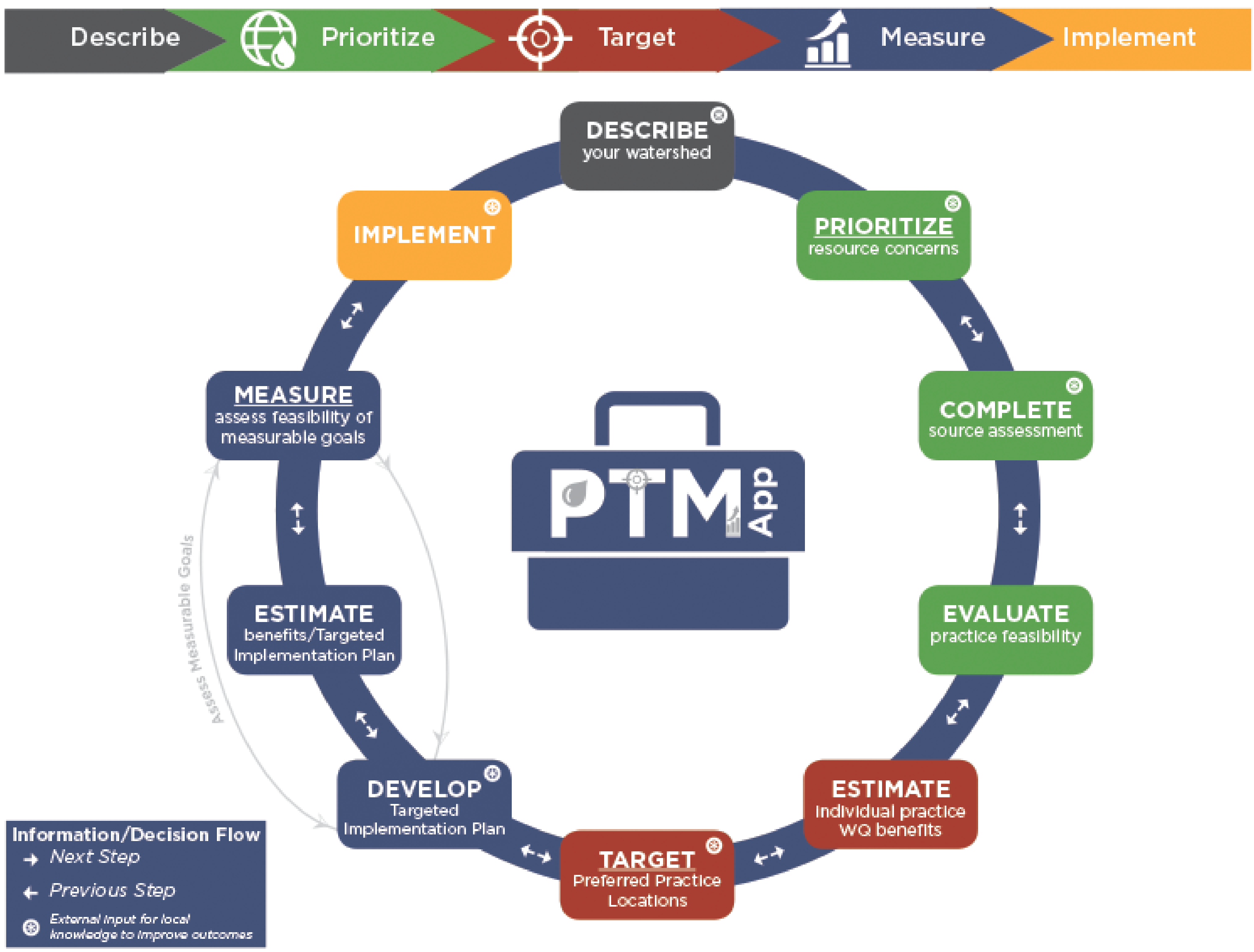
October 2019



WORKSHOP SECTION 1 MANUAL:
CREATING ELEVATION PRODUCTS AND PTMAPP-DESKTOP INPUTS

AN INNOVATIVE SOLUTION BY:

Board of Water and Soil Resources

International Water Institute
Supporting Flood Research and Watershed Education

Red River Watershed Management Board

Houston Engineering Inc.

Clean Water Land & Legacy Amendment

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1 PURPOSE

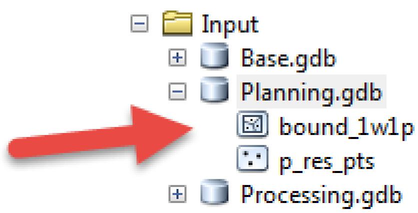
The purpose of this document is to provide descriptions of data inputs needed to run the PTMApp-Desktop GIS toolbar and provide detailed instructions on how to create these data inputs. The datasets listed in the below table are covered in this document. It does not include several optional datasets. To accomplish this purpose, the document walks through examples of how to generate each of the input datasets listed in the table below. At the end of this workshop, participants should be able to use these examples to generate their own inputs for PTMApp-Desktop.

	Dataset	PTMApp Name	Description	Format
1	Plan Boundary			
		bound_1w1p	Project boundary; naming convention for boundary of 1W1P planning area	polygon
2	SSURGO			
		ssurgo_cpi	SSURGO - Crop productivity index	raster
		ssurgo_hs	SSURGO - Hydric rating	raster
		ssurgo_hsg	SSURGO – Hydrologic group	raster
		ssurgo_dtgw	SSURGO - Depth to groundwater	raster
3	Curve Number			
		curve_num	Curve number raster	raster
4	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
5	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
6	Travel Time			
		tt_grid	Cell to cell travel time in seconds	raster
7	Priority Locations			
		p_res_pts	Point locations of priority resources and/or plan regions, with water quality goals in attributes	point

2 PLAN BOUNDARY

The plan boundary is the extent of the study area where PTMApp-Desktop will be run. This can be an existing watershed boundary or another boundary defining the project area. For the purposes of PTMApp-Desktop the plan boundary layer must be named “bound_1w1p”and placed in the PTMApp-Desktop “Planning” geodatabase. If performing intensive (i.e. H3DEM Plus) hydrologic conditioning, the watershed delineated from the conditioned DEM should be used as the plan boundary. Bound_1w1p will be used in future geoprocessing steps, hydro-conditioning, and within PTMApp-Desktop, to clip feature class and rasters to the project area.

Dataset	PTMApp Name	Description	Format
Plan Boundary			
	bound_1w1p	Project boundary; naming convention for boundary of 1W1P planning area	polygon



3 SSURGO SOILS

SSURGO Soils data are produced by USDA NRCS. Background information about SSURGO Soils can be found on their website. The PTMApp base.gdb has a complete Minnesota statewide SSURGO polygon shapefile for use. Watersheds that cross the state line have complete SSURGO data as well.

At the end of this section, you will know how to develop the following inputs for PTMApp-Desktop:

Dataset	PTMApp Name	Description	Format
SSURGO			
	ssurgo_cpi	SSURGO - Crop productivity index	raster
	ssurgo_hs	SSURGO - Hydric rating	raster
	ssurgo_hsg	SSURGO – Hydrologic group	raster
	ssurgo_dtgw	SSURGO - Depth to groundwater	raster

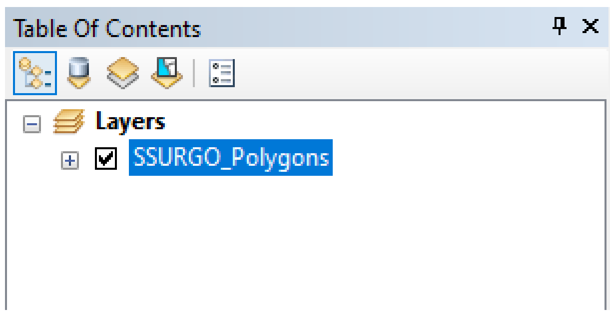
3.1 PREPARING SSURGO DATA INPUTS

HOW TO:

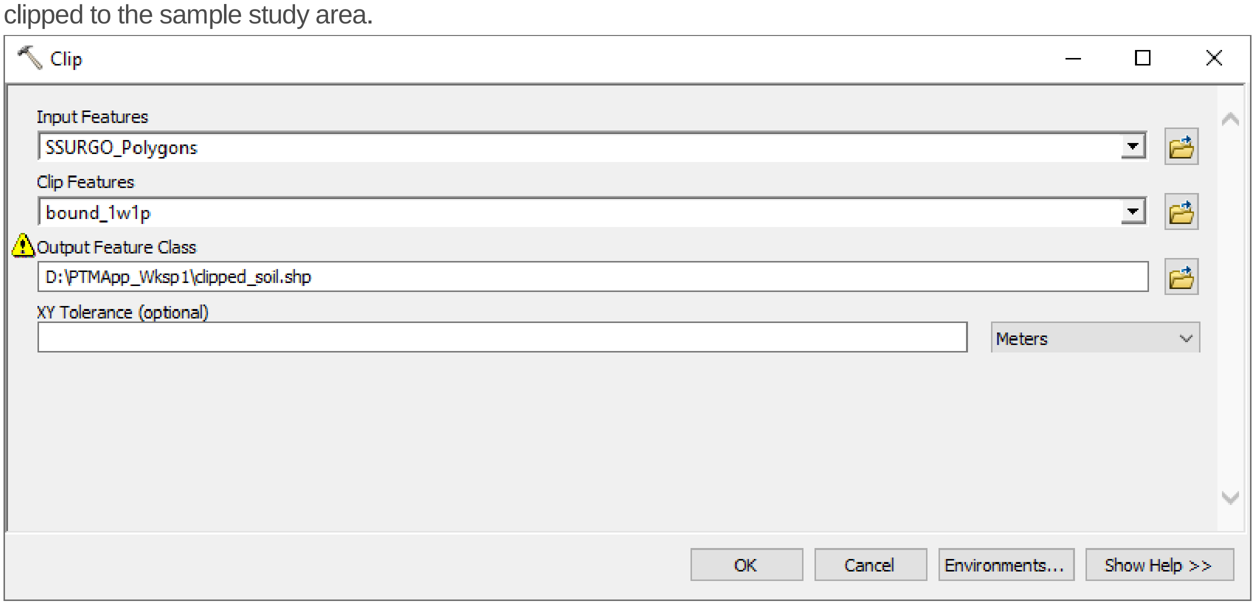
Description – This example will take you through the creation of one of the five SSURGO/RUSLE inputs for PTMApp-Desktop and the preparation of SSURGO data needed for other portions of the input preparation. The process for creating the inputs is the same for all four inputs. The information for this section is located in: WorkshopMaterials\Input_Creation\SSURGO

Steps

1. The screenshot below shows the statewide polygon layer name, 'SSURGO_Polygons'. This shapefile has all SSURGO soil data for the state and any bordering watersheds that cross state lines with Minnesota. For best performance, the shapefile will need to be clipped to the bound_1w1p shapefile.



2. The SSURGO data is a statewide layer so it is recommended to clip the SSURGO_Polygons layer using a buffered version of the plan boundary. For this workshop, the SSURGO_Polygons has been clipped to the sample study area.



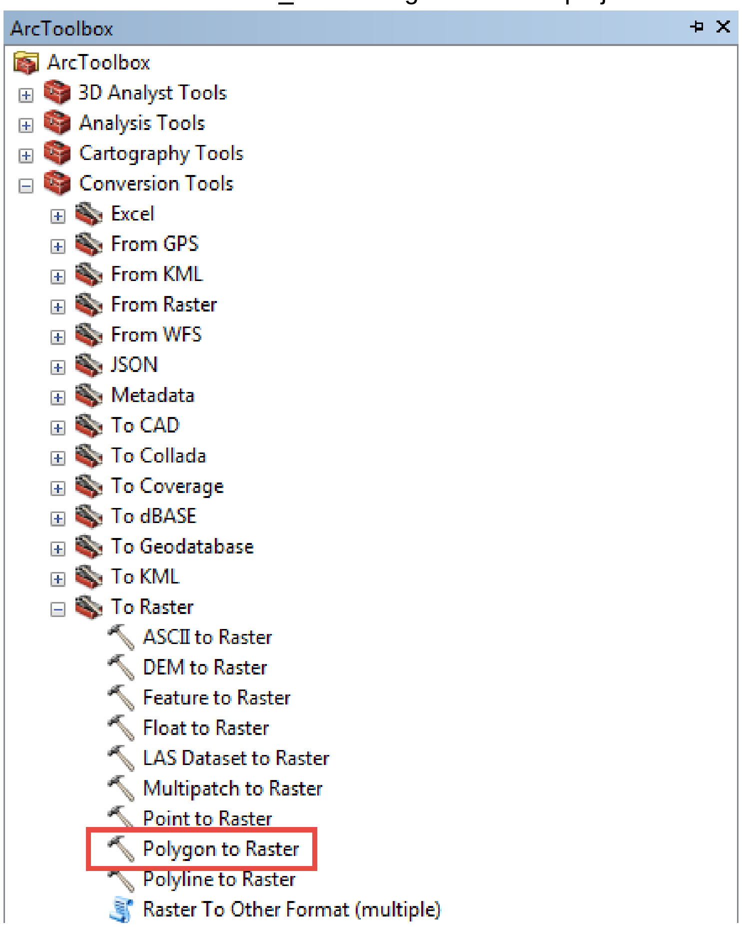
3. You should now have a clipped SSURGO soils layer for your watershed boundary. Open the attribute table for the newly clipped soils layer and make sure it is populated. You should see 12 columns containing SSURGO/RUSLE soil data.

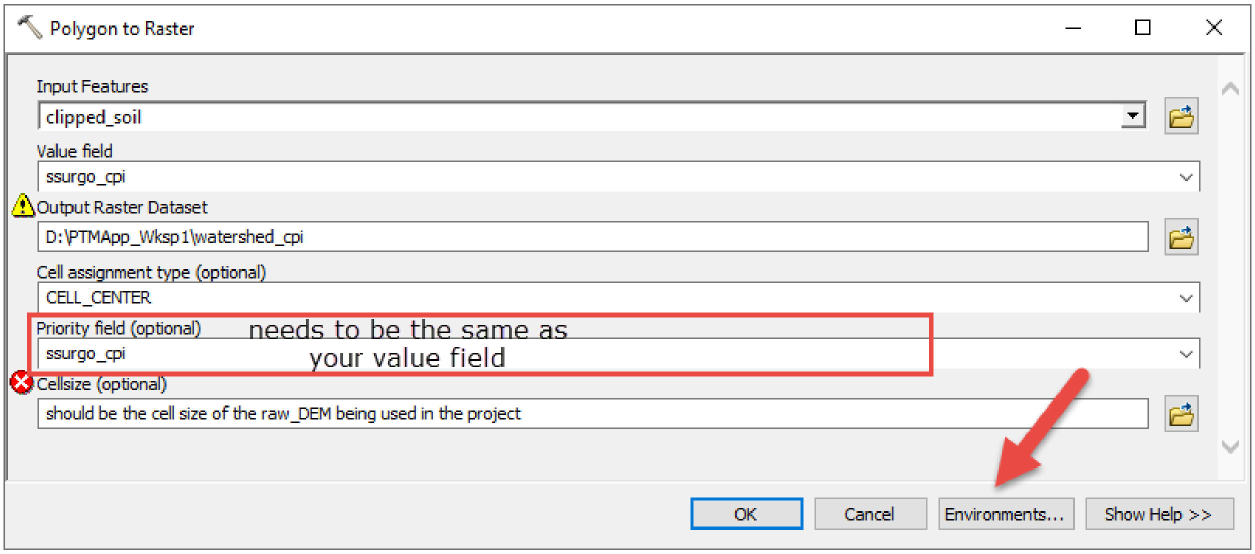
FID	Shape *	SPATIALVER	MUKEY	ssurgo_cpi	ssurgo_hs	ssurgo_hsg	ssurgo_dtg	rusle_kw	Shape_Leng	Shape_Area
0	Polygon	5	435015	37	0	1	201	0.24	1319.246546	40437.102901
1	Polygon	5	435007	70	0	2	201	0.32	1302.761525	25431.810909

The data you are obtaining are ssurgo_cpi, ssurgo_hs, ssurgo_hsg, ssurgo_dtg. You will obtaine the rusle_kw value in a later section.

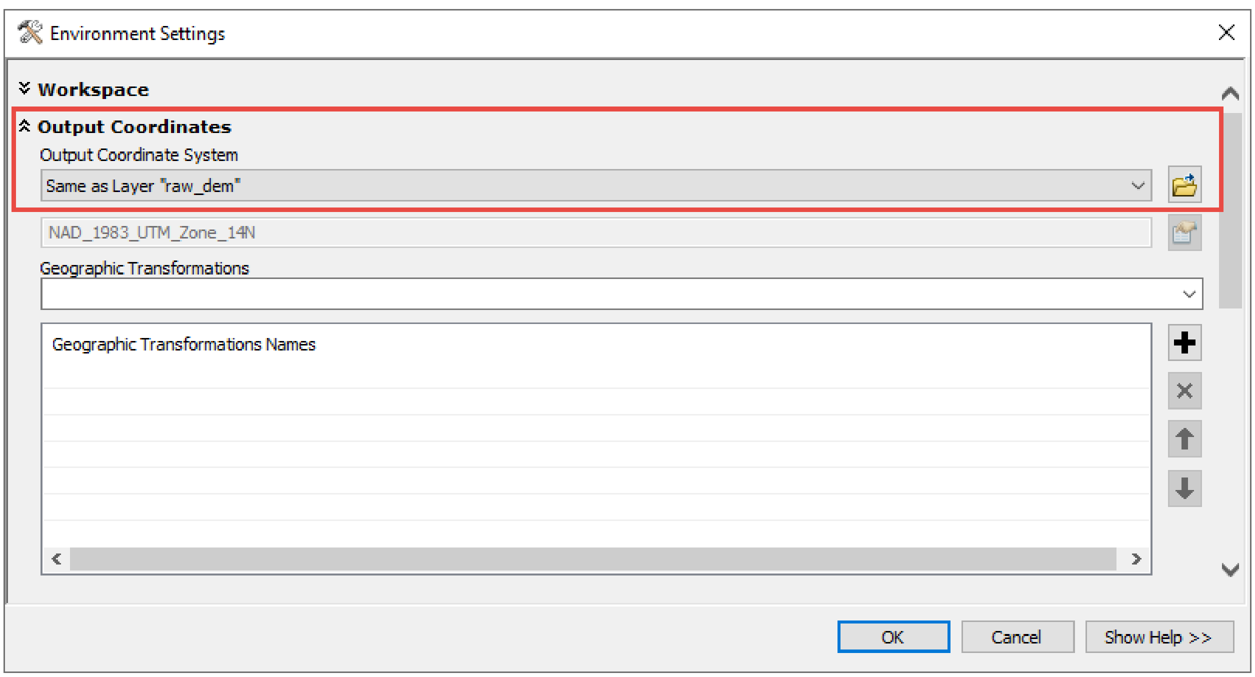
PTMApp uses these data in raster form. They are currently in polygon shapefiles. The following steps will show how to convert the data of interest from polygon shapefiles to raster data files. The following steps will be completed for ssurgo_cpi but must be completed for all data of interest in the same way.

4. Perform Polygon to Raster for ssurgo_cpi using the clipped_soil polygon as your input feature and ssurgo_cpi as the value field (see image below). Ensure that cellsize (the last optional input field) is the same cell size of the raw_DEM being used for the project.

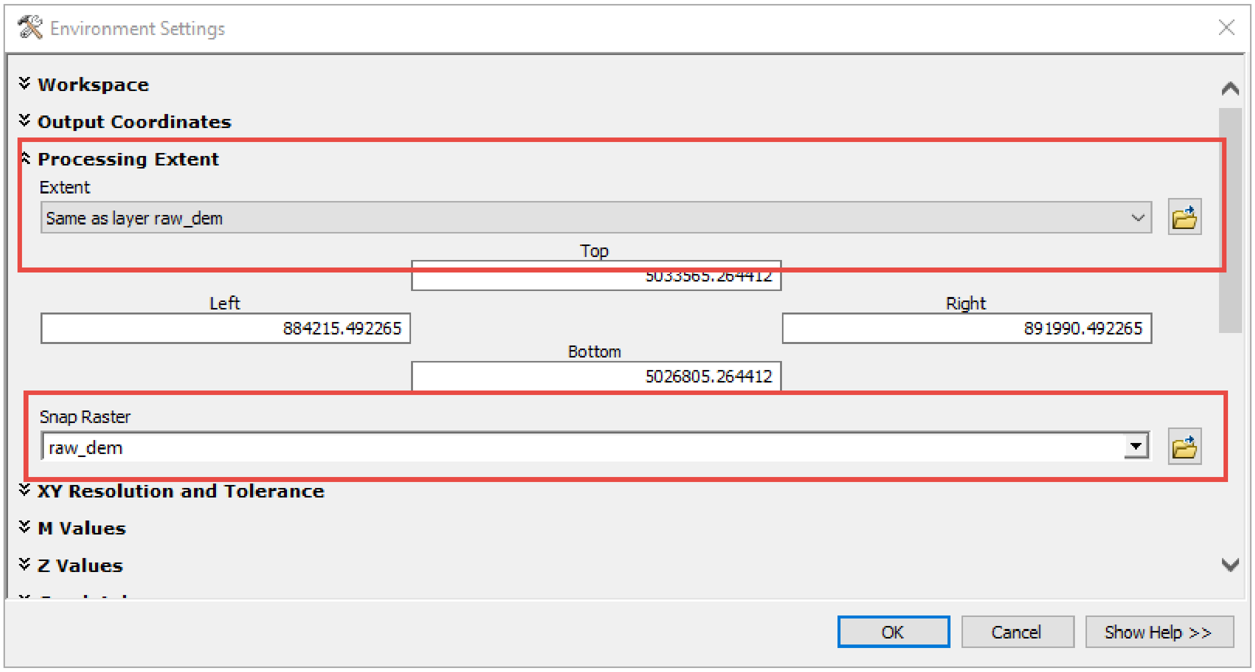




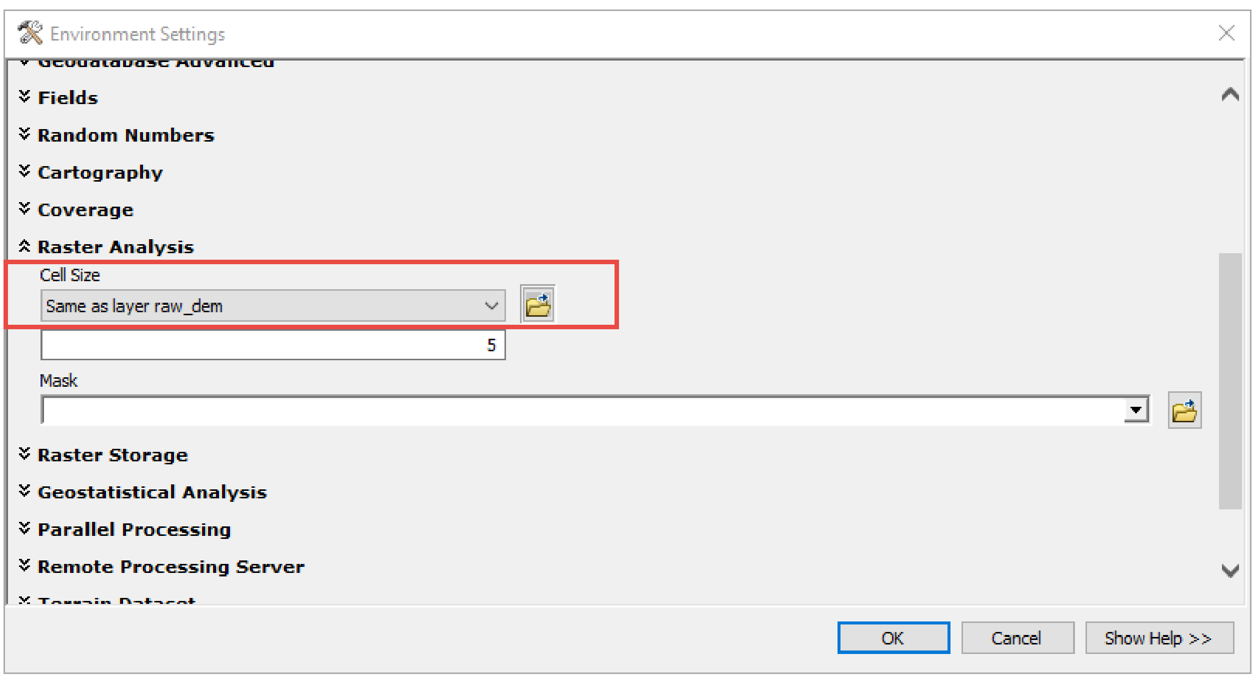
5. Before pushing OK, you must set your Environments to ensure the conversion from Polygon to Raster does not get distorted. Go to Environments:
    a. Click Output Coordinates. Using the dropdown menu, change Output Coordinate System to "raw_dem".



    b. Click Processing Extent. Change Extent "Default" to "raw_dem". Below that, "Snap Raster" to "raw_dem".

