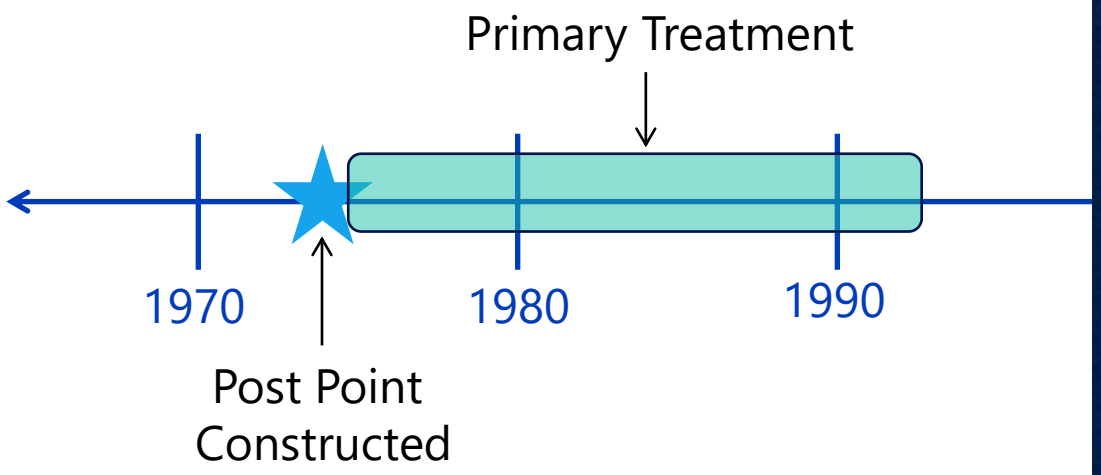
Automation, Adaptation and Beyond to Implement Nitrogen Optimization at Post Point

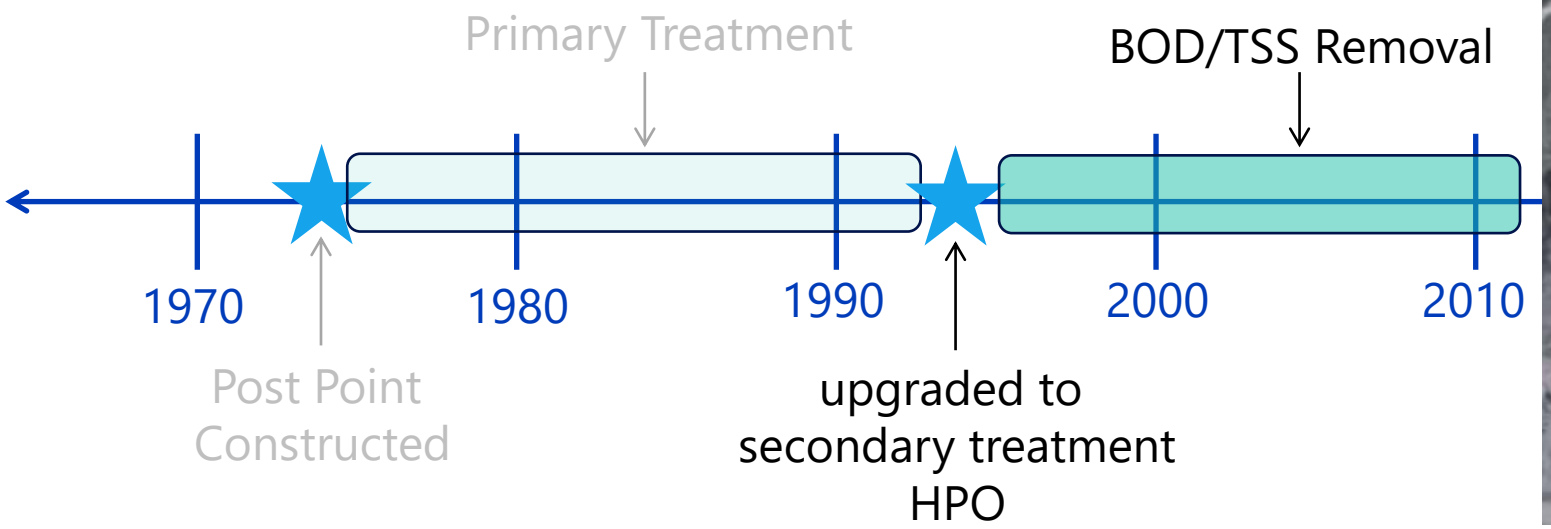
Anne Conklin, Carollo Engineers, Inc.
Richard Hoover, City of Bellingham

May 2, 2024

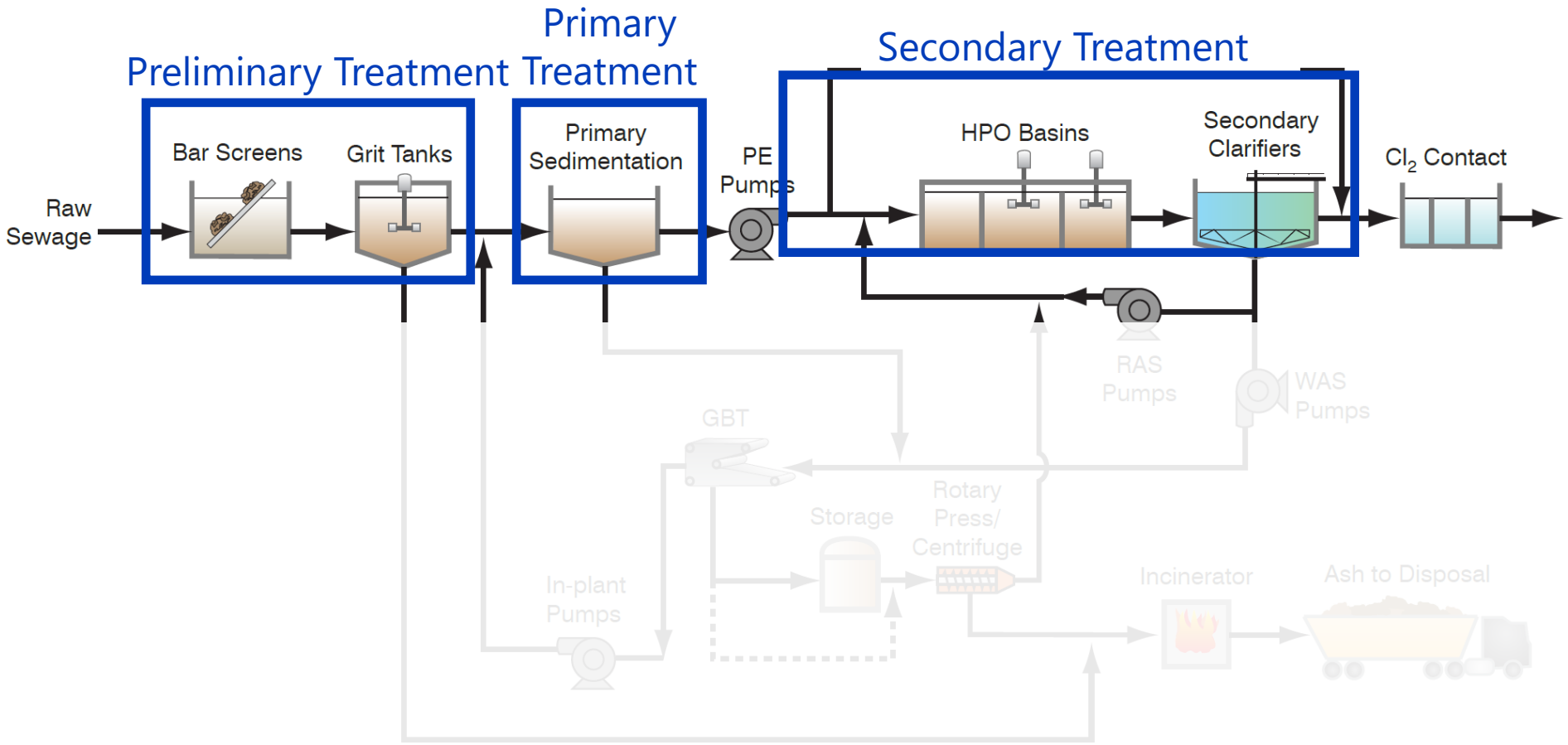
1. Primary treatment only



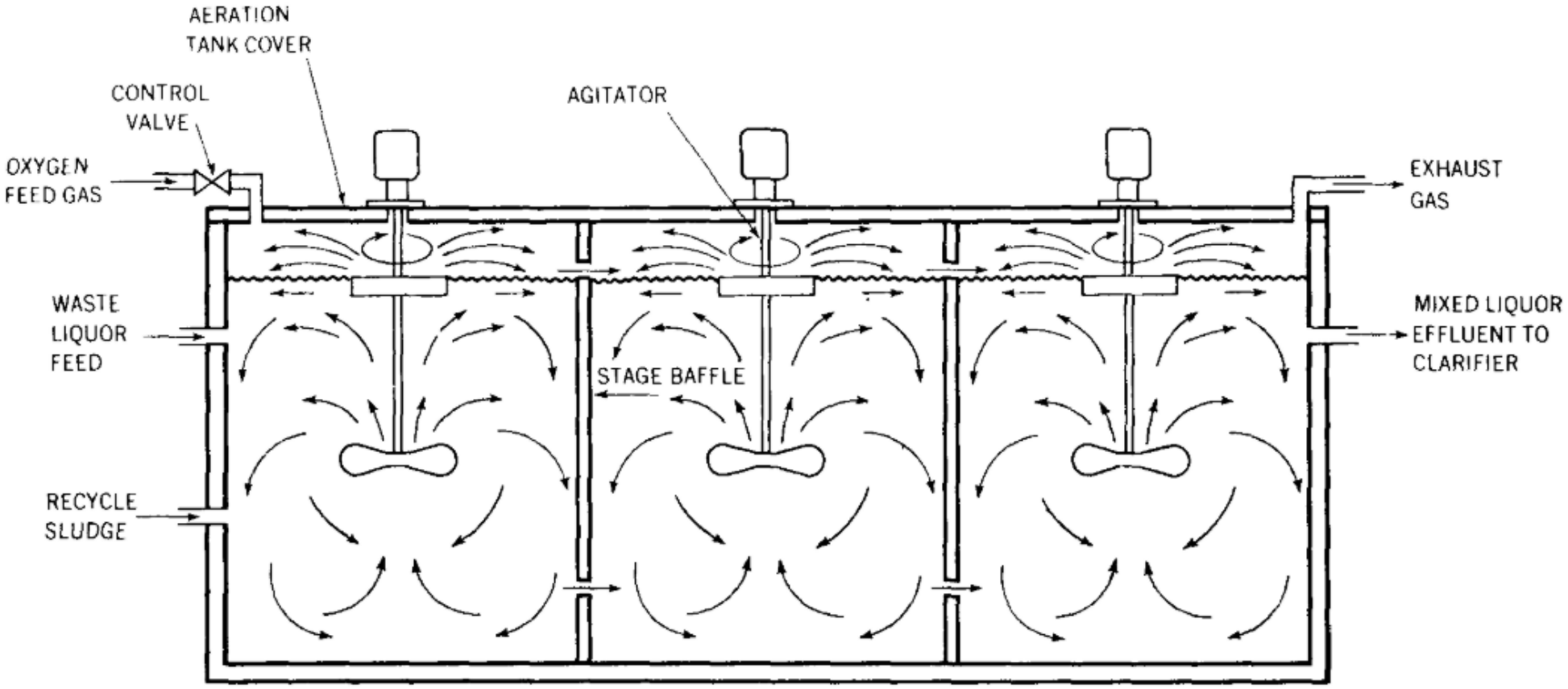
2. Secondary treatment with a HPO process



The Bellingham Post Point Plant (prior to recent upgrades)



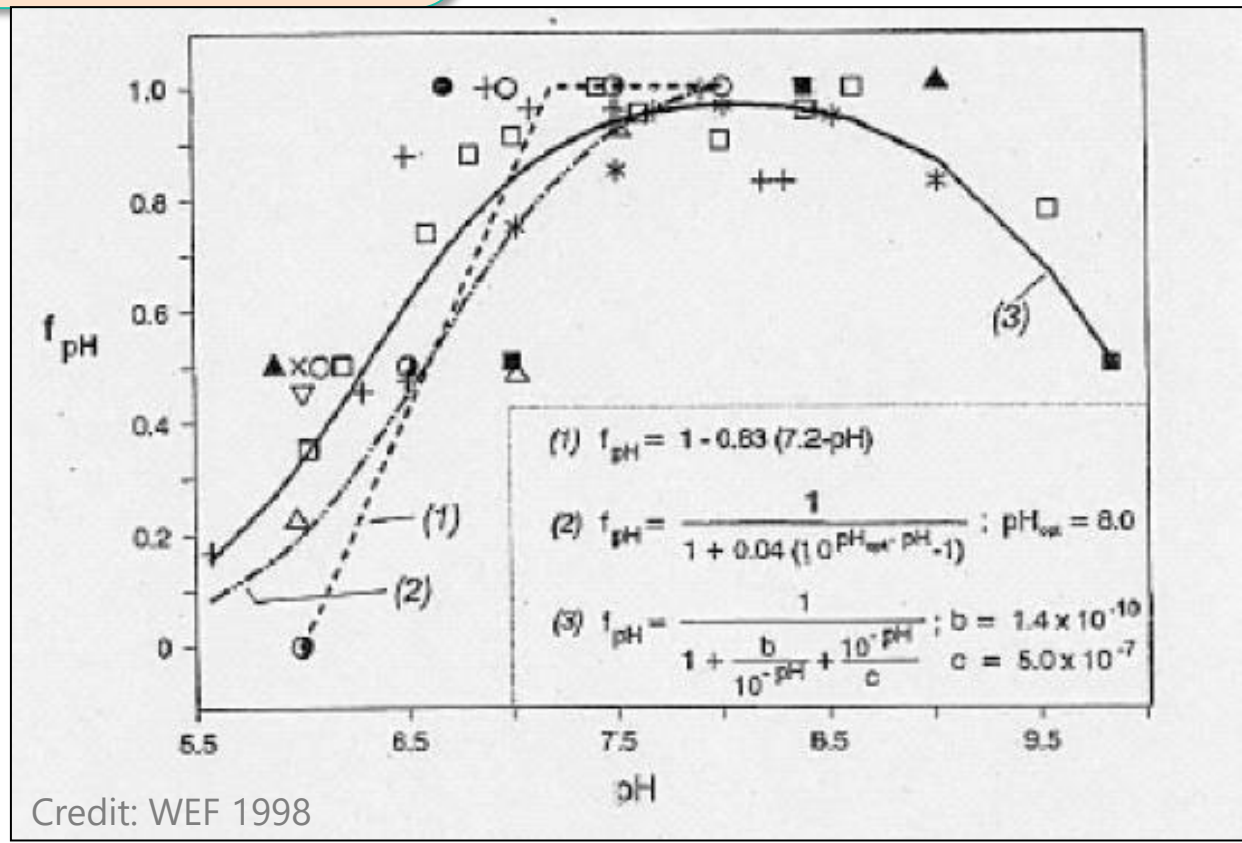
The HPO process



CO2 accumulation suppresses nitrification in HPO processes

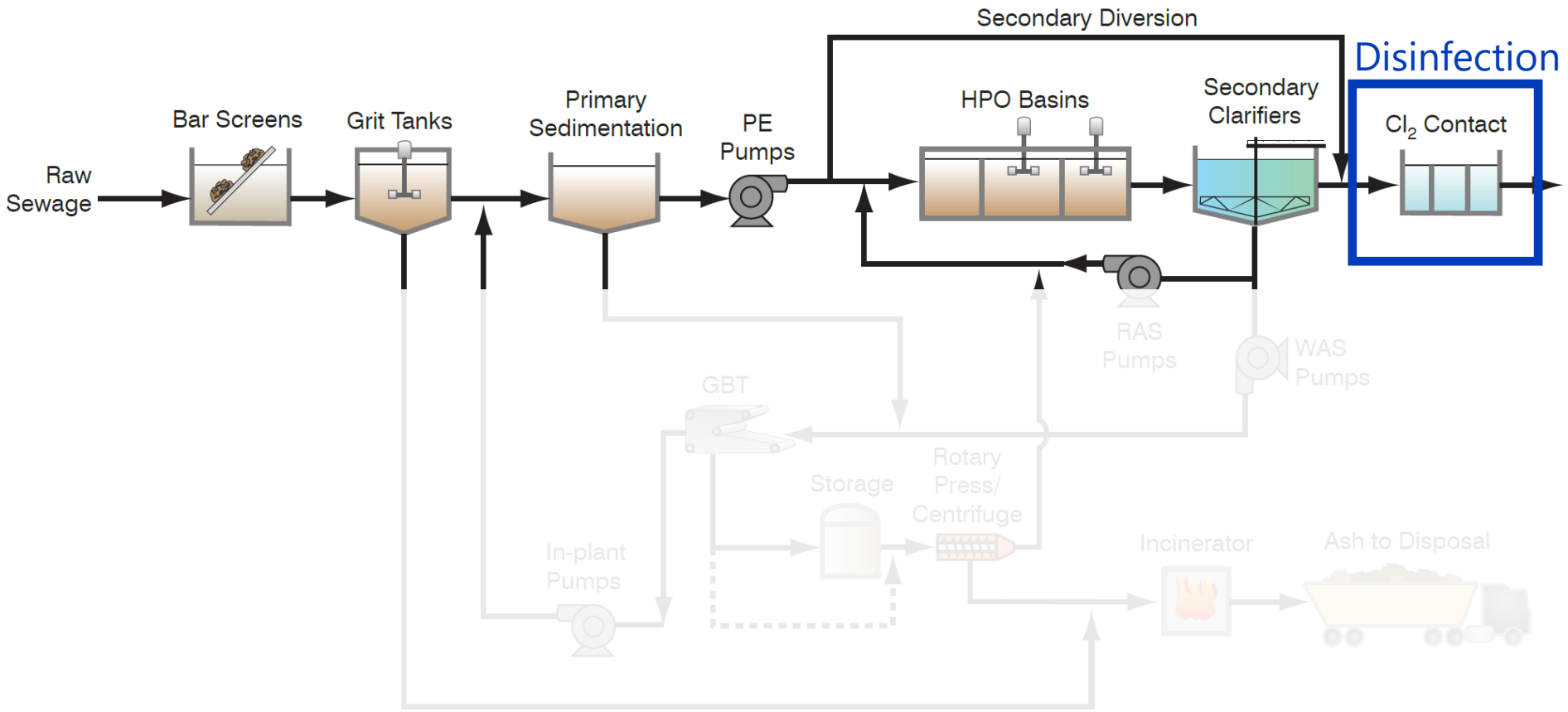
$$NH_3 + 2\,O_2 \xrightarrow{\text{Bacteria}} NO_3^- + H_2O + H^+$$

