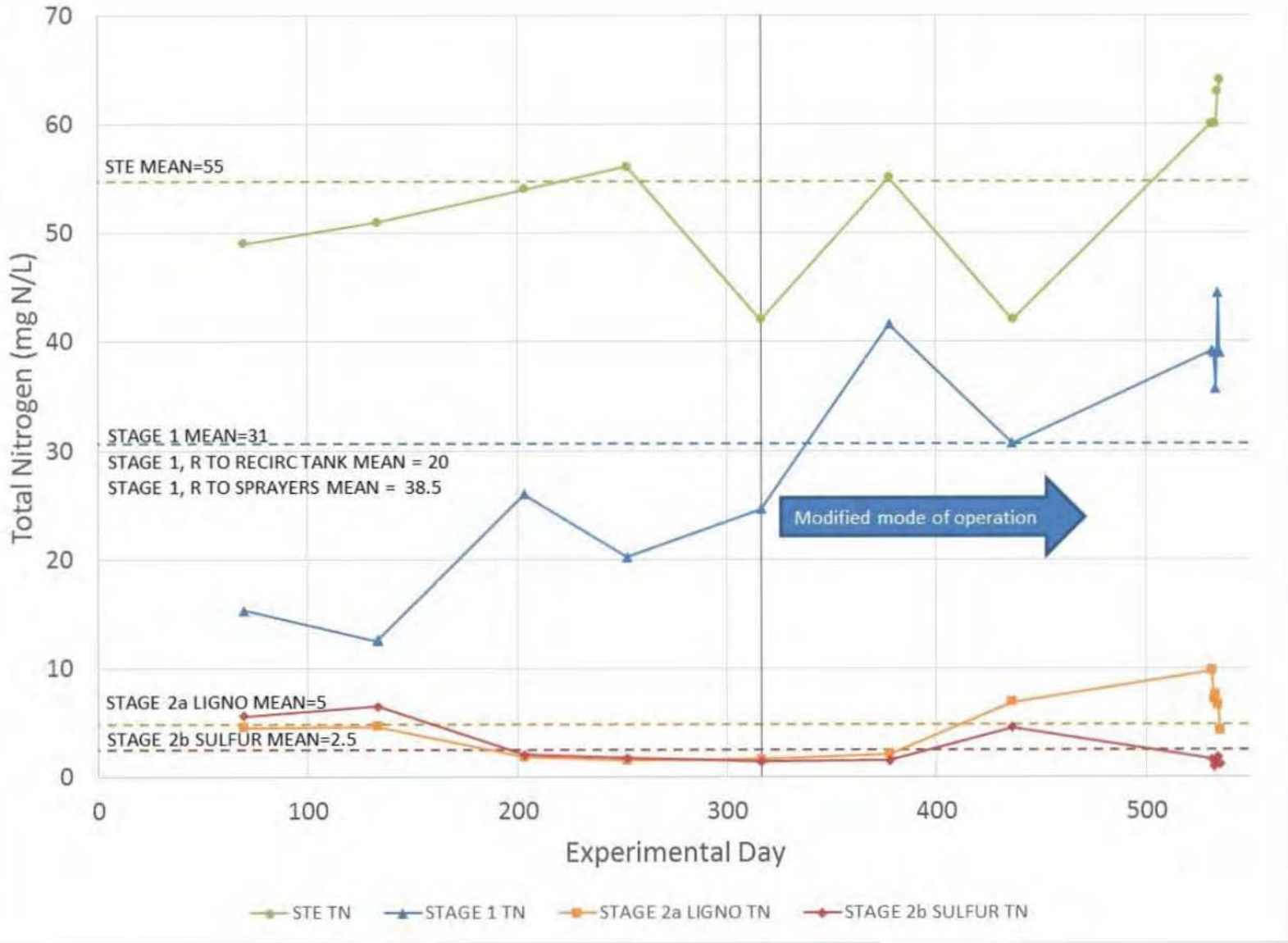
Hillsborough County PNRS
Results through Experimental Day 535



		Septic tank effluent		Stage 1 effluent	Stage 2 Lignocellulosic Effluent	Stage 2 Sulfur Effluent
n		12		12	12	12
$CBOD_5$ mg/L	mean	192.3		11.3	27.5	60.2
TKN mg N/L	mean	54.7		3.9	2.5	2.5
NH_3 mg N/L	mean	41.3		0.9	1.1	1.3
NO_x mg N/L	mean	0.05		26.8	2.3	0.02
TN mg N/L	mean	54.7		30.7	4.9	2.5
Sulfate mg/L	mean	53.6		154	156	202
Fecal Coliform (Ct/100 Ml)	geomean	90,160		1,297	19	31

TN Reduction
Stage 1, 44%
Stage 2b, 95%
prior to STU/drainfield

Hillsborough County PNRS: Time series of nitrogen data



Hillsborough County PNRS: Operation and maintenance

- Average energy consumption of 0.31 kWh/day or 2.7 kWh/1000 gal treated
- Stage 1 biofilter – no surficial biomat or clogging present
- Stage 2 biofilter – reactive media shows very little reduction in volume

