USER MANUAL

AFFF PFAS Aquatic Ecological Risk Model Tool User's Manual

SERDP Project ER18-1614

MARCH 2021

Jason Conder
Jennifer Arblaster
Kristin Bridges
Geosyntec Consultants

SERDP
DOD ▪ EPA ▪ DOE

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
01-03-2021

2. REPORT TYPE
SERDP User's Manual

3. DATES COVERED *(From - To)*
3/24/2020 - 5/31/2022

4. TITLE AND SUBTITLE
AFFF PFAS Aquatic Ecological Risk Model Tool User's Manual

5a. CONTRACT NUMBER
20-P-0030

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Jason Conder, Jennifer Arblaster, Kristin Bridges

5d. PROJECT NUMBER
ER18-1614

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Geosyntec Consultants
2100 Main St., Ste. 150,
Huntington Beach, CA 92677

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Strategic Environmental Research and Development Program
4800 Mark Center Drive, Suite 16F16
Alexandria, VA 22350-3605

10. SPONSOR/MONITOR'S ACRONYM(S)
SERDP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
ER18-1614

12. DISTRIBUTION / AVAILABILITY STATEMENT
•Distribution A: Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT TThis document is a user's manual for the customizable Microsoft ExcelTM food web and wildlife exposure modeling tool ("Model Tool") for assessing the potential ecological risks associated with exposure to perfluoroalkyl and polyfluoroalkyl substances (PFAS) for common and threatened and endangered (T&E) species in aquatic habitats potentially impacted by aqueous film forming foam (AFFF)1. The Model Tool (a multi-worksheet ExcelTM file) enables ecological risk assessors to enter site-specific data (e.g., concentrations of PFAS in sediment, water, and/or biota), exposure factors for site-relevant wildlife species of interest, and available toxicological information for common PFAS. Model outputs consist of an evaluation of the potential for direct effects to aquatic communities, as well as model-predicted concentrations of PFAS in food webs and wildlife diet items. The model also features tables that provide ecological risk assessment (ERA) effects assessment and risk characterization (i.e., hazard quotients) and other useful information that can facilitate ERA-based decision making.

15. SUBJECT TERMS
perfluoroalkyl, polyfluoroalkyl, PFAS, aqueous film forming foam, AFFF, model tool, aquatic habitats, threatened and endangered, T&E

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE		35	Jason Conder
					19b. TELEPHONE NUMBER *(include area code)* 714-465-1226

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

AFFF PFAS Aquatic Ecological Risk Model Tool User's Manual

Project: ER18-1614

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

ACRONYMS AND ABBREVIATIONS

A&A	Acronyms and Abbreviations
AFFF	Aqueous Film Forming Foam
BCF	Bioconcentration factors sediment accumulation factors
BMF	Biomagnification factors
BSAF	Biota sediment accumulation factors
DoD	U.S. Department of Defense
EF	Exposure Factors
EPC	Exposure Point Concentrations
ERA	Ecological Risk Assessment
ESTCP	Environmental Security Technology Certification Program
HQ	Hazard Quotient
PFAS	Per- and polyfluoroalkyl substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonate
QSAR	Quantitative Structure Activity Relationship
SERDP	Strategic Environmental Research and Development Program
SSD	Species sensitivity distribution
T&E	Threatened and endangered
TDI	Total daily intake
TOC	Table of Contents
TRV	Toxicity reference value

1. OVERVIEW

1.1 Purpose of the User's Manual and Model Tool

This document is a user's manual for the customizable Microsoft Excel™ food web and wildlife exposure modeling tool ("Model Tool") for assessing the potential ecological risks associated with exposure to perfluoroalkyl and polyfluoroalkyl substances (PFAS) for common and threatened and endangered (T&E) species in aquatic habitats potentially impacted by aqueous film forming foam (AFFF)[1]. The Model Tool (a multi-worksheet Excel™ file) enables ecological risk assessors to enter site-specific data (e.g., concentrations of PFAS in sediment, water, and/or biota), exposure factors for site-relevant wildlife species of interest, and available toxicological information for common PFAS. Model outputs consist of an evaluation of the potential for direct effects to aquatic communities, as well as model-predicted concentrations of PFAS in food webs and wildlife diet items. The model also features tables that provide ecological risk assessment (ERA) effects assessment and risk characterization (i.e., hazard quotients) and other useful information that can facilitate ERA-based decision making.

The Model Tool was based on a current state-of-the-practice overview of available methods, best practices, and key data gaps presented in the "Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam Impacted Sites" document ("Guidance Document"; Conder et al., 2020), available on the ER18-1614 project page (https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER18-1614). This Model Tool was developed by Geosyntec Consultants with funding provided by the Strategic Environmental Research and Development Program (SERDP).

1.2 T&E Species Focus

This model tool was developed for use with T&E species, although it is also applicable for ecological risk assessments for common species. The quantitative ecological risk modeling tools, parameters, and receptors are specifically selected for assessing Federally listed T&E species present at AFFF release sites, particularly with regard to the characterization of effects, are much more conservative than approaches used for common species. For example, less conservative (higher) Toxicity Reference Values can be considered for use in the model to evaluate risks to common species. Please refer to the guidance regarding modifications that should be considered when focusing on common species.

[1] A second Model Tool has been developed for use in terrestrial systems and a separate User's Manual is available on the ER18-1614 project page.

1.3 Warning and Disclaimer

Before proceeding further, it is recommended that the reader review the Guidance Document and confirm whether subsequent (improved) versions of the Model Tool and/or User's Manual are available at the URL provided in Section 1.1.

All cells and formulae in the Model Tool can be edited by the user (i.e., they're unprotected); therefore, updates to exposure factors, uptake models or toxicity reference values can be made by the user as data gaps are filled by additional research. However, it is recommended that the user save a backup (unedited) version of the original file before entering values or modifying parameters, equations, or algorithms in the model.

This Model Tool is intended to aid in quantitatively evaluating ecological risks from PFAS exposures, and to enable site managers to make defensible, risk-based management decisions using the best and most current scientific information and approaches available. This file outlines best practices, recommendations and suggestions that are based on the current state-of-the-science; it is not intended as regulation or a binding set of procedures. The user of this model takes full responsibility for the use and application of this model, including the input values, equations, assumptions and outputs. Therefore, it is recommended that all aspects of the model be evaluated by an experienced ecological risk assessor, prior to making site-specific or regulatory decisions.

1.4 Model Uncertainties and Limitations

Ecological risks assessments for PFAS, especially for PFAS beyond PFOS and PFOA, are in their infancy, and a high degree of uncertainty remains. Specifically, for the Model Tool, the uptake parameters included in the model are generally based on laboratory studies where model organisms are exposed to PFAS-spiked media. The use of model organisms may not reflect the same uptake rates as field species as PFAS-impacted sites. Additionally, the use of spiked media often results in uptake factors higher than those measured in the field studies due to higher bioavailability of contaminants in fresh versus aged media. As a result, the Model Tool is considered a conservative estimate of exposure but the uncertainty in over-predicting exposure is acknowledged. The Model Tool can be used to calculate site-specific risk-based thresholds however these should not be considered regulatory clean up goals or be used as such without risk management discussions with stakeholders. Where important, site-specific remedial decisions making needs to be supported, modeled risks estimated should be confirmed in the field. For example, site-specific bioaccumulation studies with terrestrial or aquatic invertebrates or fish can be performed or samples of wildlife diet items can be collected and PFAS concentrations measured directly to better estimate exposures on a site-specific basis. The Model Tool is built with options for including site-specific tissue data to help refine preliminary risk estimates.

1.5 Remainder of the User's Manual

The remainder of this User's Manual presents a step-by-step overview of the features and operations of the Model Tool and includes an explanation of the main worksheets contained within the Excel^{TM} file.

The references section also includes the citations for all references cited in this User's Manual and Model Tool.

The User's Manual also features two attachments:

- Attachment 1 provides supporting information used to fill data gaps in bioaccumulation uptake factors applied in the Model Tool.
- Attachment 2 provides a demonstration of the Model Tool using PFAS data from a hypothetical United States Navy site.

The Model Tool and Guidance Document can be cited as:

Conder, J.; Arblaster, J.; Larson, E.; Brown, J.; Higgins, C. (2020). Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species at Aqueous Film Forming Foam-Impacted Sites. SERDP Project ER18-1614. September.

2. INTRODUCTION, TABLE OF CONTENTS, AND ACRONYMS & ABBREVIATIONS (WORKSHEETS: INTRODUCTION, TOC, AND A&A)

The first three worksheets in the Model Tool are un-numbered, and consist of the following:

- **Introduction:** The Introduction worksheet contains an overview of the file and critical information on the applicable version of the Model Tool.
- **Table of Contents (TOC):** The TOC worksheet contains a Table of Contents that provides a guide to the main model worksheets in the file. Users can input their Site name or model/file name in cell B2. This entry is carried forward in the remainder of the workbook.
- **Acronyms and Abbreviations (A&A):** The A&A worksheet contains a list of acronyms and abbreviations used in the Model Tool and User's Guide.

3. TABLE 1. EXPOSURE FACTORS FOR SELECTED RECEPTORS (WORKSHEETS: EXPOSURE FACTORS AND EF LOOKUP)

> ➢ **The first step in applying the Model Tool is to select vertebrate wildlife receptors (birds and mammals) that will be evaluated in the ecological risk model. Direct risks to aquatic life in the water column (fish, invertebrates, algae) are included by default and do not require species selection. Direct risks to benthic invertebrates are not available at this time due to a lack of bulk sediment toxicity testing which has been identified as an existing data gap.**

In the "Exposure Factors" worksheet (Table 1), the user can select three avian species and three mammalian species from different feeding guilds from a **drop-down menu** (see red box in the screenshot below). The user also defines the "Site Area" in acres (**purple box**), which will allow the model to generate a site-specific "Area Use Factor" (AUF)[2]. If impacted surface water is freshwater and can be used as a wildlife drinking water source at the Site, type an "X" in the **green box** to direct the model to evaluate the exposure of vertebrate terrestrial wildlife via drinking surface water. Salinity in freshwater considered suitable for wildlife use as drinking water should be less than 1 part per thousand. The **green box** should remain blank if surface water at your site is not suitable for drinking water, as the inclusion of text in the **green box** will result in the addition of unnecessary columns pertaining to surface water throughout the workbook.

Test Site #1

Site Area (acres): 10

Type an "X" in the green box if surface water is a drinking water source for wildlife at your site: x

Table 1: Exposure Factors for Selected Receptors

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)
				Mummichog	**Perch**	**Wood Duck**	**Spotted sandpiper**	**Osprey**	**Muskrat**	**Southern Sea Otter**	**Steller sea lion**
				Fundulus heteroclitus	*Perca flavescens*	*Aix sponsa*	*Actitis macularius*	*Pandion haliaetus*	*Ondatra zibethicus*	*Enhydra lutris*	*Eumetopias jubatus*
BW	Body Weight		kg	--	--	0.700	0.043	1.600	1.200	35.000	263.000
FIR_{dw}	Daily Food Ingestion Rate (dry matter)	[1]	kg, dw/day	--	--	0.041	0.008	0.084	0.102	2.188	3.945
FIR_{ww}	Daily Food Ingestion Rate (wet matter)	[2]	kg, ww/day	--	--	0.127	0.023	0.336	0.408	8.750	15.780
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	0.110	0.073	-	0.020	-	-
DWI	Daily Water Ingestion		L/day	NA	NA	0.041	0.054	0.085	0.882	2.870	16.832
HR	Home Range		acres	7.60	2.27	274.00	8.50	2200.00	0.32	4700.00	8645.00
AUF	Area Use Factor	[5]	proportion	1.000	1.000	0.036	1.000	0.005	1.000	0.002	0.001

Notes:
Details on Threatened & Endangered receptor selection are provided in Section 3.3 and Appendix A of Conder et al. 2020.
References for all species-specific exposure factors are provided in the Exposure Factors Lookup Table
1: Dry weight FIR is applied to concentrations of PFAS in sediment, generally reported on dry weight basis.
2: Wet weight FIR is applied to tissue data, generally reported on fresh or wet weight basis.
3: Forage fish are assumed to eat 33% plant, 33% pelagic invertebrates, and 33% benthic invertebrates regardless of species, but these can be adjusted by users.
4: Predatory fish as assumed to eat 70% forage fish and 30% benthic invertebrates regardless of species, but these can be adjusted by users.
5: AUF values for receptors were calculated by dividing home range by site area. At some sites for some receptors, it may be more accurate to express AUF with additional approaches that consider shoreline length or other animal foraging strategies at the site.

Abbreviations:
dw - dry weight
ww - wet weight
L - liters
kg - kilogram

[2] It should be noted that the model will automatically calculate a "default" AUF for all receptors by dividing the user-specified Site Area by the receptor's Home Range. Although this approach generally provides a reasonably representative AUF value for many receptors, it may not be the most appropriate approach for species (e.g., those that forage linearly along shorelines, and/or do not forage in deep water). Therefore, after site-specific and receptor-specific considerations are made, the user may also opt to provide a modified equation or AUF value that considers additional species-specific factors (e.g., water depth, habitat preferences) for such receptors.

The surrogate receptors available for user selection include examples of T&E species, as well as common species without any Federally protected status. This approach allows the user to more accurately represent various site-specific receptor traits, life histories, and/or statuses. Once the desired surrogates have been selected by the user, the key exposure factor parameters inside the **blue box** in the image above will be pre-filled with values from the "EF Lookup" worksheet. Note that all the parameters in Table 1 can be supplanted or revised by the user. For example, if the user wants to use an alternate receptor species than the Wood Duck (or other avian herbivores), one can simply revise the information in that column as desired. The information for that receptor will be used in the remainder of the worksheet as "Bird 1". The columns to the right refer to "Bird 2"and "Bird 3" respectively. The mammals to be modeled are "Mammal 1", "Mammal 2", and "Mammal 3", proceeding left to right.