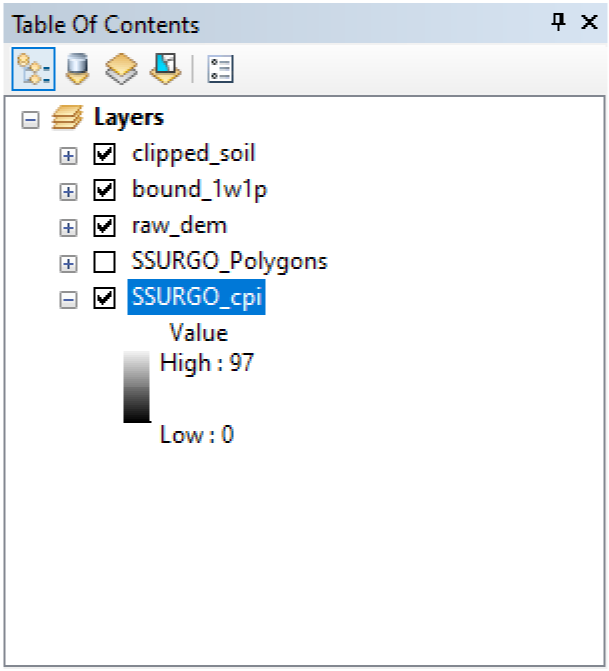


c. Click Raster Analysis. Change Cell Size from "Maximum of Inputs" to "raw_dem".



d. Click OK
e. Run the Polygon to Raster conversion tool

6. The output of the Polygon to Raster should now be a range of values as seen in the table of contents under watershed_cpi.



7. Perform steps 4 and 5 for the remaining data of interest to obtain raster layers for ssurgo_hs, ssurgo_hsg, and ssurgo_dtg.

4 ELEVATION PRODUCTS

The purpose of hydrologic conditioning (or conditioning) is to modify raw Light Detection And Ranging (LiDAR) data in order to determine accurate surface flow patterns using automated GIS processes. Intensive conditioning is a labor-intensive process that requires several iterations of manually creating and editing polylines referred to as "Burnlines" and "Wall-lines" primarily based on interpretation of LiDAR features and aerial photography. Burnlines are used to artificially lower the LiDAR based Digital Elevation Model (DEM) at culverts, bridges, ditches and other locations where water travels below the surface. Wall-lines artificially raise the DEM at locations where water should be diverted.

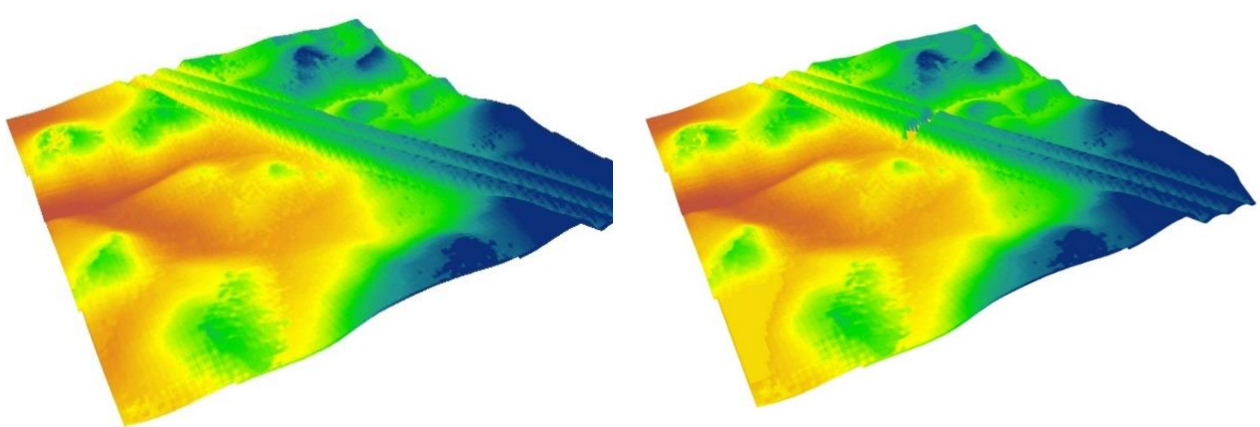


Figure 1. Displays "before and after" DEM's affected by burnline placement. (a) Digital dam created by roadway. (b) Digitally lowered flow path from burnline.

The conditioned DEM and GIS layers produced from the conditioned DEM are used to derive many of PTMApp-Desktop inputs and are also used internally in the PTMApp-Desktop tools. This section lays out detailed steps for three methods of performing conditioning:

1) PTMApp-Desktop Planning and Field Scale Implementation (H3DEM Plus)
2) PTMApp-Desktop Planning (H2DEM Plus)
3) PTMApp-Desktop Planning (H2DEM & Equivalent)

The three methods outlined in this document come from the full list shown on the following page. The H3DEM and H2DEM standards are similar to those developed by the MNDNR. HD3DEM Plus conditioning is time intensive and requires significant work to develop, but provides field scale BMP siting and effectiveness along with flow and load routing in PTMApp-Desktop. H2DEM conditioning is less time intensive (typically using streamlines to largely guide burnline placement) and requires less work to develop, and therefore provides only flow and loading routing and BMP analysis at a watershed scale. H2DEM Plus includes intensive hydro-conditioning procedures only for the incorporation of lakes, but otherwise follows H2DEM protocols. Each of these methods will be described in detail on the following pages.

*Operational Nomenclature Used for Various Hydrologic Digital Elevation Models***
February 13, 2017

International Water Institute
Supporting Flood Research and Watershed Education
HoustonEngineering 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 <u>and</u> 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.

An ESRI Arc Basic License with Spatial Analyst Extension is sufficient for all hydro-conditioning tools unless otherwise noted. At the end of this section, you will have been provided examples of the steps needed to create the follow PTMApp-Desktop inputs:

Dataset	PTMApp Name	Description	Format
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

4.1 PREPARING LIDAR DATA FOR HYDROLOGIC CONDITIONING

4.1.1 DEFINE STUDY AREA AND CLIP INPUTS

☞ HOW TO:

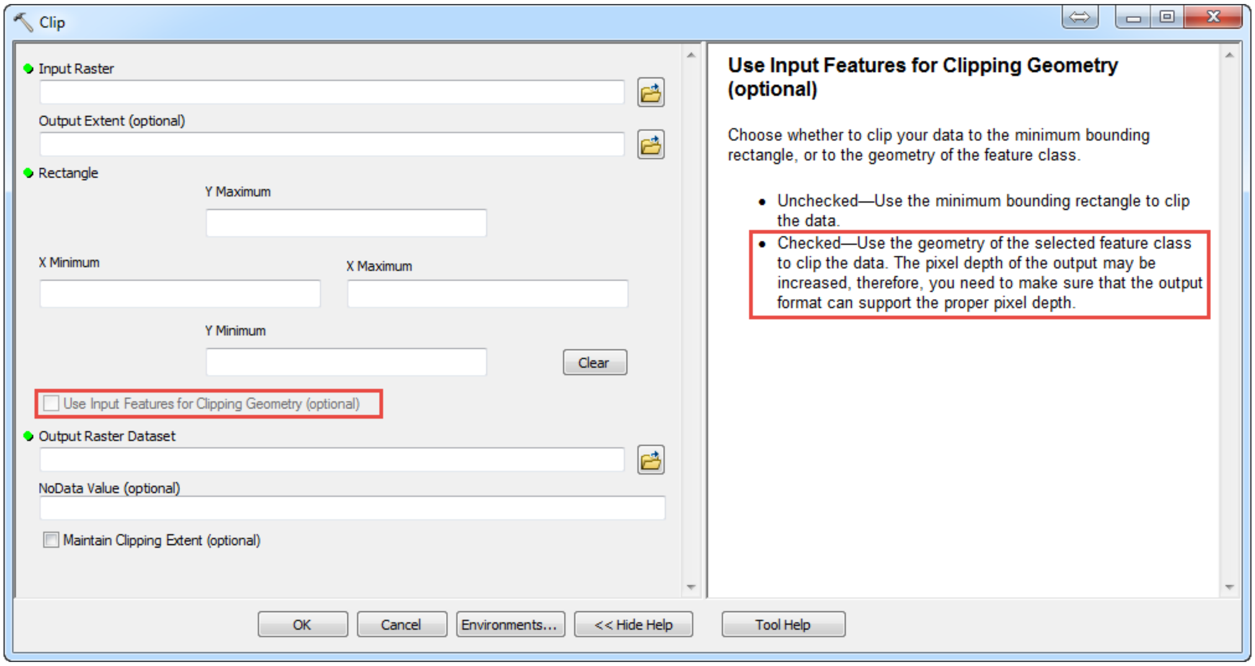
Description – In this step, you will buffer the study area boundary to ensure that the actual hydrologic boundary is not missed.

Steps

1. Define the working boundary of the study area with an existing watershed boundary or project area and buffer it to include an additional 1,000 feet (~1/4 mile) to 5,000 feet (~1 mile) to ensure the actual hydrologic boundary is not missed during the conditioning process.

2. Once the working boundary is defined, the LiDAR DEM and any other layers used in the conditioning process can be clipped. This will be the raw DEM modified during the conditioning process. It is recommended that you store all the conditioning inputs within a geodatabase for organizational purposes.

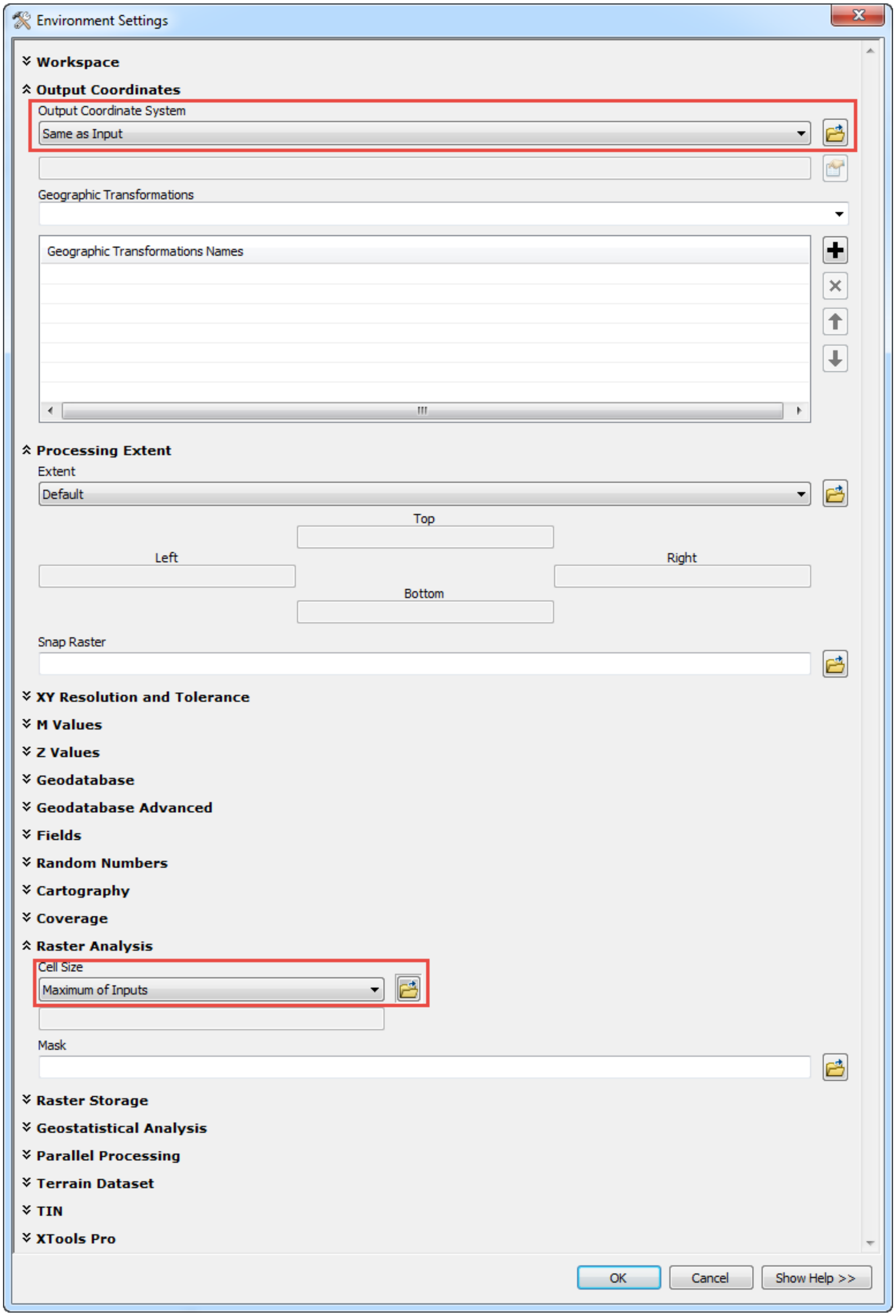
   Tip: Make sure to check the Use Input Features box.



Tips:

Make sure to set the Environments settings in the Geoprocessing menu and checking the following settings:

- Output Coordinates: Select the raw DEM
- The "Processing Extent" and "Snap to Raster" should be set to the Raw DEM.
- Raster Analysis: Select the Raw DEM as the cell size for the output.


Environment Settings
Workspace
Output Coordinates
Output Coordinate System
Same as Input
Geographic Transformations
Geographic Transformations Names
Processing Extent
Extent
Default
Top
Left
Right
Bottom
Snap Raster
XY Resolution and Tolerance
M Values
Z Values
Geodatabase
Geodatabase Advanced
Fields
Random Numbers
Cartography
Coverage
Raster Analysis
Cell Size
Maximum of Inputs
Mask
Raster Storage
Geostatistical Analysis
Parallel Processing
Terrain Dataset
TIN
XTools Pro
OK
Cancel
Show Help >>

4.2 PTMAPP-DESKTOP PLANNING AND FIELD SCALE IMPLEMENTATION – H3DEM PLUS

4.2.1 BACKGROUND

H3DEM Plus hydrologic conditioning is the process of a GIS analysist identifying locations where flow obstructions exist in the DEM but not necessarily in real life. These are typically caused by features such as roadways, driveways, and field crossings, but may also include farm fields where tile has been installed or marshy lands where flow pathways are not evident in the DEM. This process is informed by the review of various GIS layers, depressions, and hydrologic analysis to determine whether a subsurface flow path exists. The general work flow is as follows:

1. Review aerial imagery, LiDAR topography, or other available datasets to place initial burnlines and wall-lines (Sections 5.2.2 and 5.2.3)
2. Modify raw DEM to reflect burnlines and wall-lines and create preliminary flowpaths, delineations, and remaining depression layers (Section 5.2.4)
3. Review preliminary DEM conditioning layers and place additional burnlines and wall-lines (or edit previously placed burnlines and wall-lines; Section 5.2.4)
4. Repeat steps 2 and 3 until sufficient accuracy for the conditioned DEM is achieved.

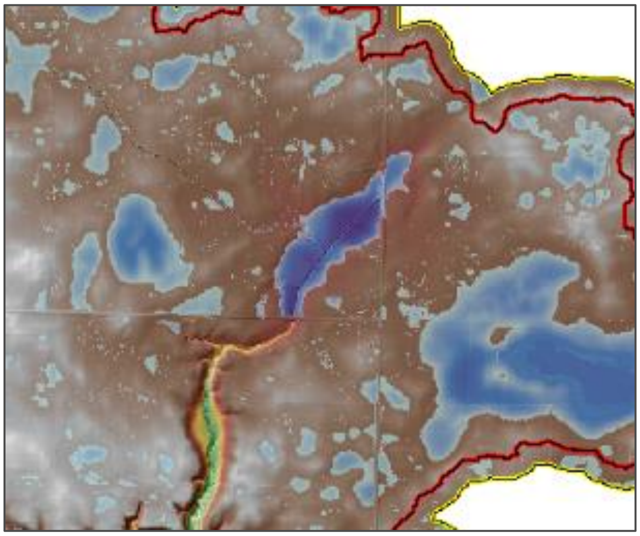
4.2.2 PLACING BURNLINES AND WALL-LINES

The exact procedure used to place burnlines and wall-lines may vary based on your preferences but generally consists of reviewing various datasets, most commonly aerial photography and LiDAR topography. If more detailed data such as a culvert inventory is available, it should also be utilized. Burnlines are typically used to breach obstacles that impede flow in the LiDAR dataset, including roadways, driveways, field crossings, and field approaches. Burnlines can also be used to reinforce flow pathways which may have been missed during the LiDAR data gathering (e.g. lake outlet covered by vegetation). Wall-lines are typically used to block erroneous flow pathways or used (in conjunction with a burnline) to concentrate flow to specific points. NOTE THIS WILL BE DISCUSSED MORE IN LAKE ROUTING SECTION.

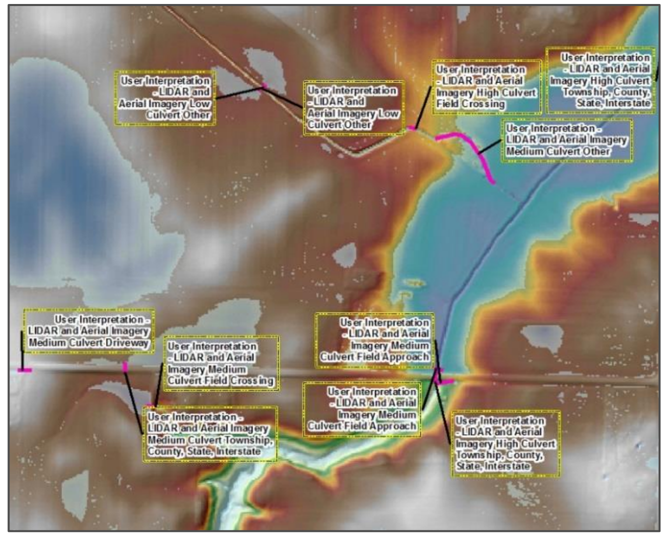
TIPS:

- The LiDAR DEM (1-meter resolution DEM for much of MN) is useful for burnline placement as it can provide greater definition of culvert end points.
- The highest quality aerial imagery source varies by location. Consider checking for sources such as the county or Google Earth.
- ArcGIS processing can help locate digital dams using the following Spatial Analyst commands:
  - **Fill** – command raises elevations of all sinks in the raw DEM (Fill DEM)
  - **Minus -** command used to create a layer identifying all sinks in the raw DEM; functionally represents: (Fill DEM – Raw DEM).

The following figures provide examples of burnline and wall line placement.



The center of the image shows a depression created by the lack of a burnline.



Example burnlines with placement attribution.

