

NORTH CAROLINA
DEPARTMENT OF ENVIRONMENTAL QUALITY

NCDEQ RISK CALCULATOR
USER GUIDE



May 2019

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1.0 INTRODUCTION

The North Carolina Department of Environmental Quality (NCDEQ) Risk Calculator has been developed to evaluate the risks of multiple contaminants and multiple exposure routes associated with contaminated environmental media at a site.

The Risk Calculator is an Excel-based, menu-driven program. The risk evaluation procedures, equations, and default parameters used to create the calculator follow current United States Environmental Protection Agency (US EPA) risk assessment guidance. Refer to the [Risk Evaluation Resources](#) page on the NCDEQ Risk-Based Remediation website for a link to the list of equations and default parameters used in the calculator.

In addition to risk-based remediation for site closure, the Risk Calculator has also proven helpful in refining excavation limits, determining the quality of imported or exported soil, directing vapor intrusion evaluations, and siting monitoring wells for assessment.

The Risk Calculator incorporates a database that contains toxicity values and other chemical-specific parameters obtained directly from the [EPA Regional Screening Level \(RSL\) Tables](#). The Risk Calculator will be updated when the RSL tables are updated by EPA, typically twice per year. Where EPA default exposure parameters or inputs

are not available, the NCDEQ has established North Carolina specific factors or adopted those used in other nearby states. Some of these defaults cannot be changed by the user because the worksheets are “protected” and can only be “unprotected” by a NCDEQ toxicologists.

This Risk Calculator User Guide (Guide) describes the data needs and functionality of the Risk Calculator and provides instructions on its use. For general procedures on how to use these risk assessment results to implement a risk-based remedy according to N.C.G.S 130A-310.65 through 310.77, refer to the [Technical Guidance for Risk-Based Environmental Remediation of Sites](#) (Technical Guidance).

1.1 Key Terms and Concepts

Combined Pathways – An Exposure Pathway that includes the primary routes of entry: ingestion, dermal contact and inhalation. Used when evaluating risks of contaminated soil, tap water, and/or recreational surface water.

Conceptual Site Model - A three-dimensional picture of site conditions that conveys what is known or suspected about the sources, releases and release mechanisms, contaminant fate and transport, exposure pathways, potential receptors, and risks. The conceptual site model is based on the information available at a given point in time and will evolve as more information becomes available.

Contaminant Migration Parameters – Site specific factors pertaining to the aquifer and plume geometry, and aquifer properties. These parameters are used in the contaminant migration calculations.

Exposure Factors – Quantitative values related to human behavior and characteristics that help determine an individual's exposure to an agent. The default exposure factors issued by EPA for conducting human health risk assessments are used in the risk calculator.

Exposure Pathway – The physical course a chemical or pollutant takes from the source to the organism exposed.

Exposure Point Concentration – an estimate of the contaminant concentration in a particular medium.

Exposure Route - The way a chemical or pollutant enters an organism after contact, e.g., by ingestion, inhalation, or dermal absorption.

Exposure Unit – An area of a contaminated site represented by similar concentrations and land-uses. Refer to Section 2.4 for more information about exposure units

NC = Not calculated, an abbreviation used in the calculator.

NM = Not modeled, an abbreviation used in the calculator.

Point of Exposure – The location where a human or environmental receptor can come into contact with a hazardous substance present in the environment.

Receptor - The species, population, community, habitat, etc. that may be exposed to contaminants.

Soil Saturation Concentration (C_{sat}) - The C_{sat} is the contaminant concentration above which the contaminant may be present in free phase (non-aqueous-phase liquid or solid).

Target Risk – The level of risk that, above which, is unacceptable:

- For known or suspected carcinogens, the sum of individual excess lifetime cancer risk values for all contaminants for all exposure pathways may not exceed one in 10,000 (10^4).
- For systemic toxicants, the Hazard Index (HI) for all contaminants for all complete exposure pathways may not exceed 1.0.

Target Organ - The biological organ(s) most adversely affected by exposure to a chemical, physical, or biological agent.

Volatilization Factor - An estimate of the rate at which a chemical is emitted from soil as a vapor.

1.2 Risk Calculator Cell Color Codes

	Data entry field. All other cells are locked and cannot be changed by the user
	Non-volatile chemical*
	Soil concentration exceeds the soil saturation concentration, C _{sat}
	Entry not required for pathways selected
Red text	An entry has been modified from the default value, or no defaults are established

* chemicals with a Henry's Law constant greater than or equal to 1×10^{-5} atm-m³/mole or a vapor pressure greater than or equal to 1 mm Hg.

2.0 GATHERING SITE INFORMATION

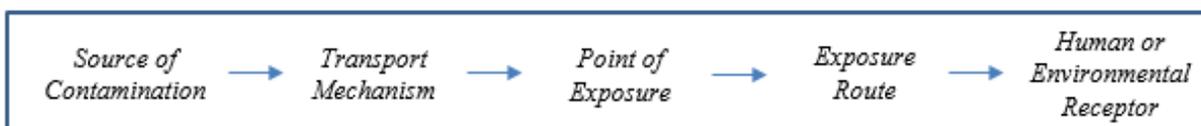
2.1 Site Contamination

To assess risk of a site, the remedial investigation or comprehensive site assessment must be complete, and the following should be documented in a well-understood site conceptual model:

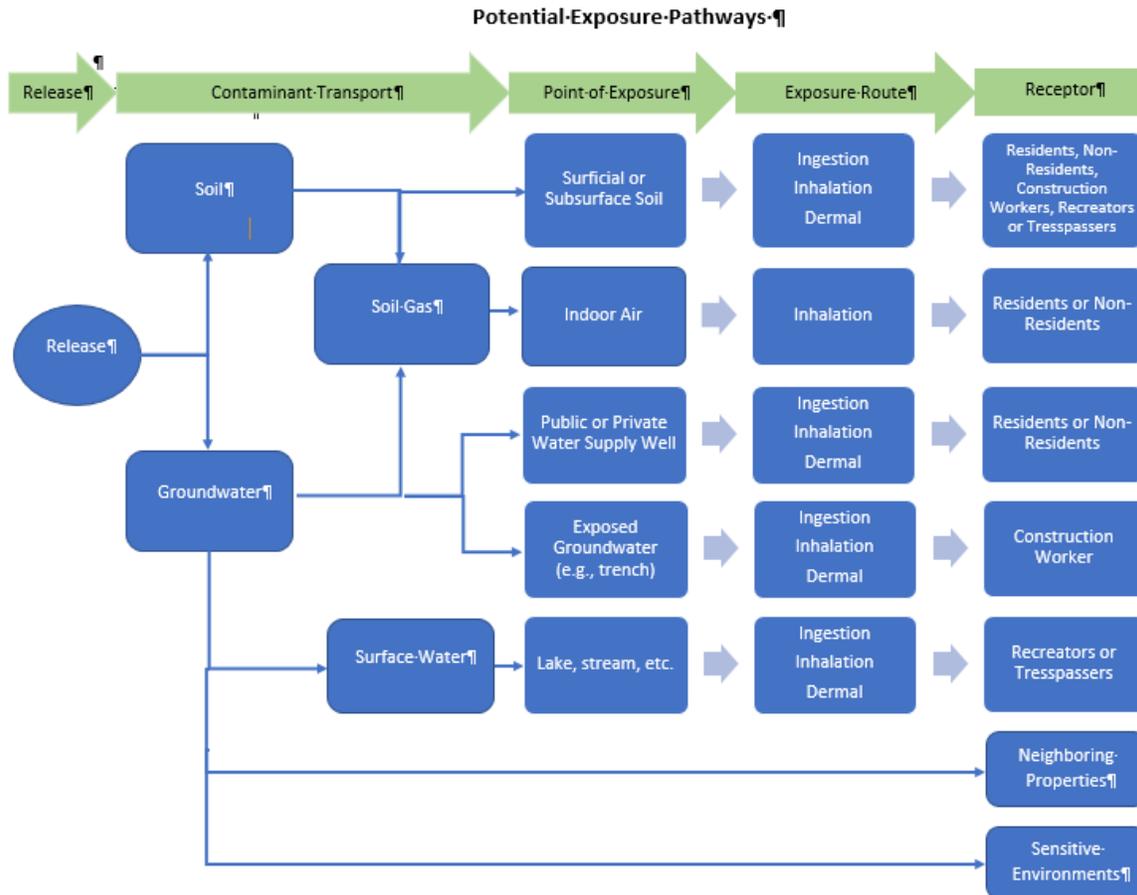
1. Sufficient sampling to identify the type and extent of contamination in all media and the concentration trends over time.
2. Geology, hydrogeology, preferential flow paths, and other features influencing the movement of contaminants.
3. The maximum concentration of each contaminant in each medium. Note, contaminants with concentrations demonstrated to be within naturally occurring background levels may be excluded from the risk evaluation;
4. Current and potential future receptors; and
5. Complete exposure pathways.

2.2 Exposure Pathways

An exposure pathway has five parts: a source of contamination, a transport mechanism (e.g. movement through groundwater); a point of exposure (e.g. a private well); a route of exposure (oral, dermal, or inhalation), and a receptor population. When all five parts are present, the exposure pathway is termed a complete exposure pathway. Conversely, if an element in an exposure pathway is missing or removed, i.e., through remediation or institutional controls, then the pathway is rendered incomplete.



The user must identify the site-specific exposure pathways that are complete or may be expected to become complete under current or reasonably anticipated future conditions, e.g., site or building reconstruction or contaminant migration, etc. The following graphic illustrates common exposure pathways.



2.3 Receptors

Receptors may be human (children and adults in specific settings as described below), or environmental (uncontaminated groundwater, surface waters, or wetlands). Human receptors are represented by the following designated land uses:

- Residential** – Includes single-family homes, townhouses, apartment buildings, and college/university dormitories. These are areas where both children and adults are expected to spend most of their time. Child/daycare facilities, schools through high school, hospitals, and churches, are also considered residential.

