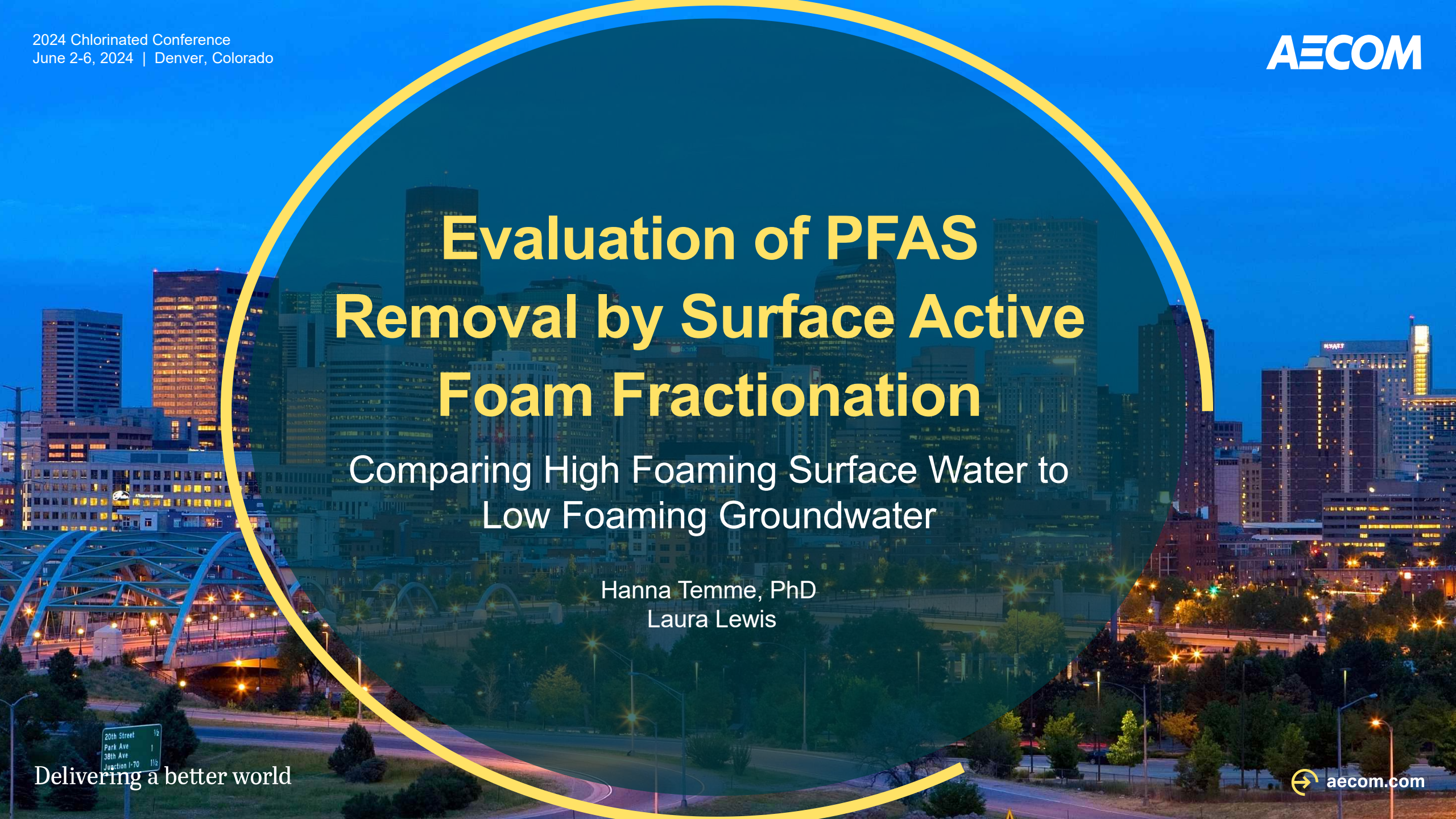
2024 Chlorinated Conference
June 2-6, 2024 | Denver, Colorado

