

# Flux and Mass Balance Evaluation of a PFAS Fire Training Area

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Groundwater Quality 2019, Liège Belgium

# Fire Training Areas (FTA)



**Fire Fighting Foams  
With PFAS**

**Aqueous Film  
Forming Foams  
(AFFF)**

**Major issue at  
military and civilian  
aircraft facilities and**

# Per- and Polyfluoroalkyl Substances (PFASs)

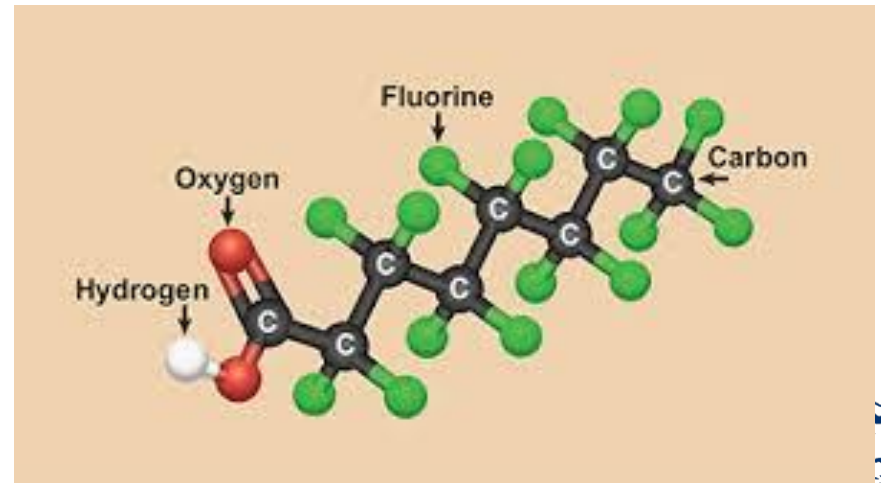
## Perfluorinated chemicals

A group of toxic chemicals that includes PFOA and PFOS and other per- and polyfluoroalkyl substances (PFASs).

## Perfluorooctanoic Acid (PFOA)

## Perfluorooctyl Sulfonate (PFOS)

That's as far as I'm going on Chemistry it gets very complicated



## PFAS in the Headlines

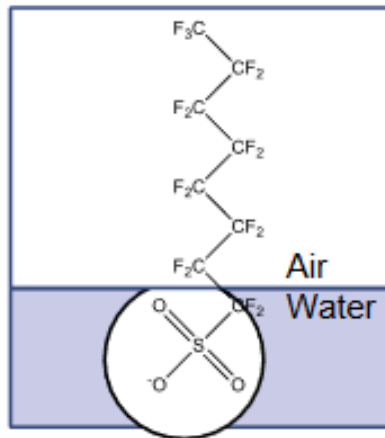
**‘Not a problem you can run away from’:  
Communities confront the threat of  
unregulated chemicals in their drinking water**

**The Washington Post**

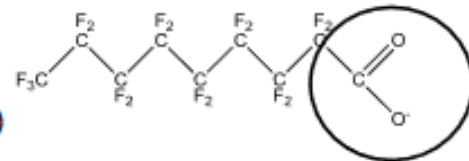
January 2, 2019

## Characteristics - Unique Chemistry

- C-F bond is one of the shortest and strongest bonds
- Few degradation processes: too much energy to break bonds
  - stable in acids, bases, oxidants, heat
  - microorganisms cannot gain energy from breaking the bond

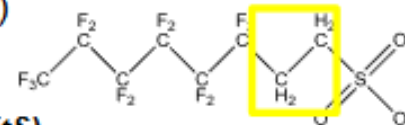


- Perfluorinated = all carbon atoms fully fluorinated (no hydrogen atoms)



PFOA (perfluorooctanoate)

- Polyfluorinated = some carbons are not fully fluorinated (have H)



(Poly)fluorotelomer sulfonate (FtS)

## Persistence of PFAS



## Aircraft Hanger Fire suppression System Where does the foam go?

(many cool youtube videos)

# States With Numerical PFAS Limits

## Washington

- Banned in firefighting foam and food packaging
- Proposed drinking water standard

## Vermont

- 20 PPT (PFAS)
- Drinking water health advisory for 5 PFAS

## Massachusetts

- 70 PPT (PFAS)
- State guidance for concentrations of 5 PFAS in drinking water

## New Jersey

- Set PFNA standard at 13 ppt
- Weighing proposed standards for:  
PFOA at 14 ppt  
PFOS at 13 ppt

