**BOARD OF WATER AND SOIL RESOURCES**

# Prioritize, Target, Measure Application (PTMApp)

Desktop ArcGIS Pro Toolbar User's Guide

03/2021

**Project Partners**

# Contents

# 2 Introduction

## 2.1 Overview

This document provides instructions for the setup and use of the **PTMApp Desktop Toolbar**. The documentation assumes the user understands Environmental Systems Research Institute's (ESRI) ArcGIS tools and data structure. ArcGIS Information can be found under the Help menu in the ArcMap or ArcGIS Pro interface. Currently PTMApp–Desktop is supported for versions 10.5.x, 10.6.x, and ArcGIS Pro 2.5.

The **PTMApp-Desktop Toolbar** is a collection of many modules developed for the PTMApp project to create a suite of Geographic Information System (GIS) products. PTMApp outputs include hydrology, water quality, nonpoint source (rural) Best Management Practice, and cost GIS products. The toolbar is organized into a series of modules which create a set of GIS products used in subsequent modules. The toolbar is distributed with base GIS data which can be clipped to your specific planning boundary. The products developed using the PTMApp toolbar are intended to be included in One Watershed - One Plan documents. The products are also useful for completing source assessment, developing implementation plans, and assessing the ability to achieve various load reductions for sediment, nitrogen, and phosphorus.

## 2.2 General Information

The **PTMApp-Desktop Toolbar** is a custom add-in for the ESRI ArcGIS. The toolbar enables features and functionality not present in the standard out-of-the-box tools provided by ESRI ArcGIS Desktop. If you are processing data for a larger area (HUC 10 watershed or larger), plan to maintain at least 100 GB of available space within your processing and scratch workspace.

This application can be used at watershed scales approaching an 8-digit HUC. However, the user should be prepared for long processing times, which can exceed 30 days.

# 3 Input Data Requirements

The **PTMApp Desktop Toolbar** requires several input data layers (Table 1). It is important to note that the quality of the output data products developed by PTMApp-Desktop is wholly dependent upon the quality of the inputs. ***Without these inputs you will not be able to run PTMApp-Desktop.*** Make sure that all the input raster data layers are snapped and have the same resolution and projection.

Choice of cell size for each raster (e.g., 3m or 10m) is dependent upon project goals and the resolution of available input data. PTMApp-Desktop processing time greatly increases as raster size increases. Thus, PTMApp processes will take significantly more time (on the order of days) when raster resolution and size increases. When determining the raster cell size to resolve PTMApp-Desktop products in, thought should be given to the processing power available along with project goals and input data resolution.

Default values for inputs and parameters are included within PTMApp-Desktop, generally based on literature values. However, these values should be reviewed and modified by the user to ensure they reflect local or desired values.

Table 1 Required Input Data

| | Dataset | PTMApp Name | Description | Format |
|---|---|---|---|---|
| 1 | Plan Boundary | | | |
| | | bound_1w1p | Project boundary; naming convention for boundary of 1W1P planning area | polygon |
| 2 | Priority Locations | | | |
| | | p_res_pts | Point locations of priority resources and/or plan regions, with water quality goals in attributes | point |
| 3 | Elevation Products | | | |
| | | raw_dem | Non-conditioned digital elevation model | raster |
| | | fdr_total | Flow direction raster from fill all | raster |
| | | fac_total | Flow accumulation from fill all | raster |
| | | hyd_dem | Hydrologically conditioned digital elevation model | raster |
| | | us_tt | Upstream travel time in hours | raster |
| | | ds_tt | Downstream travel time in hours | raster |
| 4 | Travel Time | | | |
| | | tt_grid | Cell to cell travel time in seconds | raster |

| | Dataset | PTMApp Name | Description | Format |
|---|---|---|---|---|
| 5 | Curve Number | | | |
| | | curve_num | Curve number raster | raster |
| 6 | SSURGO | | | |
| | | ssurgo_cpi | SSURGO - Crop productivity index | raster |
| | | ssurgo_hs | SSURGO - Hydraulic rating | raster |
| | | ssurgo_hsg | SSURGO – Hydrologic group | raster |
| | | ssurgo_dtgw | SSURGO - Depth to groundwater | raster |
| 7 | RUSLE Inputs | | | |
| | | rusle_kw | RUSLE - Soil erodibility factor | raster |
| | | rusle_r | RUSLE - Rainfall-runoff erosivity factor | raster |
| | | rusle_c | RUSLE - Cover management factor | raster |
| | | rusle_p | RUSLE - Support practice factor | raster |
| | | rusle_m | RUSLE - m-weight factor | raster |

In addition, there are several optional inputs that can be used to adjust the output data products developed by PTMApp-Desktop (Table 2) Additional information on the rasters and feature classes listed in Tables 1 and 2 can be found in the subsequent sections of this User Guide along with Workshop Sessions 1 and 2 on the PTMApp website's Theory and Documentation page: https://ptmapp.bwsr.state.mn.us/User/Documentation.

Table 2 Optional Inputs

| | Data | PTMApp Name | Description | Format |
|---|---|---|---|---|
| 1 | Scale Loads | | | |
| | | scaleload_point | Location of one known scaling load point, preferably 1W1P boundary pour point | point |
| | | landseg_polygon | Distribution of land segments with yields data attached based upon modelling data (e.g., HSPF, SWAT, etc.) | polygon |
| 2 | Existing Conservation Practices | | | |
| | | exbmp_py | Existing BMPS | polygon |
| 3 | BMP Screening Polygon | | | |
| | | bmp_null | File that can be used to screen out locations as having potential for BMPs | polygon |
| 4 | User Weighting Factor for Ranking | | | |
| | | usr_rank_weight | Optional file to weight TP, TN, Sed and WQI Ranks | polygon |
| 5 | Elevation Products | | | |
| | | fdr_surf | Flow direction raster from surface contributing area only | raster |
| | | fac_surf | Flow accumulation from surface contributing area only | raster |
| 6 | Lake Polygons | | | |

| Data | PTMApp Name | Description | Format |
|---|---|---|---|
| | lakes_route | Feature Class including lake polygons to be run through lake routing | polygon |

# 4 Creating the Required Inputs

This section provides an overview of recommended methods for generating the required inputs for PTMApp-Desktop. PTMApp-Desktop will function as long as these inputs are provided in the proper format. The recommendations below are provided to give users a guide for developing inputs in a manner consistent with the inputs used during the development and testing of PTMApp-Desktop. *Greater detail on how to collect and create input data for PTMApp-Desktop can be found in the Workshop Session 1 materials on the PTMApp-Desktop Theory & Documentation tab on the PTMApp website:* https://ptmapp.bwsr.state.mn.us/User/Documentation

## 4.1 Plan Boundary

This input establishes the extent of all the data that will be generated by PTMApp-Desktop. It needs to be provided as an ArcGIS layer within a file geodatabase. In Minnesota, HUC10 and HUC12 watershed boundaries are available in the Base Geodatabase (Base.gdb) available on the PTMApp website: https://ptmapp.bwsr.state.mn.us/User/PTMAppDesktop.

## 4.2 Priority Locations

These are the locations within the watershed where upstream estimated annual yields and loads for sediment, total nitrogen (TN), and total phosphorus (TP) are "routed" to and where information about the benefits and costs of conservation practices are generated. These are typically some feature of interest, i.e., a lake or river reach. These points need to be provided within your plan boundary.

## 4.3 Elevation Products

Any digital elevation model (DEM) can be inserted as the raw_dem and/or the hyd_dem. However, at a minimum a fill all operation should be performed on the hyd_dem to ensure that flow sinks have been removed from the data. The PTMApp development team recommends following the conditioning standards which were developed implemented by Houston Engineering, Inc., and the International Water Institute for deciding on the level of conditioning needed for your input hyd_dem **(Figure 1).** When using the hyd_dem, users must also develop a flow direction grid (fdr_total) and a flow accumulation grid (fac_total). Upstream (us_tt) and downstream (ds_tt) grids also need to be developed in hours. This can be accomplished by running the Flow Length command in ArcGIS with the tt_grid as a weight factor. A professional paper on hydrologic conditioning has been developed by the United States Geological Survey and is available at: http://pubs.usgs.gov/fs/2014/3051/pdf/fs2014-3051.pdf. Information on hydro-conditioning can also be found on the PTMApp website: https://ptmapp.bwsr.state.mn.us/User/Documentation.

International Water Institute
Supporting Flood Research and Watershed Education

Houston Engineering Inc.

| HEI Conditioning Level | None | Low | Medium | Medium Plus | High | High Plus |
|---|---|---|---|---|---|---|
| DNR Nomenclature (modified by HEI) | H1DEM** | H2DEM-Planning Equivalent | H2DEM** | H2DEM Plus | H3DEM** | H3DEM Plus |
| Hydro-conditioning Process / Description | None, Raw Bare-Earth, Hydro-flattened DEM Products | NHD Plus streams or other watercourses burned into DEM OR automated enforcement process for streams | Stream-lines used to guide placement of user-defined burnlines | H2DEM plus specific modified by placing burn lines at the pour point of Level 8 lakes to ensure correct drainage areas to lakes | User-identified burnlines, informed by depressional analysis capturing water movement through public and private culverts and ephemeral watercourses. Generally lacks local review of product at field (40 acres or less) scale, documentation describing reasons for burn-line placement and formal QA/QC due diligence process for field scale flow direction | User-identified burnlines, informed by iterative depressional analysis **and** hydrologic routing, capturing water movement through public and private culverts at field scale, and field scale flow path. Includes local review of product at field (40 acres or less) scale, documentation describing reasons for burn-line placement and formal QA/QC due diligence process for field scale flow direction |
| Typical Burnline Density*** (burnlines/sq-mi) | 0 | 0 | 1-3 | 1-3 | 3-16 | 12-20+ |
| Fraction of Watershed With Non-Contributing Depressions† (%) | >30% ‡ | 20-30% with little to no analysis of depressions | 20-30% with little to no analysis of depressions | 20-30% with little to no analysis of depressions | Typically 10-30% and includes analysis of depressions but no incorporation of local knowledge or within-field analysis | % varies but based on hydrologic analysis compared to depression locations, Intensive analysis based on local knowledge of tile and limited field review |
| Description of Burnline Efficacy | No burnlines placed on landscape, numerous digital dams exist with potential for incorrect hydrologic routing | Use stream or other water course or other automated methods to enforce flow path. May include enforcing existing watershed boundaries | Stream-line enforcement at road crossings (larger public and some private) removes some but not many digital dams to less than field scale | Based product is H2DEM but burn lines added to ensure proper representation of the location and drainage area of lake or other large storage locations | Digital dams removed at public and private roadways and some other locations as determined by user (e.g. private roadways, field accesses and crossings, etc.). Digressional analysis used to guide burn line placement. | Digital dams removed at all locations supported by geospatial evidence including within specific fields. Extensive analysis of non-contributing areas using hydrologic analysis. |
| QA/QC Procedure | None | None to minor review, no stakeholder input | None to minor review, no stakeholder input | None to minor review, no stakeholder input | Some review, none to little documentation supporting procedures, little to no independent review, varied stakeholder input | Documented methods, independent review, input and review of field scale flow patterns provided by local, knowledgeable individuals |

† 'Non-contributing depressions' defined as depressions which do not overflow for rain events up to the 10-yr, 24-hr design storm; Often a function of landscape terrain. Certainty that an area is "land locked" and non-contributing should increase greater level of conditioning.

‡ Values may range based on watershed characteristics (e.g. hydrologic connectivity, history of drainage, etc.)

** See definitions for H1DEM, H2DEM and H3DEM are described by Vaughn, S.R. (2015). hDEM. L Definitions and Classifications of Hydrologic DEM Modifications for Minnesota

*** Not the sole factor used to develop nomenclature. Burnline density is a function of the landscape slope and extent of human modification of the landscape. More burnlines are needed in flat versus hilly terrain.

Figure 1 Hydrologic conditioning standards developed by Houston Engineering, Inc.

## 4.4 Travel Time

Travel time measures the amount of time it takes water to flow through a cell, by first measuring flow velocity within the cell, and then using the cell size (flow length) to estimate the time it takes water to exit the cell. Within-cell travel times can then be accumulated downstream or upstream based on the flow accumulation grid to determine either the downstream or upstream travel time of each cell.

The Minnesota Department of Natural Resources (MNDNR) developed an ArcGIS tool which estimates the cell-to-cell travel time following the methodology listed below (Loesch, 2011):

*Description: This script creates a raster whose cells measure the length of time in seconds that it takes water to flow across it and then accumulate the time from the cell to the outlet of the watershed. Water velocity is calculated as a function of hydraulic radius, Manning's N and slope using a DEM as a source, flow direction, flow accumulation and slope (percent) is calculated. Using flow accumulation, each cell is assigned one of three flow regimes. Slopes are processed so that there are no cells with zero slopes.*

*Landcover is used to assign flow N and R values to non-channelized cells. Users can use various landcover sources, but these must be matched to the N and R table that is stored in the /data folder in this distribution. The N and R table must contain one record for each of the raster values in the landcover grid and there must be the same fields in that table for the program to work. R and N values     are assigned based on landcover and flow regime.*

*Hydraulic Radius is calculated using:*

*(X)a + Y where:*

*X = hydraulic radius factor 1 (User setting, 0.0032 default)*

*a = drainage area in square miles (calculated from Flow Accumulation)*

*Y = hydraulic radius factor 2 (User setting, 1.7255 default)*

*Velocity is calculated as:*

*vel(feet/second) = (1.49 \* Hydraulic Radius^0.667 \* slope^0.5) / Mannings N*

*Travel Time across individual cells is calculated as:*

*1 / vel \* 0.3048 (if the xy units are meters, otherwise the conversion factor is not used*

*This calculation converts the value from feet/second to seconds/measurement unit (feet or meters)*

*Once travel time (seconds per feet/meter) individual cells is known then Travel Time is calculated for each cell to the outlet of the basin using the FlowLength command using the cell-based travel time grid as an impedance (sic) factor.*

## 4.5 Curve Number

The National Land Cover Dataset (NLCD) land use classes - website: NLCD 2016 Land Cover (CONUS) | Multi-Resolution Land Characteristics (MRLC) Consortium and hydrologic soil group (HSG) designations from the Natural Resources Conservation Service's (NRCS) SSURGO database – website: https://gdg.sc.egov.usda.gov  can be used in developing 24-hour AMC II runoff Curve Numbers. The method is based on guidance from NRCS Urban Hydrology for Small Watersheds (TR-55) and Minnesota Hydrology Guide to determine an appropriate 24-hour Curve Number for a given hydrologic soils/land use combination. Land use also determines the curve numbers assigned to dual HSG (A/D, B/D, and C/D). Typically, land use types that have development (for example urban or cultivated agriculture) are assumed to be drained resulting in the use of the A, B, or C classification. Undeveloped land uses are assumed to be undrained, resulting in the D classification.  Following this methodology, a CN raster grid was developed for all of Minnesota, and can be downloaded for use in PTMApp-Desktop projects on the PTMApp website: https://ptmapp.bwsr.state.mn.us/User/PTMAppDesktop

An example of a 24-hour Curve Number lookup table that can be used to apply a CN value based on the NLCD code and HSG is also provided in Table 3.  These values were developed for the Red River of the North Basin and are therefore only valid within that watershed.  These were developed as part of the Fargo-Moorhead Metro Basin-Wide Modeling Approach-Hydrologic Modeling-Phase 1.  The report can be accessed here: https://www.redriverjointwrd.org/uploads/4/0/1/1/4011927/lower_red_basin_retention_report_may2019.pdf

Table 3 Curve Number Lookup Table Based Upon Hydrologic Soils Group and NLCD Land Use Land Cover

| NLCD Code | Hydrologic Soil Group | | | | | | |
|-----------|-----|-----|-----|-----|-----|-----|-----|
|           | A   | B   | C   | D   | A/D | B/D | C/D |
| 11        | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 12        | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| 21        | 45  | 65  | 76  | 82  | 45  | 65  | 76  |
| 22        | 60  | 74  | 82  | 86  | 60  | 74  | 82  |
| 23        | 77  | 85  | 90  | 92  | 77  | 85  | 90  |
| 24        | 92  | 94  | 96  | 96  | 92  | 94  | 96  |
| 31        | 77  | 86  | 91  | 94  | 94  | 94  | 94  |
| 41        | 36  | 60  | 73  | 79  | 79  | 79  | 79  |
| 42        | 30  | 55  | 70  | 77  | 77  | 77  | 77  |
| 43        | 30  | 55  | 70  | 77  | 77  | 77  | 77  |
| 52        | 35  | 56  | 70  | 77  | 77  | 77  | 77  |
| 71        | 30  | 58  | 71  | 78  | 78  | 78  | 78  |
| 81        | 49  | 69  | 79  | 84  | 84  | 84  | 84  |
| 82        | 61  | 71  | 78  | 81  | 61  | 71  | 78  |
| 90        | 78  | 78  | 78  | 78  | 78  | 78  | 78  |
| 95        | 85  | 85  | 85  | 85  | 85  | 85  | 85  |

## 4.6 SSURGO Data

PTMApp-Desktop requires ssurgo_cpi, ssurgo_hs, ssurgo_hsg, and ssurgo_dtgw files.  These data have been generated using the SSURGO Create Soil Map tool and are now available in the Base.gdb on the PTMApp website (https://ptmapp.bwsr.state.mn.us/User/PTMAppDesktop). These data are summarized for the State of

Minnesota in the SSURGO_Polygons feature class but still require conversion to rasters, which can be completed using the 'Feature Class to Raster' geoprocessing operation in ArcGIS.

## 4.7 Revised Universal Soil Loss Equation Inputs

The RUSLE calculations performed by PTMApp-Desktop require several inputs. Table 4 below provides guidance on where to get information to generate each of these inputs. Each input should be developed as a raster data, orthogonal to your elevation data products.  Guidance is available for the development of each of these factors in Minnesota on the NRCS website: (Web Soil Survey - Home (usda.gov)).

Table 4 Required Revised Universal Soil Loss Equation (RUSLE) Inputs

| RUSLE Input | Description |
|---|---|
| rusle_kw | Soil erodibility factors used in PTMApp should be taken directly from the NRCS's SSURGO Database.  The K factor accounts for the effects of soil characteristics on erosion rates. |
| rusle_r | The R-factor accounts for the impact of meteorological characteristics of the watershed on erosion rates. Information on R-factors across the State of Minnesota is available from the NRCS Field Guide, on a county-by-county basis (NRCS, 1996) |
| rusle_c | The C-factor accounts for land cover effects on erosion rates. C-values in the NRCS's MN Field Office Technical Guide should be used as the basis for developing the values used in this analysis.   These C-Factors can be transcribed based upon land use, land cover.  The most recent National Agricultural Statistics Service (NASS) Crop Land Data layer (CDL) is the recommended land use, land cover data source.  below provides suggestions based upon NASS CDL.  These values could be refined/improved with local knowledge |
| rusle_p | The P-factor accounts for the impact of support practices on erosion rates.  Examples of support practices include contour farming, cross-slope farming, and buffer strips. For the purposes of PTMApp, variations in P-factors across the study area were not accounted for in Sediment yield and load calculations, since there is not sufficient information to derive P-factors at the scale required for this analysis.  Support practice P-factors are typically less than one and result in lower estimates of sediment yield than if the support practices were not accounted for.  As such, the results of the RUSLE analysis in this work are conservative estimates of soil erosion, not accounting for support practices that may be in-place.  Practices such as contour farming and buffer strips can be accounted for in the Benefits Analysis module within PTMApp. |
| rusle_m | By default, value is typically set to 1.  Can be adjusted with local knowledge |

Table 5 Revised Universal Soil Loss Equation (RUSLE) C-Factor Suggestions Based Upon NASS CDL Classifications

| C- Factor | NASS CDL Classification |
|---|---|
| 0.200 | Corn, Soybeans, Sunflower, Barley, Spring Wheat, Durum Wheat, Winter Wheat, Rye, Oats, Canola, Flaxseed, Peas, Herbs, Dry Beans, Potatoes, Other Crops, Fallow/Idle Cropland |
| 0.100 | Alfalfa, Other Hay/Non-Alfalfa, Sod/Grass Seed, Herbs |
| 0.005 | Clover/Wildflowers |
| 0.003 | Developed/Open Space, Developed/Low Intensity, Developed/Medium Intensity, Developed/High Intensity, Barren |
| 0.002 | Deciduous Forest, Evergreen Forest, Shrubland, Mixed Forest |
| 0.001 | Grassland Herbaceous, Woody Wetlands, Herbaceous Wetlands |
| 0.000 | Open Water |

## 4.8 Lake Routing

Lake Routing is a tool with in PTMApp which large wetlands, lakes, and reservoirs modify the fate and transport of suspended sediment, nitrogen, and phosphorus as biogeochemical processes including sedimentation and burial, bio-assimilation, and denitrification (specifically for nitrate-nitrogen), capture and reduce loads. Because of this, a Priority Resource point can be placed at the inlets and outlet of lakes to capture loading information. For PTMApp to properly calculate the loads at the Priority Resource point, a connection needs to be made between the two datasets. This connection is only needed for the outlet of the lakes. The lakes_route shapefile will need to have the number of the Priority Resource point outlet in the lake_count attribute field. To complete this connection, follow the guidance below:

1. Add field "lake_count" to lakes_route attribute table (Input – Processing.gdb)
    a. lake_count must appear exactly as shown (no capital letters and an underscore)
2. Add field "lake_count" to p_res_pts attribute table (Input – Processing.gdb)
    a. lake_count must appear exactly as shown (no capital letters and an underscore)
3. Using the Priority Resource point as the numerical connection, put the Priority Resource point value (of the lake outlet) as the value in the 'lake_count' field in both the lakes_route and p_res_pts attribute tables.

Table 6 Lakes Route Connection to Priority Resource Point

| Shapefile | Attribute: Connection | Attribute: Properties |
|-----------|----------------------|----------------------|
| **lakes_route** | lake_count | long |
| **p_res_pts** | lake_count | long |

# 5 Installation

## 5.1 System Requirements

The following are required to utilize the **PTMApp-Desktop Toolbar**:

Table 7 ArcGIS Pro Toolbar Software Requirements

| Software Requirements | Version |
|-----------------------|---------|
| ArcGIS Pro (any license level*) | 2.5* |
| .NET Framework | 4.8 or later |
| Windows Operating System | 8.1 or 10 |

*Note: Versions higher than ArcGIS Pro 2.5 may work but have not been tested.  Use these versions at your own risk.*

ESRI software will sometimes implement patches when issues are found after a service pack release.  No Patches are currently required for use within ArcGIS Pro.

## 5.2 Installing the Toolbar

This section explains how to install the toolbar.  The installation procedure assumes that the target computer meets all system requirements described in Section 5.1 Table 7. The installer file can be downloaded from the PTMApp website: https://ptmapp.bwsr.state.mn.us/User/PTMAppDesktop. Click the ArcGIS version that matches the one installed on your computer.  The installer file is named **PTMApp.esriAddInX**. Double-click it to install.

PTMAppPro.esriAddinX
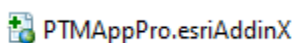
This window will appear.  Click the **Install Add-In** button to proceed.
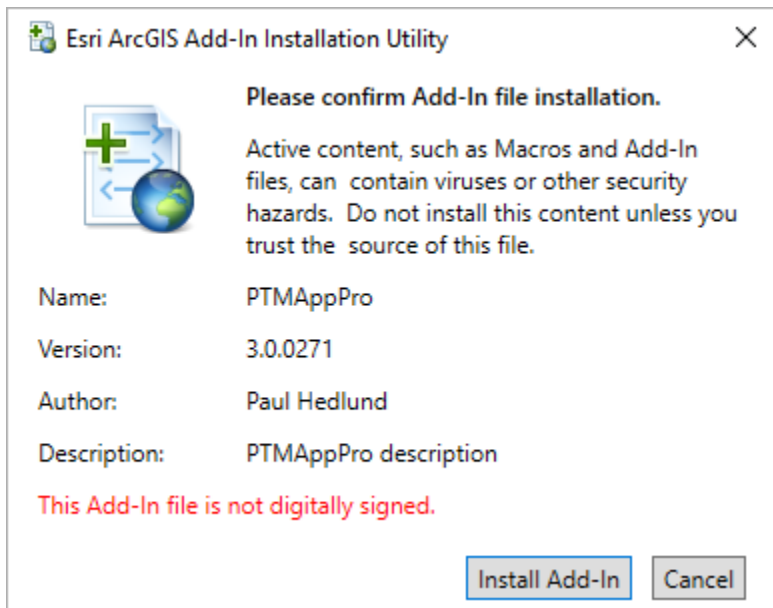


An installation confirmation window will appear.
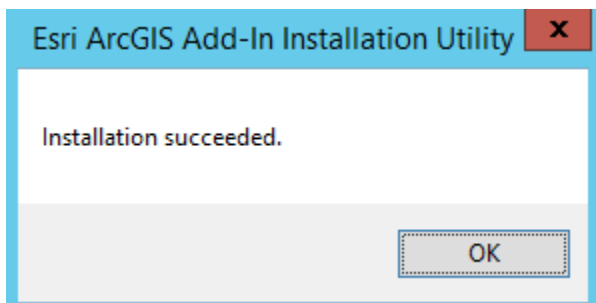


Open **ArcGIS Pro** and open a project.  You should now see a new PTMApp tab on the top ribbon.
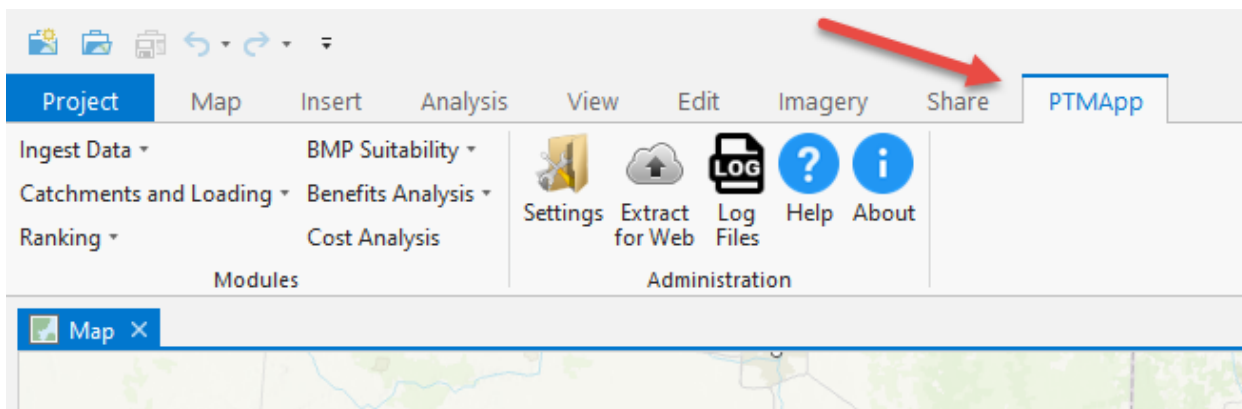
If you want to see the version of **PTMApp** Add-In, it will be listed at **Project - > Add-In Manager - > PTMAppPro**.
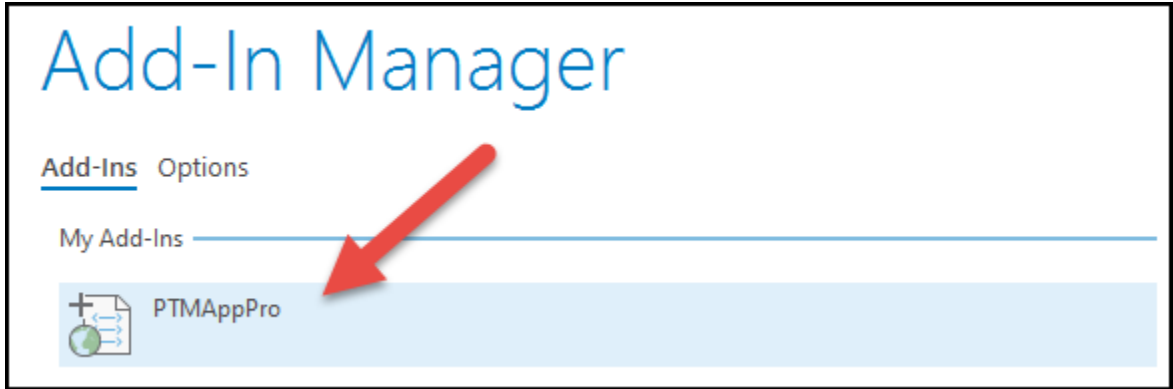


# 6 Map Data Setup

## 6.1 Set Up Base Data

The toolbar is distributed with a state-wide (Minnesota) geodatabase called **Base.gdb.** The geodatabase contains many different types of geographic information system data useful in completing watershed plans, understanding water movement, and for characterizing watershed conditions. It also contains vital rasters and shapefiles that are used when running the toolbar. Place this file geodatabase on your local computer or system network in a preferred location.  Then, click the settings button on the toolbar.
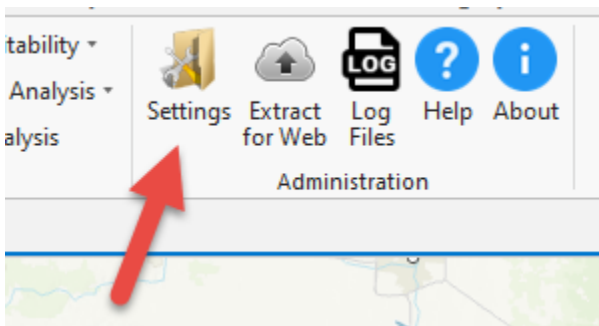
Specify the path to the **Base.gdb** here.
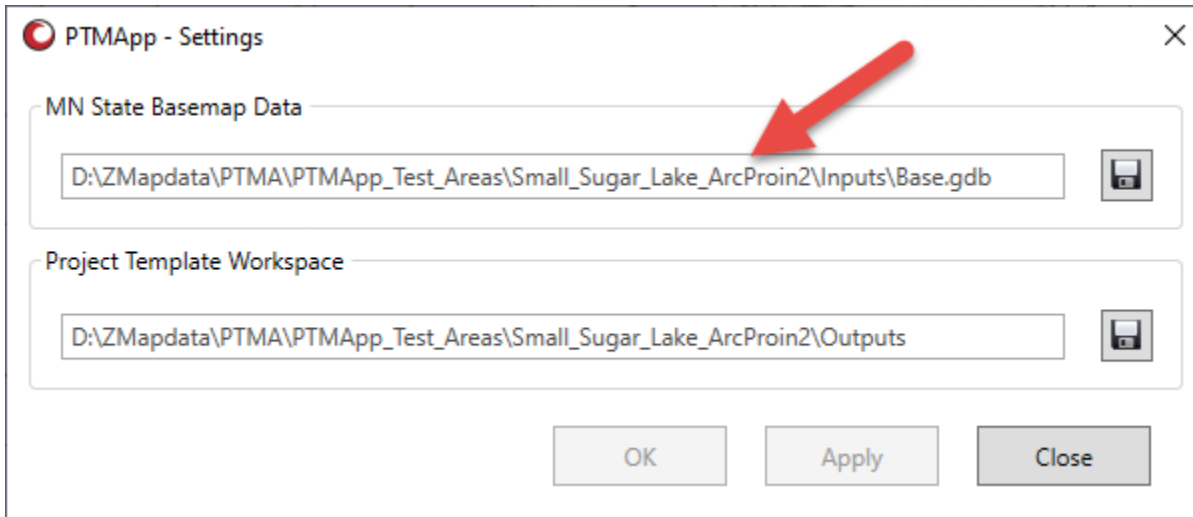