AECOM

Evaluation of PFAS Removal by Surface Active Foam Fractionation

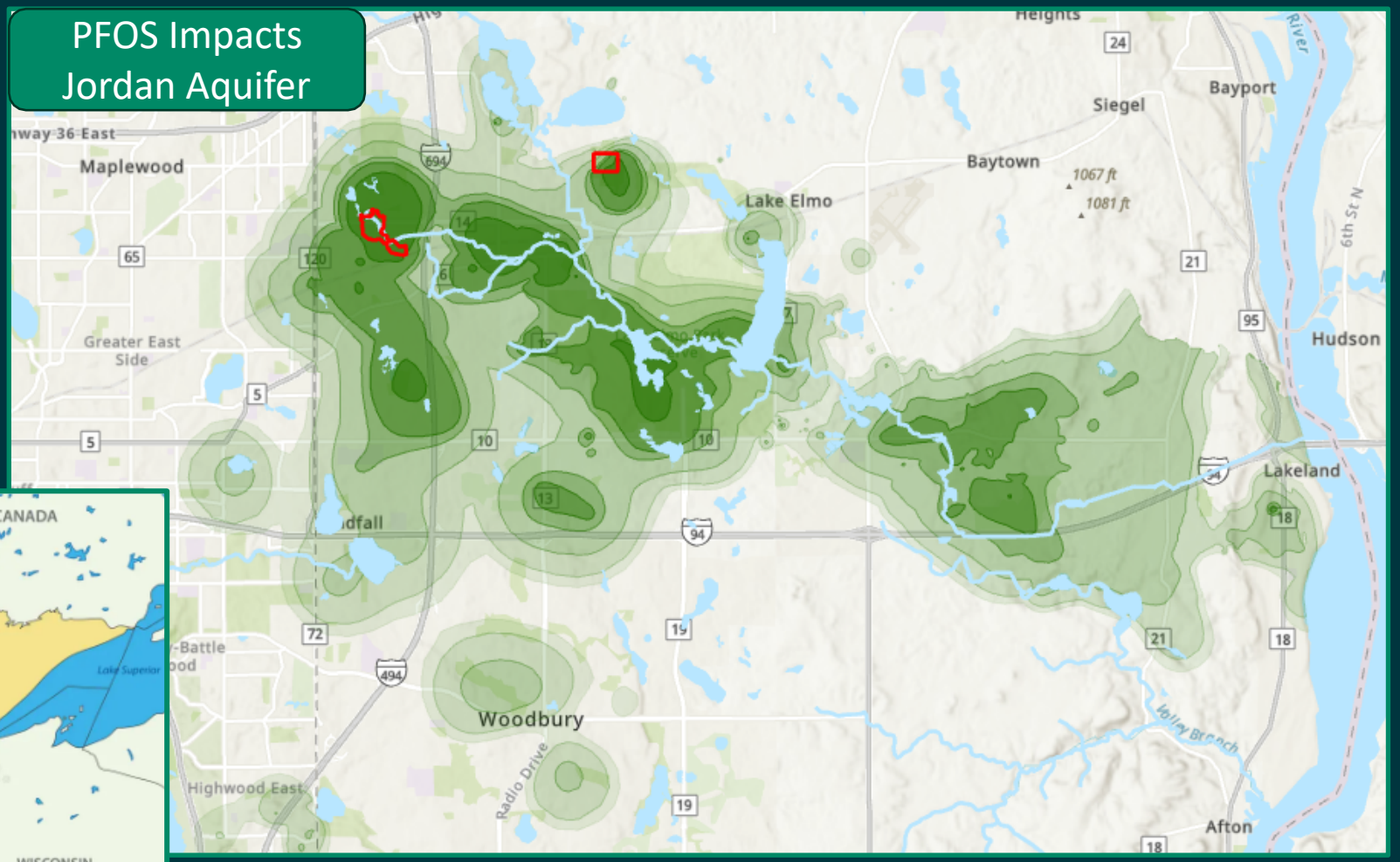
Comparing High Foaming Surface Water to Low Foaming Groundwater

Hanna Temme, PhD
Laura Lewis



Project Area

- Twin Cities east metro area, Minnesota
- Over 125 sq miles of PFAS impacted groundwater and surface water



