Nitrogen Loading from Onsite Wastewater Treatment Systems in the Greater Narragansett Bay Watershed: Magnitude and Reduction Strategies

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THE UNIVERSITY OF RHODE ISLAND

LSEM
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University of Rhode Island

THANK YOU:

NARRAGANSETT BAY ESTUARY PROGRAM

Town of Charlestown, RI Homeowners

CO-AUTHORS:

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- Brittany Lancellotti
- Kevin Hoyt
- Ed Avizinis
- Bianca Ross
- Josef Görres

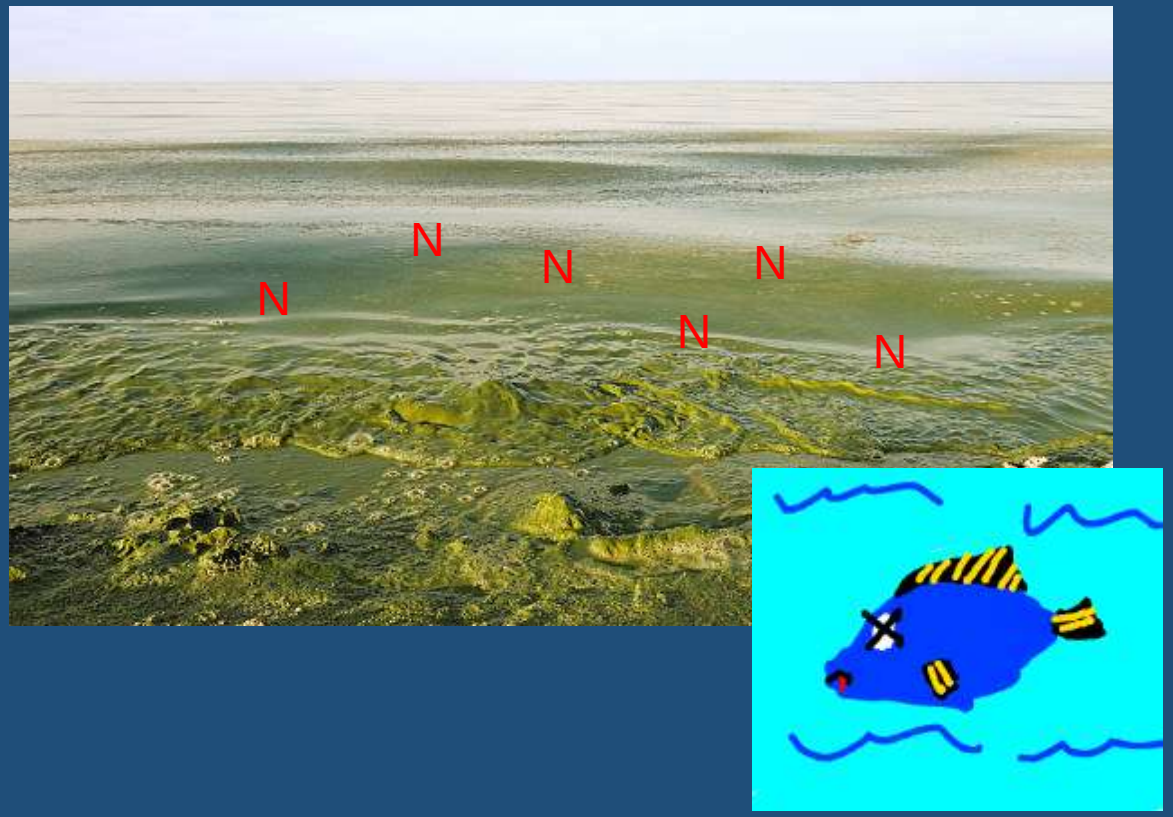
DISCLAIMER

Although the information in this document has been funded wholly or in part by the United States Environmental Protection Agency under agreement CE96184201 to NEIWPCC, it has not undergone the Agency's publications review process and therefore, may not necessarily reflect the views of the Agency and no official endorsement should be inferred. The viewpoints expressed here do not necessarily represent those of the Narragansett Bay Estuary Program, NEIWPCC, or EPA, nor does mention of trade names, commercial products, or causes constitute endorsement or recommendation for use.

Main Questions

- How does performance of advanced N-removal OWTS vary?
- How much N do OWTS contribute to the watershed & what can we do about it?
- How can we monitor N in effluent to improve performance?

N affects ground and coastal waters:

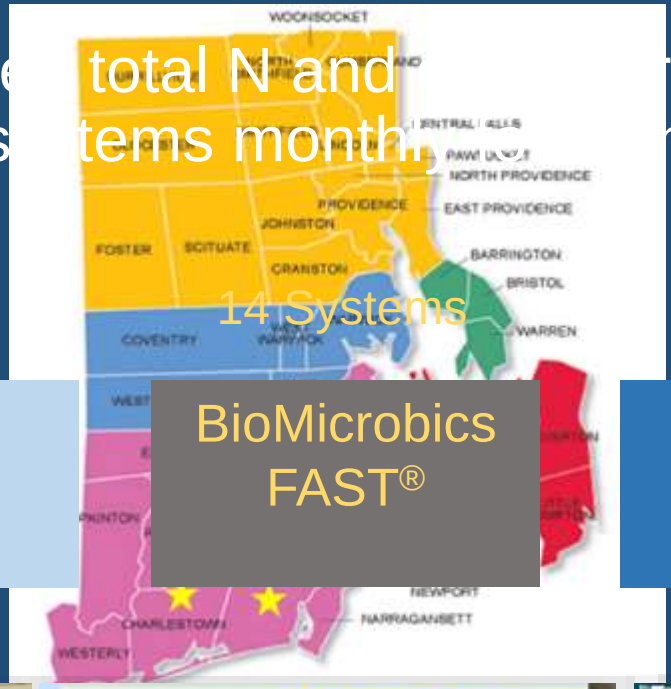


Performance of Advanced N-Removal OWTS

Lancellotti, B.V., G. Loomis, K. Hoyt, E. Avizinis, and J.A. Amador. 2017**. Evaluation of nitrogen concentration in final effluent of advanced nitrogen-removal onsite wastewater treatment systems (OWTS)**. *Water, Air and Soil Pollution* 228:383-298.

Project Design

Monitore total N and ameters
in 42 s tems month months



17 Systems

Orenco Advantex AX20®

14 Systems

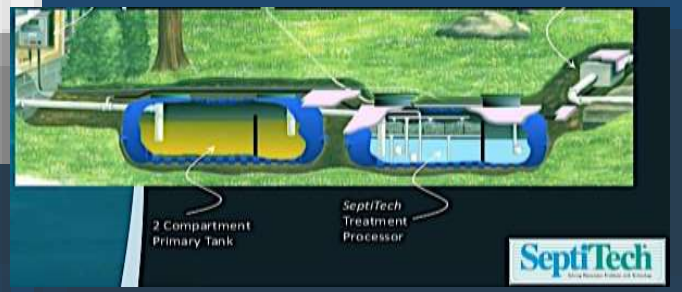
BioMicrobics FAST®

11 Systems

SeptiTech D®

http://www.orenco.com/sales/choose_asystem/index.cfm

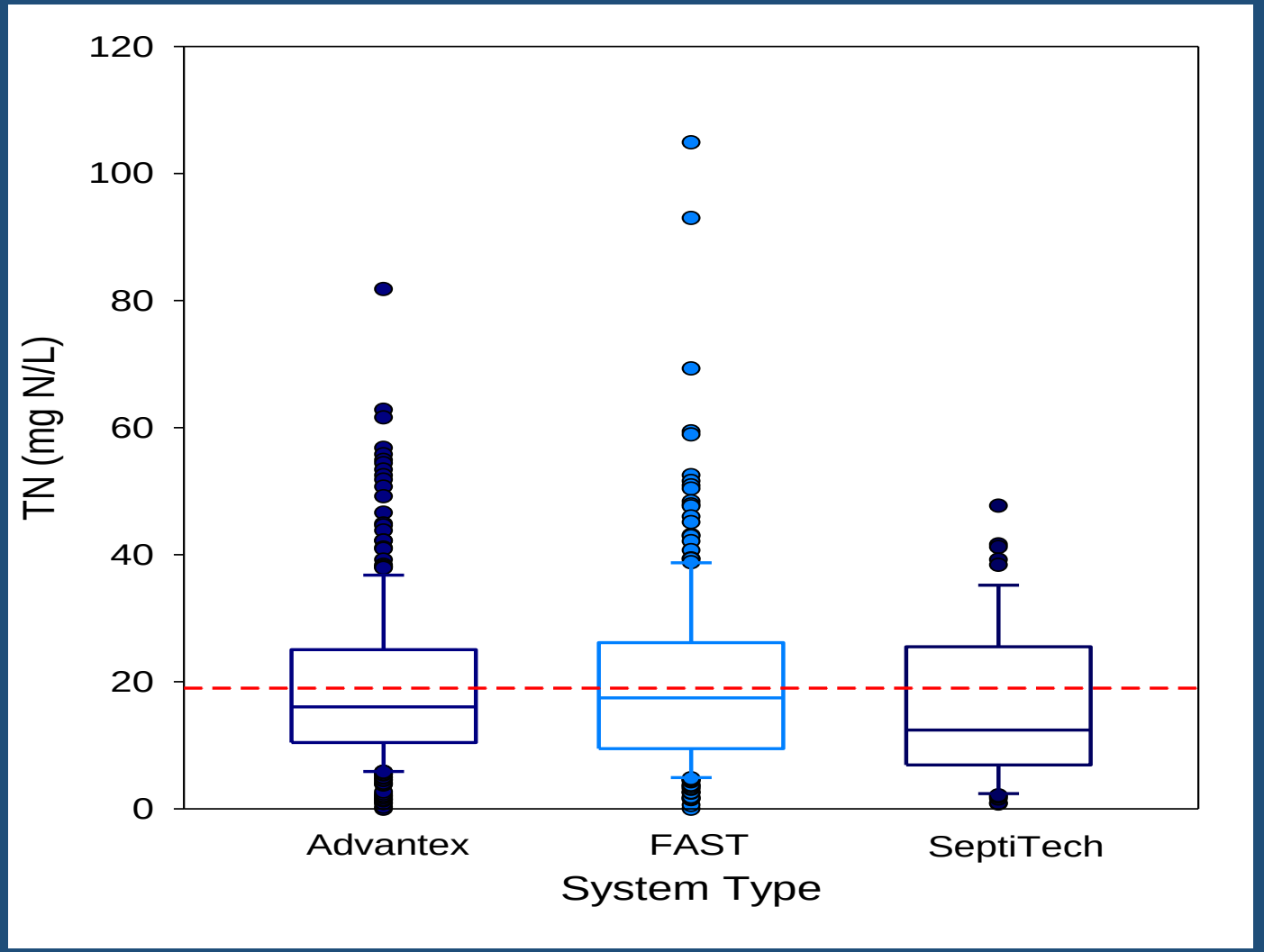
http://www.biomicrobics.com/products/fast-wastewater-treatment-systems/microfast/