The "EF Lookup" worksheet (an internal lookup worksheet at the end of the workbook) lists all parameter **values** that auto-populate cells inside the **blue box** in Table 1 following selection of avian and mammalian receptors from the **drop-down menus** on the "Exposure Factors" worksheet. Users can also select forage and predatory fish species for food web modeling from their respective drop-down menus. Selection of fish species from the drop-down menus will prompt the model to auto-populate home range values; however, users must manually enter fish dietary preferences in the green highlighted cells in Table 1 (note that the sum of the values must equal 1).

The EF Lookup worksheet is also where users can find **references** for all exposure parameters, as well as any additional **notes** pertaining to a given parameter.

Note: The values in this table are initial suggestions only. Additional efforts should be considered to verify the use of these values with particular site-specific risk assessments, such as consultation of the literature and information cited herein, consideration of site conditions, and consultation with a biologist. Full citations are provided in the User Guidance

RECEPTOR TYPE	GUILD	Species	Parameter	Definition	Lookup Code	Value	Units	Reference	Notes
AVIAN	HERBIVORE	Wood Duck	BW	Body Weight	Wood Duck_BW	0.70	kg	North Carolina Wildlife Resources Commission Wildlife Profiles (2019)	Lowest reported body weight; https://www.ncwildlife.org/Learning/Species
AVIAN	HERBIVORE	Wood Duck	FIR_{dw}	Daily Food Ingestion Rate (dry matter)	Wood Duck_FIRdw	0.041	kg, dw/day	Nagy (2001)	Calculated using DW allometric equation for omnivorous birds: FIR (dw) = 0.67 x BW ^ 0.627
AVIAN	HERBIVORE	Wood Duck	FIR_{ww}	Daily Food Ingestion Rate (wet matter)	Wood Duck_FIRww	0.13	kg, ww/day	Nagy (2001)	Calculated using WW allometric equation for omnivorous birds: FIR (ww) = 2.094 x BW ^ 0.627
AVIAN	HERBIVORE	Wood Duck	Pveg	Proportion of Diet - Vegetation	Wood Duck_Pveg	1.00	kg diet item, ww/kg diet, ww	Delnicki & Reinecke (1986)	Consume 74.3% acorns 23.4% soybeans, remaining plant material
AVIAN	HERBIVORE	Wood Duck	Pbi	Proportion of Diet - Benthic Invertebrates	Wood Duck_Pbi	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	HERBIVORE	Wood Duck	Ppi	Proportion of Diet - Pelagic Invertebrates	Wood Duck_Ppi	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	HERBIVORE	Wood Duck	Pff	Proportion of Diet - Forage Fish	Wood Duck_Pff	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	HERBIVORE	Wood Duck	Ppf	Proportion of Diet - Predatory Fish	Wood Duck_Ppf	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	HERBIVORE	Wood Duck	Pso	Proportion of Diet - Sediment	Wood Duck_Pso	0.110	kg sediment, dw/kg diet, dw	USEPA (1993)	Table 4-4
AVIAN	HERBIVORE	Wood Duck	DWI	Daily Water Ingestion	Wood Duck_DWI	0.041	L water/day	USEPA (1993)	Mallard used as a surrogate; IR L/day= IR 0.058 (L/kg)*BW (kg)
AVIAN	HERBIVORE	Wood Duck	HR	Home Range	Wood Duck_HR	274	Acres	USEPA (1993)	Mallard used as a surrogate; HR for egg laying females selected (111 ha converted to acres)
AVIAN	HERBIVORE	Canada Goose	BW	Body Weight	Canada Goose_BW	3.0	kg	USEPA (1993)	Average of all adult body weights
AVIAN	HERBIVORE	Canada Goose	FIR_{dw}	Daily Food Ingestion Rate (dry matter)	Canada Goose_FIRdw	0.023	kg, dw/day	USEPA (1993)	Calculated from the ww-based FIR, assuming an 75% moisture content of food (i.e., 0.25 g, dw/g, ww).
AVIAN	HERBIVORE	Canada Goose	FIR_{ww}	Daily Food Ingestion Rate (wet matter)	Canada Goose_FIRww	0.09	kg, ww/day	USEPA (1993)	FIR kg/day= WW FIR (kg/kg-day)*BW (kg) with FIR (kg/kg-day) of 0.03 from USEPA (1993)
AVIAN	HERBIVORE	Canada Goose	Pveg	Proportion of Diet - Vegetation	Canada Goose_Pveg	0.99	kg diet item, ww/kg diet, ww	USEPA (1993)	< 1 % invertebrates
AVIAN	HERBIVORE	Canada Goose	Pbi	Proportion of Diet - Benthic Invertebrates	Canada Goose_Pbi	0.01	kg diet item, ww/kg diet, ww	USEPA (1993)	< 1 % invertebrates
AVIAN	HERBIVORE	Canada Goose	Ppi	Proportion of Diet - Pelagic Invertebrates	Canada Goose_Ppi	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	HERBIVORE	Canada Goose	Pff	Proportion of Diet - Forage Fish	Canada Goose_Pff	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	HERBIVORE	Canada Goose	Ppf	Proportion of Diet - Predatory Fish	Canada Goose_Ppf	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	HERBIVORE	Canada Goose	Pso	Proportion of Diet - Sediment	Canada Goose_Pso	0.082	kg sediment, dw/kg diet, dw	USEPA (1993)	Table 4-4
AVIAN	HERBIVORE	Canada Goose	DWI	Daily Water Ingestion	Canada Goose_DWI	0.16	L water/day	USEPA (1993)	IR L/day= IR (L/kg)*BW (kg)
AVIAN	HERBIVORE	Canada Goose	HR	Home Range	Canada Goose_HR	2429	Acres	USEPA (1993)	Converted from 983 ha
AVIAN	INVERTIVORE	California clapper rail	BW	Body Weight	California clapper rail_BW	0.32	kg	NatureServe (2018)	Average weight for similar species Light-footed Clapper Rail
AVIAN	INVERTIVORE	California clapper rail	FIR_{dw}	Daily Food Ingestion Rate (dry matter)	California clapper rail_FIRdw	0.032	kg, dw/day	Nagy (2001)	Calculated using DW allometric equation for insectivore birds: FIR (dw) = 0.54 x BW ^ 0.705
AVIAN	INVERTIVORE	California clapper rail	FIR_{ww}	Daily Food Ingestion Rate (wet matter)	California clapper rail_FIRww	0.10	kg, ww/day	Nagy (2001)	Calculated using WW allometric equation for insectivore birds: FIR (ww) = 1.633 x BW ^ 0.705
AVIAN	INVERTIVORE	California clapper rail	Pveg	Proportion of Diet - Vegetation	California clapper rail_Pveg	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	INVERTIVORE	California clapper rail	Pbi	Proportion of Diet - Benthic Invertebrates	California clapper rail_Pbi	1	kg diet item, ww/kg diet, ww	NatureServe (2018)	Diet mostly mussels, clams, small crabs, and spiders; probes in mud or sand in or near shallow water, or picks items from substrate
AVIAN	INVERTIVORE	California clapper rail	Ppi	Proportion of Diet - Pelagic Invertebrates	California clapper rail_Ppi	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	INVERTIVORE	California clapper rail	Pff	Proportion of Diet - Forage Fish	California clapper rail_Pff	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	INVERTIVORE	California clapper rail	Ppf	Proportion of Diet - Predatory Fish	California clapper rail_Ppf	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	INVERTIVORE	California clapper rail	Pso	Proportion of Diet - Sediment	California clapper rail_Pso	0.180	kg sediment, dw/kg diet, dw	USEPA (1993)	Assumed similar to Western sandpiper in EFH Table 4-4.
AVIAN	INVERTIVORE	California clapper rail	DWI	Daily Water Ingestion	California clapper rail_DWI	0.054	L water/day	USEPA (1993)	IR L/day= IR (L/kg)*BW (kg); Sandpiper used as surrogate
AVIAN	INVERTIVORE	California clapper rail	HR	Home Range	California clapper rail_HR	0.988	Acres	NatureServe (2018)	Little information available, but most rails appear to have very small breeding home ranges: Clapper Rail, varies from an average of 0.4 hectares in California and Louisiana to 3.6 hectares (incubating males) in Arizona; average of 0.19 ha during brood-rearing. 0.4 ha converted to acres.
AVIAN	INVERTIVORE	Spotted sandpiper	BW	Body Weight	Spotted sandpiper_BW	0.043	kg	USEPA (1993)	Average values reported for adult male and female spotted sandpipers (USEPA 1993).
AVIAN	INVERTIVORE	Spotted sandpiper	FIR_{dw}	Daily Food Ingestion Rate (dry matter)	Spotted sandpiper_FIRdw	0.0076	kg, dw/day	Nagy (2001)	Calculated using DW allometric equation for insectivore birds: FIR (dw) = 0.54 x BW ^ 0.705
AVIAN	INVERTIVORE	Spotted sandpiper	FIR_{ww}	Daily Food Ingestion Rate (wet matter)	Spotted sandpiper_FIRww	0.0230	kg, ww/day	Nagy (2001)	Calculated using WW allometric equation for insectivore birds: FIR (ww) = 1.633 x BW ^ 0.705
AVIAN	INVERTIVORE	Spotted sandpiper	Pveg	Proportion of Diet - Vegetation	Spotted sandpiper_Pveg	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	INVERTIVORE	Spotted sandpiper	Pbi	Proportion of Diet - Benthic Invertebrates	Spotted sandpiper_Pbi	1	kg diet item, ww/kg diet, ww	Bent (1929)	Assumed to eat 100% benthic invertebrates (Bent, 1929)
AVIAN	INVERTIVORE	Spotted sandpiper	Ppi	Proportion of Diet - Pelagic Invertebrates	Spotted sandpiper_Ppi	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	INVERTIVORE	Spotted sandpiper	Pff	Proportion of Diet - Forage Fish	Spotted sandpiper_Pff	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	INVERTIVORE	Spotted sandpiper	Ppf	Proportion of Diet - Predatory Fish	Spotted sandpiper_Ppf	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	INVERTIVORE	Spotted sandpiper	Pso	Proportion of Diet - Sediment	Spotted sandpiper_Pso	0.073	kg sediment, dw/kg diet, dw	USEPA (1993)	Soil/sediment estimated in Least sandpiper diet (USEPA, 1993).
AVIAN	INVERTIVORE	Spotted sandpiper	DWI	Daily Water Ingestion	Spotted sandpiper_DWI	0.054	L water/day	USEPA (1993)	IR L/day= IR (L/kg)*BW (kg); Sandpiper used as surrogate
AVIAN	INVERTIVORE	Spotted sandpiper	HR	Home Range	Spotted sandpiper_HR	8.5	Acres	CDFG (2005)	Average of the average home ranges from two studies reviewed in CDFG (2005).
AVIAN	OMNIVORE	Hawaiian stilt	BW	Body Weight	Hawaiian stilt_BW	0.17	kg	NatureServe (2018)	Average weight for similar species black-necked stilt
AVIAN	OMNIVORE	Hawaiian stilt	FIR_{dw}	Daily Food Ingestion Rate (dry matter)	Hawaiian stilt_FIRdw	0.017	kg, dw/day	Nagy (2001)	Calculated using DW allometric equation for omnivorous birds: FIR (dw) = 0.67 x BW ^ 0.627
AVIAN	OMNIVORE	Hawaiian stilt	FIR_{ww}	Daily Food Ingestion Rate (wet matter)	Hawaiian stilt_FIRww	0.052	kg, ww/day	Nagy (2001)	Calculated using allometric equation for omnivorous birds: FIR (ww) = 2.094 x BW ^ 0.627
AVIAN	OMNIVORE	Hawaiian stilt	Pveg	Proportion of Diet - Vegetation	Hawaiian stilt_Pveg	-	kg diet item, ww/kg diet, ww		Assumed not to be consumed based on reported diet contents; consult additional literature for more information.
AVIAN	OMNIVORE	Hawaiian stilt	Pbi	Proportion of Diet - Benthic Invertebrates	Hawaiian stilt_Pbi	0.40	kg diet item, ww/kg diet, ww	NatureServe (2018)	Eats various aquatic organisms--worms, small crabs, insects, small fishes
AVIAN	OMNIVORE	Hawaiian stilt	Ppi	Proportion of Diet - Pelagic Invertebrates	Hawaiian stilt_Ppi	0.40	kg diet item, ww/kg diet, ww	NatureServe (2018)	Eats various aquatic organisms--worms, small crabs, insects, small fishes
AVIAN	OMNIVORE	Hawaiian stilt	Pff	Proportion of Diet - Forage Fish	Hawaiian stilt_Pff	0.20	kg diet item, ww/kg diet, ww	NatureServe (2018)	Eats various aquatic organisms--worms, small crabs, insects, small fishes
AVIAN	OMNIVORE	Hawaiian stilt	Ppf	Proportion of Diet - Predatory Fish	Hawaiian stilt_Ppf	0	kg diet item, ww/kg diet, ww	NatureServe (2018)	Eats various aquatic organisms--worms, small crabs, insects, small fishes

4. TABLE 2. BIOACCUMULATION PARAMETERS (WORKSHEET: BIOACCUMPARAMS)

> ➢ **The second step in applying the Model Tool is to consider the food web modeling parameters that will be used to predict concentrations of PFAS in the diet items of wildlife receptors (birds and mammals) that are being evaluated by the ecological risk model.**

The Table 2 "BioaccumParams" worksheet contains experimentally determined bioconcentration factors (BCF), biota sediment accumulation factors (BSAF), and biomagnification factors (BMF) that have been published in the peer reviewed literature and recommended for use in modeling in the Guidance Document. Users should review the Guidance Document for details on the full selection of parameters evaluated, the selection process and criteria and full references to the supporting information. Additionally, the user is encouraged to consider alternate model parameters from additional resources (i.e., Gobas et al. (2020) and Zodrow et al. (2020), as discussed in the Guidance), or the use of site-specific uptake factors. For example, if site-specific BSAFs are developed as part of Remedial Investigations, these can be entered into the model in the BSAF table, however users should be cautious to enter uptake factors in the same units currently used in the model to avoid calculation errors. The bioaccumulation parameters identified in Table 2 will be used to model site-specific concentrations in biota (on a nanogram per kilogram of body weight [ng/kg ww] basis) in subsequent steps.

