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Ozone Equipment Replacement: How to Increase Resiliency of Your Ozone System Amidst Supply Chain Issues

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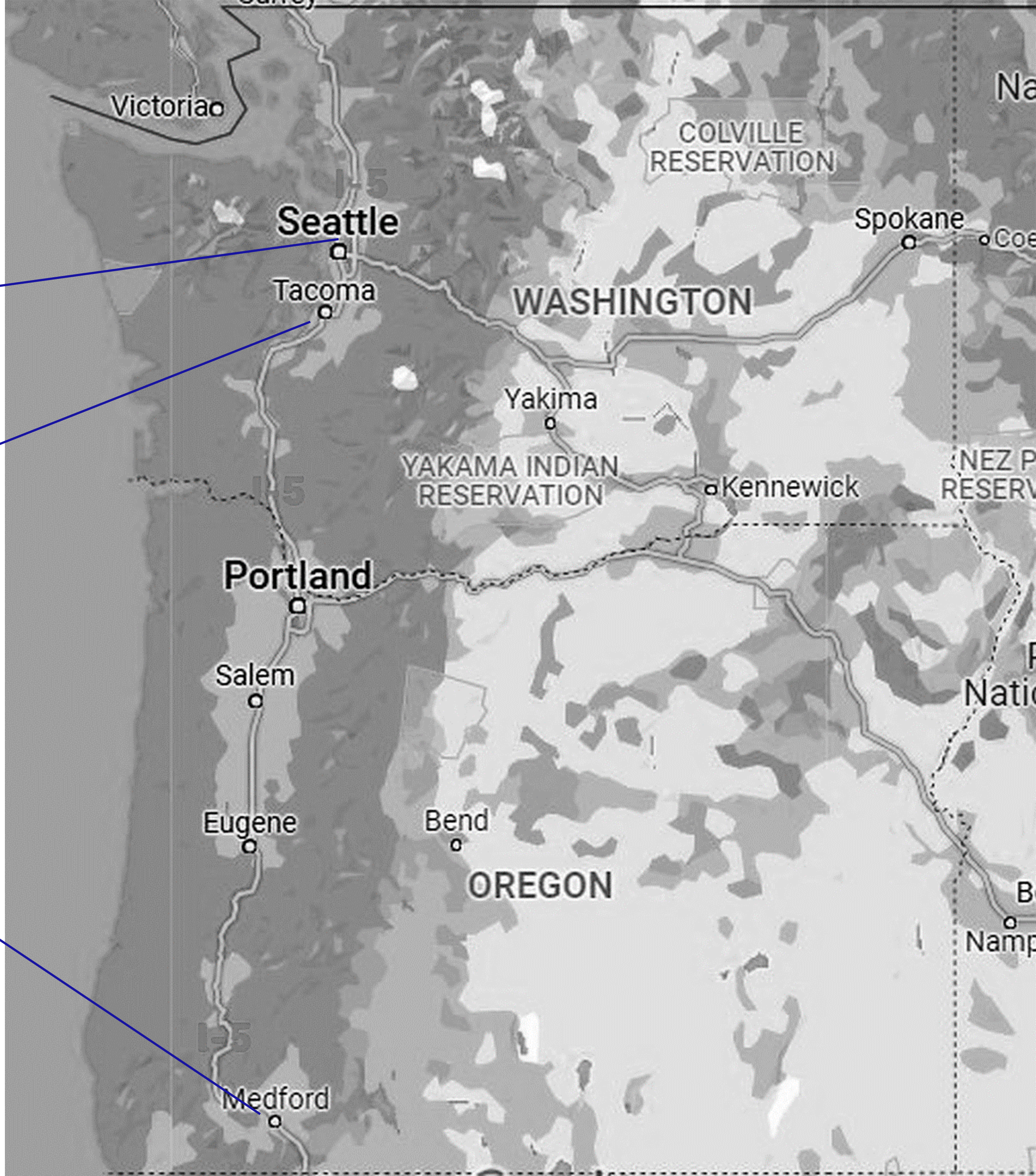
Agenda – 3 Ozone Replacement/ Upgrade Case Studies

Seattle Tolt WTF
(in construction)

Tacoma Green River FF
(planning)

Medford Duff WTP
(completed 2022)



Ozone Replacement Considerations

- How much of the existing system needs to be replaced or refurbished?
- How is the existing system performing?
- Can the system size be optimize based on historical operating data?
- What new ozone technologies or sub systems are better suited for replacement/retrofits?
- Can the existing plant operate without ozone temporarily?
- What are the constructability and logistic issues to transition from the old to the new system?
- How should the new equipment be procured, e.g. sole source or competitively bid or a mix?

Tacoma Water
Ozone Replacement

Evaluation and Planning

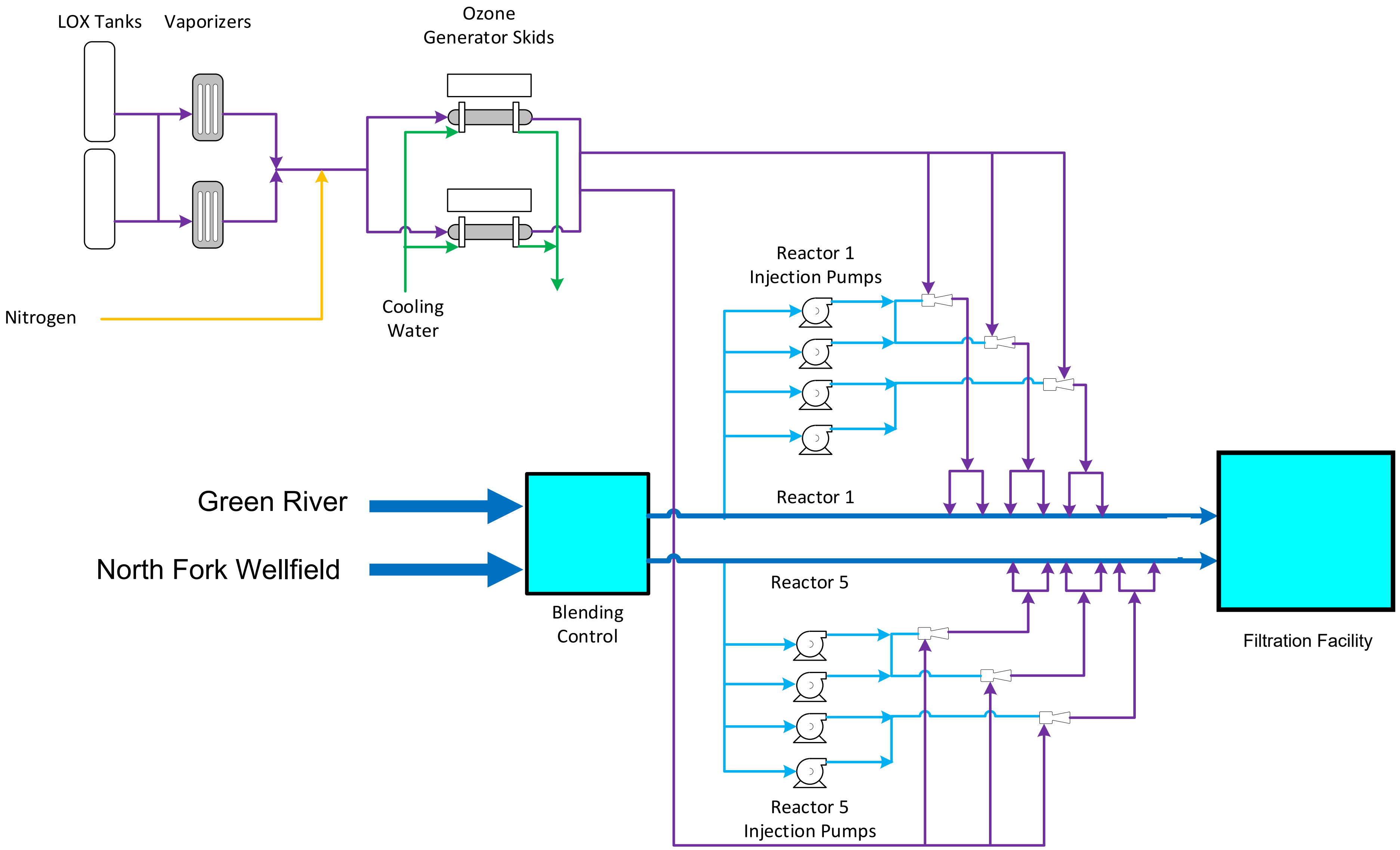
System Summary
Tacoma Water Green River Ozone Facility

Criteria	Value
WTP capacity	150 mgd
Ozone location and purpose	Pre-ozone; T&O control
Ozone system capacity	2800 lbs/day (1 duty + 1 standby)
Installation date	2007
Reason for replacement	Power supply unit (PSU) failure
Manufacturer	Ozonia (now Veolia)

Treatment Goals

- ✓ Reduce taste and odor
- ✓ Enhance biological filtration
- ✓ Reduce DBP precursors
- ✓ Protect against algae and algal toxins

