Water Body Identification, Regional Setting, and Drainage Catchment Attributes

This packet is your first assignment. We recommend that you save this document as a .pdf to facilitate toggling between this file and the website links.

Please have this assignment completed before the webinar. We will go over the answers during the webinar and answer any specific questions you may have.

In addition to in-stream habitat measurements, it is always important to characterize the sampling site within its larger context. This characterization includes water body identification (especially location), regional description (e.g., physiographic province, ecoregion), and drainage catchment size and characteristics. We will make use of three on-line mappers: the USGS "The National Map", the EPA's "*WATERS GeoViewer*" and the USGS "*StreamStats*".

For this assignment, we will take you through the process to characterize a sampling site using a specific stream location in Maryland. After you have become familiar with the various tools, then you will do the characterization of the field site we will be visiting during the week of class. It is very important that you finish this assignment prior to the webinar as there will be no time to complete it after the class has begun.

Water Body Identification

Detailed identification is important for:

- Organization of sample sites in data bases;
- Identification by other data users; and
- Relocation on maps (e.g., GIS) or in the field.

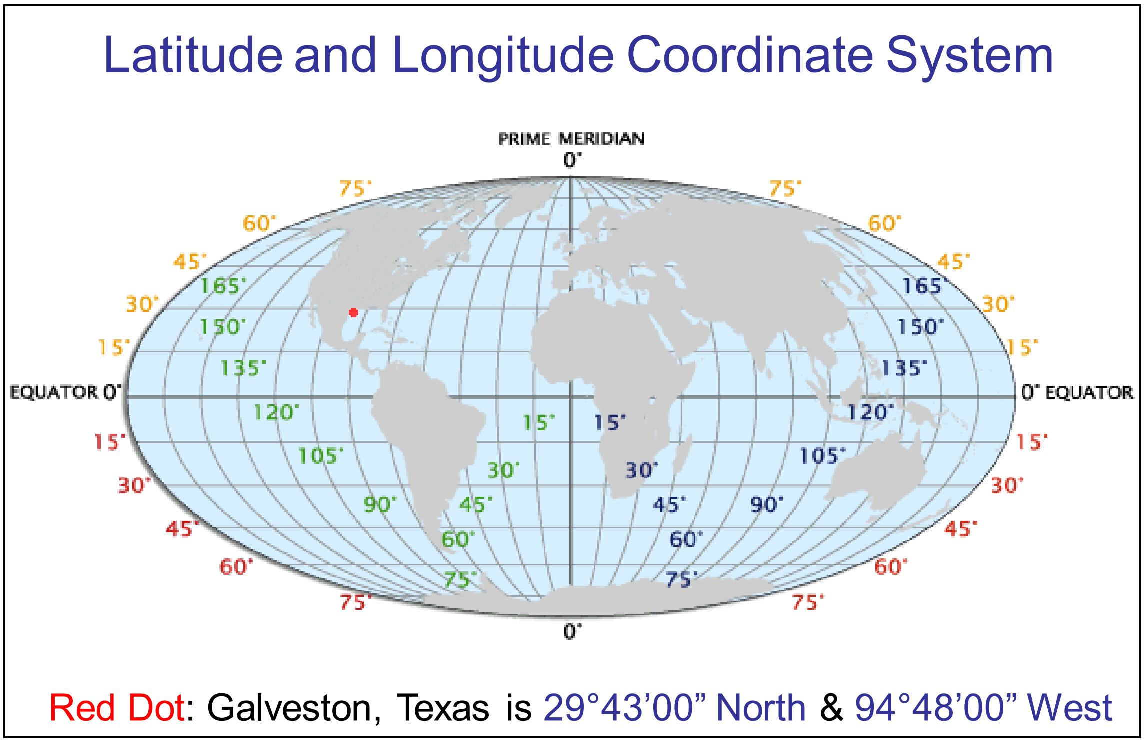
Three forms of documentation:

- Descriptive attributes as name, stream classification (e.g., Rosgen), state designated use, impairment status (Clean Water Act section 303(d)), ownership, accessibility, etc.;
- Location coding with a unique number assignment (e.g., HUCs, EPA reach codes); and
- Position identification (latitude, longitude, UTMs, elevation)

Position identification ('exact' location) :

- Latitude, longitude, and Universal Transverse Mercator (UTM) coordinates define the location of a point on earth in two-dimensional space (elevation can be used as well to add the 3rd dimension)
- Latitude, longitude, UTM coordinates, and elevation can be obtained easily from map viewers on the internet or USGS topographic maps.
- River mile or river kilometer still used, particularly on larger rivers, but less common overall

Latitude and Longitude-



***Practical Exercise-* (fill out the data form in Appendix 2 as you go through the exercises, the answers are located in *Appendix 4* at rear of this document):**

We will now work with the location of the stream sample site. The site is on an unnamed tributary of Little Antietam Creek.

The position is: **Latitude 39.6611˚ N and Longitude -77.5464˚ W**

These readings are in "decimal degrees" (the coordinates are expressed as decimal fractions).

- ✓ **Convert latitude and longitude in decimal degrees to degrees, minutes, and seconds.**

There are simple formulas to do this task, however it's even easier to use an internet-based converter. Go to:

https://www.fcc.gov/media/radio/dms-decimal

Use the lower box to plug in latitude decimal degrees and then longitude decimal degrees of the sample site to convert to degrees, minutes, and seconds. Enter only numbers and the negative sign if appropriate, do not enter units (as degrees, minutes).

Record the Answer on your Data Sheet, Appendix 2

Note that the converter also will convert degrees, minutes, and seconds into decimal degrees.

- ✓ **Convert site position from latitude and longitude to Universal Transverse Mercator (UTM) coordinates. See *Appendix 1: Universal Transverse Mercator Geographic Coordinate System* for an overview of the UTM coordinate system.**

Go to UTM converter: **http://www.dmap.co.uk/ll2tm.htm**

Enter Degrees, Minutes, and Seconds for the stream site location (numbers only, no units). Do not enter negative signs for lat/long coordinates west of Greenwich or south of the equator. Specify W or S instead. Then choose grid area UTM (WGS84 datum) and select "Calculate" for determining the central meridian longitude. Finally, click the convert button to derive the Easting, Northing, and Grid Reference. The number(s) preceding the letters of the Grid Reference is the UTM zone.

Your answer will be the coordinates for the sample site defined as:

Zone# Easting (m) Northing (m)

Record the Answer on your Data Sheet, Appendix 2

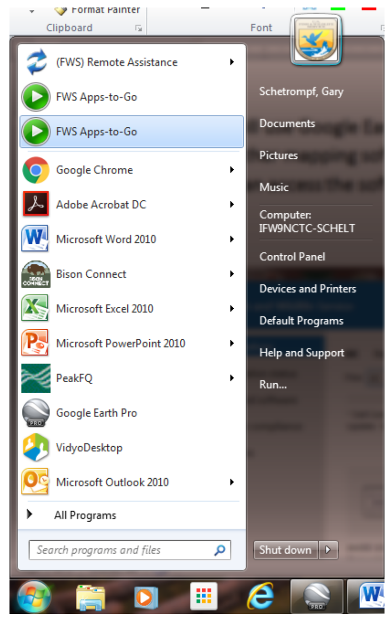
***Note: A good way to visualize lat-long and UTM is using *Google Earth*.**

If you have Google Earth downloaded on your computer:

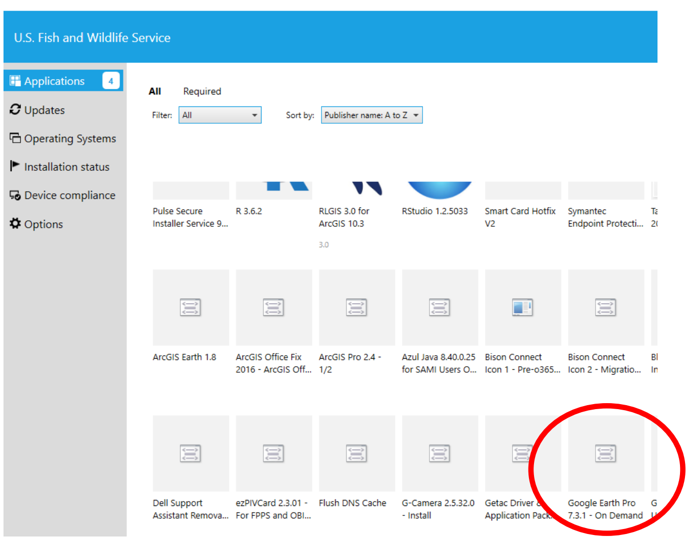
Open Google Earth > click on “View” menu on upper left > select “grid” > click on “Tools” > “Options” > select the “3D View” tab > select the “Decimal Degrees” radial button in middle left of the box. Click “OK”. You’ll see the latitude-longitude grid appear on the globe. You can scroll in and out for a close-up or father-out perspective.

Now, to get the UTM grid, go back to “Tools” > “Options” > select the “Universal Transverse Mercator” radial button. Click “OK”. You’ll see the UTM grid appear, with zone numbers laterally and zone alphabetical designations vertically.

If Google Earth is not installed on your computer (and you are a FWS employee), you can access the software through FWS Apps-to-Go without having to go through your IT personnel.



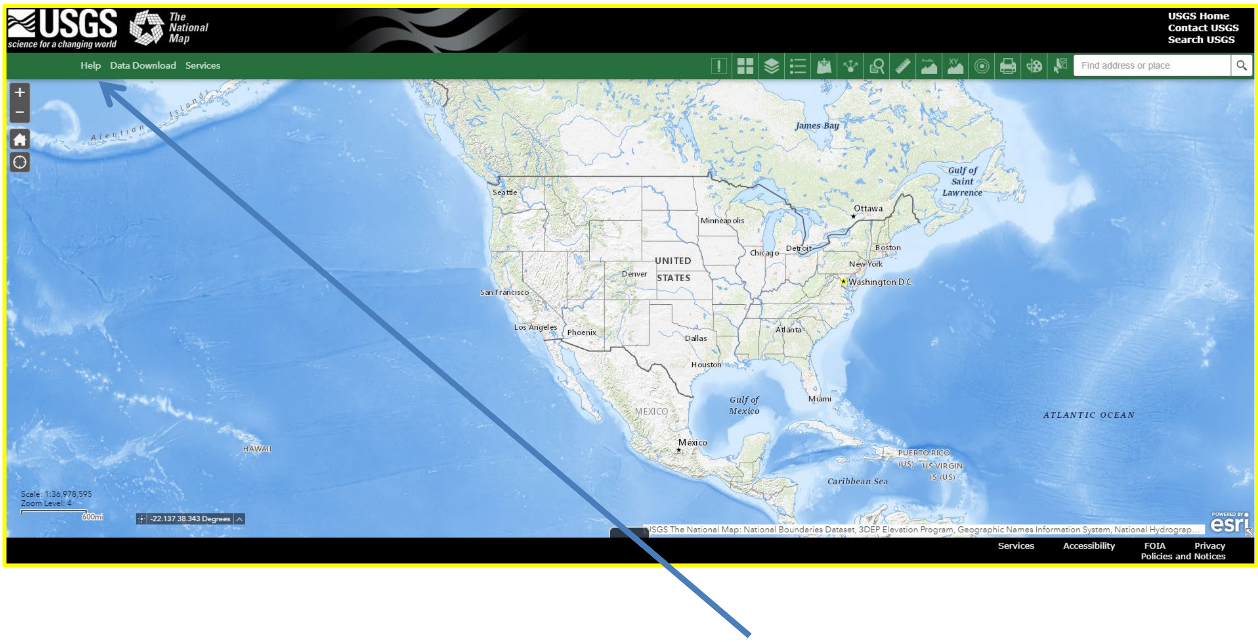
Within FWS Apps-to-Go there are Google Earth-Pro files you will need to access when downloading the program. The “Google Earth Pro-On Demand” file will download the program and the “Google Earth Pro-Registration” file will access a PDF file with Online Registration Information.



