TRANSMITTAL MEMORANDUM

To: Interested Parties

From: Alec Naugle, Chief, Toxics Cleanup Division

Date: May 27, 2020

Digitally signed by Alec Naugle
Date: 2020.05.29 11:10:05 -07'00'

Subject: Transmittal of Interim Final Environmental Screening Levels (ESLs) for Two Per- and Polyfluoroalkyl Substances (PFAS): Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoate (PFOA)

Introduction

The State Water Board's Division of Water Quality (DWQ) and Division of Drinking Water (DDW), in coordination with Regional Water Boards, developed an investigation approach to evaluate the presence of *per- and polyfluoroalkyl substances* (PFAS) throughout California. In 2019, DWQ sent statewide investigation orders to many commercial airports, municipal solid waste landfills, and chrome plating facilities. They plan to send similar orders to wastewater treatment plants, oil refineries and bulk terminals later this year. DDW also sent orders to hundreds of public water systems, based on proximity to the investigation facilities, prior system detections, and the need for continued monitoring. That effort continues as the list of facilities under investigation grows and PFAS are detected.

Regional Water Board staff is overseeing these PFAS investigations, and screening levels are needed to help assess the potential threats to human health and the environment. To assist in these efforts, we have developed risk-based Environmental Screening Levels (ESLs) for two PFAS: perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA).

Our ESL team developed the ESLs presented in the attached memorandum after review of available published information. The memorandum describes background information, the basis and derivation of the ESLs, and additional considerations (e.g., laboratory analytical reporting limits, ambient levels, site-specific risk evaluations for other PFAS chemicals). Our plan is to incorporate these *interim final* ESLs into our ESL Workbook and User's Guide as part of the next major ESL update, which will tentatively be in 2021.

There may be local background (i.e., ambient) concentrations of PFOS and PFOA above the ESLs. This is both a reflection of the widespread use, mobility, and persistence of PFAS substances, and their toxicity and bioaccumulation potential. This is the case in parts of the San Francisco Bay where, based on available information, ambient levels exceed the relatively low PFOS and PFOA ESLs for human health protection considering seafood ingestion. Therefore, background sampling is

recommended to distinguish between site-related contamination and ambient concentrations.

In some cases, PFOS and PFOA ESLs may be less than achievable method reporting limits. The *Additional Considerations* section in the attached memorandum provides more information on both issues.

Regulatory Approach for PFAS Testing, Investigation, and Cleanup

Occurrence Testing

Occurrence testing helps determine whether a PFAS release has occurred and provides information about the potential source strength of the release. We have developed the following preliminary prioritization approach to help us identify potential sites for occurrence testing that were not included in the State Water Board investigation orders.

It is our intention to begin implementing this approach gradually as our time and resources allow. In general, our approach is site-specific, however, where appropriate, we may consider issuing requests to categories of sites that share common characteristics.

Identification of Sites for Possible Occurrence Testing

Prioritization would consider the current and historical use of PFAS in specific industrial/manufacturing processes or fire-fighting efforts. Following are some examples of facilities or processes where PFAS sampling may be warranted:

- fire-fighting practice training areas
- semiconductors
- electronics manufacturers
- former chrome plating facilities, non-chrome metal plating and finishing facilities
- mining industry (copper, gold, aluminum, vanadium, and uranium)
- textile manufacturers and processors
- furniture manufacturers and upholsterers
- carpet manufacturers
- cardboard/paper packaging manufacturers
- surface coatings/paints/varnish manufacturers and high-volume users
- manufacturers of non-stick or known PFAS-containing products such as dental floss, non-stick cookware, food packaging materials, waterproof and water repellant textiles, polishes waxes, cleaning products, medical garments, adhesives, cosmetics, hair conditioners, and lotions

Prioritizing Sites for Occurrence Testing

As sites are identified for potential occurrence testing based on current or historical use, we will prioritize them considering, among other things, the potential for spill or discharge to the environment and proximity or connection to drinking water or aquatic

resources that could be affected: Higher priority will be given to sites where there is a reasonable potential to affect drinking water or aquatic receptors.

Site Investigation and Cleanup

Our decisions to request additional investigation (e.g., delineation) and cleanup will consider the afore-mentioned priorities as well as technical and economic feasibility. Investigation and cleanup will proceed in accordance with State Water Resources Control Board Resolution No. 92-49, which describes the policies and procedures for site investigation and cleanup of discharges under the Water Code and other relevant policies and guidelines. We will provide responsible parties with relevant cost-recovery program information for sites where our regulatory review of additional investigation or cleanup is needed.

