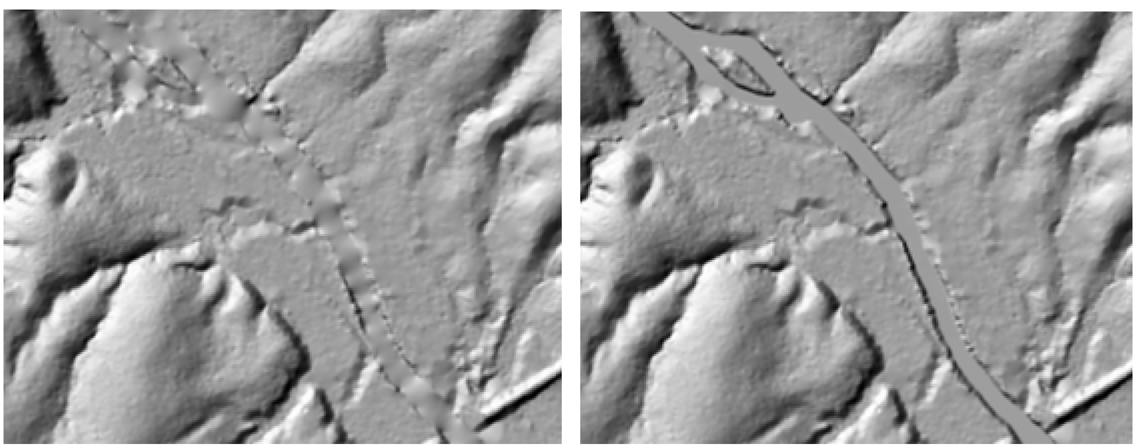
Proposed SGIC DEM Creation Methodology

Saskatchewan Watershed Authority Geomatics Branch, February 2011

Background

Elevation data has been provided by MapCon to the SGIC group as a deliverable along with the aerial photography product. This data was derived as a necessary “byproduct” of the orthorectification process but is potentially very valuable to the group as a stand-alone product. The data types provided by MapCon include USGS “.dem” format raster files (with either 100m or 30m grid cell size) as well as shapefiles which are the equivalent of centroids for these grid cells. MapCon has also provided “breaklines”, which are polyline shapefiles derived by softcopy stereo digitizing of features that represent breaks in the topography (for example, tops of ridges, bottoms of V-shaped valleys, tops and bottoms of cliffs, edges of waterbodies, etc.). These breaklines greatly add to the detail of the topography and have the potential to greatly increase the accuracy and precision of an elevation model. However, the .dem raster files provided by MapCon do not appear to have incorporated this breakline data. Figure 1 shows an example of the importance of using breaklines in the DEM creation process.

Figure 1 – Hillshades of raster DEMs created without versus with breaklines



On the left is a surface made without breaklines along the river banks. The image on the right has breakline enforcement. Breaklines are important for maintaining the definition of topographic and water related features in the elevation model. Breaklines are used to capture linear discontinuities in the surface. The most common types are edge of pavement, lake shorelines, streams, and valley bottoms. Sometimes breaklines are also collected to help define and sculpt the surface without necessarily representing discontinuities. Examples of these include contour-like form lines and the crests of rounded ridges. Graphic taken from ESRI website: http://blogs.esri.com/Dev/blogs/geoprocessing/archive/2008/12/15/Lidar-Solutions-in-ArcGIS_5F00_part2_3A00_-Creating-raster-DEMs-and-DSMs-from-large-lidar-point-collections.aspx

Therefore, the SGIC elevation data needs to be re-processed and a new product created that reflects the breakline information. It makes sense to coordinate the further processing of the SGIC elevation amongst TAB and SGIC members in order to reduce redundant efforts. To this end, we would like to get consensus on a methodology for further processing such that we end up with a product that people are confident with and that meets most requirements.

Proposed Methodology

SWA proposes using the following methodology to create a final raster DEM:

1. Merge/append together the elevation point shapefiles for all townships into one file. Likewise for all breakline polyline shapefiles.
2. Create “Terrain Dataset” dataset by importing the elevation point shapefile and breakline polyline shapefile. This “Terrain Dataset” is basically a fancy version of a triangular irregular network “TIN” dataset (see figure 2).

