Better with Age: 30-year History of Ozone at the Mannheim Water Treatment Plant

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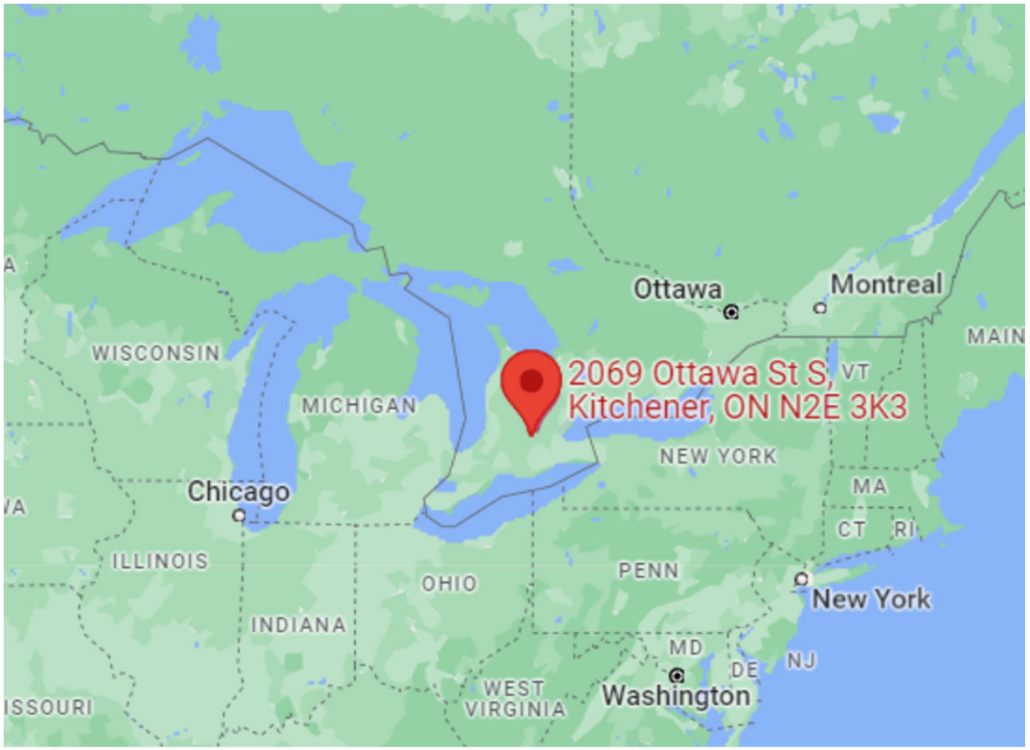
Mannheim Water Treatment Plant



Mannheim Water Treatment Plant

Mannheim Water Treatment Plant

72 MLD (16 MGD) surface water treatment plant

Temperature ranges from 0 – 27°C

Raw water DOC 3 – 6 mg/L

pH 7.3 – 8.2

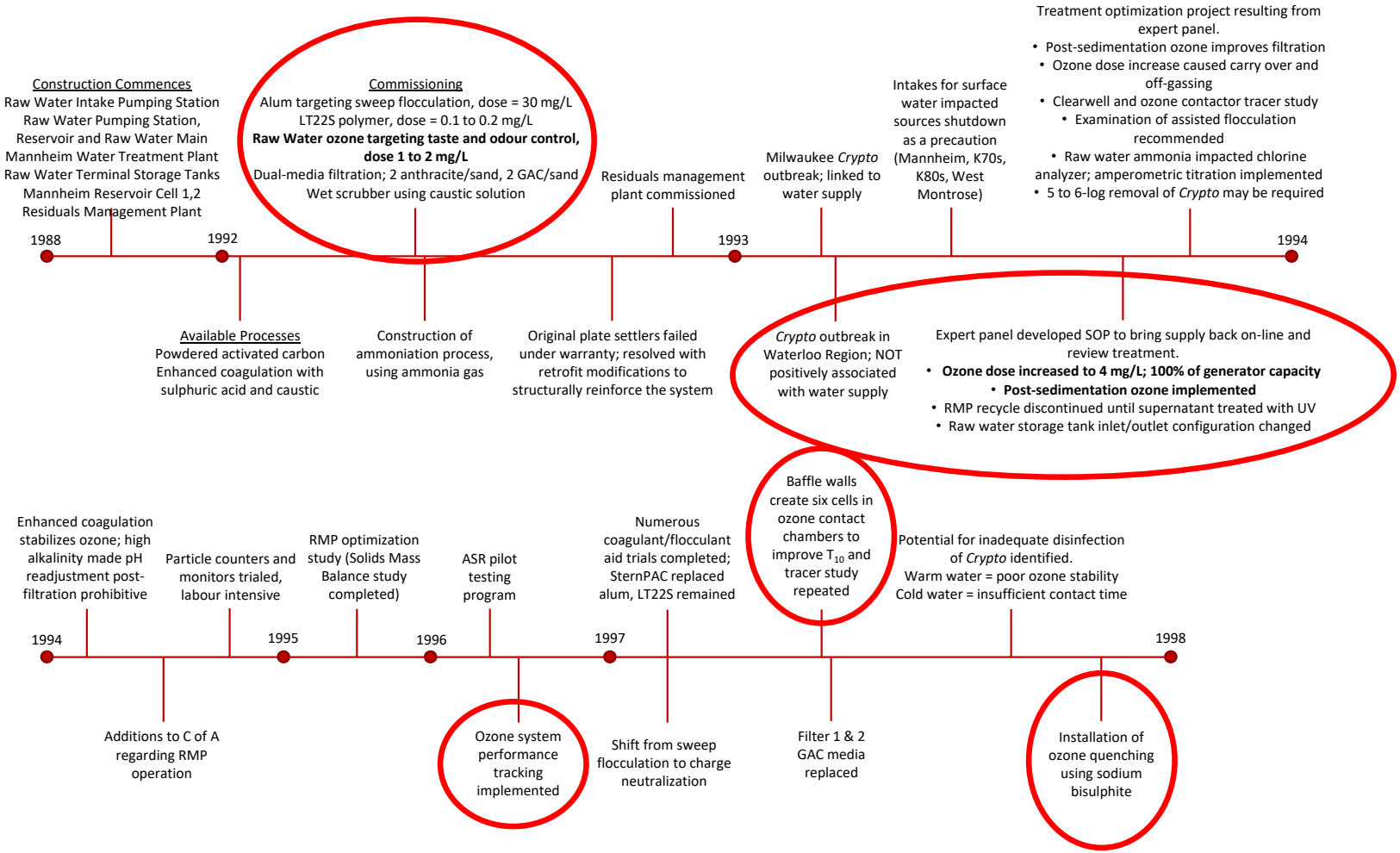
Turbidity 2 – 10 NTU

- Grand River may exceed 100 NTU
- Substantial sedimentation in Hidden Valley reservoirs

