



Groundwater Standard Summary Document

Division of Water Resources

PERFLUOROCTANE SULFONIC ACID (CASRN 1763-23-1)

Health Effects Summary

Human health effects associated with chronic, low environmental exposures to perfluorooctane sulfonic acid (PFOS) are unknown. Perfluorooctane sulfonic acid is slowly eliminated and therefore accumulates in the human body. Its estimated human serum biological half-life (time necessary for half of dose to be eliminated) is 4.8-5.4 years. The biological half-life of perfluorooctane sulfonic acid in other species, including rats and monkeys, is much smaller (48-121 days).

Animals exposed to perfluorooctane sulfonic acid via ingestion exhibited decreased body weight, decreased cholesterol, decreased liver weight, increased liver fat, and liver histopathology. Animal reproductive and developmental studies showed decrease survival and weight of offspring. Animals exposed during gestation and lactation had higher serum glucose levels and their offspring exhibit insulin resistance as adults.

Epidemiological studies of workers exposed to perfluorooctane sulfonic acid via inhalation and general populations exposed via drinking water report increased cholesterol and high density lipoproteins (HDLs), decreased female fertility and decreased weight of offspring.

Data used for Groundwater Standard

U.S. EPA's Office of Water established an oral reference dose (RfD) of 0.00002 mg/kg-day for perfluorooctane sulfonic acid based on decreased rat pup body weight in a two-generation reproductive study (https://www.epa.gov/sites/production/files/2016-05/documents/pfos_hesd_final_508.pdf). A systemic threshold concentration of 0.14 µg/L can be calculated using the oral reference dose for perfluorooctane sulfonic acid in accordance with 15A NCAC 02L .0202(d)(1).

U.S. EPA considers perfluorooctane sulfonic acid as having “suggestive evidence of carcinogenic potential” according to its 2005 Guidelines for Carcinogen Risk Assessment. Liver tumors were reported at the highest dose tested in a long-term rat study. However, there is lack of demonstrated genotoxicity and comparable human epidemiological evidence from workers exposed to perfluorooctane sulfonic acid. The U.S. EPA Office of Water has not derived a cancer slope factor for perfluorooctane sulfonic because the weight of evidence for human carcinogenic is limited. A human exposure concentration associated with an incremental lifetime cancer risk estimate of 1×10^{-6} cannot be calculated per the requirements of 15A NCAC 02L .0202(d)(2).

No aqueous odor threshold, aqueous taste threshold, federal maximum contaminant level (MCL) or secondary drinking water standard has been established for perfluorooctane sulfonic acid.

Recommended Groundwater Standard

U.S. EPA Office of Water issued a Health Advisory and Health Effects Support Document for Perfluorooctane Sulfonic Acid (PFOS) in 2016. The Health Advisory of 0.07 µg/L was calculated based on reduced pup body weight using the 90th percentile drinking water intake and body weight of lactating women and represents the most recent evaluation published by the US EPA. Alternatively, the calculation provided by the derivation of the non-cancer endpoint (0.1 µg/L) is advised.

Groundwater standards are to be the “lesser of” the criteria in 15A NCAC 02L .0202(d)(1-6).



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The recommended groundwater standard for perfluorooctane sulfonic acid (PFOS) is 0.07 ug/L (ppb) based on the calculated noncancer systemic threshold using the 90th percentile drinking water intake and body weight of lactating women.

Uses

Perfluorooctane sulfonic acid is used as a water and oil repellent and as a surfactant in firefighting foams. It is used in carpet, upholstery, and textiles in waterproofing and stain resistance applications. It is also used in food packaging as a paper grease proofing agent. It is commonly used as the sodium or potassium form of the acid.

References

Agency for Toxic Substances and Disease Control. 2015. Toxicological Profile for Perfluoroalkyls. U.S. Department of Health and Human Services. (<https://www.atsdr.cdc.gov/toxprofiles/index.asp>)

Amoore, JE and Hautala E. 1983. Odor as an aid to chemical safety: Odor thresholds compared with threshold limit values and volatiles for 214 industrial chemicals in air and water dilution. *Journal of Applied Toxicology*, Volume 3. No. 6.

