Ditch your nitrate problems by optimizing that Oxidation Ditch!

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NEWEA
2023 Annual Conference & Exhibit

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Non-confidential - Standard

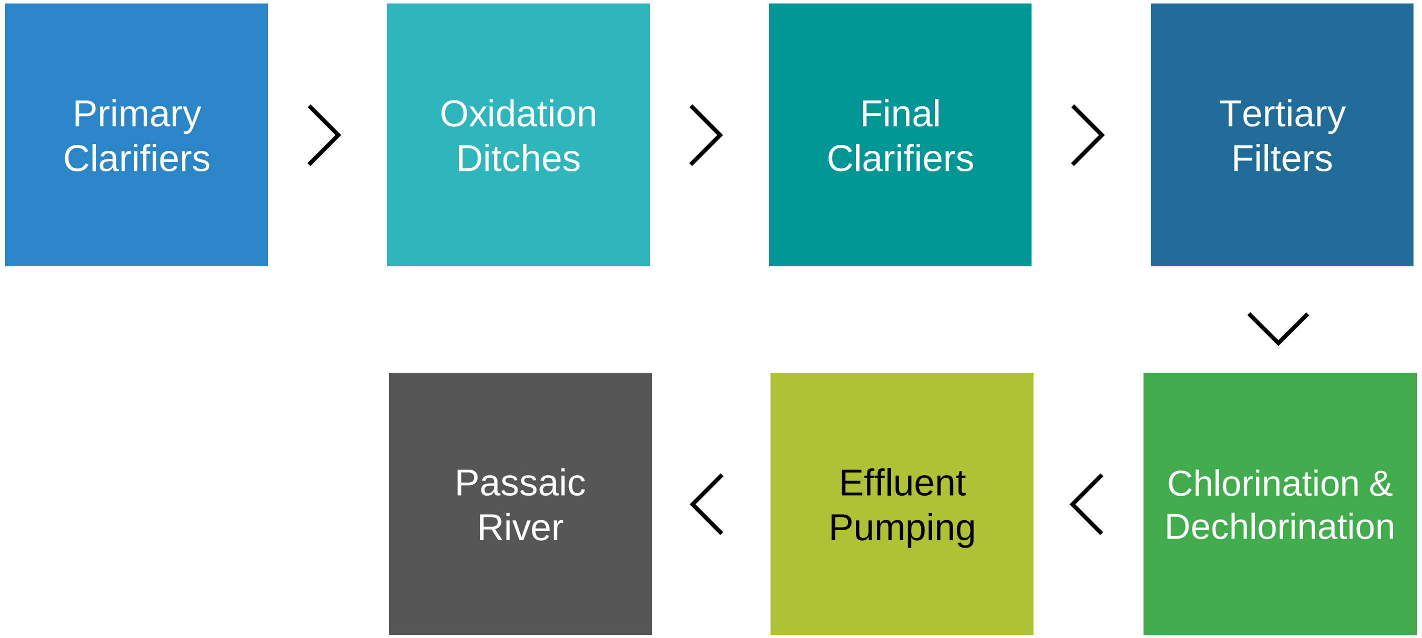
Safety Moment

Agenda

1. Background on Caldwell WRRF
2. Alternatives Evaluation
3. Ditch Optimization
4. Results

Caldwell WRRF

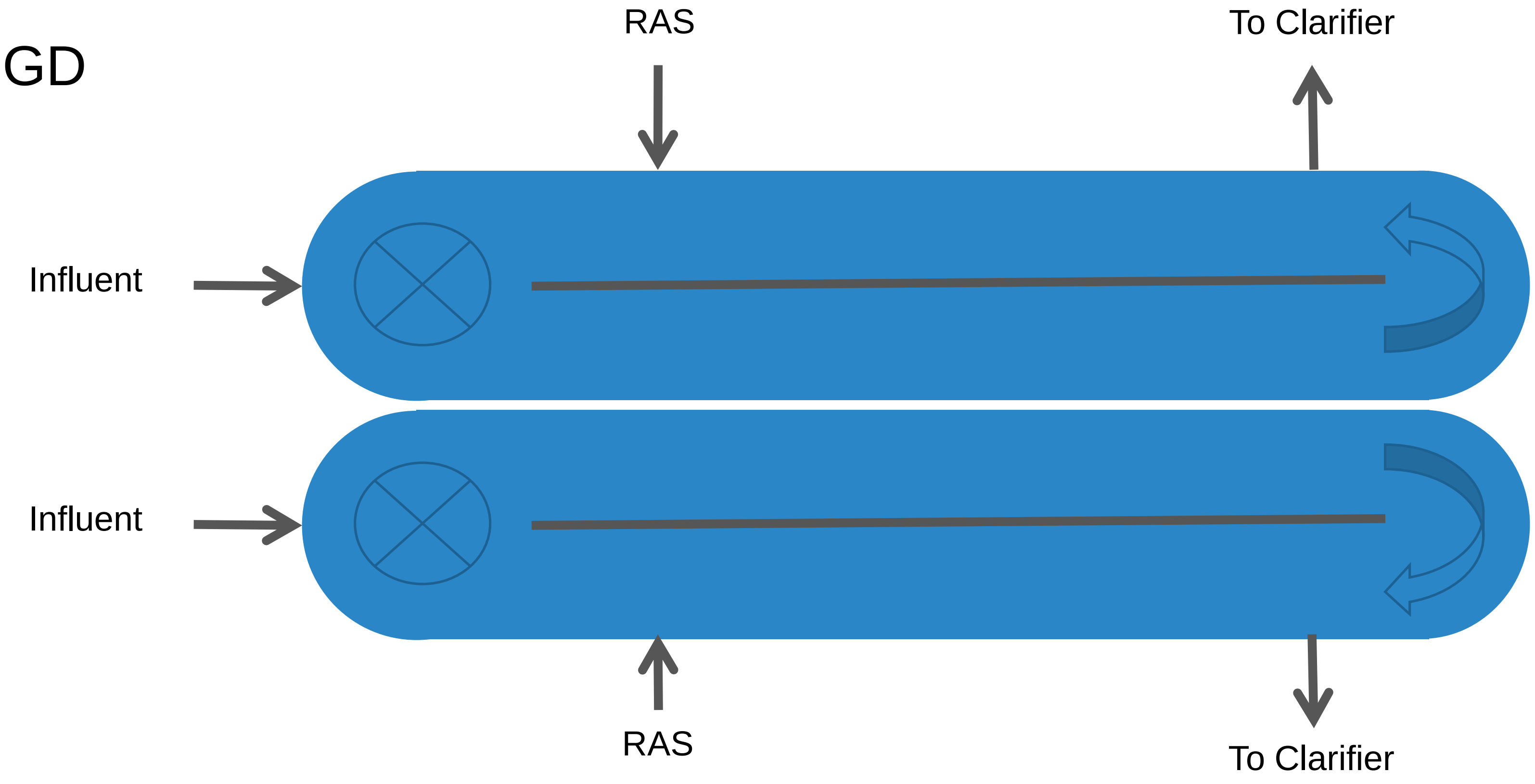
4.5 MGD plant serving 5 municipalities