Nitrification Reaction

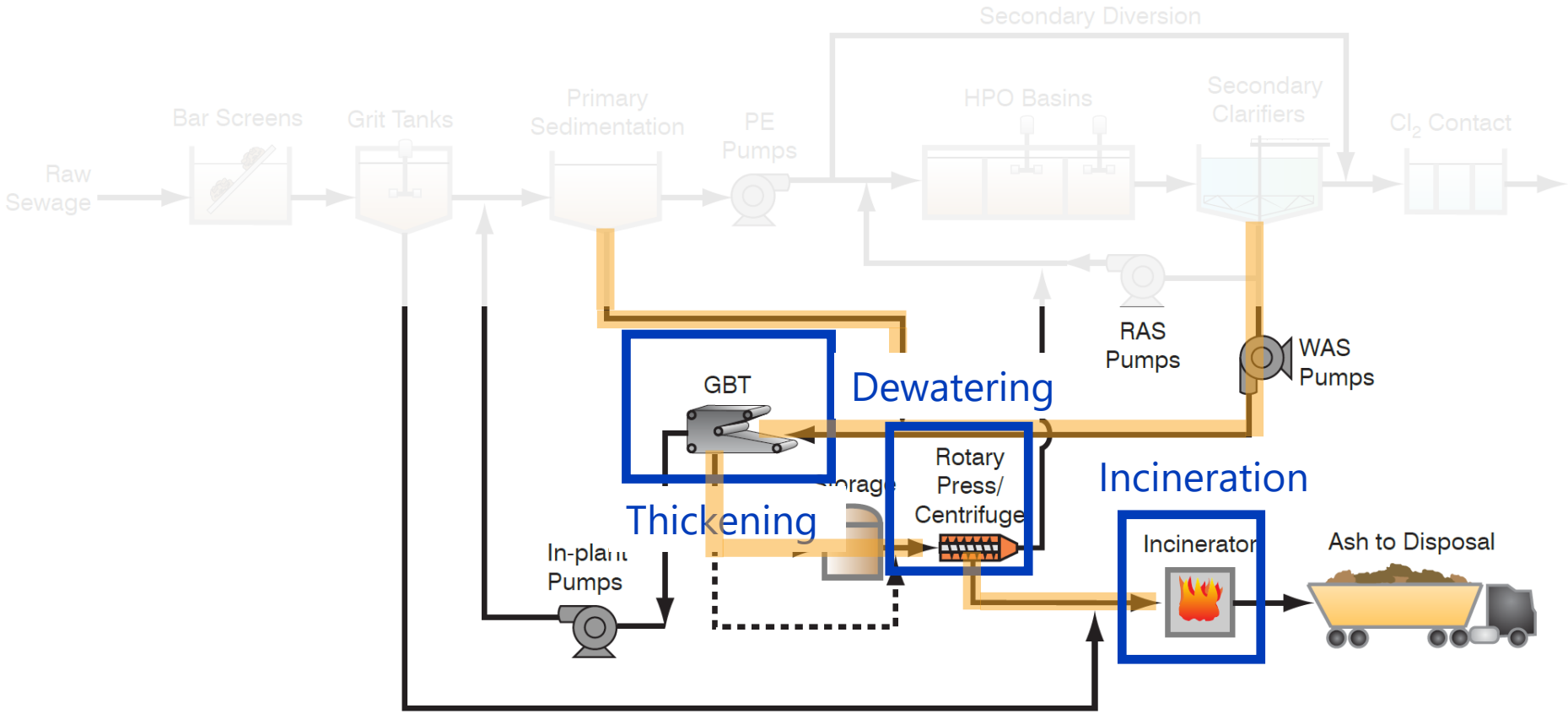


Credit: WEF 1998

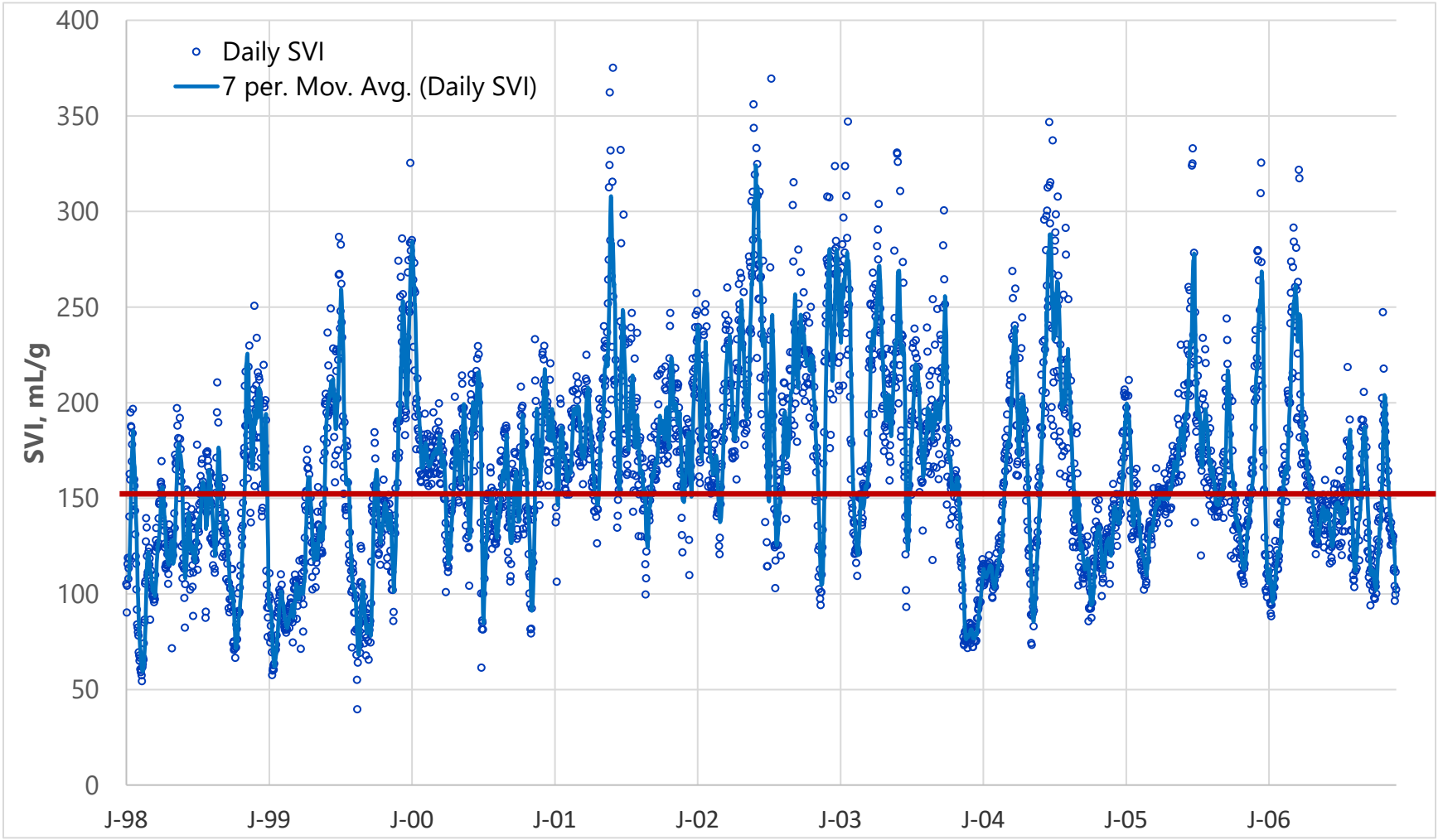
The Bellingham Post Point Plant (prior to recent upgrades)



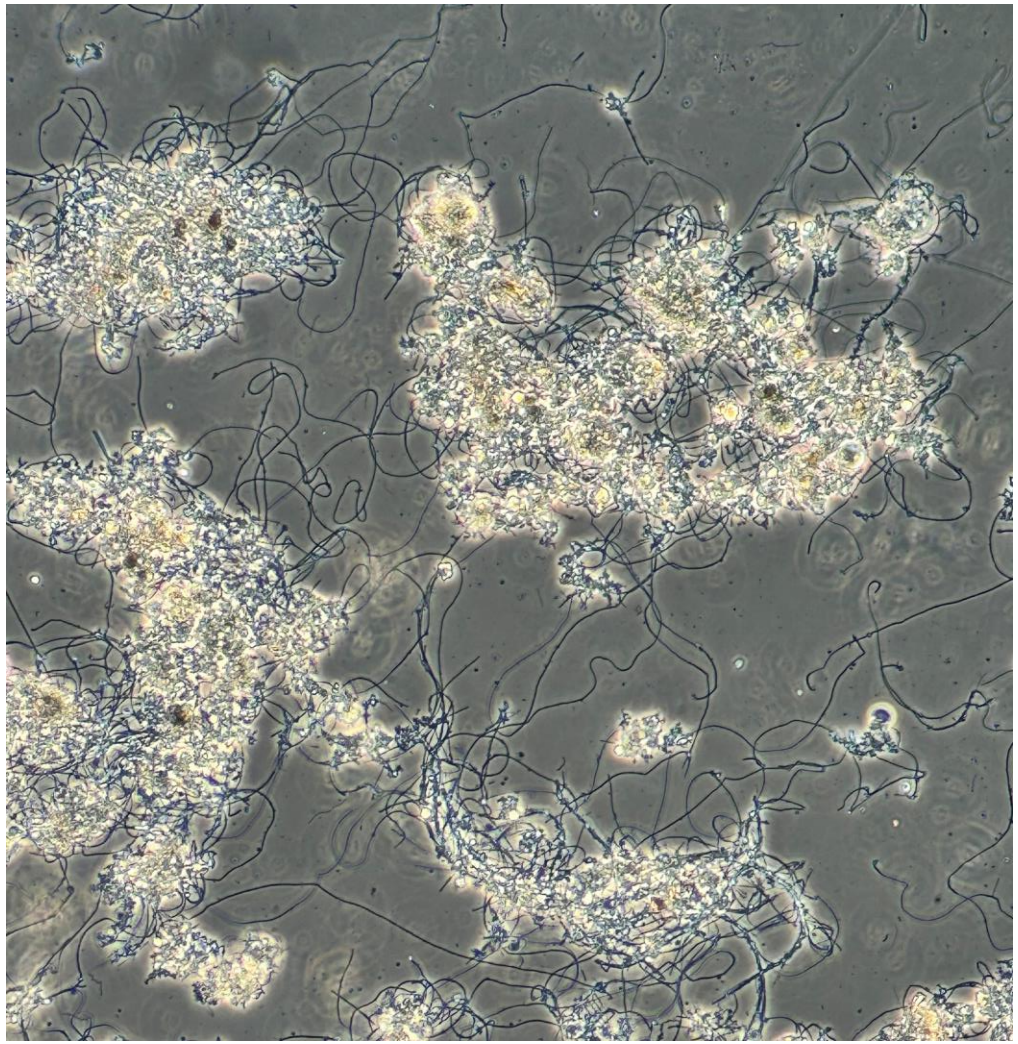
The Bellingham Post Point Plant (prior to recent upgrades)



Historically poor settling sludge

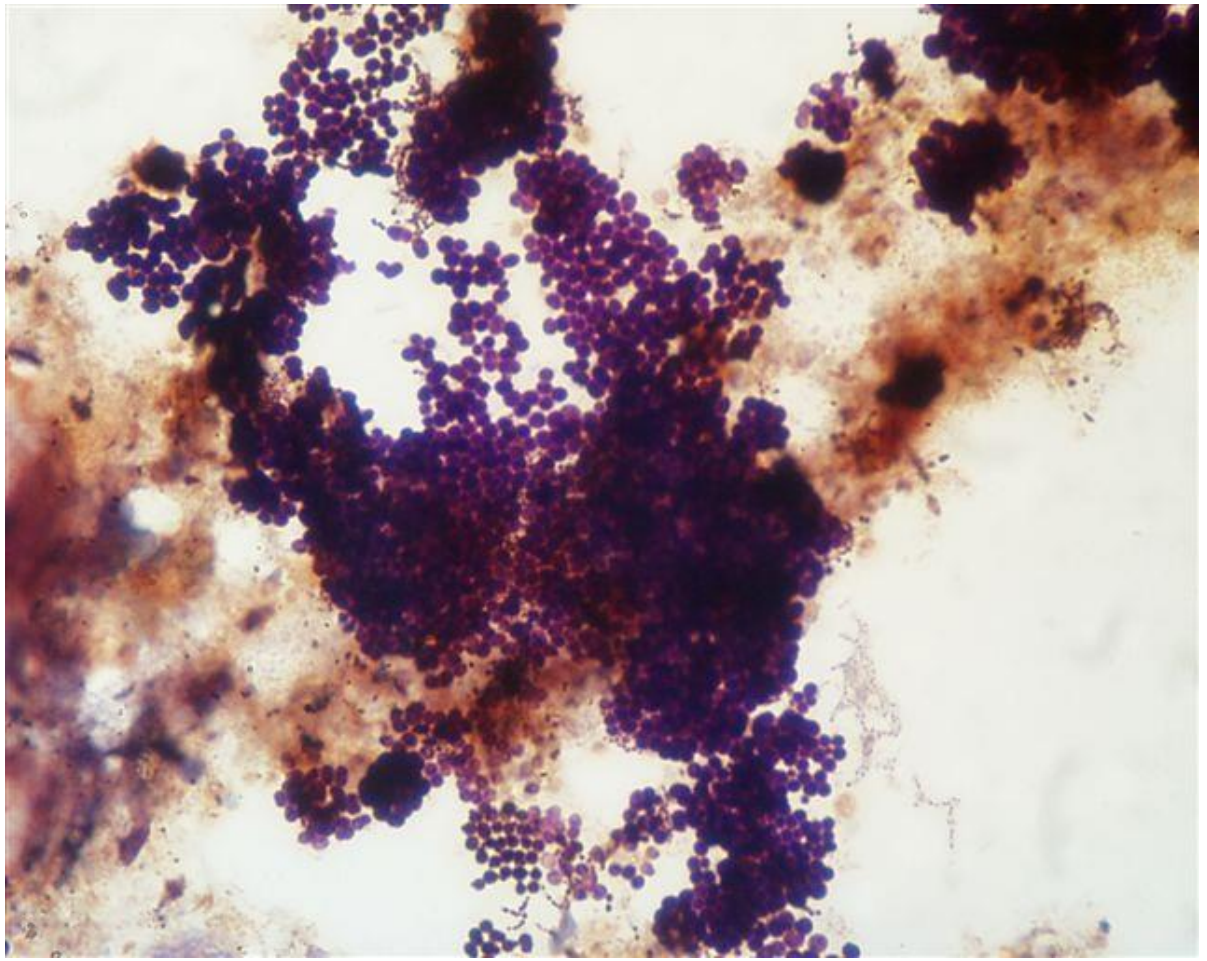


Filaments cause poor settleability

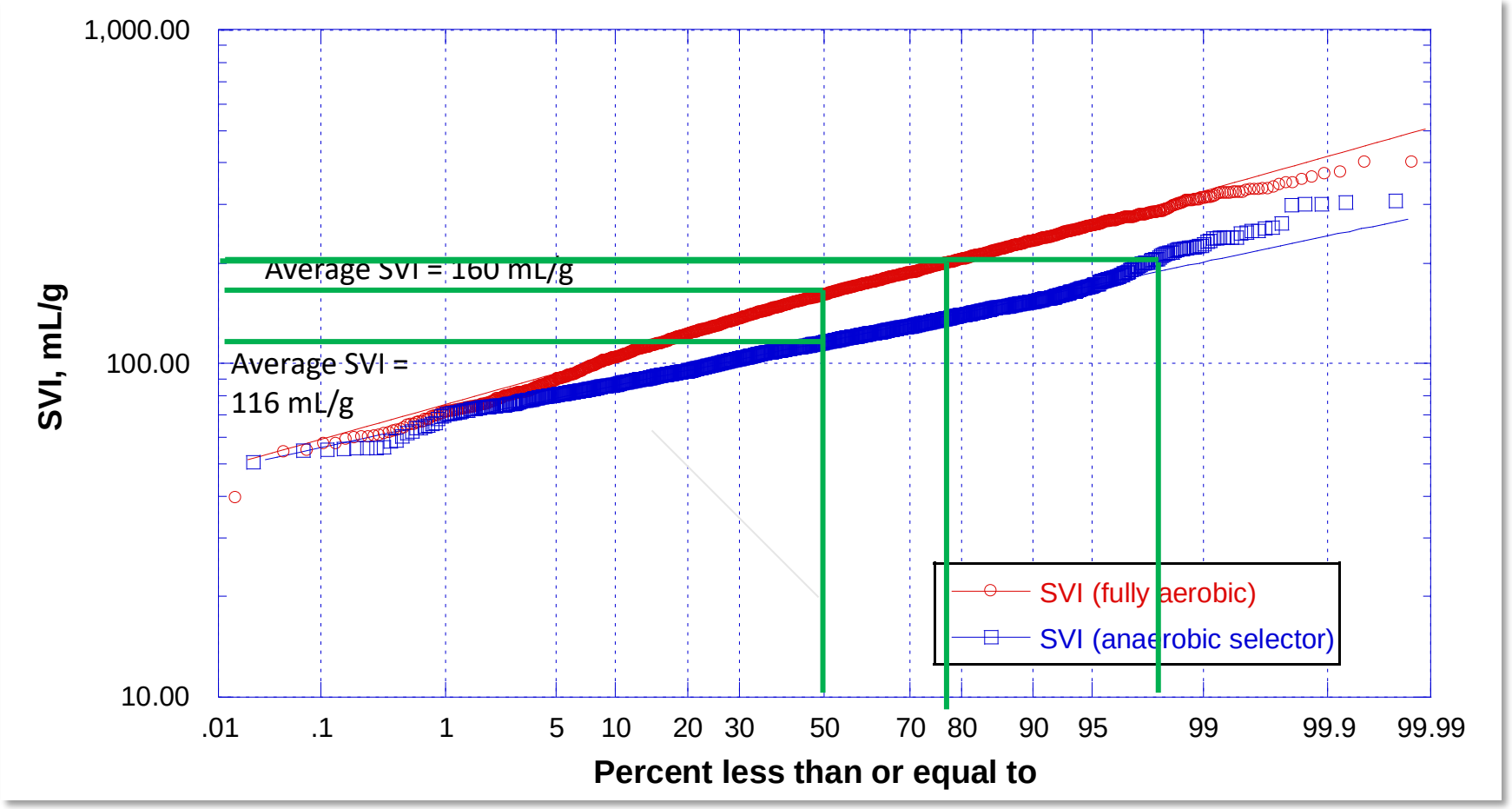


Addition of an anaerobic selector allowed for the growth a PAOs

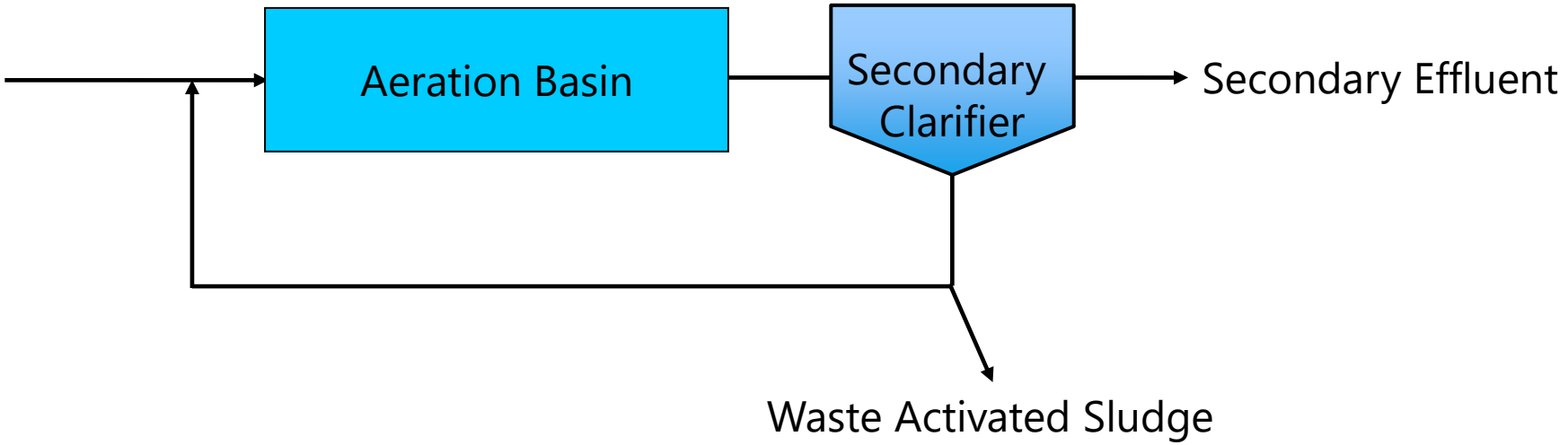
- Provide an uptake zone for VFAs
- Encourage growth of Phosphorus Accumulating Organisms (PAOs)
- Compact flocs settle faster than highly filamentous sludges



Selector improved SVIs

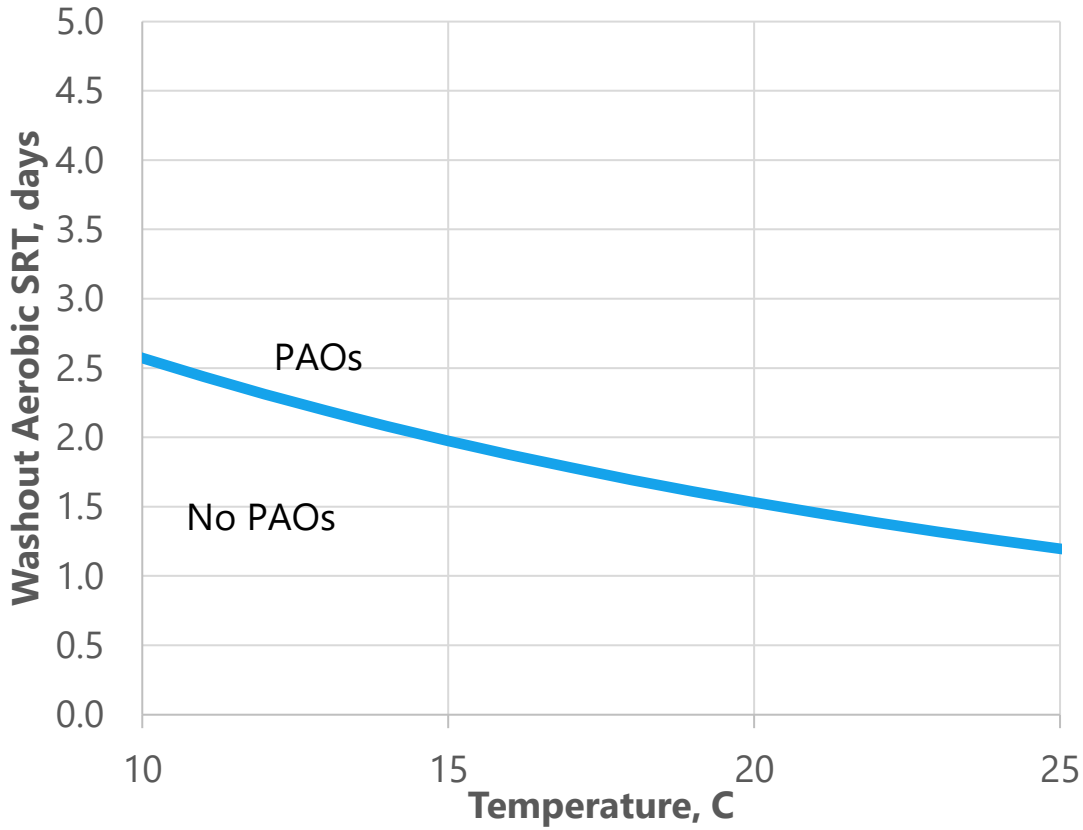


SRT Refresher Courser

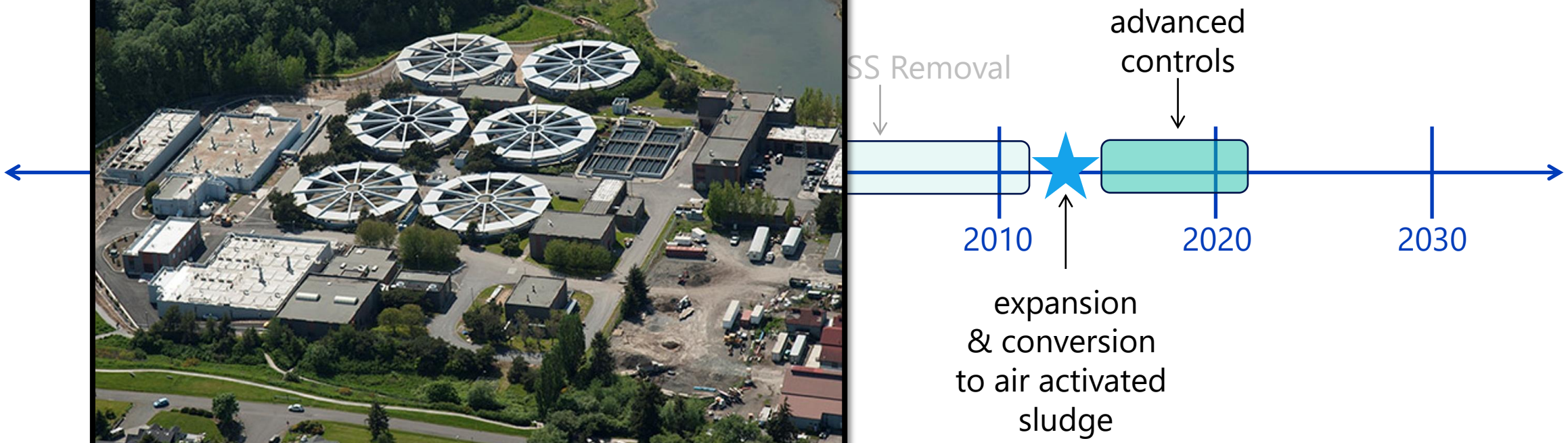


$$\text{SRT} = \frac{\text{Total Aeration Basin Solids}}{\text{Total Solids Wasted}}$$

