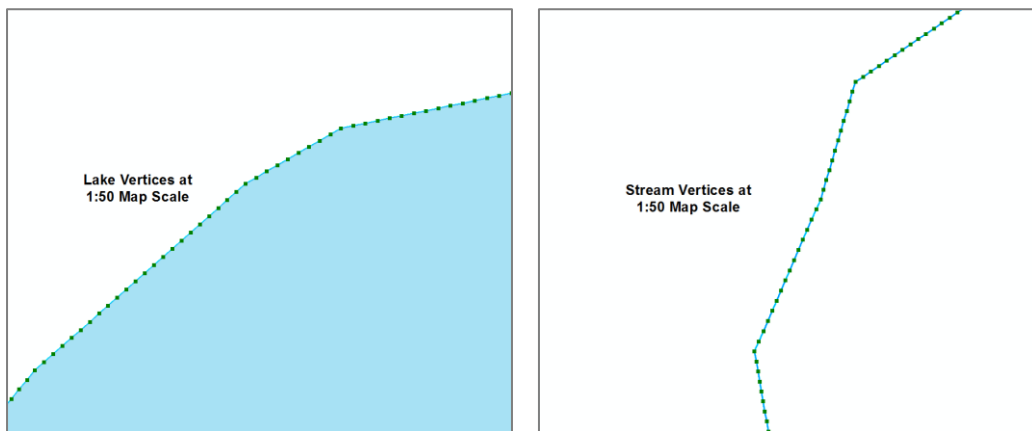


EXERCISE 1

How to simplify overly complex geometries



Introduction

The automated generation of one-dimensional flowlines (e.g., 1D streams) and two-dimensional polygons (e.g., 2D waterbodies) from LiDAR or IfSAR surfaces often results in the creation of features containing an unnecessarily high number of vertices. Derived 1D and 2D features containing an excessive number of vertices can be problematic for basic stewardship tasks like desktop editing, file management, and feature display; this can be due to both unnecessarily large file size and feature complexity. Where LiDAR or IfSAR derived features are discovered to have an excessive number of vertices, it's important to ensure that any necessary simplification of the features does not negatively degrade the shape and/or spatial position of those features. In this exercise, we will be using the Simplify Line and Simplify Polygon tools within ArcMap to remove redundant vertices from a stream dataset and a lake dataset that were derived from a LiDAR surface. This is a typical first step when beginning to prepare IfSAR/lidar derived hydrography data for submission to the NHD GeoConflation Tool. It is important to remember that this is the first step of the preprocessing workflow, and it is not the first step in the official GeoConflation workflow, which requires a separate training offered by the USGS.



Objectives

- Learn how to do a quick visual assessment of vertex density within LiDAR derived stream and lake features.
- Learn how to use the Simplify Line and Simplify Polygon tools within ArcMap to batch process features that contain redundant vertices.

Required Data

- **Dense_Vertices.gdb** – file geodatabase that contains the two feature classes used during this exercise – “**Draft_NHDFlowline**” and “**Draft_NHDWaterbody**”. The data provided for this exercise are real world data that were LiDAR derived for a project in Southcentral Alaska and intended for uplift to the National Hydrography Database (NHD). The data used here had to undergo the very processes described in this exercise in order to begin their path towards NHD uptake.
- Assuming that the data providers/creators have not already simplified hydrographic features derived from native LiDAR or IfSAR surfaces, users could potentially use their own LiDAR or IfSAR derived hydrography features for this exercise. This option is not required, but something users may wish to explore.

Prerequisites

- ESRI ArcGIS Desktop v10.5.1 (or newer) is installed on the user’s computer
 - “Standard” or “Advanced” level ArcGIS Desktop license required – exercise will not work with “Basic” level ArcGIS Desktop license.
- User has a basic level of experience with the ArcMap interface.





