# NHDPlusV2 Workshop Hands-on Exercise

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## Objective of Hands-on Session

Provide students with an opportunity to apply the knowledge gained during workshop lectures. See "Workshop Presentations" on the NHDPlus Webpage under "Documentation.

It will also help the student to have access to the NHDPlusV21 User Guide to research documentation on data files and fields.

## Conventions Used in Hands-on Instructions

**Bold text** is generally text that you will see in ArcMap or ArcCatalog. Sometimes, you will need to hover over menus and buttons to see the text provided in the instructions.

There are several places throughout the session where the user must join data to other data. If the user has a problem with a join not executing properly, close your ArcMap session, remove any existing indexes using ArcCatalog, re-open ArcMap and try the join again.

Occasionally, the instructions request that you save the ArcMap mxd. This is simply good practice and in some instances you will need the mxd later in the exercise.

## Install Data

a. On your computer, create a folder called \NHDPlusV21. The illustrations throughout the exercise may use

C:\Users\<user name>\Documents\NHDPlusV21 or

D:\<user name>\NHDPlusV21,

however you may put this folder in any location where you have full read/write access. Avoid any folder that contains spaces in the path name.

- b. Obtain all Workshop\*.zip files from the NHDPlus website under "Documentation" and place them in the \NHDPlusV21 folder.
- c. Unzip each Workshop\*.zip file "here" preserving the folder structure inside the .zip file. Your workshop folder should look like this:



- d. Make sure that you have ArcGIS installed. Version 10.2.2 was used to build this exercise. Higher versions of ArcGIS should work, however screen displays may may vary.
- e. Open ArcMap.

- f. Open \NHDPlusV21\Workshop1.MXD and ensure that ArcMap has located all data in the table of contents. If not, return to step c above and confirm that your folder structure and naming is correct and that you have downloaded and uncompressed all of the Workshop materials.
- g. Close ArcMap.

### Set Up Data

The first step after obtaining and installing NHDPlusV21 data is to perform some data setup. The set up involves creating spatial and attribute indexes, and building raster pyramids. This step will greatly improve the experience of using the NHDPlusV2 data.

- a. Make a working sub-folder called \NHDPlusV21\Working.
- b. Open ArcCatalog
- c. Open ArcToolbox
- d. Add new Toolbox
  - i. Right click on ArcToolBox at the top of the tool list,
  - ii. Select Add Toolbox,
  - iii. Navigate to \NHDPlusV21\Tools\NHDPlusToolbox\_V2.1.07
  - iv. Select NHDPlusUserV2.1 Toolbox.tbx.
- e. Prepare your NHDPlusV21 data.
  - v. Click on the newly added NHDPlusUserV2.1 Toolbox and open Prep NHDPlus V2.1 Data tool.



vi. Specify the **NHDPlus V2.1 Top-Level Data Folder** by navigating to the \NHDPlusV21 folder. You may need to use the **Connect to Folder** button to find it.

💐 1. Prep NHDPlus V2.1 Data	
NHDPlus V2.1 Top-level Data folder C:\Users\LDM\Documents\NHDPlusV21	
Build raster pyramids?	
OK Cancel Env	rironments Show Help >>

- vii. If you chose to check the "Build raster pyramids" option, the preparation will take longer. However, you may want to build pyramids because they greatly improve raster display performance.
- viii. The tool displays messages about which files and attributes are being indexed. If you do not see the messages, make sure you have background processing disabled. To do this, click the **Geoprocessing** menu in ArcCatalog, Select **Geoprocessing Options**, and uncheck the box next to **Enable**.
- f. Create a working file geodatabase.
  - i. Open ArcCatalog
  - ii. Create a Working folder under \NHDPlusV21.
  - iii. Right click on \NHDPlusV21\Working and add a **New->File Geodatabase** called Workshop1.gdb.
  - iv. Close ArcCatalog.

## Create a Working ArcMap Document.

Typically, you'll create an ArcMap document which contains the NHDPlusV21 data that you plan to use for your work. This section of the hands-on exercise walks you through adding, symbolizing, joining and relating NHDPlusV21 data.

- a. Open ArcMap
- b. Right click on Layers. Select **Properties** and the **Coordinate System** tab. Set the map projection to Albers by importing the projection as follows. Click the **Add**

**Coordinate System** button and select **Import.** Browse to and chose \NHDPlusV21\NHDPlusMS\NHDPlus05\NEDSnapshot\Ned05a\elev\_cm to set the projection.

#### c. Add Data

\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDFlowlin e.shp. Symbolize with \NHDPlusV21\NHDFlowline.lyr.

\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDWaterb ody.shp. Symbolize with \NHDPlusV21\NHDWaterbody.lyr.

\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDArea.sh p. Symbolize with \NHDPlusV21\NHDArea.lyr

Perform the following steps to symbolize each feature class with cooresponding layers: Right click on feature class in the **Table of Contents** and open the **Properties** dialog box. Click on the **Symbology** tab and select **Import**. Navigate to the NHDPlusV21 folder and select the appropriate layer file. Click **Add**. Choose to import **Complete Symbology Definition** and click **OK**. Accept defaults and click **OK**. Then click **Apply** and **OK** before closing the **Layer Properties** dialog box.

riaconos		Joins &	Relates	Time			HTML Pop	up
General Source	Selection	n Display	Symbology	Fields	Definition Qu	Jery	Labels	Routes
General Source how: Features Categories Unique values, many Match to symbols in a Quantities Charts Multiple Attributes	Selection Draw ca Value File FTYPE FLOWD none Symbol Add All V	n Display ategories using ategories using alds IR Value (Heading) ArtificialPath, Urt CanalDich, With Donnector, With Pipeline, With D -StreamRiver, Wi alues) Add Va	Symbology J unique value Unique value Uni	Fields s combining Color Ran Color Ran Color Ran Field Color Ran Color	Definition Qu g up to 3 field op Dig itialized; C ? h Digitized ? Digitized ? Digitized ? Digitized ? h Digitized ? Remove All	Jery I	Labels	Routes

Note: NHDFlowlines with FlowDir = "Uninitialized" are made invisible. This is because these flowlines are ones where the NHD is not sure of the direction of flow. Consequently, these are not considered part of the NHDPlus network

d. Join NHDFlowline.ComID with

 $\label{eq:http://www.second} $$ NHDPlus 05 NHDPlus Attributes Plus Flowline VAA. Com D $$ MIDPlus 05 NHDPlus Attributes Plus Flowline VAA. Com D $$ NHDPlus 05 NHDP$ 

example, symbol	ze the layer's features using this data.
at do you want t	o join to this layer?
n attributes from	a table
1. Choose the fi	eld in this layer that the join will be based on:
COMID	-
2. Choose the ta	able to join to this layer, or load the table from disk:
DiusElou	vlineVAA 🔽 🔽
FIUSTION	
Show the GomID	attribute tables of layers in this list eld in the table to base the join on:
Show the 3. Choose the fi	attribute tables of layers in this list eld in the table to base the join on:
Show the ComID Join Options	attribute tables of layers in this list eld in the table to base the join on:
Show the ComID Join Options C Keep all re All record: Unmatche appended	attribute tables of layers in this list eld in the table to base the join on: cords : in the target table are shown in the resulting table. d records will contain null values for all fields being into the target table from the join table.
Show the Choose the fi ComID Join Options Ckeep all re All record: Unmatche appended Keep only	attribute tables of layers in this list eld in the table to base the join on: cords s in the target table are shown in the resulting table. d records will contain null values for all fields being into the target table from the join table. matching records
<ul> <li>Show the</li> <li>Choose the fi</li> <li>ComID</li> <li>Join Options</li> <li>Keep all re All records</li> <li>Meep only</li> <li>Keep only</li> <li>If a record table, that</li> </ul>	attribute tables of layers in this list eld in the table to base the join on: cords : in the target table are shown in the resulting table. d records will contain null values for all fields being into the target table from the join table. matching records d in the target table doesn't have a match in the join t record is removed from the resulting target table.

e. **Relate** NHDFlowline.WBAREAComI to NHDWaterbody.ComID. Call the relate "Waterbody-WBAreaComID".

Relate	
Relate lets you associate data with appended into this layer's attribute can access the related data when vice-versa.	n this layer. The associated data isn't table like it is in a Join. Instead you you work with this layer's attributes or
Establishing a relate is particularly ( many-to-many association between	useful if there is a 1-to-many or n the layer and the related data.
1. Choose the field in this layer that	t the relate will be based on:
WBAREACOMI	•
<ol> <li>Choose the table or layer to relative NHDWaterbody</li> </ol>	te to this layer, or load from disk:
3. Choose the field in the related ta	able or layer to base the relate on:
COMID	¥.
4. Choose a <u>n</u> ame for the relate:	
Waterbody-WBAreaComID	
About relating data	

Note: This relates the NHDFlowline Artificial Path features to the NHDWaterbody feature through which the Artificial Path flows.

f. **Relate** NHDFlowline.WBAREAComID to NHDArea.ComID. Call the relate "Area-WBAreaComID".

Note: This relates the NHDFlowline Artificial Path features to the NHDArea feature through which the Artificial Path flows.

#### g. Add Data

\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusCatchment\Catchment.shp. Symbolize with no fill and red edges.

h. **Relate** Catchment.FeatureID to NHDFlowline.ComID. Call the relate "FeatureID-ComID".

Note: This links the flowline to the catchment which represents the immediate drainage area for the flowline.

#### i. Add Data

\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusAttributes\PlusFlow.dbf

- j. **Relate** PlusFlow.FromComID to NHDFlowline.Comid. Call the relate "FromComID".
- k. Relate PlusFlow.ToComID to NHDFlowline.Comid. Call the relate "ToComID".
- I. **Relate** PlusFlow.NodeNumber to NHDFlowline.ToNode. Call the relate "ToNode".

Note: The PlusFlow.NodeNumber is the node between FromComID and ToComID. The relate links the PlusFlow record to the bottom of the FromComID.

- m. Save \NHDPlusV21\Working\Student1.mxd
- n. Use the **Zoom to XY** tool, on the ArcMap Toolbar. Use the arrow pull down to change the units to Meters. Enter the coordinates and click the **Zoom** button to zoom to these coordinates:

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o. Set the Map Scale to 1:125,000. Select the NHDFlowline shown in the picture.



- p. Open the NHDFlowline table. Open the PlusFlow table.
- q. Use **Table Options->Arrange Tables->New Horizontal Tab Group** and display just selected records.

Tab	Table - PlusFlow							
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NH	NHDFlowline							
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•	11	I					4	
н	•	1 • •	1 out	t of 174433 Se	elected)			
N	HDFlov	vline						
Plus	Flow						×	
	OID	FROMCOMID	FROMH	YDSEQ *	FROMLVLPAT *	TOCOMID *	TOHYDSEQ *	
•		III					Þ	
н	•	0 🕨 🖬	0 out	of 238966 Se	elected)			
Plu	usFlow							

- **r.** Using the relates between NHDFlowline and PlusFlow, we're going to walk down the network. Each time the following two steps are performed, the navigation in the PlusFlow table will move down one flowline. Perform these steps 4 times and watch what happens. Note that when the navigation gets to the flow split, it continues down both paths progressing one flowline at a time along each path.
  - i. From the NHDFlowline table, execute the FromComID relate. This selects the PlusFlow records where the selected flowline is the upstream/from flowline.

Table - PlusFlow								
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NHDFlowline ×								
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Plus	Flow	vinic					×	
Plus	Flow OID	FROMCOMID	* FROMH	YDSEQ *	FROMLVLPAT *	TOCOMID *	× TOHYDSEQ *	
Plus	Flow <b>OID</b> 8933	FROMCOMID 101577	FROMH	YDSEQ * 430000155	FROMLVLPAT * 430000004	TOCOMID * 10157793	× TOHYDSEQ * 3 430000153	
Plus	Flow OID 8933 8934	FROMCOMID 101577 101577	• FROMH 97 97	YDSEQ * 430000155 430000155	FROMLVLPAT * 430000004 430000004	TOCOMID * 10157793 10157693	TOHYDSEQ *           3         430000153           3         430000154	

**ii.** From the PlusFlow table, execute the ToComID relate. This selects the flowlines that are next downstream.





Note: There is a desktop tool, available from the NHDPlusV2 tools web page, which scripts the navigation using the PlusFlow table. The tool is called NHDPlusV2 Flow Table Navigator.