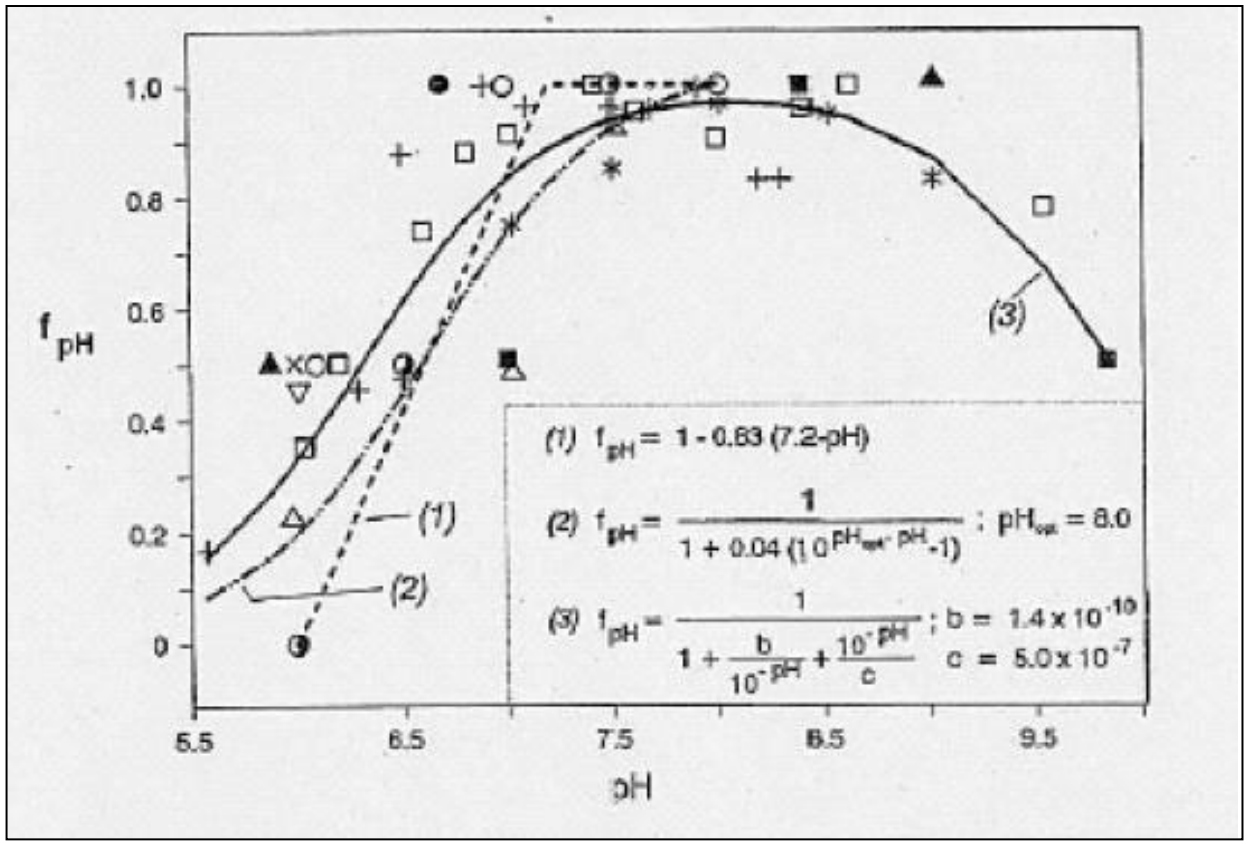
Post Point adjusted SRT to maintain a healthy population of PAOs



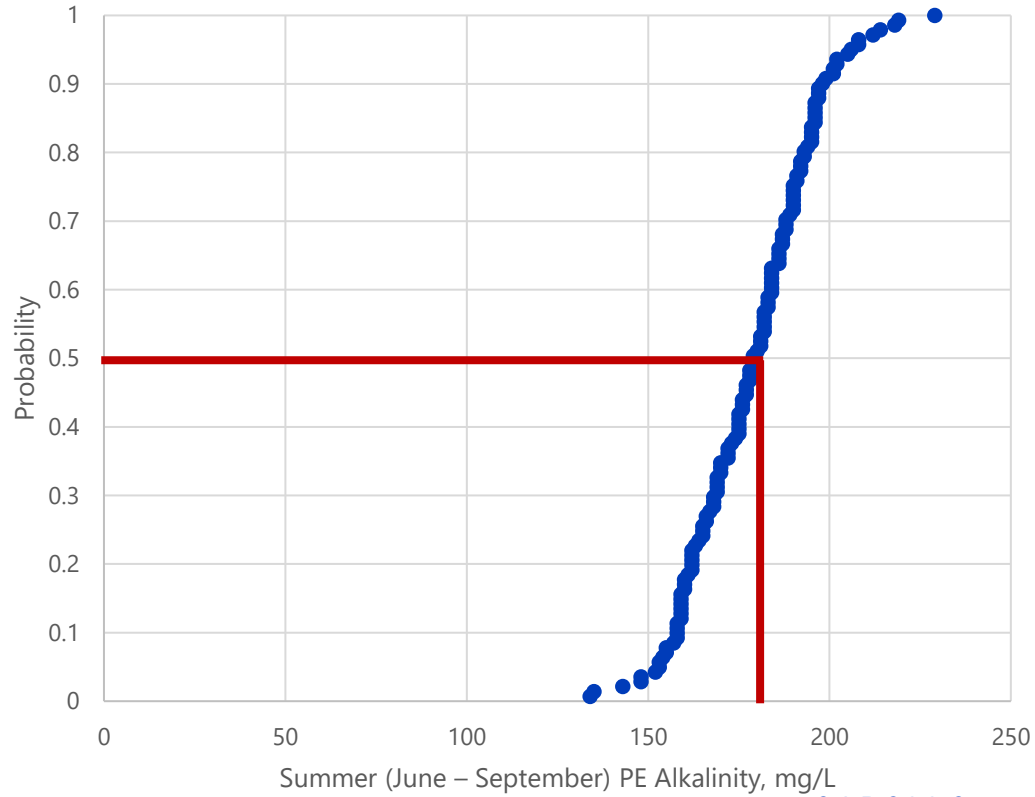
3. Air activated sludge



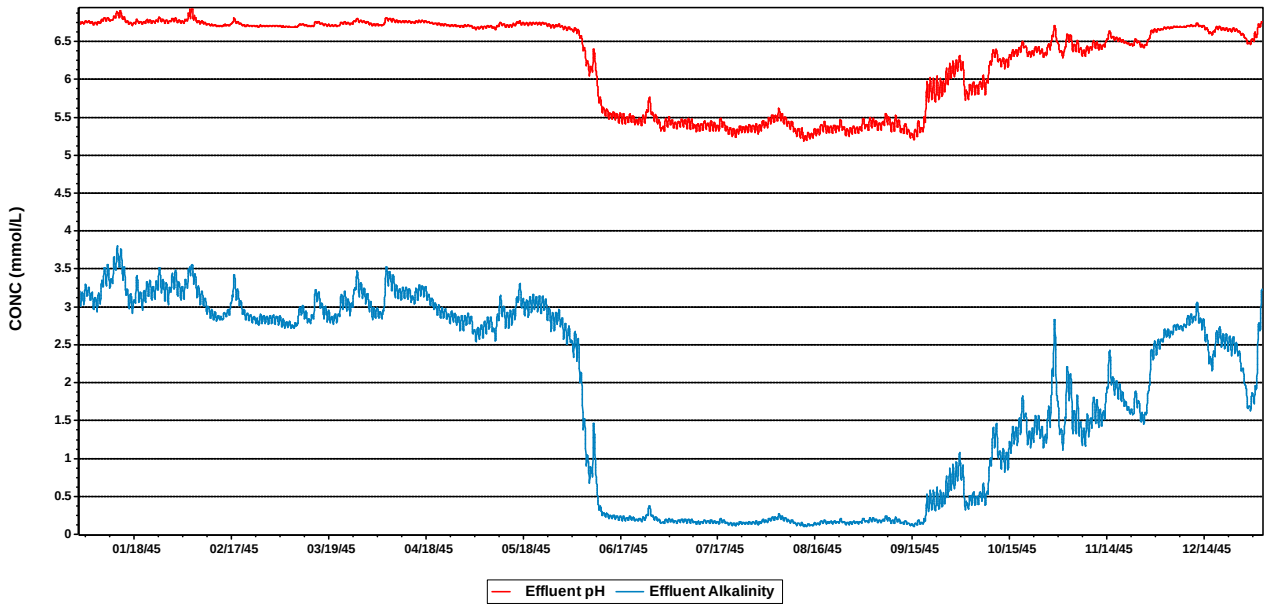
Converting from HPO to air increased need for control

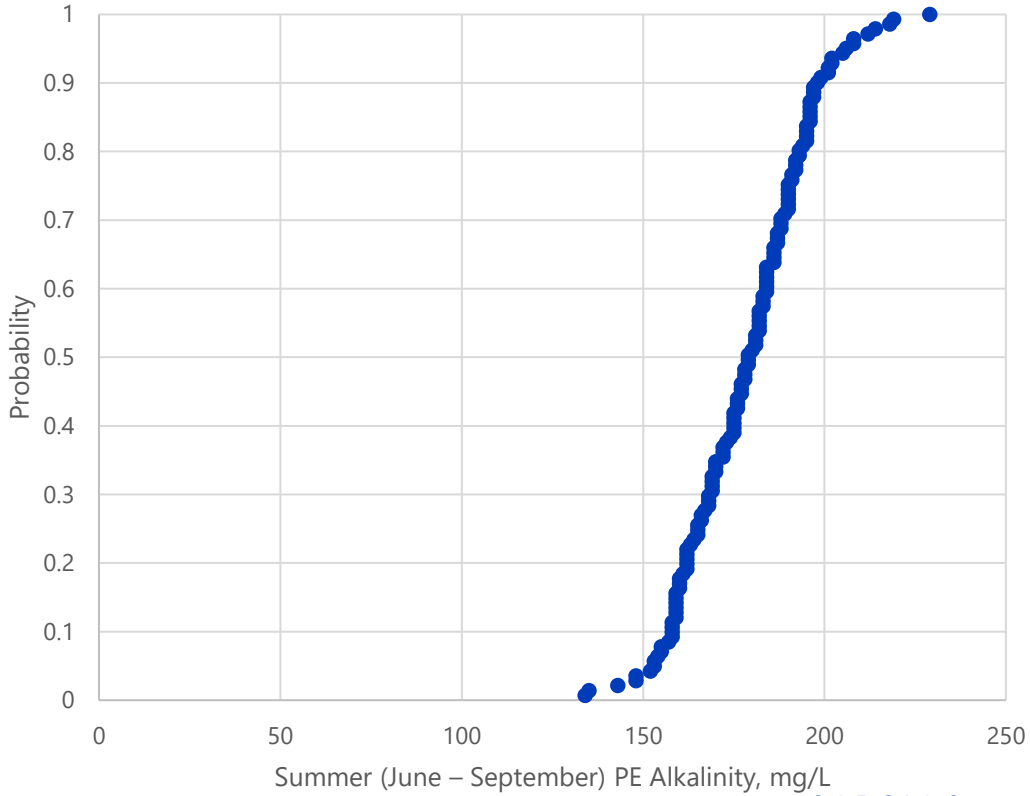


Credit: WEF 1998

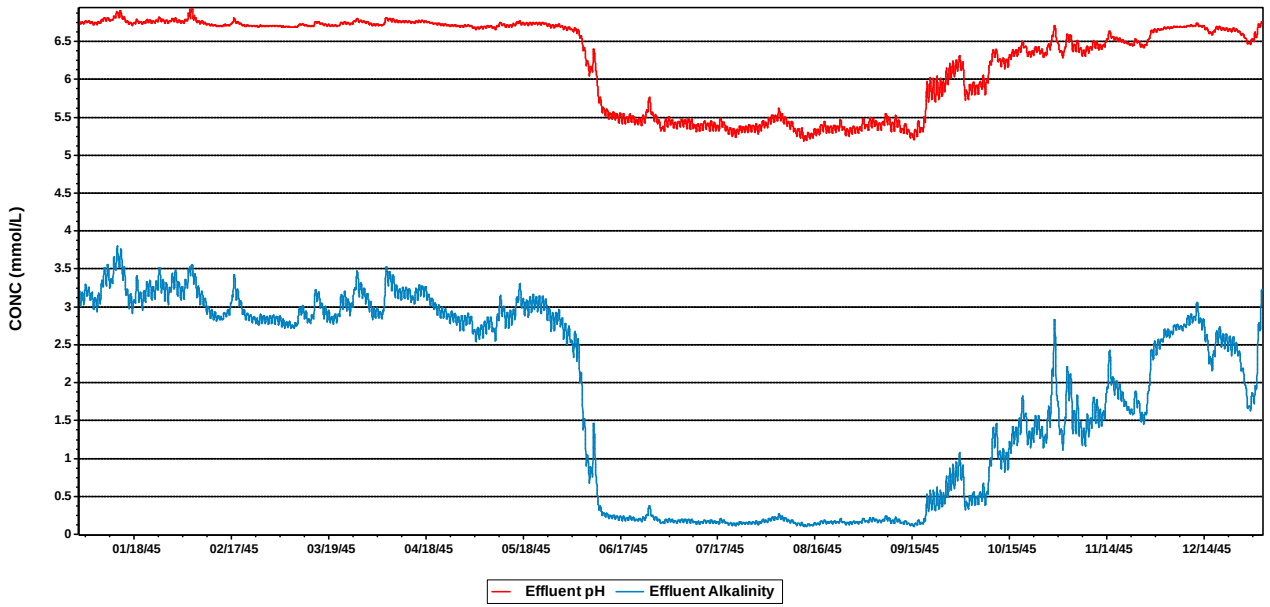


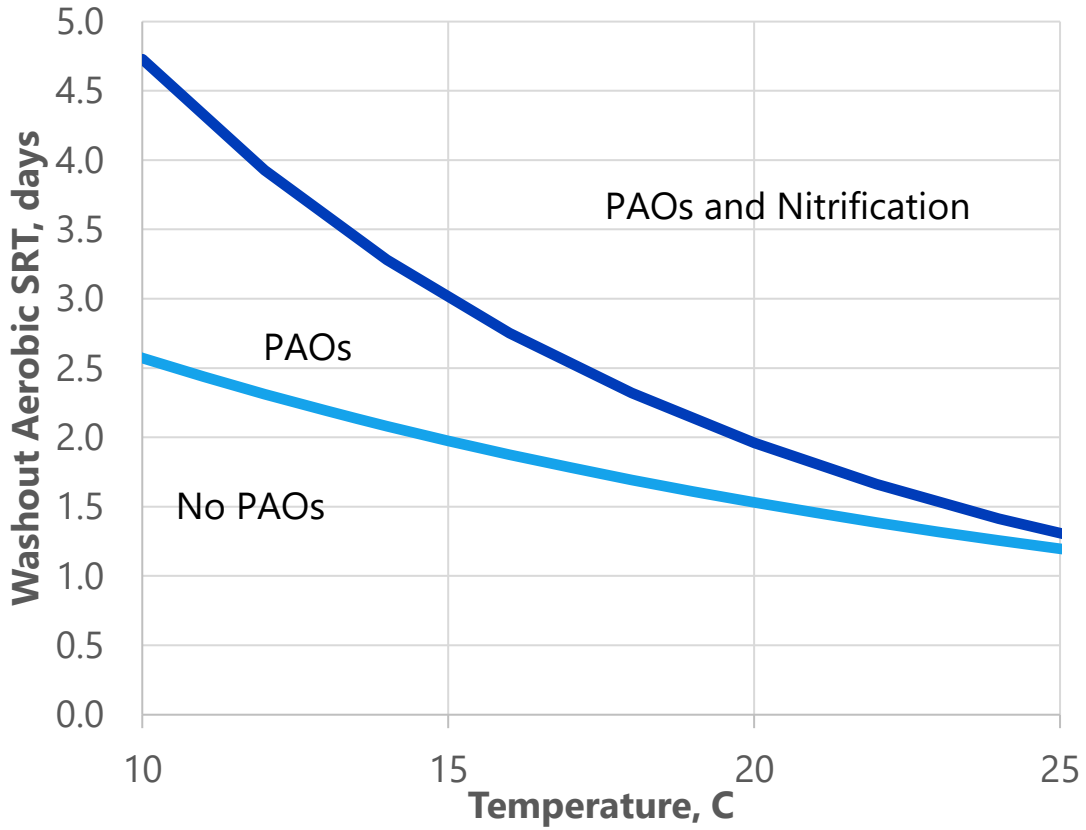
Converting from HPO to air increased need for control





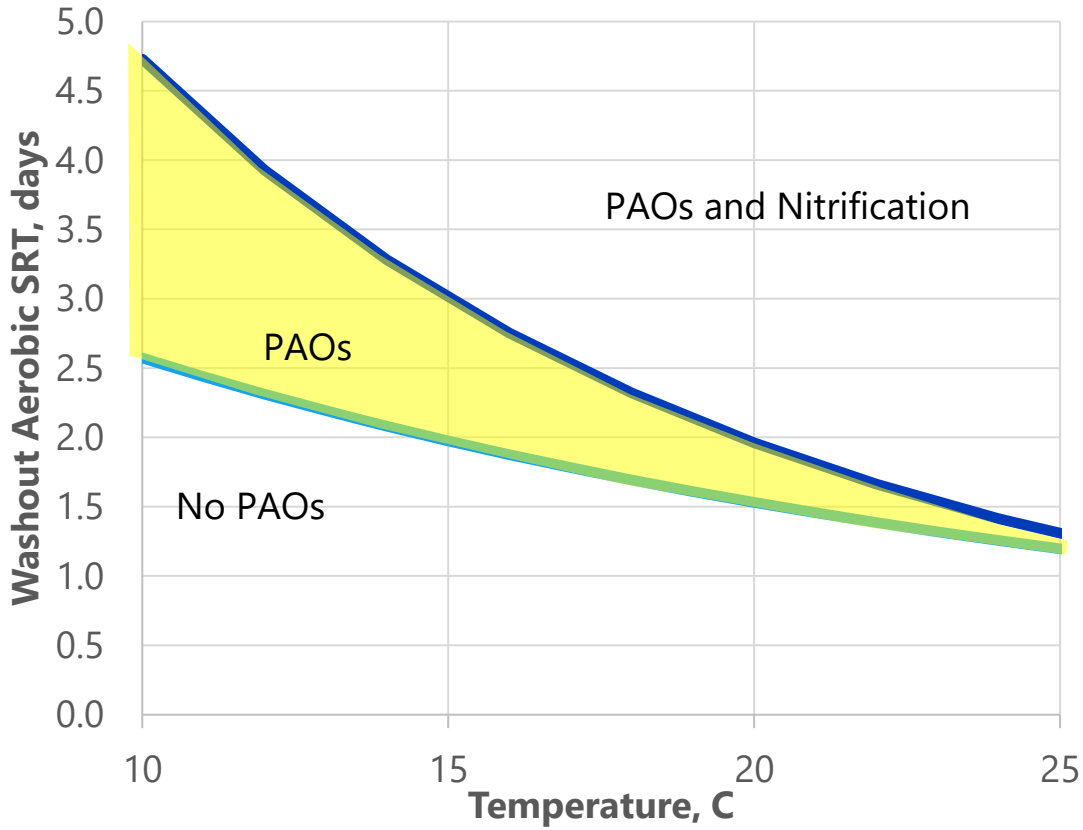
Converting from HPO to air increased need for control