## California

- 14 PPT (PFOA)
- 13 PPT (PFOS)
- Drinking water notification guidance

## Colorado

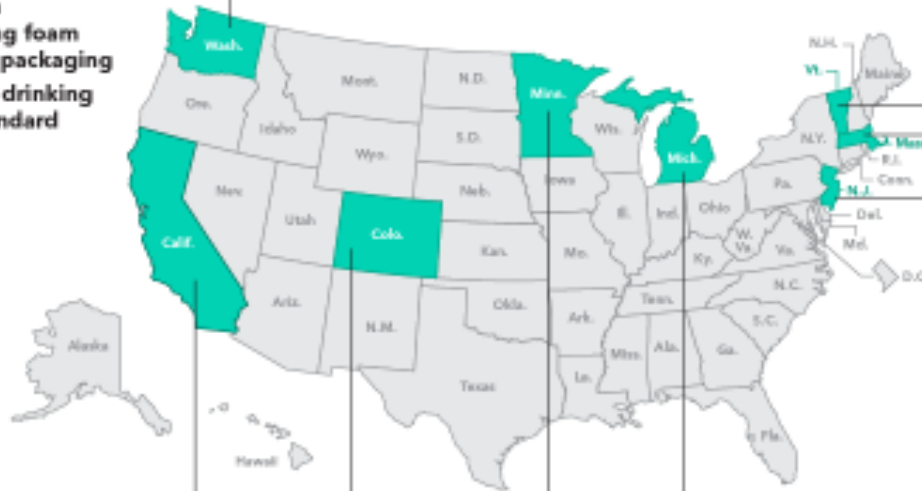
- PFOA/PFAS listed as hazardous waste
- 70 PPT (Combined PFOA/PFOS)
- Groundwater quality standard for El Paso County only

## Minnesota

- 35 PPT (PFOA)
- 27 PPT (PFOS)
- Health-based guidance values

## Michigan

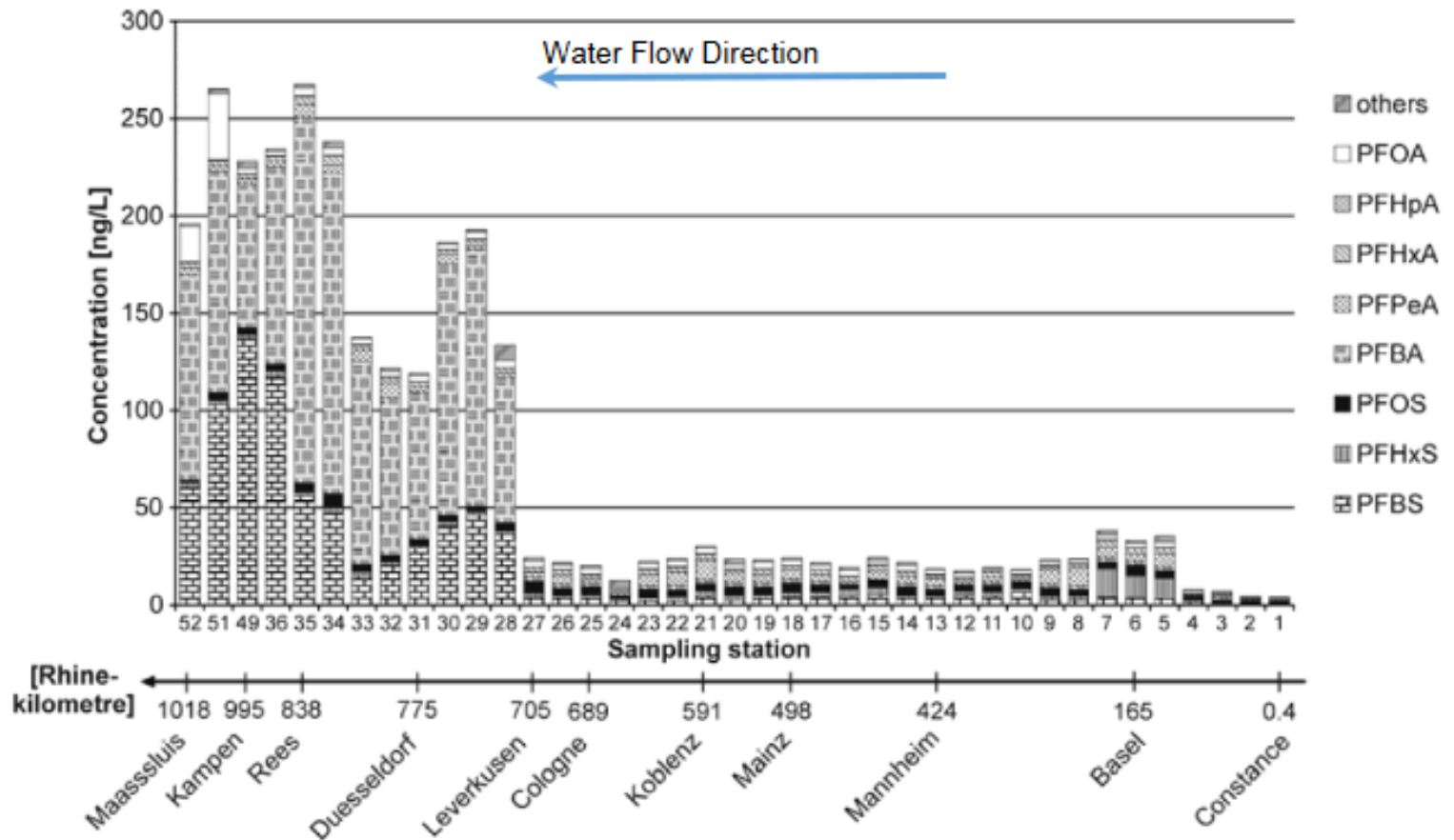
- 70 PPT (Combined PFOA/PFOS)
- State standard for concentrations in drinking water



