

Electrochemical Degradation of PFAS Mass in Wastewaters

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Environmental Technologies

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Agenda

- DE-FLUORO™ PFAS Destruction Technology
- Technology Readiness Level
- Batch System Demonstration Program – Meg
- Evaluation Program – Barracuda
- Coupled Demonstration Programs - Pike



DE-FLUORO™

PFAS DESTRUCTION TECHNOLOGY

Developed by AECOM and our academic partners

An economically and environmentally sustainable treatment technology that destroys PFAS from contaminated liquids

Offers a PFAS destruction solution through electrochemical oxidation

Can be coupled with non-destructive technologies as part of a treatment train

Can operate as a stand-alone onsite technology

DE-FLUORO has been proven in an operational environment and development continues

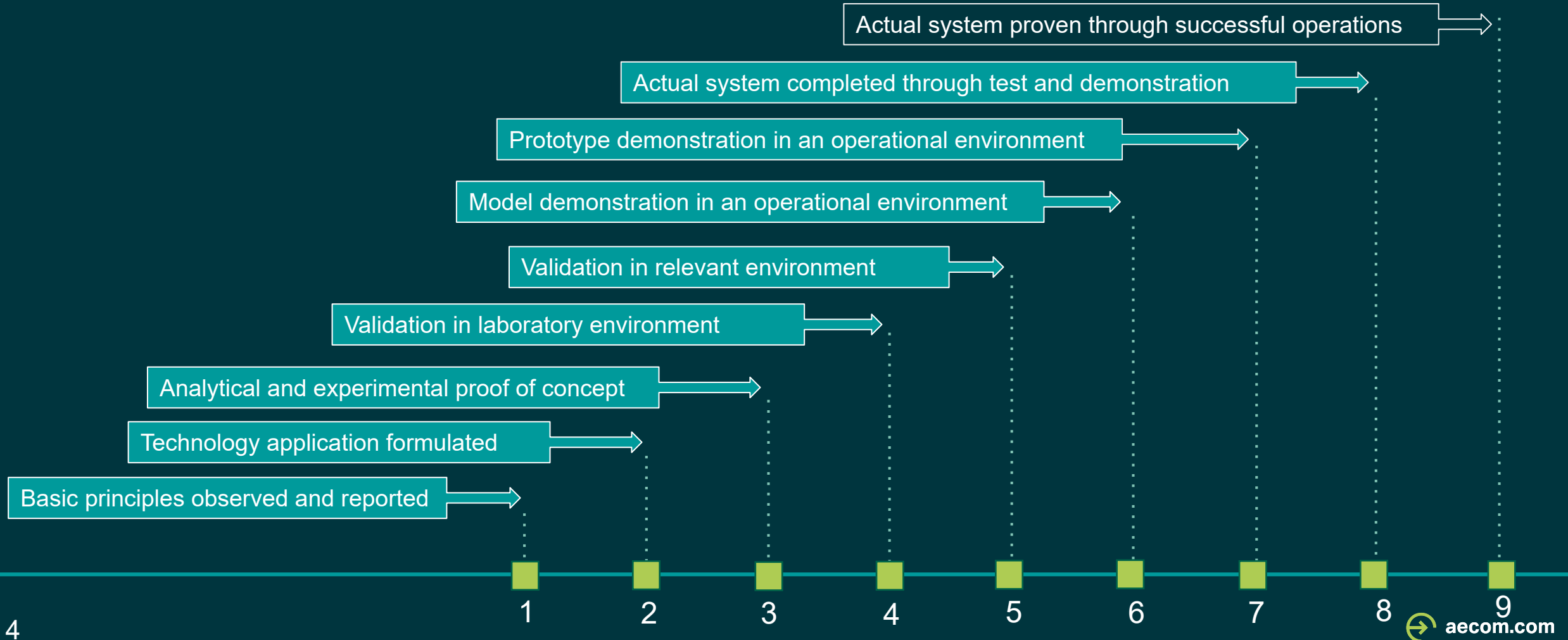


Megalodon “Meg”

