FLORIDA ONSITE SEWAGE NITROGEN REDUCTION STRATEGIES (FOSNRS) STUDY

Presentation to the FDOH Research Review and Advisory Committee (RRAC)

July 28, 2015

by

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PROJECT TEAM ACKNOWLEDGEMENTS

Florida HEALTH

HAZEN AND SAWYER
Environmental Engineers & Scientists

SCHOOL OF MINES 1874 COLORADO

UF UNIVERSITY of FLORIDA Gulf Coast Research and Education Center

AET Applied Environmental Technology

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And many support firms and staff!

Special acknowledgements to the volunteer homeowners!

Presentation Outline

- Excess Nitrogen impacts water quality!
- Florida onsite sewage nitrogen reduction strategies (FOSNRS) project background
- Task A: Technology Review and Pilot Testing
- Task B: Full Scale Prototype PNRS Testing
  - Proprietary system (System 1)
  - In-tank PNRS (System 2)
  - In-ground PNRS (System 3)
- Task C: Soil and Groundwater Monitoring
- Task D: Nitrogen Fate & Transport Modeling and Tool Development
- Summary & Questions

Why are we here?

Excess Nitrogen impacts water quality!

Adverse effects of nitrogen

- **Public Health:** SDWA Limit of 10 mg/L NO_3 – N, Harmful Algal Blooms (HABs)
- **Ecosystem Health/ Water Qualty:** N is limiting nutrient in many water bodies
  - Algal blooms, loss of habitat, hypoxia
- **Impacts of excess nitrogen on water quality have been documented in many areas:**
  - Tampa Bay, Sarasota Bay, Indian River Lagoon
  - Florida Keys
  - Florida's Freshwater Springs and elsewhere

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

Photos courtesy of John Moran - SpringsEternalProject.org

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Nitrogen reducing onsite wastewater systems (OWS)

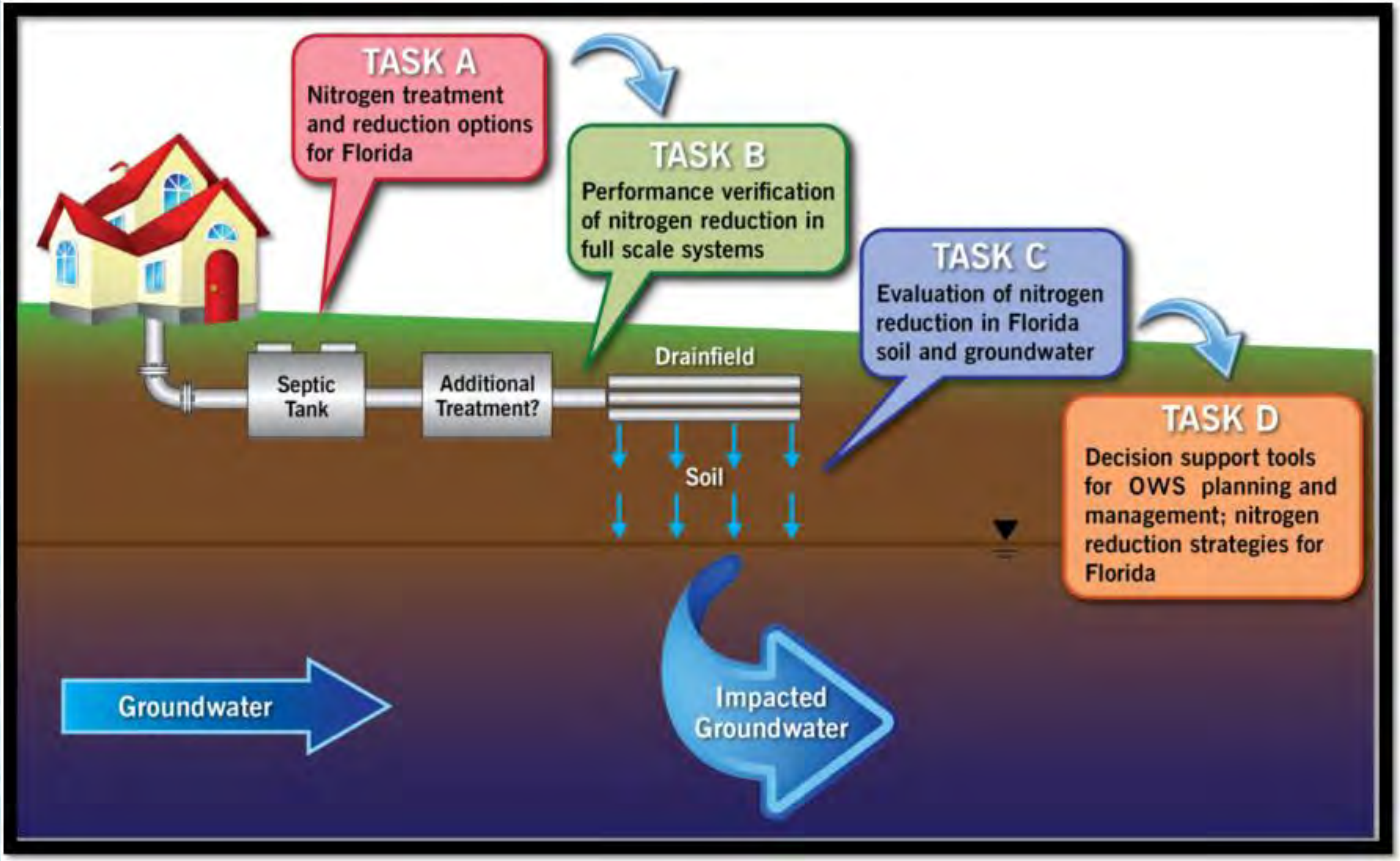
- Concerns over nitrogen impacts have led to requirements to reduce nitrogen, typically to a 10 mg/L total nitrogen goal prior to discharge to the soil
  - Florida Keys
  - Wakulla County, FL
- Performance based treatment systems (PBTS) utilizing an activated sludge biological (BNR) process, similar to a municipal treatment plant, have been typically used.
- Inconsistent performance of PBTS has been documented, with systems generally unable to meet 10 mg/L TN goal.

Florida Onsite Sewage Nitrogen Reduction Strategies (FOSNRS) project background

FOSNRS project initiated by Florida legislature

- Florida Legislature directed FDOH to conduct a study to further develop more "**passive**" & cost-effective nitrogen reduction strategies for onsite sewage treatment and disposal systems (OSTDS)
- "Passive" nitrogen reducing OSTDS should be more similar to conventional onsite systems in their operation and maintenance
- Initiated the Florida Onsite Sewage Nitrogen Reduction Strategies (FOSNRS) Project in 2009
- RFP identified four primary study areas

Four primary study areas



Task A: Technology Review and Pilot Testing

Task A Components

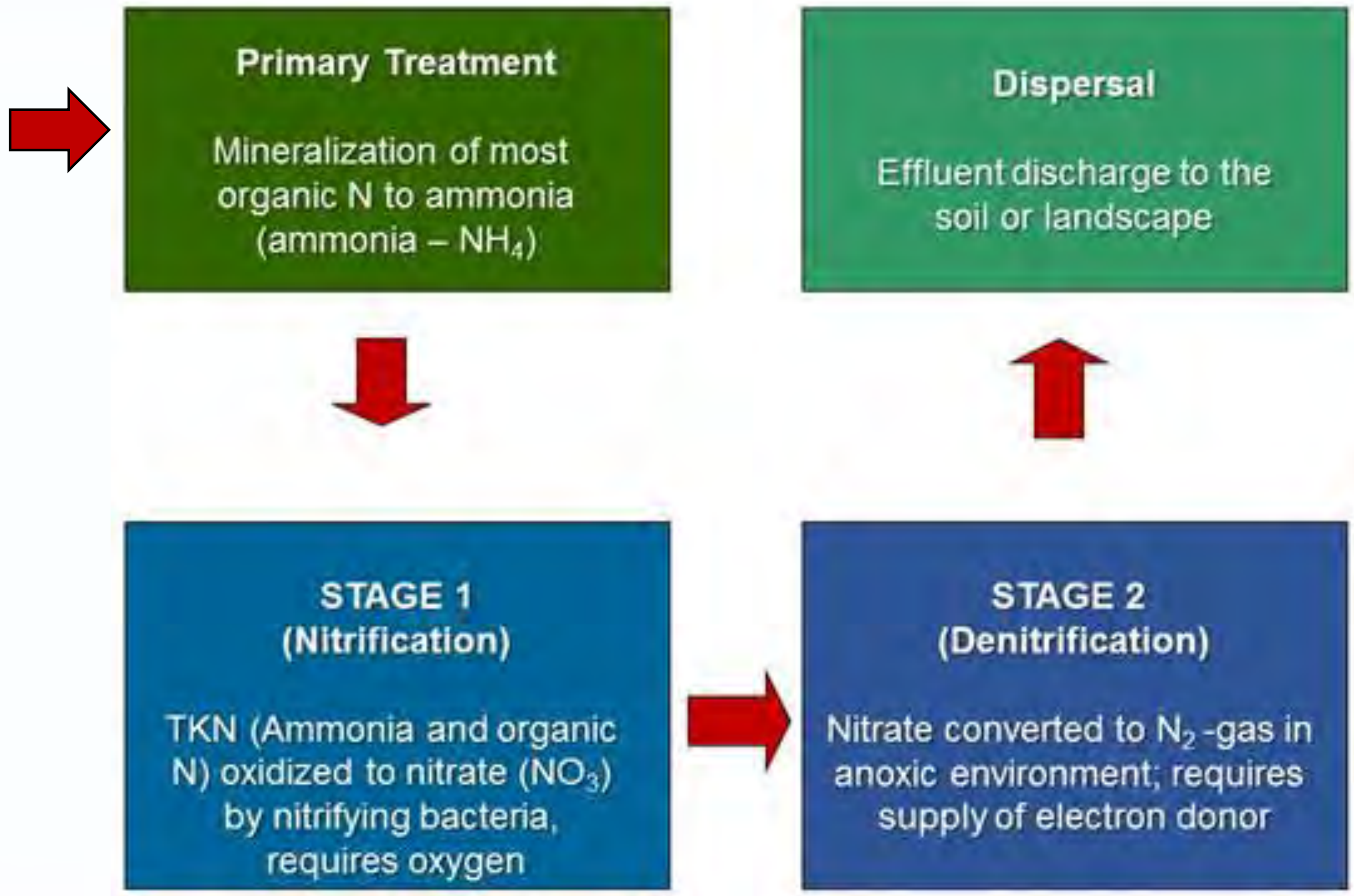
- Literature review to evaluate nitrogen reducing technologies
- Ranking and prioritization of nitrogen reducing technologies for field testing
- Technology ranking workshop with RRAC conducted on May 28, 2009
- Pilot testing of passive nitrogen reduction systems (PNRS)
- Materials testing for FDOH additives rule

Treatment Technology Rankings

System Rank	Technology/Process	Comments
1	**Two stage (segregated biomass) system:** ***Stage 1:*** Biofiltration with recycle (nitrification) ***Stage 2:*** Autotrophic denitrification with reactive media biofilter	• Top ranked system capable of meeting the lowest TN concentration standard • Suitable for new systems or retrofit
2	**Two stage (segregated biomass) system:** ***Stage 1:*** Biofiltration with recycle (nitrification) ***Stage 2:*** Heterotrophic denitrification with reactive media biofilter	• Top ranked system capable of meeting the lowest TN concentration standard • Suitable for new systems or retrofit
3	**Natural system:** Septic tank/STU (Drainfield) with in-situ reactive media layers, Stage 1 media over Stage 2 media	• Lower cost natural system that is untested but appears capable of achieving 75-78% TN removal before reaching groundwater • Suitable for new systems or replacing existing systems at end of useful life

Biological Nitrogen Removal (BNR)
Two stage biofiltration is more stable process

WW
From
Home



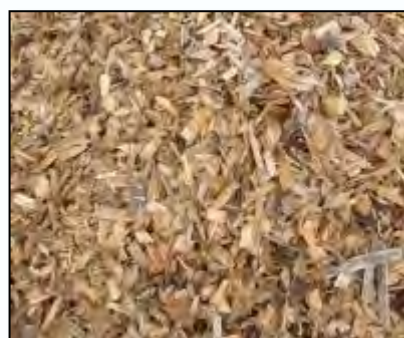
Unique pilot test facility was designed and constructed

- Follow up to PNRS I with larger, pilot scale units and various media combinations
- Established test facility at Gulf Coast Education and Research Center (University of Florida IFAS)
- Operated on septic tank effluent for 12+ months
- Produce scalable design criteria from pilot scale biofilters for subsequent full-scale testing

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: sand & expanded clay



denitrification media: lignocellulosics

denitrification media: elemental sulfur

Two stage single pass pilot-scale biofilters

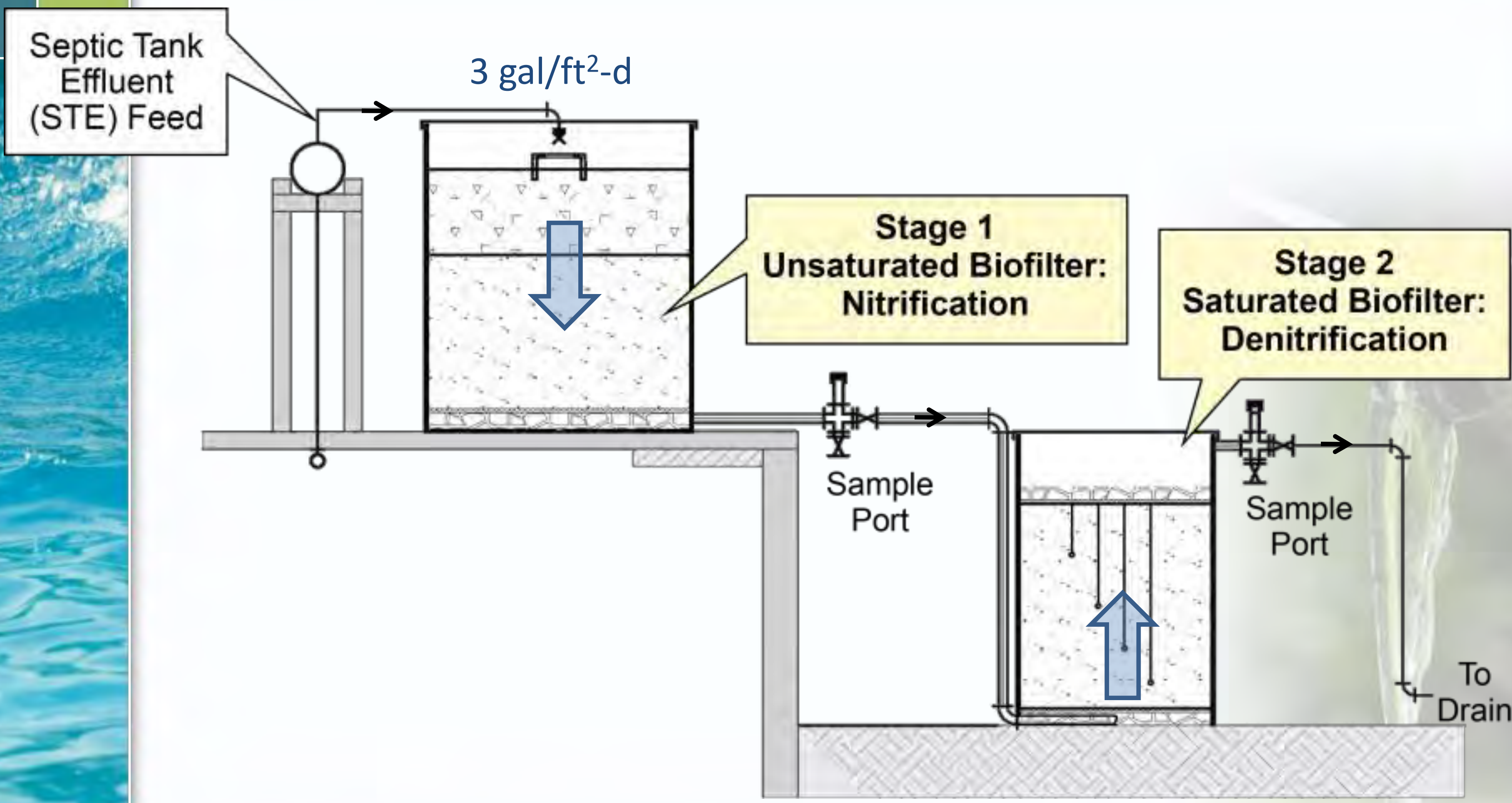
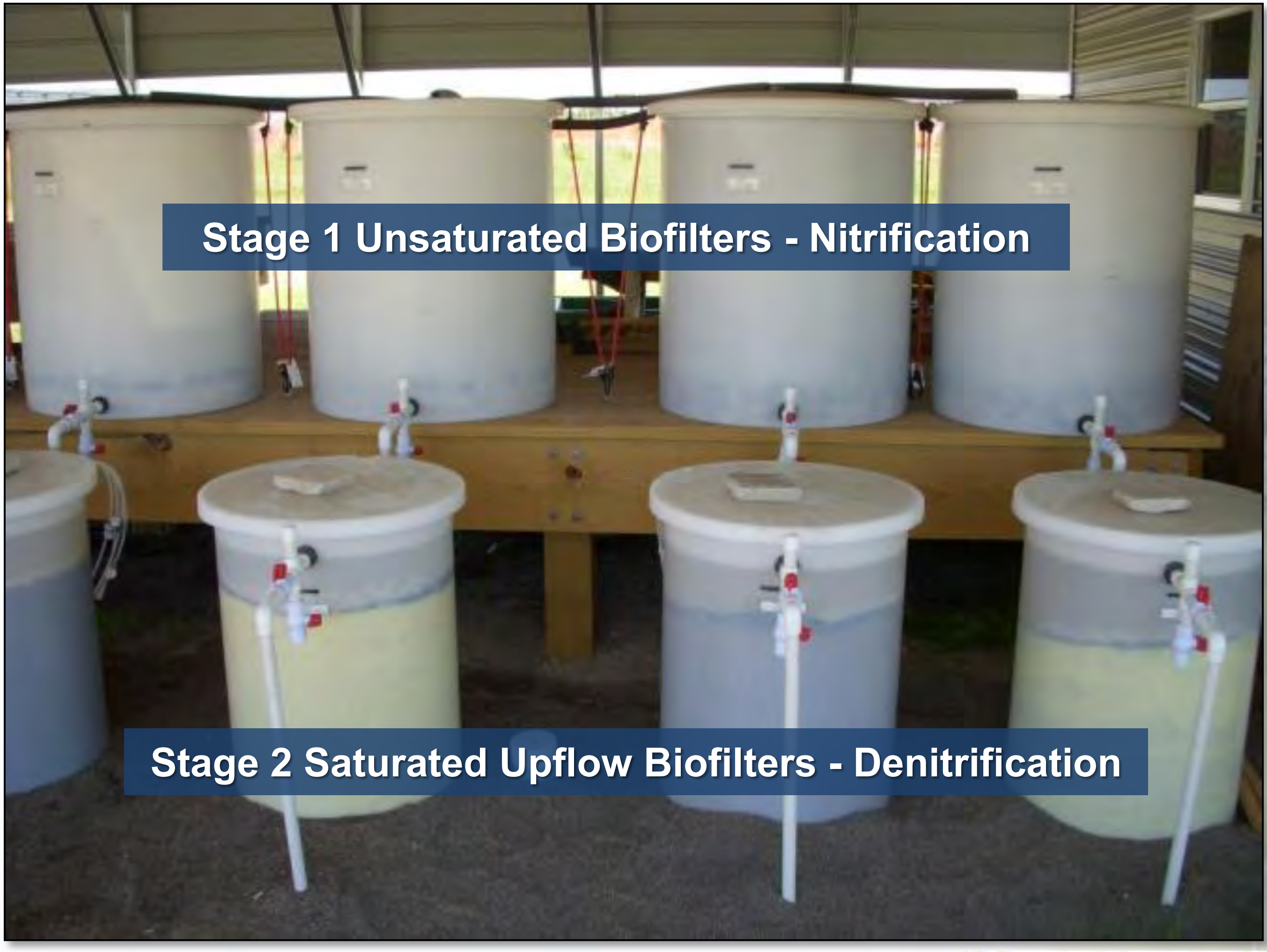


