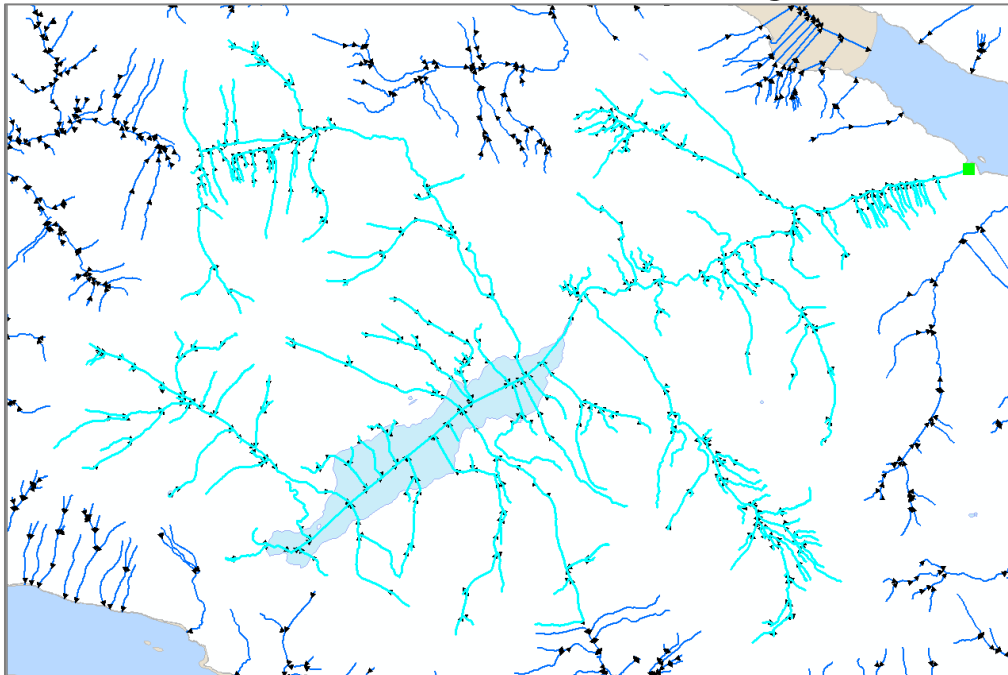


EXERCISE 6

Using a Geometric Network to assess feature connectivity



Introduction

The NHD requires, in most instances, that related stream features are connected end to end with a consistent direction of flow/travel running between features. Where gaps occur in a stream network or features have an invalid flow direction (i.e. flowing uphill/upstream), features that share NHD attributes, such as ReachCode or GNIS values, will get flagged as errors during the GeoConflation and NHD Update workflows. To avoid issues during these workflows, it is useful to revise gaps or invalid flow directions within the network prior to initiating those workflows where possible. The application of a Geometric Network gives editors and/or data stewards a framework for finding errant gaps and invalid flow directions within a stream dataset. This exercise will demonstrate how geometric networks are created, the conditions required for creating geometric networks, and the primary toolset used to interact with a geometric network on stream data.

Objectives

- Learn how to build a geometric network that operates on a stream dataset.
- Learn how to identify disconnected stream features in the dataset.
- Learn how to change the directionality of stream feature.
- Learn how to update a geometric network after modifying stream features within the network.

Required Data

- **USFS_Streams_Subset.gdb** – file geodatabase that contains a number of features created in the previous exercise, as well as the primary featureclass which will be modified over the course of this exercise. The featureclasses contained within the geodatabase include the following:
 - **Streams_Subset** – featureclass depicting stream features that were compiled by USFS staff on the Plumas National Forest for use in updating the NHD.
 - **HU10_AOI** – featureclass that contains a bounding polygon from the Watershed Boundary Dataset (WBD) and serves as the bounding extent for the area of interest for this exercise. Dataset was created during Exercise 2 of this series.
 - **NHDArea_Subset** – this featureclass contains a subset of polygons representing areal hydrographic landmark features that were extracted from the NHD. Any feature in this dataset intersects the HU10_AOI dataset and was created during Exercise 2 of this series.
 - **NHDFlowline_Subset** – this featureclass contains a subset of polylines representing 1D routes that make up a linear surface water drainage network and were extracted from the NHD. Any feature in this dataset intersects the HU10_AOI dataset and was created during Exercise 2 of this series.
 - **NHDPoint_Subset** – this featureclass contains a subset of points representing NHD hydrographic landmark features that were extracted from the NHD. Any feature in this dataset intersects the HU10_AOI dataset and was created during Exercise 2 of this series.
 - **NHDWaterbody_Subset** – this featureclass contains a subset of polygons representing areal NHD hydrographic waterbody features that were extracted from the NHD. Any feature in this dataset intersects the HU10_AOI dataset and was created during Exercise 2 of this series.
 - **NHDArea_Waterbody_Combined** – featureclass containing the combined content of the NHDArea_Subset and NHDWaterbody_Subset layers described above.
 - **Intersection_Points** – this featureclass contains point features depicting the location of intersections between the Streams_Subset, NHDArea_Subset, and NHDWaterbody_Subset layers described above.
 - **Streams_Subset_Split** – the features within this dataset are a subset of data that were compiled by USFS staff on the Plumas National Forest for use in updating the NHD and have been modified to accommodate boundary intersections with existing NHD polygons (see Exercise 3 in this series).
 - **Streams_Subset_Split_Dissolved** – primary featureclass for this exercise. The features within this dataset are a subset of data that were compiled by USFS staff on the Plumas



National Forest for use in updating the NHD. The features have been modified to accommodate boundary intersections with existing NHD polygons, as well as modified to remove unnecessary line breaks (see Exercise 5 in this series).

Note: *not all of the datasets listed above will be used within this exercise, but they comprise the full list of content within the USFS_Streams_Subset geodatabase that users will encounter. Some of these datasets were used in previous exercises, some will be used in this exercise, and others will be used in later exercises.*

Prerequisites

- ESRI ArcGIS Desktop v10.5.1 (or newer) will be 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.
- User has administrative privileges on local machine so that they may install the required Visual Basic utility for geometric networks.





