United States Environmental Protection Agency

Clean or Replace?
Decontamination Framework for Firefighting Equipment and Hangars (ER20-5361)

Matthew Magnuson

US Environmental Protection Agency

August 24, 2021

SERDP ESTCP
AFFF PROJECT MEETING
2021 PFAS-Free Firefighting Foams

Disclaimer

The views expressed in this presentation are those of the authors and do not reflect the official policy or position of the Air Force Institute of Technology, the United States Air Force, the Department of Defense, or the United States government. The U.S. EPA through its Office of Research and Development managed the research in this presentation. It does not necessarily reflect the Agency's views. Any mention of trade names, products, or services does not imply an endorsement by the EPA or the U.S. Government. EPA does not endorse the purchase or sale of any commercial products or services.

Project Team

- US Environmental Protection Agency (Office of Research and Development)
  - Matthew Magnuson
  - Terra Haxton
  - Jonathan Burkhardt
  - Marc Mills

- US Air Force Institute of Technology
  - Lt Col John Stubbs (USAF)
  - Maj Trevor Sleight (USAF)
  - Maj Daniel Schurman (USMC)
  - Capt Jacob Spaulding (USMC)

Technical Objectives

- **Purpose:** Provide data and information to refine existing guidance about how to flush per- and polyfluoroalkyl substances (PFAS) from firefighting systems, specifically hangar systems and Aircraft Rescue and Firefighting (ARFF) vehicles
- **DOD Relevance:** As many as 4,350 DOD aqueous film forming foam (AFFF) delivery systems in aircraft hangars and firefighting vehicles may require decontamination. Unless effective cleaning solutions are available, replacement will cost $2.1 billion, according to CBO.
- **Technical Gap:** No framework is available for evaluating cost and environmental impact of decontamination compared to costs of replacing components and systems.

Technical Questions

- How to ensure decontamination?
  - Potential PFAS rebound?
  - Is sampling necessary and how to do it?
  - For different systems?
- How to adapt decontamination protocols for one AFFF delivery system to a different one?
  - Construction
  - Age and system condition
  - AFFF exposure history
- Most useful format for protocols?

Test/Task Design

Task 1. Establishing a technical expert group of DOD and civilian experts from Airport Council International – North America

Task 2. Investigating decontamination protocols that take into account PFAS interaction with wetted surfaces

Task 3. Developing sample and analysis to avoid system recontamination

Task 4. Including small pipe hydraulics in models

Performance Summary

Task 1. Establishing technical expert group

Civilian: Airport Council International – North America

- 95% of domestic airports
- technical committees

ACI NORTH AMERICA
AIRPORTS COUNCIL INTERNATIONAL

DOD: PFAS Task Force, AFCEC, CNIC, NAVAIR, NAVFAC, USACE

SECRETARY OF DEFENSE
1000 DEFENSE PENTAGON
WASHINGTON, DC 20301-1000

7/23/19

MEMORANDUM FOR SECRETARIES OF THE MILITARY DEPARTMENTS
UNDER SECRETARY OF DEFENSE FOR ACQUISITION AND SUSTAINMENT
UNDER SECRETARY OF DEFENSE (COMPTROLLER)/CHIEF FINANCIAL OFFICER OF THE DEPARTMENT OF DEFENSE
UNDER SECRETARY OF DEFENSE FOR PERSONNEL AND

Performance Summary

Task 4. Including small pipe hydraulics in predictive models

- **US Air Force Institute of Technology has developed working hydraulic models for ARFF and hangar systems**

- Piping system testbed being constructed at USEPA Test and Evaluation facility based on these design

- Model calibration parameters will be developed for PFAS, based on experimental results from testbed

