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Ecological Risk Assessment Approaches at PFAS-Impacted Sites

April 9, 2020

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Welcome and Introductions

Rula A. Deeb, Ph.D.
Webinar Coordinator

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Webinar Agenda

- **Webinar Logistics** (5 minutes)
  Dr. Rula Deeb, Geosyntec Consultants
- **Overview of SERDP and ESTCP** (5 minutes)
  Dr. Andrea Leeson, SERDP and ESTCP
- **Development of PFAS Toxicity Reference Values in Amphibians for use in Ecological Risk Assessments of AFFF-Contaminated Sites** (25 minutes + Q&A)
  Dr. Marisol Sepúlveda, Purdue University
- **Guidance for Assessing the Ecological Risks of Threatened and Endangered Species at AFFF-Impacted Sites** (25 minutes + Q&A)
  Dr. Jason Conder, Geosyntec Consultants
- **Final Q&A session**

Zoom Instructions

- Download Zoom
  - https://zoom.us/download
- If you cannot download Zoom, you can view the slides using an internet browser
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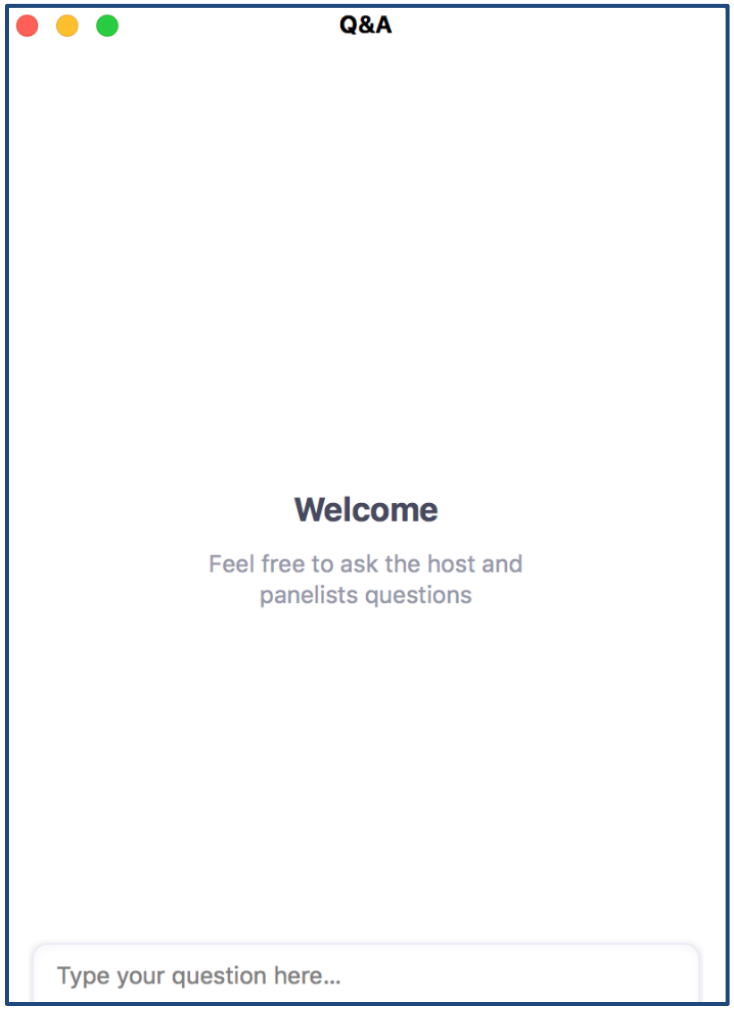
- Find the Q&A button on your control bar and type in your question(s)
- Make sure to add your organization name at the end of your question so that we can identify you during the Q&A sessions



SERDP and ESTCP Overview

Andrea Leeson, Ph.D.
SERDP and ESTCP

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DoD's Environmental Technology Programs

Science and Technology

- Statutory program established 1991
- DoD, DOE, EPA partnership
  - Advanced technology development to address near-term needs
  - Fundamental research to impact real world environmental management

Demonstration and Validation

- Demonstrate innovative cost-effective environmental and energy technologies
  - Transition technology out of the lab
  - Establish cost and performance
  - Partner with end user and regulator
  - Technology transfer
    - Accelerate commercialization or broader adoption
    - Direct technology insertion

Environmental Drivers

Sustaining Ranges, Facilities and Operations

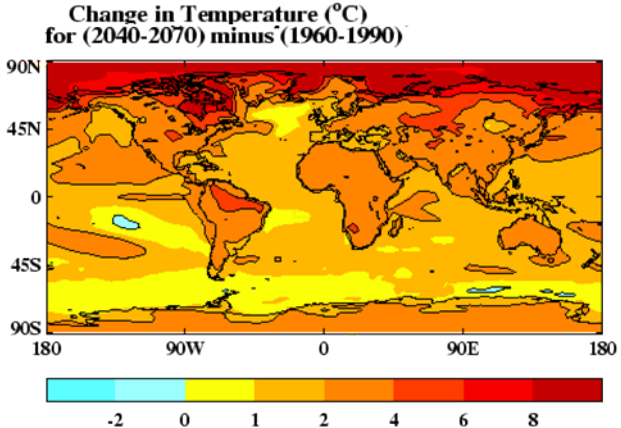
Maritime Sustainability
Threatened and Endangered Species

Toxic Air Emissions and Dust

UXO and Munitions Constituents

Noise

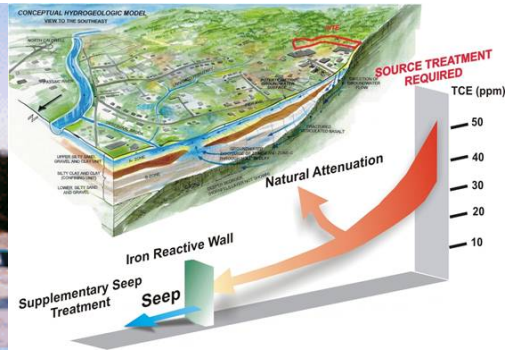
Sustainable FOB



Environmental Drivers

Reducing Current and Future Liability

Contamination from Past Practices



- Groundwater, soils and sediments
- Large UXO liability
- Emerging contaminants

Pollution Prevention to Control Life Cycle Costs

- Elimination of pollutants and hazardous materials in manufacturing, maintenance, and operations
- Achieve compliance through pollution prevention

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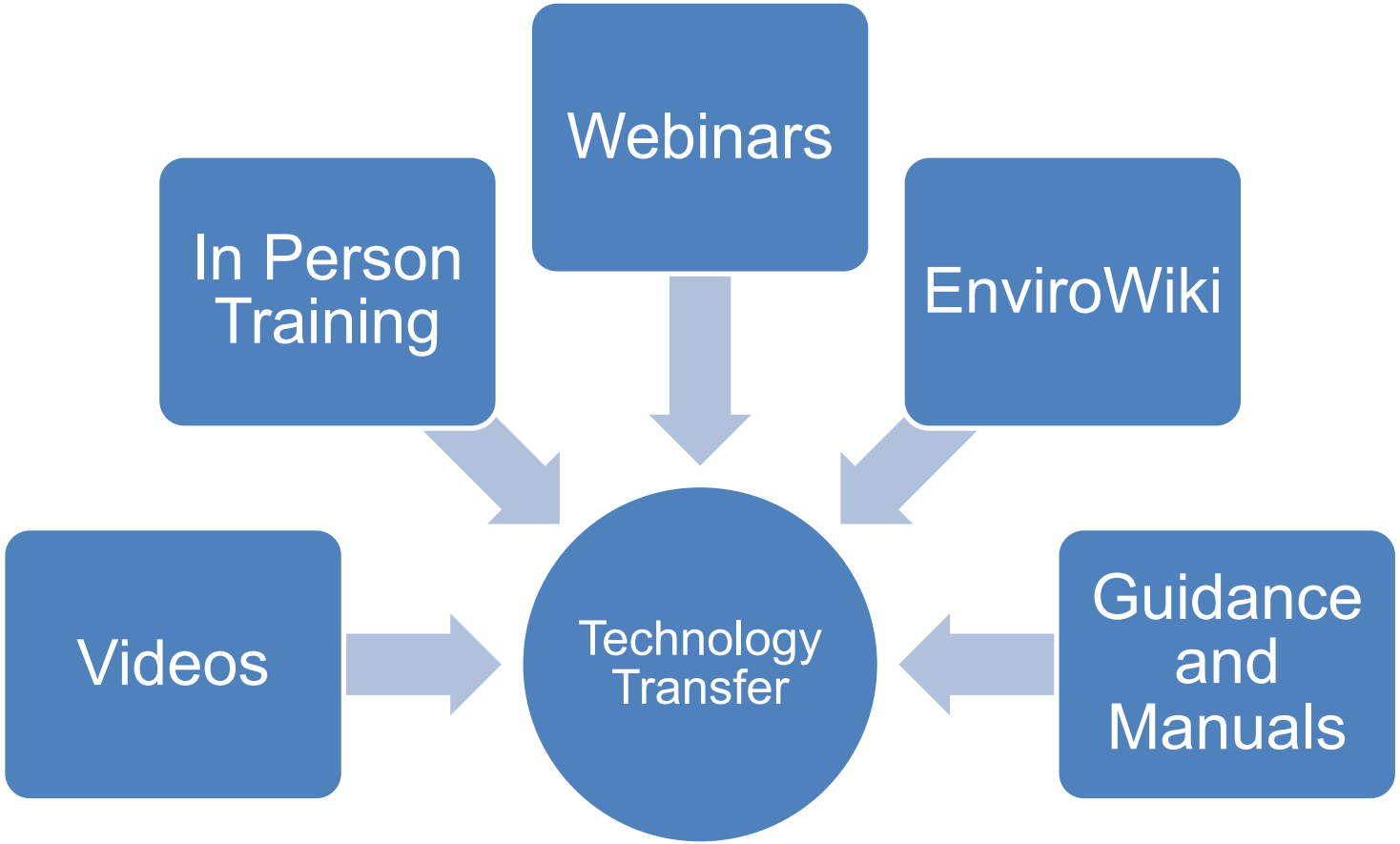

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Webinars

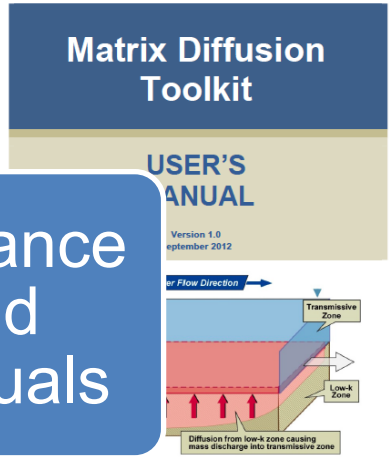
In Person Training

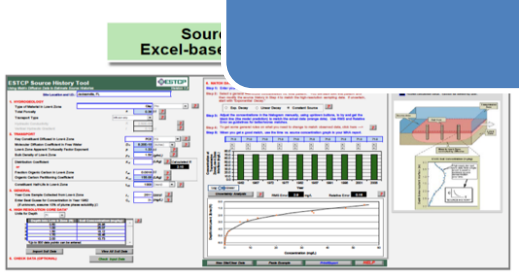
EnviroWiki

Videos

Technology Transfer

Guidance and Manuals





SERDP and ESTCP Webinar Series

Date	Topic
April 23, 2020	From Basic Research to a Prototype Towbody Platform: Progress on Underwater Unexploded Ordnance Remediation
May 7, 2020	Innovative Technologies for PFAS Destruction in Investigation Derived Wastes
May 21, 2020	Analysis of Defense Related Ecosystem Services
June 4, 2020	Waste Reduction and Treatment in Armed Forces Vessel Environments
June 18, 2020	Predicting PFAS Fate and Transport in Subsurface Environments, and Treatment

For upcoming webinars, please visit

http://serdp-estcp.org/Tools-and-Training/Webinar-Series

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Bioaccumulation and Toxicity of PFAS in Amphibians

Marisol Sepúlveda, Ph.D., DVM
Purdue University

SERDP
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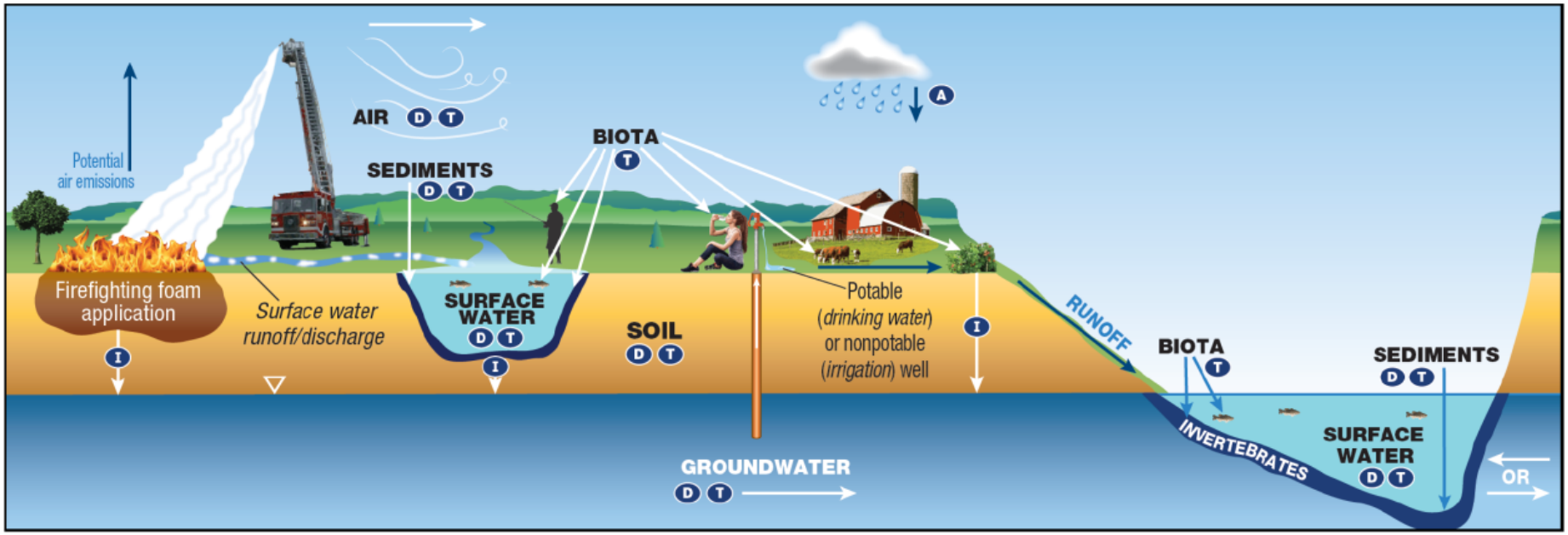
Webinar Agenda

- PFAS in aquatic environments
- Bioaccumulation of PFAS in amphibians
- Effects of PFAS on amphibian growth and development
- Relevance of research to DoD efforts
- Benefits of research to end users

PFAS in Aquatic Environments

Aqueous Fire Fighting Foams (AFFF)

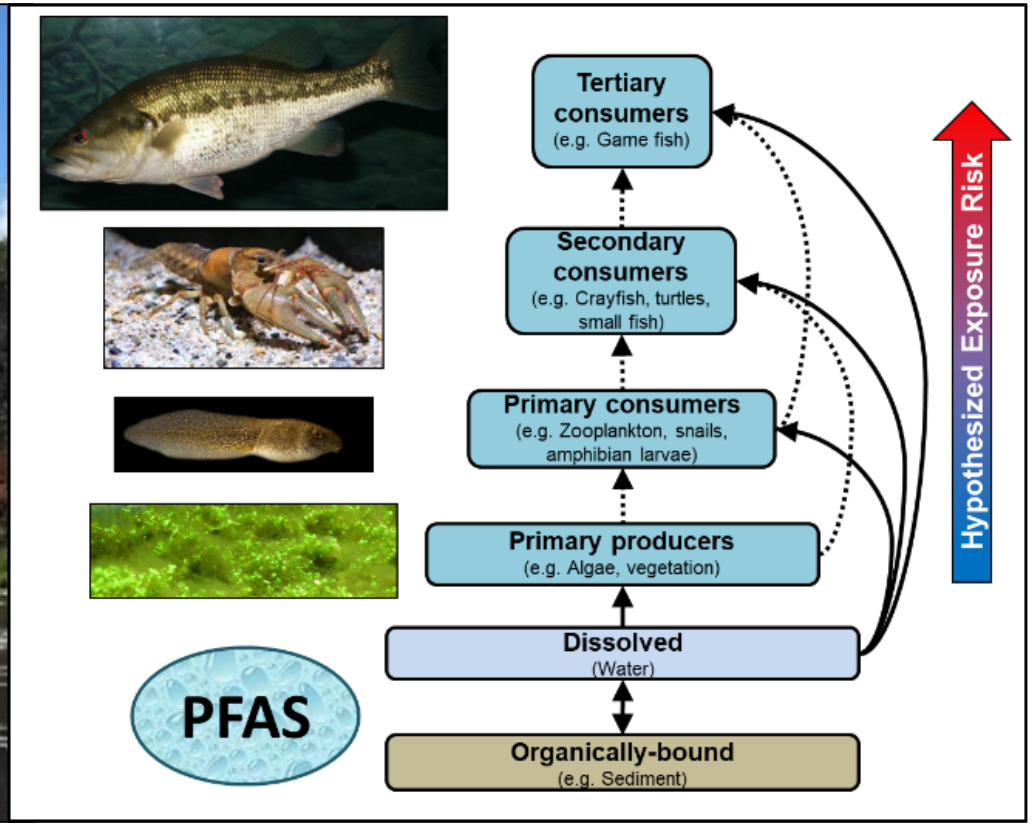


KEY A Atmospheric Deposition D Diffusion/Dispersion/Advection I Infiltration T Transformation of precursors (abiotic/biotic)

Figure 1. Conceptual site model for fire training areas.