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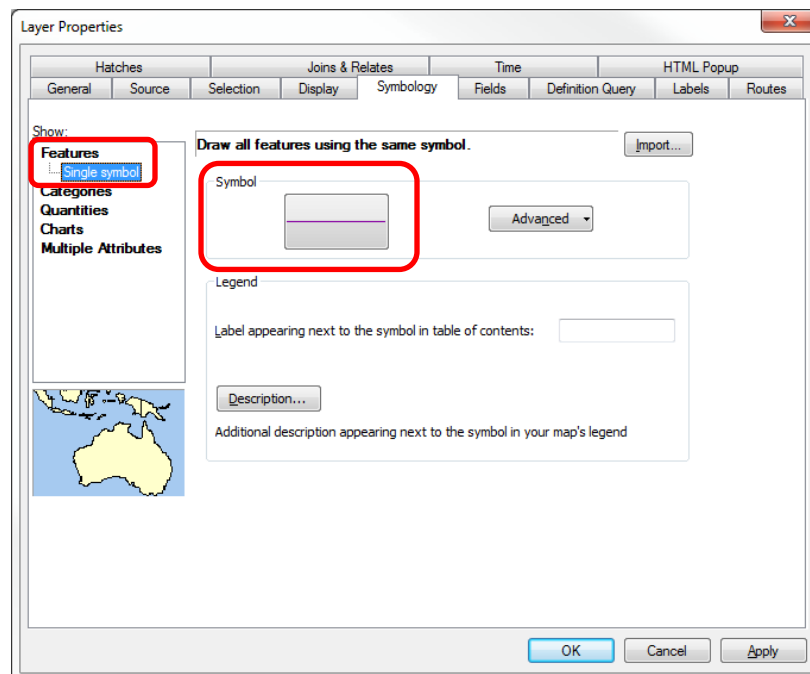


Part 1: Visual assessment of underlying geometry

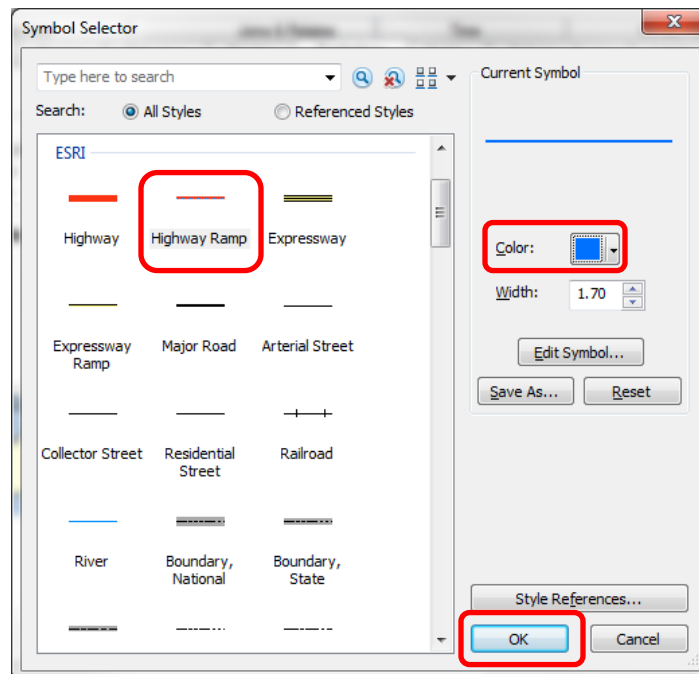
A good way to assess the underlying geometry of features that were derived from LiDAR or IfSAR surfaces is via a simple visual check in ArcMap. This can be done by loading the derived data into ArcMap, beginning an edit session, double clicking on a feature, and assessing the average distance between feature vertices.

A. Load the datasets into ArcMap and symbolize them

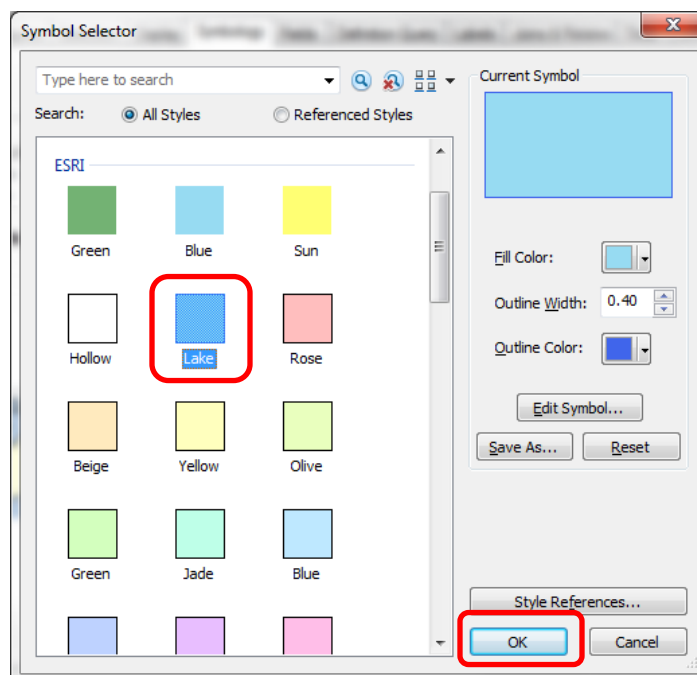
1. Launch ArcMap from the start menu by clicking **Start, Programs, ArcGIS, ArcMap 10.5**.
2. Click the **Add Data** button and navigate to where you placed the course material.
3. While holding the Shift key, select the **Draft_NHDFlowline** and **Draft_NHDWaterbody** feature classes, then click **Add**.
4. Right click on the **Draft_NHDFlowline** dataset in the table of contents (TOC) and select **Properties**.
5. In the Layer Properties dialog box, select the **Symbology** tab and change the default from **Categories** to **Features-Single Symbol**.