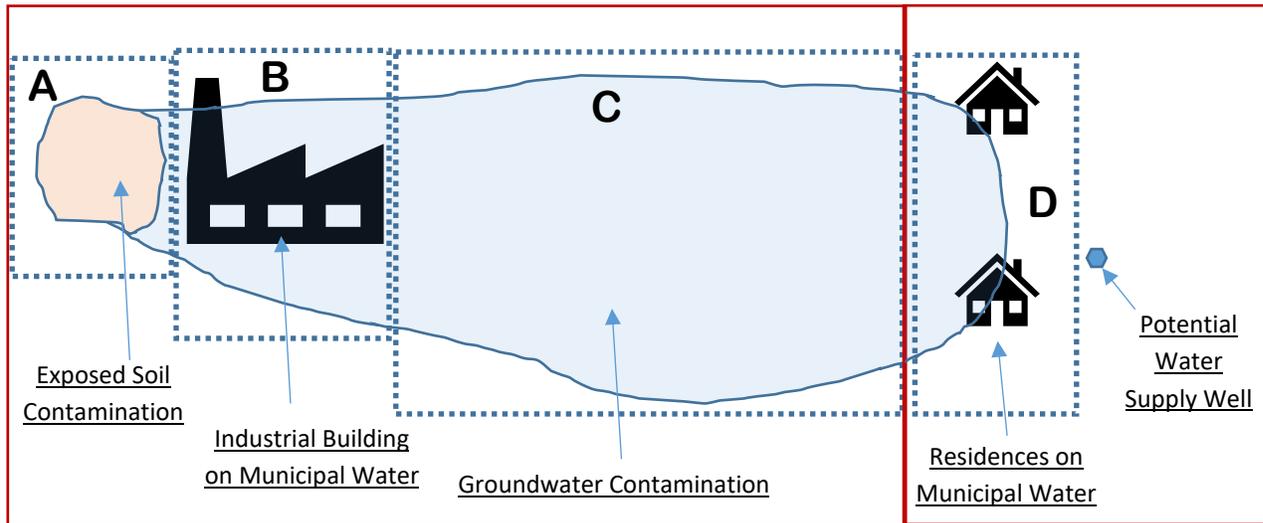
- **Non-residential** – Includes office buildings and commercial/industrial facilities where adult workers routinely spend a significant part of their day. Colleges and universities (excluding dormitories) are considered non-residential. Risks associated with occupational settings that fall under the purview of the Occupational Safety and Health Administration (OSHA) may be handled differently.
- **Construction Worker** – Assumes that adult construction/utility workers may be exposed to soils through large-scale redevelopment activities at depths of up to 10 feet. The associated exposure parameters assume a shorter exposure duration and higher contamination exposure relative to residential and non-residential worker scenarios.
- **Recreator** – Assumes a total exposure time of 26 years, 6 years as a child (0 to 6 years old) and 20 years as an adult (6 to 26 years old). With DWM approval, these exposure durations can be adjusted for situations where a 26-year exposure duration would not be feasible, such as 4-year housing rotations at a military base. This pathway is often only complete at unsecured properties, undeveloped properties or properties with open space.
- **Trespasser** – Assumes an exposure duration of 10 years (6 to 16 years old). This pathway is often only complete at unsecured properties, undeveloped properties or properties with open space.

2.4 Exposure Units

Exposure units are described as areas within a site having similar concentrations, exposures and use. Defining exposure units across a site allows evaluation of specific sub-areas that may require a different set of engineered or institutional controls than other areas. Some properties may be best evaluated as one exposure unit, providing the user understands the current and potential risks associated with the contaminated media across the entire property. Other contaminated sites, such as those covering a large areal extent, may be best evaluated by dividing the site into multiple exposure units. Refer to the example on the following page showing multiple exposure units across a site and the current and potential future risks associated with each exposure unit.

Once the engineered and/or institutional controls are established across the site, the boundaries of all restricted areas of the property must be physically discernable, surveyable, and shown on a survey plat.

Example site with multiple Exposure Units.



Pathways and Receptors for Example Exposure Units

Exposure Unit	Contaminated Media	Current/Future	Receptor
A	Soil	Current	Non-residential Worker, Trespasser
		Future	Resident
	Groundwater	Future	Resident, Non-Residential Worker
	Indoor Air	Future ¹	Resident, Non-Residential Worker
B	Groundwater	Future	Potential Water Supply Well on Uncontaminated Property(ies)
		Future	Resident and Non-Residential Worker
C	Indoor Air	Current	Non-residential Worker
		Future ¹	Resident
D	Groundwater	Future	Resident and Non-Residential Worker
		Future ¹	Resident and Non-Residential Worker
D	Indoor Air	Current	Resident
		Current	Resident

¹ When no suitable structures are present, future indoor air risk should be evaluated using soil gas data.

² Contaminant migration modules in the calculator are used to evaluate movement of contaminants to a known or hypothetical receptor (such as to a property where a water supply well may be installed).

3.0 USING THE RISK CALCULATOR

Download the latest version of the Risk Calculator from the [Risk-Based Remediation](#) website. Due to the complexity of the Risk Calculator, a few minutes may be needed to complete the download. Once downloaded, the Risk Calculator opens to the “Main Menu” page. The entire functionality of the Risk Calculator is displayed in the Main Menu page and is organized in four general sections as shown below.

**North Carolina Department of Environmental Quality
Risk Calculator
January 2019 Version**

COVER PAGE **TABLE OF CONTENTS** **SELECT SHEETS TO PRINT**

LINKS

NCDEQ Risk Calculator User Guide Preliminary Soil Remediation Goals (PSRG) Table What's New

DATA INPUT SHEETS

1. Exposure Pathways & Parameters

A. Complete Exposure Pathways B. Exposure Factors and Target Risks C. Contaminant Migration Parameters D. Sample Statistics

2. Exposure Point Concentrations

A. Soil B. Groundwater C. Surface Water D. Soil Gas E. Air

DATA OUTPUT SHEETS

1. Summary Output for All Calculators

A. Risk for Individual Pathways B. Sitenwide Risk

2. Direct Contact Soil and Water Calculators

A. RESIDENT Soil B. RESIDENT Groundwater Use C. NON-RESIDENTIAL WORKER Soil D. NON-RESIDENTIAL WORKER Groundwater Use E. CONSTRUCTION WORKER Soil

F. RECREATOR/TRESPASSER Soil G. RECREATOR/TRESPASSER Surface Water

3. Vapor Intrusion Calculators

A. RESIDENT Groundwater to Indoor Air B. RESIDENT Soil Gas to Indoor Air C. RESIDENT Indoor Air D. NON-RESIDENTIAL WORKER Groundwater to Indoor Air E. NON-RESIDENTIAL WORKER Soil Gas to Indoor Air F. NON-RESIDENTIAL WORKER Indoor Air

4. Contaminant Migration to Receptor Worksheets

A. Soil Source to Groundwater Receptor Forward Mode B. Groundwater Source to Groundwater Receptor Forward Mode C. Soil Source to Surface Water Receptor Forward Mode D. Groundwater Source to Surface Water Receptor Forward Mode

E. Soil Source to Groundwater Receptor Backward Mode F. Groundwater Source to Groundwater Receptor Backward Mode G. Soil Source to Surface Water Receptor Backward Mode H. Groundwater Source to Surface Water Receptor Backward Mode

For NCDEQ Use Only

UNPROTECT ALL SHEETS PROTECT ALL SHEETS

Optional project information and report buttons

Default input values and site data entry

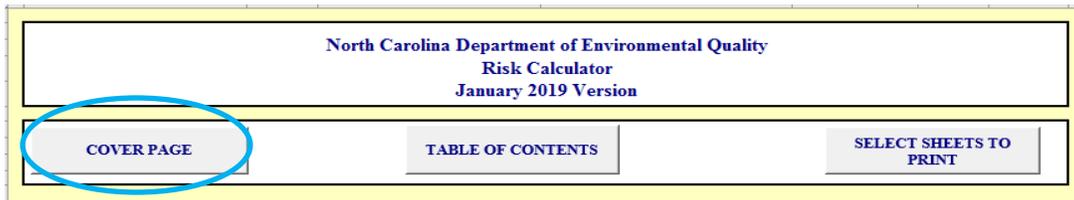
Risk calculations for each pathway specified

Conservative contaminant migration calculations

3.1 Project Information and Report Organization Section

This section is optional and includes sheets to add project information and prepare a report of key risk assessment results with a cover page and table of contents.

3.1.1 Cover Page



The first button on the “Main Menu” takes the user to the “Cover Page” where the applicable site and exposure unit information can be entered in the yellow data entry cells, where it is automatically carried forward to the other sheets.

Main Menu
Print
Next
Previous

Shortcut buttons allow the user to return to the main menu, or proceed to the next sheet, or previous sheet at any step. The print button will print the current sheet.

North Carolina Department of Environmental Quality
Risk Calculator

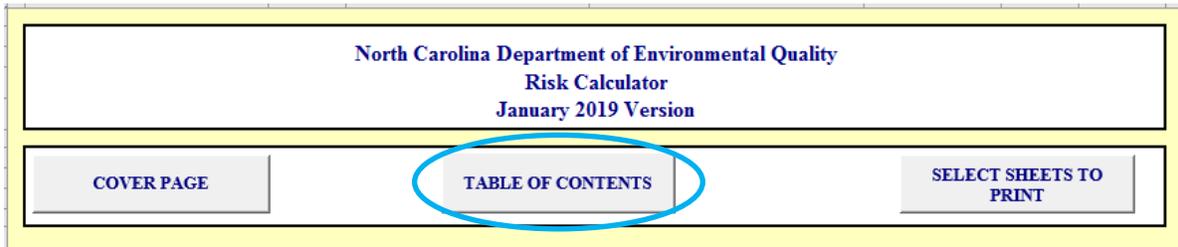
NCDEQ Risk Calculator date and date of the EPA Regional Screening Level table used in the risk calculations.

Cells for data entry are highlighted yellow. All other cells are locked and can only be edited by NCDEQ

Version Date:	January 2019
Basis:	November 2018 EPA RSL Table
Site Name:	
Site Address:	
DEQ Section:	
Site ID:	
Exposure Unit ID:	
Submittal Date:	
Prepared By:	
Reviewed By:	

Enter site information here. The site ID and exposure unit ID are automatically carried forward to the other sheets.

3.1.2 Table of Contents



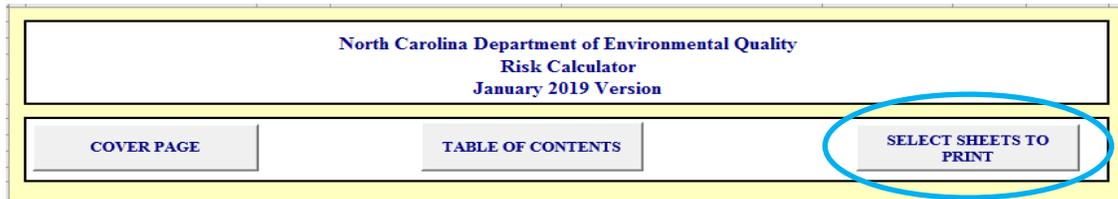
The “Table of Contents” sheet is optional. The check boxes are not linked to any other functions in the Risk Calculator, so completion of this sheet has no effect on the risk assessment calculations.

