

White Paper

Development of Surface Water Criteria for PFOA and PFOS Based on the Protection of Aquatic Receptors

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This white paper develops surface water criteria for perfluorooctanoic acid (PFOA; CAS# 335-67-1) and perfluorooctane sulfonate (PFOS; CAS# 1763-23-1) protective of aquatic receptors. These criteria are based on direct contact with contaminants in surface water for aquatic plants and animals. PFOA and PFOS are manmade chemicals that belong to a group of thousands of chemicals known as perfluoroalkyl substances (PFAS). PFASs are water- and lipid-resistant. They are used as waterproofing and stain-resistant coatings for carpets, leather, textiles, furniture, and packaging materials. They are also used in fire-fighting foam and are added to aviation fluids to decrease flammability. PFOA and PFOS degrade slowly and are very persistent in the environment and the human body (USEPA, 2016a; USEPA, 2016b).

The current methodology for the derivation of ecological surface water criteria for the State of Florida is promulgated in Chapter 62-777, F.A.C. Briefly, only animal acute LC₅₀ (lethal concentration for 50% of the organisms) and IC₂₅ (inhibitory concentration for 25% of the organisms) data from non-salmonids are considered. The lowest LC₅₀ (or IC₂₅) is then divided by a factor of 20 to derive the surface water cleanup target levels (SWCTLs). We note that this methodology appears to be a simplified version of the derivation of ambient water quality criteria for the protection of aquatic life currently used by the United States Environmental Protection Agency (USEPA). However, the FDEP method uses only one toxicity test to derive the criteria and uses a default acute-to-chronic ratio (ACR) of 20. The other toxicity data and chemical-specific ACR data are not considered and do not influence the final SWCTL. We developed SWCTLs for PFOA and PFOS using this methodology in a letter to the Florida Department of Environmental Protection (FDEP) dated June 15, 2018. In this letter we noted that limitations in the data considered using the Chapter 62-777, F.A.C. methodology reduces the confidence in the derivation of the surface water criteria. Surface water criteria developed elsewhere using an array of species as well as different methods for criteria calculation resulted in criteria as much as five orders of magnitude lower. To increase the confidence of the surface water criteria, this white paper derives surface water criteria for PFOA and PFOS using an approach that more closely follows the current USEPA methodology for the derivation of ambient water quality criteria for the protection of aquatic life (USEPA 1985; USEPA, 1995).

The chronic criteria derived for PFOA and PFOS are summarized in the table below:

Chemical	Secondary Chronic Criterion (µg/L)
PFOA in freshwater	1,300
PFOA in marine water	ND
PFOS in freshwater	37
PFOS in marine water	13

ND – no acceptable toxicity data are available for the derivation of a criterion

Based on the USEPA methodology, the following procedure was followed:

1. A search was performed in the USEPA's ECOTOX database for aquatic toxicity data on April 17, 2019. The search terms utilized to gather toxicity data are listed in Appendix A. This search resulted in 2,404 toxicity studies.
2. Only North American species were retained for the analysis. Excluded species for each chemical are listed below:

PFOA:

- a. *Dugesia japonica*
- b. *Gobiocypris rarus*
- c. *Mytilus galloprovincialis*
- d. *Neocaridina denticulate*
- e. *Oreochromis niloticus*
- f. *Oryzias latipes*
- g. *Paracentrotus lividus*
- h. *Perna viridis*
- i. *Siriella armata*
- j. All tests where genus and species were not listed

PFOS:

- a. *Cottus gobio*
- b. *Dugesia japonica*
- c. *Eriocheir sinensis*
- d. *Monoporeia affinis*
- e. *Neocaridina denticulate*
- f. *Oreochromis niloticus*
- g. *Oryzias latipes*
- h. *Paracentrotus lividus*
- i. *Perna viridis*
- j. *Psammechinus millaris*
- k. *Sebastes schlegelii*
- l. *Siriella armata*
- m. *Xenopus laevis*
- n. *Xiphophorus helleri*
- o. All tests where genus and species were not listed

The modified dataset included 1,765 toxicity tests for North American species:

Chemical	Number of freshwater studies	Number of marine studies
PFOA	688	25
PFOS	879	173

3. Acute and chronic toxicity test data were separated for each chemical in both types of surface water (fresh and marine). An acute study was defined as a toxicity study with a duration less than or equal to 96 hours and the chronic study was defined as a toxicity study with a duration greater than or equal to 21 days. If the toxicity test length was not reported, the study was removed from the dataset. Toxicity data with test length between 4 (96 hours) and 21 days were not utilized. The available toxicity tests included:

Chemical	Number of freshwater acute studies	Number of marine acute studies	Number of freshwater chronic studies	Number of marine chronic studies
PFOA	207	25	222	0
PFOS	410	45	286	11

4. Based on the USEPA methodology, the following adjustments were made to the acute toxicity data:
 - a. For daphnia and water fleas: i) all acute test data from a duration less than 48 hours were removed and ii) only LC₅₀ and EC₅₀ data were retained
 - b. For bivalves: i) all acute test data from a duration less than 48 hours were removed and ii) only LC₅₀ and EC₅₀ data were retained
 - c. For all other animals: only LC₅₀ and EC₅₀ data were retained. All other endpoints were removed.

The resulting dataset is considered the final acute dataset. These data are listed in Appendix B. After the modifications, the available acute toxicity tests included:

Chemical	Number of freshwater acute studies	Number of marine acute studies
PFOA	34	0
PFOS	40	4

5. The acute datasets were screened to determine whether Tier I criteria could be developed for PFOA and PFOS. For the development of a Tier I criterion in freshwater, the USEPA requires the results of acceptable acute tests with at least one species of freshwater animal in eight different families such that all of the following are included:
 - a. The family Salmonidae
 - b. A second family in the class Osteichthyes
 - c. A third family in the phylum Chordata
 - d. A planktonic crustacean
 - e. A benthic crustacean
 - f. An insect
 - g. A family in a phylum other than Arthropoda or Chordata
 - h. A family in any order of insect or any phylum not already represented

The PFOA freshwater acute data have six of the eight criteria. Benthic crustaceans and insects are not represented in the dataset. The PFOS freshwater acute data have five of the eight criteria. Benthic crustaceans, insects, and the extra phylum are not represented. Because toxicity data were not available from all eight families, Tier I criteria could not be developed for freshwater for PFOA and PFOS.

6. For marine water, the USEPA requires the results of acceptable acute tests with at least one species of marine animal in eight different families such that all of the following are included:
 - a. Two families in the phylum Chordata
 - b. A family in a phylum other than Arthropoda or Chordata
 - c. The Mysidae or Penaeidae family
 - d. Three other families not in the phylum Chordata
 - e. Any other family

There are no eligible PFOA acute marine water data. The PFOS acute marine water data has one of the eight criteria — the data include the family Mysidae. Therefore, Tier I criteria could not be developed for marine water for either chemical.

7. Because it was not possible to calculate Tier I criteria, Tier II criteria (secondary criteria) were developed using the USEPA methodology from the Great Lakes Initiative (USEPA, 1995). Tier II criteria have less confidence than Tier I criteria since less than eight families are used to derive the criterion. The confidence in these criteria depend on the number of families represented, quality of the data, and variability of the data. As few as one study can be used to derive a Tier II criterion. The final acute dataset developed in Step 4 was used for this procedure. The calculations for the Tier II secondary acute values (SAVs) are presented in Appendix C. To calculate the Tier II SAVs:
- A species mean acute value (SMAV) was calculated for each species. The SMAV is the geometric mean of the acute toxicity data for an individual species.
 - The genus mean acute value (GMAV) was calculated for each genus. The GMAV is the geometric mean of the SMAVs for all species in the genus. If only one species from the genus is present, the SMAV for that species becomes the GMAV.
 - The lowest GMAV is divided by the secondary acute factor (SAF):

Number of USEPA Tier I criteria satisfied	Secondary Acute Factor
1	21.9
2	13.0
3	8.0
4	7.0
5	6.1
6	5.2
7	4.3

For PFOA and PFOS the secondary acute factors include:

Chemical	Number of criteria satisfied	Secondary Acute Factor
PFOA freshwater	6	5.2
PFOA marine water	0	-
PFOS freshwater	5	6.1
PFOS marine water	1	21.9

The calculated SAVs (Appendix C; rounded to two significant figures) are summarized below:

Chemical	Secondary Acute Value ($\mu\text{g/L}$)
PFOA freshwater	20,000
PFOA marine water	ND
PFOS freshwater	530
PFOS marine water	210

ND – no data. Data were not available that were suitable for the derivation of acute criteria for PFOA in marine water

8. The SAV is divided by two (before rounding) to derive the secondary maximum criterion (SMC). Due to rounding, the SMC may not be exactly half of the SAV. The SMC is the Tier II acute surface water criterion. The final SMCs (rounded to two significant figures) are listed below:

Chemical	Secondary Maximum Criterion* ($\mu\text{g/L}$)
PFOA freshwater	9,900
PFOA marine water	ND
PFOS freshwater	270
PFOS marine water	110

ND – no data. Data were not available that were suitable for the derivation of acute criteria for PFOA in marine water

* The raw SAVs were divided by two and then rounded for this table. Rounded SAV values are shown in the table above, see appendix C for the raw values.