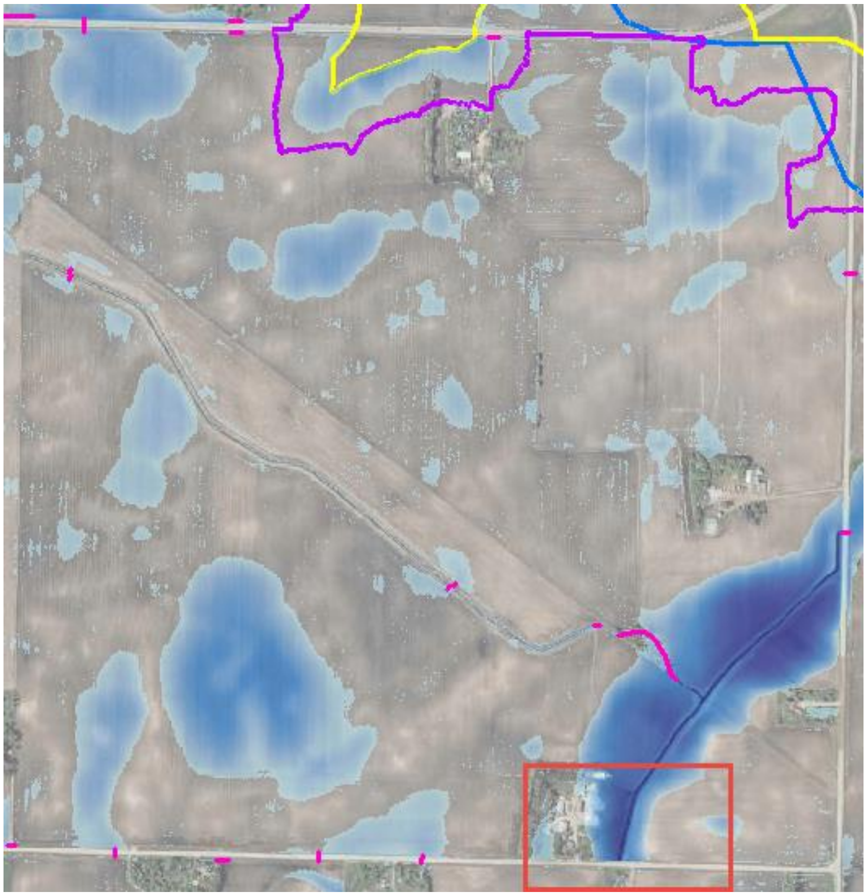
4.2.3 EXAMPLE OF HOW TO PLACE A BURNLINE

☞ HOW TO:

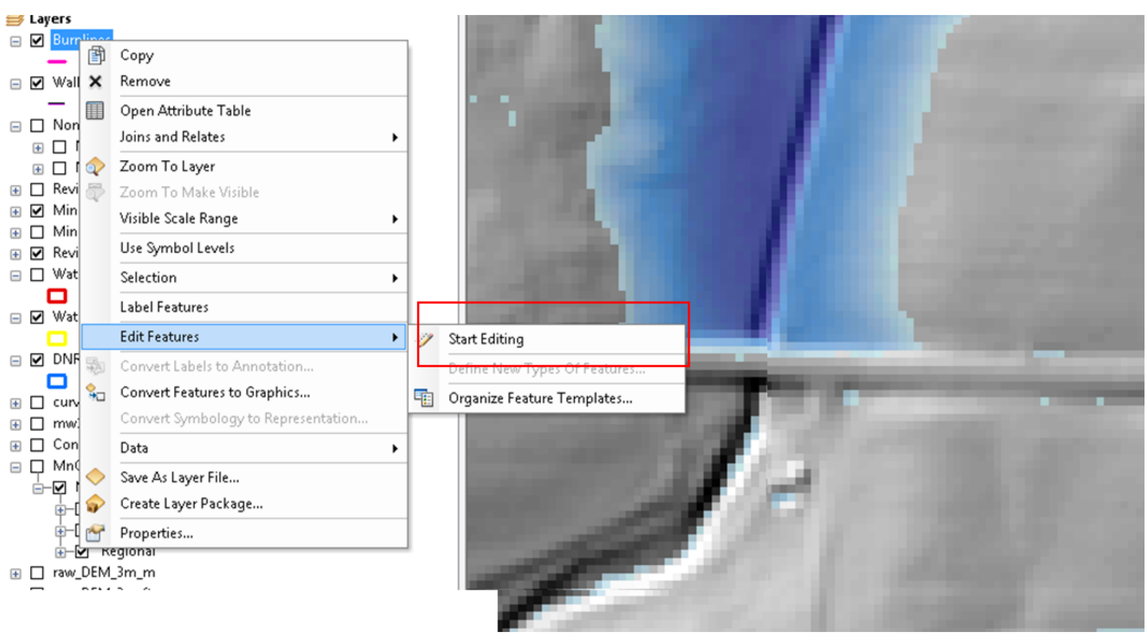
Description – You'll now go through an example of creating a burnline in the area shown above. After this section you should be familiar with the process of creating burnlines and wall-lines.

Steps

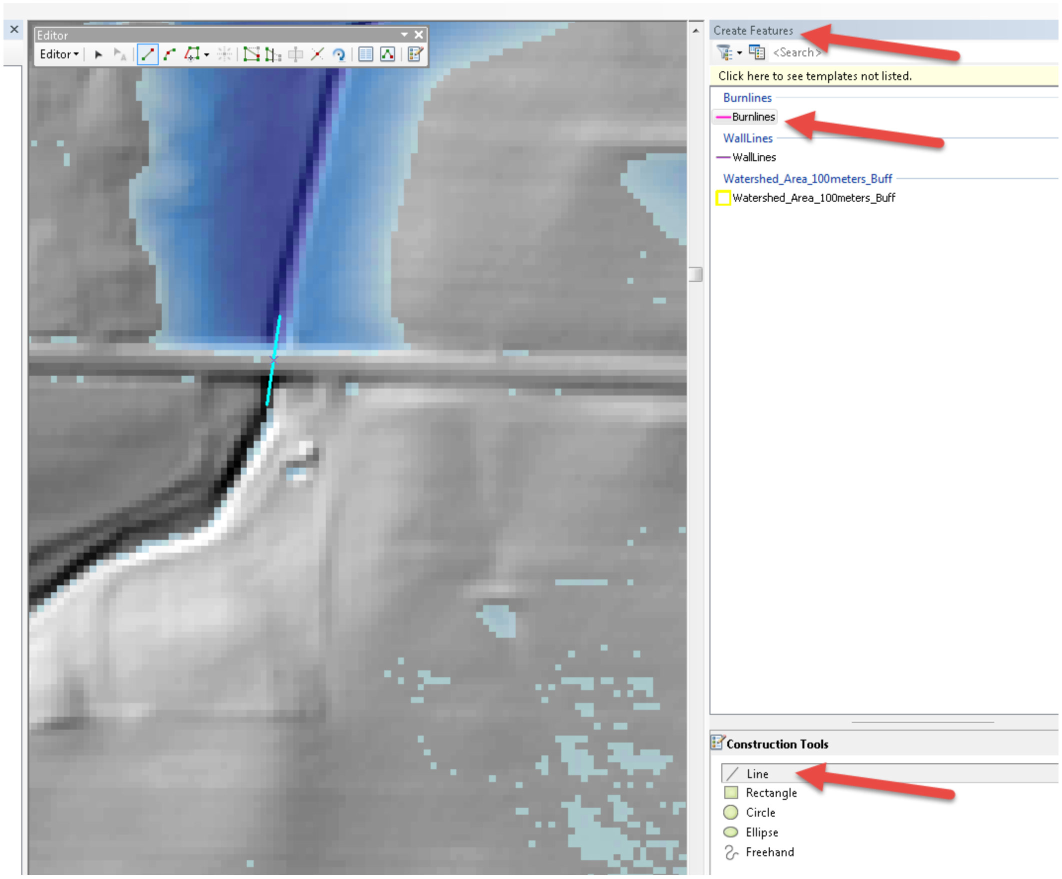
1. In the screenshot below, notice the artificial ponding and missing burnline upstream (north) of the road way (in red box). We will add a burnline to this area.



2. Zooming into the area in the red box, and turning off the aerial photograph and turning on the Hillshade_3m raster, we can right click on the burnline file and start editing.



3. In the create features window, be sure to select the burnlines file and the Line option under Construction Tools and digitize a line across the road in the center of the ditch.



4. We strongly recommend documenting the reason the burnline was created. This should be done in the burnline attribute table. Explore existing burnlines provided with the workshop data to see examples of how this has been done in other locations.

Table

Burnlines

OBJECTID *	SHAPE *	Desktop Interpretation Source	Desktop Confidence Level	Type	Road Type	Internal Review	Internal Review Comments
1	Polyline	User Interpretation - LIDAR and Aerial Imagery	Medium	Culvert	Driveway	None	<Null>
2	Polyline	User Interpretation - LIDAR and Aerial Imagery	Low	Culvert	Township, County, State, Interstate	None	<Null>
3	Polyline	User Interpretation - LIDAR and Aerial Imagery	Low	Culvert	Township, County, State, Interstate	None	<Null>
4	Polyline	User Interpretation - LIDAR and Aerial Imagery	Low	Culvert	Township, County, State, Interstate	None	<Null>
5	Polyline	User Interpretation - LIDAR and Aerial Imagery	Medium	Culvert	Field Approach	None	<Null>
6	Polyline	User Interpretation - LIDAR and Aerial Imagery	Medium	Culvert	Driveway	None	<Null>
7	Polyline	User Interpretation - LIDAR and Aerial Imagery	High	Culvert	Township, County, State, Interstate	None	<Null>
8	Polyline	User Interpretation - LIDAR and Aerial Imagery	Medium	Culvert	Township, County, State, Interstate	None	<Null>
9	Polyline	User Interpretation - LIDAR and Aerial Imagery	Low	Culvert	Township, County, State, Interstate	None	<Null>
10	Polyline	User Interpretation - LIDAR and Aerial Imagery	Medium	Culvert	Township, County, State, Interstate	None	<Null>
11	Polyline	User Interpretation - LIDAR and Aerial Imagery	Medium	Culvert	Driveway	None	<Null>
12	Polyline	User Interpretation - LIDAR and Aerial Imagery	Low	Culvert	Township, County, State, Interstate	None	<Null>
13	Polyline	User Interpretation - LIDAR and Aerial Imagery	Low	Culvert	Township, County, State, Interstate	None	<Null>
14	Polyline	User Interpretation - LIDAR and Aerial Imagery	Medium	Culvert	Field Approach	None	<Null>
15	Polyline	User Interpretation - LIDAR and Aerial Imagery	Medium	Culvert	Field Approach	None	<Null>
16	Polyline	User Interpretation - LIDAR and Aerial Imagery	Low	Culvert	Township, County, State, Interstate	None	<Null>
17	Polyline	User Interpretation - LIDAR and Aerial Imagery	Medium	Culvert	Driveway	None	<Null>

5. Stop editing and save your edits.

4.2.4 WATERSHED CONDITIONING REVIEW

4.2.4.1 CREATING CONDITIONING OUTPUT PRODUCTS

Once burnlines have been placed across the plan area, you can begin creating the preliminary hDEM products. These includes a hydrologically-conditioned DEM, Flow Accumulation (fac), and Flow Direction (fdr) raster.

There are a number of existing resources for creating hDEM products. Some of these are listed below:

- Tools from ESRI Spatial Analyst Hydrology toolbox http://resources.arcgis.com/en/communities/hydro/01vn00000010000000.htm
- TauDEM: http://hydrology.usu.edu/taudem/taudem5/
- Topaz: http://homepage.usask.ca/~lwm885/topaz/
- ESRI: http://proceedings.esri.com/library/userconf/proc15/tech-workshops/tw_897-156.pdf
- Mankato St. WRC: https://www.wrc.umn.edu/lidar-materials

One or more of these resources should be used to create the following input elevation products generated for PTMApp-Desktop:

Dataset	PTMApp Name	Description	Format
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

After a preliminary set of hDEM products has been created, we strongly recommend a second round of review occur to locate additional obstructions that may have been missed during the first pass.

Additional analysis may also be helpful, including:

REVIEW REMAINING DEPRESSIONS – use the 'minus' function to subtract the raw_DEM from the hyd_dem. This gives you the location and depth of remaining "depressions" on the model landscape. Many of these are real, but some may be created by remaining 'digital dams'.

COMPARE SUBWATERSHED BOUNDARIES – create a pour point shapefile to match pour points from an existing hydrologic dataset (e.g. MNDNR minor subwatersheds or USGS HUC-12s) and run the 'Watershed' tool to compare the two datasets. Its expected that your improved hydrologic conditioning process will lead to at least some discrepancies, and the majority of them will result from improved delineations. But very large ones (e.g. top 10^{th} percentile resulting from a 'union' of the watershed datasets) may signify serious delineation issues.

NON-CONTRIBUTING ANALYSIS – rainfall-runoff grids can be used to estimate depressional storage in certain rain events (e.g. 10-yr, 24-hr design storm) and, through a "fill-and-spill" iteration process be used to estimate which depressions would not contribute flow downstream during certain runoff events. Such depressions are call non-contributing, or closed, basins. PTMApp-Desktop allows for inputs of non-contributing basins through the use of surface flow accumulation (fac_surf) and surface flow direction (fdr_surf) grids. These would replace the fac_total and fdr_total grids, respectively, in our inputs/processing.gdb. Your hyd_dem should also reflect only surface flow pathways.

4.2.5 HYDROLOGIC CONDITIONING FOR LAKES

☞ **HOW TO:**

Description - In this section we will describe how to condition your DEM to ensure flow is properly routed to and through lake systems. We recommend incorporating lakes into your hydro-conditioning procedure after you've generated a flow accumulation grid (fac_total), as this grid will determine the amount of necessary hydro-conditioning work for lake routing. Typically, we recommend completing one pass placing burnlines and wall-lines across your entire watershed and working through the steps in sections 5.2.3 and 5.2.4. Once the flow accumulation grid (fac_total) has been generated you can proceed to the steps below.

STEPS

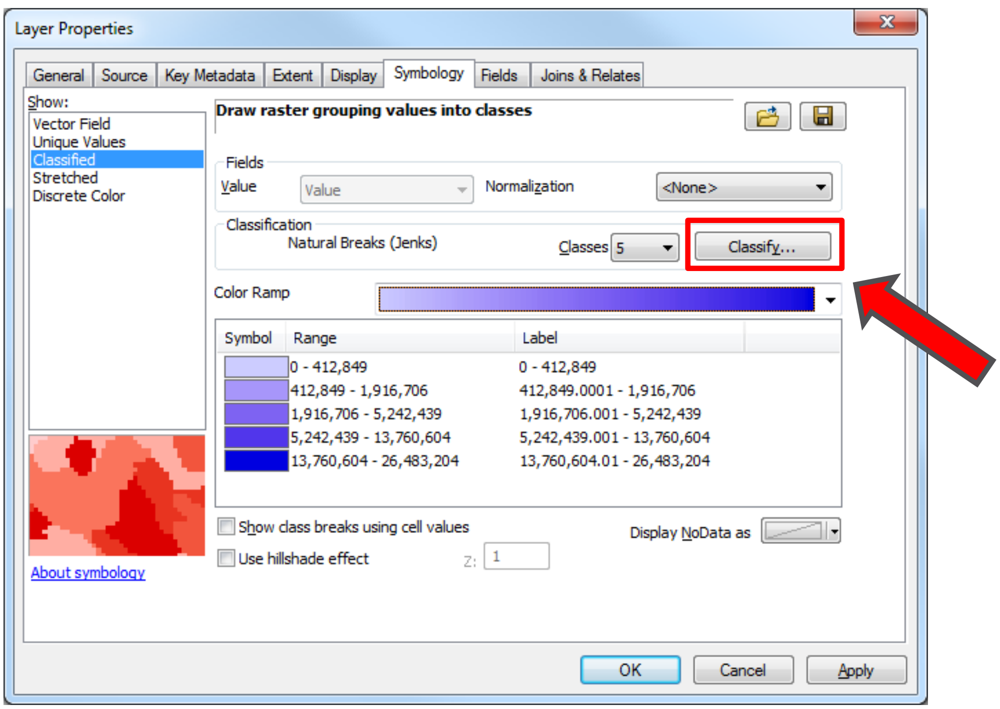
1) Determine the lake polygons you wish to use for lake routing. Any polygon feature class can be used. We recommend starting with either of the following datasets provided by the Minnesota Department of Natural Resources (MNDNR):
    a. MNDNR Autocatchment Lakes – this dataset is part of the MNDNR Watershed Suite and includes both lake and wetland polygons from the public water inventory. Waterbody delineations are up to the OHWL for waterbodies up to 10 acres in surface area. This data can be accessed here: https://gisdata.mn.gov/dataset/geos-dnr-watersheds. A copy of this dataset has also been saved to your Base.gdb, and is titled 'Lakes_DNR_auto'.
    b. MNDNR Hydrography Dataset – specifically the 'All Water Features (polygons)' feature class. This is the new "official" public water basins feature class for MNDNR, replacing the '24K Lakes' feature class. This data was originally based off 24K but is continually updated with local delineations and what MNDNR calls "the best available spatial features representing MN surficial hydrology". If significant local work has been performed, delineations may be more accurate than the Autocatchment Lakes feature class. This data can be accessed here: ftp://ftp.gisdata.mn.gov/pub/gdrs/data/pub/us_mn_state_dnr/water_dnr_hydrography/metadata/dnr_hydrography_dataset.html

    Modifications may need to be made to lake polygons within either of these datasets to account for flow pathways in your DEM or to better cover the full lake basin. Either of these polygon datasets provide great starting points for preparing your lake routing input data.

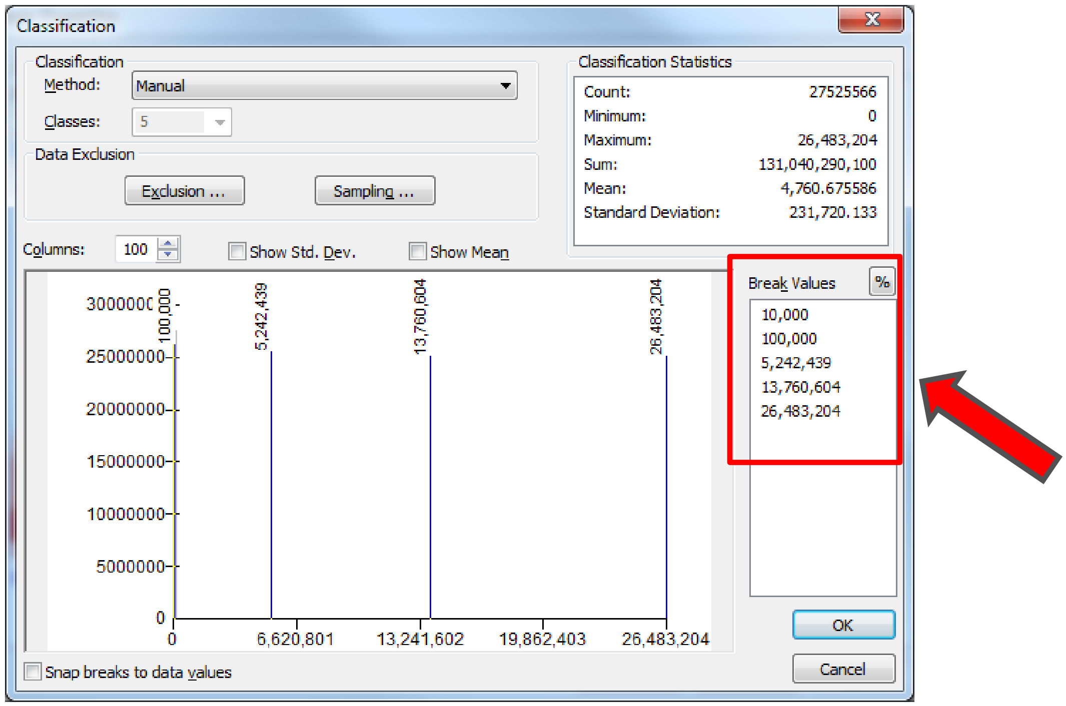
2) Whichever lake polygon dataset you choose to use, export the shapefile to a folder or geodatabase that also houses your burnlines and wall-lines and rename the shapefile 'lakes_route'. Add this shapefile to your working ArcMap Document.
3) Once the lake polygons have been added to your working ArcMap Document, you can see what modifications must be made to either your DEM or your lake polygon to ensure flow is accurately routed through the lake. To find your flow pathways, add fac_total and symbolize as shown below:

Note: Any tool that generates flowpaths (e.g. tools in ArcHydro) can be used instead of these steps

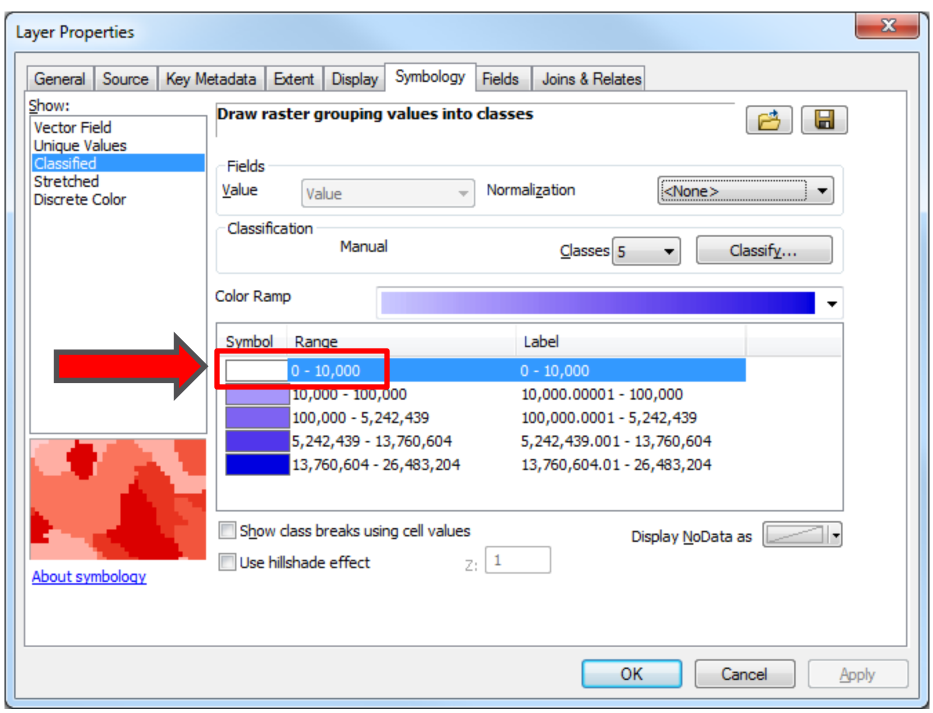
a. In the Symbology tab of your 'fac_total' raster's properties, choose the 'Classified' renderer and click on 'Classify…'



b. In the Classification dialog box, choose smaller break values. '10,000' is a good starting point as this will color all cells receiving flow from 10,000 upstream cells. It's very likely all lakes you intend to include will receive flow from at least 10,000 cells. You could also choose a value less than 10,000 if you want to create more and longer flow lines.



c. Close the Classification dialog box and be sure to hollow out the first symbol, representing the range ‘0-10,000’ in this case.