Now, **find the sample site on a map**. Go to the USGS *The National Map Advanced Viewer* at:

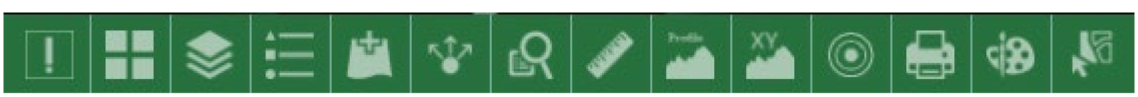
https://viewer.nationalmap.gov/advanced-viewer/

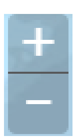
Screenshot of the *National Map*



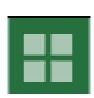
If you want additional assistance, click on the “Help” link.

All tools you will be using are located under the “Widget Panel” at the top of the map.



Go to the  icon set on the top left. Click on the  button until you reach Zoom Level 14.

(The zoom level is noted in lower left)

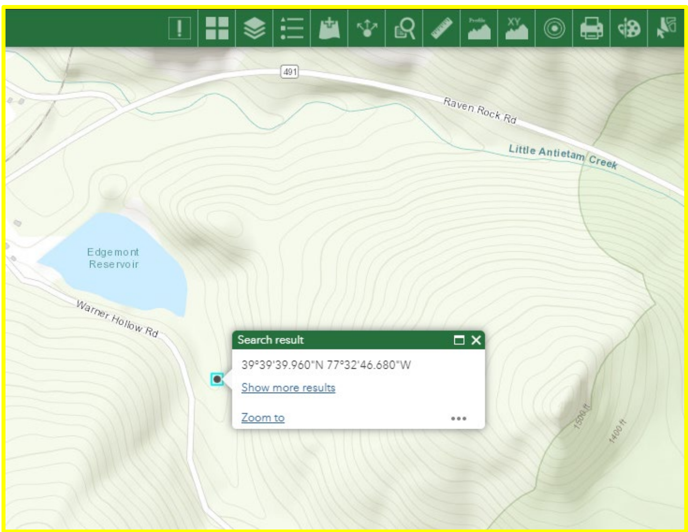
Click on the Basemap Gallery icon  and select “USGS National Map”.

(Try other basemaps as “USA Topo Maps”, “Topographic”, “USGS Imagery Topo”).

In the “Find address or place” search box to the right of the Widget Panel, enter the following latitude and longitude coordinates in decimal degrees (separated by a space and do not include the degree symbol or letter designations) for the unnamed tributary of Little Antietam Creek. Click "".

Latitude 39.6611˚ N and Longitude -77.5464˚ W

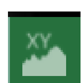
Note: Searching for the location may take a couple minutes. Let the wheel "spin". Eventually, you'll get a search result.



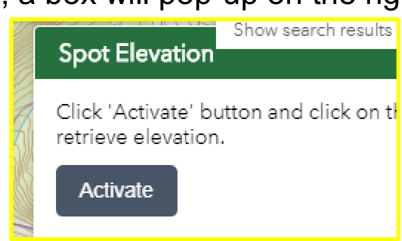
Point "A" is our site. Click on "<u>Zoom To</u>"

You can add a site marker by clicking on the three dots in the lower right of the Search result box, then clicking on "Add a marker". You can eliminate the box by clicking on the "X" in the upper right corner. Or display the box by clicking on the location gray dot.

- ✓ **Find the sampling site elevation**

To find the sampling site elevation, go to the icon  . Note: This is the elevation number you will use throughout the entire assignment.

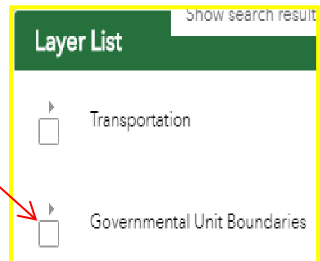
Once you click on the Spot Elevation icon, a box will pop-up on the right and you will need to click on the "Activate" button.



When you do, the site marker might disappear so you'll want to make a mental note of the location or have added a marker prior. Click on the sample site location, and a "Spot Elevation Results" box will appear with site elevation <u>and location coordinates</u>.

✓ **What is the county and state of the sampling location?**

To find this information, open the Layer List icon  and activate "Government Unit Boundaries"



Record the Answer on your Data Sheet, Appendix 2

✓ **Find the USGS topographic map name that contains the sample site**

In the Layer List pop-up box, deselect "Government Unit Boundaries". Select the "US Topo Availability" layer by checking the adjacent box. The topo name will be in white text. If the screen is too opaque green, then go to the US Topo Availability layer, click on the right-hand corner three dots, and select "Transparency"; move the slider towards 100% transparency.

Record the Answer on your Data Sheet, Appendix 2

✓ **Find water body codes (HUC, reach codes)**

Hydrologic Unit Codes (HUC)

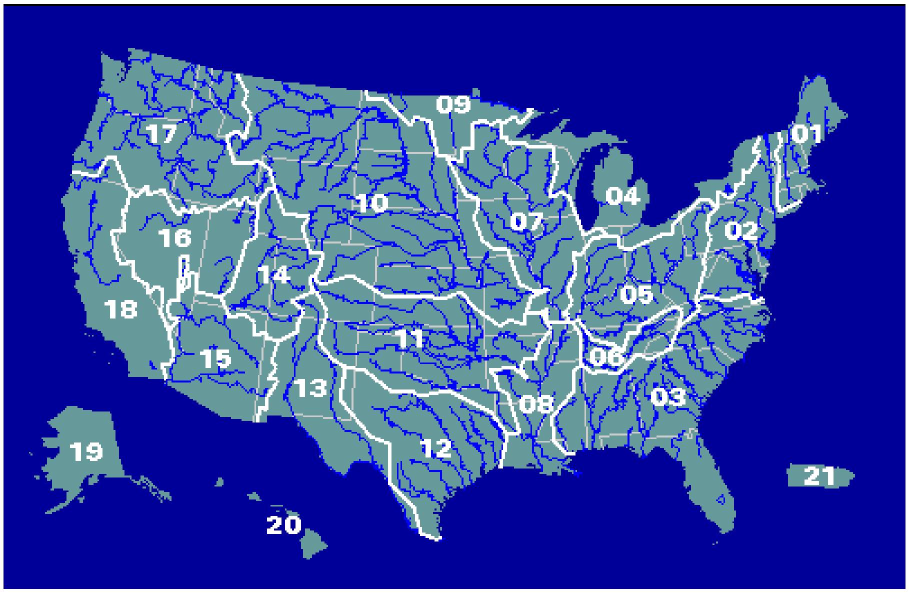
The USGS organizes watersheds or drainage basins of the United States into a hydrologic system that divides and subdivides the country into successively smaller watersheds. These levels of subdivision, used for organization of hydrologic data, are called "hydrologic units." Numerical codes, called "hydrologic unit codes (HUC)," are associated with these units. The hydrologic unit codes describe the relation among the hydrologic units to represent the way smaller watersheds drain areas that together form larger watersheds.

Agencies use HUCs for:

- managing natural resource data;
- presenting stream survey and monitoring results;
- storing and retrieving water quality data;
- mapping land cover

Regions are the largest watersheds shown. Regions contain either the drainage areas of a major river, such as the Missouri region, or the combined drainage areas of several rivers, such as the Texas-Gulf region. **Regions are identified by 2 digit codes.**

Regions of the United States



Subregions divide the regions and they include the area drained by a river system, a section of a river and its tributaries in that reach, a closed basin(s), or a group of streams forming a coastal drainage area. **Subregions are identified by 4 digit codes.**

Basins (or Accounting units) subdivide many of the subregions. They are used by the USGS for managing national water data. **Basins are identified by 6 digit codes.**

Subbasins (or Cataloging units) are larger than 700 square miles in area. A subbasin is a geographic area representing part or all of a surface drainage basin, a combination of drainage basins, or a distinct hydrologic feature. Subbasins are sometimes called "watersheds" as in *EPA's Surf Your Watershed* (example: Conococheague-Opequon Watershed). **Subbasins are identified by 8 digit codes.**

Watersheds are identified by 10 digit codes.

Subwatersheds are identified by 12 digit codes.

Hydrologic unit codes are from 2 – 12 digits. A HUC8 (subbasin or cataloging unit) is 8 digits. For example, Nyes Run in the Susquehanna River drainage in Pennsylvania is a part of the subwatershed identified by the code:

020503050905

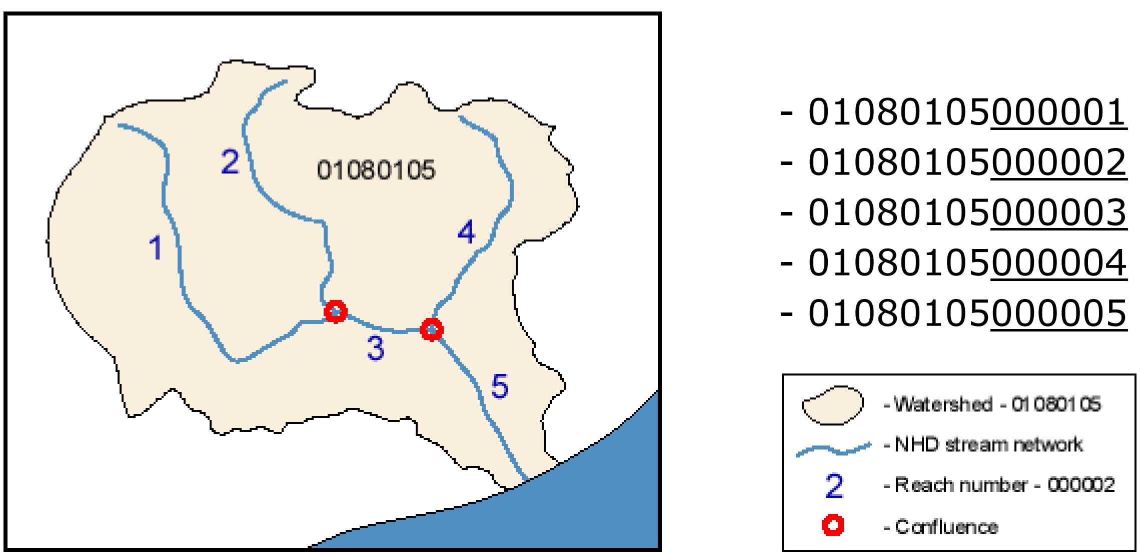
Region =	02	
Subregion =	0205	
Basin =	020503	(Accounting unit)
Subbasin =	02050305	(Cataloging unit, EPA watershed)
Watershed =	0205030509	
Subwatershed =	020503050905	

EPA Reach Codes

The National Hydrography Dataset (NHD) is a digital (computerized) collection of points, lines and polygons that represent surface water features, such as streams, lakes and swamps. Simply put, the NHD can be thought of as 'the blue lines on a map'. The NHD addressing system employs a unique, standard identifier, known as the reach code, for each segment of water across the country. Reach codes provide the foundation or common 'language' supporting integrated surface water analysis between EPA Water Programs, states, tribes and other users. Reach codes contain 14 digits.

A reach is the portion of a stream between two points of confluence. A confluence is the location where two or more streams flow together. 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 EPA watershed code followed a 6-digit arbitrarily-assigned sequence number.

Using the reach coding scheme, we can see that watershed 01080105 contains the five reaches:



Position along a reach is determined relative to the reach extent. The downstream end of a reach is labeled as 0% and the upstream end as 100%. If a monitoring site, for instance, lies halfway along a reach, its position is 50%.

Start "National Hydrography (NHD) Dataset:

- Under the Layer List, deselect the "US_Topo_Availability" operational layer, and select the "National Hydrography Dataset" operational layer.

First thing you'll notice is more complete stream delineation by blue flow lines and stream names. Reaches are delineated by triangles. The triangles point in a downstream direction. Scroll in and out to see more or less of the surrounding landscape.

✓ **Determine the EPA Reach Code for the sample site (also stream name, type, and length)**

- Click somewhere on the reach containing the sampling site (reach ends denoted by triangles); a search box will appear with NHD information (including stream name [GNIS_Name], water body type, reach code, and length of reach). BTW, there are vertical and horizontal scroll bars. The identified reach is colored lighter green. (*It may be frustrating to get the search results boxes to appear with a click, but keep trying. Eventually, this will work).

