Introduction to the National Hydrography Dataset in ArcGIS 9

Objective:

Establish a fundamental understanding of the National Hydrography Dataset (NHD) and its uses with ArcGIS 9.

Recommended Prerequisite:

Introduction to ArcGIS 9 - Basic Concepts
Estimated Time: 2 Hours

The National Hydrography Dataset (NHD) is the surface water component of the National Map. NHD is a comprehensive set of digital spatial data representing the surface waters of the United States. It contains common hydrologic features such as lakes, ponds, streams, rivers, canals, and oceans. These data are designed to be used in general mapping and in the analysis of surface-water systems using geographic information systems (GIS).

Utilizing GIS technology with NHD enables a comprehensive set of embedded attributes that are processed by a computer system. To enhance better understanding of the data the resulting specialized information can then be displayed in customized maps. Hydrographic analyses are possible due to the fact NHD contains a flow direction network that traces water flow upstream and downstream. It also uses an addressing system to link specific information; such as water discharge rates, water quality variables, and fish populations. Using NHD's basic water features, flow network, linked information, and other characteristics, it is possible to study cause and affect relationships; for example, how a source of poor water quality upstream might affect a fish population downstream.

This tutorial will introduce you to the fundamental tasks required to access and utilize NHD at the Maine Department of Environmental Protection (MEDEP). It will focus on using NHD in everyday applications. Examples will include entry-level functions: such as adding NHD data to display surface waters to more advanced tasks that determine utilization of the flow network to select watersheds and display flow directions. The tutorial will also cover the creation of Event Tables that link data to the NHD.

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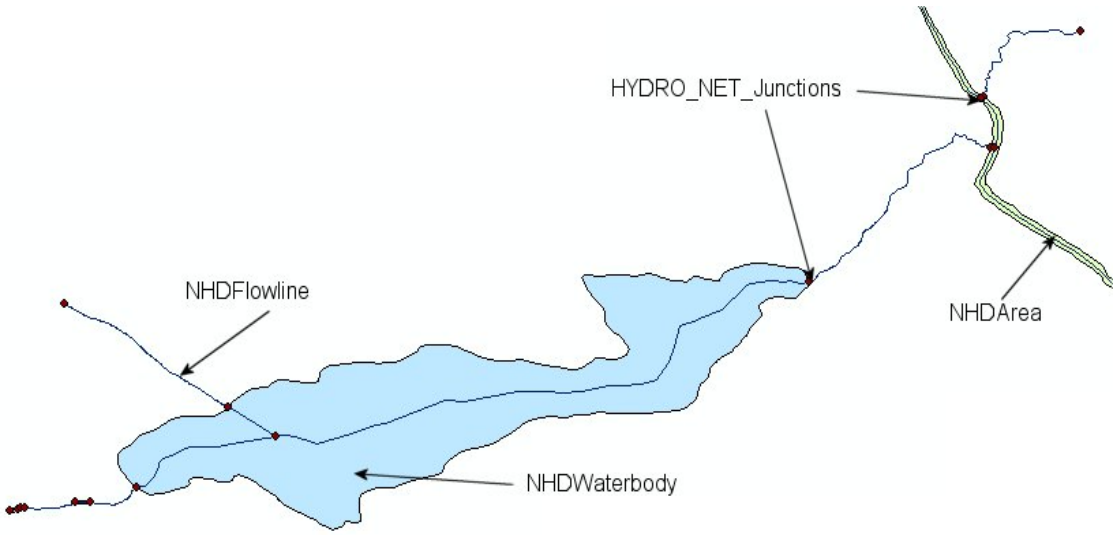
NOTES:

Getting Started

NHD Data Model

The National Hydrography Dataset is collection of feature classes and tables stored in datasets within a geodatabase.

The NHD dataset contains the following feature classes:
HYDRO_NET – This is the geometric network that is used to show flow relations and model surface waters as a connected network.
HYDRO_NET_Junctions – These are the nodes between NHDFlowlines used by the geometric network for flow navigations.
NHDFlowline – This is a line feature that represents all the surface waters. The system consists of streams, artificial paths (a line traversing ponds, lakes and large rivers and streams), coastlines, connectors, pipelines and shorelines.
NHDArea – This polygons feature represents rivers, streams, and ocean waters larger than 100' wide.
NHDWaterbody - This polygon represents waterbody features including: lakes, ponds, swamps and marshes.
NHDLine – A line features representing linear hydrographic landmarks including: dams, bridges or gates.
NHDPoint - Points representing hydrographic landmark features including: gauging stations, rocks, spring/seeps and waterfalls.
NHDPointEventFC – A point event feature currently populated with gauging stations and dam locations
NHDAreaEventFC – An event table not populated at this time.
NHDLineEventFC – A line event table not populated at this time



The NHDArea (Rivers), NHDFlowline (Streams), and NHDWaterbody (Lakes and Ponds) represent the three features that have replaced old hydrography layers.

Each of the above feature classes share a field named **ComID** that acts as the unique identifier relating all the feature classes.

The USGS National Hydrography Dataset Webpage
The USGS National Hydrography Dataset webpage (http://nhd.usgs.gov/techref.html) contains technical documents essential to a detailed understanding of the NHD.

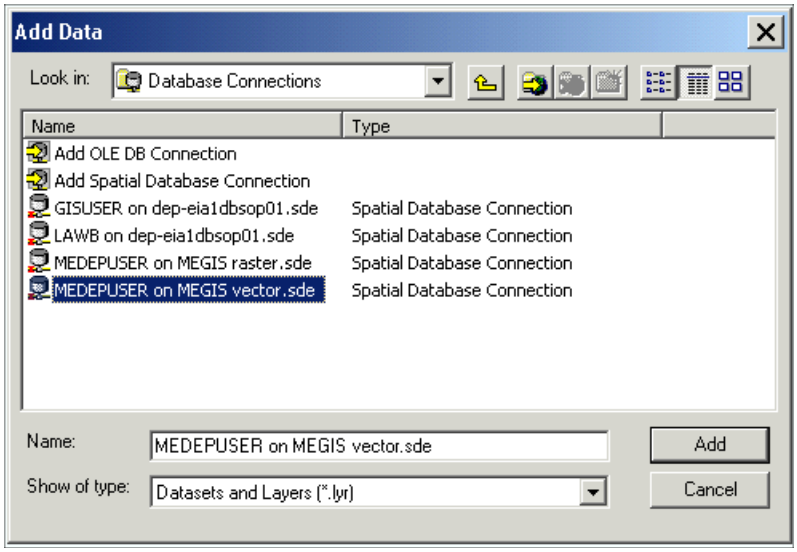
NOTES:

Adding NHD Data

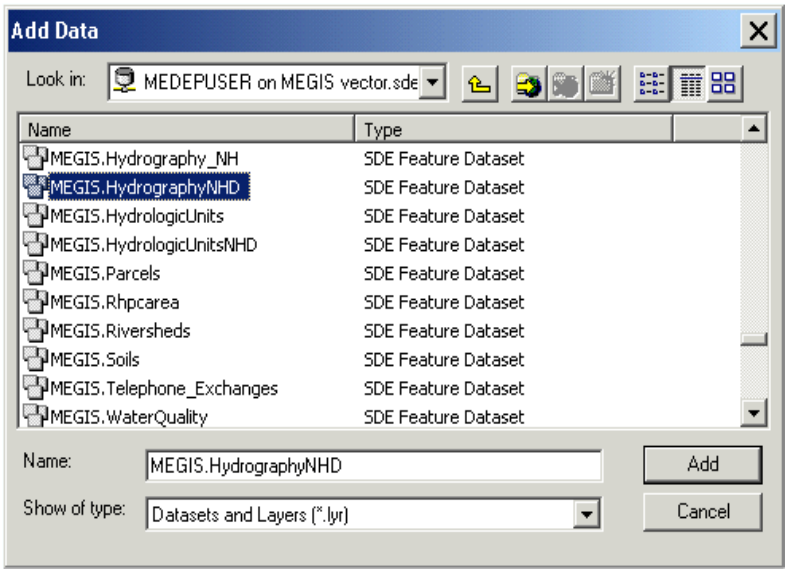
State of Maine Users -

When using the NHD simply as a substitute for hydrography layers three layers will be needed: NHDArea, NHDFlowline, and NHDWaterbody.

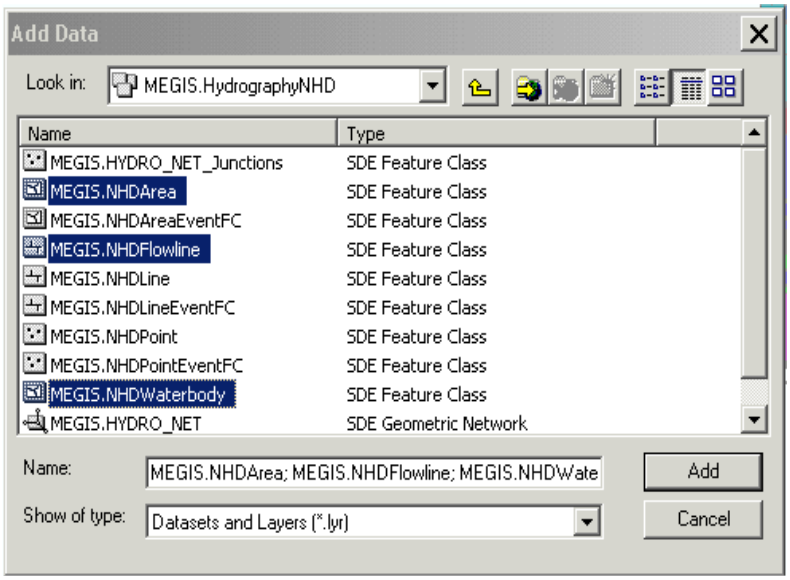
To add the NHD Data select the MEDEPUSER on MEGIS vector.sde from the database connections folder.



Double-click MEGIS.HydrographyNHD.



Select NHDArea, NHDFlowline, and NHDWaterbody and click add.



External Users -
When using the NHD simply as a substitute for hydrography layers three layers will be needed: NHDArea, NHDFlowline, and NHDWaterbody.

The NHD data can be obtained from the USGS through the NHD website (http://nhd.usgs.gov/index.html). The NHD data provided by the USGS in the GCS_North_American_1983 coordinate system. The tools

The USGS provides three ways to access the data including: the ability to download subbasin units, 4 digit subregion units, or the entire State. The three methods are detailed on the Data tab (http://nhd.usgs.gov/data.html) at the above website.

For this tutorial we will download and use the NHD data for the entire State. The USGS NHD data website (http://nhd.usgs.gov/data.html) contains a link to the ftp site with the State downloads (ftp://nhdftp.usgs.gov/StateExtracts/High/FileGDB/). Page down to the zip file titled NHDME.zip and double click on the file, this will open a file download box.

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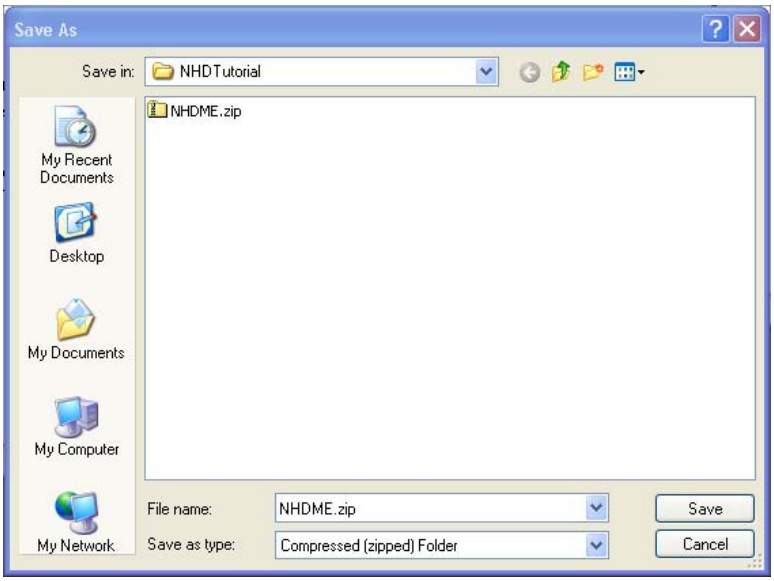
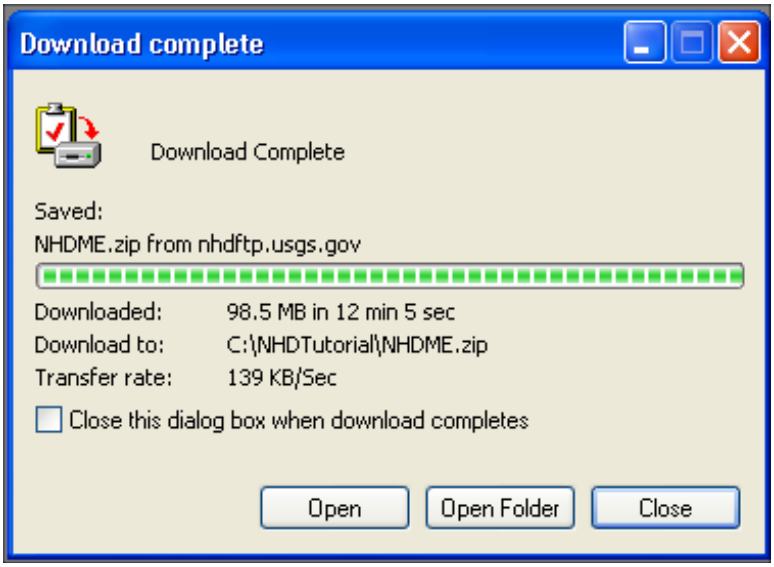
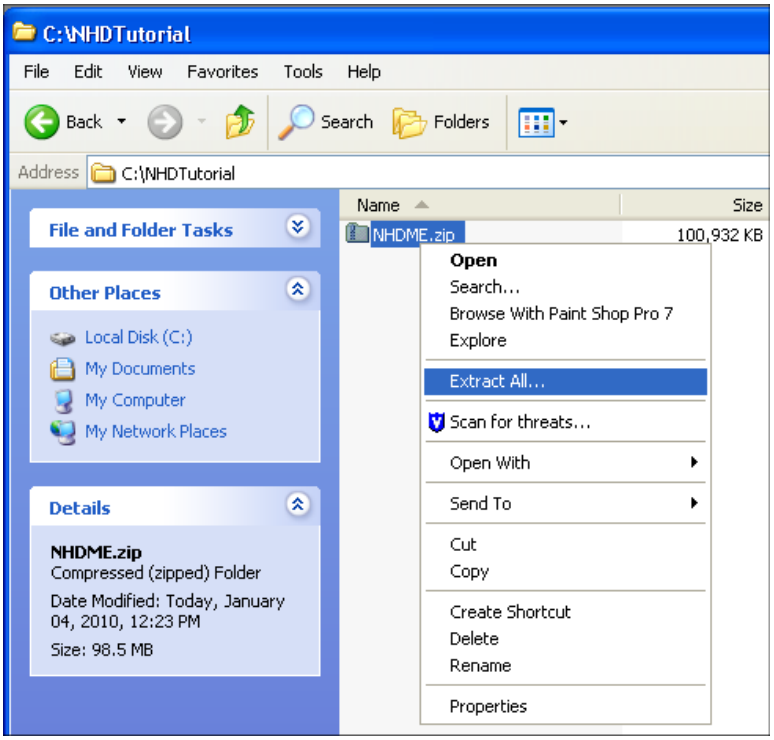
Select Save and you will be prompted to select a location for the file such as C:\NHDTutorial that can be easily found and accessed. Click the save button.