Luebker, D.J., M.T. Case, R.G. York, J.A. Moore, K.J. Hansen, and J.L. Butenhoff. 2005b. Two-generation reproduction and cross-foster studies of perfluorooctanesulfonate (PFOS) in rats. *Toxicology* 215:126–148.

Olsen GW, Burriss JM, Ehresman DJ, Froehlich JW, Seacat AM, Butenhoff JL, Zobel LR. 2007. Half-life of serum elimination of perfluorooctanesulfonate, perfluorohexanesulfonate, and perfluorooctanoate in retired fluorochemical production workers. *Environ Health Perspect.* 115(9):1298-305.

U.S. EPA Drinking Water Standards and Health Advisories. 2012. Office of Water (EPA 822-S-12-001) <https://www.epa.gov/sites/production/files/2015-09/documents/dwstandards2012.pdf>

U.S. EPA Guidelines for Carcinogen Risk Assessment. 2005. (EPA/630/P-03/001B). Risk Assessment Forum, Washington, DC. (<https://www.epa.gov/risk/guidelines-carcinogen-risk-assessment>).

U.S. EPA Drinking Water Health Advisory for Perfluorooctane Sulfonic Acid (PFOS). 2016. Office of Water. (EPA 822-R-16-004) https://www.epa.gov/sites/production/files/2016-05/documents/pfos_hesd_final_508.pdf

U.S. National Library of Science Toxicology Data Network (TOXNET) <https://toxnet.nlm.nih.gov/>

Young WF, Horth H, Crane R, Ogden T and Arnott M. 1996. Taste and odour threshold concentrations of potential potable water contaminants. *Water Research*, 30:2, pp. 331-340.



Groundwater Standard Summary Document

Division of Water Resources

PERFLUOROCTANOIC ACID (PFOA) (CASRN 335-67-1)

Health Effects Summary

Human health effects associated with chronic, low environmental exposures to perfluorooctanoic acid (PFOA) are unknown. Perfluorooctanoic acid is slowly eliminated from humans and accumulates in the body. It has an estimated biological half-life (time necessary for half of dose to be eliminated) of 3.5-4 years.

Animals exposed to perfluorooctanoic acid via ingestion exhibited liver and kidney toxicity, immune effects, developmental effects and liver, testicular, and pancreatic cancer. Epidemiological studies of workers exposed to perfluorooctanoic acid via inhalation and general populations exposed via drinking water report high cholesterol, increased liver enzymes, decreased vaccination response, thyroid disorders, pregnancy induced hypertension and preeclampsia, and testicular and kidney cancer.

Data used for Groundwater Standard

U.S. EPA's Office of Water established an oral reference dose (RfD) of 0.00002 mg/kg-day for perfluorooctanoic acid based on skeletal variations and accelerated puberty observed in male mice offspring (https://www.epa.gov/sites/production/files/2016-05/documents/pfoa_hesd_final_508.pdf). A systemic threshold concentration of 0.14 µg/L can be calculated using the oral reference dose for perfluorooctanoic acid in accordance with 15A NCAC 02L .0202(d)(1).

U.S. EPA considers perfluorooctanoic acid as having “suggestive evidence of carcinogenic potential” according to its 2005 Guidelines for Carcinogen Risk Assessment. U.S. EPA Office of Water derived a cancer slope factor of 0.07 (mg/kg-day)⁻¹ for perfluorooctanoic acid based on testicular cancer (Leydig cells) observed in rats. A human exposure concentration of 0.50 µg/L associated with an incremental lifetime cancer risk estimate of 1 x 10⁻⁶ can be calculated per the requirements of 15A NCAC 02L .0202(d)(2).