DE-FLUORO™ Batch System

DE-FLUORO – Technology Readiness Level Advancement

Reference: https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf

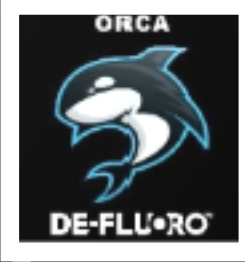


Demonstration & Commercial Systems:

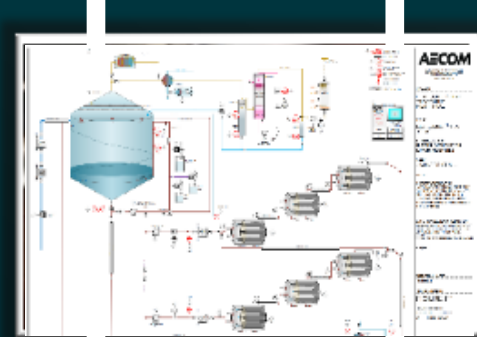
Meg: 



Orca: 



Blue:   



Pilot & Evaluation Systems:

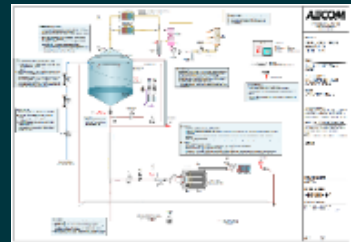
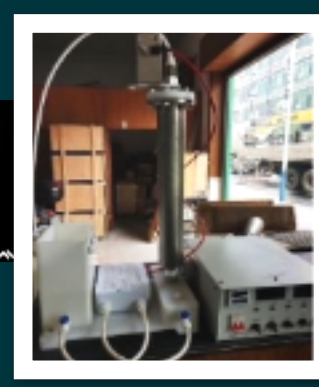
Barracuda: 



Pike: 



Penguin & Manta: 



System Demonstration Programs

Batch System Demonstration (Complete)

Client: Department of Defence (Australia)

Location: Confidential Australian Site

Duration: June – September 2021

Treatment Liquid: Wash Water Solution



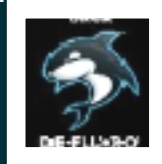
Flow Through System Demonstration (Ongoing)

Client: Confidential United States Federal Client

Location: Confidential United States Site

Duration: March 2022 - ongoing

Treatment Liquid: Fire training water & AFFF



Batch System Demonstration (Ongoing)

Client: Department of Defence (Australia)

Location: Confidential Australian Site

Duration: November 2022 - ongoing

Treatment Liquid: Wash Water Solution



Bench Evaluation (Ongoing)

Client: Oil & Gas Major

Location: Confidential Australian Site

Duration: November 2022 - ongoing

Treatment Liquid: Wash Water Solution, Spill Recovery Waste & AFFF



Bench Evaluation (Ongoing)

Client: Confidential Industrial Client

Location: Italy, Europe

Duration: January 2023

Treatment Liquid: Concentrated Groundwater



Bench Evaluation (Ongoing)

Client: Department of Defence (Australia)

Location: Various

Duration: January 2023

Treatment Liquid: New Generation Foam mixed with Residual PFAS





DE-FLUORO – Batch System Demonstration

System Overview

Scale: Modular system contained within 20-foot shipping container

Reactors: Six reactors containing seven titanium suboxide anode-cathode pairs

Power Requirements: 3 phase power / potential for solar with battery support

Treatment Setup: Stand-alone, batch mode

Operator Requirement: Single operator supported through telemetry system

Pilot Overview

Client: AUS Dept of Defense

Treatment Solution: 20,000L Wash Water

Origin of Solution: AFFF tank decontamination associated with foam transition program

