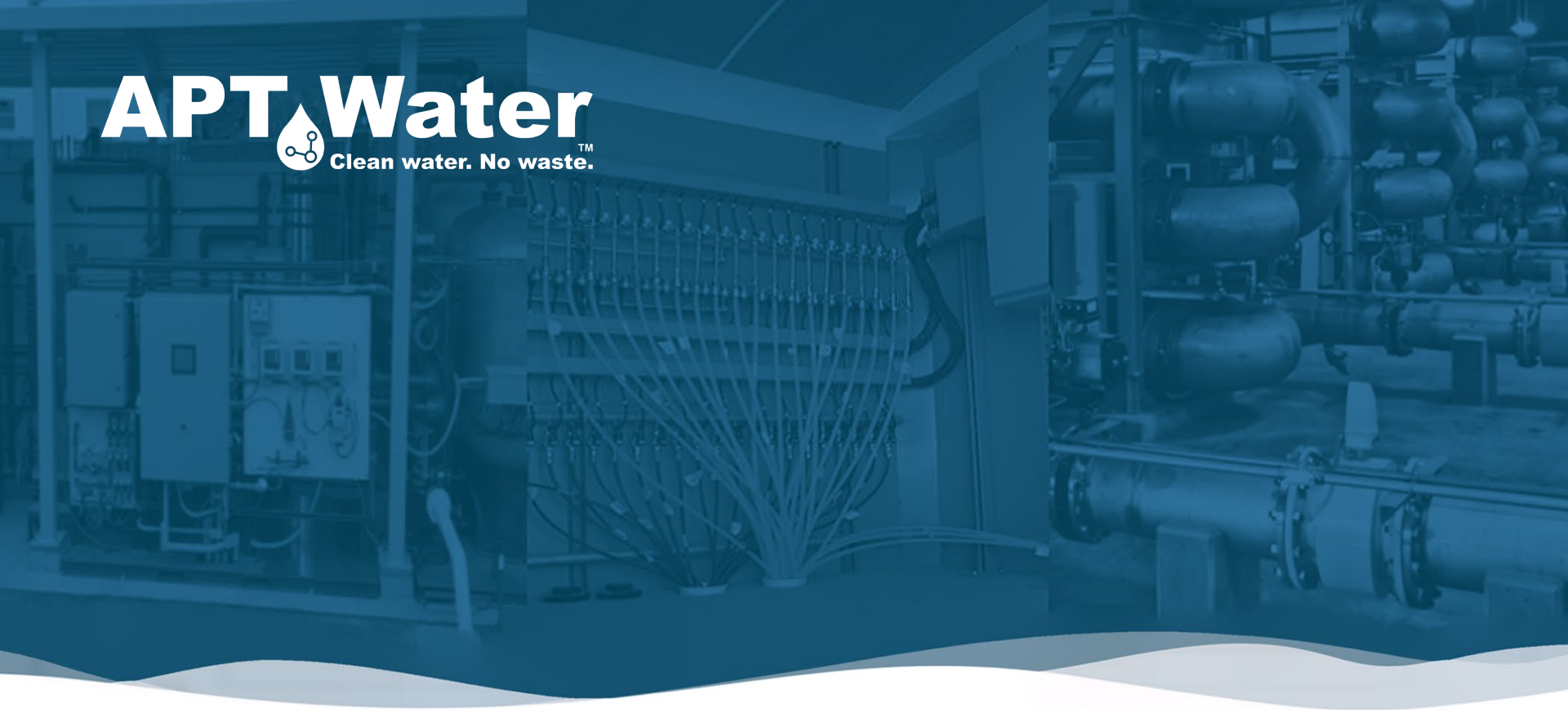


TCE & 1,4-DIOXANE AOP TREATMENT IN GROUNDWATER

NEW BRIGHTON/ARDEN HILLS SUPERFUND SITE

ARDEN HILLS, MINNESOTA

Scott A. Miller, P.E., CEO

APT Presentation Outline

- Site Background of TCAAP
- OU2 Recovery and Treatment System
- AOP Treatment Technologies Evaluation
- Water Quality Treatment Challenges
- SGRS Treatment for TCE & 1,4-Dioxane
- HiPOx AOP Treatment Technology
- Operational Review of Treatment System
- Questions