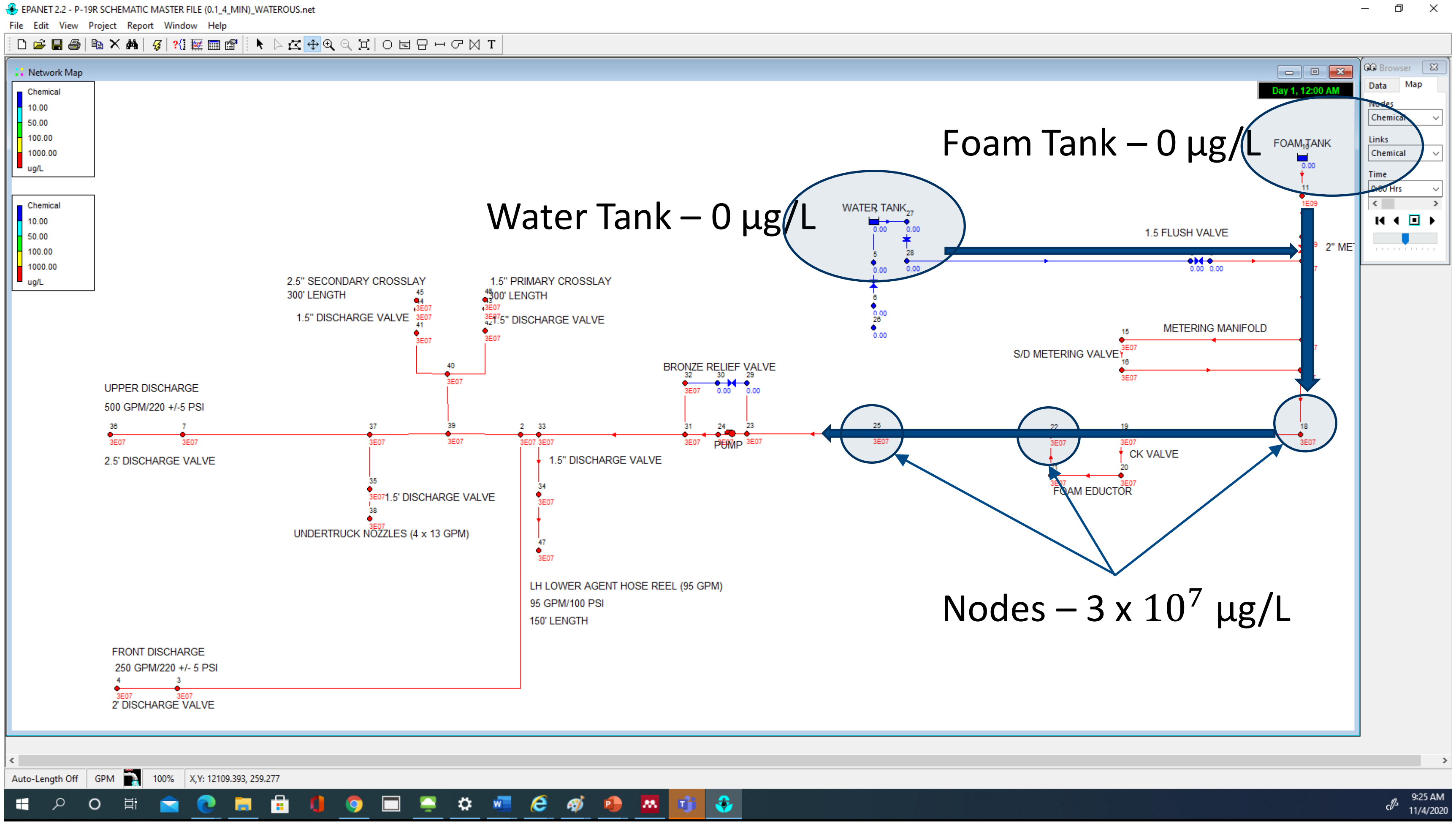
Basis for Analysis (ARFF)