Coagulant: PACl (~28 mg/L; may exceed 60 mg/L during high turbidity/pH events)

Cationic polymer: Magnafloc LT22S (~0.2 – 0.3 mg/L)

Mannheim Water Supply History – 1988 to 1998



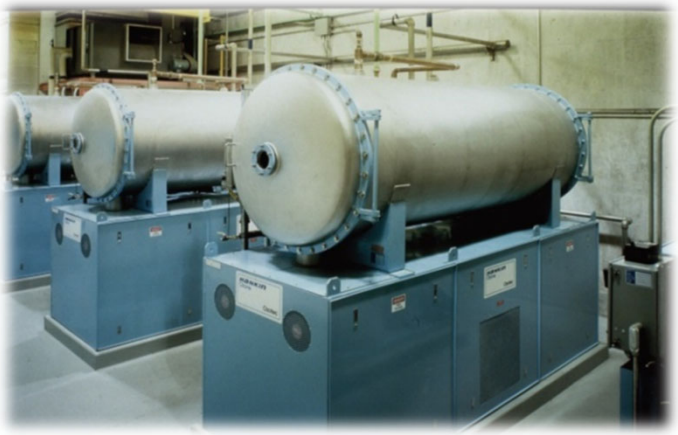
Original Ozone System

Hankin air-fed system

3 generators – 2 duty/1 standby

90 Kg/day capacity at 1.8% w/w ozone

2 contact chambers with stone rod diffusers



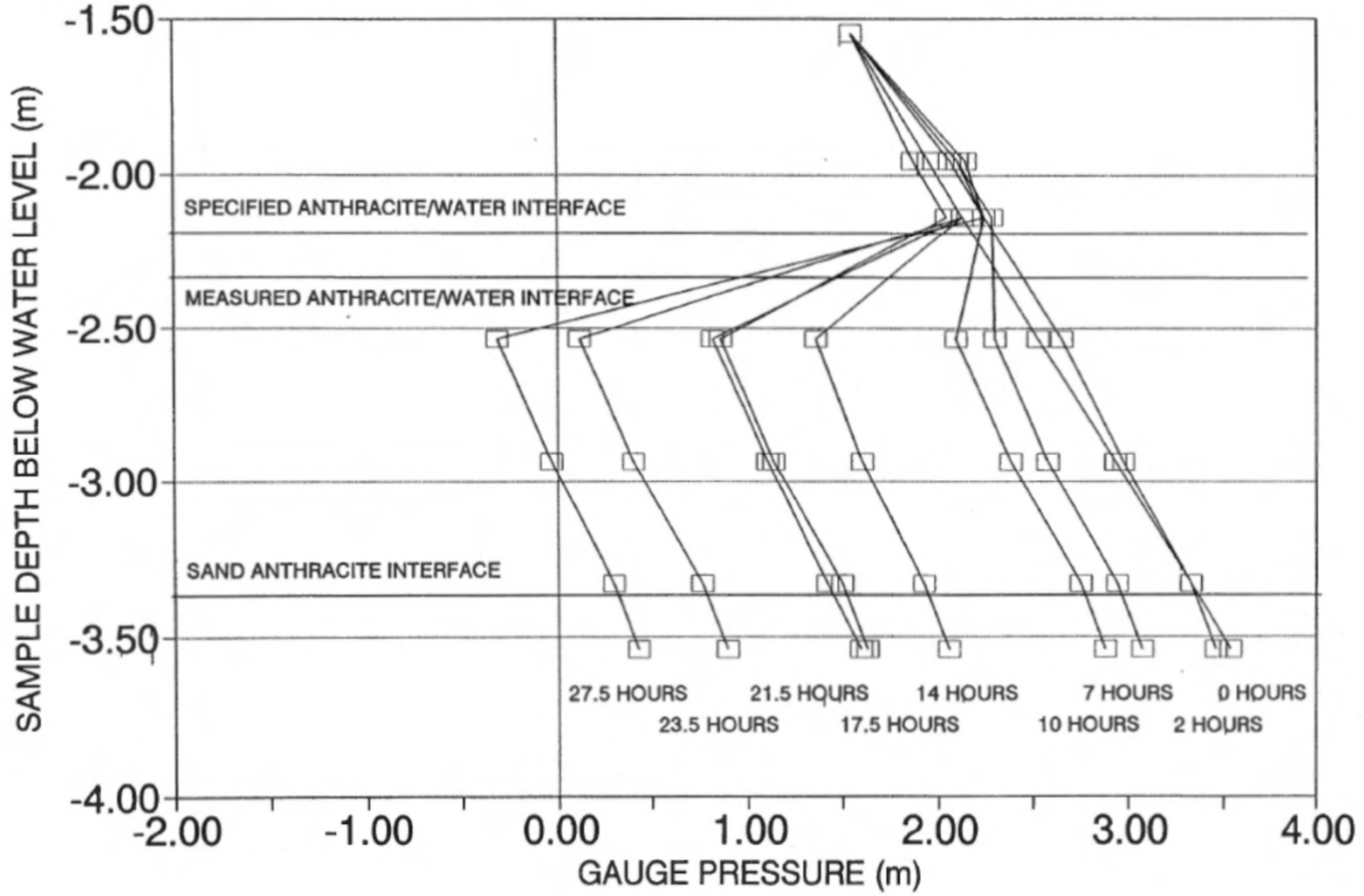
Impact of Cryptosporidiosis Incident

- Ozonation process focus switched from a taste, odour and colour to disinfection
- Mannheim WTP switched from raw water ozonation to post-sedimentation ozonation
- Dosage maximized.