Due to current gaps in knowledge, experimentally derived values are not available for all parameters in the "BioaccumParams" table for several PFAS. As an alternative, the user can opt to fill data gaps with Quantitative Structure Activity Relationship (QSAR)-modelled or read-across bioaccumulation parameters (i.e., BAFs, BCFs, and BSAFs) by typing "Yes" in the green shaded cell at the top of Table 2 (identified by the green highlighted cell in the image below). When the option to apply QSAR-modeled parameters is selected, a surrogate value derived using the technical approaches described in Attachment 1 is applied for plants and invertebrates.

Type "Yes" in the green shaded cell to replace data gaps with QSAR-modeled values

Test Site #1

Table 2: Bioaccumulation Parameters

OPTIONAL - To apply QSAR modelled bioaccumulation parameters to all data gaps type "Yes" in green cell: **Yes**

PFAS	Plant		Invertebrates							
	Water to Aquatic Plant BCF-AP (L/kg, ww)		Water to Pelagic Invertebrate BCF-PI (L/kg, ww)		Sediment to Benthic Invertebrate BSAF-BI (g, OC/g, ww)		Water to Fish Tissue BCF-Fish (L/kg, ww)		Diet to Tissue BMF-Fish (kg fish, ww/kg diet, ww)	
	Value	Notes	Value	Source	Value	Source	Value	Source	Value	Source
PFCAs										
PFBA	3.9	a	25	d	0.0017	e	0.60	Wen et al., 2017	0.0066	Martin et al., 2003a
PFPeA	3.9	Pi et al., 2017	35	d	0.0081	e	0.23	Wen et al., 2017	0.011	Martin et al., 2003a
PFHxA	3.7	Pi et al., 2017	49	d	0.040	Lasier et al., 2011	0.69	Wen et al., 2017	0.019	Martin et al., 2003a
PFHpA	3.8	Pi et al., 2017	69	d	0.18	Lasier et al., 2011	3.2	Wen et al., 2017	0.031	Martin et al., 2003a
PFOA	4.1	Pi et al., 2017	91	Dai et al., 2013	0.95	Higgins et al., 2007	4.0	Martin et al., 2003b	0.038	Martin et al., 2003a
PFNA	8.8	Pi et al., 2017	152	Dai et al., 2013	1.6	Higgins et al., 2007	39	Martin et al., 2003b	0.23	Goeritz et al., 2013
PFDA	17	Pi et al., 2017	175	Dai et al., 2013	1.0	Higgins et al., 2007	450	Martin et al., 2003b	0.23	Martin et al., 2003a
PFUnDA	47	Pi et al., 2017	270	Dai et al., 2013	0.62	Higgins et al., 2007	2700	Martin et al., 2003b	0.28	Martin et al., 2003a
PFDoDA	87	Pi et al., 2017	380	Dai et al., 2013	0.55	Higgins et al., 2007	18000	Martin et al., 2003b	0.43	Martin et al., 2003a
PFTrDA	192	Pi et al., 2017	550	d	0.55	Lasier et al., 2011	21627	Chen et al., 2016	0.71	Martin et al., 2003a
PFTeDA	169	Pi et al., 2017	776	d	0.55	Lasier et al., 2011	23000	Martin et al., 2003b	1.00	Martin et al., 2003a
PFSAs										
PFBS	2.8	Pi et al., 2017	0.0065	Chen et al., 2018	0.34	Lasier et al., 2011	1.0	Wen et al., 2017	0.020	Goeritz et al., 2013
PFHxS	4.2	Pi et al., 2017	69	d	0.86	Lasier et al., 2011	9.6	Martin et al., 2003b	0.14	Martin et al., 2003a
PFOS	13	Pi et al., 2017	179	Dai et al., 2013	1.2	Higgins et al., 2007	1100	Martin et al., 2003b	0.32	Martin et al., 2003a
PFDS	26	b	275	d	0.50	Higgins et al., 2007	2630	Martin et al., 2003b	0.25	Martin et al., 2003a
FASAs										
PFOSA	13	c	179	c	0.098	Bertin et al., 2014	39	Martin et al., 2003b	0.023	Brandsma et al., 2011
EtFASAAs and MeFASAAs										
N-EtFOSAA	13	c	179	c	0.12	Higgins et al., 2007	39	Martin et al., 2003b	0.089	Martin et al., 2003a
N-MeFOSAA	13	c	179	c	1.2	c	39	Martin et al., 2003b	0.089	Martin et al., 2003a

Notes:

Supporting information for recommended bioaccumulation values are provided in Section 3.3, Table 2 and Appendix B of Conder et al. 2020

See Acronyms & Abbreviations table for PFAS names.

a: Assumed equal to PFPeA

b: BCF-AP calculated from log10 regression on BCF-AP for PFSAs

c: PFOS used as a surrogate for FASAs and FASAAs

d: BCF-PI calculated from log10 regression on BCF-PI for PFCAs

e: BSAF-BI calculated from log10 regression on BSAF-BI for PFCAs

Abbreviations:

L/kg - Liter per kilogram

OC - Organic carbon

ww - wet weight

BCF - Bioconcentration Factor

BMF - Biomagnification Factor

BSAF - Biota Sediment Accumulation Factor

The surrogate bioaccumulation parameters are uncertain and are to be used with caution. As there is no established scientific consensus regarding the selection of alternative PFAS as surrogates for predicting bioaccumulation of closely related and/or precursor compounds, caution should be exercised when using modeled values as a basis for site-specific decision making. A description of their derivation is provided in Attachment 1.

If the user does not type "Yes" in the green shaded cell, the bioaccumulations parameters for which no experimentally derived values are available will remain blank and predictions for these PFAS will be unavailable for some of the biota. This may result in a potential underestimation of concentrations of PFAS in the food web diet items and subsequent calculations for estimating exposure and risks to wildlife, as noted in subsequent sections.

Please also note that there is a hidden row (Row 1) at the top of the BioaccumParams worksheet that contains values supporting model formulae. This row should not be modified or deleted by the user, or a loss in model functionality may occur.

5. TABLE 3. SITE-SPECIFIC DATA INPUT (WORKSHEET: DATA INPUT & FWM)

➢ **The third step in applying the Model Tool is to enter in available site-specific measurements to facilitate the calculation of PFAS in diet items for the wildlife receptors (birds and mammals) addressed in the ecological risk model.**

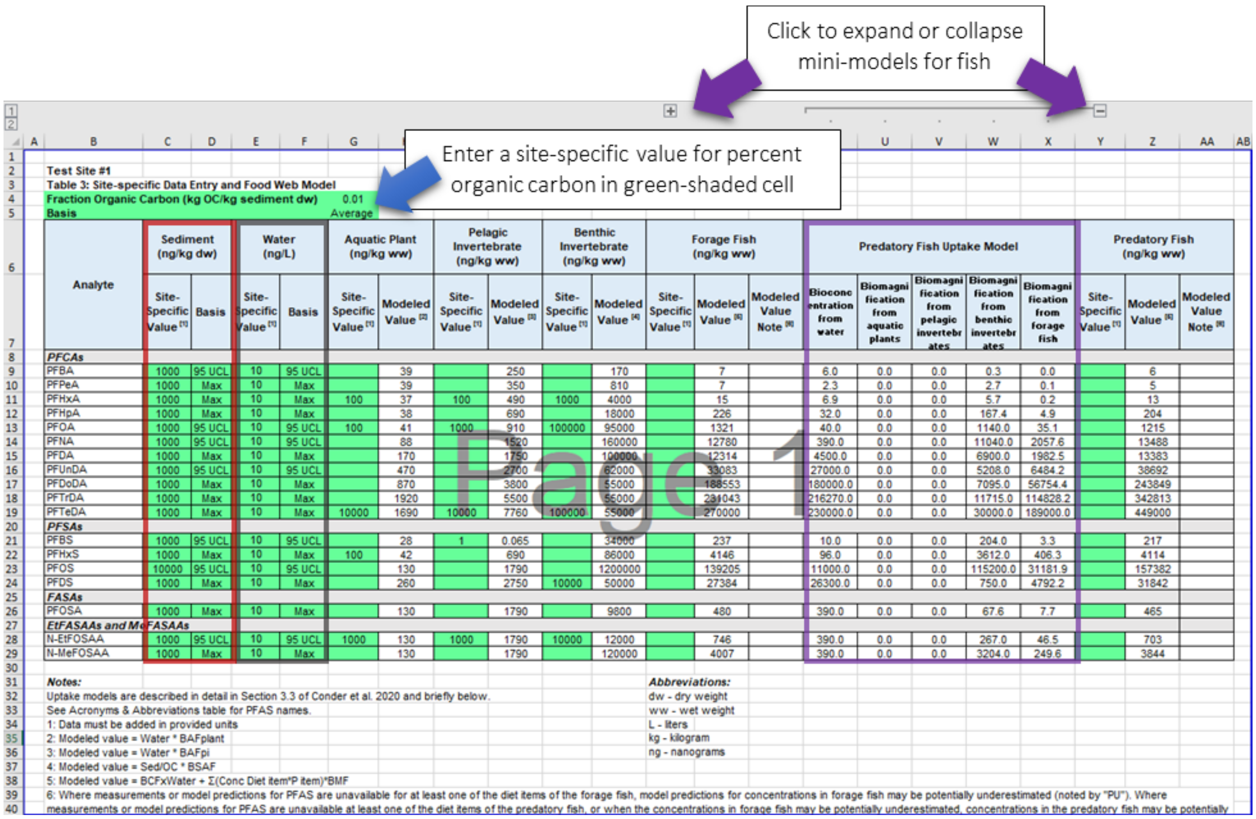
The "Data Input & FWM" worksheet is where the user will enter the results of environmental sampling conducted at the site of interest, including physical parameters (total organic carbon), and concentrations of PFAS measured in abiotic media (e.g., sediment and water) and biotic media (i.e., tissues), where available.

Concentrations of PFAS in sediment and water, and TOC in sediment are required model entry values in Table 3:

- Under the header "**Sediment**," the user should enter concentrations of PFAS into the "Site Specific Value" column of Table 3, using the units **nanograms per kilogram of dry weight (ng/kg dw)**. Laboratories often report concentrations of PFAS in sediment as micrograms per kilogram (µg/kg), which would require conversion before entering data, specifically, multiplication of the µg/kg values by 1000. A "Basis" column, in which the origin of the site-specific sediment PFAS concentrations can also be noted (e.g., maximum value [Max], 95% upper confidence limit [95 UCL]), is also included under the "Sediment" heading as a bookkeeping measure for the user.
- A similar format is used for PFAS concentrations in **water** at the Site; however, the user should take care to enter water concentrations in **nanograms per liter (ng/L)**.
- Users must enter a site-specific value for the fraction organic carbon (**kg TOC/kg, sediment, dw**) in the green shaded cell at the top of Table 3 (identified by the green cell in the image below).
- If a User is including site-specific tissue data for use in the model, the data must be entered as **nanograms per kilogram of wet weight (ng/kg ww)**.

Measured concentrations of PFAS in biota are not required for the model; however, in the event that measured data are available for a site, values can be entered into the "Site Specific Value" columns under the appropriate receptor type headings (i.e., plant, pelagic or benthic invertebrate, forage or predatory fish) in the model. Regardless of whether measured concentrations are entered into Table 3, the model will generate predicted PFAS concentrations for each receptor type, although if a measured value is available, the models will use the measured value instead of the model-predicted values in subsequent calculations.

For the purposes of evaluating risks to aquatic avian and mammalian receptors, fish are evaluated as a prey (dietary) item rather than a receptor. For users who wish to more closely examine the relative PFAS contribution made by various sources to the overall PFAS body burden of fish, a "mini-model" option is available. The fish mini-models (**purple box**) can be expanded by clicking on the "+" signs at the top of the spreadsheet (this will reveal a group of hidden columns). Conversely, the mini-models can be collapsed to simplify the table, by clicking on the "-" signs at the top of the spreadsheet.