6. Next, click on the line feature within the Layer Properties dialog box, choose the predefined Esri symbol titled **"Highway Ramp"**, set the color to a shade of **Blue**, and click **OK** (see below).



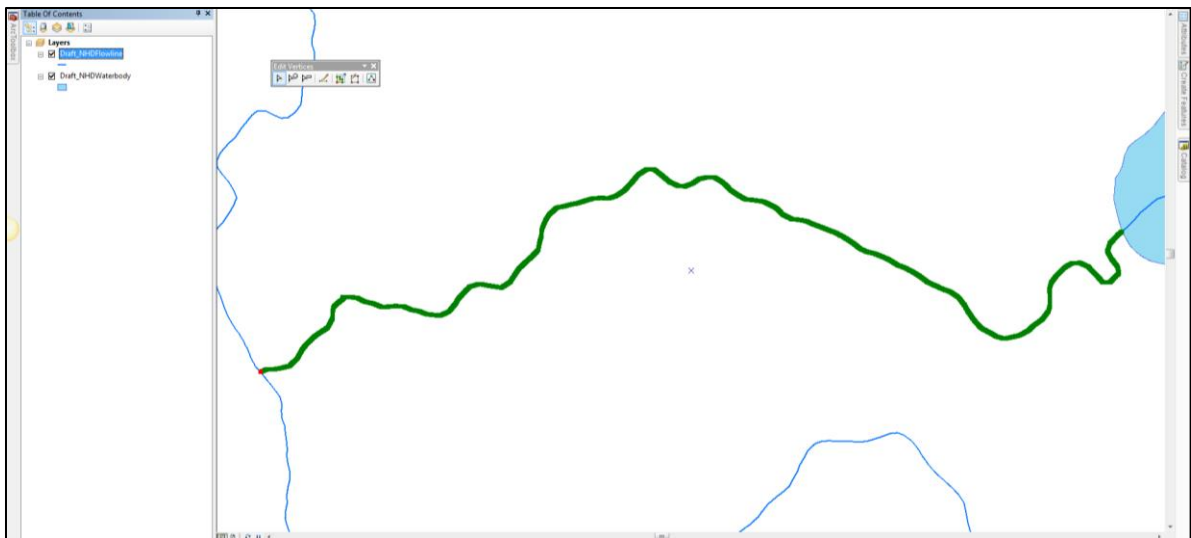
7. Right click on the **Draft_NHDWaterbody** in the TOC and select **Properties**.
8. In the Layer Properties dialog box, select the **Symbology** tab and change the default from Categories to **Features-Single Symbol**.
9. Next, click on the line feature within the Layer Properties dialog box, choose the predefined Esri symbol titled "**Lake**", and click **OK**.