Client Objective: Treat First Flush for discharge to the onsite treatment system

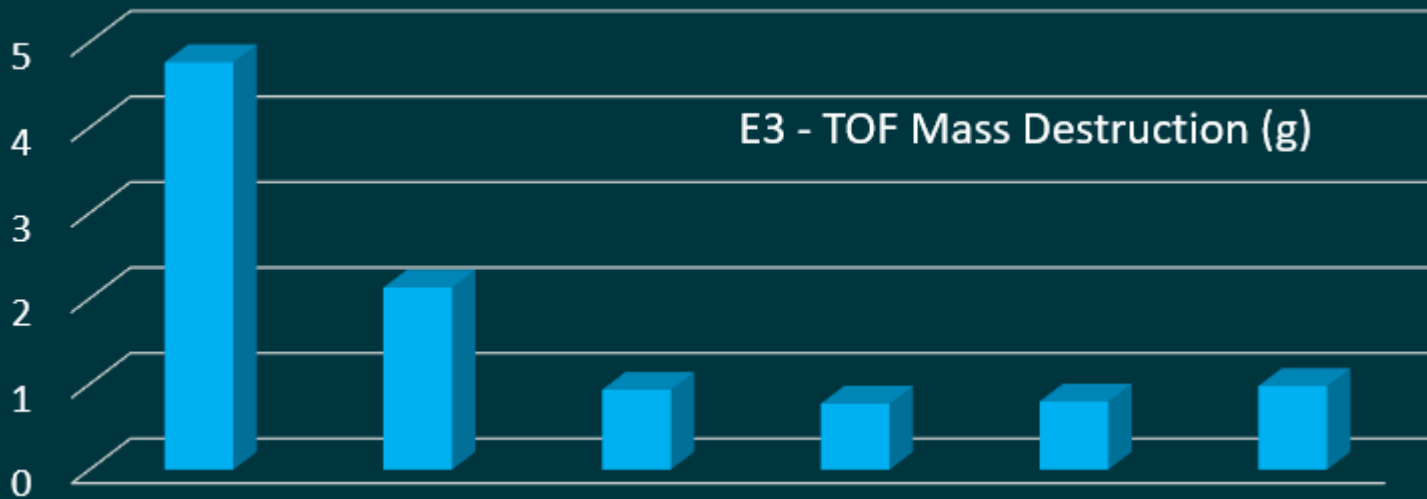




DE-FLUORO – Batch System Demonstration

Wash Water Performance & Observations

- System performance was generally maintained with telemetry with limited need for onsite personnel
- Initially tested two conditions: 1) flow rate 60 L/min and current 180 amps; 2) flow rate 100 L/min and current 220 amps.
- Limited foam generation and excellent foam management without intervention
- About 83% reduction TOF mass achieved in 24 hours
- Achieved required levels for discharge via onsite water treatment plant

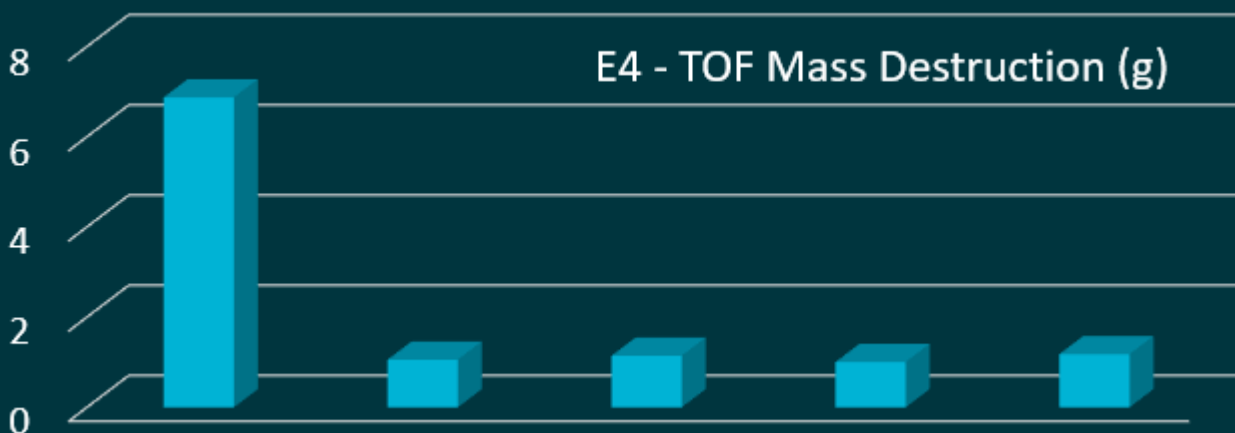




DE-FLUORO – Batch System Demonstration

Wash Water Performance & Observations

- System performance was generally maintained with onsite staff and telemetry
- Shutdowns associated with overheating (>45 degrees Celsius) due to high ambient temperature conditions; allowed 8-10 hour treatment times before cooling was required
- Maximum flow rate (105 L/min) and increased current (270 amps) to further assess destruction performance
- Limited foam generation with system able to manage foam without intervention
- About 86% reduction in TOF mass achieved in 24 hours; achieved required levels for discharge via onsite water treatment plant



