SCREENING LEVELS FACT SHEET

Introduction

Concentration-based vapor intrusion (VI) screening is performed using either generic or site-specific screening levels for vapor-forming chemicals (VFCs) in environmental media such as groundwater, shallow and deep soil vapor, sewer vapor, crawl-space air, and indoor air. VI screening levels (VISLs) are based on applying equations to estimate concentrations associated with specific target human health risks that factor in a hierarchy of chronic and subchronic toxicity data and conservative assumptions for inhalation exposure and exposure duration, vapor migration from the subsurface to indoor air (including vapor attenuation across building foundations), and mixing and diluting in indoor air. Toxicity values for vapor inhalation are reference concentrations for noncancer and inhalation unit risks for cancer. Reference concentrations may be chronic (long-term) or subchronic (typically an exposure duration up to seven years). The U.S. Environmental Protection Agency (USEPA) Integrated Risk Information System (IRIS) publishes chronic reference concentrations (USEPA ORD 2025) and Provisional Peer Reviewed Toxicity Values (USEPA 2025). The Agency of Toxic Substances and Disease Registry (ATSDR) also publishes reference concentration data (ATSDR 2024), as do various states. Inhalation unit risks are published by USEPA IRIS (USEPA ORD 2025) and various states.

Generic VISLs are meant to be health-protective (i.e., they overestimate inhalation exposures) by relying on default input values for chemical exposures and vapor migration. As such, VISLs should not be used directly as cleanup levels for remediation. In site-specific screening, the default parameter values used to derive the generic screening levels can be substituted with site-specific values for parameters such as exposure duration, soil type, and groundwater temperature. Some states (e.g., Massachusetts, Connecticut) also incorporate background VFC concentrations into screening levels. Attenuation factors used to derive subsurface screening levels can also be default/generic; for example, USEPA's generic attenuation factors can be found in USEPA's VI guidance (USEPA 2015, Table 6-1) or site-specific. The use of attenuation factors is discussed further in the **Attenuation Factors Fact Sheet** and in **Section 8.5.3**.

Generic VISLs are developed based on a general conceptual model that assumes the following conditions:

- The site is reasonably homogeneous (e.g., no fractures or other preferential pathways between the VFC source and building foundation, no perched groundwater units, no significant soil layering).
- Groundwater is located sufficiently far below a building foundation to avoid wet basements.
- A constant and infinite source of VFC vapors is present in the subsurface directly below the building.
- Vapor migration through the vadose zone is occurring by diffusion as a one-dimensional (vertical) upward, steady-state migration pathway.
- Vapor migration across basement or slab-on-grade concrete foundations occurs by diffusion and pressure-driven advection through foundation perimeter gaps and cracks.
- A steady, well-mixed indoor air environment is present with mixing and dilution of VFCs caused by heating, ventilation, and air conditioning operation and indoor–outdoor air exchange and leakage.

Concentration-based screening should therefore not be applied in situations where site conditions differ from those cited above, including sites with the following conditions:

- VI preferential pathways for vapor migration through the subsurface or across the building or occupied space foundations, such as sewer and other utility conduits (see the **Vapor Intrusion Preferential Pathways Fact Sheet**).
- Pressure- or density-driven transport caused by certain liquid releases of VFCs from commercial or industrial settings, gas leaks from pressurized piping, or methane migration from landfills.

To promote consistency in the development and application of VISLs, USEPA publishes Regional Screening Levels (RSLs) that are typically updated in May and November of each year (USEPA 2024a) and a VISL calculator (USEPA 2024b) for assessing the threat of VI in residential and commercial buildings for approximately 187 VFCs. Equations and default exposure parameters used in the VISL calculator are located in the VISL User's Guide (USEPA 2024b). Likewise, the equations and approaches used to calculate the USEPA RSLs can be found in the RSL User's Guide (USEPA 2024a).

The RSLs are determined from risk equations that factor in mainly chronic inhalation exposure, the chemical toxicity data available as of the most recent RSL update, and default assumptions regarding vapor migration from the subsurface to indoor air (including the attenuation of VFC vapor concentrations across building foundations) and mixing and dilution in indoor air. Biodegradation is not factored into the development of VISLs for subsurface soil vapor. In addition, the screening levels from these calculators do not account for the cumulative effect from all VFCs that may be present in the subsurface or as mixtures. Thus, if multiple chemicals produce a common toxic effect, such as cancer or non-cancer effect on the same target organ, VI risk as evaluated in a risk evaluation could result in a risk above an applicable threshold even if no individual VFC concentrations exceed their respective VISLs (see **Chapter 8: Data Evaluation and Vapor Intrusion Risk Assessment**).