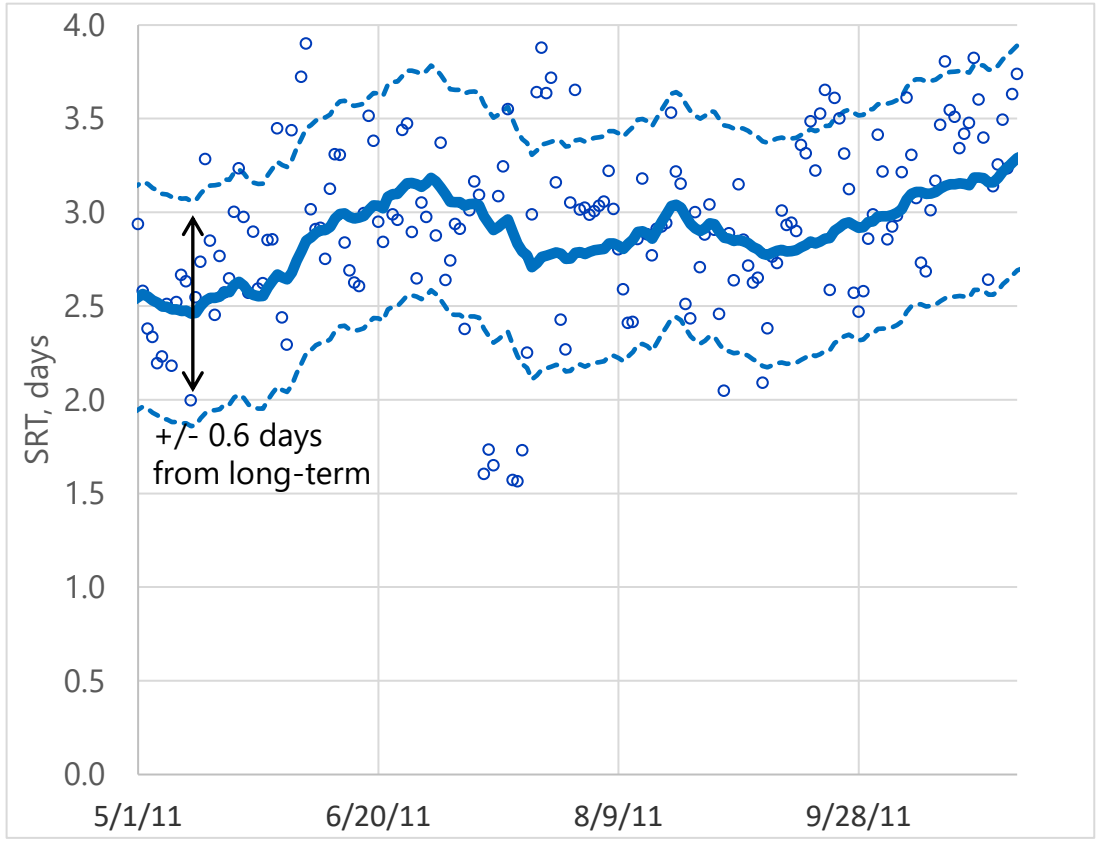


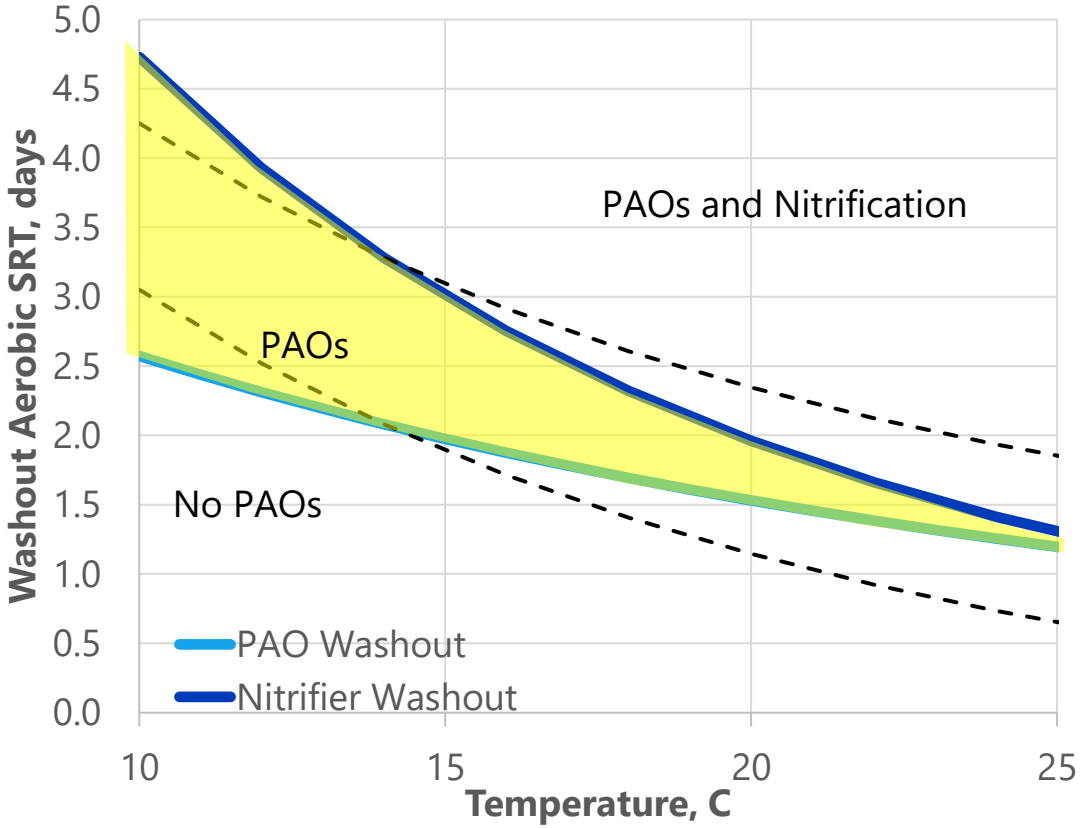
Converting from HPO to air increased need for control

- Acceptable operating band is quite narrow in the summer months

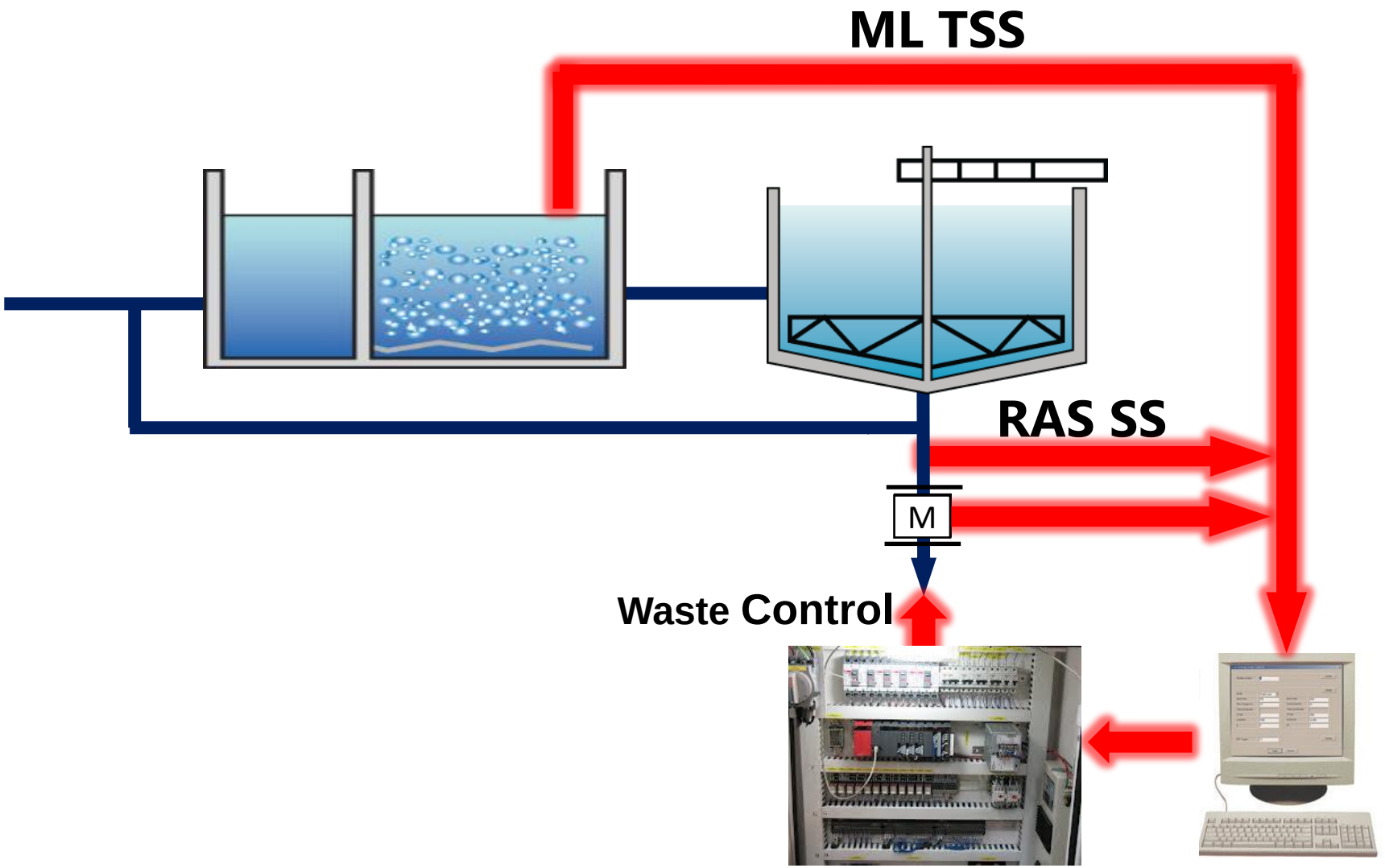


Manual control was not sufficient during the summer

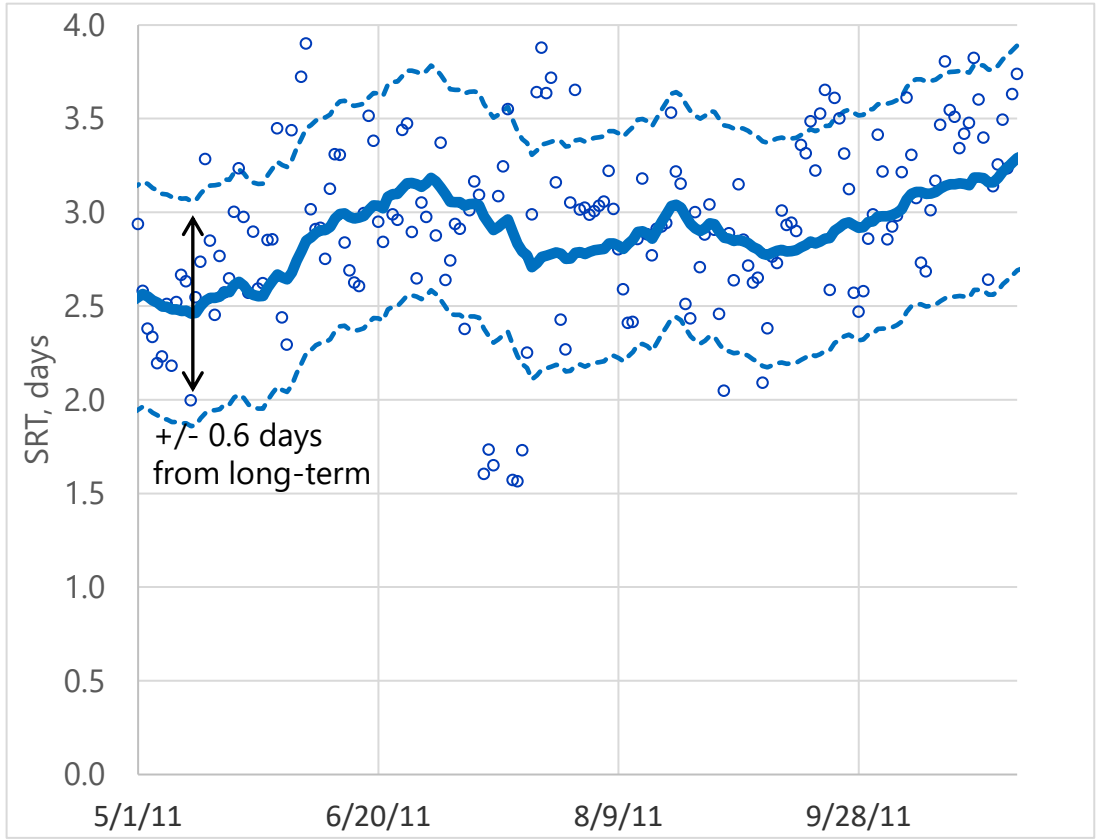


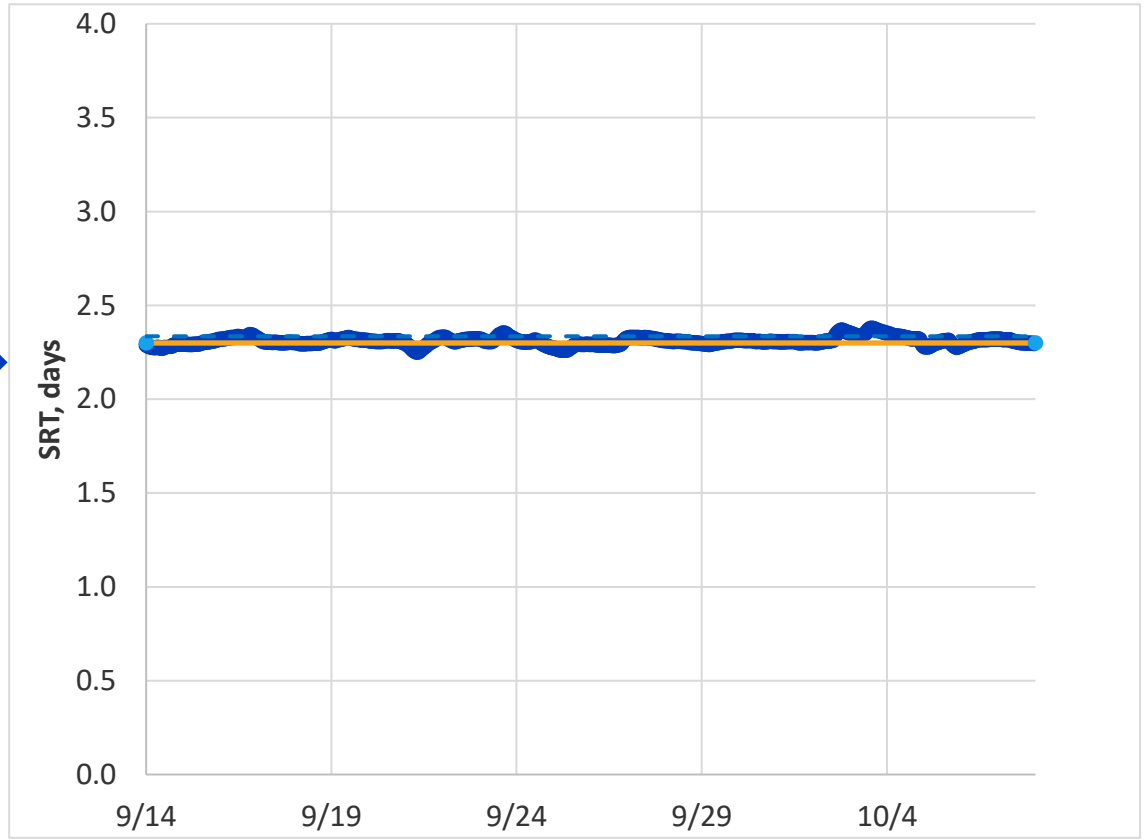


Automated SRT control can provide tight control



Automated system resulted in tight SRT control





Advanced SRT control helped Post Point maintain good settleability

No nitrogen removal

- Advanced SRT control provided a great tool to allow Post Point to stay out of nitrification while maintaining good settleability

Implementing advanced SRT control at Post Point

- Automation allows accurate real-time tracking, correction, and optimization of plant performance
- Requires planning, proper location, proper installation, and programming of instruments / PLCs
- Comes with increased cleaning, checking, maintenance, calibration, and operation duties

Automating Solids Retention Time (SRT)

Where we are headed

- Continuous online measurement of mixed liquor and waste activated sludge TSS
- SRTmaster™ algorithms control wasting and return rates based on desired SRT setpoint
- Based on real time data vs. waiting on lab results
- Better settleability and more consistent loading to sludge handling facilities

How we got there

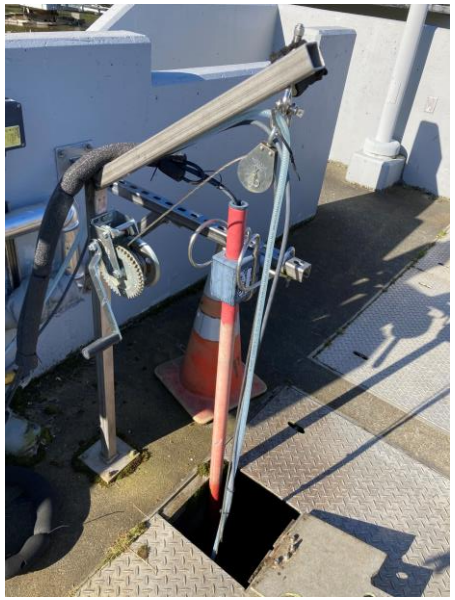
Installation of TSS probes at mixed liquor splitter box and WAS line.

Tuning of SRTmaster™ based on plant specific computerized modeling.

Adapting to the real-world dynamics of the plant and new instrumentation.

Online TSS probes

Cerlic ITX20



MLSS
Submerged probe
Stanchion mounted
Easy access
Relatively stable
Self cleaning (W3)
Not prone to fouling

Cerlic ITXIL

WAS TSS
Inline probe
Pipe insert
Complicated access
More variable
Self cleaning (W3)
Prone to fouling
Effected by process changes

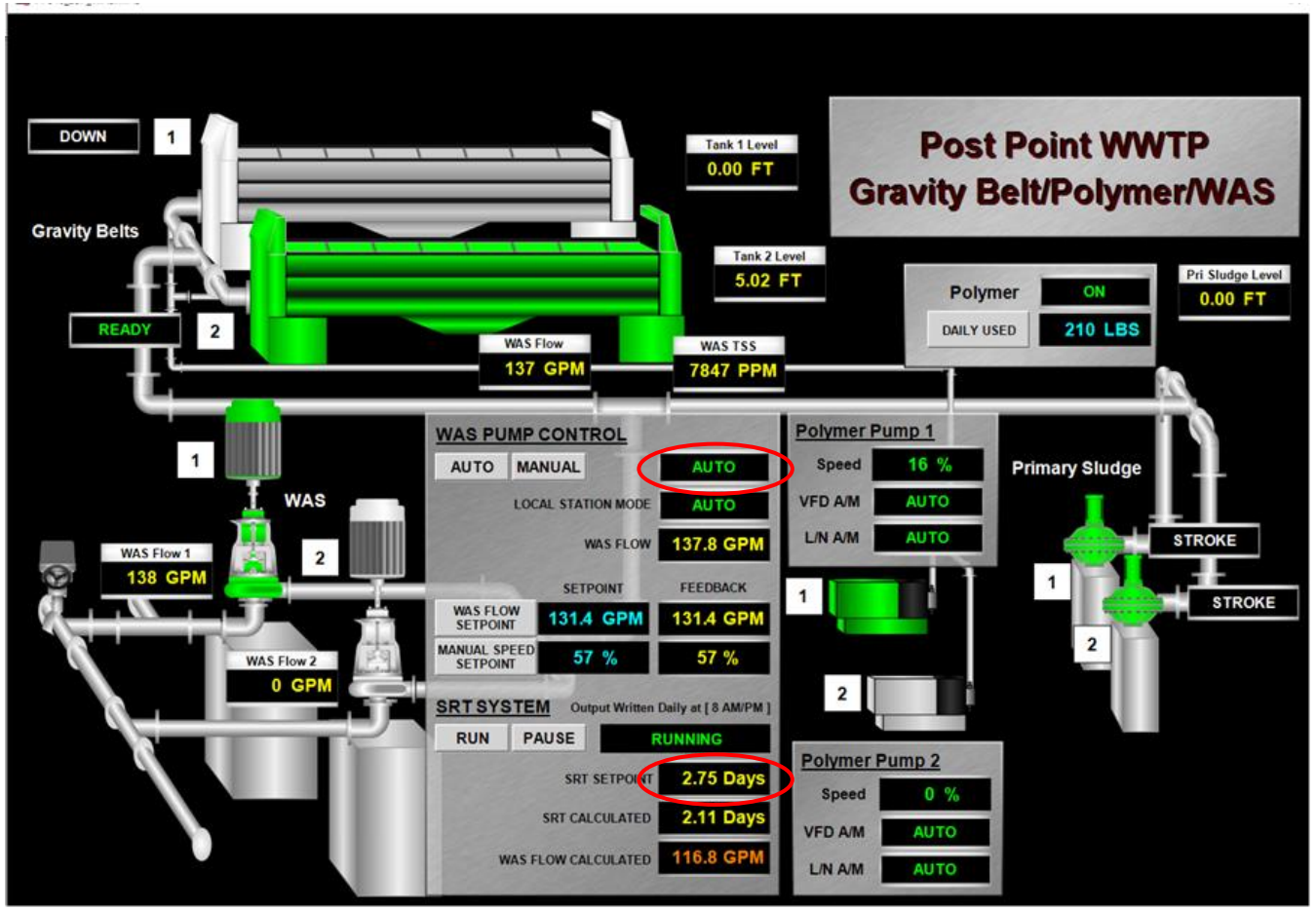
Easy-peasy right?