The **Base.gdb** data as well as some planning and processing data needs to be clipped to your watershed for analysis. All output data will be stored in a workspace (a folder). Specify that workspace (folder) path here. Click **Ok** to save changes. Later tools will automatically create a **Base.gdb**, **Processing.gdb** and a **Planning.gdb** inside that output folder to store all the output data.
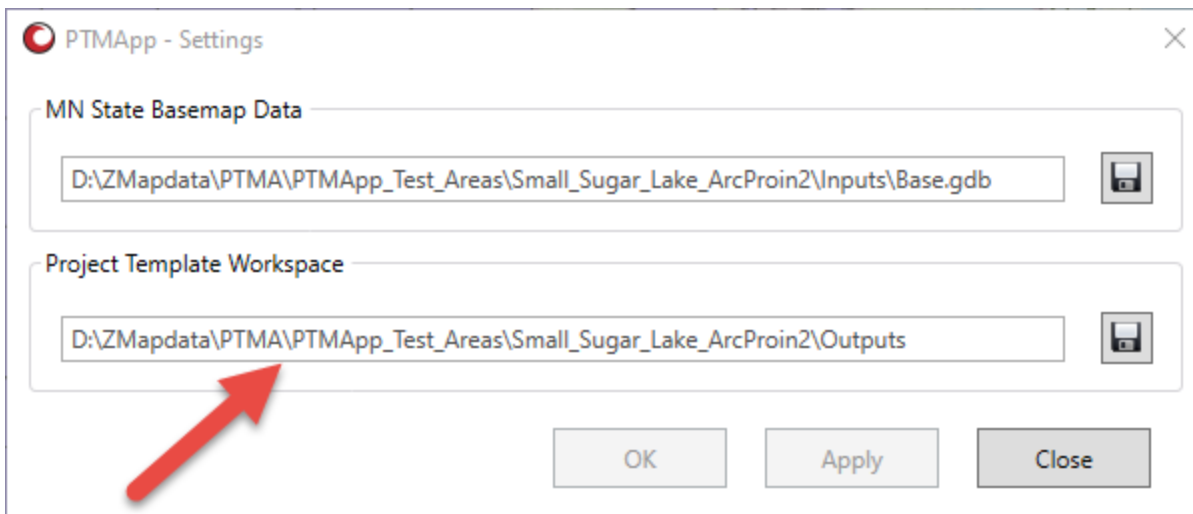


In the Base.gdb there are several items that are directly used with in the toolbar for specific processes. The rest of the items in the database are clipped out to be used for planning purposes only, they are not used with in the tool bar. See the screen shot below to see which items are used in the toolbar.
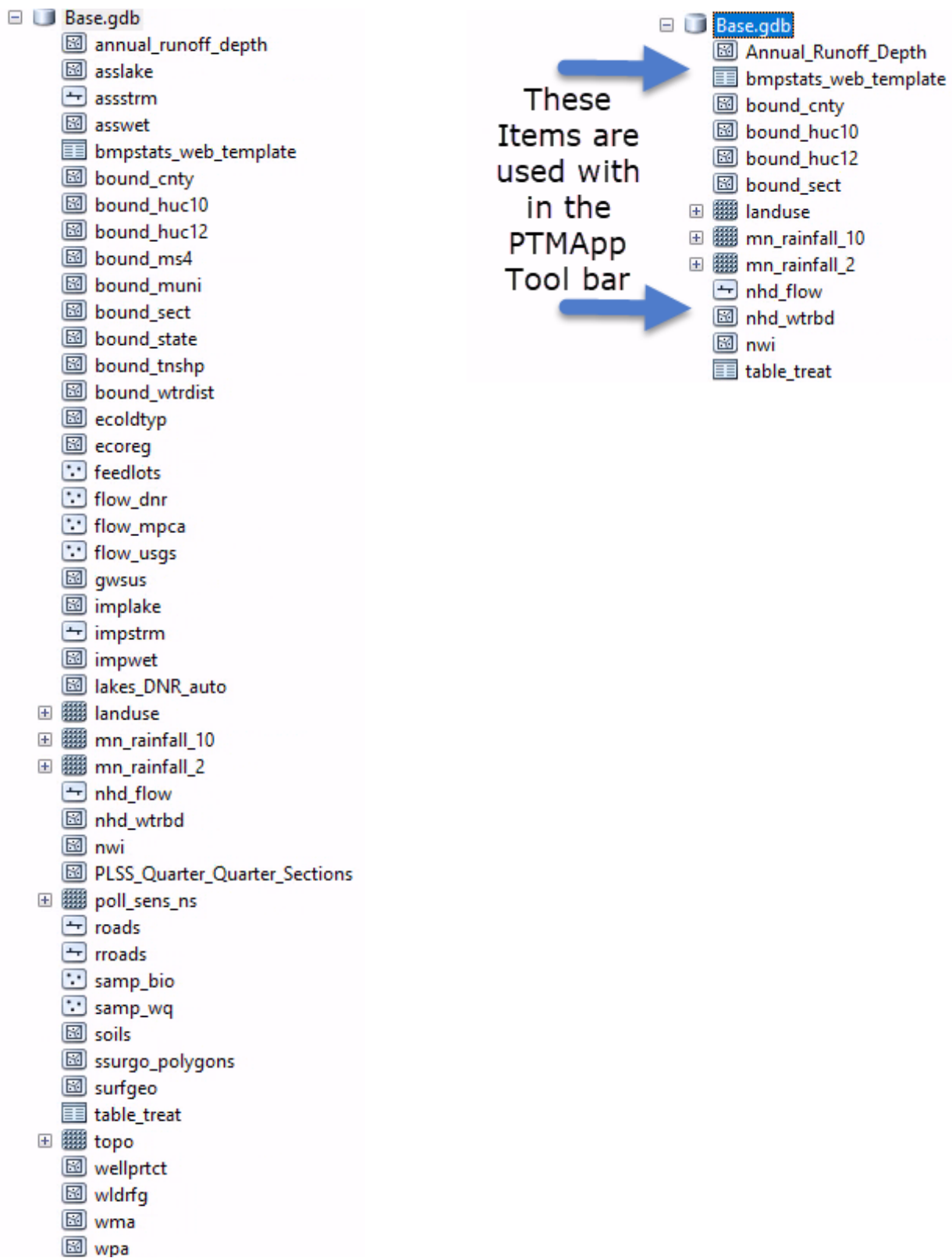
## 6.2 Error Logging

Occasionally errors may occur when running the PTMApp-Desktop toolbar.  To efficiently mitigate these issues errors are tracked in some PTMApp logs.  Click the **Logs Files** button on the **PTMApp** ribbon.  The first option will zip up the log files and send to a specified email address.  The second option will place the same zipped file with the logs into a specific location on the local network.  The second option is only need if email access is not available on the machine (Virtual Machines used for processing would be an example where email is not installed).  When an error occurs the is the recommended method for sending to the software developers for review.

When you hit **Send Email**, a composed email will be generated in Outlook.  The log files will automatically attach to the email.  This can then be sent to the desired email for review and debugging.
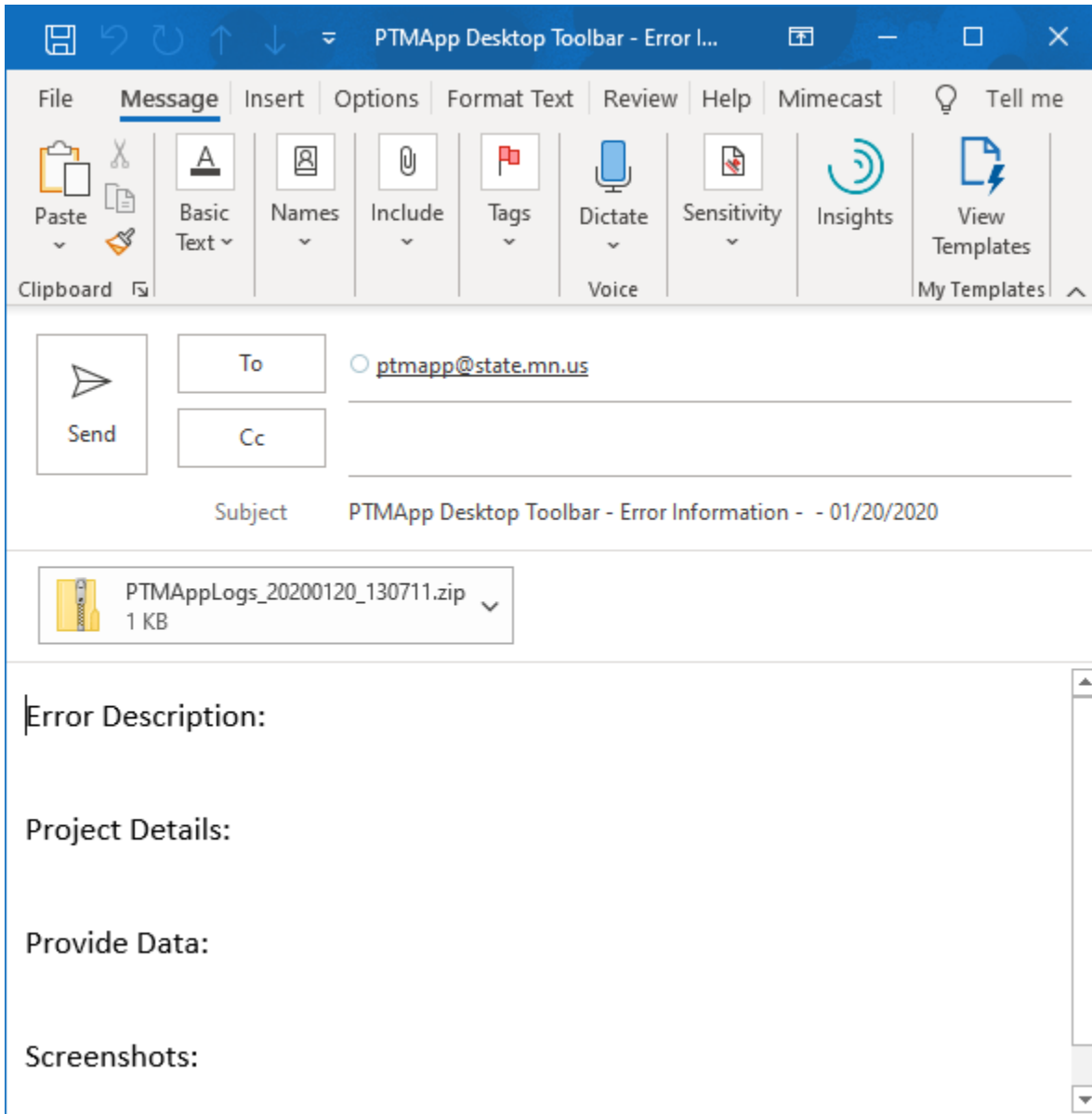


## 6.3 Schema Locking

In ArcGIS Desktop there is four main types of locks:

- Edit Locks
- Read Locks
- Write Lock
- Schema Locks

The PTMApp-Desktop toolbar checks for all these locks at the beginning of each tool processing run. If data is not getting edited the only lock type that can become an issue in PTMApp-Desktop is Schema Locks. Schema locks occur when a layer is being viewed within ArcGIS Pro. Problems occur when a PTMApp-Desktop tool attempts to add, delete, or modify the attribute fields of a layer or table. Another cause of Schema Locks is overwriting existing data layers.

To avoid Schema Locks, do the following:

- Check the help section for the tool you are running. It will indicate tables or layers that must be closed in ArcGIS Pro when processing that tool.
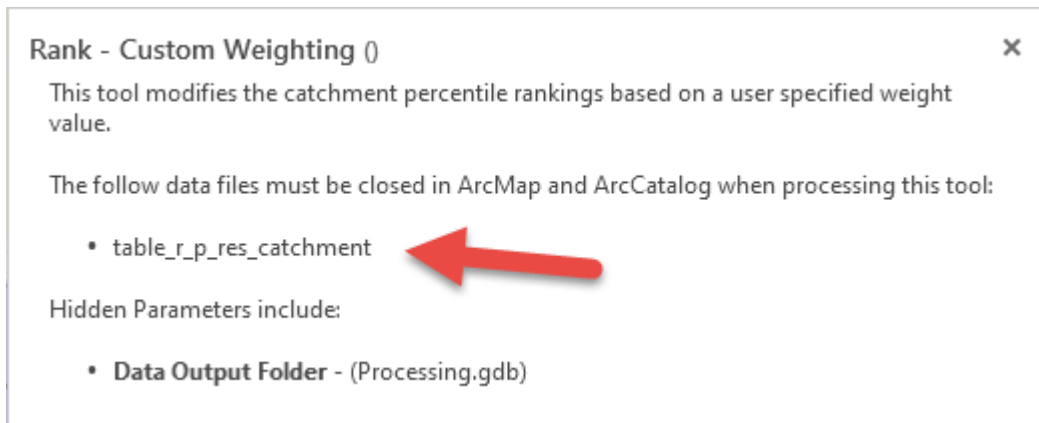


- If you are overwriting existing layers, rasters, or tables, make sure all layers are closed as well.
- Some tools take several hours to process. Remember to avoid opening data relevant to that tool during processing. Schema locks can occur when this happens. The tool will error out and a message should appear indicating which data layer has a schema lock on it. This is the most common type of Schema Lock situation that occurs with PTMApp-Desktop.

If a Schema Lock is found in the initial tool validation the tool will stop and a message like this will appear:



If a Schema Lock occurs after the initial validation this means some data was open for viewing during processing. In this scenario, the error message will look something like this:
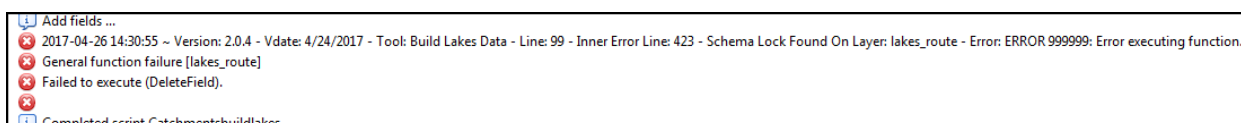
## 6.4 Tool – Daisy Chaining

Daisy chaining tools means multiple tools can be run one after the other.  All PTMApp-Desktop tools can be daisy chained except for the following:

- Ingest Data – Clip Watershed
- Extract for Web
- Administrator
- Help

To apply daisy chaining of tools run each tool in the proper order.  Each tool will wait for the previous tools to complete.  A **Pending …** message will appear for the tools waiting to run.



Items to note when daisy chaining:

- If an error occurs in a tool the daisy chaining will continue running on the next tool.  Therefore, since each tool often depends on outputs from previous tools an issue will probably arise.

# 7 Running the PTMApp – Desktop Toolbar Modules

## 7.1 Module:  Ingest Data

The Ingest Data Module is the starting point for processing data using PTMApp-Desktop.  This module allows the user to set their analysis study area, clip the base data to their study area, and complete pre-processing necessary to run the remainder of the Modules.  The study area file must be created prior to this step as a required input for PTMApp-Desktop.

### 7.1.1 Clip Watershed

Clip Watershed confirms that all files needed to run PTMApp-Desktop are present and clips them to the extent of your study area (study area = bound_1w1p).  Users have the option to drag and drop individual files or input their entire workspace.   We suggest the following structure for the required processing workspace (called processing.gdb here) and planning workspace (called planning.gdb).   We recommend using this structure as the same structure will be created in your output files.
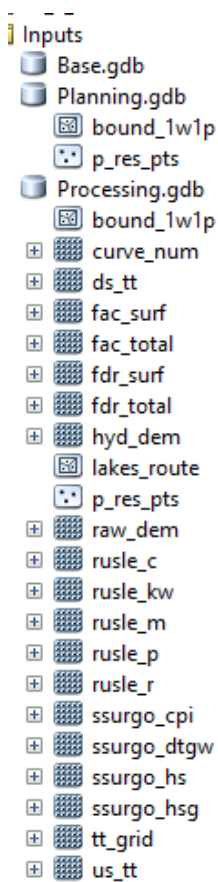
1. On the PTMApp-Desktop toolbar go to Ingest Data - > **Clip Watershed**
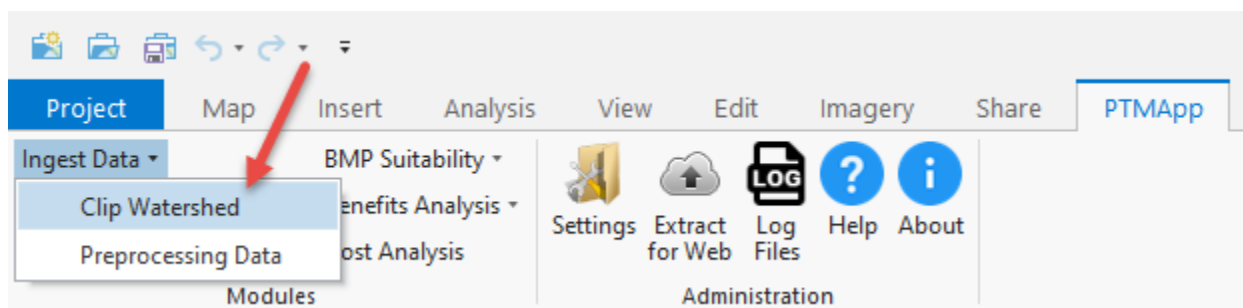


2. The window below will appear. Specify the study area boundary, bound_1w1p shapefile, to clip all the Base.gdb layers to in the **Study area boundary** shapefile. Set Cell Size based on the cell size of your input rasters (in the example below, 3 meters) Input data (e.g., Planning and Processing file geodatabases). **Project name** is to allow the project to be tracked for future use. The **Select one watershed one plan** is for identifying how the data get processed up onto PTMApp web. There is a selection called 'Unnamed' as well if the project does not fit into the other selections. **Creator Name** is to help keep track of who made data. The **HUC ID** is used to identify in which watershed the project is located. This could be in a HUC 8, HUC 10 or HUC 12. The HUC ID information needs to be entered by typing 'huc' followed by 8 to

12 digits.  The last two parameters are asking for the locations of the input planning and processing geodatabases.  After this tool information is set up, push the 'OK' button to begin processing.

3. When a project gets used on PTMApp Web, some information from Ingest – Clip will be used for the naming convention.  Please keep this in mind when filling out the information in the 'Ingest Data, Clip Watershed' tool.   The following information is used for naming convention on PTMApp Web: 'One Watershed One Plan name' + - + 'Project Name' + '(HUC ID)'.  If the user specifies 'Unnamed' in the One Watershed One Plan drop down menu, that part of the naming convention on PTMApp Web will be removed so that the name on PTMApp Web will only show 'Project Name' + '(HUC ID)'.
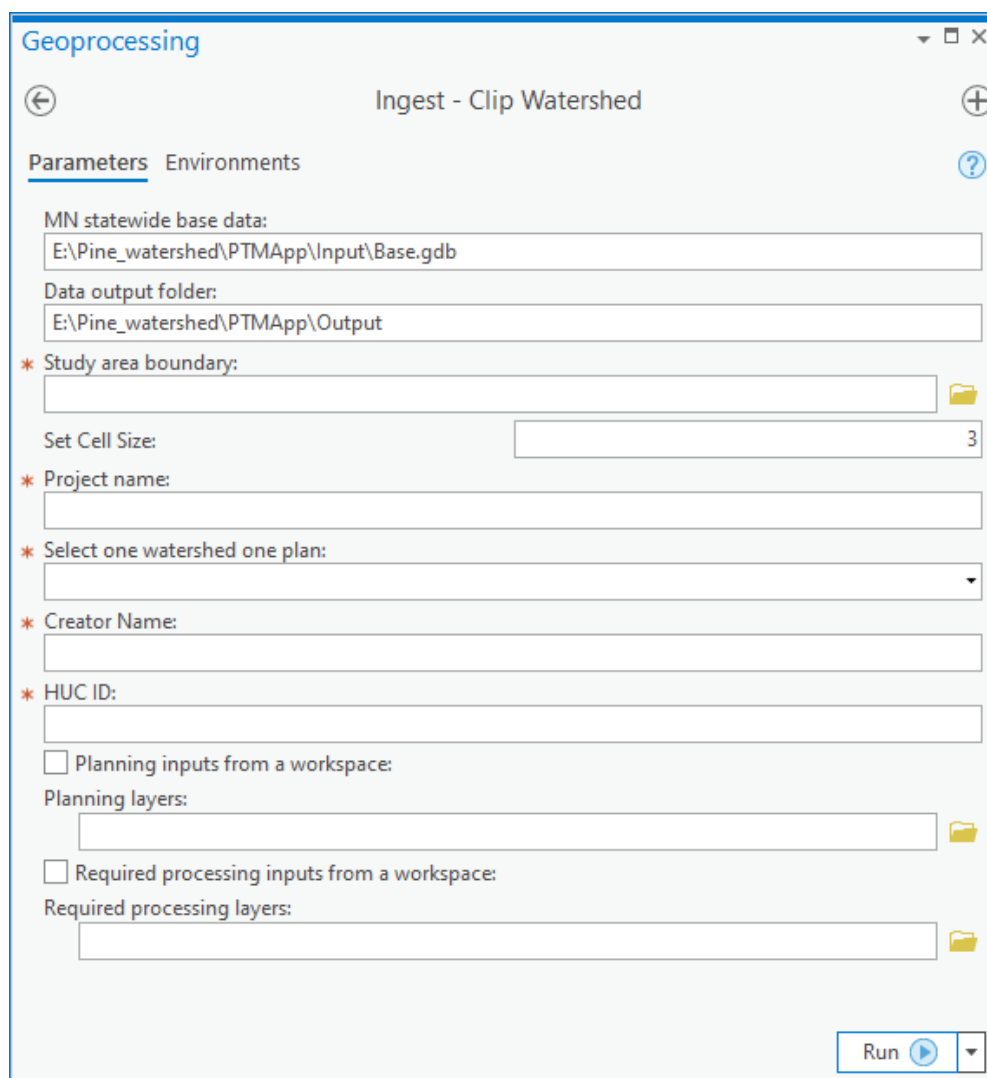


4. Upon completion, a text file is created indicating any potential issues with the data used within **PTMApp-Desktop** modules.  This includes missing layers, raster validation, re-projected layers, and resampled rasters.  This text file should be reviewed carefully to make sure everything with the data

looks correct.  Clip Watershed now also includes functionality to check inputs provided by the user to ensure they fit data formatting requirements of PTMApp-Desktop and are within expected bounds for data gathered in the State of Minnesota.  A list of these checks is provided in the Download QA/QC Desktop Outputs document on the PTMApp-Desktop/Theory & Documentation website.
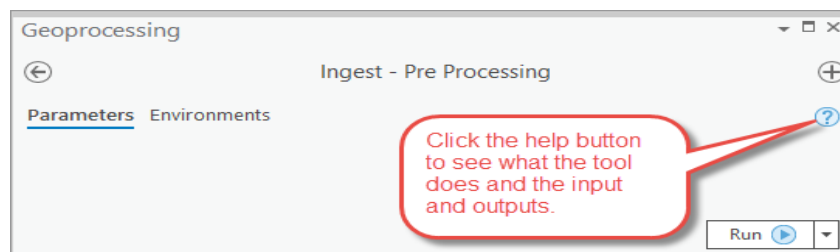
```
Clip Watersheds Summary
--------------------------------------------------------------------------------
--------------------------------------------------------------------------------


Version
--------------------------------------------------------------------------------
Version Number        : 3.0.0263
Version Date          : 10/30/2020


Completion Time
--------------------------------------------------------------------------------
Start Time            : 2020-10-30 13:16:57
End Time              : 2020-10-30 13:31:52
Processing Time       : 0:14:55


Minnesota State-Wide Feature Layers - No features found within the study area!
--------------------------------------------------------------------------------
 ~ asswet
 ~ bdrkgeo
 ~ bound_ms4
 ~ bound_wtrdist
 ~ flow_dnr
 ~ flow_usgs
 ~ impwet
 ~ rroads
 ~ wldrfg
 ~ wma
 ~ wpa


Missing PTMApp Processing Feature Layers
--------------------------------------------------------------------------------
 ~ lakes_route


Missing PTMApp Processing Optional Raster Layers
--------------------------------------------------------------------------------
 ~ scaleload_point
 ~ exbmp_py
 ~ bmp_null
 ~ usr_rank_weight
 ~ ssurgo_volcap


Reprojected Layers
--------------------------------------------------------------------------------
 ~ rusle_c


Resampled Rasters
--------------------------------------------------------------------------------
 ~ topo
 ~ landuse
 ~ poll_sens_ns
 ~ mn_rainfall_10
 ~ mn_rainfall_2


PTMApp Input Data Value Discrepancies
--------------------------------------------------------------------------------
 ~ The 'lake_count' field was not found in the 'p_res_pts' layer.
```

Clip Watershed now also includes functionality to check inputs provided by the user to ensure data meets formatting requirements of PTMApp-Desktop and is within expected bounds for data gathered in the State of Minnesota. A list of these checks is provided in the Download QA/QC Desktop Outputs document on the PTMApp-Desktop/Theory & Documentation website.
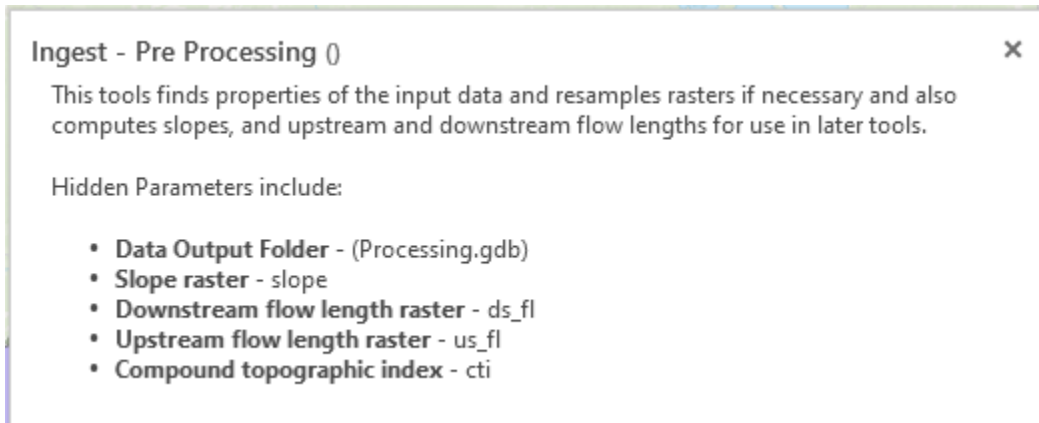
## 7.1.2 Preprocessing

In this step, the remainder of preprocessing data needed for subsequent modules will be generated. After successfully running Clip Watersheds, the Preprocessing tool will automatically find all required inputs.

In many of the steps throughout the PTMApp toolbar there will be no parameters showing up in the geoprocessing window. If this occurs, click on the help button ⓘ with in the Geoprocessing tool to see the hidden parameters.
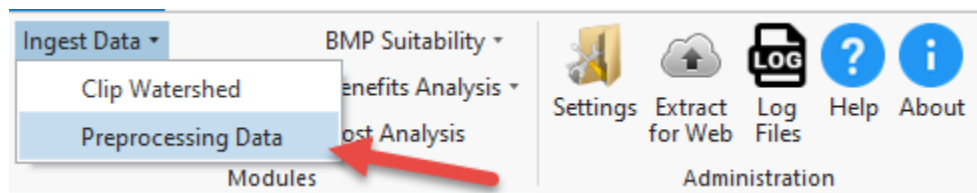


1. Inputs:
   i. *Data output folder*: This is the output path where the standardized PTMApp-Desktop geodatabases and associated data will be saved. Users can change this file path in the settings button.
2. Outputs:
   i. *Slope:* Slope of the raw DEM as a percent
   ii. *ds_fl:* Downstream flow length in meters
   iii. *us_fl:* Upstream flow length in meters
   iv. *cti:* Compound topographic index. Cells are relative dimensionless values

Ingest - Pre Processing ()                                    ×

This tools finds properties of the input data and resamples rasters if necessary and also
computes slopes, and upstream and downstream flow lengths for use in later tools.