   Figure 2 – Example of Terrain Dataset data model

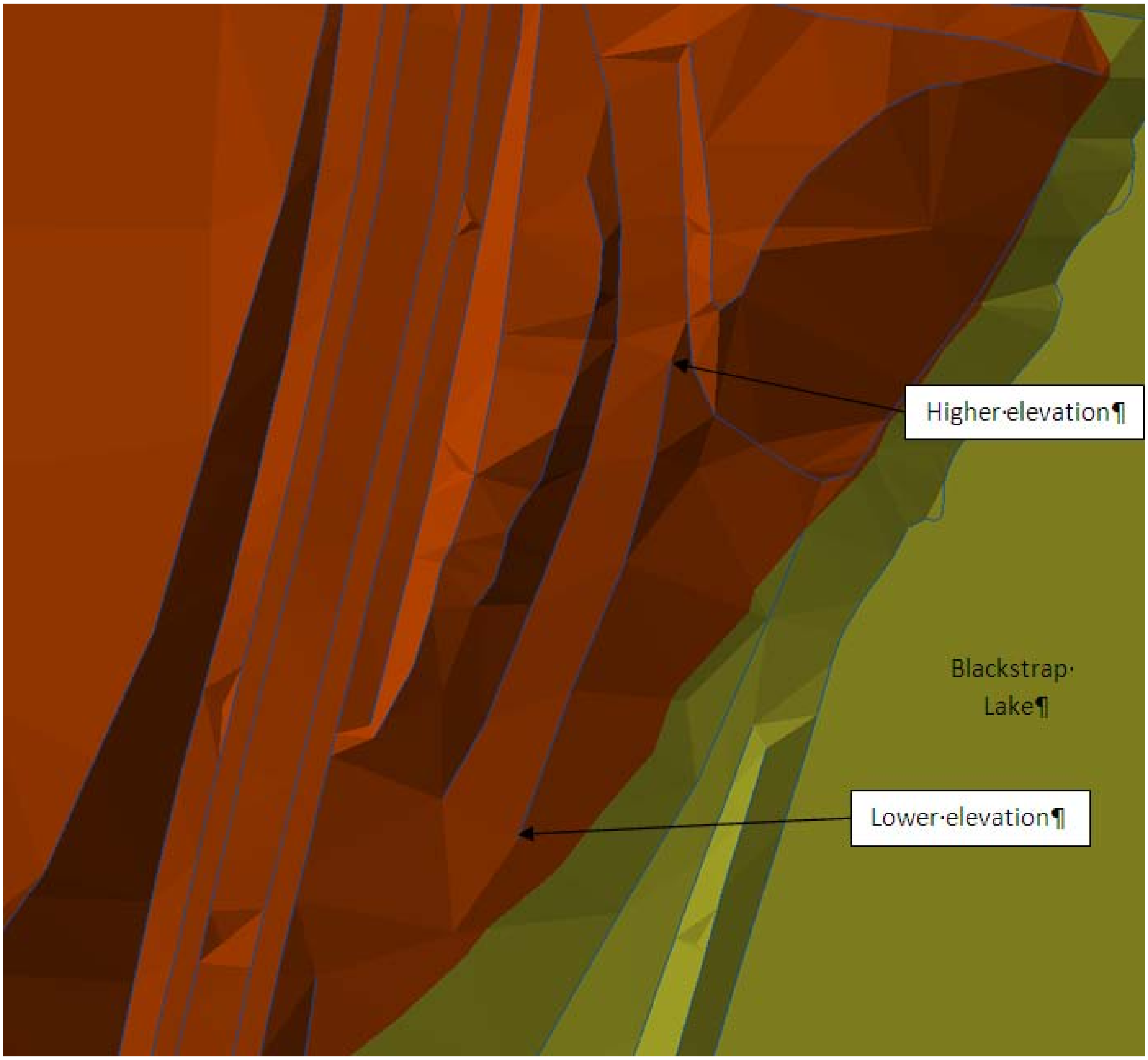
   The advantage of this Terrain format is that it incorporates all of the breakline information very precisely but only requires a minimal number of polygons to represent flatter areas (see Figure 3). For more information on the ESRI “Terrain Dataset” format in general, see: http://webhelp.esri.com/arcgiSDEsktop/9.3/index.cfm?TopicName=What%20is%20a%20terrain%20dataset?   This data format will be useful as is for some applications but a raster grid will be more widely usable for other applications and non-ESRI software.
3. Convert the Terrain Dataset into a raster DEM in ESRI grid format. We propose a 15meter cell size as a general purpose DEM but smaller or larger versions could be generated fairly easily. Although the elevation grid of point of the original data is 30 metre of 100 metre spacing, the vertices of the breaklines are much closer together; usually around 10-20 metres apart, and sometimes as close as 2 metres apart. Therefore it makes sense to use a grid spacing that will capture most of this detail.
4. Convert grid to tiff format so as to be more widely usable by other software

Figure 3 – Example of Terrain Dataset created with SGIC data

This image shows a sample area of the completed terrain dataset. The image has an apparent TIN like look to it. The blue lines are the breaklines. The image shows highway 11 crossing a valley, with Blackstrap Lake to the north. Normally all open water such as lakes, ponds, and large rivers should be flat or at one elevation. By using the Terrain dataset, these flat features are enforced. Without the use of the breaklines, this area could be interpreted as having different elevations, and so it wouldn't look flat, more like a V or U shape valley.

It is important to note that the breaklines are not "contours" (i.e. lines of equal elevation) but have a slope to them that is inherent to each vertex "behind the scenes" in the 3D shapefile structure (as is shown in Figure 4). These lines do have an elevation value associated with them in the attribute table, this is the elevation at one of the ends of the line, **NOT A CONTOUR ELEVATION OF THE ENTIRE LINE!**

Figure 4 – Zoomed-in view of Terrain shown in previous figure



A close-up view of the previous image. The breaklines here correspond to the tops of ridges, along the valley sides of Blackstrap Lake. The ridges here show that it descends in elevation along its length. Breaklines not only enforce flat areas like a lake, but ridges or rivers that have elevation changes along its length.

Why not use the "Topo to Raster" Tool instead?

The "Topo to Raster" tool in ArcGIS (formerly called "TopoGRID" in workstation ArcInfo) is a popular tool for interpolating contour and spot elevation data into raster DEMs. One of the advantages of this tool is that it allows you to "force" the DEM to fit with stream linework to help create a more hydrologically correct DEM. The problems with using this tool in this case are:

1. It doesn't allow the use of breaklines in the processing (unless they are specifically streams or lakes)
2. It only has the ability to processes a relatively small number of points at a time. Perhaps there is a way to batch process tiles but then edge-matching the tiles may be an issue.

