Treatment of a 1-MGD Aerated Lagoon POTW Effluent to PFAS Drinking Water Standards Using Foam Fractionation

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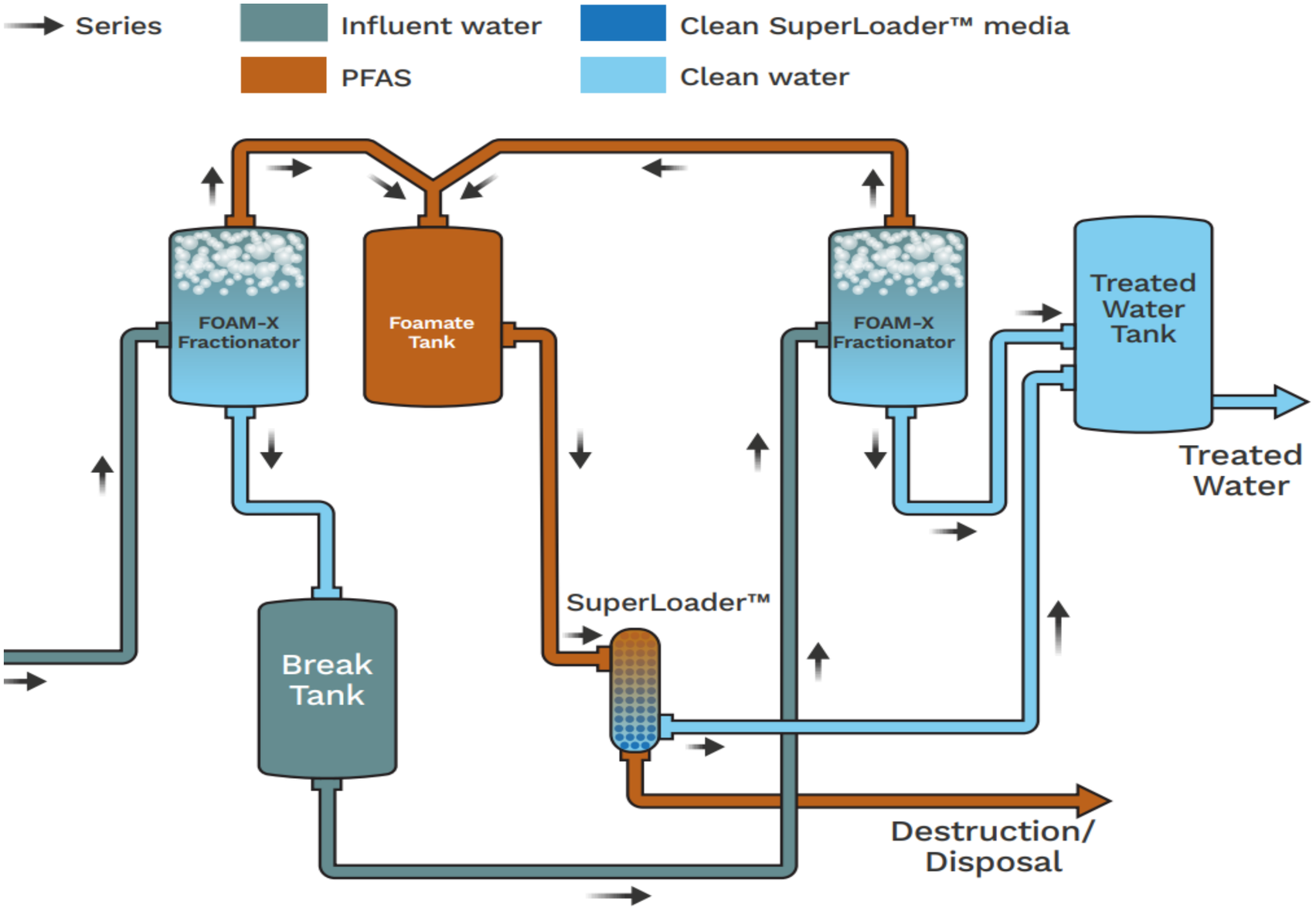
Project Objectives

- Demonstrate ability of ECT2's FOAM-X™ technology to treat combined leachate waste stream (aerated lagoon effluent) to Maine drinking water standards
  - Raw influent is approximately 50% landfill leachate blended with municipal wastewater, septage and other hauled wastes
  - Pumped aerated lagoon effluent (from end of Cell 3) to FOAM-X pilot
- Scale up FOAM-X system to facilitate full-scale average system flowrate of 1 MGD (700 gpm)
- Incorporate optimization measures to remove TSS (afterthought)