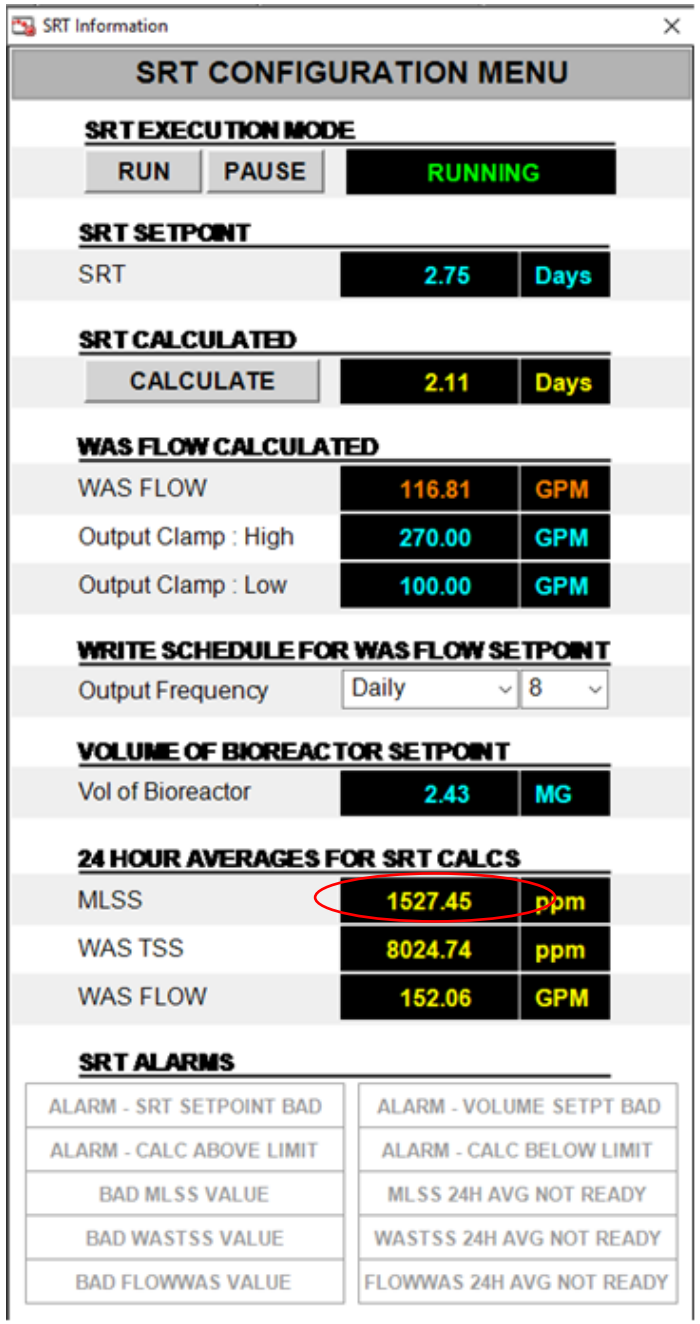
- Step #1

SRT setpoint entered

- Step #2

Sit back and watch as wasting is automated



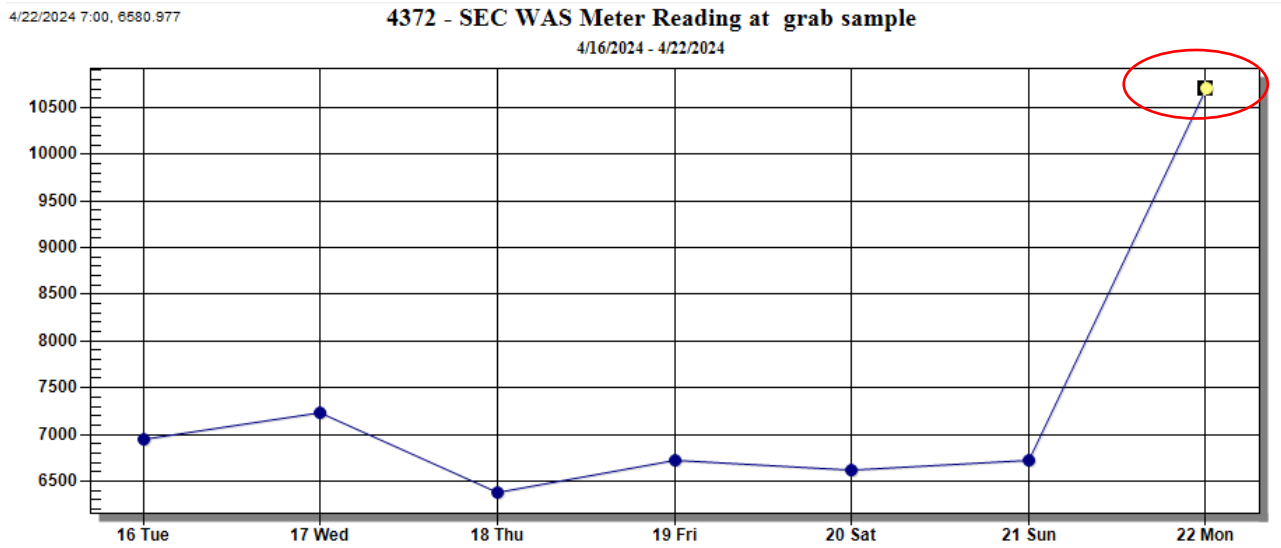


Set it and forget it?

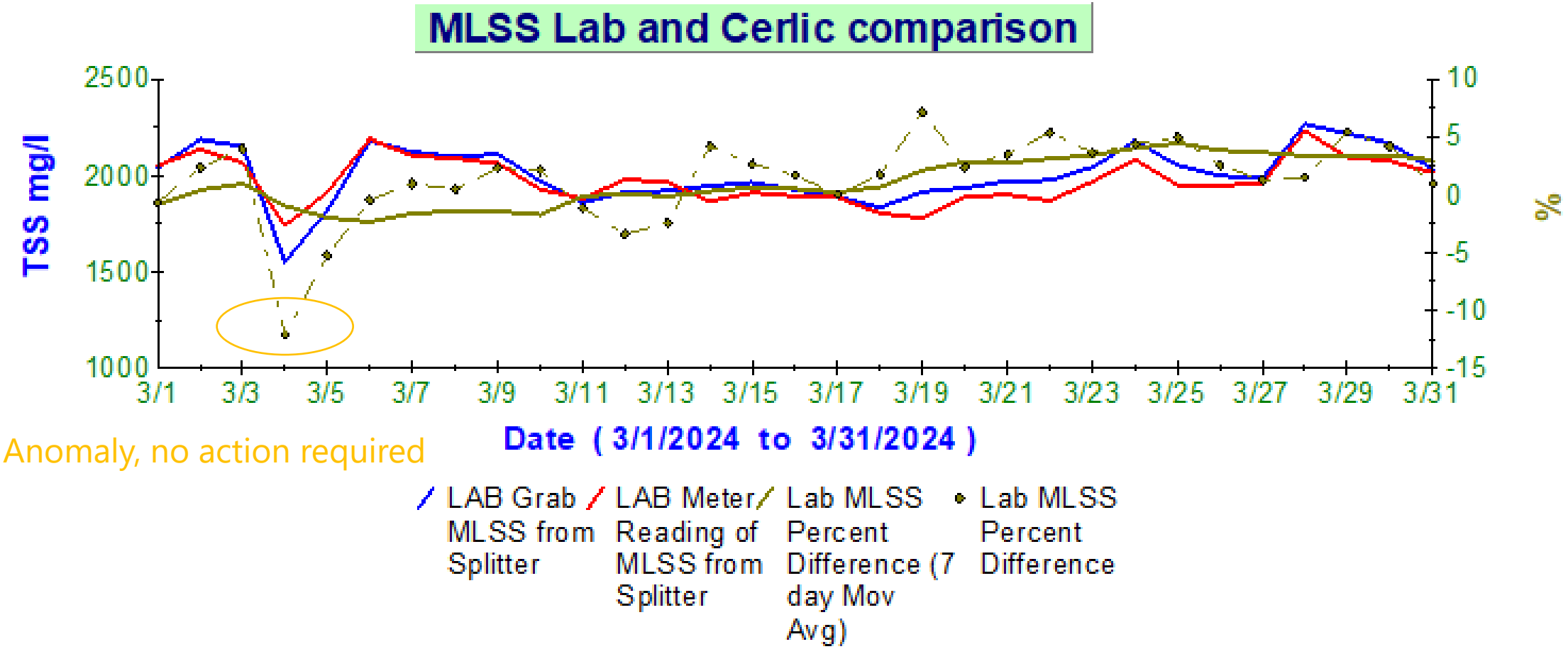
NO!

- Situational Awareness Needed!

  SRTmaster™ not put in hold while clarifier being dewatered. High WAS TSS affects SRT calculations!

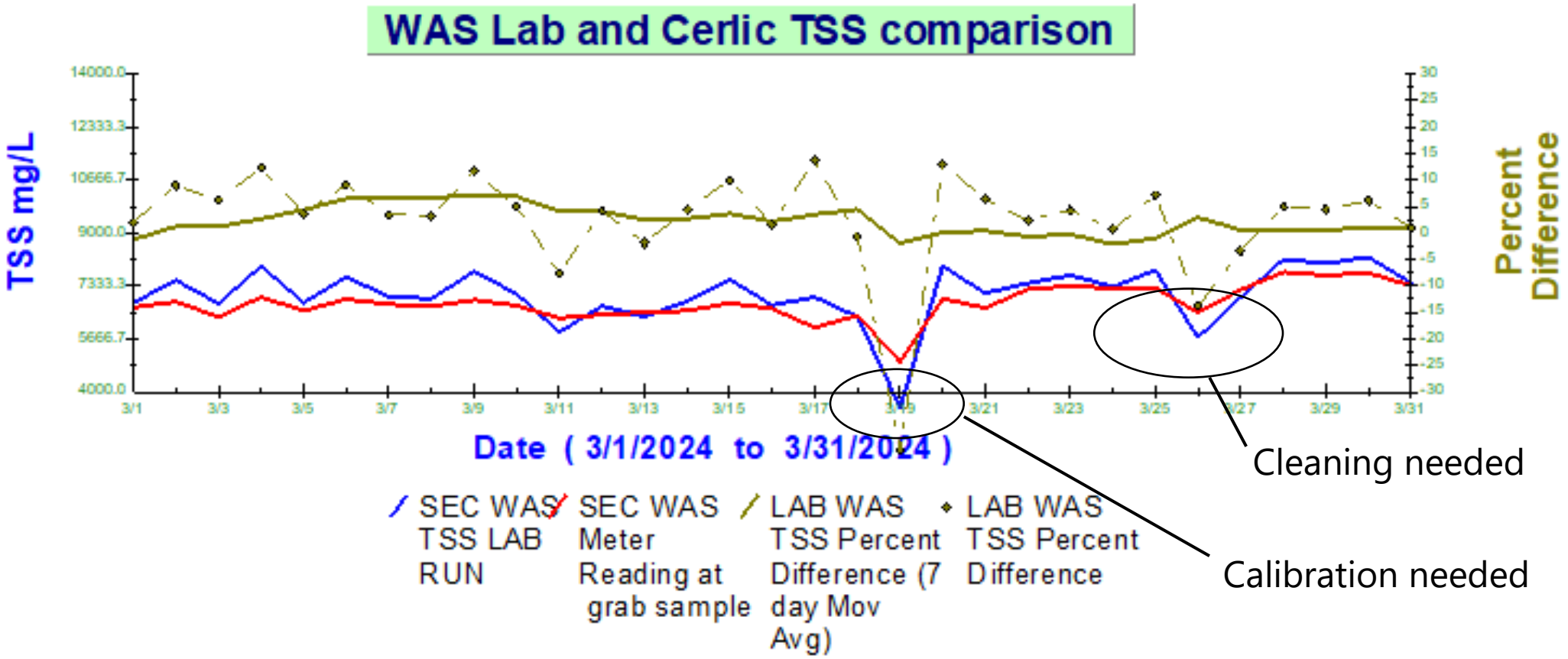


Daily calibration checks – mixed liquor

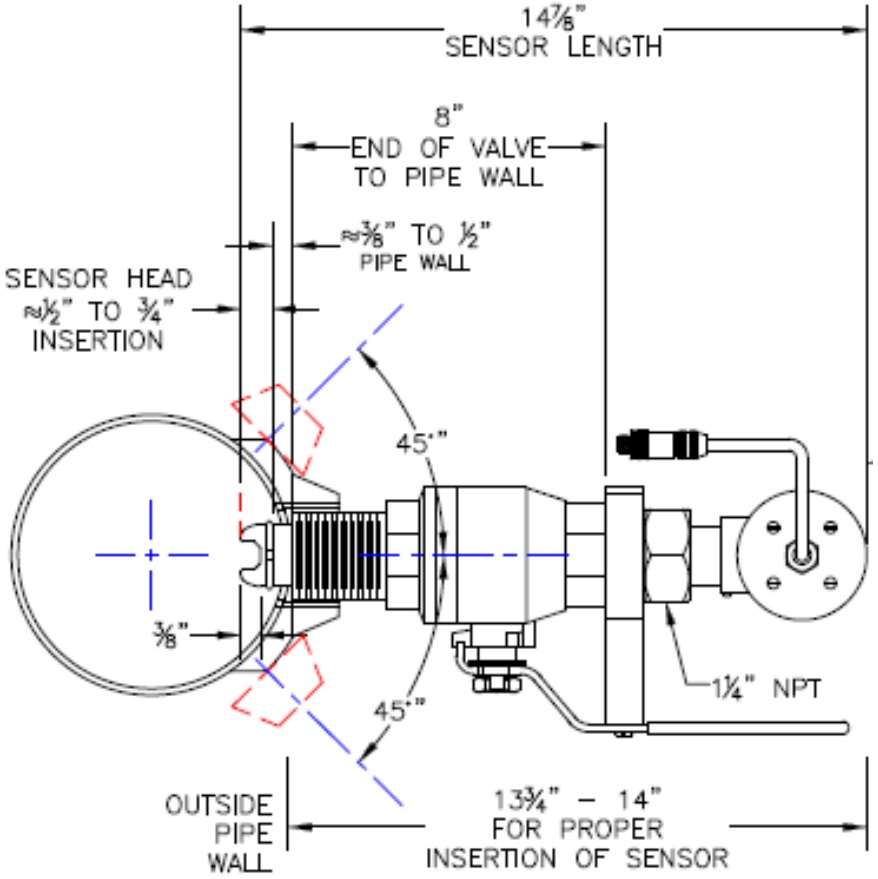


Anomaly, no action required

Daily calibration checks - WAS



Other lessons learned



HORIZONTAL MOUNTING
4" & LARGER PIPE

- Location matters!
- 100% to Spec. Installation matters!
- Process variability can have large and sometimes unexpected effects.