NPDES Permit imposed future 10 mg/L nitrate limit

Caldwell's Oxidation Ditches

Length: 358 feet
Width: 26 feet (each channel)
SWD: 14 feet
Volume: 3.75 MG
HRT: 20 hrs @ 4.5 MGD



Evaluation of alternatives

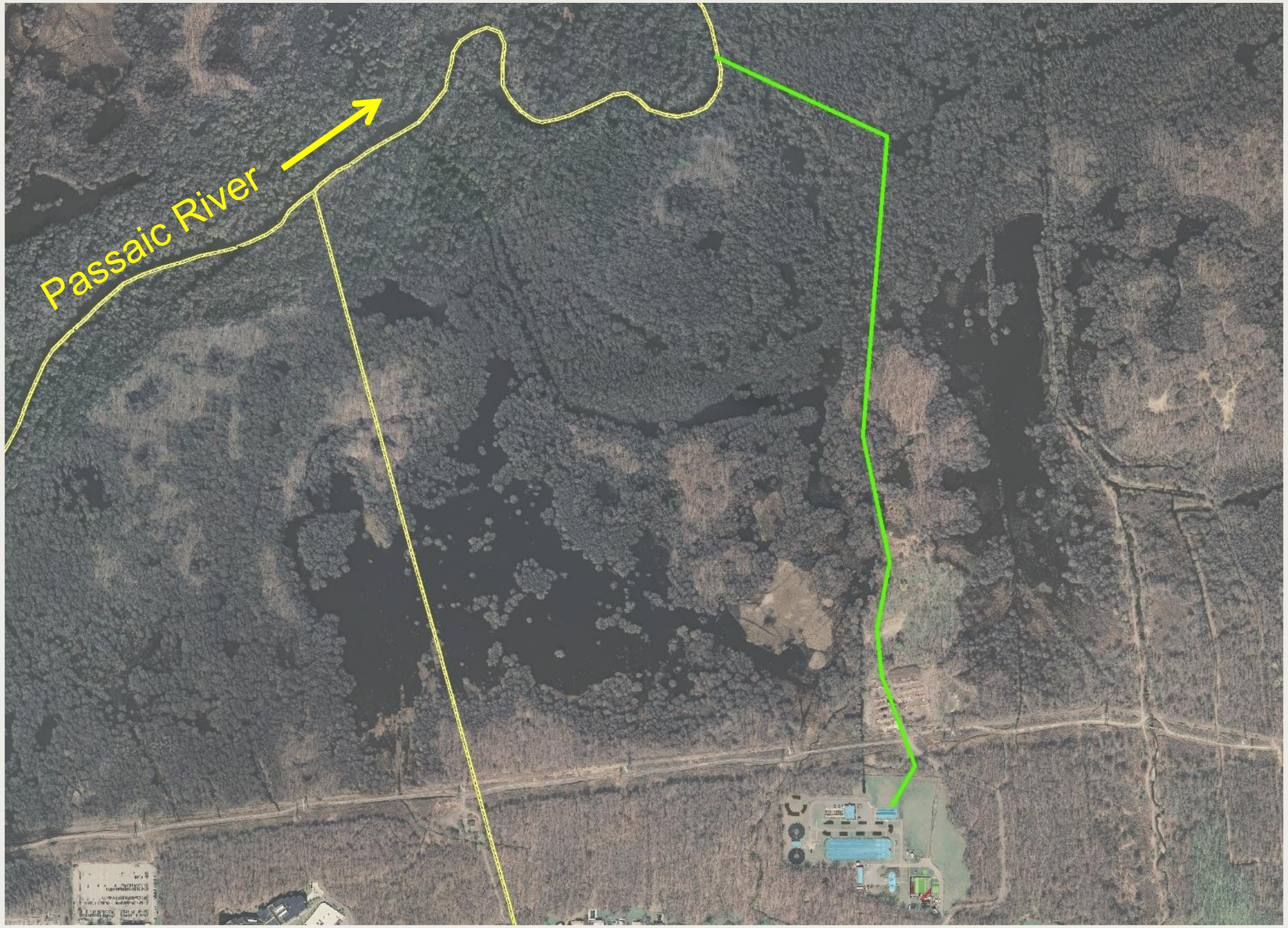
1. 4,600 LF Outfall Extension to Passaic River main stem

2. Denitrification using New Anoxic Tanks with Internal Recycle Streams

3. Control Oxidation Ditch operations for Simultaneous Nitrification/ Denitrification (SND)

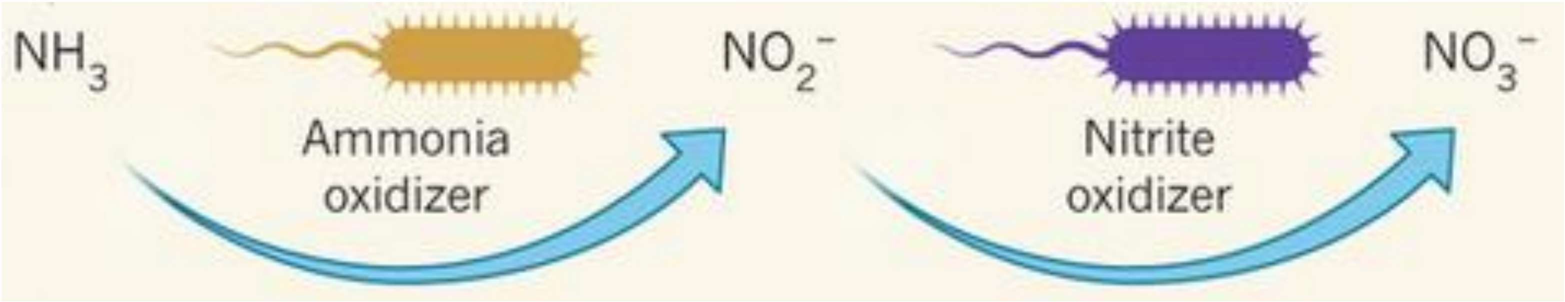
Option 1:

Extend Outfall to Passaic River



Existing process: Nitrification

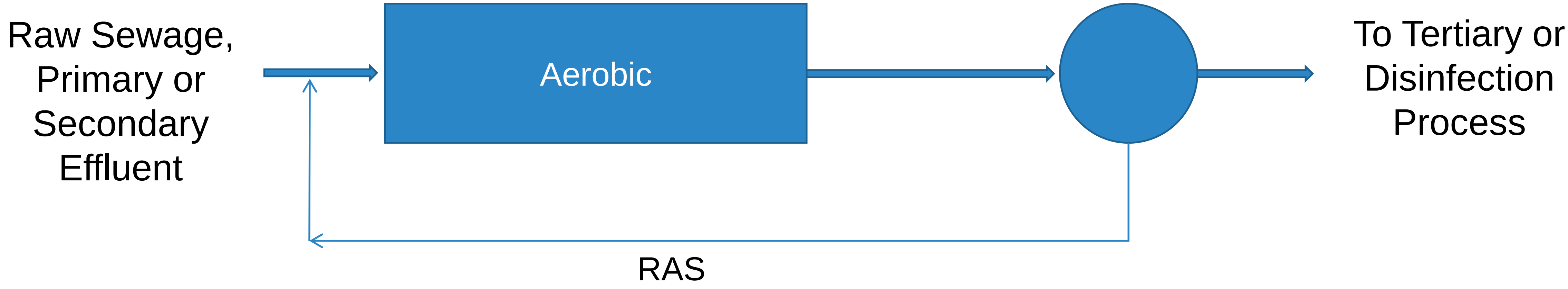
- Two step oxidation of ammonia to nitrate, mediated by bacteria



- Two distinct groups of chemolithotrophic autotrophs
- Chemolithotrophs
  - energy from inorganic source (NH_3)
- Autotrophs
  - carbon from inorganic source (CO_2)

Nitrogen removal

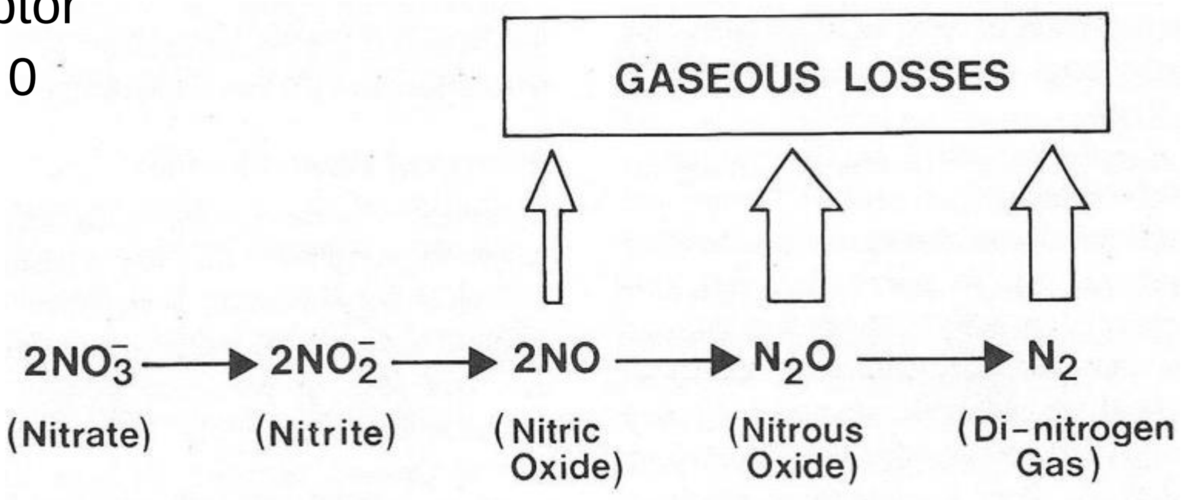
Single sludge nitrification



Required process: Denitrification

The Nitrogen removal step

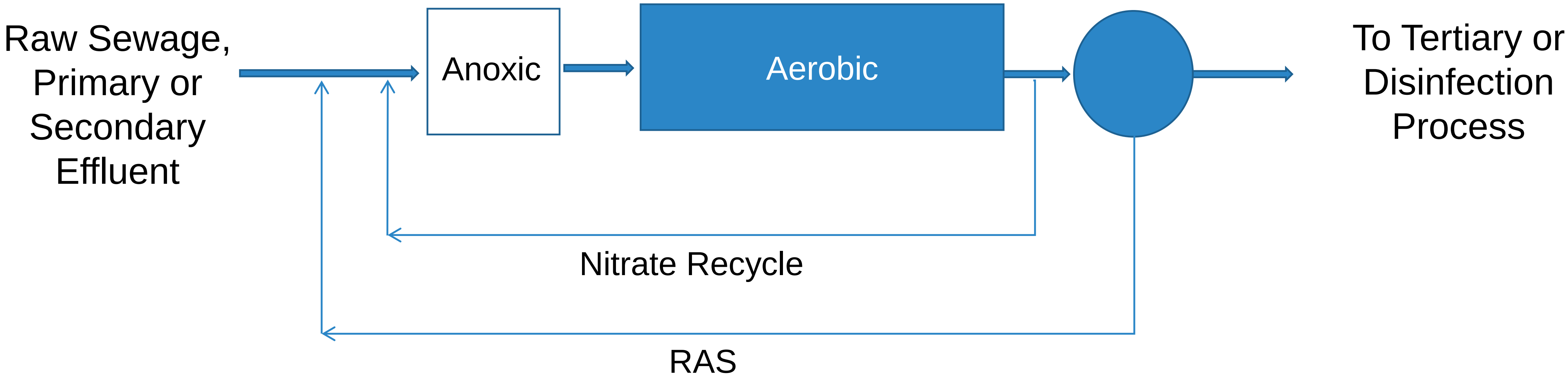
- Removal of carbonaceous matter (BOD_5) under anoxic conditions
- Step-wise reduction of nitrate to nitrogen gas
  - Nitrate is the terminal electron acceptor
  - oxidation state of N goes from +5 to 0