Ozone System Schematic



Green River Ozone Facility

Recommended Improvements

Equipment	Condition	Recommended Improvements
LOX Tank	⚠	• Adjust economizer setpoint to work with current operating conditions • Route economizer relief piping upstream of vaporizer • Replace insulation of LOX piping and valves
Vaporizers	✓	
Nitrogen Boost System	⚠	• Evaluate options (1) new compressor or (2) liquid N2
Ozone Generators and Power Supply Units	⊘	• Generators in good condition • Replace outdated PSUs including PLCs and HMIs
Cooling Water System	⚠	• Open loop: replace basket strainers with flushable screens
Sidestream Injectors	⚠	• Update operation of small injectors
Off-Gas Destruct	✓	
Instrumentation	⚠	• Replace all obsolete instruments and analyzers
Control System	⚠	• Replace PLCs and update programming if needed • Consider automated dose based on ozone residual

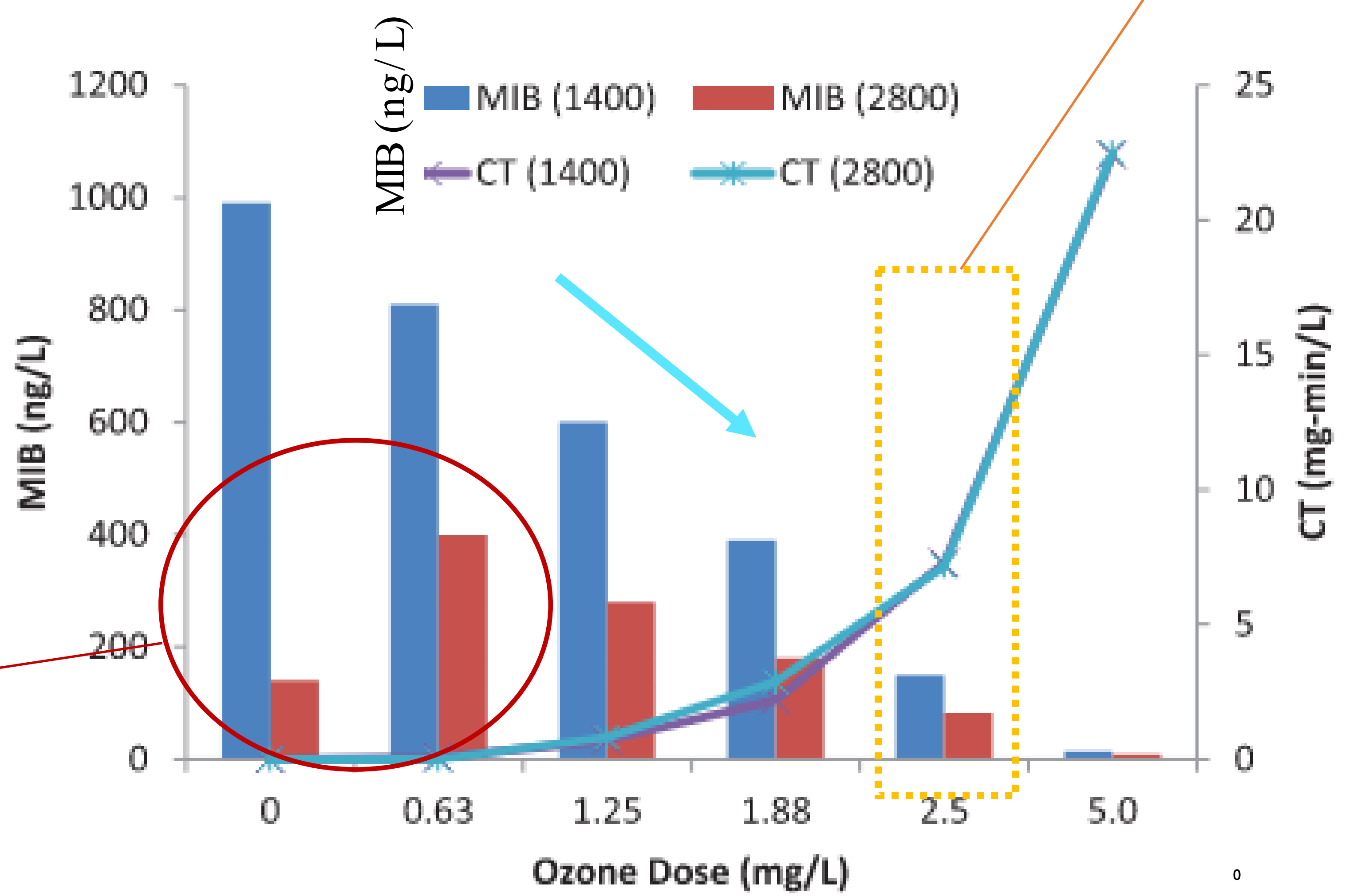
Ozone Dose Evaluation

Recommended Ozone to DOC ratios:

- O_3:DOC ≥ 1 for T&O control
- 0.5 ≤ O_3:DOC ≤ 1 to improve biofiltration by making NOM assimilable

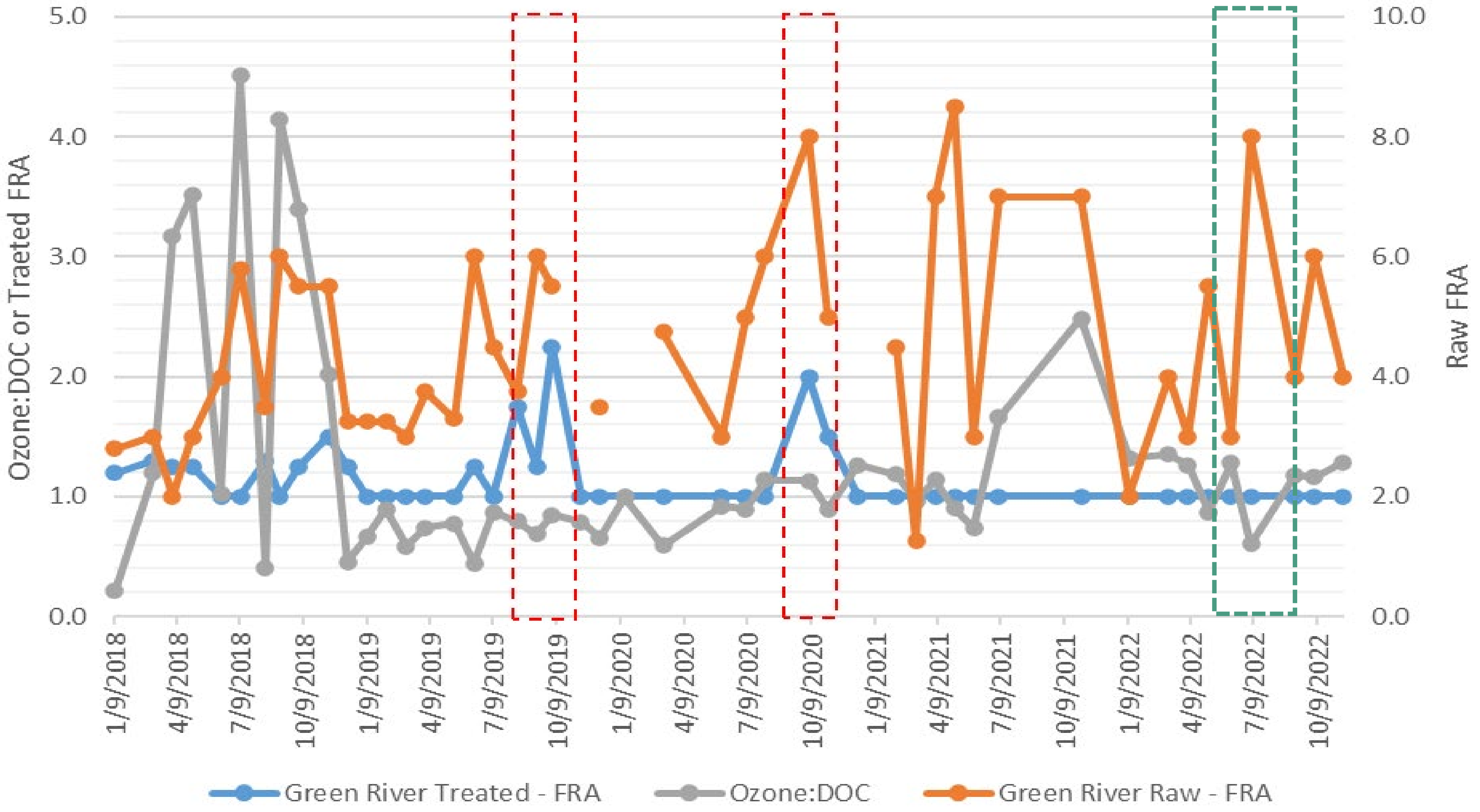
Low Ozone dose oxidizes algal cells and releases intracellular T&O