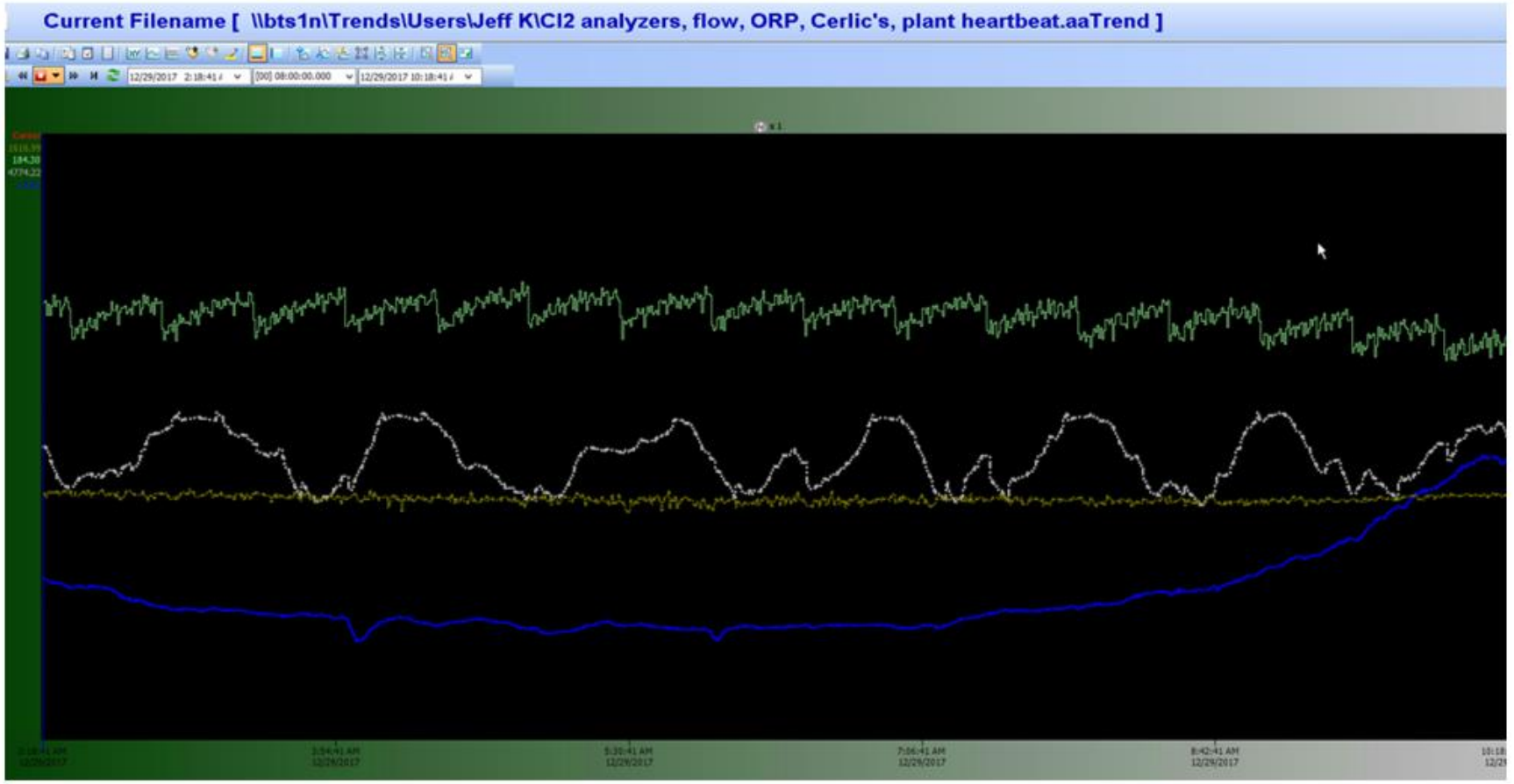
SRTMaster low flow feedback loop

WAS Flow

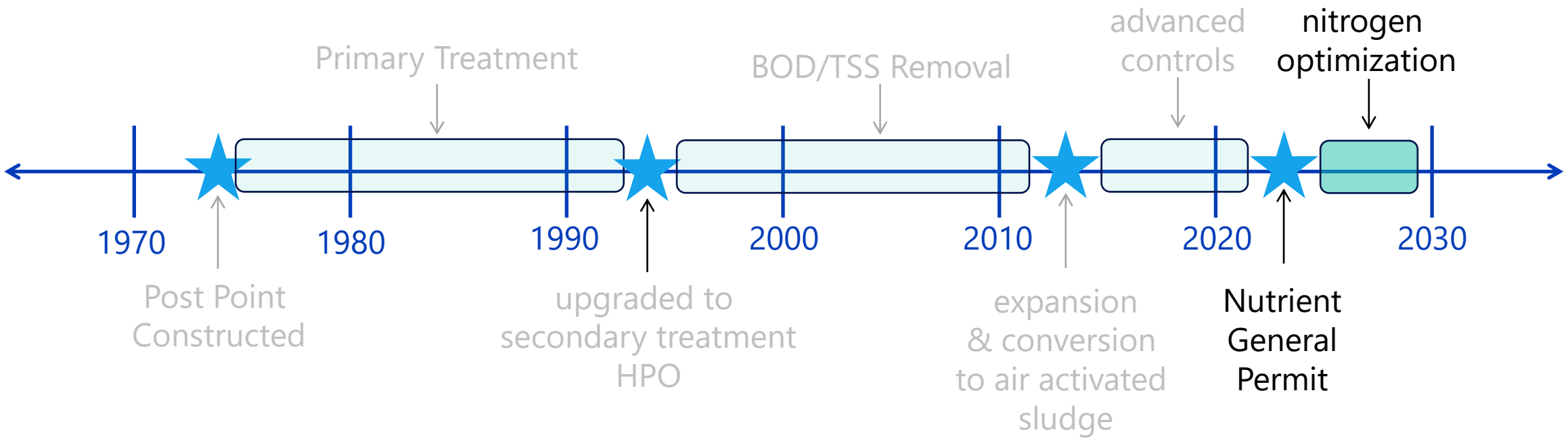
WAS TSS

MLSS

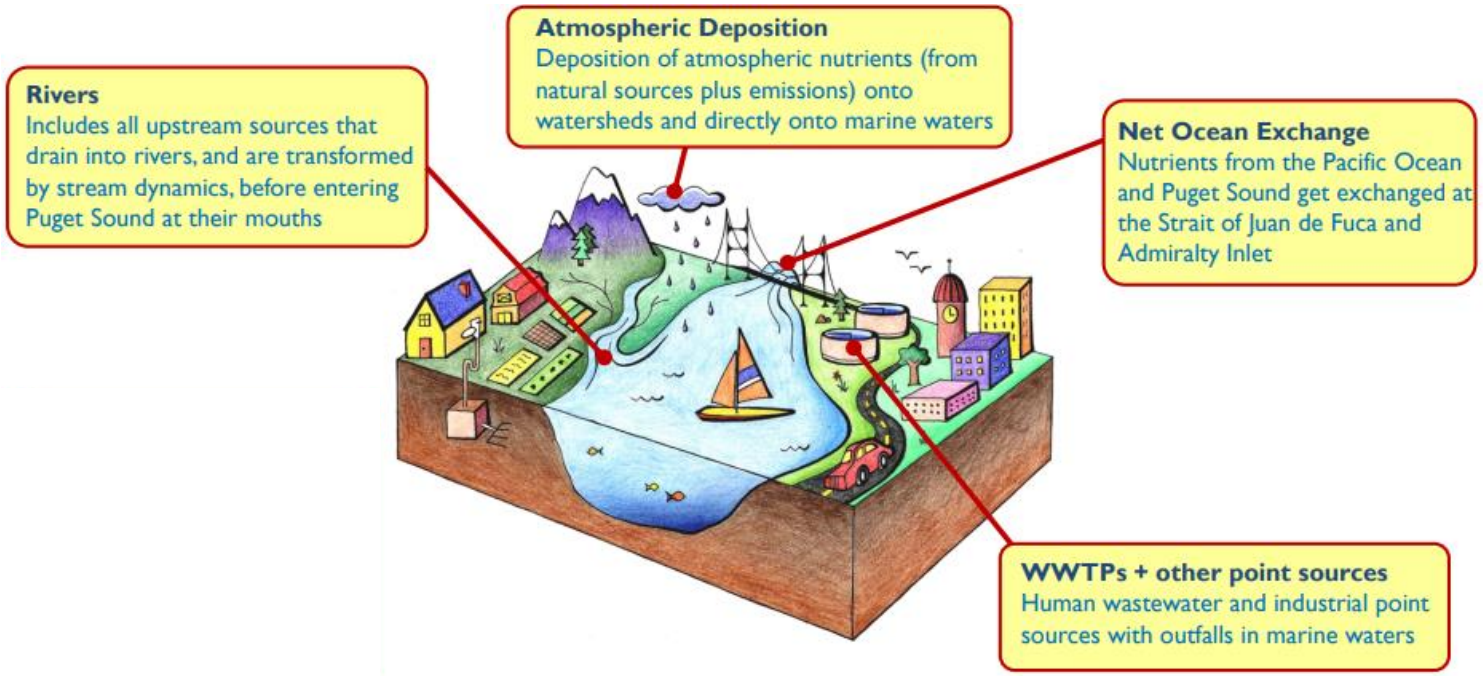
Plant Flow



4. Nitrogen optimization

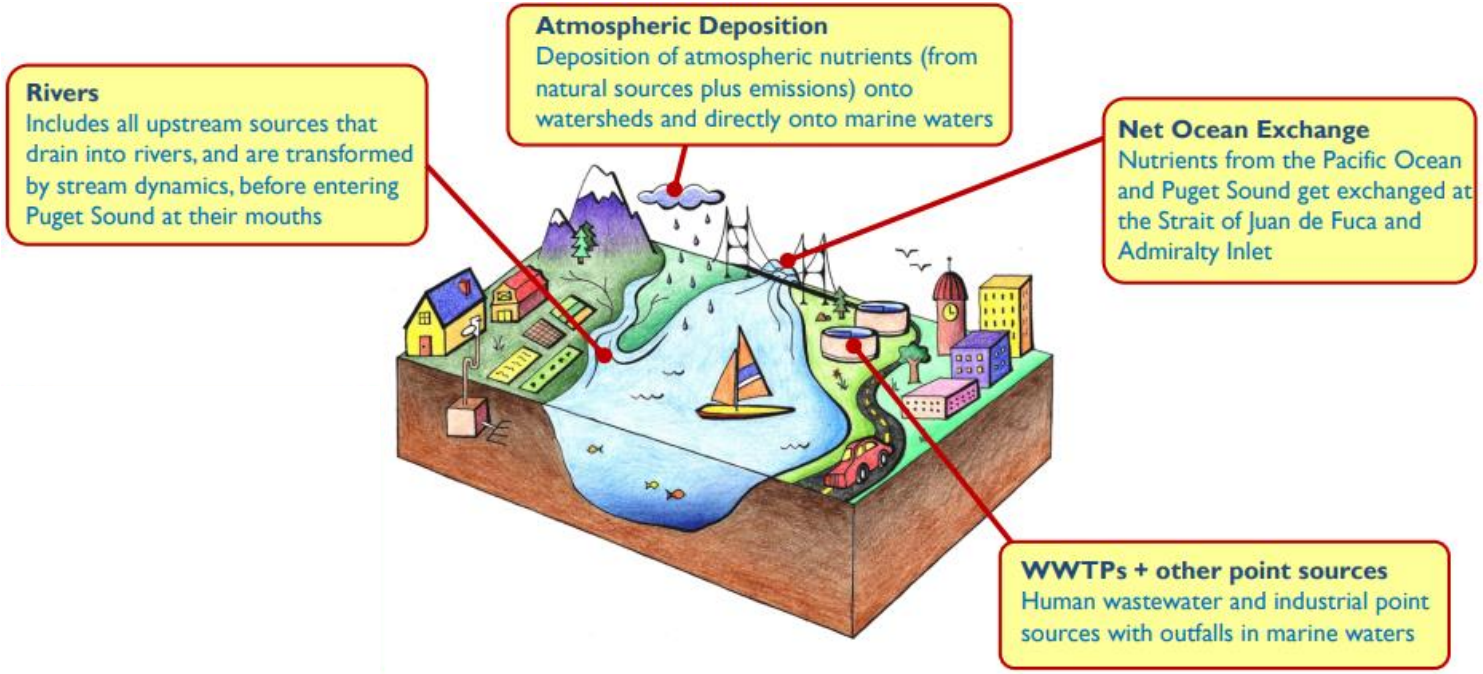


Nitrogen in Puget Sound comes from a variety of different sources

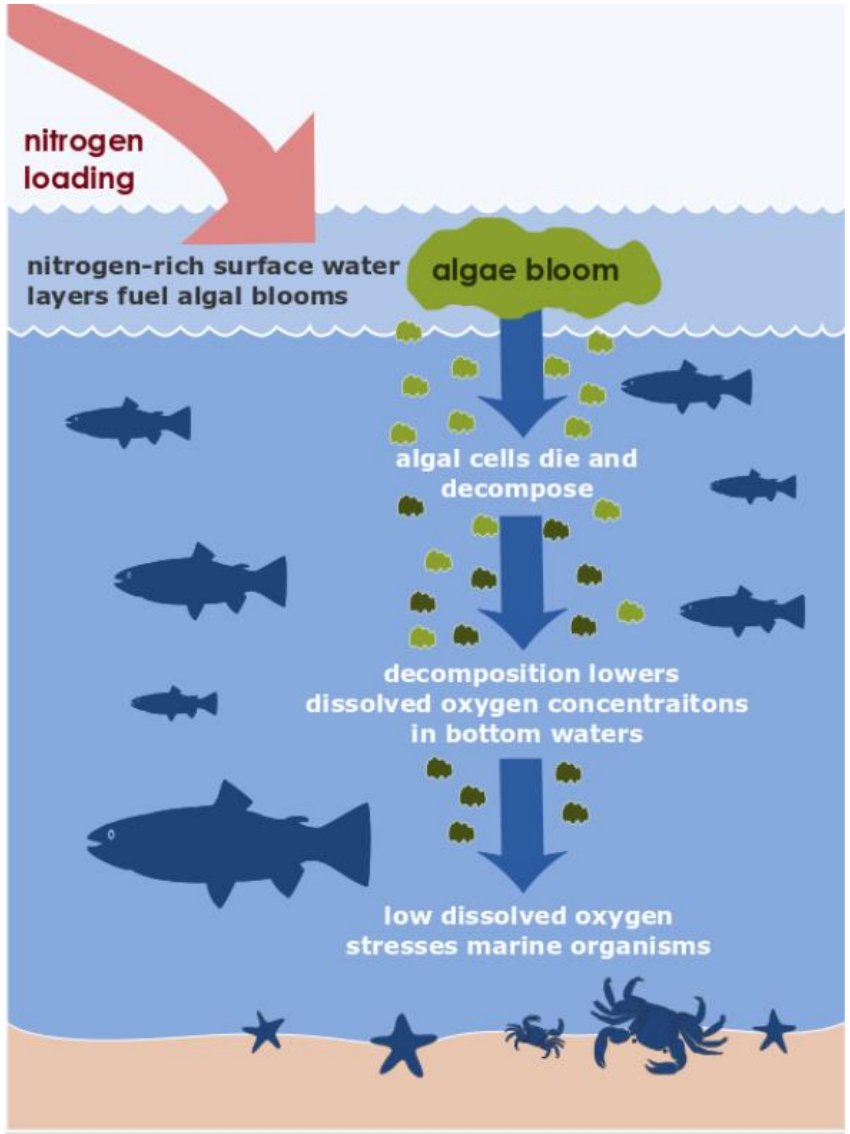


Credit: Washington State Department of Ecology

Excess nitrogen can lead to low DO concentrations in Puget Sound

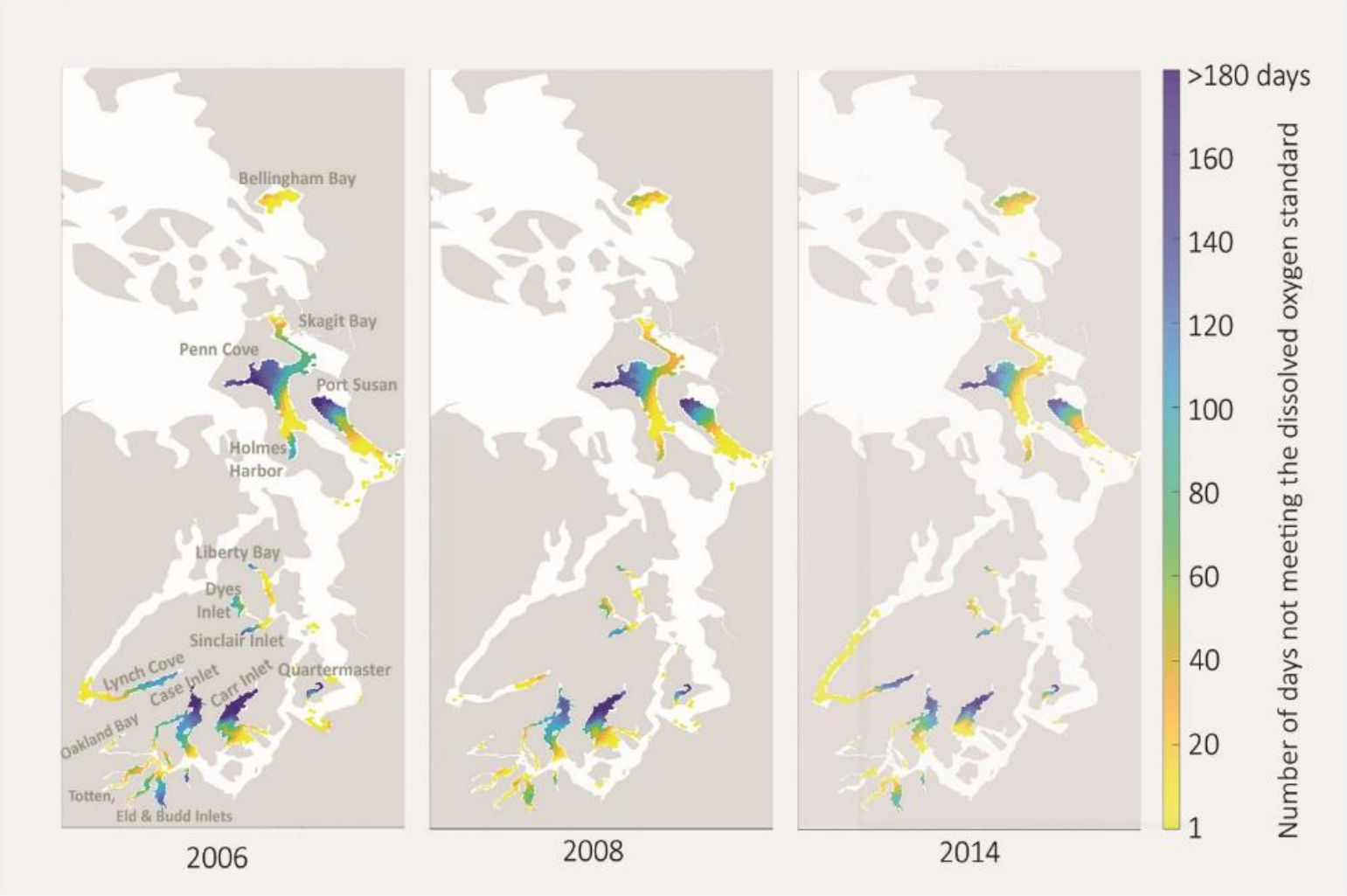


Credit: Washington State Department of Ecology



Credit: Washington State Department of Ecology

Ecology's Boundary Scenario report documented DO depletion in Puget Sound



Credit: Washington State Department of Ecology

- Boundary scenario report estimated that Nitrogen Removal at all treatment plants would reduce the number of noncompliant days by 50 – 60%

In 2022 Ecology issued the Puget Sound Nutrient General Permit

Issuance Date: December 1, 2021
Effective Date: January 1, 2022
Expiration Date: December 31, 2026

PUGET SOUND NUTRIENT GENERAL PERMIT

A NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM AND STATE WASTE DISCHARGE GENERAL PERMIT

State of Washington
Department of Ecology
Olympia, Washington

In compliance with the provisions of
The State of Washington Water Pollution Control Law
Chapter 90.48 Revised Code of Washington
and
The Federal Water Pollution Control Act
(The Clean Water Act)
Title 33 United States Code, Section 1251 et seq.

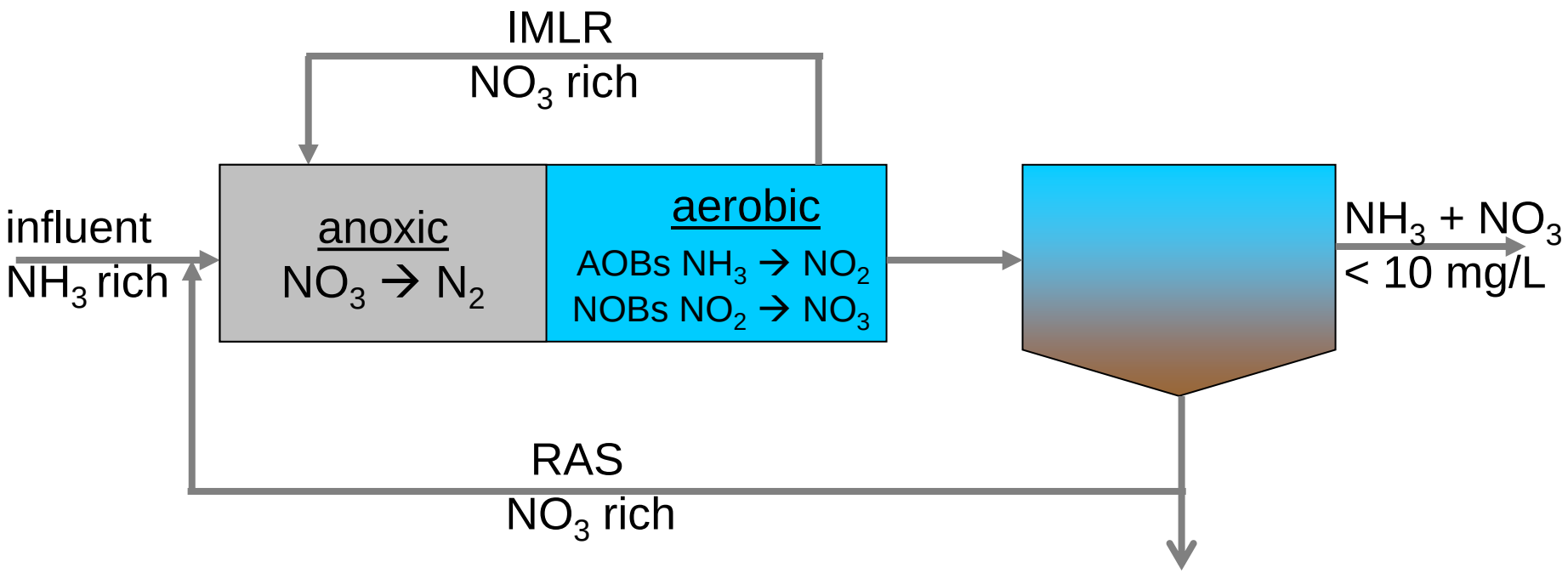
Until this permit expires, is modified or revoked, Permittees that have properly obtained coverage under this general permit are authorized to discharge nutrients in accordance with the conditions, which follow.

DEPARTMENT OF ECOLOGY
State of Washington

Vincent McGowan, P.E.
Water Quality Program Manager
Washington State Department of Ecology

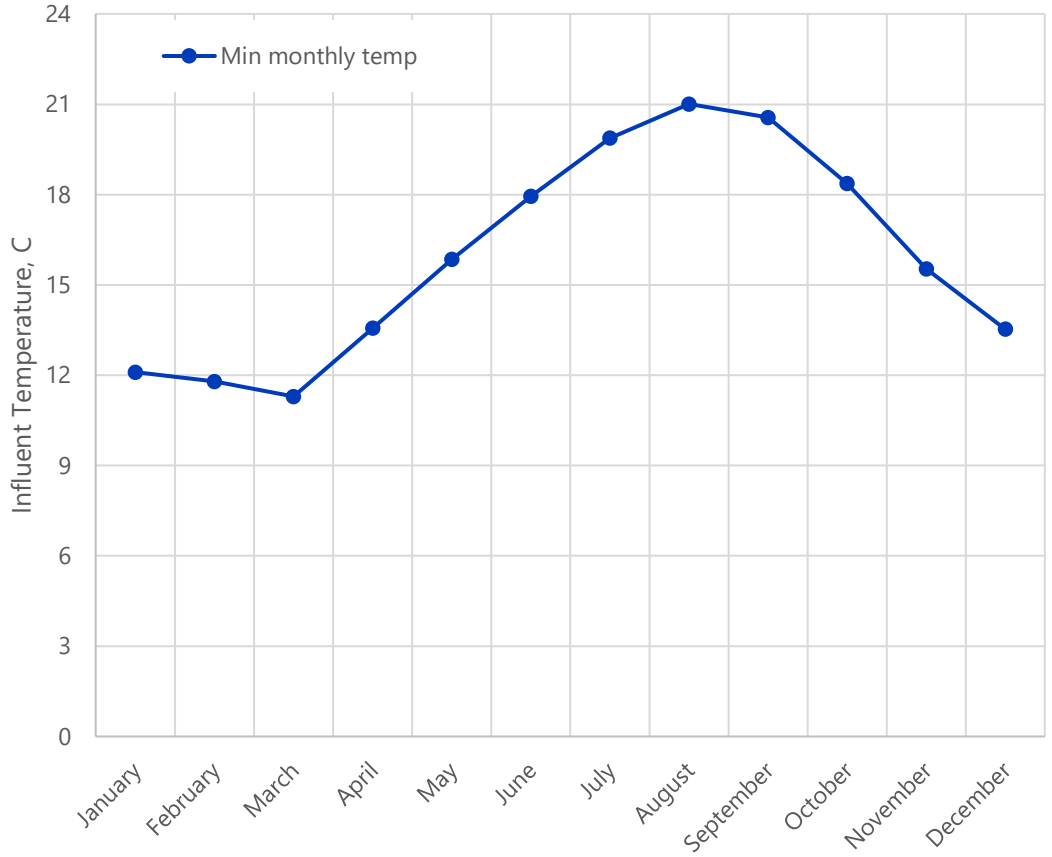
- Puget Sound Nutrient General Permit requires dischargers to:
  - Implement optimization measures to limit effluent nitrogen loads to current levels (defined Action Levels)
  - Evaluate the cost and feasibility of reducing effluent total inorganic nitrogen to levels as low as 3 mg/L during April - October

Nitrogen removal at Post Point will require several process changes



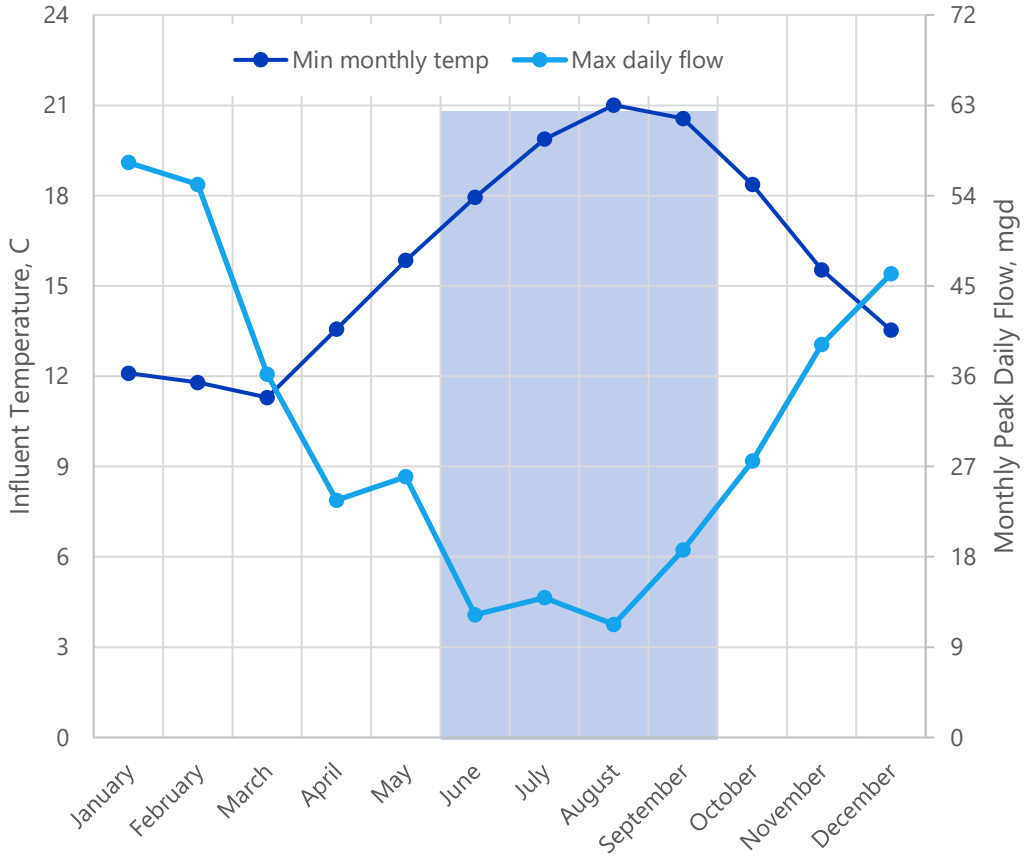
Optimum conditions for nitrogen removal occur in the warm/dry summer months

