Sand –Sawdust Layer Cakes

The hope of a passive onsite denitrification system

epi log

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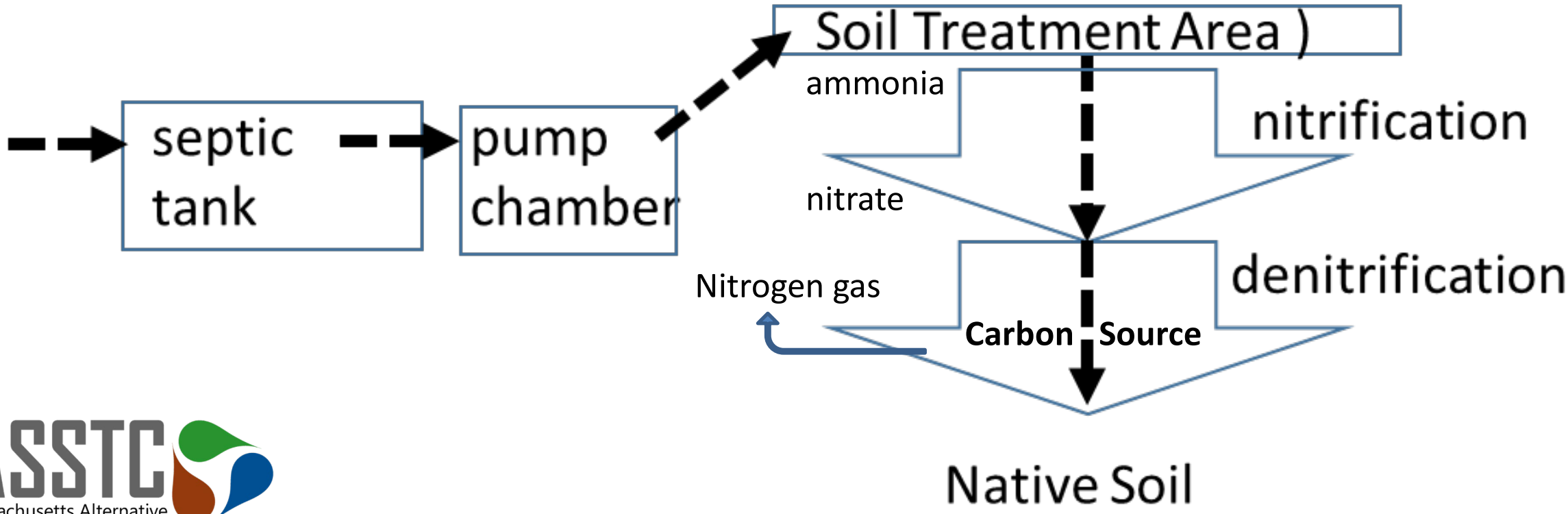
MASSTC

The Massachusetts Alternative Septic System Test Center

So, What is a layer cake?

Besides a sugary treat you don’t give your grandkids before you send them to bed?

Layer cake is the nickname for a layered soil absorption system which we (MASSTC) have been experimenting with to investigate the possibility of passively removing nitrogen from wastewater as it passes through successive layers of material on its way to the groundwater.



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So, What is a layer cake?

The metaphor that stuck

Other names for the layer cake

- Nitrogen Reducing Barriers (NRB)
- Wood-based bioreactors
- Sand-sawdust layered systems
- “Those things George is always talking about”

Design 1

- Easiest to install
- Overall 75%+ removal
- Uncertain media life

Design 2

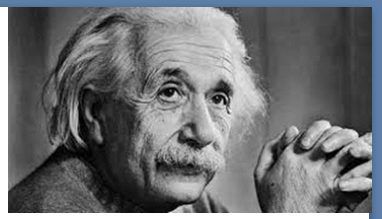
- Liner required
- Overall 75%+ removal
- Final disposal required
- More certain media life

1 of 3

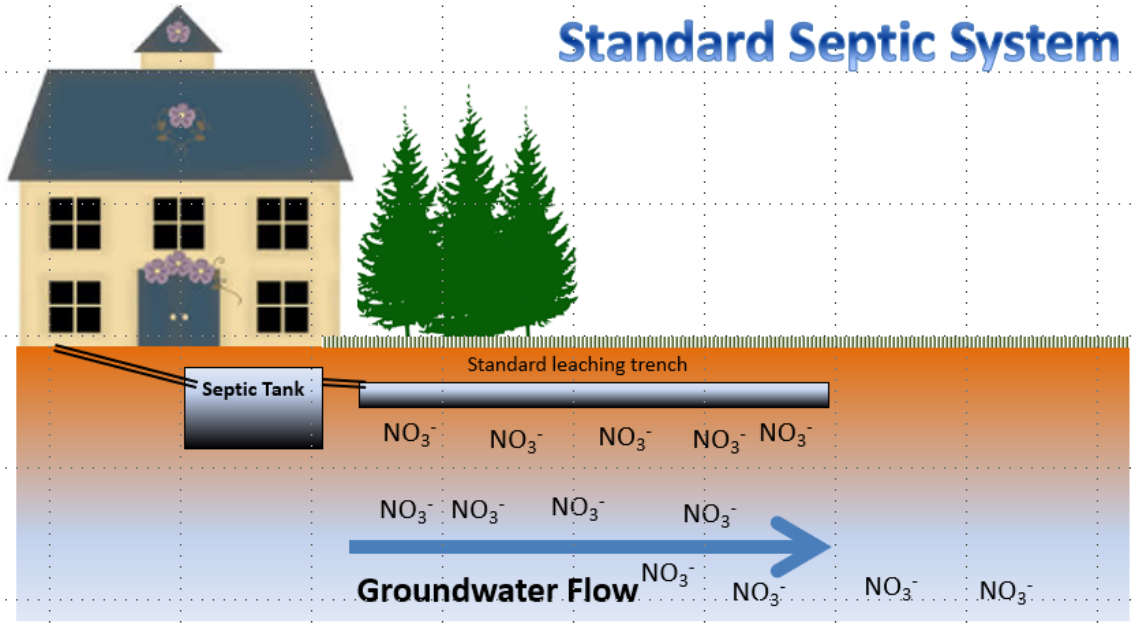
Design 3

- Overall 85-90% removal
- Final disposal required
- More certain media life
- Easy access for media replacement