O_3:DOC = 1.0

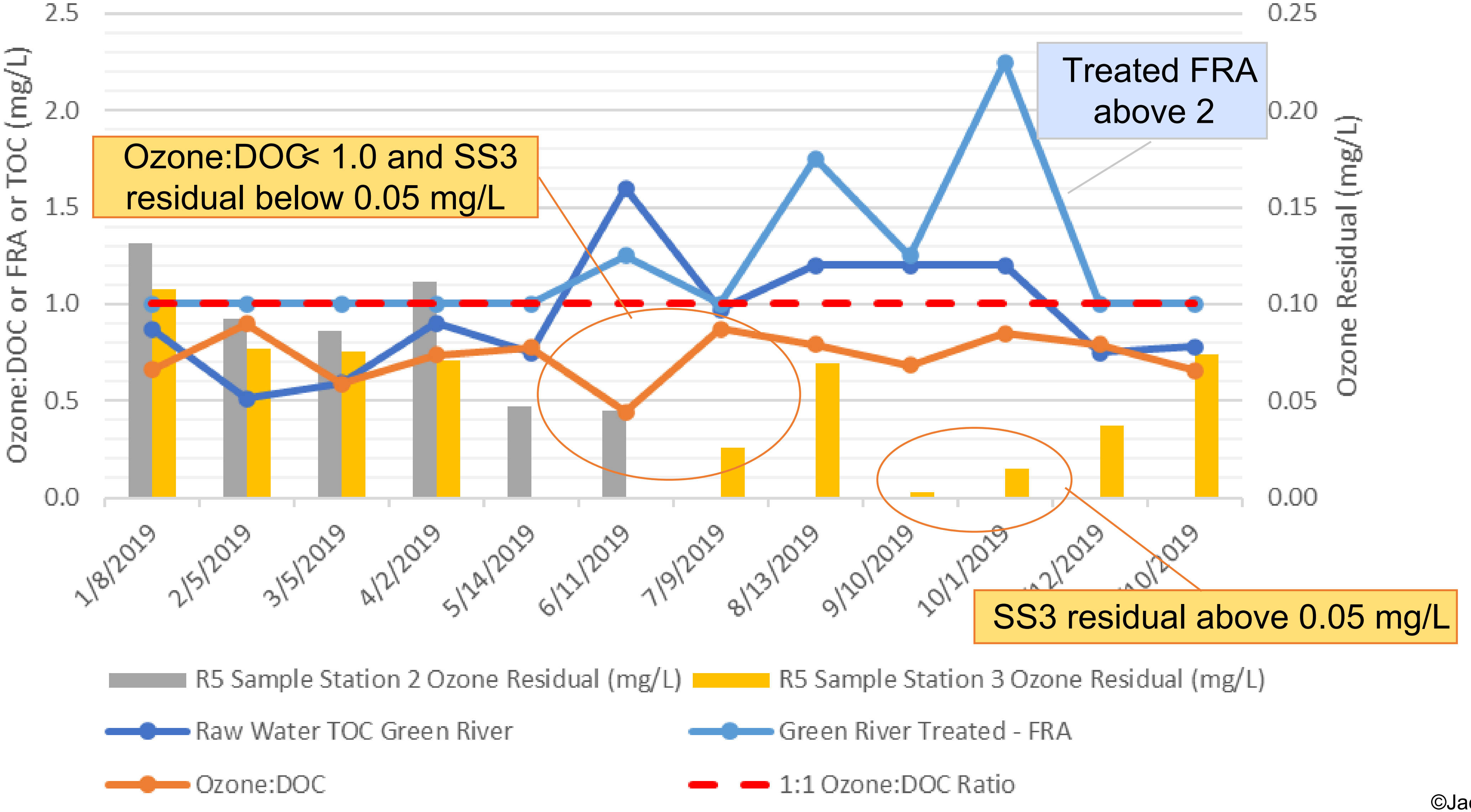


Citation: Wert et al. (2014)

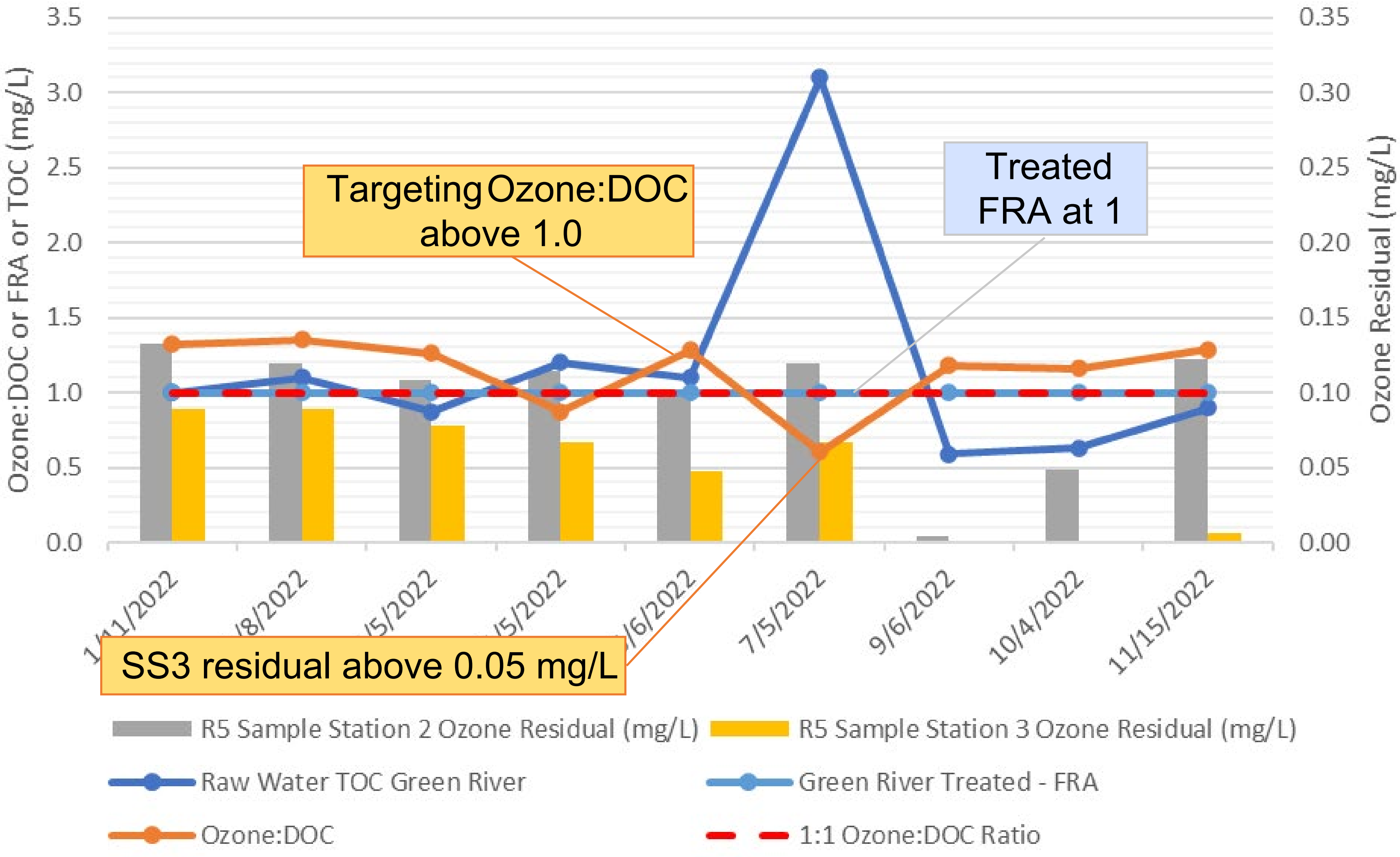
Treatment Effectiveness



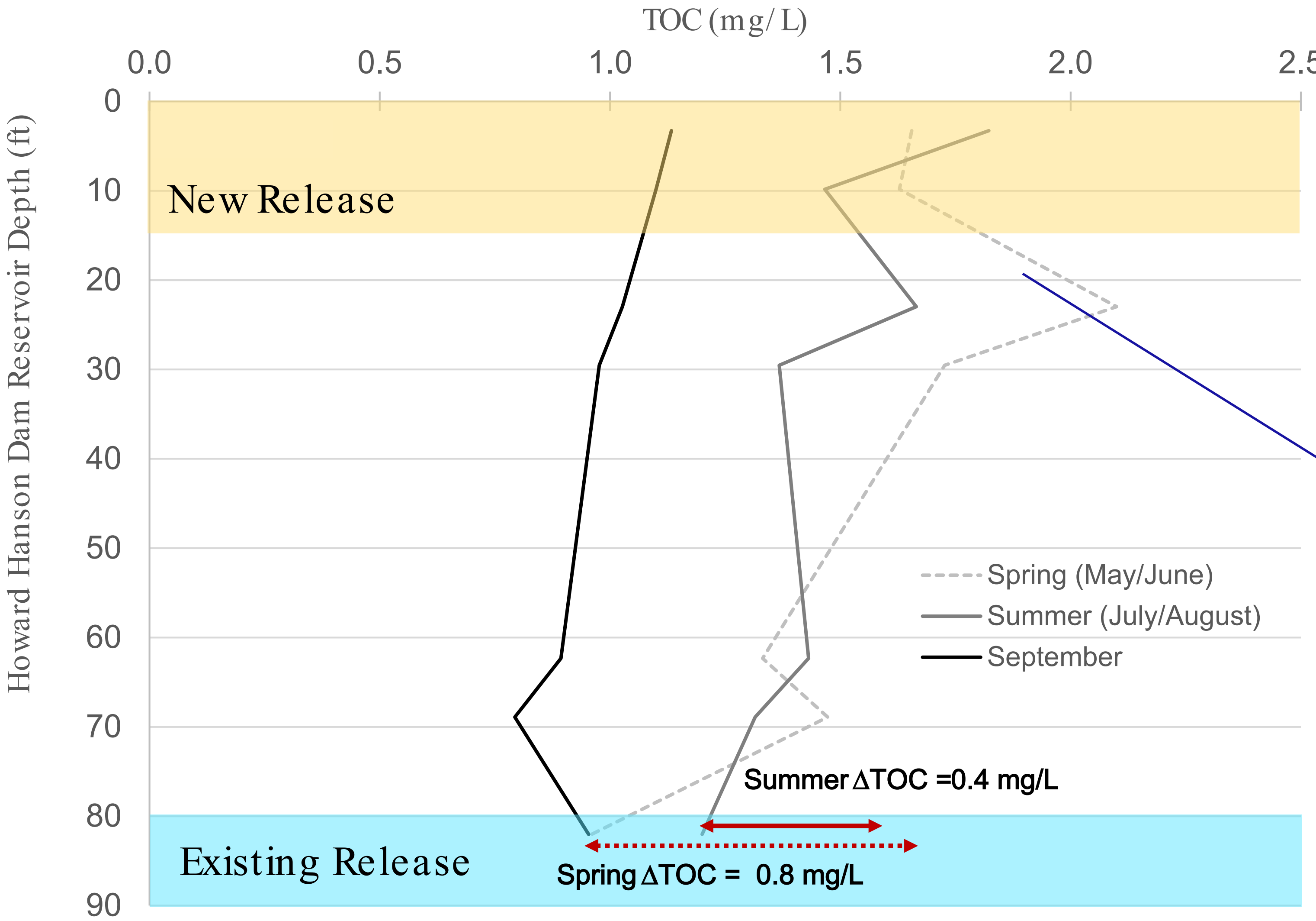
Treatment Effectiveness: 2019 Challenges



