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Adjustment Factors Supporting Document

Proposed changes to Nonresidential, Multipathway, and Early Life Adjustment Factors for Deriving Risk-Based Concentrations from Toxicity Reference Values

DEQ

This document was prepared by
Oregon Department of Environmental Quality
Program Name
700 NE Multnomah Street, Portland Oregon, 97232

Contact: Mike Poulsen
Phone: 503-863-0770
mike.poulsen@deq.oregon.gov

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800-452-4011 | TTY: 711 | deqinfo@deq.oregon.gov

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Executive summary

In the current Toxic Air Contaminant Review and Update Rulemaking, the Oregon Department of Environmental Quality is proposing revisions to some of the regulatory values the Cleaner Air Oregon program uses to determine compliance with its health-based standards. These values, known as Risk-Based Concentrations, are developed by applying three types of adjustment factors to the Toxicity Reference Values defined by Oregon's air quality standards for Toxic Air Contaminants.

1. **Nonresidential Adjustment Factors** (NRAFs): consider different exposure frequency and duration for specific nonresidential exposures— for example, nonresidential worker cancer risks, or nonresidential child chronic noncancer risks.
2. **Multipathway Adjustment Factors** (MPAFs): consider alternative exposure pathways other than simple inhalation— for example, soil ingestion, vegetable consumption, and breastmilk.
3. **Early-Life Adjustment Factors** (ELAFs): consider additional cancer risk associated with exposure to infants and children for chemicals with a mutagenic mode of action.

To support this effort DEQ contracted with a consulting firm, Eastern Research Group (ERG), to provide research and analysis support, as well as to develop a user-friendly tool that enables modifications to the underlying assumptions and parameters of the MPAF and ELAF calculations.

It is important to note that MPAFs and ELAFs are not specified in rule, but changes to how they are established lead to some of the proposed updates to RBCs in this rulemaking. This supporting document provides information about the proposed changes to the MPAFs and ELAFs to aid in the review of the proposed changes to the specific RBCs where these adjustment factors are applied. DEQ is not proposing changes to any of the NRAFs in this rulemaking.

Appendix A to this document, "Development of RBCs from TRVs," shows schematically the specific considerations the Oregon Department of Environmental Quality uses to develop RBCs for the CAO program. Appendix B, "Equations for Development of RBCs," provides the detailed equations used to calculate the RBCs. Appendices C and D provide ERG memoranda with plant uptake factors for the MPAF calculations.

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Acronyms

ATSDR	U.S. Agency for Toxic Substances and Disease Registry
CAO	Cleaner Air Oregon
DEQ	Oregon Department of Environmental Quality
DPM	Diesel Particulate Matter
ELAF	Early Life Adjustment Factor
EPA	United States Environmental Protection Agency
ERG	Eastern Research Group
GRAF	Gastrointestinal Relative Absorption Factor
MPAF	Multi-Pathway Adjustment Factor
NHANES	National Health and Nutrition Examination Survey
OEHHA	California Office of Environmental Health Hazard Assessment
OHA	Oregon Health Authority
PAH	Polycyclic Aromatic Hydrocarbon
PFAS	Per- and Polyfluoroalkyl Substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctanesulfonic Acid
RBC	Risk-Based Concentration
RPF	Relative Potency Factor
SCAQMD	South Coast Air Quality Management District
TAC	Toxic Air Contaminant
TRV	Toxicity Reference Value

Multipathway Adjustment Factors (MPAFs)

MPAFs account for exposure pathways in addition to inhalation of chemicals in air, such as incidental ingestion and dermal contact with Toxic Air Contaminants (TACs) migrating to soil and water. DEQ applies MPAFs when assessing risk for chemicals that persist and bioaccumulate in the environment.

When the CAO program was originally established in 2018, DEQ considered developing MPAFs specific to Oregon but determined that the agency had neither the time nor resources to undertake this effort. After evaluating MPAFs from other agencies, including Minnesota (MPCA 2016) and California's South Coast Air Quality Management District (SCAQMD 2016b), DEQ decided to use the MPAFs from SCAQMD because of the extensive modeling performed for the development of the MPAFs, and the large list of TACs evaluated. At the time, DEQ acknowledged that exposure conditions may not be the same in Oregon but considered the MPAFs appropriately protective. As part of this current rulemaking, DEQ is proposing to modify some of the assumptions used to develop the original MPAFs, while continuing to apply the same general approach used by California's Office of Environmental Health Hazard Assessment (OEHHA) and SCAQMD.

The details for developing RBCs from TRVs are provided in the Appendices to this report but have been taken directly from DEQ's 2022 Recommended Procedures for Toxic Air Contaminant Health Risk Assessments document (DEQ 2022). Note that this DEQ document currently only mentions resident and nonresident MPAFs following SCAQMD guidance. The new proposed MPAFs distinguish between nonresident children (schools and daycares) and nonresident adult (worker) exposure scenarios. DEQ does not consider it appropriate to include MPAFs for acute RBCs because acute RBCs are based only on inhalation exposure.

Modifications to the original MPAF approach

Upon review of the original SCAQMD methodologies and assumptions, DEQ has proposed a number of changes that align with historic DEQ practices when assessing risk, these include following the US Environmental Protection Agency (EPA) practices and guidance, and incorporating Oregon-specific information. Additionally, new MPAFs are proposed for new TRVs established as part of this rulemaking. The major revisions and updates DEQ is proposing to the MPAFs are listed below.

- New and updated TRVs are applied, taken from proposed TRVs developed by Oregon Health Authority (OHA).

- DEQ Updated TRVs for oral and dermal exposure that are taken from EPA's November 2024 Regional Screening Level tables (EPA 2024). The term EPA uses in the tables is reference dose (RfD) rather than TRV.
- For arsenic and dioxin only, DEQ revised the Gastrointestinal Relative Absorption Factors (GRAFs) from 1.0 to 0.6 (arsenic) and 1.0 to 0.43 (dioxin) to match values currently used by EPA (2024).
- DEQ revised produce ingestion rates from California's Office of Environmental Health Hazard Assessment's 95th percentile default to OEHHA's 75th percentile by age group. EPA states that upper percentiles of the National Health and Nutrition Examination Survey (NHANES) tend to overestimate true long-term ingestion rates (EPA 2018). DEQ is balancing uncertainty while still protecting the health of people who eat more produce than average.
- DEQ updated the soil ingestion rates from OEHHA's to those recommended by the Agency for Toxic Substances and Disease Registry (ATSDR 2016). For the residential noncancer exposure scenario, OEHHA's approach of using an average of soil ingestion rates across several age groups is not a standard EPA noncancer risk assessment method (EPA 1989). Instead, the exposure rates should correspond to the most vulnerable age group. DEQ is proposing to use the 1-to-2-year age group because this has the maximum soil ingestion rate.
- Per- and polyfluoroalkylsubstances (PFAS) with inhalation toxicity information were added. Seven PFAS had both inhalation and oral toxicity information, allowing for the calculation of MPAFs. Additionally, five PFAS had sufficient information for including plant uptake adjustments in their MPAFs

DEQ contracted with a consulting firm, Eastern Research Group (ERG), to assist with compiling relevant parameter values and to develop a user-friendly spreadsheet tool to calculate MPAFs. The spreadsheet provided by ERG documents the selection of input parameter values. In addition, ERG provided memoranda regarding recommendations for plant uptake factors (ERG 2025a and 2025b). These memoranda are included as Appendices C and D. DEQ accepted the recommended values, with chemical-specific modifications as noted in the introductions to the appendices.