Positive Impact of Ozonation and Preoxidation on Filtration

- ‘93 to ‘94 Mannheim WTP process review and plant optimization
  - Positive effect of post-ozonation operation on filtration documented

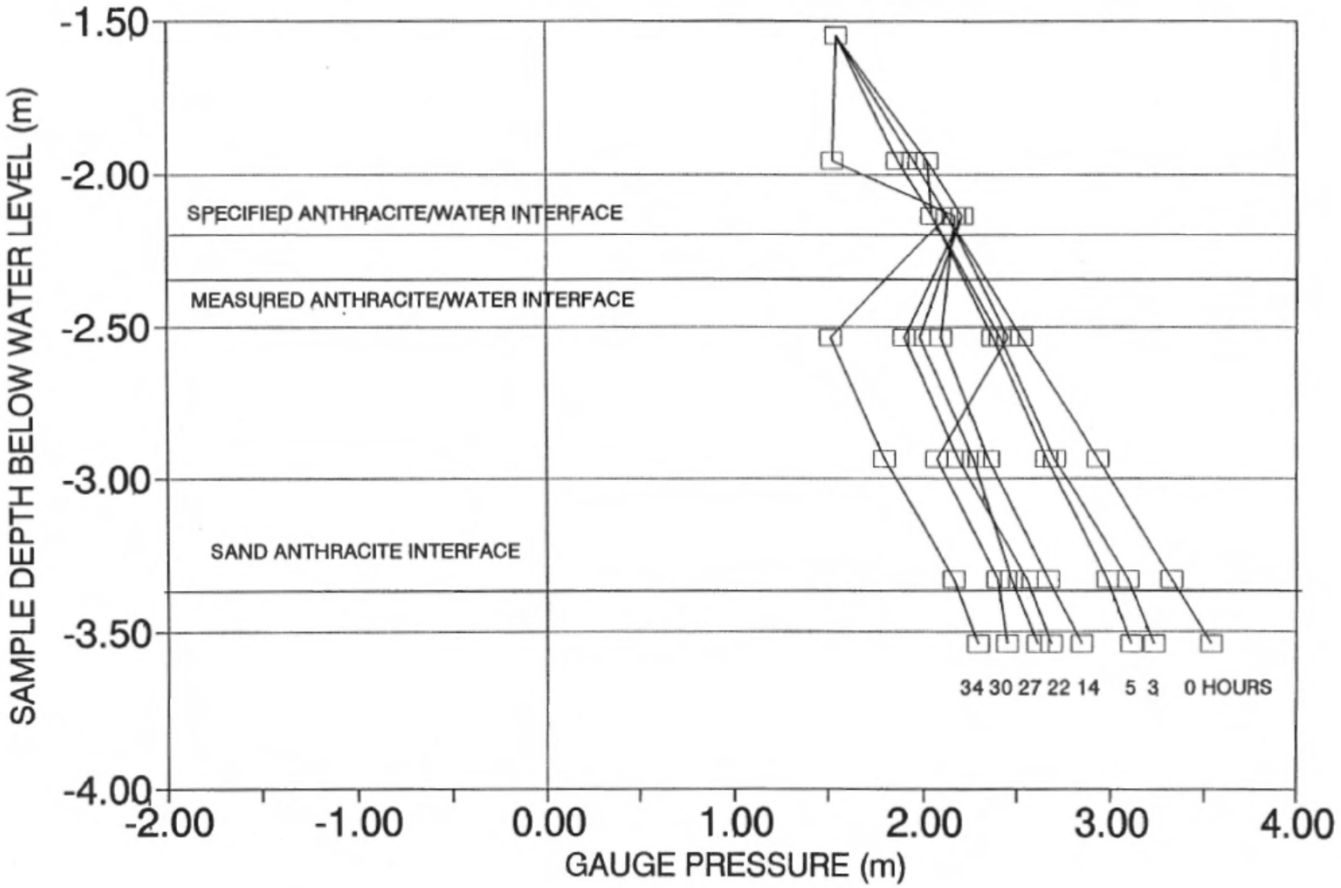
Figure 3.4 FILTER PRESSURE PROFILE - FILTER 4
PRESEDIMENTATION OZONE MODE



