

## Watershed Analysis Lab – Heterogeneous, Gaged Watershed I (Northwest Branch)

The previous lab demonstrated the process of selecting quadrangles, specifying data types, delineating a watershed, and using the USGS regression equations and TR-20 to predict the peak discharge. The peak discharge for the 5-yr storm as predicted by TR-20 was significantly smaller than that of the USGS regression equations (was it?). This suggests that treating the Northwest Branch as a homogenous watershed is probably a poor assumption.

In this lab, we will explore the steps involved in using GISHydro2000 to set up a heterogeneous model for the Northwest Branch Watershed. Students will subdivide the watershed based on their own criteria and compare their results.

### **Task**

Calculate the peak discharge resulting from the 5- and 100-yr storm for the Northwest Branch Watershed under 1997 conditions using the USGS regression equations and TR-20. For the TR-20 model, subdivide the watershed into an *appropriate* number of subareas. Compare the peak discharges for the USGS estimates, the homogeneous model, and the predicted TR-20 values for the heterogeneous model. Discuss.

### **Step One –Assemble and Process Data**

This laboratory will use the same watershed outlet and therefore the same GIS data. If you haven't already done so after completing the previous lab, exit out of ArcView. Open the "gishydro.apr" file and use the "Q" button to select the Kennsington, Beltsville, Clarksville, and Sandy\_Spring quads. We will use the same watershed outlet, the Northwest Branch flowing under Randolph Road in Montgomery County, Maryland.

### ***Select Data Types and Processing Options***

So that our results will be directly comparable with that of the previous lab, we will select the same data types and processing options. From the "Select DEM Data" pull-down menu on the select quads dialog box, select 30m DEMs. Next, choose "1997 MOP Landuse" from the "Select Landuse Data" pull-down menu. Finally, Select "Ragan Soils" from the "Select Soils data" pull-down menu.

Make sure the "Perform DEM processing" option is checked and keep the default threshold drainage area of 250 pixels. After selecting the four quads press "Apply" to begin the data extraction/processing sequence.

### **Question: Why do I have to re-process the data to perform another analysis?**

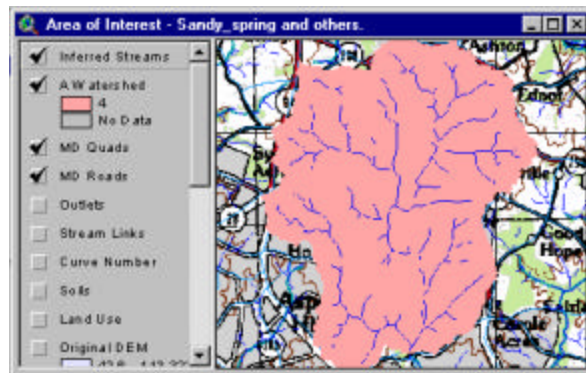
Strictly speaking, you don't have to. While in the "Area of Interest" view for the homogeneous model of the Northwest Branch, it is possible to simply delete selected themes and begin a new analysis without re-processing the data. To do this, delete *only* the following themes:

- Symp#.shp and Smp1#.shp (where # is a sequential number)
- Hydrom#.shp and Hydrol#.shp (if present)
- Longest Flow Path
- Subrivs.shp and Subsheds.shp
- Subwatersheds
- AddasStreams.shp
- A Watershed (only if you want to examine another watershed within the extent of the data)

**Tip:** To delete multiple themes, hold down the SHIFT key and click on the themes described above. From the Edit menu, select “Delete Themes” and then say “Yes to All”. A new analysis can begin by using the “W” tool to select the new watershed outlet.

### **Step Two – Delineate the Watershed**

As in the previous lab, delineate the watershed draining to USGS Gage No.: 01650500. Remember that it is necessary to zoom into the pixel representing the watershed outlet before clicking on it. Doing this insures that the watershed will be delineated to the stream and not to a pixel adjacent to the stream. The delineated watershed should look like the figure below:




**Tip:** To view the raster streams on top of the watershed, drag-and-drop the “Inferred Streams” theme from its location on the view legend to the top of the list.

### **Step Three – Define Main Channel Streams and Add Outlet Points**

In the previous lab, only the main channel of the watershed was defined. In order to subdivide the watershed into multiple subareas, it is necessary to define the main branches of the stream network in addition to points lying in-line with the streams.

