Design of a Treatment Process for High Nitrate Industrial Waste

Jeanette Brown, PE, BCEE, D.WRE, Dist.M. ASCE, F.WEF
David Vaccari, PhD, PE, BCEE, F.ASCE
Stevens Institute of Technology

PRESENTATION CONTENT

- Introduction
- Treatment Concept
- BioWin simulations
- Proposed design
- Next steps

SOURCES OF HIGH NITRATE WASTE

- Many industries produce wastewater with a high nitrate-nitrogen concentration, such as,
  - fertilizer,
  - explosives, and
  - stainless-steel manufacturing, and
  - certain food processing operations

CHARACTERISTICS OF HIGH NITRATE WASTE

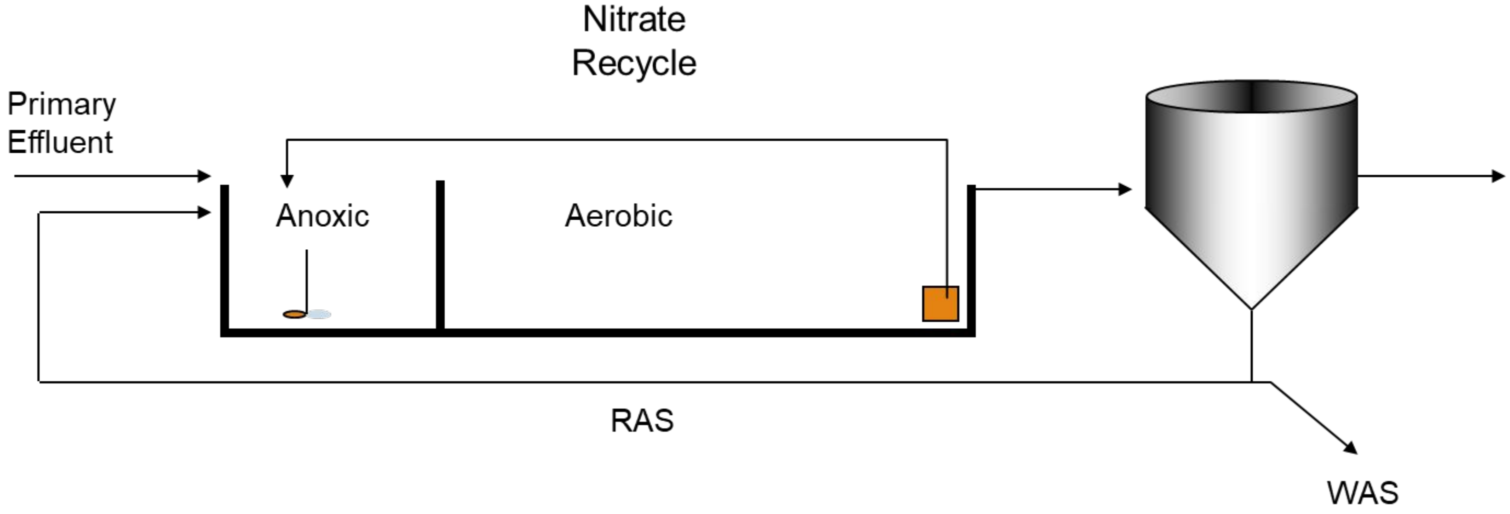
- Depending on the industry
  - Nitrate-nitrogen concentration-200 to >3000 mg/L
  - Anions and cations-chloride, sulfate, calcium, sodium
  - Organics-measured as COD
  - Toxic compounds
- In some cases, wastes discharged directly to water bodies,
  - many now have total maximum loads (TMDL) for nitrogen, so direct disposal is no longer an option

TREATMENT OPTIONS

- High nitrate wastewater can be treated by
  - Ion exchange,
  - membrane filtration, and
  - electrodialysis
- Problems
  - expensive and
  - can result in a secondary waste stream which must be treated
- Possible solution
  - treat the waste at a municipal WRRF