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Part 1: Feature Datasets

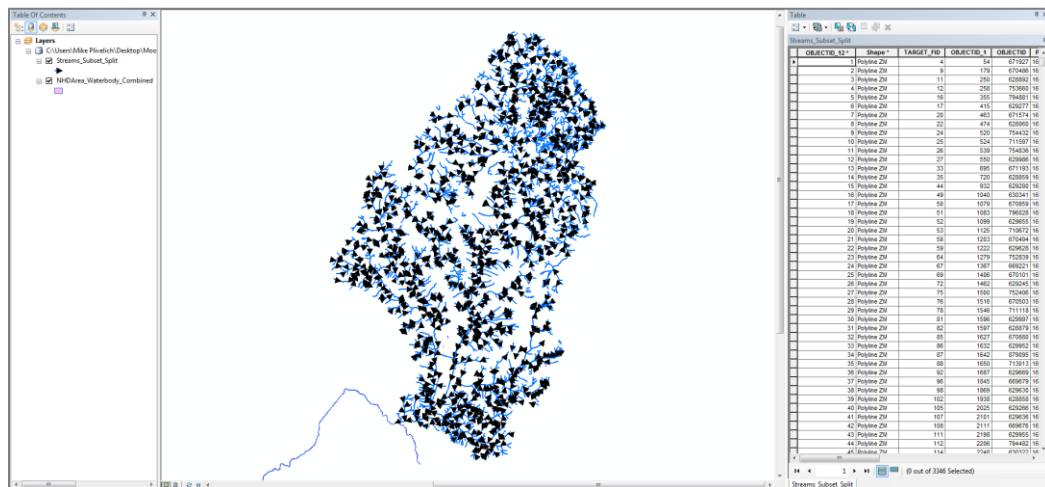
While the main focus of this exercise is interacting with linear features in a geometric network, because Geometric Networks can only be created within a Feature Dataset in a geodatabase (they cannot be created at the root directory within a geodatabase), users must first create a feature dataset and then load the linear stream features into the resulting feature dataset. In this section of the exercise, users will learn how to create a new feature dataset that will later contain both a geometric network and the framework data for the geometric network.

A. Creating a new Feature Dataset

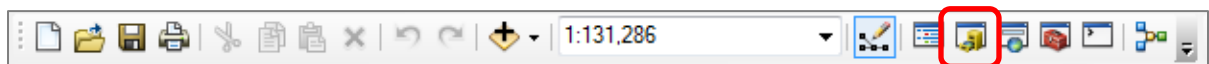
1. Either open the ArcMap document saved at the end of exercise 5 **OR** navigate to the directory containing the content for exercise 6 and double file titled “Streams_4_NHD_Update.mxd” to open the required ArcMap document.

Note: the stream symbology used in this map demonstrates **line breaks** and **flow direction**. The black arrows including in the stream symbology denote the endpoint of the line feature, as well as the current flow direction. The symbology used for the **Streams_Subset_Split_Dissolved** features in this exercise have been saved for reference in the Exercise 6 directory and are titled “FlowDirection.lyr”.

2. Once open, the map document should look like the screenshot below.



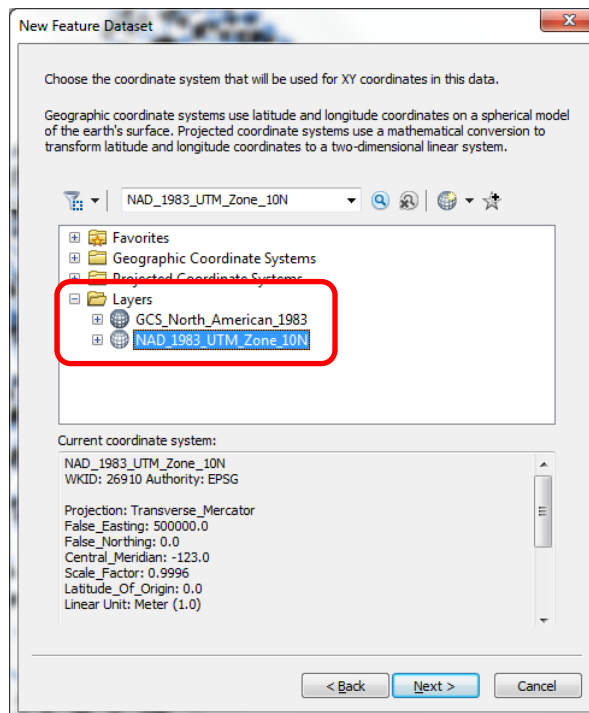
3. Once the file is open in ArcMap, click on the **ArcCatalog** icon located on the **Standard** toolbar.



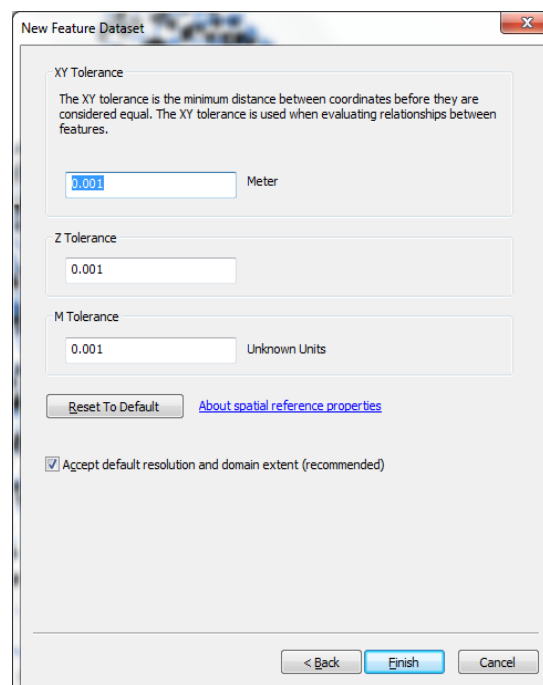
4. Within the resulting ArcCatalog window, navigate to the geodatabase for Exercise 6, right click on the geodatabase, select **New**, and then **Feature Dataset**. When the New Feature Dataset window opens, name it “**Networked_Streams**” as shown below, then click **Next**.