Record the Reach Code & Reach Length on your Data Sheet, Appendix 2

- Click on tributaries or other streams to see additional reaches and reach codes; if the reach is named, the GNIS_Name will be populated.

Start "Watershed Boundary Dataset":

- In the Layer List box, deselect "National Hydrography Dataset" and click the box next to "Watershed Boundary Dataset".

HUC codes should appear. Scroll out to Level 4 (or click on ) and then scroll in to view the complete range of nested HUCs for the sampling site, from HUC-2 (Region) to HUC-12 (Subwatershed). Give the Map time to populate with information, it probably will take a few seconds. Note: For this Subregion, there is only one Basin, therefore the Subregion and Basin are the same geographic area.

✓ **Determine the HUC-12 subwatershed area for the sample site**

Practice determining areas by tracing the boundary of the Subwatershed HUC unit with the area tool under the Measurement icon.  Click on the Measurement icon and select the area tool in the pop-up box.

- Enlarge the Subwatershed HUC unit on your screen (make sure the no part of the HUC-12 is covered by the pop-up box. Using the area tool, follow the Subwatershed boundaries. To change direction, click once; to finish, click twice.

Once you double-click, the area measured is filled in and area measurements appear in the pop-up box.

Record the Answer in the chart provided on your Data Sheet, Appendix 2

✓ **List HUCs and their names and areas:**

Another way to locate the name of each HUC2 – HUC8 in the Region, go to:

http://water.usgs.gov/GIS/regions.html

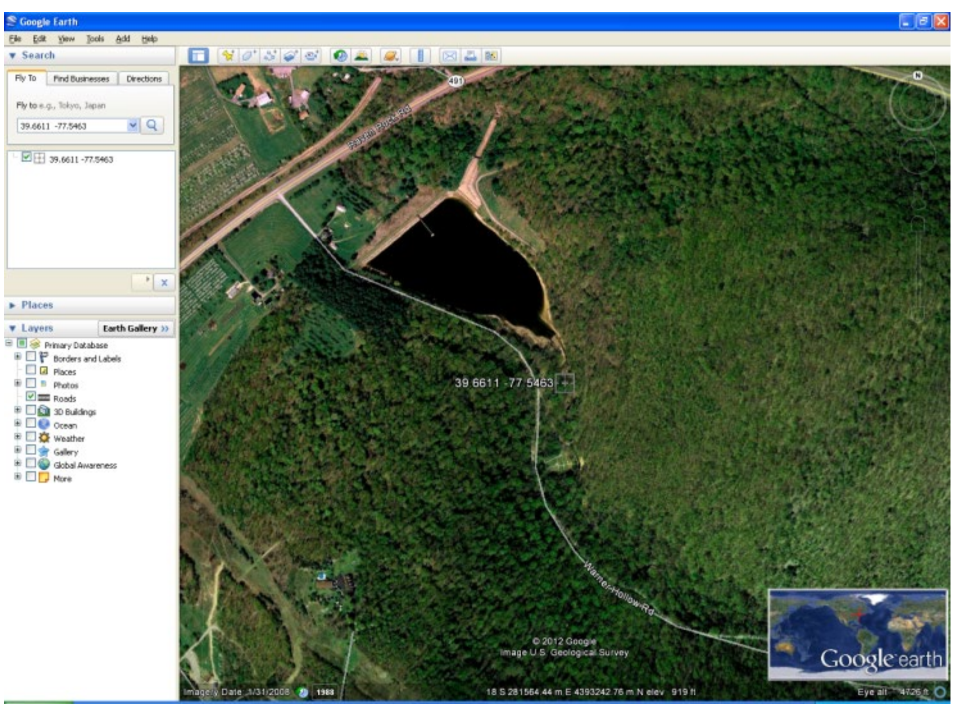
(Hint: the site is in HUC 02 Mid-Atlantic Region)

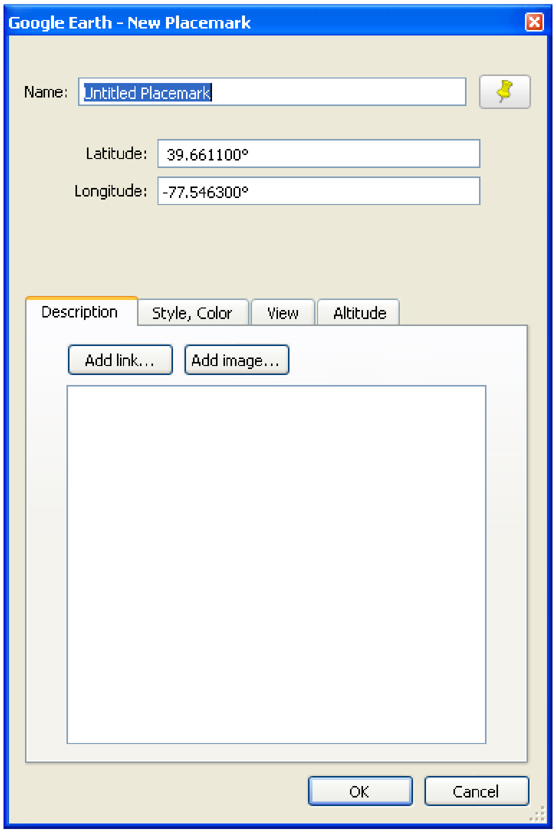
Note: areas are only listed for HUC4, HUC6, and HUC8.

- Determine area of the Subregion HUC 0207

Record the Answers in the chart provided on your Data Sheet, Appendix 2

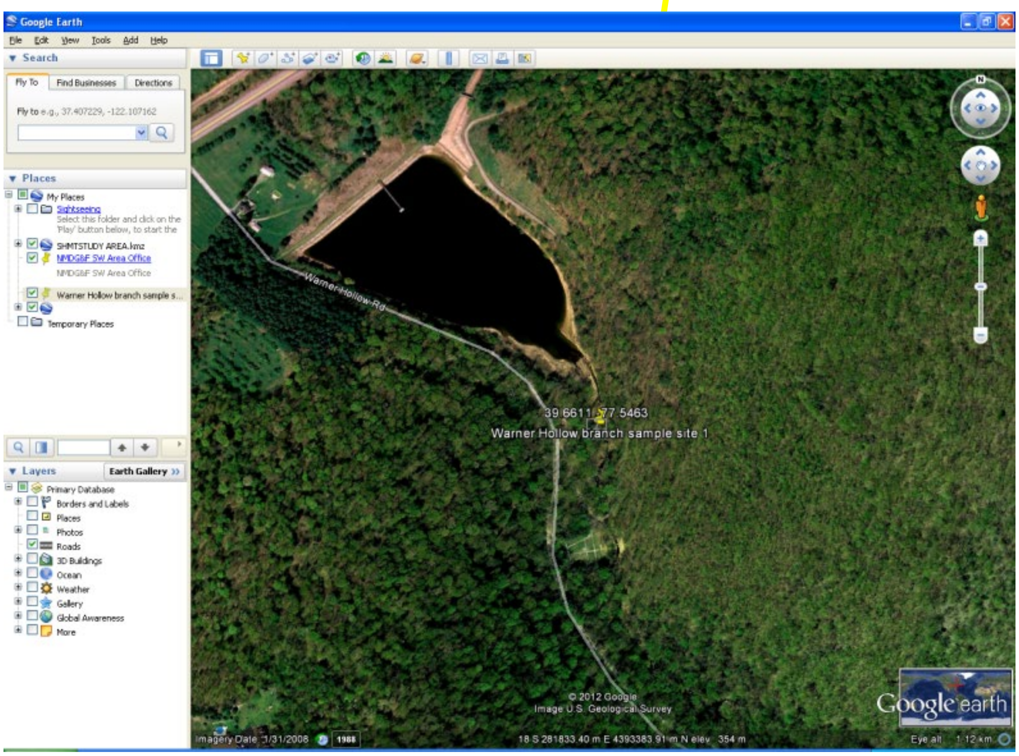
Google Earth can be a good communication tool to share sample site location data. For example, open Google Earth and enter the lat-long coordinates for our sample site (39.6611 -77.5464) in the search box upper left. You should get something like this:





Click on the "Add Placemark" . A "New Placemark" box and a yellow location placemark on the map will appear. In the box, the coordinates will be automatically filled. If, under Tools>Options, the Decimal Degrees radial button is selected, then the coordinates listed will be Latitude and Longitude. However, if the Universal Transverse Mercator radial button is selected, coordinates will be in UTMs. Next, type in "Warner Hollow branch sample site 1" in the Name box. You can enter a description as "Just upstream of Edgemont Reservoir" in the Description tab. Click "OK".

Placemark indicating the sampling site.



To save the location on your hard drive, in the upper left corner, click on File>Save>Save Place As…

A "Save As" box will appear. You can change the name of the file. The extension is ".kmz". This file can be double-clicked which will open Google Earth and take the view to the sampling site. This .kmz file can be emailed for others to view your sampling location.

✓ **Determine "Impairment Status"**

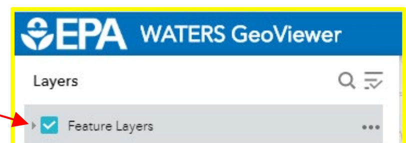
We will leave The National Map Viewer and use another Viewer entitled *WATERS GeoViewer*, an EPA application. Go to:

https://epa.maps.arcgis.com/apps/webappviewer/index.html?id=ada349b90c26496ea52aab66a092593b

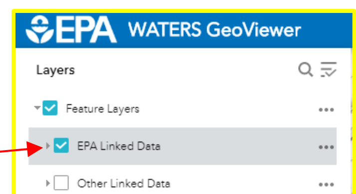
- Enter the following sampling site latitude and longitude coordinates (numbers and negative sign only) into the "Find surfacewater or place" bar on left. Click on the search icon.

Latitude 39.6611˚ N and Longitude -77.5464˚ W

- Sample site should be centered in view and show as a gray dot.
- On the right, click and change Basemap to "USGS National Map".
- On the left, click on the arrow next to "Feature Layers".



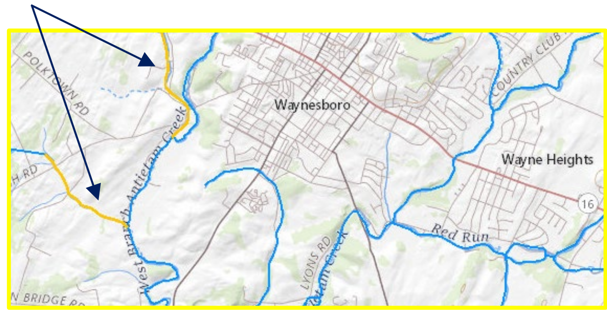
- Check box next to "EPA Linked Data"



- Click on the arrow next to "EPA Linked Data"
- Now, check box next to "303(d) Listed Impaired Waters"
- Scroll out slightly. Is the stream containing the site a 303(d) impaired water?
- Scroll out further, eventually you will see streams outlined in red indicating impaired reaches.

By clicking on the arrow by "303(d) Line", you'll eventually see the color and shape legend.

- Deselect “303(d) Listed Impaired Waters” and check the box next to “TMDLs on Impaired Waters”
- Scroll in and out to see where TMDLs are located in the area.

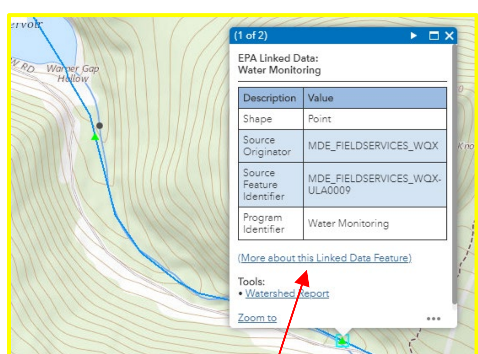


- Optionally, you can continue this investigation by checking “Fish Consumption Advisories”, or “Fish Tissue Data” or “Facilities that Discharge to Water”.
- Back to our sample site on an un-named tributary of Little Antietam Creek, is this reach designated as “impaired water”?