Test Site #1
Table 3: Site-specific Data Entry and Food Web Model
Fraction Organic Carbon (kg OC/kg sediment dw) 0.01
Basis Average

Analyte	Sediment (ng/kg dw)		Water (ng/L)		Aquatic Plant (ng/kg ww)		Pelagic Invertebrate (ng/kg ww)		Benthic Invertebrate (ng/kg ww)		Forage Fish (ng/kg ww)			Predatory Fish Uptake Model					Predatory Fish (ng/kg ww)		
	Site-Specific Value [1]	Basis	Site-Specific Value [1]	Basis	Site-Specific Value [1]	Modeled Value [2]	Site-Specific Value [1]	Modeled Value [3]	Site-Specific Value [1]	Modeled Value [4]	Site-Specific Value [1]	Modeled Value [5]	Modeled Value Note [6]	Bioconcentration from water	Biomagnification from aquatic plants	Biomagnification from pelagic invertebrates	Biomagnification from benthic invertebrates	Biomagnification from forage fish	Site-Specific Value [1]	Modeled Value [5]	Modeled Value Note [6]
PFCAs																					
PFBA	1000	95 UCL	10	95 UCL		39		250		170		7		6.0	0.0	0.0	0.3	0.0		6	
PFPeA	1000	Max	10	Max		39		350		810		7		2.3	0.0	0.0	2.7	0.1		5	
PFHxA	1000	Max	10	Max	100	37	100	490	1000	4000		15		6.9	0.0	0.0	5.7	0.2		13	
PFHpA	1000	Max	10	Max		38		690		18000		226		32.0	0.0	0.0	167.4	4.9		204	
PFOA	1000	95 UCL	10	95 UCL	100	41	1000	910	100000	95000		1321		40.0	0.0	0.0	1140.0	35.1		1215	
PFNA	1000	95 UCL	10	95 UCL		88		1520		160000		12780		390.0	0.0	0.0	11040.0	2057.6		13488	
PFDA	1000	Max	10	Max		170		1750		100000		12314		4500.0	0.0	0.0	6900.0	1982.5		13383	
PFUnDA	1000	95 UCL	10	95 UCL		470		2700		62000		33083		27000.0	0.0	0.0	5208.0	6484.2		38692	
PFDoDA	1000	Max	10	Max		870		3800		55000		188553		180000.0	0.0	0.0	7095.0	56754.4		243849	
PFTrDA	1000	Max	10	Max		1920		5500		55000		231043		216270.0	0.0	0.0	11715.0	114828.2		342813	
PFTeDA	1000	Max	10	Max	10000	1690	10000	7760	100000	55000		270000		230000.0	0.0	0.0	30000.0	189000.0		449000	
PFSAs																					
PFBS	1000	95 UCL	10	95 UCL		28	1	0.065		34000		237		10.0	0.0	0.0	204.0	3.3		217	
PFHxS	1000	Max	10	Max	100	42		690		86000		4146		96.0	0.0	0.0	3612.0	406.3		4114	
PFOS	10000	95 UCL	10	95 UCL		130		1790		1200000		139205		11000.0	0.0	0.0	115200.0	31181.9		157382	
PFDS	1000	Max	10	Max		260		2750	10000	50000		27384		26300.0	0.0	0.0	750.0	4792.2		31842	
FASAs																					
PFOSA	1000	Max	10	Max		130		1790		9800		480		390.0	0.0	0.0	67.6	7.7		465	
EtFASAAs and MeFASAAs																					
N-EtFOSAA	1000	95 UCL	10	95 UCL	1000	130	1000	1790	10000	12000		746		390.0	0.0	0.0	267.0	46.5		703	
N-MeFOSAA	1000	Max	10	Max		130		1790		120000		4007		390.0	0.0	0.0	3204.0	249.6		3844	

Notes:
Uptake models are described in detail in Section 3.3 of Conder et al. 2020 and briefly below.
See Acronyms & Abbreviations table for PFAS names.
1: Data must be added in provided units
2: Modeled value = Water * BAFplant
3: Modeled value = Water * BAFpi
4: Modeled value = Sed/OC * BSAF
5: Modeled value = BCFxWater + Σ(Conc Diet item*P item)*BMF
6: Where measurements or model predictions for PFAS are unavailable for at least one of the diet items of the forage fish, model predictions for concentrations in forage fish may be potentially underestimated (noted by "PU"). Where measurements or model predictions for PFAS are unavailable at least one of the diet items of the predatory fish, or when the concentrations in forage fish may be potentially underestimated, concentrations in the predatory fish may be potentially

Abbreviations:
dw - dry weight
ww - wet weight
L - liters
kg - kilogram
ng - nanograms

If the user did not type "Yes" on the Table 2 (Bioaccumulation Parameters) worksheet, some predictions for PFAS in aquatic plants, pelagic invertebrates, or benthic invertebrates will be listed as "n/a" and treated as zeros (i.e., no PFAS) in subsequent calculations used to predict concentrations of PFAS forage fish and predatory fish. In these cases, concentrations of PFAS in forage fish and predatory fish may be potentially underestimated, and a "PU" note is added adjacent to the model-predicted values. In cases in which measured values are available for relevant PFASs in the food web items (aquatic plants, pelagic invertebrates, and/or benthic invertebrates, depending on the specified dietary preferences of the fish), the measured value(s) will be used, and there will be no potential underestimation note next to the predicted concentration of PFAS in fish. If the concentration of PFAS in the forage or predatory fish has been measured and entered in the green cells, subsequent model calculations will use the measured value, and no PU note will be added.

6. TABLE 4. EXPOSURE POINT CONCENTRATIONS FOR ALL MEDIA (WORKSHEET: EPCS)

➢ **The fourth step in the Model Tool summarizes the available site-specific measurements and model predictions that will be used as Exposure Point Concentrations (EPCs) in the exposure modeling for wildlife receptors (birds and mammals) and aquatic life performed in the remainder of the ecological risk model.**

The "EPCs" worksheet provides the user with a printer friendly summary of EPCs for PFAS in various environmental media at the site. While Table 4 does not require any user input, it serves as a lookup table that is referenced in a number of equations in subsequent steps of the model. Table 4 populates cells using values from the "Data Input & FWM" worksheet (Table 3). In the event that measured site-specific PFAS concentrations were provided by the user in previous steps, those values will be preferentially selected for inclusion in Table 4. Remaining cells will be populated with modeled values from Table 3.

Users should be aware that while the uptake factors in the Modeling Tool represent the current state-of-the-science, limited validation of the current Model Tools has been performed. This is due to the limited scope of the current project and the limited number of AFFF site investigations featuring sufficient data to conduct a robust assessment of model accuracy. Evaluation performed to date (Larson et al., 2018) indicates good model performance, however, additional validation would improve confidence in the accuracy and conservatism of the model predictions. As with any modeling process within ecological risk assessment, users should consider and acknowledge uncertainty in modeled EPCs as part of evaluating risks, and carefully consider the need for model validation prior to final decision making.

Please note: There is a hidden row (Row 1) at the top of the "EPCs" worksheet that contains values supporting model formulae. This row should not be modified or deleted by the user, or a loss in model functionality may occur. Adding or deleting columns from this worksheet will also result in a loss of model functionality.

Test Site #1
Table 4: Exposure Point Concentrations for All Media

Analyte	Sediment EPC (ng/kg, dw)	Surface Water (ng/L)	Aquatic Plant EPC (ng/kg, ww)		Pelagic Invertebrate EPC (ng/kg, ww)		Benthic Invertebrate EPC (ng/kg, ww)		Forage Fish EPC (ng/kg, ww)			Predatory Fish EPC (ng/kg, ww)		
			Value	Basis	Value	Basis	Value	Basis	Value	Basis	Note	Value	Basis	Note
PFCAs														
PFBA	1000.0	10.0	39.0	Modeled	250.0	Modeled	170.0	Modeled	7.0	Modeled		6.4	Modeled	
PFPeA	1000.0	10.0	39.0	Modeled	350.0	Modeled	810.0	Modeled	6.7	Modeled		5.0	Modeled	
PFHxA	1000.0	10.0	100.0	Measured	100.0	Measured	1000.0	Measured	14.5	Modeled		12.8	Modeled	
PFHpA	1000.0	10.0	38.0	Modeled	690.0	Modeled	18000.0	Modeled	225.5	Modeled		204.3	Modeled	
PFOA	1000.0	10.0	100.0	Measured	1000.0	Measured	100000.0	Measured	1320.6	Modeled		1215.1	Modeled	
PFNA	1000.0	10.0	88.0	Modeled	1520.0	Modeled	160000.0	Modeled	12779.9	Modeled		13487.6	Modeled	
PFDA	1000.0	10.0	170.0	Modeled	1750.0	Modeled	100000.0	Modeled	12313.9	Modeled		13382.5	Modeled	
PFUnDA	1000.0	10.0	470.0	Modeled	2700.0	Modeled	62000.0	Modeled	33082.5	Modeled		38692.2	Modeled	
PFDoDA	1000.0	10.0	870.0	Modeled	3800.0	Modeled	55000.0	Modeled	188552.7	Modeled		243849.4	Modeled	
PFTrDA	1000.0	10.0	1920.0	Modeled	5500.0	Modeled	55000.0	Modeled	231042.7	Modeled		342813.2	Modeled	
PFTeDA	1000.0	10.0	10000.0	Measured	10000.0	Measured	100000.0	Measured	270000.0	Modeled		449000.0	Modeled	
PFSAs														
PFBS	1000.0	10.0	28.0	Modeled	1.0	Measured	34000.0	Modeled	236.9	Modeled		217.3	Modeled	
PFHxS	1000.0	10.0	100.0	Measured	690.0	Modeled	86000.0	Modeled	4146.2	Modeled		4114.3	Modeled	
PFOS	10000.0	10.0	130.0	Modeled	1790.0	Modeled	1200000.0	Modeled	139204.8	Modeled		157381.9	Modeled	
PFDS	1000.0	10.0	260.0	Modeled	2750.0	Modeled	10000.0	Measured	27384.2	Modeled		31842.2	Modeled	
FASAs														
PFOSA	1000.0	10.0	130.0	Modeled	1790.0	Modeled	9800.0	Modeled	479.9	Modeled		465.3	Modeled	
EtFASAAs and MeFASAAs														
N-EtFOSAA	1000.0	10.0	1000.0	Measured	1000.0	Measured	10000.0	Measured	746.0	Modeled		703.5	Modeled	
N-MeFOSAA	1000.0	10.0	130.0	Modeled	1790.0	Modeled	120000.0	Modeled	4007.0	Modeled		3843.6	Modeled	

Notes:
Table selects for Site-specific empirical data over modeled values where available.
See Acronyms & Abbreviations table for PFAS names.
PU: May be potentially underestimated (see Table 3).

Abbreviations:
dw - dry weight
EPC - exposure point concentration
kg - kilogram
L - liters
ng - nanograms
ww - wet weight

7. TABLES 5 & 6. TOXICITY REFERENCE VALUES FOR BIRDS AND MAMMALS (WORKSHEETS: TRVS_BIRDS AND TRVS_MAMMALS)

> ➢ **The fifth step in applying the Model Tool is to review and select PFAS toxicity benchmarks for comparison with wildlife (birds and mammals) exposure estimates.**

Worksheets "TRVs_birds" and "TRVs_mammals" contain a range of **low and high toxicity reference values (TRVs)** reported in the literature for various PFAS. TRVs in Tables 5 and 6 will be used to generate hazard quotients for avian (Table 5) and mammalian (Table 6) receptors at AFFF impacted sites in subsequent steps of the model. The tables also provide the basis upon which each of the TRVs was established, as well as the source from which the value was retrieved (in their respective "Reference" columns). Additionally, the user is encouraged to consider alternate model parameters from additional resources (i.e., Gobas et al. (2020) and Zodrow et al. (2020), as discussed in the Guidance).

While a range of TRVs are available for mammalian receptors exposed to various PFAS, a significant number of data gaps still exist. This is particularly true for avian receptors, as evidenced by the lack of TRVs for most PFAS (Table 5). The lack of reliable TRVs for PFAS complicates the process of evaluating potential risks to ecological receptors. Users may opt to provide their own TRVs in the "**User Input TRV Value**" columns in Tables 5 and 6 values (an adjacent column for any notes/rationale that may accompany the user-selected TRV is also provided).

Tables 5 & 6 also provide the user with an option to apply "read across" surrogate TRVs (derived for other PFAS) to some or all of the PFAS that do not have available TRVs:

- For avian receptors (Table 5), the user can opt to apply the avian TRV for PFOS to the three precursor compounds (i.e., PFOSA, N-EtFOSAA, and N-MeFOSAA) by typing "Yes" in the green highlighted cell at the top of Table 5. Surrogate TRVs are not substituted for other PFAS with missing values, due to the paucity of reliable TRVs available for avian receptors.

- For mammalian receptors, typing "Yes" in the similarly placed green highlighted cell at the top of Table 6 will prompt the model to apply surrogate mammalian TRVs for all missing values (i.e., not just precursors) in Table 6. Mammalian surrogate TRVs were selected by examining TRVs from PFCAs or PFSAs (whichever is appropriate) with perfluorocarbon chain lengths of $n + 1$ and $n – 1$ (where n = the number of carbons in the PFAS of interest) and selecting the more conservative (i.e., lower) of the two measured TRV values.

It is important to note that TRVs for individual PFAS may vary by orders of magnitude in relation to one another. Thus, while applying available TRVs for PFAS as surrogates for those missing values helps to provides some estimate of risk for PFAS for which a measured TRV is unavailable, this approach also introduces an additional source of uncertainty into the overall hazard evaluation. There is little scientific basis or precedent for the approaches used to derive the surrogate TRVs; therefore, the user should exercise appropriate professional caution and use professional judgement when selecting whether or not to apply surrogate values in the model. This approach is best used as a sensitivity analysis rather than primary risk estimate for decision making, and should include a thorough discussion of the inherent uncertainty involved when applied.

Type "Yes" here to apply the avian TRV for PFOS as a surrogate for <u>precursors</u>

Test Site #1
Table 5: Toxicity Reference Values - Birds

OPTIONAL: To apply surrogate TRVs to precursors only (FASAs and FASAAs) type "Yes" in green cell:

Analyte	TRV for Birds (mg/kg-day)							
	Low TRV	Basis	Reference	High TRV	Basis	Reference	User Input TRV Value	User Input TRV Value Notes or Rationale
PFCAs								
PFBA	No TRV	--	--	No TRV	--	--		
PFPeA	No TRV	--	--	No TRV	--	--		
PFHxA	No TRV	--	--	No TRV	--	--		
PFHpA	No TRV	--	--	No TRV	--	--		
PFOA	1	No effect on growth (body weight) of 1-day old chickens; exposed to PFOA/PFDA/PFOS mixture	Yeueng et al. 2009	No TRV	--	--		
PFNA	No TRV	--	--	No TRV	--	--		
PFDA	1	No effect on growth (body weight) of 1-day old chickens; exposed to PFOA/PFDA/PFOS mixture	Yeueng et al. 2009	No TRV	--	--		
PFUnDA	No TRV	--	--	No TRV	--	--		
PFDoDA	No TRV	--	--	No TRV	--	--		
PFTrDA	No TRV	--	--	No TRV	--	--		
PFTeDA	No TRV	--	--	No TRV	--	--		
PFSAs								
PFBS	88	No effect on growth (body weight) of northern bobwhite quail	Gallagher et al. (2005)	--	No High-TRV available	--		
PFHxS	No TRV	--	--	No TRV	--	--		
PFOS	0.77	No true 'no effect' values were available. 17% control-adjusted decrease in reproduction (14-day old survivors/eggs set) for northern bobwhite quail	Newsted et al. (2005, 2007)	2.64	16% control-adjusted decrease in survival of northern bobwhite quail	Newsted et al. (2005, 2007)		
PFDS	No TRV	--	--	No TRV	--	--		
FASAs								
PFOSA	No TRV	--	--	No TRV	--	--		
EtFASAAs and MeFASAAs								
N-EtFOSAA	No TRV	--	--	No TRV	--	--		
N-MeFOSAA	No TRV	--	--	No TRV	--	--		

Notes:
Details and full references for all TRVs can be found in Section 3.4 and Appendix C of Conder et al. 2019.
See Acronyms & Abbreviations table for PFAS names.