It is important to note that the SMC is intended to be a maximum allowable concentration for very short term exposures. The SAV is a concentration that will severely harm or kill 50% of the most sensitive organisms. Dividing this value by two to derive the SMC reduces the number of organisms severely affected. However, it is not intended to be used as a long term exposure concentration.

9. The secondary chronic criterion (SCC) is intended to be a good estimate of the threshold of unacceptable effect. If chemical concentrations stay above the SCC for an extended period, it will cause adverse effects. The USEPA recommends that the four-day average should never exceed the chronic criterion. The SCC is the lower of the secondary chronic value (SCV) and the final plant value (FPV). The SCV and FPV for PFOA and PFOS are derived below.
10. Based on the methodology in the USEPA's guidance for deriving numerical national water quality criteria (USEPA, 1985), only chronic toxicity tests using the following endpoints were used:
- a. For fish, acceptable endpoints include:
 - i. Survival
 - ii. Growth
 - iii. Maturation
 - iv. Embryo vitality (salmonids)
 - v. Eggs spawned per female
 - vi. Hatchability
 - b. For daphnia, acceptable endpoints include:
 - vii. Survival
 - viii. Young per female
 - c. For mysids, acceptable endpoints include:
 - ix. Survival
 - x. Growth
 - xi. Young per female
 - d. For all others, only growth, reproduction, and survival data were considered
 - e. Static tests (except for daphnia) were also omitted from the dataset

The resulting dataset is considered the final chronic dataset. These data are listed in Appendix D. The final chronic toxicity tests included:

Chemical	Number of freshwater chronic studies	Number of marine chronic studies
PFOA	53	0
PFOS	145	10

11. The datasets were screened to determine whether Tier I criteria could be developed for the PFOA and PFOS freshwater chronic datasets. The criteria for developing chronic Tier I criteria are the same as those for acute data (listed in Step 5, above). The PFOA freshwater chronic data have three of the eight criteria. A salmonid, planktonic crustacean, and the extra phylum (Rotifera) are represented in the dataset. The PFOS chronic freshwater data have six of the eight criteria. Benthic crustaceans and salmonids are not represented. Because the chemicals did not have toxicity data for all eight criteria, Tier I chronic criteria could not be developed for freshwater.
12. For marine water, the criteria for the development of a Tier I chronic value is the same as those for acute data (listed in Step 6, above). There are no eligible PFOA chronic marine water data. The PFOS chronic marine water data only has one of the eight criteria, i.e., the data include the family Mysidae. Therefore, Tier I chronic criteria could not be developed for marine water for either chemical.
13. Because it was not possible to calculate Tier I chronic criteria, Tier II chronic criteria (secondary criteria) were developed using the acute-to-chronic ratio (ACR) methodology from the Great Lakes Initiative (USEPA, 1995). In this methodology, an ACR is calculated for each species where both acceptable acute and chronic toxicity data are available. At a minimum an ACR should be available for three different species provided that one is a fish, one is an invertebrate, and one is a sensitive species. To calculate the ACR for each category, the following procedure was used:
 - a. The acute toxicity value is divided by the chronic toxicity value conducted as part of the same study. If the acute tests were not part of the same study as the chronic tests, they were compared to chronic studies from the same laboratory. If more than one acute or chronic toxicity value was available from the same laboratory, the geometric mean value was used to calculate the ACR. This results in an ACR for each species in each laboratory.
 - b. If acute and chronic data are not available from the same laboratory, a different laboratory may be used.
 - c. For each category (fish, invertebrate, and sensitive species) a geometric mean ACR is calculated from the laboratory- and species-specific ACRs.
 - d. If these ACRs are not available for all three categories of species, a default ACR of 18 is used for each category where an ACR cannot be calculated. This default was determined from a distribution of all available ACRs (as of the date of the document). The 80th percentile, 18, was chosen as the default.

14. The calculation of ACRs for PFOA and PFOS are included in Appendix E. ACRs used to calculate the secondary chronic value are presented below. They are identical to the calculations in Appendix E with the exception of the fish and invertebrate ACRs for PFOS in freshwater. The differences in the calculated and chosen ACR are explained below.

Chemical	Fish ACR	Invertebrate ACR	Sensitive Species ACR	Geometric Mean ACR
PFOA in freshwater	18*	11.2	17.7	15.3
PFOA in marine water	ND	ND	ND	ND
PFOS in freshwater	18*	9.4	18*	14.5
PFOS in marine water	18*	11.8	18*	15.6

* - the default ACR of 18 was used

ND – no data. Data were not available that were suitable for the calculation of an ACR for PFOA in marine water

The fish ACR for PFOS in freshwater was calculated as 250. This value was calculated based on the third tier of ACR calculations, dividing the geometric mean of all acute studies for a species by the geometric mean of all chronic studies for a species (in this instance, zebrafish). This was the only instance where matching acute and chronic studies in the same lab could not be found. This method also produced an ACR over ten times the other calculated ACRs for PFOS in both fresh and marine water (9.4 and 11.8, respectively). The USEPA states that acute-to-chronic ratios for species should be within a factor of ten, otherwise a defensible ACR probably cannot be obtained (USEPA, 1985). This suggests that the ACR of 250 is not valid. Based on the Great Lakes Initiative Tier II methodology, a default ACR of 18 was used (USEPA, 1995).

The invertebrate ACR for PFOS in freshwater consisted of two species, the water flea and the lamp mussel. The geometric mean ACR for the water flea is 9.4, which is similar to the marine invertebrate ACR of 11.8. The lamp mussel had an ACR of 1096. This is over 100 times the other invertebrate ACR. The lamp mussel ACR is based on the results of one chronic study while the water flea had at least four chronic studies per author. Because the chronic study for the lamp mussel was not repeated, there is greater uncertainty in the result. Due to the high level of uncertainty associated with this value and because the calculated value was much greater than 10 times the other ACR of 11.8, it was not included in the invertebrate ACR.

15. The calculation of the SCV is provided below:

$$\text{Secondary chronic value} = \frac{\text{Secondary acute value}}{\text{Acute - to - chronic ratio}}$$

Chemical	Secondary Acute Value (µg/L)	Geometric Mean ACR	Secondary Chronic Value (µg/L)
PFOA in freshwater	20,000	15.3	1,300
PFOA in marine water	ND	ND	ND
PFOS in freshwater	530	14.5	37
PFOS in marine water	210	15.6	13

ND – no acceptable toxicity data are available

16. Based on the USEPA methodology (USEPA, 1985), only the following data were used to calculate a final plant value (FPV):
- Acute 96-hour toxicity tests conducted with algae
 - Chronic tests conducted with aquatic vascular plants

The final plant dataset is presented in Appendix F. The final plant toxicity tests include:

Chemical	Number of freshwater plant studies	Number of marine plant studies
PFOA	25	0
PFOS	26	12

The lowest toxicity value from the final dataset is chosen as the FPV (USEPA, 1985). No acceptable plant toxicity data were available for PFOA in marine water. The final plant values are presented in the table below.

Chemical	Final Plant Value ($\mu\text{g/L}$)
PFOA in freshwater	6,250
PFOA in marine water	ND
PFOS in freshwater	5,300
PFOS in marine water	3,200

ND - no acceptable plant toxicity data are available

17. As stated above, the SCC is the lower of the secondary chronic value and the final plant value. In this analysis, the secondary chronic values for PFOA and PFOS are lower than the final plant values and are designated the SCCs.

Chemical	Secondary Chronic Criterion ($\mu\text{g/L}$)
PFOA in freshwater	1,300
PFOA in marine water	ND
PFOS in freshwater	37
PFOS in marine water	13

ND – no acceptable toxicity data are available

18. The proposed freshwater surface water criteria are intermediate between those derived by the State of Minnesota and the State of Michigan for PFOA and PFOS. Surface water criteria for the protection of freshwater aquatic life derived for PFOA and PFOS by these agencies and RIVM are listed for comparison purposes in the table below. The RIVM PFOA surface water value is lower than those used by the States of Minnesota and Michigan because they used a different approach. To calculate a PFOA criterion, RIVM divided the lowest relevant toxicity value (300 $\mu\text{g/L}$) by a default factor of 10. Other toxicity studies were not considered in the derivation of this value. We could not locate any marine water criterion for PFOS for comparison with our proposed criterion of 13 $\mu\text{g/L}$.

