Appendix K - Toxicity values
<table>
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<th>Test Species</th>
<th>Test Organism</th>
<th>Exposure Route</th>
<th>Biomass</th>
<th>EC10</th>
<th>EC50/LC50/IC</th>
<th>NOEC</th>
<th>Lethal Dose</th>
<th>Other Toxicity Study Data</th>
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**Notes:**
- EC10: Effective concentration at 10% response.
- EC50/LC50/IC: Effective concentration at 50% response (for growth inhibition).
- NOEC: No observed effect concentration.
- Lethal Dose: Lethal dose at 50% response.
- Other Toxicity Study Data: Additional information on toxicity studies performed with the test species.

**References:**

**Appendix K - Toxicity Study Data**
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**Notes:**
- EC50/LC50/IC50 values are provided for various test organisms, including algae and aquatic plants.
- Units for EC50/LC50/IC50 are typically in mg/L.
- The results are from different studies, cited in the table, including those by OECD (2002) and RIVM (2010).
- The endpoints measured include cell density, growth rate, and inhibition of growth rate.
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*Note: NOEC = No Observed Effect Concentration, EC10 = Effects Concentration for 10%, EC50 = Effects Concentration for 50%, IC50 = Inhibitory Concentration for 50%*
Table 1. Toxicity Study Data

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<tr>
<th>Test Organism Group</th>
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4.) Ji et al., 2008 cited in RIVM 2010

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*Note: NOEC and LOEC values are expressed in µg/L.*
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<td>Growth</td>
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<td>Lettuce</td>
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<td>4.6 mg/kg NS</td>
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<td>SP</td>
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<td>30 day</td>
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<td>Enzyme activity</td>
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<tr>
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<td>Soil bacteria</td>
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<td>59 day</td>
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<td>Enzyme activity</td>
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<td>SP</td>
<td>Williamtown ERA</td>
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**References:**

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<tr>
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<th>Test Organism</th>
<th>Source Name</th>
<th>Body Weight (kg)</th>
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<th>Effect</th>
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<th>LOEC</th>
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<td>Amphibian</td>
<td>African Clawed Frog</td>
<td>Xenopus laevis</td>
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<td>African Clawed Frog</td>
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<td>Survival</td>
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<td>African Clawed Frog</td>
<td>Xenopus laevis</td>
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<td>Direct - SW</td>
<td>~2 months</td>
<td>67.6</td>
<td>58.8</td>
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<td>Survival</td>
<td>Amphibian</td>
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<td>Rana pipiens</td>
<td>73.5</td>
<td>Direct - SW</td>
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<td>58.8</td>
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<td>Malformation</td>
<td>Amphibian</td>
<td>African Clawed Frog</td>
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<td>73.5</td>
<td>Direct - SW</td>
<td>96 h</td>
<td>67.6</td>
<td>58.8</td>
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Reference:
5. UM-WREC (2001), ref 40 in OECD, 2002 cited in RIVM 2010

Summary of Toxicity Data - Amphibians

Appendix K - Toxicity Study Data
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<tr>
<th>Treatment</th>
<th>Abbreviation</th>
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<th>Test Organism - Common Name</th>
<th>Dose</th>
<th>Duration</th>
<th>Reproduction endpoint</th>
<th>NOAEL</th>
<th>LOAEL</th>
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### Appendix K - Toxicity Study Data

