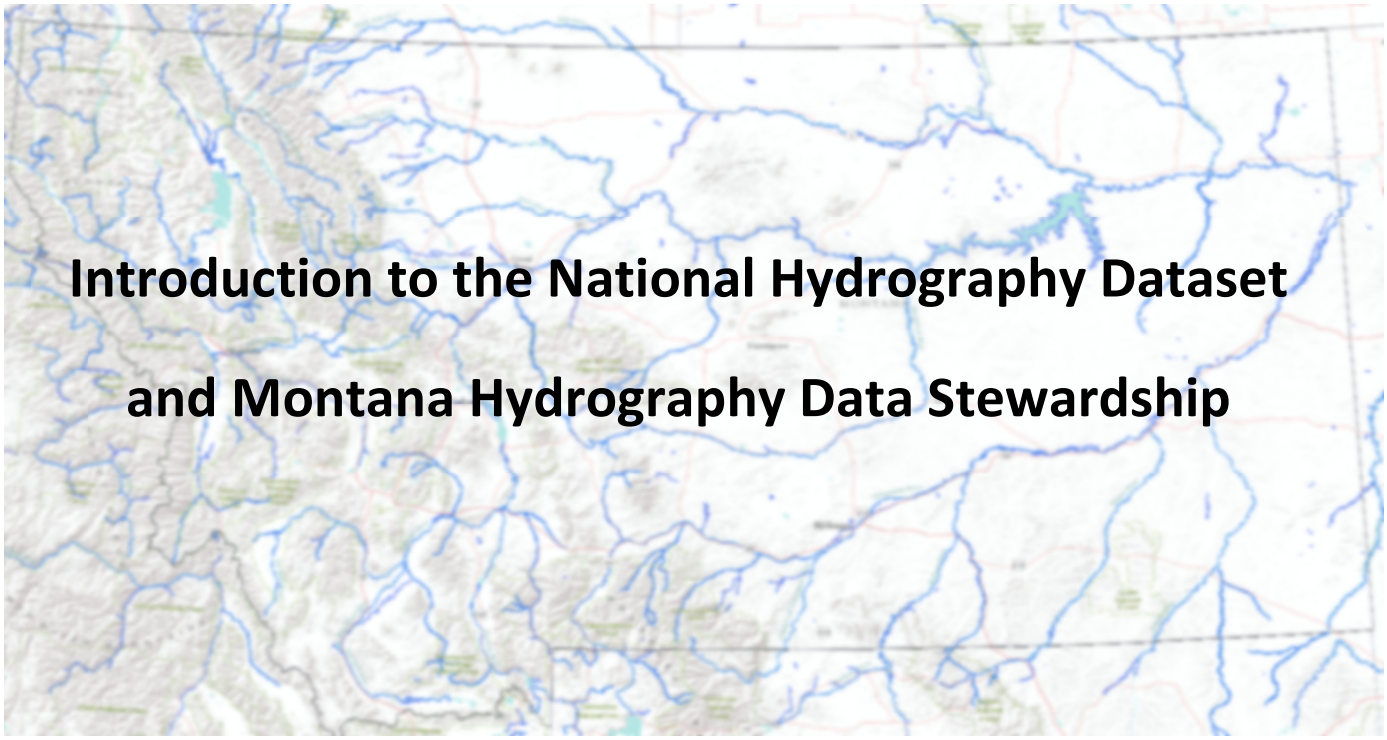

Introduction to the National Hydrography Dataset and Montana Hydrography Data Stewardship

Presented by the:

Montana State Library

MONTANA State Library Geographic Information

Water Information System

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A workshop delivered at the Intermountain GIS Conference, Billings, MT.

April 7, 2014

Table of Contents

Workshop Outline

April 7, 2014 (8:00 AM – Noon)

1. **Introduction to the NHD**
    a. Presentation: Overview of the NHD

2. **Where to get it**
    a. Presentation: Sources of the NHD

    b. Exercise 1: Obtaining data and using services from MSL, USGS NHD home, and The National Map

    c. Exercise 2: Project the entire NHD geodatabase and rebuild the network

3. **How to use it**
    a. Presentation: Overview of products, uses, and applications of the NHD,
        i. State projects benefiting from the NHD

    b. Exercise 3: Symbolizing and Cartography

    c. Exercise 4: Metadata

    d. Exercise 5: Applications and Analysis

    e. Exercise 6: Navigating the network

    f. Presentation: Events and how to tie your own data to the hydro network

4. **How to contribute updates and revisions**
    a. Presentation: Overview of the Montana Stewardship process

    b. Presentation: NHD revisions best practices

    c. Presentation/Demo: NHD Edit Submission Viewer

    d. Exercise 7: Identify issues and submit them to MSL

    e. Discussion: Leveraging existing datasets to update the Montana Hydrography Dataset
        i. General discussion about hydro datasets that attendees may have

Montana Hydrography Dataset Contacts

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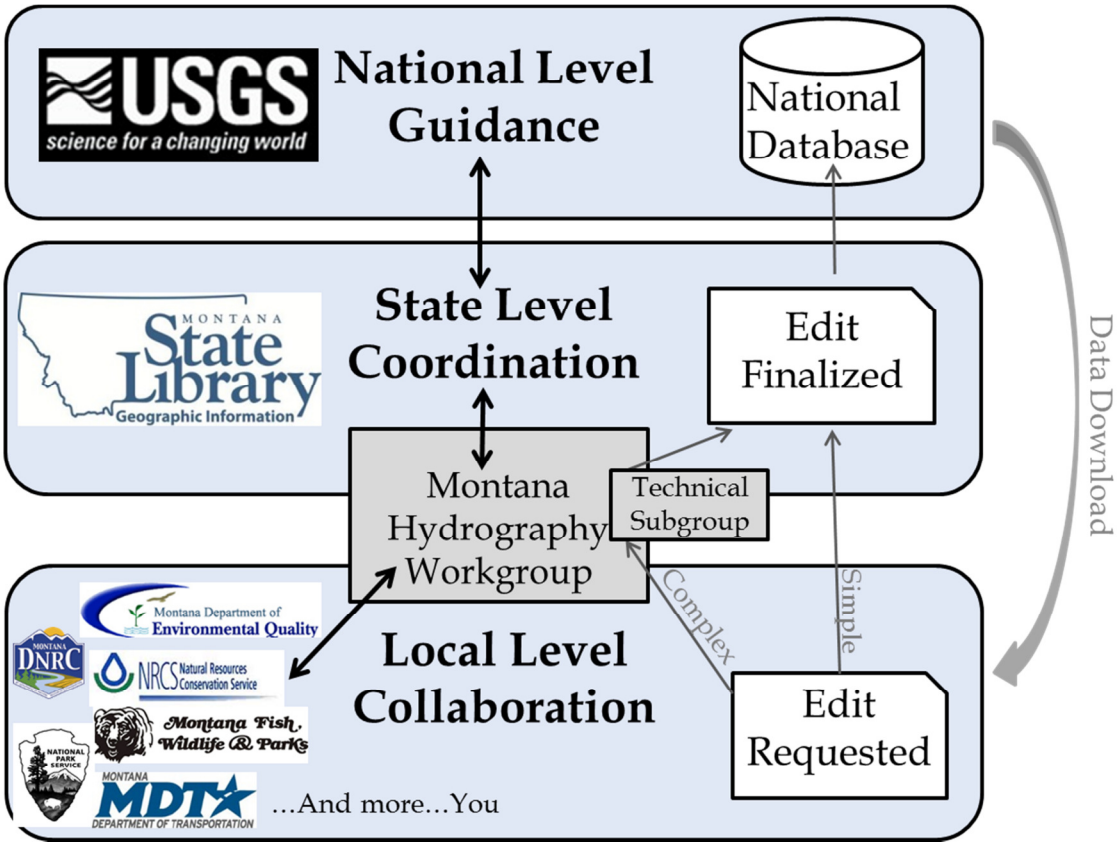
Sources and update frequency of the Montana Hydrography Dataset

Source	Description	Data Type / location	Update Freq.
MSL	Statewide in MT State Plane Projection (subset by request)	File GDB 10.1 (other by request) / MSDI Hydrography http://geoinfo.montanastatelibrary.org/data/msdi/hydrography/	~ two months
MSL	Statewide z/m disabled in MT State Plane Projection (subset by request)	File GDB 10.1 (other by request) / ftp://ftp.geoinfo.msl.mt.gov/Data/Spatial/MSDI/Hydrography/	~ two months
USGS	Staged Statewide in GCS	File GDB 9.3.1 / http://nhd.usgs.gov/index.html	~ two months
USGS	Staged subregions (4-digit) in GCS	File GDB 9.3.1 / http://nhd.usgs.gov/index.html	~ two weeks
USGS	Dynamic Extract from National Map (HUC 8 or user defined map extent)	File or personal GDB or shape / http://viewer.nationalmap.gov/viewer/	~ one week
USGS	Cached Map Service	http://basemap.nationalmap.gov/arcgis/rest/services	~ 1 year (USGS future goal is 6 months)
USGS	Dynamic Map Service	http://services.nationalmap.gov/arcgis/rest/services	~ 3-6 months (USGS future goal is 1 month)

Montana Hydrography Dataset Stewardship



Montana Hydrography Working Group

The Montana Hydrography Working Group is a primary sounding board for State water information needs. The Group meets quarterly to provide direction for the State's Water Information System (WIS) and hydrography framework, such as to discuss water data needs; to improve the hydrography dataset; to facilitate sharing opportunities; and to increase water-related data discovery. The Montana Hydrography Working Group is open to all who are interested—to join the group go to www.groups.google.com and search for "MAGIP Hydrography Workgroup".

Options for submitting Hydrography Dataset revisions to MSL

- **Option 1. Submit form or email**. Fill out a form or send an email to the MSL Stewards with the information requested in the *Edit Submission Form*. This option is intended for contributors with limited GIS or NHD experience and is ideal when a few to a handful of revisions are needed. The contributor identifies what and where, then the Steward takes 100% responsibility to complete the revisions.

- **Option 2. Use the NHD Update Tool**. Complete NHD Update Tool training provided by the USGS and coordinated with the Steward. The Stewards will then checkout the area of interest (a 4th code/8-digit HUC), run QA/QC tools, and email/FTP the HUC to the contributor. The contributor will then complete updates using the NHD Update Tool and submit the job back to the Steward. The Steward will complete final QA/QC and submit the job to the USGS for acceptance into the national database.

- **Option 3. Send Own Data.** Send a geodatabase to the Stewards (other formats may be accepted). The geodatabase should include the revisions and any sources used to vet them, such as aerial imagery or high-resolution elevation data (common public datasets need not be included). The Steward will then "import" or recreate the revisions using the NHD Update Tool. To facilitate the effort, data should include the information requested in the *Edit Submission Form* to the extent possible, such as Ftype, Fcode, and direction of flow. Failure to provide essential information will lengthen the turnaround time for the revision; in general, the closer submitted datasets are to matching the NHD schema the more readily the data can be incorporated into the NHD.

Update Option	Intended for:	Targeted NHD/GIS Skill-level	Contributor Effort	Steward Effort	Min Turnaround Time (after contributor submission)
1. Submit form or email	A few to a handful of revisions	Low	10%	90%	Days
2. Use the NHD Update Tool	Mass revisions (impending)	High	70%	30%	Weeks
3. Send own data	Multiple revisions (preexisting or resulting from other business needs)	Medium	30%	70%	Months

Montana Hydrography Edit Submission Form

Montana State Library Water Information System

Use this form to submit revisions to the Montana Hydrography Dataset

Date:

Contact Information

Name _____

Organization _____

Phone _____

Email _____

Request

Feature: ☐Flowline/line ☐Waterbody/area ☐Point ☐Event

Source(s) used to vet the edit: ☐Authority ☐Imagery ☐LIDAR ☐Topo Other:_____

Edit Description: ☐Name ☐Geometry ☐Attribute ☐Multiple

Location Description (e.g. Township, Range, Section; Lat/Long; or distance/direction from landmark):

Please provide a description of the edit. Include as much detail as possible, such as Ftype, Fcode, and direction of flow (e.g Stream/River: Intermittent: flows N towards the Beaverhead). For a list of Ftypes and Fcodes see:
http://nhd.usgs.gov/userGuide/Robohelpfiles/NHD_User_Guide/Feature_Catalog/Hydrography_Dataset/Complete_FCode_List.htm

We will be in contact via email as we progress with these edits. Thank you for the submission!