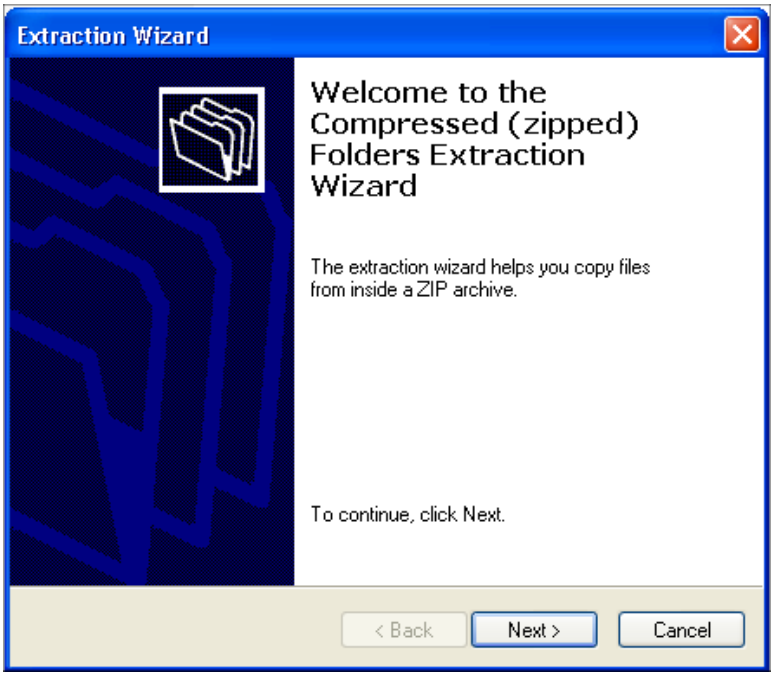
Once the download is complete click on the Open Folder button.



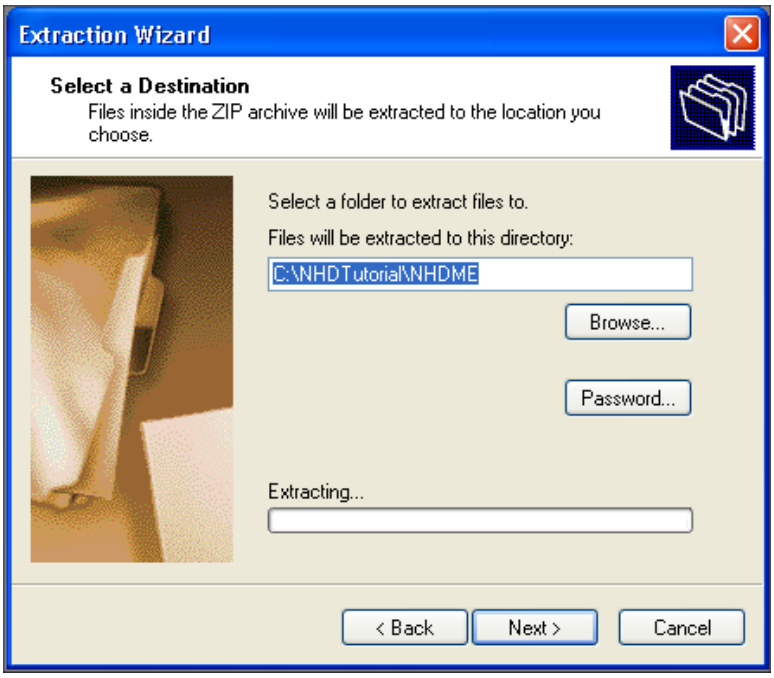
This will open the C:\NHDTutorial folder containing the NHDME.zip file. Right click the zip file and select extract all.



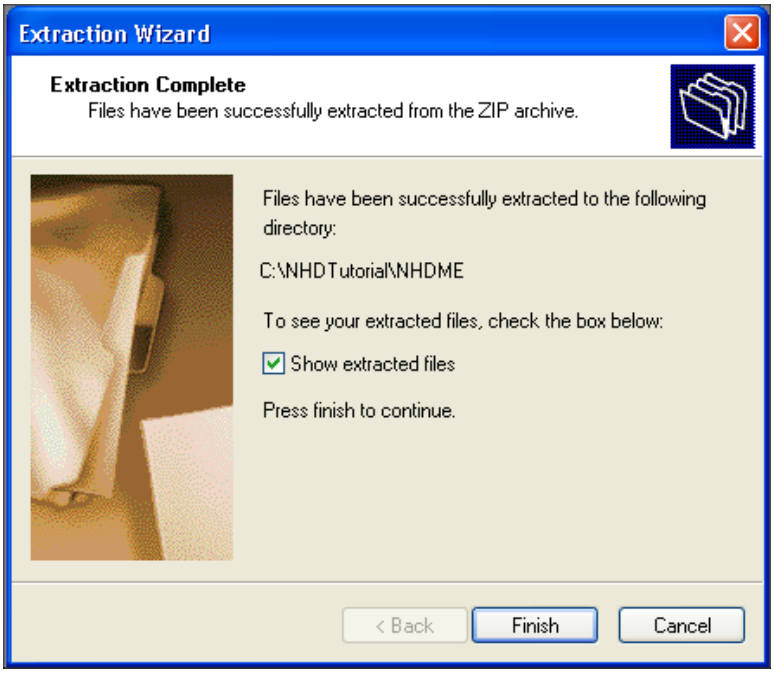
Select next from the Extraction Wizard.



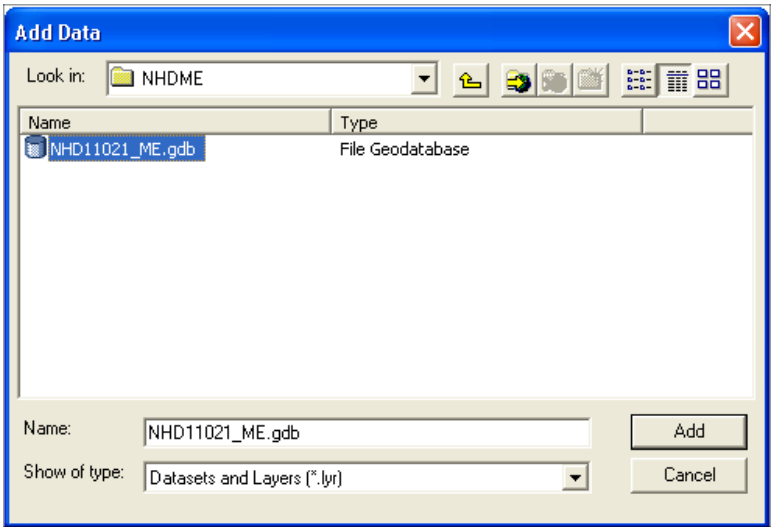
The Extraction Wizard will suggest a new folder within C:\NHDTutorial for the file, click Next.



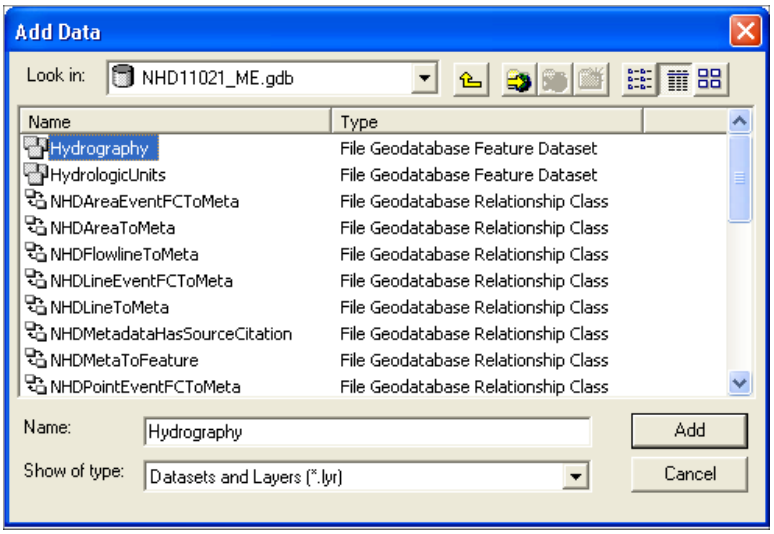
Click Finish once the files have been extracted. The NHD data is now downloaded and ready for use in the directory listed in the Extraction Wizard.



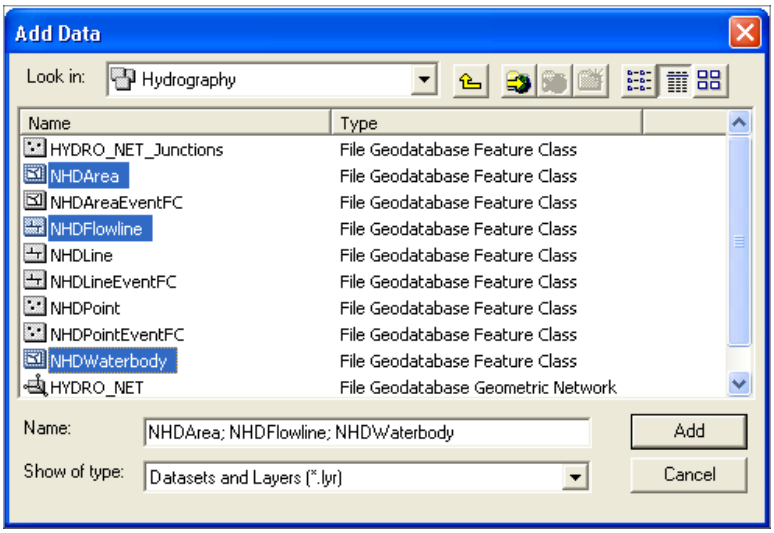
To add the NHD Data select add data from a new empty ArcMap project and navigate to the above directory. Double click the file NHD11021_ME.gdb.



Double-click Hydrography.



Select NHDArea, NHDFlowline, and NHDWaterbody and click add.



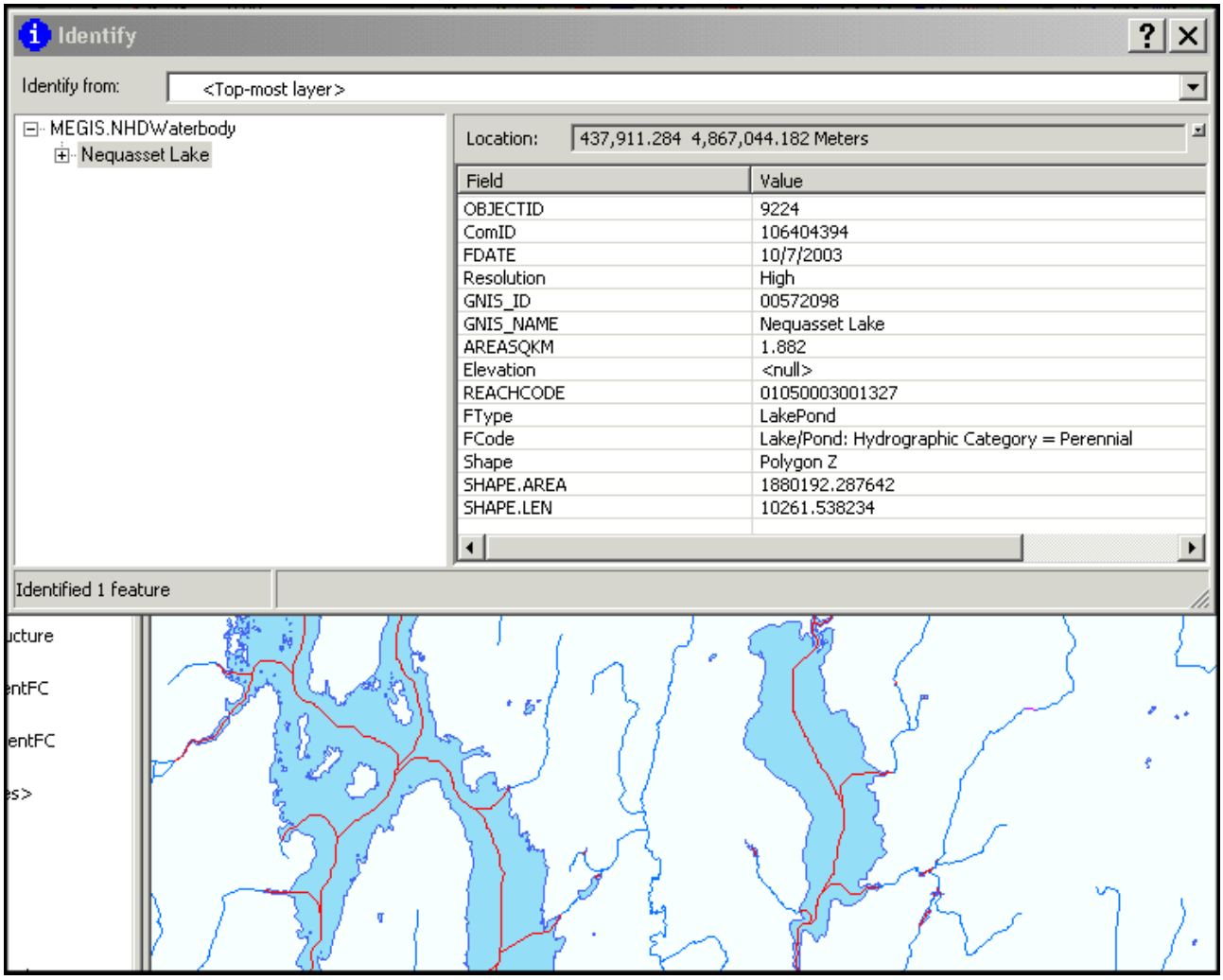
NOTES:

Where's the Metadata?

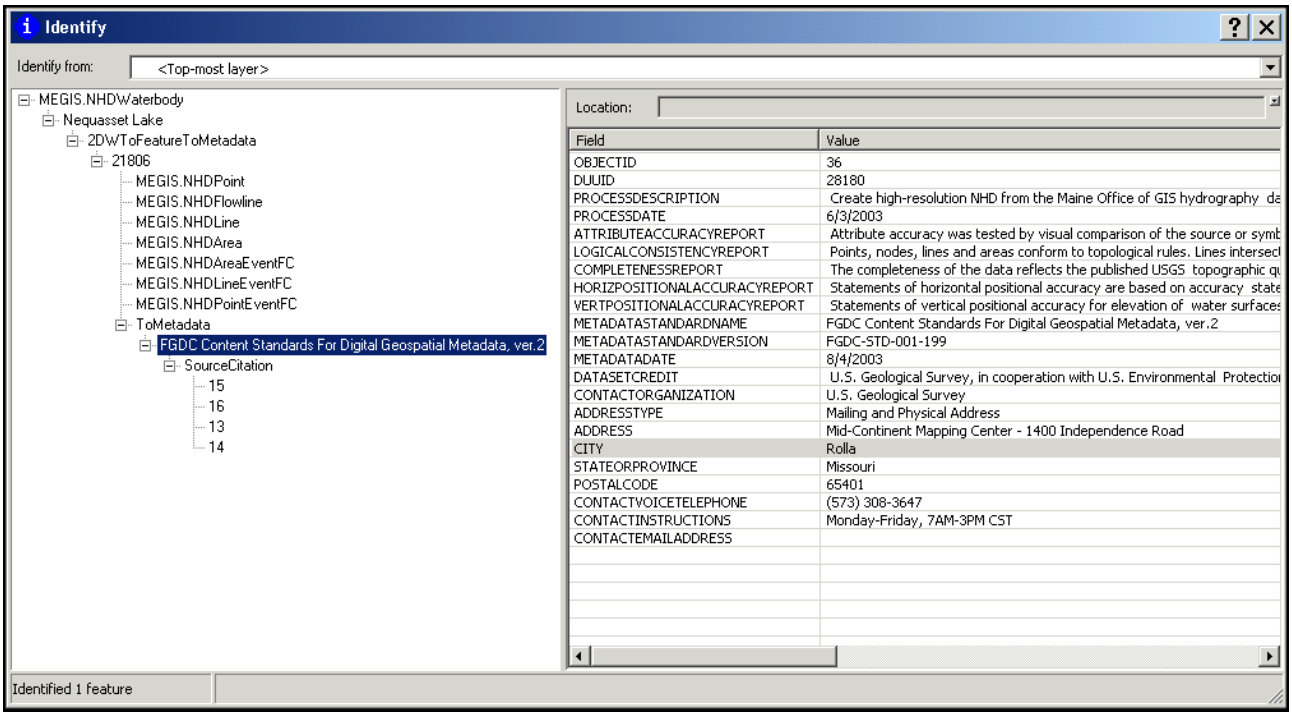
The National Hydrography Dataset's metadata is built into a number of data tables linked to the feature classes within the geodatabase.