Nitrification rates are faster at higher temperatures



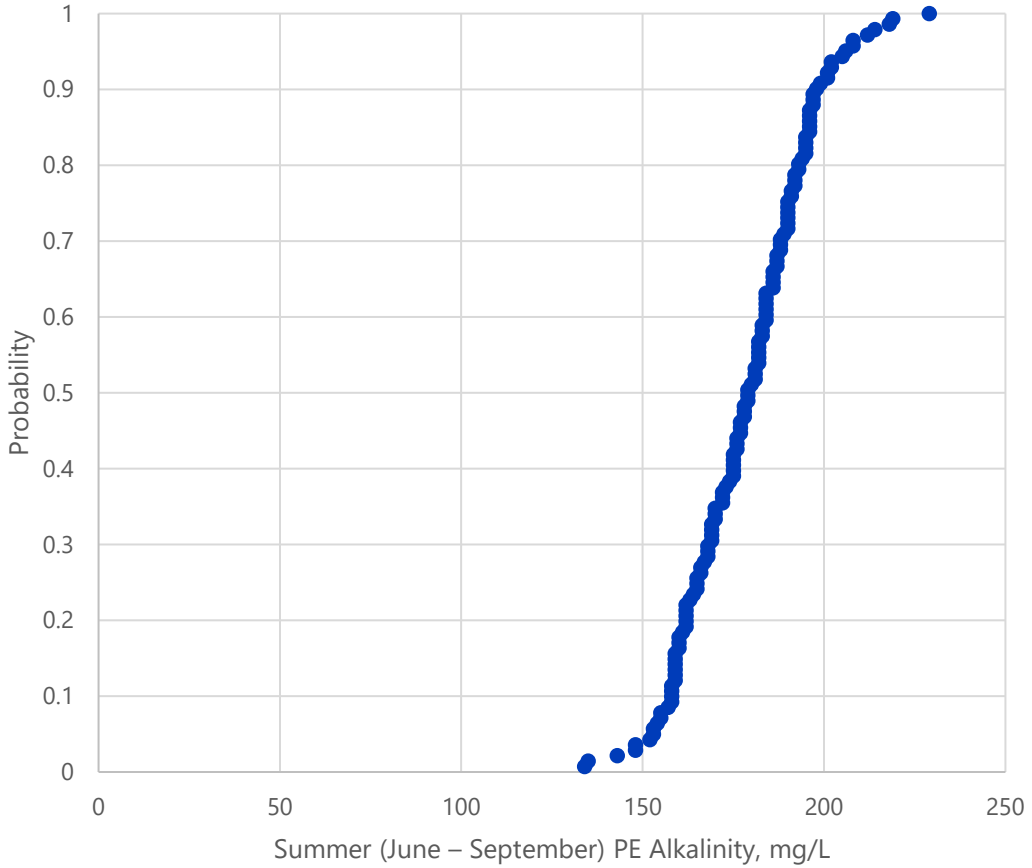
Optimum conditions for nitrogen removal occur in the warm/dry summer months

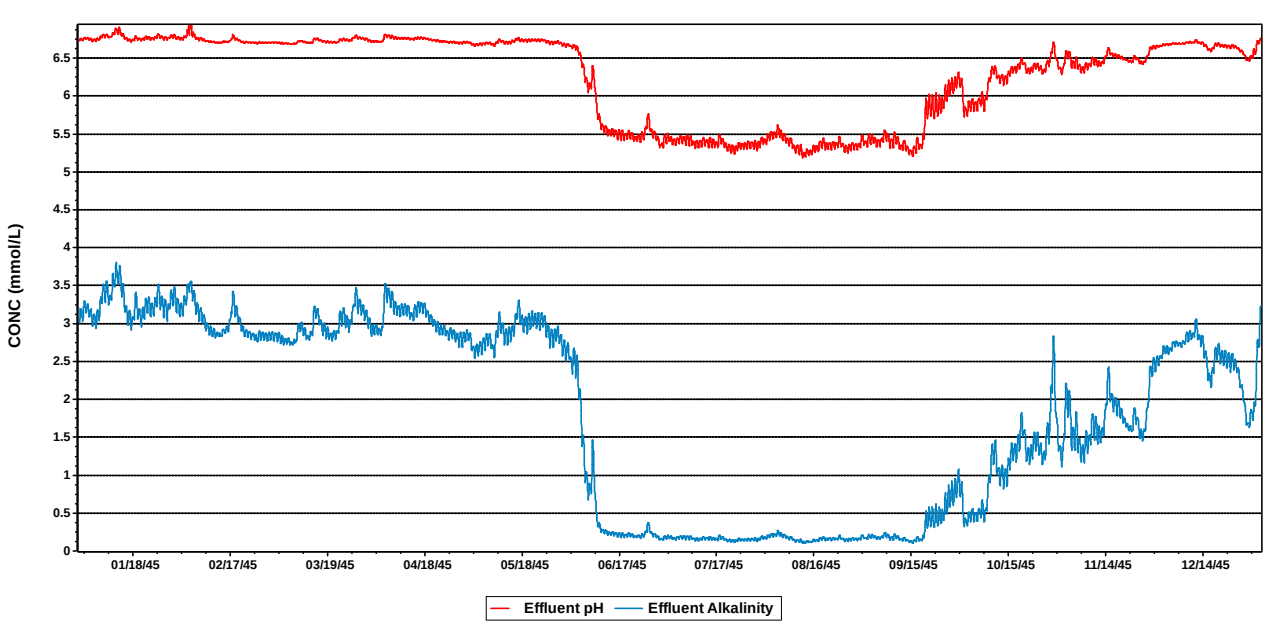
Nitrification rates are faster at higher temperatures



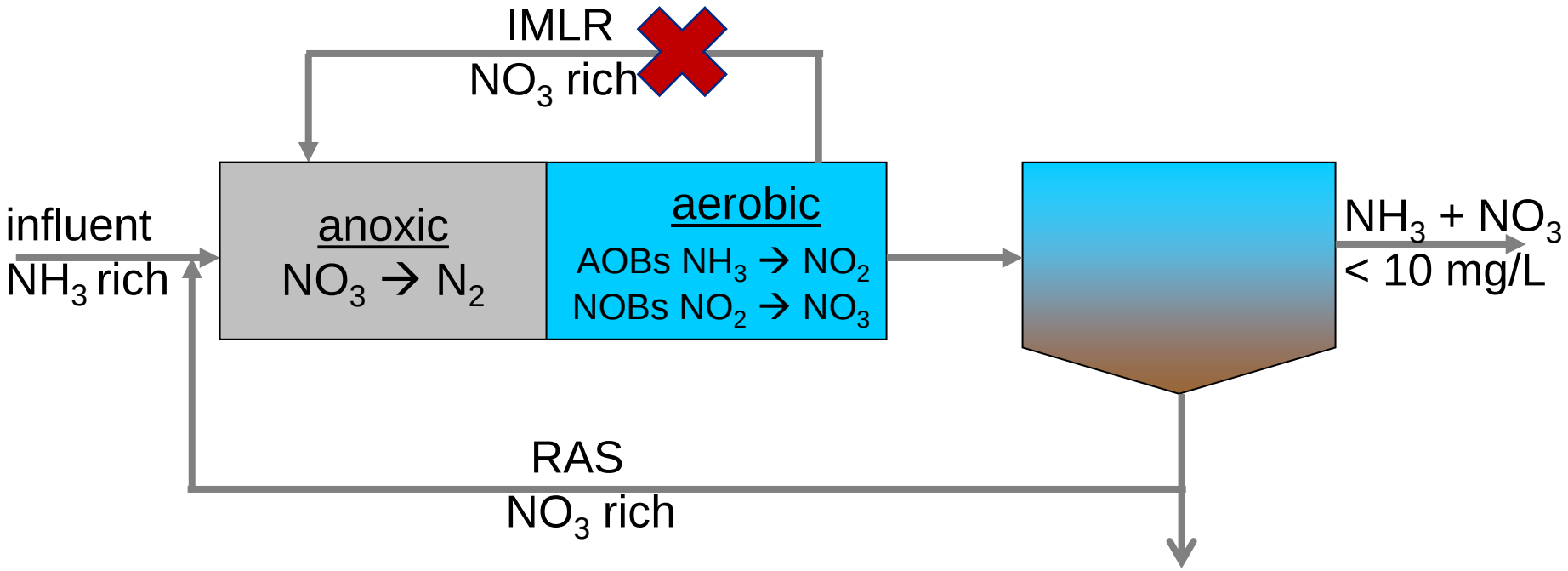
Higher MLSS concentrations can be maintained when peak flows are lower

Modeling predicted that nitrification will be limited by alkalinity

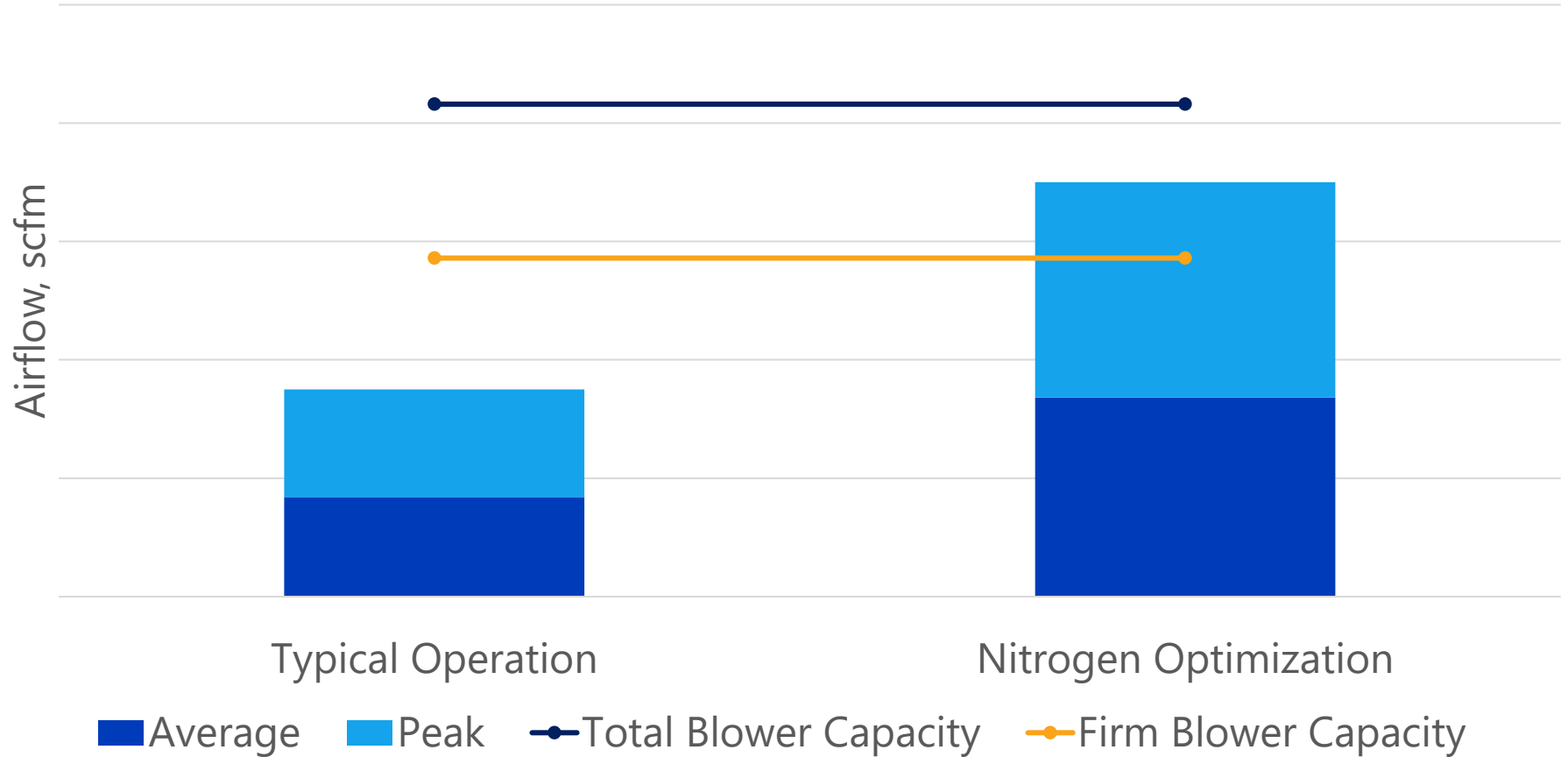




Ways to increase TIN removal between June – September *Increase RAS flow*



Modeling predicted that diffusers and blowers MAY be sufficient for the next five years



This summer Post Point will attempt to come into nitrification

Alkalinity Feed	RAS Pumps	Preventative Maintenance	Sampling	Training
• Determine type of alkalinity required • Order and commission temporary alkalinity feed system	• Test RAS pumps maximum capacity	• Perform all preventative maintenance before July 1	• Update sampling protocols • Setup additional composite samplers • Begin monitoring for CN	• Update EOM for nitrogen optimization operation • Update SOP for coming into and out of nitrification • Provide training for operators

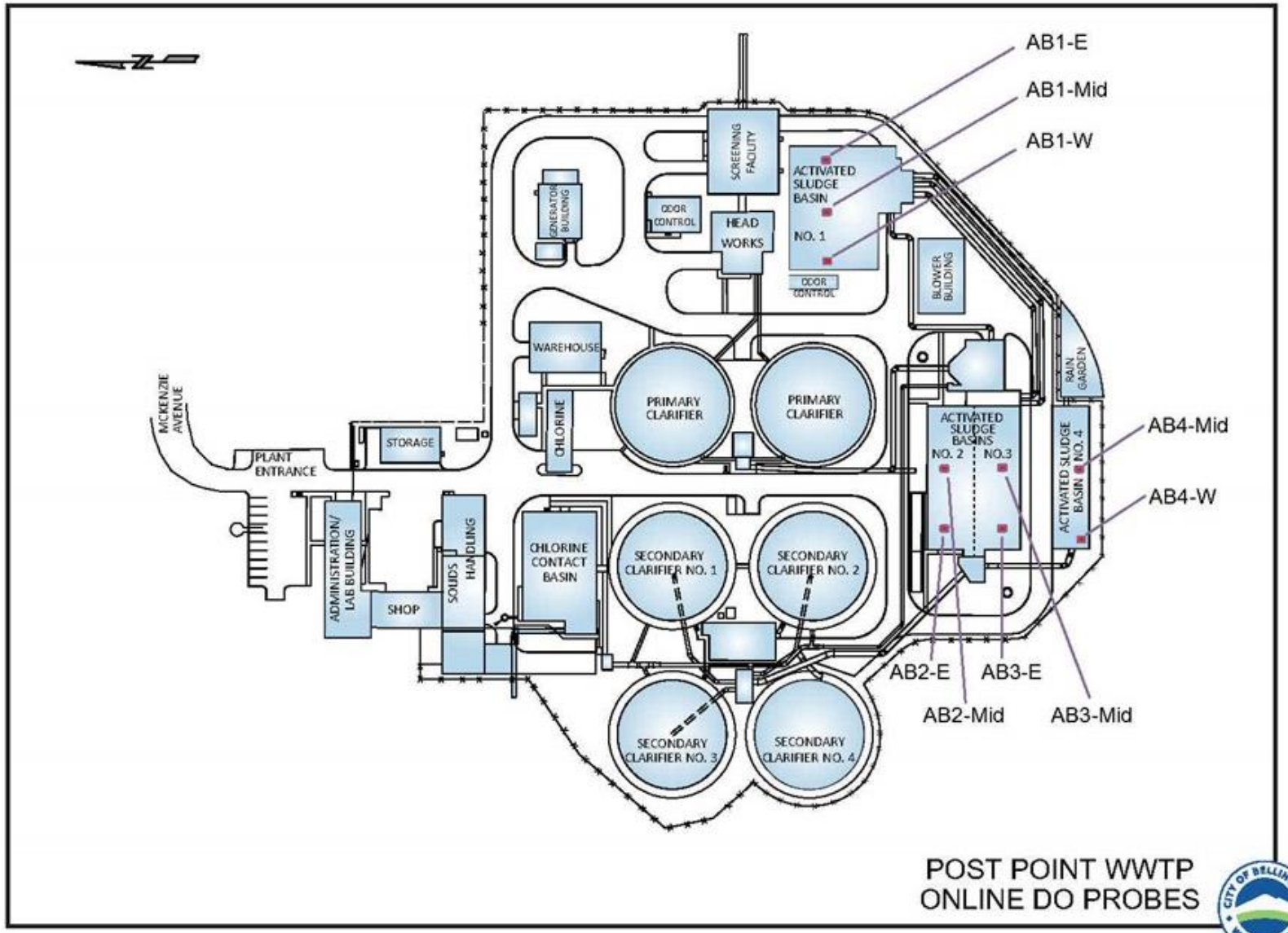
Evolution of Online Secondary Process Monitoring at Post Point

TSS probes at mixed liquor splitter box and WAS line to inform SRTmaster™ software.

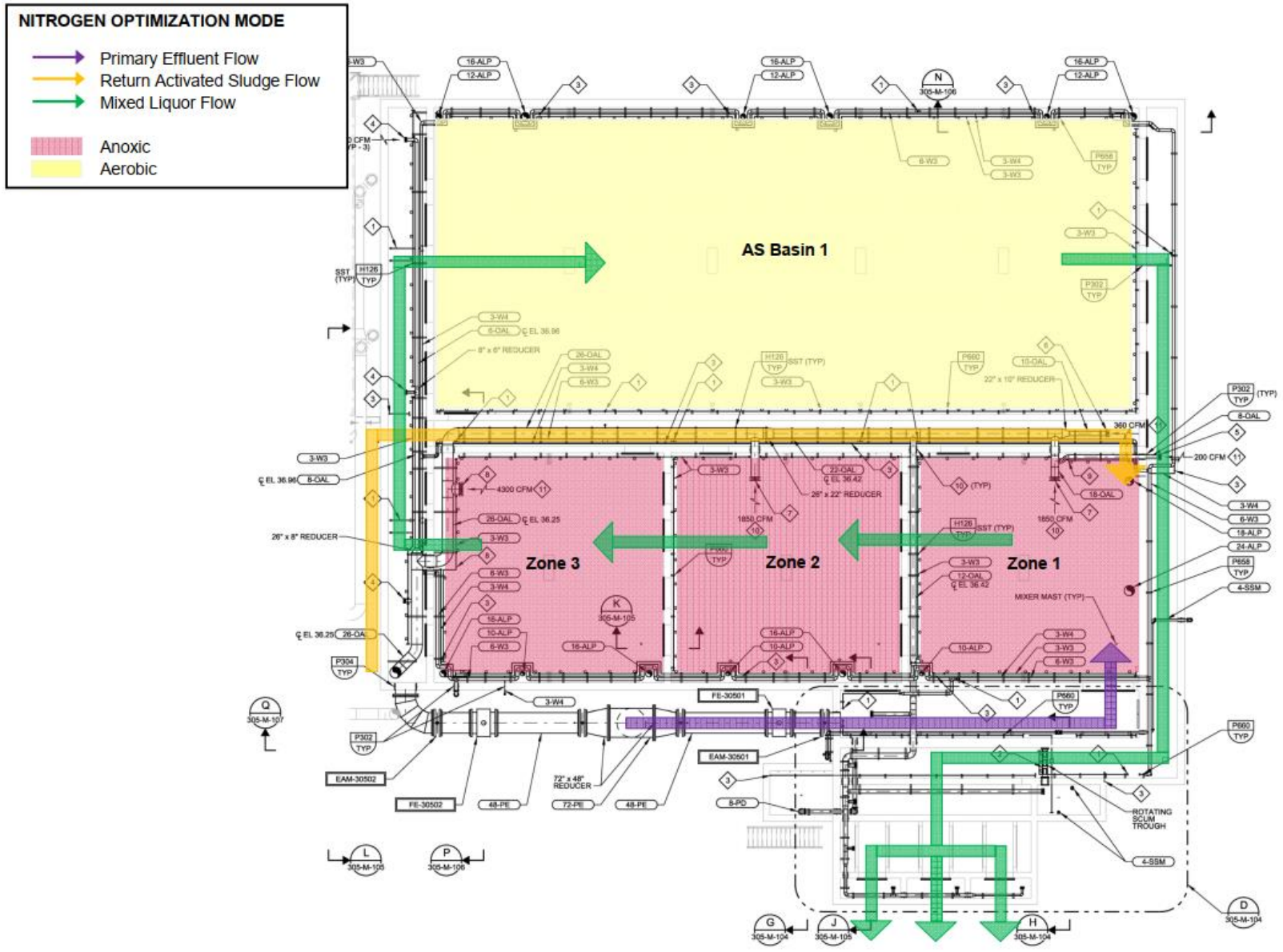
Additional DO probes installed along aeration treatment train (mid basin).