FOAM-X Pilot Block Flow Diagram

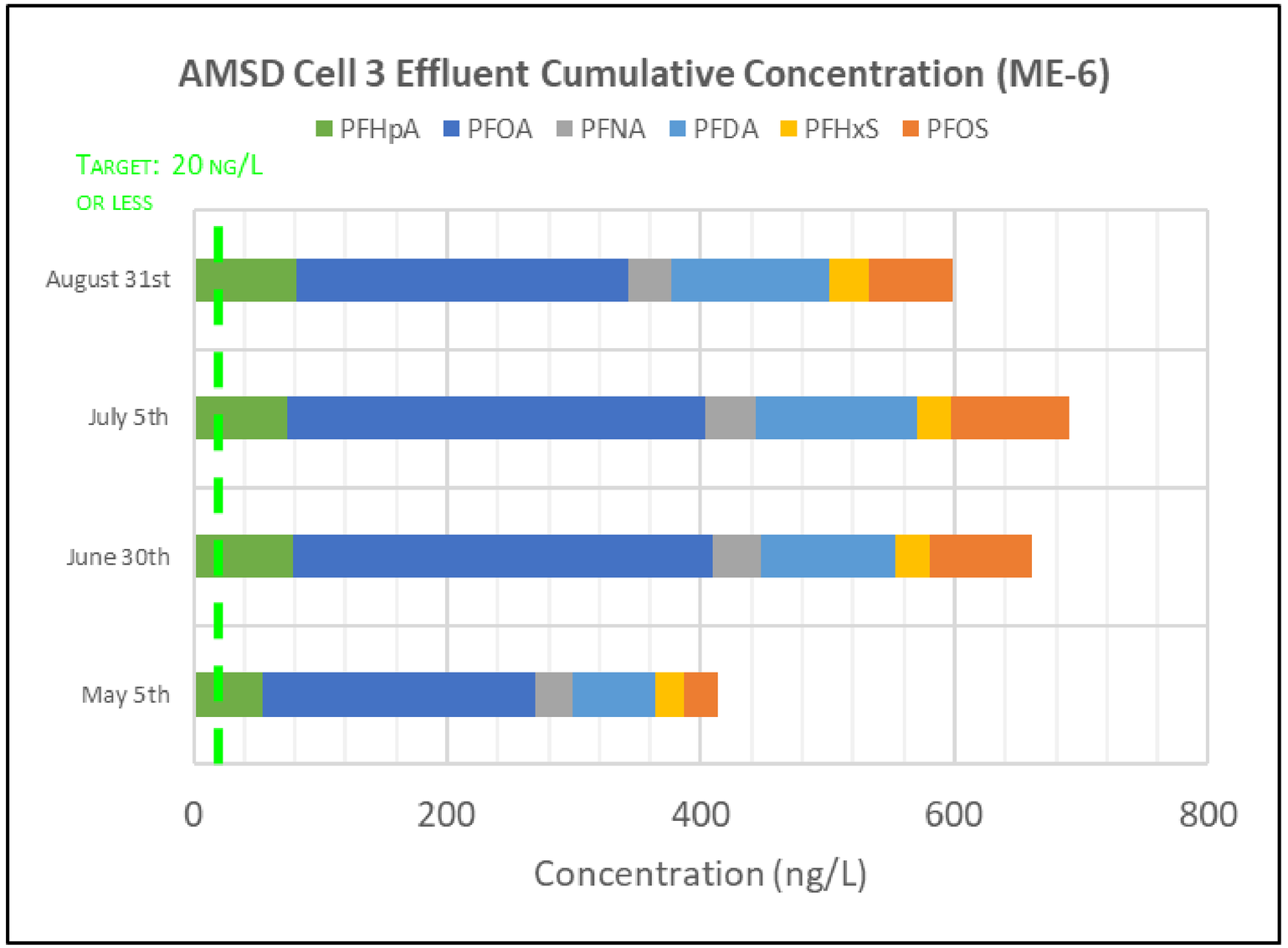


Foam Column at Top of Fractionator

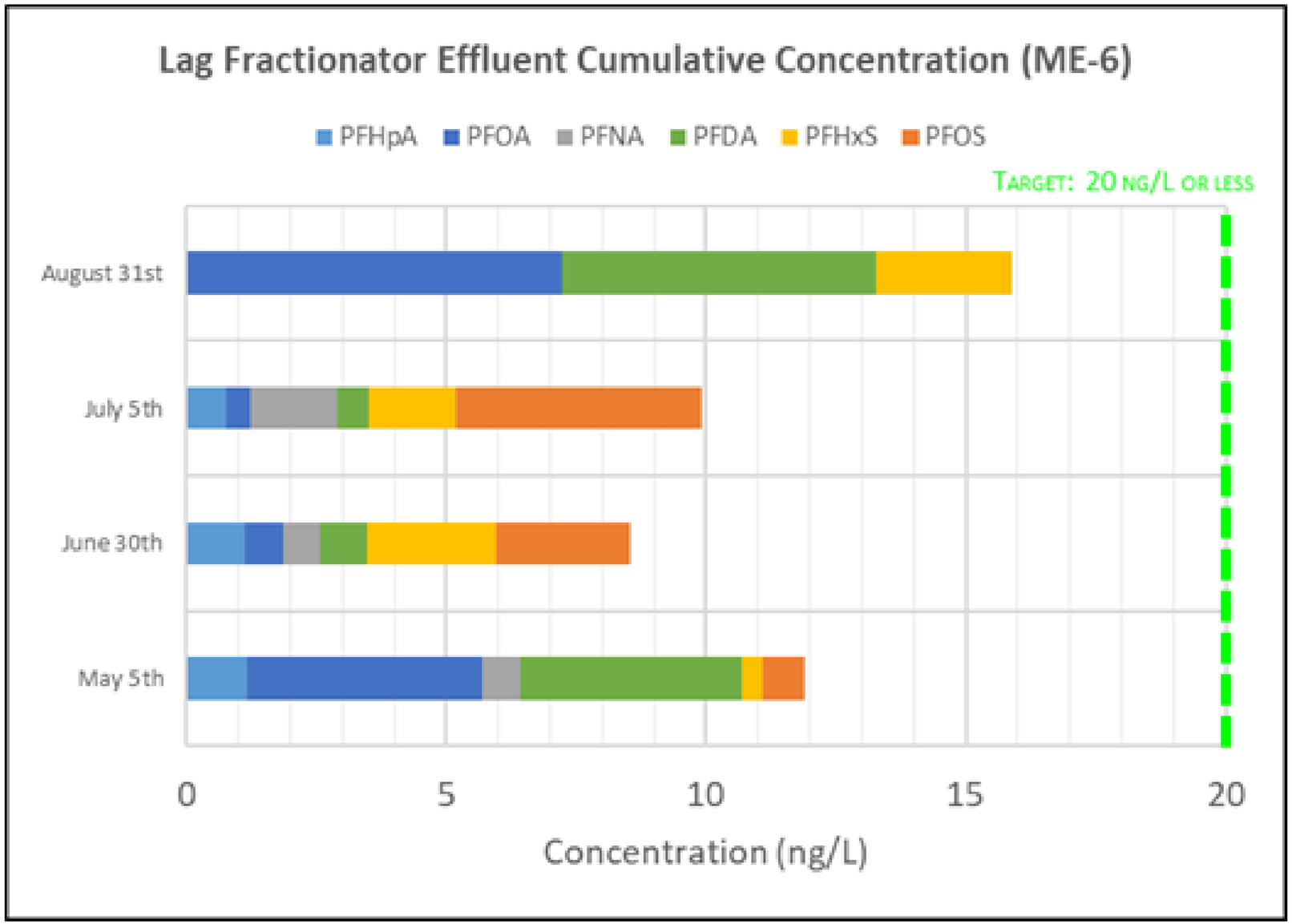
R&D North FOAM-X Pilot Testing Facility

- 3 gpm flow-through demonstration system (steady wastewater source from aerated lagoon) at the Anson-Madison Sanitary District's POTW
- Ultimate system flexibility = R&D engine
- Adjustable HRT, liquid level, reactor configuration, foamate handling, waste minimization testing, chemical additive testing, etc.
- Development of dynamic controls and operational strategies, system settings
- Processing water from all over the country
- Maine DEP and USDA Rural Development toured facility, reviewed system setup/operation/results and **pushed for funding of 1 MGD full scale system**