Agency	PFOA ($\mu\text{g/L}$)	PFOS ($\mu\text{g/L}$)
MPCA	1,705	19
MDEQ	880	140
RIVM	30	NA

MPCA - Minnesota Pollution Control Agency; MDEQ - Michigan Department of Environmental Quality; RIVM - National Institute for Public Health and the Environment, Ministry of Health, Welfare, and Support, Netherlands; NA- not available.

References:

USEPA (1985) *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*. United States Environmental Protection Agency, Office of Research and Development, Environmental Research Laboratories, Duluth, Minnesota.

USEPA (1995) *Final Water Quality Guidance for the Great Lakes System; Final Rule*. United States Environmental Protection Agency, Federal Register: March 23, 1995 (Volume 60, Number 56).

USEPA (2016a) *Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)*. United States Environmental Protection Agency, Office of Water, Washington, DC.

USEPA (2016b) *Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)*. United States Environmental Protection Agency, Office of Water, Washington, DC.

Appendix A – ECOTOX Search

Habitat

Aquatic

Chemicals**Name(s) / Number(s)**

- PFOA:
- 335-67-1
- 3825-26-1
- 335-95-5
- 2395-00-8
- PFOS:
- 1763-23-1
- 2795-39-3
- 29457-72-5
- 29081-56-9
- 70225-14-8
- 251099-16-8

Effect Measurements**Behavior Group**

- Avoidance
- Behavior
- Feeding Behavior

Biochemical Group

- Hormone
- Enzyme
- Biochemical

Cellular Group

- Cellular
- Histological
- Genetic

Growth Group

- Developmental
- Growth
- Morphological

Mortality Group

Physiology Group

- Injury
- Immunological
- Intoxication
- Physiological

Population Group

Reproduction Group

- Avian/Reptilian Egg
- Reproduction

Endpoints

Concentration Based Endpoints

- MATC
- LOEC
- IC/ID xx (all % values)
- LOEL
- NOEL
- LD50
- EC/ED xx (all % values)
- LC50
- ID50
- IC50
- LC/LD xx (all % values)

- ED50
- NOEC

Species

Animals

- Insects/Spiders
- Amphibians
- Other Invertebrates
- Fish
- Crustaceans
- Molluscs

- Worms

Plants

- Flowers, Trees, Shrubs, Ferns
- Algae, Moss, Fungi

Test Conditions

Exposure Media

- Water - Salt Water
- Water - Fresh or Saltwater Not Specified
- Water - Fresh Water

Test Locations

- Lab

Publication Options

Appendix B – Final acute toxicity dataset

PFOA freshwater acute dataset:

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Conc 1 (Standardized)	Conc 1 Units (Standardized)
335671	Brachionus calyciflorus	Rotifer	1	Day(s)	LC50	Mortality	150	Al mg/L
335671	Chydorus sphaericus	Water Flea	2	Day(s)	EC50	Intoxication	91.095576	Al mg/L
335671	Chydorus sphaericus	Water Flea	2	Day(s)	EC50	Intoxication	116.7679656	Al mg/L
335671	Danio rerio	Zebra Danio	4	Day(s) post-fertilization	EC50	Injury	198	Al mg/L
335671	Danio rerio	Zebra Danio	4	Day(s)	EC50	Development	759	Al mg/L
335671	Danio rerio	Zebra Danio	0.3333	Day(s) post-fertilization	LC50	Mortality	262	Al mg/L
335671	Danio rerio	Zebra Danio	3	Day(s) post-fertilization	LC50	Mortality	262	Al mg/L
3825261	Danio rerio	Zebra Danio	3	Day(s)	LC50	Mortality	624.2346824	Al mg/L
335671	Danio rerio	Zebra Danio	4	Day(s)	LC50	Mortality	157.346904	Al mg/L
335671	Danio rerio	Zebra Danio	4	Day(s)	LC50	Mortality	759	Al mg/L
335671	Danio rerio	Zebra Danio	4	Day(s) post-fertilization	LC50	Mortality	500	Al mg/L
3825261	Danio rerio	Zebra Danio	4	Day(s)	LC50	Mortality	386.2667648	Al mg/L
335671	Daphnia magna	Water Flea	2	Day(s)	EC50	Intoxication	223598.232	Al mg/L
335671	Daphnia magna	Water Flea	2	Day(s)	EC50	Intoxication	476.52	Al mg/L
335671	Daphnia magna	Water Flea	2	Day(s)	EC50	Intoxication	211.5901788	Al mg/L
335671	Daphnia magna	Water Flea	2	Day(s)	EC50	Intoxication	239	Al mg/L
3825261	Daphnia magna	Water Flea	2	Day(s)	EC50	Intoxication	181	Al mg/L
3825261	Daphnia magna	Water Flea	2	Day(s)	EC50	Intoxication	480	Al mg/L
335671	Daphnia magna	Water Flea	2	Day(s)	LC50	Mortality	268731.9492	Al mg/L
335671	Daphnia pulicaria	Water Flea	2	Day(s)	EC50	Intoxication	203722.8336	Al mg/L
335671	Daphnia pulicaria	Water Flea	2	Day(s)	LC50	Mortality	276599.2944	Al mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Conc 1 (Standardized)	Conc 1 Units (Standardized)
335671	Lampsilis siliquoidea	Lamp-Mussel	2	Day(s)	EC50	Behavior	162.6	Al mg/L
335671	Lampsilis siliquoidea	Lamp-Mussel	2	Day(s)	EC50	Mortality	500	Al mg/L
335671	Lampsilis siliquoidea	Lamp-Mussel	4	Day(s)	EC50	Mortality	500	Al mg/L
3825261	Lepomis macrochirus	Bluegill	4	Day(s)	LC50	Mortality	634	Al mg/L
335671	Ligumia recta	Black Sandshell	2	Day(s)	EC50	Mortality	500	Al mg/L
335671	Ligumia recta	Black Sandshell	2	Day(s)	EC50	Behavior	161.3	Al mg/L
335671	Ligumia recta	Black Sandshell	4	Day(s)	EC50	Mortality	500	Al mg/L
335671	Moina macrocopa	Water Flea	2	Day(s)	EC50	Intoxication	199.51	Al mg/L
3825261	Oncorhynchus mykiss	Rainbow Trout	4	Day(s)	LC50	Mortality	707	Al mg/L
3825261	Oncorhynchus mykiss	Rainbow Trout	4	Day(s)	LC50	Mortality	4001	Al mg/L
3825261	Physella acuta	European Physa	2	Day(s)	LC50	Mortality	732	Al mg/L
3825261	Physella acuta	European Physa	3	Day(s)	LC50	Mortality	697	Al mg/L
3825261	Physella acuta	European Physa	4	Day(s)	LC50	Mortality	672	Al mg/L

PFOS freshwater acute dataset:

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Conc 1 (Standardized)	Conc 1 Units (Standardized)
1763231	Danio rerio	Zebra Danio	0.1667	Day(s) post-fertilization	EC50	Development	113	AI mg/L
1763231	Danio rerio	Zebra Danio	0.3333	Day(s) post-fertilization	EC50	Development	76	AI mg/L
1763231	Danio rerio	Zebra Danio	3	Day(s) post-fertilization	EC50	Injury	37	AI mg/L
1763231	Danio rerio	Zebra Danio	4	Day(s)	EC50	Development	1.12	AI mg/L
1763231	Danio rerio	Zebra Danio	0.1667	Day(s) post-fertilization	LC50	Mortality	182	AI mg/L
1763231	Danio rerio	Zebra Danio	0.3333	Day(s) post-fertilization	LC50	Mortality	121	AI mg/L
1763231	Danio rerio	Zebra Danio	0.5	Day(s) post-fertilization	LC50	Mortality	86	AI mg/L
1763231	Danio rerio	Zebra Danio	1	Day(s) post-fertilization	LC50	Mortality	69	AI mg/L
1763231	Danio rerio	Zebra Danio	2	Day(s) post-fertilization	LC50	Mortality	68	AI mg/L
2795393	Danio rerio	Zebra Danio	2	Day(s)	LC50	Mortality	24.6	AI mg/L
2795393	Danio rerio	Zebra Danio	2	Day(s)	LC50	Mortality	7.7	AI mg/L
2795393	Danio rerio	Zebra Danio	2	Day(s)	LC50	Mortality	38.9	AI mg/L
1763231	Danio rerio	Zebra Danio	3	Day(s) post-fertilization	LC50	Mortality	68	AI mg/L
2795393	Danio rerio	Zebra Danio	3	Day(s)	LC50	Mortality	55.0009806	AI mg/L
2795393	Danio rerio	Zebra Danio	4	Day(s)	LC50	Mortality	22.2	AI mg/L
2795393	Danio rerio	Zebra Danio	4	Day(s)	LC50	Mortality	3.502	AI mg/L
2795393	Danio rerio	Zebra Danio	4	Day(s)	LC50	Mortality	54.4617553	AI mg/L
2795393	Danio rerio	Zebra Danio	4	Day(s) post-fertilization	LC50	Mortality	58.47	AI mg/L
1763231	Daphnia magna	Water Flea	2	Day(s)	EC50	Intoxication	37.36	AI mg/L
2795393	Daphnia magna	Water Flea	2	Day(s)	EC50	Intoxication	67.2	AI mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Conc 1 (Standardized)	Conc 1 Units (Standardized)
2795393	Daphnia magna	Water Flea	2	Day(s)	EC50	Intoxication	63	AI mg/L
2795393	Daphnia magna	Water Flea	2	Day(s)	LC50	Mortality	130	AI mg/L
2795393	Daphnia pulicaria	Water Flea	2	Day(s)	EC50	Intoxication	134	AI mg/L
2795393	Daphnia pulicaria	Water Flea	2	Day(s)	LC50	Mortality	169	AI mg/L
2795393	Elliptio complanata	Mussel, Eastern Elliptio	2	Day(s)	LC50	Mortality	79	AI mg/L
2795393	Elliptio complanata	Mussel, Eastern Elliptio	3	Day(s)	LC50	Mortality	79	AI mg/L
2795393	Elliptio complanata	Mussel, Eastern Elliptio	4	Day(s)	LC50	Mortality	59	AI mg/L
1763231	Lampsilis siliquoidea	Lamp-Mussel	2	Day(s)	EC50	Mortality	158.1	AI mg/L
1763231	Lampsilis siliquoidea	Lamp-Mussel	2	Day(s)	EC50	Behavior	17.7	AI mg/L
1763231	Lampsilis siliquoidea	Lamp-Mussel	4	Day(s)	EC50	Mortality	158.1	AI mg/L
29457725	Lepomis macrochirus	Bluegill	4	Day(s)	LC50	Mortality	49	AI mg/L
1763231	Ligumia recta	Black Sandshell	2	Day(s)	EC50	Behavior	17.1	AI mg/L
1763231	Ligumia recta	Black Sandshell	2	Day(s)	EC50	Mortality	158.1	AI mg/L
1763231	Ligumia recta	Black Sandshell	4	Day(s)	EC50	Mortality	141.7	AI mg/L
1763231	Moina macrocopa	Water Flea	2	Day(s)	EC50	Intoxication	17.95	AI mg/L
2795393	Oncorhynchus mykiss	Rainbow Trout	4	Day(s)	LC50	Mortality	2.5	AI mg/L
29457725	Oncorhynchus mykiss	Rainbow Trout	4	Day(s)	LC50	Mortality	4.2	AI mg/L
2795393	Physella acuta	European Physa	2	Day(s)	LC50	Mortality	233	AI mg/L
2795393	Physella acuta	European Physa	3	Day(s)	LC50	Mortality	208	AI mg/L
2795393	Physella acuta	European Physa	4	Day(s)	LC50	Mortality	178	AI mg/L

PFOS marine acute dataset:

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Conc 1 (Standardized)	Conc 1 Units (Standardized)
2795393	Americamysis bahia	Opossum Shrimp	1	Day(s)	LC50	Mortality	5.4	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	2	Day(s)	LC50	Mortality	5.4	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	3	Day(s)	LC50	Mortality	4.4	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	4	Day(s)	LC50	Mortality	3.6	AI mg/L

Appendix C – calculation of secondary acute values (SAVs)

PFOA freshwater SAV:

Species Mean Acute Value

Species Scientific Name	Species Common Name	Species Group	SMAV	Conc 1 Units (Standardized)
Brachionus calyciflorus	Rotifer	Invertebrates; Standard Test Species	150	AI mg/L
Chydorus sphaericus	Water Flea	Crustaceans	103.1360513	AI mg/L
Danio rerio	Zebra Danio	Fish; Standard Test Species	375.5312521	AI mg/L
Daphnia magna	Water Flea	Crustaceans; Standard Test Species	1995.053628	AI mg/L
Daphnia pulex	Water Flea	Crustaceans	237380.6901	AI mg/L
Lampsilis siliquoidea	Lamp-Mussel	Molluscs	343.8377187	AI mg/L
Lepomis macrochirus	Bluegill	Fish; Standard Test Species	634	AI mg/L
Ligumia recta	Black Sandshell	Molluscs	342.918929	AI mg/L
Moina macrocopia	Water Flea	Crustaceans	199.51	AI mg/L
Oncorhynchus mykiss	Rainbow Trout	Fish; Standard Test Species; U.S. Threatened and Endangered Species	1681.876036	AI mg/L
Physella acuta	European Physa	Molluscs	699.9027674	AI mg/L

Genus Mean Acute Value

Species Scientific Name	Species Common Name	Species Group	GMAV	Conc 1 Units (Standardized)
Chydorus	Water Flea	Crustaceans	103.1360513	AI mg/L
Brachionus	Rotifer	Invertebrates; Standard Test Species	150	AI mg/L
Moina	Water Flea	Crustaceans	199.51	AI mg/L
Ligumia	Black Sandshell	Molluscs	342.918929	AI mg/L
Lampsilis	Lamp-Mussel	Molluscs	343.8377187	AI mg/L
Danio	Zebra Danio	Fish; Standard Test Species	375.5312521	AI mg/L
Lepomis	Bluegill	Fish; Standard Test Species	634	AI mg/L
Physella	European Physa	Molluscs	699.9027674	AI mg/L
Oncorhynchus	Rainbow Trout	Fish; Standard Test Species; U.S. Threatened and Endangered Species	1681.876036	AI mg/L
Daphnia	Water Flea	Crustaceans; Standard Test Species	21762.05889	AI mg/L

Has 6 of 8 Tier I criteria so the SAF = 5.2

SAV = lowest GMAV/SAF

SAV = 103.136/5.2 mg/L

SAV = 19.8 mg/L

PFOS freshwater FAV:

Species Mean Acute Value

Species Scientific Name	Species Common Name	Species Group	SMAV	Conc 1 Units (Standardized)
Danio rerio	Zebra Danio	Fish; Standard Test Species	37.50676829	Al mg/L
Daphnia magna	Water Flea	Crustaceans; Standard Test Species	67.33874383	Al mg/L
Daphnia pulex	Water Flea	Crustaceans	150.4858797	Al mg/L
Elliptio complanata	Mussel, Eastern Elliptio	Molluscs	71.67516995	Al mg/L
Lampsilis siliquoidea	Lamp-Mussel	Molluscs	76.19836781	Al mg/L
Lepomis macrochirus	Bluegill	Fish; Standard Test Species	49	Al mg/L
Ligumia recta	Black Sandshell	Molluscs	72.62719594	Al mg/L
Moina macrocopa	Water Flea	Crustaceans	17.95	Al mg/L
Oncorhynchus mykiss	Rainbow Trout	Fish; Standard Test Species; U.S. Threatened and Endangered Species	3.240370349	Al mg/L
Physella acuta	European Physa	Molluscs	205.0909135	Al mg/L

Genus Mean Acute Value

Species Scientific Name	Species Common Name	Species Group	GMAV	Conc 1 Units (Standardized)
Oncorhynchus	Rainbow Trout	Fish; Standard Test Species; U.S. Threatened and Endangered Species	3.240370349	AI mg/L
Moina	Water Flea	Crustaceans	17.95	AI mg/L
Danio	Zebra Danio	Fish; Standard Test Species	37.50676829	AI mg/L
Lepomis	Bluegill	Fish; Standard Test Species	49	AI mg/L
Elliptio	Mussel, Eastern Elliptio	Molluscs	71.67516995	AI mg/L
Ligumia	Black Sandshell	Molluscs	72.62719594	AI mg/L
Lampsilis	Lamp-Mussel	Molluscs	76.19836781	AI mg/L
Daphnia	Water Flea	Crustaceans; Standard Test Species	100.6654365	AI mg/L
Physella	European Physa	Molluscs	205.0909135	AI mg/L

Has 5 of 8 Tier I criteria so the SAF = 6.1

SAV = lowest GMAV/SAF

SAV = 3.240/6.1 mg/L

SAV = 0.53 mg/L

PFOS marine water SAV:

Species Mean Acute Value

Species Scientific Name	Species Common Name	Species Group	SMAV	Conc 1 Units (Standardized)
Americamysis bahia	Opossum Shrimp	Crustaceans; Standard Test Species	4.635917238	AI mg/L

Genus Mean Acute Value

Species Scientific Name	Species Common Name	Species Group	GMAV	Conc 1 Units (Standardized)
Americamysis bahia	Opossum Shrimp	Crustaceans; Standard Test Species	4.635917238	AI mg/L

Has 1 of 8 Tier I criteria so the SAF = 21.9

SAV = lowest GMAV/SAF

SAV = 4.636/21.9 mg/L

SAV = 0.21 mg/L

Appendix D – Final chronic toxicity dataset

PFOA freshwater chronic toxicity data:

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
335671	Brachionus calyciflorus	Rotifer	NR	Lifetime; no associated numeric value	LOEC	Reproduction	Net Reproductive Rate	1	Al mg/L
335671	Brachionus calyciflorus	Rotifer	NR	Lifetime; no associated numeric value	LOEC	Population	Generation time	1	Al mg/L
335671	Brachionus calyciflorus	Rotifer	NR	Lifetime; no associated numeric value	LOEC	Population	Intrinsic rate of increase	0.5	Al mg/L
335671	Brachionus calyciflorus	Rotifer	NR	Day(s)	LOEC	Reproduction	Mictic ratio	0.25	Al mg/L
335671	Brachionus calyciflorus	Rotifer	NR	Maturity	LOEC	Development	Age at first reproduction	0.5	Al mg/L
335671	Brachionus calyciflorus	Rotifer	NR	Lifetime; no associated numeric value	NOEC	Population	Generation time	0.5	Al mg/L
335671	Brachionus calyciflorus	Rotifer	NR	Maturity	NOEC	Development	Age at first reproduction	0.25	Al mg/L
335671	Brachionus calyciflorus	Rotifer	NR	Lifetime; no associated numeric value	NOEC	Population	Intrinsic rate of increase	0.25	Al mg/L
335671	Brachionus calyciflorus	Rotifer	NR	Lifetime; no associated numeric value	NOEC	Reproduction	Net Reproductive Rate	0.5	Al mg/L
335671	Daphnia magna	Water Flea	21	Day(s)	LOEC	Reproduction	Progeny counts/numbers	25	Al mg/L
335671	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	12.5	Al mg/L
335671	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	50	Al mg/L
3825261	Daphnia magna	Water Flea	21	Day(s)	LC50	Mortality	Mortality	100	Al mg/L
3825261	Daphnia magna	Water Flea	21	Day(s)	LOEC	Reproduction	Progeny counts/numbers	32	Al mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
3825261	Daphnia magna	Water Flea	21	Day(s)	LOEC	Reproduction	Progeny counts/numbers	32	AI mg/L
3825261	Daphnia magna	Water Flea	21	Day(s)	LOEC	Reproduction	Progeny counts/numbers	44.2	AI mg/L
3825261	Daphnia magna	Water Flea	21	Day(s)	LOEC	Reproduction	Progeny counts/numbers	32	AI mg/L
3825261	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	20	AI mg/L
3825261	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	10	AI mg/L
3825261	Daphnia magna	Water Flea	21	Day(s)	NOEC	Mortality	Survival	100	AI mg/L
3825261	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	10	AI mg/L
3825261	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	10	AI mg/L
3825261	Daphnia magna	Water Flea	21	Day(s)	NOEC	Mortality	Survival	88.6	AI mg/L
3825261	Oncorhynchus mykiss	Rainbow Trout	85	Day(s)	NOEC	Growth	Length	40	AI mg/L
3825261	Oncorhynchus mykiss	Rainbow Trout	85	Day(s)	NOEC	Mortality	Survival	40	AI mg/L
3825261	Oncorhynchus mykiss	Rainbow Trout	85	Day(s)	NOEC	Growth	Wet weight (AQUIRE only)	40	AI mg/L
3825261	Oncorhynchus mykiss	Rainbow Trout	NR	Swim-up	NOEC	Mortality	Survival	40	AI mg/L
3825261	Oncorhynchus mykiss	Rainbow Trout	NR	Day(s)	NOEC	Mortality	Hatch	40	AI mg/L
335671	Salmo salar	Atlantic Salmon	21	Day(s)	NOEC	Growth	Weight	0.1	AI mg/L
335671	Salmo salar	Atlantic Salmon	21	Day(s)	NOEC	Growth	Length	0.1	AI mg/L
335671	Salmo salar	Atlantic Salmon	35	Day(s)	NOEC	Growth	Length	0.1	AI mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
335671	Salmo salar	Atlantic Salmon	35	Day(s)	NOEC	Growth	Weight	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	LOEC	Morphology	Organ weight in relationship to body weight	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	LOEC	Morphology	Organ weight in relationship to body weight	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	LOEC	Morphology	Organ weight in relationship to body weight	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	LOEC	Morphology	Volume	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Growth	Weight	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Growth	Length	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Volume	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Volume	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Volume	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Growth	Length	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Organ weight in relationship to body weight	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Volume	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Growth	Weight	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Volume	0.1	Al mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Volume	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Growth	Weight	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Volume	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Volume	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Volume	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Growth	Length	0.1	Al mg/L
335671	Salmo salar	Atlantic Salmon	49	Day(s)	NOEC	Morphology	Volume	0.1	Al mg/L

PFOS freshwater chronic toxicity data:

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
1763231	Danio rerio	Zebra Danio	21	Day(s) post-fertilization	LOEC	Growth	Length	250	Al mg/L
1763231	Danio rerio	Zebra Danio	21	Day(s) post-fertilization	LOEC	Growth	Weight	250	Al mg/L
1763231	Danio rerio	Zebra Danio	21	Day(s) post-fertilization	NOEC	Growth	Condition index	250	Al mg/L
2795393	Danio rerio	Zebra Danio	30	Day(s)	NOEC	Growth	Weight	0.2676	Al mg/L
2795393	Danio rerio	Zebra Danio	30	Day(s)	NOEC	Growth	Length	0.2676	Al mg/L
2795393	Danio rerio	Zebra Danio	30	Day(s)	NOEC	Growth	Weight	0.2676	Al mg/L
2795393	Danio rerio	Zebra Danio	30	Day(s)	NOEC	Growth	Length	0.2676	Al mg/L
1763231	Danio rerio	Zebra Danio	35	Day(s) post-fertilization	LOEC	Growth	Length	250	Al mg/L
1763231	Danio rerio	Zebra Danio	35	Day(s) post-fertilization	LOEC	Growth	Weight	250	Al mg/L
1763231	Danio rerio	Zebra Danio	35	Day(s) post-fertilization	NOEC	Growth	Condition index	250	Al mg/L
2795393	Danio rerio	Zebra Danio	40	Day(s)	LOEC	Growth	Condition index	0.25	Al mg/L
2795393	Danio rerio	Zebra Danio	40	Day(s)	LOEC	Growth	Condition index	0.25	Al mg/L
2795393	Danio rerio	Zebra Danio	40	Day(s)	NOEC	Growth	Condition index	0.05	Al mg/L
2795393	Danio rerio	Zebra Danio	40	Day(s)	NOEC	Growth	Weight	0.25	Al mg/L
2795393	Danio rerio	Zebra Danio	40	Day(s)	NOEC	Growth	Weight	0.25	Al mg/L
2795393	Danio rerio	Zebra Danio	40	Day(s)	NOEC	Growth	Length	0.25	Al mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
2795393	Danio rerio	Zebra Danio	40	Day(s)	NOEC	Growth	Length	0.25	Al mg/L
2795393	Danio rerio	Zebra Danio	40	Day(s)	NOEC	Growth	Condition index	0.05	Al mg/L
1763231	Danio rerio	Zebra Danio	42	Day(s) post-fertilization	LOEC	Growth	Condition index	250	Al mg/L
1763231	Danio rerio	Zebra Danio	42	Day(s) post-fertilization	NOEC	Growth	Weight	250	Al mg/L
1763231	Danio rerio	Zebra Danio	42	Day(s) post-fertilization	NOEC	Growth	Length	250	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	LOEC	Growth	Length	0.25	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	LOEC	Morphology	Organ weight in relationship to body weight	0.05	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	LOEC	Growth	Weight	0.25	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	LOEC	Growth	Condition index	0.05	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	NOEC	Growth	Weight	0.05	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	NOEC	Growth	Condition index	0.01	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	NOEC	Growth	Condition index	0.25	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	NOEC	Growth	Weight	0.25	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	NOEC	Growth	Length	0.05	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	NOEC	Morphology	Organ weight in relationship to body weight	0.01	Al mg/L
2795393	Danio rerio	Zebra Danio	70	Day(s)	NOEC	Growth	Length	0.25	Al mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
1763231	Danio rerio	Zebra Danio	90	Day(s)	LOEC	Growth	Length	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	90	Day(s)	LOEC	Growth	Weight	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	90	Day(s)	LOEC	Growth	Length	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	90	Day(s)	LOEC	Growth	Weight	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	90	Day(s)	NOEC	Morphology	Condition index	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	90	Day(s)	NOEC	Morphology	Condition index	0.2500635	Al mg/L
2795393	Danio rerio	Zebra Danio	90	Day(s)	LOEC	Growth	Weight	0.000734	Al mg/L
2795393	Danio rerio	Zebra Danio	90	Day(s)	LOEC	Growth	Length	0.000734	Al mg/L
2795393	Danio rerio	Zebra Danio	90	Day(s)	NOEC	Growth	Weight	0.2676	Al mg/L
2795393	Danio rerio	Zebra Danio	90	Day(s)	NOEC	Growth	Length	0.2676	Al mg/L
1763231	Danio rerio	Zebra Danio	120	Day(s)	LOEC	Growth	Weight	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	120	Day(s)	LOEC	Morphology	Condition index	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	120	Day(s)	LOEC	Growth	Length	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	120	Day(s)	LOEC	Growth	Weight	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	120	Day(s)	LOEC	Morphology	Condition index	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	120	Day(s)	LOEC	Growth	Length	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	150	Day(s)	LOEC	Morphology	Condition index	0.2500635	Al mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
1763231	Danio rerio	Zebra Danio	150	Day(s)	LOEC	Growth	Weight	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	150	Day(s)	LOEC	Morphology	Organ weight in relationship to body weight	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	150	Day(s)	LOEC	Growth	Weight	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	150	Day(s)	LOEC	Growth	Length	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	150	Day(s)	LOEC	Morphology	Condition index	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	150	Day(s)	NOEC	Development	Abnormal	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	150	Day(s)	NOEC	Morphology	Organ weight in relationship to body weight	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	150	Day(s)	NOEC	Mortality	Survival	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	150	Day(s)	NOEC	Growth	Length	0.2500635	Al mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	LOEC	Growth	Length	0.05	Al mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	LOEC	Growth	Condition index	0.25	Al mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	LOEC	Growth	Weight	0.05	Al mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	LOEC	Growth	Condition index	0.25	Al mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	LOEC	Growth	Weight	0.25	Al mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	LOEC	Growth	Length	0.25	Al mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	NOEC	Morphology	Weight	0.25	Al mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	NOEC	Growth	Condition index	0.05	AI mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	NOEC	Growth	Length	0.005	AI mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	NOEC	Growth	Weight	0.005	AI mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	NOEC	Growth	Length	0.05	AI mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	NOEC	Reproduction	Fecundity	0.25	AI mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	NOEC	Growth	Condition index	0.05	AI mg/L
1763231	Danio rerio	Zebra Danio	152.2	Day(s)	NOEC	Growth	Weight	0.05	AI mg/L
2795393	Danio rerio	Zebra Danio	180	Day(s)	LOEC	Growth	Length	0.000734	AI mg/L
2795393	Danio rerio	Zebra Danio	180	Day(s)	LOEC	Growth	Weight	0.000734	AI mg/L
2795393	Danio rerio	Zebra Danio	180	Day(s)	LOEC	Growth	Length	0.1069	AI mg/L
2795393	Danio rerio	Zebra Danio	180	Day(s)	NOEC	Mortality	Mortality	0.2676	AI mg/L
2795393	Danio rerio	Zebra Danio	180	Day(s)	NOEC	Growth	Length	0.000734	AI mg/L
2795393	Danio rerio	Zebra Danio	180	Day(s)	NOEC	Growth	Weight	0.2676	AI mg/L
2795393	Danio rerio	Zebra Danio	226	Day(s)	LOEC	Growth	Length	0.000734	AI mg/L
2795393	Danio rerio	Zebra Danio	226	Day(s)	LOEC	Growth	Weight	0.000734	AI mg/L
2795393	Danio rerio	Zebra Danio	226	Day(s)	LOEC	Growth	Length	0.000734	AI mg/L
2795393	Danio rerio	Zebra Danio	316	Day(s)	LOEC	Growth	Weight	0.1069	AI mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
2795393	Danio rerio	Zebra Danio	316	Day(s)	LOEC	Growth	Length	0.1069	Al mg/L
2795393	Danio rerio	Zebra Danio	316	Day(s)	LOEC	Growth	Weight	0.1069	Al mg/L
2795393	Danio rerio	Zebra Danio	316	Day(s)	LOEC	Growth	Length	0.000734	Al mg/L
2795393	Danio rerio	Zebra Danio	316	Day(s)	NOEC	Growth	Weight	0.000734	Al mg/L
2795393	Danio rerio	Zebra Danio	316	Day(s)	NOEC	Growth	Weight	0.000734	Al mg/L
2795393	Danio rerio	Zebra Danio	316	Day(s)	NOEC	Growth	Length	0.000734	Al mg/L
2795393	Danio rerio	Zebra Danio	<=180	Day(s)	NOEC	Reproduction	Progeny counts/numbers	0.2676	Al mg/L
2795393	Danio rerio	Zebra Danio	<=316	Day(s)	NOEC	Reproduction	Progeny counts/numbers	0.1069	Al mg/L
1763231	Daphnia magna	Water Flea	21	Day(s)	LOEC	Reproduction	Progeny counts/numbers	2.5	Al mg/L
1763231	Daphnia magna	Water Flea	21	Day(s)	LOEC	Reproduction	Progeny counts/numbers	2.5	Al mg/L
1763231	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	1.25	Al mg/L
1763231	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	1.25	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	LC50	Mortality	Mortality	9.1	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	LC50	Mortality	Mortality	42.9	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	LOEC	Reproduction	Progeny counts/numbers	50	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	LOEC	Reproduction	Progeny counts/numbers	5	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	LOEC	Mortality	Survival	10	Al mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
2795393	Daphnia magna	Water Flea	21	Day(s)	LOEC	Mortality	Mortality	24	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	LOEC	Mortality	Survival	50	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	LOEC	Reproduction	Fecundity	50	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	MATC	Mortality	Mortality	17	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	NOEC	Mortality	Mortality	5.3	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	NOEC	Mortality	Survival	5	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	10	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	1	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Fecundity	11.5	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	NOEC	Mortality	Survival	11.5	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	NOEC	Mortality	Mortality	11.5	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Progeny counts/numbers	25	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	NOEC	Mortality	Survival	25	Al mg/L
2795393	Daphnia magna	Water Flea	21	Day(s)	NOEC	Reproduction	Fecundity	25	Al mg/L
1763231	Lampsilis siliquoidea	Lamp-Mussel	36	Day(s)	NOEC	Reproduction	Viability	0.0695	Al mg/L
2795393	Lithobates pipiens	Leopard Frog	21	Day(s)	LC50	Mortality	Mortality	7.71	Al mg/L
2795393	Lithobates pipiens	Leopard Frog	21	Day(s)	LOEC	Mortality	Probability of Survival	12.5	Al mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
2795393	Lithobates pipiens	Leopard Frog	21	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	28	Day(s)	LC50	Mortality	Mortality	6.59	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	28	Day(s)	LOEC	Mortality	Probability of Survival	12.5	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	28	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	35	Day(s)	LC50	Mortality	Mortality	6.21	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	35	Day(s)	LOEC	Mortality	Probability of Survival	12.5	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	35	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	42	Day(s)	LOEC	Mortality	Probability of Survival	12.5	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	42	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	49	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	56	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	63	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	70	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	77	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	84	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	91	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	98	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
2795393	Lithobates pipiens	Leopard Frog	105	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	112	Day(s)	NOEC	Mortality	Probability of Survival	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	NR	Until metamorphosis	LOEC	Growth	Length	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	NR	Day(s)	LOEC	Development	Metamorphosis	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	NR	Day(s)	NOEC	Development	Metamorphosis	0.97	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	NR	Until metamorphosis	NOEC	Growth	Length	0.97	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	NR	Until metamorphosis	NOEC	Growth	Weight	3.55	AI mg/L
2795393	Lithobates pipiens	Leopard Frog	NR	Day(s)	NOEC	Development	Metamorphosis	3.55	AI mg/L
2795393	Pimephales promelas	Fathead Minnow	21	Day(s)	EC50	Reproduction	Fecundity	0.23	AI mg/L
2795393	Pimephales promelas	Fathead Minnow	45	Day(s)	NOEC	Growth	Weight	0.281	AI mg/L
2795393	Pimephales promelas	Fathead Minnow	45	Day(s)	NOEC	Reproduction	Hatch	0.281	AI mg/L
2795393	Pimephales promelas	Fathead Minnow	45	Day(s)	NOEC	Mortality	Probability of Survival	0.281	AI mg/L

PFOS marine chronic dataset:

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
2795393	Americamysis bahia	Opossum Shrimp	35	Day(s)	LOEC	Growth	Length	0.55	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	35	Day(s)	LOEC	Growth	Weight	0.55	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	35	Day(s)	LOEC	Reproduction	Progeny counts/numbers	0.55	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	35	Day(s)	MATC	Reproduction	Progeny counts/numbers	0.37	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	35	Day(s)	MATC	Growth	Weight	0.37	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	35	Day(s)	MATC	Growth	Length	0.37	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	35	Day(s)	NOEC	Growth	Length	0.25	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	35	Day(s)	NOEC	Growth	Weight	0.25	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	35	Day(s)	NOEC	Reproduction	Progeny counts/numbers	0.25	AI mg/L
2795393	Americamysis bahia	Opossum Shrimp	39	Day(s)	NOEC	Mortality	Survival	0.55	AI mg/L

Appendix E – Calculation of Acute-to-Chronic Ratios

PFOA freshwater ACR calculation:

- 1) Fish species – no fish data are available, a default of 18 is used
- 2) Invertebrates – water fleas
ACRs can be calculated for three laboratories: i) Ji, ii) Li, and iii) Colombo

Acute data:

CAS Number	Species Scientific Name	Species Common Name	Conc 1 (Standardized)	Conc 1 Units (Standardized)	Author	Geo mean
335671	Daphnia magna	Water Flea	476.52	Al mg/L	Ji et al.	476.52
3825261	Daphnia magna	Water Flea	181	Al mg/L	Li	181
3825261	Daphnia magna	Water Flea	480	Al mg/L	Colombo et al.	480

Chronic data:

CAS Number	Species Scientific Name	Species Common Name	Conc 1 (Standardized)	Conc 1 Units (Standardized)	Author	Geo mean
335671	Daphnia magna	Water Flea	25	Al mg/L	Ji et al.	25
335671	Daphnia magna	Water Flea	12.5	Al mg/L	Ji et al.	
335671	Daphnia magna	Water Flea	50	Al mg/L	Ji et al.	
3825261	Daphnia magna	Water Flea	100	Al mg/L	Li	27.5
3825261	Daphnia magna	Water Flea	32	Al mg/L	Li	
3825261	Daphnia magna	Water Flea	32	Al mg/L	Li	
3825261	Daphnia magna	Water Flea	32	Al mg/L	Li	
3825261	Daphnia magna	Water Flea	10	Al mg/L	Li	
3825261	Daphnia magna	Water Flea	100	Al mg/L	Li	
3825261	Daphnia magna	Water Flea	10	Al mg/L	Li	
3825261	Daphnia magna	Water Flea	10	Al mg/L	Li	
3825261	Daphnia magna	Water Flea	10	Al mg/L	Li	
3825261	Daphnia magna	Water Flea	20	Al mg/L	Colombo et al.	

3825261	Daphnia magna	Water Flea	44.2	Al mg/L	Colombo et al.	
3825261	Daphnia magna	Water Flea	88.6	Al mg/L	Colombo et al.	

ACR:

Author	Acute geomean	Chronic geomean	ACR
Ji et al.	476.52	25	19.1
Li	181	27.5	6.6
Colombo et al.	480	42.8	11.2
Geomean ACR:			11.2

3) Sensitive species in freshwater – Rainbow trout
 An ACR can be calculated for the Colombo laboratory

Acute data:

CAS Number	Species Scientific Name	Species Common Name	Conc 1 (Standardized)	Conc 1 Units (Standardized)	Author	Geo mean
3825261	Oncorhynchus mykiss	Rainbow Trout	707	Al mg/L	Colombo et al.	707

Chronic data:

CAS Number	Species Scientific Name	Species Common Name	Conc 1 (Standardized)	Conc 1 Units (Standardized)	Author	Geo mean
3825261	Oncorhynchus mykiss	Rainbow Trout	40	Al mg/L	Colombo et al.	40
3825261	Oncorhynchus mykiss	Rainbow Trout	40	Al mg/L	Colombo et al.	
3825261	Oncorhynchus mykiss	Rainbow Trout	40	Al mg/L	Colombo et al.	
3825261	Oncorhynchus mykiss	Rainbow Trout	40	Al mg/L	Colombo et al.	
3825261	Oncorhynchus mykiss	Rainbow Trout	40	Al mg/L	Colombo et al.	

ACR:

Author	Acute geomean	Chronic geomean	ACR
Colombo et al.	707	40	17.7

PFOS freshwater ACR calculation:

1) Fish species – Zebrafish

No laboratory was available for both acute and chronic data. Therefore, a geometric mean across laboratories was used.

Acute data:

CAS Number	Species Scientific Name	Species Common Name	Conc 1 (Standardized)	Conc 1 Units (Standardized)	Author	Geo mean	
1763231	Danio rerio	Zebra Danio	113	Al mg/L	Zheng et al.		
1763231	Danio rerio	Zebra Danio	76	Al mg/L	Zheng et al.		
1763231	Danio rerio	Zebra Danio	37	Al mg/L	Zheng et al.		
1763231	Danio rerio	Zebra Danio	1.12	Al mg/L	Huang et al.		
1763231	Danio rerio	Zebra Danio	182	Al mg/L	Zheng et al.		
1763231	Danio rerio	Zebra Danio	121	Al mg/L	Zheng et al.		
1763231	Danio rerio	Zebra Danio	86	Al mg/L	Zheng et al.		
1763231	Danio rerio	Zebra Danio	69	Al mg/L	Zheng et al.		
1763231	Danio rerio	Zebra Danio	68	Al mg/L	Zheng et al.		
2795393	Danio rerio	Zebra Danio	24.6	Al mg/L	Sharpe et al.		
2795393	Danio rerio	Zebra Danio	7.7	Al mg/L	Sharpe et al.		
2795393	Danio rerio	Zebra Danio	38.9	Al mg/L	Sharpe et al.		
1763231	Danio rerio	Zebra Danio	68	Al mg/L	Zheng et al.		
2795393	Danio rerio	Zebra Danio	55.0009806	Al mg/L	Ding et al		
2795393	Danio rerio	Zebra Danio	22.2	Al mg/L	Sharpe et al.		
2795393	Danio rerio	Zebra Danio	3.502	Al mg/L	Wang S et al.		
2795393	Danio rerio	Zebra Danio	54.4617553	Al mg/L	Ding et al		
2795393	Danio rerio	Zebra Danio	58.47	Al mg/L	Hagenaars et al		37.5

2795393	Danio rerio	Zebra Danio	0.05	Al mg/L	Du et al.
2795393	Danio rerio	Zebra Danio	0.01	Al mg/L	Du et al.
2795393	Danio rerio	Zebra Danio	0.25	Al mg/L	Du et al.
2795393	Danio rerio	Zebra Danio	0.25	Al mg/L	Du et al.
2795393	Danio rerio	Zebra Danio	0.05	Al mg/L	Du et al.
2795393	Danio rerio	Zebra Danio	0.01	Al mg/L	Du et al.
2795393	Danio rerio	Zebra Danio	0.25	Al mg/L	Du et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.2676	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.2676	Al mg/L	Keiter et al
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.

1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.2500635	Al mg/L	Cheng et al.
1763231	Danio rerio	Zebra Danio	0.05	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.25	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.05	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.25	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.25	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.25	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.25	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.05	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.005	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.005	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.05	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.25	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.05	Al mg/L	Wang, M. et al.
1763231	Danio rerio	Zebra Danio	0.05	Al mg/L	Wang, M. et al.
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.1069	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.2676	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.2676	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al

2795393	Danio rerio	Zebra Danio	0.1069	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.1069	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.1069	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.000734	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.2676	Al mg/L	Keiter et al
2795393	Danio rerio	Zebra Danio	0.1069	Al mg/L	Keiter et al

ACR:

Author	Acute geomean	Chronic geomean	ACR
All	37.5	0.15	250
Geomean ACR:			250

2) Invertebrates – Water fleas and Lamp mussel
 ACRs can be calculated for four laboratories: i) Ji, ii) Li, iii) Boudreau, and iv) Hazelton

Acute data:

CAS Number	Species Scientific Name	Species Common Name	Conc 1 (Standardized)	Conc 1 Units (Standardized)	Author	Geo mean
1763231	Daphnia magna	Water Flea	37.36	Al mg/L	Ji et al.	37.36
2795393	Daphnia magna	Water Flea	63	Al mg/L	Li,M.H.	63
2795393	Daphnia magna	Water Flea	130	Al mg/L	Boudreau et al.	93.5
2795393	Daphnia magna	Water Flea	67.2	Al mg/L	Boudreau et al.	
1763231	Lampsilis siliquoidea	Lamp-Mussel	158.1	Al mg/L	Hazelton et al	76.2
1763231	Lampsilis siliquoidea	Lamp-Mussel	17.7	Al mg/L	Hazelton et al	
1763231	Lampsilis siliquoidea	Lamp-Mussel	158.1	Al mg/L	Hazelton et al	

Chronic data:

CAS Number	Species Scientific Name	Species Common Name	Conc 1 (Standardized)	Conc 1 Units (Standardized)	Author	Geo mean
1763231	Daphnia magna	Water Flea	2.5	Al mg/L	Ji et al.	1.77
1763231	Daphnia magna	Water Flea	2.5	Al mg/L	Ji et al.	
1763231	Daphnia magna	Water Flea	1.25	Al mg/L	Ji et al.	
1763231	Daphnia magna	Water Flea	1.25	Al mg/L	Ji et al.	
2795393	Daphnia magna	Water Flea	9.1	Al mg/L	Li,M.H.	5.3
2795393	Daphnia magna	Water Flea	1	Al mg/L	Li,M.H.	
2795393	Daphnia magna	Water Flea	5	Al mg/L	Li,M.H.	
2795393	Daphnia magna	Water Flea	10	Al mg/L	Li,M.H.	
2795393	Daphnia magna	Water Flea	5	Al mg/L	Li,M.H.	
2795393	Daphnia magna	Water Flea	10	Al mg/L	Li,M.H.	
2795393	Daphnia magna	Water Flea	42.9	Al mg/L	Boudreau et al.	
2795393	Daphnia magna	Water Flea	42.9	Al mg/L	Boudreau et al.	28.6

