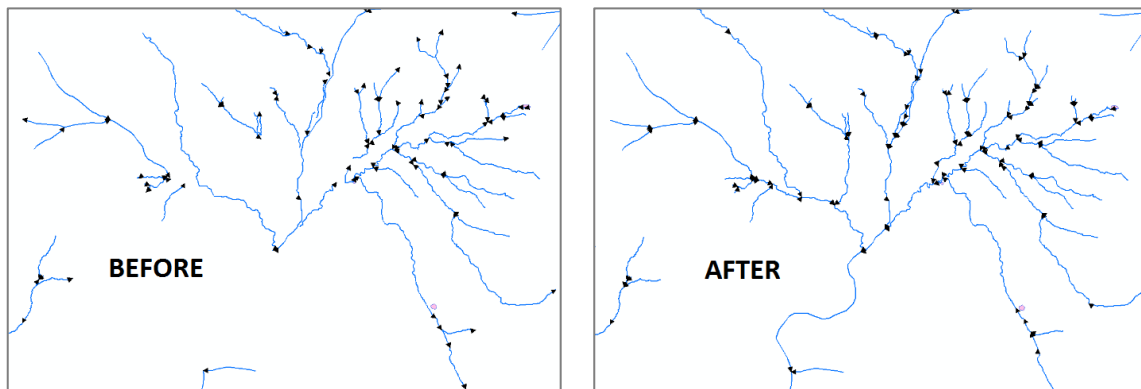


EXERCISE 7

Editing data within a Geometric Network



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 or 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. Although not all stream connections occur or are visible on the surface of the landscape, it is still imperative that users make approximate connections between disconnected features so that the NHD suite of toolsets can recognize related features and administer any required attribution within the NHD data model. This exercise will demonstrate how to trace stream features within a geometric network to find disconnected features and invalid flow directions, which will be addressed with a typical editing workflow.

Objectives

- 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).
 - **Networked_Stream_Layer** – primary featureclass for this exercise. The features in this dataset are a copy of the features within the Streams_Subset_Split_Dissolved featureclass, however, the features within this layer participate in a geometric network.
 - **Stream_Geometric_Network_Junctions** – this featureclass is the spatial representation of all transaction points within the geometric network on the Networked Stream Layer



featureclass. Geometric network junctions are features that allow two or more edges to connect and facilitates the transfer of flow and resources between edges.

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.
- Users will require the **Esri Production Mapping extension v10.5.1 for ArcGIS Desktop** to be installed on their computer for this exercise. For installation instructions, follow this link to the FS Release Library: <https://bit.ly/2m73v9q>.
- User has a basic level of experience with the ArcMap interface.
- User has experience doing basic editing tasks within ArcMap – i.e. creating new features, modifying existing features, and saving edits.





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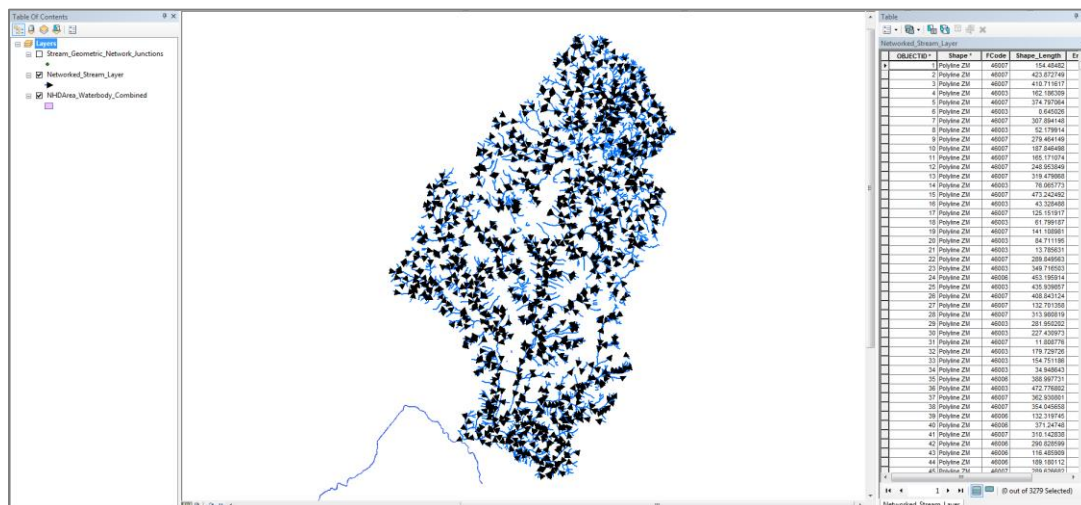


Part 1: Editing Network Gaps

There are two primary types of errors that occur within Geometric Networks – gapped features and features having an incorrect flow direction. In this section of the exercise, users will learn how to interrogate the stream dataset for errant gaps, as well as how to create and modify features to bridge those network gaps.