Early-Life Adjustment Factors (ELAFs)

For chemicals that EPA considers carcinogenic by a mutagenic mode of action, an ELAF is applied. For chemicals without MPAFs, this is a separate factor used in calculating Risk-Based Concentrations (RBCs). The details of ELAF calculations for these chemicals are discussed in Appendices C and D of DEQ's October 2022 Recommended Procedures for Toxic Air

Contaminant Health Risk Assessments. For chemicals with MPAFs, the ELAF must be included in the calculation of MPAFs for exposure scenarios involving children.

During review of MPAF and ELAF materials (EPA 2024), DEQ determined three TACs were found to now require ELAFs:

- 2-Chloro-1,3-butadiene (chloroprene)
- Formaldehyde
- 4,4′-Methylene-bis(2-chloroaniline)

In addition, two polycyclic aromatic hydrocarbons (PAHs), not previously included as having carcinogenic inhalation TRVs, now require ELAFs (EPA 2024):

- 7,12-Dimethylbenz[a]anthracene
- 3-Methylcholanthrene

OHA and DEQ, in consultation with ATSAC, developed most carcinogenic PAH (cPAH) TRVs based on Relative Potency Factors (RPFs) based on the carcinogenicity of benzo[a]pyrene, developed by the Minnesota Department of Health. Benzo[a]pyrene has been determined to be carcinogenic by a mutagenic mode of action (EPA 2024). Many of these cPAHs have not been determined by EPA to be carcinogenic by a mutagenic mode of action, the criterion we use to apply ELAFs. However, some of these cPAHs have RPFs greater than 1, indicating that they have greater potency relative to benzo[a]pyrene. DEQ, OHA and ATSAC agree that these chemicals likely act in a similar manner to benzo[a]pyrene. For these reasons, DEQ uses RPFs reviewed by ATSAC to determine early-life applicability in assigning ELAFs to all cPAHs that act in a manner similar to that of benzo[a]pyrene.

Diesel Particulate Matter (DPM) is a complex pollutant composed of a number of different chemicals. During discussions about DPM, two ATSAC members raised concern that the existing DPM cancer TRVs do not consider age as a risk factor. The comments are presented in Appendices F and I of OHA’s TRV development document (OHA 2025). OHA agreed with ATSAC’s comments. Rather than incorporate early life effects in TRV development, OHA instead recommended that DEQ consider using ELAFs in the development of DPM RBCs. DEQ accepted this recommendation, noting it is likely that DPM derives the majority of its cancer risk from cPAHs. Based on the application of early-life risk to benzo[a]pyrene and related cPAHs, the same ELAF was applied to DPM exposure. However, because the cancer risk from DPM was evaluated solely for inhalation exposure and not other routes of exposure included in the mulitpathway analysis, MPAFs were not applied to DPM, only an ELAF.

Development and Availability of an MPAF Tool

As noted, DEQ contracted with ERG for assistance in calculating MPAFs. The main part of this project was the development of an Excel spreadsheet tool to assist DEQ in updating the MPAFs for TACs with existing TRVs, as well as developing MPAFs for TACs with new TRVs. This tool allows users to vary input parameters and assumptions for different exposure scenarios and conditions to quickly assess how these changes affect the resultant MPAFs. DEQ used this MPAF tool to vary inputs and assumptions for MPAFs from the original methodologies adopted in the original 2018 CAO rulemaking that were based solely off SCAQMD methods and assumptions.

Based on the CAO Program risk assessment exposure scenarios, DEQ requested that the tool have the ability to calculate MPAFs for the following:

- Residential cancer
- Residential noncancer
- Worker cancer
- Worker noncancer
- Nonresidential child cancer
- Nonresidential child noncancer

In addition to providing a publicly available means for reviewing the proposed revisions and calculations for establishing the MPAFs and ELAFs for this rulemaking, DEQ anticipates that this tool will simplify proposing adjustments to RBCs in Risk Assessments under the CAO program.

In particular, a significant revision to the MPAF methodology involves the age-range assumptions for nonresidential child exposure for developing noncancer RBCs. As noted previously, DEQ has updated the default age range for soil exposure from the average used by SCAQMD to the 0- to 2-year-old range. However, DEQ recognizes that for some nonresidential child exposure locations, such as a high school with no daycare, this default assumption could lead to an overly conservative RBC. The tool provides a simple mechanism for adjusting the age range and providing a more appropriate RBC for that exposure locations. In this case, because the need to adjust the soil exposure age range at schools may occur frequently, coupled with the efficiency of this tool, DEQ is proposing rule language updates to allow for this specific adjustment to RBCs that does not require a source to perform a Level 4 Risk Assessment under the CAO Program.