- On the next screen of the New Feature Dataset wizard, expand the folder titled **Layers** and select “**NAD_1983_UTM_Zone_10N**” as shown below, then click **Next**.



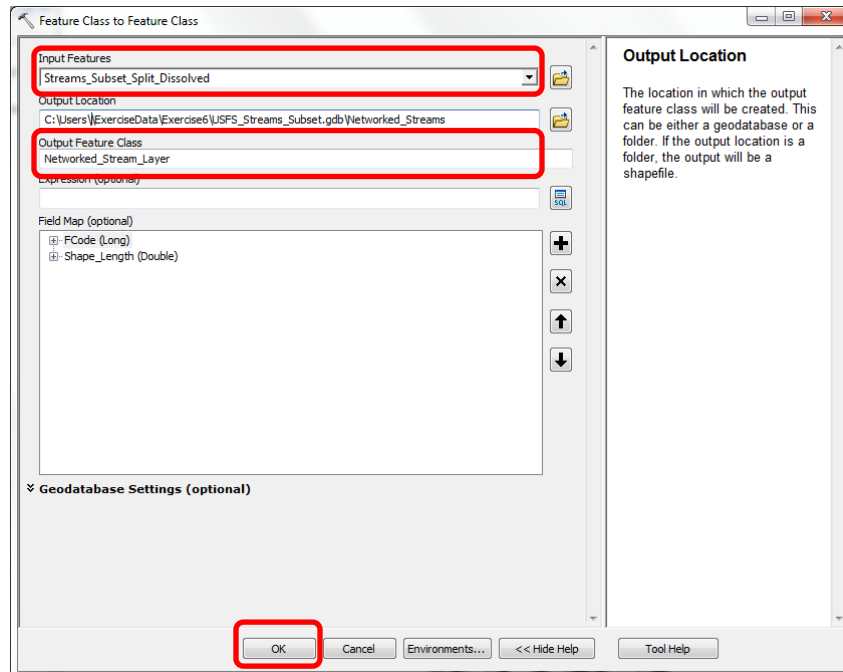
- Leave the Z coordinate information blank on the next screen of the New Feature Dataset wizard and click **Next**.
- Leave the default XY, Z and M Tolerance settings on the next screen of the New Feature Dataset wizard and click **Finish**.



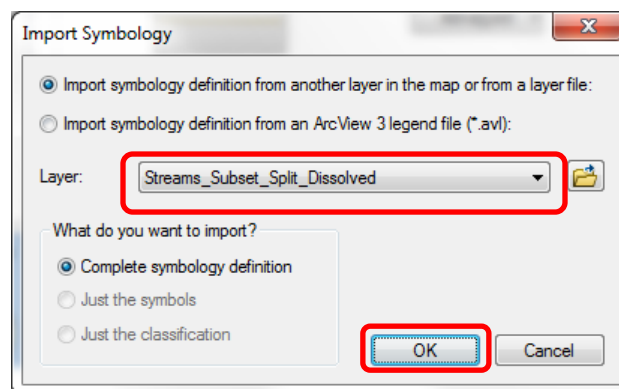
8. Upon clicking Finish, the new feature dataset will be added to the geodatabase.

B. Importing data into a Feature Dataset

1. In the ArcCatalog window, right click on the resulting Networked_Streams feature dataset, select **Import** and click **Feature Class (single)**.
2. When the **Feature Class to Feature Class** window opens, choose **Streams_Subset_Split_Dissolved** from the drop down window as the Input. Then name the Output Feature Class as "**Networked_Stream_Layer**" as shown below and click **OK**.



3. The new Networked_Stream_Layer featureclass will automatically be added to the TOC within the map document.
4. In the ArcMap TOC, right click on **Networked_Stream_Layer** and select **Properties**. On the **Symbology** tab in the Layer Properties window, click the **Import** button. When the Import Symbology window opens, select **Streams_Subset_Split_Dissolved** from the dropdown list as shown below and click **OK**.



5. Next, click **OK** on the **Layer Properties** window.

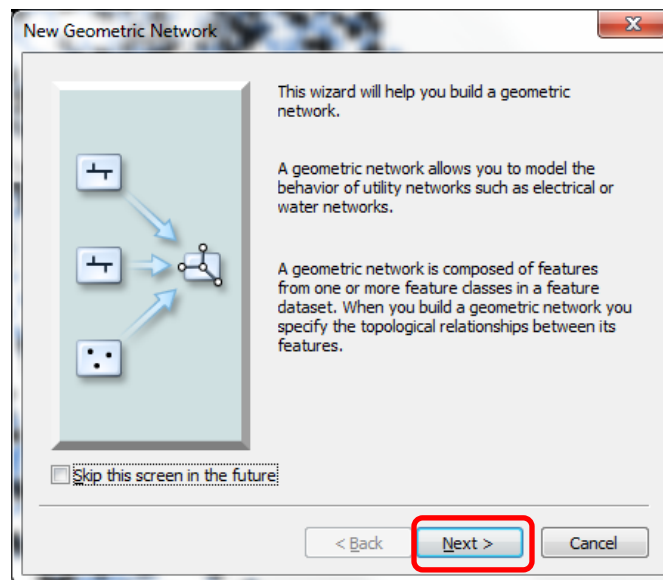
6. The new **Networked_Stream_Layer** (which currently is just a copy of the **Streams_Subset_Split_Dissolved** layer) now has the same symbology as the **Streams_Subset_Split_Dissolved** layer. Its not already turned on In the TOC, turn on the **Networked_Stream_Layer** so its visible in the map document.
7. Then, right click the **Streams_Subset_Split_Dissolved** layer in the TOC and click **Remove**. From this point forward, users will be using and editing the new **Networked_Stream_Layer** featureclass.