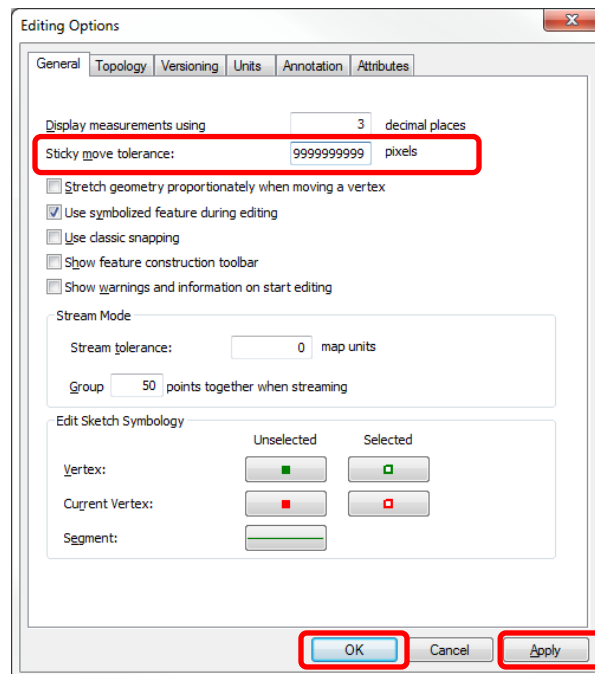
A. Setting up the Edit Environment

1. Either open the ArcMap document saved at the end of exercise 6 **OR** navigate to the directory containing the content for exercise 7 and double file titled “**Streams_4_NHD_Update.mxd**” to open the required ArcMap document. Once open, the map document should look like the screenshot below.
 - i. Make sure the Stream_Geometric_Network_Junctions layer is turned off in the TOC during this exercise to prevent the map from getting cluttered with selected features during the may selection processes later in this exercise. The layer must be present within the map for this exercise, but users don’t need to visualize the features in this layer in order to complete the exercise.

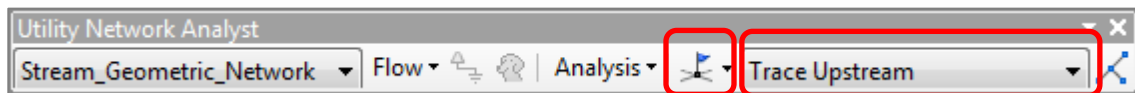


2. Once the file is open in ArcMap, click the **Editor** button on the **Editor** toolbar and select **Options**. Within the Editing Options window, click on the **General** tab. Set the **Sticky Move Tolerance** to **999999999** (i.e. the number 9 keyed nine times), click **Apply** and then click **OK**.

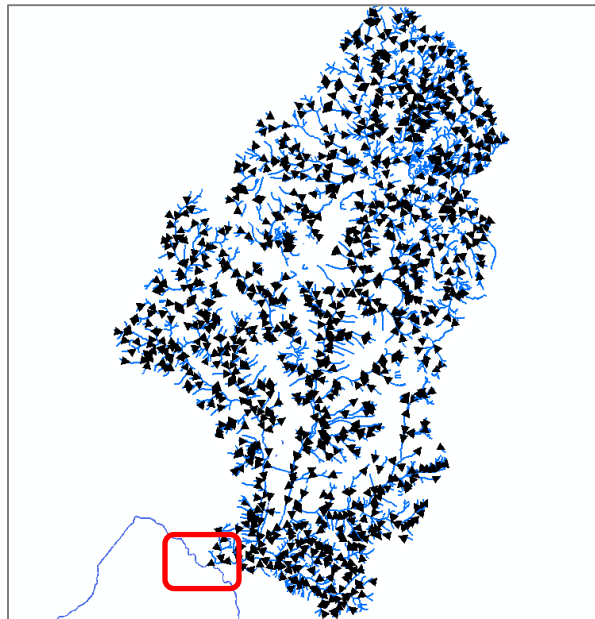
Note: the Sticky Move Tolerance in ArcMap sets a minimum number of pixels the cursor must move on the screen before a selected feature is actually moved during an edit session. The effect of setting the sticky move tolerance is to delay moving selected features until the pointer has moved at least that distance. By setting the the tolerance to 999999999, is a shortcut for setting the maximum tolerance allowed and effectively eliminating any chance of a selected feature being moved inadvertently during an edit session.



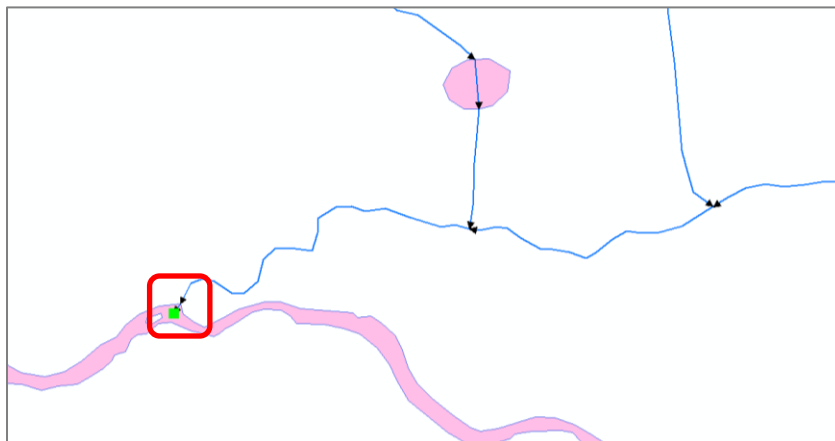
3. Right click on the **Networked_Stream_Layer** featureclass in the TOC, select **Edit Features** and **Start Editing**.
4. Click the **Analysis** menu on the Utility Network Analyst toolbar and select **Options**. When the **Analysis Options** window opens, click on the **Results** tab and make sure the “**Return results as**” parameter is set to **Selection**. Click **OK**.
5. Next, make sure that **Trace Upstream** is the selected trace task on the Utility Network Analyst toolbar. Then click the **Add Junction Flag Tool** also on the **Utility Network Analyst** toolbar.



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

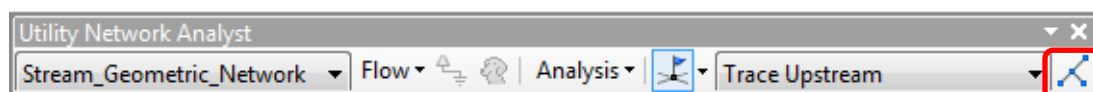


- Position the cursor at the downstream end of the stream feature that ends in the middle of the long polygon – i.e. the stream feature furthest downstream of any in the **Networked_Stream_Layer** dataset. Click once at the end of the line to place a network flag (shown as a solid green box).