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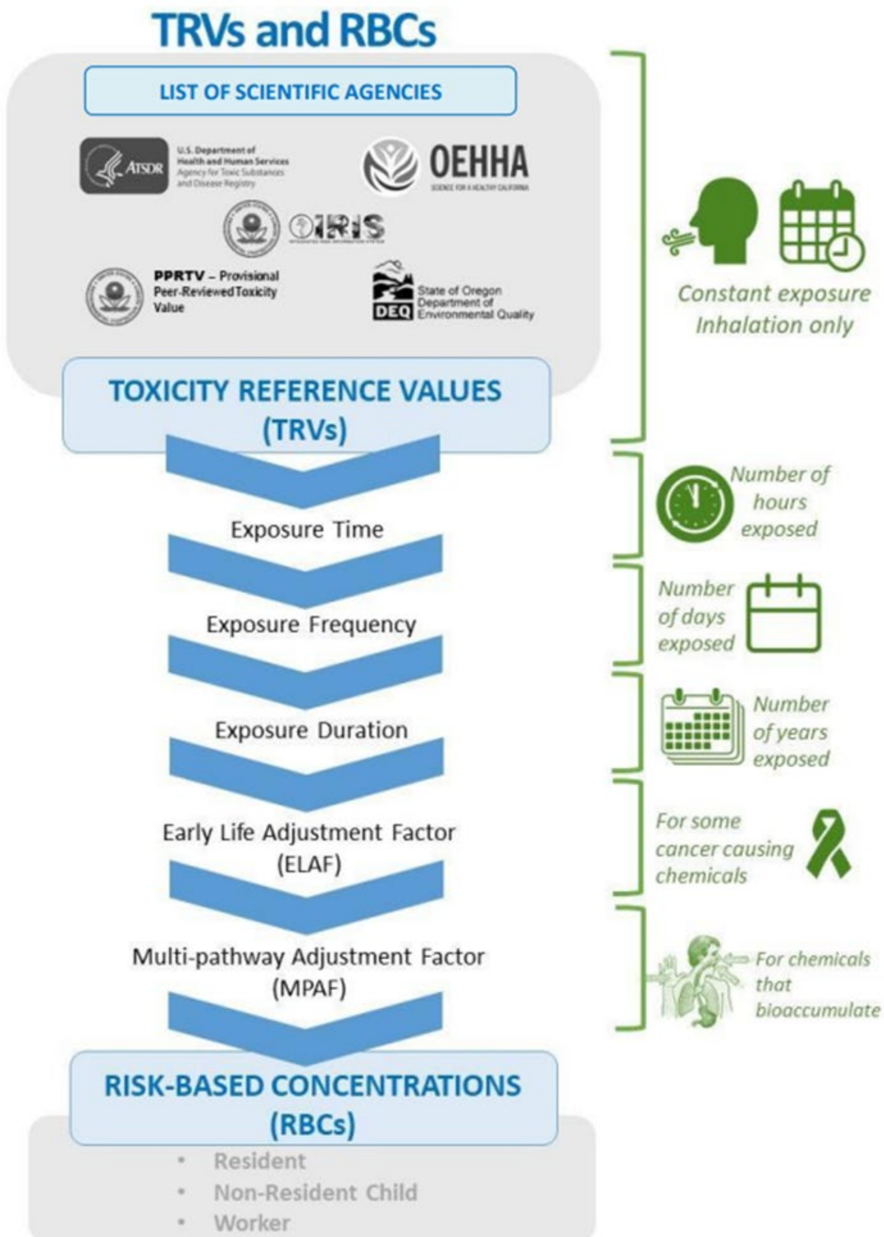
Appendix A: Development of RBCs from TRVs



Appendix B: Equations for Development of RBCs from TRVs

B.1 Introduction

The information in this appendix was taken from Appendix C of DEQ's October 2022 **Recommended Procedures for Toxic Air Contaminant Health Risk Assessments**.

When making its recommendations to the EQC, DEQ calculated RBCs for the following receptors for chronic exposure:

- Residential, including single family homes, apartments, and condominiums
- Non-residential children, including schools and daycare facilities
- Non-residential adults, including commercial and industrial facilities

DEQ also considered short-term acute exposure.

DEQ made three adjustments of TRVs, if appropriate, to calculate RBCs. The first adjustment is for a scenario-specific consideration of exposure frequency and duration. Another adjustment is for deposition and bioaccumulation of toxic air contaminants, which involve exposure routes other than inhalation alone; this is a multipathway adjustment. The third adjustment considers early-life exposure to TACs that exhibit greater toxicity to infants and children. These adjustments are reflected in the chronic RBCs listed in OAR 340-245-8010 Table 2. The development of each adjustment factor is discussed below. None of the adjustment factors is appropriate or necessary for acute RBCs because of the short period of exposure being considered.

B.2 Calculation of RBCs

B.2.1 Residential RBCs

DEQ applied the MPAF and ELAF values to the TRVs using the following equations to calculate residential RBCs.

Equation B.1

$$residRBCc = \frac{TRVc}{ELAFr \cdot MPAFrc}$$

Equation B.2

$$residRBCnc = \frac{TRVnc}{MPAFrnc}$$

Where:

residRBCc = Residential risk-based concentration for cancer effects (µg/m^3)
residRBCnc = Residential risk-based concentration for noncancer effects (µg/m^3)
TRVc = Toxicity reference value for cancer effects (µg/m^3)
TRVnc = Toxicity reference value for noncancer effects (µg/m^3)
ELAFr = Early-life adjustment factor, resident (unitless)
MPAFrc = multipathway adjustment factor, resident cancer (unitless)
MPAFrnc = multipathway adjustment factor, resident noncancer (unitless)

If multipathway or early-life considerations are not relevant for a TAC, these adjustments are omitted. For most TACs, this is the case, and the residential RBC is equal to the TRV.

B.2.2 Nonresidential RBCs

In addition to considerations of MPAF and ELAF for chronic exposure, exposure frequency and exposure duration are also included for nonresidential scenarios (child and worker) where exposure will be less than continual exposure for a lifetime. DEQ used the following equations to calculate nonresidential RBCs.

Equation B.3

$$nrchildRBCc = \frac{TRVc \cdot childNRAFc}{ELAFnr \cdot childMPAFnrc}$$

Equation B.4

$$nrchildRBCnc = \frac{TRVnc \cdot childNRAFnc}{childMPAFnrnc}$$

Equation B.5

$$workerRBCc = \frac{TRVc \ \cdot workerNRAFc}{workerMPAFnrc}$$

Equation B.6

$$workerRBCnc = \frac{TRVnc \ \cdot workerNRAFnc}{workerMPAFnrnc}$$

Where:

nrchildRBCc = Nonresidential child risk-based concentration for cancer effects (µg/m^3)
nrchildRBCnc = Nonresidential child risk-based concentration for noncancer effects (µg/m^3)
workerRBCc = Nonresidential worker risk-based concentration for cancer effects (µg/m^3)
workerRBCnc = Nonresidential worker risk-based concentration for noncancer effects (µg/m^3)
TRVc = Toxicity reference value for cancer effects (µg/m^3)
TRVnc = Toxicity reference value for noncancer effects (µg/m^3)
ELAFnr = Early-life adjustment factor, non-resident (unitless)
childMPAFnrc = Multipathway adjustment factor, nonresident child, cancer (unitless)
childMPAFnrnc = Multipathway adjustment factor, nonresident child, noncancer (unitless)
workerMPAFwnrc = Multipathway adjustment factor, nonresident worker cancer (unitless)
workerMPAFnrnc = Multipathway adjustment factor, nonresident worker noncancer (unitless)
childNRAFc = Nonresident adjustment factor, child cancer (26) (unitless)
childNRAFnc = Nonresident adjustment factor, child noncancer (4.4) (unitless)
workerNRAFc = Nonresident adjustment factor, worker cancer (12) (unitless)
workerNRAFnc = Nonresident adjustment factor, worker noncancer (4.4) (unitless)

If multipathway or early-life considerations are not relevant for a TAC, these adjustments are omitted.

B.2.3 Acute RBCs

The acute TRV is used directly as the acute RBC.