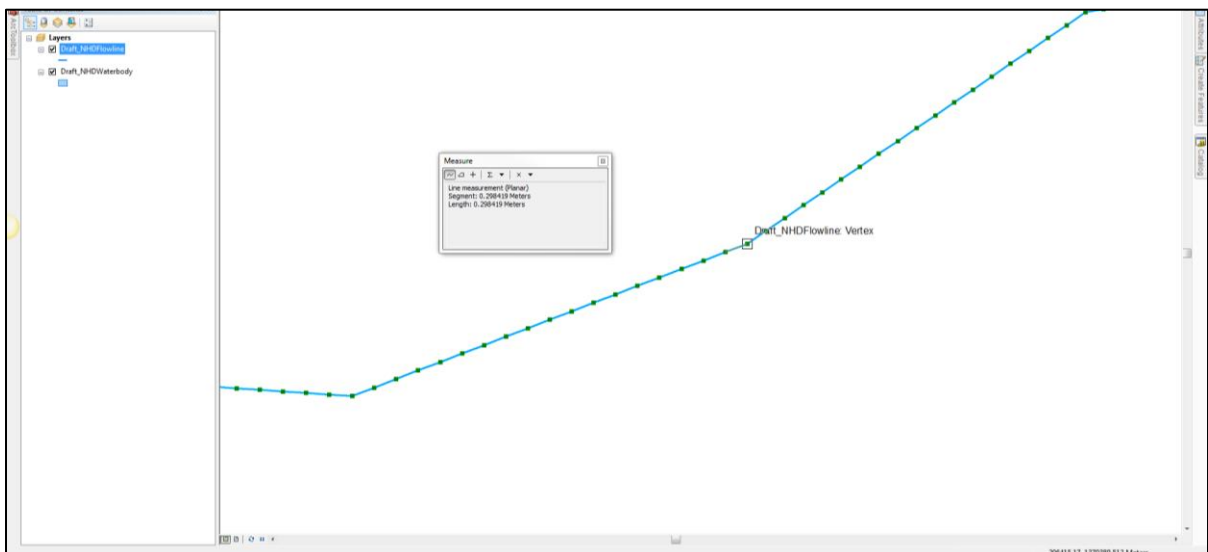
10. If the layers are not already visible in the map document, turn the layers on within the TOC.

B. Assess the underlying geometry

1. From the **Customize** menu dropdown (located at the top of the ArcMap window), select **Toolbars**, and then click on the **Editor** toolbar. Once the toolbar appears, select **Editor** and then click **Start Editing**.
2. Select and zoom into any one of the line features within the **Draft_NHDFlowline** dataset, then double click that feature to activate the underlying vertices for editing as shown below.



3. With the vertices still actively displayed, zoom in until you can clearly see individual vertices along the selected line feature. This will likely require zooming into a map scale larger than 1:50, such as 1:30 in the example below.
4. Using the **Measure** tool,  found on the standard **Tools** toolbar in ArcMap, check the distance between individual vertices along a straight portion of the selected feature. **Vertices found to be averaging closer than ½ meter together are indicative of a dataset that likely has overly complex geometries.**



5. Explore a few features within either of the layers and repeat that visual inspection (double click any feature and zoom in to see the average spacing between vertices) for any of the features within either the Draft_NHDFlowline or the Draft_NHDWaterbody datasets. Further checks should reveal that most of the features in either of those datasets contain an excessive number of vertices and that most of these vertices are not required to maintain the current shape of those features.
6. Once finished with reviewing random features, stop editing by clicking **Editor in** the Editor toolbar, selecting **Stop Editing**. Do not save any changes. You may now proceed to Part 2 of the exercise.

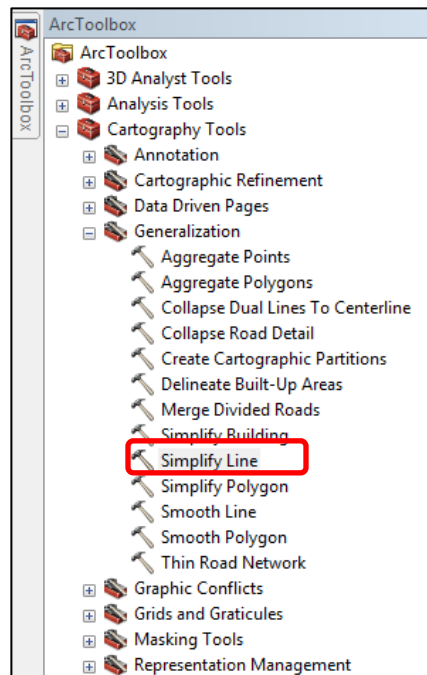
Part 2: Simplifying features with overly complex geometry

Once visual assessment of the datasets has been completed and the user has identified that there are a number of features within those datasets that have overly complex geometries, a set of tools can be used to eliminate redundant vertices while preserving overall feature shape and position.

A. Using the Simplify Line tool

The Simplify Line tool simplifies lines by removing needless vertices while preserving essential shape.