Photo of two-stage single pass biofilter pilot units



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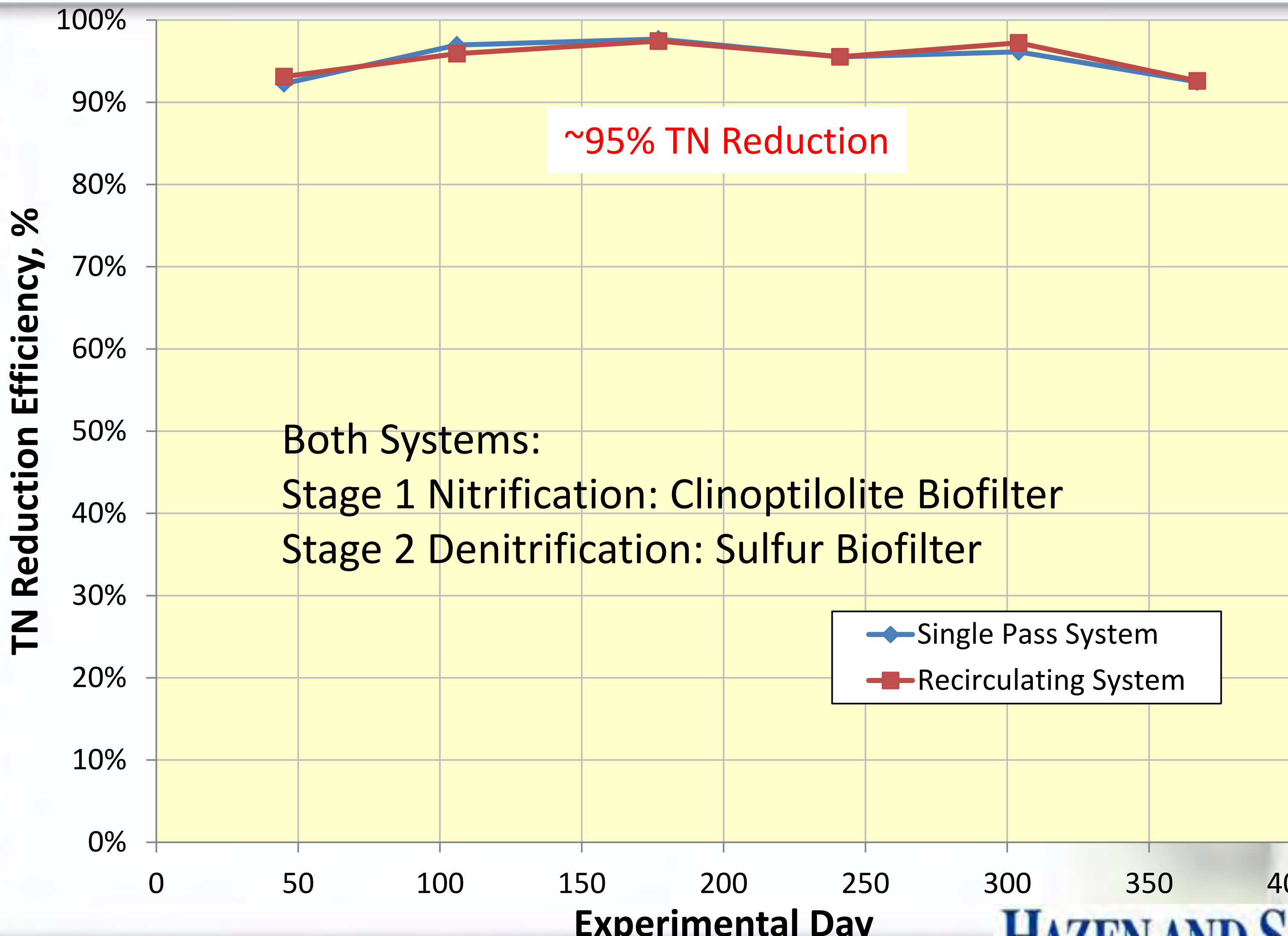
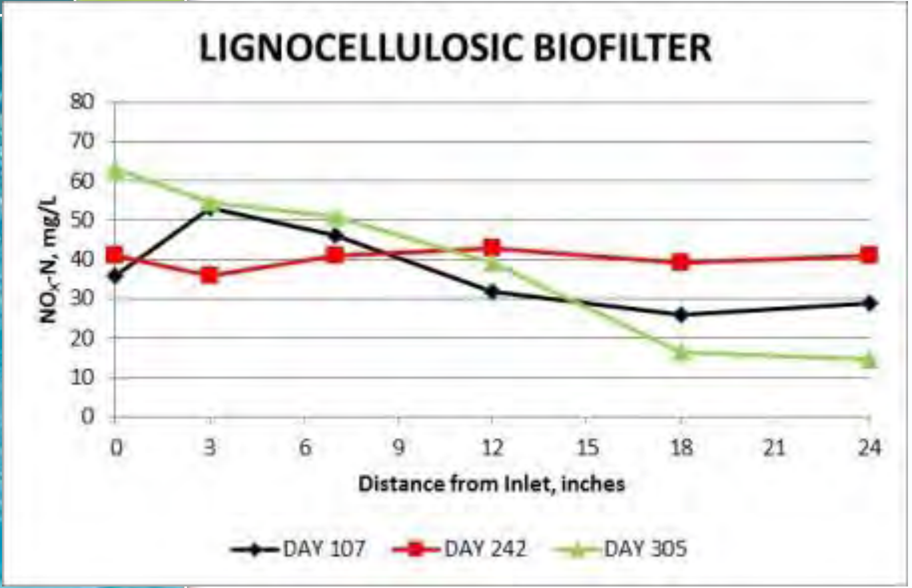
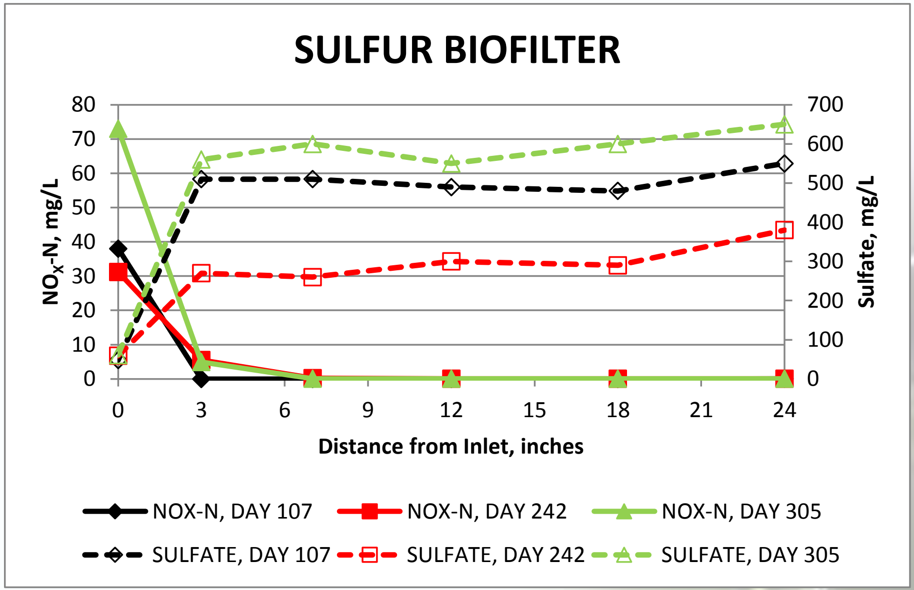
PNRS pilot-scale test results



Vertical sampler profile in upflow biofilters





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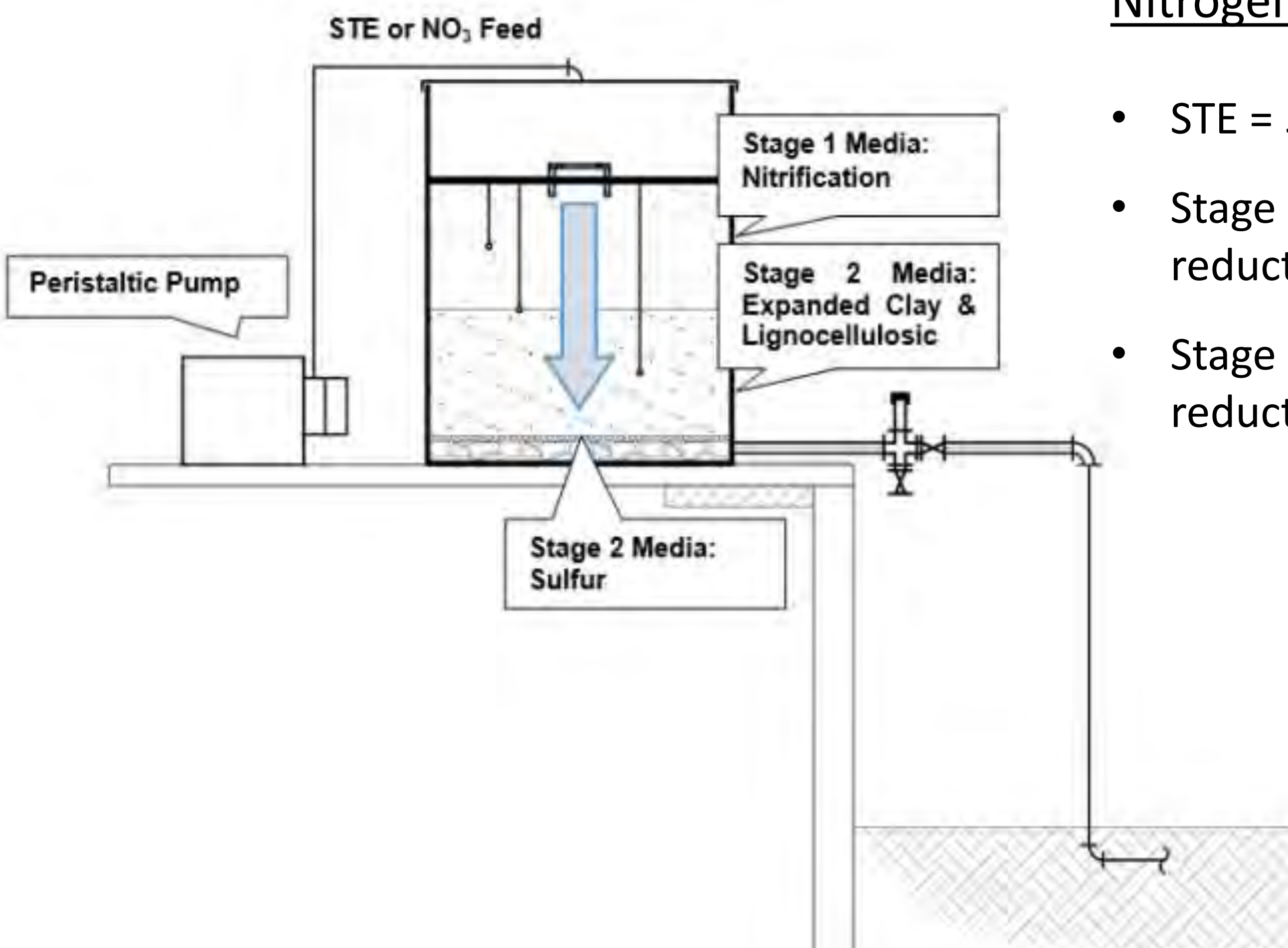
Development of in-ground PNRS concepts

- Tank based PNRS performed extremely well (previous talk), but large tankage requirements make systems expensive
- Desired an in-ground system that could be constructed like a soil treatment unit (drainfield)
- Conceptual ideas revolved around a vertically stacked PNRS, where Stage 1 media was placed over the Stage 2 media
- Liner could be used to saturate Stage 2 media and collect treated effluent

Vertically stacked Stage 1/Stage 2 concept was first pilot tested in small tanks



Nitrogen Reduction Results

- STE = 52.5 mg TN/L
- Stage 2 Ligno mix: 50-81% reduction
- Stage 2 Sulfur: 60-95% reduction

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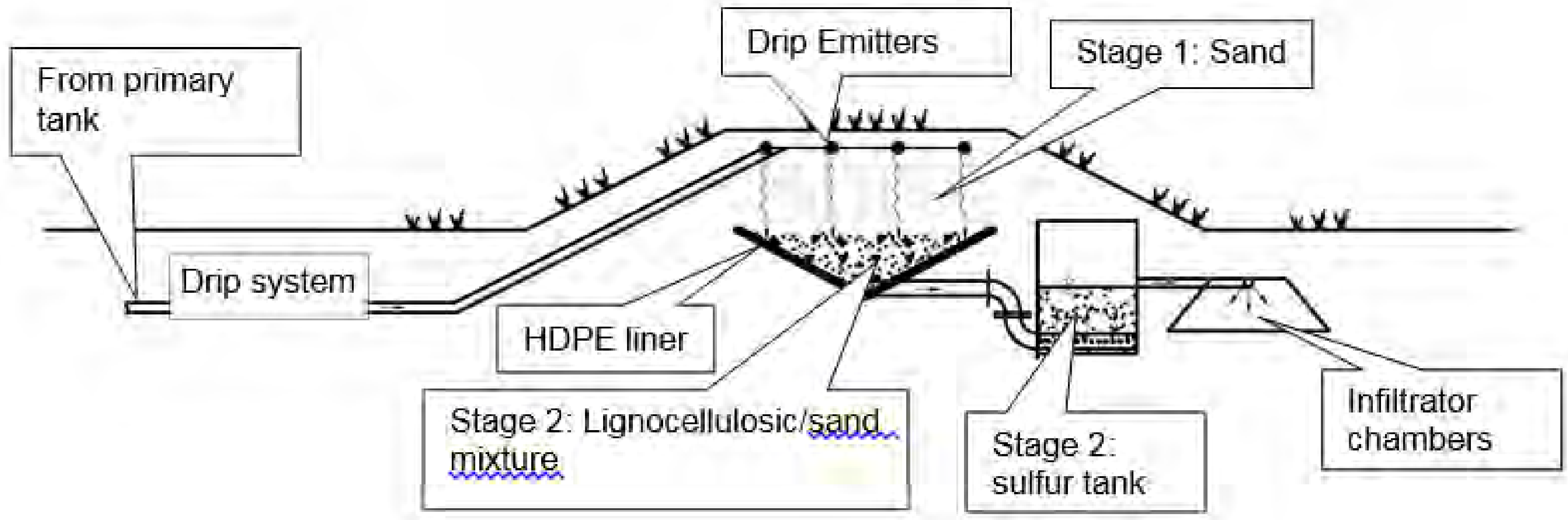
Successful pilot concept developed into prototype in-ground PNRS for further testing



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Prototype In-ground PNRS Construction

Prototype In-ground PNRS Construction

Prototype In-ground PNRS Construction

Placing sand/ligno mix in liner

Prototype In-ground PNRS Construction

Prototype in-ground PNRS 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	59,834	
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	95%
DISPERSAL								

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Lessons learned from pilot test

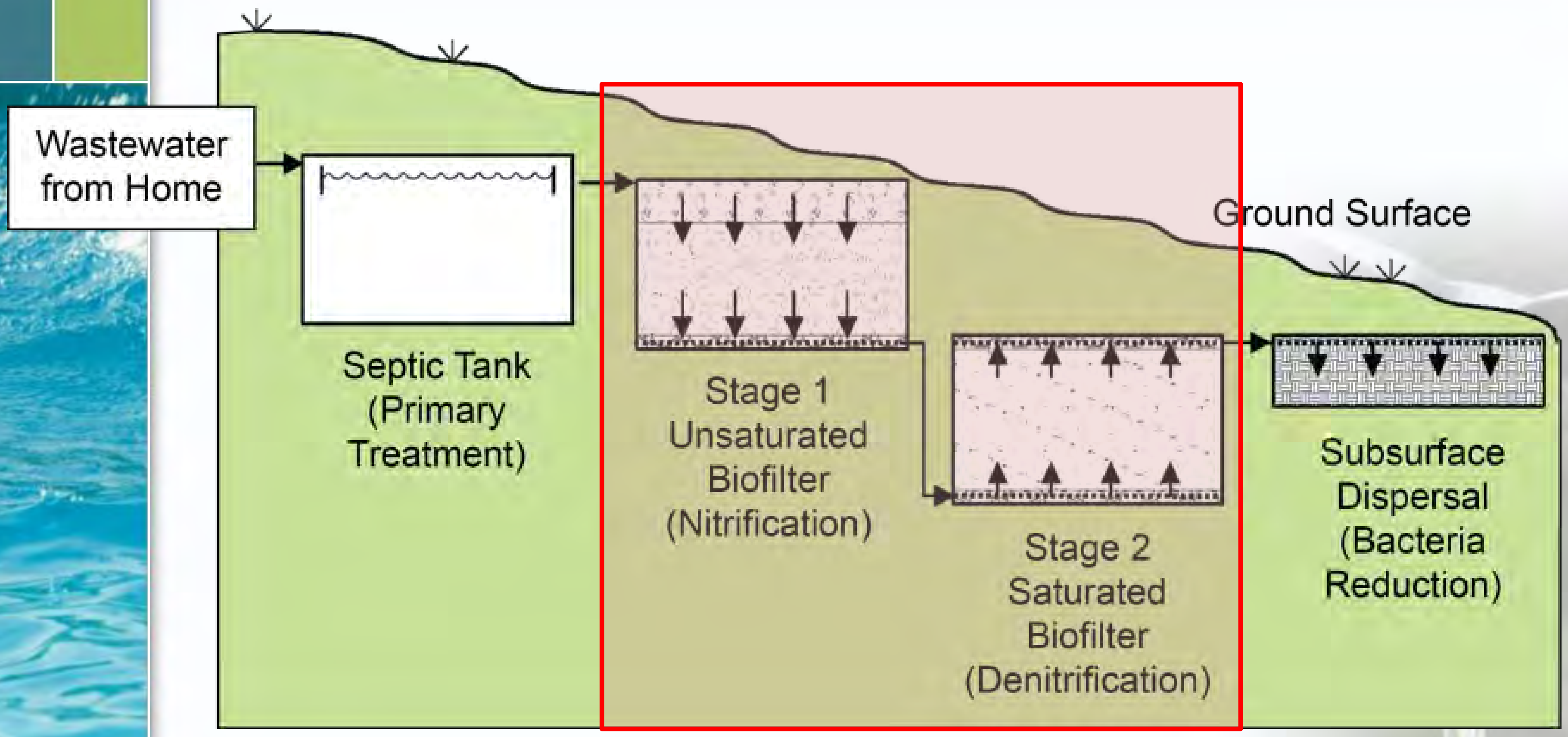
- Encouraging results from pilot PNRS; several system configurations capable of $\geq$ 95% N reduction
- Sulfate production vs nitrate reduction
- Highly reactive elemental sulfur media
- Lignocellulosic retention time issues
- Recommended evaluation of combination lignocellulosic and elemental sulfur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

Task B:
Full Scale Prototype PNRS Testing

Task B Components

- Full scale operation and monitoring of 7 nitrogen reducing technologies at single family residences
- Developed PNRS Life Cycle Cost Analysis tool