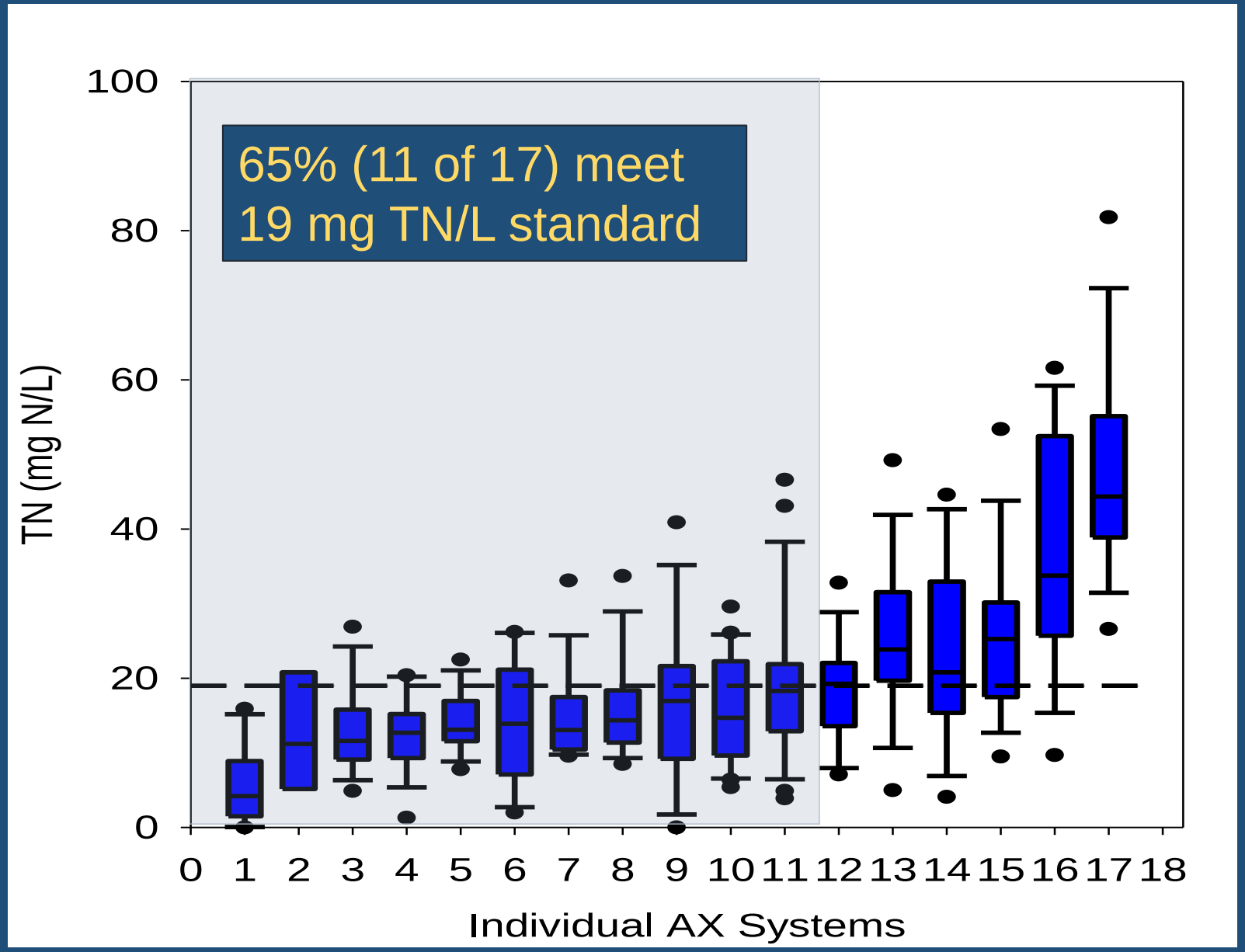
http://www.septitech.com/staar-residential/