Record any impairments for the sample site on your Data Sheet, Appendix 2

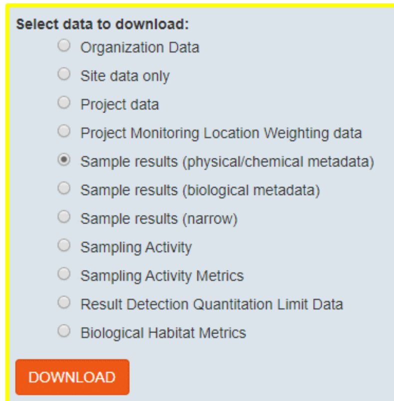
✓ **Access Water Quality Data**

- STORET (STOrage and RETrieval) is a water quality dataset. To locate STORET Water Monitoring stations near the sampling site, under the expanded “EPA Linked Data”, click on the “Water Monitoring” box. Station locations will appear as a green triangles. Go to the second upstream triangle from the sample site and click on the triangle. These actions will bring up information about that station, including a Watershed Report (watershed landuse/cover) and a link to STORET data downloads. Click on the Watershed Report, a new website will appear. View the results.
- Close the “Watershed Report” tab.



- For water quality data links, click on “More about this Linked Data Feature”.
- A new webpage will appear; click on the “Portal Page” link.
- Enter “MDE_FIELDSERVICES_WQX-ULA0009” into the “Site ID” box and then click on the white text in the blue box that appears.

- Scroll down to the bottom of the page, select "Sample results (physical/chemical metadata", and then click on the DOWNLOAD button (see figure next page).



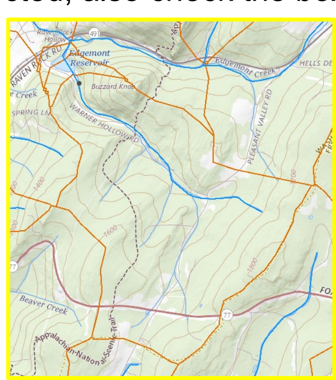
- Click "Continue" on the popup box and save it in your Downloads folder for example.
- Open the zip folder and open the .csv results file in Excel.
- You can view water quality data for that station in the AF – AI column range.

✓ Locate USGS Stream Gages

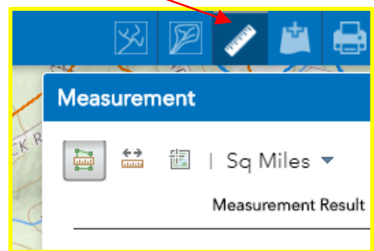
- Deselect "EPA Linked Data" and select "Other Linked Data".
- Select USGS Streamgages.
- Scroll out to see locations of the gaging stations (symbol = green circles).

✓ Delineate Catchment or Drainage Basin Boundaries

- We will address this in more detail later; however, the WATERS GeoViewer delineates catchment boundaries that can be modified to measure drainage area.
- Put the sample site (above Edgemont Reservoir) in view.
- Make sure "Surface Water Features" is checked; expand this layer by clicking on the arrow next to the checked box.
- "Streams" should be selected; also check the box next to "Catchments"
- You should get this- the drainage basins are outlined in orange.



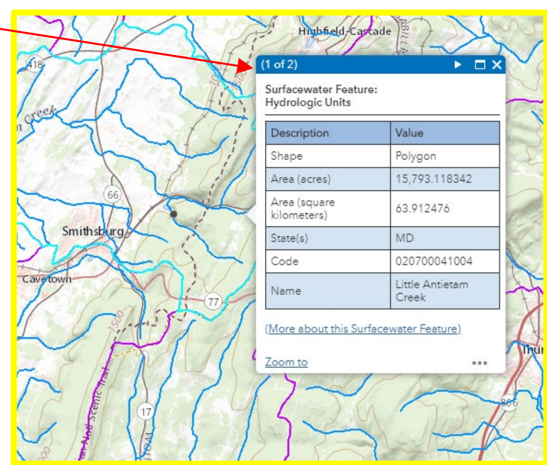
- To measure drainage basin area, use the Measurement Tool



- You can either trace the catchment boundaries (will be very close to that area draining into the sampling site, or you can start and end at the sampling site itself.

✓ **View HUCs and their information:**

- Still under the “Surface Water Features” layer, deselect “Catchments” and check the box next to “Hydrologic Units”.
- As you scroll in and out, the HUC unit will change between Region to Subwatershed.
- Click on a hydrologic unit, the HUC boundary will change color and a Surfacewater Feature box will appear with the HUC code, name, and area.



Regional Setting

Regional setting influences the physical structure (geomorphology) and biological structure of a stream reach. As such, regional setting attributes can be used to stratify streams into categories for sampling design or analysis.

- Regions represent broad patterns of climate and geology and influence many properties of aquatic habitats (hydrology, substrates, morphology, etc.).
- A region is recognized as having aquatic habitats that are more similar to each other than they are to habitats in other regions.
- When working with large spatial scales, recognizing groupings of similar habitats helps a biologist establish benchmarks for habitat potential and lowers variability in data.

Regional classification systems often are hierarchical.

- Regional management must consider multiple spatial scales to accommodate aquatic systems.
- Series of levels organized so that finer classified regions nest within the next larger class.
- These classification systems provide a stratification framework that can reduce data variability thereby improving power of projects to detect trends or differences.

Example of a hierarchical structure in spatial frameworks (Bailey's Ecoregion System)

Regional Settings include such classification systems as

- Physiographic provinces
- Hydrogeomorphic regions
- Ecoregions

Physiographic Provinces

Based on: TOPOGRAPHY (mountains, plains, plateaus, uplands) and GEOLOGY (rock type and geologic structure and history)

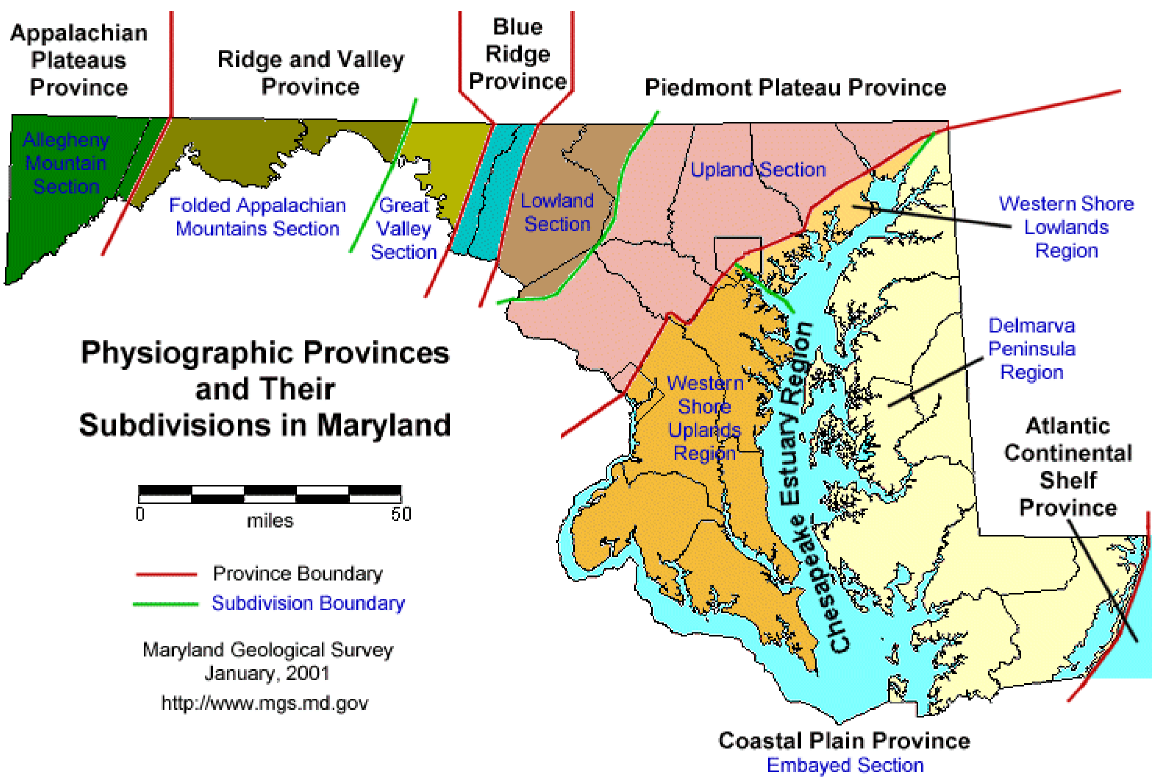
- Hierarchical, 8 major divisions, 25 natural subdivisions (provinces)

  Differ in climate, vegetation, surficial deposits and soils, water supply, mineral resources

- Boundaries between provinces are often sharp

- Used to identify fish distributions

An Example of Physiographic Provinces Contained Within a State



The Physiographic Province system may be subdivided into successively smaller units:

Major Division > Province > Section > Region > District > Area

(Note: different terminology is sometimes used; e.g., “subprovince” used for “Section”)

For example, a stream site in Maryland might be classified as within the

Applalachian Highlands *Division*
Blue Ridge *Province*
Northern Blue Ridge *Section*
Middletown Valley *Region*
Lower Middletown Valley *District*
Catoctin Creek Gorge *Area*

Practical Exercises: for the following exercises please refer to the resource maps located at:

http://nctc.fws.gov/courses/csp/csp3200/resources/index.html

✓ **Find the physiographic province, section, and region of the sample site on the un-named tributary of Little Antietam Creek. Use the *Physiographic Map of Maryland* (note that the sample site location is indicated by an arrow). You may save as a .pdf for better viewing or just use the zoom function at the bottom right corner.**

Record the Answer on your Data Sheet, Appendix 2

*Note: For a narrative description of the physiographic province characteristics, see James P. Reger, J.P. and ET. Cleaves. 2008. An Expanatory Text for the Physiographic Map of Maryland. Open-File Report 08-03-01 *Map of Maryland Description*. You’ll see an overview of the physiographic region classification system starting on page one and a brief description of the Blue Ridge Province on page 5.

Hydrogeomorphic Regions

- Used for stratifying ground-water discharge patterns and wetland functions
- Based on lithology (rock type) and physiography based on geologic formations

Open *Hydrogeomorphic Regions* which maps the hydrogeomorphic regions of the Chesapeake Bay watershed.

✓ **What hydrogeomorphic region is the sample site located in?**

Record the Answer on your Data Sheet, Appendix 2

Ecoregions

Relatively uniform areas defined by several key geographic variables (physical and biotic)

- such as, geology, landform, soils, vegetation, climate, wildlife, land use
- hierarchical classifications (broad scale to fine scale)

Ecoregions are used to:

- identify the natural characteristics and potential of aquatic systems;
- determine regional boundaries to set benchmark biotic potential and to measure and evaluate aquatic system integrity against the appropriate benchmark;
- establish water quality standards;
- stratify sampling sites;
- extrapolate to regional information from site-specific studies

2 commonly used classification systems:

Bailey's (provides a broad synthesis of ecosystem geography of the US)

Omernik's (provides a classification for regionalizing water resource management and for distinguishing regional patterns of WQ in ecosystems as a result of land use)

For this class, we will use *Omernik's* Ecoregion classification system.