Nutrient (NH4 and NO3) probes at primary effluent and mixed liquor splitter box.

Multipoint DO Monitoring



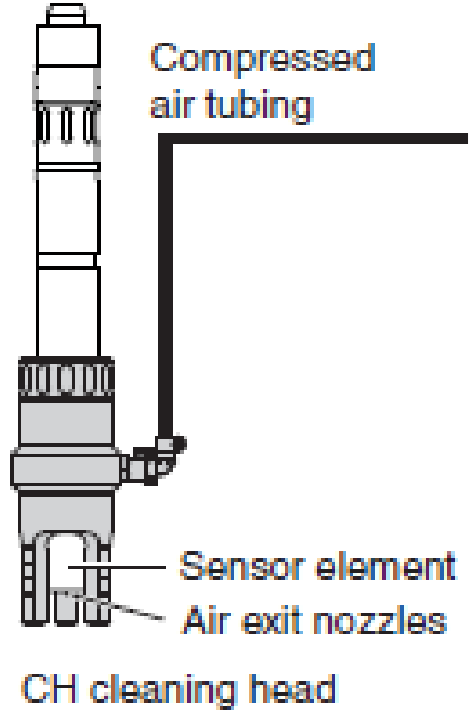
Available For All Zones/Selector Basins



YSI FDO 701 IQ Dissolved Oxygen Probes

FDO

- Easy to use HMI
- Optical DO sensor- fast response for dynamic environment
- Pre-calibrated, easily replaceable sensor caps
- Almost zero calibration drift
- 45-degree sensor caps eliminate trapped bubbles
- Self cleaning (Air)



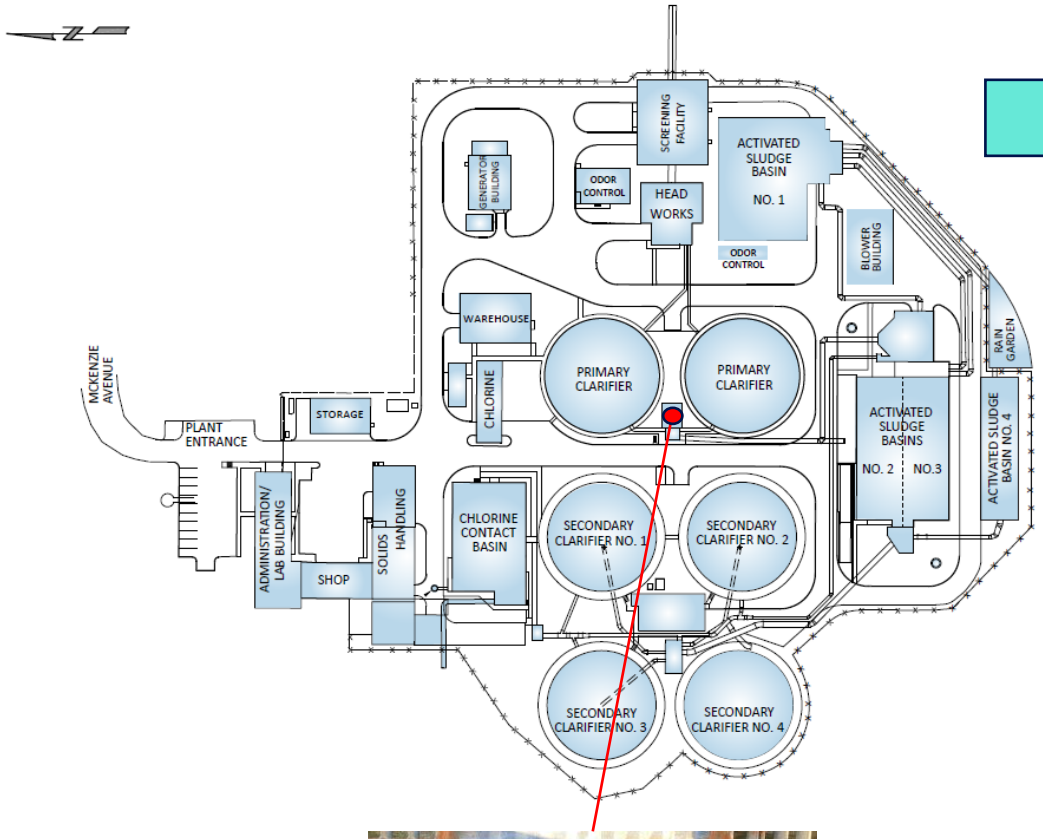
Lessons Learned

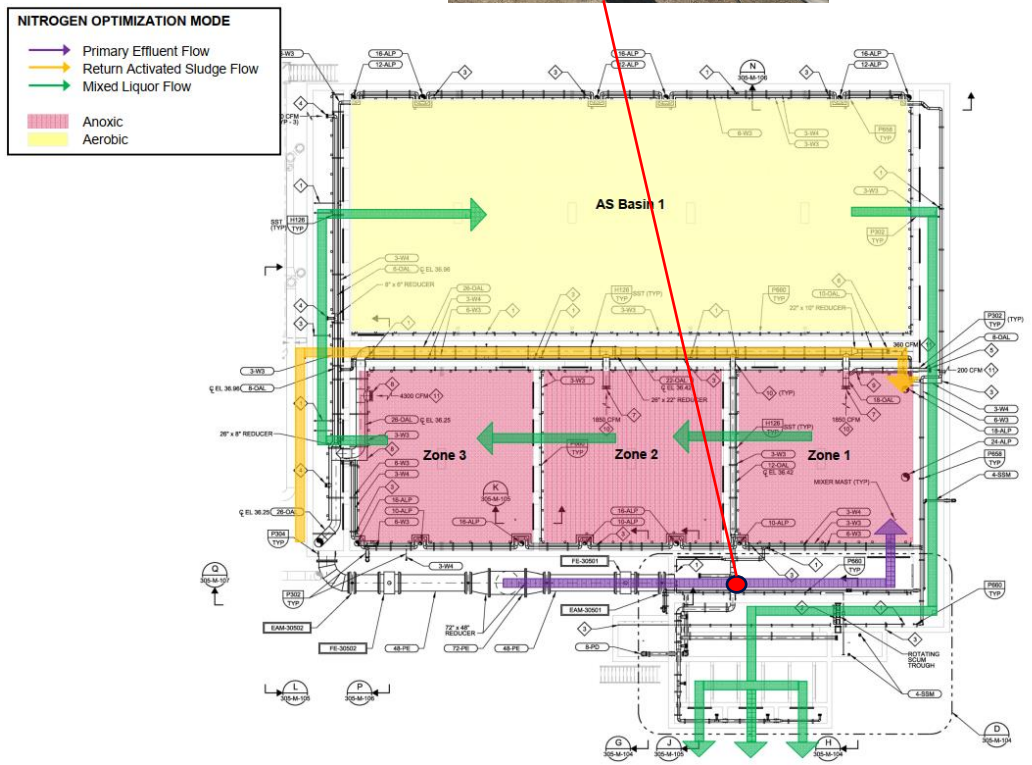
- Careful with Controller vs. PLC scaling
- Needs stanchion to hold in place
- Communication cable sheath prone to abrasion and weathering
- Daily checks against handheld DO probe
- Even with self cleaning, frequent manual cleaning still required

Nutrient Monitoring

- YSI VARiON Plus ammonium + nitrate probes (ISE)
- Located in primary effluent channel and at mixed liquor splitter box after aeration
- Used to watch for signs of nitrification → Now will be used to measure degree of nitrification/de-nitrification

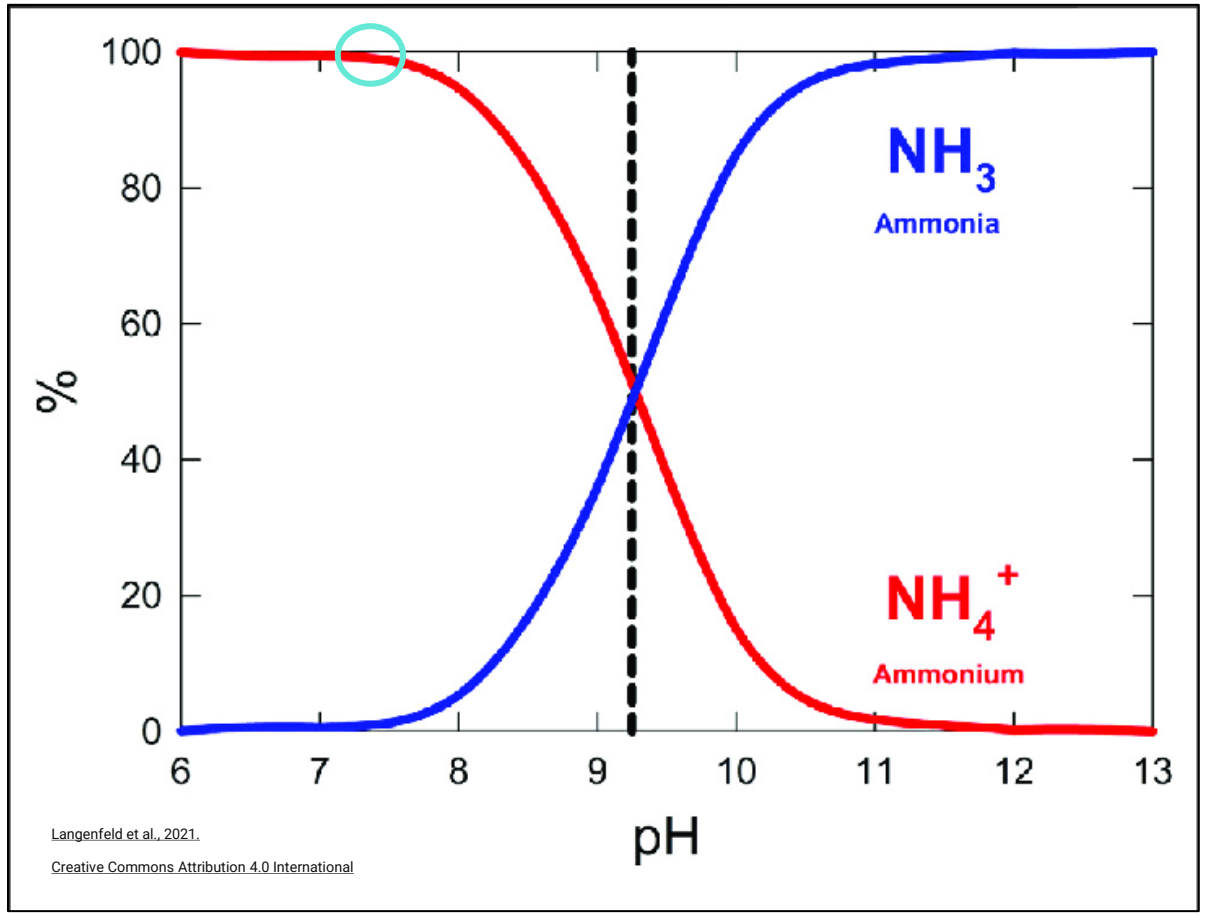
Finding The Right Location

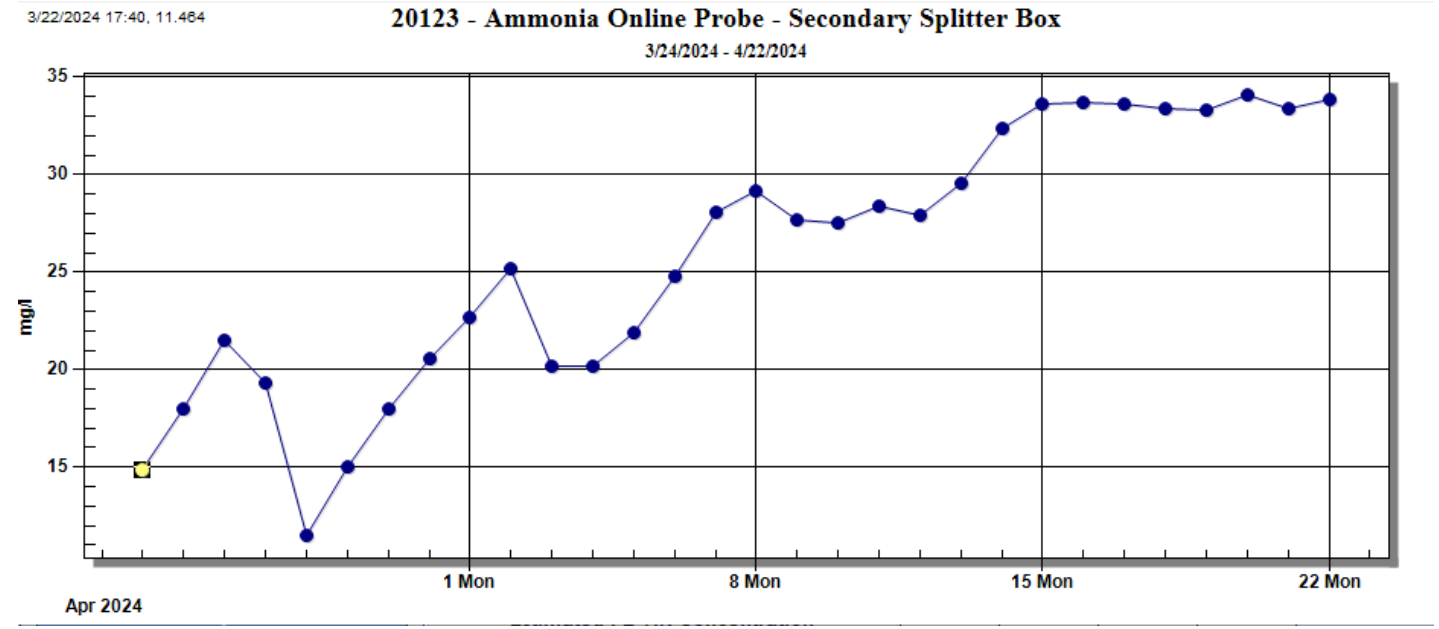


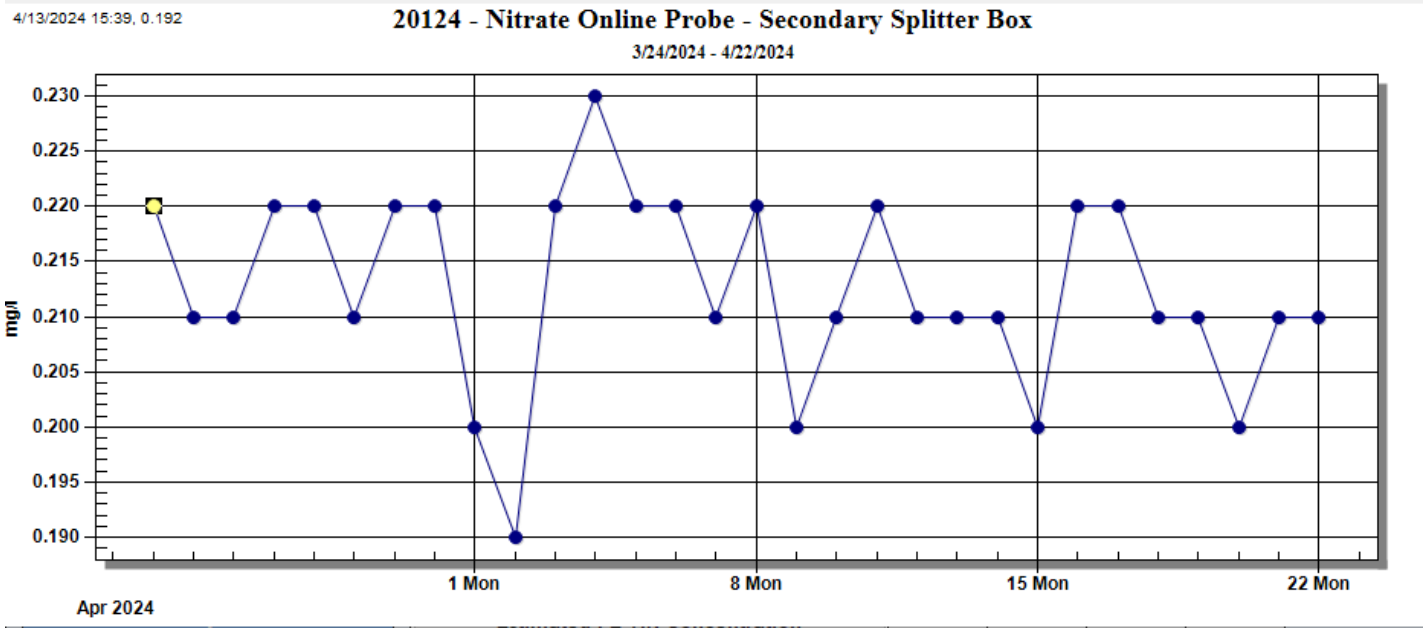


Ammonium vs Ammonia

- At typical pHs, 99% of ammonia (NH3) is present as ammonium ion (NH4)
- Influent/Primary consistently below 7.5 pH. However, anomalies can occur…
- Secondary consistently below 7.5 pH







- Calibration check / matrix adjustment currently performed 2x/month
- Moved up to once a week during nutrient optimization
- All new probes for nutrient optimization process

Operational Ramp-up

- All basins and clarifiers on deck!
- Maintenance activities usually reserved for dry weather all being performed now
- Prep solids handling for changes
- Installation of alkalinity feed
- Lab supplies being gathered

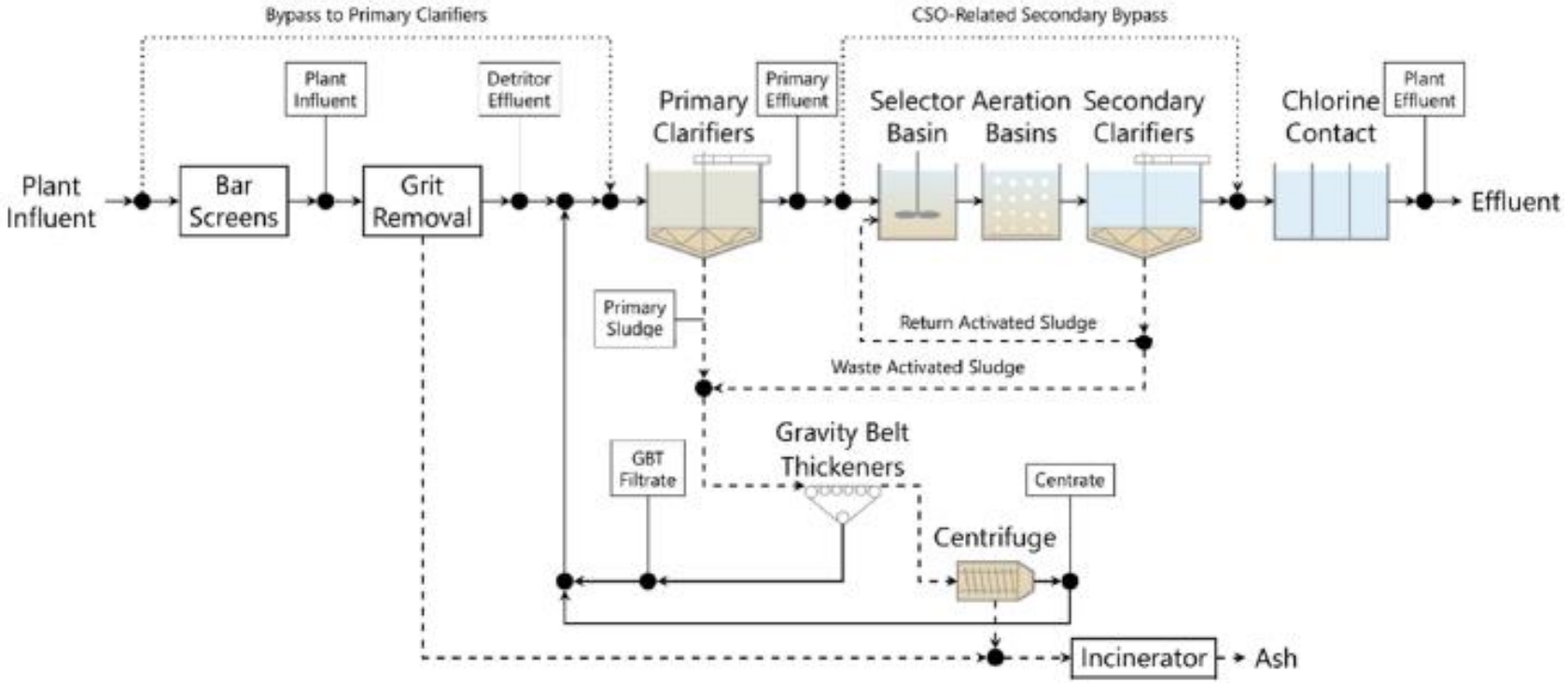


Figure 1 Post Point WWTP Simplified Process Flow Diagram with Supplemental Sample Locations

After 50 years, Post Point is still evolving to meet new regulatory requirements

Challenge	Solution	Adaptation
Clean Water Act requirement for secondary treatment	Addition of an HPO process	Anaerobic selector to improve settleability
Continued growth in the service area	Secondary expansion and conversion to air activated sludge process	Advanced control to maintain settleability while avoiding nitrification
Puget Sound Nutrient General Permit	Nitrogen optimization	Modify SRT control to grow nitrifiers

Automation, Adaptation and Beyond to Implement Nitrogen Optimization at Post Point

Anne Conklin, Carollo Engineers, Inc.
Richard Hoover, City of Bellingham

May 2, 2024

carollo®