Oshkosh P-19R

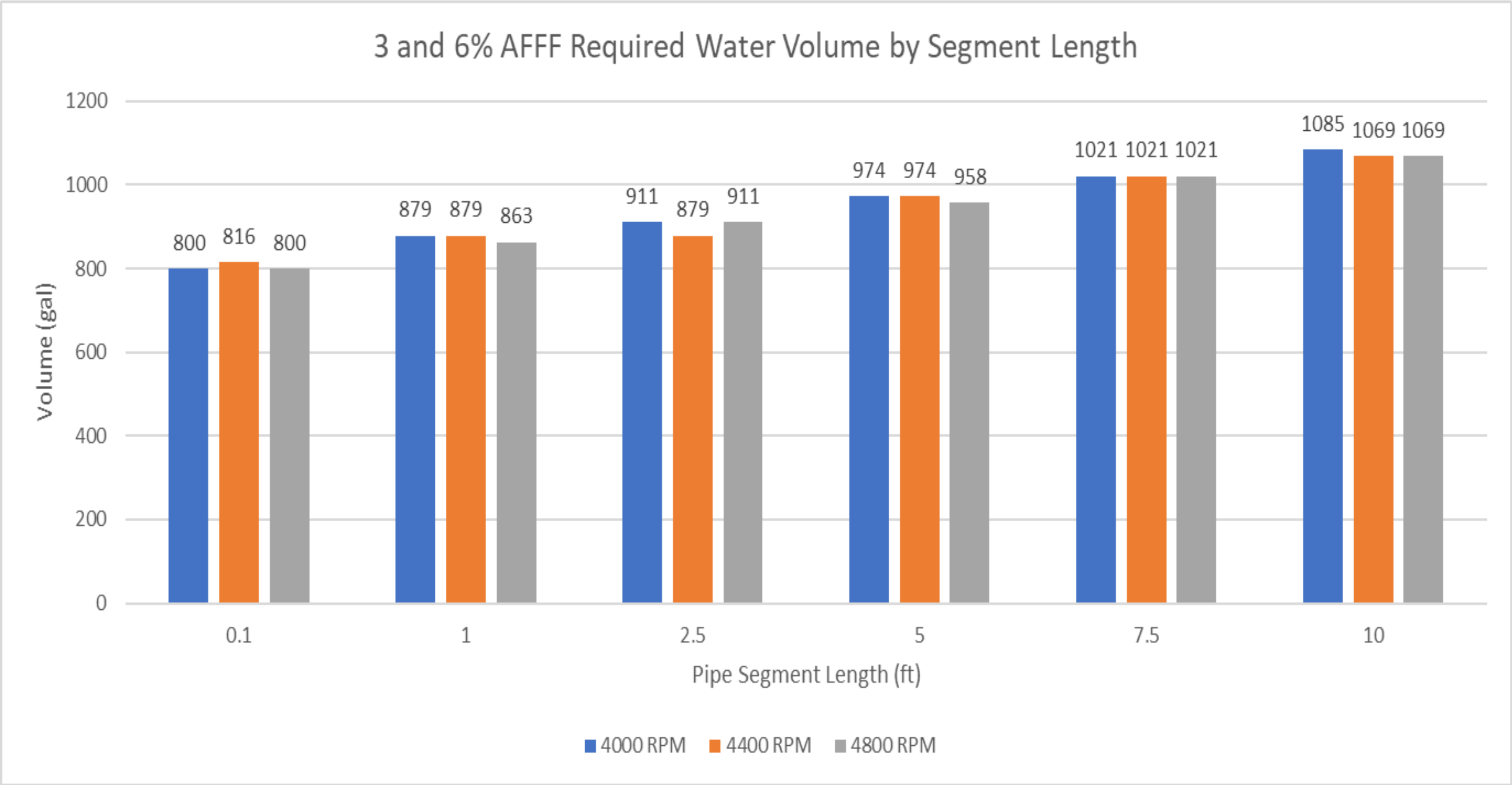
- Water Tank – 1000 gallons
- Foam Tank – 130 gallons
- Demands/Discharge
  - 500 gpm at turret
  - 250 gpm at bumper
  - Undertruck – 4 at 13 gpm
  - Hose Relay – 95 gpm
- Pressure Regimes
  - 200 – 350 psi (250 psi nominal)
- System Run Lengths
  - 8 – 15 feet on truck
  - 100 hose reel
- System Components
  - 304 Stainless Steel
  - Brass
  - Poly UPF® Tank

from Schurman, AFIT-ENV-MS-21M-267
Distribution Statement B, TO Proprietary

EPANET – Initial Condition



Example of Modelling-Enabled Results: Volume of Rinsate by Pipe Length and Flow Rate



ARFF Cost Estimate

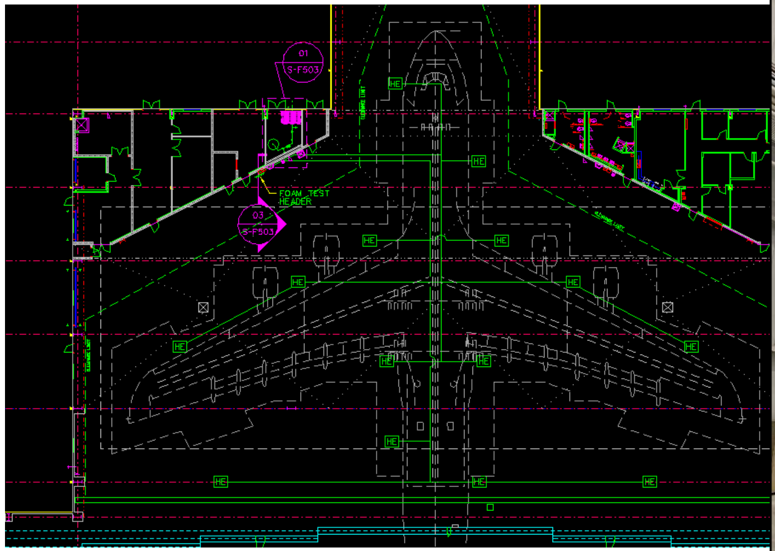
- Monte Carlo methodology applied to cost. 3000 random values generated from +/- 10% of rinsate disposal costs