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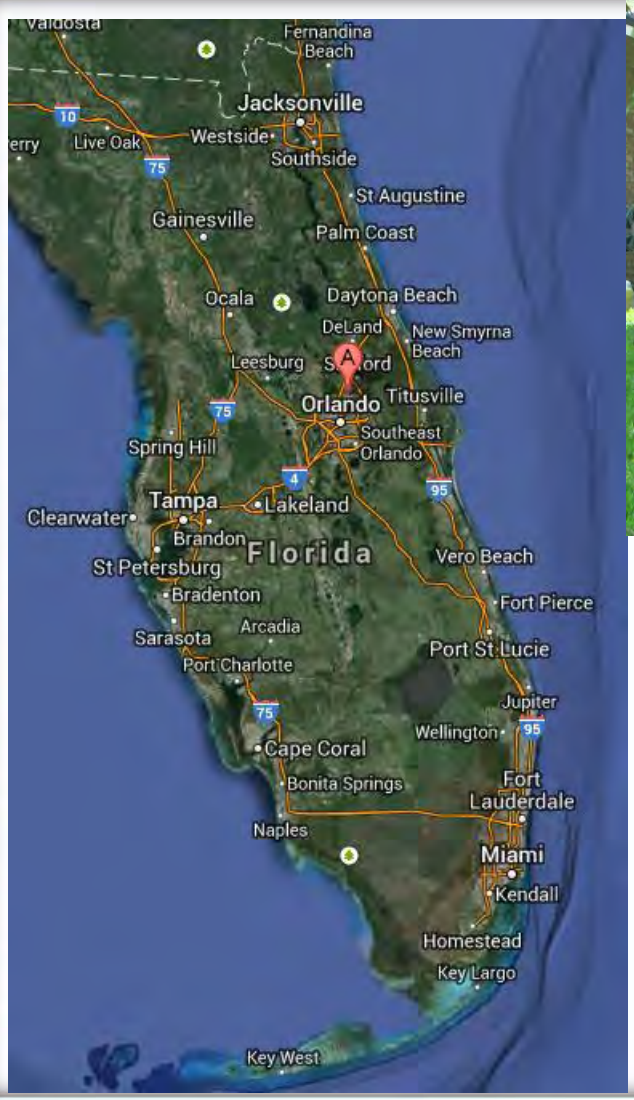
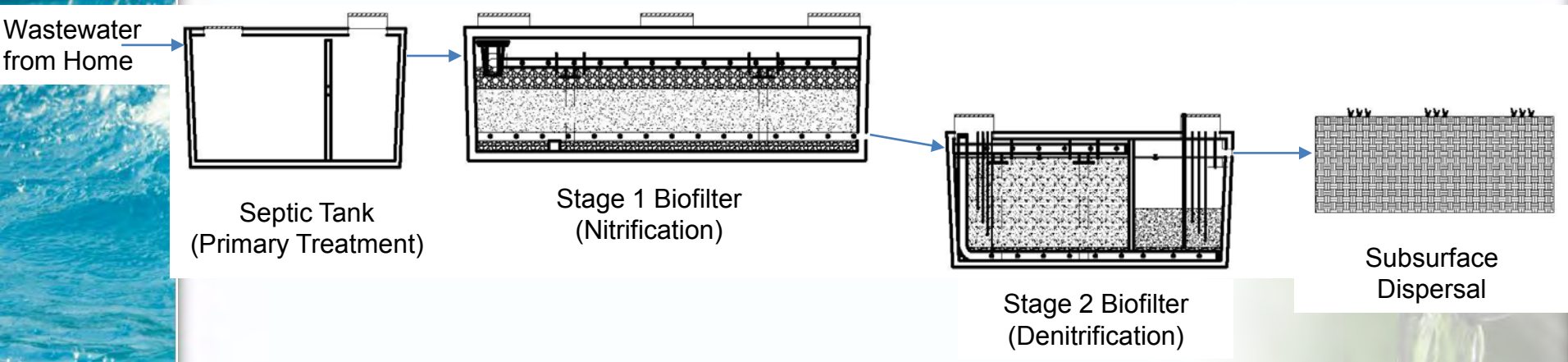
Seminole County PNRS: Single pass tank system

Seminole County, FL PNRS Location



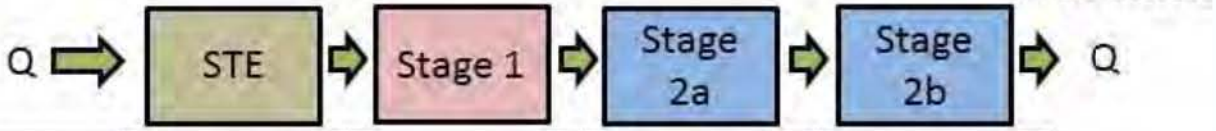
- Single family home
- 4 bedroom
- 5 residents
- Flow of ~287 gpd

PNRS Flow Schematic and Basic Design Criteria



ID	Surface Area	HLR
Stage 1	113.2 ft^2	2.5 gal/ft^2-d
Stage 2a Ligno	36.2 ft^2	7.9 gal/ft^2-d
Stage 2b Sulfur	18.1 ft^2	15.8 gal/ft^2-d

Seminole County PNRS
Preliminary results through Experimental Day 321



		Septic tank effluent	Stage 1 effluent	Stage 2 Lignocellulosic Effluent	Stage 2 Sulfur Effluent
n		9	9	9	9
$CBOD_5$ mg/L	mean	149	9.6	13.2	13.8
TKN mg N/L	mean	67.8	14.1	10.4	7.8
NH_3 mg N/L	mean	60.4	9.6	7.1	5.2
NO_x mg N/L	mean	0.05	29.4	1.4	0.04
TN mg N/L	mean	67.8	43.5	11.8	7.9
Sulfate mg/L	mean	2.0	18.1	11.8	31.7
Fecal Coliform (Ct/100 Ml)	geomean	37,811	4,279	1,140	357

TN Reduction
Stage 1, 36%
Stage 2b, 88%
prior to STU/drainfield

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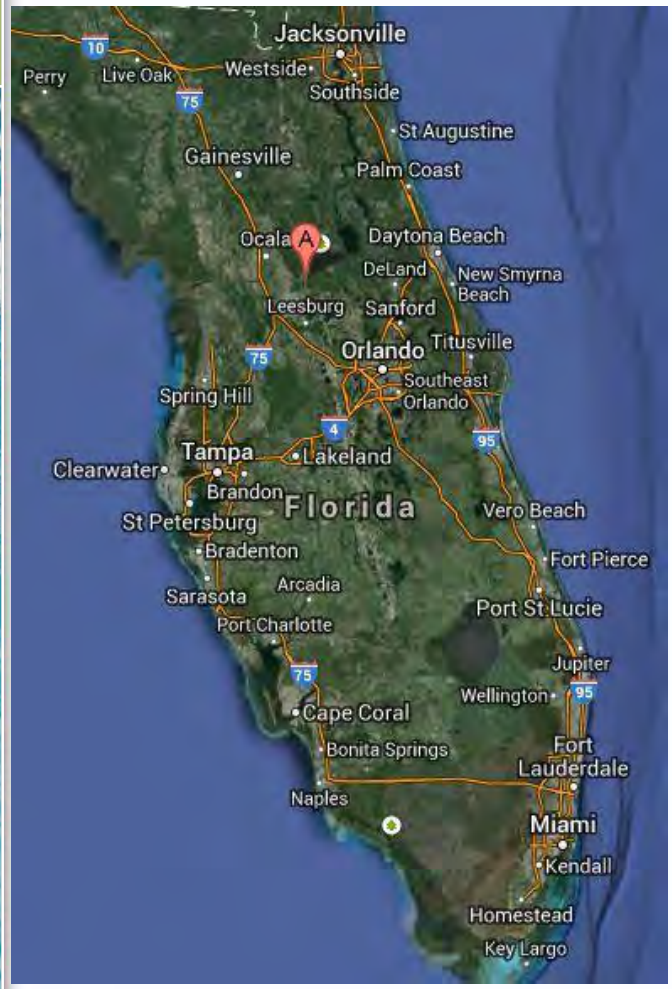
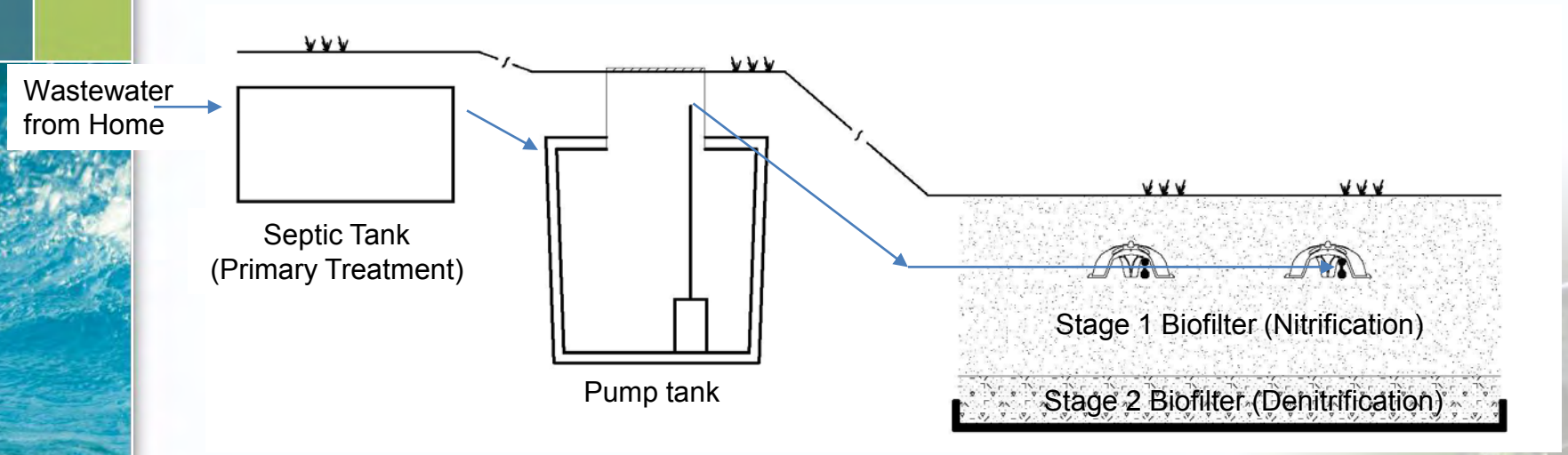
Marion County PNRS: In ground, vertically stacked biofilter system