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

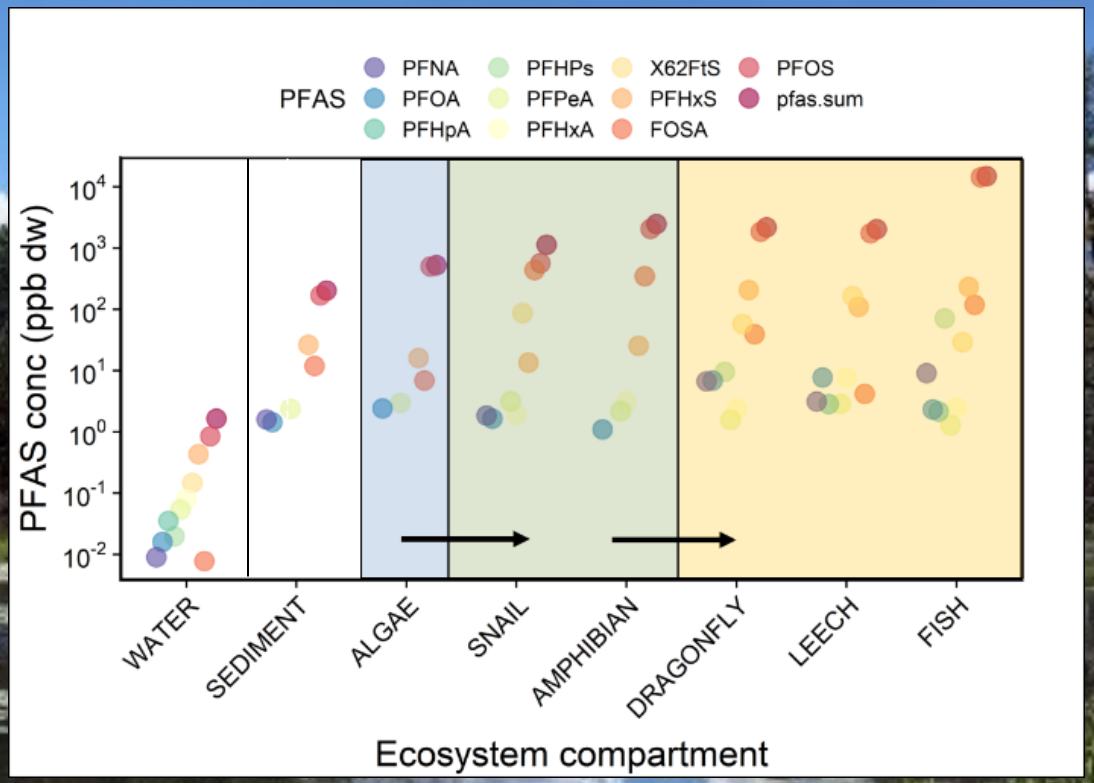
PFAS in Aquatic Environments



PFAS in Aquatic Environments

Clark's Marsh Wildlife Area AFFF-site (Wurtsmith AFB, MI)

- 24 PFAS tested
- 10 PFAS detected consistently in surface water
- 5-7 PFAS accumulating in biota
- Evidence for trophic magnification



Technical Objective

- Develop amphibian toxicity reference values (TRVs) to support ecological risk assessment of PFAS in contaminated Defense Environmental Restoration Program (DERP) sites

Technical Approach

Species

Northern Leopard Frog

Eastern Tiger Salamander

American Toad

PFOA & PFOS (C8)
0,10, 100, 1000 ppb

6:2 FTS & PFHxS (C6)
0,10,100, 1000 ppb

Life Stage

Tadpole

Subadult /Adult

Tadpole

Subadult /Adult

Exposure Source/ Route

Water/Gills, Dermal

Sediment /Dermal

Food/ Oral

Water/Gills, Dermal

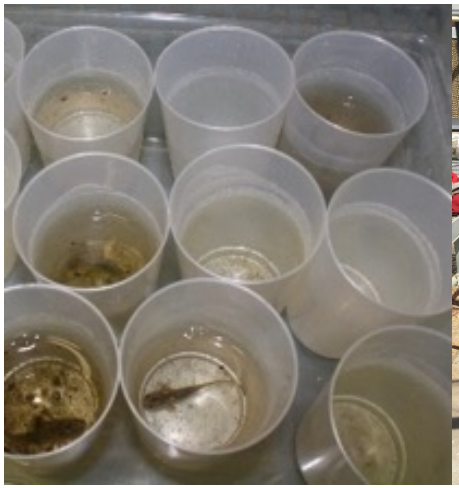
Sediment /Dermal

Food/ Oral

***Note**: FTS = Fluorotelomer sulfonate*

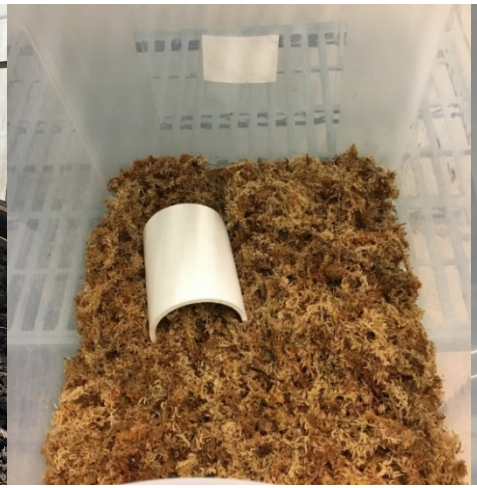
Technical Approach

- Larvae exposed via water and sediment
- Metamorphs (juveniles) exposed dermally and orally