Submit form to: Water Information System, geoinfo@mt.gov

Best Practices and Frequently Asked Questions

- **Please provide guidance on imagery as a data source for revising the NHD . . . Is NAIP adequate?**
    - *Yes, NAIP is a good source, and it does not have to be the most recent collection. Other imagery sources are sufficient as well. In fact, it is a good practice to use multiple years and dates of imagery, as hydrography varies greatly from year-to-year. Attempting to capture "average" conditions is a practical approach. The key is to document what was used.*

- **I see tradeoffs in various sources, and I am inclined to use multiple datasets. How should I proceed?**
    - *The use of multiple sources is strongly encouraged. When discrepancies exist amongst good data sources, attempt to identify average conditions. Again, what source is used is less important than making sure whatever is chosen gets documented in the metadata.*

- **Does the Hydrography Dataset have a place for storing "local" or historically-accepted names?**
    - *Currently, names that differ from those maintained in the Geographic Names Information System (GNIS) are not included in the Hydrography Dataset; however, being able to capture local and historic names is a common interest of the State and other agencies. The Montana State Library anticipates needing to devise a cross-reference table for this. A user would then grab the primary names from the NHD and be able to relate to alternative hydro names from MSL.*

- **I'm ready to begin reviewing the Hydrography Dataset and submitting revisions. Where should I start?**
    - *Editing of the Montana Hydrography Dataset occurs on a 4th code (8-digit) HUC- by-HUC basis; therefore, it is most efficient to focus review and edit submissions by area (subbasin) as opposed to by type of edit. That said, any contributions are greatly appreciated, and your business needs should drive the workflow.*

      As a local contributor (substeward) you know the area best. The most important attributes to double-check and submit are FType, FCode, direction of flow, and GNIS Name/ID.

- **I am experienced with the ArcGIS Editor. Why should I use the NHD Update Tool?**
    - *The Hydrography Model depends on many relates between features and tables, such as feature level metadata, reach code maintenance, and source citations. An edit to one feature class likely impacts other feature classes and tables. The NHD Update Tool manages these properly for you; the ArcGIS Editor does not. The NHD Update Tool also knows the rules and topologies that must be followed.*

  Editors need to be aware of how features relate. One simple edit may necessitate several additional edits. For example, editing a waterbody geometry oftentimes requires that the flowline (artificial path) running through the lake gets updated, as well as any associated points.

- **At what scale should digitizing occur?**
    - *The digitization scale can vary but in general a good practice is 1:5000 or 1:8000. Be consistent in editing similar features and be sure to document the approximate scale in the metadata.*

- **I see some problems with the data across the border in Canada. Should I submit these?**
    - *At this time, Montana is not able to complete any edits in Canada. While border harmonization efforts are ongoing, Canada is responsible for their own hydrography data.*

- **I know "events" are tied to the Hydrography Dataset by reachcodes and measures. How does editing flowlines impact reachcodes?**
    - *A best effort is made to preserve reachcodes by modifying the geometry of an existing reach whenever possible, rather than deleting and creating new ones. Regardless, sometimes new reachcodes are added or old ones are deleted. These changes are all tracked in the ReachCrossReference table.*

Helpful Hydrography Dataset Resources

The **Montana State Library** is the State Steward of the Hydrography Dataset. Please visit the Montana Water Information System:

- **Water Information System home**
  - http://geoinfo.montanastatelibrary.org/geography/water/

- **Montana Spatial Data Infrastructure- Hydrography**
  - http://geoinfo.montanastatelibrary.org/data/msdi/hydrography/

Extensive information on the NHD Data model is available through the **USGS**. Please visit the following URLs:

- **NHD Home**
  - http://nhd.usgs.gov/index.html

- **NHD Stewardship Home**
  - http://usgs-mrs.cr.usgs.gov/stewweb/index.html

- **NHD User Guide**
  - http://nhd.usgs.gov/userguide.html

- **NHD Feature Catalog**
  - http://nhd.usgs.gov/userguide.html?url=NHD_User_Guide/Feature_Catalog/NHD_Feature_Catalog.htm

- **NHD Model Schema Diagram**
  - http://nhd.usgs.gov/NHDv2.1_poster_3_23_2012.pdf

There are several ways a user can obtain NHD data or services.You can download or view data or use services from the USGS or from the Montana State Library (MSL). In this exercise, you will learn about the various options available to you and the best methods to obtain the data you need.

First, let's explore what is available from the USGS. The USGS maintains the NHD nationwide. State stewards check out 8-digit HUC watershed units, make changes to the NHD, and submit the changes to the USGS.

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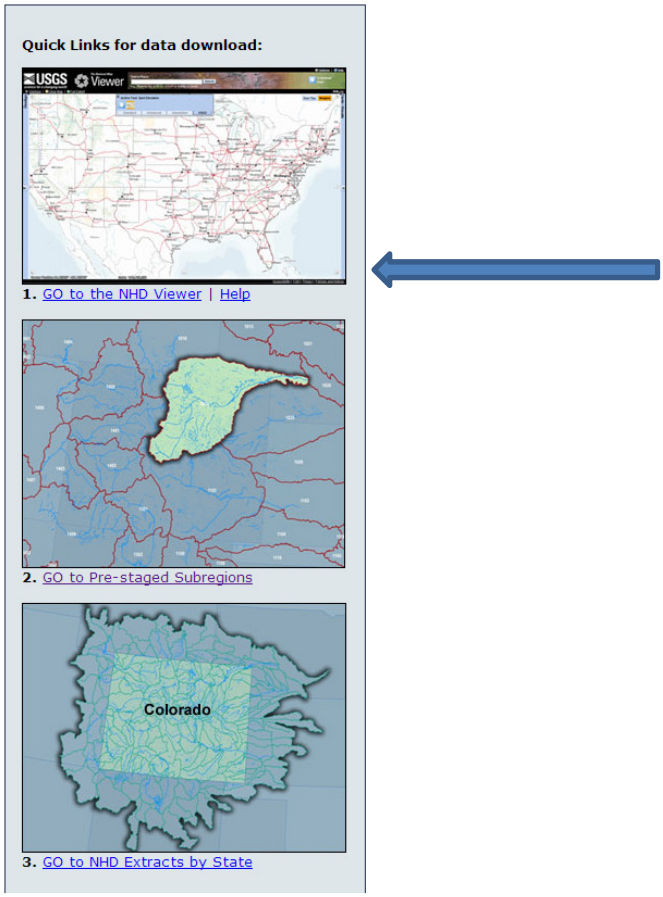
1. To obtain data directly from the USGS, go to http://nhd.usgs.gov/index.html.

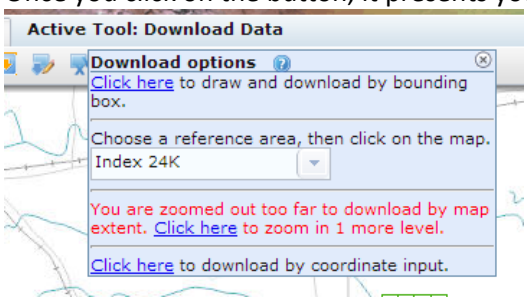
2. From the menu options on the left, select **Get Data.**

3. The most up-to-date NHD data can be downloaded using The National Map Viewer. You can access it directly from http://viewer.nationalmap.gov/viewer/ or from the quick link at the right of the page.



4. Once in the Viewer, zoom to the general area you are interested in. Click on the **Download** button at the top left of the page. 

5. Once you click on the button, it presents you with several options.

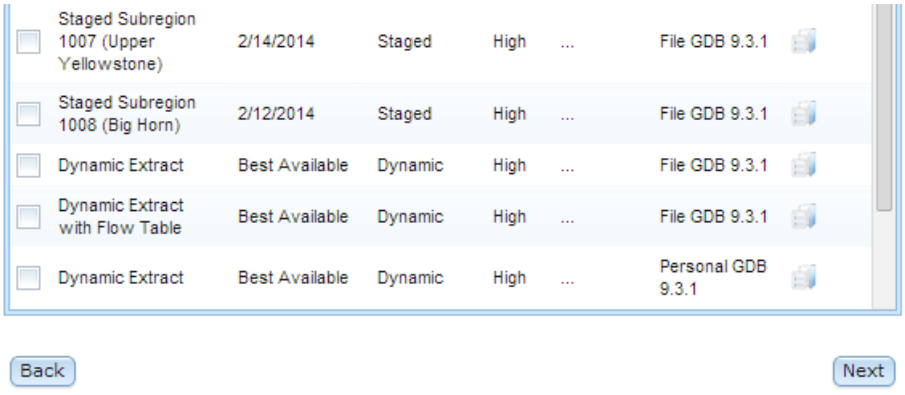


6. The first option allows you to draw a bounding box and download data by that extent. Let's try that now. After clicking where instructed, drag the tool across the screen to draw a bounding box.

   a. A dialog box will appear, allowing you to check a box next to the data you want to download.

   b. Check the box next to **Hydrography (NHD).**

   c. In the next dialog box, you will see various products in various formats available. The formats include File GDBs, Personal GDBs, and Shapefiles. The products include staged subregions (or whatever watershed boundary you're zoomed in to) and dynamic extracts. The last date the data was updated is also included. As you can see, dynamic extracts represent the best available data. The data is generally updated within the week it is submitted.



   d. Check the box next to two Dynamic Extract options, one **with Flow Table** and one without.

e. This will add these to your Cart, from where you can click **Checkout**. You will then be prompted to enter your email address and place your order.

7. Ignore these steps and go back to the **Download** button, opening the **Download options** dialog.

8. The second option to download data is to choose a reference area from the dropdown menu and then click on the map. Select **8-digit HU (NHD Subbasin)** from the dropdown menu.

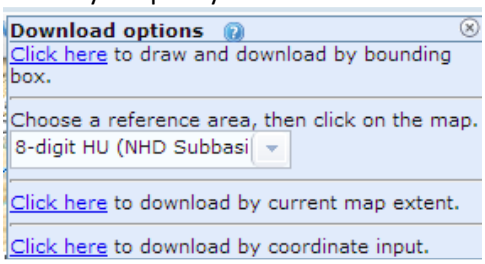
    a. You will notice that the 8-digit HUC outlines became visible on the map and are labeled with their subbasin number.

    b. Click on one of these subbasins to download it.

    c. It will appear in the **Selection** tab at the left of the screen.

    d. You can now download the data following the steps above or choose to zoom to the HUC, or create a buffer around it.

9. You can also download data by current map extent or enter coordinates to download by the extent you specify.



10. Let's go back to the **Get NHD Data** page at http://nhd.usgs.gov/data.html and explore other options for obtaining data.

11. From the **Quick Links** menu on the right, choose the **GO to Pre-staged Subregions**. This option is best used if you already know the 4-digit HUC you want to download. This data is updated within approximately two weeks of edits being submitted.

    a. This will take you to an FTP site, from where you can choose between downloading a File GDB or a Personal GDB. Click on the **FileGDB** link.

    b. You can then choose between High, Local, or Medium resolution data. Choose **HighResolution**.

        i. Select the zipfile containing the 4-digit HUC you are looking for.

12. You can also extract data by state, which is updated within approximately two months of edits being submitted. To extract data by state, go to http://nhd.usgs.gov/data.html.

    a. From the **Quick Links** menu on the right, choose the **GO to NHD Extracts by State.**

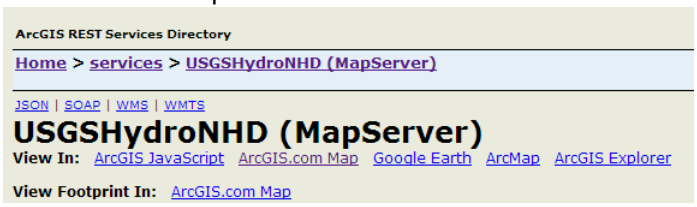
    b. Choose **FileGDB>HighResolution** and then select the zipfile for the state you want.

13. In addition to being able to download data from the USGS, you can also access map services to use within ArcGIS Desktop. Go to http://nhd.usgs.gov/data.html.

    a. From the menu options on the left part of the screen, hover over **Get Data.**

    b. From the menu that appears on the right, click on **Go to REST MapService Endpoint**.

    c. From here you have the option to view the services in various mediums, including an ArcGIS Online map.



    d. You can access other services, such as USGSTOPO or imagery, here: http://basemap.nationalmap.gov/arcgis/rest/services

14. The NHD for Montana is also available from the Montana State Library (MSL). The NHD is available in geodatabase and shapefile formats (updated every two months), and the data is in the Montana State Plane Coordinate System (NAD_1983_StatePlane_Montana_FIPS_2500_meters). In order to encourage consistency among Montana's NHD users, we encourage obtaining data from MSL.

    a. Go to <http://geoinfo.montanastatelibrary.org/data/msdi/hydrography/>. This page provides access to the Data (MSDI Hydrography Data), documentation (NHD User Guide and database schema), and a link to the National Map Viewer used earlier in this exercise.
    b. Click on MSDI Hydrography Data.
    c. On the next page click on "Download the statewide . . ." This takes you to an ftp <ftp://ftp.geoinfo.msl.mt.gov/Data/Spatial/MSDI/Hydrography/> where you can download the statewide NHD, model diagram, and metadata. You can also download the NHDLayerfiles.zip to use to import symbology for the various NHD feature classes within ArcGIS Desktop. Another exercise will go over this process.