Abbreviations:
TRV - Toxicity Reference Value
mg/kg-day - milligrams per kilogram body weight per day

8. TABLE 7. DIRECT CONTACT EXPOSURES (WORKSHEET: DIRECT CONTACT EXPOSURES)

➢ **The sixth step in applying the Model Tool is to evaluate the potential for direct effects for water column aquatic life, such as fish, invertebrates, algae, and plants.**

The "Direct Contact Exposures" worksheet provides a quantitative evaluation of the potential for direct effects of PFAS in water to aquatic biota, based on a comparison between the concentration of individual PFAS in impacted surface waters and toxicity reference values for aquatic life. Prior to proceeding, the user should select whether they would like to evaluate hazard for freshwater or marine aquatic species, by typing an "X" in the appropriate green highlighted cell at the top of Table 7. This step will adjust the TRVs used to generate hazard quotients (HQs) to those that are appropriate for freshwater or marine water bodies.

The "**Surface Water EPC**" values for each PFAS in Table 7 are populated using EPC values in Table 4, while TRVs are based on either the 1st percentile (**HC1 or Low-TRV**) or 5th percentile (**HC5 or High-TRV**) of species sensitivity distributions (SSD) reported in Appendix D of Conder et al. (2020). Using these values, the model will provide both a low and a high estimate of hazard (i.e., **Low-HQ** and **High-HQ**, respectively) to aquatic biota, for each PFAS for which an SSD was developed. Additionally, the user is encouraged to consider alternate aquatic life risk-based concentrations from additional resources (i.e., Gobas et al. (2020) and Zodrow et al. (2020), as discussed in the Guidance).

Test Site #1
Table 7: Direct Contact Exposures Assessment and Hazard Characterization

Site Characteristics:	Freshwater	Marine	
	X		← Select with an "X"

Analyte	Surface Water EPC (ng/L)	Aquatic Life TRV (ng/L)		Hazard Quotient for Aquatic Life	
		Low-TRV (HC1)	High-TRV (HC5)	Low-TRV HQ	High-TRV HQ
PFCAs					
PFBA	10.00	--	--	--	--
PFPeA	10.00	--	--	--	--
PFHxA	10.00	--	--	--	--
PFHpA	10.00	--	--	--	--
PFOA	10.00	537,000	1,112,000	1.9E-05	9.0E-06
PFNA	10.00	--	--	--	--
PFDA	10.00	--	--	--	--
PFUnDA	10.00	--	--	--	--
PFDoDA	10.00	--	--	--	--
PFTrDA	10.00	--	--	--	--
PFTeDA	10.00	--	--	--	--
PFSAs					
PFBS	10.00	--	--	--	--
PFHxS	10.00	--	--	--	--
PFOS	10.00	560	5,850	1.8E-02	1.7E-03
PFDS	10.00	--	--	--	--
FASAs					
PFOSA	10.00	--	--	--	--
EtFASAAs and MeFASAAs					
N-EtFOSAA	10.00	--	--	--	--
N-MeFOSAA	10.00	--	--	--	--

Notes:
Details on SSD development can be found in Section 3.4.4. and Appendix D of Conder et al. 2019.
See Acronyms & Abbreviations table for PFAS names.
TRVs represent the 1st (HC1) and 5th (HC5) percentiles of the no-effect level based Species Sensitivity Distributions.
Hazard Quotients are calculated as EPC/TRV; HQ greater than 1 are shown in Bold
Abbreviations:
TRV - Toxicity Reference Value
HC1 - 1% Hazardous Concentration
HC5 - 5% Hazardous Concentration
EPC - Exposure Point Concentration
HQ - Hazard Quotient

9. TABLES 8, 9, 10, 11, 12, AND 13. EXPOSURE ASSESSMENT AND HAZARD CHARACTERIZATION- BIRDS (WORKSHEETS: BIRD1, BIRD2, BIRD3) AND MAMMALS (WORKSHEETS: MAMMAL1, MAMMAL2, MAMMAL 3)

- **The seventh step in applying the Model Tool is to evaluate the potential for risks to avian and mammalian wildlife receptors.**

Worksheets "Bird1" through "Bird3" and "Mam1" through "Mam3" provide estimates of the total daily PFAS intake (TDI) that user-specified avian and mammalian receptors are exposed to via consumption of various dietary items (i.e., sediment, surface water, aquatic vegetation, pelagic invertebrate, benthic invertebrate, forage fish, predatory fish).

TDIs are calculated using EPCs from Table 4 (on the "EPCs" worksheet), species-specific exposure parameters retrieved from Table 1 (on the "Exposure Factors" Worksheet), and the exposure model detailed on the worksheets[3]. In addition to providing numerical TDI estimates in Tables 8, 9, 10, 11, 12, and 13, the model also generates a stacked bar chart (located on worksheet "Figure1 – TDI") that provides the user with a visual representation of the relative contribution of individual PFAS to an organism's overall exposure.

Following the derivation of TDIs, the model will generate HQs by comparing TDIs with TRVs from Table 5 (on the "TRVs_birds" worksheet) or Table 6 (on the "TRVs_mammals" worksheet). Depending on the availability of TRVs, the model may generate up to three HQs for each PFAS, including a **Low-TRV HQ**, **High-TRV HQ**, and a **User-selected TRV-based HQ**[4].

If the user did not type "Yes" on the Table 2 (Bioaccumulation Parameters) worksheet, some predictions for PFAS in aquatic plants, pelagic invertebrates, or benthic invertebrates will be listed as "n/a" and treated as zeros (i.e., no PFAS) in subsequent calculations used to calculate TDI values and to predict concentrations of PFAS forage fish and predatory fish. In these cases, the concentrations of PFAS in wildlife diet items are potentially underestimated, a potential underestimation of exposure and risks to wildlife may also occur. TDI and HQ values affected by this potential underestimation are noted by a "PU" value in the rightmost "**TDI and HQ note**" column.

[3] Exposure calculations take into account **modified avian AUFs**. The modified avian AUFs account for consumption of fish that were impacted by site-associated PFAS, but that were caught by predators outside of the immediate Site boundaries. The rationale behind the derivation of modified AUFs and their algorithms for piscivorous receptors is presented in more detail in Conder et al. (2009). Also, model assumptions also include a **relative bioavailability (RB)** of 1 for all PFAS, which assumes 100% dietary availability of PFAS.
[4] User-selected TRVs and HQs are hidden in the default model view.

Test Site #1
Table 8: Exposure Assessment and Hazard Characterization
Receptor: Wood Duck

Analyte	RB	Sediment		Surface Water		Aquatic Vegetation		Pelagic Invertebrate		Benthic Invertebrate		Forage Fish [1]		Predatory Fish [1]		TDI_{total} [2]	TDI_{total} [2]	Low TRV	High TRV	Low-TRV HQ [3]	High-TRV HQ [3]	User-selected TRV	User-selected TRV-based HQ [3]	TDI and HQ Note [4]
		EPC	TDI_s	EPC	TDI_{sw}	EPC	TDI_{veg}	EPC	TDI_{pi}	EPC	TDI_{bi}	EPC	TDI_{ff}	EPC	TDI_{pf}									
		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	mg/kg-day	unitless	
PFCAs																								
PFBA	1	2.0E+02	4.7E-02	1.0E+01	2.1E-02	n/a	--	n/a	--	n/a	--	6.0E+00	--	6.0E+00	--	6.8E-02	6.8E-08	No TRV	No TRV	--	--	1.0E+00	6.8E-08	PU
PFPeA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	3.9E+01	2.6E-01	n/a	--	n/a	--	2.4E+00	--	2.3E+00	--	5.1E-01	5.1E-07	No TRV	No TRV	--	--	2.0E+00	2.6E-07	
PFHxA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	1.0E+02	6.6E-01	1.0E+02	--	1.0E+03	--	1.5E+01	--	1.3E+01	--	9.2E-01	9.2E-07	No TRV	No TRV	--	--	3.0E+00	3.1E-07	
PFHpA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	3.8E+01	2.5E-01	n/a	--	1.8E+04	--	2.2E+02	--	2.0E+02	--	5.1E-01	5.1E-07	No TRV	No TRV	--	--	4.0E+00	1.3E-07	
PFOA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	1.0E+02	6.6E-01	1.0E+03	--	1.0E+05	--	1.3E+03	--	1.2E+03	--	9.2E-01	9.2E-07	1.0E+00	No TRV	9.2E-07	--	--	--	
PFNA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	8.8E+01	5.8E-01	1.5E+03	--	1.6E+05	--	1.3E+04	--	1.3E+04	--	8.4E-01	8.4E-07	No TRV	No TRV	--	--	--	--	
PFDA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	1.7E+02	1.1E+00	1.8E+03	--	1.0E+05	--	1.2E+04	--	1.3E+04	--	1.4E+00	1.4E-06	1.0E+00	No TRV	1.4E-06	--	--	--	
PFUnDA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	4.7E+02	3.1E+00	2.7E+03	--	6.2E+04	--	3.3E+04	--	3.9E+04	--	3.4E+00	3.4E-06	No TRV	No TRV	--	--	--	--	
PFDoDA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	8.7E+02	5.8E+00	3.8E+03	--	5.5E+04	--	1.9E+05	--	2.4E+05	--	6.0E+00	6.0E-06	No TRV	No TRV	--	--	--	--	
PFTrDA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	1.9E+03	1.3E+01	n/a	--	5.5E+04	--	2.3E+05	--	3.4E+05	--	1.3E+01	1.3E-05	No TRV	No TRV	--	--	--	--	
PFTeDA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	1.0E+04	6.6E+01	1.0E+04	--	1.0E+05	--	2.7E+05	--	4.5E+05	--	6.7E+01	6.7E-05	No TRV	No TRV	--	--	--	--	
PFSAs																								
PFBS	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	2.8E+01	1.9E-01	1.0E+00	--	3.4E+04	--	2.4E+02	--	2.2E+02	--	4.4E-01	4.4E-07	8.8E+01	No TRV	5.0E-09	--	--	--	
PFHxS	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	1.0E+02	6.6E-01	n/a	--	8.6E+04	--	4.1E+03	--	4.1E+03	--	9.2E-01	9.2E-07	No TRV	No TRV	--	--	--	--	
PFOS	1	5.0E+04	1.2E+01	1.0E+03	2.1E+00	1.3E+04	8.6E+01	1.8E+05	--	6.0E+06	--	1.8E+06	--	2.1E+06	--	1.0E+02	1.0E-04	7.7E-01	2.6E+00	1.3E-04	3.8E-05	--	--	
PFDS	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	n/a	--	n/a	--	1.0E+04	--	2.7E+04	--	3.2E+04	--	2.5E-01	2.5E-07	No TRV	No TRV	--	--	--	--	PU
FASAs																								
PFOSA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	n/a	--	n/a	--	9.8E+03	--	4.7E+02	--	4.7E+02	--	2.5E-01	2.5E-07	No TRV	No TRV	--	--	--	--	PU
EtFASAAs and MeFASAAs																								
N-EtFOSAA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	1.0E+03	6.6E+00	1.0E+03	--	1.0E+04	--	7.5E+02	--	7.0E+02	--	6.9E+00	6.9E-06	No TRV	No TRV	--	--	--	--	
N-MeFOSAA	1	1.0E+03	2.3E-01	1.0E+01	2.1E-02	n/a	--	n/a	--	n/a	--	3.9E+02	--	4.1E+02	--	2.5E-01	2.5E-07	No TRV	No TRV	--	--	--	--	PU

Notes:
[1] Areas Use Factors for avians are calculated to account for consumption of fish outside of Site areas but that have been exposed to the site. See Conder et al. 2009 for details.
Bird+Forage Fish AUF 0.04
Bird+Predatory Fish AUF 0.04

[2] Media-specific Total Daily Dose (TDI) is calculated using the following general equation and receptor specific parameters:
$TDI_{i,copc}$ = (EPC_{copc} x RB x FIR x P_i) + (DWI x EPC) x AUF x (1/BW), *where:*

Variable	*Value*	*Units*	*Variable Description*
TDI_i		mg/kg-day	Total Daily Intake for Dietary Item "*i*" for COPC
EPC	see above	ng/kg, ng/L	Exposure Point Concentration for each media
RB		unitless	Relative Bioavailability (only for sediment portion of diet; assumed to be 1 for all chemicals)
P_{veg}	1.00	proportion	Proportion of Diet -- Vegetation
P_{pi}	-	proportion	Proportion of Diet -- Pelagic Invertebrates
P_{bi}	-	proportion	Proportion of Diet -- Benthic Invertebrates
P_{ff}	-	proportion	Proportion of Diet -- Forage Fish
P_{pf}	-	proportion	Proportion of Diet -- Predatory Fish
P_{so}	0.11	proportion	Proportion of Diet -- Sediment
FIRdw	0.04	kg/day	Daily Food Ingestion (dry weight, used for sediment)
FIRww	0.13	kg/day	Daily Food Ingestion (wet weight, used for tissue)
DWI	0.04	L/day	Daily Drinking Water Ingestion Rate
AUF	0.04	proportion	Area Use Factor
BW	0.7	kg	Body Weight

[3] HQ = TDI/TRV; HQ greater than 1 are shown in **Bold**
[4] = Where measurements or model predictions for PFAS are unavailable for at least one of the diet items of receptor, TDI and HQ values may be potentially underestimated (noted by "PU").