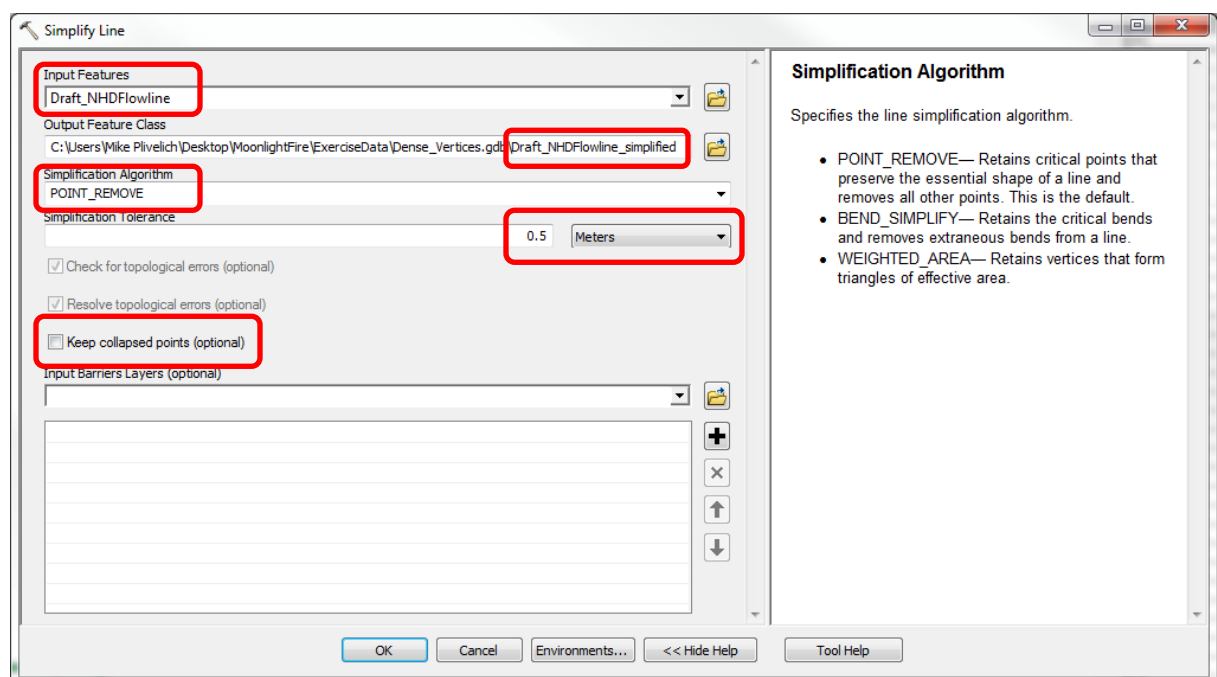
1. Within ArcMap, open the ArcToolbox interface (i.e. red toolbox icon on the “Standard” toolbar), open the **Cartography Tools** toolbox, select the **Generalization** sub-set of tools, and double click the **Simplify Line** tool to open it.



2. Once the tool opens, there are 5 input parameters that the user has to configure prior to running the tool. These parameters are described and shown via the info and screenshot below.
 - i. Using the dropdown menu, select the **Draft_NHDFlowline** dataset as the **Input Features**.
 - ii. For the **Output Feature Class** parameter, navigate to the geodatabase containing the current exercise data and name the output as **"Draft_NHDFlowline_simplified"**. The tool will create a new dataset, and this parameter describes where that data will be stored and what it will be named.
 - iii. Choose the **POINT_REMOVE** option from the dropdown list within the **Simplification Algorithm** parameter. The POINT_REMOVE algorithm retains critical points that preserve the essential shape of a line and removes all other points.
 - iv. Within the **Simplification Tolerance** parameter, type **"0.5"**, and ensure that the unit of measure is set to **Meters**. When using the POINT_REMOVE algorithm within the tool, the Simplification Tolerance defines the maximum allowable perpendicular distance between each vertex and the new line created.

The 0.5-meter threshold used here is one that has been reached through a process of trial and error by NHD Stewards in the State of Alaska who regularly work the LiDAR and IfSAR derived hydrography features. The 0.5-meter threshold is not a national standard, but it has been found to achieve a happy medium between overall shape preservation and an appropriate level of feature simplification.

- v. Ensure that the **"Keep collapsed points"** box is unchecked, or the tool will create an additional output that contains any endpoints of resulting lines that are smaller than the spatial tolerance. This exercise is unconcerned with any features meeting that criteria since they would either be processing artifacts or features can be addressed more readily in a later exercise.