Projecting data is a common GIS task important for optimizing the spatial overlay of data for different geographic areas (different regions and states have different optimal spatial projections). In this exercise, you will reproject an entire geodatabase, rather than individual feature classes, while maintaining the current NHD model schema (v2.1) and also transferring all associated tables.

The USGS distributes the NHD in an un-projected system (Geographic Coordinates, NAD 83). In order to make accurate measurements and area calculations a projected coordinate system is needed. In this exercise, we will project the hydrography dataset to Montana State Plane Coordinate System (NAD_1983_StatePlane_Montana_FIPS_2500, meters).

---

1. **Open ArcCatalog** and navigate to the *Exercise folder*
   …\Exercises\Projecting\NHD_GCS.gdb

2. **Delete the Network** from the NHD_GCS.gdb.
   a. Right click "HYDRO_NET" and delete

3. Also included in the Exercise folder is a blank geodatabase template.
   …\Exercises\Projecting\Template_NHD_MTSPC.gdb

   a. Take a look at the blank gdb template in ArcCatalog. Notice that there is no data, but all of the schema and spatial properties are populated.

   b. Check that the feature datasets are in Montana State Plane Projection by viewing the metadata.

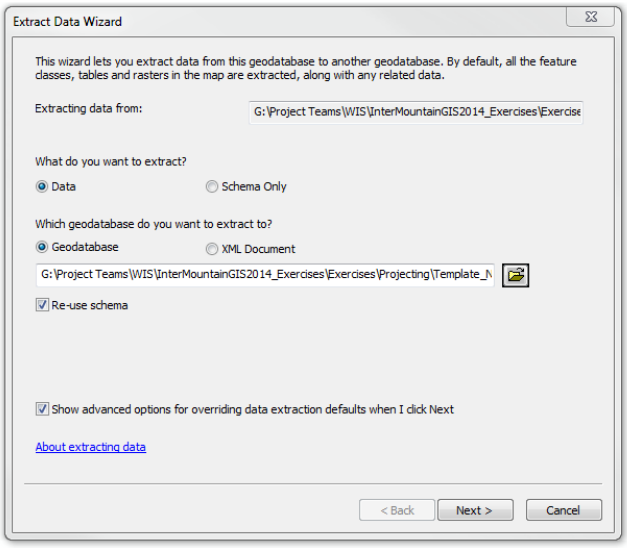
   (Blank templates for other projections can be obtained by contacting the State Library, geoinfo@mt.gov)

4. **Open ArcMap** and **add** all data (including tables and relationship classes) from the NHD_GCS.gdb.
   a. An error will pop up. Don't worry about it, just click ok.

5. Open the "**Distributed Geodatabase" toolbar** in ArcMap.
   a. Customize—Toolbars—Distributed Geodatabase

6. Use the **EXTRACT DATA** button. 

7. In the Extract Data Wizard dialogue, make sure the **Data**, **Geodatabase**, **Re-Use Schema**, and **Show advanced options**…items checked. Use the Browse button to navigate to the blank geodatabase template.

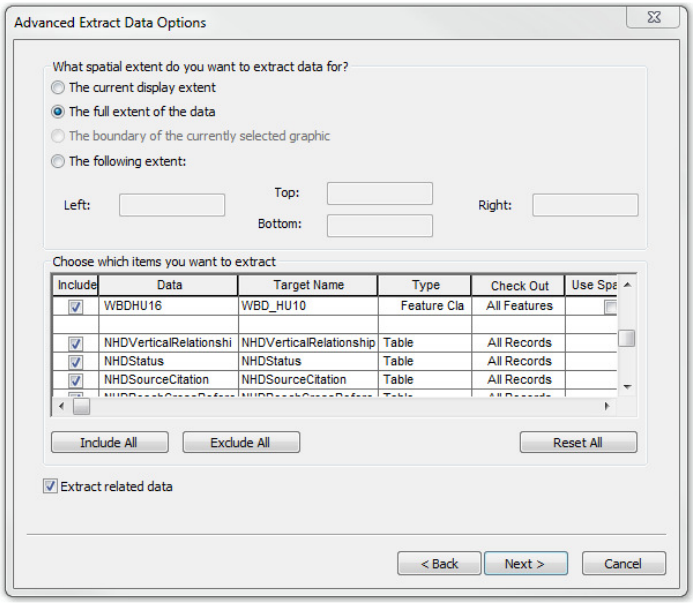


8. In the Advanced Extract Data Options dialogue:

    a. For spatial extent to extract, select the **full extent of the data**.

    b. The default Check Out selection for spatial feature classes is All Features, but for tables it is Schema Only. Scroll down and change the table Check Out selection to **All Records** to have everything from the database transferred to the new geodatabase.

    c. Make sure that the **Extract related data is checked** to ensure all relationships are maintained across the datasets.



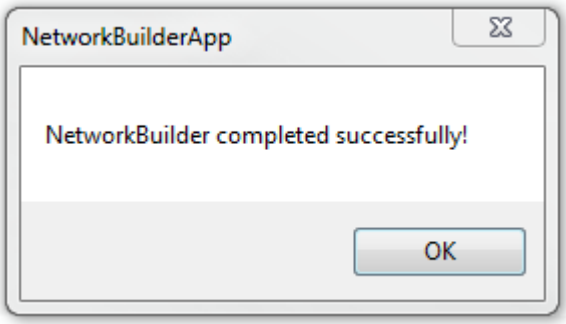
9. Click **NEXT**

10. This next screen checks the relationships. Direction from the Origin Class to the Destination Class is always **Forward. Click NEXT**

11. This next dialogue allows the user to select further actions and is pretty straight forward. The user may select Summary to view the settings or click **FINISH** to proceed with the extract.

12. After clicking FINISH, the data will be transferred and re-projected to the template database.

13. In order to enable network capabilities (upstream, downstream traces, etc) **rebuild the Flow Network** (HYDRO_NET) using the NHD Utilities
    a. **Run** the NHD Network Builder tool (Start—Programs—NHD Utilities)
    b. Navigate to the NHDFlowline feature class in the template GDB.
    c. Note: This tool takes awhile to run and often looks like it is doing nothing. Be patient, it will finish.



Like most GIS tasks, there are often multiple ways to accomplish the same task- some more efficient than others. What other options can you identify for reprojecting the Hydrography Dataset?

The NHD is a large dataset with multiple layers. Visualization of all of these layers is important to make the best use of the data. In this exercise we'll explore ways to easily symbolize the NHD and a few other cartographic tips.

1. Open an ArcMap session.

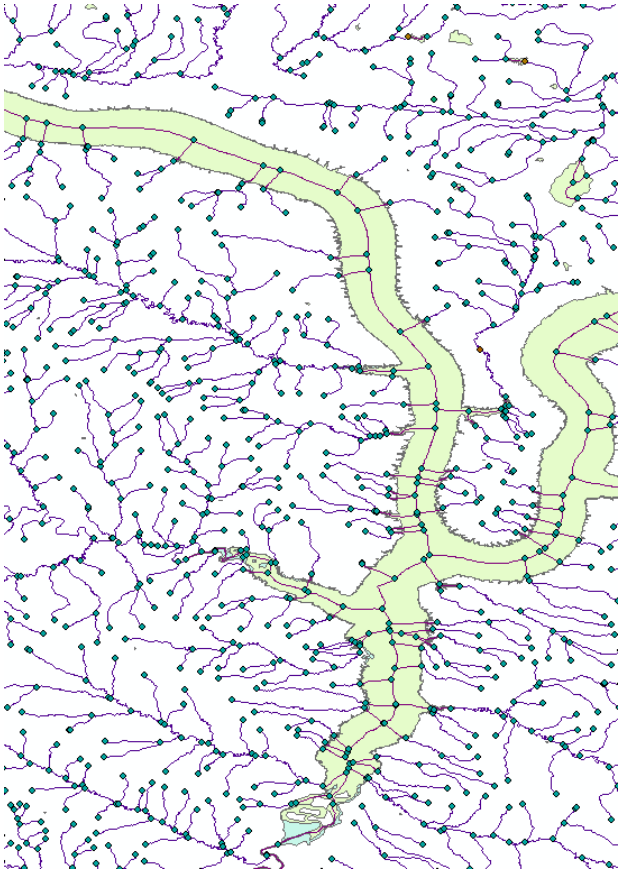
2. From the **Add Data** tool, navigate to the *Exercise folder* on your desktop, locate the *NHDSymbology* folder, and double-click on the **NHDH1004.gdb** to open it.

    a. Select the two feature datasets and all of the tables in the GDB and click **Add**.

    b. If an error message popups up, ignore it say OK

    c. Turn off all the layers in the Watershed Boundary Dataset (WBD).

    d. Zoom in to an area to better be able to see the NHD.



3. You can see that the default symbology is not very useful, nor does it indicate flow direction. You have several options to symbolize the NHD.

    a. The easiest option is to download the **NHDLayerfiles.zip** from the Montana State Library FTP site here: ftp://ftp.geoinfo.msl.mt.gov/Data/Spatial/MSDI/Hydrography/

    b. It has already been extracted to the same exercise folder containing the **NHDH1004.gdb**.

    c. Using the **Add Data** tool, add all of the layer files to ArcMap.

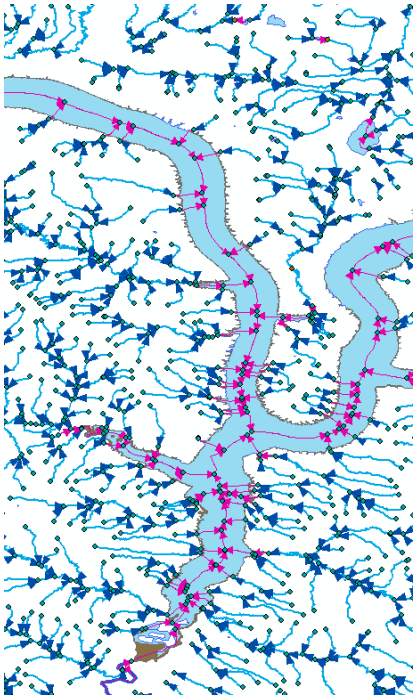
    d. For each layer file, double-click on the layer to open the **Layer Properties** dialog box.

    e. Click on the **Source** tab.

    f. Then click on **Set Data Source**.

    g. Navigate to the **NHDH1004.gdb**, open the **Hydrography** dataset, and click on the appropriate feature class. In some cases, you will be navigating to the same feature class for two layer files. For example, there are two layers for NHDFlowline, one symbolized by FType and one by FCode.