FOAM-X Demonstration:
System Loading (Aerated Lagoon Effluent)



FOAM-X Demonstration Results:
PFAS Removal Summary



FOAM-X Demonstration Results

Below EPA Proposed Primary Drinking Water Regulations (MCLs)

	Cell #3 Effluent	First Stage		Second Stage	
Compound	C3E10191400 ng/L	RFA10191400 ng/L	% Rem	RFB10191400 ng/L	% Rem
PFHpA	72.7	6.25	91	3.6	95
PFOA	213	15.7	93	1.6	99
PFNA	41.9	1.2	97	1.2	97
PFDA	39.2	3.4	91	3.4	91
PFBS	539	401	26	320	41
PFHxS	29.8	2	93	2	93
PFOS	31.3	1.9	94	1.9	94
HFPO-DA	1.8	1.8		1.8	
TSS (mg/L)	131	46	65	29	78
SUM 6	428	27	94	7	98
Total Mass	4,733	3,298	30	2,822	40
EPA Hazard Index	7.95	0.72		0.68	

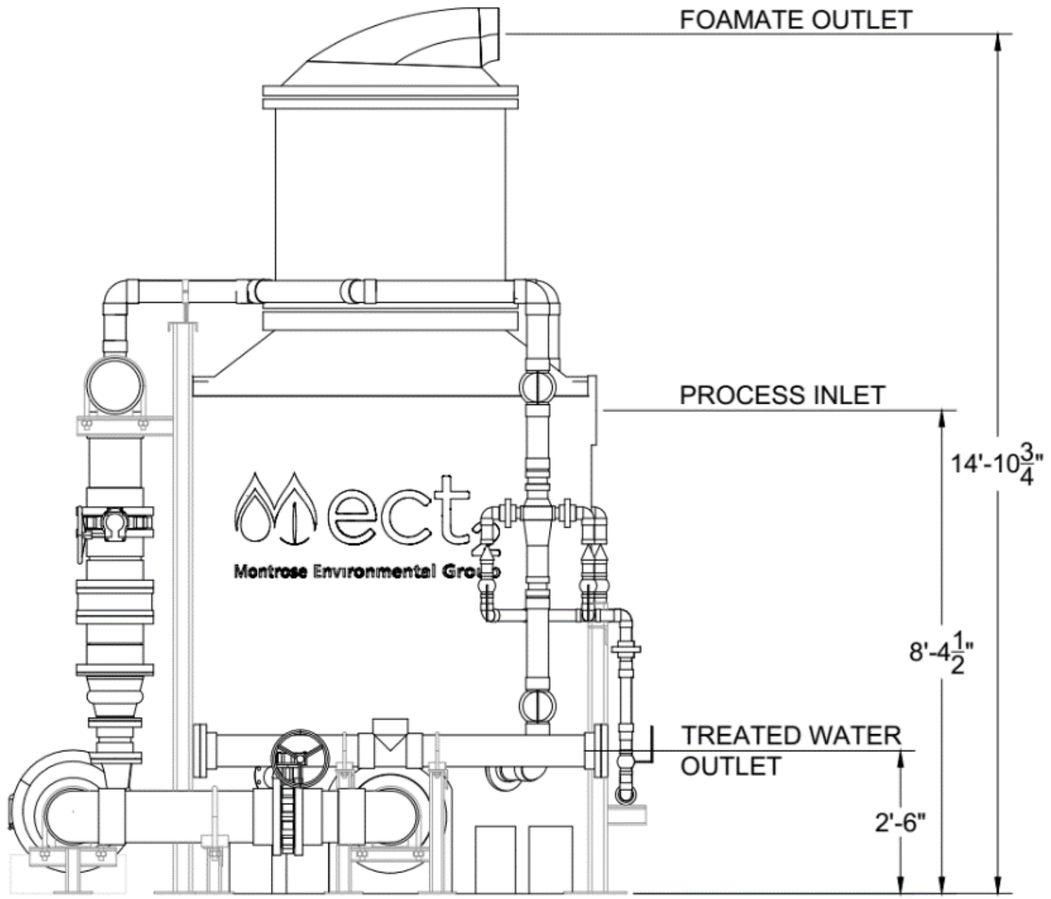
Scale-Up Testing

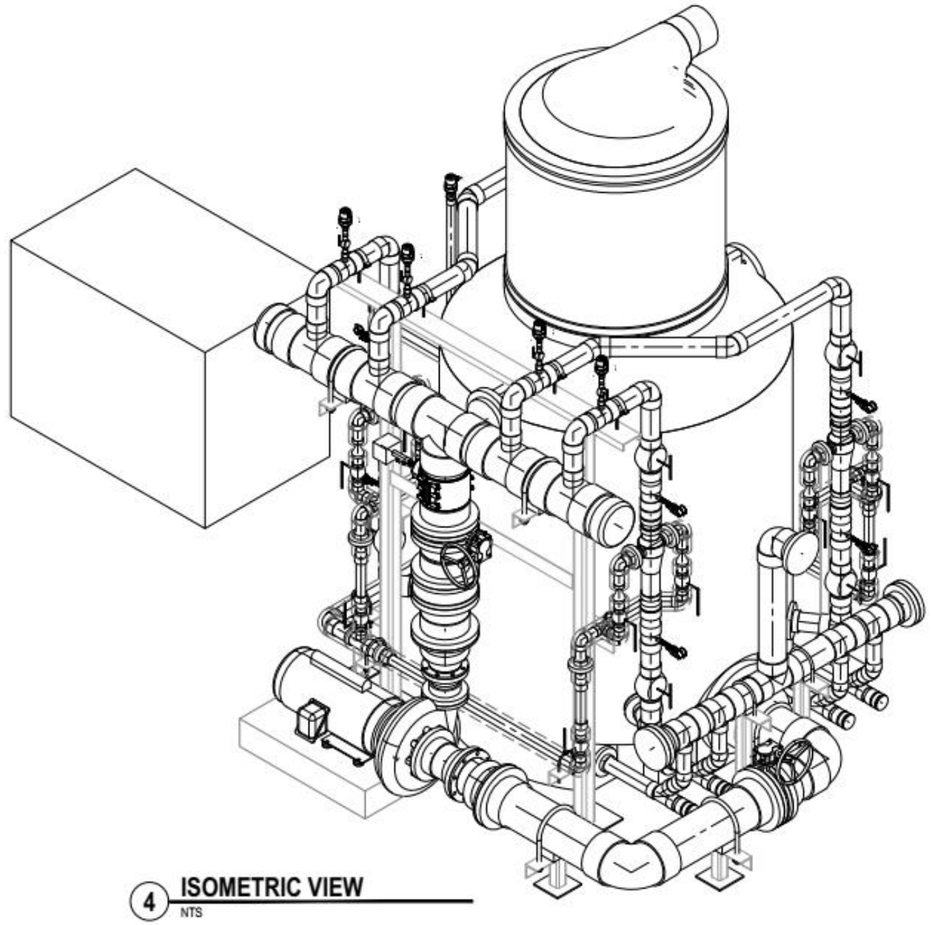
- ECT2's large vessel design provides high throughput in a very small footprint
- Confirmed hydraulics and vessel internal configuration, flow through dynamics
- Scale up of key design parameters, including airflow rate, recycle rate, etc.
- In parallel, confirmed key design parameters through multiple field demonstrations

Assembly and Testing of Full-Scale System at ECT2's Production Facility in Portland

