

Watershed Analysis Lab – Homogeneous, Gaged Watershed

The most common use for the TR-20 model is for the prediction of peak discharge behavior involving heterogeneous watershed conditions or storage. In some instances, it is desired to consider the homogeneous case where the watershed has no subdivision. The homogeneous case assumes that the behavior of runoff is the same throughout the watershed. This is usually not a good assumption, especially for larger watersheds, because the potential for runoff, represented by the curve number, is known to vary spatially. Nonetheless, the peak discharge predicted by TR-20 for an undivided watershed can serve as a baseline estimate to compare other alternatives with varying degrees of subdivisions and variations in other model parameters.

The analysis presented in this lab will involve the development of a TR-20 models for a homogeneous watershed. The watershed will have a USGS stream gage located at its outlet and it's predicted peak discharge will be compared with that of the flood-frequency peak discharge reported by the gage record. The lab is intended to slowly walk through the process of developing the TR-20 model using the GISHydro2000 software, for the simplest of cases. The next watershed analysis lab will feature a more complex combination of subdivision, channel routing, and calibration techniques.

Task

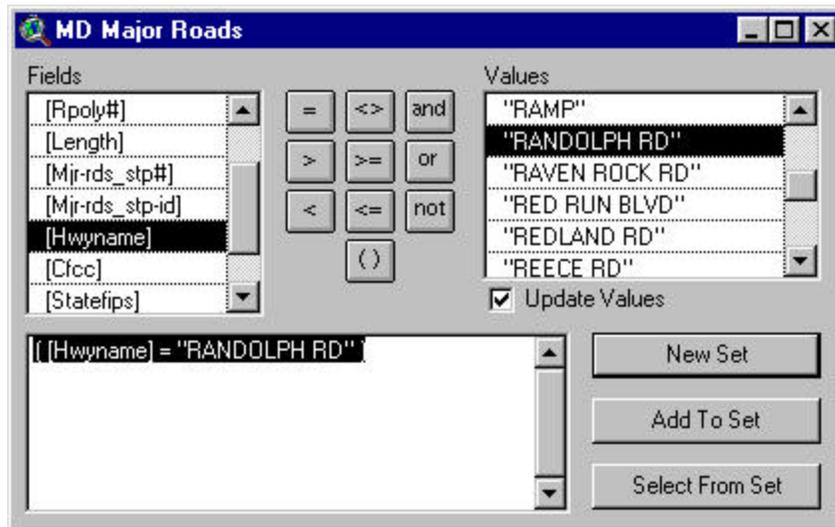
Estimate the peak discharge resulting from the 5-yr storm for the Northwest Branch Watershed located in Montgomery County, Maryland under *1997 conditions*. The watershed outlet is located exactly at USGS Stream Gage No. 01650500 near Randolph Road. Determine the peak discharge using the USGS regional regression equations and compare this value with the peak discharge predicted by TR-20. *Assume that the watershed conditions are homogenous.*

Step One – Locate Outlet and Select Quads

Note: The following Section describes how to find an outlet location to estimate which quad sheets are needed. If the quad sheets are already known, skip to the section below titled “Selecting Quads”.

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. Select the theme called “MD Major Roads” and make it active, so that its legend “pops out” from the other legends. Open the Query Builder selecting the Query option from the Theme Menu. The window on the left lists the field names in the MD Major Roads theme attribute table. The window on the right of the query builder lists the unique values for each field. Select the “Update Values” check box and build the following query by double-clicking on the [Hwyname] field, selecting the “=” relation, and scrolling through the value list to find Randolph Road.

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( [Hwyname] = "RANDOLPH RD" )
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Once the query expression is typed, press the “New Set” button to select Randolph Road from the MD Major Roads Theme. With the selection made, now we can zoom in to the selected area by pressing the  button (Zoom-to-selected). When this button is pressed View window will zoom to the extent of the selected Randolph Road, which will be colored yellow.

