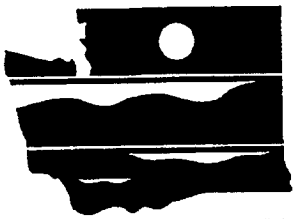

Workbook Tools for Calculating Soil and Ground Water Cleanup Levels under the Model Toxics Control Act Cleanup Regulation

User's Guide

Washington State Department of Ecology
Toxics Cleanup Program

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List of Acronyms and Abbreviations

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BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
CLARC	Ecology, *Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation (CLARC III)*, Pub. No. 94-145, Updated August 2001.
cPAHs	Carcinogenic Polycyclic Aromatic Hydrocarbons
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
HI	Hazard Index
HQ	Hazard Quotient
mg/kg	milligrams per kilogram (same as part per million [ppm])
MTCA	Model Toxics Control Act
NAPL	Nonaqueous Phase Liquid
PQL	Practical Quantitation Limit
RISK	Carcinogenic Risk
TPH	Total Petroleum Hydrocarbon
ug/l	micrograms per liter (same as parts per billion [ppb])
WAC	Washington Administrative Code

See Appendices A through D for definitions of the parameter abbreviations found in the equations.

Chapter 1 Introduction

1.1 Purpose of the Workbook Tools

The Model Toxics Control Act (MTCA) Cleanup Regulation, chapter 173-340 WAC, sets forth the requirements and procedures for establishing cleanup levels that are protective of human health and the environment. The workbooks described in this User's Guide provide tools for the calculation of Method B and Method C cleanup levels for soil and potable ground water based on protection of human health.

The regulation provides for the establishment of both **standard** and **modified** Method B and C cleanup levels.

- Under **standard** Method B and C, protective concentrations are calculated using standard equations and default assumptions provided in the regulation. Except for petroleum mixtures, protective concentrations calculated for hazardous substances under standard Method B and C are published in **CLARC**. One of the **workbooks** described in this User's Guide provides the necessary tools for calculating protective soil and ground water concentrations under standard Method B or Method C for petroleum mixtures.

- Under **modified** Method B and C, specified default assumptions may be adjusted based on site-specific or chemical-specific data. The regulation specifically describes which parameters may be adjusted and how they may be adjusted. The **workbooks** described in this User's Guide provide the necessary tools for calculating protective soil and ground water concentrations under modified Method B or Method C.

For the calculation of **soil cleanup levels**, the workbooks provide tools for evaluating the direct contact pathway, the leaching pathway (protection of ground water), and the vapor pathway (protection of air quality).

- For the evaluation of the **direct contact pathway**, the workbooks use the equations provided in the regulation. The workbooks allow the user to evaluate the soil ingestion pathway alone or in conjunction with the dermal pathway.

- For the evaluation of the **leaching pathway**, the workbooks use the 3-phase and 4-phase equilibrium partitioning models described in the regulation to calculate a soil cleanup level that will not cause an exceedance of the ground water cleanup level established under WAC 173-340-720.

- For the evaluation of the **vapor pathway**, the workbooks provide tools for calculating air cleanup levels and soil concentrations that will not cause an exceedance of the air cleanup level established under WAC 173-340-750.

NOTE: The tools for evaluating the vapor pathway are provided for informational purposes only. Please consult the regulation and the site manager for more information regarding whether the pathway must be evaluated and how the pathway may be evaluated.

For the calculation of **ground water cleanup levels**, the workbooks provide tools for calculating only potable ground water cleanup levels. The workbooks do not provide tools for calculating ground water cleanup levels for nonpotable ground water, as defined under the regulation.

When establishing cleanup levels for hazardous substances at a site, the site manager often asks **two types of questions:**

- Is the measured (or current) concentration at the site protective?
- If not, what is the protective concentration?

The workbooks allow the user to answer both of these questions. The workbooks provide the tools to calculate the risk under current site conditions (forward calculation) and to calculate protective concentrations (backward calculation) if the measured concentrations at the site are not protective. In the first instance, the workbooks require the user to enter measured soil or ground water concentrations. The workbooks then execute a "forward" calculation using the equations in the regulation and solving for risk. In the second instance, the workbooks "back-calculate" a protective concentration based on the target risk levels set forth in the regulation. Also the workbooks provides printing and previewing capabilities for all input and output screens.

This User's Guide describes the capabilities and limitations of the workbooks and provides step-by-step instructions for installing and using the workbooks.

1.2 Caution on Use of the Workbooks

The requirements and procedures for establishing cleanup levels that are protective of human health and the environment are specified in the MTCA Cleanup Regulation, chapter 173-340 WAC. The use of this manual and the associated programs are not sufficient to establish cleanup levels under the regulation. The workbooks are merely computational tools and do not provide all the information necessary to establish cleanup levels for a site. Appropriate background, training, and experience is necessary to accurately use the workbooks.

1.2.1 Calculation of Soil Cleanup Levels

The **soil cleanup levels** calculated using the workbooks account for the following:

- Concentrations based on protection of human health (direct contact pathway);
- Concentrations based on protection of ground water (leaching pathway);
- Natural background concentrations; and
- Practical quantitation limits.

The **soil cleanup levels** calculated using the workbooks **DO NOT** account for the following:

- Concentrations established under applicable state and federal laws;
- Concentrations based on protection of air (vapor pathway);
- Concentrations based on protection of terrestrial ecological receptors;
- Residual saturation limit for protection of ground water; and
- Total site risk.

The soil cleanup levels calculated using the workbooks might need to be manually adjusted to account for these considerations.

1.2.2 Calculation of Potable Ground Water Cleanup Levels

The potable ground water cleanup levels calculated using the workbooks account for the following:

- Concentrations established under applicable state and federal laws;
- Concentrations based on protection of human health;
- Natural background concentrations; and
- Practical quantitation limits.

The potable ground water cleanup levels calculated using the workbooks **DO NOT** account for the following:

- Concentrations based on potential surface water impacts;
- Nonaqueous phase liquid (NAPL) limitation; and
- Total site risk.

The ground water cleanup levels calculated using the workbooks might need to be manually adjusted to account for these considerations.

1.3 Overview of Files

This manual provides instructions on the use of the following two Microsoft Excel® workbook files described below. These two Microsoft Excel® workbook files may be obtained by:

- Contacting Ecology to obtain a compact disk containing the files; or
- Downloading the files from Ecology's Internet web site: http://www.ecy.wa.gov/programs/tcp/tools/toolmain.html

File Name	File Size (KB)	Chapter	Description
MTCASGL10.xls	554	2	Workbook for Calculating Cleanup Levels for Individual Hazardous Substances
MTCATPH10.xls	2,393	3	Workbook for Calculating Cleanup Levels for Petroleum (TPH) Mixtures

1.4 Technical Requirements for Using the Workbooks

This section describes the required (or recommended) hardware and software for using the workbooks.

1.4.1 Hardware Requirements

Recommended **hardware** for using the workbooks include:

> Any hardware capable of running Microsoft Excel® will run the workbooks. A math coprocessor is not required but is recommended. (Note: modern processors may have the coprocessor included. You can check your hardware configuration if you are using Microsoft Windows by "right-clicking" on "my computer" on the windows desktop and selecting "system information.") Some Workbook routines require intensive numeric processing best handled by hardware with greater amounts of RAM (Random Access Memory) and Pentium-level processors.

Additional **hardware** recommendations include:

- A CD-ROM drive, if you have received the workbooks on compact disc;
- A hard disk drive with at least 5.0 MB of free disk space;
- A minimum of 16 Megabytes of system memory (RAM) or higher;
- 486 DX or higher processor running at 66MHz or faster;
- Any monitor supported by Windows, with VGA or better resolution; and
- An 800 x 600 monitor resolution or higher.

1.4.2 Software Requirements

Recommended **software** needed to support the workbooks and associated functions include:

- Microsoft Excel® version 5.0 or later.

The software is implemented as a Microsoft Excel® workbook, programmed in Visual Basic® and Visual Basic for Applications® (VBA) and requires Microsoft Excel®, version 5.0 or above.

Both workbooks use automatic procedures programmed in Microsoft Visual Basic®. However, it should not be necessary to have Visual Basic® installed on your particular system to operate the workbooks.

Visual Basic® routines included in MTCATPH workbook make references or "calls" to library or add-in functions that may or may not be installed on your particular computer or activated in your current Excel® application. Even if these elements are installed, the Visual Basic® routines need to be edited to provide the correct path for them (the VB routine needs to know where they "are" on your particular computer's hard drive or network). The discussion under "Installation" below describes how to check the status of these elements and make the appropriate modifications so that MTCATPH can run without encountering errors.

1.5 Installation of the Workbooks

This section provides instructions for installing and opening the two workbook files.

[continued on next page]

1.5.1 Installation of MTCASGL

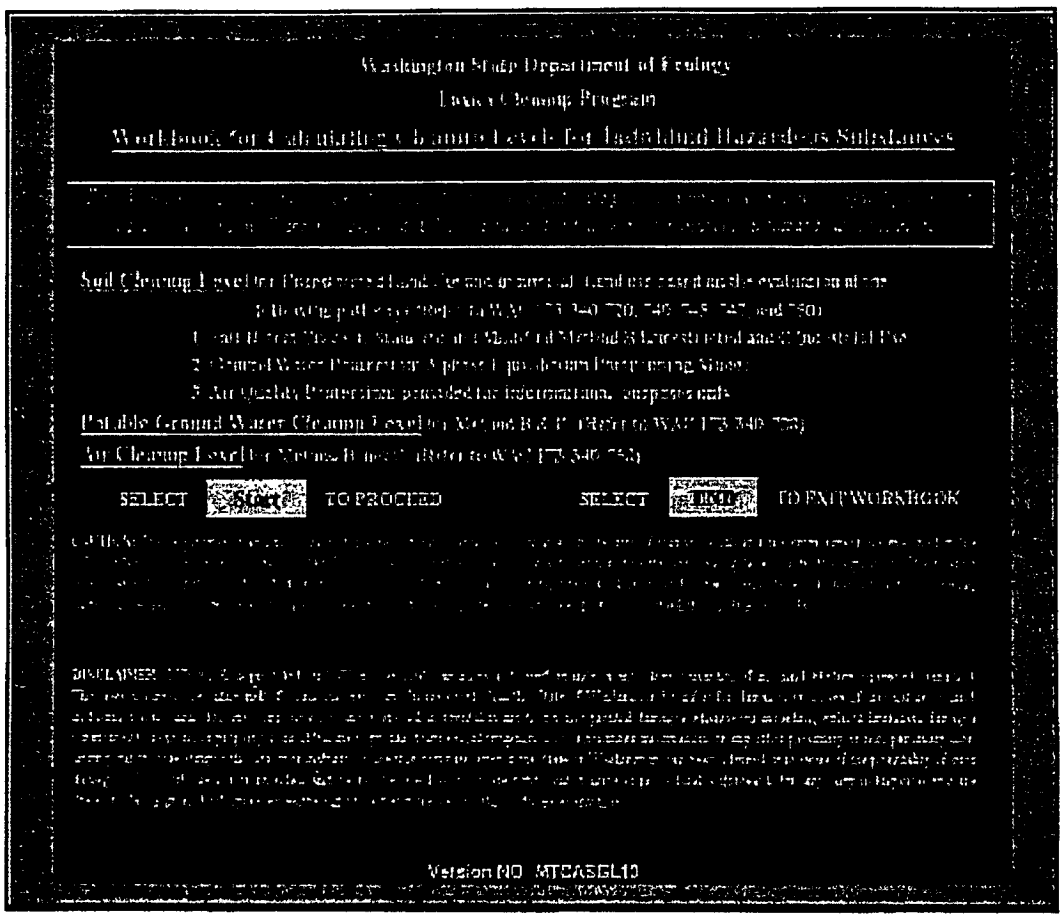
The MTCASGL workbook can be copied to your hard drive and used without modification.

To install the **MTCASGL** workbook, the user should follow the following set of instructions:

1. Copy the workbook file to the directory of choice.
2. Open Excel® and then open the file or simply double-click "***MTCASGL10.xls***" icon. as you would any other Excel® file.
3. Click YES when you are asked about enabling the macros.

Note: It is important to use the END button when closing the file, and it is good practice to save working files under a new name.

The MTCASGL Title Sheet should appear as shown below:



1.5.2 Installation of MTCATPH

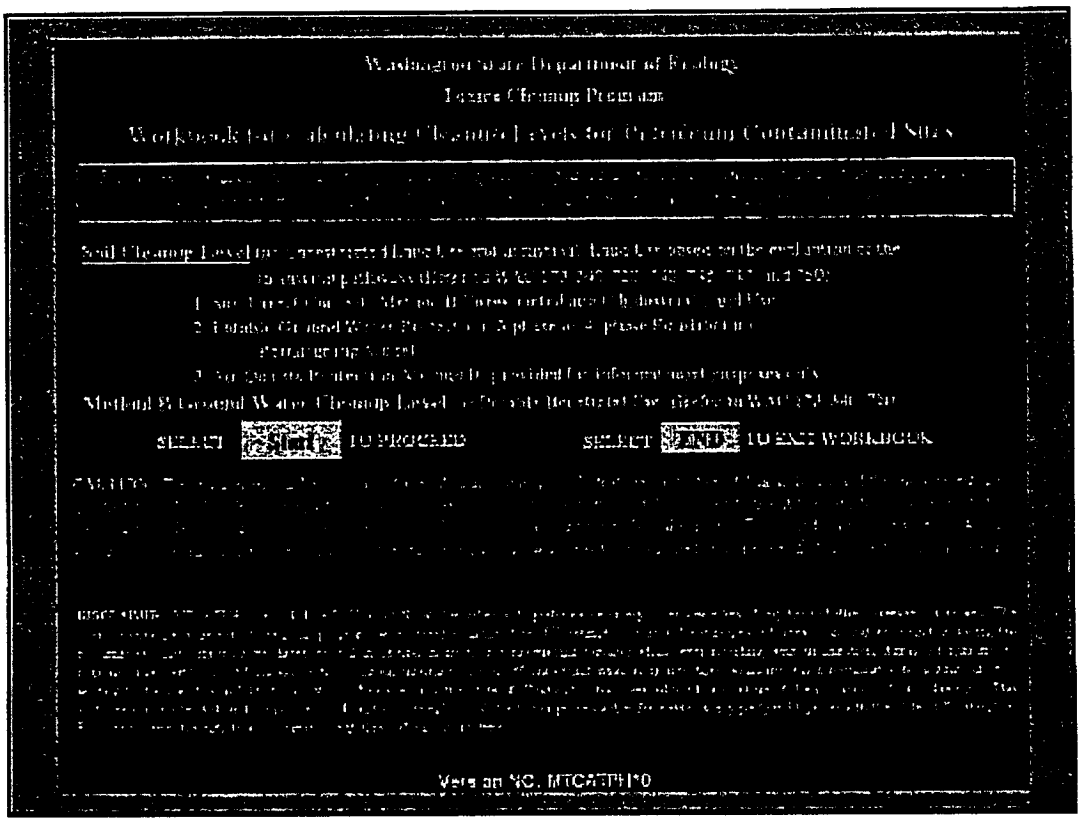
Once the MTCATPH workbook is copied to your hard drive, several modifications and changes to your Microsoft Excel® "add-in" components may be required to allow the routines contained in the workbook to operate correctly.

To install the **MTCATPH** workbook, the user should follow the following set of instructions:

1. Copy the workbook file to the directory of choice.
2. Open Excel® and then open the file or simply double-click "***MTCATPH10.xls***" icon as you would any other Excel® file.
3. Click YES when you are asked about enabling the macros.

Note: It is important to use the END button when closing the file, and it is good practice to save working files under a new name.

At this point, you should see the title screen as it appears below:



1.5.3 Troubleshooting

Potential Error Message: It is possible that Microsoft Visual Basic® may open with an error window that states ***"Compile error: Can't find project or library."*** If this is the case, it is likely that the Visual Basic® routines included in the MTCATPH workbook cannot locate one or both of the following function files that need to be present on your computer's hard drive to allow the workbook to perform correctly:

- *LOOKUP.XLA*
- *SOLVER.XLA*

To see if you have these files, use your file browser to search for them. Usually, these files are located in the Library folder contained in the Office folder. The file "*Solver.xla*" is probably contained in a folder called "*SOLVER*" within the library folder. IF you don't have these files, THEN you may need to install one or both of them from your original Microsoft Office® source disk.

In order to establish a path to these files for the workbook, you need to do the following:

1. In Visual Basic® (with the error window showing), click on [OK] in the error dialogue window to close it.
2. Click on [Run] in the main toolbar and select [Reset].
3. Click on [Tools] in the main toolbar and select [References].

A list of available references will appear for the workbook with checkmarks. Follow the following set of instructions for each checked reference that is labeled as "MISSING" (you must repeat this procedure for each missing reference):

1. Highlight the file with your cursor (if it is not already highlighted).
2. Click on [Browse] at the right side of the dialog box.
3. Using the browser, locate the missing file (probably under Office/Library). Be sure to select "All Files" in the [Files of Type:] scroll-down window so that all files in the particular folder will be displayed. If you still have trouble locating a particular file, you can right-click on "My Computer" on your desktop and select "Explorer" from the pop-up menu. Then fill in the appropriate file name to search for the location. To search for the missing file under Windows 2000:

    a) Click **Start**, point to **Search**, and then click **For Files or Folders**.
    b) In **Search for files or folders named**, type all or parts of the missing file name you want to find.
    c) In **Look in**, click the drive, folder, or network you want to search.
    d) To specify additional search criteria, click **Search Options**, and then click one or more of the options to narrow your search:
    e) Click **Search Now**.

If the file is not located, you may need to install it from the source disk or check with your PC administrator.

4. Once the file is located (be sure it's the one with the "*xla*" extension), click on it (highlight it) and then click on the [Open] button. The window should return to the "Available References" list. The file should have a check mark next to it. Repeat this process for each additional missing file.
5. Click [OK] to close the Available References window.
6. Click [File] in the main toolbar and select [Save As]. Save the corrected Visual Basic® Routines under a new file name (you cannot overwrite the original MTCATPH file name). Close Visual Basic® (This should return you to the Excel® workbook). Save the workbook under the same new name. Installation is now complete. Check by closing the workbook and re-opening in Excel®. It should open to the title sheet without any error messages.

Other Potential Error Messages: It is possible that you may receive other error messages when trying to open the workbooks. Be sure the MACROs are activated in order to use the tools properly. Some error messages may require you refer to online help or the documentation of the host application. Check with your network operator or information technology specialist to be sure your Excel® application can accept MACROs operation and to address other host application-related errors.

Viewing the Worksheets: Some users may have difficulty viewing worksheet numbers or text. To enlarge your view of a particular sheet, click on View in the main toolbar and select "Zoom." Choose a magnification that works best for your needs.

Caution: It is not advisable to load and use more than one copy of the workbooks (either ***MTCASGL*** or ***MTCATPH***) at the same time.

