User Guide of SPIN toolbox

The present guideline is an overview of the SPIN toolbox. It describes all the installation processes and the application of each tool in the toolbox.

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1.1 Overview
The SPIN toolbox allows users to estimate the risk of erosion along a stream network by calculating stream power. Stream power is the amount of energy of flowing water to move sediments. The amount of flowing water in streams changes when a watershed undergoes changes in runoff as a result of urbanization, thus changing the stream power. As such, two types of scenario of development can be run using the tool. The first scenario allows users to estimate stream power for streams in a rural area (i.e. impervious area = 0). The second scenario allows users to estimate stream power for streams in an urbanized area (i.e. impervious area > 0). An index can be calculated to estimate the magnitude of change in stream power between any two different scenarios. The scenarios are run using a Digital Elevation Model (DEM) approach. A DEM allows extraction of stream networks through drainage area characterization. Only a DEM is required to run the first type of scenario. Land use data or a HECRAS model is required in addition to the DEM to run the second type of scenario.

1.2 Partnership
The SPIN toolbox has been developed within the University of Waterloo, Canada as part of a watershed management project for consulting partners: City of Toronto, Toronto Region Conservation and Authority (TRCA), Matrix Solutions Inc. and Western University.

1.3 Installation
To ensure an operational functioning, SPIN toolbox has been developed for ArcGIS 10.3.x. All the tools are directly operational because they utilize the Python library of ArcGIS: Arcpy. This library is built into ArcGIS. The toolbox contains python files that are linked to different tools of the toolbox (Figure 1). The file that enables ArcGIS to connect to the toolbox and its contents is called “SPIN (Stream Power Index for Networks)“.

In ArcToolbox manager, right click on “ArcToolbox” and choose “SPIN (Stream Power Index for Networks)“. The SPIN toolbox will appear in the ArcToolbox and its tools will become functional.

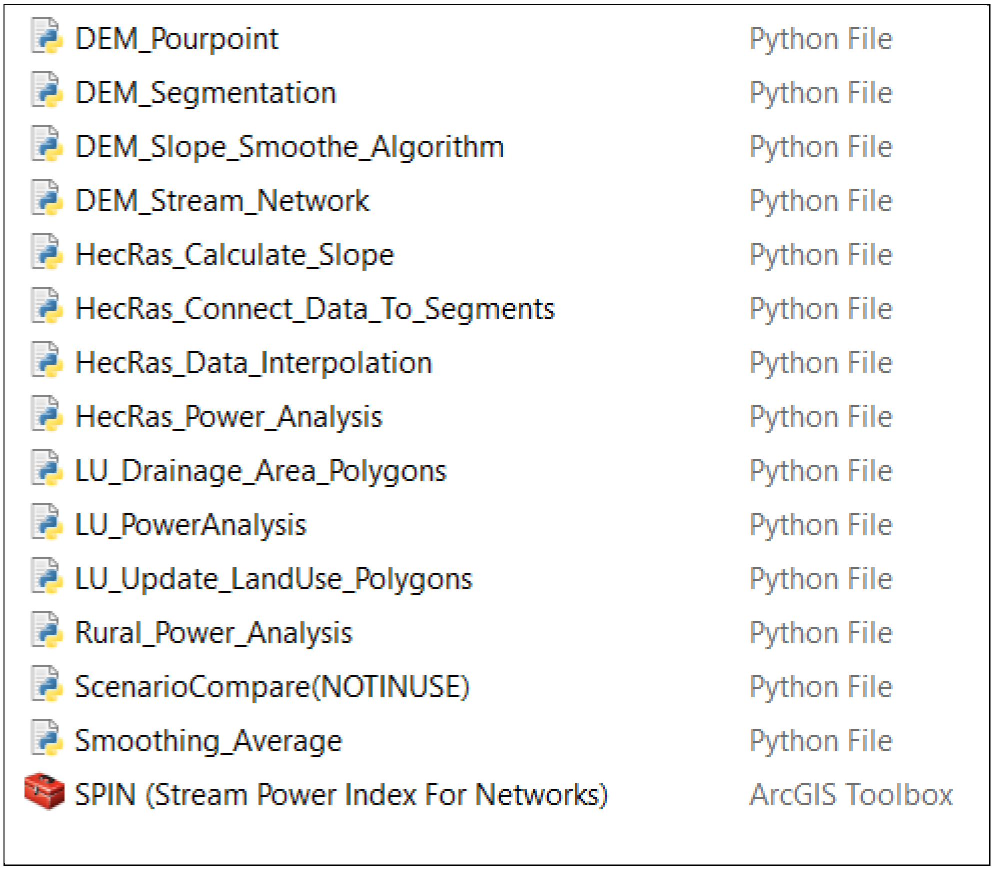

Figure 1. Contents of the package.