Abbreviations:

dw - dry weight	L - liters	HQ - Hazard Quotient (unitless)	PU - Potentially Underestimated
ww - wet weight	kg - kilogram	TDI - Total Daily Intake (mg/kg-day)	
ng - nanograms	mg - milligram	TRV - Toxicity reference value	

10. SUMMARY (WORKSHEET: HQSUM)

> ➢ **The eighth step in applying the Model Tool is to review the summary of the potential for risks to avian and mammalian wildlife receptors.**

The "HQSum" worksheet contains a table populated with all HQs (i.e., Low-HQ, High-HQ, User Selected TRV-based HQ) that were generated by the model for both avian and mammalian receptors. No inputs are required on this worksheet; rather, it serves as a printer-friendly summary table for the user.

Test Site #1

Table 14: Hazard Quotient Summary

Analyte	Hazard Quotients (HQ) - Recommended TRVs											
	Wood Duck		Spotted sandpiper		Osprey		Muskrat		Southern Sea Otter		Steller sea lion	
	Low-TRV HQ	High-TRV HQ	Low-TRV HQ	High-TRV HQ	Low-TRV HQ	High-TRV HQ	Low-TRV HQ	High-TRV HQ	Low-TRV HQ	High-TRV HQ	Low-TRV HQ	High-TRV HQ
PFCAs												
PFBA	--	--	--	--	--	--	2.6E-07	--	7.9E-11	--	4.5E-11	--
PFPeA	--	--	--	--	--	--	--	--	--	--	--	--
PFHxA	--	--	--	--	--	--	2.5E-06	3.7E-07	1.4E-08	2.1E-09	1.1E-10	1.7E-11
PFHpA	--	--	--	--	--	--	--	--	--	--	--	--
PFOA	9.2E-07	--	5.4E-02	--	1.2E-06	--	2.7E-03	2.5E-04	3.3E-05	3.0E-06	1.1E-07	9.9E-09
PFNA	--	--	--	--	--	--	6.7E-03	5.0E-03	8.4E-05	6.3E-05	1.7E-06	1.3E-06
PFDA	1.4E-06	--	5.4E-02	--	1.3E-05	--	1.2E-02	3.5E-03	1.5E-04	4.4E-05	4.6E-06	1.4E-06
PFUnDA	--	--	--	--	--	--	7.8E-03	2.3E-03	1.0E-04	3.0E-05	1.3E-05	4.0E-06
PFDoDA	--	--	--	--	--	--	4.5E-03	9.0E-04	9.3E-05	1.9E-05	5.0E-05	1.0E-05
PFTrDA	--	--	--	--	--	--	--	--	--	--	--	--
PFTeDA	--	--	--	--	--	--	2.2E-03	6.5E-04	2.7E-05	8.1E-06	1.5E-05	4.6E-06
PFSAs												
PFBS	5.0E-09	--	2.1E-04	--	2.4E-09	--	3.9E-06	1.2E-06	4.8E-08	1.4E-08	7.6E-11	2.3E-11
PFHxS	--	--	--	--	--	--	9.9E-03	3.0E-03	1.2E-04	3.7E-05	1.4E-06	4.2E-07
PFOS	1.3E-04	3.8E-05	**4.2E+00**	**1.2E+00**	2.6E-03	7.5E-04	**2.1E+00**	5.4E-01	2.8E-02	6.9E-03	2.1E-03	5.3E-04
PFDS	--	--	--	--	--	--	--	--	--	--	--	--
FASAs												
PFOSA	--	--	--	--	--	--	--	--	--	--	--	--
EtFASAAs and MeFASAAs												
N-EtFOSAA	--	--	--	--	--	--	--	--	--	--	--	--
N-MeFOSAA	--	--	--	--	--	--	--	--	--	--	--	--

Notes:
HQ greater than 1 are shown in **Bold**
See Acronyms & Abbreviations table for PFAS names.

Abbreviations:
HQ - Hazard Quotient (unitless)
TRV - Toxicity reference value

11. REFERENCES

Bent, A.C. 1929. Life histories of North American shorebirds. Part 2. U.S. Natl. Mus. Bull. 146. 412 pp.

Bertin, D., Ferrari, B. J. D., Labadie, P., Sapin, A., Garric, J., Budzinski, H., … Babut, M. (2014). Bioaccumulation of perfluoroalkyl compounds in midge (*Chironomus riparius*) larvae exposed to sediment. Environmental Pollution, 189, 27–34. https://doi.org/10.1016/j.envpol.2014.02.018

Beyer, W.N., Perry, M.C., Osenton, P.C. (2008). Sediment ingestion rates in waterfowl (*Anatidae*) and their use in environmental risk assessment. Integrated Environmental Assessment and Management, 4 (2), 246-251.

Brandsma, S. H., Smithwick, M., Solomon, K., Small, J., de Boer, J., & Muir, D. C. (2011). Dietary exposure of rainbow trout to 8: 2 and 10: 2 fluorotelomer alcohols and perfluorooctanesulfonamide: Uptake, transformation and elimination. Chemosphere, 82(2), 253-258.

Butenhoff, J. L., Chang, S.-C., Ehresman, D. J., & York, R. G. (2009). Evaluation of potential reproductive and developmental toxicity of potassium perfluorohexanesulfonate in Sprague Dawley rats. Reproductive Toxicology, 27(3–4), 331–341. https://doi.org/10.1016/j.reprotox.2009.01.004

California Department of Fish and Game (CDFG) (2005). California Interagency Wildlife Task Group. California Wildlife Habitat Relationships System. Spotted sandpiper. Sacramento, CA.

Chang, S., Butenhoff, J. L., Parker, G. A., Coder, P. S., Zitzow, J. D., Krisko, R. M., … Seed, J. G. (2018). Reproductive and developmental toxicity of potassium perfluorohexanesulfonate in CD-1 mice. Reproductive Toxicology, 78, 150–168. https://doi.org/10.1016/j.reprotox.2018.04.007

Chen, F., Gong, Z., & Kelly, B. C. (2016). Bioavailability and bioconcentration potential of perfluoroalkyl-phosphinic and -phosphonic acids in zebrafish (*Danio rerio*): Comparison to perfluorocarboxylates and perfluorosulfonates. Science of The Total Environment, 568, 33–41. https://doi.org/10.1016/j.scitotenv.2016.05.215

Conder J, Arblaster J, Larson E, Brown J, Higgins C. (2020). Guidance for Assessing the Ecological Risks of PFAS to Threatened and Endangered Species act Aqueous Film Forming Foam-Impacted Sites. SERDP Project ER18-1614. https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER18-1614.

Conder, JM; Sorensen, MT; Leitman, P; Martello, LB; Wenning, RJ (2009). Avian ecological risk potential in an urbanized estuary: Lower Hackensack River, New Jersey, U.S.A. Science of The Total Environment 407(3): 1035-1047. https://doi.org/10.1016/j.scitotenv.2008.09.043.

Custer, C.M.; Galli, J. (2002). Feeding habitat selection by great blue herons and great egrets nesting in east central Minnesota. Waterbirds 25: 115-124.

Dai, Z., Xia, X., Guo, J., & Jiang, X. (2013). Bioaccumulation and uptake routes of perfluoroalkyl acids in *Daphnia magna*. Chemosphere, 90, 1589–1596. https://doi.org/10.1016/j.chemosphere.2012.08.026

Delnicki, D., & Reinecke, K. J. (1986). Mid-winter food use and body weights of mallards and wood ducks in Mississippi. The Journal of wildlife management, 43-51.

De Solla, S. R., De Silva, A. O., & Letcher, R. J. (2012). Highly elevated levels of perfluorooctane sulfonate and other perfluorinated acids found in biota and surface water downstream of an international airport, Hamilton, Ontario, Canada. Environment international, 39(1), 19-26.

Gallagher, S. P., Van Hoven, R. L., Beavers, J. B., & Jaber, M. (2005). Final Report T-7485: A Reproduction Study with the Northern Bobwhite (Project No. 454-116; p. 444). St. Paul, MN: Wildlife International, LTD (3M Corporation sponsor).

Gobas, F. A. P. C., Kelly, B., Kim, J. (2020). A Framework for Assessing Bioaccumulation and Exposure Risks of Per- and Polyfluoroalkyl Substances in Threatened and Endangered Species on Aqueous Film Forming Foam (AFFF)-Impacted Sites. SERDP Contract Report ER18-1502. https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER18-1502

Goeritz, I., Falk, S., Stahl, T., Schäfers, C., & Schlechtriem, C. (2013). Biomagnification and tissue distribution of perfluoroalkyl substances (PFASs) in market-size rainbow trout (*Oncorhynchus mykiss*). Environ. Toxicol. Chem., 32(9), 2078–2088. https://doi.org/10.1002/etc.2279

Harris, M. W., & Birnbaum, L. S. (1989). Developmental Toxicity of Perfluorodecanoic Acid in C57BL/6N Mice. Fundamental and Applied Toxicology, 12, 442–448.

Higgins, C. P., Mcleod, Pamela, B., Macmanus-Spencer, L. A., & Luth. (2007). Bioaccumulation of Perfluorochemicals in Sediments by the Aquatic Oligochaete *Lumbriculus variegatus*. Environ. Sci. Technol, 41(13), 4600–4606. https://doi.org/10.1021/es062792o

Hirata-Koizumi, M., Fujii, S., Hina, K., Matsumoto, M., Takahashi, M., Ono, A., & Hirose, A. (2015). Repeated dose and reproductive/developmental toxicity of long-chain perfluoroalkyl carboxylic acids in rats: perfluorohexadecanoic acid and perfluorotetradecanoic acid. Fundamental Toxicological Sciences, 2(4), 177–190. https://doi.org/10.2131/fts.2.177

Hong, S., Khim, J. S., Wang, T., Naile, J. E., Park, J., Kwon, B. O., ... & Lu, Y. (2015). Bioaccumulation characteristics of perfluoroalkyl acids (PFAAs) in coastal organisms from the west coast of South Korea. Chemosphere, 129, 157-163.

Kato, H., Fujii, S., Takahashi, M., Matsumoto, M., Hirata-Koizumi, M., Ono, A., & Hirose, A. (2015). Repeated dose and reproductive/developmental toxicity of perfluorododecanoic acid in rats. Environmental Toxicology, 30(11), 1244–1263. https://doi.org/10.1002/tox.21996

Klaunig, J. E., Shinohara, M., Iwai, H., Chengelis, C. P., Kirkpatrick, J. B., Wang, Z., & Bruner, R. H. (2015). Evaluation of the Chronic Toxicity and Carcinogenicity of Perfluorohexanoic Acid (PFHxA) in Sprague-Dawley Rats. Toxicologic Pathology, 43(2), 209–220. https://doi.org/10.1177/0192623314530532

Larson, E. S., Conder, J. M., & Arblaster, J. A. (2018). Modeling avian exposures to perfluoroalkyl substances in aquatic habitats impacted by historical aqueous film forming foam releases. Chemosphere, 201, 335–341. https://doi.org/10.1016/j.chemosphere.2018.03.004

Lasier, P. J., Washington, J. W., Hassan, S. M., & Jenkins, T. M. (2011). Perfluorinated chemicals in surface waters and sediments from northwest Georgia, USA, and their bioaccumulation in *Lumbriculus variegatus*. Environ. Toxicol. Chem., 30(10), 2194–2201. https://doi.org/10.1002/etc.622

Lieder, P. H., York, R. G., Hakes, D. C., Chang, S.-C., & Butenhoff, J. L. (2009). A two-generation oral gavage reproduction study with potassium perfluorobutanesulfonate (K+PFBS) in Sprague Dawley rats. Toxicology, 259(1–2), 33–45. https://doi.org/10.1016/j.tox.2009.01.027

Liu, W., He, W., Wu, J., Qin, N., He, Q., & Xu, F. (2018). Residues, bioaccumulations and biomagnification of perfluoroalkyl acids (PFAAs) in aquatic animals from Lake Chaohu, China. Environmental Pollution, 240, 607-614.

Luebker, D. J., York, R. G., Hansen, K. J., Moore, J. A., & Butenhoff, J. L. (2005). Neonatal mortality from in utero exposure to perfluorooctanesulfonate (PFOS) in Sprague–Dawley rats: dose–response, and biochemical and pharamacokinetic parameters. Toxicology, 215(1-2), 149-169.

Martin JW, Asher BJ, Beesoon S, Benskin JP, Ross MS. (2010). PFOS or PreFOS? Are perfluorooctane sulfonate precursors (PreFOS) important determinants of human and environmental perfluorooctane sulfonate (PFOS) exposure? J Environ Monit 12:1979-2004. https://doi.org/10.1039/c0em00295j.

Minns, C. K. (1995). Allometry of home range size in lake and river fishes. Canadian Journal of Fisheries and Aquatic Sciences, 52(7), 1499-1508.

Munoz, G., Budzinski, H., Babut, M., Drouineau, H., Lauzent, M., Menach, K. L., ... & Labadie, P. (2017). Evidence for the trophic transfer of perfluoroalkylated substances in a temperate macrotidal estuary. Environmental science & technology, 51(15), 8450-8459.

Nagy K. 2001. Food requirements of wild animals: predictive equations for free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews:21R-31R.

NatureServe (2019). NatureServe Explorer: An Online Encyclopedia of Life. Available from: http://explorer.natureserve.org/

Newsted, J. L., Jones, P. D., Coady, K., & Giesy, J. P. (2005). Avian toxicity reference values for perfluorooctane sulfonate. Environmental science & technology, 39(23), 9357-9362.

Newsted, J. L., Coady, K. K., Beach, S. A., Butenhoff, J. L., Gallagher, S., & Giesy, J. P. (2007). Effects of perfluorooctane sulfonate on mallard and northern bobwhite quail exposed chronically via the diet. Environmental Toxicology and Pharmacology, 23(1), 1-9.