Save the Student1.mxd and close ArcMap.

## Add Raster Layers to ArcMap Document

There are 9 raster layers in each NHDPlus Raster Processing Unit (RPU):

The *elev\_cm* grid is the original elevation data used to build NHDPlus. It contains integer values of elevation, with centimeters as the vertical unit. The original floating-point NED data were multiplied by 100 and converted to integer in order to allow automatic compression of the grids. This saves a large amount of disk space.

The **shdrelief** grid is an integer grid. As its name implies, shdrelief contains the shaded relief generated from the elevation grid elev\_cm.

In each cell of the *fac* grid (a.k.a. flow accumulation) is the number of upslope cells that drain to that cell. The grid contains a skewed distribution of values. The vast majority of cells contain small numbers (less than 100), however the cells along major flow paths can have values into the hundreds of millions.

The *fdr* (a.k.a. flow direction) grid contains only nine unique values, one for each possible flow direction out of a cell. The values indicate the direction of flow to an adjacent cell. Each cell contains a coded numeric value that stands for east, southeast, south, southwest, west, northwest, north, or northeast. A value of zero means that the cell is a sink and there is no flow to any adjacent cell. Although it is easy to display this grid, it is not particularly easy to interpret. This grid may sometimes be inspected closely in order to understand the flow in a very small area, but generally this grid is not displayed. The fdr grid is used by automated procedures to derive flow paths or delineate basins/watersheds.

The **fdrnull** grid is a variant of the flow direction grid in which the cells of BurnLineEvent features are set to NoData. FdrNull can be used to compute flow path length grids. Flow path length grids are useful for a variety of purposes including determining the mean flow path length within a catchment or deriving stream riparian buffer areas. This grid is primarily for analysis rather than display.

The *cat* grid contains an unusually large number of unique grid values. In most cases you don't really need to see the records in the *cat* attribute table or to display the grid. All the same information is in the *catchment.shp* attribute table, and can be used much more readily in that form. The *cat* grid is primarily useful for gridded overlay analysis such as the Spatial Analyst's Zonal Statistics tool. We'll use the cat grid in the **Linking Data to the Network** section later in the exercise.

The **catseed** grid is an integer grid which contains the seed cell for each catchment. The catchment gridcodes are stored in the seed cells. This grid is distributed as documentation of the raster processes used to build NHDPlus.

The **filledareas** grid is an integer grid which identifies cells raised by the Fill process that occurs after the hydro-enforcement process. This grid is distributed as documentation of the raster processes used to build NHDPlus.

The **hydrodem** grid is an integer grid of the hydro-conditioned version of elev\_cm, with all aspects of the NHDPlus burn components integrated and filled. This grid is used to

generate the flow direction grid from which the flow accumulation and catchment grids are generated. The elevations are in centimeters. This grid is distributed to document the hydro-enforcement processes used to build NHDPlus.

- a. Starting with Student1.mxd from section above, Add Data \NHDPlusV21\NHDPlusMS\NHDPlus05\NEDSnapshot\Ned05a\shdrelief. Say Yes" to building pyramids.
- b. Right-click on the *ShdRelief* grid, and choose **Properties->Symbology**. If the renderer is not set to **Stretched**, change it to **Stretched** as shown below, then click **Apply**.

General Sou	urce Key	Metadata Exte	nt Display	Symbology	Fields Joins	s & Relates	
how: Unique Values Classified	;	Stretch val	ues along a	color ramp		Ē	5
Stretched Discrete Color	,	Color Color Ramp	:	Value 254 26	Label High : 254 Low : 26	Labeling	E
	Y	Displ	ay Backgroun hillshade effec Standar n: :	d Value: t Z: rd Deviations 2.5		as v Display NoData as v Histograms Invert	
About symbol	<u>ypq</u>		ny Gamma Str	eich:		<u> </u>	*

c. Turn off all layers except shdrelief. Right click shdrelief and **Zoom to Layer**. Set **Map Scale** to **1:24000**. Note the blocky grid cells.

d. Right-click on the *shdrelief* grid, and choose **Properties->Display**. Set **Resample During Display** pulldown to **Bilinear Interpolation** and click **Apply**. Note how the display becomes smoother.

Layer Properties			X
General Source Key M	etadata Ext	tent Display	Symbology Fields Joins & Relates
Show MapTips Display raster resoluti Allow interactive display Resample during display u	on in table of ay for Effect	f contents s toolbar	
Bilinear Interpolation (for	continuous (	data)	<b>•</b>
Contrast:			Orthorectification
Brichtroom	0	%	Orthorectification using elevation
-	0	%	Constant elevation:
Transparency:	0	%	○ DEM
Display Quality Coarse Medium	Normal		Elevation adjustment         Z factor:         1         Z offset:         0         Geoid:
			OK Cancel Apply

e. Add Data \NHDPlusV21\NHDPlusMS\NHDPlus05\NEDSnapshot\Ned05a\elev\_cm. Say "Yes" to building pyramids.

f. Right click on elev\_cm and select Properties->Symbology. Right click on the black-to-white Color Ramp and click Graphic View. The check mark beside Graphic View should disappear and the text descriptions of the items in the Color Ramp should appear in the pull down. From the Color Ramp pull down, select Elevation # 1.

Layer Properties		23
General Source Key Me	tadata Extent Display Symbology	
Show: Unique Values	Stretch values along a color ramp	
Stretched Discrete Color		<u>^</u>
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	8701	=
	Color Ramp:	
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	Display Background Value: 0 as	
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	Stretch Type: Standard Deviations   Histograms	
	n: 2.5 Invert	
About symbology	Apply Gamma Stretch: 1	-
	OK Cancel A	\pply

- g. Select the **Display** tab and change **Transparency** to 50%. Click **OK**.
- h. Set the Map Scale to 1:100,000.



Note the nice shaded relief map created using the elevation layer draped over the shaded relief layer.

- i. Add Data \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusFdrFac05a\fac. Say "Yes" to building pyramids.
- j. Right click on fac and select **Properties->Symbology**. Change the renderer from **Stretched** to **Classified**. **Build Histogram**, if prompted.

Layer Properties				×
General Source Key M	letadata Extent Display	Symbology		
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	Color Ramp			•
	Symbol         Range           0 - 10,548,805         10,548,805.96           35,315,567.77         77,510,791.6 -           99,525,690.98         99,525,690.98	.96 - 35,315,567.77 - 77,510,791.6 99,525,690.98 - 116,954,153	Label 0 - 10,548,805.96 10,548,805.97 - 35, 35,315,567.78 - 77, 77,510,791.61 - 99, 99,525,690.99 - 116	315,567.77 510,791.6 525,690.98 ,954,153
About symbology	Show class breaks usin	g cell values Z: 1	Disp	ay NoData as
			ОК	Cancel Apply



k. Click **Classify...** In the **Classification** dialog, change the number of **Classes** to 2 and change the first **Break Value** to 100. Click **OK**.

 On the Symbology tab, double-click on the black box under Symbol next to the 0 -100 Range, then choose No Color on the color menu that pops up. Double-click on the black box under Symbol next to 100 – 111784089, then choose a dark purple color on the color menu that pops up. Click OK.

Layer Properties	
General Source Key N	Aetadata Extent Display Symbology
Show: Unique Values	Draw raster grouping values into classes
Stretched Discrete Color	Fields       Value <value>       Value     <none></none></value>
	Classification Manual Classes 2  Classify
	Color Ramp
	Sym Range Label
	0 - 100 0 - 100
	100 - 111784089 100.0000001 - 111784089
About symbology	Show class breaks using cell values     Display NoData as       Use hillshade effect     Z:
	OK Cancel Apply



Note: The purple lines are made up of cells in the fac grid that have 100 or more cells upslope. These lines indicate where the drainage channels are on the HydroDEM. Turning off the elev\_cm and shdrelief layers will enable you to see the channels better. These channels are sometimes referred to as synthetic streams because they are simply channels in the DEM which may or may not contain water. In general, where the channels and NHDFlowines coincide, the channels should follow the NHDFlowline features closely, since the networked NHDFlowline features were burned into the HydroDEM. The threshold of 100 is shown to illustrate the concept, but any threshold may be chosen.



m. Turn on the NHDFlowline layer. Pan NW to be able to see more NHDFlowline features. Turn off the Topo Map layer to get a better view.

Note: The threshold of 100 creates many more channels (purple lines) than features in NHDFlowline (blue lines).

n. Repeat steps k and l, setting the threshold to 2000. You can see that, in this area of the country, a threshold of 2000 corresponds more closely with medium resolution NHD. Turn off the fac layer.

![](_page_24_Figure_1.jpeg)

 Let's measure the distances from locations within a catchment to the flowline within the catchment. This is a task for the fdrnull grid. Open Spatial Analyst->Hydrology->Flow Length tool and populate the dialog like this:

Flow Length	
Input flow direction raster	A
C:\Users\LDM\Documents\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusFdrNull05a\fdr	null 💌 🖻
Output raster	
C:\Users\LDM\Documents\ArcGIS\Default.gdb\flowlength	<b>2</b>
Direction of measurement (optional)	
DOWNSTREAM	•
Input weight raster (optional)	
	<u> </u>
	-
OK Cancel Environments	Show Help >>

Note: Be sure to have the Spatial Analyst extension turned on. You can do this by clicking the **Customize** menu in ArcMap -> **Extensions** -> check the box next to **Spatial Analyst**.

🗹 Da	ta Reviewer	
	duction Mapping	
⊡ т.	atial Analyst	
	sk Assistant Manager	

p. Click on Environments... and use the fdrnull grid to set the Output Coordinate System, the Extent and the Snap Raster:

🛠 Environment Settings	- Your	a designed of the	×	
* Output Coordinates				•
Output Coordinate System				_
As Specified Below		▼	6	
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				Ĩ.,

- q. Click **OK** and **OK** again on the **Flow Length** tool dialog. Note: It may take approximately10 minutes for the tool to run.
- r. In the flowlength output grid, cells contain the length (in meters) of the downhill flow path from the cell to the flowline in the catchment. Zoom in and do an **Identify** on some flowlength grid cells.

s. At this point, we can use **Spatial Analyst->Zonal->Zonal Statistics as Table** to compute the maximum flow path distance to water for each catchment as follows and click **OK**:

				-		
Input raster or f	eature zone data					
C:\Users\LDN	I\Documents\NHDF	lusV21\NHDF	PlusMS\NHDPl	us05\NHDPI	usCatchment\cat	- 🖻
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MAXIMUM						•

t. The flowlength grid is displayed in the picture below. The white lines are the cells where the grid has a value of 0, i.e. 0 path length to the flowline. In other words, the white cells represent the flowlines. The maxflowlength\_05a table is also shown. We can see that in the selected catchment, the maximum flow path distance to water is 1014 meters.

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7586	4004874	1374	1236600	819.411255			کی ا	
7587	4004876	6597	5937300	1973.086304				
7588	4004878	906	815400	701.543335		<u>```</u>		
7589	4004880	1289	1160100	899.116882				
7590	4004882	1755	1579500	831.837646				
7591	4004884	5631	5067900	2352.792236				
7592	4004886	482	433800	574.26416	▼			
14 4	0 ► H	(1	out of 41	249 Selected)				
maxflow	length_05a							

There are many other interesting analyses that can be done with the fdrnull grid.

Save the project as \NHDPlusV21\Working\Student2.mxd and close ArcMap.