Part 2: Using a Geometric Network

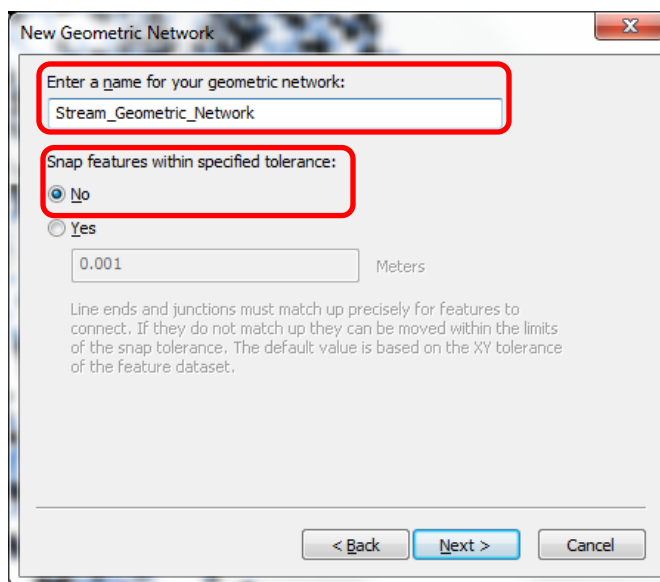
Stream data that are compiled independent of NHD formatting requirements regularly have gaps occurring between related surface features that are seasonally or itermitently connected, as well as having features with invalid flow directon. In order to identify those gaps in feautre connectivity or features with invalid flow direcion, users can employ a geometric network to analyze how features are connected relative to stream flow. In this section of the exercise, users will build a new Geometric Network that works on the linear stream data.

A. Creating a new Geometric Network

1. In the ArcCatalog window within ArcMap, right click on the **Networked_Streams** feature dataset created in the first part of the exercise, select **New** and click on **Geometric Network**. The Geometric Network wiziard window will open as shown below.



2. The initial screen provides some overview informationt aboutt geometric networks. Click **Next**. On the following screen, name the Geometric Network as **"Stream_Geometric_Network"** and leave the Snap Features parameter set to **No** as shown below, then click **Next**.



New Geometric Network

Enter a name for your geometric network:
Stream_Geometric_Network

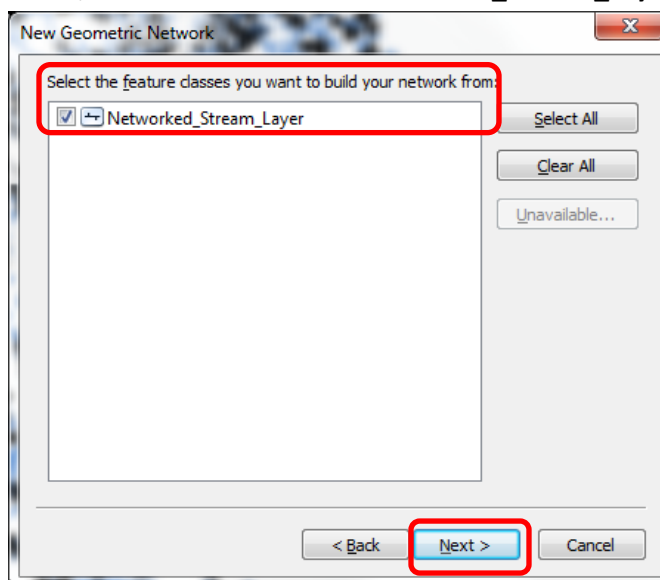
Snap features within specified tolerance:
☒ No
☐ Yes

0.001 Meters

Line ends and junctions must match up precisely for features to connect. If they do not match up they can be moved within the limits of the snap tolerance. The default value is based on the XY tolerance of the feature dataset.

< Back Next > Cancel

3. On the following screen, leave the selection as **Networked_Stream_Layer** and click **Next**.



New Geometric Network

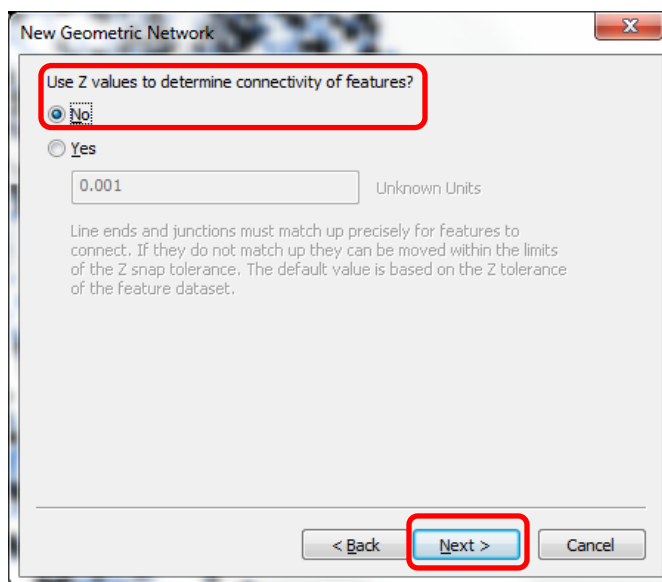
Select the feature classes you want to build your network from:

☒ Networked_Stream_Layer

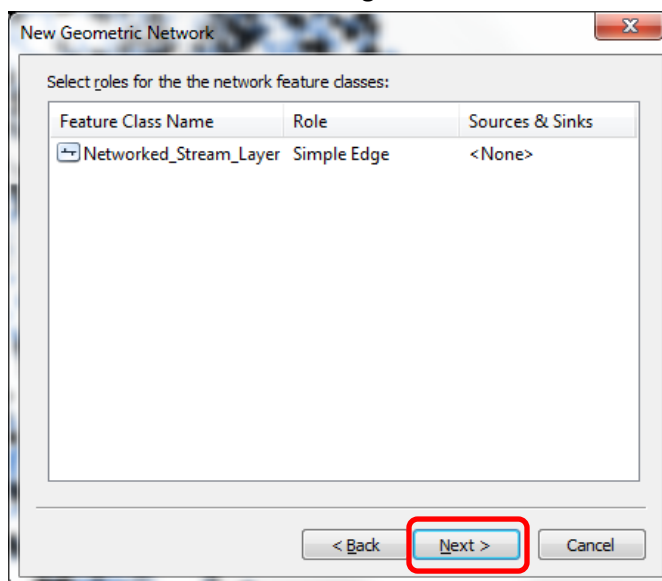
Select All
Clear All
Unavailable...

