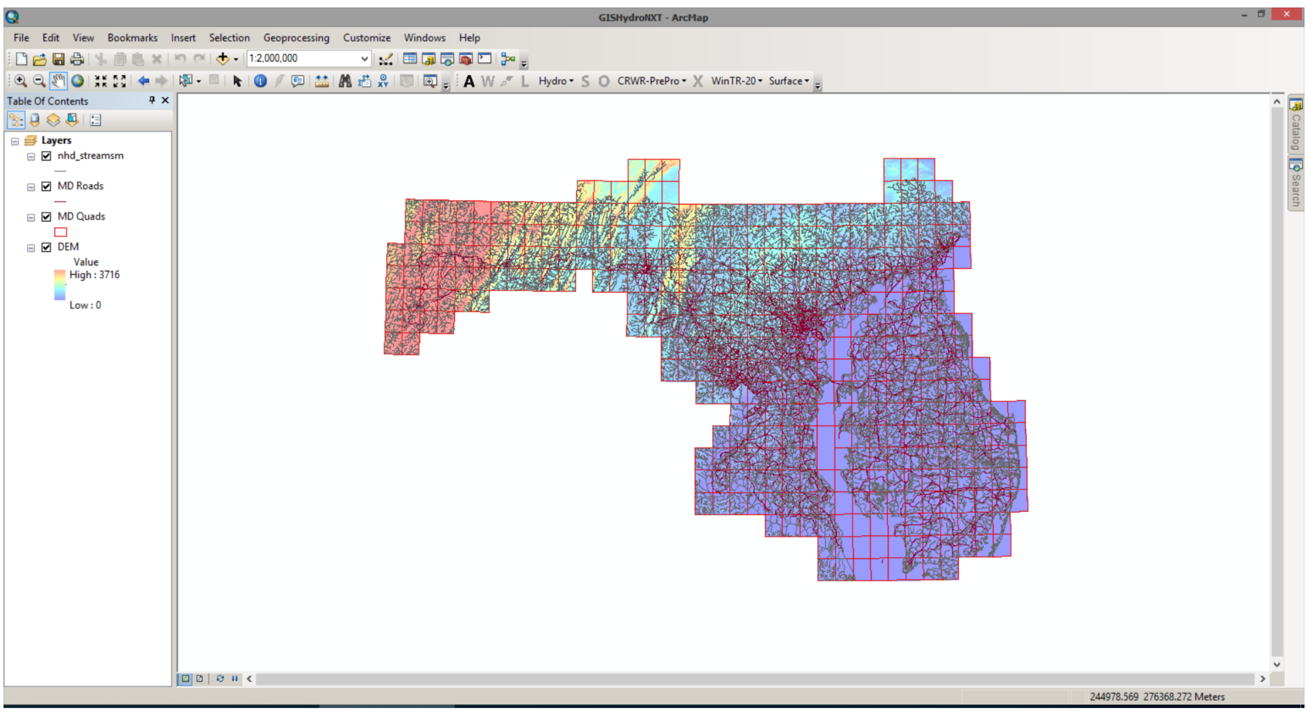
Introduction to GISHydroNXT

GIS Based Hydrologic Analysis in Maryland • *gishydro.eng.umd.edu*



Training Manual
4th Edition
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MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

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Note on Document Format

This document is formatted for two-sided printing: odd-numbered pages on the right, and even-numbered pages on the left.

The center margin is wider than the outside margin to accommodate binding or three-hole punching.

The page number is placed on the lower outer corner of each page.

Users who wish to print the Manual are encouraged to use two-sided printing.

Foreword

This training manual was developed to support training workshops on the use of GISHydroNXT software. It contains general information about ArcView, GIS-based hydrologic modeling techniques, instructions on use of the software, and detailed exercises.

GISHydroNXT is an ArcGIS-based application for conducting hydrologic analyses in the State of Maryland. Sponsored by the Maryland State Highway Administration, GISHydroNXT integrates a complete database of terrain, land use, and soils data with tools for assembling and evaluating hydrologic models including regional regression equations and WinTR-20. The program is designed to support the procedures for hydrologic analysis recommended by the Maryland Hydrology Panel.

This manual does not necessarily follow the lectures presented in the training workshop. Rather, it serves as a document for future reference when using the software. Several exercises are included to reinforce the lecture material, beginning with assembly of data for a hydrologic analysis and ending with application of calibration procedures recommended by the Maryland Hydrology Panel. As time allows, the exercises will be performed during the course of the workshop to emphasize the step-by-step techniques used.

Further explanation of the concepts and theory underlying GISHydroNXT tools can be found in a separate document, *GISHydroNXT Technical Reference.*

The GISHydro software is evolving continually and being enhanced. This software was originally written as GISHydro2000 for use in ArcView 3.3; some screen captures or references in this manual may still come from this version of the software. This manual, associated training workshops, and Technical Reference represent the first release of the GISHydroNXT software, compatible with ArcGIS 10.1.

GISHydroNXT is available to registered users in a Virtual Computer Lab environment provided by the University of Maryland. Instructions for registering can be found at: http://gishydro.eng.umd.edu/documents/mdsha_reports/GISHydro_OnlineAccess_July2018.pdf .

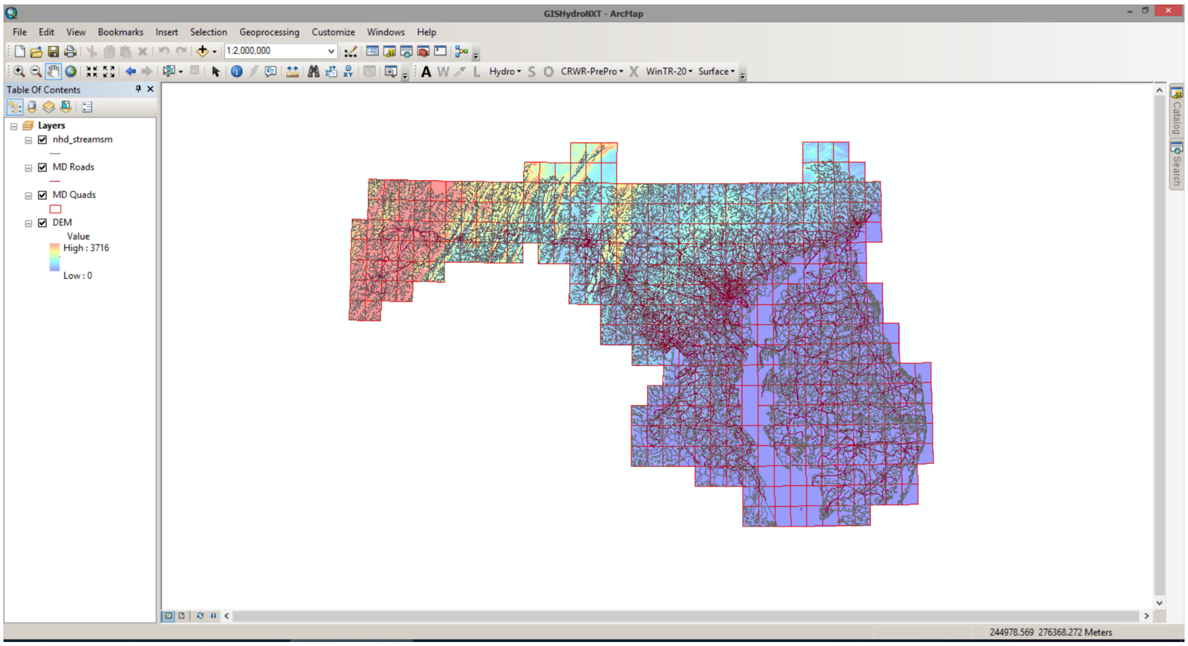
~~The GISHydro website will contain a downloadable stand-alone version of the GISHydroNXT software for users to employ on their own machines. Users will need to separately purchase and install ArcGIS 10.1. Users are encouraged to visit the **GISHydro@Maryland website (gishydro.eng.umd.edu)** frequently so that they can always have the most up-to-date version of the software and data.~~

The GISHydro software initiative has been and continues to be a cooperation among academia, federal, state, and local government, and private consultants. This cooperation continues to produce powerful tools to support engineering, conservation, and planning efforts within the State. The feedback we receive from all users has helped us to improve these tools and we encourage you to please provide comments, bug reports, and suggestions for new features as they arise. For more information, please contact the authors of this document.

Table of Contents

Background: History and Lineage of GISHydroNXT

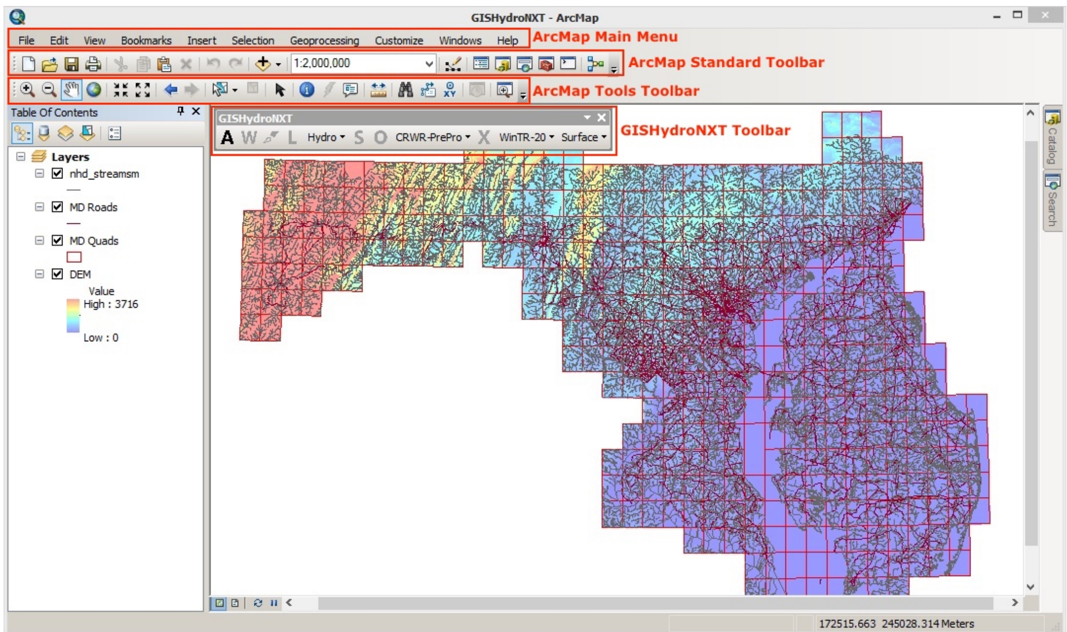
"A tool and database for aiding hydrologic analysis in Maryland."



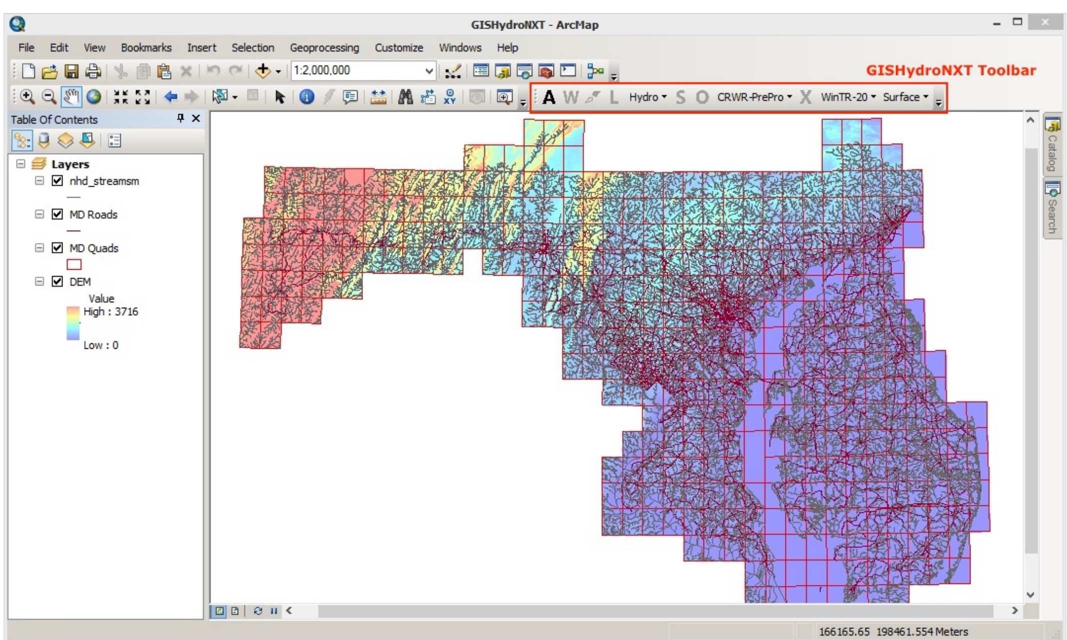
In the mid-1980's, Dr. Robert Ragan of the University of Maryland developed a QuickBasic-based program called GISHydro for use at the Maryland State Highway Administration (MSHA) and throughout the state. This program contained land use and soils data for the entire state of Maryland and enabled engineers to perform rapid, automated hydrologic analyses. From roughly 1998 to present, an ArcView-based program, GISHydro2000, funded by MSHA, was conceived in the spirit of GISHydro but designed to take advantage a true GIS software system. Now, ESRI's ArcGIS is the default industry-standard GIS, and GISHydroNXT, which is written for compatibility with this current GIS software, represents the newest version of the GISHydro family. GISHydroNXT will continue to evolve as data become available, methods change, and new features are added. Regardless, GISHydroNXT is constructed for compatibility with the methods and concepts described by the Maryland Hydrology Panel. GISHydroNXT provides hydrologic engineers with the tools and data necessary to perform a range of hydrologic analyses in the State of Maryland

The GISHydroNXT ArcMap Window

This introductory section defines certain terms used in this manual. When you launch GISHydroNXT (either on the Virtual Computer Lab or a local desktop computer), you see a window as shown. Note the locations of the "ArcMap Main Menu," the "ArcMap Standard Toolbar," and the "ArcMap Tools Toolbar." The GISHydroNXT Toolbar first appears in the data view part of the window.



If you wish, you can dock the GISHydroNXT Toolbar by click-dragging it to the window frame where the ArcMap Main Menu and Toolbars are located.



Exercise 1-A: Beginning a Hydrologic Analysis with GISHydroNXT

Every analysis performed using GISHydroNXT begins with the assembly of the necessary geospatial data for the required extent. In this exercise, you will use GISHydroNXT to select data to begin a hydrologic analysis.

Task

Using GISHydroNXT, begin a hydrologic analysis for the watershed upstream of USGS Stream Gage No. 01650500 near Randolph Road in Montgomery County, Maryland.
Use the GIS layers and ArcGIS tools to locate the basin outlet and estimate the extent of the watershed. Indicate the bounding box for the "Area of Interest" analysis and choose the appropriate data layers (DEM, Land Use, and Soils) for further analysis.

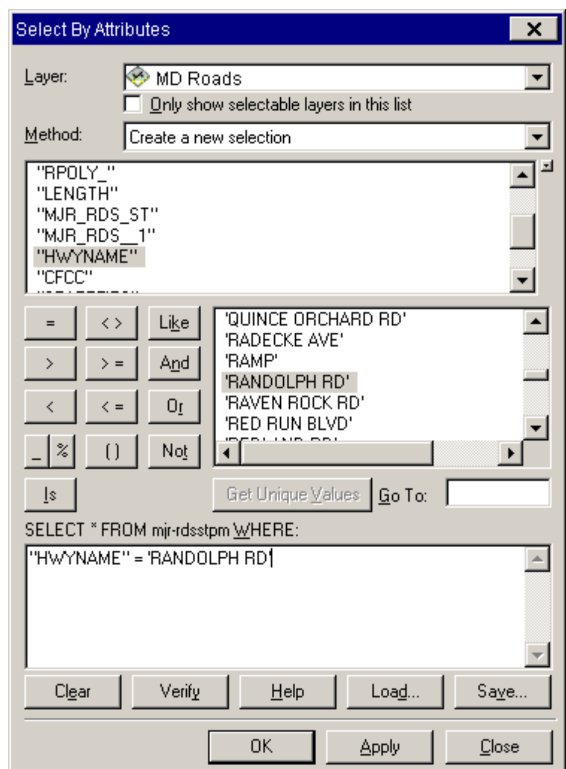
Locate Outlet

This procedure employs standard GIS database query tools, which are not unique to GISHydroNXT. The GISHydroNXT database includes the information to be queried: Maryland roads and USGS stream gages.

The location of the watershed has been given at USGS Stream Gage No. 01650500 above Randolph Road. The Maryland View contains themes useful for finding this location.

Step 1: Find the Nearby Road

In the ArcMap Main Menu, click "Selection: Select By Attributes…" This will open the dialog box shown.



Use the pulldown (small arrow) to select Layer "MD_Roads".

Build the query in the dialog box as described below:

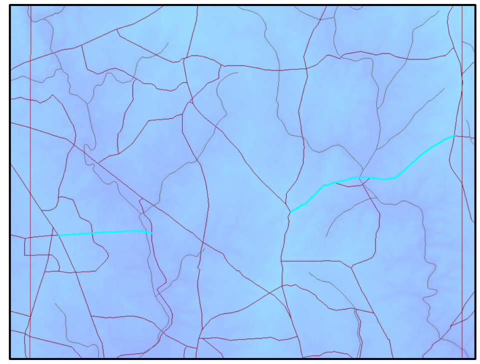
The query to be built will be based on the layer attribute "HWYNAME". Specifically, we want to locate "RANDOLPH RD". The window near the top of the dialog lists the field names. Double-click on the "HWYNAME" field, which adds this item to the beginning of the query being built in the bottom text box. Click the "=" relation button. Click on the "Get Unique Values" button to populate the available highway names. Find 'RANDOLPH RD' either by scrolling through the alphabetized value list or by typing 'Randolph Rd' in the "Go To" box. Double-click this item to complete the query,

```
"HWYNAME" = 'RANDOLPH RD'
```

Once the query expression is established, click the "OK" button.

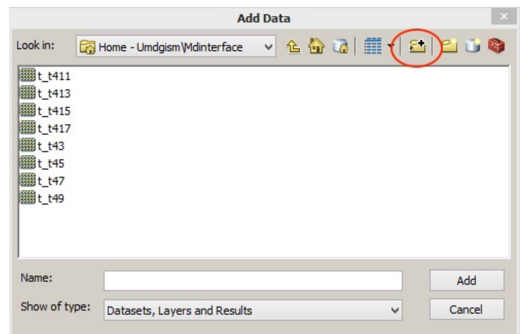
Check that the "MD Roads" layer is turned on (checkbox) in the Table of Contents.

In the ArcMap Main Menu, choose "Selection: Zoom To Selected Features". The view window will zoom to the extent of the selected segment Randolph Road, which will be colored cyan as shown.