As reported in Eklund et al. (2024), the VISLs recommended by various U.S. states vary significantly, not only in the number of VFCs for which screening levels exist, but also in the magnitude of the screening levels. The number of VFCs with VISLs in regulatory guidance can range from less than 10 to greater than 300. Certain states lack VISLs for certain media. The magnitude of the VISLs can vary by up to three orders of magnitude in indoor air, up to four orders of magnitude in groundwater, and up to five orders of magnitude in soil vapor for six of the more common VFCs reported (benzene; trichloroethylene [TCE]; tetrachloroethylene [PCE]; 1,1-dichloroethylene [1,1-DCE]; 1,1,1-trichloroethane-1,1,1-TCA; and chloroform). The variability stems from differing assumptions regarding chemical toxicity, exposure factors, building use (e.g., residential or nonresidential), and VFC migration from the subsurface to indoor air (including attenuation across building foundations and mixing and dilution in indoor air). Of the 45 U.S. states with VI guidance, 19 recommend USEPA's RSLs and VISLs for VI screening of 187 VFCs (Eklund et al. 2024). A summary of published VISLs for U.S. states is tabulated in Eklund et al. (2024). See also **Appendix A**.

Additional considerations related to VISLs can be summarized as follows:

- Some of the lowest reported VISLs for VFCs in indoor air are below background levels reported in the literature (Dawson and McAlary 2009; Plantz et al. 2025; Rago et al. 2021; USEPA 2011).
- Generic VISLs are not commonly defined for soil because of uncertainties related to (a) VFC soil-vapor partitioning; (b) VFC mass loss that can occur during soil sampling, preservation, and laboratory analyses; and (c) the high spatial variability of VFC concentrations in soil samples (USEPA 2014; 2015).
- The VISLs are periodically updated in accordance with new information on chemical toxicity.

- Some states have also established screening levels that require rapid response actions if exceeded (e.g., MassDEP 2014; NJDEP 2021). Be sure to communicate with your applicable regulatory agency to determine what screening levels are acceptable for your project.

The preferred media for comparing to VISLs varies, in large part, based on the source-building separation distance; general site conditions that consider foundation type, presence of sumps, open floor drains, foundation cracks and penetrations, or other preferential pathway for vapor migration to indoor air; current and future land use; and, at petroleum VI sites, the significant biodegradation of petroleum VFCs in the vadose zone. Soil vapor is commonly preferred for VI screening because of the potential for background (that is, non-VI related) sources of VFCs present in indoor air (Dawson and McAlary 2009; Plantz et al. 2025; Rago et al. 2021; USEPA 2011). The preferred media for concentration-based screening generally depends upon the amount of vertical separation between the vapor source and the building. Shallow, deep, near-slab, or sub-slab soil vapor is generally preferred for concentration-based screening at sites where the VFC source is not directly in contact with the building. Crawl-space vapor and/or indoor and outdoor air are generally preferred media for concentration-based screening if the VFC source is in direct or close contact with building or occupied building foundations. Indoor air is generally the preferred media for concentration-based screening when a preferential pathway exists for vapor migration through the vadose zone or across building or occupied building foundations (see the **Vapor Intrusion Preferential Pathways Fact Sheet**).

Multiple sampling events may be necessary to assess the spatiotemporal variability of VFCs that occurs in the subsurface, crawl space, and indoor and outdoor air as a result of the following factors:

- Meteorological events that cause (1) fluctuations in temperature, wind, barometric pressure, precipitation, water-table elevation, or tides over relatively short-time periods (that is, hours to days) and (2) temporal variability in VFC concentrations in various media (mainly indoor air and shallow soil vapor) (Folkes et al. 2009; Kram et al. 2019; Luo et al. 2009; McCarthy and Johnson 1993; Qi et al. 2020; USEPA 2006).

- Seasonality that affects subsurface temperature, indoor/outdoor temperature gradients, snow and frost cover, and groundwater levels over relatively longer periods (that is, weeks to months) (Folkes et al. 2009; Hers et al. 2014; Kram et al. 2019; Luo et al. 2009; McCarthy and Johnson 1993; Qi et al. 2020; USEPA 2006).

- Varying building ventilation and air exchange inside buildings, within crawl spaces, and below building foundations (Lahvis and Ettinger 2021; Ström et al. 2019; USEPA 2015).