Marion County, FL PNRS



- Single family home
- 2 bedroom
- 2 residents
- Flow of ~120 gpd

PNRS Flow Schematic and Basic Design Criteria



ID	Surface Area	Design HLR
Stage 1 Sand	375 ft^2	0.8 gal/ft^2-d
Stage 2 Lignocellulosic	792 ft^2	

Marion County, FL PNRS

Marion County, FL PNRS

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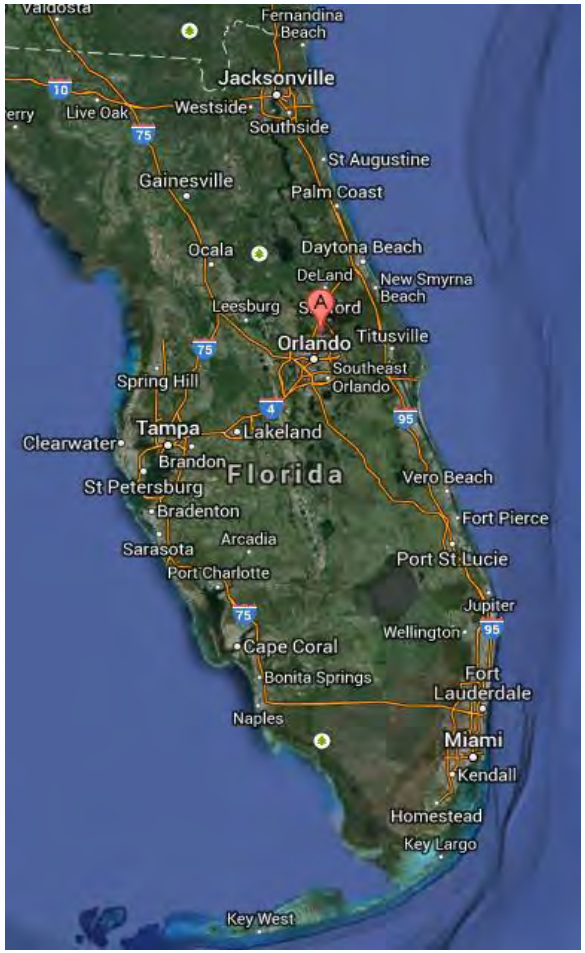
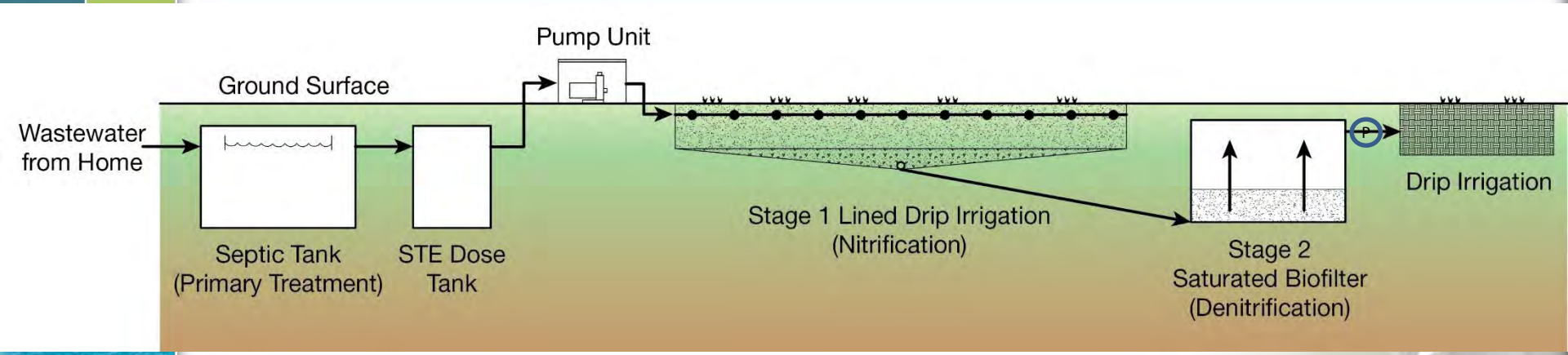
Seminole County PNRS: Drip system with reuse

Seminole County, FL PNRS Location



- Single family home
- 5 bedroom (2 residents)
- Flow of ~142 gpd
- Mounded drainfield
- Myakka and EauGallie fine sands

PNRS Flow Schematic and Basic Design Criteria



ID	Surface Area	Design HLR
Stage 1	728 ft^2	0.8 gal/ft^2-d
Stage 2	32.3 ft^2	18 gal/ft^2-d
Drip irrigation	615 ft^2	0.94 gal/ft^2-d

