

Stabilizing PFAS-Contaminated Water, Sediments, and 6,000 yd³ Soil using 6 Different Amendments (Buick City, Michigan)

Daniel Cassidy, Western Michigan Univ. - daniel.cassidy@wmich.edu

Grant Trigger, RACER Trust - gtrigger@racertrust.org

Chris Peters, Arcadis - chris.peters@arcadis.com

RACER Trust

- **Revitalizing Auto Communities Environmental Response (RACER)** established in 2011 (Old GM bankruptcy)
- 36 sites in Michigan with cleanup budgets totaling \$155 M
- **RACER Mission:**
 - Help communities harmed by closure of GM facilities,
 - Dual mission - cleanup sites AND position for redevelopment to bring new investment and jobs to local communities.

Site Location

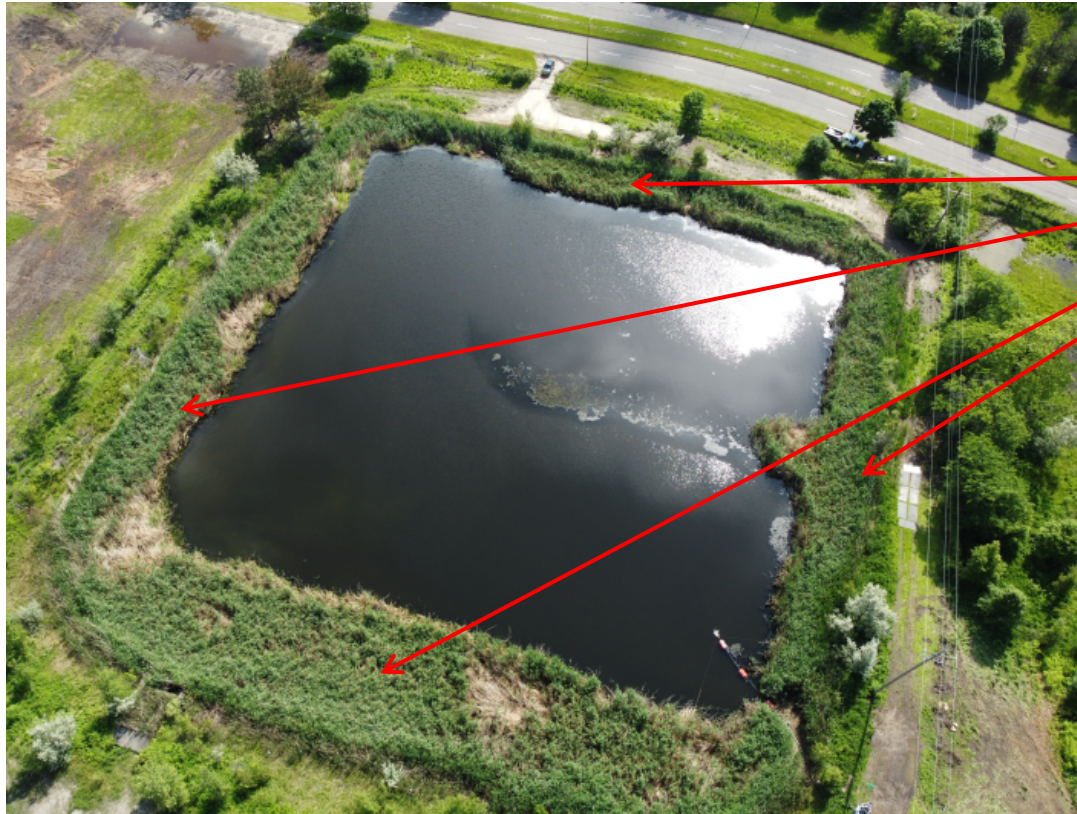


FIELD ACTIVITIES

PFAS “Hot Spots” at Buick City



Lagoon Area & Soil Stockpile



Phragmites australis

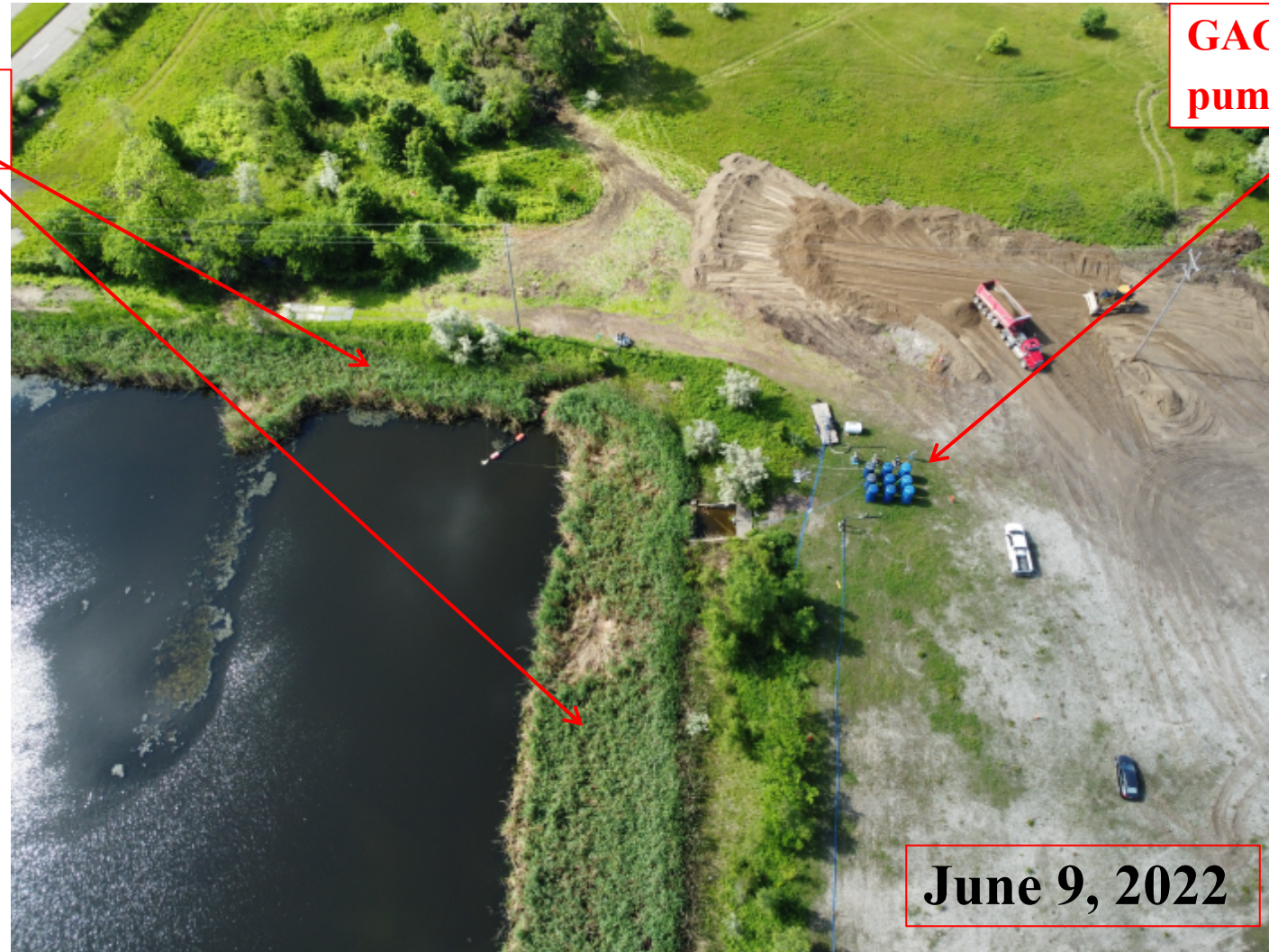


Lagoon Area & Stockpiled Soil

Phragmites australis



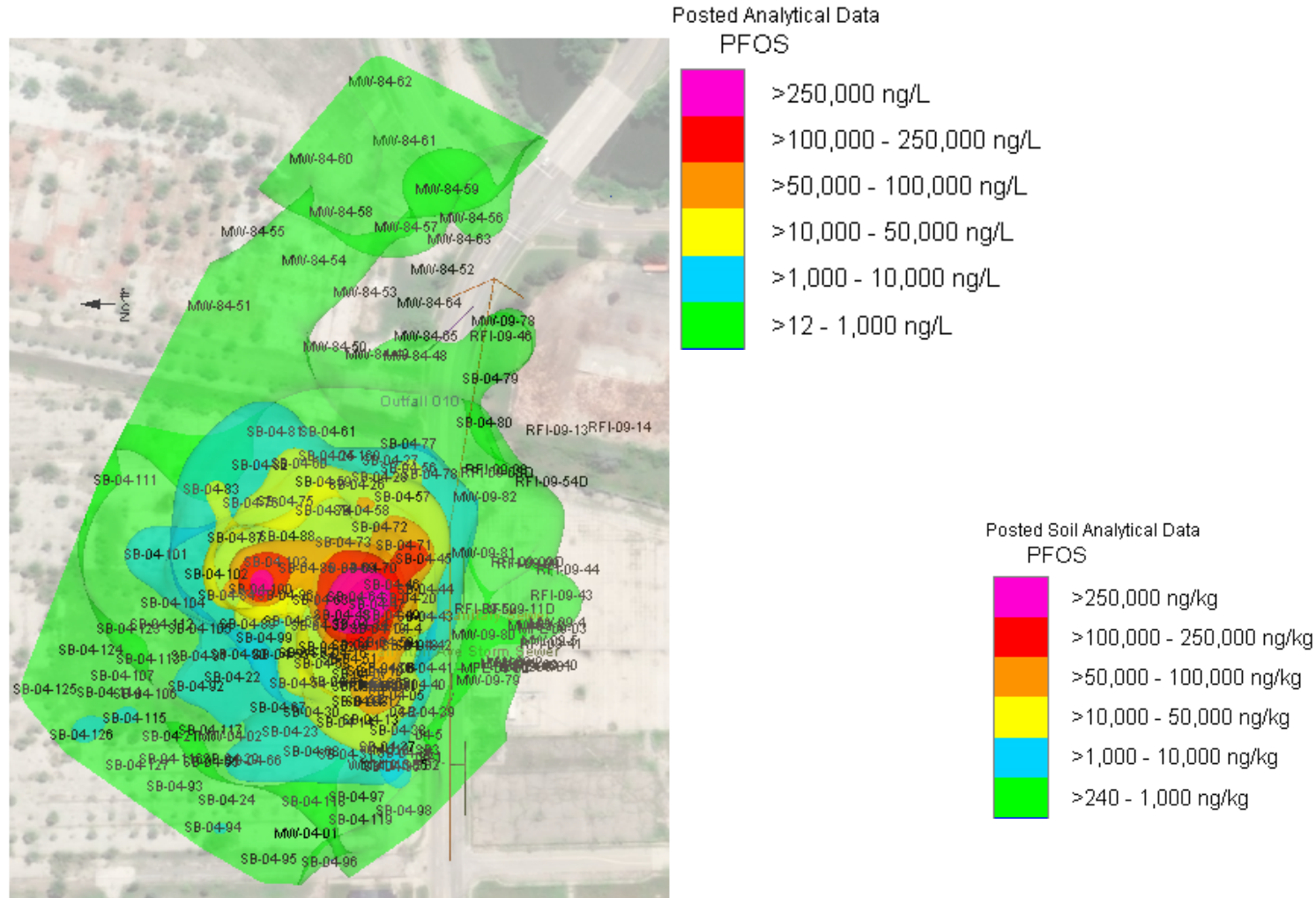
- non-native
- invasive



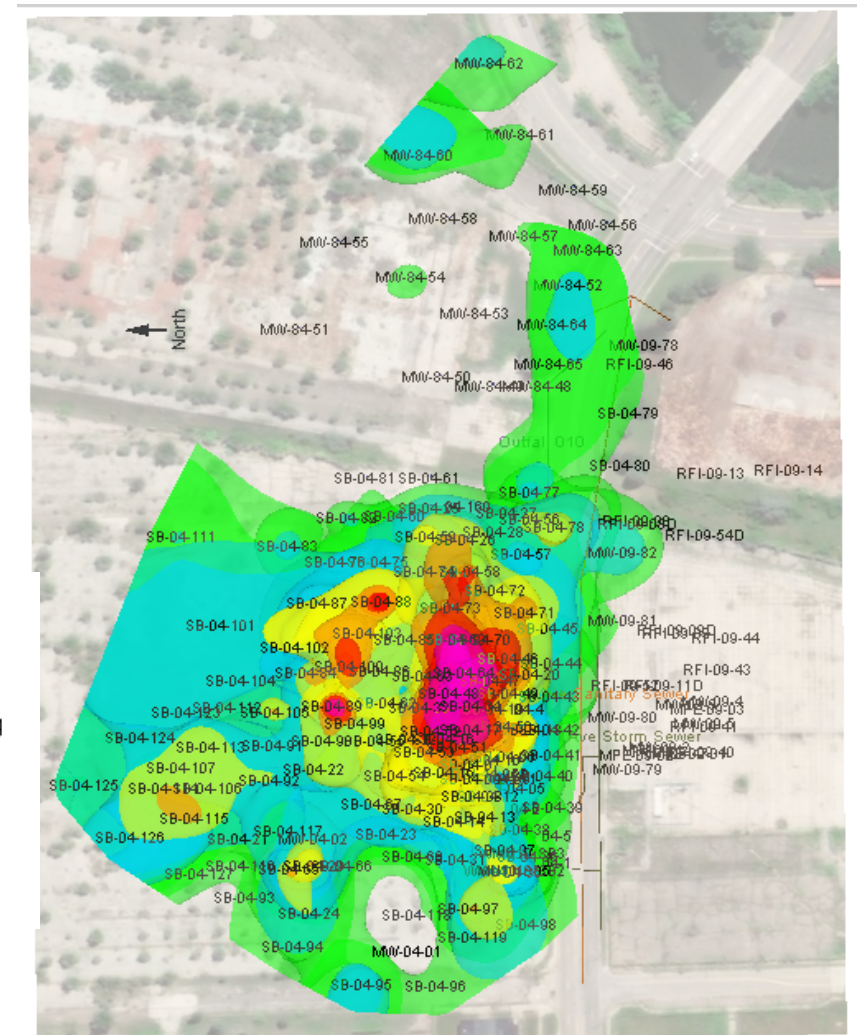
GAC tanks to treat
pumped groundwater

June 9, 2022

Hamilton Ave. Area 3-D Model (PFOS)