#### ***Delineate Stream Segments***


As was done in the homogeneous watershed lab, select the  tool from the tool bar. Using the mouse, click on the stream tips of the channel network representing the major flow segments. This is very subjective. Note that for each stream added, the path from that location to the watershed outlet is delineated.

If at any point you add a stream that you do not wish to include in the watershed model, make the “AddAsStreams.shp” theme active and select the Delete Theme item from the Edit menu. The procedure can then be repeated. (As streams are added with the Add Streams Tool, the changes are stored in the AddAsStreams.shp theme).


How many flow segments should be included? This is a question that the modeler has to answer. The direct result of the number of flow segments to include will determine the number of subwatersheds delineated. When you are satisfied with the extent of the stream network, select the Add Streams item from the CRWR-PrePro menu. As in the previous lab, a dialog box will ask you if you wish to include both the new streams and the Inferred Streams, or just the new streams. Select “No” to use only the new streams. You will see the raster channel network be updated to reflect only the new channel network.

### *Delineate Outlet Points*

In the homogenous watershed lab, no subdivision was used so no subdivision points were necessary. For this lab we need to define where the watershed will be subdivided. Recall that GISHydro2000 places a subdivision point at the confluence of all streams. The number of subwatersheds depends in part on the number of streams added with the AddStreamsTool.

It is often desired to place subdivision points in-line with the stream network. This results in series sub-division such that the hydrograph from an upstream subwatershed will be routed through a lower subwatershed and combined at the lower subwatershed’s outlet with that hydrograph. GISHydro2000 allows for the placement of in-line subdivision points using the  tool or (Add Outlets tool). Select a location along the stream network on any segment of the channel network. From the toolbar, use the Add Outlets tool to mark that location in the display window. You will see a point added to the View and a new theme called “AddAsOutlets.shp” is created. As with the “AddAsStreams.shp” theme, you can add multiple outlet points and delete the theme if you wish to start over. When you have selected an outlet point (**Important: Make sure the point you selected lies in the center of a pixel on the rasterized channel network.** Zoom-in if necessary.) To incorporate the outlet point, select the Add Outlets item from the CRWR-PrePro menu. The following dialog will appear:

**Add new outlets to stream network**

 Yes: Use selected outlets and outlets from links.  
No: Use only selected outlets.

To add the outlet point you selected to the other outlet points (the confluence points from the modified stream network) select YES. (If you chose No, *only* the point you selected would be used as a subdivision point). The Outlets theme will then be updated to reflect the new outlet location.

#### **Step Four – Delineate Subwatersheds**

In the previous step we defined our stream network to be modeled and the number and location of in-line outlet points. This information is now used to determine the arrangement of subwatersheds. From the CRWR-PrePro menu, select the “Delineate Subwatersheds” option. Two new themes will be added to the Area of Interest View: subsheds.shp and subrivs.shp. These are the vector subwatershed and stream network themes, respectively.

**Tip:** If you are not satisfied with the number or arrangement of subwatersheds, there are procedures for altering the related themes. In the next lab, instructions for merging subwatersheds are given. This allows smaller subwatersheds to be dissolved into larger ones. If it is necessary to add more subwatersheds, simply delete the subsheds.shp and subrivs.shp themes and use the AddStreamsTool and AddOutletsTool to further divide the watershed. Then, you may Delineate Subwatersheds again to include more subareas.

#### **Step Five – Calculate Attributes and Generate Schematic**

Having delineated the desired number and arrangement of subwatersheds, the next step is to calculate the necessary attributes for each subwatershed. These attributes include drainage area, curve number, length of the longest flow path, and the time of concentration.

Select the “Calculate Attributes” option from the CRWR-PrePro menu. A message box appears notifying the user when attribute processing is complete.

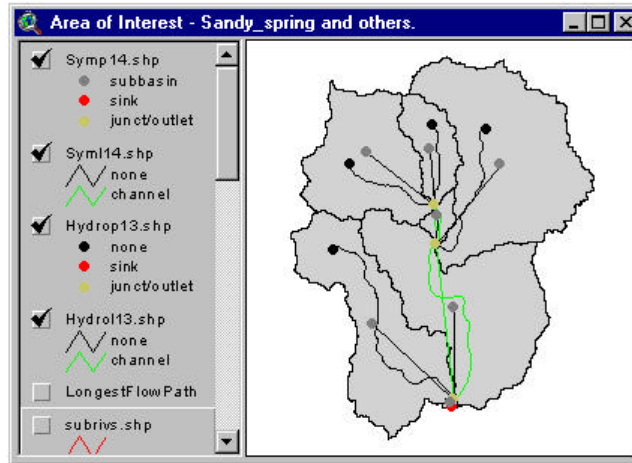
**Note:** At this time, the time of concentration is calculated using only the SCS lag formula. Although this method is suitable for homogenous areas less than 5 square miles, it may be necessary to determine  $t_c$ 's using the flow segment method. Future versions of GISHydro will feature this capability.