Chapter 2 MTCASGL – Workbook for Calculating Cleanup Levels for Individual Hazardous Substances

2.1 Overview

The **MTCASGL workbook** allows the user to use chemical and toxicity data, site-specific information, and risk-based exposure assumptions to calculate either of the following for a **single** chemical contaminant:

- **Risk under Current Conditions:** The workbook provides the tools necessary to calculate the risk (carcinogenic and non-carcinogenic) under current conditions. To calculate the risk under current conditions, the workbook requires the user to enter a measured soil or ground water concentration. The workbook then executes a "forward" calculation using the equations in the regulation and solving for risk. For soil measurements, the workbook calculates the risk corresponding to the direct contact pathway, the leaching pathway (protection of ground water), and the vapor pathway (protection of air quality). The program indicates whether or not the measured concentration (current condition) is above or below the acceptable risk indices (pass/fail).

- **Cleanup Levels for Soil and Potable Ground Water:** The workbook provides the tools necessary to calculate protective soil concentrations under Method B and Method C. The workbook "back-calculates" a protective concentration based on the target risk levels (carcinogenic and non-carcinogenic) set forth in the regulation. For soil, the workbook calculates a protective concentration for the direct contact pathway, the leaching pathway (protection of ground water), and the vapor pathway (protection of air quality). This calculated cleanup level might be lower or higher than the concentration actually measured in the sample.

The **MTCASGL workbook** consists of two worksheets – the Worksheet for Calculating Soil Cleanup Levels **(see Section 2.2)** and the Worksheet for Calculating Potable Ground Water Cleanup Levels **(see Section 2.3)**.

The **Worksheet for Calculating Soil Cleanup Levels** (soil worksheet) provides tools for evaluating both the direct contact pathway and the leaching pathway.

- For the evaluation of the **direct contact pathway**, the worksheet uses the equations provided in the regulation **(see Appendix B)**. The worksheet allows the user to evaluate the soil ingestion pathway alone or in conjunction with the dermal pathway.

- For the evaluation of the **leaching pathway**, the worksheet uses the 3-phase equilibrium partitioning model described in the regulation **(see Appendix C)** to

calculate a soil cleanup level that will not cause an exceedance of the ground water cleanup level established under WAC 173-340-720.

- For the evaluation of the **vapor pathway**, the worksheet uses the equations provided in the regulation to calculate an air cleanup level **(see Appendix D)** and then calculates a soil cleanup level that will not cause an exceedance of that air cleanup level using the 3-phase equilibrium partitioning model and the site-specific vapor attenuation factor entered by the user.

> **NOTE:** The tools for evaluating the vapor pathway are provided for informational purposes only. Please consult the regulation and the site manager for more information regarding whether the pathway must be evaluated and how the pathway may be evaluated.

The **Worksheet for Calculating Potable Ground Water Cleanup Levels** (ground water worksheet) provides tools for calculating cleanup levels for potable ground water. The worksheet uses the equations in the regulation **(see Appendix A)**. The worksheet does not provide tools for calculating cleanup levels for nonpotable ground water.

2.2 Worksheet for Calculating Soil Cleanup Levels (Soil Worksheet)

2.2.1 Accessing the Soil Worksheet

Once the MTCASGL workbook is successfully loaded into Excel®, the title sheet will appear. Be sure to enable the MACROs. To use the workbook tool, click on the START button (to exit, click on the END button). It is important to use the END button to exit the workbook so your previous default Excel® settings (toolbars, work-area format) are restored.

Selecting the START button makes the soil worksheet appear on your screen (light blue background).

Note the following regarding the structure and contents of the soil worksheet:

- Non-colored (white) cells in the sheet are used for data entry (other cells in the workbook are write-protected and cannot be modified).

- The sheet is divided ("split") into two windows – one shows the upper data entry portions and the lower provides the means of viewing the bottom "calculation summary" portion of the sheet. Place your cursor in the upper window to begin data entry. If you prefer, you can remove the split by clicking on "Window" in the main toolbar and selecting "Remove Split." The Calculation Summary shown in the bottom half of the screen is located at the bottom of the sheet.

2.2.2 Caution on Use of the Soil Worksheet

The soil cleanup levels calculated using the soil worksheet account for the following:

- Concentrations based on protection of human health (direct contact pathway);
- Concentrations based on protection of ground water (leaching pathway);
- Natural background concentrations; and
- Practical quantitation limits.

The soil cleanup levels calculated using the soil worksheet **DO NOT** account for the following:

- Concentrations established under applicable state and federal laws;
- Concentrations based on protection of air quality (vapor pathway);
- Concentrations based on protection of terrestrial ecological receptors;
- Residual saturation limit for protection of ground water; and
- Total site risk.

The soil cleanup levels calculated using the soil worksheet may need to be manually adjusted account for these considerations **(see Section 2.2.12)**.

2.2.3 Equations and Parameters

The soil worksheet provides tools for evaluating the direct contact pathway, the leaching pathway (protection of ground water), and the vapor pathway (protection of air quality).

2.2.3.1 Direct Contact Pathway

For the evaluation of the direct contact pathway, the worksheet uses the standard equations provided in the regulation **(see Appendix B)**. The worksheet allows the user to evaluate the soil ingestion pathway alone or in conjunction with the dermal pathway.

For each of the parameters used in the equations, default assumptions (values) are set forth in the regulation to calculate **standard** Method B or C cleanup levels. Under **modified** Method B and C, specified default assumptions may be adjusted based on site-specific or chemical-specific data. The regulation specifically describes which parameters may be adjusted and how they may be adjusted.

- IF the regulation does not allow a parameter to be adjusted, THEN the worksheet uses the default value for that parameter provided in the regulation. Also, the parameter is not listed in the worksheet and the user may not input data for that parameter.

- IF the regulation allows a parameter to be adjusted, THEN the parameter is listed in the worksheet and the user may input either the default value provided in the regulation or a site-specific or chemical-specific value derived under the regulation.

2.2.3.2 Leaching Pathway

For the evaluation of the leaching pathway, the worksheet uses the 3-phase equilibrium partitioning model described in the regulation **(see Appendix C)** to calculate a cleanup level that will not cause an exceedance of the ground water cleanup level established under WAC 173-340-720. For each of the parameters used in the equations, the user may input either the default value provided in the regulation or a site-specific or chemical-specific value derived under the regulation.

For the evaluation of the leaching pathway, the worksheet also checks for soil saturation limits and warns the user if the soil saturation condition is exceeded.

2.2.3.3 Vapor Pathway

For the evaluation of the vapor pathway, the worksheet **first** uses the standard equations provided in the regulation **(see Appendix D)** to calculate air cleanup levels. For each of the parameters used in the equations, default assumptions (values) are set forth in the regulation to calculate **standard** Method B or C cleanup levels. Under **modified** Method

B and C, specified default assumptions may be adjusted based on site-specific or chemical-specific data. The regulation specifically describes which parameters may be adjusted and how they may be adjusted. Irrespective of whether a parameter may be adjusted under the regulation, the worksheet uses the default value for that parameter provided in the regulation. Also, the parameter is not listed in the worksheet and the user may not input data for that parameter

Second, the worksheet converts the calculated air cleanup level into a soil vapor concentration using the vapor attenuation factor entered by the user.

Third, the worksheet uses the 3-phase equilibrium partitioning model (see **Appendix C**) and the soil vapor concentration to calculate the associated soil concentration – the concentration that is protective of air quality at the exposure point (point of compliance).

Ecology is currently evaluating appropriate procedures for evaluating the vapor pathway, including the use of vapor attenuation factors, and intends to provide further guidance on this issue in the future.

2.2.4 Entering Data for Input Parameters

As discussed above, the worksheet only lists those parameters that may be adjusted by the user. For each of the parameters listed in the worksheet, the user must either enter the default value provided in the regulation or a site-specific or chemical-specific value derived under the regulation.

NOTE: If no data is available for an input parameter, then leave the input box blank unless specified otherwise.

As illustrated in the following sections, the parameters for which the user must enter data are listed on the left side of the worksheet. The user must enter the data in the corresponding non-shaded (white) boxes on the right side of the worksheet.

The worksheet is organized into **seven parts**. Each of the parameters listed under those parts is listed and described below. For each parameter, this User's Guide lists the default value provided in the regulation and references the applicable procedures for deriving a site-specific or chemical-specific value under the regulation.

Header Information: In the rectangular box at the top of the soil worksheet, enter the date, site name, and evaluator name. NOTE: Once an evaluation has been completed for a particular site, it is good practice to print out the results. Click on the Preview or Print button to confirm that the proper header information appears on all printout sheets. Remember to change the header information EACH TIME a new set of data is entered.

2.2.5 Input Data – Part 1: General Information

The first part of the worksheet (illustrated below) requires the user to input the following general information:

Item	Symbol	Value	Unit
1. General information			
Name of Chemical:		DDT	
Measured Soil Concentration, if any	C_s	5	mg/kg
Natural Background Concentration for Soil:	NB_s		mg/kg
Practical Quantitation Limit for Soil	PQL_s	0.008	mg/kg
To evaluate the ingestion and dermal pathways concurrently, check here and input values for AF, ABS_d, GI:		☑	

Name of Chemical: Enter the name of the chemical to be evaluated.

Measured Soil Concentration (if known): This parameter is used to calculate the carcinogenic and non-carcinogenic risk at the site under current conditions. Enter the soil concentration in milligrams per kilogram of soil (dry weight basis).

Natural Background (NB_s) Soil Concentration (if known): This parameter is used to adjust the soil cleanup level, if necessary. Methods for defining natural background concentrations are provided in WAC 173-340-709. Ecology has published information on background levels of certain metals (*Natural Background Soil Metals Concentrations in Washington State*, Publication No. 94-115).

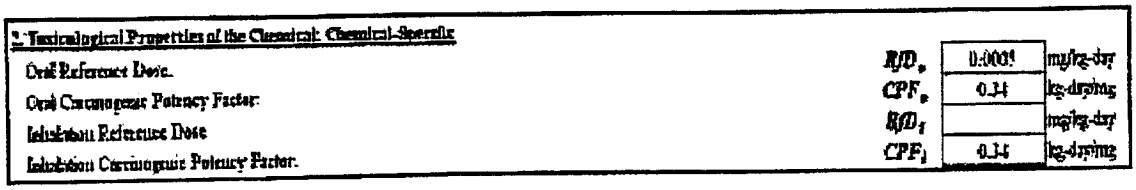
Practical Quantitation Limit (PQL_s) for Soil (if known): This parameter is used to adjust the soil cleanup level, if necessary. The PQL_s is the lowest concentration of the contaminant that can be reliably measured within specified limits of precision, accuracy, representativeness, completeness, and comparability during routine laboratory operating conditions, using department approved methods. The analytical laboratory or site manager can assist in identifying the appropriate PQL_s.

Checkbox – Is an evaluation of the dermal pathway required? The checkbox item at the bottom of the first part of the worksheet requires the user to indicate whether an evaluation of the dermal pathway is required to calculate a soil concentration that is protective of human health based on direct contact. To determine whether an evaluation of the dermal pathway is required, see WAC 173-340-740(3)(c)(iii) and 173-340-745(5)(c)(iii). If an evaluation of the dermal pathway is required, then the user must enter a check in the checkbox and enter values for the following exposure parameters in **Part 3 below (see Section 2.2.7):**

- Adherence Factor (AF);
- Dermal absorption fraction (ABS_d); and
- Gastrointestinal Absorption Conversion Factor (GI).

2.2.6 Input Data – Part 2: Toxicological Properties of the Chemical

The second part of the worksheet (illustrated below) requires the user to input the following chemical-specific toxicological data:



Oral Reference Dose (RfD_o): Enter the oral reference dose (mg/kg-day) for chemicals having non-carcinogenic toxicity. The applicable oral reference dose for a chemical is published in CLARC. Note that an oral reference dose may not be available for some chemicals. The process for establishing a reference dose is defined in WAC 173-340-708(7).

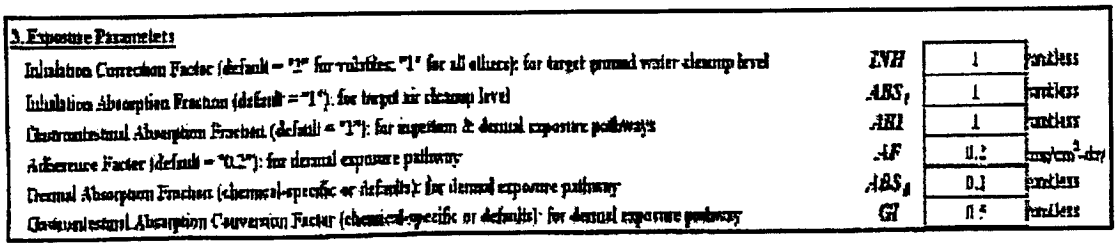
Oral Carcinogenic Potency Factor (CPF_o): Enter the oral carcinogenic potency factor (kg-day/mg) for chemicals having carcinogenic toxicity. The applicable oral cancer potency factor for a chemical is published in CLARC. Note that an oral cancer potency factor may not be available for some chemicals. The process for establishing a cancer potency factor is defined in WAC 173-340-708(8).

Inhalation Reference Dose (RfD_i): Enter the inhalation reference dose (mg/kg-day) for chemicals having non-carcinogenic toxicity. The applicable inhalation reference dose for a chemical is published in CLARC. Note that an inhalation reference dose may not be available for some chemicals. The process for establishing a reference dose is defined in WAC 173-340-708(7).

Inhalation Carcinogenic Potency Factor (CPF_i): Enter the inhalation carcinogenic potency factor (kg-day/mg) for chemicals having carcinogenic toxicity. The applicable inhalation cancer potency factor for a chemical is published in CLARC. Note that an inhalation cancer potency factor may not be available for some chemicals. The process for establishing a cancer potency factor is defined in WAC 173-340-708(8).

2.2.7 Input Data – Part 3: Exposure Parameters

The third part of the worksheet (illustrated below) requires the user to input data for the following exposure parameters:



3. Exposure Parameters			
Inhalation Correction Factor (default = "2" for volatiles; "1" for all others); for target ground water cleanup level	*INH*	1	unitless
Inhalation Absorption Fraction (default = "1"); for target air cleanup level	ABS_i	1	unitless
Gastrointestinal Absorption Fraction (default = "1"); for ingestion & dermal exposure pathways	*ABI*	1	unitless
Adherence Factor (default = "0.2"); for dermal exposure pathway	*AF*	0.2	mg/cm²-day
Dermal Absorption Fraction (chemical-specific or default); for dermal exposure pathway	ABS_d	0.1	unitless
Gastrointestinal Absorption Conversion Factor (chemical-specific or default); for dermal exposure pathway	*GI*	0.5	unitless

Inhalation Correction Factor (*INH*): This parameter is used to calculate the ground water cleanup level. Enter the applicable default value ("2.0" for volatile organic compounds (as defined in WAC 173-340-200) and "1.0" for all other chemicals) or enter a chemical-specific value established under WAC 173-340-720(4)(c)(i). The applicable default value for a chemical is published in CLARC.

Inhalation Absorption Fraction (ABS_i): This parameter is used to calculate the air cleanup level. Enter the default value of "1.0" or enter a chemical-specific value established under WAC 173-340-750(3)(c)(i).

Gastrointestinal absorption fraction (*ABI*): This parameter is used to calculate a soil concentration that is protective of human health based on direct contact. Enter the default value of "1.0" or enter a chemical-specific value established under WAC 173-340-740(3)(c)(ii)(B) or 173-340-745(5)(c)(ii)(B).

Adherence Factor (*AF*): This parameter is used to calculate a soil concentration that is protective of human health based on direct contact. The parameter is specifically used to evaluate **dermal contact**. Enter the default value of "0.2" or enter a chemical-specific value established under WAC 173-340-740(3)(c)(ii)(C) or 173-340-745(5)(c)(ii)(C). If an evaluation of the dermal pathway is not required, then leave this input box blank.

Dermal absorption fraction (ABS_d): This parameter is used to calculate a soil concentration that is protective of human health based on direct contact. The parameter is specifically used to evaluate **dermal contact**. The parameter is chemical-specific. Enter a chemical-specific value established under WAC 173-340-740(3)(c)(ii)(C) or 173-340-745(5)(c)(ii)(C) or enter the applicable default value listed below:

- "0.01" for inorganic hazardous substances
- "0.0005" for volatile organic compounds with a vapor pressure ≥ Benzene
- "0.03" for volatile organic compounds with a vapor pressure < Benzene
- "0.1" for other organic hazardous substances

NOTE: Vapor pressure of Benzene is 0.125 atm (or, 95 mm Hg, 95 torr, 12.7 kPa) at 25°C.

The applicable default value for a chemical is published in CLARC. If an evaluation of the dermal pathway is not required, then leave this input box blank.

Gastrointestinal Absorption Conversion Factor (*GI*): This parameter is used to derive a **dermal** reference dose based on the oral reference dose or a **dermal** cancer potency factor based on the oral cancer potency factor. The dermal toxicity index is derived by dividing or multiplying the oral index by GI:

$$RfD_d = RfD_o \times GI \quad \underline{\text{OR}} \quad CPF_d = CPF_o \div GI$$

This parameter is chemical-specific. Enter a chemical-specific value established under WAC 173-340-740(3)(c)(ii)(C) or 173-340-745(5)(c)(ii)(C) or enter the applicable default value listed below:

- "0.2" for inorganic hazardous substances
- "0.8" for volatile organic compounds
- "0.5" for other organic hazardous substances

The applicable default value for a chemical is published in CLARC. If an evaluation of the dermal pathway is not required, then leave the input box blank.

2.2.8 Input Data – Part 4: Physical and Chemical Properties of the Chemical

The fourth part of the worksheet (illustrated below) requires the user to input chemical-specific data for the following physical and chemical properties of the chemical:

4. Physical and Chemical Properties of the Chemical: Chemical-Specific			
Soil Organic Carbon-Water Partitioning Coefficient: for metals, enter K_d value here and enter "1" for f_{oc} value	K_{oc}	6.77E+05	l/kg
Henry's Law Constant: for the evaluation of ground water and vapor exposure pathway	H_{cc}	3.33E-04	unitless
*If the value for Henry's Law Constant is given in the unit of "atm-m³/mol", enter value here:	H	8.30E-06	atm-m³/mol
*Corrected unitless form of H_{cc} @13° C (Enter the converted value into "H_{cc} input Box" above for a calculation)	H_{cc}	3.38E-04	unitless
Solubility of the Chemical in Water: for the calculation of soil saturation limit	S	1.50E-02	mg/l

Soil Organic Carbon-Water Partitioning Coefficient (K_{oc}): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is chemical-specific.

- For **organic hazardous substances**, enter the K_{oc} value. The workbook calculates a value for K_d using the K_{oc} value entered here and the f_{oc} value entered in the sixth part of the worksheet using Equation 747-2; $K_d = K_{oc} \times f_{oc}$. Default K_{oc} values are provided in Table 747-1 for selected nonionizing organics and Table 747-2 for selected ionizing organics. K_d values for other organic hazardous substances may be established as provided in WAC 173-340-747(5)(b).