North Carolina Wildlife Resources Commission. (2019). Wildlife Profiles. Available from: https://www.ncwildlife.org/learning/species

North Pacific Universities Marine Mammal Research Consortium (2017). Stellar sea lion biology. Available from: http://www.marinemammal.org/biology/steller-sea-lion/

Pi, N., Ng, J. Z., & Kelly, B. C. (2017). Uptake and elimination kinetics of perfluoroalkyl substances in submerged and free-floating aquatic macrophytes: results of mesocosm experiments with *Echinodorus horemanii* and *Eichhornia crassipes*. Water research, 117, 167-174.

Sample, B.E., Aplin, M.S., Efroymson, R.A., Suter G.W., II. Welsh, C.J.E. (1997). Methods and tools for estimation of the exposure of terrestrial wildlife to contaminants.

Takahashi, M., Ishida, S., Hirata-Koizumi, M., Ono, A., & Hirose, A. (2014). Repeated dose and reproductive/developmental toxicity of perfluoroundecanoic acid in rats. J. Toxicol. Sci., 39(1), 97–108. https://doi.org/10.2131/jts.39.97

Teo, S. L. H., & Able, K. W. (2003). Habitat use and movement of the mummichog (*Fundulus heteroclitus*) in a restored salt marsh. Estuaries, 26(3), 720-730.

Butenhoff, J. L., Kennedy, G. L., Chang, S.-C., & Olsen, G. W. (2012). Chronic dietary toxicity and carcinogenicity study with ammonium perfluorooctanoate in Sprague–Dawley rats. Toxicology, 298(1–3), 1–13. https://doi.org/10.1016/j.tox.2012.04.001

Tinker, M. T., Tomoleoni, J., LaRoche, N., Bowen, L., Miles, A. K., Murray, M., Randell, Z. (2017). Southern sea otter range expansion and habitat use in the Santa Barbara Channel, California (No. 2017-1001). US Geological Survey.

US Fish and Wildlife Service (2020). Southern Sea Otter. Available from: https://www.fws.gov/ventura/endangered/species/info/sso.html

U.S. EPA. (1993). Wildlife exposure factors handbook [EPA Report]. (EPA/600/R-93/187). Washington, DC: Office of Research and Development.

van Otterdijk, F. M. (2007). Repeated Dose 90-Day Oral Toxicity Study with MTDID 8391 by Daily Gavage in the Rat Followed by a 3-week Recovery Period (3M Study No. 06-398; NOTOX Project 484492; p. 346). The Netherlands: NOTOX B.V. (sponsored by 3M Medical Department).

Weller, R. R. (1996). Seasonal variations in home range size and habitat preference of flathead catfish in a West Texas reservoir (Doctoral dissertation, Texas Tech University).

Wen, W., Xia, X., Hu, D., Zhou, D., Wang, H., Zhai, Y., & Lin, H. (2017). Long-Chain Perfluoroalkyl acids (PFAAs) Affect the Bioconcentration and Tissue Distribution of Short-Chain PFAAs in Zebrafish (*Danio rerio*). Environ. Sci. Technol., 51(21), 12358–12368. https://doi.org/10.1021/acs.est.7b03647

Wolf, C. J., Zehr, R. D., Schmid, J. E., Lau, C., & Abbott, B. D. (2010). Developmental Effects of Perfluorononanoic Acid in the Mouse Are Dependent on Peroxisome Proliferator-Activated Receptor-Alpha. PPAR Research, 2010, 1–11. https://doi.org/10.1155/2010/282896

Yeung, L. W., Loi, E. I., Wong, V. Y., Guruge, K. S., Yamanaka, N., Tanimura, N., ... & Lam, P. K. (2009). Biochemical responses and accumulation properties of long-chain perfluorinated compounds (PFOS/PFDA/PFOA) in juvenile chickens (*Gallus gallus*). Archives of environmental contamination and toxicology, 57(2), 377-386.

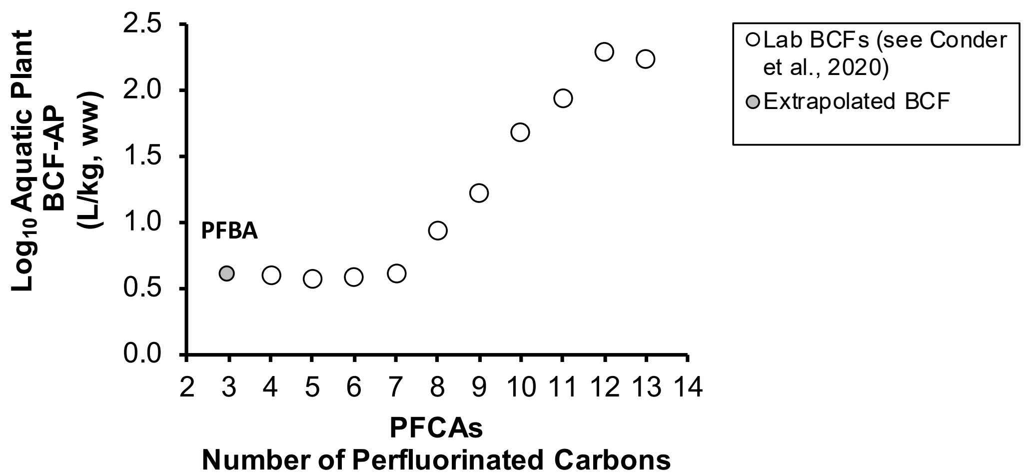
Zodrow, J., Frenchmeyer, M., Dally, K., Osborn, E., Anderson, P., Divine, C. (2020). Per- and Polyfluoroalkyl Substances Ecological Risk-Based Screening Levels. SERDP Contract Report ER18-1653. https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/ER18-1653

ATTACHMENT 1: SUPPORTING INFORMATION REGARDING THE DERIVATION SURROGATE BIOACCUMULATION PARAMETERS

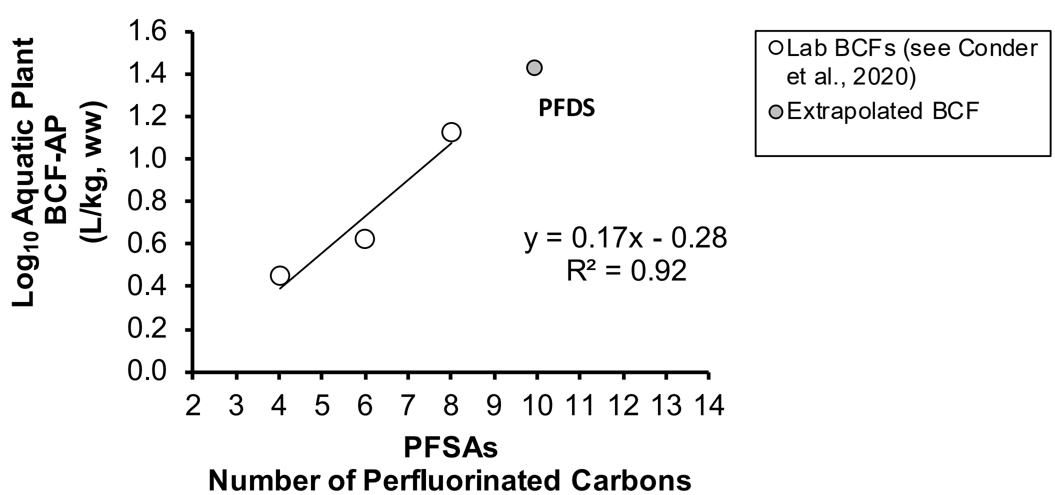
This attachment describes the derivation of the surrogate bioaccumulation parameters that are available to be selected in cases for which bioaccumulation parameters are not available (as detailed in the Guidance Document).

Aquatic Plant Bioconcentration Factors

The BCF value for PFBA in aquatic plants was assumed to be equal to that of the PFCAs of similar perfluorocarbon length (BCF-APs are reviewed in Conder et al. (2020)), as shown below.

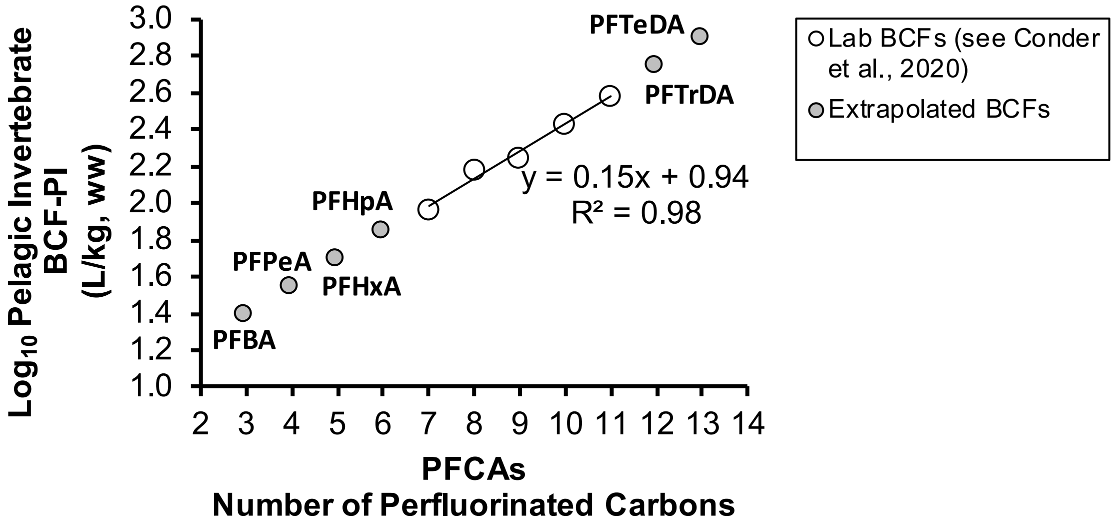


The BCF value for PFDS in aquatic plants was extrapolated using the model shown in the figure below, which was derived from available empirical information from other PFSAs.

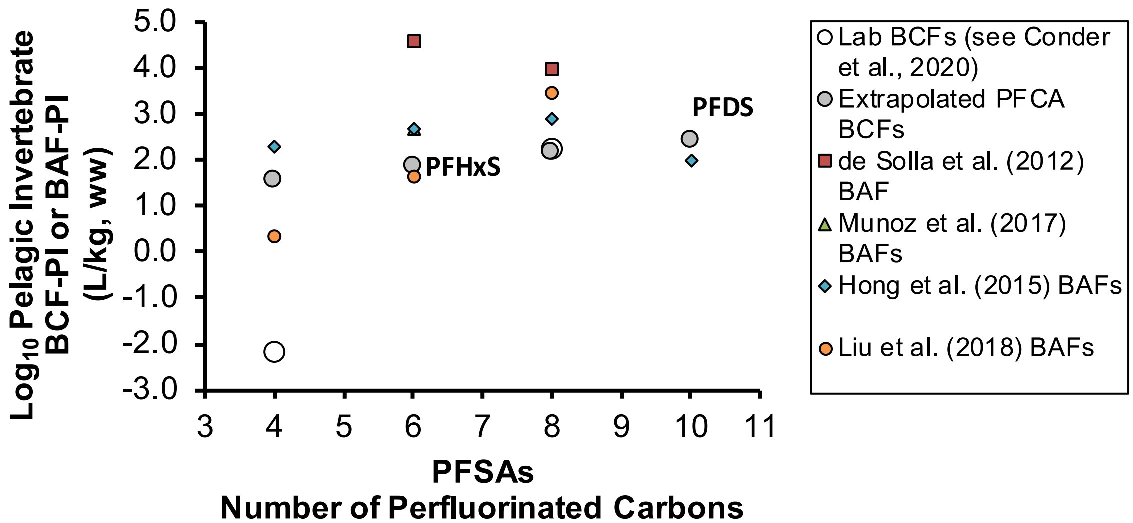


Pelagic Invertebrate Bioconcentration Factors

The water to pelagic invertebrate BCF values for PFBA, PFPeA, PFHxA, PFHpA, PFTrDA, and PFTeDA were extrapolated using the model shown in the figure below, which was derived from available empirical information from other PFCAs.

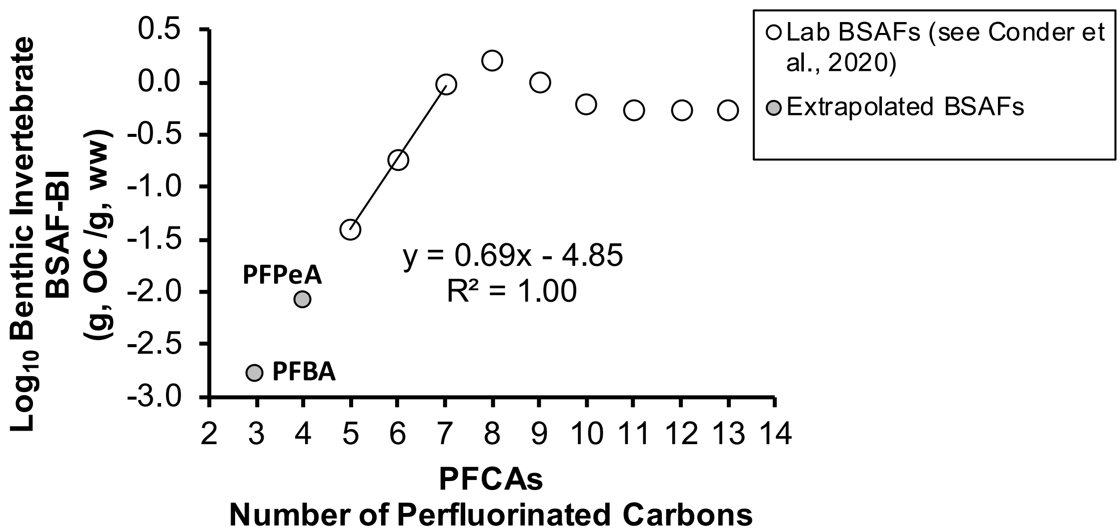


The water to pelagic invertebrate BCF values for PFHxS and PFDS were extrapolated using the model developed for PFCAs (above), as only a limited number of measured BCFs were available for PFSAs. When applied to PFSAs, predicted values for the 4-perfluorocarbon PFSA (PFBS) and 8-perfluorocarbon PFSA (PFOS) are similar to or higher than those measured empirically (Lab BCFs). Field BAFs for pelagic invertebrates are highly variable (likely due to variability/uncertainty around water exposure concentrations), but the extrapolated BCFs are within the ranges of these field BAFs.