PFOS in Groundwater



PFOS in Soil

S/S Amendments Tested (Approx. 'Dose')

- **RemBind (1.5%)**
- **Powdered Activated Carbon (PAC) (1.5%)**
- **Bentonite/PAC Blend (~1%)**
- **Recycled* Granular Activated Carbon (~2.5%)**
- **Portland Cement (~5-7%)**
- **EnviroSet (proprietary mix) (~5 -7%)**

***Spent GAC was size-reduced and used as amendment**

Materials & Volumes Treated

Material Treated	Volume (yd ³)
Lagoon Sediments	950
<i>Phragmites</i> and side slope soils	1,000
<i>Phragmites</i> and side slope soils (west)	400
Stockpiled clay soils	5,500
Surface Soils (granular)	7,000

PFOS in SPLP extract (ng/L) BEFORE & AFTER Treatment (Field Samples)

Treatment Reagent - Matrix (6 samples)	BEFORE	AFTER
GAC/PAC - Sidewall sed/ <i>Phragmites</i> mix	220	<10-15
Rembind - Clay soil stockpile	150	<10-40
PAC - Clay Soil Stockpile	160	<10
Bentonite/PAC - Lagoon bottom	210	<10
Portland - Excavated sandy soil	290	~160
EnviroSet - Excavated sandy soil	1,300	~200

%Reduction in SPLP extract (ng/L)

Mixture	% Reduction
GAC/PAC	95
PAC	92
Bentonite/PAC	63
Rembind	92
Portland	59
EnviroSet	77

Longevity, Cost, Site Conditions, Regulatory Views?