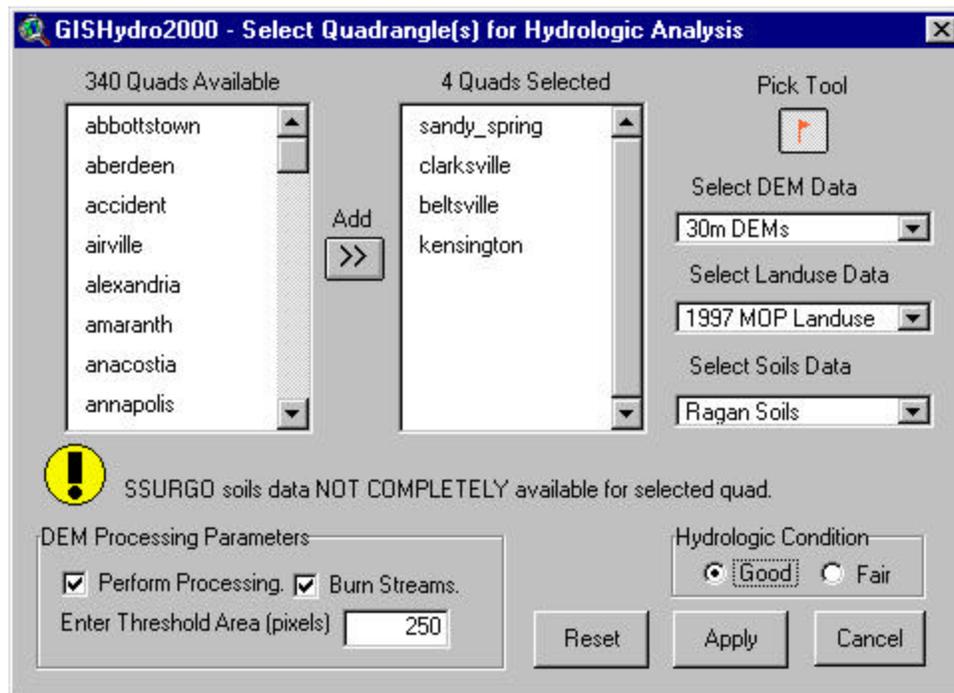
Based on the location of the Road, use the 1:250k DRG theme (Balt. 1:250K DRG) to estimate the overall size of the watershed (you may have to turn off, or re-order some themes to see it drawn correctly). Let’s assume that we have identified the quads which cover the drainage area of the Northwest Branch in the general facility of Randolph Road. They include:

- Kennington
- Beltsville
- Clarksville
- Sandy_Spring

We will now use the Select Quads Dialog Box to select these quads.

Selecting Quads

While in the Maryland View, open the **Select Quads Dialog Box** using the “Q” button from the button-bar. The Dialog box will open. Select the four quads above from the alphabetical list or visually using the pick tool. The quads are located just North of the northern-most part of Washington, DC. The graphic below shows the selected quads:



Select Data Types

The best resolution data available in GISHydro2000 is the 30m USGS DEMs which we have resampled to 100-ft cells. Use this data for this example. We want to model the predicted peak discharge for the watershed under homogeneous conditions in 1990. Select **1997 MOP Landuse** from the land use pull down menu. For soils data, select **Ragan Soils**. Note that a warning message has appeared in the center of the dialog. This is informing the user that, for the SSURGO data, there is only partial availability for the selected quads. This is because only 12 of the 23 Maryland counties are available in SSURGO format at present. (in this case, Prince George's County is unavailable SSURGO format.) If you are confident that the watershed you will later delineate is within the bounds of this data, you can proceed with SSURGO. **But**, if your watershed extends beyond the limits of this data, you will be forced to go back and select a different soils data type. This warning system also applies to watersheds that extend outside of the State. In cases where the selected quad is completely outside of the State or a SSURGO county, data choices will be removed from the soils and land use pull-down menus.