Equation B.7

$$acuteRBC = TRVa$$

Where:

acuteRBC = Acute risk-based concentration (µg/m^3)
TRVa = Toxicity reference value for acute effects (µg/m^3)

Appendix C: Recommendations for Plant Uptake Factors

Eastern Research Group memorandum to Oregon DEQ and Oregon OHA, March 2025

DEQ accepted the recommendations in the memorandum with some modifications. Cobalt and uranium factors were obtained from USNRC 2013. DEQ inadvertently omitted selenium from the original list of 2018 MPAF chemicals, so DEQ added factors for selenium from the same reference used for the other metals. The list of PAHs was expanded by DEQ to include all PAHs with toxicity information. For carcinogenic PAHs (cPAHs) where oral TRVs were not available, DEQ calculated TRVs using Relative Potency Factors (RPFs), relative to the cancer TRV for benzo[a]pyrene.

Memorandum

Date: March 2025

To: J.R. Giska, Apollonia Goeckner, Susan MacMillan, Kristen Martin, and Mike Poulsen, (Oregon Department of Environmental Quality); Holly Dixon and David Farrer (Oregon Health Authority)

From: Eastern Research Group, Inc. (ERG)

Subject: Recommendations for Plant Uptake Factors

Background

As part of the Cleaner Air Oregon (CAO) program, the Oregon Department of Environmental Quality (DEQ) is updating the way the program calculates multipathway adjustment factors (MPAFs) used during risk assessments for persistent and/or bioaccumulative substances. Specifically, DEQ will modify certain exposure assumptions and develop new MPAFs for an additional set of toxic air contaminants (TACs).

To support this effort, DEQ has tasked ERG with developing a user-friendly Excel-based tool to calculate MPAFs for six exposure scenarios. This tool will integrate DEQ's updated exposure assumptions, enable direct comparisons with previous MPAF calculations, and support regulatory risk assessments by incorporating multiple exposure pathways, including inhalation, soil deposition, bioaccumulation, and ingestion.

ERG has delivered an Excel-based tool with DEQ's updated approach to calculating MPAFs. A subtask of this overall effort involves evaluating plant root uptake factors, which are used in the MPAF calculations, for 16 new TACs identified during DEQ's triennial review of toxicity reference values (TRVs). This subtask applies to the following chemicals identified in Table 2 of the contract scope of work:

- 1H,1H,2H,2H-Perfluoroocctane sulfonic acid (6:2 FTS) (CASRN: 27619-97-2)
- Chromium III, insoluble particulate (CASRN: 16065-83-1)
- Chromium III, soluble particulate (CASRN: 16065-83-1)
- Cobalt compounds, insoluble (CASRN: 7440-48-4)
- Cobalt compounds, soluble (CASRN: 7440-48-4)
- Hexafluoropropylene oxide dimer acid (HFPO-DA/Gen-X) (CASRN: 62037-80-3)

- Perfluorobutanoic acid (PFBA) (CASRN: 375-22-4)
- Perfluorodecanoic acid (PFDA) (CASRN: 335-76-2)
- Perfluorododecanoic acid (PFDoA) (CASRN: 307-55-1)
- Perfluorohexanoic acid (PFHxA) (CASRN: 307-24-4)
- Perfluoro-1-octanesulfonamide (PFOSA) (CASRN: 754-91-6)
- Perfluorooctanesulfonic acid (PFOS) (CASRN: 1763-23-1)
- Perfluorobutylethylene (PFBE) (CASRN: 19430-93-4)
- Perfluorooctanoic acid (PFOA) (CASRN: 335-67-1)
- Uranium and compounds, insoluble (CASRN: 7440-61-1)
- Uranium and compounds, soluble (CASRN: 7440-61-1)

Plant uptake factors are unitless and defined by California Office of Environmental Health Hazard Assessment (OEHHA) as "*the ratio of the fresh weight contaminant concentration in the edible plant or plant part over the total concentration of the contaminant in wet weight soil*" (OEHHA 2012). The MPAF tool uses four different plant uptake factors for a given substance depending on the type of plant:

- "***Leafy crop*** *category consists of broad-leafed vegetables in which the leaf is the edible part. Examples include spinach, lettuce, cabbage, and kale.*
- ***Root crop*** *category includes vegetables in which the edible portion is underground. Examples are potato, radish, and carrot.*
- ***Exposed produce*** *category consists of crops with a small surface area subject to air deposition. Examples include strawberries, tomato, cucumber, zucchini, green bean and bell pepper.*
- ***Protected produce*** *category consists of crops in which the edible part is not exposed to air deposition (e.g., the exposed skin of the crop is removed and not eaten). Examples are corn, pea, pumpkin and oranges."* (OEHHA 2015).

The approach ERG took was using expert knowledge of potentially relevant resources as well as targeted searching to identify plant uptake factors published by sources that ODEQ considers to be "Authoritative Sources" during TRV development. Specifically, ERG looked for risk assessment guidance documents that might contain plant uptake factors published by:

- U.S. Environmental Protection Agency (EPA)
- Agency for Toxic Substances and Disease Registry (ATSDR)
- California Environmental Protection Agency (CalEPA)

The remainder of this memorandum presents ERG's research findings for potential plant root uptake factors for the listed substances by chemical group.

PFAS

ERG identified a recent U.S. EPA risk assessment document containing plant uptake factors, and we recommend these data as the primary source for PFAS uptake factors as discussed below. We also describe peer-reviewed citations cited by ATSDR and other relevant articles that appeared in targeted literature searches for the PFAS not included in the risk assessment document.

U.S. EPA Draft Sewage Sludge Risk Assessment for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS)— The most recent and relevant source of information from U.S. EPA is a risk assessment published on January 14, 2025 for PFOA and PFOS in sewage sludge that includes exposure scenarios where the sludge is applied to agricultural and other lands. Section 2.9.3.4 of the risk assessment document summarizes findings from a literature review on plant uptake factors for PFOA and PFOS, and presents the selected uptake factors for leafy crop, root crop, and exposed produce in Table 13. Below are the final uptake parameters, explanations on the underlying sources, and how to apply these data to other PFAS.

- EPA conducted a PubMed literature review for plant uptake factors for PFAS on March 15, 2024 (Pg. 51); 133 studies were identified.
- *"Plant uptake factors were determined by prioritizing studies where biosolids contaminated with PFOA and PFOS were applied in the study area/field. If there were multiple acceptable field-studies available where the source of PFAS contamination was sewage sludge, the median of these data was selected for the study parameter"* – Pg. 48
- EPA used the following data hierarchy for plant uptake factor studies (Pg. 51):
    - *"1. Field studies with biosolids-amended soil*
    - *2. Greenhouse studies of potted plants with biosolids-amended soil*
    - *3. Field studies with other sources of PFAS contamination impacting the soil"*

- The study data selected by EPA presented plant uptake factors in dry weight plant concentration to dry weight soil concentration, but EPA (in equation shown in 2.9.2.6) converted these to wet weight soil concentrations, which are the units used in the OEHHA models, "*using field capacity (water content of soil) and porosity (water plus air content) of soil for feed crops*". These moisture adjustment factors by crop type are presented in Table 11 (Pg. 52).