- The oxygen in NO_3^- goes to CO_2 and H_2O

Nitrogen removal

Denitrification



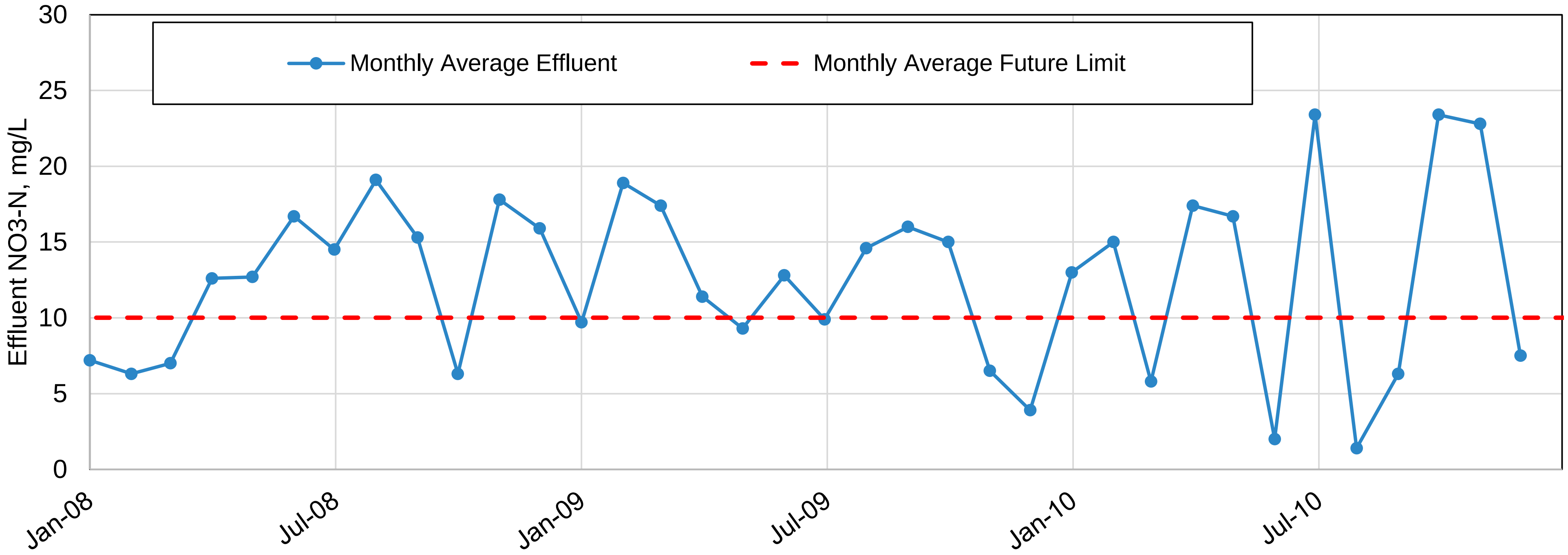
External carbon source may be required

Option 2:

New Anoxic Tanks with Internal Recycle

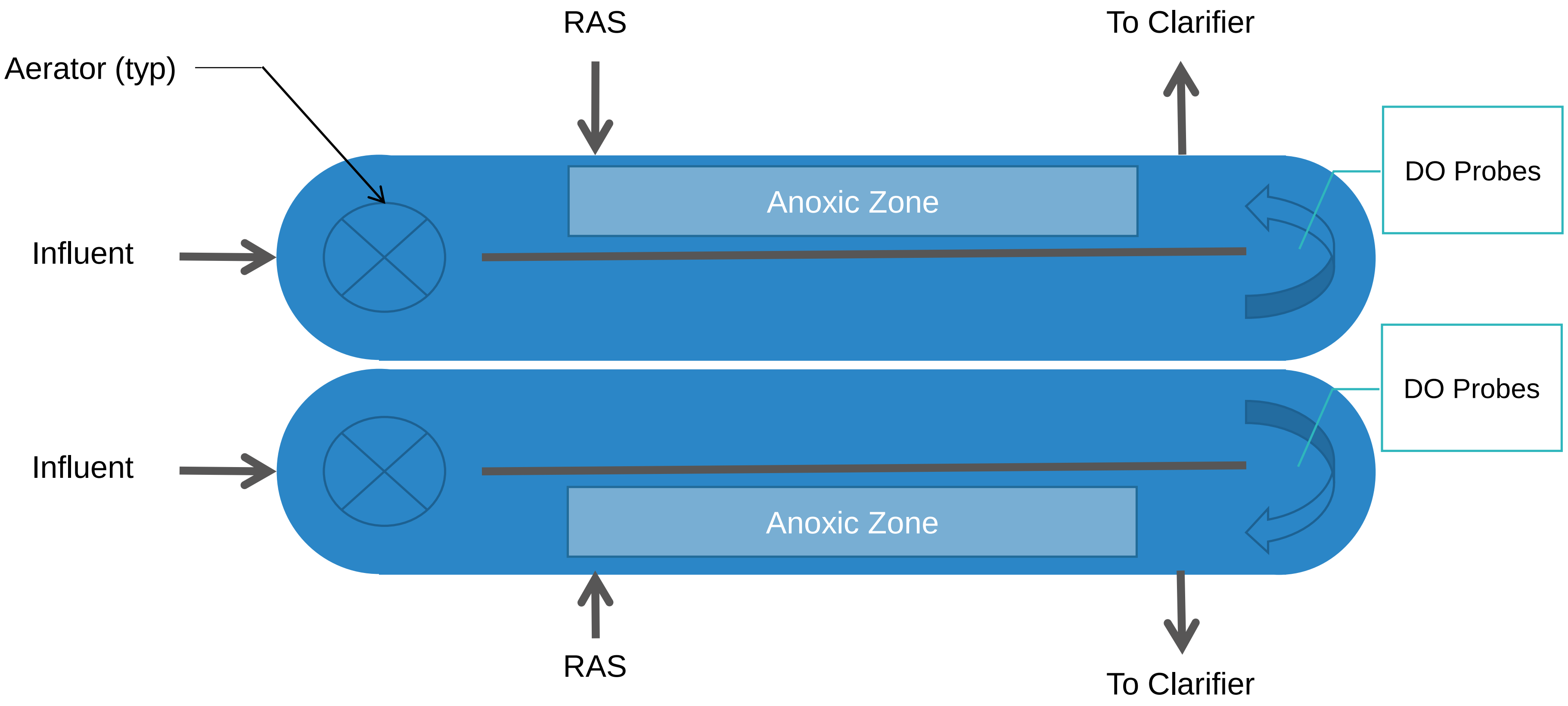
Option 3:

Implement Simultaneous Nitrification-Denitrification (SND) in existing tankage



SND Process

Control oxygen input for anoxic zone



Process considerations

- Special sampling performed to evaluate elimination of Primary Tanks
- Removal % agrees with published literature
- Oxidation Ditch volumes adequate for additional loading

Date	Influent		Primary Effluent	
	$CBOD_5$	TSS	$CBOD_5$	TSS
	mg/L		mg/L	
Nov 26-27, 2007	163	196	112	246
Dec 3-4, 2007	150	222	115	174
Dec 10-11, 2007	199	346	143	151
Dec 17-18, 2007	152	257	122	197
Jan 7-8, 2008	150	208	122	200
Jan 14-15, 2008	123	164	103	182
Jan 21-22, 2008	131	158	96	142
Jan 28-29, 2008	173	246	121	136
Feb 4-5, 2008	158	192	---	---
Feb 11-12, 2008	---	---	138	115
Average	155	221	119	171
		Removal:	23.4%	22.4%

Denitrification

Empirical based C/N ratios for denitrification with influent carbon source

- Experience indicates the expected removal of nitrogen based on the ratios of the following influent parameters

Removal Efficiency	COD/TKN	BOD_5/NH_3-N	BOD_5/TKN
Poor	< 5	< 4	< 2.5
Moderate	5 – 7	4 – 6	2.5 – 3.5
Good	7 – 9	6 – 8	3.5 – 5
Excellent	> 9	> 8	> 5

Grady et al. 2011

- When influent C/N ratio insufficient to achieve required nitrate reduction, a supplemental source is added

Foam problems

- Described as “Chocolate Mousse”
- Covers aeration basins and tank walls
- Can be Odor Source
- Can Freeze and damage sensors and other equipment
- Can pass to Clarifiers and overwhelm skimmers
- Can increase effluent TSS

Caldwell's ongoing foam battle

1. Water sprays were used to fight the foam
2. Periodical physical removal by VAC truck
3. RAS chlorination was practiced
4. Tried additives marketed for nocardia foam control
5. To prevent foam from reaching final clarifiers a surface baffle was installed around effluent weirs from the oxidation ditches

Foam continues to plague many facilities

Nocardia foam is caused by filamentous bacteria, but different from type causing bulking

Bulking sludge is well understood and research has identified root causes: low F/M, DO, nutrient deficiencies

Bulking control has included RAS chlorination, incorporation of selectors

The contributing factors for foam control are less well understood than for classical filamentous bulking

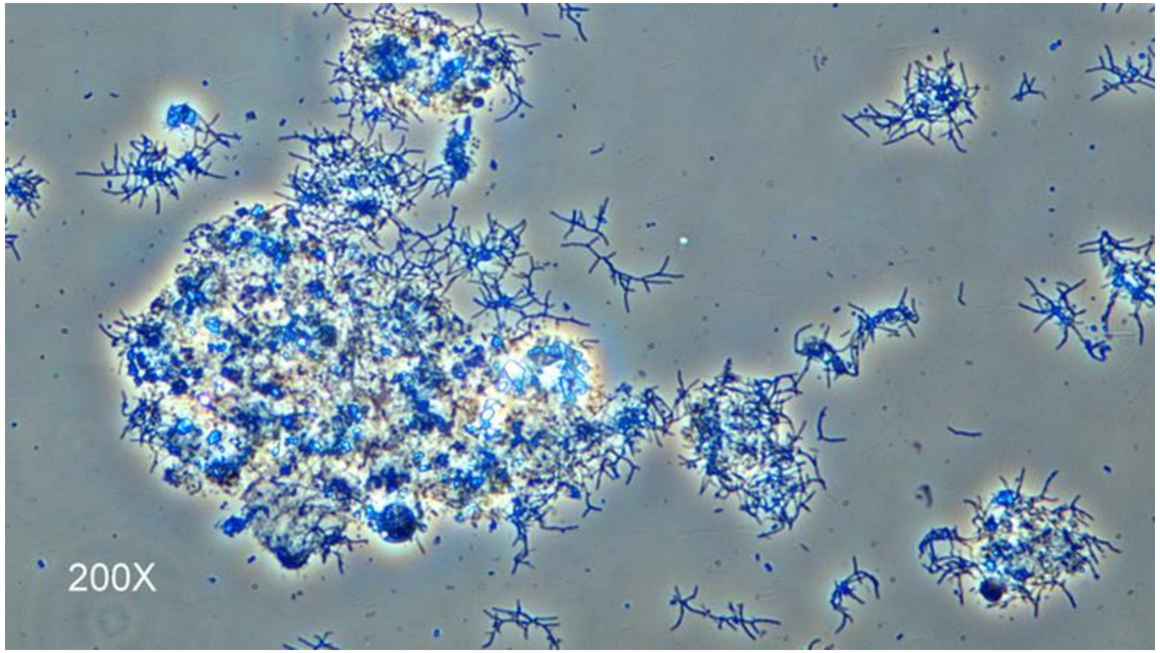
Understanding foam factors

Nocardia-type bacteria have an affinity for air bubbles generated by aeration devices - they try to escape water and stay in contact with air

Air bubbles are trapped and stabilized by flocs, which causes floating solids and heavy foam accumulation on the surface

The underlying mechanism of foam generation is the hydrophobic nature of nocardioforms