Main Menu	Table of Contents		TOC
Print	Version Date: January 2019		
Next	Basis: November 2018 EPA RSL Table		
Previous	Site ID:		
	Exposure Unit ID:		
	Form No.	Description	Check box if included
	DATA INPUT SHEETS		
	Input Section 1 - Exposure Pathways & Parameters		
	Input Form 1A	Complete Exposure Pathways	<input type="checkbox"/>
	Input Form 1B	Exposure Factors and Target Risks	<input type="checkbox"/>
	Input Form 1C	Contaminant Migration Parameters	<input type="checkbox"/>
	Input Form 1D	Sample Statistics	<input type="checkbox"/>
	Input Section 2 - Expos		
	Input Form 2A	Soil Exposure Point Concentration T	<input type="checkbox"/>
	Input Form 2B	Groundwater Exposure Point Concentration Table	<input type="checkbox"/>
	Input Form 2C	Surface Water Exposure Point Concentration Table	<input type="checkbox"/>
	Input Form 2D	Soil Gas Exposure Point Concentration Table	<input type="checkbox"/>
	Input Form 2E	Indoor Air Exposure Point Concentration Table	<input type="checkbox"/>
	DATA OUTPUT SHEETS		
	Output Section 1 - Summary Output for All Calculators		
	Output Form 1A	Risk for Individual Pathways	<input type="checkbox"/>
	Output Form 1B	Sitewide Risk	<input type="checkbox"/>
	Output Section 2 - Direct Contact Soil and Groundwater Calculators		
	Output Form 2A	Resident Soil	<input type="checkbox"/>
	Output Form 2B	Resident Groundwater Use	<input type="checkbox"/>
	Output Form 2C	Non-Residential Worker Soil	<input type="checkbox"/>

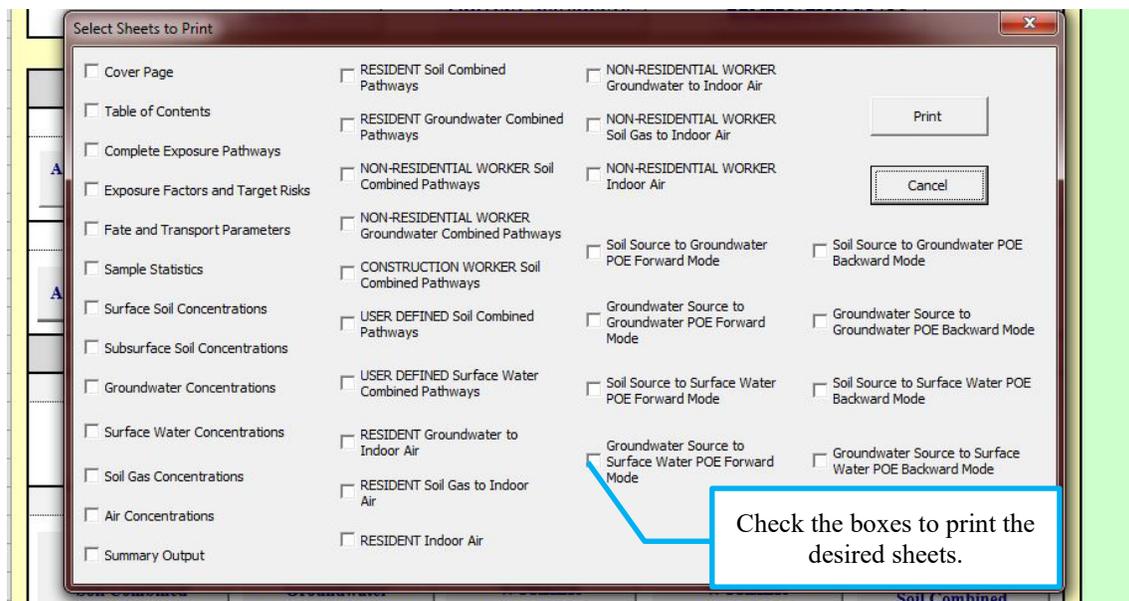
Check boxes to compile the report with the pertinent sheets (optional).

Site ID and Exposure Unit ID must be entered on the Cover Page in order to be carried through to remaining sheets.

3.1.3 Select Sheets to Print Button



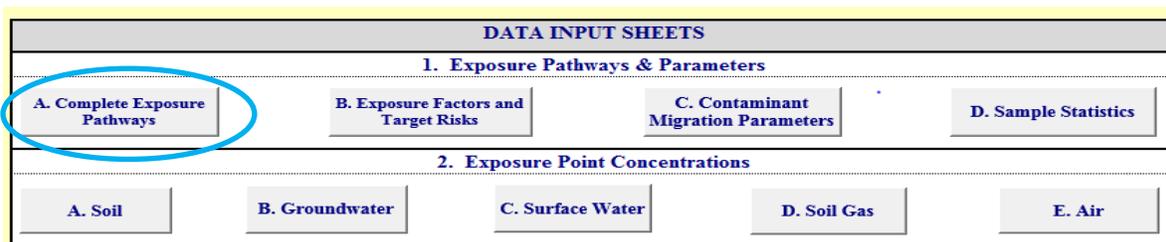
The “Select Sheets to Print” button is used to select the sheets to print in one batch. There is the option to print individual sheets at each step in lieu of the batch print option. **There is no option in this window to select the printer. The correct printer should be selected through Excel’s File>>Print menu.**



3.2 Site-Specific Data Input Section

This section contains multiple sheets for the user to enter the site-specific exposure pathways, aquifer properties, and contaminant concentrations in each medium.

3.2.1 Complete Exposure Pathways



The user should select the current and potential future exposure pathways identified as complete in the conceptual site model by checking the pertinent boxes on the “Complete Exposure Pathways” sheet. If a pathway is not checked, the risk assessment result will report “NC” (Not Calculated) on the “Output Sheet”.

Main Menu	Complete Exposure Pathways		Input Form 1A	
Print	Version Date: January 2019			
Next	Basis: November 2018 EPA RSL Table			
Previous	Site ID:			
	Exposure Unit ID:			
	<i>Note: Risk output will only be calculated for complete exposure pathways.</i>			
	Receptor	Pathway	Check box if pathway complete	
	DIRECT CONTACT SOIL AND WATER PATHWAYS			
Human Health Risk Pathways.	Resident	Soil	<input checked="" type="checkbox"/>	
		Groundwater Use	<input type="checkbox"/>	
	Non-Residential Worker	Soil	<input checked="" type="checkbox"/>	
		Groundwater Use	<input type="checkbox"/>	
	Construction Worker	Soil	<input type="checkbox"/>	
	Recreator/Trespasser	Soil	<input type="checkbox"/>	
		Surface Water	<input type="checkbox"/>	
		VAPOR INTRUSION PATHWAYS		
	Resident	Groundwater to Indoor Air	<input checked="" type="checkbox"/>	
		Soil Gas to Indoor Air	<input checked="" type="checkbox"/>	
Indoor Air		<input checked="" type="checkbox"/>		
Non-Residential Worker	Groundwater to Indoor Air	<input checked="" type="checkbox"/>		
	Soil Gas to Indoor Air	<input checked="" type="checkbox"/>		
	Indoor Air	<input checked="" type="checkbox"/>		
	CONTAMINANT MIGRATION PATHWAYS			
Protection of Groundwater Use	Source Soil	<input checked="" type="checkbox"/>		
	Source Groundwater	<input checked="" type="checkbox"/>		
Protection of Surface Water	Source Soil	<input checked="" type="checkbox"/>		
	Source Groundwater	<input checked="" type="checkbox"/>		

The common pathways will automatically be checked.

Human Health Risk Pathways.

Environmental Risk Pathways

Human Health Pathway Considerations

Soil

Since surface soil contamination can pose a risk to all human receptors and deeper soil contamination may only pose a risk to construction/utility workers, specific soil depth intervals

may need to be evaluated separately. The selection of specific depth intervals should be documented and justified.

Construction Worker Scenario

Construction-related exposures depend on many parameters, including the size of the site, the size of the contaminated source area, the dimensions of the building(s) being constructed and its location relative to the source area and to the site boundary, the type of building being constructed (e.g., a slab-on-grade structure versus a building with a basement), and the overall duration of the construction project. These parameters can vary considerably from project to project. Emissions of both volatiles and particulate matter from contaminated soils increase the inhalation risk to construction workers relative to that of other outdoor receptors.

Because there is considerable uncertainty surrounding the details of future construction and a higher risk could be calculated for a construction worker than for residential receptors in some cases, the results of construction worker evaluation should not drive a cleanup level. They should be used to help guide safety concerns for imminent or potential future construction activities. If a risk evaluation is warranted for a site-specific construction worker scenario, the exposure parameters may be adjusted in the calculator with documented justification. If further risk evaluation is warranted, e.g., for target organs, contact your program representative so they can request assistance from a NCDEQ toxicologist.

Sediment

Sediment exposure is determined using the same equations and defaults as soil, so any sediment data should be entered as soil. The user should consult with NCDEQ if modifications to the exposure factors and contaminant migration parameters may be necessary to evaluate sediment exposure.

Groundwater

The direct contact groundwater pathway calculates the risk of using private well water for drinking, cooking and bathing. Evaluation of dermal contact with groundwater may be needed to quantify risks associated with gardening, utility maintenance or digging at sites with shallow groundwater tables. This pathway is not commonly evaluated under EPA risk assessment guidance, so contact your program representative so they can get assistance from a NCDEQ toxicologist if groundwater exposure is a concern.

Risk-based groundwater remedies must rely on institutional controls (a land-use restriction and/or a notice on the property deed) that bar water supply well installation and groundwater use of any kind. As a result, this pathway will be incomplete.

Surface Water

Surface water quality must meet the 15A NCAC 02B standards to be eligible for a risk-based No Further Action.

The surface water pathway evaluates the risk for ingestion and dermal contact of a recreator or trespasser exposed by wading or swimming in contaminated surface water. Potential ecological risks should be evaluated separately. Risk-based site closure is not possible if contamination from the site discharges into surface waters at levels that violate applicable surface water quality standards.

Vapor

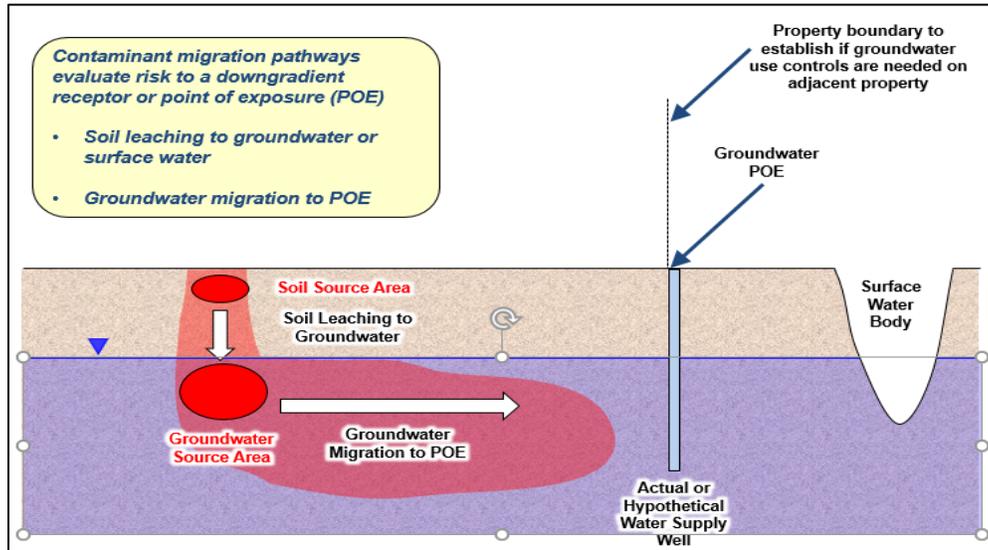
The vapor intrusion pathway should be considered complete for residential and non-residential receptors in structures overlying or within 100 feet (vertical or horizontal) of contaminated soil or groundwater. Since the construction/utility worker will remain outdoors, the vapor intrusion pathway is considered to be incomplete. Consult the DWM Vapor Intrusion Guidance Document for specific information pertaining to vapor intrusion.