- The final selected model parameter plant uptake bioconcentration factors, BCFs, are shown in Table 13 (Pg. 56) below. Note: these BCFs are in units of dry weight/dry weight.

Table 13. Selected Plant BCFs

Plant Type	Chemical	Plant uptake BCF (unitless)	Basis	Source
Forage	PFOA	0.25	field	Yoo et al. (2011) for grass
	PFOS	0.07	field	Yoo et al. (2011) for grass
Fruit	PFOA	0.11	pot	median or geomean of tomatoes from Blaine et al., 2013, sugar snap peas from Blaine et al. (2014), and cucumbers from Lechner and Knapp (2011)
	PFOS	0.03	pot	Sugar snap peas from Blaine et al. (2014) – only detected value for PFOS
Root Vegetables	PFOA	0.6	pot	median of pot carrots, potatoes, radish from Lechner and Knapp (2011), radish from Blaine (2014), and radish from Wen (2016)
	PFOS	0.7	pot	median of pot carrots, potatoes, radish from Lechner and Knapp (2011), radish from Blaine (2014), and radish from Wen (2016)
Silage	PFOA	0.25	field	Yoo et al. (2011) for grass
	PFOS	0.07	field	Yoo et al. (2011) for grass
Vegetables (above ground)	PFOA	1.3	pot	median of pot celery from Blaine et al (2014), pot lettuce industrial biosolids, and pot lettuce municipal biosolids from Blaine et al. (2013).
	PFOS	0.1	field	field lettuce from Blaine et al. (2013) – only field study for vegetables with a detected value

- Below is the model equation to show how EPA converted from soil-to-plant bioconcentration factors, ("Br" = BCF here), in dry weight/dry weight to weight weight/wet weight using Moisture Adjustment Factors, MAF. Note: the OEHHA model uses wet weight/wet weight units.

Crops

Equation 1. Crop Concentrations Due to Root Uptake from Soil, $P_{produce}$, P_{feed} (mg/kg)		
Produce (Aboveground Fruits and Vegetables, Root Vegetables)		***Feed crops (Forage and Silage)***
$P_{produce} = C_{soil} \times B_r \times \left(\frac{100 - MAF}{100}\right)$		$P_{feed} = C_{soil} \times B_r$
Name	**Description**	**Source**
$P_{produce}$, P_{feed}	Concentration of contaminant in crops (aboveground fruits or vegetables, and root vegetables or animal feed (P_{feed})	Calculated
C_{soil}	Concentration of contaminant in soil, averaged over tilling depth (mg/kg)	LAU model output
Br	Soil-to-plant bioconcentration factor: $\frac{[plant](\frac{mg}{kg} dry\ weight)}{[soil](\frac{mg}{kg} wet\ weight)}$	See model parameterization, Section 2.9.3.4
MAF	Plant tissue-specific moisture adjustment factor to convert dry weight concentrations into wet weight (percent)	See model parameterization, Section 2.9.3.4
100	Conversion factor from percent to fraction (unitless)	NA

- The Moisture Adjustment Factors (% water), MAFs, used in the Equation 1 above can be found in Table 11 (Pg. 52):

Table 11. Moisture Adjustment Factors by Type of Produce

Model Code	Description	Exposed Fruit	Exposed Vegetables	Protected Fruit	Protected Vegetables	Root Vegetables	Reference
MAF	Moisture adjustment factor (% water)	85	90	87	81	81	EFH:2011 (US EPA, 2011)

- The BCFs above are just for PFOS and PFOA. The original peer-reviewed literature cited as the source of these selected BCFs follows. Note that some studies present additional uptake factors for other PFAS (besides PFOS and PFOA) and these PFAS are noted below the study.
    - Yoo, H., Washington, J. W., Jenkins, T. M., & Ellington, J. J. (2011). Quantitative determination of perfluorochemicals and fluorotelomer alcohols in plants from biosolid-amended fields using LC/MS/MS and GC/MS. *Environ. Sci. Technol.*, *45*(19), 7985−7990.
        - Of the PFAS of interest to ODEQ, this study presents uptake factors for: PFBA, PFHxA, PFOA, PFDA, PFDoA, and PFOS.
    - Blaine, A. C., Rich, C. D., Hundal, L. S., Lau, C., Mills, M. A., Harris, K. M. & Higgins, C. P. (2013). Uptake of perfluoroalkyl acids into edible crops via land applied biosolids: field and greenhouse studies. *Environmental Science & Technology, 47*, 14062–14069.
        - Of the PFAS of interest to ODEQ, this study presents uptake factors for: PFBA, PFHxA, PFOA, PFDA, and PFOS.
    - Blaine, A. C., Rich, C. D., Sedlacko, E. M., Hundal, L. S., Kumar, K., Lau, C., Mills, M. A., Harris, K. M., & Higgins, C. P. (2014). Perfluoroalkyl acid distribution in various plant compartments of edible crops grown in biosolids-amended soils. *Environmental Science & Technology*, *48*, 7858–7865.
        - Of the PFAS of interest to ODEQ, this study presents uptake factors for: PFBA, PFHxA, PFOA, PFDA, and PFOS.
    - Lechner, M. & Knapp, H. (2011). Carryover of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) from soil to plant and distribution to the different plant compartments studied in cultures of carrots (*Daucus carota* ssp. Sativus), potatoes (*Solanum tuberosum*), and cucumbers (*Cucumis sativus*). *Journal of Agricultural and Food Chemistry, 59*, 11011–11018.

        - Of the PFAS of interest to ODEQ, this study presents uptake factors for: PFOA and PFOS.

    - Wen, B., Wu, Y., Zhang, H., Liu, Y., Hu, X., Huang, H., & Zhang, S. (2016). The roles of protein and lipid in the accumulation and distribution of perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) in plants grown in biosolids-amended soils. *Environmental Pollution, 216,* 682-688.

        - Of the PFAS of interest to ODEQ, this study presents uptake factors for: PFOA and PFOS.

ERG also reviewed ATSDR's Toxicological Profile for Perfluoroalkyls to find vetted studies with plant uptake factors. In addition to the two Blain et al. (2013 and 2014) studies cited above, the following additional studies that were cited in the ATDSR Tox Profile evaluated plant uptake of PFAS:

- Blaine, A. C., Rich, C. D., Sedlacko, E. M., Hyland, K. C., Stushnoff, C., Dickenson, E. R., & Higgins, C. P. (2014). Perfluoroalkyl acid uptake in lettuce (Lactuca sativa) and strawberry (Fragaria ananassa) irrigated with reclaimed water. Environmental science & technology, 48(24), 14361-14368.

    - Of the PFAS of interest to ODEQ, this study presents uptake factors for: PFBA, PFHxA, PFOA, and PFOS.

