Groundwater Seepage Calculation

In accordance with Ecology's 2016 guidance memo *Frequently Asked Questions (FAQ's) Regarding Empirical Demonstrations and Related Issues, Implementation Memorandum No. 15*, *Appendix 2: Example Groundwater Travel Time Calculation*, the groundwater seepage velocity and travel time were calculated to demonstrate that sufficient time has passed, since completion of the BOS-200 remedial action, for any residual contamination to reach the point of compliance at monitoring well MW-2. This simplified analysis does not incorporate chemical retardation and, therefore, is a conservative calculation.

When an evaluation of chemical retardation is not necessary, groundwater velocity can be determined using the following equation:

$$V_{gw} = (K)(i)(U) / n$$

V_{gw} = [((0.00165)*(0.087)*(2,834.646)) / 0.43] = **0.95 feet/day**

Where:

V_{gw} = calculated seepage velocity (ft/day)

K = hydraulic conductivity (cm/second) = 0.00165 cm/second for Alderwood-Urban Land complex

i = average hydraulic gradient (unitless) = 0.087 ft/ft average value from Site groundwater monitoring events.

U = unit conversion factor = 2834.646 [$(\mathrm{ft/day})/(\mathrm{cm/sec})$]

n = porosity (unitless) = 0.43 used to be consistent with the provisions contained in WAC 173-340-747(4)(e)(ii)

Input Parameters and Discussion: Based on the Natural Resources Conservation Service Web Soil Survey, soil at the Site is classified as Alderwood-Urban Land complex, 8 to 15 percent slopes. These soils are moderately well drained and classified as Hydrologic Group B. Stantec selected a saturated hydraulic conductivity value of 0.00165 cm/sec for Alderwood-Urban Land complex soils consistent with the Web Soil Survey, SSURGO database, and Site-specific geologic descriptions in Site boring logs. The SSURGO database contains empirical soil data as collected by the National Cooperative Soil Survey over the course of a century. Geologic observations from subsurface assessments at the Site confirm consistency with this data set.

A value of 0.087 feet / foot was used as the average hydraulic gradient based on groundwater monitoring of Site wells from 2015 through 2019.

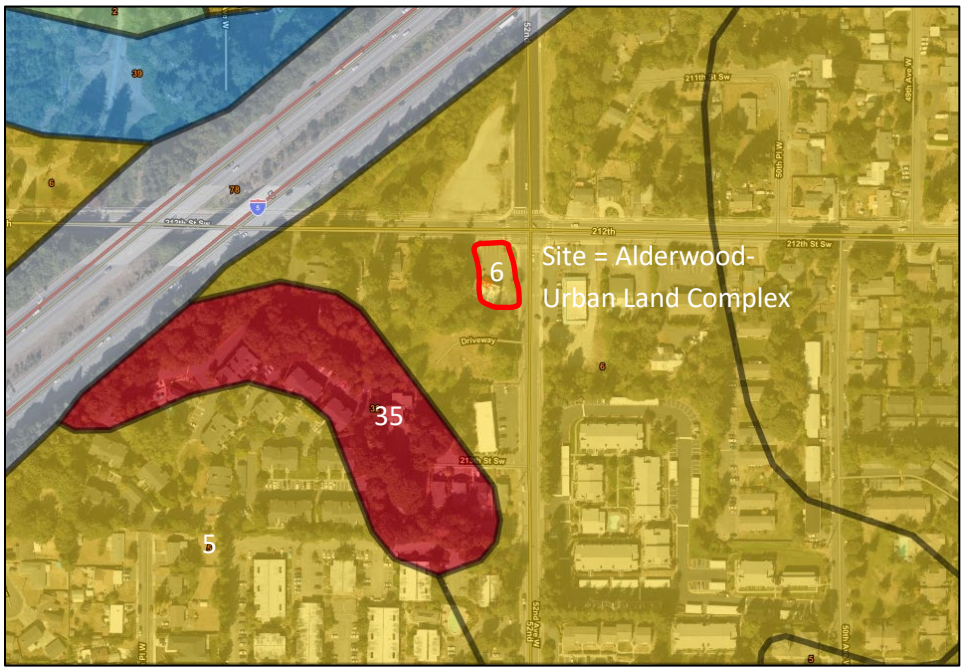
As recommended in Implementation Memo No. 15 and WAC 173-340-747(4)(e)(ii), a saturated soil porosity of 0.43 was selected.

Groundwater Seepage and Travel Time: Based on the Site-specific data described above, the groundwater seepage velocity was calculated to be 0.95 feet per day. Stantec used this calculated groundwater seepage velocity to determine a **travel time of 52 days from the farthest source of contamination in the saturated zone to the point of compliance at MW-2 and MW-7**. The travel time was calculated using a conservative lateral distance of 55-feet from SB-14 and MW-4 to the points of compliance at MW-2 and MW-7.

Horizontal Migration of Groundwater From Impacted Soil to Nearby Wells					
Start Point Soil Boring ID	End Point Well #	Distance (feet)	Groundwater Gradient Direction	Estimated Travel Time (Days)	Estimated Travel Time (Years)
SB-14	MW-2	55	NNE	52	0.14
SB-14	MW-7	44	NNE	42	0.11
MW-4	MW-2	47	NNE	45	0.12
MW-4	MW-7	46	NNE	44	0.12

Therefore, given the calculated travel time of 52 days and post-remediation groundwater analytical results for over 360 days, sufficient time has passed for potential residual contaminants in soil to leach and travel to the point of compliance. In accordance with Implementation Memo No. 15, this groundwater seepage and travel time calculation empirically demonstrates that the soil concentrations measured at the Site have not caused and will not cause an exceedance of the MTCA Method A groundwater CULs.

Additional supporting detail of screenshots from the Natural Resources Conservation Service Web Soil Survey and SSURGO database is provided below.



Source: Natural Resources Conservation Web Soil Survey

Summary by Map Unit — Snohomish County Area, Washington (WA661)

Map unit symbol	Map unit name	Rating (micrometers per second)
2	Alderwood gravelly sandy loam, 8 to 15 percent slopes	16.7948
5	Alderwood-Urban land complex, 2 to 8 percent slopes	16.4776
6	Alderwood-Urban land complex, 8 to 15 percent slopes	16.4776

Source: United States Department of Agriculture Web Soil Survey