The calculator should be used to determine the need for the next level of data in the vapor intrusion evaluation.

Contaminant Migration Pathways

The calculator can evaluate three environmental pathways as shown in the graphic below:

1. Soil contaminants vertically leaching to groundwater and migrating to a downgradient point of exposure. This distance can be set to zero to evaluate vertical leaching only.
2. Groundwater contamination migration to a specified downgradient point of exposure.
3. Contaminants in soil vertically leaching to groundwater and migrating downgradient to a surface water body and becoming diluted by a known surface water discharge rate.



3.2.2 Exposure Factors and Target Risks

DATA INPUT SHEETS				
1. Exposure Pathways & Parameters				
A. Complete Exposure Pathways	B. Exposure Factors and Target Risks	C. Contaminant Migration Parameters	D. Sample Statistics	
2. Exposure Point Concentrations				
A. Soil	B. Groundwater	C. Surface Water	D. Soil Gas	E. Air

The list of exposure parameters used in the Risk Calculator can be found in Appendix D of the [Risk Evaluation Equations and Calculations](#).

EPA and NCDEQ default values are already populated on the Exposure Factors and Target Risks sheet shown below. Justifications for changing the default value must be documented in the “Justification” column and will require NCDEQ approval.

Main Menu	Exposure Factors and Target Risks			
Print	Version Date: January 2019			
Next	Basis: November 2018 EPA RSL Table			
Previous	Site ID:			
	Exposure Unit ID:			
	Exposure Parameter	Default Value	Site Specific Value	Justification
	General			
	Target Cancer Risk (individual)	1.0E-06	1.0E-06	
	Target Cancer Risk (cumulative)	1.0E-04	1.0E-04	
	Target Hazard Index (individual)	2.0E-01	2.0E-01	
	Target Hazard Index (cumulative)	1.0E+00	1.0E+00	
	Residential Child			
	Lifetime (LT) (years)	70	85	
	Body Weight (BW) (kg)	15	15	
	Exposure Duration (ED) (yr)	6	6	
	Exposure Frequency (EF) (d/yr)	350	350	
	Exposure Time (ET) (hr)	24	24	
	Skin Surface Area - Soil Exposure (SA _s) (cm ²)	2373	2373	
	Soil Adherence Factor (AF) (mg/cm ²)	0.2	0.2	
	Soil Ingestion Rate (IRS) (mg/day)	200	200	

The target cancer risk and hazard index are established in law for individual remediation programs.

Red text alerts the user and reviewer that a default value has been changed. Space is provided to justify the change.

	User Defined Child		
	Recreator r	Trespasser r	
Lifetime (LT) (years)	70	NA	70
Averaging Time (AT) (days/yr)	365	NA	365
Body Weight (BW) (kg)	15	NA	15
Exposure Duration 0-2 (ED) (yr)	2	NA	2
Exposure Duration 2-6 (ED) (yr)	4	NA	4
Exposure Frequency (EF) (d/yr)	195	NA	195
Exposure Time (ET) (hr)	2	NA	2
Skin Surface Area - Soil Exposure (SA _s) (cm ²)	2373	NA	2373
Soil Adherence Factor (AF) (mg/cm ²)	0.2	NA	0.2
Soil Ingestion Rate (IRS) (mg/day)	200	NA	200
Skin Surface Area - Water Exposure (SA _w) (cm ²)	6365	NA	6365
Water Ingestion Rate (IRW) (L/hr)	0.12	NA	0.12
Water Exposure Time (ET _{event}) (hr/event)	2	NA	2
Water Event Frequency (EV) (events/day)	1	NA	1
	User Defined Adult		
	Recreator r	Trespasser r	
Lifetime (LT) (years)	70	70	70
Body Weight (BW) (kg)	80	45	80
Exposure Duration 6-16 (ED) (yr)	10	10	10

Children are not considered trespassers, so cells are flagged as NA to prevent data entry.

Cells become grey when these values are not needed for the exposure pathways checked as complete on the "Complete Exposure Pathways" sheet.

If the "Recreator/Trespasser" pathway was selected as complete, the user must enter the appropriate exposure parameters in the "Site Specific Value" column for the User-Defined Adult. These receptors are not common and can only be run one at a time.

3.2.3 Contaminant Migration Parameters

DATA INPUT SHEETS				
1. Exposure Pathways & Parameters				
A. Complete Exposure Pathways	B. Exposure Factors and Target Risks	C. Contaminant Migration Parameters	D. Sample Statistics	
2. Exposure Point Concentrations				
A. Soil	B. Groundwater	C. Surface Water	D. Soil Gas	E. Air

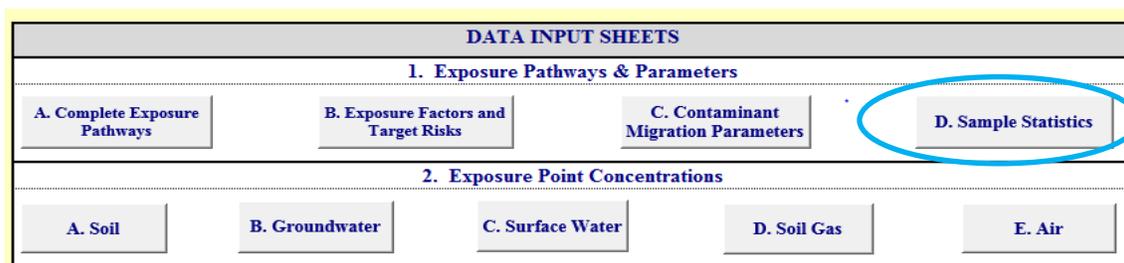
Contaminant migration parameters are primarily related to geology/hydrogeology (porosity, moisture content, hydraulic conductivity, hydraulic gradient, aquifer thickness, dry bulk density, and fraction organic carbon) and plume dimensions (thickness, length, and width of soil and groundwater source areas). Where a NCDEQ default value is not provided, a site-specific value is required. A site-specific value entered in place of a default value will change the text color to red. Justification for the change should be documented in the “Justification” column. If necessary parameters are not entered for a given pathway, the subsequent Output Forms will show “NM” (Not Modeled). See the [Risk Evaluation Equations and Calculations](#) link for documentation of the variables used.

Contaminant Migration Parameters			Input Form 1C
Version Date: February 2018			
Basis: November 2017 EPA RSL Table			
Site ID:			
Exposure Unit ID:			
Provide justification for the contaminant migration parameters used.			
Parameter	Default Value	Site Specific Value	Justification
Aerial extent of soil contamination (A ₂) (acres) (Note minimum acceptable value is 0.5 and maximum acceptable value is 500.)	0.5	0.5	<div style="border: 1px solid blue; padding: 5px; width: fit-content;"> If one or more “Contaminant Migration Pathways” are checked as complete, the parameters needed will be highlighted in yellow, otherwise the cells will be gray. </div>
Fraction of Vegetative Cover (V) (unitless)	0.5	0.5	
Water Filled Soil Porosity (θ _w) (unitless)	0.15 (soil to outdoor air pathway)	0.15	
	0.3 (soil to groundwater pathway)	0.3	
Air Filled Soil Porosity (θ _a) (unitless)	0.28 (soil to outdoor air pathway)	0.28	
	0.13 (soil to groundwater pathway)	0.13	

Water filled soil porosity, air filled soil porosity, and fraction organic carbon have two default values; one for the soil to outdoor air pathway, and one for the soil to groundwater pathway. If a site-specific value is entered, the user should enter the same value for both pathways. The default values given are considered conservative for the given pathway.

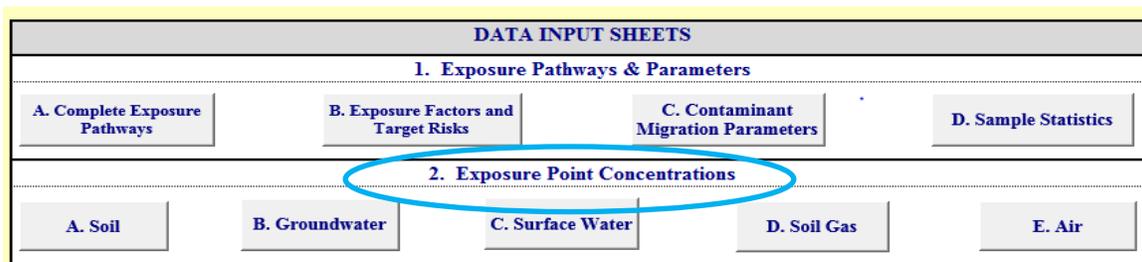
To evaluate the groundwater to surface water pathway, the user must enter a site-specific groundwater to surface water seepage area (width and thickness) and a published surface water discharge rate. If there are no surface water flow data available from published reports or acquired measurements, then the user must use the default value of zero. The Risk Calculator will calculate a surface water concentration, compare it with the standard, and determine whether the standard has been exceeded.

3.2.4 Sample Statistics



The optional “Sample Statistics” sheet is included to allow for basic statistical calculations of analytical data. This sheet is not linked to any other input or output sheets, and the data on this sheet is not carried forward in the risk assessment calculator.

3.2.5 Data Input - Exposure Point Concentrations



Enter the data into the desired sheet for the contaminated medium of interest. Both the chemical name and the CAS number can be searched in Excel. You may notice that if you select “Next” to advance to the next sheet in the calculator, an override sheet will appear. These sheets allow NCDEQ toxicologists to modify the data entry according to the routes of exposure. They are not editable by the user and a pop-up message will reflect that. Contact your remediation program representative if you would like a NCDEQ toxicologist to assist you with site-specific exposure pathways.

Exposure Point Concentration	Justification for Exposure Point Concentration	CAS Number	Chemical	Minimum Concentration (Qualifier)	Maximum Concentration (Qualifier)	Units	Lc 50 Cor
500	Max Concentration	30560-19-1	Acephate			mg/kg	
500000	Max Concentration	75-07-0	Acetaldehyde			mg/kg	
1000	Max Concentration	34256-82-1	Acetochlor			mg/kg	
6000	Max Concentration	67-64-1	Acetone			mg/kg	

Enter the maximum concentration of each detected contaminant as the “Exposure Point Concentrations” for each affected media where a risk determination is desired, including:

1. Contaminants detected at concentrations less than their residential Preliminary Soil Remediation Goal (PSRG), 15A NCAC 02L standard, or 15A NCAC 02B standard,
2. Contaminant results flagged by the analytical lab, and
3. Contaminants where the laboratory reporting limits were greater than the PSRGs, 15A NCAC 02L standards, or 15A NCAC 02B standards. Concentrations entered should be the lab’s reporting limit.