Site Background

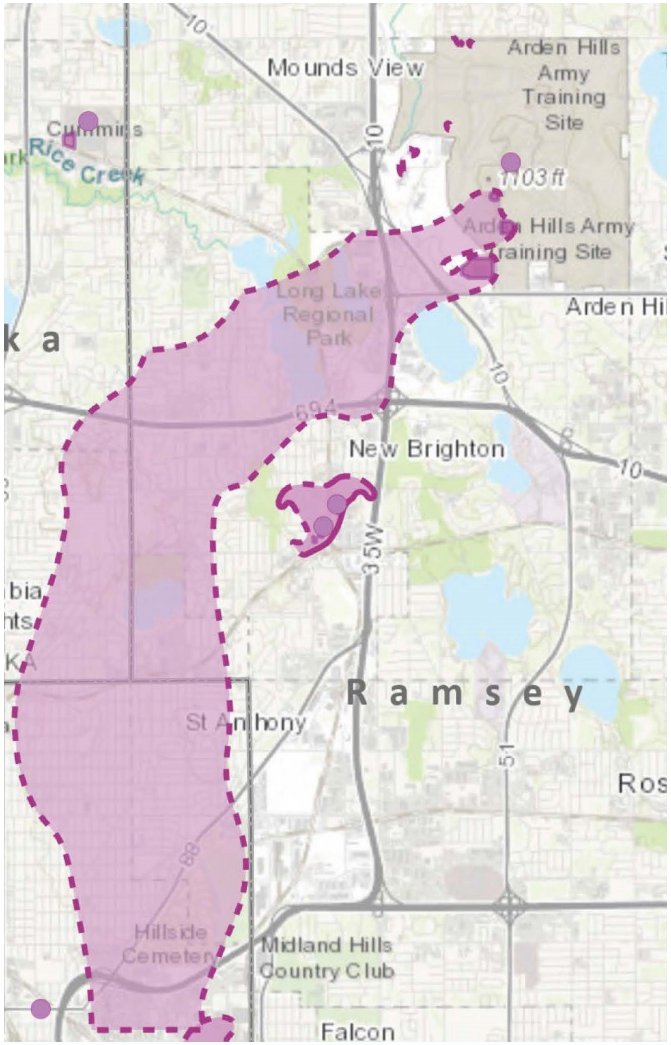
In 1941, the federal government acquired 2,370 acres for the manufacture of small arms ammunition in Arden Hills, Minnesota.

The facility is known as Twin Cities Army Ammunition Plant (TCAAP) and manufactured ammunition from 1941 through the 1970s.

Picture from Sorensen, Kara . "Twin Cities Army Ammunition Plant ." MNopedia, Minnesota Historical Society. http://www.mnopedia.org/place/twin-cities-army-ammunition-plant (accessed May 6, 2024).

Site Background

- In 1981, chlorinated solvents were discovered in groundwater wells in New Brighton, MN.
- Waste deposited within TCAAP historically led to soil, sediment and groundwater contamination.
- The contaminated groundwater plume extends approximately 25 square miles.
- The Army has been remediating soil and groundwater at the site and surrounding, impacted communities prior to 1987.



Map Generated on Minnesota Groundwater Contamination Atlas, https://webapp.pca.state.mn.us/cleanup/search/superfund?siteId=47112-AREA0000000014

Site Background - Groundwater

- In 1989, the on-site TCAAP Groundwater Recovery System (TGRS) was installed to reduce off-site migration of contaminants in deep groundwater.
- Three Operable Units address deep groundwater remediation
    1. Operable Unit 1 (the off-site North Groundwater Plume)
    2. Operable Unit 2 (the on-site contamination)
    3. Operable Unit 3 (the off-site South Groundwater Plume)
- In February 2015, MDH notified New Brighton that 1,4-dioxane had been detected at up to 6.8 micrograms per liter [µg/L] in the New Brighton Contaminated Groundwater Recovery System (NBCGRS)

OU2 Recovery and Treatment Systems

Operable Unit 2 is composed of the following two systems:

1. The Boundary Groundwater Recovery System (BGRS) designed to recover groundwater and treat low concentrations of VOCs, consists of 8 extraction wells along the property boundary and southwest portion of the property with an air stripping system
2. The Source Groundwater Recovery System (SGRS) designed to recover groundwater and treat high concentrations of VOCs and 1,4-dioxane from source areas, consists of 9 extraction wells and an Advanced Oxidation treatment system for TCE and 1,4-Dioxane destruction with an air stripping system for removing residual VOCs

AOP Treatment Technologies Evaluation

The EPA approved a 1,4-Dioxane reduction from 100 µg/L to less than 1 µg/L (MDH HRL value of 1.0 µg/L) and TCE reduction from 2500 µg/L to less than 5 µg/L with required bromate formation control (EPA's MCL value for drinking water is 10 µg/L).

Two Advanced Oxidation technologies evaluated for 1,4-Dioxane destruction;

1. TrojanUVFlex (UV and hydrogen peroxide)
2. APT Water HiPOx (ozone and hydrogen peroxide)

AOP Treatment Technologies Evaluation

Bench Test Objectives for 1,4-Dioxane AOP destruction technologies

Flow Rate (gpm)	600		
Parameters	TCE	1,4-Dioxane	Alkanes
Influent (µg/L)	2500	100	2500
Objective (µg/L)	<5	<1	<5
Required log removal	>2.7	>2.0	

Water Quality Treatment Challenges

Water quality data challenges to each of the AOP technologies

UV AOP Challenges;

- Low ultraviolet transmittance (UVT) and destruction removal efficiency caused by;
    1. Turbidity (TSS)
    2. Inorganics (Fe, Mg)

HiPOx AOP Challenges;