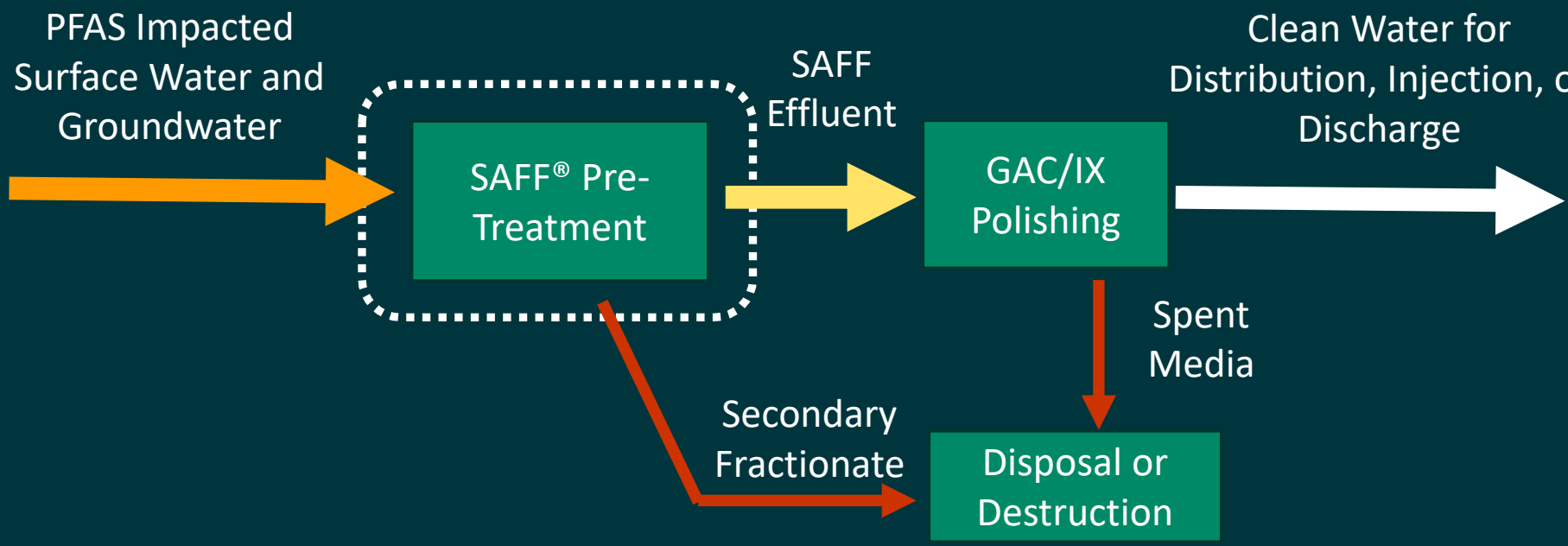
Feasibility Study

- Completing a feasibility study for Minnesota Pollution Control Agency (MPCA) to address PFAS impacts

- MPCA considering multiple technologies and treatment train alternatives

- Specifically considering technologies that may reduce filtration media

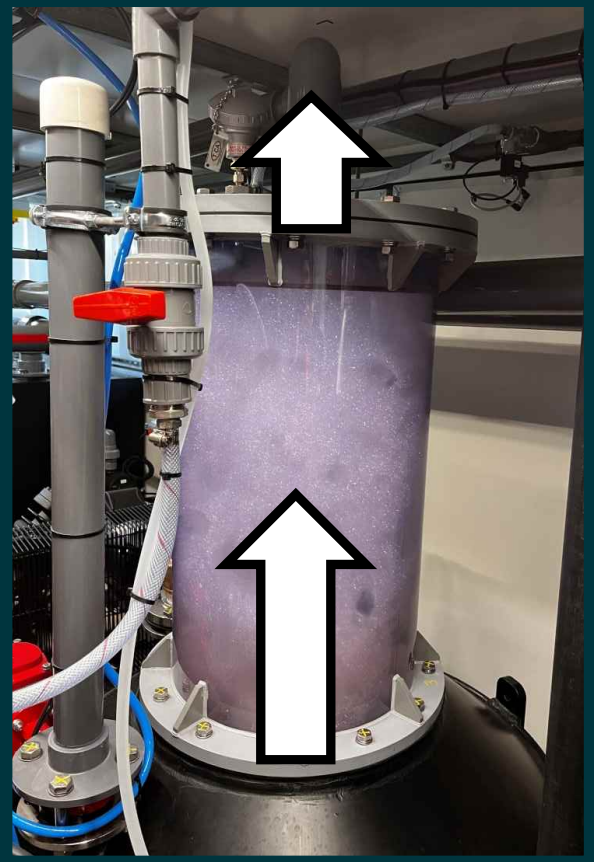
Possible Treatment Train



- Surface Active Foam Fractionation (SAFF®) one possible technology
- SAFF® could be used as a standalone technology or as pretreatment to filtration to reduce costs
- Pilot study focused on SAFF® Pre-Treatment

Surface Active Foam Fractionation (SAFF®)

1. **Inject air into water**
2. **PFAS foams**
3. **Remove foam**



- Pilot study used a SAFF®20 from EPOC
- No surfactants used

Surface Active Foam Fractionation (SAFF®)

TWO STAGE PROCESS

Primary Fractionation

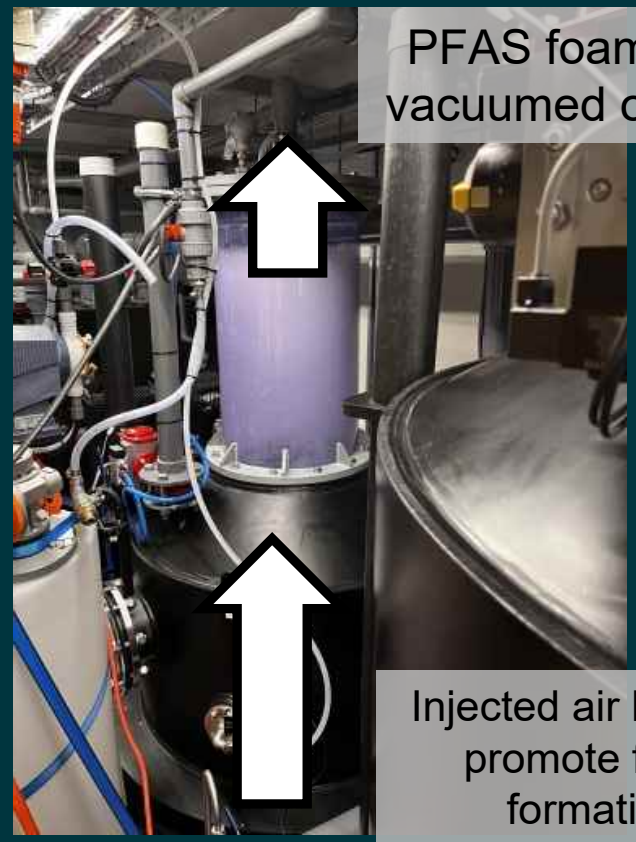
- **Goal:** Minimize PFAS concentration in effluent