2022 recorded even higher Raw Water TOC than 2019 but higher ozone doses control T&O compounds



Generator Capacity: Future Impacts



Changes to dam operation will change release to top 15 feet of the water column

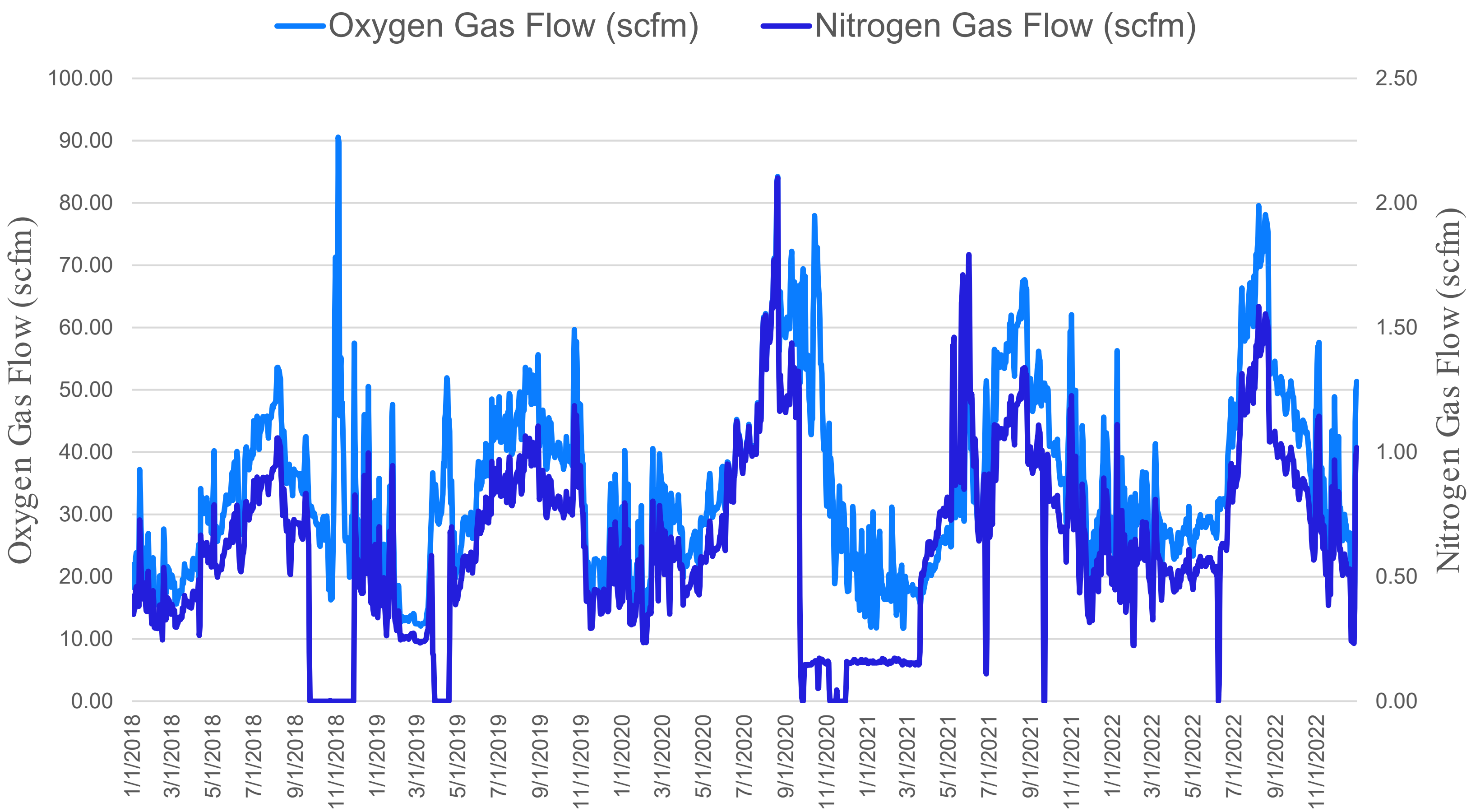
Increase TOC (average +0.5 mg/L) with new release

TOC higher in upper W.C. due to algal blooms

- Increase capacity by installing higher efficiency dielectrics

Nitrogen Boost System Options Evaluation Compressed Air vs. Liquid Nitrogen

- Existing scroll compressors have experienced several failures and downtime. This limits ozone capacity to 50%.



Nitrogen Boost

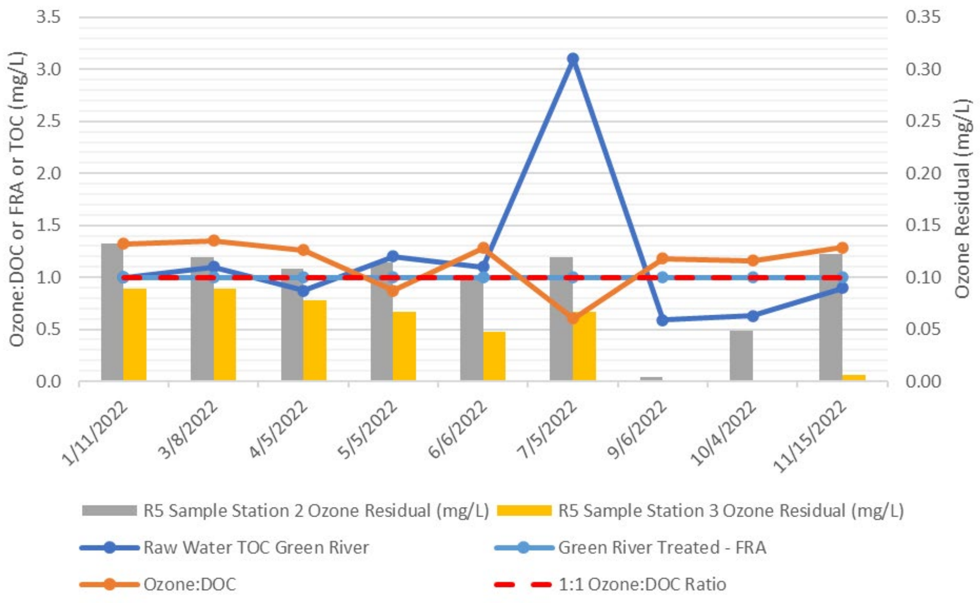
- Both capital and operating costs favor a compressed air system for this application

25 year Life Cycle Cost (LCC) Analysis	Compressor Skid	Liquid N_2
Operations (Electrical and Chemical)	$12,000	$190,000
Maintenance	$25,000	$2,000
Capital Cost[1]	$34,000	$146,000
25 year Net Present Value[2] w/ Inflation[3]	$911,000	$4,736,000

1. Initial capital investment and necessary replacement at end of lifetime (assumed 15 years for the compressor)
2. Assumed a nominal discount rate of 3.0% to calculate Net Present Value
3. Assumed an inflation rate of 3.5%

Summary

- Evaluate the system treatment performance and future ozone demand changes as part of the system sizing
- Consider equipment alternatives to maintenance-heavy sub-systems