| Time | T0 | T2 | T7 | T24 | T32 |
|-----------|------|------|------|------|------|
| Mass (mg) | 6.88 | 1.06 | 1.14 | 1.00 | 1.17 |



DE-FLUORO – Evaluation System and Experiments

System Overview

Scale: Barracuda single bench reactor with seven proprietary cathode / anode pairs

Treatment Process: Batch / Recirculation

Power: 7 DC volts / adjustable current

Operation: Remote interface and data logging

Foam Management: Foam sensors trigger foam displacement system

Emission Control: Variable control 2-stage treatment with wet scrubber and carbon sorption

Pilot Overview

Treatment Volume: 100 litres (26 gallons)

Treatment Time: 100+ hours

- Treated Liquids:** Wide range of wash water, mixed wastes,
- Relatively low PFAS impacted liquid: TOF 1300 µg/L
 - Medium PFAS impacted diluted concentrate: TOF 190,000 µg/L
 - AFFF concentrate: TOF 4,280,000 µg/L

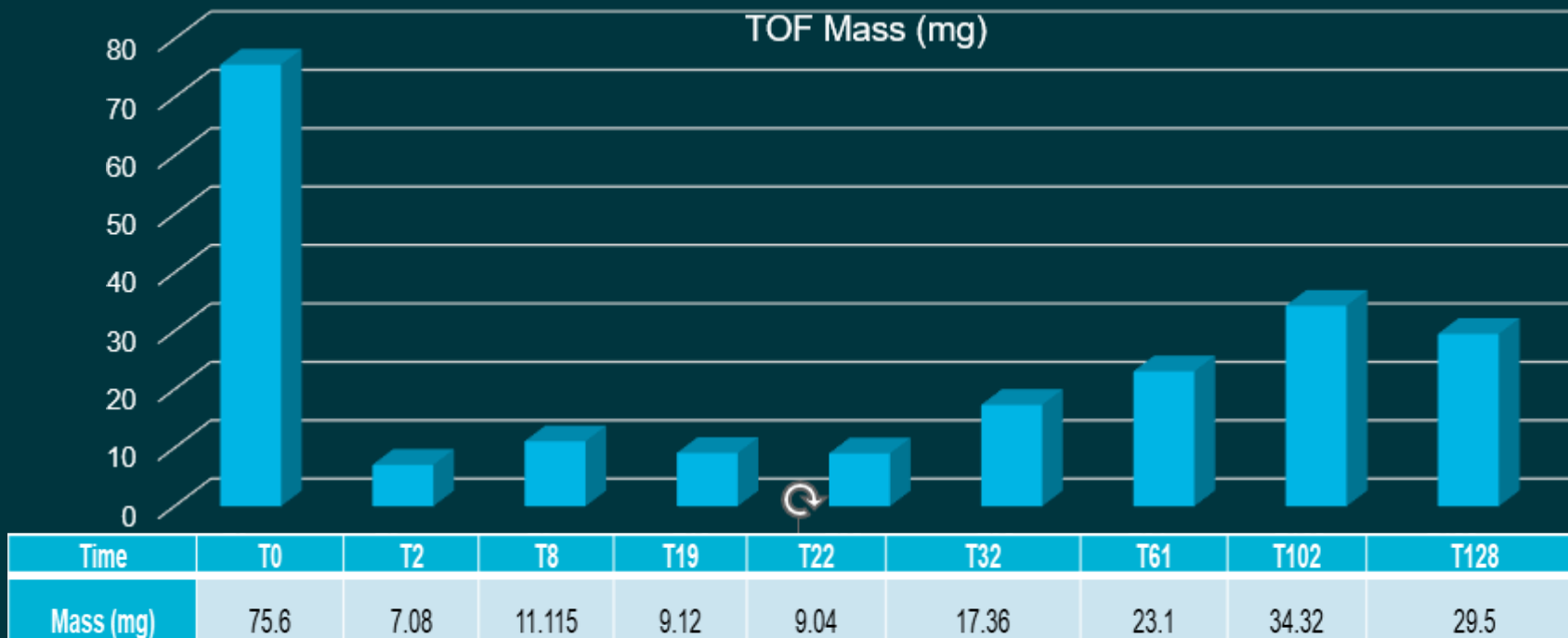




DE-FLUORO – Experiment 1: Low PFAS impacted liquid

Performance & Observations