#### Summary of Toxicity Data - Birds and Reptiles

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Species</th>
<th>Study Duration</th>
<th>Route of Administration</th>
<th>Endpoint</th>
<th>LOAEL/BW/Day</th>
<th>LC50/BW/Day</th>
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<tr>
<td>Perfluorobutanesulfonic Acid (PFBS)</td>
<td>Mallard Duck (Anas platyrhynchos)</td>
<td>NA</td>
<td>Oral in Diet</td>
<td>Survival (LC50)</td>
<td>NS</td>
<td>628 mg/kg food</td>
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<tr>
<td>Perfluorobutanesulfonic Acid (PFBS)</td>
<td>Northern Bobwhite Quail (Colinus virginianus)</td>
<td>21 weeks</td>
<td>Oral in diet</td>
<td>Reproductive endpoints (LOAEL)</td>
<td>NS</td>
<td>877 mg/kg bw/day</td>
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<tr>
<td>Perfluorobutanesulfonic Acid (PFBS)</td>
<td>Bobwhite Quail (Colinus virginianus)</td>
<td>10 days</td>
<td>Oral in diet</td>
<td>Mortality (LC50)</td>
<td>&gt;10,000 mg/kg</td>
<td>67.6 mg/kg</td>
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</table>


*RAAF Base Tindal PFAS Ecological Risk Assessment.*

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Abbreviation</th>
<th>Test Organism - Common Name</th>
<th>Species Name</th>
<th>Test Position - Container Name</th>
<th>Male/Female Age</th>
<th>Route</th>
<th>Endpoints</th>
<th>Study Duration</th>
<th>Study Name</th>
<th>Reference</th>
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</thead>
<tbody>
<tr>
<td>PFOA</td>
<td>Male</td>
<td>Mammal</td>
<td>Rat</td>
<td>13 wks</td>
<td>NS</td>
<td>Gavage</td>
<td>Body Weight</td>
<td>PFOA 0.0033 mg/kg/d</td>
<td>104 weeks</td>
<td>Seacat, et al. (2002)</td>
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<td>Mammal</td>
<td>Rat</td>
<td>26 wks</td>
<td>Gavage</td>
<td>Oral</td>
<td>immuno-tox (60d)</td>
<td>PFOA 0.00166 mg/kg</td>
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<tr>
<td>PFOS</td>
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<td>Mammal</td>
<td>Mouse (male)</td>
<td>13 wks</td>
<td>NS</td>
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<td>Immuno-tox (60d)</td>
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<td>Mouse (male)</td>
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<td>Oral-gavage</td>
<td>Oral</td>
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<td>Oral</td>
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<td>26 wks</td>
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<td>Oral</td>
<td>Body Weight</td>
<td>PFOS 0.1 mg/kg/d</td>
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<td>Rats and rabbits</td>
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<td>Oral</td>
<td>Body Weight</td>
<td>PFOA 0.0033 mg/kg/d</td>
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<td>Oral-gavage</td>
<td>Oral</td>
<td>Body Weight</td>
<td>PFOS 0.03 mg/kg/d</td>
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<td>Mouse (male)</td>
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<td>Oral-gavage</td>
<td>Oral</td>
<td>Body Weight</td>
<td>PFOS 0.017 mg/kg/d</td>
<td>42 - 47 d</td>
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**Summary of Toxicity Data - Mammals**

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<th>Species Name</th>
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<th>Endpoints</th>
<th>Study Duration</th>
<th>Study Name</th>
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<td>Rat</td>
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<td>PFOA 0.0033 mg/kg/d</td>
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<td>Seacat, et al. (2002)</td>
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<td>Mammal</td>
<td>Rat</td>
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<td>Gavage</td>
<td>Oral</td>
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<td>Mouse (male)</td>
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<td>NS</td>
<td>Gavage</td>
<td>Immuno-tox (60d)</td>
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<tr>
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<td>Mammal</td>
<td>Mouse (male)</td>
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<td>Oral-gavage</td>
<td>Oral</td>
<td>Body Weight</td>
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<td>Body Weight</td>
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<td>2 generation</td>
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<td>Oral</td>
<td>Body Weight</td>
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**Mechanisms**

Stated that the mechanistic (GD1-gene expression, inflammation, cholestasis, liver hypertrophy, necrosis, and hepatocellular hypertrophy) and toxicological (reversible) effects were observed in rats and monkeys.

**Immuno-toxicity**

Decreased plaque forming cells, decreased NK cell function, and IgM in adult male mice exposed to perfluorooctane sulfonate (PFOS) in rats.