Bloomberg Environment



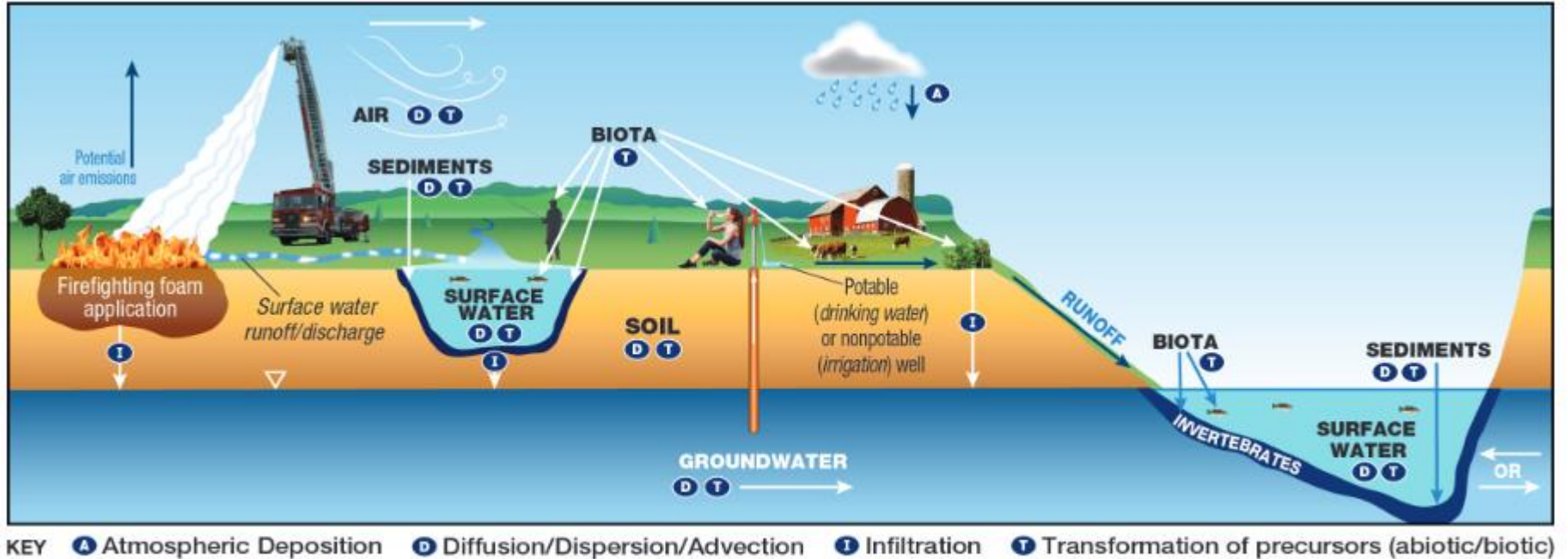
**Figure 6.1:** PFAS concentration profile in surface water along the River Rhine (Moeller et al., 2010)



Moeller et al., Distribution and sources of polyfluoroalkylsubstances (PFAS) in the River Rhine watershed, *Environmental Pollution*, 58(10), 3243-3250, 2010.



# Fire Training Areas: Conceptual Model



**Figure 1. Conceptual site model for fire training areas.**

(Source: Adapted from figure by L. Trozzolo, TRC, used with permission)

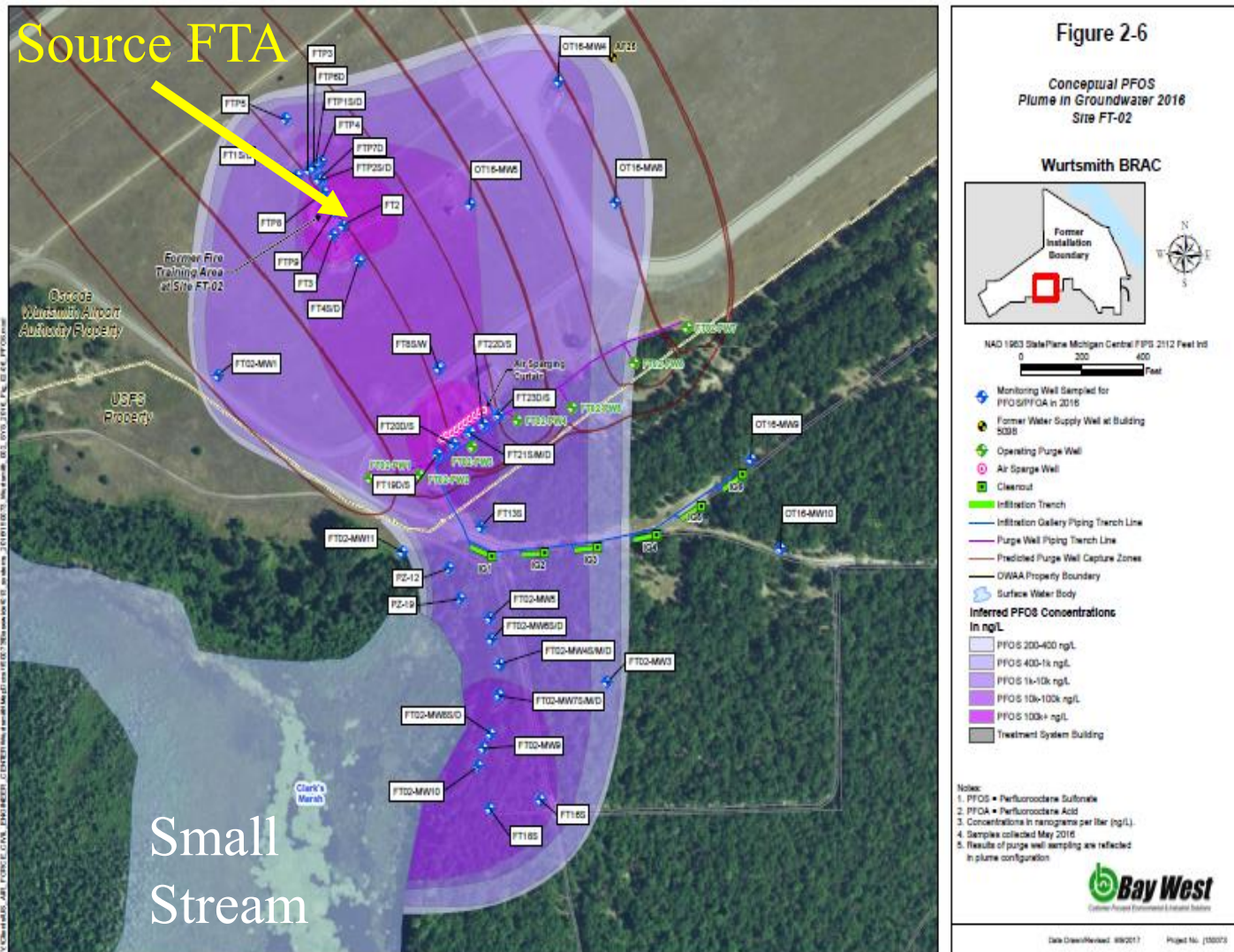
Source ITRC, Interstate Technology Regulatory Council, Environmental Fate and Transport for Per- and Polyfluoroalkyl Substances