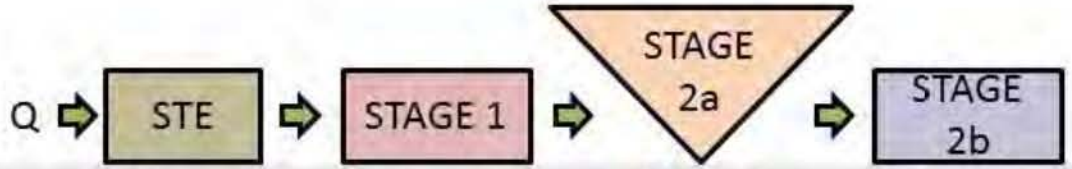
Stage 1 Lined Drip Irrigation

Pipe boot

Gravel Underdrai

Stage 2 Denite Biofilter Construction

Seminole County PNRS
Preliminary results through Experimental Day 321

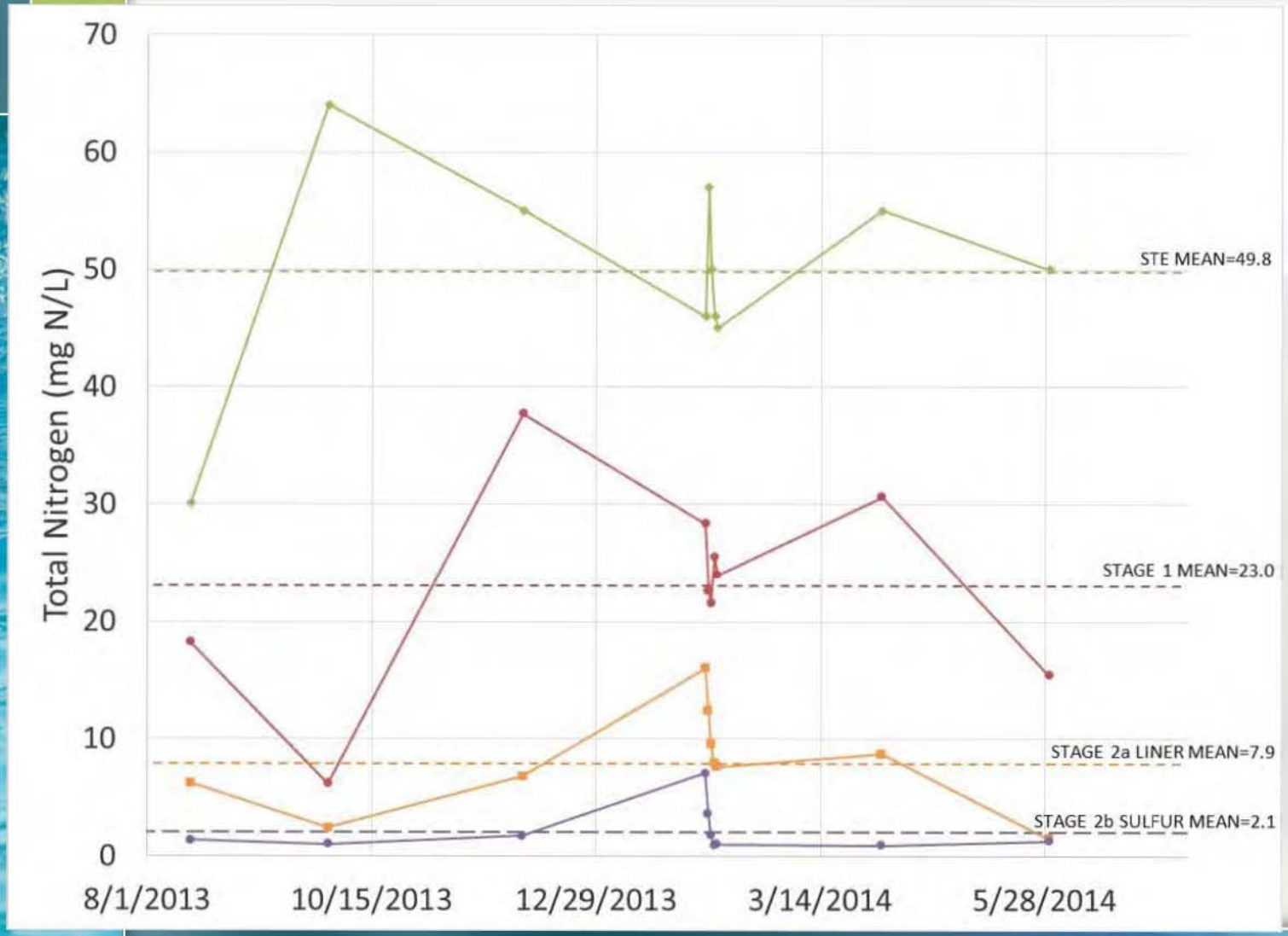


		Septic tank effluent	Stage 1 effluent	Stage 2 Lignocellulosic Effluent	Stage 2 Sulfur Effluent
n	mean	9	9	9	9
$CBOD_5$ mg/L	mean	77.2	3.8	3.6	14.9
TSS, mg/L	mean	22.6	2.6	20.4	5.0
TKN mg N/L	mean	49.8	1.8	2.0	1.3
NH_3 mg N/L	mean	38.9	0.2	0.2	0.3
NO_x mg N/L	mean	0.03	21.2	5.9	0.8
TN mg N/L	mean	49.8	23.0	7.9	2.1
Sulfate mg/L	mean	21	40	25	104
Fecal Coliform (Ct/100mL)	geomean	66,086	1,000	38	6

NA=not analyzed

TN Reduction
Stage 1, 54%
Stage 2b, 96%
prior to STU/drainfield

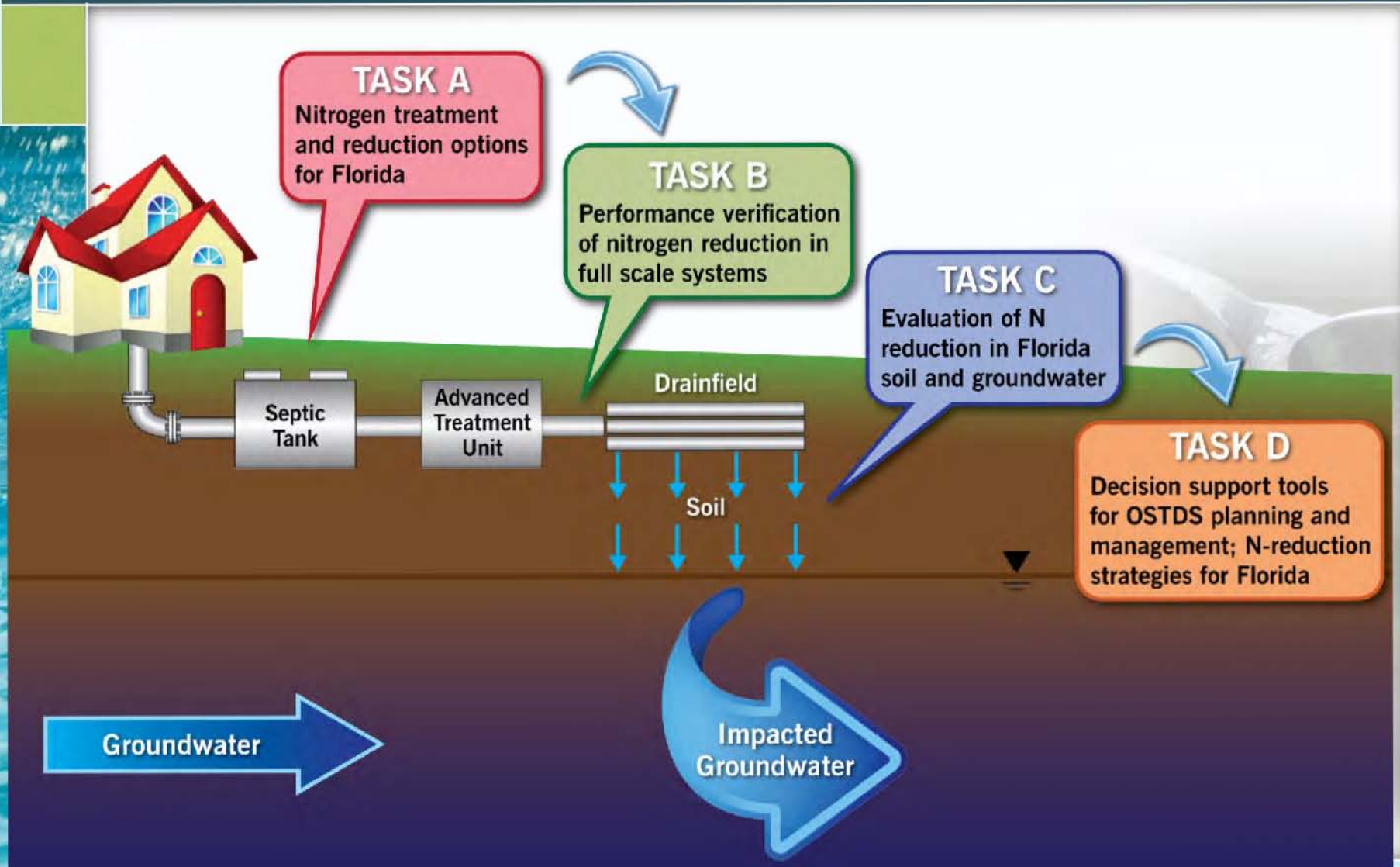
Seminole County PNRS: Time series of nitrogen data