## Build a Geometric Network and Learn to Navigate

There are many approaches to navigating the NHDPlusV2 network:

- Using an ArcGIS geometric network,
- Using a specific group of network attributes: LevelPathI, Divergence, UpLevelPat, DnLevelPat, and DnMinorHyd (often referred to as VAA Navigation),
- Using the network attribute Hydroseq,
- Using the network attributes Fromnode and Tonode, and
- Using the PlusFlow table (See section "Create a Working ArcMap Document").

NHDPlusV21 has the capability to make network connections where there is no geometry in NHDFlowline. At present there are 102 of these no-geometry connections. These connections are represented in the network attributes and in the PlusFlow table, but not in the geometry. Therefore all the approaches above will "see" these connections and traverse them except the ArcGIS geometric network approach.

Most, but not all, no-geometry connections are on the international borders where a stream leaves the U.S. and then reenters the U.S. at another location. No-geometry connects exist in VPUs 04, 05, 06, 09, 10U, 16, and 17. They can be found by querying the PlusFlow table for HasGeo = "N".

This exercise is focused on the ArcGIS geometric network approach which offers some interesting navigation capabilities in the Utility Network Toolbar.

- a. Create a new ArcMap document and add attributes to NHDFlowline
  - i. Open ArcMap
  - ii. Add Data

\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDF lowline to map.

- iii. Open the NHDFlowline table and click Select by Attributes NHDFlowline.FlowDir = "With Digitized". These are the flowlines that NHDPlus considers to be in the network. Flowlines that have FlowDir = "Uninitialized" are ignored by NHDPlus.
- iv. Right click on NHDFlowline and select **Data->Export** to save the selected flowlines to \NHDPlusV21\Working\NHDFlowline\_KnownFlow.shp and add to map
- v. Remove NHDFlowline from map
- vi. Link NHDFlowline Artificial Path features to their NHDWaterbodies
  - a. Open NHDFlowline\_KnownFlow attribute table
    - b. From Table Options->Add field NHDFlowline KnownFlow.WBFType Text(24)

Lype: Text Field Properties
Field Properties
Length 24

- c. From Table Options->Add Field NHDFlowline\_KnownFlow.WBSize Double
- d. From Table Options->Join NHDFlowline\_KnownFlow.WBAreaComI with \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrograp hy\NHDWaterbody.ComID
- e. Right click on NHDFlowline\_KnownFlow.WBFType field and use **Field Calculator** to set it to NHDWaterbody.FType If prompted, say "yes" to "the calculated value is invalid for …" Note: Make sure to calculate the field using NHDWaterbody.FType, *not* NHDFlowline\_KnownFlow.FType
- f. Right click on NHDFlowline\_KnownFlow.WBSize field and use **Field Calculator** to set it to NHDWaterbody.AreaSqKM If prompted, say "yes" to "the calculated value is invalid for …"
- g. Remove NHDWaterbody join.
- Sort descending by right clicking WBFType column header and take note that now the Artificial Path features that are inside NHDWaterbodies such as Lake/Pond features have the Feature Type and Feature Size of the waterbody through which they flow. This will enable us to discover these waterbody features when we navigate.
- vii. From **Table Options->Join** NHDFlowline\_KnownFlow.ComID with \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusAttributes\PlusFlowlineV AA.ComID
- viii. (Optional) Remove unwanted attributes from table: Right click NHDFlowline\_KnownFlow, select **Properties->Fields** tab, unclick the PlusFlowlineVAA attributes OID, ComID, Fdate, Thinnercod, OutDiv, DivEffect, Reachcode, LengthKM, and Fcode. Click **OK**. These are either duplicate or unvalued attributes.
- ix. From **Table Options->Join** NHDFlowline\_KnownFlow.ComID with \NHDPlusV21\NHDPlusMS\NHDPlus05\EROMExtension\EROM\_MA0001. ComID
- x. (Optional) Remove unwanted attributes from table: Right click NHDFlowline\_KnownFlow, select **Properties->Fields**, unclick all EROM\_MA0001 attributes except Q0001A, V0001A, Q0001C, V0001C, Q0001E, V0001E, SMGageID, and SMGageq. Click **OK**. These are the

only EROM attributes that will be useful in our navigation and analysis activities.

- xi. In the table for NHDFlowline\_KnownFlow, right click on the **Enabled** field and delete it.
- xii. Right click on NHDFlowline\_KnownFlow and use **Data->Export** to create \NHDPlusV21\Working\NHDFlowline\_KnownFlow\_Attrs.shp
- xiii. Close ArcMap
- b. Build NHDPlusV21 Junctions

NHDPlus contains virtual nodes. There is one at the top of each headwater flowline, and one at the bottom of each network terminous. (These are called Network Starts and Network Ends in NHDPlus.) And there is one at each place that one or more flowlines exchange water. Each node is uniquely numbered. The node numbers can be found in the PlusFlowlineVAA table in fields FromNode and ToNode. The NHDPlus nodes inherit the rich NHDPlus network attributes and can be used as highly functional junctions in a geometric network.

- i. Open ArcMap.
- ii. Add Data \NHDPlusV21\Working\NHDFlowline\_KnownFlow\_Attrs.shp to map
- iii. Open ArcToolbox and use Data Management->Features->Feature Verticies to Points specifying:

Input: NHDFlowline\_KnownFlow\_Attrs Output:

\NHDPlusV21\Working\NHDFlowline\_KnownFlow\_Points.shp Point Type: Both Ends.

Note: Click the **Show Help** button in the tool dialog to better understand the options and functionality.

![](_page_32_Figure_0.jpeg)

Note: The order of the output points is in the order of the features in NHDFlowline\_KnownFlow\_Attrs and in the digitized direction of the flowlines. For each feature, the start/top/from point is the first record followed by the record for the end/bottom/to point.

- iv. Open table for NHDFlowline\_KnownFlow\_Points. From Table Options >Add field PointID Double(14,0) Right click on PointID and use Calculate
   Field to FID
- v. From Table Options->Add field NodeNumber Double(14,0).
- vi. Right click on NHDFlowline\_KnownFlow\_Points.ComID and **Summarize** computing minimum PointID (i.e. the ID of the Start/Top/From point) creating \NHDPlusV21\Working\TopPoint.dbf. When prompted, add the table to the map.

Summarize
Summarize creates a new table containing one record for each unique value of the selected field, along with statistics summarizing any of the other fields.
1. Select a field to summarize:
COMID
<ol><li>Choose one or more summary statistics to be included in the output table:</li></ol>
<ul> <li>₩ V0001E</li> <li>ℜMGagelD</li> <li>ℜMGageq</li> <li>ORIG_FID</li> <li>PointID</li> <li>Minimum</li> <li>Maximum</li> <li>Average</li> <li>Sum</li> <li>Standard Deviation</li> <li>Variance</li> <li>To Na de Numbers</li> </ul>
3. Specify output table:
:\Users\LDM\Documents\NHDPlusV21\Working\TopPoint.db
Summarize on the selected records only

Note: Be sure to specify 'save as type' to dBASE Table as shown below.

Saving Data							×
Look in:	Working	•	<u>د</u>		21	2	ŭ 😜
naxflowle	ength_05a.dbf						
Name:	TopPoint.dbf				0	Sa	ve
Save as type:	dBASE Table			•		Ca	ncel

- vii. From **Table Options->Join** NHDFlowline\_KnownFlow\_Points.comid and TopPoint.comid
- viii. From Table Options->Select by attributes NHDFlowline\_KnownFlow\_Points where NHDFlowline\_KnownFlow\_Points.PointID = TopPoint.Min\_PointI. These will be the Start/Top/From point records. Half the records should be selected.
   ix. For the selected records, right click on NHDFlowline\_KnownFlow\_Points.NodeNumber and use Calculate Field to set it to NHDFlowline\_KnownFlow\_Points.Fromnode.
  - x. Switch selection
- xi. Right click on NHDFlowline\_KnownFlow\_Points.NodeNumber and use Calculate Field to set it to NHDFlowline\_KnownFlow\_Points.ToNode
- xii. Clear selection. Remove TopPoint Join.

- xiii. To remove duplicate nodes:
  - Right click on NHDFlowline\_KnownFlow\_Points.nodenumber and Summarize computing minimum PointID creating \NHDPlusV21\Working\Unique\_Node.dbf. When prompted, add the table to the map.

Summarize	X
Summarize creates a new table containing one record for each unique value selected field, along with statistics summarizing any of the other fields.	ue of the
1. Select a field to summarize:	
NodeNumber	-
<ol> <li>Choose one or more summary statistics to be included in the output table:</li> </ol>	
<ul> <li>₩ V0001E</li> <li>₩ SMGagelD</li> <li>₩ SMGageq</li> <li>₩ ORIG_FID</li> <li>PointID</li> <li>✓ Minimum</li> <li>Maximum</li> <li>Average</li> <li>Sum</li> <li>Standard Deviation</li> <li>¥ Variance</li> </ul>	1
3. Specify output table:	
sers\LDM\Documents\NHDPlusV21\Working\Unique_Nodes.c	5
About summarizing data OK Canc	el

#### 2. From Table Options->Join

NHDFlowline\_KnownFlow\_Points.PointID and Unique\_Nodes.Minimum\_PointID.

- 3. Select records that received a join (i.e. Unique\_Nodes.OID >= 0) The count should be:
  - 172400 The number of NHDFlowline tops
  - 2354 The number of minor paths (Divergence = 2) at network flow splits
  - + 57 The number of terminal flowlines (Terminalfl = 1)
  - + 1 At the bottom of the Ohio River

#### 170104

Note: If there had been terminal flowlines that were also a confluence (e.g. a terminal lake with multiple inflows that
meet in a point inside the lake), each lake terminus would be a single junction and would reduce the total number of junctions.

- 4. Remove Unique\_Nodes join.
- 5. Right click on NHDFlowline\_KnownFlow\_Points **Data->Export** to \NHDPlusV21\Working\NHDFlowline\_KnownFlow\_Junctions
- 6. Close ArcMap
- c. Create NHDPlusV21 NHDFlowline Geometric Network
  - i. Open ArcCatalog
  - Right click on Workshop1.gdb and add New->Feature Dataset called hydrography. Import the Coordinate System from \NHDPlusV211\Working\NHDFlowline\_KnownFlow\_Attrs.shp Use defaults throughout the remainder of the dialog.
  - iii. Right click on Workshop1.gdb\hydrography and Import Feature Class (single)

Input Features:

\NHDPlusV21\Working\NHDFlowline\_KnownFlow\_Attrs.shp Output Feature Class: name it NHDFlowline

Input Features	
D:\Maggie\V2Workshop\NHDPlusV21\Working\NHDFlowline KnownFlow Attrs.shp	
D:\Maggie\V2Workshop\Workshop1.gdb\hydrography	
NHDFlowline	
Expression (optional)	
	SQL
rielo map (optional)	
E CNIS ID (Text)	≡ ×
E CNIS NAME (Text)	
EACHCODE (Text)	
FLOWDIR (Text)	
- WBAREACOMI (Long)	
FTYPE (Text)	
FCODE (Long)	
HAPE_LENG (Double)	
GNIS_NBR (Long)	
H-WBFType (Text)	
🕀 WBSize (Double)	*
Geodatabase Settings (optional)	

 Right click on Workshop1.gdb\hydrography and Import Feature Class (single) Input Features:

\NHDPlusV21\Working\NHDFlowline\_KnownFlow\_Junctions Output Features: name it NHDJunctions

Feature Class to Feature Class	
Input Features	
D:\Maggie\V2Workshop\NHDPlusV21\Working\NHDFlowline_KnownFlow_Junctions.shp	
Output Location	_
D:\Maggie\V2Workshop\Workshop1.gdb\hydrography	
Output Feature Class	
NHDJunctions	
Expression (optional)	
	SQL
Field Map (optional)	
⊞- COMID (Long)	A 🕂
🗄 FDATE (Date)	
🖶 RESOLUTION (Text)	
🖶 GNIS_ID (Text)	
🗄 GNIS_NAME (Text)	
ENGTHKM (Double)	1
🕀 REACHCODE (Text)	( and a second
ELOWDIR (Text)	
🗄 WBAREACOMI (Long)	
+- FTYPE (Text)	
+- FCODE (Long)	
🗄 - SHAPE_LENG (Double)	
🗄 GNIS_NBR (Long)	
🗄 WBFType (Text)	
🗄 WBSize (Double)	+
Geodatabase Settings (optional)	
OK Cancel Environments	. Show Help >>

v. Right click on Workshop1.gdb\hydrography and add a **New-> Geometric Network**. In the New Geometric Network dialog, use defaults except as indicated below.