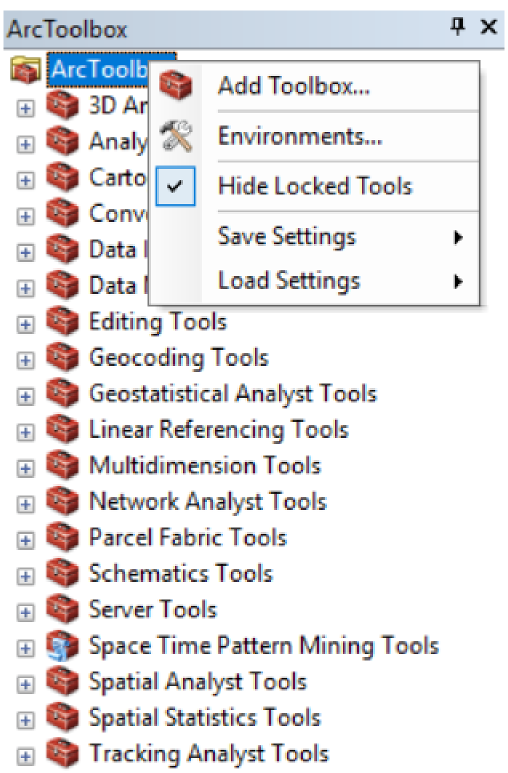

Figure 2: Add a new toolbox in ArcToolbox

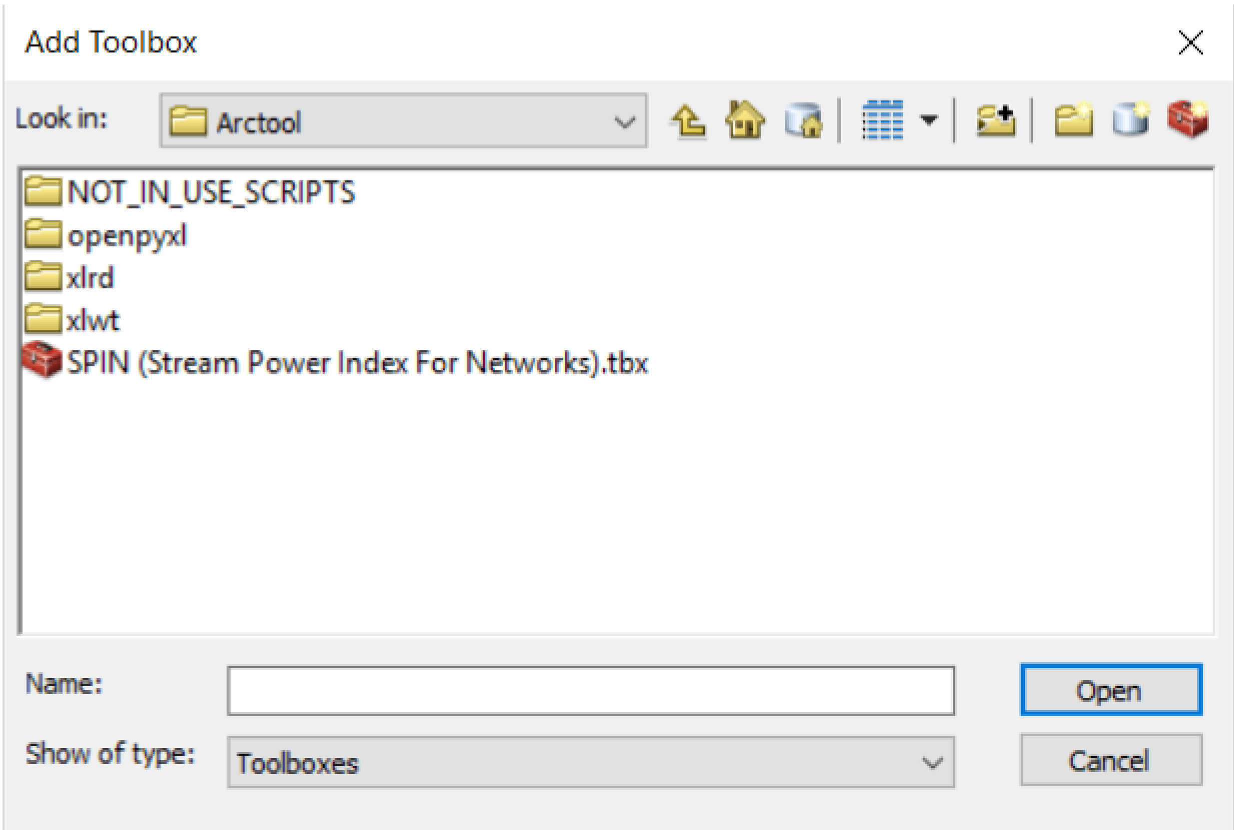