Appendix A – Detailed instructions on how to process SGIC elevation data in ArcGIS 10

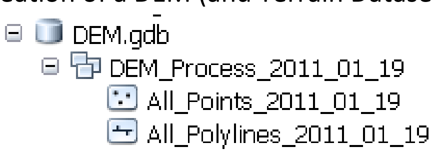
by Warren Kolysher, SWA

There are two options for creating a DEM from a Terrain Dataset in ArcCatalog (both yield the same final result):

A. Wizard Method
B. By Individual Tools from ArcToolbox

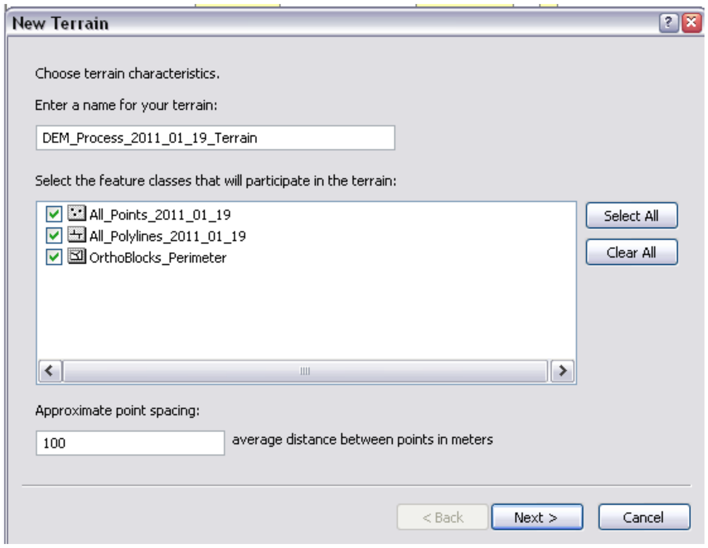
A. Wizard Method

1. Create a File Geodatabase.
2. Create a Feature Dataset in the File Geodatabase created in step 1.
3. Import all Points, Polylines and Polygons into the Feature Dataset that will be used for the creation of a DEM (and Terrain Dataset).

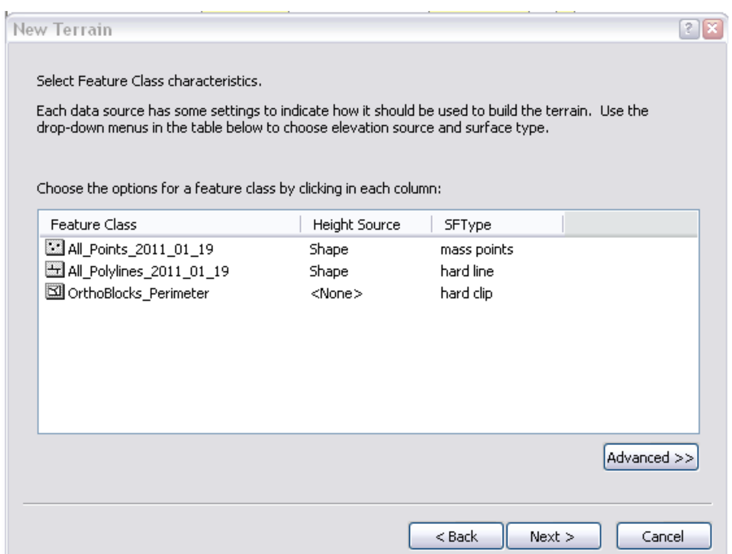


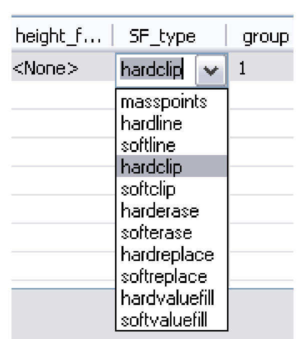
4. Create Terrain Dataset:
   Right click on the newly created Feature Dataset, choose new, Terrain, and follow wizard setup:
   a. Select all Features that are going to be used in the creation of the Terrain, use 100 for "The average distance between points in meters." Click next.

      (Usually, the average point spacing is defined as part of the data procurement process and is recorded as metadata. If you don't know the average point spacing of your data, you'll need to determine what it is. The best average spacing to use for terrain is that which represents the most common distance between points and vertices. For example, there may be some points very close, for example, 0.2 meter, and some very far apart, for example, 5 meters, but if the vast majority are approximately 2 meters, that is the value you should specify. Outliers should have little to no influence.)

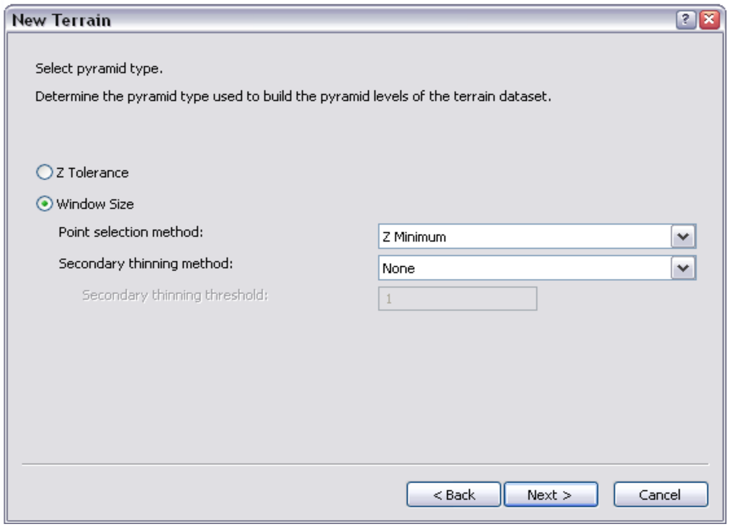


b. In the SFType field make sure points are known as mass points, hard line for the Polylines, and hard clip for the Polygons. Since we do not have all the data collected for the entire province, there are places that have no data. By using the hard clip here for the polygon feature class it will clip out the “no data” areas. Once the whole province gets collected, the provincial boundary maybe needed as the clipped area rather that the OrthoBlock Perimeter feature class. If you do not clip out the “No Data”, the No Data areas will then be used in the build terrain geoprocessing. Click next