Using ArcMap the typical method for viewing the metadata of discrete datasets is to right click the feature class or shapefile in the table of contents and select Data > View Metadata. With the NHD metadata is recorded for each individual piece of the data set.

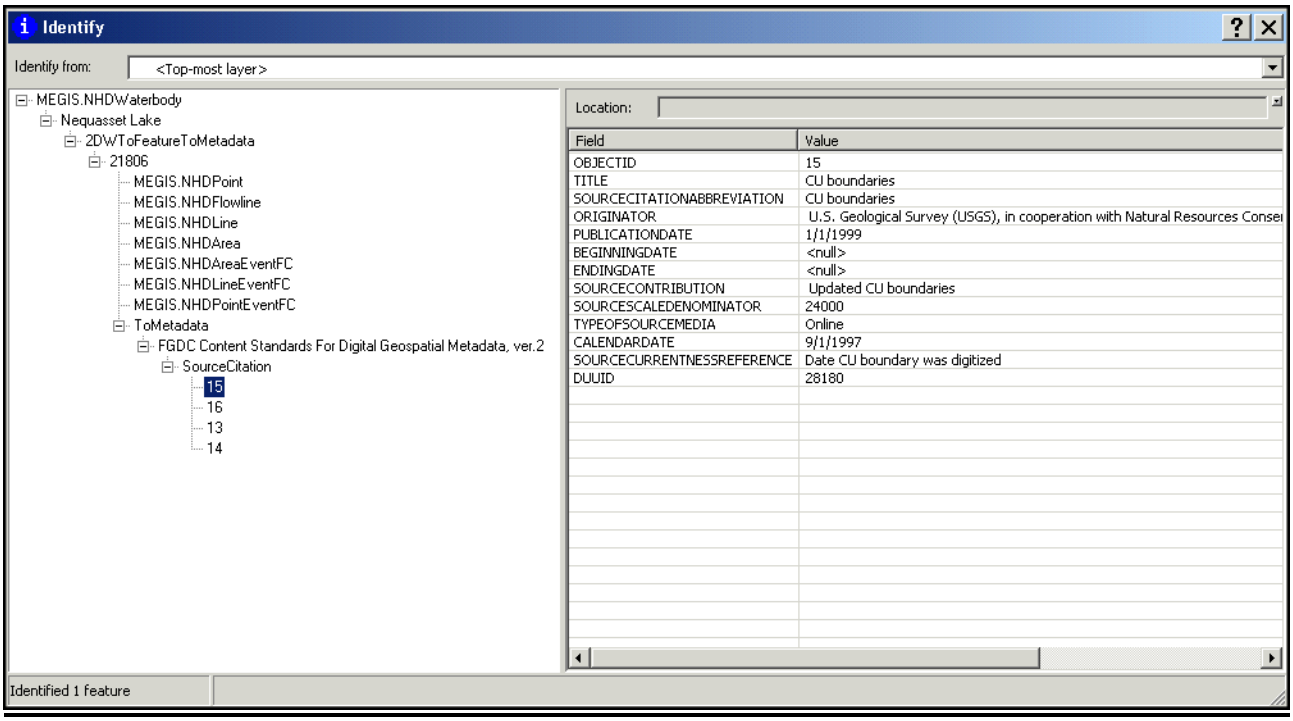
Use the Identify Tool to view the metadata by selecting a feature. In the example below I have selected Nequasset Lake with the tool.



To view the metadata expand all the data below Nequasset Lake. The Metadata for the NHD dataset is listed under the “FGDC Content Standards For Digital Geospatial Metadata, ver. 2”.



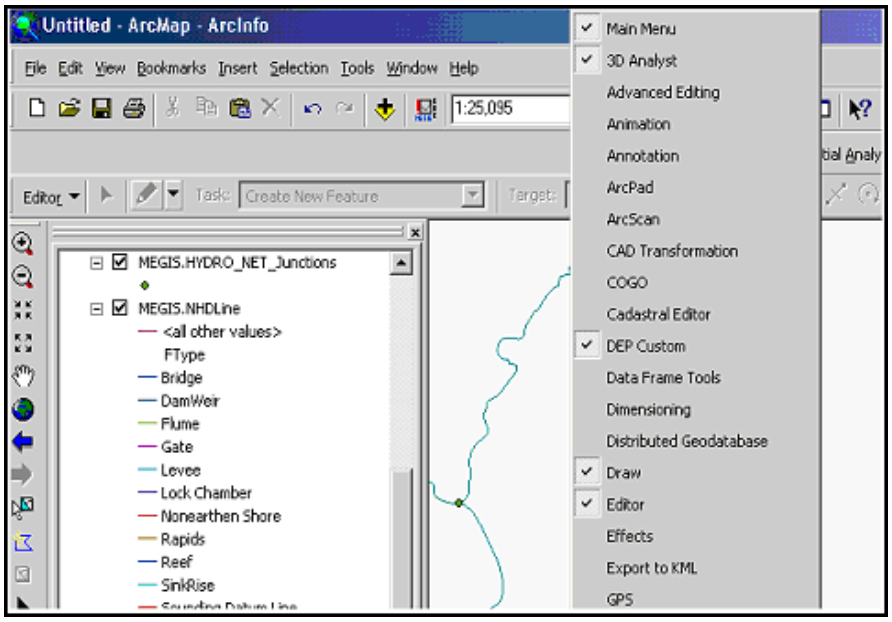
The “Source Citation” lists the details of all instances that the NHDWaterbody’s Nequasset Lake feature has been edited.



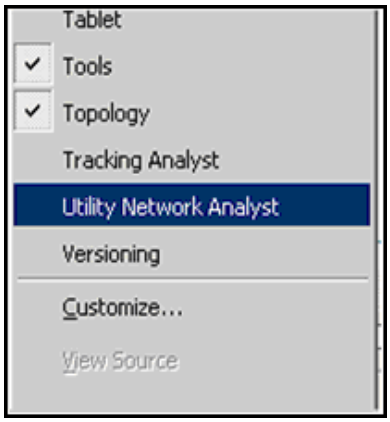
Using NHD Data for Hydrologic Analysis

Utility Network Analyst

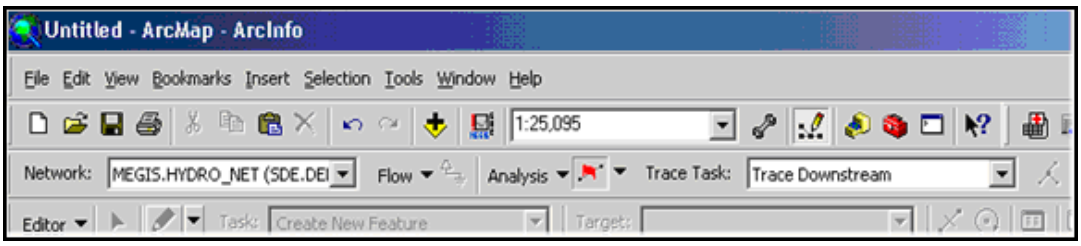
The Utility Network Analyst is a toolbar included in ArcGIS. To add the toolbar right click anywhere in the toolbar to bring up the tool bar menu



Scroll down to the bottom of the menu and select the Utility Network Analyst.



This will open the Utility Network Analyst toolbar.

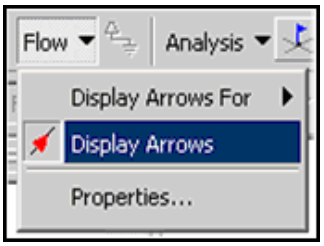


Click the dropdown arrow to the right of the network dropdown box and make sure Hydro_Net is selected.

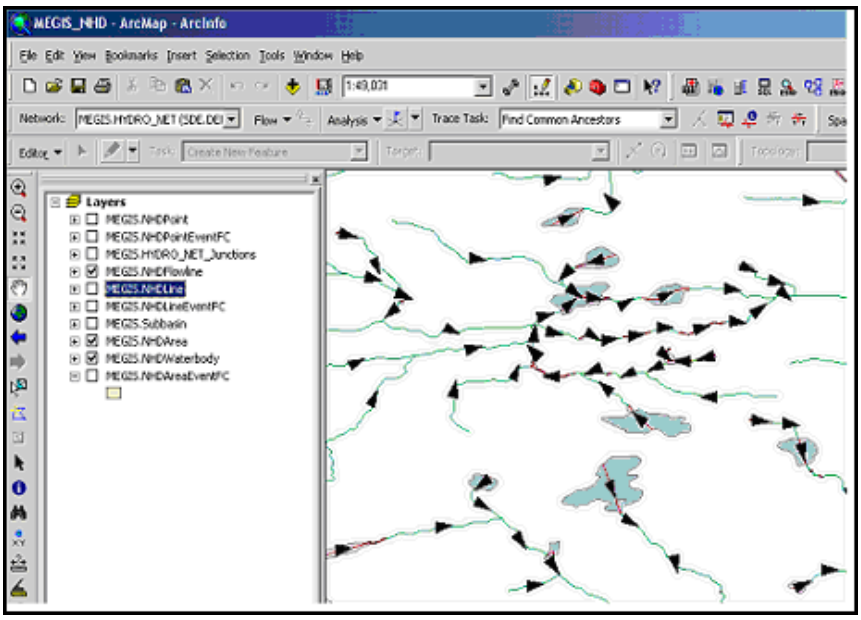
The Utility Network Analyst works with the hydro_net table within the NHD geodatabase. The tool will not function if the ArcMap drawing is in a projection other than that of the NHD. The NHD data available through MEGIS and MEDEP is projected in UTM Zone 19. Users accessing the data through the USGS will download their data in the GCS_North_American_1983 projection.

Display Flow Direction

One of the basic features of the Utility Network Analyst toolbar is the ability to add flow direction arrows to maps. Click on the Flow tab and select display arrows.



Your map will now show arrows depicting the direction of water flow.



Flag and Barrier Tool

The flag and barrier tool allows users to place a flag along the NHDFlowline and follow the network upstream or downstream of its location to the end of the river or stream or to a barrier placed along the flowline.

The Flags and Barriers are used in conjunction with the Trace Task selection and the Solve button. You will always set Flags and/or Barriers then choose the Trace Task and

then click Solve to perform the selection. The Network Analyst will only select whole reaches. If a partial reach is needed see the example Route Location Measures section below.

To use the flag and barrier tool click on the dropdown box next to red barrier

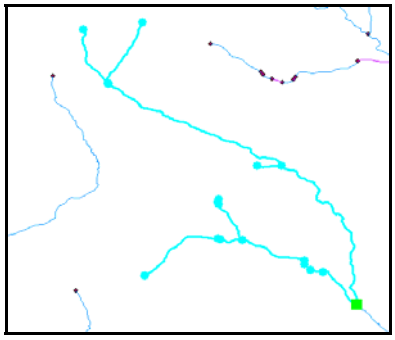
To place a flag click the blue flag on the right side of the flags and barriers tool and then click on any location along a stream or river. The flag on the left will select from a junction of 2 or more lines. A green square will be placed at the selected location.

To place a barrier, click the red barrier on the right side of the flags and barriers tool and then click on a location along a stream or river. The barrier on the left will select from a junction of 2 or more lines. A red X will be placed at the location.

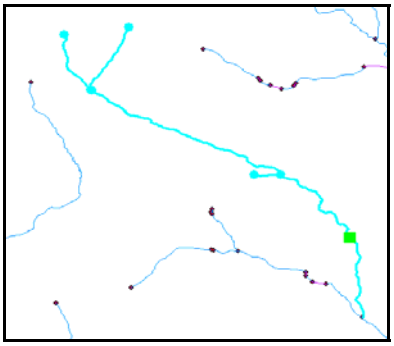
To trace upstream or down select the desired trace from the Trace Task dropdown box and click the solve button, the blue shape to the right of the dropdown box.

Below are a few examples:

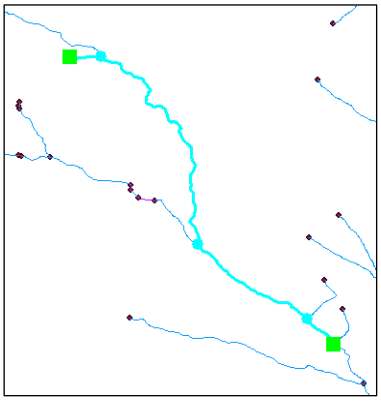
One Flag (green square) at a ***confluence***, traced upstream.



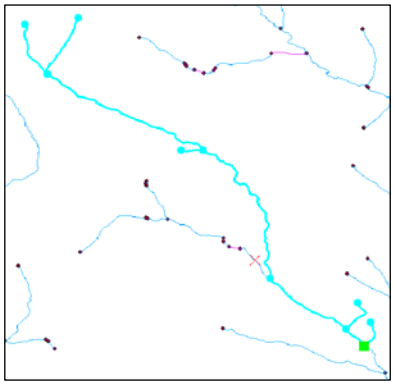
One Edge Flag along a ***reach***, traced upstream.



Two Junction Flags, ***Find Path task***



Junction Flag and Edge Barrier
Trace Upstream task



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After using the too clear flags and barriers between tasks by clicking the Analysis down arrow and selecting clear flags.

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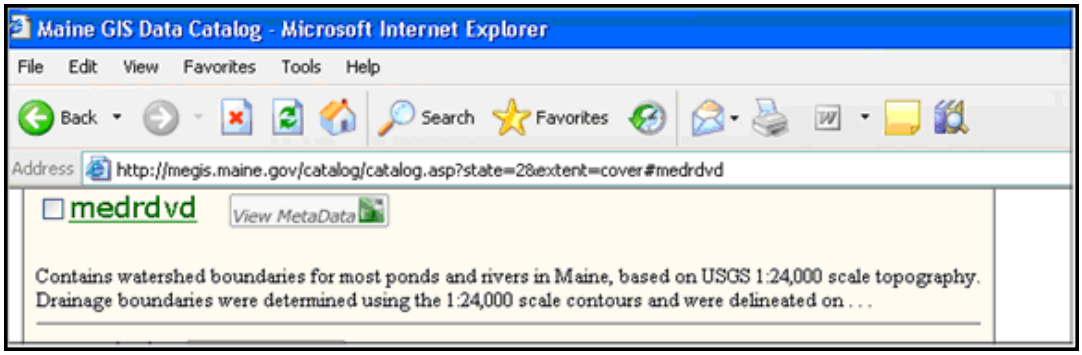
Selecting Data with the Flag and Barrier Tool

The flag and barrier tool may also be used to select data. In this example we will us the tool to select the Hydrologic Units within the watershed of Sebago Lake from the HUC12 data layer.