Task B: Full scale concepts complement existing OSTDS



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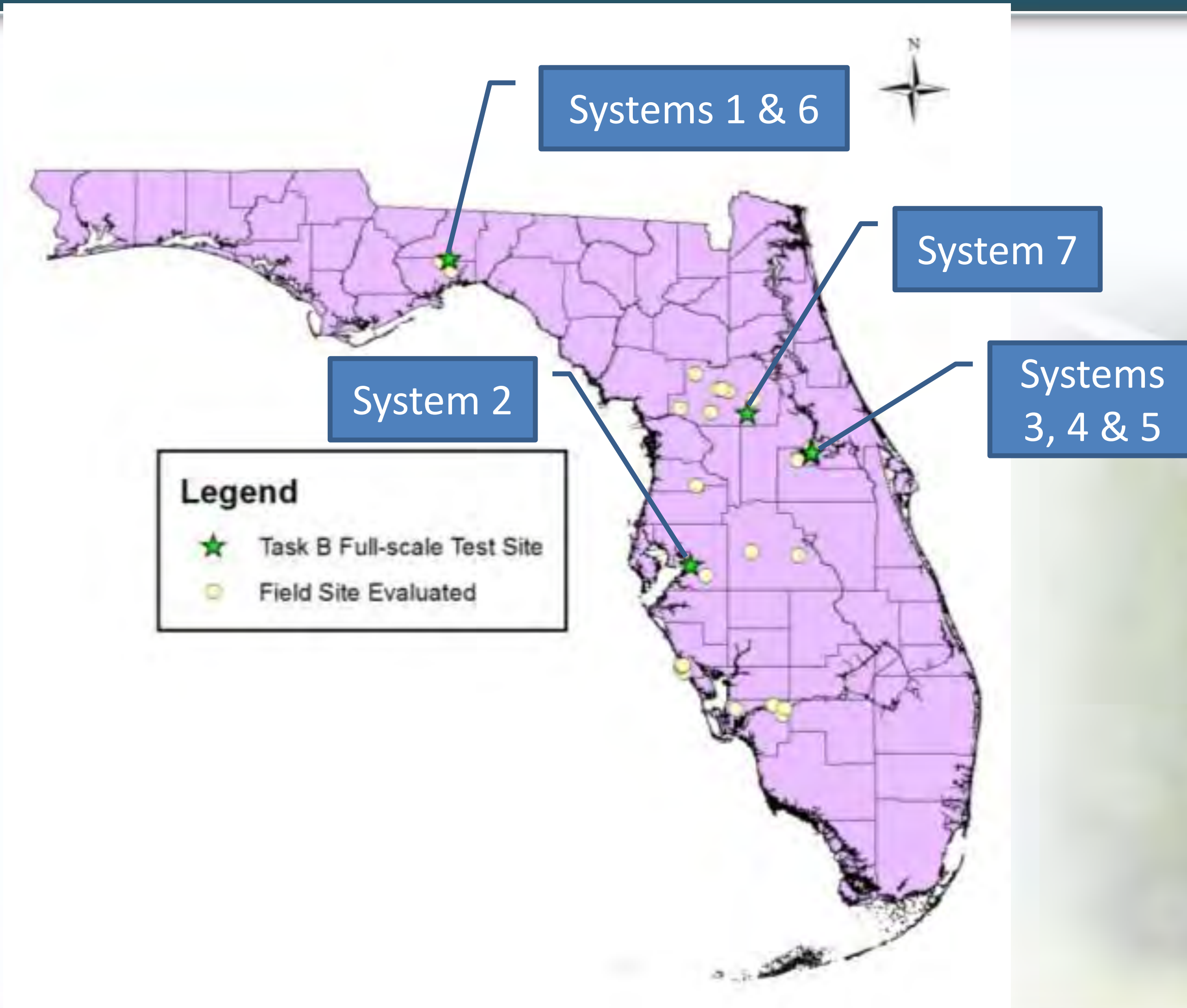
Full scale PNRS installed

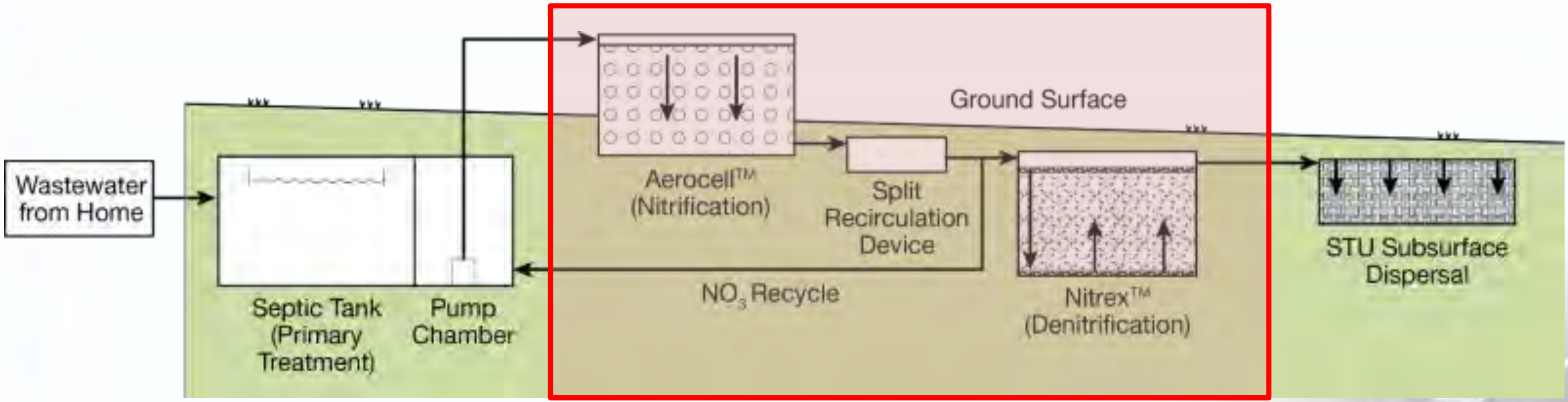


Full scale PNRS Summary

	Design	Location (County)	Stage 1 Hydraulics	Stage 2 Hydraulics
System 1	Proprietary	Wakulla	Pumped with recirculation	Gravity
System 2	In-tank PNRS	Hillsborough	Pumped with recirculation	Pumped
System 3	In-ground PNRS	Seminole	Pumped with subsurface drip irrigation	Gravity
System 4	In-tank PNRS	Seminole	Gravity	Gravity
System 5	In-tank PNRS	Seminole	Pumped single pass and tested with recirculation	Pumped
System 6	In-tank PNRS	Wakulla	Pumped single pass vertically stacked	Gravity
System 7	In-ground PNRS	Marion	Pumped low pressure distribution	Gravity

Proprietary system (System 1)

Proprietary System 1



- Single family home
- 3 bedroom
- 4 residents
- Flow of 112 gpd

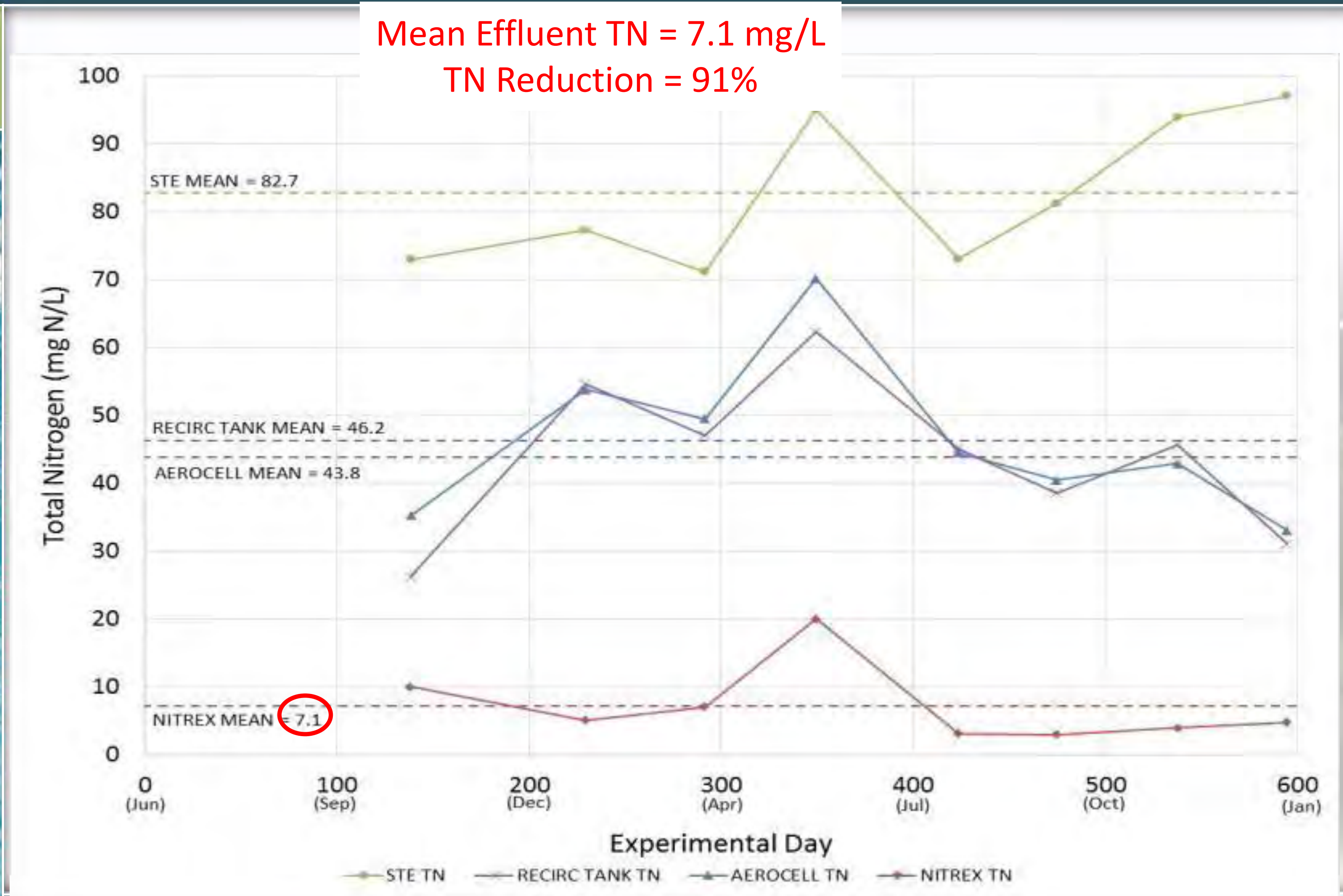
System 1 construction

System 1 construction

System 1 construction

System 1 construction

System 1
Time series of nitrogen data



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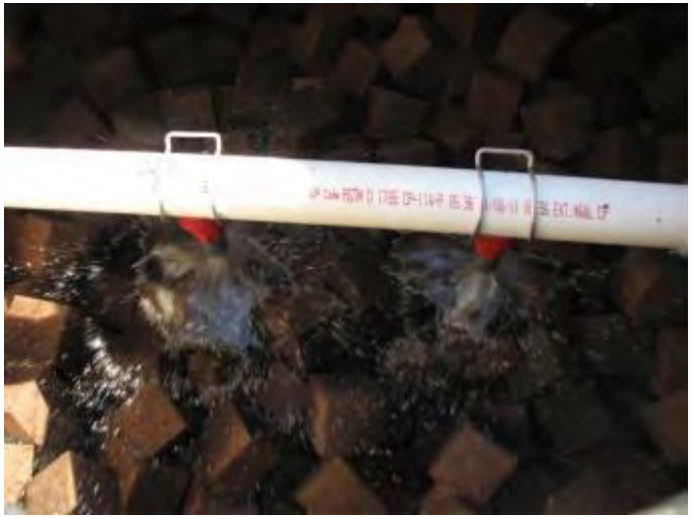
System 1: Operation and maintenance

- Average energy consumption of 3.21 kWh/day or 28.7 kWh/1000 gal treated (~$120 per year)
- Aerocell^{TM} (Stage 1 biofilter) – no surficial biomat or clogging present
- Nitrex^{TM} (Stage 2 biofilter) – reactive media showed very little reduction in volume



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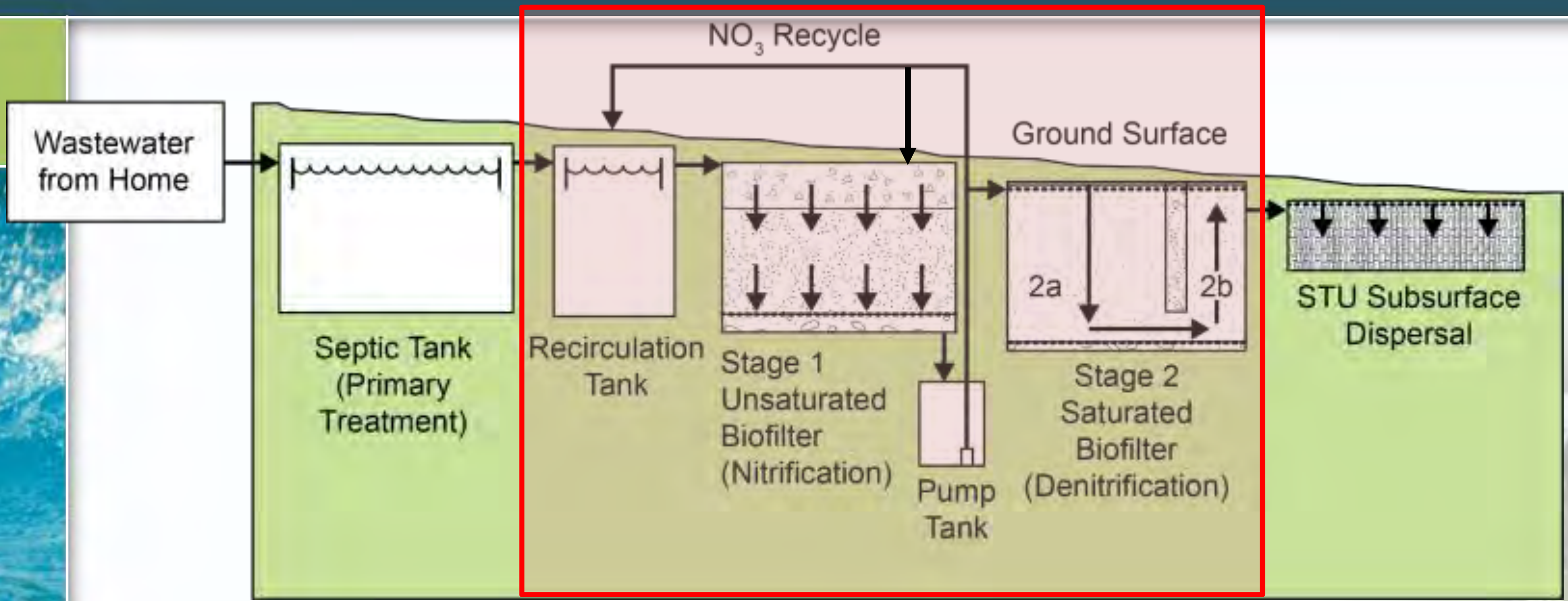
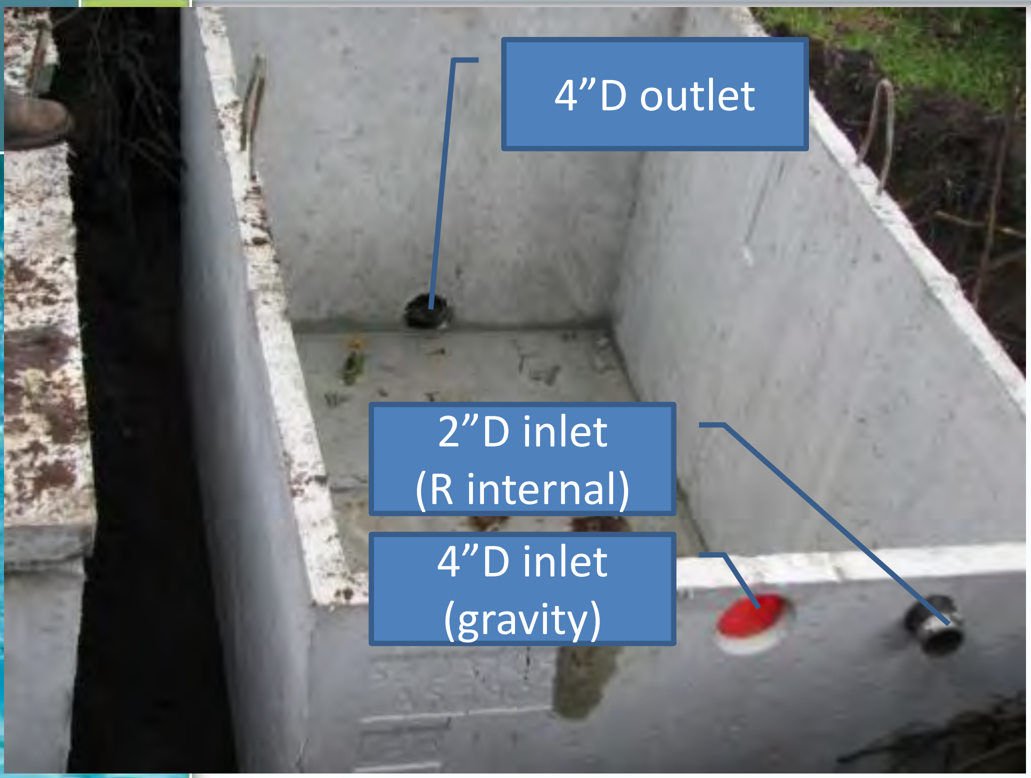
In-tank PNRS (System 2)

In-tank PNRS (System 2)