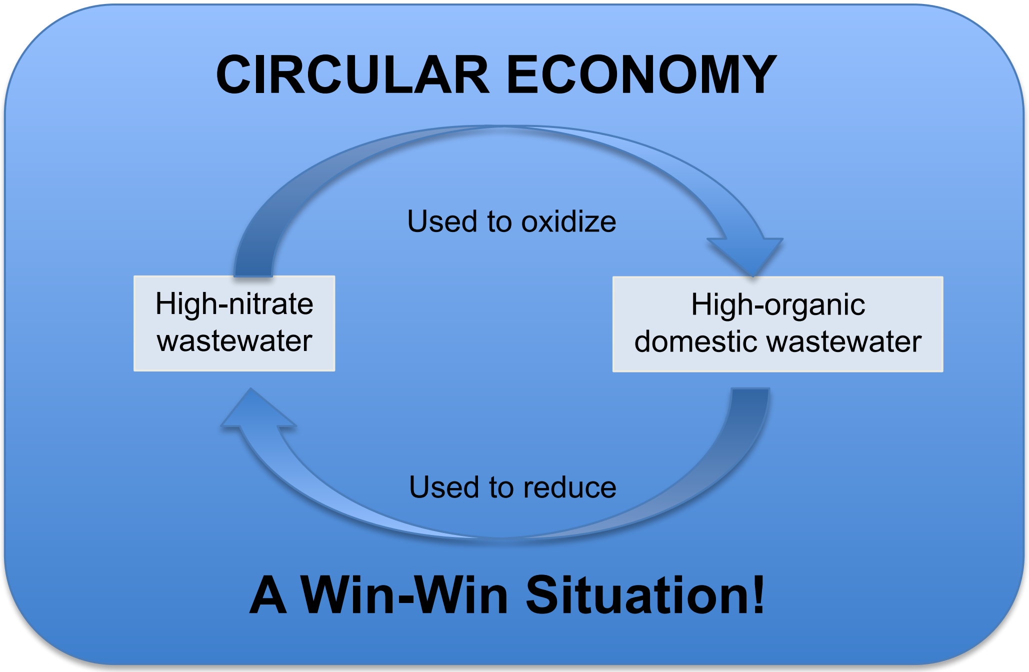
PURPOSE

- To determine if a high nitrate waste could be treated at a municipal WRRF while meeting TN permit requirements



PURPOSE

- To determine if a high nitrate waste could be treated at a municipal WRRF and reduce aeration requirements



STUDY STAGES

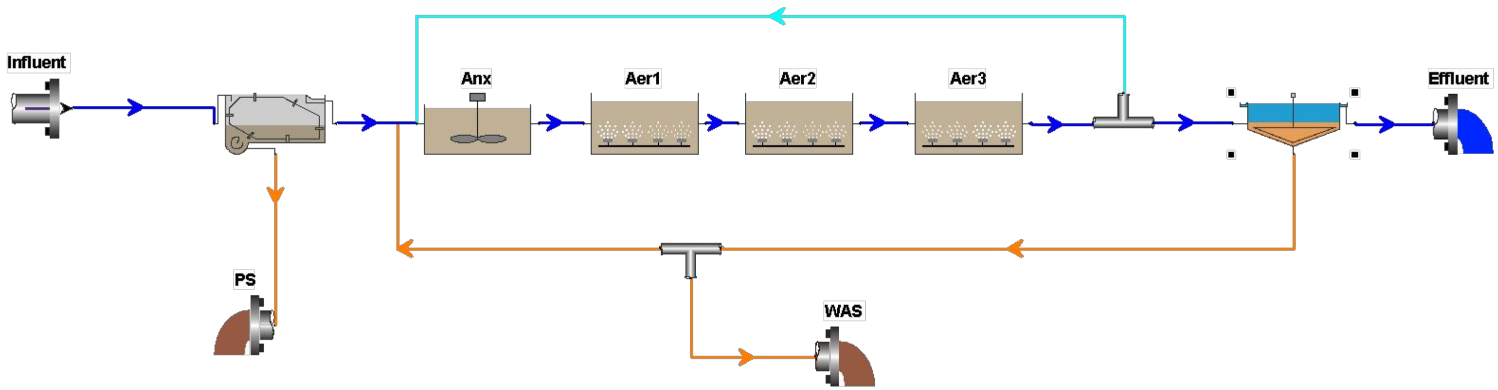
- Initial design using BioWin (this presentation)
- Design optimization using numerical methods
- Proof of Concept
  - Design, construct, and optimize a small pilot system

BIOWIN MODELING

- Commercial software program
  - Allows for the simulation of various physical and chemical processes used in wastewater treatment
  - Commonly used for design and upgrading wastewater processes
  - Used to determine design and operating parameters to achieve specific effluent requirements

MODEL CONFIGURATION

- Modified Ludzack-Ettinger biological nitrogen removal (BNR) process
  - Most common BNR process
  - Anoxic zone-denitrification
  - Aerobic zone-nitrification