- Cost for rinsate disposal (simple water rinse to non-detect)

  Assume ~$1/gallon * ~1000 gallon/ARFF * 3000 ARFFs = $3,000,000

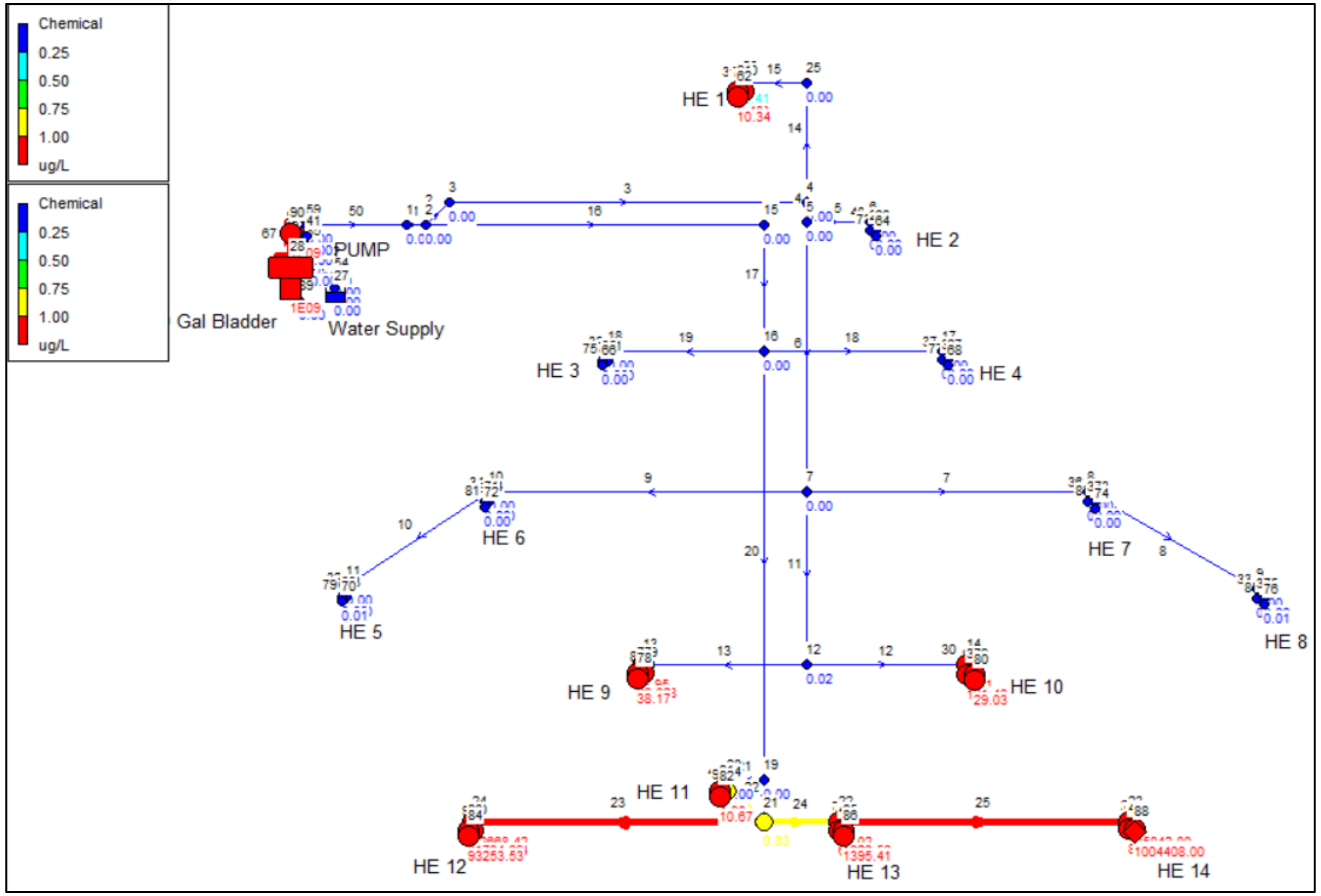
- Cost to replace (NDAA and CBO estimate)
  - $200,000 replacement cost for 3000 ARFF units
  - $600,000,000 total

Basis of Analysis (Hangar)



from Spaulding, AFIT-ENV-MS-21-M-273
Distribution Statement A

EPANET Model



Theoretical Triple Rinse

- *C = (0.0001%) (C_0),* Six-log reduction is 28.6 µg/L
- Flow rate 680 gpm, Single rinse = 510 gallons, Triple rinse = 1,530 gallons
- Assumes no PFAS interaction with pipe wall