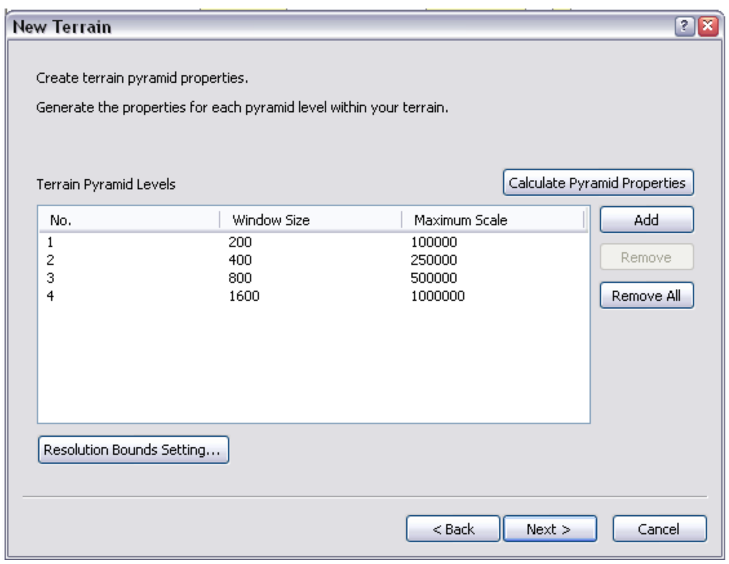




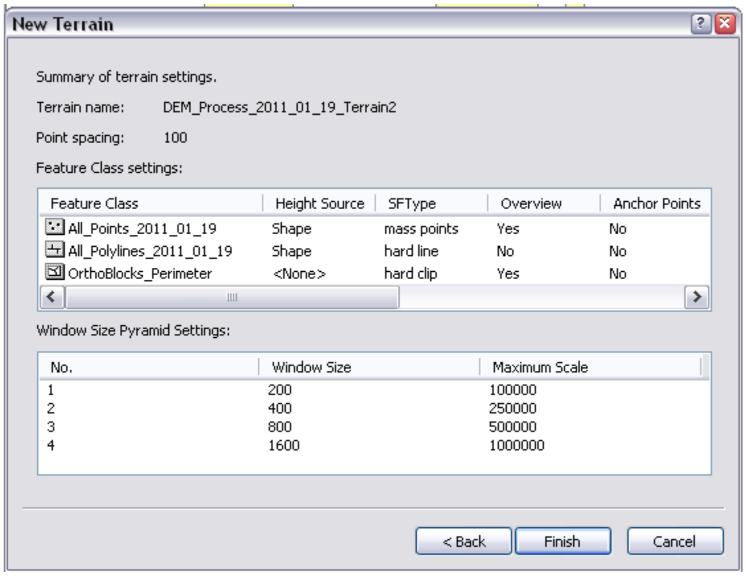
c. Click on radial “Window Size” and choose Z-Minimum for “Point selection method,” none for “Secondary thinning method”. Click next



d. Click on “Calculate Pyramid Properties” button, Click next



e. Click finished button, Terrain will now be created



f. Click yes to the popup window asking, “The new terrain has been created. Would you like to build it now?”

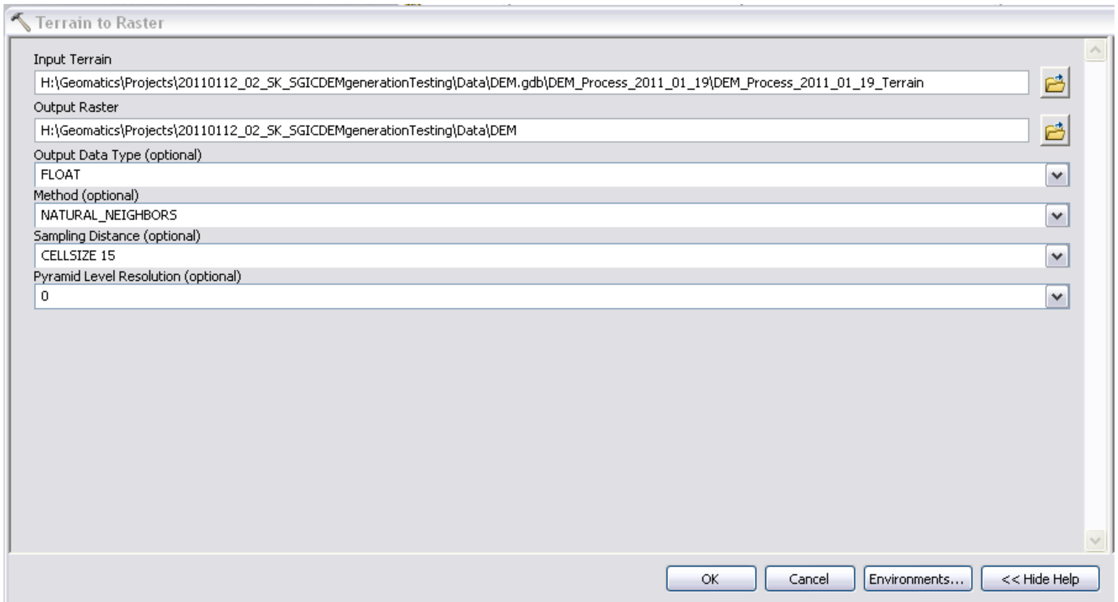
Terrain that has been clipped out

Terrain with no clipping

5. Terrain to Raster

   In ArcToolbox go to 3D Analyst Tools, Conversion, From Terrain, and open the Terrain to Raster tool

   a. Select your newly created terrain for the "Input terrain"
   b. Select output location and name it for "Output Raster"
   c. Use Float for "Output Data Type"
   d. Use Natural Neighbors for "Method"
   e. Use cell size 15 for "Sampling Distance"
   f. Use 0 for "Pyramid Level"
   g. Click Ok to create the raster image