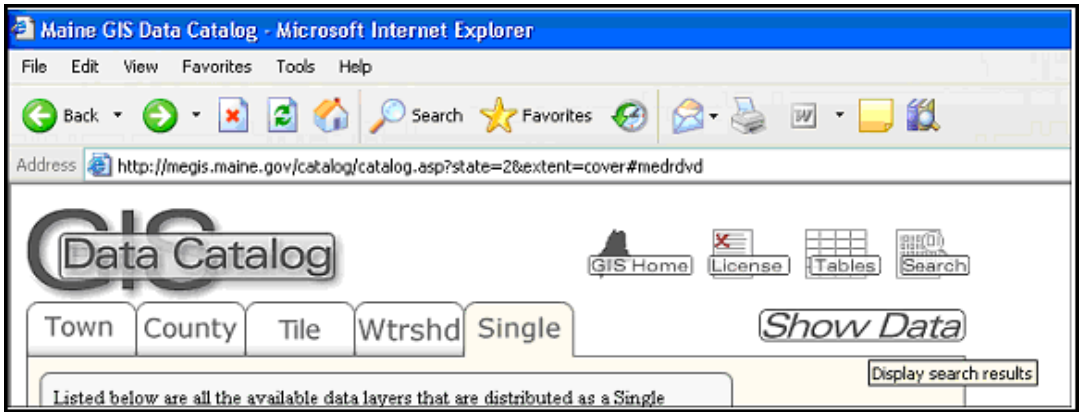
Begin by adding the Drainage Divides layer to your drawing.

State of Maine Users - MEDEPUSER on MEGIS vector.sde MEGIS.MedrdvdPoly.

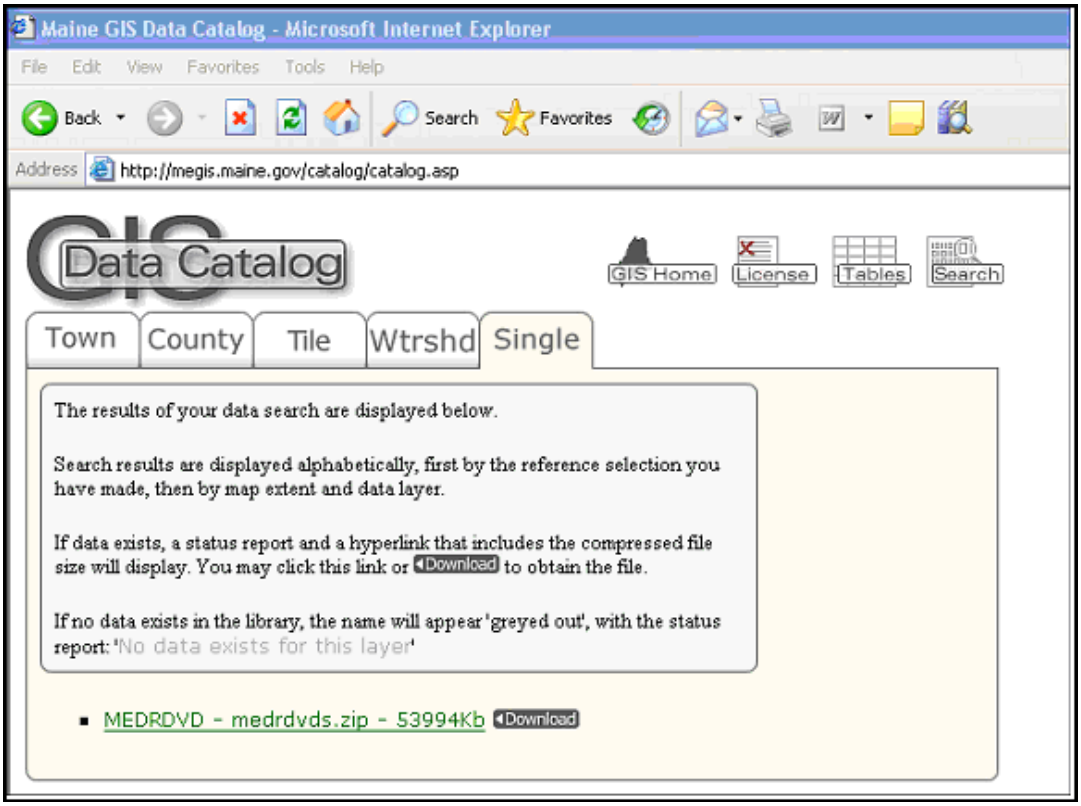
External Users - Follow the link below to the medrdvd layer on the Maine Office of GIS Data Catalog website.
http://megis.maine.gov/catalog/catalog.asp?state=2&extent=cover#medrdvd



Click the check box to the right of the layer name then page up to the top of the page



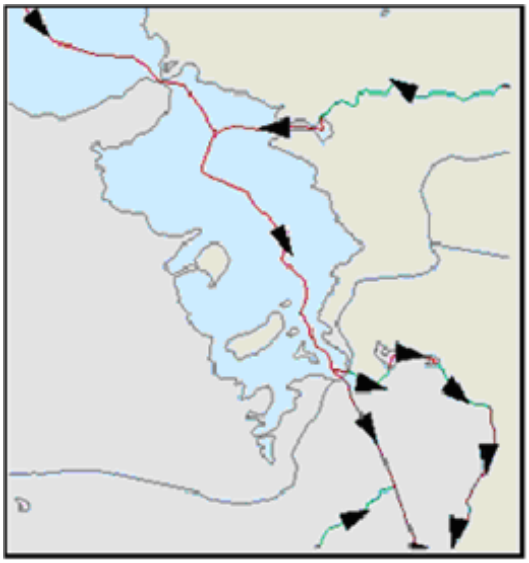
Click on the Show Data icon on the top right. This will open a download window for the layer.



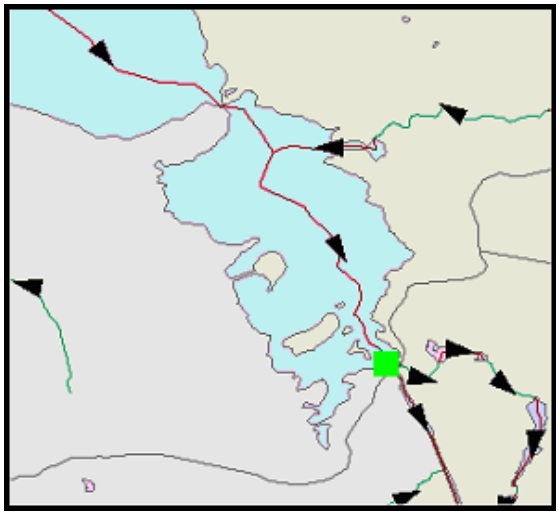
Click the download icon and save the file to your computer. Open the folder and extract the files.

NOTES:

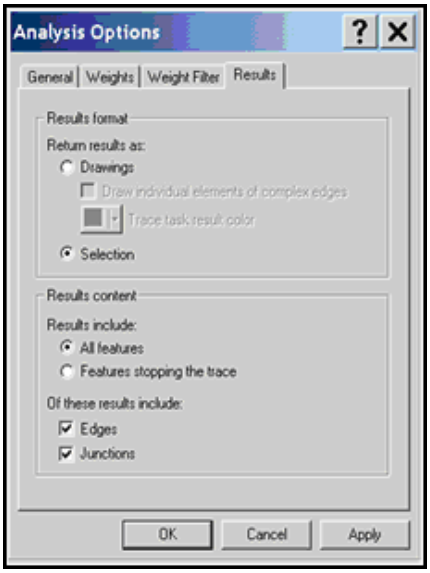
Navigate to Sebago Lake and turn the flow direction arrows on. Find the outlet of the lake and zoom in.



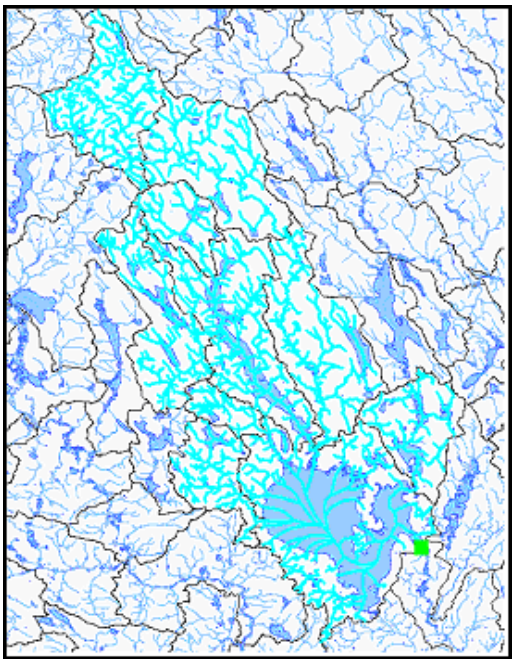
Make sure all previous flags and barriers have been cleared then using the flags and barriers tool select the add junction flag and click on the junction at the outlet of the lake.

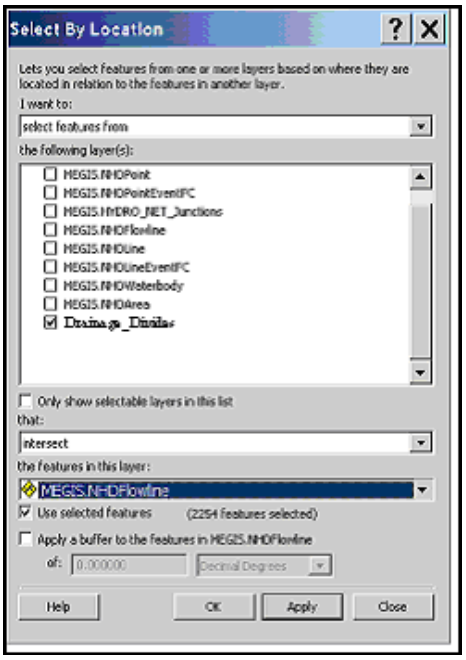


Click the Options tab under the Analysis button to open the Analysis Options box. Under the Results tab click the Selection button under Results format section. This will cause the reaches returned by the Flag Tool to be returned as a selection of the NHDFlowline table.

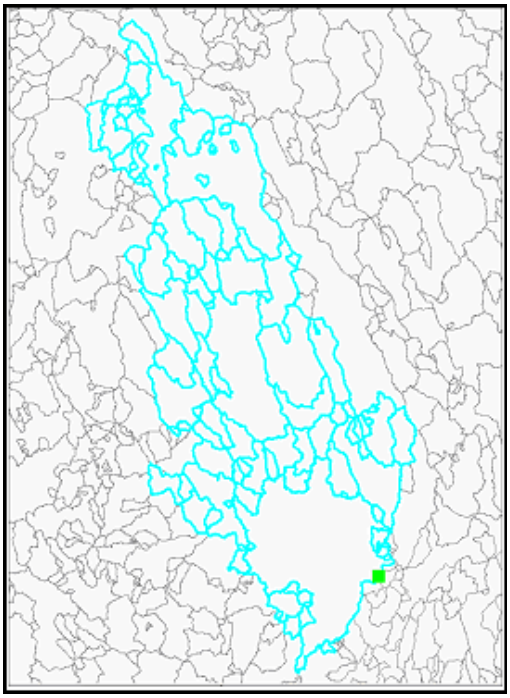


Solve the upstream trace to select the watershed of Sebago Lake. Next select features from Drainage Divides that intersects the selected features of the NHDFlowline layer.





This will return the selected Drainage Divides within the watershed of Sebago Lake.

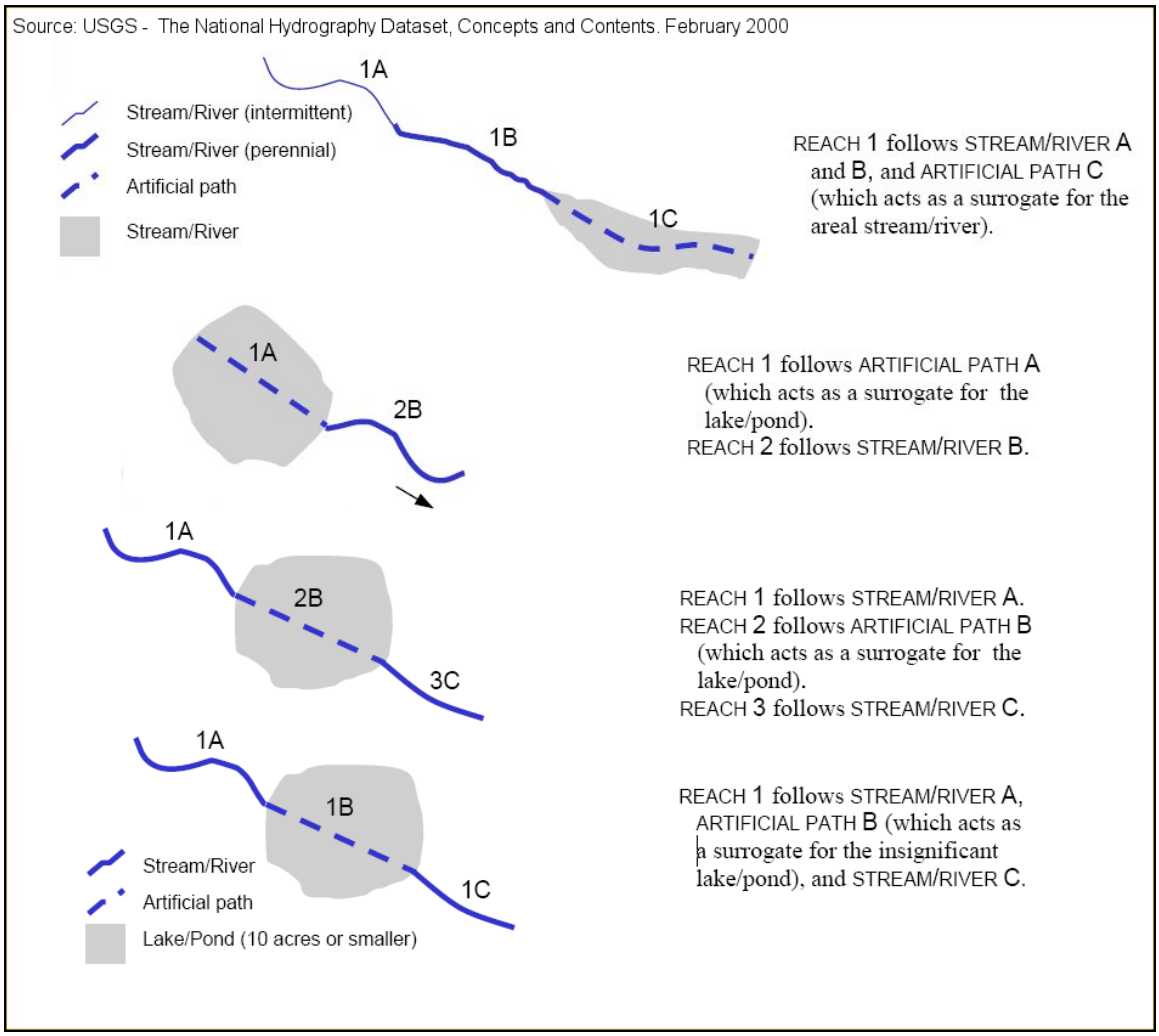


Route Location Measures

The NHD breaks surface waters into pieces called **Reaches**.
A *reach* is continuous unbroken stretch of water. This can include a stream or river between two confluences or a path through a lake/pond. Reaches tend to be waters of similar types. They are often broken at lakes/ponds or confluences but there are exceptions where the other features are not considered significant enough to break the reach. The reaches are given a unique numeric code to label the reaches called the reach code.