**Liver histology**

Increased liver weight (M & F), decreased serum T3 & HDL, increased TSH throughout the study.

**Increased liver weight (M & F) with decreased serum T3 & HDL, increased TSH throughout the study.**


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<td>Mouse</td>
<td>Interference with hearing sensitivity</td>
<td>13-26 wks</td>
<td>Decreased pup survival</td>
<td>BMDL5 73.5 mg/kg bw/day</td>
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<tr>
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<td>Mouse</td>
<td>Oral gavage</td>
<td>Mouse</td>
<td>Interference with hearing sensitivity</td>
<td>13-26 wks</td>
<td>Decreased pup survival</td>
<td>BMDL5 73.5 mg/kg bw/day</td>
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<td>BMDL5 73.5 mg/kg bw/day</td>
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<td>13-26 wks</td>
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<td>Interference with hearing sensitivity</td>
<td>13-26 wks</td>
<td>Decreased pup survival</td>
<td>BMDL5 73.5 mg/kg bw/day</td>
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</table>


PFOA oral diet 0.9 mg/kg/d

PFOA oral diet 0.4 mg/kg bw/day

PFOA oral diet 0.5 mg/kg bw/day

Covance Laboratories, Inc. 2001. Final report of the 104 week dietary carcinogenicity study with narrow range (98.1%) N-ethyl perfluorooctanesulfonamido-ethanol (N-EtPOES) in F344/N rats. Toxicological Sciences 59: 331-357.

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Covance Laboratories, Inc. 2001. Final report of the 104 week dietary carcinogenicity study with narrow range (98.1%) N-ethyl perfluorooctanesulfonamido-ethanol (N-EtPOES) in F344/N rats. Toxicological Sciences 59: 331-357.
Summary of Toxicity Data - Mammals

**Perfluorooctanoic acid (PFOA)**

- Mammal
  - Oral gavage: Oral gavage days 1 - 17 of gestation
  - LOAEL: decreased maternal liver & kidney wt (F0 females: from 22 gestation to the end of mating), growth deficits in litters, increased maternal liver wt, decreased NK cell function & IgM response in F1 males: from 22 gestation to weaning (PND20), increased motor activity & habituation (M pups on PND17), increased incidence of birth defects in F1 pups, increased early puberty (M), increased liver & kidney wt (F0 pup), increased incidence of birth sternal defects
  - NOAEL: 1 mg/kg/d

- Mouse
  - Develop (GD1-17) oral gavage
  - LOAEL: decreased maternal weight gain
  - NOAEL: 1 mg/kg/d

- Rat (f)
  - Develop & tox (GD0-PND20)
  - LOAEL: increased maternal liver wt, altered pup behavior & kidney wt; no increased relative maternal liver & early puberty (M), increased motor activity & habituation (M pups on PND17), increased liver & kidney wt (F0 pup), increased incidence of birth sternal defects
  - NOAEL: 1 mg/kg/d

- Rat (m)
  - Develop (GD1-17) oral gavage
  - LOAEL: increased maternal liver wt, decreased NK cell function & IgM response in F1 males: from 22 gestation to weaning (PND20), increased motor activity & habituation (M pups on PND17), increased incidence of birth defects in F1 pups, increased early puberty (M), increased liver & kidney wt (F0 pup), increased incidence of birth sternal defects
  - NOAEL: 1 mg/kg/d

**Perfluorooctanesulfonic acid (PFOS)**

- Mammal
  - Oral gavage: Oral gavage days 1 - 17 of gestation
  - LOAEL: decreased maternal weight gain
  - NOAEL: 1 mg/kg/d

- Mouse
  - Develop (GD1-17) oral gavage
  - LOAEL: decreased maternal weight gain
  - NOAEL: 1 mg/kg/d

- Mouse (f)
  - Develop tox (GD7-20)
  - LOAEL: decreased maternal weight gain
  - NOAEL: 1 mg/kg/d

- Mouse (m)
  - Develop tox (GD7-20)
  - LOAEL: decreased maternal weight gain
  - NOAEL: 1 mg/kg/d