- For **metals**, enter the distribution coefficient (K_d) instead of the K_{oc} value here and enter "1.0" for the f_{oc} value in the sixth part of the worksheet. Default values are provided in Table 747-3 for the selected metals. K_d values for other metals may be established as provided in WAC 173-340-747(5)(b).

The applicable default value for a chemical is published in CLARC; however, default values are not provided for all chemicals. As of this writing, Ecology is planning to publish in CLARC a more comprehensive database of K_{oc} or K_d (or K_{ow} octanol-water partition coefficient) values for organic and inorganic chemicals.

Henry's Law Constant (H_{cc} or H): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is chemical-specific.

- For metals except mercury, enter the default value of "0".
- For mercury, enter the default value of "0.47" or enter a value derived from the scientific literature, provided the requirements in WAC 173-340-702(14), (15) and (16) are met.
- For components of petroleum mixtures, enter the applicable default values provided in Table 747-4.

- For individual organic hazardous substances, enter a value derived from the scientific literature, provided the requirements in WAC 173-340-702(14), (15) and (16) are met.

The applicable default value for a chemical is published in CLARC; however, default values are not provided for all organic chemicals. As of this writing, Ecology is planning to publish in CLARC a more comprehensive database of H_{cc} values for organic chemicals.

To enter Henry's law constant, follow the following set of instructions:

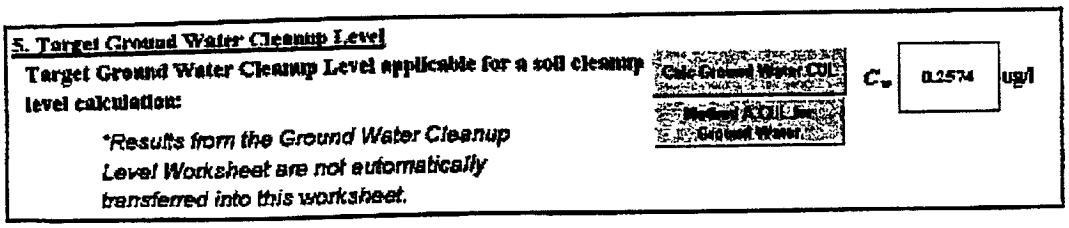
- IF Henry's law constant is provided as a **unitless** value, THEN enter that value in the "H_{cc} [ ] unitless" box.

- IF Henry's law constant is provided in units of **atm.m^3/mol**, THEN the constant must be converted to a unitless value. The workbook provides a conversion tool that allows the user to enter the constant in units of atm.m^3/mol to determine the unitless form at 13^{o}C. If the conversion tool is used, then the converted value provided by the workbook must still be manually entered by the user in the "H_{cc} [ ] unitless" box. NOTE: ANY ENTRIES MADE INSIDE THE CONVERSION BOX ARE NOT USED IN THE PROGRAM.

Aqueous Solubility (S): This parameter is used to calculate the soil saturation limit (C_{sat}). This soil saturation limit corresponds to the theoretical chemical concentration in soil at which sorption limits of the soil particles, solubility limits of the soil pore water, and saturation of soil pore air have all been reached. The parameter is chemical-specific. The aqueous solubility of the contaminant must be entered as milligrams of contaminant per liter of water (mg/l). Information on solubility for common contaminants can be obtained from the scientific literature. These literature values may be used, provided the requirements in WAC 173-340-702(14), (15) and (16) are met.

2.2.9 Input Data – Part 5: Target Ground Water Cleanup Level

The fifth part of the worksheet (illustrated below) requires the user to input the target ground water cleanup level for the site. The target ground water cleanup level is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the target ground water cleanup level). The parameter is site and chemical-specific.



The workbook provides two methods for calculating the target ground water cleanup level. These two methods are described below.

2.2.9.1 Use and Adjustment of Method A Values in Table 720-1

For chemicals listed in Table 720-1 except petroleum mixtures, the value listed in Table 720-1 for a chemical may be used as the target ground water cleanup level, provided the value is manually adjusted based on the following considerations:

- Consideration of potential surface water impacts (see WAC 173-340-720(4)(b)(ii) and 173-340-720(5)(b)(ii));
- Consideration of the nonaqueous phase liquid (NAPL) limitation (see WAC 173-340-720(7)(d)); and
- Consideration of total site risk (see WAC 173-340-720(7)(a)).

To see the values listed in Table 720-1, click the Method A CUL for Ground Water button to activate a "pop-up" list.

The value from Table 720-1 must be manually adjusted as described above and then manually entered in the soil worksheet.

WARNING: The workbook **DOES NOT** automatically enter a value from Table 720-1 in the soil worksheet.

2.2.9.2 *Calculation of Method B or Method C Value*

For chemicals not listed in Table 720-1, the user must calculate a potable ground water cleanup level using the ground water worksheet. To access the worksheet, click on the **Calc Ground Water CUL** button. See **Section 2.3** for instructions on calculating a potable ground water cleanup level.

Before calculating the potable ground water cleanup level (before clicking on the button), values for the following parameters must be entered in the soil worksheet:

- Oral Reference Dose (RfD_o) – Part 2
- Oral Carcinogenic Potency Factor (CPF_o) – Part 2
- Inhalation Correction Factor (INH) – Part 3

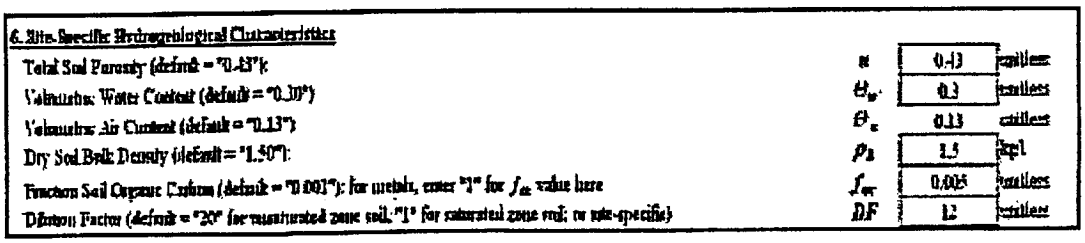
The workbook calculates a potable ground water cleanup level based on the values entered for these parameters and the parameters listed in the ground water worksheet.

The potable ground water cleanup level calculated using the ground water worksheet must be manually adjusted (as described in **Section 2.3.6**) and then manually entered in the soil worksheet (as noted in **Section 2.3.7**).

WARNING: The workbook **DOES NOT** automatically enter the result from the ground water worksheet.

2.2.10 Input Data – Part 6: Hydrogeological Characteristics of the Site

The sixth part of the worksheet (illustrated above) requires the user to input default or site-specific data for the following hydrogeological characteristics of the site:



Total Soil Porosity (n): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. Enter the default value of "0.43" or enter a site-specific value determined under WAC 173-340-747(6)(d)(iii)(D) using site-specific measurements. The site-specific soil porosity may be calculated using the following equation:

$$n = 1 - \frac{\rho_b}{\rho_s}$$

Parameter	Definition	Default Value	Units
n	Total soil porosity	Calculated	unitless
ρ_b	Dry soil bulk density	1.50 (see note 1)	kg/l
ρ_s	Soil particle specific gravity	2.65 (see note 2)	kg/l

Footnotes:

(1) Use the default value of 1.50 kg/l or use a site-specific value derived under WAC 173-340-747(5)(c). Use the same value as entered in Part 6 of the worksheet.

(2) Use the default value of 2.65 kg/l or use a site-specific value derived under WAC 173-340-747(6)(d)(iii)(D). A site-specific value may be derived by measuring the soil particle specific gravity using ASTM Method D854-00.

Note that the sum of the volumetric water content and the volumetric air content must equal the total soil porosity.

Volumetric Water Content (θ_w): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. Enter the default value of "0.30" or enter a site-specific value derived under WAC 173-340-747(5)(d) using site-specific measurements. Note that the sum of the volumetric water content and the volumetric air content must equal the total soil porosity.

Volumetric Air Content (θ_a): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. The value for volumetric air content CANNOT be entered. The workbook automatically calculates a value based on the values entered for total soil porosity (n) and volumetric water content (θ_w) using the following equation:

$$\theta_a = n - \theta_w$$

If the default values for total soil porosity (n = 0.43) and volumetric water content (θ_w = 0.3) are entered, then the "default" volumetric air content is 0.13.

Dry Soil Bulk Density (ρ_b): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. Enter the default value of "1.50" or enter a site-specific value derived under WAC 173-340-747(5)(c) using site-specific measurements.

Fraction Soil Organic Carbon (f_{oc}): The fraction of soil organic carbon is the total mass of organic carbon divided by a unit mass of soil (mass of carbon/mass of soil). This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific.

- For **organic hazardous substances**, enter the default value of "0.001" or enter a site-specific value derived under WAC 173-340-747(5)(b)(i). The workbook calculates a value for K_d using the f_{oc} value entered here and the K_{oc} value entered in the fourth part of the worksheet using Equation 747-2: $K_d = K_{oc} \times f_{oc}$.

- For **metals**, enter "1" for the f_{oc} value here and enter the distribution coefficient (K_d) instead of the K_{oc} value in the fourth part of the worksheet.

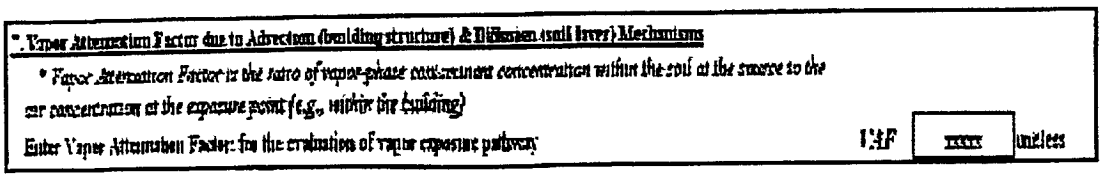
Soil samples that are analyzed for f_{oc} must be collected outside the area of contamination and below the root zone. The results are usually reported as percent organic carbon. The reported value can be converted to a fraction by dividing by 100.

Dilution Factor (DF): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. Enter the applicable default value ("20" for unsaturated zone soil and "1" for saturated zone soil) or enter a site-specific value derived under WAC 173-340-747(5)(f) using site-specific estimates of infiltration and ground water flow rate. Note that the default value of "20" might not be sufficiently

protective of the ground water for a site where the source size is significantly larger than a half acre, as specified by the EPA.[1]

2.2.11 Input Data – Part 7: Vapor Attenuation Factor for the Site

The seventh part of the worksheet (illustrated below) requires the user to input the vapor attenuation factor for the site.



Vapor Attenuation Factor (*VAF*): This parameter is used to calculate a soil concentration that is protective of air quality (that will not cause an exceedance of the air cleanup level at the point of compliance). This parameter is site and chemical-specific.

The worksheet uses the 3-phase equilibrium partitioning model to predict the soil vapor concentration at the source based on the measured soil concentration. The worksheet then uses the vapor attenuation factor to predict the air concentration at the point of compliance based on the soil vapor concentration at the source. The vapor attenuation factor is based on several factors, including the emission rate of the contaminant from soil (due to diffusion and advection) and the amount of dilution that occurs through mixing with indoor and or outdoor ambient air.

WARNING: To calculate a soil cleanup level based on the vapor pathway, the user must enter a value for *VAF*. The user must enter a **site-specific** value because a default value has not been established.

If it appears that the vapor pathway is a controlling factor at a site, the user needs to consult with the Ecology site manager to identify an appropriate method for evaluating the vapor pathway.

THIS COMPLETES DATA ENTRY FOR THE SOIL WORKSHEET.
SAVE YOUR WORK BEFORE CONTINUING.

[1] U.S. EPA, 1996. *Soil Screening Guidance: Technical Background Document*, EPA/540/R-95/128.

2.2.12 Output – Interpreting the Result

The worksheet automatically calculates protective soil concentrations for the different pathways and then calculates a soil cleanup level based on those protective concentrations and other limits.

The worksheet displays the calculation results in two tables at the bottom of the active sheet (or in the lower window, if the screen is split).

2.2.12.1 Summary of Results

The first table (example shown below) displays the most stringent soil concentration based on soil direct contact and ground water protection, as well as other limits.

The first table requires the **user** to make **two decisions** that will effect the results displayed in the table.

(1) **May soil cleanup levels be established under Method C (industrial land use)?**

To determine whether soil cleanup levels may be based on industrial land use (Method C), see WAC 173-340-745(1).

- If the site qualifies for use of Method C to establish soil cleanup levels, then enter a check in the box.
- If the site does not qualify for use of Method C to establish soil cleanup levels, then leave the checkbox blank.

(2) **May air cleanup levels be established under Method C?**

To determine whether the air cleanup level may be based on industrial land use (Method C), see WAC 173-340-745(1).

- If the site qualifies for use of Method C to establish air cleanup levels, then enter a check in the box.
- If the site does not qualify for use of Method C to establish air cleanup levels, then leave the checkbox blank.

The first table then displays the results (example shown below). A description of the content of the table is provided below.

B. SUMMARY OF SOIL CLEANUP LEVEL CALCULATIONS

Chemical of Concern: DDT

1. Summary of Results

To calculate a soil cleanup level based on Industrial Land Use (Method C) for Direct Soil Contact, check here: ☑

To calculate a soil concentration based on Method C vapor pathway, check here ☑

Basis for Soil Concentration	Conc	Units
Most stringent soil concentration based on Soil Direct Contact & Ground Water Protection	1.04E+01	mg/kg
Natural Background concentration for Soil	NA	mg/kg
Practical Quantitation Limit for Soil	0.008	mg/kg
Soil Cleanup Level (not considering vapor pathway)	1.04E+01	mg/kg
Soil concentration based on Vapor Pathway (informational purposes only)	1.62BE+04	mg/kg
Soil Saturation Limit, C_{sat}	8.47SE+01	mg/kg
Retardation Factor, R	11.825.4	unitless

C_{sat} corresponds to the total soil chemical concentration saturated in soil.

R is the ratio of the ground water flow velocity to the contaminant migration velocity in saturated zone.

Chemical of Concern: The name of the chemical as entered by the user.

Most Stringent Soil Concentration based on Evaluation of the Direct Contact Pathway and the Leaching Pathway (mg/kg): The worksheet calculates protective soil concentrations based on the direct contact pathway and the leaching pathway (protection of ground water). The lower (most stringent) of these two concentrations is presented in the table.

Natural Background Soil Concentration (mg/kg): This is the chemical-specific natural background concentration entered by the user.

Practical Quantitation Limit for Soil (mg/kg): This is the chemical-specific practical quantitation limit entered by the user.

Soil Cleanup Level (mg/kg): The soil cleanup level presented in the table is the most stringent concentration based on evaluation of the direct contact pathway and the leaching pathway, unless that concentration is more stringent than either the natural background concentration or the PQL. If the calculated concentration is lower (more stringent) than either the natural background concentration or the PQL, then the worksheet adjusts the calculated concentration upward to the natural background concentration or the PQL, whichever is higher (less stringent).

Soil Saturation Limit (C_{sat}) (mg/kg): The soil saturation limit corresponds to the chemical concentration in soil at which sorption limits of the soil particles, solubility limits of the soil pore water, and saturation of soil pore air have all been reached. It is an indicator (a theoretical threshold) that the chemical may exist as a separate pure phase in the soil and, if it is a liquid, may exist as a nonaqueous phase liquid with additional hazards to ground water quality.

Retardation Factor (R) (unitless): The retardation factor is the ratio of the ground water flow velocity to contaminant migration velocity. If the retardation factor is "10", the contaminant plume in the saturated zone would move, on average, ten times slower than the ground water flow. This result is provided so that the user can assess the chemical's relative mobility in the ground water. The result is not used in calculating the soil cleanup level.

2.2.12.2 *Summary of Results by Exposure Pathway*

The second table (example shown below) displays the results of more detailed calculations for both the direct contact pathway, the leaching pathway, and vapor pathway to allow the user to determine the basis of the cleanup level.

2. Summary of Calculation for each Exposure Pathway

Summary by Exposure Pathway

			Method B Unrestricted Land Use @ HQ=1.0, RISK =1.0E-6		Method C Industrial Land Use @ HQ=1.0, RISK =1.0E-5	
			Ingestion only	Ingestion & Dermal	Ingestion only	Ingestion & Dermal
Soil Direct Contact	Under the Current Condition	HQ? @ Exposure Point	1.250E-01	1.800E-01	2.857E-03	1.500E-02
		RISK? @ Exposure Point	1.700E-06	2.448E-06	1.295E-07	6.809E-07
	Target Soil CUL? mg/kg	@HQ=1.0	4.000E+01	2.778E+01	1.750E+03	3.333E+02
		@RISK =1.0E-6 or 1.0E-5	2.941E+00	2.042E+00	3.860E+02	7.353E+01

			Method B @ HQ=1.0, RISE =1.0E-6	Method C @ HQ=1.0, RISK =1.0E-5
Protection of Potable Ground Water	Under the Current Condition	Predicted Ground Water Conc? ug/l	1.229E-01	
		HQ? @ Exposure Point	1.536E-02	7.024E-03
		RISK? @ Exposure Point	4.776E-07	4.776E-07
	Target Ground Water CUL? ug/l		2.574E-01	
	Target Soil CUL? mg/kg		1.047E+01	

			Method B @ HQ=1.0, RISK =1.0E-6	Method C @ HQ=1.0, RISK =1.0E-5
Protection of Air Quality *(for informational purpose only)*	Under the Current Condition	Predicted Air Conc? ug/m^3 @Exposure Point	4.897E-05	
		HQ? @ Exposure Point	N/A	N/A
		RISK? @ Exposure Point	1.903E-09	1.903E-09
	Target Air CUL? ug/m^3	@ HQ=1.0	N/A	N/A
		@ RISK=1.0E-6 or 1.0E-5	2.574E-02	2.574E-01
	Target Soil CUL? mg/kg	@ HQ=1.0	N/A	N/A
		@ RISK=1.0E-6 or 1.0E-5	2.628E+03	2.628E+04

For the **direct contact pathway**, the worksheet first calculates HQ and RISK under Method B and Method C based on the current site conditions.

- **Noncarcinogenic Risk under the Current Condition:** This is the hazard quotient (HQ) based on the measured soil concentration. The worksheet calculates the HQ using the direct contact equations in the regulation (ingestion only AND ingestion + dermal) and solving for HQ.

- **Carcinogenic Risk under the Current Condition:** This is the carcinogenic risk under the current condition based on the measured soil concentration. The worksheet calculates the carcinogenic risk using the direct contact equations in the regulation (ingestion only AND ingestion + dermal) and solving for carcinogenic RISK.

For the **direct contact pathway**, the worksheet next calculates protective soil concentrations under Method B and Method C based on the regulatory standards for HQ and RISK.

- **Target Soil CUL @ HQ = 1:** This is the protective soil concentration based on noncarcinogenic risk. The worksheet calculates the protective soil concentration using the direct contact equations in the regulation (ingestion only AND ingestion + dermal).

- **Target Soil CUL @ RISK = 1×10^{-6} (Method B) or 1×10^{-5} (Method C):** This is the protective soil concentration based on carcinogenic risk. The worksheet calculates the protective soil concentration using the direct contact equations in the regulation (ingestion only AND ingestion ÷ dermal).