Injected air bubbles promote foam formation and carry PFAS upward

Foam and top layer of water flow over cone and captured in top hood

Secondary Fractionation

- **Goal:** Minimize volume of PFAS concentrate prior to destruction or disposal

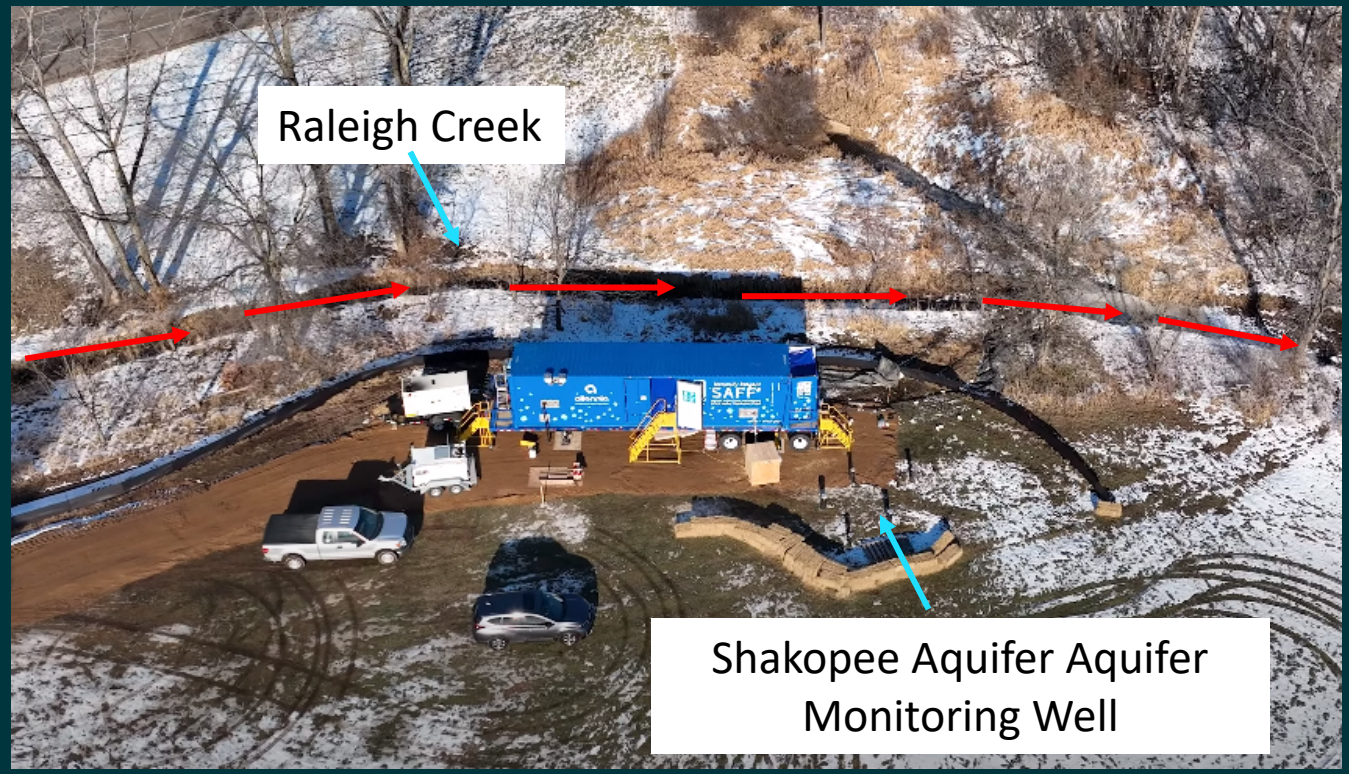


PFAS foam vacuumed off

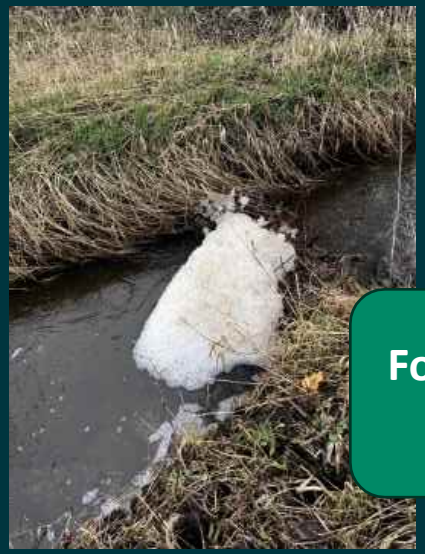
Injected air bubbles promote foam formation