Rinse		Chemical Concentration (ug/L)													
	Time (mins)	Node 62	Node 64	Node 66	Node 68	Node 70	Node 72	Node 74	Node 76	Node 78	Node 80	Node 82	Node 84	Node 86	Node 88
	0:00:00	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07
	0:00:10	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07
	0:00:20	2.86E+07	1.69E+07	2.82E+07	2.83E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07
	0:00:30	2.86E+07	5343994	2.34E+07	2.40E+07	2.83E+07	2.28E+07	2.23E+07	2.83E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07
1	0:00:40	2.86E+07	937018.7	1.08E+07	1.21E+07	2.23E+07	1.11E+07	1.06E+07	2.18E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07	2.86E+07
	0:00:50	2.86E+07	93999.33	1813753	2097407	1.08E+07	3112963	2943598	1.03E+07	2.54E+07	2.49E+07	2.84E+07	2.86E+07	2.86E+07	2.86E+07
	0:01:00	2.36E+07	5416.31	112804.3	132191.3	3007782	508622.6	476494.2	2843960	1.62E+07	1.51E+07	2.56E+07	2.86E+07	2.84E+07	2.86E+07
	0:01:10	1.16E+07	175.06	2698.83	3177.39	490054.9	48875.27	45517.42	459088.4	6570455	5756373	1.62E+07	2.84E+07	2.54E+07	2.86E+07
	0:01:20	2973448	3.03	28.94	34.14	47012.1	2742.29	2544.3	43781.87	1630693	1359716	5280159	2.64E+07	1.58E+07	2.84E+07
2	0:01:30	388970.5	0.03	0.14	0.16	2635.06	87.21	80.72	2444.81	246321.5	197957	746692.6	1.88E+07	4882884	2.56E+07
	0:01:40	24772.99	0	0	0	83.73	1.5	1.38	77.32	22316.79	17631.95	43216.37	7769701	697134.4	1.63E+07
	0:01:50	712.08	0	0	0	1.44	0.01	0.01	1.33	1223.94	941.68	1007.19	1320860	45352.8	5696148
	0:02:00	10.34	0	0	0	0.01	0	0	0.01	38.17	29.03	10.67	93262.38	1395.64	1004408
3	0:02:10	0.08	0	0	0	0	0	0	0	0.65	0.49	0.05	2975.63	22.13	91768.59
	0:02:20	0	0	0	0	0	0	0	0	0.01	0	0	48.06	0.18	4423.62
	0:02:30	0	0	0	0	0	0	0	0	0	0	0	0.4	0	119.81
	0:02:40	0	0	0	0	0	0	0	0	0	0	0	0	0	1.87
	0:02:50	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02
4	0:03:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Hangar Cost Estimate

- Cost for rinsate disposal (simple water rinse to non-detect)

  Assume ~$1/gallon * ~2000 gallon = $2000 per system

- Cost to replace (estimate from engineering firm)
  - Approximately $150,000-$250,000, including exchanging $50,000 AFFF concentrate
  - Separate fees for solid waste disposal
  - DOES NOT INCLUDE cost/feasibility of hangar downtime

Performance Summary

Task 4. Including small pipe hydraulics in predictive models

- US Air Force Institute of Technology has developed working hydraulic models for ARFF and hangar systems
- **Piping system testbed being constructed at USEPA Test and Evaluation facility based on these design**
- Model calibration parameters will be developed for PFAS, based on experimental results from testbed