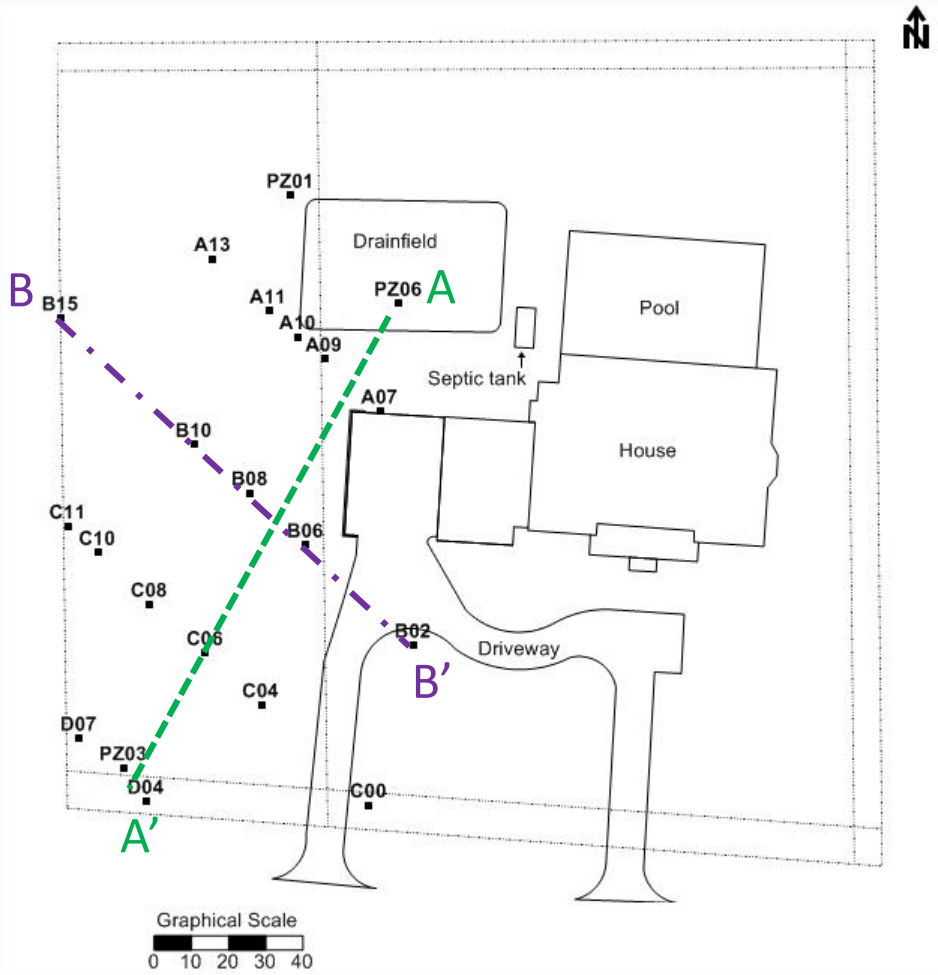
Drip Irrigation System

Subsurface Drip Irrigation Construction

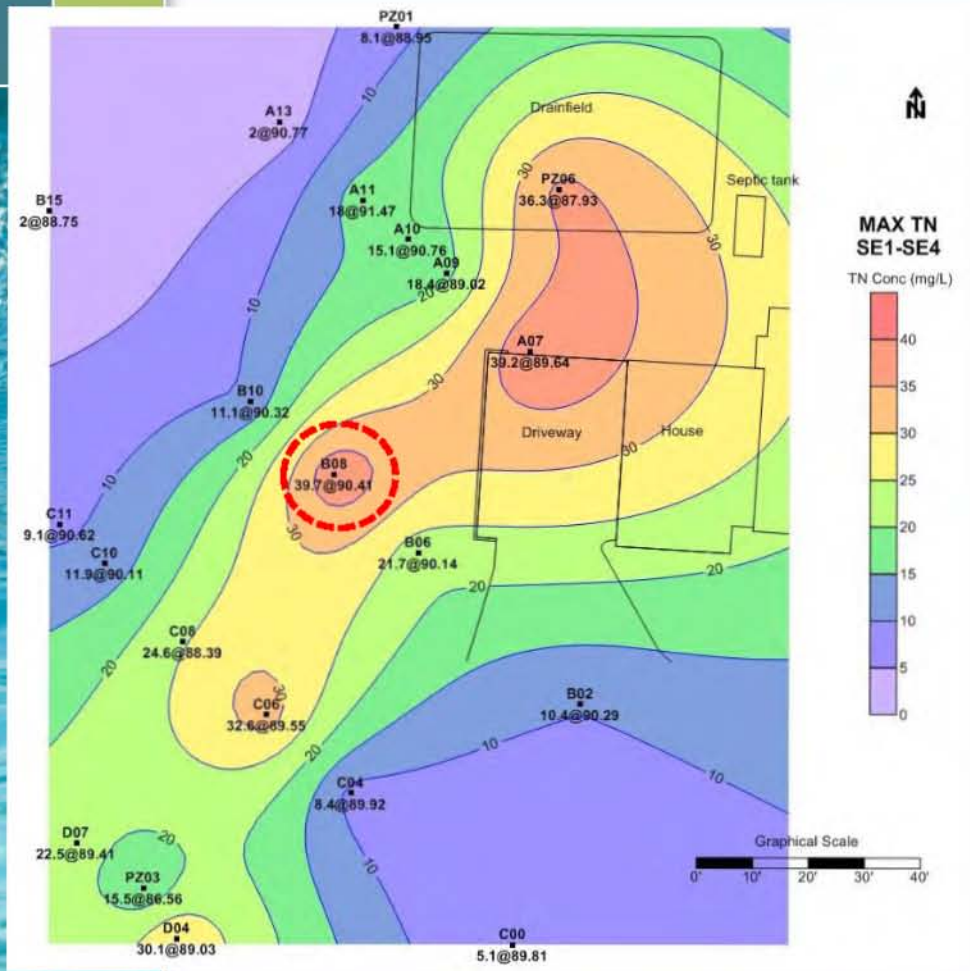
Task C Overview