Distribution of TN Concentrations

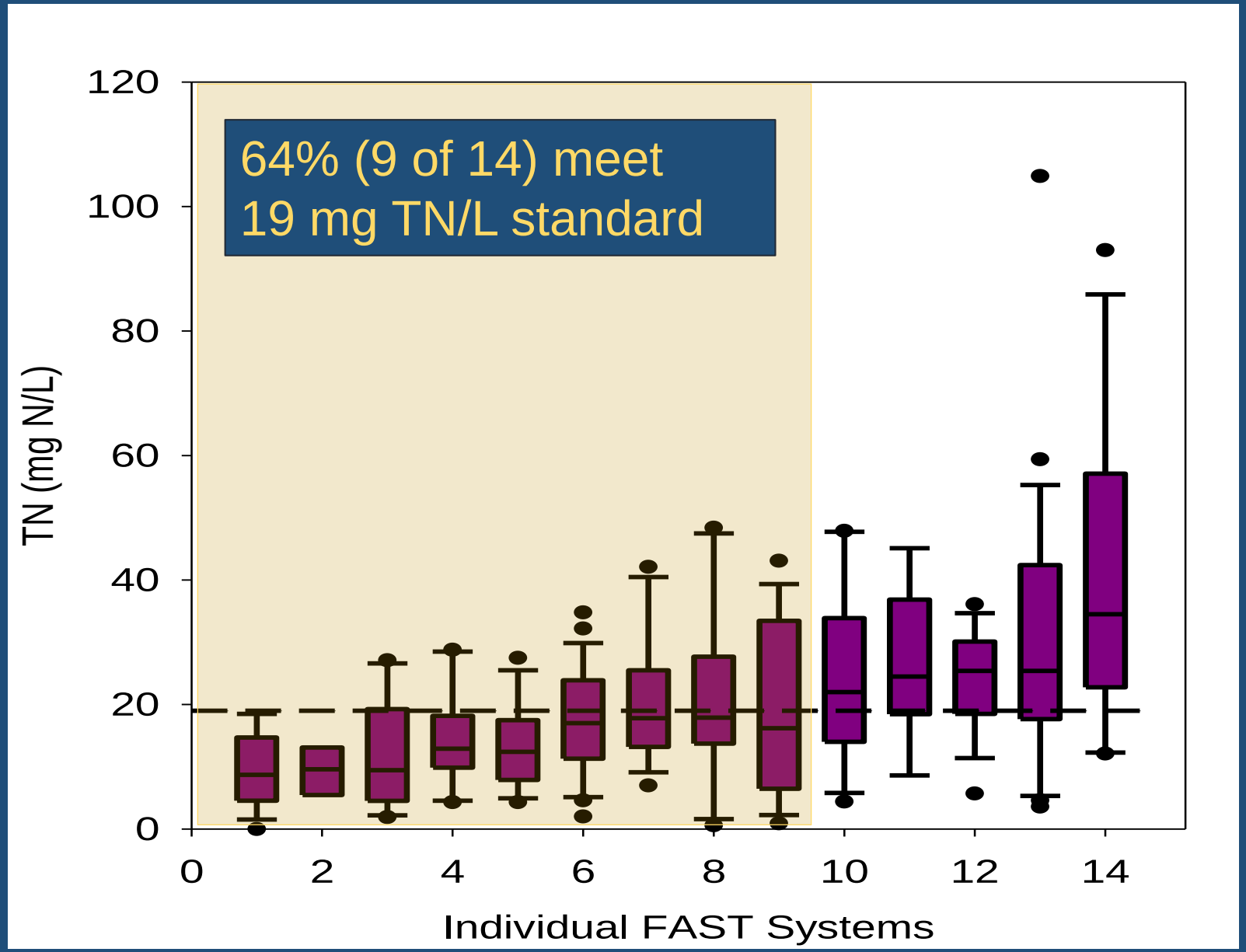
March 2015 - August 2016



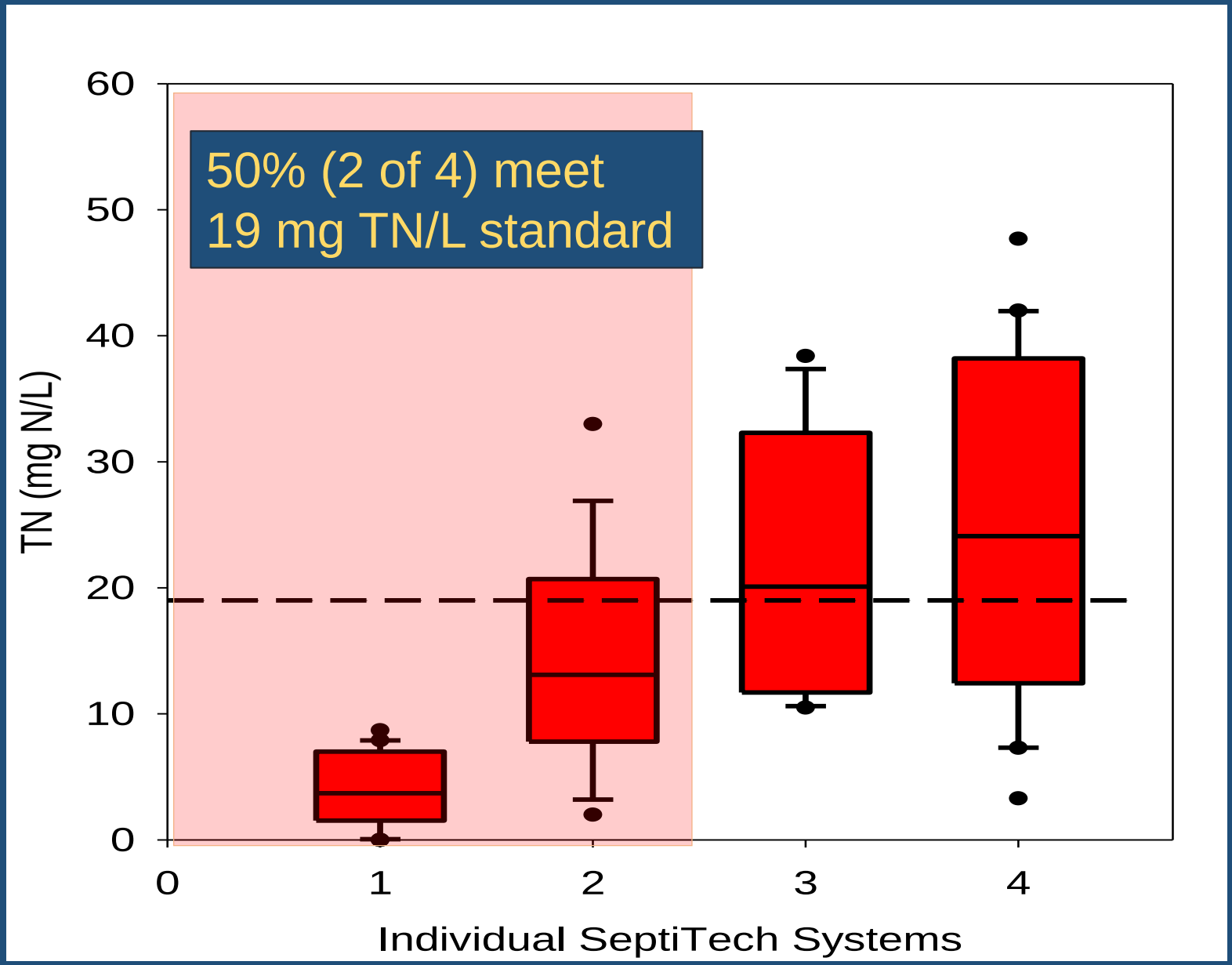
Advantex Systems



FAST Systems

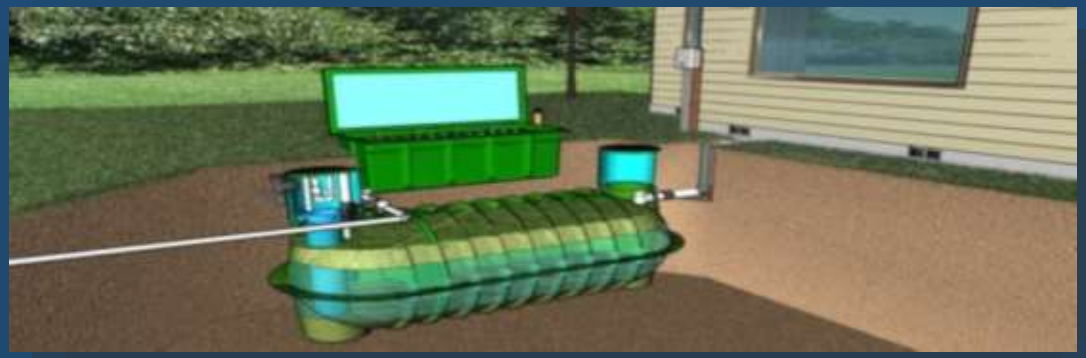


SeptiTech Systems



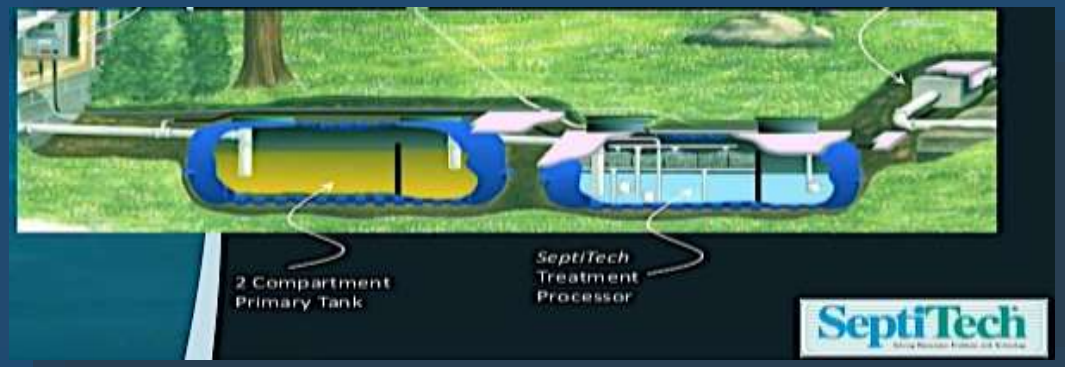
Scaling Compliance Rates

Based on Applications as of January 2016



http://www.orenco.com/sales/choose_asystem/index.cfm

3,740 Total Applications
35% Out of Compliance
(1,309)



http://www.septitech.com/staar-residential/

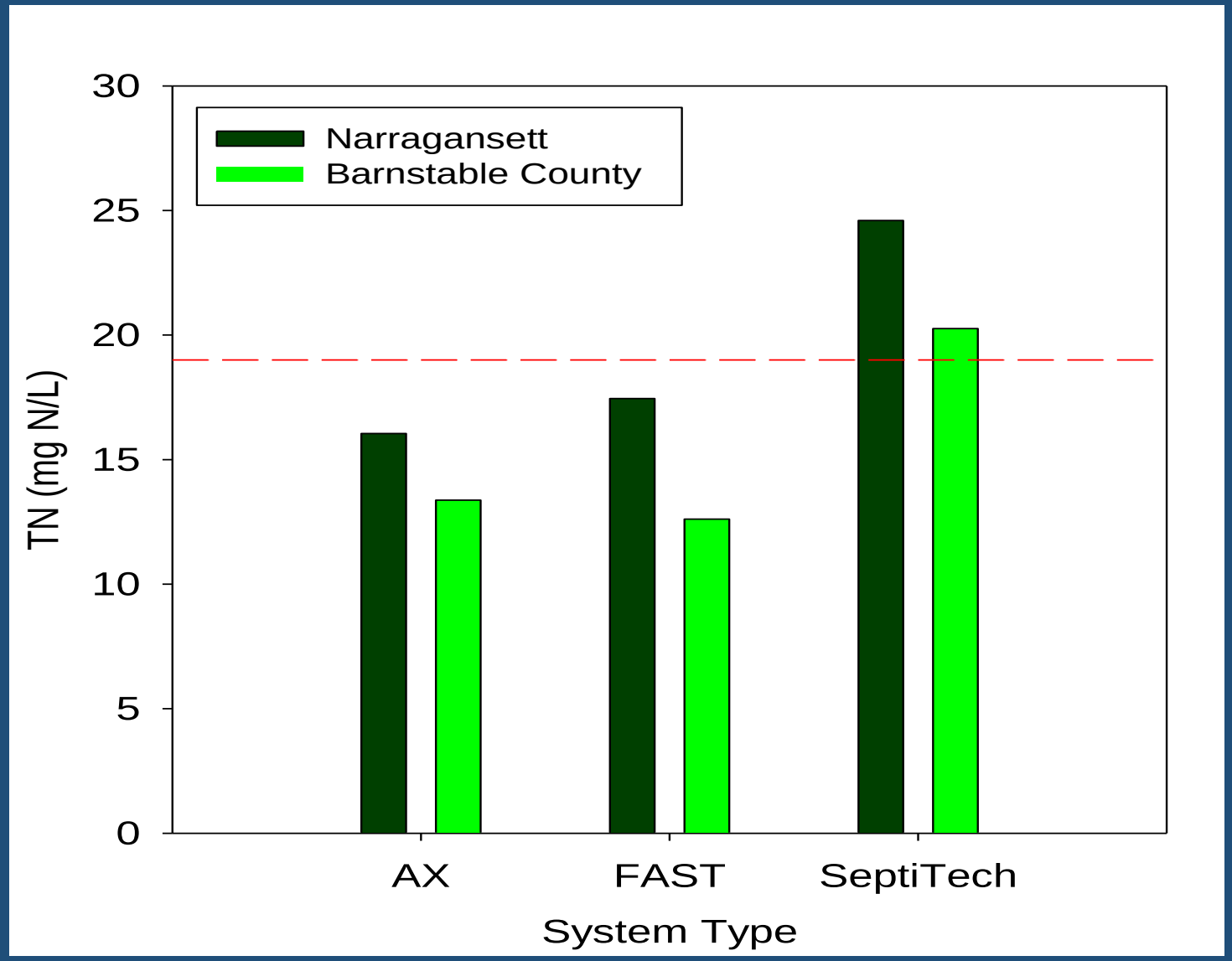
231 Total Applications
50% Out of Compliance
(115)

http://www.biomicrobics.com/products/fast-wastewater-treatment-systems/microfast/

