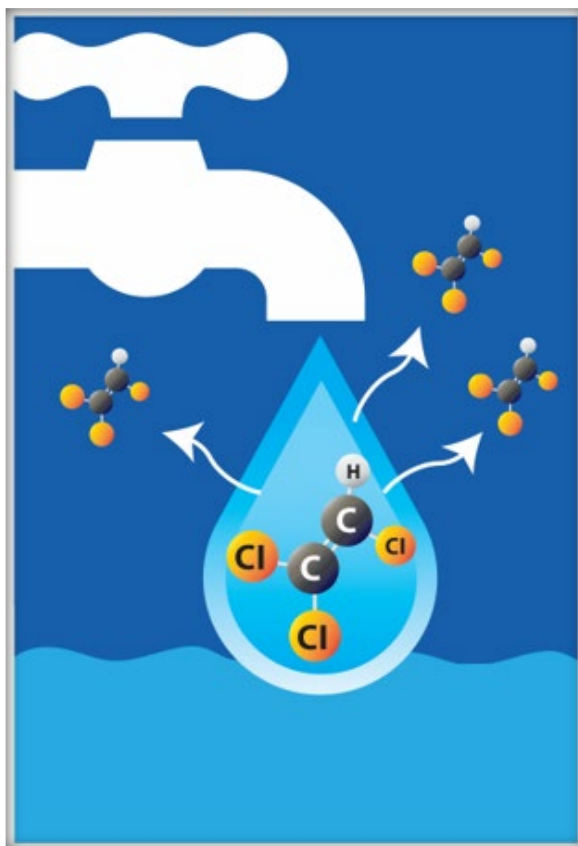# Agency for Toxic Substances and Disease Registry Shower and Household Water-use Exposure (SHOWER) Model v3.0 User's Guide

Version 3.0
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# Contents

# 1   Introduction

The ATSDR SHOWER model allows health assessors to rapidly evaluate inhalation and dermal exposures from volatile chemicals in household water. Using only the name of a contaminant and its concentration in water, health assessors can quickly determine daily air concentrations, dermal doses, and, if appropriate, inhalation doses for exposed households.

ATSDR has released three major versions of the SHOWER model:

- SHOWER model v1.0 was released in May 2018. It required the user to enter only a contaminant name and concentration to obtain results for a representative household. The model's default report provided exposure results for households with 1, 2, 3, and 4 persons in which family members sequentially took 8-minute showers followed by 5-minute bathroom stays. The user also had the option to choose between several individual scenarios where some variables were altered. For example, instead of four consecutive morning showers, the user could select a scenario with two morning showers and two evening showers. Four additional versions of v1.0 were released (v1.0.1 to v1.0.4) that included minor updates and bug fixes to the original version.

- SHOWER model v2.0 was released in February 2020. In addition to the default scenario from v1.0, SHOWER model v2.0 allowed health assessors to answer specific questions from residents and evaluate the sensitivity of simulation results to changes in model parameters. It expanded upon the functionality of v1.0 by allowing the user to customize many of the model parameters, including:

  o number of bathrooms,
  o activity sequence and duration for each household member,
  o size and layout of the house, and
  o household appliance parameters (e.g., appliance flow rate, use duration).

- SHOWER model v3.0 was released in May 2022 and included three major changes.

  o The default scenario was modified to include central tendency exposure (CTE) and reasonable maximum exposure (RME) results for households with 1, 2, 3, and 4 persons.
  o The effects of contaminant saturation in air were incorporated into the SHOWER model's governing equations.
  o An export function was added that allowed health assessors to import and analyze SHOWER model data within ATSDR's Public Health Assessment Site Tool (PHAST).

This document (the user's guide) describes the steps to install and use SHOWER model v3.0. Section 2 of this document outlines the SHOWER model's basic system requirements and provides instructions on how to install and uninstall the program. Section 3 includes a walkthrough of how to use each screen in the SHOWER model. Section 4 summarizes the output

data that the model generates. Throughout the document, screenshots are provided showing relevant aspects of the installation procedure and steps to run the program.

The guide does not include information on the mathematical equations underlying the SHOWER model, nor does it include information on how to interpret the model results. For further information on the model's physical and mathematical basis, see the accompanying technical document (ATSDR 2022a). For further information on using the program's output and information on how to apply the model to public health assessments, see the accompanying exposure dose guidance document and the instructions for health assessors document (ATSDR 2022b, 2022c).

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**Contact**

Users may send questions or comments about the SHOWER model to
showermodel@cdc.gov.

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## 2   Installation

This section describes the steps for downloading and installing the SHOWER model. We highly recommend that you read through the entire section before attempting to install the program. If you are unable to download or install the program after reading through the entire section, contact showermodel@cdc.gov for assistance.

### 2.1   System Requirements

The current version of the SHOWER model is compatible with the following:

- Windows 7, Windows 8, or Windows 10 (32-bit or 64-bit)

- Microsoft Office 2007 or later (32-bit or 64-bit)

- A hard disk with at least 100 MB of free space

The installation procedure will also check if your computer has the following components installed. If not, it will retrieve these files from Microsoft's website and install them as part of the program installation:

- Microsoft .NET Framework 4.6.1 (x86 and x64)

Finally, to minimize computation time and to ensure that the program runs smoothly, it is recommended that your computer have each of the following:

- A processor with two or more cores

- At least 1 GB of available RAM

The SHOWER model is a Windows-only application and does not run in macOS. If you use an Apple Mac computer, you can run the SHOWER model by installing either Apple Boot Camp or a third-party program that runs Windows on a Mac. More information may be found in the document *Instructions for Loading Model onto MAC Computers*, which is located in ATSDR's Public Health Assessment Site Tool (PHAST) via SAMS and can also be requested by email (showermodel@cdc.gov).

### 2.2   Download Instructions

The SHOWER model executable and installation files are available for download at ATSDR's Public Health Assessment Guidance Manual (PHAGM) website (https://www.atsdr.cdc.gov/pha-guidance/index.html). From the PHAGM homepage, click on the Toolbox page and navigate down to the Evaluating Exposure Pathways section. The SHOWER model installation package is available in this section under the ATSDR SHOWER Model link beneath the Modeling tools sub-bullet. Clicking the link will download the file **ATSDR_SHOWER_Model_v3_0_0.zip** to your computer. You can also download the SHOWER model installation package directly by

clicking the following link: https://www.atsdr.cdc.gov/pha-guidance/toolbox/ATSDR_SHOWER_Model_v3_0_0.zip.

### Evaluating Exposure Pathways

- Chemical- and Site-Specific Factors That May Affect Contaminant Transport
- Exposure Pathways Checklist 📕 [PDF – 100 KB]
- Examples of Exposure Assessment Tools
    - R package openair ⬈ as a tool for evaluating air pathway data
    - Interpolation and data visualization (water levels / concentration plume to determine groundwater flow direction): gstat R package ⬈
    - Modeling tools:
        - ATSDR SHOWER Model 🗄 [ZIP – 22 MB]
        - Water Resources Groundwater Software ⬈
        - EPA Science Models and Research Tools (SMaRT) ⬈
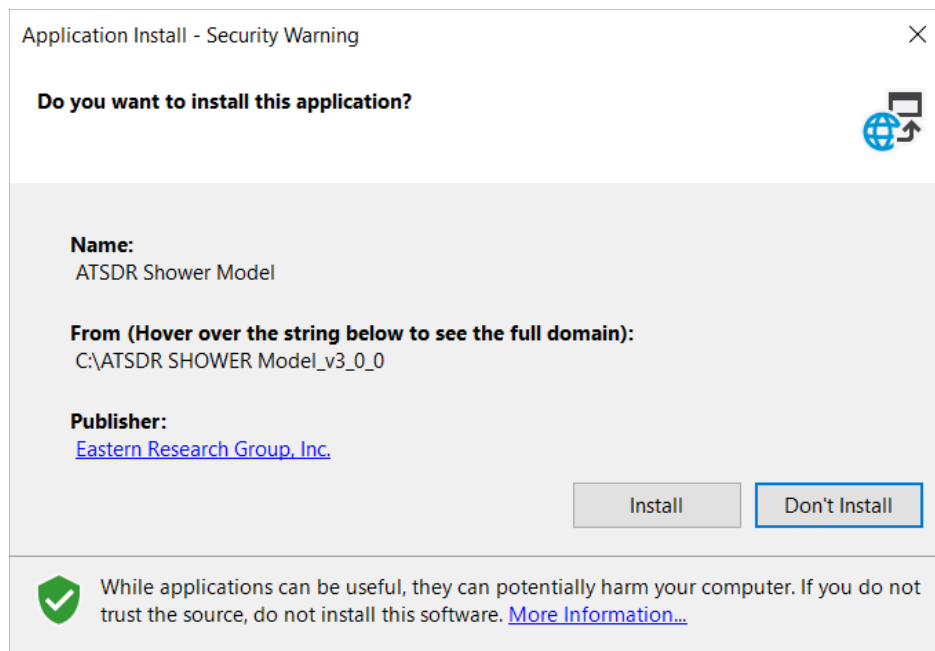        - EPANET ⬈

## 2.3   Installation Procedure

The installation package described in Section 2.2 comes in the form of a zipped folder, the outer level of which contains three items: **setup.exe**, **ATSDRShowerModel.application**, and the **Application Files** folder. The image below shows these files after the installation package is unzipped. The file **setup.exe** is the primary installation file for the program. Double-clicking this file will begin the installation process for all the software components associated with the SHOWER model.
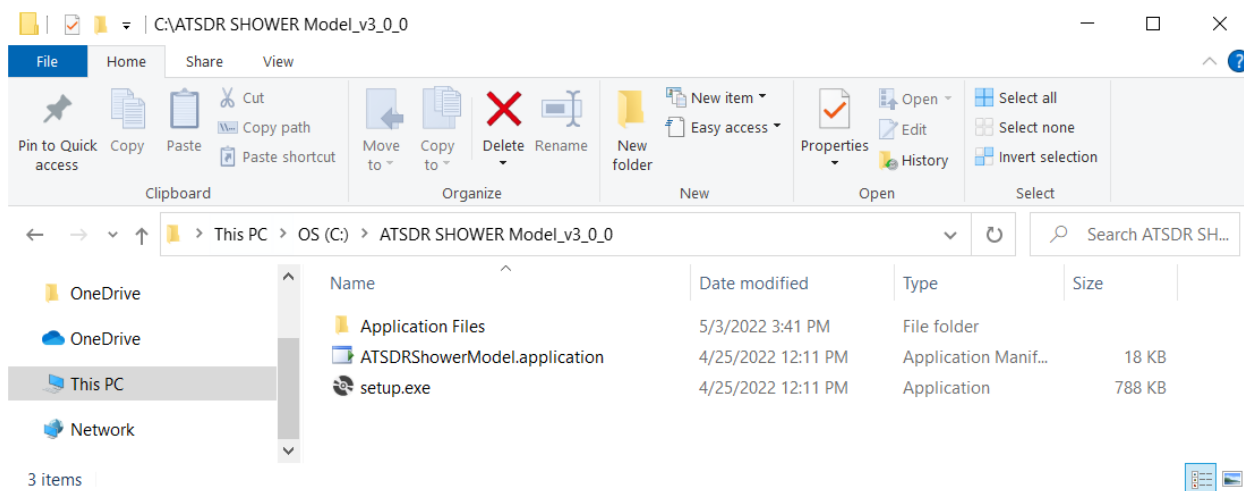


Before installing the current version, it is recommended that you uninstall any previous versions of the program already on your computer (see Uninstall Procedure for further instructions). Note that installation onto CDC/ATSDR computers requires the user to have administrative privileges, such that most CDC/ATSDR users will need to submit a request through ITSO's Software Request Tool to have the program installed onto CDC/ATSDR computers. In addition, the SHOWER model is not currently approved for installation onto CITGO.

