APPENDIX H

METHODS FOR THE DEVELOPMENT, IDENTIFICATION, AND APPLICATION OF SCREENING STANDARDS AND MO-1, MO-2, AND MO-3 RECAP STANDARDS

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H1.0 IDENTIFICATION/DEVELOPMENT AND APPLICATION OF THE SCREENING STANDARDS AND MO-1, MO-2, AND MO-3 RECAP STANDARDS

This appendix presents the methods for the identification/development and application of the Screening Standards and the MO-1, MO-2, and MO-3 RECAP Standards for soil and groundwater. Methods for the development and application of MO-3 RS for other media and/or pathways shall be: 1) identified/derived by the Submitter; 2) consistent with current EPA risk assessment guidance and recommendations; and 3) subject to Department approval.

H1.1 Soil Standards

Screening Option Overview:

1. Identify the $Soil_{SSni}$ or $Soil_{SSi}$ and $Soil_{SSGW}$ in Table 1;

2. Identify the lower of the two values as the limiting soil SS; and

3. Compare the limiting soil SS to the maximum concentration detected at the AOC.

Management Option 1 Overview:

1. Identify the $Soil_{ni}$ or $Soil_{i}$, $Soil_{GW}$ (multiply by a DF2 or DF3 if applicable), and $Soil_{sat}$ in Table 2.

2. If the soil is present at < 15 ft bgs, contains a volatile COC, and an enclosed structure is present over the AOI, identify the $Soil_{es}$ in Table 2;

3. Identify the lowest of the these values as the limiting soil RS; and

4. Compare the limiting soil RS to the lower of the maximum detected concentration and the 95%UCL-AM concentration.

Management Options 2 and 3 Overview:

1. Calculate a site-specific $Soil_{ni}$ or $Soil_{i}$, $Soil_{GW}$ (multiply by a DAF2 or DAF3 if applicable), and $Soil_{sat}$.

2. If the soil is present at < 15 ft bgs, contains a volatile COC, and an enclosed structure is present over the AOI, calculate a $Soil_{es}$;

3. Identifiy the lowest of these values as the limiting soil RS; and

4. Compare the limiting soil RS to the lower of the maximum detected concentration and the 95%UCL-AM concentration.

Detailed guidance on the identification and application of the SS and RS is presented in the following sections.

H1.1.1 Screening Option

The soil SS include $Soil_{SSni}$, $Soil_{SSi}$, $Soil_{SSGW}$, and $Soil_{sat}$ (refer to Section 2.12). The $Soil_{SSni}$, $Soil_{SSi}$, and $Soil_{SSGW}$ are presented in Table 1 of the main document [$Soil_{sat}$ is not listed in Table 1. The $Soil_{SSni}$, $Soil_{SSi}$, and $Soil_{SSGW}$ were compared to the $Soil_{sat}$ (where appropriate) and the lower of the two values was entered in Table 1.] For a constituent not included in Table 1, the Submitter shall calculate a $Soil_{SSni}$ or $Soil_{SSi}$, $Soil_{SSGW}$, and $Soil_{sat}$ in acccordance with Section H2.1. The SS shall be calculated using: 1) the spreadsheet located at http://www.deq.state.la.us/technology/recap/; or 2) a spreadsheet or computer program that generates an output that is consistent with the output of the LDEQ spreadsheet. The toxicity and chemical-specific values shall be obtained using the hierarchy of references listed in Table H-3. Screening Standards shall only be developed for the exposure pathways, exposure scenarios, and land uses included in Appendix H. Site-specific data [with the exception of the area (acres) of impacted soil] shall **not** be used in the development of a soil SS. For a non-detect result, the SQL shall be compared to the limiting SS to document that the SQL is less than or equal to the limiting SS prior to eliminating the constituent from further evaluation under RECAP.

To evaluate soil under the Screening Option:

(1) Identify the AOIC (i.e., the maximum COC concentration detected in soil in the most heavily impacted area(s) known or suspected to be present within the AOC);

(2) Refer to Table 1. Identify the $Soil_{SSni}$ for non-industrial land use or $Soil_{SSi}$ for industrial/commerical land use. If a COC is not listed in Table 1, calculate a $Soil_{SSni}$ (EQ1-EQ4) or $Soil_{SSi}$ (EQ16-EQ19) and a $Soil_{sat}$ (EQ38);

(3) Evaluate the soil to groundwater pathway using either the $Soil_{SSGW}$ in Table 1 or a leach test.

If using the $Soil_{SSGW}$ to evaluate the soil to groundwater pathway:

(a) Refer to Table 1. Identify the $Soil_{SSGW}$. If a COC is not listed in Table 1, calculate a $Soil_{SSGW}$ in accordance with Section H2.1.4.1. Note: Even though the $Soil_{SSGW}$ is based on the protection of a groundwater 1 zone, it is applicable to the protection of **all** groundwater zones under the SO.

(b) Compare: (1) the $Soil_{SSni}$ or $Soil_{SSi}$ and (2) $Soil_{SSGW}$; select the lower of the two values as the limiting SS. For a COC not included in Table 1, compare: (1) the $Soil_{SSni}$ or $Soil_{SSi}$, (2) the $Soil_{SSGW}$, and (3) the $Soil_{sat}$ calculated using EQ38, and select the lowest of the three values as the limiting SS;

(c) Compare the limiting SS to the AOIC:

If the AOIC detected for a COC exceeds the limiting SS, then the soil shall be assessed under a Management Option or the soil shall be remediated to the limiting SS.

If the AOIC for all COC detected in soil are less than the limiting SS, then typically, no further evaluation of the soil is warranted.

If using a leach test to evaluate the soil to groundwater pathway:

(a) Conduct a leach test (e.g., SPLP) in accordance with Appendix B;

(b) Identify the GW_1 in Table 3 and multiply the value by 20 (default value for $DF_{Summers}$). If a COC is not listed in Table 3, determine the GW_1 in accordance with Section H1.2.2.1;

(c) Compare the leach test results to the product of GW_1 x 20:

If the leach test results for all COC are less than or equal to the GW_1 x 20, then the COC concentrations in the soil are protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the GW_1 x 20, then the COC concentration in the soil may not be protective of groundwater and further evaluation of the soil to groundwater pathway is required under a MO or the soil shall be remediated to the $Soil_{SSGW}$.

(d) Compare the AOIC identified in Step (1) with the $Soil_{SSni}$ or $Soil_{SSi}$ (if the COC was not listed in Table 1, compare the $Soil_{SSni}$ or $Soil_{SSi}$ to the $Soil_{sat}$ and then compare the lower of the two values to the AOIC):

If the AOIC for all COC detected in soil are less than the limiting SS, then typically, no further evaluation of the soil is warranted for direct exposure to the soil.

If the AOIC detected for a COC exceeds the limiting SS, then the soil shall be assessed under a Management Option or the soil shall be remediated to the limiting SS.

If the limiting $Soil_{SS}$ calculated by the Submitter is less than the background concentration (as approved by the Department, refer to Section 2.13), then the background concentration shall be identified as the $Soil_{SS}$.

If the limiting $Soil_{SS}$ calculated by the Submitter is less than a Department-approved analytical quantitation limit, then the analytical quantitation limit shall be identified as the $Soil_{SS}$. The analytical quantitation limit identified for application as the $Soil_{SS}$ shall be the lowest quantitation limit available by routine analysis and shall be approved by the Department prior to use.

In applying the limiting SS for TPH fractions and mixtures, it should be noted that the total concentration of petroleum hydrocarbons in soil shall not exceed 10,000 mg/kg (i.e.,

the sum of the residual concentrations of the TPH fractions and mixtures shall not exceed 10,000 mg/kg). Refer to Appendix D (Page D-TPH-3) for further guidance on addressing petroleum hydrocarbon releases.

If the Department determines that impacted soil is a source medium only (exposure to impacted soil is not likely based on current or future land use and site-specific conditions), then it shall not be required that the risk-based standard for soil ($Soil_{SSni}$ or $Soil_{SSi}$) be considered in the identification of the limiting screening standard.

Application of SO soil SS shall not result in soil that exhibits hazardous waste characteristics of ignitability, corrosivity or reactivity as defined in the Hazardous Waste Regulations (LAC 33:V).

Refer to Section 3.0 of the main document for further guidance on the screening process.

For the generation of Table 1, the $Soil_{SSni}$, $Soil_{SSi}$, and $Soil_{SSGW}$ were each compared to the $Soil_{sat}$ (where applicable) and the lower of the two values was entered in Table 1 as the soil SS. The analytical quantitation limit was presented as the SS in Table 1 when the $Soil_{SSni}$, $Soil_{SSi}$, $Soil_{SSGW}$, or $Soil_{sat}$ was less than the analytical quantitation limit. The toxicity and chemical-specific values used to calculate the SS are presented in Tables H-1 and H-2. The hierarchies of references used to obtain the toxicity and chemical-specific parameters are presented in Table H-3. The SQL values used in Table 1 are presented in Table H-4. The worksheets for the development of the SS are presented at the end of this Appendix.

The procedures used in the development of the soil screening standards are illustrated in Figures 10 and 11.

H1.1.2 Management Option 1

The MO-1 soil RS include $Soil_{ni}$, $Soil_{i}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, $Soil_{GW3NDW}$, $Soil_{es}$, and $Soil_{sat}$ (refer to Section 2.12). The soil RS are presented in Table 2 of the main document. For a constituent not included in Table 2, the Submitter shall calculate a $Soil_{ni}$ or $Soil_{i}$, $Soil_{es}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, or $Soil_{GW3NDW}$, and $Soil_{sat}$ in accordance with Section H2.1. The MO-1 RS and AOIC shall be calculated using: 1) the spreadsheets located at http://www.deq.state.la.us/technology/recap/; or 2) a spreadsheet or computer program that generates an output that is consistent with the output of the LDEQ spreadsheet. MO-1 RECAP Standards shall only be developed for the exposure pathways, exposure scenarios, and land uses defined in Section 2.12. Site-specific data shall **not** be used in the development of a soil MO-1 RS. For a non-detect result, the SQL shall be compared to the limiting MO-1 RS to document that the SQL is less than or equal to the limiting RS prior to eliminating the constituent from further evaluation under the RECAP. If the release of volatile emissions from soil (< 15 ft bgs) to an enclosed structure is a pathway of concern at the AOI, include the $Soil_{es}$ from Table 2 in the identification of the limiting soil RS. For detailed guidance on the application of the $Soil_{es}$ RS refer to Section H1.1.3.4. Note: Indoor air sampling shall **not** be used under

MO-1 for the evaluation of the volatile emissions from soil to an enclosed structure pathway.

For the evaluation of soil using $Soil_{ni}$ or $Soil_i$, $Soil_{GW}$, and $Soil_{sat}$, follow the guidelines in Section H1.1.2.1.

For the evaluation of soil using a leach test instead of the $Soil_{GW}$, follow the guidelines in Section H1.1.2.2.

H1.1.2.1 Evaluation of Soil using MO-1 RECAP Standards ($Soil_{ni}$ or $Soil_i$, $Soil_{GW}$, and $Soil_{sat}$)

(1) Determine the appropriate land use scenario (industrial or non-industrial) for current and future land use in accordance with the guidelines presented in Section 2.9. Identify the appropriate risk-based RS ($Soil_{ni}$ for non-industrial land use or $Soil_i$ for industrial land use) in Table 2. If more than one COC identified for MO-1 elicits noncarcinogenic effects on the same target organ/system, modify the $Soil_{ni}$ or $Soil_i$ to account for additivity according to the guidelines presented in Appendix G. If a COC is not listed in Table 2, then the Submitter shall calculate a $Soil_{ni}$ (EQ1-EQ4) or a $Soil_i$ (EQ16-EQ19);

(2) Determine the soil concentration protective of groundwater standard ($Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, or $Soil_{GW3NDW}$) based on the classification of the groundwater to be protected (refer to Section 2.10 for the Groundwater Classifications) as presented below.

If the groundwater to be protected meets the criteria for Groundwater Classification 1:

Identify the $Soil_{GW1}$ value presented in Table 2. If a COC is not listed in Table 2, then the Submitter shall calculate a $Soil_{GW1}$ in accordance with Section H2.1.4.2.

If the groundwater to be protected meets the criteria for Groundwater Classification 2:

(a) Identify the $Soil_{GW2}$ value presented in Table 2. If a COC is not listed in Table 2, then the Submitter shall calculate a $Soil_{GW2}$ in accordance with Section H2.1.4.2.

(b) If the $Soil_{GW2}$ value in Table 2 is footnoted with DF2, identify the longitudinal dilution factor (DF2) to be applied to the $Soil_{GW2}$ from the table below based on: (1) the shortest distance between the POC and the nearest downgradient property boundary (POE); and (2) the thickness of the groundwater source (S_d). (The S_d is defined as the thickness of the impacted groundwater within the permeable zone; refer to Section H2.5, EQ66 and Figure H-1.) If the S_d is greater than 20 feet then a site-specific DAF shall be calculated under MO-2 or MO-3. If the distance from the source is greater than 2000 feet, then: (1) the DF2 for 2000 feet may be used under MO-1; or (2) a site-specific DAF may be calculated under MO-2 or MO-3 (refer to Section H2.5). **Note:** If there is the potential for constituent migration to

be influenced by pumping activities within the zone, then the DF2 values presented below are not valid and shall not be used. The Submitter may develop a site-specific DAF2 under MO-3;

Distance from POC to POE (feet)	MO-1 Longitudinal DF2 (dimensionless)			
	$S_d \leq 5$ ft	S_d = 6-10 ft	S_d = 11-15 ft	S_d = 16-20 ft
0 - 50	1.5	1	1	1
51 - 100	2.6	1.5	1.2	1.1
101 - 150	4.1	2.1	1.6	1.3
151 - 250	8.4	4.3	3	2.3
251 - 500	29	15	9.8	7.4
501 - 750	63	32	21	16
751 - 1000	111	57	37	28
1001 - 1250	173	86	58	43
1251 - 1500	248	124	83	62
1501 - 1750	337	169	113	84
1751 - 2000	440	220	147	110

(c) If the $Soil_{GW2}$ in Table 2 is footnoted with a DF2, multiply the $Soil_{GW2}$ value identified in Step (a) by the longitudinal DF2 identified in Step (b). If the $Soil_{GW2}$ in Table 2 is not footnoted with a DF2, then do not multiply by the DF2. If the $Soil_{GW2}$ (after multiplying by the DF2) for a COC is less than the $Soil_{GW1}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 1 aquifer and the $Soil_{GW1}$ shall be identified as the $Soil_{GW}$ standard. A DF shall not be applied to the $Soil_{GW1}$ RS.

If the groundwater to be protected meets the criteria for Groundwater Classification 3:

(a) Identify the nearest surface water body (segment or subsegment) downgradient of the soil AOI;

(b) Determine if the surface water body (segment or subsegment) is classified as a drinking water supply ($Soil_{GW3DW}$) or a non-drinking water supply ($Soil_{GW3NDW}$) (LAC 33:IX.Chapter 11) and identify the appropriate $Soil_{GW}$ in Table 2. If a COC is not listed in Table 2, the Submitter shall calculate a $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ in accordance with Section H2.1.4.2.

(c) If the $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ in Table 2 is footnoted with a DF3, identify the longitudinal dilution factor (DF3) to be applied to the $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ from the table below based on: (1) the shortest distance between the POC and the nearest downgradient surface water body (POE) identified in Step (a); and (2) the thickness of the groundwater source (S_d). (The S_d is defined as the thickness of the impacted groundwater within the permeable zone; refer to Section H2.5, EQ66 and Figure H-1.) If the S_d is greater than 20 feet then a site-specific DAF shall be calculated under MO-2 or MO-3. If the distance from the source is greater than 2000 feet, then: (1) the DF3 for 2000 feet may be used under MO-1;

or (2) a site-specific DAF3 may be calculated under MO-2 or MO-3 (refer to Section H2.5). Note: If there is the potential for constituent migration to be influenced by pumping activities within the zone, then the DF3 presented below are not valid and shall not be used. The Submitter may develop a site-specific DAF3 under MO-3;

Distance from POC to POE (feet)	MO-1 Longitudinal DF3 (dimensionless)			
	$S_d \leq 5$ ft	S_d = 6-10 ft	S_d = 11-15 ft	S_d = 16-20 ft
0 - 50	1.5	1	1	1
51 - 100	2.6	1.5	1.2	1.1
101 - 150	4.1	2.1	1.6	1.3
151 - 250	8.4	4.3	3	2.3
251 - 500	29	15	9.8	7.4
501 - 750	63	32	21	16
751 - 1000	111	57	37	28
1001 - 1250	173	86	58	43
1251 - 1500	248	124	83	62
1501 - 1750	337	169	113	84
1751 - 2000	440	220	147	110

(d) If the $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ in Table 2 is footnoted with a DF3, multiply the $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ obtained in Step (b) by the longitudinal DF3 identified in Step (c). If the $Soil_{3DW}$ or $Soil_{3NDW}$ in Table 2 is not footnoted with a DF3, do not multiply the $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ by a DF3;

If the $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ (after multiplying by the DF3) for a COC is less than the $Soil_{GW2}$, then for that COC, the aquifer to be protected shall be managed as an aquifer meeting the definition of Groundwater Classification 2 and the $Soil_{GW2}$ shall be identified as the $Soil_{GW}$ standard. A DF2 (not a DF3) shall be applied to the $Soil_{GW2}$ if the $Soil_{GW2}$ is footnoted with a DF2 in Table 2. If the $Soil_{GW2}$ (after multiplying by the DF2) for a COC is less than the $Soil_{GW1}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 1 aquifer and the $Soil_{GW1}$ shall be identified as the $Soil_{GW}$ standard. A DF shall not be applied to the $Soil_{GW1}$.

(3) Identify the $Soil_{sat}$ in Table 2. If a COC is not listed in Table 2, then the Submitter shall calculate a $Soil_{sat}$ (if applicable for the COC) using EQ38;

(4) Identify and apply the limiting soil RS as follows:

Surface soil (ground surface to 15 ft bgs):

(a) Compare: (1) the $Soil_{ni}$ or $Soil_i$ identified in Step (1), (2) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ identified in Step (2), and (3) the $Soil_{sat}$ identified in Step (3); select the lowest of the three values as the limiting RS;

(b) Determine the AOIC for surface soil in accordance with Section 2.8; and

(c) Compare the AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation is warranted for surface soil.

If the AOIC is greater than the limiting RS, then the surface soil shall be further evaluated under MO-2 or MO-3 or remediated to the MO-1 limiting RS.

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into 2 intervals: (1) ground surface to 3 ft bgs and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

Subsurface soil (> 15 ft bgs):

(a) Compare: (1) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, or $Soil_{GW3NDW}$ identified in Step (2), and (2) the $Soil_{sat}$ identified in Step (3); select the lower of the two values as the limiting soil RS;

(b) Determine the AOIC for subsurface soil in accordance with Section 2.8;

(c) Compare the AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the subsurface soil is warranted.

If the AOIC is greater than the limiting RS, then the subsurface soil shall be further evaluated under MO-2 or MO-3 or remediated to the MO-1 limiting RS.

H1.1.2.2 Evaluation of Soil Using a Leach Test and MO-1 RECAP Standards ($Soil_{ni}$ or $Soil_i$ and $Soil_{sat}$)

Surface soil (ground surface to15 ft bgs):

(1) Determine the appropriate land use scenario (industrial or non-industrial) for current and future land use in accordance with the guidelines presented in Section 2.9. Identify the appropriate risk-based RS ($Soil_{ni}$ for a non-industrial scenario or $Soil_i$ for an industrial scenario) in Table 2. If more than one COC identified for MO-1 elicits noncarcinogenic effects on the same target organ/system, modify the $Soil_{ni}$ or $Soil_i$ to account for additivity according to the guidelines presented in Appendix G. If a COC is not listed in Table 2, the Submitter shall calculate a $Soil_{ni}$ (EQ1-EQ4) or $Soil_i$ (EQ16-EQ19);

(2) Identify the $Soil_{sat}$ in Table 2. If a COC is not listed in Table 2, the Submitter shall calculate a $Soil_{sat}$ using EQ38;

(3) Compare: (1) the $Soil_{ni}$ or $Soil_i$ identified in Step (1), and (2) the $Soil_{sat}$ calculated in Step (2); select the lower of the two values as the limiting RS;

(4) Determine the AOIC for surface soil in accordance with Section 2.8;

(5) Compare the AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for **all** COC, then typically, no further evaluation of the surface soil is warranted for the direct contact exposure pathways or for the protection of resource aesthetics.

If the AOIC is greater than the limiting soil RS, then the surface soil shall be further evaluated under MO-2 or MO-3 or remediated to the MO-1 limiting soil RS.

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into two intervals: (1) ground surface to 3 ft bgs; and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

(6) Compare the leach test results (e.g., SPLP) to the appropriate groundwater standard based on the classification of the groundwater to be protected as follows:

For the protection of groundwater meeting the definition of Groundwater Classification 1:

(a) Identify the GW_1 in Table 3. If a COC is not listed in Table 3, the Submitter shall identify/calculate a GW_1 in accordance with Section H2.2.2;

(b) Determine the product of GW_1 x 20 (default value for $DF_{Summers}$);

(c) Compare the leach test results to the product of GW_1 x 20:

If the leach test results are less than or equal to the product of GW_1 x 20, then the soil AOIC is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the product of GW_1 x 20, then the soil AOIC may not be protective of groundwater. Further evaluation of the soil to groundwater pathway is required under MO-2 or MO-3 or corrective action is required under MO-1.

For the protection of groundwater meeting the definition of Groundwater Classification 2:

(a) Identify the GW_2 in Table 3. If a COC is not listed in Table 3, the Submitter shall calculate a GW_2 in accordance with Section H2.2.3;

(b) Identify the longitudinal dilution factor (DF2) in the table below based on: (1) the shortest distance between the POC and the nearest downgradient property boundary (POE); and (2) the thickness of the groundwater source (S_d). (The S_d is defined as the thickness of the impacted groundwater within the permeable zone;

refer to Section H2.5, EQ66 and Figure H-1.) If the S_d is greater than 20 feet then a site-specific DAF shall be calculated under MO-2 or MO-3. If the distance from the source is greater than 2000 feet, then: (1) the DF2 for 2000 feet may be used under MO-1; or (2) a site-specific DAF2 may be calculated under MO-2 or MO-3 (refer to Section H2.5). **Note:** If there is the potential for constituent migration to be influenced by pumping activities within the zone, then the DF2 values presented below are not valid and shall not be used. The Submitter may develop a site-specific DAF2 under MO-3;

Distance from POC to POE (feet)	MO-1 Longitudinal DF2 (dimensionless)			
	$S_d \leq 5$ ft	S_d = 6-10 ft	S_d = 11-15 ft	S_d = 16-20 ft
0 - 50	1.5	1	1	1
51 - 100	2.6	1.5	1.2	1.1
101 - 150	4.1	2.1	1.6	1.3
151 - 250	8.4	4.3	3	2.3
251 - 500	29	15	9.8	7.4
501 - 750	63	32	21	16
751 - 1000	111	57	37	28
1001 - 1250	173	86	58	43
1251 - 1500	248	124	83	62
1501 - 1750	337	169	113	84
1751 - 2000	440	220	147	110

(c) Determine the product of GW_2 x 20 (default value for $DF_{Summers}$) x DF2;

(d) Compare the leach test results to the product of GW_2 x 20 x DF2:

If the leach test results are less than or equal to the product of GW_2 x 20 x DF2, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the product of GW_2 x 20 x DF2, then the AOIC in the soil may not be protective of groundwater. Further evaluation of the soil to groundwater pathway is required under MO-2 or MO-3 or corrective action is required under MO-1.

For the protection of groundwater meeting the definition of Groundwater Classification 3:

(a) Identify the GW_{3DW} or GW_{3NDW} in Table 3. If a COC is not listed in Table 3, the Submitter shall calculate a GW_3 in accordance with Section H.2.2.4;

(b) Identify the longitudinal dilution factor (DF3) in the table below based on: (1) the shortest distance between the POC and the nearest downgradient surface water body (POE); and (2) the thickness of the groundwater source (S_d). (The S_d is defined as the thickness of the impacted groundwater within the permeable zone.

Refer to Section H2.5, EQ66 and Figure H-1.). If the S_d is greater than 20 feet then a site-specific DAF3 shall be calculated under MO-2 or MO-3. If the distance from the source is greater than 2000 feet, then: (1) the DF3 for 2000 feet may be used under MO-1; or (2) a site-specific DAF3 may be calculated under MO-2 or MO-3 (refer to Section H2.5). **Note:** If there is the potential for constituent migration to be influenced by pumping activities within the zone, then the DF3 values presented below are not valid and shall not be used. The Submitter may develop a site-specific DAF3 under MO-3;

Distance from POC to POE (feet)	MO-1 Longitudinal DF3 (dimensionless)			
	$S_d \leq 5$ ft	S_d = 6-10 ft	S_d = 11-15 ft	S_d = 16-20 ft
0 - 50	1.5	1	1	1
51 - 100	2.6	1.5	1.2	1.1
101 - 150	4.1	2.1	1.6	1.3
151 - 250	8.4	4.3	3	2.3
251 - 500	29	15	9.8	7.4
501 - 750	63	32	21	16
751 - 1000	111	57	37	28
1001 - 1250	173	86	58	43
1251 - 1500	248	124	83	62
1501 - 1750	337	169	113	84
1751 - 2000	440	220	147	110

(c) Determine the product of GW_3 x 20 (default value for $DF_{Summers}$) x DF3;

(d) Compare the leach results to the product of GW_3 x 20 x DF3:

If the leach test results are less than or equal to the GW_{3DW} or GW_{3NDW} x 20 x DF3, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the GW_{3DW} or GW_{3NDW} x $DF_{Summers}$ x DF3, then the soil AOIC may not be protective of groundwater. Further evaluation of the soil to groundwater pathway is required under MO-2 or MO-3 or corrective action is required under MO-1.

Subsurface soil (> 15 ft bgs):

(1) Identify the $Soil_{sat}$ in Table 2. If a COC is not listed in Table 2, the Submitter shall calculate a $Soil_{sat}$ (if applicable for the COC) using EQ38;

(2) Determine the AOIC for subsurface soil in accordance with Section 2.8;

(3) Compare the leach test results to the appropriate groundwater standard based on the classification of the groundwater to be protected as follows:

For the protection of groundwater meeting the definition of Groundwater Classification 1:

(a) Identify the GW_1 in Table 3. If a COC is not listed in Table 3, the Submitter shall calculate a GW_1 in acccordance with Section H2.2.2;

(b) Determine the product of GW_1 x 20 (default value for $DF_{Summers}$);

(c) Compare the leach test results to the product of GW_1 x 20:

If the leach test results are less than or equal to the product of GW_1 x 20, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the product of GW_1 x $DF_{Summers}$, then the AOIC may not be protective of groundwater. Further evaluation of the soil to groundwater pathway is required under MO-2 or MO-3 or corrective action is required under MO-1.

For the protection of groundwater meeting the definition of Groundwater Classification 2:

(a) Identify the GW_2 in Table 3. If a COC is not listed in Table 3, the Submitter shall calculate a GW_2 in accordance with Section H2.2.3;

(b) Identify the longitudinal dilution factor (DF2) from the table based on: (1) the shortest distance between the POC and the nearest downgradient property boundary (POE); and (2) the thickness of the groundwater source (S_d). (The S_d is defined as the thickness of the impacted groundwater within the permeable zone; refer to Section H2.5, EQ66 and Figure H-1.) If the S_d is greater than 20 feet then a site-specific DAF2 shall be calculated under MO-2 or MO-3. If the distance from the source is greater than 2000 feet, then: (1) the DF2 for 2000 feet may be used under MO-1; or (2) a site-specific DAF2 may be calculated under MO-2 or MO-3 (refer to Section H2.5). **Note:** If there is the potential for constituent migration to be influenced by pumping activities within the zone, then the DF2 values presented below are not valid and shall not be used. The Submitter may develop a site-specific DAF2 under MO-3;

Distance from POC to POE (feet)	MO-1 Longitudinal DF2 (dimensionless)			
	$S_d \leq 5$ ft	S_d = 6-10 ft	S_d = 11-15 ft	S_d = 16-20 ft
0 - 50	1.5	1	1	1
51 - 100	2.6	1.5	1.2	1.1
101 - 150	4.1	2.1	1.6	1.3
151 - 250	8.4	4.3	3	2.3
251 - 500	29	15	9.8	7.4
501 - 750	63	32	21	16
751 - 1000	111	57	37	28
1001 - 1250	173	86	58	43
1251 - 1500	248	124	83	62
1501 - 1750	337	169	113	84
1751 - 2000	440	220	147	110

(c) Determine the product of GW_2 x 20 (default value for $DF_{Summers}$) x DF2;

(d) Compare the leach test results to the product of GW_2 x 20 x DF2:

If the leach test results are less than or equal to the product of GW_2 x 20 x DF2, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the product of GW_2 x 20 x DF2, then the soil AOIC may not be protective of groundwater. Further evaluation of the soil to groundwater pathway is required under MO-2 or MO-3 or corrective action is required under MO-1.

For the protection of groundwater meeting the definition of Groundwater Classification 3:

(a) Identify the GW_{3DW} or GW_{3NDW} in Table 3. If a COC is not listed in Table 3, the Submitter shall calculate a GW_3 in accordance with Section H2.2.4;

(b) Identify the longitudinal dilution factor (DF3) from the table below based on: (1) the shortest distance between the POC and the nearest downgradient surface water body (POE); and (2) the thickness of the groundwater source (S_d). (The S_d is defined as the thickness of the impacted groundwater within the permeable zone; refer to Section H2.5, EQ66 and Figure H-1.) If the S_d is greater than 20 feet then a site-specific DAF3 shall be calculated under MO-2 or MO-3. If the distance from the source is greater than 2000 feet, then: (1) the DF3 for 2000 feet may be used under MO-1; or (2) a site-specific DAF3 may be calculated under MO-2 or MO-3 (refer to Section H2.5). **Note:** If there is the potential for constituent migration to be influenced by pumping activities within the zone, then the DF3 values presented below are not valid and shall not be used. The Submitter may develop a site-specific DAF3 under MO-3;

Distance from POC to POE (feet)	MO-1 Longitudinal DF3 (dimensionless)			
	$S_d \leq 5$ ft	S_d = 6-10 ft	S_d = 11-15 ft	S_d = 16-20 ft
0 - 50	1.5	1	1	1
51 - 100	2.6	1.5	1.2	1.1
101 - 150	4.1	2.1	1.6	1.3
151 - 250	8.4	4.3	3	2.3
251 - 500	29	15	9.8	7.4
501 - 750	63	32	21	16
751 - 1000	111	57	37	28
1001 - 1250	173	86	58	43
1251 - 1500	248	124	83	62
1501 - 1750	337	169	113	84
1751 - 2000	440	220	147	110

(c) Determine the product of GW_3 x 20 (default value for $DF_{Summers}$) x DF3;

(d) Compare the leach test results to the product of GW_3 x 20 x DF3:

If the leach test results are less than or equal to the GW_{3DW} or GW_{3NDW} x 20 x DF3, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the GW_{3DW} or GW_{3NDW} x 20 x DF3, then the soil AOIC may not be protective of groundwater. Further evaluation of the soil to groundwater pathway is required under MO-2 or MO-3 or corrective action is required under MO-1.

(4) Compare the AOIC to the $Soil_{sat}$:

If the AOIC is less than or equal to the $Soil_{sat}$ for all COC, then typically, no further evaluation of the subsurface soil is warranted for the protection of resource aesthetics.

If the AOIC is greater than the $Soil_{sat}$, then the subsurface soil shall be further evaluated under MO-2 or MO-3 or remediated to the MO-1 $Soil_{sat}$.

If a limiting MO-1 soil RS developed by a Submitter is below the analytical quantitation limit, then the analytical quantitation limit shall be identified as the limiting soil RS. The analytical quantitation limit identified for application as a RS shall be the lowest quantitation limit available by routine analysis and shall be approved by the Department prior to use. A MO-1 Soil RS based on the analytical quantitation limit shall not be multiplied by a DF.

If the limiting MO-1 soil RS is below a Department-approved (refer to Section 2.13) background concentration, the background concentration shall be identified as the

limiting soil RS. A MO-1 soil RS based on an approved background concentration shall not be multiplied by a DF.

A MO-1 $Soil_{GW}$ shall not result in an unacceptable constituent concentration (greater than GW_1 or GW_2) in deeper groundwater zones meeting the definition of Groundwater Classifications 1 or 2.

If the Department determines that impacted soil is a source medium only (exposure to impacted soil is not likely based on current or future land use and site-specific conditions), then it shall not be required that the risk-based standard for soil ($Soil_{ni}$ or $Soil_i$) be considered in the identification of the limiting RS.

Application of MO-1 soil RS shall not result in soil that exhibits hazardous waste characteristics of ignitability, corrosivity or reactivity as defined in the Hazardous Waste Regulations (LAC 33:V).

In applying the MO-1 limiting RS for the TPH fractions and mixtures, it should be noted that the total concentration of petroleum hydrocarbons in soil shall not exceed 10,000 mg/kg (i.e., the sum of the residual concentrations for the TPH fractions and mixtures shall not exceed 10,000 mg/kg). Refer to Appendix D (Page D-3) for further guidance on addressing petroleum hydrocarbon releases.

Refer to Section 4.0 of the main document for further guidance on the implementation of MO-1.

For the generation of Table 2, the analytical quantitation limit was presented in Table 2 as the RS if the $Soil_{ni}$, $Soil_i$, $Soil_{GW1}$, $Soil_{GW2}$ (after multiplying by the DF2), $Soil_{GW3DW}$ (after multiplying by the DF3), $Soil_{GW3NDW}$ (after multiplying by the DF3), or $Soil_{sat}$ developed under MO-1 was below the analytical quantitation limit. The toxicity and chemical-specific values used to calculate the MO-1 RS are presented in Tables H-1 and H-2. The hierarchies of references used to obtain the toxicity and chemical-specific parameters are presented in Table H-3. The SQL values used in Table 2 are presented in Table H-4. The worksheets for the development of the MO-1 RS are presented at the end of this Appendix. The procedures used in the development of the soil MO-1 RECAP standards are illustrated in Figures 10 and 13 of the main document.

H1.1.3 Management Option 2

The MO-2 soil RS include $Soil_{ni}$, $Soil_i$, $Soil_{ni}$-PEF, $Soil_i$-PEF, $Soil_{es}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, $Soil_{GW3NDW}$, and $Soil_{sat}$ (refer to Section 2.12). Based on the conceptual site model, the Submitter shall calculate all applicable soil RS in accordance with Section H2.1. The MO-2 RS and AOIC shall be calculated using: 1) the spreadsheets located on LDEQ's website at http://www.deq.state.la.us/technology/recap/; or 2) a spreadsheet or computer program that generates an output that is consistent with the output of the LDEQ spreadsheet. Site-specific environmental fate and transport data may be used as specified in Section H2.1. Site-specific exposure data shall **not** be used in the development of MO-2 RS; standard exposure parameters representative of a reasonable maximum exposure

scenario shall be used as presented in Section H2.1. If available, the chemical-specific data presented in the worksheets at the end of this appendix shall be used in the calculation of the MO-2 RS. MO-2 RECAP Standards shall only be developed for the exposure pathways, exposure scenarios, and land uses defined in Section 2.12. Environmental fate and transport models other than those presented in this Appendix shall **not** be used in the MO-2 assessment. For a non-detect result, the SQL shall be compared to the limiting MO-2 RS to document that the SQL is less than or equal to the limiting RS prior to eliminating the constituent from further evaluation under the RECAP.