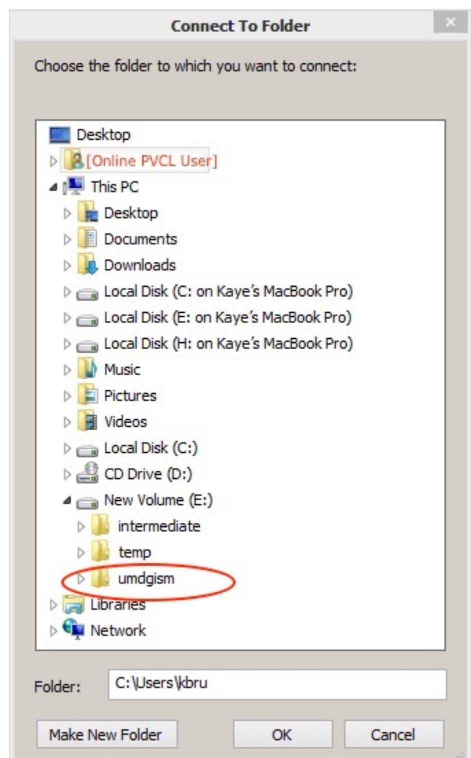
Step 2: Find the USGS Gage

To further locate the watershed outlet, build a second query to find the desired gage location, which will pinpoint the watershed outlet. Since it is known that the outlet of the Northwest Branch watershed is located at USGS Stream Gage No. 01650500, this theme can be used to find our outlet point. However this theme is not, by default, loaded into the view so the USGS stream gage shapefile must be added to the current view.

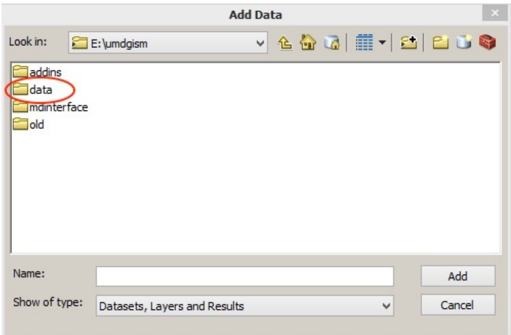


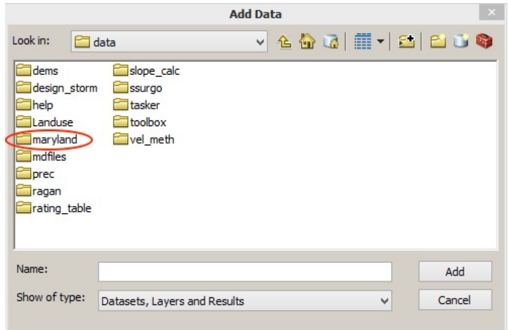
Click the "Add Data" button ( ) in the ArcMap Standard Toolbar. A browser window will appear as seen to the right. Click the "Connect to Folder" icon (circled in this image).

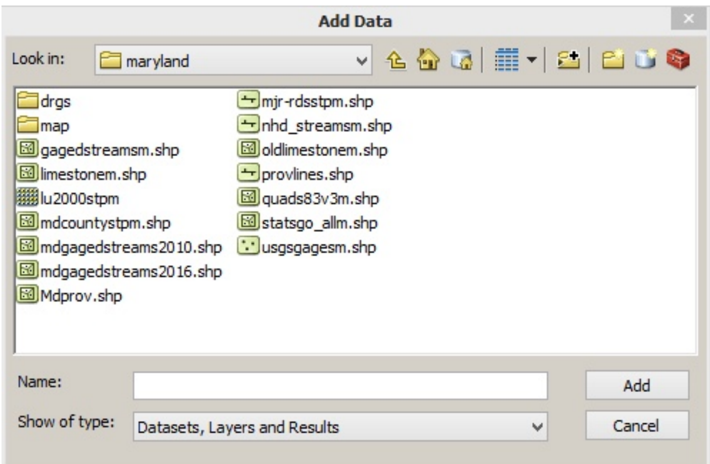
Use the file browser to locate the folder "umdgism". If you are using the Private Virtual Computer Lab installation of GISHydroNXT, this folder is in the "E:/" drive. If you are using a local desktop installation, the drive letter may be different, but the enclosed folder structure will be identical. Seelct the folder "umdgism".



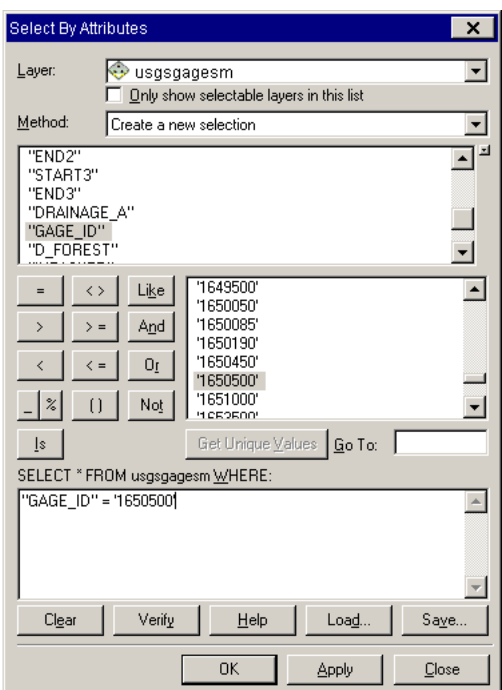
Continue to click through the folder structure until you have opened the "maryland" folder.







Select the item “usgsgagesm.shp” and click the “Add” button to add the USGS gages shapefile to the view.



From the ArcMap Main Menu, choose “Selection: Select By Attributes…” as done when selecting Randolph Road. A query builder dialog will appear as shown. Build the query as shown below:

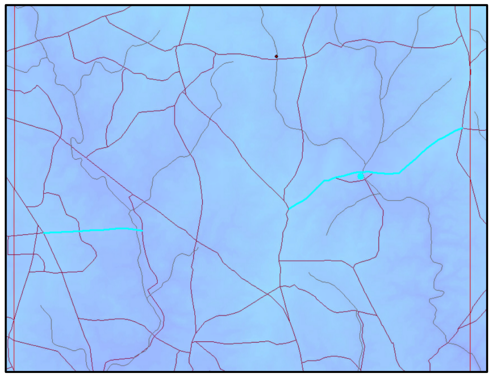
```
"GAGE_ID" = '1650500'
```

Note that the leading “0” in the gage does not appear.

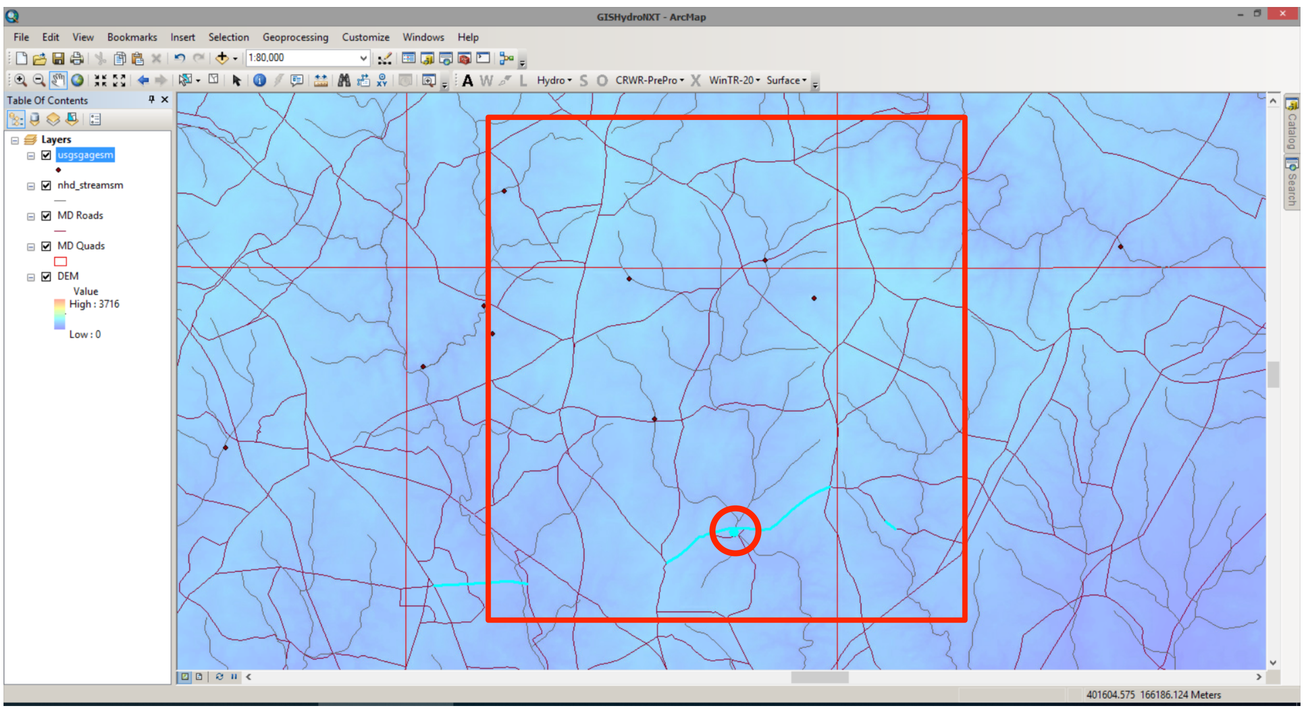
Press the “Apply” button.

Right-click on the “usgsgagesm” layer in the Table Of Contents”. Choose: Selection > Zoom to Selected Features.

You should see the selected gage as a cyan-colored dot near the center of the screen. This will guide the watershed delineation selection point.



The view window should look somewhat as shown below. (The red box and red circle will not appear on your screen.)



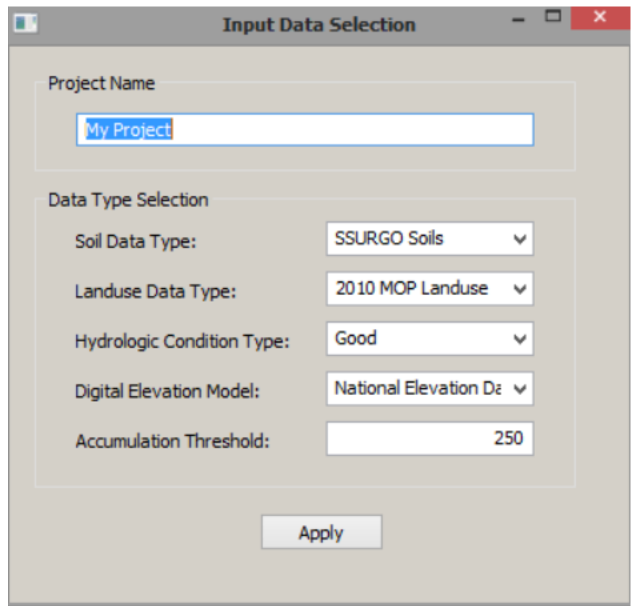
The red circle indicates the location of the USGS gage and the red box is an approximation of a box that completely bounds the watershed draining to this gage. The red bounding box is shown here for purposes of easy visualization, but it is the user's responsibility to envision a similar box, using hydrologic knowledge, for each analysis that is undertaken. The effective use of GISHydroNXT depends on the user's ability to envision the watershed being studied. It is important to identify the entire watershed drainage and make sure that the "Area of Interest" window (selected in the next step) completely covers this area, if not, the entire watershed will not be accounted for.

Step 3: Specify the Area of Interest:

From the GISHydroNXT toolbar, Click the "A" tool in the toolbar. In the view window, click, hold, and drag a bounding rectangle that completely encompasses the watershed that is to be studied. For this analysis, this bounding rectangle should approximate the red rectangle indicated in the screen capture shown above.

SUGGESTION: If the user is not familiar with the watershed in analysis it is advisable to choose an area of interest conservatively bigger, to avoid delineating a watershed that is truncated by the boundary box (check Exercise 1-B, Step 3 for further insight).

<u>Step 4: Select Analysis Data:</u>
When the user releases the far corner of the bounding rectangle specified in Step 3, a dialog box will appear prompting the user to specify a Project name, Land Use, Soils data, hydrologic condition, a digital elevation model, and an accumulation threshold to be used in this analysis. The hydrologic condition item is needed so that the appropriate NRCS curve numbers can be assigned. The selections shown for this example represent the highest quality data; however, the user may encounter cases when the other choices are more appropriate.



First name the project, we will use the default "My Project" but the user is free to choose a meaningful name (with no special characters). Note that the name we specify here will be the project folder name (located in "E:/temp/").

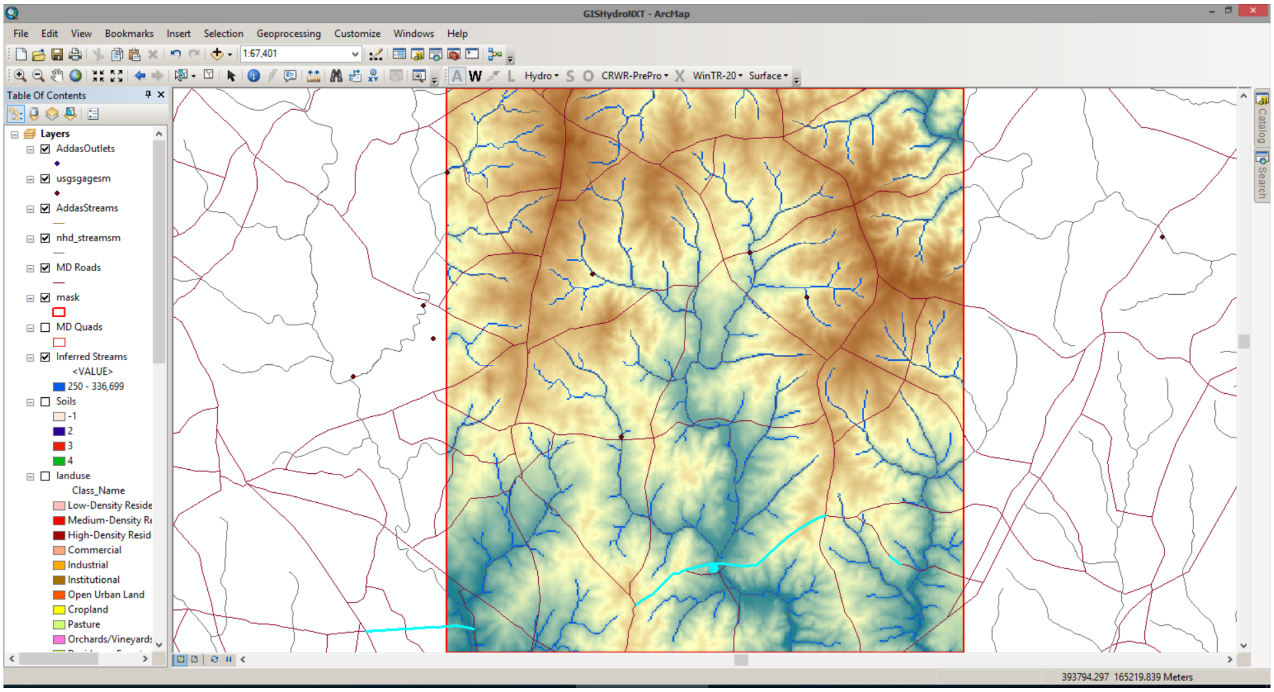
For this exercise we will use the default dataset; select the best soils data, "SSURGO Soils", the most current Maryland-centric land use data, "2010 MOP Landuse", and "Good" for the hydrologic condition.

Next to "Digital Elevation Model," select the "National Elevation Dataset" (accept the default choice).

In the text box next to "Accumulation Thresholds", enter 250 (accept the default choice).

When all selections are specified, click the "Apply" button.

After the "Apply" button is pressed, you will observe changes appearing in both the view window and in the Table of Contents panel. A courtesy message may appear in your view, acknowledging the data source; click "OK" to proceed. Eventually, GISHydroNXT will reach completion and the view window will look something like what is shown below.



Note that, within the view window, the bounding box that was previously specified now shows a shaded topographic map of the "Area of Interest". The Table of Contents panel should also now include new layers: inferred streams, land use, soils, elevation, flow accumulation, and flow direction. The view window is now ready for the next exercise, Delineating the Watershed.

Exercise 1-B: Watershed Delineation and Basin Statistics

In this exercise, you will define the watershed outlet and delineate the extent of the Northwest Branch watershed.

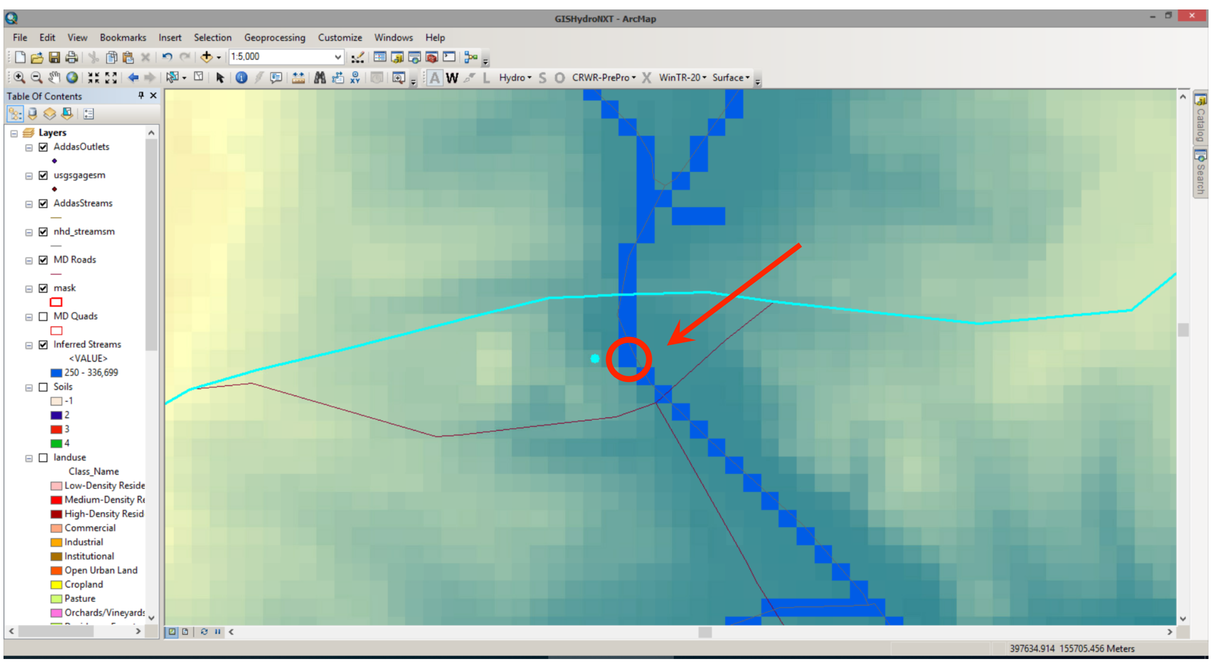
Task

Delineate the watershed draining to USGS Stream Gage No. 01650500 near Randolph Road in Montgomery County, Maryland (Northwest Branch watershed). Using this watershed, determine the basin statistics that apply to the watershed draining to this USGS gage.

Step 1: Zoom in to the Watershed Outlet

Exercise 1-A showed how to use the Query Builder to locate a feature within a particular theme. Since we know that the outlet of the Northwest Branch watershed is located at USGS Stream Gage No. 01650500, we can use this theme to find our outlet point.

Zoom in on the southern central part of the "Area of Interest" to the selected gage, which will appear cyan, and is indicated in the red circle. (The red circle and arrow will not appear in your view.) Note that the cyan road just to the north of the gage is a segment of the previously selected "Randolph Rd".



The selected gage is a guide to the watershed delineation, but its precise location should not be used. Instead, it is important to focus on the pixelated "Inferred Streams" layer for watershed delineation.