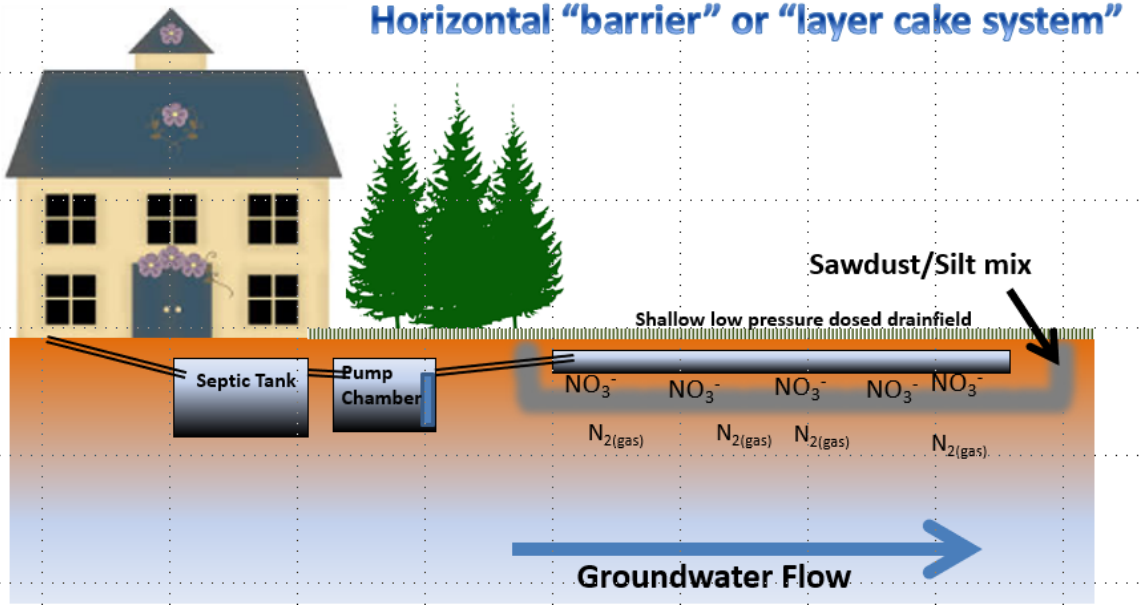
THE HOPE WAS SIMPLICITY

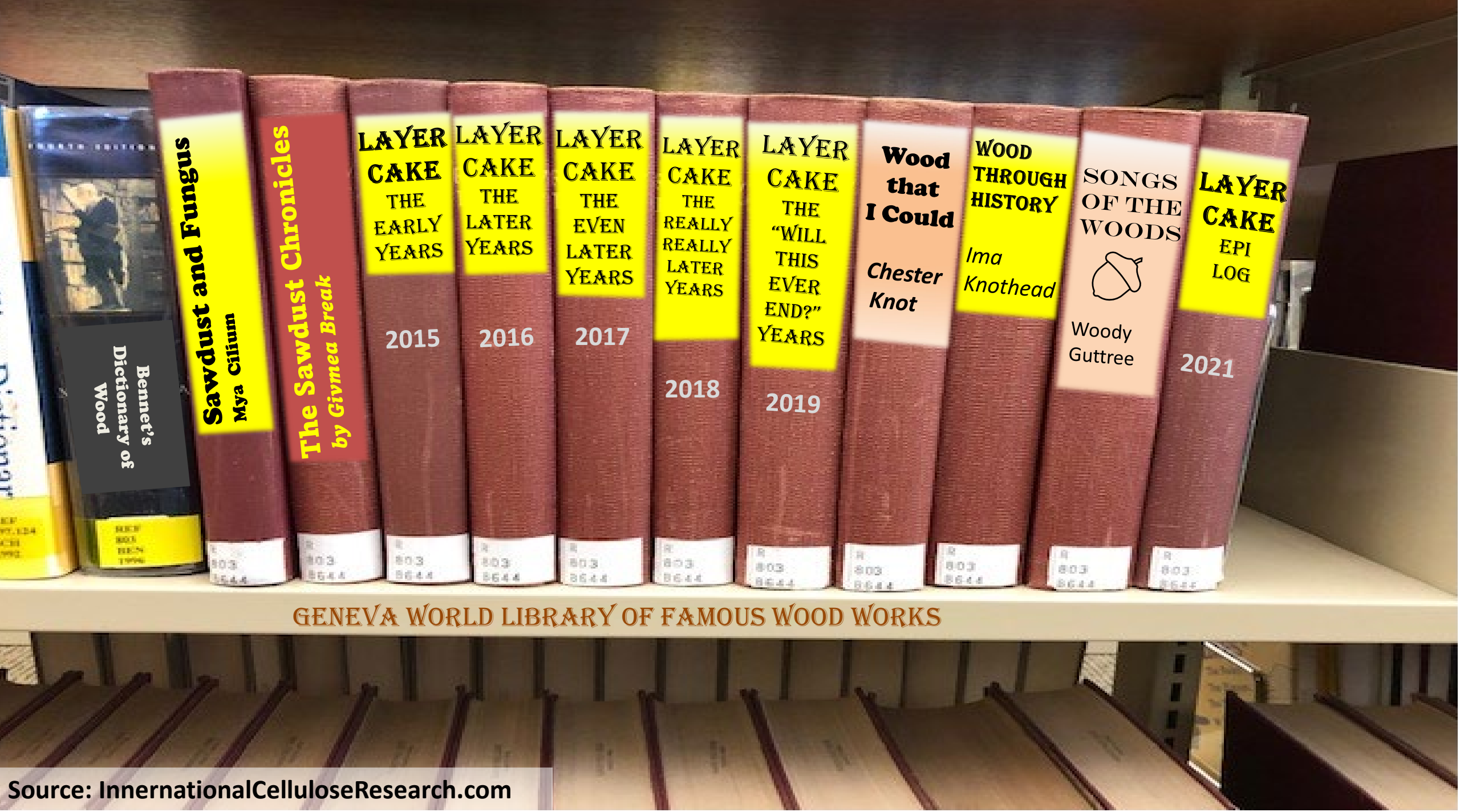


Standard Septic System



Horizontal "barrier" or "layer cake system"





Source: InnernationalCelluloseResearch.com

Storyline

Early success

Questions arise

Real world experience

More questions

Some answers

More questions

Some answers

More questions

Some answers

More questions

Some answers

More questions

Conclusions

Storyline

Early success

Questions arise

2014-2017

Real world experience

2017-2019

More questions

Some answers

More questions

2019-2021

Some answers

More questions

2021-20??

Some answers

More questions

Some answers

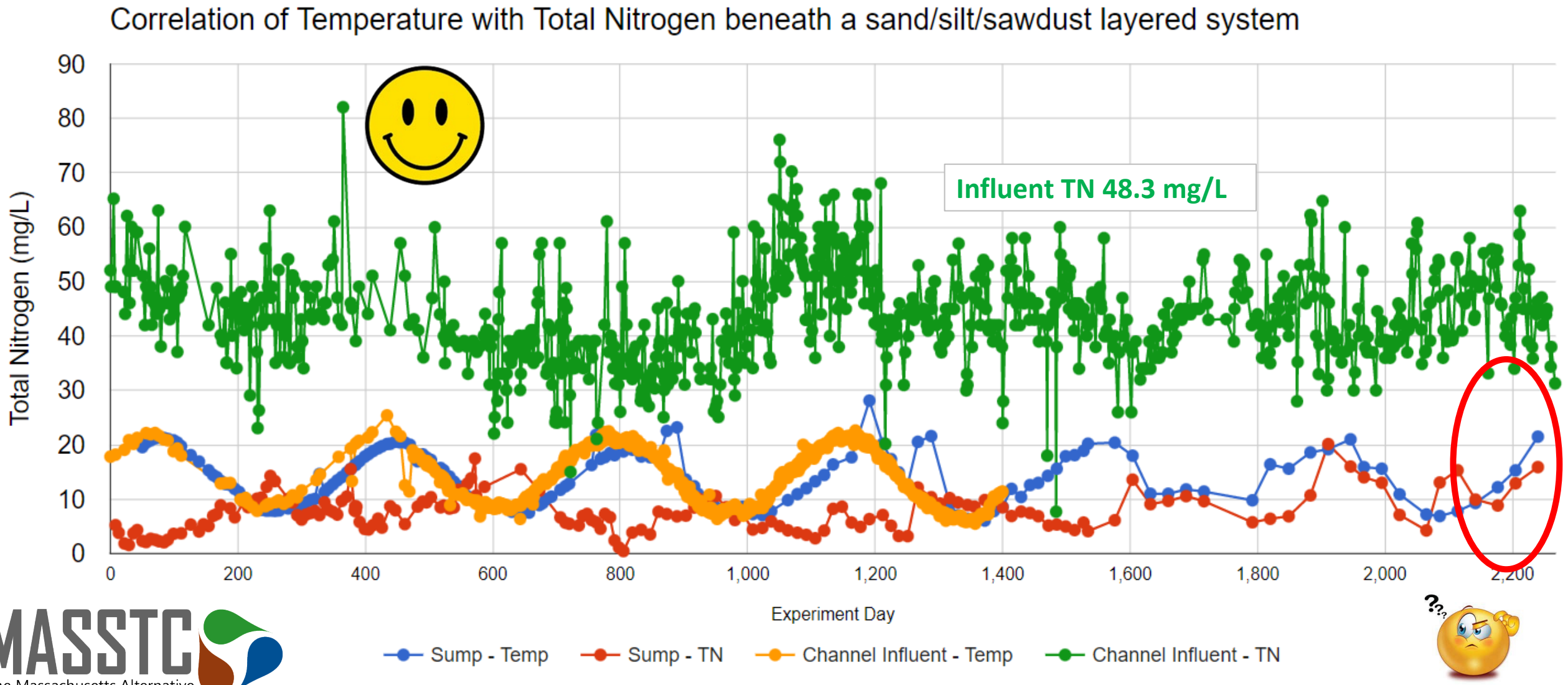
More questions

Conclusions

Early Success

Early Success

6.1 YEARS TN 7.6 mg/L (7.1 – 8.1 mg/L, *p= .05*)



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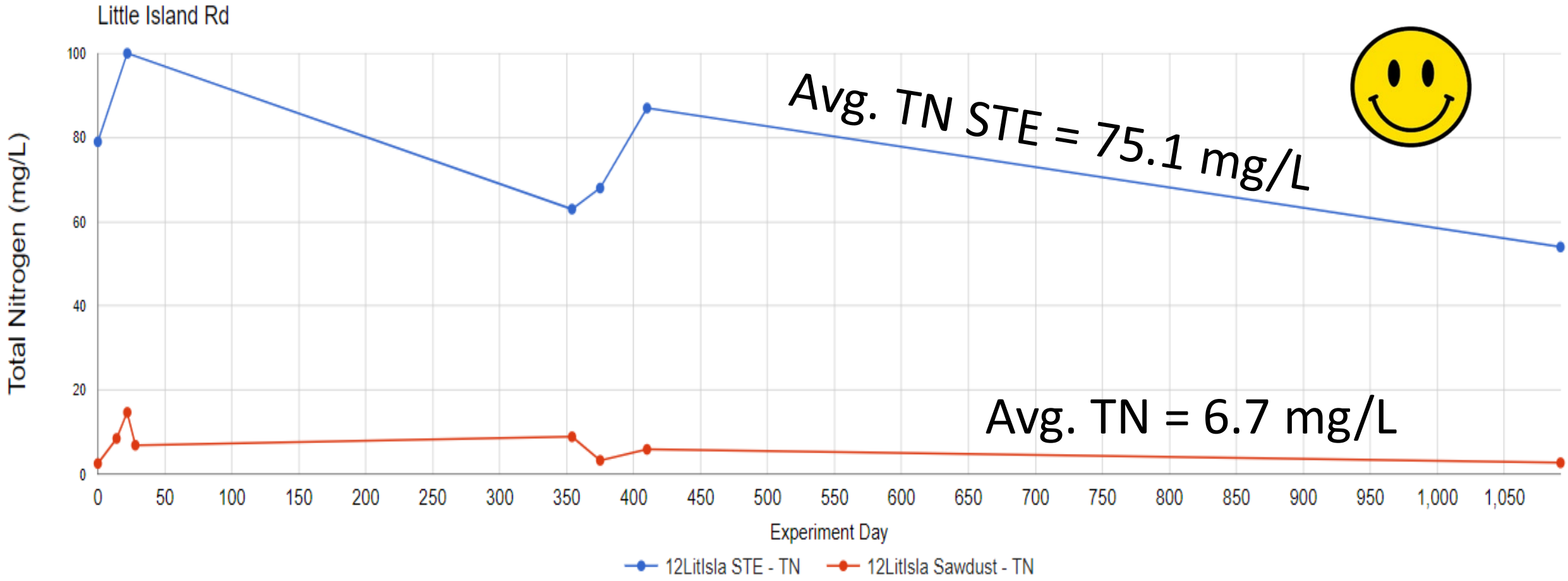
First residential installation