MODEL INPUTS AND CONSTRAINTS

WRRF DESIGN SPECIFICATIONS	
Design flow, MGD	13
Anoxic Volume, MG	1.1
Aerobic Volume, MG	3.3
Clarifier SLR, $lb/ft^2.d$	26
Clarifier SOR, gal/ft2.d	544

WASTEWATER CHARACTERISTICS	PE	IW
Q, MGD	10.5	2.5
COD, mg/L	356	-
TSS, mg/L	124	-
TKN, mg/L	42	-
NH4-N, mg/L	31	-
NOx-N, mg/L	-	390

PERMIT CONDITIONS	Current	Future
CBOD, mg/L	20	20
TSS, mg/L	20	20
TN, mg/L	10	8
NH4-N, mg/L	2	2

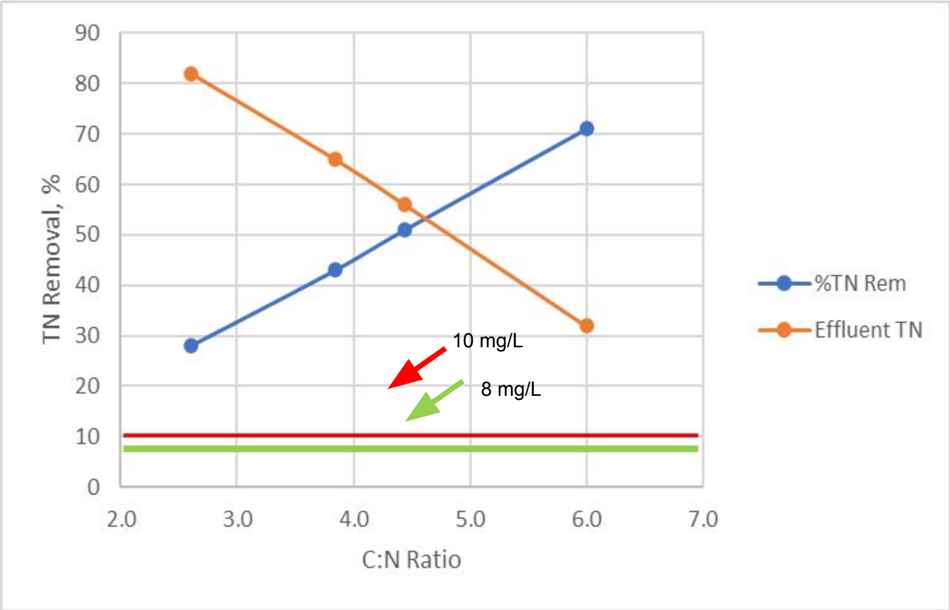
EFFLUENT CHARACTERISTICS	Daily Avg.
CBOD, mg/L	2.2
TSS, mg/L	5.5
TN, mg/L	9.71
NH4-N, mg/L	0.33

MODEL OUTPUTS

- Effluent NO3-N, NO2-N, NH4-N,TKN, TN
- Effluent BOD5, COD, and TSS
- MLSS concentration
- RAS concentration
- SRT

