

Soil Cleanup Levels to Protect Groundwater

Protecting Groundwater from Contaminants in Soil

Under the MTCA regulation (WAC 173-340), when selecting a cleanup level for a chemical contaminant in soil, one criterion to consider is the potential for the contaminant to leach from soil into groundwater. Specifically, the concentrations of hazardous substances in soil should not cause contamination of groundwater that exceeds cleanup levels established under WAC 173-340-720. This pathway is considered in addition to the direct-contact criterion that is based on ingestion of soil (and dermal absorption for Modified Methods B and C evaluations).

Default Soil Concentrations Protective of Groundwater

WAC 173-340-747 presents several methods to establish soil concentrations that are considered protective of groundwater. Most of the options require a site-specific evaluation based on data collected from the site. However, one method uses default values to derive soil cleanup levels protective of groundwater (for any hazardous substance) and does not require site-specific data. This “fixed parameter three-phase partitioning model” (described in WAC 173-340-747(4) and based on MTCA Equation 747-1) was used to calculate default soil cleanup levels protective of potable groundwater, and the results are listed in CLARC. Concentrations for both unsaturated and groundwater-saturated soils have been listed in the CLARC tables to provide protective concentrations that are easy to use without site-specific data and calculations.

Importance of the Target Groundwater Concentration

A critical parameter for soil-to-groundwater calculations is the target groundwater cleanup level. The soil cleanup level depends on back-calculating from this groundwater cleanup level. The selection of potable and nonpotable groundwater cleanup levels is discussed in WAC 173-340-720. The soil-to-groundwater cleanup levels listed in CLARC are based on protection of potable groundwater to appropriate standard Method B concentrations.

Selecting the Appropriate Groundwater Cleanup Level Target

The general framework for selecting standard Method B groundwater cleanup levels is described in WAC 173-340-720(4)(b) and WAC 173-340-720(7). Briefly, there are three sets of numbers to consider when selecting standard Method B cleanup levels for potable groundwater:

- First, groundwater cleanup levels calculated with MTCA Equations 720-1 (for noncarcinogens) and 720-2 (for carcinogens). These are available in CLARC.
- Second, the drinking water standards (Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs)) established by the federal government and the state of Washington.
- Third, adjustments to the MCLs and MCLGs, as described in WAC 173-340-720(7)(b). Specifically, cleanup levels based on MCLs and MCLGs may have to be adjusted to lower concentrations to ensure that the excess cancer risk associated with exposure to the chemical in groundwater is no more than one in one hundred thousand (1×10^{-5}) and the hazard index is no more than one (1) at the site.

To derive the target groundwater cleanup levels for the soil-to-groundwater pathway, the following procedure, consistent with the MTCA regulation, was used:

- ***If a chemical does not have an MCL or MCLG:*** The groundwater Method B cleanup level is calculated using MTCA Equations 720-1 (for noncarcinogens) and 720-2 (for carcinogens), whichever concentration is lower. These are available in CLARC.
- ***If a chemical has an MCL or, for some noncarcinogens, an MCLG:*** The groundwater Method B cleanup level is the lower of these values, unless it requires adjustment (see below).
- ***Check to see if the MCL should be adjusted downward:*** If an MCL is associated with an excess cancer risk of greater than one in one hundred thousand (1×10^{-5}) or a hazard index of more than one (1), as calculated using MTCA Equations 720-1 or 720-2, then the groundwater Method B cleanup level must be adjusted downward from the MCL concentration so that the excess cancer risk is no greater than one in one hundred thousand (1×10^{-5}) and the hazard index is no more than one (1). See WAC 173-340-720(7)(b).

Lists of Soil-to-Groundwater Cleanup Levels in CLARC for Nonionic Organics and Metals

The CLARC Method B Soil Table has five columns related to the soil-to-groundwater pathway:

1. The first two columns list the soil-to-groundwater cleanup levels for vadose zone soil calculated using Henry's constants at 25 degrees Celsius and 13 degrees Celsius calculated using the fixed parameter three-phase partitioning model (MTCA Equations 747-1 and 747-2) and default values listed in the equations and CLARC. We recommend that site managers use the cleanup levels calculated with Henry's constants at 13 degrees Celsius, which reflects typical groundwater temperatures in Washington. However, for some chemicals, we have Henry's constants only for 25 degrees Celsius, and cleanup levels have been calculated at that temperature. Note that temperature-dependent changes in cleanup levels appear to be roughly related to the magnitude of the Henry's constant, with values less than 10^{-2} corresponding to changes in cleanup levels of less than one percent (for example, 10 milligrams per kilogram versus 9.9 milligrams per kilogram). This is the case for all but one of the

chemicals without a 13 degree Celsius Henry's constant, the exception being ethylbenzene with a 25 degree Celsius value of 3.23×10^{-1} .