- Background (that is, non-VI) sources in indoor air (Dawson and McAlary 2009; Plantz et al. 2025; Rago et al. 2021; USEPA 2011).

Further details on the best approaches for sampling groundwater, soil vapor (shallow and deep), sub-slab and crawl-space vapor, and indoor and outdoor air can be found in **Chapter 7: Sampling and Analysis**.

Medium-Specific Screening Levels

Chapter 5: Site Screening discusses concentration-based screening as one method of “screening in or out” a site for potential VI concerns. In addition to site screening, screening levels can be used in other contexts, such as screening of chemicals of potential concern (COPC) for a risk assessment if accepted by the regulatory agency or for calculating risks in a screening risk assessment. As mentioned in **Chapter 5: Site Screening**, screening levels can be generic/default or site specific. The following subsections discuss screening levels by medium.

During the site screening phase, generic/default soil-vapor or groundwater screening levels, as defined in regulatory guidance or other documents, are used to determine whether the potential exists for subsurface contaminants to be present in indoor air at levels that could result in adverse health effects to exposed receptors. If the chemical concentrations in soil vapor or groundwater are below regulatory screening levels (and potential concerns due to cumulative effects have been ruled out), then significant human health risks would generally not be expected. Further assessment is typically not needed, as long as the analytical data are considered sufficient and reliable, and there are additional lines of evidence supporting the conclusion (**Section 11.3**).

While conditions below an applicable soil-vapor or groundwater screening level can indicate the absence of a human health risk under many circumstances, the presence of chemicals at concentrations exceeding screening levels does not mean that unacceptable human health risks exist. Because regulatory screening levels are developed to be conservative (i.e., health-protective) and generic (i.e., applicable under many circumstances), an exceedance could simply be an indication that further site-specific evaluation is needed. For example, if a review of groundwater or exterior soil-vapor data resulted in an exceedance of applicable screening levels, it would be appropriate to collect sub-slab or indoor air samples for further evaluation.

USEPA and many states have developed screening levels for various media related to VI starting with indoor air. The indoor air screening levels are typically calculated using a set of generic exposure factors, and then health-protective attenuation factors are applied to estimate associated screening values for crawl-space air, sub-slab soil vapor, exterior soil vapor, sewer gas, and groundwater. While certain regulatory agencies have developed VISLs for soil, these are typically not recommended due to the uncertainties associated with bulk soil sampling (e.g., USEPA 2014; 2015).

The attenuation factors used to calculate screening values for crawl-space air, sub-slab soil vapor, exterior soil vapor, and groundwater refer to the attenuation and reduction in concentration that occurs during vapor migration in the subsurface, coupled with the dilution and attenuation that can occur when the vapors enter through cracks in a building's foundation and mix with indoor air (California DTSC 2023). The attenuation factor is a unitless number defined as the ratio of the indoor air concentration for a given COPC divided by its subsurface concentration.

Exceedance of the applicable regulatory screening levels does not automatically mean that a remedial action is warranted. A determination will have to be made regarding whether additional data are necessary as part of the investigative phase (**Chapter 6**). For many regulatory frameworks, an exceedance of the VISL identifies the need for further investigation (especially during the screening phase). If there is enough information to confirm that concentrations in indoor air are present due to VI at a concentration that poses a potential acute risk to human health, the investigator may move into the mitigation phase (see **Chapter 10: Vapor Intrusion Mitigation**). Otherwise, further characterization may be required as part of the site investigation phase. In addition, many state and federal agencies will allow a responsible party to implement a remedial action to address VI at any point in the process, even prior to confirming the pathway is complete. Such actions should be conducted consistent with guidance and recommendations from the specific agency overseeing the site management.

Indoor Air Screening Levels

USEPA and many state agencies (see Eklund et al. 2024 for a comprehensive list) have developed indoor air screening levels considered protective of specific exposure scenarios, most commonly for residential properties and commercial/industrial workers. In the case of USEPA, equations to calculate indoor air screening levels for residential and commercial/industrial scenarios, including the exposure parameters used for each of these scenarios, are presented in USEPA's RSL website (USEPA 2024a). The residential category applies if the primary activity of the property is residential in nature and includes single-family dwellings, condominiums, and apartment buildings. Residential screening levels may also apply to facilities deemed to have similar exposure potential as a residence (such as a day-care center, school, or elder-care facility). Activities and uses within the nonresidential land-use category are extremely variable but are generally uses that have lower exposure potential than those assumed for the residential exposure scenario, (e.g., where the most sensitive receptor would be a worker present at the location for approximately 40 hours per week, 250 days of the year).