Figure 3: Choice of the SPIN toolbox.

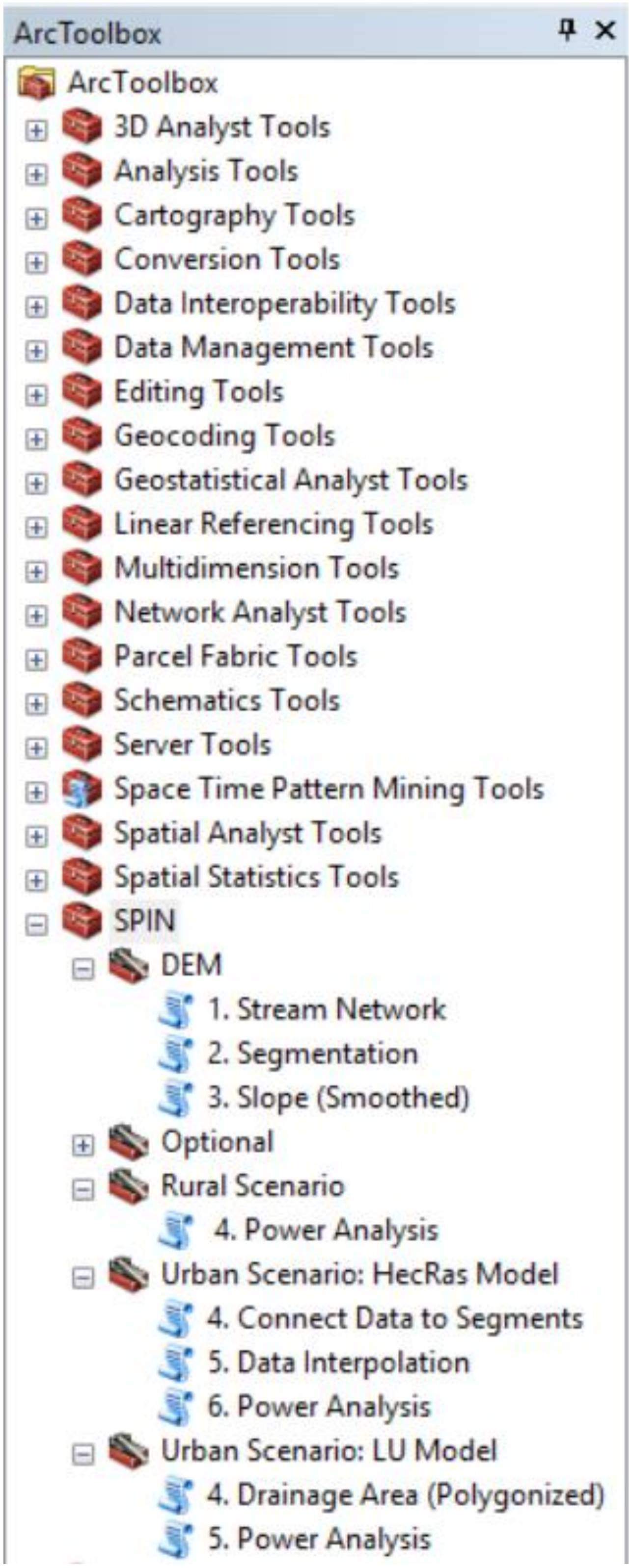

Figure 4: SPIN toolbox available for use in ArcToolbox.