For the **leaching pathway**, the worksheet first calculates the predicted ground water concentration based on current site conditions using 3-phase model and then calculates the HQ and RISK under Method B and Method C based on the predicted ground water concentration.

- **Noncarcinogenic Risk under the Current Condition:** This is the hazard quotient (HQ) based on the measured soil concentration and the predicted ground water concentration. The worksheet calculates the HQ using the equation in the regulation and solving for HQ.

- **Carcinogenic Risk under the Current Condition:** This is the carcinogenic risk based on the measured soil concentration and the predicted ground water concentration. The worksheet calculates the RISK using the equation in the regulation and solving for carcinogenic RISK.

For the **leaching pathway**, the worksheet next calculates the soil concentration that is protective of ground water under either Method B or Method C using the 3-phase model. The protective soil concentration is based on the target ground water cleanup level calculated using the ground water worksheet or defined by the user.

2.2.13 Output – Adjustment of Result

As noted previously **(see Section 2.2.2)**, the soil cleanup levels calculated using the soil worksheet **DO NOT** account for several factors. Consequently, to establish a soil cleanup level under the regulation, the cleanup level calculated using the worksheet may need to be manually adjusted to account for the following:

- Concentrations established under applicable state and federal laws (WAC 173-340-740(3)(b)(i) or 173-340-745(5)(b)(i));
- Terrestrial ecological impacts (see WAC 173-340-740(3)(b)(ii) or 173-340-745(5)(b)(ii));
- Impacts on air quality (vapor pathway) (see WAC 173-340-740(3)(b)(iii)(C), (c)(iv) or 173-340-745(5)(b)(iii)(C), (c)(iv));
- Residual saturation (see WAC 173-340-747(2)(b) and (10)); and
- Total site risk (see WAC 173-340-740(5)(a) or 173-340-745(6)(a)).

2.3 Worksheet for Calculating Potable Ground Water Cleanup Levels (Ground Water Worksheet)

This worksheet calculates a Method B or Method C potable ground water cleanup level.

2.3.1 Accessing the Ground Water Worksheet

The ground water worksheet is accessed by selecting the **Calc Ground Water CUL** button in **Part 5** of the soil worksheet described in **Section 2.2.9** above.

2.3.2 Caution on Use of the Ground Water Worksheet

The potable ground water cleanup levels calculated using the ground water worksheet account for the following:

- Concentrations established under applicable state and federal laws;
- Concentrations based on protection of human health;
- Natural background concentrations; and
- Practical quantitation limits.

The potable ground water cleanup levels calculated using the ground water worksheet **DO NOT** account for the following:

- Concentrations based on potential surface water impacts;
- Nonaqueous phase liquid (NAPL) limitation; and
- Total site risk.

The ground water cleanup levels calculated using the ground water worksheet may need to be manually adjusted to account for these considerations. See Section 2.3.6.

2.3.3 Equations and Parameters

The worksheet uses the standard equations for calculating potable ground water cleanup levels provided in the regulation **(see Appendix A)**. For each of the parameters used in the equations, default assumptions (values) are set forth in the regulation to calculate **standard** Method B or C cleanup levels. Under **modified** Method B and C, specified default assumptions may be adjusted based on site-specific or chemical-specific data. The regulation specifically describes which parameters may be adjusted and how they may be adjusted.

- IF the regulation does not allow a parameter to be adjusted, THEN the worksheet uses the default value for that parameter provided in the regulation. Also, the parameter is not listed in the worksheet and the user may not input data for that parameter.

- IF the regulation allows a parameter to be adjusted, THEN the parameter is listed in the worksheet and the user may input either the default value provided in the regulation or a site-specific or chemical-specific value derived under the regulation.

2.3.4 User Input – Soil and Ground Water Worksheets

To calculate a potable ground water cleanup level, the workbook requires the user to input data for several parameters, some of which are listed in the soil worksheet.

The following parameters necessary for calculating a potable ground water cleanup level are listed in the soil worksheet and must be entered there:

- Oral Reference Dose (RfD_o) – Part 2
- Oral Carcinogenic Potency Factor (CPF_o) – Part 2
- Inhalation Correction Factor (INH) – Part 3

The following parameters necessary for calculating a potable ground water cleanup level are listed in the ground water worksheet and must be entered there:

- Practical Quantitation Limit for Ground Water (if known)
- Natural Background Ground Water Concentration (if known)
- Most stringent ground water concentration based on applicable state and federal laws

This worksheet requires the user to provide information listed on the left side (see illustration below). Data is entered in the corresponding non-shaded (white) boxes on the right.

1. Calculation of Method B Cleanup Levels for Potable Ground Water	
Basis for Ground Water Concentration	Concentration, ug/l
Concentration based on non-carcinogenic risk @ HQ=1.0	8.000E+00
Concentration based on carcinogenic risk @ Risk = 1 in 1,000,000 (1.0E-6)	2.574E-01
Concentration based on carcinogenic risk @ Risk = 1 in 100,000 (1.0E-5)	2.574E+00
Enter Practical Quantitation Limit of Ground Water	0.1
Enter Natural Background Level of Ground Water	0
Enter Most stringent concentration based on Applicable State or Federal Laws	N/A
Method B Potable Ground Water Cleanup Level =	2.574E-01

Practical Quantitation Limit (PQL) for Ground Water (if known): This parameter is used to adjust the ground water cleanup level as provided in WAC 173-340-720(7)(c), if necessary. The parameter is chemical-specific. The PQL is the lowest concentration of the contaminant that can be reliably measured within specified limits of precision,

accuracy, representativeness, completeness, and comparability during routine laboratory operating conditions, using department approved methods. The analytical laboratory or site manager can assist the user in identifying the appropriate PQL. Enter the PQL for the chemical, if known. If the PQL is not known, leave the entry box blank.

Natural Background Ground Water Concentration (if known): This parameter is used to adjust the ground water cleanup level as provided in WAC 173-340-720(7)(c), if necessary. The parameter is chemical and site-specific. Enter the natural background ground water concentration, if known. Methods for defining natural background concentrations are provided in WAC 173-340-709. If the natural background concentration is not known, leave the entry box blank.

Most Stringent Ground Water Concentration Based on Applicable State or Federal Laws: This parameter is used to calculate a ground water cleanup level and is chemical-specific. Enter the most stringent (lowest) ground water concentration (criteria) established under applicable state or federal law for the chemical of concern. Ground water concentrations (criteria) established under applicable state or federal law are published in CLARC.

THIS COMPLETES DATA ENTRY FOR THE GROUND WATER WORKSHEET. SAVE YOUR WORK BEFORE CONTINUING.

2.3.5 Output – Interpreting the Result

For hazardous substances for which sufficiently protective, health-based concentrations have been established under applicable state and federal laws, the worksheet establishes a ground water cleanup level based on the most stringent of those concentrations. A concentration established under applicable state and federal laws is sufficiently protective if the excess cancer risk does not exceed 1 in 100,000 (1×10^{-5}) and the hazard quotient does not exceed one (1). If the concentration is not sufficiently protective, the worksheet calculates a protective concentration by adjusting the concentration downward in accordance with WAC 173-340-720(7)(b), using the equations provided in the regulation.

For hazardous substances for which health-based concentrations have not been established under applicable state and federal laws, the worksheet calculates a protective concentration using the equations provided in the regulation.

If the ground water cleanup level is lower (more stringent) than either the natural background concentration or the PQL, then the worksheet adjusts the cleanup level upward to the natural background concentration or the PQL, whichever is higher (less stringent).

2.3.6 Output – Adjustment of Result

As noted previously **(see Section 2.3.2)**, the potable ground water cleanup levels calculated using the ground water worksheet **DO NOT** account for several factors. Consequently, to establish a potable ground water cleanup level under the regulation, the cleanup level calculated using the worksheet may need to be manually adjusted to account for the following:

- Concentrations based on potential surface water impacts (see WAC 173-340-720(4)(b)(ii) and (5)(b)(ii));
- Nonaqueous phase liquid (NAPL) limitation (see WAC 173-340-720(7)(d)); and
- Total site risk (see WAC 173-340-720(7)(a)).

2.3.7 Output – Transfer of Adjusted Result to Soil Worksheet

To calculate a corresponding soil cleanup level using the soil worksheet, the potable ground water cleanup level calculated using the ground water worksheet must be manually adjusted (as described above) and then manually entered in the soil worksheet. The workbook DOES NOT automatically enter the result from the ground water worksheet.

2.4 Saving and Closing the Workbook

→ **USE THE END BUTTON** ←

Once an analysis is complete, it is good practice to print out a copy of the entire workbook as a record. At this point, you may also wish to save the workbook under a new name [FILE – SAVE AS]. IMPORTANT: the workbook should be closed (exited) using the END button at the top of the sheet. Do not close the workbook using the typical means provided in Excel (i.e., [FILE-CLOSE] or clicking on the "X"). Using the END button allows the programmed routines in the workbook to return the Excel toolbar displays and other format options to those you normally use.

If you accidentally exit without using the END button, you can re-establish your toolbars by clicking on [VIEW-TOOLBARS] and selecting the toolbars you wish to use. You may also need to click on [TOOLS-OPTIONS] and make selections as appropriate to re-establish certain work area components.

When you click on the END button, you will be prompted to save your work and you can do so by answering [yes] and saving the file under a new file name. Otherwise, answer [no] and you will exit the workbook without saving any changes.

Chapter 3 MTCATPH – Workbook for Calculating Cleanup Levels for a Petroleum Mixture

3.1 Overview

The **MTCATPH workbook** allows the user to use pre-established chemical and toxicity data, risk-based exposure assumptions, and user-defined site-specific information to calculate either of the following for a **petroleum mixture**:

- **Risk under Current Conditions:** The workbook provides the tools necessary to calculate the risk (carcinogenic and non-carcinogenic) under current conditions. To calculate the risk under current conditions, the workbook requires the user to enter a measured soil or ground water concentration. The workbook then executes a "forward" calculation using the equations in the regulation and solving for risk. For soil measurements, the workbook calculates the risk corresponding to the direct contact pathway, the leaching pathway (protection of ground water), and the vapor pathway (protection of air quality).

- **Cleanup Levels for Soil and Potable Ground Water:** The workbook provides the tools necessary to calculate protective soil concentrations under Method B and Method C. The workbook "back-calculates" a protective concentration based on the target risk levels (carcinogenic and non-carcinogenic) set forth in the regulation. For soil, the workbook calculates a protective concentration for the direct contact pathway, the leaching pathway (protection of ground water), and the vapor pathway (protection of air quality).

The **MTCATPH workbook** consists of two worksheet sets – the Worksheet set for Calculating Soil Cleanup Levels and the Worksheet set for Calculating Potable Ground Water Cleanup Levels.

3.2 Prerequisites for Use

To use the MTCATPH workbook, the user should be familiar with the concept of TPH fractions and the analytical requirements for TPH mixtures. Special analyses are required for various types of TPH mixtures (see Table 830-1 in WAC 173-340-900) to adequately characterize TPH for evaluation using this workbook tool. Depending on the type of TPH, analysis may also be required for specific volatile petroleum components (BTEX), fuel additives, semi-volatile compounds and other contaminants. A primer on TPH mixtures, fractions and analytical requirements is included in **Appendix E.**

The fundamental equations, associated parameters and default values for calculating soil cleanup levels based on the leaching pathway (protection of ground water) are set forth in

WAC 173-340-747 and reproduced in **Appendix C**. An in-depth technical discussion of the model theory is included in a separate article (Park and San Juan, 2000[2]).

3.3 Restrictions on Use

The MTCATPH workbook uses the three and four-phase equilibrium partitioning models to calculate soil concentrations that are protective of potable ground water. The four-phase model may only be used on a case-by-case basis for soil containing fuels (e.g., gasoline) that have been enhanced with alcohol. If the model is used for alcohol enhanced fuels, then it needs to be demonstrated that the effects of cosolvency have been adequately considered and, where necessary, taken into account when using the tools. Use of the model for alcohol enhanced fuels without considering the effects of cosolvency and increased ground water contamination is prohibited. See WAC 173-340-747(6)(b).

The four-phase model is primarily intended for use on known fresh or weathered TPH mixtures. Use of the tool for other mixtures of organic compounds (a mixture of solvents and creosote compounds, for example) is not as well tested as for petroleum product applications and the results may or may not be as reliable. Such applications need to be thoroughly scrutinized (quality checked) to make sure the results are within reasonable bounds.

3.4 Cautions on Use

3.4.1 Calculating Soil Cleanup Levels

The soil cleanup levels calculated using the soil worksheet account for the following:

- Concentrations based on protection of human health (direct contact pathway);
- Concentrations based on protection of ground water (leaching pathway);
- Natural background concentrations; and
- Practical quantitation limits.

The soil cleanup levels calculated using the soil worksheet **DO NOT** account for the following:

- Concentrations established under applicable state and federal laws (as of this writing, there are no applicable soil criteria for substances that are part of a TPH mixture);
- Concentrations based on protection of air quality (vapor pathway);

[2] Hun Seak Park and Charles San Juan, 2000. *A Method for Assessing Leaching Potential for Petroleum Hydrocarbons Release Sites: Multiphase and Multi-substance Equilibrium Partitioning*, Journal of Soil and Sediment Contamination, 9(6):611-632.

- Concentrations based on protection of terrestrial ecological receptors;
- Residual saturation limit for protection of ground water; and
- Total site risk (where chemicals other than petroleum mixtures exist at a site; e.g., chlorinated solvents).

The soil cleanup levels calculated using the soil worksheet may need to be manually adjusted to account for these considerations **(see Section 3.9.1).**

3.4.2 Calculating Ground Water Cleanup Levels

The potable ground water cleanup levels calculated using the ground water worksheet account for the following:

- Concentrations established under applicable state and federal laws;
- Concentrations based on protection of human health;
- Natural background concentrations; and
- Practical quantitation limits.

The potable ground water cleanup levels calculated using the ground water worksheet **DO NOT** account for the following:

- Concentrations based on potential surface water impacts;
- Nonaqueous phase liquid (NAPL) limitation; and
- Total site risk (where chemicals other than petroleum mixtures exist at a site; e.g., chlorinated solvents).

The ground water cleanup levels calculated using the ground water worksheet may need to be manually adjusted to account for these considerations. **See Section 3.9.2.**

WARNING: The MTCATPH workbook (unlike the MTCASGL workbook) DOES NOT provide the user the means to manually enter the target ground water cleanup levels (including values that have been manually adjusted) in the soil worksheet. THEREFORE, IF the potable ground water cleanup levels calculated using the ground water worksheet must be manually adjusted as described above to establish a cleanup level under the regulation, THEN the MTCATPH workbook CANNOT be used to calculate soil cleanup levels, except as described below.

NOTE: IF the ground water cleanup level must be manually adjusted to account for **total site risk** as described above, THEN the MTCATPH workbook can still be used to calculate a soil cleanup level by manually adjusting the target risk for the TPH mixture and using the "TPH Test" button in Sheet A2. **See Section 3.8.4.**

3.5 Overview of Equations and Parameters

3.5.1 Calculating Soil Cleanup Levels

The soil worksheet provides tools for evaluating the direct contact pathway, the leaching pathway (protection of ground water), and the vapor pathway (protection of air quality).

3.5.1.1 Direct Contact Pathway

For the evaluation of the direct contact pathway, the worksheet uses the standard equations provided in the regulation **(see Appendix B)** and summarized below. For petroleum mixtures, the evaluation of the direct contact pathway involves a concurrent evaluation of both soil ingestion and dermal contact.

Method B

TPH Mixture	
• Non-carcinogenic risk	Equation 740-3
TPH Components	
• Non-carcinogenic risk	Equation 740-4
• Carcinogenic risk	Equation 740-5

Method C

TPH Mixture	
• Non-carcinogenic risk	Equation 745-3
TPH Components	
• Non-carcinogenic risk	Equation 745-4
• Carcinogenic risk	Equation 745-5

For each of the parameters used in the equations, default assumptions (values) are set forth in the regulation to calculate **standard** Method B or C cleanup levels. Under **modified** Method B and C, specified default assumptions may be adjusted based on site-specific or chemical-specific data. The regulation specifically describes which parameters may be adjusted and how they may be adjusted.

Irrespective of whether a parameter may be adjusted under the regulation, the worksheet uses the default value for that parameter provided in the regulation. Also, the parameter is not listed in the worksheet and the user may not input data for that parameter

The default values for parameters are documented in the "Data Base" [accessed using MAIN (the tool navigator)] and in **Appendix F**. The user should refer to these sources to understand the basis for the cleanup levels calculated using the MTCATPH workbook.

3.5.1.2 Leaching Pathway

For the evaluation of the leaching pathway, the worksheet uses the three and four-phase equilibrium partitioning models (depending upon NAPL formulation) described in the regulation **(see Appendix C)** to calculate a cleanup level that will not cause an exceedance of the ground water cleanup level established under WAC 173-340-720. For each of the parameters used in the equations, the user may input either the default value provided in the regulation or a site-specific or chemical-specific value derived under the regulation.

3.5.1.3 Vapor Pathway

For the evaluation of the vapor pathway, the worksheet **first** uses the standard equations provided in the regulation **(see Appendix D)** to calculate air cleanup levels. For each of the parameters used in the equations, default assumptions (values) are set forth in the regulation to calculate **standard** Method B or C cleanup levels. Under **modified** Method B and C, specified default assumptions may be adjusted based on site-specific or chemical-specific data. The regulation specifically describes which parameters may be adjusted and how they may be adjusted. Irrespective of whether a parameter may be adjusted under the regulation, the worksheet uses the default value for that parameter provided in the regulation. Also, the parameter is not listed in the worksheet and the user may not input data for that parameter

Second, the worksheet converts the calculated air cleanup level into a soil vapor concentration using the vapor attenuation factor entered by the user.

Third, the worksheet uses the 3 and 4-phase equilibrium partitioning models **(see Appendix C)** and the soil vapor concentration to calculate the associated soil concentration – the concentration that is protective of air quality at the exposure point (point of compliance).

Ecology is currently evaluating appropriate procedures for evaluating the vapor pathway, including the use of vapor attenuation factors, and intends to provide further guidance on this issue in the future.

NOTE: The tools for evaluating the vapor pathway are provided for informational purposes only. Please consult the regulation and the site manager for more information regarding whether the pathway must be evaluated and how the pathway may be evaluated.

3.5.2 Calculating Ground Water Cleanup Levels

The ground water worksheet uses the standard equations provided in the regulation **(see Appendix A)**. For each of the parameters used in the equations, default assumptions (values) are set forth in the regulation to calculate **standard** Method B or C cleanup levels. Under **modified** Method B and C, specified default assumptions may be adjusted

based on site-specific or chemical-specific data. The regulation specifically describes which parameters may be adjusted and how they may be adjusted.