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 positioned as shown above, click the **Solve** button on the Utility Network Analyst Toolbar.

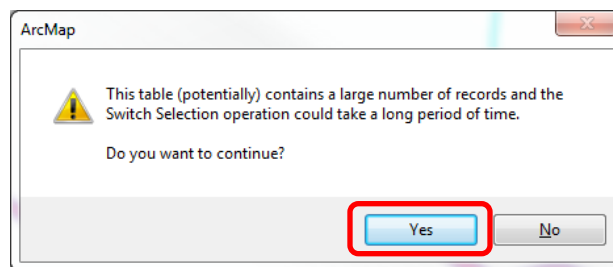


- At the top of the attribute table for the Networked_Stream_Layer featureclass, click the **Switch Selection** button as shown below.

Note: The Switch Selection function unselects every selected feature in the table and selects every record that was previously unselected. In this example, the Switch Selection operation selects every disconnected stream feature within the dataset so users can visualize where network disconnects are occurring within the dataset.

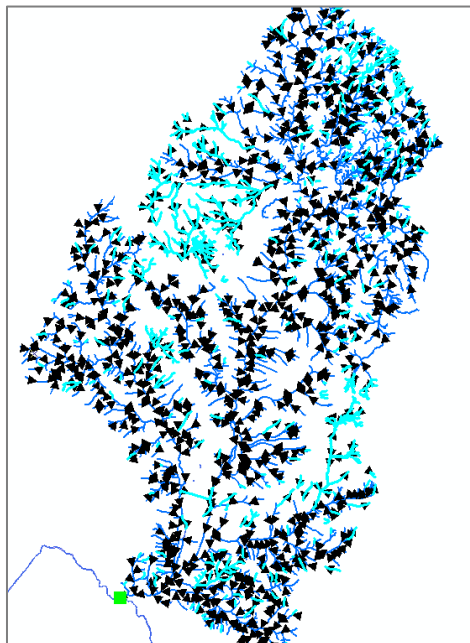
OBJECTID *	Shape *	FCode	Shape_Length	Er
1	Polyline ZM	46007	154.48482	
2	Polyline ZM	46007	423.872749	
3	Polyline ZM	46007	410.711617	

10. Upon clicking Switch Selection, ArcMap will pop-up the following warning message. Users can ignore this message and click **Yes**.



11. Next, on the top of the attribute table click the **Zoom to Selected** button.

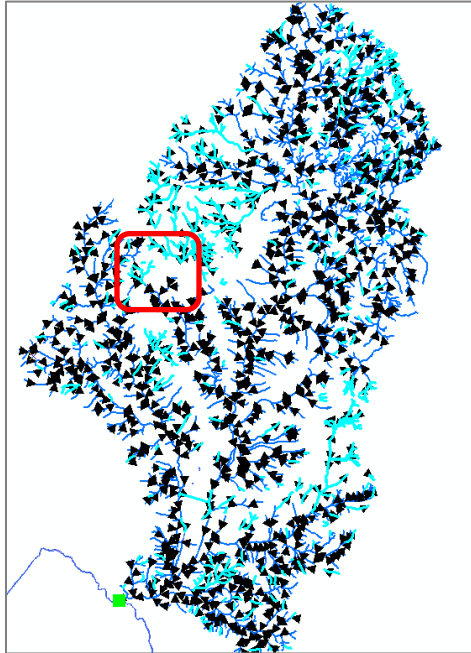
12. The map, as shown in the screenshot below, will now show each of the 822 highlighted stream features that need to be addressed in order to bring them into compliance with NHD connectivity requirements.



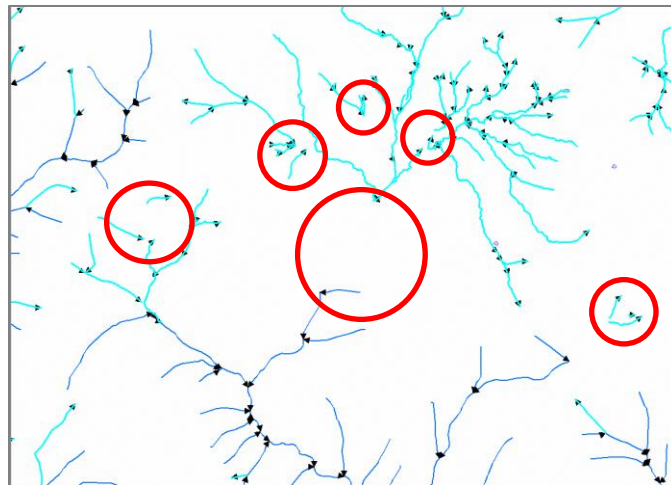
Note: So long as there is a junction flag in the map document which is placed at the lowest downstream location, the process described above can be used to select any disconnected stream features.

B. Identifying and modifying gaps in the stream network

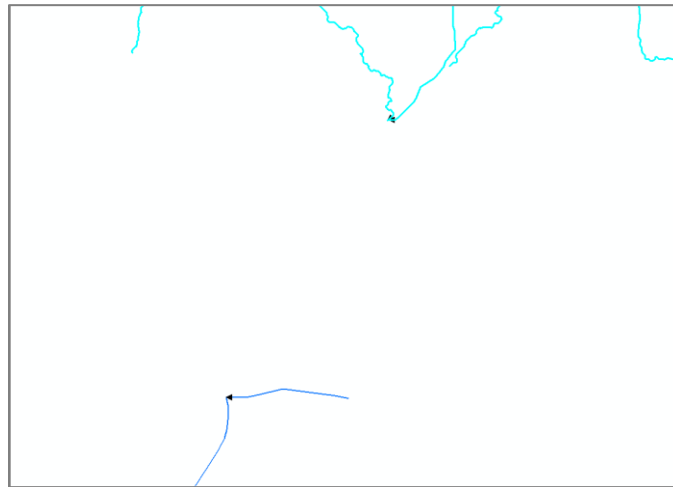
1. With all of the disconnected stream features selected in the map, zoom into the location shown below.