Seattle Tolt WTP
Ozone Replacement

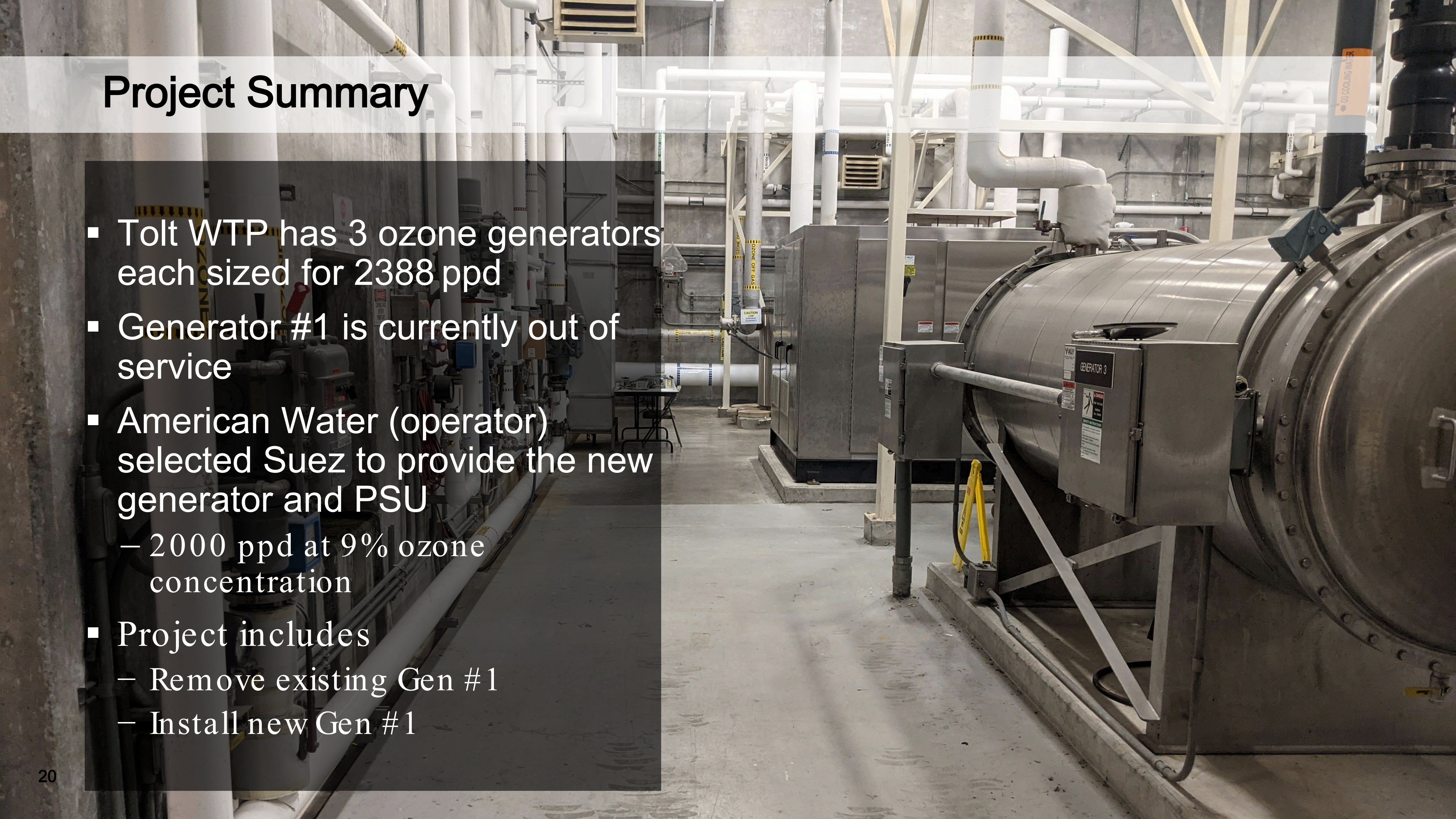
In progress to complete summer 2023

System Summary
Seattle Public Utilities
Tolt Water Treatment Facility

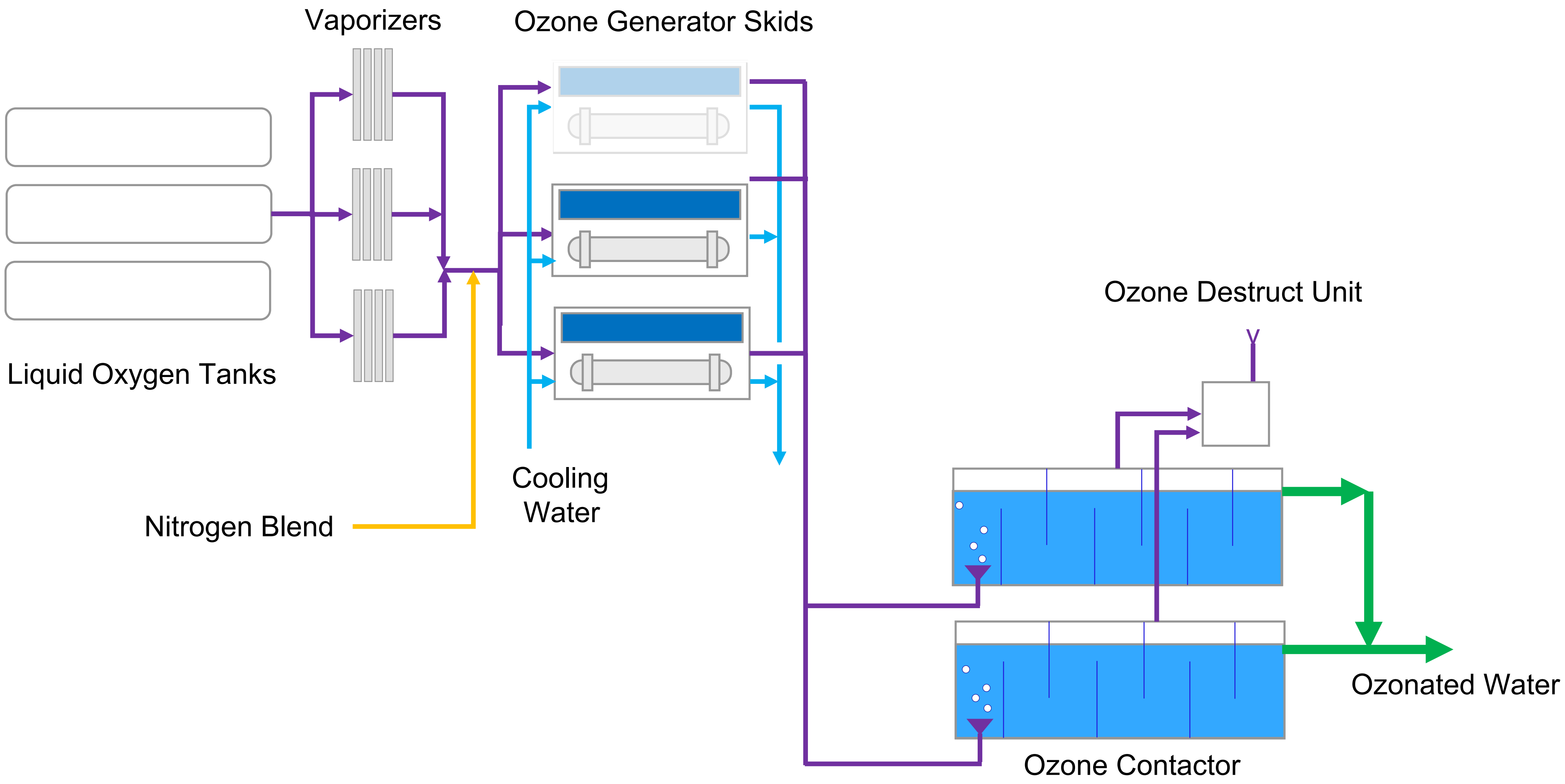
Criteria	Value
WTP capacity	120 mgd
Ozone location and purpose	Pre-ozone; T&O control
Ozone system capacity	4766 lbs/day (2 duty + 1 standby)
Installation date	2001
Reason for replacement	Generator failure from internal corrosion and power surge
Manufacturer	PCIWedeco (now Xylem)

Project Summary

- Tolt WTP has 3 ozone generators each sized for 2388 ppd
- Generator #1 is currently out of service
- American Water (operator) selected Suez to provide the new generator and PSU
  - 2000 ppd at 9% ozone concentration
- Project includes
  - Remove existing Gen #1
  - Install new Gen #1