Aqueous exposures

Spiking sediments

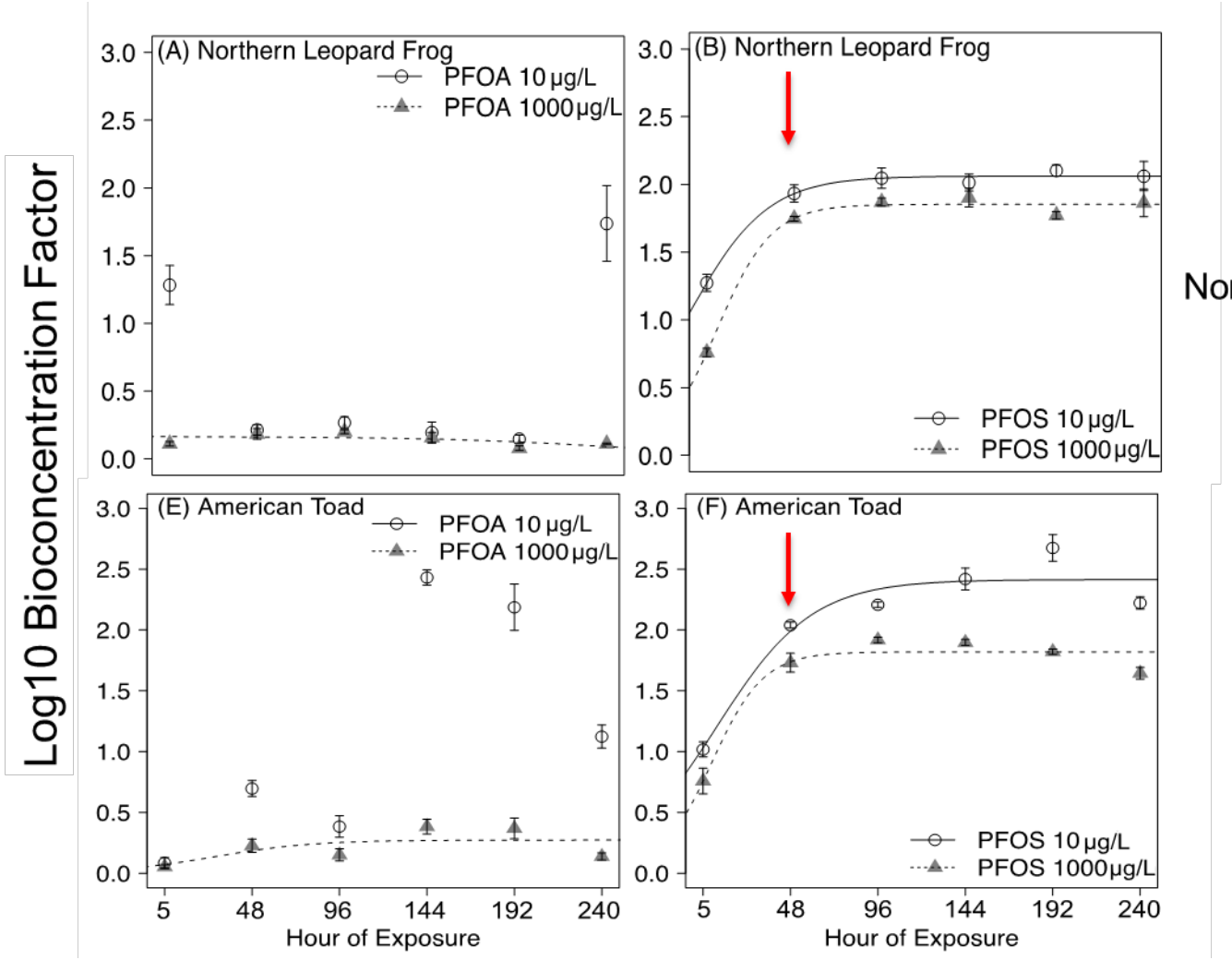


Dermal exposure

Oral exposures

Results

Larvae Rapidly Bioaccumulate PFAS



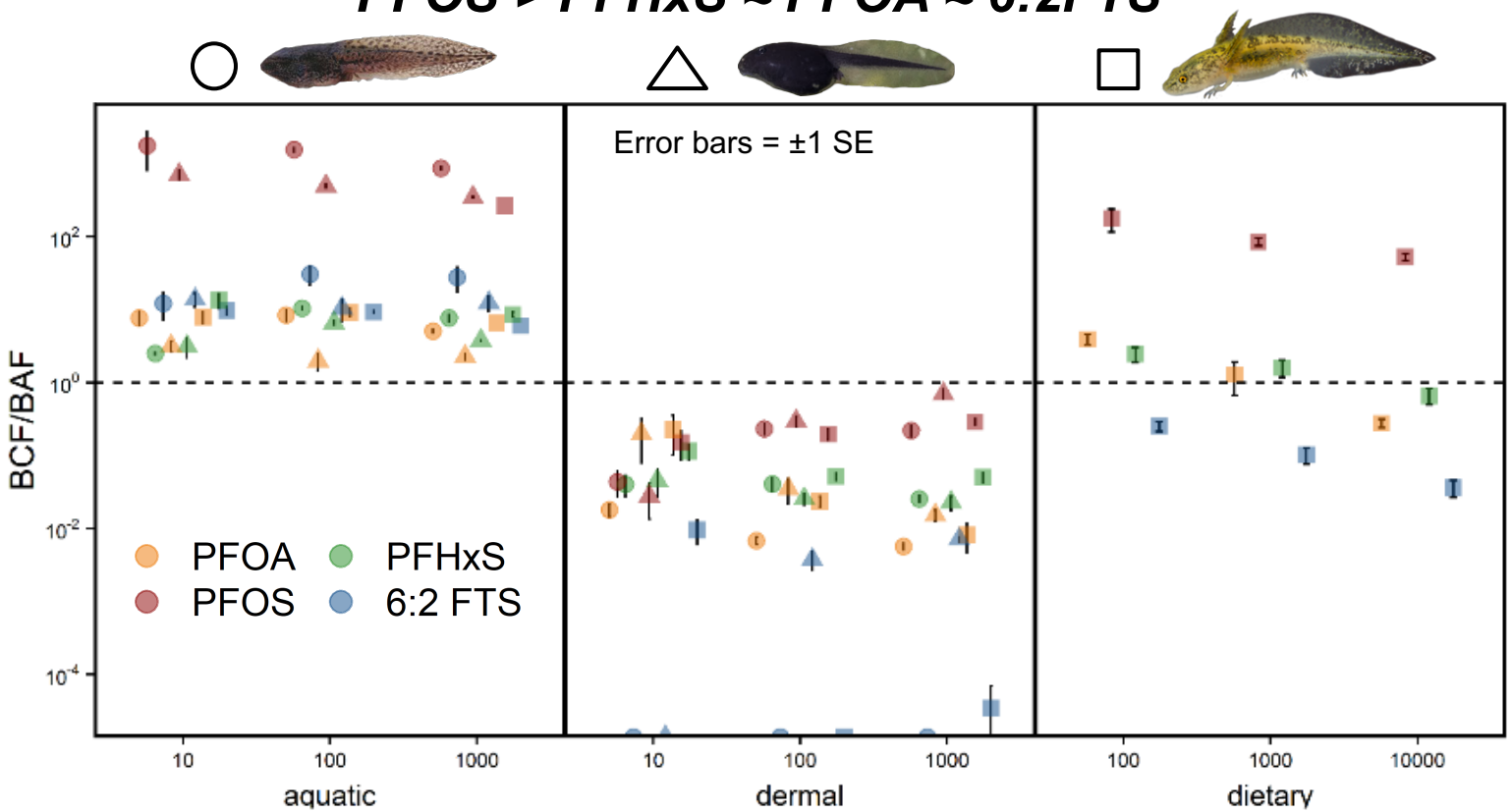
Northern Leopard Frog

American Toad

Results

Larvae Aquatic > Juveniles Dietary > Juveniles Dermal

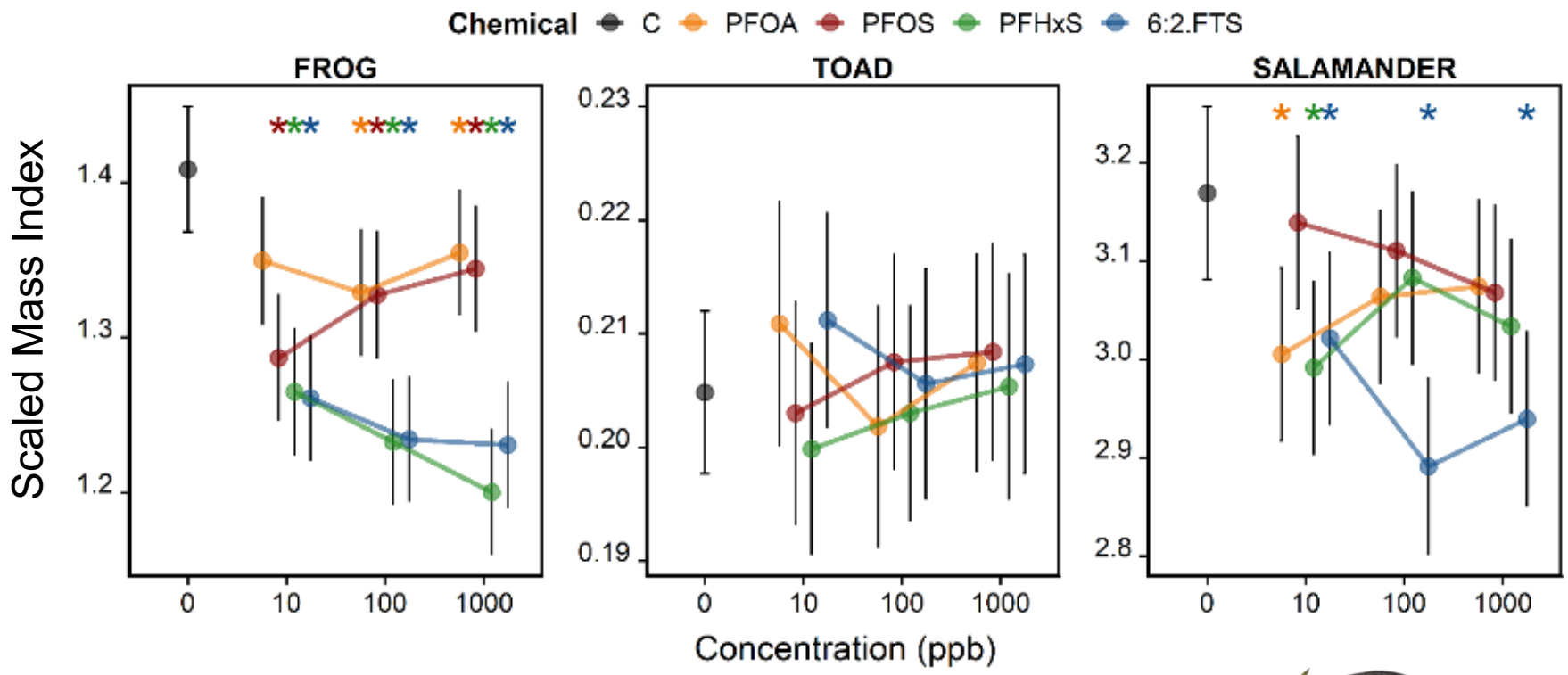
PFOS > PFHxS ≈ PFOA ≈ 6:2FTS



Bioconcentration Factors (BCF) and Bioaccumulation Factors (BAF) vary by species and exposure route

Results

Effects on Body Condition Vary by Species and PFAS



Notes: *Asterisks denote treatments differing significantly from controls; error bars = 95% confidence interval*

Results

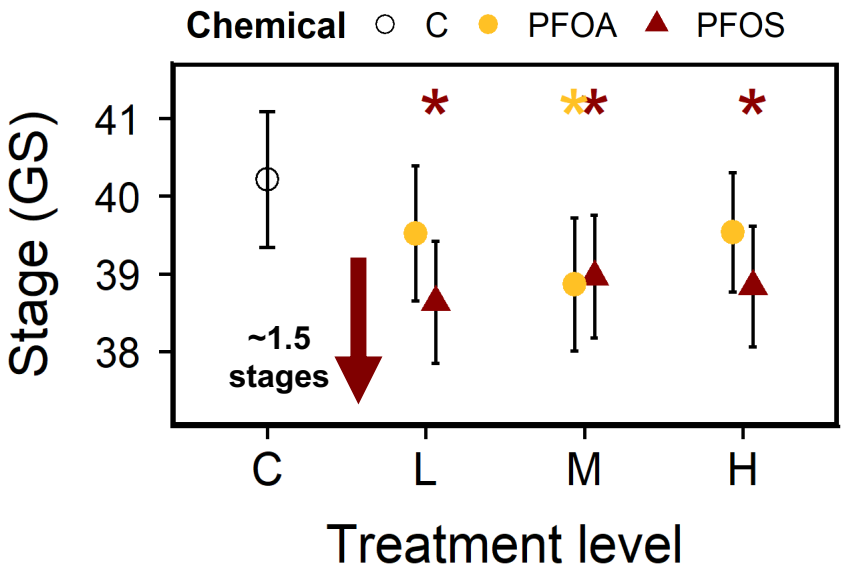
Mesocosm Sediment Exposures

- Sediments spiked with 3 levels of PFOS or PFOA in 180-L outdoor tanks
- Larval leopard frogs exposed for 30 days
- Effects on survival, growth, and development

Results

Mesocosm Sediment Exposures Delay Development

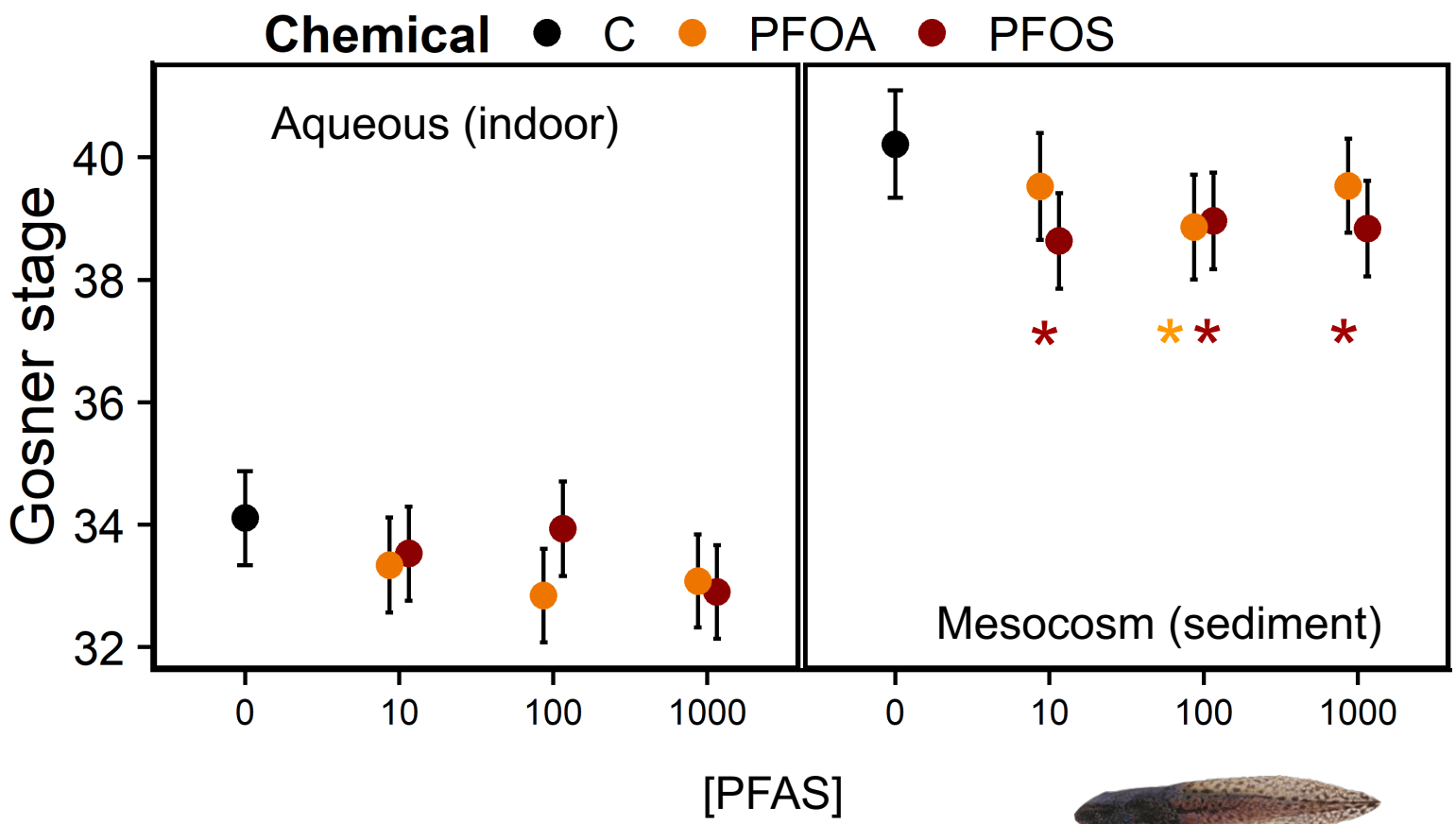
- PFOS
  - Water: 0.06 – 16 µg/L
  - Sediment: 8 – 740 ng/g
  - Tadpoles: 90 – 4,500 ng/g
- PFOA
  - Water: 6 – 8 µg/L
  - Sediment: 14 – 42 ng/g
  - Tadpoles: 161 ng/g



***Notes**: Error bars = 95% confidence interval; GS = Gosner Stage*

Results

Mesocosms >> Effects than Aqueous Indoor Exposures

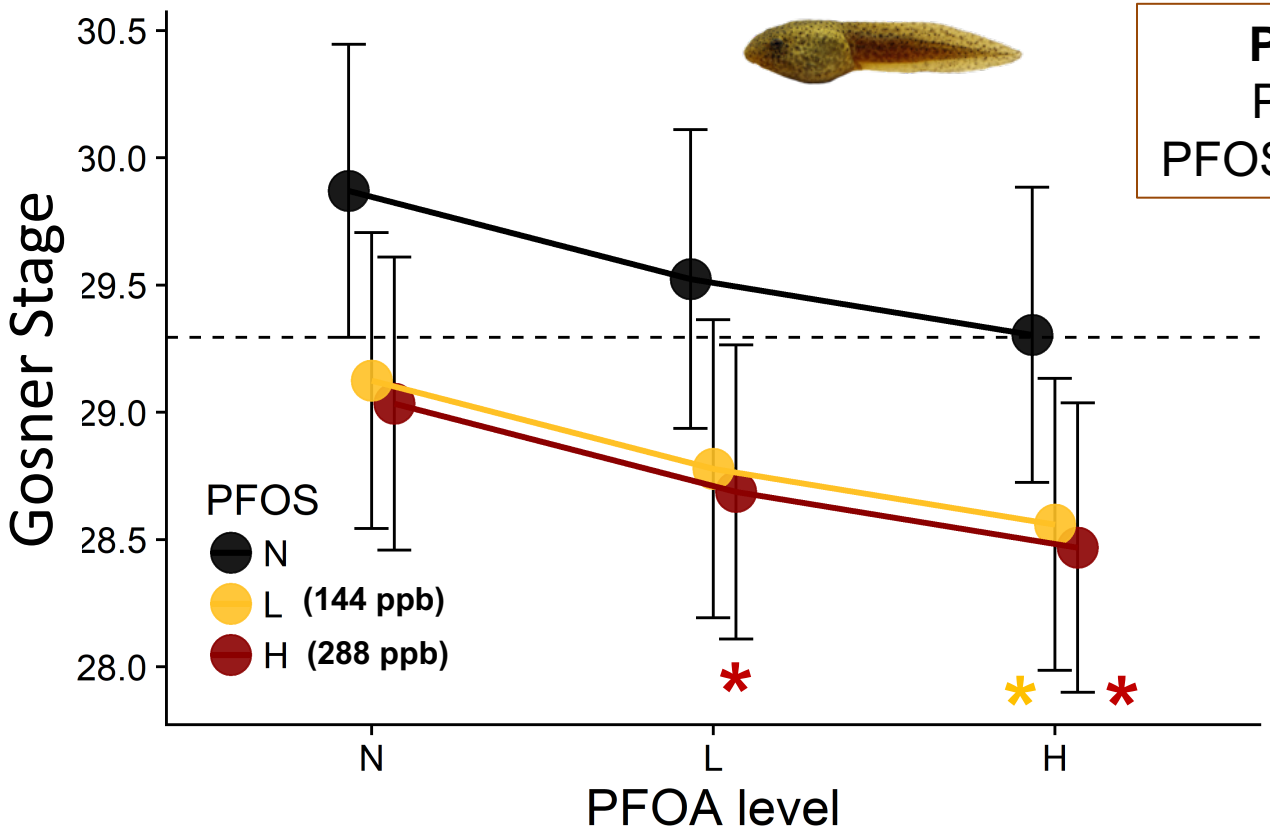


Northern Leopard Frog

***Note**: Error bars = 95% confidence interval*

Results

Effects of PFAS Mixtures are Additive



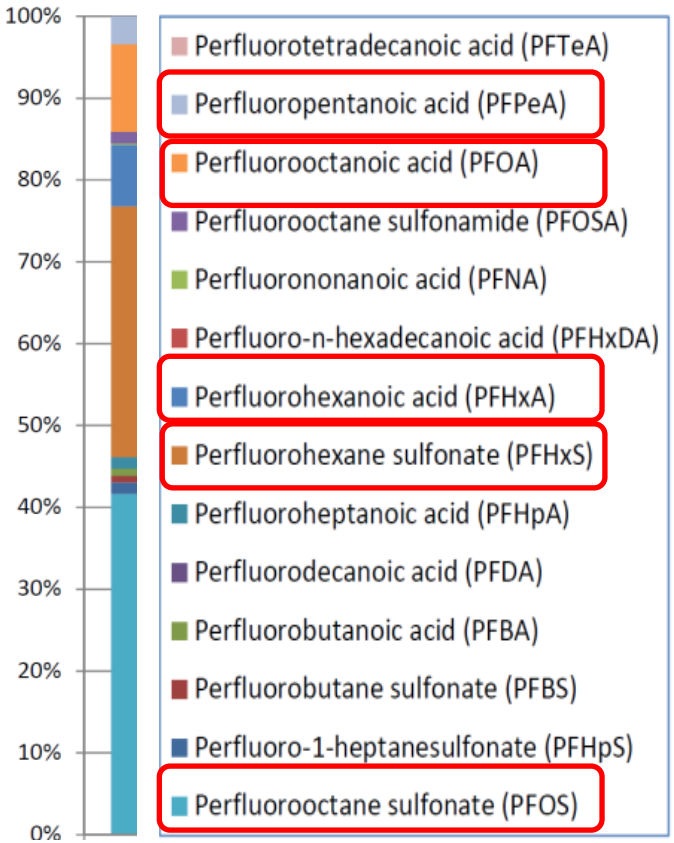
PFOS: *p = 0.01*
PFOA: *p = 0.18*
PFOS x PFOA: *p = 0.85*

***Notes**: Asterisks denote treatments differing significantly from controls. Error bars = 95% confidence interval*

Ongoing Work

Replicating AFFF Mixtures

- Data from AFFF-sites (Clark's Marsh; 10 unknown Air Force Bases (Anderson et al., 2016)
- 5 PFAS comprise ~95% of surface water mixtures at AFFF-sites