Step 2: Delineate the Watershed

Click on the "W" tool in the GISHydroNXT toolbar. Then click on the pixel on the "Inferred Streams" layer that is closest to the USGS gage location. Select the pixel highlighted by the red arrow above.

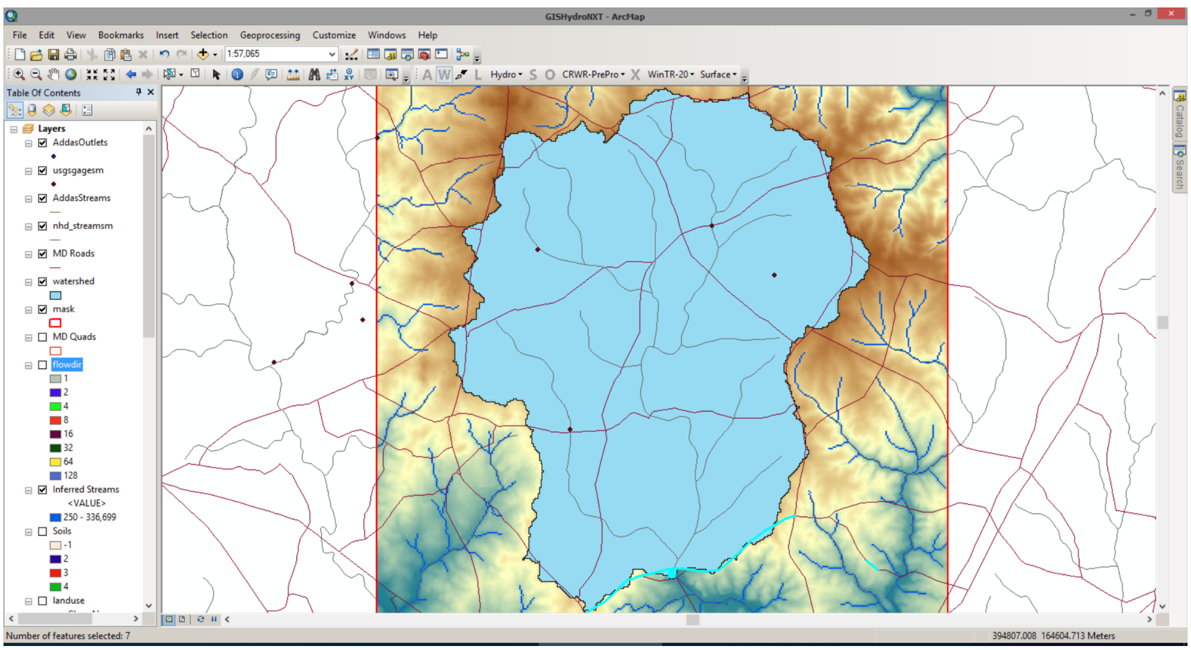
This is a matter of some interpretation, but the red arrow in the above screen capture points to the pixel identified in this demonstration as the watershed outlet. It is important to have the view window zoomed to a sufficient scale so that a precise and certain click can be performed on the exact pixel you wish to be your watershed outlet.

REMINDER: the watershed outlet selected by the "W" tool must lie on an inferred stream pixel.

After you click on the "inferred streams" pixel, GISHydroNXT will perform the calculations required and display the delineated watershed.

Step 3: Examine Delineated Watershed

As earlier when the Area of Interest bounding box was specified, the user will observe changes in the appearance and content of both the view window and the Table of Contents panel. Eventually, the software process will complete; the view window should look something like that shown below:

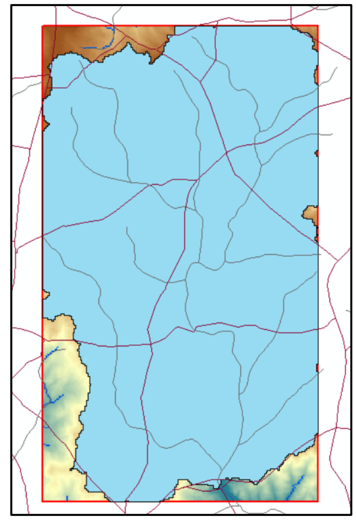


Note that you may need to zoom out to view the entire watershed. Click the ArcGIS "Zoom out" button as many times as necessary, or right-click on the "watershed" item in the Table of Contents and choose "Zoom to Layer."

There are two important items to examine.

1. Is the delineated watershed the watershed that was intended? This is easily and generally intuitively determined from the resulting displayed watershed. In some cases the user may fail to click on the true intended watershed outlet (generally because the view was not sufficiently zoomed in to click on the outlet) and the resulting delineated watershed is instead only a few pixels in area and may be hard to even see or interpret.
2. Is the Area of Interest (AOI) bounding box sufficient for the analysis? This too should be easy to determine. Examine the watershed boundary, looking for places where this boundary touches

the AOI box. Generally, such an error is very obvious with an unnatural, straight section of watershed boundary clearly seen.



An example of what the watershed would look like if the AOI were made too small is shown to the right. If either of the above errors are encountered a re-analysis is indicated.

If Item 1 applies, click the “Hydro” menu in the GISHydroNXT toolbar, select “Reset,” and return to Step 1 above in this exercise. If Item 2 applies, the user must exit and re-launch the GISHydroNXT software and return to Exercise 1, being sure to specify a larger bounding box for the Area of Interest.

Step 4: Calculate Basin Composition and Basin Statistics:
Once satisfied with the watershed delineation step, the calculation of the watershed’s characteristics is very easy.

In the GISHydroNXT toolbar “Hydro” menu, click “Basin Composition”.

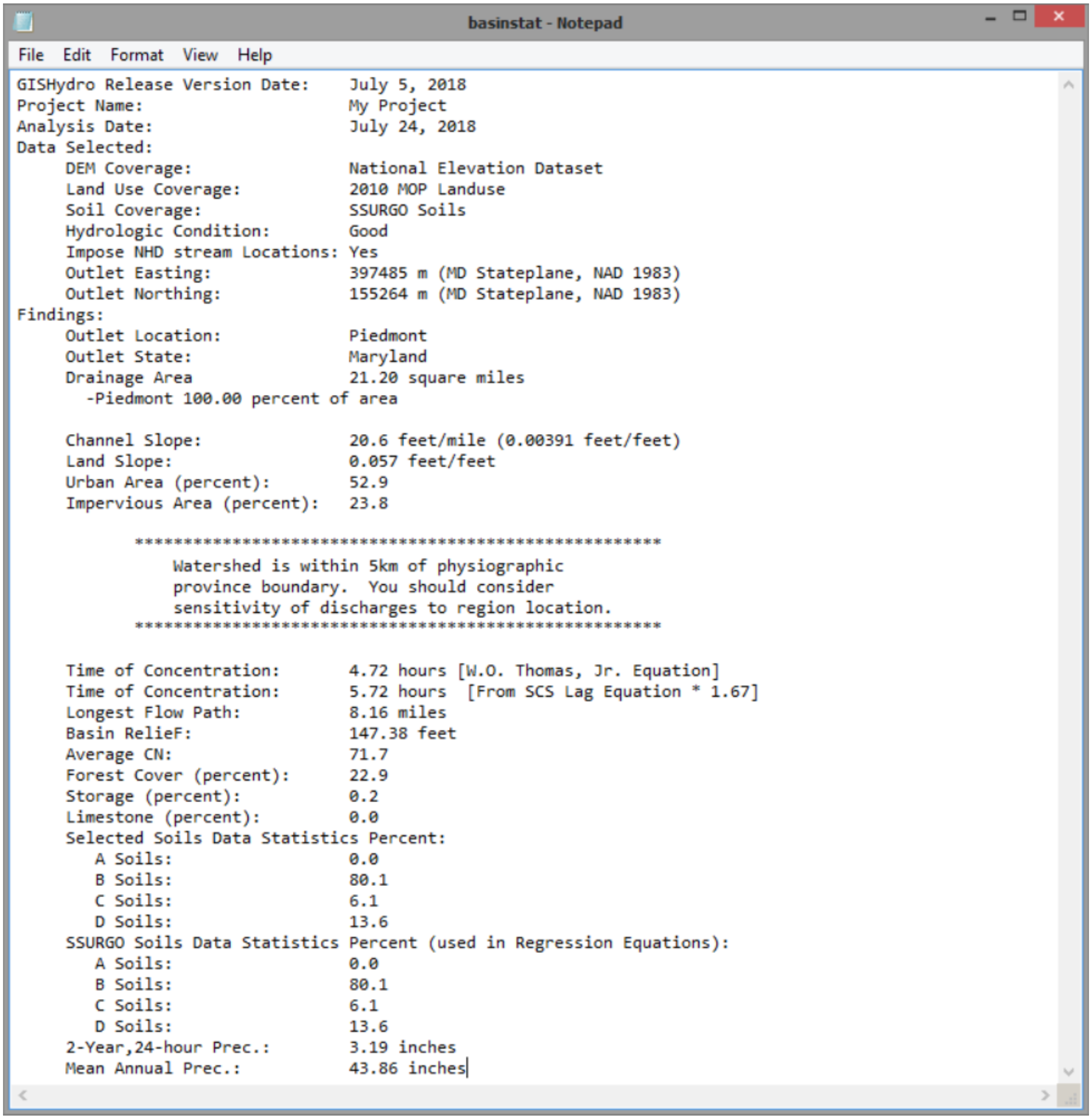
A text document will appear summarizing the composition of the watershed by soil type and land use. The data shown in this notepad window are archived to a document called “basincomp.txt,” which is stored in a “basincomp” folder in your working directory.

In the GISHydroNXT toolbar “Hydro” menu, click “Calculate Basin Statistics”.

A message alerting you to Basins Statistics wait time will appear. Click “OK” to proceed. You will again note activity both within the view window and the Table of Contents panel. It may take approximately 30-60 seconds depending on watershed size and computer speed for computations to be complete, however, you will eventually see that a Notepad window has appeared such as the one shown below on the next page. The presence of this window indicates that the basin statistics calculations have completed.

This Notepad window provides a summary of the data and watershed outlet chosen for analysis followed by a suite of basin statistics that are both of immediate value to the user for informational use, as well as of subsequent value for analyses yet to take place.

The data shown in this Notepad window have been archived to a text file (called “basinstat.txt”) and can be used in subsequent reporting. It is useful to note at this point that all files generated in a given analysis are archived to a single folder, either on the user’s stand-alone installation machine or on the GISHydro virtual computer lab. The demonstration illustrated here was performed on the virtual computer lab. Switching the Table of Contents panel view to “List by Source” shows that the files in these illustrations are located in “E:/temp/20180724_115237_My_Project/”. Every user’s project folder name will be unique. Note that although the GIS data area stored in SI/metric units, the calculated quantities (area, basin relief, slope, etc.) are reported in English (American Customary) units.



```
GISHydro Release Version Date:   July 5, 2018
Project Name:                    My Project
Analysis Date:                   July 24, 2018
Data Selected:
     DEM Coverage:               National Elevation Dataset
     Land Use Coverage:          2010 MOP Landuse
     Soil Coverage:              SSURGO Soils
     Hydrologic Condition:       Good
     Impose NHD stream Locations: Yes
     Outlet Easting:             397485 m (MD Stateplane, NAD 1983)
     Outlet Northing:            155264 m (MD Stateplane, NAD 1983)
Findings:
     Outlet Location:            Piedmont
     Outlet State:               Maryland
     Drainage Area               21.20 square miles
       -Piedmont 100.00 percent of area

     Channel Slope:              20.6 feet/mile (0.00391 feet/feet)
     Land Slope:                 0.057 feet/feet
     Urban Area (percent):       52.9
     Impervious Area (percent):  23.8

            ******************************************************
                Watershed is within 5km of physiographic
                province boundary.  You should consider
                sensitivity of discharges to region location.
            ******************************************************

     Time of Concentration:      4.72 hours [W.O. Thomas, Jr. Equation]
     Time of Concentration:      5.72 hours  [From SCS Lag Equation * 1.67]
     Longest Flow Path:          8.16 miles
     Basin RelieF:               147.38 feet
     Average CN:                 71.7
     Forest Cover (percent):     22.9
     Storage (percent):          0.2
     Limestone (percent):        0.0
     Selected Soils Data Statistics Percent:
        A Soils:                 0.0
        B Soils:                 80.1
        C Soils:                 6.1
        D Soils:                 13.6
     SSURGO Soils Data Statistics Percent (used in Regression Equations):
        A Soils:                 0.0
        B Soils:                 80.1
        C Soils:                 6.1
        D Soils:                 13.6
     2-Year,24-hour Prec.:       3.19 inches
     Mean Annual Prec.:          43.86 inches
```

Exercise 1-C: Discharge Estimation Using Regression Techniques

GISHydroNXT calculates discharge using regression equations developed by the Maryland Hydrology Panel and adopted as the recognized regression-based predictor equations for peak discharge estimation by the USGS. These statistical predictions of peak flow are based on watershed parameters, land use, physiographic region, and other factors. The regression discharge estimates are used for comparison and calibration of discharges predicted by WinTR-20 in accordance with the recommendations of the Maryland Hydrology Panel. This exercise describes the use of GISHydroNXT to calculate peak flow regression estimates for the Northwest Branch watershed.

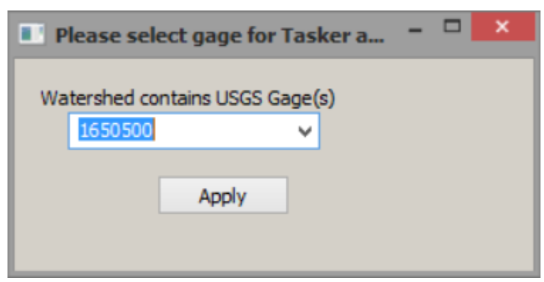
Task

Estimate the peak discharges (Q1.25 – Q500) for the Northwest Branch watershed analyzed earlier: USGS Gage 0160500 located in Montgomery County, Maryland. Use the observed flows at this gage to adjust the predicted regression equation estimates. Verify the gage adjustment for discharges at the 2-year return period. Examine the peak discharge estimates and the confidence intervals on these estimates.

Step 1: Calculate Thomas Discharges:

Choose from the GISHydroNXT toolbar, "Hydro: Calculate Thomas Discharge".

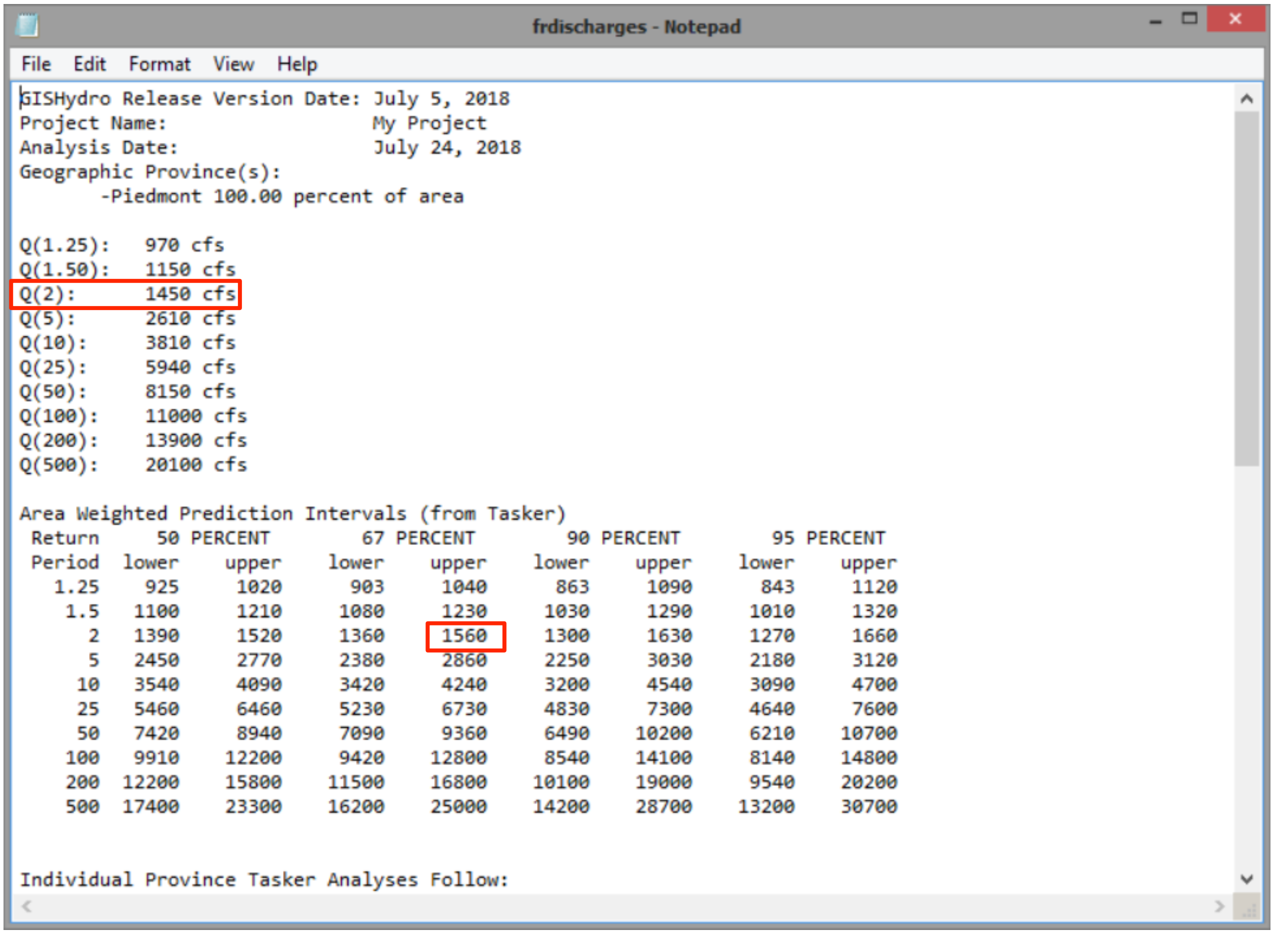
The program will use the basin statistics determined earlier to execute the regression equations that are applicable. In this case, as observed in Exercise 1-B, the watershed is 100 percent in the Maryland Piedmont, with a high amount of impervious area (23.8%).
This example analysis is taking place precisely at the location of a USGS gage. This makes adjustment of flood estimates possible, taking advantage of both observed flood frequency information at the gage and the calibrated regression equation at this same location.



GISHydroNXT automatically detects the presence of the USGS gage for potential adjustment and launches the dialog box shown at right. The box initially asks the user to select a gage.
Clicking the dropdown arrow, two choices will be available: the USGS gage number, "1650500", or "Perform no adjustment". Choose the USGS gage number 1650500 to perform the Thomas discharge estimation adjusting for the presence of the USGS gage.

(Refer to the GISHydroNXT *Technical Reference Manual* for theoretical details on gage adjustment.)

