Field_SWAT User Manual

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1.0 Acknowledgements

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2.0 Background

The soil and water assessment tool (SWAT) hydrological/water quality model was initially developed as a river basin scale model. However, it has been recently used for simulating field scale runoff (Anand et al., 2007), sediment, and nutrient (Gollamudi et al., 2007) loss. While these studies have used the hydrological response unit (HRU) output from the SWAT model, it is important to note that the spatial scale of HRUs does not necessarily align with field boundaries.

SWAT modelers and conservation personnel could benefit from a tool that allows them to visualize the SWAT model outputs at a “real world” scale such as the field boundaries. Therefore, an automated method was developed to consolidate annual runoff or sediment loading responses from HRUs that are encompassed within individual field boundaries. Interested users are encouraged to refer Pai et al. (2011) to get in-depth understanding of the Field_SWAT method.

Further, the method was incorporated in a desktop-based, graphical user interface tool, Field_SWAT. The purpose of Field_SWAT tool is to provide a user-friendly interface so that users can easily map their existing SWAT outputs to field boundaries. This user manual was developed to familiarize users with the installation, setup, and working of the Field_SWAT tool. The user manual is organized as follows:

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3.0 Tool Installation

The 32-bit version of the Field_SWAT tool is compatible with Windows operating system and does not require any specialized software except the MATLAB component runtime (MCR) libraries. The MCR is a standalone set of shared libraries that enables the execution of MATLAB files on computers without an installed version of MATLAB.

To support processing data for watersheds with large number of HRUs (approximately 800 or more) or perform regional scale analysis, an encrypted version of the code for use on 64-bit computer has also been provided at the above-referred link. However, MATLAB software will need to be installed first on the computer in order to run the 64-bit encrypted version of Field_SWAT tool.

3.1 MCR Installation

In addition to the hardware requirements, MCR libraries should be installed before Field_SWAT is downloaded on for running in stand-alone mode. The MCR libraries will enable the execution of MATLAB files on your computer without an installed version of MATLAB. The MCR libraries are available for download on Downloads page of the Field_SWAT website. Note that this is a one-time install only. Future updates of Field_SWAT will not require re-installation of MCR libraries.

To install the MCR libraries on a Windows operating system 32-bit computer, the user can click the Downloads page (1) and then click MCR_Library.exe hyperlink (2) as shown below.
A dialog box will appear asking the user to run, save, or cancel file download. This can vary depending on the browser settings. The file can be saved (1) at any location on your computer. It is recommended that you save all the files from the Field_SWAT website in a single folder (for e.g. C:\Field_SWAT).

Start installation by double-clicking on the installer icon, MCRInstaller.exe

The setup process will ask for your choice of language. Under most circumstances, choose the default English (United States) and click OK.
The InstallShield Wizard window will start extracting necessary libraries and ask user input in the next few windows.

After the extraction is complete, the following window will appear. Click Next on this window.
Enter User Name and Organization on the next window. You can enter any User Name and Organization.

The Destination Folder window will open. Keep the default and click Next.
The MCR libraries are now ready to be installed. Click on the Install button.

The installation time will vary depending on the configuration of your computer. Typically it takes 3-5 minutes.
Once the installation is complete, the following window will appear. Click Finish.

You have now successfully installed the MCR libraries on your computer!
3.2 Field_SWAT 32-bit Installation

After installing MCR libraries, the user can download the Field_SWAT tool. Once again, go to the Downloads page (1) on the Field_SWAT website and click the Field_SWAT.zip hyperlink (2) as shown below.

A dialog box will appear asking the user to run, save, or cancel the file download. This can vary depending on your browser setting. The file can be saved (1) at any location on your computer. However, it is recommended that you save all files downloaded from the Field_SWAT website in a single folder (for e.g. C:\Field_SWAT).

After clicking the Save button, the tool downloads as a .zip file, Field_SWAT.zip.
Right click on the Field_SWAT.zip icon and extract the contents (1).

After the extraction is complete, a folder titled Field_SWAT will be created containing the package, Field_SWAT_pkg.exe. Double-click on this executable file to begin the installation of Field_SWAT.

The following window will appear during the installation process.
After the installation is complete, the folder will contain an additional sub-folder titled `doc`, and University of Arkansas logo. The `doc` folder and logo should always be kept in the same folder as the Field_SWAT tool. Double-click the executable, `Field_SWAT.exe (1)`, to start the tool.