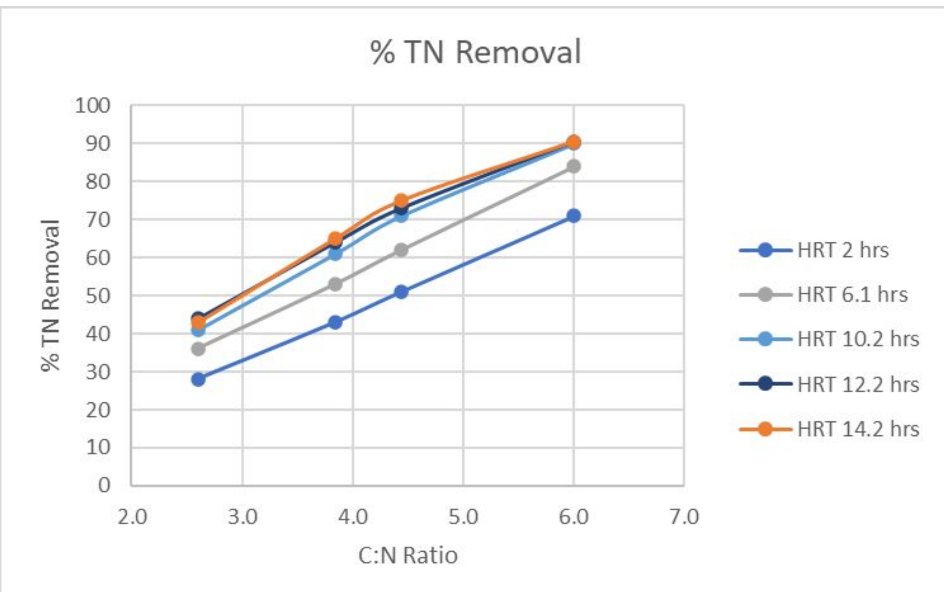
INITIAL SIMULATIONS-PHASE 1

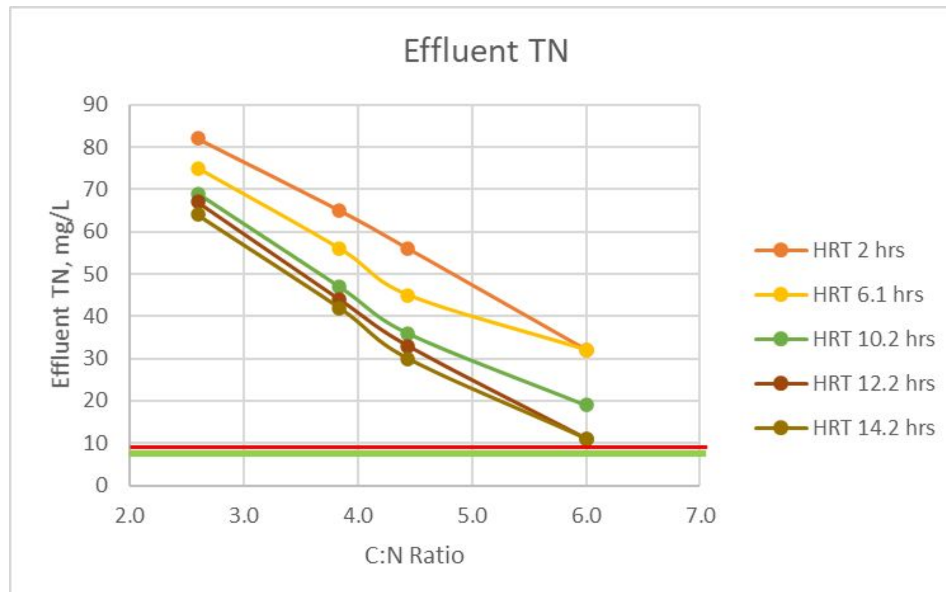
- Goal of the initial simulations
  - Determine highest removal rate of industrial waste assuming no plant modifications and
  - Varying C:N ratio based from 2.6 (no external carbon addition) to 6 using methanol
  - Anoxic HRT-2 hours



VARIATION OF ANOXIC HRT

- Anoxic zone HRT varied from 2 hr (current WRRF) to 14.2 hrs
- Varying C:N ratio based from 2.6 (no external carbon addition) to 6 using methanol