When the calculation is complete, a Notepad window will open (similar to the "Calculate Basin Statistics" outcome) showing the text output from the peak flow regression equations as shown below (Note: the red boxes will not appear in your view). This text output is saved in the same output directory as the basin statistics file shown earlier with the name "frdischarges.txt" and is of value for subsequent analysis steps and reporting.



```
frdischarges - Notepad
File  Edit  Format  View  Help
GISHydro Release Version Date: July 5, 2018
Project Name:                  My Project
Analysis Date:                 July 24, 2018
Geographic Province(s):
       -Piedmont 100.00 percent of area

Q(1.25):   970 cfs
Q(1.50):   1150 cfs
Q(2):      1450 cfs
Q(5):      2610 cfs
Q(10):     3810 cfs
Q(25):     5940 cfs
Q(50):     8150 cfs
Q(100):    11000 cfs
Q(200):    13900 cfs
Q(500):    20100 cfs

Area Weighted Prediction Intervals (from Tasker)
 Return      50 PERCENT         67 PERCENT         90 PERCENT         95 PERCENT
 Period  lower     upper    lower     upper    lower     upper    lower     upper
   1.25    925      1020      903      1040      863      1090      843      1120
    1.5   1100      1210     1080      1230     1030      1290     1010      1320
      2   1390      1520     1360      1560     1300      1630     1270      1660
      5   2450      2770     2380      2860     2250      3030     2180      3120
     10   3540      4090     3420      4240     3200      4540     3090      4700
     25   5460      6460     5230      6730     4830      7300     4640      7600
     50   7420      8940     7090      9360     6490     10200     6210     10700
    100   9910     12200     9420     12800     8540     14100     8140     14800
    200  12200     15800    11500     16800    10100     19000     9540     20200
    500  17400     23300    16200     25000    14200     28700    13200     30700


Individual Province Tasker Analyses Follow:
```

Step 2: Verify Gage Adjustment:

At the bottom of the "frdischarges.txt" file, note the statement that discharges have been adjusted for proximity to the USGS station.

frdischarges - Notepad

File Edit Format View Help

Return Period	Discharge (cfs)	Standard Error of Prediction (percent)	Equivalent Years of Record	Standard Error of Prediction (logs)
1.25	970.	7.2	77.59	0.0311
1.50	1150.	6.7	77.99	0.0293
2.00	1450.	6.9	78.49	0.0301
5.00	2610.	9.1	83.98	0.0395
10.00	3810.	10.7	90.78	0.0465
25.00	5940.	12.6	99.77	0.0547
50.00	8150.	14.0	105.77	0.0603
100.00	11000.	15.4	108.76	0.0663
200.00	13900.	19.3	106.79	0.0831
500.00	20100.	21.8	104.79	0.0936

P R E D I C T I O N I N T E R V A L S

Return	50 PERCENT		67 PERCENT		90 PERCENT		95 PERCENT	
Period	lower	upper	lower	upper	lower	upper	lower	upper
1.25	925.	1020.	903.	1040.	863.	1090.	843.	1120.
1.50	1100.	1210.	1080.	1230.	1030.	1290.	1010.	1320.
2.00	1390.	1520.	1360.	1560.	1300.	1630.	1270.	1660.
5.00	2450.	2770.	2380.	2860.	2250.	3030.	2180.	3120.
10.00	3540.	4090.	3420.	4240.	3200.	4540.	3090.	4700.
25.00	5460.	6460.	5230.	6730.	4830.	7300.	4640.	7600.
50.00	7420.	8940.	7090.	9360.	6490.	10200.	6210.	10700.
100.00	9910.	12200.	9420.	12800.	8540.	14100.	8140.	14800.
200.00	12200.	15800.	11500.	16800.	10100.	19000.	9540.	20200.
500.00	17400.	23300.	16200.	25000.	14200.	28700.	13200.	30700.

Estimates adjusted for proximity to station 1650500

The procedures in the Maryland Hydrology Panel state that calibration of the WinTR-20 model (to be discussed later in this Manual) should aim for estimates between the t-year regression estimate and the t-year plus one standard error (the 67 percent estimate). This discharge interval can be determined from the text file produced and shown in Step 1 above. For instance, focusing on the 2-year return period, the regression estimate (boxed in red in the text output above) is 1,450 ft3/s while the 2-year plus one standard error (67 percent, also boxed in red in the text output above) is 1,560 ft3/s. Thus, in later exercises in this manual, a calibrated WinTR-20 model would produce a discharge between 1,450 and 1,560 ft3/s. This discharge interval will be referred to as the "calibration window".

At this point, it is a good idea to clear selections using the "Clear Selected Features" button () in the ArcMap Tools Toolbar or "Selection > Clear Selected Features" in the ArcMap Main Menu.

Exercise 2-A: Subdivision of Watershed for WinTR-20 Modeling

In this exercise we will carry out the first steps in developing a WinTR-20 model. Assume that the goal of the modeling procedure is to predict 2-year return period discharge occurring at the outlet of the Northwest Branch watershed at Gage 01650500. The first step is to subdivide the watershed into the spatial elements that WinTR-20 defines: subareas and routing reaches. The geospatial data allow GISHydroNXT tools to define these segments based on elevation and the stream network in the watershed.

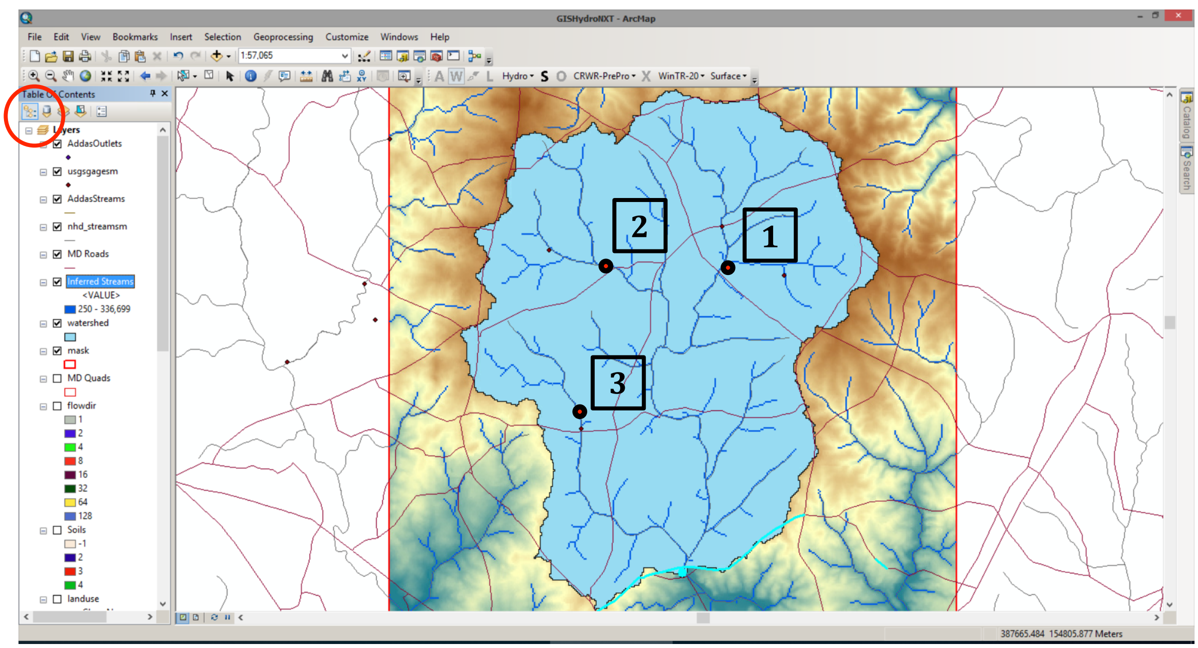
Task

Use the GISHydroNXT program to define the elements of the Northwest Branch watershed for a WinTR-20 model. We will subdivide the watershed into 5 sub-watersheds corresponding to the main channel segments and identify routing reaches.

Step 1: Change View to Visualize Stream Network

At the top of the Table of Contents Panel, change the list to “List by Drawing Order” (this choice is shown in the red circle in the screen capture below). This ArcGIS feature allows the user to drag layers up/down in the Table of Contents to control the order of layer rendering.

Click and drag the “Inferred Streams” layer up in the Table of Contents panel so that it above the “watershed” layer. This will have the effect of making the stream network visible within the watershed as shown below. (Note – the red dots, and boxed numbers will not appear in your view.)

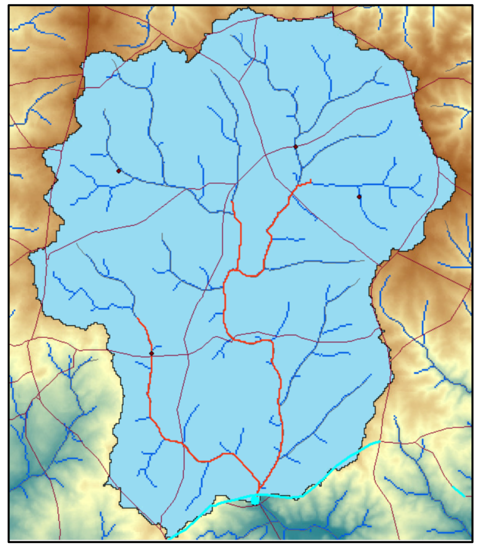


Step 2: Draw Streams

The stream network within the study watershed (“Inferred Streams”) is shown to a high drainage density. The goal is to subdivide this watershed, but not at the level of resolution indicated by the drainage network. Instead, a brief study of the watershed suggests a northeast subwatershed (indicated by the “1”), and northwest subwatershed (indicated by the “2”) and a southwestern subwatershed (indicated by the "3"). Study this watershed and try to visualize these three sub-watersheds along with the confluence points where drainage from these sub-watersheds would meet. These confluence points will become points of internal subdivision.

Click on the "S" tool, in the GISHydroNXT toolbar to launch the sub-watershed identification tool. Now click in each of the three sub-watersheds indicated by the boxed numbers in the screen capture above. Note: it is not necessary to click on a stream. Any click within each of the three subwatersheds will produce the same result. Be sure to make only three clicks, as selecting more would create more sub-watersheds.

When this step is complete, the user should see three red flowlines tracing downstream from the points that were clicked. It should appear somewhat like the figure shown at right. Note: clicking in different locations will give a slightly different appearance. Because it was not necessary to click on a stream pixel, the red lines might not begin on identified streams, but they should coincide with the stream pixels farther downstream.

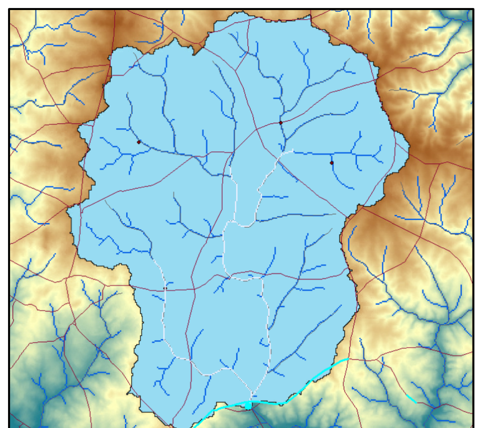


Step 3: Delineate Main Channels and Sub-watersheds

For this manual's purpose, the end goal is to model the watershed with the three main channel segments created in the previous step. This will result in five subareas and two routing reaches, as will be seen shortly.

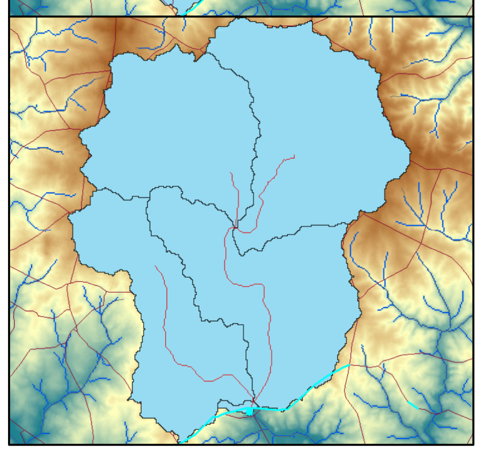
From the GISHydroNXT toolbar, choose: "CRWR-PrePro: Add Streams".

Some brief computations will take place. The view window will update with the red streams replaced by a white pixelated drainage network, much simpler (and coarser in drainage density) than the "Inferred Streams" network initially visualized in Step 1.



Now choose: "CRWR-PrePro: Delineate Subwatersheds".

Again, some brief computations will take place. The view window will update showing a new layer, (called "subshed") that shows the subdivided watershed as visualized at right. Confirm that the three subwatersheds initially envisioned (by the boxed numbers, above) are now clearly delineated. In addition, there is a large subarea in the southeast part of the



watershed and a very small subarea at the very downstream, southern extreme of the watershed for a total of five subareas (three true subwatersheds — as defined by the tributaries — and two additional subareas).

Exercise 2-B: Time of Concentration Determination

After subdividing the watershed, the next step is to assign a time of concentration, Tc, to each subarea in the Northwest Branch watershed. WinTR-20 requires the time of concentration to simulate the runoff hydrograph for each subarea. GISHydroNXT includes an interactive tool to specify the method of calculation for Tc and to enter associated parameters such as lengths of sheet and channel flow. Three Tc calculation methods are available: SCS Lag Formula, Hydrology Panel, and Velocity Method. For more background on these methods, see the *Technical Reference Manual*.

Task

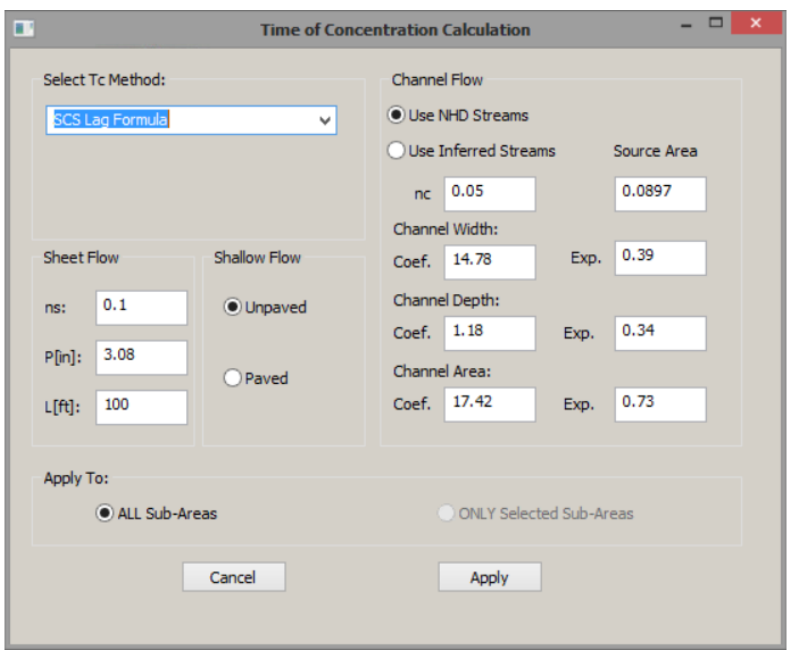
Use the GISHydroNXT Time of Concentration Calculation dialog box to specify the time of concentration for each of the five subareas in the Northwest Branch watershed. Calculate Tc using each of the three methods available. Examine the differences in the time of concentration methods by examining the subshed.shp attribute table. and generate the watershed schematic, which forms the logical organization of the WinTR-20 input file.

Note: In practice, the analyst would select the appropriate Tc method and run it, rather than exploring all three methods. The goal of this exercise is to introduce you to all three methods. Guidance on how to determine which time of concentration is most appropriate can be found in the *Technical Reference Manual*. Please continue to work through the exercise, as all three methods are introduced here.

SCS Lag Formula Time of Concentration Method

Step 1: Choose Method:

Open the Time of Concentration Calculator by selecting "CRWR-PrePro: Set Tc Parameters" within the GISHydroNXT toolbar. The dialog box shown will appear.



Select the "SCS Lag Formula" option for this particular exercise.

Step 2: Apply Method and Parameters

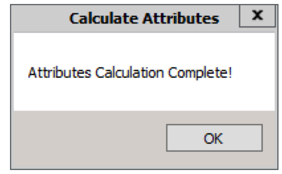
The dialog box contains a number of parameters and choices. For the purposes of this exercise, leave all parameters at their default settings.

GISHydro2000 provided the option of selecting specific subareas to apply a certain Tc method and parameters. This option is currently unavailable in GISHydroNXT. Therefore, the "ONLY Selected Sub-Areas" choice is grayed out and unavailable. The selection of SCS Lag Formula, and the parameters, will be applied to all sub-areas.

Click the "Apply" button in the dialog to apply the selected method and parameters to all subareas.

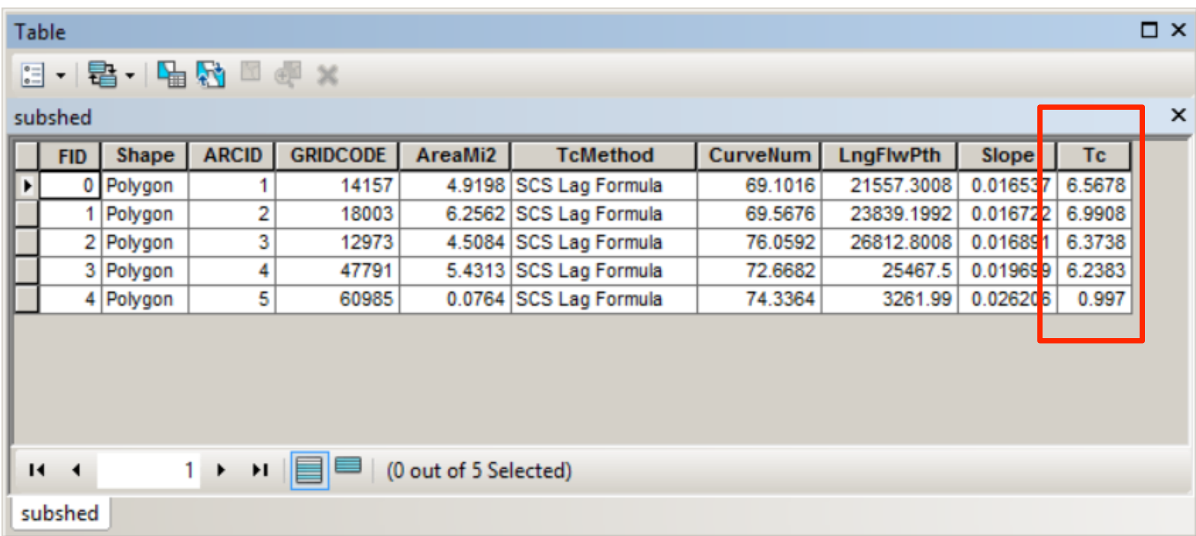
Step 3: Calculate Attributes:
From the GISHydroNXT toolbar, select "CRWR-PrePro: Calculate Attributes".

This step will determine the length of the longest flow path and apply time of concentration settings for each subarea. Please be patient, depending the number of subareas, the size of the subareas, and the computer speed, total computation time can take several minutes. A small dialog box will appear when computations are complete.



Step 4: Examine Attribute Table to See Tc Computation Results:
In the Table of Contents panel, right-click on the "subshed" layer and choose, "Open Attribute Table".

A portion of the resulting attribute table for this exercise is shown below. The attribute table contains numerous fields (columns). Of the greatest interest is the far right field (shown boxed in blue), which provides the computed time of concentration, Tc, values in units of hours.