# Evaluation of PFAS Flux Measurement Using Passive Flux meters

Dirk Pohlmann, PE, Ryan Morrish, and Andrea Slowey  
(Bay West LLC)

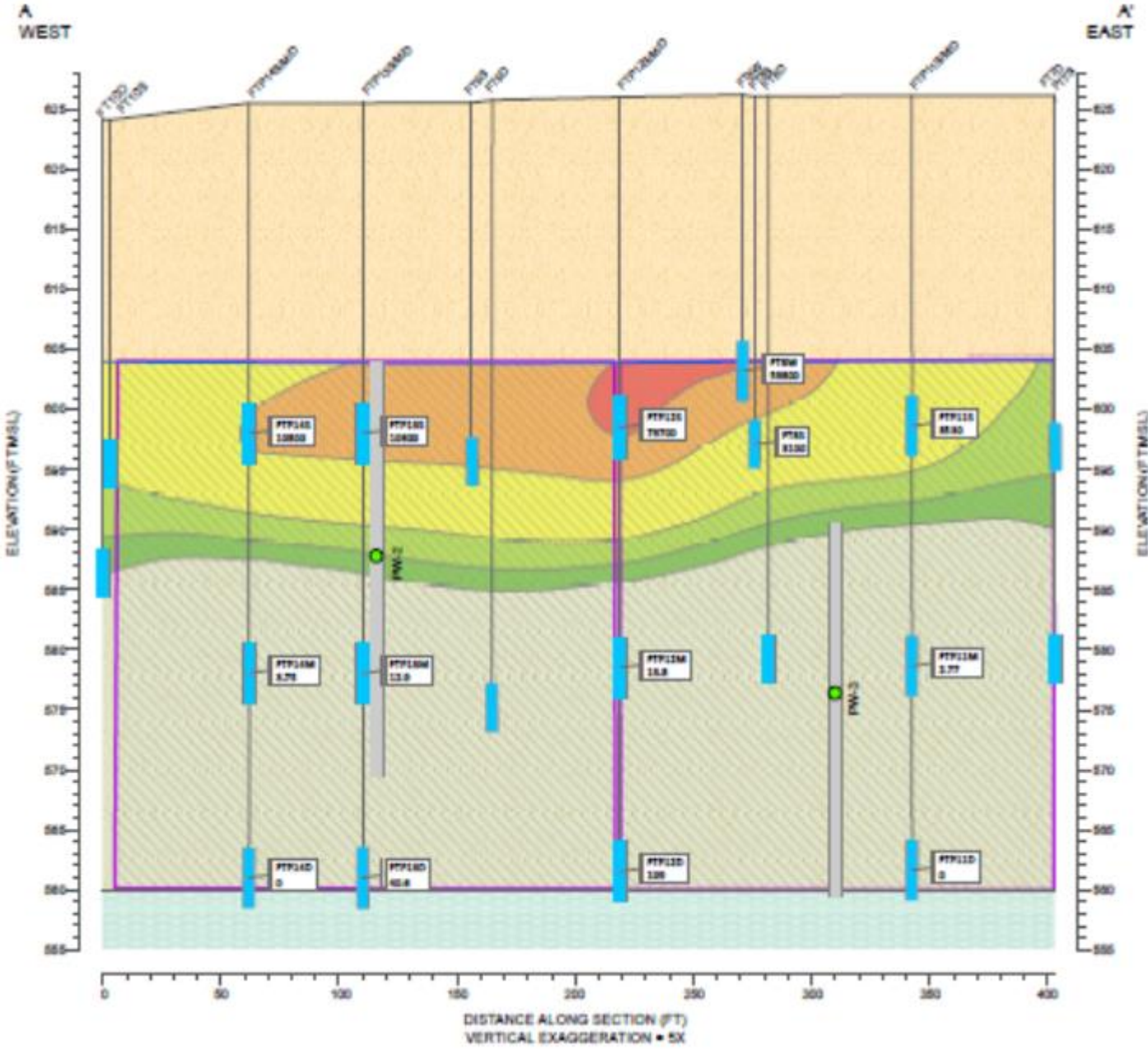
Matt Marrs, PG, REM (Air Force Civil Engineer Center) and Paul Rekowski, PE (AGEISS Inc.)