1.4 Toolbox Structure

The toolbox contains tools which perform specialized analyses (Figure 4). The specialized analyses are classified as general analyses and scenario analyses (rural scenario and urban scenario) (Table 1). General analyses must be executed before scenario analyses in the sequence in which they are numbered in the toolbox and in this report. The workflow requires both intermediate and final results to be used in subsequent tools. The general analyses and the rural scenario analyses require a hydrologically enforced raster Digital Elevation Model (eDEM) as input. The urban scenario analyses require a vector shapefile containing land parcels representing land use type and their associated imperviousness (%) or a HecRas model (.csv) and a point shapefile containing the river stations found in the model (.csv).

Table 1: Descriptive list of tools in the SPIN Toolbox

Analysis	**Tools**	**Description**	**Input from User**
General (DEM)	1. Stream Network	Streams are extracted from an enforced DEM (eDEM).	DEM
	2. Segmentation	Streams are split into smaller segments by using the center of the superimposed DEM cells	
	3. Slope	Slope is calculated using the start and end nodes of each segment and then, averaged over a distance window of 500m	
Scenario: Rural	4. Power Analysis	Rural discharge, width, total and specific stream power and D84 particle size are calculated for each segment. Stream power gradient is also available as an optional analysis.	
Scenario: Urban - LU	4. Drainage Area (Polygonized)	Polygons representing the drainage basin for each segment are created for use in the Power Analysis.	Land Use Polygons (.shp)
	5. Power Analysis	Urban discharge, width, total and specific stream power are calculated for each segment. Stream power gradient is also available as an optional analysis.	
Scenario: Urban - HecRas	4. Connect Data to Segments	HecRas Data (.csv) is transformed and connected to the River Stations (.shp). The river stations are joined to the closest stream segments.	HecRas Data (.csv) and their corresponding River Stations as points (.shp)
	5. Data Interpolation	Hecras data are interpolated from one river station to the other river station downstream along the stream network.	
	6. Power Analysis	Total and specific stream power are calculated for each segment. Stream	

		power gradient is also available as an optional analysis.	

1.4.1 Use of tools

The dialog box of the tools is similar to ArcGIS tools. Each tool has a general description of the analysis (Figure 5) and specific descriptions of each parameter when selected (Figure 6). Each tool requires a set of specifc parameters. They can be vector, raster, Boolean, strings and integers (Figure 7). During processing, a processing window is shown and messages will appear about the state of the process (Figure 8). Scripts can be modified only with given knowledge of Python and ArcPY. To modify the code, open the script (.py) (Figure 1) of the related tool using an IDE (Integrated Development Environment) such as IDLE, Sublime Text or Spyder or right click on the related tool and choose “Modify”.