Example data input scenarios:

Maximum Detection	Laboratory Practical Quantitation Limit (PQL)	Screening Level (e.g., PSRG)	Value to Enter in Calculator
ND	0.8	1	Enter no value
0.8	0.5	1	0.8
0.8J	0.5	1	0.8
ND	1.5	1	1.5

The “Justification” column can state the source of the data, e.g., boring or monitoring well ID. These maximum concentrations are intended to be conservative and can represent either sitewide conditions or a defined exposure unit. If the risk assessment indicates cumulative risks below acceptable levels using sitewide maximum concentrations, then no further evaluation of multiple exposure units is necessary. If cumulative risks exceed acceptable levels using maximum concentrations, alternative and more representative average concentrations may be calculated as discussed for each medium below.

If the contaminant list is revised for subsequent calculator runs, all associated sheets should be “refreshed” by clicking “See All Chemicals” and then clicking “See Selected Chemicals”.

If chemicals are eliminated as possible contaminants of concern, the lines of evidence for those decisions should be appropriately documented and discussed in the risk assessment report. For example, the contribution of background chemicals (detected at the site) to the overall site-wide risk should be considered before eliminating background chemicals. If site contaminant concentrations are in the range of background levels, the initial risk

calculations should include all contaminant concentrations. If risk is exceeded, further evaluation would then consider the separate risk contributions of the site contaminants versus the background concentrations. While NCDEQ only requires clean up to background levels, the risk should be

calculated from all contaminants present, and the results may warrant additional risk communication with suggestions for reducing risk if risk levels are exceeded.

If a contaminant is not listed in the Risk Calculator, then contact your program representative so they can request further guidance from a NCDEQ toxicologist.

Soil

An average soil contaminant concentration may be calculated in areas of consistent use (e.g., residential or industrial) and generally uniform release of contaminants (e.g., former waste lagoons, spray fields, orchards, etc.), with the following considerations and the procedures documented:

- No single sample point may exceed ten times the site-specific adjusted cleanup level for all contaminants except lead. For lead, no single sample point used in an average may exceed 1000 ppm for unrestricted-use and no more than three times the site-specific cleanup level for restricted-use.
- The quarter-acre zone may be a circle or a square or triangle of generally equal sides. One dimension of the zone's perimeter may not be disproportionately longer than another.
- Samples must generally be evenly spaced over the zone of averaging.
- Only samples of the same vertical horizon may be averaged (0-6 inches for surface samples and no more than 5-foot vertical spread for subsurface samples).
- Only actual sample data may be used for all points included in the average and not published averages for background concentrations.
- The laboratory practical quantitation limit (PQL) must be used for points where concentrations are at or below lab reporting limits. Sample data should not be diluted or elevated unnecessarily above normal reporting limits.

Chromium

Enter the speciated analytical results for Cr(III) and Cr(VI), if available. If only Total Cr is reported, the result may only be entered as Cr(III) if it can be verified that Total Cr levels are within natural background concentrations. Otherwise enter the Total Cr result as Cr(VI).

Lead

Currently there is no EPA reference dose or cancer potency factor to quantify risks associated with exposures to lead. Exposure risks to lead are characterized based on predicted blood lead levels.

The US EPA's health-based screening levels for lead in soil are as follows:

- **Lead Compounds, residential soil exposure:** The screening value for direct residential contact is 400 mg/kg where it has been demonstrated the lead contribution from well water is less than 5 ug/l.
- **Lead Compounds, combination of residential soil AND water exposure:** The screening value is 250 mg/kg for a residential scenario if there are untested drinking water wells in

use that are located in the area of lead contamination, or if the wells have been tested and the tap water concentration is greater than 5 ug/l.

- **Lead Compounds, industrial/commercial soil exposure:** The screening value is 800 mg/kg for an industrial/commercial scenario.

If either of these levels is exceeded, the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children and the Adult Lead Methodology (ALM) may be used as appropriate to assess the site-specific risks and calculate remedial levels. The USEPA has also developed the ALM for evaluating the potential risks from lead in pregnant females. Refer to the USEPA lead guidance for additional information.

Polychlorinated Biphenyls (PCBs)

Compare the concentrations of the 12 dioxin-like PCB congeners (listed below) to their respective PSRGs. Total the remaining 197 congener concentrations and compare the sum to the “PCBs (high-risk)” PSRG. Do not use the Aroclor values without first consulting with the appropriate remediation program within NCDEQ.

IUPAC No.	Dioxin-like PCB Congener
PCB-77	3,3',4,4'-Tetrachlorobiphenyl
PCB-81	3,4,4',5-Tetrachlorobiphenyl
PCB-105	2,3,3',4,4'-Pentachlorobiphenyl
PCB-114	2,3,4,4',5-Pentachlorobiphenyl
PCB-118	2,3',4,4',5-Pentachlorobiphenyl
PCB-123	2',3,4,4',5-Pentachlorobiphenyl
PCB-126	3,3',4,4',5-Pentachlorobiphenyl
PCB-156	2,3,3',4,4',5-Hexachlorobiphenyl
PCB-157	2,3,3',4,4',5'-Hexachlorobiphenyl
PCB-167	2,3,4,4',5,5'-Hexachlorobiphenyl
PCB-169	3,3',4,4',5,5'-Hexachlorobiphenyl
PCB-189	2,3,3',4,4',5,5'-Heptachlorobiphenyl

Total Petroleum Hydrocarbons

Total petroleum hydrocarbon analyses for gasoline-range organics, diesel-range organics, or select ranges of aliphatic and aromatic hydrocarbons do not provide adequate information for risk analysis. For purposes of human health and ecological risk evaluation, environmental matrices known or potentially contaminated with petroleum hydrocarbons must be analyzed using EPA Method 8260 for volatile organic compounds (VOCs) and EPA Method 8270 for semi-volatile organic compounds (SVOCs) to provide compound-specific identification and quantitation.

Groundwater

Due to the dynamic nature of groundwater conditions, the maximum historic concentration may not be the most representative input concentration, nor will the most recent concentration. Overall trends in groundwater concentration data should be considered on a site-specific basis when selecting the input concentration. Safety factors may need to be considered in some cases.

Vapor

The calculator can evaluate *current* indoor air risks using any of the following data:

- indoor air data
- crawl space air data
- sub-slab gas data
- exterior soil gas data
- groundwater data

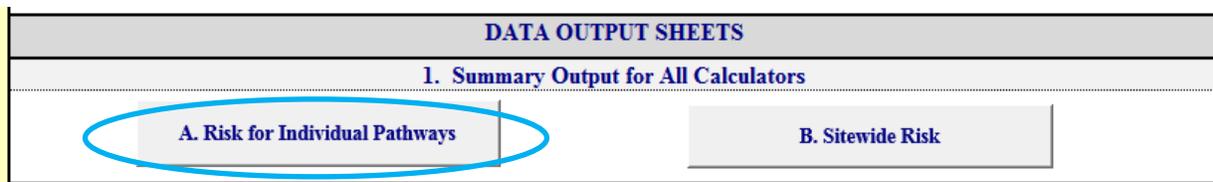
Due to the variable construction characteristics of structures, risk to *future structures* on vacant properties can only be calculated using exterior soil gas or groundwater data.

In all cases, maximum concentrations detected should be used as input concentrations. However, if cumulative risks exceed acceptable levels using maximum concentrations, limited spatial and/or temporal averaging may be allowed in some situations. Refer to the DWM Vapor Intrusion Guidance Document for additional details regarding gathering data for a proper vapor intrusion evaluation.

3.3 Data Output Sheets

Each button in the “Data Output Sheet” in Sections 2 and 3 is a unique risk calculation for that pathway. Before viewing the outputs for individual pathways, the calculator presents a summary output of all pathways for a quick understanding of which pathways present an unacceptable risk.

3.3.1 Summary Output for All Calculators



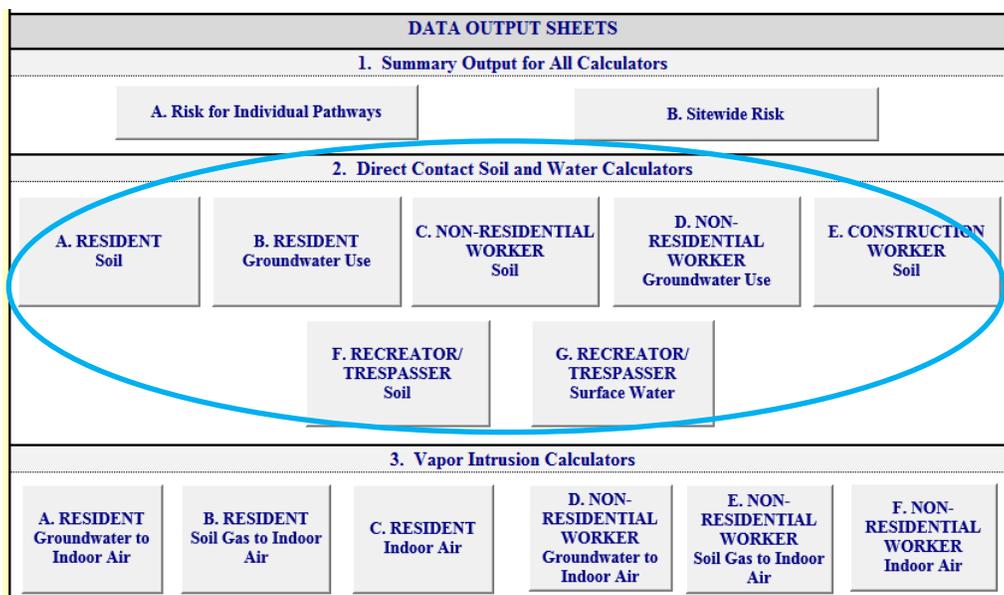
The “Risk for Individual Pathways” presents the calculated risks for all the complete pathways and allow the user to see which pathways exceed acceptable risk levels and may require further evaluation and/or risk management. A “NC” result indicates that the pathway was Not Calculated because it was not checked as complete by the user.

Risk for Individual Pathways				
Version Date: January 2019				
Basis: November 2018 EPA RSL Table				
Site ID:				
Exposure Unit ID:				
DIRECT CONTACT SOIL AND WATER CALCULATORS				
Receptor	Pathway	Carcinogenic Risk	Hazard Index	Risk exceeded?
Resident	Soil	4.1E-04	8.0E+00	YES
	Groundwater Use*	NC	NC	NC
Non-Residential Worker	Soil	9.3E-05	5.8E-01	NO
	Groundwater Use*	NC	NC	NC
Construction Worker	Soil	NC	NC	NC
Recreator/Trespasser	Soil	NC	NC	NC
	Surface Water*	NC	NC	NC
VAPOR INTRUSION CALCULATORS				
Receptor	Pathway	Carcinogenic Risk	Hazard Index	Risk exceeded?
Resident	Groundwater to Indoor Air	0.0E+00	0.0E+00	NO
	Soil Gas to Indoor Air	4.2E-06	1.1E+00	YES
	Indoor Air	4.6E-06	1.2E+00	YES
Non-Residential Worker	Groundwater to Indoor Air	0.0E+00	0.0E+00	NO
	Soil Gas to Indoor Air	3.2E-07	8.6E-02	NO
	Indoor Air	1.1E-06	2.9E-01	NO
CONTAMINANT MIGRATION CALCULATORS				

NC=not calculated because the user did not check this pathway as complete

Calculated risk

3.3.2 Direct Contact Soil and Water Calculators



This section provides details on the risk posed by each chemical in the complete exposure pathways. An example output sheet is shown for soil below.