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

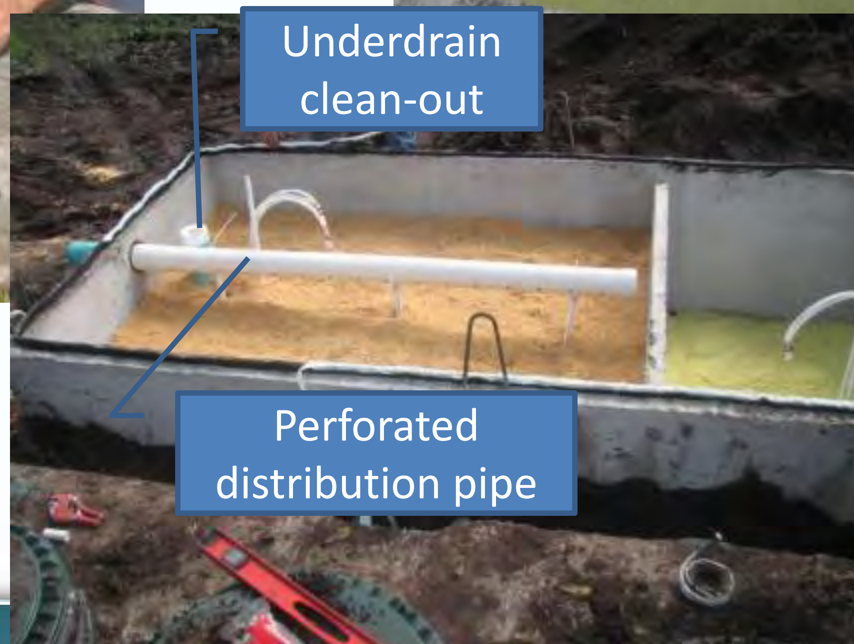
Stage 1 biofilter construction



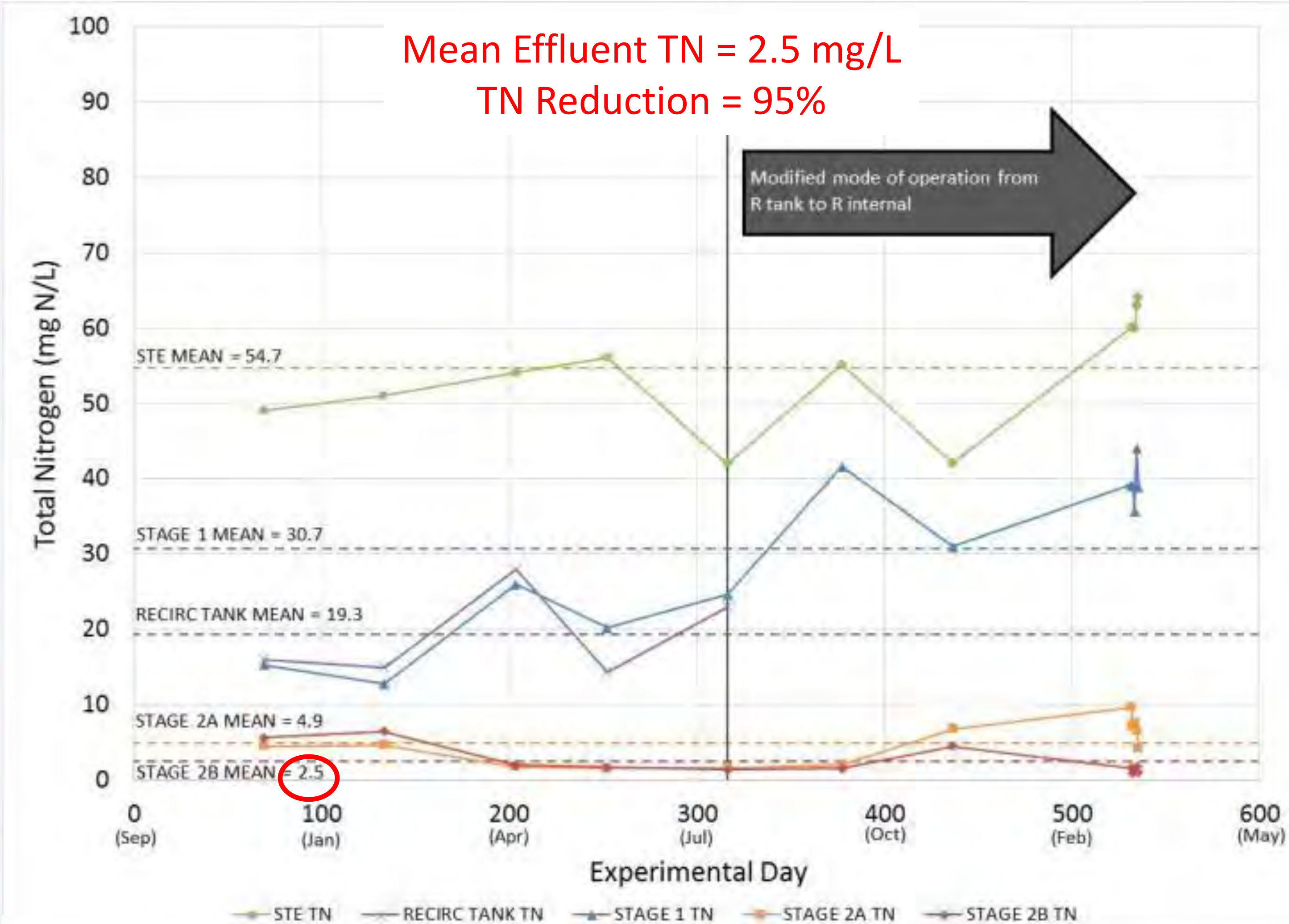
Stage 1 biofilter construction

Stage 2 biofilter construction

Stage 2 biofilter construction



System 2
Time series of nitrogen data



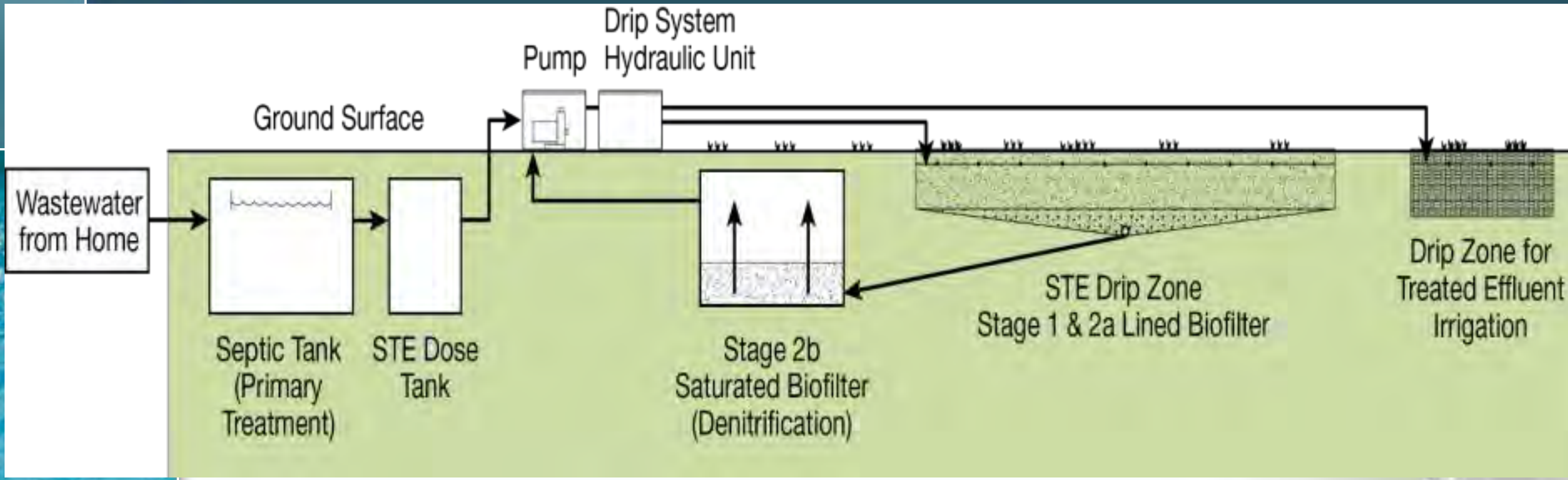
[1]Daily samples were collected on experimental days 531 through 535

System 2: Operation and maintenance

- Average energy consumption of 0.28 kWh/day or 2.6 kWh/1000 gal treated (~$10 per year)
- Stage 1 biofilter – no surficial biomat or clogging present
- Stage 2 biofilter – reactive media showed very little reduction in volume

In-ground PNRS (System 3)

In-ground PNRS (System 3) with onsite reuse



- 5 bedroom (2 residents)
- Flow of 145 gpd
- Mounded drainfield
- Soils: Myakka and EauGallie fine sands

Construction: Liner installation

Construction: Liner installation

Stage 1 biofilter w drip irrigation of STE

Stage 2 sulfur biofilter construction

Subsurface drip irrigation of treated effluent

Subsurface drip irrigation of treated effluent

Subsurface drip irrigation of treated effluent

Drip irrigation controls & headworks

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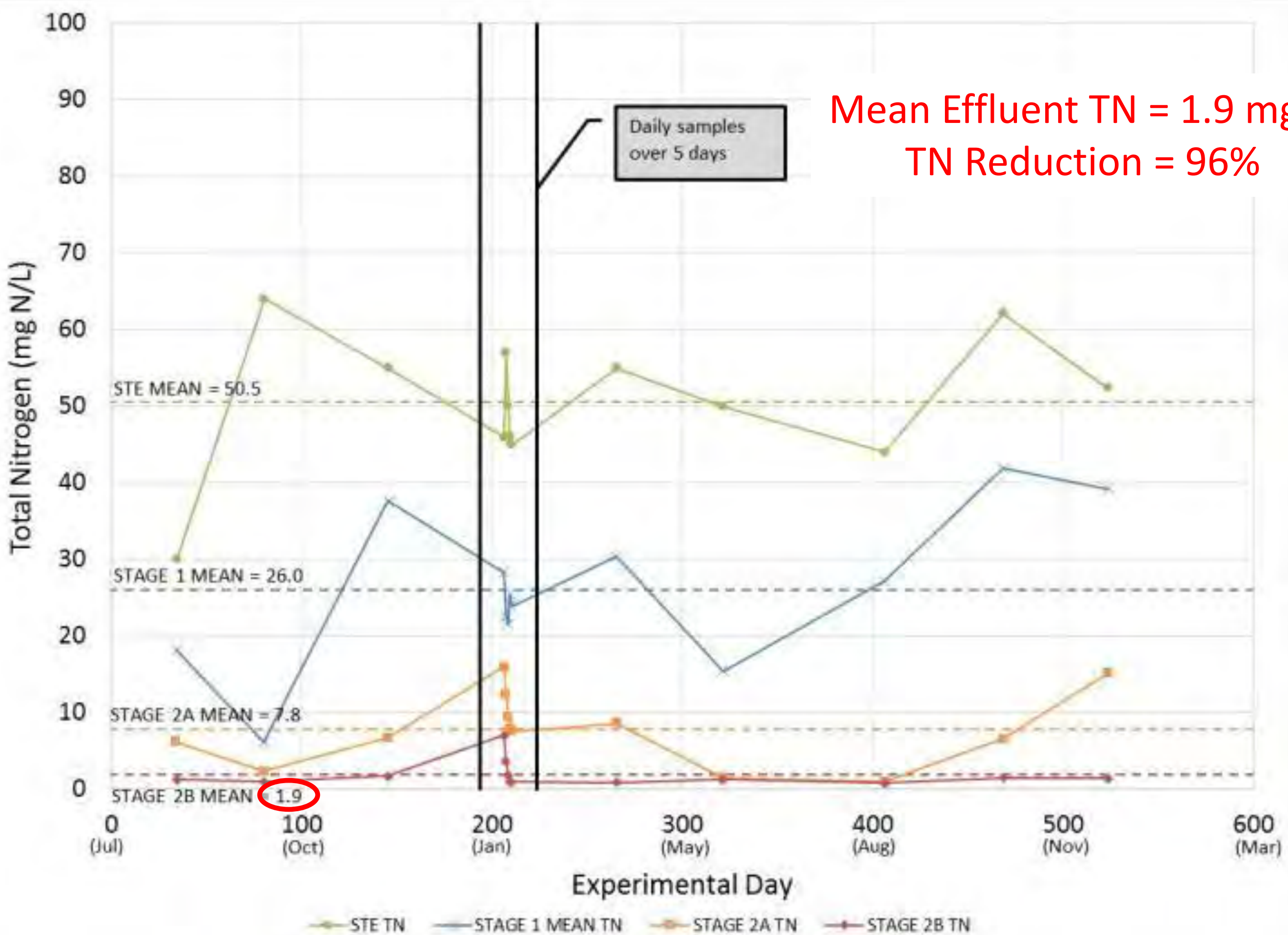
Completed full-scale vertically stacked in-ground PNRS with onsite reuse

System 3
Time series of nitrogen data



Mean Effluent TN = 1.9 mg/L
TN Reduction = 96%

[1]Daily samples were collected on experimental days 531 through 535

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System 3: Operation and maintenance

- Average energy consumption of ~1 kWh/day or 7.8 kWh/1000 gal treated
- Stage 1 biofilter – no surficial biomat or clogging present
- Stage 2 biofilter – reactive media shows immeasurable reduction in volume

Summary of full scale prototype PNRS nitrogen results

System	Design	System Description	Mean Influent TN, mg/L	Mean Effluent TN, mg/L	Mean TN Removal %
1	Proprietary	Stage 1 Aerocell™, Stage 2 Nitrex™	82.7	7.1	91
2	PNRS In-tank	Stage 1 with R, dual-media Stage 2	54.7	2.5	95
3	PNRS In-ground	Stacked Stage 1 over Stage 2a ligno with supplemental Stage 2b sulfur	50.5	1.9	96
4	PNRS In-tank	Gravity Stage 1, dual-media Stage 2	70.1	7.4	89
5	PNRS In-tank	Stage 1 SP and with R, dual-media Stage 2	72.1	2.1	97
6	PNRS In-tank	Stacked Stage 1 over Stage 2a ligno with supplemental Stage 2b sulfur	66.3	12.4	81[a]
7	PNRS In-ground	In-ground stacked SP Stage 1 over Stage 2 ligno	54.9	19.1	65[a]

[a] Performance of systems 6 and 7 may have been significantly improved with design and construction revisions based on lessons learned in this study.

Lignocellulosic Media Life Estimates

System	% Reactive Media	Media Volume, ft^3	Calculated Longevity[1], years	Longevity with factor of safety[2], years
1	100%	194.8	83.8	64.5
2	100%	126.0	107.5	82.7
3	50%	136.5	80.8	62.2
4	100%	126.0	21.6	16.6
5	100%	126.0	43.6	33.5
6	100%	67.0	39.1	30.1
7	100%	362.0	176.2	135.5

[1] Assumptions regarding lignocellulosic media included: dry bulk density of 20 lb./ft^3; 50% carbon content by weight with available carbon being approximately 50% of carbon content
[2] Factor of safety used was 1.3

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Sulfur Media Life Estimates

System	% Reactive Media	Media Volume, ft^3	Study Conditions			If lignocellulosic depleted		
			Mean influent NOx-N	Calculated Longevity[1], years	Longevity with factor of safety[2], years	Stage 1 mean influent NOx-N	Calculated Longevity[1], years	Longevity with factor of safety[2], years
2	90%	32.4	0.02	N/A	N/A	16.7	194.0	149.2
3	90%	34.7	5.8	461.2	354.8	23.9	112.2	86.3
4	90%	24.3	3.2	348.5	268.0	33.6	27.2	20.9
5	90%	24.3	4.1	520.5	400.4	43.4	53.5	41.1
6	90%	18.0	24.9	57.2	44.0	42.3	34.0	26.1

[1]Assumptions regarding sulfur media included: dry bulk density of 76 lb./ft^3 and influent NOx concentrations from the preceding process. In systems where lignocellulosic denitrification preceded the sulfur, low influent NO_x concentrations resulted in very long estimates of longevity.

[2] Factor of safety used was 1.3

PNRS Cost Analysis Tool

- User specifies nitrogen removal efficiency range, selects desired treatment process, and the tool calculates all system costs over the entire specified project life
  - Low Level (25-35% nitrogen removal efficiency)
  - Medium Level (50-70% nitrogen removal efficiency)
  - High Level (95% nitrogen removal efficiency)
- Derives the Present Worth cost
- Reported as $/lb nitrogen removed

PNRS Cost Analysis Tool Inputs

2. Table of LCCA Worksheets

Worksheet	Contents
1. LCCA Structure	Two-Stage PNRS Description ▪ Basic Model Structure ▪ Example PNRS Systems
2. Table of LCCA Worksheets	Summary Table of LCCA Worksheets
3. Wastewater Quantity & System Parameters	Determine design flowrate ▪ Specify conventional system parameters ▪ Select nitrogen removal level as high, medium or low @ 95%, 50-70%, or 25-30% ▪ Specify PNRS system parameters ▪ Specify recurring costs ▪ Specify net interest rate
4. PNRS Process Selection	Select specific PNRS system
5. Baseline Design & Cost	Summary of conventional system default design & cost ▪ Summary of PNRS design and default cost
6. Baseline Design Cost Summary	Default cost summary for conventional system, for PNRS system and for total system
7. User Override Costs	User specified costs for conventional system ▪ User specified costs for PNRS
8. LCCA: Conventional	Characteristics of conventional system ▪ Life Cycle Cost Analysis of conventional system
9. LCCA: Total System	Characteristics of conventional system + PNRS ▪ Life Cycle Cost Analysis of conventional system + PNRS
10. Design Data	Compilation of flow and sizing criteria, unit cost factors for materials, energy, site access and installation complexity
11. Example LCCAs	Example Life Cycle Costs

Developed by: HAZEN AND SAWYER Environmental Engineers & Scientists and AET

PNRS Cost Analysis Tool Inputs

Nomenclature for LCCA Identification

	Example

Wastewater Quantity

No. of Bedrooms	3
Building area, square feet	2,200

Level of Treatment

What level of nitrogen removal efficiency is needed for the site?	High

Low conventional (25 - 35%)
Medium (50 - 70%)
High (95+%)

Conventional System Parameters

Existing system	
Size of existing primary treatment tank, gallons	0
Size of existing pump treatment tank, gallons	0
Size of existing soil treatment unit, square feet	0
Soil treatment unit	
Trench or bed configuration	trench
Infiltrative surface loading rate, gal/ft^2-day	0.80
Depth to seasonal high water table (inches) at soil treatment unit	60

PNRS Cost Analysis Tool Inputs

PNRS Parameters

New OSTDS system installation or retrofit of existing system?	new
Will a PNRS Stage 1 biofilter be used or a proprietary system (e.g. Hoot, FAST, Norweco)?	PNRS
What is the construction complexity? enter 1, 2 or 3 1 Simple (new undeveloped property) 2 Moderate (retrofit of existing system, easy accessibility to site) 3 Complex (retrofit of existing system, difficult accessibility to site)	1
Is there at least an 8 foot elevation drop from the house out 60 feet in the direction of the proposed system?	no
Standard or complex control panel?	standard

Construction permit fees

Enter new system conventional construction permit County fee add-on, $	
Enter new PBTS system construction permit County fee add-on, $	

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PNRS Cost Analysis Tool Inputs

Annual operating costs

Energy Consumption

Electrical rate, $/kw-hour	0.100

Inspections, permit and monitoring

Number of inspection visits per year	2
Inspection & maintenance cost per visit, $	150
Enter PBTS operating permit County fee add-on, $	
Number of water quality monitoring events per year	1
Water quality monitoring cost per sample event, $	120

Maintenance costs

Primary treatment tank pump out

Interval, years	5.0
Cost, $	300

Media Replacement

Stage 2 media replacement interval, years	15

Equipment Replacement

Pump replacement interval, years	10

Cost Analysis Parameters

Life Cycle Cost Analysis

Project life, years	30
Net Interest rate, %	2.000

PNRS LCCA Process Selection

Processes: Stage 1&2, Stage 1 only, or Stage 2 only	Stage1&2

All blue shaded cells below must be filled in to fully specify the PNRS process

Stage 1&2 Biofilters System Selections

Stage 1 biofilter: in-tank or in-ground	Tank
Is the Stage 2 lignocellulosic media underlying the Stage 1 media?	No
Stage 1 biofilter mode of operation, single pass or recirculation?	Recirculation
Stage 1 biofilter type of media, expanded clay or sand?	Expanded clay
Stage 2 biofilter type of media: lignocellulosic, sulfur or dual media?	Dual_media

Stage 1 Only Selections

Stage 2 Only Selections

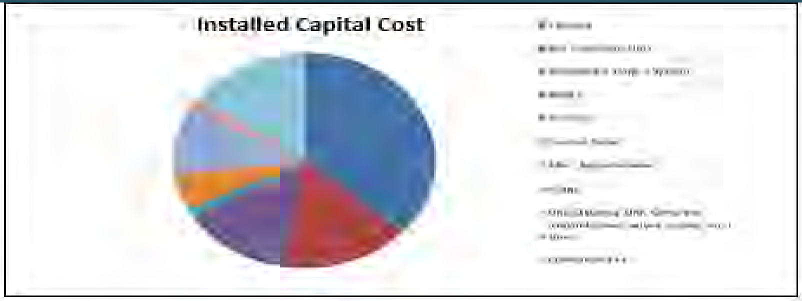
PNRS System Number (refers to LCCA logic)	9

PNRS System Summary	
Nitrogen Removal Efficiency	High
Stage 1: PNRS or proprietary	PNRS
PNRS Stage(s)	Stage1&2
Stage 1: in-tank or in-ground	Tank
Stage 1: Single pass or recirculation	Recirculation
Stage 1 media type	Expanded Clay
Lignocellulosic disposition	Tank
Stage 2 media type	Dual: Ligno & sulfur

LCCA PNRS Output

Worksheet

1. LCCA Structure
2. Table of LCCA Worksheets
3. WW Quantity & System Parameters
4. PNRS Process Selection
5. Baseline Design & Cost
6. Baseline Design Cost Summary
7. User Override Costs
8. LCCA Conventional
9. LCCA Total System
10. Design Data
11. Example LCCAs