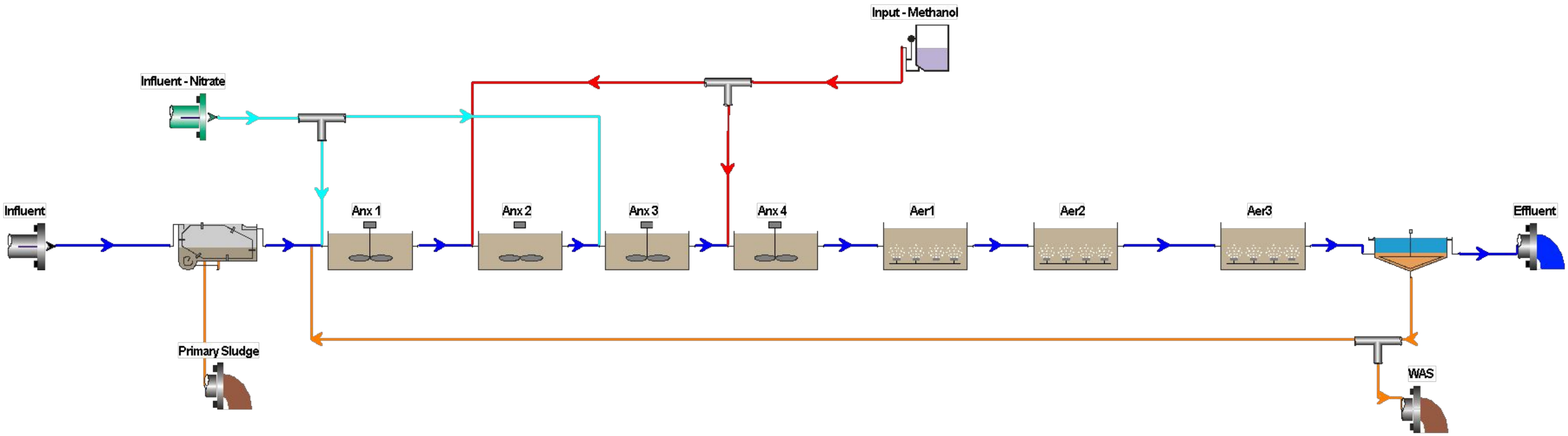


CONCLUSION FROM INITIAL SIMULATIONS

- As expected-higher the C:N ratio, lower TN concentration
  - C:N ratio of 6 produced lowest effluent TN concentration
    - Nitrification was inhibited and TN mostly NH4-N
    - Effluent COD was greater than 50 mg/L
- Higher anoxic HRT resulted in greater TN removal
  - TN higher than the current permit requirement
- Provided information for next stage

PHASE 2 BASELINE MODEL

- Phase 2 model
  - Used a plug flow configuration for anoxic zone, as well as aerobic zone



PHASE 2 SIMULATIONS

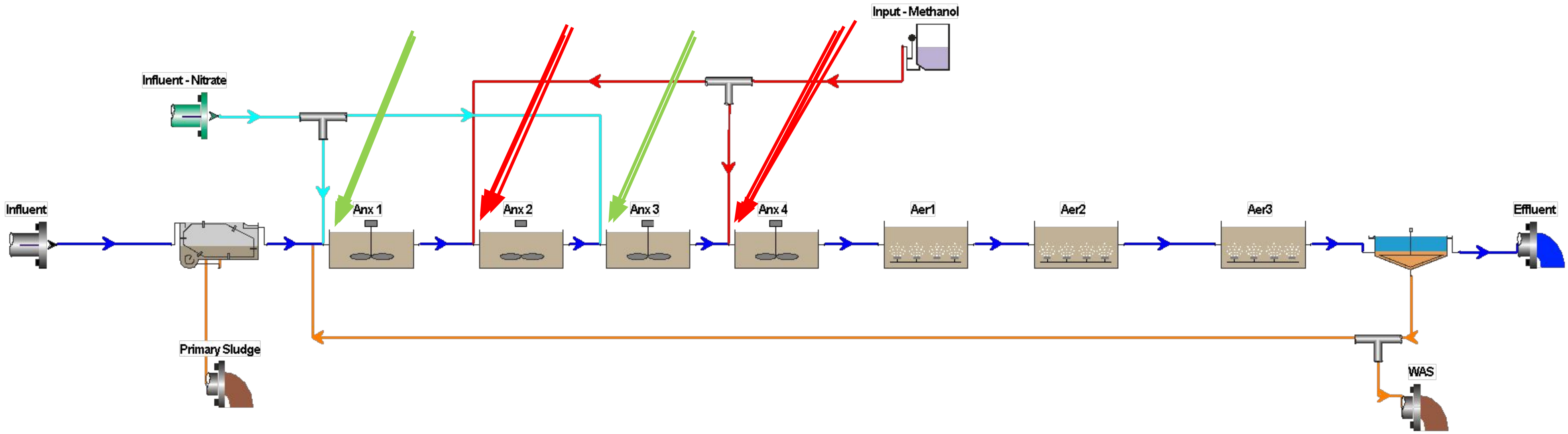
- Modified to allow feeding of high nitrate waste and carbon at more than one location
  - Goal-Achieve an effluent TN ≤ 8 mg/L and NH4-N < 2 mg/L
    - Started with 14.2 hr anoxic HRT and an 6.1 hr aerobic HRT based on initial simulations
- Modifications included
  - Vary anoxic HRT
  - Varied industrial waste feed location
    - Single or multiple feed points
  - Varied methanol feed location
    - Single or multiple feed points