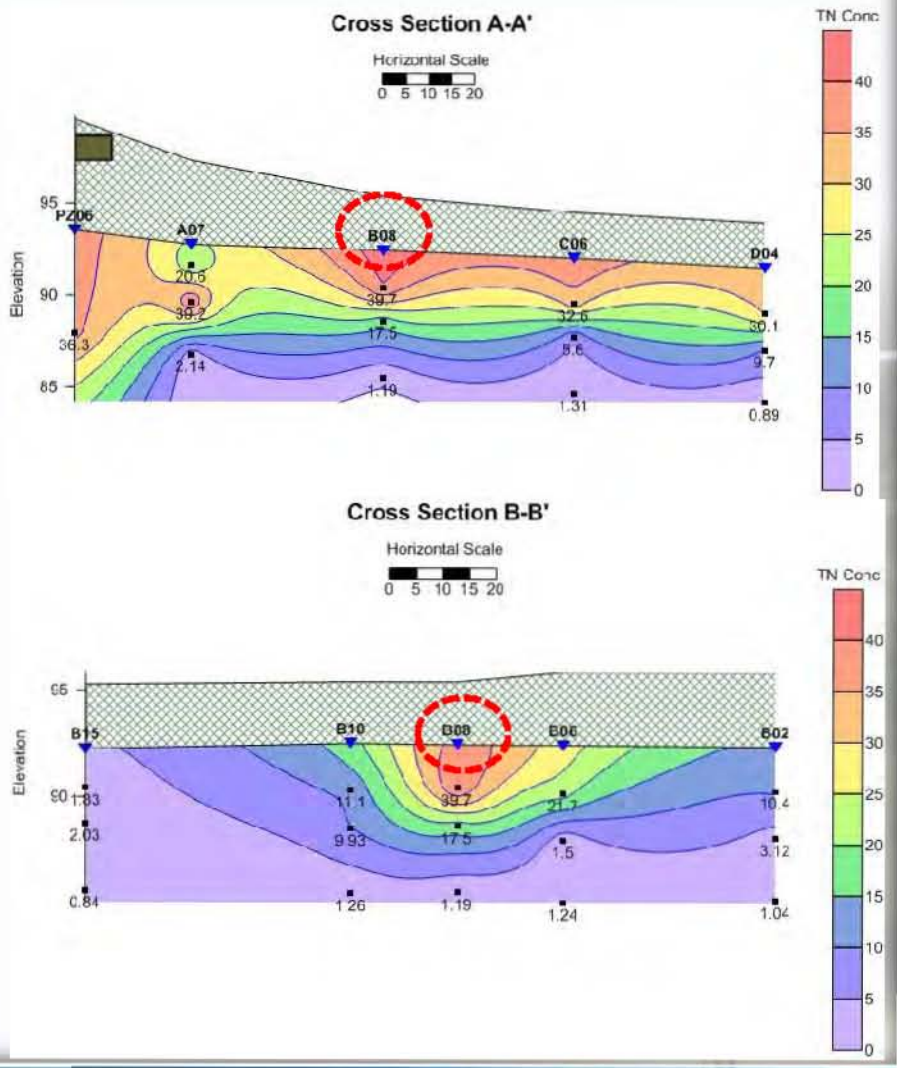


C-HS2 Longwood, FL

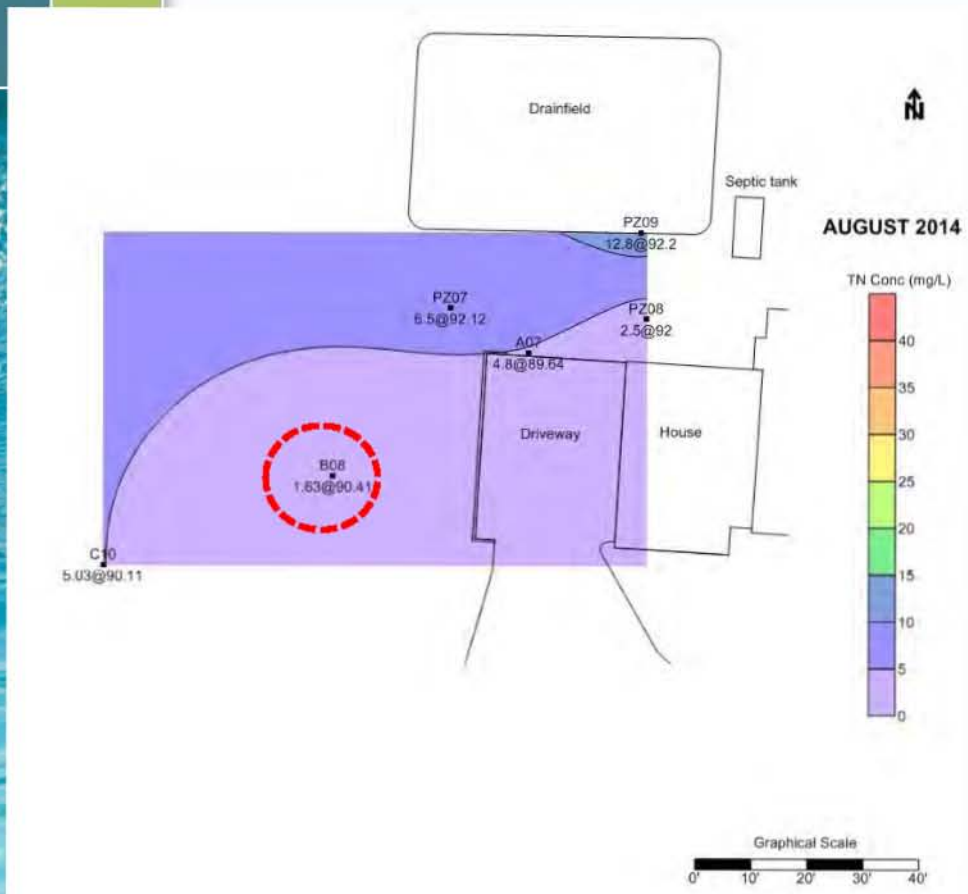


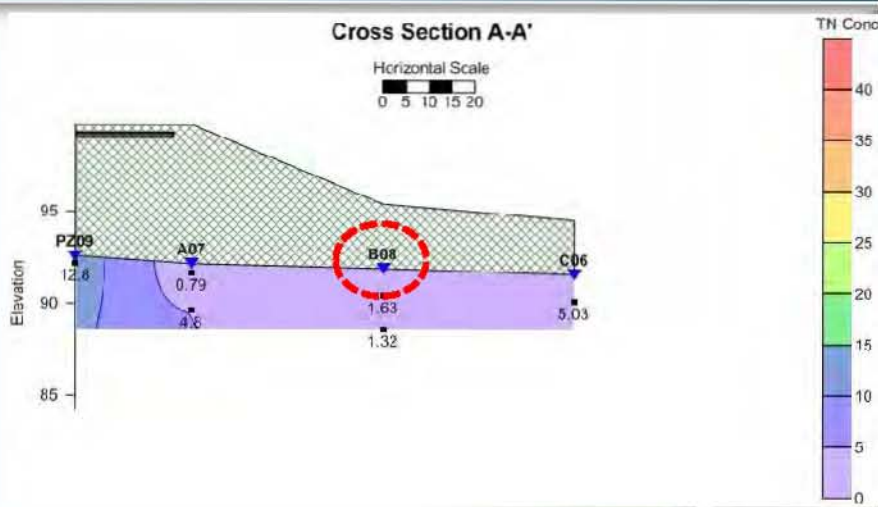
Task C monitoring – before PNRS installed