4) Modifying your hDEM products and lake polygons for lake routing is done for two reasons:

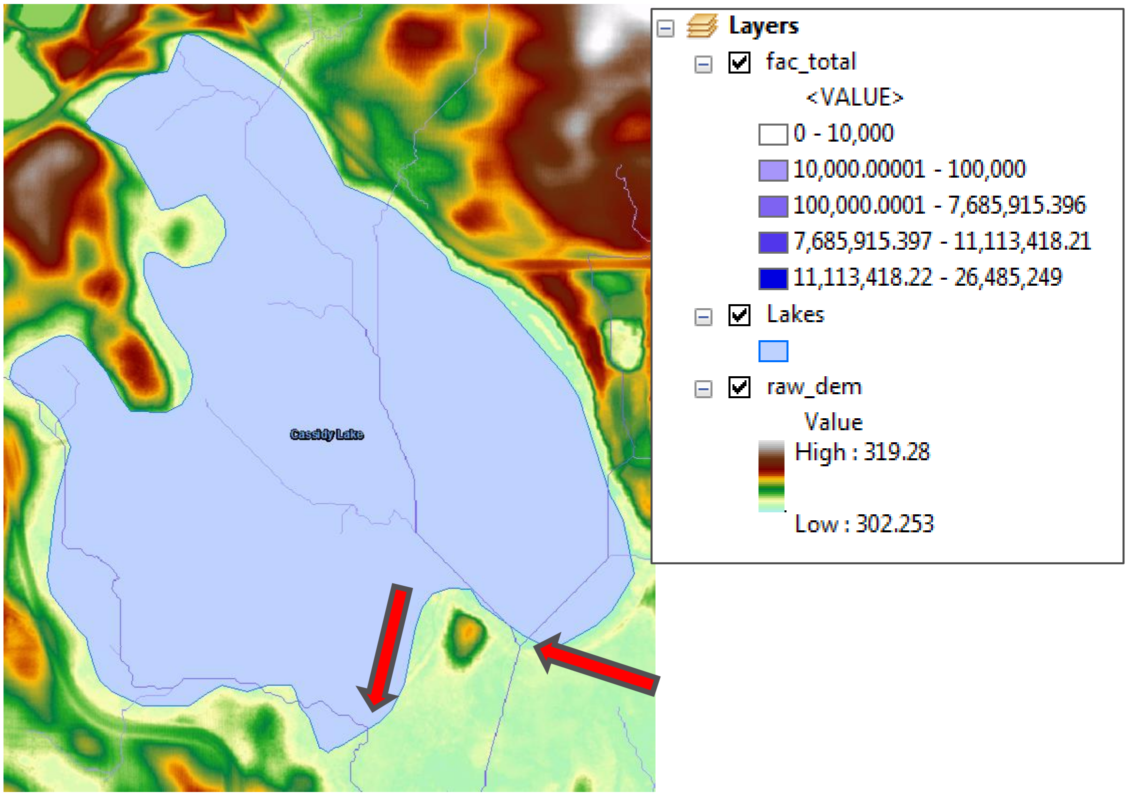
A) To ensure the lake polygon extent matches the physical lake basin extent; and

B) To make sure hydrologic flow through the lake in PTMApp-Desktop mimics flow through the actual lake.

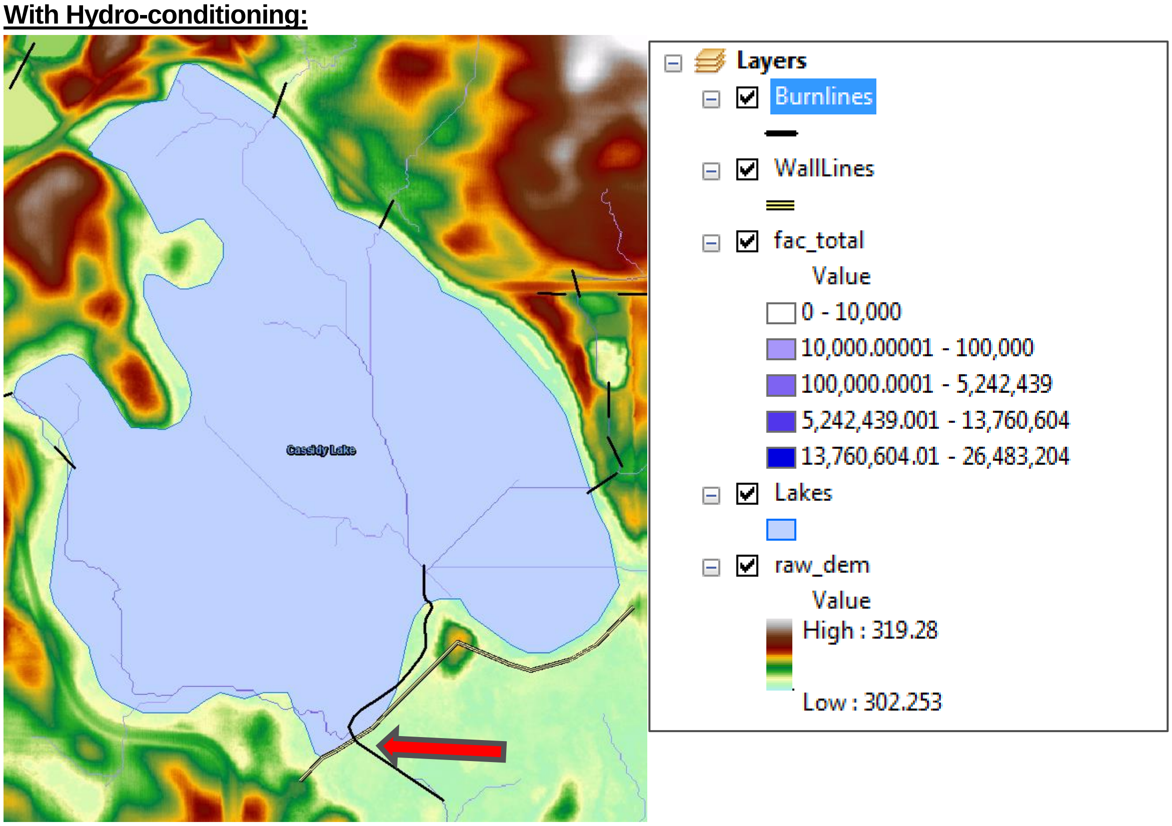
Reason (A) is necessary as the lake's ability to retain sediment, TP, and TN is calculated in PTMApp-Desktop based on the lake's volume, mean depth, and hydraulic residence time. Each of these is a function of the lake's surface area. Reason (B) is necessary as the sediment, TP, and TN retention values that reduce sediment and nutrient loading in PTMApp-Desktop are only applied for raster cells that flow through the lake polygon to its outlet. Therefore, we must ensure both the flow pathways and lake extent (i.e. its surface area) are as close to real-world conditions as possible.

An example of a modification to your DEM is shown on the following page. In the top figure, we see flow exiting the polygon in two locations (denoted by the red arrows). For lake routing purposes in PTMApp-Desktop, flow must exit the polygon at only one location. This is accomplished by adding a wall line across the entire southern portion of the lake (spanning points above the Ordinary High Water Level (OHWL)), and adding a burnline at the outlet of the lake which acts as a "breakthrough point" for the lake. In this case flow is forced through the breakthrough point created by the burnline.

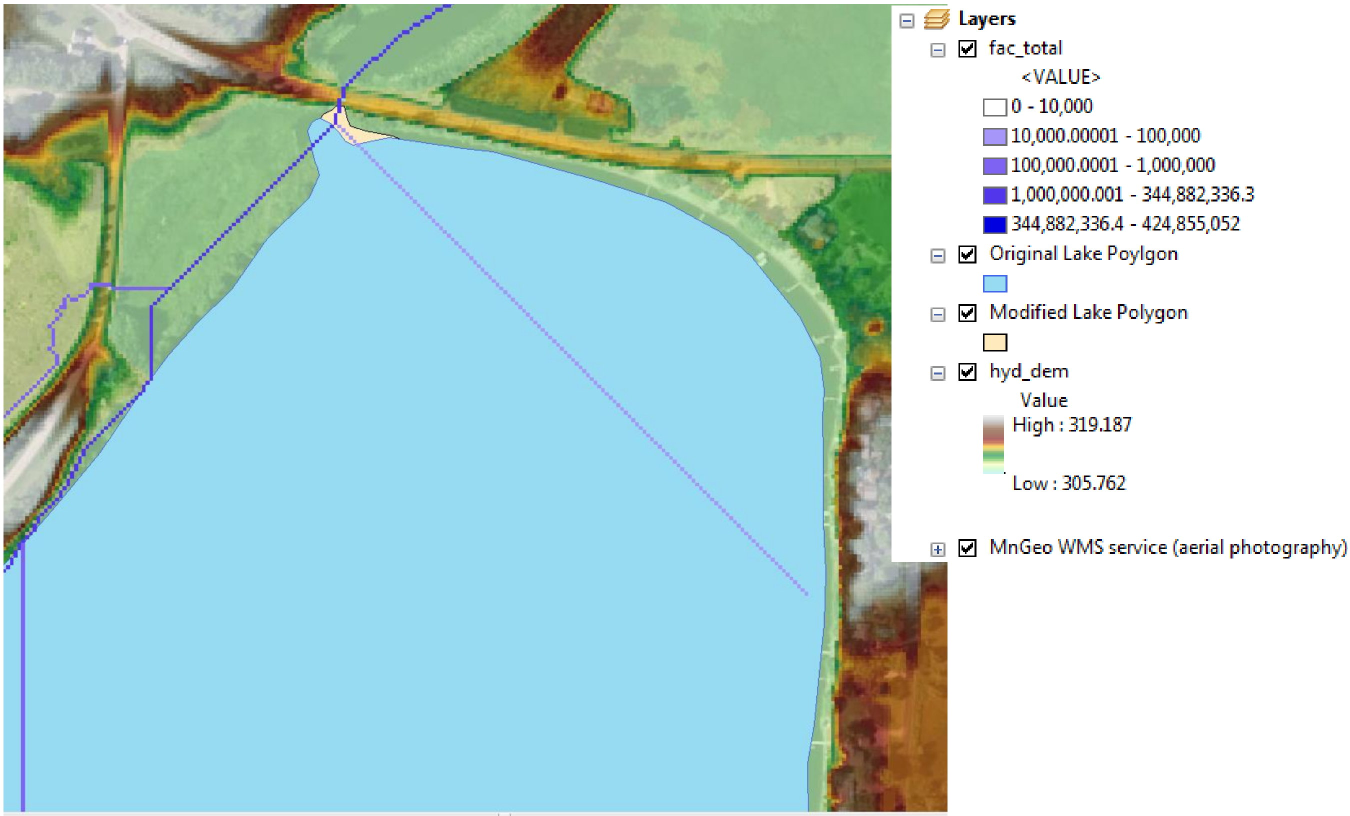
Without Hydro-conditioning:



With Hydro-conditioning:



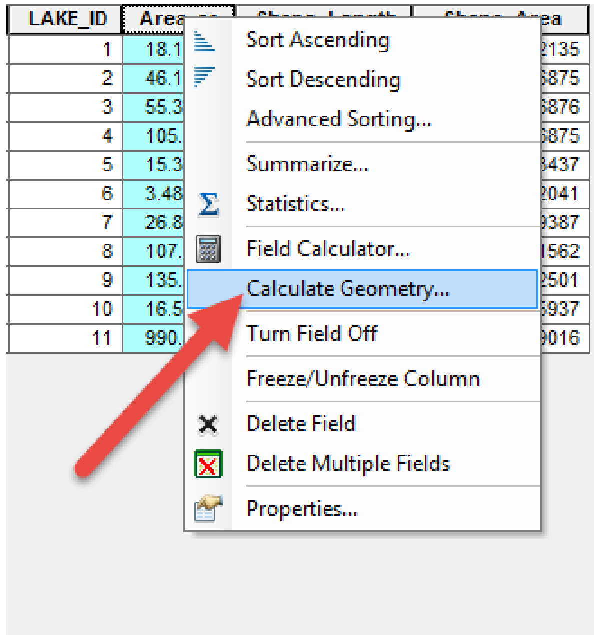
An example of a modification to your lake polygon is shown below:



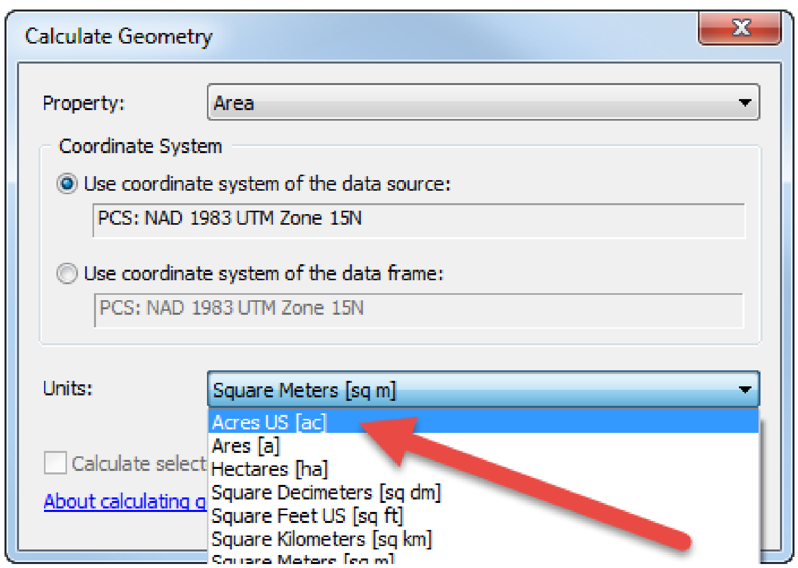
In this figure, the original lake polygon (shown in blue) has two outlets – one with the flow from southwest to southeast (shown in dark blue in the fac_total scale) and another with flow from southeast to northwest (shown in purple in the fac_total scale). By modifying the lake polygon to include the extra area to the north (shown in beige) we've now included both flowlines and have one outlet. The Modified Lake Polygon Feature Class has been properly conditioned for use in lake routing.

5) Once hydro-conditioning has been completed, and lake polygons have been modified to best fit (within the analyst's ability and the project's need) the lake's full basin size, two attribute fields must be added to run through PTMApp-Deskop lake routing buttons:
   a. 'Lake_ID' (long integer) – this field will be used as the unique identifier for each lake within lake routing
   b. 'Area_ac' (floating point) – lake surface area, in acres
6) These fields can be populated as follows:
   a. For 'Lake_ID', just provide each lake an integer value. No two lakes can have the same value.
   b. To populate lake surface area for 'Area_ac', right-click the 'Area_ac' attribute and click 'Calculate Geometry'

<u>Please note:</u> *raster statistics used for lakes in PTMApp requires the distance between lakes must be more than 1 grid cell apart. Meaning, if you're modeling two adjacent lakes/impoundments and your rasters (e.g. raw_dem) have a 5 meter cell size, your two impoundment polygons must have at least 5 meters separating them.*



In the 'Calculate Geometry' dialog box, choose 'Area' for a Property and 'Acres US [ac]' for Units.



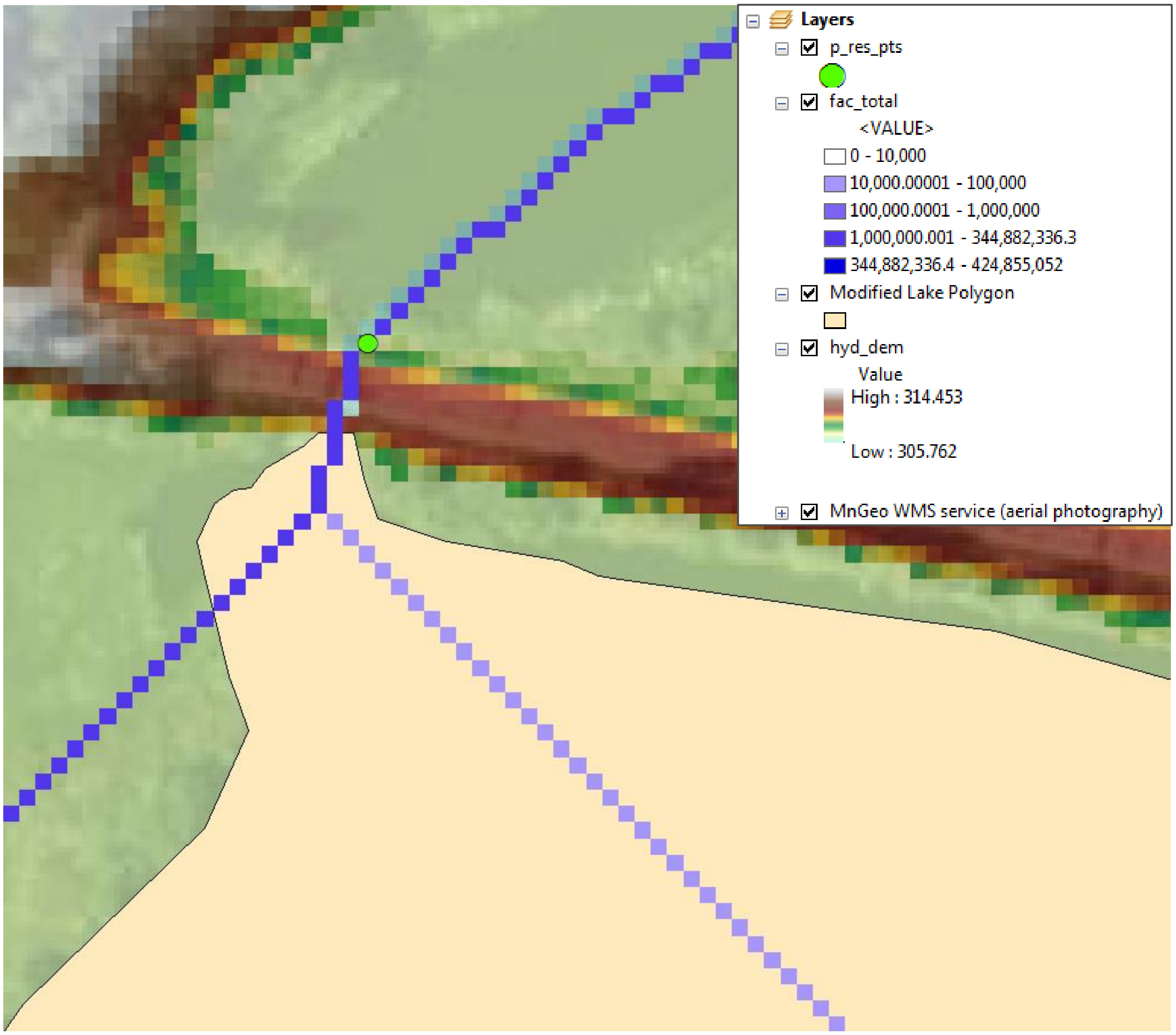
Close the editing session and save your edits. Your final 'lakes_route' attribute table should now include the attributes as shown below

LAKE_ID	Area_ac
1	18.12464
2	46.12189
3	55.36657
4	105.9712
5	15.31615

Lake routing and priority resource points

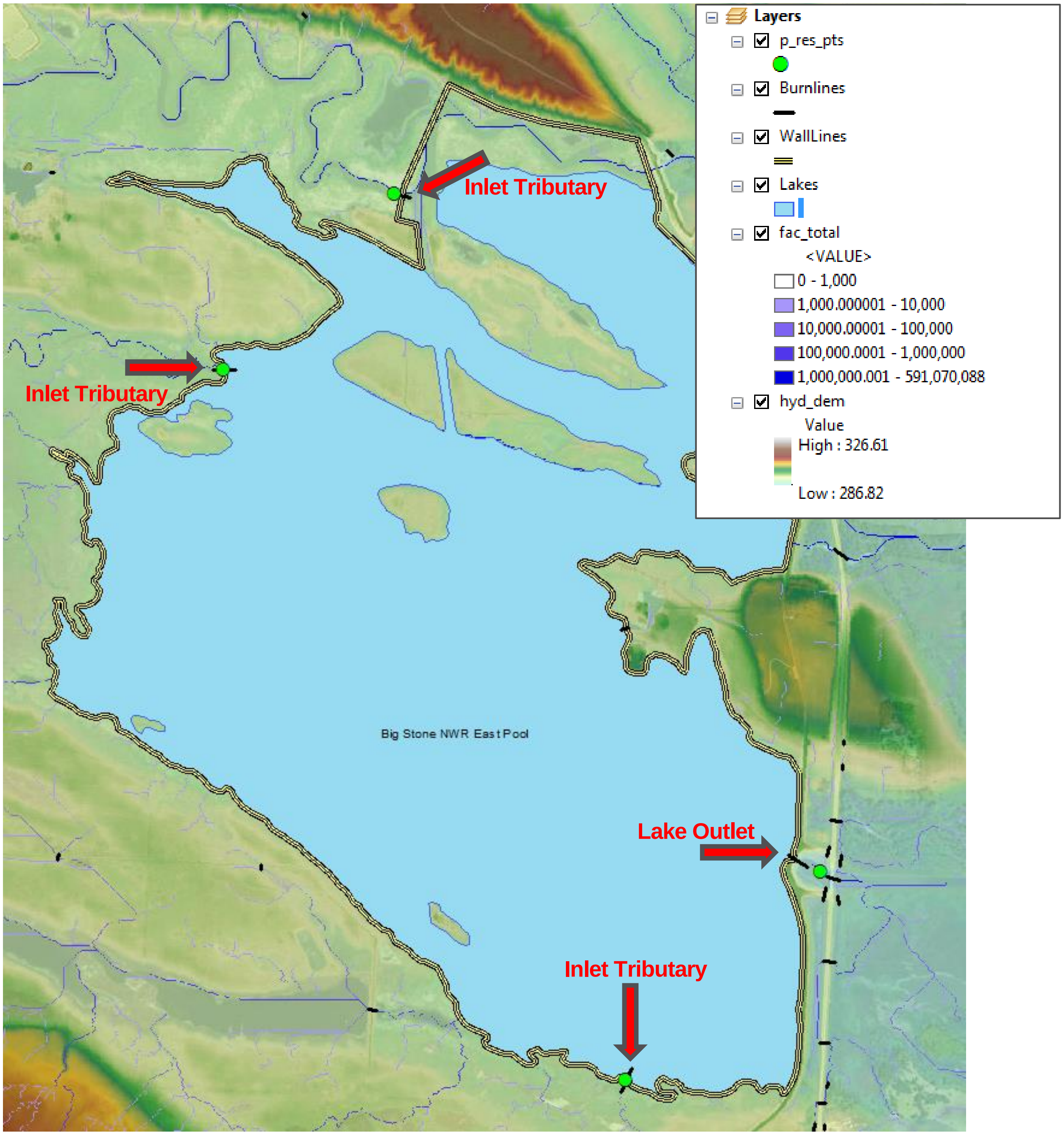
Because lakes are oftentimes much larger than catchment-scale (~40 acres), lake routing is only applied and measured at priority resource catchment scale. Therefore, each lake must have a priority resource point if you wish to determine the sediment, TP, and TN load leaving the lake. At this time, we recommend adding the resource point just downstream of the lake outlet at a point upstream of any other major flow lines (such as the example below) such that any added drainage area to that point is negligible compared to the drainage area to the lake.