- System performance was maintained throughout the experiment without on-site personnel for 128 hours of treatment time
- Relatively low PFAS impacted liquid: TOF 1200 µg/L (pre-TOP 33.5 µg/L; post-TOP 830 mg/L)
- Significant sturdy and persistent foam was generated
- Foam management system maintained treatment with minimal disruption
- Apparent 91% reduction achieved in 2 hours and 88% reduction at 22 hours; spikes from foam collapse

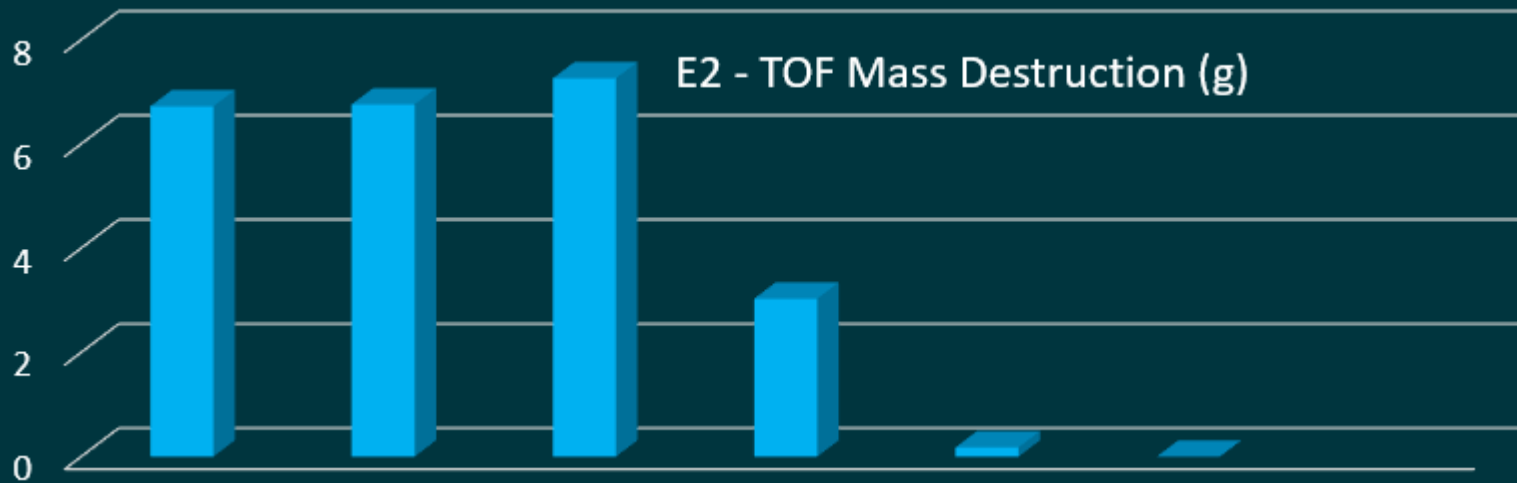




DE-FLUORO - Experiment 2: Medium level concentration wash water

Performance & Observations

- Total of 105 hours of treatment time
- Medium PFAS impacted diluted concentrate: TOF 190 mg/L (pre-TOP 47 µg/L; post-TOP 87 mg/L)
- System initially experienced interruptions about every 30 minutes from significant foam generation; shutdowns while foam dried
- Foam management modifications included increased mechanical suppression and inclusion of foam overflow tank
- Successful results with less interrupted run time as experiment concluded due to foam management controls
- About 98% reduction achieved in 47 hours