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)
- **Slope raster** - slope
- **Downstream flow length raster** - ds_fl
- **Upstream flow length raster** - us_fl
- **Compound topographic index** - cti

## 7.2 Module: Catchments and Loading

The Catchments and Loading module generate the field scale catchments, estimates TN, TP, and sediment loads
and yields both leaving the landscape and delivered to downstream priority resources, generates the stream
power index (SPI), and performs volume and peak discharge calculations.
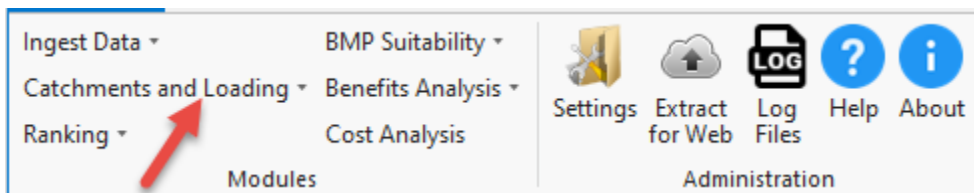


### 7.2.1 Generate Catchments

The 'Generate Catchments' tool divides the planning area into catchments averaging approximately 40 acres in
size (classified as either head or in-stream catchments), creates overlapping adjoint catchments that vary in size
(used in internal calculations) and priority resource catchments containing the watershed area for input priority
resource outlet points.
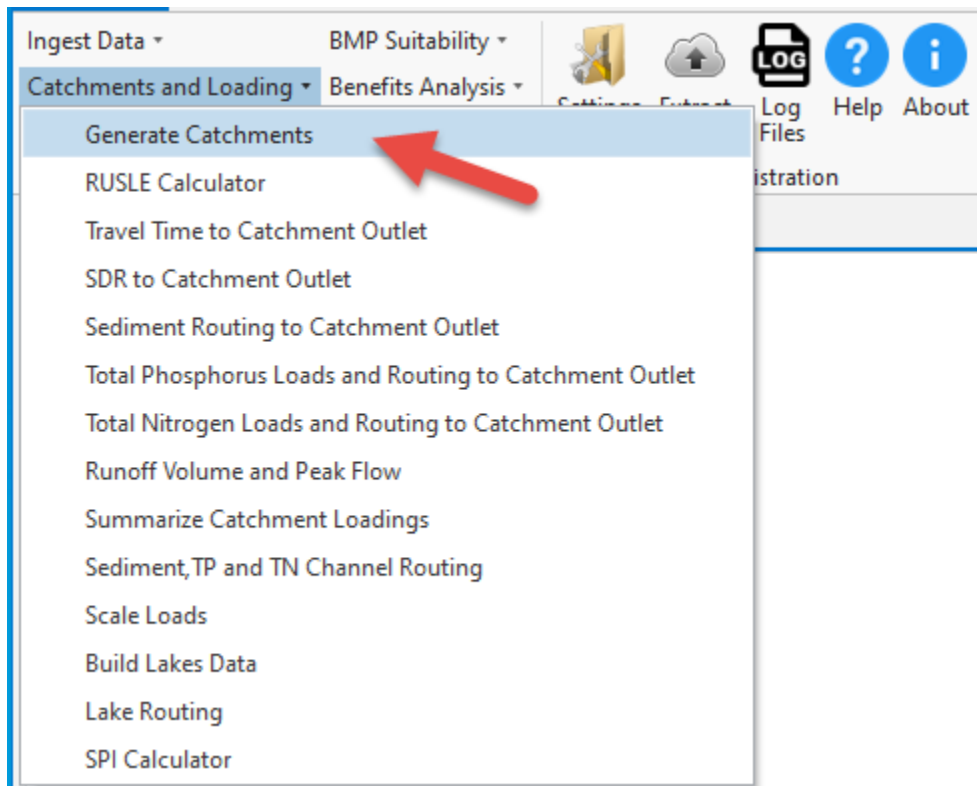
    a.   Inputs:

        i.   *Processing Options*:  You may choose to generate priority resource catchments, adjoint catchments, or both (represented by the input 'All').  New catchments will be created (or re-created if running again) for any of the three options available.  The default for this input is 'All'.

        ii.   *Data output folder*: This is the output path where the standardized PTMApp-Desktop geodatabases and associated data will be saved. Users can change this file path in the settings button.

        iii.   *Priority resource snap point*: This value determines the number of cells around each priority resource point to search for the highest flow accumulation cell.  This input is necessary as priority resource points may not always be placed directly over the flow line.  The default value is 0.  Please reference section 5.2.5 in Workshop Session 1 for setting this value while running Lake routing.  A lower value may be recommended if lakes were conditioned using the "Breakthrough" method to capture lake inlets (pages 28-30 in Workshop Session 1).  For most applications values 0 to 5 are suitable.

        iv.   *Priority resource snap raster*: Watershed outlet point of priority resource and/or plan regions
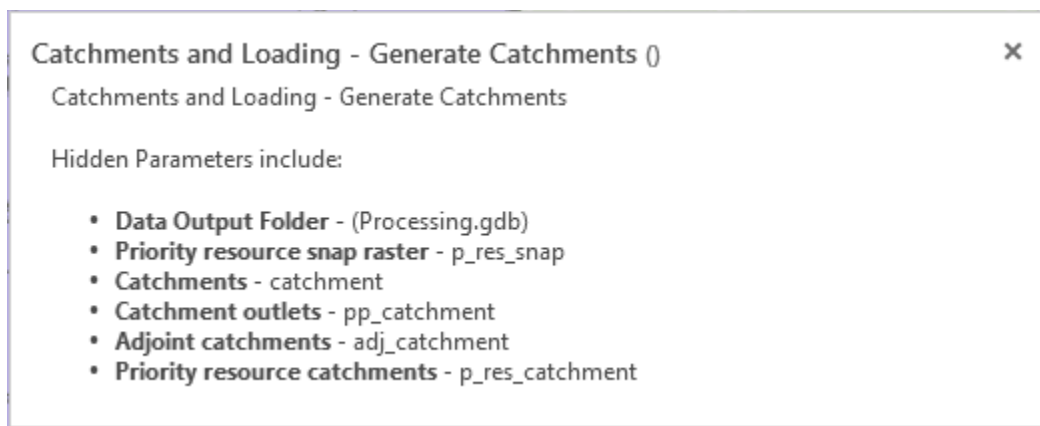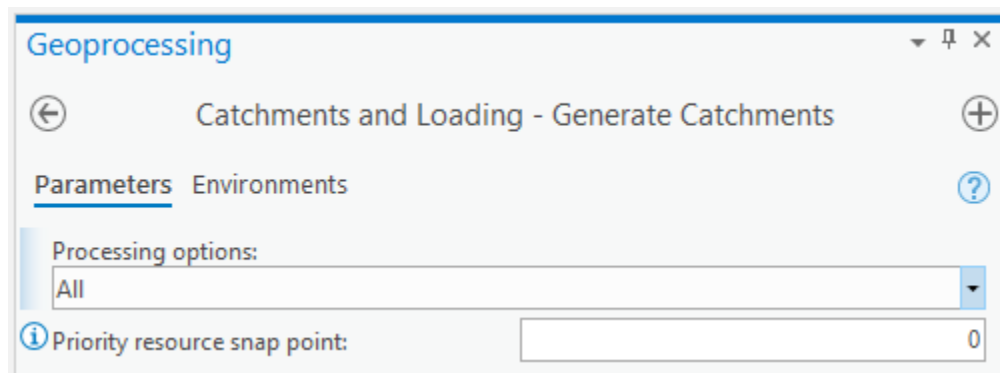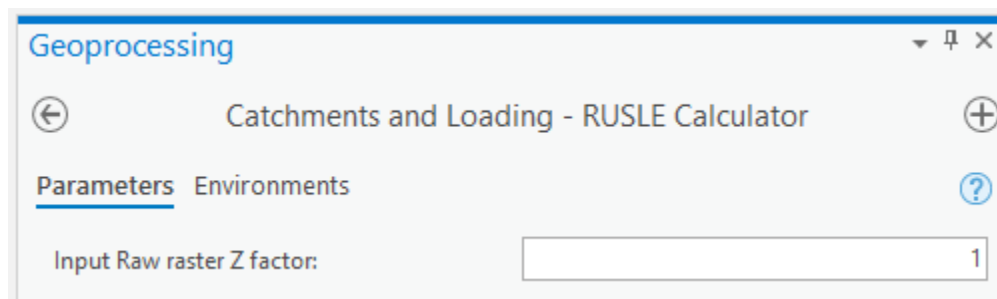
b. Outputs:
     i. *Catchments*: Subwatershed polygons delineated from the flow direction raster ranging in size from 10-125 acres covering the entire planning boundary.
     ii. *Catchment outlets*: Raster layer with unique IDs corresponding to the catchments, adjoint catchments, and priority resource catchments pour points.
     iii. *Adjoint catchments*:  Watershed polygons delineated from the flow direction raster for all non-head catchments.  Each watershed polygon is for the entire upstream drainage area for the corresponding pour point.
     iv. *Priority resource catchments*:  Watershed polygons delineated from the flow direction raster for all priority resource pour points imported in the Planning geodatabase.

## *7.2.2 RUSLE Calculator*

The RUSLE Calculator uses methodology and processes described in the USDA-ARS Agricultural Handbook No. 703 to compute an estimated annual sediment load leaving the landscape.
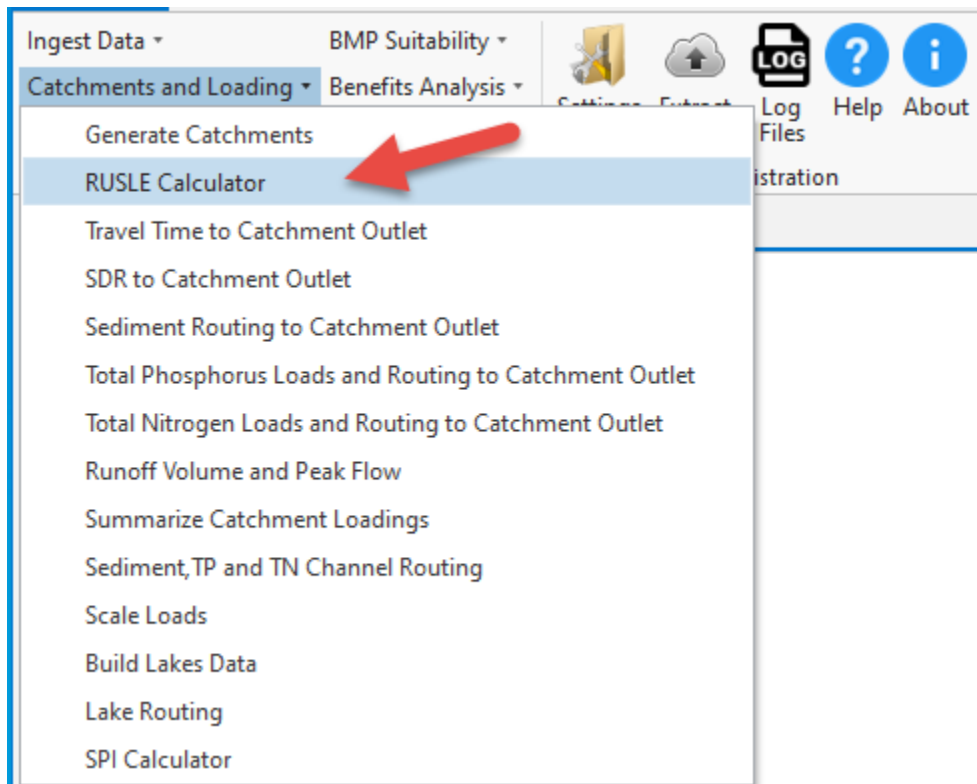
a.  Inputs:
    i.   *Data output folder*: This is the output path where the standardized PTMApp-Desktop geodatabases and associated data will be saved. Users can change this file path in the settings button
    ii.  *Input Raw raster Z factor*:  Multiplies the elevation values by the factor.
b.  Outputs:
    i.   *RUSLE sediment loss raster*:  The sediment loss rate predicted by RUSLE in tons/acre/year.
    ii.  *Output LS Factor*:  Length-slope factor computed using the conditioned DEM.

Catchments and Loading - RUSLE Calculator ()                          ✕

The RUSLE Calculator uses methodology and processes described in the USDA-ARS Agricultural Handbook No. 703 to compute an estimated annual sediment load leaving the landscape.

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)
- **RUSLE sediment loss raster** - Sed_mass_raw
- **Output LS factor** - ls_factor
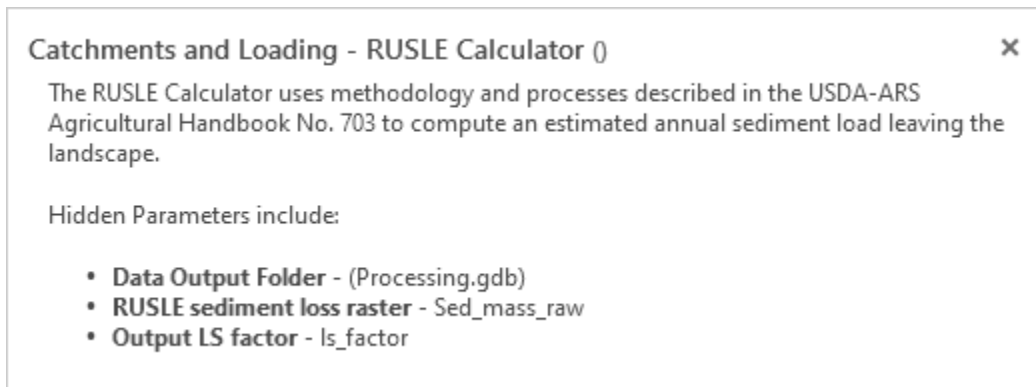
### 7.2.3 Travel Time to Catchment Outlet

The tool computes the travel times for each raster cell to the nearest downstream catchment outlet using conditioned DEM products and a raster representing the travel time between cells.
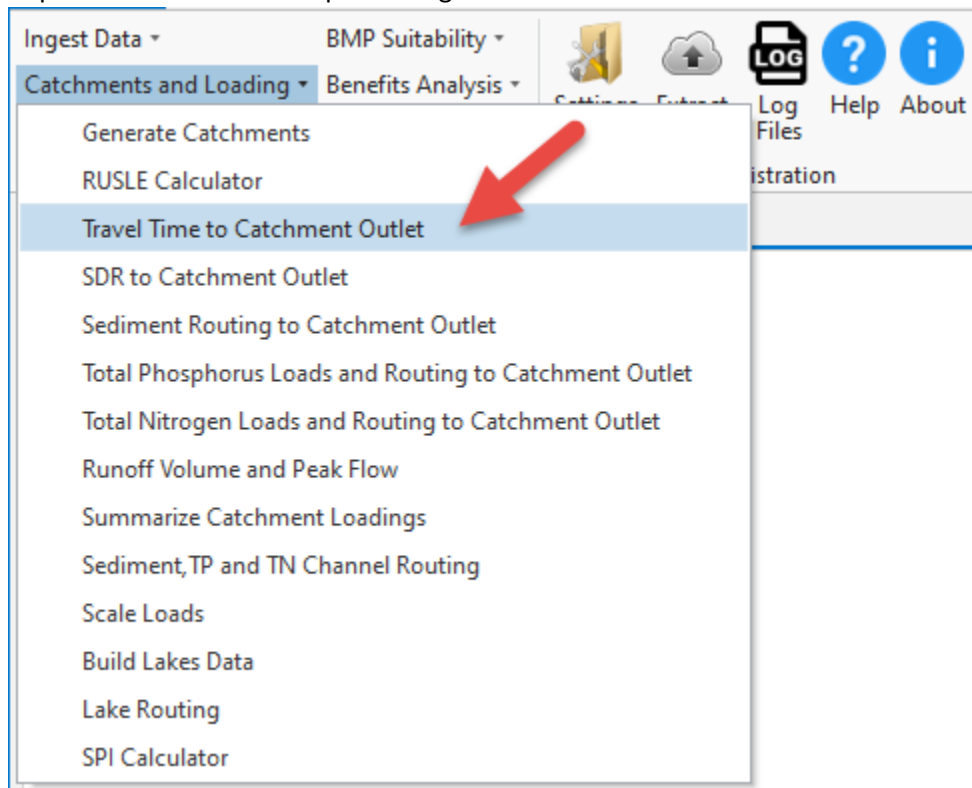


a. Inputs:
   i. *Flow Direction Raster*: A raster of flow direction from each cell to its steepest downslope neighbor. This layer is created outside of PTMApp preferably from a hydrologically conditioned DEM.
b. Outputs:
   i. *Travel time to catchment outlet (in hours):* Travel times for each raster cell to the nearest downstream catchment outlet.
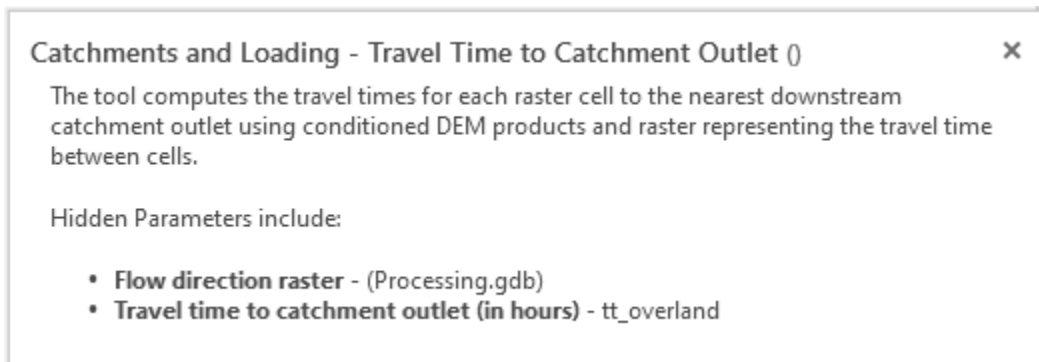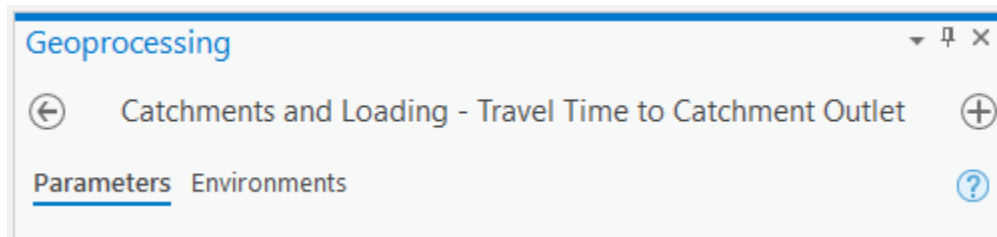
## 7.2.4 Sediment Delivery Ratio to Catchment Outlet

The Overland SDR Calculator uses drainage area and flow length to calculate an overland Sediment Delivery Ratio (SDR) computed as SDR = 0.41 x Drainage Area (in square kilometers)$^{-0.3}$ with an additional adjustment based on the flow length distance to the flow line.
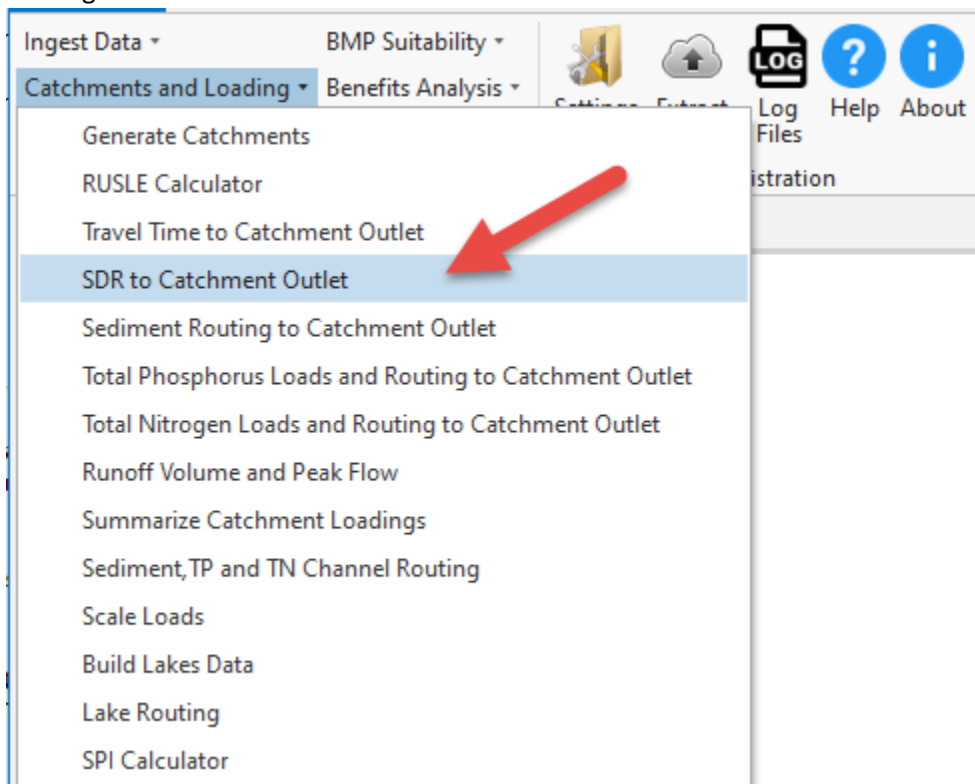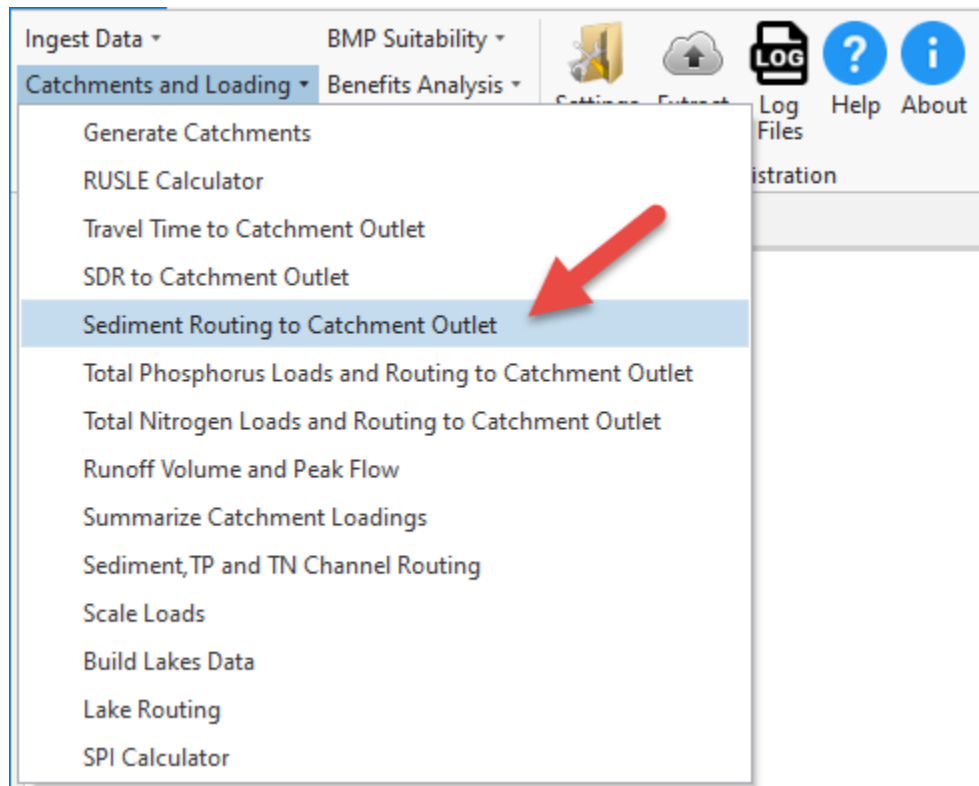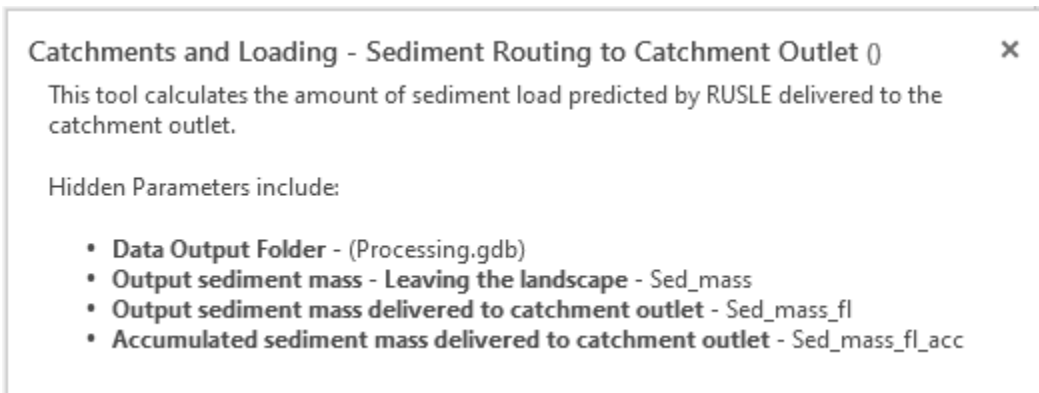


    a.   Inputs:

i. *Data output folder:* This is the output path where the standardized PTMApp-Desktop geodatabases and associated data will be saved. Users can change this file path in the settings button

ii. *Grid cell SDR adjustment factor*: Coefficient used within the Overland SDR Adjustment Factor equation to adjust the Overland SDR based on flow length.  Default value is '0.75'.

b. Outputs:

i. *Output sediment delivery ratio*: The ratio of the RUSLE sediment load delivered to the catchment outlet.
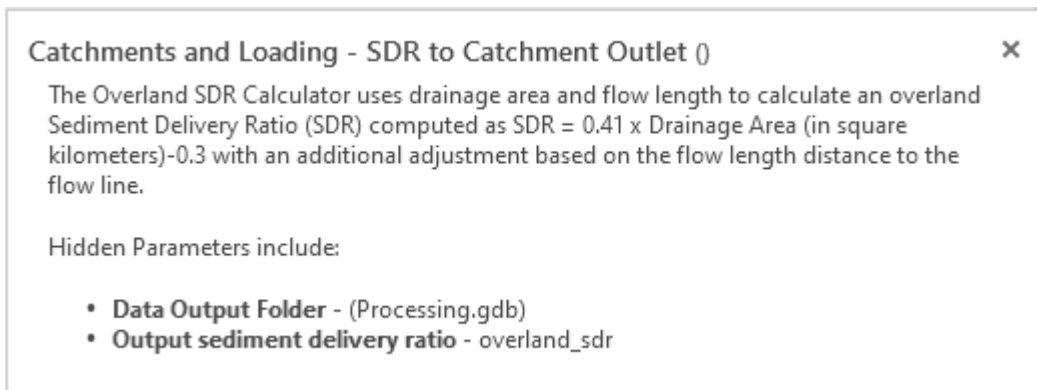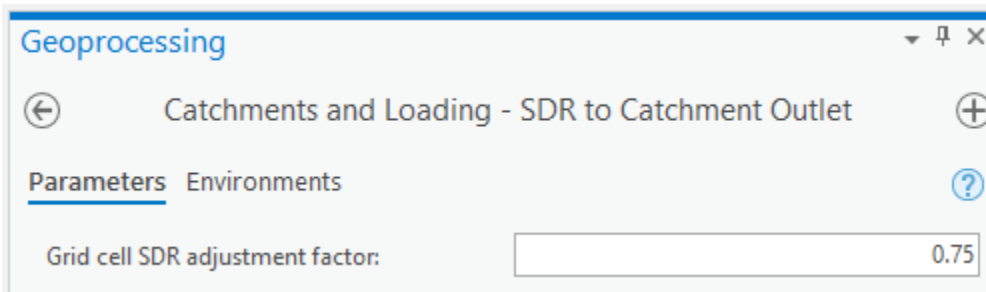


## 7.2.5 Sediment Routing to Catchment Outlet

This tool calculates the amount of sediment load predicted by RUSLE delivered to the catchment outlet.

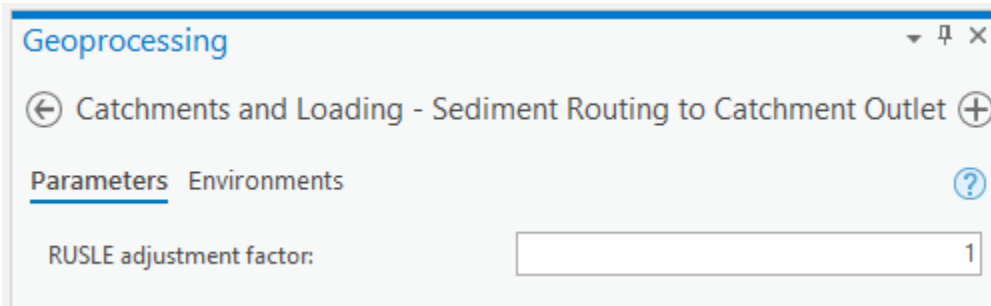a. Inputs:

    i. *Data output folder:* This is the output path where the standardized PTMApp-Desktop geodatabases and associated data will be saved. Users can change this file path in the settings button

    ii. *RUSLE adjustment factor*: A multiplying factor used to calibrate the predicted sediment load by RUSLE to observed sediment load measurements.  Default value is '1', meaning no addition calibration.
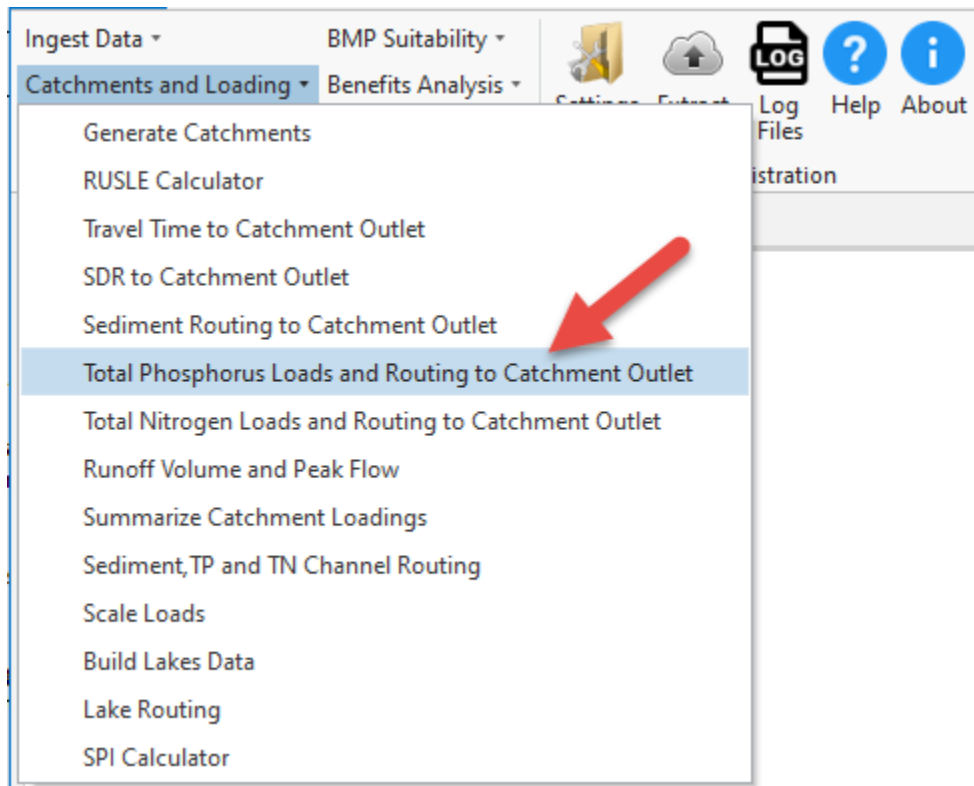
b. Outputs:

    i. *Output sediment mass – Leaving the Landscape*: The input sediment loss raster multipled by the RUSLE adjustment factor.

    ii. *Output sediment mass delivered to catchment outlet*:  The amount of sediment load predicted by RUSLE delivered to the catchment outlet

    iii. *Accumulated sediment mass delivered to catchment outlet*:  The amount of sediment load delivered to the catchment outlet accumulated in the downstream direction.