- Stahl, T., Heyn, J., Thiele, H., Hüther, J., Failing, K., Georgii, S., & Brunn, H. (2009). Carryover of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) from soil to plants. Archives of environmental contamination and toxicology, 57, 289-298.

    - Of the PFAS of interest to ODEQ, this study presents uptake factors for: PFOA and PFOS.

The above resources do not contain information on plant uptake factors for four of the ten PFAS that were a part of this effort:

- 6:2 FTS,
- HFPO-DA/Gen-X,
- PFOSA, and
- PFBE.

ERG conducted a targeted literature search to identify additional sources of plant uptake factors for these PFAS. The following are example articles identified from the targeted search:

- For PFOSA, the following potentially relevant article was found:
    - Bizkarguenaga, E., Zabaleta, I., Mijangos, L., Iparraguirre, A., Fernández, L.A., Prieto, A. and Zuloaga, O., 2016. Uptake of perfluorooctanoic acid, perfluorooctane sulfonate and perfluorooctane sulfonamide by carrot and lettuce from compost amended soil. *Science of the Total Environment*, *571*, pp.444-451.
    - Zhao, S., Zhou, T., Wang, B., Zhu, L., Chen, M., Li, D. and Yang, L., 2018. Different biotransformation behaviors of perfluorooctane sulfonamide in wheat (Triticum aestivum L.) from earthworms (Eisenia fetida). *Journal of hazardous materials*, *346*, pp.191-198.
- For 6:2 FTS, the following potentially relevant article was found:
    - Zhao, S., Liang, T., Zhou, T., Li, D., Wang, B., Zhan, J. and Liu, L., 2018. Biotransformation and responses of antioxidant enzymes in hydroponically cultured soybean and pumpkin exposed to perfluorooctane sulfonamide (FOSA). *Ecotoxicology and Environmental Safety*, *161*, pp.669-675.
    - Zhou, J., Li, M., Li, J., Shao, Z., Liu, Y., Wang, T. and Zhu, L., 2020. Bioavailability and bioaccumulation of 6: 2 fluorotelomer sulfonate, 6: 2 chlorinated polyfluoroalkyl ether sulfonates, and perfluorophosphinates in a soil–plant system. *Journal of Agricultural and Food Chemistry*, *68*(15), pp.4325-4334.
    - Zhi, Y., Lu, H., Grieger, K.D., Munoz, G., Li, W., Wang, X., He, Q. and Qian, S., 2022. Bioaccumulation and translocation of 6: 2 fluorotelomer sulfonate, GenX, and perfluoroalkyl acids by urban spontaneous plants. *Acs Es&T Engineering*, *2*(7), pp.1169-1178.
- For hexafluoropropylene oxide dimer acid (HFPO-DA/Gen-X), the following potentially relevant article was found:
    - Zhi, Y., Lu, H., Grieger, K.D., Munoz, G., Li, W., Wang, X., He, Q. and Qian, S., 2022. Bioaccumulation and translocation of 6: 2 fluorotelomer sulfonate, GenX, and perfluoroalkyl acids by urban spontaneous plants. *Acs Es&T Engineering*, *2*(7), pp.1169-1178.

- Al Zbedy, A., Müller, V., Kindness, A., Ebel, R., Norton, G.J. and Feldmann, J., 2024. GenX uptake by wheat and rice in flooded and non-flooded soils: a greenhouse experiment. *Environmental Science and Pollution Research*, *31*(1), pp.1607-1620.
- Wang, X., Zhang, W., Lamichhane, S., Dou, F. and Ma, X., 2023. Effects of physicochemical properties and co-existing zinc agrochemicals on the uptake and phytotoxicity of PFOA and GenX in lettuce. *Environmental Science and Pollution Research*, *30*(15), pp.43833-43842.
- Zhang, W., Cao, H. and Liang, Y., 2021. Plant uptake and soil fractionation of five ether-PFAS in plant-soil systems. *Science of The Total Environment*, *771*, p.144805.

Plant uptake factors were not found for PFBE.

Uranium and Compounds

ERG identified two ATSDR health consultations that reference a study conducted by the Los Alamos National Laboratory (Hayes et al. 2000). The study measured uranium uptake in leafy crops (lettuce), root crops (radishes), and exposed produce (tomatoes, squash) after being irrigated with water containing uranium. Both consultations, listed below, use this study to approximate exposure doses from ingestion of produce irrigated with uranium-contaminated water:

- Desert View Estates Water System Health Consultation
- Mission Creek Water System Health Consultation
- Hayes AC, Fresquez PR and WF Whicker. 2000. Uranium uptake study, Nambe, New Mexico: Source Document. LA-13614-MS: Los Alamos National Laboratory, October 2000.

The “concentration ratios” from Hayes et al. (2000) are presented in Table 12 below. Note: it is unclear if these are dry-weight or fresh-weight values as different parts of the report present conflicting descriptions.

Table 12. Mean (± SD) Concentration Ratios for Edible Portions Irrigated with Well Water Containing Various Levels of Natural Uranium

Water U Concentration ($\mu g\ U\ L^{-1}$)	Tomato	Squash	Radish	Lettuce
< 1	$3.5 \times 10^{-3} \pm 7.0 \times 10^{-4}$	$5.6 \times 10^{-3} \pm 2.8 \times 10^{-4}$	$3.6 \times 10^{-2} \pm 4.7 \times 10^{-3}$	$3.4 \times 10^{-2} \pm 5.0 \times 10^{-1}$
150	$4.0 \times 10^{-2} \pm 1.0 \times 10^{-2}$	$1.3 \times 10^{-1} \pm 5.5 \times 10^{-2}$	$1.6 \times 10^{-0} \pm 5.3 \times 10^{-1}$	$1.4 \times 10^{-0} \pm 4.4 \times 10^{-1}$
500	$3.3 \times 10^{-2} \pm 9.9 \times 10^{-5}$	$1.6 \times 10^{-1} \pm 7.1 \times 10^{-2}$	$1.4 \times 10^{-0} \pm 4.6 \times 10^{-1}$	$1.4 \times 10^{-0} \pm 3.0 \times 10^{-1}$
1200	$2.9 \times 10^{-2} \pm 8.2 \times 10^{-3}$	$1.3 \times 10^{-1} \pm 4.6 \times 10^{-2}$	$1.4 \times 10^{-0} \pm 4.3 \times 10^{-1}$	$1.1 \times 10^{-0} \pm 3.9 \times 10^{-1}$

In ATSDR's Toxicological Profile for Uranium, ERG found one publicly available source with plant uptake factors:

- **Morishima et al. 1977** – Evaluated the uptake of uranium in leafy vegetables, root vegetables, exposed crops, and grains irrigated with river water near a uranium mill. This study and its results are discussed in the more recent Hayes et al. (2000) report above.

The plant uptake factors in the above sources would represent soluble uranium. ERG did not find any sources that explicitly differentiated between plant uptake factors of insoluble and soluble uranium, but Hayes et al. (2000) discusses that exposure to insoluble uranium occurs primarily via inhalation.