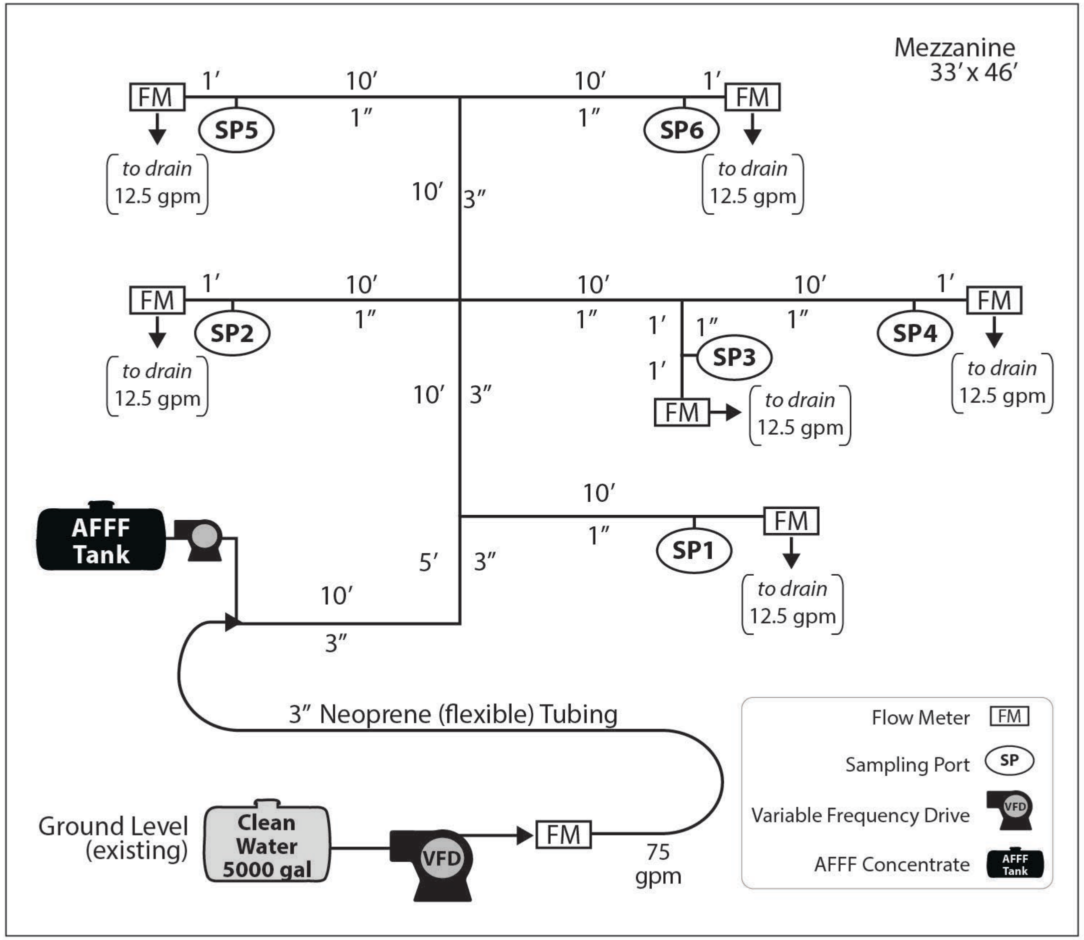
Experimental Site Description

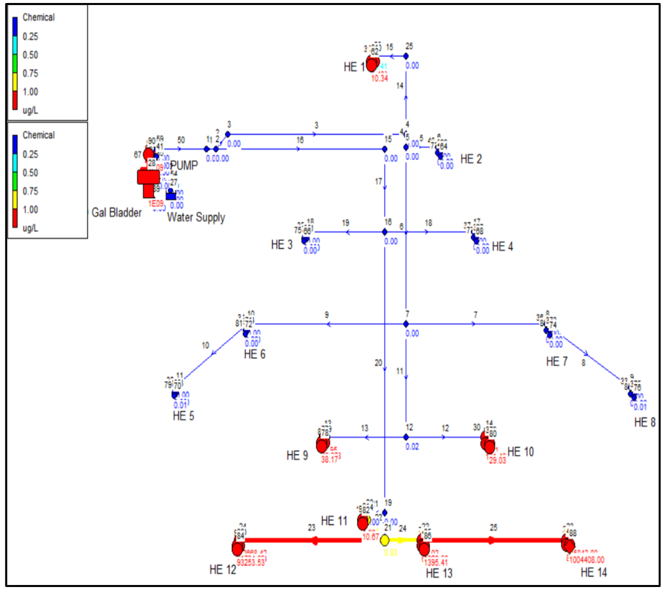
- RCRA-permitted TSDF, adjacent to Greater Cincinnati WRRF
- High-bay (33,000 sq. ft.) and 5 labs, including BSL-2 lab
- Analytical instrumentation and machine shop

Pilot-Scale Hangar Piping Testbed

Current leak detection system being converted to hangar AFFF delivery system testbed

Testbed Pipe Network Design



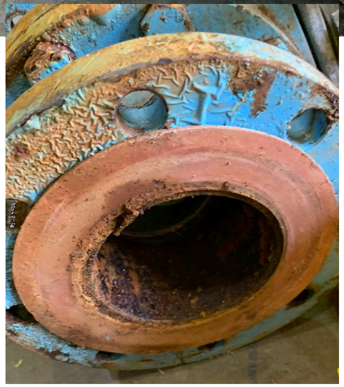


- Scaled down portion of modeled hangar (above)
- Sampling points at nozzle locations with flow and conductivity meters

What Pipes/materials?