#### ***Generate the Model Schematic***

After attribute calculation is complete, the next step is to generate the schematic diagram representing the sequence of hydrologic features. The diagram is used to assemble and format input for the TR-20 model. Select the “Generate Schematic” option from the CRWR-PrePro menu. All themes except for subsheds.shp and subrivs.shp will be turned off. The screen will flicker several times before a message box appears indicating that the processing is complete.

**Shortcut:** Press CNTRL+G on the keyboard as a shortcut to generating the schematic.

An example of a watershed schematic for the Northwest Branch is shown below:




### **Step Seven – Draw Cross Section Transects**

In order to perform the desired reach routings for the model schematic shown, it will be necessary for us to define a cross section rating table for each. Recall that 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 cross section, the geometry and roughness for both the main channel and the cross section.

Typically this information is obtained by field survey. In the absence of this information however, flood plain geometry is used with synthetic channel geometry and default values of roughness. A cross section editor allows the user to edit this information. The cross section editor is used to enter new transect data or to edit the data for transects already drawn.

#### ***Add transects***

From the toolbar, select the  tool. In the display window, identify those channel reaches colored green. These channels have been identified as routing reaches and require cross section rating table information. For each routing reach, use the AddCrossSectionTool to draw a perpendicular line across the stream channel. After letting go of the second point, the cross section editor dialog box appears:

**Cross Section Editor - Reach No. 5**

**Transect Line Geometry**  
 Transect Line Width: 1691.73 ft  
 Maximum Elevation: 362.00 ft  
 Minimum Elevation: 327.00 ft  
 Upstream Drainage Area: 4.80 mi<sup>2</sup>

**Channel Geometry**  
 Bankfull Channel Width: 24.73 ft  
 Bankfull Channel Depth: 2.13 ft

**Reach Characteristics**  
 Reach Slope: 0.0052 ft/ft  
 Bankfull Elevation: 327.00 ft

**Roughness Characteristics**  
 Main Channel n Value: 0.050  
 Left\* Overbank n Value: 0.100  
 Right\* Overbank n Value: 0.100  
 \* Facing Downstream

**Cross Section Rating Table**

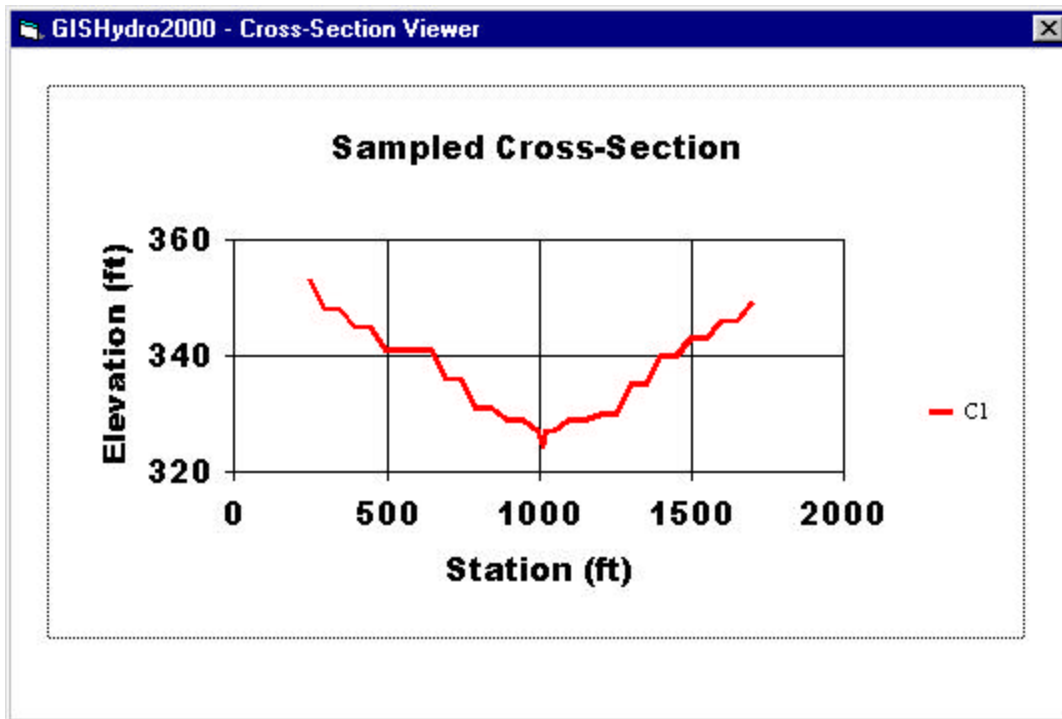
| Stage [ft] | Discharge [cfs] | End Area [ft <sup>2</sup> ] |
|------------|-----------------|-----------------------------|
| 324.87     | 0.00            | 0.00                        |
| 325.40     | 2.37            | 2.67                        |
| 325.94     | 14.59           | 9.55                        |
| 326.47     | 39.15           | 19.20                       |
| 327.00     | 77.65           | 31.25                       |