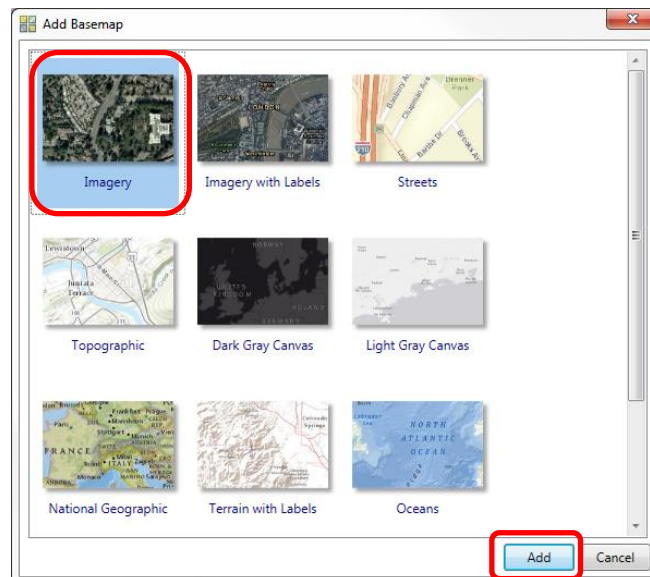
2. Notice that there are a number of features in the map view that are either disconnected or shown to be flowing in the wrong direction. Some examples of gap issues are highlighted below.



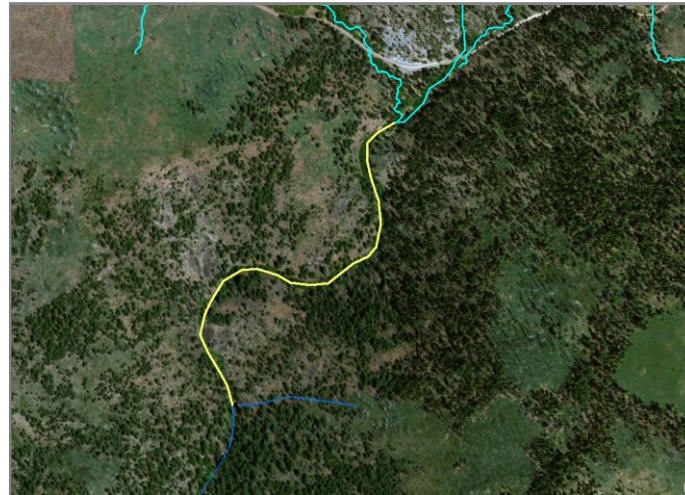
3. Using the largest circle shown above for reference, zoom into the approximate area of that circle. With the map zoomed into a map scale of 1:5,000, the result should look similar to below.



4. In order to create a feature that spans the gap between these features, we'll first need to add some reference imagery. Reference imagery can be used to determine the approximate surface location of features that should be connecting the stream features above. Click the drop down arrow next to the **Add Data** button, , on the Standard toolbar and select **Add Basemap**. When the **Add Basemap** window opens, select the Imagery thumbnail and click **Add** as shown below.

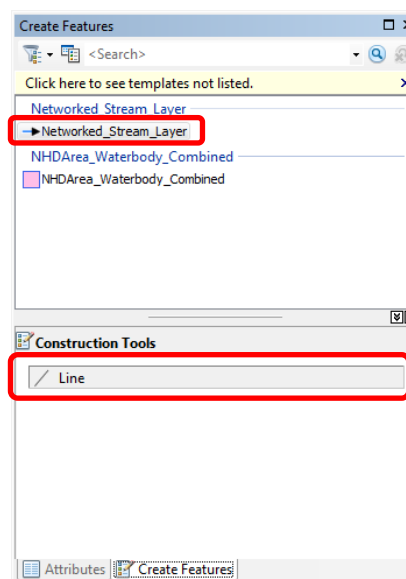


5. Upon clicking add, ArcMap may pop-up a warning message about conflicting Geographic Coordinate Systems. Users can ignore the warning message and click **Close**.
6. Once added to the map and turned on in the TOC, users can see that there is a band of low-lying, darker green vegetation winding between the set of selected features to the north and the set of unselected features to the south. That sinuous band of vegetation is characteristic of a surface watercourse and is highlighted below by the yellow line.



Note: reference imagery, topographic maps, hillshades, etc can all be used to determine the approximate location of watercourses on the surface of the landscape. While this example is focused on imagery, where possible, users should use as many sources of referecne data to determine the best location and postion of watercourses on the surface of the landscape.

7. In order to connect the two sets of features along the watercourse identified above, click the **Editor** button on the Editor toolbar, select **Editing Windows** and then click **Create Features**.
8. On the Create Features window, click on the **Networked_Stream_Layer** featureclass and then click on the **Line** symbol near the bottom of the window.



9. With the line tool selected, users will attempt to replicate the yellow line shown above and create a feature which traces the watercourse and connects the unselected set of streams to the selected set of streams. Beginning at the top of the map near the selected features and working downstream toward the unselected features, hover the cursor near the stream endpoints until the ArcMap displays an automated snap tip/text that says **"Networked_Stream_Layer: Endpoint"** and click once to start the feature. Continue moving

the cursor along the watercourse shown in the imagery clicking at various points where the line changes direction. Once you have reached the downstream end and ArcMap again displays an automated snap tip/text that says “**Networked_Stream_Layer: Endpoint**”, double click to finish the feature. The end result should look similar to below.