< Back Next > Cancel

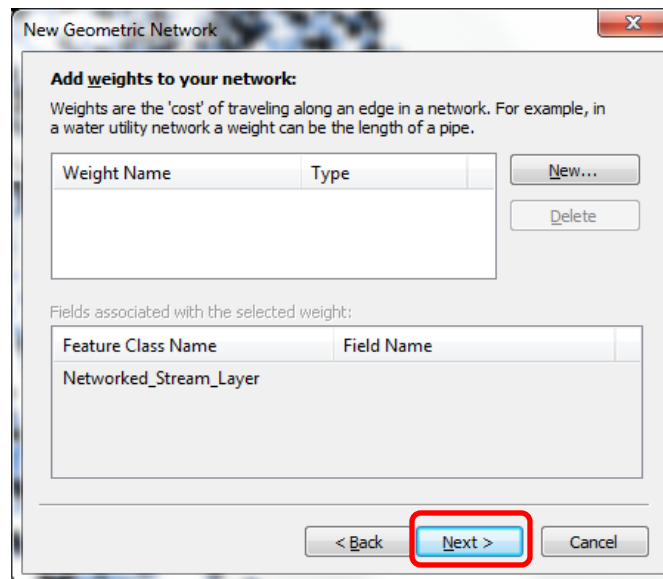
4. On the following screen of the wizard, change the **Use Z values** parameter from Yes to **No** and click **Next**.



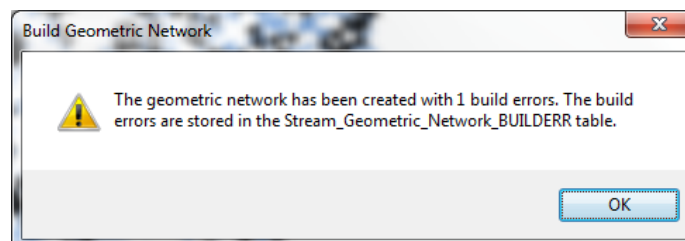
5. On the following screen leave the default setting and click **Next**.



6. Again, on the following screen leave the default setting and click **Next**.



7. The final screen of the wizard provides a summary review the chosen settings for the geometric network. Click **Finish**.
8. Upon clicking Finish, the software creates the geometric network within the Networked_Streams feature dataset and then provides the user with a warning message about any Build Errors encountered during the process. A screenshot of the expected warning is shown below. For this exercise, users can ignore this warning message and click **OK**.



Note: it's a common occurrence for errors to be encountered during the creation of geometric networks. These errors often relate to invalid or empty geometries. However, because the data will be systematically reviewed for networked compliance and modified as necessary, users can ignore these error messages for the most part. It's up to the user if they wish to seek out specific errors noted by the warning messages and address them prior to looking for them within the network.

9. Upon clicking OK, two layers are automatically added to the map document in the TOC. The first of which is a duplicate of the **Networked_Stream_Layer** – this duplicate is not actually a separate or new featureclass, but rather a copy (i.e. a duplicate record within the TOC) of the one already occurring within the map. Users can right click the duplicate (i.e. the one not having the custom symbology that demonstrates flow direction) and **Remove** it from the TOC.
10. The second featureclass, titled "**Stream_Geometric_Network_Junctions**", is an entirely new featureclass that was created during Build Geometric Network process and resides within the Networked_Streams feature dataset along with the new Geometric Network and the Networked_Stream_Layer featureclass. This point featureclass must be present within the

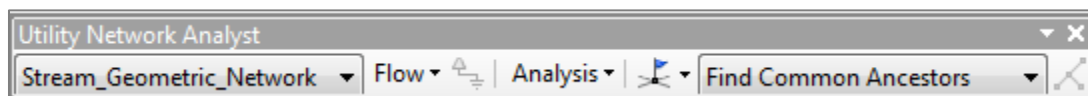
map anytime the Networked_Stream_Layer featureclass is to be edited or analyzed within the Geometric Network.

Note: *geometric network junctions are features that allow two or more edges to connect and facilitates the transfer of flow and resources between edges. Junctions are created as point feature classes in a feature dataset. These features are created anytime a geometric network is deployed.*

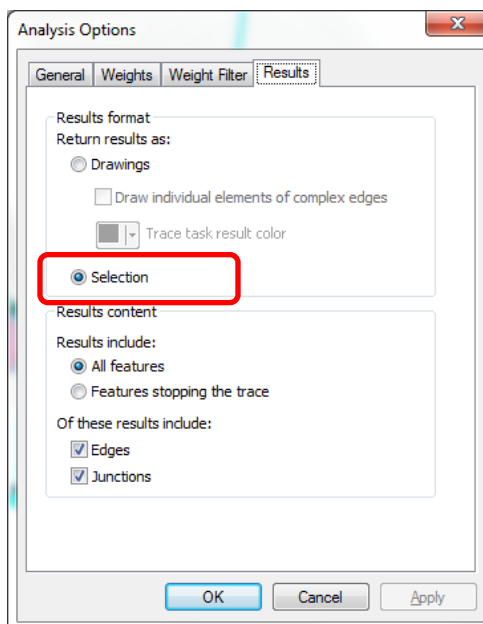
11. Users do not need to alter the symbology of the **Stream_Geometric_Network_Junctions** layer – the default symbology is fine for this exercise. Users can turn on the layer in the TOC to get a sense of where these features are occurring, but aside from that there is no functional reason to have the features turned on in the map.
12. Users may close the ArcCatalog window within ArcMap at this time, but leave ArcMap itself open.