Select Processing Options

The last step before closing the Select Quads Dialog box is to set the desired processing options. In order to delineate streams and watersheds, the "Perform Processing" checkbox must be checked. The "Burn Streams" checkbox is recommended to be checked to insure that the alignment of the extracted drainage network corresponds with known locations from the 1:100k blue lines. The threshold drainage area in pixels controls the extent and amount of streams to be extracted from the DEM topography. A high value (>1000) will provide less streams while a low value (<250) will produce many streams. The default value of 250 corresponds roughly to the extent of the blue lines visible on a 1:24k topographic map.

There are two hydrologic conditions to choose from: good and fair. These conditions control which curve number lookup table will be used when creating a curve number grid. "Good" is the default. When all data selections, data types, and processing options are complete, press apply to begin the data extraction and processing process.

A word about processing time

For this example, we have selected four quad sheets. For an average PC, processing will take 3-4 minutes. For a single watershed, processing typically takes 1 minute. During the processing stage, you will see a little blue bar move rapidly back and forth on the ArcView Window. This is normal. During the processing phase, ArcView determines the flow directions and flow accumulations for each cell in the **combined grid** (the four quads are extracted from the database and merged for the DEM, land use, and soils layers).

The Area of Interest View

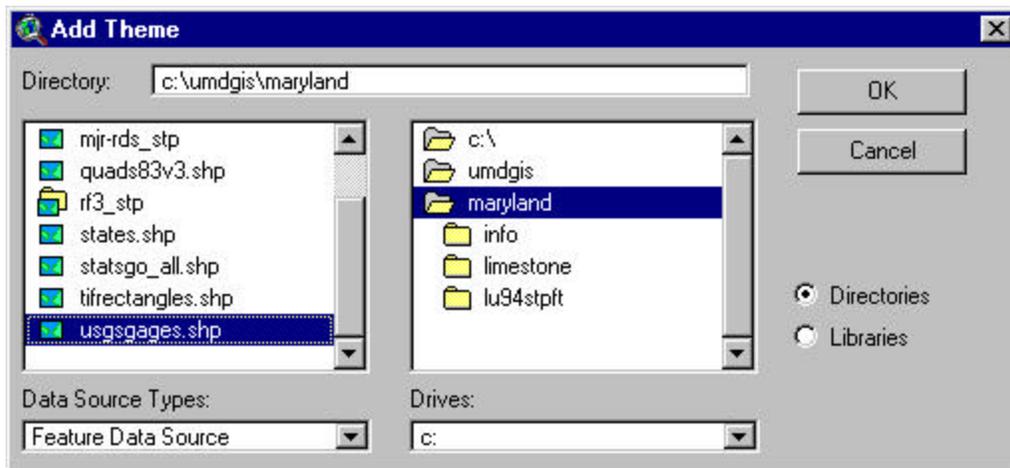
When processing is complete, a new View will be created limited to the extent of the four quads. It is from this View that all further steps will take place (the Maryland View is closed automatically, but remains part of the gishydro.apr project.)

Step Two – Delineate Watershed

In step one we showed how to use the Query Builder to locate 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.

Load USGS Gage Network

To locate the gage, we must add the USGS stream gage network to the current view. Select the “Add Theme” option from the View Menu. Use the file browser to locate the file: ussggages.shp located in the umdgis/maryland directory:



Now, make the gage theme active and open the query builder, as in step one. Insure that the “update fields” box is checked, then build the query:

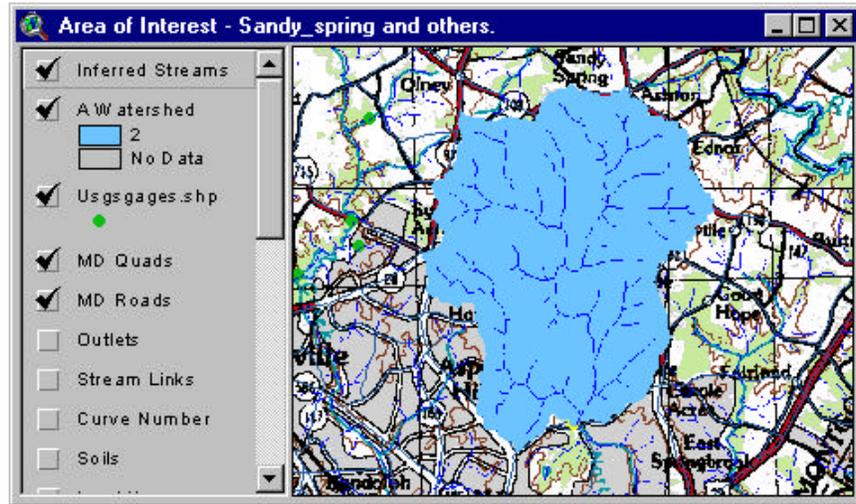
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( [Gage_id] = "1650500" )
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Note that the leading “0” in the gage is not entered. Select the “New Set” button then close the Query Builder box. Now repeat the procedure described in Step One to zoom to the selected feature, in this case a gage. Make sure the theme is turned on (visible). You should see the selected gage colored yellow. This will be the watershed subdivision point.

Delineate the Watershed

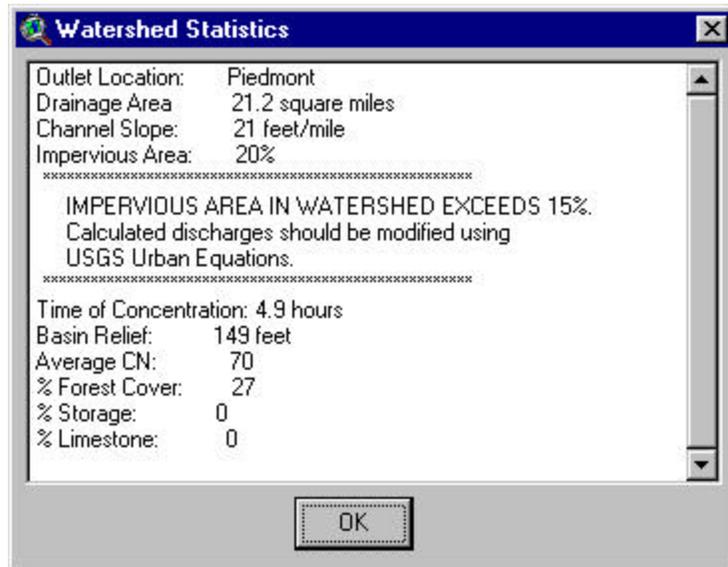
Zoom-in to the selected gage and arrange the themes so that the “Inferred Streams” theme is turned on and visible. Note that the selected gage is not shown directly on the drainage network. This is OK. Use the  tool to select the pixel (select the tool from the toolbar, then click on the pixel in the display window), *on the inferred streams, nearest to*

the selected gage. The watershed will be delineated after some processing is complete. Use the zoom-out feature to adjust the view extent to the boundary of the watershed. The delineated watershed should look like:



Step Three – Calculate Basin Statistics

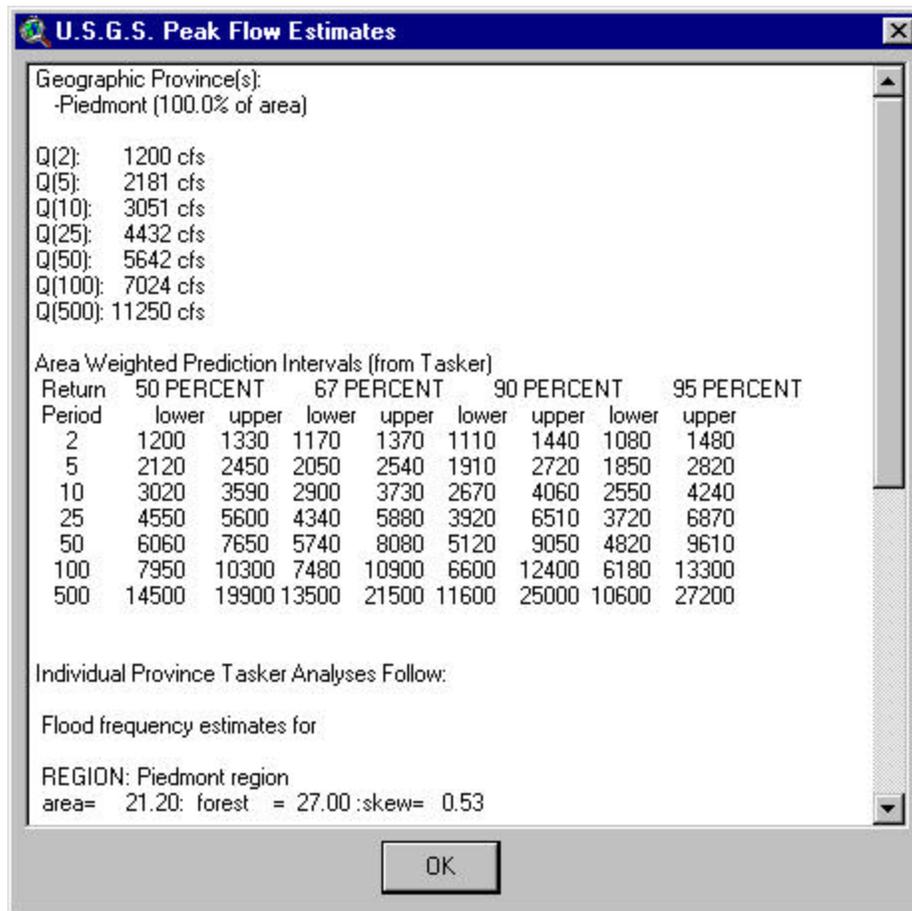
With the watershed now delineated, we now want to determine its relevant basin statistics. From the Hydro Menu, select Basin Statistics. The following Dialog box should appear.



Note the warning message indicating that the watershed contains more than 15% impervious area. This suggests that the Urban regression equations should be used. At the time this manual was written, the USGS Urban equations are not included with GISHydro2000. But, the equations use the same basin statistics. Values of drainage area, basin relief, etc. should be noted or written out to a file.

Step Four – Calculate Peak Discharges

After the Basin Statistics have been calculated, the next step is to calculate the peak discharges. Select “Calculate Discharges” from the Hydro Menu. The peak discharges are calculated in conjunction with their appropriate confidence intervals. For the case when a stream gages is located within +/- 50% of the drainage area of the watershed outlet, the predicted peak must be adjusted by the gage record. In this case, a dialog box appears requesting us to select a gage for adjustment. Select 0160500 and press OK. After some processing, the following dialog box will appear:



As with the Basin Statistics, the discharges shown in the above dialog box can be output to a file.

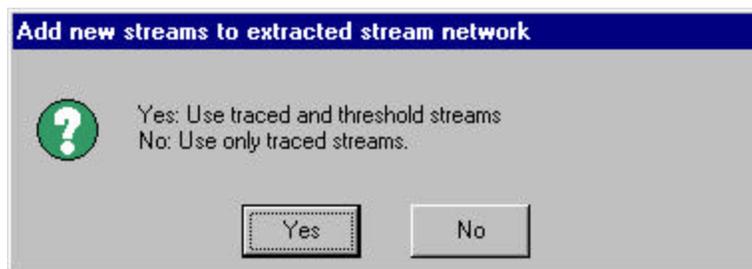
Step Five – Delineate Main Channel and Subwatersheds

Inspection of the drainage network (the Inferred Streams theme) shows that there are a large amount of short, stream branches that extend from the main stream segments. These features are not typically seen on a 1:24k blue line coverage and are an artifact of the channel extraction process.