To install the SHOWER model onto your computer:

1) Download a copy of the SHOWER model zipped installation package and save the zipped folder somewhere on your computer.

2) Unzip the folder.

3) Double-click the file **setup.exe**. The file will check to see if the required components mentioned in Section 2.1 are installed. If they are not, accept any prompts provided by the program for their installation.

4) A security warning will appear showing basic information about the program, as shown below. Click **Install**.

Application Install - Security Warning                              ×

**Do you want to install this application?**

**Name:**
ATSDR Shower Model

**From (Hover over the string below to see the full domain):**
C:\ATSDR SHOWER Model_v3_0_0

**Publisher:**
Eastern Research Group, Inc.

Install          Don't Install

While applications can be useful, they can potentially harm your computer. If you do not trust the source, do not install this software. More Information...

5) Following a successful installation, the program will load and open to the home screen (Section 3.1).

6) If you receive a message saying that the SHOWER Model is already installed, follow the steps in Section 2.4 to uninstall the program, then perform the steps listed below. These steps clear the cached Windows installation directories, which when done after a full uninstall should allow the program to install correctly.

   a. Open a command prompt window (search for cmd.exe in the windows search bar).

   b. Type in the command: rundll32 dfshim CleanOnlineAppCache

      c.   Install the program using the **setup.exe** file from the zip folder that you downloaded.

After the program has been installed, an ATSDR folder will be added to your Programs menu under the Start menu. The icon to run the SHOWER model will be located within that folder. If desired, you can create a desktop shortcut by dragging the SHOWER model icon from the Start menu folder onto the desktop.

The actual executable for the program and all its associated references will be placed in a folder under the individual user's directory in Windows. To identify the location of the executable:

1) Run the program.

2) Open Task Manager. You can access Task Manager by holding Ctrl+Alt+Del, then selecting Task Manager from the screen that appears.

3) Right click the program's name in Task Manager.

4) Select **Open File Location**. A window will open to the folder containing the SHOWER model executable file, and the executable file will be highlighted.

## 2.4   Uninstall Procedure

To uninstall the SHOWER model from your computer:

1) Open the Control Panel.

2) Within the Control Panel window, click **Programs and Features**.

3) Within the Uninstall or Change a Program section, right-click the entry for the SHOWER model.

4) In the window that appears, select the option for "Remove the application from this computer" and click **Ok**.

# 3   Model Screens

SHOWER model v3.0 allows health assessors to rapidly evaluate inhalation and dermal exposures from volatile contaminants in household water. The SHOWER model includes two simulation pathways. The default model pathway requires only general information on the site name and address, the contaminant name, and the contaminant concentration in household water as inputs. The custom pathway allows users to simulate site-specific conditions or to observe the sensitivity of model results to changes in model parameters. The user interacts with the program through a graphical user interface, which in the SHOWER model consists of the following:

- A home screen and resources page.

- A series of seven screens in which the user can select and modify model input parameters.

- A screen that displays the model results.

This section describes how to navigate the program's user interface and highlights the various calculation and reporting options available within the program.
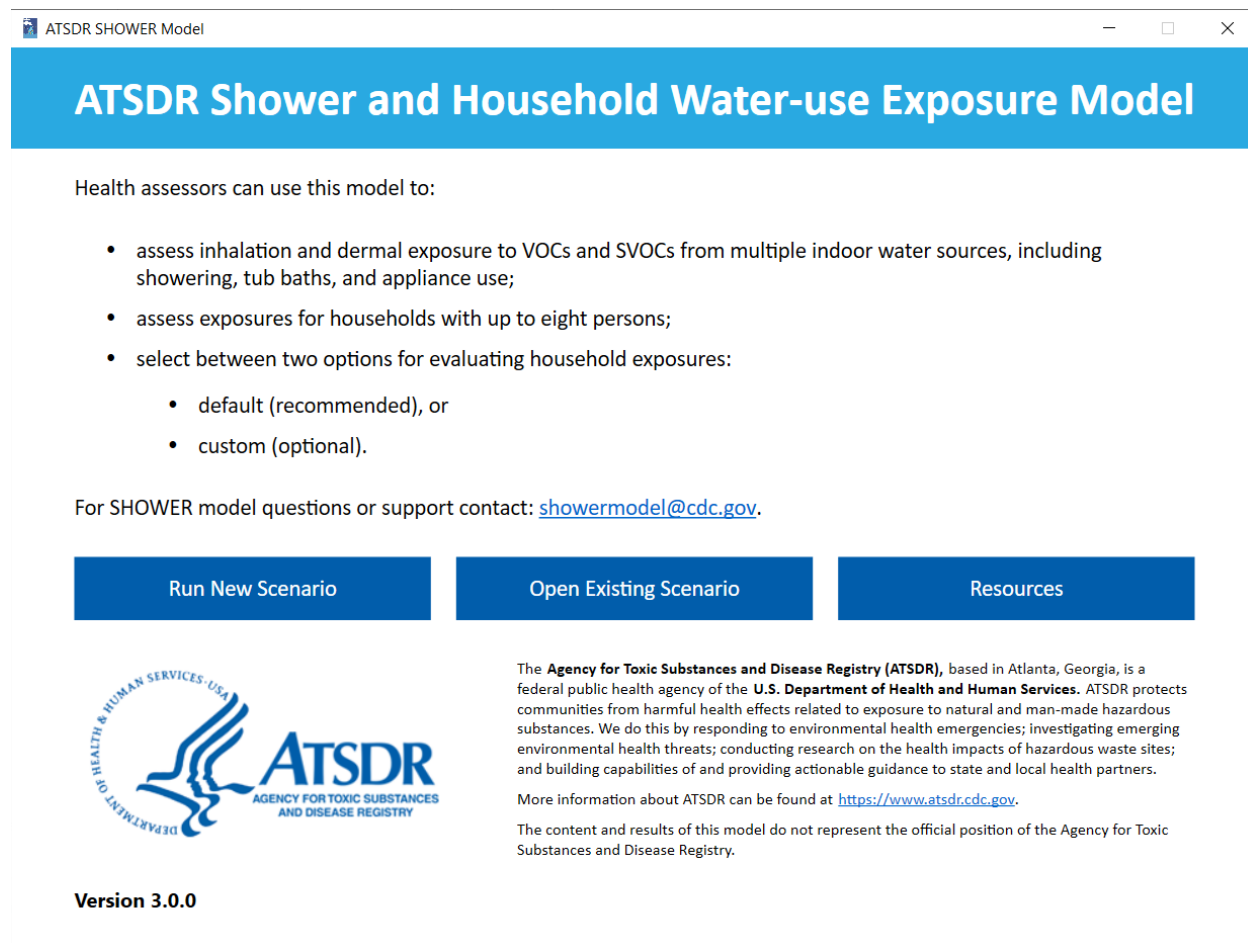
## 3.1   Home Screen

The first screen that you will see after opening the program is the Home screen. The Home screen contains introductory text that explains the overall purpose and use of the SHOWER model. This screen also provides the SHOWER model email address ([showermodel@cdc.gov](mailto:showermodel@cdc.gov)) where users can submit questions and comments.

Users have the choice to run a new scenario or open an existing scenario.

- **Run New Scenario** takes you to the Site Information screen where you can begin entering parameter values for a new scenario.

- **Open Existing Scenario** allows you to open a previously saved scenario. The program saves scenario data in SQLite database files with the extension ".showermodel". After clicking on the blue button, navigate to where you previously saved a scenario file to open it.

The **Resources** button opens a new screen that references documents that might be helpful in understanding and applying the model, such as the SHOWER model technical document, instructions on using model results, and many more. The resources are located in PHAST via SAMS and can also be requested by email ([showermodel@cdc.gov](mailto:showermodel@cdc.gov)).

The current model version is displayed in the lower-left corner of the home screen. ATSDR will change this version number any time the model is updated and will notify staff from ATSDR and the agency's cooperative agreement states whenever a new version is available. For persons outside these two groups, send an email to showermodel@cdc.gov with your contact information, and ATSDR will notify you when an update is available.

> **Tip:** Information icons are displayed in various locations throughout the program. Hovering the mouse over one of these icons will generate a tooltip box that displays further information regarding the associated field. Moving the mouse away from the icon will make the tooltip disappear.

## 3.2   Navigation

After beginning or opening a scenario, the program loads the seven scenario data entry screens. The progress bar across the top of these screens lets you know which screen you are on, which screens you have opened, and which screens you have yet to visit. The progress bar colors have the following meanings:

- Light blue indicates the current screen.

- Dark blue indicates a visited screen.

- Gray indicates screens that have not yet been visited.

The progress bar will also display icons that indicate whether each screen is complete.

- A green check indicates a completed screen.

- No icon indicates that a field on the screen is incomplete.

- A red circle with an exclamation point indicates an error exists on the screen.

You can navigate back to any screen you have already visited by clicking on the dark blue area in the progress bar associated with the screen. When a screen contains an error, you can return to screens that you have previously visited, but you cannot navigate to the next screen, save your data, or run a simulation until the error is resolved.

Consider the example progress bars that follow. In the first example, the user is on the Simulation Type screen (light blue). The user has completed the Site Information and Simulation Type screens (green checks) and has visited the Chemical Information screen but has not completed it (dark blue but no green check). The user has not visited the remaining screens (gray).