DEQ Risk Calculator - Direct Contact - Resident Soil Output Form 2A

Version Date: January 2019

Basis: November 2018 EPA RSL Table

Site ID:

Exposure Unit ID:

* - Note that inhalation on this calculator refers to the use of the EPA's default values for the dispersion constants for Raleigh, NC. The Risk Calculator uses a default dispersion constant recommended by EPA for Raleigh, NC. Since construction activities vary greatly from site to site, EPA does not provide default inputs for the construction worker scenario. North Carolina has chosen very conservative default inputs that represent worst case situations and may result in overly restrictive risk values in the majority of cases. Therefore, the construction worker pathway should only be evaluated when large construction activities are possible. Refer to the construction worker assumptions in Section 3.2.1.

** - Note that the EPA has no consensus on the screening level of 400 mg/kg for residential soil associated with vapor intrusion to calculate cancer risk.

Concentrations carried over from input sheet. Will be the same for each route of exposure unless approved by a NCDEQ toxicologist

Shaded cells are the calculated risk for individual chemicals. Bold values indicate a risk exceedance.

CAS #	Chemical Name:	Ingestion Concentration (mg/kg)	Dermal Concentration (mg/kg)	Inhalation Concentration (mg/kg)*	Ingestion Carcinogenic Risk	Dermal Carcinogenic Risk	Inhalation Carcinogenic Risk*	Calculated Carcinogenic Risk	Ingestion Hazard Quotient	Dermal Hazard Quotient	Inhalation Hazard Quotient*	Calculated Non-Carcinogenic Hazard Quotient
7440-38-2	Arsenic, Inorganic	26	26	26	3.4E-05	4.7E-06	6.7E-10	3.8E-05	6.6E-01	7.9E-02	2.8E-05	7.4E-01
5902-51-2	Terbacil	300	300	300					3.0E-01	7.0E-02		3.7E-01
E1790678	Tributyltin Compounds	88	88	88					3.8E+00	8.9E-01		4.6E+00
Cumulative:								3.8E-05				5.7E+00

Cumulative risk from this pathway. An unacceptable risk will be bold.

The calculated risks for each route of entry is shown in the gray cells and summed in the white cell to the right. Target risks for individual chemicals are 1×10^{-6} for carcinogens and a 0.2 for noncarcinogens. The individual risks are summed to determine the cumulative risks for each receptor. Cumulative risks for each receptor are then compared to a risk of 1×10^{-4} for carcinogens and 1 for noncarcinogens.

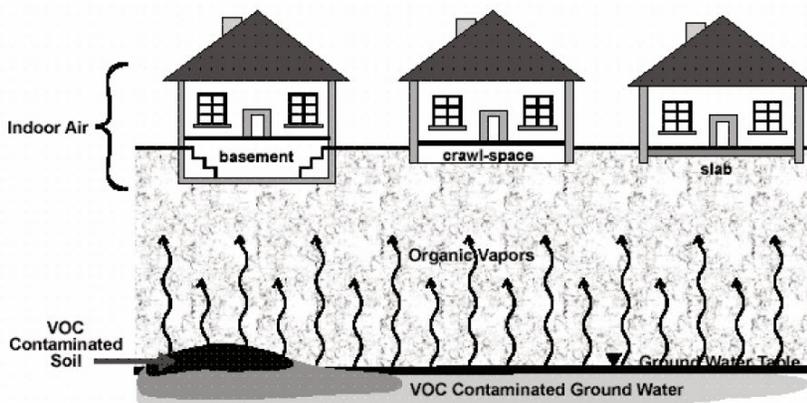
For evaluation of outdoor inhalation risks due to contaminated soils, two additional parameters are incorporated into the calculations: the volatilization factor (VF) and particulate emission factor (PEF). The VF is calculated using both the unlimited source and mass limit equations and the VF yielding the higher risk value is carried through in the final output. The PEF is used to evaluate outdoor inhalation of particulates by incorporating dispersion constants. The EPA RSL website provides default values for the dispersion constants for different geographic locations. The Risk Calculator uses a default dispersion constant recommended by EPA for Raleigh, NC. Since construction activities vary greatly from site to site, EPA does not provide default inputs for the construction worker scenario. North Carolina has chosen very conservative default inputs that represent worst case situations and may result in overly restrictive risk values in the majority of cases. Therefore, the construction worker pathway should only be evaluated when large construction activities are possible. Refer to the construction worker assumptions in Section 3.2.1.

3.3.3 Vapor Intrusion Calculators

3. Vapor Intrusion Calculators					
A. RESIDENT Groundwater to Indoor Air	B. RESIDENT Soil Gas to Indoor Air	C. RESIDENT Indoor Air	D. NON- RESIDENTIAL WORKER Groundwater to Indoor Air	E. NON- RESIDENTIAL WORKER Soil Gas to Indoor Air	F. NON- RESIDENTIAL WORKER Indoor Air

It is important that the user be familiar with EPA’s Vapor Intrusion Guidance prior to conducting vapor intrusion evaluations. For users preparing vapor intrusion evaluations for the Division of Waste Management, read the [North Carolina Division of Waste Management Vapor Intrusion Guidance Document](#).

The “Vapor Intrusion Calculators” evaluate risk associated with indoor inhalation of contaminated vapor intruding into a structure from subsurface contamination. Vapor intrusion risk can be calculated for a resident or a non-residential worker using either indoor air data, soil gas data, or groundwater data, depending on the site-specific data availability. The calculations for indoor air are based on the equations specified on the EPA RSL website and NCDEQ-approved input parameters. The calculations for soil gas and groundwater to indoor air are based on the equations specified on the EPA Vapor Intrusion Screening Level (VISL) Calculator using NCDEQ-approved default parameters. An overview of the risk characterization approach used in each calculator is summarized as follows:



The Risk Calculator does not include a calculation for soil to indoor air due to challenges associated with modeling vapor intrusion for soil sources. If impacted soil is present beneath or adjacent to a building, sub-slab gas, crawl space, and/or indoor air samples should be collected.

- Site-specific indoor air concentrations are compared the EPA screening levels to calculate the risk for each individual constituent, then the risks for individual constituents are summed to calculate the cumulative risk.
- For the soil gas to indoor air calculator, soil gas concentrations are multiplied by an attenuation factor of 0.01 for the non-residential calculator and 0.03 for the residential calculator to predict indoor air concentrations. Cumulative risks are then calculated for the predicted indoor air concentrations using the same process as the indoor air calculator.
- For the groundwater to indoor air calculator, groundwater concentrations are multiplied by Henry’s Law Constant to predict soil gas concentrations, then multiplied by an attenuation factor of 0.001 (same for residential and non-residential), and then multiplied by a 1,000 L/m³ conversion factor to predict indoor air concentrations. Cumulative risks are then calculated for the predicted indoor air concentrations using the same process as the indoor air calculator.

An example vapor intrusion output sheet is shown below.

DEQ Risk Calculator - Vapor Intrusion - Non-Residential Worker Indoor Air						Output Form 3F
Version Date: January 2019						
Basis: November 2018 EPA RSL Table						
Site ID:						
Exposure Unit ID:						
** - Note that the EPA has no consensus on reference dose or cancer slope factor values for lead, therefore it is not possible to calculate carcinogenic risk or hazard quotient. Lead concentrations are compared to the National Ambient Air Quality Standard of 0.15 $\mu\text{g}/\text{m}^3$.						
Carcinogenic risk and hazard quotient cells highlighted in orange are associated with non-volatile chemicals. Risks are calculated for these values if indoor air concentrations are entered and indoor air screening levels have been established, but it should be noted that detections of these chemicals are likely not associated with vapor intrusion.						
All concentrations are in ug/m^3						
CAS #	Chemical Name:	Indoor Air Concentration (ug/m^3)	Target Indoor Air Conc. for Carcinogens @ TCR = 1E-06	Target Indoor Air Conc. for Non-Carcinogens @ THQ = 0.2	Calculated Carcinogenic Risk	Calculated Non-Carcinogenic Hazard Quotient
7440-38-2	Arsenic, Inorganic	0.002	2.9E-03	1.3E-02	7.0E-07	3.0E-02
71-43-2	Benzene	0.56	1.6E+00	2.6E+01	3.6E-07	4.3E-03
79-01-6	Trichloroethylene	8.8	3.0E+00	1.8E+00	2.9E-06	1.0E+00
75-01-4	Vinyl Chloride	0.23	2.8E+00	8.8E+01	8.3E-08	5.3E-04
Cumulative:					4.1E-06	1.0E+00

Orange cells indicate the chemical is non-volatile.

3.3.4 Sitewide Human Health Risk Summary

DATA OUTPUT SHEETS	
1. Summary Output for All Calculators	
A. Risk for Individual Pathways	B. Sitewide Risk

The calculator computes the total risks of all contaminants for each pathway in each medium individually. To ensure that all site risks are within the allowable limits, a Sitewide Risk Summary Sheet has been developed within the calculator to sum the risks of all pathways. The user selects the pathways that are complete, similar to the “Complete Exposure Pathways” sheet.

The vapor intrusion risk can be calculated either using groundwater, soil gas or indoor air data. **The calculator’s sitewide risk summary sheet is designed to consider only one vapor risk calculation, so the inhalation risk will not be overestimated.**

Sitewide Risk															Output				
Version Date: January 2019																			
Basis: November 2018 EPA RSL Table																			
Site ID:																			
Exposure Unit ID:																			
Receptor	Pathway	Resident - Current Scenario			Resident - Future Scenario			Non-Residential Worker - Current			Non-Residential Worker - Current			Construction Worker			Recreator/Trespasser		
		Check box to include in site-wide risk	Carcinogeni c Risk	Hazard Index	Check box to include in site-wide risk	Carcinogeni c Risk	Hazard Index	Check box to include in site-wide risk	Carcinogeni c Risk	Hazard Index	Check box to include in site-wide risk	Carcinogeni c Risk	Hazard Index	Check box to include in site-wide risk	Carcinogeni c Risk	Hazard Index	Check box to include in site-wide risk	Carcinogeni c Risk	Hazard Index
DIRECT CONTACT SOIL AND WATER CALCULATORS																			
Resident	Soil	<input checked="" type="checkbox"/>	4.1E-04	8.0E+00	<input checked="" type="checkbox"/>	4.1E-04	8.0E+00	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
	Groundwater Use*	<input type="checkbox"/>	NM	NM	<input type="checkbox"/>	NM	NM	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
Non-Residential Worker	Soil	<input type="checkbox"/>			<input type="checkbox"/>			<input checked="" type="checkbox"/>	9.3E-05	5.8E-01	<input type="checkbox"/>	NM	NM	<input type="checkbox"/>	NM	NM	<input type="checkbox"/>		
	Groundwater Use*	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>	NM	NM	<input type="checkbox"/>	NM	NM	<input type="checkbox"/>			<input type="checkbox"/>		
Construction Worker	Soil	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
	Groundwater Use*	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
Recreator/Trespasser	Soil	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
	Surface Water Use*	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
VAPOR INTRUSION CALCULATORS																			
Resident	Groundwater to Indoor Air	<input type="checkbox"/>	NM	NM	<input type="checkbox"/>	NM	NM	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
	Soil Gas to Indoor Air	<input type="checkbox"/>	NM	NM	<input checked="" type="checkbox"/>	4.2E-06	1.1E+00	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
	Indoor Air	<input checked="" type="checkbox"/>	4.6E-06	1.2E+00	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
Non-Residential Worker	Groundwater to Indoor Air	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>	NM	NM	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
	Soil Gas to Indoor Air	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>	NM	NM	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
	Indoor Air	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>	NM	NM	<input type="checkbox"/>			<input type="checkbox"/>			<input type="checkbox"/>		
TOTAL SITEWIDE RISK FOR EACH RECEPTOR			4.2E-04	9.2E+00	4.2E-04	9.1E+00			9.4E-05	8.7E-01	0.0E+00	0.0E+00							