NOTES:

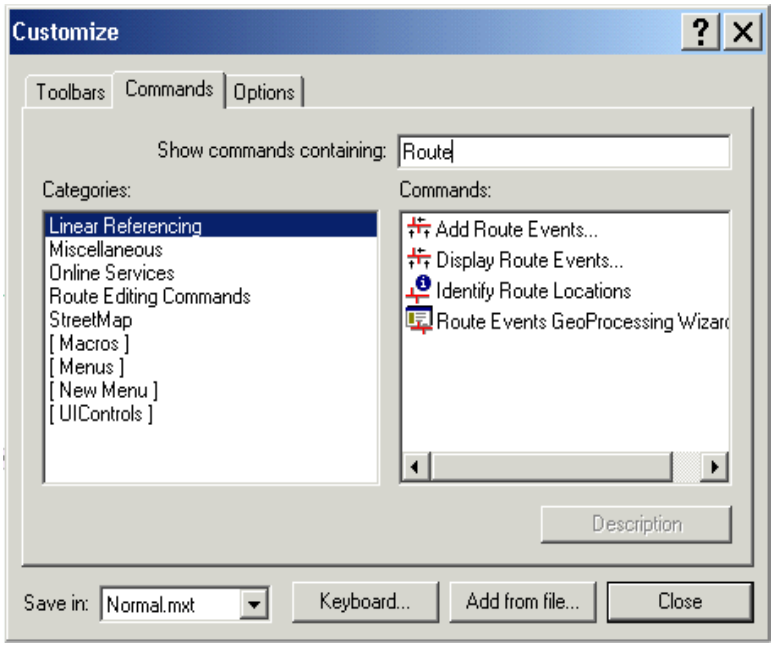
The figure below provides some examples of how waters are divided into reachs.



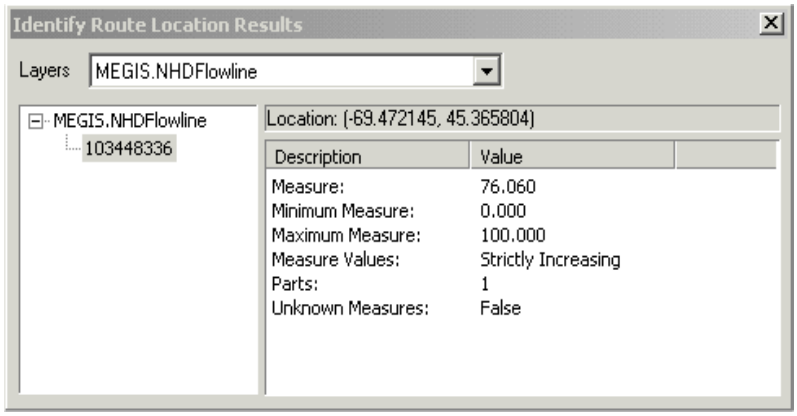
The NHD has an addressing system that can be used to measure distances along a reach.

This is accomplished through the use of identify route locations tool  . To add the tool right click anywhere in the toolbar to bring up the tool bar menu. Scroll down to the bottom of the menu and select customize.

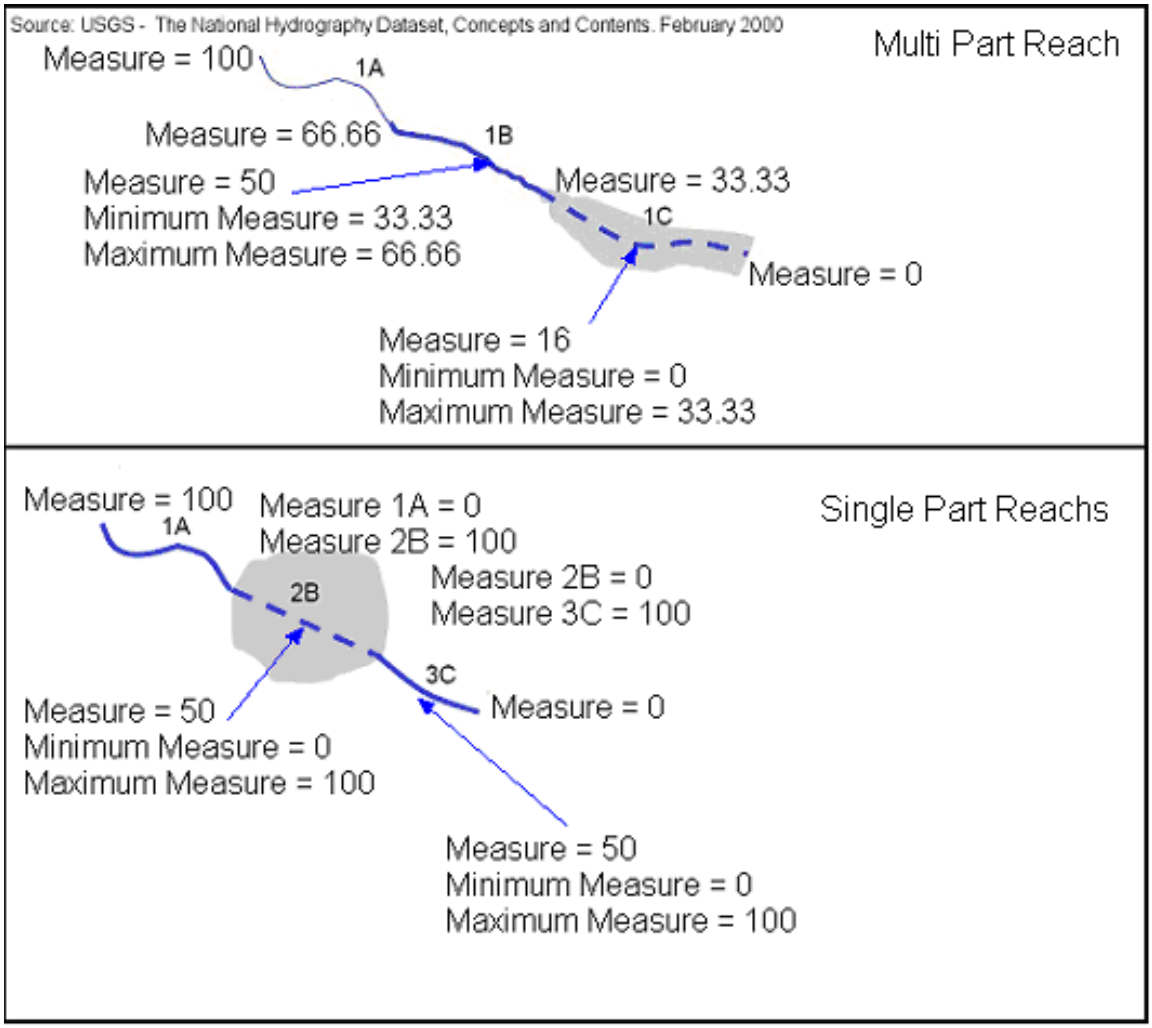
Select the commands tab and type route into the search window. Click the Identify Route Locations tool and drag it to the toolbar.



To use the tool click on a location along a reach. The results table will provide a measurement value for the location along the reach clicked on. It will also provide a minimum and maximum measure for the reach section.

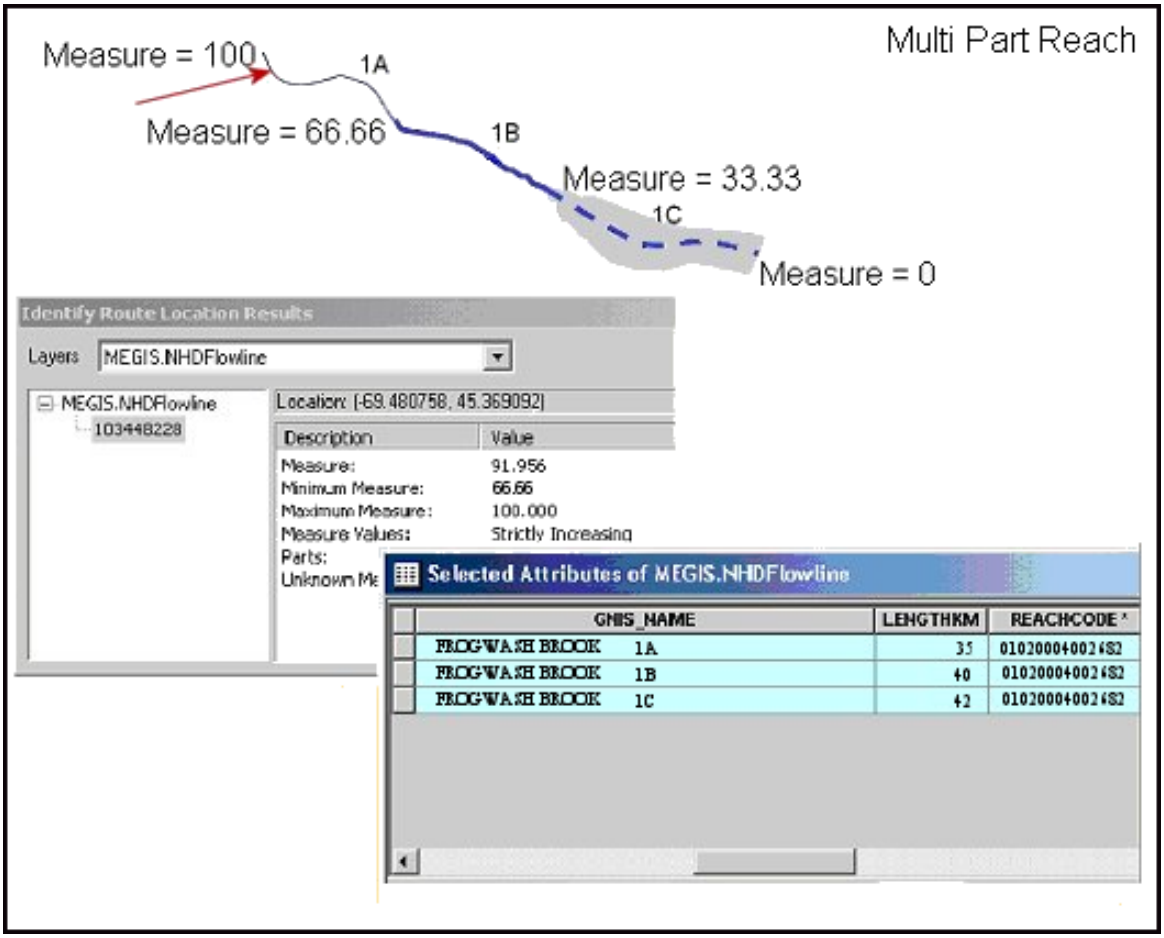


The figure below provides an example of how measurements differ between single and multipart reaches.



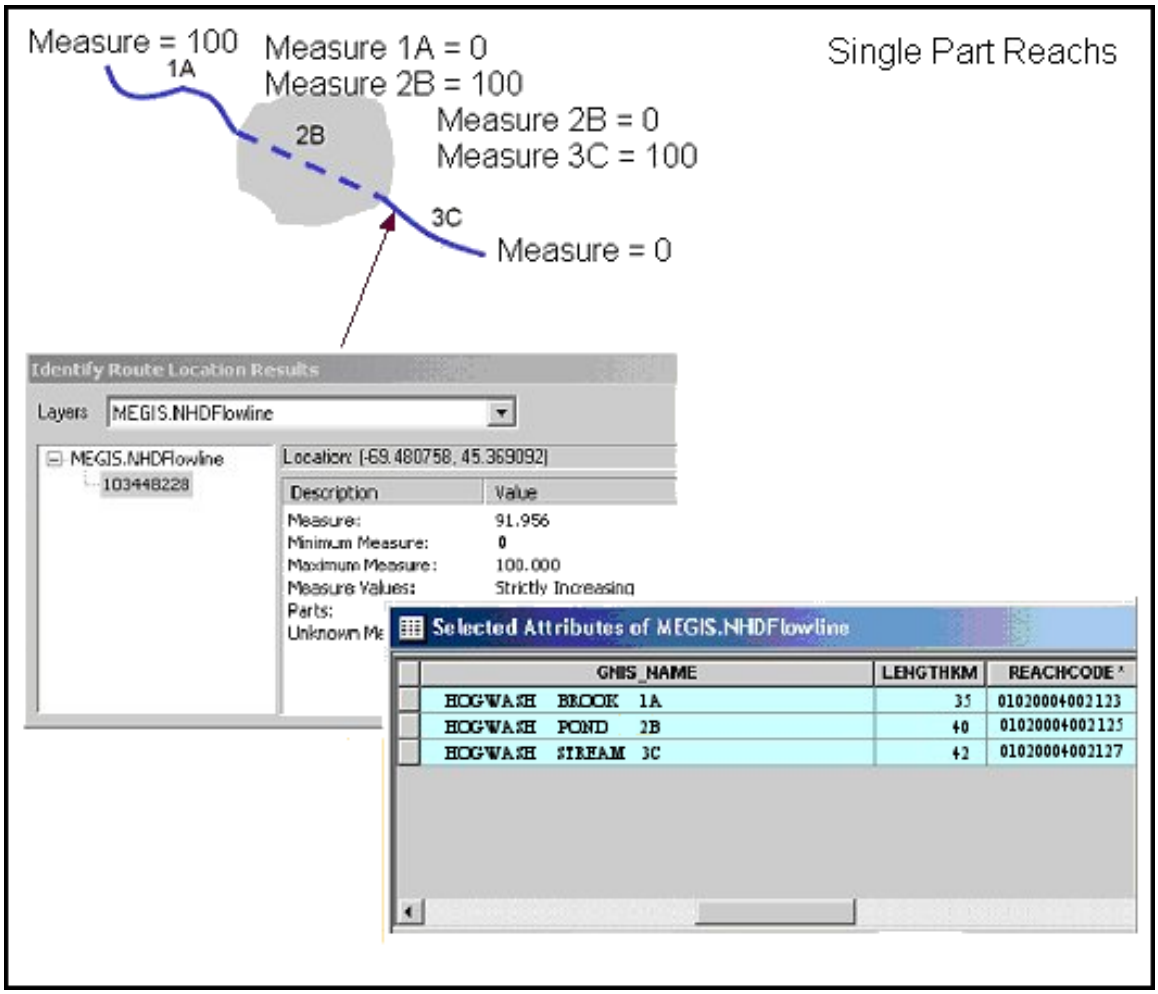
The tool can be used to calculate river lengths in combination with the length data from the NHDFlowline attribute table.

The below example shows the location of the red arrow on Frogwash Brook (a water body composed of three reach parts) to be 91.956% of the selected reach. Using the values in the NHDFlowline attribute table the calculated brook length is .91956 x (35km + 40km + 42km) = 107.56km



NOTES:

The below example shows the location of the red arrow on Hogwash Stream (a single part reach) to be 91.956% of the selected reach. Using the values in the NHDFlowline attribute table the calculated stream length is .91956 x 42km = 38.6km



NOTES:

NHD Event Tables

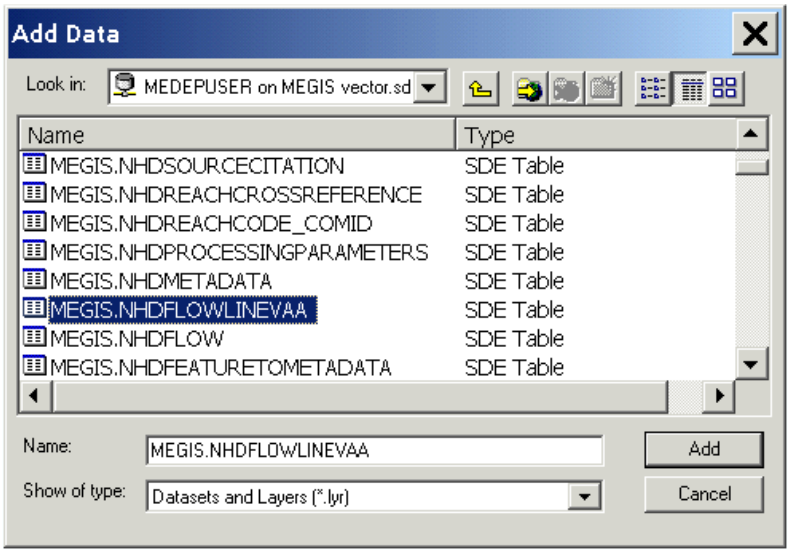
Linking Data to the NHD

Within the NHD, surface water features with their reach codes provide the framework for linking water-related data to the NHD surface water drainage network. These linkages enable the analysis and display of these water-related data in upstream and downstream order. The NHD uses the reach codes as the basis of its addressing systems. In the NHD addressing system, a reach code identifies each reach in the same manner that a street name identifies each street. Reach codes are comprised of the 8-digit watershed code followed by a 6-digit arbitrarily-assigned sequence number. Because a *reach* is the portion of a stream between two points of confluence multiple line segments of a stream my share a common Reach code. Each line segment will have an independent identifier, the ComID.