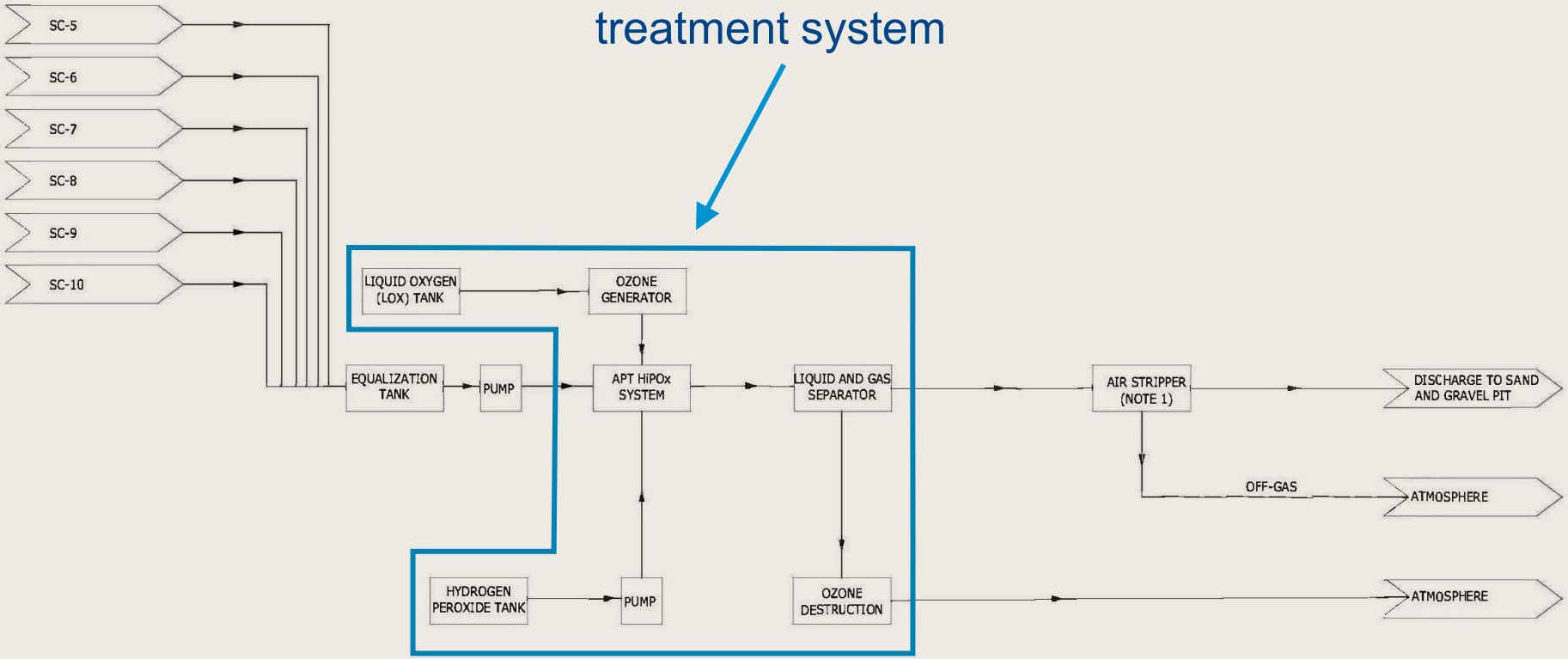
- Ozone forming bromate from naturally occurring bromide (40 µg/L)
- Low destruction efficiency for chlorinated alkanes

Modified SGRS for 1,4-Dioxane Removal

- In July of 2021, the final design modifications for the SGRS were completed.
- APT Water's HiPOx technology was selected as the AOP treatment system. The HiPOx component was designed to destroy TCE and 1,4-dioxane while the air stripping system would remove residual VOCs (alkanes)
- HiPOx did not require pretreatment to remove TSS or dissolved inorganics and controlled the formation of bromate below treatment objective (<10 µg/L)
- The operation of the AOP treatment system would destroy enough VOCs to allow for the air stripping system to meet air quality objectives without additional treatment.

SGRS Treatment for 1,4-Dioxane Removal

HiPOx AOP component of the SGRS treatment system



NOTE:

1. PUMPS ON AIR STRIPPER SKID WILL DISCHARGE TREATED WATER TO SAND AND GRAVEL PIT.

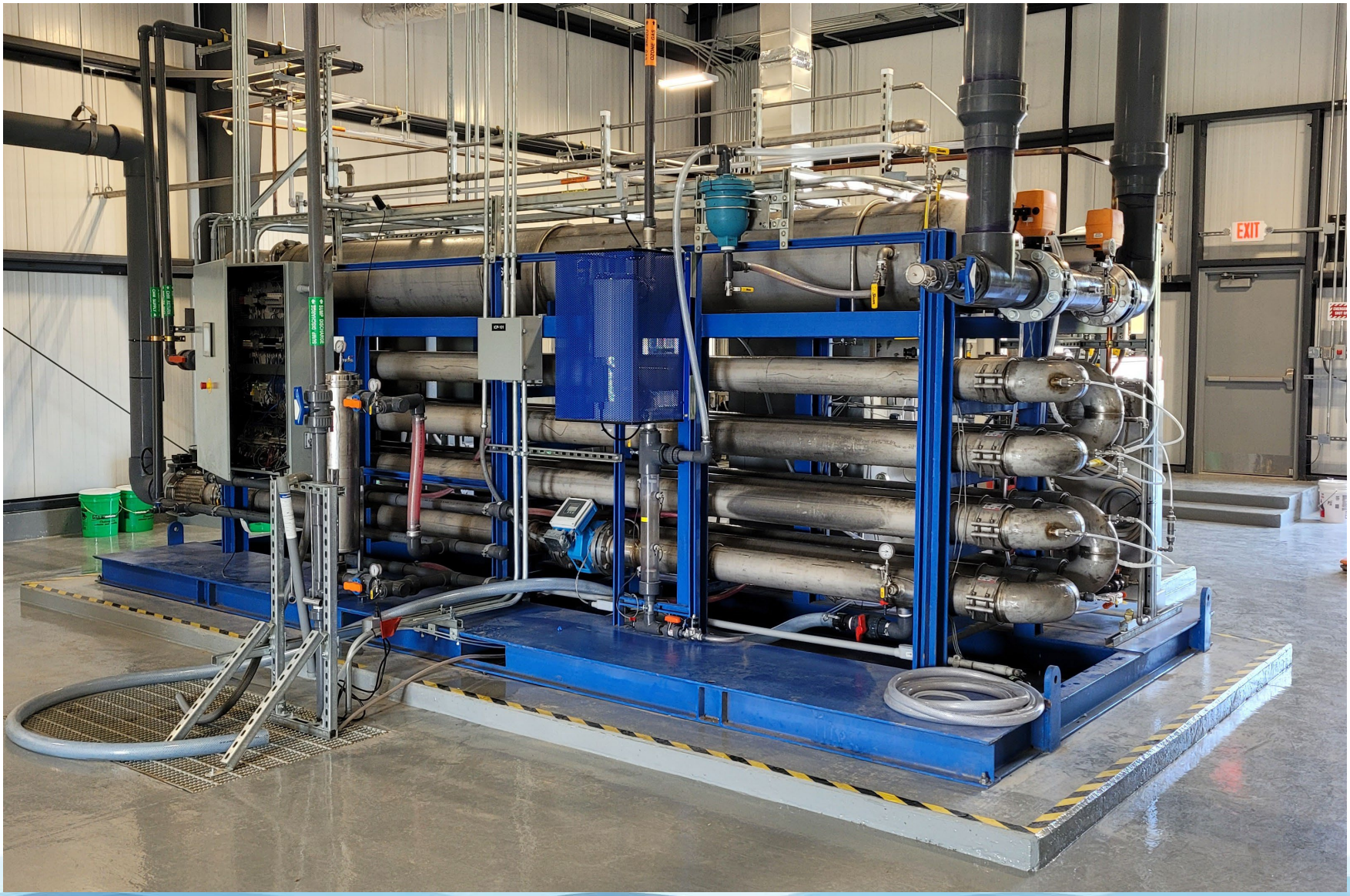
TWIN CITIES ARMY AMMUNITION PLANT
ARDEN HILLS, MN