A blank window will appear for about 3 minutes (or more, depending on the configuration of your computer) while background processes are executed. A similar blank window will also appear during each time the tool is started; however, subsequent startup time will be shorter than the first time the tool is started.

Note: Field_SWAT tool can take about 3 minutes or more to start up.
Once the background processes are complete, Field_SWAT interface will appear. This indicates that the Field_SWAT tool has been installed successfully.
3.3 Field_SWAT 64-bit Installation

For large watersheds, the 32-bit standalone tool may be insufficient due to memory restrictions. Hence, a 64-bit version of the tool is also available for download on the website.

A stand-alone version of this tool for 64-bit computers is currently unavailable. Therefore, **MATLAB must be installed on your computer before the 64-bit tool is downloaded and used.**

To download and use the 64-bit version of Field_SWAT tool within the MATLAB environment, go to the Downloads page (1) of the Field_SWAT website and click the Field_SWAT_encrypted.zip hyperlink (2) as shown below.
A dialog box will appear asking the user to run, save, or cancel the file download. The file can be saved at any location on your computer. It is recommended that all the files be downloaded from the Field_SWAT website in a single folder (for e.g. C:\Field_SWAT).

The tool downloads as a .zip file titled Field_SWAT_encrypted.zip.

Right click on the Field_SWAT_encrypted.zip icon and extract the contents.
After the extraction is complete, a folder titled Field_SWAT will be created containing the three sub-folders (doc, gdal, and utils) and the main program (Field_SWAT.p).

Start MATLAB on your computer. One of the ways to do this is by clicking Start (1) on the Windows taskbar and click Run (2). In the Run window, type the word MATLAB (3) and the click OK (4).
Once MATLAB starts, navigate to the folder where the tool was downloaded. You should see all the sub-folders and the Field_SWAT.p code on the left Current Directory window (1). Next, type Field_SWAT on the Command Window (2) and press Enter.

Field_SWAT interface will appear which indicates that the tool is ready to be used. Quick steps for using this tool are discussed in section 5.0. However, please ensure that all input datasets are prepared as outlined in section 4.0.
4.0 Input Data Preparation

Field_SWAT tool has been developed to enable users to visualize the annual-scale runoff and sediment HRU outputs of the SWAT model at the field-scale. While the interface is user-friendly and modular, you can ensure smooth running of the tool by following these best practices closely. The two inputs required for the Field_SWAT tool are a SWAT model and field boundary shapefile.

Develop the SWAT model using ArcSWAT. Calibration and validation are not essential for using the Field_SWAT tool but are recommended. Before running the Field_SWAT tool, ensure that the the SWAT model is simulated at least once an annual scale (1) with HRU outputs turned on (2) using ArcSWAT as shown below.

Once the simulation is complete, click on the SWAT Simulation button on ArcSWAT toolbar (1), select the Read SWAT Output option (2). This opens the SWAT Output dialog box. Select the output.hru radio button (3) and then, click on the Import Files to Database button (4). The output will be saved by ArcSWAT in a Microsoft Access database file titled SWATOutput.mdb in the Scenarios\Default\TablesOut folder of the SWAT project.
The Field_SWAT tool also requires a geo-referenced polygon shapefile to map the HRU outputs. There are several ways to do this.
1. Use GPS coordinates of the field(s) and export it into GIS software.
2. Using aerial imagery as basemap, manually delineate the fields in any GIS software.

### 4.1 Example Dataset

An example dataset has been provided on the Field_SWAT website to familiarize the user with the input dataset requirements and to perform a trial run of the tool. To download the example dataset, go to the Downloads page (1) on the Field_SWAT website and click the Example_Dataset.zip hyperlink (2).
A dialog box will appear asking the user to run, save, or cancel the File Download. This may vary based on your browser settings. The file can be saved (1) at any location on your computer. It is recommended that you save all files downloaded from the Field_SWAT website in a single folder (for e.g. C:\Field_SWAT).
The file downloads as a .zip file titled Example_Dataset.zip.

Right click on the Example_Dataset.zip icon and extract the contents (1).
After the extraction is complete, a folder titled Example_Dataset will be created containing the two sub-folders (Field and SWAT_Project) containing the input files required for operating the Field_SWAT tool.