USEPA screening levels are often used by other agencies in the calculation of their own screening levels. These health-based screening levels are based on chemical toxicity and generic assumptions about exposure, typically for residents and workers. As part of the screening level development process, some state agencies also incorporate the consideration of (1) generic background values of indoor air concentrations from unimpacted locations (where background values exist) or (2) practical detection limits associated with the laboratory analytical methods. In the case that a typical background concentration or the quantitation limit is higher than the risk-based screening level, the screening level may be instead set equal to background or the quantitation limit (e.g., MassDEP 2016; NHDES 2013). For example, background concentrations of benzene in air from fuel combustion are frequently higher than the calculated indoor air risk-based screening level and, if measured in indoor air, may be a result of neither VI nor an indoor source. In this case, the final screening level could be set equal to background, so that benzene would not be screened in as a potential VI COPC if concentrations are consistent with background conditions. In other states, background may not be incorporated into the screening levels; however, it may need to be discussed in the uncertainty analysis section or as a component of risk management. With respect to the quantitation limits, some regulatory agencies evaluate practical quantitation limits on a chemical-specific basis, while others select one value to represent the practical quantitation limits for all chemicals for a specific medium. For example, the Connecticut Department of Environmental Protection sets a floor for the soil-vapor volatilization criteria at 0.5 part per billion by volume (CTDEP 2003) (note 1 part per billion by volume is not equal to 1 µg/m^3—see the **Units and Unit Conversions Fact Sheet** for further information on units).

Crawl-Space Air Screening Levels

Based on the preliminary results of USEPA's VI database review process prior to the publication of the database in 2012 (USEPA 2012), the USEPA concluded that there is limited empirical data from which to develop an attenuation factor for crawl-space air (Dawson 2004). The USEPA recommends using a default attenuation factor of 1 for crawl-space attenuation to indoor air (USEPA 2015); in that case, the screening levels for crawl-space air are the same as the screening levels for indoor air. Sixteen states use this attenuation factor of 1 to calculate crawl-space air screening levels, as of a 2023 review (Eklund et al. 2024).

Sub-Slab and Shallow Soil-Vapor Screening Levels

For sub-slab and shallow soil vapor, regulatory screening levels may be derived by using the target indoor air concentrations and dividing by a generic attenuation factor such as 0.03, as recommended by USEPA based on their 2012 VI database (USEPA 2012; 2015). The attenuation factor of 0.03 may not be applicable in certain geographical areas since the underlying data used to derive this generic attenuation factor is concentrated in a few U.S. states. See the **Attenuation Factors Fact Sheet** for further details on attenuation factors.

Several regulatory agencies, including the USEPA, include both shallow soil vapor collected from a depth of approximately 5 feet (and below, to some depth, outside a building or below a building floor slab) and sub-slab soil vapor (collected below a building floor slab) in the same screening-level category (typically designated "shallow soil vapor") when evaluating the VI pathway. In other words, the same generic attenuation factor is applied for deriving the shallow soil-vapor or sub-slab soil-vapor screening level. This screening level assumes that two different transport mechanisms—migration within soil vapor to the slab and then migration from beneath the slab into the building—have the same rate of attenuation. Therefore, migration mechanisms should be considered during the data evaluation stage. Some states (e.g., California) allow consideration of this migration distinction for site-specific screening levels. Additional site evaluation and coordination with the regulatory agency may be required to develop a site-specific attenuation factor for shallow soil-vapor screening levels (see the **Attenuation Factors Fact Sheet**).

Specific considerations may be applicable to petroleum hydrocarbons due to biodegradation (see the **Screening Levels for Biodegradable Compounds** section of this fact sheet.

Groundwater Screening Levels

The VISLs for groundwater are typically groundwater concentrations calculated to be protective of indoor air quality. These screening levels are typically applicable to groundwater data obtained from monitoring wells screened at or near the water table. Groundwater samples collected from deeper aquifers or well-screen intervals are not appropriate for evaluating the VI pathway because volatilization and upward vapor migration occurs for chemicals in groundwater at the water table.

When nonimpacted shallow groundwater lies above an impacted groundwater zone, the shallow groundwater acts as a clean water lens or barrier for volatilization from groundwater at deeper depths. If a clean water lens is suspected, then it should be empirically documented and not assumed.