Clark's Marsh Water [PFAS]
Michigan DEQ, 2015

Ongoing Work

Replicating AFFF Mixtures

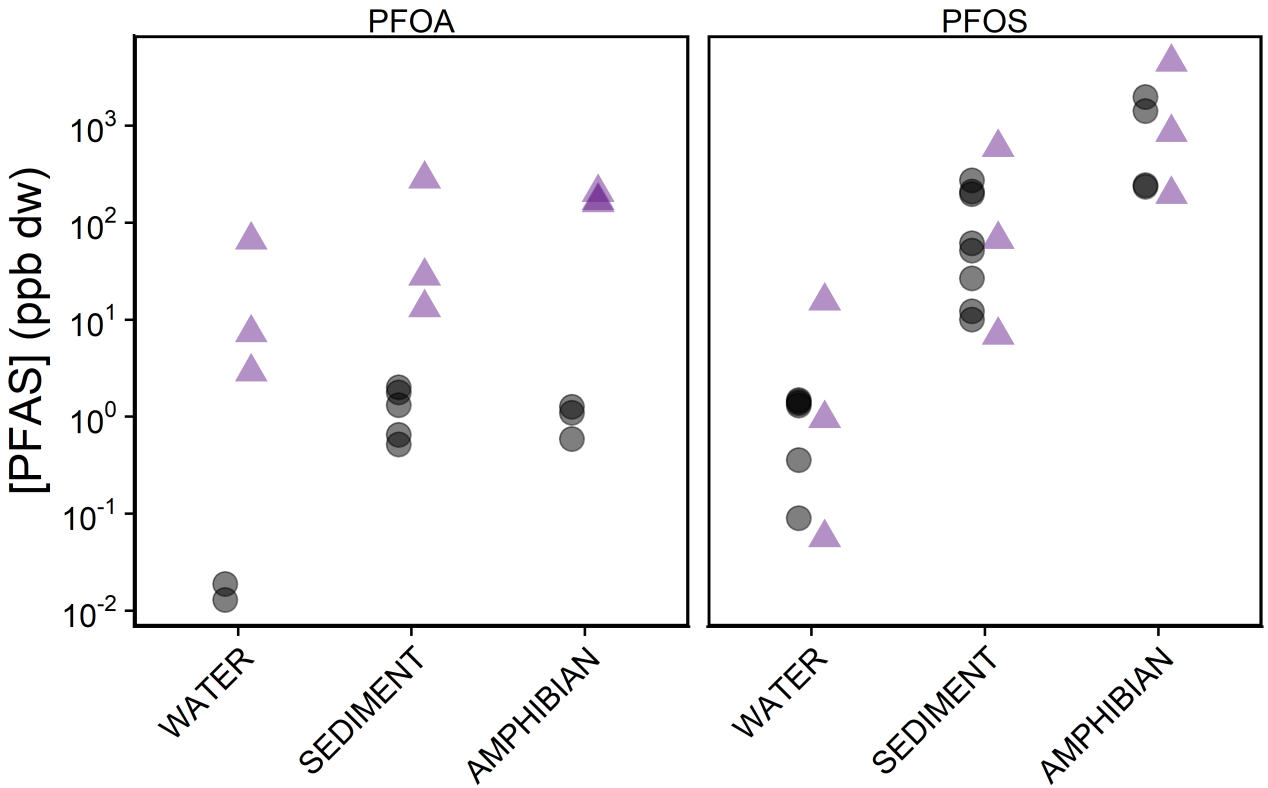
- Conducted 2 experiments with leopard frogs
- Chronic exposures: 120+ days
- Covered complete metamorphosis

Treatment	PFOS	PFHxS	PFOA	PFHxA	PFPeA	∑PFAS
Control	-	-	-	-	-	-
PFOS-L	4	-	-	-	-	4
PFOS-H	10	-	-	-	-	10
MIX + PFOS	4	3	1.25	1.25	0.5	10
MIX-L	-	3	1.25	1.25	0.5	6
MIX-H	-	5	2.1	2.1	0.8	10

All values given in µg/L

Ongoing Work

Our PFAS Doses Compare to an AFFF Site



Technology Transfer

- Digital Environment to Enable Data-driven Science (DEEDS)
  - Four-year NSF grant (PI, Ann Christine Catlin, Professor Computer Sciences, Purdue University)
- Developing easy-to-use, web-based platform to help preserve, use, and share our SERDP data and tools

- https://datacenterhub.org/ecotox

Conclusions

- Rapid bioaccumulation (and depuration) of PFAS by amphibian larvae
- Bioaccumulation highest for PFOS
  - PFHxS, PFOA, and 6:2 FTS do not appear to bioaccumulate significantly
- PFAS are lethal only at high ppm-levels
- Direction of effects on growth and development dependent on species and chemical
- Evidence for effects on body condition (SMI) and development
  - LOEC at lowest dose tested, 10 ppb

Notes: *LOEC = lowest observed effect concentration*

Conclusions (Cont'd)

- Under semi-natural conditions (mesocosms) PFOS delayed development at low aqueous concentrations
  - ~100x lower than previously observed
  - 0.06 vs 10 µg/L
- Binary mixtures of PFOS-PFOA act additively
- Effective simulation of field exposure
- Some AFFF-impacted sites could pose risk to amphibians

Benefits to DoD

- Amphibians are a useful sentinel species for assessing ecosystem health
- Our research will help assess ecological risk of PFAS at DoD AFFF-impacted sites

Acknowledgements

- Jason Hoverman, Ph.D., Department Forestry and Natural Resources, Purdue University
- Linda Lee, Ph.D., Agronomy Department, Purdue University
- Post-docs
  - Wes Flynn and Tyler Hoskins
- Amphibian husbandry and experiments
  - Grace Coogan, Sam Guffey, Matthew Hamilton, Michael Iaccheta, Brian Tornabene
- Chemical analyses
  - Chloe De Perre
- Ph.D. students
  - Gary Hoover, Edgar Perez, Allison Scott
- MS students
  - Sarah Abercrombie, Evelyn Barragan, Melissa Lech, Ashley Newton
- Quality assurance
  - Laurel Branstator

For additional information, please visit

https://serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/Emerging-Issues/ER-2626

Speaker Contact Information

mssepulv@purdue.edu; 765-496 3428

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Q&A Session 1

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Guidance for Assessing the Ecological Risks of Threatened and Endangered Species at AFFF-Impacted Sites

Jason Conder, Ph.D.
Geosyntec Consultants

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Outline

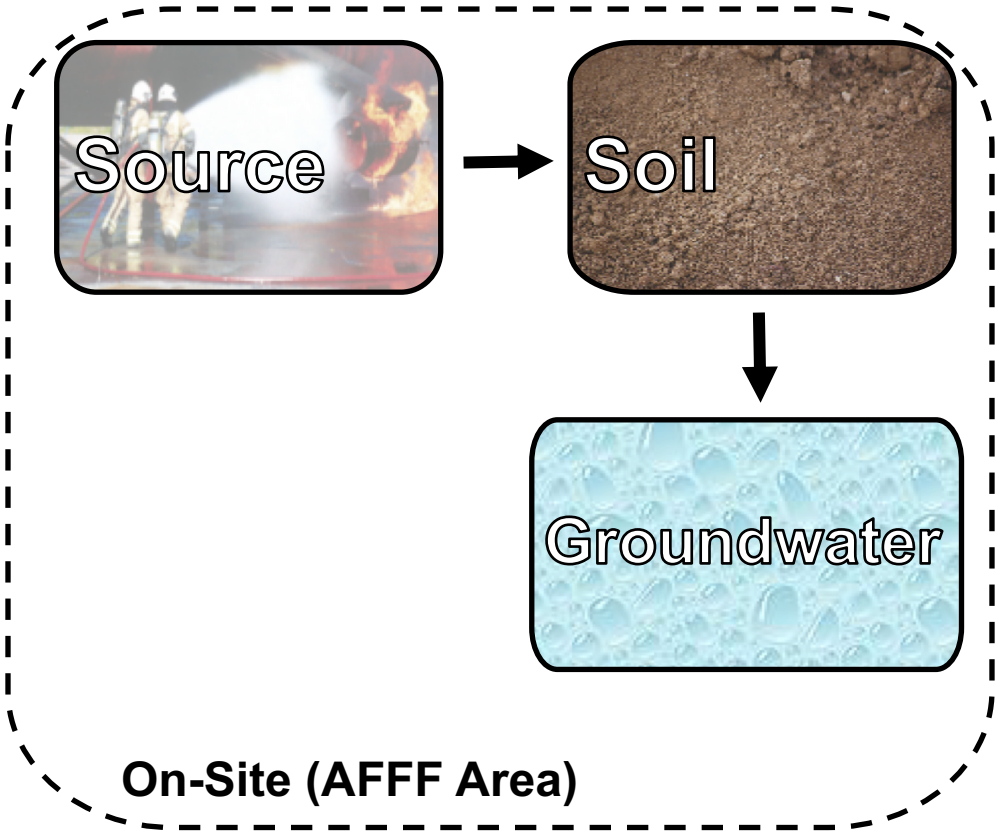
- Overview of ecological risks to PFAS at Aqueous Film Forming Foam sites
- Technical objectives and benefits of our guidance on PFAS ecological risk
- High-level overview of the guidance

AFFF

- AFFF = Aqueous Film Forming Foam
  - Complex, proprietary mixtures of fluorinated and hydrocarbon surfactants, water, corrosion inhibitors, solvent
  - ~1-10% PFAS by weight, 10s to 1000s of liters per use

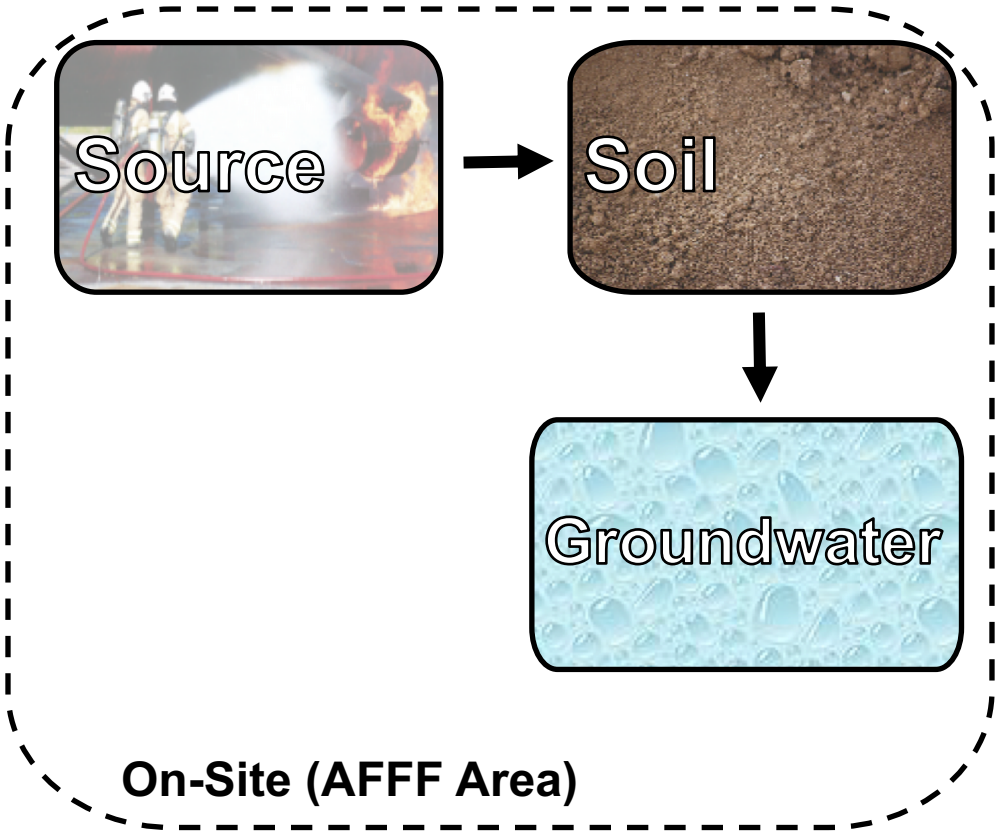
- Hundreds to thousands of sites, some resulting in potential PFAS exposure to ecological receptors
  - Ecorisk driving decision making at sites in U.S., Australia, etc.

AFFF and Ecological Resources

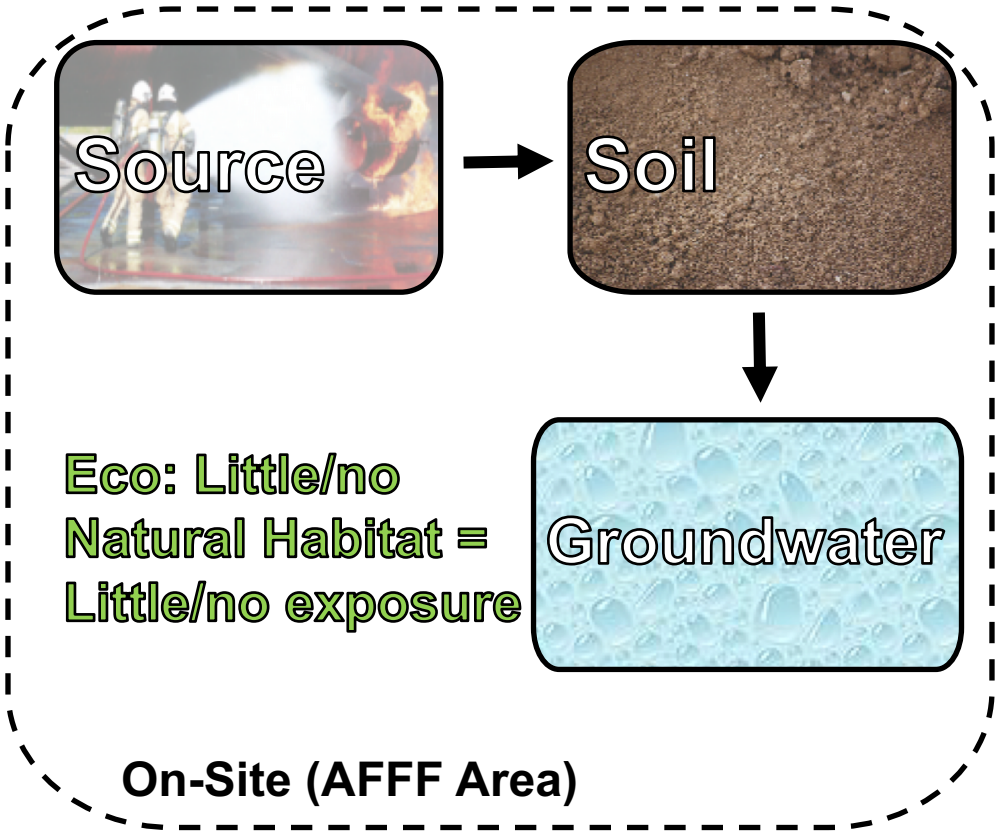


- Wide range of behaviors
  - Some PFAS can sorb to soil and aquatic sediment
  - Some PFAS are more water soluble