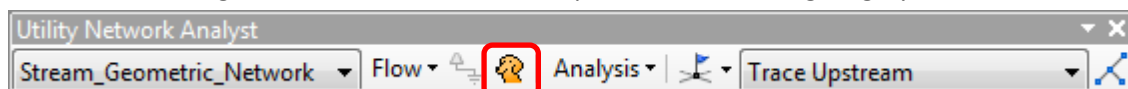


- Because we’ve created a new feature in the dataset we are also responsible for assigning it an FCode Value in the attribute table. Because editors may or may not be familiar with the NHD data schema or specific FCode values, users should assign a generic FCode value (i.e. FCode = **33400**) to the feature so that any new features can either be reclassified by an NHD Steward or local hydrologist, or they can be submitted without conflict to the NHD schema and revised at a later date. Users are advised to type **33400** as the FCode value for any new feature they create. 33400 translates as “**Connector**” in the NHD data model – Connectors indicate a measure of uncertainty around either the position or classification of a feature.

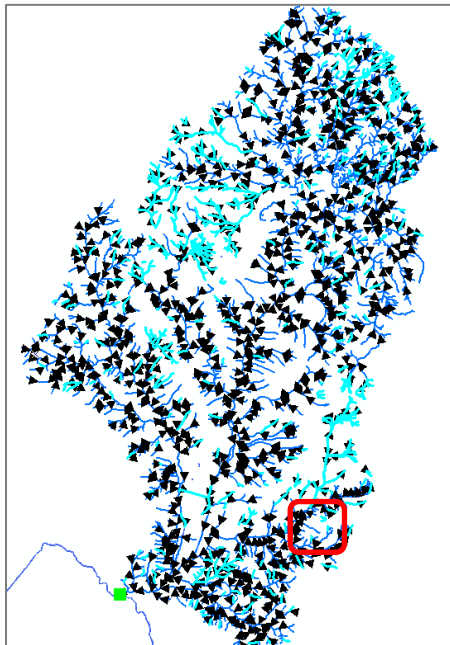
Table					
Networked_Stream_Layer					
OBJECTID *	Shape *	FCode	Shape_Length	Enabled	
3280	Polyline ZM	33400	1040.110321	True	

Note: NHD FCodes are five-digit integer values comprised of the NHD feature type and the combinations of characteristics and values. Via the NHD FCode attribute field (every geospatial feature within the NHD is assigned an FCode value), features can be categorized on the basis of their physical form and function. A full listing of the NHD FCodes is available here - <https://bit.ly/2slzeXW>

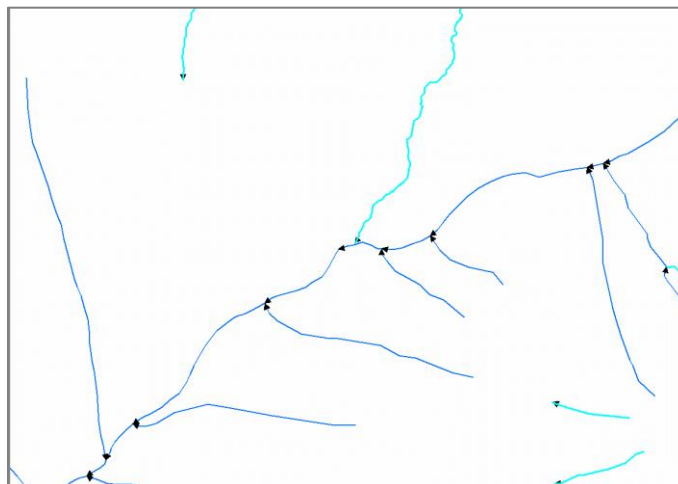
- Once the new feature has been completed, notice that the Set Flow by Digitized Direction tool on the Utility Network Analyst toolbar is now active. Click the tool to incorporate the recent change to the network – once completed, the tool is again grayed out.



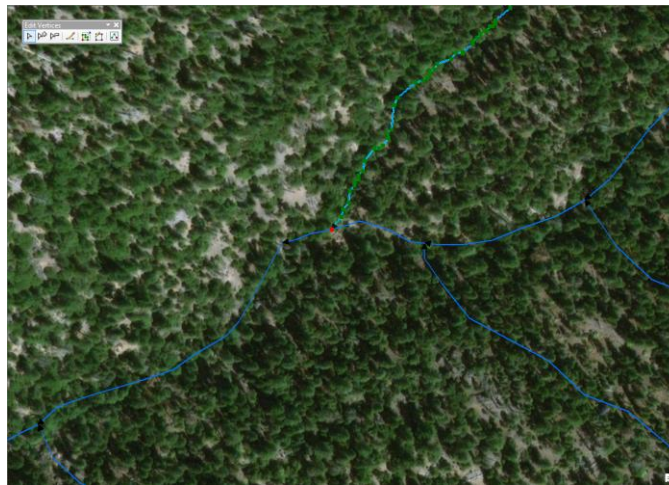
12. Click the **Solve** button the Utility Network Analyst toolbar to see how this new feature affected the total count of disconnected features. Upon clicking Solve, then click the **Switch Selection Button** and **Zoom to Selected** buttons on the attribute table. Notice the the number of selected features has been reduced from 822 to 817 by connecting those two portions of the stream dataset with a new feature.
 - i. Its acceptable if users find that their selected feature counts don't match the selection results exactly as noted above. The gist of the example to demonstrate how as users work through various editing scenarios, the total number of disconnected features gets smaller with each modification.
13. For our next example, lets zoom into the area indicated below. First, turn off the imagery layer (Basemap) in the TOC in order to speed up the map performance (we'll turn it back on once to we get zoomed in).