9. LCCA Total System

Conventional System Summary	
No. of Bedrooms	3
Building area, square feet	2200
Depth to seasonal high water table (inches)	60
New OSTDS installation or retrofit of existing system	new
Design wastewater flow, gallons/day	300

No user override Conventional costs have been specified

PNRS System Summary	
PNRS System	4
Stage 1: PNRS or proprietary	PNRS
PNRS Stage(s)	Stage 1&2
Stage 1 in-tank or in-ground	Tank
Stage 1 single pass or recirculation	Recirculation
Stage 1 media type	Expanded Clay
Ligno disposition	Tank
Stage 2 media type	Dual: Ligno & sulfur
Construction Complexity	Simple
Level of nitrogen removal efficiency provided by system	High

No user override PNRS costs have been specified

Life Cycle Cost Calculations	
Project Life (PL), years	30
Interest Rate (IR), %	2.000
Primary tank pump out interval (TI), years	5.0
Pump out analysis life (PL), years	25.0
Stage 2 media replacement interval (MI), years	15.0
Stage 2 media cost analysis life (ML), years	15.0
Equipment replacement interval (EI), years	10.0
Equipment replacement analysis life (EL), years	20.0
Compound Interest Factors	
P/A PL,IR	22.396
A/P PL,IR	0.04465
A/F TI	0.19216
P/A PL	19.523
A/F MI	0.05783
P/A ML	12.849
A/F EI	0.09133
P/A EL	16.351
Nitrogen Removal	
Mass loading/year, lbs	27.0
Removal efficiency, %	95.0
Mass removal/year, lbs	25.66

Life Cycle Cost

Cost Item	Present Worth, $	Uniform Annual Cost, $	% of Total Life Cycle Cost
Conventional System Installation			
Primary treatment tank	1,400.00	62.51	4.5
Pump tank	0.00	0.00	0.0
Conventional system pump	0.00	0.00	0.0
Soil treatment unit	2,625.00	117.21	8.4
Subtotal Conventional	4,025.00	179.72	12.8
Proprietary Stage 1 system	0.00	0.00	0.0
PNRS Installation			
Tankage	4,609.29	205.80	14.7
Media	2,226.78	99.43	7.1
PNRS Pump	250.00	11.16	0.8
Control Panel	875.00	39.07	2.8
Piping	289.60	12.93	0.9
Misc. Appurtenances	1,693.00	75.59	5.4
Stage 1 Drip Dispersal System Complete (control panel, valves, tubing, etc.)	0.00	0.00	0.0
Liner	0.00	0.00	0.0
Contractor Fee	2,500.00	111.62	8.0
Subtotal	12,443.67	555.61	39.7
Total System Installation	16,468.67	735.32	52.5
Engineering Design & Construction Permit			
Construction permit	375.00	16.74	1.2
Engineering design fees	1,000.00	44.65	3.2
Operation and Maintenance			
Annual energy cost	736.23	32.87	2.3
Annual inspection & maintenance	6,718.94	300.00	21.4
Primary tank pump out	1,125.48	50.25	3.6
Stage 2 media replacement	737.58	32.93	2.4
Equipment replacement	373.33	16.67	1.2
Subtotal	9,691.56	432.73	30.9
Compliance			
Operating permit fee	1,119.82	50.00	3.6
Water quality monitoring	2,687.57	120.00	8.6
Subtotal	3,807.40	170.00	12.1
Total	31,342.63	1,399.45	100.00

Installed Capital Cost

Installation Cost Item	Present Worth, $	Uniform Annual Cost, $	% of Installation Cost
Tankage	6,009.29	268.31	36.5
Soil Treatment Unit	2,625.00	117.21	15.9
Proprietary Stage 1 System	0.00	0.00	0.0
Media	2,226.78	99.43	13.5
Pump(s)	250.00	11.16	1.5
Control Panel	875.00	39.07	5.3
Misc. Appurtenance	1,693.00	75.59	10.3
Piping	289.60	12.93	1.8
Drip Dispersal Unit Complete (control panel, valves, tubing, etc.)	0.00	0.00	0.0
Liner	0.00	0.00	0.0
Contractor Fee	2,500.00	111.62	15.2
Total System	16,468.67	735.32	100.0

Life Cycle Cost

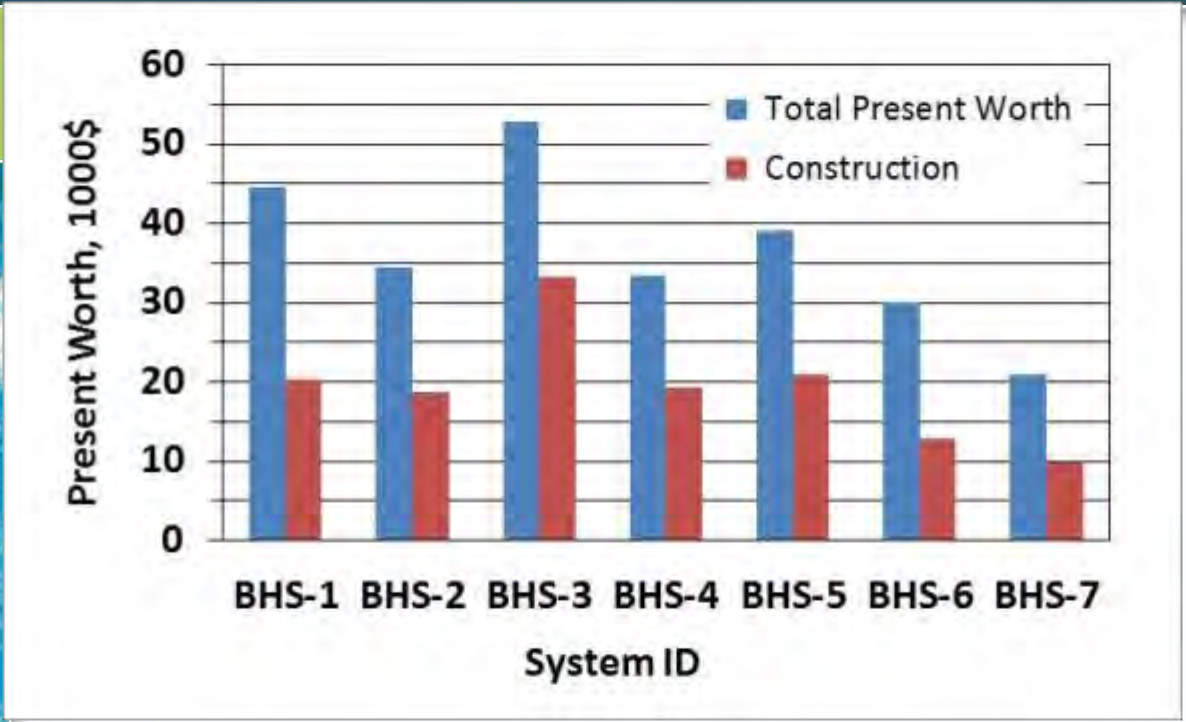
Cost Item	Present Worth, $	Uniform Annual Cost, $	% of Total Life Cycle Cost
Installed Capital Cost	16,468.67	735.32	52.5
Engineering Design & Construction Permit	1,375.00	61.39	4.4
Operation & Maintenance	9,691.56	432.73	30.9
Compliance	3,807.40	170.00	12.1
Total	31,342.63	1,399.45	100.0
$/lb nitrogen removed	40.71	54.52	

Developed by: HAZEN AND SAWYER and AET

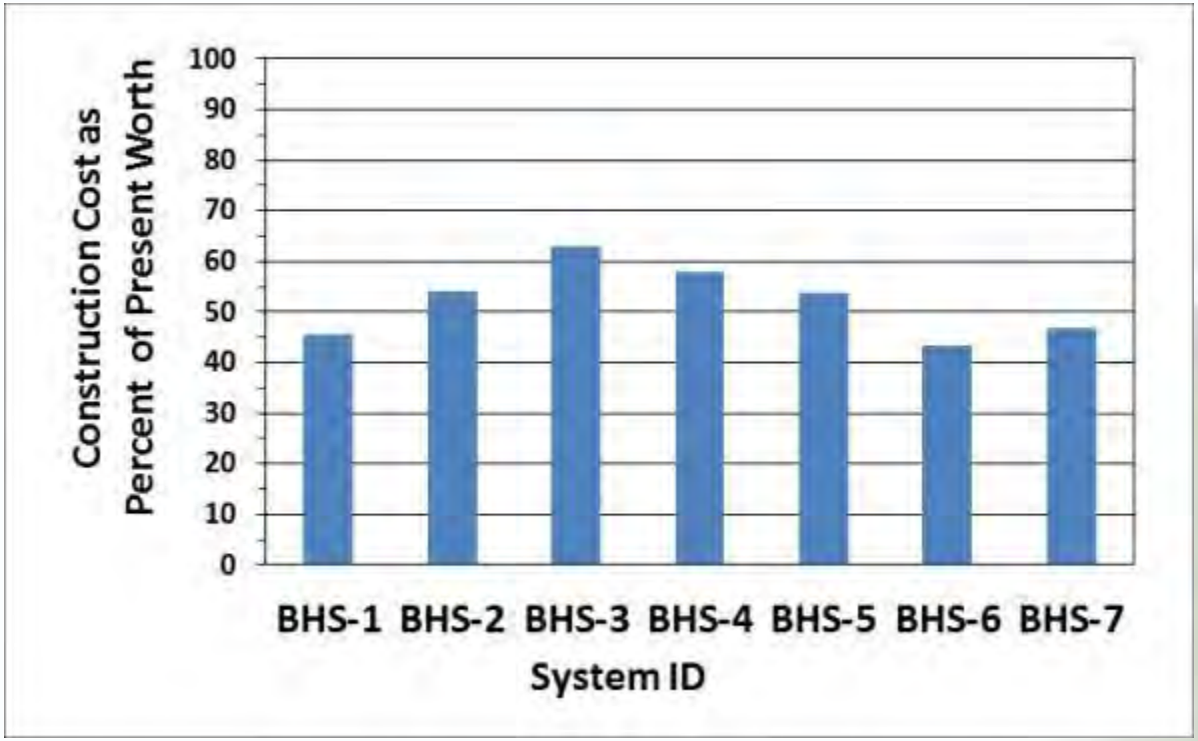
Summary of PNRS Construction Cost

System	System Description	Total System Costs		Conv. Component Construction Cost, $	PNRS Component Construction Cost, $
		Total PW, $	Total Construction Cost, $		
BHS-1	Proprietary	44,533	20,349	5,225	15,124
BHS-2	In-tank	34,545	18,697	2,576	16,121
BHS-3	In-ground	52,763	33,155	10,734	22,421
BHS-4	In-tank	33,373	19,350	3,171	16,180
BHS-5	In-tank	39,003	20,920	0	20,920
BHS-6	In-tank	29,926	12,926	0	12,926
BHS-7	In-ground	20,940	9,800	0	9,800

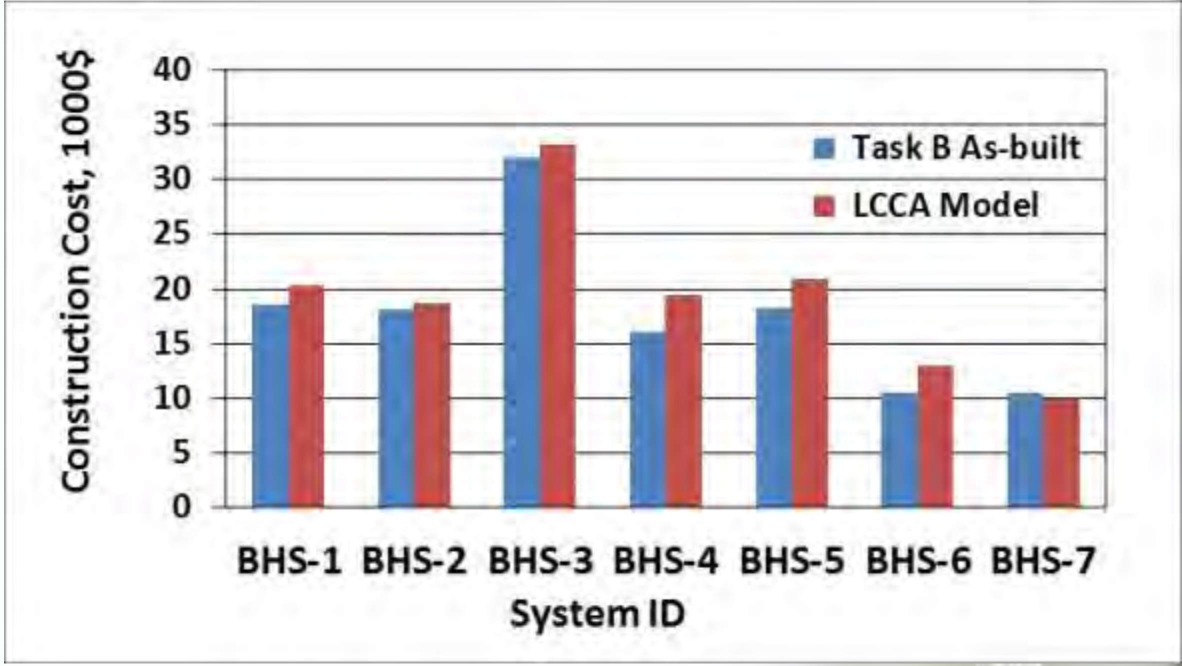
PNRS LCCA Construction Costs



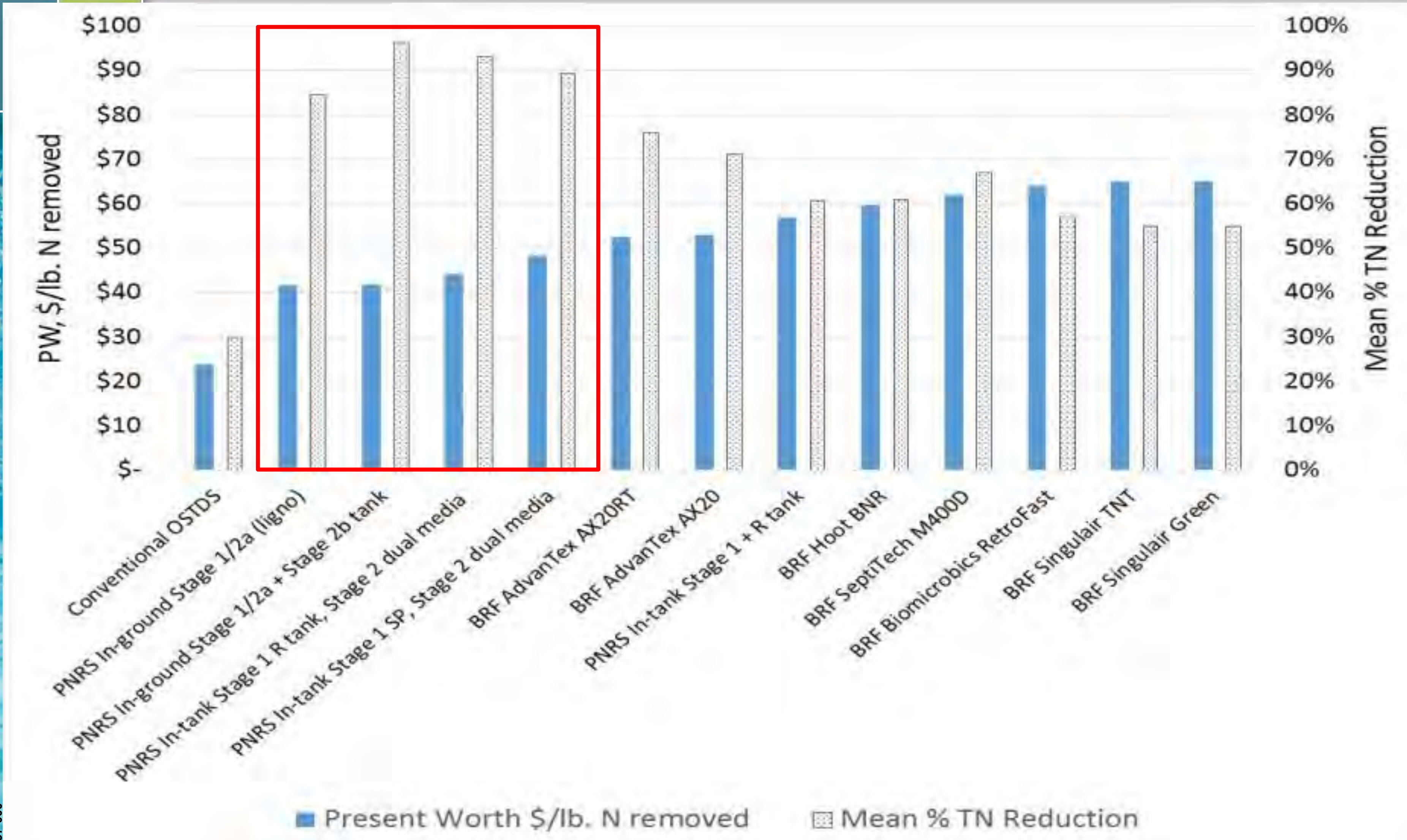
PNRS LCCA Construction Costs



PNRS LCCA Construction Costs



Comparison of PNRS LCCA to Other Studies (Maryland BRF)



Task B Recommendations: Treatment Process – 3 Levels of Treatment

- Low level onsite wastewater nitrogen removal
  - TN reductions (from STE) of 25-35% prior to GW
  - Compliant conventional system with STU meets this level of treatment
- Medium level onsite wastewater nitrogen removal
  - TN reductions (from STE) of 50 – 70% prior to GW
  - Stage 1 PNRS w recirculation or in-ground Stage1/Stage 2 PNRS followed by STU
- High level onsite wastewater nitrogen removal
  - TN reductions of 95% prior to GW
  - Numerous 2-stage PNRS configurations from study followed by STU

Task B Recommendations: Technical Recommendations

- Long term monitoring of PNRS is needed to evaluate reliability and life
- PNRS specific tanks, equipment, media, appurtenances are needed prior to widespread implementation
- Detailed design criteria and designs should be developed for several standardized PNRS
- PNRS specifications should be established for all materials and methods
  - Tanks, lids & covers, liners, media, pipe, controls, process controls, operations

Recommendations: PNRS Implementation

- Establish uniform guidance for PNRS regulation and permitting, streamline permitting requirements.
- Establish uniform requirements for PNRS inspection, operation and maintenance
- Establish uniform requirements for PNRS performance monitoring
- Implement technology transfer and training on PNRS implementation
- Establish sufficient FDOH staffing for PNRS implementation, including wastewater engineering staff