MODIFIED REMEDY:
PROCESS FLOW DIAGRAM: TREATMENT SYSTEM FOR SOURCE AREA WELLS

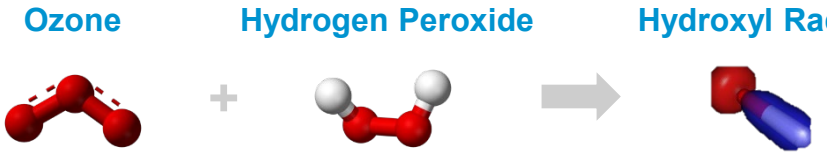
PIKA
ARCADIS
a joint venture

FIGURE 3

HiPOx AOP Treatment Technology



HiPOx® Chemistry

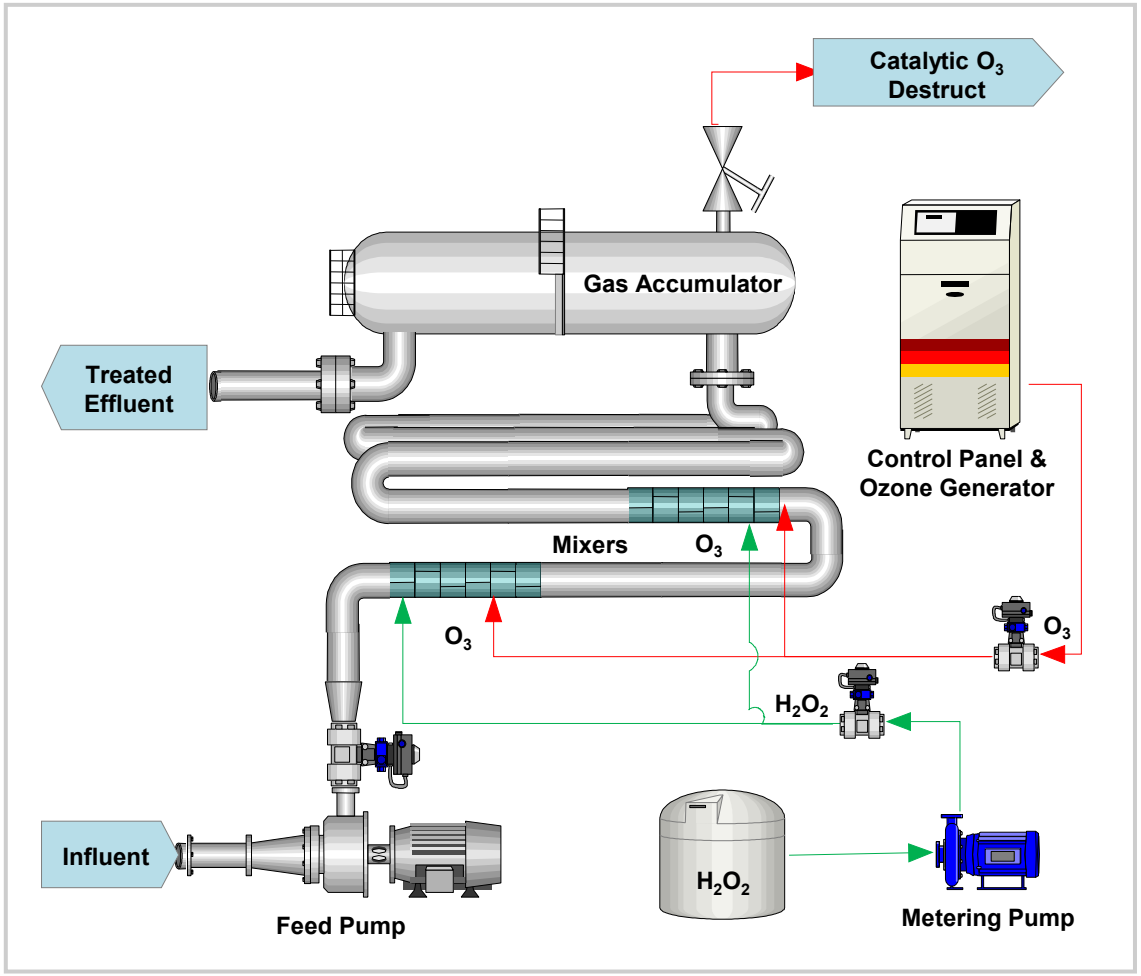


- Relies on nature's chemical reactions ensuring reliable water treatment, while eliminating the possibility of discharging untreated water
- Ozone with peroxide accelerates the production of hydroxyl radicals resulting in faster reactions while eliminating need for significant contact time
- The chemistry will always work if hydrogen peroxide and ozone are injected and mixed properly at the right concentrations

COMPLETE DESTRUCTION & MINERALIZATION OF MANY CONTAMINANTS INCLUDING:

- **Chlorinated Solvents:** 1,4-Dioxane, PCE, TCE, VC, DCE
- **Fuels**: BTEX, TPHg, TPHd
- **Oxygenates**: MTBE, TBA, Benzene, TAME
- **Aromatics**: PAHs, Phenols, Chlorobenzenes, Creosols
- **Pesticides & Herbicides:** Atrazine, Dioxins, Lindane
- **Taste, Odor, Color Compounds:** MIB, Geosmin, Sulfides

HiPOx® System Highlights



PROCESS FEATURES:

- **Plug flow reactor technology**
- Multiple O_3/H_2O_2 injection points
- High mass transfer efficiency
- High mixing efficiency >98%
- Patented bromate control
- Application specific reaction times
- Easy adjustment to different 1,4-Dioxane influent concentrations

SAFETY FEATURES:

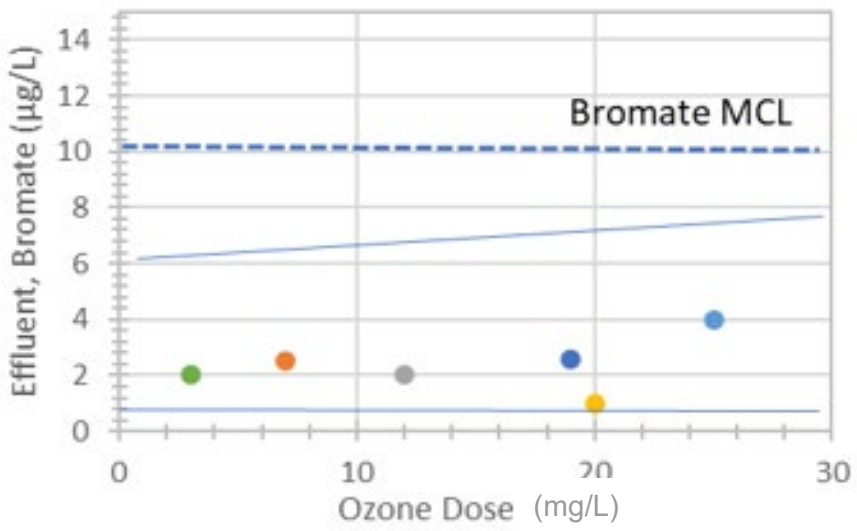
- Catalytic ozone destruct
- **Ozone sensors/alarms**
- Automatic alarms

OPERATION FEATURES:

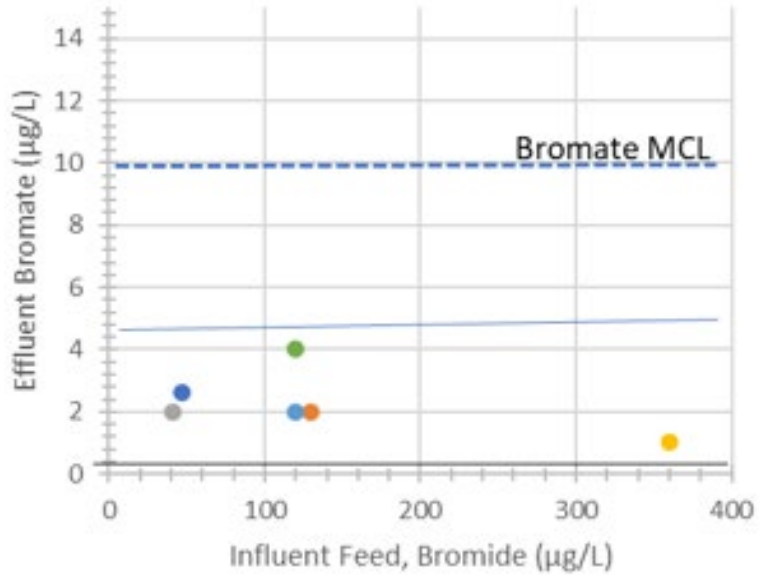
- Fully automated, remote operation
- **5 positive auto-shutdown modes**
- Touchscreen PLC
- Fully enclosed control panel

APT's Patented Bromate Control

BROMATE CONTROL & OZONE DOSE – CASE STUDIES



BROMATE CONTROL - CASE STUDIES

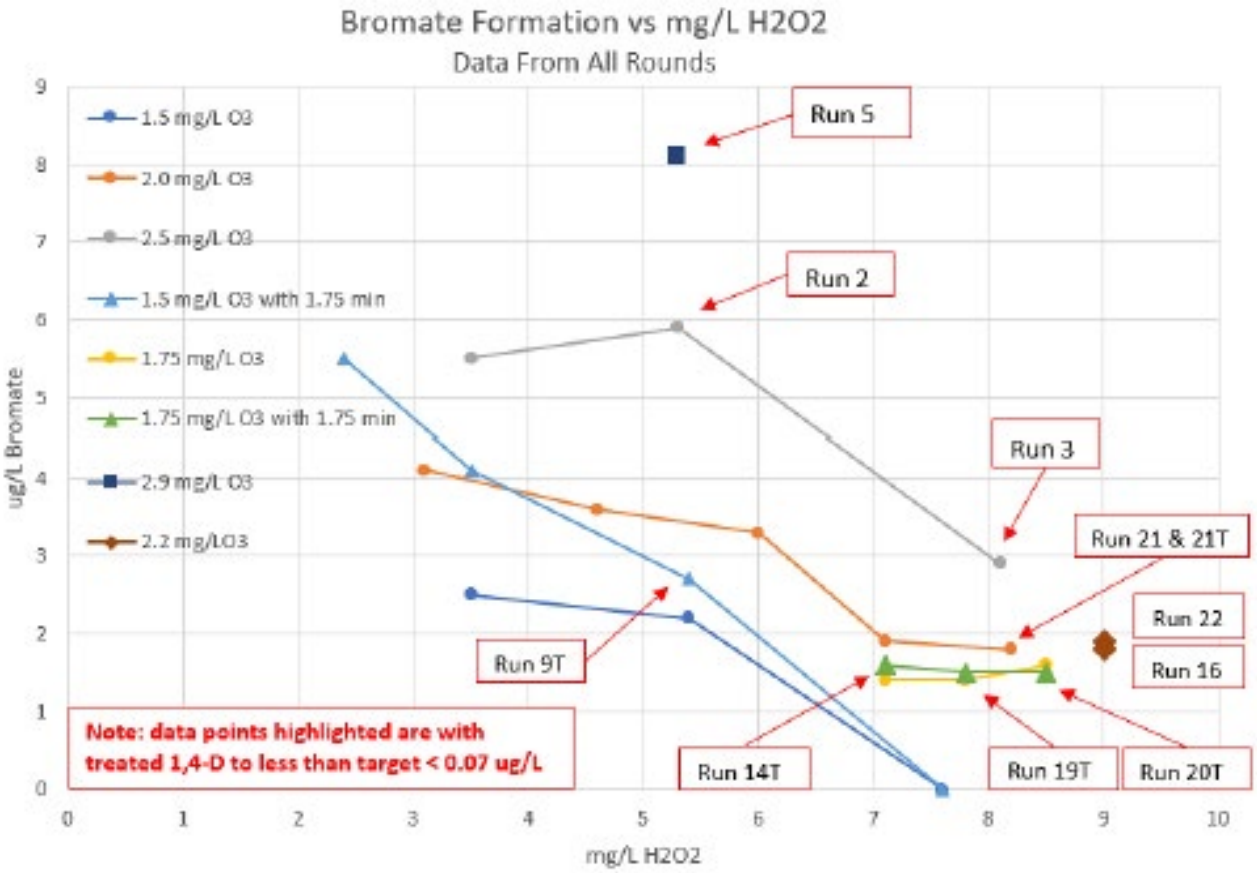


- Bromate can be controlled with ozone doses over 25 ppm vs conventional AOP systems limited to ~4 ppm
- Bromate is maintained below the bromate target limit of <10 µg/L even at high bromide concentrations