725 Total Applications
36% Out of Compliance (261)

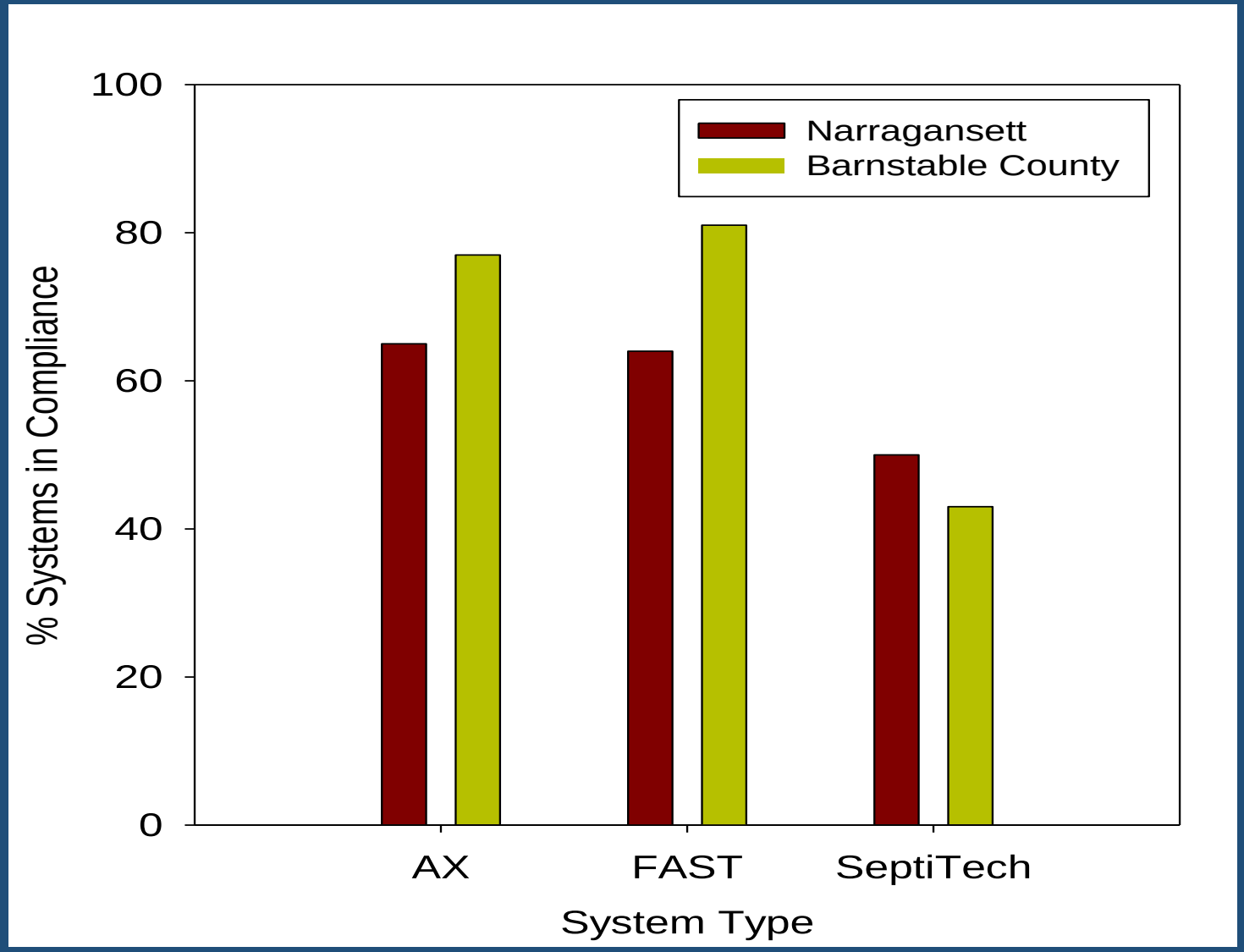
Median TN Concentration

Greater Narragansett Bay Watershed, RI *vs*. Barnstable County, MA



Percentage of Systems in Compliance

Greater Narragansett Bay Watershed, RI *vs*. Barnstable County, MA



Differences in Regulations

Rhode Island

- 2 maintenance visits required/year
  - Focus on mechanical function
  - **No effluent sampling**
  - 19 mg TN/L standard

Barnstable County, MA

- 4 maintenance visits required/year
  - **Effluent sampling required**
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- Online management database
  - Tracks maintenance visits
  - Tracks effluent constituent levels
  - Alerts when effluent does not meet standards
  - Triggers a corrective action

Nitrogen inputs from OWTS to the watershed

Amador, J.A., J.H. Görres, G. Loomis, and B.V. Lancellotti. 2018. **Nitrogen loading from onsite wastewater treatment systems in the Greater Narragansett Bay (Rhode Island, USA) Watershed: Magnitude and reduction strategies.** *Water, Air and Soil Pollution* 229 (3): 65.

We realized we had an interesting data set…

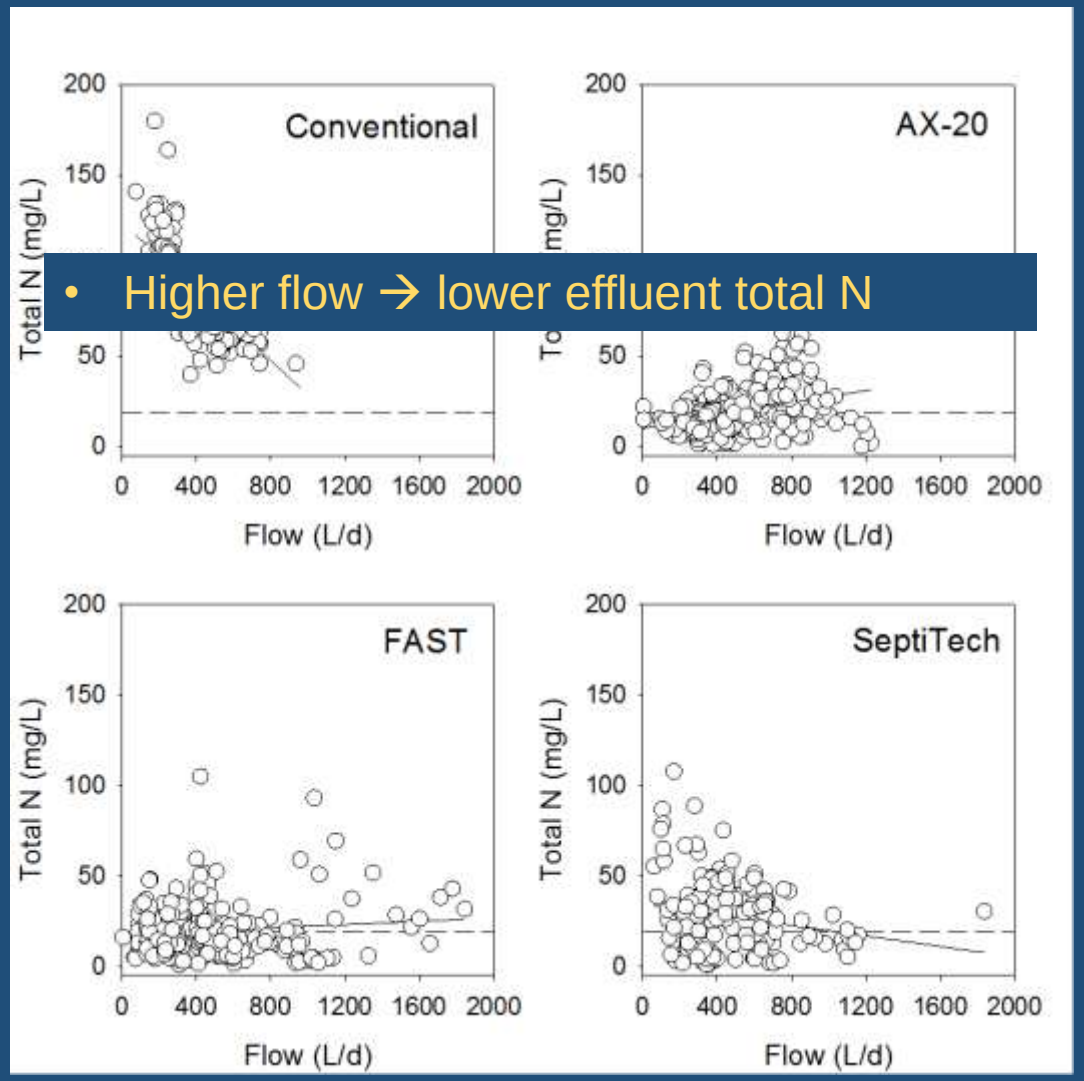
Table 1. Median, maximum and minimum values of daily wastewater flow, total N concentration, and daily mass load of N from conventional and advanced N-removal OWTS used in this study.