For the evaluation of soil using $Soil_{ni}$ or $Soil_i$, $Soil_{GW}$, and $Soil_{sat}$, follow the guidelines in Section H1.1.3.1.

For the evaluation of soil using a leach test instead of the $Soil_{GW}$, follow the guidelines in Section 1.1.3.2.

For the evaluation of soil with high fugitive dust emissions (Soil-PEF), follow the guidelines in Section 1.1.3.3.

For the evaluation of soil impacted with volatile constituents located beneath an enclosed structure ($Soil_{es}$), follow the guidelines in Section 1.1.3.4.

H1.1.3.1 Evaluation of Soil using MO-2 RECAP Standards ($Soil_{ni}$ or $Soil_i$, $Soil_{GW}$, and $Soil_{sat}$)

(1) Determine the appropriate land use scenario (industrial or non-industrial) for current and future land use at the AOI in accordance with the guidelines presented in Section 2.9. Calculate the appropriate risk-based soil RECAP Standard for the direct exposure pathways ($Soil_{ni}$ for a non-industrial scenario or $Soil_i$ for an industrial scenario) using EQ1-EQ4 or EQ16-EQ19. If more than one COC identified for MO-2 elicits noncarcinogenic effects on the same target organ/system, modify the $Soil_{ni}$ or $Soil_i$ to account for additivity according to the guidelines presented in Appendix G. **Note:** If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 $Soil_i$ or $Soil_{ni}$ presented in Table 2.

(2) Calculate a site-specific soil concentration protective of groundwater standard ($Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, or $Soil_{GW3NDW}$) based on the classification of the groundwater to be protected (refer to Section 2.10 for the groundwater classifications) using one of the 4 methods presented in Section H2.1.4.3. If the $Soil_{GW3}$ (after applying the DAF3) for a COC is less than the $Soil_{GW2}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 2 aquifer and the $Soil_{GW2}$ shall be identified as the $Soil_{GW}$ RS. **Note:** A DAF2 (not a DAF3) shall be applied to the $Soil_{GW2}$. If the $Soil_{GW2}$ (after applying the DAF2) for a COC is less than the $Soil_{GW1}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 1 aquifer and the $Soil_{GW1}$ shall be identified as the $Soil_{GW}$ RS. A DAF shall not be applied to the $Soil_{GW1}$ RS. **Note:** If the area of impacted soil is less than or equal to

0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF2 or DF3 (refer to Section H1.1.2.1).

(3) If applicable for the COC, calculate a site-specific $Soil_{sat}$ using EQ38;

(4) Identify and apply the limiting soil RS as follows:

Surface soil (ground surface to 15 ft bgs):

(a) Compare: (1) the $Soil_{ni}$ or $Soil_i$ calculated in Step (1), (2) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (2), and (3) the $Soil_{sat}$ calculated in Step (3); select the lowest of the three values as the limiting RS;

(b) Determine the AOIC for surface soil in accordance with Section 2.8; and

(c) Compare the AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COCs, then typically, no further evaluation is warranted for surface soil.

If the AOIC is greater than the limiting RS, then the surface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into 2 intervals: (1) ground surface to 3 ft bgs; and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

Subsurface soil (> 15 ft bgs):

(a) Compare: (1) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (2), and (2) the $Soil_{sat}$ calculated in Step (3); select the lower of the two values as the limiting soil RS;

(b) Determine the AOIC for subsurface soil in accordance with Section 2.8;

(c) Compare the AOIC with the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the subsurface soil is warranted.

If the AOIC is greater than the limiting RS, then the subsurface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

H1.1.3.2 Evaluation of Soil using a Leach Test and MO-2 RECAP Standards ($Soil_i$ or $Soil_{ni}$ and $Soil_{sat}$)

Surface soil (ground surface to 15 ft bgs):

(1) Determine the appropriate land use scenario (industrial or non-industrial) for current and future land use in accordance with the guidelines presented in Section 2.9 and calculate a risk-based soil RECAP Standard for the direct exposure pathways ($Soil_{ni}$ for a non-industrial scenario or $Soil_i$ for an industrial scenario) using EQ1-EQ4 or EQ16-EQ19. If more than one COC identified for MO-2 elicits noncarcinogenic effects on the same target organ/system, modify the $Soil_{ni}$ or $Soil_i$ to account for additivity according to the guidelines presented in Appendix G. **Note:** If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 $Soil_i$ or $Soil_{ni}$ presented in Table 2.

(2) Calculate a site-specific $Soil_{sat}$ (if applicable for the COC) using EQ38;

(3) Compare: (1) the $Soil_{ni}$ or $Soil_i$ calculated in Step (1) and (2) the $Soil_{sat}$ calculated in Step (2); select the lower of the two values as the limiting RS;

(4) Determine the AOIC for surface soil in accordance with Section 2.8;

(5) Compare the AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the surface soil is warranted for the protection of human health for direct exposure or for the protection of resource aesthetics.

If the AOIC is greater than the limiting soil RS, then the surface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting soil RS.

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into 2 intervals: (1) ground surface to 3 ft bgs; and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

(6) Compare the leach test results (e.g., SPLP) to the appropriate standard based on the classification of the groundwater to be protected as follows:

For the protection of groundwater meeting the definition of Groundwater Classification 1:

(a) Identify the GW_1 in Table 3. If a COC is not listed in Table 3, the Submitter shall identify/calculate a GW_1 in accordance with Section H2.2.2;

(b) Calculate a site-specific $DF_{Summers}$ using EQ61 (refer to Section H2.4) (the default value of 20 may be used for the $DF_{Summers}$);

(c) Determine the product of GW_1 x $DF_{Summers}$;

(d) Compare the leach test results to the product of GW_1 x $DF_{Summers}$:

If the leach test results are less than or equal to the product of GW_1 x $DF_{Summers}$, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the product of GW_1 x $DF_{Summers}$, then the COC source concentration in the soil may not be protective of groundwater and further evaluation of the soil to groundwater pathway is required under MO-3 or corrective action is required under MO-2.

For the protection of groundwater meeting the definition of Groundwater Classification 2:

(a) Identify the GW_2 in Table 3. If a COC is not listed in Table 3, the Submitter shall calculate a GW_2 in accordance with Section H2.2.3;

(b) Calculate a site-specific $DF_{Summers}$ (EQ61) (the default value of 20 may be used for the $DF_{Summers}$) and a site-specific DAF2 (EQ65) in accordance with Sections H2.4 and H2.5. **Note:** If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF2 (refer to Section H1.1.2.1);

(c) Determine the product of GW_2 x $DF_{Summers}$ x DAF2;

(d) Compare the leach test results to the product of GW_2 x $DF_{Summers}$ x DAF2:

If the leach test results are less than or equal to the product of GW_2 x $DF_{Summers}$ x DAF2, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the product of GW_2 x $DF_{Summers}$ x DAF2, then the AOIC in the soil may not be protective of groundwater and further evaluation of the soil to groundwater pathway is required under MO-3 or corrective action is required under MO-2.

For the protection of groundwater meeting the definition of Groundwater Classification 3:

(a) Identify the GW_{3DW} or GW_{3NDW} in Table 3. If a COC is not listed in Table 3, the Submitter shall calculate a GW_3 in accordance with Section H2.2.4;

(b) Calculate a site-specific $DF_{Summers}$ (EQ61) and a site-specific DAF3 (EQ65) in accordance with Sections H2.4 and H2.5. **Note:** If the area of impacted soil is

less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF3 (refer to Section H1.1.2.1);

(c) Determine the product of GW_3 x $DF_{Summers}$ x DAF3;

(d) Compare the leach test results to the product of GW_3 x $DF_{Summers}$ x DAF3:

If the leach test results are less than or equal to the product of GW_{3DW} or GW_{3NDW} x $DF_{Summers}$ x DAF3, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the product of GW_{3DW} or GW_{3NDW} x $DF_{Summers}$ x DAF3, then the AOIC in the soil may not be protective of groundwater and further evaluation of the soil to groundwater pathway is required under MO-3 or corrective action is required under MO-2.

Subsurface soil (> 15 ft bgs):

(1) Compare the leach test results to the appropriate standard based on the classification of the groundwater to be protected as follows:

For the protection of groundwater meeting the definition of Groundwater Classification 1:

(a) Identify the GW_1 in Table 3. If a COC is not listed in Table 3, the Submitter shall identify a GW_1 in accordance with Section H2.2.2;

(b) Calculate a site-specific $DF_{Summers}$ using EQ61 (refer to Section H2.4) (the default value of 20 may be used for the $DF_{Summers}$);

(c) Multiply the GW_1 by the $DF_{Summers}$;

(d) Compare the leach test results to the product of GW_1 x $DF_{Summers}$:

If the leach test results are less than or equal to the GW_1 x $DF_{Summers}$, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the GW_1 x $DF_{Summers}$, then the COC source concentration in the soil may not be protective of groundwater and further evaluation of the soil to groundwater pathway is required under MO-3 or corrective action is required under MO-2.

For the protection of groundwater meeting the definition of Groundwater Classification 2:

(a) Identify the GW_2 in Table 3. If a COC is not listed in Table 3, the Submitter shall identify a GW_2 in accordance with Section H2.2.3;

(b) Calculate a site-specific $DF_{Summers}$ (EQ61; refer to Section H2.4) (the default value of 20 may be used for the $DF_{Summers}$) and a site-specific DAF2 (EQ65; refer to Section H2.5). **Note:** If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF2 (refer to Section H1.1.2.1);

(c) Determine the product of GW_2 x $DF_{Summers}$ x DAF2;

(d) Compare the leach test results to the GW_2 x $DF_{Summers}$ x DAF2:

If the leach test results are less than or equal to the product of GW_2 x $DF_{Summers}$ x DAF2, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the product of GW_2 x $DF_{Summers}$ x DAF2, then the AOIC in the soil may not be protective of groundwater and further evaluation of the soil to groundwater pathway is required under MO-3 or corrective action is required under MO-2.

For the protection of groundwater meeting the definition of Groundwater Classification 3:

(a) Identify the GW_{3DW} or GW_{3NDW} in Table 3. If a COC is not listed in Table 3, the Submitter shall calculate a GW_3 in accordance with Section H2.2.4;

(b) Calculate a site-specific $DF_{Summers}$ (EQ61; refer to Section H2.4) the default value of 20 may be used for the $DF_{Summers}$) and a site-specific DAF3 (EQ65; refer to Section H2.5). **Note:** If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF3 (refer to Section H1.1.2.1);

(c) Determine the product of GW_3 x $DF_{Summers}$ x DAF3;

(d) Compare the leach test results to product of GW_3 x $DF_{Summers}$ x DAF3:

If the leach test results are less than or equal to the product of GW_{3DW} or GW_{3NDW} x $DF_{Summers}$ x DAF3, then the AOIC in the soil is protective of groundwater. Therefore, this pathway is eliminated from further consideration.

If the leach test results are greater than the product of GW_{3DW} or GW_{3NDW} x $DF_{Summers}$ x DAF3, then the AOIC in the soil may not be protective of groundwater and further evaluation of the soil to groundwater pathway is required under MO-3 or corrective action is required under MO-2.

(2) Calculate a site-specific $Soil_{sat}$ (if applicable to the COC) using EQ38;

(3) Determine the AOIC for subsurface soil in accordance with Section 2.8;

(4) Compare the AOIC to the $Soil_{sat}$:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the soil is warranted for the protection of resource aesthetics.

If the AOIC is greater than the limiting soil RS, then the soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting soil RS.

H1.1.3.3 Evaluation of Surface Soil Associated with High Fugitivie Dust Emissions (Soil-PEF, $Soil_{GW}$, and $Soil_{sat}$)

If high fugitive dust emissions are a concern throughout the AOI:

(1) Determine the appropriate land use scenario (industrial or non-industrial) for current and future land use in accordance with the guidelines presented in Section 2.9 and calculate the appropriate risk-based soil RECAP Standard that includes the inhalation of dust emissions pathway ($Soil_{ni}$-PEF for a non-industrial scenario or $Soil_i$-PEF for an industrial scenario) using EQ5, EQ6, EQ7, EQ8, EQ21, EQ22, EQ23, or EQ24. If more than one COC identifed for MO-2 elicits noncarcinogenic effects on the same target organ/system, modify the $Soil_{ni}$-PEF or $Soil_i$-PEF to account for additivity according to the guidelines presented in Appendix G.

(2) Calculate a site-specific soil concentration protective of groundwater standard ($Soil_{GW1,}$ $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ depending on the classification of the groundwater to be protected - refer to Section 2.10 for the groundwater classifications) using one of the $Soil_{GW}$ Methods presented in Section H2.1.4.3. If the $Soil_{GW3}$ (after applying the DAF3) for a COC is less than the $Soil_{GW2}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 2 aquifer and the $Soil_{GW2}$ shall be identified as the $Soil_{GW}$ RS. A DAF2 (not a DAF3) shall be applied to the $Soil_{GW2}$. If the $Soil_{GW2}$ (after applying the DAF2) for a COC is less than the $Soil_{GW1}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 1 aquifer and the $Soil_{GW1}$ shall be identified as the $Soil_{GW}$ RS. A DAF shall not be applied to the $Soil_{GW1.}$

Note: If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF2 or DF3 (refer to Section H1.1.2.1).

Note: In lieu of applying a $Soil_{GW}$ RS at the AOI, the soil to groundwater pathway may be evaluated using a leach test (refer to Section H1.1.3.2 and Section H2.1.4.3, $Soil_{GW}$ Method 3);

(3) Calculate a site-specific $Soil_{sat}$ (if applicable to the COC) using EQ38;

(4) Identify and apply the limiting RS as follows:

(a) Compare: (1) the $Soil_{ni}$-PEF or $Soil_{i}$-PEF calculated in Step (1), (2) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (2), and (3) the $Soil_{sat}$ calculated in Step (3); select the lowest of the three values as the limiting RS;

(b) Determine the AOIC for surface soil in accordance with Section 2.8;

(c) Compare the AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COCs, then typically, no further evaluation is warranted for surface soil.

If the AOIC is greater than the limiting RS, then the surface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into 2 intervals: (1) ground surface to 3 ft bgs and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

If high fugitivie dust emissions are a concern for only a portion of the AOI:

(1) Determine the appropriate land use scenario (industrial or non-industrial) for current and future land use at the AOI in accordance with the guidelines presented in Section 2.9. Calculate the appropriate risk-based soil RECAP Standard for the direct contact exposure pathways ($Soil_{ni}$ for a non-industrial scenario or $Soil_{i}$ for an industrial scenario) using EQ1-EQ4 or EQ16-EQ19. If more than one constituent is present in soil that elicits noncarcinogenic effects on the same target organ/system, modify the $Soil_{ni}$ or $Soil_{i}$ to account for additivity according to the guidelines presented in Appendix G;

(2) Calculate a site-specific soil concentration protective of groundwater standard ($Soil_{GW1,}$ $Soil_{GW2}$, $Soil_{GW3DW}$, or $Soil_{GW3NDW}$) depending on the classification of the groundwater to be protected (refer to Section 2.10 for the groundwater classifications) using one of the methods in Section H2.1.4.3. If the $Soil_{GW3}$ (after applying the DAF3) for a COC is less than the $Soil_{GW2}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 2 aquifer and the $Soil_{GW2}$ shall be identified as the $Soil_{GW}$ RS. A DAF2 (not a DAF3) shall be applied to the $Soil_{GW2}$. If the $Soil_{GW2}$ (after applying the DAF2) for a COC is less than the $Soil_{GW1}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 1 aquifer and

the $Soil_{GW1}$ shall be identified as the $Soil_{GW}$ RS. A DAF shall not be applied to the $Soil_{GW1}$ RS.

Note: If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF2 or DF3 (refer to Section H1.1.2.1).

Note: In lieu of applying a $Soil_{GW}$ RS at the AOI, the soil to groundwater pathway may be evaluated using a leach test (refer to Section H1.1.3.2 and Section H2.1.4.3, $Soil_{GW}$ Method 3);

(3) If applicable for the COC, calculate a site-specific $Soil_{sat}$ using EQ38;

(4) Identify and apply the limiting soil RS to **all** of the current/potenital surface soil within the boundaries of the AOI as follows:

(a) Compare: (1) the $Soil_{ni}$ or $Soil_i$ calculated in Step (1), (2) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (2), and (3) the $Soil_{sat}$ calculated in Step (3); select the lowest of the three values as the limiting RS;

(b) Determine the AOIC for surface soil in accordance with Section 2.8; and

(c) Compare the AOIC for surface soil to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COCs, then typically, no further evaluation is warranted for surface soil (ingestion, dermal contact, and inhalation of volatile emissions).

If the AOIC is greater than the limiting RS, then the surface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into 2 intervals: (1) ground surface to 3 ft bgs and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

(5) Calculate the appropriate risk-based RECAP Standard that includes the inhalation of dust emissions pathway [$Soil_{ni}$-PEF for a non-industrial scenario (EQ5, EQ6, EQ7, or EQ8) or $Soil_i$-PEF for an industrial scenario (EQ21, EQ22, EQ23, or EQ24)]. If more than one constituent is present that elicits noncarcinogenic effects on the same target organ/system, modify the Soil-PEF to account for additivity according to the guidelines presented in Appendix G;

(6) Determine the AOIC for the portion of the AOI that is associated with high fugitive dust emissions;

(7) Compare the AOIC that is associated with high fugitive dust emissions to the Soil-PEF:

If the AOIC is less than or equal to the Soil-PEF, then typically, no further evaluation is warranted for this pathway.

If the AOIC is greater than the Soil-PEF, then the soil associated with high fugitive dust emissions shall be further evaluated under MO-3 or remediated to the MO-2 Soil-PEF.

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into 2 intervals: (1) ground surface to 3 ft bgs and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

H1.1.3.4 Evaluaton of Soil Impacted with Volatile Constituents Located Beneath an Enclosed Structure ($Soil_{es}$, $Soil_{ni}$ or $Soil_{i}$, $Soil_{GW}$, and $Soil_{sat}$)

If the volatile emissions from soil to an enclosed structure pathway is a concern throughout the AOI:

(1) Determine the appropriate land use scenario (industrial or non-industrial) for current and future land use in accordance with the guidelines presented in Section 2.9 and calculate a risk-based soil RECAP Standard for direct contact pathways ($Soil_{ni}$ for a non-industrial scenario or $Soil_{i}$ for an industrial scenario) using EQ1-EQ4 and EQ16-EQ19. If more than one COC elicits noncarcinogenic effects on the same target organ/system, modify the $Soil_{ni}$ or $Soil_{i}$ to account for additivity according to the guidelines presented in Appendix G;

(2) Calculate the risk-based RECAP Standard for the inhalation of volatile emissions from soil to an enclosed structure pathway ($Soil_{es}$ for a non-industrial or an industrial scenario) using EQ26. If more than one constituent is present in soil that elicits noncarcinogenic effects on the same target organ/system or both soil and groundwater are contributing volatile emissions to the enclosed structure, modify the $Soil_{es}$ (C_a) to account for additivity according to the guidelines presented in Appendix G.

Note: In lieu of applying a $Soil_{es}$ RECAP Standard at the AOI, soil gas sampling or indoor air sampling may be conducted at the AOI (for further guidance on the evaluation of COC concentrations in indoor air refer to Section B2.5.15 of Appendix B and Sections H1.1.3.5 and H2.3 of this Appendix);

(3) Calculate a site-specific soil concentration protective of groundwater standard ($Soil_{GW1,}$ $Soil_{GW2}$, $Soil_{GW3DW}$, or $Soil_{GW3NDW}$ depending on the classification of the groundwater to be protected - refer to Section 2.10 for the groundwater classifications) in accordance with Section H2.1.4.3. If the $Soil_{GW3}$ (after applying the DAF3) for a COC is less than the $Soil_{GW2}$, then for that COC, the

aquifer to be protected shall be managed as a Groundwater 2 aquifer and the $Soil_{GW2}$ shall be identified as the $Soil_{GW}$ RS. A DAF2 (not a DAF3) shall be applied to the $Soil_{GW2}$. If the $Soil_{GW2}$ (after applying the DAF2) for a COC is less than the $Soil_{GW1}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 1 aquifer and the $Soil_{GW1}$ shall be identified as the $Soil_{GW}$ RS. A DAF shall not be applied to the $Soil_{GW1}$.

Note: If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF2 or DF3 (refer to Section H1.1.2.1).

Note: In lieu of applying a $Soil_{GW}$ RS at the AOI, the soil to groundwater pathway may be evaluated using a leach test (refer to Section H1.1.3.2 and Section H2.1.4.3, $Soil_{GW}$ Method 3).

(4) Calculate a site-specific $Soil_{sat}$ (if applicable for the COC) using EQ38;

(5) Identify and apply the limiting RS to as follows:

For a non-permanent enclosed structure:

Surface soil (ground surface to 15 ft bgs):

(a) Compare: (1) the $Soil_{ni}$ or $Soil_{i}$ calculated in Step (1), (2) the $Soil_{es}$ calculated in Step (2), (3) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (3), and (4) the $Soil_{sat}$ identified in Step (4); select the lowest of the four values as the limiting RS;

(b) Determine the AOIC for surface soil in accordance with Section 2.8; and

(c) Compare the AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COCs, then typically, no further evaluation is warranted for surface soil.

If the AOIC is greater than the limiting RS, then the surface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into 2 intervals: (1) ground surface to 3 ft bgs and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

Subsurface soil (> 15 ft bgs):

(a) Compare: (1) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (3) and (2) the $Soil_{sat}$ calculated in Step (4); select the lower of the two values as the limiting soil RS;

(b) Determine the AOIC for subsurface soil in accordance with Section 2.8;

(c) Compare the AOIC with the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the subsurface soil is warranted.

If the AOIC is greater than the limiting RS, then the subsurface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

For a permanent enclosed structure:

Surface soil (ground surface to 15 ft bgs):

(a) Compare: (1) the $Soil_{es}$ calculated in Step (2), (2) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (3), and (3) the $Soil_{sat}$ identified in Step (4); select the lowest of the three values as the limiting RS;

(b) Determine the AOIC for surface soil in accordance with Section 2.8; and

(c) Compare the AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COCs, then typically, no further evaluation is warranted for surface soil.

If the AOIC is greater than the limiting RS, then the surface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into 2 intervals: (1) ground surface to 3 ft bgs and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

Subsurface soil (> 15 ft bgs):

(a) Compare: (1) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (3) and (2) the $Soil_{sat}$ calculated in Step (4); select the lower of the two values as the limiting soil RS;

(b) Determine the AOIC for subsurface soil in accordance with Section 2.8;

(c) Compare the AOIC with the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the subsurface soil is warranted.

If the AOIC is greater than the limiting RS, then the subsurface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

If the volatile emissions from soil to an enclosed structure pathway is a concern for only a portion of the AOI:

(1) Determine the appropriate land use scenario (industrial or non-industrial) for current and future land use at the AOI in accordance with the guidelines presented in Section 2.9. Calculate the risk-based soil RECAP Standard for the direct exposure pathways ($Soil_{ni}$ for a non-industrial scenario or $Soil_i$ for an industrial scenario) using EQ1-EQ4 or EQ16-EQ19. If more than one COC identified for the soil to an enclosed structure pathway elicits noncarcinogenic effects on the same target organ/system, modify the $Soil_{ni}$ or $Soil_i$ to account for additivity according to the guidelines presented in Appendix G;

(2) Calculate a site-specific soil concentration protective of groundwater standard ($Soil_{GW1,}$ $Soil_{GW2}$, $Soil_{GW3DW}$, or $Soil_{GW3NDW}$) depending on the classification of the groundwater to be protected (refer to Section 2.10 for the groundwater classifications) in accordance with Section H2.1.4.3 of this Appendix. If the $Soil_{GW3}$ (after applying the DAF3) for a COC is less than the $Soil_{GW2}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 2 aquifer and the $Soil_{GW2}$ shall be identified as the $Soil_{GW}$ RS. A DAF2 (not a DAF3) shall be applied to the $Soil_{GW2}$. If the $Soil_{GW2}$ (after applying the DAF2) for a COC is less than the $Soil_{GW1}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 1 aquifer and the $Soil_{GW1}$ shall be identified as the $Soil_{GW}$ RS. A DAF shall not be applied to the $Soil_{GW1}$ RS.

Note: If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF2 or DF3 (refer to Section H1.1.2.1).

Note: In lieu of applying a $Soil_{GW}$ RS at the AOI, the soil to groundwater pathway may be evaluated using a leach test (refer to Section H1.1.3.2 and Section H2.1.4.3, $Soil_{GW}$ Method 3);

(3) If applicable for the COC, calculate a site-specific $Soil_{sat}$ using EQ38;

(4) Identify and apply the limiting soil as follows:

Surface soil (ground surface to 15 ft bgs):

(a) Compare: (1) the $Soil_{ni}$ or $Soil_i$ calculated in Step (1), (2) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (2), and (3) the $Soil_{sat}$ calculated in Step (3); select the lowest of the three values as the limiting RS;

(b) Determine the AOIC for **all** surface soil within the boundaries of the AOI in accordance with Section 2.8; and

(c) Compare the AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation (i.e., ingestion of soil, inhalation of volatiles from soil, dermal contact with soil, soil to groundwater cross-media transfer, and protection of resource aesthetics) is warranted for surface soil.

If the AOIC is greater than the limiting RS, then the surface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into 2 intervals: (1) ground surface to 3 ft bgs and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

Subsurface soil (> 15 ft bgs):

(a) Compare: (1) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (2), and (2) the $Soil_{sat}$ calculated in Step (3); select the lower of the two values as the limiting soil RS;

(b) Determine the AOIC for all subsurface soil within the AOI in accordance with Section 2.8;

(c) Compare the AOIC with the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation (soil to groundwater cross-media transfer and protection of resource aesthetics) of the subsurface soil is warranted.

If the AOIC is greater than the limiting RS, then the subsurface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

(5) Calculate the risk-based RECAP Standard for the inhalation of volatile emissions from soil to an enclosed structure ($Soil_{es}$) for the appropriate land use scenario (non-industrial or industrial) using EQ26. If more than one constituent is present that elicits noncarcinogenic effects on the same target organ/system or both soil and groundwater are contributing volatile emissions to the enclosed structure, modify the $Soil_{es}$ (C_a) to account for additivity according to the guidelines presented in Appendix G. **Note:** In lieu of applying a $Soil_{es}$ RECAP Standard at the AOI, soil gas sampling or indoor air sampling may be conducted at the AOI (for guidance on evaluating COC concentrations in indoor air refer to Section B2.5.12 of Appendix B and Sections H1.1.3.5 and H2.3 of this Appendix).

(6) Determine the AOIC for the area of soil within the AOI that is associated with volatile emissions to the enclosed structure;

(7) Compare the AOIC for the portion of the AOI that is associated with volatile emissions to the enclosed structure to the $Soil_{es}$:

If the AOIC is less than or equal to the $Soil_{es}$, then typically, no further evaluation is warranted for this pathway.

If the AOIC is greater than the $Soil_{es}$, then the soil associated with volatile emissions to an enclosed structure shall be further evaluated under MO-3 or remediated to the MO-2 $Soil_{es}$.

H1.1.3.5 Evaluation of Soil Impacted with Volatile Constituents Located Beneath an Enclosed Structure Using Indoor Air Sampling

For a non-permanent enclosed structure:

(1) Evaluate the soil AOI in accordance with Section H1.1.3.1;

(2) Determine the indoor air concentration at the AOI in accordance with the guidelines in Appendix B;

(3) Identify the C_a in accordance with Section H2.3:

If the indoor air concentration is less than or equal to the C_a for all COCs, then typically, no further evaluation is warranted for the volatile emissions from soil to an enclosed structure pathway for surface soil.

If the indoor air concentration is greater than the C_a then the surface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting $Soil_{es}$.

For a permanent enclosed structure:

Surface soil:

(1) Determine the indoor air concentration at the AOI in accordance with the guidelines in Appendix B;

(2) Identify the C_a in accordance with Section H2.3:

If the indoor air concentration is less than or equal to the C_a for all COCs, then typically, no further evaluation is warranted for the volatile emissions from soil to an enclosed structure pathway for surface soil.

If the indoor air concentration is greater than the C_a then the surface soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting $Soil_{es}$ (EQ26).

Note: The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into two intervals: (1) ground surface to 3 ft bgs and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

Soil from ground surface to depth of impact:

(1) Compare: (1) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ and (2) the $Soil_{sat}$; select the lower of the two values as the limiting RS;

(2) Determine the AOIC for soil in accordance with Section 2.8; and

(3) Compare the AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the soil to groundwater pathway or soil aesthetics is warranted.

If the AOIC is greater than the limiting RS, then the soil shall be further evaluated under MO-3 or remediated to the MO-2 limiting RS.

If the MO-2 limiting soil RECAP Standard is below the background concentration (as approved by the Department, refer to Section 2.13), the background concentration shall be identified as the limiting soil RS.

If the MO-2 limiting soil RECAP Standard is below the Department-approved analytical quantitation limit, then the analytical quantitation limit shall be identified as the limiting soil RS. The lowest analytical quantitation limit identified for application as the MO-2 RS shall be the lowest analytical quantitation limit available by routine analysis and shall be approved by the Department. A limiting soil RS based on an analytical quantitation limit or a background concentration shall not be multiplied by a DAF.

A MO-2 $Soil_{GW}$ shall not result in an unacceptable (greater than GW_1 or GW_2) constituent concentration in deeper groundwater zones meeting the definition of Groundwater Classifications 1 or 2.

Application of MO-2 soil RS shall not result in soil that exhibits hazardous waste characteristics of ignitability, corrosivity, or reactivity as defined in the Hazardous Waste Regulations (LAC 33:V).

In identifying the MO-2 limiting RS for TPH fractions and mixtures, it should be noted that the total concentration of petroleum hydrocarbons in soil shall not exceed 10,000 mg/kg (i.e., the sum of the residual concentration for the TPH fractions and mixtures shall not exceed 10,000 mg/kg). Refer to Appendix D for further guidance on addressing petroleum hydrocarbon releases.

If the Department determines that impacted soil is a source medium only (exposure to impacted soil is not likely based on current or future land use and site-specific conditions), then it shall not be required that the risk-based standard for soil ($Soil_{ni}$ or $Soil_i$) be considered in the identification of the limiting RS.

Refer to Section 5.0 of the main document for further guidance on the implementation of MO-2.

H1.1.4 Management Option 3

The MO-3 soil RS shall include $Soil_{ni}$, $Soil_i$, $Soil_{ni}$-PEF, $Soil_i$-PEF, $Soil_{es}$, $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, $Soil_{GW3NDW,}$ and $Soil_{sat}$ (EQ1-EQ8, EQ16-EQ19, EQ21-EQ24, and EQ38) (refer to Section 2.12 for the RS definitions). Based on the conceptual site model, the Submitter shall calculate **all** applicable soil RS in accordance with Section H2.1. MO-3 soil RECAP Standards shall be developed for **all** exposure pathways, exposure scenarios, and land uses identified to be applicable at the AOI. The applicable soil RS shall be compared and the lowest RS shall be identified as the limiting soil RS. Site-specific environmental fate and transport data and site-specific exposure data may be used in the development of the MO-3 RS. If available, the chemical-specific data presented in the worksheets at the end of this Appendix shall be used in the calculation of the MO-3 RS.

Evaluation of Soil using MO-3 RECAP Standards:

(1) Determine the appropriate land use scenario (industrial or non-industrial) for current and future land use at the AOI in accordance with the guidelines presented in Section 2.9. Calculate risk-based RS to address the exposure pathways identifed for the soil in the CSM [e.g., $Soil_{ni}$ (EQ1-EQ4), $Soil_i$ (EQ16-EQ19), $Soil_{ni}$-PEF (EQ5-EQ8), $Soil_i$-PEF (EQ21-EQ24)]. Site-specific exposure parameters shall be representative of a reasonable maximum exposure scenario and are subject to approval by the Department. In the absence of site-specific data, the default values presented in Section H2.1 shall be used unless otherwise approved by the Department. If more than one COC identified for MO-3 elicits the same noncarcinogenic critical effect (or affects the same target organ/system), then the risk-based RS shall be adjusted to account for potential additive health effects associated with simultaneous exposure to multiple noncarcinogens in accordance with the guidelines in Section 2.14. If a receptor may be exposed to more than one impacted medium, then the risk-based RS shall be adjusted to account for potential additive effects associated with simultaneous exposure to more than one medium.

For the release of volatile emissions from soil to an enclosed structure pathway, a $Soil_{es}$ (EQ26) RS shall be calculated. If more than one COC identified for MO-3 elicits the same noncarcinogenic critical effect (or affects the same target organ/system), then the C_a shall be adjusted to account for potential additive health effects associated with simultaneous exposure to multiple noncarcinogens in accordance with the guidelines in Section 2.14. If volatile emissions are orginating from both soil and groundwater, then the C_a shall be adjusted to account for additivity

associated with two sources of exposure. Note: In lieu of applying a MO-3 $Soil_{es}$ RS at the AOI, soil gas sampling or indoor air sampling may be conducted (for guidance on evaluating indoor air COC concentrations refer to Section B2.5.12 of Appendix B and Section H2.3 of this Appendix).

(2) Calculate a site-specific soil concentration protective of groundwater standard ($Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, or $Soil_{GW3NDW}$) based on the classification of the groundwater to be protected (refer to Section 2.10 for the groundwater classifications). An appropriate and protective estimate of COC attenuation associated with mixing in the groundwater zone and longitudinal migration from the soil AOI to the nearest downgradient property boundary may be used in the calculation of the $Soil_{GW2}$ RS. An appropriate and protective estimate of COC attenuation associated with mixing in the groundwater zone and longitudinal migration from the soil AOI to the nearest downgradient surface water body may be used in the calculation of the $Soil_{GW3}$. Attenuation associated with mixing in the groundwater zone may be used in the calculation of the $Soil_{GW1}$ but a longitudinal dilution and attenuation factor shall not be applied to the $Soil_{GW1}$.

If the $Soil_{GW3}$ (after applying the DAF3) for a COC is less than the $Soil_{GW2}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 2 aquifer and the $Soil_{GW2}$ shall be identified as the $Soil_{GW}$ RS. A DAF2 (not a DAF3) shall be applied to the $Soil_{GW2}$. If the $Soil_{GW2}$ (after applying the DAF2) for a COC is less than the $Soil_{GW1}$, then for that COC, the aquifer to be protected shall be managed as a Groundwater 1 aquifer and the $Soil_{GW1}$ shall be identified as the $Soil_{GW}$ RS. A MO-3 $Soil_{GW}$ shall not result in an unacceptable constituent concentration (greater than GW_1 or GW_2) in deeper groundwater zones meeting the definition of Groundwater Classifications 1 or 2.

Note: In lieu of applying a MO-3 $Soil_{GW}$ RS to the soil AOI, the soil to groundwater pathway may be evaluated using a leach test.

(3) Calculate a site-specific $Soil_{sat}$ using EQ38;

(4) Identify the limiting soil MO-3 RS:

Surface soil (ground surface to 15 ft bgs):

(a) Compare: (1) the risk-based standard(s) calculated in Step (1), (2) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (2), and (3) the $Soil_{sat}$ calculated in Step (3); select the lowest of the three values as the limiting RS;

(b) Determine the AOIC for surface soil in accordance with Section 2.8; and

(c) Compare the surface soil AOIC to the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COCs, then typically, no further evaluation is warranted for surface soil.