The solids content in the floating foam layer can be substantially higher than typical mixed liquor suspended solids concentrations



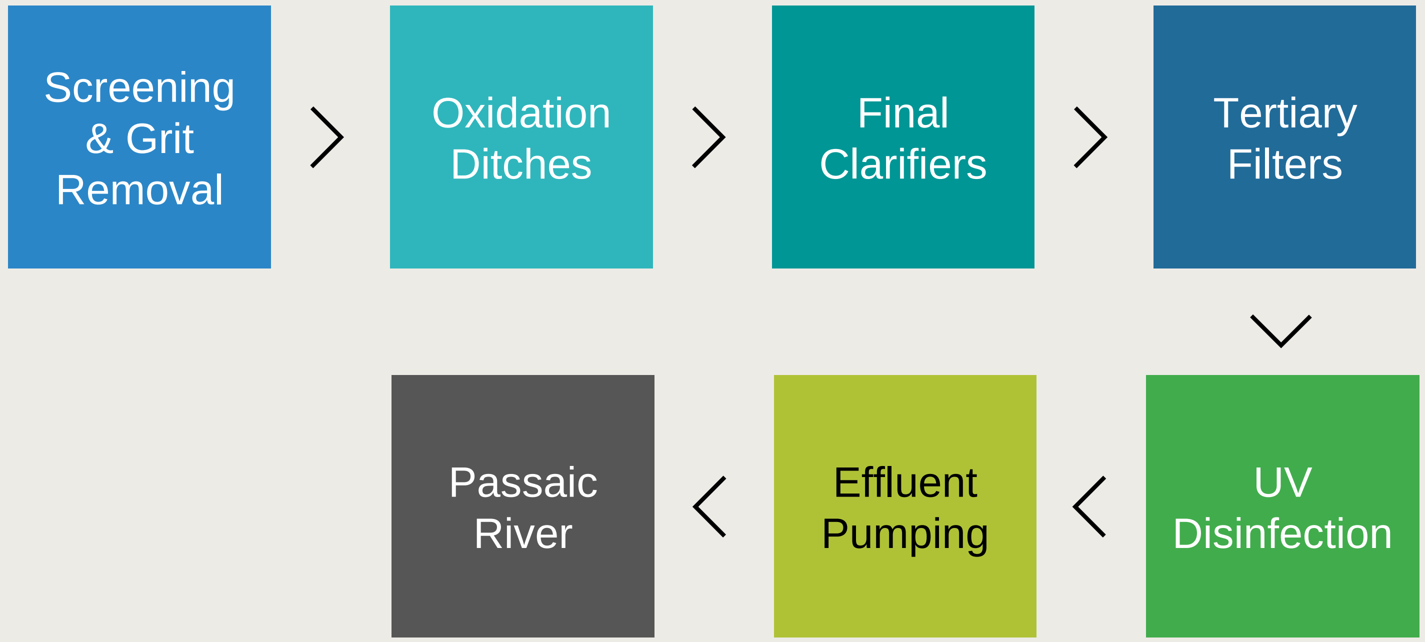
Foam proliferation factors

- There is some evidence that oil and grease tend to promote nocardioforms growth
- Foam can get trapped in the aeration tank selecting for nocardioforms
- Typical sludge wasting locations (submerged RAS lines) further promote nocardioforms proliferation and foam accumulation

RAS chlorination is effective in settling control but has less impact on surface foam layer

Upgraded Caldwell WRRF

Liquid process train



Ditch modifications

1
Aerators
Replaced with a larger dual impeller style

2
Tank Modifications
Installed velocity baffle

3
VFDs
Provided Variable Frequency Drive controls

4
Instruments
Installed DO probes for process control

5
Chemicals
Sodium hypochlorite storage and metering facility

6
Feed Points
Can add hypochlorite to both RAS and to a surface spray system

7
Polymer
Standby system to improve clarifier performance

No Nocardia-type filamentous bacteria after improvements

Old impeller

New impeller




FLOW



Process control

1.

DO Probe setpoint to achieve 1.2 mg/L at end of each ditch

2.

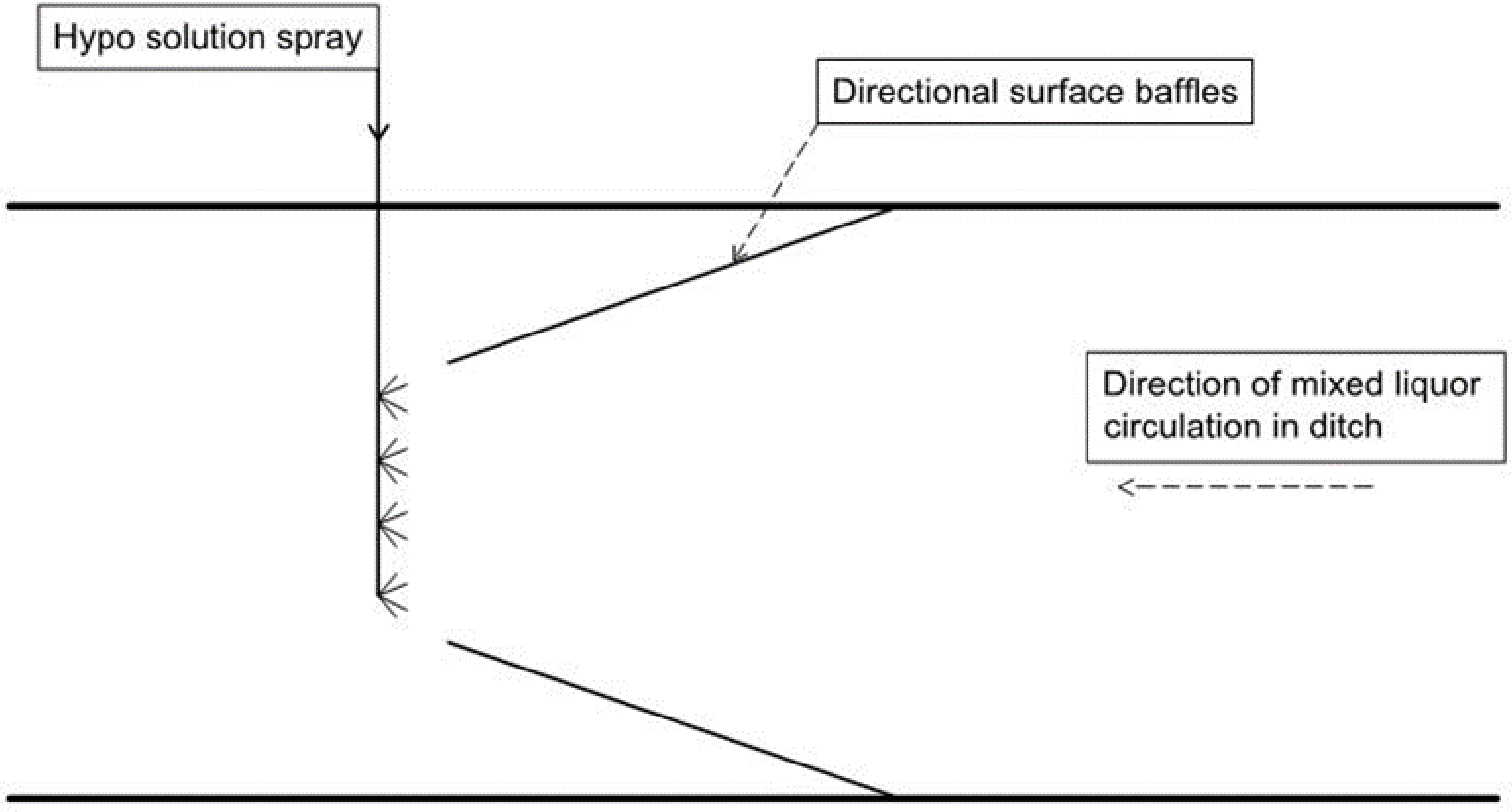
Aeration “on” for 60 minutes. Aerator at 100% speed until 1.2 mg/L setpoint reached. Aerator speed reduced to maintain 1.0 mg/L