B. Setting up the Utility Network Analyst toolbar

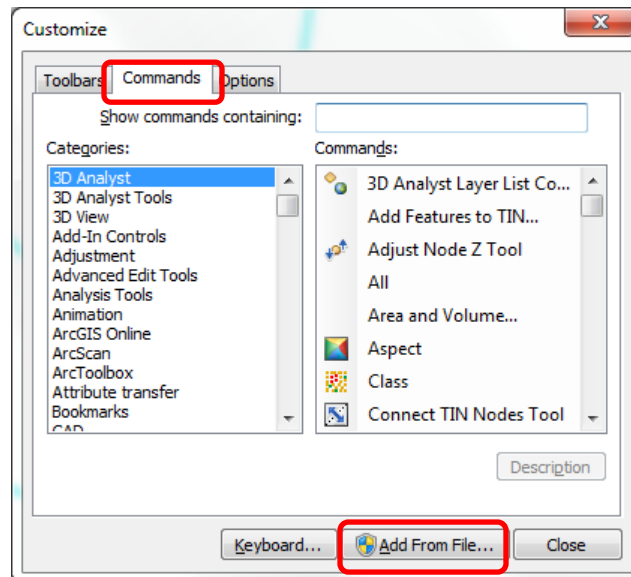
1. From the Customize tab within ArcMap, select Toolbars and turn on the **Utility Network Analyst** toolbar. Note that users may have to scroll down the list of available toolbars before the Utility Network Analyst toolbar is visible. Once turned on, the toolbar should look as per below.



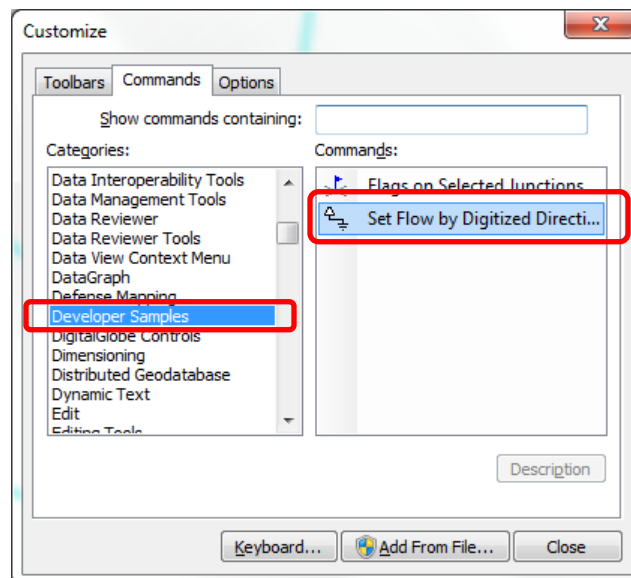
2. Note that the toolbar automatically recognizes layers within the map that participate within a geometric network and that the name of the geometric network we created is automatically populated in the toolbar.
3. Click the **Analysis** menu on the toolbar and select **Options**. When the **Analysis Options** window opens, click on the **Results** tab and change the “Return results as” parameter from Drawings to **Selection** as shown below. Click **OK**.



- Next, users will load a customized tool for geometric networks onto the Utility Network Analyst toolbar. From the Customize tab within ArcMap, select **Customize Mode**. When the Customize Window opens, select the **Commands** tab and then click **Add From File** as shown below.

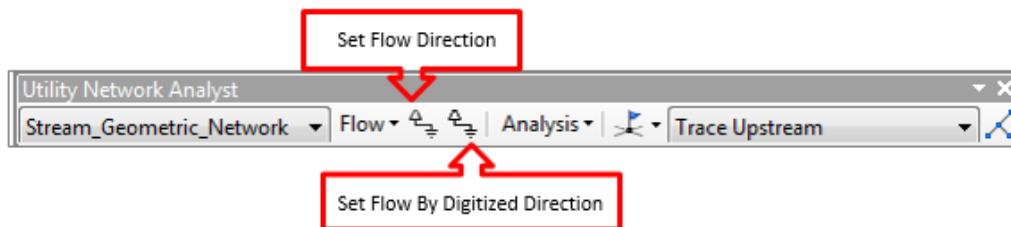


- In the **Open** window, navigate to the Exercise6 directory on your local machine and open the folder titled **Set_Flow_by_Digitized_Direction**. Then open the sub-directory titled **Visual_Basic** and select the file titled **MyFlowDirectionSolver.dll**.
- Upon clicking Open, a popup appears letting you know that the tool was added to the list of available commands. Click **OK** to close the popup.
- The tool will then appear as an available Command that can be added from under the Developer Samples category as shown below.

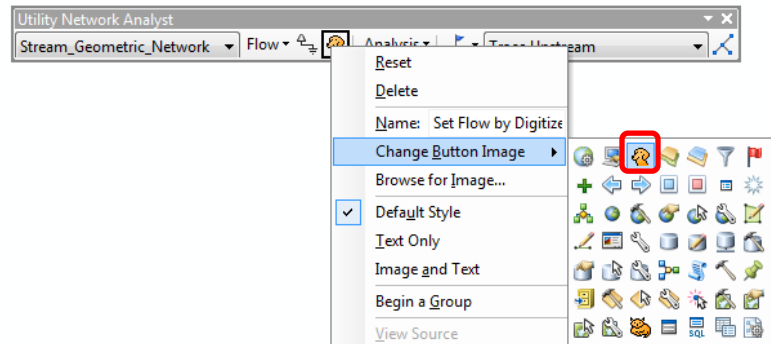


Note: The Set Flow by Digitized Direction tool sets the flow direction for each edge feature in the network along the direction in which the feature was digitized. The task can be achieved with a combination of standard tools in ArcMap, but the Set Flow by Digitized Direction tool allows for increased efficiency in resetting flow direction within a Geometric Network.

- Left click on the Set Flow by Digitized Direction tool in the Customize window and drag it onto the Network Utility Analyst toolbar. Notice that the default symbol for the newly added tool is identical to the symbol for the Set Flow Direction tool which is automatically loaded onto the toolbar.