If the AOIC is greater than the limiting RS, then the surface soil shall be remediated to the MO-3 limiting RS.

Subsurface soil (> 15 ft bgs):

(a) Compare: (1) the $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$ or $Soil_{GW3NDW}$ calculated in Step (2), and (2) the $Soil_{sat}$ calculated in Step (3); select the lower of the two values as the limiting soil RS;

(b) Determine the AOIC for subsurface soil in accordance with Section 2.8;

(c) Compare the subsurface soil AOIC with the limiting RS:

If the AOIC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the subsurface soil is warranted.

If the AOIC is greater than the limiting RS, then the subsurface soil shall be evaluated further using a leach test or remediated to the MO-3 limiting RS.

The Submitter may elect (or the Department may require based on site-specific conditions) to divide the surface soil interval into 2 intervals: (1) ground surface to 3 ft bgs; and (2) 3 ft bgs to depth of impact. An AOIC shall be determined for each interval.

If the Department determines that impacted soil is a source medium only (exposure to impacted soil is not likely based on current or future land use and site-specific conditions), then it shall not be required that the risk-based standard for direct contact with soil ($Soil_{ni}$, $Soil_i$, $Soil_{ni}$-PEF $Soil_i$-PEF) be considered in the identification of the limiting RS.

If a limiting MO-3 RS is below the analytical quantitation limit, then the analytical quantitation limit shall be identified as the limiting soil RS. The analytical quantitation limit identified for application as a RS shall be the lowest quantitation limit available by routine analysis and shall be approved by the Department prior to use. A MO-3 Soil RS based on the analytical quantitation limit shall not be multiplied by a dilution and attentuation factor.

If the limiting soil MO-3 RS is below a Department-approved (refer to Section 2.13) background concentration, the background concentration shall be shall be identified as the limiting soil RS. A MO-3 soil RS based on an approved background concentration shall not be multiplied by a dilution and attenuation factor.

In applying the MO-3 limiting RS for the TPH fractions and mixtures, it should be noted that the total concentration of petroleum hydrocarbons in soil shall not exceed 10,000 mg/kg (i.e., the sum of the residual concentrations for the TPH fractions and mixtures

shall not exceed 10,000 mg/kg). Refer to Appendix D (Page D-3) for further guidance on addressing petroleum hydrocarbon releases.

For a non-detect result, the SQL shall be compared to the limiting MO-3 RS to document that the SQL is less than or equal to the limiting RS prior to eliminating the constituent from further evaluation under the RECAP.

Application of MO-3 soil RS shall not result in soil that exhibits hazardous waste characteristics of ignitability, corrosivity or reactivity as defined in the Hazardous Waste Regulations (LAC 33:V).

Environmental fate and transport models and site-specific and/or default inputs are subject to Department approval. Models provided by, or recommended by, the Department or EPA shall be used under RECAP unless otherwise approved by the Department.

H1.2 Groundwater Standards

Screening Option Overview:

1. Identify the GW_{SS} in Table 1;

2. Compare the GW_{SS} to the CC.

Management Options 1, 2, and 3 Overview for GW_1:

1. Identify the GW_1 in Table 3; and

2. Compare the GW_1 to the CC.

Management Options 1, 2, and 3 Overview for GW_2:

1. Identify the GW_2 (if applicable, multiply by DF2 or DAF2) and $Water_{sol}$ in Table 3;

2. If the GW2 zone is present at < 15 ft bgs, identify the GW_{air};

3. If the GW2 zone is present at < 15 ft bgs and an enclosed structure is over the AOI, identify the GW_{es};

4. Select the lower of these values as limiting groundwater RS; and

5. Compare the limiting groundwater RS to the CC.

Management Options 1, 2, and 3 Overview for GW_3:

1. Identify the GW_3 (if applicable, multiply by DF3 or DAF3) and $Water_{sol}$ in Table 3;

2. If the GW3 zone is present at < 15 ft bgs and a COC is volatile, identify the GW_{air};

3. If the GW3 zone is present at < 15 ft bgs and an enclosed structure is over the AOI, identify a GW_{es};

4. Select the lower of these values as limiting groundwater RS; and

5. Compare the limiting groundwater RS to the CC.

Detailed guidance on the identification and application of the groundwater RS is presented in the following sections.

H1.2.1 Screening Option

The groundwater SS (GW_{SS}) is defined in Section 2.12. The SO GW_{SS} are presented in Table 1 of the main document. For a constituent not listed in Table 1, the Submitter shall identify/calculate a GW_{SS} as presented below. The GW_{SS} requiring calculation shall be calculated using: 1) the spreadsheet at http://www.deq.state.la.us/technology/recap/; or 2)

a spreadsheet or computer program that generates an output that is consistent with the output of the LDEQ spreadsheet. The toxicity and chemical-specific values shall be obtained using the hierarchy of references listed in Table H-3.

For a non-detect result, the SQL shall be compared to the GW_{SS} to document that the SQL is less than or equal to the GW_{SS} prior to eliminating the constituent from further evaluation under the RECAP.

Identification and Application of the Groundwater Screening Standard for **Groundwater Classifications 1, 2, and 3:**

(1) Identify the GW_{SS} in Table 1. If a COC is not listed in Table 1, the MCL (http://www.epa.gov/ost/drinking/standards/) shall be identified as the GW_{SS}. If an MCL is not available, then a risk-based GW_{SS} shall be calculated using EQ39, EQ40, EQ41, or EQ42 in Section H2.2.1;

(2) For a COC not listed in Table 1, the $Water_{sol}$ shall be identified and compared to the GW_{SS} identified/calculated in Step (1). The lower of the two values shall be identified as the GW_{SS};

(3) Determine the compliance concentration (CC) (refer to Section 2.8.3) at the POC (refer to Section 2.11); and

(4) Compare the GW_{SS} to the CC:

If the CC is less than or equal to the GW_{SS}, then typically, no further evaluation of the groundwater shall be required.

If the CC for a COC exceeds the GW_{SS}, then the groundwater shall be evaluated under a Management Option or remediated to the GW_{SS}.

If the limiting GW_{SS} calculated by the Submitter is less than a Department-approved background concentration (Section 2.13) or analytical quantitation limit, then the Department-approved background concentration or analytical quantitation limit, respectively, shall be identified as the GW_{SS}. The analytical quantitation limit identified for application as the GW_{SS} shall be the lowest quantitation limit available by routine analysis and shall be approved by the Department prior to use.

For the generation of Table 1, the risk-based GW_{SS} was compared to the $Water_{sol}$ and the lower of the two values was entered in Table 1 as the GW_{SS}. The equations, input values, and worksheets used to calculate the GW_{SS} are presented later in this Appendix. The RfD, SF, and chemical-specific values used to calculate the GW_{SS} are presented in Tables H-1 and H-2. If the limiting GW_{SS} was less than the analytical quantitation limit (refer to Table H-4), then the analytical quantitation limit was presented as the SS in Table 1.

The procedures used in the development of the groundwater screening standard are illustrated in Figure 12 of the main document. Refer to Section 3.0 of the main document for further guidance on the screening process.

H1.2.2 Management Option 1

The MO-1 groundwater RS include GW_1, GW_2, GW_{3DW}, GW_{3NDW}, GW_{air}, and GW_{es}, and $Water_{sol}$ (refer to Section 2.12). The MO-1 groundwater RECAP Standards are presented in Table 3 of the main document. For constituents not included in Table 3, the Submitter shall identify/calculate a GW_1, GW_2, GW_{3DW}, GW_{3NDW}, GW_{air}, or GW_{es} in accordance with Sections H2.2.2, H2.2.3, H2.2.4, H2.2.5, and H2.2.6, respectively. The MO-1 groundwater RS requiring calculation shall be calculated using: 1) the spreadsheet at http://www.deq.state.la.us/technology/recap/; or 2) a spreadsheet or computer program that generates an output that is consistent with the output of the LDEQ spreadsheet. The toxicity and chemical-specific values shall be obtained from the hierarchy of references listed in Table H-3. A MO-1 groundwater RS shall be developed for the exposure pathways, exposure scenarios, and land uses defined in Section 2.12. Site-specific data (with the exception of S_d and distance for the identification of the DF2 or DF3) shall not be used in the development of a MO-1 groundwater RS. Refer to Section 2.10 for guidance on determining the groundwater classification for the groundwater zone to be protected/restored. For a non-detect result, the SQL shall be compared to the limiting MO-1 RS to document that the SQL is less than or equal to the limiting RS prior to eliminating the constituent from further evaluation under the RECAP. If the release of volatile emissions from groundwater (< 15 ft bgs) to an enclosed structure is a pathway of concern at the AOI, include the GW_{es} from Table 3 in the identification of the limiting groundwater RS. For detailed guidance on the application of the GW_{es} RS refer to Section H1.2.3.4. Note: Indoor air sampling shall **not** be used under MO-1 for the evaluation of the volatile emissions from groundwater to an enclosed structure pathway.

H1.2.2.1 MO-1 Evaluation of a Groundwater Classification 1 Aquifer

(1) Identify the GW_1 in Table 3. If a COC is not listed in Table 3, the MCL (http://www.epa.gov/ost/drinking/standards/) shall be identified as the GW_1. If an MCL is not available, then a risk-based GW_1 shall be calculated using EQ39, EQ40, EQ41, or EQ42. If exposure to impacted groundwater is occurring (e.g., the groundwater is currently being used as a drinking water source) and more than one COC identified for MO-1 elicits effects on the same target organ/system, modify the GW_1 to account for additivity according to the guidelines presented in Appendix G;

(2) Identify the $Water_{sol}$ in Table 3. If the COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(3) If the GW_1 zone is present at < 15 ft bgs, identify the GW_{air} in Table 3. If a COC is not listed in Table 3, calculate a GW_{air} for the appropriate land use scenario (non-industrial or industrial) using EQ55. If more than one COC identified for the groundwater to ambient air pathway elicits noncarcinogenic critical effect or affects

the same target organ/system, modify the GW_{air} to account for additivity according to the guidelines presented in Appendix G;

(4) Compare: (1) the GW_1 value obtained in Step (1); (2) the $Water_{sol}$ indentified in Step (2); and (3) the GW_{air} identified in Step (3); select the loweest of the three values as the limiting RS;

(5) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(6) Compare the CC to the limiting RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the limiting RS, then groundwater shall be further evaluated under MO-2 or MO-3 or remediated to the MO-1 limiting groundwater RS.

H1.2.2.2 MO-1 Evaluation of a Groundwater Classification 2 Aquifer

(1) Identify the GW_2 in Table 3. If a COC is not listed in Table 3, the MCL (http://www.epa.gov/ost/drinking/standards/) shall be identified as the GW_2. If an MCL is not available, then a risk-based GW_2 shall be calculated using EQ39, EQ40, EQ41, or EQ42. If exposure to impacted groundwater is occurring and more than one noncarcinogenic COC identified for MO-1 elicits effects on the same target organ/system, modify the GW_2 to account for additivity according to the guidelines presented in Appendix G;

(2) If the GW_2 in Table 3 is footnoted with DF2, identify the longitudinal dilution factor (DF2) to be applied to the GW_2 from the table below based on: (1) the shortest distance between the POC and the nearest downgradient property boundary (POE); and (2) the thickness of the groundwater source (S_d). (The S_d is defined as the thickness of the impacted groundwater within the permeable zone; refer to EQ66 and Figure H-1.) If the S_d is greater than 20 feet then a site-specific DAF shall be developed under MO-2 or MO-3. If the distance from the source is greater than 2000 feet, then: (1) the DF2 for 2000 feet shall be used under MO-1; or (2) a site-specific DAF2 shall be calculated under MO-2 or MO-3. **Note:** If there is the potential for constituent migration to be influenced by pumping activities within the zone, then the DF2 values presented below are not valid and shall not be used. The Submitter may develop a site-specific DAF2 under MO-3.

Distance from POC to POE (feet)	MO-1 Longitudinal DF2 (dimensionless)			
	$S_d \leq 5$ ft	S_d = 6-10 ft	S_d = 11-15 ft	S_d = 16-20 ft
0 - 50	1.5	1	1	1
51 - 100	2.6	1.5	1.2	1.1
101 - 150	4.1	2.1	1.6	1.3
151 - 250	8.4	4.3	3	2.3
251 - 500	29	15	9.8	7.4
501 - 750	63	32	21	16
751 - 1000	111	57	37	28
1001 - 1250	173	86	58	43
1251 - 1500	248	124	83	62
1501 - 1750	337	169	113	84
1751 - 2000	440	220	147	110

(3) Multiply the GW_2 identified in Step (1) by the DF2 identified in Step (2). Note: If the GW_2 in Table 3 is not footnoted with a DF2, do not multiply by a DF2. If the GW_2 is to be applied at the POE (i.e., exposure to a COC in groundwater is occurring at the POE) do not multiply by a DF2. If the GW_2 (after applying the DF2) for a COC is less than the GW_1, then for that COC, the aquifer to be protected shall be managed as a Groundwater 1 aquifer and the GW_1 shall be identified as the GW RS. The GW_1 RS shall not be multiplied by a DF;

(4) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3.

(5) If the GW2 zone is present at < 15 ft bgs, identify the GW_{air} in Table 3. If a COC is not listed in Table 3, calculate a GW_{air} using EQ55;

(6) Compare: (1) the product of GW_2 x DF2 obtained in Step (3); (2) GW_{air} identified in Step (5); and (3) the $Water_{sol}$ identified in Step (4); select the lowest of these values as the limiting groundwater RS.

(7) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(8) Compare the CC to the limiting RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the limiting RS, then groundwater shall be further evaluated under MO-2 or MO-3 or remediated to the MO-1 limiting groundwater RS.

NOTE: If a **POE is present** within the AOI for a Groundwater Classification 2 aquifer, compare the limiting RS (Note: A DF shall **not** be applied to a RS applied at the POE) to the COC concentration detected at the POE **and** compare the limiting RS

(Note: A DF may be applied to a RS applied at the POC) to the concentration at the POC:

If the concentrations at the POE **and** the POC are less than or equal to the respective limiting groundwater RS, then typically, no further evaluation of the groundwater shall be required.

If the concentration at the POE is greater than the limiting groundwater RS, then the Submitter shall remediate to the limiting groundwater RS.

If the concentration at the POC is greater than the limiting groundwater RS, then the Submitter shall remediate to the limiting groundwater RS.

H1.2.2.3 MO-1 Evaluation of a Groundwater Classification 3 Aquifer

(1) Identify the nearest surface water body downgradient of the AOI and determine if the surface water body (segment or subsegment) is classified as a drinking water supply or a non-drinking water supply (refer to LAC 33:IX.Chapter 11) (http://www.deq.state.la.us/planning/regs/title33/33v09.pdf);

(2) Identify the GW_3 in Table 3 based on the use classification of the surface water body (segment or subsegment) (GW_{3NDW} for a surface water body classified as a non-drinking water supply or the GW_{3DW} for a surface water body classified as a drinking water supply). If COC is not listed in Table 3, then the appropriate human health protection criterion shall be identified in Table 1 of LAC 33:IX.1113 (http://www.deq.state.la.us/planning/regs/title33/33v09.pdf). If a COC is not listed in Table 1 of LAC 33:IX.1113, then a criterion shall be calculated in accordance with Section H2.2.4.

(3) If the GW_{3DW} or GW_{3NDW} in Table 3 is footnoted with a DF3, identify the longitudinal dilution factor (DF3) to be applied to the GW_{3NDW} or the GW_{3DW} in the table below based on: (1) the shortest distance between the POC and the nearest downgradient surface water body (POE); and (2) the thickness of the groundwater source (S_d). (The S_d is defined as the thickness of the impacted groundwater within the permeable zone. Refer to EQ66 and Figure H-1.) If the S_d is greater than 20 feet then a site-specific DAF3 shall be calculated under MO-2 or MO-3. If the distance from the source is greater than 2000 feet, then: (1) the DF3 for 2000 feet shall be used under MO-1; or (2) a site-specific DAF3 shall be calculated under MO-2 or MO-3. **Note:** If there is the potential for constituent migration to be influenced by pumping activities within the zone, then the DF3 values presented below are not valid and shall not be used. The Submitter may develop a site-specific DAF3 under MO-3;

Distance from POC to POE (feet)	MO-1 Longitudinal DF3 (dimensionless)			
	$S_d \leq 5$ ft	S_d = 6-10 ft	S_d = 11-15 ft	S_d = 16-20 ft
0 - 50	1.5	1	1	1
51 - 100	2.6	1.5	1.2	1.1
101 - 150	4.1	2.1	1.6	1.3
151 - 250	8.4	4.3	3	2.3
251 - 500	29	15	9.8	7.4
501 - 750	63	32	21	16
751 - 1000	111	57	37	28
1001 - 1250	173	86	58	43
1251 - 1500	248	124	83	62
1501 - 1750	337	169	113	84
1751 - 2000	440	220	147	110

(4) Multiply the GW_{3NDW} or GW_{3DW} identified in Step (2) by the DF3 identified in Step (3). If the GW_{3DW} or GW_{3NDW} in Table 3 is not footnoted with a DF3, do not multiply the GW_{3DW} or GW_{3NDW} by a DF3. If the GW_3 (after applying the DF3) for a COC is less than the GW_2, then for that COC, the aquifer to be protected shall be managed as an aquifer meeting the definition of Groundwater Classification 2 and the GW_2 shall be identified as the GW RS. Note: A DF2 (not a DF3) shall be applied to the GW_2 if the GW_2 value is footnoted with a DF2 in Table 3. If the GW_2 (after applying the DF2) for a COC is less than the GW_1, then for that COC, the aquifer shall be managed as Groundwater 1 aquifer and the GW_1 shall be identified as the GW RS. Note: A DF shall not be applied to the GW_1 RS;

(5) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(6) If the GW3 zone is present at < 15 ft bgs, identify the GW_{air} in Table 3. If a COC is not listed in Table 3, calculate a GW_{air} using EQ55;

(7) Compare: (1) the product of GW_3 x DF3 obtained in Step (4); (2) the $Water_{sol}$ identified in Step (5); and (3) the GW_{air} identified in Step (6); select the lowest of these values as the limiting groundwater RS;

(8) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(9) Compare the CC to the limiting RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the limiting RS, then the groundwater shall be further evaluated under MO-2 or MO-3 or remediated to the MO-1 limiting groundwater RS.

A limiting MO-1 groundwater RS shall not result in an unacceptable constituent concentration in deeper groundwater zones meeting the definition of Groundwater Classifications 1 or 2. If there is concern that a limiting MO-1 GW_3 may result in unacceptable constituent concentrations in a deeper Groundwater 1 or 2 Zone, the potential for constituent migration from the Groundwater 3 Zone to a Groundwater 1 or 2 Zone shall be addressed under MO-3. Criteria for this determination shall include constituent mobility, constituent concentration, vertical distance from Groundwater 3 Zone to a Groundwater 1 or 2 Zone, and probability of public/domestic well installation at or in the vicinity of the AOI.

If there is potential for exposure to constituents present in, or released from, groundwater via pathways not considered in the development of GW_1, GW_2, GW_3, GW_{air}, or GW_{es} then these pathways shall be addressed under MO-3.

If a MO-1 GW_1, GW_2 (after applying the DF2), GW_3 (after applying the DF3), GW_{es}, or GW_{air} developed by a Submitter is below the analytical quantitation limit, then the analytical quantitation limit may be used as the limiting groundwater RS if determined to be appropriate by the Department. The analytical quantitation limit identified for application as the MO-1 GW RS shall be the lowest quantitation limit available by routine analysis and shall be approved by the Department prior to use. A MO-1 GW RS based on the analytical quantitation limit shall not be multiplied by a DF.

If the limiting MO-1 GW_1, GW_2 (after applying the DF2), or GW_3 (after applying the DF3), is less than the Department-approved (refer to Section 2.13) background concentration, then the background concentration shall be identified as the GW_3 RS. A MO-1 GW RS based on an approved background concentration shall not be multiplied by a DF.

In identifying and applying the MO-1 limiting RS, it should be noted that the total concentration of petroleum hydrocarbons in groundwater shall not exceed 10,000 mg/l. Refer to Appendix D for further guidance on addressing petroleum hydrocarbon releases.

The procedures to be used in the development of the groundwater RECAP Standards are presented in Figures 12, 14, and 15 of the main document.

Refer to Section 4.0 for further guidance on the implementation of MO-1.

For the generation of Table 3, the analytical quantitation limit was reported as the RS if the GW_1, GW_2, or GW_3 developed under MO-1 was below the analytical quantitation limit. The toxicity and chemical-specific values used to calculate the MO-1 groundwater RS are presented in Tables H-1 and H-2. The hierarchies of references used to obtain the toxicity and chemical-specific parameters are presented in Table H-3. The SQL values used in Table 3 are presented in Table H-4. The worksheets for the development of the MO-1 RS are presented at the end of this Appendix.

A limiting groundwater RECAP Standard shall not result in unacceptable exposure levels to construction workers or other receptors exposed to constituents present in, or released from, groundwater. If there is concern that unacceptable exposure to constituents present

in, or released from groundwater may occur, then the pathway(s) of concern shall be evaluated under the appropriate Option.

The GW_2 and GW_3 RS standards do not authorize the migration of COC offsite to adjacent property but rather serves to evaluate the acceptability of constituent concentrations in the environment over time.

A GW_2 or GW_3 standard shall not result in a constituent concentration in groundwater that poses unacceptable health risk for other pathways of exposure. Based on site-specific conditions, the identification of more than one POC may be warranted. If the POE for one exposure pathway lies between the POC and POE for another exposure pathway, then the RS for both pathways shall be evaluated and if warranted, the RS and/or DF shall be adjusted such that exposure levels are acceptable at the points of exposure for both pathways (e.g., if the POE for the inhalation of volatile emissions released from groundwater to the ambient air or the inhalation of volatile emissions released from groundwater to an enclosed structure lies between the POC and the POE for a GW3 zone, then the GW_3, DF3, GW_{es}, and GW_{air} RS shall be evaluated, and if warranted, adjusted so that the COC concentrations potentially reaching all identified POE are acceptable).

H1.2.3 Management Option 2

The MO-2 groundwater RS include GW_1, GW_2, GW_{3DW}, GW_{3NDW}, $Water_{sol}$, GW_{es}, and GW_{air} (refer to Section 2.12). The GW_1, GW_2, GW_{3DW}, GW_{3NDW}, and $Water_{sol}$ shall be obtained from Table 3. For constituents not included in Table 3, the Submitter shall identify/calculate a GW_1, GW_2, GW_{3DW} or GW_{3NDW} in accordance with Sections H2.2.2, H2.2.3, H2.2.4, H2.2.5, and H2.2.6, respectively. The MO-2 groundwater RS requiring calculation shall be calculated using: 1) the spreadsheet at http://www.deq.state.la.us/technology/recap/; or 2) a spreadsheet or computer program that generates an output that is consistent with the output of the LDEQ spreadsheet. The toxicity and chemical-specific values shall be obtained form the hierarchy of references listed in Table H-3. A MO-2 groundwater RS shall only be developed for the exposure pathways, exposure scenarios, and land uses defined in Section 2.12. Refer to Section 2.10 for guidance on determining the groundwater classification for the groundwater zone to be protected/restored.

For a non-detect result, the SQL shall be compared to the MO-2 limiting RS to document that the SQL is less than or equal to the limiting RS prior to eliminating the COC from further evaluation of the RECAP.

H1.2.3.1 MO-2 Evaluation of a Groundwater Classification 1 Aquifer

(1) Identify the GW_1 in Table 3. If a COC is not listed in Table 3, identify the MCL (http://www.epa.gov/ost/drinking/standards/) as the GW_1. If an MCL is not available, a risk-based GW_1 shall be calculated using EQ39, EQ40, EQ41, or EQ42. If exposure to impacted groundwater is occurring (e.g., the groundwater is currently being used as a drinking water source) and more than one noncarcinogenic COC

identified for MO-2 elicits effects on the same target organ/system, the GW_1 shall be modified to account for additivity according to the guidelines presented in Appendix G;

(2) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(3) If the GW_1 zone is present at < 15 ft bgs, calculate a GW_{air} for the appropriate land use scenario (non-industrial or industrial) using EQ55. If more than one COC identified for the groundwater to ambient air pathway elicits the same noncarcinogenic critical effect or affects the same target organ/system, modify the GW_{air} to account for additivity according to the guidelines presented in Appendix G;

(4) Compare: (1) the GW_1 identified/calculated in Step (1); (2) the $Water_{sol}$ identified in Step (2); and (3) the GW_{air} identified in Step (3); select the loweest of the three values as the limiting groundwater RS;

(5) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(6) Compare the CC to the limiting RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the limiting RS, then groundwater shall be further evaluated under MO-3 or remediated to the MO-2 limiting groundwater RS.

H1.2.3.2 MO-2 Evaluation of a Groundwater Classification 2 Aquifer

(1) Identify the GW_2 in Table 3. For a constituent not listed in Table 3, the MCL (http://www.epa.gov/ost/drinking/standards/) shall be identified as the GW_2. If an MCL is not available, a risk-based GW_2 shall be calculated using EQ39, EQ40, EQ41, or EQ42. If exposure to impacted groundwater is occurring and more than one noncarcinogenic COC identified for MO-2 elicits effects on the same target organ/system, the GW_2 shall be modified to account for additivity according to the guidelines presented in Appendix G;

(2) Calculate a site-specific DAF2 based on (1) the shortest distance between the POC and the nearest downgradient property boundary (POE); and (2) the thickness of the groundwater source (S_d) using EQ66 (refer to Section H2.5). If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF2 (refer to Section H1.1.2.1);

(3) Determine the product of GW_2 x DAF2 [If the limiting GW_2 (after applying the longitudinal DAF2) for a COC is less than the GW_1, then for that COC, the aquifer shall be managed as a Groundwater 1 aquifer and the GW_1 shall be identified as the

limiting GW RS. A DAF shall not be applied to the GW_1 prior to application at the AOI.];

(4) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(5) If the GW2 zone is present at < 15 ft bgs, calculate a GW_{air} for the appropriate land use scenario (non-industrial or industrial) using EQ55. If more than one COC identified for the groundwater to ambient air pathway elicits noncarcinogenic effects on the same target organ/system, modify the GW_{air} to account for additivity according to the guidelines presented in Appendix G;

(6) Compare: (1) the product of GW_2 x DAF2 calculated in Step (3); (2) the $Water_{sol}$ identified in Step (4); and (3) if applicable, the GW_{air} identified in Step (5); select the lowest of these values as the limiting groundwater RS;

(7) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(8) Compare the CC to the limiting RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the limiting RS, then groundwater shall be further evaluated under MO-3 or remediated to the MO-2 limiting groundwater RS.

A limiting MO-2 groundwater RS shall not result in an unacceptable constituent concentration in deeper groundwater zones. If there is concern that a limiting MO-2 GW_2 may result in unacceptable constituent concentrations in a deeper zone, the potential for constituent migration from the Groundwater 2 zone shall be addressed under MO-3. Criteria for this determination shall include constituent mobility, constituent concentration, vertical distance from Groundwater 2 zone to the next zone of concern, and probability of public/domestic well installation at or in the vicinity of the AOI.

If a **POE is present** within the AOI for a Groundwater Classification 2 aquifer, compare the limiting RS (Note: A DAF shall **not** be applied to a RS applied at the POE) to the COC concentration at the POE **and** compare the limiting RS (Note: A DAF may be applied to a RS applied at the POC) to the COC concentration at the POC:

If the COC concentrations at the POE **and** the POC are less than or equal to the respective limiting groundwater RS, then typically, no further evaluation shall be required.

If the COC concentration at the POE is greater than the limiting groundwater RS, then the Submitter shall remediate to the limiting groundwater RS.

If the COC concentration at the POC is greater than the limiting groundwater RS, then the Submitter shall remediate to the limiting groundwater RS.

H1.2.3.3 MO-2 Evaluation of a Groundwater Classification 3 Aquifer

(1) Identify the nearest downgradient surface water body and determine if the surface water body (segment or subsegment) to be protected is classified as a drinking water or a non-drinking water supply (refer to LAC 33:IX.Chapter 11) (http://www.deq.state.la.us/planning/regs/ title33/33v09.pdf);

(2) Identify the appropriate human health protection criterion in Table 3. If COC is not listed in Table 3, then the appropriate human health protection criterion shall be identfied in Table 1 of LAC 33:IX.1113 (http://www.deq.state.la.us/planning/regs/title33/33v09.pdf). If a COC is not listed in Table 1 of LAC 33:IX.1113, then a criterion shall be calculated in accordance with Section H2.2.4;

(3) Calculate a site-specific DAF3 based on (1) the shortest distance between the POC and the nearest downgradient surface water body (POE); and (2) the thickness of the groundwater source (S_d) using EQ66 (refer to Section H2.5). If the area of impacted soil is less than or equal to 0.5 acre, the S_d is less than or equal to 20 ft, and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF3 (refer to Section H1.1.2.1);

(4) Determine the product of GW_3 x DAF3 [If the limiting GW_3 (after applying the longitudinal DAF3) for a COC is less than the GW_2, then for that COC, the aquifer shall be managed as a Groundwater 2 aquifer and the GW_2 shall be identified as the limiting GW RS. Note: A DAF2 (not a DAF3) shall be applied to the GW_2. If the limiting GW_2 (after applying the longitudinal DAF2) is less than the GW_1, then the aquifer shall be managed as a Groundwater 1 aquifer and the GW_1 shall be identified as the limiting groundwater RS.];

(5) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(6) If the GW3 zone is present at < 15 ft bgs, calculate a GW_{air} for the appropriate land use scenario (non-industrial or industrial) using EQ55. If more than one COC identified for the groundwater to ambient air pathway elicits noncarcinogenic effects on the same target organ/system, modify the GW_{air} to account for additivity according to the guidelines presented in Appendix G;

(7) Compare: (1) the product of GW_3 x DAF3 calculated in Step (4); (2) the $Water_{sol}$ identified in Step (5); if applicable, the GW_{air} identified in Step (6); select the lowest of these values as the limiting groundwater RS;

(8) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(9) Compare the CC to the limiting RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the limiting RS, then groundwater shall be further evaluated under MO-3 or remediated to the MO-2 limiting groundwater RS.

A limiting MO-2 groundwater RS shall not result in an unacceptable constituent concentration in deeper groundwater zones. If there is concern that a limiting MO-2 GW_3 may result in unacceptable constituent concentrations in a deeper zone, the potential for constituent migration from the Groundwater 3 zone shall be addressed under MO-3. Criteria for this determination shall include constituent mobility, constituent concentration, vertical distance from Groundwater 3 zone to the next zone of concern.

H1.2.3.4 MO-2 Evaluation of Groundwater 1, 2, or 3 Impacted with a Volatile Constituent Located Beneath an Enclosed Structure (GW_{es})

If the volatile emissions from groundwater (< 15 ft bgs) to an enclosed structure pathway is a concern throughout the groundwater AOI:

(1) Calculate a GW_{es} for the appropriate land use scenario (non-industrial or industrial) using EQ50. If more than one COC identified for the soil to enclosed structure pathway elicits noncarcinogenic effects on the same target organ/system or both soil and groundwater are contributing volatile emissions to the enclosed structure, modify the GW_{es} to account for additivity according to the guidelines presented in Appendix G.

Note: In lieu of applying a GW_{es} RECAP Standard at the AOI, soil gas sampling or indoor air sampling may be conducted (for further guidance on the evaluation of COC concentrations in indoor air refer to Section B2.5.15 of Appendix B and Sections H1.2.3.5 and H2.3 of this Appendix);

(2) Determine the GW_1, GW_2, or GW_3 in accordance with Section H1.2.3.1, H1.2.3.2, or H1.2.3.3, respectively;

(3) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(4) Compare: (1) the GW_{es} value calculated in Step (1); (2) the GW_1, GW_2, or GW_3 identified in Step (2); and (3) the $Water_{sol}$ identified in Step (3); select the lowest of these values as the limiting groundwater RS;

(5) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(6) Compare the CC to the limiting groundwater RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the limiting RS, then groundwater shall be further evaluated under MO-3 or remediated to the MO-2 limiting groundwater RS.

If the volatile emissions from groundwater (< 15 ft bgs) to an enclosed structure pathway is a concern for only a portion of the groundwater AOI:

(1) Determine the GW_1, GW_2, or GW_3 in accordance with Section H1.2.3.1, H1.2.3.2, or H1.2.3.3, respectively;

(2) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(3) Compare: (1) the GW_1, GW_2, or GW_3 identified in Step (1); and (2) the $Water_{sol}$ identified in Step (2); select the lower of the two values as the limiting groundwater RS;

(4) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(5) Compare the CC to the limiting groundwater RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted for the household use of groundwater.

If the CC is greater than the limiting RS, then groundwater shall be further evaluated under MO-3 or remediated to the MO-2 limiting groundwater RS.

(6) Calculate a GW_{es} for the appropriate land use scenario (non-industrial or industrial) using EQ50. If more than one constituent is present in groundwater that elicits noncarcinogenic effects on the same target organ/system or both soil and groundwater are contributing volatile emissions to the enclosed structure, modify the GW_{es} to account for additivity according to the guidelines presented in Appendix G.

Note: In lieu of applying a GW_{es} RECAP Standard at the AOI, soil gas sampling or indoor air sampling may be conducted (for further guidance on the evaluation of COC concentrations in indoor air refer to Section B2.5.15 of Appendix B and Sections H1.1.3.5 and H2.3 of this Appendix);

(7) Determine the CC (refer to Section 2.8.3) at the GW_{es} POC (the CC should be representative of the portion of the groundwater AOI beneath, or expected to migrate beneath, the enclosed structure);

(8) Compare the CC to the GW_{es}:

If the CC is less than or equal to the GW_{es} for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the GW_{es}, then groundwater shall be further evaluated under MO-3 or remediated to the MO-2 limiting groundwater RS.

H1.2.3.5 MO-2 Evaluation of Groundwater 1, 2, or 3 (< 15 ft bgs) Impacted with a Volatile Constituent Located Beneath an Enclosed Structure Using Indoor Air Sampling

(1) Determine the GW_1, GW_2, or GW_3 in accordance with Section H1.2.3.1, H1.2.3.2, or H1.2.3.3, respectively;

(2) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(3) Compare: (1) the GW_1, GW_2, or GW_3 identified in Step (1); and (2) the $Water_{sol}$ identified in Step (2); select the lower of the these values as the limiting groundwater RS;

(4) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(5) Compare the CC to the limiting groundwater RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted for the pathways represented by the GW_1, GW_2, or GW_3 RS.

If the CC is greater than the limiting RS, then groundwater shall be further evaluated under MO-3 or remediated to the MO-2 limiting groundwater RS.

(6) Determine the air COC concentration at the AOI in accordance with the guidelines in Appendix B;

(7) Determine the C_a in accordance with Section H2.3; compare the air COC concentration at the AOI with the C_a:

If the indoor air concentration is less than or equal to the C_a for all COCs, then typically, no further evaluation is warranted for the volatile emissions from groundwater to an enclosed structure pathway.

If the indoor air concentration is greater than the C_a, then the groundwater shall be further evaluated under MO-3 or remediated to the MO-2 limiting GW_{es}.