Intermittent and seasonal use

3 Years - 91% TN removal



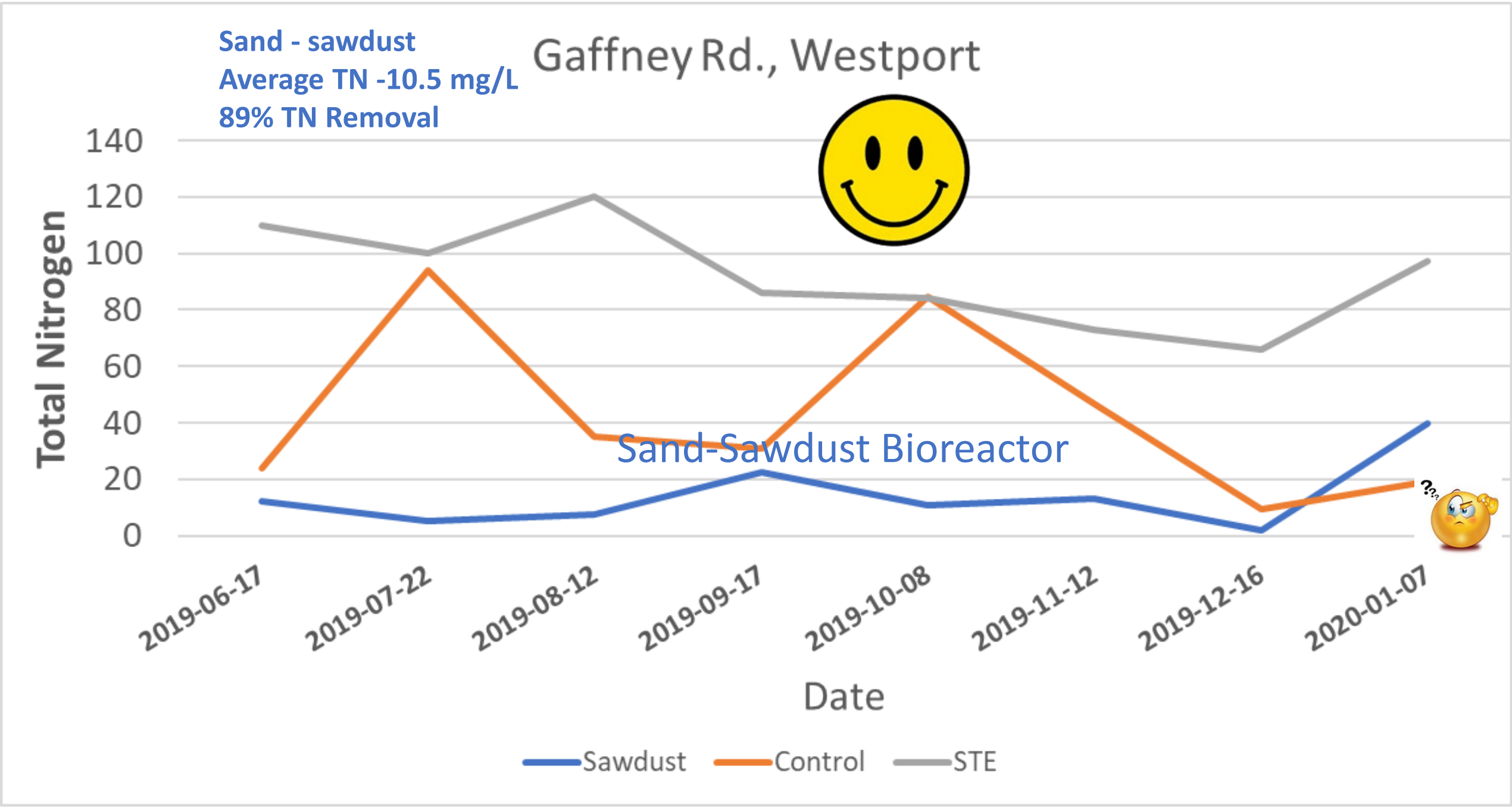
Real World Experience

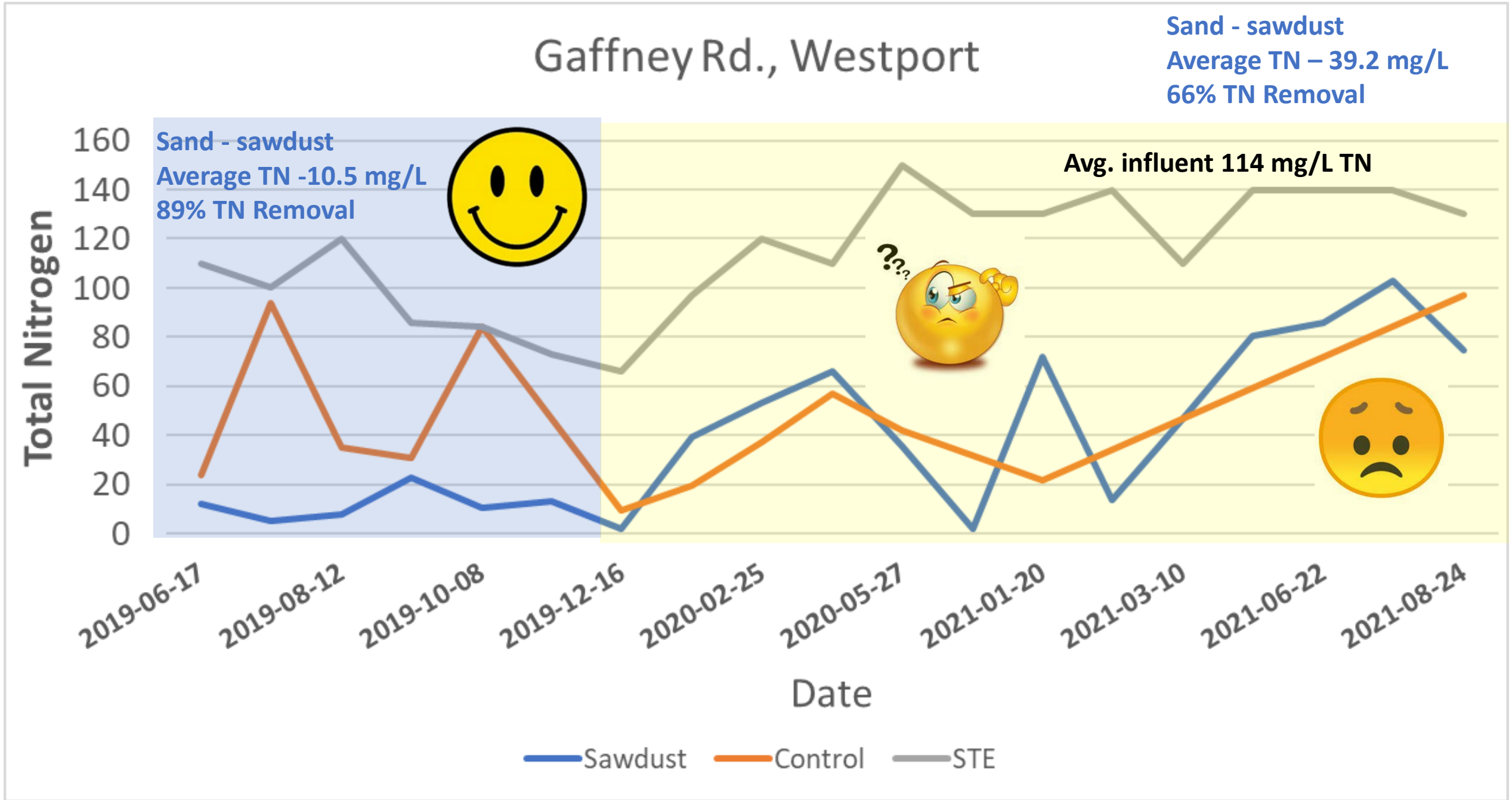
Three characteristic cases that shape

the true picture

Case #1

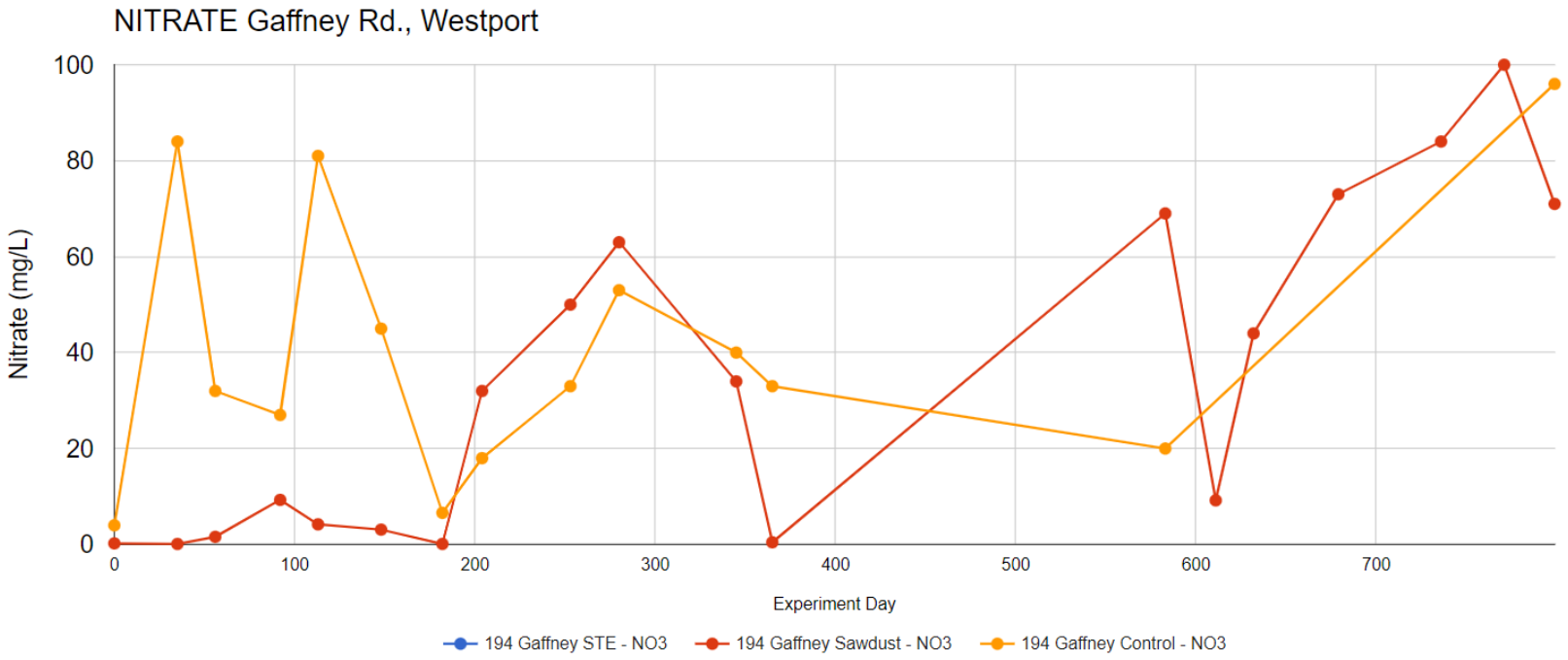
Two adults
Year Round
Somewhat intermittent use


Sand - sawdust
Average TN -10.5 mg/L
89% TN Removal
Gaffney Rd., Westport
Total Nitrogen
140
120
100
80
60
40
20
0
Sand-Sawdust Bioreactor
2019-06-17
2019-07-22
2019-08-12
2019-09-17
2019-10-08
2019-11-12
2019-12-16
2020-01-07
Date
Sawdust
Control
STE


Gaffney Rd., Westport
Sand - sawdust
Average TN – 39.2 mg/L
66% TN Removal
Sand - sawdust
Average TN -10.5 mg/L
89% TN Removal
Avg. influent 114 mg/L TN
Total Nitrogen
160
140
120
100
80
60
40
20
0
2019-06-17
2019-08-12
2019-10-08
2019-12-16
2020-02-25
2020-05-27
2021-01-20
2021-03-10
2021-06-22
2021-08-24
Date
Sawdust
Control
STE