Example progress bar 1:
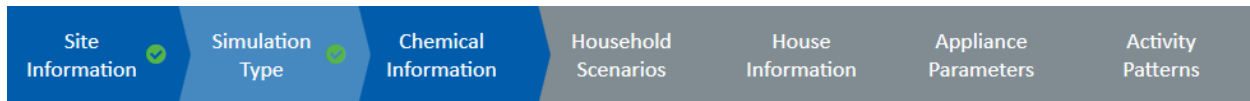


In the second example, the user has completed the first four screens (dark blue with green checks) and is on the House Information screen (light blue). The House Information screen contains an error (red exclamation point). The user cannot proceed to the remaining two screens (gray) as long as an error is present on the House Information screen.
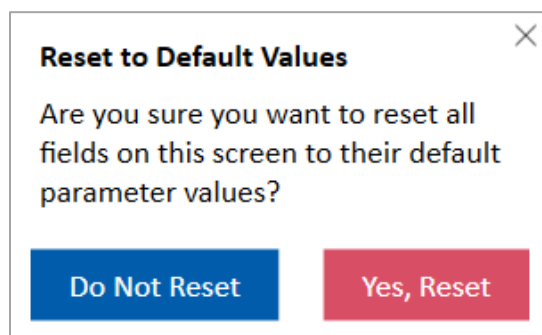
Example progress bar 2:



As shown below, each data entry screen contains two rows of navigation buttons at the bottom of the screen.

The upper row contains the **Back** and **Next** buttons. These buttons will disappear when you cannot proceed backward or forward to another data entry screen from the screen you are on. You must click the **Next** button to visit each new screen for the first time.

Depending on the program screen, the upper row will also contain either the **Clear All** button or the **Reset to Default Values** button. Clicking **Clear All** will clear all fields on the screen and clicking **Reset to Default Values** will restore all fields on the screen to their default values. Clicking either button can also reset values on other screens, as discussed in the sections that follow. Clicking either button will create a popup asking you to confirm whether you want to clear/reset the fields.

**Reset to Default Values**                                             ✕

Are you sure you want to reset all fields on this screen to their default parameter values?

| Do Not Reset | Yes, Reset |
|---|---|

The bottom row contains the following buttons:

1) **Home:** Takes you back to the home screen. This action will reset parameters on all screens to their default values.

2) **Help:** Offers information on required fields and other guidance specific to the screen you are viewing.

3) **Notes:** Provides an opportunity to enter notes that are visible from all screens and are exported in the model report.

4) **Save:** Allows you to save your scenario. The save button will always prompt you for a file location before saving.

5) **Run Default/Custom Scenario:** Runs the scenario using the parameter values you have entered. This button remains inactive until all required parameters are entered for the scenario type you have selected on the Simulation Type screen (see Section 3.4 for further information).

**Tip:** A red error message will appear anytime you enter invalid data in a data field. The error message will pop up next to the field and will provide information about how to correct the data. Whenever an error message appears, you will be unable to navigate to the next screen, save your data, or run a simulation until the error is resolved.

## 3.3   Site Information Screen

The Site Information screen is where you can enter data related to the name and location of the site under review.

The Site Information screen contains the following fields:

- **Site Name:** Enter the name of the site under investigation.

- **Address:** Enter the site's address.

- **City/Town/County:** Enter the city, town, or county where the site is located.

- **State/Territory:** Select the state or territory where the site is located from the dropdown menu. If the site's state or territory is not included in the dropdown list, choose "Other" and enter the state or territory in the new field that appears.

- **Zip/Postal Code:** Enter the zip or postal code where the site is located.

Of the fields on this page, only the **Site Name** field is required. Once you have entered a site name, the **Next** button will appear at the lower right of the screen and you can proceed. Clicking the **Next** button will take you to the Simulation Type screen. After moving to the Simulation Type screen, the program will store and use the site information entered on the Site Information screen throughout the rest of the program, unless you return to the Site Information screen to enter new data. To delete existing data on this screen, you can either delete the data in each field, or you can press the **Clear All** button to clear the data from all fields simultaneously.

## 3.4   Simulation Type Screen

The Simulation Type screen allows you to choose whether to run the default scenario, which is recommended, or an optional custom scenario. The scenario options are:

- **Run Default Scenario (recommended):** Provides CTE and RME results for the most highly exposed person in a 4-person household, using default scenario parameter values. Results for 1-person, 2-person, and 3-person households are also included for additional information. When the number of persons in a household is unknown, health assessors should use the RME results for the 4-person household to determine whether a health concern exists.

- **Run Custom Scenario (optional):** Allows users to build a custom scenario using one of the model's predefined scenarios as a starting point.

The **Run Default Scenario (recommended)** radio button is selected by default. To run the default scenario, you need only select a chemical name and enter a water concentration on the Chemical Information screen. You cannot change chemical properties or any parameter values on screens after the Chemical Information screen when the **Run Default Scenario (recommended)** option has been chosen.

To run a custom scenario, select the **Run Custom Scenario (optional)** radio button on the Simulation Type screen. As a helpful reminder, the text in the **Run Default Scenario** button at the bottom right of the screen will change to "Run Custom Scenario" if you select this option. If you haven't already, you will need to input the chemical name and water concentration on the Chemical Information screen. After selecting the **Run Custom Scenario (optional)** radio button, you can change chemical properties and all other parameter values on subsequent screens, the titles of which are shown in the header on the screenshot that follows.

You can click the **Back** button to go back to the Site Information screen or the **Next** button to continue to the Chemical Information screen. Clicking **Reset to Default Values** will reselect the default scenario option.

## 3.5   Chemical Information Screen

The Chemical Information screen is where you enter data related to the chemical under investigation, as well as the concentration of the chemical in household water and outdoor air.

Select a chemical by typing either its name or its Chemical Abstract Service Registry Number (CASRN) into the **Chemical Name** field at the top of the screen. The program will search for the chemical in the database that accompanies the program using one of three methods:

- Selecting the **Begins With** radio button will search the database for any chemical name or CASRN that begins with the characters entered in the field.

- Selecting the **Contains** radio button will search the database for any chemical name or CASRN that contains the characters entered in the field.

- Selecting the **Exact Match** radio button will search the database for any chemical name or CASRN that exactly matches the contents of the field.

As you type data into the text entry field, the program will show options from the database that match the search criteria in a dropdown menu below the text entry field. To select a chemical, single-click the entry for that contaminant in the dropdown menu.

If you selected the option to run the default scenario on the Simulation Type screen, both the **Edit Properties** and **Add Chemical** buttons will be inactive (grayed out). Users cannot modify chemical properties for the default scenario, nor can they simulate a custom chemical. These options are available only if you run a custom scenario.

Within a custom scenario, the **Edit Properties** button will activate after you select a chemical. Clicking this button will open a popup that allows you to change chemical properties from their default values. In the popup that appears:

- Clicking **Cancel** will close the screen without saving any changes.

- Clicking **Reset** will restore the parameters to their default values included with the program.

- Clicking **Save** will save any changes you made for use within your scenario.

Note that clicking **Save** stores modified chemical properties for use in the current scenario only — it does not modify the default values included within the program.

The **Add Chemical** button allows you to add a new chemical for use in your scenario (see screenshot to right). The **Chemical Name**, **Chemical CASRN**, **Molecular Weight,** and **Chemical Type** fields are required. To evaluate inhalation exposure, at least one **Chemical f Value** (fractional release value) and the chemical's **Henry's law constant** must be non-zero. To evaluate dermal exposure, all three **Chemical Dermal Parameters** must be non-zero. The **Save** button will activate only once you have completed the required fields. Click **Save** to save your new chemical or **Cancel** to exit without saving.

| Add/Edit Chemical Data ⓘ | |
|---|---|
| **Chemical Name** | |
| **Chemical CASRN** | |
| **Molecular Weight** | g/mol |
| **Chemical Type** | ⦿ Organic  ◯ Inorganic |
| **Inhalation Parameters** | |
| Shower f value | 0 |
| Bathroom sink f value | 0 |
| Bathtub f value | 0 |
| Toilet f value | 0 |
| Clothes washer f value | 0 |
| Dishwasher f value | 0 |
| Kitchen sink f value | 0 |
| Henry's law constant ($K_H$) ⓘ | 1E+99 |
| **Dermal Parameters** | |
| Dermal permeability coefficient ($K_p$) | 0  cm/hr |
| Fraction absorbed through the skin (FA) | 0 |
| Fraction absorbed in GI tract ($ABS_{GI}$) | 0 |

Cancel    Save

**Tip:** Adding a new chemical applies only to the current scenario. The chemical will not be added to the list of default chemicals included with the program's chemical database. However, if you save the scenario to a .showermodel scenario file, you can retrieve the added chemical information the next time you open the file.

Enter the concentration of the contaminant in household water and outdoor air in the **Concentration in Water** and **Concentration in Outdoor Air** fields, respectively. The program will accept concentrations entered in the following formats:

- Whole numbers

- Decimal numbers

- E notation (e.g., 1E-4)

The program uses a default value of 0 $\mu g/m^3$ for the outdoor air concentration of each chemical. It does not have a default value for water concentration. You can select units for each concentration using the dropdown menus to the right of each concentration field. The program will automatically convert the selected units into the units needed for calculation and output. The **Report Units** option specifies whether the model report will use units of ppb or $\mu g/m^3$ to display contaminant air concentrations.

You must select a chemical name and enter a chemical concentration in water to proceed. Changing the outdoor air concentration from the default value of 0 $\mu g/m^3$ is optional.

Outdoor air concentrations can be obtained from ATSDR's chemical-specific toxicological profiles or EPA's National Air Toxics Assessment (NATA). The NATA program includes emissions, ambient air concentrations, and exposure estimates for 180 of the 187 Clean Air Act air toxics. NATA takes information about emissions and models local ambient air concentrations and the risk of harmful effects. Modeled outdoor air estimates are available at the national, state, county, and census tract levels. The resources section in PHAST has a link to EPA's NATA program along with instructions on how to locate outdoor air levels in the NATA tables. If you do not have access to PHAST, you can request this information from showermodel@cdc.gov. If you have reliable, site-specific outdoor air measurements, you should use those values in the SHOWER model.

The **Preview Default Scenario Results** button will generate a popup that provides the average daily human exposure concentration for the most highly exposed person in the RME 4-person household default scenario. Results are provided in units of ppb and $\mu g/m^3$ to assist with selecting units for your output report. The **Preview Default Scenario Results** button will show you results for the default scenario regardless of whether you selected a default or custom scenario on the Simulation Type screen. Any custom changes to chemical or scenario parameter values will not be reflected in the preview results on the Chemical Information screen.

Depending on whether you selected a default or custom simulation on the Simulation Type screen, one of two things will happen once you complete all required fields on the Chemical Information screen:

- If you selected a default simulation, the **Run Default Scenario** button will activate at the bottom-right of the screen. Clicking the **Run Default Scenario** button will run the consecutive morning shower scenarios for the 1-person, 2-person, 3-person, and 4-person households. See Section 4.2 for more details on the default results that are generated. A

more detailed description of these scenarios is provided in the SHOWER model exposure dose guidance document (ATSDR 2022b).