Contact Us

If you have questions, please contact the ESL team at ESLs.ESLs@waterboards.ca.gov.

PFAS ESL MEMORANDUM

To: Alec Naugle, Toxics Cleanup Division Chief
Terry Seward, Groundwater Protection Division Chief

From: Nicole Fry, Toxics Cleanup Division
Ross Steenson, Groundwater Protection Division

Date: May 11, 2020

Subject: **Interim Final Environmental Screening Levels (ESLs) for Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoate (PFOA)**

Introduction

We reviewed readily available information and derived Interim Final Environmental Screening Levels (ESLs) for two per- and polyfluoroalkyl substances (PFAS): perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA).[1] These ESLs are intended to assist Regional Water Board staff currently overseeing the investigation and cleanup of PFAS spills and releases. This memorandum serves to describe the basis of these ESLs and considerations for their use. The PFOS and PFOA ESLs will be updated and incorporated into the Workbook and User's Guide as part of the next major ESL update.

Background

PFAS are a family of man-made substances consisting of thousands of unregulated chemicals that have been produced since the mid-1900s. PFAS are commonly found in stain resistant and waterproof textiles, food contact paper, non-stick cookware, certain class B firefighting foams, metal plating operations, and many other industrial and commercial products and processes. Several PFAS chemicals have been found to be toxic to humans and wildlife (ATSDR 2018).

In 2019, the State Water Board's Division of Water Quality (DWQ) and Division of Drinking Water (DDW), in coordination with Regional Water Boards, developed an investigation approach to evaluate the presence of PFAS throughout California. In 2019, DWQ sent statewide investigation orders to many commercial airports, municipal solid waste landfills, and chrome plating facilities. They plan to send similar orders to wastewater treatment plants, oil refineries and bulk terminals later this year. DDW also sent orders to hundreds of public water systems, based on proximity to the investigation

[1] Chemical names for the anionic form of the molecules are used since that is the state in which they occur in the environment.

facilities, prior system detections, and the need for continued monitoring. That effort continues as the list of facilities under investigation grows and PFAS are detected. Regional Water Board staff is overseeing these investigations, and risk-based screening levels are needed to help assess the potential threats to human health and the environment posed by PFAS contamination identified during these site investigations.

As with all the ESLs, the PFOS and PFOA ESLs are guidance so their use is not mandatory. Alternative levels or approaches must be supported by adequate technical documentation. Intended uses of the ESLs are described in Section 1.3 of the ESL User's Guide (Regional Water Board 2019). The ESLs are not default cleanup standards. State Water Board Resolution No. 92-49 (the Policy) describes the policies and procedures for site investigation and cleanup of discharges under the Water Code, including setting cleanup standards. Cleanup standards typically are chemical concentration levels for a specific site that are supported by a site-specific feasibility evaluation and agreed-upon between the overseeing regulatory agency and the discharger. In accordance with the Policy, cleanup standards should promote attainment of either background water quality, or the best water quality that is reasonable if background water quality conditions cannot be restored. In other words, cleanup standards may be lower or greater than risk-based levels (e.g., ESLs), depending on background conditions. Further details are provided in the Policy.

PFOS and PFOA ESL Derivation Methods

In this document we derive ESLs only for PFOS and PFOA. However, as more information becomes available, ESLs for other PFAS chemicals may be derived. Final ESL values are listed in the *Recommended Interim Final PFAS ESLs* section at the end of this document.

Human Health Direct Exposure Screening Levels for Soil and Groundwater

Direct exposure human health risk-based levels for groundwater and soil were derived using the USEPA Regional Screening Level (RSL) equations (i.e., residential tapwater exposure and soil exposure for residential and commercial scenarios), as described in Section 3 of the ESL User's Guide. In addition, the following Office of Environmental Health Hazard Assessment (OEHHA 2019) recommended toxicity values were used in the ESL calculations:

- **Oral Cancer Slope Factors:**
  - PFOS – 4.6E+01 $(mg/kg\text{-}day)^{-1}$
  - PFOA – 1.4E+02 $(mg/kg\text{-}day)^{-1}$
- **Oral Reference Doses:**
  - PFOS – 1.8E-06 mg/kg-day
  - PFOA – 4.5E-07 mg/kg-day

The resulting soil screening levels for PFOS and PFOA (tabulated at the end of the document) are protective of incidental soil ingestion, particulate inhalation, and dermal soil contact. Soil Direct Exposure ESLs are provided for three different receptors: residents, commercial/industrial workers, and construction workers. All receptors may

be exposed to contaminated soil at or above 10 feet below ground surface. Construction workers could also be exposed to deeper soil.