Water Sources

Site selected because of access to impacted surface water and impacted aquifer



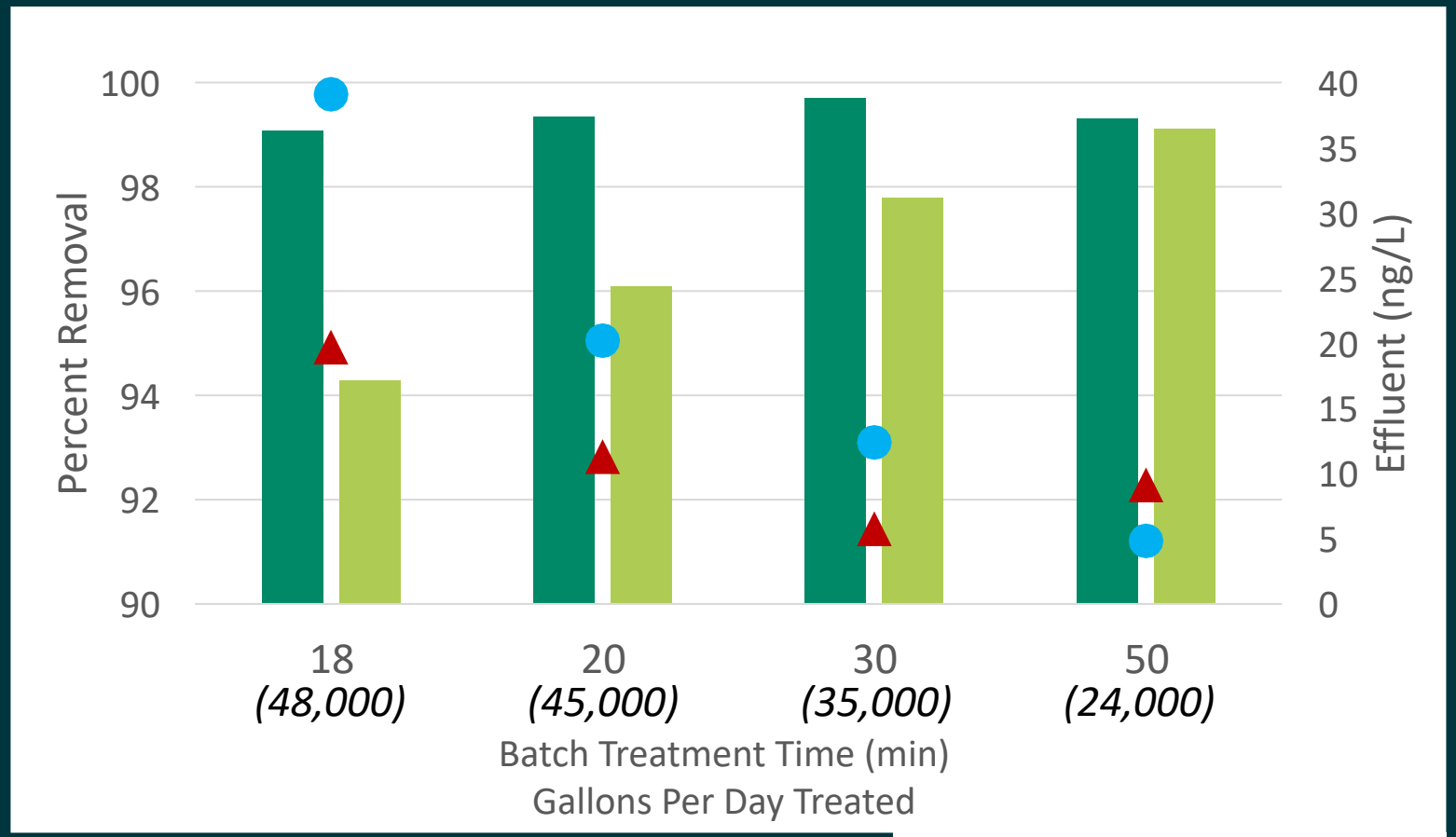
	PFOS	PFOA	Total Organic Carbon
Raleigh Creek	2,000-3,000 ng/L	700-900 ng/L	6.5 mg/L
Shakopee Aquifer	950 ng/L	330 ng/L	<0.5 mg/L



Foam readily forms on Raleigh Creek

Raleigh Creek Treatment

Foam formed during primary fractionation



Longer treatment time results in higher percent removal but less water treated per day

Raleigh Creek Optimized Results

PFAS	Influent (ng/L)	Effluent (ng/L)	Percent Removal	Surface Water Quality Criteria (ng/L)
PFBA	303	175	42	5,700
PFHxA	51.5	22	57	220
PFOA	515	2.12	99	25
PFBS	18.4	8.08	56	140
PFHxS	41.1	1.69	96	20
PFOS	1570	1.8	99	0.05