- If you selected a custom simulation, the **Next** button will appear and you can proceed to the Household Scenarios screen. Note that the Household Scenarios screen and all subsequent screens will only be available if you select a custom simulation from the Simulation Type screen.

The **Back** button will take you back to the Simulation Type screen. The **Clear All** button will delete the data from the **Chemical Name** and **Concentration in Water** fields and will reset all other fields on the screen to their defaults.

## 3.6   Household Scenarios Screen



The Household Scenarios screen is accessible only if you selected the **Run Custom Scenario (optional)** radio button on the Simulation Type screen. The Household Scenarios screen is where you select a standard scenario that will form the basis of your custom scenario. Changes made on this screen affect the parameter values on the subsequent three screens: the House Information screen, the Appliance Parameters screen, and the Activity Patterns screen.

There are three settings that you need to select on this screen:

1) **The number of persons in the household**. Options include 1- to 8-person households. After selecting the number of persons in the household, you will see four different scenario options that can form the basis of your custom scenario. The scenario that you select from these four options will establish the initial parameter values used on the subsequent three screens. Click the **View Default Parameter Values** link to download a Word file that displays the default parameter settings for the selected scenario.



2) **Whether the exhaust fans are on or off when the bathrooms are occupied**. This field activates after you select a scenario. The default setting for the exhaust fan is off but you have the option of selecting on.

3) **Whether the bathroom doors are open or closed when the bathrooms are occupied**. This field activates after you select a scenario. The default setting is the bathroom door is closed when the bathroom is occupied.

The SHOWER model includes ATSDR's nine standard exposure groups in each model report. You also have the option of adding up to two additional exposure groups by clicking the **Add Additional Exposure Group** button. In the popup, enter an exposure group name and the required physical/exposure parameters (all fields are required). Click **Save** to add the exposure group or click **Cancel** if you decide not to add the exposure group. After the group is added, you can **Edit Parameter Values** or **Delete** the exposure group.



The **Run Custom Scenario** button in the lower right corner of the screen will become active after the number of persons in the household is selected. You can click this button to generate your custom scenario results. If you would like to continue to customize the scenario's parameter

values on the following screens, the **Next** button will appear after the number of persons in the household is selected. Clicking **Next** will take you to the House Information screen. Clicking **Back** will take you back to the Chemical Information screen and clicking **Clear All** will delete all data on this screen AND will reset all values on the subsequent screens.

> **Tip:** Every time you select a new scenario on the Household Scenarios screen, all parameter values on the House Information, Appliance Parameters, and Activity Patterns screens will automatically update to the default values associated with the new scenario you selected. Any user-defined custom values will be overwritten. This process may take a while on older computers. Be sure to save any custom settings to a new .showermodel database file before changing the scenario if you want to return to them in the future.

## 3.7   House Information Screen

The House Information screen allows you to modify the size and configuration of the house in your scenario. Default values are already selected based on information entered on the previous Household Scenarios screen.

Users can customize the scenario by changing any of the following parameters:

- **Number of Bathrooms with Showers.** Options are 1 or 2 bathrooms. If only one bathroom is selected, then all parameters associated with bathroom #2 are inactive (gray) on this screen and subsequent screens.

- **Shower/Bathtub Layout.** You can choose either "Bathtub with shower" or "Shower stall and bathtub separate". Selecting "Bathtub with shower" means that people taking tub baths will be located in a shower compartment while they are taking a tub bath, whereas selecting "Shower stall and bathtub separate" means that they will be located in a bathroom compartment while they are taking a tub bath. Note that changing a bathroom's **Shower/Bathtub Layout** will change its compartment volume as well. The default value for the total bathroom volume changes with the shower/bathtub layout:

  o  Bathroom containing a bathtub with shower: 9.061 m$^3$  (5 ft x 8 ft x 8 ft)

  o  Bathroom with shower stall and bathtub separate: 11.326 m$^3$  (5 ft x 10 ft x 8 ft)

- **Clothes Washer Location.** The clothes washer location can be in the main house, bathroom 1, or bathroom 2 (if two bathrooms were selected). Note that changes to the **Clothes Washer Location** will change the bathroom volume as well. With a clothes washer included, the default values for the total bathroom volume are:

  o  Bathroom containing a bathtub with shower plus clothes washer: 11.326 m$^3$  (5 ft x 10 ft x 8 ft)

  o  Bathroom with shower stall and bathtub separate plus clothes washer: 13.592 m$^3$  (5 ft x 12 ft x 8 ft)

- **Exhaust Fan Location.** Choices are bathroom or shower.

- **Area Volumes.** Values are needed for the total house, bathroom(s), and shower(s). If you choose to change the area volumes, open the information icon first and review the details of how compartment volumes are calculated. If you have information on house dimensions in English or metric units (e.g., square feet or meters), you can use the calculator to the right of each compartment to calculate volume in cubic meters. An example of the calculator icon is shown below.



- **Air Exchange Rates.** Air exchange rates determine the flow rates of air between model compartments, per equations described in the SHOWER model technical document (ATSDR 2022a). Values are needed for the main house, bathroom(s), and shower(s). If you have data on air residence times (the average amount of time that a parcel of air stays within a compartment), you can use the calculator to the right of each compartment to calculate the air exchange rate in units of air changes per hour (ACH). If you receive an error stating that the entered parameter values result in negative flow rates, refer to the SHOWER model technical document for further information on the equations affected by these terms (ATSDR 2022a).

You can use the **View House Layout** link to display a house layout image that reflects the options selected on the House Information screen. The layout image will show you the number of compartments in the house, their locations relative to each other, and the location of each appliance considered within the model. Note that the image is not to scale.

Changes to the **Number of Bathrooms with Showers** and the **Shower/Bathtub Layout** options will change the default values that appear on subsequent screens. Changes to the **Number of Bathrooms with Showers** will automatically update the values on the Appliance Parameters and Activity Patterns screens, and changes to the **Shower/Bathtub Layout** options will automatically update the parameter values on the Activity Patterns screen. Any user-defined custom values on these screens will be overwritten during the automatic updates. For example, if a user makes changes on the Appliance Parameters screen or the Activity Patterns screen and then returns to the House Information screen and changes the number of bathrooms, the model will replace the user-defined custom values entered on the Appliance Parameters and Activity Patterns screens with default values. Because user-defined custom values appear in red in the report, the user can always double-check that the intended custom values were used by the model.

After making any desired changes to the default parameter settings on this screen, you can either click the **Run Custom Scenario** button to run the scenario or click the **Next** button to proceed to the Appliance Parameters screen. Clicking the **Back** button will take you back to the Household Scenarios screen. Clicking **Reset to Default Values** will reset all parameter values on this screen and on the subsequent two screens to the default values associated with the standard scenario you selected on the Household Scenarios screen.

## 3.8   Appliance Parameters Screen

The Appliance Parameters screen allows you to customize the appliance parameter values in your scenario. Default values are already selected based on the information entered on the Household Scenarios screen. For more information about the governing equations that use these parameters, see the SHOWER model technical document (ATSDR 2022a).

The location parameters on this screen (**Clothes Washer Location**, **Exhaust Fan Location,** and **Bathtub Location**) are permanently inactive. These location parameters can be changed on the House Information screen as explained in the information icon associated with each parameter. The parameter settings associated with Bathroom #2 will be active only for a scenario in which the **Number of Bathrooms with Showers** setting on the House Information screen is set to two.

Each standard scenario in the SHOWER model assumes one dishwasher use and one clothes washer use per day. Users can add additional dishwasher or clothes washer uses by clicking the **Add Additional Start Times** buttons. Up to five start times are allowed per appliance. The model will automatically check the start times and appliance durations for conflicts and will indicate an error if a conflict is detected. The model does not allow intermittent use of the clothes washer or dishwasher (for example, 3 times a week).

From the Appliance Parameters screen, users can:

1) Proceed directly to the Activity Patterns screen by clicking the **Next** button.

2) Generate custom scenario results by clicking the **Run Custom Scenario** button in the lower right corner of the screen.

3) Go back to the Household Information screen by pressing the **Back** button.

4) Reset all fields on this screen to their default values by pressing the **Reset to Default Values** button. The **Reset to Default Values** button affects parameters on this screen only.

> **Tip:** The SHOWER model does not include explicit options for removing appliances from scenarios. To simulate a house without a particular appliance, set the flowrate, volume, or volume per cycle parameters associated with that appliance to zero on the Appliance Parameters screen. For example, setting the kitchen sink flow rate to zero will eliminate any contaminant contribution from the kitchen sink, effectively removing it from consideration within the simulation. Contributions from the dishwasher and clothes washer can also be eliminated by deleting the start times associated with those appliances. In addition, you can also simulate a house without contaminant air contributions from an appliance by setting the appliance's f value to zero in the **Add/Edit Chemical Data** menu on the **Chemical Information** screen.

ATSDR SHOWER Model - Unsaved                                              —  ☐  ✕

| Site Information ✓ | Simulation Type ✓ | Chemical Information ✓ | Household Scenarios ✓ | House Information ✓ | Appliance Parameters ✓ | Activity Patterns |

## Appliance Parameters

### Main House Compartment Parameters

| | | |
|---|---|---|
| Kitchen sink flow rate | 3.347 | L/min |
| Kitchen sink duration per use | 0.64 | min |
| Utility sink volume use per person | 8.544 | L |
| Dishwasher volume per cycle | 23.1 | L |
| Dishwasher cycle duration | 145.0 | min |
| Dishwasher start time(s) | 9 : 00  PM ▼ | **Delete** |

**Add Additional Start Time**

### Clothes Washer Parameters

| | | |
|---|---|---|
| Clothes washer location ⓘ | Bathroom #1 | |
| Clothes washer volume per cycle | 117.0 | L |
| Clothes washer cycle duration | 75.0 | min |
| Clothes washer start time(s) | 7 : 00  PM ▼ | **Delete** |

**Add Additional Start Time**

### Bathroom Compartment Parameters

| | Bathroom #1 | | Bathroom #2 | |
|---|---|---|---|---|
| Bathroom sink flow rate | 3.347 | L/min | 3.347 | L/min |
| Bathroom sink duration per use | 0.64 | min | 0.64 | min |
| Toilet volume per flush | 8.7 | L | 8.7 | L |

### Exhaust Fan Parameters

| | Bathroom #1 | | Bathroom #2 | |
|---|---|---|---|---|
| Exhaust fan location ⓘ | Bathroom #1 | | Bathroom #2 | |
| Exhaust fan flow rate | 1416.0 | L/min | 1416.0 | L/min |

**Bathtub Parameters**

| Bathtub location ℹ️ | Bathroom #1 | Shower #2 |
|---|---|---|
| Bathtub volume | 76.47   L | 76.47   L |

**Shower Compartment Parameters**

|  | Shower #1 | Shower #2 |
|---|---|---|
| Shower flow rate | 7.6   L/min | 7.6   L/min |