H1.2.3.6 MO-2 Evaluation of Groundwater 1, 2, or 3 (< 15 ft bgs) Impacted with a Volatile Constituent Releasing Vapors to Ambient Air Using Air Sampling

(1) Determine the GW_1, GW_2, or GW_3 in accordance with Section H1.2.3.1, H1.2.3.2, or H1.2.3.3, respectively;

(2) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(3) Compare: (1) the GW_1, GW_2, or GW_3 identified in Step (1); and (2) the $Water_{sol}$ identified in Step (2); select the lower of the these values as the limiting groundwater RS;

(4) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(5) Compare the CC to the limiting groundwater RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted for the pathways represented by the GW_1, GW_2, or GW_3 RS.

If the CC is greater than the limiting RS, then groundwater shall be further evaluated under MO-3 or remediated to the MO-2 limiting groundwater RS.

(6) Determine the air COC concentration at the AOI in accordance with the guidelines in Section B2.5.12 of Appendix B;

(7) Determine the C_a in accordance with Section H2.3; compare the air COC concentration at the AOI with the C_a:

If the air concentration is less than or equal to the C_a for all COC, then typically, no further evaluation is warranted for the volatile emissions from groundwater to air pathway.

If the air concentration is greater than the C_a, then the groundwater shall be further evaluated under MO-3 or remediated to the MO-2 limiting GW_{air}.

If the limiting groundwater MO-2 RS (after applying the longitudinal DAF) is less than the analytical quantitation limit, then the analytical quantitation limit shall be identified as the limiting groundwater RS. The analytical quantitation limit identified for application as the MO-2 RS shall be the lowest quantitation limit available by routine analysis and shall be approved by the Department prior to use. A DAF shall not be applied to a groundwater RS that is based on an analytical quantitation limit.

If the limiting groundwater MO-2 RS (after applying the longitudinal DAF) is less than the background concentration (as approved by the Department, refer to Section 2.13),

then the background concentration shall be identified as the limiting groundwater RS. A DAF shall not be applied to a groundwater RS that is based on a background concentration.

If there is potential for unacceptable exposure to constituents present in groundwater via pathways not considered in the development of GW_1, GW_2, GW_3, GW_{es}, or GW_{air} then these pathways shall be addressed under MO-3.

A limiting groundwater RECAP Standard shall not result in unacceptable exposure levels to construction workers or other receptors exposed to constituents present in, or released from, groundwater. If there is concern that unacceptable exposure to constituents present in, or released from groundwater may occur, then the pathway(s) of concern shall be evaluated under the appropriate Option.

A GW RS shall not result in unacceptable constituent concentrations in a deeper groundwater zone. The criteria that the Department shall use to determine if this pathway should be addressed include constituent mobility, constituent concentration, distance from the impacted zone to un-impacted zone to be protected, and probability of well installation in the area of investigation. If there is concern that a limiting GW RS may result in unacceptable constituent concentrations in a deeper groundwater zone, then the potential for constituent migration shall be addressed under MO-3.

The GW_2 and GW_3 RS standards do not authorize the migration of COC offsite to adjacent property but rather serves to evaluate the acceptability of constituent concentrations in the environment over time.

A GW_2 or GW_3 standard shall not result in a constituent concentration in groundwater that poses unacceptable health risk for other pathways of exposure. Based on site-specific conditions, the identification of more than one POC may be warranted. If the POE for one exposure pathway lies between the POC and POE for another exposure pathway, then the RS for both pathways shall be evaluated and if warranted, the RS and/or DAF shall be adjusted such that exposure levels are acceptable at the points of exposure for both pathways (e.g., if the POE for the inhalation of volatile emissions released from groundwater to the ambient air or the inhalation of volatile emissions released from groundwater to an enclosed structure lies between the POC and the POE for a GW3 zone, then the GW_3, DAF3, GW_{es}, and GW_{air} RS shall be evaluated, and if warranted, adjusted so that the COC concentrations potentially reaching all identified POE are acceptable).

H1.2.4 Management Option 3

The MO-3 groundwater RS include GW_1, GW_2, GW_{3DW}, GW_{3NDW}, $Water_{sol}$, GW_{es}, and GW_{air} (refer to Section 2.12). The GW_1, GW_2, GW_{3DW}, GW_{3NDW}, and $Water_{sol}$ shall be obtained from Table 3. For constituents not included in Table 3, the Submitter shall identify/calculate a GW_1, GW_2, GW_{3DW} or GW_{3NDW} in accordance with Sections H2.2.2, H2.2.3, and H2.2.4, respectively. The MO-3 groundwater RS requiring calculation shall be calculated using: 1) the spreadsheet at http://www.deq.state.la.us/technology/recap/; or 2) a spreadsheet or computer program that generates an output that is consistent with the

output of the LDEQ spreadsheet. The toxicity and chemical-specific values shall be obtained form the hierarchy of references listed in Table H-3. MO-3 groundwater RS shall be developed for all exposure pathways, exposure scenarios, and land uses identified in the CSM. Refer to Section 2.10 for guidance on determining the groundwater classification for the groundwater zone to be protected/restored. For a non-detect result, the SQL shall be compared to the MO-3 limiting RS to document that the SQL is less than or equal to the limiting RS prior to eliminating a constituent from the list of COC. Site-specific exposure data shall **not** be used in the development of a GW_1, GW_2, or GW_3 MO-3 RS. Site-specific exposure data may be used in the development of a GW_{es} and GW_{air} MO-3 RS. Site-specific data shall be representative of a reasonable maximum exposure scenario and are subject to Department approval. In the absence of site-specific data, standard default exposure parameters shall be used. Site-specific environmental fate and transport data may be used in the development of dilution and attenuation factors for GW_2 and GW_3, volatilization factors for GW_{es} and GW_{air}, and model input for the estimation of AOIC or exposure concentrations.

H1.2.4.1 MO-3 Evaluation of a Groundwater Classification 1 Aquifer

(1) Identify the GW_1 in Table 3. If a COC is not listed in Table 3, identify the MCL (http://www.epa.gov/ost/drinking/standards/) as the GW_1. If an MCL is not available, a risk-based GW_1 shall be calculated using EQ39, EQ40, EQ41, or EQ42. If exposure to impacted groundwater is occurring (e.g., the groundwater is currently being used as a drinking water source) and more than one noncarcinogenic COC identified for MO-3 elicits effects on the same target organ/system, the GW_1 shall be modified to account for additivity according to the guidelines presented in Section 2.14;

For the release of volatile emissions from groundwater to an enclosed structure pathway, a GW_{es} (EQ50) RS shall be calculated. If more than one COC identified for MO-3 elicits the same noncarcinogenic critical effect (or affects the same target organ/system), then the C_a shall be adjusted to account for potential additive health effects associated with simultaneous exposure to multiple noncarcinogens in accordance with the guidelines in Section 2.14. If volatile emissions are orginating from both soil and groundwater, then the C_a shall be adjusted to account for additivity associated with two sources of exposure. Note: In lieu of applying a MO-3 GW_{es} RS at the AOI, soil gas sampling or indoor air sampling may be conducted (for further guidance on the evaluation of COC concentrations in indoor air refer to Section B2.5.12 of Appendix B and Sections H1.2.3.5 and H2.3 of this Appendix). For the release of volatile emissions from groundwater to ambient air pathway, a GW_{air} (EQ55) RS shall be calculated. If more than one COC identified for MO-3 elicits the same noncarcinogenic critical effect (or affects the same target organ/system), then the C_a shall be adjusted to account for potential additive health effects associated with simultaneous exposure to multiple noncarcinogens in accordance with the guidelines in Section 2.14.

(2) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(3) Compare: (1) the GW_1; and (2) the $Water_{sol}$; select the lower of the two values as the limiting groundwater RS. If other groundwater RS (e.g., GW_{es} or GW_{air}) are applicable at the AOI, these standards shall be included in the identification of the limiting RS;

(4) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(5) Compare the CC to the limiting RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the limiting RS, then groundwater shall be remediated to the MO-3 limiting groundwater RS.

H1.2.4.2 MO-3 Evaluation of a Groundwater Classification 2 Aquifer

(1) Identify the GW_2 in Table 3. For a constituent not listed in Table 3, the MCL (http://www.epa.gov/ost/drinking/standards/) shall be identified as the GW_2. If an MCL is not available, a risk-based GW_2 shall be calculated using EQ39, EQ40, EQ41, or EQ42. If exposure to impacted groundwater is occurring and more than one noncarcinogenic COC identified for MO-3 elicits the same critical effect or has the same target organ/system, the GW_2 shall be modified to account for additivity according to the guidelines presented in Section 2.14.

For the release of volatile emissions from groundwater to an enclosed structure pathway, a GW_{es} (EQ50) RS shall be calculated. If more than one COC identified for MO-3 elicits the same noncarcinogenic critical effect (or affects the same target organ/system), then the C_a shall be adjusted to account for potential additive health effects associated with simultaneous exposure to multiple noncarcinogens in accordance with the guidelines in Section 2.14. If volatile emissions are orginating from both soil and groundwater, then the C_a shall be adjusted to account for additivity associated with two sources of exposure. Note: In lieu of applying a MO-3 GW_{es} RS at the AOI, soil gas sampling or indoor air sampling may be conducted (for further guidance on the evaluation of COC concentrations in indoor air refer to Section B2.5.12 of Appendix B and Sections H1.2.3.5 and H2.3 of this Appendix).

The GW_2 may be multiplied by a site-specific dilution and attentuation factor (DAF2) to account for: (1) dilution of the COC concentration due to mixing within the groundwater zone (refer to Section H2.4) (the default value of 20 may be used for the $DF_{Summers}$); (2) dilution and attenuation of the COC concentration associated with the longitudinal migration of the groundwater for the source area (POC) to the nearest downgradient property boundary (POE) (refer to Section H2.5); and (3) COC degradation and retardation based on site-specific, quantitative data. The DAF2 is subject to Department approval.

(2) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(3) If the GW2 zone is present at < 15 ft bgs, calculate a GW_{air} for the appropriate land use scenario (non-industrial or industrial) using EQ55. If more than one COC identified for the groundwater to ambient air pathway elicits noncarcinogenic effects on the same target organ/system, modify the GW_{air} to account for additivity according to the guidelines presented in Appendix G;

(4) Compare: (1) the product of GW_2 x DAF2; (2) the $Water_{sol}$; and (3) the GW_{air} identified in Step (3); select the lowest of these values as the limiting groundwater RS. If other groundwater RS (e.g. GW_{es}) are applicable at the AOI, these standards shall be included in the identification of the limiting RS;

(5) Determine the CC (refer to Section 2.8.3) at the POC (refer to Section 2.11);

(6) Compare the CC to the limiting RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the limiting RS, then groundwater shall be remediated to the MO-3 limiting groundwater RS.

If a **POE is present** within the AOI for a Groundwater Classification 2 aquifer, compare the limiting RS (Note: A DF shall **not** be applied to a RS applied at the POE) to the concentration at the POE **and** compare the limiting limiting RS (Note: A DF may be applied to a RS applied at the POC) to the concentration at the POC:

If the concentrations at the POE **and** the POC are less than or equal to the respective limiting groundwater RS, then typically, no further evaluation shall be required.

If the concentration at the POE is greater than the limiting groundwater RS, then the Submitter shall remediate to the limiting groundwater RS.

If the concentration at the POC is greater than the limiting groundwater RS, then the Submitter shall remediate to the limiting groundwater RS.

If the limiting GW_2 (after applying the longitudinal DAF2) for a COC is less than the GW_1, then for that COC, the aquifer shall be managed as a Groundwater 1 aquifer and the GW_1 shall be identified as the limiting GW RS. A DAF shall not be applied to the GW_1 prior to application at the AOI.

H1.2.4.3 MO-3 Evaluation of a Groundwater Classification 3 Aquifer

(1) Identify the nearest downgradient surface water body and determine if the surface water body (segment or subsegment) to be protected is classified as a drinking water (GW_{3DW}) or a non-drinking water (GW_{3NDW}) supply (refer to LAC 33:IX.Chapter 11) (http://www.deq.state.la.us/ planning/regs/ title33/33v09.pdf);

(2) Identify the appropriate human health protection criterion in Table 3. If a COC is not listed in Table 3, then the appropriate human health protection criterion shall be identfied in Table 1 of LAC 33:IX.1113 (http://www.deq.state.la.us/planning/regs/title33/33v09.pdf). If a COC is not listed in Table 1 of LAC 33:IX.1113, then a criterion shall be calculated in accordance with Section H2.2.3. If a GW_3 is not available in Table 3 or Table 1 of LAC 33:IX.1113, then a GW_3 shall be determined in accordance with Section H2.2.4.

For the release of volatile emissions from groundwater to an enclosed structure pathway, a GW_{es} (EQ50) RS shall be calculated. If more than one COC identified for MO-3 elicits the same noncarcinogenic critical effect (or affects the same target organ/system), then the C_a shall be adjusted to account for potential additive health effects associated with simultaneous exposure to multiple noncarcinogens in accordance with the guidelines in Section 2.14. If volatile emissions are orginating from both soil and groundwater, then the C_a shall be adjusted to account for additivity associated with two sources of exposure. Note: In lieu of applying a MO-3 GW_{es} RS at the AOI, soil gas sampling or indoor air sampling may be conducted (for further guidance on the evaluation of COC concentrations in indoor air refer to Section B2.5.12 of Appendix B and Sections H1.2.3.5 and H2.3 of this Appendix).

The GW_3 may be multiplied by a site-specific dilution and attentuation factor (DAF3) to account for: (1) dilution of the COC concentration due to mixing within the groundwater zone (refer to Section H2.4) (the default value of 20 may be used for the $DF_{Summers}$); (2) dilution and attenuation of the COC concentration associated with the longitudinal migration of the groundwater for the source area (POC) to the nearest downgradient surface water body (POE) (refer to Section H2.5); and (3) COC degradation and retardation based on site-specific, quantitative data. The DAF3 is subject to Department approval.

(3) Identify the $Water_{sol}$ in Table 3. If a COC is not listed in Table 3, obtain a water solubility value using the hierarchy of references listed in Table H-3;

(4) If the GW3 zone is present at < 15 ft bgs, calculate a GW_{air} for the appropriate land use scenario (non-industrial or industrial) using EQ55. If more than one COC identified for the groundwater to ambient air pathway elicits noncarcinogenic effects on the same target organ/system, modify the GW_{air} to account for additivity according to the guidelines presented in Appendix G;

(5) Compare: (1) the product of GW_3 x DAF3; (2) the $Water_{sol}$; and (3) the GW_{air} identified in Step (4); select the lowest of these values as the limiting groundwater RS. If other groundwater RS (e.g. GW_{es}) are applicable at the AOI, these standards shall be included in the identification of the limiting RS;

(6) Determine the CC (refer to Section 2.8.1) at the POC (refer to Section 2.11);

(7) Compare the CC to the limiting RS:

If the CC is less than or equal to the limiting RS for all COC, then typically, no further evaluation of the groundwater is warranted.

If the CC is greater than the limiting RS, then groundwater shall be remediated to the MO-3 limiting groundwater RS.

If the limiting GW_3 (after applying the longitudinal DAF3) for a COC is less than the GW_2 (after applying the DAF2), then for that COC, the aquifer shall be managed as a Groundwater 2 aquifer and the GW_2 shall be identified as the limiting GW RS. If the limiting GW_3 (after applying the DAF3) for a COC is less than the GW_1, then for that COC, the aquifer shall be managed as a Groundwater 1 aquifer and the GW_1 shall be identified as the limiting GW RS. A DAF shall not be applied to the GW_1 prior to application at the AOI.

A limiting MO-3 groundwater RS shall not result in unacceptable constituent concentrations in a deeper groundwater zone.

If a limiting MO-3 groundwater RS is below the analytical quantitation limit, then the analytical quantitation limit shall be identified as the limiting groundwater RS. The analytical quantitation limit identified for application as a RS shall be the lowest quantitation limit available by routine analysis and shall be approved by the Department prior to use. A MO-3 groundwater RS based on the analytical quantitation limit shall not be multiplied by a dilution and attentuation factor.

If the limiting groundwater MO-3 RS is below a Department-approved (refer to Section 2.13) background concentration, the background concentration shall be identified as the limiting groundwater RS. A MO-3 groundwater RS based on an approved background concentration shall not be multiplied by a dilution and attenuation factor.

In applying the MO-3 limiting RS for the TPH fractions and mixtures, it should be noted that the total concentration of petroleum hydrocarbons in groundwater shall not exceed 10,000 mg/l (i.e., the sum of the residual concentrations for the TPH fractions and mixtures shall not exceed 10,000 mg/l). Refer to Appendix D (Page D-3) for further guidance on addressing petroleum hydrocarbon releases.

For a non-detect result, the SQL shall be compared to the limiting MO-3 RS to document that the SQL is less than or equal to the limiting RS prior to eliminating the constituent from evaluation under the RECAP.

A limiting MO-3 groundwater RECAP Standard shall not result in unacceptable exposure levels to construction workers or other receptors exposed to constituents present in, or released from, groundwater. If there is concern that unacceptable exposure to constituents present in, or released from groundwater may occur, then the pathway(s) of concern shall be evaluated.

The MO-3 GW_2 and GW_3 RS standards do not authorize the migration of COC offsite to adjacent property but rather serves to evaluate the acceptability of constituent concentrations in the environment over time.

A MO-3 GW_2 or GW_3 standard shall not result in a constituent concentration in groundwater that poses unacceptable health risks for other pathways of exposure. Based on site-specific conditions, the identification of more than one POC may be warranted. If the POE for one exposure pathway lies between the POC and POE for another exposure pathway, then the RS for both pathways shall be evaluated and if warranted, the RS and/or DAF shall be adjusted such that exposure levels are acceptable at the points of exposure for both pathways (e.g., if the POE for the inhalation of volatile emissions released from groundwater to the ambient air or the inhalation of volatile emissions released from groundwater to an enclosed structure lies between the POC and the POE for a GW3 zone, then the GW_3, DAF3, GW_{es}, and GW_{air} RS shall be evaluated, and if warranted, adjusted so that the COC concentrations potentially reaching all identified POE are acceptable).

H2.0 EQUATIONS FOR THE DEVELOPMENT OF SCREENING STANDARDS AND RECAP STANDARDS

H2.1 Soil Standards

Screening Standards for constituents not listed in Table 1, MO-1 RS for constituents not listed in Table 2, MO-2 RS, and MO-3 RS shall be calculated using: (1) the spreadsheets provided at http://www.deq.state.la.us/technology/recap/; or (2) a spreadsheet or computer program that generates an output that is consistent with the output of the LDEQ spreadsheet. All calculations shall be included in the RECAP submittal. Where available, chemical-specific data presented in the worksheets at the end of this Appendix shall be used in the calculation of MO-2 and MO-3 RS. Refer to Section 2.15 for guidance for the identification of toxicity values.

H2.1.1 Risk-Based Standards – Non-industrial ($Soil_{SSni}$, $Soil_{ni}$, $Soil_{ni}$-PEF)

$Soil_{SSni}$ or $Soil_{ni}$ - Carcinogenic Effects - Organic Constituents (mg/kg):

$$\frac{TR \, x \, AT_c \, x \, 365 \, days/year}{EF_{ni} \, x \left[\left(SF_o \, x 10^{-6} \frac{kg}{mg} \, x \, IRS_{adj} \right) + \left(SF_i \, x \, IRA_{adj} \, x \left(\frac{1}{VF_{ni}} \right) \right) + \left(SF_o \, x 10^{-6} \frac{kg}{mg} \, x \, ABS \, x \, IRD_{adj} \right) \right]} \qquad \textbf{(EQ1)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	MO-1	MO-2	MO-3
$Soil_{SSni}$ or $Soil_{ni}$	non-industrial risk-based chemical concentration in soil (mg/kg)	--	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]	10^{-6} [a]	10^{-6} [a]	10^{-6} [b]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [c]	CS [c]	CS [c]	CS [c]
SF_i	inhalation cancer slope factor ((mg/kg-day)$^{-1}$)	CS [c]	CS [c]	CS [c]	CS [c]
AT_c	averaging time – carcinogens (yr)	70 [a]	70 [a]	70 [a]	70 [a]
EF_{ni}	exposure frequency, non-industrial (days/yr)	350 [a]	350 [a]	350 [a]	350 [a]
IRS_{adj}	age-adjusted soil ingestion rate (mg-yr/kg-day)	114 [d]	114 [d]	114 [d]	114 [d]
IRA_{adj}	age-adjusted inhalation rate (m^3-yr/kg-day)	11 [d]	11 [d]	11 [d]	11 [d]
IRD_{adj}	age-adjusted dermal contact rate (mg-yr/kg-day)	360 [d]	360 [d]	360 [d]	360 [d]
VF_{ni}	non-industrial soil-to-air volatilization factor (m^3/kg)	CS [c,e]	CS [c,e]	CS [c,e]	CS [c,e]
ABS	dermal absorption factor (unitless)	CS [c,f]	CS [c,f]	CS [c,f]	CS [c,f]

[a] *Soil Screening Guidance: User's Guide*, EPA 1996.
[b] Refer to Section 2.14.3.
[c] Chemical-specific.
[d] *Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003.
[e] Refer to EQ12.
[f] Refer to Table H-6.

$Soil_{SSni}$ or $Soil_{ni}$- Carcinogenic Effects - Inorganic Constituents (mg/kg):

$$\frac{TR \; x \; AT_c \; x \; 365 \, days / year}{EF_{ni} \; x \left[\left(SF_o \; x 10^{-6} \; \frac{kg}{mg} \; x \; IRS_{adj} \right) + \left(SF_o \; x 10^{-6} \; \frac{kg}{mg} \; x \; ABSxIRD_{adj} \right) \right]} \qquad \textbf{(EQ2)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{SSni}$ or $Soil_{ni}$	non-industrial risk-based chemical concentration in soil (mg/kg)	--	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]	10^{-6} [a]	10^{-6} [a]	10^{-6} [b]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [c]	CS [c]	CS [c]	CS [c]
AT_c	averaging time – carcinogens (yr)	70 [a]	70 [a]	70 [a]	70 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]	350 [a]	350 [a]	350 [a]
IRS_{adj}	age-adjusted soil ingestion rate (mg-yr/kg-day)	114 [d]	114 [d]	114 [d]	114 [d]
IRD_{adj}	age-adjusted dermal contact rate (mg-yr/kg-day)	360 [d]	360 [d]	360 [d]	360 [d]
ABS	dermal absorption factor (unitless)	CS [c,e]	CS [c,e]	CS [c,e]	CS [c,e]

[a] *Soil Screening Guidance: User's Guide*, EPA 1996.
[b] Refer to Section 2.14.3.
[c] Chemical-specific.
[d] *Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003.
[e] Refer to Table H-6.

$Soil_{SSni}$ or $Soil_{ni}$ - Noncarcinogenic Effects - Organic Constituents (mg/kg):

$$\frac{THQ \times BW_c \times AT_{nc} \times 365\ days/yr}{EF_{ni} \times ED_c \times \left[\left(\left(\frac{1}{RfD_o}\right) \times 10^{-6}\ \frac{kg}{mg} \times IRS_c\right) + \left(\left(\frac{1}{RfD_i}\right) \times IRA_c \times \left(\frac{1}{VF_{ni}}\right)\right) + \left(\left(\frac{1}{RfD_o}\right) \times SA_c \times AF_c \times ABS \times 10^{-6}\ \frac{kg}{mg}\right)\right]} \quad \textbf{(EQ3)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{SSni}$ or $Soil_{ni}$	non-industrial risk-based chemical concentration in soil (mg/kg)	--	--	--	--
THQ	target hazard quotient (unitless)	0.1 [a]	1 [b]	1 [b]	1 [b]
RfD_o	oral chronic reference dose (mg/kg-day)	CS [c]	CS [c]	CS [c]	CS [c]
RfD_i	inhalation chronic reference dose (mg/kg-day)	CS [c]	CS [c]	CS [c]	CS [c]
BW_c	average child body weight ages 1-6 (kg)	15 [b]	15 [b]	15 [b]	15 [b]
AT_{nc}	averaging time - noncarcinogens, child (yr)	6 [b]	6 [b]	6 [b]	6 [b]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [b]	350 [b]	350 [b]	350 [b]
ED_c	child exposure duration ages 1-6 (yr)	6 [b]	6 [b]	6 [b]	6 [b]
IRS_c	child soil ingestion rate ages 1-6 (mg/day)	200 [b]	200 [b]	200 [b]	200 [b]
IRA_c	child inhalation rate ages 1-6 (m^3/day)	10 [d]	10 [d]	10 [d]	10 [d]
VF_{ni}	non-industrial soil-to-air volatilization factor (m^3/kg)	CS [c,e]	CS [c,e]	CS [c,e]	CS [c,e]
SA_c	child skin surface area (cm^2/day)	2800 [f]	2800 [f]	2800 [f]	2800 [f]
AF_c	child soil-to-skin adherence factor (mg/cm^2)	0.2 [f]	0.2 [f]	0.2 [f]	0.2 [f]
ABS	dermal absorption factor (unitless)	CS [c,g]	CS [c,g]	CS [c,g]	CS [c,g]

[a]LDEQ default value.
[b]*Soil Screening Guidance: User's Guide*, EPA 1996.
[c]Chemical-specific.
[d]*Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.
[e]Refer to EQ12.
[f]*Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*, EPA/540/R-99/005.
[g]Refer to Table H-6.

$Soil_{SSni}$ or $Soil_{ni}$ - Noncarcinogenic Effects - Inorganic Constituents (mg/kg):

$$\frac{THQ \times BW_c \times AT_{nc} \times 365\ days/yr}{EF_{ni} \times ED_c \times \left[\left(\left(\frac{1}{RfD_o}\right) \times 10^{-6}\ \frac{kg}{mg} \times IRS_c\right) + \left(\left(\frac{1}{RfD_o}\right) \times SA_c \times AF_c \times ABS \times 10^{-6}\ \frac{kg}{mg}\right)\right]} \quad \textbf{(EQ4)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{SSni}$ or $Soil_{ni}$	non-industrial risk-based chemical concentration in soil (mg/kg)	--	--	--	--
THQ	target hazard quotient (unitless)	0.1 [a]	1 [b]	1 [b]	1 [b]
RfD_o	oral reference dose (mg/kg-day)	CS [c]	CS [c]	CS [c]	CS [c]
BW_c	average child body weight ages 1-6 (kg)	15 [b]	15 [b]	15 [b]	15 [b]
AT_{nc}	averaging time – noncarcinogens, child (yr)	6 [b]	6 [b]	6 [b]	6 [b]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [b]	350 [b]	350 [b]	350 [b]
ED_c	child exposure duration ages 1-6 (yr)	6 [b]	6 [b]	6 [b]	6 [b]
IRS_c	child soil ingestion rate ages 1-6 (mg/day)	200 [b]	200 [b]	200 [b]	200 [b]
SA_c	child skin surface area (cm^2/day)	2800 [d]	2800 [d]	2800 [d]	2800 [d]
AF_c	child soil-to-skin adherence factor (mg/cm^2)	0.2 [d]	0.2 [d]	0.2 [d]	0.2 [d]
ABS	dermal absorption factor (unitless)	CS [c,e]	CS [c,e]	CS [c,e]	CS [c,e]

[a] LDEQ default value.
[b] *Soil Screening Guidance: User's Guide*, EPA 1996.
[c] Chemical-specific.
[d] *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.
[e] Refer to Table H-6.

$Soil_{ni}$-PEF - Carcinogenic Effects - Organic Constituents (mg/kg):

$$\frac{TR\,x\,AT_c\,x\,365\,days/year}{EF_{ni}\,x\left[\left(SF_o\,x10^{-6}\,kg/mg\,x\,IRS_{adj}\right)+\left(SF_i\,x\,IRA_{adj}\,x\left(\frac{1}{VF_{ni}}+\frac{1}{PEF_{ni}}\right)\right)+\left(SF_o\,x\,10^{-6}\,\frac{kg}{mg}\,x\,ABS\,x\,IRD_{adj}\right)\right]} \quad \textbf{(EQ5)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{ni}$-PEF	non-industrial risk-based chemical concentration in soil (mg/kg)	NA [a]	NA [a]	--	--
TR	target excess individual lifetime cancer risk (unitless)	NA [a]	NA [a]	10^{-6} [b]	10^{-6} [c]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	NA [a]	NA [a]	CS [d]	CS [d]
SF_i	inhalation cancer slope factor ((mg/kg-day)$^{-1}$)	NA [a]	NA [a]	CS [d]	CS [d]
AT_c	averaging time - carcinogens (yr)	NA [a]	NA [a]	70 [b]	70 [b]
EF_{ni}	non-industrial exposure frequency (days/yr)	NA [a]	NA [a]	350 [b]	350 [b]
IRS_{adj}	age- adjusted soil ingestion rate (mg-yr/kg-day)	NA [a]	NA [a]	114 [e]	114 [e]
IRA_{adj}	age-adjusted inhalation rate (m^3-yr/kg-day)	NA [a]	NA [a]	11 [e]	11 [e]
VF_{ni}	non-industrial soil-to-air volatilization factor (m^3/kg)	NA [a]	NA [a]	CS [d,f]	CS [d,f]
PEF_{ni}	non-industrial particulate emission factor (m^3/kg)	NA [a]	NA [a]	SS [g]	SS [g]
ABS	dermal absorption factor (unitless)	NA [a]	NA [a]	CS [d,h]	CS [d,h]
IRD_{adj}	age-adjusted dermal contact rate (mg-yr/kg-day)	NA [a]	NA [a]	360 [e]	360 [e]

[a]Not Applicable to this Option.
[b]*Soil Screening Guidance: User's Guide*, EPA 1996.
[c]Refer to Seciton 2.14.3.
[d]Chemical-specific.
[e]*Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.
[f]Refer to EQ12.
[g]Site-specific; Refer to EQ14.
[h]Refer to Table H-6.

$Soil_{ni}$-PEF - Carcinogenic Effects - Inorganic Constituents (mg/kg):

$$\frac{TR \, x \, AT_C \, x \, 365 \, days / \, year}{EF_{ni} \, x \left[\left(SF_O \, x 10^{-6} kg / \, mg \, x \, IRS_{adj} \right) + \left(SF_i \, x \, IRA_{adj} \, x \left(\frac{1}{PEF_{ni}} \right) \right) + \left(SF_O \, x \, 10^{-6} \frac{kg}{mg} \, x \, ABS \, x \, IRD_{adj} \right) \right]} \qquad \textbf{(EQ6)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{ni}$-PEF	non-industrial risk-based chemical concentration in soil (mg/kg)	NA [a]	NA [a]	--	--
TR	target excess individual lifetime cancer risk (unitless)	NA [a]	NA [a]	10^{-6} [b]	10^{-6} [c]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	NA [a]	NA [a]	CS [d]	CS [d]
SF_i	inhalation cancer slope factor ((mg/kg-day)$^{-1}$)	NA [a]	NA [a]	CS [d]	CS [d]
AT_c	averaging time - carcinogens (yr)	NA [a]	NA [a]	70 [b]	70 [b]
EF_{ni}	non-industrial exposure frequency (days/yr)	NA [a]	NA [a]	350 [b]	350 [b]
IRS_{adj}	age-adjusted soil ingestion rate (mg-yr/kg-day)	NA [a]	NA [a]	114 [e]	114 [e]
IRA_{adj}	age-adjusted inhalation rate (m^3-yr/kg-day)	NA [a]	NA [a]	11 [e]	11 [e]
PEF_{ni}	non-industrial particulate emission factor (m^3/kg)	NA [a]	NA [a]	SS [f]	SS [f]
ABS	dermal absorption factor (unitless)	NA [a]	NA [a]	CS [d,g]	CS [d,g]
IRD_{adj}	age-adjusted dermal contact rate (mg-yr/kg-day)	NA [a]	NA [a]	360 [e]	360 [e]

[a]Not Applicable to this Option.
[b]*Soil Screening Guidance: User's Guide*, EPA 1996.
[c]Refer to Section 2.14.3.
[d]Chemical-specific.
[e]*Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003.
[f]Site-specific; Refer to EQ14.
[g]Refer to Table H-6.

$Soil_{ni}$-PEF - Noncarcinogenic Effects - Organic Constituents (mg/kg):

$$\frac{THQ \times BW_c \times AT_{nc} \times 365\ days/yr}{EF_{ni} \times ED_c \times \left[\left(\left(\frac{1}{RfD_o}\right) \times 10^{-6} \frac{kg}{mg} \times IRS_c\right) + \left(\left(\frac{1}{RfD_i}\right) \times IRA_c \times \left(\frac{1}{VF_{ni}} + \frac{1}{PEF_{ni}}\right)\right) + \left(\left(\frac{1}{RfD_o}\right) \times 10^{-6} \frac{kg}{mg} \times ABS \times AF_c \times SA_c\right)\right]} \quad \textbf{(EQ7)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{ni}$-PEF	non-industrial risk-based chemical concentration in soil (mg/kg)	NA [a]	NA [a]	--	--
THQ	target hazard quotient (unitless)	NA [a]	NA [a]	1	1
RfD_o	oral reference dose (mg/kg-day)	NA [a]	NA [a]	CS [b]	CS [b]
RfD_i	inhalation reference dose (mg/kg-day)	NA [a]	NA [a]	CS [b]	CS [b]
BW_c	average child body weight ages 1-6 (kg)	NA [a]	NA [a]	15 [c]	15 [c]
AT_{nc}	averaging time - noncarcinogens, child (yr)	NA [a]	NA [a]	6 [c]	6 [c]
EF_{ni}	non-industrial exposure frequency (days/yr)	NA [a]	NA [a]	350 [c]	350 [c]
ED_c	child exposure duration ages 1-6 (yr)	NA [a]	NA [a]	6 [c]	6 [c]
IRS_c	child soil ingestion rate ages 1-6 (mg/day)	NA [a]	NA [a]	200 [c]	200 [c]
IRA_c	child inhalation rate ages 1-6 (m^3/day)	NA [a]	NA [a]	10 [d]	10 [d]
VF_{ni}	non-industrial soil-to-air volatilization factor (m^3/kg)	NA [a]	NA [a]	CS [b,e]	CS [b,e]
PEF_{ni}	non-industrial particulate emission factor (m^3/kg)	NA [a]	NA [a]	SS [f]	SS [f]
ABS	dermal absorption factor (unitless)	NA [a]	NA [a]	CS [b,g]	CS [b,g]
AF_c	child soil-to-skin adherence factor (mg/cm^2)	NA [a]	NA [a]	0.2 [h]	0.2 [h]
SA_c	child skin surface area (cm^2/day)	NA [a]	NA [a]	2,800 [h]	2,800 [h]

[a]Not Applicable to this Option.
[b]Chemical-specific.
[c]*Soil Screening Guidance: User's Guide*, EPA 1996.
[d]*Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.
[e]Site-specific; refer to EQ12.
[f]Site-specific; refer to EQ14.
[g]Refer to Table H-6.
[h]*Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*, EPA/540/R-99/005.