14. With the map zoomed into a map scale of 1:5,000, the result should look similar to below.



15. Turn on the imagery in the TOC and let's look at the highlighted feature in the center of the map. Rather than create a new feature to complete the connection here, we'll modify existing features.
16. Despite the imagery, it's difficult to see the exact location where the highlighted feature should connect to the networked features. However, because the gap is less than 5m, simply double click on the highlighted feature and drag its endpoint to the nearest snapping location on the unselected stream as shown below.



17. Click the Editor button and select **Save Edits**. Notice that by dragging the endpoint of one feature onto an adjoining feature and clicking Save, the geometric network automatically creates a new junction in that location. Now click **Set Flow by Digitized Direction** and then click **Solve**.
18. Turn off the imagery in the TOC. Click the **Switch Selection** and **Zoom to Selected** buttons on the attribute table. Notice the the number of selected features has been reduced from 817 to 796 by connecting those two portions of the stream dataset with a new feature.
19. The two previous examples demonstrate the typical workflow that an editor or data steward would employ for iteratively finding and fixing network gaps.
20. Users are encouraged at this point to continue exploring the disconnected features within the dataset and making a few more gap fixes where appropriate.

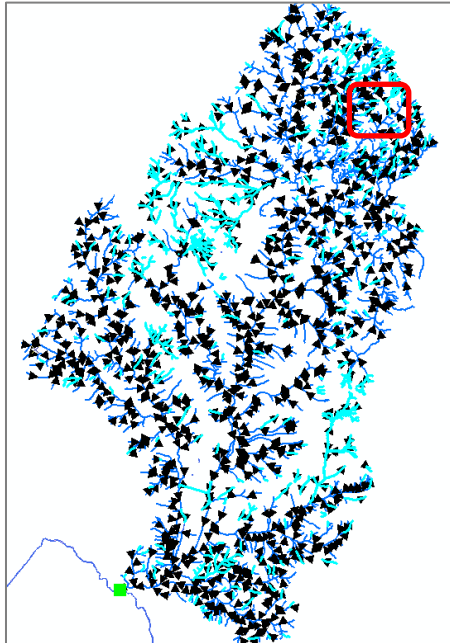
Note: users are not expected to fix all of the network gaps in this exercise. The point of the exercise is to see the process for identifying and fixing those gaps. **A completed dataset is provided for example at the end of the dataset**

Part 2: Editing Flow Direction

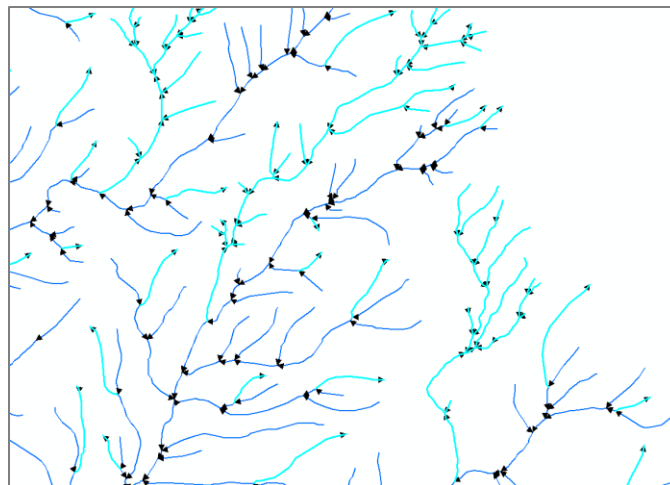
There are two primary types of errors that occur within Geometric Networks – gapped features and features having an incorrect flow direction. In this section of the exercise users will learn how to interrogate the stream dataset for invalid flow direction, as well as the common steps for correcting flow direction.

A. Fixing flow direction on individual features

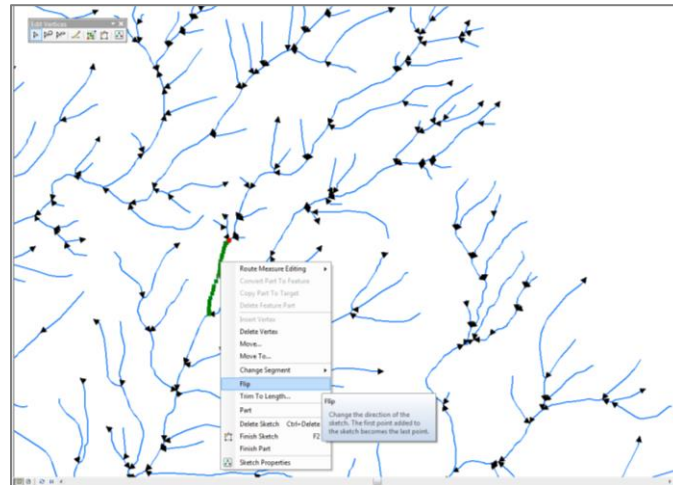
1. Using the steps described previously (i.e. Solve, Switch Selection, Zoom to Selected), select all of the disconnected features and zoom to the extent of those features. Then zoom into the area indicated by the red box below.



2. Once zoomed into an approximate map scale of 1:12,500 the map should look as per below. Notice that there a number of features that appear to be connected properly, but are shown to be flowing in the wrong direction.



3. From the current map view, select the feature indicated below and then double click it to enable Vertex Editing on the feature. Right click on any one of that feature's vertices and select **Flip**.