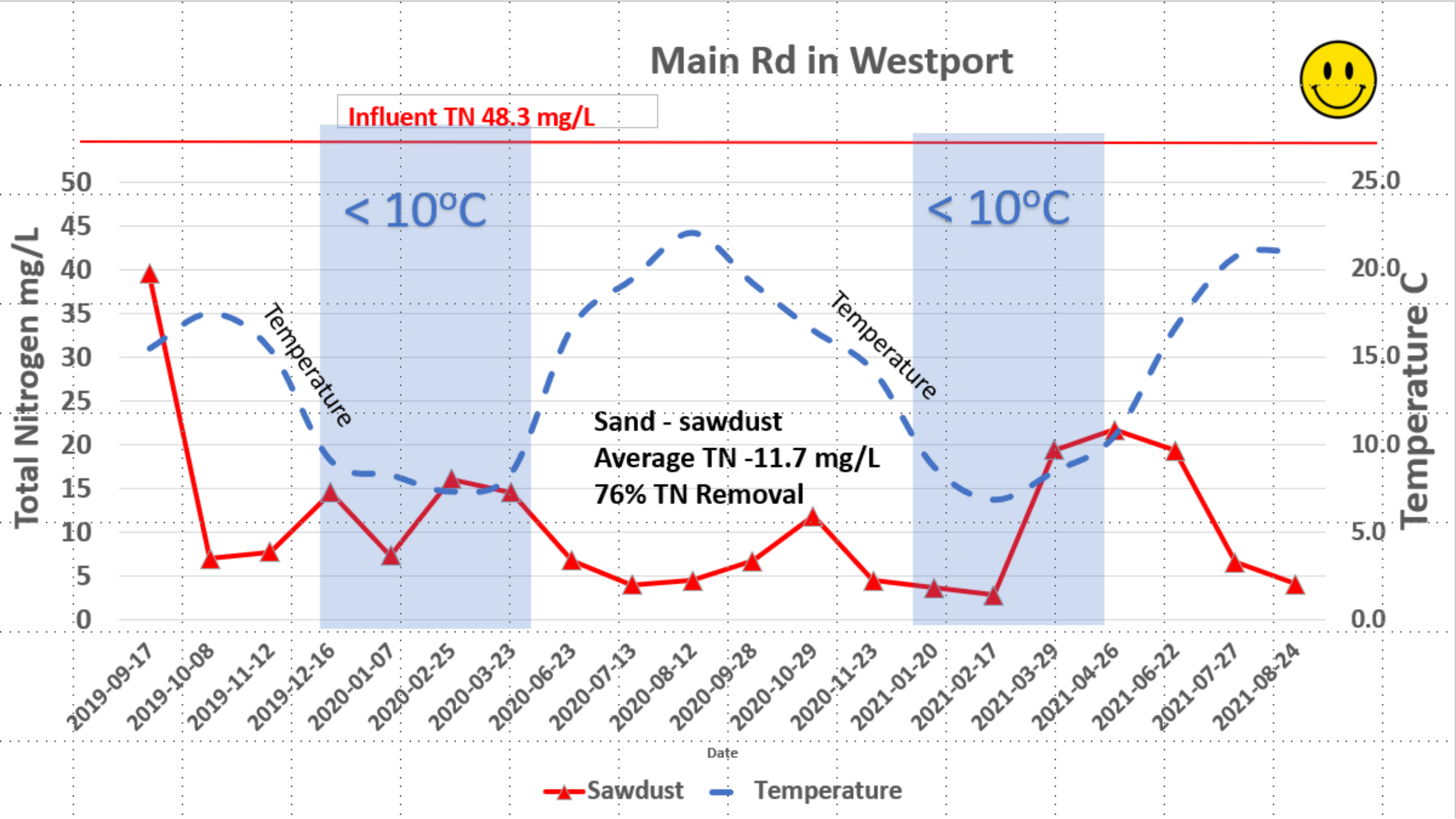
Case #1 Findings and Conclusions

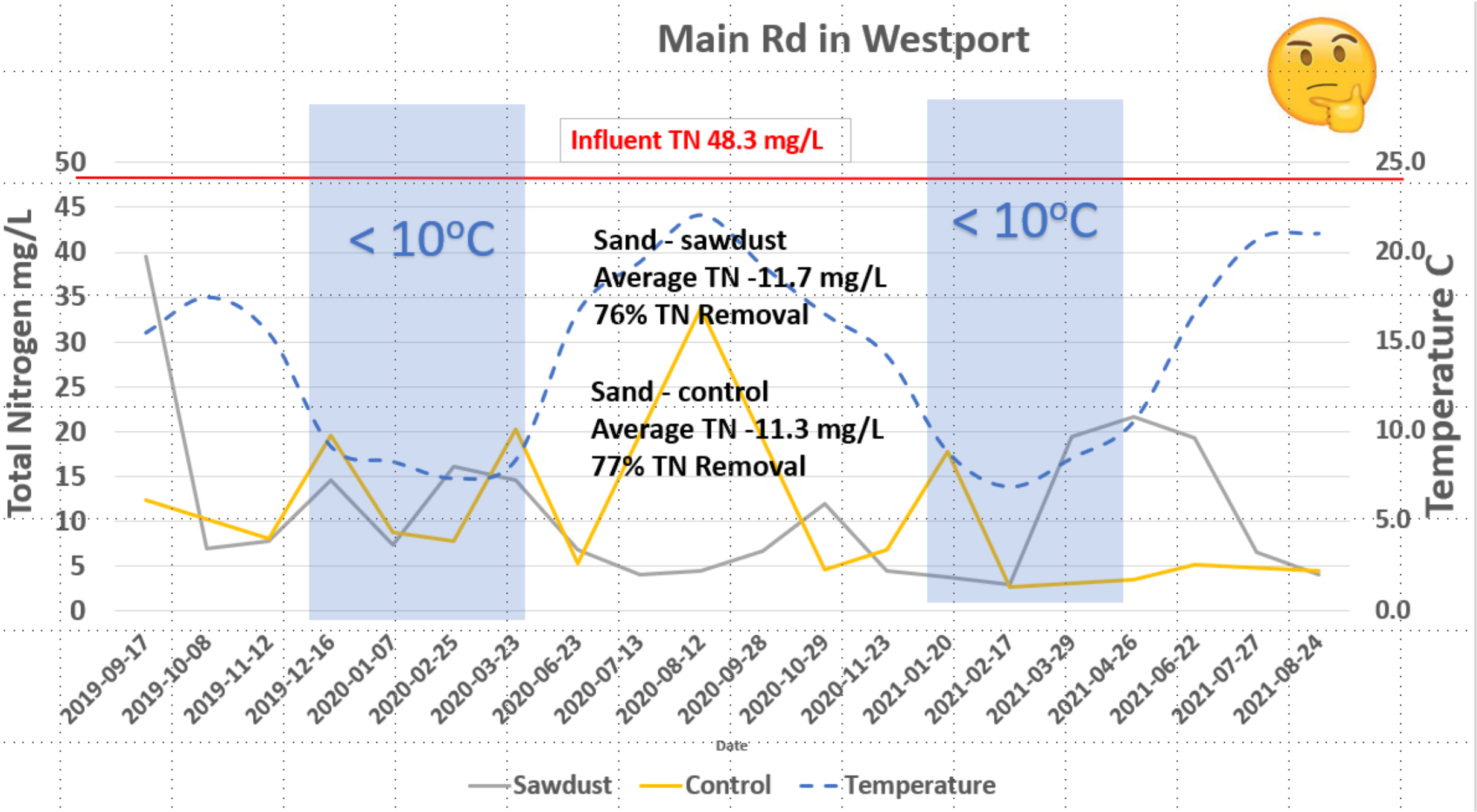
- Although intermittently, the control with no sawdust performed as well as the sand/sawdust area. What's that all about?
- The extreme high nitrogen in the influent (average 114 mg/L) may have been a factor in the performance (although it still achieved a 66% TN removal).
- Great finding *** despite high influent nitrogen, nitrification is nearly complete, so the "problem" is in the denitrification stage when it occurs.



Case #2

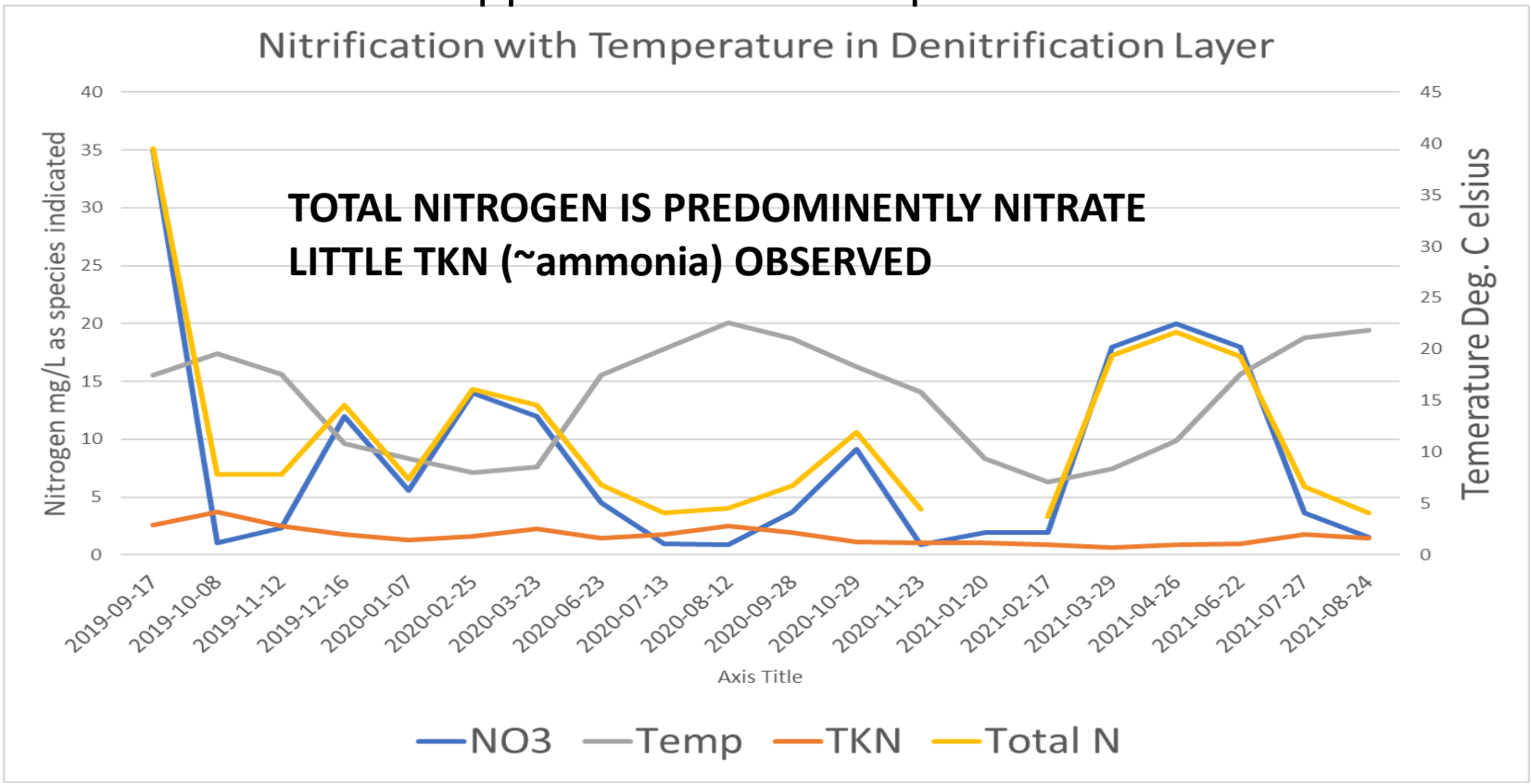
Two adults
Year Round
Some intermittent use