$Soil_{ni}$-PEF - Noncarcinogenic Effects - Inorganic Constituents (mg/kg):

$$\frac{THQ \times BW_c \times AT_{nc} \times 365\ days/yr}{EF_{ni} \times ED_c \times \left[\left(\left(\frac{1}{RfD_o}\right) \times 10^{-6}\ \frac{kg}{mg} \times IRS_c\right) + \left(\left(\frac{1}{RfD_i}\right) \times IRA_c \times \left(\frac{1}{PEF_{ni}}\right)\right) + \left(\left(\frac{1}{RfD_o}\right) \times 10^{-6}\ \frac{kg}{mg} \times ABS \times AF_c \times SA_c\right)\right]} \quad \textbf{(EQ8)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	MO-1	MO-2	MO-3
$Soil_{ni}$-PEF	non-industrial risk-based chemical concentration in soil (mg/kg)	NA [a]	NA [a]	--	--
THQ	target hazard quotient (unitless)	NA [a]	NA [a]	1	1
RfD_o	oral reference dose (mg/kg-day)	NA [a]	NA [a]	CS [b]	CS [b]
RfD_i	inhalation reference dose (mg/kg-day)	NA [a]	NA [a]	CS [b]	CS [b]
BW_c	average child body weight ages 1-6 (kg)	NA [a]	NA [a]	15 [c]	15 [c]
AT_{nc}	averaging time - noncarcinogens, child (yr)	NA [a]	NA [a]	6 [c]	6 [c]
EF_{ni}	non-industrial exposure frequency (days/yr)	NA [a]	NA [a]	350 [c]	350 [c]
ED_c	child exposure duration ages 1-6 (yr)	NA [a]	NA [a]	6 [c]	6 [c]
IRS_c	child soil ingestion rate ages 1-6 (mg/day)	NA [a]	NA [a]	200 [c]	200 [c]
IRA_c	child inhalation rate ages 1-6 (m^3/day)	NA [a]	NA [a]	10 [d]	10 [d]
PEF_{ni}	non-industrial particulate emission factor (m^3/kg)	NA [a]	NA [a]	SS [e]	SS [e]
ABS	dermal absorption factor (unitless)	NA [a]	NA [a]	CS [b,f]	CS [b,f]
AF_c	child soil-to-skin adherence factor (mg/cm^2)	NA [a]	NA [a]	0.2 [g]	0.2 [g]
SA_c	child skin surface area (cm^2/day)	NA [a]	NA [a]	2,800 [g]	2,800 [g]

[a]Not Applicable to this Option.
[b]Chemical-specific.
[c]*Soil Screening Guidance: User's Guide*, EPA 1996.
[d]*Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.
[e]Site-specific; refer to EQ14.
[f]Refer to Table H-6.
[g]*Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.

EQ1 through EQ8 were obtained from *Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003. A RECAP Standard shall be determined for both carcinogenic and noncarcinogenic effects and the more protective value shall be used as the RS.

IRA_{adj} (m^3-yr/kg-d):

$$\frac{IRA_c \, xED_c}{BW_c} + \frac{IRA_a \, xED_a}{BW_a} \qquad \textbf{(EQ9)}$$

where:

Parameter	Definition (units)	Input Value
IRA_{adj}	age-adjusted inhalation rate (m^3-yr/kg-day)	11
IRA_c	child inhalation rate ages 1-6 (m^3/day)	10
IRA_a	adult inhalation rate ages 7-31 (m^3/day)	20
ED_c	child exposure duration ages 1-6 (yr)	6
ED_a	adult exposure duration ages 7-31 (yr)	24
BW_c	average child body weight ages 1-6 (kg)	15
BW_a	average adult body weight ages 7-31 (kg)	70

IRS_{adj} (mg-yr/kg-d):

$$\frac{IRS_c \; x \; ED_c}{BW_c} + \frac{IRS_a \, x \, ED_a}{BW_a} \qquad \textbf{(EQ10)}$$

where:

Parameter	Definition	Input Value
IRS_{adj}	age-adjusted soil ingestion rate (mg-yr/kg-day)	114
BW_c	average child body weight ages 1-6 (kg)	15
BW_a	average adult body weight ages 7-31 (kg)	70
ED_c	child exposure duration ages 1-6 (yr)	6
ED_a	adult exposure duration ages 7-31 (yr)	24
IRS_c	child soil ingestion rate age 1-6 (mg/day)	200
IRS_a	adult soil ingestion rate ages 7-31 (mg/day)	100

IRD_{adj} (mg-yr/kg-d):

$$\frac{ED_c \, x AF_c \, x SA_c}{BW_c} + \frac{ED_a \, x AF_a \, x SA_a}{BW_a} \qquad \textbf{(EQ11)}$$

where:

Parameter	Definition (units)	Input Value
IRD_{adj}	age-adjusted dermal contact rate (mg-yr/kg-day)	360
ED_c	child exposure duration ages 1-6 (yr)	6
AF_c	child skin-to-soil adherence factor (mg/cm^2)	0.2
SA_c	child skin surface area (cm^2/day)	2,800
BW_c	average child body weight ages 1-6 (kg)	15
AF_a	adult skin-to-soil adherence factor (mg/cm^2)	0.07
ED_a	adult exposure duration ages 7-31 (yr)	24
SA_a	adult skin surface area (cm^2/day)	5,700
BW_a	average adult body weight ages 7-31 (kg)	70

EQ9, EQ10, and EQ11 were obtained from *Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003 and *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.

VF_{ni} (m^3/kg):

$$\frac{(Q/C)x(3.14xD_AxT)^{1/2}x10^{-4}(m^2/cm^2)}{(2x\rho_bxD_A)} \quad \textbf{(EQ12)}$$

where:

$$D_A(cm^2/s) = \frac{[(\theta_a{}^{10/3}xD_ixH'+\theta_w{}^{10/3}xD_w)/n^2]}{\rho_bxK_d+\theta_w+\theta_axH'} \quad \textbf{(EQ13)}$$

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
VF_{ni}	non-industrial soil-to-air volatilization factor (m^3/kg)	--	--	--	--
D_A	apparent diffusivity (cm^2/s)	--	--	--	--
Q/C	inverse of the mean concentration at the center of source (g/m^2-s per kg/m^3)	EQ14	EQ14	SS [b]	SS [b]
T	exposure interval – carcinogens (s)	9.5E+08 [a]	9.5E+08 [a]	9.5E+08 [a]	9.5E+08 [a]
T	exposure interval – noncarcinogens (s)	1.9E+08 [a]	1.9E+08 [a]	1.9E+08 [a]	1.9E+08 [a]
ρ_b	dry soil bulk density (g/cm^3)	1.7 [c]	1.7 [c]	SS [d] (1.7)	SS [d] (1.7)
θ_a	air-filled soil porosity (L_{air}/L_{soil})	n-θ_w	n-θ_w	n-θ_w	n-θ_w
n	total soil porosity (L_{pore}/L_{soil})	1 - (ρ_b/ρ_s)	1 - (ρ_b/ρ_s)	1 - (ρ_b/ρ_s)	1 - (ρ_b/ρ_s)
θ_w	water-filled soil porosity (L_{water}/L_{soil})	0.21 [c]	0.21 [c]	SS [d] (0.21)	SS [d] (0.21)
ρ_s	soil particle density (g/cm^3)	2.65 [c]	2.65 [c]	SS [d] (2.65)	SS [d] (2.65)
D_i	diffusivity in air (cm^2/s)	CS [e]	CS [e]	CS [e]	CS [e]
H'	Henry's Law Constant (dimensionless)	CS [e,f]	CS [e,f]	CS [e,f]	CS [e,f]
D_w	diffusivity in water (cm^2/s)	CS [e]	CS [e]	CS [e]	CS [e]
K_d	soil-water partition coefficient (cm^3/g) = K_{oc} x f_{oc}	CS [e]	CS [e]	CS [e]	CS [e]
K_{oc}	soil organic carbon partition coefficient (cm^3/g)	CS [e]	CS [e]	CS [e]	CS [e]
f_{oc}	fractional organic carbon in soil (g/g) = percent organic matter/174 (ASTM 2974)	0.006 [c]	0.006 [c]	SS [g] (0.006)	SS [g] (0.006)

[a] *Soil Screening Guidance*, *User's Guide,* EPA 1996.
[b] Site-specific; refer to EQ14.
[c] LDEQ default value.
[d] Site-specific.
[e] Chemical-specific.
[f] H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^oC)].
[g] Site-specific; the sample(s) for f_{oc} determination shall be collected from an un-impacted area that is representative of the soil conditions in the impacted area.

Q/C (g/m^2-s per kg/m^3):

$$Ax\exp\left[\frac{(\ln A_c - B)^2}{C}\right] \qquad \textbf{(EQ14)}$$

where:

Parameter	Definition	Input Value
Q/C	inverse mean of constituent concentration at center of a square source (g/m^2-s per kg/m^3)	site-specific
A	constant [a]	13.6482
B	constant [a]	18.1754
C	constant [a]	206.7273
A_c	areal extent of site soil contamination (acres)	site-specific

[a]Constants for meteorological station Zone 6, Houston, Texas; *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites*, EPA March 2001.

The volatilization factor (VF) is used for defining the relationship between the concentration of constituents in soil and the volatilized constituents in air. The basic principle of the model is applicable only if the soil constituent concentration is at or below saturation. Saturation is the soil constituent concentration ($Soil_{sat}$) at which the adsorptive limits of the soil particles and the solubility limits of the available soil moisture have been reached. Above saturation, pure liquid-phase constituent may be present in the soil. It is important to recognize that free phase constituents may be present at concentrations below $Soil_{sat}$ if multiple constituents are present.

(Note: For organic constituents that are solid at ambient temperature, concentrations above $Soil_{sat}$ do not pose the potential for NAPL occurrence.) $Soil_{sat}$ concentrations represent an upper limit to the applicability of the VF model because a basic principle of the model (Henry's Law) does not apply where constituents are present in free phrase. Therefore, above saturation, the risk-based soil RS based on the VF model cannot be accurately calculated based on volatilization. Because of this limitation, the risk-based RS calculated using the VF must be compared with the $Soil_{sat}$ calculated using EQ38. If the $Soil_{ni}$ is greater than $Soil_{sat}$, then the risk-based RS is set equal to $Soil_{sat}$. $Soil_{sat}$ should be calculated using the same soil characteristics (bulk density, average water content, organic carbon content, etc.) used to calculate VF (*Soil Screening Guidance*, EPA 1996).

EQ12 and EQ13 were obtained from *Soil Screening Guidance: User's Guide*, EPA 1996. Site-specific data may be used where indicated. In the absence of site-specific data for a particular parameter, the default values presented in parentheses shall be used.

PEF_{ni} for EQ5, EQ6, EQ7, and EQ8 (m^3/kg):

$$Q/Cx\frac{3{,}600\text{sec}/hr}{0.036x(1-V)x(U_m/U_t)^3 xF(x)} \qquad \textbf{(EQ15)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
PEF_{ni}	non-industrial particulate emission factor (m^3/kg)	NA [a]	NA [a]	--	--
Q/C	inverse of mean concentration at center of source (g/m^2-s per kg/m^3)	NA [a]	NA [a]	SS [b]	SS [b]
V	fraction of vegetative cover (unitless)	NA [a]	NA [a]	SS [c] (0.5)	SS [c] (0.5)
U_m	mean annual windspeed (m/s)	NA [a]	NA [a]	SS [c] (4.69)	SS [c] (4.69)
U_t	equivalent threshold value of windspeed at 7 m, (m/s)	NA [a]	NA [a]	SS [c] (11.32)	SS [c] (11.32)
F(x)	function dependent on U_m/U_t (unitless); derived using Cowherd et. al. (1985)[d]	NA [a]	NA [a]	SS [c,d] (0.194)	SS [c,d] (0.194)

[a]Not Applicable to this Option.
[b]Site-specific, refer to EQ14.
[c]Site-specific.
[d]Cowherd, C., G. Muleski, P. Engelhart, and D. Gillette. 1985. Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination. Prepared for U.S. EPA, Office of Health and Environmental Assessment, Washington, DC. EPA/600/8-85/00. F(x) is a complex function of x, which is a ratio of the threshold windspeed and average annual windspeed:

$x = 0.886 \times [U_t/U_m]$

where:

U_t = equivalent threshold value of windspeed at 7 m, (m/s)

U_m = mean annual windspeed (m/s)

$$F(x) = \begin{cases} 1.91 & x < 0.5 \\ 2.06 - 0.33x & 0.5 < x < 0.8 \\ 2.6 - x & 0.8 < x < 1 \\ 2.9 - 1.3x & 1 < x < 2 \\ 0.18\,(8x^3 + 12x)\,e^{-x^2} & x > 2 \end{cases}$$

EQ15 was obtained from *Soil Screening Guidance: User's Guide*, EPA 1996. Site-specific data may be used where indicated. In the absence of site-specific data for a particular parameter, the default values presented in parentheses shall be used.

H2.1.2 Risk-Based Standards – Industrial ($Soil_{SSi}$, $Soil_i$, $Soil_i$-PEF)

$Soil_{SSi}$ or $Soil_i$ - Carcinogenic Effects - Organic Constituents (mg/kg):

$$\frac{TR \times BW_a \times AT_c \times 365 days/yr}{EF_i \times ED_i \times \left[\left(SF_o \times 10^{-6} \frac{kg}{mg} \times IRS_i\right) + \left(SF_i \times IRA_a \times \left(\frac{1}{VF_i}\right)\right) + \left(SF_o \times SA_i \times AF_i \times ABS \times 10^{-6} \frac{kg}{mg}\right)\right]} \quad \textbf{(EQ16)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{SSi}$ or $Soil_i$	industrial risk-based chemical concentration in soil (mg/kg)	--	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]	10^{-6} [a]	10^{-6} [a]	10^{-6} [b]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [c]	CS [c]	CS [c]	CS [c]
SF_i	inhalation cancer slope factor ((mg/kg-day)$^{-1}$)	CS [c]	CS [c]	CS [c]	CS [c]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]	70 [a]
AT_c	averaging time - carcinogens (yr)	70 [a]	70 [a]	70 [a]	70 [a]
EF_i	industrial exposure frequency (days/yr)	250 [a]	250 [a]	250 [a]	SS [d] (250)
ED_i	industrial exposure duration (yr)	25 [a]	25 [a]	25 [a]	SS [d] (25)
IRS_i	industrial soil ingestion rate (mg/day)	50 [a]	50 [a]	50 [a]	SS [d] (50)
IRA_a	adult inhalation rate (m^3/day)	20 [e]	20 [e]	20 [e]	SS [d] (20)
VF_i	industrial soil-to-air volatilization factor (m^3/kg)	CS [f]	CS [f]	CS [f]	CS [f]
SA_i	skin surface area for an industrial worker (cm^2/day)	3,300 [e]	3,300 [e]	3,300 [e]	SS [d] (3,300)
AF_i	soil-to-skin adherence factor for an industrial worker (mg/cm^2)	0.2 [e]	0.2 [e]	0.2 [e]	SS [d] (0.2)
ABS	dermal absorption factor (unitless)	CS [g]	CS [g]	CS [g]	CS [g]

[a] *Soil Screening Guidance: User's Guide*, EPA 1996.
[b] Refer to Section 2.14.3.
[c] Chemical-specific.
[d] Site-specific.
[e] *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.
[f] Chemical-specific; refer to EQ20.
[g] Chemical-specific; refer to Table H-6.

$Soil_{SSi}$ or $Soil_i$ - Carcinogenic Effects - Inorganic Constituents (mg/kg):

$$\frac{TR \times BW_a \times AT_c \times 365 days/yr}{EF_i \times ED_i \times \left[\left(SF_o \times 10^{-6}\ \frac{kg}{mg} \times IRS_i\right) + \left(SF_o \times SA_i \times AF_i \times ABS \times 10^{-6}\ \frac{kg}{mg}\right)\right]} \quad \textbf{(EQ17)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{SSi}$ or $Soil_i$	industrial risk-based chemical concentration in soil (mg/kg)	--	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]	10^{-6} [a]	10^{-6} [a]	10^{-6} [b]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [c]	CS [c]	CS [c]	CS [c]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]	70 [a]
AT_c	averaging time - carcinogens (yr)	70 [a]	70 [a]	70 [a]	70 [a]
EF_i	industrial exposure frequency (days/yr)	250 [a]	250 [a]	250 [a]	SS [d] (250)
ED_i	industrial exposure duration (yr)	25 [a]	25 [a]	25 [a]	SS [d] (25)
IRS_i	industrial soil ingestion rate (mg/day)	50 [a]	50 [a]	50 [a]	SS [d] (50)
SA_i	skin surface area for an industrial worker (cm^2/day)	3,300 [e]	3,300 [e]	3,300 [e]	SS [d] (3,300)
AF_i	soil-to-skin adherence factor for an industrial worker (mg/cm^2)	0.2 [e]	0.2 [e]	0.2 [e]	SS [d] (0.2)
ABS	dermal absorption factor (unitless)	CS [f]	CS [f]	CS [f]	CS [f]

[a] *Soil Screening Guidance: User's Guide*, EPA 1996.
[b] Refer to Section 2.14.3.
[c] Chemical-specific.
[d] Site-specific.
[e] *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.
[f] Chemical-specific; refer to Table H-6.

$Soil_{SSi}$ or $Soil_i$ - Noncarcinogenic Effects - Organic Constituents (mg/kg):

$$\frac{THQ \times BW_a \times AT_{ni} \times 365 days/yr}{ED_i \times EF_i \times \left[\left(\left(\frac{1}{RfD_o}\right) \times 10^{-6} \frac{kg}{mg} \times IRS_i\right) + \left(\left(\frac{1}{RfD_i}\right) \times IRA_a \times \left(\frac{1}{VF_i}\right)\right) + \left(\left(\frac{1}{RfD_o}\right) \times 10^{-6} \frac{kg}{mg} \times SA_i \times AF_i \times ABS\right)\right]} \quad \textbf{(EQ18)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{SSi}$ or $Soil_i$	industrial risk-based chemical concentration in soil (mg/kg)	--	--	--	--
THQ	target hazard quotient (unitless)	0.1	1 [a]	1 [a]	1 [a]
RfD_o	oral reference dose (mg/kg-day)	CS [b]	CS [b]	CS [b]	CS [b]
RfD_i	inhalation reference dose (mg/kg-day)	CS [b]	CS [b]	CS [b]	CS [b]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]	70 [a]
AT_{ni}	averaging time - noncarcinogens, industrial (yr)	25 [a]	25 [a]	25 [a]	SS [c] (25)
EF_i	industrial exposure frequency (days/yr)	250 [a]	250 [a]	250 [a]	SS [c] (250)
ED_i	industrial exposure duration (yr)	25 [a]	25 [a]	25 [a]	SS [c] (25)
IRS_i	industrial soil ingestion rate (mg/day)	50 [a]	50 [a]	50 [a]	SS [c] (50)
IRA_a	adult inhalation rate (m^3/day)	20 [d]	20 [d]	20 [d]	SS [c] (20)
VF_i	industrial soil-to-air volatilization factor (m^3/kg)	CS [e]	CS [e]	CS [e]	CS [e]
SA_i	skin surface area for an industrial worker (cm^2/day)	3,300 [d]	3,300 [d]	3,300 [d]	SS [c] (3,300)
AF_i	soil-to-skin adherence factor for an industrial worker (mg/cm^2)	0.2 [d]	0.2 [d]	0.2 [d]	SS [c] (0.2)
ABS	dermal absorption factor (unitless)	CS [f]	CS [f]	CS [f]	CS [f]

[a] *Soil Screening Guidance: User's Guide*, EPA 1996.
[b] Chemical-specific.
[c] Site-specific.
[d] *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.
[e] Chemical-specific; refer to EQ20.
[f] Chemical-specific; refer to Table H-6.

$Soil_{SSi}$ or $Soil_i$ - Noncarcinogenic Effects - Inorganic Constituents (mg/kg):

$$\frac{THQxBW_a\,xAT_{ni}\,x365days/yr}{ED_i\,xEF_i\,x\left[\left(\left(\frac{1}{RfD_o}\right)x10^{-6}\,\frac{kg}{mg}xIRS_i\right)+\left(\left(\frac{1}{RfD_o}\right)x10^{-6}\,\frac{kg}{mg}xSA_i\,xAF_i\,xABS\right)\right]} \qquad \textbf{(EQ19)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{SSi}$ or $Soil_i$	industrial risk-based chemical concentration in soil (mg/kg)	0.1	1 [a]	1 [a]	1 [a]
THQ	target hazard quotient (unitless)	CS [b]	CS [b]	CS [b]	CS [b]
RfD_o	oral reference dose (mg/kg-day)	CS [b]	CS [b]	CS [b]	CS [b]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]	70 [a]
AT_{ni}	averaging time - noncarcinogens, industrial (yr)	25 [a]	25 [a]	25 [a]	SS [c] (25)
EF_i	industrial exposure frequency (days/yr)	250 [a]	250 [a]	250 [a]	SS [c] (250)
ED_i	industrial exposure duration (yr)	25 [a]	25 [a]	25 [a]	SS [c] (25)
IRS_i	industrial soil ingestion rate (mg/day)	50 [a]	50 [a]	50 [a]	SS [c] (50)
SA_i	skin surface area for an industrial worker (cm^2/day)	3,300 [d]	3,300 [d]	3,300 [d]	SS [c] (3,300)
AF_i	soil-to-skin adherence factor for an industrial worker (mg/cm^2)	0.2 [d]	0.2 [d]	0.2 [d]	SS [c] (0.2)
ABS	dermal absorption factor (unitless)	CS [e]	CS [e]	CS [e]	CS [e]

[a] *Soil Screening Guidance: User's Guide*, EPA 1996.
[b] Chemical-specific.
[c] Site-specific.
[d] *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.
[e] Chemical-specific; refer to Table H-6.

EQ16 through EQ19 were obtained from *Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003. A RECAP Standard shall be determined for both carcinogenic and noncarcinogenic effects and the more protective value shall be used as the RS.

VF_i (m^3/kg):

$$\frac{(Q/C)x(3.14xD_A xT)^{1/2} x10^{-4}(m^2/cm^2)}{(2x\rho_b xD_A)} \quad \textbf{(EQ20)}$$

where:

$$D_A(cm^2/s) = \frac{[(\theta_a{}^{10/3} xD_i xH' + \theta_w{}^{10/3} xD_w)/n^2]}{\rho_b xK_d + \theta_w + \theta_a xH'} \quad \textbf{(EQ13)}$$

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
VF_i	industrial soil-to-air volatilization factor (m^3/kg)	--	--	--	--
D_A	apparent diffusivity (cm^2/s)	--	--	--	--
Q/C	inverse of the mean concentration at the center of source (g/m^2-s per kg/m^3)	79.25	79.25	SS [a]	SS [a]
T	exposure interval – industrial (s)	7.9E+08 [b]	7.9E+08 [b]	7.9E+08 [b]	SS [c] (7.9E+08)
ρ_b	dry soil bulk density (g/cm^3)	1.7 [d]	1.7 [d]	SS [c] (1.7)	SS [c] (1.7)
θ_a	air-filled soil porosity (L_{air}/L_{soil})	n-θ_w	n-θ_w	n-θ_w	n-θ_w
n	total soil porosity (L_{pore}/L_{soil})	1 - (ρ_b/ρ_s)	1 - (ρ_b/ρ_s)	1 - (ρ_b/ρ_s)	1 - (ρ_b/ρ_s)
θ_w	water-filled soil porosity (L_{water}/L_{soil})	0.21 [d]	0.21 [d]	SS [c] (0.21)	SS [c] (0.21)
ρ_s	soil particle density (g/cm^3)	2.65 [d]	2.65 [d]	SS [c] (2.65)	SS [c] (2.65)
D_i	diffusivity in air (cm^2/s)	CS [e]	CS [e]	CS [e]	CS [e]
H'	Henry's Law Constant (dimensionless)	CS [e,f]	CS [e,f]	CS [e,f]	CS [e,f]
D_w	diffusivity in water (cm^2/s)	CS [e]	CS [e]	CS [e]	CS [e]
K_d	soil-water partition coefficient (cm^3/g) = K_{oc} x f_{oc}	CS [e]	CS [e]	CS [e]	CS [e]
K_{oc}	soil organic carbon partition coefficient (cm^3/g)	CS [e]	CS [e]	CS [e]	CS [e]
f_{oc}	fractional organic carbon in soil (g/g) = percent organic matter/174 (ASTM 2974)	0.006 [d]	0.006 [d]	SS [g] (0.006)	SS [g] (0.006)

[a] Site-specific; refer to EQ14.
[b] *Soil Screening Guidance*, *User's Guide,* EPA 1996.
[c] Site-specific.
[d] LDEQ default value.
[e] Chemical-specific.
[f] H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^oC)].
[g] Site-specific, the sample(s) for f_{oc} determination shall be collected from an un-impacted area that is representative of the soil conditions in the impacted area.

The volatilization factor (VF) is used for defining the relationship between the concentration of constituents in soil and the volatilized constituents in air. The basic principle of the model is applicable only if the soil constituent concentration is at or below saturation. Saturation is the soil constituent concentration ($Soil_{sat}$) at which the adsorptive limits of the soil particles and the solubility limits of the available soil moisture have been reached. Above saturation, pure liquid-phase constituent may be present in the soil. It is important to recognize that free phase constituents may be present at concentrations below $Soil_{sat}$ if multiple constituents are present.

(Note: For organic constituents that are solid at ambient temperature, concentrations above $Soil_{sat}$ do not pose the potential for NAPL occurrence.) $Soil_{sat}$ concentrations represent an upper limit to the applicability of the VF model because a basic principle of the model (Henry's Law) does not apply where constituents are present in free phrase. Therefore, above saturation, the risk-based soil RS based on the VF model cannot be accurately calculated based on volatilization. Because of this limitation, the risk-based RS calculated using the VF must be compared with the $Soil_{sat}$ calculated using EQ38. If the $Soil_{ni}$ is greater than $Soil_{sat}$, then the risk-based RS is set equal to $Soil_{sat}$. $Soil_{sat}$ should be calculated using the same soil characteristics (bulk density, average water content, organic carbon content, etc.) used to calculate VF (*Soil Screening Guidance*, EPA 1996).

EQ13 and EQ20 were obtained from *Soil Screening Guidance: User's Guide*, EPA 1996. Site-specific data may be used where indicated. In the absence of site-specific data for a particular parameter that is designated as site-specific, the default value presented in paraentheses shall be used.

$Soil_i$-PEF - Carcinogenic Effects - Organic Constituents (mg/kg):

$$\frac{TR \, x \, BW_a \, x \, AT_c \, x \, 365 days/yr}{EF_i \, x \, ED_i \, x \left[\left(SF_o \, x 10^{-6} \, \frac{kg}{mg} \, x \, IRS_i \right) + \left(SF_i \, x \, IRA_a \, x \left(\frac{1}{VF_i} + \frac{1}{PEF_i} \right) \right) + \left(SF_o \, x SA_i \, x AF_i \, x ABS \, x 10^{-6} \, \frac{kg}{mg} \right) \right]} \quad \textbf{(EQ21)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_i$-PEF	industrial risk-based chemical concentration in soil (mg/kg)	NA [a]	NA [a]	--	--
TR	target excess individual lifetime cancer risk (unitless)	NA [a]	NA [a]	10^{-6} [b]	10^{-6} [c]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	NA [a]	NA [a]	CS [d]	CS [d]
SF_i	inhalation cancer slope factor ((mg/kg-day)$^{-1}$)	NA [a]	NA [a]	CS [d]	CS [d]
BW_a	average adult body weight (kg)	NA [a]	NA [a]	70 [b]	70 [b]
AT_c	averaging time – carcinogens (yr)	NA [a]	NA [a]	70 [b]	70 [b]
EF_i	industrial exposure frequency (days/yr)	NA [a]	NA [a]	250 [b]	SS [e] (250)
ED_i	industrial exposure duration (yr)	NA [a]	NA [a]	25 [b]	SS [e] (25)
IRS_i	industrial soil ingestion rate (mg/day)	NA [a]	NA [a]	50 [b]	SS [e] (50)
IRA_a	adult inhalation rate (m^3/day)	NA [a]	NA [a]	20 [b]	SS [e] (20)
SA_i	skin surface area for an industrial worker (cm^2/day)	NA [a]	NA [a]	3,300 [f]	SS [e] (3,300)
AF_i	soil-to-skin adherence factor for an industrial worker (mg/cm^2)	NA [a]	NA [a]	0.2 [f]	SS [e] (0.2)
VF_i	industrial soil-to-air volatilization factor (m^3/kg)	NA [a]	NA [a]	CS [g]	CS [g]
PEF_i	industrial particulate emission factor (m^3/kg)	NA [a]	NA [a]	SS [h]	SS [h]
ABS	dermal absorption factor (unitless)	NA [a]	NA [a]	CS [i]	CS [i]

[a]Not Applicable to this Option.
[b]*Soil Screening Guidance: User's Guide*, EPA 1996.
[c]Refer to Section 2.14.3.
[d]Chemical-specific.
[e]Site-specific.
[f]*Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.
[g]Chemical-specific; refer to EQ20.
[h]Site-specific, refer to EQ25.
[i]Chemical-specific; refer to Table H-6.

$Soil_i$ - PEF - Carcinogenic Effects - Inorganic Constituents (mg/kg):

$$\frac{TR x BW_a x AT_c x 365 days/yr}{EF_i x ED_i x \left[\left(SF_o x 10^{-6} \frac{kg}{mg} x IRS_i\right) + \left(SF_i x IRA_a x \left(\frac{1}{PEF_i}\right)\right) + \left(SF_o x SA_i x AF_i x ABS x 10^{-6} \frac{kg}{mg}\right)\right]} \quad \textbf{(EQ22)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_i$-PEF	industrial risk-based chemical concentration in soil (mg/kg)	NA [a]	NA [a]	--	--
TR	target excess individual lifetime cancer risk (unitless)	NA [a]	NA [a]	10^{-6} [b]	10^{-6} [c]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	NA [a]	NA [a]	CS [d]	CS [d]
SF_i	inhalation cancer slope factor ((mg/kg-day)$^{-1}$)	NA [a]	NA [a]	CS [d]	CS [d]
BW_a	average adult body weight (kg)	NA [a]	NA [a]	70 [b]	70 [b]
AT_c	averaging time – carcinogens (yr)	NA [a]	NA [a]	70 [b]	70 [b]
EF_i	industrial exposure frequency (days/yr)	NA [a]	NA [a]	250 [b]	SS [e] (250)
ED_i	industrial exposure duration (yr)	NA [a]	NA [a]	25 [b]	SS [e] (25)
IRS_i	industrial soil ingestion rate (mg/day)	NA [a]	NA [a]	50 [b]	SS [e] (50)
IRA_a	adult inhalation rate (m^3/day)	NA [a]	NA [a]	20 [b]	SS [e] (20)
SA_i	skin surface area for an industrial worker (cm^2/day)	NA [a]	NA [a]	3,300 [f]	SS [e] (3,300)
AF_i	soil-to-skin adherence factor for an industrial worker (mg/cm^2)	NA [a]	NA [a]	0.2 [f]	SS [e] (0.2)
PEF_i	industrial particulate emission factor (m^3/kg)	NA [a]	NA [a]	SS [g]	SS [g]
ABS	dermal absorption factor (unitless)	NA [a]	NA [a]	CS [h]	CS [h]

[a]Not applicable to this Option.
[b]*Soil Screening Guidance: User's Guide*, EPA 1996.
[c]Refer to Section 2.14.3.
[d]Chemical-specific.
[e]Site-specific.
[f]*Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.
[g]Site-specific, refer to EQ25.
[h]Chemical-specific; refer to Table H-6.

$Soil_i$-PEF - Noncarcinogenic Effects - Organic Constituents (mg/kg):

$$\frac{THQ \times BW_a \times AT_{ni} \times 365 days/yr}{ED_i \times EF_i \times \left[\left(\left(\frac{1}{RfD_o}\right) \times 10^{-6} \frac{kg}{mg} \times IRS_i\right) + \left(\left(\frac{1}{RfD_i}\right) \times IRA_a \times \left(\frac{1}{VF_i} + \frac{1}{PEF_i}\right)\right) + \left(\left(\frac{1}{RfD_o}\right) \times SA_i \times AF_i \times ABS \times 10^{-6} \frac{kg}{mg}\right)\right]} \quad \textbf{(EQ23)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_i$-PEF	industrial risk-based chemical concentration in soil (mg/kg)	NA [a]	NA [a]	--	--
THQ	target hazard quotient (unitless)	NA [a]	NA [a]	1 [b]	1 [b]
RfD_o	oral reference dose (mg/kg-day)	NA [a]	NA [a]	CS [c]	CS [c]
RfD_i	inhalation reference dose (mg/kg-day)	NA [a]	NA [a]	CS [c]	CS [c]
BW_a	average adult body weight (kg)	NA [a]	NA [a]	70 [b]	70 [b]
AT_{ni}	averaging time - noncarcinogens, industrial (yr)	NA [a]	NA [a]	25 [b]	SS [d] (25)
EF_i	industrial exposure frequency (days/yr)	NA [a]	NA [a]	250 [b]	SS [d] (250)
ED_i	industrial exposure duration (yr)	NA [a]	NA [a]	25 [b]	SS [d] (25)
IRS_i	industrial soil ingestion rate (mg/day)	NA [a]	NA [a]	50 [b]	SS [d] (50)
IRA_a	adult inhalation rate (m^3/day)	NA [a]	NA [a]	20 [b]	SS [d] (20)
SA_i	skin surface area for an industrial worker (cm^2/day)	NA [a]	NA [a]	3,300 [e]	SS [d] (3,300)
AF_i	soil-to-skin adherence factor for an industrial worker (mg/cm^2)	NA [a]	NA [a]	0.2 [e]	SS [d] (0.2)
VF_i	industrial soil-to-air volatilization factor (m^3/kg)	NA [a]	NA [a]	CS [f]	CS [f]
PEF_i	industrial particulate emission factor (m^3/kg)	NA [a]	NA [a]	SS [g]	SS [g]
ABS	dermal absorption factor (unitless)	NA [a]	NA [a]	CS [h]	CS [h]

[a]Not Applicable to this Option.
[b]*Soil Screening Guidance: User's Guide*, EPA 1996.
[c]Chemical-specific.
[d]Site-specific.
[e]*Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.
[f]Chemical-specific; refer to EQ20.
[g]Site-specific; refer to EQ25.
[h]Chemical-specific; refer to Table H-6.

$Soil_i$-PEF - Noncarcinogenic Effects - Inorganic Constituents (mg/kg):

$$\frac{THQ \times BW_a \times AT_{ni} \times 365 days/yr}{ED_i \times EF_i \times \left[\left(\left(\frac{1}{RfD_o}\right) \times 10^{-6} \frac{kg}{mg} \times IRS_i\right) + \left(\left(\frac{1}{RfD_i}\right) \times IRA_a \times \left(\frac{1}{PEF_i}\right)\right) + \left(\left(\frac{1}{RfD_o}\right) \times SA_i \times AF_i \times ABS \times 10^{-6} \frac{kg}{mg}\right)\right]} \quad \textbf{(EQ24)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_i$-PEF	industrial risk-based chemical concentration in soil (mg/kg)	NA [a]	NA [a]	--	--
THQ	target hazard quotient (unitless)	NA [a]	NA [a]	1 [b]	1 [b]
RfD_o	oral reference dose (mg/kg-day)	NA [a]	NA [a]	CS [c]	CS [c]
RfD_i	inhalation reference dose (mg/kg-day)	NA [a]	NA [a]	CS [c]	CS [c]
BW_a	average adult body weight (kg)	NA [a]	NA [a]	70 [b]	70 [b]
AT_{ni}	averaging time - noncarcinogens, industrial (yr)	NA [a]	NA [a]	25 [b]	SS [d] (25)
EF_i	industrial exposure frequency (days/yr)	NA [a]	NA [a]	250 [b]	SS [d] (250)
ED_i	industrial exposure duration (yr)	NA [a]	NA [a]	25 [b]	SS [d] (25)
IRS_i	industrial soil ingestion rate (mg/day)	NA [a]	NA [a]	50 [b]	SS [d] (50)
IRA_a	adult inhalation rate (m^3/day)	NA [a]	NA [a]	20 [b]	SS [d] (20)
SA_i	skin surface area for an industrial worker (cm^2/day)	NA [a]	NA [a]	3,300 [e]	SS [d] (3,300)
AF_i	soil-to-skin adherence factor for an industrial worker (mg/cm^2)	NA [a]	NA [a]	0.2 [e]	SS [d] (0.2)
PEF_i	industrial particulate emission factor (m^3/kg)	NA [a]	NA [a]	SS [f]	SS [f]
ABS	dermal absorption factor (unitless)	NA [a]	NA [a]	CS [g]	CS [g]

[a]Not Applicable to this Option.
[b]*Soil Screening Guidance: User's Guide*, EPA 1996.
[c]Chemical-specific.
[d]Site-specific.
[e]*Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance*. EPA/540/R-99/005.
[f]Site-specific; refer to EQ25.
[g]Chemical-specific; refer to Table H-6.