For our previous example, with the lake polygon that was expanded to include all flow lines, the priority point added for this lake should look like this:



In this case, the priority resource point was snapped to the flowline and added just downstream of the lake. Similarly, priority resource points should be added for each lake you wish to determine sediment, TP, and TN load from. This can be done during the conditioning process or while preparing PTMApp-Desktop input data products.

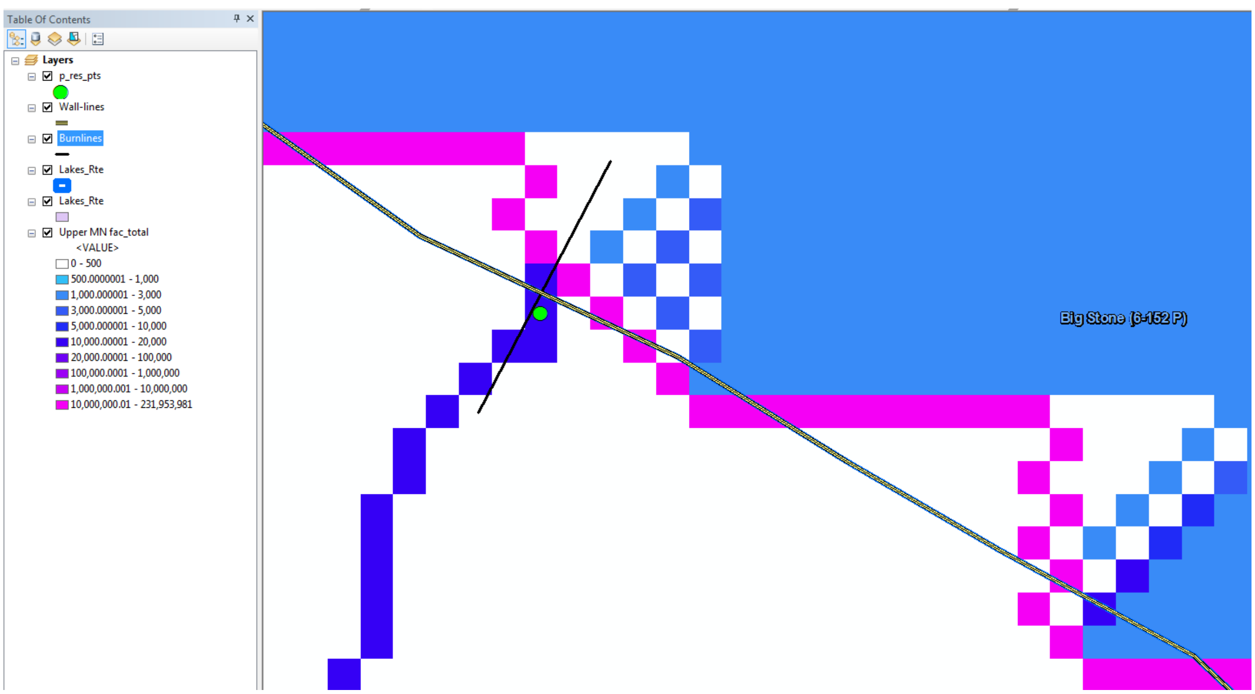
If you wish to determine not only loads leaving the lake, but also the loads entering the lake from various sources (e.g. stream tributaries, pipe outfalls, direct drainage), this can be accomplished by drawing a wall-line around the lake, and adding breakthrough points (i.e. burnlines intersecting your wall-line) at locations you wish to determine load into the lake. An example is shown below:



In this figure, there are three breakthrough points represented by burnlines through the lake wall-line. A fourth breakthrough point is the outlet of the lake. Priority resource points were added for each of these breakthrough points to summarize (1) load to each inlet (where the priority resource point was added just upstream of the breakthrough point) and (2) load exiting the lake at the lake outlet (where the priority resource point was added just downstream of the breakthrough point).

Please note that if you wish to use this method, you MUST PLACE THE PRIORITY RESOURCE POINT DIRECTLY ON THE FLOWLINE. This is important as the delineation tool in PTMApp-Desktop, run in the *Catchments and Loading >> Generate Catchments* button, will delineate a catchment directly upstream of the priority resource location. If the resource point is not placed directly on the flowline, represented by the flow accumulation grid (fac_total or fac_surf), a significant amount of the upstream area may be missed in resulting priority resource catchment. This can be accomplished by adding pour points directly onto the highest flow accumulation cell upstream of the lake's breakthrough point (or intersection of a burnline through the wall-line surrounding the lake).

After adding the priority resource points, you can check your work by running the 'Snap Pour Point' tool. This tool scans the flow accumulation grid for the largest flow accumulation cell based on the snap distance you provide. For example, a snap distance of '1' would scan only the cells next to the cell you placed the resource point on. The output of the Snap Pour Point tool is an integer raster grid which can be exported to a shapefile and used to adjust you priority resource points by snapping to the new point feature class.



4.3 PTMAPP-DESKTOP PLANNING – H2DEM & EQUIVALENT

H2DEM conditioning is a more simplified version of conditioning, typically using one or more existing streamline feature classes (e.g. National Hydrography Dataset (NHD)) in place of user-identified burnlines to hydrologically condition the DEM. Even though this category may also include some user-identified burnlines, it is still largely based on conditioning using existing flow lines and drainage boundaries to construct the burnlines and wall-lines, respectively. The main advantage of this method is that it requires a lower investment of time and effort compared to H3DEM Plus conditioning. However, accuracy at the local or field catchments scale will certainly be negatively affected by the less detailed approach..

A list of the data which could be used to perform H2DEM conditioning analysis is shown below. For creating burnlines we will use streamline data in the form of NHD flowlines. For creating wall-lines we will use hydrologic boundary data in the form of the Watershed Boundary Dataset (WBD).

- Raw DEM raster
- Hydrologic boundary polygon layer (Example: Watershed Boundary Dataset, HUC 10, or MNDNR Minors Catchments)
- Flowline polyline layer (Example: NHD Flowlines)

Using these datasets, the user can access one of the resources listed in Section 5.2.4 to create the hDEM products listed below:

Dataset	PTMApp Name	Description	Format
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

Please note that many of the processing steps used in this approach require ArcGIS Spatial Analyst extension, similar to H3DEM Plus conditioning.

4.4 PTMAPP-DESKTOP PLANNING – H2DEM PLUS

H2DEM Plus is a modification to H2DEM conditioning to incorporate lakes into the flow network. This process is a hybrid of both the H3DEM and H2DEM conditioning processes, creating burnlines and wall-lines following H2DEM methodology and intensively conditioning the DEM around lake systems following H3DEM methodology. Workflow for this process is shown below

- Gather and prepare H2DEM data, burnlines, and wall-lines following guidance listed in Sections 5.3.1 and 5.3.2 through 5.3.2.5 (“QA/QC NHD Burnline Crossings”)
- Gather lake data and hydrologically condition lakes following guidance in Section 5.2.5.
- Create conditioning outputs, following guidance in Section 5.3.2.6 (“Conditioning Processes”)
- Review results and rerun process to improve lake conditioning if necessary (optional based on project budget and objectives).

The output data will include the following PTMApp-Desktop inputs:

Dataset	PTMApp Name	Description	Format
Elevation Products			
	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
	lakes_route	Lake polygons	polygon

5 RUSLE INPUTS

Sediment yields are estimated based on the implementation of the revised universal soil loss equation (RUSLE). RUSLE accounts for land cover, soil type, topography, and management practices to determine an average annual sediment yield estimate generated solely from sheet and rill erosion. RUSLE requires several input parameters to be developed and multiplied in the equation to form the estimated annual sediment yield. The following section summarizes the development of input variables to RUSLE. RUSLE was calculated as:

$$A = R \ x \ K \ x \ LS \ x \ C \ x \ P$$

where, A is the estimated annual sediment erosion, R is the Rainfall and Runoff Factor, K is the Soil Erodibility Factor, LS is the Length-Slope Factor, C is the Cover and Management Factor, and P is the Support Practice Factor.

In this section, you'll learn to create the following PTMApp-Desktop Inputs:

Dataset	PTMApp Name	Description	Format
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

*The rusle_kw factor is now part of the base.gdb.

5.1 C-FACTOR

The C-factor accounts for land cover effects on erosion rates. C-values in the NRCS's MN Field Office Technical Guide were used as the basis for developing the values used in this analysis. These values apply only to MN, and will likely vary based on your project area's location. The USDA's National Agricultural Statistics Service's (NASS) Cropland Data Layer (CDL) can be used to define land cover and crop type in the study area. The table below summarizes common NASS land cover classifications and the corresponding C-factors used.

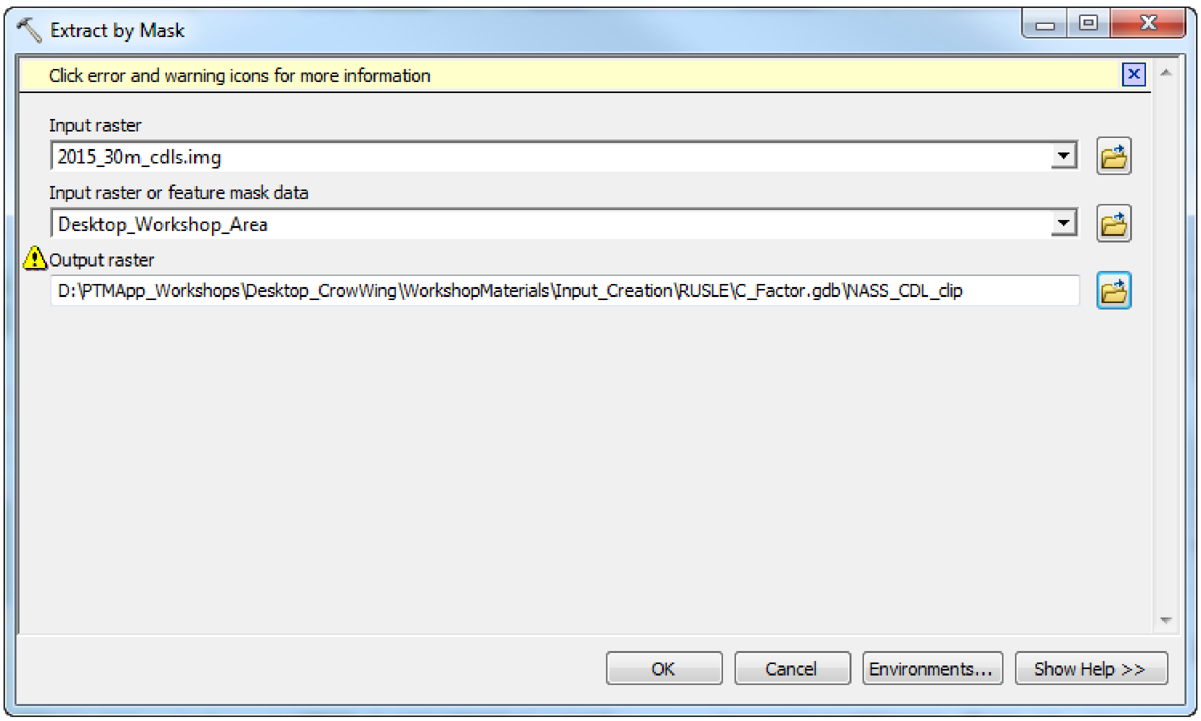
2010 NASS Classification	Support Practice Factor	Cover and Management Factor
Corn	0.5	0.200
Soybeans	0.5	0.200
Sunflower	0.5	0.200
Barley	0.5	0.200
Spring Wheat	0.5	0.200
Winter Wheat	0.5	0.200
Rye	0.5	0.200
Oats	0.5	0.200
Alfalfa	0.5	0.100
Other Hay	0.5	0.100
Sugarbeets	0.5	0.200
Dry Beans	0.5	0.200
Potatoes	0.5	0.200
Other Crops	0.5	0.200
Clover/Wildflowers	0.1	0.005
Sod/Grass Seed	0.1	0.100
Fallow/Idle Cropland	0.1	0.200
Pasture/Grass	0.5	0.005
Woodland	0.1	0.002
Wetlands	0.1	0.001
Open Water	0.1	0.000
Developed/Open Space	0.1	0.003
Developed/Low Intensity	0.1	0.003
Developed/Medium Intensity	0.1	0.003
Developed/High Intensity	0.1	0.003
Barren	0.1	0.003
Deciduous Forest	0.1	0.002
Evergreen Forest	0.1	0.002
Mixed Forest	0.1	0.002
Shrubland	0.1	0.002
Grassland Herbaceous	0.1	0.001
Pasture/Hay	0.1	0.005
Woody Wetlands	0.1	0.001
Herbaceous Wetlands	0.1	0.001
Vetch	0.5	0.200
Dbl. Crop Soybeans/Oats	0.5	0.200
Apples	0.5	0.100
Christmas Trees	0.5	0.100
Cantaloupes	0.5	0.200

☞ HOW TO:

Description – In this section you will learn how to convert NASS CDL data to a RUSLE C-Factor input raster for PTMApp-Desktop. There are many methods available to reclassify raster data in ArcGIS. Below is an example that was used for the purposes of this workshop.

Steps

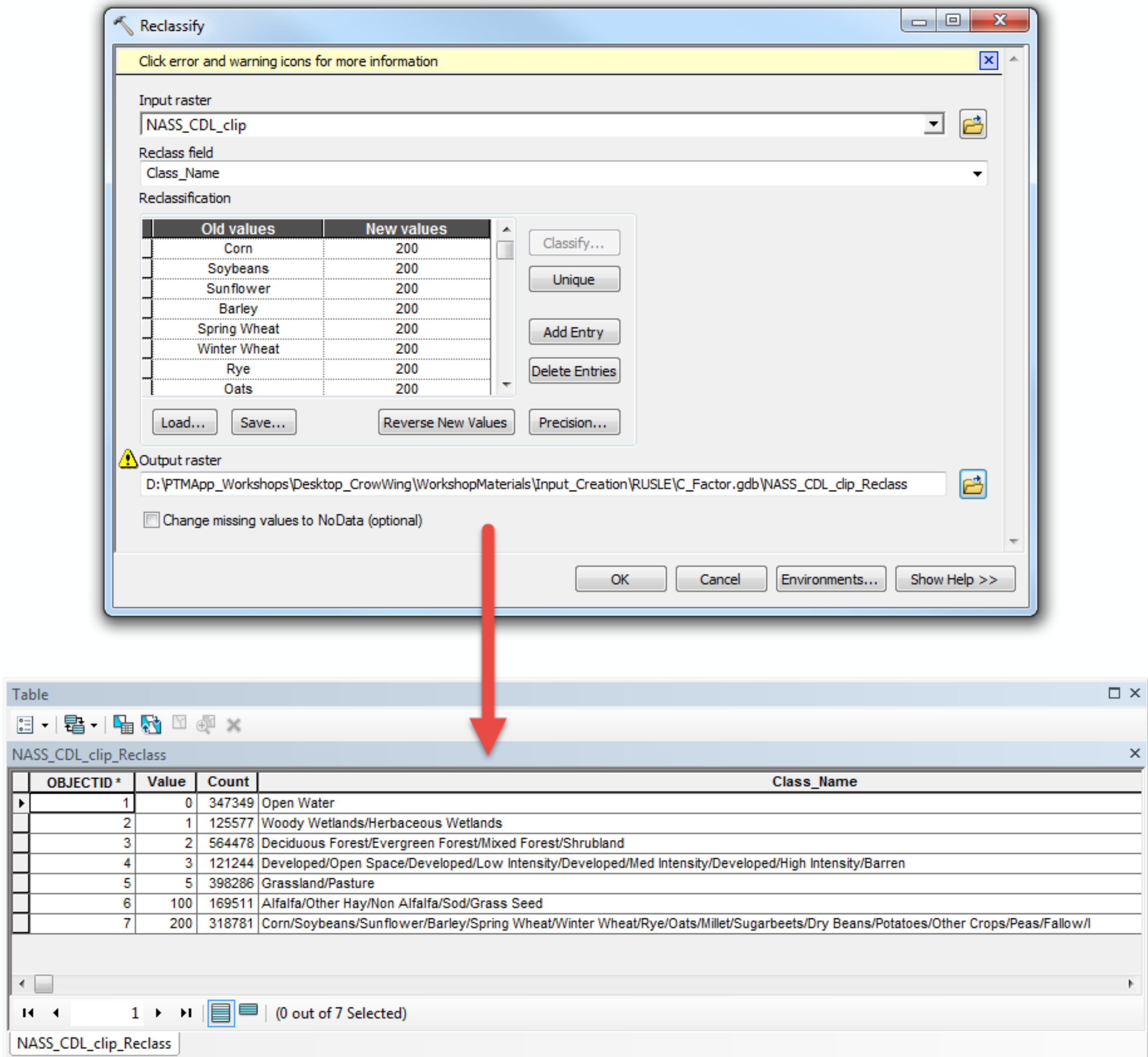
1. Download and clip NASS CDL data to the extent of your study area using the Extract by Mask tool. In the environments settings, set the cell size and snap raster to match either your raw_dem or the hyd_dem created in previous steps. This operation clips, resamples, and snaps your raster data to the appropriate scale.



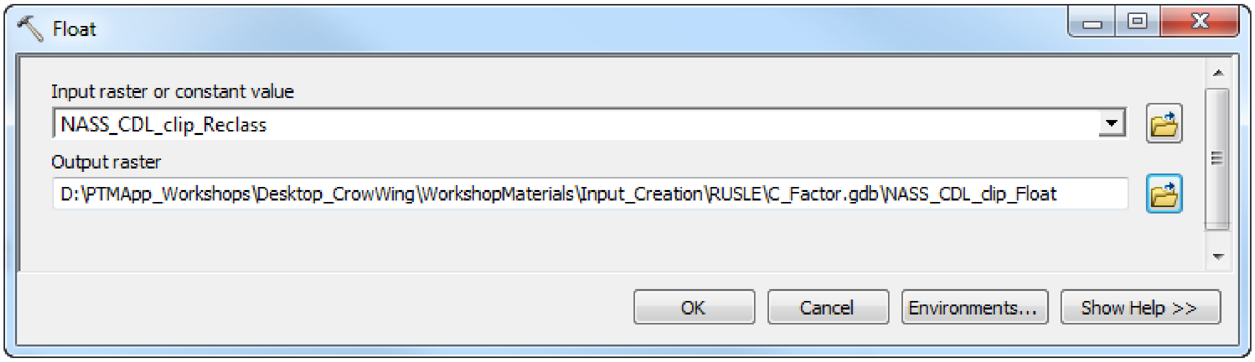
The yellow triangle with the exclamation point just states the output has already been created.

For the purposes of this workshop, the clipped output has been provided for you: (…WorkshopMaterials\Input_Creation\RUSLE\C_Factor.gdb\NASS_CDL_clip)

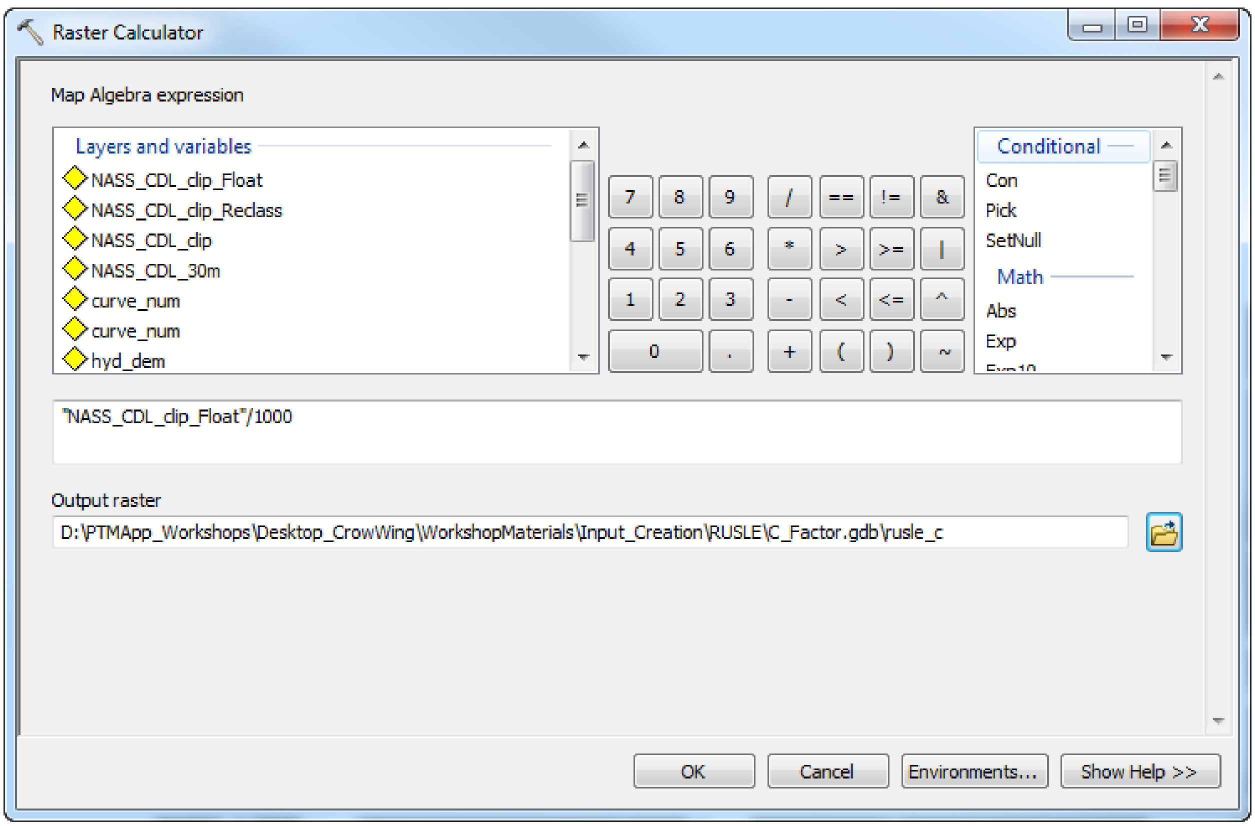
2. Use the Reclassify function, to reclassify the CDL layer to C-Factor values according to the figure below. Make sure you select “Class_Name” as the name. “Old values” in the Reclassify dialog below should show the Class_Name (i.e. the NASS CDL Classification). “New Values” should be updated to reflect the “Value” field in the second figure below for each respective land cover type. The value field is the (C-factor*1000) because the reclassified raster will be in integer form:



3. Convert the NASS_CDL_clip_Reclass file from an integer to a floating point raster (this allows decimal values) using the Float function.



