When conducted, a Tier 2 risk assessment follows a Tier 1 risk assessment and includes:

Step 1: Compilation of site-specific fate and transport parameters,
Step 2: Development of Tier 2 site-specific target levels (SSTLs); this step will typically be done with the computational software available through MDNR,
Step 3: Comparison of the Tier 2 SSTLs with exposure pathway-specific representative concentrations,
Step 4: Recommend a course of action, and
Step 5: Documentation of the Tier 2 risk assessment.

When doing a Tier 2 risk assessment, SSTLs must be calculated for all of the complete and potentially complete routes of exposure identified in the exposure model (EM) and all applicable chemicals of concern (COCs). As indicated in section 2.3, any Tier 2 SSTLs which are lower than the Tier 1 RBTLs for that site must be used as the applicable corrective action standards.

Details of each of these steps are presented below.

## 8.1 STEP 1: COMPILATION OF SITE-SPECIFIC FATE AND TRANSPORT PARAMETERS

The objective of this step is to select fate and transport parameters to be used for the development of Tier 2 SSTLs. Values will be considered site-specific if (i) correctly measured on site, (ii) literature values are representative of site conditions, or (iii) use of default values can be justified or shown to be conservative based on site conditions. Note that a work plan for the collection of site-specific fate and transport data need not be submitted to MDNR for approval.

The fate and transport parameters that may be modified for a Tier 2 risk assessment are presented below. The evaluator shall review the site information and select values for each of these parameters, providing justification for the selection of each specific value. For a few of the fate and transport parameters (e.g., the thickness of the capillary fringe), literature values consistent with the site stratigraphy may be used in lieu of field measurements. Note that the use of any default parameters will also require justification.

### 8.1.1 Soil Parameters

**Length of Area of Release Parallel to Wind ($W_a$)** (Tier 1 default value = 1500 cm)

Since the wind direction is variable, and the exact dimensions of the area of release are generally not known, $W_a$ should represent the longest dimension of the area of release (e.g. diagonal if the soil source is roughly rectangular, diameter if the area of release is roughly circular.)

**Depth to Subsurface Soil Sources ($d_{ts}$)** (Tier 1 default value = 91.44 cm)

Tier 2 allows for the actual measured depth of contaminated soils to be used in developing Tier 2 SSTLs. Conservatively, the measured depth to subsurface soil may be the shallowest detected contamination or an average depth of the shallowest detected contamination from several borings. Either way, the measurements should reflect the distance from the surface to the top of the first zone of contaminated soil.

**Thickness of Capillary Fringe ($h_c$)** (Tier 1 default value = 5 cm)

The value used at Tier 2 to represent the capillary fringe thickness must be representative of the site soils/sediments and is dependent on soil grain size. Typically, the thickness of the capillary fringe should be based on literature values since direct measurement will be generally impractical. Note that the sum of the thickness of the capillary fringe and the thickness of the vadose zone should equal the depth to groundwater (i.e., $h_c + h_v = L_{gw}$). A site-specific capillary fringe thickness value may be used only if the evaluator adequately demonstrates that the capillary fringe is uncontaminated. Otherwise, the default value of 5 cm must be used.

**Thickness of Vadose Zone ($h_v$)** (Tier 1 default value = 295 cm)

At Tier 2, the thickness of the vadose zone is calculated by subtracting the capillary fringe thickness from the depth to groundwater (i.e., $L_{gw} - h_c = h_v$).

**Vadose Zone Dry Soil Bulk Density ($\rho_s$)** (Tier 1 default value = 1.5 g/cm$^3$)

See Section 5.6.2 for a discussion related to the determination of soil bulk density. If multiple measurements from the vadose zone are available or when multiple values are necessary to represent different soil types, use the average value.

**Fractional Organic Carbon Content in Vadose Zone ($f_{ocv}$)** (Tier 1 default value = 0.006)

See Section 5.6.5 for a discussion of sample collection and laboratory methods. If measurements of fractional organic matter (not the same as fractional organic carbon) are available, the value must be corrected as discussed in Section 5.6.5. If multiple values are available (as is recommended), the average value should be used. Where soil lithology is significantly heterogeneous, samples should be collected at each change in lithology and composited into one sample for fractional organic carbon content analysis.

**Porosity in the Vadose Zone ($\theta_T$)** (Tier 1 default value = 0.434 cm$^3$/cm$^3$)

In both Tier 1 and Tier 2, the assumption is made that the porosity of vadose zone, capillary fringe, and soil that fills the foundation or wall cracks is identical. This assumption is necessary, as, generally, measuring porosity in the capillary fringe and in foundation and wall cracks is not practical. See Section 5.6.3 for a discussion of

laboratory methods. If multiple porosity values are available, an average value should be used. Where total and effective porosity differ or are expected to differ, the effective porosity value must be used.