4. Now you can see flow directions associated with the flowlines, and waterbodies are symbolized more intuitively.



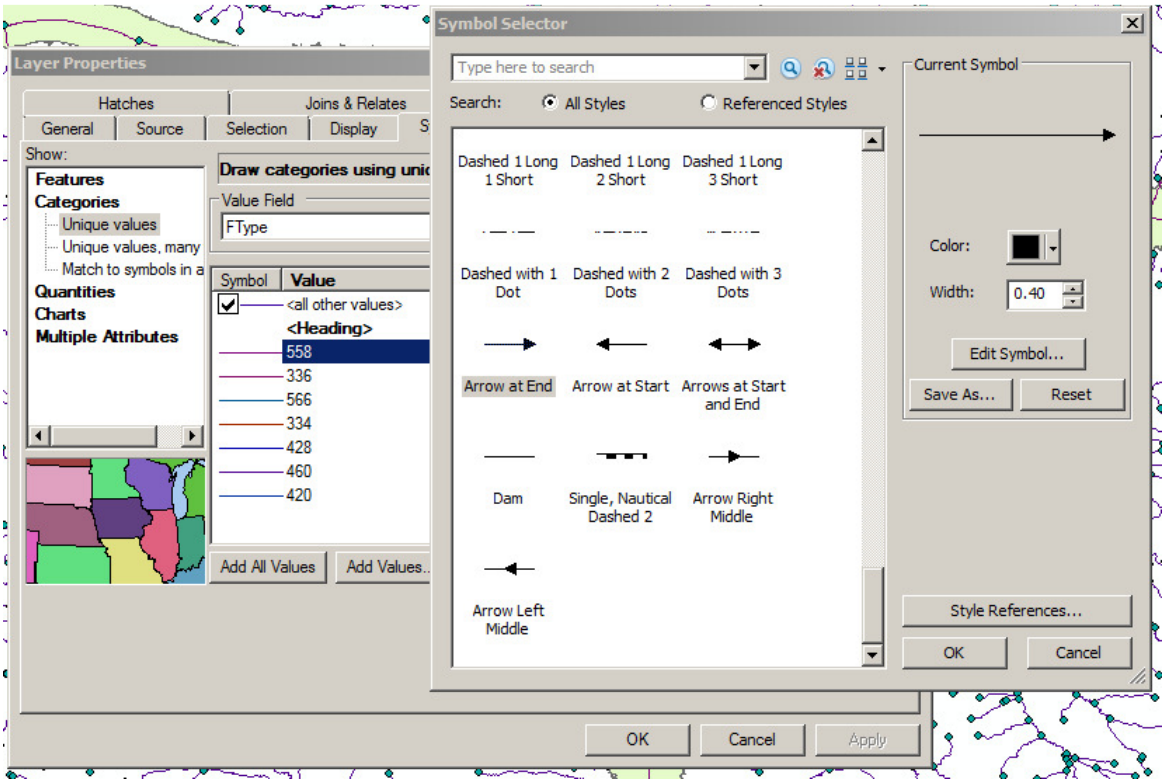
5. Click the boxes next to the layer files you just enabled to turn them off.

6. Let's assign our own symbology to a layer.

    a. Double-click on **NHDFlowline** to open the **Layer Properties**.

    b. Double-click on the line symbol next to **558**, representing **ArtificialPath**.

    c. Choose the line called **Arrow at End**.



    d. Choose the color you want to represent ArtificialPath.

    e. Then click on **Edit Symbol**.

    f. In the **Symbol Property Editor**, choose the **Line Properties** tab.

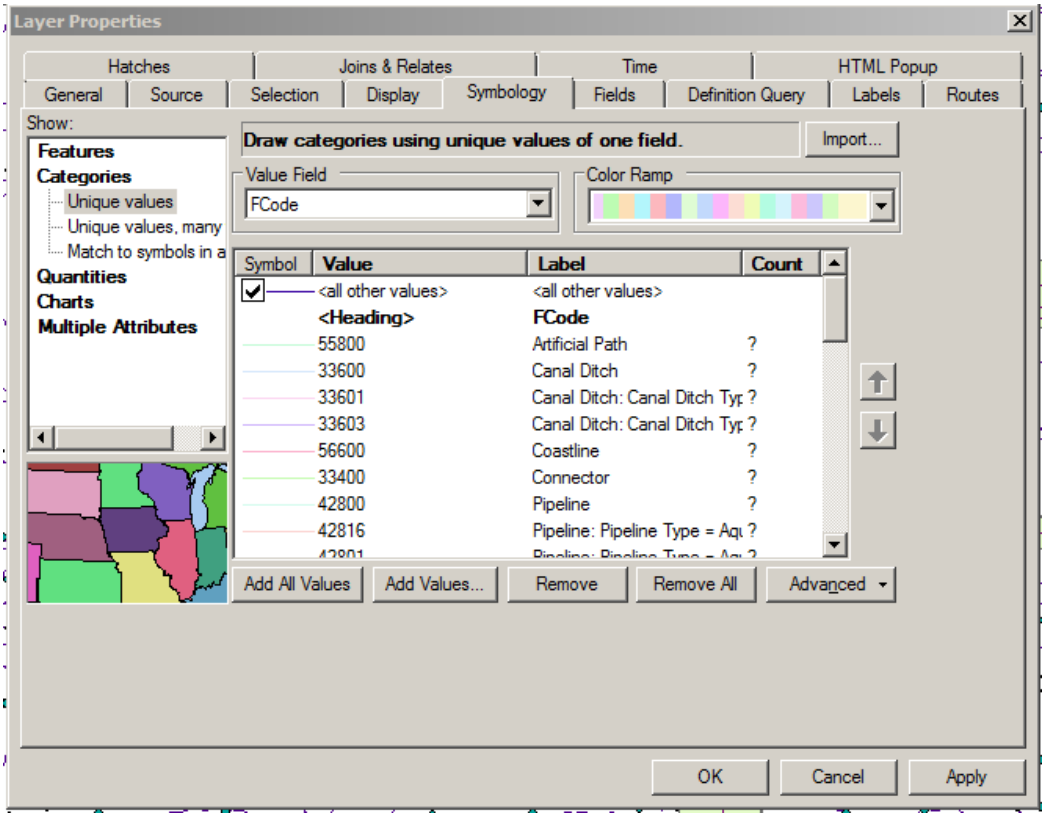
    g. Click on **Properties** under **Line Decorations**.

    h. In the **Line Decoration Editor**, click on **Symbol**.

i. In the **Symbol Selector**, choose the color corresponding to the line color you selected above.

j. Follow the same steps for each of the line features in the NHDFlowline layer.

k. If you want to symbolize by FCode*, simply change the Value Field under the Symbology tab, click on **Add All Values**, and then follow the same steps as above to symbolize accordingly. You can remove any values you don't want to show up or which are not present in your data.



l. If you want to save the symbology as a layer file, right-click on the layer in the **Table of Contents** and select **Save as Layer File**.
*For a complete list of FCodes, see the PDF document **FCodeTable** located in the Exercise folder.

7. There are other ways to visualize the NHD in a map that may aid in analysis or help you to better understand your project area. One way to do this is to set a definition query on a layer to only show certain FTypes or FCodes.

a. Using the same data as earlier in the exercise, let's query the data to only show large rivers in order to easily be able to calculate how many square kilometers of larger rivers there are in the Missouri-Musselshell.

b. Turn all Hydrography layers off (use the **Ctrl** key and click on one of the boxes next to the layers in the Table of Contents to deselect them all).

c. The large rivers are mapped as polygons and are located in the **NHDArea** layer.

d. Double-click on the **NHDArea** layer to open the **Layer Properties**.

e. Click on the **Definition Query** tab.

f. Click on the **Query Builder** tab.

g. Open the **FCodeTable** PDF located in the exercise folder.

h. Find the table for **NHDArea** and locate the FCodes for **Stream/River**.

i. Let's query for 46000 and 46006.

j. Double-click on "**FCode**" in the **Query Builder**.

k. Build a query that looks like this or copy and paste this into the Query Builder window: "FCode" = 46000 OR "FCode" = 46006

l. Click Ok and then check the box next to **NHDArea** to turn the layer on

m. You can see that only a selection of NHDArea appears.

n. In order to be able to identify what the rivers are, let's also select the **ArtificialPath** features that run through the NHDAreas.

o. From the **Selection** menu, choose **Select by Location**.

p. Select features from **NHDFlowline** that are within the source layer feature of **NHDArea**.

q. Right-click on **NHDFlowline** in the **Table of Contents** and choose Selection>**Create Layer from Selected Features**.

r. Now use the **Identify**  tool to see what the names of the rivers are. If the ArtificialPath is associated with a name, it will be under the GNIS_Name.

i. You can see that Missouri River, Judith River, Blood Creek, Arrow Creek, and the Musselshell River are some of the larger rivers in the Missouri –Musselshell

s. Now right-click on the **NHDArea** layer in the **Table of Contents** and select **Open Attribute Table**.

t. You should see eight features.

u. Right-click on the Field Name **AreaSqKm** and select **Statistics**.

v. Look at the Sum number, and you will see that major rivers constitute 66.7 sqkm.

w. Remove the definition query from NHDArea and remove the temporary selected flowline layer.

8. Let's play around with the symbology of the Watershed Boundary Dataset (WBD).
   a. Turn off all Hydrography layers for now.

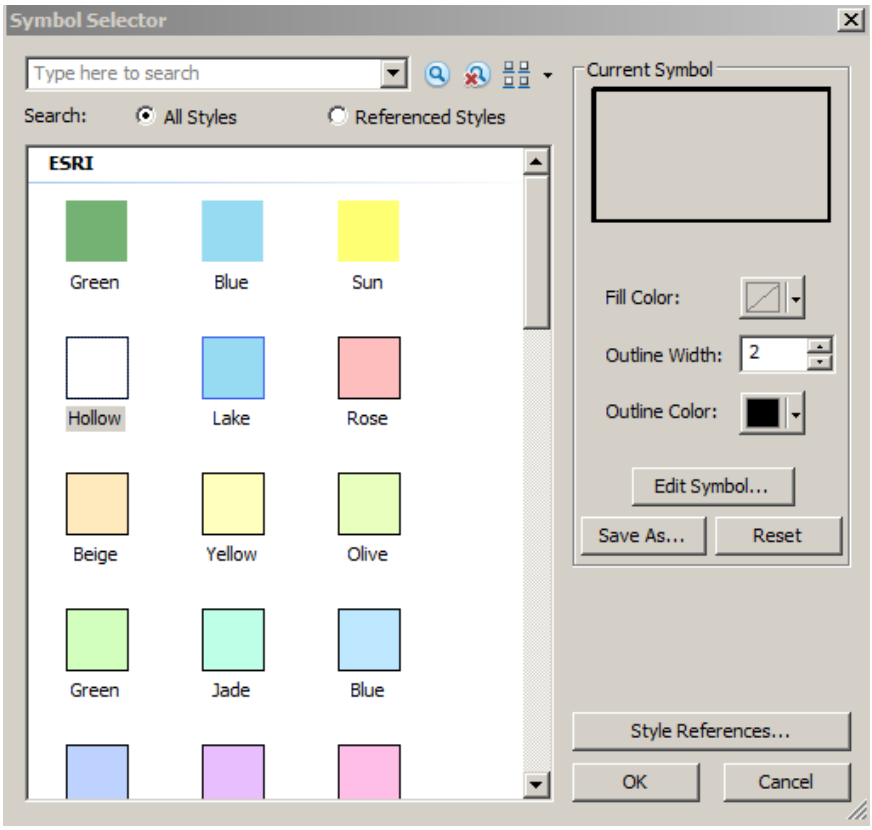
   b. Turn off all WBD layers except for **WBDHU4**.

   c. Right-click and **Zoom to Layer**.

   d. Turn on **WBDHU8**, and you will see that all 8-digit HUCs available are contained within the Missouri-Musselshell 10-digit HUC because the GDB was downloaded as a pre-staged extract.

   e. Click on the symbology box below **WBDHU4** to open the **Symbol Selector** window.

f. Select Hollow from the window on the left and change the Outline Width to 2.



g. Change the symbol for WBDHU8 to **Hollow** with an **Outline Color** of orange and an **Outline Width** of 1.

h. Double-click on **WBDHU8** to open the **Layer Properties**.

i. Select the **Labels** tab.

j. Check the box next to **Label features in this layer** and confirm that the **Label Field** is **Name**. Click OK.

k. Now it is easier to view and identify the watershed boundaries.

l. Right-click on **WBDHU8** and choose **Selection>Make This The Only Selectable Layer**.

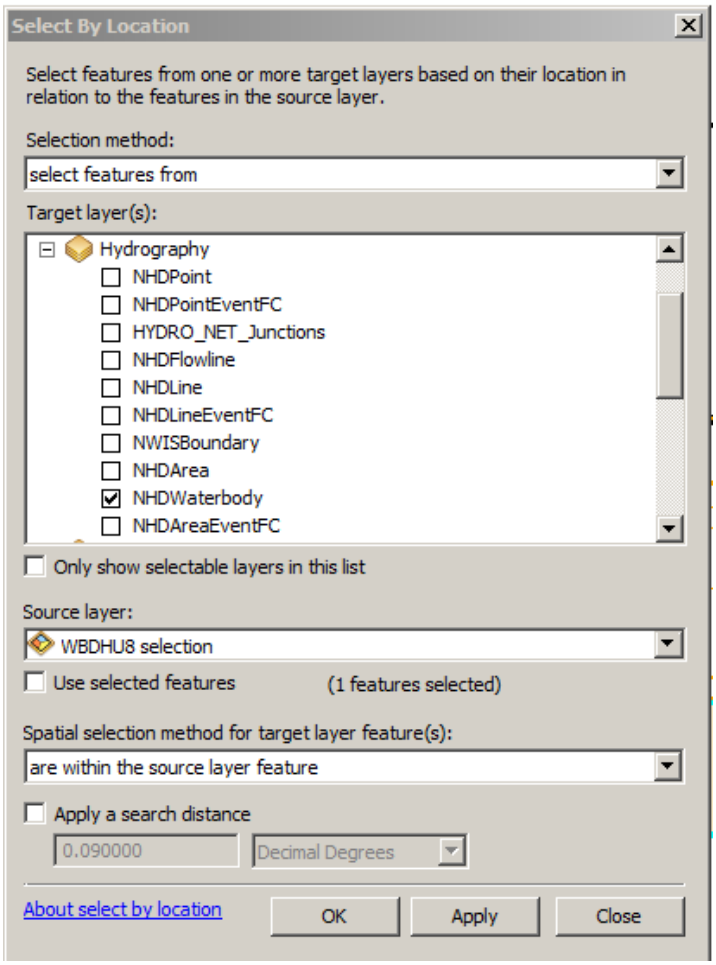
m. Using the Selection tool  select the Upper Musselshell.

n. Right-click on **WBDHU8** and choose **Selection>Create Layer from Selected Features**. You could also choose to **Export Data** and create a new feature class of this one subregion if you wanted to.

o. Clear selected features. 

p. From the **Selection** menu, choose **Select by Location**.

q. Let's query all **NHDWaterbody** features contained within the **WBDHU8 selection**.



r. Open the attribute table for NHDWaterbody to see the selected features.

s. You can either create a temporary layer from these features or export the data to a separate feature class in order to further analyze it.