Main Rd in Westport
Influent TN 48.3 mg/L
< 10°C
< 10°C
Temperature
Temperature
Sand - sawdust
Average TN -11.7 mg/L
76% TN Removal
Total Nitrogen mg/L
Temperature C
50
45
40
35
30
25
20
15
10
5
0
25.0
20.0
15.0
10.0
5.0
0.0
2019-09-17
2019-10-08
2019-11-12
2019-12-16
2020-01-07
2020-02-25
2020-03-23
2020-06-23
2020-07-13
2020-08-12
2020-09-28
2020-10-29
2020-11-23
2021-01-20
2021-02-17
2021-03-29
2021-04-26
2021-06-22
2021-07-27
2021-08-24
Date
Sawdust
Temperature


Main Rd in Westport
Influent TN 48.3 mg/L
< 10°C
< 10°C
Sand - sawdust
Average TN -11.7 mg/L
76% TN Removal
Sand - control
Average TN -11.3 mg/L
77% TN Removal
Total Nitrogen mg/L
Temperature C
Date
Sawdust
Control
Temperature

Case #2 Findings and Conclusions

- Although intermittently, the control with no sawdust performed as well as the sand/sawdust area, particularly in colder weather. What's that all about?
- The temperature dependency of denitrification appears re-confirmed with highest levels of nitrogen at temperatures < 10°C.
- Nitrification appears not to be impacted.