System type	Wastewater flow (L/d)				Total N concentration (mg N/L)				Mass load of N (g N/d)			
	Median	Max	Min	n	Median	Max	Min	n	Median	Max	Min	n
Conventional	472	960	68	158	74	180	40	169	31.1	73.8	10.4	157
AX-20	471	1557	4	304	16	82	0	268	10.8	55.7	0.1	252
FAST	476	1843	4	239	17	105	1	213	10.1	96.2	0.1	213
SeptiTech	374	1837	17	170	25	108	1	192	9.6	55.7	0.3	142

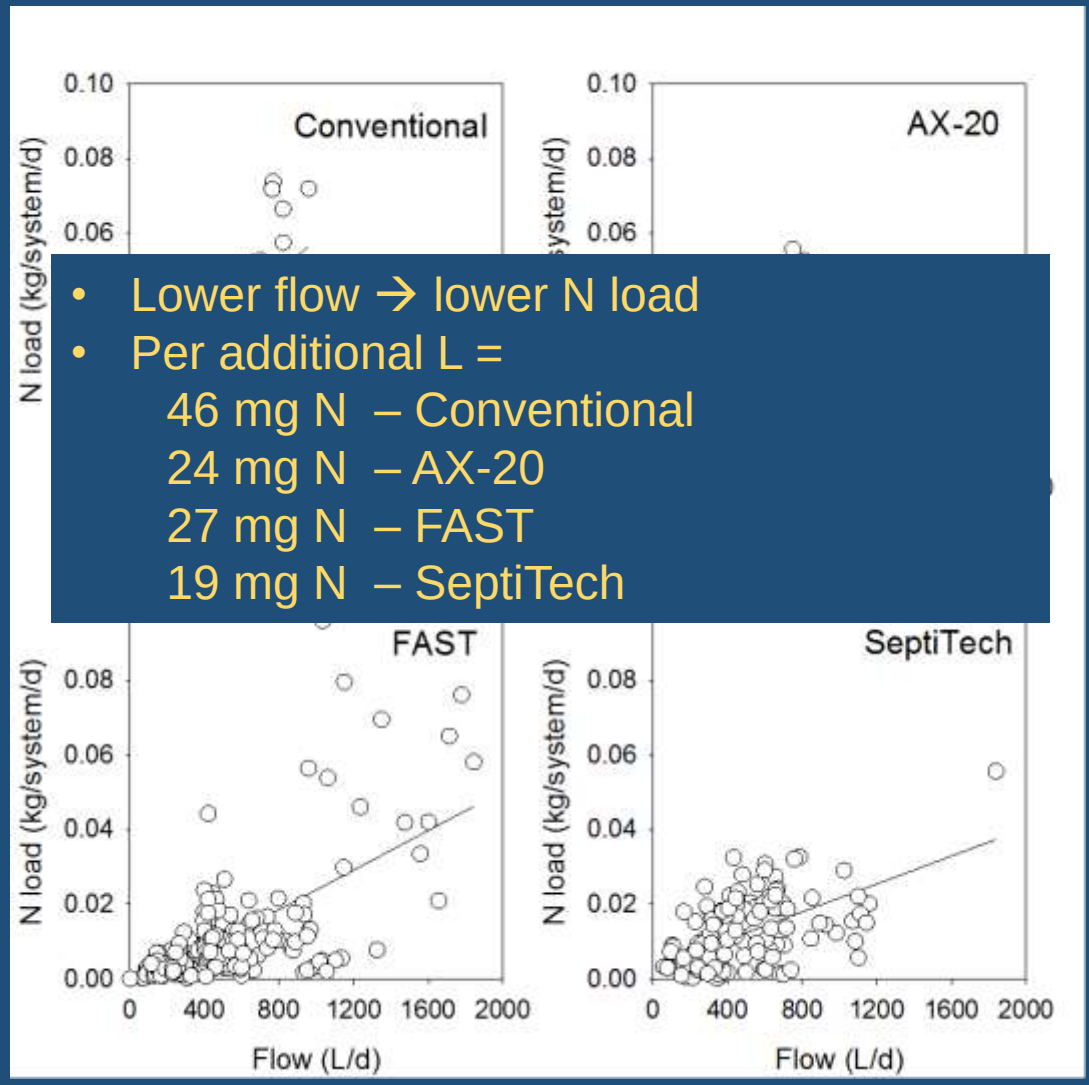
…that could answer interesting questions:

- What's the relationship between total N, N load & flow?
- What is the N load from different OWTS to the watershed?
- How does OWTS N load compare with WTP?
- How can we lower OWTS N load?

Relationship between total N, N load & flow



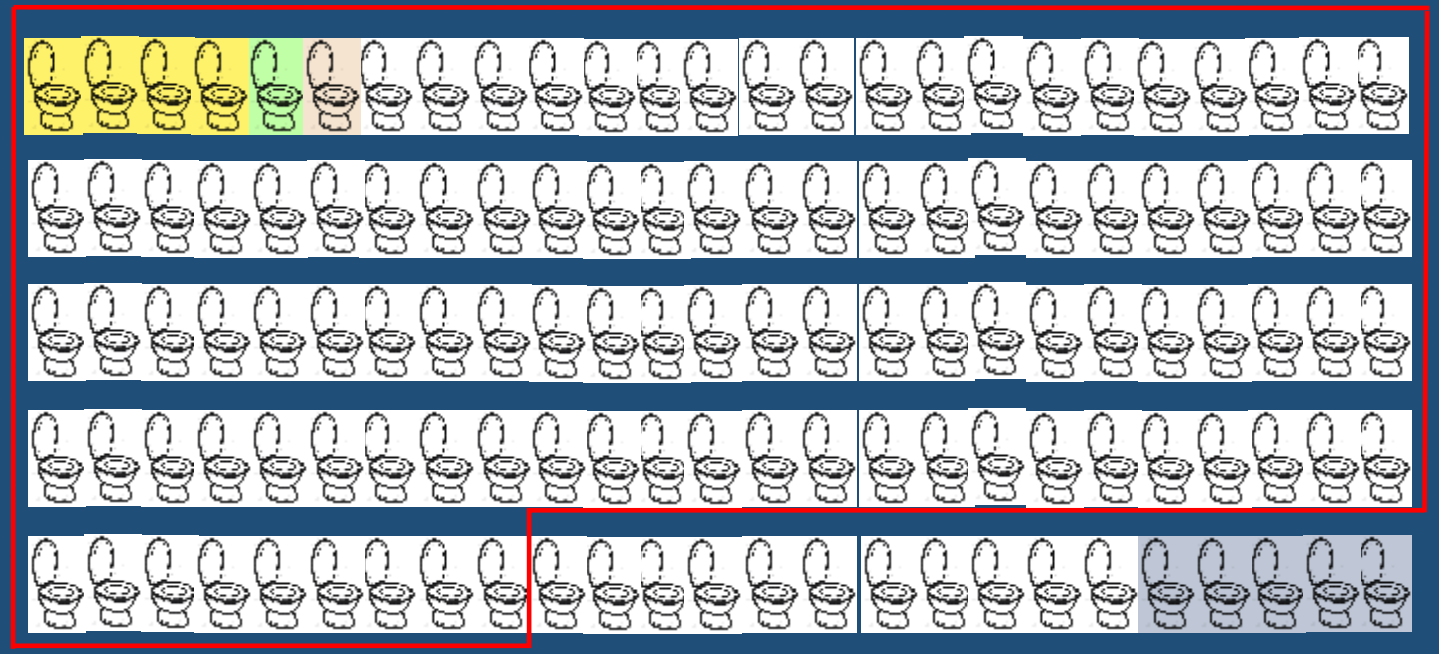
- Higher flow → lower effluent total N



- Lower flow → lower N load
- Per additional L =
  - 46 mg N – Conventional
  - 24 mg N – AX-20
  - 27 mg N – FAST
  - 19 mg N – SeptiTech