- A classification for regionalizing water resource management
- Used to distinguish regional patterns of water quality due to land uses
- Found to correspond well to spatial patterns of water quality and fish distribution

<u>Hierarchical:</u>

Level I (15 ecoregions in North America)
Level II (50)
Level III (182; descriptions include landforms, potential vegetation, land use,soils)
Level IV (NA coverage not comprehensive)

✓ **List Omernik Ecoregion levels I, II, III, and IV for the sample site**

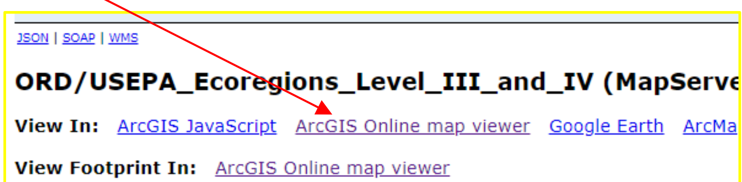
- For all Ecoregion levels, select the appropriate link on the course page under the *Resource Maps* section. View the pdf or download the maps

  http://nctc.fws.gov/courses/csp/csp3200/resources/index.html

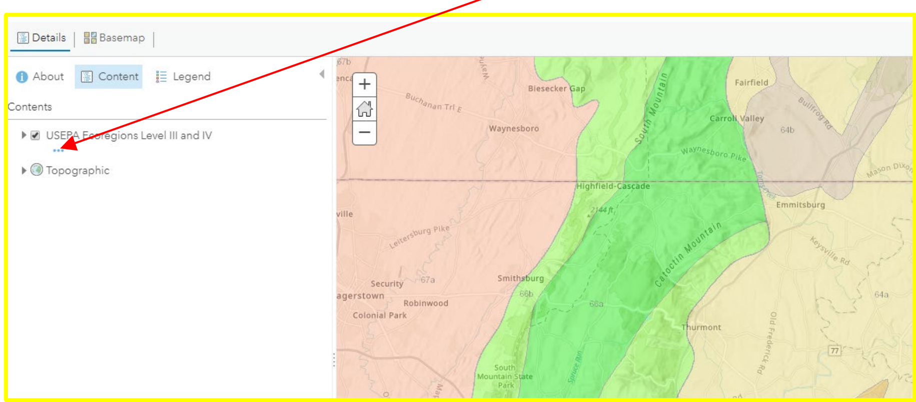
Note: You can zoom in and out using the maps. For more exact assignment of the sampling site to Level III and IV Ecoregions, go to:

https://geodata.epa.gov/ArcGIS/rest/services/ORD/USEPA_Ecoregions_Level_III_and_IV/MapServer/

- Click on "ArcGIS Online map viewer".



- Move screen until you locate the sample site.
- The Ecoregion overlay probably will be too opaque to see where the sample site is located; so, adjust the transparency by clicking on the 3 dots under the USEPA Ecoregions Level III and IV.



You may need to move the screen to see the number/letter Ecoregion designation.

You can download layers for a GIS or a .kmz file for use in Google Earth. Under "View In:", select your platform, such as Google Earth. Then open Google Earth. The Omernik levels will be in the "Places" window on the right. To view the satellite image, de-check the box next to ORD/USEPA_Ecoregions_Lev…, to view the Ecoregion designations, check the box.

Record the Answers on your Data Sheet, Appendix 2.

See also the description of the Level III Ecoregions for the continental U.S. in:

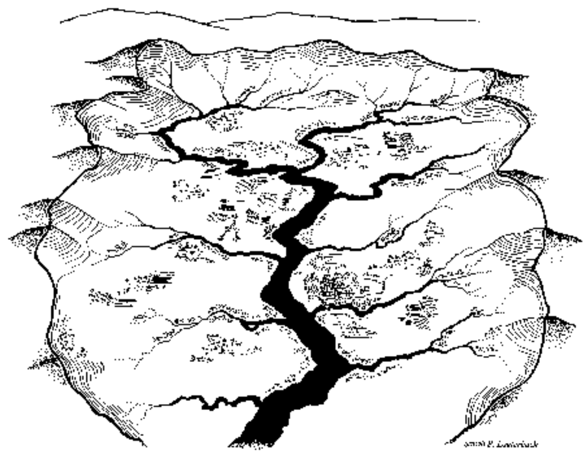
Eco Level III Descriptions

For both Level III and Level IV Ecoregion descriptions for the sample site, see

EPA Region 3 Eco Description

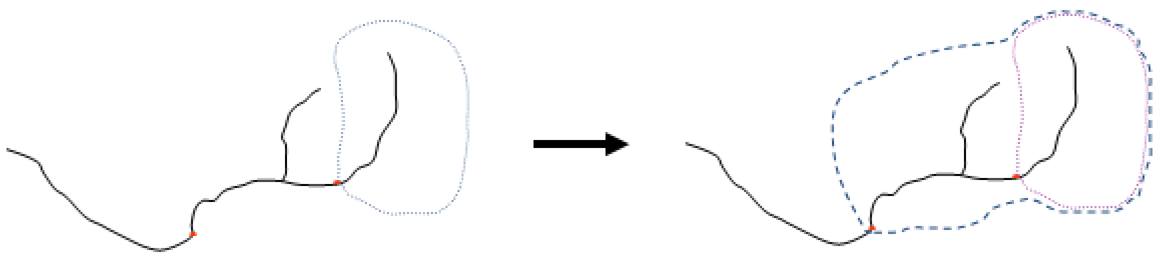
Catchment Basin Characteristics

A sample site's catchment is all the stream segments upstream of the sample site and all of the land that drains into those streams. The topographic watershed boundary runs along ridges ("divides").



From *Rivers of Alabama*

Catchments are nested: here's an example with sample sites denoted as red circles, and catchment areas as dashed lines-



Important catchment attributes,

- Size (e.g., acres, hectares, square miles)
- Geomorphic properties (e.g., basin length and relief, drainage density and shape)
- Stream size of reaches (e.g., stream order)
- Land cover (e.g., geology, soils, vegetation, and land use in area & proportions)

Catchment basin attributes influence hydrology (water yield and pattern of floods) and sediment yields; both factors influence stream morphology and in-stream habitat.

Catchment basin size

Importance of catchment basin size include:

- A factor behind geomorphological attributes as bankfull discharge, mean depth, width, and cross-sectional area (i.e., stream size and shape).

- Drainage basin size often used to match study sites; for example, comparing similar-sized impaired sites to reference sites

- Assume similar sized stream sites have similar potential (e.g., fish species richness), other factors being equal

Catchment basin size can be determined by

- U.S. Geological Survey topographic maps (e.g., scale of 1:24,000 or 1 distance unit on map equals 24,000 distance units on ground)

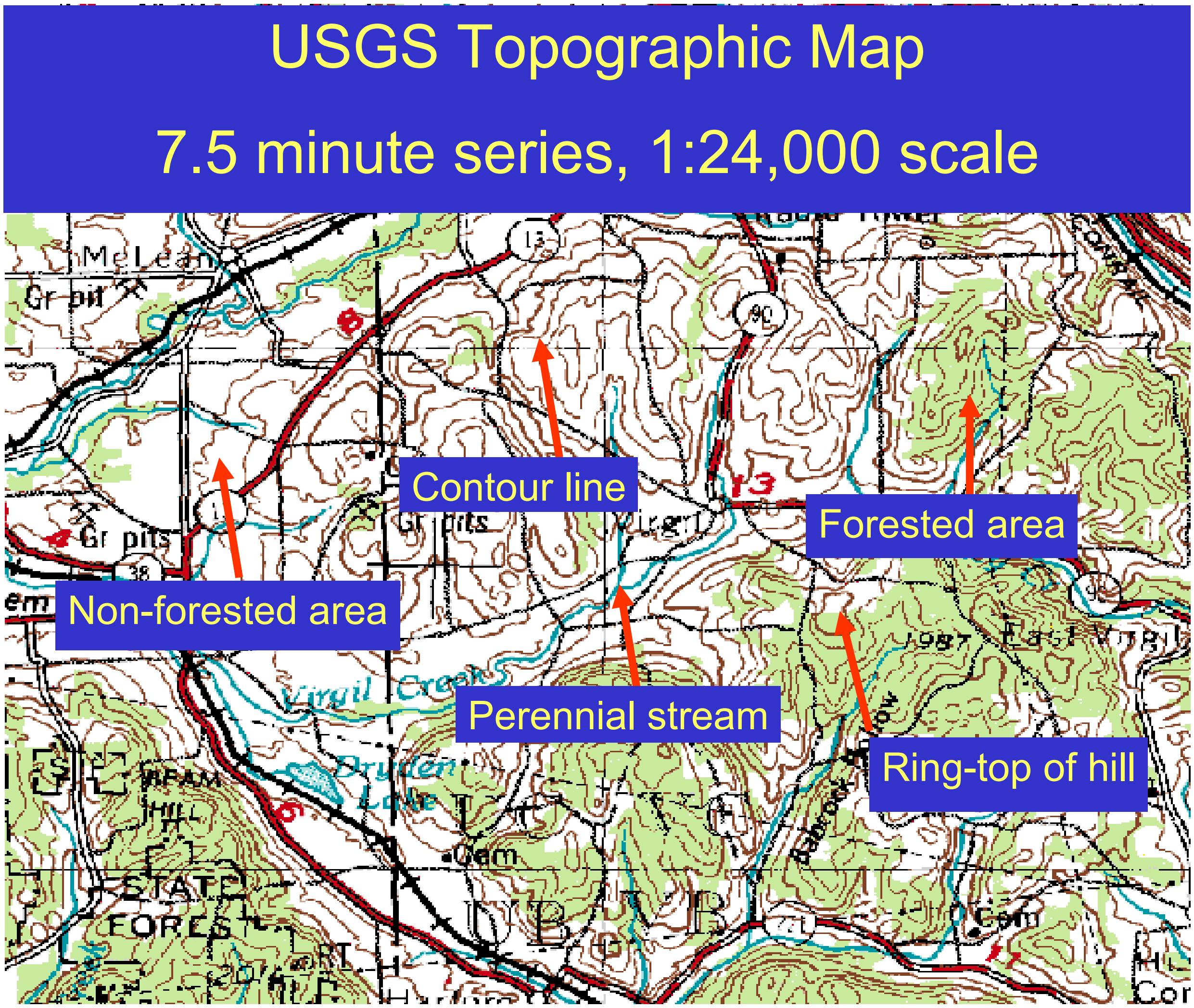
- or more commonly, Geographic Information Systems (GIS) or map viewers

Some basics,

Topographic map features:

- **blue lines = streams**
  - solid lines = perennial streams
  - dashed lines = intermittent streams
- **brown lines = contour lines**
  - form “V”s where they intersect streams (“M”s above stream junctions); “V”s point upstream
  - topographic high points marked by ring
- Headwater streams = streams with no tributaries

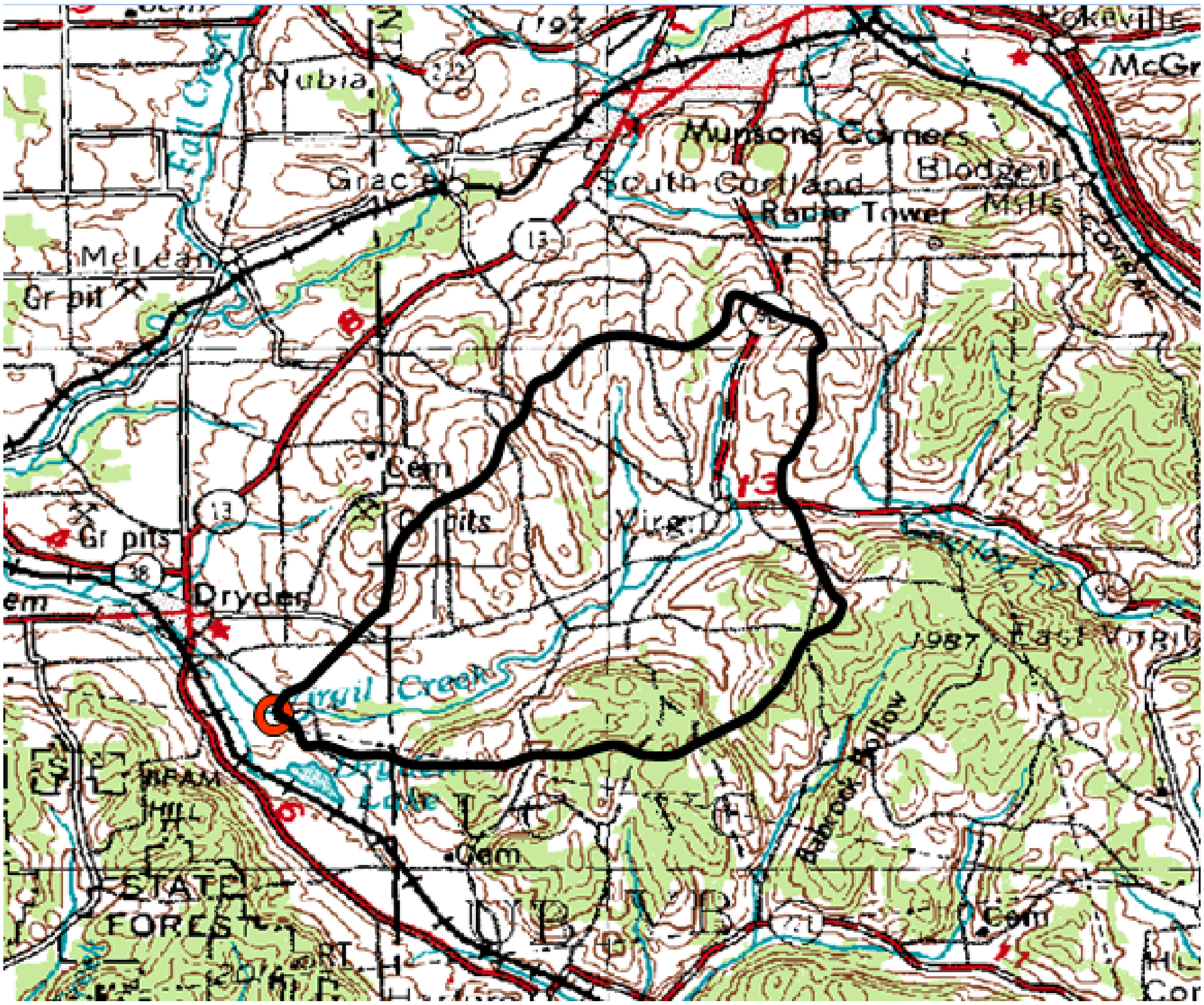
Note: It is important to realize that blue lines may not be an accurate representation of the spatial extent of perennial or intermittent streams. Aquatic macroinvertebrate taxa that require perennial water have often been found “above the blue line” in Appalachia.