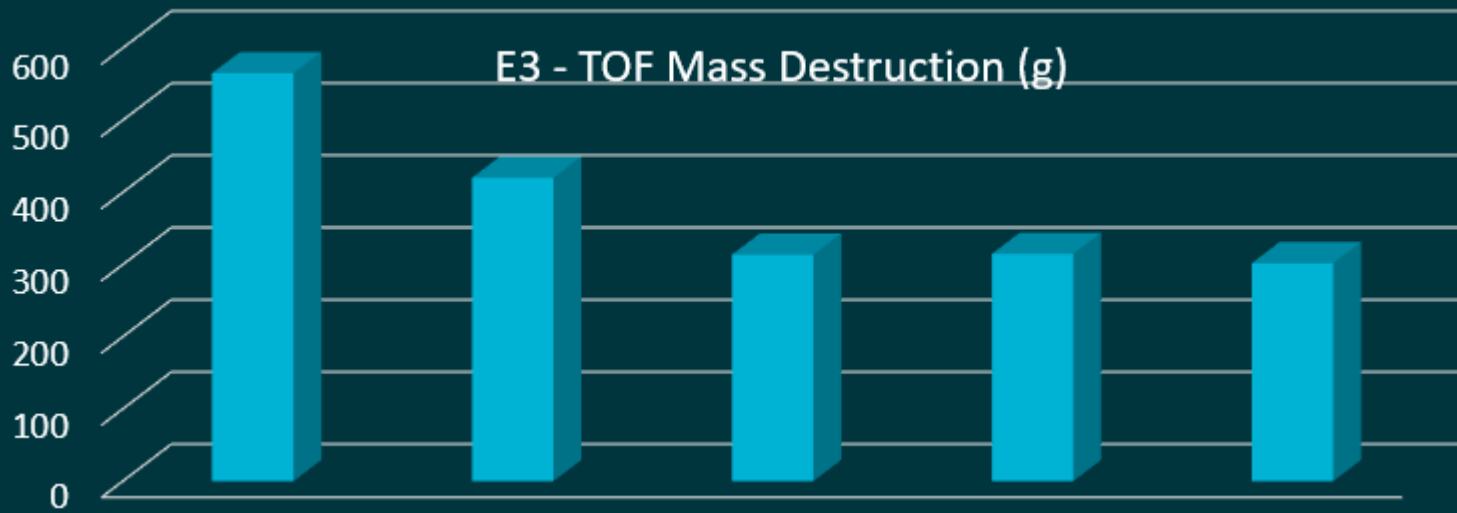




DE-FLUORO - Experiment 3: AFFF Concentrate

Performance & Observations

- Total of 180 hours of treatment time
- AFFF concentrate: TOF 4,280 mg/L (pre-TOP 51 mg/L; post-TOP 2,210 mg/L)
- Foam generation inconsistent. Suspect waste properties change with treatment
- Improved foam management system performed well and was able to maintain continuous treatment
- Treatment time interrupted due to system overheating, chiller modifications resulted in increased uninterrupted run times up to 14 hours
- About 47% TOF mass reduction achieved in 100 hours





DE-FLUORO – Summary of Learnings



Successes

- Confirmed system integrity and performance; electrodes durable
- Significant TOF mass reduction within first 8 to 24 hours suitable for discharge to WTP
- Recirculation rate between 2,000-6,000 litres (800-2,400 gallons) per 24 hours
- Foam management controls improved over earlier demonstrations

Challenges

- Temperature management designs underway
- Reduced performance compared to earlier programs: variables include cathode materials, waste chemistry, site conditions

Successes

- Significant mass reduction up to 98% in high concentrated waste streams
- Electrode and cathode durability and performance good
- Modified foam management controls-- performing well

Challenges

- Ambient temperatures causing automatic shutdowns
- Foam management and foam collapse learnings essential to future system success
- AFFF residency time will require optimization to meet onsite time constraints



Field Demonstrations - Pike

Mobile Unit (Ongoing)

Client: MPCA

Location: Minnesota, USA

Duration: January-May 2023

Treatment Solution: Foam Fractionate Generated from Impacted Surface and Groundwater