The calculated groundwater direct exposure screening levels are protective of potential adverse effects to humans through exposure to groundwater used as tapwater for common domestic activities, such as drinking, bathing/showering, cooking, dishwashing/laundry, and flushing the toilet. However, the final Groundwater Direct Exposure ESLs also consider other drinking water levels, in addition to the calculated risk-based levels:

- Maximum Contaminant Levels (MCLs) – MCLs are drinking water standards adopted by the California State Water Resources Control Board, Division of Drinking Water (DDW) pursuant to the California Safe Drinking Water Act.
- Other Drinking Water Levels – These values include Public Health Goals developed by OEHHA, Notification Levels (NL) by DDW, or Public Health Archived Advisory Levels by DDW.

The final Groundwater Direct Exposure ESLs for cancer risk and noncancer hazard select the lowest of the calculated risk-based levels (i.e., tapwater cancer risk and noncancer hazard), MCL, and Other Drinking Water Levels.

MCL Priority ESLs were considered for PFOS and PFOA. If *MCL Priority* is chosen and a chemical has an MCL, the MCL is selected as the final ESL for groundwater direct exposure. Because PFOS and PFOA do not currently have MCLs, selecting MCL Priority will, in the interim, default to DDW's NLs. Section 3.1.2 of the ESL User's Guide provides additional information about the MCL Priority concept.

Options for site-specific direct exposure human health risk evaluations are discussed in Section 3.7 of the ESL User's Guide. Alternative approaches will be considered, provided there is adequate technical justification.

Aquatic Habitat Screening Levels for Groundwater

The Aquatic Habitat ESLs are comprised of two types of exposure risks depending on the receptor type (ecological species versus humans):

- Ecotoxicity ESLs
    - Direct exposure – Toxicity to freshwater and saltwater aquatic species from direct contact with contaminated water.
    - Secondary poisoning – Bioaccumulation-based risk to species higher in the food chain (e.g., mammals, birds) through consumption of aquatic species that have bioaccumulated high levels of PFAS.
- Seafood Ingestion ESLs – Bioaccumulation-based risk to humans through consumption of contaminated seafood.

The final Aquatic Habitat ESLs selected for a site are the lower of the Ecotoxicity ESLs and the Seafood Ingestion ESLs.

PFAS direct exposure ecotoxicity levels were selected from a Department of Defense Strategic Environmental Research and Development Program (SERDP) publication (Conder et al. 2020). This work compiles toxicity criteria for several freshwater and marine organisms to determine species sensitivity distributions (SSD) following U.S. Environmental Protection Agency (USEPA) methodologies (USEPA 2010). The SSD for PFOS and PFOA were used to calculate one percent (1%) hazardous concentration (HC1) that represents a concentration in surface water expected to be protective of 99% of all aquatic species. Due to limited saltwater PFOA toxicity data, no HC1 value was calculated. Therefore, the freshwater PFOA value was used as a surrogate for the saltwater ecotoxicity of PFOA, consistent with ESL derivation practices.

The secondary poisoning screening levels are based on the aquatic receptor wildlife risk-based screening levels in a separate SERDP publication (Divine et al. 2020). These levels were developed using standard methodologies (USEPA 2005, 2012). The selected levels are based on no observed adverse effects levels (NOAELs) and exposure information for common receptors with well-characterized exposure information:

- **Mammals:**
  - Harbor Seal, River Otter, and Mink (Piscivore Surrogate)
  - Little Brown Bat (Insectivore Surrogate)
  - Muskrat (Herbivore Surrogate)
- **Birds:**
  - Brown Pelican (Piscivore Surrogate)
  - Tree Swallow (Invertivore Surrogate)
  - Red-Winged Blackbird (Omnivore Surrogate)

Potential exposure scenarios were modeled based on the dietary preferences of each receptor and information on the bioaccumulation of PFOS or PFOA from surface water into the aquatic species consumed by each receptor. Food web models were then used to back-calculate protective concentrations in surface water.