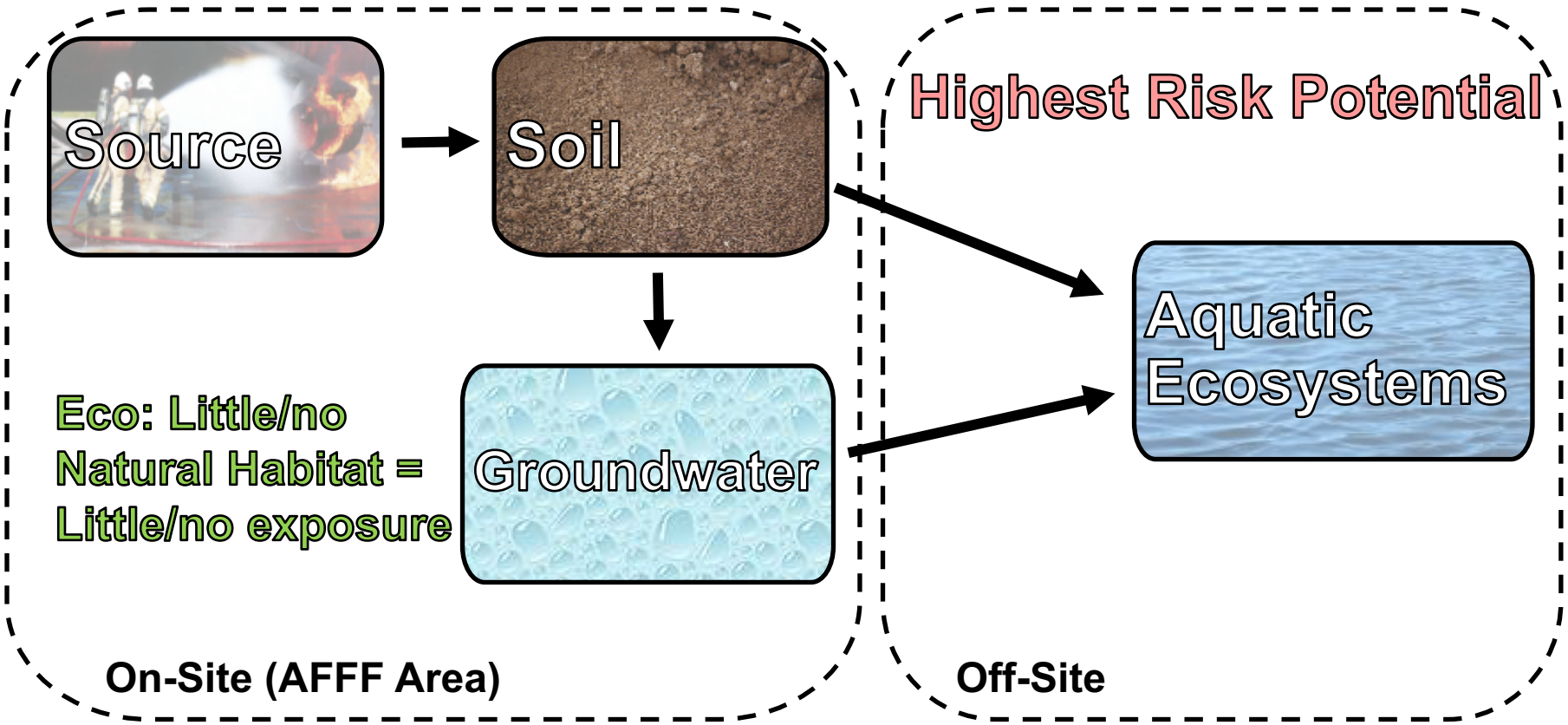
AFFF and Ecological Resources



AFFF and Ecological Resources



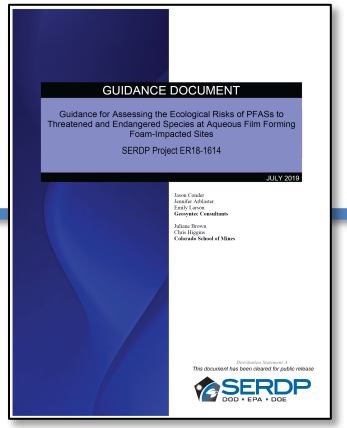
AFFF and Ecological Resources



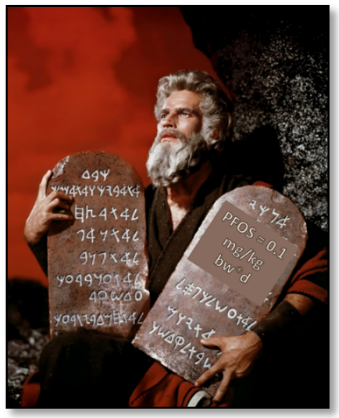
Technical Objective

- Strategic overview of state-of-the-practice for the ecological risk assessment (ERA) at AFFF sites (Threatened and Endangered [T&E] species focus, per SERDP Statement of Need ERSON-18-L2, 2017)
  - Guidance for quantitatively assessing and managing ecological risks, targeting ecological risk assessors
  - Current best approach for ecological risk assessments?

Another Review/Catalogue of Research Papers



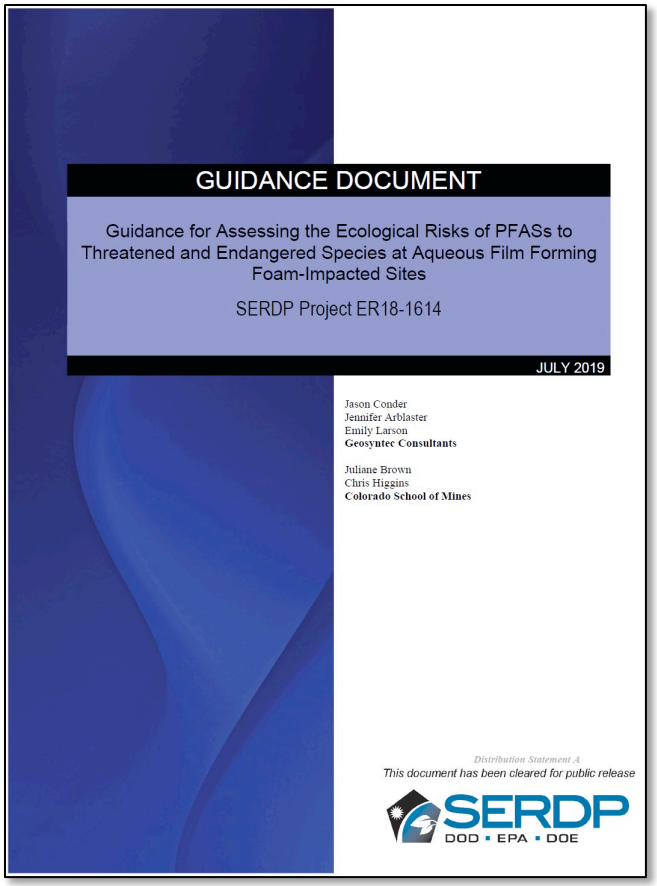
Our Project: Current Best Practices Guidance



***Ten Commandments of* PFAS Ecorisk**

Guidance by the Numbers

- Guidance
  - 60-page main guidance text with 9 tables and 10 figures
  - 5 appendices (62 pages total)
- Recommended values for use in ERAs for 18 target PFAS
  - 82 bioaccumulation values for predicting uptake by aquatic biota
  - 35 bioaccumulation values for predicting uptake by terrestrial biota
  - 23 wildlife Toxicity Reference Values (TRVs)
  - 6 aquatic life criteria
  - 4 plant/invertebrate soil criteria
- Based on a comprehensive and thorough review
  - Over 250 studies reviewed
  - Over 200 toxicity values and over 1300 bioaccumulation values considered


GUIDANCE DOCUMENT

Guidance for Assessing the Ecological Risks of PFASs to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites

SERDP Project ER18-1614

JULY 2019

Jason Conder
Jennifer Arblaster
Emily Larson
Geosyntec Consultants

Juliane Brown
Chris Higgins
Colorado School of Mines

Distribution Statement A
This document has been cleared for public release

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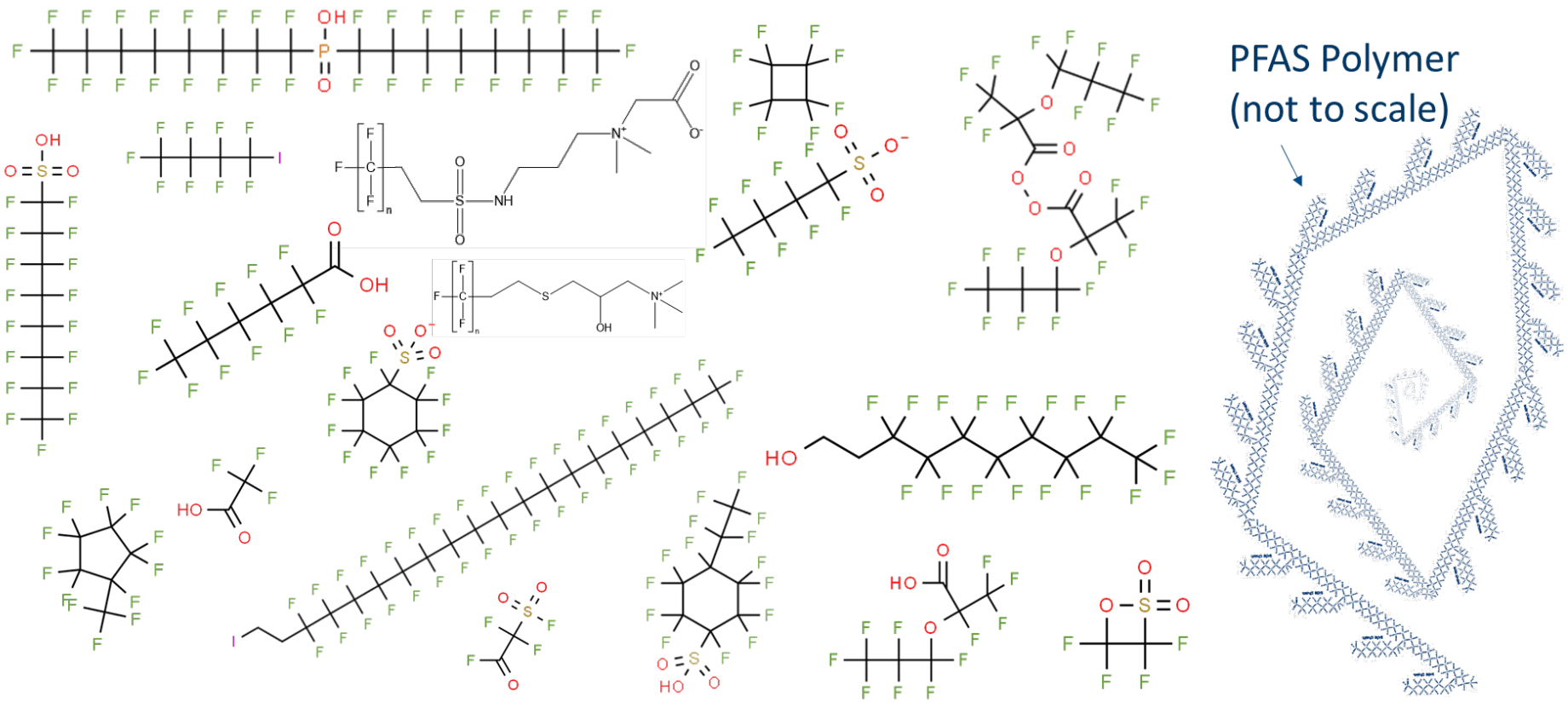
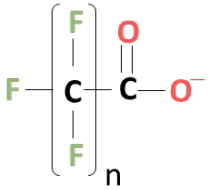
Which PFAS?

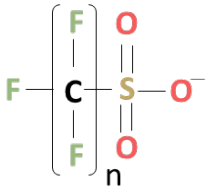


18 Target PFAS in the Guidance

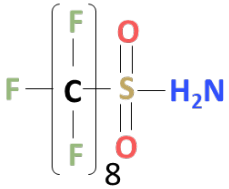
- 18 PFAS
  - Perfluoroalkyl carboxylic acids (PFCAs) (11)
    - e.g., PFOA
  - Perfluoroalkyl sulfonic acids (PFSAs) (4)
    - e.g., PFOS
  - PFAS precursors
    - PFOSA
    - N-EtFOSAA
    - N-MeFOSAA
- Based on
  - Method 537.1
  - EPA UCMR3
  - ATSDR Toxicological Profile
  - PFAS with state guidance/standards
  - General data availability



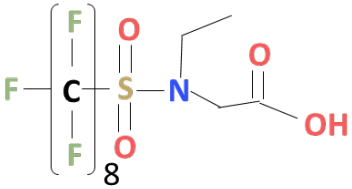
Perfluoroalkyl Carboxylates (n = 3-13)



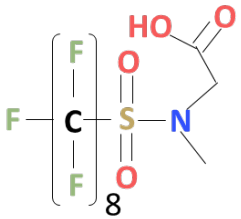
Perfluoroalkyl Sulfonates (n = 4, 6, 8, 10)



Perfluorooctane sulfonamide (PFOSA)



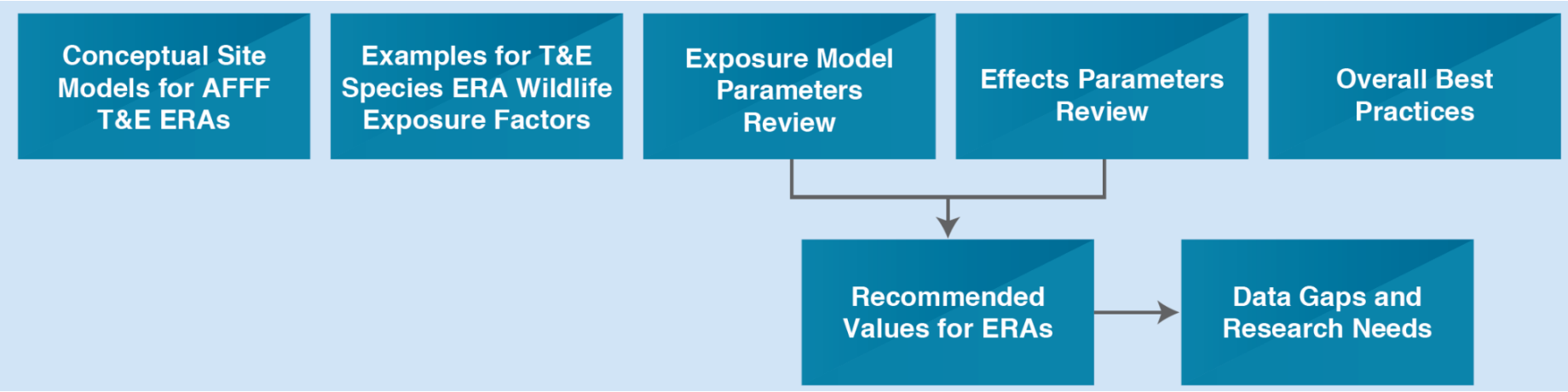
2-(N-Ethyl perfluorooctane sulfonamido) acetic acid (N-EtFOSAA)



2-(N-Methyl perfluorooctane sulfonamido) acetic acid (N-MeFOSAA)

Notes: *ASTDR = Agency for Toxic Substances and Disease Registry, UCMR = Unregulated Contaminant; Monitoring Rule*

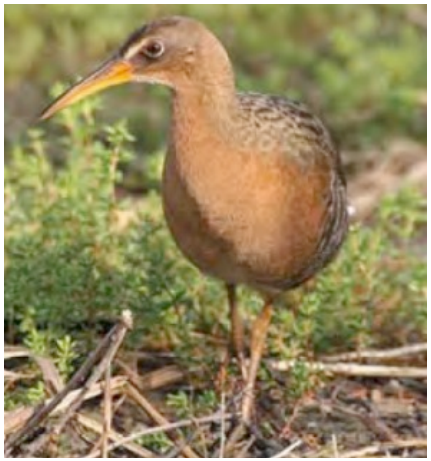
Guidance Organization



T&E Species Focus

- SERDP need specifically intended a focus on T&E species ecorisk
- Portion of guidance provides example exposure factors (and sources of info) for T&E species
- Guidance is broadly applicable for ecological risk assessment with common species