Table

subshed

FID	Shape	ARCID	GRIDCODE	AreaMi2	TcMethod	CurveNum	LngFlwPth	Slope	Tc
0	Polygon	1	14157	4.9198	SCS Lag Formula	69.1016	21557.3008	0.016537	6.5678
1	Polygon	2	18003	6.2562	SCS Lag Formula	69.5676	23839.1992	0.016722	6.9908
2	Polygon	3	12973	4.5084	SCS Lag Formula	76.0592	26812.8008	0.016891	6.3738
3	Polygon	4	47791	5.4313	SCS Lag Formula	72.6682	25467.5	0.019699	6.2383
4	Polygon	5	60985	0.0764	SCS Lag Formula	74.3364	3261.99	0.026206	0.997

1 (0 out of 5 Selected)

subshed

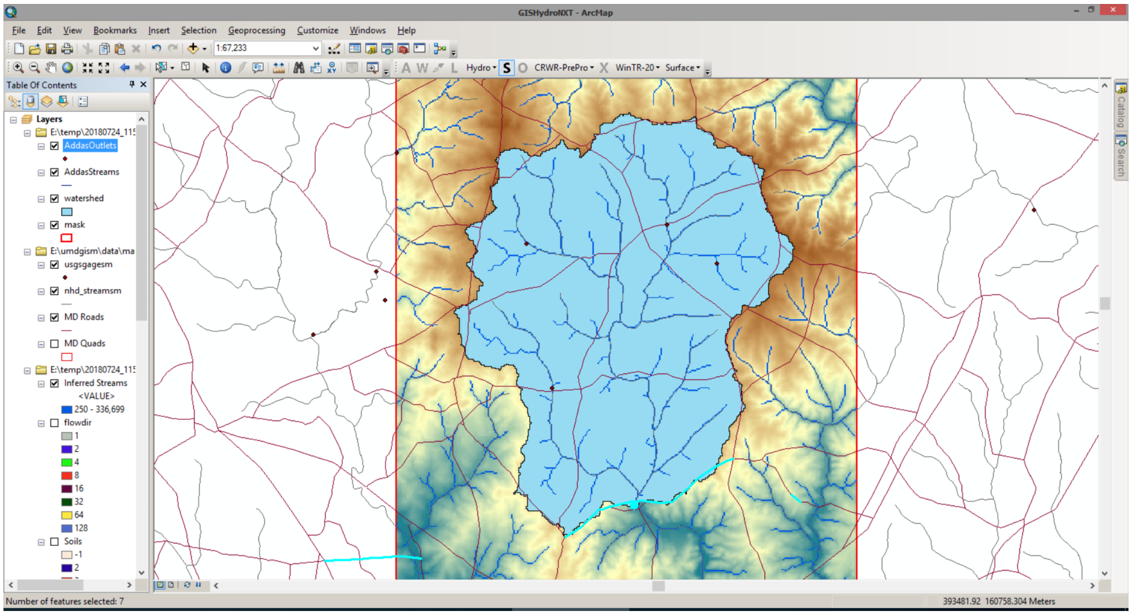
Computed Tc's, rounded to the nearest tenth of an hour, are 6.6, 7.0, 6.4, 6.2, and 1.0 hours for the five subareas. The small Tc for the final subarea is owing to its very small area (reported at only 0.0764 mi2).

Hydrology Panel Time of Concentration Method

We will now analyze the second time of concentration method.

Step 1: Reset the Watershed.
Select "CRWR-PrePro: Reset". This should reset the session to be the same as it was before flow paths were selected for watershed subdivision. The screen should appear as shown below. If the

watershed is not present and the “S” tool is not bold black, close the session and repeat the steps to get to the beginning of this exercise.



Repeat the steps performed in Exercise 2-A.

Step 2: Select Method:

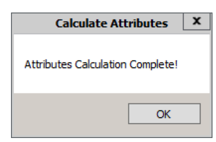
Open the Time of Concentration Calculator by selecting “CRWR-PrePro: Set Tc Parameters” within the GISHydroNXT toolbar. The dialog box from the previous exercise will appear.

Select the “Hydrology Panel Method” option for this particular exercise.

Step 3: Apply Method and Parameters; Calculate Attributes

Accept all parameter values that appear in the dialog box.

Click the “Apply” button in the dialog to apply the selected method and parameters to all the sub-watersheds.



From the GISHydroNXT toolbar, select “CRWR-PrePro: Calculate Attributes”. Wait for the completion message to appear.

Step 4: Examine Attribute Table to See Tc Computation Results:

In the Table of Contents panel, right-click on the “subshed” layer and choose, “Open Attribute Table”.

The resulting attribute table for this exercise is shown below. The attribute table contains numerous fields (columns). Of the greatest interest is the far right field (shown circled in blue), which provides the computed time of concentration, Tc, values in units of hours.

Table

subshed

FID	Shape	ARCID	GRIDCODE	AreaMi2	TcMethod	CurveNum	LngFlwPth	Slope	Tc
0	Polygon	1	14157	4.9198	Hydrology Panel Tc Method	69.1016	21557.3008	0.016537	3.2107
1	Polygon	2	18003	6.2562	Hydrology Panel Tc Method	69.5676	23839.1992	0.016722	3.3242
2	Polygon	3	12973	4.5084	Hydrology Panel Tc Method	76.0592	26812.8008	0.016891	3.5606
3	Polygon	4	47791	5.4313	Hydrology Panel Tc Method	72.6682	25467.5	0.019699	3.3239
4	Polygon	5	60985	0.0764	Hydrology Panel Tc Method	74.3364	3261.99	0.026206	0.6873

(0 out of 5 Selected)

subshed

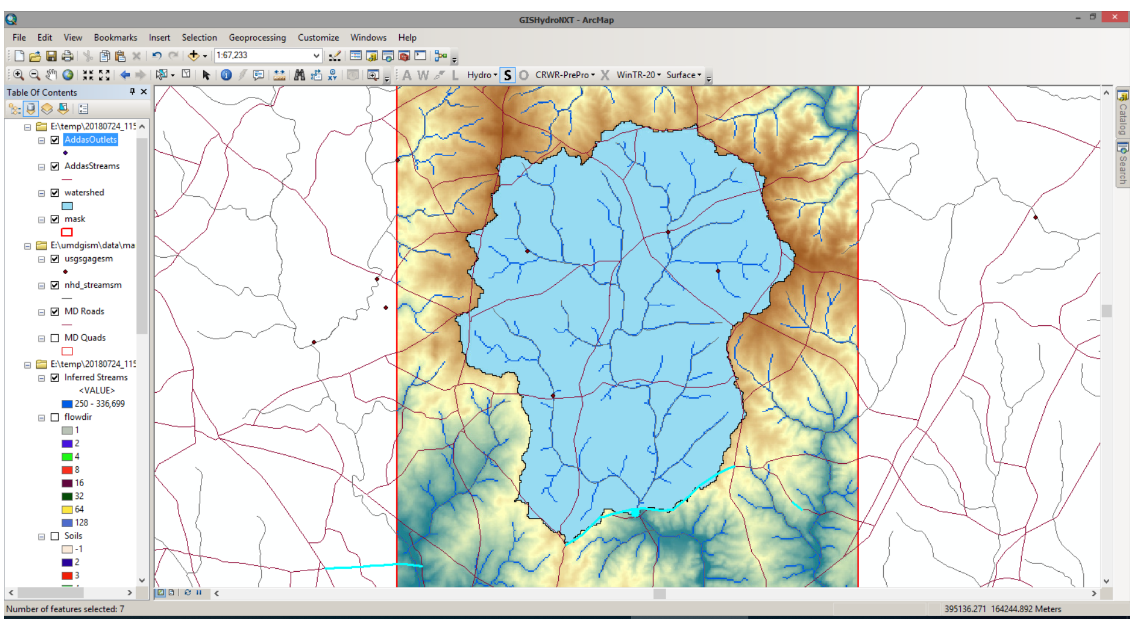
Computed Tc's, rounded to the nearest tenth of an hour, are 3.2, 3.3, 3.6, 3.3, 0.7 hours for the five subareas. These values are very different from the calculated values using the SCS Lag Method, which were previously found to be 6.6, 7.0, 6.4, 6.2, and 1.0 hours for the respective subareas.

Velocity Method Time of Concentration

The next step is to analyze the third time of concentration method.

Step 1: Reset the Watershed.

Select "CRWR-PrePro: Reset". This should reset the file to be the same as it was before any time of concentrations were calculated. The screen should appear as shown below.



Repeat the steps performed in Exercise 2-A.

Step 2: Select Method:
Open the Time of Concentration Calculator by selecting “CRWR-PrePro: Set Tc Parameters” within the GISHydroNXT toolbar. The dialog box from the previous exercise will appear.

Select the “Velocity Method Tc Calculation” option for this particular exercise.

Step 3. Apply Method and Parameters; Calculate Attributes
Accept all parameter values that appear in the dialog box.

Click the “Apply” button in the dialog to apply the selected method and parameters to all the subwatersheds.

From the GISHydroNXT toolbar, select “CRWR-PrePro: Calculate Attributes”. Wait for the completion message to appear.

Step 4: Examine Attribute Table to See Tc Computation Results:
In the Table of Contents panel, right-click on the “subshed” layer and choose “Open Attribute Table”.

The resulting attribute table for this exercise is shown below. In this case, the attribute table is split in two because of its size. The Velocity Method uses more input values (parameters) than the other two methods; these parameters are listed as fields in the “subshed” attribute table generated for this Tc method. Of the greatest interest is the far right field (shown boxed in blue), which provides the computed time of concentration, Tc, values in units of hours.

Table

subshed

FID	Shape	ARCID	GRIDCODE	AreaMi2	TcMethod	CurveNum	sheet_n	sheet_P	sheet_L	shal_Paved	channel_n	ChanDef
0	Polygon	1	14157	4.9198	Velocity Method Tc Calculation	69.1016	0.1	3.08	100	Unpaved	0.05	NHD
1	Polygon	2	18003	6.2562	Velocity Method Tc Calculation	69.5676	0.1	3.08	100	Unpaved	0.05	NHD
2	Polygon	3	12973	4.5084	Velocity Method Tc Calculation	76.0592	0.1	3.08	100	Unpaved	0.05	NHD
3	Polygon	4	47791	5.4313	Velocity Method Tc Calculation	72.6682	0.1	3.08	100	Unpaved	0.05	NHD
4	Polygon	5	60985	0.0764	Velocity Method Tc Calculation	74.3364	0.1	3.08	100	Unpaved	0.05	NHD

1 (0 out of 5 Selected)

subshed

ChanDef	ChanSA	WidthCoef	WidthExp	DepthCoef	DepthExp	XAreaCoef	XAreaExp	LngFlwPth	Slope	Tc
NHD	0.0897	14.78	0.39	1.18	0.34	17.42	0.73	21557.3008	0.054254	3.182
NHD	0.0897	14.78	0.39	1.18	0.34	17.42	0.73	23839.1992	0.05[illegible]486	4.558
NHD	0.0897	14.78	0.39	1.18	0.34	17.42	0.73	26812.8008	0.055417	5.602
NHD	0.0897	14.78	0.39	1.18	0.34	17.42	0.73	25467.5	0.064627	4.503
NHD	0.0897	14.78	0.39	1.18	0.34	17.42	0.73	3261.99	0.085977	0.441

(0 out of 5 Selected)

Computed Tc's, rounded to the nearest tenth of an hour, are 3.2, 4.6, 5.6, 4.5, 0.4 hours for the five subareas. These values differ from the calculated values using the SCS Lag Method, which were previously found to be 6.6, 7.0, 6.4, 6.2, and 1.0 hours for each subarea. They also differ from the calculated values using the Hydrology Panel Method, which were found to be 3.2, 3.3, 3.6, 3.3 and 0.7 hours for the five subareas.

Time of Concentration Method Summary

The table below summarizes the subarea Tc's calculated by the different methods.

Note: These values are all rounded to the nearest tenth.

Method	**Subarea Time of Concentration (Hrs)**				
	1	**2**	**3**	**4**	**5**
SCS Lag	6.6	7.0	6.4	6.2	1.0
Hydrology Panel	3.2	3.3	3.6	3.3	0.7
Velocity Method	3.2	4.6	5.6	4.5	0.4

GISHydroNXT allows substantial adjustments to the Velocity Method Tc estimation. An exercise later in this Manual guides you in exploring this option.

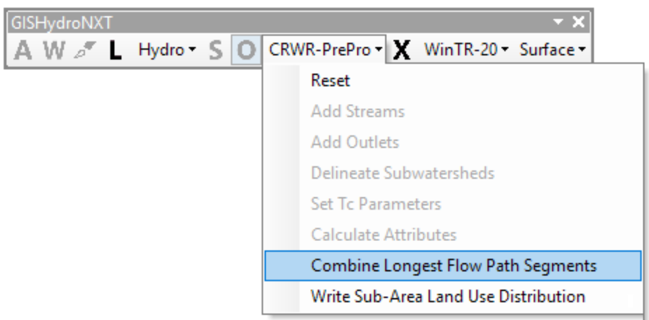
Exercise 2-B(supp): Combine Flow Paths to Adjust Velocity Method Tc

This supplement to Exercise 2-B describes an optional step to refine the velocity method Tc calculation. In a basic introduction to the operation of GISHydroNXT, this step may be skipped. You may wish to move on to Exercise 2-C, and return to this exercise later.

The velocity method Tc can be adjusted by combining flow paths. A full discussion of the numerical approach and why this step decreases the estimate of Tc can be found in the *Technical Reference Manual*.

If no combination is applied, the Tc determined from the "Calculate Attributes" menu choice will be used in writing the tc to the WinTR-20 input file.

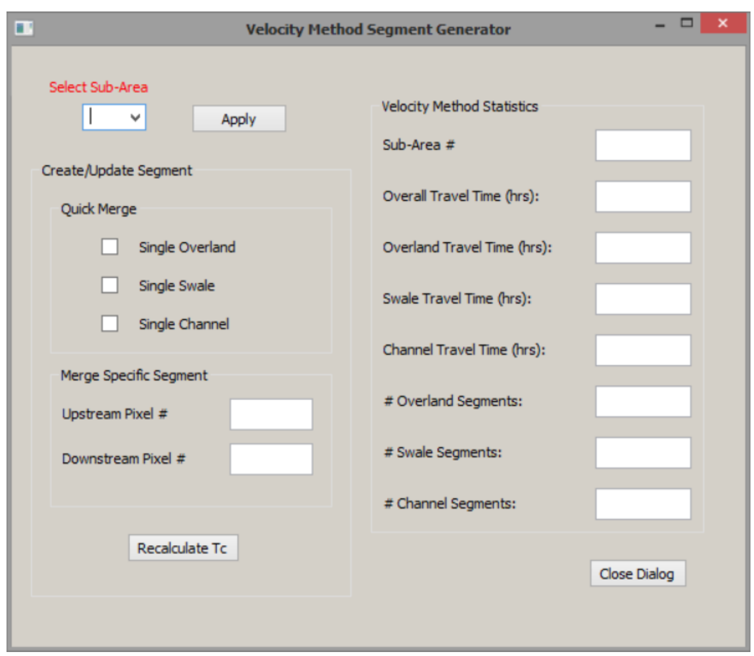
In the "CRWR-PrePro" menu, select "Combine Longest Flow Path Segments".



Selecting this choice produces the Velocity Method Segment Generator dialog shown. The dialog initially appears blank when it is first opened.

The Velocity Method Segment Generator is divided into a left and right side. The left side is the input side while the right side is the output side. On the left side, the engineer can quickly merge all pixels of a particular flow type (i.e. overland, swale, or channel) into a single segment (upper part) or select specific segments to merge on a pixel-by-pixel basis.

In the "Select Sub-Area" dropdown, select sub-area number 1 (one) from the watershed to be studied. Since the example watershed has been subdivided into multiple sub-areas, the tool will need to be used once for each sub-area.

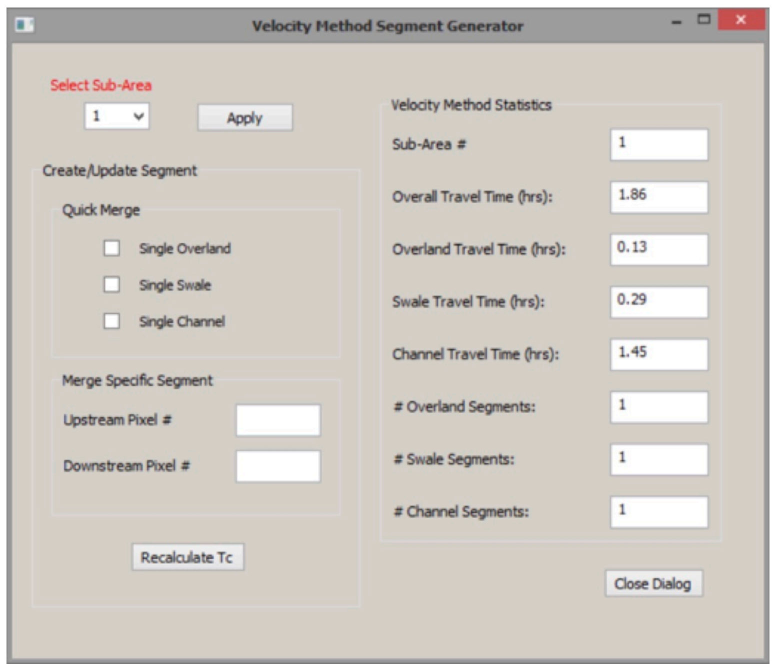


Click the Apply button. A new window called “Segment Attributes –Sub-area-1” will appear. An example of what the screen is below (first 16 rows only). For a more detailed description of each of the fields (columns) in the table, see the *Technical Reference Manual*.

Segment Attributes - Sub-area 1

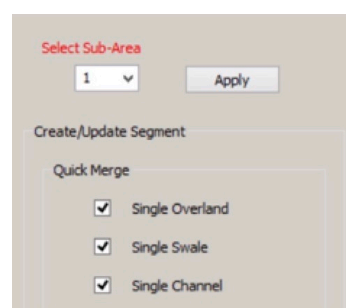
FID	UpPixel	SegName	Type	DownPixel	Avg. Area	UpElev	DownElev	Slope	Width	Depth	Xarea	l_Length	Tot_Leng...	Vel.	l_Time	Tot_Time
0	0	M1	overland	1	0.000173...	554.1	550.5	0.036836	-1.0	-1.0	-1.0	98.4	98.4	0.29	0.093	0.093
1	1	M2	overland	2	0.000521...	550.5	549.9	0.006478	-1.0	-1.0	-1.0	98.4	196.9	0.99	0.028	0.121
2	2	S1	swale	3	0.001042...	549.9	548.6	0.012718	-1.0	-1.0	-1.0	98.4	295.3	1.82	0.015	0.136
3	3	S2	swale	4	0.00173746	548.6	546.8	0.018453	-1.0	-1.0	-1.0	98.4	393.7	2.19	0.012	0.148
4	4	S3	swale	5	0.002258...	546.8	544.7	0.020737	-1.0	-1.0	-1.0	98.4	492.1	2.32	0.012	0.16
5	5	S4	swale	6	0.002953...	544.7	542.1	0.027005	-1.0	-1.0	-1.0	98.4	590.6	2.65	0.01	0.17
6	6	S5	swale	7	0.003648...	542.1	537.5	0.046704	-1.0	-1.0	-1.0	98.4	689.0	3.49	0.008	0.178
7	7	S6	swale	8	0.003996...	537.5	532.1	0.039105	-1.0	-1.0	-1.0	139.2	828.2	3.19	0.012	0.19
8	8	S7	swale	9	0.004517...	532.1	528.4	0.02603	-1.0	-1.0	-1.0	139.2	967.4	2.6	0.015	0.205
9	9	S8	swale	10	0.005386...	528.4	526.3	0.015596	-1.0	-1.0	-1.0	139.2	1106.6	2.01	0.019	0.224
10	10	S9	swale	11	0.006776...	526.3	522.4	0.039269	-1.0	-1.0	-1.0	98.4	1205.0	3.2	0.009	0.233
11	11	S10	swale	12	0.008861...	522.4	519.0	0.024719	-1.0	-1.0	-1.0	139.2	1344.2	2.54	0.015	0.248
12	12	S11	swale	13	0.010772...	519.0	516.2	0.02765	-1.0	-1.0	-1.0	98.4	1442.6	2.68	0.01	0.258
13	13	S12	swale	14	0.011640...	516.2	511.1	0.052459	-1.0	-1.0	-1.0	98.4	1541.0	3.7	0.007	0.266
14	14	S13	swale	15	0.01650587	511.1	507.1	0.028338	-1.0	-1.0	-1.0	139.2	1680.2	2.72	0.014	0.28
15	15	S14	swale	16	0.02432444	507.1	502.9	0.043392	-1.0	-1.0	-1.0	98.4	1778.6	3.36	0.008	0.288

At this point, the Velocity Method Segment Generator window will appear as shown. Note that initially for sub area number one, there are 2 pixels defining the overland flow part of the longest path, 27 pixels defining the swale, and 166 pixels defining the channel. This amounts to 195 individual segments over which incremental travel times are summed to produce the overall estimate of the time of concentration. Each pixel corresponds to a row in the “Segment Attributes” table. The overall tc is 3.18 hours.