The Human Health Seafood Ingestion ESLs are the lower of the cancer risk vs noncancer hazard screening levels. These ESLs were calculated using the following equations (USEPA 2000, 2019b):

$$\textbf{Cancer Risk ESL (µg/L)} = \frac{\textbf{TR x LT x (365 days/yr) x BW}}{\textbf{EF x ED x SFo x } (10^{-3}\ \textbf{mg/µg}) \textbf{ x IRF x BAF}}$$

$$\textbf{Noncancer Hazard ESL (µg/L)} = \frac{\textbf{THQ x LT x (365 days/yr) x BW}}{\textbf{EF x ED x (1/RfDo) x } (10^{-3}\ \textbf{mg/µg}) \textbf{ x IRF x BAF}}$$

Where:
TR *= Target Risk ($1x10^{-6}$)*
THQ *= Target Hazard Quotient (1)*
LT *= Lifetime (years)*
BW *= Body Weight (kg)*
EF *= Exposure Frequency (days/year)*
ED *= Exposure Duration (years)*
SFo *= Oral Slope Factor $(mg/kg\text{-}day)^{-1}$*
RfDo *= Oral Reference Dose (mg/kg-day)*
IRF *= Fish ingestion rate (kg/day)*
BAF *= Bioaccumulation factor (L/kg)*

The following input values were used in the above equations:

- Adult body weight (BW) of 80 kilograms (kg), lifetime (LT) of 70 years, exposure frequency (EF) of 350 days/year, and exposure duration (ED) of 26 years recommended by USEPA (USEPA 2014);
- Fish tissue bioaccumulation factors (BAF) of 13,229 liters per kilogram (L/kg) for PFOS and 894 L/kg for PFOA (Divine et al. 2020);
- Cancer oral slope factors (SFo) recommended by OEHHA (2019) and presented above;
- A 95th percentile upper bound estimate of the local ingestion rate (IRF) for recent fish-consuming anglers of 80 grams fish per day (San Francisco Estuary Institute or SFEI 2000).

The PFAS Aquatic Habitat ESLs apply to groundwater plumes in proximity to surface water bodies (e.g., the Bay, streams, wetlands) given the default assumption that a potentially harmful discharge is occurring until demonstrated otherwise via site-specific evaluation. Characterizing the distribution and extent of contaminated groundwater and assessing plume stability are critical steps necessary to determine the need for further evaluation and/or remediation.

Section 7 of the ESL User's Guide presents the generic conceptual site model and describes several options for site-specific evaluations. Alternative approaches will be considered, provided there is adequate technical justification.

Terrestrial Habitat Screening Levels for Soil

The Terrestrial Habitat ESLs were developed to ensure soils at developed sites provide a healthy functioning ecosystem capable of sustaining the current and likely future uses of the site by ecological receptors. Terrestrial Habitat ESLs are published for two scenarios: (1) Significantly Vegetated Areas; or (2) Minimally Vegetated Areas, as defined in Section 8.1.2 of the ESL User's Guide. In general, the Terrestrial Habitat ESLs are not intended for use in agricultural or areas where special status species are present. Also, the Terrestrial Habitat ESLs do not apply to aquatic habitats or sediment; the latter is discussed in ESL User's Guide Section 12.

The PFOS and PFOA Terrestrial Habitat ESL values are adopted from the terrestrial screening levels in a SERDP guidance (Divine et al. 2020), which were derived using standard USEPA methodologies (USEPA 2005). The levels are considered protective of direct exposure and bioaccumulation-based exposure for the following receptor categories:

- Terrestrial Plants and Invertebrates
- Terrestrial Mammals and Birds

Screening levels based on NOAELs and lowest observed adverse effect levels (LOAELs) were considered for each receptor category. For both PFOS and PFOA, the lowest NOAEL-based screening level of all receptor categories was selected for the Significantly Vegetated Area ESL while the lowest LOAEL-based screening level of all receptor categories was selected for the Minimally Vegetated Area ESL.

For sites where soil concentrations exceed the Terrestrial Habitat ESLs, further site-specific evaluation is necessary. See Section 8.3 of the ESL User's Guide for more information about site-specific, terrestrial ecological screening evaluations.