Chromium III

ERG identified a fertilizer risk assessment by EPA that was published in 1999, Estimating Risk from Contaminants Contained in Agricultural Fertilizers. The source of the plant uptake factors are discussed throughout the report including in Sections 4.2.6.2, 5.2.2.4.1.1, 8.1.1.4.2, 9.1.2.1, and 9.2.2.2. Appendix G of this report is a database with plant uptake factors for various metals including Chromium that can be downloaded here: https://archive.epa.gov/epawaste/hazard/web/html/index-29.html

Various factors are presented for, roots, grains, fruits (e.g., fruits, flowers, nuts, seeds), herbage (nonreproductive aerial parts consumed by humans), and forage (nonreproductive aerial parts consumed by animals but not humans) plants. A discussion on the plant types can be found on Pg. 5-28 (PDF page 87).

The chromium database cites the following original peer-reviewed articles for all of its data:

- Cary, E.E. and Kubota, J., 1990. Chromium concentration plants: effects of soil chromium concentration and tissue contamination by soil. *Journal of Agricultural and Food Chemistry*, *38*(1), pp.108-114.

A review of this study suggests that these chromium plant uptake factors represent total chromium and do not distinguish between Chromium III and Chromium VI.

A detailed discussion of Chromium III and Chromium VI plant uptake and the difficulties in characterizing the differences can be found in:

- Smith, S., Peterson, P.J. and Kwan, K.H.M., 1989. Chromium accumulation, transport and toxicity in plants. *Toxicological & Environmental Chemistry*, *24*(4), pp.241-251.

Note: the source discussed in the Cobalt section also presents results for chromium without distinguishing between chromium compounds.

Cobalt Compounds

The U.S. Nuclear Regulatory Commission published a document titled Transfer Factors for Contaminant Uptake by Fruit and Nut Trees (2013), documenting results of a study of various plant uptake factors for a range of substances, including cobalt (U.S. NRC 2013). “Soil-to-plant” transfer values are presented across various tables started with Table 4.1 on page 4-2 (PDF Pg. 39) for forage and grain plants. Transfer factors for various specific fruits and nut trees are presented across multiple subsequent tables and factors for a ‘generic’ fruit and nut are presented in Table 4.14

Appendix D: Follow-up to Questions Related to March Memo: “Recommendations for Plant Uptake Factors”

Eastern Research Group memorandum to Oregon DEQ and Oregon OHA, April 2025

DEQ accepted the recommendations in the memorandum with some modifications. For two per- and polyfluoroalkyl substances (PFAS), perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), plant bioaccumulation factors were taken from EPA 2025. DEQ accepted those recommendations with the minor revision that the moisture adjustment factor MAF for exposed fruit match the value in Table 11 of EPA’s document. For the other PFAS compounds, accumulation factors were developed from values in Blaine 2013 and Blaine 2014. DEQ generally followed the recommendations on obtaining values, although rather than use two fruit bioconcentration factors as shown in Table 1, only one fruit bioconcentration factor was used, based on data for both protected fruit (snap peas) and exposed fruit (tomatoes). This approach is more consistent with EPA’s approach for PFOA and PFOS. The revised Table 2 bioconcentration factors are documented in a worksheet included in the MPAF calculation spreadsheet.

Memorandum

Date: April 2025

To: J.R. Giska, Apollonia Goeckner, Susan MacMillan, Kristen Martin, and Mike Poulsen, (Oregon Department of Environmental Quality); Holly Dixon and David Farrer (Oregon Health Authority)

From: Eastern Research Group, Inc. (ERG)

Subject: Follow-up to Questions Related to March Memo: Recommendations for Plant Uptake Factors"

Background

In March 2025, ERG submitted a memorandum to the Oregon Department of Environmental Quality's (DEQ's) Cleaner Air program summarizing plant uptake factors used in calculating multipathway adjustment factors (MPAFs). This memorandum focused on identifying plant uptake factors for several substances, including per- and polyfluoroalkyl substances (PFAS), and incorporated findings from authoritative sources. For PFAS, ERG recommended U.S. EPA Draft Sewage Sludge Risk Assessment for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS) as a primary reference for plant uptake factors.

Following DEQ's review of the memorandum, the agency requested follow-on support to:

- Evaluate the scientific information presented in the memorandum and recommend specific uptake factors for PFAS, when feasible;
- Advise on how to align EPA's plant type categories with those used in California's Office of Environmental Health Hazard Assessment (OEHHA's) risk assessment framework applied in DEQ's MPAF calculations; and
- Confirm appropriate unit conversions for plant uptake factors in OEHHA/DEQ model units (wet weight plant/wet weight soil).

This memorandum provides ERG's responses to these follow-up requests.

Recommendation for PFAS Plant Uptake Factors

ERG recommends using the uptake factors for PFOS and PFOA from the U.S. EPA's 2025 *Draft Sewage Sludge Risk Assessment* in DEQ's MPAF tool. These factors are based on a thorough literature review prioritizing field studies with biosolids-amended soils and reflect the most current estimates available from authoritative sources. In addition, the peer-reviewed studies cited as the source of the PFOS and PFOA values in EPA's risk assessment also reported plant uptake factors for other PFAS compounds on DEQ's priority list, including PFBA, PFHxA, and PFDA. ERG recommends using the corresponding values from these sources for these additional PFAS.

To support integration into DEQ's existing MPAF tool, ERG mapped EPA's crop categories to OEHHA's plant types used in MPAF calculations. Table 1 presents ERG's suggested mapping of OEHHA and EPA plant types and the rationale for our recommendation. Note: these recommendations are in some cases different than what DEQ described in their email communication to ERG.