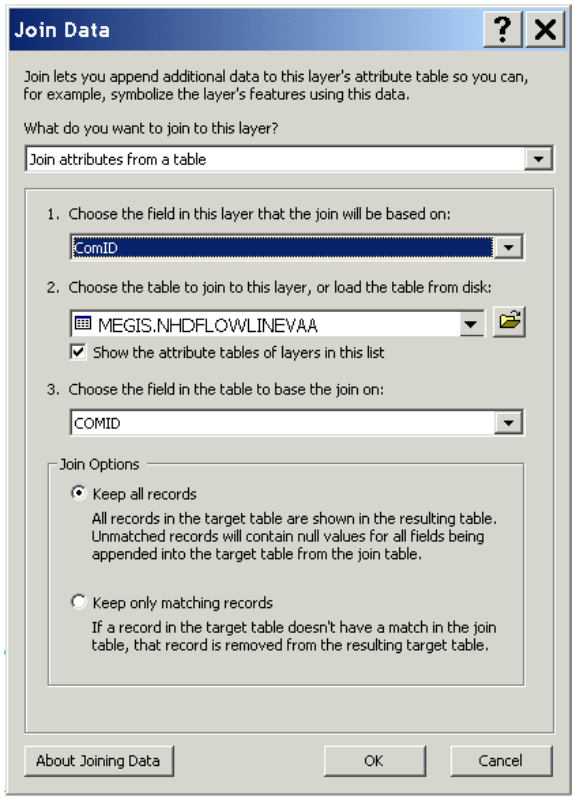
External data may be joined to the NHD for analysis and display purposes. We will use the NHDFLOWLINEVAA table. The NHD Value Added Attributes are a set of 20 attributes that are computed from the NHDFlow table and assigned to each drainage feature in the stream network. The VAAs are designed to enhance the capabilities of NHD in three areas: navigation, analysis, and display. The VAA's are a component of NHDPlus, an integrated suite of application-ready geospatial data sets that incorporate many of the best features of the National Hydrography Dataset (NHD), and National Elevation Dataset (NED). The NHDPlus includes a stream network, improved networking, naming, and "value-added attributes" (VAA's). The VAA table for Maine will have the Stream Level attribute populated at this time. Stream Order is currently being populated through maintenance of the dataset; the rest of the attribute values will follow.

Add the VAA table to your ArcMap project.

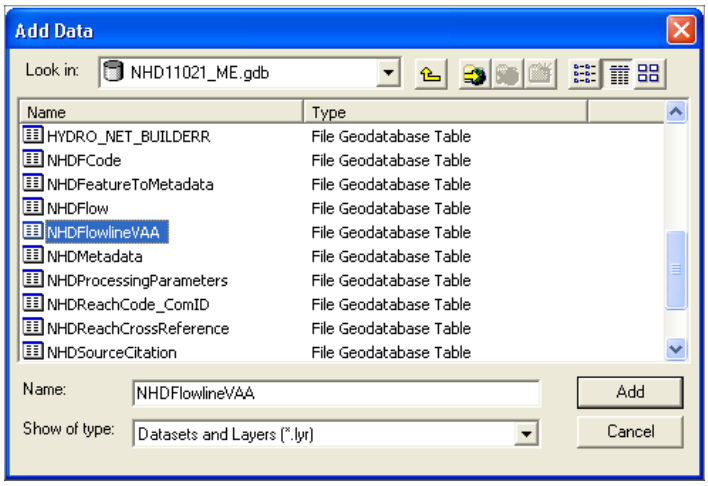
State of Maine Users - Select add data and again navigate to MEDEPUSER on MEGIS vector.sde from the database connections folder. Navigate to MEGIS.NHDFLOWLINEVAA and add.



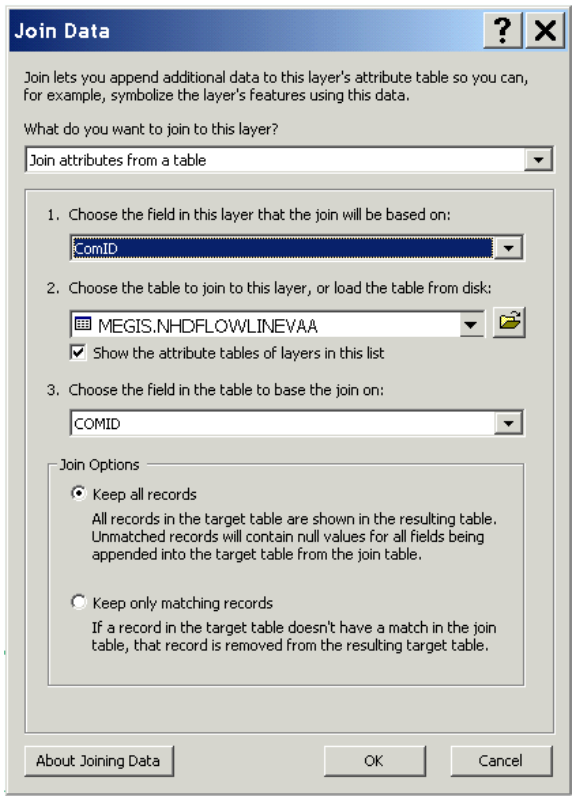
Join the MEGIS.NHDFlowline feature class to the VAA table using the ComID attribute.



External Users - Select add data and again navigate to the location where we saved the NHD geodatabase earlier. Double click the database then navigate to NHDFLOWLINEVAA and select add.

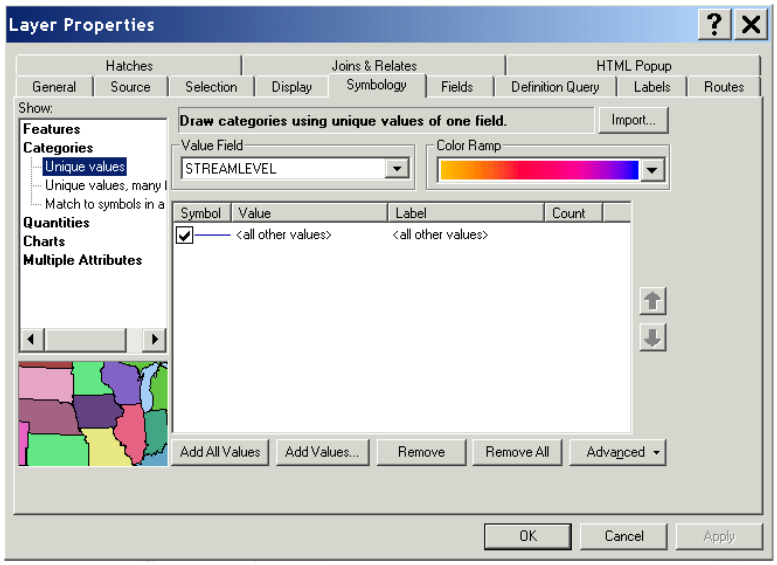


Join the NHDFlowline feature class to the VAA table using the ComID attribute.

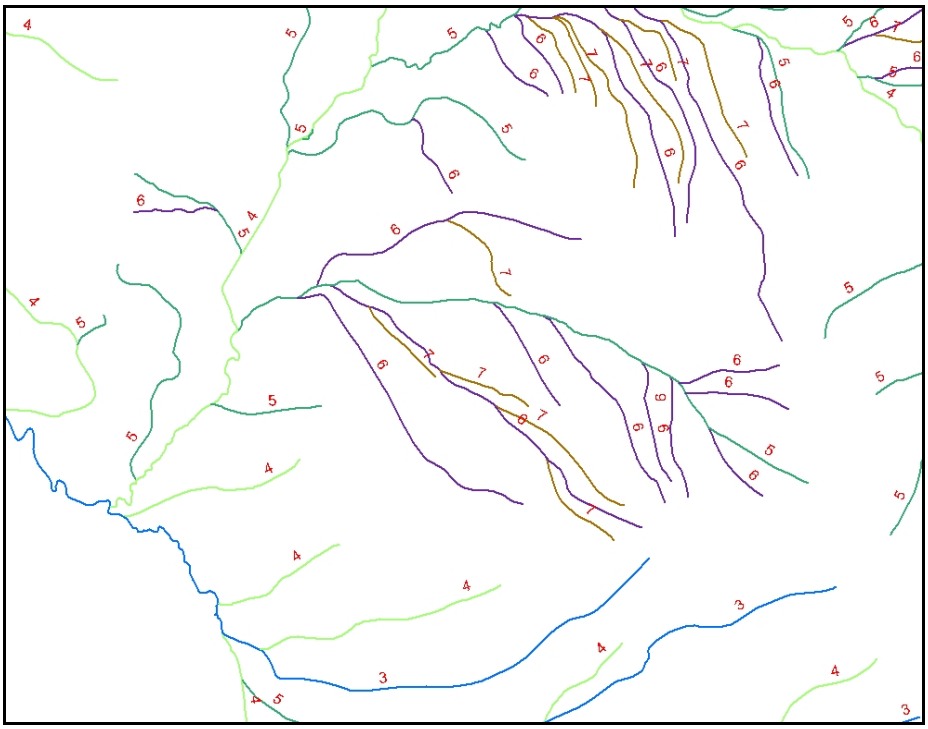

Join Data
Join lets you append additional data to this layer's attribute table so you can, for example, symbolize the layer's features using this data.
What do you want to join to this layer?
Join attributes from a table
1. Choose the field in this layer that the join will be based on:
ComID
2. Choose the table to join to this layer, or load the table from disk:
MEGIS.NHDFLOWLINEVAA
Show the attribute tables of layers in this list
3. Choose the field in the table to base the join on:
COMID
Join Options
Keep all records
All records in the target table are shown in the resulting table. Unmatched records will contain null values for all fields being appended into the target table from the join table.
Keep only matching records
If a record in the target table doesn't have a match in the join table, that record is removed from the resulting target table.
About Joining Data
OK
Cancel

NOTES:

Right click the NHDFlowline layer and open the properties. In the layer properties click the symbology tab. Symbolize the value field for STREAMLEVEL.



Click the Add All Values button and label with the field stream level. You can now see the stream level values for the stream network.



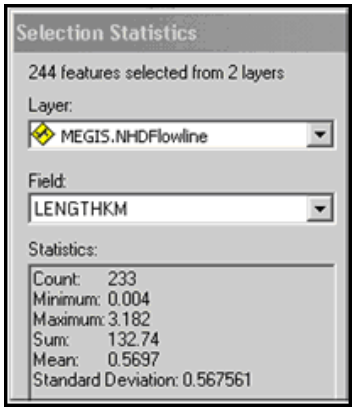
External data in the form of shapefiles or data tables can be made “NHD enabled” by linking them to the NHD reach codes. The Maine Department of Environmental Protection has created links that allow the NHD to be used to show attributes of waters that include: water quality classifications based on water quality, program specific codes for waters, and EPA ratings of impacted waters.

The above are only a few of the possibilities available to users of the NHD.

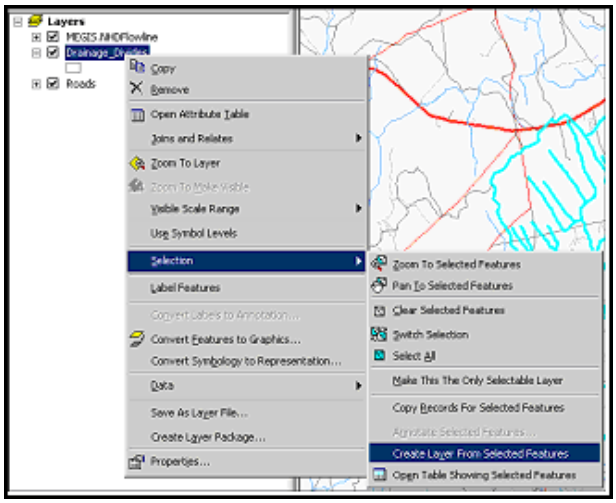
Final Example

We will use this final example to tie together some of the possibilities within the NHD by creating a "NHD enabled" data set of unimpacted Atlantic Salmon habitat within the Ducktrap river.

Starting with a new ArcMap project add the NHDFlowline layer, the Drainage_Divides[1] and the Roads[2] layers. From the NHDFlowline layer select the Ducktrap River and zoom to the mouth of the river. Place a flag at the mouth and trace the river upstream. Using the selection statistics tool we see that there are 132.74 km of waters potentially available to Atlantic Salmon in the Ducktrap River watershed.

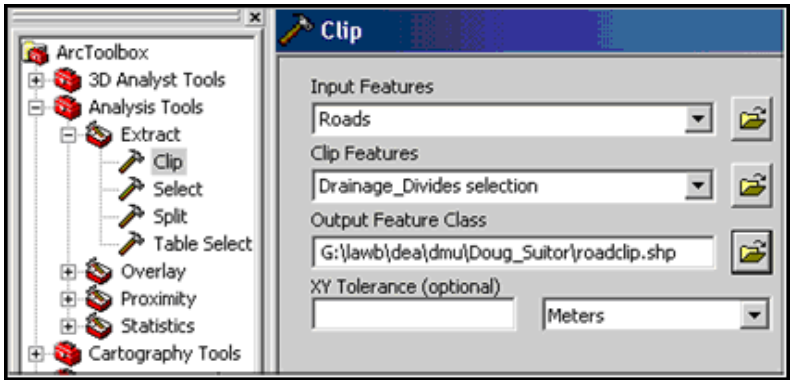


Select the watershed of the Ducktrap River from the Drainage Divides layer, right click the layer and create a layer from the selected features.

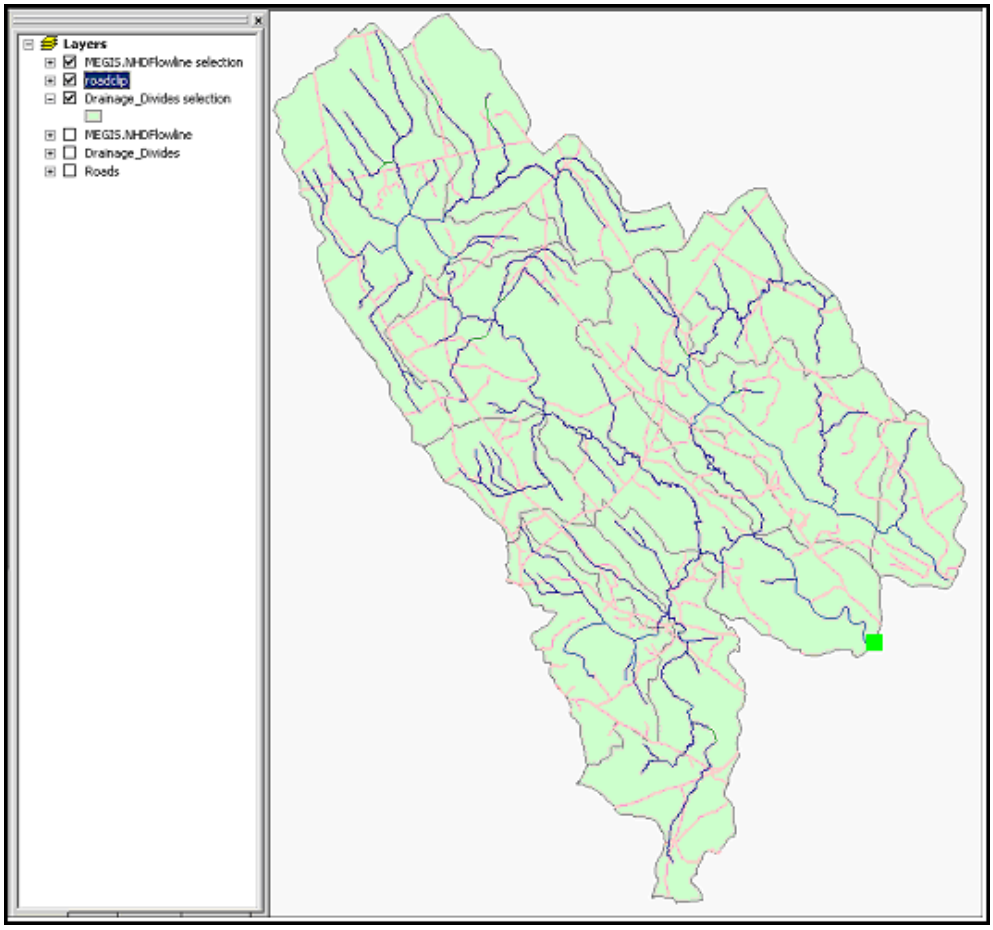


Do the same with the selected features of the NHDFlowline.