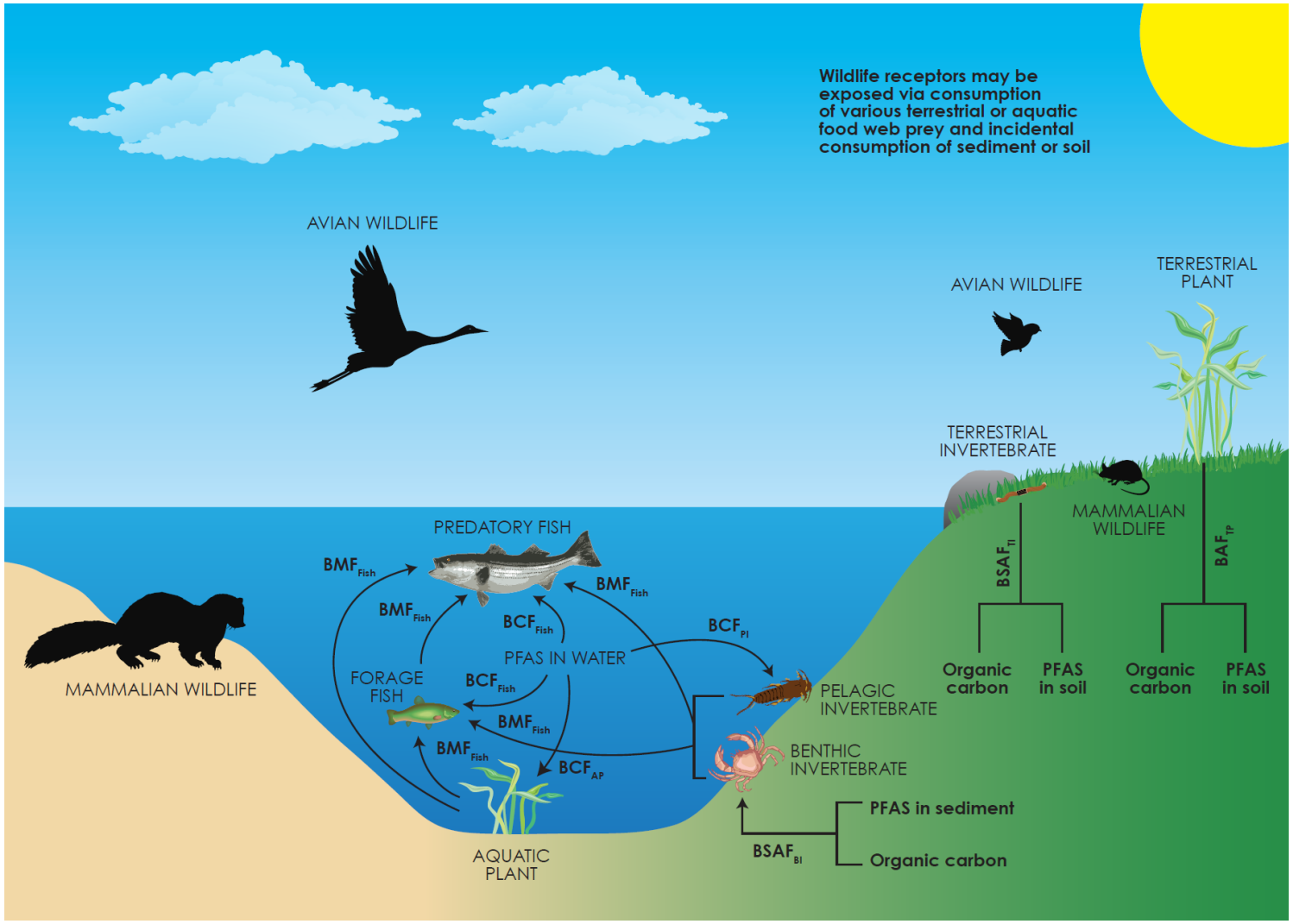
Buena Vista Lake Ornate Shrew (*Sorex ornatus relictus*)



California clapper rail (*Rallus obsoletus)*

Western Pocket Gopher (*Thomomys mazama*)

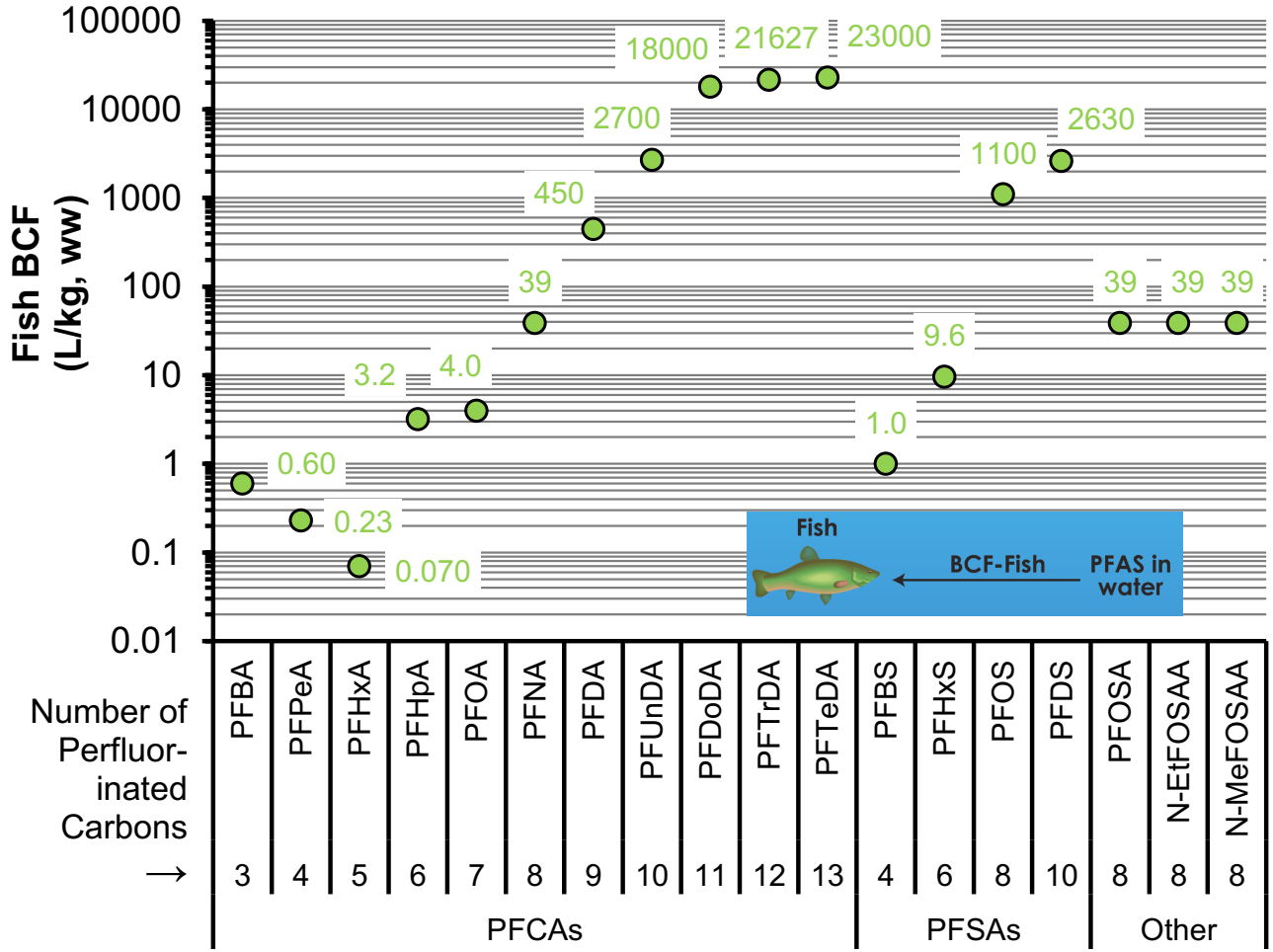
Conceptual Site Model



Exposure

- How can we predict accumulation of PFAS in the food web (diet items for wildlife)?
- Bibliography of studies reviewed
- Process for selection of recommended values
- Tables and figures to present recommended values for bioaccumulation modeling
  - Bioconcentration factors
    - Water to pelagic invertebrate
    - Water to aquatic plant
    - Water to fish tissue
  - Bioaccumulation factors
    - Sediment to benthic invertebrate (Biota-sediment)
    - Soil to terrestrial invertebrate (Biota-soil)
    - Soil to terrestrial plant
  - Diet to fish tissue biomagnification factors

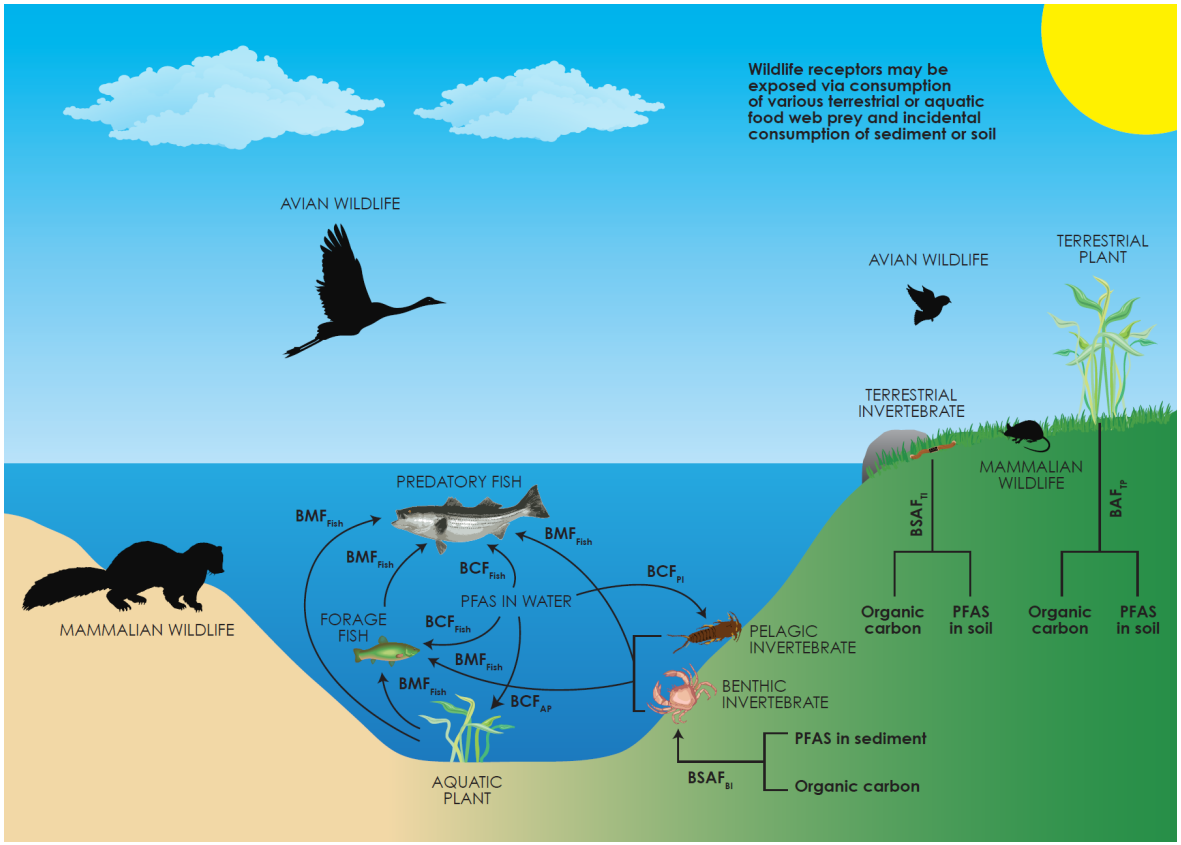
Example: Bioconcentration in Fish



Log-linear relationships between perfluorinated chain length and BCFs

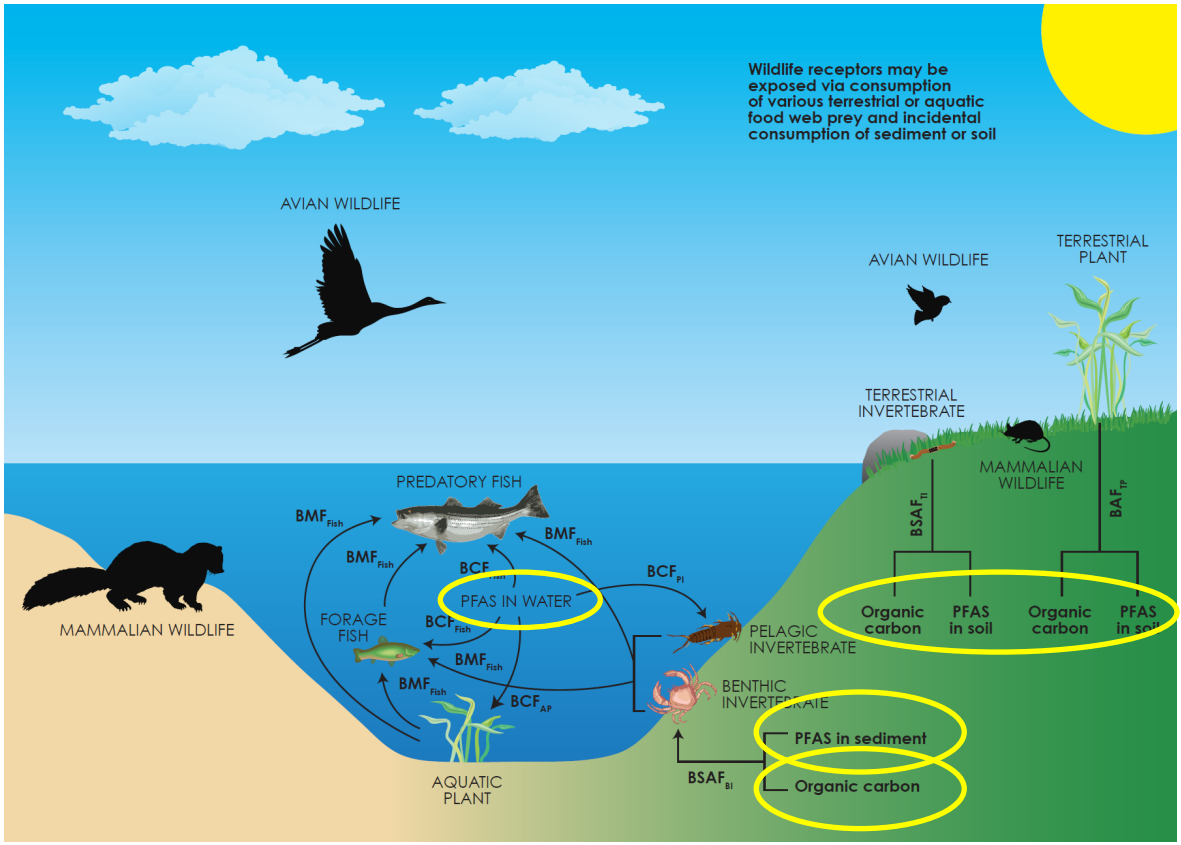
Bioaccumulation Model Framework

- Models and parameters to predict PFAS in food web components using measured concentrations of PFAS in soil, sediment, and water



Bioaccumulation Model Framework

- Models and parameters to predict PFAS in food web components using measured concentrations of PFAS in soil, sediment, and water