These are just some of the many ways you can symbolize NHD data and query the layers in order to glean more specific information. The large number of features and types in the NHD can be overwhelming, but by applying symbology and setting definition queries or selections to subset the data to only those features of interest it can be turned into an aesthetically pleasing and intuitive cartographic product.

Anyone familiar with GIS data, or any data for that matter, knows that metadata (data describing data) is absolutely essential. The National Hydrography Dataset is rich in metadata, containing both geodatabase-level metadata and feature-level metadata. Fortunately, relationship classes are included with the NHD model that make navigating the metadata tables straightforward. In this exercise, we will take a brief look at the database-level metadata and other sources of information that describe the hydrography model and how to use it, then we'll take a more in depth look at feature-level metadata.

---

1. View NHD metadata in ArcCatalog

a. **Open** ArcCatalog and navigate to the *Exercise folder*.
… \Exercises\Metadata\NHD_UpperMusselshell.gdb

b. **Expand** the File Geodatabase and select the Hydrography feature dataset.
   i. In Catalog, click on the **Description Tab**.
   ii. Take a few minutes to scan through the metadata.

2. The metadata that come embedded with the NHD geodatabase are minimal. Additional information is available in the NHD Model Diagram, the NHD Data dictionary, and at the feature level.

a. Explore the NHD Model Diagram <http://nhd.usgs.gov/NHDv2.1_poster_3_23_2012.pdf>
   i. What **FType** would you use to represent a reservoir?
   ii. What **FCode** would you use if the reservoir were a settling pond?

b. Use the **NHD Feature Catalog** to learn about the three tables and relationship classes used to discover NHD feature level metadata <http://nhd.usgs.gov/userguide.html>
   i. What key fields link a feature class to its metadata tables?

3. **Explore feature level metadata**

a. **Add all features and tables** from the exercise geodatabase to ArcMap.

b. Collapse all layers in the table of contents and make sure you are on the "**List by Source"** tab.

c. **Open** the NHDFlowline feature class attribute table
   i. The Permanent_Identifier field is the field used to associate a feature with its metadata.
      1. Note that some Permanent Identifiers are short some are very long. The shorter ones are grandfathered in from an older data model that contained

a field known as Com_Id. As these features are updated these shorter perm ids will be replaced by the standard 36 character strings (global id).

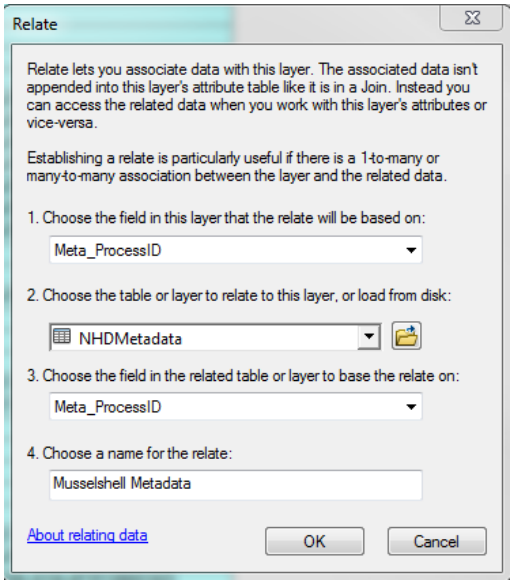
ii. **Close** the table

d. **Open** the NHDFeatureToMetadata table
   i. This table is used to build a relationship between the permanent_identifier field in the NHDFlowline attribute table and the Meta_ProcessID.
   ii. **Close** the table

e. **Open** the NHDMetadata table
   i. This table contains all metadata information for the features found in this dataset.

4. Relate a Feature to its Metadata

a. NHD Databases have relationship classes built between the three tables explored in Step 3 allowing features to be linked to their metadata.
   i. **Open** the NHDFlowline Attribute Table.
   ii. In the upper left-hand corner of the table, click on the **options menu**  and then choose the option to select by attributes.
      1. Enter this query in the space provided exactly as follows:
         a. "GNIS_Name" = 'Musselshell River'
      2. All Flowlines with the name Musselshell River will be selected (202).
   iii. Next, we will see all metadata records associated with these feature. Again, click on the **Options menu** of the attribute table. In the drop down menu, Choose "**Related Table**s", then click on '**NHDFlowlinetoMeta : 1DFToFeaturetoMetadata**. '
      1. The NHDFeaturetoMetadata table will appear with all of the Meta_ProcessID records (557) that are related to the Musselshell River.
   iv. Next, we need to relate this table to the NHDMetadata table to get descriptive information.
      1. Click on the **Options menu** of the NHDFeaturetoMetadata table. Choose the option for "**Joins and Relates**". Then Choose "**Relate**". Relate the NHDFeatureToMetadata table to the NHDMetadata table by the Meta_ProcessID and name the relate "MusselshellMetadata". Click "**Ok**".



v. Again click on the **Options menu**  of the attribute table. Choose "Related Tables" from the dropdown menu. Click on "Musselshell Metadata : NHDMetadata" This relate should be at the bottom of the dropdown menu. The Metadata table will open with a description of all of the edits that have been made to the Musselshell River.

1. What organizations have made revisions to the Musselshell flowlines?

5. **Relate Metadata to its Features. Just like features can be related to their metadata records, we can use an inverse approach to relate metadata records to the features associated with them. In this step we want to select all flowline features that have been revised in 2014 to "match current 2011 NAIP imagery".**

a. **Open** the NHDMetadata table.

b. Make sure you are viewing all records, not just selected records. If any records are selected, **clear**  **your selection**.

c. Click on the **Options menu**. Choose "**Select by Attributes**".

d. We will create a query to select the MetaProcess IDs related to the process description of "match current 2011 NAIP imagery"

i. Enter the following query: **"ProcessDescription" LIKE '%match current 2011 NAIP imagery%'**

ii. The metadata records associated with 2011 NAIP are selected (3)

e. Next, we will relate these records to their associated record(s) in the NHDFeaturetoMetadata table. The relationship class to do this is already built into the database.
    i. Click on the **Options menu** of the NHDMetadata table.
    ii. Choose "**Related Tables**" from the dropdown menu, then select the relationship "NHDMetatoFeature : MToFeatureToMetadata".
    iii. The NHDFeatureToMetadata table will appear with the associated records selected (205)

f. Next, we will relate these records to their associated flowline features.
    i. Click on the **Options menu** of the NHDFeatureToMetadata table.
    ii. Choose "**Related Tables**" from the dropdown menu, then select the relationship "NHDFlowlineToMeta:ToNHDFlowline"
    iii. The flowline features associated with these metadata records are now selected in the NHDFlowline attribute table

g. Since we only want features changed in 2014, click on the Options menu and Select by Attributes.
    1. Change the selection Method to "**Select From Current Selection**"
    2. Enter the following query: **"FDate" >= date '2014-01-01'**
    3. How many revisions have been made in 2014 to better match NAIP?

The NHD has a lot of applications and uses. In this exercise, we'll explore how to generate river mile markers and also take a look at NHDPlus.

River mile markers are used in a similar way as road mile markers, as a reference to specific areas of the river or to easily identify the location of events or features tied to the **NHDFlowline** features, such as dams or fish species found between two river mile markers.

The NHDPlus is a seamless 1:100K NHD with value added attributes (VAA) that enhance stream network navigation, analysis, and display. Some uses of VAAs in analysis include stream order, waterbody identifier, upstream miles, and distance to terminus.

In a previous exercise, we used The National Map Viewer to download NHD data. For this exercise, the data has been downloaded for you and is located in the **Applications** exercise folder and called **NHD311911_SPC.gdb**. This GDB has already been projected.

River Mile Markers

1. Open ArcMap.

2. Using the **Add Data** button  navigate to the **NHD311911_SPC.gdb** and select all features before clicking **Add**.

    a. If you get a Warning message stating "A selected item could not be added to the map. Item not found in this collection," say OK.

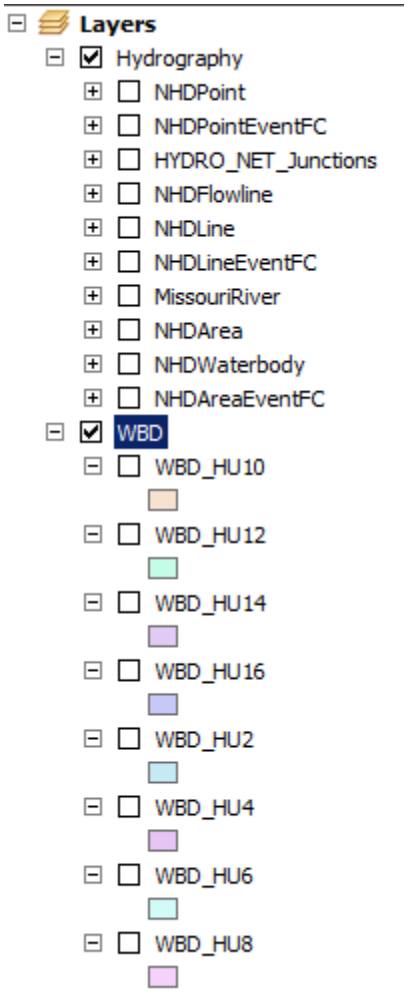
3. Deselect all layers by holding the **Ctrl** key and checking one of the boxes next to the layers.

4. Select all of the layers that are part of the **Hydrography** dataset and right-click and select **Group**.

    a. Rename the group **Hydrography**.

    b. Group all the layers of the **Watershed Boundary Dataset** and rename it **WBD**.

    c. The group layers should appear similar to the snapshot below.



5. This data was extracted using the bounding box in the National Map Viewer, so the extent doesn't fall within a certain watershed boundary. Let's generate river mile markers for the Missouri River which runs through this extent.

    a. Open the attribute table of the **NHDFlowline** layer.

    b. Open the **Table Options** menu and choose **Select by Attributes**.

    c. Create a query to search for all reaches identified as the Missouri River:

    "GNIS_Name" = 'Missouri River'

    d. In the attribute table, you should see 321 features selected. Right-click on the **NHDFlowline** layer and select **Export Data**.

i. Navigate to the GDB and save the selected features as a new feature class called **MissouriRiver**.
ii. Add the exported data to the map as a layer.

e. Clear selected features and close the attribute table

f. Zoom to the extent of the **MIssouriRiver** and turn off all other **Hydrography** features.

g. Let's dissolve the 321 segments to create a single flowline.

i. From the **Geoprocessing** menu, select the **Dissolve** tool.

ii. Select the **MissouriRiver** layer for **Input Features**.

iii. Navigate to the **NHD311911.gdb** and name the new feature class **MissRivDissolve**.

iv. Check the box next to **GNIS_Name** under the **Dissolve_Field(s)** field.

v. Click OK and then OK again to run the tool.

6. Right-click the **NHD311911_SPC.gdb** in Catalog and select **New>Feature Class**.

a. Create a point feature class called **MissRivMiles**.

b. Select **NAD_1983_StatePlane_Montana_FIPS_2500** as the coordinate system.

c. Click through the rest of the dialog and click **Finish**.

7. Right-click **MissRivDissolve** and select **Edit Features>Start Editing**.

8. Right-click **MissRivDissolve** and choose **Selection>Select All**.

9. From the **Editor** dropdown menu, select **Construct Points**.

10. In the **Construct Points** dialog, confirm that **MissRivMiles** is the **Template**.

a. Under **Construction Options**, choose **Distance**.

b. Enter **1609.34** (this is how many meters are in a mile). The data frame is in meters.

c. Check the box next to **Create additional points at start and end**.

d. Click OK.

e. Save edits. Stop editing.