New Geometric Network	X							
Use Z values to determine connectivity of features?								
No     No								
0.001	Unknown Units							
Line ends and junctions must match up connect. If they do not match up they co of the Z snap tolerance. The default val tolerance of the feature dataset.	precisely for features to an be moved within the limits ue is based on the Z							
< B	ack Next > Cancel							

 Use ArcToolbox Data Management->Geometric Network->Set Flow Direction to establish the flow direction as being WITH\_DIGITIZED\_DIRECTION of the NHDFlowlines in the geometric network you just created. Close ArcCatalog.



- d. Navigate the Geometric Network
  - i. Open ArcMap.
  - ii. Add Data
  - \NHDPlusV21\Working\Workshop1.gdb\hydrography\NHDFlowline
  - iii. Right click on an empty area of the ArcMap toolbar ribbon and add the **Utility Network Analyst** toolbar.

Utility Network Analyst 🗕 Flow 🖣 Analysis 🕹 🖌 Find Common Anceste 💌

iv. Use the **GO To XY** tool ( ) from the ArcMap standard toolbar to zoom to this location:



v. Use the **Edge Flag** ( **I**) tool from the Utility Analyst toolbar to place a flag on the Flowline near this coordinate point.



Note: To remove an unwanted flag, click Analysis dropdown -> Clear Flags.

vi. From the Analysis pulldown, select Options->Results. Select Return Results as Selection.

vii. Select "Trace Upstream" from the Trace Tasks drop down.



Click the **Solve** ( ) button Right click NHDFlowline and **Selection**->**Zoom to Selected Features**.



- e. Using Weights in the Geometric Network
  - i. Save the ArcMap document as \NHDPlusV21\Working\Student3.mxd. Close ArcMap.
  - ii. Open ArcCatalog.
  - iii. Right click on \NHDPlusV21\Working\Workshop1.gdb\hydrography\hydrography\_Net and select Properties->Weights
  - iv. Click **New** and **Add a Weight** called StreamFlow with type as Double.
  - v. In the pull down next to NHDFlowline, select Q0001E (i.e. NHDPlusV2 gage-adjusted stream flow). Click OK.
     Note: Applying the weight will take some time.
     Close ArcCatalog.

Delete
Delete

- vi. Open ArcMap. Open \NHDPlusV21\Working\Student3.mxd.
- vii. In the Utility Network Analyst Toolbar, click on Analysis-> Options-> Weights tab. Under Edge Weights-> Weight Along Digitized Direction and Weight Against Digitized Direction of Edge, select StreamFlow in the pull down.

viii. On the Weight Filter tab, under Edge Weight Filter-> From-To
 Weight and To-from Weight, select StreamFlow and in Weight Range
 put 0 – 1000 and checkmark Not.

General Weights We	eight Filter Results
Junction weight filter Junction weight	<none></none>
Weight range	
Edge weight filter From-to weight	StreamFlow -
To-from weight	StreamFlow
Weight range	0 - 1000
	v not veny

- Under the **Results** tab, Select **Return Results as Selection**. Click **OK**. ix.
- х.
- Click **Solve** Solve button. Only flowlines with Streamflow > 1000 are xi. navigated.



Note: Any attribute in your junctions or network edges can be added as a weight and used to control navigation.

Save the Student3.mxd and close ArcMap.

## Put Network Attributes to Work

The Geometric network that we built in the previous segment contains many of the NHDPlus attributes joined to NHDFlowline. We're going to use those attributes now to do some interesting things.

- a. Create a working mxd.
  - i. Open ArcMap. Add Data \NHDPlusV21\Working\Workshop1.gdb\hydrography\NHDFlowline. Symbolize with \NHDPlusV21\NHDFlowline.lyr.
  - ii. Add Data \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDWat erbody. Symbolize with \NHDPlusV21\NHDWaterbody.lyr.
  - iii. Add Data \NHDPlusV21\ NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDArea. Symbolize with \NHDPlusV21\NHDArea.lyr.

Save ArcMap document as \NHDPlusV21\Working\Student4.mxd.

- b. Find all the tributaries to the Ohio River.
  - i. Use the **Go To XY** tool on the ArcMap toolbar to zoom to the following coordinates. This is the mouth of the Ohio River.



ii. Use the **Identify** tool to display the NHDFlowline attributes for the most downstream flowline. Note that the LevelPathID is 430000004. This is a unique id that defines the main path from the mouth of the Ohio to the main head water flowline.

Identify		□ ×
Identify from:	<top-most layer=""></top-most>	•
NHDFlowline	e er	
		<u> </u>
Location:	504977.524 1570839.670 Meters	
Field	Value	*
REACHCODE	05140206001100	
FLOWDIR	With Digitized	
WBAREACOMI	120049871	
FTYPE	ArtificialPath	
FCODE	55800	
SHAPE_LENG	0.007674	
ENABLED	True	
GNIS_NBR	0	
OID	172278	=
ComID	1844789	
Fdate	6/9/2012	
StreamLeve	2	
StreamOrde	9	
StreamCalc	9	
FromNode	430008458	
ToNode	510057566	
Hydroseq	43000004	
LevelPathI	43000004	
Pathlength	1562.531	
TerminalPa	350002977	
ArbolateSu	409424.438	
Divergence	0	
StartFlag	0	
TerminalFl	0	
Dol ovol	1	-

iii. To see the entire water course, from the mouth of the Ohio River to the main headwater, do a select "LevelPathI" = 430000004 and zoom to selected. This is the entire mainpath of Hydrologic Region 05.



 iv. To see just the entire Ohio River, do a select "LevelPathI" = 430000004 AND "GNIS\_ID" = '425264'. Right click on NHDFlowline, Selection->Zoom to Selected.

Note that when zooming to a named stream it's always best to use the GNIS\_ID rather than the GNIS\_Name. This is because the GNIS\_ID is a unique identifier for the named feature and if there are multiple streams with the same name (e.g. Mill Creek is a very popular name), each named feature has a unique GNIS\_ID.



- v. Find the tributaries to the Ohio River: Opening the NHDFlowline attribute table. Display selected records. Sort ascending on Hydroseq. Record the minimum and maximum Hydroseq of the Ohio 430000004 and 430001608.
- vi. To find the tributaries, perform a selection as follow:

"DnLevelPat" = 430000004 AND "DnHydroseq" >= 430000004 AND "DnHydroseq" <= 430001608 AND "GNIS\_ID" <> '425264'

In English, this statement says, select any NHDFlowline features whose immediate downstream flowline is the Ohio River and whose downstream hydroseq is greater than or equal to the minimum hydroseq on the Ohio and whose downstream hydroseq is less than or equal to the maximum hydroseq on the Ohio and which is not the Ohio itself.

## NHDFlowline

	COMID *	FDATE	RESOLUTION	GNIS_ID	GNIS_NAME				
	3408269	7/6/1999	Medium	485795	Agniels Creek				
	11050844	5/10/2009	Medium	1209386	Allegheny River				
	15434074	2/11/2009	Medium	1075253	Allen Run				
	10109483	2/17/2009	Medium	450631	Anderson River				
	11870020	2/17/2009	Medium	424572	Anthony Creek				
	3407463	7/6/1999	Medium	430276	Arnold Creek				
	19455283	7/29/1999	Medium	1535157	Baker Run				
	19442967	2/11/2009	Medium	1535205	Bar Run				
	10161976	3/9/2009	Medium	486338	Barebone Creek				
	15429776	2/11/2009	Medium	1075304	Bares Run				
	15429810	2/11/2009	Medium	1075307	Barnes Run				
	11870188	2/17/2009	Medium	424598	Barren Creek				
	11870184	2/17/2009	Medium	424607	Bay Creek				
	10157677	2/17/2009	Medium	430595	Bayou Creek				
	11870198	2/17/2009	Medium	510435	Bayou Creek				
	1840003	3/9/2009	Medium	486491	Bayou Creek				
	10157721	2/17/2009	Medium	430596	Bayou Drain				
	1922922	2/13/2009	Medium	1066562	Bear Creek				
	10164000	3/9/2009	Medium	486584	Beargrass Creek				
	1921952	2/13/2009	Medium	486596	Beasley Creek				
	19464504	3/8/2001	Medium	1169025	Beaver River				
	15429720	2/11/2009	Medium	1535454	Beaver Run				
	10157709	2/17/2009	Medium	430683	Beaverdam Creek				
•			111						
н	• • • ■ ■ (799 out of 174433 Selected)								

And we find that there are 799 tributaries to the Ohio in NHDPlus. Some of the named tributaries are in the list above. Note that Bayou Creek occurs three times. By looking at the GNIS\_IDs, we can see that these are three different Bayou Creeks

Save the Student5.mxd.

- c. How many lakes are along the Cumberland River? How far are the lakes from the mouth of the Cumberland? How far apart are the lakes from each other?
  - i. In NHDFlowline, find the Cumberland River using this select LevelPathI = 430000065 AND GNIS\_ID = '517018' Zoom to selected.



ii. Zoom in to the mouth of the Cumberland and do an **Identify** on the most downstream flowline. Make note of the PathLength (1659.291 kilometers) which is the distance from the mouth of the Cumberland to the mouth of the Mississippi.

and the second s	- NHDFlowline	e land River
	Location:	88.409134 37.143282 Decimal Degrees
	Field	Value
	COMID	11888866
	FDATE	3/9/2009
	RESOLUTION	Medium
	GNIS_ID	517018
$\Lambda$ $I$ $\mathcal{A}$ $/$	GNIS_NAME	Cumberland River
	LENGTHKM	0.132
	REACHCODE	05130205000001
	FLOWDIR	With Digitized
	WBAREACOMI	120049863
	FTYPE	ArtificialPath
	FCODE	55800
	SHAPE_LENG	0.001495
	GNIS_NBR	0
	WBFType	
	WBSize	0
	StreamLeve	3
	StreamOrde	7
	StreamCalc	7
	FromNode	430074807
	ToNode	430008245
	Hydroseq	430000573
	LevelPathI	430000065
	Pathlength	1659.291
	TerminalPa	350002977

 iii. To find the lakes on the Cumberland River, start with the following selection from NHDFlowline: LevelPathI = 430000065 AND GNIS\_ID = '517018' AND WBFType = 'LakePond'

There are 395 NHDFlowlines inside lake features along the Cumberland.