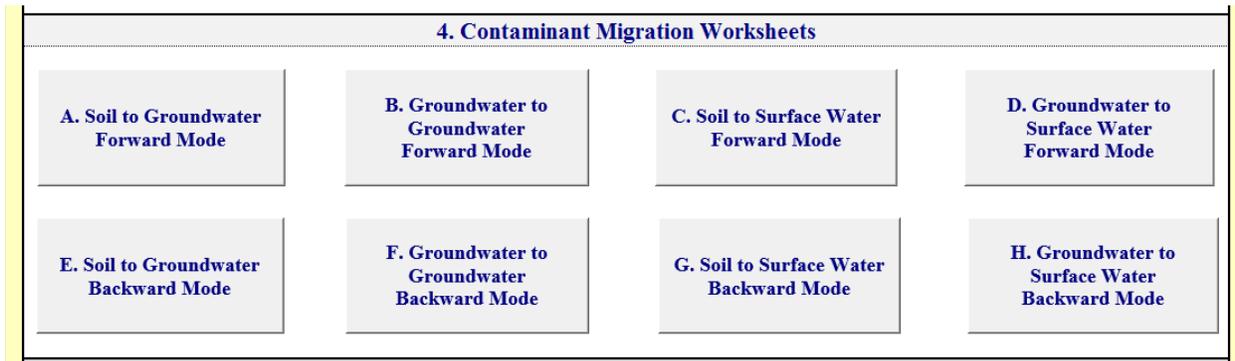
Notes:

- If lead concentrations were entered in the exposure point concentration tables, see the individual calculator sheets for lead concentrations in comparison to secondary standards.
- * = If concentrations in groundwater exceed the NC 2L Standards or IMAC, or concentrations in surface water exceed the NC 2B Standards, appropriate remedial actions should be considered based on the site-specific risk-based closure.
- NM = Not Modeled

The user selects the pathways that will remain complete following the use of engineered or institutional controls, i.e. those to be summed.

The calculator only allows one set of vapor data to be checked.

When risk from any contaminated media is exceeded, it is up to the risk manager on how to best mitigate those risks through remediation, engineered controls or institutional controls.



3.4 Contaminant Migration Worksheets

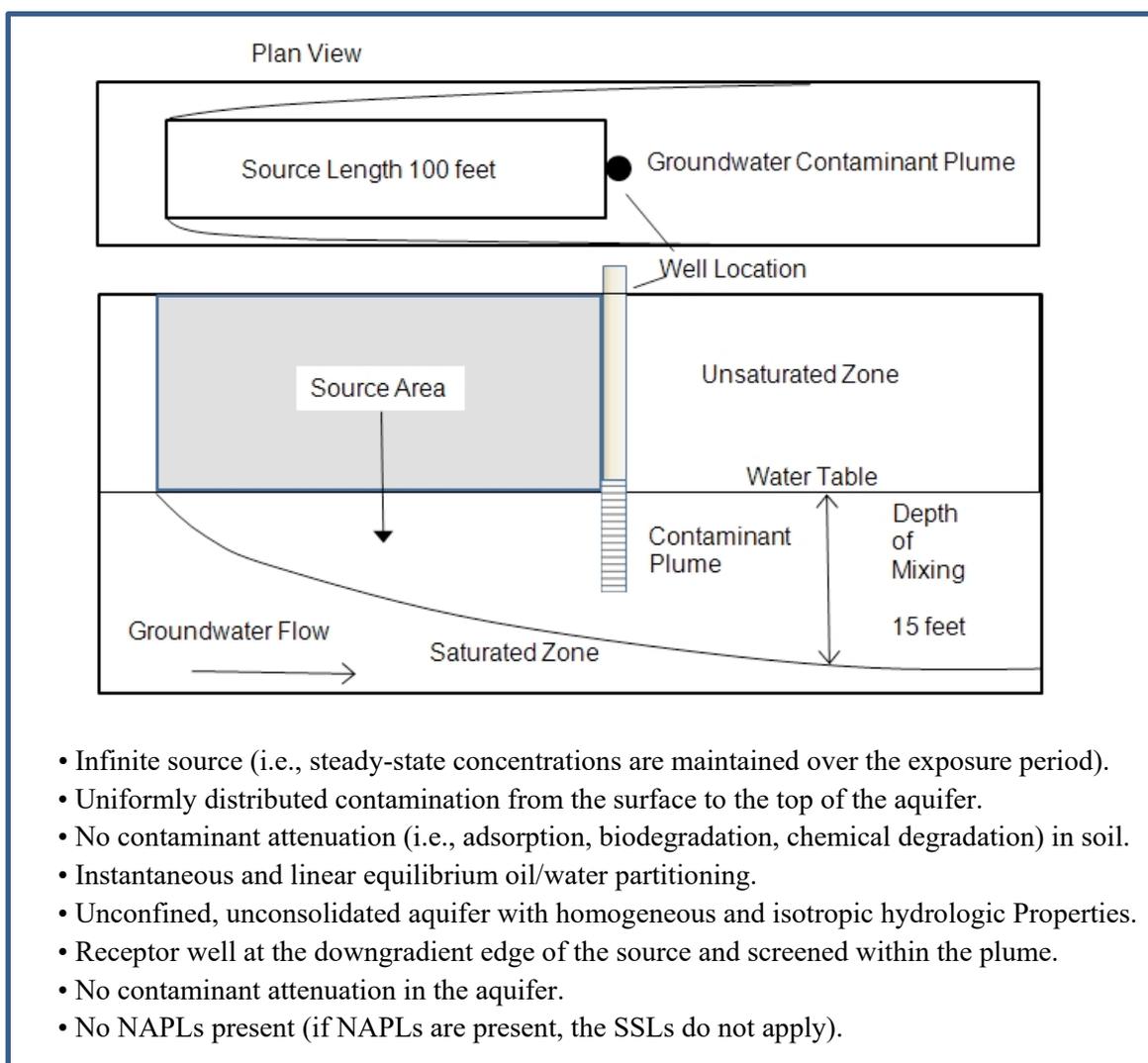
The contaminant migration equations predict contaminant concentrations at a specified distance that have migrated from a known source concentration. Three transport equations are included in the Risk Calculator: (i) soil leaching to groundwater, (ii) groundwater migration to a potential exposure point, and (iii) surface water dilution. The [Risk Evaluation Equations and Calculations](#) are accessible on the Risk-Based Remediation website.

3.4.1 Soil Leaching to Groundwater Calculations

The soil leaching to groundwater calculations are based on methodology presented in the EPA Soil Screening Guidance (EPA, 1996) and EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (EPA, 2002). These equations are also used to develop the Protection of Groundwater PSRGs. The equations predict a groundwater concentration based on source area soil concentration. If “0 feet” is entered for the distance to the POE on the “Contaminant Migration Parameters” sheet, the calculator will only consider vertical leaching to groundwater to predict the groundwater concentration directly beneath the soil source area. A distance greater than zero will also include the lateral transport equation described in the next section.

When only the default parameters are used, the result will approximate the Protection of Groundwater PSRG.

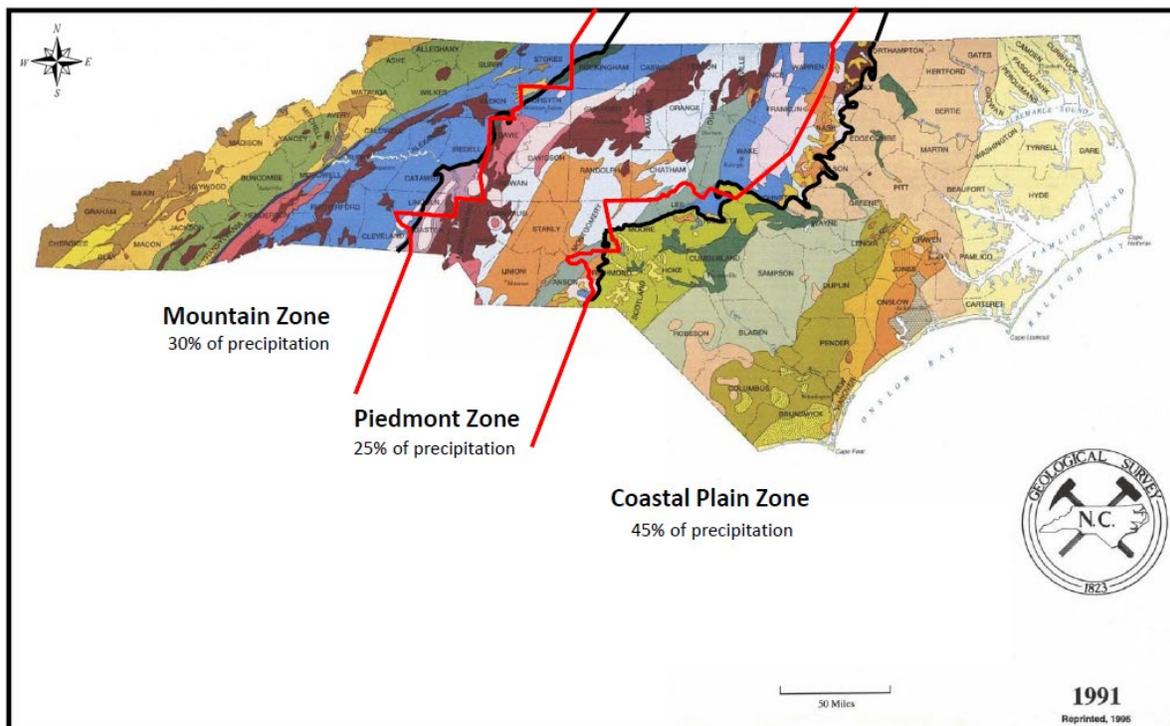
The assumptions used in the leaching equation are depicted in the EPA graphic below:



Two equations are available for soil leaching to groundwater, (i) unlimited source model for chronic exposure and (ii) mass limit model for chronic exposure. Per the EPA Soil Screening Guidance, the unlimited source model assumes an infinite source, so it may violate mass-balance considerations, especially for small sources. As a result, the EPA guidance also specifies a mass limit equation that may be used when the depth of the contaminated soil source is known or can be estimated with confidence. Also, per the EPA Soil Screening Guidance, screening levels are calculated using both the unlimited source equation and the mass limit equation. The higher screening level is then used for subsequent modeling calculations.