Case #3
December, 2020
DEERE
DEERE
The “layer cake” comes to Eastham

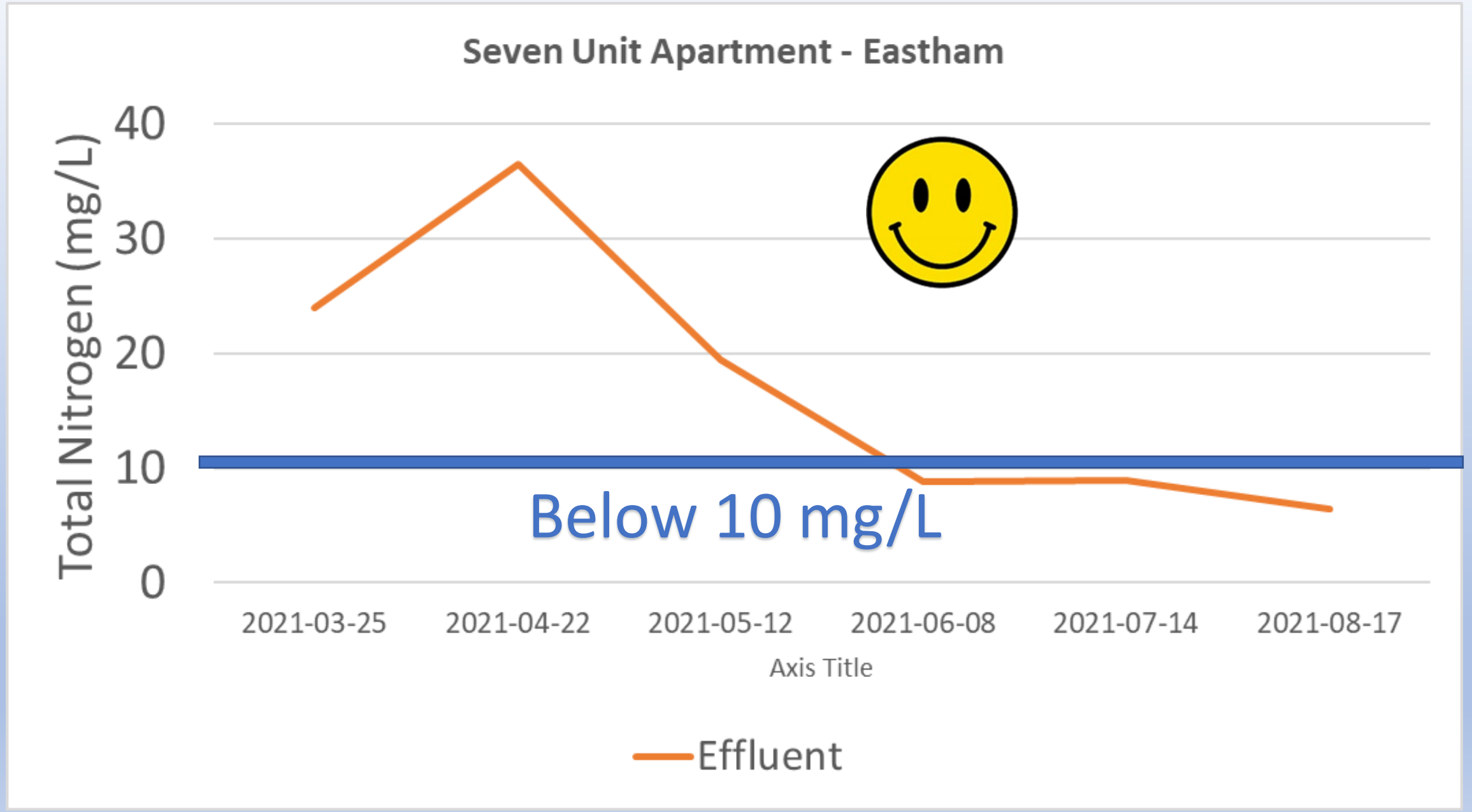
Case #3

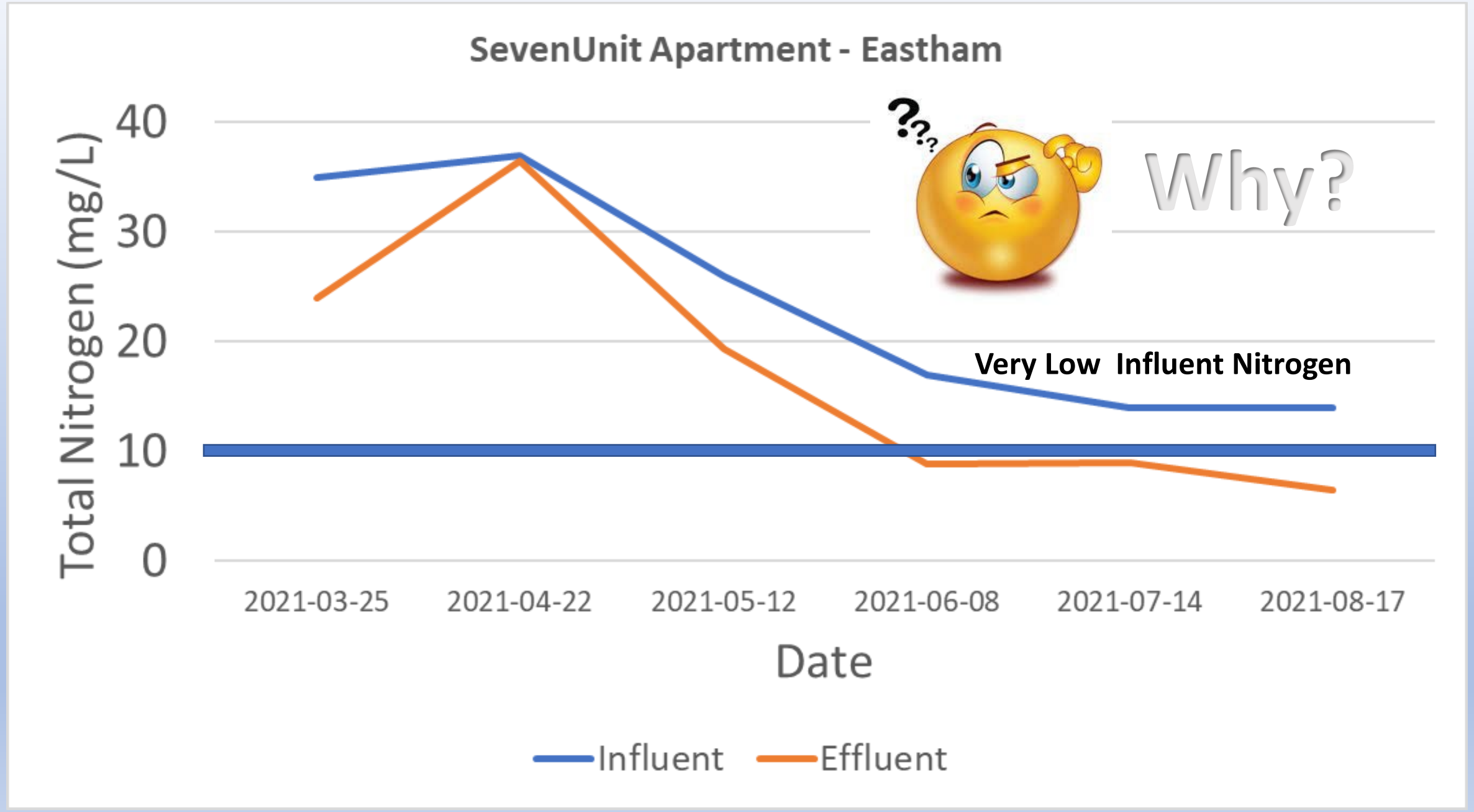
Seven apartment structure

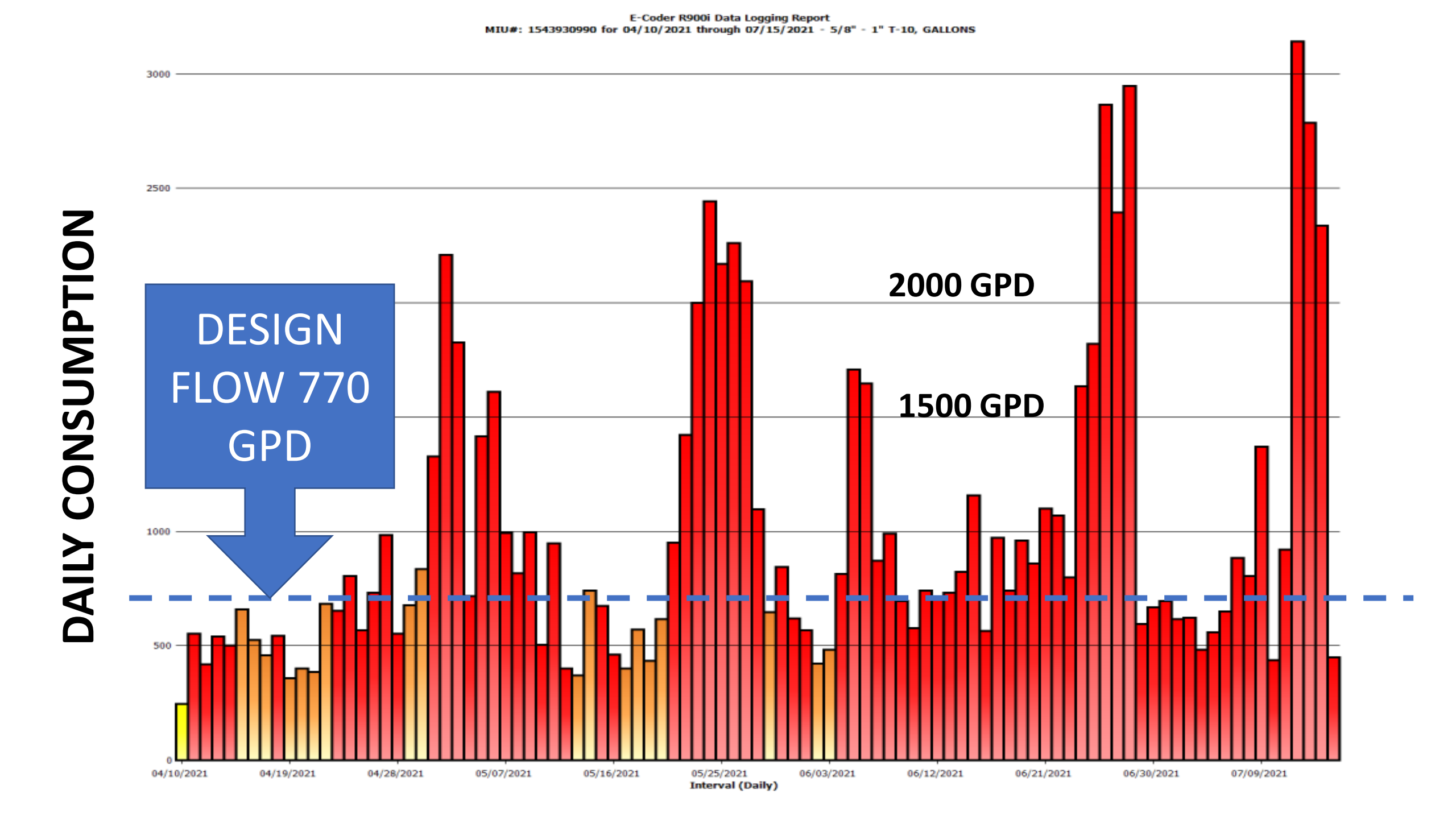
7-10 adults ?

Year Round

Some seasonal changes in occupancy

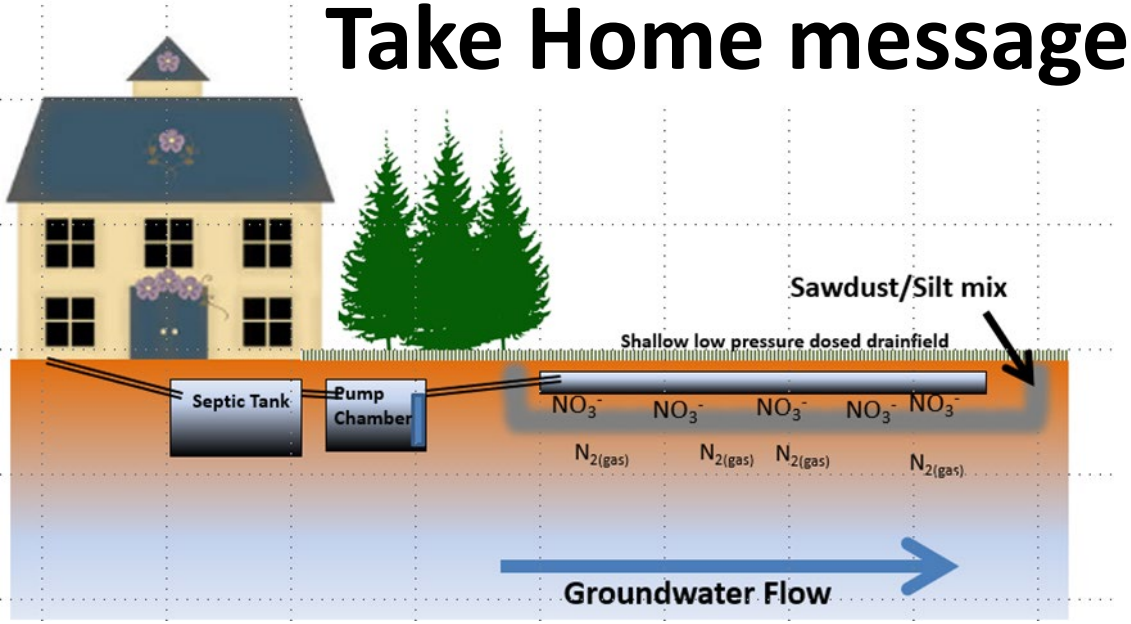

Seven Unit Apartment - Eastham
Total Nitrogen (mg/L)
40
30
20
10
0
Below 10 mg/L
2021-03-25
2021-04-22
2021-05-12
2021-06-08
2021-07-14
2021-08-17
Axis Title
Effluent


SevenUnit Apartment - Eastham
Total Nitrogen (mg/L)
40
30
20
10
0
2021-03-25
2021-04-22
2021-05-12
2021-06-08
2021-07-14
2021-08-17
Date
Influent
Effluent
Why?
Very Low Influent Nitrogen


E-Coder R900i Data Logging Report
MIU#: 1543930990 for 04/10/2021 through 07/15/2021 - 5/8" - 1" T-10, GALLONS
DAILY CONSUMPTION
DESIGN FLOW 770 GPD
2000 GPD
1500 GPD
3000
2500
1000
500
0
04/10/2021
04/19/2021
04/28/2021
05/07/2021
05/16/2021
05/25/2021
06/03/2021
06/12/2021
06/21/2021
06/30/2021
07/09/2021
Interval (Daily)


Where is all this leading?

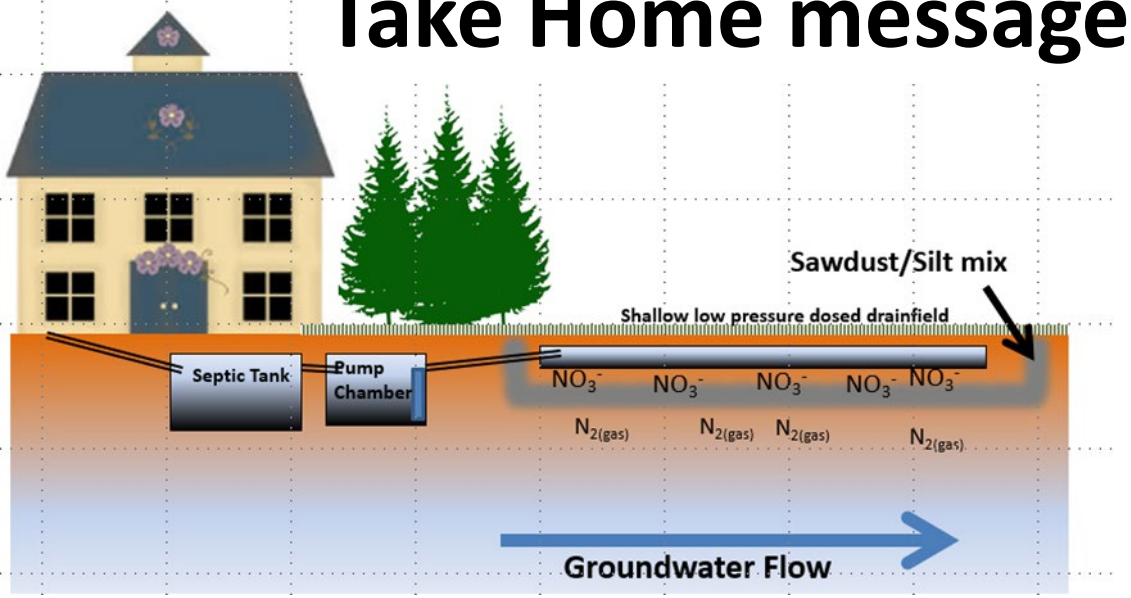
Take Home messages after six years



- Residences are extremely variable in use patterns and total nitrogen (TN) influent levels. Generally, TN levels exceed 60 mg/L which agrees with published literature.

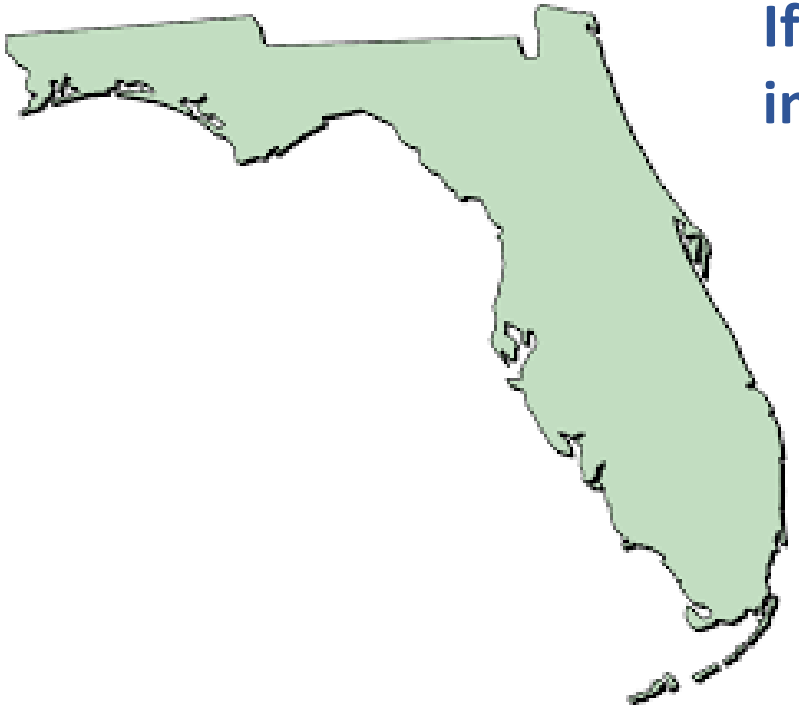
- Generally, layer cake systems provide > 50% removal on average, working better in warmer weather and achieving >75% TN removal during those warmer periods.
- There is a lag period following the onset of warmer weather before denitrification resumes.