N	IHDFlowline											
	COMID	FDATE	RESOLUTION	GNIS_ID	GNIS_NAME	LENGTHKM	REACHCODE	FLOWDIR	WBAREACOMI	FTYPE	FCODE	SI
	3575808	3/9/2009	Medium	517018	Cumberland River	0.856	05130103010306	With Digitized	166899300	ArtificialPath	55800	
	3574700	3/9/2009	Medium	517018	Cumberland River	2.558	05130103010331	With Digitized	166899300	ArtificialPath	55800	
	3574686	3/9/2009	Medium	517018	Cumberland River	0.76	05130103010338	With Digitized	166899300	ArtificialPath	55800	
	3574670	3/9/2009	Medium	517018	Cumberland River	0.116	05130103010345	With Digitized	166899300	ArtificialPath	55800	
	3574668	3/9/2009	Medium	517018	Cumberland River	1.047	05130103010346	With Digitized	166899300	ArtificialPath	55800	
	3574666	3/9/2009	Medium	517018	Cumberland River	1.518	05130103010347	With Digitized	166899300	ArtificialPath	55800	
	3574662	3/9/2009	Medium	517018	Cumberland River	0.094	05130103010348	With Digitized	166899300	ArtificialPath	55800	
	1017709	8/3/1999	Medium	517018	Cumberland River	1.657	05130106000825	With Digitized	10175533	ArtificialPath	55800	
	9351300	8/3/1999	Medium	517018	Cumberland River	3.774	05130106000826	With Digitized	10175533	ArtificialPath	55800	
	9351300	8/3/1999	Medium	517018	Cumberland River	3.226	05130106000826	With Digitized	10175533	ArtificialPath	55800	
	4047740	0/0/4000	1	547040		0.000	0540040000000	torest proved at	40475500	A CELORENCE	65000	
•												

• • • ■ ■ (395 out of 172400 Selected)

iv. Determine the lake outlets. Right click on the NHDFlowline table WBAreaComID and **Summarize** computing minimum Hydroseq and minimum Pathlength creating \NHDPlusV21\Working\LakeOutlets.dbf.

WBAREACOMI	Count_WBAREACOMI	Minimum_Hydroseq	Minimum_Pathlength
166899385	119	430000645	1705.687
11882216	36	430000946	1859.244
19551084	16	430001059	1891.635
18421865	51	430001105	1916.406
18415569	56	430001278	2000.658
18421871	3	430001567	2137.605
10175533	40	430001611	2155.143
166899300	74	430002667	2392.443

There are a total of 8 lakes on the Cumberland. Each lake's outlet is the NHDFlowline that has the Hydroseq value in the Minimum\_Hydroseq column.

v. Open LakeOutlets table. From **Table Options, Joins and Relates->Relate**, relate LakeOutlets.Min\_Hydros to NHDFlowline.Hydroseq. Select all LakeOutlet records and execute the relate. Highlight the first selected NHDFlowline and Zoom to Highlighted. Perform an **Identify** on the lake. This is the outlet to Lake Cumberland.



vi. For LakeOutlets, **Table Options**, **Add Field** RiverKM double. Right click on RiverKM and use **Field Calculator** set it to

(Minimum\_PathLength – 1659.291).

PathLength is the distance from the bottom of the NHDFlowine feature to the network terminous and, in this case, that's the mouth of the Mississippi River. Remember from above that 1659.291 is the PathLength for the mouth of the Cumberland. Therefore, RiverKM now contains the distance from the mouth of the Cumberland for each of the eight lakes. And, of course, by subtracting any two values in this column, we know how far apart the outlets of the lakes are from each other.

La	LakeOutlets								
	OID	WBAREACOMI	Count_WBAREACOMI	Minimum_Hydroseq	Minimum_Pathlength	RiverKM			
	7	166899385	119	430000645	1705.687	46.396			
	1	11882216	36	430000946	1859.244	199.953			
	5	19551084	16	430001059	1891.635	232.344			
	3	18421865	51	430001105	1916.406	257.115			
	2	18415569	56	430001278	2000.658	341.367			
	4	18421871	3	430001567	2137.605	478.314			
	0	10175533	40	430001611	2155.143	495.852			
	6	166899300	74	430002667	2392.443	733.152			

Save the Student5.mxd.

- d. Make a profile plot of stream flow in the Ohio River.
  - i. From NHDFlowline, select the flowlines for the Ohio River GNIS\_ID ='425264' and LevelPathI = 430000004
  - Open NHDFlowline Properties->Fields. Turn off all the fields except ComID, GNIS\_ID, GNIS\_NAME, PathLength, Q0001A and Q0001E Note: Q0001A values are flow from runoff estimates and Q0001E values are flow from gages adjustments.
  - iii. Export selected NHDFlowline table records to OhioAttributes.dbf
  - iv. Open Excel.
  - v. Open \NHDPlusV21\Working\OhioAttributes.dbf in Excel. Make sure to show 'All Files' so Excel will recognize the dbf.

	А	В	С	D	E	F
1	COMID	GNIS_ID	GNIS_NAME	Pathlength	Q0001A	Q0001E
2	1844789	425264	Ohio River	1562.531	283557.635	306436.967
3	1842647	425264	Ohio River	1563.328	283557.298	306436.630
4	1841447	425264	Ohio River	1565.682	283555.609	306434.941
5	1841445	425264	Ohio River	1568.391	283553.154	306432.486
6	1841439	425264	Ohio River	1573.205	283522.224	306401.556
7	1841437	425264	Ohio River	1575.130	283519.617	306398.949
8	1841431	425264	Ohio River	1576.459	283517.802	306397.134
9	1841427	425264	Ohio River	1577.474	283517.353	306396.684
10	1841423	425264	Ohio River	1577.778	283490.719	306370.051
11	1841419	425264	Ohio River	1582.424	283464.688	306344.020
12	1841415	425264	Ohio River	1584.415	283331.218	306210.550
13	1841403	425264	Ohio River	1591.697	283314.074	306193.406

- vi. Sort Pathlength in column D from smallest to largest.
- vii. Highlight columns E and F, right click and select **Format Cells**. Change the decimal places to 3.
- viii. Highlight all the values from row 1 to row 876 in the columns for Pathlength, Q0001A and Q0001E.

ix. **Insert->Charts->Scatter Chart**. Select one with lines connecting the points (the second choice).





- x. The chart x axis is from mouth (on the left) to headwaters (on the right). Notice the places where the flow Q0001A or Q0001E have large changes in value. For example, from the Excel chart we see one around a pathlength of 1600.
- xi. Return to ArcMap. Add Data \NHDPlusV21\US\_Topo\_Maps.lyr to the map. Ignore the "Geographic Coordinate Systems Warning" by clicking **OK**. In the NHDFlowline table, sort the Pathlength column ascending.
- xii. Scroll down to approximately 1600 in the Pathlength column. Highlight the flowline where the large change in Q0001A value (flow volume) occurs (COMID 1840095)

COMID	GNIS_ID	GNIS_NAME	Pathlength	Q0001A	Q0001E
1840043	425264	Ohio River	1628.943	282510.63	294119.48
1840053	425264	Ohio River	1630.178	282509.82	294118.68
1840057	425264	Ohio River	1631.082	282505.92	294114.77
1840069	425264	Ohio River	1632.05	282452.41	294061.20
1840191	425264	Ohio River	1634.556	282437.44	293773.65
1840075	425264	Ohio River	1637.055	252270.69	266387.36
1840193	425264	Ohio River	1637.61	252270.45	266387.11
1840095	425264	Ohio River	1638.479	252269.98	266135.57
1840097	425264	Ohio River	1639.684	205154.58	223191.18
1840105	425264	Ohio River	1641.261	205152.86	223189.47
1840103	425264	Ohio River	1645.906	205147.37	223183.96
1840099	425264	Ohio River	1647.545	205144.81	223181.40
1840087	425264	Ohio River	1649.85	205140.69	223177.28
1840079	425264	Ohio River	1650.759	205137.99	223174.57
1840061	425264	Ohio River	1653.523	205134.71	223171.3
1840047	425264	Ohio River	1654.204	205130.45	223167.03
1840035	425264	Ohio River	1655.276	174840.06	183938.24
1187023	425264	Ohio River	1658.184	174829.92	183928.09
1187023	425264	Ohio River	1659.262	174829.50	183927.67
1187028	425264	Ohio River	1659 864	174829.33	183927 50

xiii. Zooming to the highlighted flowline, we see that this is where the Tennessee River (Region 06 to the south) is discharging to the Ohio.



xiv.	Examining the Excel plot, we see another extreme flow change at a
	Pathlength of 1750.

COMID	GNIS_ID	GNIS_NAME	Pathlength	Q0001A	Q0001E
1186672	425264	Ohio River	1762.993	170969.2	180113.51
1186671	425264	Ohio River	1765.008	170966.13	180110.44
1186671	425264	Ohio River	1767.893	170944.37	180088.66
1186671	425264	Ohio River	1767.923	170930.71	180074.98
1186681	425264	Ohio River	1772.633	170925.83	180070.1
1015862	425264	Ohio River	1772.782	138164.48	144615.79
1015862	425264	Ohio River	1773.413	138164.26	144615.57
1015777	425264	Ohio River	1775.137	138159.92	144611.22
1015772	425264	Ohio River	1775.869	138159.67	144610.97
4045772	405004	OL:- Dive-	4770 000	400450.04	444040.00

xv. If we zoom in to the highlighted flowline above, we see that this is where the Wabash River discharges to the Ohio. The confluence of the Wabash River and the Ohio River explains the sudden change in flow volume.



Profile plots are just one of the many ways that NHDPlusV2 data can be charted to visualize information about the river network.

Save the Student5.mxd.

- e. Navigating with Network Attributes
  - Navigating <u>Upstream Mainstem</u> is relatively easy. Open the NHDFlowline table options and turn on LevelPathID, Hydroseq, DnLevelPat and DnMinorHyd. Then select the level path of the Green River LevelPathI = 430001637. This selects 390 flowlines from where the Green discharges into the Ohio to the top of this level path. This is an <u>Upstream Mainstem</u> navigation.

Save the Student5.mxd.

- ii. To navigate <u>Upstream with Tributaries</u> from the bottom of a level path is more complex and requires an iterative process.
  - A. Starting with the Mainstem navigation from above. Export the selected NHDFlowlines (for Green River's LevelPathI = 430001637) to \NHDPlusV21\Working\Workshop1.gdb\NavResults1, adding NavResults1 to the map.
  - B. This iterative process involves performing a **Select By Attributes** query on **NHDFlowline.** Enter the following text in the Select By Attributes Dialog:

"DnLevelPat" in (SELECT "LevelPathI" FROM NavResults1) OR "DnMinorHyd" in (SELECT "Hydroseq" FROM NavResults1)

Select By Att	tributes	×
Layer:	NHDFlowline <u>O</u> nly show selectable layers in this list	•
Method:	Create a new selection	•
COMID GNIS_ID GNIS_NAM LENGTHKI REACHCO	/E M DE	-
	Null Get Unique Values Go To:	
"DnLevelPa "DnMinorHy	NUM NHUHowiine <u>w</u> HERE: t" in (SELECT "LevelPath!" FROM NavResults1) OR d" in (SELECT "Hydroseq" FROM NavResults1)	А Т
Cl <u>e</u> ar	Verify <u>H</u> elp Loa <u>d</u> Sa <u>v</u> e	
	OK Apply Close	

The selection statement above involves a SQL sub-query, which only works on geodatabase feature classes. This code will not work on shapefiles.

The query is looking for any records from NHDFlowline whose "DnLevelPat" value is also located in the "LevelPathl" field in the NavResults1 feature class, OR any records from NHDFlowline whose "DnMinorHyd" value is also located in the "Hydroseq" field from NavResults1.

Basically, since NavResults1 is the mainstem of the Green River, this Select By Attributes query is looking for any tributaries in NHDFlowline that flow into that mainstem.

Proceeding to the next step (C), use 1 as the value for m.

C. Compare the number of selected records in NHDFlowline to the number of records in NavResults<m>.

If the number of selected records in NHDFlowline is less than or equal to the number of records in NavResults<m>, then the process ends because all of the waters have been found that flow into the starting stream. The final results should look like the picture below.

If the number of selected records in NHDFlowline is greater than the number of records in NavResults<m>, then the Upstream with Tributaries navigation is still finding new waters that flow into the starting stream's network, so the process needs to continue.

Export the selected NHDFlowline records to a new geospatial feature class called

**\NHDPlusV21\Working\Workshop1.gdb\NavResults<m+1>**, where the number <m+1> is m incremented by 1 each time through this step.

So, the file name should be NavResults2 the first time through this step, then NavResults3 the next time, etc.