# Site PFAS Plume



Wurtsmith AFB, PFAS Plume Migrating toward Creek



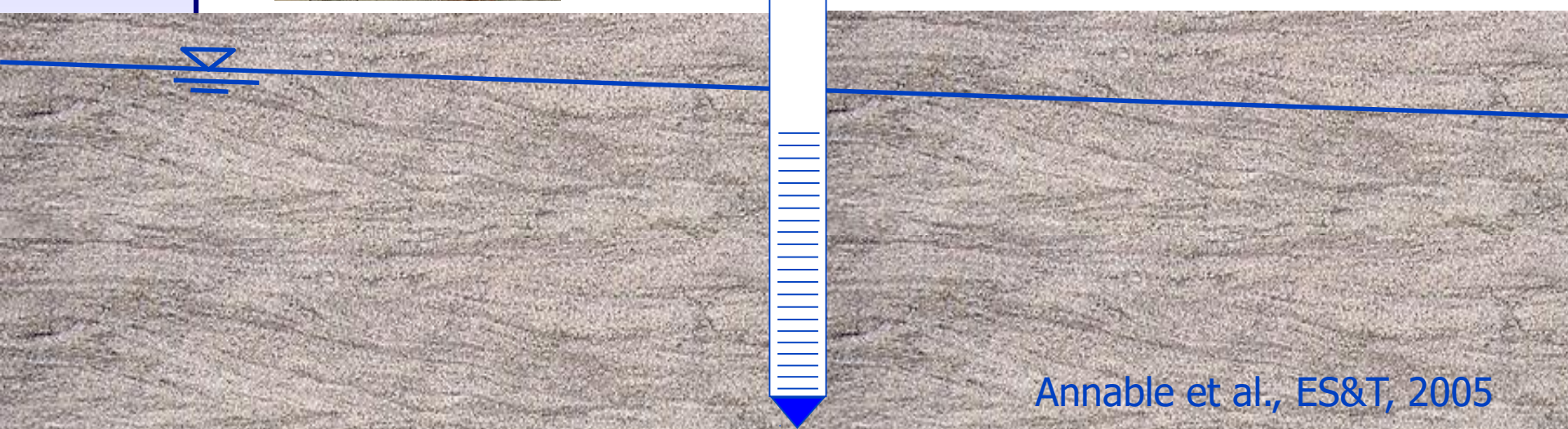
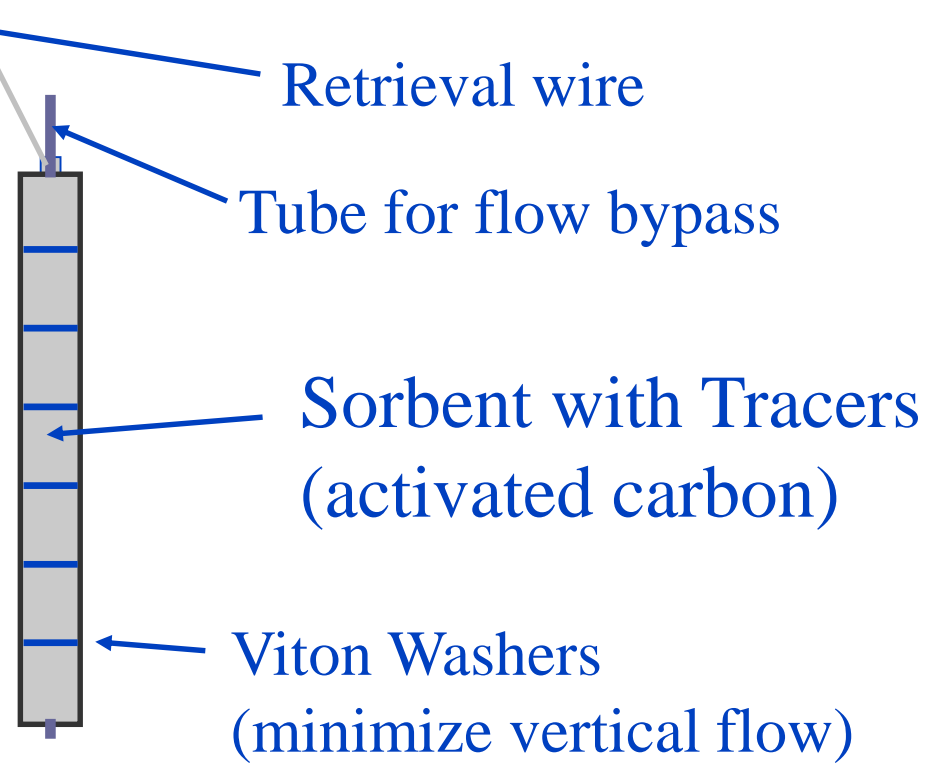


PFOS  
Plume

PFMs deployed  
in 10 wells.