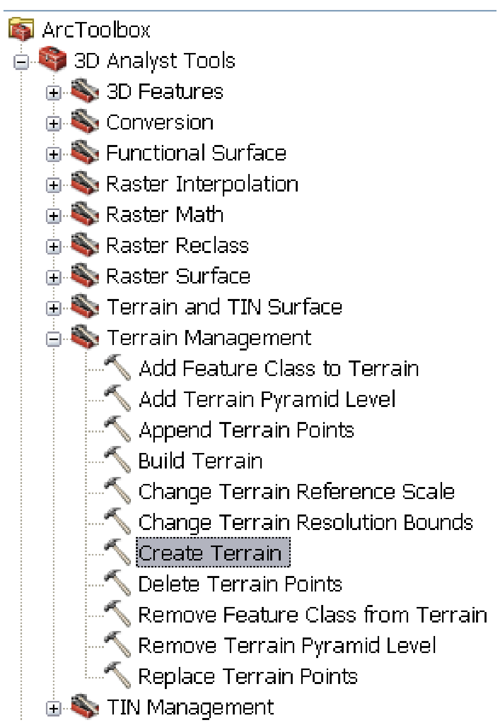

Terrain to Raster
Input Terrain
H:\Geomatics\Projects\20110112_02_SK_SGICDEMgenerationTesting\Data\DEM.gdb\DEM_Process_2011_01_19\DEM_Process_2011_01_19_Terrain
Output Raster
H:\Geomatics\Projects\20110112_02_SK_SGICDEMgenerationTesting\Data\DEM
Output Data Type (optional)
FLOAT
Method (optional)
NATURAL_NEIGHBORS
Sampling Distance (optional)
CELLSIZE 15
Pyramid Level Resolution (optional)
0
OK
Cancel
Environments...
<< Hide Help

B. By Individual Tools from ArcToolbox

If you are planning on using individual geoprocessing tools to automate and create terrain datasets, use these tools in the following order:

1. Create Terrain
2. Add Terrain Pyramid Level
3. Add Feature Class to Terrain
4. Build Terrain
5. Terrain to Raster Tool

Each of the above geoprocessing tools must be run separately and in the exact order described. The first four geoprocessing tools used to create terrain datasets can be found in the Terrain toolbox displayed in ArcToolbox (below). Steps for each geoprocessing tool used to create terrain datasets are explained below.



1. Create Terrain geoprocessing tool

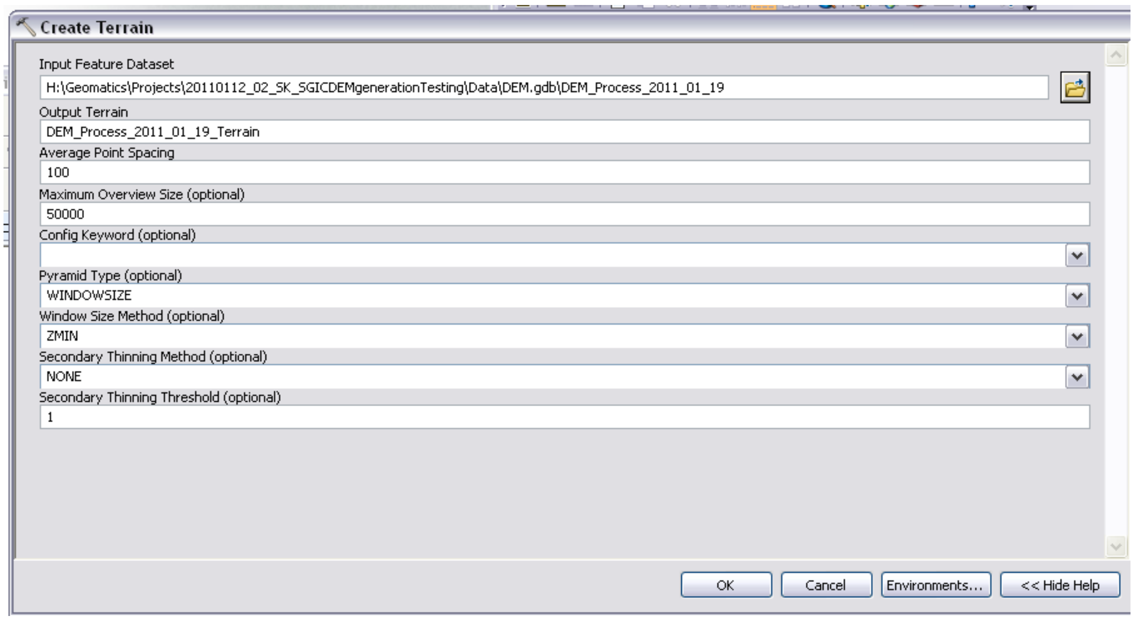
The Create Terrain geoprocessing tool creates a new terrain dataset inside the specified feature dataset.

a) In ArcToolbox, expand 3D Analyst Tools, and expand the Terrain Management toolset.
b) Double-click Create Terrain to open the geoprocessing tool. The Create Terrain dialog box is displayed below.

c) Click the Input Feature Dataset browse button  to navigate to the location where the terrain dataset is to be created.
d) Highlight the feature dataset and click Add.
e) Type a name for the new terrain dataset in the Output Terrain text box.
f) Type the average point spacing in the Average Point Spacing text box.
The Average Point Spacing parameter needs to be determined by the data that will be used to build the terrain dataset. This value doesn't need to be exact but should represent a good approximation. If the data has been gathered at significantly different densities from one location to another, give more weight to the smaller spacing. Use 100.