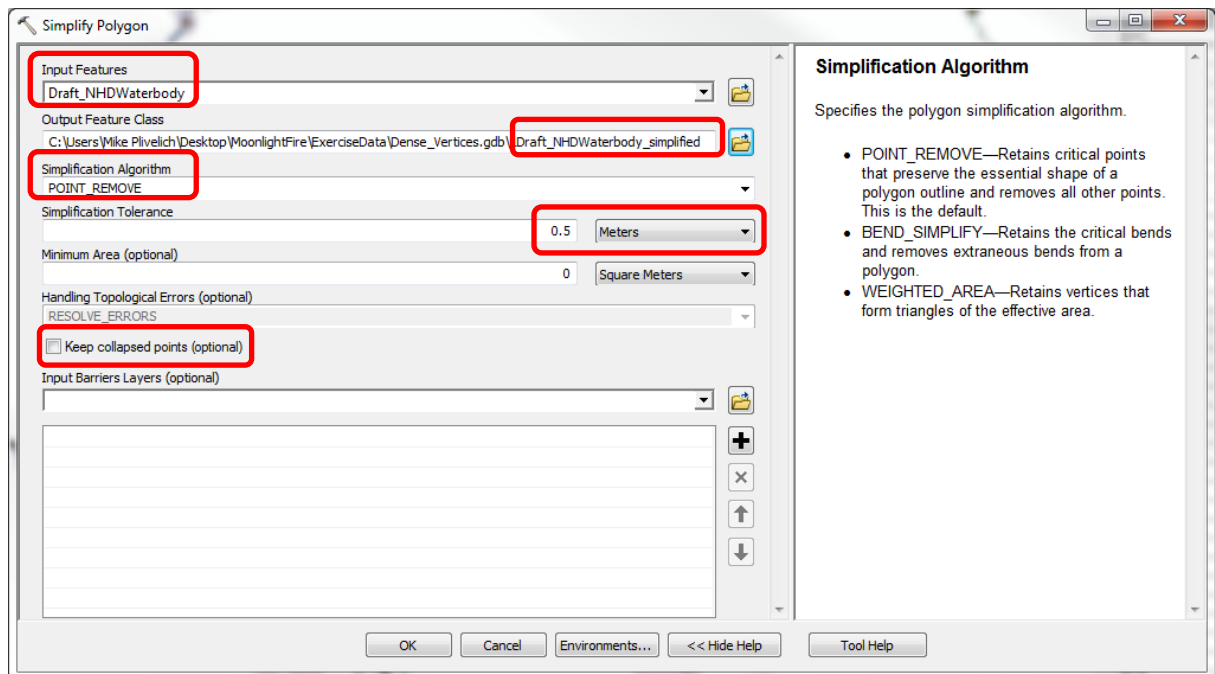


3. Once the tool has been populated per the instructions and screenshot above, click **OK** to run the tool. When complete, the tool will add the resulting **Draft_NHDFlowline_simplified** dataset to the TOC.
4. Right click on the **Draft_NHDFlowline_simplified** dataset in the TOC and select **Properties**.
5. In the Layer Properties dialog box, select the **Symbology** tab and change the default from Categories to **Features-Single Symbol**.
6. Next, click on the line feature within the Layer Properties dialog box, choose the predefined Esri symbol titled **"Highway Ramp"**, however, this time leave the color set to **red** (so it contrasts with the features in the Draft_NHDFlowline dataset) and click **OK**.

B. Using the Simplify Polygon tool

This tool simplifies polygon outlines by removing needless vertices while preserving essential shape.

1. Within ArcMap, open the ArcToolbox interface (i.e. red toolbox icon on the "Standard" toolbar), open the **Cartography Tools** toolbox, select the **Generalization** sub-set of tools, and double click the **Simplify Polygon** tool to open it.
2. Once the tool opens, there are 5 input parameters that the user has to configure prior to running the tool. These parameters are described and shown via the info and screenshot below.
 - i. Using the dropdown menu, select the **Draft_NHDWaterbody** dataset as the **Input Features**.
 - ii. For the **Output Feature Class** parameter, navigate to the geodatabase containing the exercise data and name the output as **"Draft_NHDWaterbody_simplified"**. The tool will create a new dataset, and this parameter describes where that data will be stored and what it will be named.
 - iii. Choose the **POINT_REMOVE** option from the dropdown list within the **Simplification Algorithm** parameter. The POINT_REMOVE algorithm retains critical points that preserve the essential shape of a line and removes all other points.
 - iv. Within the **Simplification Tolerance** parameter, type **"0.5"**, and ensure that the unit of measure is set to **Meters**. When using the POINT_REMOVE algorithm within the tool, the Simplification Tolerance defines the maximum allowable perpendicular distance between each vertex and the new line created.
 - v. Ensure that the **"Keep collapsed points"** box is unchecked, or the tool will create an additional output that contains any endpoints of resulting lines that are smaller than the spatial tolerance. This exercise is unconcerned with any features meeting that criteria since they would either be processing artefacts or something that can be addressed more readily in a later exercise.