When prompted, add NavResults<m+1> to the map.

D. Incremented m by 1. Substitute m's new value in the query below. Cut and paste the query into a new Select By Attributes from NHDFlowline.

"DnLevelPat" in (SELECT "LevelPathI" FROM NavResults<m>) OR "DnMinorHyd" in (SELECT "Hydroseq" FROM NavResults<m>)

The query is looking for any records from NHDFlowline whose "DnLevelPat" value is also located in the "LevelPathl" field in the NavResults<m> feature class, OR any records from NHDFlowline whose "DnMinorHyd" value is also located in the "Hydroseq" field from NavResults<m>.

Basically, each time the Select By Attributes is performed another level of tributaries is added to the select. We started with the Green River, then added the tribs to the Green River and then added the tribs to the tribs, and so on until we reach the top of the network that drains into the Green River.

After the Select By Attributes is executed, go to Step C.

iii. The final result of this Upstream with Tributaries navigation from the bottom of the level path looks like this.



Homework assignment: Develop the steps necessary to perform the following navigations:

- 1. Upstream with Tributaries beginning in the middle of the Green River (i.e. up the Green River level path.
- 2. Downstream mainstem from the top and middle of the Green River.
- 3. Downstream with Divergences from the top and middle of the Green River.

There is an NHDPlus desktop tool that performs all of these VAA navigations from an ArcMap toolbar. This navigator performs point-to-point navigations and has many options. The tool is callable from Python. The NHDPlusV2 VAA Navigator is available from the NHDPlusV2 Tools web page.

Save the Student5.mxd and close ArcMap.

## Link Information the Network

Note: If you have not performed the section above entitled "Build Geometric Network and Learn to Navigate", please perform steps a through c of that section now.

During this section of the exercise, we're going to create point and line events that link to the NHD/NHDPlus network. Events use NHDFlowline.Reachcodes and the measure values imbedded in the NHDFlowline coordinates to link external information to a point along the network or a linear section of the network.

A point event is linked to a Reachcode and a measure. A line event is linked to a Reachcode, a from-measure (the starting endpoint of the event) and a to-measure (the ending endpoint of the event).

Note that measures along the one or more flowlines that have a given Reachcode begin at 0 at the downstream end of the Reach and stop at 100 at the upstream end of the Reach.

Events are entries in a table without geometry. The events can be rendered (and the geometry saved) by using the ArcGIS Linear Referencing Toolbox. The event geometry comes from the NHDFlowlines based on the Reachcode and measure values.

- a. Open ArcCatalog.
- b. Create a shapefile for point events:

Right click on **\NHDPlusV21\Working**, select **New->shapefile** and create a point shapefile called **MyPoints**. Use GCS North American 1983 as the coordinate system.

Right click on MyPoints, select Properties->Fields, add fields:

EventID	Text(20)
EventDesc	Text(100)
ComID	Long

c. Create a shapefile for line events:

Right click on **\NHDPlusV21\Working**, select **New->Shapefile** and create a line shapefile called **MyLines**. Use GCS North American 1983 as the coordinate system.

Right click on MyLines, select Properties->Fields, add fields:

Text(20)
Text(14)
Double(9,5)
Double(9,5)
Text(100)
Long

d. Create a shapefile for the line event endpoints. Event endpoints will be used to determine the beginning measure and ending measure of the event.

Right click on **\NHDPlusV21\Working**, select **New->Shapefile** and create a point shapefile called **MyLineEndPoints**. Use GCS North American 1983 as the coordinate system.

Right click on **MyLineEndPoints**, select **Properties->Fields**, add fields: EventID Text(20) WhichEnd Text(1)

- e. Close ArcCatalog.
- f. Open ArcMap.
- g. Add Data \NHDPlusV21\Working\Workshop1.gdb\ hydrography\NHDFlowline.
- h. Create some point events:
  - i. Add Data \NHDPlusV21\Working\MyPoints
  - ii. Add ArcGIS Editor toolbar, if necessary.
  - From Editor toolbar pulldown, select Snapping and add Snapping Toolbar. From Snapping pulldown, make sure that Use Snapping is checked.
  - iv. From Editor toolbar pulldown, select Start Editing and then MyPoints.
  - v. From Editor toolbar pulldown, select Editing Windows and open Create Features window. Select MyPoints.
  - vi. Use the **Map Scale** window to zoom in to about 1:250,000 scale somewhere in the NHDFlowline layer.
  - vii. Click on Construction Tools, then MyPoints in the Create Features window. Now point and click on NHDFlowline features creating points where you would like to have point events. Populate
     MyPoints.EventID with a unique value for each point. Optionally, populate the MyPoints.EventDesc field
  - viii. From Editor toolbar, Save Edits and Stop Editing.
  - ix. Open ArcToolbox, Linear Referencing Tools.
  - x. Open Locate Features Along Routes and fill in the dialog as follows:

S Locate Features Along Routes	X
Input Features	-
MyPoints 💌 🖻	
Input Route Features	
NHDFlowline 💌 🖻	
Route Identifier Field REACHCODE	
Search Radius 0 Decimal degrees	
Output Event Table	
C:\Users\LDM\Documents\NHDPlusV21\Working\MyPointEvents.dbf	
Output Event Table Properties	,
Reachcode	E
Event Type	
POINT	
Measure Field	
Measure -	
To-Measure Field	]
✓ Keep only the closest route location (optional)	
✓ Include distance field on output table (optional)	
✓ Keep zero length line events (optional)	
✓ Include all fields from input (optional)	Ŧ
OK Cancel Environments Show Help	>>

This creates an event table called **MyPointsEvents** and adds it to the map. Open the attribute table and note that the NHDFlowline Reachcode and Measure location for each point have been added to the table.

xi. To render the events in the map, open the Linear Referencing->Make Route Event Layer tool dialog and fill it out like this:

Make Route Event Layer	2	~			X
Input Route Features					
NHDFlowline				- 2	5
Route Identifier Field					
Input Event Table				•	
MyPointEvents				- 2	5
Event Table Properties					
Route Identifier Field					
Reachcode				•	·
Event Type					
POINT				•	
Measure Field					
Measure				•	·
To-Measure Field					
					·
Layer Name or Table View					
MyPointEvents Events1					
Offset Field (optional)				_	
Generate a field for locating errors (optional)				•	
Generate an angle field (optional)					
Calculated Angle Type (optional)					
NORMAL					r
Write the complement of the angle to the angle f	ield (optional)				Ŧ
	ОК	Cancel	Environments	Show Help	>>

This creates a temporary layer in the map called **MyPointEvents Events**. To permanently save the point events with geometry, export the layer to **\NHDPlusV21\Working\MyPointEvents\_Rendered.shp**.

- xii. Remove all the point event tables and layers from the map, leaving only NHDFlowline.
- i. Create some line events:
  - i. Add Data \NHDPlusV21\Working\MyLineEndPoints and \NHDPlusV21\Working\MyLines to the map.
  - ii. Add the **Utility Network Analyst** toolbar to ArcMap if necessary.
  - iii. From the Utility Network Analyst toolbar, use the Analysis pulldown and select Options. On the Results tab select Return Results as Selection. Click OK.
  - iv. From the Editor toolbar, Start Editing and select MyLineEndPoints.

- v. From Editor toolbar pulldown, select Editing Windows and open Create Features window and select MyLineEndPoints in the Create Features window.
- vi. Create a bottom point and a top point for your event. By convention, the bottom point should be downstream of the top point. Open the **MyLineEndPoints** table and populate the WhichEnd field with "B" for Bottom and "T" for Top.
- vii. Populate EventID for both the Bottom and Top points with the same unique identifier.
- viii. From the **Utility Network Analyst** toolbar, select the **Add Edge Flag** tool . Place an edge flag over your bottom point and another over your top point.
- ix. From the Choose Trace Task pulldown, select Find Path.

÷	Analysis •	1-	Find Path 🔹 🗸
---	------------	----	---------------

Click the **Solve** button. The flowlines between your bottom and top points are selected.

x. Use the **Data Management->General->Append** tool as follows:

Input Datasets	
NHDFlowline	
	×
	(Ť
arnet Dataset	
MyLines	
ichema Type (optional)	
NO_TEST	-
ïeld Map (optional)	
EventID (Text)	+
ReachCode (Text)	
NHDFIOWINE.REACHCODE (Text)	×
MHDFlowline, FromMeas (Double)	
ToMeas (Double)	1
MHDFlowline.ToMeas (Double)	
EventDesc (Text)	+
I NHDFlowline.COMID (Long)	
Subtype (optional)	

- xi. From the **Editor** toolbar, click **Save Edits**. Note that the selected flowlines from the **Find Path** solution are now in your MyLines shapefile.
- xii. Calculate the EventID for these records to the EventID you used for the Bottom and Top points.
- xiii. At this point, you may continue to create line events by repeating steps (v) through (xii). When you are finished, continue on with the instructions below.
- xiv. From the Editor toolbar, click Stop Editing. Save edits, if prompted.
- xv. Use Linear Referencing->Locate Features Along Routes to obtain the exact measure values for your Bottom and Top points as follows:

S Locate Features Along Routes	X
Input Features	_ ^
MyLineEndPoints	3
Input Route Features	_
NHDFlowline 🗾 🖻	3
Route Identifier Field	
REACHCODE	•
Search Radius	_
0 Decimal degrees	•
Output Event Table	.
C:\Users\LDM\Documents\NHDPlusV21\Working\MyLineEndPointEvents	3
Output Event Table Properties	
Route Identifier Field	
Reachcode	•
Event Type	
POINT	-
Manager Field	
Measure Held	-
	-
To-Measure Field	_
	•
Keep only the closest route location (optional)	
✓ Include distance field on output table (optional)	
✓ Keep zero length line events (optional)	
Include all fields from input (optional)	Ŧ
OK Cancel Environments Show Help	) >>

- i. Open MyLines table. This contains the lines between the Bottom point and the Top point of the linear events.
- ii. Open MyLineEndPointsEvents table. These are the Bottom and Top points of the new linear events.
- iii. If you created more than one line event, you may have two or more line events on a given reach. Therefore the unique id for each reachcode/event combination in MyLines and MyLineEndPointsEvents is a combination of Reachcode and EventID. To make a join on two fields, one easy way is to combine the fields into one field (called ComboKey below).
  - a. Add field MyLines.ComboKey Text(34). Use Field Calculator value ComboKey to [Reachcode] + " " + [EventID]. This create a unique ComboKey for each line event on a Reach.
  - Add field MyLineEndPointsEvents.ComboKey Text(34). Use Field Calculator to value ComboKey to [Reachcode] + " " + [EventID]

- iv. Now we need to populate the From measure and To measure values on each line in MyLines. Join MyLines with MyLineEndPointsEvents on ComboKey.
  - a. **Select** WhichEnd = 'B' and use **Field Calculator** to value FromMeas = Measure.
  - b. **Select** WhichEnd = 'T' and use **Field Calculator** to value ToMeas = Measure.
- v. Remove Join.
- vi. From **Table Options**, select **Export** for MyLines table to MyLineEvents.dbf
- vii. To render the events, open the Linear Referencing->Make Route Event Layer tool dialog and fill it out like this:

Nake Route Event Layer						•	3
Input Route Features						_	*
NHDFlowline					-	6	
Route Identifier Field							
REACHCODE						•	
Input Event Table						_	
MyLineEvents					-	8	
Event Table Properties						22-38	
Route Identifier Field							
ReachCode						-	
Event Type							
LINE						-	Е
From-Measure Field FromMeas						•	
To-Measure Field							
ToMeas						•	
Laver Name or Table View							
MyLineEvents Events							
Offset Field (optional)							
Generate a field for locating errors ( Generate an angle field (optional) Calculated Angle Type (optional) NORMAL	(optional)						_
	ОК	Cancel	Environ	ments	Show H	lelp >>	

viii. This creates a temporary layer in the map called MyLineEvents Events. To permanently save the line events with geometry, right click and Export the layer to \NHDPlusV21\Working\MyLineEvents\_Rendered.shp.

ix. Remove all the line/point event tables and layers from the map, leaving only NHDFlowline.
j. Link Data to Catchments:

Except for catchments associated with Sinks, each catchment is associated with an NHDPlus network feature. Therefore, another way to link data to the network is to link the data to catchments.