Ozone System Background

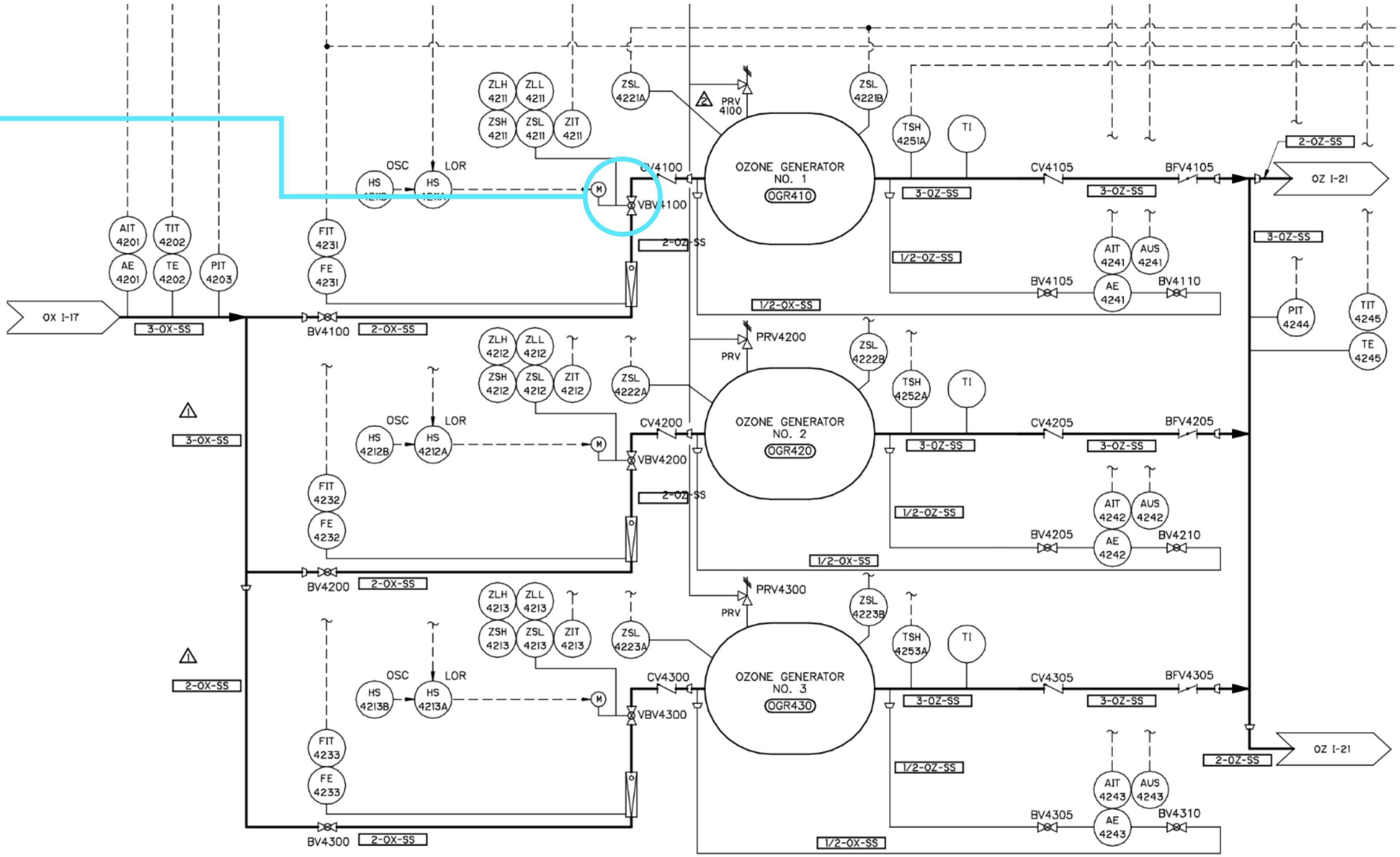


Recommended Improvements

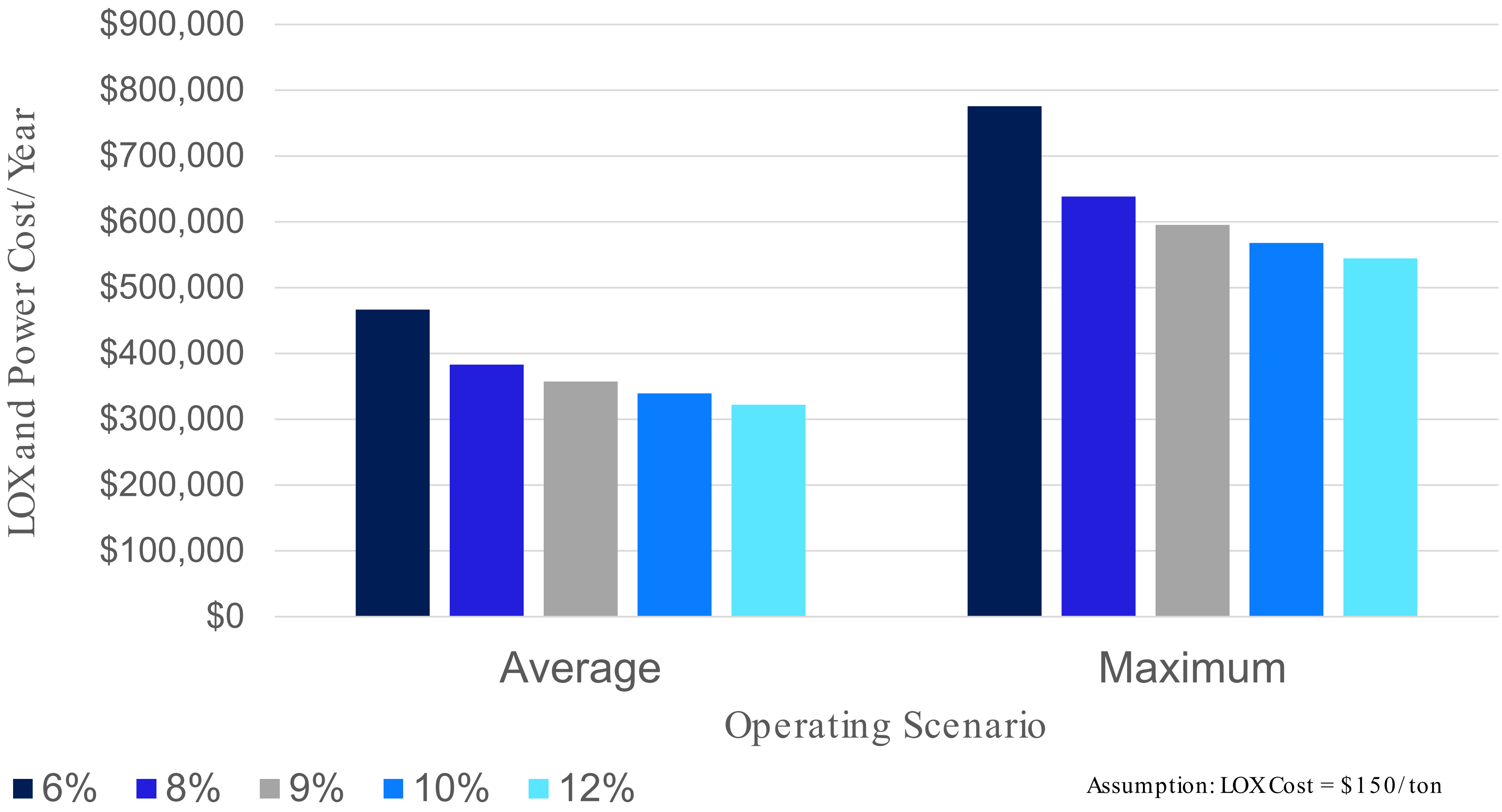
Equipment	Condition	Recommended Improvements
LOX Tank		
Vaporizers		
Nitrogen Boost System		
Ozone Generators and Power Supply Units		• Replace 1 generator and PSU
Cooling Water System		• Upgrade to run closed-loop cooling as duty-standby to 1 generator or duty to 2 different generators
Fine bubble injection		
Ozone Contactor		
Off-Gas Destruct		
Instrumentation		• Replace dewpoint analyzers
Control System		• Update SCADA control to accommodate new ozone generation and more automated control

Design Challenge – SCADA System Integration

- Current remote manual control due to limitations on gas valve adjustments – adjust gas concentration instead.
- Results in operating at low gas concentrations (typically 5 -6%)
- New system designed with different valves in full auto to operate at 9%
- Can use the existing generators (if needed) to supplement the capacity