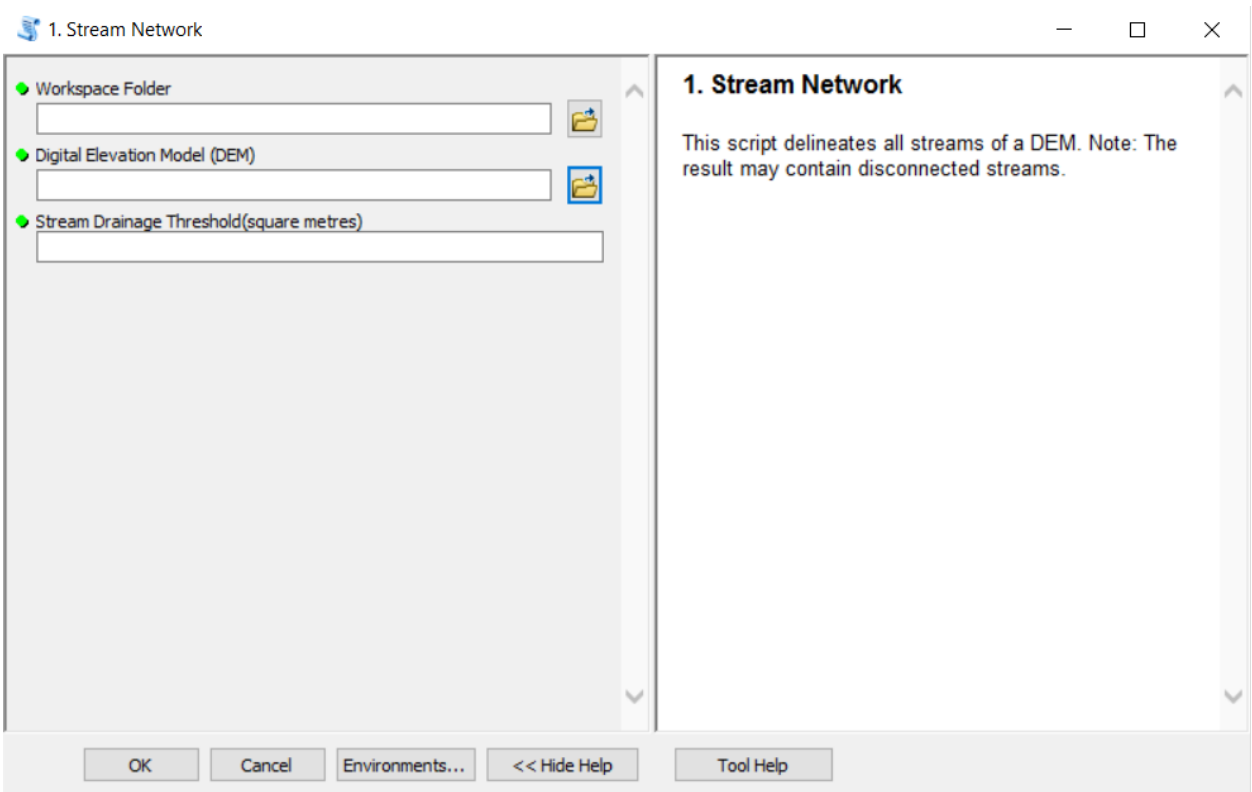

Figure 5: General description of Stream Network tool.