◄ Back    Reset to Default Values        Next ►

Home    Help    Notes        Save    Run Custom Scenario

## 3.9 Activity Patterns Screen

The Activity Patterns screen allows you to enter custom activity patterns for each person in the house. Default activity patterns and parameter values are already programmed in this screen based on the information entered on the Household Scenarios screen and on the House Information screen.

| Site Information | Simulation Type | Chemical Information | Household Scenarios | House Information | Appliance Parameters | Activity Patterns |
|---|---|---|---|---|---|---|
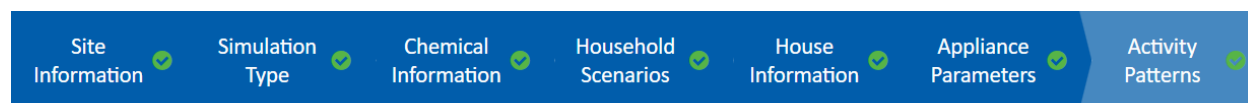
## Activity Patterns

View Activity Pattern

| Person | Activity Time | Activity Type + Compartment ℹ️ | Activity Duration (min) | Time in Bathroom after Activity (min) | Person Helping with Tub Bath ℹ️ |
|---|---|---|---|---|---|
| 1 | Morning | Showering - Shower #1 ▼ | 7 | 5 | ▼ |
| 1 | Evening | ▼ |  |  | ▼ |

The SHOWER model procedurally generates activity patterns for each person in the house using the parameters shown on this screen. You can customize activity patterns by modifying the morning or evening activities for each person in the house, their activity durations, and the time they spend in the bathroom after each activity. For each person that takes a tub bath, you can also specify a person that helps them with their bath. All residents of the house must have either a major morning or evening activity (shower or bath) scheduled for the simulation to proceed.

The custom scenario report displays results for only one person in the house at a time. By default, the program displays results for the most highly exposed person in the house. To view results for a different person, select their number in the **Target Person** dropdown menu.

Target Person ⓘ                                    | Most Highly Exposed Person                          ▼ |

The **Other Activity Information** section includes a few more parameters that help define activity patterns:

- **Time between bathroom stays and next shower/tub bath** defines the amount of time between one person exiting the bathroom after their shower or bath and the next person entering the same bathroom for their shower or bath. The default value is 1 minute, meaning 1 minute elapses between consecutive showers or baths.

- **Bathroom visits separate from shower/tub bath** specifies how many additional bathroom visits each person makes throughout the day. You have the option of changing the number of additional visits per person (from zero to five), but you cannot specify the times that the visits occur — those times are fixed within the program. If a shower or tub bath activity setting or an away from home setting conflicts with a fixed time for an additional bathroom visit, the additional bathroom visit will not occur. For example, if you select a person to be away from home from 1 pm to 3 pm, their scheduled 2 pm bathroom visit will not take place.

- **Kitchen sink uses** specifies the number of times each person uses the kitchen sink during the day (from 0 to 30). The default number of kitchen sink uses for each person in the household is 15, such that people who are home all day will use the kitchen sink 15 times when the default value is used. If the person is away from home, the number of times they use the kitchen sink will be scaled in proportion to the number of hours they are away from home. Changes to this parameter do not affect the activity pattern generated for each person.

**Other Activity Information**

| | | |
|---|---|---|
| Time between bathroom stays and next shower/tub bath | 1 | min |
| Bathroom visits separate from shower/tub bath ⓘ | 4 ▼ | visits per person per day (max 5) |
| Kitchen sink uses ⓘ | 15 | uses per person per day (max 30) |

The SHOWER model generates activity patterns for each person in the house by working backward from an established end time for morning and evening bathing activities. These end times are set using the **Activity End Time** parameters shown on this screen. Separate end times are assigned for activities in Bathroom #1 and Bathroom #2.

The model requires a morning and evening end time for each bathroom in which a major activity is scheduled. Each scenario in the model will have default end times. Note that staggering the end times between bathrooms 1 and 2 allows Figure 1 in the model report to show distinct concentration profiles when the scenario includes two bathrooms. The example shown below is for a household where both bathrooms have morning and evening bathing activities. If a morning or evening bathing activity does not occur in a bathroom, end times are not shown.

**Activity End Times**                                      **Bathroom #1**        **Bathroom #2**

Time when all morning showers/tub baths are complete    7 : 13 AM        7 : 23 AM

Time when all evening showers/tub baths are complete    7 : 43 PM        7 : 53 PM

To see how these parameters are used, consider the following two examples:

- *Example 1*: A 1-person scenario in which the person spends seven minutes showering in Shower #1 and spends five minutes after the shower in Bathroom #1. If the **Time when all morning showers/tub baths are complete** in Bathroom #1 is 7:13 AM, the person will begin their shower at 7:01 AM (7:01 AM = 7:13 AM – five minutes in the bathroom – seven minutes in the shower). Thus, the start time calculated within the model is 7:13 AM – 12 minutes or 7:01 AM.

- *Example 2*: A 2-person scenario in which both people take 7-minute morning showers in Shower #1 followed by 5-minute bathroom stays in Bathroom #1. Assume the **Time when all morning showers/tub baths are complete** in Bathroom #1 is still 7:13 AM as in the previous example. If the **Time between bathroom stays and next shower/tub bath** equals one minute, the first shower in the bathroom will occur at 6:48 AM (6:48 AM = 7:13 AM – five minutes in the bathroom for person 2 – seven minutes in the shower for person 2 – one minute between consecutive bathroom stays – five minutes in the bathroom for person 1 – seven minutes in the shower for person 1). Thus, the start time calculated within the model is 7:13 AM – 25 minutes or 6:48 AM.

The SHOWER model provides the **Activity Start Times** in each compartment for reference. Knowing the start time may be useful in resolving scheduling conflicts (see next section). You cannot directly enter activity start times, as they are calculated within the model based on activity end times, bathing duration, bathroom stay duration, and time between bathing activities.

**Activity Start Times** ⓘ                                  **Bathroom #1**        **Bathroom #2**

Time when all morning showers/tub baths begin      6 : 18 AM        6 : 28 AM

Time when all evening showers/tub baths begin      6 : 48 PM        6 : 58 PM

You can use the **Home All Day/Away From Home Options** to specify whether each person in the house is away from home during a portion of the day. All people that are away from home will be away during the time specified in the **Away from home start time** and **Away from home end time** fields (shown below). When selected, the default time away from home is 10 hours. Because of the complexity in this parameter, the SHOWER model does not include a mechanism for setting different away from home times for different people in the house.

**Home All Day/Away From Home Options**

| | | |
|---|---|---|
| Away from home start time | ☐ : ☐ AM | |
| Away from home end time | ☐ : ☐ PM | |

| | | |
|---|---|---|
| Person 1 | ⦿ Home All Day | ◯ Away From Home |
| Person 2 | ⦿ Home All Day | ◯ Away From Home |
| Person 3 | ⦿ Home All Day | ◯ Away From Home |
| Person 4 | ⦿ Home All Day | ◯ Away From Home |

The SHOWER model will automatically check the settings entered on the Activity Pattern screen to ensure that all entered time settings are valid and that no conflicts exist. The program will ensure that all morning activities begin after midnight and that all evening activities begin after noon. For example, an error will appear if afternoon activities are back-calculated to start before 12:00 noon.

In addition, the program requires that persons cannot leave the house before the last bathing activity takes place. Thus, the away from home start time must occur *after* the end time of all morning bathing activities. Similarly, persons must return home in the evening before evening bathing activities start. Thus, the away from home end time must occur *before* the start time of all evening bathing activities. Any violations to these validity checks will result in an error which must be resolved. To fix the error, follow the prompts that appear in the error message popups.

Consider the following two examples of how to resolve errors for the away from home start and end times:

- *Example 1:* A standard 4-person, four morning showers scenario in which someone is away from home. When a person is selected for being away from home, the model will automatically enter a 10-hour window using 8:00 AM as the start time and 6:00 PM as the end time.

  - If you change the **Away from home start time** from the default of 8:00 AM to 7:00 AM, you will see an error informing you that the away from home start time must occur after the time when all morning bathing activities are complete (see screenshot that follows).

    - In this example, the error occurred because the **Away from home start time** of 7:00 AM is before the **Time when all morning showers/tub baths are complete** in Bathroom #1 (7:13 AM). The error occurs because household members cannot be out of the house before their shower or bath is finished.

o To fix the error, do either of the following:

- Change the time when all morning showers/tub baths are complete in Bathroom #1 to an earlier time. For example, change 7:13 AM to 6:55 AM. With this change, the time when all morning showers/tub baths are complete (6:55 AM) is earlier than the start time when people are away from home (7:00 AM), and the error is resolved.

- Change the away from home start time to a later time. For example, change 7:00 AM to 7:20 AM. With this change, the away from home start time (7:20 AM) is later than the time when all morning showers/tub baths are complete in Bathroom #1 (7:13 AM), and the error is resolved.

o Once corrected, the error message will disappear.

**Activity End Times** ⓘ

| | Bathroom #1 | | | | Bathroom #2 | | |
|---|---|---|---|---|---|---|---|
| Time when all morning showers/tub baths are complete | 7 | : | 13 | AM | | : | AM |
| Time when all evening showers/tub baths are complete | | : | | PM | | : | PM |

**Activity Start Times** ⓘ

| | Bathroom #1 | | | | Bathroom #2 | | |
|---|---|---|---|---|---|---|---|
| Time when all morning showers/tub baths begin | 6 | : | 22 | AM | | : | AM |
| Time when all evening showers/tub baths begin | | : | | PM | | : | PM |

**Home All Day/Away From Home Options**

| | | | | |
|---|---|---|---|---|
| Away from home start time | 7 | : | 00 | AM |
| Away from home end time | 6 | : | 00 | PM |

Compare the away from home start time here with the activity start and end times above. The away from home start time must occur after the time when all morning showers/baths are complete.

| | | |
|---|---|---|
| Person 1 | ○ Home All Day | ◉ Away From Home |
| Person 2 | ◉ Home All Day | ○ Away From Home |
| Person 3 | ◉ Home All Day | ○ Away From Home |
| Person 4 | ◉ Home All Day | ○ Away From Home |

- *Example 2:* A standard 2-person, one morning shower and one evening shower scenario in which someone is away from home.

  o If you change the **Away from home end time** from the default of 6:00 PM to 7:35 PM, you will see an error informing you that the away from home end time must

occur before the time when all evening showers/baths begin (see screenshot below). That is, everyone who is out of the house must return home before evening bathing activities start.

- The only evening activity in this scenario is a 7-minute shower followed by a 5-minute bathroom stay in Bathroom #1. Based on the evening activity end time of 7:43 PM in bathroom #1, the shower begins at 7:31 PM (7:31 PM = 7:43 PM – five minutes in the bathroom – seven minutes in the shower).