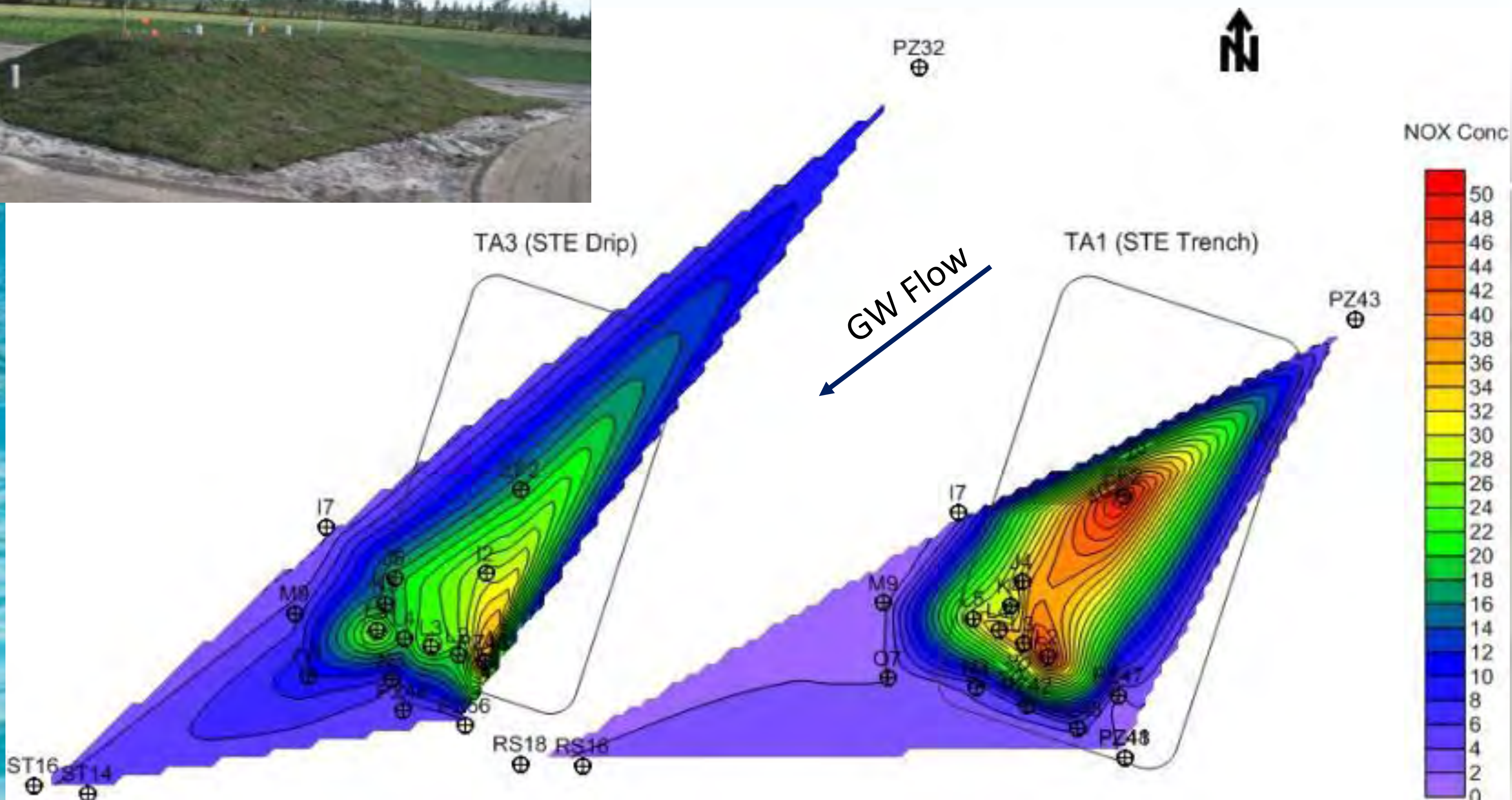
Task C:
Soil and Groundwater Monitoring

Task C Components

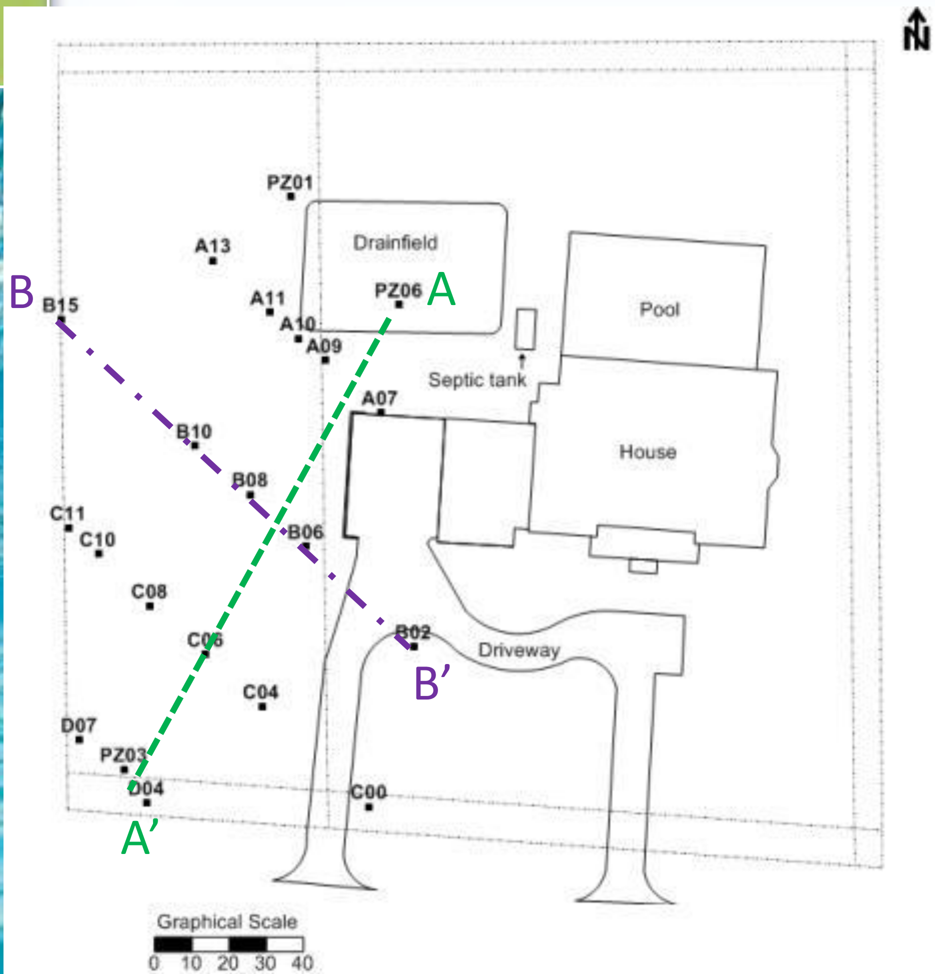
- Literature review to evaluate nitrogen fate and transport in saturated and unsaturated soils
- Developed the soil and groundwater (S&GW) research test facility
- Conducted soil and groundwater monitoring at test facility
- Conducted 3 tracer tests at the S&GW test facility
- Groundwater monitoring at 4 single family residences

Soil and Groundwater Test Facility: N transport studies

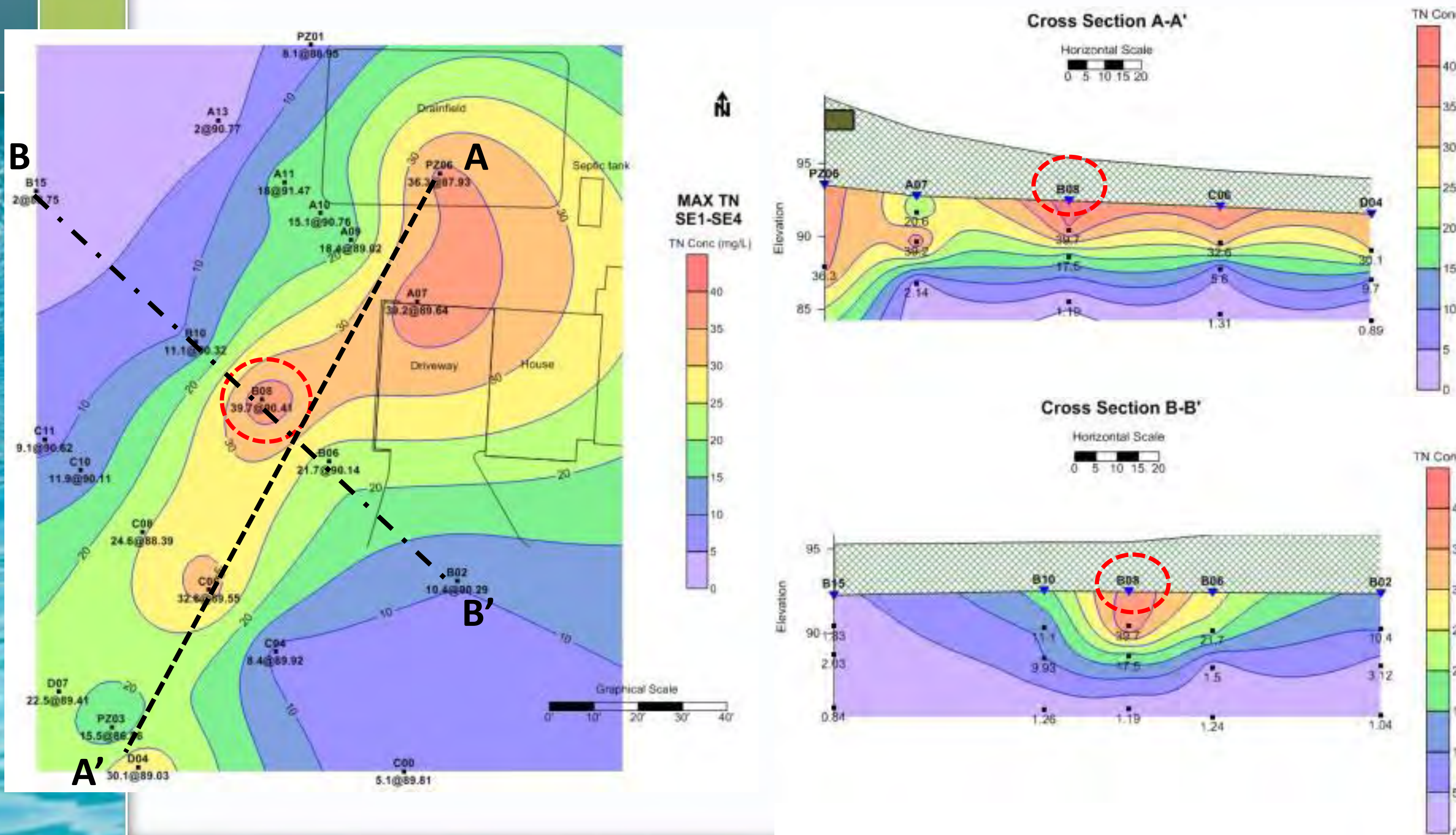
NOx plumes at ~ 400 days



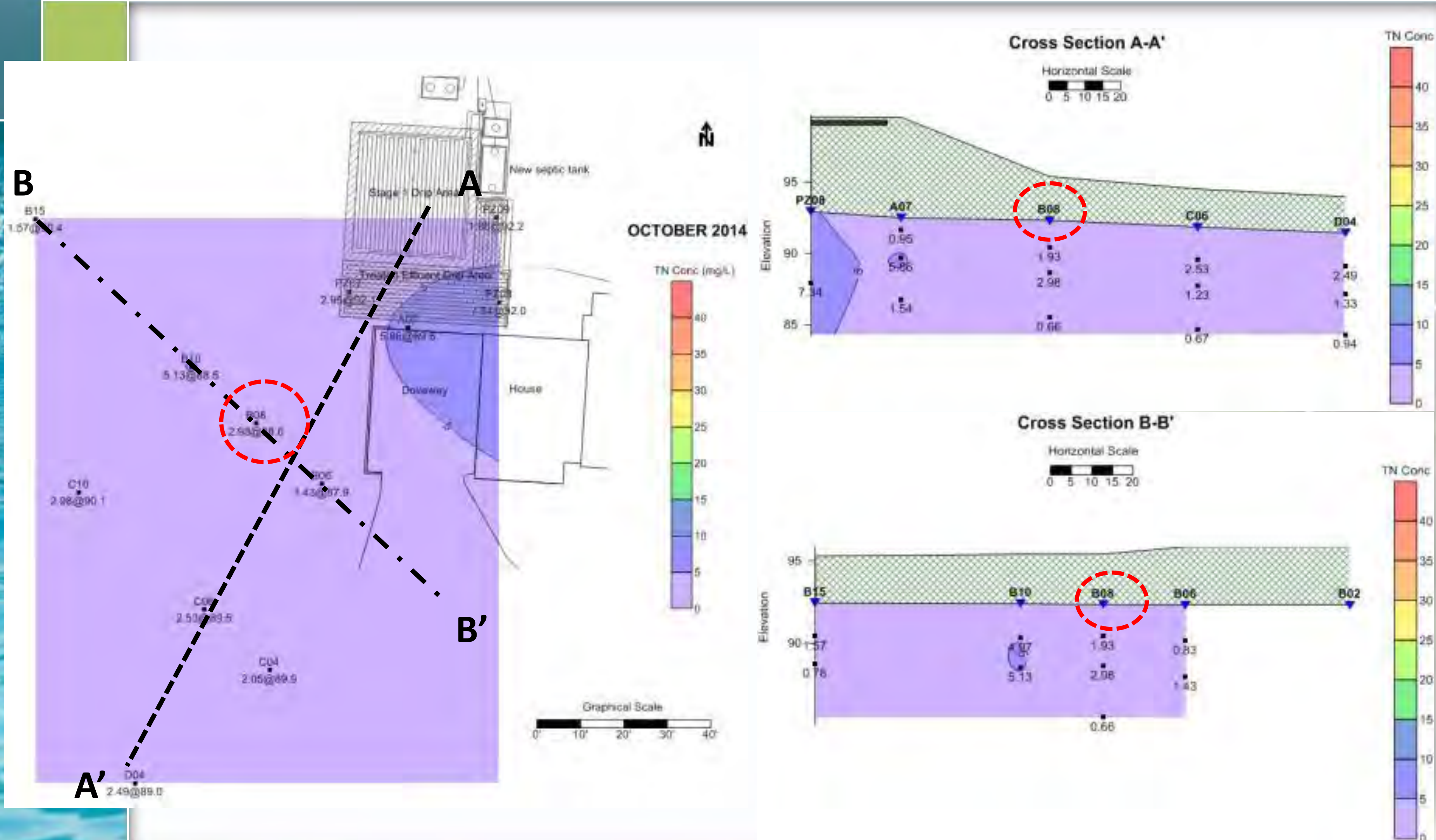
Home site (conventional system) groundwater monitoring network



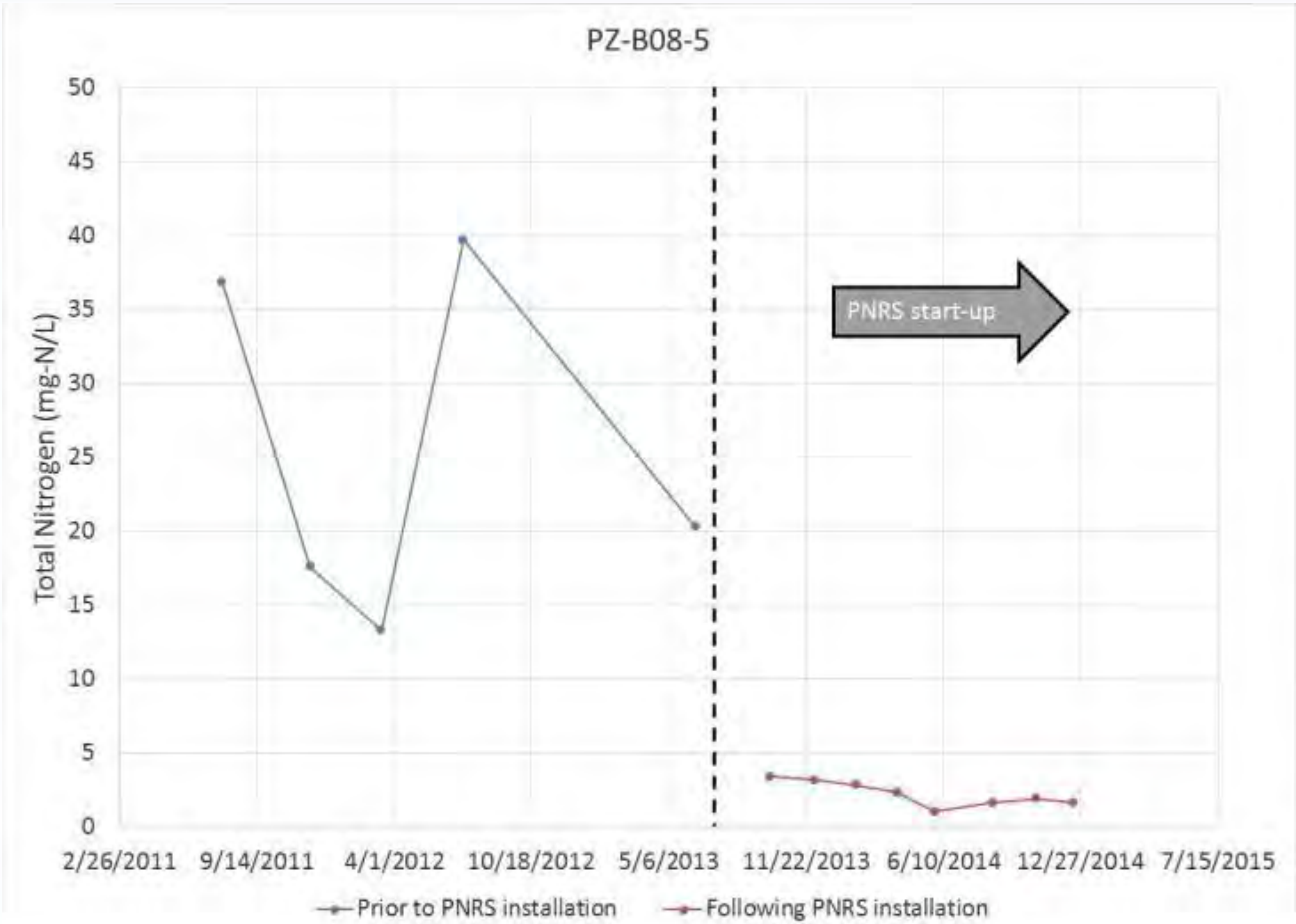
Groundwater monitoring results



Groundwater monitoring: After PNRS installation (System 3)



Most impacted groundwater well Total nitrogen time series



Florida HEALTH

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Environmental Engineers & Scientists

Task D:
Nitrogen Fate and Transport Modeling and Tool Development

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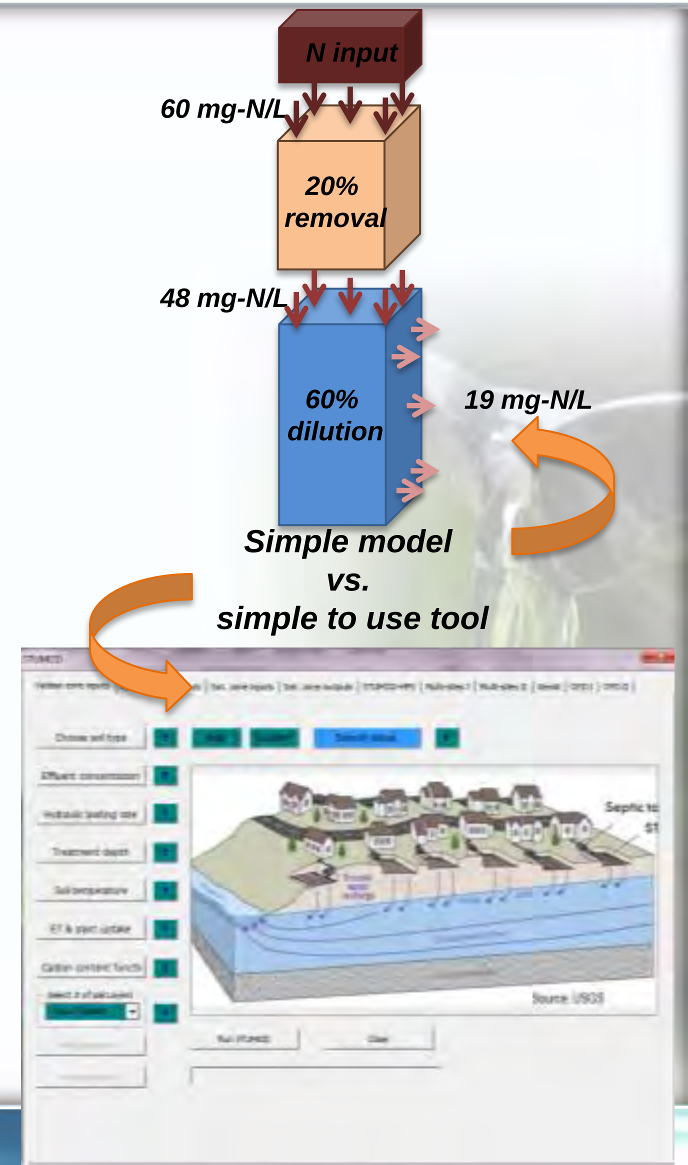
Task D Components