### 7.2.6 Total Phosphorus Loads and Routing to Catchment Outlet

This tool calculates a predicted Total Phosphorus (TP) load leaving the landscape based on land use and literature values (see PTMApp theory and technical documentation for details) and the amount of that load reaching downstream locations.

a. Inputs:

   i. *Data output folder*: This is the output path where the standardized PTMApp-Desktop geodatabases and associated data will be saved. Users can change this file path in the settings button

   ii. *Overland decay coefficient*: The routing coefficient used in a $1^{st}$-order decay equation to predict the sediment lost in transport during overland transport to the channelized streams. The default value for this input is '0.1'.

   iii. *NLCD lookup*: A lookup table relating the NLCD integer code value to a literature based annual loading value. The lookup values are multiplied by 1,000 for proper conversion within the tool (1 kg/hectare/year is entered as 1,000)

b. Outputs:

   i. *Output TP mass – Leaving the landscape*: The amount of TP mass generated from the raster cell based on the land use and literature values. Units are in pounds/acre/year.

   ii. *Output TP mass delivered to catchment outlet*: The TP mass multiplied by a delivery ratio based on overland travel time to the catchment outlet.

   iii. *Output accumulated TP mass delivered to catchment outlet*: The TP mass delivered to the catchment outlet and accumulated in the downstream direction.
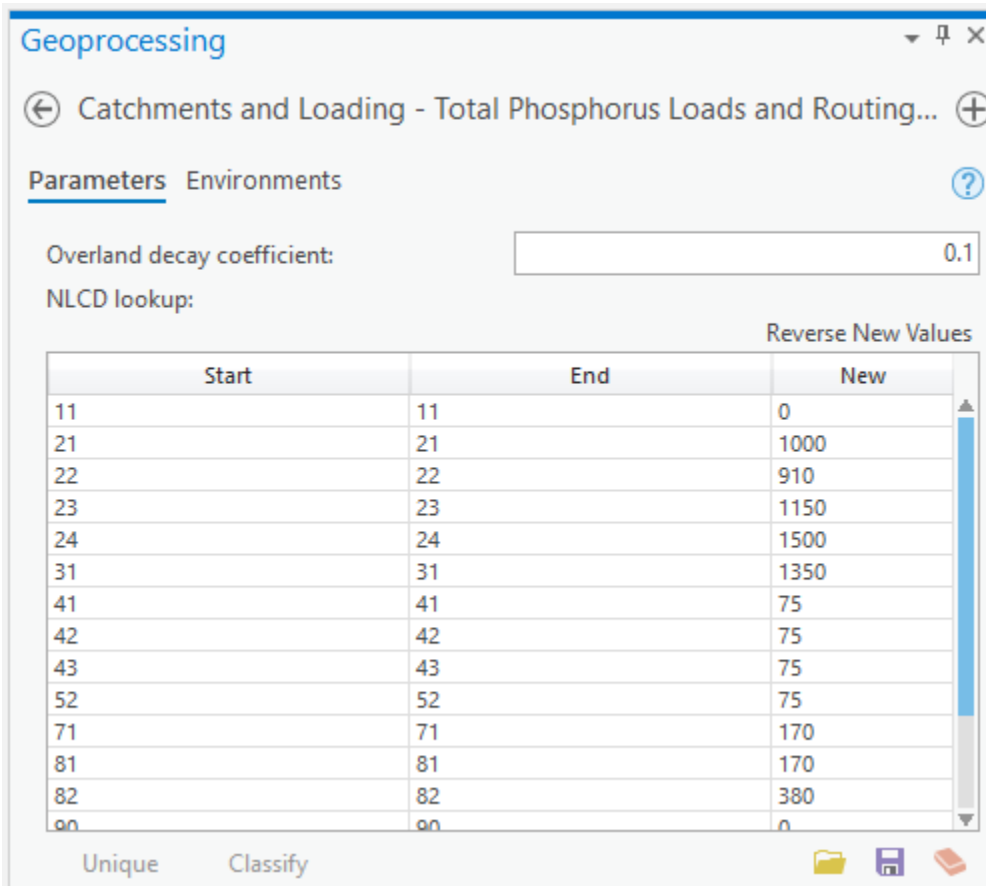
Catchments and Loading - Total Phosphorus Loads and Routing to Catchment Outlet () ✕
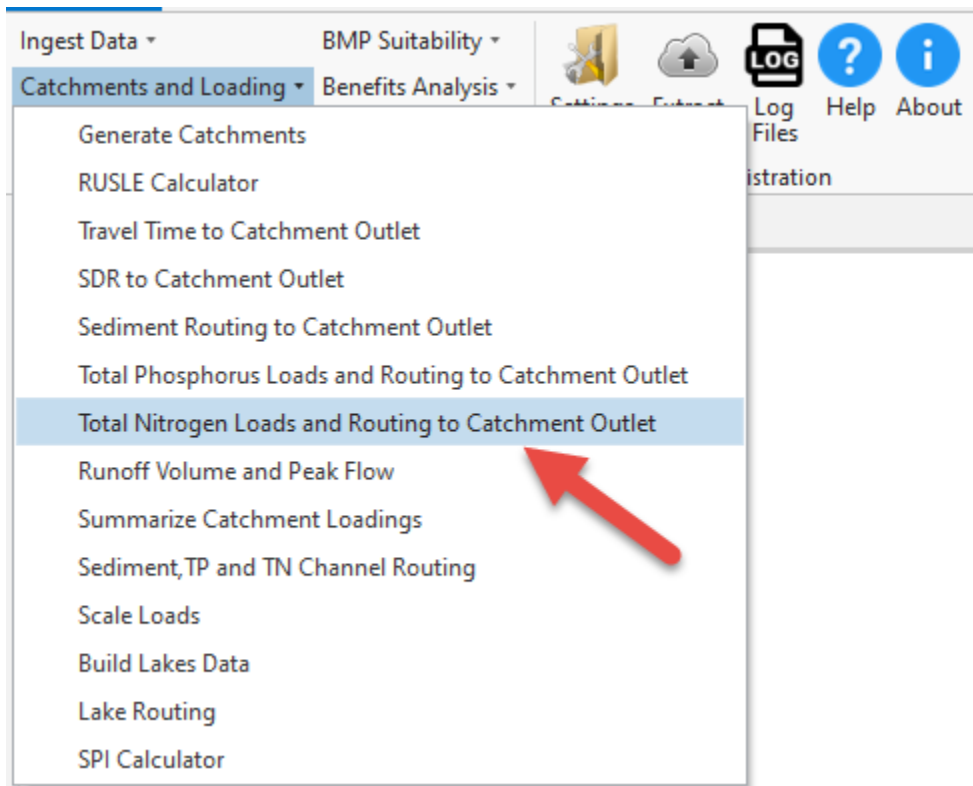
The tool calculates a predicted Total Phosphorus (TP) load leaving the landscape based on land use and literature values and the amount of that load reaching downstream locations.

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)
- **Output TP mass leaving the landscape** - TP_mass
- **Output TP mass delivered to catchment outlet** - TP_mass_fl
- **Output accumulated TP mass delivered to catchment outlet** - TP_mass_fl_acc

### 7.2.7 Total Nitrogen Loads and Routing to Catchment Outlet

This tool calculates a predicted TN load leaving the landscape based on land use and literature values (see PTMApp theory and technical documentation for details) and the amount of that load reaching downstream locations.
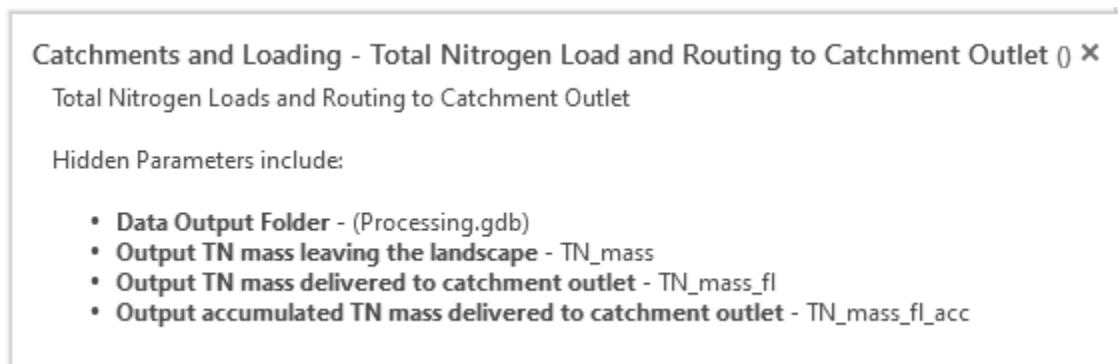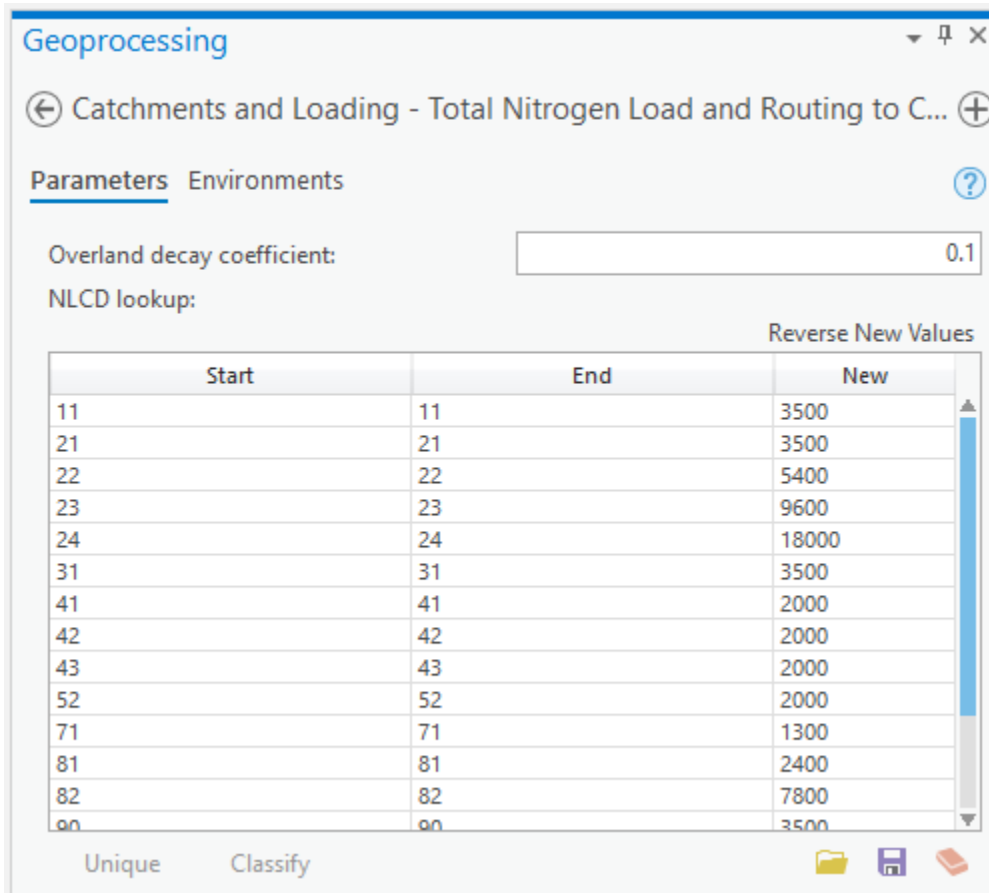
a. Inputs:

    i. *Data output folder:* This is the output path where the standardized PTMApp-Desktop geodatabases and associated data will be saved. Users can change this file path in the settings button

    ii. *Overland decay coefficient*: The routing coefficient used in a 1st-order decay equation to predict the sediment lost in transport during overland transport to the channelized streams.  The default value for this input is '0.1'.

    iii. *NLCD lookup*:  A lookup table relating the NLCD integer code value to a literature based annual loading value.  The lookup values are multiplied by 1,000 for proper conversion within the tool (1 kg/hectare/year is entered as 1,000).
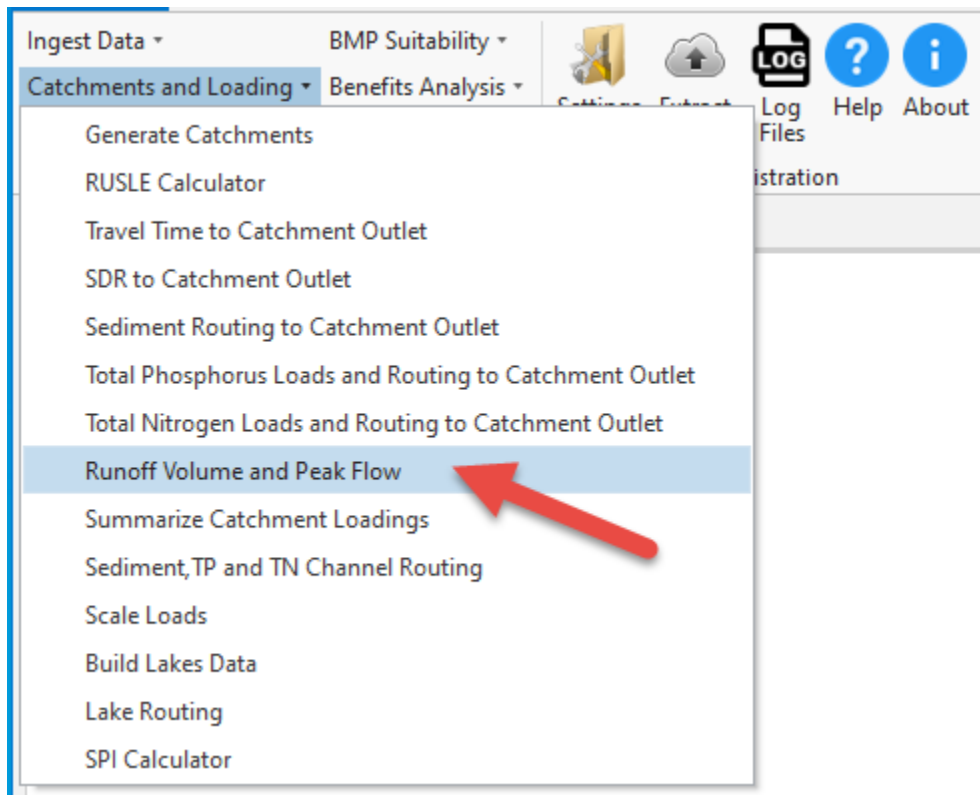
b. Outputs:

    i. *Output TN mass – Leaving the landscape*:  The amount of TN mass generated from the raster cell based on the land use and literature values.  Units are in pounds/acre/year.

    ii. *Output TN mass delivered to catchment outlet*:  The TN mass multiplied by a delivery ratio based on overland travel time to the catchment outlet.

    iii. *Output accumulated TN mass delivered to catchment outlet*:  The TN mass delivered to the catchment outlet and accumulated in the downstream direction.
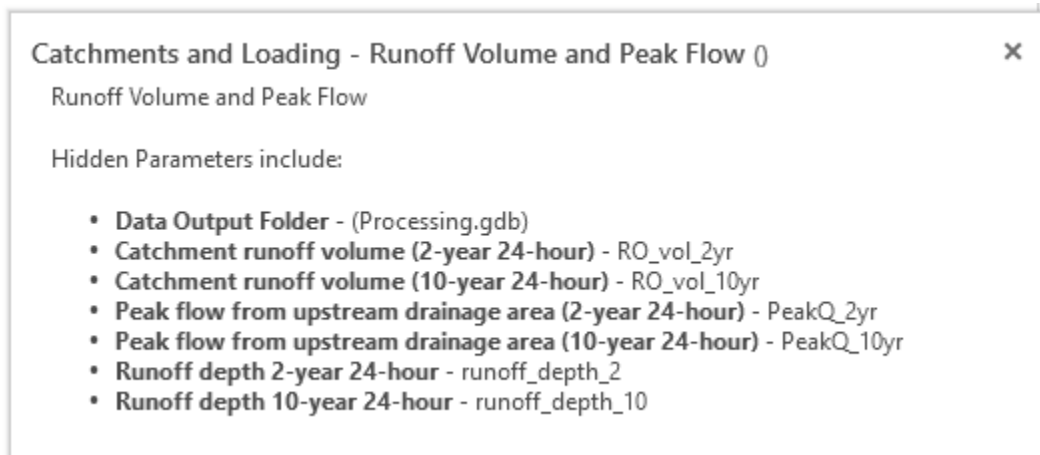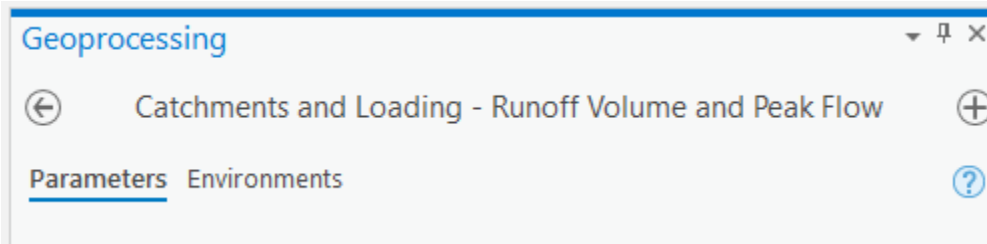
### 7.2.8 Runoff Volume and Peak Flow

In this step, PTMApp calculates the runoff volume and peak discharge for 2-year, 24-hour, and 10-year, 24-hour precipitation events.  The user has the option to manually change the precipitation depth of the rainfall events.
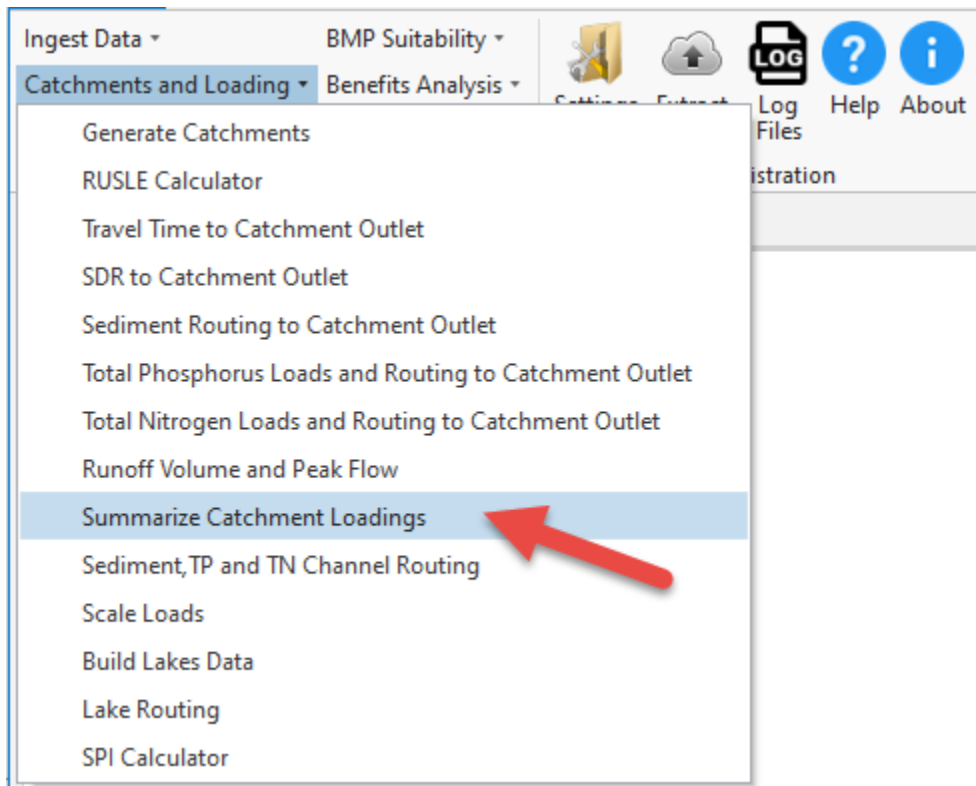
a. Inputs:
    i. *Data output folder*:  This is the output path where the standardized PTMApp-Desktop geodatabases and associated data will be saved. Users can change this file path in the settings button

b. Outputs:
    i. *Catchment Runoff volume  (2-year 24-hour):*  The catchment runoff volume in cubic feet for 2-year 24-hour rainfall event
    ii. *Catchment Runoff volume (10-year 24-hour):* The catchment runoff volume in cubic feet for 10-year 24-hour rainfall event
    iii. *Peak flow from upstream drainage area (2-year 24-hour)*: Catchment peak discharge in cubic feet per second for 2-year 24-hour rainfall event
    iv. *Peak flow from upstream drainage area (10-year 24-hour)*: Catchment peak discharge in cubic feet per second for 10-year 24-hour rainfall event
    v. *Runoff depth (2-year 24-hour)*: Catchment runoff depth in inches for 2-year 24-hour rainfall event
    vi. *Runoff depth (10-year 24-hour):* Catchment runoff depth in inches for 10-year 24-hour rainfall event

Geoprocessing ▾ ⊓ ×

⊕      Catchments and Loading - Runoff Volume and Peak Flow     ⊕

Parameters   Environments     ⑦

Catchments and Loading - Runoff Volume and Peak Flow ()     ×

Runoff Volume and Peak Flow

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)
- **Catchment runoff volume (2-year 24-hour)** - RO_vol_2yr
- **Catchment runoff volume (10-year 24-hour)** - RO_vol_10yr
- **Peak flow from upstream drainage area (2-year 24-hour)** - PeakQ_2yr
- **Peak flow from upstream drainage area (10-year 24-hour)** - PeakQ_10yr
- **Runoff depth 2-year 24-hour** - runoff_depth_2
- **Runoff depth 10-year 24-hour** - runoff_depth_10

### 7.2.9 Summarize Catchment Loadings

The Summarize Catchment Loading tool generates an output table that contains the source assessment information, routed to the catchment outlet, for the intervening drainage area of each unique catchment.
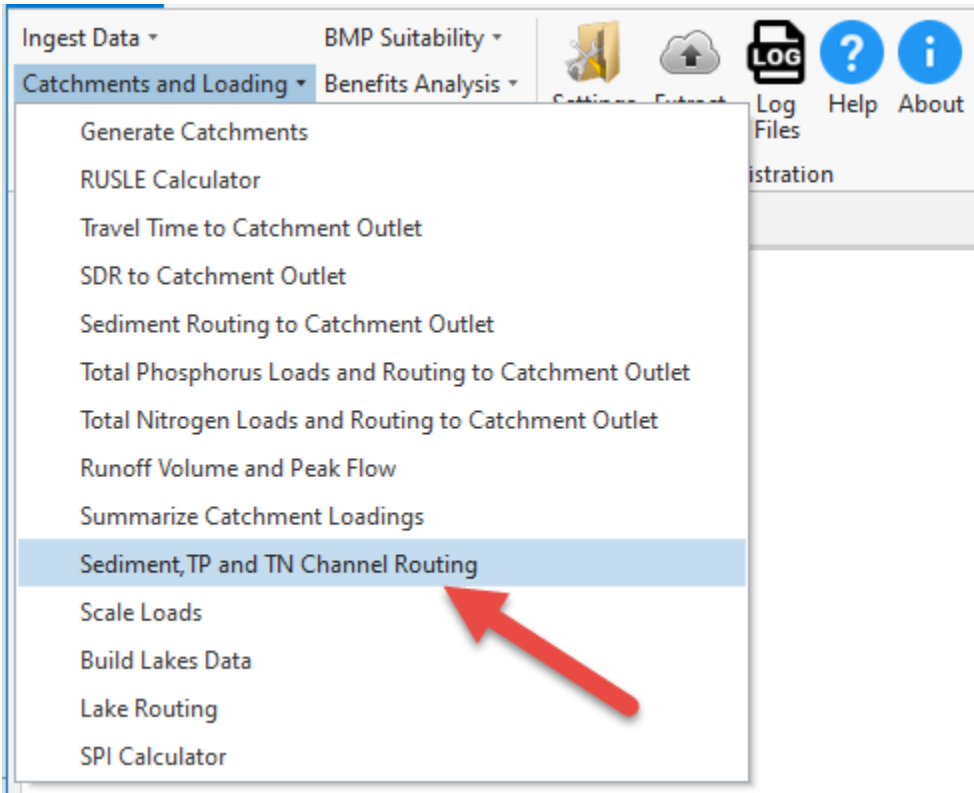
a. Inputs:
   i. *Data Output Folder:* location where output products will be saved.
   ii. *PTMApp products process internally include:* Catchments, Sed_mass, Sed_mass_fl, Sed_mas_fl_acc, TP_mass, TP_mass_fl, TP_mas_fl_acc, TN_mass, TN_mass_fl, TN_mas_fl_acc
b. Outputs:
   i. *table_catchment:* stores sediment, TP, and TN loads/yields routed to the catchment outlet
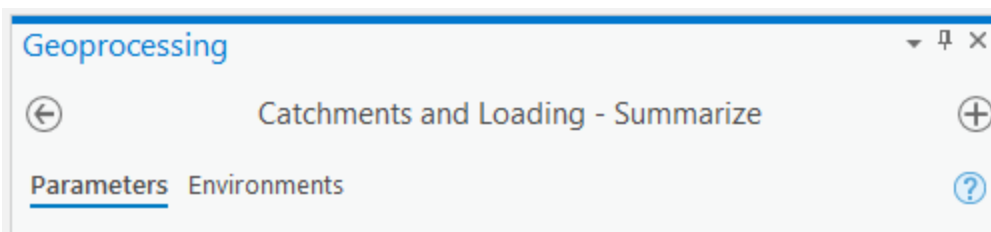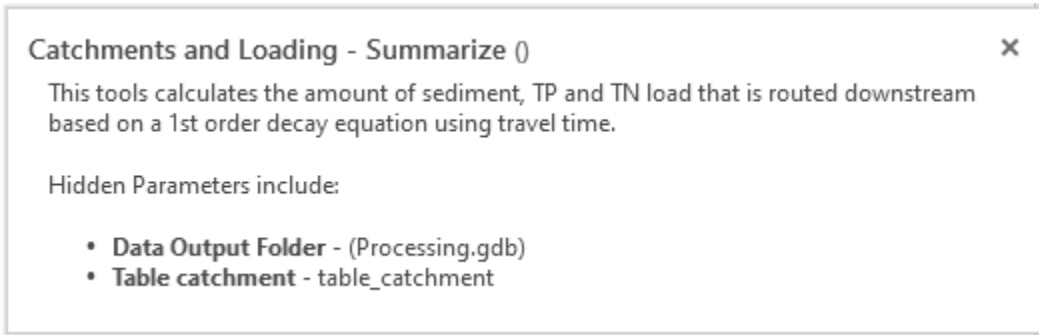
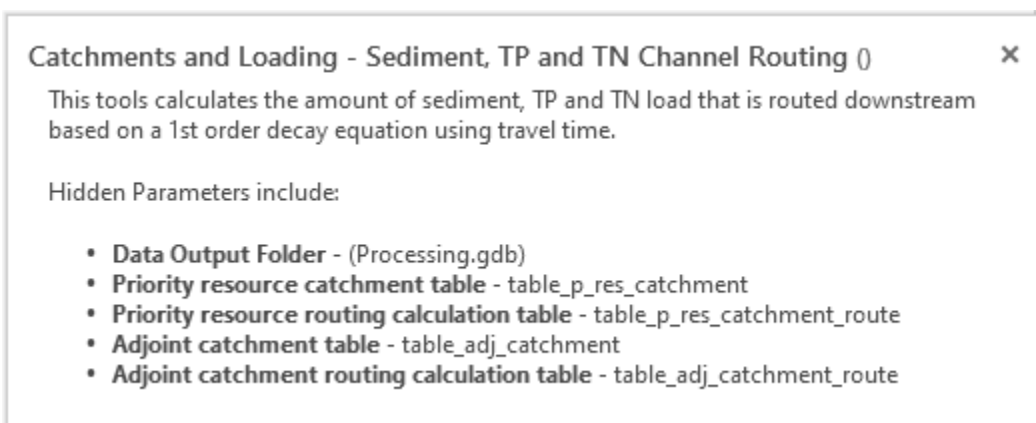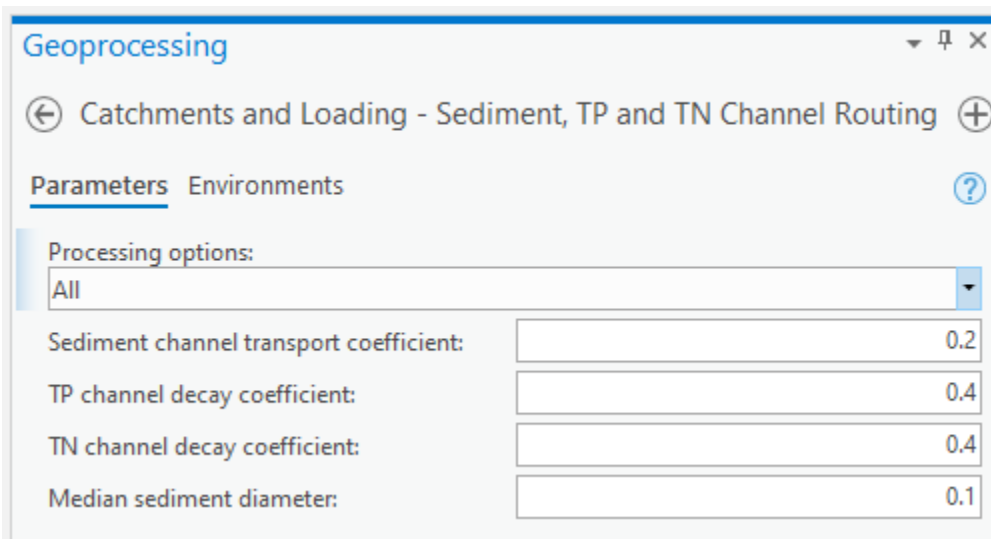## 7.2.10 Sediment, Total Phosphorus and Total Nitrogen Channel Routing

This tool calculates the amount of sediment, TP and TN load that is routed downstream based on a 1$^{st}$ order decay equation using travel time.



a. Inputs:
   i. *Processing options*: You may choose to determine loads/yields for priority resource catchments, adjoint catchments, or both (represented by the input 'All'). This option should match the option chosen when you generated your catchments. The default for this input is 'All'.
   ii. *Data Output Folder:* location where output products will be saved.
   iii. *Sediment channel transport coefficient:* The routing coefficient used in a 1$^{st}$-order decay equation to predict the sediment lost in transport through channelized streams prior to or between priority resource points. The default value for this input is '0.2'.

iv. *TP and TN channel decay coefficient:* The routing coefficient used in a 1st-order decay equation to predict the TP and TN lost in transport through channelized streams prior to or between priority resource points.  The same value is applied for both TP and TN routing.  The default value for this input is '0.1'.

v. *Median sediment diameter:* median diameter (mm) of eroded sediment.  The default value for this input is '0.1'.

b. Outputs:

i. *Priority Resource Catchment Tables:* Store the sediment, TP and TN loads routed to each priority resource outlet (table_p_res_catchment and table_p_res_catchment_route).

ii. *Adjoint Catchment Tables:*  Store the sediment, TP and TN loads routed to each adjoint catchment outlet (table_adj_catchment and table_adj_catchment_route).

---

**Geoprocessing**　　　　　　　　　　▾ ⊥ ✕

◉ Catchments and Loading - Sediment, TP and TN Channel Routing ⊕

**Parameters**  Environments　　　　　　　　　　　⑦

Processing options:

| All | ▾ |
|---|---|

| Sediment channel transport coefficient: | 0.2 |
|---|---|
| TP channel decay coefficient: | 0.4 |
| TN channel decay coefficient: | 0.4 |
| Median sediment diameter: | 0.1 |

---

Catchments and Loading - Sediment, TP and TN Channel Routing ()　　　✕

This tools calculates the amount of sediment, TP and TN load that is routed downstream based on a 1st order decay equation using travel time.