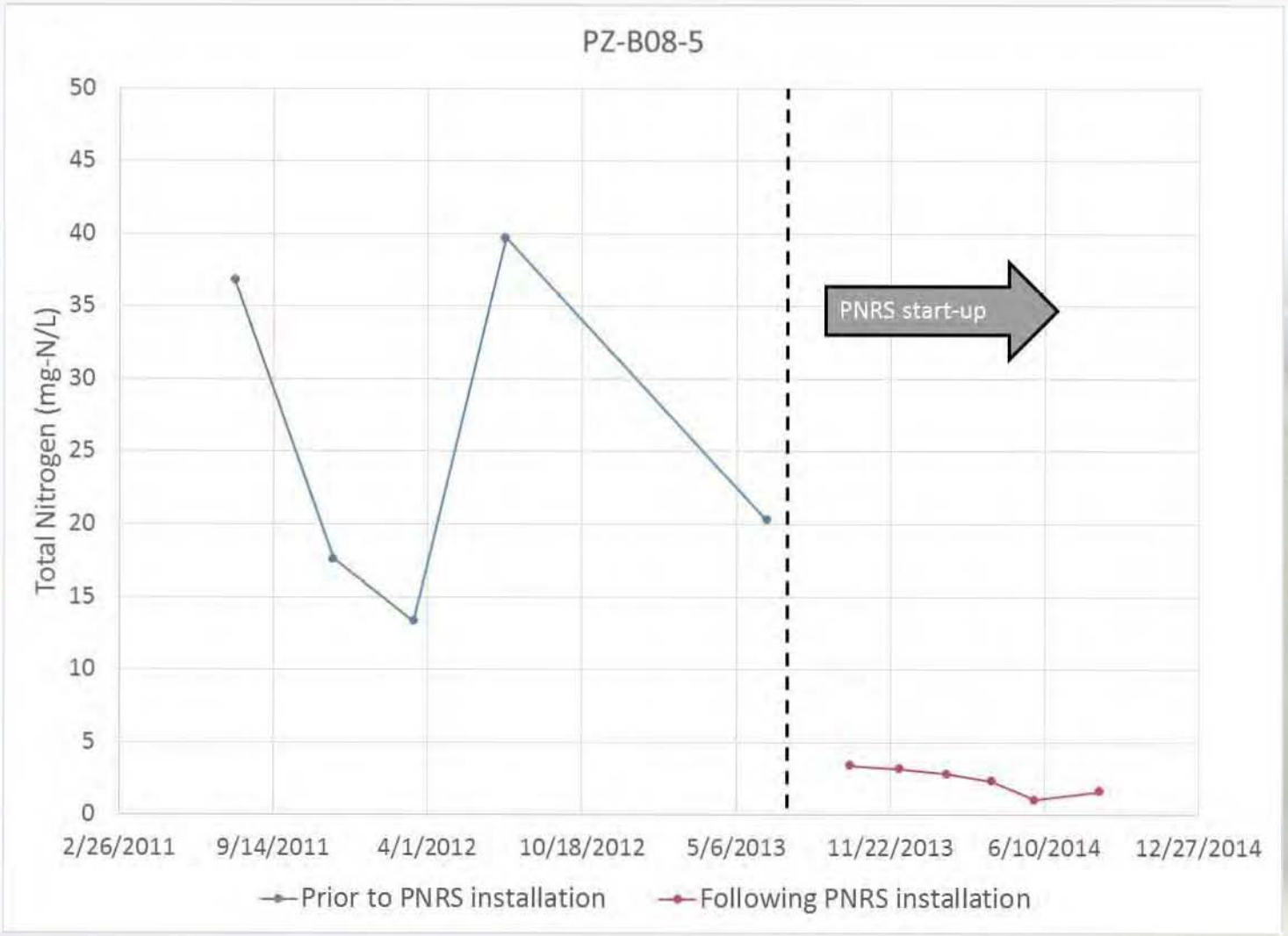


Task C monitoring – after PNRS installed



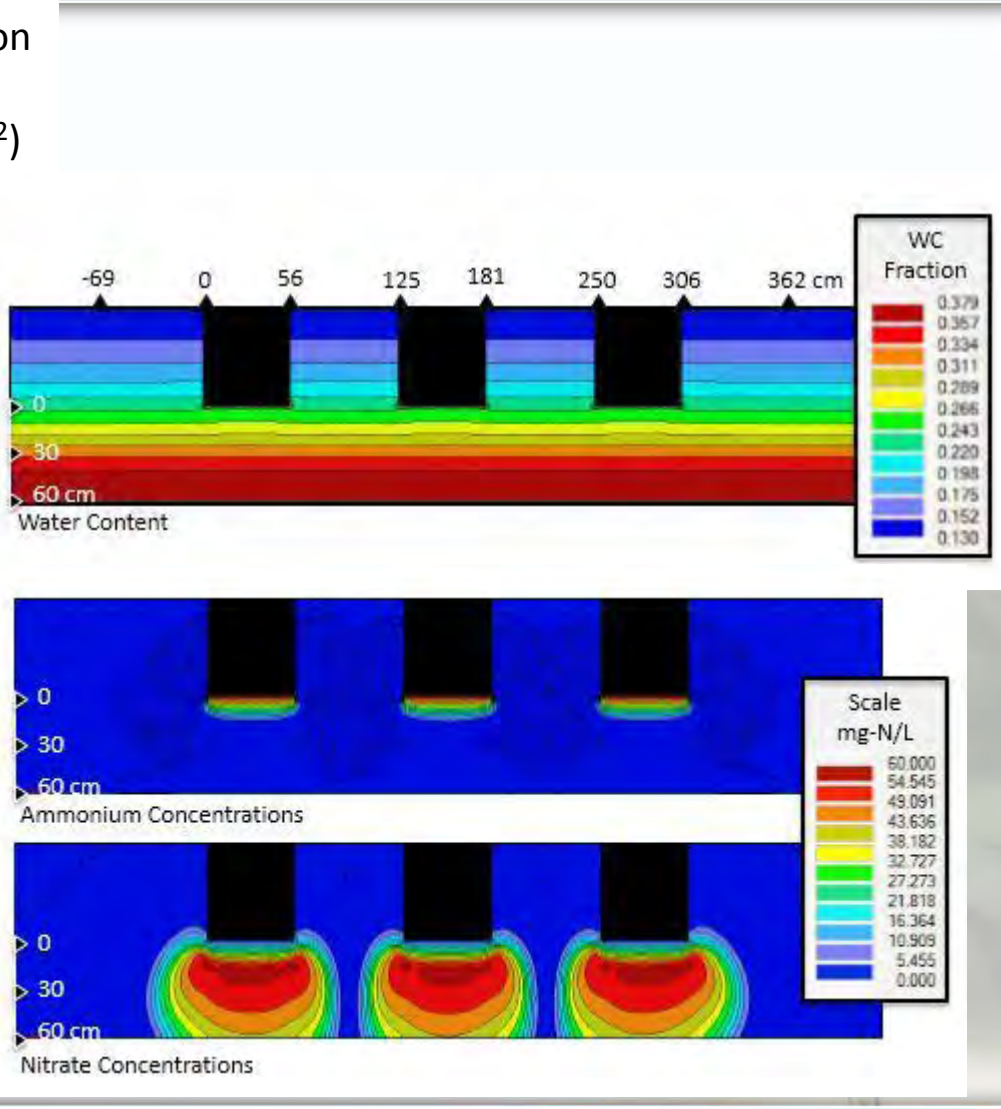


Task C monitoring – after PNRS installed

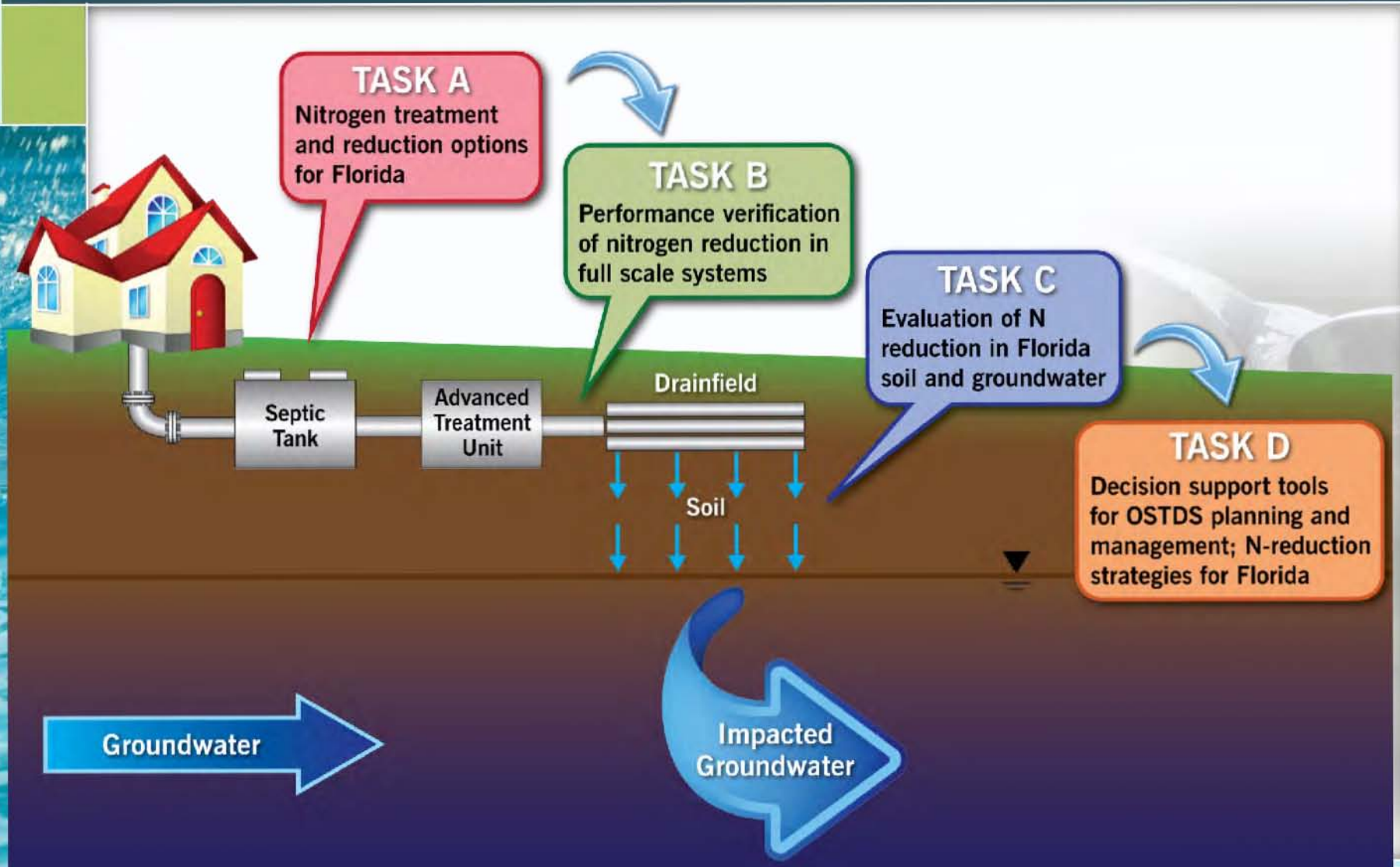


Task D is evaluating nitrogen fate and transport scenarios

Configuration: trench, equal distribution
Soil Type: less permeable sand
Loading Rate: 2.67 cm/d (0.65 gpd/ft^2)
Effluent Nitrogen: 60 mg-N/L as NH_4
Depth to Water Table: 60 cm (2 ft)



Putting it all together…



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Summary & Questions

FOSNRS Summary

- Multi-prong project underway to reduce nitrogen from Florida's Onsite Sewage Treatment and Disposal Systems
- Integrated tasks of:
  - Treatment technology evaluation including new passive systems
  - Full-scale field testing of PNRS treatment technologies
  - Monitoring of nitrogen fate and transport in subsurface
  - Modeling and planning tools to support regulatory decision making
- Successful results would allow OSTDS to achieve nitrogen removal similar to wastewater treatment plants and play a role in nitrogen reduction in sensitive watersheds.

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QUESTIONS ?

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