AFFF delivery system is composed of:

- Unified Facilities Guide Specifications
  - Stainless steel (AFFF concentrate)
  - Black steel pipe (foam/water solution)
- Carbon steel (some commercial specs)
- Polypropylene (tanks)
- Others



from AFFF concentrate stainless steel system

Next Steps

- Complete construction of testbed at EPA-Cincinnati
- Establish reset conditions between experiments for assuring results represent realistic PFAS contamination.
- Validate hydraulic models with tracers and non-tracers, e.g., PFAS.
- Elucidate sampling procedure to verify decontamination
- Demonstration on actual ARFFs and hangars
- Transparent, consistent, and quantitative multi-criteria analysis approach for making decisions in the face of inherent uncertainties

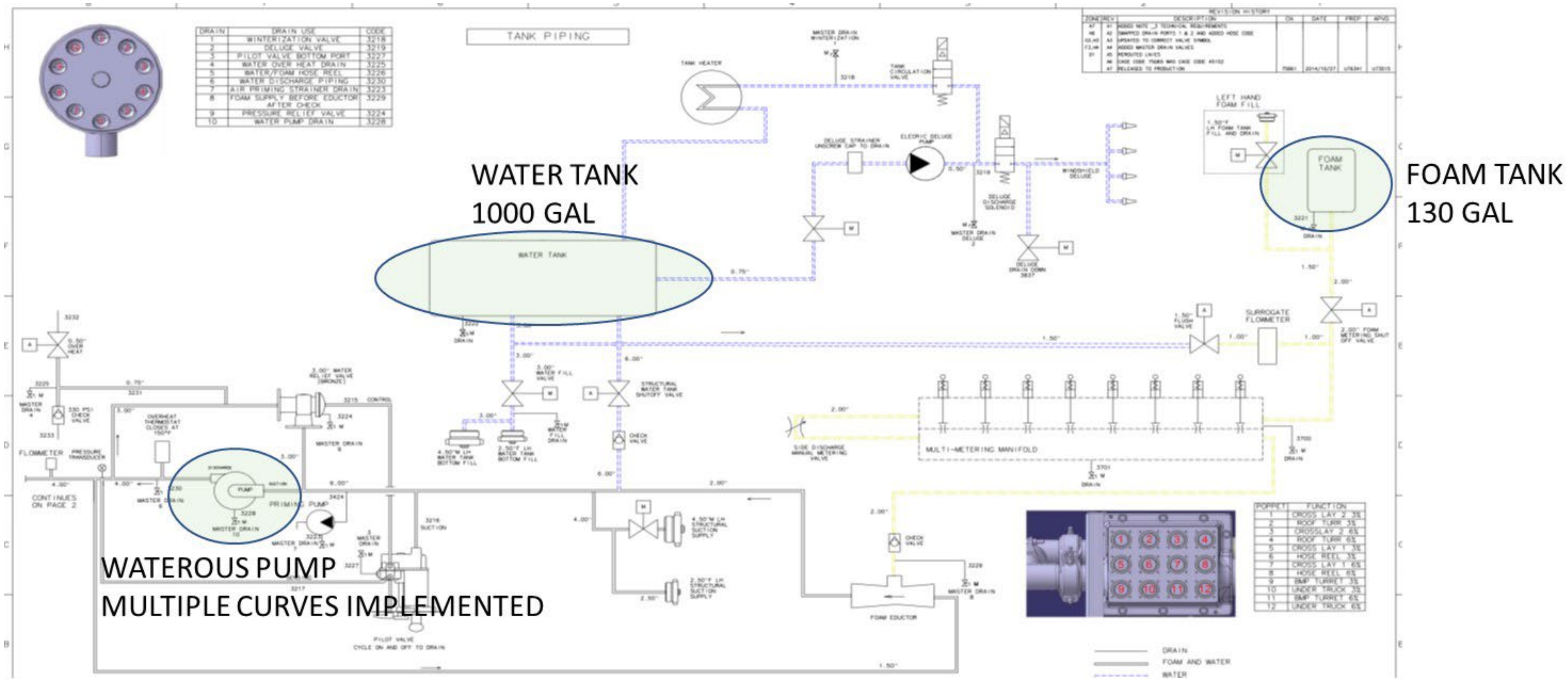
Key Points

- Use of modelling enables flexibility when priorities change
  - System type and construction specifics
  - Changes in discharge limits, if any
  - Desired volume of rinsate
- Inherent uncertainties may limit experimental solutions
  - AFFF adherence to system components may vary with component and experimental approach, limiting replication.
  - System specific conditions, including age and construction, may influence decontamination potential and approach.
  - Some systems and components may not be designed to be drained or accessed.