Used non-ionic  
resin for PFOS  
Sorbent  
Ambesorb

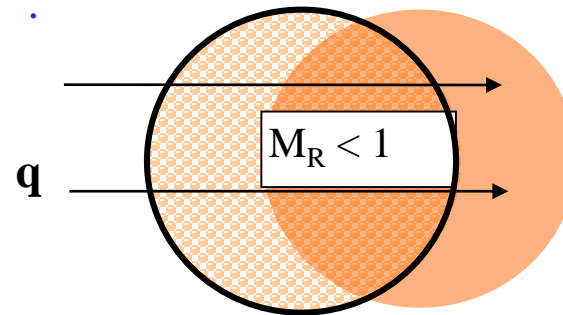
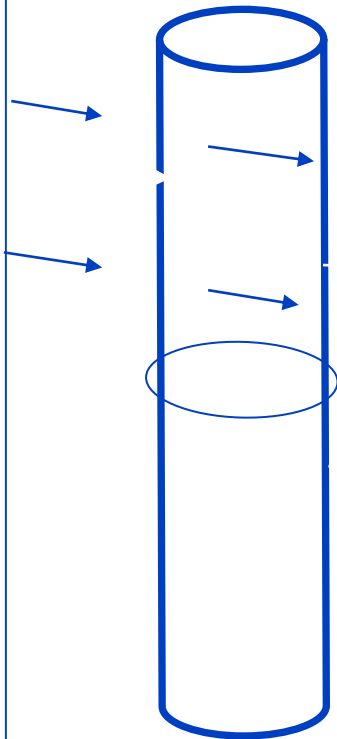
# Passive Flux Meter Technology



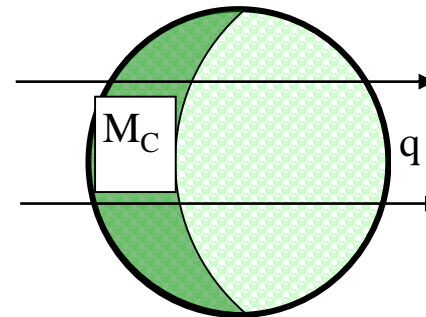
# Passive Flux Meter™:

## Groundwater & Contaminant Fluxes

Slotted well screen



**Displaced resident tracers for groundwater flux**

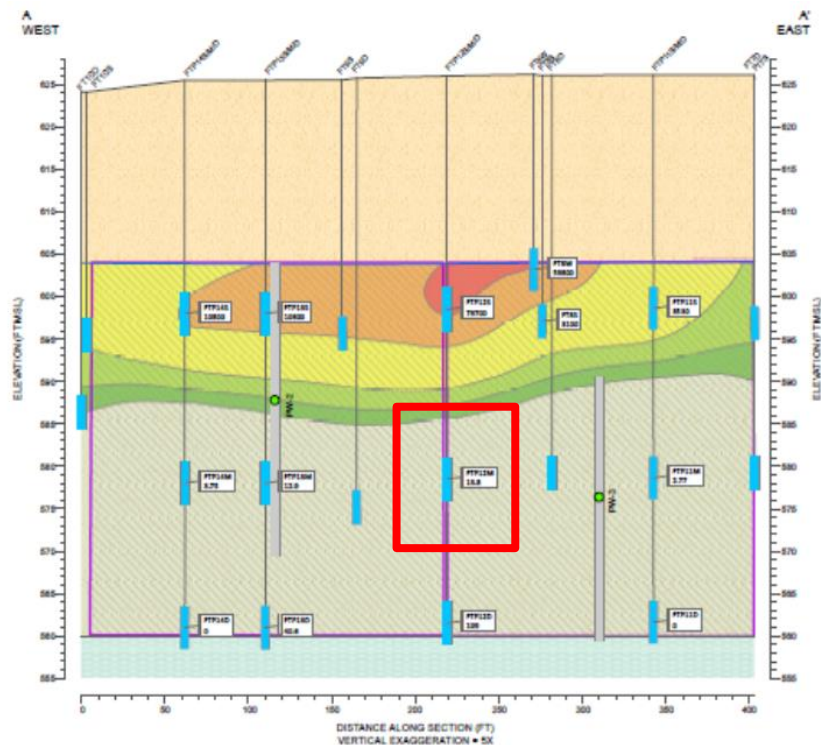


**Captured contaminants for contaminant fluxes**



Hatfield et al., Journal of Contaminant Hydrology, 2004





PFAS-PFM based  
block centered Mass  
Discharge

About 2.5 g/day PFOS

Table 2. PFOA/PFOS Flux and Daily Mass Based on PFMs

Well ID	Area (M <sup>2</sup> )	PFOS flux (ug/M <sup>2</sup> /day)	PFOS Mass (g/day)	PFOA flux (ug/M <sup>2</sup> /day)	PFOA Mass (g/day)
FT02-FTP11S	114.0	651	0.074	51	0.006
FT02-FTP11M	139.9	0.0	0.000	0.7	0.000
FT02-FTP11D	77.7	0.0	0.000	0.7	0.000
FT02-FTP12S	104.1	16,205	1.686	1,990	0.207
FT02-FTP12M	127.7	2.5	0.000	1.9	0.000
FT02-FTP12D	71.0	5.7	0.000	4.6	0.000
FT02-FTP13S	178.4	3,200	0.571	251	0.045
FT02-FTP13M	218.9	0.8	0.000	0.9	0.000
FT02-FTP13D	121.6	6.8	0.001	1.9	0.000
FT02-FTP14S	178.4	413	0.074	1.3	0.000
FT02-FTP14M	218.9	0.0	0.000	0.8	0.000
FT02-FTP14D	121.6	0.9	0.000	0.9	0.000
Total			2.407		0.259