- The error occurs because household members cannot be out of the house when their evening bathing activity begins.

o  To fix the error, do either of the following:

- Change the **Time when all evening showers/tub baths are complete** in Bathroom #1 to a later time. For example, change 7:43 PM to 7:50 PM. With this change, the time when activities begin in Bathroom #1 changes to 7:38 PM (7:38 PM = 7:50 PM – five minutes in the bathroom – seven minutes in the shower), which is later than the away from home end time (7:35 PM). Thus, the error is resolved.

- Change the **Away from home end time** to an earlier time. For example, change 7:35 PM to 7:25 PM. With this change, the away from home end time (7:25 PM) is earlier than the time when evening bathing activities begin in Bathroom #1 (7:31 PM), and the error is resolved.

o  Once corrected, the error message will disappear.

**Activity End Times** ⓘ

|  | Bathroom #1 | Bathroom #2 |
|---|---|---|
| Time when all morning showers/tub baths are complete | 7 : 13  AM | :    AM |
| Time when all evening showers/tub baths are complete | 7 : 43  PM | :    PM |

**Activity Start Times** ⓘ

|  | Bathroom #1 | Bathroom #2 |
|---|---|---|
| Time when all morning showers/tub baths begin | 7 : 01  AM | :    AM |
| Time when all evening showers/tub baths begin | 7 : 31  PM | :    PM |

**Home All Day/Away From Home Options**

| Away from home start time | 8 : 00  AM |
|---|---|

Away from home end time | Compare the away from home end time here with the activity start and end times and durations above. The away from home end time must occur before the time when all evening showers/baths begin. | 7 : 35  PM |

| Person 1 | ○ Home All Day | ◉ Away From Home |
|---|---|---|
| Person 2 | ◉ Home All Day | ○ Away From Home |

You can use the **Activity Pattern Visualization Tool** to view a diagram that shows each person's activity pattern based on the current parameter settings selected on the Activity Patterns screen. To open the tool, click the **View Activity Pattern** link in the upper right corner of the screen.



The **Activity Pattern Visualization Tool** uses color blocks to identify the location of each person throughout the day. Hover the mouse over a color block in the tool to open a popup window with the specific start and end times of each activity. Click the "x" in the upper right corner of the tool to close the window. Below is a screenshot showing part of the activity pattern for an 8-person household with each person taking a morning shower or bath in either Bathroom #1 or Bathroom #2, followed by a short bathroom stay before entering the main house.
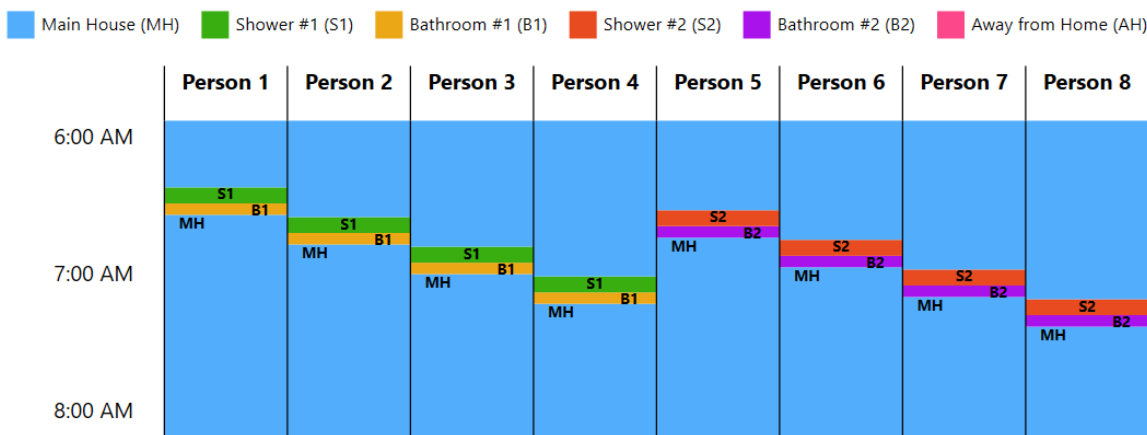


From the Activity Patterns screen, users can:

1) Generate custom scenario results by clicking the **Run Custom Scenario** button in the lower right corner of the screen.

2) Go back to the Appliance Parameters screen by pressing the **Back** button.

3) Reset the parameters on this screen to their default values by pressing the **Reset to Default Values** button.

**Tip:** If you cannot determine how to resolve an error message while implementing a custom activity pattern, click the **Reset to Default Values** button on the Activity Patterns screen to restore the original values and try rebuilding the scenario step by step, checking the View Activity Pattern tool after each modification. If you still cannot determine why an error is triggered in your scenario, contact showermodel@cdc.gov for assistance.

# 4   Model Reports

This section discusses the SHOWER model results screen and provides examples of the results generated by the SHOWER model. It does not provide information on interpreting these results. For further information on interpreting and applying the model results, see the SHOWER model exposure dose guidance document and the SHOWER model instructions for health assessors document (ATSDR 2022b, 2022c). For details regarding the equations underlying the data in the report tables and figures, refer to the SHOWER model technical document (ATSDR 2022a).

## 4.1   Report Screen

The reports generated by the model appear as a scrollable screen in the program. Use the scroll bar located at the right of the program window to scroll through the report.

There are five blue action buttons located at the bottom of the Report screen window:

- **Back:** Takes users back to the program screen from which they ran the simulation.

- **Export Raw Data:** Generates Excel files with raw data for the simulation. Pressing this button will generate eight Excel files for a default simulation run (one for each household scenario) and one Excel file for a custom simulation.

- **Export Word:** Generates a Word file with details about the simulation and the simulation results. The Word file will contain the same content as that shown on the Report screen.

- **Export to PHAST:** Generates a file with simulation information and results that can be imported to PHAST. This file has the extension .showermodelphastexport.

- **Save:** Allows you to choose a location on your computer to save your simulation as a ".showermodel" extension. Saving a simulation will allow you to load the same parameter values into the model for future work.

Each Excel file includes the following tabs:

- **ReadMe:** This tab provides a definition for each field in the workbook.

- **ConcentrationArrays:** This tab lists the air concentration of the contaminant in each compartment at each minute of the day. These data are used to generate Figure 1 in the model report. This tab also shows the target person's location throughout the day, and the air concentration in the compartment where the target person is located at each minute. These data are used to generate Figure 2 in the model report, as well as the average exposure concentration data reported in various report tables. The results are in $\mu g/m^3$ or ppb depending on the units chosen for the model report on the Chemical Information screen.

- **InhalationIntake:** This tab lists the cumulative inhaled mass intake of the contaminant at each minute of the day. The results are in $\mu g$ and can be used to confirm the average daily dose for the target person presented in the model report.

- **ApplianceInfo:** This tab provides summary data on the total amount of water used by each appliance in the household.

- **Scenario:** This tab provides summary information about the scenario represented in the Excel file. Use the information in this tab to differentiate between the eight scenario Excel files generated for the default simulation.

> **Tip:** The Excel and Word files are both created in the temp folder under your user account in Windows. Once the file opens on your computer, you should rename it and save it in a desired location. For reference, the initial file name includes the following information:
>
> - Word File: {Site name}_{D (default) or C (custom)}_{Contaminant name} {Date}.docx
> - Excel File: {Site name}_{D (default) or C (custom)}_{Contaminant name} {Date}.xlsx

## 4.2   Default Scenario Results

To obtain default scenario results, you must first select **Run Default Scenario (recommended)** on the Simulation Type screen and enter a contaminant and a water concentration on the Chemical Information screen. After entering these data, clicking the **Run Default Scenario** button will run the simulation and bring up the default scenario results in an onscreen report. The example text and screenshots in this section show data for tetrachloroethylene at 100 ppb in household water.

The title of the onscreen report is "ATSDR SHOWER Model Report, Default 4-Person Household (With Additional Results for 1-, 2-, and 3-Person Households). The report starts by displaying the user-entered **Site and Model Input Information**, followed by the **Default Scenario Report** section which provides a description of the report contents. The default scenario report provides both RME and CTE results for households with 1, 2, 3, and 4 persons. The RME and CTE results approximate the 95th and 50th percentile exposures, respectively, for the target person in each household.

Although a default simulation includes results for eight households, only one of these (the 4-person household RME scenario) is the default scenario. All other scenarios are provided for additional information only. Results for each scenario are given for the last person who showers (child and adult) because they are the most highly exposed. This person is referred to as the target person.

The **Primary Results: Used to Make Health Determinations** section of the model report presents tabular result data for the default scenario. This section contains two data tables of results.

**Table S1** provides the RME daily exposure concentration for the target person in the default scenario. The default scenario assumes three people take 10-minute consecutive morning showers and the fourth person takes a 15-minute shower, each followed by 5-minute bathroom stays. The fourth person is the target person in the default scenario. The concentrations shown in **Table S1** apply to all age groups including infants (birth to < 1 year) who are exposed from taking baths. Although infants do not shower, their inhalation and dermal exposures from a 20-minute bath scenario are comparable to the RME inhalation and dermal exposures from the default shower scenario.

**Table S1. RME daily exposure concentration in µg/m³ for the target person (person 4) in the 4-person household**

| RME Daily Exposure Concentration |
|---|
| 72 |

Abbreviations: µg/m³ = micrograms chemical per cubic meter air; RME = reasonable maximum exposure

**Table S2** provides the average RME daily administered dermal dose from contact with water for the target person in the default scenario. These doses are based on age-specific factors, such as breathing rate, skin surface area, and body weight, and thus vary with age group.

**Table S2. RME daily administered dermal dose in µg/kg/day for the target person (person 4) in the 4-person household**

| Exposure Group | RME Administered Dermal Dose |
|---|---|
| Birth to < 1 year | 2.5 |
| 1 to < 2 years | 2.3 |
| 2 to < 6 years | 1.9 |
| 6 to < 11 years | 1.6 |
| 11 to < 16 years | 1.3 |
| 16 to < 21 years | 1.2 |
| Adult | 1.2 |
| Pregnant & breastfeeding women | 1.2 |

Abbreviations: µg/kg/day = micrograms chemical per kilograms body weight per day

The **Secondary Results: Optional Supporting Information** section of the model report presents supporting tabular result data for the additional scenarios provided along with the default scenario. These additional scenarios include a CTE scenario for the 4-person household and CTE and RME scenarios for households with 1, 2, and 3 persons. This section contains two data tables of results.

**Table S3** shows the CTE and RME daily air concentrations for the 1-, 2-, 3-, and 4-person household scenarios in the default simulation. The highlighted cell in Table S3 represents the default scenario concentration and is the same as the concentration shown in Table S1.