Determining a topographic catchment basin

- locate all upstream tributaries that contribute flow through study site
- locate headwaters to determine top of drainage basin
- determine approximate location where surface run-off splits flow into and away from basin
- connect topographic high points
- draw drainage divide perpendicular to each contour line it crosses
- on flat areas, divide in half the area between streams

Example of a catchment basin for a sampling site on Virgil Creek



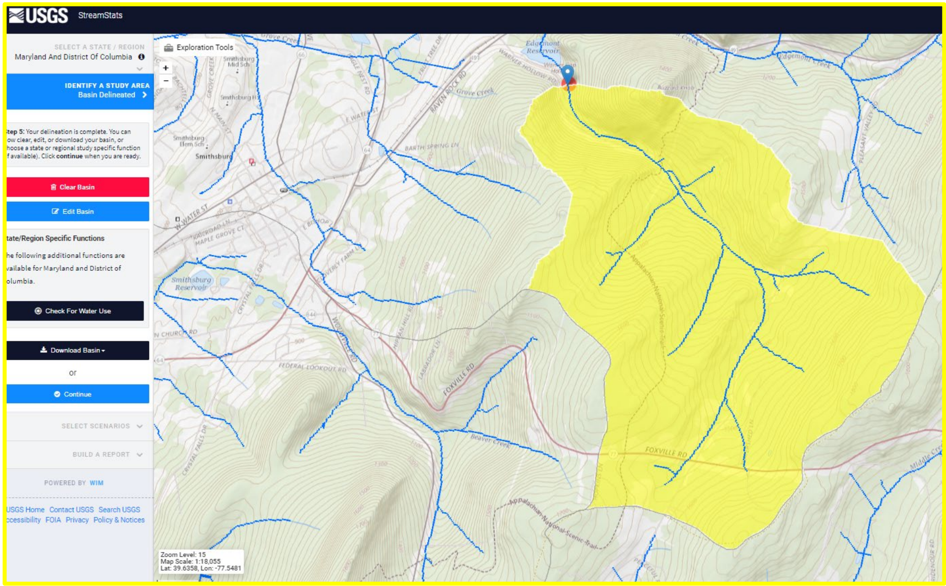
✓ **Determine the catchment basin size in square miles for the sample site on the un-named tributary of Little Antietam Creek.**

Open the USGS StreamStats:

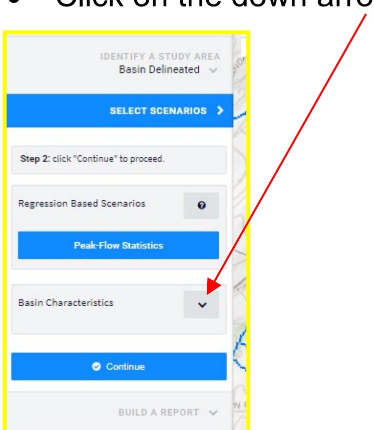
https://streamstats.usgs.gov/ss/

- Click on Base Maps bar on the right and select “National Map” for topographic interface
- Enter the sample site location coordinates: **Latitude 39.6611˚ N and Longitude -77.5463˚ W** in the searchbox on the left. Do not input the degrees unit or letters. Click on the coordinates in the results box.
- Select “Maryland and District of Columbia” study area (blue bar far left).
- The study site should be denoted and the NHD “blue lines” active; you may have to scroll out or in.

- Click on the blue “Delineate” button. Now, click on a blue pixel at the sampling site; you may need to scroll in; the delineation will take a few seconds.
- The drainage basin for the study site should be highlighted in yellow. Click “Continue”.



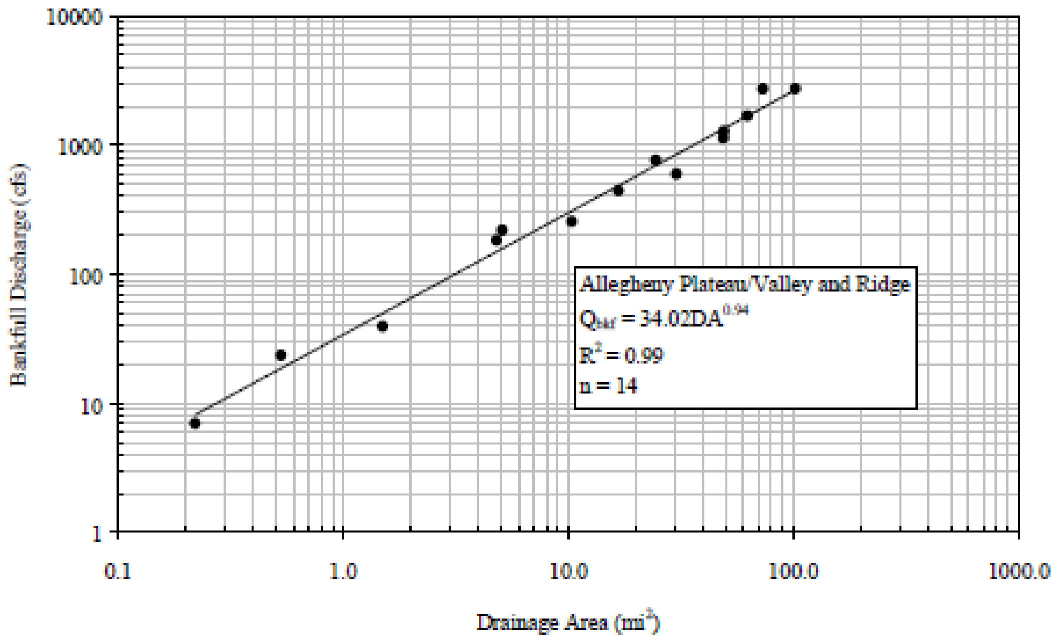
- Click the “Peak-Flow Statistics” button (it will turn blue)
- Click on the down arrow by “Basin Characteristics”

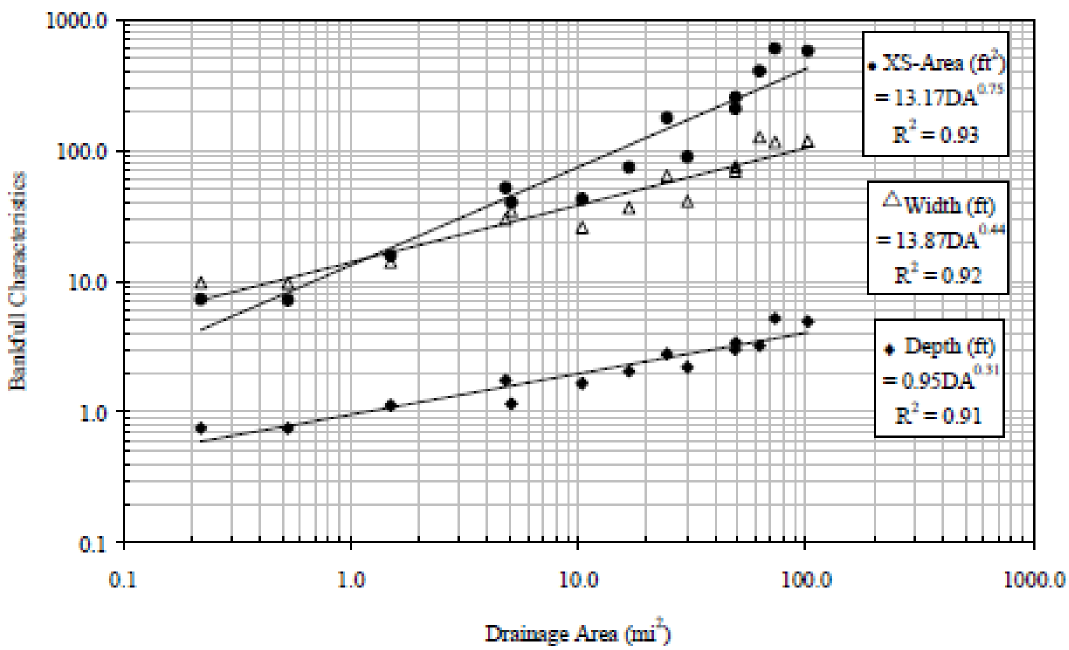


- Select DRNAREA, FOREST_MD
- Click “Continue”
- After computation, click “Show Basin Characteristics”; you will see calculated values for the parameters you selected. For the data sheet, only drainage area and % FOREST will be recorded.
- Click “Continue” for the Basin Characteristics Report.
- Note that some locations have the additional capacity to calculate low-flow statistics for the selected site.

Record your answer on your Data Sheet, Appendix 2

- ✓ **Plug your catchment size (in square miles) into the regional curves listed below. Either estimate from the graph or enter the sampling site catchment area into variable "DA" of the prediction equations. Determine expected bankful discharge, cross-sectional area, width, and mean depth for the sample site.**





Record your answers on your Data Sheet, Appendix 2

Steam size

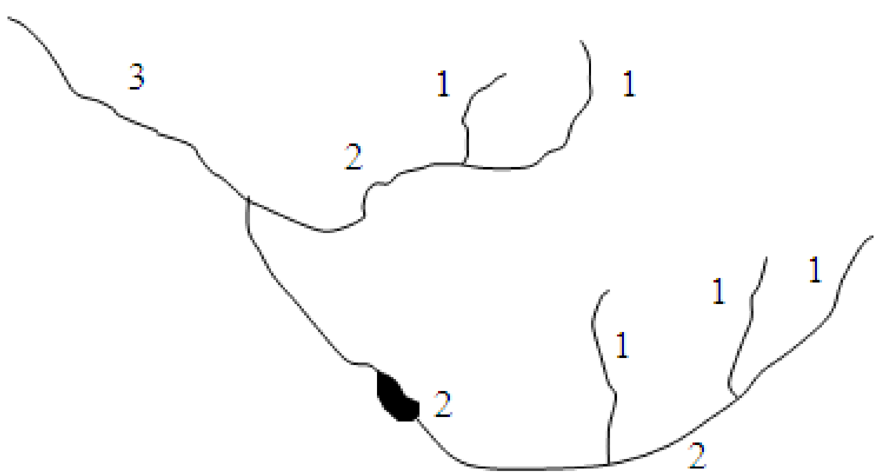
Stream size can be characterized in several ways, including by catchment size, average stream width, or by stream order (Strahler, Link Magnitude, D-Link, C-Link, and B-Link). Stream size is important for determining biotic potential of streams. Larger streams support more species of fish, for example.

Position of streams in the larger watershed can be described by the link system. Position also can be an important determiner of species richness.