- Literature review to evaluate nitrogen fate and transport models
- Simple soil tool for vadose zone N transport
- Development of Florida specific vadose zone fate and transport model (STUMOD-FL)
- Development of saturated zone fate and transport model (HPS)
- Development of combined vadose and saturated zone fate and transport model (STUMOD-FL-HPS)
- Incorporation of multiple OWTS inputs
- Sensitivity analysis
- Uncertainty analysis

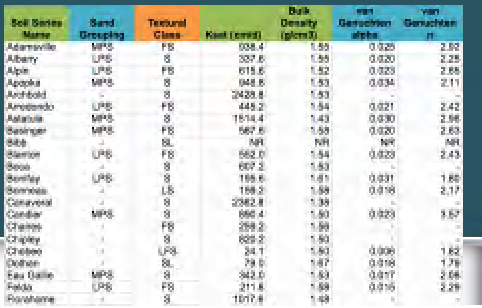
Task D - Overview

- Provide a simple to use tool for assessment of OWTS performance and impact to groundwater
  - Literature Review
  - Simple tool
  - Simple to use spreadsheet model, STUMOD-FL-HPS

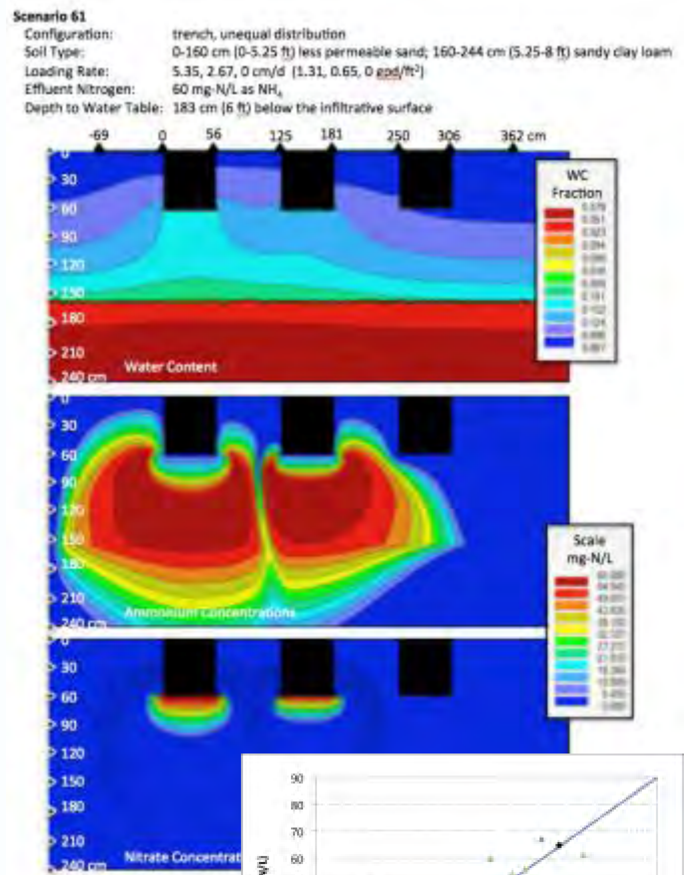


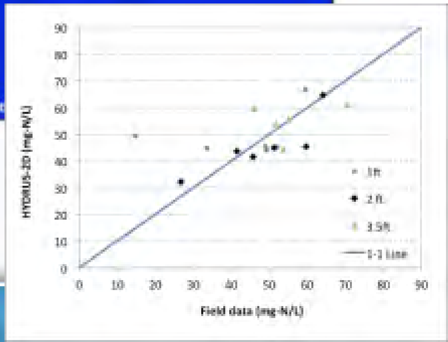
Task D – Deliverables

- Simple tools
  - tables of selected Florida conditions
- Outcomes
  - white paper discussing relative differences in nitrogen behavior based on various conditions
  - 64 numerical model simulations (HYDRUS-2D)
  - corroboration to field data
  - look-up tables



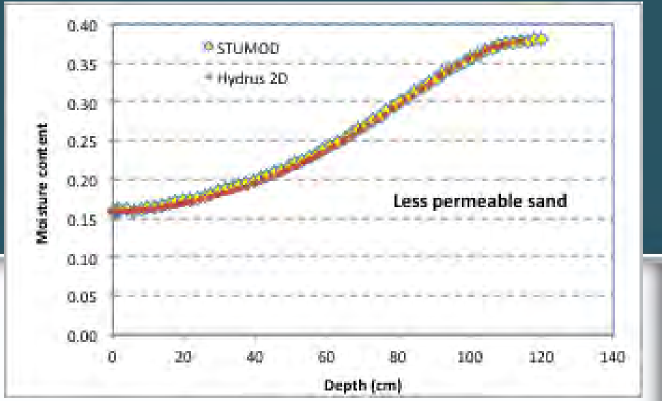
Soil Series Name	Sand Grouping	Textural Class	Ksat (cm/d)	Bulk Density (g/cm3)	van Genuchten alpha	van Genuchten n
Adamsville	MPS	FS	938.4	1.55	0.025	2.92
Albany	LPS	S	327.6	1.55	0.020	2.25
Alpin	LPS	FS	615.6	1.52	0.023	2.88
Apopka	MPS	S	948.8	1.53	0.034	2.11
Archbold	-	S	2428.8	1.53	-	-
Arredondo	LPS	FS	449.2	1.54	0.021	2.42
Astatula	MPS	S	1514.4	1.43	0.030	2.98
Basinger	MPS	FS	567.6	1.59	0.020	2.83
Bibb	-	SL	NR	NR	NR	NR
Blanton	LPS	FS	552.0	1.54	0.023	2.43
Boca	-	S	607.2	1.53	-	-
Bonifay	LPS	S	159.6	1.61	0.031	1.80
Bonneau	-	LS	159.2	1.59	0.018	2.17
Canaveral	-	S	2382.8	1.39	-	-
Candler	MPS	S	886.4	1.50	0.023	3.57
Chaires	-	FS	259.2	1.59	-	-
Chipley	-	S	829.2	1.50	-	-
Chobee	-	LFS	24.1	1.50	0.006	1.82
Dothan	-	SL	79.0	1.67	0.018	1.79
Eau Gallie	MPS	S	342.0	1.53	0.017	2.08
Felda	LPS	FS	211.8	1.58	0.015	2.29
Floridana	-	S	1017.8	1.48	-	-

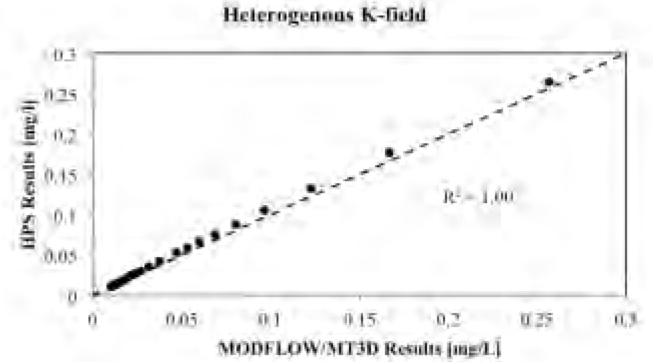


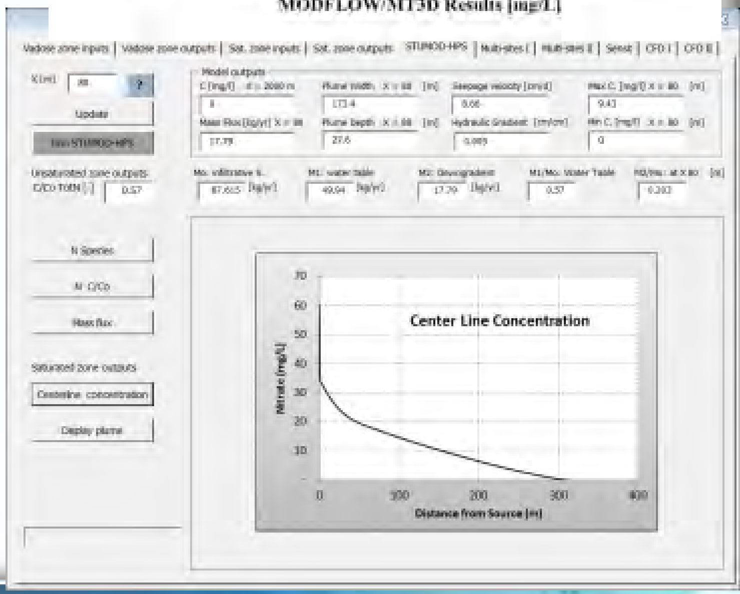


Task D - Deliverables

- Complex soil-aquifer model
  - rigorous scientific principals, but simple to use
  - stand alone tool
- Outcomes
  - STUMOD-FL-HPS
  - combined unsaturated and saturated zone model
  - corroborated to field data / validated with numerical model
  - demonstration…







Summary & Questions

FOSNRS Summary

- Multi-prong project for evaluating nitrogen reduction from onsite sewage treatment and disposal systems:
  - 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

FOSNRS Summary (cont)

- Results indicate that OSTDS are capable of achieving high levels of nitrogen reduction and can play a role in nitrogen reduction from OSTDS in sensitive watersheds
- Useful tools were developed to assist with planning and implementation of nitrogen reduction strategies for OSTDS in Florida
  - PNRS-LCCA
  - Simple Soil Tools
  - STUMOD FL
  - STUMOD FL HPS

What's left to do?

- Link the results of all FOSNRS tasks together into a final database and report.
- Link treatment, soil and groundwater tools to develop onsite wastewater nitrogen reduction best management practices (BMPs)
- Develop onsite wastewater nitrogen reduction management strategies for Florida, based on nutrient sensitivity. Watershed/water body sensitivity varies, N reduction is not needed everywhere.
- Develop detailed design criteria, performance definitions, performance boundaries, and strategy implementation guidance
- Move forward with implementation

QUESTIONS ?

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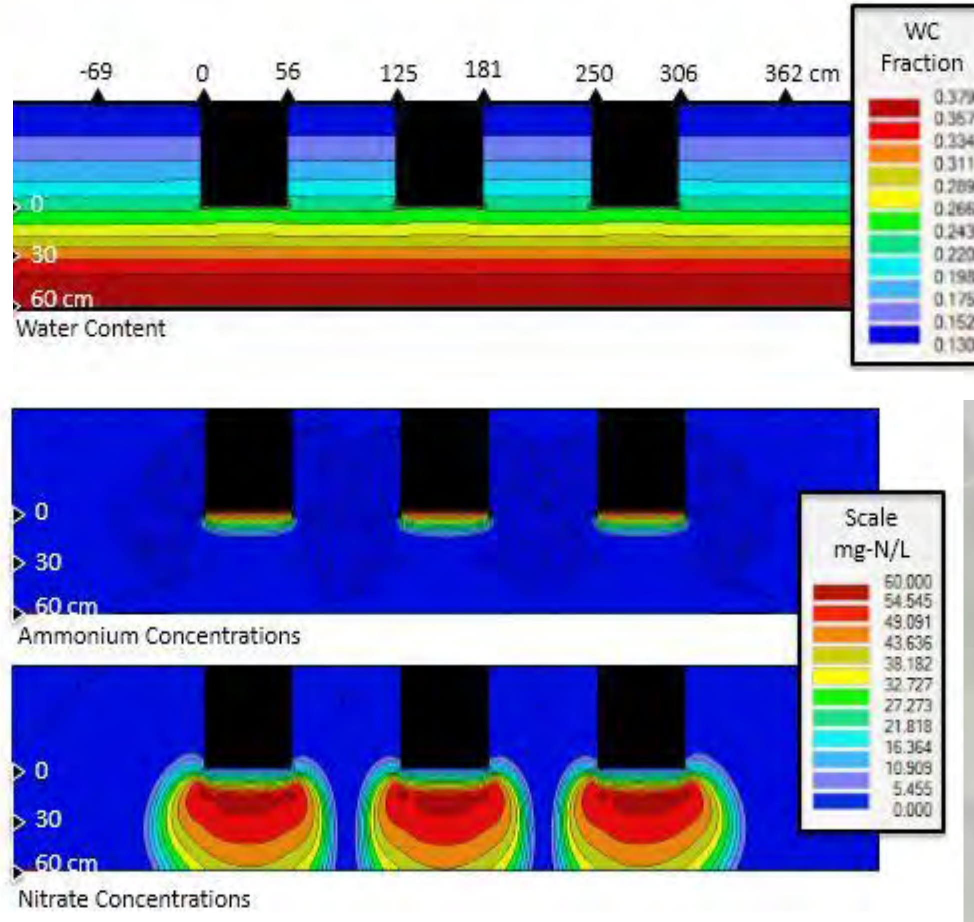
Hydrus 2D modeling of multiple vadose zone nitrogen fate and transport scenarios

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)

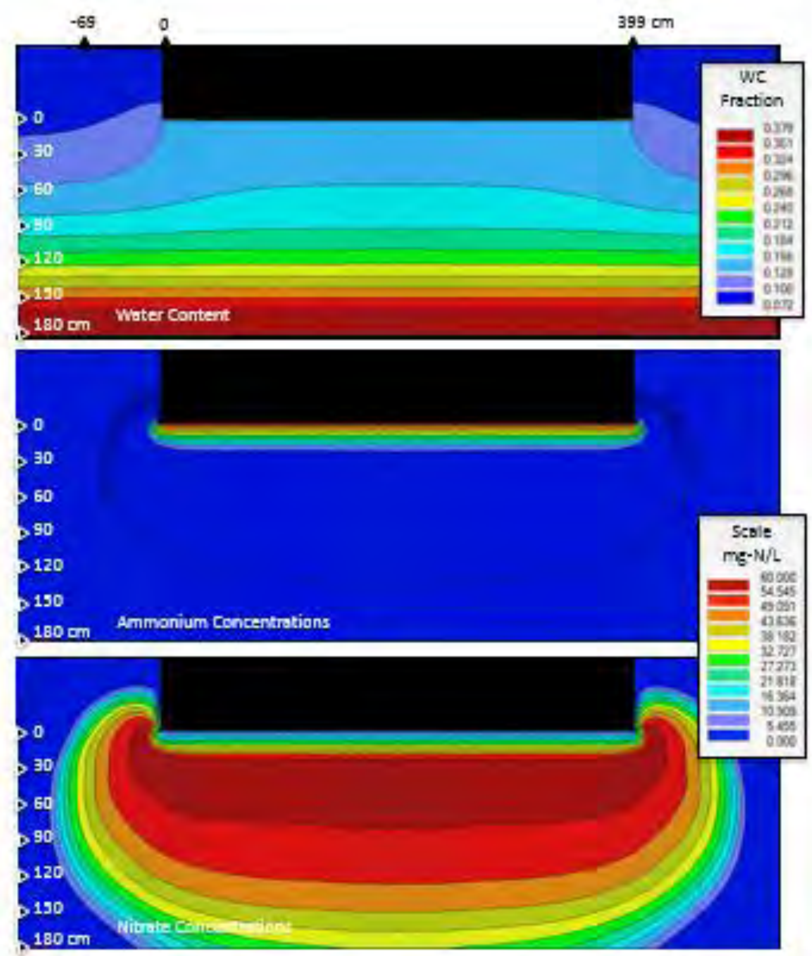


Vadose Zone Operating Conditions Modeled

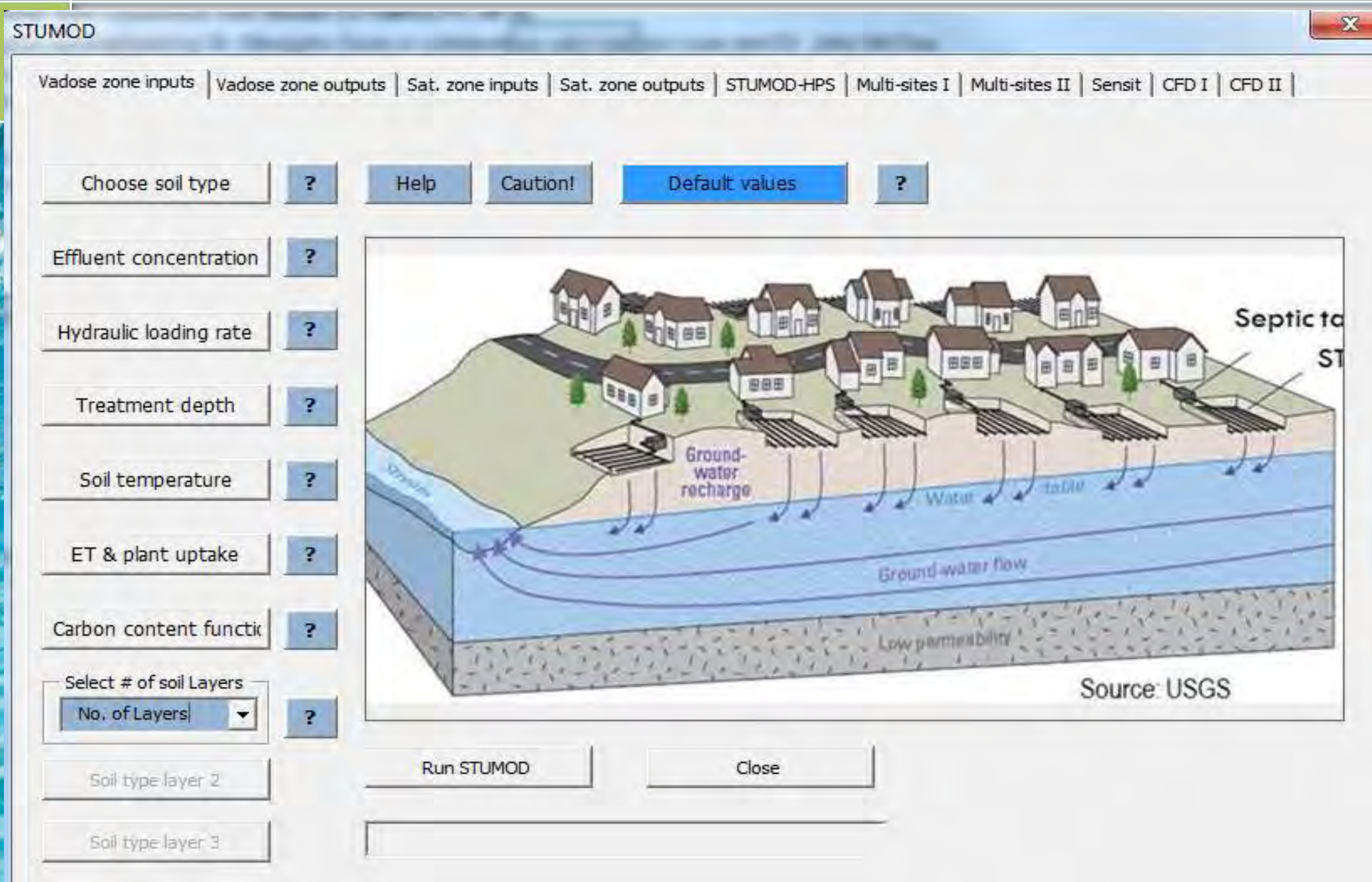
Condition	Variations Simulated
Distribution Configuration	Trenches, equal effluent distribution to each trench; Trenches, unequal effluent distribution to each trench; Bed, equal effluent distribution to each bed; or Bed, unequal effluent distribution to each bed.
Soil Texture	sandy clay loam; less permeable sand; or more permeable sand.
Soil Profile	homogenous; or layered
Effluent Nitrogen Composition	typical STE; or nitrified effluent.
Depth to Water Table	1 ft below the infiltrative surface; 2 ft below the infiltrative surface; 6 ft below the infiltrative surface; or free drainage (deep water table).