If groundwater is very shallow (e.g., less than 5 feet below the ground surface) or in contact with the slab, the use of groundwater screening levels may not be appropriate. For further discussion of groundwater in contact with a slab and VI, see the **Direct Volatilization to Indoor Air Fact Sheet**.

The length of the well screen should be considered when comparing VFC concentrations to screening levels, as longer well screens may span groundwater zones (e.g., shallow and medium depth), which could affect how the groundwater results should be interpreted relative to screening levels. Wells with long screens can also exhibit attenuated VFC concentrations due to the averaging that occurs throughout the vertically screened section (Martin-Hayden and Robbins 1997).

Similar to other subsurface screening levels, the application of groundwater screening levels can be state specific. Therefore, state guidance should be consulted to identify the applicable groundwater screening levels and their limitations. Some states may also use distance- or depth-based screening. For example, in Massachusetts, the groundwater screening levels for VI apply for groundwater at 15 feet or shallower within a 30-foot lateral distance of a building (MADEP 2016).

The groundwater VI human health risk screening levels can be calculated using the following formula, which is modified from Section 2.2 Groundwater Screening Level of the USEPA VISL calculator User’s Guide (USEPA 2024b):

$$SL_{GW-IA} = \frac{SL_{IA}}{H' \times \left(\frac{1{,}000L}{m^3}\right) \times AF_{GW}}$$

where:

$SL_{GW\text{-}IA}$	=	calculated screening level for groundwater VI
SL_{IA}	=	indoor air screening level
H’	=	chemical-specific Henry’s Law constant (dimensionless) at the specified groundwater temperature
L	=	liters
m^3	=	cubic meters
AF	=	USEPA default attenuation factor of 0.001 for groundwater to indoor air (unitless) (USEPA 2015)

For example, using a TCE indoor air screening level of 0.478 µg/m³ (based on target risk of 1e-06 and target hazard quotient of 1), the groundwater screening level at 25°C and 1 atmosphere pressure would be as follows:

$$\frac{0.478\ \mu g/m^3}{0.403 \times \left(\frac{1{,}000L}{m^3}\right) \times 0.001} = 1.19\ \mu g/L$$

The Henry's Law constants that are referenced in the USEPA RSLs and in the USEPA VISL calculator assume a water temperature of 25°C, which may need to be modified, depending on geographic location and site conditions, to be more representative of local groundwater temperature (**Figure 1**). A lower groundwater temperature results in less volatilization from the groundwater phase to the vapor phase and, therefore, groundwater screening levels for temperatures below 25°C are higher than those calculated at 25°C.