Stream order:

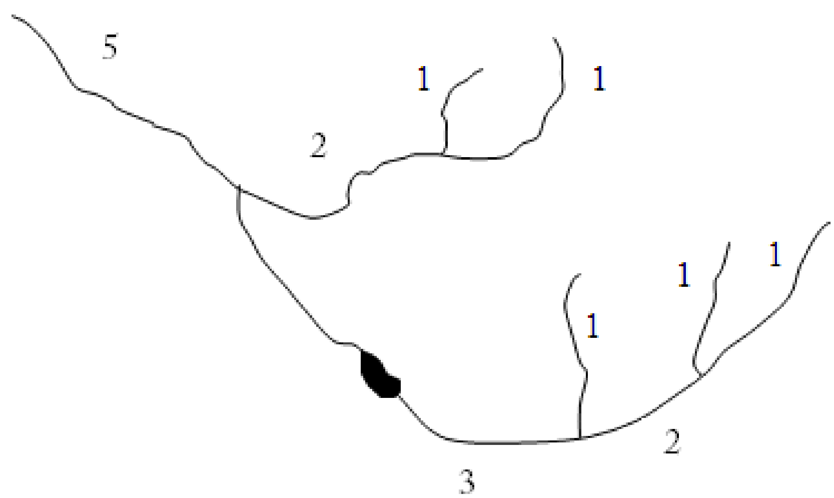
The oldest and most commonly used is Strahler stream order (Strahler 1957).

- headwater streams = 1st order
- 2 streams of order *n* form a stream of order *n* + 1
- 2 streams of different orders -- the stream they form does not change order (below confluence, stream order is the higher of the two parent streams)



Stream Order: Link Magnitude (Shreve 1966)

- Link magnitude is the number of un-branched source streams upstream of a given segment in the drainage network.
- Think of it as a "finer-grained" stream size metric than stream order (used more in benthic invertebrate work



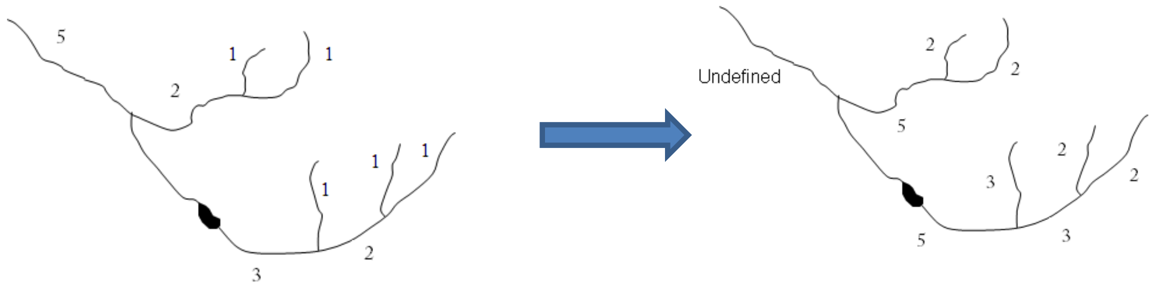
- The Link

Magnitude number of a reach indicates how many tributaries are upstream of the reach.

Stream Order: D-Link

- Osborne and Wiley defined D-link as the link magnitude of the next downstream segment from the segment in question.
- Emphasizes differences of small streams in upper watershed vs. small streams directing joining much larger streams. Reason: similar sized streams could have different fish faunas depending upon where they link up to the stream system.
- "Adventitious streams" are small streams that join much larger streams (have small link number and large D-link number)
- First determine Link Magnitude for a drainage. Then "shift up" the rating from the lower to the adjacent upper reaches (= D-Link).

For example,



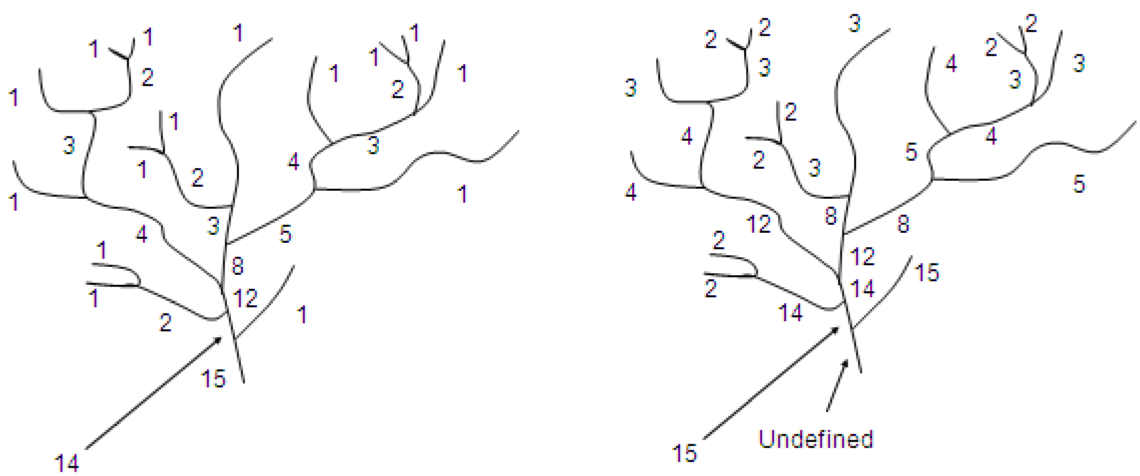
Link Magnitude

D-Link

Now, use more complicated drainage examples of Link magnitude and D-Link to illustrate D-Link application.

Link Magnitude

D-Link



- ✓ **Print out the catchment for the sample site in the USGS map viewer or make hand sketches of the drainage. Determine Strahler stream order, Link Magnitude, and D-Link for each stream reach. What is the Strahler stream order, Link Magnitude, and D-Link values for the reach at the sample site?**

Geomorphic Properties

Several geomorphic properties of catchments are listed and explained in **Appendix 3 Geomorphic Properties Exercises.** These basin characteristics can be determined using the USGS *The National Map* and the basin drainage area you calculated in StreamStats. We will not calculate these properties in this class, but provide answers at the end of this document.

****

Now that you have completed the example exercise for the unnamed tributary of Little Antietam Creek, go through the same process to characterize our class field trip site (note: the sampling site is in Virginia). Complete *Appendix 2 Sample Site Identification, Regional Setting, Catchment and Reach Size Data Sheet* and *Appendix 3: Geomorphic Properties Exercises* for the Sweet Run site. An aerial photo and topo map for "Sweet Run" and a *Physiographic Map of Virginia* are located at:

http://nctc.fws.gov/courses/csp/csp3200/resources/index.html

Note: the field trip sites are designated as "degraded reaches" on the photo and topo. This designation was for another class, although our sites are located within the rectangle.

The Field Site Location (Sweet Run) coordinates are:

Latitude 39.280278° N, Longitude -77.742550° W

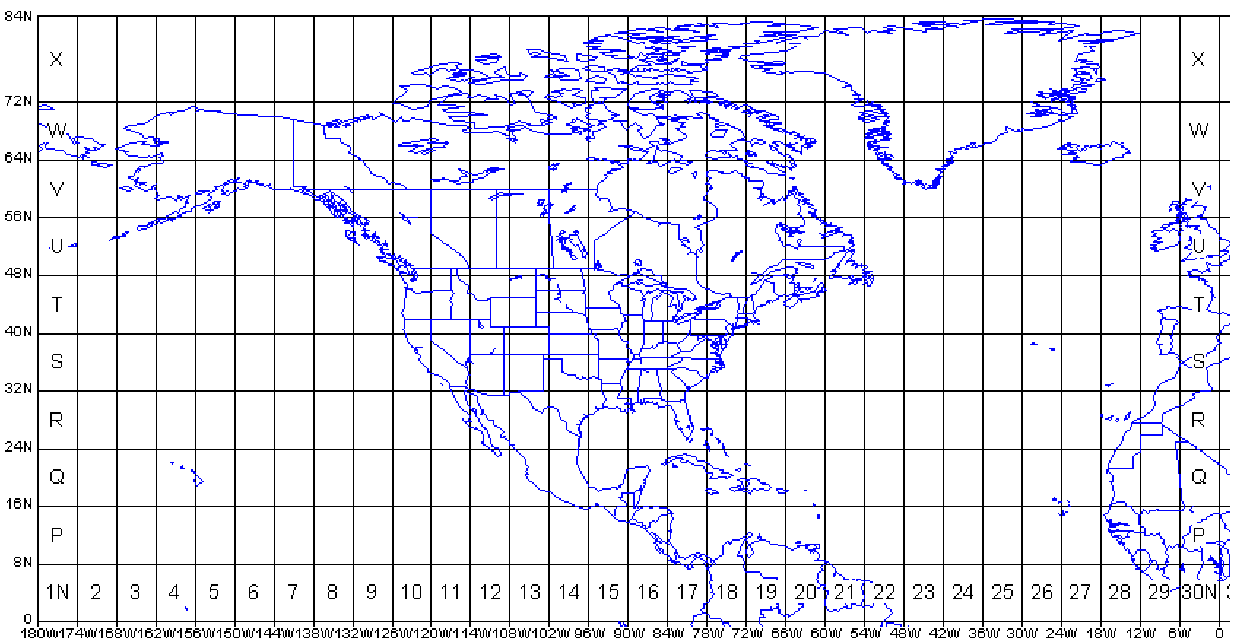
Answers will be discussed during the webinar. We will be using this information as part of our analysis of the sampling site.

Appendix 1: Universal Transverse Mercator Geographic Coordinate System

The Universal Transverse Mercator (UTM) geographic coordinate system is a grid-based method of specifying locations on the surface of the Earth that is a practical application of a 2-dimensional Cartesian coordinate system. It is a horizontal position representation, i.e., it is used to identify locations on the earth independently of vertical position, but differs from the traditional method of latitude and longitude in several respects.

The UTM system divides the surface of Earth between 80°S and 84°N latitude into 60 zones, each 6° of longitude in width and centered over a meridian of longitude. Zone 1 is bounded by longitude 180° to 174° W and is centered on the 177th West meridian. Zone numbering increases in an easterly direction.

UTM Zones in the Northern and Western Hemisphere



Each of the 60 longitude zones in the UTM system is based on a transverse Mercator projection, which is capable of mapping a region of large north-south extent with a low amount of distortion.

An Earth location is defined as a point with x and y coordinates. In the UTM system, the terms easting and northing are geographic Cartesian coordinates for a point. A position is referenced by the UTM zone, and the easting and northing coordinate pair. The *easting* is the projected distance of the position eastward from the central meridian, while the *northing* is the projected distance of the point north from the equator (in the northern hemisphere). Eastings and northings are measured in meters. The point of origin of each UTM zone is the intersection of the equator and the zone's central meridian. In order to avoid dealing with negative numbers, the central meridian of each zone is given a "false easting" value of 500,000 meters. Thus, anything west of the central meridian will have an easting less than 500,000 meters. For example, UTM eastings range from 167,000 meters to 833,000 meters at the equator (these ranges narrow towards the poles). In the northern hemisphere, positions are measured northward from the equator, which has an initial "northing" value of 0 meters and a maximum "northing" value of approximately 9,328,000 meters at the 84th parallel — the maximum northern extent of the UTM zones. In the southern hemisphere, northings decrease as you go southward from the equator, which is given a "false northing" of 10,000,000 meters so that no point within the zone has a negative northing value.

As an example, the CN Tower is located at the geographic position 43°38′33.24″N, 79°23′13.7″W or 43.6425667°N, 79.387139°W or 43.6425667, -79.387139. This is in zone 17, and the grid position is 630084m east, 4833438m north. There are two points on the earth with these coordinates, one in the northern hemisphere and one in the southern. To define the position uniquely:

- Append a letter designator to the zone number, in this case "T" (see previous figure), thus "17T 630084 4833438".