11. If you zoom into the **MissRivDissolve** layer, you can see that there are points every mile along the Missouri River. If you wanted to be able to identify which mile is which, you can add a field to the **MissRivMiles** layer called **RiverMile** , Type **Long Integer**.

    a. Use **Field Calculator** to populate **RiverMile** with the contents of **OBJECTID**.

    b. You can then label each point with its river mile number.

NHDPlus Network Analysis

There are many steps involved to prepare the NHDPlus. The most straight-forward instructions can be found under Option 1 under **Other Resources** at the bottom of this document. We will complete a short exercise on **NHDPlus Network Analysis**, following the steps outlined in the exercise with the same name created by Horizon Systems and available here. The data has already been downloaded for you and is available in the **Exercises\Applications\NHDPlusData\NHDPlusV2_1ExerciseData** folder. It contains data from Tennessee.

1. Start ArcMap.
2. Using **Add Data**  , navigate to **Exercises\Applications\NHDPlusData\NHDPlusV2_1ExerciseData\NHDPlusMS\NHDPlus06|NHDSnapshot|Hydrography**. Click on **Flowline.shp** and then **Add**.
3. Open ArcToolbox  and expand the **Linear Referencing Tools**.
4. Load the **Discharge Point** events (dbf) into the map. These events represent locations where something is being discharged into a surface water feature. (Exercises\Applications\NHDPlusData\NHDPlusV2_1ExerciseData)

    a. Double-click on **Make Route Event Layer** in the **Linear Referencing** toolbox.

    b. Use the **Input Route Features** dropdown menu to select the NHD route feature class which is **NHDFlowline**.

c. Use the **Route Identifier Field** to select the NHD route identifier which is **ReachCode**.

d. Use the **Input Event Table Folder** dropdown to select the **NHDPlusData** folder and select **Discharge_Points.dbf**.

e. Use the **Route Identifier Field** pull down to select **RCH_CODE** as the route identifier in the event table.

f. Use the **Event Type** pull down to select **Point**.

g. Use the **Measure Field** pull down to select **P_Meas**.

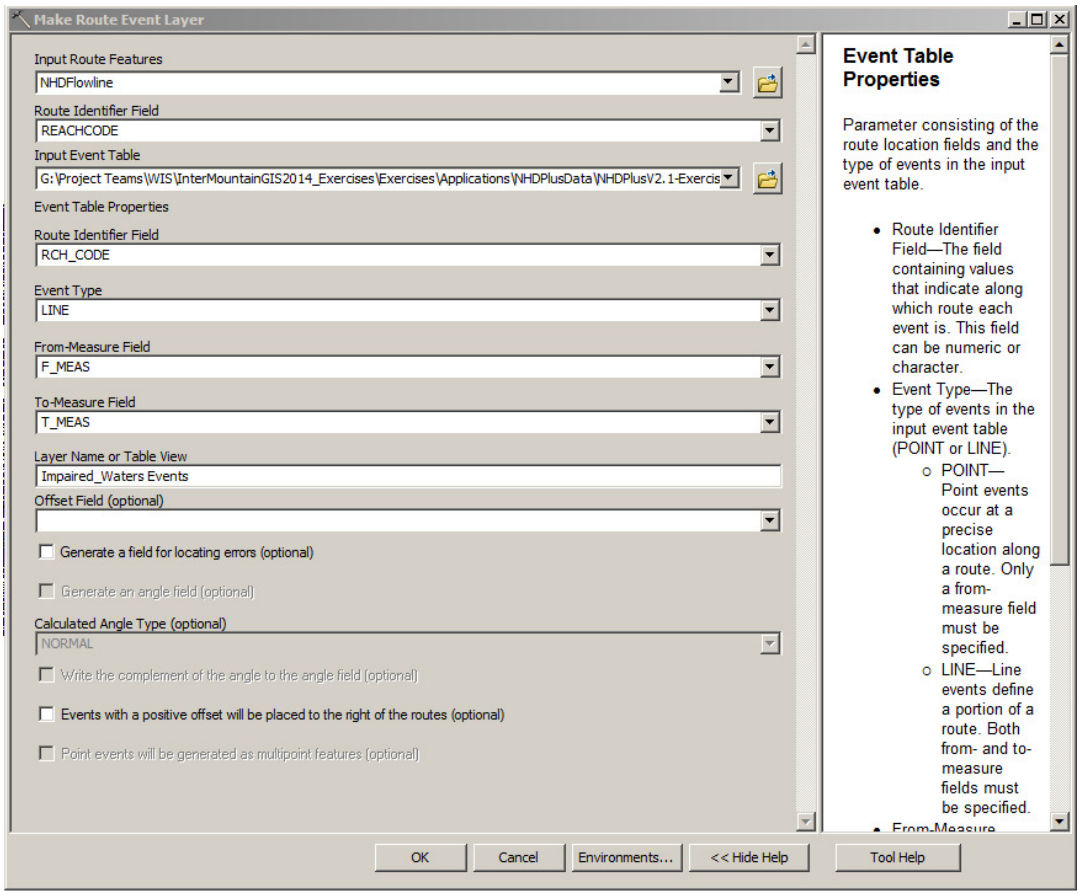
h. Use the dropdown menu to set the **Offset Field** to **EOFFSET**.

i. Leave the remaining items at their default values.

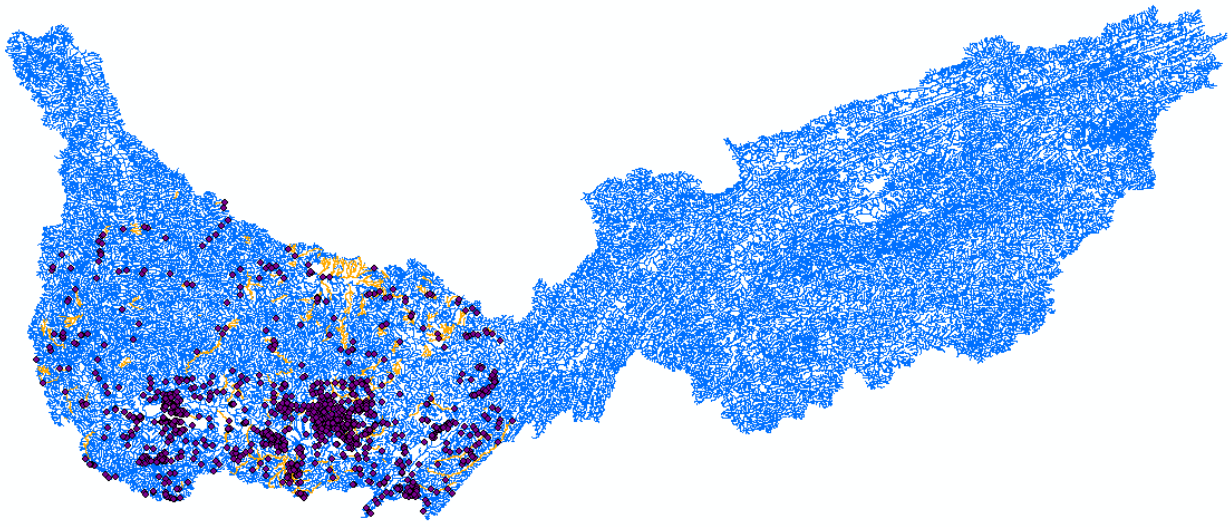
j. Click OK.

5. A new feature class called **Discharge_Points Events** will be added to the map.

6. Repeat the steps above to load the **Impaired Waters** linear events to the map Exercises\Applications\NHDPlusData\NHDPlusV2_1ExerciseData). Impaired Waters represent stretches of the stream network that have been monitored and found to be impaired.



7. Change the symbology of the **Impaired_Waters Events** to make them more visible.



8. We want to find out which discharge points are located on impaired waters. To answer this question, double-click on **Overlay Route Events**.

    a. In the dialog, use the **Input Event Table** pull down to select **Discharge_Points Events**.

    b. Use the **Route Identifier Field** pull down to select **RCH_CODE**.

    c. Use the **Event Type** pull down to select **Point**.

    d. Use the **Measure Field** pull down to select **P_MEAS**.

    e. Use the **Overlay Event Table** pull down to select **Impaired_Waters Events**.

    f. Use the **Route Identifier Field** pull down to select **RCH_CODE**.

    g. Use the **Event Type** pull down to select **LINE**.

    h. Use the **From-Measure Field** pull down to select **F_MEAS**.

    i. Use the **To-Measure Field** pull down to select **T_MEAS**.

    j. Use the **Type of Overlay** pull down to select **INTERSECT**.

    k. Use the **Output Event Table Folder** button, to browse to the **\NHDPlus06** folder and name the output event table **ImpairedWater_Discharges.dbf**.
    Note: If any part of the filepath name has spaces in it, this tool won't accept it.

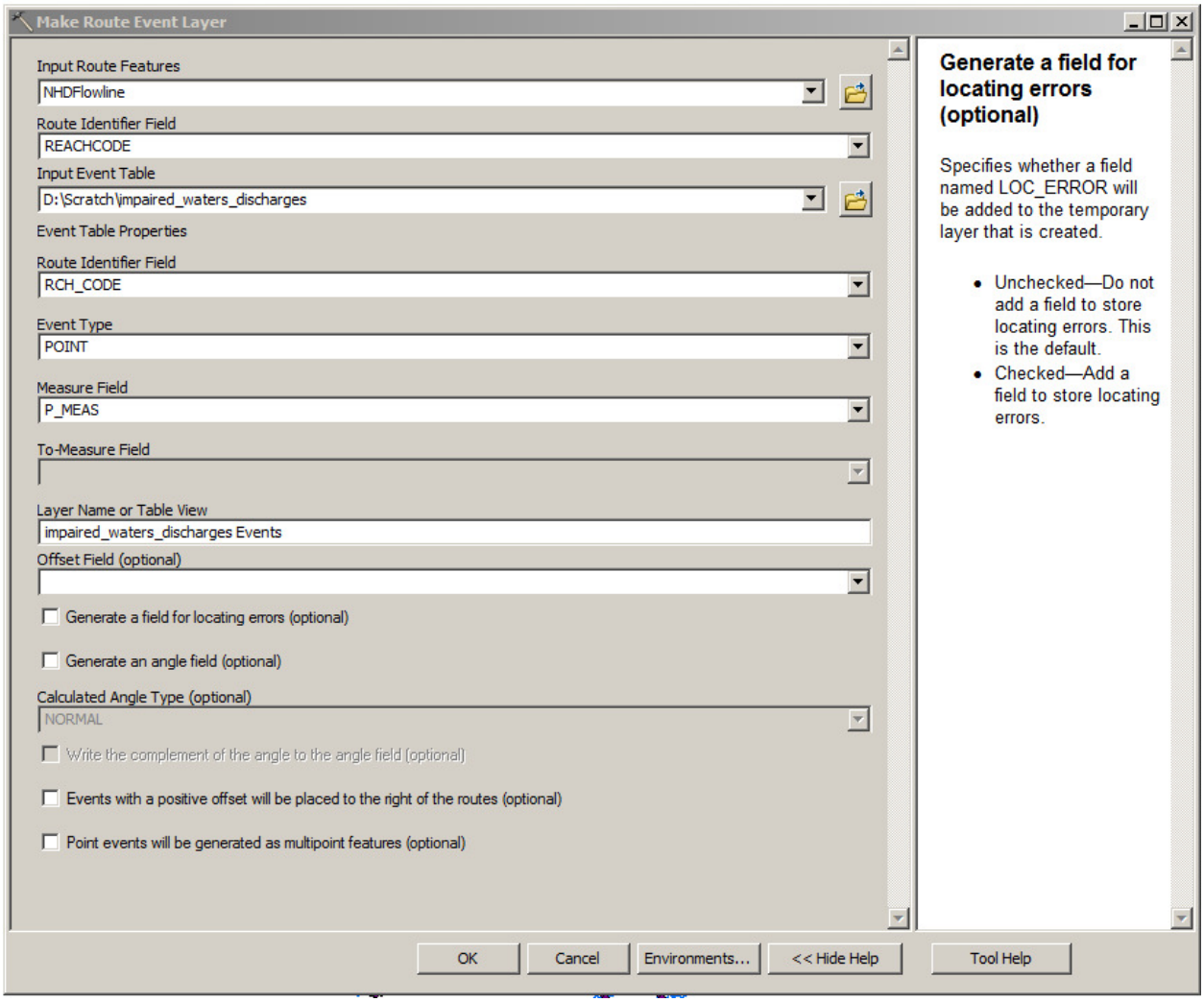
    l. Use the **Route Identifier Field** pull down to select **RCH_CODE**.

    m. Use the **Measure Field** pull down to select **P_MEAS**.