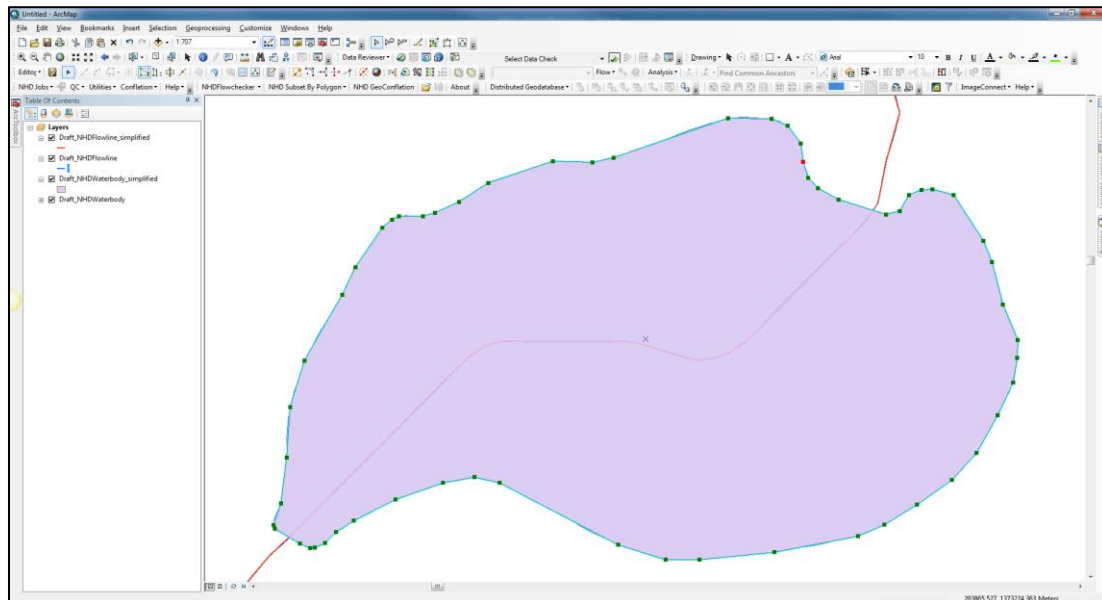
3. The **Minimum Area** and **Input Barrier** Layers parameters can be ignored for this exercise. Once the tool has been populated per the instructions and screenshot above, the user may click **OK** to run the tool. When complete, the tool will add the resulting **Draft_NHDWaterbody_simplified** dataset to the TOC.
4. Right click on the **Draft_Waterbody_simplified** dataset in the TOC and select Properties.
5. In the Layer Properties dialog box, select the **Symbology** tab and change the default from Categories to **Features-Single Symbol**. Choose a polygon fill color that contrasts with the blue color used by the Draft_NHDWaterbody dataset and click OK.

Part 3: Comparing complex inputs to simplified outputs

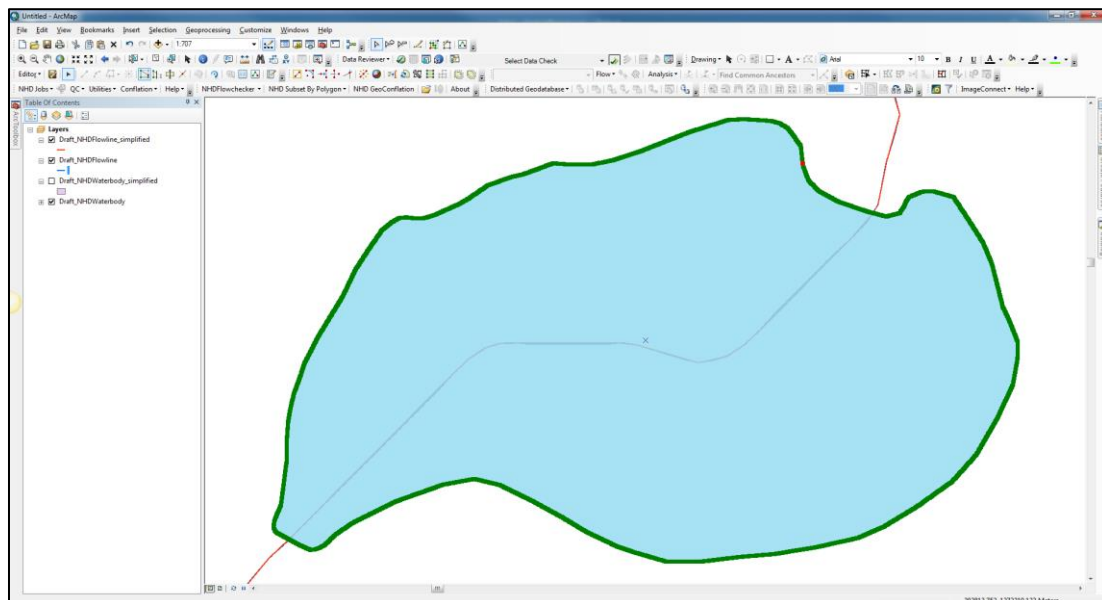
Having now simplified the complex polyline and polygon datasets, it's useful to contrast the underlying geometry of the output feature classes with the originals to understand what this process achieved.