Exercise-

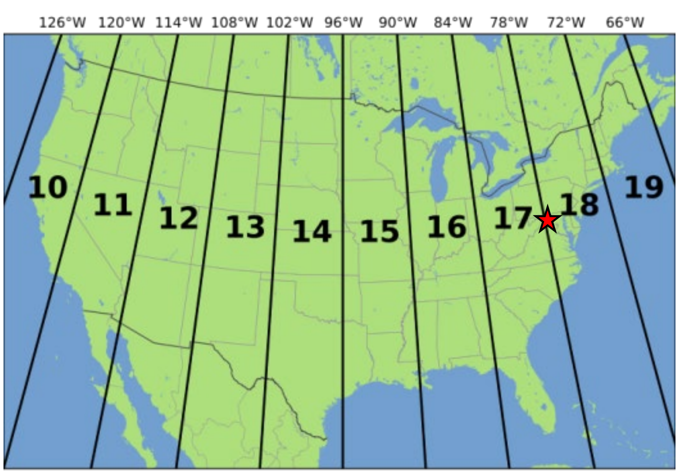
Go to UTM converter http://www.dmap.co.uk/ll2tm.htm

Enter Degrees, Minutes, and Seconds for the stream site location. Then choose grid area UTM (WGS84 datum) and the calculate button for determining the central meridian longitude. Finally, click convert to finish calculation.

Your answer will be in easting and northing (x,y) coordinates (281507, 4393344); the grid reference is 18STJ 81507 93344. The first number of the grid reference number is the UTM zone. You would report your location as 18S 281507m E 4393344m N.

Notice that the central meridian of zone 18 is 75° W longitude, because the eastern boundary is 72° W and the western boundary is 78° W.

UTM Zones in the Continental United States



Red star denotes approximate location of stream sampling site.

Appendix 2: Sample Site Identification, Regional Setting, Catchment and Reach Size Data Sheet

Investigator: ________________________ Date: ________________

Position Identification

Stream name/Study site name: ____

Latitude _________________ Longitude ________________ Elevation _________

Grid Reference____

Zone_____________ UTM ____

County ___________________________ State _____________________________

USGS Topographic Map Name ____

Water Body Coding

USGS catalog unit (HUC-8, sub-basin, EPA watershed)

Division	HUC	Name	Area
Region			———
Subregion			
Basin			
Subbasin			
Watershed			———
Subwatershed			

USEPA reach code ____________________ Reach Length ____________________

Water Impairments: ____

Regional Setting

Physiographic Province code/name: _______________________________________

Section code/name (or subprovince): ______________________________________

Region code/name: ____

District code/name: _____N/A____

Area code/name: ______N/A____

Hydrogeomorphic region: ____

Ecoregions:

Omernik Level I ____

Omernik Level II ____

Omernik Level III ____

Omernik Level IV ____

Catchment ("Drainage") Basin Characteristics

Catchment area ____

Percent Forest ____________

Bankfull discharge______________________

Cross-sectional area____________________

Width______________________________

Mean depth__________________________

*Reach type (e.g., Rosgen classification) __________________________________

Reach size:

*Average bankfull width ____________

Strahler Stream Order _____________

Link Magnitude ________________

D-Link _________________________

* Stream classification and average bankfull width will be determined after field data collection.

Appendix 3: Geomorphic Properties Exercises

Once the catchment divide is drawn on a map and the area has been estimated (via *StreamStats*), the geomorphic properties can be estimated, measured, or computed in *The National Map*. Each of the geomorphic properties listed below includes a definition and explanation of its importance to catchment characterization. The downstream boundary of the catchment is the sample site.

In The National Map, locate the study site. In the Layer List, check the “National Hydrography Dataset” and the “Watershed Boundary Dataset”. Remember, you can get reach lengths using the NHD information. You can determine drainage area in The National Map or in StreamStats.

1. **Main channel slope:** Main channel slope is an estimate of the typical rate of elevation change along the main channel that drains the catchment. This measurement is often related to peak flow magnitude and flood volume. Estimate the main channel slope by measuring the length of the main channel from the study site to the mapped source of the main stream. At each stream channel bifurcation, follow the fork with either the higher stream order number or the longer pathway to a stream source. Mark off 10% and 85% of the main channel length on the map. Estimate the elevation in meters at the 10% and 85% distance points, using the contour lines on the topographic map. Compute the main channel slope as follows:

   Slope = (elevation at 85% length – elevation at 10% length) / 0.75 (main channel length).

   Use: Elevation profile tool

   ANSWER: ____

2. **Total stream length:** Total stream length is the sum of the lengths of all perennial streams within a catchment as shown on a topographic map. Determine the total stream length by using NHD information. Sum individual stream lengths. The summed stream lengths determine the total amount of stream habitat in a catchment and the availability of sediment for transport.

   ANSWER: ____

3. **Catchment length:** Catchment length is estimated as the straight-line distance between the stream site and the drainage divide nearest to the source of the main stream [see "Main Channel Slope" description to find out how to delineate the main stream}. Catchment length is used to calculate drainage shape.

   Use: Distance tool in Measurement icon.

   ANSWER: ____

4. **Catchment relief:** Catchment relief is the difference in elevation between the highest and lowest points in the catchment. It controls the stream gradient and therefore influences flood patterns and the amount of sediment that can be transported. Sediment load increases exponentially with catchment relief.

   Use: Spot Elevation tool

   ANSWER: ____

5. **Catchment relief ratio:** The catchment relief ratio index is the catchment relief divided by the catchment length. It is useful when comparing catchments of different sizes because it standardizes the change in elevation over distance.

   ANSWER: ____

6. **Catchment surface storage:** The percentage of the catchment covered in lentic and impounded water bodies, including wetlands (optional), reflects the surface storage capacity of the catchment. Determine the catchment surface storage by measuring the area of each lake or impounded water body. Wetland areas will have to be estimated because the borders are not delineated on topographic maps. Add all water body and wetland areas and divide this sum by the drainage area.

   Make a visual estimate or use StreamStats to calculate impoundment percent.

   ANSWER: ____

7. **Drainage density:** An index of the length of stream per unit area of catchment is calculated by dividing the total stream length by the drainage area [see #8]. This ratio represents the amount of stream necessary to drain the catchment. High drainage density may indicate high water yield and sediment transport, high flood peaks, steep hills, low suitability for agriculture, and high difficulty of access.

   ANSWER: ____

8. **Drainage shape:** An index of drainage shape is computed as a unit-less dimension of drainage area divided by the square of catchment length. It describes the elongation of the catchment and is useful for comparing catchments. If two catchments have the same area, the more elongated one will tend to have smaller flood peaks but longer lasting flood.

   ANSWER: ____

Appendix 4: Answers to Questions

Sample Site Identification, Regional Setting, Catchment and Reach Size Data Sheet

Position Identification

Stream name/Study site name: unnamed tributary of Little Antietam Creek

Latitude 39° 39' 39.9594" N Longitude -77° 32' 47.04" W Elevation 937

Grid Reference 18STJ 8155693243

Zone 18S UTM 18 281556m E 4393243m N

County Washington State Maryland

USGS Topographic Map Name Smithsburg

Water Body Coding

USGS catalog unit (HUC-8, sub-basin, EPA watershed)

Division	HUC	Name	Area
Region	02	Mid-Atlantic	N/A
Subregion	0207	Potomac	14,600 mi^2
Basin	020700	Potomac	14,600 mi^2
Subbasin	02070004	Conococheague - Opequon	2,278.9 mi^2
Watershed	0207000410	Antietam Creek	290.9 mi^2
Subwatershed	020700041004	Little Antietam Creek	24.7 mi^2

USEPA reach code 02070004002574 Reach Length 1.18 km

Water Impairments None

Regional Setting

Physiographic Province code/name: 300000 Blue Ridge Province
Section code/name (or subprovince): 310000 Northern Blue Ridge Section
Region code/name: 312000 Catoctin-South Mountain Region
District code/name: N/A
Area code/name: N/A

Hydrogeomorphic region: Blue Ridge

Ecoregions:

Omernik Level I Eastern Temperate Forests (8)

Omernik Level II Ozark, Ouachita-Appalachian Forests (8.4)

Omernik Level III Blue Ridge (66)

Omernik Level IV Northern Sedimentary and Metasedimentary Ridges (66b)

Catchment Basin Characteristics

Catchment area 2.27 square miles or 5.88 square kilometers

Percent Forest 90.6 %

Bankfull discharge 73 cfs

Cross-sectional area 24 ft2

Width 20 ft

Mean depth 1.2 ft

*Reach type (e.g., Rosgen classification) ____

Reach size:

*Average bankfull width ____

Strahler Stream Order 2

Link Magnitude 6

D-Link "Undefined"

* Stream classification and average bankfull width will be determined after field data collection.

Geomorphic Properties Exercises (answers)

Once the catchment divide is drawn on a map and the area has been estimated (via *StreamStats*), the geomorphic properties can be estimated, measured, or computed in *The National Map*. Each of the geomorphic properties listed below includes a definition and explanation of its importance to catchment characterization. The downstream boundary of the catchment is the sample site.

In The National Map, locate the study site. In the Layer List, check the “National Hydrography Dataset” and the “Watershed Boundary Dataset”. Remember, you can get reach lengths using the NHD information. You can determine drainage area in The National Map or in StreamStats.

1. **Main channel slope:** Main channel slope is an estimate of the typical rate of elevation change along the main channel that drains the catchment. This measurement is often related to peak flow magnitude and flood volume. Estimate the main channel slope by measuring the length of the main channel from the study site to the mapped source of the main stream. At each stream channel bifurcation, follow the fork with either the higher stream order number or the longer pathway to a stream source. Mark off 10% and 85% of the main channel length (feet or meters) on the map. Estimate the elevation in feet or meters at the 10% and 85% distance points, using the spot elevation tool or the contour lines on the topographic map. Compute the main channel slope as follows:

   Slope = (elevation at 85% length – elevation at 10% length) / 0.75 (main channel length).

   Use: Elevation profile tool

   ANSWER: __________442m – 286m / 0.75(3828.6m) = 0.54, 5.4%________

2. **Total stream length:** Total stream length is the sum of the lengths of all perennial streams within a catchment as shown on a topographic map. Determine the total stream length by using NHD information. Sum individual stream lengths. The summed stream lengths determine the total amount of stream habitat in a catchment and the availability of sediment for transport.

   ANSWER: ___________4.522 mi or 7.2775km___________________________

3. **Catchment length:** Catchment length is estimated as the straight-line distance between the stream site and the drainage divide nearest to the source of the main stream [see "Main Channel Slope" description to find out how to delineate the main stream}. Catchment length is used to calculate drainage shape.

   Use: Distance tool in Measurement icon.

   ANSWER: 3.548 kilometers - 11,641.448 feet - 2.205 miles

4. **Catchment relief:** Catchment relief is the difference in elevation between the highest and lowest points in the catchment. It controls the stream gradient and therefore influences flood patterns and the amount of sediment that can be transported. Sediment load increases exponentially with catchment relief.

   Use: Spot Elevation tool

   ANSWER: 936' - 1826' = 890'

5. **Catchment relief ratio:** The catchment relief ratio index is the catchment relief divided by the catchment length. It is useful when comparing catchments of different sizes because it standardizes the change in elevation over distance.

   ANSWER: 890' / 11,641' = 0.08

6. **Catchment surface storage:** The percentage of the catchment covered in lentic and impounded water bodies, including wetlands (optional), reflects the surface storage capacity of the catchment. Determine the catchment surface storage by measuring the area of each lake or impounded water body. Wetland areas will have to be estimated because the borders are not delineated on topographic maps. Add all water body and wetland areas and divide this sum by the drainage area then multiply by 100.

   Make a visual estimate or use StreamStats to calculate impoundment percent.

   ANSWER: (.016 mi^2 / 2.4mi^2) x 100 = 0.67%

7. **Drainage density:** An index of the length of stream per unit area of catchment is calculated by dividing the total stream length by the drainage area. Drainage density is usually expressed in terms of stream miles per square mile. This ratio represents the amount of stream necessary to drain the catchment. High drainage density may indicate high water yield and sediment transport, high flood peaks, steep hills, low suitability for agriculture, and high difficulty of access.

   ANSWER: 4.522 miles/ 2.4 mi^2 = 1.89 mi/ mi^2

8. **Drainage shape:** An index of drainage shape is computed as a unit-less dimension of drainage area divided by the square of catchment length. It describes the elongation of the catchment and is useful for comparing catchments. A more elongated watershed will have a lower value. If two catchments have the same area, the more elongated one will tend to have smaller flood peaks but longer lasting flood.

   ANSWER: 2.4 mi^2 / $(2.205)^2$ = 0.49