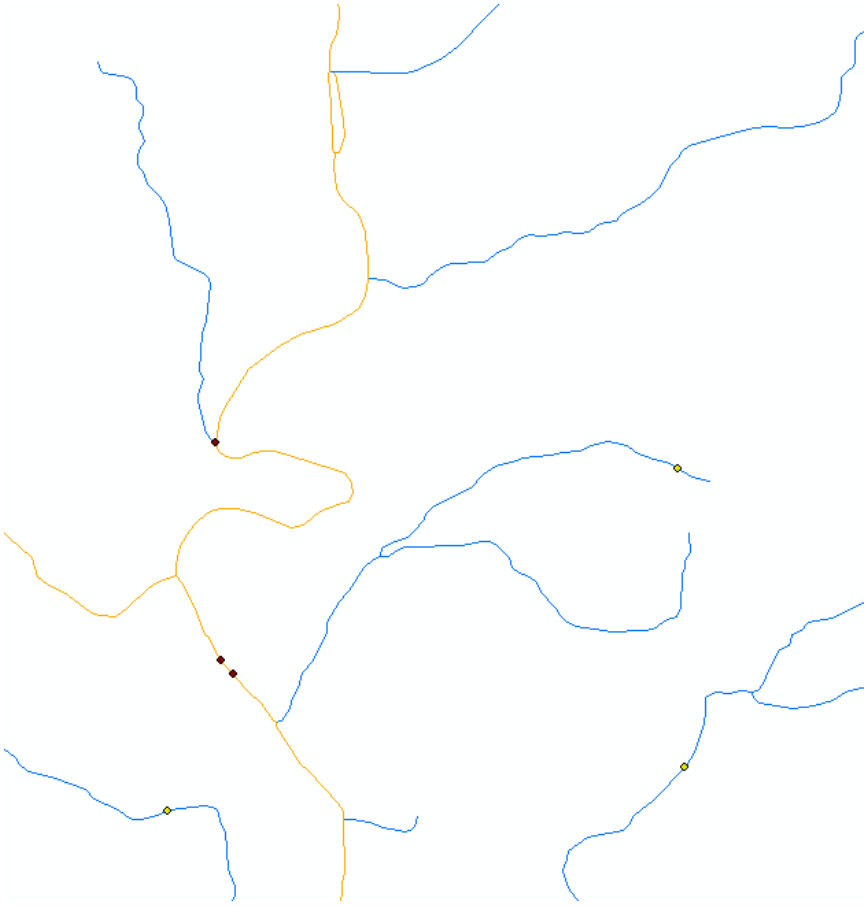
    n. Allow all other options to take their default values.

    o. Click OK. The **Overlay Route Events** will execute.

9. We have just created a new point event table that contains all of the Discharge Points that fall on Impaired Waters. In order to add the new event table to the map, double-click on **Make Route Event Layer** in the **Linear Referencing** toolbox. Fill out the parameters as shown below.



10. You may want to symbolize the events to make them more visible. Zoom in to the map to verify that the **Discharge** points fall on **Impaired Waters**, as seen below.



This is just one of the analyses that can be performed with the NHDPlus network and data that has been linked to the network.

Downloading NHDPlus – to be completed on your own

In this section, we'll use some of the exercise data and instructions provided by Horizon Systems, which hosts the **NHDPlusV2**, to download and explore NHDPlus.

1. The NHDPlus is hosted by Horizon Systems and made available by the U.S. EPA.

2. Go to http://www.horizon-systems.com/NHDPlus/index.php for the NHDPlus homepage.

3. Click on **NHDPlus Version 2** and then **Tools** on the menu to the left of the page.

4. Create a folder **NHDPlusTools** in the Applications exercise folder.

a. Right-click the **NHDPlusV2 Flow Table Navigator** and **NHDPlusV2 Toolbox** downloads and select **Save Link As**, browsing to the **NHDPlusTools** folder.

    i. In order to extract the 7z files, the free 7z utility needs to be installed. It has already been installed on your computer for you, but it can be downloaded from: http://www.7-zip.org/

b. Open **7z**, select all **7z** files, and choose **Extract**, navigating to the same **NHDPlusTools** folder in the **Applications** exercise folder.

c. In Windows Explorer, right-click on the **NHDPlusV2FlowNavigatorToolbarSetup.exe** and select **Run as Administrator**. Use the wizard to install, making sure to check **Everyone** for anyone who uses the computer on the second page of the wizard.

    i. From the **Start** menu, right-click on **ArcMap** and choose **Run as Administrator**.

    ii. From the **Customize** menu, select **Customize Mode**.

    iii. In the **Customize** dialog box, select **Add From File** and navigate to the folder where the toolbar was installed (it might need to be on the C: drive).

    iv. Select **NHDFlowNavigationToolbar.tlb**.

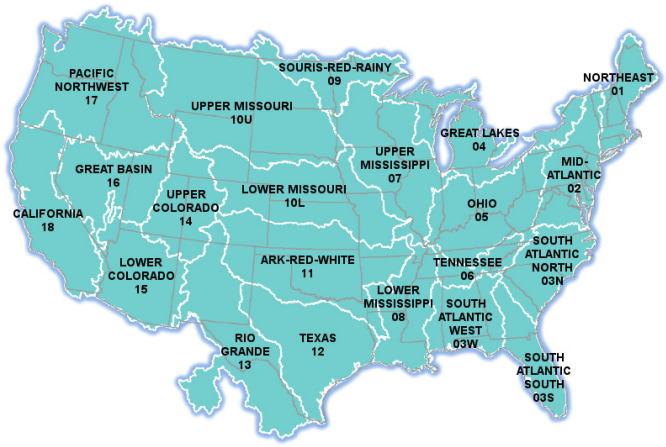
5. Open **ArcCatalog** and click on the **ArcToolbox** icon  at the top of the page.

    a. Right-click on **ArcToolbox** and select **Add Toolbox** .

    b. Navigate to the **NHDPlusTools** folder and add the **NHDPlusV21Toolbox**.

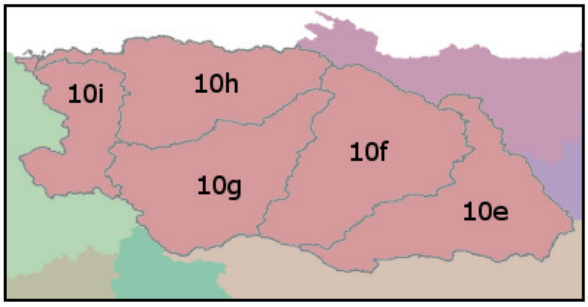
6. Create another folder in the **Applications** exercise folder called **NHDPlusData**.

7. There are two ways to download the data. The first option is to click on **NHDPlus Version 2** on the menu at the left of the page and then **Data**. NHDPlus data is distributed according to hydrologic regions, and you will be taken to a map delineated by these 2-digit HUCs.



01 Northeast
02 Mid Atlantic
03N South Atlantic North
03S South Atlantic South
03W South Atlantic West
04 Great Lakes
05 Ohio
06 Tennessee
07 Upper Mississippi
08 Lower Mississippi
09 Souris-Red-Rainy
10U Upper Missouri
10L Lower Missouri
11 Ark-Red-White
12 Texas
13 Rio Grande
14 Upper Colorado
15 Lower Colorado
16 Great Basin
17 Pacific Northwest
18 California

a. Click on the **Upper Missouri (10U)** region, and you will see an inventory of data available for the region along with download instructions. You'll also see the region broken out into RPUs. We'll download data just for RPU 10e.

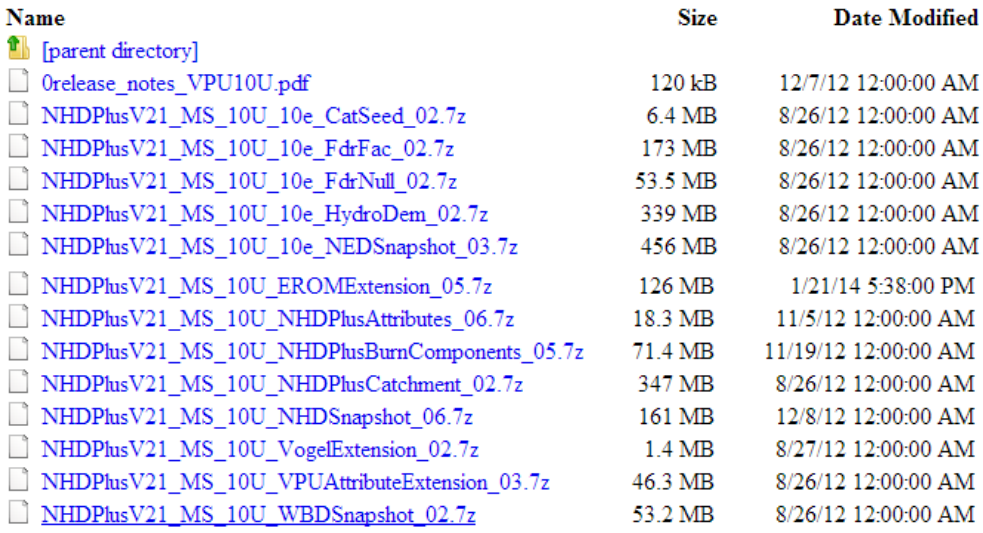


b. Option 2 for downloading data is to use the FTP site, which will be easier and quicker. Go to ftp://ftp.horizon-systems.com/nhdplus/NHDPlusV21/.

   i. Click on **Data**, then **NHDPlusMS**, then **NHDPlus10U**.

   ii. NHDPlus contains raster (grid), vector (shapefile), and tabular data (DBF) for each region. Grid files contain topography, flow direction, and flow accumulation grids. Shapefiles contain drainage and hydrography data, and DBF files contain value added attributes, metadata, and other miscellaneous information.

   iii. **Right-click** on each layer identified as **10e** (as well as other items shown below)and choose **Save Link As**. Save the data to a folder named **NHDPlus** in the **Applications** exercise folder.



Name	Size	Date Modified
[parent directory]		
0release_notes_VPU10U.pdf	120 kB	12/7/12 12:00:00 AM
NHDPlusV21_MS_10U_10e_CatSeed_02.7z	6.4 MB	8/26/12 12:00:00 AM
NHDPlusV21_MS_10U_10e_FdrFac_02.7z	173 MB	8/26/12 12:00:00 AM
NHDPlusV21_MS_10U_10e_FdrNull_02.7z	53.5 MB	8/26/12 12:00:00 AM
NHDPlusV21_MS_10U_10e_HydroDem_02.7z	339 MB	8/26/12 12:00:00 AM
NHDPlusV21_MS_10U_10e_NEDSnapshot_03.7z	456 MB	8/26/12 12:00:00 AM
NHDPlusV21_MS_10U_EROMExtension_05.7z	126 MB	1/21/14 5:38:00 PM
NHDPlusV21_MS_10U_NHDPlusAttributes_06.7z	18.3 MB	11/5/12 12:00:00 AM
NHDPlusV21_MS_10U_NHDPlusBurnComponents_05.7z	71.4 MB	11/19/12 12:00:00 AM
NHDPlusV21_MS_10U_NHDPlusCatchment_02.7z	347 MB	8/26/12 12:00:00 AM
NHDPlusV21_MS_10U_NHDSnapshot_06.7z	161 MB	12/8/12 12:00:00 AM
NHDPlusV21_MS_10U_VogelExtension_02.7z	1.4 MB	8/27/12 12:00:00 AM
NHDPlusV21_MS_10U_VPUAttributeExtension_03.7z	46.3 MB	8/26/12 12:00:00 AM
NHDPlusV21_MS_10U_WBDSnapshot_02.7z	53.2 MB	8/26/12 12:00:00 AM

c. Extract the data to the **NHDPlusData** folder.
d. Use **7-zip** to uncompress the data.

8. Open **ArcCatalog** and navigate to the **NHDPlusV2.1 Toolbox**.

9. Double-click on the **1. Prep NHDPlus V2.1 Data**. This builds indexes and pyramids for the data.

    a. Navigate to **NHDPlus10U** folder and select it. Click OK. This will take a long time depending on how much data there is.