FILPRE.WQ1
MAY 94

Figure 3.5

FILTER PRESSURE PROFILE - FILTER 4
POSTSEDIMENTATION OZONE MODE



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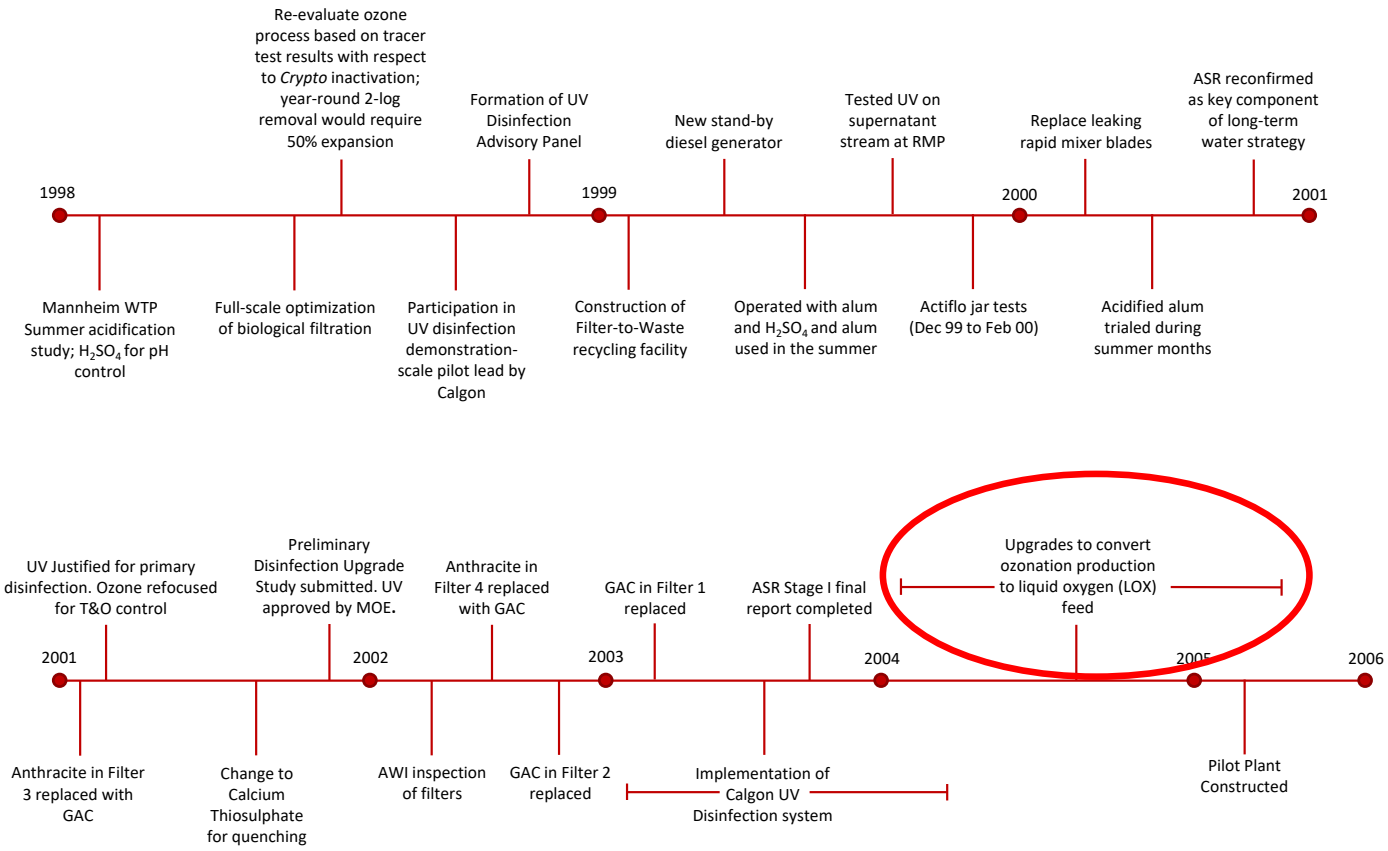
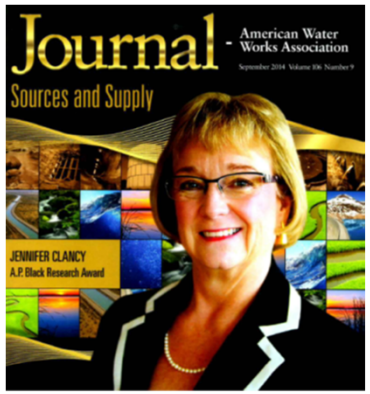
Mannheim WTP History – 1998 to 2005



Advent of UV Disinfection

- ’99-’01 Advent of UV disinfection
- Pioneering work that proved UV irradiation efficacy for *Cryptosporidium* inactivation occurred at Mannheim
- The patent battle



2004 - Conversion from Air-fed to LOX

Old air fed system was worn out

- Ran at 100% power output continuously for 10 years trying to achieve disinfection

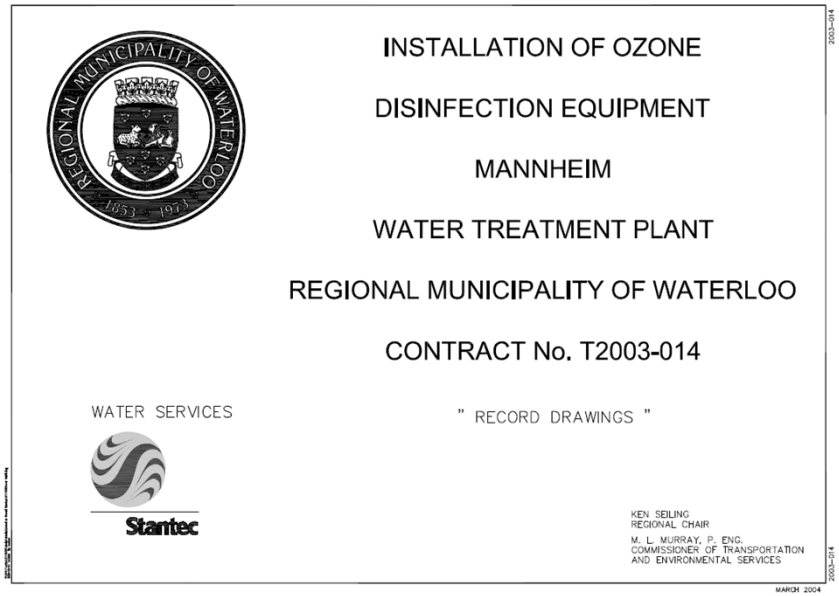
Increased system capacity

- 180 kg/day @ 10% w/w ozone
- 360 kg/day @ 6% w/w ozone
- Dose up to 5 mg/L at max plant flow

Improved process performance and efficiency

Trickle down impacts were experienced

- Reduction in gas flow impacted the diffuser system
  - Diffuser lines cut and capped to accommodate reduced flow
- Changes to destruct system