A. Assess outputs

1. In the TOC, make sure all 4 layers are turned on/visible in the map and then right click on any of the layers (since they should all be collocated within the same file geodatabase), **select Edit Features**, and **Start Editing**.
2. Select any of the **output** features (i.e., simplified flowlines or waterbodies) within the map, then zoom in to a fairly large scale (e.g., >1:1000) while keeping a portion of that feature visible in the map and double click the feature to display its underlying vertices.

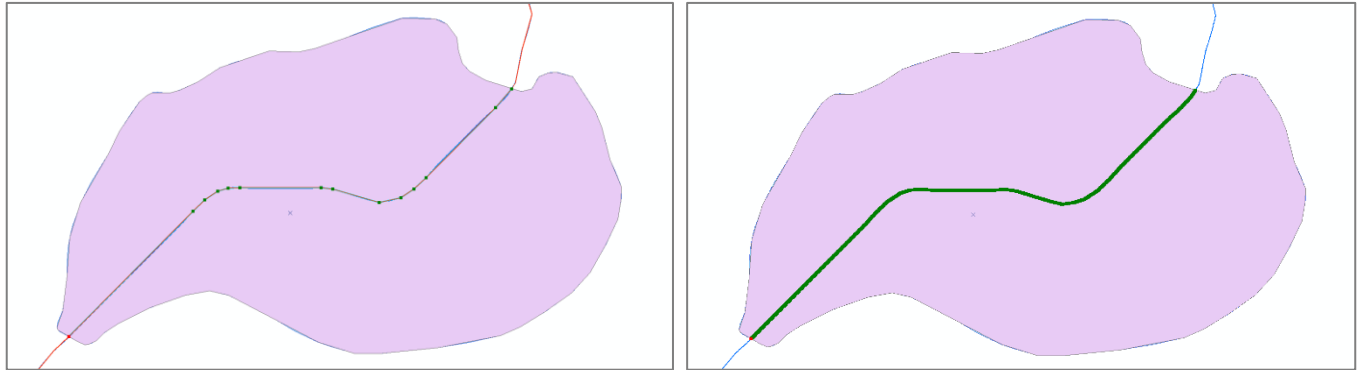


3. Notice that the vertices are appropriately spaced around the polygon (or along the flowline if you chose a linear feature) such that they maintain most of the original underlying boundary.
4. In the TOC, turn off the layer containing the feature you currently have selected and double click the underlying feature to compare the density of vertices. Note that the underlying feature contains far more vertices than is required to maintain its overall shape or position.



5. Unselect the feature and turn the output layer your first looked at back on.

6. Zoom around the map looking at this same type of contrast for the underlying vertices of both polygon and polyline features.



7. Note that while the output features largely maintain the shape of the original feature, there are minor differences present (visible particularly at larger map scales). The magnitude of these differences is directly related to the Simplification Tolerance used during the Simplify Line and Simplify Polygon tools. According to how acceptable these minor shape variations are to user requirements, users are encouraged to find a Simplification Tolerance that both achieves the goal of reducing feature complexity and preservation of derived feature shape.
8. Once finished comparing output features against the originals, stop editing (i.e., click Editor and then Stop Editing) and do not save any changes.

Congratulations! You have successfully completed this exercise and have been introduced to methods that can quickly address the condition where features that were automatically generated from IfSAR and LiDAR derived surfaces contain excessive underlying geometric complexity.