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)
- **Priority resource catchment table** - table_p_res_catchment
- **Priority resource routing calculation table** - table_p_res_catchment_route
- **Adjoint catchment table** - table_adj_catchment
- **Adjoint catchment routing calculation table** - table_adj_catchment_route

## 7.2.11 Scaled Loads

This tool is an optional tool. It scales the sediment, TP and TN loading values generated within PTMApp to match either modeled output or observed data, which may come from a calibrated watershed model or estimated loads based on monitoring data:
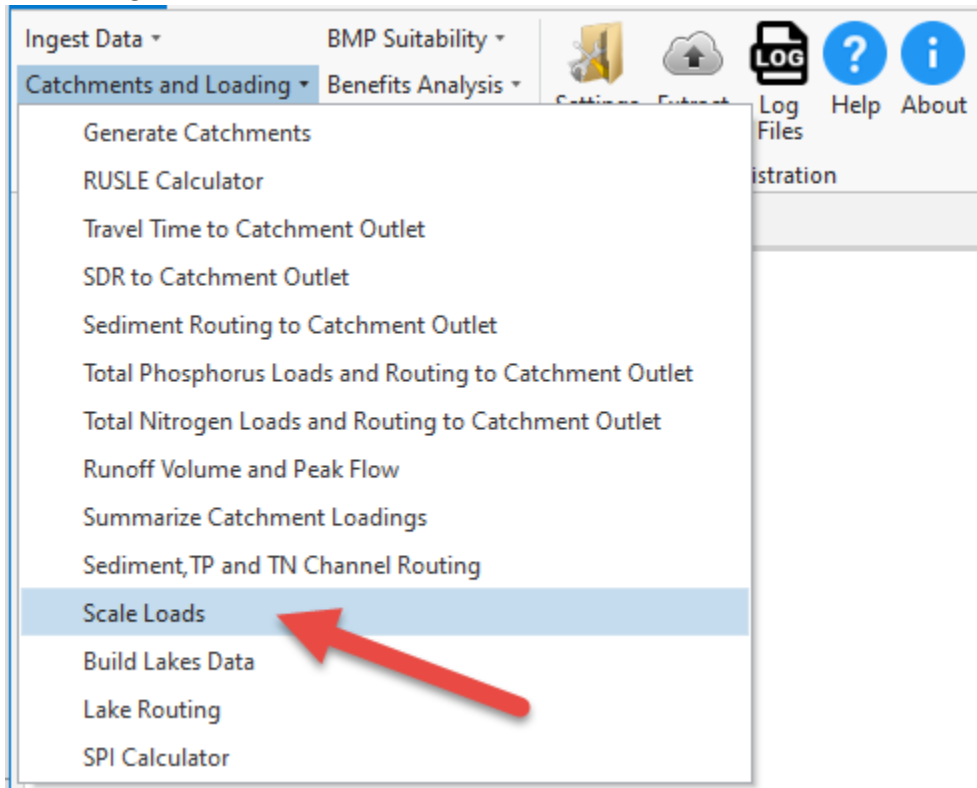


a. Inputs:
   i. *Data output folder*: This is the output path where the standardized PTMApp desktop geodatabases and associated data will be saved. Users can change this file path in the settings button.
   ii. *Scale type*: Select the type of data for the scaling. The model type will allow polygon features to be used for load scaling. The point type will scale loads based on observed data at one location.
      a. *Point*: This can only use 1 point from guage data.
      b. *Model*: This polygon cover the whole project area.
   iii. *Processing type*: Select Adjoint Catchments or Proresource Catchments to run the scale loads on.
   iv. *Spatial data layer*: Choose the point or polygon feature class that contain the correct attributes.
      1. The point layer for the Gauge type must be attributed with "sed_gauge", "tp_gauge" and "tn_gague" fields. Only one point can be used for this option.
      2. The polygon layer for the Model type must be attributed with "sed_yld_model", "tp_yld_model", and "tn_yld_model" fields. It would be user generated. It can

be any masking layer (e.g. PERLND layer from HSPF, polygon layer for HRU in SWAT, subbasins, etc.) with yields attached to the polygons.
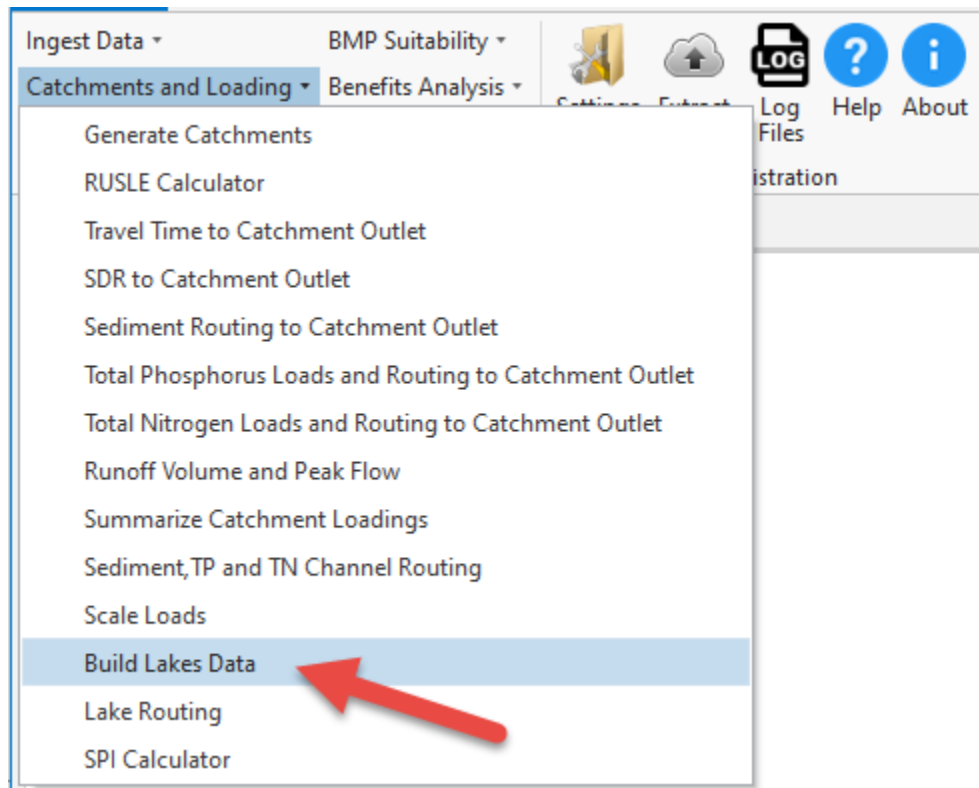
 b. Outputs:

   i. *Table scaled load*:  Stores the scaled loads for sediment, TP and TN for each catchment.
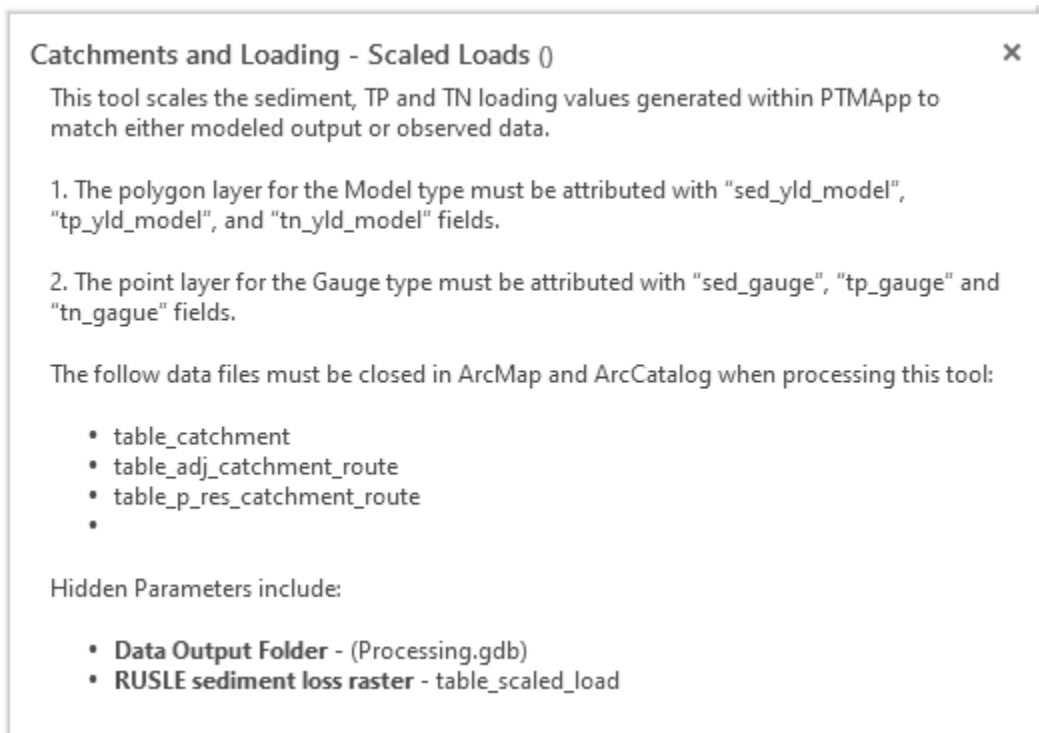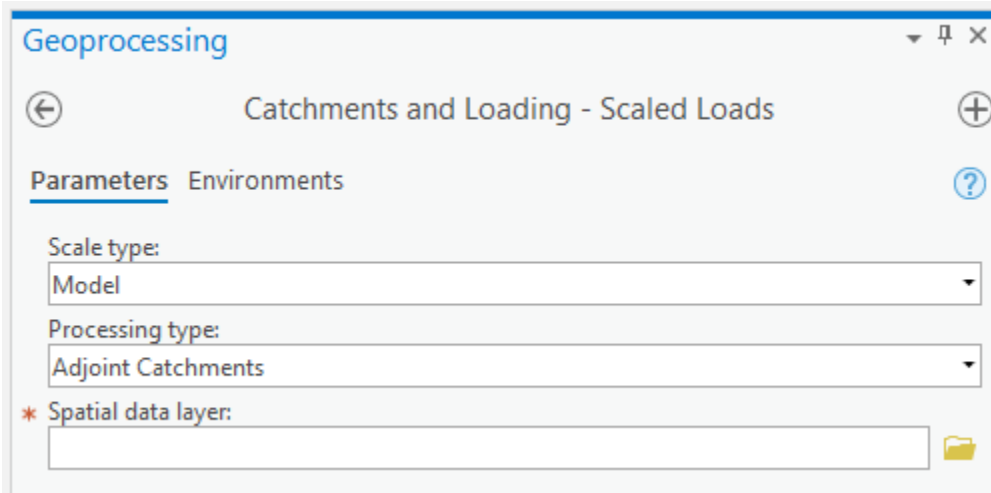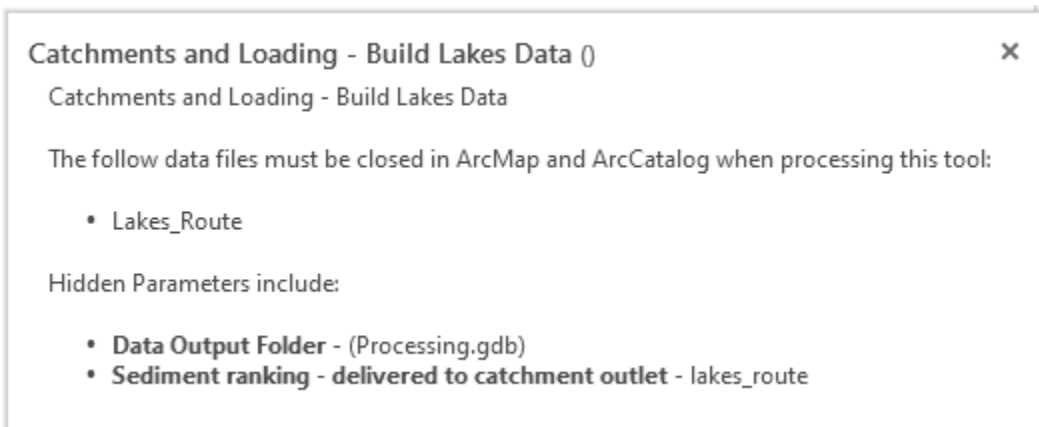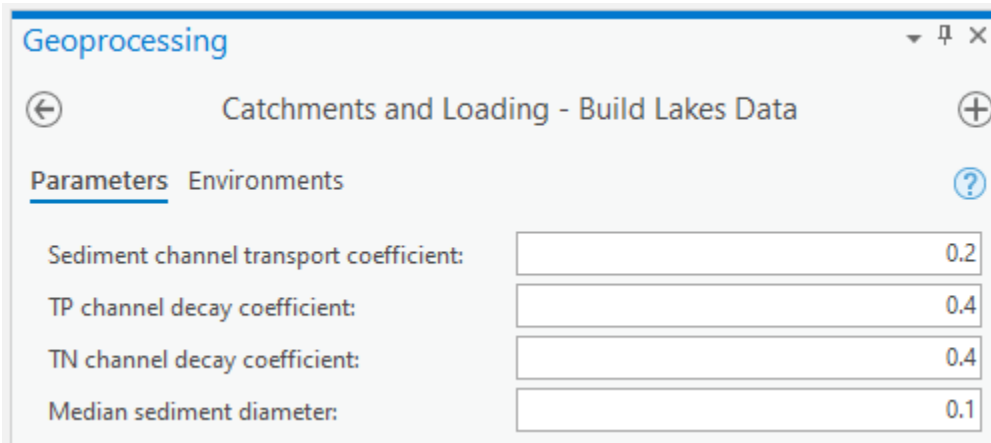




### 7.2.12 Build Lakes Data

The Build Lakes Data tool uses an input lakes polygon layer to build the attribute catalog necessary to run lakes routing.  This tool can be run for any storage feature provided in the lakes polygon layer, including lakes, reservoirs, wetlands, and sloughs.

a. Inputs:
   i. *Data Output Folder:* location where output products will be saved.
   ii. *Lakes layer:* A feature class including lake polygons which will be run through lake routing. The feature class must include the following attributes.
      - 'LAKE_ID' (long integer) - a unique identifier for each lake
      - 'Area_ac' (floating point) – surface area of the lake (acres)
      - 'lake_count' (long) – Connects lakes data to the priority resource point to calculate loads received, retained, and exported from the lake. This column should only be populated by the user for the lakes that have priority resource points at a lake exit. If there is no priority resource point at a lake exit, leave the cell blank. See section 4.8 for additional information if you have not completed this step yet.
   iii. *Sediment channel transport coefficient:* The routing coefficient used in a 1st-order decay equation to predict the sediment lost in transport through channelized streams prior to or between priority resource points. The default value for this input is '0.2'.
   iv. *TP channel decay coefficient:* The routing coefficient used in a 1st-order decay equation to predict the TP lost in transport through channelized streams prior to or between priority resource points. The default value for this input is '0.4'.
   v. *TN channel decay coefficient:* The routing coefficient used in a 1st-order decay equation to predict the TN lost in transport through channelized streams prior to or between priority resource points. The default value for this input is '0.4'.

vi. *Median sediment diameter:* median diameter (mm) of eroded sediment.  The default value for this input is '0.1'.

b. Outputs:

i. *Lakes_route:* attributes were added to the Lake_route feature class in your Processing.gdb.  A full description of these attributes can be found in the Attribute Catalog.
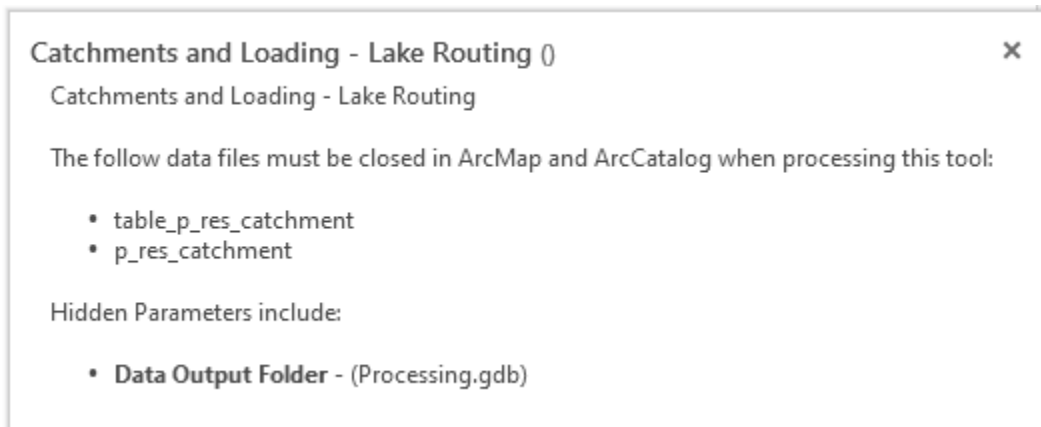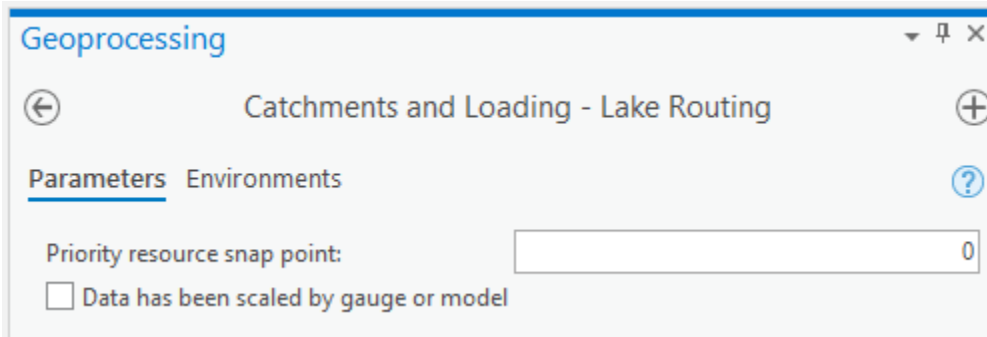




## 7.2.13 Lake Routing

The Lake Routing tool uses the sediment, TP, and TN retention fractions estimated in Build Lakes Data based on the morphometric features of each lake basin to estimate the sediment and nutrient load retained in each lake. The Build Lakes Data tool MUST be run prior to running the Lake Routing tool.

Lake Routing will not run if the user has not added the lake_count field to the p_res_pts point file and the lake_route shapefile.  See section 4.8 Lake Routing to complete this task correctly if it has not already been done.  Keep in mind that if you have not done steps in section 4.8 yet, you must update the information as written in that section in the output processing.gdb, not the input processing.gdb like you would have done in section 4.8 Lake Routing because you have already ingested the data.
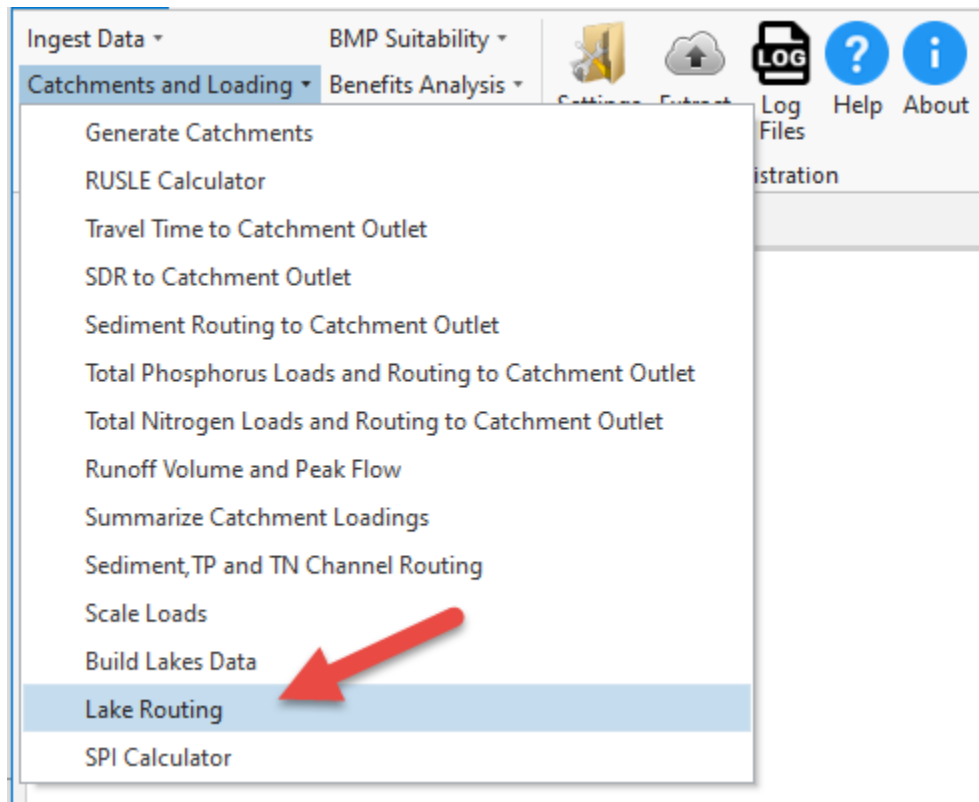
a. Inputs:
  i. *Data Output Folder:* location where output products will be saved.
  ii. *Priority resource snap point*: This value determines the number of cells around each priority resource point to search for the highest flow accumulation cell. This input is necessary as priority resource points may not always be placed directly over the flow line. The default value is 0. Please reference section 5.2.5 in Workshop Session 1 for setting this value while running Lake routing. A lower value may be recommended if lakes were conditioned using the "Breakthrough" method to capture lake inlets (pages 28-30 in Workshop Session 1). For most applications values 0 to 5 are suitable.
  iii. *Data has been scaled by gauge or model (optional):* optional input that should be checked if data has been scaled and you wish to have it reflected in your lake modeling results
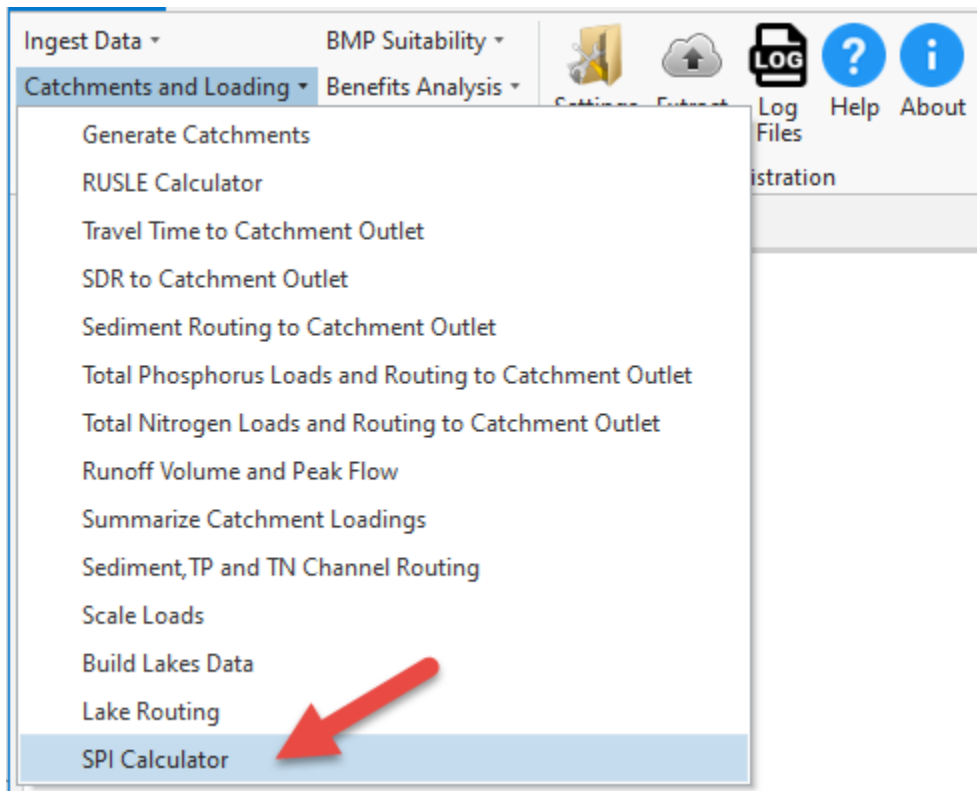
    b.  Outputs:

        i.  *Table priority resource catchment route*: table summarizing load/yield delivered to each priority resource catchment outlet.  This table will be updated based on lake routing results (not shown in user interface).

## 7.2.14 Stream Power Index (SPI) Calculator

The SPI Calculator uses rasters derived from a conditioned DEM to compute the Stream Power Index (SPI) expressed as:  In $(\frac{\text{drainage area}}{\text{slope}})$.  The SPI raster excludes cells with a upstream flow length less than 300 feet and cells with a larger drainage area than specified in the tool setting.

a. Inputs:
    i. *Data output folder*:  location where output products will be saved.
    ii. *In-channel flow threshold (acres):* The value defines the transistion between shallow concentrated flow and channelized flow using the cell count in the flow accumulation raster.  The default value is '124'.
b. Outputs:
    i. *SPI output raster*:  The output SPI raster.

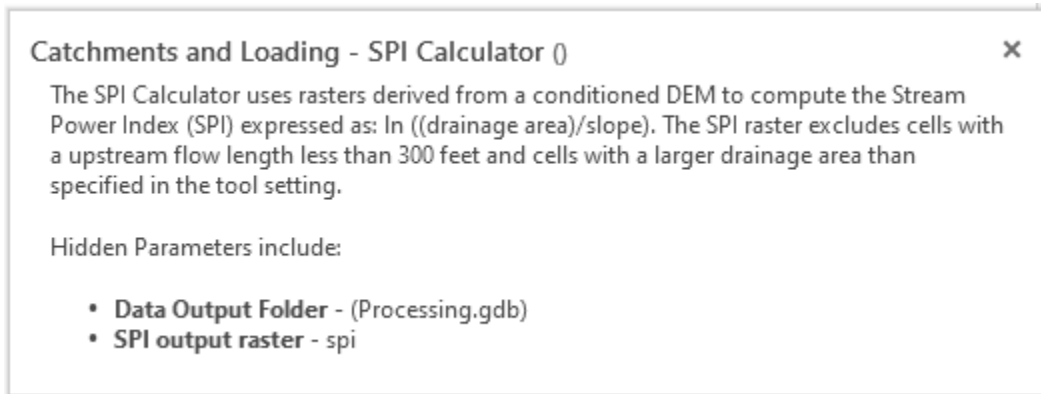**Catchments and Loading - SPI Calculator ()**

The SPI Calculator uses rasters derived from a conditioned DEM to compute the Stream Power Index (SPI) expressed as: ln ((drainage area)/slope). The SPI raster excludes cells with a upstream flow length less than 300 feet and cells with a larger drainage area than specified in the tool setting.
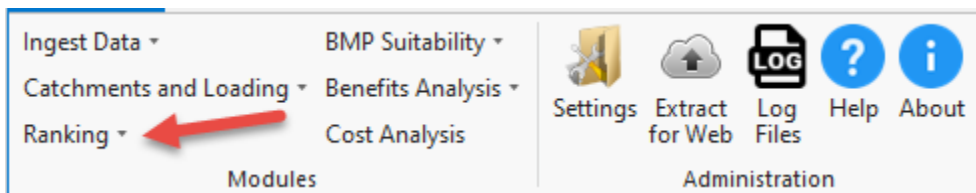
Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)
- **SPI output raster** - spi

## 7.3 Module:  Ranking

This Module allows the user to rank all the TP, TN, and sediment loading and delivery data generated in the Catchments and Loading Module (see section 4.2).



### 7.3.1 Rank - SPI

This tool assigns a percentile ranking to each value in the SPI raster based on an assumed distribution.
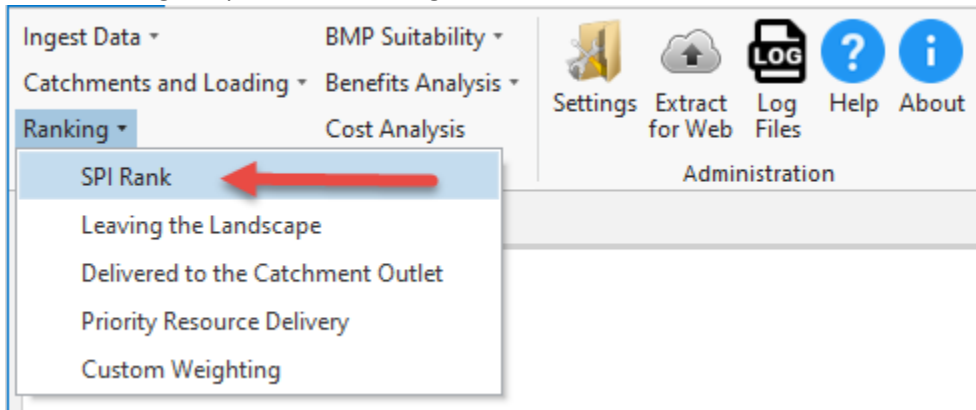


a. Input:
  i.  *Data output folder*:  location where output products will be saved.
b. Output:
  i.  *SPI rank output*:  Raster with ranks assigned based on the input SPI raster.

### 7.3.2 Rank – Leaving the Landscape

This tool assigns percentile rank values for the Sediment, TP and TN leaving the landscape loading raster using an assumed distribution.
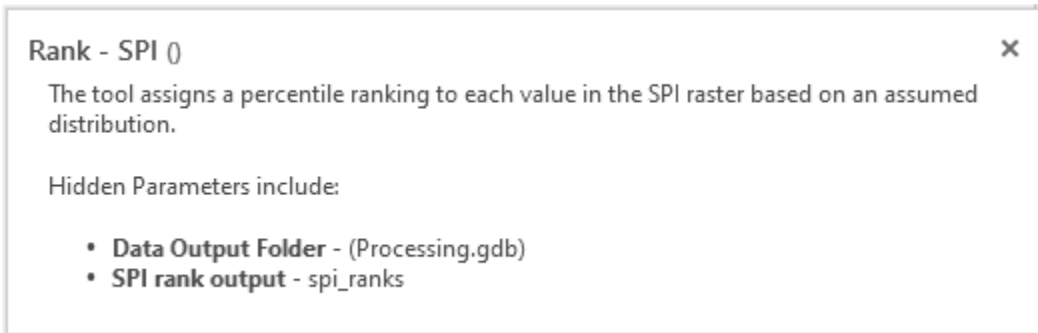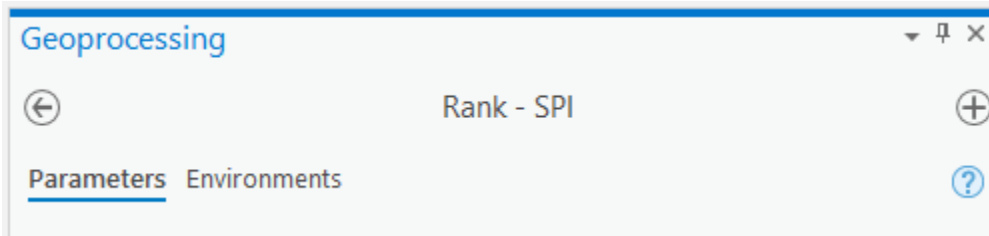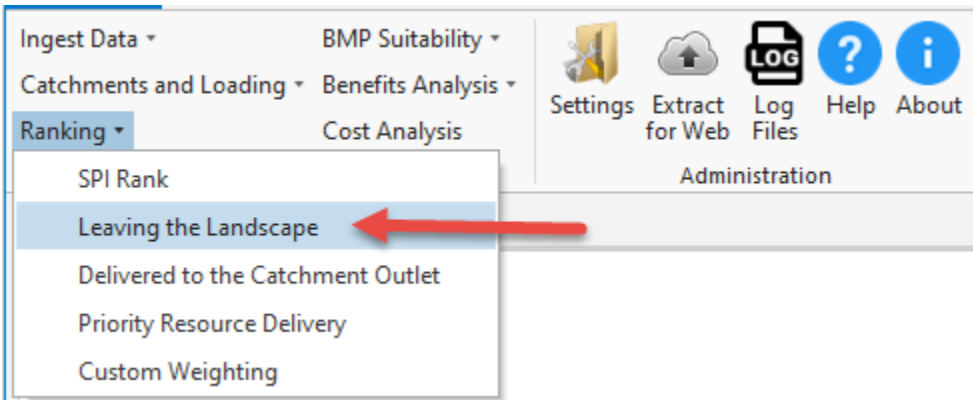


a. Inputs:
   i. *Data output folder*: This is the output path where the standardized PTMApp desktop geodatabases and associated data will be saved. Users can change this file path in the settings button.

b. Outputs:
   i. *Sediment ranking – leaving the landscape*: A raster with the percentile ranking values assigned using the assumed distribution from the sediment loading.
   ii. *TN ranking – leaving the landscape*: A raster with the percentile ranking values assigned using the assumed distribution from the TN loading.

iii. *TP ranking – leaving the landscape*: A raster with the percentile ranking values assigned using the assumed distribution from the TP loading.

iv. *WQI mass rank*:  A raster combining the sediment, TP, and TN ranking values with the following equation (WQI is a Water Quality Index):

$$WQI = 0.25 * TN\_rank + 0.25 * TP\_rank + 0.5 * sed\_rank$$
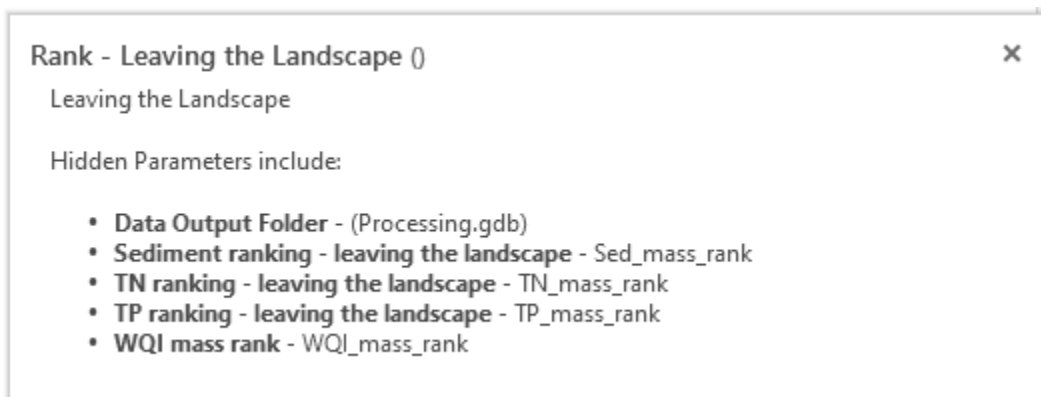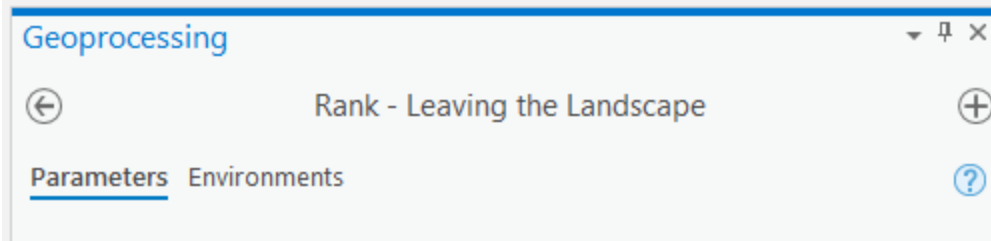