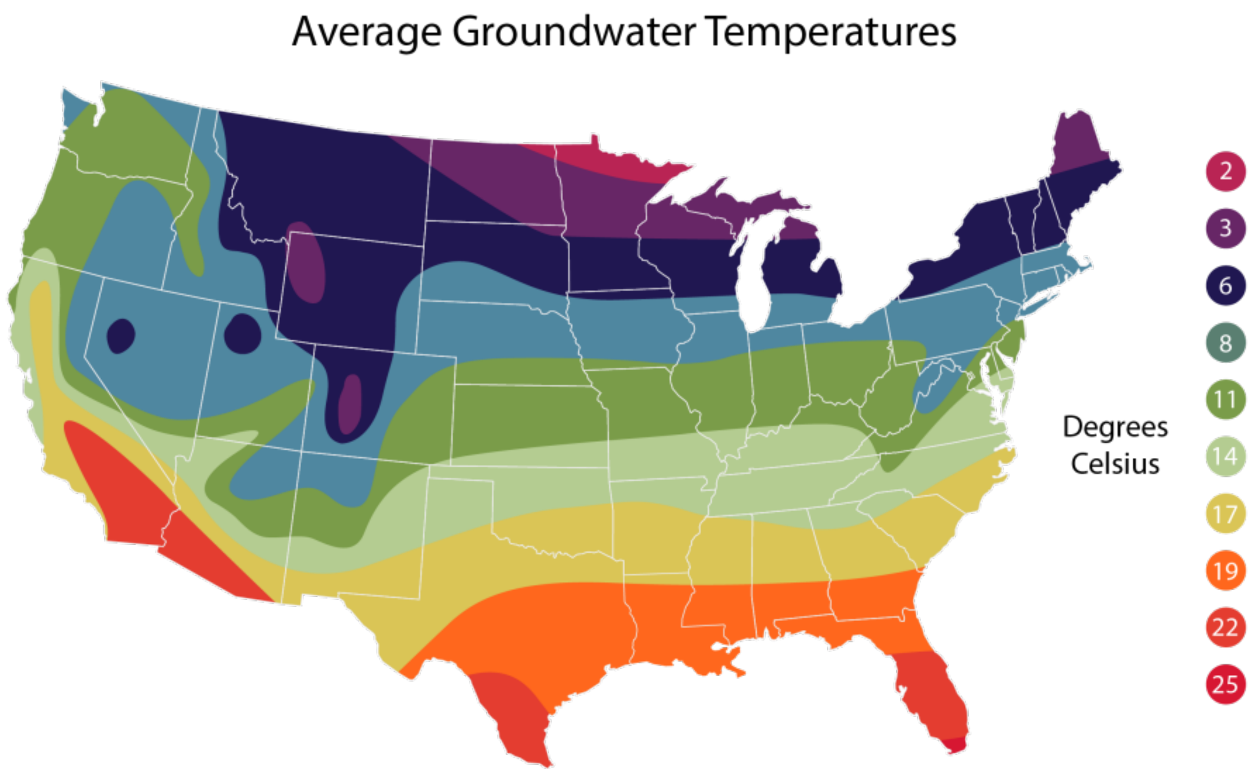

Figure 1. Average groundwater temperatures.

Source: USEPA VISL User's Guide (USEPA 2024b), used with permission.

Calculation of the Henry's Law constant at a groundwater temperature other than 25°C is outside the scope of this fact sheet. Due to the complexities associated with this calculation, ITRC refers the user to the USEPA VISL User's Guide (USEPA 2024b) and recommends the use of the USEPA VISL calculator (USEPA 2024b).

Soil Screening Levels

As noted previously, screening levels for soil concentrations are not generally derived for assessing the VI pathway. USEPA and most states do not use or encourage the use of soil screening levels for VI. USEPA cites uncertainties related to soil partitioning calculations and analytical limitations when sampling and evaluating VFCs in the soil matrix, which reduce the defensibility of soil screening levels (USEPA 2014; 2015).

Generally, soil-vapor measurements are recommended as an alternative to bulk soil measurements to evaluate potential vapor migration from a soil medium. There are situations, however, in which it is not feasible to collect a defensible soil-vapor sample. For instance, the presence of a shallow water table or clay-rich soils may preclude soil-vapor sampling. In these situations, where contaminants originate from a soil source (as compared to a groundwater source), bulk soil measurements may be considered to evaluate the VI pathway, particularly when nonaqueous-phase liquid may be present.

Few states have derived VISLs for soil (see Eklund et al. 2024 for states with soil-based VISLs). The Pennsylvania Department of Environmental Protection (PADEP 2021; 2022) has developed and promulgated soil screening levels based on the application of the Johnson and Ettinger model.

Sewer Gas Screening Levels

Starting in the early 2010s, researchers identified conduits (e.g., sanitary sewers) as potential preferential transport pathways for VI (see the **Vapor Intrusion Preferential Pathways Fact Sheet**). Subsequent research efforts included work to better understand risk factors and potential attenuation associated with the pathways (e.g., (e.g., Beckley and McHugh 2020; Loll 2025).

As of 2023, only a few states have defined specific screening levels for sewer (conduit) vapor (Eklund et al. 2024). These states include Indiana (IDEM 2025) and Wisconsin, which provide guidance on when sewer VI is likely to be most significant. Wisconsin guidance recommends calculating sewer gas screening levels by dividing the indoor air screening level by an attenuation factor of 0.03 (WI DNR 2021) when samples are collected from a sewer main. Samples collected from sewer lines within or near a building or behind p-traps do not have an attenuation factor because there is little dilution from these locations to indoor air.

Screening Levels for Biodegradable Compounds

Screening levels for biodegradable compounds (e.g., petroleum hydrocarbons) typically include the evaluation of other factors such as distance to VI source, geochemistry, and lithology. Because vapors from petroleum hydrocarbons rapidly biodegrade as they migrate through unsaturated vadose-zone soils, the potential for the petroleum VI pathway to be complete is greatly limited. Please refer to **Chapter 5: Site Screening** of the guidance document.

In their derivation of groundwater screening levels, certain states include an additional attenuation factor to account for biodegradation of petroleum compounds (e.g., NHDES 2013; NJDEP 2021).

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