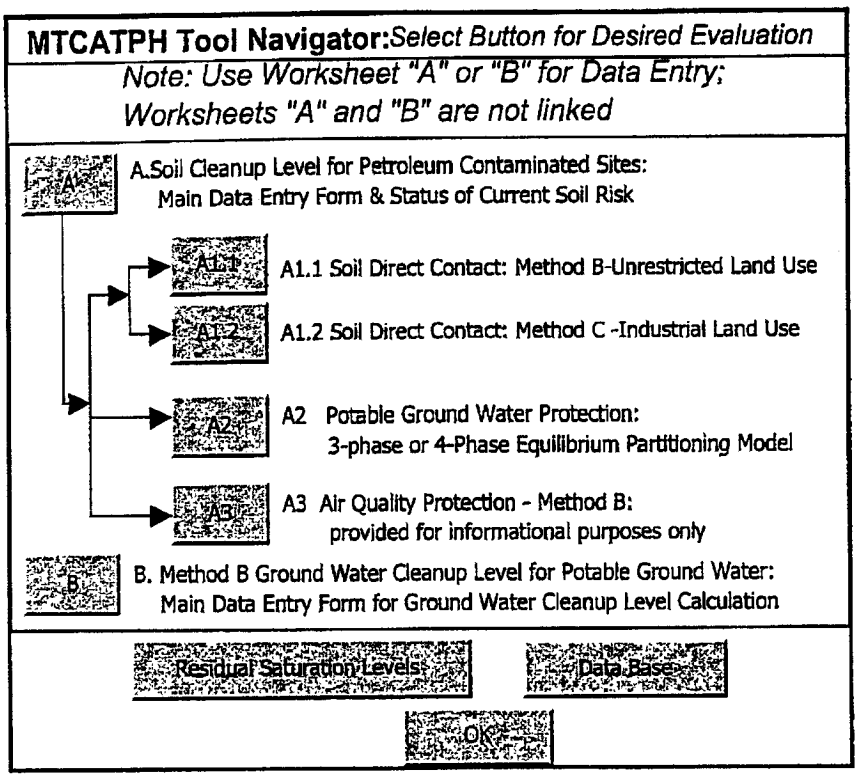
Irrespective of whether a parameter may be adjusted under the regulation, the worksheet uses the default value for that parameter provided in the regulation. Also, the parameter is not listed in the worksheet and the user may not input data for that parameter

The default values for parameters are documented in the "Data Base" [accessed using MAIN (the tool navigator)] and in **Appendix F.** The user should refer to these sources to understand the basis for the cleanup levels calculated using the MTCATPH workbook.

3.6 Navigating the Workbook

Once the workbook is successfully loaded into Excel®, the title sheet will appear as shown in **Section 1.5** (Installation). To use the workbook, click on the START button (to exit, click on the END button).

When the START button is selected, the workbook loads a navigation box as shown below:



NOTE: EACH SHEET IN THE WORKBOOK CONTAINS A BUTTON LABELED MAIN. THIS BUTTON CAN BE USED TO GO BACK TO THE NAVIGATION BOX SHOWN ABOVE. ONCE YOU ARRIVE AT A PARTICULAR SHEET USING THE NAVIGATION BOX, YOU MUST CLICK ON THE OK BUTTON (AT BOTTOM) BEFORE CONTINUING.

As shown in the hierarchical structure, only sheets A and B are used for data entry. Sheets A1.1 and A1.2 are used to examine the detailed calculations for the soil direct contact pathway under the unrestricted and industrial land use scenarios that result from the data entry for soil. **Section 3.8** of this manual provides additional discussion of the results and evaluation options presented in these sheets. This detail is useful in determining what TPH fractions or other compounds are actually causing a risk

exceedance, and therefore what components may be "driving" a site cleanup action. Similar information is provided in sheets A2 and A3 for the leaching pathway (protection of ground water) and the vapor pathway (protection of air quality). Sheet B is used for entering data and evaluating the potable ground water cleanup level.

Additional buttons provided at the bottom of the tool navigator are:

Default Residual Saturation Screening Levels: This shows the default residual saturation screening levels for different TPH mixtures as set forth in WAC 173-340-900, Table 747-5. For a soil concentration to be protective of ground water, the regulation requires that the concentration must not result in the accumulation of nonaqueous phase liquid (NAPL) on or in the ground water. WAC 173-340-747(2)(b). The default residual saturation screening levels may be used to determine whether the soil concentration calculated using the 3 and 4-phase models meets the regulatory requirement. Site-specific residual saturation screening levels may also be established. See WAC 173-340-747(10).

Data Base: This shows the supporting physical-chemical and toxicological information used in the workbook calculations for TPH fractions and associated hazardous compounds. Click on MAIN in the upper left corner to return to the navigation tool.

3.7 Input – Entering Data

3.7.1 Worksheet for Calculating Soil Cleanup Levels

3.7.1.1 Accessing the Soil Worksheet

In the MTCATPH Workbook Navigator Box, select Worksheet A.

3.7.1.2 Input Data – Part 1: Enter Measured Soil Concentration

The first part of the worksheet (illustrated below) requires the user to input analytical data (soil concentrations: dry basis mg/kg) in the non-shaded (white) cells for the chemicals of concern and EC groups appropriate for the type of TPH mixture being evaluated.

1. Enter Soil Concentration Measured

Chemical of Concern or Equivalent Carbon Group	Measured Soil Conc dry basis	Composition Ratio
	mg/kg	%
Petroleum EC Fraction		
AL_EC >5-6	23	23.69%
AL_EC >6-8	19	19.57%
AL_EC >8-10	9	9.27%
AL_EC >10-12	3	3.09%
AL_EC >12-16	0	0.00%
AL_EC >16-21	0	0.00%
AL_EC >21-34	0	0.00%
AR_EC >8-10	13	13.39%
AR_EC >10-12	2.5	2.57%
AR_EC >12-16	0	0.00%
AR_EC >16-21	0	0.00%
AR_EC >21-34	0	0.00%
Benzene	0.5	0.51%
Toluene	13	13.39%
Ethylbenzene	2	2.06%
Total Xylenes	11	11.33%
Total Naphthalenes	0	0.00%
n-Hexane	0	0.00%
MTBE	0	0.00%
Ethylene Dibromide (EDB)	0	0.00%
1,2 Dichloroethane (EDC)	0	0.00%
Benzo(a)anthracene	0.1	0.10%
Benzo(b)fluoranthene	0	0.00%
Benzo(k)fluoranthene	0	0.00%
Benzo(a)pyrene	1	1.03%
Chrysene	0	0.00%
Dibenzo(a,h)anthracene	0	0.00%
Indeno(1,2,3-cd)pyrene	0	0.00%
Sum	97.1	100.00%

Note that the right-hand column automatically calculates the percentage of the total mixture represented by the particular fraction/compound. Be sure that the correct units are used for all chemical concentrations (milligrams/kilogram = mg/kg = ppm) and that you use the same number of significant figures as reported by the laboratory. Enter zero (0) for substances that are not analyzed (i.e., for gasoline, you probably would not test for the cPAHs, so these entries would all be zero). For values below the method detection limit, substitute one-half the method detection limit. For values above the method detection limit but below the practical quantitiation limit, substitute the method detection limit. However, for a hazardous substance or petroleum fraction that has never been detected in any sample at a site and these substances are not suspected of being present at the site based on site history or other knowledge, enter "0" for that value. If the sample has been analyzed using both the VPH (Volatile Petroleum Hydrocarbons) and EPH (Extractable Petroleum Hydrocarbons) methods, use the higher value for the fraction where there is an overlap between these two methods.

All entries must be numeric values. Any text entry will cause a #VALUE# error to appear in the column to the right. This must be corrected or the workbook will not execute its calculations correctly.

Avoid Double Counting: The petroleum fractions include hazardous substances that may also be individually quantified, depending upon the type of mixture(s) present at a site (see Table 830-1 in WAC 173-340-900). If you have quantified one or more hazardous substances that are included in one of the TPH Equivalent Carbon (EC) - fractions, you need to make sure to subtract those concentrations from the appropriate EC-fraction concentrations. Otherwise, you are "double-counting" that particular substance. The Table below provides information on the individual substances that are represented by a particular EC-fraction:

Hazardous Substance	Associated EC-Fraction
n-Hexane (C_6H_6)	AL_EC>5 -6
Ethylbenzene and Xylenes (C_8H_{10})	AR_EC>8-10
Naphthalene ($C_{10}H_8$)*	AR_EC>10-12
Benzo(a)anthracene ($C_{18}H_{12}$)	AR_EC>16-21
Benzo(b)fluoranthene ($C_{20}H_{12}$)	AR_EC>16-21
Benzo(k)fluoranthene ($C_{20}H_{12}$)	AR_EC>16-21
Benzo(a)pyrene ($C_{20}H_{12}$)	AR_EC>16-21
Chrysene ($C_{18}H_{12}$)	AR_EC>16-21
Dibenzo(a,h)anthracene ($C_{22}H_{14}$)	AR_EC>21-34
Indeno(1,2,3-cd)pyrene ($C_{22}H_{12}$)	AR_EC>21-34

Footnote:

* Naphthalene-based compounds consisting of additional carbon-bearing structures may be included in heavier EC fractions.

3.7.1.3 Input Data – Part 2: Enter Hydrogeological Characteristics of the Site

The second part of the worksheet (illustrated below) requires the user to input default or site-specific data for the following hydrogeological characteristics of the site:

2. Enter Site-Specific Hydrogeological Data		
Total soil porosity: default is 0.43	0.43	Unitless
Volumetric water content: default is 0.3	0.3	Unitless
Volumetric air content: default is 0.13	0.13	Unitless
Soil bulk density measured: default is 1.5	1.5	kg/l
Fraction Organic Carbon: default is 0.001	0.001	Unitless
Dilution Factor: default is 20	20	Unitless

Total Soil Porosity (n): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. Enter the default value of "0.43" or enter a site-specific value determined under WAC 173-340-747(6)(d)(iii)(D) using site-specific measurements. Note that the sum of the volumetric water content and the volumetric air content must equal the total soil porosity. The site-specific soil porosity may be calculated using the following equation:

$$n = 1 - \frac{\rho_b}{\rho_s}$$

Parameter	Definition	Default Value	Units
n	Total soil porosity	Calculated	unitless
ρ_b	Dry soil bulk density	1.50 (see note 1)	kg/l
ρ_s	Soil particle specific gravity	2.65 (see note 2)	kg/l

Footnotes:

(1) Use the default value of 1.50 kg/l or use a site-specific value derived under WAC 173-340-747(5)(c).

(2) Use the default value of 2.65 kg/l or use a site-specific value derived under WAC 173-340-747(6)(d)(iii)(D). A site-specific value may be derived by measuring the soil particle specific gravity using ASTM Method D854-00.

Volumetric water content (θ_w): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. Enter the default value of "0.30" or enter a site-specific value derived under WAC 173-340-747(5)(d) using site-specific measurements. Note that the sum of the volumetric water content and the volumetric air content must equal the total soil porosity.

Volumetric Air Content (θ_a): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. The value for volumetric air content CANNOT be entered. The workbook automatically calculates a value based on the values entered for total soil porosity (n) and volumetric water content (θ_w) using the following equation:

$$\theta_a = n - \theta_w$$

If the default values for total soil porosity (n = 0.43) and volumetric water content (θ_w = 0.3) are entered, then the "default" volumetric air content is 0.13.

Dry Soil Bulk Density (ρ_b): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. Enter the default value of "1.50" or enter a site-specific value derived under WAC 173-340-747(5)(c) using site-specific measurements.

Fraction Soil Organic Carbon (f_{oc}): The fraction of soil organic carbon is the total mass of organic carbon divided by a unit mass of soil (mass of carbon/mass of soil). This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. Enter the default value of "0.001" or enter a site-specific value derived under WAC 173-340-747(5)(b)(i). The workbook calculates a value for K_d using the f_{oc} value entered here and the K_{oc} value in the database using Equation 747-2: $K_d = K_{oc} \times f_{oc}$.

Soil samples that are analyzed for f_{oc} must be collected outside the area of contamination and below the root zone. The results are usually reported as percent organic carbon. The reported value can be converted to a fraction by dividing by 100.

Dilution Factor (DF): This parameter is used to calculate a soil concentration that is protective of ground water (that will not cause an exceedance of the ground water cleanup level). The parameter is site-specific. Enter the applicable default value ("20" for unsaturated zone soil and "1" for saturated zone soil) or enter a site-specific value derived under WAC 173-340-747(5)(f) using site-specific estimates of infiltration and ground water flow rate. Note that the default value of "20" might not be sufficiently protective of the ground water for a site where the source size is significantly larger than a half acre, as specified by the EPA.[3]

THIS COMPLETES DATA ENTRY FOR THE SOIL WORKSHEET.
SAVE YOUR WORK BEFORE CONTINUING. You should save the file under a new file name that pertains to the particular site and sample.

[3] U.S. EPA, 1996. *Soil Screening Guidance: Technical Background Document*, EPA/540/R-95/128.

3.7.2 Worksheet for Calculating Ground Water Cleanup Levels

3.7.2.1 Accessing the Ground Water Worksheet

In the MTCATPH Workbook Navigator Box, select Worksheet B.

3.7.2.2 Input Data – Enter Measured Ground Water Concentrations

The ground water worksheet (illustrated below) requires the user to input analytical data (ground water concentrations: ug/l) in the non-shaded (white) cells for the chemicals of concern and EC groups appropriate for the type of TPH mixture being evaluated.

Enter Ground Water Concentration Measured		
Chemical of Concern or EC Group	Ground Water Conc measured	Ground Water Cleanup Level
	ug/l	ug/l
Petroleum EC Fraction		
AL_EC >5-6	15	
AL_EC >6-8	164	
AL_EC >8-10	35	
AL_EC >10-12	72	
AL_EC >12-16	5	
AL_EC >16-21	1	
AL_EC >21-34	1	
AR_EC >8-10	35	
AR_EC >10-12	98	
AR_EC >12-16	176	
AR_EC >16-21	198	
AR_EC >21-34	1	
Benzene	6.5	5
Toluene	156	1000
Ethylbenzene	112	700
Total Xylenes	215	1000
Total Naphthalenes	29	160
n-Hexane	16	
MTBE	17	20
Ethylene Dibromide (EDB)	0	0.01
1,2 Dichloroethane (EDC)	0	5
Benzo(a)anthracene	0	
Benzo(b)fluoranthene	0	
Benzo(k)fluoranthene	0.001	
Benzo(a)pyrene	0.001	
Chrysene	0	
Dibenzo(a,h)anthracene	0	
Indeno(1,2,3-cd)pyrene	0	
Sum	**1352.502**	

Be sure that the correct units are used for all chemical concentrations (micrograms/liter = ug/l = ppb) and that you use the same number of significant figures as reported by the laboratory. Enter zero (0) for substances that are not analyzed (i.e., for gasoline, you probably would not test for the cPAHs, so these entries would all be zero). For values below the method detection limit, substitute one-half the method detection limit. For values above the method detection limit but below the practical quantitation limit, substitute the method detection limit. For a hazardous substance or petroleum fraction that has never been detected in any sample at a site and these substances are not suspected of being present at the site based on site history or other knowledge, enter "0" for that value. If the sample has been analyzed using both the VPH (Volatile Petroleum Hydrocarbons) and EPH (Extractable Petroleum Hydrocarbons) methods, use the higher value for the fraction where there is an overlap between these two methods.

All entries must be numeric values. A text entry will cause a #VALUE# error to appear in one or more columns to the right. This must be corrected or the workbook will not execute its calculations correctly.

Note that the right-hand column provides, where available, the listed Method A ground water cleanup levels for certain chemicals to facilitate direct comparison.

Avoid Double Counting: The petroleum fractions include certain individual hazardous substances that may be quantified separately, depending upon the type of mixture(s) present at a site (see Table 830-1 in WAC 173-340-900). If you have quantified one or more hazardous substances that are included in one of the TPH EC-fractions, you need to make sure to subtract those concentrations from the appropriate EC-fraction concentrations. Otherwise, you are "double-counting" that particular substance. The Table below provides information on the individual substances that are represented by a particular EC-fraction:

Hazardous Substance	Associated EC-Fraction
n-Hexane (C_6H_6)	AL_EC>5 -6
Ethylbenzene and Xylenes (C_8H_{10})	AR_EC>8-10
Naphthalene ($C_{10}H_8$)*	AR_EC>10-12
Benzo(a)anthracene ($C_{18}H_{12}$)	AR_EC>16-21
Benzo(b)fluoranthene ($C_{20}H_{12}$)	AR_EC>16-21
Benzo(k)fluoranthene ($C_{20}H_{12}$)	AR_EC>16-21
Benzo(a)pyrene ($C_{20}H_{12}$)	AR_EC>16-21
Chrysene ($C_{18}H_{12}$)	AR_EC>16-21
Dibenzo(a,h)anthracene ($C_{22}H_{14}$)	AR_EC>21-34
Indeno(1,2,3-cd)pyrene ($C_{22}H_{12}$)	AR_EC>21-34

Footnote:

* Naphthalene-based compounds consisting of additional carbon-bearing structures may be included in heavier EC fractions.

THIS COMPLETES DATA ENTRY FOR THE GROUND WATER WORKSHEET. SAVE YOUR WORK BEFORE CONTINUING.

3.8 Output – Interpreting the Results

Every worksheet in the **MTCATPH workbook** provides a means for observing and evaluating the results based on the entered data. The following discussion of these observations and analytical tools are **organized by worksheet.**

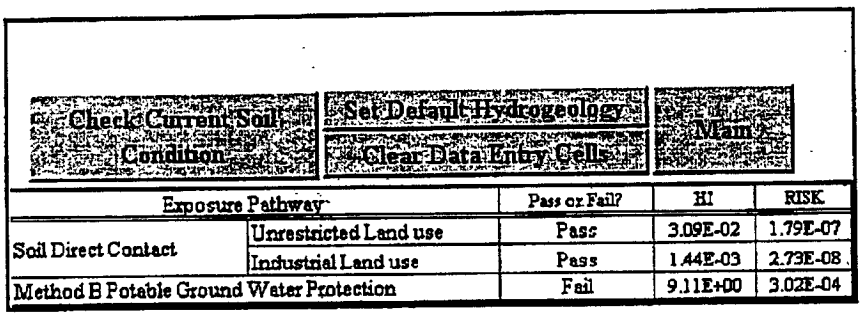
As described previously, the workbook allows the user to examine **two situations.**

- **First,** the workbook provides the tools necessary to calculate the risk (carcinogenic and non-carcinogenic) under current conditions. To calculate the risk under current conditions, the workbook requires the user to enter a measured soil or ground water concentration. The workbook then executes a "forward" calculation using the equations in the regulation and solving for risk.

- **Second,** the workbook provides the tools necessary to calculate protective concentrations under Method B and Method C. The workbook "back-calculates" a protective concentration based on the target risk levels (carcinogenic and non-carcinogenic) set forth in the regulation.