Take Home messages after six years



- The life expectancy of the wood blend used in the denitrification layer is still unknown, however where it appears to be waning, systems do not appear to be affected in their hydraulic performance.

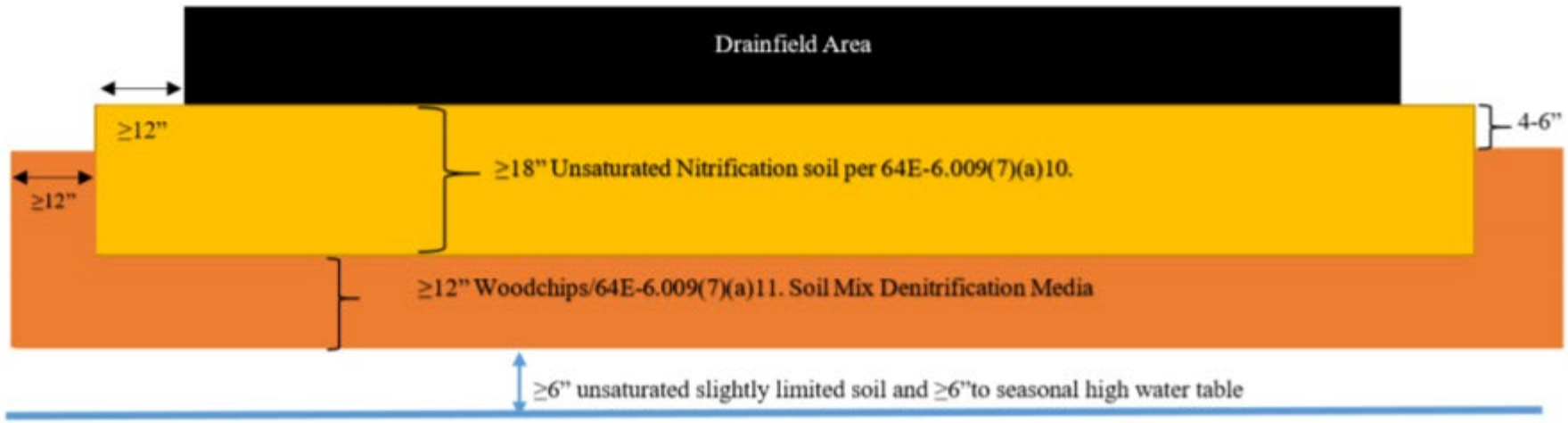
- The distribution of septic tank effluent in the shallow soil horizon alone appears to enhance nitrogen removal (sometimes in colder months).
- Results from over eight installations does not allow the assignment of nitrogen concentration that can be consistently achieved.



If you're in Florida, there is probably little impact by temperature ☺

Source: STATE OF FLORIDA DEPARTMENT OF HEALTH CHAPTER 64E-6, FLORIDA ADMINISTRATIVE CODE - STANDARDS FOR ONSITE SEWAGE TREATMENT AND DISPOSAL SYSTEMS.

Allowed




Where do
We go from here?

Remembering our goal

To examine all elements of successful non-proprietary onsite denitrification projects and determine how to adjust the design features to work in our particular climatological and geological setting.

To determine whether the principles used in these projects will allow a design that is economical and feasible to install in coastal settings.

Although the simple layer cake held the promise of simplicity, it does not appear to be robust enough in northern climates enough to perform through colder weather or to resume peak performance as warm weather returns.

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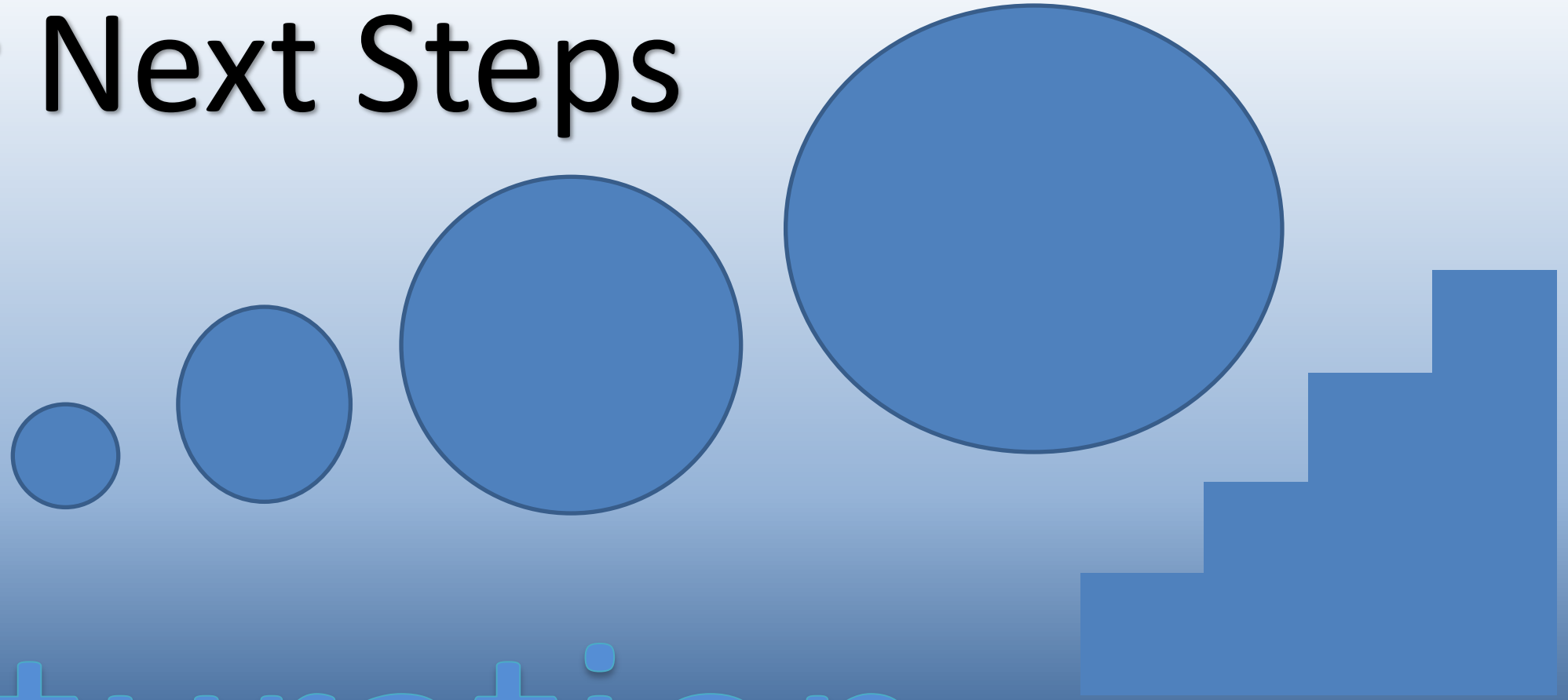
Our Next Steps



Saturation

The saturated layer cake

Why saturated ?

- **Less controversy on longevity of wood due to occlusion of oxygen.**
- **Less immediate impact by temperature.**
- **Immediate sampling point for verification of performance.**

Design 1

- Easiest to install
- Overall 75%+ removal
- Uncertain media life

Design 2

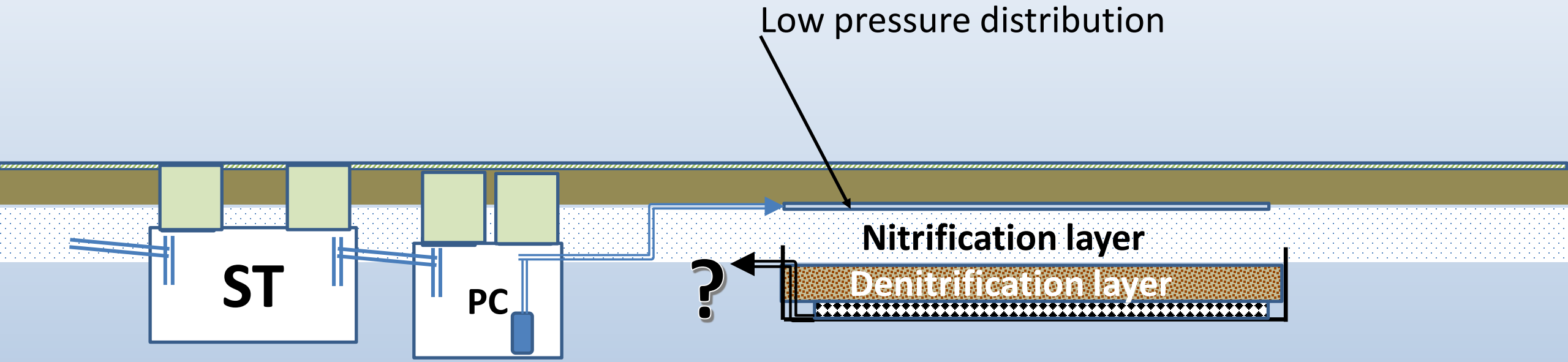
- Liner required
- Overall 75%+ removal
- Final disposal required
- More certain media life

1 of 3

Design 3

- Overall 85-90% removal
- Final disposal required
- More certain media life
- Easy access for media replacement