We will merge the pixels that make up the longest flow path into a single overland flow segment, a single swale segment, and a single channel segment. This will be done using the Quick Merge tool.

Select each of the check boxes under the “Quick Merge” area. Click the “Recalculate Tc” button. GISHydroNXT will calculate the Tc treating each flow type as a single segment, rather than a series of pixels.



This will cause another window, called “Segment Merge Attributes – Sub-area 1” to appear with the recalculated values. These values are seen below. Note that the database now includes only 3 rows, one for each flow segment (overland, swale, and channel).

For a more detailed description of each of the columns in the table, see the *Technical Reference Manual*.

Segment Merge Attributes - Sub-area 1

FID	UpPixel	SegName	Type	DownPixel	Avg. Area	UpElev	DownElev	Slope	Width	Depth	Xarea	I_Length	Tot_Leng...	Vel.	I_Time	Tot_Time
0	0	M1	overland	2	0.000347...	554.1	549.9	0.021341...	-1.0	-1.0	-1.0	196.8	196.8	0.432798...	0.126309...	0.126309...
1	2	S1	swale	29	0.043616...	549.9	487.4	0.020667...	-1.0	-1.0	-1.0	3024.0	3220.8	2.922456...	0.287429...	0.413739...
2	29	C1	channel	195	2.294579...	487.4	316.8	0.009305...	20.43377...	1.565024...	31.94195...	18333.6	21554.4	3.520946...	1.446391...	1.860130...

The Velocity Method Segment Generator window will now appear with updated values. Notice that now that there is now only one segment for each of the three flow types and that the overall tc has been reduced to about 1.86 hours. This is a large reduction from the 4.75 hours originally calculated for this subwatershed area.

Performing the Quick Merge procedure for each of the 5 subareas in this model result in the tc's shown in the last column in the table below.

Northwest Branch Velocity Method Flow Times [hrs]				
Sub-area	*SCS Lag Tc*	*Hydrology Panel Tc*	*Velocity Method Pre-Merge Tc*	*Velocity Method Post-Merge Tc*
1	6.6	3.2	3.2	1.9
2	7.0	3.3	4.6	2.2
3	6.4	3.6	5.6	2.8
4	6.2	3.3	4.5	1.9
5	1.0	0.7	0.4	0.4

The Segment Merge tool overwrites the dataset with the recalculated values. The last segment merge will be the data that is entered into WinTR-20.

Note that the Quick Merge procedure produces the shortest time of concentration that you can realize for a given subwatershed (see the *Technical Reference Manual* for explanation). The pixel-by-pixel flow times (Pre-Merge) generally produce the longest time of concentration for each subwatershed.

Exercise 2-C: Calculating Routing Reach Cross-Section Parameters

In order to route hydrographs from upstream subareas to points downstream in the WinTR 20 model of the watershed, it is necessary to define a cross-section rating table for each reach element. The cross-section rating table contains the stage/discharge/end-area relationship at a section along the stream reach chosen to be representative of the overall length. To determine the rating table relationship, we need to specify for each routing reach the geometry and roughness for the channel and overbank areas of the cross-section.

Task

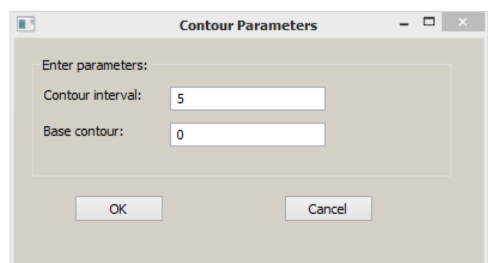
Use the GISHydroNXT program to calculate reach routing tables for the reaches identified in the Northwest Branch watershed schematic. Use the draw transect tool to sample a cross section at a representative location along the routing reach. Use the Cross Section Editor dialog box to adjust the geometry, slope, or roughness characteristics of the sampled cross-sections as needed.

Draw Reach Routing Transects

The procedure for gathering this information using GISHydroNXT is to use the "X" tool to draw perpendicular transects across each of the routing reaches. The transect lines are used to extract the profile of the floodplain at the selected point crossing the stream. At the intersection with the stream, a synthetic channel is incised since the DEM topography is too low resolution to capture the channel geometry. A surveyed cross-section rating table may also be loaded.

Step 1: Add Elevation Contours

Before drawing any cross sections, an optional, but useful, step is to generate contour lines corresponding to the DEM. The contours aid in selecting the correct positioning of the transect line. This is a tool available in ArcGIS, not specific to GISHydroNXT.



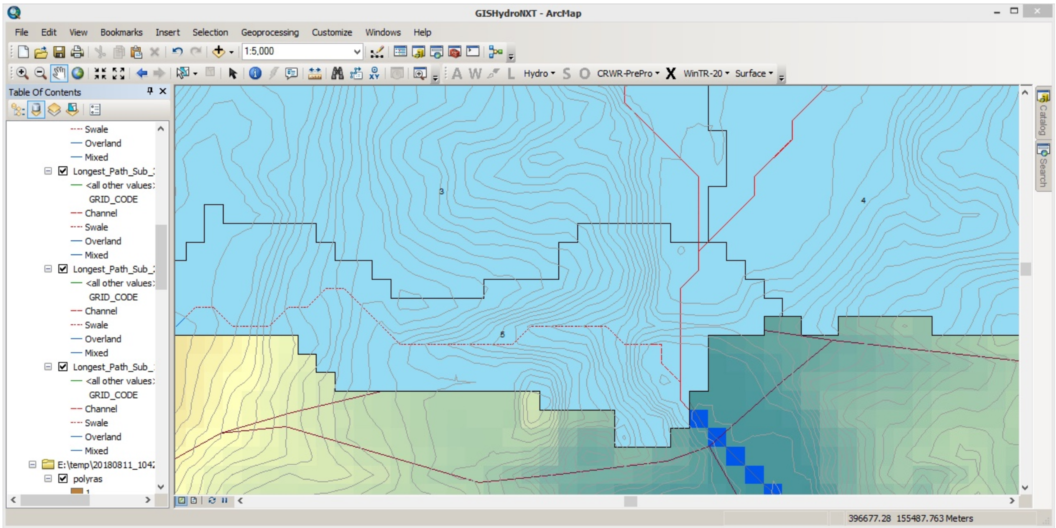
In the GISHydroNXT toolbar select "Create Contours" from the "Surface" drop down list. This will allow the user to create contours with a defined interval and base level. For this exercise, set "Contour Interval" to 5 and leave "Base Contour" at its default value, 0.

Step 2: Draw Transect Line

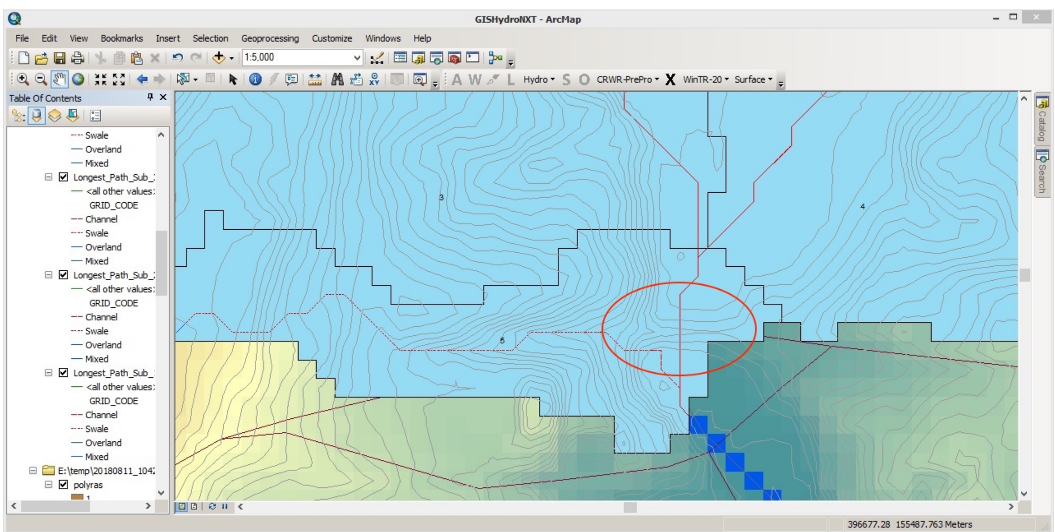
There are two things to strive for when drawing the transect line:

1. The transect line should be at a representative location for that stream reach. "Representative" as used here suggests a cross-section location that represents some average of what is seen over the entire stream reach. The transect chosen should be neither the narrowest nor widest section along the reach, but somewhere in-between.
2. The transect line should be drawn perpendicular to the stream and the contour lines.

Select the Add Transects tool, "X" from the GISHydroNXT toolbar. To facilitate the transect digitizing, we first zoom in to subwatershed #5.



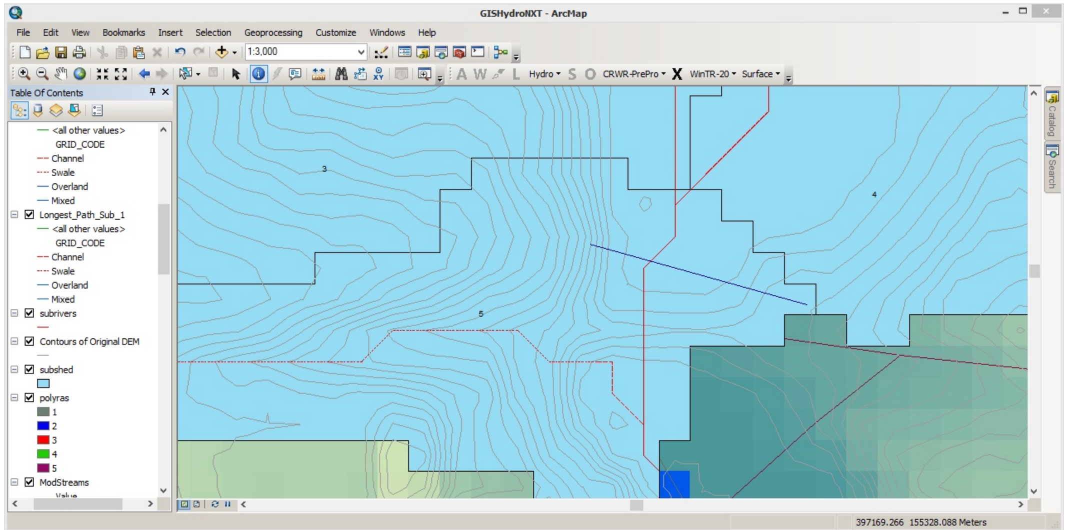
In this example, we observe a surprising result: the model flow line crosses the contour lines at right angles. Turning on an image basemap reveals an embankment where Randolph Road crosses the Northwest Branch stream valley. The contour lines are created from the Digital Elevation data, in which the embankment is represented. The stream locations were created from the NHD streamline data, which were "burned" into the digital elevation in order to infer flow direction and flow accumulation consistent with the actual locations of streams. The intermediate digital elevation generated by that process does not provide a realistic representation of the terrain.



The transect needs to be drawn such that:

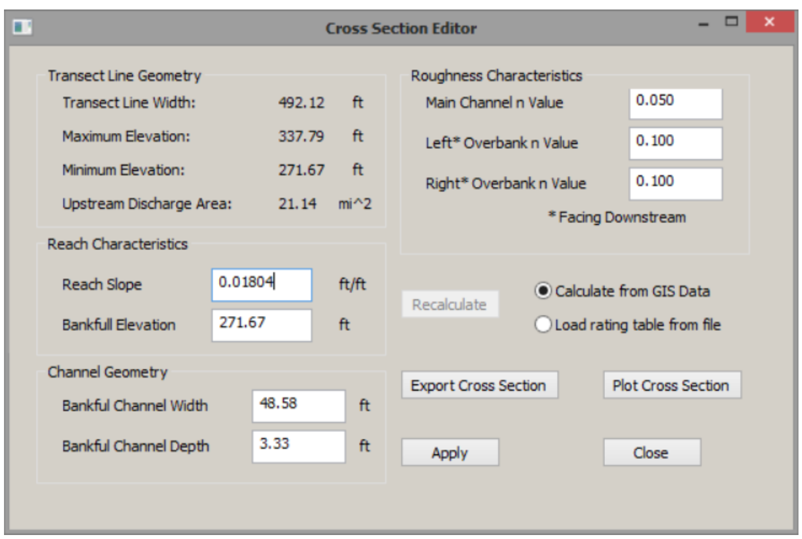
- It reflects the geometry of the stream valley, not the embankment.
- It is completey contained within the surrounding subarea (i.e., do not extend the transect past the subarea divide, which shows as a thin black line in your view and in the screen capture).

Click to begin the line, then drag the cursor across the routing reach. On the far end of the drawn transect, double-click to close the line.

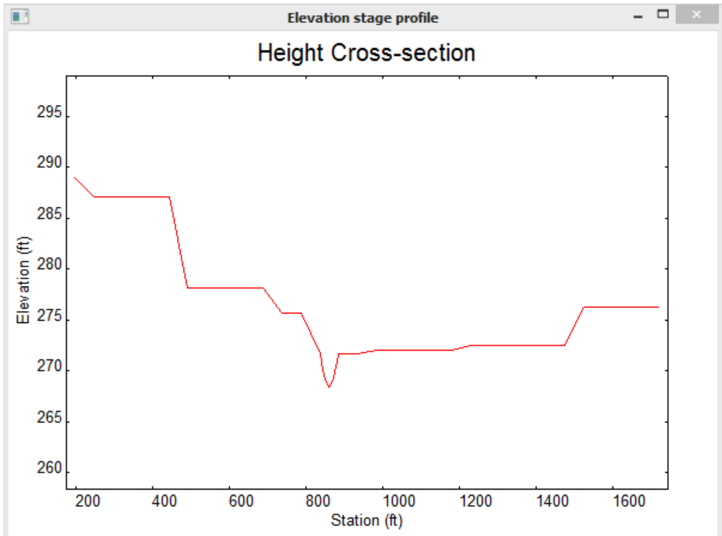


Step 3: The Cross Section Editor Dialog Box

After Step 2 is completed, a dialog box (see below), called "Cross Section Editor" will appear. The illustrated dialog box corresponds to the transect line shown in the screen-capture above. This dialog allows the sample cross-section data to be edited (in English units), the rating table to be recalculated based on those edits, and a 2-D plot of the sampled cross section to be displayed.

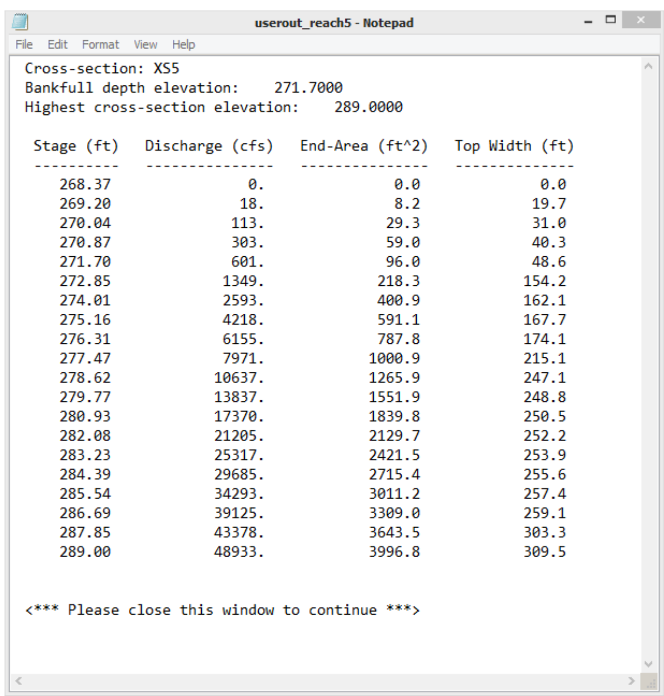


To view a 2-D graph of the cross-section, click "Plot Cross Section." The plotted cross section will look like the image below.



The cross section station and elevation data may be exported to a text file using the "Export Cross Section" button.

GISHydroNXT calculates the rating table for the reach using Manning's equation and the parameters provided in the "Cross Section Editor" dialog box. The rating table for the reach will be output to a text file and presented in a notepad window as shown below.



userout_reach5 - Notepad

File Edit Format View Help

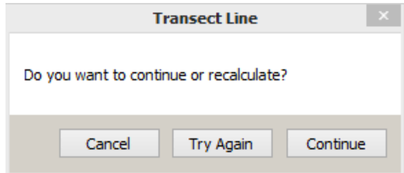
Cross-section: XS5
Bankfull depth elevation: 271.7000
Highest cross-section elevation: 289.0000

Stage (ft)	Discharge (cfs)	End-Area (ft^2)	Top Width (ft)
268.37	0.	0.0	0.0
269.20	18.	8.2	19.7
270.04	113.	29.3	31.0
270.87	303.	59.0	40.3
271.70	601.	96.0	48.6
272.85	1349.	218.3	154.2
274.01	2593.	400.9	162.1
275.16	4218.	591.1	167.7
276.31	6155.	787.8	174.1
277.47	7971.	1000.9	215.1
278.62	10637.	1265.9	247.1
279.77	13837.	1551.9	248.8
280.93	17370.	1839.8	250.5
282.08	21205.	2129.7	252.2
283.23	25317.	2421.5	253.9
284.39	29685.	2715.4	255.6
285.54	34293.	3011.2	257.4
286.69	39125.	3309.0	259.1
287.85	43378.	3643.5	303.3
289.00	48933.	3996.8	309.5

<*** Please close this window to continue ***>

Check that the range of discharge accounted for in the rating table is consistent with peak flows expected in the model.