3.8.1 Sheet A – Worksheet for Calculating Soil Cleanup Levels

The soil worksheet includes a summary in the box at the right-hand side of the sheet as shown below:



Exposure Pathway		Pass or Fail?	HI	RISK
Soil Direct Contact	Unrestricted Land use	Pass	3.09E-02	1.79E-07
	Industrial Land use	Pass	1.44E-03	2.73E-08
Method B Potable Ground Water Protection		Fail	9.11E+00	3.02E-04

The Check Current Soil Condition button should be clicked in order to run all the calculations needed to generate the results. Once the calculations are updated, the results for each exposure pathway are displayed. Additional information on why a particular assessment passed or failed can be obtained by clicking the Main button and navigating to the appropriate sheet (A1.1, A1.2, A2, or A3) for the particular pathway:

A1.1: Direct Contact Pathway – Unrestricted Land Use
A1.2: Direct Contact Pathway – Industrial Land Use
A2: Leaching Pathway (Protection of Potable Ground Water)
A3: Vapor Pathway (Protection of Air Quality)

Each sheet provides additional observations and "what if" options as described in further detail below.

3.8.2 Sheet A1.1 – Evaluation of the Direct Contact Pathway under Method B (Unrestricted Land Use)

3.8.2.1 Current Condition

Results for the current condition (based on the soil data entered in Sheet A) are shown in two places in the sheet.

First, a summary box (shown below) is located in the upper right-hand portion of the sheet.

Current Condition	
TPH, mg/kg=	29313.588
HI=	8.612E+00
Cancer RISK=	3.321E-05
Pass or Fail?	Fail

This box provides the total concentration (mg/kg) of all the TPH fractions and compounds entered by the user, and the corresponding hazard index and cancer risk. In this particular example, the Pass/Fail indicates a "Fail" since both the carcinogenic and non-carcinogenic risks exceed the allowable level established for Method B for mixtures under 173-340-708(5).

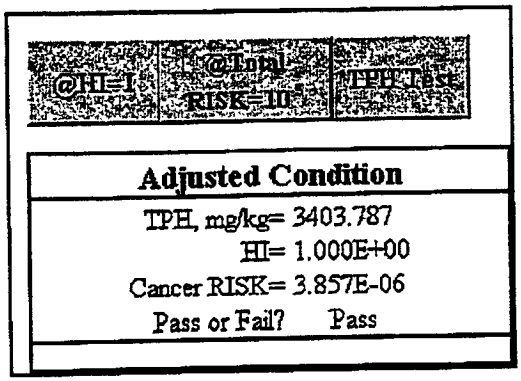
Second, the three columns located to the right of the data entry columns (heading: "Current Condition") provide the detail necessary to determine which fractions and chemicals are contributing to the hazard index and carcinogenic risk. The sums of the hazard quotient and total carcinogenic risk are shown at the bottom of their respective columns.

Pass/Fail Criteria: A failure is registered IF either of the following conditions is true:

- For a single hazardous substance (TPH component), the hazard quotient exceeds 1 or the carcinogenic risk exceeds 1×10^{-6};
- For total site risk (TPH mixture), the hazard index exceeds 1 or the sum of the carcinogenic risk exceeds 1×10^{-5};

3.8.2.2 Adjusted Condition

One of the most useful tools included in the workbook is the ability to determine, based on the relative composition of the sample, what TPH concentration would meet the risk-based limitations. This concentration would be the "target soil cleanup level." This can be done using the buttons and the box located at the right side of the sheet as shown below:



The **first button** back-calculates a TPH concentration (using the relative fraction/compound percentages based on the entered data) that meets the non-carcinogenic hazard index of 1 for multiple hazardous substances (total site risk). The result is immediately shown in the box below the buttons.

The **second button** back-calculates a TPH concentration (using the relative fraction/compound percentages based on the entered data) that meets the 1×10^{-5} carcinogenic risk level for multiple hazardous substances (total site risk). Again, the result is immediately shown in the box below the buttons.

The **third button** allows the user to enter a specific concentration and check the results.

For all three "adjusted" conditions, the details are provided in the four columns to the left under the heading "Adjusted Condition." The column shows the soil concentration corresponding to the total "adjusted" concentration and the corresponding hazard index or carcinogenic risk. The pass/fail criteria are the same as those for the "current condition".

3.8.3 Sheet A1.2 – Evaluation of the Direct Contact Pathway under Method C (Industrial Land Use)

The Sheet for the evaluating the direct contact pathway under Method C (industrial land use) has the all the same features as described for the unrestricted land use scenario in **Section 3.8.2** above. Under Method C, cleanup levels are calculated the same as under Method B, except that concentrations that are protective of human health are calculated using a less stringent target cancer risk for individual hazardous substances (1×10^{-5}) and less stringent default exposure assumptions **(see Appendix B).**

3.8.4 Sheet A2 – Evaluation of the Leaching Pathway (Protection of Ground Water)

Sheet A2 provides additional detail regarding the evaluation of the leaching pathway (protection of ground water). The sheet is divided into different columns and boxes that can be used to view results or develop "what-if" analyses. These areas are shown in the figure on the next page.

3.8.4.1 Current Condition

When first viewed, the results displayed are for the current condition. Check to see that the total soil concentration being tested at the bottom of the column is the same as the total concentration listed in Sheet A.

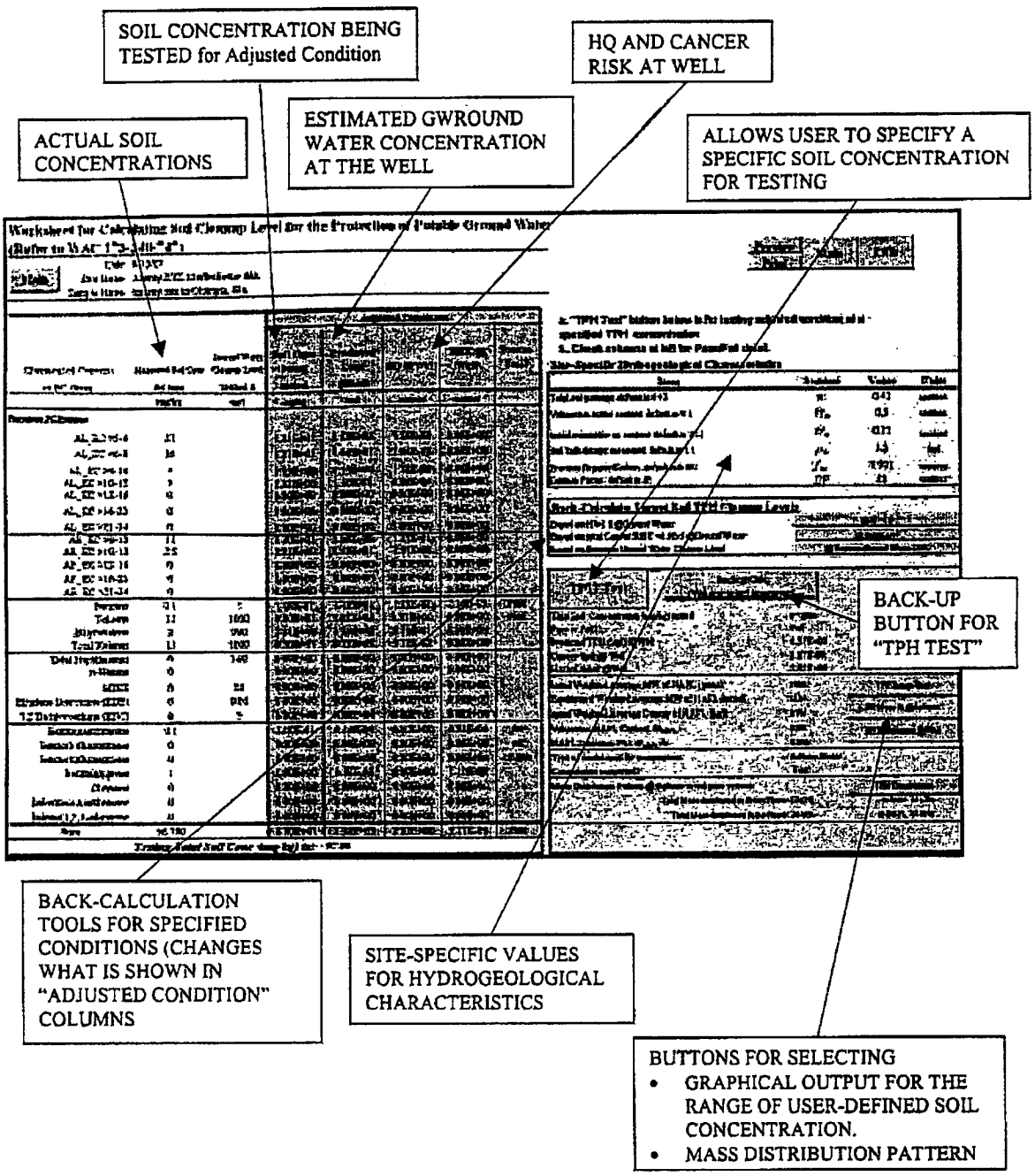
The information provided in the columns (from left to right) are as follows:

- **Measured Soil Concentration – dry weight basis (mg/kg):** These concentrations correspond to the data entered in Sheet A. It is provided for reference and is not changed by any of the "adjusted condition" calculations.

- **Ground Water Cleanup Level – Method A (ug/l):** These concentrations are the Method A ground water cleanup levels listed in Table 720-1. The Method A cleanup level is used to determine whether a chemical meets applicable requirements under state and federal law (ARARs) and the risk criteria for individual hazardous substances under Method B (RISK = 1×10^{-6} for carcinogens and HQ = 1 for non-carcinogens). The Method A cleanup levels in Table 720-1 were calculated under Method B and account for ARARs, protection of human health, natural background concentrations, and practical quantitation limits.

- **Predicted Concentration at Well (ug/l):** The predicted ground water concentration based on the partitioning equations presented in Appendix C.

- **Hazard Quotient (HQ) at Well:** The hazard quotient for each fraction or hazardous substance that contributes to the total hazard index for exposure to potable ground water (sum at bottom of column).



Sheet B2: Potable Ground Water Protection – Location of Columns and Toolboxes

- **RISK at Well:** The carcinogenic risk for each fraction or hazardous substance that contributes to the total cancer risk is summed at the bottom of the column.

- **Pass or Fail:** If any predicted individual chemical concentration at the well exceeds the applicable Method A ground water cleanup level, a "FAIL" is indicated in the column. Also, at the bottom of the column, a "FAIL" is indicated if the hazard index exceeds 1 or the total cancer risk exceeds 1×10^{-5}.

3.8.4.2 Adjusted Condition

The "Adjusted Condition" is displayed at the request of the user. The user may calculate the protective soil concentration by selecting one of the following back-calculation buttons on the right side of the sheet:

- Target Soil Cleanup Level @ HI = 1
- Target Soil Cleanup Level @ RISK = 1×10^{-5}
- Target Soil Cleanup Level based on benzene ground water cleanup level

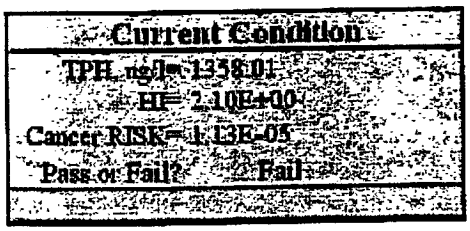
The adjusted concentration is scaled up or down (by proportionality) based on the same relative percentages as those for the actual measured soil concentrations.

3.8.5 Sheet B – Worksheet for Calculating Ground Water Cleanup Levels

3.8.5.1 Current Condition

Results for the current condition are shown in two places in the sheet.

First, a summary box (shown below) is located in the upper right-hand portion of the sheet.



This box provides the total concentration (ug/l) of all the TPH fractions and compounds entered by the user, and the corresponding hazard index and cancer risk. In this particular example, the Pass/Fail indicates a "Fail" since both the carcinogenic and non-carcinogenic risks exceed the acceptable levels for total site risk (HI = 1 and RISK = 1 x 10^{-5}).

Second, the three columns located to the right of the data entry columns (with the heading "Current Condition") provide the detail necessary to determine why the sample has failed and which fractions and chemicals are contributing to the hazard index and carcinogenic risk. The sums of the hazard quotient and total carcinogenic risk are shown at the bottom of their respective columns.

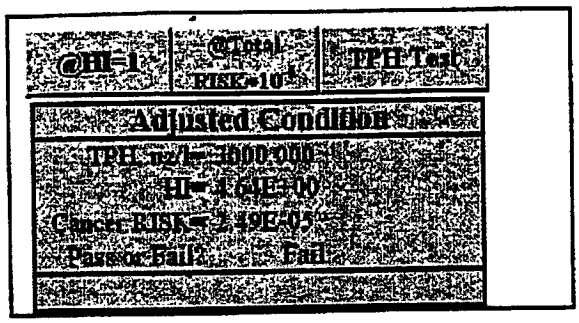
Pass/Fail Criteria: A failure is registered IF either of the following conditions is true:

- For a single hazardous substance (TPH component), the hazard quotient exceeds 1 or the carcinogenic risk exceeds 1 x 10^{-6} (i.e., the ground water concentration exceeds the applicable Method A concentration (listed immediately to the right of the data entry field));

- For total site risk (TPH mixture), the hazard index exceeds 1 or the sum of the carcinogenic risk exceeds 1 x 10^{-5};

3.8.5.2 Adjusted Condition

One of the most useful tools included in the workbook is the ability to determine, based on the relative composition of the sample, what TPH concentration would meet the risk-based limitations. This concentration would be the "target ground water cleanup level." This can be done using the buttons and the box located at the right side of the sheet as shown below:



The **first button** back-calculates a TPH concentration (using the relative fraction/compound percentages based on the entered data) that meets the non-carcinogenic hazard index of 1 for multiple hazardous substances (total site risk). The result is immediately shown in the box below the buttons.

The **second button** back-calculates a TPH concentration (using the relative fraction/compound percentages based on the entered data) that meets the 1×10^{-5} carcinogenic risk level for multiple hazardous substances (total site risk). Again, the result is immediately shown in the box below the buttons.

The **third button** allows the user to enter a specific concentration and check the results.

For all three "adjusted" conditions, the details are provided in the four columns to the left under the heading "Adjusted Condition." The column shows the ground water concentration corresponding to the total "adjusted" concentration and the corresponding hazard index or carcinogenic risk. The pass/fail criteria are the same as those for the "current condition" **(see Section 3.8.5.1).**

3.9 Output – Adjusting the Results

3.9.1 Calculating Soil Cleanup Levels

As noted previously **(see Section 3.4.1)**, the soil cleanup levels calculated using the soil worksheet **DO NOT** account for several factors. Consequently, to establish a soil cleanup level under the regulation, the cleanup level calculated using the worksheet may need to be manually adjusted to account for the following:

- Concentrations established under applicable state and federal laws (WAC 173-340-740(3)(b)(i) or 173-340-745(5)(b)(i));
- Terrestrial ecological impacts (see WAC 173-340-740(3)(b)(ii) or 173-340-745(5)(b)(ii));
- Impacts on air quality (vapor pathway) (see WAC 173-340-740(3)(b)(iii)(C), (c)(iv) or 173-340-745(5)(b)(iii)(C), (c)(iv));
- Residual saturation (see WAC 173-340-747(2)(b) and (10)); and
- Total site risk (see WAC 173-340-740(5)(a) or 173-340-745(6)(a)).

3.9.2 Calculating Ground Water Cleanup Levels

As noted previously **(see Section 3.4.2)**, the potable ground water cleanup levels calculated using the ground water worksheet **DO NOT** account for several factors. Consequently, to establish a potable ground water cleanup level under the regulation, the cleanup level calculated using the worksheet may need to be manually adjusted to account for the following:

- Concentrations based on potential surface water impacts (see WAC 173-340-720(4)(b)(ii) and (5)(b)(ii));
- Nonaqueous phase liquid (NAPL) limitation (see WAC 173-340-720(7)(d)); and
- Total site risk (see WAC 173-340-720(7)(a)).

WARNING: The MTCATPH workbook (unlike the MTCASGL workbook) DOES NOT provide the user the means to manually enter the target ground water cleanup levels (including values that have been manually adjusted) in the soil worksheet. THEREFORE, IF the potable ground water cleanup levels calculated using the ground water worksheet must be manually adjusted as described above to establish a cleanup level under the regulation, THEN the MTCATPH workbook CANNOT be used to calculate soil cleanup levels, except as described below.

NOTE: IF the ground water cleanup level must be manually adjusted to account for **total site risk** as described above, THEN the MTCATPH workbook can still be used to calculate a soil cleanup level by manually adjusting the target risk for the TPH mixture and using the "TPH Test" button in Sheet A2. **See Section 3.8.4.**

3.10 Saving and Closing the Workbook

→ USE THE END BUTTON ←

Once an analysis is complete, it is good practice to print out a copy of the entire workbook as a record. At this point, you may also wish to save the workbook under a new name [FILE – SAVE AS]. IMPORTANT: the workbook should be closed (exited) using the END button at the top of the sheet. Do not close the workbook using the typical means provided in Excel® (i.e., [FILE-CLOSE] or clicking on the "X"). Using the END button allows the programmed routines in the workbook to return the Excel® toolbar displays and other format options to those you normally use.

If you accidentally exit without using the END button, you can re-establish your toolbars by clicking on [VIEW-TOOLBARS] and selecting the toolbars you wish to use. You may also need to click on [TOOLS-OPTIONS] and make selections as appropriate to re-establish certain work area components.

When you click on the END button, you will be prompted to save your work and you can do so by answering [yes] and saving the file under a new file name. Otherwise, answer [no] and you will exit the workbook without saving any changes.

Appendix A

Equations and Default Values for Calculating Potable Ground Water Cleanup Levels

Equation 720-1: Potable Ground Water Cleanup Levels – Noncarcinogens

$$Potable\ Ground\ Water\ CleanupLevel\ (ug/l) = \frac{RfD_o \times ABW \times UCF \times HQ \times AT}{DWIR \times INH \times DWF \times ED}$$

Parameter	Definition	Default Value		Units
		Method B	Method C	
RfD_o	Oral Reference Dose	Chemical-specific	Chemical-specific	mg/kg-day
ABW	Average Body Weight over the exposure duration	16	70	kg
UCF	Unit Conversion Factor	1,000	1,000	ug/mg
HQ	Hazard Quotient	1.0	1.0	unitless
AT	Averaging Time	6	6	years
DWIR	Drinking Water Ingestion Rate	1.0	2.0	l/day
INH	Inhalation Correction Factor (1)	See Note (1)	See Note (1)	unitless
DWF	Drinking Water Fraction	1.0	1.0	unitless
ED	Exposure Duration	6	6	years

Footnotes:
(1) Use value of 2 for volatile organic compounds and 1 for all other substances.

Equation 720-2: Potable Ground Water Cleanup Levels – Carcinogens

$$Potable\ Ground\ Water\ Cleanup\ Level\ (ug/l) = \frac{RISK \times ABW \times AT \times UCF}{CPF_o \times DWIR \times ED \times INH \times DWF}$$

Parameter	Definition	Default Value		Units
		Method B	Method C	
RISK	Acceptable Cancer Risk Level	1.0E-6	1.0E-5	unitless
ABW	Average Body Weight over the exposure duration	70	70	kg
AT	Averaging Time	75	75	years
UCF	Unit Conversion Factor	1,000	1,000	ug/mg
CPF_o	Oral Carcinogenic Potency Factor	Chemical-specific	Chemical-specific	kg-day/mg
DWIR	Drinking Water Ingestion Rate	2.0	2.0	l/day
INH	Inhalation Correction Factor	See Note (1)	See Note (1)	unitless
DWF	Drinking Water Fraction	1.0	1.0	unitless
ED	Exposure Duration	30	30	years

Footnotes:
(1) Use value of 2 for volatile organic compounds and 1 for all other substances.