3.

Aeration “off” for 30 minutes (Denitrification mode)

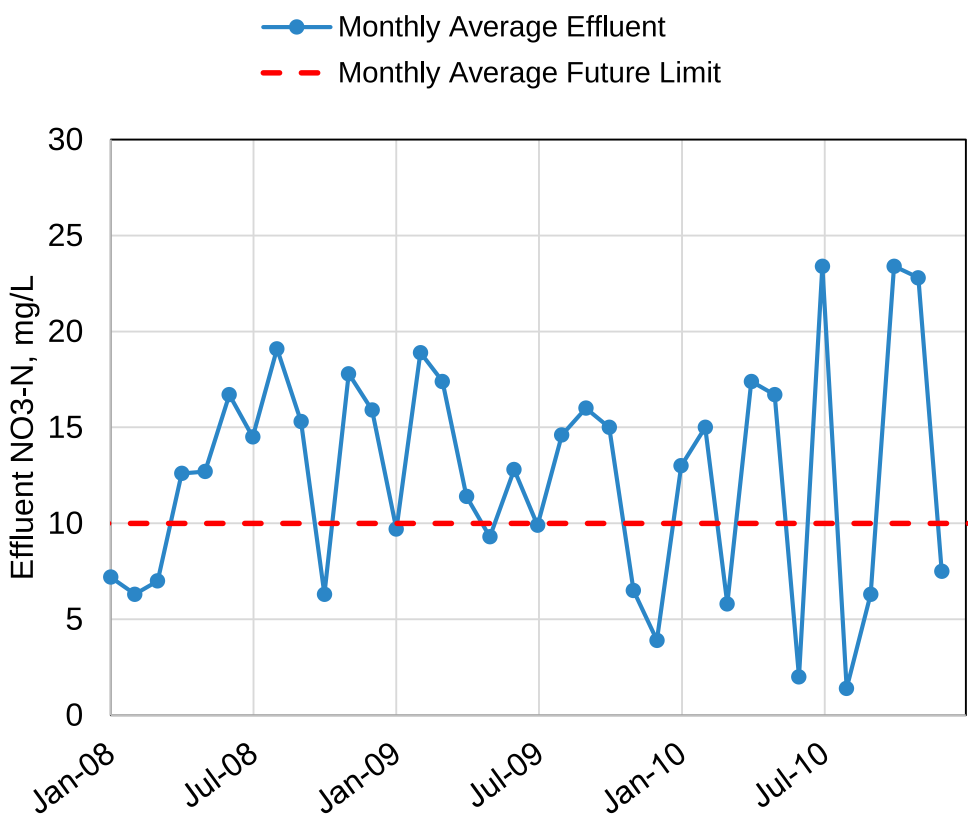
By controlling the DO input to the process in time, nitrogen removal is achieved