GISHydro2000 chooses as the default to subdivide the watershed at all stream confluence points. As you can see, this would result in an extraordinarily large amount of subdivision. It is therefore necessary for us to modify the stream network to a more simple case. For our purposes, we wish to mode the watershed as a single, homogeneous one with no subdivisions.

Select the  tool from the tool bar and click on a point somewhere near the upper divide of the watershed. You will see a single flow path delineated from the point you clicked on to the watershed outlet. We will choose this flow path as our primary channel segment. Note that this segment isn't necessarily the longest flow path in the watershed. That path will be determined later.

From the CRWR-PrePro menu, select "Add Streams". This option is necessary to incorporate the delineated stream in the stream network. The following box appears:



Select NO to use only the single stream segment. The modified stream network looks like:



Subwatersheds

The next step is a bit of a misnomer for a homogeneous watershed, but is nonetheless necessary. From the CRWR-PrePro Menu, select delineate subwatersheds. In our case, we have only a single flow path with a single outlet. As a result, only one subwatershed will be produced; the original watershed.

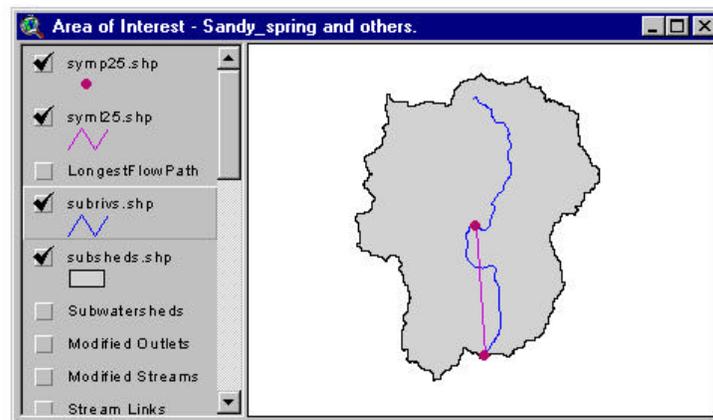
The raster stream and watershed are converted into new vector themes: subrivs.shp and subsheds.shp, respectively. Future processing of the model will be based on these themes.

Step Six – Calculate Attributes

From the CRWR-PrePro menu, select the “Calculate Attribute” option. This step will determine the length of the longest flow path and time of concentration for the watershed. A choice of time of concentration methods will be presented. Select SCS Lag formula which calculates the t_c as a function of slope, CN, and watershed length. A dialog box will appear notifying you when the processing is complete.

Step Seven – Generate Schematic

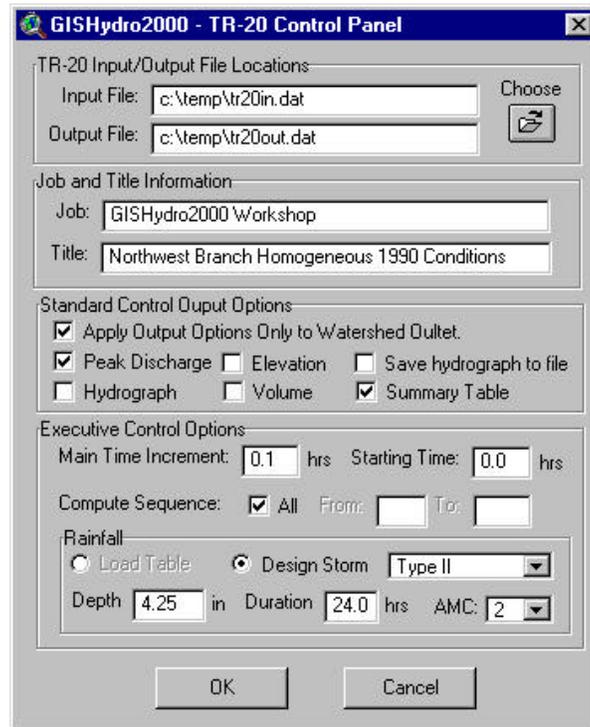
Once processing is complete, select the “Generate Schematic” option from the CRWR-PrePro menu. This option will translate the watershed and stream theme (and their attributes) into a schematic format which can be translated into TR-20. The generated schematic should look like the figure below. Hydrologically speaking, a runoff hydrograph is generated for the watershed at its center and is transposed to the outlet (not translated in time or routed).