**Table S3. Daily exposure concentration in μg/m³ in each scenario**

| Scenario Type | 1-Person Household | 2-Person Household | 3-Person Household | 4-Person Household |
|---|---|---|---|---|
| RME | 20 | 39 | 56 | 72 |
| CTE | 8.4 | 17 | 24 | 32 |

Abbreviations: CTE = central tendency exposure; μg/m³ = micrograms chemical per cubic meter air; RME = reasonable maximum exposure

**Table S4** shows the daily administered dermal doses for the CTE and RME 1-, 2-, 3-, and 4-person household scenarios in the default simulation. The highlighted cells in Table S4 represent the default scenario doses and are the same as those shown in Table S2.

**Table S4. Daily administered dermal dose in μg/kg/day in each scenario**

| Exposure Group | RME 1-P | RME 2-P | RME 3-P | RME 4-P | CTE 1-P | CTE 2-P | CTE 3-P | CTE 4-P |
|---|---|---|---|---|---|---|---|---|
| Birth to < 1 year | NC | 2.4 | 2.5 | 2.5 | NC | 1.6 | 1.6 | 1.6 |
| 1 to < 2 years | NC | 2.3 | 2.3 | 2.3 | NC | 1.5 | 1.5 | 1.5 |
| 2 to < 6 years | NC | 1.9 | 1.9 | 1.9 | NC | 1.3 | 1.3 | 1.3 |
| 6 to < 11 years | NC | 1.6 | 1.6 | 1.6 | NC | 1.1 | 1.1 | 1.1 |
| 11 to < 16 years | NC | 1.3 | 1.3 | 1.3 | NC | 0.86 | 0.86 | 0.87 |
| 16 to < 21 years | NC | 1.2 | 1.2 | 1.2 | NC | 0.79 | 0.79 | 0.79 |
| Adult | 1.2 | 1.2 | 1.2 | 1.2 | 0.77 | 0.77 | 0.78 | 0.78 |
| Pregnant & breastfeeding women | 1.2 | 1.2 | 1.2 | 1.2 | 0.78 | 0.78 | 0.78 | 0.78 |

Abbreviations: -P = person; CTE = central tendency exposure; μg/kg/day = micrograms chemical per kilograms body weight per day; NC = not calculated; RME = reasonable maximum exposure

After this table, the default SHOWER model report includes information about custom scenarios and other resources related to the SHOWER model. Topics addressed include:

- **Custom Scenarios**—users can change model parameters by running a custom scenario, which can be useful to answer site-specific questions about community exposure from longer or shorter showers or from taking a bath instead of a shower.

- **Generating Hazard Quotients and Cancer Risk Estimates**—users can export air concentrations and dermal doses from the SHOWER Model to PHAST to calculate hazard quotients and cancer risks. To export SHOWER model scenario results, click the **Export to PHAST** button at the bottom of the Results screen.

- **Additional Resources and Supporting Documents**—users can find more information about the SHOWER Model on the Resources page, which is accessible from the Home

Screen. Most documents mentioned on the SHOWER model Resources page can be obtained through PHAST.

The **Detailed Results for the 4-Person Household** section provides more information about the default RME 4-person scenario beyond what is provided in Tables S1 and S2. This section provides information about

- All four members in a 4-person household (Table 1),

- Inhalation and dermal doses for the target person (Table 2),

- Exposure concentration by location in the house (Table 3), and

- Percent exposure by location in the house (Table 4).

In addition, two figures are provided that show air concentrations in each compartment throughout the day.

**Table 1** shows the RME daily exposure concentration for each person in the 4-person household, including the most highly exposed person (person 4 in the default scenario). The air concentration estimated by the model is independent of who is showering and thus applies to both children and adults.

Table 1. RME daily exposure concentration in µg/m³ for each person in the house

| Person | Target Person | Main Activities | RME Daily Exposure Concentration |
|--------|--------------|-----------------|----------------------------------|
| 1 | — | Showering in Shower #1 at 6:05 a.m. | 23 |
| 2 | — | Showering in Shower #1 at 6:21 a.m. | 34 |
| 3 | — | Showering in Shower #1 at 6:37 a.m. | 44 |
| 4 | X | Showering in Shower #1 at 6:53 a.m. | 72 |

Abbreviations: µg/m³ = micrograms chemical per cubic meter air

**Table 2** presents the dermal doses from contact with water only for the most highly exposed person in this scenario (person 4). **Table 2** also shows the inhaled dose in µg/kg/day, which is derived from the RME daily exposure concentration for the most highly exposed person in **Table 1**.

**Table 2. RME daily inhalation dose in µg/kg/day and administered dermal dose for the target person**

| Exposure Group | Inhalation | Dermal |
|---|---|---|
| Birth to < 1 year | 96 | 2.5 |
| 1 to < 2 years | 103 | 2.3 |
| 2 to < 6 years | 64 | 1.9 |
| 6 to < 11 years | 35 | 1.6 |
| 11 to < 16 years | 23 | 1.3 |
| 16 to < 21 years | 17 | 1.2 |
| Adult | 16 | 1.2 |
| Pregnant & breastfeeding women | 22 | 1.2 |

Abbreviations: µg/kg/day = micrograms chemical per kilograms body weight per day; NC = not calculated

The SHOWER model's default scenario simulates a house that consists of three compartments: a shower stall, the bathroom, and the main house. The next two tables (**Table 3** and **Table 4**) provide exposure information for the time that the target person spends taking a shower, the time they spend in the bathroom afterward, and the time that they spend in the main house throughout the rest of the day. When the target person visits the bathroom during other parts of the day, those bathroom times are included in the main house exposure time. **Table 3** shows the average human exposure concentration that the target person experiences in each location, and **Table 4** shows the percent of exposure that the target person experiences in each location.

**Table 3. Exposure time and average human exposure concentration by location for the target person**

| Location | Exposure Time (min) | Average Human Exposure Concentration (µg/m³) |
|---|---|---|
| Shower | 15 | 4,921 |
| Bathroom after shower | 5 | 600 |
| Main house with additional bathroom visits | 1,420 | 19 |
| Away from house | 0 | 0 |
| Average daily exposure | 1,440 | 72 |
| Main house (all day) | 1,440 | 8.2 |

Abbreviations: µg/m³ = micrograms chemical per cubic meter air; min = minute

Table 4. Exposure time and percent of total exposure by location for the target person

| Location | Exposure Time (min) | Percent Exposure (%) |
|---|---|---|
| Shower | 15 | 71 |
| Bathroom after shower | 5 | 2.9 |
| Main house with additional bathroom visits | 1,420 | 26 |
| Away from house | 0 | 0 |
| Average daily exposure | 1,440 | 100 |
| Main house (all day) | 1,440 | 100 |

Abbreviations: min = minute; % = percent

The **4-Person Household Results—Figures** section provides two figures showing chemical air concentrations within the house. Using a log scale for concentration, **Figure 1** shows the chemical air concentrations in the shower, bathroom, and main house compartments throughout the day for the default scenario.

Figure 1. Calculated air concentrations in the shower, bathroom, and main house compartments for a 4-person household
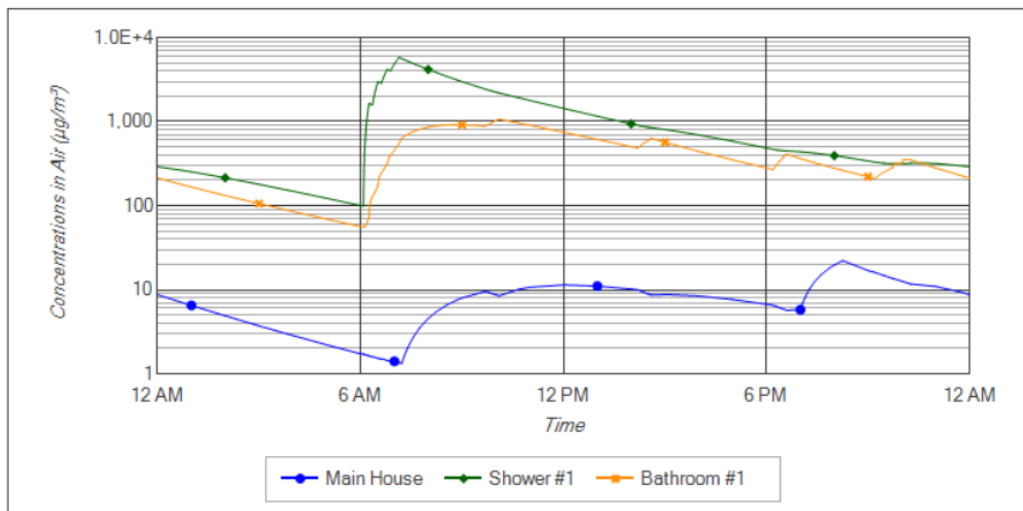


Using a log scale, **Figure 2** shows the contaminant air concentrations for the target person (person 4 in the default scenario) as they move between compartments throughout the day. The contaminant air concentrations shown in **Figure 2** are used to calculate the RME daily exposure concentration and dermal doses for the target person (person 4) shown in **Tables S1** and **S2**. The contaminant air concentrations are also used to calculate the doses and location statistics for the target person shown in **Tables 2, 3,** and **4**.

**Figure 2. Calculated exposure air concentrations in different compartments throughout the day for the target person selected in this scenario (person 4)**
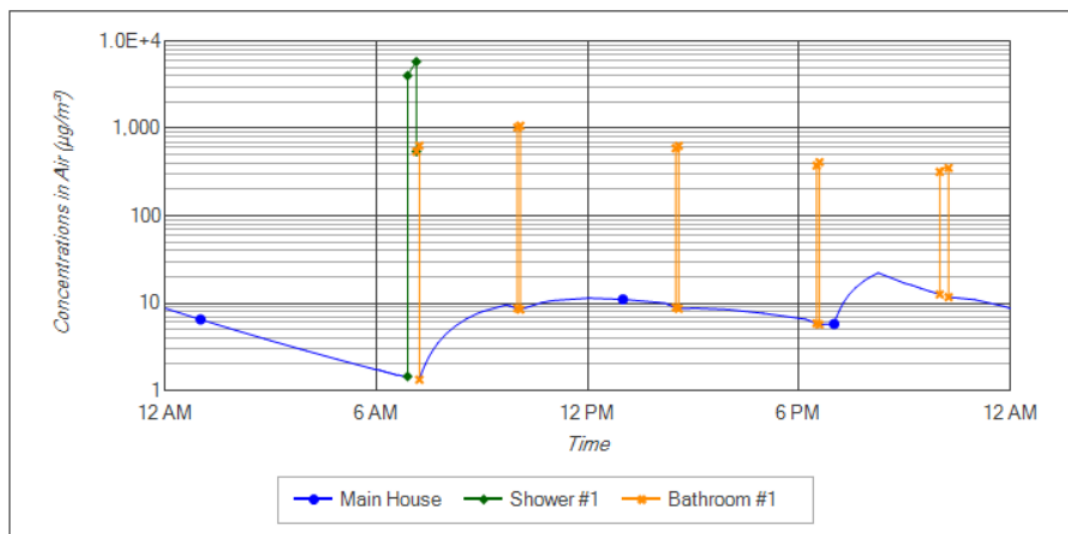


The **Model Parameters** section of the report identifies the default parameter values that were used to run the scenarios. It includes the following:

- **Table 5** presents the chemical properties.