Nitrogen load from OWTS to watershed

First, we need to count OWTS…



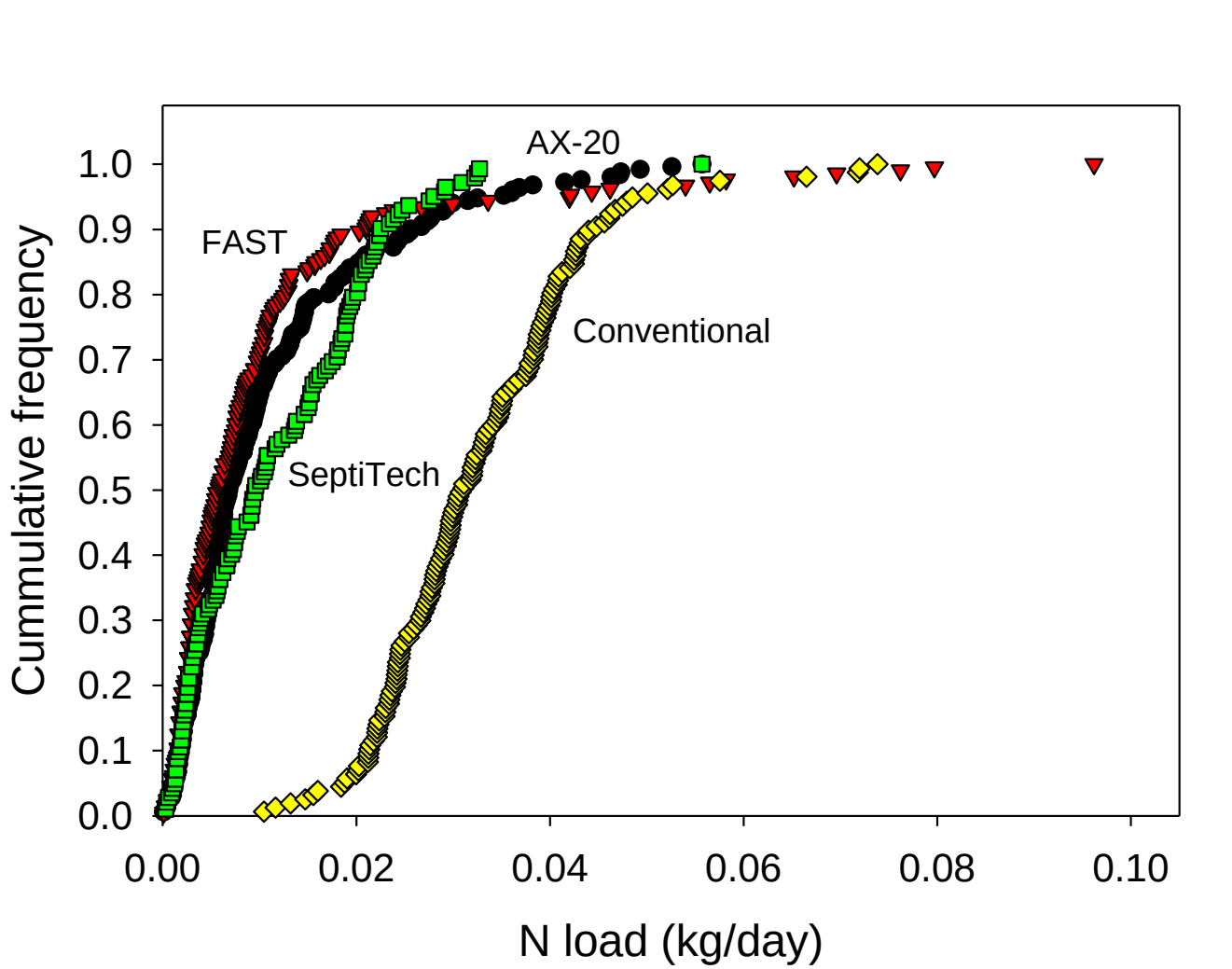
Statewide	= 125,000
Watershed	= 120,265

Our analysis included **105,833** systems:

101,098	Conventional	(95.30%)
3,740	AX-20	(3.53%)
270	SeptiTech	(0.26%)
725	FAST	(0.69%)

NBEP (2017)

Then we need the distribution of N loads…



Lancellotti et al. (2017) and Loomis et al. (2004)

Then we fly to Monte Carlo…

Distribution of N values

N/sys.

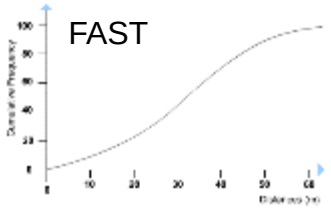
sys.

N load

N load to watershed

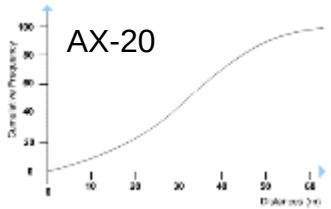
Simulated distribution of N loading to watershed

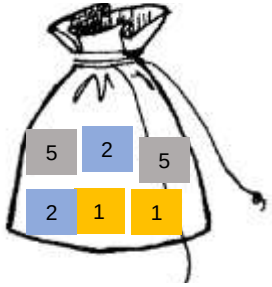
FAST



2 × 100 = 200

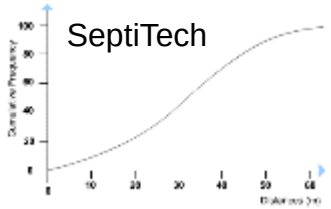
AX-20

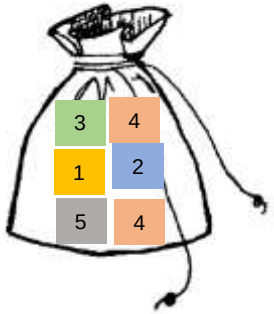




1 × 300 = 300

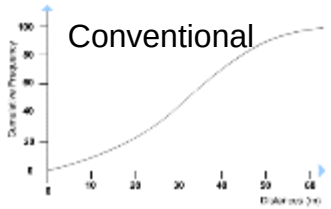
SeptiTech

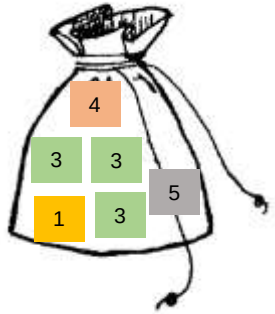




4 × 200 = 800

Conventional





4 × 400 = 1,600

2,900

Repeat process 3,000 times

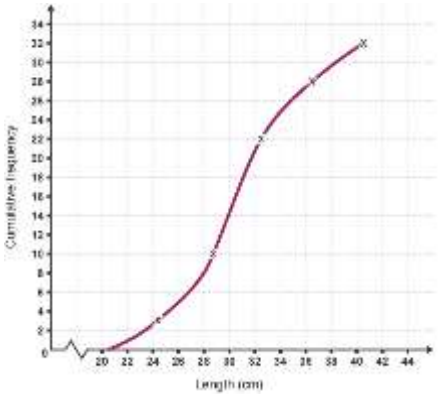
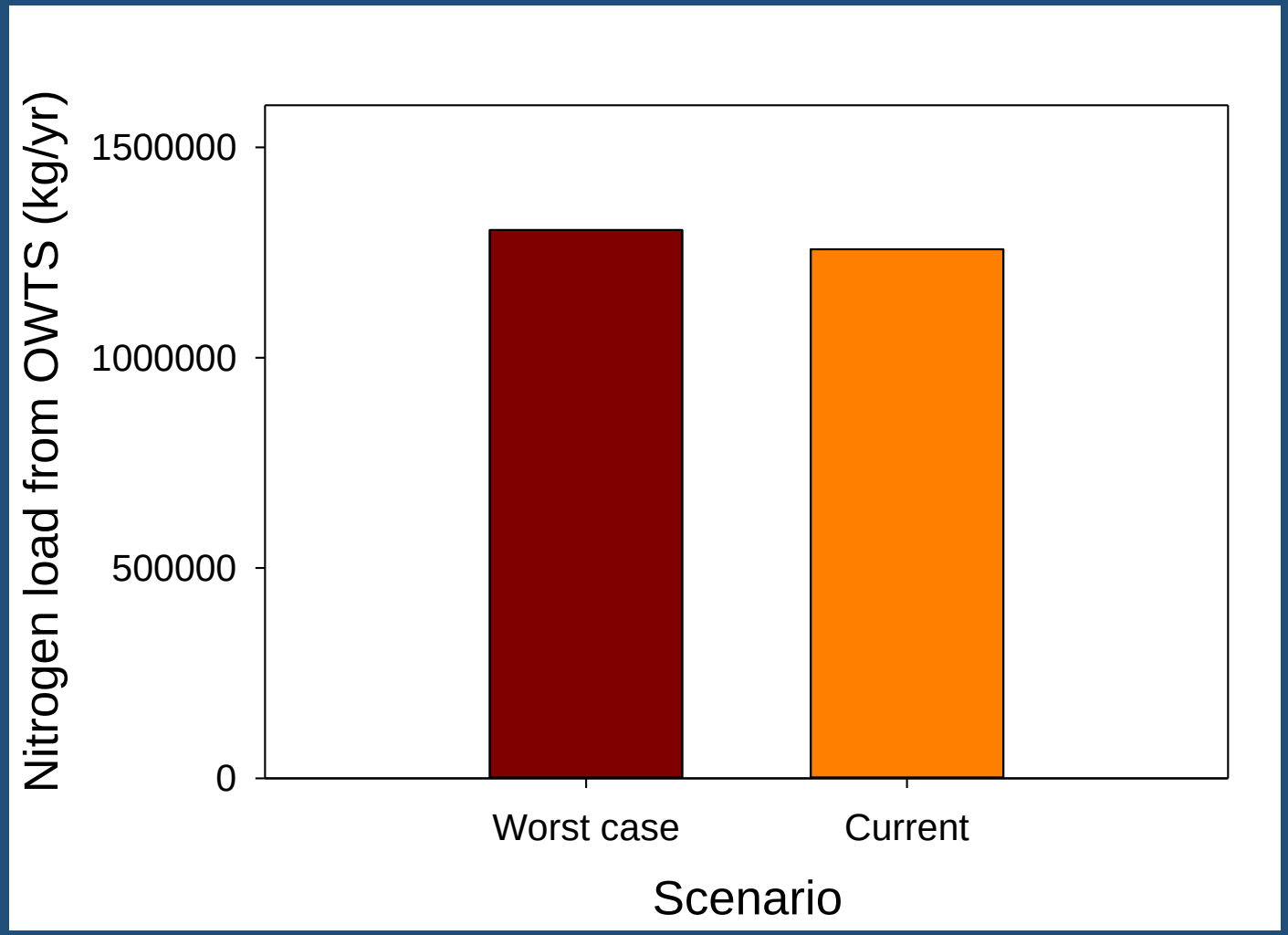


Table 2 Results of Monte Carlo simulation of N load from conventional and advanced N-removal onsite wastewater treatment systems (OWTS) within the Greater Narragansett Bay watershed (Rhode Island, USA). The simulation was based on a total of 105,833 systems within the watershed. The simulation assumes no removal of N after effluent is dispersed to the soil treatment area