When you close the window, a small box will appear:



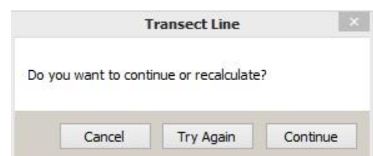
If you are satisfied with the cross section and rating table, click "Continue." If not satisfied, click "Try Again," redraw the transect line, and repeat the steps.

These data will ultimately be written to the WinTR-20 input file being created by this series of exercises. Compare the maximum discharge in this text file to the range of discharges expected for the watershed (frdischarges.txt). If the maximum is too low, errors will be encountered when running WinTR-20, because the model may generate flows beyond the range of the rating table. If the maximum is orders of magnitude greater than expected discharges, then your cross section is too wide, and potentially inaccurate for the range of flows expected in the model.

Close the plotted cross section window and click Apply.

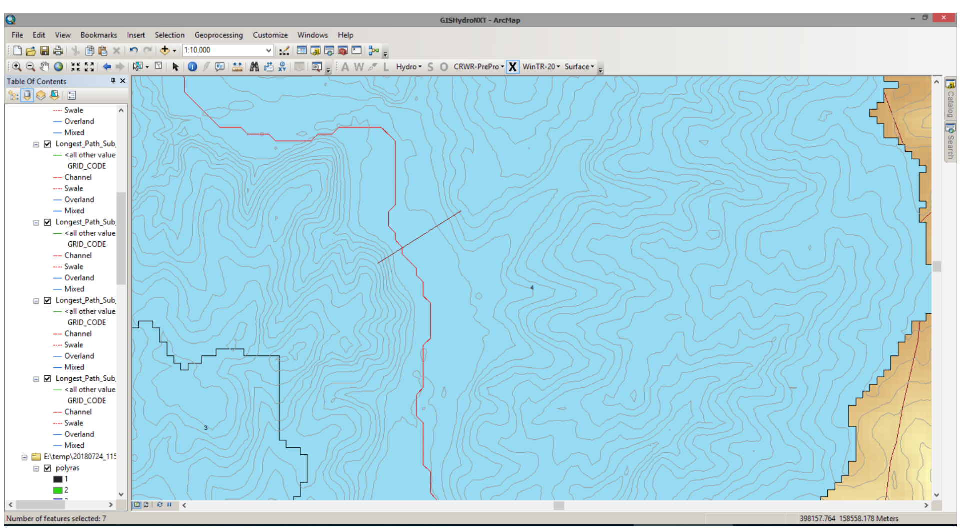
This short routing reach between the confluence of the two main stream segments and the downstream gage will likely have little effect on the simulated runoff created by WinTR-20. Nonetheless, a rating curve is required for this reach.

After the text file with the transect data is created close the Notepad. You will be prompted to continue, try again or cancel. If you are satisfied with the results, click on Continue. If not, click "Try Again". Your transect will be removed from the map and you will be able to draw a new one.



Step 4. Create Cross-Section for Second Routing Reach

Repeat Steps 2 and 3 for subwatershed #4 (north of the overall watershed outlet).



After the transect line for subwatershed #4 is created and the text file closed, the transect line tool will be disabled (greyed out) because no further routing reaches are required in the WinTR-20 model.

Exercise 2-D: Creation and Execution of WinTR-20 Model

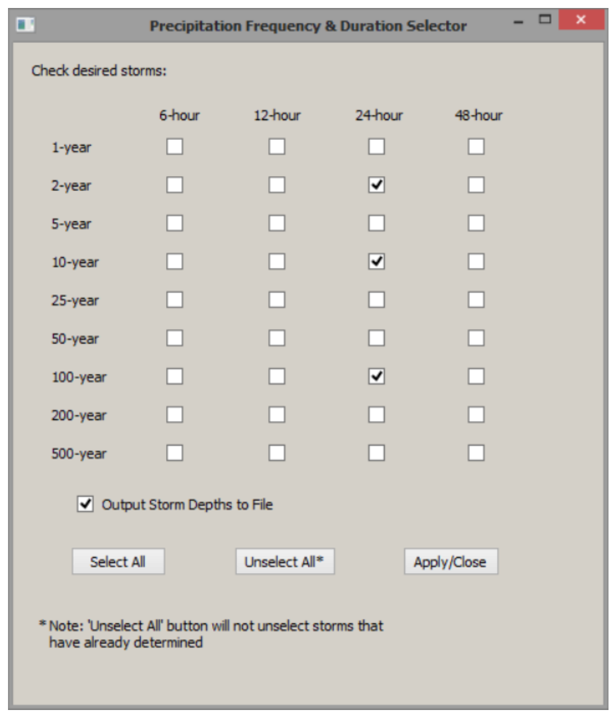
GISHydroNXT uses the divided sub-watersheds, reach rating tables, and calculated attributes to assemble the input for the WinTR-20 model. In this exercise, you will specify input and output files for WinTR-20, specify output options, and assign a rainfall distribution for rainfall/runoff calculations for the Northwest Branch watershed. You will then execute the WinTR-20 model and examine the output.

Tasks

1. Use GISHydroNXT to determine design storm rainfall depths for the 2-, 10-, and 100-year, 24-hour storms for the footprint of the Northwest Branch watershed.
2. Using WinTR-20, estimate the 2-, 10-, and 100-year return period discharges for the Northwest Branch watershed. Use the 24-hr. duration storm. Compile the WinTR-20 input file, execute the program, and examine the output.

Step 1: Precipitation Depth Selection

The engineer needs to indicate to GISHydroNXT all storm frequency/durations that are to be simulated.



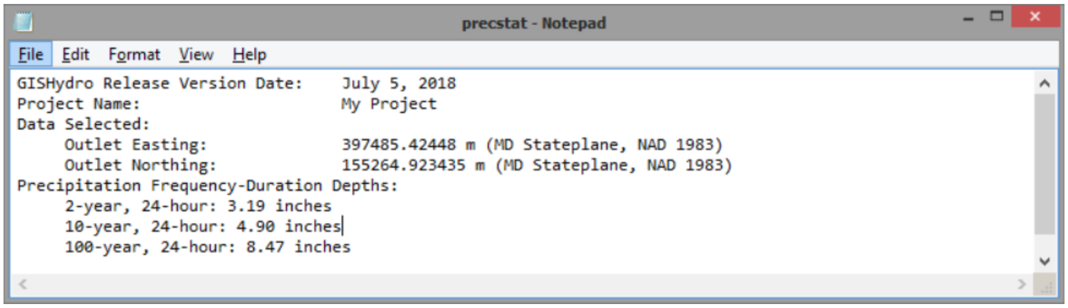
In the GISHydroNXT toolbar, pull down the “WinTR-20” menu and select “Precipitation Depths”. The dialog box shown will appear.

Click check boxes for the 2-, 10-, and 100-year, 24-hour storms to determine these storm depths.

Click the “Apply/Close” button to initiate computations.

Note: only those storms selected here will be available later for inclusion in a WinTR-20 input file.

GISHydroNXT determines precipitation depth based on spatially distributed precipitation from NOAA Atlas 14 precipitation data. The areal average storm depth over the domain of the watershed is calculated directly. This is effectively a watershed-specific design storm with the storm distributions. After computing is complete, a dialog box will report the selected storm depth(s) with the distribution stored for subsequent analysis (as seen below).



These depths and storm distributions will be available for automatic inclusion into the WinTR-20 input file when selected by the user from the WinTR-20 control panel at a later step (below).

More information about the precipitation data is available from the US NOAA Atlas 14 web page at http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_data.html.

Step 2: Use TR-20 Control Panel:

The following items must be complete before this step can be undertaken:

1. Watershed attributes must be computed (See Exercise 2-B, Step 2).
2. Transects for all routing reaches must specified and their reach routing tables determined (See Exercise 2-C, Steps 2 and 3).
3. At least one storm must be selected (See Exercise 2-D, Step 1)

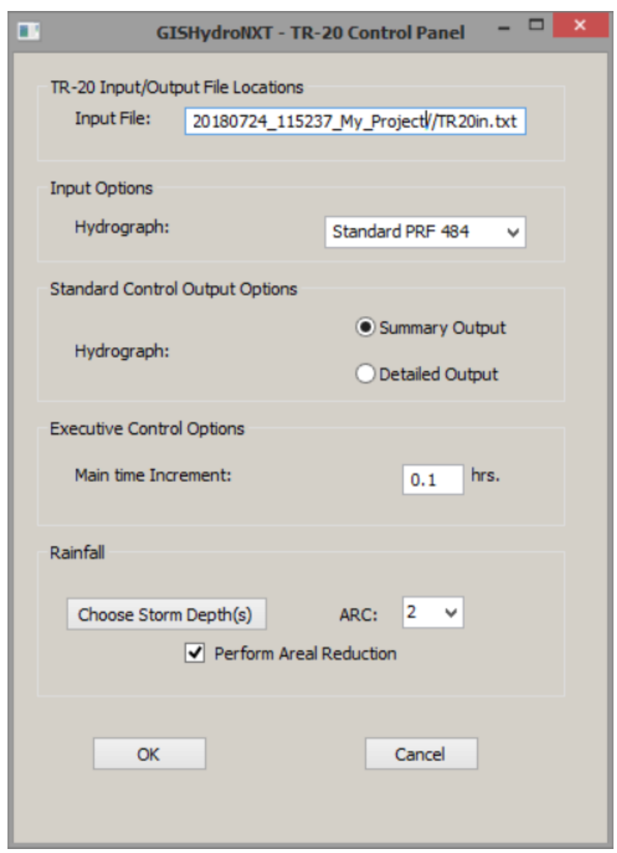
The tool will be unavailable (grayed out) if these steps have not been completed.

Note: If you have been following these exercises in sequence, each of these items has been completed at this point.

From the GISHydroNXT toolbar, choose "TR-20 Interface: Control Panel". The dialog box shown at right will appear. The following items must be specified.

- Input File name: By default, GISHydroNXT will produce a WinTR-20 input file in the same directory where all other files associated with this analysis have been stored. The file will have the name: "TR20in.txt". There is nothing that needs to be changed or specified.

- Choose the "Detailed Output" button (as shown) to get output hydrographs, rather than just peaks. By default, Standard Control Output: the "Summary Output Only" radio button is set, which only provide the peak flows.

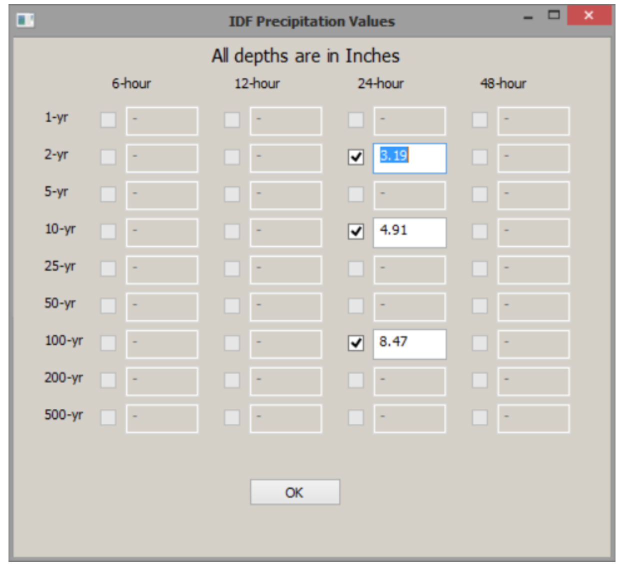


- Main time Increment: This is set by default to 0.1 hours. There is generally no need to change it.

- Rainfall: IMPORTANT: Click the “Choose Storm Depth(s)” button.

The dialog shown (IDF Precipitation Values) will appear. Notice that the table is populated mostly with “-999” values indicating that those storm depths were not determined in Step 1 of this exercise.

For this exercise, click in the check boxes next to the 2-, 10-, and 100-year, 24-hour storms to select each of these as seen in the image. Only storms that are checked will be written to the WinTR-20 input file, even if the total storm depths were calculated in Step 1. Click the “OK button when all desired total storm depths have been selected.



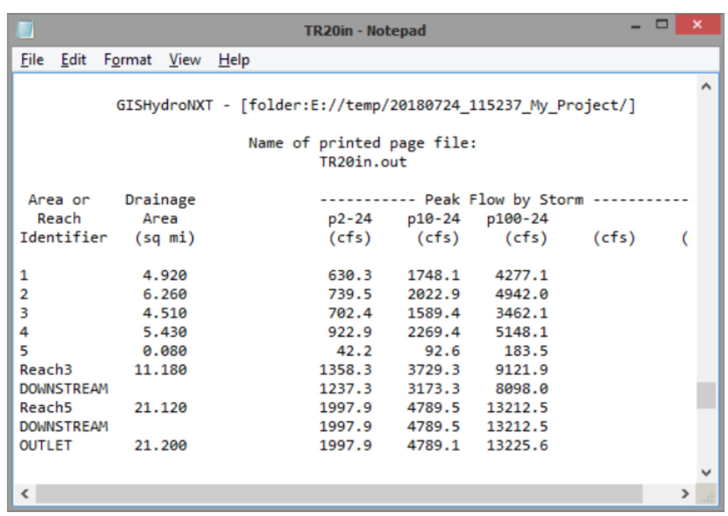
Your view will return to the TR-20 Control Panel window.

- Antecedent Rainfall Condition (ARC): The ARC is set to 2 by default. Conditions 1 or 3 can also be chosen to select unusually dry or wet conditions, respectively.

- Areal Reduction: GISHydroNXT reduces the rainfall depths calculated in Step 1 of this exercise and seen again in the “IDF Precipitation Values” table above. Reduction is done using the TP-40 areal reduction curves presented in the Maryland Hydrology Panel report.

Click the “OK” button to close the “TR-20 Control Panel” dialog box. When the dialog box is closed, GISHydroNXT will perform a few computations and a Notepad window will appear showing the WinTR-20 input file.

Step 3: Execute the WinTR-20 Model:
Select: “TR-20 Interface: Execute TR-20” from the GISHydroNXT toolbar to execute the WinTR-20 model for the input file generated in the previous step. WinTR-20 will execute automatically and return the generated output file in a Notepad window for review. The output file shown reports that the peak discharges for the 2-,10-, and 100-year storms are approximately 1,567 ft^3/s, 3,852 ft^3/s, and 9,124 ft^3/s. Your results may vary slightly due to individual differences in placing the cross-section


TR20in - Notepad

File Edit Format View Help

GISHydroNXT - [folder:E://temp/20180724_115237_My_Project/]

Name of printed page file: TR20in.out

Area or Reach Identifier	Drainage Area (sq mi)	Peak Flow by Storm p2-24 (cfs)	p10-24 (cfs)	p100-24 (cfs)	(cfs)
1	4.920	630.3	1748.1	4277.1	
2	6.260	739.5	2022.9	4942.0	
3	4.510	702.4	1589.4	3462.1	
4	5.430	922.9	2269.4	5148.1	
5	0.080	42.2	92.6	183.5	
Reach3	11.180	1358.3	3729.3	9121.9	
DOWNSTREAM		1237.3	3173.3	8098.0	
Reach5	21.120	1997.9	4789.5	13212.5	
DOWNSTREAM		1997.9	4789.5	13212.5	
OUTLET	21.200	1997.9	4789.1	13225.6	

transects.

For purposes of quick comparison, we can create a table. The regression estimates were calculated in Exercise 1-C, and stored in the file frdischarge.txt.

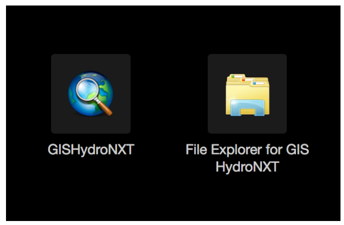
Return Period	Regression Estimate (ft^3/s)	Regression Estimate + 1SE (ft^3/s)	WinTR-20 Estimate (ft^3/s)
2 years	1,700.7	2,297.6	1,997.9
10 years	4,571.6	5,769.4	4,789.1
100 years	12,135.1	15,860.6	13,225.6

In all cases, the predicted peak discharge from WinTR-20 is greater than those from the regression equations, but less than the Regression Estimate + one standard error. Therefore, these WinTR-20 results lie within the calibration envelope suggested by the Hydrology Panel.

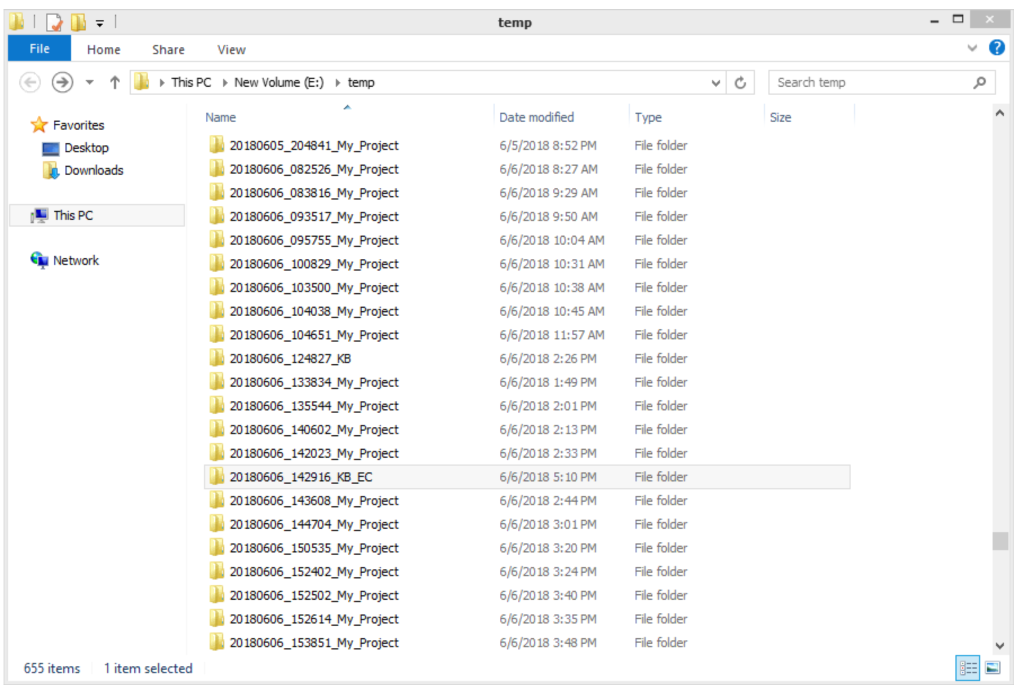
Appendix A: File Upload/Download within the GISHydro Private Virtual Computer Lab

Files created in the course of running a GISHydroNXT analysis on the Private Virtual Computer Lab may be saved to the user's local computer by following these steps.

On the PVCL main page, launch the "File Explorer for GIS HydroNXT" application by clicking on its icon.



The File Explorer window opens to the folder in which GISHydroNXT output is stored (E:) on the Virtual Machine.