# Mass Discharge from Pump and Treat

**Table 1. Daily PFOA/PFOS Capture Rate**

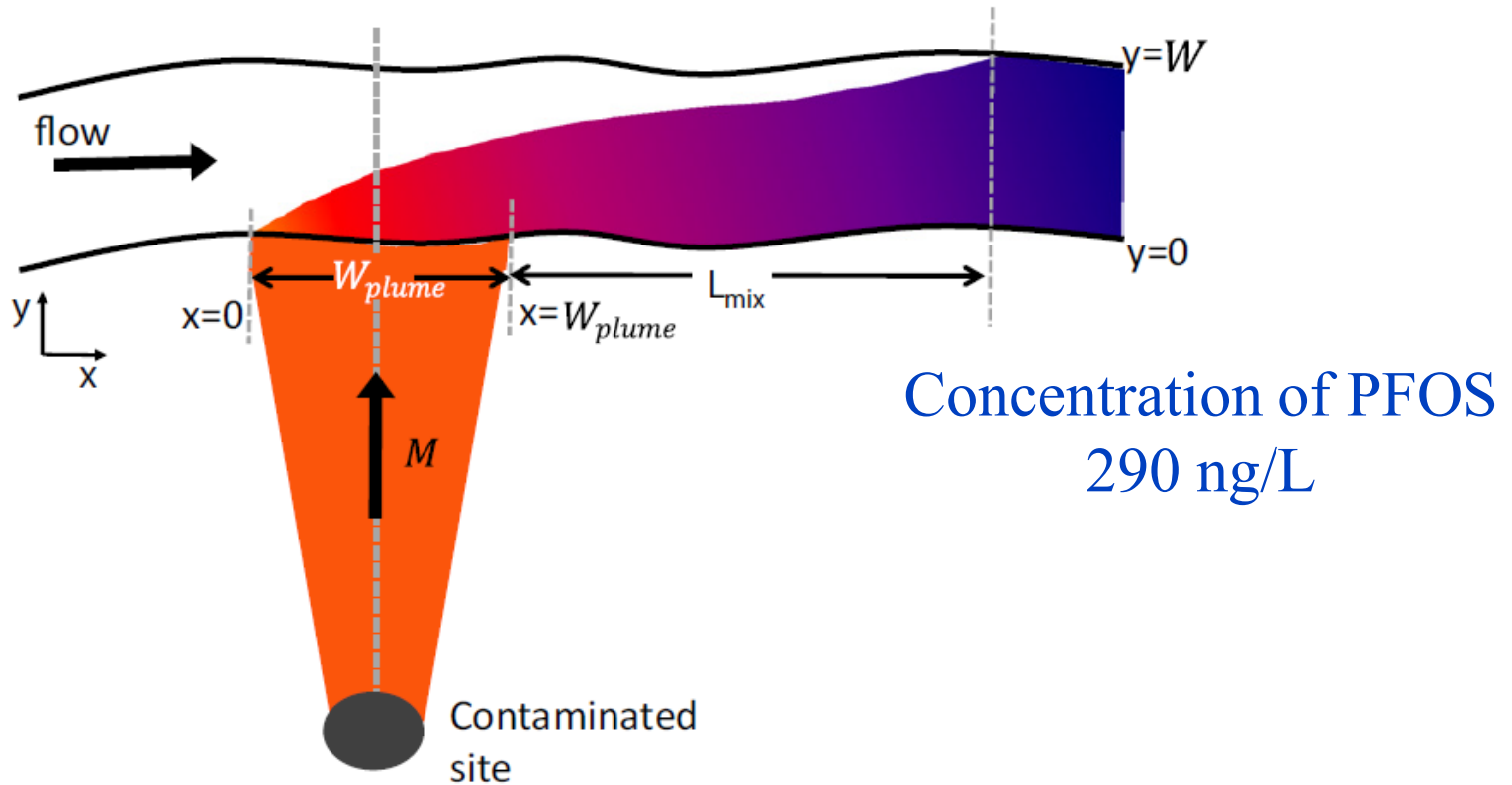
Pumping well	FT02-PW2	FT02-PW3
Avg. Flow Rate - July 26 - Sept 24 2017 (L)	78.0	120.2
PFOA (09Sept17) ( $\mu\text{g/L}$ )	4.990	0.891
Daily Mass ( $\mu\text{g}$ )	560,328	154,285
Daily Mass (g)	0.56	0.15
<b>Total Daily PFOA Mass Captured (g)</b>	<b>0.71</b>	
PFOS (09Sept17) ( $\mu\text{g/L}$ )	25.30	9.26
Daily Mass ( $\mu\text{g}$ )	2,840,940	1,039,806
Daily Mass (g)	2.84	1.04
<b>Total Daily PFOS Mass Captured (g)</b>	<b>3.88</b>	
<b>Total Daily PFOA/PFOS Mass Captured (g)</b>	<b>4.60</b>	