PEF_i (m^3/kg):

$$Q/Cx\frac{3{,}600\text{sec}/hr}{0.036x(1-V)x(U_m/U_t)^3 xF(x)} \qquad \textbf{(EQ25)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
PEF_i	industrial particulate emission factor (m^3/kg)	NA [a]	NA [a]	--	--
Q/C	inverse of mean concentration at center of source (g/m^2-s per kg/m^3)	NA [a]	NA [a]	SS [b]	SS [b]
V	fraction of vegetative cover (unitless)	NA [a]	NA [a]	SS [c] (0)	SS [c] (0)
U_m	mean annual windspeed (m/s)	NA [a]	NA [a]	SS [c] (4.69)	SS [c] (4.69)
U_t	equivalent threshold value of windspeed at 7 m, (m/s)	NA [a]	NA [a]	SS [c] (11.32)	SS [c] (11.32)
F(x)	function dependent on U_m/U_t (unitless); derived using Cowherd et. al. (1985)[d]	NA [a]	NA [a]	SS [c] (0.194)	SS [c] (0.194)

[a]Not Applicable to this Option.
[b]Site-specific, see EQ14.
[c]Site-specific.
[d]Cowherd, C., G. Muleski, P; Engelhart, and D. Gillette. 1985. Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination. Prepared for U.S. EPA, Office of Health and Environmental Assessment, Washington, DC. EPA/600/8-85/002. F(x) is a complex function of x, which is a ratio of the threshold windspeed and average annual windspeed:

$x = 0.886 \times [U_t/U_m]$

where:

U_t = equivalent threshold value of windspeed at 7 m, (m/s)

U_m = mean annual windspeed (m/s)

$$F(x) = \begin{cases} 1.91 & x < 0.5 \\ 2.06 - 0.33x & 0.5 < x < 0.8 \\ 2.6 - x & 0.8 < x < 1 \\ 2.9 - 1.3x & 1 < x < 2 \\ 0.18\,(8x^3 - + 12x)\,e^{-x^2} & x > 2 \end{cases}$$

EQ25 was obtained from *Soil Screening Guidance: User's Guide*, EPA 1996. Site-specific data may be used where indicated. In the absence of site-specific data for a particular parameter that is designated as site-specific, the default value presented in paraentheses shall be used.

H2.1.3 Volatile Emissions from Soil to an Enclosed Structure Pathway ($Soil_{es}$)

$Soil_{es}$ (mg/kg):

$$\frac{C_a\left[\frac{\mu g}{m^3}\right]}{VF_{Soiles}} x10^{-3} \frac{mg}{\mu g} \qquad \textbf{(EQ26)}$$

where:

Parameter	Definition (units)	SO	MO-1	MO-2	MO-3
$Soil_{es}$	soil RECAP Standard for soil impacted with volatile constituents located beneath an enclosed-structure (mg/kg)	NA [a]	--	--	--
C_a	risk-based chemical concentration in air for enclosed-structure (indoor) vapor inhalation (ug/m^3)	NA [a]	refer to Section H2.3	refer to Section H2.3	refer to Section H2.3
VF_{Soiles}	soil to enclosed-structure vapors volatilization factor (mg/m^3-air/mg-kg-soil)	NA [a]	EQ27 – EQ28 [b]	EQ27 – EQ28 [b]	EQ27 – EQ28 [b]

[a]Not applicable to this Option.
[b]Refer to EQ27 for non-industrial land use; refer to EQ28 for industrial land use.

$VF_{Soilesni}$ - Non-Industrial Scenario ($mg/m^3/mg/kg$):

$$\frac{\frac{H'\rho_b}{\theta_w + K_d\rho_b + H'\theta_a}\left[\frac{D_s/L_s}{ER_{ni}xL_{Bni}}\right]}{1+\frac{D_s/L_s}{ER_{ni}xL_{Bni}}+\left[\frac{D_s/L_s}{(D_{crack}/L_{crack})_{FC}}\right]} x10^3 \frac{cm^3-kg}{m^3-g} \qquad \textbf{(EQ27)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$VF_{Soilesni}$	non-industrial soil vapors to enclosed-structure volatilization factor ($mg/m^3/mg/kg$)	NA [a]	--	--	--
H′	Henry's Law Constant (dimensionless)	NA [a]	CS [b,c]	CS [b,c]	CS [b,c]
ρ_s	soil particle density (g/cm^3)	NA [a]	2.65 [e]	SS [d] (2.65) [e]	SS [d] (2.65) [e]
ρ_b	dry soil bulk density (g/cm^3)	NA [a]	1.7 [e]	SS [d] (1.7 [e])	SS [d] (1.7 [e])
D_s	effective diffusion coefficient in soil based on vapor-phase concentration (cm^2/sec)	NA [a]	CS [b]	SS [f]	SS [f]
n	total soil porosity (L_{pore}/L_{soil})	NA [a]	$1-(\rho_b/\rho_s)$	$1-(\rho_b/\rho_s)$	$1-(\rho_b/\rho_s)$
L_s	depth from ground surface to impacted subsurface soils (cm)	NA [a]	100	SS [d] (100)	SS [d] (100)
θ_w	water-filled soil porosity (L_{water}/L_{soil})	NA [a]	0.21 [e]	SS [d] (0.21 [e])	SS [d] (0.21 [e])
K_d	soil-water partition coefficient (cm^3/g) = f_{oc} x K_{oc}	NA [a]	CS [b]	CS [b]	CS [b]
θ_a	air-filled soil porosity (L_{air}/L_{soil})	NA [a]	$n-\theta_w$	$n-\theta_w$	$n-\theta_w$
ER_{ni}	non-industrial enclosed-structure air exchange rate (1/s)	NA [a]	0.00014	SS [d] (0.00014)	SS [d] (0.00014)
L_{Bni}	non-industrial enclosed-structure volume/infiltration area ratio (cm)	NA [a]	200	SS [d] (200)	SS [d] (200)
D_{crack}	effective diffusion coefficient through foundation cracks (cm^2/s)	NA [a]	CS [b]	SS [g]	SS [g]
L_{crack}	enclosed-structure foundation or wall thickness (cm)	NA [a]	15	SS [d] (15)	SS [d] (15)
K_{oc}	soil organic carbon partition coefficient (cm^3/g)	NA [a]	CS [b]	CS [b]	CS [b]
f_{oc}	fractional organic carbon in soil (g/g); f_{oc} = percent organic matter/174 (ASTM 2974)	NA [a]	0.006 [e]	SS [h] (0.006) [e]	SS [h] (0.006) [e]
FC	areal fraction of cracks in foundation/walls (cm^2-cracks/cm^2 "total area")	NA [a]	0.01	SS [d] (0.01)	SS [d] (0.01)

[a]Not applicable for this Option.
[b]Chemical-specific.
[c]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^o C)].
[d]Site-specific; a default value demonstrated to be representative of site conditions may be used in the Johnson and Ettinger model if approved by the Department. Department approval for the use of an alternate default value shall be obtained prior to calculation of the $Soil_{es}$ RS.
[e]LDEQ default value.
[f]Site-specific; refer to EQ29.
[g]Site-specific; refer to EQ30.
[h]Site-specific; the sample(s) for f_{oc} determination shall be collected from an un-impacted area that is representative of the soil conditions in the impacted area.

$VF_{Soilesi}$ - Industrial Scenario ($mg/m^3/mg/kg$):

$$\frac{\dfrac{H'\rho_b}{\theta_w + K_d\rho_b + H'\theta_a}\left[\dfrac{D_s/L_s}{ER_i L_{Bi}}\right]}{1+\dfrac{D_s/L_s}{ER_i L_{Bi}}+\left[\dfrac{D_s/L_s}{(D_{crack}/L_{crack})xFC}\right]} x10^3\ \frac{cm^3-kg}{m^3-g} \qquad \textbf{(EQ28)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$VF_{Soilesi}$	industrial soil vapors to enclosed-structure volatilization factor ($mg/m^3/mg/kg$)	NA [a]	--	--	--
H′	Henry's Law Constant (dimensionless)	NA [a]	CS [b,c]	CS [b,c]	CS [b,c]
ρ_s	soil particle density (gm/cm^3)	NA [a]	2.65 [e]	SS [d] (2.65) [e]	SS [d] (2.65) [e]
ρ_b	dry soil bulk density (g/cm^3)	NA [a]	1.7 [e]	SS [d] (1.7 [e])	SS [d] (1.7 [e])
D_s	effective diffusion coefficient in soil based on vapor-phase concentration (cm^2/sec)	NA [a]	CS [b]	SS [f]	SS [f]
n	total soil porosity (L_{pore}/L_{soil})	NA [a]	$1-(\rho_b/\rho_s)$	$1-(\rho_b/\rho_s)$	$1-(\rho_b/\rho_s)$
L_s	depth from ground surface to impacted subsurface soils (cm)	NA [a]	100	SS [d] (100)	SS [d] (100)
θ_w	water-filled soil porosity (L_{water}/L_{soil})	NA [a]	0.21 [e]	SS [d] (0.21 [e])	SS [d] (0.21 [e])
K_d	soil-water partition coefficient (cm^3/g) = f_{oc} x K_{oc}	NA [a]	CS [b]	CS [b]	CS [b]
θ_a	air-filled soil porosity (L_{air}/L_{soil})	NA [a]	$n-\theta_w$	$n-\theta_w$	$n-\theta_w$
ER_i	industrial enclosed-structure air exchange rate (1/s)	NA [a]	0.00023	SS [d] (0.00023)	SS [d] (0.00023)
L_{Bi}	industrial enclosed-structure volume/infiltration area ratio (cm)	NA [a]	300	SS [d] (300)	SS [d] (300)
D_{crack}	effective diffusion coefficient through foundation cracks (cm^2/s)	NA [a]	CS [b]	SS [g]	SS [d]
L_{crack}	enclosed-structure foundation or wall thickness (cm)	NA [a]	15	SS [d] (15)	SS [d] (15)
K_{oc}	soil organic carbon partition coefficient (cm^3/g)	NA [a]	CS [b]	CS [b]	CS [b]
f_{oc}	fractional organic carbon in soil (g/g); f_{oc} = percent organic matter/174 (ASTM 2974)	NA [a]	0.006 [e]	SS [h] (0.006) [e]	SS [h] (0.006) [e]
FC	areal fraction of cracks in foundation/walls (cm^2-cracks/cm^2 "total area")	NA [a]	0.01	SS [d] (0.01)	SS [d] (0.01)

[a]Not applicable for this Option.
[b]Chemical-specific.
[c]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^oC)].
[d]Site-specific; a default value demonstrated to be representative of site conditions may be used in the Johnson and Ettinger model if approved by the Department. Department approval for the use of an alternate default value shall be obtained prior to calculation of the $Soil_{es}$ RS.
[e]LDEQ default value.
[f]Site-specific; refer to EQ29.
[g]Stie-specific; refer to EQ30.
[h]Site-specific; the sample(s) for f_{oc} determination shall be collected from an un-impacted area that is representative of the soil conditions in the impacted area.

D_s (cm^2/s):

$$D_{air}\ \frac{\theta_a^{3.33}}{n^2} + D_{wat}\ \frac{1}{H'}\frac{\theta_w^{3.33}}{n^2} \qquad \textbf{(EQ29)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	MO-1	MO-2	MO-3
D_s	effective diffusion coefficient in soil based on vapor-phase concentration (cm^2/s)	NA [a]	--	--	--
D_{air}	diffusion coefficient in air (cm^2/s)	NA [a]	CS [b]	CS [b]	CS [b]
θ_a	air-filled soil porosity (L_{air}/L_{soil})	NA [a]	n-θ_w	n-θ_w	n-θ_w
n	total soil porosity (L_{pore}/L_{soil})	NA [a]	1-(ρ_b/ρ_s)	1-(ρ_b/ρ_s)	1-(ρ_b/ρ_s)
D_{wat}	diffusion coefficient in water (cm^2/s)	NA [a]	CS [b]	CS [b]	CS [b]
H′	Henry's Law Constant (dimensionless)	NA [a]	CS [b,c]	CS [b,c]	CS [b,c]
ρ_b	dry soil bulk density (g/cm^3)	NA [a]	1.7 [e]	SS [d] (1.7) [e]	SS [d] (1.7) [e]
ρ_s	soil particle density (g/cm^3)	NA [a]	2.65 [e]	SS [d] (2.65) [e]	SS [d] (2.65) [e]
θ_w	water-filled soil porosity (L_{water}/L_{soil})	NA [a]	0.21 [e]	SS [d] (0.21) [e]	SS [d] (0.21) [e]

[a]Not Applicable for this Option.
[b]Chemical-specific.
[c]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^oC)].
[d]Site-specific; a default value demonstrated to be representative of site conditions may be used in the Johnson and Ettinger model if approved by the Department. Department approval for the use of an alternate default value shall be obtained prior to calculation of the $Soil_{es}$ RS.
[e]LDEQ default value.

D_{crack} (cm^2/s):

$$D_{air}\frac{\theta_{acrack}^{3.33}}{n^2}+D^{wat}\frac{1}{H'}\frac{\theta_{wcrack}^{3.33}}{n^2} \qquad \textbf{(EQ30)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
D_{crack}	effective diffusion coefficient through foundation cracks (cm^2/s)	NA [a]	--	--	--
D_{air}	diffusion coefficient in air (cm^2/s)	NA [a]	CS [b]	CS [b]	CS [b]
θ_{acrack}	volumetric air content in foundation/wall cracks (L_{air}/L_{soil})	NA [a]	n-θ_{wcrack}	SS [c] (n-θ_{wcrack})	SS [c] (n-θ_{wcrack})
n	total porosity of foundation/wall (L_{pore}/L_{soil})	NA [a]	1-(ρ_b/ρ_s)	SS [c] [1-(ρ_b/ρ_s)]	SS [c] [1-(ρ_b/ρ_s)]
D_{wat}	diffusion coefficient in water (cm^2/s)	NA [a]	CS [b]	CS [b]	CS [b]
θ_{wcrack}	volumetric water content in foundation/wall cracks (L_{water}/L_{soil})	NA [a]	0.21 [d]	SS [c] (0.21 [d])	SS [c] (0.21 [d])
ρ_b	dry bulk density of foundation/wall (g/cm^3)	NA [a]	1.7 [d]	SS [c] (1.7) [d]	SS [c] (1.7) [d]
ρ_s	particle density of foundation/wall (g/cm^3)	NA [a]	2.65 [d]	SS [c] (2.65) [d]	SS [c] (2.65) [d]
H′	Henry's Law Constant (dimensionless)	NA [a]	CS [b,e]	CS [b,e]	CS [b,e]

[a]Not Applicable to this Option.
[b]Chemical-specific.
[c]Site-specific; a default value demonstrated to be representative of site conditions may be used in the Johnson and Ettinger model if approved by the Department. Department approval for the use of an alternate default value shall be obtained prior to calculation of the $Soil_{es}$ RS.
[d]LDEQ default value.
[e]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^oC)].

EQ26 through EQ30 were obtained from *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (*ASTM E 1739).* A RECAP Standard shall be determined for both carcinogenic and noncarcinogenic effects and the more protective value shall be used as the RS. Additional information on the Johnson and Ettinger Model is available in *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (EPA November 2002).

H2.1.4 Soil to Groundwater Pathway

H2.1.4.1 Screening Option:

SO $Soil_{SSGW}$ Method 1 - Soil/Water Partition Coefficient – Organic Constituents:

(1) The GW_1 shall be identified in Table 3. If a COC is not listed in Table 3, then a GW_1 shall be determined in accordance with Section H2.2.2. If the GW_1 is greater than the $Water_{sol}$, then the $Water_{sol}$ shall be identified as the acceptable concentration in groundwater and shall be used instead of the GW_1 in Step (2).

(2) The soil/water partition equation (C_{soil}) shall be used to relate the constituent concentration adsorbed to the soil organic carbon to the soil leachate concentration in the zone of contamination. The GW_1 identified in Step (1) shall be used as the target soil leachate concentration.

C_{soil} (mg/kg):

$$\frac{GW(\rho_b x K_d + \theta_W + \theta_a x H')}{\rho_b} \qquad \textbf{(EQ31)}$$

where:

Parameter	Definition (units)	SO Input Value
C_{soil}	concentration adsorbed to soil organic carbon (mg/kg dry weight)	--
GW	target soil leachate concentration (mg/L)	Groundwater RS identified in Step (1)
ρ_b	dry soil bulk density (g/cm^3)	1.7 [a]
θ_W	water filled soil porosity (L_{water}/L_{soil})	0.21[a]
K_d	soil-water partition coefficient = K_{oc} x f_{oc} (cm^3/g)	chemical-specific
K_{oc}	soil-organic carbon partition coefficient (cm^3/g)	chemical-specific
f_{oc}	fractional organic carbon in soil (g/g); f_{oc} = percent organic matter/174 (ASTM 2974)	0.006 [a]
θ_a	air filled soil porosity (L_{air}/L_{soil})	n-θ_w
n	total soil porosity (L_{pore}/L_{soil})	1 - ρ_b/ρ_s
ρ_s	soil particle density (g/cm^3)	2.65 [a]
H’	Henry’s Law Constant (dimensionless)	chemical-specific [b]

[a]LDEQ default value.
[b]H’ = H x 41 where: H = Henry’s Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^oC)].

If the most heavily impacted soils occur below the water table, then the term (θ_a H') should be omitted as all pores are water saturated. EQ31 was obtained from *Soil Screening Guidance: User's Guide*, EPA 1996.

(3) The constituent concentration adsorbed to soil organic carbon calculated in Step (2) shall be multiplied by a dilution factor (DF) of 20 to yield the maximum theoretical contaminant concentration in soil that is protective of the appropriate groundwater use. As chemicals present in the soil migrate, their concentrations are reduced by physical, chemical, and biochemical processes. To account for these processes, a dilution factor is used in the estimation of a soil concentration that is protective of groundwater. A DF of 20 shall be used for $Soil_{SSGW}$. A DF of 20 is considered protective of groundwater resources for soil sources up to 0.5 acre in size (*Soil Screening Guidance: Technical Background Document*, EPA 1996).

$Soil_{SSGW}$ (mg/kg):

(C_{soil}) x (20) **(EQ32)**

SO $Soil_{SSGW}$ Method 2 – TCLP Back-Calculation - Inorganic Constituents:

For inorganic constituents, the $Soil_{GW}$ shall be derived from the Toxicity Characteristic Leaching Procedure (TCLP) regulatory levels (Maximum Concentrations of Contaminants for the Toxicity Characteristic). The TCLP is an extraction process that assesses the leaching potential of constituents present in soil. TCLP regulatory levels represent maximum constituent concentrations in leachate that comply with the health-based criteria specified by the Safe Drinking Water Act for an assumed drinking water well downgradient of the source. The TCLP model assumes a dilution factor of 100 to account for dilution of the leachate in groundwater before reaching a drinking water well. Therefore, in general, the TCLP regulatory levels are 100 times the drinking water standard.

To determine the $Soil_{GW}$ from the TCLP regulatory level the TCLP regulatory level shall be multiplied by a factor of 20 to back-calculate to the corresponding "acceptable" concentration in soil. (A multiplier of 20 was used because the TCLP procedure requires the soil sample to be diluted 20:1 prior to acid extraction and leachate analysis.)

For inorganic constituents for which a TCLP regulatory level is not available, the $Soil_{GW}$ shall be estimated by multiplying the GW_1 by a dilution factor of 100 and then by a factor of 20. This back-calculation approach duplicates the assumptions and methods used in the development of TCLP regulatory levels and serves to identify an "acceptable" concentration in soil for those inorganic constituents for which a TCLP regulatory value was not available. *(Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule,* EPA, 40 CFR Part 261 et. al.). Refer to Table 3 for the GW_1 value. If a COC is not listed in Table 3, identify/calculate a GW_1 in accordance with Section H2.2.2.

SO $Soil_{SSGW}$ Method 3 - Leach Test – Organic and Inorganic Constituents:

A leach test may be used instead of the soil/water partition equation to relate concentrations of constituents adsorbed to soil organic carbon to soil leachate concentrations in the impacted zone. The EPA Synthetic Precipitation Leaching Procedure (SPLP, EPA SW-846 Method 1312, U.S. EPA, 1994d) is the recommended leach test for evaluation of the soil to groundwater pathway. The SPLP was developed to model an acid rain leaching environment and is generally appropriate for an impacted soil scenario (*Soil Screening Guidance*, EPA 1996). The SPLP may not be appropriate for all situations thus alternative leach tests may be approved on a site-specific basis. In general, TCLP data will be considered acceptable if the data are current and appropriately represent site conditions for the evaluation of the soil to groundwater pathway.

The soil sample(s) to be submitted for SPLP should be collected from the most heavily impacted area(s) of the AOI. This sampling strategy allows for a worst case analysis of leach potential. If the results of the SPLP test (and appropriate application of dilution factors) indicate that soils do not pose an unacceptable leach potential, then all other locations at the AOI would also provide similar results. If SPLP testing (and appropriate application of dilution factors) indicates that soils from the most heavily impacted area(s) of the AOI pose an unacceptable leach potential, then additional soil samples surrounding the location are recommended to delineate the horizontal extent of impacts.

Refer to Section H1.1.1.2 for guidance on the application of the leach test results.

H2.1.4.2 Management Option 1:

MO-1 $Soil_{GW}$ Method 1 - Soil/Water Partition Coefficient – Organic Constituents:

(1) Identify the appropriate groundwater RECAP Standard (GW_1, GW_2, GW_{3DW}, or GW_{3NDW}) in Table 3 based on the classification of the groundwater to be protected (refer to Section 2.10). If a COC is not listed in Table 3, a GW_1, GW_2, GW_{3DW}, or GW_{3NDW} shall be determined in accordance with Sections H2.2.2, H2.2.3, and H2.2.4, respectively. For GW_2 and GW_3, the site-specific DF shall **not** be applied to the GW_2 risk-based value or the GW_{3DW} or GW_{3NDW} limiting water quality criterion to define the target soil leachate concentration for the soil/water partition equation in Step (2). If the GW_1, GW_2, GW_{3DW}, or GW_{3NDW} is greater than the $Water_{sol}$, then the $Water_{sol}$ shall be used as the target soil leachate concentration in Step (2).

(2) The soil/water partition equation (C_{soil}) (EQ31) shall be used to relate the concentration of constituent adsorbed on soil organic carbon to the soil leachate concentration in the impacted zone. The GW_1, GW_2, GW_{3DW}, or GW_{3NDW} identified in Step (1) shall be used as the target soil leachate concentration.

(3) Multiply the C_{soil} obtained in Step (2) by a vertical DF of 20 [A DF of 20 is considered protective of groundwater resources for soil sources up to 0.5 acre in size (*Soil Screening Guidance: Technical Background Document*, EPA 1996).] to yield

the maximum theoretical contaminant concentration in soil that is protective of the appropriate groundwater use as follows:

$Soil_{GW1, 2, or 3}$ (mg/kg):

C_{soil} x 20 **(EQ33)**

(4) Refer to Section H1.1.2.1 (2) for guidance on applying the MO-1 DF2 and DF3 to the $SoilGW_2$, and $SoilGW_3$, respectively.

MO-1 $Soil_{GW}$ Method 2 – TCLP Back-Calculation - Inorganic Constituents:

For inorganic constituents, the $Soil_{GW}$ shall be developed using an approach based on the Toxicity Characteristic Leaching Procedure (TCLP) regulatory levels (Maximum Concentrations of Contaminants for the Toxicity Characteristic). The TCLP is an extraction process that assesses the leaching potential of constituents present in soil. TCLP regulatory levels represent maximum constituent concentrations in leachate that comply with the health-based criteria specified by the Safe Drinking Water Act for an assumed drinking water well downgradient of the source. The TCLP model assumes a dilution factor of 100 to account for dilution of the leachate in groundwater before reaching a drinking water well. Therefore, in general, the TCLP regulatory levels are 100 times the drinking water standard.

To determine the $Soil_{GW}$ from the TCLP regulatory level the TCLP regulatory level shall be multiplied by a factor of 20 to back-calculate to the corresponding "acceptable" concentration in soil. (A multiplier of 20 was used because the TCLP procedure requires the soil sample to be diluted 20:1 prior to acid extraction and leachate analysis.)

For inorganic constituents for which a TCLP regulatory level is not available, the $Soil_{GW}$ shall be estimated by multiplying the GW_1 by a dilution factor of 100 and then by a factor of 20. This back-calculation approach duplicates the assumptions and methods used in the development of TCLP regulatory levels and serves to identify an "acceptable" concentration in soil for those inorganic constituents for which a TCLP regulatory value was not available. *(Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule,* EPA, 40 CFR Part 261 et. al.). The GW_1 value shall be obtained from Table 3. If a COC is not listed in Table 3, a GW_1 shall be determined in accordance with Section H2.2.2.

MO-1 $Soil_{GW}$ Method 3 - Leach Test - Organic and Inorganic Constituents:

A leach test may be used instead of the soil/water partition equation to relate concentrations of constituents adsorbed to soil organic carbon to soil leachate concentrations in the impacted zone. The EPA Synthetic Precipitation Leaching Procedure (SPLP, EPA SW-846 Method 1312, U.S. EPA, 1994d) is the recommended leach test for evaluation of the soil to groundwater pathway. The SPLP was developed to model an acid rain leaching environment and is generally appropriate for an impacted soil scenario (*Soil Screening Guidance*, EPA April 1996). The SPLP may not be appropriate for all situations thus alternative leach tests may be approved on a site-specific basis. In general, TCLP data will be considered acceptable if the data are current and appropriately represent site conditions for the evaluation of the soil to groundwater pathway.

The soil sample(s) to be submitted for SPLP should be collected from the most heavily impacted area(s) of the AOI. This sampling strategy allows for a worst case analysis of leach potential. If the results of the SPLP test (and appropriate application of dilution factors) indicate that soils do not pose an unacceptable leach potential, then all other locations at the AOI would also provide similar results. If SPLP testing (and appropriate application of dilution factors) indicates that soils from the most heavily impacted area(s) of the AOI pose an unacceptable leach potential, then additional soil samples surrounding the location are recommended to delineate the horizontal extent of impacts.

Refer to Section H1.1.2.2 for guidelines on applying the leach test results.

The **Domenico analytical solute transport model** (Refer to Section H2.5, EQ65) was used to calculate the MO-1 default DF2 and DF3 values presented in Section H1.1 2.

H2.1.4.3 Management Option 2:

MO-2 $Soil_{GW}$ Method 1 - Soil/Water Partition Coefficient - Organic Constituents:

(1) Identify the appropriate groundwater RS (GW_1, GW_2, GW_{3DW}, or GW_{3NDW}) in Table 3 based on the classification of the groundwater to be protected (refer to Section 2.10). If a COC is not listed in Table 3, a GW_1, GW_2, GW_{3DW}, or GW_{3NDW} shall be determined in accordance with Sections H2.2.2, H2.2.3, and H2.2.4, respectively. For GW_2 and GW_3, the site-specific DAF shall **not** be applied to the GW_2 risk-based value or the GW_{3DW} or GW_{3NDW} limiting water quality criterion to define the target soil leachate concentration for the soil/water partition equation in Step (2). If the GW_1, GW_2, GW_{3DW}, or GW_{3NDW} is greater than the $Water_{sol}$ (refer to Table 3) then the $Water_{sol}$ shall be used as the target soil leachate concentration in Step (2). If a COC is not listed in Table 3, a $Water_{sol}$ shall be obtained from an appropriate reference.

(2) The soil/water partition equation (C_{soil}) (EQ31) shall be used to relate the concentration of constituent adsorbed on soil organic carbon to the soil leachate concentration in the impacted zone. The GW_1, GW_2, GW_{3DW}, or GW_{3NDW} identified in Step (1) shall be used as the target soil leachate concentration.

(3) Calculate a site-specific $DF_{Summers}$ (refer to Section H2.4) (the default value of 20 may be used for the $DF_{Summers}$) and a site-specific DAF (refer to Section H2.5). If the area of impacted soil is less than or equal to 0.5 acre and site-specific environmental fate and transport data are not available, the Submitter shall use the MO-1 default DF2 or DF3 (refer to Section H1.1.2.1);

The site-specific $DF_{Summers}$ shall be developed using the Summers Model (refer to Section H2.4) or a default DF of 20 may be used (*Soil Screening Guidance*, EPA 1996). The $DAF_{Domencio}$ shall be developed using the Domenico analytical solute transport model (Domenico, P.A. and F.W. Schwartz, 1990. *Physical and Chemical Hydrogeology,* John Wiley and Sons, New York, N.Y.) (for the saturated zone) (refer to Section H2.5). The DAF2 is representative of dilution and attenuation of the constituent concentration associated with groundwater migration from the source area to the nearest downgradient property boundary. The DAF3 is representative of dilution and attenuation of the constituent concentration associated with groundwater migration from the source area to the nearest downgradient surface water body. If there is potential for constituent migration to be influenced by pumping activities within the zone, then a site-specific $DF_{Summers}$ and $DAF_{Domenico}$ shall not be used in the development of the $Soil_{GW}$.

(4) Multiply the C_{soil} calculated in Step (2) by the site-specific $DF_{Summers}$ (for $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, and $Soil_{GW3NDW}$) and the site-specific $DAF_{Domenico}$ (for $Soil_{GW2}$, $Soil_{GW3DW}$, and $Soil_{GW3NDW}$) calculated in Step (3) to yield the maximum theoretical constituent concentration in soil leachate that will not cause the groundwater RECAP Standard to be exceeded as follows:

For $Soil_{GW1}$:

$$Soil_{GW1} = C_{soil} \times DF_{Summers} \qquad \textbf{(EQ34)}$$

For $Soil_{GW2}$:

$$Soil_{GW2} = C_{soil} \times DF_{Summers} \times DAF2_{Domenico} \qquad \textbf{(EQ35)}$$

For $Soil_{GW3DW}$ or $Soil_{GW3NDW}$:

$$Soil_{GW3DW} \text{ or } Soil_{GW3NDW} = C_{soil} \times DF_{Summers} \times DAF3_{Domenico} \qquad \textbf{(EQ36)}$$

MO-2 $Soil_{GW}$ Method 2 – TCLP Back-Calculation - Inorganic Constituents:

For inorganic constituents, the $Soil_{GW}$ shall be developed using an approach based on the Toxicity Characteristic Leaching Procedure (TCLP) regulatory levels (Maximum Concentrations of Contaminants for the Toxicity Characteristic). The TCLP is an extraction process that assesses the leaching potential of constituents present in soil. TCLP regulatory levels represent maximum constituent concentrations in leachate that comply with the health-based criteria specified by the Safe Drinking Water Act for an assumed drinking water well downgradient of the source. The TCLP model assumes a dilution factor of 100 to account for dilution of the leachate in groundwater before reaching a drinking water well. Therefore, in general, the TCLP regulatory levels are 100 times the drinking water standard.

To determine the $Soil_{GW}$ from the TCLP regulatory level the TCLP regulatory level shall be multiplied by a factor of 20 to back-calculate to the corresponding "acceptable" concentration in soil. (A multiplier of 20 was used because the TCLP procedure requires the soil sample to be diluted 20:1 prior to acid extraction and leachate analysis.)

For inorganic constituents for which a TCLP regulatory level is not available, the $Soil_{GW}$ shall be estimated by multiplying the GW_1 by a dilution factor of 100 and then by a factor of 20. This back-calculation approach duplicates the assumptions and methods used in the development of TCLP regulatory levels and serves to identify an "acceptable" concentration in soil for those inorganic constituents for which a TCLP regulatory value was not available. *(Hazardous Waste Management System; Identification and Listing of Hazardous Waste; Toxicity Characteristics Revisions; Final Rule,* EPA, 40 CFR Part 261 et. al.). The GW_1 shall be obtained from Table 3. If a COC is not listed in Table 3, then a GW_1 shall be determined in accordance with Section H2.2.2.

MO-2 $Soil_{GW}$ Method 3 - Leach Test - Organic and Inorganic Constituents:

A leach test may be used instead of the soil/water partition equation to relate concentrations of constituents adsorbed to soil organic carbon to soil leachate concentrations in the impacted zone. The EPA Synthetic Precipitation Leaching Procedure (SPLP, EPA SW-846 Method 1312, U.S. EPA, 1994d) is the recommended leach test for the soil to groundwater pathway. The SPLP was developed to model an acid rain leaching environment and is generally appropriate for an impacted soil scenario (*Soil Screening Guidance*, EPA April 1996). The SPLP may not be appropriate for all situations thus alternative leach tests may be approved on a site-specific basis. In general, TCLP data will be considered acceptable if the data are current and appropriately represent site conditions for the evaluation of the soil to groundwater pathway. An appropriate dilution and attenuation factor is to be applied to the results to determine if the COC concentration in the soil is protective of groundwater.

The soil sample(s) to be submitted for SPLP should be collected from the most heavily impacted area(s) of the AOI. This sampling strategy allows for a worst case analysis of leach potential. If the results of the SPLP test (and appropriate application of dilution

factors) indicate that soils do not pose an unacceptable leach potential, then all other locations at the AOI would also provide similar results. If SPLP testing (and appropriate application of dilution factors) indicates that soils from the most heavily impacted area(s) of the AOI pose an unacceptable leach potential, then additional soil samples surrounding the location are recommended to delineate the horizontal extent of impacts.

Calculate a site-specific $DF_{Summers}$ and a site-specific $DAF_{Domenico}$ (refer to Sections H2.4 and H2.5); refer above to MO-2 $Soil_{GW}$ Method 1, Step (3). Refer to Section H1.1.3.2 for guidelines on applying the DAF and interpreting the leach test results.

MO-2 $Soil_{GW}$ Method 4 - Site-Specific Soil/Water Partition Coefficient - Organic and Inorganic Constituents:

A site-specific soil/water partition coefficient may be used to develop a site-specific $Soil_{GW}$ when: (1) groundwater and soil data are available; (2) groundwater concentrations are less than soil concentrations; and (3) groundwater data indicate the GW_1, GW_2, or GW_3 has been exceeded (to determine the appropriate groundwater RECAP Standard refer to the groundwater classifications presented in Section 2.10).

(1) Identify site-specific soil and groundwater concentrations (GW_{conc} and $Soil_{conc}$) that are representative of site-specific partitioning of the COC between soil and groundwater (e.g., the soil and groundwater sampled should be: (1) from the same location; (2) in communication with each other; (3) and at equilibrium and /or declining conditions.