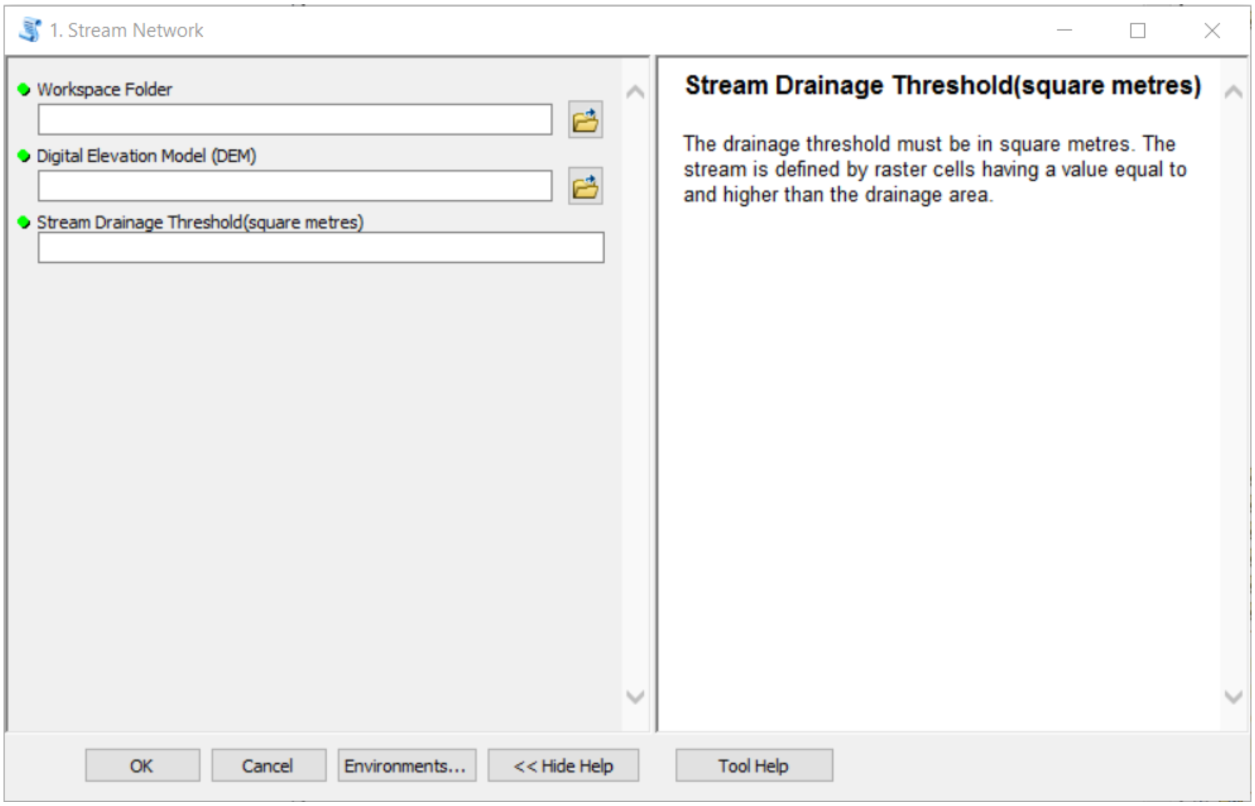

Figure 6: Specific description of the parameter “Stream Drainage Threshold”.

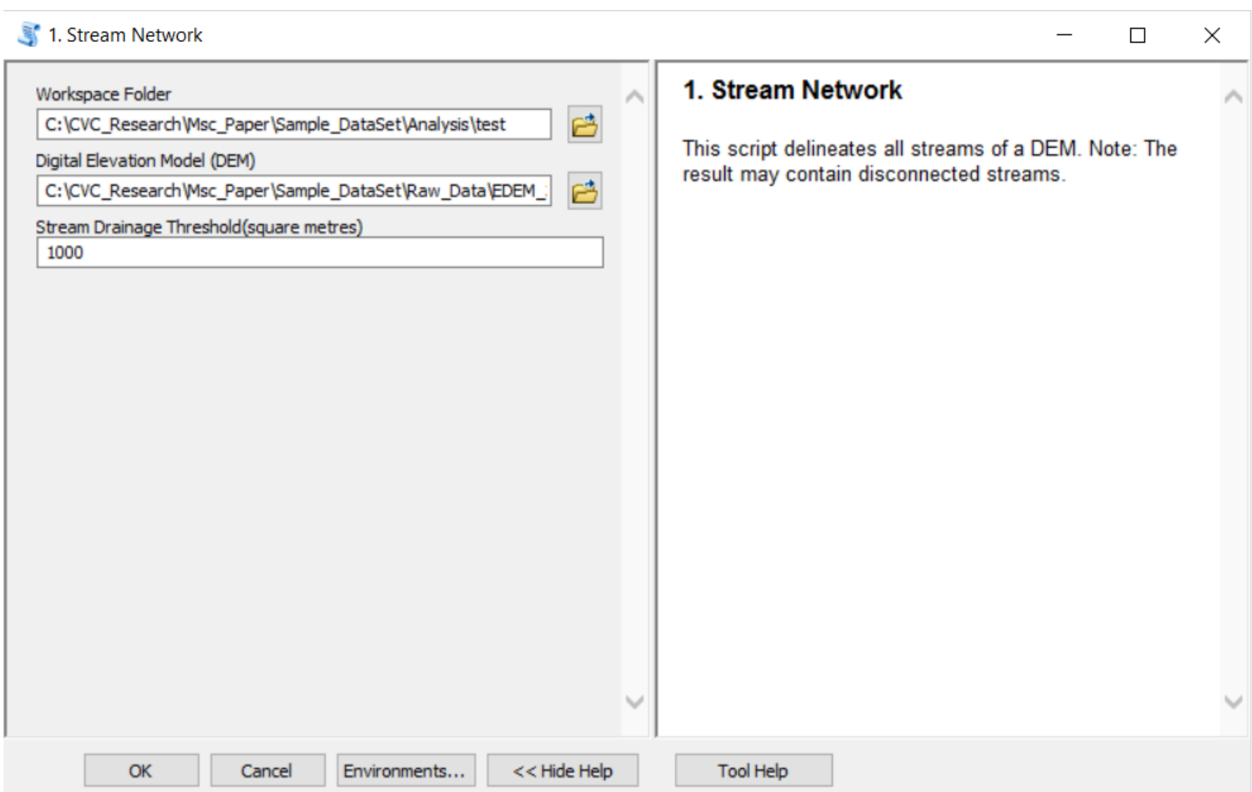

Figure 7: Parameters entered in the tool.