- Rat (f)
  - Develop (GD1-17) oral gavage
  - LOAEL: decreased maternal weight gain
  - NOAEL: 1 mg/kg/d

- Rat (m)
  - Develop & tox (GD0-PND20)
  - LOAEL: increased maternal liver wt, altered pup behavior & kidney wt; no increased relative maternal liver & early puberty (M), increased motor activity & habituation (M pups on PND17), increased liver & kidney wt (F0 pup), increased incidence of birth sternal defects
  - NOAEL: 1 mg/kg/d

- Rat (v)
  - Develop (GD1-17) oral gavage
  - LOAEL: increased maternal liver wt, decreased NK cell function & IgM response in F1 males: from 22 gestation to weaning (PND20), increased motor activity & habituation (M pups on PND17), increased incidence of birth defects in F1 pups, increased early puberty (M), increased liver & kidney wt (F0 pup), increased incidence of birth sternal defects
  - NOAEL: 1 mg/kg/d

**Perfluorooctane sulfonate (PFOS)**

- Mammal
  - Oral gavage: Oral gavage days 1 - 17 of gestation
  - LOAEL: decreased maternal weight gain
  - NOAEL: 1 mg/kg/d

**Perfluorohexane Sulfonate**

- Mammal
  - Oral gavage: Oral gavage days 1 - 17 of gestation
  - LOAEL: decreased maternal weight gain
  - NOAEL: 1 mg/kg/d

**Reference**

- Yahia et al. 2010 cited in Williamtown ERA
- Williamtown ERA


<table>
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<tr>
<th>Chemical</th>
<th>Abbreviation</th>
<th>Route of Exposure</th>
<th>Species Name</th>
<th>Species Abbrev.</th>
<th>NOAEL, mg/kg bw/day</th>
<th>LOAEL, mg/kg bw/day</th>
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<td>2.52</td>
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<td>Tweet 2021 (unpublished) (oral gavage), establishing a NOAEL of 2.52 mg/kg bw/day and a LOAEL of 2 mg/kg bw/day.</td>
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<td>90 d</td>
<td>2 mg/kg/d</td>
<td>3 mg/kg bw/day</td>
<td>Mammal 90 d Dietary Toxicity Study with T-6314 in Rats. # 6329-225. Covance Laboratories, Inc. 1999d. 13-week dietary toxicity study with T-6314 in rats. # 6329-225.</td>
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<td>Perfluorooctanesulfonic acid</td>
<td>PFOA</td>
<td>Oral gavage</td>
<td>Monkey</td>
<td>14 wks</td>
<td>2 mg/kg/d</td>
<td>3 mg/kg bw/day</td>
<td>Mammal 14 wks Oral Gavage. Argus Research Laboratories, Inc. 1999c. Oral (stomach tube) developmental toxicity study of N-EtFOSE in rabbits. # 418-010.</td>
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</tbody>
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** Norfolk Teratogenicity Study, Summary of Toxicity Data **

- **Species:** Rat (m/f), Monkey, Mouse
- **Route of Exposure:** Oral gavage, Oral capsule
- **Exposure:** 13 weeks, 90 days
- **Endpoints:** Neonate mortality, Hepatocellular hypertrophy, Hapatic gene expression
- **Findings:** Decreased body weight, Increased maternal liver weight, Decreased pup survival

**References:***
- ATSDR 2015 cited in Ablatross HHERA.
<table>
<thead>
<tr>
<th>Chemical</th>
<th>Abbreviation</th>
<th>Test Organism - Common Name Species Name</th>
<th>Test Species</th>
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<th>Route</th>
<th>Units</th>
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<td>Mouse</td>
<td>Reproductive endpoints</td>
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<td>Perfluorooctanoic acid</td>
<td>Sprague Dawley rats</td>
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<td>Reproductive endpoints</td>
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<td>2-(N-ethylperfluoro-1-octanesulfonamido) ethanol</td>
<td>Sprague Dawley rats</td>
<td>Mouse</td>
<td>Reproductive endpoints</td>
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**Summary of Toxicity Data - Mammals**