Leaching to Groundwater Screening Levels for Soil

The Soil Leaching ESLs (tabulated at the end of the document) provide for the protection of groundwater from leaching and migration of chemicals through vadose zone soil. They are calculated based on target groundwater ESLs for two groundwater exposure scenarios:

- **Groundwater used as Drinking Water** – The MCL Priority ESLs are used as the target groundwater concentration.
- **Groundwater Discharge to Aquatic Habitats** – The lowest of the Ecotoxicity and Seafood Ingestion ESLs are used as the target groundwater concentration.

For situations where both groundwater exposure scenarios are applicable, the lowest of these Soil Leaching ESLs should be used.

The conceptual site model and mathematical equations used to calculate the Soil Leaching ESLs are presented in Section 9 of the ESL User's Guide. The following physical-chemical parameters were used to determine the leaching dilution attenuation factor (DAF):

- **Henry's Law Constants (H)**
  - PFOS: 4.7E-09 atm-m^3/mol (OECD 2002)
  - PFOA: 4.0E-06 atm-m^3/mol (RSL Calculator, December 2019)
- **Organic Carbon Partition Coefficient (Koc)**
  - PFOS: 3.7E+02 L/kg (USEPA 2019a)
  - PFOA: 1.2E+02 L/kg (USEPA 2019a)

The Soil Leaching ESLs are intended for use as a general indication of potential leachability. In general, these ESLs should not be used as the sole line of evidence to

screen out further evaluation of groundwater impacts because it can be difficult to find the location in soil where the contamination was transported to groundwater. Groundwater should be sampled where feasible.

PFOS and PFOA are surfactants; containing a hydrophobic and a hydrophilic portion of the molecule. Many PFAS will self-assemble into films at the air-water interface, with the hydrophobic end of the molecule oriented towards the air and the hydrophilic end dissolved in the water. This behavior could significantly affect vadose zone transport. For example, soils with more air/water interfacial area available for PFAS partitioning could increase retention of PFAS (Anderson 2019). The PFAS Soil Leaching ESLs would overestimate the threat in this situation. The calculation of site-specific soil leaching screening levels using alternative leaching models or groundwater targets is discussed in Section 9.4 of the ESL User's Guide. Alternative approaches will be considered, provided there is adequate technical justification.

Additional Considerations

Laboratory Analytical Methods and Reporting Limits

USEPA approved Methods 537 (14 analytes), 537.1 (18 analytes), and 533 (25 analytes) can detect a total of 29 PFAS in drinking water and groundwater (with total dissolved solids/hardness below 300 milligrams per liter) with reporting limits in single-digit nanograms per liter (ng/L). Modified versions of these methods are currently being used to detect PFOS and PFOS in soil and sediment at sites. Draft USEPA SW-846 Method 8327 (24 analytes) is designed to analyze PFAS in non-potable water (i.e., surface water, groundwater, and wastewater effluent) high-throughput applications with reporting limits ranging from 10 to 50 ng/L. US EPA SW-846 Draft Method 8328 is being developed to analyze non-drinking water aqueous samples as well as solids (soil, sediment, solid waste).

Method detection limits and laboratory reporting limits are not considered in derivation of ESLs. In some cases, PFOS and PFOA ESLs may be less than achievable method reporting limits. Therefore, an evaluation of data quality objectives early in the investigation will help ensure that specific reporting limits are appropriate for the project. In some situations, it may be acceptable to consider the method reporting limit in place of the screening level, with the approval of the overseeing regulatory agency. For determining a reasonable laboratory reporting limit to substitute as the screening level for a given chemical, the discharger should obtain reporting levels from three laboratories and select either the lowest or the median level, considering appropriate factors (e.g., protectiveness, cost, etc.). The selection should be approved by the overseeing regulatory agency.

Ambient Levels

Given the widespread use of PFAS substances, local ambient levels of PFOS and PFOA greater than the soil and groundwater ESLs may be present at some sites (Tarazona and Ramos-Peralonso 2014; Vedagiri et al. 2018; University of Vermont 2019). Therefore, background sampling is recommended to distinguish between site related contamination and the ambient concentrations of PFOS and PFOA at a site and

in surface water at any suspected points of discharge. For example, surface water samples from several monitoring stations in San Francisco Bay (the Bay), collected in 2009, detected concentrations of PFOS and PFOA greater than the Aquatic Habitat ESLs (SFEI 2018). Background surface water sampling should be designed to distinguish between ambient levels from diffuse sources versus levels resulting from other cleanup sites discharging to the Bay. If the site-specific, local ambient concentrations (in soil, groundwater, or surface water) are greater than the risk-based ESLs, the background concentrations may be used to evaluate sites for excess risk posed by site contamination. This should only be performed in consultation with the overseeing regulatory agency. Risk from background or ambient levels of chemicals of concern should still be documented in the risk assessment report, so those risks can be considered for risk communication and risk management decisions. Further information about assessing background conditions is provided in Section 12.4 of the ESL User's Guide.