Table 1. Recommended mapping of EPA Plant Types to OEHHA Plant Types

OEHHA Plant Type	Recommended Corresponding EPA Plant Type	Rationale
Leafy crop Broad-leafed vegetables in which the leaf is the edible part. Examples include spinach, lettuce, cabbage, and kale.	Exposed Vegetables	For the 'Exposed Vegetables' BCF, EPA selected median values for lettuce and celery from Blaine et al. (2013, 2014), which corresponds to the vegetables listed by OEHHA.
Root crop Vegetables in which the edible portion is underground. Examples are potato, radish, and carrot.	Root Vegetables	For the 'Root Vegetables' BCF, EPA selected median values for carrots, potatoes, and radish from Blaine et al. (2014); Lechner and Knapp (2011); and Wen et al. (2016), which corresponds to the vegetables listed by OEHHA.
Exposed produce Crops with a small surface area subject to air deposition. Examples include strawberries, tomato, cucumber, zucchini, green bean and bell pepper.	Vegetables (exposed/protected)	OEHHA's 'produce' is a mixture of fruit and vegetables. EPA lumps all fruit together and all vegetables together. For the 'Fruit' BCF, EPA selected median values for tomatoes, sugar snap peas, and cucumbers from Blaine et al. (2013, 2014) and Lechner and Knapp (2011). For the 'Vegetables' BCF, EPA selected values for lettuce and celery from Blaine et al. (2013, 2014). The vegetables BCFs are higher than the fruit, and so ERG recommends choosing these values since we would expect 'exposed' produce to be more affected by deposition when compared to protected produce (see below).
Protected produce Crops in which the edible part is not exposed to air deposition (e.g., the exposed skin of the crop is removed and not eaten). Examples are corn, pea, pumpkin and oranges.	Fruit (exposed/protected)	OEHHA's 'produce' is a mixture of fruit and vegetables. EPA lumps all fruit together and all vegetables together. For the 'Protected Fruit' BCF, EPA selected median values for tomatoes, sugar snap peas, and cucumbers from Blaine et al. (2013, 2014) and Lechner and Knapp (2011).For the 'Protected Vegetables' BCF, EPA selected values for lettuce and celery from Blaine et al. (2013, 2014). The fruit BCFs are lower than the vegetables, and so ERG recommends choosing these values, since we would expect 'protected' produce to be less affected by deposition when compared to exposed produce (see above).

Table 2 below presents the final recommended values converted to wet weight units for direct use in DEQ's MPAF tool. Note: the EPA document presents two types of bioconcentration factors (BCFs). In Table 3 on page 56, the BCFs are in units of "dry weight crop concentrations to dry weight soil concentrations". As noted in footnote 13 on page 55, dry weight soil concentrations (the denominator) were converted to wet weight soil concentrations for the model input by dividing by a dry soil mass fraction of 0.87. These converted BCFs are presented in Table B-13 on page B-12. It is these BCFs in units of "dry weight crop concentration to wet weight soil concentration" that would fit into the equation described in DEQ's email and shown below:

$$BCF_W = BCF_D \times (1 - MAF_{frac})$$

Where:

$$BCF_W = Bioconcentration\ factor, ww\ plant\ to\ ww\ soil\ = \frac{\frac{mg\ PFAS}{kg\ plant\ wet\ weight}}{\frac{mg\ PFAS}{kg\ soil\ wet\ weight}}$$

$$BCF_D = Bioconcentration\ factor, dw\ plant\ to\ ww\ soil = \frac{\frac{mg\ PFAS}{kg\ plant\ dry\ weight}}{\frac{mg}{kg\ soil\ wet\ weight}}$$

$$MAF_{frac} = moisture\ adjustment\ factor\ (\%\ water) = \frac{plant\ water\ weight}{plant\ wet\ weight}$$

Table 2 also presents recommended values for PFBA, PFHxA, and PFDA. These values were taken from the same underlying sources as the PFOS and PFOA values described in the EPA risk assessment for each respective plant category when feasible. For example, EPA's PFOA BCF_d of 1.5 for exposed/protected vegetables was calculated by EPA by taking the median BCF (in dw plant-dw soil units) of:

- pot celery (0.71 from Blaine et al. 2014),
- pot lettuce grown in municipal soil (1.34 from Blaine et al. 2013) and
- pot lettuce grown in industrially impacted soil (2.52 from Blaine et al. 2013).

This median value of 1.3 was then divided by 0.87 to convert it to get 1.5 in units of dw plant-ww soil. Finally, the BCF_w was calculated by using the equation above to get 0.15. This same series of steps was taken to calculate a BCF_w for PFBA, PFHxA, and PFDA using the same underlying studies. Footnotes for each of these calculated BCF values are shown in Table 2 to describe the specific calculation steps and values used following EPA's approach when feasible.

Table 2. Recommended plant uptake factors for use in DEQ MPAF tool (BCF_W)

	Root crop (root vegetables)	Leafy crop (exposed/protected vegetables)	Protected produce (exposed/protected fruit)	Exposed produce (exposed/protected vegetables)
1 - MAF	0.19	0.1	0.13	0.1
PFOS				
BCF_D	0.8	0.11	0.03	0.11
BCF_W	**0.152**	**0.011**	**0.004**	**0.011**
PFOA				
BCF_D	0.73	1.5	0.13	1.5
BCF_W	**0.1387**	**0.15**	**0.17**	**0.15**
PFBA				
BCF_D	15.89 [g]	56.9 [a]	13.3[d]	56.9 [a]
BCF_W	**3.02**	**5.69**	**1.73**	**5.69**
PFHxA				
BCF_D	4.44 [h]	13.7[b]	3.7[e]	13.7[b]
BCF_W	**0.84**	**1.37**	**0.48**	**1.37**
PFDA				
BCF_D	1.26 [i]	0.39[c]	0.17[f]	0.39[c]
BCF_W	**1.4**	**0.039**	**0.022**	**0.039**

[a] Median of pot celery (49.49 from Blaine et al. 2014), pot lettuce industrially impacted soil (56.8 from Blaine et al. 2013), and pot lettuce municipal soil (28.4 from Blaine et al. 2013), divided by 0.87.

[b] Median of pot celery (11.91 from Blaine et al. 2014), pot lettuce industrially impacted soil (9.90 from Blaine et al. 2013), and pot lettuce municipal soil (11.7 from Blaine et al. 2013), divided by 0.87.

[c] Median of pot celery (0.32 from Blaine et al. 2014), pot lettuce industrially impacted soil (0.52 from Blaine et al. 2013), and pot lettuce municipal soil (0.34 from Blaine et al. 2013), divided by 0.87.
[d] Median of tomatoes (12.2 from Blaine et al. 2013) and sugar snap peas (10.89 from Blaine et al. 2014), divided by 0.87. Note: EPA also used cucumbers from Lechner and Knapp 2011, which did not measure PFBA.
[e] Median of tomatoes (2.9 from Blaine et al. 2013) and sugar snap peas (3.46 from Blaine et al. 2014), divided by 0.87. Note: EPA also used cucumbers from Lechner and Knapp 2011, which did not measure PFHxA.
[f] BCF for sugar snap peas (3.46 from Blaine et al. 2014) divided by 0.87. Note: EPA also used cucumbers from Lechner and Knapp 2011, which did not measure PFDA, as well as tomatoes from Blaine et al. 2013, which was ND.
[g] BCF for radish (13.82 from Blaine 2014) divided by 0.87. Note: EPA also used pot carrots, potatoes and radish from Lechner and Knapp (2011), and radish from Wen (2016) neither of which measured PFBA.
[h] BCF for radish (3.86 from Blaine 2014) divided by 0.87. Note: EPA also used pot carrots, potatoes and radish from Lechner and Knapp (2011), and radish from Wen (2016) neither of which measured PFHxA.
[i] BCF for radish (1.1 from Blaine 2014) divided by 0.87. Note: EPA also used pot carrots, potatoes and radish from Lechner and Knapp (2011), and radish from Wen (2016) neither of which measured PFDA.