- In order to avoid potential confusion due to the two tools each having similar icons, it is useful to give the Set Flow by Digitized Direction tool a custom icon on the toolbar. If closed, reopen the Customize window, then right click on the Set Flow by Digitized Direction tool icon on the Utility Network Analyst toolbar, select Change Button Image and select a new unique icon for the **Set Flow by Digitized Direction** tool. For the purposes of this exercise, it is suggested that users select the dog icon which is unmistakable when compared to any other icon in ArcMap.

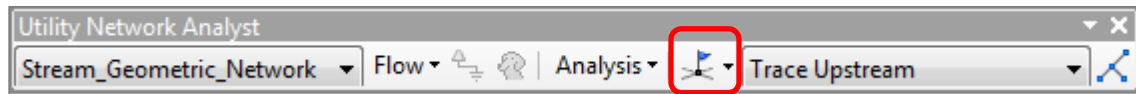


- Once the **Set Flow by Digitized Direction** tool has been assigned a custom icon, users can close the Customize dialog, and dock the Utility Network Analyst toolbar in a location of their choosing within ArcMap. The toolbar is not ready for use.

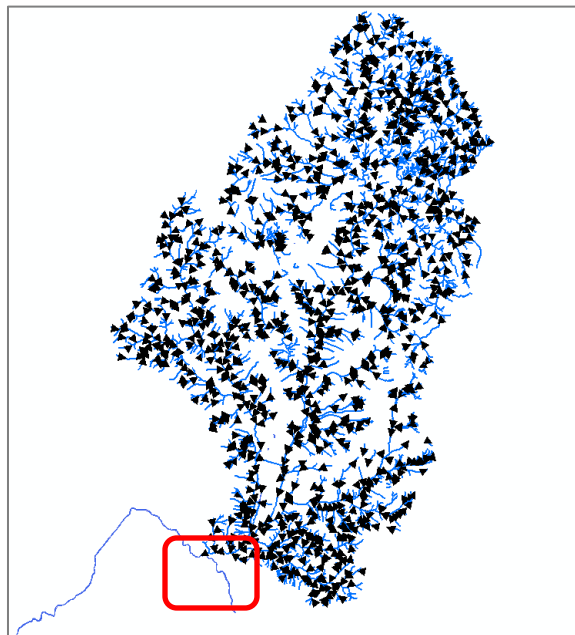
C. Interacting with features in a Geometric Network

- If the entire extent of the stream features is not already visible in the map document, right click on the **Networked_Stream_Layer** in the TOC and select **Zoom to Layer**. Again, on the **Networked_Stream_Layer** in the TOC and this time select **Edit Features** and **Start Editing**.
- Notice that once an edit session is begun on the stream features, the icon for the **Set Flow by Digitized Direction** tool becomes highlighted on the **Utility Network Analyst** toolbar. Anytime this icon is highlighted/available to click, it is indicating to the user that there is an unset flow direction somewhere within the Geometric Network. Click the icon and it will become grayed out once it completes resolving flow directions.

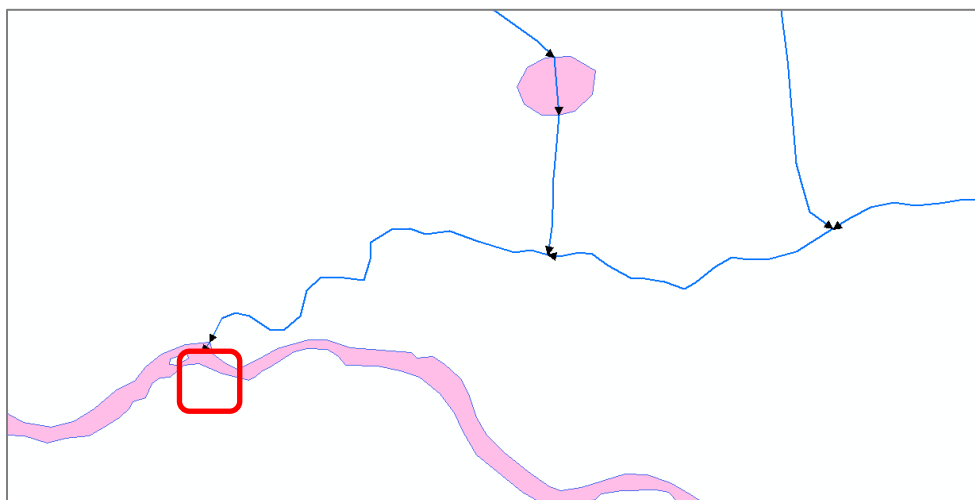
- Next, click the **Add Junction Flag Tool** also on the **Utility Network Analyst** toolbar.



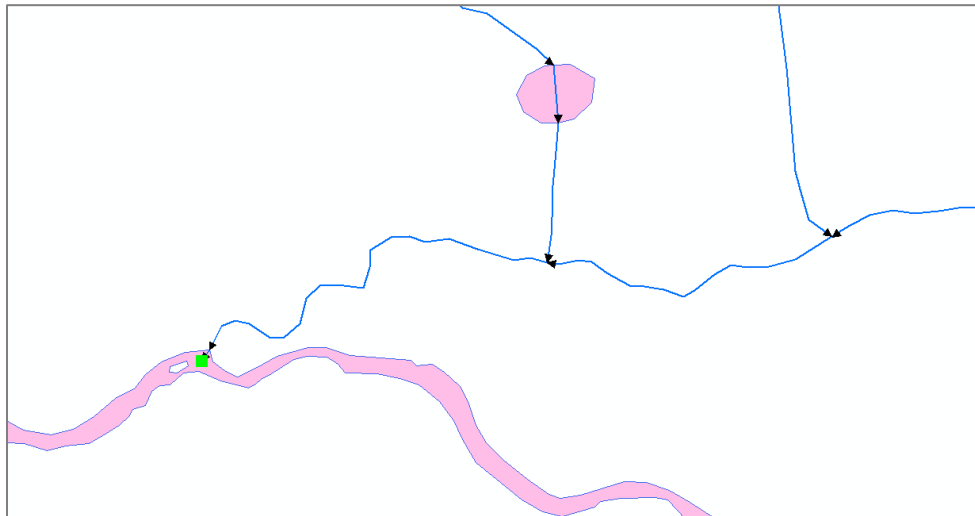
- Near the bottom of the map document, zoom into the area where the stream data intersects the long polygon as shown below.