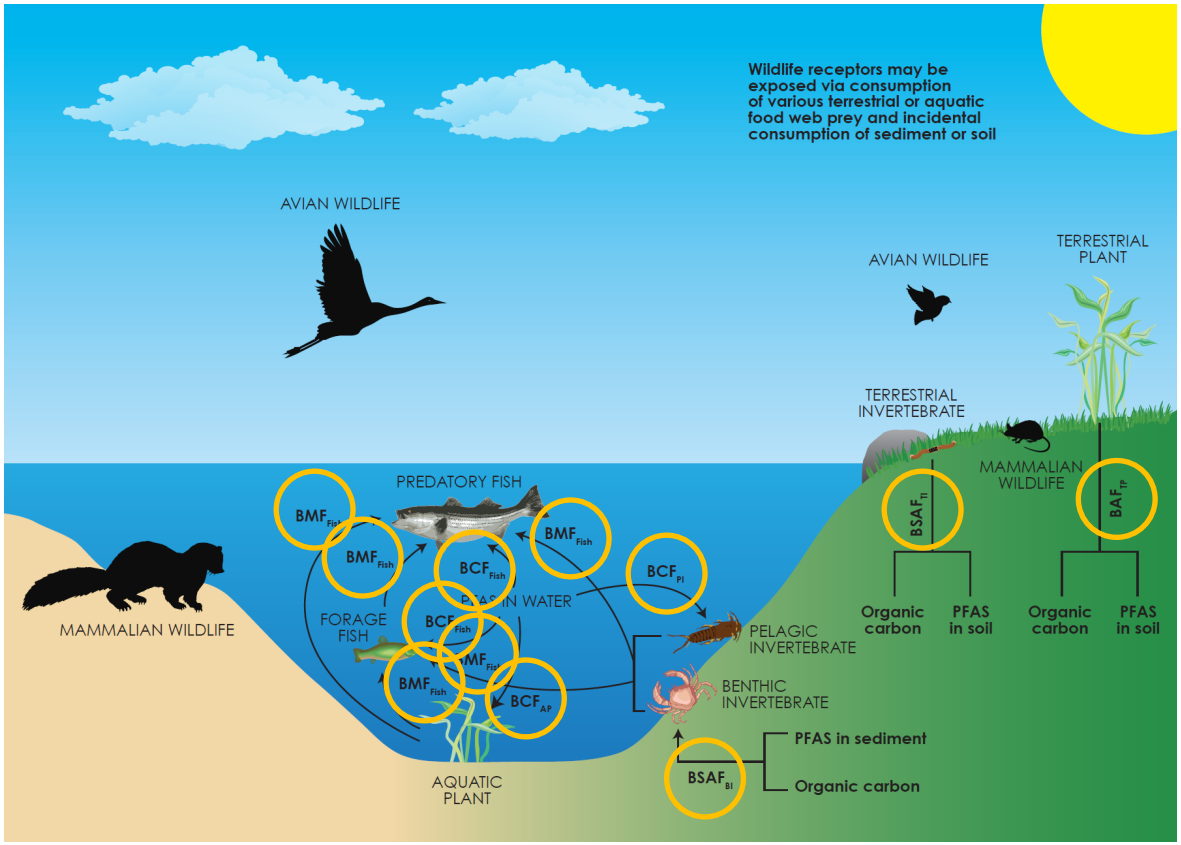


Inputs (provided by the model user)

- Concentrations of PFAS in soil, sediment, and/or water (plus organic carbon contents of soil and sediment)

Bioaccumulation Model Framework

- Models and parameters to predict PFAS in food web components using measured concentrations of PFAS in soil, sediment, and water

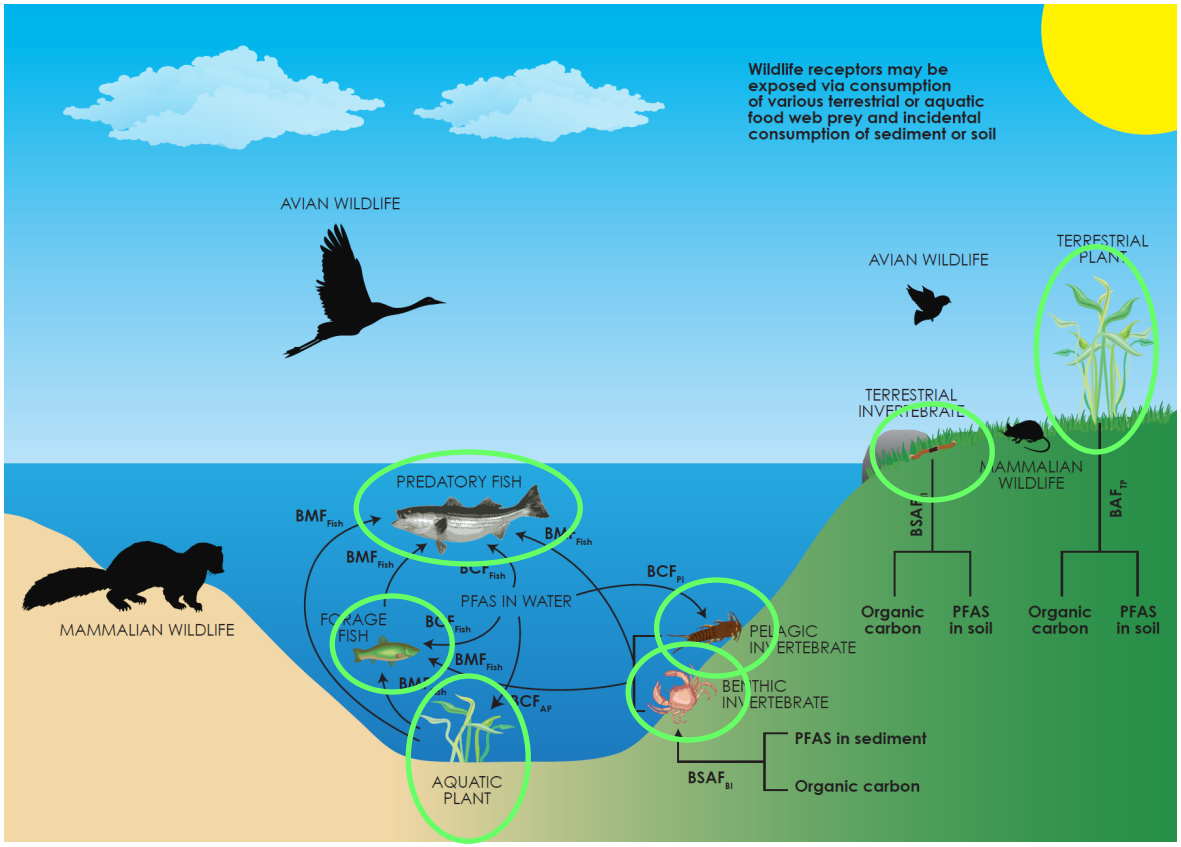


Model parameters (provided by the guidance)

- Uptake factors (bioaccumulation metrics) to predict concentrations in biota

Bioaccumulation Model Framework

- Models and parameters to predict PFAS in food web components using measured concentrations of PFAS in soil, sediment, and water

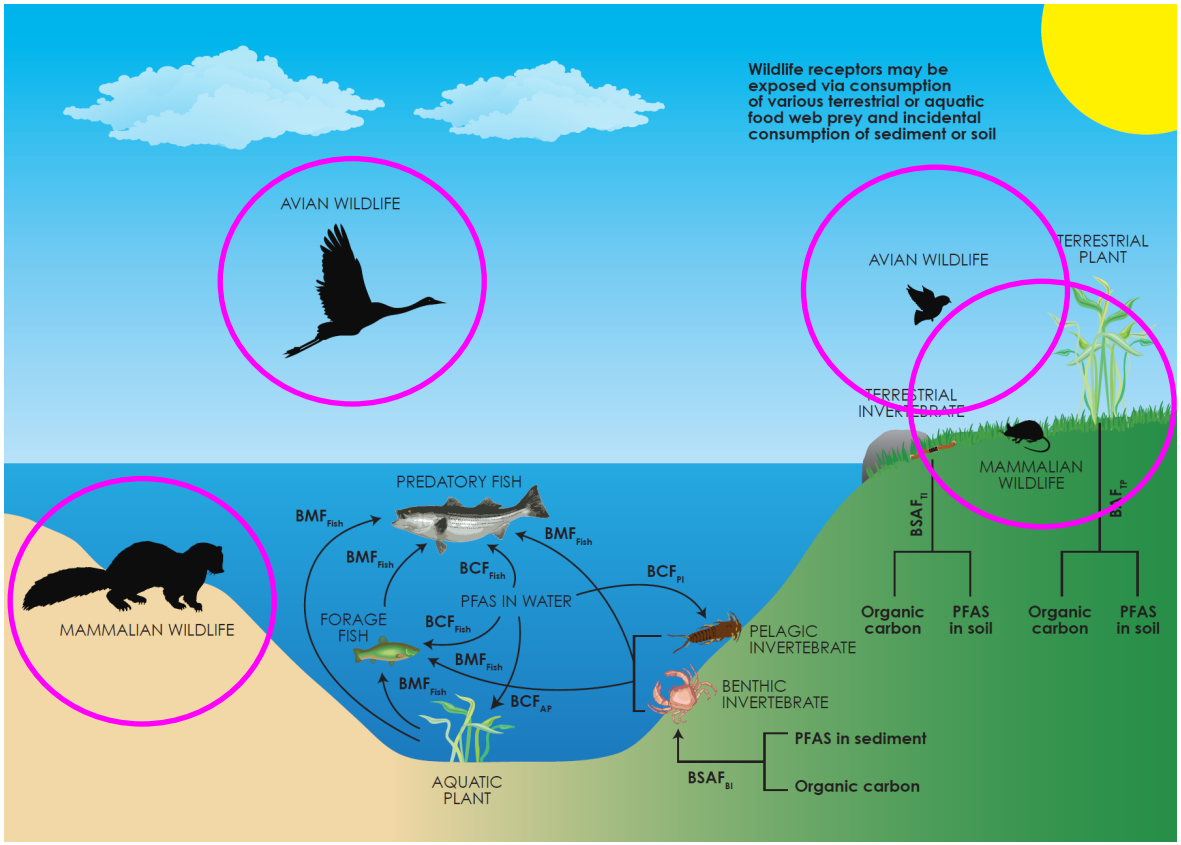


Predicted concentrations in biota (wildlife diet items)

- Calculated with model parameters and input values

Bioaccumulation Model Framework

- Models and parameters to predict PFAS in food web components using measured concentrations of PFAS in soil, sediment, and water



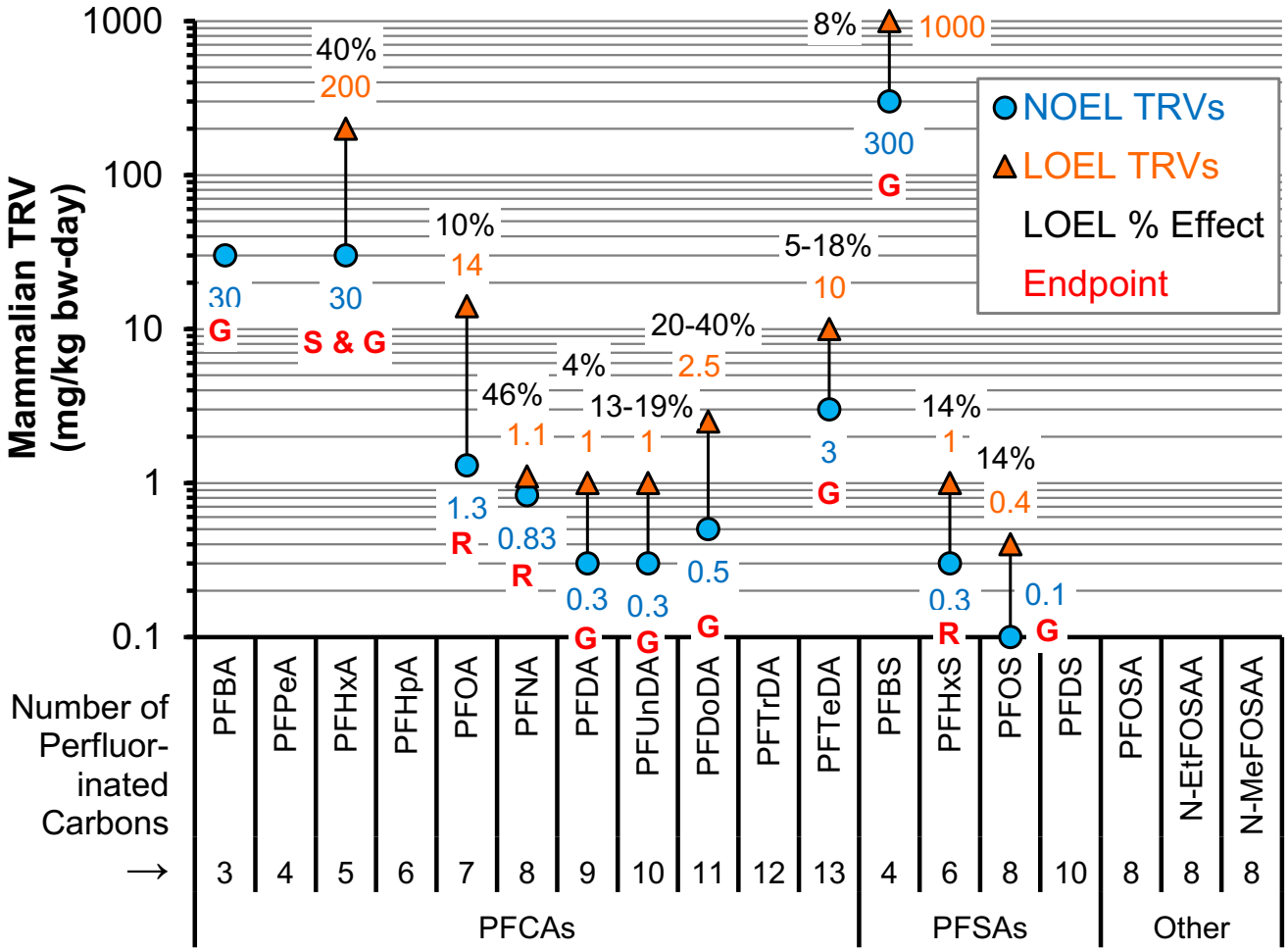
Predicted dietary exposures of wildlife

- Calculated with predicted concentrations in biota and wildlife exposure factors

Effects

- How can we characterize the likelihood of adverse effects from site-specific PFAS exposures?
- Bibliography of studies
- Process for selection of recommended values, with 10-point scoring system for wildlife Toxicity Reference Values (TRVs)
- Tables and figures to present recommended values for:
  - Mammalian TRVs
  - Avian TRVs
  - Aquatic life criteria (marine and freshwater), developed via EPA Species Sensitivity Distribution (SSD) approach
  - Criteria for soil invertebrates and terrestrial plants

Example: Effects in Mammals



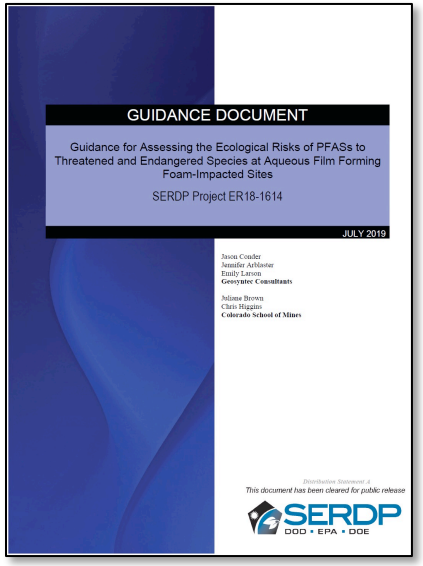
Longest PFCAs and PFSAs most toxic

Ecological Risk Assessment Recommendations

- Selection of representative wildlife species and sources of information on species exposure factors
- Data needs and investigation approaches
  - Environmental samples for PFAS analysis
  - Recommendations for a phased approach for ERA investigation: Evaluation abiotic samples, modeling, then tissue samples and ecological studies
- Characterizing risks
  - When more than one PFAS is detected
  - PFAS precursors/PFAS that are unable to be measured by current commercially-available techniques