4. Use the Raster Calculator to divide NASS_CDL_clip_Float by 1000 and save new raster as rusle_c



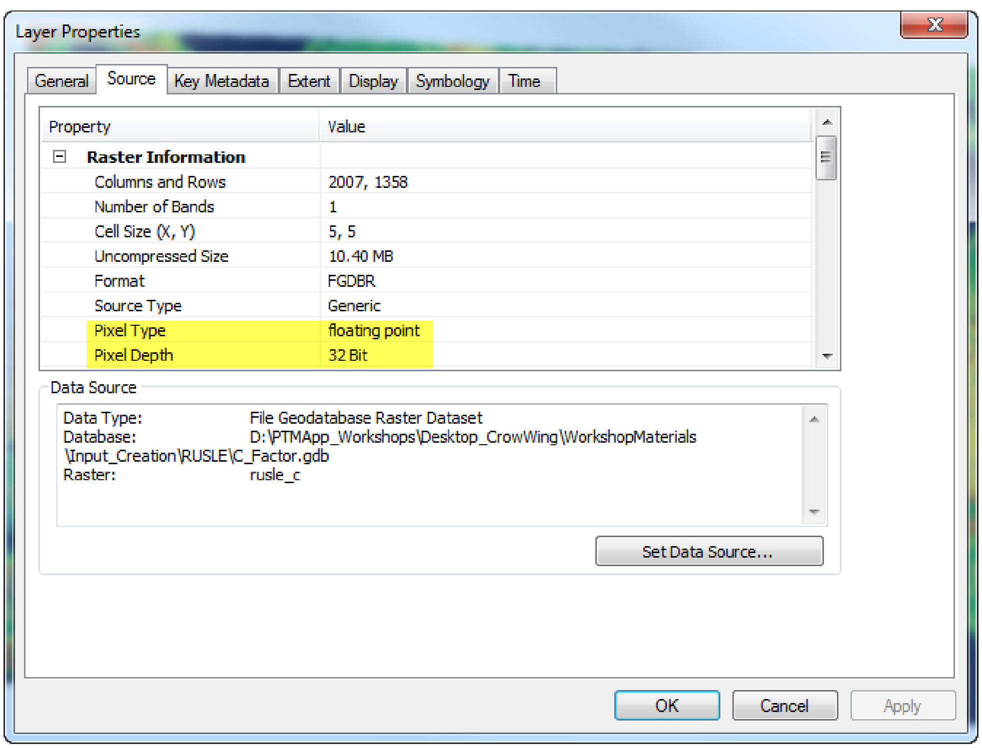
Final C-factor values should reflect those in the table below. Each of the steps above are saved here for your reference: (…WorkshopMaterials\Input_Creation\RUSLE\C_Factor.gdb).

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

At this point, you've created the following input for PTMApp-Desktop:

Dataset	PTMApp Name	Description	Format
RUSLE Inputs			
	rusle_c	RUSLE - Cover management factor	raster

Please note this raster should be in floating point, 32-bit. This can be checked in *Layer Properties > Source,* and is highlighted in the figure below.

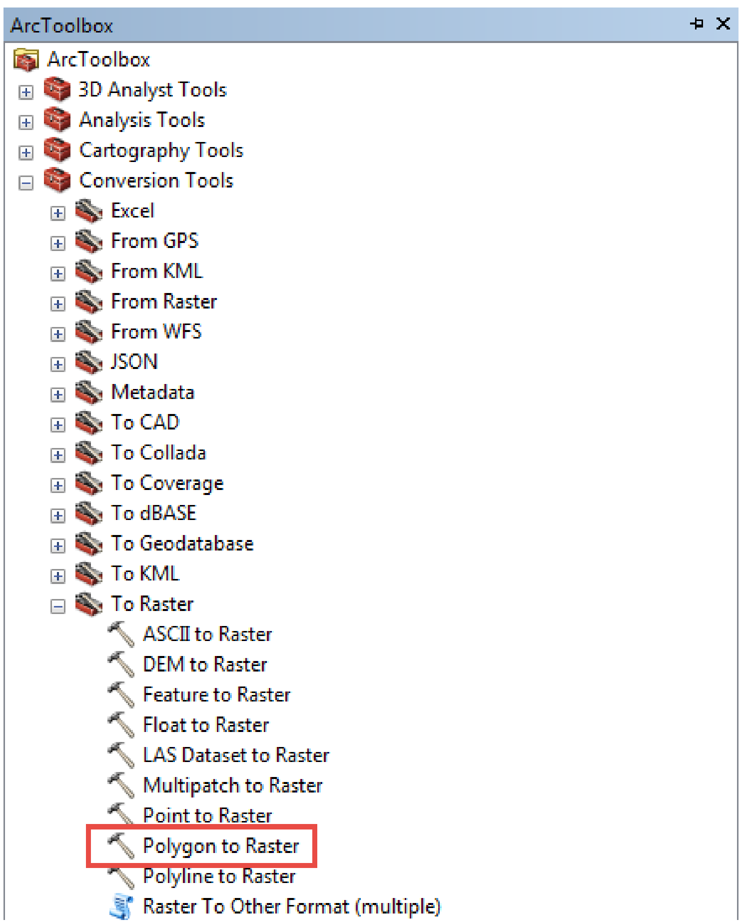


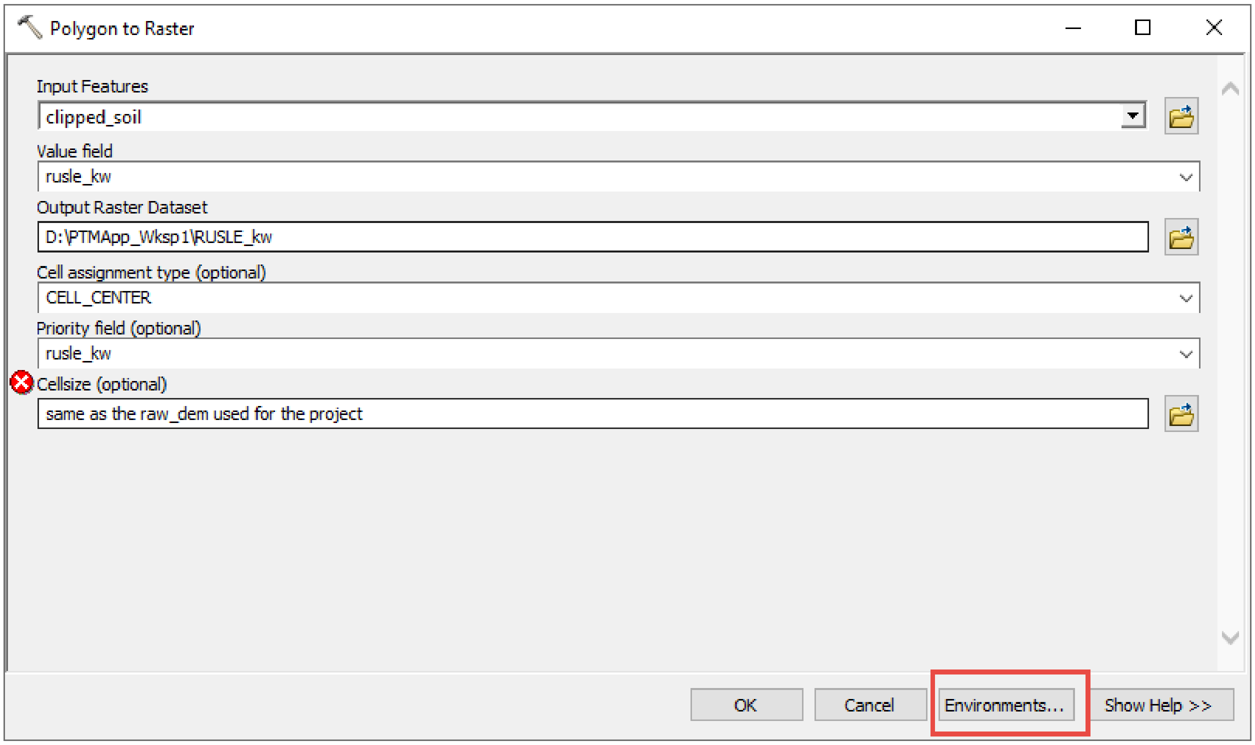
5.2 K-FACTOR

The soil erodibility factor can be taken directly from the base.gdb. Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Estimates are based primarily on percentage of silt, sand, and organic matter and on soil structure and saturated hydraulic conductivity (Ksat). Values are estimated as Factor Kw, which applies to all soil types, and Factor Kf, which applies only to the very fine (<2mm diameter) grain sizes. For this analysis, Factor Kw (Referred hereinafter as "K-Factor") was used. K-Factor values range from 0.02 to 0.65 in Minnesota. Other factors being equal, the higher the value, the more susceptible the soil is to sheet and rill erosion by water.

"Erosion factor Kw (whole soil)" indicates the erodibility of the whole soil. The estimates are modified by the presence of rock fragments.

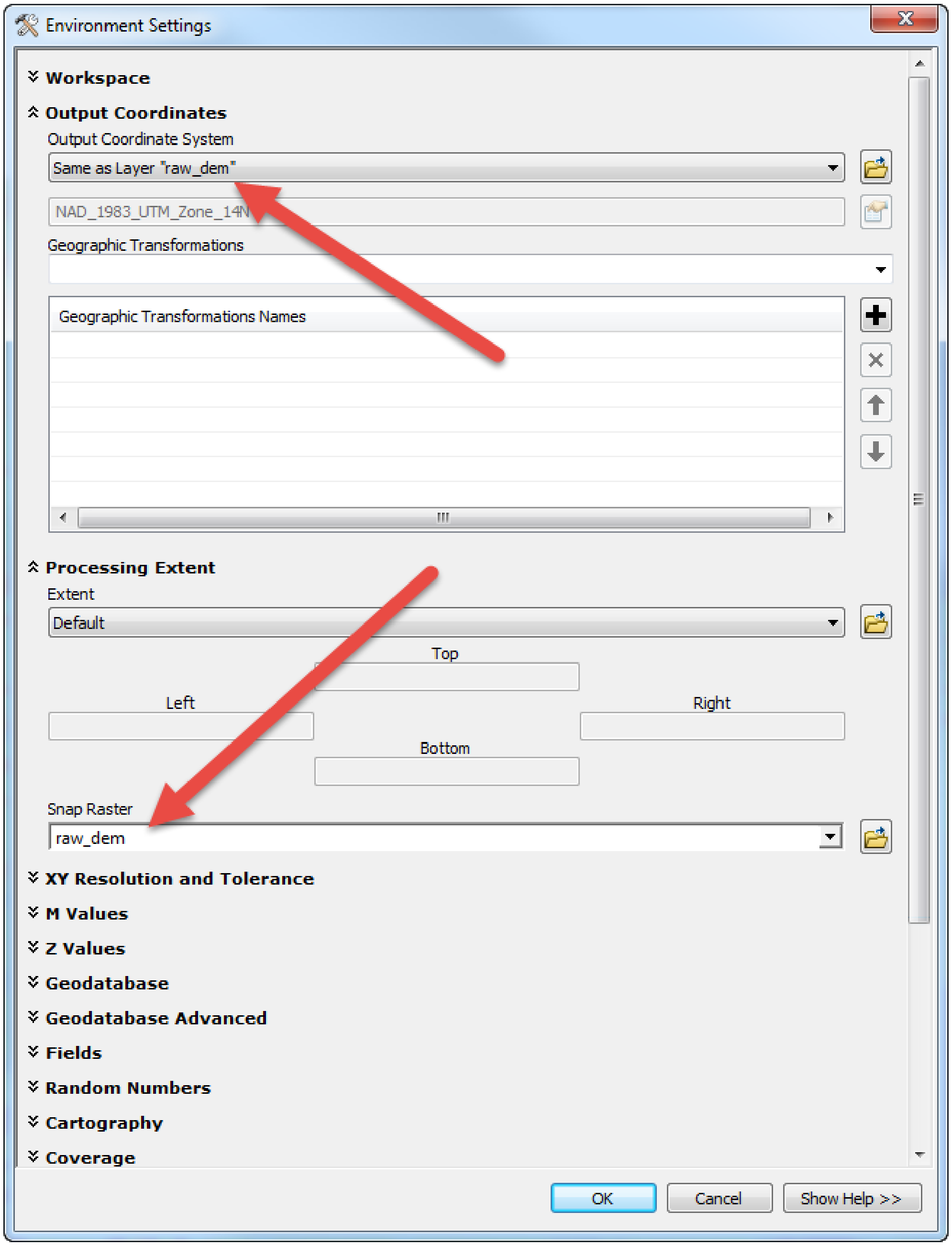
To create the K-Factor raster data, the same procedure used to obtain the SSURGO soil data will be used. Part of the process was already completed when you clipped the SSURGO_Polygon file. Using the clipped_soil layer created in Section 3, follow these steps to create the K-Factor RUSLE value raster data:

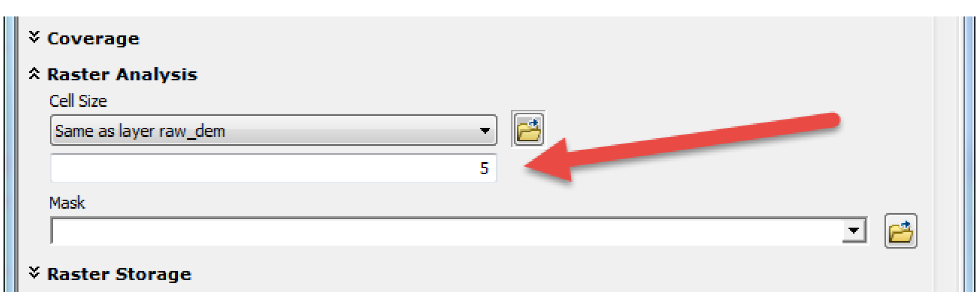




Make sure the cell size is set to the raw dem raster that was previously added into the map. For this project its 5 meters. Hit OK and the tool will create a raster of Kw values for the county.

Make sure to set your Environments before pushing OK.

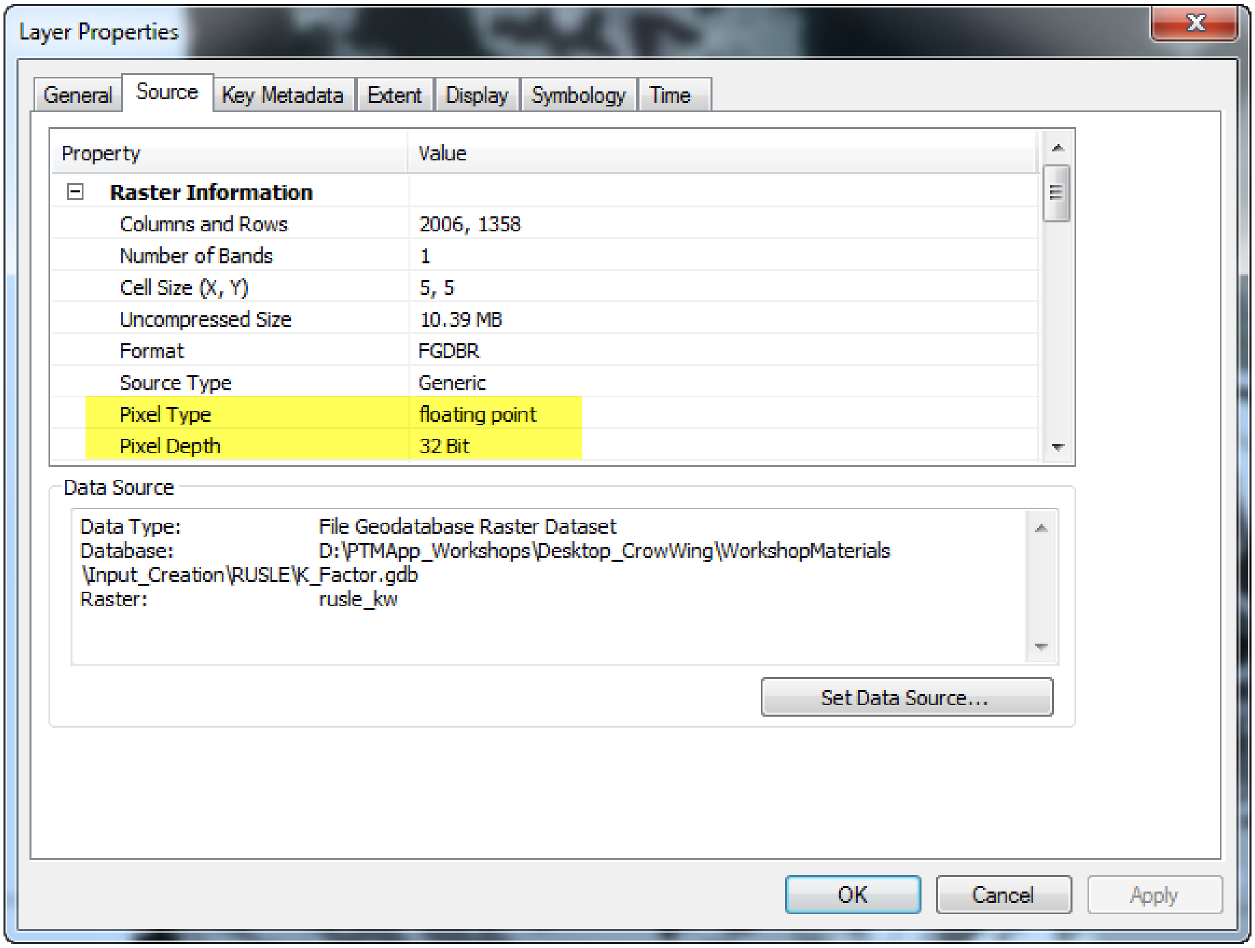




At this point, you've created the following input for PTMApp-Desktop:

Dataset	PTMApp Name	Description	Format
RUSLE Inputs			
	rusle_kw	RUSLE - Soil erodibility factor	raster

Please note this raster should be in floating point, 32-bit. This can be checked in *Layer Properties > Source,* and is highlighted in the figure below.

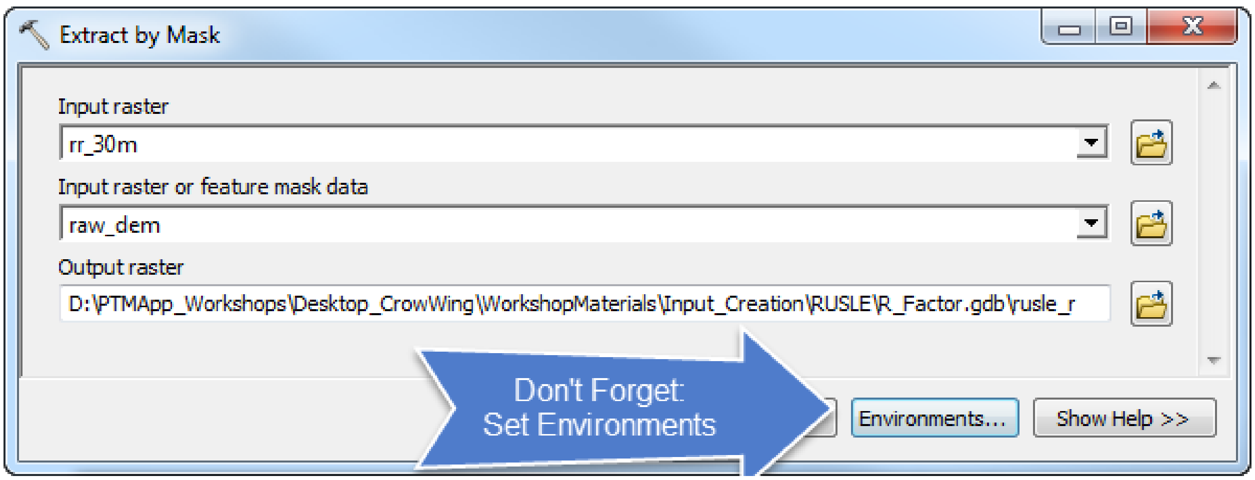


5.3 R-FACTOR

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. This layer is provided with these workshop materials, titled mw10yr24ha15n, that covers the entire Midwest. This layer was clipped to Minnesota, resampled to a 30m grid, converted to a floating point raster with the correct index values, and renamed 'rr_30m'. Please use rr_30m for the next step.