- As shown below, position the cursor at the downstream end of the stream feature which ends in the middle of the long polygon – i.e. the stream feature furthest downstream of any in the **Networked_Stream_Layer** dataset. Click once at the end of the line to place a network flag (shown as a solid green box).

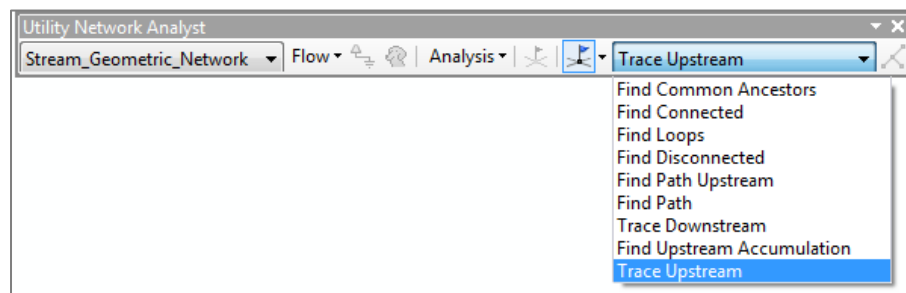


- The network flag will serve as a starting point for network operations such as tracing upstream or downstream. Once the flag is placed in the correct location the map should look as per below.

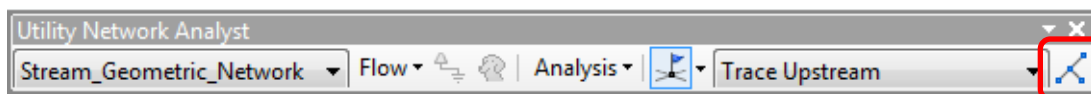


Note: in the event that a flag is placed in the wrong location (for example, next to but not contacting the end point), errant flags can be removed by clicking Analysis and Clear Flags from the Utility Network Analyst toolbar.

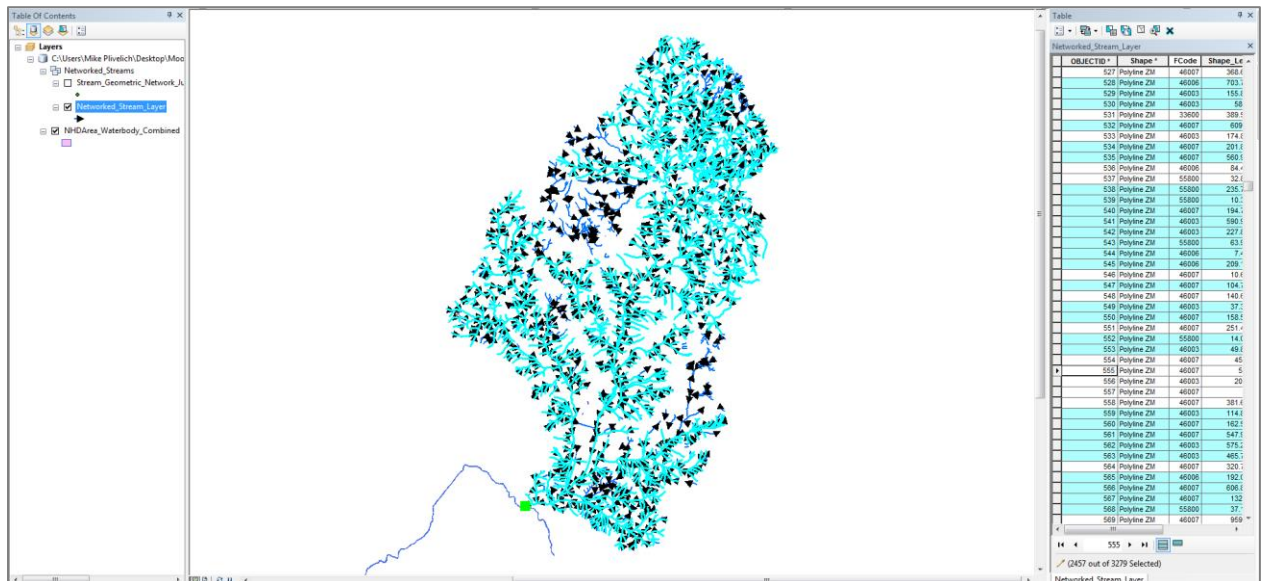
- With the flag placed as shown above, click the dropdown **Trace Task** menu on the Utility Network Analyst toolbar and select **Trace Upstream**.



- Next, with the flag placed and Trace Upstream set, click the Solve button as shown below.



- Clicking the Solve button initiates the trace task. This task will select any stream feature upstream of the flag that is both correctly connected and routed within the stream network. Right click on the **Networked_Stream_Layer** featureclass in the TOC and select **Zoom to Layer**.
- Again, right click on the **Networked_Stream_Layer** featureclass in the TOC and this time select **Open Attribute Table**. The resulting map should look as per below.



11. Each of the selected features in the map and their corresponding records in the attribute table are features that correctly participate in the geometric network. Looking at the record count at the bottom of the attribute table, we can see that 2,457 features out of 3,279 total features are currently selected – i.e. 2,457 features out of 3,279 total features are connected and routed within the stream network. Our goal in the next exercise will be to address those features which are currently unselected/not participating in the geometric network. For now, we have a means by which to assess the stream data and locate features that should be addressed.
12. On the Editor toolbar, click **Editor** and **Save Edits**. Then click **Editor** and **Stop Editing**. Then click the **File** tab at the top of ArcMap and select **Save**. Finally, close ArcMap.

Congratulations! You have successfully completed this exercise and have been introduced to a geometric network, the database conditions required and some basic tools for interrogating data within a geometric network.