Ecological Risk Assessment Model Tool

- Enables ecological risk assessors to enter site-specific data (e.g., concentrations of PFAS in sediment, soil, water, and/or biota) and predict concentrations in the food web, exposures, and risks
- Customizable, multi-worksheet ExcelTM tool (with user's manual)



GUIDANCE DOCUMENT

Guidance for Assessing the Ecological Risks of PFASs to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites

SERDP Project ER18-1614

JULY 2019

Jason Conder
Jennifer Arblaster
Emily Larsen
Geosyntec Consultants

Jaime Brown
Chris Higgins
Colorado School of Mines

Distribution Statement A
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Parameter	Parameter Definition		Units	Fish		Birds			Mammals		
				Forage Fish [3]	Predatory Fish [4]	Avian Consumer (Herbivore)	Avian Consumer (Omnivore / Invertivore)	Avian Consumer (Piscivore)	Mammalian Consumer (Herbivore)	Mammalian Consumer (Omnivore / Invertivore)	Mammalian Consumer (Piscivore)
				Bluegill	**Largemouth Bass**	**Wood Duck**	**Spotted sandpiper**	**Osprey**	**Muskrat**	**Southern Sea Otter**	**Steller sea lion**
				Lepomis macrochirus	*Micropterus salmoides*	*Aix sponsa*	*Actitis macularius*	*Pandion haliaetus*	*Ondatra zibethicus*	*Enhydra lutris*	*Eumetopias jubatus*
BW	Body Weight		kg	--	--	0.70	0.04	1.60	1.20	35.00	263.00
FIR_{dw}	Daily Food Ingestion Rate (dry matter)	[1]	kg, dw/day	--	--	0.04	0.01	0.08	0.10	2.19	3.95
FIR_{ww}	Daily Food Ingestion Rate (wet matter)	[2]	kg, ww/day	--	--	0.13	0.02	0.34	0.41	8.75	15.78
P_{veg}	Proportion of Diet - Vegetation		kg diet item, ww/kg diet, ww	0.33	0.00	1.00	-	-	0.80	-	-
P_{bi}	Proportion of Diet - Benthic Invertebrates		kg diet item, ww/kg diet, ww	0.33	0.30	-	1.00	-	0.10	0.80	-
P_{pi}	Proportion of Diet - Pelagic Invertebrates		kg diet item, ww/kg diet, ww	0.33	0.00	-	-	-	0.10	0.00	0.20
P_{ff}	Proportion of Diet - Forage Fish		kg diet item, ww/kg diet, ww	NA	0.70	-	-	-	-	0.10	-
P_{pf}	Proportion of Diet - Predatory Fish		kg diet item, ww/kg diet, ww	NA	NA	-	-	1.00	-	0.10	0.80
P_{so}	Proportion of Diet - Sediment		kg sediment, dw/kg diet, dw	NA	NA	0.11	0.07	-	0.02	-	-
DWI	Daily Water Ingestion		L/day	NA	NA	0.04	0.05	0.08	0.88	2.87	16.83
HR	Home Range		acres	1.80	8.50	274.00	8.40	2500.00	0.32	4700.00	8645.00
AUF	Area Use Factor	[5]	proportion	1.000	1.000	0.036	1.000	0.004	1.000	0.002	0.001

Analyte	RB	Sediment		Surface Water		Aquatic Vegetation		Pelagic Invertebrate		Benthic Invertebrate		Forage Fish [5]		Predatory Fish [5]		TDI_{total} [2]	TDI_{total} [2]	Low TRV	High TRV	Low-TRV HQ [2]	High-TRV HQ [2]	TDI and HQ Note [6]
		EPC	TDI_s	EPC	TDI_{sw}	EPC	TDI_{veg}	EPC	TDI_p	EPC	TDI_b	EPC	TDI_f	EPC	TDI_d							
		ng/kg dw	ng/kg-day	ng/L	ng/kg-day	ng/kg ww	ng/kg-day	ng/kg ww	ng/kg-day	ng/kg ww	ng/kg-day	ng/kg ww	ng/kg-day	ng/kg ww	ng/kg-day	ng/kg-day	mg/kg-day	mg/kg-day	mg/kg-day	unitless	unitless	
PFCAs																						
PFBA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	2.6E+02	--	2.5E+02	--	1.7E+02	9.2E+01	7.5E+00	--	6.4E+00	--	1.2E+02	1.2E-04	No TRV	No TRV	--	--	
PFPeA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	2.6E+02	--	3.5E+02	--	8.1E+02	4.4E+02	7.5E+00	--	5.0E+00	--	4.8E+02	4.6E-04	No TRV	No TRV	--	--	
PFHxA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	1.0E+02	--	1.0E+02	--	1.0E+03	5.4E+02	1.5E+01	--	1.3E+01	--	5.7E+02	5.7E-04	No TRV	No TRV	--	--	
PFHpA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	2.5E+02	--	6.9E+02	--	1.8E+04	9.7E+03	2.3E+02	--	2.0E+02	--	9.8E+03	9.8E-03	No TRV	No TRV	--	--	
PFOA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	1.0E+02	--	1.0E+03	--	1.0E+05	5.4E+04	1.3E+03	--	1.2E+03	--	5.4E+04	5.4E-02	1.0E+00	No TRV	5.4E-02	--	
PFNA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	5.8E+02	--	1.5E+03	--	1.6E+05	8.6E+04	1.3E+04	--	1.3E+04	--	8.6E+04	8.6E-02	No TRV	No TRV	--	--	
PFDA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	1.1E+03	--	1.8E+03	--	1.0E+05	5.5E+04	1.3E+04	--	1.4E+04	--	5.5E+04	5.5E-02	1.0E+00	No TRV	5.5E-02	--	
PFUnDA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	3.1E+03	--	2.7E+03	--	6.2E+04	3.3E+04	3.3E+04	--	3.9E+04	--	3.4E+04	3.4E-02	No TRV	No TRV	--	--	
PFDoDA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	5.8E+03	--	3.8E+03	--	5.5E+04	3.0E+04	1.9E+05	--	2.4E+05	--	3.0E+04	3.0E-02	No TRV	No TRV	--	--	
PFTrDA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	1.3E+04	--	5.5E+03	--	5.5E+04	3.0E+04	2.3E+05	--	3.4E+05	--	3.0E+04	3.0E-02	No TRV	No TRV	--	--	
PFTeDA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	1.0E+04	--	1.0E+04	--	1.0E+05	5.4E+04	2.7E+05	--	4.5E+05	--	5.4E+04	5.4E-02	No TRV	No TRV	--	--	
PFSAs																						
PFBS	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	1.9E+02	--	1.0E+00	--	3.4E+04	1.8E+04	2.4E+02	--	2.2E+02	--	1.8E+04	1.8E-02	8.8E+01	--	2.1E-04	--	
PFHxS	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	1.0E+02	--	6.9E+02	--	8.6E+04	4.6E+04	4.1E+03	--	4.1E+03	--	4.6E+04	4.6E-02	No TRV	No TRV	--	--	
PFOS	1	1.0E+04	1.3E+02	1.0E+01	1.3E+01	9.0E+02	--	1.8E+03	--	1.2E+06	6.6E+05	1.4E+05	--	1.6E+05	--	6.6E+05	6.6E-01	7.7E-01	2.6E+00	8.6E-01	2.5E-01	
PFDS	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	1.7E+03	--	2.8E+03	--	1.0E+04	5.4E+03	2.8E+04	--	3.2E+04	--	5.4E+03	5.4E-03	No TRV	No TRV	--	--	
FASAs																						
PFOSA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	9.0E+02	--	1.8E+03	--	9.8E+03	5.3E+03	4.9E+02	--	4.7E+02	--	5.3E+03	5.3E-03	7.7E-01	2.6E+00	6.9E-03	2.0E-03	
EtFASAAs and MeFASAAs																						
N-EtFOSAA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	1.0E+03	--	1.0E+03	--	1.0E+04	5.4E+03	7.5E+02	--	7.0E+02	--	5.4E+03	5.4E-03	7.7E-01	2.6E+00	7.1E-03	2.1E-03	
N-MeFOSAA	1	1.0E+03	1.3E+01	1.0E+01	1.3E+01	9.0E+02	--	1.8E+03	--	1.2E+05	6.6E+04	4.1E+03	--	3.9E+03	--	6.6E+04	6.6E-02	7.7E-01	2.6E+00	8.6E-02	2.5E-02	

Data Gaps and Critical Research Needs

- Derivation of toxicity benchmarks using lab toxicity studies with birds, benthic invertebrates, terrestrial plants, and terrestrial invertebrates
- ERA bioaccumulation models for terrestrial ecosystems
- Biomagnification factors for higher trophic levels transfer (prey to predator)
- PFAS precursors exposures, particularly regarding invertebrate bioaccumulation and effects
- Mixture toxicity
- Field ecology studies at AFFF sites to evaluate PFAS effects

PFAS	Carbon Chain Length	Number of Perfluor-inated Carbon Atoms	Summary	Key Data Gaps	Relative Importance of Data Gap
PFBA	C4	3	Moderate occurrence, low bioaccumulation	Avian Toxicity	Low
PFPeA	C5	4	Moderate occurrence, low bioaccumulation	Avian Toxicity	Low
PFHxA	C6	5	High occurrence, low bioaccumulation	Avian Toxicity	Moderate
PFHpA	C7	6	Moderate occurrence, low bioaccumulation	Avian Toxicity	Moderate
PFOA	C8	7	High occurrence, moderate bioaccumulation in benthic invertebrates	Avian Toxicity	Moderate
PFNA	C9	8	Low occurrence, high bioaccumulation in benthic invertebrates, moderate bioaccumulation in pelagic invertebrates	Avian Toxicity	Moderate
PFDA	C10	9	Moderate occurrence, high bioaccumulation in pelagic invertebrates	Avian Toxicity	High
PFUnDA	C11	10	Low occurrence, high bioaccumulation in pelagic invertebrates	Avian Toxicity	Moderate
PFDoDA	C12	11	Moderate occurrence, high bioaccumulation in pelagic invertebrates and fish	Avian Toxicity	High
PFTrDA	C13	12	Low occurrence, high bioaccumulation in fish	Avian Toxicity	Moderate
PFTeDA	C14	13	Low occurrence, high bioaccumulation in fish	Avian Toxicity	Moderate
PFBS	C4	4	Moderate occurrence, low bioaccumulation	Avian Toxicity	Low
PFHxS	C6	6	High occurrence, moderate bioaccumulation	Avian Toxicity	High
PFOS	C8	8	High occurrence, high bioaccumulation in pelagic invertebrates	None	Low
PFDS	C10	10	Moderate occurrence, moderate bioaccumulation in fish	Avian Toxicity	Moderate
PFOSA	C8	8	Moderate occurrence, low bioaccumulation	Avian Toxicity	Moderate
N-EtFOSAA	C8	8	Uncertain occurrence, likely low/uncertain bioaccumulation	Avian Toxicity	Moderate
N-MeFOSAA	C8	8	Uncertain occurrence, likely low/uncertain bioaccumulation	Avian Toxicity	Moderate

Prioritization of PFAS data needs by compound

Ongoing Efforts

- Model tools
  - Aquatic Excel ERA model spreadsheet tool available now
  - Terrestrial Excel ERA model spreadsheet tool coming soon
- Deep-dive training courses (3-4 hours)
  - March 2020: Emerging Contaminants Summit, Denver, CO (coming soon to YouTube)
  - November 2020: SETAC North America, Ft. Worth, TX (proposed)
- Overview courses (1 hour)
  - State Risk Assessor Quarterly Webinar (July)
  - Tri Services Ecological Risk Assessment Work Group (proposed)
  - Other opportunities available, please contact us

Conclusions

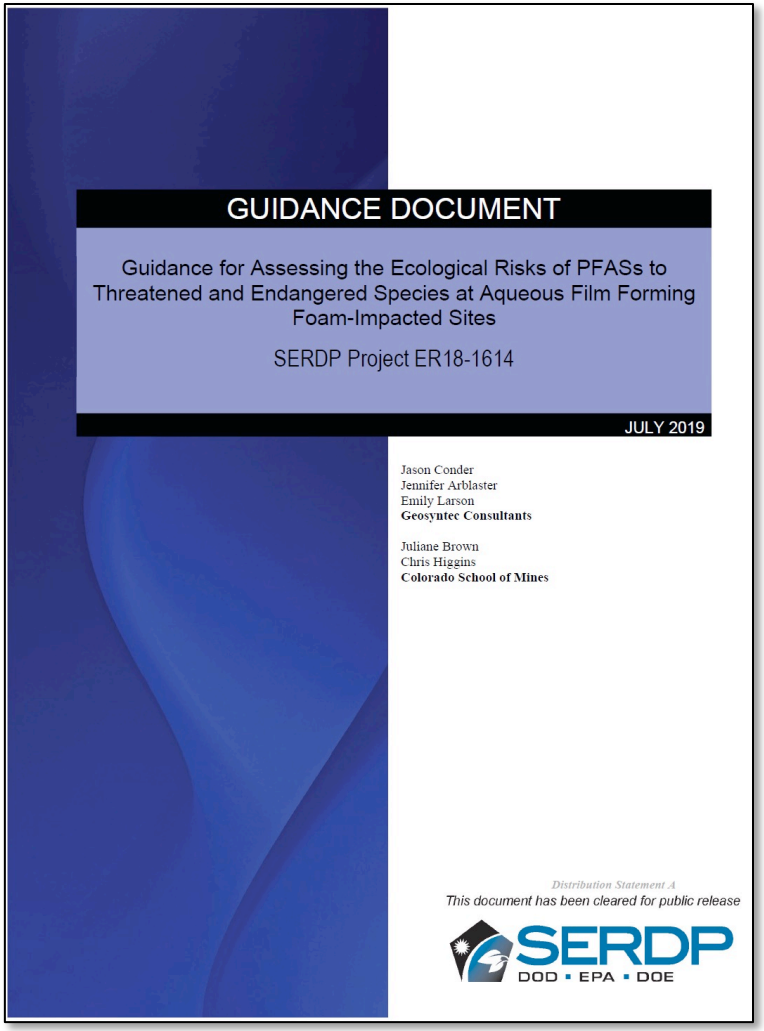
- Ecological Risk Assessment of AFFF-derived PFAS to T&E species is possible and ongoing now
- Guidance and the model tools provides DoD project managers a path forward for site-specific ecological risk assessments
- Data gap analysis useful in helping DoD identify and prioritize research needs to improve ERAs

Benefits to DoD

- Path forward for site-specific ecological risk assessments at DoD AFFF sites
  - Investigation strategy and planning
  - Backdrop for technical dialogue with stakeholders
  - Improves data collection and investigation efforts efficiency
  - Evaluation of potential risks
  - Delineation of investigation and management areas
- Identifies key data gaps for program-wide research

Acknowledgments

- Jenn Arblaster, Emily Larson, Kristin Bridges (Geosyntec)
- Chris Higgins and Julianne Brown (Colorado School of Mines)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Distribution Statement A
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For additional information, please visit

https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER18-1614

Speaker Contact Information

jconder@geosyntec.com; 714-465-1226

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Q&A Session 2

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ESTCP

The next webinar is on April 23, 2020

From Basic Research to a Prototype Towbody Platform: Progress on Underwater Unexploded Ordnance Remediation

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Survey Reminder

Please take a moment to complete the survey that will pop up on your screen when the webinar ends

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