No aqueous odor threshold, aqueous taste threshold, federal maximum contaminant level (MCL) or secondary drinking water standard has been established for perfluorooctanoic acid.

Recommended Groundwater Standard

An interim maximum allowable concentration (IMAC) of 2 µg/L was established under 15A NCAC 02L .0202(c) for perfluorooctanoic acid in 2006. New toxicological information relevant to the derivation of a North Carolina groundwater standard is available. U.S. EPA Office of Water issued a Health Advisory and Health Effects Support Document for Perfluorooctanoic Acid (PFOA) in 2016. The Health Advisory of 0.07 µg/L was calculated based on potential adverse effects for fetuses during pregnancy and breastfed infants using the 90th percentile drinking water intake and body weight of lactating women. Alternatively, the calculation provided by the derivation of the non-cancer endpoint (0.1 µg/L) is advised.

Groundwater standards are to be the “lesser of” the criteria in 15A NCAC 02L .0202(d)(1-6).

The recommended groundwater standard for perfluorooctanoic acid (PFOA) is 0.07 ug/L (ppb) based on the calculated noncancer systemic threshold using calculation parameters specific to lactating women.



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Uses

Perfluorooctanoic acid is used as a water and oil repellent, a surfactant in firefighting foams, and as an intermediate in the synthesis of fluoroacrylic esters. It is used in Teflon, floor waxes and polishes, outdoor clothing and similar chemicals (known as fluorotelomers). According to the 2010/2015 EPA PFOA Stewardship Program, manufacture of PFOA was scheduled to be phased out by 2015.

References

Agency for Toxic Substances and Disease Control. 2015. Toxicological Profile for Perfluoroalkyls. U.S. Department of Health and Human Services. (<https://www.atsdr.cdc.gov/toxprofiles/index.asp>)

Amoore, JE and Hautala E. 1983. Odor as an aid to chemical safety: Odor thresholds compared with threshold limit values and volatiles for 214 industrial chemicals in air and water dilution. *Journal of Applied Toxicology*, Volume 3. No. 6.

Lau, C., J.R. Thibodeaux, R.G. Hanson, M.G. Narotsky, J.M. Rogers, A.B. Lindstrom, and M.J. Strynar. 2006. Effects of perfluorooctanoic acid exposure during pregnancy in the mouse. *Toxicological Sciences* 90:510–518.

U.S. EPA Drinking Water Standards and Health Advisories. 2012. Office of Water (EPA 822-S-12-001) <https://www.epa.gov/sites/production/files/2015-09/documents/dwstandards2012.pdf>

U.S. EPA Guidelines for Carcinogen Risk Assessment. 2005. (EPA/630/P-03/001B). Risk Assessment Forum, Washington, DC. (<https://www.epa.gov/risk/guidelines-carcinogen-risk-assessment>).

U.S. EPA Health Effects Support Document for Perfluorooctanoic Acid (PFOA). 2016. Office of Water. (EPA 822-R-16-003) https://www.epa.gov/sites/production/files/201605/documents/pfoa_health_advisory_final-plain.pdf

U.S. National Library of Science Toxicology Data Network (TOXNET) <https://toxnet.nlm.nih.gov/>

Young WF, Horth H, Crane R, Ogden T and Arnott M. 1996. Taste and odour threshold concentrations of potential potable water contaminants. *Water Research*, 30:2, pp. 331-340.



North Carolina Groundwater Standard Calculation Sheet

Total Perfluorooctane sulfonic acid (PFOS) and Perfluorooctanoic acid (PFOA)

CASRNs 1763-23-1 and 335-67-1

North Carolina Groundwater (GW) Standard = **0.07 µg/L***

Summary

The North Carolina GW standard for total perfluorooctane sulfonic acid (PFOS) and per is based on a noncancer endpoint in accordance with selection criteria defined in 15A NCAC 02L .0202 (highlighted in yellow below).
Critical health effect: Reduced pup body weight (2-generation rat gavage study).