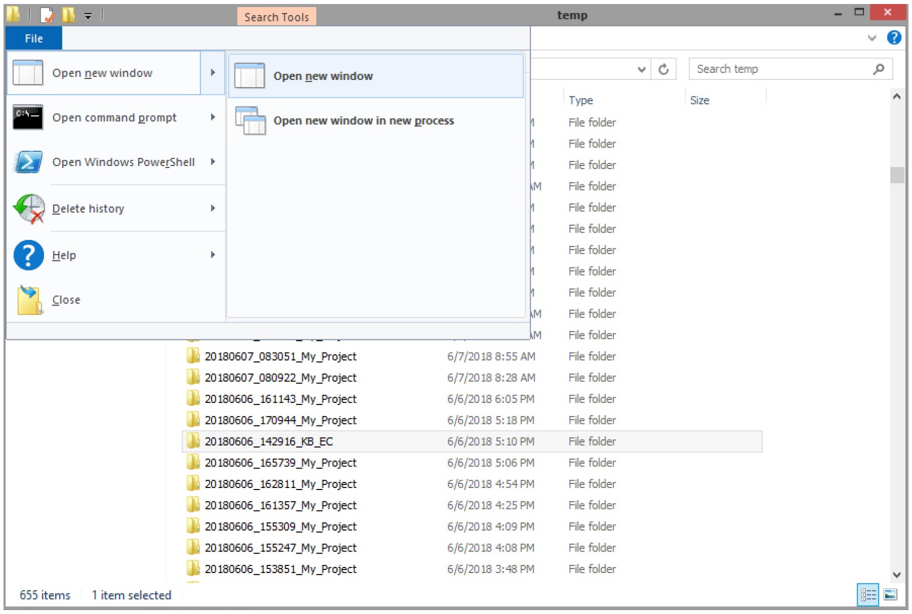
Navigate to the folder corresponding to your analysis. The naming convention is:

YYYYMMDD_HHMMSS_ProjectName

Where YYYY is year, MM is month, DD, is day, HH is hour, MM is minute, SS is second, and ProjectName is the name entered in the Area of Interest "Input Data Selection" dialog (Exercise 1A, Step 4).

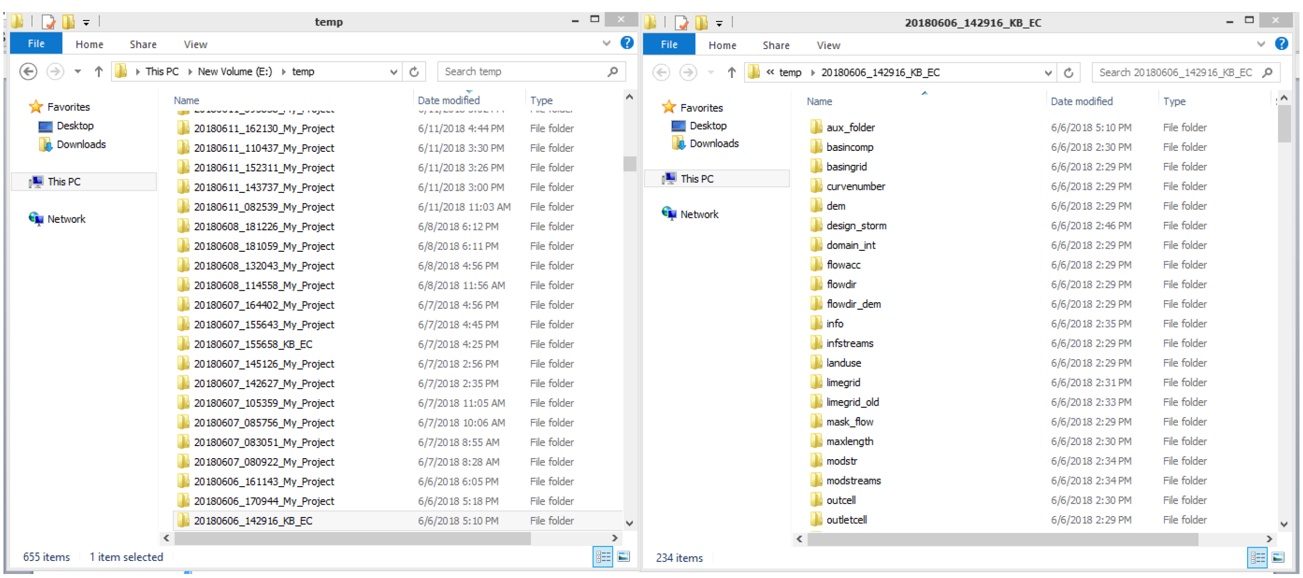
This is a Windows File Explorer; you can navigate the folders just as you would in any Windows operating system.

To copy files to your local computer, the easiest approach is to open a second File Explorer Window. Pull down the “File” menu to “Open new window”. Select “Open new window”.

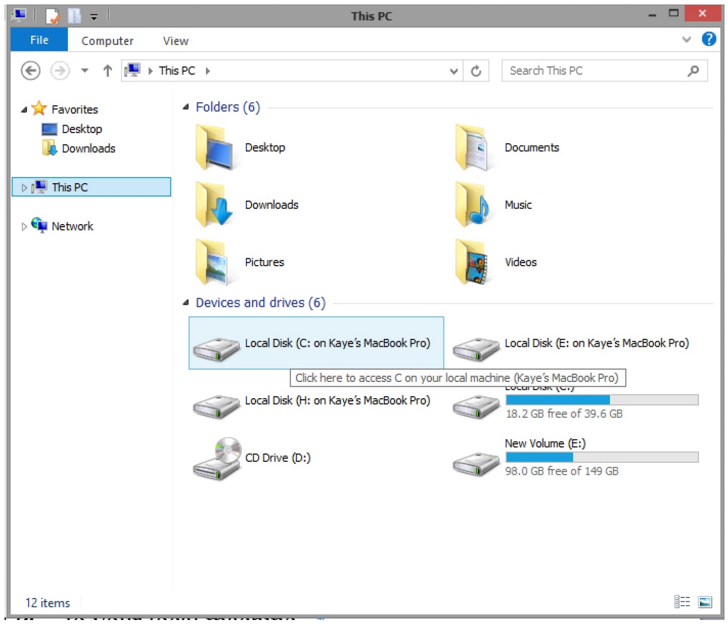


A new window will be launched, opened to the folder that you selected in the first window – it does not matter where it opens, as we will soon change to a folder on the local computer.

Place the two windows side by side.



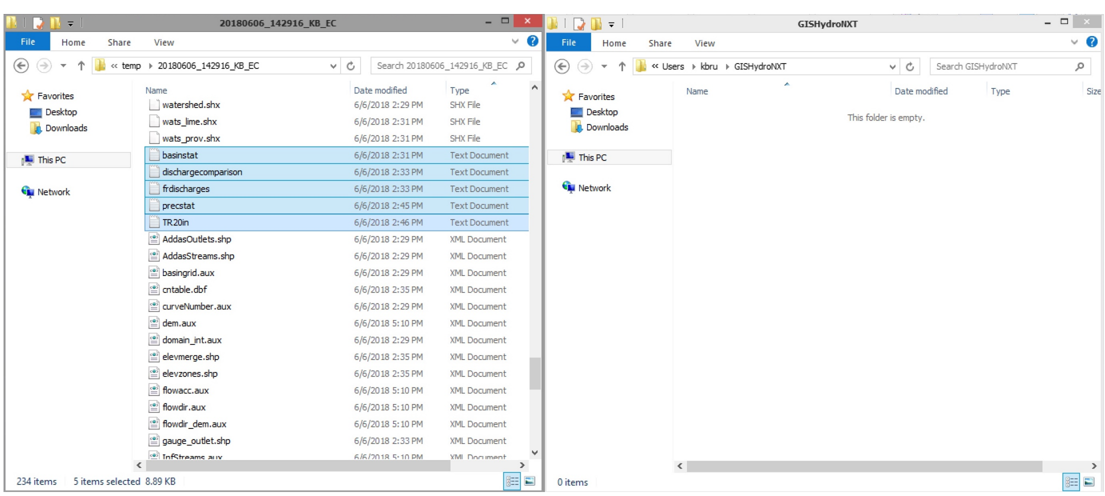
In the right-hand window, navigate using “This PC” to your local machine. This example was done on a MacBook Pro, but the target local machine can be any type of computer. Double-click to move to the desired disk.

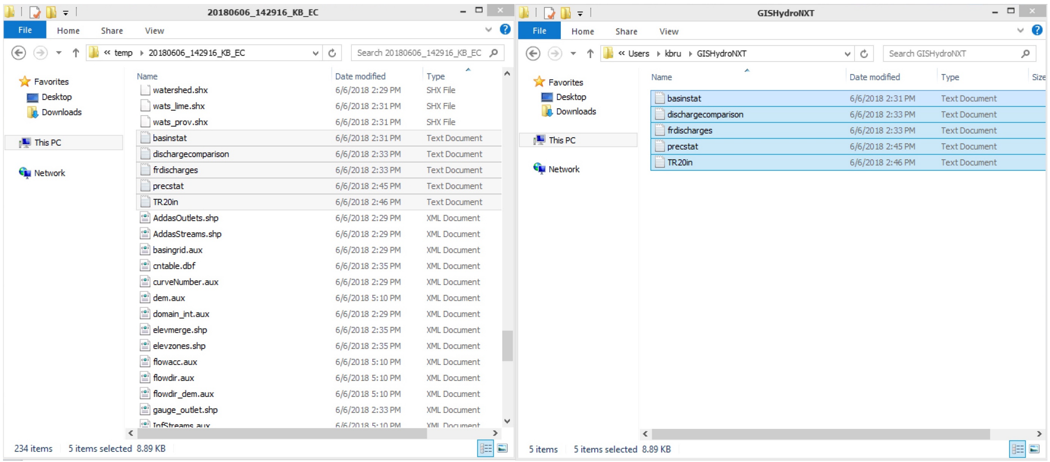


Navigate to the desired folder as you would normally in Windows File Explorer. You can use the menu tools to add a new folder, if you wish.

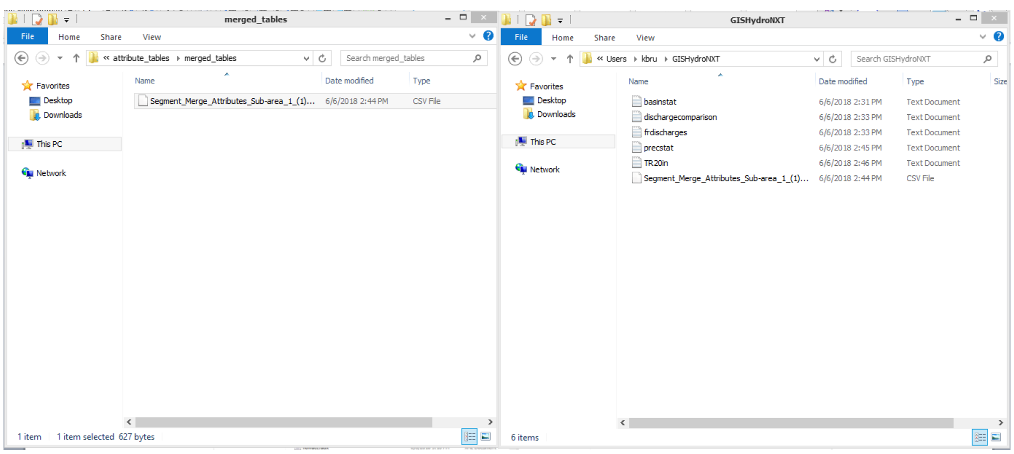
In the left-hand window, navigate to the working folder on the PVCL (Virtual Machine) (remote machine).

In this example, the files in the working folder on the Virtual Machine were sorted by “Type,” then all the text files (*.txt) were copied and pasted to the local folder using standard Windows file copy-paste methods.

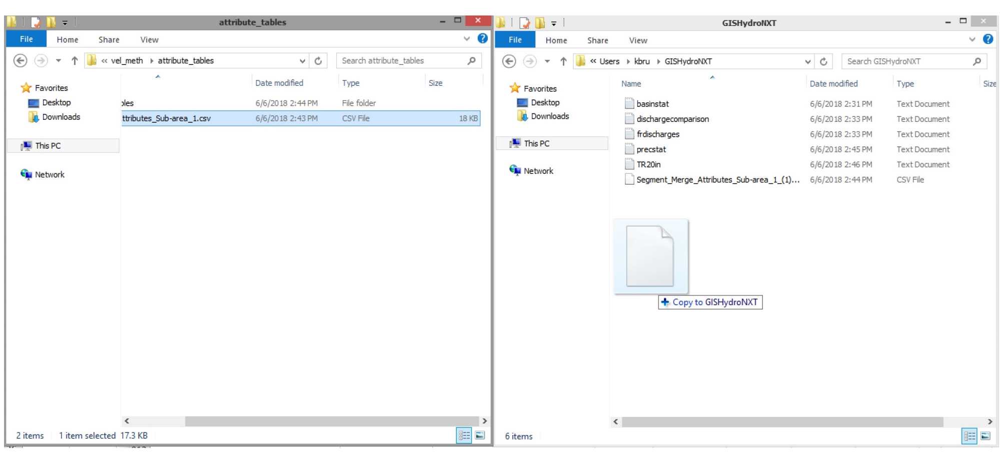




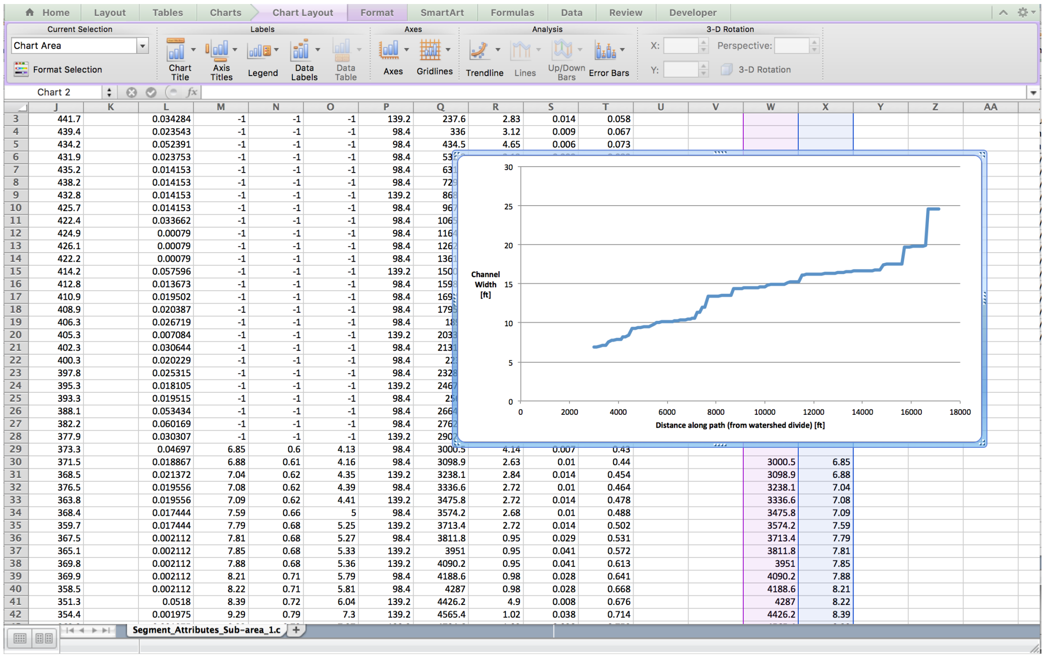
From the path “E:\temp\20180606_142916_KB_EC\vel_meth\attribute_tables\merged_tables,” a CSV file was copy-pasted.



You can also click and drag items from one window to the other. Here, for example, the CSV file containing the pixel-by-pixel segment information for the Velocity Method Tc longest path, before any merging, has been dragged to the local folder.

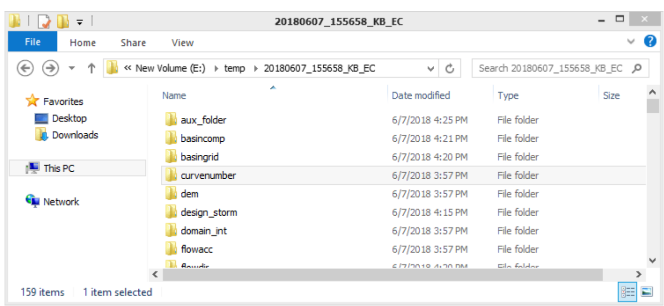


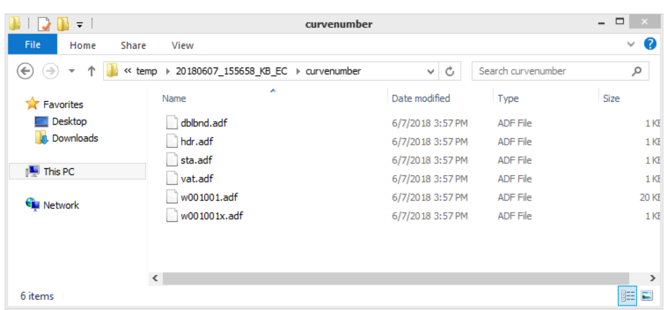
On the local computer, the CSV file is now available for analysis and plotting, for example, this longitudinal graph of channel width.



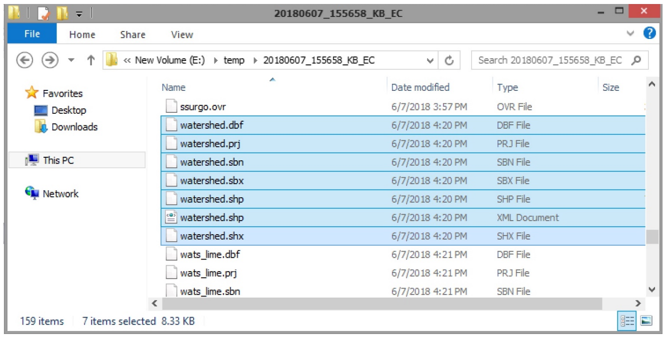
If you choose to copy and paste GIS items (raster/grid data or vector/shapefile data), be sure you know what you are doing.

Each raster data set consists of its own folder, for example, the "curvenumber" folder is a raster data set giving the curve number for every 30×30 m pixel in the watershed. If you wish to save this raster data set to your local machine, you must copy the entire folder.





Each vector data set (shapefile) consists of 7 items. For example, if you wish to save the “watershed” shapefile, you must copy all 7 of the “watershed.xxx” items listed:



The File Explorer windows can be closed by clicking on the red X button in the upper right corner.

Appendix B: Links to Useful and Relevant Documents for GISHydroNXT

(last revised: August 2018)

GISHydro Web Page: http://gishydro.eng.umd.edu

GISHydro Documentation: http://gishydro.eng.umd.edu/document.htm

Application of Hydrologic Methods in Maryland – Maryland Hydrology Panel, 4th Edition
http://gishydro.eng.umd.edu/HydroPanel/July 2016 Hydrology Panel Report.pdf

Bankfull Discharge and Channel Characteristics of Streams in the:
Piedmont: https://www.fws.gov/chesapeakebay/pdf/piedmont.pdf
Allegheny Plateau and Valley and Ridge: https://www.fws.gov/chesapeakebay/pdf/plateau.pdf
Coastal Plain: https://www.fws.gov/chesapeakebay/pdf/plain.pdf

Evaluation of Alternative Statistical Methods for Estimating Frequency of Peak Flows in Maryland
http://gishydro.eng.umd.edu/documents/mdsha_reports/peakflowsfinalreport.pdf

Technique for Estimating Magnitude and Frequency of Peak Flows in Maryland
http://md.water.usgs.gov/publications/wrir-95-4154/

NOAA Atlas 14 Precipitation Data
http://hdsc.nws.noaa.gov/hdsc/pfds/index.html

NRCS WinTR-20
https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/hydrology/?cid=stelprdb1042793
or (short URL) http://go.usa.gov/cZeg9