FOAM-X 3000 Standard Product Offering

Treats Flows up to 160 gpm



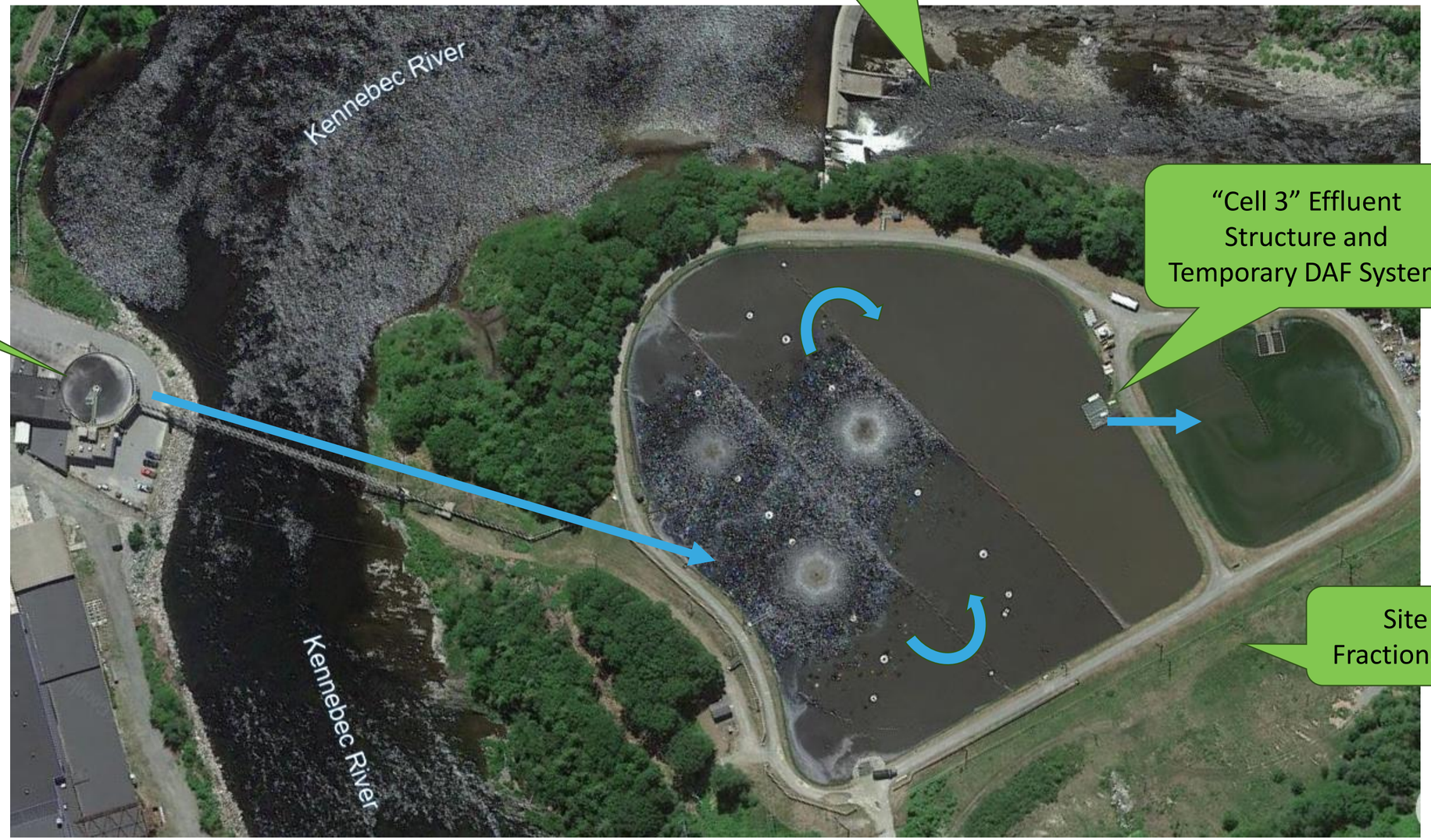


Low Energy Consumption:

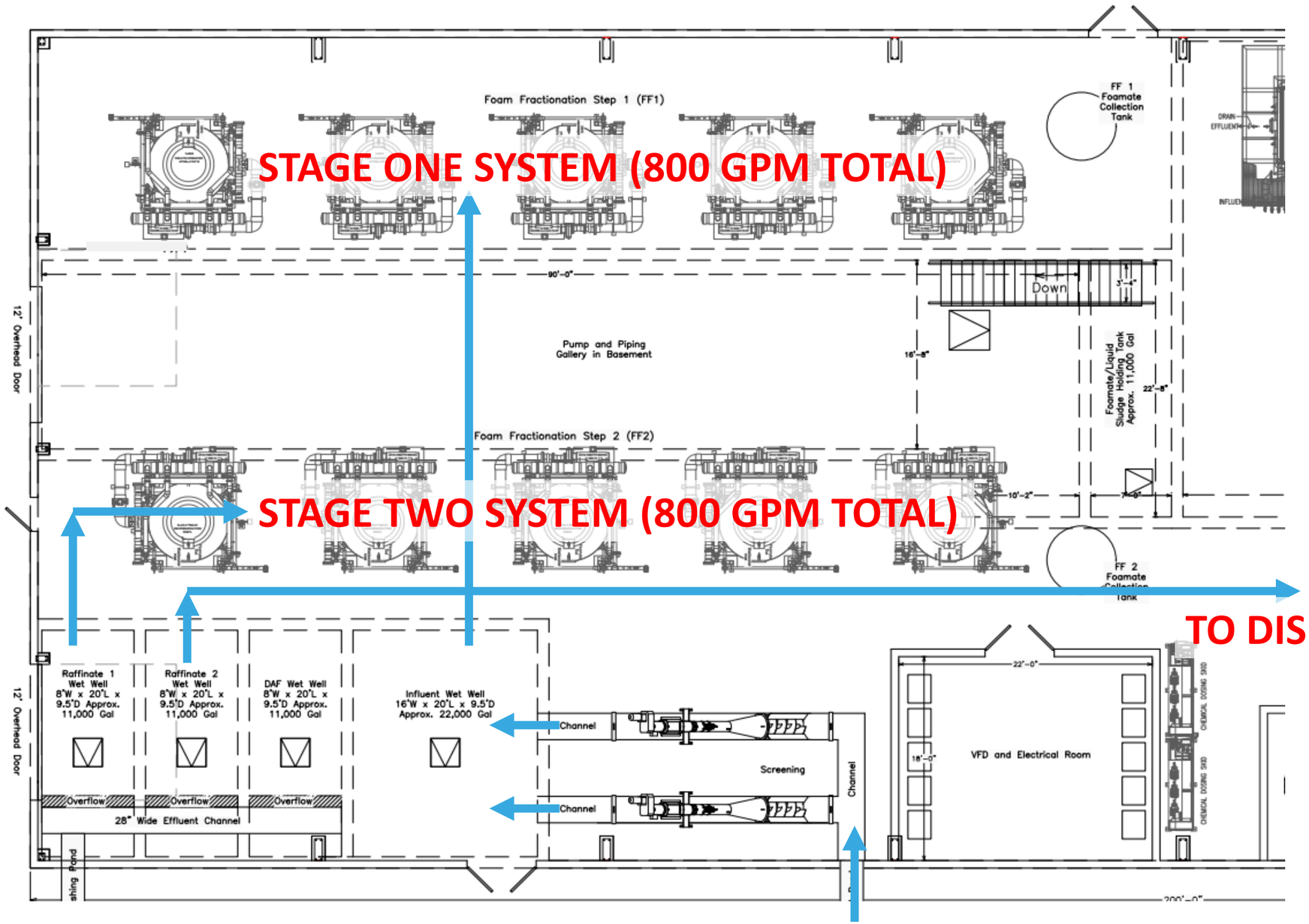
- 225 kW for 1 MGD two stage treatment (**10 units** operating)