Bromate Formation Control

2024 Long Island Pilot for 1,4-Dioxane Destruction

- HiPOx achieves the destruction of 1,4-Dioxane to below the 0.07 ug/L treatment goal and still control the formation of bromate to near the detection limit of 1 ug/L.
- The ability to control bromate using ozone-peroxide advanced oxidation is an <u>extraordinary accomplishment</u>



Example OpX Comparison: HiPOx vs. UV AOP

Annual Operating Cost Comparison of APT's HiPOx AOP technology vs. Low-pressure UV AOP With a Typical 2,000 GPM – 3 MGD Project

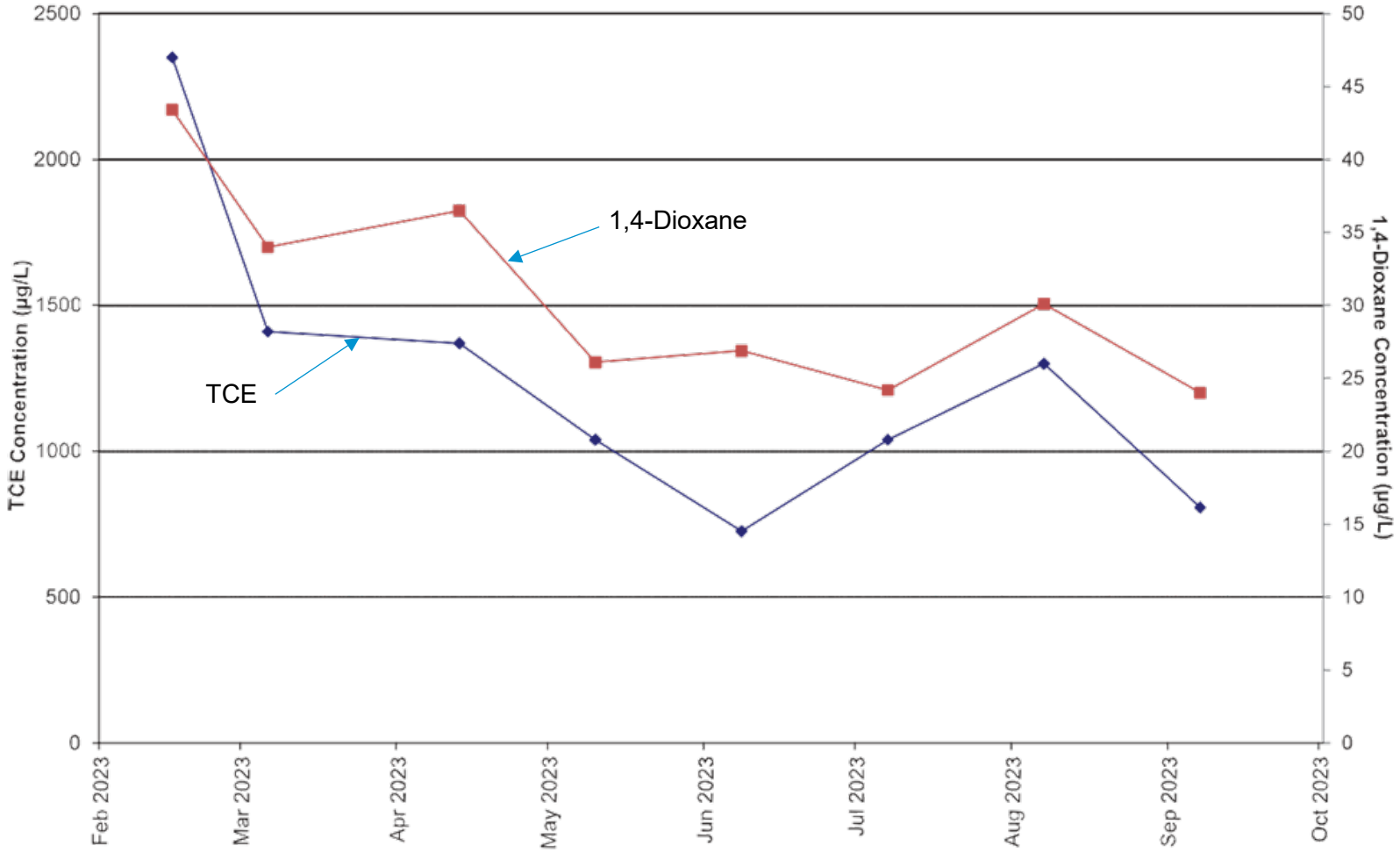
COST ITEM DESCRIPTION	UV AOP	HiPOx AOP	ANNUAL HiPOx SAVINGS
Annual Total Energy Consumption	$181K	$77K	**$104K**
Annual Maintenance (bulb replacement)	$128K	$37K	**$91K**
Annual Monitoring & Sampling	$82K	$18K	**$64K**
TOTALS:	**$391K**	**$132K**	**$259K**