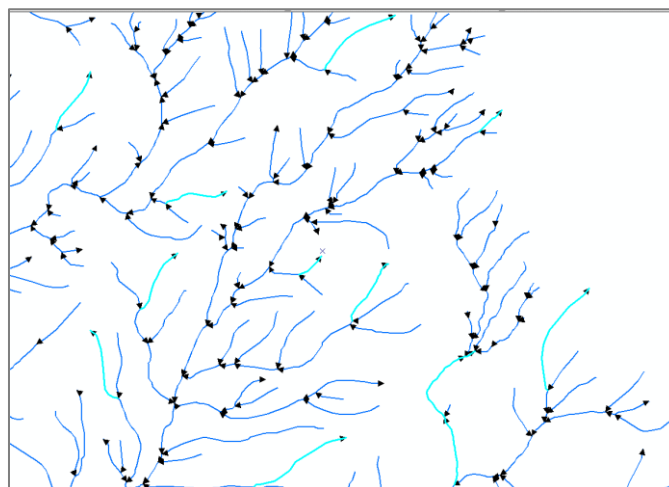
4. Upon clicking Flip, the Set Flow by Digitized Direction tool becomes active on the Utility Network Analyst toolbar. Click the **Set Flow by Digitized Direction** so the Geometric Network accounts for the direction change.
5. Click Solve and Switch Selection as described above (**don't Zoom to Selected yet** – we want the map to remain at its current location). Notice that the by fixing the directionality of the one stream feature, the number of selected features has been reduced from 796 to 766.

B. Batch processing flow direction edits

1. From the **Customize** tab within ArcMap, click **Extensions** and then turn on the **Production Mapping** extension by clicking the box next to it.
2. With the Customization tab still open, select **Toolbars** and turn on the **Production Editing** toolbar. Note, users may have to scroll down the list of available toolbars before the Production Editing toolbar is visible. Once turned on, the toolbar should look as per below.



3. Next, select any 10-15 of the features in the current map view that are shown to be flowing in the wrong direction. An example of this selection task is shown below.



- Once you have a variety of features with invalid flow directions selected, click the **Production Flip Selection** tool on the Production Editing toolbar as shown below. This effectively “flips” the flow direction of the selected flowlines.



- Upon clicking the Production Flip Selection tool, notice that the Set Flow by Digitized Direction tool has again become active. Click the Set Flow by Digitized Direction and then click the Editor button and Save Edits. Then Click solve and Switch Selection as described above. Using the selection example above, the number of disconnected features has now been reduced from 766 to 734.
- Users are encouraged at this point to continue exploring the disconnected features within the dataset and making a few more directionality fixes where appropriate.

Note: users are not expected to fix all of the flow directions in this exercise. The point of the exercise is to see the process for seeking out and fixing those features with invalid directions.

- Once comfortable with the process for repairing network gaps and invalid flow directions, click **Editor** and **Save Edits**. Then click **Editor** and **Stop Editing**. Finally, click **File** and **Save**, then close ArcMap.

Part 3: Final Clean-up and Review of Completed Edits

Once all edit tasks related to gaps and flow direction have been addressed, the user should be left with a fully connected stream network (or series of networks depending on the extent of the area being updated). Prior to loading the data into an NHD template for the formal update process, users will need to confirm that all of the stream features are participants in the stream network and that there are no unnecessarily short features in the dataset.

A. Reviewing network connectivity

- Open ArcMap and click **File** and **Open**. Then navigate to the folder for Exercise 7 (this exercise) and open the subdirectory titled “Fixed”. The **Fixed** directory contains a copy of the **Streams_4_NHD_Update** map document which has been preloaded with data from an edited copy of the **USFS_Streams_Subset** file geodatabase. Open the **Streams_4_NHD_Update** map document.
- Using the **Add Junction Flag Tool** on the **Utility Network Analyst** toolbar, place a flag at the most downstream end of the streams dataset, as you did previously in this exercise.
- Once the Junction Flag has been placed, set the trace task on the Utility Network Analyst to **Trace Upstream** and click **Solve**. Notice that all of the features in this copy of the **Networked_Stream_Layer** featureclass are selected – i.e. they participate in the geometric network.

B. Addressing short features

- In the **Networked_Stream_Layer** attribute table, scroll all the way to the right so that the **Shape_Length** column is visible. **Right click** on the column named Shape_Length and select **Sort Ascending**. The result should look similar to below.


Table					
Networked_Stream_Layer					
OBJECTID *	Shape *	FCode	Shape_Length	Enabled	
6567	Polyline ZM	46007	1.544513	True	
6566	Polyline ZM	46007	1.61849	True	
4625	Polyline ZM	46007	2.414143	True	
6063	Polyline ZM	46006	2.44457	True	
3900	Polyline ZM	46003	2.477123	True	
3483	Polyline ZM	46003	3.877497	True	
5013	Polyline ZM	46003	4.098463	True	
5986	Polyline ZM	46006	4.590854	True	
3732	Polyline ZM	46006	5.255707	True	

- Notice that there are 2 features at the top of the attribute table that are less than 2m long. Because segments shorter than 2m are prone to getting flagged as errors during the NHD Update workflow, we should remove them prior to moving the stream data into an NHD template.


Note: it is best practice to remove, modify or merge (when possible) any features which are less than 2m prior to attempting to update the NHD. Functionally, there are very few features on the landscape under the 2m threshold which warrant inclusion in the NHD. As such, the NHD uses a threshold just under 2m to detect things like microgaps and short segments during its QC routines. Removing them prior to an NHD update saves editors and/or stewards the hassle of dealing with short segments during a formal QC run within the NHD Update workflow.