To use Rainfall Runoff Grid in RUSLE:

1. Take the rr_30m and clip down to the proper size boundary using the Extract by Mask tool. Use the environment settings in Extract by Mask, to set the projection, snap and resample the grid cell size to your raw DEM Data. See the example on page 39 to set these.



At this point, you've created the following input for PTMApp-Desktop:

Dataset	PTMApp Name	Description	Format
RUSLE Inputs			
	rusle_r	RUSLE - Rainfall-runoff erosivity factor	raster

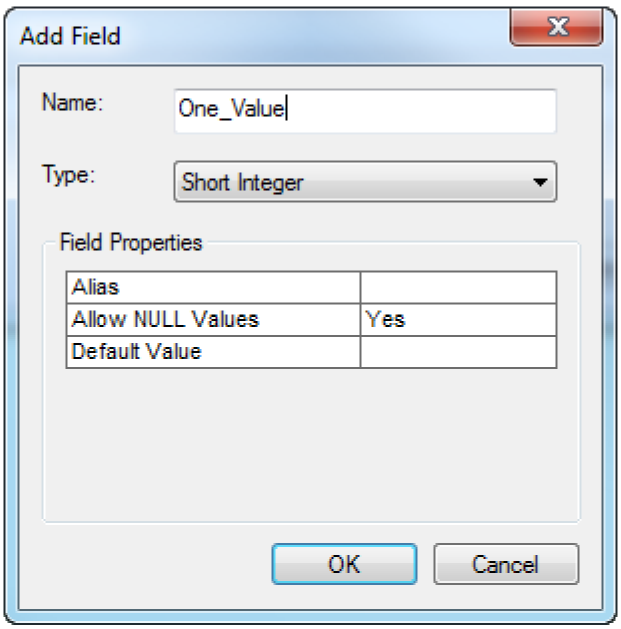
Similar to the RUSLE C-Factor (Section 6.1) and K-Factor (Section 6.2) rasters, this raster must be in 32-bit, floating point.

5.4 P-FACTOR

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. Due to a general lack of GIS data on support practices they are often set to a constant value such as ‘1’. By doing this, any effects of support practices are not accounted for. To create constant value P-factor raster, use the Polygon to Raster command and convert the watershed polygon to a raster.

Note – if users have information on P-factors for their study area, they can adjust these values.

Prior to using the Polygon to Raster command, add a field within your practice watershed polygon which will be used to create the ‘1’ raster. Then populate that attribute with a ‘1’ value using the Raster Calculator. These steps are shown below:



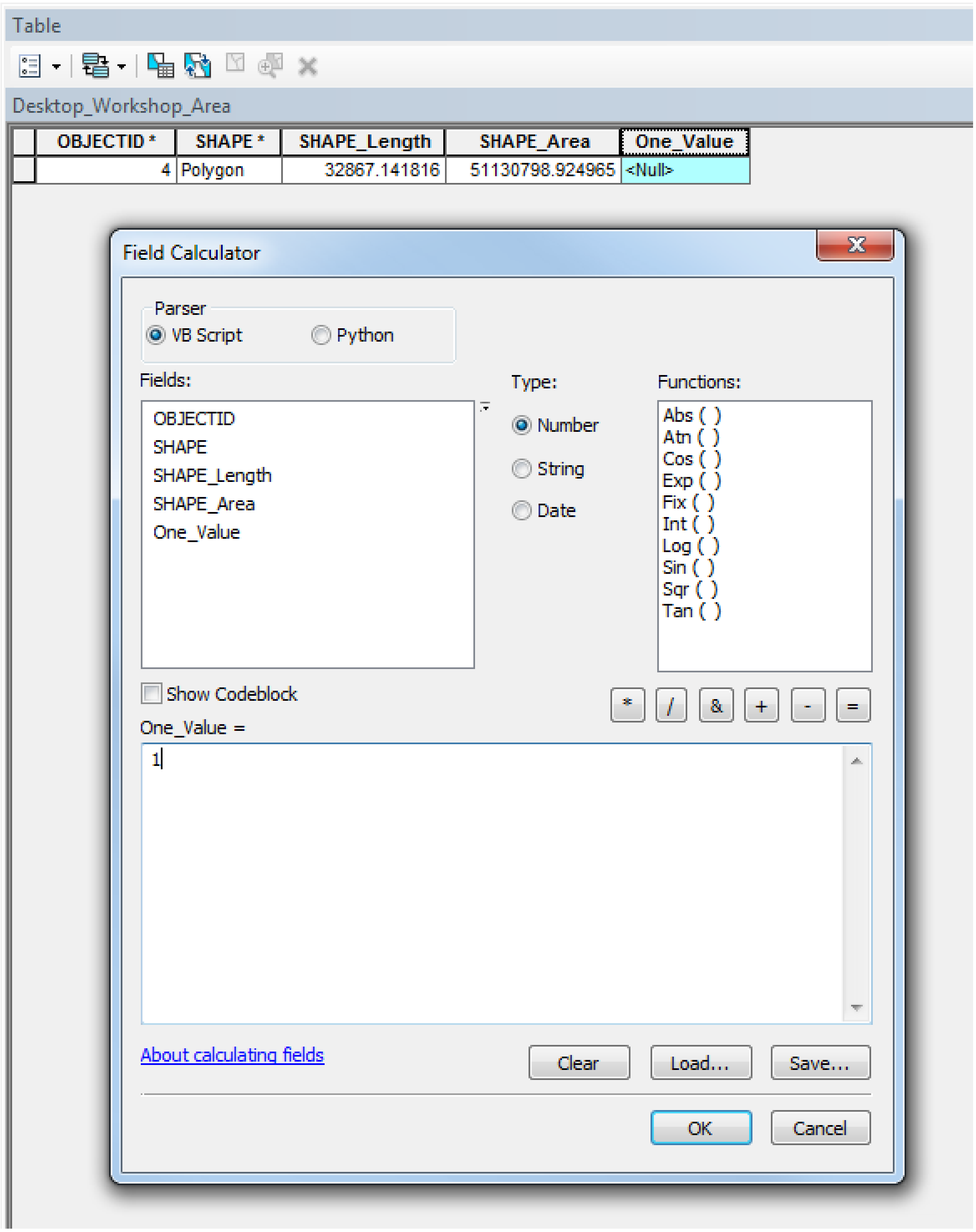
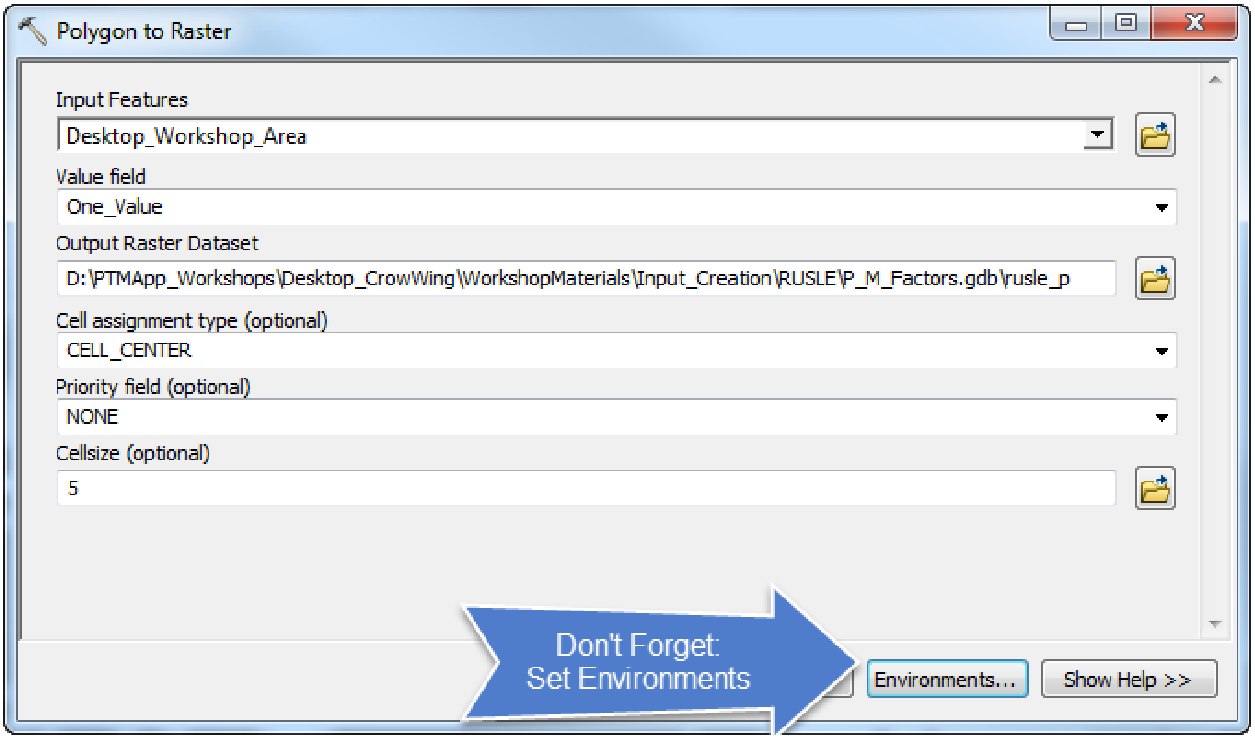


Table
Desktop_Workshop_Area
OBJECTID *
SHAPE *
SHAPE_Length
SHAPE_Area
One_Value
4
Polygon
32867.141816
51130798.924965
<Null>
Field Calculator
Parser
VB Script
Python
Fields:
OBJECTID
SHAPE
SHAPE_Length
SHAPE_Area
One_Value
Type:
Number
String
Date
Functions:
Abs ( )
Atn ( )
Cos ( )
Exp ( )
Fix ( )
Int ( )
Log ( )
Sin ( )
Sqr ( )
Tan ( )
Show Codeblock
* / & + - =
One_Value =
1
About calculating fields
Clear
Load...
Save...
OK
Cancel



At this point, you've created the following input for PTMApp-Desktop:

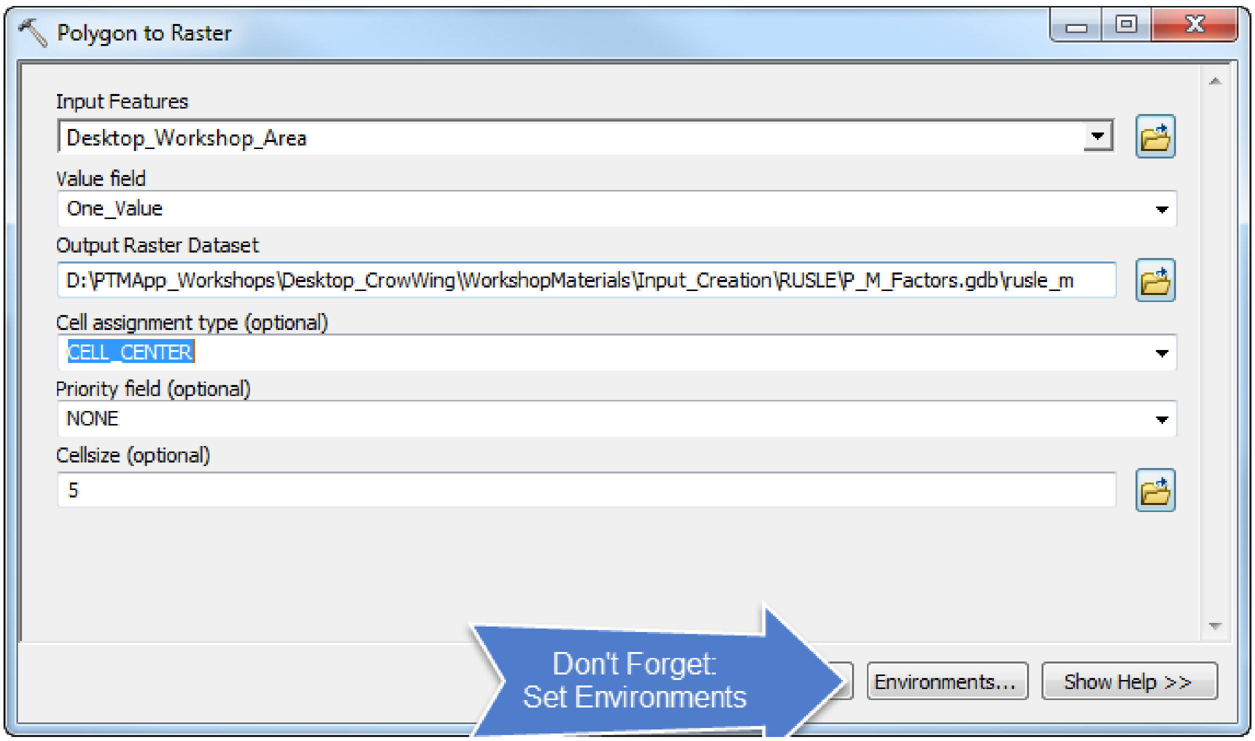
Dataset	PTMApp Name	Description	Format
RUSLE Inputs			
	rusle_p	RUSLE - Support practice factor	raster

The P-Factor raster may be in integer (signed or unsigned, any pixel depth (1-bit to 64-bit)) type if all raster cells are equal to 1. If support practices are included (and raster cells can hold fractions from 0-1), then the raster must be in floating point, 32-bit.

5.5 M-FACTOR

The RUSLE M-Factor accounts for any management activities occurring on the landscape. Similar to the P-Factor, our lack of existing, watershed-wide information on management activities means we will just use a constant value for this factor in the RUSLE equation. Follow the steps in Section 6.4 but instead save the Output Raster Datset as 'rusle_m'. This is shown in the example below. Set environments as shown on page 39.

Similar to P-Factor, if user's have information on M-Factors for their study area, this grid can be adjusted based upon that local knowledge



At this point you've created the following input for PTMApp-Desktop:

Dataset	PTMApp Name	Description	Format
RUSLE Inputs			
	rusle_m	RUSLE - m-weight factor	raster

The M-Factor raster may be in integer (signed or unsigned, any pixel depth (1-bit to 64-bit)) type if all raster cells are equal to 1. If M-Factors are adjusted to values from 0-1, then the raster must be in floating point, 32-bit.

6 TRAVEL TIME

6.1 BACKGROUND

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. Therefore, the following grids must be created to route flow (and its subsequent sediment and nutrient load) to downstream priority resources in PTMApp-Desktop:

Dataset	PTMApp Name	Description	Format
Elevation Products			
	us_tt	Upstream travel time in hours	raster
	ds_tt	Downstream travel time in hours	raster
	tt_grid	Cell to cell travel time in seconds	raster

A travel time tool was originally created by the Minnesota Department of Natural Resource (MNDNR) to develop downstream travel time rasters for each cell in a watershed. The tool was created in ArcGIS v.9 and then updated to v.10.0. A more complete description and methodology for the MNDNR tool is 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 impedence (sic) factor.

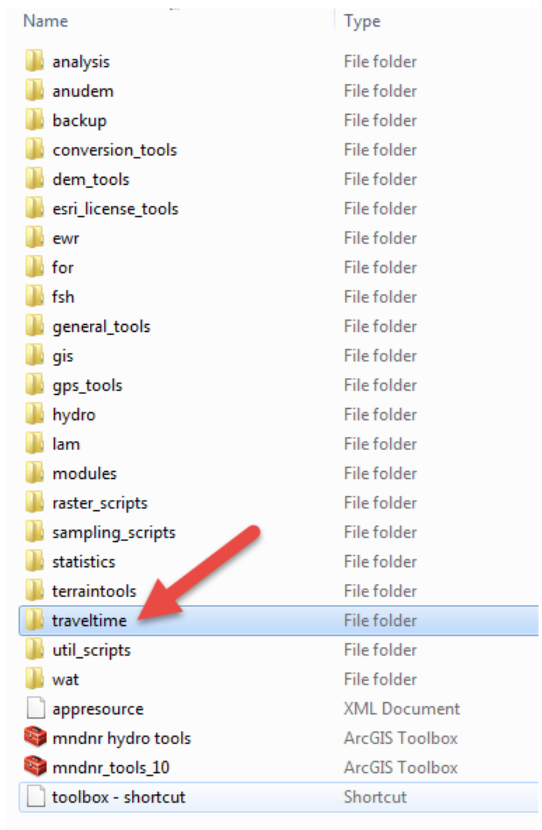
A current version of the tool can be downloaded from the 'MNDNR Tools v10' link here:

https://www.dnr.state.mn.us/mis/gis/tools/arcgis/index.html

A number of different tools are included with the download, including the toolboxes shown in the screenshot to the right. The relevant one for analyzing travel time is noted by the red arrow.

Follow the guidance provided by DNR to create the output products shown below.

After completing this section, you will have developed the following PTMApp-Desktop inputs:



Dataset	PTMApp Name	Description	Format
Elevation Products			
	us_tt	Upstream travel time in hours	raster
	ds_tt	Downstream travel time in hours	raster
	tt_grid	Cell to cell travel time in seconds	raster

7 PRIORITY POINTS

During this workshop, we will not walk through any geospatial techniques for creating point files for two reasons:

1. If you've made it this far, you certainly already have the geospatial know how to create a point file
2. More importantly – this should be a process that involves local input on the priority locations on the landscape where information on water quality is needed.

Below is guidance on some standard layers that may provide useful points for priority resource points in PTMApp-Desktop. However, specific local priority resources **WILL** vary across Minnesota. As such, local input is crucial at this point.

This guidance is meant to provide a DRAFT starting point for assembling priority resource points for PTMApp-Desktop. Note, each watershed where PTMApp-Desktop is applied may have special considerations that need to be added to this list (e.g. significant recreation areas, DNR zonation hotspots, etc.).

1. For all subsequent steps, make sure to attribute the source data of the file. To do this, add a text field call "source" to each point file. Populate the field with the source data (i.e. source = "AUIDstream", "AUIDLake", etc.).
2. Extract all downstream locations of AUID streams, lakes, and wetlands within your study area boundary. These files can be found in PTMApp-Desktop base.gdb. Attribute data as described in #1 above.
3. Extract all HUC 12 outlets. Attribute data as described in #1 above, source: "HUC12".
4. Add all monitoring and flow data points from base.gdb
    a. Flow_dnr
    b. Flow_mpca
    c. Flow_usgs
    d. Samp_wq
    e. Samp_bio
5. Refine dataset to remove areas where points are in close proximity to one another. You should only keep 1 point within any 1 square mile radius, unless a major tributary intersects the waterway. Keep points in this order:
    a. AUID downstream locations
    b. Monitoring locations
    c. HUC 12 outlets
6. Screen all points to see if any of them could serve as a location to validate PTMApp-Desktop outputs. These include sites that have existing monitoring data and/or sediment, TP, and TN loads (mass/time) and yields (mass/area/time). Be sure to see if field-scale sites with loads/yields exist. These include Discovery Farms and Field-to-Stream Partnership sites where edge-of-field data is gathered. If these sites exist in your project area they should be included as a priority resource point.
7. Use local knowledge to add any needed additional priority resource points. These may include things such as:
    a. Locations where you might build a project
    b. Have a project that you'd like information on
    c. Have a resource you want managed/protected
8. If lake routing is included and you wish to pull PTMApp-Desktop load/yield data from either lake outlet or inlets, priority resource points must be added. Please see Section 5.2.5 for guidance on how to add these.

9. Export the final point file to create:

Dataset	PTMApp Name	Description	Format
Priority Locations			
	p_res_pts	Point locations of priority resources and/or plan regions, with water quality goals in attributes	point

8 ACPF PRACTICES

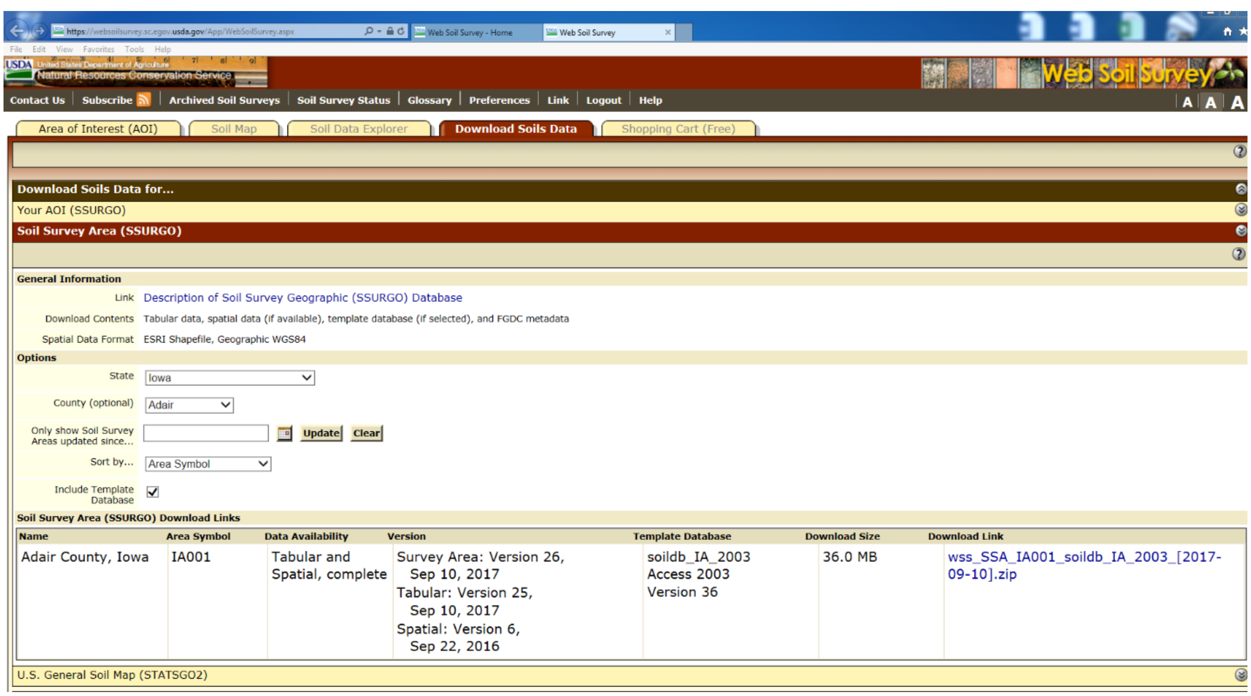
PTMApp-Desktop now has functionality to import BMPs from the Agricultural Conversation Planning Framework (ACPF) tool and format them to determine their benefits for reducing sediment, TP, and TN loading on the landscape using PTMApp, where PTMApp-Desktop data have already been created. This is performed using the Ingest ACPF tool in the BMP Suitability module. Prior to running this tool, some data generation must be conducted and is outlined below.