Schematic of baffles & spray system

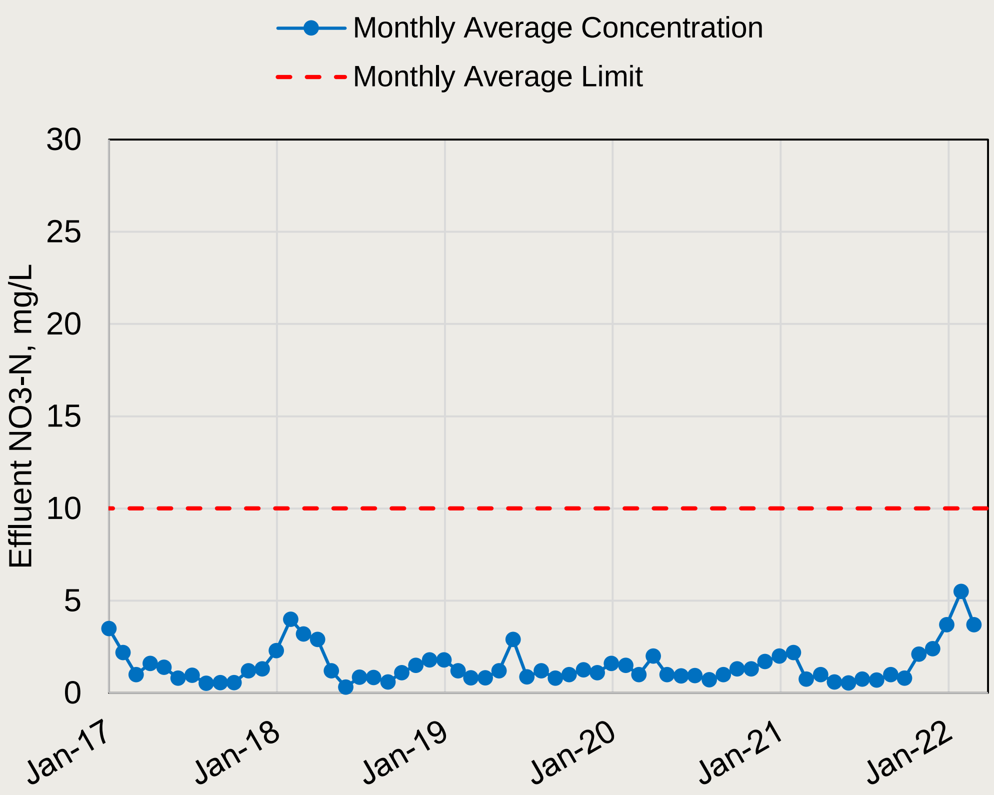


Spray system

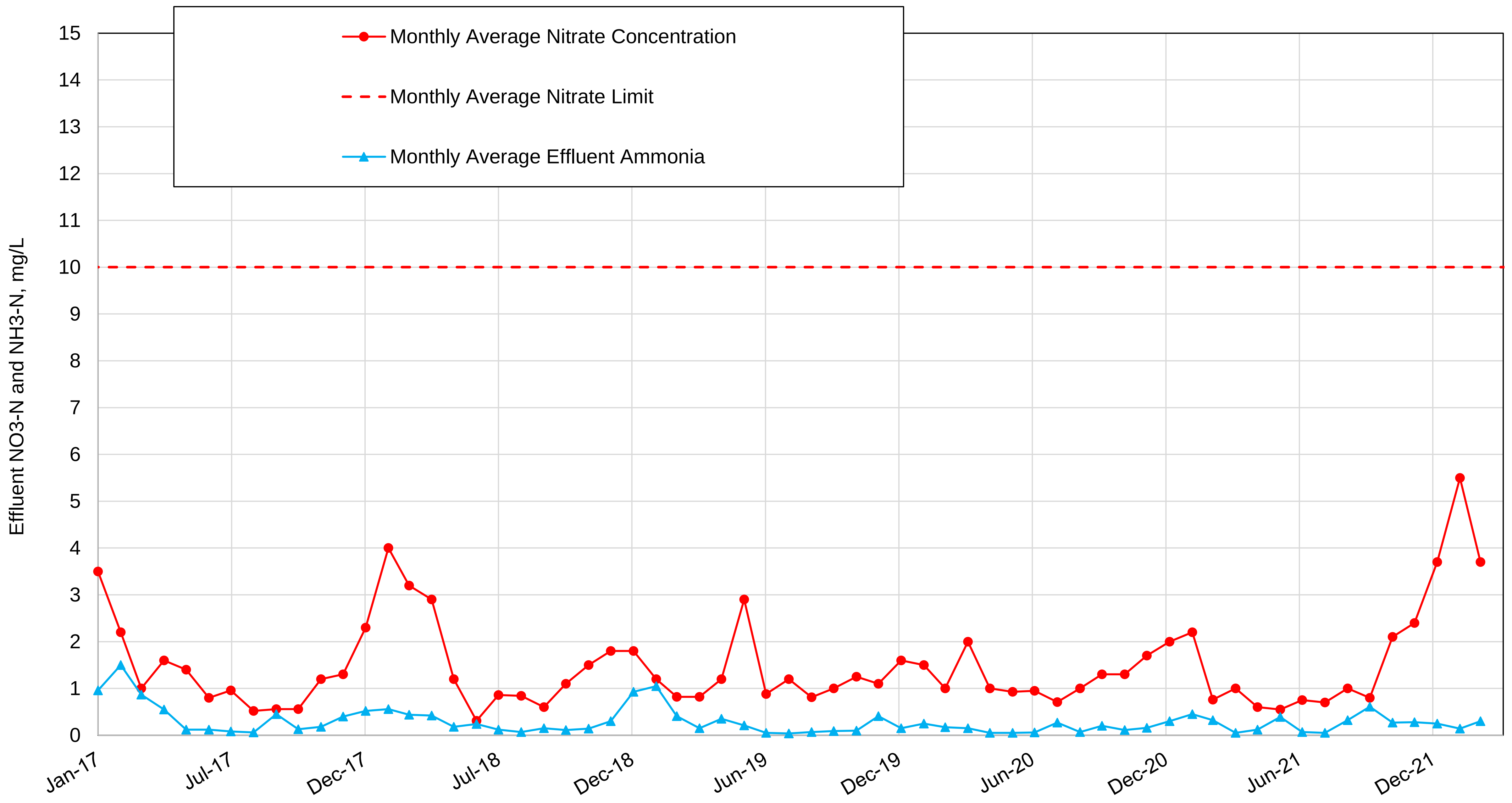
- Designed to deliver hypochlorite solution in the range 2,000 to 3,000 mg/L as Cl_2
- Provided required flow rate and dose through nozzles without excessive (corrosive) mist
- Restricted operation to several hours each day to control dose at safe levels for mixed liquor



Continuous aeration



Intermittent aeration



Monthly Average Nitrate Concentration
Monthly Average Nitrate Limit
Monthly Average Effluent Ammonia
Effluent NO3-N and NH3-N, mg/L
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Jan-17
Jul-17
Dec-17
Jul-18
Dec-18
Jun-19
Dec-19
Jun-20
Dec-20
Jun-21
Dec-21

Before

Caldwell’s facility dealt with persistent foaming issues for several decades

After

Results confirm that preventive and remedial measures, when correctly applied, bring excellent results

Caldwell’s WWTP today

Major points

1. Adequate C/N ratio allows denitrification without supplemental carbon source
2. Low DO setpoint and VFD control provide required anoxic conditions
3. Conventional SND in a ditch (or elsewhere) depends on finely balanced aeration, typically hard without sophisticated instrumentation and controls
4. Introduction of on/off regime allows much better, positive control of denitrification without losing nitrification
5. SND systems are prone to filamentous bulking due to a chronic, by design, oxygen deficiency. On/off regime is much better for sludge settleability and bulking control

Thank you, any questions?

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