(Usually, the average point spacing is defined as part of the data procurement process and is recorded as metadata. If you don't know the average point spacing of your data, you'll need to determine what it is. The best average spacing to use for terrain is that which represents the most common distance between points and vertices. For example, there may be some points very close, for example, 0.2 meter, and some very far apart, for example, 5 meters, but if the vast majority are approximately 2 meters, that is the value you should specify. Outliers should have little to no influence.)

g) Optionally, specify the Maximum Overview Size.
The terrain overview is the coarsest representation of the terrain dataset. The maximum size is the upper limit to the number of measurement points sampled to create the overview.
h) Optionally, enter a Configuration keyword for ArcSDE.
A configuration keyword is used to indicate storage and location parameters for optimal space. It applies only to ArcSDE geodatabases and is provided by the database administrator.
i) Select the Pyramid Type used to create and organize the terrain data, either Window Size or Z Tolerance. The default is Window Size. Use Window size.
j) If Window Size is chosen, the following must also be specified:
    - A Window Size method. The default is ZMIN.
    - A Secondary Thinning Method. The default is none.
    - Optionally, set a Secondary Thinning Threshold. The default is 1.
    - Use ZMIN
k) Click OK to execute the Create Terrain geoprocessing tool.



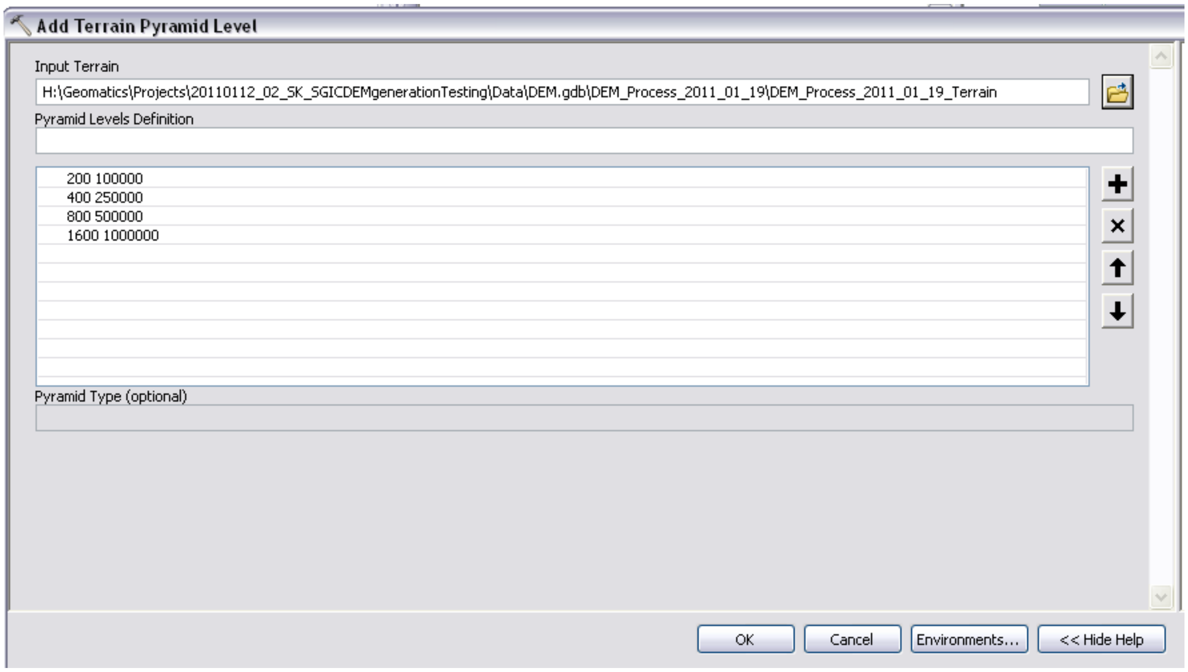
2. Add Terrain Pyramid Level geoprocessing tool

The Add Terrain Pyramid Level geoprocessing tool defines the pyramid levels for an existing terrain dataset.

a) In ArcToolbox, expand 3D Analyst Tools, and expand the Terrain Management toolset.
b) Double-click the Add Terrain Pyramid Level geoprocessing tool. The Add Terrain Pyramid Level dialog box is displayed below.
c) Click the Input Terrain browse button to navigate to the location where the terrain dataset resides to add the pyramid-level definition.
d) Highlight the terrain dataset and click Add.
e) Type the first pyramid level in the Pyramid Levels Definition window ("200 100000").
f) Click the Add Data button to add the first defined pyramid level to the display window.