To determine default infiltration rates, an evaluation was performed by the NCDEQ Dry Cleaning Program at 20 sites that were selected to be representative of different geological and weather conditions across NC. For each site, the EPA’s Hydrologic Evaluation of Landfill Performance (HELP) Model Version 3.07 was used to calculate infiltration rates as a percentage of precipitation. Based on review of the spatial distribution of the calculated infiltration rates, default infiltration rates were selected for different geographic zones across the State of North Carolina. A description of each zone and recommended default infiltration rates to be applied to each zone are summarized below:

- Mountain Zone (includes Blue Ridge and Western Piedmont belts) – 30% of precipitation
- Piedmont Zone (includes Eastern and Central Piedmont belts) – 25% of precipitation
- Coastal Plain Zone (includes Inner and Outer Coastal Plain belts) – 45% of precipitation



The user should determine average precipitation in the site area using published references, then multiply the precipitation value by the infiltration percentage applicable to the site's geographic zone to calculate the infiltration rate to be input.

Infiltration rates should represent source areas with no surface cover in order to confirm whether an engineered surface cover is warranted to prevent future leaching of soil contaminants.

3.4.2 Groundwater Migration Calculations

Groundwater migration is calculated using the Domenico model [Domenico and Robbins (1985) and Domenico (1987)]. This one-dimensional model is recognized by EPA and is the recommended modeling equation in the ASTM Standard Guide for Risk-Based Corrective Action at Petroleum Release Sites (ASTM, 2002). This methodology is used to predict the steady-state groundwater concentration at a specified downgradient distance from a source area accounting for advection and dispersion. Dispersivity values are calculated based on the user-specified migration distance using equations specified the ASTM guidance (ASTM, 2002). The Risk Calculator conservatively assumes no chemical degradation.

Source soil or groundwater contaminant concentrations are used to estimate the concentrations of each contaminant in groundwater at the specified distance. The calculated groundwater concentrations are compared with the 15A NCAC 02L standards to determine if the standards are exceeded. Because this is a simple, 1-D model, it should only be used as a screening tool.

Due to the simplicity of the transport equations, empirical monitoring data that confirm the plume is stable and unlikely to impact a downgradient receptor are more reliable to support risk management decisions.

3.4.3 Surface Water Dilution Calculations

To predict the contaminant concentrations in a surface water receptor, the calculator first employs the leaching and/or lateral transport equations to predict the groundwater concentrations at the surface water location. The user-specified plume thickness and width are used to calculate the volume of groundwater entering the surface water body to calculate the surface water dilution factor. The surface water dilution factor is applied only if the surface water flow rate is known or measured, otherwise, no surface water dilution is assumed.

DEQ Risk Calculator - Contaminant Migration - Groundwater Source to Surface Water Receptor - Forward Mode					Output Form 4D
Version Date: January 2019					
Basis: Novem					
Site ID:					
		er Receptor	800	feet	
Notes: This is a 1-D model and should be used as a screening tool. NM= Not modeled because contaminant migration parameters have not been entered.					
CAS #	Chemical Name:	Source Groundwater Concentration (ug/L)	2B Standard (ug/L)	(ug/L)	
7440-38-2	Arsenic, Inorganic	80	10	4.1E-01	NO
156-59-2	Dichloroethylene, 1,2-cis-	60		3.1E-01	NA
156-60-5	Dichloroethylene, 1,2-trans-	23		1.2E-01	NA
79-01-6	Trichloroethylene	590	2.5	3.1E+00	YES
NA = Not applicable because no 2B Standard entered.					

This surface water dilution equation is based on standard groundwater and surface water mixing calculations. If the results of the initial modeling indicate concentrations at the surface water body above 15A NCAC 02B standards, site-specific values for flow should be estimated based on published references available from the United States Geological Survey (USGS). Surface water flow rates should be equivalent to the 7Q10, which is the lowest flow that occurs on average once every 20 years. The calculated surface water concentrations are then compared to the 15A NCAC 02B standards to determine if the standards are exceeded. The user is responsible for determining the classification of the surface water body and entering the appropriate 15A NCAC 02B standards into the calculator.

3.4.4 Model Verification for Transport Pathways

Predicting the plume’s extent is important for protecting future receptors and implementing land-use restrictions. The default parameters in the transport equations are conservative, and it is common to find that the plume extent is not as far as the model projects. The results of the contaminant transport pathways should always be compared with site-specific empirical sampling data to confirm the validity of the modeling results. Determination of plume stability is based on concentration versus time graphs for selected monitoring wells, concentration versus distance graphs along the plume centerline and professional judgement.

Other software packages, e.g., the Mann-Kendall toolkit, can be used to characterizes groundwater concentrations trends in individual monitoring wells. Indications of biodegradation based on daughter product formation and/or geochemical parameter data may also provide lines of evidence of plume stability.

3.5 Unprotect All Sheet and Protect All Sheets

The Unprotect/Protect All Sheets buttons at the bottom of the Main Menu page are for NCDEQ use only. The Risk Calculator is password-protected so that the equations and required default exposure parameters can only be changed by a NCDEQ toxicologists.

4.0 CALCULATING CLEANUP LEVELS

The Risk Calculator incorporates both “Forward Mode” and “Backward Mode” for the contaminant migration calculations. The “Forward Mode” calculators predict contaminant concentrations at a downgradient location. For the “Backward Mode” calculators, the user enters the target concentrations (e.g., 15A NCAC 02L, 15A NCAC 02B standards) at a point of exposure and the calculator predicts the source area concentrations that would meet the designated target concentrations. The “2L Standard” column on the “Soil Source to Groundwater Receptor” and “Groundwater Source to Groundwater Receptor” sheets shows the 15A NCAC 02L standards for reference. However, the user may manually enter a target concentration in the “Target Groundwater Concentration at the Receptor” column. This is designed to account for scenarios where the user may want to enter a target groundwater concentration other than 15A NCAC 02L standards, such as screening levels protective of vapor intrusion. On the Soil Source to Surface Water Receptor” and “Groundwater Source to Surface Water Receptor” sheets, the user must also manually enter 15A NCAC 02B standards or other target screening levels.

DEQ Risk Calculator - Contaminant Migration - Groundwater Source to Groundwater POE - Backward Mode				Output Form 4F
Version Date: February 2018				
Basis: November 2017 EPA RSL Table				
Site ID:				
Distance to Protection of Groundwater POE		1000	feet	
Notes: This is a 1-D model and should be used as a screening tool. NM= Not modeled because contaminant migration parameters have not been entered.				
CAS #	Chemical Name:	Target Groundwater Concentration at POE (ug/L)	2L Standard (ug/L)	Calculated Source Groundwater Concentration (ug/L)
71-43-2	Benzene	5	1	4.8E+02
127-18-4	Tetrachloroethylene	10	0.7	9.5E+02
Note: The 2L Standards are shown for convenience. However, if the 2L Standards are the target groundwater concentration at the POE they must be manually entered in column G. This is to allow for situations where the target groundwater concentration at the POE may be values other than 2L Standards (vapor intrusion screening levels for example).				

The backward calculators may also be used to calculate source area remedial goals for target concentrations at a downgradient location for other cumulative risk pathways. For example, if remedial goals are needed to address vapor intrusion on an off-source property, the distance to the property boundary will be entered, and the target concentrations protective of vapor intrusion could be entered as the target concentration at that boundary. The calculator would then provide a cleanup goal for source soil or groundwater. The Risk Calculator allows manual entry of any concentration as the desired target in order to provide flexibility for use under a number of scenarios.

4.1 Remedial Goals for Direct Contact Pathways

The direct contact pathways include three different individual exposure pathways and commonly incorporates risks for multiple contaminants. Unless there is one contaminant clearly driving the risk at a site, a number of combinations of different cleanup goals would be needed. Due to this complexity, development of a simple backward mode calculator is not feasible. An acceptable approach to determining remedial goals for soil, for example, is to simply enter various combinations of concentrations into the calculator until the desired risk output is achieved. The concentrations that result in acceptable risk levels may then be used as remedial goals. Alternately, the user may calculate a risk at each sample location and remediate only the area with unacceptable risk.

4.2 Remedial Goals for Indoor Inhalation Pathways

Development of remedial goals for the indoor inhalation pathway is likely the most complex, particularly when the source of vapors is impacted soil in the vadose zone. Modeling of soil emissions to indoor air presents challenges and is the subject of current research in the field of vapor intrusion. If soil remediation is required to address the vapor intrusion pathway, the remediation should focus on source removal followed by soil gas monitoring to evaluate remediation progress. The soil gas monitoring results can be evaluated with the calculator to determine if the target risks have been met. Because of the heterogeneity of soil gas, many soil remedies to address vapor intrusion will also incorporate measures to ensure that the vapor intrusion pathway is incomplete by installing subsurface vapor extraction piping in the backfill in case vapor removal becomes necessary in the future.

If the primary source of vapors is from impacted groundwater, the groundwater to indoor air calculator may be used. The user may enter various combinations of concentrations into the calculator until the desired risk output is achieved. The concentrations that result in acceptable risk levels may then be used as remedial goals. The backward mode calculators may also be used to evaluate source area groundwater concentrations that are protective of vapor intrusion at a specified distance from the source area.

5.0 REPORTING

If the Risk Calculator is being used to make decisions as part of a site assessment or a remediation plan, the pertinent Risk Calculator forms containing data must be included in the report. Refer to the [Technical Guidance for Risk-Based Environmental Remediation of Sites](#) for procedures on developing a risk-based remedial action plan.

If a risk evaluation requires discussion with a NCDEQ program representative or toxicologist, the following information is recommended to facilitate discussion:

- Figures clearly showing assessment data available for the site and the basis for risk characterization. The figures should include the following information:
 - Property boundaries, buildings, covered areas, and open spaces shown,
 - Extent of soil and groundwater contamination, groundwater potentiometric surface/groundwater flow, exposure unit boundaries, and distance to receptors,
 - Graphs of groundwater contamination over time.
- Tables summarizing the following:
 - The contaminants detected, and justification for any that are demonstrated to not be associated with the site's release,
 - The basis for the input concentrations for each exposure unit and exposure pathway,
 - Any calculations performed.
- Analytical data for each medium evaluated.

6.0 REFERENCES

ASTM. Standard Guide for Risk-Based Corrective Action. E2081-11. 2000.

Domenico, P.A. and Robbins, G.A. A New Method of Contaminant Plume Analysis. Groundwater 23: 476-485. 1985.

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EPA. Region 4 Human Health Risk Assessment Supplemental Guidance. March 2018.

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