Step Eight – Configure TR-20 Control Panel

Once the schematic is created, the TR-20 model can be setup for execution. Open the TR-20 control panel from the TR-20 Interface Menu. Select a name and location for the TR-20 input file to be generated and also for the output file that TR-20 will create. Enter

the optional Job and Title header information, which will be written into the TR-20 input file.

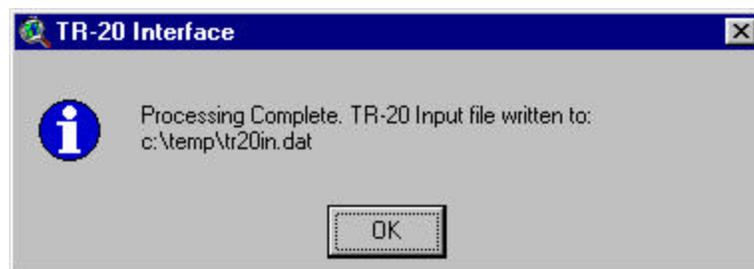


Because there is only one subwatershed, leave the “Apply Output Options only to Watershed Outlet” box checked and select any additional output values desired.

Set Simulation Parameters (Executive Control)

The default time increment and starting time are recommended in most cases. The compute sequence can be specified directly if only portions of a complex watershed are to be analyzed.

The rainfall parameters are typically based on the 24-hr design storm (Type II) for Maryland. The rainfall depth corresponding to the 5-yr return frequency is 4.25 inches. When all of the simulation parameters are set, press ok. The following Dialog appears indicating that the input file has been created:



Step Nine – Execute TR-20 Model

To execute the TR-20 model for the current watershed select the Execute option from the TR-20 Interface Menu or simply press Cntrl+E. You will be asked some questions related to TR-20 logging. Finally, when asked, select yes to execute the TR-20 model.

Step Ten – Evaluate and Compare Results

TR-20 will execute automatically and return the generated output file in Notepad for review. The output file is shown below which reports that the peak discharge for the 5 year storm is approximately 1177 cfs. The peak discharge predicted by the USGS regression equations was 2181 cfs, a difference of -46%. In considering the computed confidence intervals, the TR-20-predicted discharge does not fall within any level. It is rational to conclude that the assumption of homogeneity for the Northwest Branch is probably not valid.

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1
TR20 ----- SCS -
03/10/** GISHydro2000 Workshop VERSION
09:27:30 GISHydro2000 Workshop 2.04TEST
PASS 1 JOB NO. 1 PAGE 1

EXECUTIVE CONTROL INCREM MAIN TIME INCREMENT = .100 HOURS

EXECUTIVE CONTROL COMPUT FROM XSECTION 3 TO XSECTION 3
STARTING TIME = .00 RAIN DEPTH = 4.25 RAIN DURATION = 1.00
ANT. RUNOFF COND. = 2 MAIN TIME INCREMENT = .100 HOURS
ALTERNATE NO. = 1 STORM NO. = 1 RAIN TABLE NO. = 2

OPERATION RUNOFF XSECTION 3

PEAK TIME(HRS) 25.15 PEAK DISCHARGE(CFS) 1176.7 PEAK ELEVATION(FEET)
(RUNOFF)
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