Any landscape raster data can be used to compute catchment attributes. As an illustration, let's use the NHDPlus elevation grids to compute some elevation statistics for NHDPlus catchments.

i. Open the Spatial Analyst Tools->Zonal->Zonal Statistics as Table.



ii. In the **Zonal Statistics as Table** dialog:

> Input raster or feature zone data is the NHDPlus cat grid -\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusCatchment\cat

> **Zone Field** is FeatureID which is the direct link between catchments and other NHDPlus components,

#### input Value Raster is

\NHDPlusV21\NHDPlusMS\NHDPlus05\NEDSnapsot\NED05a\elev

\_cm The elevation grids are by RPU. To create these attributes for all catchments, it would be necessary to run this process for each of the 4 RPUs in Region 05 - 05a, 05b, 05c, and 05d.

Create the **Output table** as \NHDPlusV21\Working\elev\_stats\_05a.dbf.

Set Statistics Type to "MIN\_MAX\_MEAN". Do not use All or Median, because the elev\_cm grid contains too many values to compute median and all 32-bit versions of ArcMap will crash with an "Out of Memory" error.

NOTE: Do not click OK. Environment settings need to be changed.

Szonal Statistics as Table		
Input raster or feature zone data	-	-
D:\Maggie\V2Workshop\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusCatchment\cat	1	
Zone field		
FEATUREID	+	
Input value raster		
D:\Maggie\V2Workshop\NHDPlusV21\NHDPlusM5\NHDPlus05\NED5napshot\Ned05a\elev_cm	6	
Output table		
D:\Maggie\V2Workshop\NHDPlusV21\Working\elev_stats_05a.dbf	2	
Ignore NoData in calculations (optional)	-	
Statistics type (optional)		
OK Cancel Environments Show I	Help >>	]

iii. It's not always necessary, but it's always wise to set several environment settings before running Zonal tools. Click the **Environments...** button.

Set the **Processing Extent** to the extent of the elev\_cm grid.

Set the Snap Raster to the cat grid.

Press OK.

Press OK on the Zonal Statistics as Table.

🛠 Environment Settings		and the later of	X	
<ul> <li>Workspace</li> <li>Output Coordinates</li> <li>Processing Extent</li> <li>Extent</li> </ul>				
Same as dataset elev_cm		▼	<b>E</b>	
	Top 1859775.000000			≡
Left		Right		
573015.000000		1198305.000000		
	Bottom			
	1378035.000000			
Snap Raster				
C:\Users\Cindy\Documents\NHDP	lusV21\NHDPlusMS\NHDPlus05\NH	IDPlusCatchment\cat	2	
* XY Resolution and Tolerance	e			
* M Values				
× 7 Values				
* Geodatabase				
* Geodatabase Advanced				-
		OK Cancel Show H	ielp >>	

- iv. Add Data \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusCatchment\Catchment .shp to the map.
- v. Join Catchment.shp.FeatureID with \NHDPlusV21\Working\elev\_stats\_05a.dbf.FeatureID
- vi. Right Click on **Catchment** and select **Properties**, **Symbology** tab. Select **Quantities-Graduated Colors.** Under **Fields-Value**, select **MEAN.** Set **Classes** to **10** and click **Classify.** In the **Classification**

dialog, Click **Sampling** and change the default value from **10,000** to **500,000**. Click **OK**. The elevation values are large. This is due to the units of the **elev\_cm** grid which is centimeters.

vii. Back on the **Symbology** tab, right click on **Color Ramp** and un-check **Graphic View.** Then select **Elevation #2** from the **Color Ramp** dropdown.

Note: Attributes like Mean, Minimum and Maximum elevation are just a few of many potential attributes that can be allocated to catchments for useful analysis.

Save the project as \NHDPlusV21\Working\Student6.mxd and close ArcMap.

## Analyze Linked Data

- a. Start ArcMap.
- b. Open \NHDPlusV21\Workshop2.mxd.
- c. Add linked data to the map:
  - i. Add Data \NHDPlusV21\LinkedData\EPA\303d\_NHDPlus05\_Lines.shp and NHDPlusV21\LinkedData\EPA\TMDL\_NHDPlus05\_Lines.shp

Symbolize 303d\_NHDPlus05\_Lines with red. These are waters that have been found to be impaired by states.

Symbolize TMDL\_NHDPlus05\_Lines with green. These are impaired waters for which a Total Maximum Daily Load (TMDL) has been computed and possibly implemented.

### ii. Add Data

\NHDPlusV21\LinkedData\USGS\WaterQualityStationsLoc.shp. These are water quality monitoring sites found in the USGS National Water Information System.

### iii. Add Data

\NHDPlusV21\NHDPlusMS\NHDPlus05\VPUAttributeExtensions\CumTot NLCD2011.txt.

- iv. Right Click on CumTotNLCD2011.txt and Export to \NHDPlusV21\Working\CumTotNLCD2011.dbf (this may take a few minutes). Remove .txt file from map.
- d. Investigate impaired waters and TMDLs.

i. Use the **Zoom to XY** tool to go to this location. Set **Map Scale** to 1:125,000.



ii. Turn off the TMDL layer. Note that there are a number of red 303d impaired waters here. Perform an **Identify** on the 303d water shown below.

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iii. Note the field **Src\_FeatID**. This is the identifier assigned by the state to the impaired water. The **DetailURL** field contains a link to more information. If you're connected to the internet, copy the URL and paste it into a browser and examine the EPA data that tells us the impairments and tells us that a TMDL has been completed. The TMDL report is available from a link on the page.

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- iv. Do an **Identify** on the water quality station near the bottom of this stream.
- □ × Identify Identify from: -- WaterQualityStationsLoc United States Geological Survey (USGS) **\$**1 Location: -87.514125 36.798485 Decimal Degrees Ξ Field Value FID 1204 Shape Point ZM ComID 11880716 MEASURE 15.43126 Distance 0.000004 SOURCE\_ORI United States Geological Survey (USGS) SOURCE\_DAT National Water Information System (NWIS) SOURCE\_FEA 03437600 FEATUREDET http://waterdata.usgs.gov/nwis/nwisman/?sit 🐔 EVENTTYPE 57004 GLOBALID {94C28EF9-EDE9-405E-88D6-829F10920264} 05130205000429 Reachcode • Ш Þ Identified 1 feature
- v. Like the 303d data, the NWIS data also provides a URL in the **FeatureDET** field.

vi. Copy and paste the NWIS URL into a browser.

sci		
Na US	ational Water Information System: Web Interface <u>GS Water Resources</u>	
•	<ul> <li>Click to hide News Bulletins</li> <li>June 20, 2016</li> <li>Changes coming this summer to some water-data formats on this website. The changes are minor for most end users. Learn More</li> <li>Use our Mobile-friendly water data site from your mobile device!</li> <li>Full News</li> </ul>	
U	SGS 03437600 S FK LITTLE R AT KY 107 NR HOPKINSVILLE, KY	
S	itream Site	
	DESCRIPTION: Latitude 36°47'54", Longitude 87°30'52" NAD27 Christian County, Kentucky, Hydrologic Unit 05130205 Drainage area: 58 square miles	
	Data Type     Begin Date     End Date     Count       Field measurements     2012-11-15     2013-07-16     9       Field/Lab water-quality samples     2003-03-20     2014-11-06     76	
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Samples Enter the f	<find <u="">parameter codes that include above selection criteria plus one or more of these parameters in a file full pathname of a file containing parameter codes. (Limit: 200 codes)</find>	

2 Tab-separated data One sample per row with remark codes combined with values 
 Default attributes 
 YYYY-MM-DD 
 Save to file
 \*

Table of data Default attributes •

Submit Reset Help

\* Save compressed files with a .gz file extension.

viii. Click on **Table of Data** and **Submit** (both near the bottom of the page). This takes us to a table of the results of all the water quality samples taken at this monitoring site. If you scroll across you can find the coliform measurements which were cited in the list of impairments on the EPA website.

Water Q To view additiona Additional precau	uality al data-qua utions are <u>h</u>	<b>/ Samp</b> lity attributes ere.	oles fo	r the N results using	<b>lation</b>	s: one result	per row, exp	panded attril	butes.							
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Sample Datetime	Time datum ♀	datum reliability ≎ code	Sample Medium ≎ Code	Collecting Sample, Code	width, feet (00004)	water, deg C (00010)	air, deg C (00020)	sure, mm Hg (00025)	sample, code (00028)	charge, ft3/s (00061)	points, count (00063)	height, feet (00065)	@ 25 degC (00095)	calcd, mg/L (00191)	oxygen, mg/L (00300)	of sat- uration (00301)
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2003-06-18 13:30	CDT	К	WS	USGS-WRD	52.0	18.9	27.4	763	80020	70	5		454	0.00002	8.6	93
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2004-06-15 12:30	CDT	K	WS	USGS-WRD	31.0	20.2	28.3	762	80020	E 50	5		464	0.00002	5.4	60
2004-07-14 08:40	CDT	K	WS	USGS-WRD	51.0	22.1	28.9	745	80020	85	5		375	0.00005	7.1	83
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2004-08-10 11:10	CDT	к	WS	USGS-WRD	41.0	19.9	31.2	764	80020	E 90	7	3.65	485	0.00002	8.1	88
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- ix. Let's look for a clue about what might be going on in this stream's drainage area.
- x. Join NHDFlowline.ComID with CumTotNLCD2011.ComID

xi. Do an **Identify** on the flowline underneath the selected impaired stream. We can see that over 60% of the basin for this stream is either Pasture land (NLCD81PC) or Cultivated Crops (NLCD82PC). These can help explain the coliform and nutrient impairments here.





This short exercise illustrates the nearly unlimited capabilities that can be achieved as the water resources community links more and more data to the NHDPlus network.

Save the project as \NHDPlusV21\Working\Student7.mxd and close ArcMap.

# Delineate a Basin/Drainage Area

Note: If you have not performed the section above entitled "Build Geometric Network and Learn to Navigate", please perform steps a through c of that section now.

The basic steps for delineating a basin are:

Establish a Pourpoint on a drainage channel defined by the flow accumulation raster.

Run the ArcGIS Watershed tool to create a basin polygon.

Optionally, fill holes that represent non-contributing areas.

If necessary, add areas in upstream Raster Processing Units: Navigate the network. Select catchments based on navigation results. Dissolve basin polygon and selected catchments.

- a. Create a Pourpoint file.
  - i. Open ArcCatalog.
  - ii. Right click on \NHDPlusV21\Working\ and select New->Shapefile.
  - iii. Create a point shapefile called MyPourpoints.shp. Set the coordinate system to GCS North America 1983.
  - iv. Open ArcMap.
  - v. Add Data \NHDPlusV21\Working\Workshop1.gdb\hydrography\NHDFlowline to map. Symbolize with \NHDPlusV21\NHDFlowline.lyr
  - vi. Add Data \NHDPlusV21\Working\MyPourpoints.shp to map

### vii. Add Data \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDSnapshot\hydrography\NHDWat erbody and NHDArea to map. Symbolize with corresponding layers: \NHDPlusV21\NHDWaterbody.lyr and \NHDPlusV21\NHDArea.lyr

viii. Add Data \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusfdrfac05c\fac and fdr. No need to build pyramids. Turn fac and fdr layers off in Table of Contents.

ix. Use the **Go To XY** tool on the ArcMap toolbar to zoom to the following coordinates. Then use the **Map Scale** window on the ArcMap Toolbar and zoom in to 1:30,000.