Mobile Unit (Pending)

Client: Confidential United States Federal Client

Location: Confidential

Duration: June 2023

Treatment Solution: Distilled Regenerant Concentrate from Impacted Groundwater

Mobile Unit (Pending)

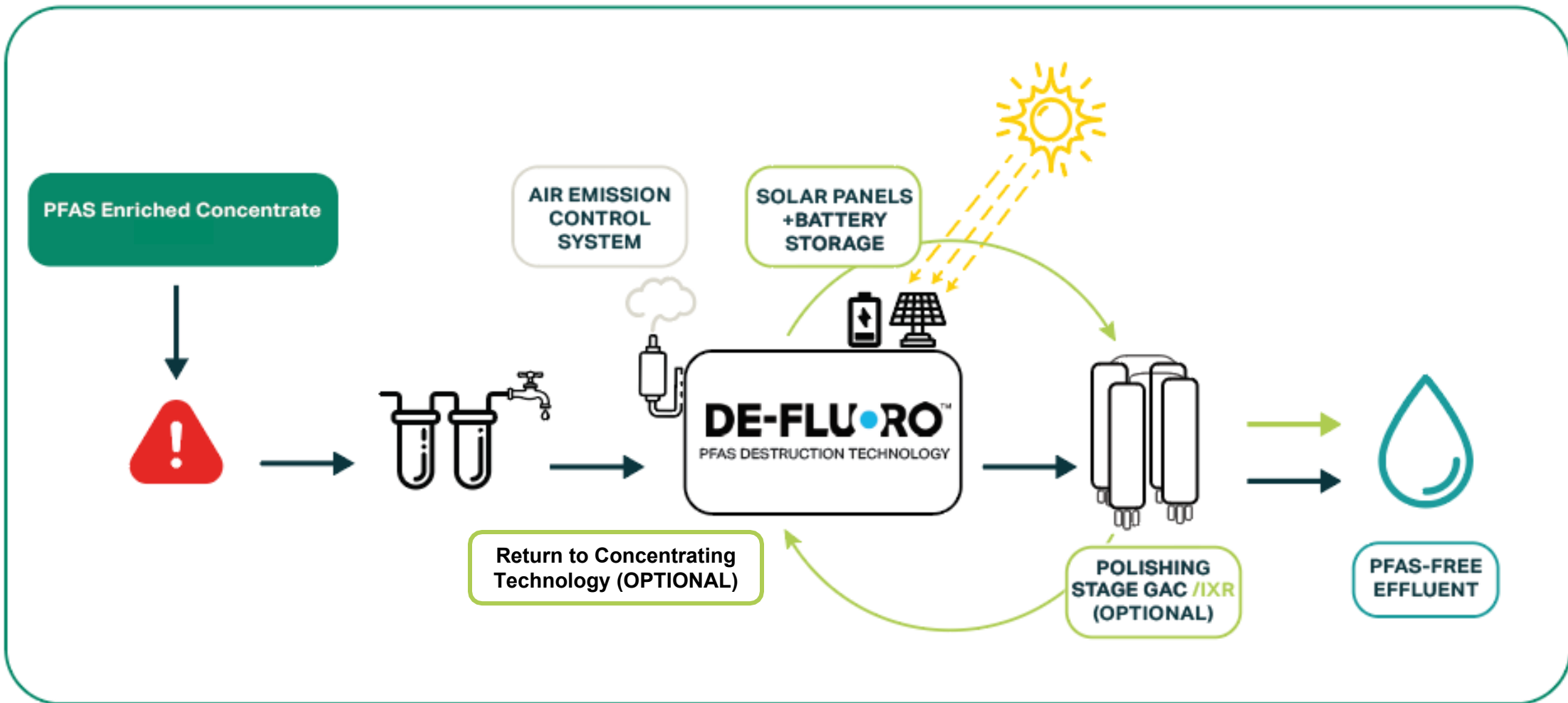
Client: Confidential United States Federal Client

Location: Confidential

Duration: September 2023

Treatment Solution: Foam Fractionate Generated from Impacted Groundwater





Questions?



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