PHASE 2 RESULTS

NEWEA
WORKING FOR WATER QUALITY

		HRT 10.5	HRT 12.4	HRT 14.2
IW Zone 1,3 COD Zone 2, 4	1	13.1	10.3	7.9
IW Zone 1-3, COD Zone 2	2	13.6	10.8	8.2
IW Zone 1-3, COD Zone 4	3	10.5	8.4	7.1
IW Zone 1, COD Zone 2,4	4		8.9	7.2
IW Zone 1, COD Zone 2	5	11.2	8.6	7.2
IW Zone 1, COD Zone 4	6	11.2	8.5	7.2
IW Zone 3, COD Zone 2,4	7	16.6	12.9	9.6
IW Zone 3, COD Zone 2	8	16.6	13.1	9.8
IW Zone 3, COD Zone 4	9	16.3	12.7	9.5

Nitrate
Methanol



PHASE 2 RESULTS

Meets permit goal of ≤ 8 mg/L when

1. *IW is fed entirely to Zone 1 independent of COD addition zone*
2. *IW split between Zone 1 and 3 and COD fed in Zone 4*
3. *HRT 14.2*

In all cases, NH4-N concentration <0.5 mg/L

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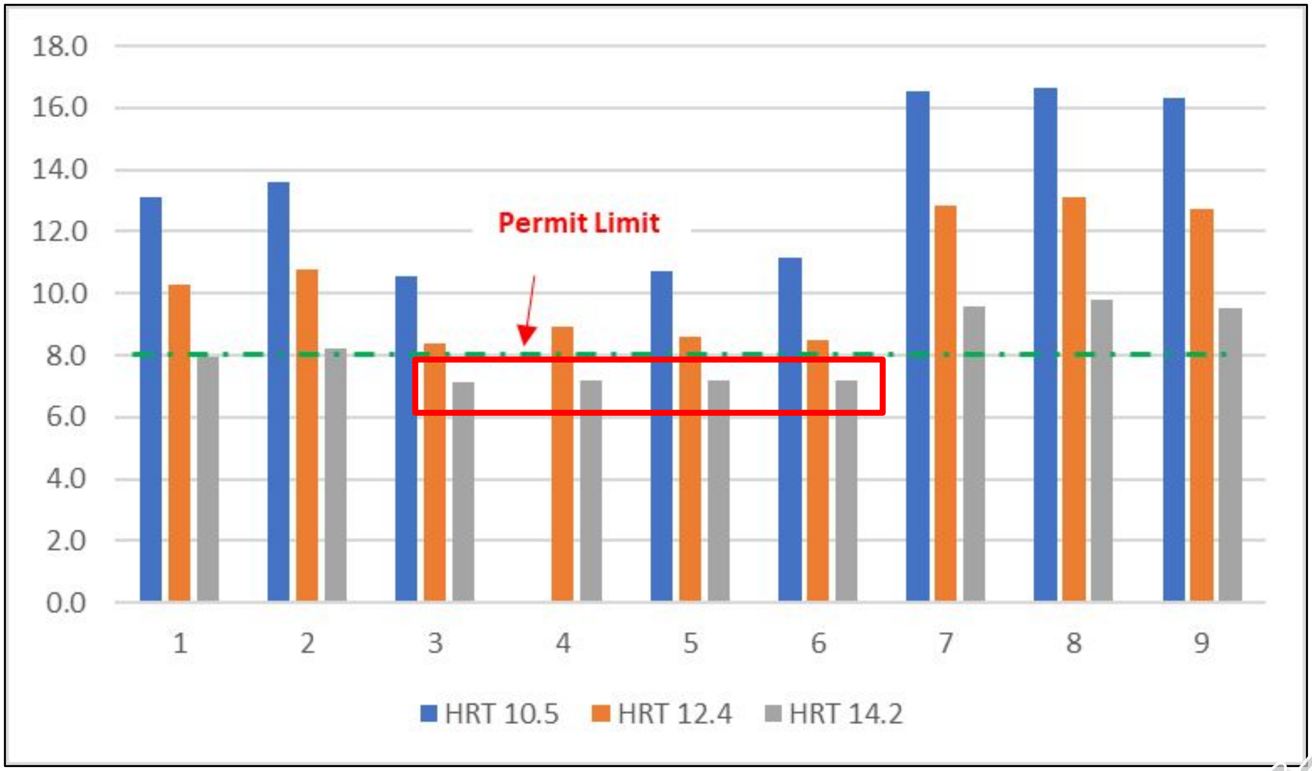

NEXT STEPS

- Numerical optimization
  - Determine most optimal design based on cost and effluent quality
- Design, build, operate small pilot process for Proof of Concept
  - 5-10 liter per hour flow rate
  - Various zones to allow for anoxic and aerobic environments

Questions?

Jbrown7@stevens.edu
Dvaccari@stevens.edu