### 7.3.3 Rank – Delivered to the Catchment Outlet

This tool assigns percentile rank values for the Sediment, TP and TN delivered to catchment outlet loading raster using an assumed distribution.



a. Inputs:

i. *Data output folder*:  This is the output path where the standardized PTMApp desktop geodatabases and associated data will be saved. Users can change this file path in the settings button.

b. Outputs:

i. *Sediment ranking – delivered to catchment outlet*:  A raster with the percentile ranking values assigned using the assumed distribution from the sediment loading.

ii. *TN ranking – delivered to catchment outlet*: A raster with the percentile ranking values assigned using the assumed distribution from the TN loading.
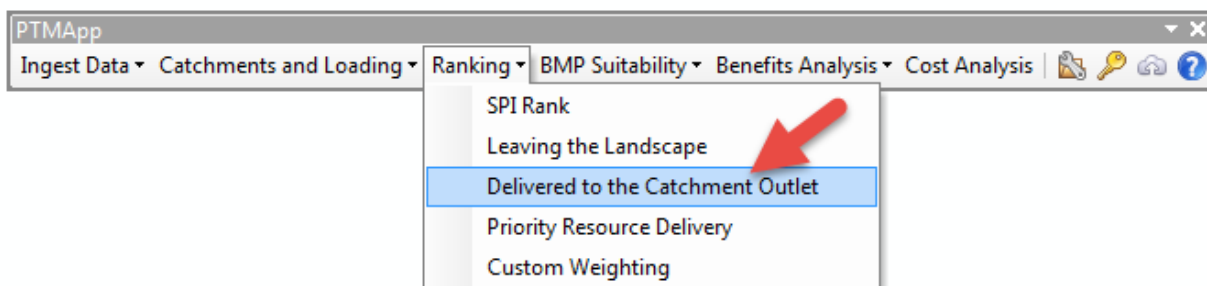
iii. *TP ranking – delivered to catchment outlet*: A raster with the percentile ranking values assigned using the assumed distribution from the TP loading.

iv. *WQI mass rank*: A raster combining the sediment, TP, and TN ranking values with the following equation:

$$WQI = 0.25 * TN\_rank + 0.25 * TP\_rank + 0.5 * sed\_rank$$

Geoprocessing ▾ ⊣ ✕

Rank - Delivered to the Catchment Outlet ⊕

Parameters  Environments ⑦

Rank - Delivered to the Catchment Outlet () ✕

Delivered to the Catchment Outlet

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)
- **Sediment ranking** - delivered to catchment outlet - Sed_mass_fl_rank
- **TN ranking** - delivered to catchment outlet - TN_mass_fl_rank
- **TP ranking** - delivered to catchment outlet - TP_mass_fl_rank
- **WQI mass rank** - WQI_mass_fl_rank

## 7.3.4 Rank – Priority Resource Delivery

This tool assigns percentile rankings to catchments based on their contribution to overall loads delivered to priority resources.
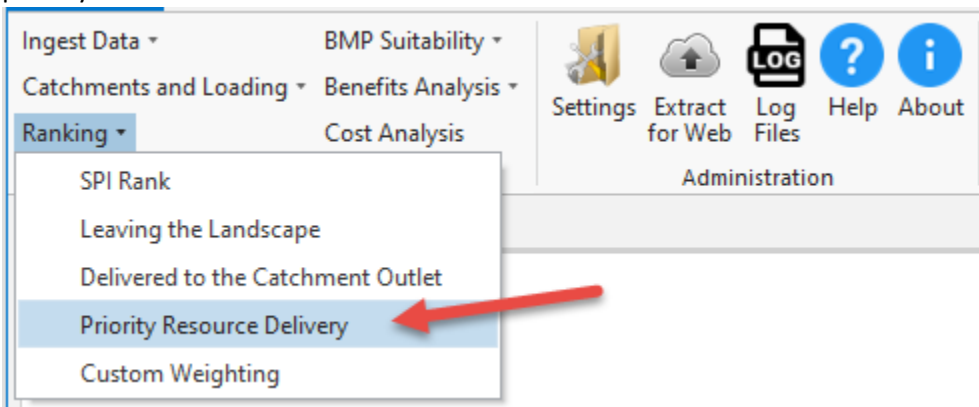
Ingest Data ▾          BMP Suitability ▾
Catchments and Loading ▾  Benefits Analysis ▾        Settings  Extract  Log    Help  About
Ranking ▾              Cost Analysis                       for Web  Files

SPI Rank
Leaving the Landscape
Delivered to the Catchment Outlet
Priority Resource Delivery  ⟵
Custom Weighting

Administration

a.   Inputs:

i. *Data output folder*:  This is the output path where the standardized PTMApp desktop geodatabases and associated data will be saved. Users can change this file path in the settings button.

b. Outputs:

  i. *Ranking Catchment Table*:  Stores percentile rankings based on a catchment's unit yield of sediment, TP, and TN for both leaving the landscape and delivered to catchment outlet for the entire project area.

  ii. *Ranking Catchment Table Priority Resource:*  Stores percentile rankings based on a catchment's unit yield of sediment, TP and TN delivered to each priority resource.
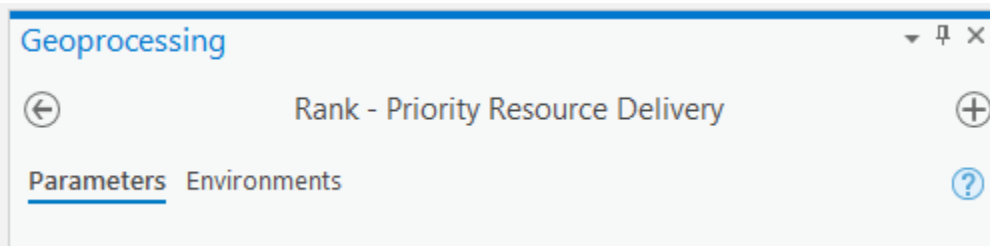




## 7.3.5 Custom Weighting

This tool is an optional tool. It modifies the catchment percentile rankings based on a user specified weight value.

a. Inputs:
  i. *Data output folder*:  This is the output path where the standardized PTMApp desktop geodatabases and associated data will be saved. Users can change this file path in the settings button.
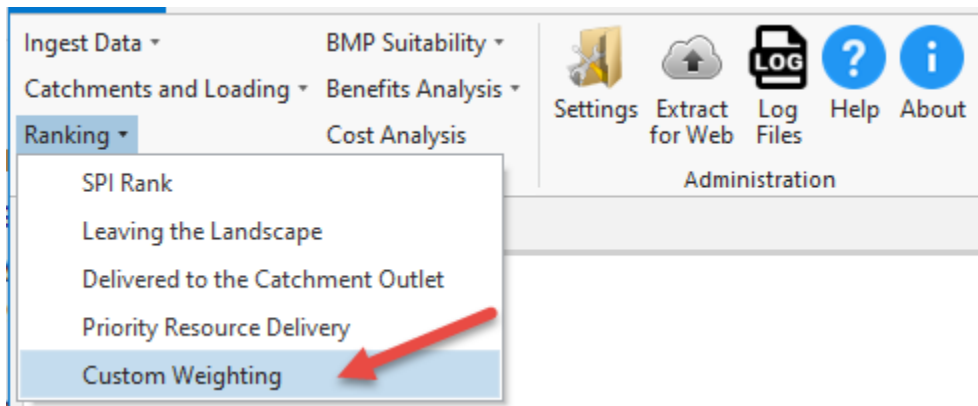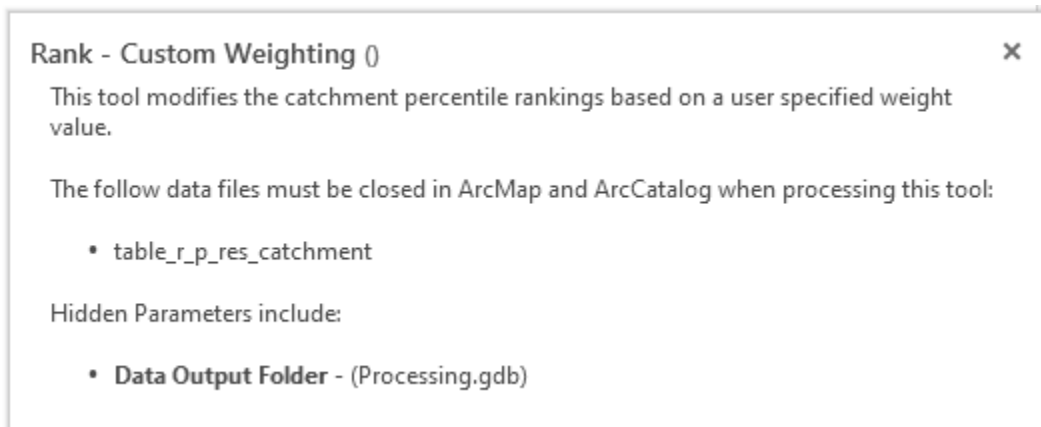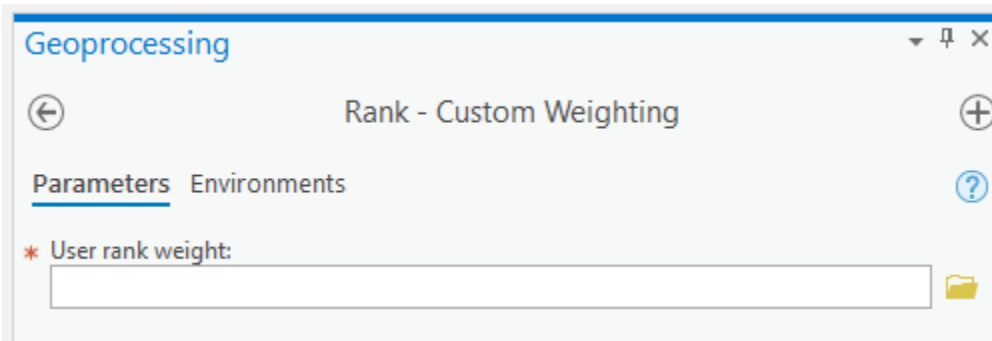  ii. *User rank weight*:  A polygon feature class properly attributed with a "rank_value" field with values between 0-1.
b. Outputs*:*
  i. *Table r p res catchment*:  Appends modified ranking values to the table based on the user specified values. (Not shown in the user interface)

Geoprocessing                                    ▾ ⊣ ✕

⊙                    Rank - Custom Weighting                    ⊕

Parameters  Environments                                      ⑦

✳ User rank weight:

[                                                        ] 📁

Rank - Custom Weighting ()                                      ✕

This tool modifies the catchment percentile rankings based on a user specified weight value.

The follow data files must be closed in ArcMap and ArcCatalog when processing this tool:

• table_r_p_res_catchment

Hidden Parameters include:

• **Data Output Folder** - (Processing.gdb)

## 7.4 Module:  Best Management Practice (BMP) Suitability

This Module allows the user to identify potential locations on the landscape for the placement of BMPs and Conservation Practice (CP).  In addition, the user can exclude areas for potential BMP placement based on local knowledge.

Ingest Data ▾          BMP Suitability ▾
Catchments and Loading ▾  Benefits Analysis ▾
Ranking ▾              Cost Analysis          Settings  Extract  Log  Help  About
                                                 for Web  Files
          Modules                                 Administration

## 7.4.1 BMP Suitability

This tool uses topographic and land use characteristics and typical placement and design criteria for Best Management and Conservation Practices to locate suitable areas.  NRCS practices are created in this tool.  The user can choose what practices to run through the toolbar.  By default, all practices are selected.
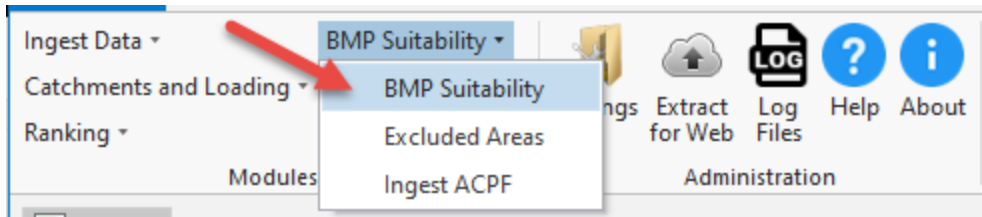


    a.  Inputs:
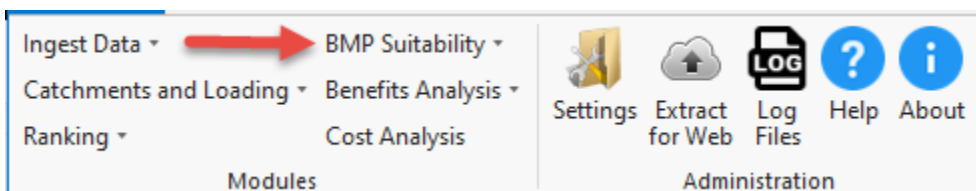- i. *Data output folder*: Data output folder: This is the output path where the standardized PTMApp desktop geodatabases and associated data will be saved. Users can change this file path in the settings button.
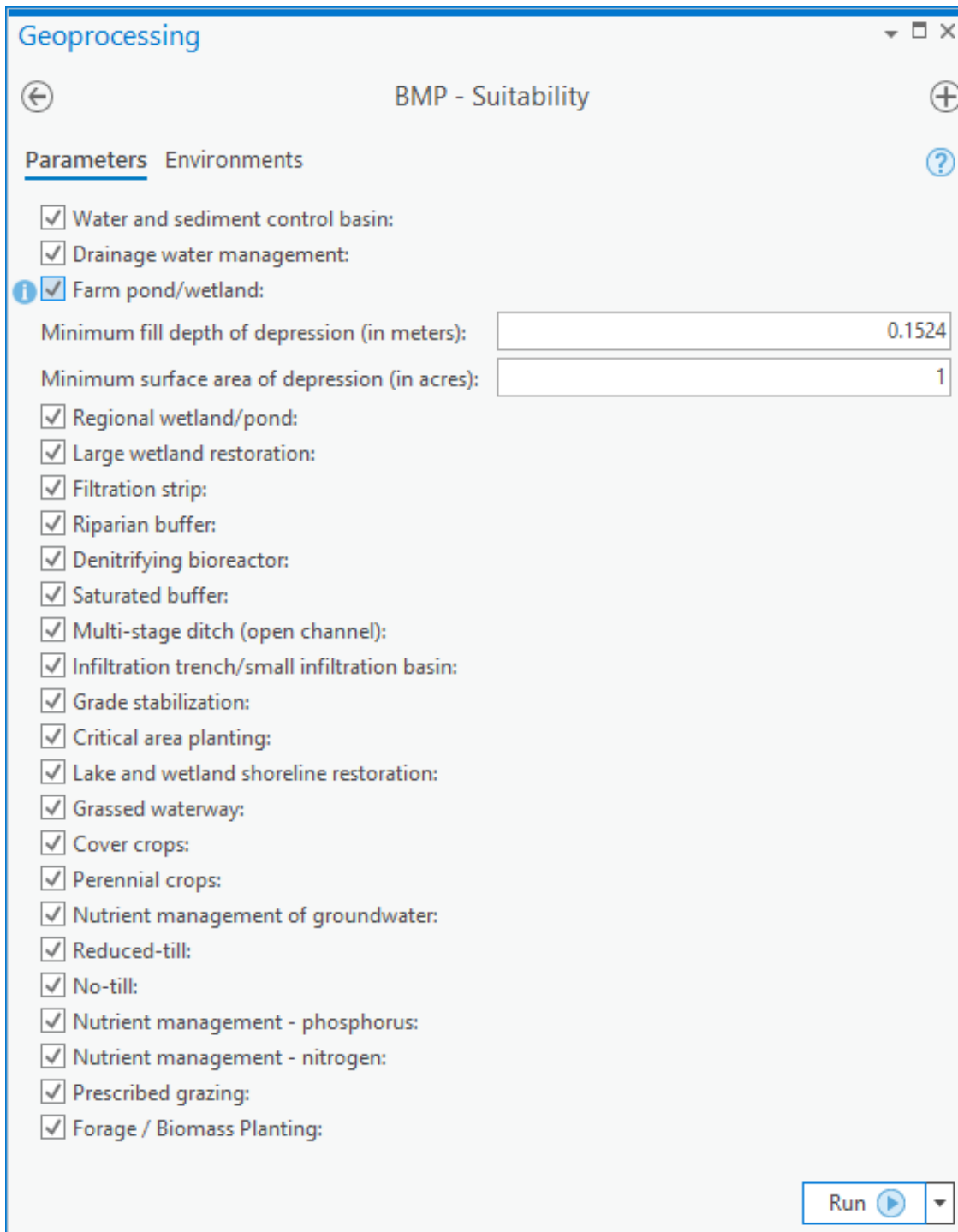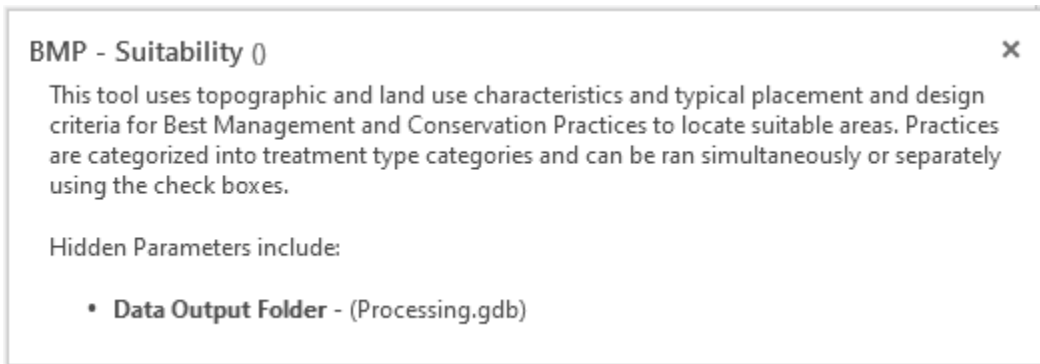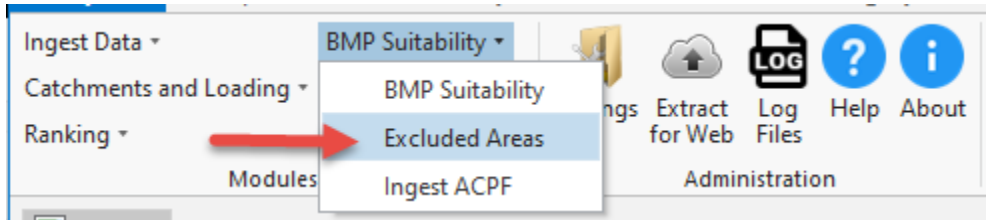- ii. *NRCS practices check boxes (Run: Water and sediment control basin, Drainage water management, Farm pond/wetland, Regional wetland/pond, Large wetland restoration, Filtration strip, Riparian buffer, Denitrifying bioreactor, Saturated buffer, Multi-stage ditch (open channel), Infiltration trench/small infiltration basin, Grade stabilization, critical area planting, Lake and wetland shoreline restoration, Grassed waterway, Cover crops, perennial crops, Nutrient management of groundwater, Reduced-till, No-till, Nutrient management- phosphorus, Nutrient management- nitrogen, Prescribed grazing, Forage/Biomass planting):* Check each of the NRCS practices you wish to have BMPs created for.  By default, all NRCS practices are checked.
- iii. *Minimum fill depth of depression (in meters):*   A depressional area must have a depth greater than the minimum fill depth value to be considered suitable for storage BMPs. The default value is '0.1524' meters (6 inches).
- iv. *Minimum surface area of depression (in acres):*  A depressional area must have a surface area greater than the minimum surface area value to be considered suitable for storage BMPs.  The default value is '1' acre.

    b.  Outputs:
- i. *Data output folder:* Separate feature classes are created for each NRCS practice in the assigned output folder.

## Geoprocessing

←            BMP - Suitability            ⊕

**Parameters**   Environments          ?

☑ Water and sediment control basin:

☑ Drainage water management:

ⓘ ☑ Farm pond/wetland:

Minimum fill depth of depression (in meters):     `0.1524`

Minimum surface area of depression (in acres):     `1`

☑ Regional wetland/pond:

☑ Large wetland restoration:

☑ Filtration strip:

☑ Riparian buffer:

☑ Denitrifying bioreactor:

☑ Saturated buffer:

☑ Multi-stage ditch (open channel):

☑ Infiltration trench/small infiltration basin:

☑ Grade stabilization:

☑ Critical area planting:

☑ Lake and wetland shoreline restoration:

☑ Grassed waterway:

☑ Cover crops:

☑ Perennial crops:

☑ Nutrient management of groundwater:

☑ Reduced-till:

☑ No-till:

☑ Nutrient management - phosphorus:

☑ Nutrient management - nitrogen:

☑ Prescribed grazing:

☑ Forage / Biomass Planting:

Run ▶ ▼

## 7.4.2 Excluded Areas

This is an optional tool which excludes areas from the BMP suitability results based on user-specified areas. This tool can be run on treatment types simultaneously or separately using the check boxes.
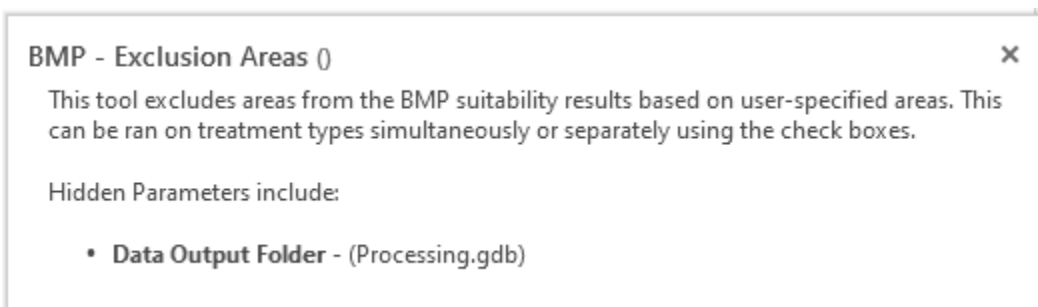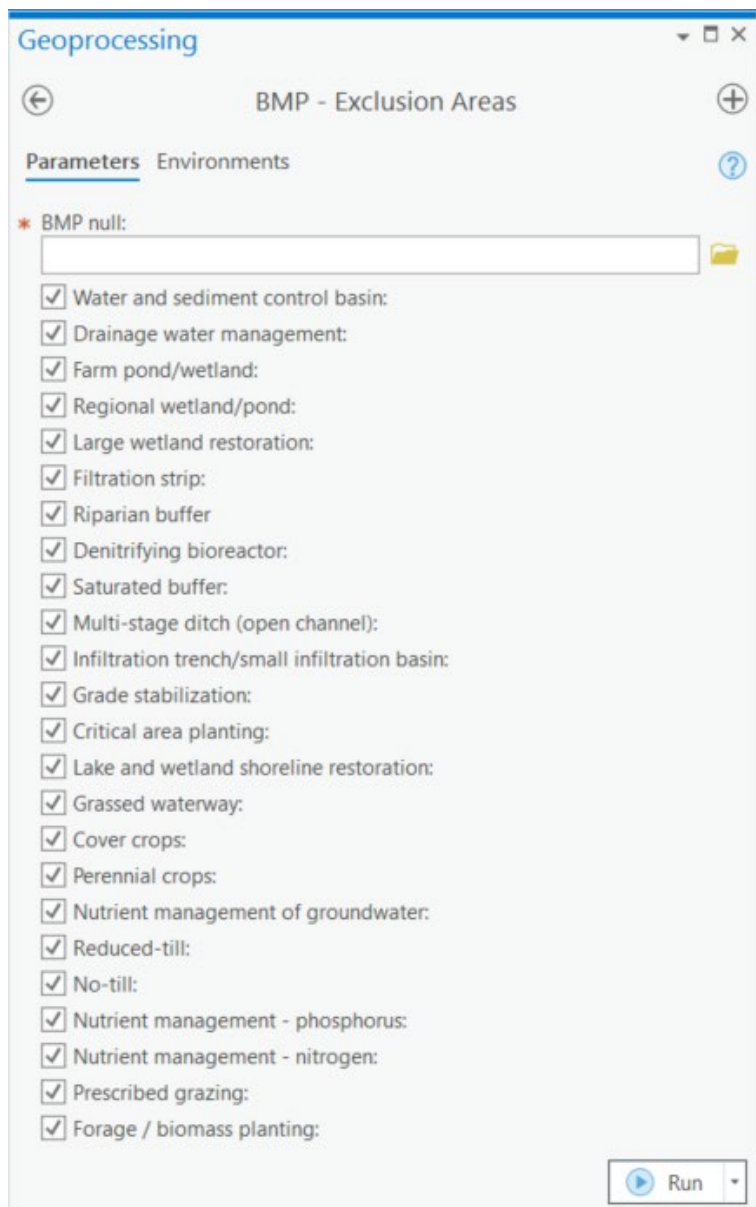


    a. Inputs:
- i. *Data output folder:* location where output products will be saved.
- ii. *BMP null*: A polygon feature class properly attributed with a "bmp_group" value of 0.
- iii. *NRCS Practices check boxes (Water and sediment control basin, Drainage water management, Farm pond/wetland, Regional wetland/pond, Large wetland restoration, Filtration strip, Riparian buffer, Denitrifying bioreactor, Saturated buffer, Multi-stage ditch (open channel), Infiltration trench/small infiltration basin, Grade stabilization, critical area planting, Lake and wetland shoreline restoration, Grassed waterway, Cover crops, perennial crops, Nutrient management of groundwater, Reduced-till, No-till, Nutrient management- phosphorus, Nutrient management- nitrogen, Prescribed grazing, Forage/Biomass planting):* Select the specific NRCS practices you wish to have excluded. By default, all NRCS practices are checked.
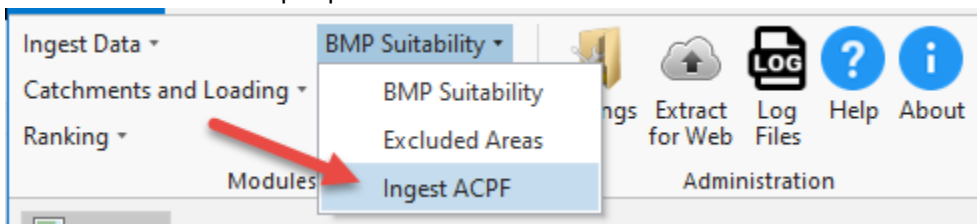
    b. Outputs
- i. *Data output folder*: Updates feature classes for each treatment type initially created in the BMP suitability tool.

**Geoprocessing**

← BMP - Exclusion Areas ⊕

Parameters  Environments  ⑦

\* BMP null:

☑ Water and sediment control basin:
☑ Drainage water management:
☑ Farm pond/wetland:
☑ Regional wetland/pond:
☑ Large wetland restoration:
☑ Filtration strip:
☑ Riparian buffer
☑ Denitrifying bioreactor:
☑ Saturated buffer:
☑ Multi-stage ditch (open channel):
☑ Infiltration trench/small infiltration basin:
☑ Grade stabilization:
☑ Critical area planting:
☑ Lake and wetland shoreline restoration:
☑ Grassed waterway:
☑ Cover crops:
☑ Perennial crops:
☑ Nutrient management of groundwater:
☑ Reduced-till:
☑ No-till:
☑ Nutrient management - phosphorus:
☑ Nutrient management - nitrogen:
☑ Prescribed grazing:
☑ Forage / biomass planting:

▶ Run ▾

**BMP - Exclusion Areas ()**                    ✕

This tool excludes areas from the BMP suitability results based on user-specified areas. This can be ran on treatment types simultaneously or separately using the check boxes.

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)

## 7.4.3 Ingest ACPF

This tool ingests practice polygons into PTMApp-Desktop that were identified by the Agricultural Conservation Planning Framework (ACPF) tool. Conservation practice placement opportunities mapped by the ACPF toolset include 13 different practices, including controlled drainage, grassed waterways, water and sediment control basins, and nutrient removal wetlands. The Ingest ACPF button attributes ACPF practice locations with necessary PTMApp-Desktop attributes and then estimates water quality benefits, including constituent delivery to the practices, and sediment, total phosphorus, and total nitrogen removal both locally and regionally.

Please note that you do not need to run Benefits Analysis or Cost Analysis for ACPF polygons run through this tool. The Ingest ACPF button runs the algorithms in the Benefits Analysis and Cost Analysis tools for you and creates each of the output products otherwise created in those modules.



a. Inputs:
    i. *Data output folder:* location with PTMApp-Desktop output products.
    ii. *Input ACPF GDB:* File geodatabase containing the ACPF dataset
    iii. *Output ACPF GDB:* Empty file geodatabase to save ACPF data to which now include PTMApp-Desktop attributes following Ingest ACPF.
    iv. *Enter manual depth (optional)* – Use your custom 2yr and 10yr depths instead of the raster values (check if entering your own values).
    v. *2yr rainfall depth*: Optional 2-year, 24-hour rainfall depth to enter. Units are in 'inches x 1,000'. Current default is '3,550', which is 3.55 inches.
    vi. *10yr rainfall depth*: Optional 2-year, 24-hour rainfall depth to enter. Units are in 'inches x 1,000'. Current default is '4,010', which is 4.01 inches.
    vii. *Treatment Table:* the tool internally accesses and uses 'table_treat' in the Base.gdb in your output folder. This table, also called the 'Treatment Table', lists the removal efficiency statistics (including minimum, maximum, 1st quartile, 2nd quartile (a.k.a. median), and 3rd quartile removal potentials for sediment, TP, and TN) for each BMP NRCS practice. This table will be used to estimate the removal efficiencies of BMPs in PTMApp.
    viii. *Scale Load Reductions:* check-box option to scale load reductions to the catchment outlets provided by potential BMPs. Please see guidance in the Scaled Loads section for additional information.
    ix. *Table scaled load:* look-up table used to scale loads based on monitoring or model results. Only used when 'Scaled Load Reductions' is checked.
    x. *Apply lakes:* Optional input that should be selected when *Catchments and Loading >> Lake Routing* has been run and the user wishes to include the effect of lakes on BMP sediment, TN, and TP reduction (at the priority resource catchment scale).

xi. *Water and Sediment Control Basin cost ($/each), Drainage Water Management cost ($/acre), Farm Pond/Wetland cost ($/acre), Large Wetland Restoration cost ($/acre), Filtration Strip cost ($/acre), Denitrifying Bioreactor cost ($/sq yd), Saturated Buffer cost ($/acre), Critical Area Planting cost ($/acre), Lake and Wetland Shoreline Restoration cost ($/sq yd), Grassed Waterway cost ($/acre):* applied to each BMP.  PTMApp sorts ACPF BMPs into each practice type.

xii. *Enable minimum cost:* this is optional to help sort out practices to a minimum cost for the selected practices.

xiii. *Water and Sediment Control Basin cost ($/each), Drainage Water Management cost ($/acre), Farm Pond/Wetland cost ($/acre), Large Wetland Restoration cost ($/acre), Filtration Strip cost ($/acre), Denitrifying Bioreactor cost ($/sq yd), Saturated Buffer cost ($/acre), Critical Area Planting cost ($/acre), Lake and Wetland Shoreline Restoration cost ($/sq yd), Grassed Waterway cost ($/acre):* Defaults are set and can be changed and adjusted.

b. Outputs

i. *Ingest ACPF GDB*: All PTMApp output products will be saved to this file geodatabase, including those otherwise created in Benefits Analysis and Cost Analysis.