	X
Long: -82.613	Lat: 38.441



- x. Using the **Editor** toolbar, **Editor** pulldown a. **Start Editing**, choose MyPourpoints.
  - b. Editing Windows->Create Features
  - c. In Create Features window, Select MyPourpoints
- xi. Using Edit Tool, create a point on the network. Save edits, Stop Editing. Close Create Features window.



xii. Use ArcToolbox **Spatial Analyst-> Hydrology->Snap Pour Point** to ensure that the pourpoint is located on a high value FAC cell. Save the output raster as \NHDPlusV21\Working\pourpoint.



Snap Pour Point	
Input raster or feature pour point data	*
MyPourpoints	- 🖻
Pour point field (optional)	
Id	•
Input accumulation raster	
fac	⊻ 🖆
Output raster	
C:\Users\LDM\Documents\NHDPlusV21\Working\pourpoint	<b></b>
Snap distance	
	50
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OK Cancel Environmer	nts Show Help >>

- b. Create Basin Polygon
  - i. Use ArcToolbox **Spatial Analyst-> Hydrology->Watershed** to delineate the basin in RPU 05c. Save the output raster as \NHDPlusV21\Working\watershed.

Natershed	
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fdr	- 🖻
Input raster or feature pour point data	
pourpoint	▼ 🞽
Pour point field (optional) VALUE	
Output raster	
C:\Users\LDM\Documents\NHDPlusV21\Working\watershed	2
	*
OK Cancel Environments.	Show Help >>

Note: The Watershed command will run for about 15 minutes.

- ii. Zoom to watershed layer. Turn off the NHDFlowline layer to improve the view.
- iii. This basin does not have holes, but it does stop at the RPU boundary. We need to add the upstream portion to have a full basin. To do this, we're going to navigate the network upstream from the top of our current basin and gather the NHDPlus catchments to complete the basin.
- iv. Use the Go To XY tool on the ArcMap toolbar to zoom to these coordinates.

	×
୧୩୦ ୫ ୭ ୫ ୮ = ▼	
Long: -82.144	Lat: 38.838

Then use the **Map Scale** window on the ArcMap Toolbar to zoom in to 1:100,000. Turn back on NHDFlowline layer.



v. From the **Utility Network Analyst** Toolbar, use the **Add Edge Flag** tool to place a flag just inside the basin. From the **Analysis** pulldown, select **Options->Results**. Click on **Return Results As->Selection**. Select **Trace Upstream** from the **Choose Trace Task** pulldown. Click the **Solve** button.



vi. Zoom to the extent of the selected NHDFlowlines.



### vii. Add Data

\NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusCatchment\Catchment.shp

viii. **Relate** NHDFlowline.ComID to Catchment.FeatureID. Open the NHDFlowline table and execute the relate. Zoom to selected Catchment. Right click on Catchment and export selected to \NHDPlusV21\Working\BasinTop.shp ix. In ArcToolbox, use **Conversion->From Raster->Raster To Polygon** to convert the partial basin to a polygon called \NHDPlusV21\Working\BasinBottom.shp.

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watershed		
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VALUE		•
Output polygon features		
C:\Users\LDM\Documents\NHDPlusV21\Wo	rking\BasinBottom.shp	2
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Field Map (optional)	
GRIDCODE (Long)	+
AreaSqKM (Double)	×
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ОК	Cancel Environments Show Help >>

x. Using **Data Management->General->Append**, add BasinBottom into BasinTop.

xi. Using **Data Management->Generalize->Dissolve**, dissolve BasinTop into a single polygon called BasinWhole.

S Dissolve	
Input Features	
BasinTop	
Output Feature Class	
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Dissolve_Field(s) (optional)  FID GRIDCODE FEATUREID SourcEFC AreaSqKM  Select All Unselect All Statistics Field(s) (optional)	· Add Field
Field	Statistic Type
0	K Cancel Environments Show Help >>



xii. Note that the basin contains some holes.

xiii. To get a solid basin, use **Data Management->Features->Polygon to Line** creating BasinLines.shp



xiv. Use **Data Management->Features->Feature to Polygon**, creating BasinPolys.shp

Feature To Polygon	$\sim$					X
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xv. Finally, use **Data Management->Generalize->Dissolve** to create our final basin called MyBasin.

√ Dissolve	9	
Input Features		
BasinPolys		- 🖻
Output Feature Class		
C:\Users\LDM\Documents\NHDPlusV21\Working\MyB	asin.shp	6
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Select All Unselect All Statistics Field(s) (optional)	[	Add Field
Field	Statistic Type	+ × +
	OK Cancel Environments	5 Show Help >>



MyBasin.shp should look like the figure shown above.

Save the project as \NHDPlusV21\Working\Student7.mxd and close ArcMap.

Basin characterization is another exploration of information that has been linked to the NHDPlus network and catchments. Save BasinDelineation.mxd.

As a homework assignment see how many attributes you can develop for this basin. The workshop data already contains a wealth of information in \LinkedData (impaired waters, TMDLs, dams, road crossings, many stream characteristics in StreamCat), \NHDPlusAttributes (slope, streamflow, elevation, stream order), and \VPUAttributesExtension (NLCD, Runoff, Temperature, Precip). Go beyond these sources and search the internet for information that has been generated by 1000's of NHDPlus users.

We hope you've enjoyed the hands-on exercise. Hopefully, you'll be able to take the techniques we've used to further your own NHDPlus applications.

# NHDPlusV2 VAA Navigator – Extra Credit

The best and most complete way to navigate the NHDPlusV2 network is using the NHDPlusV2 VAA Navigator tool. This tool comes with its own ArcMap toolbar and it can also be called from an application you might write in Python. If you anticipate an application that requires navigation, you may want to consider learning about the VAA navigator.

- 1. Visit the NHDPlus website Tools page. Download the NHDPlusV2 VAA Navigator, other required software components, and install/user guides.
- 2. Follow the instructions for installing the VAA navigator. When you install the VAA navigator you get the ArcMap Toolbar and the Python-callable tool.
- 3. Open ArcMap
- 4. Add NHDPlusV2 VAA Navigator Toolbar to ArcMap
  - a. Right Click on an empty spot on the ArcMap Toolbar. Choose Customize.
  - b. Click Add from File. Browse to where the VAA Navigator is installed (default directory is C:\NHDPlusTools\NHDPlusV2VaaNavigatorToolBar). Choose NHDPlusV2VAANavToolbar.tlb. You should see the following response:

Customize		X
Toolbars Commands Options		
Toolbars:		
Added Objects	X	
ClsNavDnDiv clsNavDnMain clsNavToolbar clsNavUpMain clsNavUptrib		
	ОК	
Keyb	oard 😽 Add From File 🤇	Close

c. Click OK.

d. Checkmark NHDPlusV2VAANavToolbar. Click Close.

Customize (Not Responding)					
Toolbars Commands Options					
Toolbars:					
Feature Cache	New				
Feature Construction					
Geocoding	Rename				
Geodatabase History	Delete				
Geometric Network Editing	Delete				
CPS -	Reset				
Graphics					
Image Classification					
Labeling					
Layout					
Main Menu					
NHDPlusV2 VAA Nav Toolbar					
Parcel Editor					
Keyboard 😽 Add From File Close					

- e. Dock navigator toolbar.
- f. Open \NHDPlusV21\Working\Student1.mxd
- g. Zoom in to see individual flowlines about 1:200,000 map scale.

h. Select the **NHDPlusV2 VAA Navigator Up Mainstem** navigation tool. Make NHDFlowline the active layer. Point and click on a flowline. The **Navigation** 

NHDPlusV2 VAA Navigation Options				
Navigation Information				
Navigator Database Path: HDPlusV21\NavigatorDBs				
Navigation Start Options				
Start at top or bottom of "clicked" NHDFlowline				
Start at Reachcode measur 93.3538677073968				
Stop Navigation based on Distance Traveled Navigation Stop Distance: 0 KM				
If a non-zero value is provided, navigation will stop when it reaches that distance from the navigation starting point.				
Filter Navigation Results				
Navigation starts based on the mouse click and start options selected above. Only NHDFlowline features that satisfy the filter condition specified below will be included in the navigation results.				
Attribute Name:				
Operator:				
Attribute Comparison Value:				
Navigate Cancel				

Options dialog will appear.

- i. During the first navigation in a VPU, the navigator will build a SQL database that it will use for all future navigations in that VPU. In the Navigation Information->Navigator Database Path window, browse to a disk location where you have full read/write access. The recommended location is the folder where you have your NHDPlusV2 data installed, which for the workshop is <your path>\NHDPlusV21. Right click on that folder and Add->New->Folder naming it \NavigationDBs. Select this new folder.
- j. Click **Navigate** and wait for the **Navigations Results** to appear in the map **Table** of **Contents**.
- k. Zoom to the **Navigation Results** layer to see the extent of this first navigation.
- I. Click the Go Back to Previous Extent button.

m. Zoom in to the navigation start point (the black dot). Note how the navigation began at the exact point where you clicked on the flowline. This is because we used the default option **Start at Reachcode Measure** in the **Navigation Options** 



- dialog
- n. Using the Up Mainstem navigation tool, click on the same spot again and select the Start at Top or Bottom of "Clicked" NHDFlowline. Click Navigate. Note that this time, the navigation includes the full flowline. This option starts at the bottom of the flowline for upstream navigations and at the top of the flowline for downstream navigations.



o. Right click on **Navigation Results** and open the attributes table. Note that it contains Reachcode, From Measure, and To Measure. In other words, it's an event table.

Navigation Results ×								
	OID	comid	reachcode	frommeas	tomeas	hydroseq	Shape *	
Þ	18	10286344	05120111000065	0	100	430001614	Polyline ZM	
	282	20100942	05120105000095	0	4.15942	430003465	Polyline ZM	
	79	18507600	05120101000058	0	100	430008410	Polyline ZM	]
	46	10286212	05120111000980	0	72.49387	430001706	Polyline ZM	1
	88	18507660	05120101000077	0	100	430009292	Polyline ZM	]
	0	10286960	05120111000001	52.04425	100	430001528	Polyline ZM	]
	180	18508910	05120101000683	0	9.46631	430005527	Polyline ZM	
	34	10286436	05120111000954	70.73265	100	430001696	Polyline ZM	1
	241	10380153	05120113000599	0	100	430001490	Polyline ZM	]
	206	10382135	05120113000296	0	1.97392	430001324	Polyline ZM	]
	131	18509618	05120101000119	0	100	430019106	Polyline ZM	
	111	18509526	05120101000099	0	100	430012698	Polyline ZM	1
	004	00400070	05400405000004	0.0004	CD 0404E	420004055	Deluise 7M	1

- p. Add Data \NHDPlusV21\NationalData\GageLoc.shp.
- q. Join NHDFlowline,ComID with
- r. \NHDPlusV21\NHDPlusMS\NHDPlus05\NHDPlusAttributes\PlusFlowlineVAA.
- s. Join NHDFlowline.ComID with \NHDPlusV21\NHDPlusMS\NHDPlus05\EROMExtension\EROM\_MA0001.dbf.C omID.
- t. Let's discover which stream flow gages are along the navigation results:
  - i. Join Navigation Results.Reachcode with GageLoc.Reachcode.
  - Select Navigation\_Results.Reachcode = GageLoc.Reachcode and Navigation\_Results.Frommeas <= GageLoc.Measure and GageLoc.Measure <= Navigation\_Results.ToMeas. Note that each of the Flowlines in the Navigation Results which are now selected are the location of stream flow gages.
- u. Join GageLoc.SourceFea with GageInfo.GageID.
- v. Symbolize GageLoc with GageInfo.DASQKM in red text.
- w. Symbolize NHDFlowline with TotDASQKM in blue text.
- x. Highlight individual selected records in Navigation Results. Zoom to Highlighted. Compare the red and blue drainage area labels. When the labels have similar values, it's safe to assume that the gage was used to perform EROM stream flow gage adjustment.