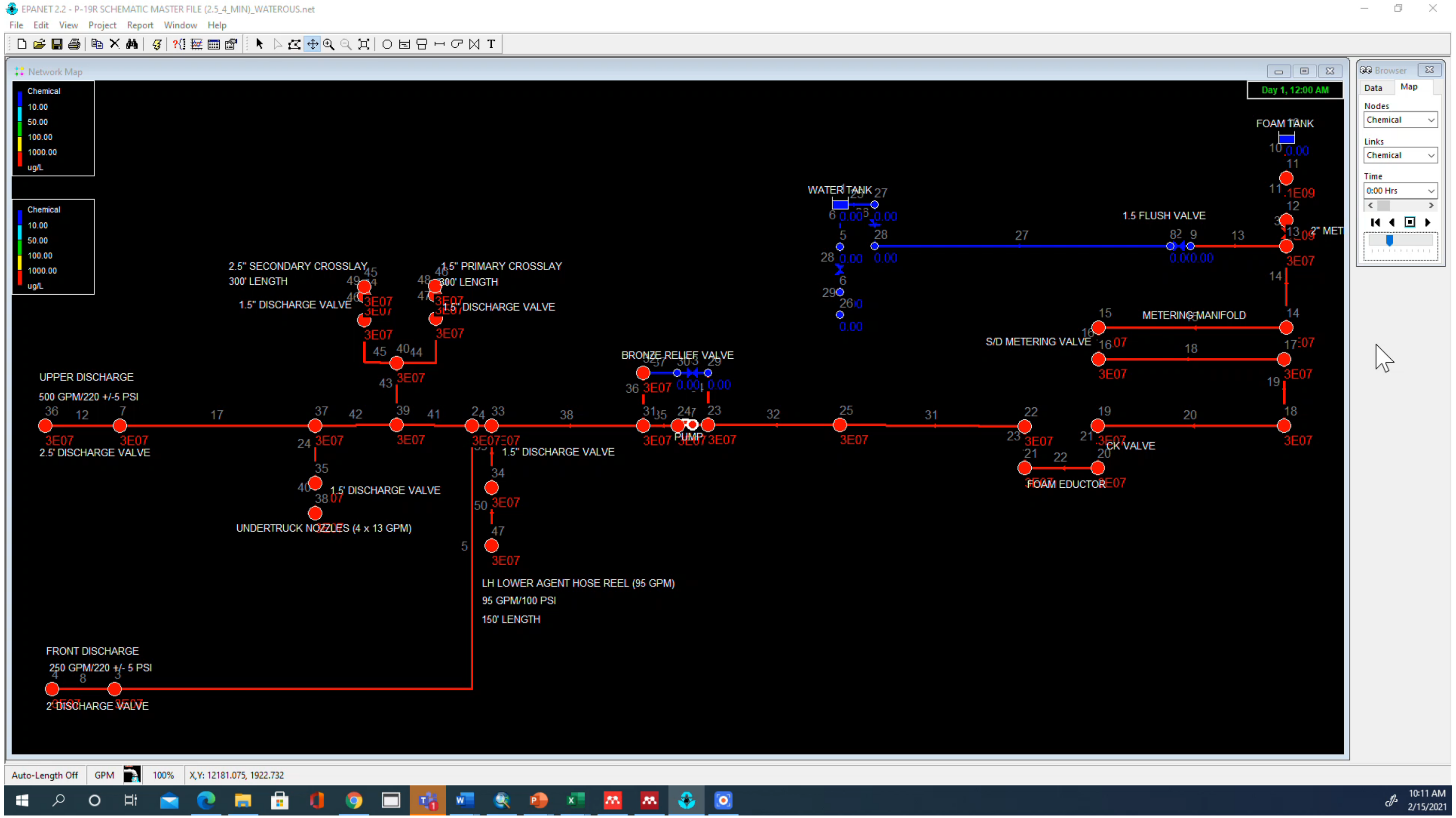
United States Environmental Protection Agency

BACKUP MATERIAL

P-19R Foam Delivery System



EPANET Demo



This video has no audio.

Applying Decontamination Protocols in the Face of Uncertainty

- How to ensure decontamination?
  - Potential PFAS rebound?
  - Is sampling necessary and how to do it?
  - For different systems?
- How to apply decontamination protocols for one AFFF delivery system to a different one?
  - Construction
  - Age and system condition
  - AFFF exposure history
- Most useful format for protocols?