Site-Specific Risk Evaluations for Other PFAS Chemicals

Ideally, all PFAS present at a site would be evaluated. However, due to a limited number of validated analytical methods, the initial PFAS investigations in California have focused on up to 38 PFAS analytes. Some laboratories may be capable of analyzing additional PFAS that are not included on the current list of 38. The development of site-specific screening criteria may be needed when PFAS other than PFOS and PFOA are identified at a site. For example, the following PFAS chemicals have been detected in multiple wells throughout California during initial PFAS investigations, and the State Water Board has requested OEHHA's recommendation in developing notification levels for these chemicals:

- Perfluorohexane sulfonic acid (PFHxS)
- Perfluorobutane sulfonic acid (PFBS)
- Perfluorohexanoic acid (PFHxA)
- Perfluoroheptanoic acid (PFHpA)
- Perfluorononanoic acid (PFNA)
- Perfluorodecanoic acid (PFDA)
- 4,8-dioxia-3H-perflourononanoic acid (ADONA)

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Recommended Interim Final PFAS ESLs

Groundwater ESLs (µg/L): Direct Exposure Human Health Risk Levels

Chemical	Tapwater: Cancer Risk	Tapwater: Noncancer Hazard	Notification Level	Direct Exposure ESL	MCL Priority ESL
PFOS	1.7E-03	3.6E-02	6.5E-03	1.7E-03	6.5E-03
PFOA	5.4E-04	9.0E-03	5.1E-03	5.4E-04	5.1E-03

Note: DDW NLs are substituted for MCL Priority since MCLs have not yet been promulgated.

Groundwater ESLs (µg/L): Aquatic Habitat Ecotoxicity Levels

Chemical	Direct Exposure Ecotoxicity: Freshwater	Direct Exposure Ecotoxicity: Saltwater	Secondary Poisoning Ecotoxicity: Freshwater & Saltwater	Ecotoxicity ESL: Freshwater & Saltwater
PFOS	5.6E-01	2.6E+00	7.5E-02	7.5E-02
PFOA	5.4E+02	5.4E+02	4.4E+00	4.4E+00

Groundwater ESLs (µg/L): Aquatic Habitat Seafood Ingestion Levels (µg/L)

Chemical	Cancer Risk	Noncancer Hazard	Seafood Ingestion ESL: Freshwater & Saltwater
PFOS	4.7E-06	3.8E-04	4.7E-06
PFOA	2.2E-05	1.4E-03	2.2E-05

Soil ESLs (mg/kg): Direct Exposure Human Health Risk Levels

Chemical	Resident Cancer Risk ESLs	Resident Noncancer Hazard ESLs	Com/ Ind Cancer Risk ESLs	Com/ Ind Noncancer Hazard ESLs	CW Cancer Risk ESLs	CW Noncancer Hazard ESLs
PFOS	1.2E-02	1.1E-01	5.1E-02	1.5E+00	2.9E-01	3.4E-01
PFOA	3.8E-03	2.8E-02	1.6E-02	3.7E-01	9.3E-02	8.6E-02

Note: Com/Ind = Commercial Industrial Worker; CW = Construction Worker

Soil ESLs (mg/kg): Terrestrial Habitat Levels

Chemical	Plant & Invert. NOAEL	Mammal & Bird NOAEL	Significantly Vegetated Area ESLs (NOAEL)	Plant & Invert. LOAEL	Mammal & Bird LOAEL	Minimally Vegetated Area ESLs (LOAEL)
PFOS	7.7E+00	1.3E-02	1.3E-02	3.3E+01	5.0E-02	5.0E-02
PFOA	8.4E-02	5.7E-01	8.4E-02	8.4E-01	1.1E+00	8.4E-01

Note: Invert = Invertebrate

Soil ESLs (mg/kg): Leaching to Groundwater Levels

Chemical	Leaching ESLs: Drinking Water	Leaching ESLs: Aquatic Habitat
PFOS	4.0E-04	2.9E-07
PFOA	9.7E-05	4.2E-07