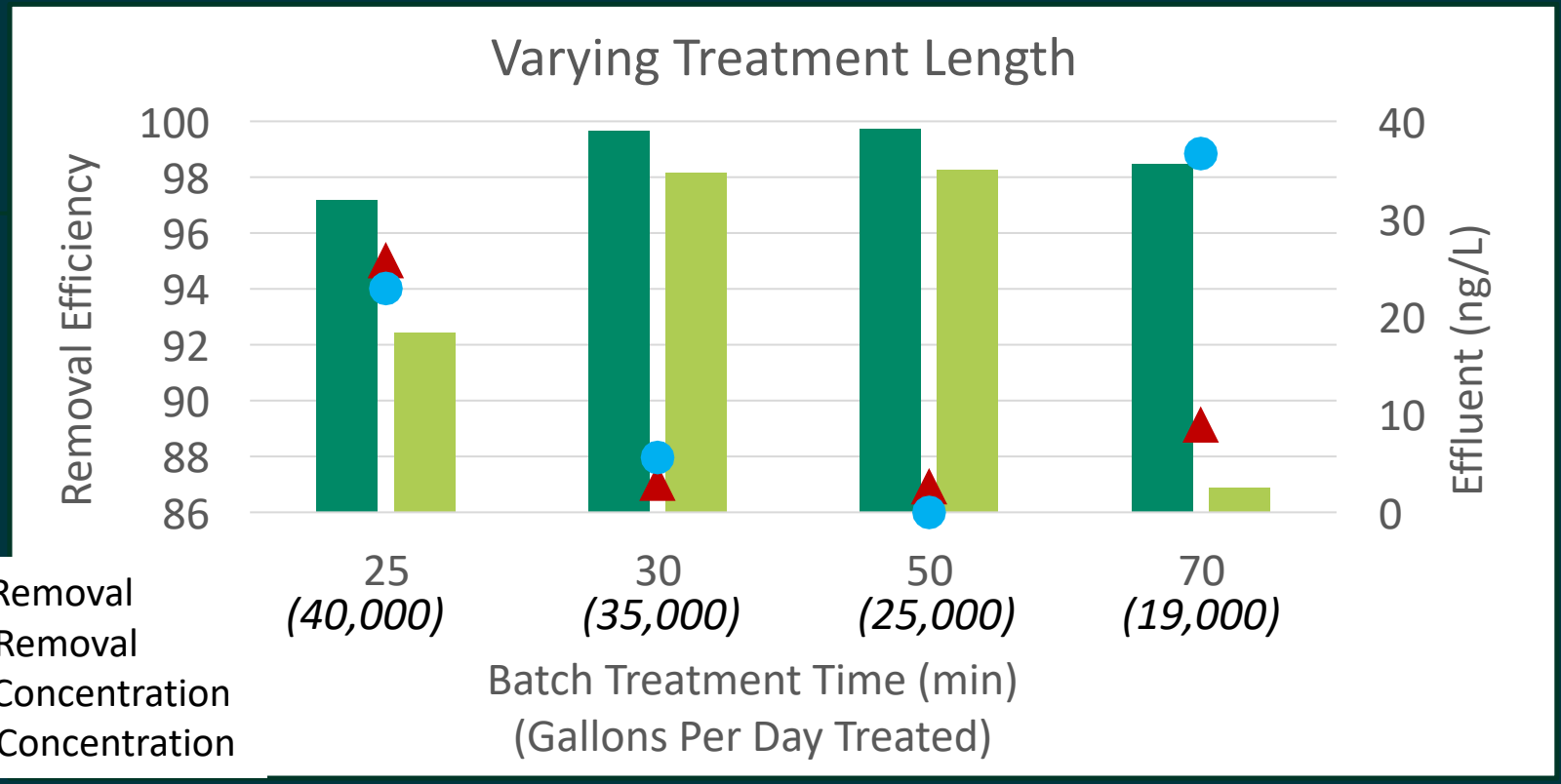
- Removal observed to be variable with changes in flow and PFAS concentrations
  - PFOS: 1.8-5 ng/L
  - PFOA: 2-4 ng/L

Met criteria
Exceeded criteria

Shakopee Aquifer Treatment

No foam observed during primary fractionation

- Tested conditions to improve efficiency:
  - Higher air injection
  - Addition of clean water to push PFAS out of top cone
  - Dosing with PFAS concentrate
  - Oscillating between high and low air injection



Shakopee Aquifer: Optimized Results

PFAS Analyte	Influent Concentration (ng/L)	Effluent Concentration (ng/L)	Percent Removal	MDH HBV/HRL (ng/L)
PFBA	372	361	2.96	7,000
PFHxA	44.3	36.1	18.51	200
PFOA	281	<0.887	>99.68	0.0079
PFNA	2.12	<0.887	>58.16	
PFBS	15.4	13.5	12.34	100
PFHxS	34.1	1.62	95.25	47
PFOS	939	2.67	99.2	2.3

- Variations observed in long term study
  - PFOS: 2 to 5 ng/L
  - PFOA: ND to 7 ng/L
- Adjustment of settings results in decreased PFOS effluent concentration but increased PFOA effluent concentration