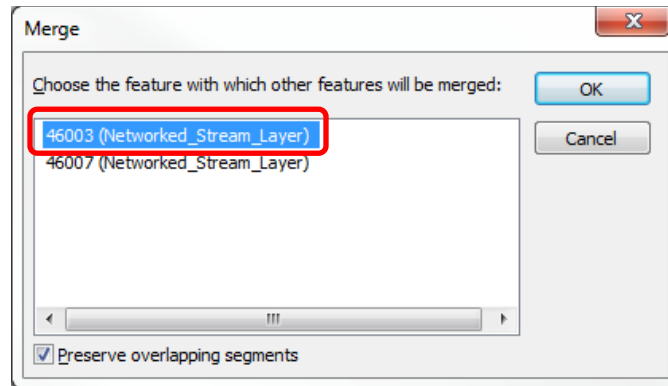
- Right click on **Networked_Stream_Layer** featureclass in the TOC and select **Edit Features**, then **Start Editing**.
- Next, within the attribute table, right click the small gray box at the left-hand side of the first record having a Shape_Length value less than 2m as shown below. Select **Zoom To** from the list of options.

Table					
Networked_Stream_Layer					
OBJECTID *	Shape *	FCode	Shape_Length	Enabled	
6567	Polyline ZM	46007	1.544513	True	
6566	Polyline ZM	46007	1.61849	True	
4625	Polyline ZM	46007	2.414143	True	
6063	Polyline ZM	46006	2.44457	True	
3900	Polyline ZM	46003	2.477123	True	
3483	Polyline ZM	46003	3.877497	True	
5013	Polyline ZM	46003	4.098463	True	
5986	Polyline ZM	46006	4.590854	True	
3732	Polyline ZM	46006	5.255707	True	

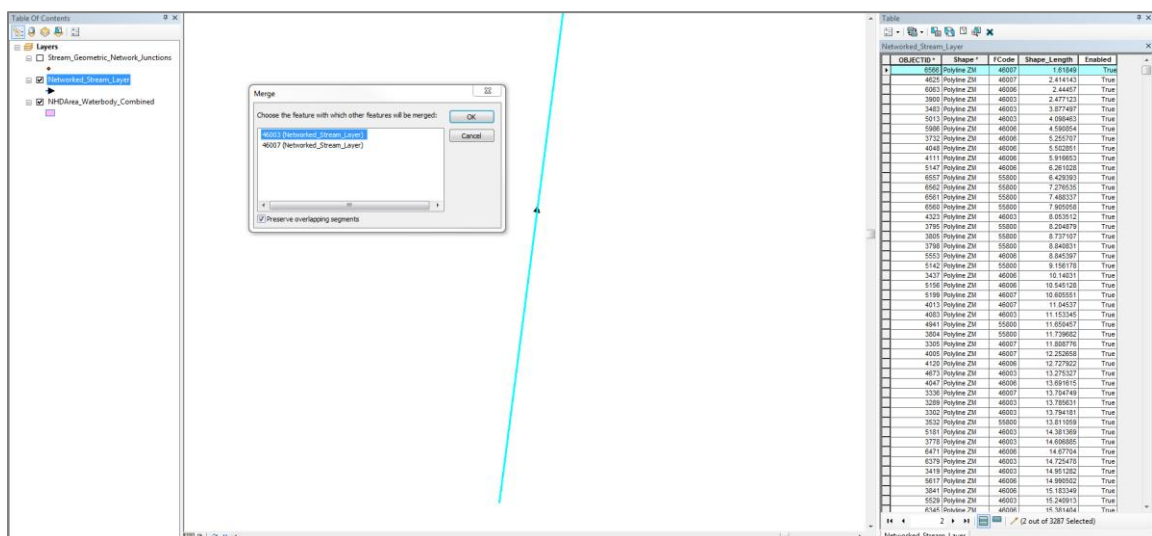
- The map will zoom to the extent of the short segment. From the table we can see that this segment has an FCode value of **46007** (which equates to an ephemeral stream in the NHD data model). Whether we delete or merge this feature with an adjoining feature will depend on how well the FCodes across features match up. Using the **Identify** tool, , on the **Tools** toolbar, click on the only feature touching the highlighted short segment.
- In the resulting **Identify** window, we can see that the adjoining feature has an FCode value of 46003 (which equates to an intermittent stream in the NHD data model). While the two

features don't share the same FCode value, they are both classified as stream features and not something that might indicate a conflict with a related polygon (for instance an Artificial Path/55800 feature would indicate the presence of a polygon boundary). In this instance it is safe to merge the short feature with its neighbor.

- Using the **Edit Tool**, , on the Editor toolbar, select both of the stream features currently visible in the map and then click the Editor Button and select **Merge**. The following window will pop up.



- Make sure that the **"46003"** record is highlighted in the Merge window and click **OK**. The short record for the short feature will disappear from the attribute table and the geometry of the short feature will be merged with its neighboring feature.
- Returning to the attribute table, right click the small gray box at the left-hand side of the remaining record having a Shape_Length value less than 2m as shown below. Select **Zoom To** from the list of options.
- Using the steps above to compare this features FCode to the adjoining feature's FCode, we can see that this scenario is a repeat of the previous scenario. **Merge** the short ephemeral stream segment with its neighboring intermittent stream segment as shown below.



- Seeing that there are no more short segments in the **Networked_Stream_Layer** featureclass, we can update the network and save edits. Click the **Set Flow by Digitized**



Direction button to update the Geometric Network. Then click the **Editor** button and select **Save Edits**. Finally, click the **Editor** button and select **Stop Editing**.

12. Now that all of the short segments have been addressed, any network gaps have been removed and the invalid flow directions have been modified, this dataset is generally ready for use in updating the NHD. Users are welcome to explore the data and to compare it against the imagery used previously in the exercise to see how former gaps have been mitigated or similar changes have been made to the data they were working on above.
13. Once users are finished getting a sense of what a completely prepared dataset looks like, 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 some concepts for interrogating and modifying data within a geometric network. These concepts include methods for finding and fixing short segments, network gaps or invalid flow directions. Users have also been provided with an example of how a fully compliant dataset is expected to operate within a geometric network.