LOX Savings by Operating at Higher Ozone Gas Concentration

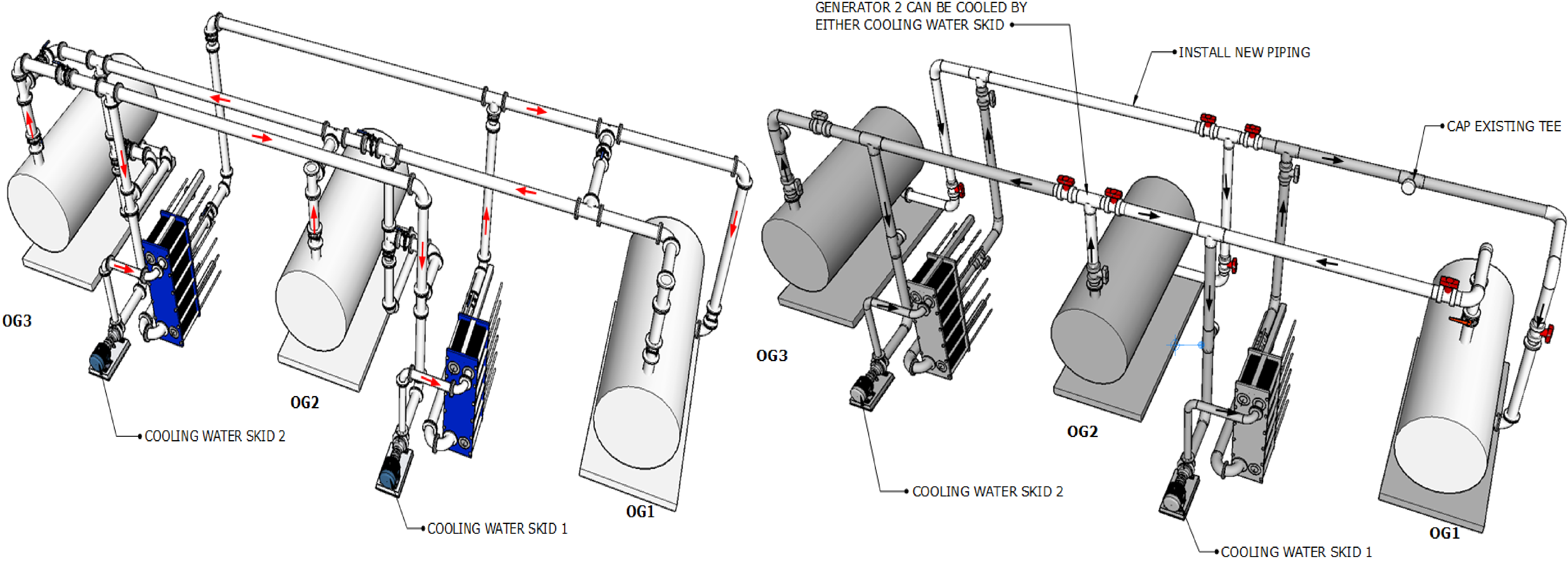


Assumption: LOX Cost = $150/ton

Design Challenge – Cooling Water Supply

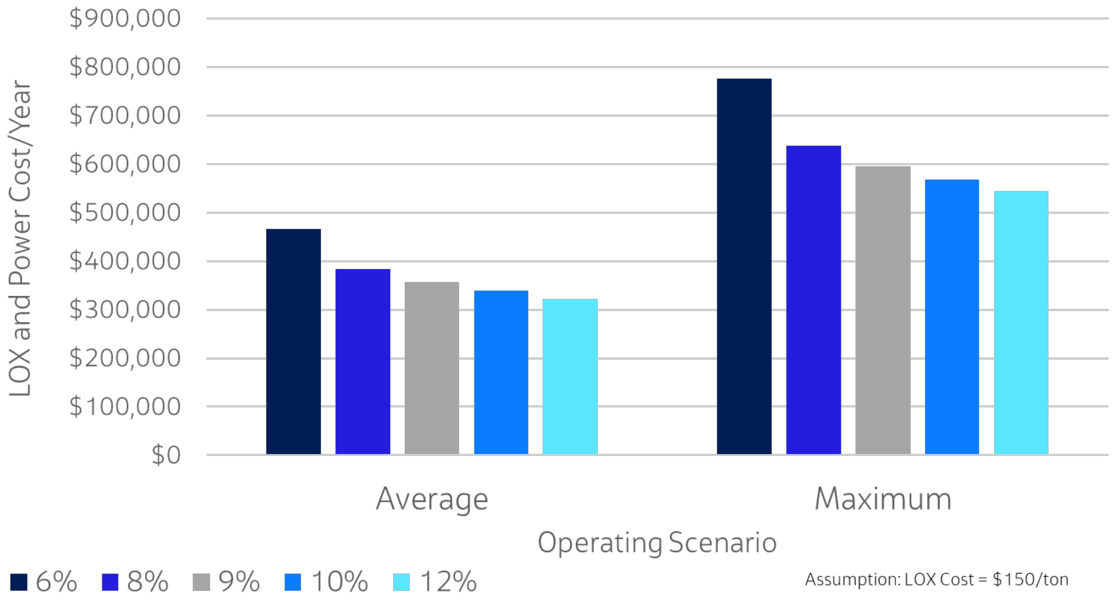
- Original system was open loop which contributed to the corrosion issues
- Installed closed loop system a few years ago but did not include flexibility to operate 2 generators at the same time – would have to operate in series
- New generator has different flow and temperature constraints
- Reconfiguring the cooling water system to dedicate one cooling water skid to one generator and also allow duty standby for each generator

Revised Cooling Water Pipe Design– Before and After



Summary

- Evaluate the system performance for optimization/cost saving opportunities that may help pay for the system replacement
- Review system functionality and reliability

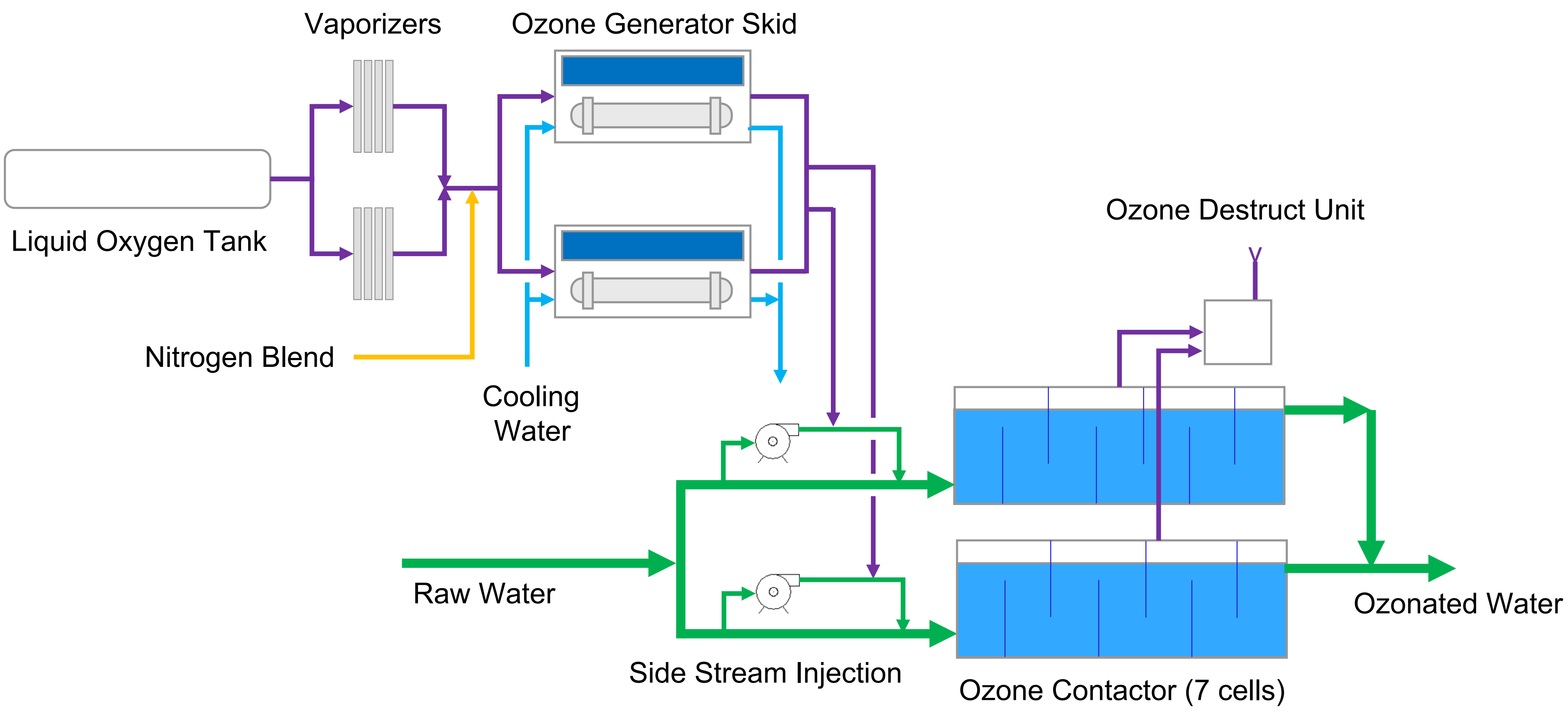


Medford Water
Ozone Replacement Completed Summer 2022

System Summary
Medford Water Duff Water Treatment Plant

Criteria	Value
WTP capacity	65 mgd
Ozone location and purpose	Pre-ozone; T&O control
Ozone system capacity	1200 lbs/day (1 duty + 1 standby)
Installation date	2003
Reason for replacement	Generator damage due to internal corrosion
Manufacturer	PCIWedeco (now Xylem)