(2) Identify the appropriate groundwater RECAP Standard based on the current or potential use of the impacted groundwater (See Section 2.10 for groundwater classifications) in Table 3. If a COC is not listed in Table 3, determine the groundwater RECAP Standard in accordance with Section H2.2.2, H2.2.3, or H2.2.4. For GW_2 and GW_3, the site-specific DAF shall **not** be applied to the GW_2 risk-based value or the GW_3 human health limiting water quality criterion to define the acceptable concentration in groundwater for the soil/water partition equation in Step (3).

(3) Calculate a site-specific water/soil partition coefficient using the site-specific soil and groundwater data identified in Step (1) and the groundwater RS identified in Step (2) as follows:

$Soil_{GW}$ (mg/kg):

$$\left(\frac{GW1,2or3}{GW_{conc}}\right)\left(Soil_{conc}\right) \qquad \textbf{(EQ37)}$$

where:

Parameter	Definition (units)	Input Value
$Soil_{GW}$	soil concentration protective of groundwater (mg/kg)	site-specific
$GW_{1, 2, or 3}$	groundwater RECAP Standard (mg/l)	refer to Section H2.2
GW_{conc}	site-specific groundwater concentration at the POC (mg/l)	site-specific
$Soil_{conc}$	site-specific soil concentration at the POC (mg/kg)	site-specific

(4) Calculate a site-specific $DF_{Summers}$ (EQ61) and a site-specific $DAF_{Domenico}$ (EQ65) (refer above to MO-2 $Soil_{GW}$ Method 1, Step (3);

(5) Multiply the $Soil_{GW}$ calculated in Step (3) by the site-specific $DF_{Summers}$ (for $Soil_{GW1}$, $Soil_{GW2}$, $Soil_{GW3DW}$, or $Soil_{GW3NDW}$) and the site-specific $DAF_{Domenico}$ (for $Soil_{GW2}$, $Soil_{GW3DW}$, or $Soil_{GW3NDW}$) calculated in Step (4) to yield the maximum theoretical constituent concentration in soil leachate that will not cause the groundwater RECAP Standard to be exceeded as follows:

For $Soil_{GW1}$:

$$Soil_{GW1} = C_{soil} \times DF_{Summers} \quad \textbf{(EQ34)}$$

For $Soil_{GW2}$:

$$Soil_{GW2} = C_{soil} \times DF_{Summers} \times DAF2_{Domenico} \quad \textbf{(EQ35)}$$

For $Soil_{GW3DW}$ and $Soil_{GW3NDW}$:

$$Soil_{GW3DW} \text{ or } Soil_{GW3NDW} = C_{soil} \times DF_{Summers} \times DAF3_{Domenico} \quad \textbf{(EQ36)}$$

H2.1.5 Soil Saturation ($Soil_{sat}$) – Organic Constituents

$Soil_{sat}$ (mg/kg):

$$\frac{S}{\rho_b}(K_d\ \rho_b + \theta_w + H'\theta_a) \qquad \textbf{(EQ38)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
$Soil_{sat}$	soil saturation concentration (mg/kg)	--	--	--	--
S	solubility in water (mg/L-water)	CS [a]	CS [a]	CS [a]	CS [a]
ρ_b	dry soil bulk density (g/cm^3)	1.7 [b]	1.7 [b]	SS [c] (1.7) [b]	SS [c] (1.7) [b]
K_d	soil-water partition coefficient = K_{oc} x f_{oc} (cm^3/g)	CS [a]	CS [a]	CS [a]	CS [a]
K_{oc}	soil-organic carbon partition coefficient (cm^3/g)	CS [a]	CS [a]	CS [a]	CS [a]
f_{oc}	fraction organic carbon of soil = percent organic matter/174 (g/g) (ASTM 2974)	0.006 [b]	0.006 [b]	SS [d] (0.006) [b]	SS [d] (0.006) [b]
θ_w	water-filled soil porosity (L_{water}/L_{soil})	0.21 [b]	0.21 [b]	SS [c] (0.21) [b]	SS [c] (0.21) [b]
H'	Henry's Law Constant (dimensionless)	CS [a,e]	CS [a,e]	CS [a,e]	CS [a,e]
θ_a	air-filled soil porosity (L_{air}/L_{soil})	n - θ_w	n - θ_w	n - θ_w	n - θ_w
ρ_s	soil particle density (g/cm^3)	2.65 [b]	2.65 [b]	SS [c] (2.65) [b]	SS [c] (2.65) [b]
n	total soil porosity (L_{pore}/L_{soil})	1 - (ρ_b/ρ_s)	1 - (ρ_b/ρ_s)	1 - (ρ_b/ρ_s)	1 - (ρ_b/ρ_s)

[a]Chemical-specific.
[b]LDEQ default value.
[c]Site-specific.
[d]Site-specific; the sample(s) for f_{oc} determination shall be collected from an un-impacted area that is representative of the soil conditions in the impacted area.
[e]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^{o}K); and T = Absolute temperature of soil (^{o}K) [273 + ^{o}C (25^{o}C)].

EQ38 was obtained from *Soil Screening Guidance: User's Guide,* EPA 1996. In the absence of site-specific data the default values presented in parentheses shall be used.

Note: The $Soil_{sat}$ is not applicable to constituents that are in a solid phase at ambient temperatures (i.e., constituents having melting points equal to or greater than 20^{o}C).

H2.2 Groundwater Standards

Groundwater SS or RS requiring calculation shall be calculated using: (1) the spreadsheets provided at http://www.deq.state.la.us/technology/recap/; or (2) a spreadsheet or computer program that generates an output that is consistent with the output of the LDEQ spreadsheet. All calculations shall be included in the RECAP submittal. Where available, chemical-specific data presented in the worksheets at the end of this Appendix shall be used.

H2.2.1 Groundwater Screening Standard – Risk-based Standard (GW_{SS})

Under the Screening Option, the GW_{SS} is applicable to groundwater meeting Groundwater Classifications 1, 2, and 3 (refer to Section 2.10 for the groundwater classifications). For constituents not listed in Table 1, the MCL shall serve as the GW_{SS}. If an MCL is not available, then a risk-based GW_{SS} shall be calculated as follows:

GW_{SS} - Carcinogenic Effects - Volatile Constituents (mg/l):

$$\frac{TR x AT_c x 365 days/yr}{EF_{ni} x[(SF_i x K_w x IRA_{adj})+(SF_o x IRW_{adj})]} \qquad \textbf{(EQ39)}$$

where:

Parameter	Definition (units)	SO Input Value
GW_{SS}	risk-based chemical concentration in water (mg/L)	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [b]
SF_i	inhalation cancer slope factor ((mg/kg-day)$^{-1}$)	CS [b]
AT_c	averaging time - carcinogens (yr)	70 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]
IRW_{adj}	age-adjusted water ingestion rate (L-yr/kg-day)	1.1 [a]
IRA_{adj}	age-adjusted inhalation rate (m^3-yr/kg-day)	11 [a]
K_w	water-to-indoor air volatilization factor (L/m^3)	0.5 [c,d]

[a] *Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.
[b] Chemical-specific.
[c] *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual Part B Development of Risk-Based Preliminary Remedial Goals*, EPA 1991.
[d] The water-air concentration relationship represented by the volatilization factor (K_w) is applicable only to chemicals with a Henry's Law Constant of greater than 1E-05 atm-m^3/mole and a molecular weight of less than 200 g/mole.

GW_{SS} - Noncarcinogenic Effects - Volatile Constituents (mg/l):

$$\frac{THQ \times BW_a \times AT_{nni} \times 365\ days/yr}{EF_{ni} \times ED_{ni} \times \left[\left(\frac{1}{RfD_i} \times K_w \times IRA_a\right) + \left(\frac{1}{RfDo} \times IRW_a\right)\right]} \quad \textbf{(EQ40)}$$

where:

Parameter	Definition (units)	SO Input Value
GW_{SS}	risk-based chemical concentration in water (mg/L)	--
THQ	target hazard quotient (unitless)	0.1
RfD_i	inhalation reference dose (mg/kg-day)	CS [a]
RfD_o	oral reference dose (mg/kg-day)	CS [a]
BW_a	average adult body weight (kg)	70 [b]
AT_{nni}	averaging time - noncarcinogens, non-industrial (yr)	30 [b]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [b]
ED_{ni}	non-industrial exposure duration (yr)	30 [b]
IRW_a	adult water ingestion rate (L/day)	2 [b]
IRA_a	adult inhalation rate (m^3/day)	20 [b]
K_w	water-to-indoor air volatilization factor (L/m^3)	0.5 [c,d]

[a]Chemical-specific.
[b]*Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003.
[c]*Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual Part B Development of Risk-Based Preliminary Remedial Goals*, EPA 1991.
[d]The water-air concentration relationship represented by the volatilization factor (K_w) is applicable only to chemicals with a Henry's Law Constant of greater than 1E-05 atm-m^3/mole and a molecular weight of less than 200 g/mole.

GW_{SS} - Carcinogenic Effects - Non-Volatile Constituents (mg/l):

$$\frac{TR \times AT_c \times 365\ days/yr}{EF_{ni} \times (SF_o \times IRW_{adj})} \quad \textbf{(EQ41)}$$

where:

Parameter	Definition (units)	SO Input Value
GW_{SS}	risk-based chemical concentration in water (mg/L)	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]
SF_o	oral cancer slope factor ($(mg/kg\text{-}day)^{-1}$)	CS [b]
AT_c	averaging time - carcinogens (yr)	70 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]
IRW_{adj}	age-adjusted water ingestion rate (L-yr/kg-day)	1.1 [a]

[a]*Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003.
[b]Chemical-specific.

GW_{SS} - Noncarcinogenic Effects - Non-Volatile Constituents (mg/l):

$$\frac{THQxBW_a xAT_{nni} x365 days/yr}{EF_{ni} xED_{ni} x(1/RfD_o xIRW_a)} \quad \textbf{(EQ42)}$$

where:

Parameter	Definition (units)	SO Input Value
GW_{SS}	risk-based chemical concentration in water (mg/L)	--
THQ	target hazard quotient (unitless)	0.1
RfD_o	oral reference dose (mg/kg-day)	CS [a]
BW_a	average adult body weight (kg)	70 [b]
AT_{nni}	averaging time - noncarcinogens, non-industrial (yr)	30 [b]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [b]
ED_{ni}	non-industrial exposure duration (yr)	30 [b]
IRW_a	adult water ingestion rate (L/day)	2 [b]

[a]Chemical-specific.
[b]*Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003.

EQ39 through EQ42 were obtained from *Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003. A RECAP Standard shall be determined for both carcinogenic and noncarcinogenic effects and the more protective value shall be used as the RS.

H2.2.2 Groundwater Classification 1 – Risk-based Standard (GW_1)

For constituents not listed in Table 3, the MCL shall serve as the GW_1. If an MCL is not available, then a risk-based GW_1 shall be calculated as follows:

GW_1 - Carcinogenic Effects - Volatile Constituents (mg/l):

$$\frac{TR \, x \, AT_c \, x \, 365 \, days / yr}{EF_{ni} \, x \, [(SF_i \, x \, K_w \, x \, IRA_{adj}) + (SF_o \, x \, IRW_{adj})]} \qquad \textbf{(EQ39)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_1	risk-based chemical concentration in water (mg/L)	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]	10^{-6} [a]	10^{-6} [a]
SF_o	oral cancer slope factor $((mg/kg\text{-}day)^{-1})$	CS [b]	CS [b]	CS [b]
SF_i	inhalation cancer slope factor $((mg/kg\text{-}day)^{-1})$	CS [b]	CS [b]	CS [b]
AT_c	averaging time - carcinogens (yr)	70 [a]	70 [a]	70 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]	350 [a]	350 [a]
IRW_{adj}	age-adjusted water ingestion rate (L-yr/kg-day)	1.1 [a]	1.1 [a]	1.1 [a]
IRA_{adj}	age-adjusted inhalation rate (m^3-yr/kg-day)	11 [a]	11 [a]	11 [a]
K_w	water-to-indoor air volatilization factor (L/m^3)	0.5 [c,d]	0.5 [c,d]	0.5 [c,d]

[a] *Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.
[b] Chemical-specific.
[c] *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual Part B Development of Risk-Based Preliminary Remedial Goals*, EPA 1991.
[d] The water-air concentration relationship represented by the volatilization factor (K_w) is applicable only to chemicals with a Henry's Law Constant of greater than 1E-05 atm-m^3/mole and a molecular weight of less than 200 g/mole.

GW_1 - Noncarcinogenic Effects - Volatile Constituents (mg/l):

$$\frac{THQ \times BW_a \times AT_{nni} \times 365\ days/yr}{EF_{ni} \times ED_{ni} \times \left[\left(\frac{1}{RfD_i} \times K_w \times IRA_a\right) + \left(\frac{1}{RfDo} \times IRW_a\right)\right]} \quad \textbf{(EQ40)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_1	risk-based chemical concentration in water (mg/L)	--	--	--
THQ	target hazard quotient (unitless)	1.0 [a]	1.0 [a]	1.0 [a]
RfD_i	inhalation reference dose (mg/kg-day)	CS [b]	CS [b]	CS [b]
RfD_o	oral reference dose (mg/kg-day)	CS [b]	CS [b]	CS [b]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]
AT_{nni}	averaging time - noncarcinogens, non-industrial (yr)	30 [a]	30 [a]	30 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]	350 [a]	350 [a]
ED_{ni}	non-industrial exposure duration (yr)	30 [a]	30 [a]	30 [a]
IRW_a	adult water ingestion rate (L/day)	2 [a]	2 [a]	2 [a]
IRA_a	adult inhalation rate (m^3/day)	20 [a]	20 [a]	20 [a]
K_w	water-to-indoor air volatilization factor (L/m^3)	0.5 [c,d]	0.5 [c,d]	0.5 [c,d]

[a] *Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003.
[b] Chemical-specific.
[c] *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual Part B Development of Risk-Based Preliminary Remedial Goals*, EPA 1991.
[d] The water-air concentration relationship represented by the volatilization factor (K_w) is applicable only to chemicals with a Henry's Law Constant of greater than 1E-05 atm-m^3/mole and a molecular weight of less than 200 g/mole.

GW_1 - Carcinogenic Effects - Non-Volatile Constituents (mg/l):

$$\frac{TR \; x \; AT_c \; x \; 365 \; days / yr}{EF_{ni} \; x \; (SF_o \; x \; IRW_{adj})} \qquad \textbf{(EQ41)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_1	risk-based chemical concentration in water (mg/L)	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]	10^{-6} [a]	10^{-6} [a]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [b]	CS [b]	CS [b]
AT_c	averaging time - carcinogens (yr)	70 [a]	70 [a]	70 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]	350 [a]	350 [a]
IRW_{adj}	age-adjusted water ingestion rate (L-yr/kg-day)	1.1 [a]	1.1 [a]	1.1 [a]

[a] *Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.
[b] Chemical-specific.

GW_1 - Noncarcinogenic Effects - Non-Volatile Constituents (mg/l):

$$\frac{THQ \; x \; BW_a \; x \; AT_{nni} \; x \; 365 \; days / yr}{EF_{ni} \; x \; ED_{ni} \; x \; \left(1 / RfD_o \; x \; IRW_a\right)} \qquad \textbf{(EQ42)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_1	risk-based chemical concentration in water (mg/L)	--	--	--
THQ	target hazard quotient (unitless)	1.0 [a]	1.0 [a]	1.0 [a]
RfD_o	oral reference dose (mg/kg-day)	CS [b]	CS [b]	CS [b]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]
AT_{nni}	averaging time - noncarcinogens, non-industrial (yr)	30 [a]	30 [a]	30 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]	350 [a]	350 [a]
ED_{ni}	non-industrial exposure duration (yr)	30 [a]	30 [a]	30 [a]
IRW_a	adult water ingestion rate (L/day)	2 [a]	2 [a]	2 [a]

[a] *Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.
[b] Chemical-specific.

H2.2.3 Groundwater Classification 2 – Risk-based Standard (GW_2)

For constituents not listed in Table 3, the MCL shall serve as the GW_2. If an MCL is not available, then a risk-based GW_2 shall be calculated as follows:

(1) Calculate a GW_2 using EQ39, EQ40, EQ41, or EQ42;

GW_2 - Carcinogenic Effects - Volatile Constituents (mg/l):

$$\frac{TR x AT_c x 365 days/yr}{EF_{ni} x[(SF_i x K_w x IRA_{adj})+(SF_o x IRW_{adj})]} \qquad \textbf{(EQ39)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_2	risk-based chemical concentration in water (mg/L)	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]	10^{-6} [a]	10^{-6} [a]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [b]	CS [b]	CS [b]
SF_i	inhalation cancer slope factor ((mg/kg-day)$^{-1}$)	CS [b]	CS [b]	CS [b]
AT_c	averaging time - carcinogens (yr)	70 [a]	70 [a]	70 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]	350 [a]	350 [a]
IRW_{adj}	age-adjusted water ingestion rate (L-yr/kg-day)	1.1 [a]	1.1 [a]	1.1 [a]
IRA_{adj}	age-adjusted inhalation rate (m^3-yr/kg-day)	11 [a]	11 [a]	11 [a]
K_w	water-to-indoor air volatilization factor (L/m^3)	0.5 [c,d]	0.5 [c,d]	0.5 [c,d]

[a] *Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003.
[b] Chemical-specific.
[c] *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual Part B Development of Risk-Based Preliminary Remedial Goals*, EPA 1991.
[d] The water-air concentration relationship represented by the volatilization factor (K_w) is applicable only to chemicals with a Henry's Law Constant of greater than 1E-05 atm-m^3/mole and a molecular weight of less than 200 g/mole.

GW_2 - Noncarcinogenic Effects - Volatile Constituents (mg/l):

$$\frac{THQ \times BW_a \times AT_{nni} \times 365\ days/yr}{EF_{ni} \times ED_{ni} \times \left[\left(\frac{1}{RfD_i} \times K_w \times IRA_a\right) + \left(\frac{1}{RfDo} \times IRW_a\right)\right]} \quad \textbf{(EQ40)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_2	risk-based chemical concentration in water (mg/L)	--	--	--
THQ	target hazard quotient (unitless)	1.0 [a]	1.0 [a]	1.0 [a]
RfD_i	inhalation reference dose (mg/kg-day)	CS [b]	CS [b]	CS [b]
RfD_o	oral reference dose (mg/kg-day)	CS [b]	CS [b]	CS [b]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]
AT_{nni}	averaging time - noncarcinogens, non-industrial (yr)	30 [a]	30 [a]	30 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]	350 [a]	350 [a]
ED_{ni}	non-industrial exposure duration (yr)	30 [a]	30 [a]	30 [a]
IRW_a	adult water ingestion rate (L/day)	2 [a]	2 [a]	2 [a]
IRA_a	adult inhalation rate (m^3/day)	20 [a]	20 [a]	20 [a]
K_w	water-to-indoor air volatilization factor (L/m^3)	0.5 [c,d]	0.5 [c,d]	0.5 [c,d]

[a] *Human Health Medium-Specific Screening Levels*, EPA Region VI, 2003.
[b] Chemical-specific.
[c] *Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual Part B Development of Risk-Based Preliminary Remedial Goals*, EPA 1991.
[d] The water-air concentration relationship represented by the volatilization factor (K_w) is applicable only to chemicals with a Henry's Law Constant of greater than 1E-05 atm-m^3/mole and a molecular weight of less than 200 g/mole.

GW_2 - Carcinogenic Effects - Non-Volatile Constituents (mg/l):

$$\frac{TR \; x \; AT_c \; x \; 365 \; days/yr}{EF_{ni} \; x \; (SF_o \; x \; IRW_{adj})} \qquad \textbf{(EQ41)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_2	risk-based chemical concentration in water (mg/L)	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]	10^{-6} [a]	10^{-6} [a]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [b]	CS [b]	CS [b]
AT_c	averaging time - carcinogens (yr)	70 [a]	70 [a]	70 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]	350 [a]	350 [a]
IRW_{adj}	age-adjusted water ingestion rate (L-yr/kg-day)	1.1 [a]	1.1 [a]	1.1 [a]

[a] *Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.
[b] Chemical-specific.

GW_2 - Noncarcinogenic Effects - Non-Volatile Constituents (mg/l):

$$\frac{THQxBW_a \, xAT_{nni} x365 days/yr}{EF_{ni} \, xED_{ni} \, x(1/RfD_o \, xIRW_a)} \qquad \textbf{(EQ42)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_2	risk-based chemical concentration in water (mg/L)	--	--	--
THQ	target hazard quotient (unitless)	1.0 [a]	1.0 [a]	1.0 [a]
RfD_o	oral reference dose (mg/kg-day)	CS [b]	CS [b]	CS [b]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]
AT_{nni}	averaging time - noncarcinogens, non-industrial (yr)	30 [a]	30 [a]	30 [a]
EF_{ni}	non-industrial exposure frequency (days/yr)	350 [a]	350 [a]	350 [a]
ED_{ni}	non-industrial exposure duration (yr)	30 [a]	30 [a]	30 [a]
IRW_a	adult water ingestion rate (L/day)	2 [a]	2 [a]	2 [a]

[a] *Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.
[b] Chemical-specific.

IRW_{adj} for EQ41, EQ42, EQ43, and EQ44 (L-yr/kg-day):

$$\frac{IRW_c \ x \ ED_c}{BW_c} + \frac{IRW_a \ x \ ED_a}{BW_a} \qquad \textbf{(EQ43)}$$

where:

Parameter	Definition (units)	Input Value
IRW_{adj}	age-adjusted water ingestion rate (L-yr/kg-day)	1.1
IRW_c	child average water ingestion rate ages 1-6 (L/day)	1
ED_c	child exposure duration ages 1-6 (yr)	6
BW_c	average child body weight ages 1-6 (kg)	15
IRW_a	adult average water ingestion rate ages 7-31 (L/day)	2
ED_a	adult exposure duration ages 7-31 (yr)	24
BW_a	average adult body weight ages 7-31 (kg)	70

The IRW_{adj} equation and default parameters were obtained from *Human Health Medium-Specific Screening Levels,* EPA Region VI, 2003.

(2) Under MO-1, the GW_2 shall be multiplied by a DF2 in accordance with Section H1.2.2.2. Under MO-2, a site-specific longitudinal dilution and attenuation factor (DAF2) shall be calculated using the Domenico model (EQ65) and site-specific data and/or default parameters (refer to Section H2.5) and applied to the GW_2 in accordance with Section H1.2.3.2. Under MO-3, a site-specific longitudinal dilution and attenuation factor (DAF2) shall be calculated using the Domenico model or other appropriate model approved by the Department and site-specific data and/or default parameters. Note: The DF2 or the site-specific DAF2 shall be representative of dilution and attenuation of the COC concentration associated with groundwater migration to the nearest downgradient property boundary.

H2.2.4 Groundwater Classification 3 (GW_3)

For constituents not listed in Table 3, refer to Table 1 of LAC 33:IX.1113. For constituents not listed in Table 1 of LAC 33:IX.1113, a GW_3 shall be calculated based on the classification of the nearest surface water body downgradient of the groundwater AOI as follows:

(1) Calculate a GW_3 using EQ44, EQ47, EQ48, or EQ49;

Protection of Surface Water Classified as a Non-Drinking Water Supply:

The State human health protection non-drinking water supply criterion in LAC 33:IX.1113, Table 1 shall be used as the GW_{3NDW}. If a State human health protection non-drinking water supply criterion for a COC does not exist, then compare: (1) the risk-based criterion developed using the equations presented below (a GW_{3NDW} protective of carcinogenic effects and a GW_{3NDW} protective of noncarcinogenic effects shall be calculated and the more protective criterion shall be used as the human health non-drinking water supply criterion); (2) the MCL; and (3) the State human health protection drinking water supply criterion and select the highest of these three values as the GW_{3NDW}. Note: No substitutions shall be made for the input values presented below for the calculation of the GW_{3NDW}. A GW_{3NDW} RS shall be determined for both carcinogenic and noncarcinogenic effects and the more protective value shall be used as the RS. EQ44 and EQ47 were obtained from *Human Health Numerical Criteria Derivations for Toxic Substances*, LDEQ, Office of Water Resources, June 23, 1994. For the generation of Table 3, the State human health protection non-drinking water supply criterion was identified in LAC 33:IX.1113, Table 1; if a criterion was not available, then (1) a GW_{3NDW} was determined for both carcinogenic and noncarcinogenic effects and the lower of the two values was identified as the GW_{3NDW}; (2) the MCL was identified; and (3) the State human health protection drinking water supply criterion was identified in LAC 33:IX.1113, Table 1 and the highest of the three values was listed as the GW_{3NDW}.

GW_{3NDW} - Protection of Surface Water Classified as a Non-Drinking Water Supply - Carcinogenic Effects (mg/l):

$$\frac{TR \times BW_a}{SF_o[IRW_{NDW} + (BCF \times IRF)]} \qquad \textbf{(EQ44)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_{3NDW}	risk-based constituent concentration in water (mg/l)	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]	10^{-6} [a]	10^{-6} [a]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]	0.02 [a]	0.02 [b]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [c]	CS [c,d]	CS [c,d]
IRW_{NDW}	incidental water ingestion rate (L/day)	0.089 [a,e]	0.089 [a,e]	0.089 [a,e]
BCF	bioconcentration factor (L/kg)	CS [c,f]	CS [c,f]	CS [c,f]

[a] *Human Health Criteria Derivations for Toxic Substances,* LDEQ 1994.

[b] An fish ingestion rate of 0.02 kg/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, a fish ingestion rate of 0.0065 kg/day shall be used.

[c] Chemical-specific; if the COC is listed in Tables 1-3, the chemical-specific data presented in the worksheets at the end of this Appendix shall be used under MO-2 and MO-3; if the COC is not listed in Tables 1-3, the Submitter shall follow the hierarchy of references listed at the end of this Appendix for the collection of chemical-specific data.

[d] For the calculation of a GW_{3NDW} for PCB, the equation presented above will have to be modified to include a SF for water ingestion and SF for fish ingestion. A RECAP Standard shall be determined for both carcinogenic and noncarcinogenic effects and the more protective value shall be used as the risk-based RS.

[e] An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, an incidential water ingestion rate of 0 L/day shall be used.

[f] If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K_{ow} and EQ45 (and/or EQ46) presented below or using another appropriate model approved by the Department.

$$\log BCF = 0.76 \log K_{ow} - 0.23 \qquad \textbf{(EQ45)}$$

where:

Parameter	Definition	Input Value
BCF	Bioconcentration factor (L/kg)	chemical-specific
K_{ow}	Octanol-water partition coefficient	chemical-specific

(EQ45: Fundamentals of Aquatic Toxicology. 1985. Ed. Rand and S. Petrocelli, Washington: Hemisphere Publishing Corp., Chapter 17, Bioaccumulation, A. Ipacie and J. L. Hamelink)

If a K_{ow} is not available in the literature, a K_{ow} value may be estimated from the K_{oc} using the equation presented below (or other appropriate model):

$$\text{Log } K_{oc} = 0.0784 + (0.7919 \text{ x log } K_{ow}) \quad \textbf{(EQ46)}$$

(EQ46: *Soil Screening Guidance: Technical Background Document*, EPA, 1996).

GW_{3NDW} - Protection of a Surface Water Classified as a Non-Drinking Water Supply - Noncarcinogenic Effects (mg/l):

$$\frac{THQ \times RfD_o \times BW_a}{IRW_{NDW} + (BCF \times IRF)} \qquad \textbf{(EQ47)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_{3NDW}	risk-based constituent concentration in water (mg/l)	--	--	--
THQ	target hazard quotient (unitless)	1.0 [a]	1.0 [a]	1.0 [a]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]	0.02 [a]	0.02 [a,b]
RfD_o	oral reference dose (mg/kg-day)	CS [c]	CS [c,d]	CS [c,d]
IRW_{NDW}	incidental water ingestion rate (L/day)	0.089 [a,e]	0.089 [a,e]	0.089 [a,e]
BCF	bioconcentration factor (L/kg)	CS [c,f]	CS [c,f]	CS [c,f]

[a] *Human Health Numerical Criteria Derivations for Toxic Substances*, LDEQ 1994.

[b] An fish ingestion rate of 0.02 kg/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, a fish ingestion rate of 0.0065 kg/day shall be used.

[c] Chemical-specific; if the COC is listed in Tables 1-3, the chemical-specific data presented in the worksheets at the end of this Appendix shall be used under MO-2 and MO-3; if the COC is not listed in Tables 1-3, the Submitter the hierarchy pf references presented at the end of this Appendix for the collection of chemical-specific data.

[d] For the calculation of a GW_{3NDW} for PCB, the equation presented above will have to be modified to include a SF for water ingestion and SF for fish ingestion. A RECAP Standard shall be determined for both carcinogenic and noncarcinogenic effects and the more protective value shall be used as the risk-based RS.

[e] An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion. For water bodies designated as classification B secondary contact recreation and limited aquatic and wildlife use, an incidential water ingestion rate of 0 L/day shall be used.

[f] If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K_{ow} and EQ45 and/or EQ46 or another appropriate model approved by the Department.

Protection of Surface Water Classified as a Drinking Water Supply:

The State human health protection drinking water supply criterion in LAC 33:IX.1113, Table 1 shall be used as the GW_{3DW}. If a State human health protection drinking water supply criterion is not available, then the MCL shall be used. If an MCL is not available for a COC, then a risk-based criterion shall be developed using the equation presented below. A GW_{3DW} protective of carcinogenic effects and a GW_{3DW} protective of noncarcinogenic effects shall be calculated and the lower of the two values shall be used as the human health drinking water supply criterion. Note: No substitutions shall be made for the input values presented below for the calculation of the GW_{3DW}. A GW_{3DW} RS shall be determined for both carcinogenic and noncarcinogenic effects and the more protective value shall be used as the RS. EQ48 and EQ49 were obtained from *Human Health Numerical Criteria Derivations for Toxic Substances*, LDEQ, Office of Water Resources, June 23, 1994. For the generation of Table 3, the State human health protection drinking water supply criterion was identified in LAC 33:IX.1113, Table 1; if a criterion was not available, the MCL was identified as the GW_{3DW}; if an MCL was not available, a GW_{3DW} was determined for both carcinogenic and noncarcinogenic effects and the lower of the two values was identified as the GW_{3DW}.

GW_{3DW} - Protection of a Surface Water Classified as a Drinking Water Supply - Carcinogenic Effects (mg/l):

$$\frac{TR x BW_a}{SF_o x\left[IRW_a + IRW_{NDW} + \left(BCF x IRF\right)\right]} \qquad \textbf{(EQ48)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_{3DW}	risk-based constituent concentration in water (mg/l)	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	10^{-6} [a]	10^{-6} [a]	10^{-6} [a]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]	0.02 [a]	0.02 [a]
SF_o	oral cancer slope factor ((mg/kg-day)$^{-1}$)	CS [b]	CS [b,c]	CS [b,c]
IRW_a	adult water ingestion rate (L/day)	2 [a]	2 [a]	2 [a]
IRW_{NDW}	incidental water ingestion rate (L/day)	0.089 [a,d]	0.089 [a,d]	0.089 [a,d]
BCF	bioconcentration factor (L/kg)	CS [b,e]	CS [b,e]	CS [b,e]

[a] *Human Health Numerical Criteria Derivations for Toxic Substances*, LDEQ 1994.

[b] Chemical-specific; if the COC is listed in Tables 1-3, the chemical-specific data presented in the worksheets at the end of this Appendix shall be used under MO-2 and MO-3; if the COC is not listed in Tables 1-3, the Submitter shall establish an hierarchy for the collection of chemical-specific data.

[c] For the calculation of a GW_{3DW} for PCBs, the equation presented above will have to be modified to include a SF for water ingestion and slope factor for fish ingestion. A RECAP Standard shall be

determined for both carcinogenic and noncarcinogenic effects and the more protective value shall be used as the risk-based RS.

[d]An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion.

[e]If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K_{ow} and EQ45 and/or EQ46 or another appropriate model approved by the Department.

GW_{3DW} - Protection of Surface Water Classified as a Drinking Water Supply - Noncarcinogenic Effects (mg/l):

$$\frac{THQxRfD_o xBW_a}{IRW_a + IRW_{NDW} + (BCFxIRF)} \qquad \textbf{(EQ49)}$$

where:

Parameter	Definition (units)	Input Value		
		MO-1	**MO-2**	**MO-3**
GW_{3DW}	risk-based constituent concentration in water (mg/l)	--	--	--
THQ	target hazard quotient (unitless)	1.0 [a]	1.0 [a]	1.0 [a]
BW_a	average adult body weight (kg)	70 [a]	70 [a]	70 [a]
IRF	fish/shellfish ingestion rate (kg/day)	0.02 [a]	0.02 [a]	0.02 [a]
RfD_o	oral reference dose (mg/kg-day)	CS [b]	CS [b,c]	CS [b,c]
IRW_a	adult water ingestion rate (L/day)	2 [a]	2 [a]	2 [a]
IRW_{NDW}	incidental water ingestion rate (L/day)	0.089 [a,d]	0.089 [a,d]	0.089 [a,d]
BCF	bioconcentration factor (L/kg)	CS [b,e]	CS [b,e]	CS [b,e]

[a]*Human Health Numerical Criteria Derivations for Toxic Substances*, LDEQ 1994.

[b]Chemical-specific; if the COC is listed in Tables 1-3, the chemical-specific data presented in the worksheets at the end of this Appendix shall be used under MO-2 and MO-3; if the COC is not listed in Tables 1-3, the Submitter shall establish an hierarchy for the collection of chemcial-specific data.

[c]For the calculation of a GW_{3DW} for PCBs, the equation presented above will have to be modified to include a SF for water ingestion and slope factor for fish ingestion. A RECAP Standard shall be determined for both carcinogenic and noncarcinogenic effects and the more protective value shall be used as the risk-based RS.

[d]An incidental ingestion rate of 0.089 L/day shall be used in accordance with the calculation of Louisiana Water Quality Standards for water bodies designated for primary contact recreation. This rate is based on the following assumptions: 250 mL/hr possible ingestion X 5 hrs/week swimming duration X 6 months/12 months swimming season X 1 week/7 days = 0.089 L/day incidental ingestion.

[e]If there is potential for a COC to be bioconcentrated by fish and a BCF value is not available for the COC, then a BCF may be estimated using the K_{ow} and EQ45 and/or EQ46 or another appropriate model approved by the Department.

(2) Under MO-1, the GW_3 shall be multiplied by a DF3 in accordance with Section H1.1.2.1. Under MO-2, a site-specific longitudinal dilution and attenuation factor (DAF3) shall be calculated using the Domenico model (EQ65) and site-specific data and/or default parameters and applied to the GW_3 in accordance with Section H1.1.3.1. Under MO-3, a site-specific longitudinal dilution and attenuation factor (DAF3) shall be calculated using the Domenico model or other appropriate model approved by the Department and site-specific data and/or default parameters. Note: The DF3 or the site-specific DAF3 shall be representative of dilution and attenuation of the COC concentration associated with groundwater migration to the nearest downgradient surface water body.