This is an OpX cost comparison for a different groundwater treatment project and not one that represents the TCAAP alternatives evaluation

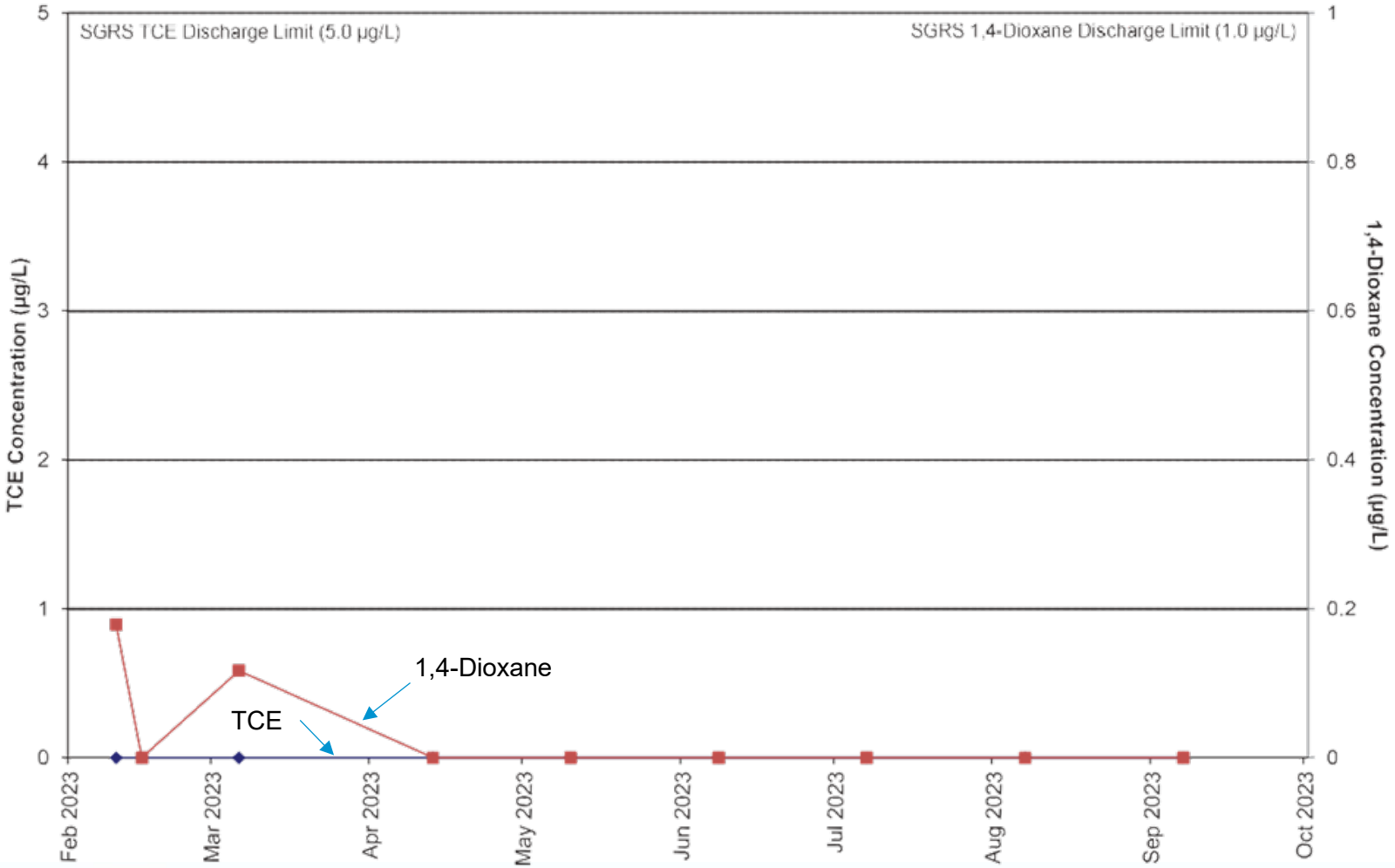
Operational Timeline and Results

- The SGRS was fully operational in February 2023
- The draft Fiscal Year 2023 Annual Performance Report for October 2022 through September 2023 reported treatment results for the SGRS;
    1. A total of 2,389 lbs of VOCs were removed from OU2
    2. Average SGRS VOC influent concentration was 2,019.1 µg/L
    3. Monthly influent VOC concentrations generally decreasing from 3,274.8 µg/L to 1,066.6 µg/L over reporting period
    4. Decreasing SGRS influent VOC concentrations are expected as VOCs are removed from the source areas

SGRS Influent Concentrations



SGRS Effluent Concentrations



Operational Adjustment Capabilities

- APT Water has designed each HiPOx system to ensure destruction and compliance with variable influent contaminant concentrations
- HiPOx ozone and peroxide usage can be adjusted lower as influent concentrations decrease over time
- Annual operational costs get even lower as energy and chemical usage decreases as the HiPOx system is adjusted with variable influent concentrations.

THANK YOU!

ANY QUESTIONS?

Scott A. Miller, P.E.
Chief Executive Officer
smiller@aptwater.com
(860) 670-7608

www.aptwater.com