2. The third column lists soil-to-groundwater cleanup levels for groundwater-saturated soil as calculated using the fixed parameter three-phase partitioning model (MTCA Equations 747-1 and 747-2) and default values listed in the equations and CLARC. Temperature is not important because Henry's constants are not used to calculate cleanup levels for saturated soil.

3. The fourth column lists target groundwater cleanup levels used in the calculations and the fifth column shows the criteria used select the target levels. The abbreviations used in the table for the fifth column are:

- **C** = Carcinogen, Method B calculation using MTCA Equation 720-2.
- **N** = Noncarcinogen, Method B calculation using MTCA Equation 720-1.
- **MCL** = Federal drinking water maximum contaminant level or maximum contaminant level goal (except for nickel, which is a Washington state MCL).
- **MCL C ADJ** = MCL adjusted to a lower concentration so that the excess cancer risk is one in one hundred thousand (1×10^{-5}). See WAC 173-340-720(7)(b).
- **MCL N ADJ** = MCL adjusted to a lower concentration so that the noncancer hazard index is no greater than one (1). See WAC 173-340-720(7)(b).
- **Background** = Specific to arsenic, the Washington groundwater background concentration listed in MTCA Table 720-1.

Soil-to-Groundwater Cleanup Levels in CLARC for Ionizing Organics – Additional Steps

Seven chemicals, listed in MTCA Table 747-2, have carbon-water partitioning coefficients (K_{oc}) that vary as a function of soil pH:

- benzoic acid (CAS # 65-85-0)
- 2-chlorophenol (CAS # 95-57-8)
- 2,4-dichlorophenol (CAS # 120-83-2)
- 2,4-dinitrophenol (CAS # 51-28-5)
- pentachlorophenol (CAS # 87-86-5)
- 2,4,5-trichlorophenol (CAS # 95-95-4)
- 2,4,6-trichlorophenol (CAS # 88-06-2)

Default soil-to-groundwater cleanup levels for vadose zone soil and groundwater-saturated soil as calculated using the fixed parameter three-phase partitioning model (MTCA Equations 747-1 and 747-2) and K_{oc} at pH 6.8 (as listed in MTCA Table 747-2) are shown in CLARC. Cleanup levels for three different pH conditions (4.9, 6.8, and 8.0) are listed below:

Soil Cleanup Level (mg/kg)

	pH = 4.9		pH = 6.8		pH = 8.0	
	vadose	saturated	vadose	saturated	vadose	saturated
Benzoic acid	263	18.9	257	18.4	257	18.4
2-Chlorophenol	0.48	0.027	0.47	0.027	0.39	0.023
2,4-Dichlorophenol	0.172	0.011	0.167	0.01	0.131	0.0086
2,4-Dinitrophenol	0.128	0.0092	0.128	0.0092	0.128	0.0092
Pentachlorophenol	0.185	0.0093	0.0158	0.00088	0.0122	0.00069
2,4,5-Trichlorophenol	41.2	2.14	28.8	1.51	7.97	0.468
2,4,6-Trichlorophenol	0.097	0.0053	0.046	0.0027	0.026	0.0017

If the soil pH falls between those listed in this table, you cannot calculate the cleanup level by interpolating between the cleanup levels listed here. Instead, you must interpolate between the Koc values listed in MTCA Table 747-2 and, using that Koc, calculate the cleanup level with MTCA Equation 747-1. See WAC 173-340-747(4)(c)(i)(B).

Note that two chemicals in MTCA Table 747-2 (2,3,4,5-tetrachlorophenol, and 2,3,4,6-tetrachlorophenol) are not listed in CLARC and do not have pre-calculated soil-to-groundwater cleanup levels.

Cautions and Limitations

As noted above, the generic soil-to-groundwater cleanup levels listed in the CLARC table:

- have been calculated using only one of several possible methods,
- are based on the assumption that the groundwater is potable,
- do not address Method C groundwater cleanup levels, and
- do not consider site-specific factors.

Depending on conditions at the site, one of the other approaches described in WAC 173-340-747 may be more appropriate. Further, the generic values in the CLARC table may need to be adjusted to account for multiple hazardous substances, multiple exposure pathways, soil background concentrations, or practical quantitation limits.