Scenario	Distribution of technologies (%)				Change from current scenario (no. of systems)				Simulated N load:					Difference (kg N/year) from	
									Daily (g N/system/day)		Yearly (kg N/system/year)		Yearly—all (kg N/year)	Current case	Worst case
	Conv.	Septi	FAST	AX	Conv.	Septi	FAST	AX	Mean	SD	Mean	SD			
Worst Case	100.00	0	0	0	4735	−270	−725	−3740	32.914	0.050	12.01	0.02	1,271,436	53,898	0
Current	95.53	0.26	0.69	3.53	0	0	0	0	31.519	0.070	11.50	0.02	1,217,539	0	−53,898
1	86.08	0.26	10.13	3.53	−10,000	0	10,000	10,000	29.500	0.070	10.77	0.02	1,139,557	−77,982	−131,880
2	76.63	0.26	19.58	3.53	−20,000	0	20,000	20,000	27.608	0.060	10.08	0.02	1,0664,54	−151,085	−204,983
3	48.28	0.26	47.93	3.53	−50,000	0	50,000	50,000	21.096	0.230	7.70	0.08	814,908	−402,631	−456,528
4	86.08	9.70	0.69	3.53	−10,000	10,000	0	0	29.383	0.081	10.72	0.03	1,135,040	−82,498	−136,396
5	76.63	19.15	0.69	3.53	−20,000	20,000	0	0	27.176	0.082	9.92	0.03	1,049,778	−167,760	−221,658
6	48.28	46.30	0.69	3.53	−50,000	50,000	0	0	21.563	0.072	7.87	0.03	832,959	−384,579	−438,477
7	86.08	0.26	0.69	12.98	−10,000	0	0	10,000	28.751	0.044	10.49	0.02	1,110,634	−106,905	−160,803
8	76.63	0.26	0.69	22.43	−20,000	0	0	20,000	26.086	0.048	9.52	0.02	1,007,692	−209,847	−263,745
9	48.28	0.26	0.69	50.78	−50,000	0	0	50,000	18.154	0.061	6.63	0.02	701,280	−516,258	−570,156
10	48.28	19.15	14.86	18.65	−50,000	20,000	15,000	15,000	20.703	0.240	7.56	0.09	799,726	−417,813	−471,711
All Septi	0	100	0	0	−101,098	105,833	−725	−3740	11.937	0.081	4.36	0.03	461,134	−756,405	−810,303
All FAST	0		100		−101,098	−270	105,833	−3740	10.157	0.969	3.71	0.35	392,336	−825,202	−879,100
All AX	0			100	−101,098	−270	−725	105,833	4.141	0.017	1.51	0.01	159,948	−1,057,591	−1,111,489

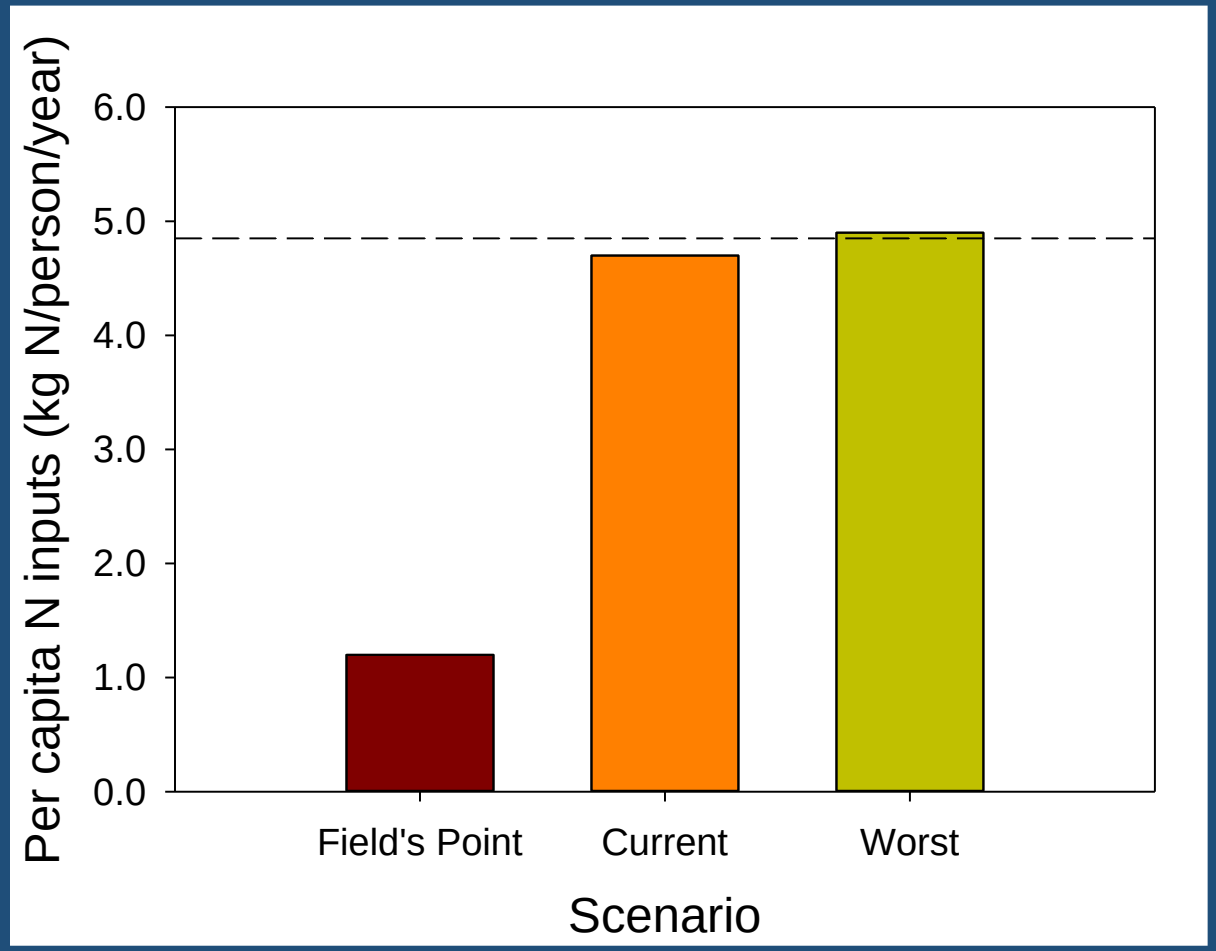
Advanced OWTS make a difference…

- Worst case:
  - Conv. = 100%
- Current:
  - Conv. = 95.30%
  - AX-20 = 3.53%
  - SeptiTech = 0.26%
  - FAST = 0.69%
- **Δ = -45,790 kg N/yr (3.5% less N)**



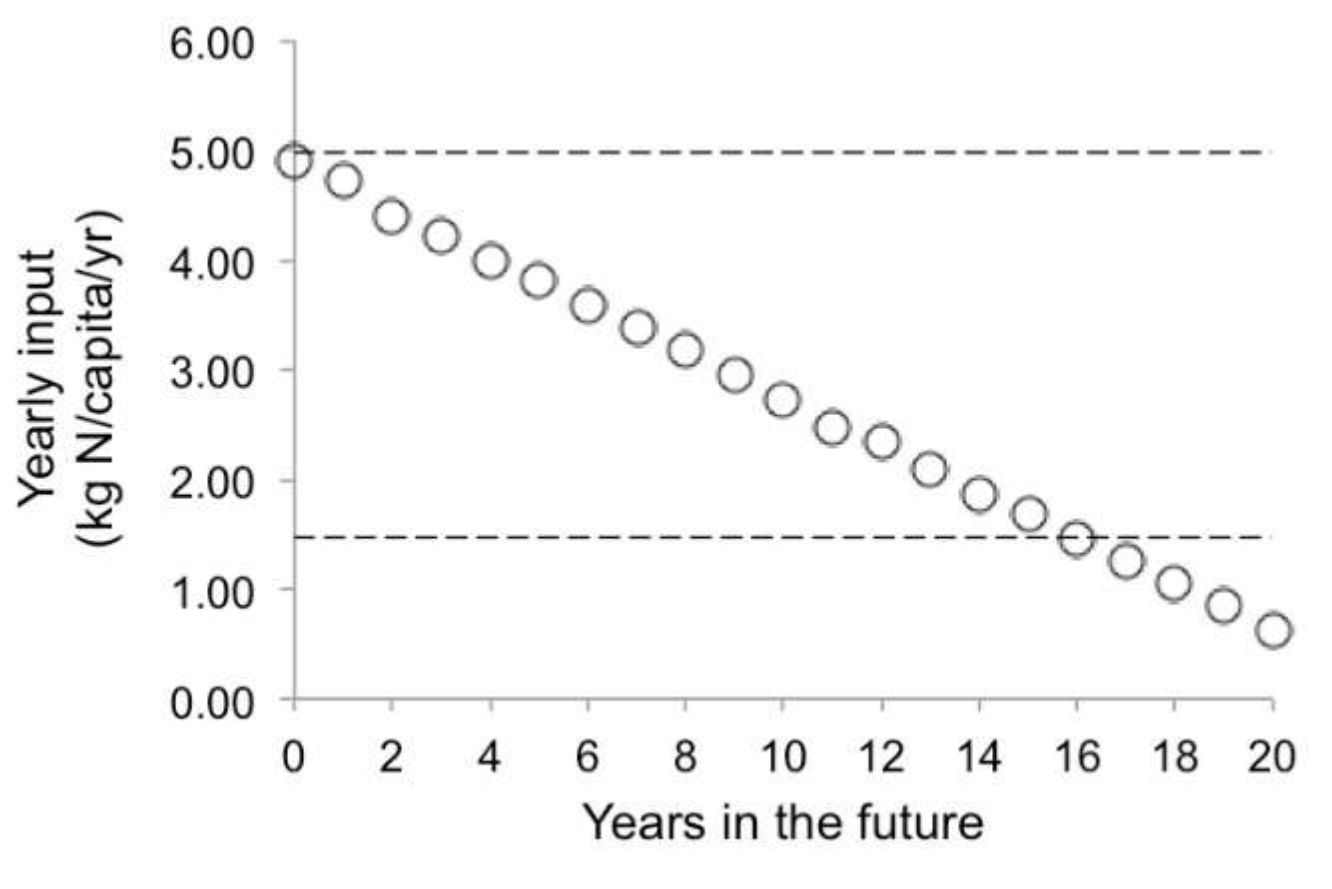
But things could be better…

- Field's Point WWTP:
  - Pop. = 226,000
- OWTS in GNBW:
  - Pop. = 267,618
- 5-fold difference in per capita N inputs