Clip the roads layer to the new layer using ArcToolbox's Analysis Tools / Extract / Clip tool.

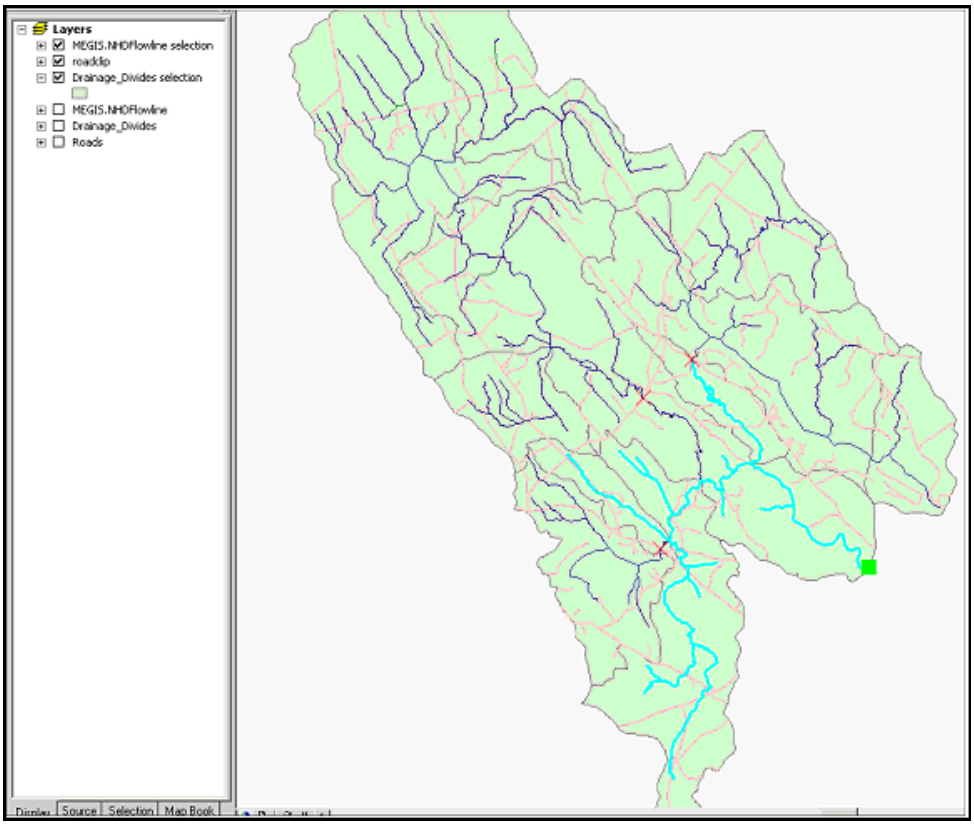


You may now turn off the original three layers and display only the data for the Ducktrap River watershed.



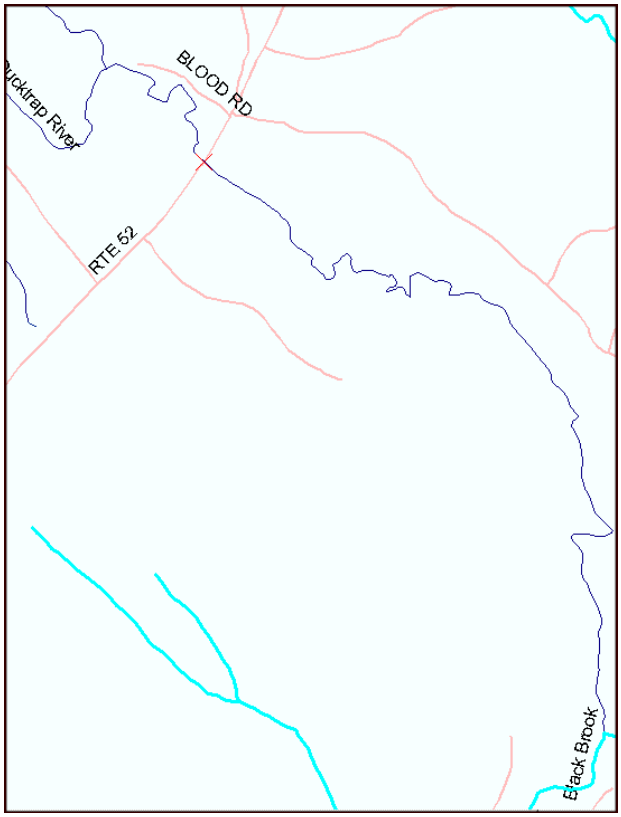
Using the Flag and barrier tool we will now place barriers at road crossings that present hypothetical barriers to fish passage. Place a barrier at the intersections of No. Cobbtown Road and Kendall Brook, Route 52 and the Ducktrap River, and Slab City Road and Reach 01050002009814.

With a flag again at the mouth of the Ducktrap River solve the trace upstream.



The flag and barrier tool will only trace a single part of a reach. For example a barrier placed in the middle of a reach will exclude the entire reach and one placed in the multi part reach will only exclude the section with the barrier. To calculate the waters available as Atlantic Salmon habitat we will need to calculate the waters selected by the tool and add the partial reaches excluded by the barrier tool. The Selection Statistics show us that 26.053 km of waters were selected by the flag and barrier tool.

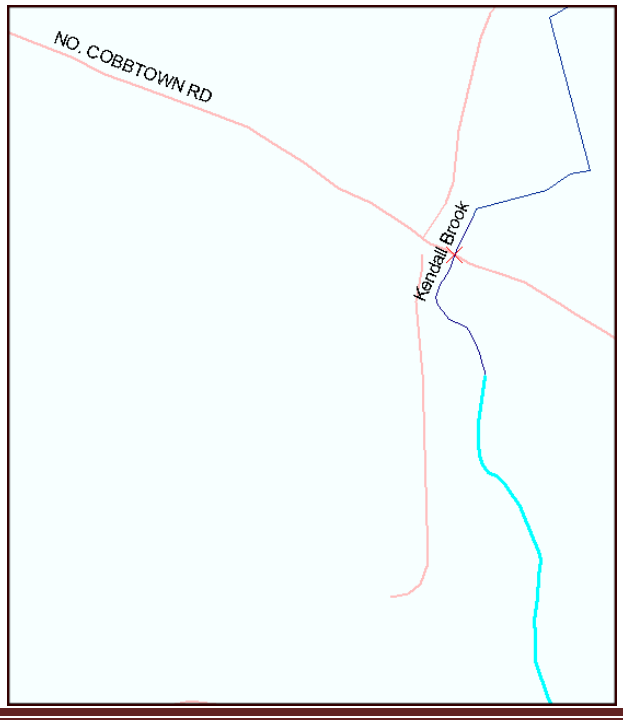
The barrier at the intersection of Route 52 and the Ducktrap River (reach 01050002000671) excluded the entire reach and will need to be calculated manually and added to the total.



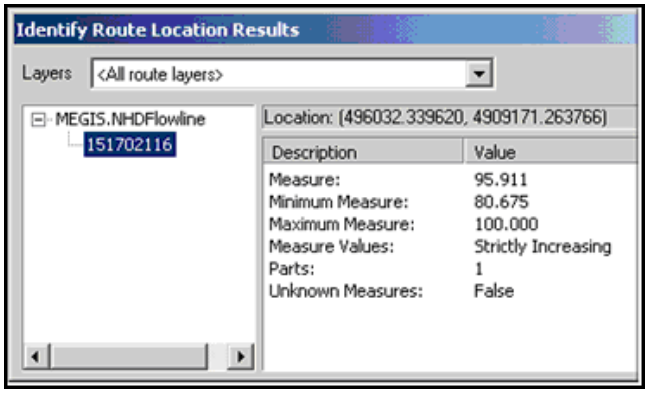
We know from the attribute table that reach 01050002000671 is 4.197 km. Using the Identify Route Location we find the river crossing is located 61.849% or 2.596 km along the reach.

The barrier at the intersection of No. Cobbtown Road and Kendall Brook (reach 01050002009424) excluded only one piece of the reach. We will need to calculate the part not counted, excluding the parts in the original selection.

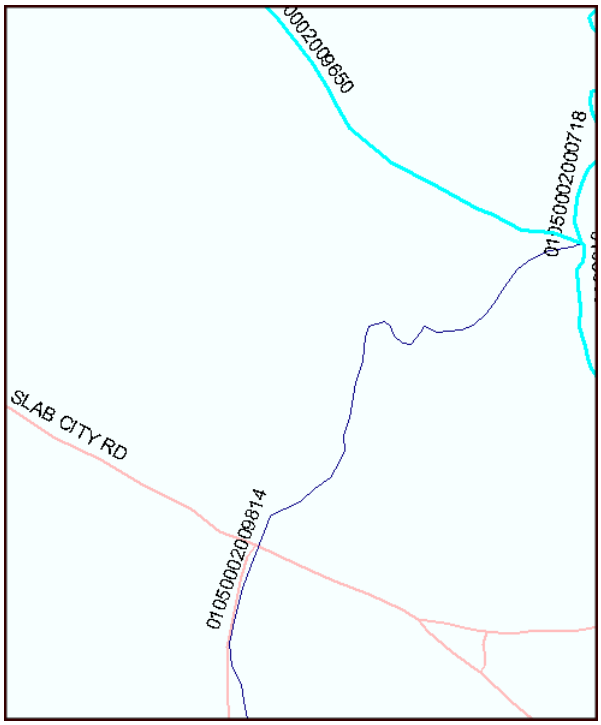
NOTES:



We know from the attribute table that reach 01050002009424 is 0.652km. Using the Identify Route Location we find the river crossing is located 95.911% or 0.625 km along the reach. The tool also tells us that 80.675% or 0.526 km of the reach is included in the original selection.



The barrier at the intersection of Slab City Road and reach 01050002009814 excluded the entire reach and will need to be calculated manually and added to the total. We know from the attribute table that the reach is 0.411km. Using the Identify Route Location we find the river crossing is located 73.818% or 0.303 km along the reach.



Based on this hypothetical model we find the total river length available as Atlantic Salmon habitat within the Ducktrap River watershed to be (26.053 + 2.596 + 0.099 + 0.303) = 29.051 km.

We can create a NHD enabled layer by exporting the selected NHDFlowline data to a table that contains the reachcode and in the case of partial reaches a from and a to measure. The table will contain all the reaches selected in the initial analysis (exclude duplicate

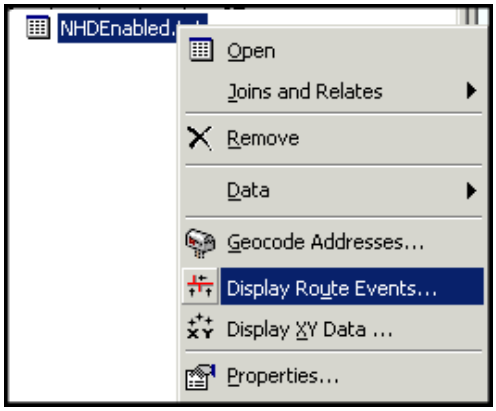
reachcodes) with a from measurement = 0 and to measurement = 100. The three partial reaches listed above would be described as follows:
Route 52 and the Ducktrap River
Reachcode 01050002000671, from = 0 to = 61.849
No. Cobbtown Road and Kendall Brook
Reachcode 01050002009424, from = 0 to = 95.911
Slab City Road and reach 01050002009814
Reachcode 01050002009814, from = 0 to = 73.818

REACHCODE	FROM	TO
01050002000670	0.000	100.000
01050002000671	0.000	61.849
01050002000717	0.000	100.000
01050002000718	0.000	100.000
01050002000900	0.000	100.000
01050002001033	0.000	100.000
01050002009424	0.000	95.911
01050002009471	0.000	100.000
01050002009472	0.000	100.000
01050002009603	0.000	100.000
01050002009611	0.000	100.000
01050002009634	0.000	100.000
01050002009650	0.000	100.000
01050002009675	0.000	100.000
01050002009683	0.000	100.000
01050002009684	0.000	100.000
01050002009814	0.000	73.818
01050002009845	0.000	100.000
01050002009899	0.000	100.000
01050002010093	0.000	100.000
01050002016406	0.000	100.000
01050002016407	0.000	100.000
01050002016408	0.000	100.000
01050002016409	0.000	100.000
01050002016410	0.000	100.000

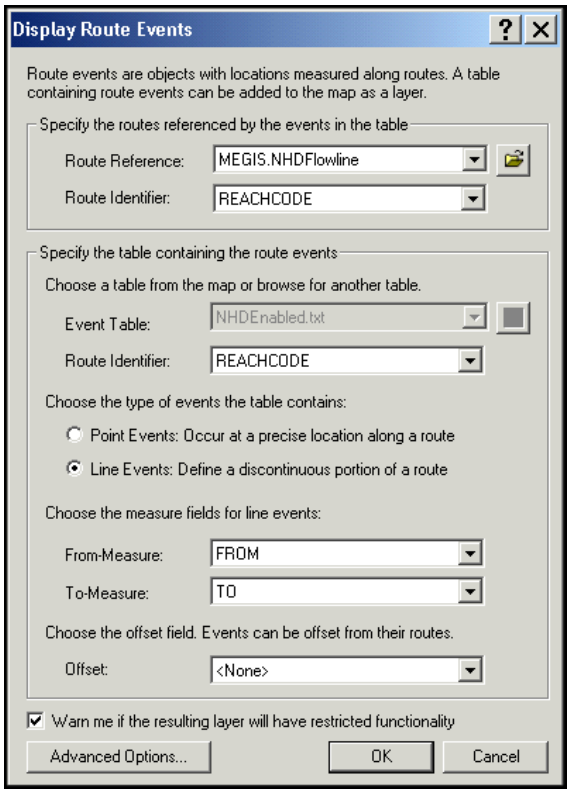
Save the table as a delimited text file and we can now add it to ArcMap to display our salmon habitat data.