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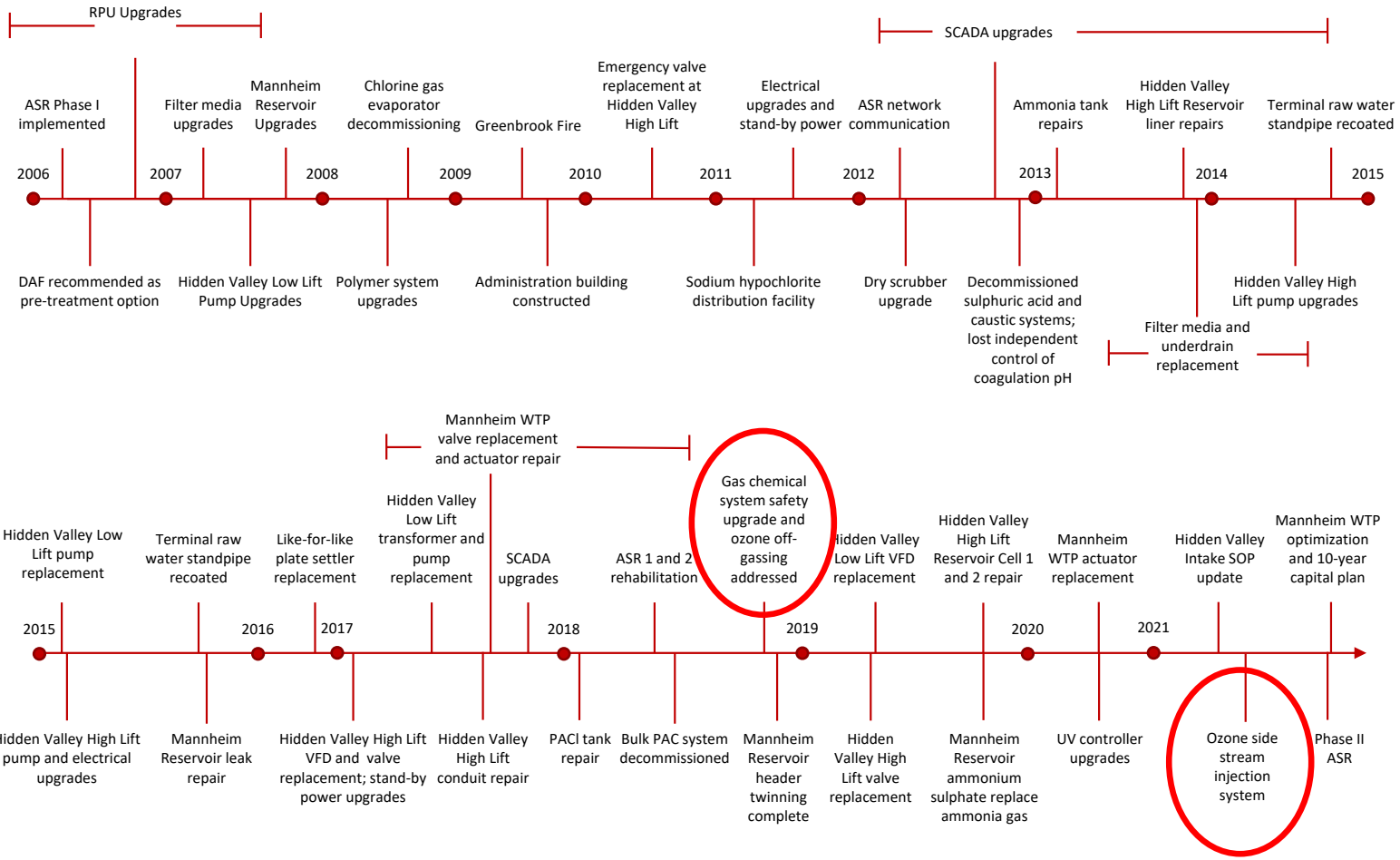
Mannheim WTP History – 2006 to present



2017 - Chemical Gas Safety System Upgrades

Operations staff threatened a work refusal due to the ozone concentrations through the plant

Ozone off gassing in the filter gallery was perceived to be a health and safety issue

- Ozone into the plant drain and back up through raw water overflows
- HVAC ran primarily on recirculation mode, even during an ozone release
- Ozone periodically vented from the building was recirculated to the administration building

Substantial modifications were completed:

- **Review of plant start-up and shutdown procedures**
- Programming changes related to interactions between SCADA, building alarms, security, and PA
- Ventilation modifications throughout the plant and administration area
- Installation of additional ozone monitors in areas of concern
- Upgrades to calcium thiosulphate quenching system

2019 - Quenching System Upgrades

Transition from SBS to calcium thiosulphate had already occurred
- SBS unpleasant to work with; calcium thiosulphate is safer/cheaper

Quencher system modified to reduce off gassing in filter gallery

Historically, quencher dosed in the effluent trough
- Missed a significant portion of the outflow stream
- Immediately before filtration with limited contact time

Modifications as part of this project included:
- Dosing quencher at the end of cell 5
- Redundant pumps for each side of the plant
- **Improved controls programming**

2021/22 - Sidestream Injection

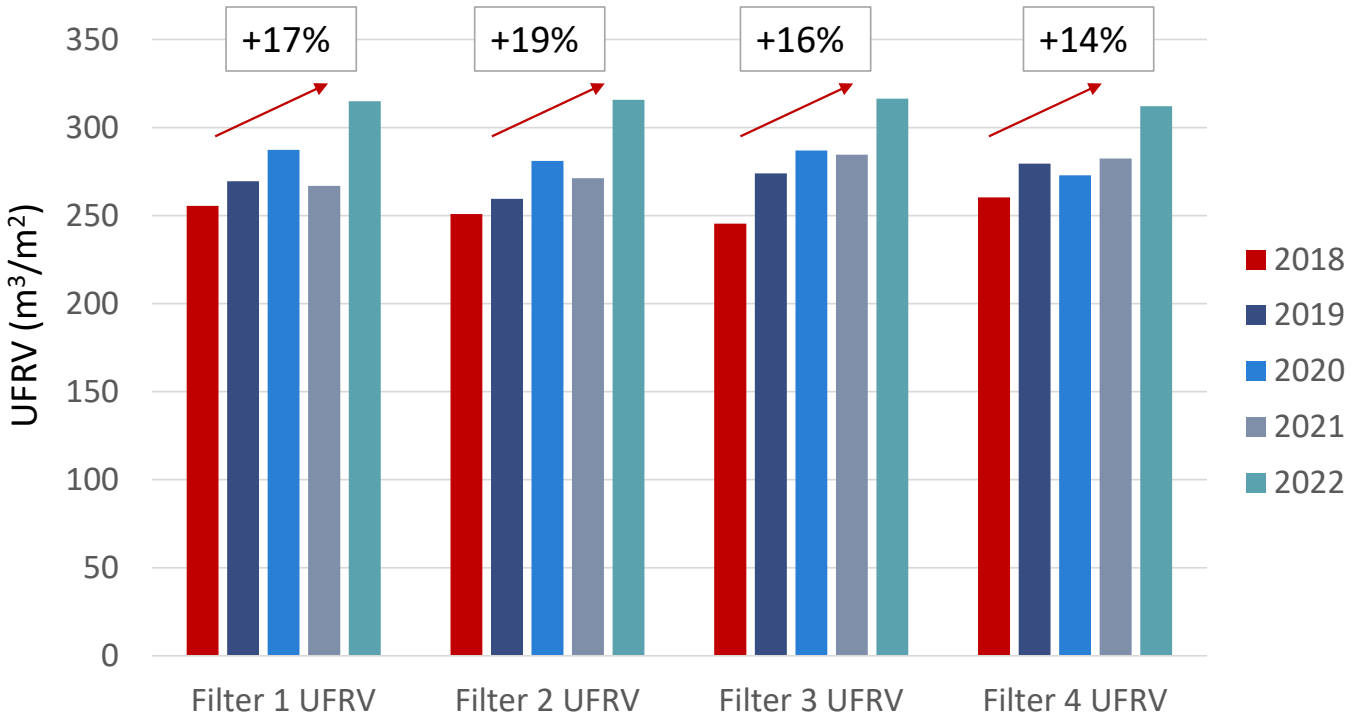
System upgrade completed to address issues with ozone transfer and inefficiencies of fine-bubble diffuser system