Biota-sediment Accumulation Factors

The sediment to benthic invertebrate BSAF values for PFBA and PFPeA were extrapolated using the model shown in the figure below, which was derived from available empirical information from other PFCAs of 5, 6, and 7 perfluorocarbons.



Precursor PFAS

Where empirical values were unavailable, aquatic plant BCF, water to pelagic invertebrate BCF, sediment to benthic invertebrate BSAF values for precursor compounds (PFOSA, N-EtFOSAA, and N-MeFOSAA) were assumed to be equal to their respective values for PFOS. This assumption was made due to a combination of factors, including the potential for all three compounds to fully or partially transform to PFOS under certain environmental conditions, as well as laboratory evidence that tentatively suggests these compounds have similar bioaccumulative potentials to that of PFOS under controlled conditions (reviewed in Martin et al., 2010).

ATTACHMENT 2: MODEL TOOL DEMONSTRATION FOR NAVY SITE 1

To demonstrate the use of the Model Tool, data for PFAS in surface water, sediment and soil were obtained for a representative DoD Site (referred to herein as Navy Site 1). This demonstration is a hypothetical example of how the model can be used using real-world data, and does not represent a complete ERA for Navy Site 1. The use of this data is included only as demonstration of the Model Tool and the risk-focused conclusions from the model output are for illustrative purposes only.

First, the representative species for the aquatic portion of the site were selected from the drop-down menu of Table 1: Exposure Factors for Selected Receptors. Navy Site 1 was assumed to feature a freshwater aquatic system, so drinking water use for wildlife was selected by making an "X" in the green selection cell. Fish and wildlife receptors typically used at freshwater ecological risk assessments were selected from the drop-down menus. An aquatic exposure area was estimated by evaluating the size of the habitat assumed to be represented by the available PFAS sediment and water samples. This value (84 acres) was entered into the green Site Area cell.

Size of aquatic area added here in acres

Selected to include drinking water use here

Navy Site 1

Site Area (acres): 84

Type an "X" in the green box if surface water is a drinking water source for wildlife at your site: x

Table 1: Exposure Factors for Selected Receptors

Selected from included receptor here

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**	**Belted Kingfisher**	**Great Blue Heron**	**Muskrat**	**Mink**	**River Otter**
				Lepomis macrochirus	*Micropterus salmoides*	*Aix sponsa*		*Ardea herodias*	*Ondatra zibethicus*	*Neovison vison*	*Lontra canadensis*
BW	Body Weight		kg	--	--	0.700	0.147	2.400	1.200	1.000	8.000
FIR_{dw}	Daily Food Ingestion Rate (dry matter)	[1]	kg, dw/day	--	--	0.041	0.023	0.108	0.102	0.040	0.275
FIR_{ww}	Daily Food Ingestion Rate (wet matter)	[2]	kg, ww/day	--	--	0.127	0.105	0.432	0.408	0.160	0.784
P_{veg}	Proportion of Diet - Vegetation		kg diet item, ww/kg diet, ww	0.33	0.00	1.00	0.00	-	0.80	0.10	-
P_{bi}	Proportion of Diet - Benthic Invertebrates		kg diet item, ww/kg diet, ww	0.33	0.30	-	0.20	0.20	0.10	0.10	0.10
P_{pi}	Proportion of Diet - Pelagic Invertebrates		kg diet item, ww/kg diet, ww	0.33	0.00	-	0.00	-	0.10	0.10	-
P_{ff}	Proportion of Diet - Forage Fish		kg diet item, ww/kg diet, ww	NA	0.70	-	0.50	0.80	-	0.20	0.20
P_{pf}	Proportion of Diet - Predatory Fish		kg diet item, ww/kg diet, ww	NA	NA	-	0.30	-	-	0.50	0.70
P_{so}	Proportion of Diet - Sediment		kg sediment, dw/kg diet, dw	NA	NA	0.[illegible]10	0.020	0.004	0.020	0.030	-
DWI	Daily Water Ingestion		L/day	NA	NA	0.041	0.016	0.108	0.882	0.055	0.410
HR	Home Range		acres	1.80	8.50	274.00	143.00	780.00	0.32	19.00	864.00
AUF	Area Use Factor	[5]	proportion	1.000	1.000	0.307	0.587	0.108	1.000	1.000	0.097

Manually added Exposure Factors for preferred receptor here

Added Manually

Second, On the Bioaccumulation Parameters tab (Table 2: Bioaccumulation Parameters), the option to include surrogates/QSARs for data gaps was checked "Yes" by making an "X" in the green selection cell to allow the evaluation of as many PFAS as possible.

Third, 95 Upper Confidence Limits on the Mean (95UCL) were calculated for the concentrations of PFAS in surface water and sediment using measurements of samples collected at the site. Units were converted from µg/kg to ng/kg for sediment 95UCLs. These values were input manually into Table 3: Site-specific Data Entry and Food Web Model. To the right of the values, "95UCL" was entered for most PFAS to specify the basis for the values. Since the maximum measured concentration of PFHxA was used, "Max" was noted for this value. No site-specific tissue data have been collected, so only abiotic data were entered (green cells under the "Site-specific Value" for aquatic plants, invertebrates, and fish were left blank). PFAS that were all non-detect in sediment and water at the site were not included. As organic carbon data for sediment was not available, the default of 1% was assumed.

Navy Site 1
Table 3: Site-specific Data Entry and Food Web Model
Fraction Organic Carbon (kg OC/kg sediment dw) 0.01
Basis Average

Analyte	Sediment (ng/kg dw)		Water (ng/L)		Aquatic Plant (ng/kg ww)		Pelagic Invertebrate (ng/kg ww)		Benthic Invertebrate (ng/kg ww)		Forage Fish (ng/kg ww)			Predatory Fish (ng/kg ww)		
	Site-Specific Value [1]	Basis	Site-Specific Value [1]	Basis	Site-Specific Value [1]	Modeled Value [2]	Site-Specific Value [1]	Modeled Value [3]	Site-Specific Value [1]	Modeled Value [4]	Site-Specific Value [1]	Modeled Value [5]	Modeled Value Note [6]	Site-Specific Value [1]	Modeled Value [5]	Modeled Value Note [6]
PFCAs																
PFBA			7	95UCL		26		168		0		4			4	
PFPeA			13	95UCL		51		457		0		5			3	
PFHxA	1,250	Max	120	95UCL		445		5,895		5,000		155			114	
PFHpA			13	95UCL		50		903		0		52			43	
PFOA	1,352	95UCL	140	95UCL		574		12,749		128,440		2,356			2,087	
PFNA			2	95UCL		18		308		0		104			96	
PFDA			0.67	95UCL		11		118		0		312			353	
PFUnDA			0.57	95UCL		27		153		0		1,545			1,831	
PFDoDA						0		0		0		0			0	
PFTrDA						0		0		0		0			0	
PFTeDA						0		0		0		0			0	
PFSAs																
PFBS			15	95UCL		43		0		0		16			16	
PFHxS	2,860	95UCL	460	95UCL		1,934		31,768		245,960		17,471			16,462	
PFOS	6,600	95UCL	157	95UCL		2,046		28,175		792,000		260,844			307,601	
PFDS						0		0		0		0			0	
FASAs																
PFOSA			2	95UCL		28		382		0		86			85	
EtFASAAs and MeFASAAs																
N-EtFOSAA						0		0		0		0			0	
N-MeFOSAA						0		0		0		0			0	

Fourth, to illustrate the ability to customize TRVs in the model, an alternate avian TRV for PFOS was entered into the green “User Input TRV Value” cell for PFAS in Table 5: Toxicity Reference Values- Birds. This value was 0.077 mg/kg-day. Surrogate TRVs were not included for analysis by leaving the green selection box blank.

Navy Site 1

Did not include surrogate TRVs here

Table 5: Toxicity Reference Values- Birds

OPTIONAL: To apply Surrogate TRVs to precursors only (FASAs and FASAAs) type "Yes" in green cell:

Analyte	TRV for Birds (mg/kg-day)							
	Low TRV	Basis	Reference	High TRV	Basis	Reference	User Input TRV Value	User Input TRV Value Notes or Rationale
PFCAs								
PFBA	No TRV	--	--	No TRV	--	--		
PFPeA	No TRV	--	--	No TRV	--	--		
PFHxA	No TRV	--	--	No TRV	--	--		
PFHpA	No TRV	--	--	No TRV	--	--		
PFOA	1	No effect on growth (body weight) of 1-day old chickens; exposed to PFOA/PFDA/PFOS mixture	Yeung et al. 2009	No TRV	--	--		
PFNA	No TRV	--	--	No TRV	--	--		
PFDA	1	No effect on growth (body weight) of 1-day old chickens; exposed to PFOA/PFDA/PFOS mixture	Yeung et al. 2009	No TRV	--	--		
PFUnDA	No TRV	--	--	No TRV	--	--		
PFDoDA	No TRV	--	--	No TRV	--	--		
PFTrDA	No TRV	--	--	No TRV	--	--		
PFTeDA	No TRV	--	--	No TRV	--	--		
PFSAs								
PFBS	88	No effect on growth (body weight) of northern bobwhite quail	Gallagher et al. (2005)	No TRV	No High-TRV available	--		
PFHxS	No TRV	--	--	No TRV	--	--		
PFOS	0.77	No true 'no effect' values were available. 17% control-adjusted decrease in reproduction (14-day old survivors/eggs set) for northern bobwhite quail	Newsted et al. (2005, 2007)	2.64	16% control-adjusted decrease in survival of northern bobwhite quail	Newsted et al. (2005, 2007)	0.077	
PFDS	No TRV	--	--	No TRV	--	--		
FASAs								
PFOSA	No TRV	--	--	No TRV	--	--		
EtFASAAs and MeFASAAs								
N-EtFOSAA	No TRV	--	--	No TRV	--	--		
N-MeFOSAA	No TRV	--	--	No TRV	--	--		

Manually added Alternate TRV here

Following the last step, hazard quotients automatically update in Table 7 through 13 (Receptor-specific Total Daily Intake and HQ) and the Table 14: Wildlife Hazard Quotient Summary.

As shown below in the hazard quotient summary, one hazard quotient value (2.08) exceeded 1 and was auto- bolded. This result indicated that the site-specific exposure for Belted Kingfisher to PFOS was predicted to exceed the user-selected PFOS TRV of 0.077 mg/kg-day (by a factor of 2.08).

Navy Site 1

Table 14: Hazard Quotient Summary

Analyte	Hazard Quotients (HQ) - Recommended TRVs												Hazard Quotients (HQ) - User Selected TRVs (if applicable)					
	Wood Duck		Belted Kingfisher		Great Blue Heron		Muskrat		Mink		River Otter							
	Low-TRV HQ	High-TRV HQ	Low-TRV HQ	High-TRV HQ	Low-TRV HQ	High-TRV HQ	Low-TRV HQ	High-TRV HQ	Low-TRV HQ	High-TRV HQ	Low-TRV HQ	High-TRV HQ	Wood Duck	Belted Kingfisher	Great Blue Heron	Muskrat	Mink	River Otter
PFCAs																		
PFBA	--	--	--	--	--	--	5.9E-07	--	1.3E-07	--	1.3E-08	--	--	--	--	--	--	--
PFPeA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFHxA	--	--	--	--	--	--	1.9E-05	2.9E-06	6.8E-06	1.0E-06	5.4E-07	8.1E-08	--	--	--	--	--	--
PFHpA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFOA	3.7E-05	--	1.2E-02	--	5.4E-04	--	3.9E-03	3.6E-04	1.9E-03	1.8E-04	2.4E-04	2.2E-05	--	--	--	--	--	--
PFNA	--	--	--	--	--	--	2.0E-05	1.5E-05	2.0E-05	1.5E-05	1.0E-05	7.8E-06	--	--	--	--	--	--
PFDA	6.5E-07	--	1.1E-04	--	4.8E-06	--	2.5E-05	7.6E-06	1.3E-04	4.0E-05	1.0E-04	3.0E-05	--	--	--	--	--	--
PFUnDA	--	--	--	--	--	--	4.3E-05	1.3E-05	6.6E-04	2.0E-04	5.2E-04	1.6E-04	--	--	--	--	--	--
PFDoDA	--	--	--	--	--	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--	--	--	--	--	--
PFTrDA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PFTeDA	--	--	--	--	--	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	--	--	--	--	--	--
PFSAs																		
PFBS	3.1E-08	--	7.2E-08	--	3.6E-09	--	7.7E-08	2.3E-08	1.1E-08	3.3E-09	4.9E-09	1.5E-09	--	--	--	--	--	--
PFHxS	--	--	--	--	--	--	3.4E-02	1.0E-02	2.1E-02	6.4E-03	5.7E-03	1.7E-03	--	--	--	--	--	--
PFOS	1.69E-04	4.92E-05	2.08E-01	6.08E-02	9.24E-03	2.70E-03	2.86E-01	7.14E-02	4.61E-01	1.15E-01	2.70E-01	6.74E-02	1.69E-03	**2.08E+00**	9.24E-02	--	--	--
PFDS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
FASAs																		
PFOSA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
EtFASAAs and MeFASAAs																		
N-EtFOSAA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
N-MeFOSAA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

AFFF PFAS Aquatic Ecological Risk Model Tool

To view the "AFFF PFAS Aquatic Ecological Risk Model Tool" please select it from the paperclip option to the far left.