NOTES:

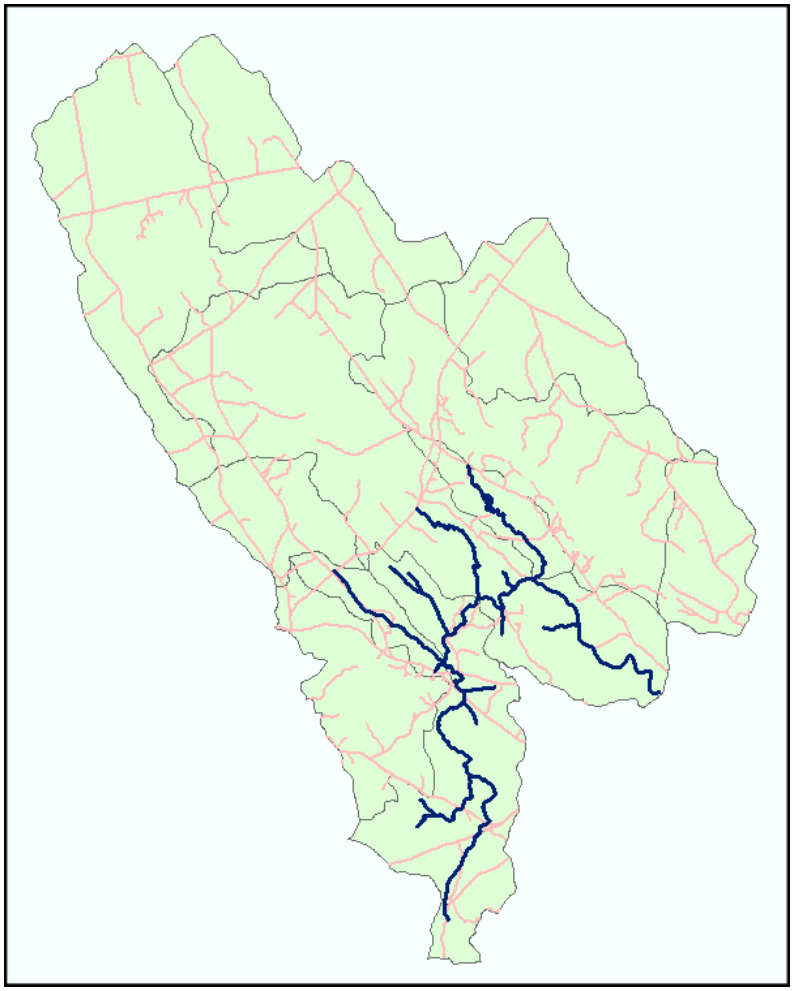
After adding the table to the project, right click on the table to bring up the Display Route Events options.



From the Display Route Events selection box choose the NHDFlowline as the route reference and the reachcode as the identifier. Select Line Events and the fields that show from and to measures then click OK.

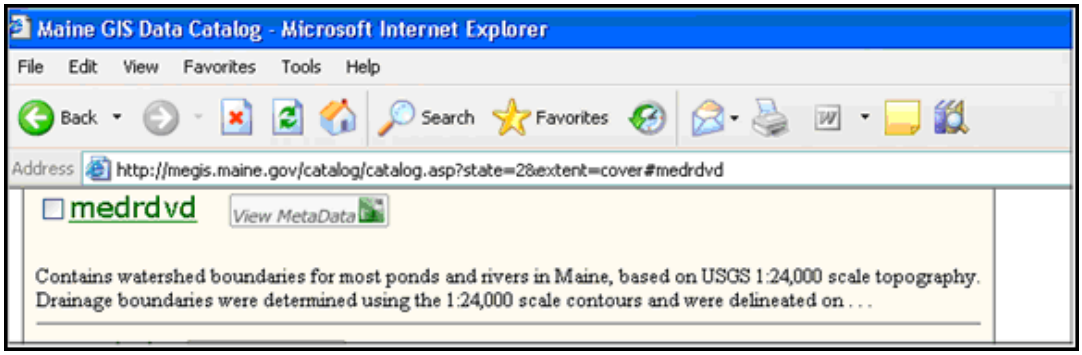


We have now created a NHD enabled layer of unimpaired Atlantic Salmon habitat within the Ducktrap River watershed that can be easily shared with other users of the National Hydrography Dataset.

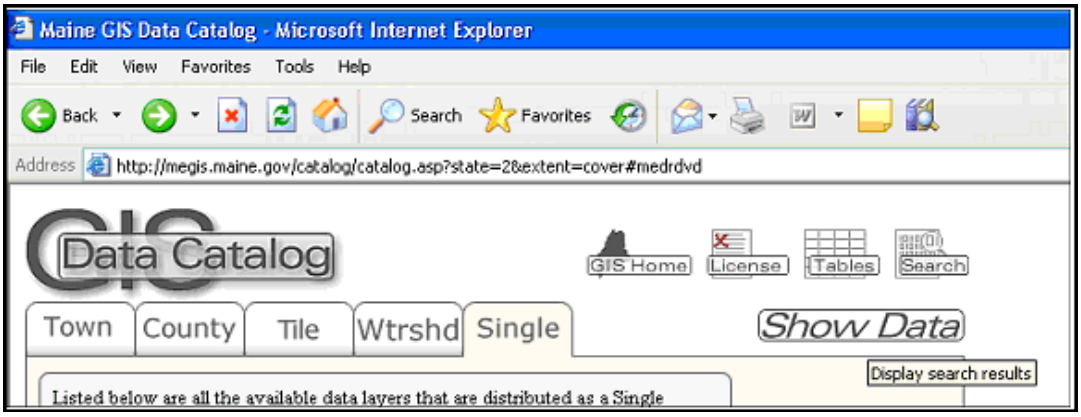


[1] Layer source –
State of Maine Users - MEDEPUSER on MEGIS vector.sde MEGIS.MedrdvdPoly.

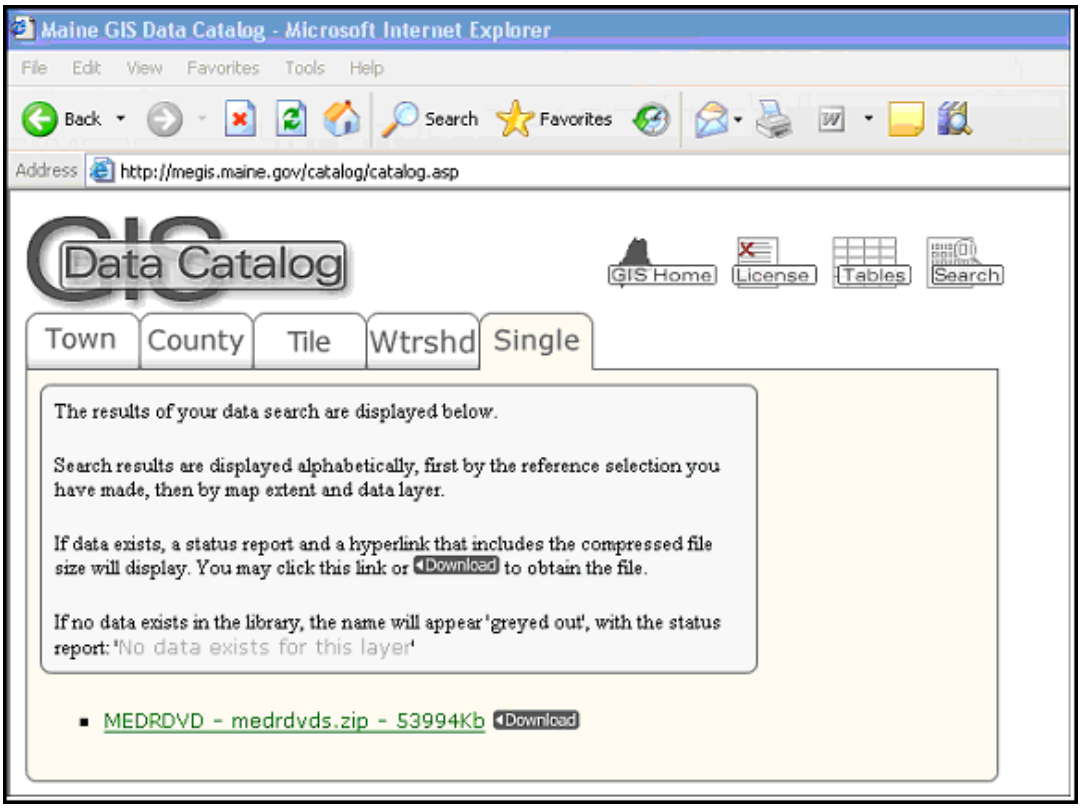
External Users - Follow the link below to the medrdvd layer on the Maine Office of GIS Data Catalog website.
http://megis.maine.gov/catalog/catalog.asp?state=2&extent=cover#medrdvd



Click the check box to the right of the layer name then page up to the top of the page



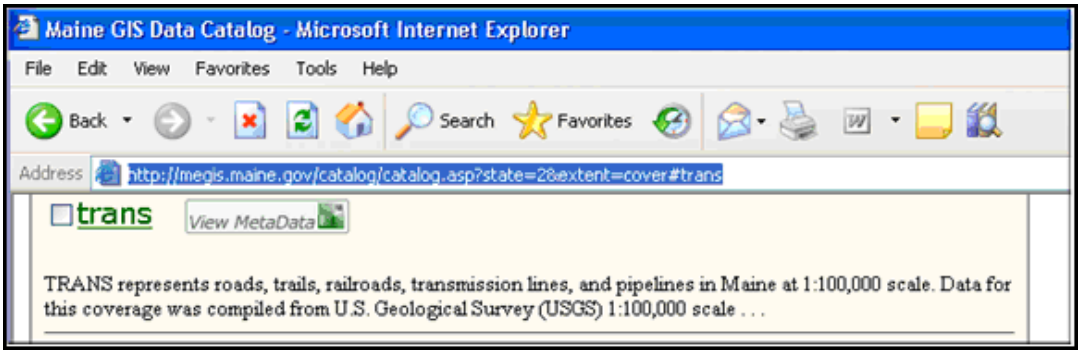
Click on the Show Data icon on the top right. This will open a download window for the layer.



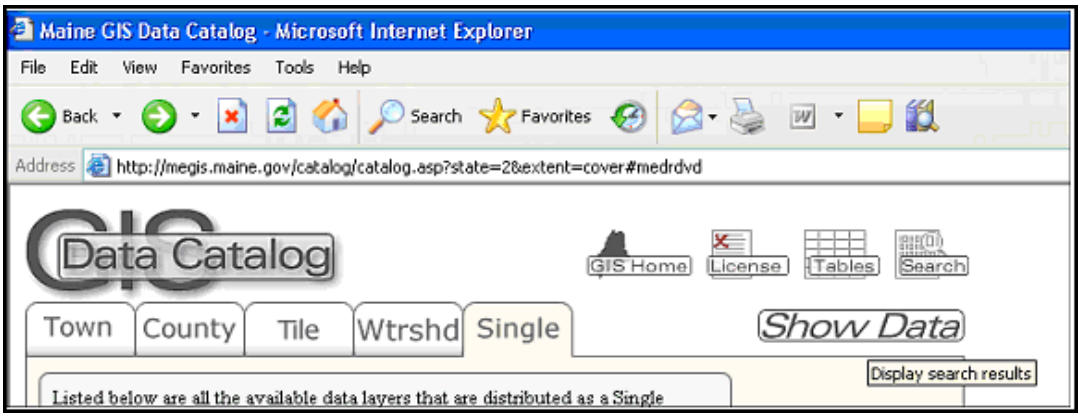
Click the download icon and save the file to your computer.
Open the folder and extract the files.

[2] Layer source –
State of Maine Users - MEDEPUSER on MEGIS vector.sde MEGIS.Roads.

External Users - Follow the link below to the trans layer on the Maine Office of GIS Data Catalog website.
http://megis.maine.gov/catalog/catalog.asp?state=2&extent=cover#trans

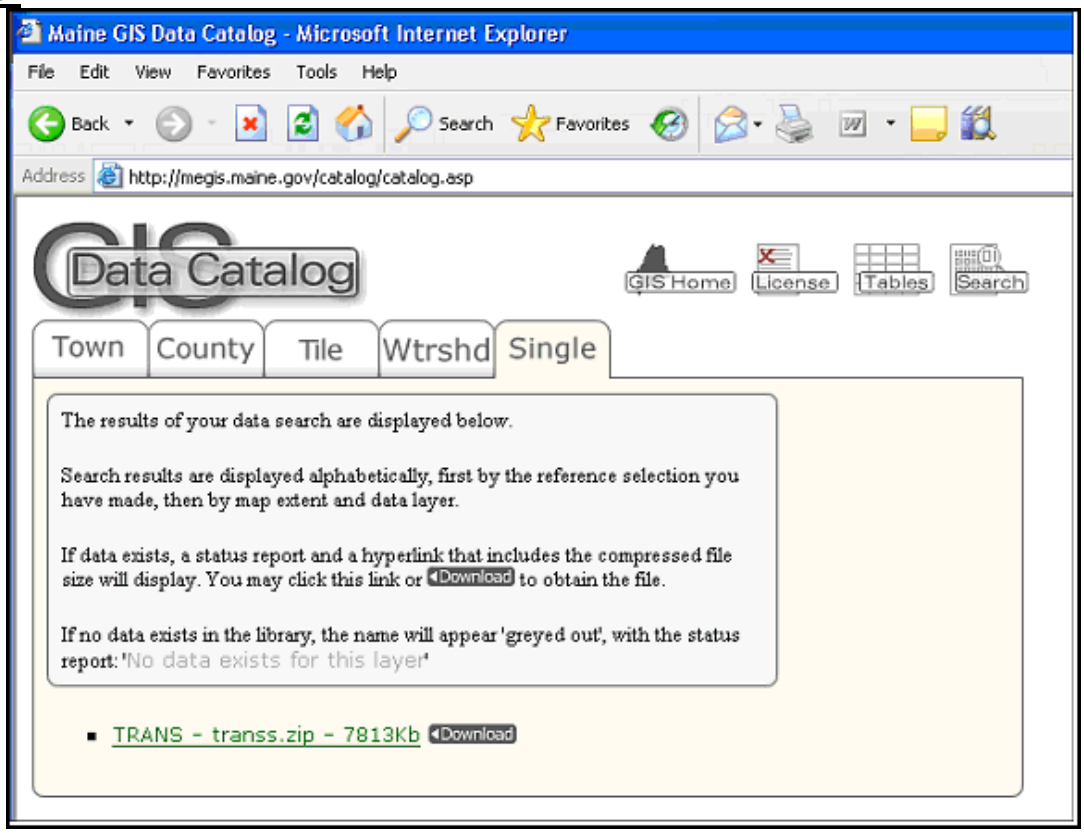


Click the check box to the right of the layer name then page up to the top of the page



Click on the Show Data icon on the top right. This will open a download window for the layer.

NOTES:



Click the download icon and save the file to your computer.
Open the folder and extract the files.

NOTES:

Congratulations!

You have now completed the tutorial:

Introduction to the
National Hydrography Dataset in ArcGIS 9

Introduction to the
National Hydrography Dataset in ArcGIS 9

Quiz

1. What tool would you use to determine the direction of flow through a lake?
   a. Utility Network Analyst
   b. Hydro_Net
   c. Display Arrows Tool
   d. All Of The Above

2. What tools would you use to measure the length of a stream?

   _____

3. What is the VAA table?

   _____

4. Clicking a line with the Identify Route Locations tool, will do what?
   a. Measure The Stream
   b. Provide A Measure of the Reach in Percentages
   c. Crash ArcMap
   d. Select The Reach

5. What NHD data layer will contain lakes and ponds?
   a. *NHDFlowline*
   b. *HYDRO_NET*
   c. *NHDArea*
   d. *NHDWaterbody*

6. An Artificial Path traces water under bridges.
   a. True b. False

7. In what coordinate system does the USGS provide NHD downloads?
   a. UTM Zone 19
   b. WGS84
   c. GCS_North_American_1983
   d. Decimal Degrees

8. What allows the NHD to trace water flow directions?
   a. *NHDFlowlin*
   b. *HYDRO_NET*
   c. *NHDArea*
   d. *NHDWaterbody*

9. What other types of data can be linked to the NHD?
   a. River Names
   b. Fish Habitat
   c. Water Quality
   d. All Of The Above

10. What field can be used as a common identifier within the NHD?
    a. Reachcode
    b. ComID
    c. ObjectID
    d. All Of The Above

Signature_____ Date _____/ _____/ _____

Quiz Answers:
1) D **2)** To measure the length of a stream use the attribute table in combination with the identify Route Location Tool. **3)** The VAA table is the Value Added Attributes table. An event table that is used to add external data to the NHD. **4)** B/or C **5)** D **6)** B **7)** C **8)** B **9)** D **10)** D