- High off-gas concentration
- Diffusers were maintenance intensive
- Reduce CSE frequency
- Ozone under vacuum

Improvements since SSI commissioning include:

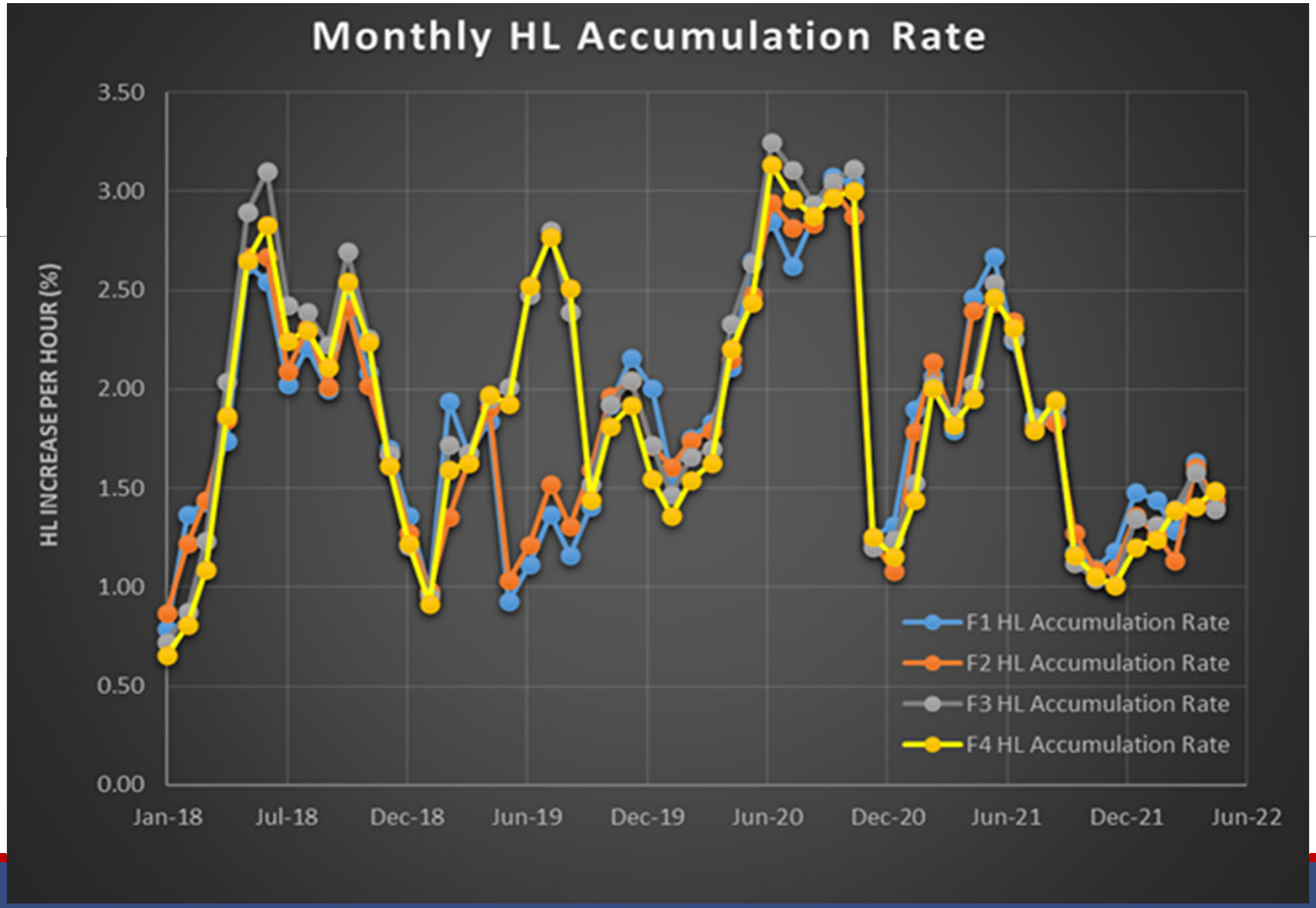
- Lower off gas concentrations
- Improving filter performance
- Lower chlorine requirements