GW standard based on noncancer endpoint

$$GWQS = [(RfD \times WT \times RSC) / WI] \times 1000$$

	PFOS	PFOA	
RfD = reference dose ¹	2.0E-05	2.0E-05	mg/kg/day
WT = average adult human body weight ²	70	70	kg
RSC= relative source contribution ³	0.2	0.2	unitless value
WI = average daily human adult water intake ⁴	2	2	L/day
1000 = conversion factor	1000	1000	µg/mg
Calculated GW Standard using noncancer endpoint	0.1	0.1	µg/L

GW Standard based on cancer endpoint

$$GWQS = [(RL \times WT) / (q1^* \times WI)] \times 1000$$

	PFOS	PFOA	
RL = risk level	1.0E-06	1.0E-06	
WT = average adult human body weight ²	70	70	kg
q1* = carcinogenic potency factor (slope factor) ⁵	NA	0.07	(mg/kg / day) ⁻¹
WI = average daily human adult water intake ⁴	2	2	L/day
1000 = conversion factor	1000	1000	µg/mg
Calculated GW Standard using cancer endpoint	NA	0.5	µg/L

GW Standards based on published values

Taste Threshold⁶	NA	NA	µg/L
Odor Threshold⁷	NA	NA	µg/L
Maximum Contaminant Level (MCL)⁸	NA	NA	µg/L
Secondary Drinking Water Standard (SMCL)⁹	NA	NA	µg/L

Additional Information

US EPA Health Advisory for PFOA/PFOS (2016)¹⁰ **0.07** **0.07** **µg/L**

Practical Quantitation Limit (PQL)¹¹

0.04 0.002 µg/L

References

¹ US EPA Drinking Water Health Advisory for Perfluorooctane sulfonic acid (PFOS). 2016. US EPA Office of Water (EPA 822-R-16-004). Luebker, D.J., M.T. Case, R.G. York, J.A. Moore, K.J. Hansen, and J.L. Butenhoff. 2005b. Two-generation reproduction and cross-foster studies of perfluorooctanesulfonate (PFOS) in rats. Toxicology 215:126–148.

² Average adult body weight from 15A NCAC 02L .0202 (effective date April 1, 2013).

³ RSC=0.1 for nonorganics, 0.2 for organics in accordance with 15A NCAC 02L .0202 (effective date April 1, 2013).

⁴ Average adult water consumption from 15A NCAC 02L .0202 (effective date April 1, 2013).

⁵ US EPA has not classified PFOS for carcinogenicity. A cancer slope factor is not available.

⁶ NA; Contact NC DEQ Groundwater Standards Coordinator for list of taste threshold resources examined.

⁷ NA; Contact NC DEQ Groundwater Standards Coordinator for list of odor threshold resources examined.

⁸ NA; MCL: <https://www.epa.gov/your-drinking-water/table-regulated-drinking-water-contaminants#Organic> (accessed 12/22/16).

⁹ NA; SMCL: <https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-chemicals>.

¹⁰ US EPA Office of Water derived the Health Advisory for PFOS using the 90th percentile consumers-only estimate of combined direct and indirect community water ingestion for lactating women (Table 3-81 in US EPA 2011 Exposure Factors Handbook). A value of 0.054 L/kg-day was used in the calculation which equates roughly to 3.8 L of water consumed per day for a 65 Kg woman. * EPA established equivalent Health Advisory Levels of 0.07 µg/L for PFOA and PFOS. The Health Advisory Level also applies to the sum total of both compounds if they co-occur.

¹¹ PQL provided for informational purposes only. PQL not established by North Carolina Water Resources Laboratory. Using EPA Method 537, Pace Analytical reports a PRL (ie- PQL) of 0.04 µg/L for PFOS and 0.002 µg/L for PFOA. (<https://www.pacelabs.com/environmental-services/specialty-services/pfas-analysis.html>)

NA = Not available

History

December 2016- IMAC for PFOS developed by DWR in conjunction with review for PFOA.