Treatment System Overview

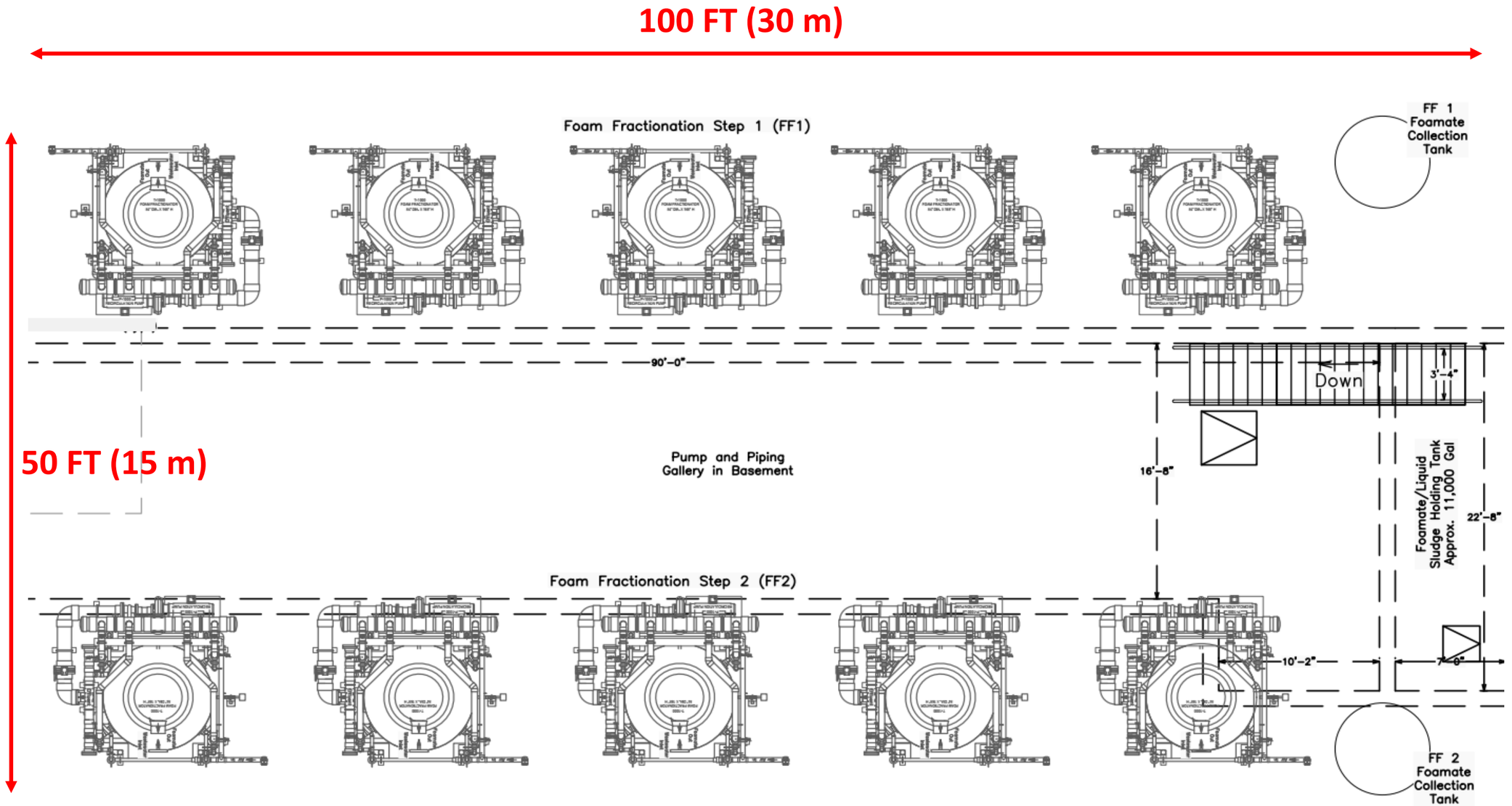
Anson-Madison, Maine



1-MGD FOAM-X System General Arrangement



1-MGD Two Stage FOAM-X System Footprint



Cell 3 Effluent TSS Removal Challenges

- TSS > 100 mg/l
- Elevated colloidal solids concentration
- Heavy coagulant dose required due to leachate content, high TDS, humic substances
- Substantial sludge generation; polishing pond dredged frequently (post-coagulation)

Temporary Facilities for TSS Removal

- To address issue, the District rented a Dissolved Air Floatation clarifier
- Treatment capacity ~500 gpm
- Chemical cost alone is $2,940/day (>$1MM/yr)
- Sludge disposal costs (not including O&M) $500/day

Optimization of Foam Fractionation for Combined PFAS and TSS Removal

- Leveraged R&D facility co-located at the POTW to trial numerous chemical additive combinations that met both the PFAS removal objective AND removed TSS
- Effluent TSS compliance limit <30 mg/l monthly average
- Existing polishing pond downstream of the foam fractionation system provides additional buffer/process resiliency

PFAS and TSS Co-Removal Trials TSS Results	
Cell 3 Effluent TSS (Avg)	113
Two Stage FF Effluent TSS (Avg)	29
Average % TSS Removal	75%

Maximizing Foam Fractionation for TSS Removal

Realizing Substantial Long-Term Savings

- Optimized chemical additive selection and dosing
- Substantial reduction in chemical cost
  - DAF: $2,940/day
  - Optimized FF: $1,160/day
- Optimized FF system generates 67% less sludge than the DAF
- Experience tells us the polishing pond will consistently reduce final effluent TSS < 30 mg/l
- Expected TSS removal cost savings of optimized FF system:
  - $2,100/day
  - $770,000/year

Summary

- Foam fractionation was successfully demonstrated to meet Maine's drinking water standard, treating lagoon effluent processing substantial quantities of leachate
- Construction is underway on the world's largest foam fractionation facility for PFAS removal
- TSS removal poses a significant challenge for WWTPs treating substantial quantities of leachate
- Foam fractionation can be optimized to provide significant (75%+) TSS removal while maintaining PFAS removal goals, resulting in substantial savings

FOAM-X 3000 System for Leachate Treatment Under Construction (US, MO)

Discussion/Questions