Filter Performance Has Improved

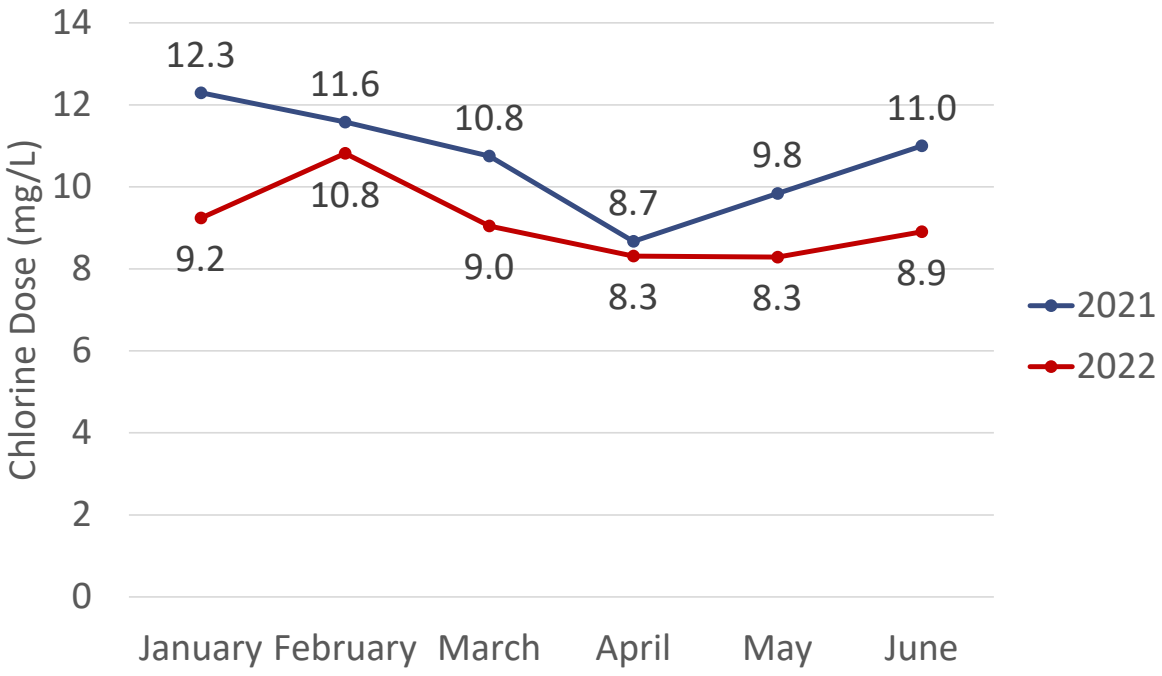


Seasonal UFRV compared
- March 1 to May 31

SSI resulted in:
- 10-18% improvement when compared to 2021
- 14-19% increase when compared to 2018-2021 average


Monthly HL Accumulation Rate
HL INCREASE PER HOUR (%)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Jan-18
Jul-18
Dec-18
Jun-19
Dec-19
Jun-20
Dec-20
Jun-21
Dec-21
Jun-22
F1 HL Accumulation Rate
F2 HL Accumulation Rate
F3 HL Accumulation Rate
F4 HL Accumulation Rate

Chlorine Consumption is Reduced



Monthly reduction in chlorine dose ranges from 4 to 25%

- Average 14%

Treated water chlorine residual increased by 3.5% in 2022

- 2.07 vs 1.99 mg/L

Takeaway: less chlorine required and residual is more stable

~30 Years of Ozone Evolution

	1991	2021
Purpose	T&O, Colour 1993 - Disinfection	2004 T&O, Colour, Back-Up Primary Disinfection, Readiness for Emerging Contaminants
Application Point	Pre-Coagulation	Post Sedimentation
Dosing Range	1-2 mg/L	3-5 mg/L
Gas Feed	Air	Liquid Oxygen
Concentration Range	~2%	6-10%
Production Capacity	90 kg/day	360 kg/day
Application	Stone diffuser rods	SSI
Quenching	None	Calcium Thiosulphate

What's Next?

Ozone currently being applied for taste and odour control, improving filter performance and organics reduction

- Raw water intake SOP includes attempt to operate at 1-log inactivation of *Cryptosporidium* during wastewater by-pass

Assess ozone sample station and **destruct system configuration** and operation

- Off-gassing occurs under some conditions
- Calculate ozone transfer efficiency
  - Make-up air currently prevents an accurate calculation from being completed
  - Modifications being completed as part of an upcoming contract

Generator mechanical inspection and refurbishment

PSU replacement

- Controllers have become obsolete

Ozone Destruct System Modifications

Ozone transfer efficiency has been identified as a key performance metric for the plant

Destruct unit operates at ~1,050 CFM; ozone generator maximum is ~125 CFM

- Typical ozone generator gas flow is much lower

Safety vacuum break located upstream of high concentration ozone analyzer

- Off-gas concentration diluted

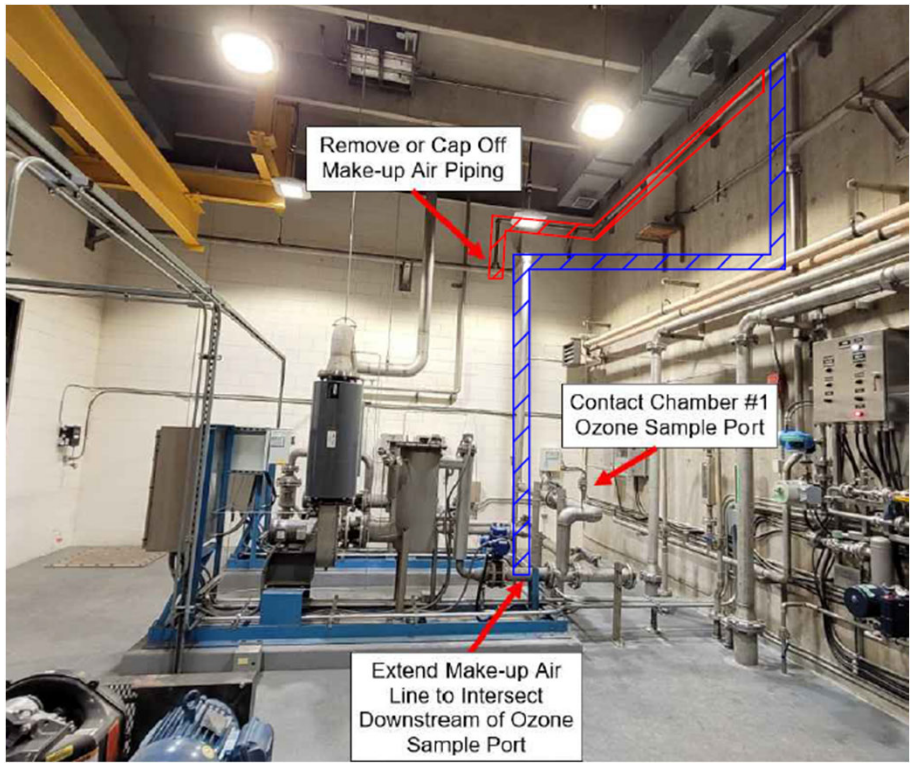
This configuration initially hypothesized to cause “saturation” of destruct media