Similar Mass Discharge Range

# Mass balance for groundwater to surface water

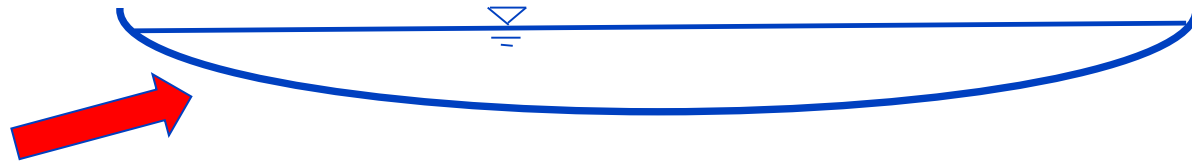
Assume PFOS  $M_D = 2.5$  g/day

Streamflow estimated at  $0.1 \text{ m}^3/\text{s}$



# PFAS Discharge to a Groundwater Fed Lake

Lake volume estimated at 18M m<sup>3</sup>



2.5 g/day PFOS

After one year concentration = 50 ng/L



# Summary

- PFM is a versatile passive device to measure cumulative fluxes of water and contaminants
- PFOS and PFOA PFM development continues
- A second sampling is planned for Wurtsmith AFB



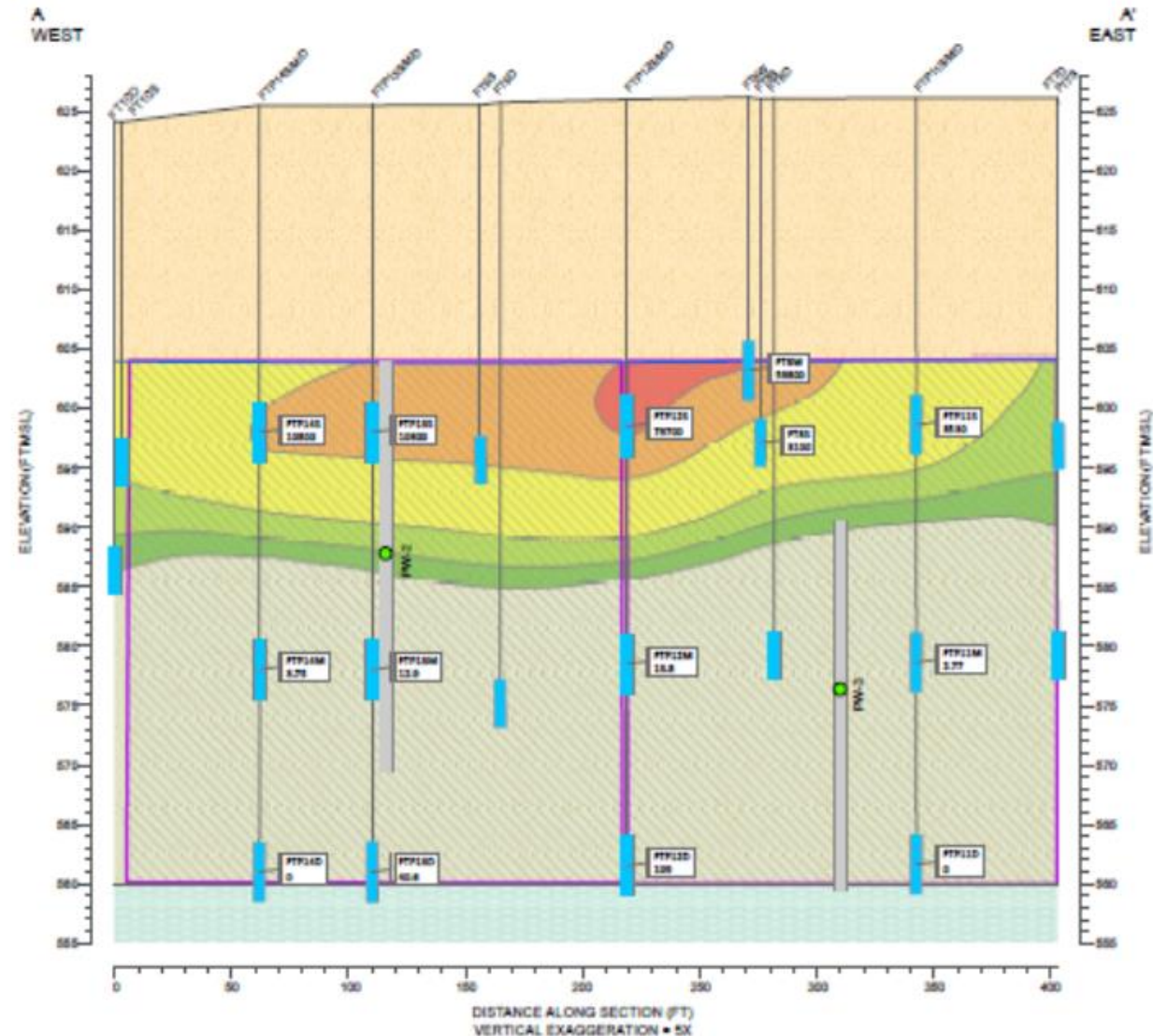
# Flux Session

PFAS  
Plume

PFMs deployed in  
10 wells.

Used non-ionic  
resin for PFOS  
Sorbent

5 g/day



# Stuart's New Water Woes: Are They the Canary in the Coal Mine for Florida?

By NANCY SMITH

January 18, 2019 - 6:00am



In an ironic twist, in the same city where Gov. Ron DeSantis rolled out his no-holds-barred environmental statement last week, another multimillion-dollar water-contamination crisis has reared its ugly head.

Stuart, Florida's "blue-green algae central," is only just finding out it's knee-deep in more *bad*.

The same cancer-causing chemicals found in high concentrations underground near [Florida State Fire College](#) in

Ocala and [on military bases](#) around the state, have turned up in lower concentration after testing in three of six separate municipal wells in Stuart, City Manager David Dyess confirmed this week.