- **Table 6** presents the parameters associated with calculating inhalation and dermal doses for ATSDR's standard exposure groups.

- **Table 7** presents parameters associated with the house layout and size.

- **Table 8** presents the appliance parameters.

- **Table 9** presents the clothes washer and dishwasher use schedule.

- **Table 10** presents the timing and duration of showers and bathroom stays for each person in the household.

- **Table 11** presents several activity parameters not covered in other tables.

## 4.3   Custom Scenario Results

You can perform a custom simulation by clicking on the **Run Custom Scenario** button on the bottom navigation row of the data entry screens. The onscreen report starts by displaying the user-entered **Site and Model Input Information**, followed by the **Scenario Description**. Parameter values in the custom scenario that differ from the default values are highlighted in red. If you select a target person that is not the most highly exposed person, you will also see a message box which provides information on the most highly exposed person in your scenario.

The **Results – Tables** section of the model report presents tabular result data for the scenario. The report contains four data tables of results. The example screenshots in this section show data for a standard 8-person, eight morning showers scenario with tetrachloroethylene at 100 ppb in household water. The scenario also includes an additional exposure group with the parameters that follow; all other parameters were left at the standard values for the 8-person, eight morning showers scenario.

- Exposure group name: Seniors

- Total body surface area: 19,000 cm$^2$

- Hand surface area: 980 cm$^2$

- Body weight: 75.8 kg

- Daily breathing rate: 9.1 L/min

- Shower and bathroom breathing rate: 12 L/min

**Table 1** provides the average daily exposure concentration for each person in the house. It also lists each person's main activities and indicates the target person in the scenario.

**Table 1. Average daily exposure concentration in µg/m³ for each person in the house**

| Person | Target Person | Main Activities | Average Daily Exposure Concentration |
|--------|---------------|-----------------|--------------------------------------|
| 1 | — | Showering in Shower #1 at 6:22 a.m. | 19 |
| 2 | — | Showering in Shower #1 at 6:35 a.m. | 25 |
| 3 | — | Showering in Shower #1 at 6:48 a.m. | 31 |
| 4 | — | Showering in Shower #1 at 7:01 a.m. | 36 |
| 5 | — | Showering in Shower #2 at 6:32 a.m. | 20 |
| 6 | — | Showering in Shower #2 at 6:45 a.m. | 26 |
| 7 | — | Showering in Shower #2 at 6:58 a.m. | 31 |
| 8 | X | Showering in Shower #2 at 7:11 a.m. | 36 |

Abbreviations: µg/m³ = micrograms chemical per cubic meter air

**Table 2** provides the average daily inhalation and dermal doses for the target person. The table lists a value of "NC" for any age group where a dose is not calculated. For example, when the target person takes a shower in a custom scenario, dermal doses are not calculated for the "birth to < 1 year" group because infants do not shower regularly. The inhalation dose reported for the "birth to < 1 year" group is calculated using the main house (all day) average air concentration when the target person takes a shower.

**Table 2. Average daily inhalation dose in µg/kg/day and administered dermal dose for the target person**

| Exposure Group | Inhalation | Dermal |
|---|---|---|
| Birth to < 1 year | 7.1 | NC |
| 1 to < 2 years | 47 | 1.5 |
| 2 to < 6 years | 30 | 1.3 |
| 6 to < 11 years | 17 | 1.1 |
| 11 to < 16 years | 11 | 0.87 |
| 16 to < 21 years | 8.6 | 0.79 |
| Adult | 7.7 | 0.78 |
| Pregnant & breastfeeding women | 11 | 0.78 |
| Seniors | 7.7 | 0.80 |

Abbreviations: µg/kg/day = micrograms chemical per kilograms body weight per day; NC = not calculated

**Table 3** shows the exposure time for the target person's primary bathing activity, the time they spend in the bathroom immediately afterwards, and the time they spend in the house the rest of the day. The table also shows the average exposure concentration associated with their time in these areas. The exposure from bathing and being in the bathroom immediately afterwards can be much higher (but for shorter periods) than the exposure from being in the main house throughout the day. **Table 4** shows these exposures as percentages.

**Table 3. Exposure time and average human exposure concentration by location for the target person**

| Location | Exposure Time (min) | Average Human Exposure Concentration (µg/m³) |
|---|---|---|
| Shower | 7 | 3,392 |
| Bathroom after shower | 5 | 373 |
| Main house with additional bathroom visits | 1,428 | 18 |
| Away from house | 0 | 0 |
| Average daily exposure | 1,440 | 36 |
| Main house (all day) | 1,440 | 10 |

Abbreviations: µg/m³ = micrograms chemical per cubic meter air; min = minute

**Table 4. Exposure time and percent of total exposure by location for the target person**

| Location | Exposure Time (min) | Percent Exposure (%) |
|---|---|---|
| Shower | 7 | 46 |
| Bathroom after shower | 5 | 3.6 |
| Main house with additional bathroom visits | 1,428 | 51 |
| Away from house | 0 | 0 |
| Average daily exposure | 1,440 | 100 |
| Main house (all day) | 1,440 | 100 |

Abbreviations: min = minute; % = percent

The **Results – Figures** section contains figures showing minute-by-minute concentration data from the scenario. This section contains two figures in the custom report.

**Figure 1** shows the chemical air concentrations in the shower, bathroom, and main house compartments throughout the day. The example shown below is for an 8-person household with two bathrooms.

Figure 1. Calculated air concentrations in the shower, bathroom, and main house compartments for a 8-person household
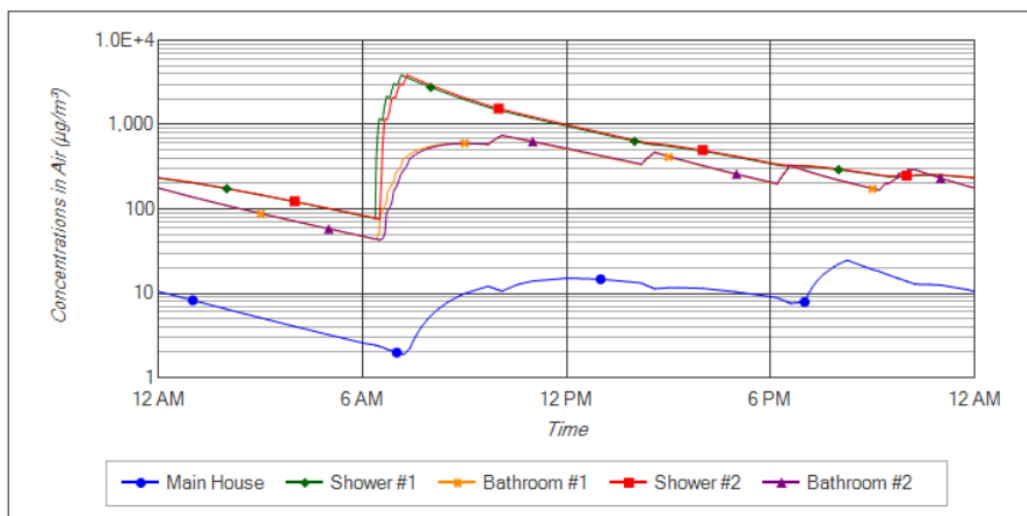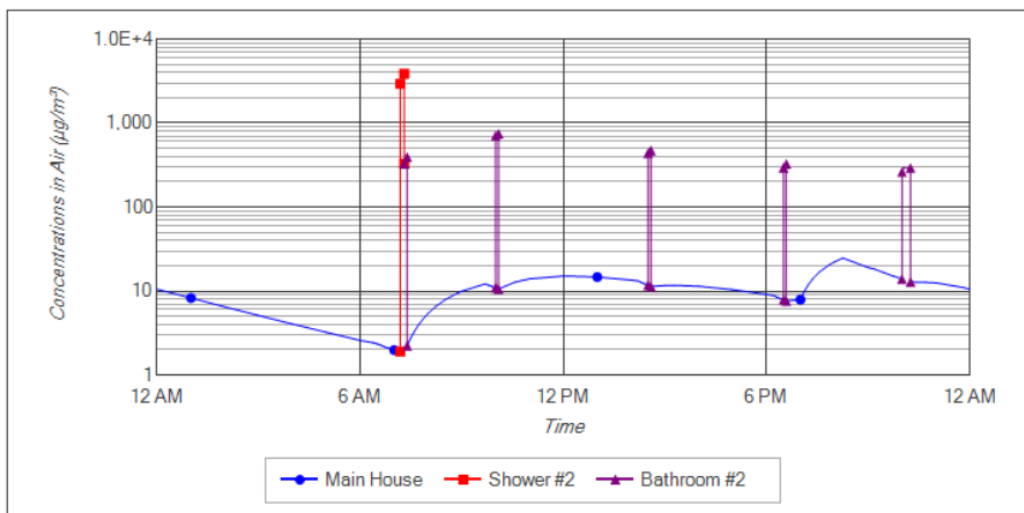


**Figure 2** shows the chemical air concentrations that the target person is exposed to as they move between compartments throughout the day.

**Figure 2. Calculated exposure air concentrations in different compartments throughout the day for the target person selected in this scenario (person 8)**



The **Model Parameters** section of the report contains the parameters with either default or user-specified values that were used to run the scenarios. It includes the following:

- **Table 5** presents the chemical properties.

- **Table 6** presents the parameters associated with calculating inhalation and dermal doses for ATSDR's standard exposure groups and any custom exposure groups included in the scenario.

- **Table 7** presents parameters associated with the house layout and size.

- **Table 8** presents the appliance parameters.

- **Table 9** presents the clothes washer and dishwasher use schedule.

- **Table 10** presents the timing and duration of showers/tub baths and bathroom stays for each person in the household.

- **Table 11** presents several activity parameters not covered in the other tables.

- **Table 12** presents the human activity pattern for each person in the scenario. The report will include a separate sub-table (labeled a through h) for each person in the scenario if your custom scenario has more than one person.

- **Figure 3** presents a chart showing the human activity patterns throughout the day.

# 5 References

[ATSDR] Agency for Toxic Substances and Disease Registry. 2022a. Technical Document for the Shower and Household Water-use Exposure (SHOWER) Model v3.0. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2022b. Exposure Dose Guidance for the Shower and Household Water-use Exposure (SHOWER) Model. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2022c. Instructions for Health Assessors Using the ATSDR SHOWER Model in Public Health Documents. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.