Simple Soil Tool for estimating vadose zone N transport

Configuration: bed, equal distribution
Soil Type: less permeable sand
Loading Rate: 1.68 cm/d (0.41 gpd/ft^2)
Effluent Nitrogen: 60 mg-N/L as NH_4
Depth to Water Table: 183 cm (6 ft)



STUMOD FL: Graphical user interface



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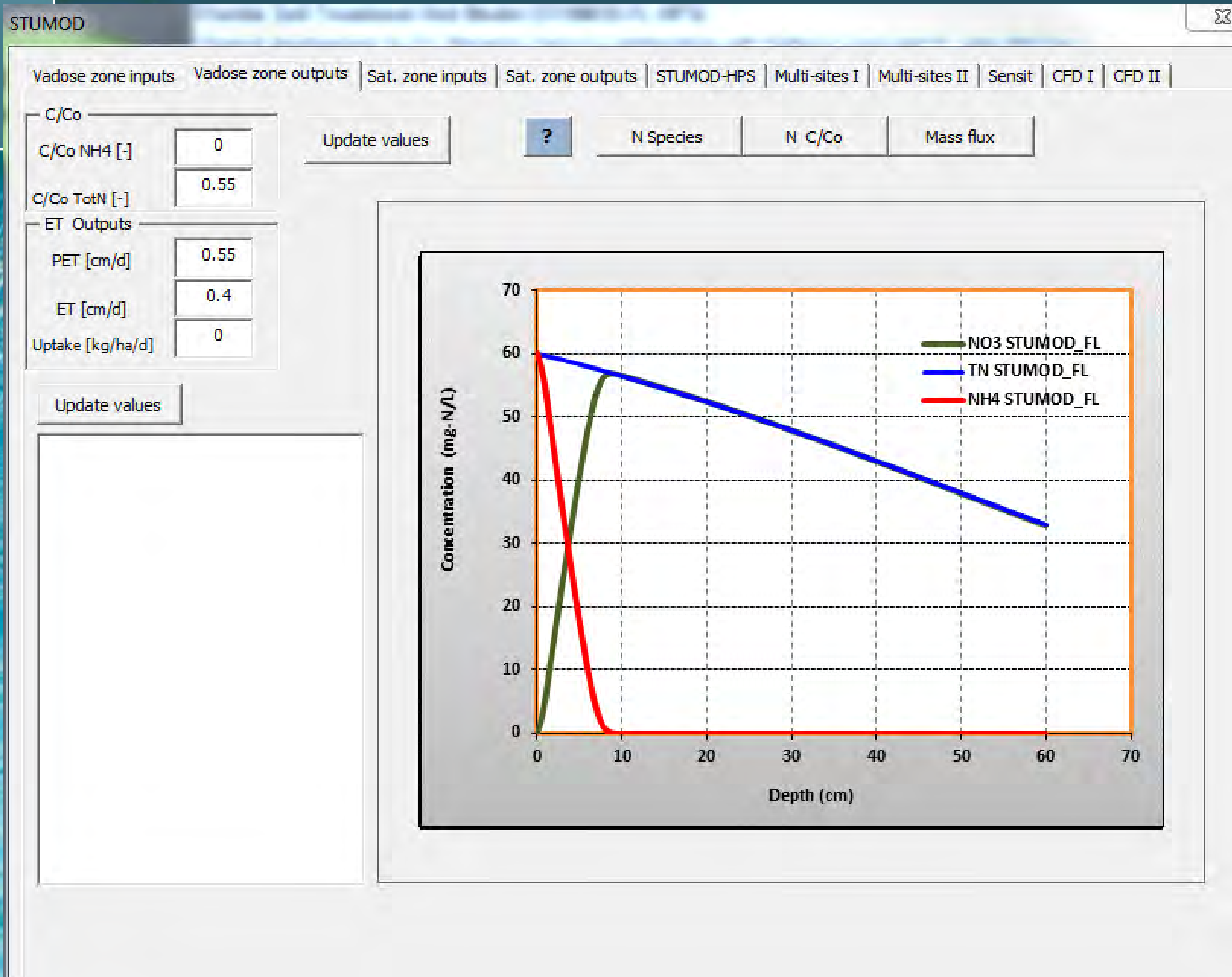
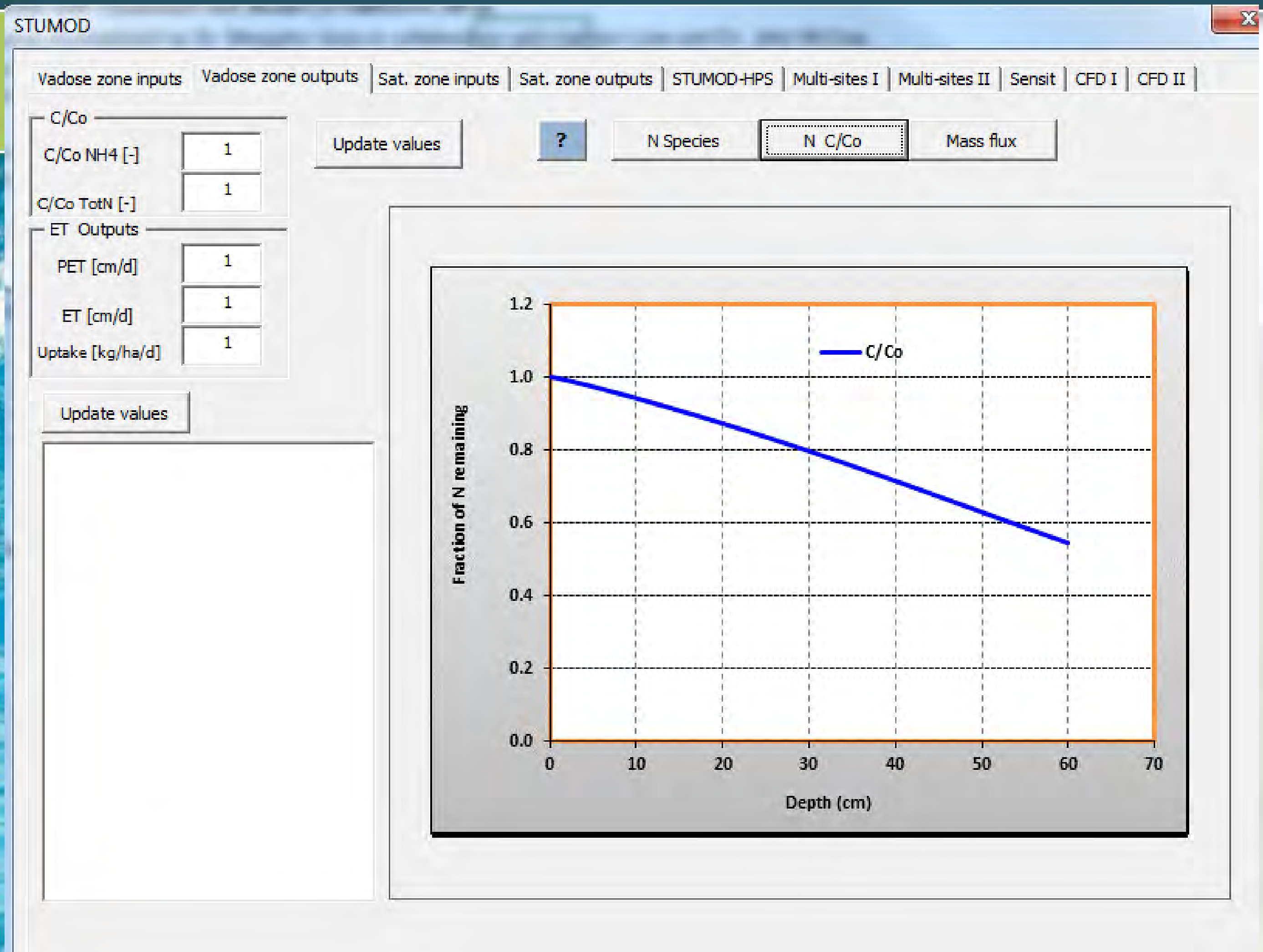
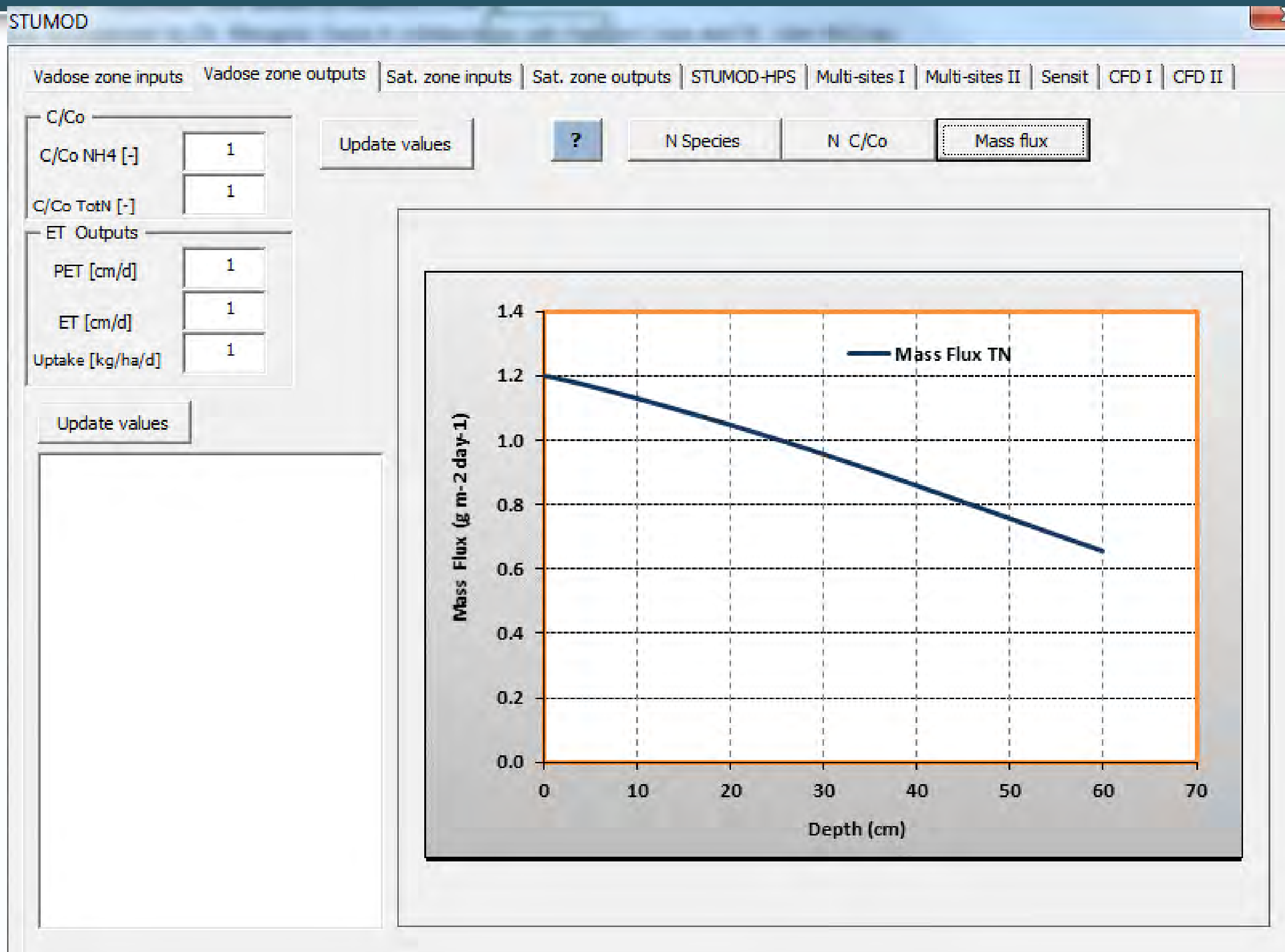
Vadose zone output (STUMOD-FL)



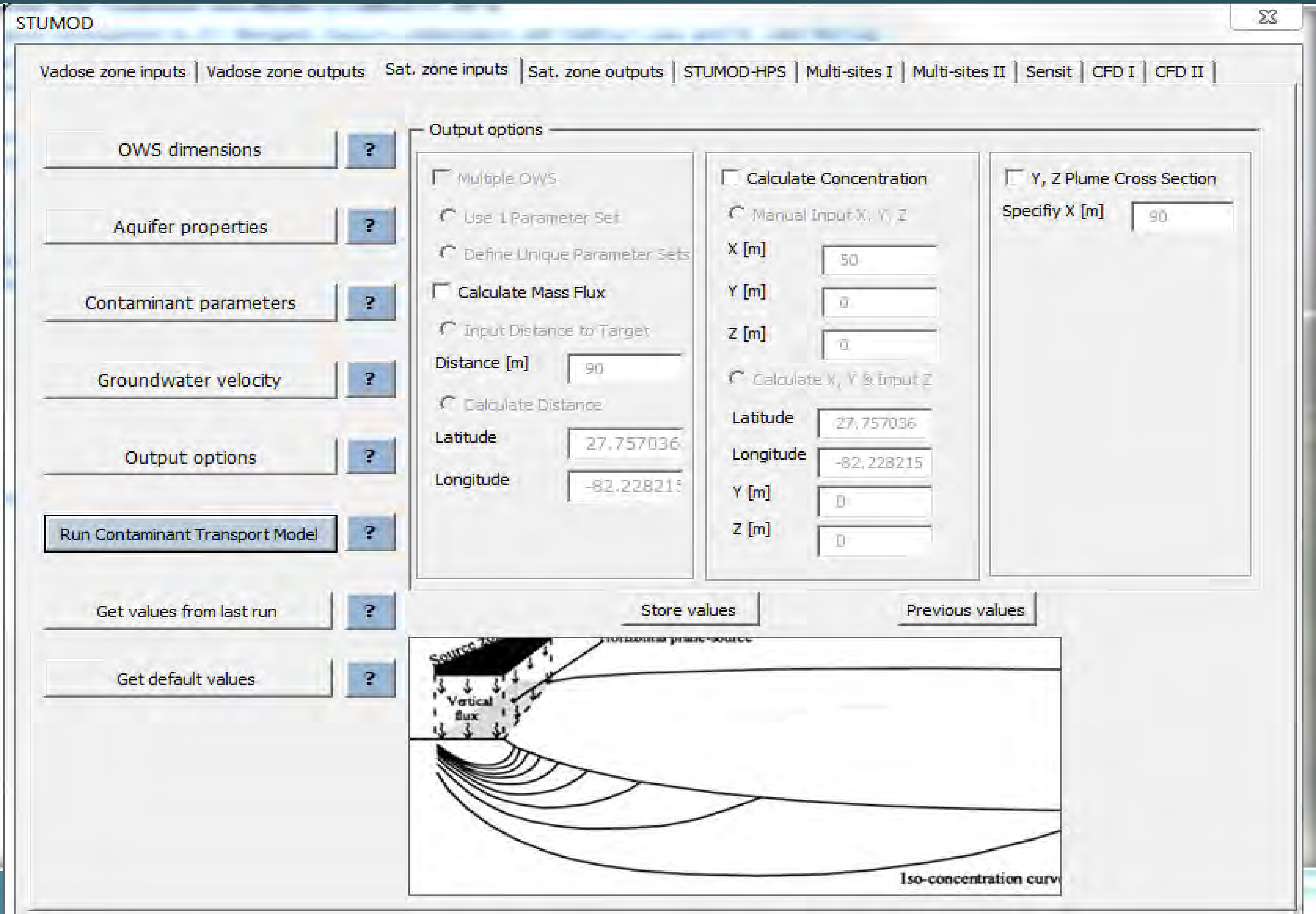
Vadose zone output (STUMOD-FL)



Vadose zone output (STUMOD-FL)



Saturated zone (HPS) inputs



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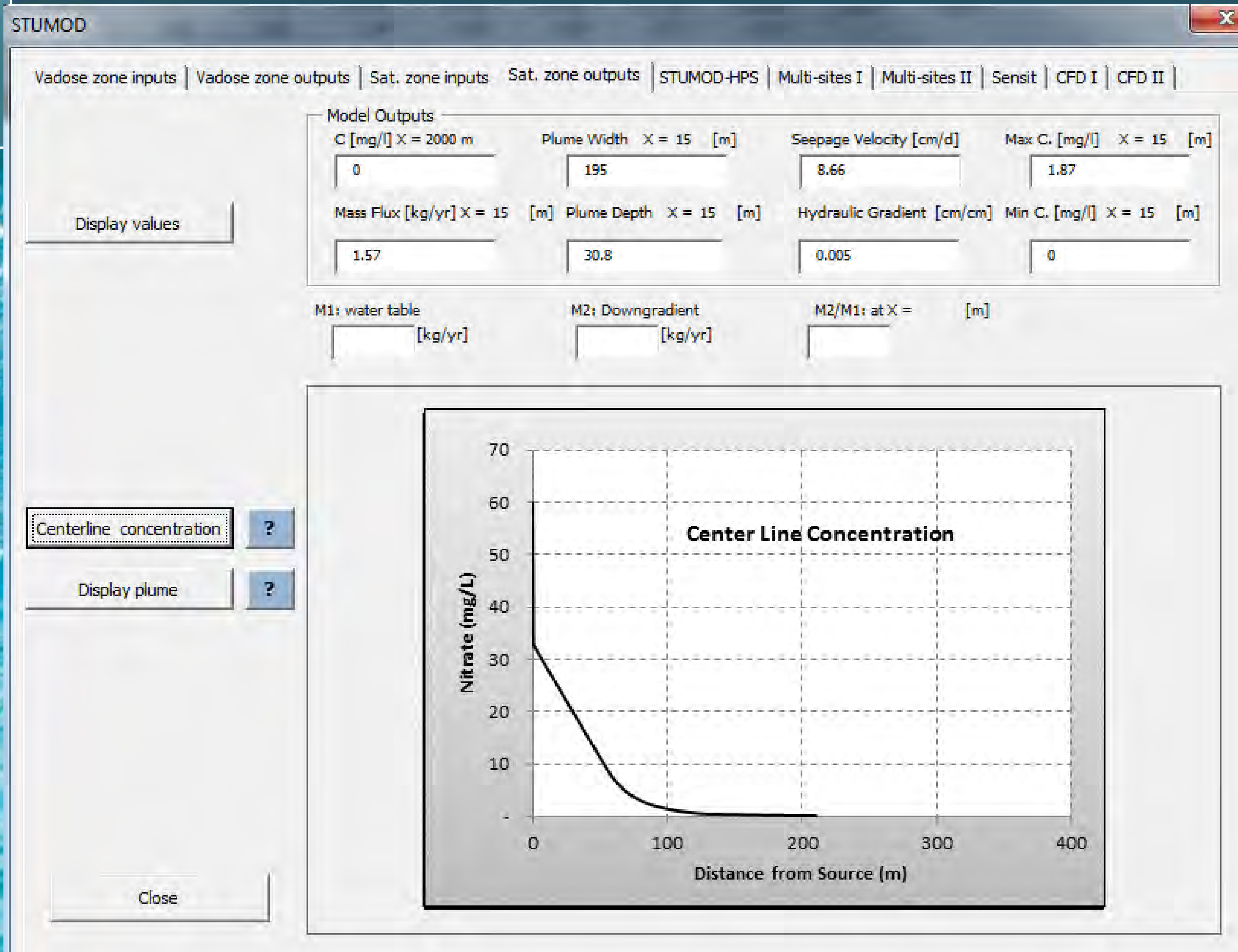
Saturated zone (HPS) outputs



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Saturated zone (HPS) outputs