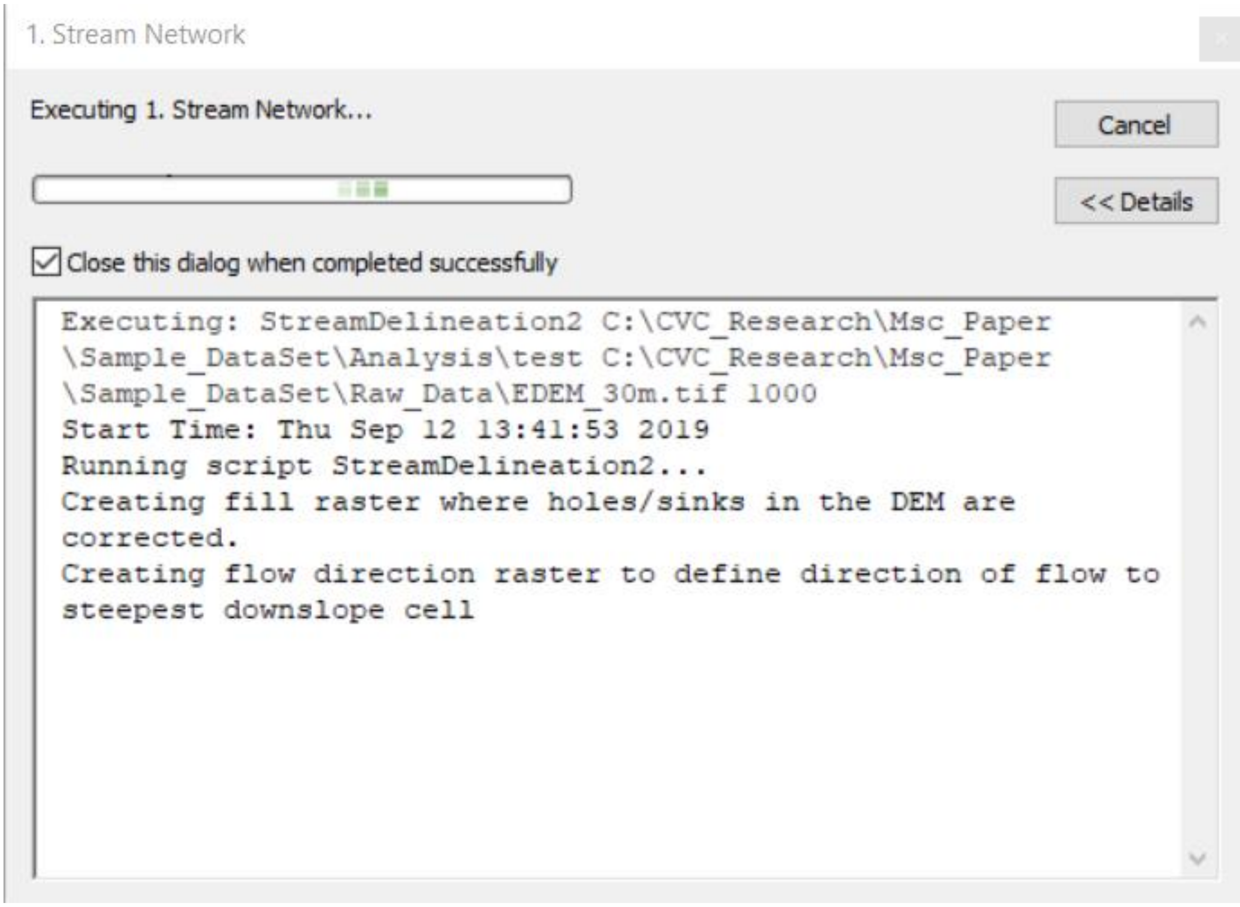

Figure 8: Dialog box during processing.

1.5 Sample Dataset

A test database is provided in the package to demonstrate the application of the tool (Table 2). The format of the input data and their attribute tables as required by the tools must be in the same format as the format of the test dataset provided. The input data is found in the folder “Raw_Data” and the results are classified according to their tools in the folder “Analysis”.