Lined layer cakes - saturated



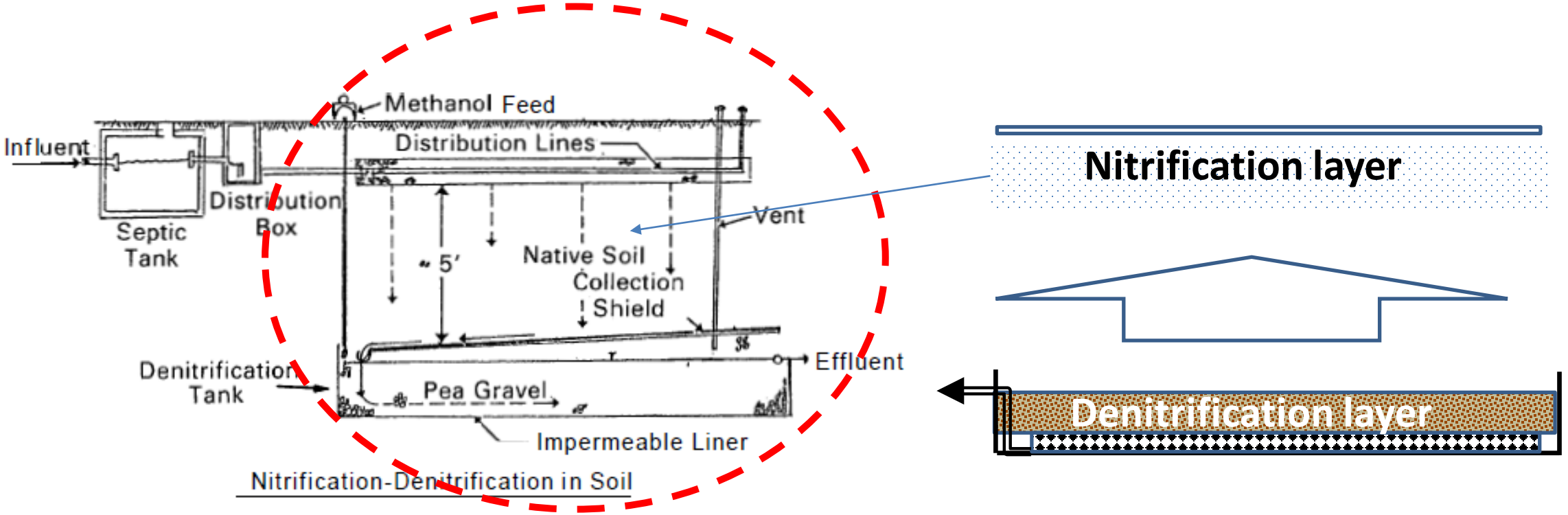
Final Disposal options limited in Massachusetts to standard soil treatment areas (perhaps reduced).

A Blast from the Past

1980

EPA features a profile system that interrupts nitrified percolate and supplies carbon for denitrification

Source: EPA 1980 ONSITE WASTEWATER TREATMENT AND DISPOSAL DESIGN MANUAL



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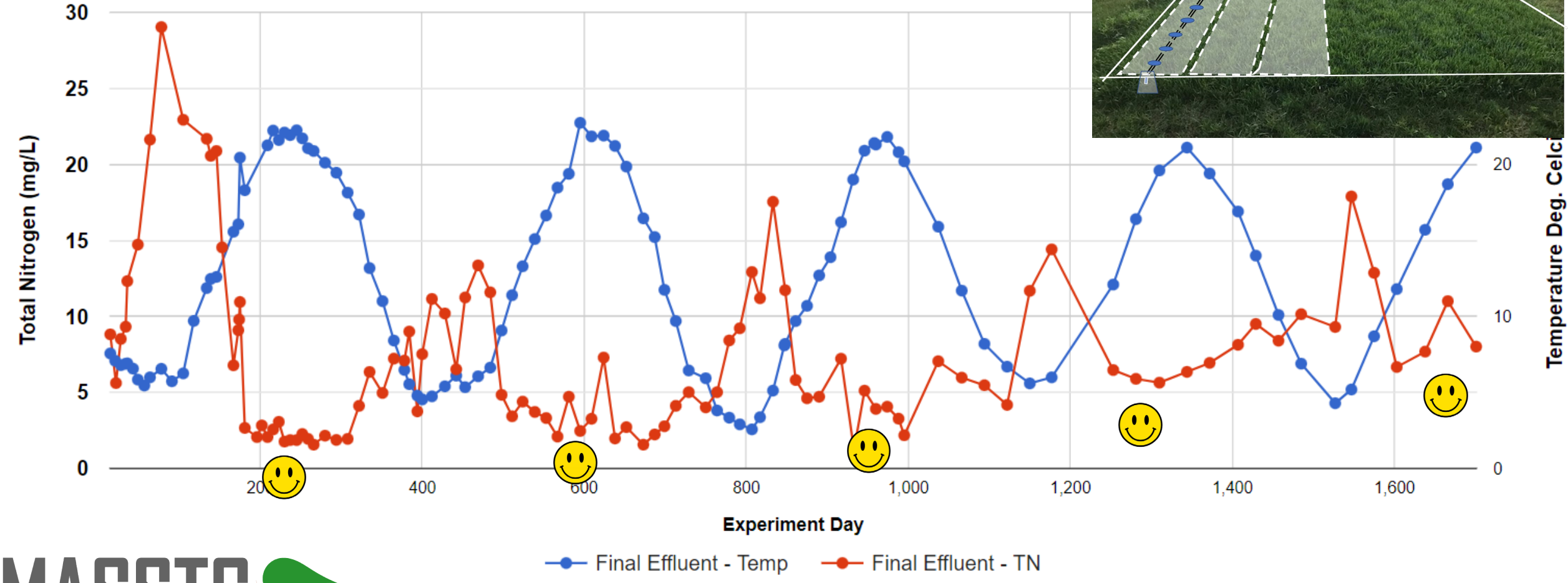
For the past five years MASSTC has been testing the saturated system design in parallel with simple layer cakes

SATURATED SYSTEM



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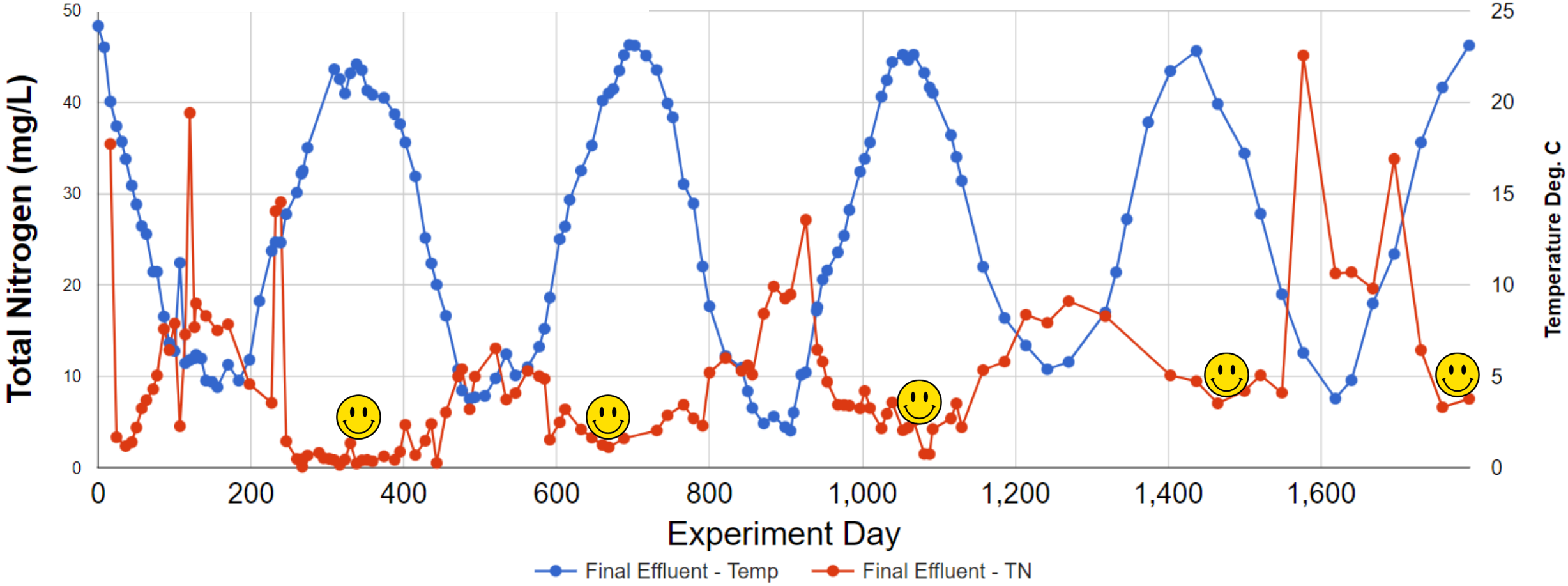
Average TN = 7.5 mg/L

SATURATED SYSTEM



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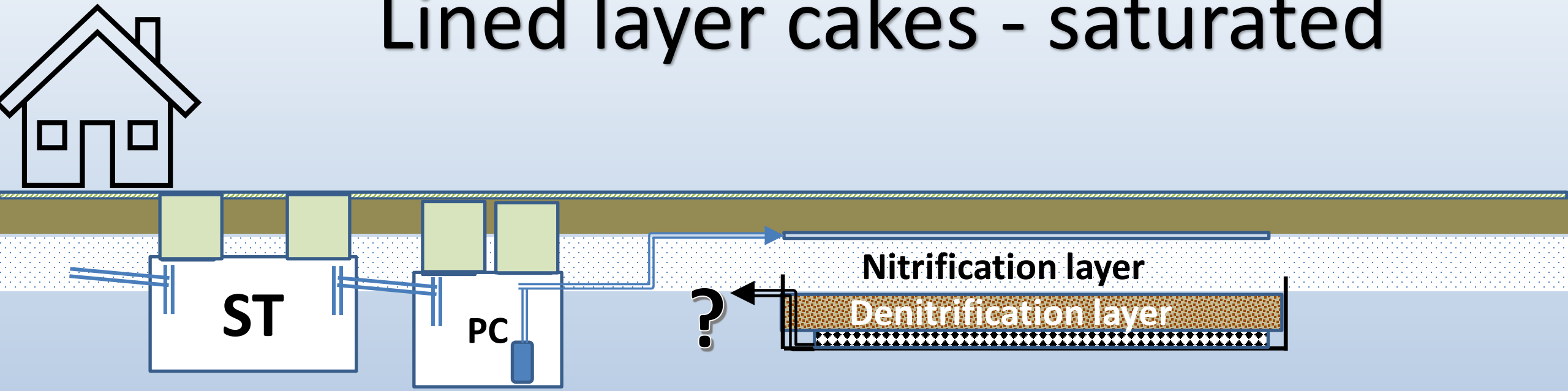
Average TN = 8.8 mg/L

Lined layer cakes - saturated



Although more complicated to install, the saturated system appears to offer a robust design that can be adapted to our climatological conditions and achieve average TN reductions of 80 %.

Questions?

Lawn atop saturated system since January 1, 2016