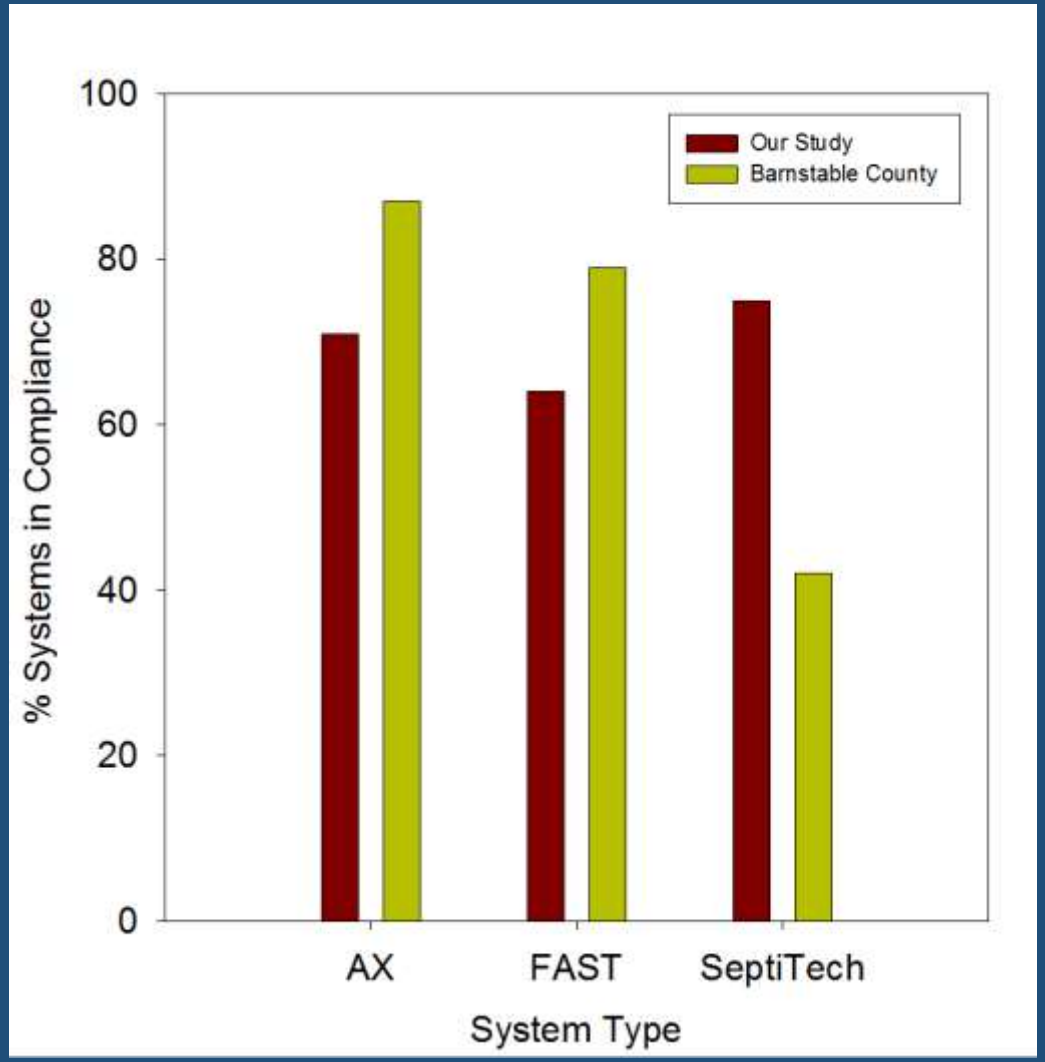


*Ignores N removal in soil, ground water, landscape

We could change distribution of OWTS…



We could require recursive monitoring…



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Monitoring Tools

Lancellotti, B. V., R. J. Bercaw, G. W. Loomis, K. P. Hoyt, E. J. Avizinis, and J. A. Amador. 2016. **Accuracy of rapid tests used for analysis of advanced onsite wastewater treatment system effluent.** *Water, Air and Soil Pollution* 227:310.

Ross, B. N., G. W. Loomis, K. P. Hoyt, and J. A. Amador. 2018. **User-based photometer analysis of effluent from advanced nitrogen-removal onsite wastewater treatment systems.** *Water, Air and Soil Pollution* 229:389.

Evaluation of Rapid Field Tests

Rapid Field Tests

?

Standard Laboratory Methods

Rapid Field Test Methods (outdoors)

Alkalinity

Nitrate

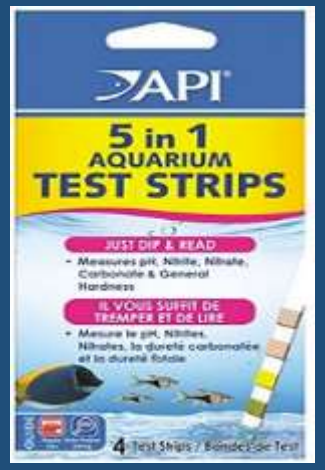
Ammonium

pH

Dissolved Oxygen

pH ✓

Alternative Rapid Field Test Methods (outdoors)



pH ✓

Nitrite ✗

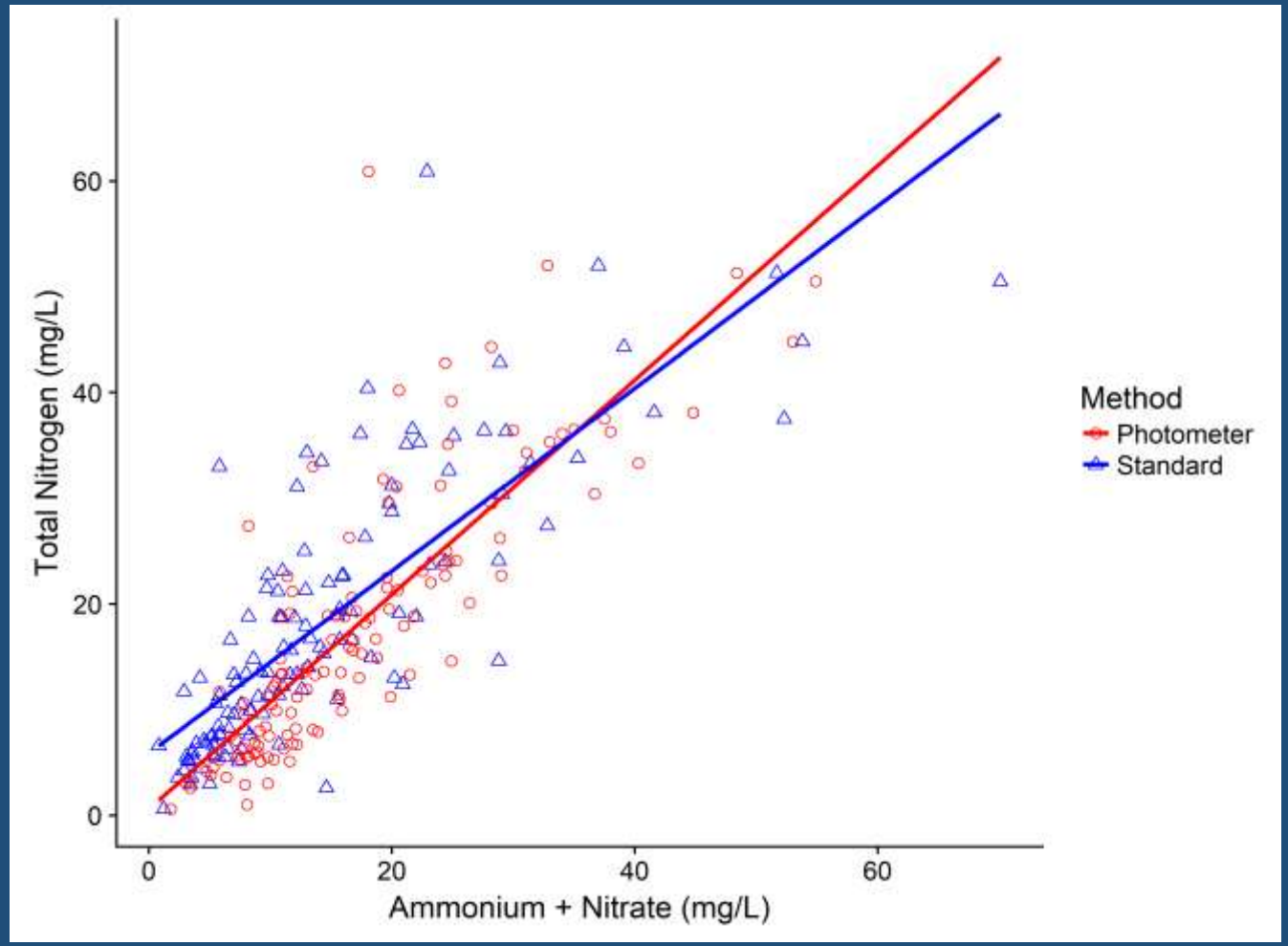
Alkalinity ✗

Ammonium ✓

Ammonium & Nitrate ✓

Enter the Field Photometer!

Can be used to estimate TN from ammonium and nitrate



Conclusions

- How does performance of advanced N-removal OWTS vary?
  - Compliance is good (50% - 65%)
  - Can be better (Barnstable County, MA)
- How much N do OWTS contribute to the watershed & what can we do about it?
  - 1.2 million kg N per year
  - Advanced OWTS make a difference to N inputs
    - But per capita N inputs for OWTS 5X for WTP
    - Gradual replacement
    - Monitor to improve performance
    - Combination
- How can we monitor N in effluent to improve performance?
  - May be able to monitor effluent total N inexpensively with photometer