**Volumetric Water Content in Vadose Zone ($\theta_{ws}$)** (Tier 1 default value = 0.15 $cm^3/cm^3$)

The Tier 2 value is typically measured as discussed in Section 5.6.4. When using a site-specific value, the value is measured on a weight basis (gravimetric: grams of water/grams of dry soil) and must be converted to a volumetric value ($cm^3$ of water/$cm^3$ of soil) as discussed in Section 5.6.4. An average value based on multiple samples shall be used. Note that moisture content values may be obtained from soil samples to be analyzed for COCs (COCs must be reported by laboratories on a dry weight basis; therefore, the moisture content of each sample must be determined).

**Volumetric Air Content in Vadose Zone ($\theta_{as}$)** (Tier 1 default value = 0.284 $cm^3/cm^3$)

This parameter is the difference between the total soil porosity in the vadose zone and the volumetric water content in the vadose zone (i.e., $\theta_T - \theta_{WS} = \theta_{as}$).

**Volumetric Water Content in Capillary Fringe ($\theta_{wcap}$)** (Tier 1 default value = 0.39 $cm^3/cm^3$)

This value is typically estimated as 90% of the total vadose zone soil porosity (i.e., $0.9\theta_T$). Total soil porosity in the capillary fringe is typically assumed to be equal to the total vadose zone porosity.

**Volumetric Air Content in Capillary Fringe ($\theta_{acap}$)** (Tier 1 default value = 0.0434 $cm^3/cm^3$)

Tier 2 assumes that the volumetric air content in the capillary fringe is 10% of the total porosity in the vadose zone (i.e., $0.1\theta_T$).

**Volumetric Water Content in Foundation or Wall Cracks ($\theta_{wcrack}$)** (Tier 1 default value = 0.15 $cm^3/cm^3$)

Tier 2 assumes that the volumetric water content in soil that fills foundation or wall cracks is the same as the volumetric water content of the soil in the vadose zone.

**Volumetric Air Content in Foundation or Wall Cracks ($\theta_{acrack}$)** (Tier 1 default value = 0.284 $cm^3/cm^3$)

The volumetric air content in foundation wall/cracks is assumed to be the same as the volumetric air content of the soil in the vadose zone. The latter is determined as mentioned above.

### 8.1.2 Groundwater Parameters

**Depth to Groundwater ($L_{gw}$)** (Tier 1 default value = 300 cm)

Since the depth to groundwater fluctuates, an average depth to groundwater using data no more than 2 years old should be used. However, calculating an average depth to groundwater using data collected from several monitoring events over an extended period of time (such as one year of quarterly measurements or six months of monthly measurements) is preferable. If such data are available, the average should be calculated using the average depth to groundwater for each quarter (the average for all wells for each event should be used to calculate an overall average depth to groundwater for the entire site).

For consistency, static water levels should be used unless justification can be provided for the use of the depth to the "first water encountered while drilling." If data collected over an extended period of time is not available, the site-specific average depth to groundwater should be calculated by determining the depth to groundwater in each well and then averaging the single well water depths. However, where significant differences in static water levels occur across the site, the shallowest average depth to groundwater should be used (i.e., a single well average using data from the well showing the shallowest depth to groundwater).

**Width of Groundwater Source Area Perpendicular to Groundwater Flow Direction (Y)** (Tier 1 default value = 1500 cm)

Figure 8-1 shows a schematic of the groundwater source that is considered by Domenico's groundwater model. The model assumes that COCs migrate vertically downward from the area of release to groundwater. By projecting the area of release to the water table, Y can be estimated. Domenico's model is used to simulate migration in the saturated zone and will be necessary only in cases where the groundwater use pathway is complete.

**Length of Groundwater Source Area Parallel to Groundwater Flow Direction ($W_{ga}$)** (Tier 1 default value = 1500 cm)

Figure 8-1 shows a schematic of the groundwater source that is considered by Domenico's groundwater model. The model assumes that COCs migrate vertically downward from the area of release to groundwater. By projecting the area of release to the water table, $W_{ga}$ can be estimated.

**Porosity in Saturated Zone ($\theta_{TS}$)** (Tier 1 default value = 0.434 $cm^3/cm^3$)

An accurate estimate of the total soil porosity in the saturated zone is essential when biodecay is considered. If the unsaturated and saturated zone stratigraphies are similar, the saturated zone porosity may be set equal to the vadose zone porosity. If multiple values are available, an average should be used. If the vadose and saturated zone soil

stratigraphies are significantly dissimilar, the porosity of the saturated zone must be measured in the field or an appropriate literature value used. Where total and effective porosity differ or are expected to differ, the effective porosity value must be used.

**Saturated Zone Dry Soil Bulk Density ($\rho_{ss}$)** (Tier 1 default value = 1.5 g/cm$^3$)

An accurate estimate of the total soil bulk density in the saturated zone is essential when biodecay is considered. If the unsaturated and saturated zone stratigraphies are similar, the saturated zone dry soil bulk density may be set equal to the vadose zone dry soil bulk density. If multiple values are available, an average should be used. If the vadose and saturated zone stratigraphies are significantly dissimilar, the dry soil bulk density of the saturated zone must be measured in the field or an appropriate literature value used.