H2.2.5 Volatile Emissions from Groundwater to an Enclosed Structure Pathway (GW_{es})

GW_{es} (mg/l):

$$\frac{C_a\left[\frac{\mu g}{m^3 - air}\right]}{VF_{GWes}} x10^{-3}\frac{mg}{\mu g} \qquad \textbf{(EQ50)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
GW_{es}	risk-based chemical concentration in groundwater for enclosed structure (indoor) vapor inhalation (mg/l)	NA [a]	--	--	--
C_a	risk-based chemical concentration in air for enclosed-structure (indoor) vapor inhalation ($\mu g/m^3$)	NA [a]	refer to Section H2.3	refer to Section H2.3	refer to Section H2.3
VF_{GWes}	groundwater to enclosed-structure vapor volatilization factor ($mg/m^3/mg/l$)	NA [a]	EQ51-EQ52 [b]	EQ51 - EQ52 [b]	EQ51 - EQ52 [b]

[a]Not Applicable to this Option.
[b]Refer to EQ51 for non-industrial land use and EQ52 for industrial land use.

VF_{GWesni} – Non-industrial Scenario ($mg/m^3/mg/L$):

$$\frac{H'\left[\frac{D_{ws}/L_{GW}}{ER_{ni}xL_{Bni}}\right]}{1+\left[\frac{D_{ws}/L_{GW}}{ER_{ni}xL_{Bni}}\right]+\left[\frac{D_{ws}/L_{GW}}{(D_{crack}/L_{crack})FC}\right]}x10^3\frac{L}{m^3} \qquad \textbf{(EQ51)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
VF_{GWesni}	groundwater to enclosed-structure vapor volatilization factor for a non-industrial scenario ($mg/m^3/mg/l$)	NA [a]	--	--	--
H'	Henry's Law Constant (dimensionless)	NA [a]	CS [b,c]	CS [b,c]	CS [b,c]
D_{ws}	effective diffusion coefficient between groundwater and soil surface (cm^2/s)	NA [a]	CS [b]	SS [d]	SS [d]
L_{GW}	depth to groundwater (cm)	NA [a]	300	SS [e]	SS [e]
ER_{ni}	non-industrial enclosed-structure air exchange rate (1/s)	NA [a]	0.00014	SS [e] (0.00014)	SS [e] (0.00014)
L_{Bni}	non-industrial enclosed-structure volume/infiltration area ratio (cm)	NA [a]	200	SS [e] (200)	SS [e] (200)
FC	areal fraction of cracks in foundation/walls (cm^2cracks/cm^2 total area)	NA [a]	0.01	SS [e] (0.01)	SS [e] (0.01)
L_{crack}	enclosed-structure foundation or wall thickness (cm)	NA [a]	15	SS [e] (15)	SS [e] (15)
D_{crack}	effective diffusion coefficient through foundation cracks (cm^2/s)	NA [a]	CS [b]	SS [f]	SS [f]

[a]Not Applicable to this Option.
[b]Chemical-specific.
[c]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^oC)].
[d]Refer to EQ53.
[e]Site-specific; a default value demonstrated to be representative of site conditions may be used in the Johnson and Ettinger model if approved by the Department. Department approval for the use of an alternate default value shall be obtained prior to calculation of the GW_{es} RS.
[f] Site-specific; refer to EQ30.

VF_{GWesi} – Industrial Scenario ($mg/m^3/mg/L$):

$$\frac{H'\left[\frac{D_{ws}/L_{GW}}{ER_i x L_{Bi}}\right]}{1+\left[\frac{D_{ws}/L_{GW}}{ER_i x L_{Bi}}\right]+\left[\frac{D_{ws}/L_{GW}}{(D_{crack}/L_{crack})FC}\right]} x10^3 \frac{L}{m^3} \qquad \textbf{(EQ52)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
VF_{GWesi}	groundwater to enclosed-structure vapor volatilization factor for an industrial scenario ($mg/m^3/mg/l$)	NA [a]	--	--	--
H'	Henry's Law Constant (dimensionless)	NA [a]	CS [b]	CS [b]	CS [b]
D_{ws}	effective diffusion coefficient between groundwater and soil surface (cm^2/s)	NA [a]	CS [b]	SS [c]	SS [c]
L_{GW}	depth to groundwater (cm)	NA [a]	300	SS [d]	SS [d]
ER_i	industrial enclosed-structure air exchange rate (1/s)	NA [a]	0.00023	SS [d] (0.00023)	SS [d] (0.00023)
L_{Bi}	industrial enclosed-structure volume/infiltration area ratio (cm)	NA [a]	300	SS [d] (300)	SS [d] (300)
FC	areal fraction of cracks in foundation/walls (cm^2cracks/cm^2 total area)	NA [a]	0.01	SS [d] (0.01)	SS [d] (0.01)
L_{crack}	enclosed-structure foundation or wall thickness (cm)	NA [a]	15	SS [d] (15)	SS [d] (15)
D_{crack}	effective diffusion coefficient through foundation cracks (cm^2/s)	NA [a]	CS [b]	SS [e]	SS [e]

[a]Not Applicable to this Option.
[b]Chemical-specific; H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^oC)].
[c]Site-specific; refer to EQ53.
[d]Site-specific; a default value demonstrated to be representative of site conditions may be used in the Johnson and Ettinger model if approved by the Department. Department approval for the use of an alternate default value shall be obtained prior to calculation of the GW_{es} RS.
[e]Site-specific; refer to EQ30.

D_{ws} (cm^2/s):

$$D_{ws}\left[\frac{cm^2}{s}\right] = (h_{cap} + h_v)\left[\frac{h_{cap}}{D_{cap}} + \frac{h_v}{D_s}\right]^{-1} \quad \textbf{(EQ53)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
D_{ws}	effective diffusion coefficient between groundwater and soil surface (cm^2/s)	NA [a]	--	--	--
h_{cap}	thickness of capillary fringe (cm)	NA [a]	5	SS [b] (5)	SS [b] (5)
h_v	thickness of vadose zone (cm)	NA [a]	295	SS [b] (295)	SS [b] (295)
D_{cap}	effective diffusion coefficient through capillary fringe (cm^2/s)	NA [a]	CS [c]	SS [d]	SS [d]
D_s	effective diffusion coefficient in soil based on vapor-phase concentration (cm^2/s)	NA [a]	CS [c]	SS [e]	SS [e]

[a]Not Applicable to this Option.
[b]Site-specific; a default value demonstrated to be representative of site conditions may be used in the Johnson and Ettinger model if approved by the Department. Department approval for the use of an alternate default value shall be obtained prior to calculation of the GW_{es} RS.
[c]Chemical-specific.
[d]Site-specific; refer to EQ54.
[e]Site-specific; refer to EQ29.

D_{cap} (cm^2/s):

$$D_{air}\frac{\theta_{acap}^{3.33}}{n^2}+D_{wat}\frac{1}{H'}\frac{\theta_{wcap}^{3.33}}{n^2} \qquad \textbf{(EQ54)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
D_{cap}	effective diffusion coefficient through capillary fringe (cm^2/s)	NA [a]	--	--	--
D_{air}	diffusion coefficient in air (cm^2/s)	NA [a]	CS [b]	CS [b]	CS [b]
θ_{acap}	volumetric air content in capillary fringe soils (cm^3-air/cm^3soil)	NA [a]	n-θ_{wcap} (0.015)	SS [c] n-θ_{wcap} (0.015)	SS [c] n-θ_{wcap} (0.015)
n	total soil porosity (L_{pore}/L_{soil})	NA [a]	(1-ρ_b/ρ_s)	(1-ρ_b/ρ_s)	(1-ρ_b/ρ_s)
θ_{wcap}	volumetric water content in capillary fringe soils (cm^3-H_2O/cm^3-soil)	NA [a]	0.345 [d]	SS [c] (0.345) [d]	SS [c] (0.345) [d]
D_{wat}	diffusion coefficient in water (cm^2/s)	NA [a]	CS [b]	CS [b]	CS [b]
ρ_b	dry soil bulk density (g/cm^3)	NA [a]	1.7 [d]	SS [c] (1.7) [d]	SS [c] (1.7) [d]
ρ_s	soil particle density (g/cm^3)	NA [a]	2.65 [d]	SS [c] (2.65) [d]	SS [c] (2.65) [d]
H′	Henry's Law Constant (dimensionless)	NA [a]	CS [b,e]	CS [b,e]	CS [b,e]

[a]Not Applicable to this Option.
[b]Chemical-specific.
[c]Site-specific; a default value demonstrated to be representative of site conditions may be used in the Johnson and Ettinger model if approved by the Department. Department approval for the use of an alternate default value shall be obtained prior to calculation of the GW_{es} RS.
[d]LDEQ
[e]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^oC)].

EQ29, EQ30, EQ50, EQ51, EQ52, EQ53, and EQ54 were obtained from *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*, ASTM E-1739 with the exception of the default input values footnoted LDEQ. Additional information on the Johnson and Ettinger Model is available in *Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (EPA November 2002).

H2.2.6 Volatile Emissions from Groundwater to Ambient Air Pathway (GW_{air})

GW_{air} (mg/l):

$$\frac{C_a\left[\frac{\mu g}{m^3 - air}\right]}{VF_{GW_{air}}} x10^{-3} \frac{mg}{\mu g} \qquad \textbf{(EQ55)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
GW_{air}	risk-based chemical concentration in groundwater for ambient air (outdoor) vapor inhalation (mg/l)	NA [a]	--	--	--
C_a	risk-based chemical concentration in air for ambient air (outdoor) vapor inhalation ($\mu g/m^3$)	NA [a]	refer to Section H2.3	refer to Section H2.3	refer to Section H2.3
VF_{GWair}	groundwater to ambient air vapor volatilization factor ($mg/m^3/mg/l$)	NA [a]	EQ56	EQ56	EQ56

[a]Not Applicable for this Option.

VF_{Gwair} ($mg/m^3/mg/L$):

$$\frac{H'}{1+\left[\frac{U_{air}\delta_{air}L_{GW}}{WD_{ws}}\right]} x10^3 \frac{L}{m^3} \qquad \textbf{(EQ56)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
VF_{GWair}	groundwater to ambient air vapor volatilization factor ($mg/m^3/mg/l$)	NA [a]	--	--	--
H′	Henry's Law Constant (dimensionless)	NA [a]	CS [b,c]	CS [b,c]	CS [b,c]
D_{ws}	effective diffusion coefficient between groundwater and soil surface (cm^2/s)	NA [a]	CS [b]	SS [d]	SS [d]
L_{GW}	depth to groundwater (cm)	NA [a]	300	SS [e]	SS [e]
U_{air}	wind speed above ground surface in ambient mixing zone (cm/s)	NA [a]	225	SS [e] (225)	SS [e] (225)
W	width of source area parallel to wind (cm)	NA [a]	4511	SS [e]	SS [e]
δ_{air}	ambient air mixing zone height (cm)	NA [a]	200	SS [e] (200)	SS [e] (200)

[a]Not Applicable for this Option.
[b]Chemical-specific.
[c]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^oK); and T = Absolute temperature of soil (^oK) [273 + ^oC (25^oC)].
[d]Site-specific; refer to EQ53.
[e]Site-specific.

H2.2.7 Water Solubility

The water solubility ($Water_{sol}$) shall be considered in the identification of the limiting groundwater RS for Groundwater Classifications 1, 2, and 3. The $Water_{sol}$ shall be identified in Table 3 of the text. If a COC is not listed in Table 3, a $Water_{sol}$ value shall be identified from an appropriate reference. A $Water_{sol}$ value used as a RS is subject to Department approval.

H2.3 Risk-Based Constituent Concentration in Air (C_a) for GW_{es}, GW_{air}, and $Soil_{es}$

MO-1 and MO-2: Identify the C_a in Table H-5. If a COC is not listed in Table H-5, refer to the Louisiana Toxic Air Pollutant Ambient Air Standards in Table 51.2 of LAC 33:III.5112. If the COC is a noncarcinogen, identify the 8-hour average ambient air standard as the C_a. If the COC is a carcinogen, identify the annual average ambient air standard as the C_a. If a COC is not listed in Table 51.2, a risk-based C_a for the appropriate land use shall be calculated using EQ57, EQ58, EQ59, or EQ60 (C_a shall not be calculated using the methods for standard development under LAC 33:III.5112). If multiple COC are present, the C_a shall be adjusted to account for additive health effects as warranted based on site-specific conditions.

MO-3: The C_a shall be based on: (1) the C_a in Table H-5: if a COC is not listed in Table H-5, refer to the Louisiana Toxic Air Pollutant Ambient Air Standards in Table 51.2 of LAC 33:III.5112; if the COC is a noncarcinogen, identify the 8-hour average ambient air standard as the C_a; if the COC is a carcinogen, identify the annual average ambient air satandard as the C_a; (2) a risk-based value calculated using EQ57, EQ58, EQ59, or EQ60 and default exposure assumptions for the appropriate land use scenario (a risk-based C_a shall not be calculated using the methods for standard development under LAC 33:III.5112); (3) a risk-based value calculated using EQ57, EQ58, EQ59, or EQ60 based on site-specific exposure data (a C_a shall not be calculated using the methods for standard development under LAC 33:III.5112); or (4) other risk-based value determined to be acceptable for site-specific conditions and approved by the Department. If multiple COC are present, the C_a shall be adjusted to account for additive health effects as warranted based on site-specific conditions.

If a C_a is below the analytical quantitation limit, then the analytical quantitation limit shall be identified as the C_a. The analytical quantitation limit identified for application as a C_a shall be the lowest quantitation limit available by routine analysis and shall be approved by the Department prior to use.

If the C_a is below a Department-approved (refer to Section 2.13) background concentration, the background concentration shall be shall be identified as the C_a.

For a non-detect result, the SQL shall be compared to C_a to document that the SQL is less than or equal to the C_a prior to eliminating the constituent from further evaluation under the RECAP.

If a calculated vapor concentration (C_a) exceeds the maximum theoretical vapor concentration, then the maximum theoretical vapor concentration shall be used as the C_a for the calculation of the $Soil_{es}$ (EQ26), GW_{es} (EQ50), and GW_{air} RS (EQ55). The maximum theoretical vapor concentration is subject to Department approval.

Risk-based C_a for Non-Industrial Land Use (C_{ani})

C_{ani} – Carcinogenic Effects (ug/m^3):

$$\frac{TR x AT_c x 365 \frac{days}{year} x 10^3 \mu g / mg}{EF_{ni} x SF_i x IRA_{adj}} \qquad \textbf{(EQ57)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
C_{ani}	non-industrial risk-based chemical concentration in air for vapor inhalation (µg/m^3)	NA [a]	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	NA [a]	10^{-6}	10^{-6}	10^{-6} [b]
SF_i	inhalation cancer slope factor (mg/kg-day)$^{-1}$	NA [a]	CS [c]	CS [c]	CS [c]
AT_c	averaging time - carcinogens (year)	NA [a]	70	70	70
EF_{ni}	non-industrial exposure frequency (days/year)	NA [a]	350	350	350
IRA_{adj}	age-adjusted inhalation rate (m^3-yr/kg-d)	NA [a]	11	11	11

[a]Not Applicable.
[b]Refer to Section 2.14.3.
[c]Chemical-specific.

C_{ani} - Noncarcinogenic Effects (ug/m^3):

$$\frac{THQ x RfD_i x BW_a x AT_{nni} x 365 \frac{days}{year} x 10^3 \frac{\mu g}{mg}}{IRA_a x EF_{ni} x ED_{ni}} \qquad \textbf{(EQ58)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
C_{ani}	non-industrial risk-based chemical concentration in air for vapor inhalation (µg/m^3)	NA [a]	--	--	--
THQ	target hazard quotient (unitless)	NA [a]	1.0	1.0	1.0
RfD_i	inhalation reference dose (mg/kg-day)	NA [a]	CS [b]	CS [b]	CS [b]
BW_a	adult body weight (kg)	NA [a]	70	70	70
IRA_a	adult indoor inhalation rate (m^3/day)	NA [a]	20	20	20
EF_{ni}	non-industrial exposure frequency (days/year)	NA [a]	350	350	350
AT_{nni}	averaging time- noncarcinogens, non-industrial (yr)	NA [a]	30	30	30
ED_{ni}	non-industrial exposure duration (yr)	NA [a]	30	30	30

[a]Not Applicable.
[b]Chemical-specific.

A C_{ani} shall be determined for both carcinogenic and noncarcinogenic effects and the more conservative value shall be used as the RS.

Risk-Based C_a Industrial/Commerical Land Use (C_{ai})

C_{ai} – Carcinogenic Effects (ug/m^3):

$$\frac{TR x BW_a x AT_c x 365 \frac{days}{years} x 10^3 \frac{\mu g}{mg}}{SF_i x IRA_a x EF_i x ED_i} \qquad \textbf{(EQ59)}$$

where:

Parameter	Definiton (units)	Input Value (Default Value)			
		SO	**MO-1**	**MO-2**	**MO-3**
C_{ai}	industrial risk-based chemical concentration in air for vapor inhalation (µg/m^3)	NA [a]	--	--	--
TR	target excess individual lifetime cancer risk (unitless)	NA [a]	10^{-6}	10^{-6}	10^{-6} [b]
SF_i	inhalation cancer slope factor (mg/kg-day)$^{-1}$	NA [a]	CS [c]	CS [c]	CS [c]
EF_i	industrial exposure frequency (days/year)	NA [a]	250	250	SS [d] (250)
ED_i	industrial exposure duration (yr)	NA [a]	25	25	SS [d] (25)
BW_a	average adult body weight (kg)	NA [a]	70	70	70
AT_c	averaging time - carcinogens (yr)	NA [a]	70	70	70
IRA_a	adult inhalation rate (m^3/day)	NA [a]	20	20	SS [d] (20)

[a]Not Applicable.
[b]Refer to Section 2.14.3.
[c]Chemical-specific.
[d]Site-specific.

C_{ai} – Noncarcinogenic Effects (ug/m^3):

$$C_{ai}(\mu g/m^3) = \frac{THQ \times RfD_i \times BW_a \times AT_{ni} \times 365\frac{days}{year} \times 10^3 \frac{\mu g}{mg}}{IRA_a \times EF_i \times ED_i} \quad \textbf{(EQ60)}$$

where:

Parameter	Definition (units)	Input Value			
		SO	**MO-1**	**MO-2**	**MO-3**
C_{ai}	industrial risk-based chemical concentration in air for vapor inhalation (µg/m^3)	NA [a]	--	--	--
THQ	target hazard quotient (unitless)	NA [a]	1.0	1.0	1.0
RfD_i	inhalation reference dose (mg/kg-day)	NA [a]	CS [b]	CS [b]	CS [b]
BW_a	adult body weight (kg)	NA [a]	70	70	70
IRA_a	adult inhalation rate (m^3/day)	NA [a]	20	20	SS [c] (20)
EF_i	industrial exposure frequency (days/year)	NA [a]	250	250	SS [c] (250)
AT_{ni}	averaging time- noncarcinogen, industrial (yr)	NA [a]	25	25	SS [c] (25)
ED_i	industrial exposure duration (yr)	NA [a]	25	25	SS [c] (25)

[a]Not Applicable.
[b]Chemical-specific.
[c]Site-specific.

A C_{ai} shall be determined for both carcinogenic and noncarcinogenic effects and the more conservative value shall be used as the RS.

H2.4 Summers Model

The mixing of unimpacted groundwater with impacted infiltration and the resultant concentrations in groundwater are estimated using the Summers Model:

$DF_{Summers}$:

$$\frac{(Q_\rho + Q_a)}{Q_\rho} = \frac{C_l}{C_{si}} \qquad \textbf{(EQ61)}$$

where:

Parameter	Definition (units)	Input Value
C_{si}	constituent concentration in the groundwater (mg/l or g/m^3)	--
Q_ρ	volumetric flow rate of infiltration (soil pore water) from the AOI into the aquifer (m^3/day)	site-specific (refer to EQ61)
Q_a	volumetric flow rate of groundwater (m^3/day)	site-specific (refer to EQ62)
C_l	dissolved constituent concentration in the liquid phase (mg/l)	site-specific (refer to EQ63)

The volumetric flow rate of infiltration from the AOI into the aquifer:

Q_ρ (m^3/day):

$I \times S_W \times L$ **(EQ62)**

where:

Parameter	Definition (units)	Input Value (Default Value)
Q_ρ	volumetric flow rate of infiltration (soil pore water) from the AOI into the aquifer (m^3/day)	site-specific
I	infiltration rate (m/yr)	site-specific (0.1) [a]
S_W	source width perpendicular to groundwater flow (m)	site-specific
L	length of impacted area parallel to flow direction of aquifer (m)	site-specific

[a] *Soil Screening Guidance, User's Guide*, EPA 1996.

The volumetric flow rate of the groundwater is estimated as:

Q_a (m^3/day):

$D_v \times S_d \times S_W$ **(EQ63)**

where:

Parameter	Definition (units)	Input Value (Default Value)
Q_a	volumetric flow rate of groundwater (m^3/day)	--
D_v	groundwater darcy velocity in the aquifer (K x i) (m/yr)	site-specific (9.144 m/yr)
S_d	source thickness (i.e., the thickness of the impacted groundwater within the permeable zone) (m)	refer to EQ39
S_W	width of impacted area perpendicular to flow direction of aquifer (m)	site-specific

The aqueous-phase concentration (C_l) is estimated from the total soil concentration (C_{Tw}) as follows:

C_l (mg/l):

$$C_{Tw}\left(\frac{[(\rho_w x\theta_w)+\rho_b]}{\rho_b K_d+\theta_w+(n-\theta_w)xH'}\right) \qquad \textbf{(EQ64)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)
C_l	dissolved constituent concentration in the liquid phase (mg/l)	--
C_{Tw}	total soil concentration on a wet weight basis (mg/kg)	site-specific
ρ_w	density of water (g/cm^3)	1.0
ρ_b	dry bulk density of soil (g/cm^3)	site-specific (1.7) [a]
ρ_s	soil particle density (g/cm^3)	site-specific (2.65) [a]
n	total porosity of soil (L_{pore}/L_{soil})	site-specific (1 - ρ_b/ρ_s)
θ_w	water filled soil porosity (L_{water}/L_{soil})	site-specific (0.21) [a]
K_{oc}	soil organic carbon partition coefficient (cm^3/g)	chemical specific
f_{oc}	fractional organic carbon in soil = percent organic matter /174 (g/g) (ASTM 2974)	site-specific (0.006) [a]
K_d	soil water partition coefficient = K_{oc} x f_{oc} (cm^3/g)	chemical-specific
H'	Henry's Law Constant (dimensionless)	chemical-specific [b]

[a]LDEQ default value.
[b]H' = H x 41 where: H = Henry's Law Constant (atm-m^3/mol); R = Universal Law Constant (0.0000821 atm-m^3/mole-^{o}K); and T = Absolute temperature of soil (^{o}K) [273 + ^{o}C (25^{o}C)].

H2.5 Domenico Model

Before site-specific $DAF_{Domenico}$ values are developed using the Domenico model equation presented below, the boundary conditions used to derive this equation shall be reviewed to determine if all of the assumptions are appropriate for the case being modeled (see reference) [a]. The Department will only allow the use of a $DAF_{Domenico}$ that is based on the modeling of an infinite permeable zone to a distance of 2000 feet if constituent retardation and first-order degradation rate values are set to LDEQ default values (an equivalent situation was provided to typical UST sites). Otherwise, site-specific conditions (geological conditions) are to be taken into account in the model equation. If there is the potential for constituent migration to be influenced by pumping activities within the zone, a site-specific DAF shall not be calculated using the Domenico model. The Submitter may develop a site-specific DAF using an appropriate model under MO-3. An example $DAF_{Domenico}$ calculation of a case where the vertical boundary of the permeable zone is finite and the horizontal boundary of the permeable zone is considered infinite is provided at the end of this Appendix.

$DAF_{Domenico}$ [a]:

$$\frac{C_{si}}{C_{(x)_i}} = 1/\left(\exp\left(\frac{x}{2\alpha_x}\left[1-\sqrt{1+\frac{4\lambda_i \alpha_x R_i}{v}} \right] \right) \left(erf\left[\frac{S_w}{4\sqrt{\alpha_y x}} \right] \right) \left(erf\left[\frac{S_d}{2\sqrt{\alpha_z x}} \right] \right) \right) \qquad \textbf{(EQ65)}$$

where:

Parameter	Definition	Input Value (Default Value)		
		MO-1	**MO-2**	**MO-3**
$C_{(x)i}$	concentration of constituent i in groundwater at distance *x* downstream of source (mg/L) or (mg/m^3)	--	--	--
C_{si}	concentration of constituent i in source zone (mg/L) or (mg/m^3)	--	--	--
S_w	source width perpendicular to groundwater flow (m)	45 [b]	SS [c]	SS [c]
D_v	groundwater Darcy velocity (K x i) (m/yr)	9.1 [d]	SS [c] (9.1)	SS [c] (9.1)
n	total soil porosity (L_{pore}/L_{soil}))	0.36 [d]	SS [c] ($1-\rho_b/\rho_s$)	SS [c] ($1-\rho_b/\rho_s$)
λ_i	first-order degradation rate for constituent i (day^{-1})	0 [d]	SS [c,e] (0)	SS [c,e] (0)
R_i	constituent retardation factor (dimensionless)	1 [d]	SS [c,e] (1)	SS [c,e] (1)
i	hydraulic gradient (dimensionless)	--	SS [c]	SS [c]
ν	groundwater seepage velocity (m/yr)	25.4	(K x i)/n	(K x i)/n
x	distance downgradient from source (m)	SS [c]	SS [c]	SS [c]
K	hydraulic conductivity (m/yr)		SS [c]	SS [c]

α_x	longitudinal groundwater dispersivity (m)	(x * 0.1)	(x * 0.1)	(x * 0.1)
α_y	transverse groundwater dispersivity (m)	(α_x / 3)	(α_x / 3)	(α_x / 3)
α_z	vertical groundwater dispersivity (m)	(α_x / 20) or L/200	(α_x / 20) or L/200	(α_x / 20) or L/200
erf	error function; $erf\chi = \frac{2}{\sqrt{\pi}}\int_o^{\chi} e^{-t^2} dt$	refer below	refer below	refer below
S_d	source thickness (i.e., the thickness of the impacted groundwater within the permeable zone) (m)	SS [c,f]	SS [c,f]	SS [c,f]
ρ_b	dry soil bulk density (g/cm^3)	1.7 [d]	SS (1.7) [d]	SS (1.7) [d]
ρ_s	soil partical density (g/cm^3)	2.65 [d]	SS (2.65) [d]	SS (2.65) [d]

[a]Domenico, P.A. and F.W. Schwartz, 1990. *Physical and Chemical Hydrogeology*, John Wiley and Sons, New York, N.Y.
[b]Based on a 0.5 acre source.
[c]Site-specific.
[d]LDEQ default value.
[e]Degradation and/or retardation shall only be included in the model when site-specific quantitative data documents occurrence. Derivation of constants for these processes shall be included with the model input data. Degradation and retardation data are by definition monitored natural attenuation processes. Therefore, literature values for retardation and degradation are not acceptable under the RECAP.
[f] Estimation of S_d using Method 1 or 2 as presented below.

The **S_d** is defined as the thickness of the contaminated groundwater within the permeable zone. Refer to Figure H-1 for an illustration of S_d.

For the purpose of developing a $DAF_{Domenico}$ for GW_2, LDEQ requires that the S_d be estimated using Method 1 or 2. If the estimated S_d value exceeds the aquifer thickness, S_d should be set to the thickness of the aquifer.

Method 1: Sum of advective and dispersive depths:

$$S_d = h_{adv} + h_{disp} \quad \textbf{(EQ66)}$$

where:

Parameter	Definition (units)	Input Value (Default Value)
S_d	source thickness (i.e., the thickness of the impacted groundwater within the permeable zone) (m)	--
h_{adv}	advective component of the plume depth (m)	site-specific
h_{disp}	dispersive component of the plume depth (m)	Site-specific

$h_{adv} = B[1-\exp((-I \times L)/(B \times D_v))]$ **(EQ67)**

where:

Parameter	Definition (units)	Input Value (Default Value)
h_{adv}	advective component of the plume depth (m)	site-specific
I	infiltration rate (m/yr)	site-specific (0.1) [a]
D_v	Darcy groundwater velocity (K x i) (m/yr)	site-specific (9.144) [a]
B	thickness of the shallow water bearing zone (m)	site-specific (< 6.1) [a]
L	length of the source parallel to the groundwater flow at the water table (m)	site-specific

[a]LDEQ default value.

$h_{disp} = (2 \times \alpha_z \times L)^{1/2}$ **(EQ68)**

where:

Parameter	Definition (units)	MO-2 Input Value (Default Value)
h_{disp}	dispersive component of the plume depth (m)	site-specific
α_z	vertical groundwater dispersivity (m)	site-specific (α_x/20) or (L/200) [a]
L	length of the source parallel to the groundwater flow at the water table (m)	site-specific

Method 2: Thickness of the aquifer:

The thickness of the impacted permeable zone shall be used as the S_d if the thickness of the groundwater plume is not known.

SOLUTION TO THE ERROR FUNCTION

χ	erf χ
0.00	0.000 000
0.05	0.056 372
0.10	0.112 463
0.15	0.167 996
0.20	0.222 703
0.25	0.276 326
0.30	0.328 627
0.35	0.379 382
0.40	0.428 392
0.45	0.475 482
0.50	0.520 500
0.55	0.563 323
0.60	0.603 856
0.65	0.642 029
0.70	0.677 801
0.75	0.711 156
0.80	0.742 101
0.85	0.770 668
0.90	0.796 908
0.95	0.820 891
1.00	0.842 701
1.1	0.880 205
1.2	0.910 314
1.3	0.934 008
1.4	0.952 285
1.5	0.966 105
1.6	0.976 348
1.7	0.983 790
1.8	0.989 091
1.9	0.992 790
2.0	0.995 322
2.2	0.998 137
2.4	0.999 311
2.6	0.999 764
2.8	0.999 925
3.0	0.999 978
3.2	0.999 994
3.4	0.999 998
3.6	1.000 000
3.8	1.000 000
$\geq$ 4.0	1.000 000

TABLE H-3
HIERARCHY OF REFERENCES FOR CHEMICAL-SPECIFIC AND TOXICITY VAULES USED FOR THE GENERATION OF THE SS AND MO-1 RS

K_{oc}:

(1) *Soil Screening Guidance: Technical Background Document* (EPA 1996)
(2) *Groundwater Chemicals Desk Reference*, 1990
(3) *Groundwater Chemicals Desk Reference*, Vol. 2, 1991
(4) *Handbook of Environmental Fate and Exposure Data or Organic Chemicals*, Volume IV, 1991
(5) *Handbook of Environmental Fate and Exposure Data or Organic Chemicals*, Volume III, 1991
(6) *Soil Chemistry of Hazardous Materials*, 1988
(7) Total Petroleum Hydrocarbon Working Group, 1997

Henry's Law Constant:

(1) *Soil Screening Guidance: Technical Background Document* (EPA 1996)
(2) *Superfund Chemical Data Matrix* (EPA 1994)
(3) *Groundwater Chemicals Desk Reference*, 1990. Montgomery, John H., Welkom, Linda, Michigan: M. Lewis Publishing, Inc.
(4) *Handbook of Environmental Fate and Exposure Data for Organic Chemicals Volume IV*, 1991
(5) Total Petroleum Hydrocarbon Criteria Working Group, 1997

Solubility:

(1) *Soil Screening Guidance: Technical Background Document* (EPA 1996)
(2) *Superfund Chemical Data Matrix* (EPA 1994)
(3) *Air Emissions Models for Waste and Wastewater*, 1994

Diffusivity:

(1) *Soil Screening Guidance: Technical Background Document* (EPA 1996)
(2) *Air Emissions Models for Waste and Wastewater*, 1994
(3) CHEMDAT 8

Air diffusivities (D_A) were estimated using the following equation:

$$\frac{D_{A_b}}{D_{A_a}} = \sqrt{\frac{MW_a}{MW_b}}$$

where:

TABLE H-3
(Continued)

MW = molecular weight
a = chemical a
b = chemical b
D_A = diffusivity coefficient in air

Note: Either chemical a or chemical b must have a published diffusivity value to use this equation. Dragun, James. 1988. *The Soil Chemistry of Hazardous Materials*, Hazardous Materials Control Research Institute, Silver Springs, Maryland.

Water diffusivities (D_W) were estimated using the following algorithm:

$$\frac{D_{W\,b}}{D_{W\,a}} = \sqrt{\frac{MW_a}{MW_b}}$$

where:

MW = molecular weight
a = chemical a
b = chemical b
D_W = diffusivity coefficient in water

Note: Either chemical a or chemical b must have a published diffusivity value to use this equation.

RfD and SF:

(1) IRIS (*Integrated Risk Information System*, EPA, http://www.epa.gov/iris/)

(2) HEAST (*Health Effects Assessment Summary Tables*, EPA)

(3) HEAST alternative method or EPA NCEA Superfund Health Risk Technical Support Center (EPA Region III *Risk-based Concentration Tables*, http://www.epa.gov/reg3hwmd/risk/riskmenu.htm; EPA Region IX *Preliminary Remediation Goals*, http://www.epa.gov/region09/waste/sfund/prg/index.html; or EPA Region VI *Human Health Medium-Specific Screening Levels*, http://www.epa.gov/earth1r6/6pd/rcra_c/pd-n/screen.htm)

(4) Withdrawn from IRIS or HEAST (EPA Region III Risk-based Concentration Tables, EPA Region IX Preliminary Remediation Goals, or EPA Region VI Human Health Medium-Specific Screening Levels)

TABLE H-3
(Continued)

REFERENCES FOR CHEMICAL-SPECIFIC PARAMETERS

Dragun, J., *Soil Chemistry of Hazardous Materials*, 1988.

Howard, P.H., *Handbook of Environmental Fate and Exposure Data for Organic Chemicals, vol. IV, 1993.* Lewis Publishers, Inc. 121 South Main Street, Chelsea, Michigan 48118.

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Montgomery, J.H., and Welkom, L.M., *Groundwater Chemicals Desk Reference,* 1990. Lewis Publishers, Inc. 121 South Main Street, Chelsea, Michigan 48118.

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Gustafson, J.B., *Selection of Representative TPH Fractions Base on Fate and Transport Considerations,* Total Petroleum Hydrocarbon Criteria Workgroup, 1997.

U. S. EPA (Environmental Protection Agency). November 1994. *Air Emissions Models for Waste and Wastewaters.* Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27711. USEPA Contract No. 68D10118. EPA/453/R/94/080A.

U. S. EPA (Environmental Protection Agency). 1996. *Soil Screening Guidance: Technical Background Document.* EPA/540/R-96/018. Office of Emergency and Remedial Response, Washington, D.C. NTIS PB96-963505.

U. S. EPA (Environmental Protection Agency). June 1994. *Superfund Chemical Data Matrix.* EPA/540/R-94/00. Solid Waste and Emergency Response (5204G), Washington, D.C. NTIS PB94-963506.

U. S. EPA (Environmental Protection Agency). November 1994. *CHEMDAT8, Compound Properties Estimation and Data,* ver 1.0. Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina 27709.

TABLE H-6
DERMAL ABSORPTION FACTORS

Constituent	ABS (unitless)
Arsenic	0.03
Cadmium	0.001
Chlordane	0.04
2,4-D	0.05
DDT	0.03
Gamma-hexachlorocyclohexane	0.04
TCDD	0.03
Pentachlorophenol	0.25
Polychlorinated biphenyls	0.14
Polycyclic aromatic hydrocarbons	0.13
Other semivolatile organic constituents	0.10
Other inorganic constituents (metals)	0
Volatile constituents	0

The dermal ABS values were obtained from *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment), Interim Guidance.* EPA 2000. EPA/540/R-99/005.