   NOTE: The Pyramid Levels Definition window defines the z-tolerance or window size and reference scale of one or more pyramid levels that will be added to the terrain dataset. The values are given in space-delimited pairs; one pair for each level. The z-tolerance can be specified as a floating-point value. The reference scale must be provided as a whole number (e.g., a value of 24,000 represents a scale of 1:24,000).

g) Repeat steps 5 and 6 to continue defining each pyramid level of the terrain dataset. Now add the rest: "400 250000", "800 500000", "1600 1000000"
h) Click OK to execute the Add Terrain Pyramid Level geoprocessing tool.



3. Add Feature Class to Terrain geoprocessing tool

The Add Feature Class to Terrain geoprocessing tool defines how each feature class will contribute to an existing terrain dataset. Each feature class must already reside within the feature dataset along with the terrain dataset.

a) In ArcToolbox, expand 3D Analyst Tools, and expand the Terrain Management toolset.
b) Double-click Add Feature Class to Terrain to open the tool. The Add Feature Class to Terrain dialog box is displayed below.
c) Click the Input Terrain browse button to navigate to the feature dataset where the terrain dataset resides.
d) Highlight the terrain dataset and click Add.
e) Click the Input Feature Class browse button to navigate to the feature dataset where the input feature class resides.
f) Highlight the feature class and click Add.
g) Click the Add Data button to add the first feature class to the display window.
h) Set the following feature class properties appropriately for the contributing feature class:

- Height Source: The field supplying heights for the features. If z-values are coming from the feature geometry, the Shape field is listed.

- SFType: This is the Surface Feature Type. It defines how the feature geometry is incorporated into the triangulation for the surface. Points should be mass points, polylines should be hardline, and polygons in this case hardclip

- [Group:]() Thematically similar data, representing the same geographic features but at different levels of detail. Feature classes belonging to the same group are assigned the same group ID.

- [Pyramid Resolution Bounds:]() The minimum and maximum pyramid levels polyline or polygon surface feature types will be enforced in the surface.

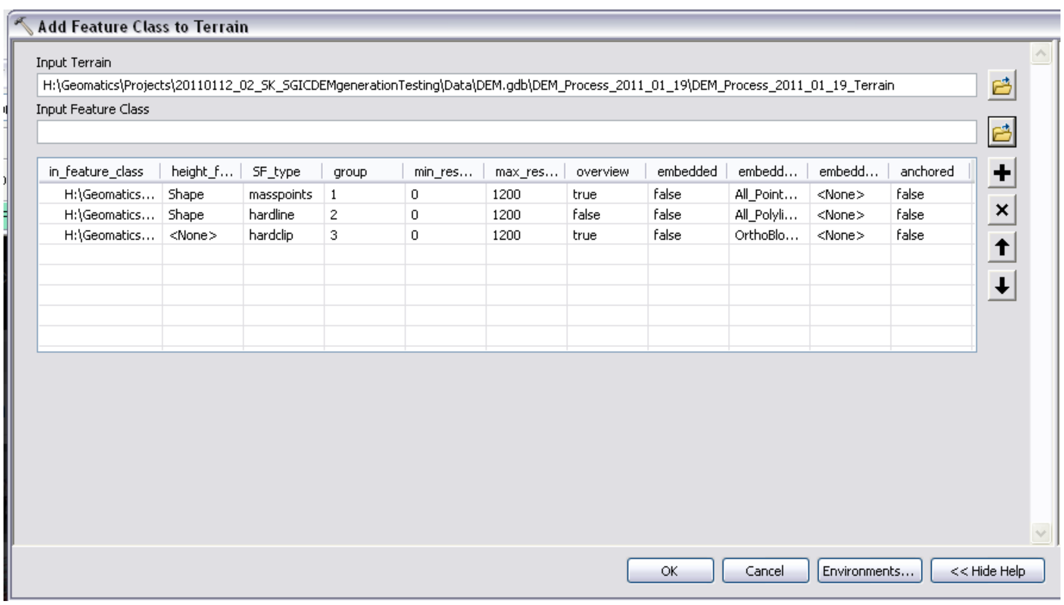
- [Overview:]() Indicates whether the feature class contributes measurements to the coarsest representation of the terrain dataset.

- [Embedded:]() Feature classes that are embedded are contained by the terrain itself. They will not be visible in ArcCatalog or the Add Data browser. Only multipoint feature classes can be embedded.

- [Embedded Fields:]() If the multipoint feature class is being embedded and has LAS (i.e., lidar) attributes created via the LAS to Multipoint import geoprocessing tool, you can have those attributes preserved. Specify here which LAS attributes to save with the embedded points.

i) Repeat steps 5 through 8 for each contributing feature class to continue defining the terrain dataset.

j) Click OK to execute the Add Feature Class to Terrain geoprocessing tool.