Equation 720-3: Potable Ground Water Cleanup Levels – Petroleum Mixtures (Non-Carcinogenic Risk)

$$C_w = \frac{HI \times AT}{\left[\frac{DWIR \times DWF \times ED}{ABW \times UCF}\right] \times \sum_{i=1}^{n} \frac{F_{(i)} \times INH_{(i)}}{RfD_{o(i)}}}$$

Parameter	Definition	Default Value		Units
		Method B	Method C	
C_w	TPH ground water cleanup level	---	---	ug/l
HI	Hazard Index	1.0	1.0	unitless
AT	Averaging Time	6	6	years
DWIR	Drinking Water Ingestion Rate	1.0	2.0	l/day
DWF	Drinking Water Fraction	1.0	1.0	unitless
ED	Exposure Duration	6	6	years
ABW	Average Body Weight over the exposure duration	16	70	kg
UCF	Unit Conversion Factor	1,000	1,000	ug/mg
$F_{(i)}$	Fraction (by weight) of petroleum component (i)	Chemical-specific	Chemical-specific	unitless
$INH_{(i)}$	Inhalation Correction Factor for petroleum component (i)	See Note (1)	See Note (1)	unitless
$RfD_{o(i)}$	Oral Reference Dose of Petroleum component (i)	Chemical-specific	Chemical-specific	mg/kg-day
n	The number of petroleum components (petroleum fractions plus volatile organic compounds with an RfD_o) present in the petroleum mixture (See Table 830-1.)	Mixture-specific	Mixture-specific	unitless

Footnotes:
(1) Use value of 2 for volatile organic compounds and 1 for all other substances.

Appendix B

Equations and Default Values for Calculating Protective Soil Concentrations based on the Direct Contact Pathway

Equations 740-1 and 745-1: Soil Direct Contact (Ingestion Only) – Noncarcinogens

$$Soil\ Cleanup\ Level\ (mg/kg) = \frac{RfD_o \times ABW \times UCF \times HQ \times AT}{SIR \times AB1 \times EF \times ED}$$

Parameter	Definition	Default Value		Units
		Method B Equation 740-1	Method C Equation 745-1	
RfD_o	Oral Reference Dose	Chemical-specific	Chemical-specific	mg/kg-day
ABW	Average Body Weight over the exposure duration	16	70	kg
UCF	Unit Conversion Factor	1.0E+6	1.0E+6	mg/kg
SIR	Soil Ingestion Rate	200	50	mg/day
$AB1$	Gastrointestinal Absorption fraction	1.0	1.0	unitless
EF	Exposure Frequency	1.0	0.4	unitless
HQ	Hazard Quotient	1.0	1.0	unitless
AT	Averaging Time	6	20	years
ED	Exposure Duration	6	20	years

Equations 740-2 and 745-2: Soil Direct Contact (Ingestion Only) – Carcinogens

$$Soil\ Cleanup\ Level\ (mg/kg) = \frac{RISK \times ABW \times AT \times UCF}{CPF_o \times SIR \times AB1 \times ED \times EF}$$

Parameter	Definition	Default Value		Units
		Method B Equation 740-2	Method C Equation 745-2	
$RISK$	Acceptable cancer risk level	1.0E-6	1.0E-5	mg/kg-day
ABW	Average Body Weight over the exposure duration	16	70	kg
UCF	Unit Conversion Factor	1.0E+6	1.0E+6	mg/kg
CPF_o	Oral Carcinogenic Potency Factor	Chemical-specific	Chemical-specific	kg-day/mg
AT	Averaging Time	75	75	years
SIR	Soil Ingestion Rate	200	50	mg/day
$AB1$	Gastrointestinal Absorption fraction	1.0	1.0	unitless
ED	Exposure Duration	6	20	unitless
EF	Exposure Frequency	1.0	0.4	years

Equations 740-3 and 745-3: Soil Direct Contact (Ingestion + Dermal) – Petroleum Mixtures (Non-Carcinogenic Risk)

$$C_{soil} = \frac{HI \times ABW \times AT}{EF \times ED \times \left[\left(\frac{SIR \times AB1}{10^6 mg/kg} \sum_{i=1}^{n} \frac{F_{(i)}}{RfD_{o(i)}}\right) + \left(\frac{SA \times AF}{10^6 mg/kg} \sum_{i=1}^{n} \frac{F_{(i)} \times ABS_{d(i)}}{RfD_{d(i)}}\right)\right]}$$

Parameter	Definition	Default Value		Units
		Method B Equation 740-3	Method C Equation 745-3	
C_{soil}	TPH soil cleanup level	---	---	mg/kg
HI	Hazard Index	1	1	unitless
ABW	Average Body Weight over the exposure duration	16	70	kg
AT	Averaging Time	6.0	20	years
EF	Exposure Frequency	1.0	0.7	unitless
ED	Exposure Duration	6.0	20	years
SIR	Soil Ingestion Rate	200	50	mg/day
AB1	Gastrointestinal Absorption fraction	1.0	1.0	unitless
$F_{(i)}$	Fraction (by weight) of petroleum component (i)	Chemical-specific	Chemical-specific	unitless
SA	Dermal Surface Area	2,200	2,500	cm^2
AF	Adherence Factor	0.2	0.2	mg/cm^2-day
$ABS_{d(i)}$	Dermal Absorption Fraction for petroleum component (i).	See Note (1)	See Note (1)	unitless
$RfD_{o(i)}$	Oral Reference Dose for petroleum component (i)	Chemical-specific	Chemical-specific	mg/kg-day
$RfD_{d(i)}$	Dermal Reference Dose for petroleum component (i)	See Note (2)	See Note (2)	mg/kg-day
GI	Gastrointestinal Absorption conversion factor	See Note (3)	See Note (3)	unitless
n	The number of petroleum components (petroleum fractions plus volatile organic compounds with an RfD_o) present in the petroleum mixture (See Table 830-1.)	Mixture-specific	Mixture-specific	unitless

Footnotes:

(1) May use chemical-specific values or the following defaults: 0.0005 for volatile petroleum components with vapor pressure ≥ benzene; 0.03 for volatile petroleum components with vapor pressure < benzene; 0.1 for other petroleum components.

(2) Derived by RfD_o x *GI* (see note 3).

(3) May use chemical-specific values or the following defaults: 0.8 for volatile petroleum components; 0.5 for other petroleum components.

Equations 740-4 and 745-4: Soil Direct Contact (Ingestion + Dermal) – Noncarcinogens

For hazardous substances that are part of a petroleum mixture, cleanup levels must be calculated using Equations 740-4 and 745-4 for noncarcinogens and Equations 740-5 and 745-5 for carcinogens. See WAC 173-340-740(3)(b)(iii)(B)(III) and 173-340-745(5)(b)(iii)(B)(III).

For hazardous substances other than petroleum mixtures, cleanup levels for dermal contact with the soil must be evaluated whenever the proposed changes to Equations 740-1/745-1 or 740-2/745-2 would result in a significantly higher soil cleanup level than would be calculated without the proposed changes. See WAC 173-340-740(3)(c)(iii) and 173-340-745(5)(c)(iii).

$$C_{soil} = \frac{HQ \times ABW \times AT}{EF \times ED \times \left[\left(\frac{1}{RfD_o} \times \frac{SIR \times AB1}{10^6 mg/kg}\right) + \left(\frac{1}{RfD_d} \times \frac{SA \times AF \times ABS_d}{10^6 mg/kg}\right)\right]}$$

Parameter	Definition	Default Value		Units
		Method B Equation 740-4	Method C Equation 745-4	
C_{soil}	Soil cleanup level	—	—	mg/kg
HQ	Hazard Quotient	1	1	unitless
ABW	Average Body Weight over the exposure duration	16	70	kg
AT	Averaging Time	6.0	20	years
EF	Exposure Frequency	1.0	0.7	unitless
ED	Exposure Duration	6.0	20	years
SIR	Soil Ingestion Rate	200	50	mg/day
$AB1$	Gastrointestinal Absorption fraction	1.0	1.0	unitless
SA	Dermal Surface Area	2,200	2,500	cm^2
AF	Adherence Factor	0.2	0.2	mg/cm^2-day
ABS_d	Dermal Absorption Fraction	See Note (1)	See Note (1)	unitless
RfD_o	Oral Reference Dose	Chemical-specific	Chemical-specific	mg/kg-day
RfD_d	Dermal Reference Dose	See Note (2)	See Note (2)	mg/kg-day
GI	Gastrointestinal Absorption conversion factor	See Note (3)	See Note (3)	unitless

Footnotes:

(1) May use chemical-specific values or the following defaults: 0.01 for inorganic hazardous substances; 0.0005 for volatile organic compounds with vapor pressure ≥ benzene; 0.03 for volatile organic compounds with vapor pressure < benzene; 0.1 for other hazardous substances.

(2) Derived by $RfD_o \times GI$ (see note 3).

(3) May use chemical-specific values or the following defaults: 0.2 for inorganic hazardous substances; 0.8 for volatile organic compounds; 0.5 for other organic hazardous substances.

Equations 740-5 and 745-5: Soil Direct Contact (Ingestion + Dermal) – Carcinogens

For hazardous substances that are part of a petroleum mixture, cleanup levels must be calculated using Equations 740-4 and 745-4 for noncarcinogens and Equations 740-5 and 745-5 for carcinogens. See WAC 173-340-740(3)(b)(iii)(B)(III) and 173-340-745(5)(b)(iii)(B)(III).

For hazardous substances other than petroleum mixtures, cleanup levels for dermal contact with the soil must be evaluated whenever the proposed changes to Equations 740-1/745-1 or 740-2/745-2 would result in a significantly higher soil cleanup level than would be calculated without the proposed changes. See WAC 173-340-740(3)(c)(iii) and 173-340-745(5)(c)(iii).

$$C_{soil} = \frac{RISK \times ABW \times AT}{EF \times ED \times \left[\left(\frac{SIR \times AB1 \times CPF_o}{10^6 mg/kg}\right) + \left(\frac{SA \times AF \times ABS_d \times CPF_d}{10^6 mg/kg}\right)\right]}$$

Parameter	Definition	Default Value		Units
		Method B Equation 740-5	Method C Equation 745-5	
C_{soil}	Soil cleanup level	—	—	mg/kg
RISK	Acceptable cancer risk level	1.0E-6	1.0E-5	unitless
ABW	Average Body Weight over the exposure duration	16	70	kg
AT	Averaging Time	75	75	years
EF	Exposure Frequency	1.0	0.7	unitless
ED	Exposure Duration	6.0	20	years
SIR	Soil Ingestion Rate	200	50	mg/day
AB1	Gastrointestinal Absorption fraction	1.0	1.0	unitless
SA	Dermal Surface Area	2,200	2,500	cm^2
AF	Adherence Factor	0.2	0.2	mg/cm^2-day
ABS_d	Dermal Absorption Fraction	See Note (1)	See Note (1)	unitless
CPF_o	Oral Cancer Potency Factor	Chemical-specific	Chemical-specific	mg/kg-day
CPF_d	Dermal Cancer Potency Factor	See Note (2)	See Note (2)	mg/kg-day
GI	Gastrointestinal Absorption conversion factor	See Note (3)	See Note (3)	unitless

Footnotes:

(1) May use chemical-specific values or the following defaults: 0.01 for inorganic hazardous substances; 0.0005 for volatile organic compounds with vapor pressure ≥ benzene; 0.03 for volatile organic compounds with vapor pressure < benzene; 0.1 for other hazardous substances.

(2) Derived by $CPF_o \div GI$ (see note 3).

(3) May use chemical-specific values or the following defaults: 0.2 for inorganic hazardous substances; 0.8 for volatile organic compounds; 0.5 for other organic hazardous substances.

Appendix C

Equations and Default Values for Calculating Protective Soil Concentrations based on the Leaching Pathway

(Protection of Ground Water)

THREE-PHASE PARTITIONING

Equation 747-1: Three Phase Partitioning Equation.

$$C_s = C_w \times UCF \times DF \times \left[K_d + \frac{\theta_w + \theta_a \times H_{cc}}{\rho_b} \right]$$

Parameter	Definition	Default Value	Units
C_s	Soil concentration	(calculated)	mg/kg
C_w	Ground water cleanup level established under WAC 173-340-720	Chemical-specific	ug/l
UCF	Unit Conversion Factor	1E-3	mg/ug
DF	Dilution Factor	20	unitless
K_d	Distribution Coefficient	Chemical-specific (1)	l/kg
θ_w	Water-filled soil porosity	0.3	unitless, ml/ml
θ_a	Air-filled soil porosity	0.13	unitless, ml/ml
H_{cc}	Henry's law constant	Chemical-specific (2)	unitless
ρ_b	Dry soil bulk density	1.5	kg/l

Footnotes:

(1) The regulation specifies default values for certain chemicals and procedures for establishing chemical-specific values. See WAC 173-340-747(4)(c).

(2) The regulation specifies default values for certain chemicals and procedures for establishing chemical-specific values. See WAC 173-340-747(4)(d).

Equation 747-2: Derivation of a Distribution Coefficient (K_d) for Organic Hazardous Substances based on the Soil Organic Carbon-Water Partitioning Coefficient (K_{oc})

$$K_d = K_{oc} \times f_{oc}$$

Parameter	Definition	Default Value	Units
K_d	Distribution coefficient	(calculated or site-specific)	ml/g, l/kg
K_{oc}	Soil organic carbon-water partitioning coefficient	Chemical-specific (1)	ml/g, l/kg
f_{oc}	Soil fraction of organic carbon	0.001	unitless, g/g

Footnotes:

(1) The regulation specifies default values for certain chemicals and procedures for establishing chemical-specific values. See WAC 173-340-747(4)(c)(i).

Equation 747-3: Deriving a Dilution Factor from Site-Specific Estimates of Infiltration and Ground Water Flow Volume

$$DF = \frac{(Q_p + Q_a)}{Q_p} = 1 + \frac{Q_a}{Q_p}$$

Parameter	Definition	Default Value	Units
DF	Dilution Factor	(calculated)	unitless
Q_p	Flowrate of water infiltering (see Equation 747-5)	(calculated)	m^3/yr
Q_a	Ground water flowrate (see Equation 747-4)	(calculated)	m^3/yr

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Equation 747-4: Calculating Ground Water Flowrate (Q_a)

$$Q_a = K \times A \times I$$

Parameter	Definition	Default Value	Units
Q_a	Ground water flowrate	(calculated)	m^3/yr
K	Hydraulic conductivity	Site-specific measurement	m/yr
A	Cross-sectional Area of Aquifer mixing zone (1)	Site-specific measurement	m^2
I	Hydraulic Gradient	Site-specific measurement	unitless, m/m

Footnotes:

(1) The aquifer mixing zone thickness shall not exceed 5 meters in depth and be equal to a unit width of 1 meter, unless it can be demonstrated empirically that the mixing zone thickness exceeds 5 meters.

Equation 747-5: Calculating the Flowrate of Water Infiltrating (Q_p)

$$Q_p = L \times W \times Inf$$

Parameter	Definition	Default Value	Units
Q_p	Flowrate of water infiltering	(calculated)	m^3/yr
L	Estimated length of contaminant source area parallel to ground water flow	Site-specific measurement	m
W	Unit width of contaminant source area	1.0	m
Inf	Infiltration rate	Site-specific measurement (1)	m/yr

Footnotes:

(1) A default value may be used. For sites west or east of the Cascade Mountains, the default annual infiltration value shall be **70 percent** or **25 percent**, respectively, of the average annual precipitation amount.

FOUR-PHASE PARTITIONING

Equation 747-6: Conservation of Volume Equation.

$$n = \theta_w + \theta_a + \theta_{NAPL}$$

n	Total soil porosity (ml total pore space/ml total soil volume). Use a default value of 0.43 ml/ml or use a value determined from site-specific measurements.
θ_w	Volumetric water content (ml water/ml soil). For unsaturated soil use a default value of 0.3 or a value determined from site-specific measurements. For saturated soil this value is unknown and must be solved for. Volumetric water content equals the total soil porosity minus volume occupied by the NAPL.
θ_a	Volumetric air content (ml air volume/ml total soil volume). For unsaturated soil this value is unknown and must be solved for. Volumetric air content equals the total soil porosity minus the volume occupied by the water and NAPL. For saturated soil this value is zero.
θ_{NAPL}	Volumetric NAPL content (ml NAPL volume/ml total soil volume). For both unsaturated and saturated soil this value is unknown and must be solved for.

Equation 747-7: Four-Phase Partitioning Equation

$$\frac{M_T^i}{m_{soil}} = \frac{x_i S_i}{\rho_b}\left[\theta_w + K_{oc}^i f_{oc} \rho_b + H_{cc}^i \theta_a + \frac{GFW_i}{S_i}\rho_{NAPL}\,\theta_{NAPL}\right]$$

M^i_T	Total mass of each component in the system (mg). This value is derived from site-specific measurements.
m_{soil}	Total soil mass (kg). This value is derived from site-specific measurements.
x_i	Mole fraction (at equilibrium) of each component (dimensionless). This value is unknown and must be solved for.
S_i	Water Solubility of each component (mg/l). See Table 747-4 for petroleum hydrocarbons; see the scientific literature for other hazardous substances.
ρ_b	Dry soil bulk density (default is 1.5 kg/l).
K^i_{oc}	Soil organic carbon-water partitioning coefficient for each component (l/kg). See Table 747-4 for petroleum hydrocarbons; see WAC 173-340-747(4)(b) for other hazardous substances.
f_{oc}	Mass fraction of soil natural organic carbon (default is 0.001 g soil organic/g soil).
H^i_{cc}	Henry's law constant for each component (dimensionless). See Table 747-4 for petroleum hydrocarbons; see WAC 173-340-747(4)(c) for other hazardous substances.
GFW_i	Gram formula weight, or molecular weight of each component (mg/mol). See Table 747-4 for petroleum hydrocarbons; see the scientific literature for other hazardous substances.
ρ_{NAPL}	Molar density of the mixture (mol/l). See Equation 747-8.
Component	For petroleum mixtures, this means the petroleum fractions, and organic hazardous substances with a reference dose; for other hazardous substances, this means each organic hazardous substance that is found in the NAPL.