The SWAT_Project folder contains a SWAT model developed for a test watershed. The Field folder contains a geo-referenced shapefile of few field boundaries in the test watershed. In combination with the steps outlined in section 5.0, these datasets can be used to understand the working of the tool.
5.0 Quick Steps for Field_SWAT

This section provides quick steps to use the Field_SWAT tool. The Field_SWAT user interface was designed so that it would be used in a stepwise manner and hence, the elements in the interface (i.e. pushbutton, radio button, etc.) will activate sequentially only when previous steps are completed. For instance, the browse button for the SWAT Project Folder (2) will activate only when the previous Field_SWAT Folder (1) is identified.

Elements in the user interface have been grouped under three panels: Input Data, Status, and Display. Before running the tool, make sure that the input data conforms to the requirements mentioned in section 4.0 of this manual. Stepwise instructions for running the tool are explained below and illustrated in screen-capture above.

1) **Field_SWAT Folder**: Use the browse button to select an empty folder.
2) **SWAT Project Folder**: Use the browse button to select the SWAT project folder. Note that the tool is expecting subfolders such as Watershed and Scenarios to be present within this folder. A sample SWAT model folder has been included in the Example Dataset folder that can be downloaded from the Downloads page on the Field_SWAT website.

3) **Field layer file**: Use the browse button to select a polygon shapefile containing the boundaries of the fields within the watershed.

4) **Output**: Select either Runoff or Sediment in the list box

5) **Aggregation Method**: Use the radio button to select an aggregation method.

6) **Run Field_SWAT**: Click Run Field_SWAT button to start the mapping process. The tool will run through several background processes, which are listed in the Status panel. The tool will also ask the user to interactively select the annual SWAT output database (SWATOutput.mdb). If the database has output for multiple years output, a list box will appear to select a particular year. Once the process is complete, the field and HRU outputs are shown in the Display panel.

7) **Export Field Output (.shp)**: Users will typically want to export the results in the form of shapefile to perform further analysis in a GIS environment. Click Export Field Output to create a shapefile of the field output. The shapefile will be automatically saved in the Output folder of the Field_SWAT folder selected in step 1.
6.0 Frequently Asked Questions (FAQs)

1. Why was Field_SWAT developed in MATLAB?

MATLAB has a set of toolboxes that allows efficient processing of large geospatial datasets. It allows development of stand-alone tools that do not require the user to own proprietary software. Since we frequently use MATLAB in our research projects, it is easier to convert new ideas into usable products.

2. Do I need to develop a SWAT model separately?

Yes. Field_SWAT is a post-processing tool that uses some of the files developed by ArcSWAT. We recommend that you develop the model in ArcSWAT until it writes all the files to TxtInOut folder. Calibration/validation of the model is not required.

3. I get an error that the computer has run out of memory

Field_SWAT is a computationally intensive tool. For large watersheds, a 32-bit computer could run out of memory. In such cases, run the tool on a 64-bit computer with MATLAB software installed on it, using the source code available on the Downloads page of the Field_SWAT website.

4. How do I create a field layer layer for Field_SWAT?

Field_SWAT has stringent requirements for the land-use layers. Details have been provided in the section 3 of the user-manual. In general, ensure that:

- Extent and pixel resolution of land-use layers is exactly same as HRU raster (found in Watershed\grid folder of SWAT project).
- No new land uses are included that were not there in original land-use layer used for HRU delineation.

5. When I run the tool, I get the error "??? Undefined function or variable 'Field_SWAT'"?

This could be because MATLAB is unable to locate the MCR library installation correctly. The solution is to set two environment variables manually as follows:

- **Variable name:** Path
  - **Variable value:** C:\Program Files\MATLAB\MATLAB Compiler Runtime\v78\runtime\win32

- **Variable name:** MCR_CACHE_ROOT
  - **Variable value:** %USERPROFILE%\Local Settings\Temp
To view or add environment variables:

a) Right-click **My Computer**, and then click **Properties**.
   - Click the **Advanced** tab.
   - Click **Environment variables**.
   - Click the following options for user variable:

1. Delete existing variables with similar Variable name.
2. Click New (1) to add a new Variable name and value.
3. Copy and paste the Variable name (2) and value (3) from above and click OK (4).
4. Repeat the same process for the other variable (5, 6, 7, and 8)
7.0 Relevant References