Spent GAC vs. PAC

Mixing of Spent Activated Carbon with
Phragmites on Slope



PAC was “black dusty”-- Operator
able to “Visually Evaluate” mixing



July 6, 2022

Lagoon Sediments and *Phragmites*

Sediments - Mixing/Stabilization

1



**Bentonite/PAC
blend mixed with
sediments and
spread across
bottom**

4



**Phragmites - Sampled for PFAS
Chopped with bush hog down to ground**

2



3

**Recycled GAC/PAC was
mixed with *Phragmites*
on west slope and
scraped into lagoon over
treated sediments**



BENCH STUDY OBJECTIVES

(1) Sorption capacity for PFOS of various materials from the Site:

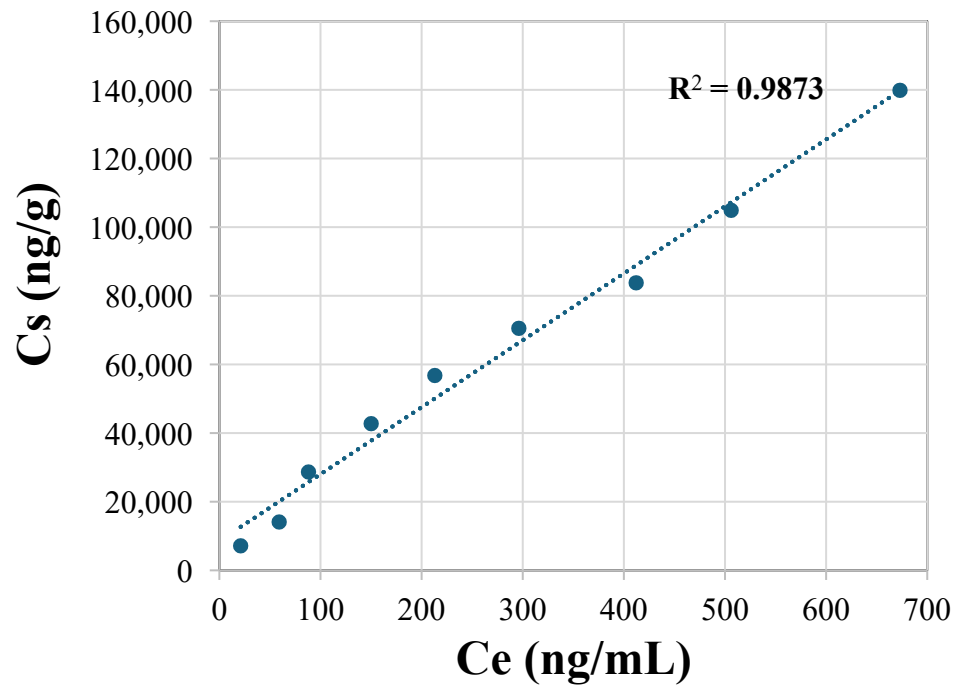
- a) $K_d = C_s/C_e$ (Soil Concentration/Water Concentration)
- b) Leaves & Rhizomes of *Phragmites australis* growing in lagoon
- c) Spent GAC from onsite Pump & Treat system

(2) Reduced Leaching (i.e., “Stabilization”) of amendments in soils:

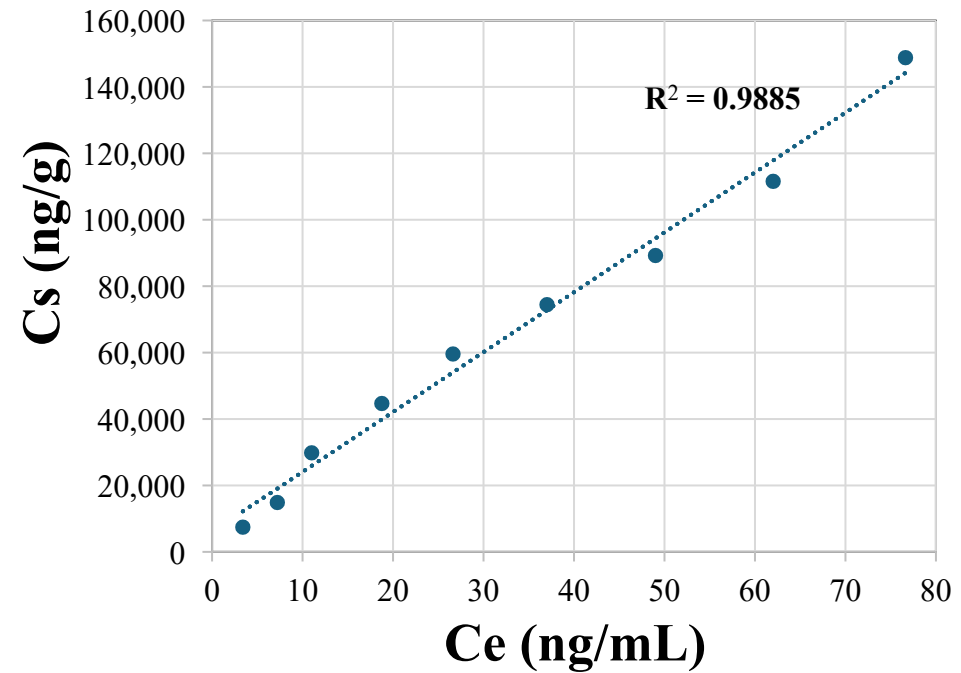
- a) Synthetic precipitation leaching procedure, or **SPLP** (EPA Method 1312)
- b) 28 PFAS compounds Michigan EGLE requires for soil
- c) Dose-Response Curves: % reduction in PFAS Leached with increasing dose