Low foaming water can be effectively treated with SAFF

MDH: Minnesota Department of Health
HBV: Health Based Value
HRL: Health Risk Limit

Optimizing Secondary Fractionation: Concentration Factor Comparison

Influent
(30,000-40,000 gpd)

Primary Concentrate
(700-1,300 gpd)

Secondary Concentrate
(<0.5 gpd)

<u>Raleigh Creek</u>
PFOA: 0.9 ug/L
PFOS: 2.5 ug/L

<u>Shakopee Aquifer</u>
PFOA: 0.33 ug/L
PFOS: 0.95 ug/L

<u>Raleigh Creek</u>
PFOA: 24 ug/L (27X)
PFOS: 72 ug/L (29X)

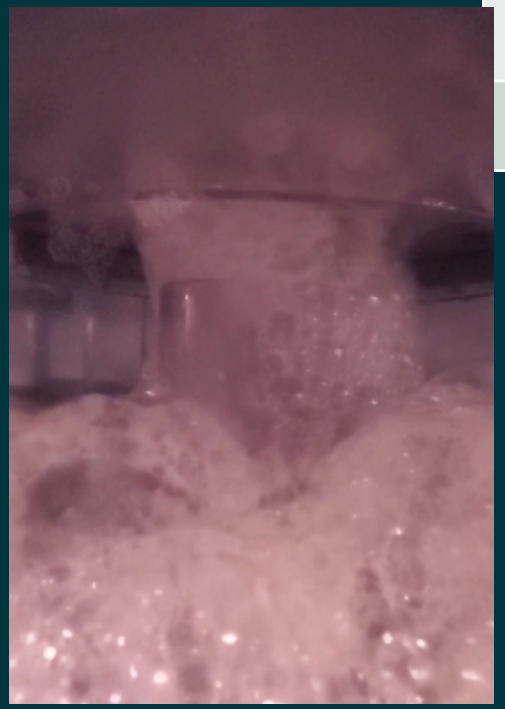
<u>Shakopee Aquifer</u>
PFOA: 11 ug/L (34X)
PFOS: 35 ug/L (36X)

<u>Raleigh Creek</u>
PFOA: 9020 ug/L
(10,000 X)
PFOS: ug/L (8,000X)

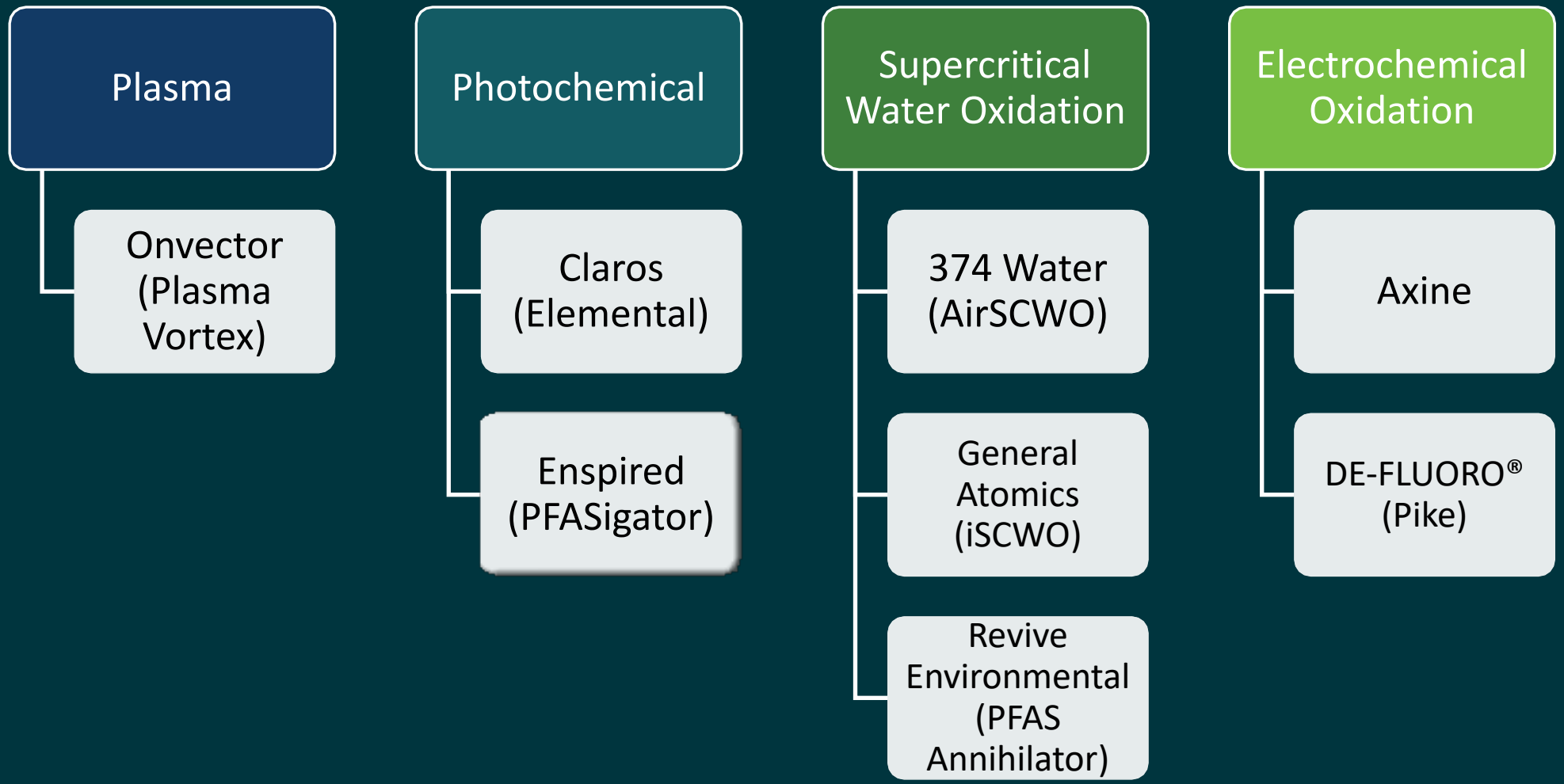
<u>Shakopee Aquifer</u>
PFOA: 6360 ug/L
(20,000 X)
PFOS: 19100 ug/L
(21,000 X)