## Geoprocessing

### BMP - ACPF

**Parameters**  Environments

* Input ACPF GDB:

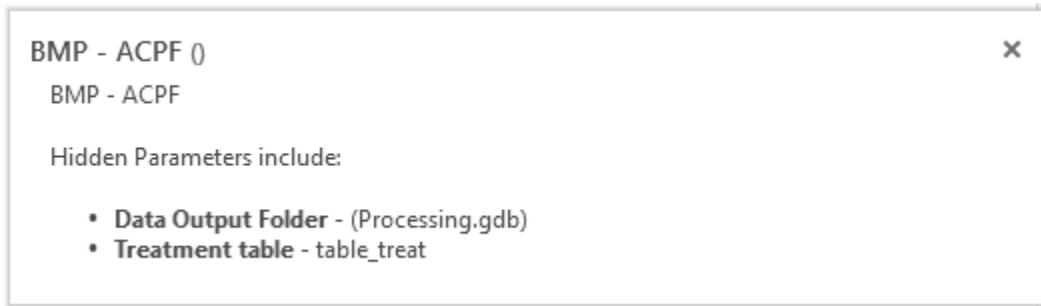[                                                    ] 📁

* Output ACPF GDB:

[                                                    ] 📁

☐ Enter manual depth:

☐ Scale Load Reductions:

ℹ️ ☐ Apply lakes:

| | |
|---|---|
| Water and Sediment Control Basin cost ($/each): | 4500 |
| Drainage Water Management cost ($/acre): | 5.54 |
| Farm Pond/Wetland cost ($/acre): | 812.05 |
| Large Wetland Restoration cost ($/acre): | 20439.57 |
| Filtration Strip cost ($/acre) | 496.08 |
| Denitrifying Bioreactor cost ($/sq yd): | 57.03 |
| Saturated Buffer cost ($/acre): | 1367.78 |
| Critical Area Planting cost ($/acre): | 293.77 |
| Lake and Wetland Shoreline Restoration cost ($/sq yd): | 37.98 |
| Grassed Waterway cost ($/acre): | 1062.86 |

☑ Enable minimum cost:

| | |
|---|---|
| Water and Sediment Control Basin minimum cost ($/each): | 4500 |
| Drainage Water Management minimum cost ($/acre): | 69.25 |
| Farm Pond/Wetland minimum cost ($/acre): | 203.01 |
| Large Wetland Restoration minimum cost ($/acre): | 1277.47 |
| Filtration Strip minimum cost ($/acre) | 124.02 |
| Denitrifying Bioreactor minimum cost ($/sq yd): | 1896.25 |
| Saturated Buffer minimum cost ($/acre): | 341.95 |
| Critical Area Planting minimum cost ($/acre): | 293.77 |
| Lake and Wetland Shoreline Restoration minimum cost ($/sq yd): | 1053.95 |
| Grassed Waterway minimum cost ($/acre): | 664.29 |

Run ▶ ▼

BMP - ACPF ()                                              ×

  BMP - ACPF

  Hidden Parameters include:

      • **Data Output Folder** - (Processing.gdb)
      • **Treatment table** - table_treat

## 7.5 Module:  Benefits Analysis

This Module allows the user to estimate the efficiency of potential BMPs, calculate load reductions from BMPs at the BMP and downstream priority resources, scale load reductions based upon modeling or gage data, and conduct a treatment train analysis.
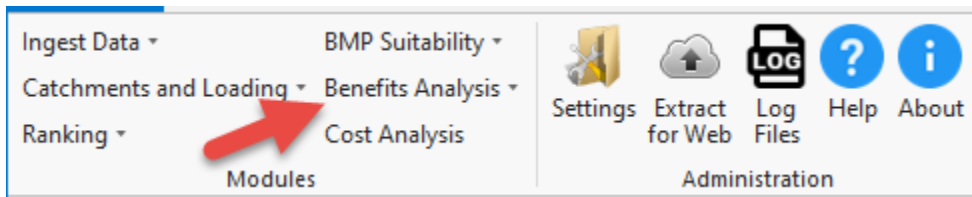


### 7.5.1 Reduction Ratio

This tool estimates the ratio of water treatment to water delivered to potential BMPS and CPs.  Reduction Ratio automatically finds the required inputs for completing the calculations after previous tools have been run.   The tool will process even if only a subset of BMP treatment categories are present.  However, if treatment categories are missing a warning will be generated in the geoprocessing results, notifying the user of the categories that were not processed.  The output is the addition of data to the BMP Suitability attribute tables.

*The Reduction Ratio tool is sensitive to schema locks and fails to complete in case it detects such a lock – see instructions under GENERAL INFORMATION on page 5.*
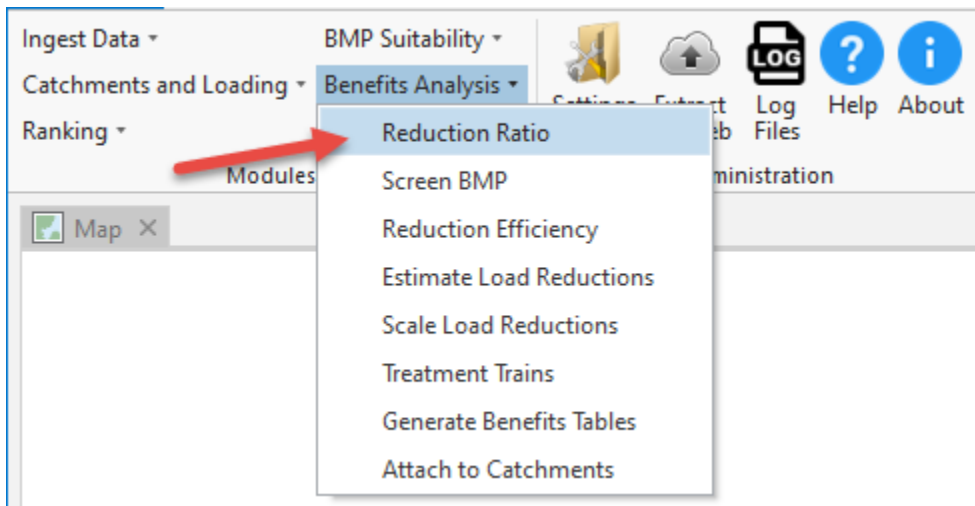
a. Inputs:
   i. *Data output folder*: This is the output path where the standardized PTMApp desktop geodatabases and associated data will be saved. Users can change this file path in the settings button.
   ii. *Enter manual depth (optional)* – Use custom 2-yr, 24-hr and 10-yr, 24-hr rainfall depths instead of the raster values (check if entering your own values).
   iii. *2yr rainfall depth*: Optional 2-year, 24-hour rainfall depth to enter. Units are in 'inches x 1,000'. Current default is '3550', which is 3.55 inches.
   iv. *10yr rainfall depth*: Optional 2-year, 24-hour rainfall depth to enter. Units are in 'inches x 1,000'. Current default is '4010', which is 4.01 inches.

b. Outputs:
   i. Various fields in the BMP NRCS practice feature classes are populated. Please see the Data and Attribute Catalogs for a full list of updated attributes.
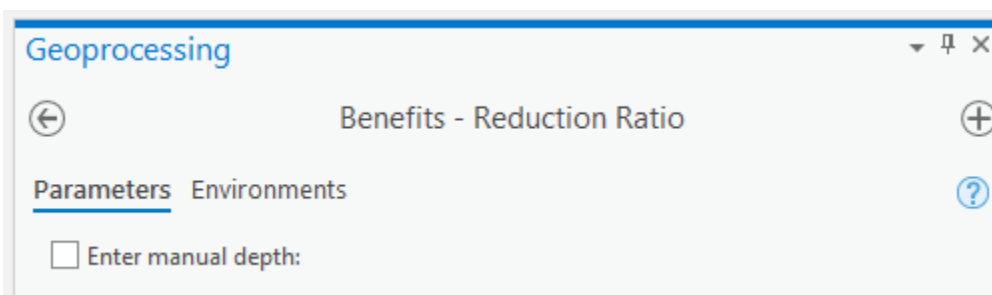
Benefits - Reduction Ratio ()                                              ×

This tool is used to generate the Reduction Ratio for each BMP within the treatment groups. By default, the tool performs the calculations for 2 year and 10 year, 24 hour events. The use has the option to override these events and input their own depths. The reduction ratio is used in subsequent steps to estimate the efficiency of potential BMPs.

The follow data files must be closed in ArcMap and ArcCatalog when processing this tool:

- All treatment group feature class layers

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)

### 7.5.2 Screen BMPs

This tool allows the user to screen BMPs that are either too small or too inefficient to include.  The input is the output from Reduction Ratio, which the tool automatically locates/accesses after the Reduction Ratio analysis has been performed.  The user has the option to select which BMP Suitability NRCS practices will be screened. The output is screened BMP Suitability datasets.

Screen BMP can be used any time after the "Reduction Ratio" tool has been completed, but before the "Generates Benefit Tables" tool has been run.  The "Screen BMP" tool deletes records within the bmp layers attribute tables based on a default or user defined logic equation (e.g., R_2yr24hr > 0.5, C_SQ2_02 > 10, theacres < 5, etc.).  Logic equations can be created for any field within a BMP layer attribute table if they have been populated by the reduction ratio, reduction efficiency, or estimated load reductions tool prior to running the Screen BMP tool.  See the attribute catalog for determining when specific fields are populated.

*Caution* – *the Screen BMPs tool overwrites the original BMP Suitability outputs, while maintaining the attributes of those BMPs that are retained.*
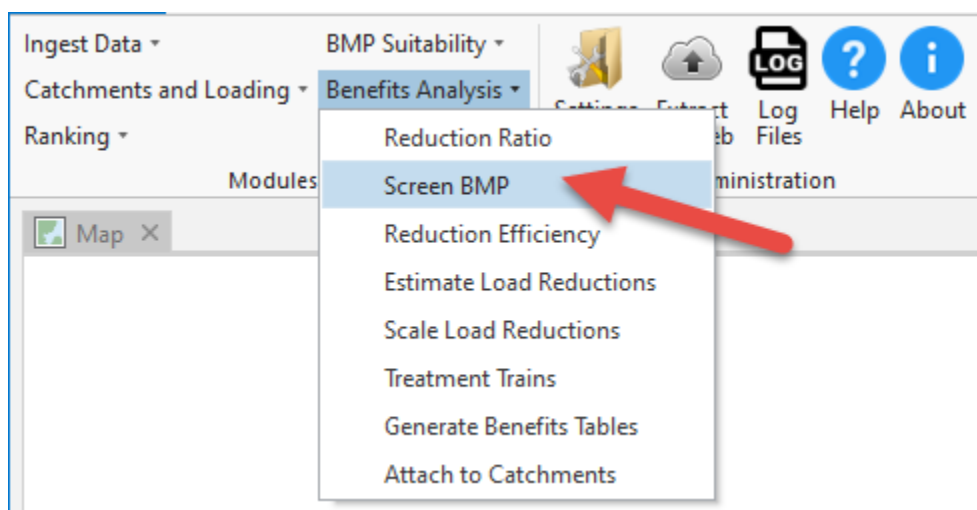
a. Inputs:
    i. *Data output folder:* location where output products will be saved
    ii. *BMP NRCS Practices Expressions: (Water and sediment control basin, Drainage water management, Farm pond/wetland, Regional wetland/pond, Large wetland restoration, Filtration strip, Riparian buffer, Denitrifying bioreactor, Saturated buffer, Multi-stage ditch (open channel), Infiltration trench/small infiltration basin, Grade stabilization, critical area planting, Lake and wetland shoreline restoration, Grassed waterway, Cover crops, perennial crops, Nutrient management of groundwater, Reduced-till, No-till, Nutrient management- phosphorus, Nutrient management- nitrogen, Prescribed grazing, Forage/Biomass planting):* Query out BMPs which fall below size requirements for treating a particular design storm. Default values are based on the 10-yr, 24-hr design storm runoff. (**R_10yr24hr > .5** is Reduction ratio for 10-year, 24-hour event greater than 0.5)

b. Outputs:
    i. BMPs removed from existing NRCS practice feature classes.

Geoprocessing

Benefits - Screen BMPs

Parameters  Environments

Water and sediment control basin expression:
R_10yr24hr > .5

Drainage water management expression:
R_10yr24hr > .5

Farm pond/wetland expression:
R_10yr24hr > .5

Regional wetland/pond expression:
R_10yr24hr > .5

Large wetland restoration expression:
R_10yr24hr > .5

Filtration strip expression:
R_10yr24hr > .5

Riparian buffer expression:
R_10yr24hr > .5

Denitrifying bioreactor expression:
R_10yr24hr > .5

Saturated buffer expression:
R_10yr24hr > .5

Multi-stage ditch (open channel) expression:
R_10yr24hr > .5

Infiltration trench/small infiltration basin expression:
R_10yr24hr > .5

Grade stabilization expression:
R_10yr24hr > .5

Critical area planting expression:
R_10yr24hr > .5

Lake and wetland shoreline restoration expression:
R_10yr24hr > .5

Grassed waterway expression:
R_10yr24hr > .5

Cover crops expression:
R_10yr24hr > .5

Perennial crops expression:
R_10yr24hr > .5

Nutrient management of groundwater expression:
R_10yr24hr > .5

Reduced-till expression:

Run ▶

---

Benefits - Screen BMPs ()                                          ✕

This tool is used to screen BMPs that are either to small or to inefficient to be practical for implementation.

The follow data files must be closed in ArcMap and ArcCatalog when processing this tool:

- All treatment group feature class layers

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)

*7.5.3 Reduction Efficiency*

The Reduction Efficiency tool utilizes the Reduction Ratio outputs to estimate the percent effectiveness of each potential BMP for treating TP, TN, and sediment.  The Input for this tool is the BMP suitability output that has been processed through Reduction Ratio.  The output from Reduction Efficiency is the percent reduction in TP, TN, and sediment attached to the BMP Suitability output attribute table for both the 2-yr, 24-hr and 10-yr, 24-hr runoff events. 2 year and 10-year, 24-hour events.
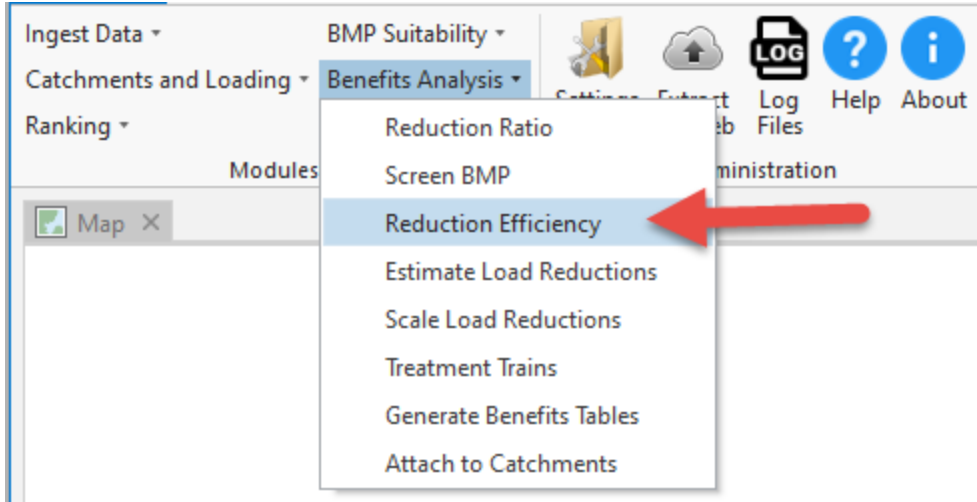


- a. Inputs:
  - i. *Data output folder:* location where output products will be saved
  - ii. *Treatment Table:* the tool internally accesses and uses 'table_treat' in the Base.gdb in your output folder.  This table, also called the 'Treatment Table', lists the removal efficiency statistics (including minimum, maximum, 1st quartile, 2nd quartile (a.k.a. median), and 3rd quartile removal potentials for sediment, TP, and TN) for each BMP NRCS practice.  This table will be used to estimate the removal efficiencies of BMPs in PTMApp.
- b. Outputs:
  - i. Various fields in the BMP NRCS practice feature classes are populated.  Please see the Data and Attribute Catalogs for a full list of updated attributes.

*Note: The treatment table (table_treat) was developed based on an analysis of load reduction efficiencies presented in the MN Agricultural BMP Handbook, and other sources. You may wish to update the statistics in this table to better reflect BMP efficiencies estimated in your project area or as better data becomes available.*
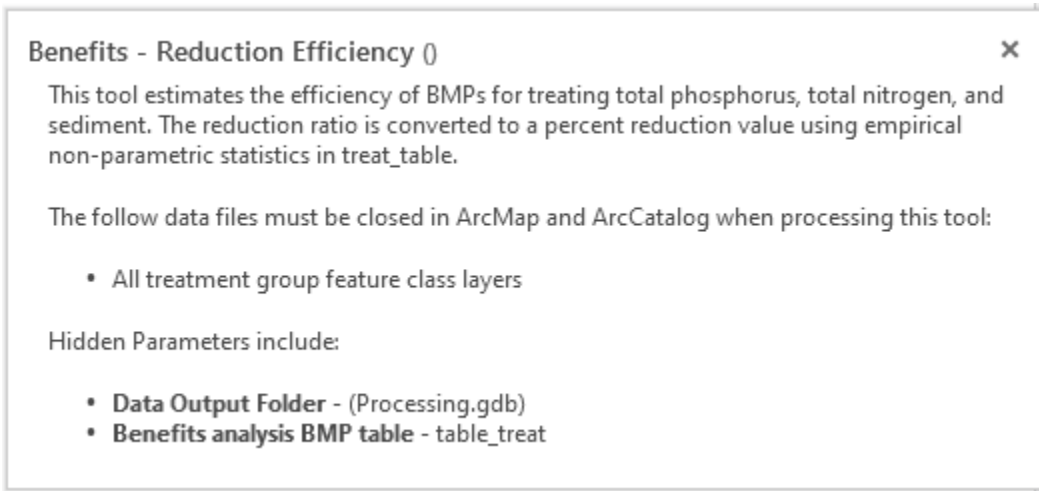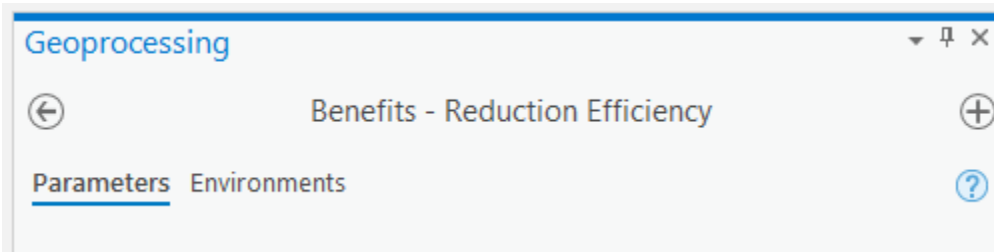
### 7.5.4 Estimate Load Reductions

This tool uses the Reduction Efficiency outputs as an input and estimates TP, TN, and sediment load reductions provided by BMPs to the outlets of catchments.  These calculations are performed for both the 2-yr, 24-hr and 10-yr, 24-hr runoff events.
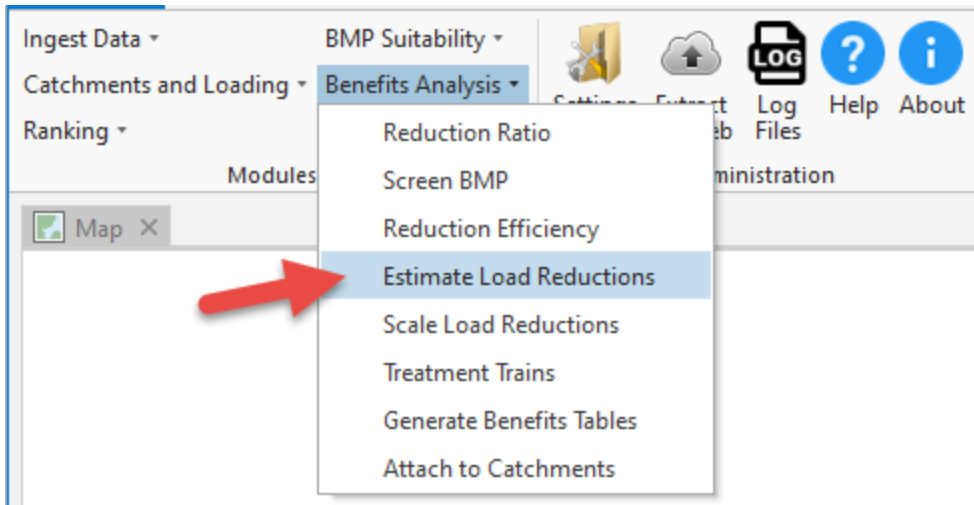


   a.  Inputs:
        i.    Data output folder: location where output products will be saved
   b.  Outputs:

i.  Various fields in the BMP NRCS practice feature classes are populated.  Please see the Data and Attribute Catalogs for a full list of updated attributes.
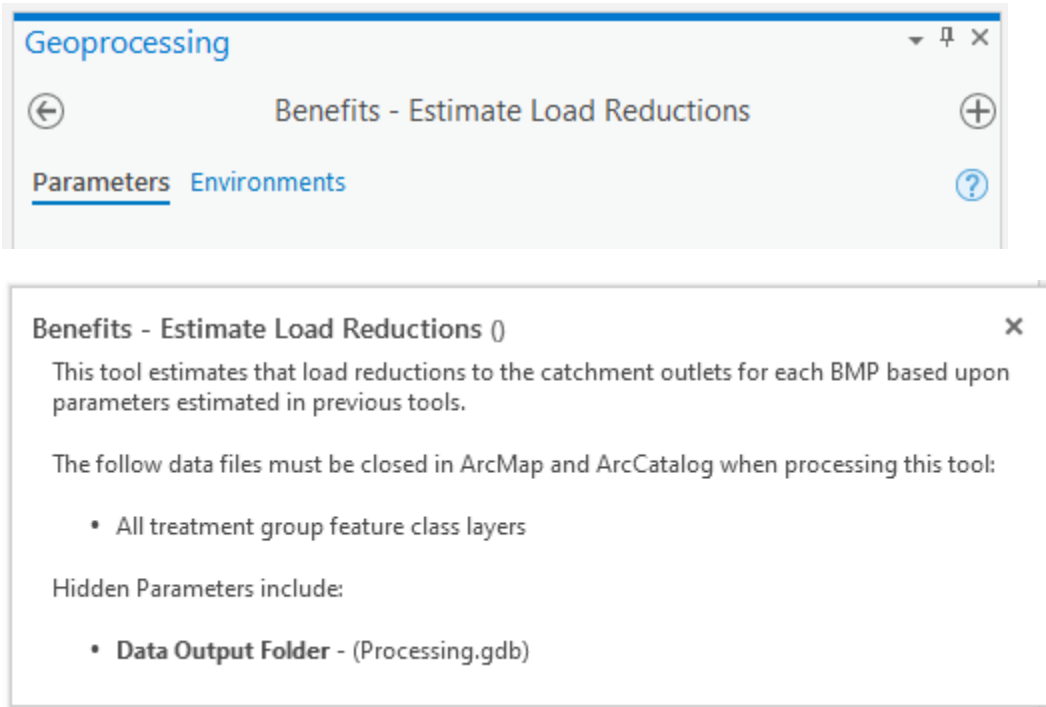


### 7.5.5 Scale Load Reductions

This is an optional tool that will scale the load reductions to the catchment outlets provided by potential BMPs. The input table for scaling loads was generated in *Catchments and Loading > Scale Loads* and will be automatically found after that tool has been run.

*Note – you are strongly encouraged to run this tool, if Scale Loads was run in the Catchments and Loading module to ensure load reduction outputs are consistent with your Source Assessment outputs.*
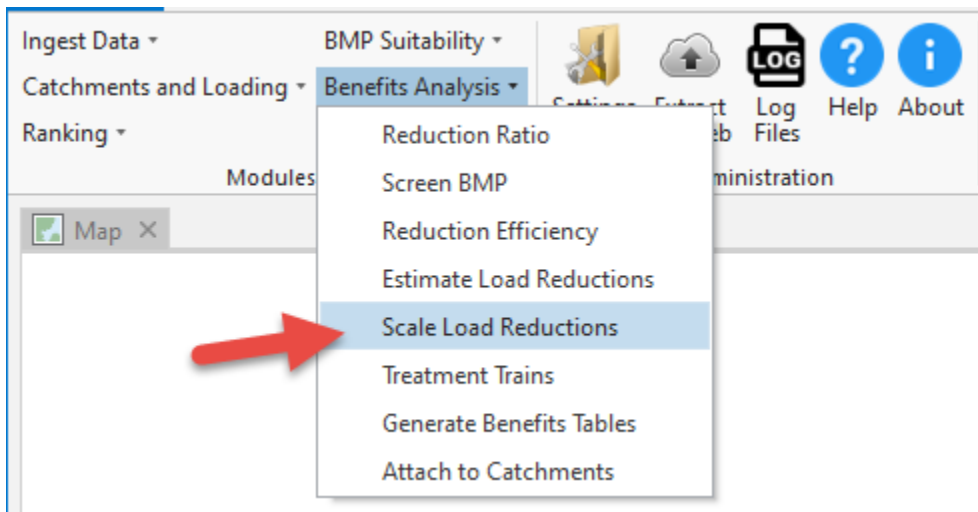
a. Inputs:

  i. Data output folder: location where output products will be saved.
  ii. Table scaled load: look-up table used to scale loads based on monitoring or model results.  This was an output from the Catchments and Loading >> Scale Loads tool if you ran the tool (which was optional).

b. Outputs:

  i. Various fields in the BMP NRCS practice feature classes are populated.  Please see the Data and Attribute Catalogs for a full list of updated attributes
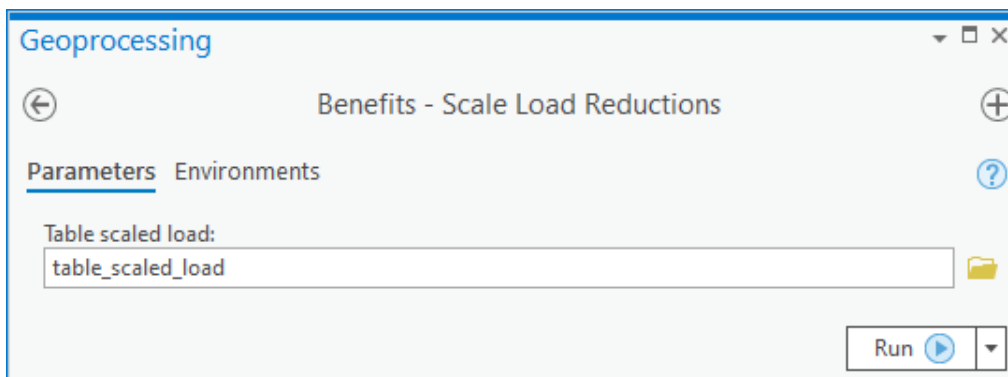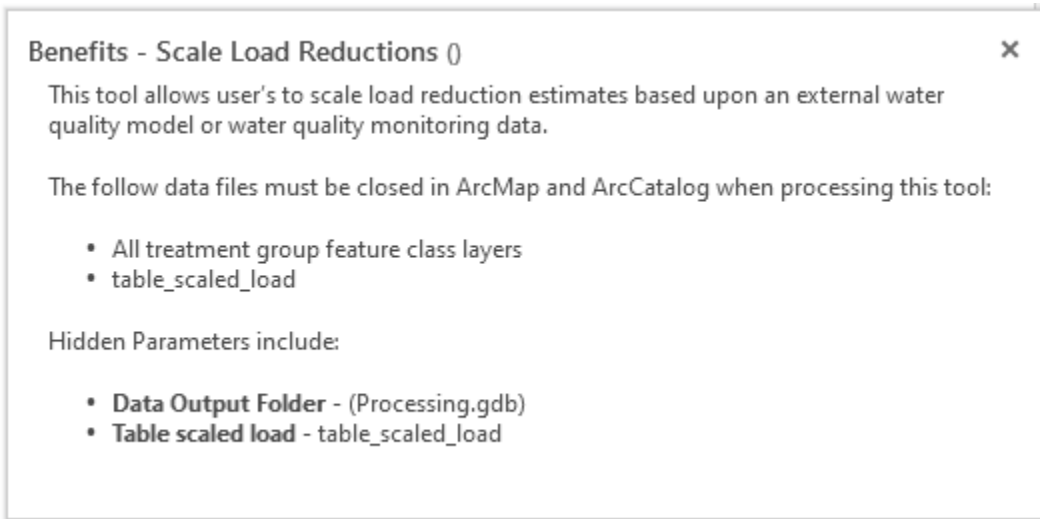
## 7.5.6 Treatment Trains

This tool allows the user to estimate the load reductions in TN, TP, and sediment by BMPs that may be providing treatment in sequence.  The user inputs one shapefile that has each record attributed with a treatment group code or NRCS practice code.  The load reductions of the treatment train of BMPs are estimated relative to the priority resource points.