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<th>Route</th>
<th>Units</th>
<th>LOAEL</th>
<th>NOAEL</th>
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<td>CD rats</td>
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<td>Reproductive endpoints</td>
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<td>Reproductive endpoints</td>
<td>Oral gavage</td>
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<td>2-(N-ethylperfluoro-1-octanesulfonamido) ethanol</td>
<td>CD rats</td>
<td>Rat (m/f)</td>
<td>Reproductive endpoints</td>
<td>Oral gavage</td>
<td>10 mg/kg/day</td>
<td>10 mg/kg/day</td>
<td>10 mg/kg/day</td>
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**Reproductive endpoints**

- Slight decreased body weight gain in dams
- Increased motor activity & reduced viability and lactation controls
- Delayed maternal: decreased weight, mortality, skull closure twice that of control
- Reduced live fetal body weight & total activity; increased liver necrosis
- Decreased heart and brain weight
- Defects

**Notes**


**ATSDR 2015 cited in Williamtown ERA**

**Appendix L - Toxicity Study Data**

**Summary of Toxicity Data**

**Toxicity Study Data**

<table>
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<tr>
<th>Chemical</th>
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<th>Endpoint</th>
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<th>LOAEL</th>
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<td>PFOA</td>
<td>Oral (diet)</td>
<td>Increased liver weight</td>
<td>Rat (Female)</td>
<td>Oral diet</td>
<td>15.15 mg/kg/d</td>
<td>26 weeks</td>
<td>69.6 mg/L</td>
<td>50 mg/kg/d</td>
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<td>PFOA</td>
<td>Oral (diet)</td>
<td>Decreased body weight (dams)</td>
<td>Mouse</td>
<td>Oral diet</td>
<td>30 mg/kg/d</td>
<td>20 ppm</td>
<td>26 weeks</td>
<td>15.53 mg/L serum</td>
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<td>PFHx(A)</td>
<td>Oral gavage</td>
<td>Decreased pup survival and decreased pup body weight (at day 22)</td>
<td>Mouse</td>
<td>Oral gavage</td>
<td>30 mg/kg/d</td>
<td>20 ppm</td>
<td>14 wks</td>
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<td>PFOS</td>
<td>Oral gavage</td>
<td>Increased liver weight, decreased total protein, increased peroxisome proliferation index</td>
<td>Mammal</td>
<td>Oral gavage</td>
<td>40 mg/kg/d</td>
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**References**

### Summary of Toxicity Data - Mammals

#### Oral Gavage

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<th>Duration</th>
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<th>LOAEL</th>
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<td>Rat</td>
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<td>100 mg/kg bw/day</td>
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<td>PFHxS</td>
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<td>100 mg/kg bw/day</td>
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<td>PFHxS</td>
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<td>PFHxS</td>
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<td>Oral</td>
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#### Oral Diet

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<tr>
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<td>Oral</td>
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<td>Oral gavage</td>
<td>300 mg/kg bw/day</td>
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<td>Reduced serum P and K NOEL</td>
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#### Aerosol Inhalation

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<td>PFHxS</td>
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<td>4 h</td>
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<td>4 h</td>
<td>73.5 mg/kg bw</td>
<td>Inhalation</td>
<td>65 mg/kg bw</td>
<td>Reduced serum P and K NOEL</td>
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<td>4 h</td>
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#### Dermal Application

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<tr>
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<td>100 mg/kg bw</td>
<td>Reduced serum P and K NOEL</td>
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### References

- AR226-0419.
- AR226-0419.
- Available at http://www.nicnas.gov.au
- Available at http://www.nicnas.gov.au
- https://www.nicnas.gov.au
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**Notes:**
- NOAEL: No Observed Adverse Effect Level
- LD50: Lethal dose that causes death in 50% of the test population
- BMDL10: The lowest adverse effect level for the 10% response probability