Calculate from GIS data  
 Load rating table from file

A rating table is calculated automatically from default values of channel and overbank roughness, slope detected from the DEM data, and synthetic channel geometry. Any of these values can be edited with the exception of the bankfull elevation. Use the “Recalculate” button to update the rating table based on changed values.

### ***Plot Cross Section Profiles***

To display a section profile of the transect line drawn, press the “Plot Cross Section” button on the Cross Section Editor dialog box. A separate window appears displaying the section:



Close the Cross Section Viewer window by using the window-dismiss button in the upper right hand corner.


**Tip:** You can use ALT+PrnScrn to capture the Cross Section plot to the Windows clipboard. You may then paste it into any graphics program or word processing program such as MS Word.

### *Load Rating Tables from File*

Finally, it is possible to load-in rating table information from external files. For example, if a detailed survey is available for a given cross section, a rating table can be calculated *external* to GISHydro2000 and loaded to represent the rating table at the location drawn by the transect.

**Question: What if I want to draw more than one transect for a routing reach?** This suggests that you want to route a flood hydrograph through two or more cross sections in series. To do this, use the AddOutletsTool to place in-line subdivision points on these reaches. After generating the model schematic, these reaches will be separated at their subdivision points and multiple transects can be added.

### *Editing Rating Tables*

You can edit the cross section rating table for a transect already drawn by selecting the second tool from the AddTransect drop-down tool menu. When the  tool is selected, the user can click on a transect in the display with the “hand point” cursor. The cross



section editor dialog box will appear displaying that transect's data at which time it can be edited or updated.

Click OK to accept any changes made to the transect data and to update the rating table or click Cancel to disregard any changes.

### **Step Eight – TR-20 Control Panel**

**Important Note:** You must draw a transect line for each routing reach before proceeding.

After adding all of the transects, the next step is to open the TR-20 control panel and to specify the simulation options. From the TR-20 Interface Menu, click on “TR-20 Control Panel”. As in the homogeneous lab, enter a name and location for both the input file and output file.

Select the 5- and 100-yr return periods as input storms. Click the OK button to write the TR-20 input file.

### **Step Nine – Execute the TR-20 Program**

Execute the TR-20 program by choosing the “Execute TR-20” option from the TR-20 Interface menu. The program will evaluate the input file created by GISHydro2000 and the generated output file will be displayed by the Notepad program:

**Shortcut:** Use CNTRL+E as a shortcut to execute the TR-20 model.

### **Step Ten – Evaluate and Compare Results**

This laboratory was the third approach to calculating peak discharges for the Northwest Branch Watershed. In the USGS Regression equation lab, peak discharges were calculated with their respective confidence intervals. In the homogeneous watershed lab, peak discharge was calculated for the 100-year storm using TR-20. For this lab, subdivision was used to determine yet another estimate. It is expected that members of the workshop determined very different magnitudes for the 5 and 100-year peak discharge. What were your results? The rest of the group's?

| Return Period | No. Subwatersheds | No. Reaches | Peak Discharge |
|---------------|-------------------|-------------|----------------|
| 5-yr          |                   |             |                |
| 100-yr        |                   |             |                |

**Workshop Results**

|          | Q <sub>p5</sub> (cfs) | Q <sub>p100</sub> (cfs) |
|----------|-----------------------|-------------------------|
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|          |                       |                         |
| Average  |                       |                         |
| Std. Dev |                       |                         |