Equation 747-8: Molar Density Equation

$$\rho_{NAPL} = \frac{\left[\sum x_i GFW_i \cdot \left(\sum x_i GFW_i / \rho_i\right)\right]}{\sum x_i GFW_i}$$

$$= \frac{1}{\sum (x_i GFW_i / \rho_i)}$$

GFW_i	Gram formula weight, or molecular weight of each component (mg/mol). See Table 747-4 for petroleum hydrocarbons; see the scientific literature for other hazardous substances.
x_i	Mole fraction (at equilibrium) of each component (dimensionless) after equilibration. This value is unknown and must be solved for.
ρ_i	Density of each component (mg/l). See Table 747-4 for petroleum hydrocarbons; see the scientific literature for other hazardous substances.
Component	For petroleum mixtures, this means the petroleum fractions plus organic hazardous substances with a reference dose; for other hazardous substances, this means each organic hazardous substance that is found in the NAPL.

Appendix D

Equations and Default Values for Calculating Air Cleanup Levels

Equation 750-1: Air Cleanup Levels – Noncarcinogens

$$Air\ Cleanup\ Level\ (ug/m^3) = \frac{RfD_i \times ABW \times UCF \times HQ \times AT}{BR \times ABS_i \times ED \times EF}$$

Parameter	Definition	Default Value		Units
		Method B Equation 750-1	Method C Equation 750-1	
RfD_i	Inhalation Reference Dose	Chemical-specific	Chemical-specific	mg/kg-day
ABW	Average Body Weight over the exposure duration	16	70	kg
UCF	Unit Conversion Factor	1.0E+3	1.0E+3	ug/mg
BR	Breathing Rate	10	20	m^3/day
ABS_i	Inhalation Absorption fraction	1.0	1.0	unitless
HQ	Hazard Quotient	1.0	1.0	unitless
AT	Averaging Time	6	6	years
ED	Exposure Duration	6	6	years
EF	Exposure Frequency	1.0	1.0	unitless

Equation 750-2: Air Cleanup Levels – Carcinogens

$$Air\ Cleanup\ Level\ (ug/m^3) = \frac{RISK \times ABW \times AT \times UCF}{CPF_i \times BR \times ABS_i \times ED \times EF}$$

Parameter	Definition	Default Value		Units
		Method B Equation 750-2	Method C Equation 750-2	
RISK	Acceptable cancer risk level	1.0E-6	1.0E-5	mg/kg-day
ABW	Average Body Weight over the exposure duration	70	70	kg
AT	Averaging Time	75	75	years
UCF	Unit Conversion Factor	1.000	1.000	ug/mg
CPF_i	Inhalation Carcinogenic Potency Factor	Chemical-specific	Chemical-specific	kg-day/mg
BR	Breathing Rate	20	20	m^3/day
ABS_i	Inhalation Absorption fraction	1.0	1.0	unitless
ED	Exposure Duration	30	30	unitless
EF	Exposure Frequency	1.0	1.0	years

Appendix E

Primer on TPH Fractions and Analytical Requirements for TPH Mixtures

Unlike individual hazardous substances, petroleum hydrocarbon mixtures such as gasoline, diesel fuel, lubricating oils, etc. are comprised of thousands of chemical compounds. Typically, the concentration of these mixtures is measured as "total petroleum hydrocarbons" or "TPH" that represents the expected range of these materials such as the "gasoline range" or the "diesel range". In reality, these measured concentrations are the collective concentrations of the individual petroleum compounds. A laboratory test result for NWTPH-Gx expressed as 235 mg/kg (milligrams of TPH per kilogram of soil) for example, represents the measured total TPH concentration in the sample within the range of compounds typically contained in gasoline.

TPH mixtures can also contain specific chemicals of concern and, depending on the type of mixture, they may need to be tested to make sure a site is adequately characterized and that all cleanup requirements are considered. These include volatile compounds such as benzene, toluene, ethylbenzene and xylenes (collectively referred to as "BTEX"), n-Hexane, and Naphthalene, but may also include fuel additives such as Methyl tertiary-butyl ether (MTBE). Information contained in WAC 173-340-830 provides a more detailed discussion of the types of testing required for petroleum releases. Table 830-1 in WAC 173-340-900 is a summary of the required testing for different types of petroleum releases.

The MTCA Cleanup Regulation allows for "mixture-specific" chemical characterization of released petroleum in order to develop a cleanup level tailored to the types of compounds actually present in soil or ground water. This method, known as "TPH fractionation", measures the concentration of twelve sub-groups or "fractions" of TPH within the released mixture and is based on work by a consortium of national experts (TPH Criteria Working Group, 1997[4]). These fraction groups are defined based upon their relative average molecular "size", with the lighter-weight (and typically more volatile and soluble) compounds in one group, and heavier, less volatile and soluble compounds in others. The measured concentrations of each of the twelve groups are then assessed, together with their individual chemical and toxicological properties, to determine the appropriate cleanup level. Depending on the particular TPH mixture present, certain hazardous substances (i.e., benzene, carcinogenic PAHs or MTBE) must still also be measured, in addition to the individual TPH fractions.

The detailed analytical methods, including VPH (Volatile Petroleum Hydrocarbons) and EPH (Extractable Petroleum Hydrocarbons) for petroleum hydrocarbons, are described in a separate Ecology document (Analytical Methods for Petroleum Hydrocarbons, 1997[5]).

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[4] TPH Criteria Working Group, 1997. *Total Petroleum Hydrocarbon Criteria Working Group Series. Volume III: Selection of Representative Total Petroleum Hydrocarbon (TPH) Fractions Based on Fate and Transport Considerations*, Ed.: J. B. Gustafson, J. G. Tell, and D. Orem, Amherst Scientific Publishers.

NOTE: As of this writing, this and other volumes are available on the Internet through Amherst Scientific Publishers at: http://www.aehs.com/publications/catalog/tph.htm.

[5] Washington State Department of Ecology, 1997. *Analytical Methods for Petroleum Hydrocarbons*, Publication No. ECY 97-602.

Appendix F

Properties of Chemicals Commonly found at Petroleum Contaminated Sites

Properties of Chemicals commonly found at Petroleum Contaminated Sites

Note: Please refer to "CLARC III 2001" for the source of Database

		Physical-Chemical Properties					Toxicological Properties						
CAS NO	Compound or Petroleum Equivalent Carbon Fraction	Molecular Weight	Aqueous Solubility	Henry's Law Constant	Soil Organic Carbon-Water Partitioning Coef	Liquid Density	Oral Reference Dose	Inhalation Correction Factor	Inhalation Reference Dose	Dermal Absorption Fraction	Gastroint-estinal Absorption Conversion Factor	Oral Carcinogenic Potency Factor (with CalEPA's TEF for cPAHs)	Inhalation Carcinogenic Potency Factor (with CalEPA's TEF for cPAHs)
		GFW	S	H_{cc}	K_{oc}	ρ	RfD_o	INH	RfD_i	ABS_d	GI	CPF_o	CPF_i
		mg/mol	mg/l	unitless	l/kg	mg/l	mg/kg-day	unitless	mg/kg-day	unitless	unitless	kg-day/mg	kg-day/mg
	Petroleum EC Fraction												
	AL_EC >5-6	8.100E+04	3.600E+01	3.300E+01	8.000E+02	6.700E+05	5.7	2	5.7	0.03	0 8		
	AL_EC >6-8	1 000E+05	5.400E+00	5.000E+01	3.800E+03	7.000E+05	5.7	2	5 7	0.03	0.8		
	AL_EC >8-10	1.300E+05	4.300E-01	8.000E+01	3 020E+04	7.300E+05	0.03	2	0.085	0.03	0.8		
	AL_EC >10-12	1.600E+05	3.400E-02	1.200E+02	2.340E+05	7.500E+05	0.03	2	0.085	0.03	0.8		
	AL_EC >12-16	2.000E+05	7.600E-04	5.200E+02	5.370E+06	7.700E+05	0.03	1		0.1	0.5		
	AL_EC >16-21	2.700E+05	1.300E-06	4.900E+03	9.550E+09	7.800E+05	2	1		0.1	0.5		
	AL_EC >21-34	4.000E+05	1.500E-11	1.000E+05	1.070E+10	7.900E+05	2	1		0.1	0.5		
	AR_EC >8-10	1.200E+05	6.500E+01	4.800E-01	1.580E+03	8.700E+05	0.05	2	0 05	0.03	0.8		
	AR_EC >10-12	1.300E+05	2.500E+01	1.400E-01	2.510E+03	9.000E+05	0.05	2	0.05	0.03	0.8		
	AR_EC >12-16	1.500E+05	5.800E+00	5.300E-02	5.010E+03	1.000E+06	0.05	1		0.1	0.5		
	AR_EC >16-21	1.900E+05	5.100E-01	1.300E-02	1.580E+04	1.160E+06	0.03	1		0.1	0.5		
	AR_EC >21-34	2.400E+05	6.600E-03	6.700E-04	1.260E+05	1.300E+06	0.03	1		0 1	0.5		
71-43-2	Benzene	7 800E+04	1.750E+03	2.280E-01	6.200E+01	8.765E+05	0.003	2	0.00171	0.0005	0.95	0.055	0.027
108-88-3	Toluene	9.200E+04	5.260E+02	2.720E-01	1.400E+02	8.669E+05	0.2	2	0 114	0.03	1		
100-41-4	Ethylbenzene	1.060E+05	1.690E+02	3.230E-01	2.040E+02	8.670E+05	0.1	2	0.286	0.03	0.92		
	Total Xylenes	1.060E+05	1.710E+02	2.790E-01	2.330E+02	8.752E+05	2	2	0.2	0.03	0.9		
	Total Naphthalenes	1.280E+05	3.100E+01	1.980E-02	1.191E+03	1 145E+06	0.02	2	0.00086	0.13	0.89		
110-54-3	n-Hexane	8.600E+04	9.500E+00	7.400E+01	3.410E+03	6.594E+05	0.06	2	0.057	0.03	0.8		
1634-04-4	MTBE	8.800E+04	5.000E+04	1.800E-02	1.090E+01	7.440E+05		2	0.86				
106-93-4	Ethylene Dibromide (EDB)	1.879E+05	3.400E+03	1.290E-02	4.400E+01	2.170E+06	0.000057	2	0.000057	0.03	0.8	85	0.76
107-06-2	1,2 Dichloroethane (EDC)	9.900E+04	8.520E+03	4.010E-02	1.410E+01	1.253E+06	0.03	2	0.0014	0.03	0.8	0.091	0.091
56-55-3	Benzo(a)anthracene	2.283E+05	9.400E-03	1.370E-04	3.575E+05	1.274E+06		1		0.13	0.89	0.73	0.61
205-99-2	Benzo(b)fluoranthene	2.523E+05	1.500E-03	4.550E-03	1.230E+06	1.300E+06		1		0.13	0.89	0 73	0.61
207-08-9	Benzo(k)fluoranthene	2.523E+05	8.000E-04	3.400E-05	1.230E+06	1.300E+06		1		0.13	0.89	0.73	0.61
50-32-8	Benzo(a)pyrene	2.523E+05	1.620E-03	4.630E-05	9.688E+05	1.300E+06		1		0.13	0.89	7.3	6.1
218-01-9	Chrysene	2.283E+05	1.600E-03	3.880E-03	3.980E+05	1.274E+06		1		0.13	0.89	0 073	0.061
57-70-3	Dibenzo(a,h)anthracene	2.780E+05	2.490E-03	6.030E-07	1.789E+06	1.260E+06		1		0.13	0.89	2.92	2.44
193-39-5	Indeno(1,2,3-cd)pyrene	2.763E+05	2.200E-05	6.560E-05	3.470E+06	1.300E+06		1		0.13	0.89	0.73	0.61

Cleanup Levels and Risk Calculations under the Model Toxics Control Act Cleanup Regulation

CLARC

Version 3.1

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Part IV – Calculation of Method B and Method C Cleanup Levels for Petroleum Mixtures

Part V – Background Information

Introduction

Overview

Cleanup Levels and Risk Calculations (CLARC) is a compendium of technical information related to the calculation of cleanup levels under the Model Toxics Control Act (MTCA) Cleanup Regulation, Chapter 173-340 WAC. The Washington State Department of Ecology (Ecology) has compiled and calculated this technical information to assist the user in the development of cleanup levels at a site. As emphasized below, the formula values pre-calculated under standard Method B and standard Method C and provided in CLARC are **NOT cleanup levels**. The use of CLARC is not sufficient to establish cleanup levels. The following discussion provides an overview of the contents of this document.

- **Part I** provides an overview of the methods for establishing cleanup levels and guidance on the development of cleanup standards for each of the different media – ground water, surface water, soil and air.

- **Part II** includes several memos and tables that provide background information for the Method A values for potable ground water (Table 720-1), unrestricted soil (Table 740-1), and industrial soil (Table 745-1). These memos and tables were previously published as Appendix D to the Concise Explanatory Statement for the Amendments to the MTCA Cleanup Regulation (February 12, 2001).

- **Part III** includes several tables that provide pre-calculated standard Method B and standard Method C formula values for each of the different media (ground water, surface water, soil and air) and pathways using the equations and default values set forth in the regulation. CLARC does not provide pre-calculated values for petroleum mixtures (see Part IV).

  Part III also includes tables that list the applicable criteria under state and federal laws (ARARs) for potable ground water and surface water.

  Part III also includes several tables that provide default values for various chemical-specific parameters. These parameters include the toxicological properties of a chemical (e.g., cancer potency factors, reference doses, and bioconcentration factors), as well as the physical and chemical properties of a chemical (e.g., soil organic carbon-water partitioning coefficient, distribution coefficient, Henry's law constant, and solubility).

- **Part IV** provides an overview of the process for establishing Method B and Method C cleanup levels for petroleum mixtures. CLARC does not provide pre-calculated formula values for petroleum mixtures because the calculation depends on the composition of a mixture that must be determined on a site-specific basis. Part IV does provide the default chemical-specific reference doses for the constituents of a petroleum mixture.

- **Part V** provides important background information for each of the tables in Part III.

Caution on Use of CLARC

The requirements and procedures for establishing cleanup levels that are protective of human health and the environment are specified in the MTCA Cleanup Regulation, chapter 173-340 WAC. The use of CLARC is not sufficient to establish cleanup levels under the regulation.

Use of Formula Values as Cleanup Levels: The formula values pre-calculated under standard Method B and C and provided in CLARC are **NOT cleanup levels**. The formula values **DO NOT**, for example, account for the following:

- Consideration of applicable state and federal laws (for all media);
- Consideration of surface water impacts (for ground water);
- Consideration of ecological impacts (for surface water and soil);
- Consideration of the residual saturation limit for protection of ground water (for soil)
- Consideration of the vapor pathway (for soil);
- Consideration of the lower explosive limit limitation (for air);
- Consideration of natural background concentrations (for all media);
- Consideration of the practical quantitation limit (for all media);
- Consideration of the NAPL limitation (for surface water and ground water);
- Consideration of total site risk (for all media);

The department may also establish cleanup levels that are more stringent than those required under the applicable method when the department determines, based on a site-specific evaluation, that such levels are necessary to protect human health and the environment.

Limitations of CLARC

- **Modified Method B and C (Site-Specific Risk Assessment)**

  CLARC does not provide pre-calculated formula values for modified Method B or C. The calculation of modified Method B or C values requires the use of site-specific and/or chemical-specific values instead of the default values provided in the regulation.

- **Soil – Direct Contact Pathway – Concurrent Exposure (Ingestion and Dermal Contact)**

  For petroleum mixtures, the standard Method B and C formula values are based on concurrent exposure (ingestion and dermal contact). CLARC does not provide pre-calculated standard Method B or C formula values for petroleum mixtures, including values based on the direct contact pathway (see discussion below).

  For hazardous substances other than petroleum mixtures, the standard Method B and C formula values are based on ingestion only. CLARC does provide pre-calculated standard Method B and C formula values for those substances.

  For hazardous substances other than petroleum mixtures, evaluation of concurrent exposure (ingestion and dermal contact) is only required under modified Method B and C and then only under certain specified circumstances. The regulation provides standard equations and default values for evaluating concurrent exposure. CLARC does not provide pre-calculated Method B or C formula values using those standard equations and default values.

- **Petroleum Mixtures**

  CLARC does not provide pre-calculated standard Method B or C formula values for petroleum mixtures. The calculation of standard Method B and C formula values for petroleum mixtures depends on the composition of a mixture. The composition must be determined on a site-specific basis.

- **Ammonia**

  CLARC does not provide pre-calculated standard Method B or C formula values for ammonia. The calculation of standard Method B and C formula values depends on the water quality characteristics (temperature and pH) and the chemical form/species of ammonia (e.g., ionized or non-ionized).

- **Asbestos**

  CLARC does not provide pre-calculated standard Method B or C formula values for asbestos. The calculation of standard Method B and C formula values depends on the fiber type and content. Note that the metric for asbestos is based on fiber type and is usually expressed as fibers/L and not as the usual mg/L or ug/L metric.

❖ **Chromium**

CLARC does not provide pre-calculated standard Method B or C formula values for total chromium. CLARC does provide pre-calculated standard Method B and C formula values for chromium III and chromium VI.

Assessors should test for total chromium first and then test for chromium VI only if the concentration for total chromium exceeds the cleanup level for chromium VI.

- If chromium VI is present at the site, then the concentration of chromium III is determined by subtracting the chromium VI concentration from the total chromium concentration.
- If chromium VI is NOT present at the site, then the site assessor may assume that the measured concentration of total chromium is the concentration of chromium III.

Of course, if there is documented evidence that chromium VI was never used at the site, then the site assessor does not need to test for chromium VI and may assume that the measured concentration of total chromium is the concentration of chromium III.

❖ **Lead**

CLARC does not provide pre-calculated standard Method B or C formula values for lead. Values for lead cannot be calculated using the equations provided in the regulation. Assessors should consult with the Department of Ecology regarding the use of EPA's Integrated Exposure Uptake Biokinetic (IEUBK) model to calculate soil cleanup levels.

❖ **Manganese**

CLARC provides pre-calculated standard Method B or C formula values for manganese. The formula value for manganese depends on the reference dose (RfD). The reference dose was obtained from the U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS), but was not modified as recommended by the EPA. The recommended modification depends on the route of exposure. EPA recommends that a modifying factor of "1" should be used when assessing exposure from food and that a modifying factor of "3" should be used when assessing exposure from drinking water or soil. This modification factor is based on the increased exposure of children to manganese-contaminated water and soil. Please consult IRIS for a more complete description of the basis for the modification factors. As noted, the RfD for manganese listed in CLARC and used to pre-calculate the formula values for standard Method B and C has not been adjusted. If the modifying factor of "3" for manganese is used, then the formula values for standard Method B and C for soil and ground water would be one-third the value presented in CLARC.

Versions

Version 2.0 of CLARC (or CLARC II) was published in February 1996.

Version 3.0 of CLARC was published in August 2001 and includes changes based on the amendments to the MTCA Cleanup Regulation, chapter 173-340 WAC, adopted on February 12, 2001. Version 3.0 superceded Version 2.0.

Version 3.1 of CLARC was published in November 2001 and includes corrections to Version 3.0. These corrections are noted in the enclosed Modification History. Version 3.1 supercedes Version 3.0.

Ecology expects to periodically update CLARC to provide additional technical information. Users of CLARC should contact the Toxics Cleanup Program at (360) 407-7170 or check the program's web site at http://www.ecy.wa.gov/programs/tcp/cleanup.html to ensure that they have the most recent version.