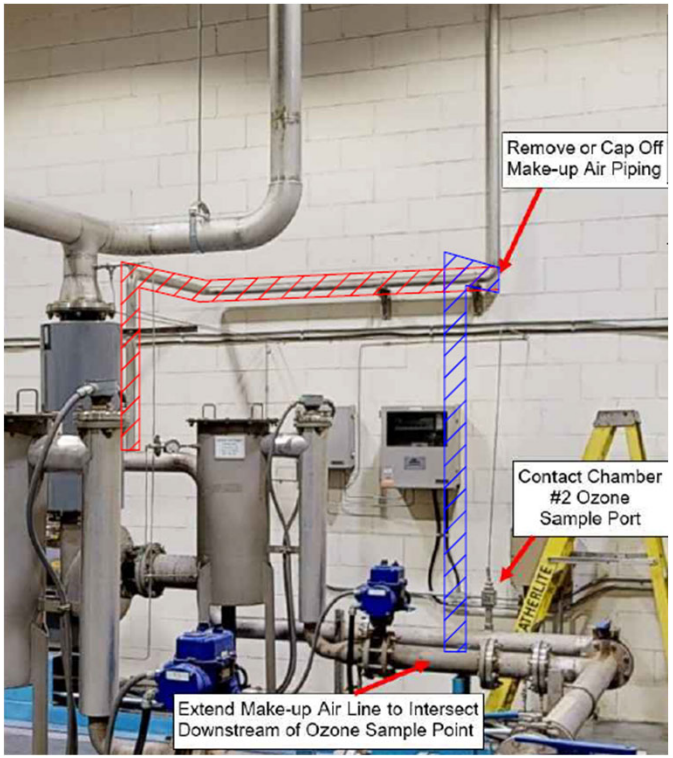
- High-humidity air poisons the media

Media has not been replaced since SSI

- Potential that fine-bubble diffusers were performing as coarse-bubble diffusers
- High-ozone off-gas concentrations saturated media

Ozone Destruct System Photos





10-year Generator Refurbishment

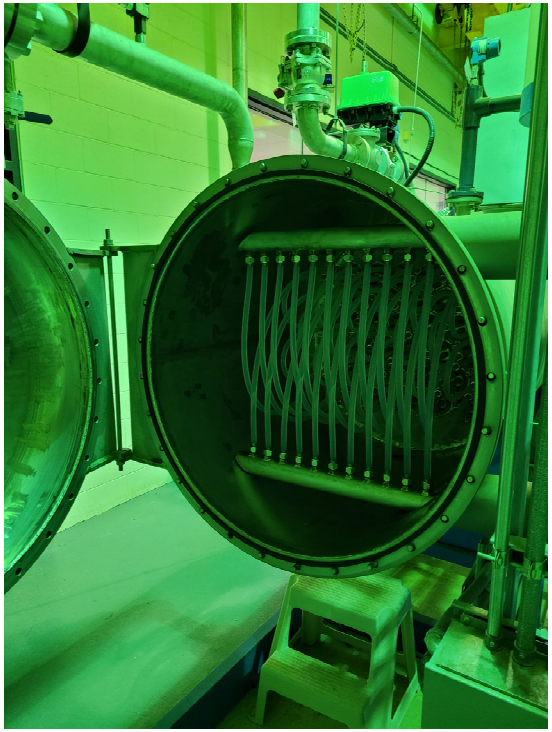
Disassemble and inspect critical generator components and structure

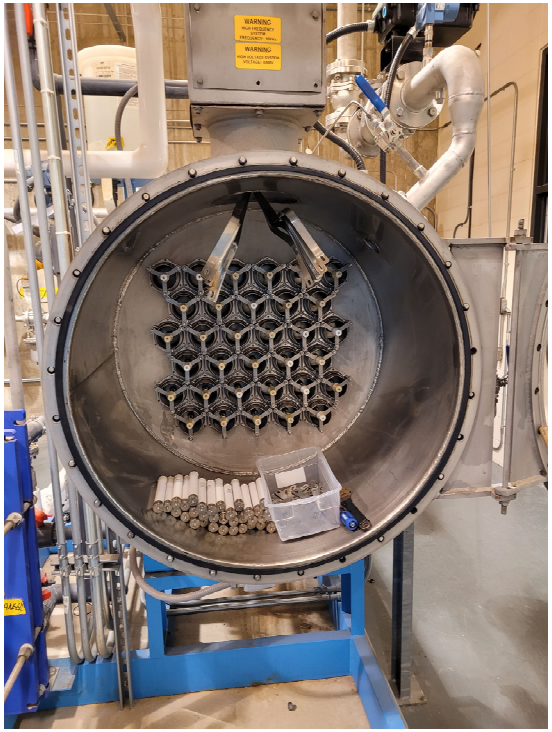
Clean all contact surfaces

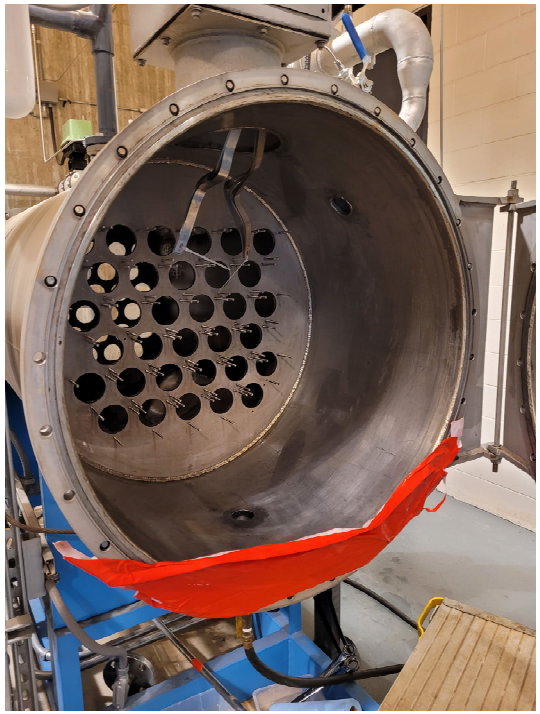
Replace all wear components

- Electrical
- Gaskets

Re-assemble and test key systems and components







Power Supply Unit Replacement

Control cards have become obsolete
- Replacements no longer available

PSU replacement underway
- Provide additional process resiliency
- Avoid a long-term process upset
- Scheduled for installation September 2023

Transition planning critical
- Low water-demand periods
- Avoid causing process upsets/plant shutdowns
- Proactively prepare for potential disruptions

Paired with 10-year mechanical inspection and refurbishment to be completed in fall 2022

Looking to the Future

Process performance testing and optimization

- Continue to test SSI system performance and plant response to higher doses

Understand the relationship with other parameters

- Organics removal, UFRV, chlorine demand, secondary disinfectant residual stability

Identify “optimal” operating conditions

- Water quality, production costs, maintenance requirements, etc.

Generator replacement (10+ year timeline)

THANK YOU FOR LISTENING! ANY QUESTIONS?