2795393	Daphnia magna	Water Flea	50	Al mg/L	Boudreau et al.	
2795393	Daphnia magna	Water Flea	50	Al mg/L	Boudreau et al.	
2795393	Daphnia magna	Water Flea	50	Al mg/L	Boudreau et al.	
2795393	Daphnia magna	Water Flea	5.3	Al mg/L	Boudreau et al.	
2795393	Daphnia magna	Water Flea	25	Al mg/L	Boudreau et al.	
2795393	Daphnia magna	Water Flea	25	Al mg/L	Boudreau et al.	
2795393	Daphnia magna	Water Flea	25	Al mg/L	Boudreau et al.	
1763231	Lampsilis siliquoidea	Lamp-Mussel	0.0695	Al mg/L	Hazelton et al	0.0695

ACR:

Author	Organism	Acute geomean	Chronic geomean	ACR
Ji	Water flea	37.36	1.77	21.1
Li	Water flea	63	5.3	11.9
Boudreau	Water flea	93.5	28.6	3.3
Geomean ACR:				9.4

ACR:

Author	Organism	Acute geomean	Chronic geomean	ACR
Hazelton	Lamp Mussel	76.2	0.0695	1096
Geomean ACR:				1096

3) Sensitive freshwater species – none, a default of 18 was used

PFOS marine water ACR calculation:

- 1) Fish species – no fish data are available, a default of 18 was used
- 2) Invertebrates – opossum shrimp
Data are available from one lab: Drottar and Kuregar

Acute data:

CAS Number	Species Scientific Name	Species Common Name	Conc 1 (Standardized)	Conc 1 Units (Standardized)	Author	Geo mean
2795393	Americamysis bahia	Opossum Shrimp	5.4	Al mg/L	Drottar and Kruegar	4.6
2795393	Americamysis bahia	Opossum Shrimp	5.4	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	4.4	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	3.6	Al mg/L	Drottar and Kruegar	

Chronic data:

CAS Number	Species Scientific Name	Species Common Name	Conc 1 (Standardized)	Conc 1 Units (Standardized)	Author	Geo mean
2795393	Americamysis bahia	Opossum Shrimp	0.55	Al mg/L	Drottar and Kruegar	0.39
2795393	Americamysis bahia	Opossum Shrimp	0.55	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	0.55	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	0.37	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	0.37	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	0.37	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	0.25	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	0.25	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	0.25	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	0.55	Al mg/L	Drottar and Kruegar	
2795393	Americamysis bahia	Opossum Shrimp	0.55	Al mg/L	Drottar and Kruegar	

ACR:

Author	Acute geomean	Chronic geomean	ACR
Drottar and Kruegar	4.6	0.39	11.8
Geomean ACR:			11.8

3) Sensitive species – no sensitive species data are available, a default of 18 was used

Appendix F – Plant toxicity dataset

PFOA freshwater plant toxicity dataset

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1	Conc 1 Units
3825261	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	NOEC	Population	Population growth rate	6.25	Al mg/L
3825261	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	NOEC	Population	Population growth rate	11.37	Al mg/L
3825261	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	NOEC	Population	Biomass	11.37	Al mg/L
335671	Chlorella pyrenoidosa	Green Algae	4	Day(s)	LOEC	Physiology	Permeability, tissue, membrane	15	Al mg/L
3825261	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	LOEC	Population	Biomass	22.7	Al mg/L
3825261	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	LOEC	Population	Population growth rate	22.7	Al mg/L
3825261	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	NOEC	Population	Biomass	100	Al mg/L
335671	Chlorella pyrenoidosa	Green Algae	4	Day(s)	EC50	Population	Abundance	190.99	Al mg/L
335671	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC50	Population	Abundance	207.46	Al mg/L
335671	Chlorella vulgaris	Green Algae	4	Day(s)	IC10	Population	Abundance	5796.9912	Al mg/L
335671	Chlorella vulgaris	Green Algae	4	Day(s)	IC25	Population	Abundance	14078.4072	Al mg/L
335671	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	IC10	Population	Abundance	53829.204	Al mg/L
335671	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	IC25	Population	Abundance	81571.9476	Al mg/L
335671	Chlorella vulgaris	Green Algae	4	Day(s)	IC50	Population	Abundance	115525.753	Al mg/L
335671	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	IC50	Population	Abundance	123393.098	Al mg/L
3825261	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC50	Population	Population growth rate	>100	Al mg/L
3825261	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC50	Population	Biomass	>100	Al mg/L

335671	Lemna gibba	Inflated Duckweed	21	Day(s)	NOEC	Growth	Number of leaves	24	AI mg/L
335671	Lemna gibba	Inflated Duckweed	28	Day(s)	NOEC	Growth	Number of leaves	24	AI mg/L
335671	Lemna gibba	Inflated Duckweed	35	Day(s)	NOEC	Growth	Number of leaves	24	AI mg/L
335671	Lemna gibba	Inflated Duckweed	21	Day(s)	LOEC	Growth	Number of leaves	74	AI mg/L
335671	Lemna gibba	Inflated Duckweed	28	Day(s)	LOEC	Growth	Number of leaves	74	AI mg/L
335671	Lemna gibba	Inflated Duckweed	35	Day(s)	LOEC	Growth	Number of leaves	74	AI mg/L
335671	Lemna gibba	Inflated Duckweed	35	Day(s)	IC10	Growth	Number of leaves	20289.4692	AI mg/L
335671	Lemna gibba	Inflated Duckweed	35	Day(s)	IC50	Growth	Number of leaves	46375.9296	AI mg/L

PFOS freshwater plant toxicity dataset

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1	Conc 1 Units
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	NOEC	Population	Abundance	5.3	Al mg/L
2795393	Chlorella vulgaris	Green Algae	4	Day(s)	NOEC	Population	Abundance	8.2	Al mg/L
2795393	Chlorella vulgaris	Green Algae	4	Day(s)	NOEC	Population	Chlorophyll A concentration	9.6	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	NOEC	Population	Chlorophyll A concentration	16.6	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	NOEC	Population	Population growth rate	44	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	NOEC	Population	Abundance	44	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	NOEC	Population	Abundance	44	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	NOEC	Population	Abundance	44	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC50	Population	Abundance	48.2	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC10	Population	Abundance	49	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC10	Population	Abundance	49	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC10	Population	Population growth rate	59	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC50	Population	Chlorophyll A concentration	59.2	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC50	Population	Abundance	71	Al mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC50	Population	Abundance	71	Al mg/L
2795393	Chlorella vulgaris	Green Algae	4	Day(s)	EC50	Population	Abundance	81.6	Al mg/L

2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	LOEC	Population	Population growth rate	86	AI mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	LOEC	Population	Abundance	86	AI mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	LOEC	Population	Abundance	86	AI mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	LOEC	Population	Abundance	86	AI mg/L
2795393	Chlorella vulgaris	Green Algae	4	Day(s)	EC50	Population	Chlorophyll A concentration	88.1	AI mg/L
2795393	Chlorella vulgaris	Green Algae	4	Day(s)	NOEC	Physiology	Permeability, tissue, membrane	120	AI mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC50	Population	Population growth rate	126	AI mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC90	Population	Abundance	145	AI mg/L
2795393	Chlorella vulgaris	Green Algae	4	Day(s)	LOEC	Physiology	Permeability, tissue, membrane	160	AI mg/L
2795393	Pseudokirchneriella subcapitata	Green Algae	4	Day(s)	EC90	Population	Population growth rate	>179	AI mg/L

PFOS marine water plant toxicity

CAS Number	Species Scientific Name	Species Common Name	Observed Duration (Days)	Observed Duration Units (Days)	Endpoint	Effect	Effect Measurement	Conc 1 (Standardized)	Conc 1 Units (Standardized)
2795393	Skeletonema costatum	Diatom	4	Day(s)	EC10	Population	Abundance	>3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	EC10	Population	Population growth rate	>3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	EC10	Population	Population changes, general	>3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	EC50	Population	Abundance	>3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	EC50	Population	Population growth rate	>3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	EC50	Population	Population changes, general	>3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	EC90	Population	Population changes, general	>3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	EC90	Population	Abundance	>3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	EC90	Population	Population growth rate	>3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	NOEC	Population	Abundance	3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	NOEC	Population	Population changes, general	3.2	Al mg/L
2795393	Skeletonema costatum	Diatom	4	Day(s)	NOEC	Population	Population growth rate	3.2	Al mg/L