Sorption Isotherm: Plots

GAC-Tank 1



PAC*-Tank 1



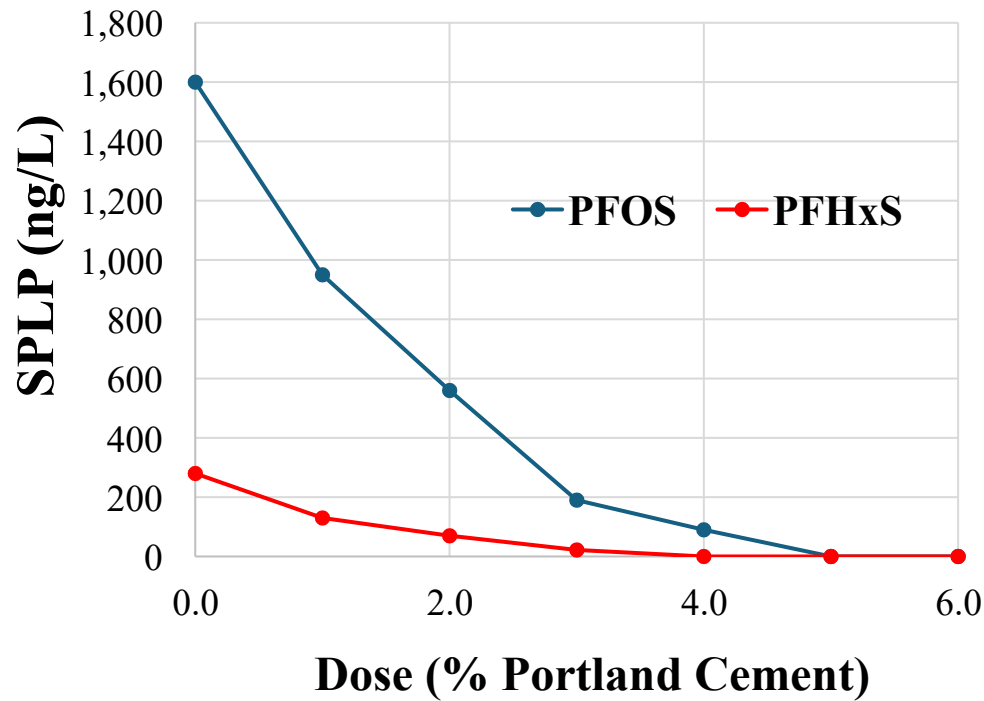
PAC*: size reduced spent GAC

Sorption Isotherm: $\log K_d$ Values

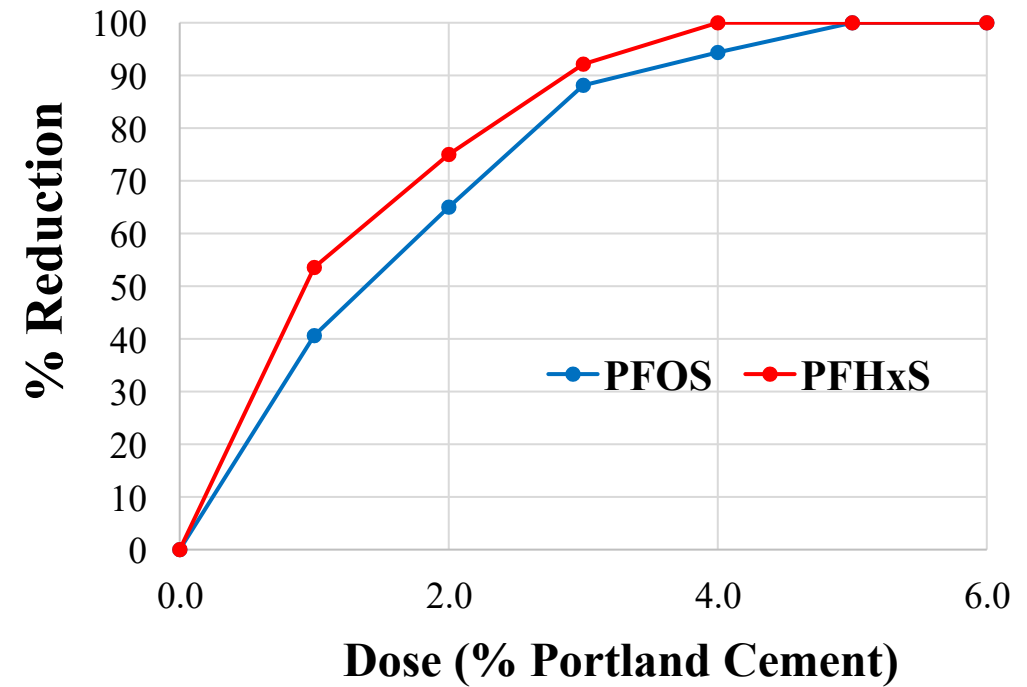
Material	$\log K_d$
Used GAC 1	2.3
Used GAC 1 ground to PAC	3.3
Used GAC 4	4.5
Used GAC 4 ground to PAC	5.4
<i>P. australis</i> Leaves	2.8
<i>P. australis</i> Rhizomes	2.7

Dose-Response Curves

[PFAS] in SPLP Extract



Dose-Response



East Stockpile-North Half

Doses required to achieve Non-Detect

Soil	Amendment	Dose (%)
West Stockpile	PAC	2.5
West Stockpile	Rembind	3
East Stockpile-South Half	EnviroSet	3
East Stockpile-North Half	EnviroSet	5
East Stockpile-North Half	Portland	5

Phragmites australis

- non-native
- invasive



www.greatlakesphragmites.net/blog/20200910-rhizomes-getting-to-the-root-of-it-all/

Rhizomes & Root Mass



Phragmites-Bioconcentration Factors (BCF)

	Leaf	Root Mass	Stalk	Rhizome
PFOS Conc. (ng/kg)	3,800	7,200	900	1,100
%BCF*	16.5%	31.3%	3.9%	4.8%

*Average PFOS conc. in sediment = 23,000 ng/kg

CONCLUSIONS

- ALL amendments reduced PFAS leaching significantly (even at low doses).
- Grinding “spent” GAC to PAC increases K_d by about one log unit.
- *Phragmites* tissues have a large capacity to sorb PFAS (leaves surprisingly so).
- Field Application & Conditions are ALL-IMPORTANT (e.g., mixing, water content).

QUESTIONS: Bench Study

Dan Cassidy: daniel.cassidy@wmich.edu

QUESTIONS: Field Application

Grant Trigger: gtrigger@racertrust.org

Chris Peters: chris.peters@arcadis.com