Ozone System Schematic



Treatment Goals and Optimization

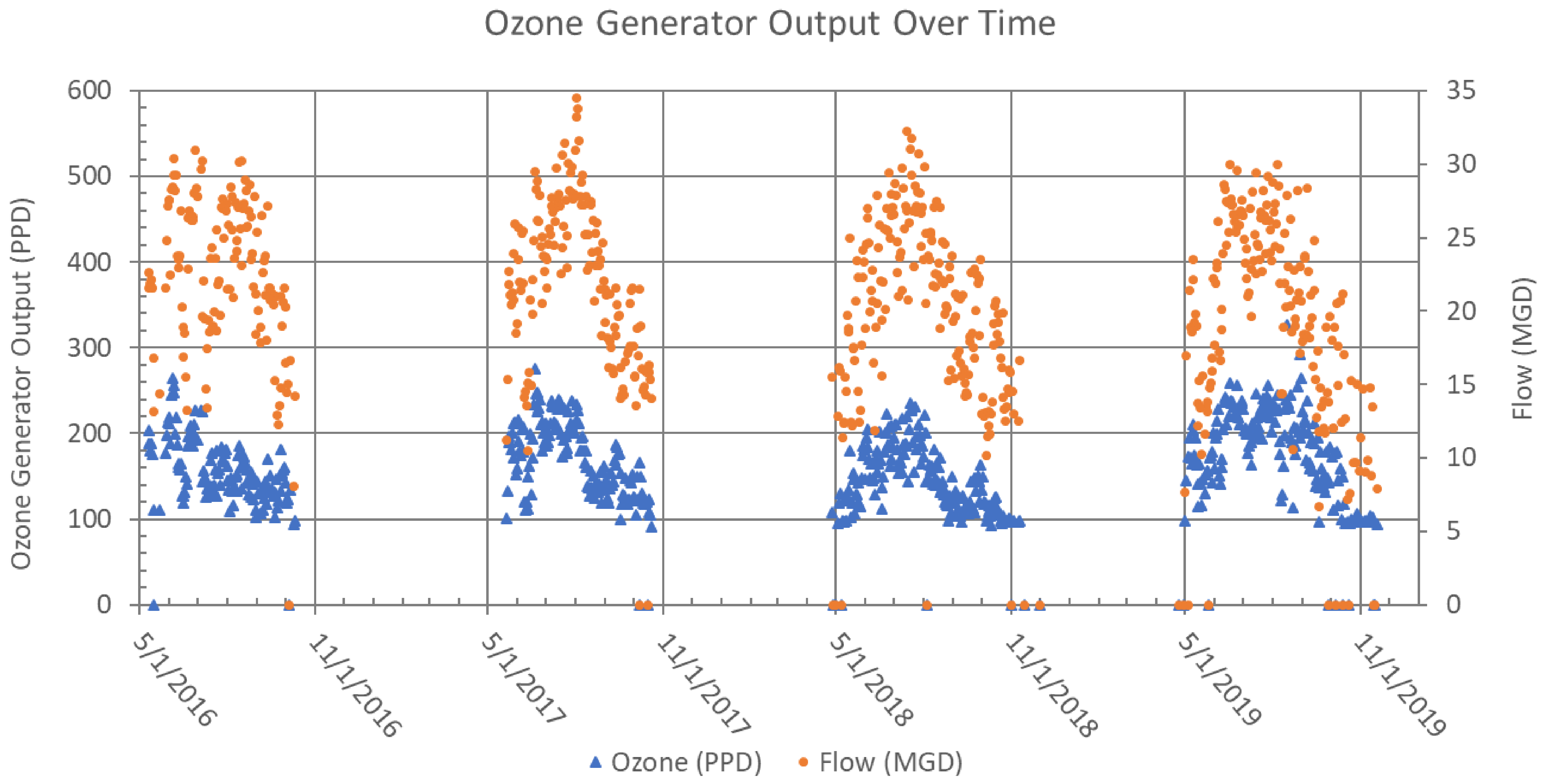
Treatment Goals

- ✓ Reduce T&O to below Odor Threshold limits
- ✓ Reduce in DBP precursors (natural organic matter (NOM) and TOC)
- ✓ Protect against algae and algal toxins
- ✓ Reduce operating costs

Recommended Improvements

Equipment	Condition	Recommended Improvements
LOX Tank	✓	
Vaporizers	✓	
Nitrogen Boost System	⊘	• Install dew point sensor and replace compressor skid
Ozone Generators and Power Supply Units	⊘	• Replace generators and PSUs
Cooling Water System	⊘	• Upgrade to closed-loop cooling system
Sidestream Injectors	⚠	• Replace sidestream pumps
Ozone Contactor	✓	
Off-Gas Destruct	⚠	• Replace HMI screens • Integrate controls into master panel • Replace catalyst media
Instrumentation	⚠	• Replace all instruments and analyzers
Control System	⚠	• Replace master control back panel

Historical Ozone Generation



Operational Savings from equipment replacement

Parameter	Low Concentration	High Concentration
LOX Usage		
Avg Ozone Concentration	6%	12%
LOX Usage	450 tons / year	225 tons / year
Annual Cost	$112,500 / year	$56,250 / year
Power Usage		
Unit Power Consumption	3.9 kWh / lb O^3	4.7 kWh / lb O_3
Annual Consumption	210,600 kWh / year	253,800 kWh / year
Annual Cost	$19,000 / year	$23,000 / year
Total Estimated Savings		$52,250/year

Evaluation Conditions

1. 300 ppd average ozone production
2. 180 days of operation/year
3. LOX cost $250/ton
4. Power cost $0.09/kWh

Oxygen System

LOX Tank and Vaporizers

Nitrogen Boost System

Ozone Generation

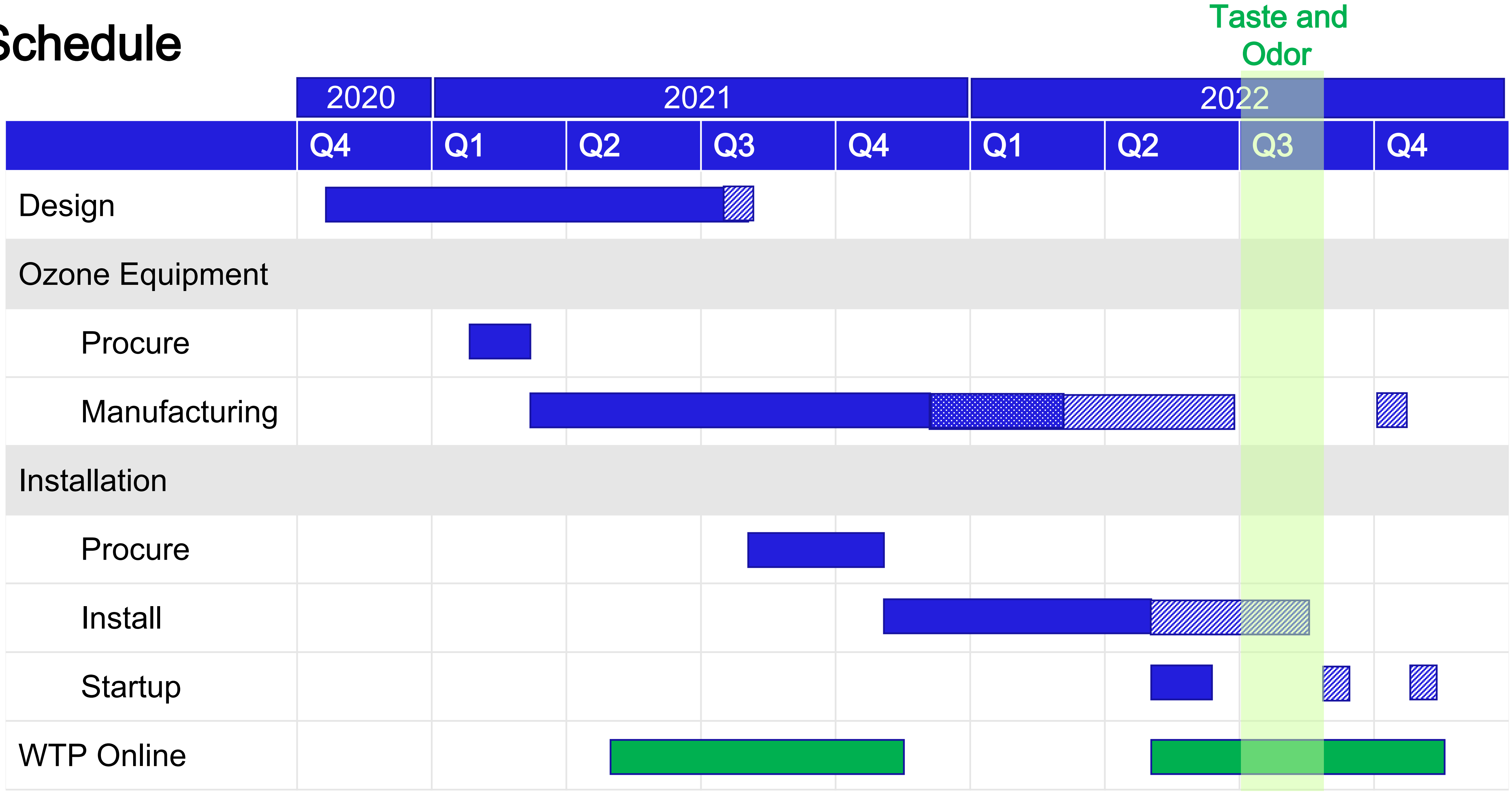
Before

After

Ozone Injection and Destruct

- Upstream ozone ("Pre-ozonation") to oxidize T&O compounds
- Sidestream ozone injection
  - 3 pumps (2 duty)
  - 3 injectors per train (6 total)
- Two contactors, 12.6 min contact time at 45 mgd
- Two destruct units (duty-standby)

Schedule



Taste and Odor
2020
2021
2022
Q4
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
Design
Ozone Equipment
Procure
Manufacturing
Installation
Procure
Install
Startup
WTP Online

Lessons Learned and Recommendations

1. Evaluate the performance of the existing ozone system for optimization and reliability opportunities
2. Verify the size of equipment needed for the next 20-25 years
3. Evaluate the condition of all components and categorize need
   a. Replace now (poor condition and long lead time)
   b. Replace when fails (short lead time and redundant unit(s) available)
   c. Purchase shelf spares (frequently used parts or long lead time)
   d. Component in good condition and expected to last 20+ years.
4. Develop an implementation plan to meet WTP operation needs
5. Develop a contingency plan

Acknowledgements

Kim DeFolo, Tacoma Water

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