**Fractional Organic Carbon Content in Saturated Zone ($f_{ocs}$)** (Tier 1 default value = 0.006)

An accurate estimate of the fractional organic carbon content in the saturated zone is essential when biodecay is considered. Refer to Section 5.6.5 for discussion of this parameter. If a site-specific value for saturated zone fractional organic carbon content is to be used at Tier 2, the value must be determined based on field samples collected below the water table or by choosing an appropriate, justifiable literature value.

**Groundwater Mixing Zone Thickness ($\delta_{gw}$)** (Tier 1 default value = 200 cm)

The groundwater mixing zone thickness is a measure of the thickness over which COCs mix within the saturated zone, primarily due to water table fluctuations. While difficult to estimate accurately, the mixing zone thickness may be approximated based on photoionization detector (PID) readings or soil concentrations measured in borings. The 200 cm Tier 1 default value should be considered a minimum. EPA's Soil Screening Guidance (1996, page 45, equation 45) contains an equation to calculate the groundwater mixing zone thickness that may be used at Tier 2. Other procedures for determining the mixing zone thickness may be utilized with the prior approval of MDNR.

**Groundwater Darcy Velocity ($U_{gw}$)** (Tier 1 default value = 2500 cm/yr)

At Tier 2, the groundwater Darcy velocity must be a site-specific value. The value is the product of the saturated zone hydraulic conductivity and the hydraulic gradient.

Site-specific hydraulic conductivity can be estimated based on the results of site-specific pump tests, if available, or using literature values based on site-specific lithology. The hydraulic gradient should be estimated (as the average gradient) using groundwater elevation data not more than two years old. At sites where the groundwater flow direction shows marked variations, the hydraulic gradient and, hence, the Darcy velocity might have to be estimated for more than one direction.

**Infiltration Rate (I)** (Tier 1 default value = 14 cm/yr)

The infiltration rate may be estimated as 10% of the average annual rainfall at the site. Annual rainfall values are based on a 30-year average and may be obtained from literature.

## 8.2 STEP 2: DEVELOPMENT OF TIER 2 SSTLs

The evaluator shall use the parameter values compiled in Step 1 of Section 8.1 to develop Tier 2 SSTLs. These levels can be developed by the use of the MRBCA software or by equivalent methods. The values compiled in Step 1 are entered on the Fate and Transport Parameters page of the software.

## 8.3 STEP 3: COMPARISON OF TIER 2 SSTLs WITH SITE-SPECIFIC REPRESENTATIVE CONCENTRATIONS

In this step, the Tier 2 SSTLs calculated in Step 2 are compared with the representative concentrations (or, for surficial soil in a residential setting, maximum COC concentrations) previously calculated for the Tier 1 risk assessment (unless there is reason to modify the calculation). Based on the results of this comparison, the entity doing the cleanup shall recommend the path forward as discussed in Step 4 below.

## 8.4 STEP 4: RECOMMENDATIONS FOR THE NEXT COURSE OF ACTION

Depending on the results of the comparison, one of the following alternatives is available:

**Alternative 1**: If the representative concentrations (or maximum COC concentrations for surficial soil in a residential setting) of the COCs do not exceed the Tier 2 SSTLs for any of the complete pathways and all the following conditions are met, the tank owner or operator may request that MDNR issue a no further action (NFA) letter for the release.

**Condition 1**: Confirmation that the plume is stable or decreasing (see Section 5.9.3 for definition). If this condition is not met, the evaluator shall recommend continued groundwater monitoring until the plume stabilizes and/or take actions to hasten stabilization.

**Condition 2**: The maximum concentration of any COC does not exceed 10 times the representative concentration of that COC, for each complete route of exposure. This condition should be documented and MDNR will stipulate what actions, if any, must be taken.

**Condition 3:** If current site use is non-residential and exposure pathways are incomplete because of non-residential use (i.e., residential use would result in a complete pathway), or non-residential Tier 2 SSTLs are met but residential risk-based target levels (RBTLs) or

SSTLs are not, future non-residential use of the site must be assured through an AUL (see Section 11) or other adequate documentation. If this condition is not met, the evaluator must report this to MDNR, and MDNR will specify what actions, if any, must be taken.

**Condition 4**: Absence of ecological concerns at the site. If this condition is not met, the entity conducting the cleanup shall provide recommendations to MDNR to address the condition.

**Alternative 2**: If one or more representative concentrations exceed the Tier 2 SSTLs, the tank owner or operator shall determine whether to perform corrective action to achieve Tier 2 SSTLs or perform a Tier 3 risk assessment. MDNR will review the Tier 2 Risk Assessment Report and the recommendations and provide comments to the tank owner or operator.

## 8.5 STEP 5: DOCUMENTATION OF TIER 2 RISK ASSESSMENT

The Tier 2 risk assessment shall be documented as described in Section 12, and submitted to MDNR.