*Note – This tool is the suggested method for estimating load reductions for a targeted implementation plan.  The results will provide load reduction estimates at each priority resource point based upon the input BMP layer.*
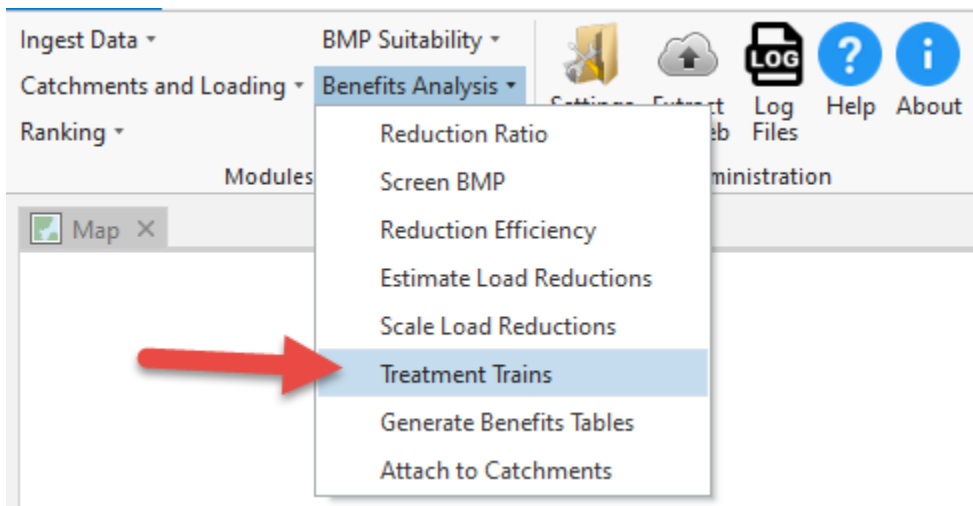


a. Inputs:

      i. *Data output folder*: location where output products will be saved.

      ii. *User BMP Path*: User-created shapefile which includes all BMPs to run through the Treatment Trains procedures.  This shapefile can include BMPs from multiples treatment groups or NRCS practices.

iii. *Data has been scaled by gauge or model*: Optional input that should be selected when PTMApp data has been scaled through *Catchment and Loadings >> Scaled Data* and *Benefits Analysis >> Scaled Load Reductions* tools.

iv. *Apply lakes:* Optional input that should be selected when *Catchments and Loading >> Lake Routing* has been run and the user wishes to include the effect of lakes on BMP sediment, TN, and TP reduction (at the priority resource catchment scale).

b. Outputs:

i. *Table treat train catch*: table listing results of the treatment train analysis with loads relative to the catchment outlet.

ii. *Table treat train priority resource*: table listing results of the treatment train analysis with loads relative to the priority resource catchment outlet.
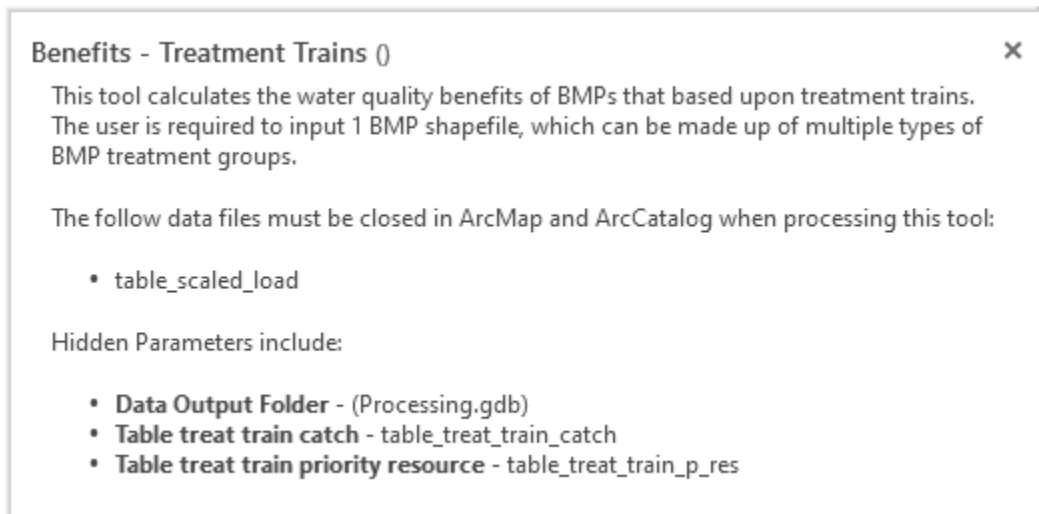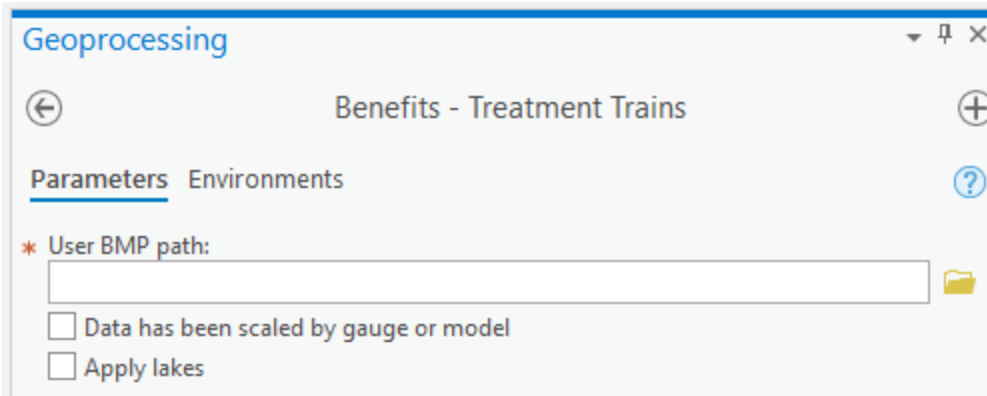


The input file needs to contain the outputs fields from the previous steps in the Benefits Analysis module. In other words, your input file structure should mirror the format of the BMP Suitability analysis treatment groups or NRCS practices.
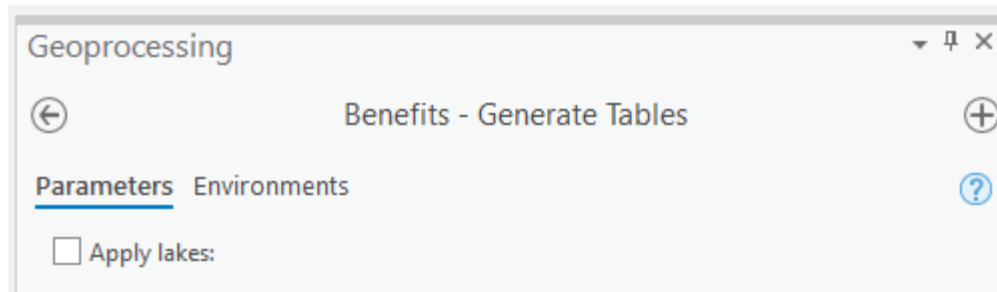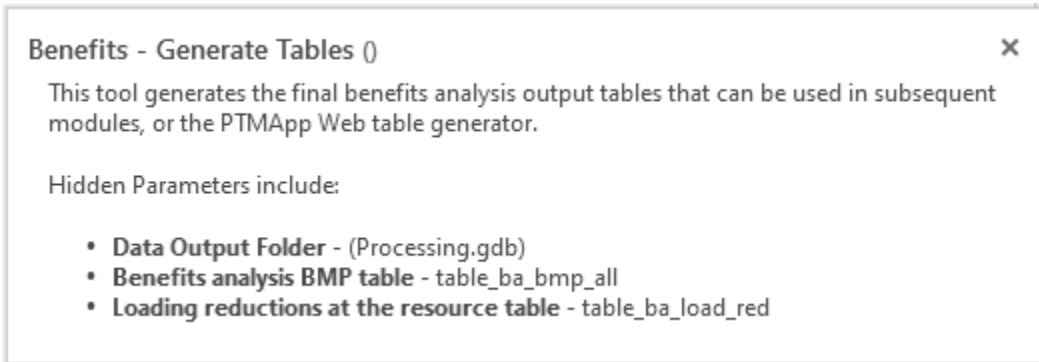
## 7.5.7 Generate Benefits Tables

This tool uses the results of Estimate Load Reductions to generate output tables from the Benefits Analysis Module that can be used for subsequent processes and generating output tables for local reporting. This tool also calculates the BMP load reductions to the priority resource points.
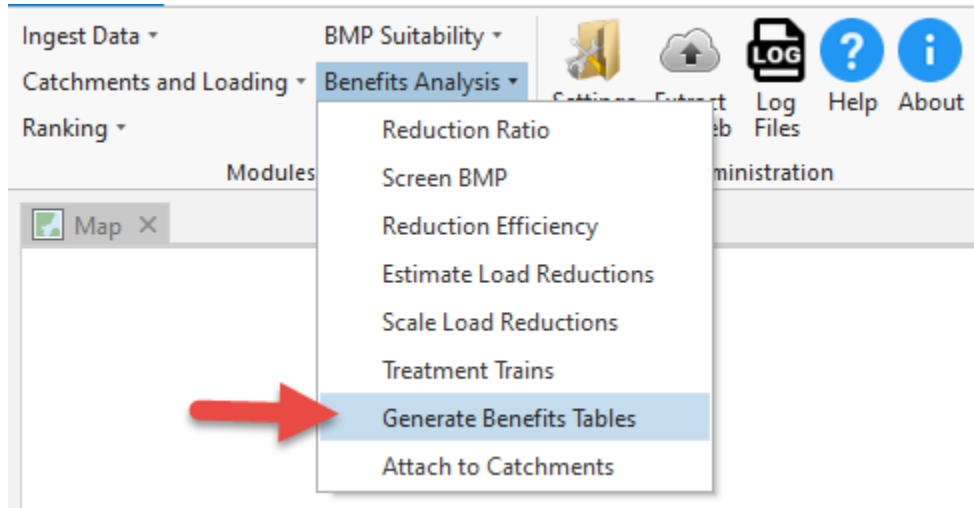


a. Inputs:
   i. *Data output folder:* location where output products will be saved.
   ii. *Apply lakes:* Optional input that should be selected when *Catchments and Loading >> Lake Routing* has been run and the user wishes to include the effect of lakes on BMP sediment, TN, and TP reduction (at the priority resource catchment scale).
b. Outputs:
   i. *Table ba bmp all:* table listing results of the benefits analysis.
   ii. *Table ba load red:* table listing BMP load reductions at the resource of concern.

*Note: Please see the Data Catalog, Attribute Catalog, and Workshop Session 3 for information on how these output tables can be used.*

Benefits - Generate Tables ()                                                    ×

This tool generates the final benefits analysis output tables that can be used in subsequent
modules, or the PTMApp Web table generator.

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)
- **Benefits analysis BMP table** - table_ba_bmp_all
- **Loading reductions at the resource table** - table_ba_load_red

## 7.5.8 Attach to Catchments

This tool attaches the outputs from Benefits Analysis to the Catchment databases and prepares the data for use
in the Cost Analysis Module.  The output from this tool is needed to run tools in the Cost Analysis Module.
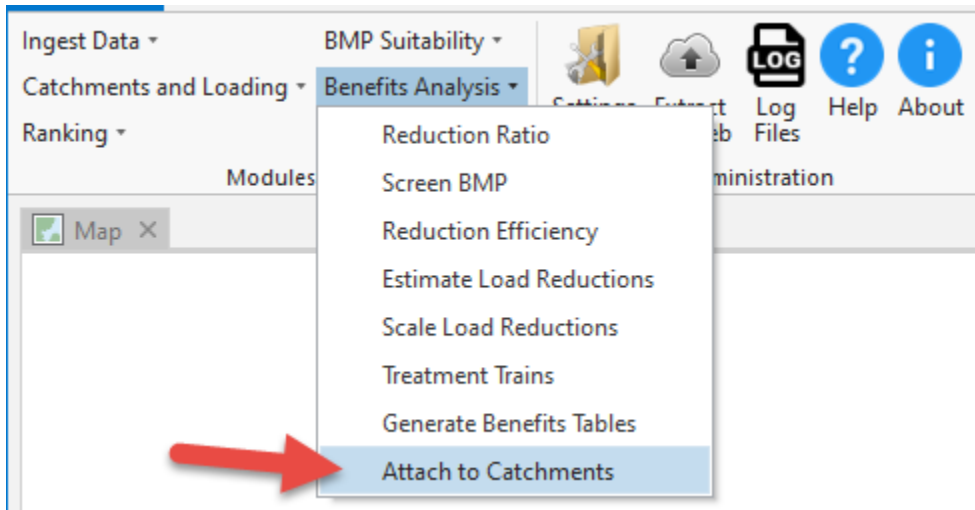


a.   Inputs:
   i.   *Data output folder:* location where output products will be saved.
b.   Outputs:
   i.   *Table ba bmp all catchment:* table showing one set of values per BMP for each
        catchment.
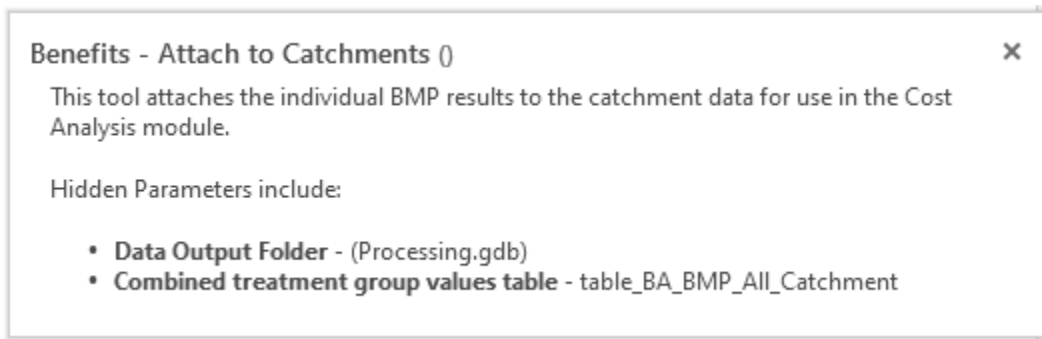
## 7.6 Module:  Cost Analysis

This module estimates the treatment cost ($/mass reduced) for potential BMPs based upon the default Minnesota EQIP payment schedule on a per unit basis.   The user has the option to adjust the per unit cost estimates based upon local knowledge. Useful life annualized cost is calculated within the cost analysis module for each BMP.  To estimate the useful life annualized cost, the total cost of each BMP is estimated over the lifespan of the BMP.  The expected useful life of the BMP is provided for the creation of the annualized estimate (cost per year) for the BMP.  Annualized cost-effectiveness estimates (useful life annualized cost / load reduction) are now also calculated for load reductions estimated at the catchment outlet and the priority resource catchment outlet.  Documentation is forthcoming and will provide greater details regarding the calculation of useful life annualized costs.  Check the PTMApp documentation webpage for resources.

Table 8 gives an overview for each NRCS practice.

Useful life annualized cost is calculated within the cost analysis module for each BMP.  To estimate the useful life annualized cost, the total cost of each BMP is estimated over the lifespan of the BMP.  The expected useful life of the BMP is provided for the creation of the annualized estimate (cost per year) for the BMP.  Annualized cost-effectiveness estimates (useful life annualized cost / load reduction) are now also calculated for load reductions estimated at the catchment outlet and the priority resource catchment outlet.  Documentation is

forthcoming and will provide greater details regarding the calculation of useful life annualized costs.  Check the PTMApp documentation webpage for resources.

Table 8 Cost Analysis Table Describing Cost Estimates by NRCS Practices

| NRCS Practice Name | PTMApp NRCS Codes | Treatment Group | Unit Cost ($) | Units | Suggested PTMApp Minimum Cost | Description of Cost Calculation* |
|---|---|---|---|---|---|---|
| Farm Pond/Wetland | 378 | Storage | $812.05 | acre | $203.01 | Unit Cost ($) multiplied by the estimated BMP footprint (theacres attribute) |
| Drainage Water Management | 554 | Storage | $5.54 | acre | $277.00 | |
| Water and Sediment Control Basin | 638 | Storage | $4,500.00 | each | $4,500.00 | Static cost per practice |
| Regional Wetland/Pond | 656_1 | Storage | $20,439.57 | acre | $1,277.47 | Unit Cost ($) multiplied by the estimated BMP footprint (theacres attribute) |
| Large Wetland Restoration | 656_2 | Storage | $20,439.57 | acre | $1,277.47 | |
| Riparian Buffer | 390 | Filtration | $1,065.87[†] | acre | $799.40 | |
| Filtration Strip | 393 | Filtration | $496.08 | acre | $124.02 | |
| Saturated Buffer | 604 | Biofiltration | $1,367.78 | acre | $1,258.36 | |

| NRCS Practice Name | PTMApp NRCS Codes | Treatment Group | Unit Cost ($) | Units | Suggested PTMApp Minimum Cost | Description of Cost Calculation* |
|---|---|---|---|---|---|---|
| Denitrifying Bioreactor | 605 | Biofiltration | $38.02 | cu. yd | $1,896.25 | Treated runoff volume multiplied by the Unit Cost ($), where treated runoff volume is estimated as 1/8" runoff depth multiplied by the practice drainage area (wtsArea_ft attribute) |
| Infiltration Trench/Small Infiltration Basin | 350 | Infiltration | $36.45 | sq. yd | $1,011.49 | Unit Cost ($) multiplied by the estimated BMP footprint (theacres attribute) |
| Multi-stage Ditch (open channel) | 582 | Infiltration | $4,036.56 | acre | $1,261.43 | |
| Critical Area Planting | 342 | Protection | $293.77 | acre | $73.44 | |
| Grade Stabilization | 410 | Protection | $53.10 | sq. yd | $1,062.00 | |
| Grassed Waterway | 412 | Protection | $1,062.86 | acre | $664.29 | |
| Lake and Wetland Shoreline Restoration | 580 | Protection | $37.98 | sq. yd | $1,053.95 | |
| Perennial Crops | 327 | Source Reduction | $480.80 | acre | $120.20 | |

| NRCS Practice Name | PTMApp NRCS Codes | Treatment Group | Unit Cost ($) | Units | Suggested PTMApp Minimum Cost | Description of Cost Calculation* |
|---|---|---|---|---|---|---|
| No Tillage | 329 | Source Reduction | $11.03 | acre | $275.75 | |
| Cover Crops | 340 | Source Reduction | $33.52 | acre | $335.20 | |
| Reduced Tillage | 345 | Source Reduction | $11.03 | acre | $275.75 | |
| Forage / Biomass Planting | 512 | Source Reduction | $44.84[†] | acre | $448.40 | |
| Prescribed Grazing | 528 | Source Reduction | $6.34[†] | acre | $63.40 | |
| Nutrient Management of Groundwater | 590_1 | Source Reduction | $6.84 | acre | $68.40 | |
| Nutrient Management for Phosphorus | 590_2 | Source Reduction | $6.84 | acre | $68.40 | |
| Nutrient Management for Nitrogen | 590_3 | Source Reduction | $6.84 | acre | $68.40 | |

*The cost calculation description does not include any necessary unit conversions.

† 2020 EQIP payment rate used.
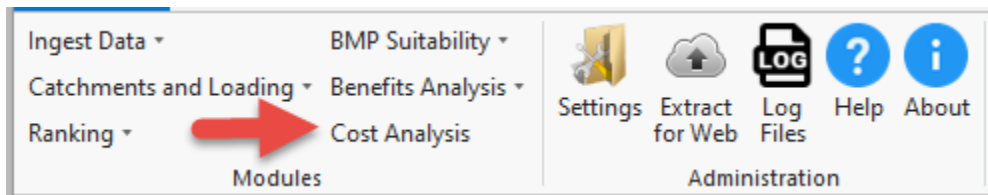
a. Inputs:

  i. *Data output folder*:  location where output products will be saved.
  ii. Unit costs for BMP NRCS practices.  Default values are shown below and should be adjusted based on local knowledge:

- Farm Pond/Wetland: $812.05 per acre
- Drainage Water Management: $5.54 per acre
- Water and Sediment Control Basin: $4,500.00 each
- Regional Wetland/Pond: $20,439.57 per acre
- Large Wetland Restoration: $20,439.57 per acre
- Riparian Buffer: $1,065.87 per acre
- Filtration Strip: $496.08 per acre
- Saturated Buffer: $1,367.78 per acre†
- Denitrifying Bioreactor: $38.02 per cu. yd‡
- Infiltration Trench/Small Infiltration Basin: $36.45 per sq. yd¹
- Multi-stage Ditch (open channel): $4,036.56 per acre†
- Critical Area Planting: $293.77 per acre
- Grade Stabilization: $53.10 per sq. yd
- Grassed Waterway: $1,062.86 per acre†
- Lake and Wetland Shoreline Restoration: $37.98 per sq. yd
- Perennial Crops: $480.80 per acre
- No Tillage: $11.03 per acre
- Cover Crops: $33.52 per acre
- Reduced Tillage: $11.03 per acre
- Forage / Biomass Planting: $44.84 per acre
- Prescribed Grazing: $6.34 per acre
- Nutrient Management of Groundwater: $6.84 per acre
- Nutrient Management for Phosphorus: $6.84 per acre
- Nutrient Management for Nitrogen: $6.84 per acre

  iii. Minimum BMP Cost: Default values are shown below and should be adjusted based on local knowledge.  Checking Minimum BMP Cost will create minimum cost floor.  BMPs are not screened in this process.  BMP cost is being set to the minimum cost or greater depending on the cost equations per BMP.

- Farm Pond/Wetland: $203.01 per acre
- Drainage Water Management: $277.00 per acre
- Water and Sediment Control Basin: $4,500.00 each

- Regional Wetland/Pond: $1,277.47 per acre
- Large Wetland Restoration: $1,277.47 per acre
- Riparian Buffer: $799.40 per acre
- Filtration Strip: $124.02 per acre
- Saturated Buffer: $1,258.36 per acre†
- Denitrifying Bioreactor: $1,896.25 per cu. yd‡
- Infiltration Trench/Small Infiltration Basin: $1,011.49 per sq. yd[1]
- Multi-stage Ditch (open channel): $1,261.43 per acre†
- Critical Area Planting: $73.44 per acre
- Grade Stabilization: $1,062.00 per sq. yd
- Grassed Waterway: $664.29 per acre†
- Lake and Wetland Shoreline Restoration: $1,053.95 per sq. yd
- Perennial Crops: $120.20 per acre
- No Tillage: $275.75 per acre
- Cover Crops: $335.20 per acre
- Reduced Tillage: $275.75 per acre
- Forage / Biomass Planting: $448.40 per acre
- Prescribed Grazing: $63.40 per acre
- Nutrient Management of Groundwater: $68.40 per acre
- Nutrient Management for Phosphorus: $68.40 per acre
- Nutrient Management for Nitrogen: $68.40 per acre

\* Costs are based on 2019 EQIP payment rates with three exceptions.  Riparian buffer, forage / biomass planting, and prescribed grazing are based on 2020 EQIP values.

† EQIP payment rate based on linear feet.  An assumed practice width was applied to bmp_satbuff, bmp_ditch2s, and bmp_gwater (50ft, 60ft, and 100ft, respectively).

‡ Volume was calculated based on an assumed 1/8" runoff across the drainage area of the BMP

[1] EQIP payment rate based on cubic yards.  A practice depth of 1.5 yd was assumed.

*Note: We strongly recommend you review and update (if necessary) these costs to ensure they reflect costs of BMP installations in your area.*

b. Outputs:
   i. *Cost information is appended to the table_ba_bmp_all table, and table_ba_load_red.*
   ii. *Table ca bmp costeff:* Data table with estimated BMP cost-index, as measured at the priority resource outlet.  BMP calculations in this table represent one reduction value per NRCS_code per catchment (i.e., if multiple BMPs of the same NRCS_code are present in a single catchment, their values are aggregated).

## Geoprocessing

### Cost - Optimal Scenarios

**Parameters**  Environments

#### ˅ BMP Unit Cost

| | |
|---|---|
| Water and Sediment Control Basin cost ($/ each): | 4500 |
| Drainage Water Management cost ($/acre): | 5.54 |
| Farm Pond/Wetland cost ($/acre): | 812.05 |
| Regional Wetland/Pond cost ($/acre): | 20439.57 |
| Large Wetland Restoration cost ($/acre): | 20439.57 |
| Filtration Strip cost ($/acre): | 496.08 |
| Riparian cost ($/acre): | 1065.87 |
| Denitrifying Bioreactor cost ($/cu yd): | 38.02 |
| Saturated Buffer cost ($/acre): | 1367.78 |
| Multi-stage Ditch (open channel) cost ($/acre): | 4036.56 |
| Infiltration Trench/Small Infiltration Basin cost ($/sq yd): | 36.45 |
| Grade Stabilization cost ($/sq yd): | 53.1 |
| Critical Area Planting cost ($/acre): | 293.77 |
| Lake and Wetland Shoreline Restoration cost ($/ sq yd): | 37.98 |
| Grassed Waterway cost ($/acre): | 1062.86 |
| Cover Crops cost ($/acre): | 33.52 |
| Perennial Crops cost ($/acre): | 480.8 |
| Nutrient Management of Groundwater cost ($/ acre): | 6.84 |
| Reduced-till cost ($/acre): | 11.03 |
| No-till cost ($/acre): | 11.03 |
| Nutrient management - phosphorus cost ($/ acre): | 6.84 |
| Nutrient management - nitrogen cost ($/acre): | 6.84 |
| Prescribed grazing cost ($/acre): | 6.34 |
| Forage / biomass planting cost ($/acre): | 44.84 |

#### ˃ Minimum BMP Cost

Run ▶ ▾

## Geoprocessing

← Cost - Optimal Scenarios ⊕

**Parameters** Environments ⑦

> **BMP Unit Cost**

∨ **Minimum BMP Cost**

☑ Enable minimum cost limit:

| Parameter | Value |
|---|---|
| Water and Sediment Control Basin minimum cost ($): | 4500 |
| Drainage Water Management minimum cost ($): | 277 |
| Farm Pond/Wetland minimum cost ($): | 203.01 |
| Regional Wetland/Pond minimum cost ($): | 1277.47 |
| Large Wetland Restoration minimum cost ($): | 1277.47 |
| Filtration Strip minimum minimum cost ($): | 124.02 |
| Riparian minimum cost ($): | 799.4 |
| Denitrifying Bioreactor minimum cost ($): | 1896.25 |
| Saturated Buffer minimum cost ($): | 1258.36 |
| ⓘ Multi-stage Ditch (open channel) minimum cost ($): | 1261.43 |
| Infiltration Trench/Small Infiltration Basin minimum cost ($): | 1011.49 |
| Grade Stabilization minimum cost ($): | 1062 |
| Critical Area Planting minimum cost ($): | 73.44 |
| Lake and Wetland Shoreline Restoration minimum cost ($): | 1053.95 |
| Grassed Waterway minimum cost ($): | 664.29 |
| Cover Crops minimum cost ($): | 335.2 |
| Perennial Crops minimum cost ($): | 120.2 |
| Nutrient Management of Groundwater minimum cost ($): | 68.4 |
| Reduced-till minimum cost ($): | 275.75 |
| No-till minimum cost ($): | 275.75 |
| Nutrient management - phosphorus minimum cost ($): | 68.4 |
| Nutrient management - nitrogen minimum cost ($): | 68.4 |
| Prescribed grazing ($): | 63.4 |
| Forage / biomass minimum cost ($): | 448.4 |

Run ▶ ▾

Cost - Optimal Scenarios ()                                              ×

This tool estimates the treatment costs based upon BMP treatment groups for each catchment in the study area. It also generates the outputs that can be used to build treatment efficiency frontiers by treatment group.

Hidden Parameters include:

- **Data Output Folder** - (Processing.gdb)
- **BMP Cost Effectiveness Table** - table_ca_bmp_costeff
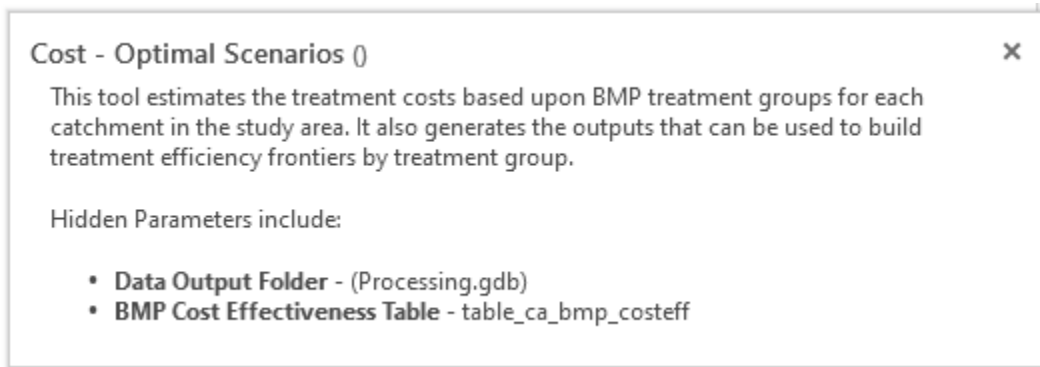
## 7.7 Extract for Web

This tool formats and packages data into a zip file for use in the PTMApp website.
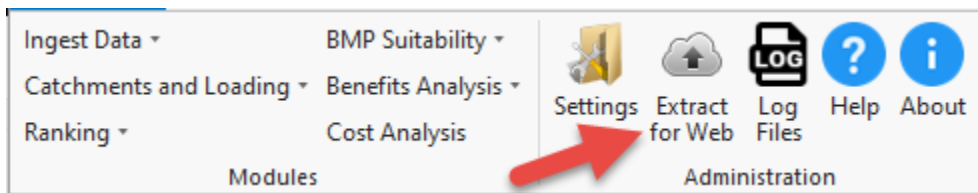


a. Inputs:
   i. *Input processing geodatabase*:  This is the output path where the standardized PTMApp desktop geodatabases and associated data will be saved. Users can change this file path in the settings button.
   ii. *Output location*: Folder where the output zip file will be written.
   iii. *Quality control output path*:  Location where QC text file will be created
   iv. *Quality control file name*:  Name of QC text file.
   v. *Eliminate small doughnut holes for performance (requires Advanced license)*: This helps performance issues on the PTMApp website.
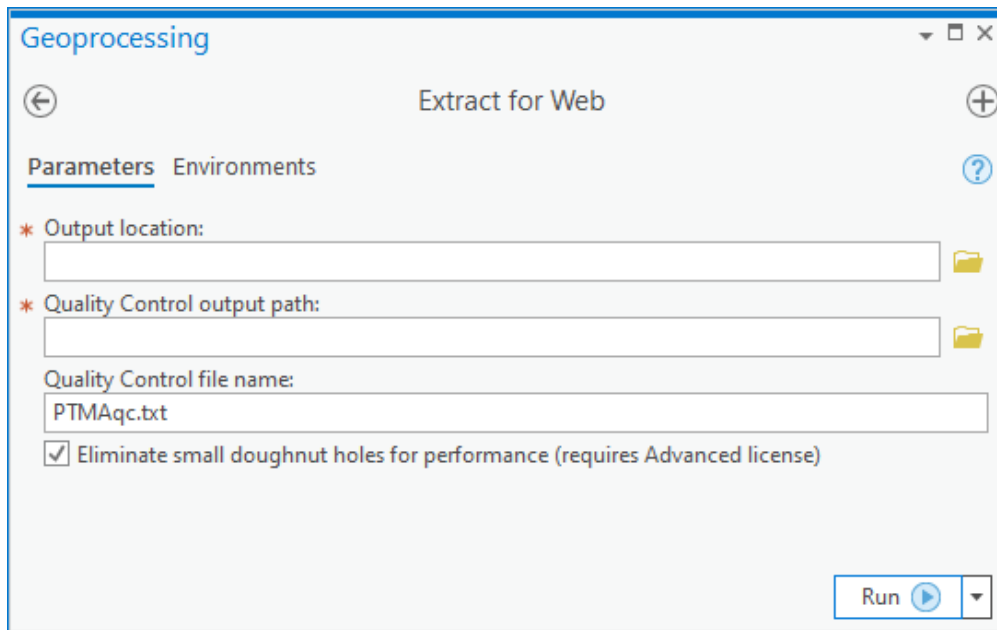
## 7.8 Help

For help documents on PTMApp-Desktop click the **Help** button.
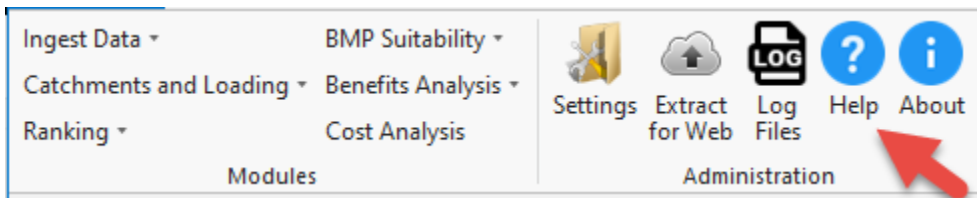


You can choose the **PTMApp User Guide** or the **PTMApp Error Submission** documents.
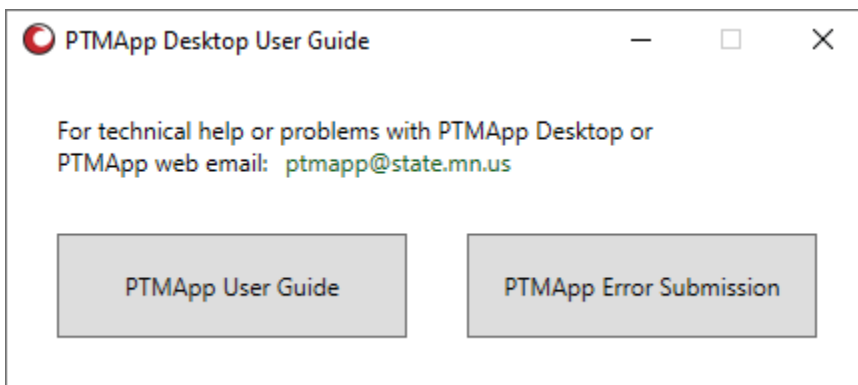


## 7.9 About

The about page shows PTMApp partners.