Other Resources

1. NHDPlusV2 Exercises

http://www.horizon-systems.com/NHDPlus/NHDPlusV2_documentation.php

2. **NHDPlus and Flow Networks exercise**

http://www.crwr.utexas.edu/gis/gishydro07/Introduction/Exercises/Ex5.htm

3. NHDPlusV2 User Guide

ftp://ftp.horizon-systems.com/NHDPlus/NHDPlusV21/Documentation/NHDPlusV2_User_Guide.pdf

In this exercise, we will learn how to use one of the most valuable functions of the Hydrography Dataset: the network. We will use the Utility Network Analyst (included with ArcGIS) to navigate the hydrography network and perform upstream and downstream traces. This analysis is user interactive, allowing the user to add barriers and modify the trace, and, best of all, it is fast because processing is vector-based.

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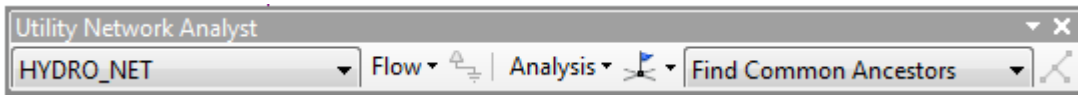
1. **Take a look at the exercise geodatabase and make sure a network is present.**
   a. **Open** ArcCatalog or ArcMap and navigate to the exercise geodatabase …\NetworkNavigation\NHD_RedRock.gdb

   b. You should see a geometric network called **HYDRO_NET**

   c. **Add** HYDRO_NET to ArcMap (notice that two feature classes are added, HYDRO_NET_Junctions and NHDFlowline)

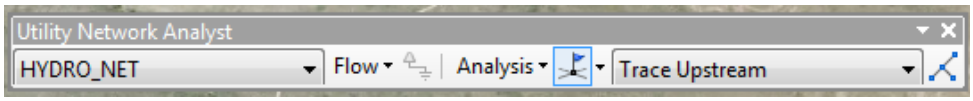
2. **Explore the network in ArcMap and determine where and why network navigation won't work. Fix issues where appropriate.**
   a. Activate the **Utility Network Analyst** (Customize>Toolbars>Utility Network Analyst)



   b. Display the direction of flow by using **Utility Network Analyst>Flow>Display Arrows**

   c. **Add** an aerial image for reference (Add Data>Add Basemap>Imagery with Labels).

   d. Let's perform an upstream trace to identify all surface waters contributing to Clark Canyon Reservoir.
      i. Place a **junction flag**  on the flowline junction nearest the dam.
      ii. In the Utility Network Analyst dropdown choose "**Trace Upstream**"



      iii. Hit the **Solve** button 

   e. Since Clark Canyon Dam is the most downstream point (outlet) of this basin, we would expect all of the flowlines to be part of the trace results. However, notice this is not the case. Let's investigage why:

i. **Are there disconnected networks?**
    1. Notice the large number of flowlines just upstream of the reservoir inlets that are not included in the trace results. These flowlines never connect back into the bigger system. Many of these may be a correct representation of the surface hydrology (e.g. water dissipates underground); others may not. Fix some of the disconnected flowlines that seem incorrect by starting the Editor and adding a Connector Line from the end of the gap to the main network or by extending an existing flowline. Digitize in the direction of flow from upstream to downstream. (For this exercise, you don't have to fix all of the problems you see; just fix a few of the larger issues for practice). Save Edits.

ii. **Is flow direction correct?**
    1. Notice the large number of headwater flowlines (south corner of the basin) that are not included in the trace results. Perform a downstream trace starting high in these headwaters to investigate why. Find the reach where flow direction is incorrect, then fix it by starting the Editor, double-clicking the reach, then right-clicking and choosing Flip. This will flip the flow direction. Save Edits.

iii. **Is flow initialized?**
    1. Open the NHDFlowline attribute table and investigate the FlowDir field. Records marked "WithDigitized" participate in the network. For this exercise, switch all "Uninitialized" features to "WithDigitized." Save Edits.

f. In order for the new changes to participate in the flow network, the network needs to be deleted then rebuilt.
    i. Using ArcCatalog, **delete HYRO_NET**.
    ii. Use Network Builder (**Start>Programs>NHDUtilities**) to **rebuild the flowline network. Be patient.**

g. **Redo Step d**. (place a junction flag at the dam and perform an upstream trace). Are more flowlines included in the trace results than before? If yes, then continue to Step 3. If no, try to determine why not and repeat step e.

3. Hypothetically, an aggressive, exotic species has been introduced to the Red Rock River just downstream of the town of Lima. The parasite is able to quickly migrate downstream by drifting and can take advantage of any flow regime by going dormant when there is no flow. To slow the spread, biologists develop a special filter that is harmless to the environment but deadly on the parasite. The filter is ideally installed at USGS Stream Gaging Station locations.

a. Using the skills you've learned in this exercise and previous ones, do the filters stop the species from reaching Clark Canyon Reservoir?

i. Tips: Use NHDPointEventFC to identify the locations of Gaging Stations. Place Utility Network Analyst "barrier" flags at these locations.

b. How many miles of streams, rivers, and canal/ditches are invaded by the exotic species?
   i. Tips: The Utility Network Analyst—Analysis Options—Results tab provides an option to select flowlines, rather than draw. Once flowlines are selected, export and project to a Projected Coordinate System (such as MT State Plane), so that linear measures are accurate.

In this exercise you will apply what you have learned throughout this workshop to explore the Montana NHD in an area of interest to you, identify needed revisions, then submit the revisions to the Montana State Library using the Montana Hydrography Stewardship Edit Submission Form and the Montana Hydrography Edit Request Viewer (web application). Lastly, you'll be provided information about other ways to contribute.

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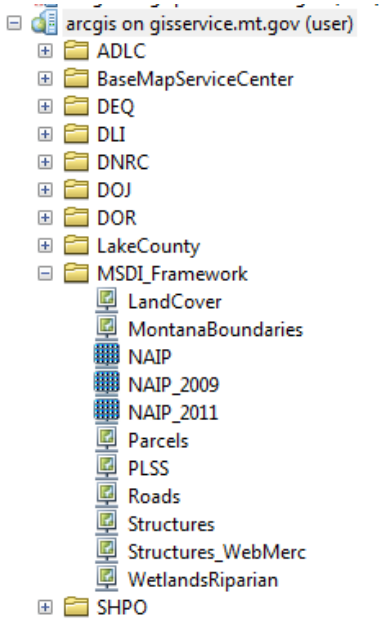
1. **Explore the exercise NHD Flowlines and Waterbodies in an area of interest to you**
    a. **Add** NHD Flowlines and Waterbodies from the MTHydroStew.GDB to ArcMap
        i. Note: The data are statewide, so you may want to zoom in first to expedite drawing.

    b. **Use the layer files** from the Symbology Exercise **or set your own symbology** to better represent the flowlines and waterbodies, such as by FType, by FCode, show flow direction arrows, etc.

    c. Make a connection to NAIP imagery services
        ii. ArcCatalog>GIS Servers>Add ArcGIS Server
        iii. In the "**Add ArcGIS Server**" window choose Use GIS Services. **Next**.
        iv. For the Server URL enter: http://gisservice.mt.gov/arcgis/services **OK**.
            1. A new server connection is added to ArcCatalog
            2. This connection provides access to 2009 and 2011 NAIP in the MSDI Framework folder



h. **Add the NAIP 2009 and NAIP 2011** services to ArcMap (these services are statewide)
    i. Tip: Use multiple imagery years when reviewing the hydrography dataset due to the dynamic nature of rivers and streams. An "average" or compromise of multiple years is a reasonable expectation.

i. Other reference datasets that may be helpful can be found through **ArcMap>Add Data>Add Basemap (or from ArcGIS Online)**

j. **Choose an area** in Montana that you are familiar with, such as near your home, place of work, or a favorite recreation spot.
    i. **Zoom** to the area in ArcMap
        1. Keep the area relatively small (1:100k to 200k or so)
    ii. **Set a Bookmark** so you can easily return to this extent as needed (Bookmarks—Create Bookmark)

2. Identify features needing revision

a. With the NHD flowlines and waterbodies overlayed on NAIP imagery or other reference layers, pan around your area of interest to visually inspect the quality of the hydrography dataset. You'll want to **zoom in to take a closer look** (1:5K to 1:12k seems reasonable without being overly scrupulous).
    i. **Try to identify problems**, such as missing waterbodies, poorly digitized waterbodies, flowlines that poorly align with the imagery, missing names (where the name does exist on a topo), disconnected flowlines, incorrect Ftype or Fcodes, or flowline density that appears inconsistent with adjacent areas. There are many other possibilities; see what you can find!
    ii. Tip: Color Infrared (**CIR**) can be very helpful in identifying drainages. Wetter areas appear bright red. To do this, change the NAIP symbology to display Band 4 in the red channel, Band 1 in the green channel, and Band 2 in the blue channel.
    iii. If you can't find any issues, congratulations—this is rare! Pick another area of interest and search some more (there are many missing stock ponds in eastern Montana).

b. Look for additional issues with the flow network by performing traces using the Utility Network Analyst.
    i. Does an upstream trace started low in the drainage trace to the headwaters? If not, try to figure out why and if there is a problem with the network or if the results are legitimate.

3. **Submit edits to the Montana State Library using the Montana Hydrography Edit Submission Form**
    a. Hopefully, in Step 2 you identified atleast a few edits that need to be made to the Montana Hydrography Dataset.

    b. Open the "**MontanaHydrographyEditSubmissionFrom.doc**" found in the Exercise folder.
        i. **Fillout** the form as best as you can. If you have any questions about what is being requested on the form, ask the instructors (we will appreciate learning what needs to be more clear on the form)
        ii. **Email** the completed form to tblandford@mt.gov
        iii. Pat yourself on the back and feel good about contributing to the improvement of the Montana Hydrography Dataset.

4. **Submit edits to the Montana State Library using the Montana Hydrography Edit Request Viewer (web application)**
    a. Go to **arcgis.com**

    b. **Login**. If you do not have an ArcGIS Online account, create one by clicking "Create A Public Account"

    c. Once logged in search for "**Montana Hydrography**"
        i. In the list of results choose, "**Montana Hydrography Edit Request Viewer**"
        ii. Choose Open, "**Open in ArcGIS.com Map Viewer**"

    d. Take a few minutes to explore the application
        i. Familiarize yourself with how to navigate (zoom and pan)
            1. Many of the "Hydro_Edit" features are so small that they do not appear until you zoom in.
        ii. Click on a feature to return more information about it (info. comes from the feature's attribute table)
        iii. Explore **Content** (turn layers on and off, set transparency, control the popup, show the attribute table)
        iv. Explore **Legend** (make a mental note of what the various Hydro Edit colors mean)
        v. Explore **Basemap** (Imagery with Labels will be the most useful reference layer for this exercise)

    e. **Turn on** one of the NHD layers (the cached layer is faster but less up-to-date)
        i. If you use the cached NHD you will want to be able to see imagery underneath. To do this, change the transparency setting.

    f. **Zoom** to your area of interest and find some of the revisions you noticed in Step 2.

g. In the top left corner of the application, click **Edit**. An Editing template appears on the left side of the map.
    i. To add a feature, click its symbol in the template (for this exercise there is only one option: a yellow polygon)
    ii. **Draw** a polygon around the feature that needs to be reviewed. The goal is to "highlight" where the edit is needed, not necessarily digitize the feature itself. To complete the polygon, double click.
    iii. A window will popup requesting attribute information about the revision. **Fill out** the fields as best as possible. Try to include as much information as possible. A good goal is to include the info requested on the Edit Submission Form (Step 2). When finished, click Ok.
    iv. **Repeat** to enter more revision requests.
    v. When finished click the Edit button to close the editing template . If you notice you have made a mistake or want to add some additional information, click the feature then choose "edit" in the popup.

h. Pat yourself on the back and feel good about contributing to the improvement of the Montana Hydrography Dataset. The data stewards at the Montana State Library will review the submissions and add them to the official edit queue. You will be emailed when the revision is completed and submitted to USGS.

5. **Do it yourself/Take Home:** Other ways to contribute to the Montana Hydrography Dataset are to:

    a. **Become a substeward and partner with the Montana State Library**. If you think you or your agency may be interested in becoming a substeward, notify the instructors so they can schedule a followup training with you about the USGS NHD Update Tool.

    b. Submit your own hydrography GIS data (such as shapefiles or geodatabases). Do you or your agency have hydrography data that may be beneficial to the Montana Hydrography Dataset? If so, notify the instructors. We'll take a look at the data and tackle the job of incorporating it into the Hydrography Dataset. To facilitate the process consider adding some of the key NHD fields to your data (such as those requested in the Edit Submission Form- Step 3).