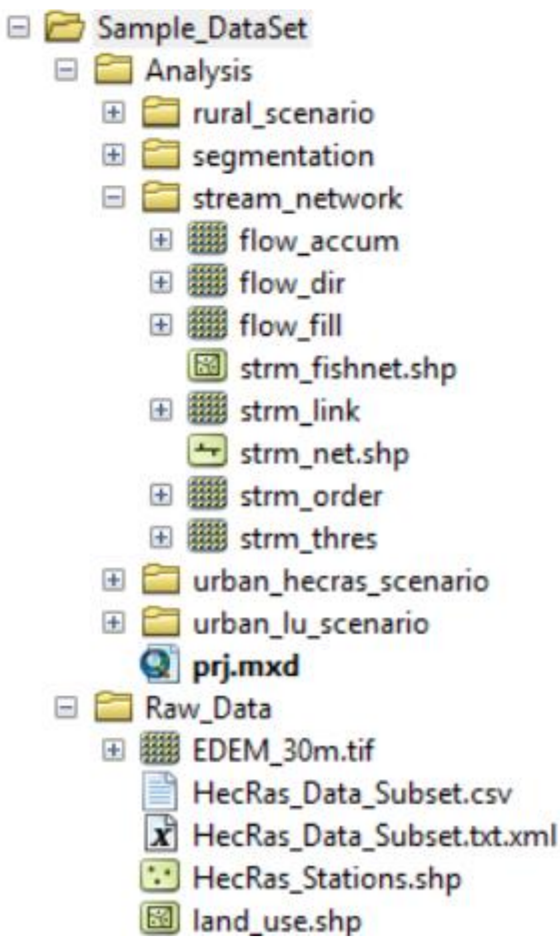

Figure 9. Sample dataset and its content.

Table 2: Required input and all results of each tool.

	Tool	**Input**	**Output**	
			Intermediate	Final
EDEM	Stream Network	1. folder Name 2. EDEM (.tif) 3. drainage threshold (integer)	1. flow_accum 2. flow_dir 3. flow_fill 4. strm_fishnet.shp 5. strm_link 6. strm_order 7. strm_thres	1. strm_net.shp
	Segmentation	1. folder name 2. flow_fill 3. strm_thres 4. flow_accum 5. strm_net.shp	1. segments.shp 2. strmthrespts.shp 3. segments 4. strmthrespts	1. final_segments

	Slope (Smoothed)	1. final_segments		New fields: 1. S_mperm 2. S_mperm_SAVG
Rural	Power Analysis	1. folder name 2. final_segments 3. strmthrespts 4. gradient (optional)		1. R_pow
Urban Scenario (LU)	Drainage Area	1. folder name 2. strmthrespts 3. strm_thres 4. flow_dir	1. dashp folder 2. pointshp folder 3. pointscopy.shp	1. final_da
	Power Analysis	1. folder name 2. strmthrespts 3. final_da 4. landuse 5. final_segments 6. gradient(optional)	1. dischda_lu 2. final_da 3. land_use 4. strm_ptcopy 5. sumimper_da	1. LU_Pow
Urban Scenario (HecRas)	Connect Data to Segments	1. folder name 2. HecRas River Station.shp 3. HecRas Data (.csv) 4. final_segments	1. hec_2points_connected 2. hec_2points_connected_c 3. hec_data_formatted 4. HecRas_Stations	1. hecras_data_connected
	Data Interpolation	1. hecras_data_connected 2. field "OBJECTID" 3. fields for interpolation (e.g. Q_Channel_m3pers_2yr_Fut) 4. field "SHAPE_LENGTH"		New field with prefix "INTP_" 1. INTP_Q_Channel_m3pers_2yr_Fut (example)
	Power Analysis	1. hecras_data_connected 2. field for smoothed slope (e.g. "S_mperm_SAVG") 3. field for interpolated discharge (e.g. "INTP_Q_Channel_m3pers_2yr_Fut") 4. field for width (e.g. "Width_m")		New fields with postfix: 1. Power_Wperm_2yr 2. SPower_Wperm2_2yr

		5. Postfix (e.g. for a flood event of 2 yr can be "_2yr")		