Results Summary

Surface Water	Groundwater
Foam readily formed	No foam observed
99% PFOS and PFOA removal	99% PFOS and PFOA removal
10,000x concentration	20,000x concentration

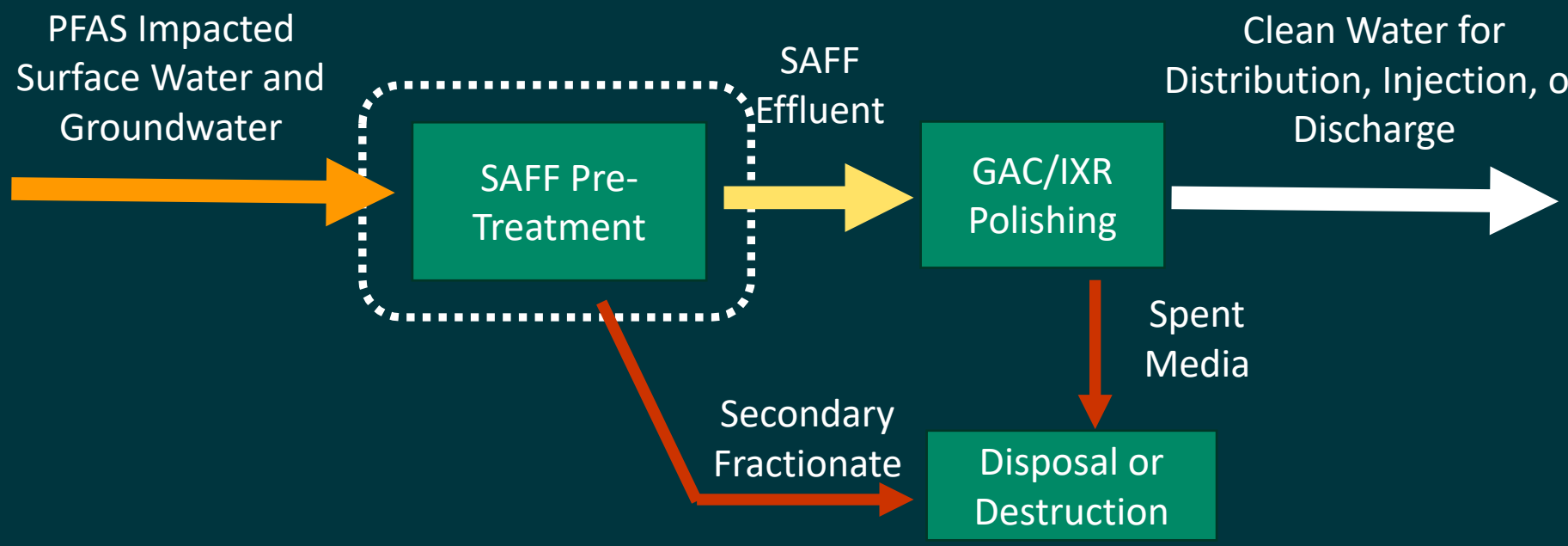


Testing of Destruction Technologies with SAFF Concentrate



Next Steps

- Determine if SAFF can reduce GAC/IX costs to achieve the applicable standards
  - Bench scale testing planned to compare media usage
- Incorporate results into a feasibility study to address PFAS impacts in the Twin Cities east metro which includes providing clean drinking water to communities



Acknowledgements

AECOM

Daryl Beck

Geoff Goodwin

Rebecca Higgins

Drew Tarara

Andrew Wilcox

MPCA

Andri Dahlmeier

EPOC

Jon Heffer

Naresh Isidore

Peter Murphy

AECOM

THANK YOU!

Hanna Temme (hanna.temme@aecom.com)
Laura Lewis (laura.lewis@aecom.com)