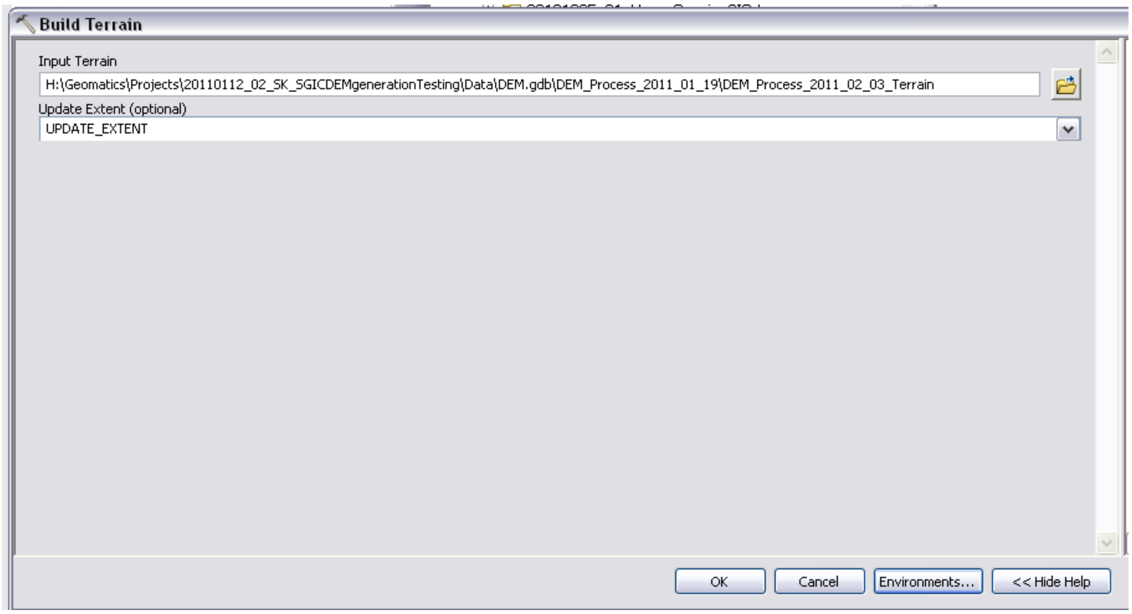


4. Build Terrain geoprocessing tool

The Build Terrain geoprocessing tool performs the necessary steps to make a terrain dataset functional after it has been initially defined.

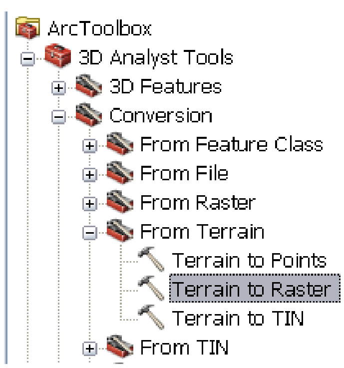
1. In ArcToolbox, expand 3D Analyst Tools, and expand the Terrain Management toolset.
2. Double-click Build Terrain to open the tool. The Build Terrain dialog box is displayed below.

3. Click the Input Terrain browse button  to navigate to the feature dataset where the terrain dataset resides.
4. Highlight the terrain dataset and click Add.
5. Click OK to execute the Build Terrain geoprocessing tool

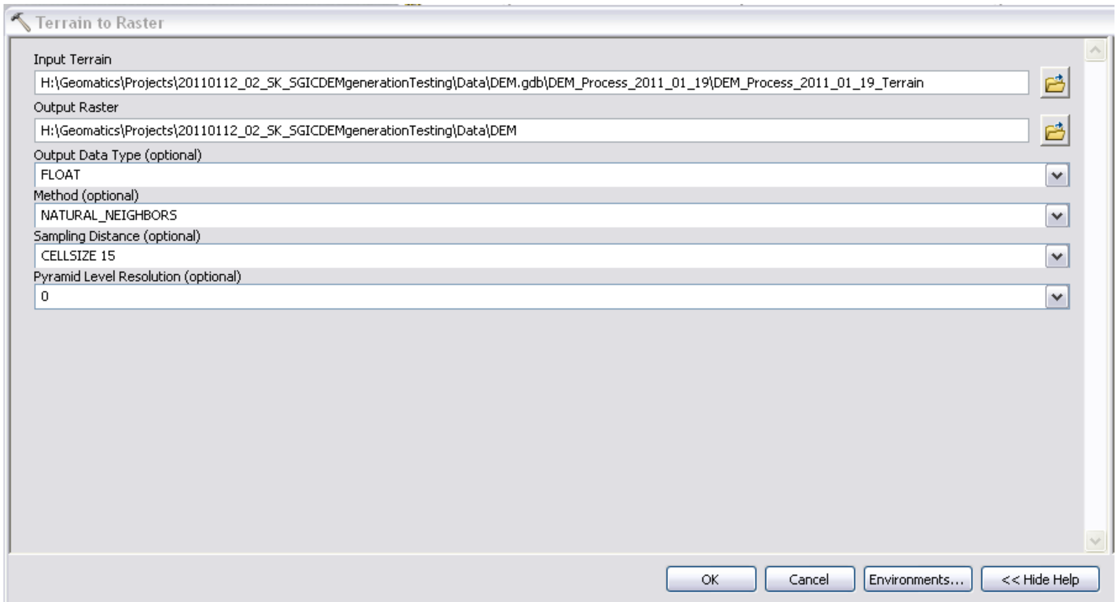


5. Terrain to Raster Tool

In ArcToolbox go to 3D Analyst Tools, Conversion, From Terrain, and open the Terrain to Raster tool



a. Select your newly created terrain for the “Input terrain”
b. Select output location and name for “Output Raster”
c. Use Float for “Output Data Type”
d. Use Natural Neighbors for “Method”
e. Use cell size 15 for “Sampling Distance”
f. Use 0 for “Pyramid Level”
g. Click Ok to create the raster image


Terrain to Raster
Input Terrain
H:\Geomatics\Projects\20110112_02_SK_SGICDEMgenerationTesting\Data\DEM.gdb\DEM_Process_2011_01_19\DEM_Process_2011_01_19_Terrain
Output Raster
H:\Geomatics\Projects\20110112_02_SK_SGICDEMgenerationTesting\Data\DEM
Output Data Type (optional)
FLOAT
Method (optional)
NATURAL_NEIGHBORS
Sampling Distance (optional)
CELLSIZE 15
Pyramid Level Resolution (optional)
0
OK
Cancel
Environments...
<< Hide Help

Done!