One additional input that must be created is 'SSURGO_Volcap'. Below are the steps for creating SSURG_Volcap:

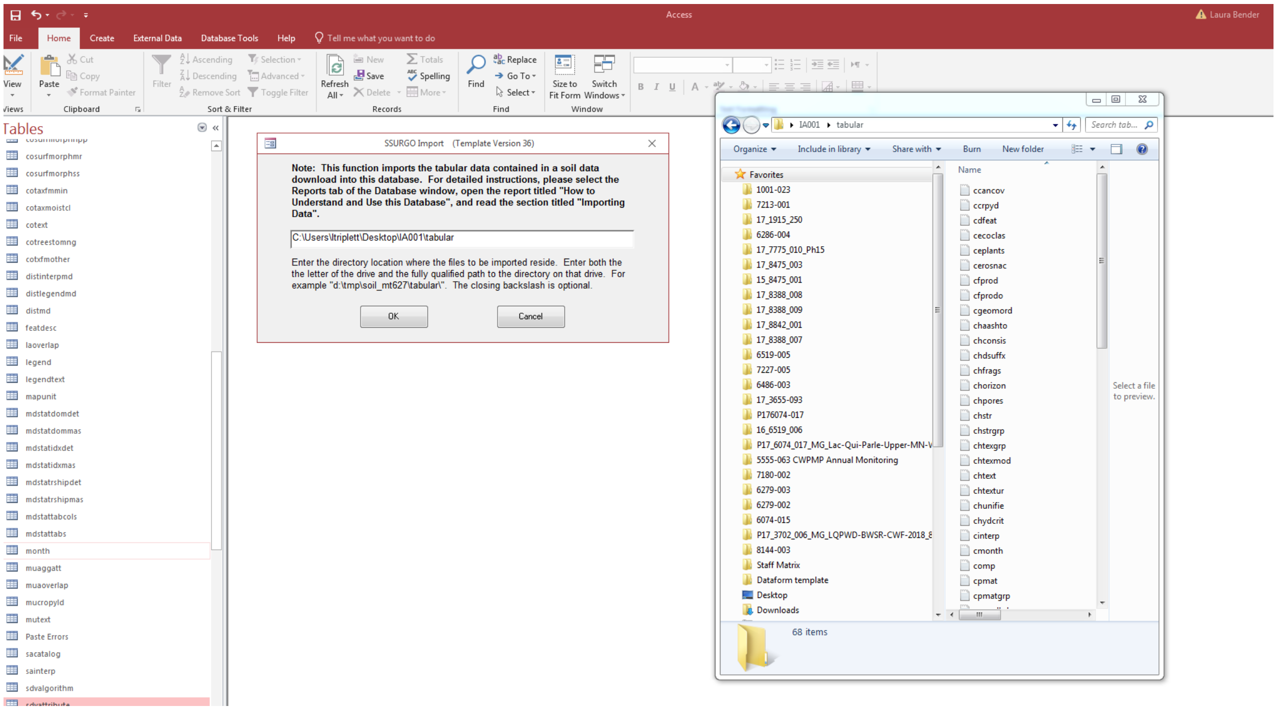
1. Generate available water holding capacity raster for each cell in the study area

   1.1 Download the soil data viewer toolbar
   https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcseprd337066

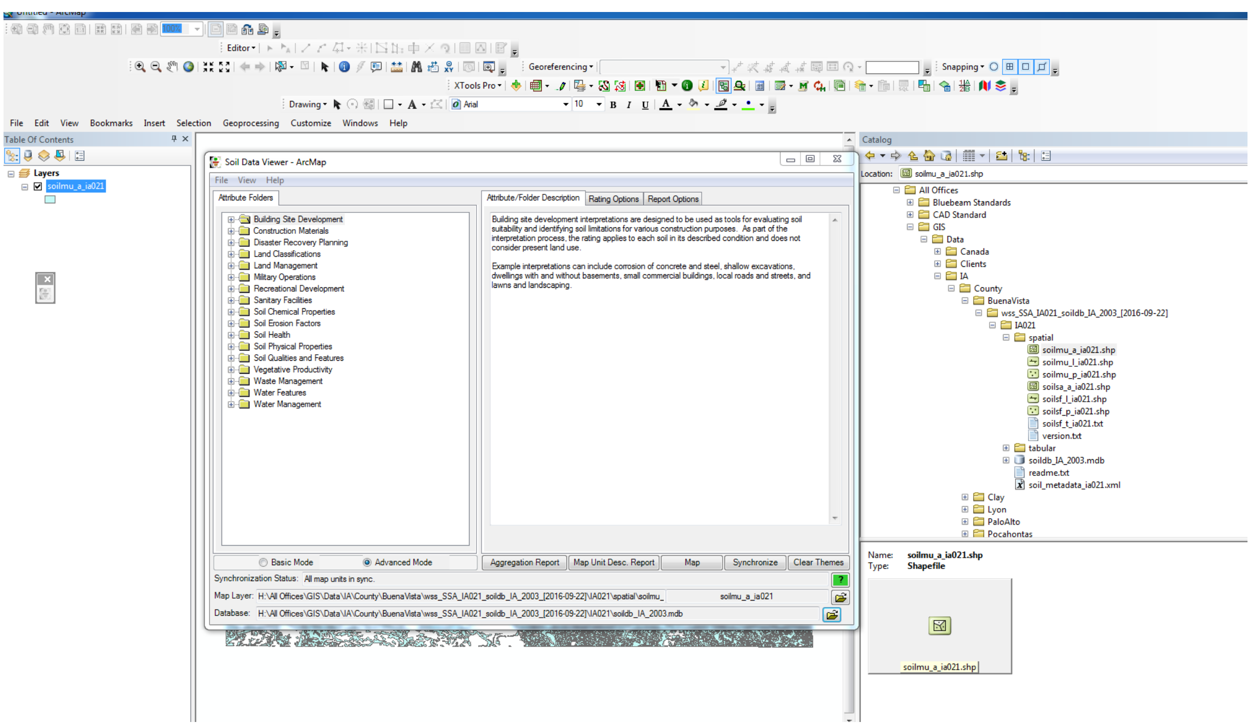
   1.2 Download SSURGO soil data for each county within the area of interest



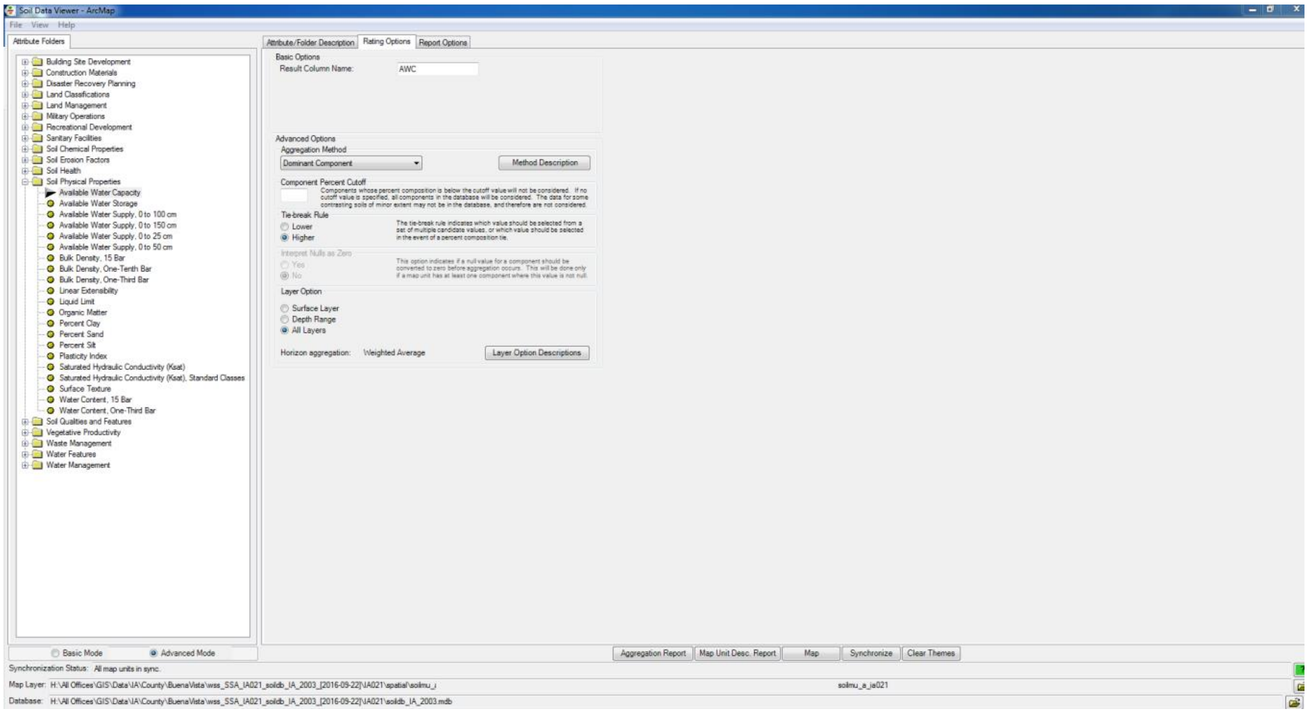
1.3 Connect Microsoft Access database to tabular data:



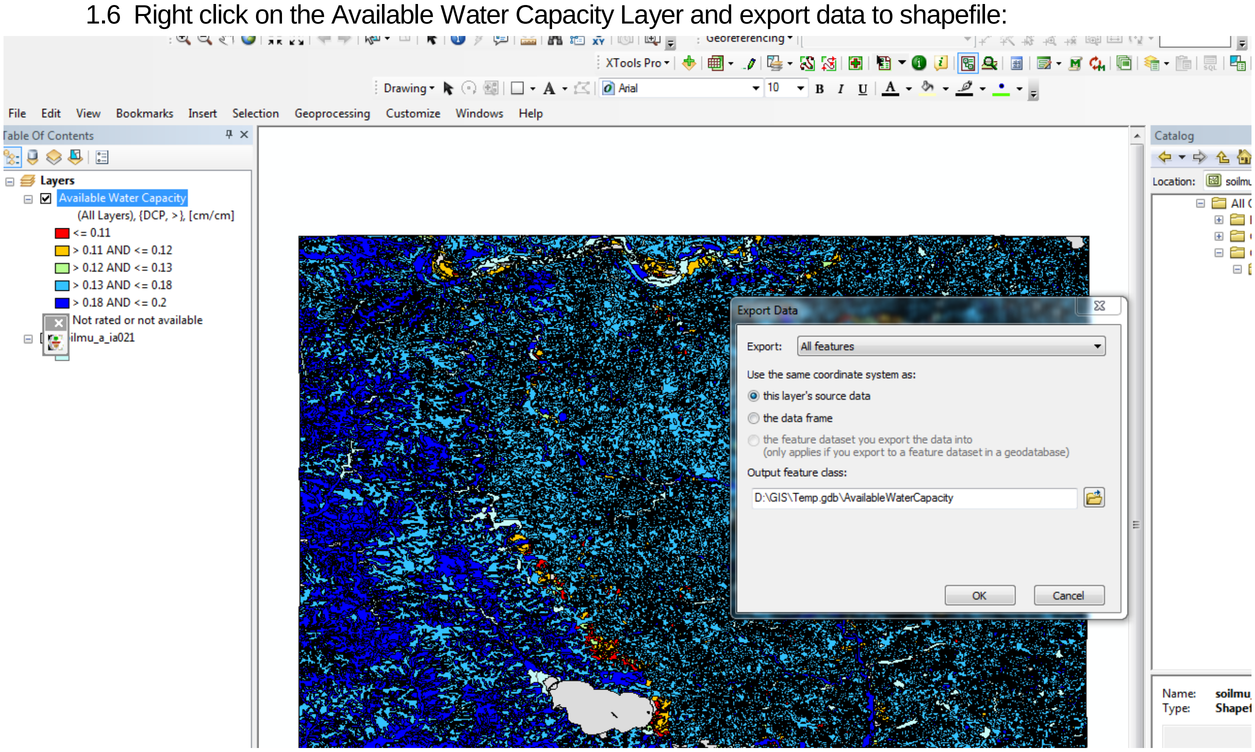
1.4 Pull ‘soilmu.a.iaXXX’ into an .mxd and open the soil data viewer toolbar. Connect the map layer and Microsoft Access database.



1.5 Map Available Water capacity

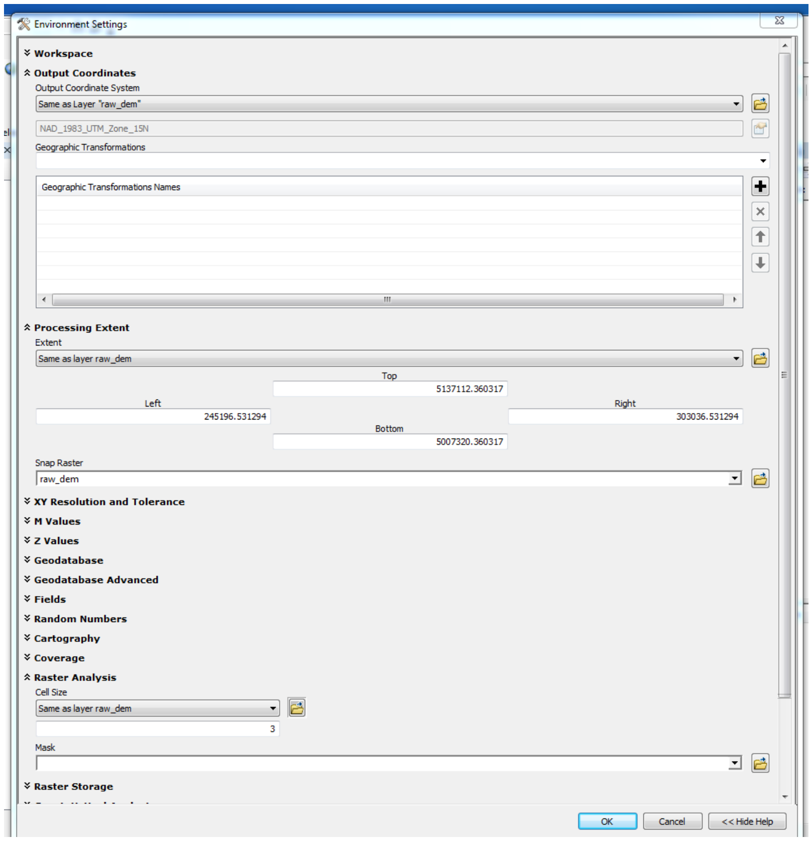


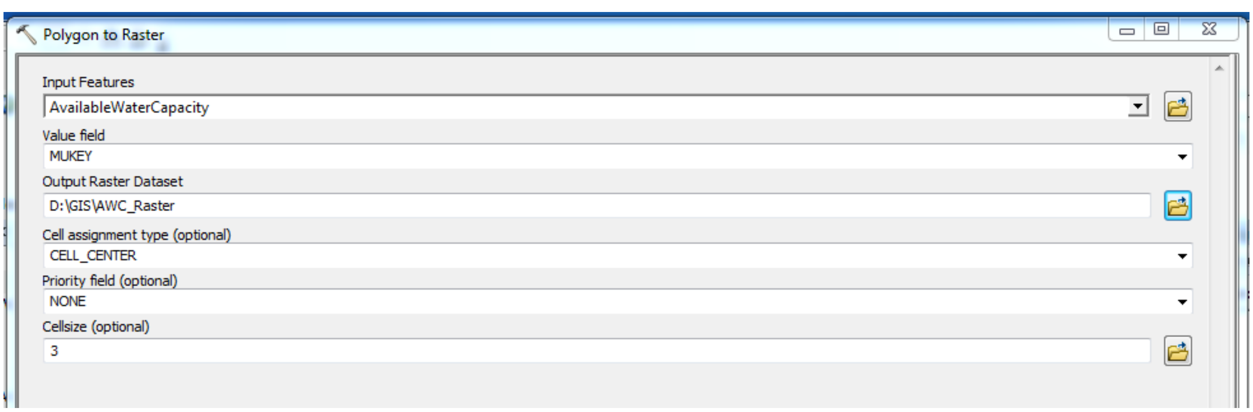
1.6 Right click on the Available Water Capacity Layer and export data to shapefile:



1.7 Complete steps 1.1 to 1.6 for all counties within the study area and merge into one shapefile.

1.8 Convert combined shapefile from previous step to raster. Set environments as follows to the study area “raw_dem”:





This raster represents the available water capacity of soils represented in each cell.

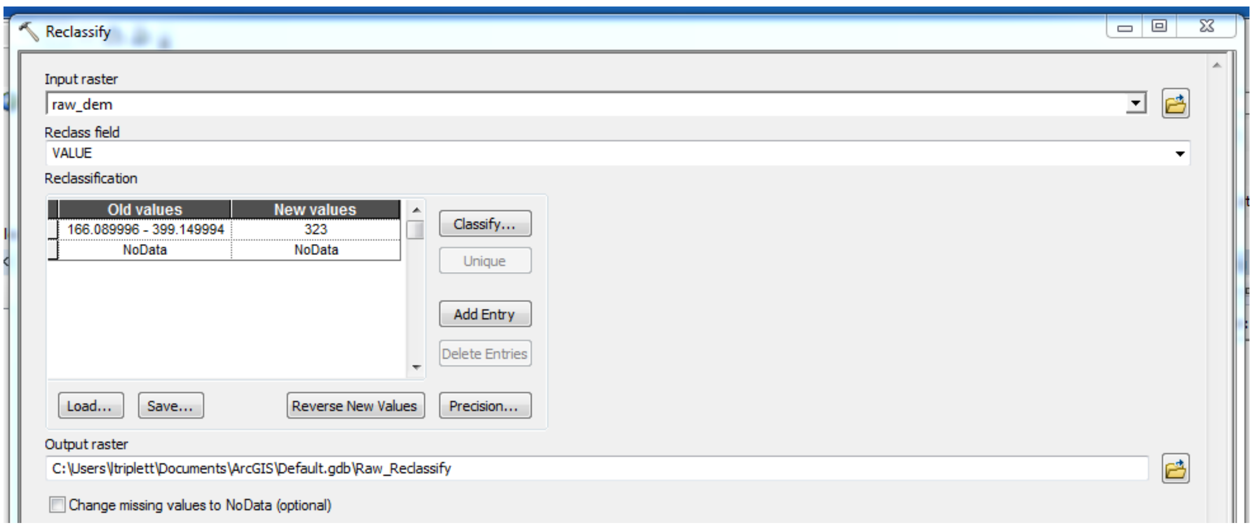
2. Generate total volume holding capacity potential for each raster cell in the study area:

2.1 Reclassify “raw_dem”:

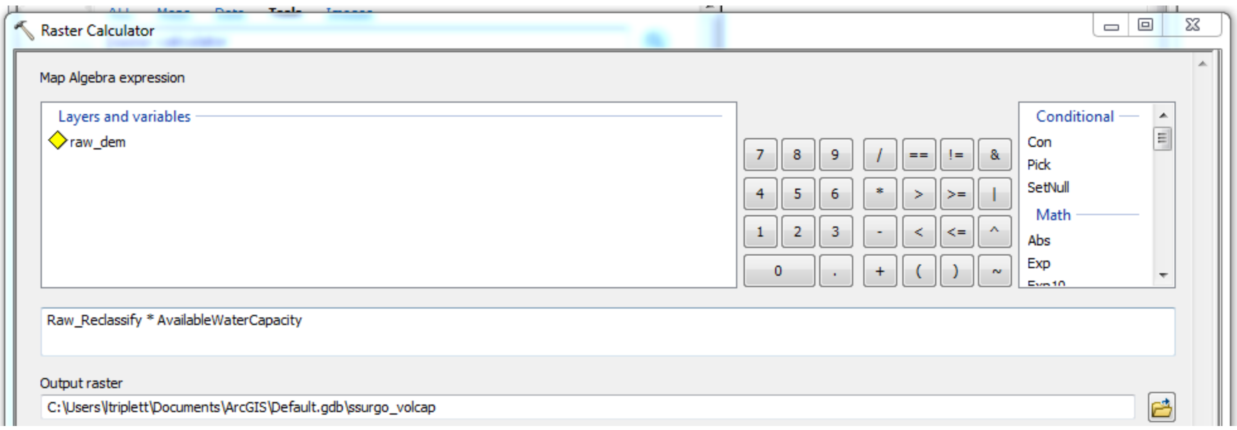
2m Cell Size – 215 (cubic feet)
3m Cell Size - 323
5m Cell Size – 538
10m Cell Size – 1076

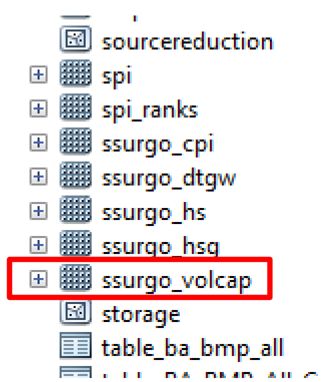
This value can change depending on desired depth of a biofiltration practice, values above are set for a 5ft depth. Equation is as follows:

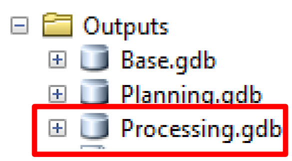
(Cell Size) * (Cell Size) * (1.524m) * (5ft) * (35.3147 [cubic-m to cu-ft conversion])



3. Multiply output raster's from steps 1 and 2 and place final raster (SSURGO_volcap) into the PTMApp-Desktop's Output/Processing.gdb.







Dataset	PTMApp Name	Description	Format
ACPF Practices (optional)			
	ssurgo_volcap	SSURGO – Available water capacity	raster

Final database structure should be similar as to what's shown below:

1. PTMApp-Desktop Dataset (input and output folders)
2. ACPF Dataset (ACPF_07080205 in example below)
3. Empty output file geodatabase to save 'Ingest ACPF' results to (ACPFOutput in example below)