

# Appendix to Final Report

## GISHydro

June 2010

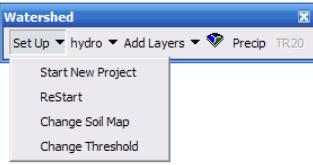
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## Tools

### SET UP MENU



#### *Start New -*

Allows user to set up their project and select the desired DEM, Land Use and Soil Type. It is important for the user to verify the path to the GISHydro folder.

#### *Restart-*

Resets screen and return user to the whole state view with inferred rivers. For use when need to the initial outlet point selected was incorrect.

#### *Change Soil Map-*

Allows user to change soils map

#### *Change Threshold-*

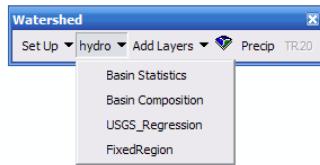
Allows user to change threshold

### WATERSHED- (BUTTON)



Delineates a watershed based on the outlet point selected by the user. Each watershed is given a four digit code based on its time of creation, and saved in the project folder.

## HYDRO MENU



### **Basin Statistic-**

Creates a listing of the basins features including: drainage area, channel slope, land slope, longest path, time of concentration, average CN, % Forest, %A Soils, %B Soils, %C Soils %D soils and 2yr 24hr precipitation.

### *Basin Composition -*

Creates two tables, these tables are saved in the project folder

- Curve Number by Land Use
- Soil Type by Land Use

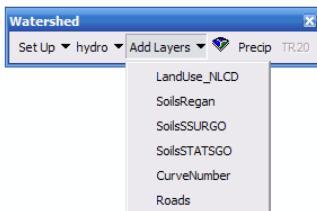
### *USGS Regression Equations*

The Q<sub>2</sub> through Q<sub>500</sub> discharges estimated from Dillow (1996) are computed

### *Fixed Region Equations*

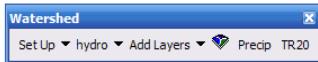
The Q<sub>1.25</sub> through Q<sub>500</sub> discharges estimated from the Thomas (Moglen, et al., 2006) equations are computed

## ADD LAYERS MENU



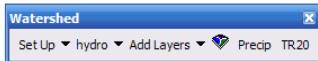
Allows uses to add custom layers

## PRECIP- (BUTTON)



Brings up user form to select Precipitation Frequency and Duration

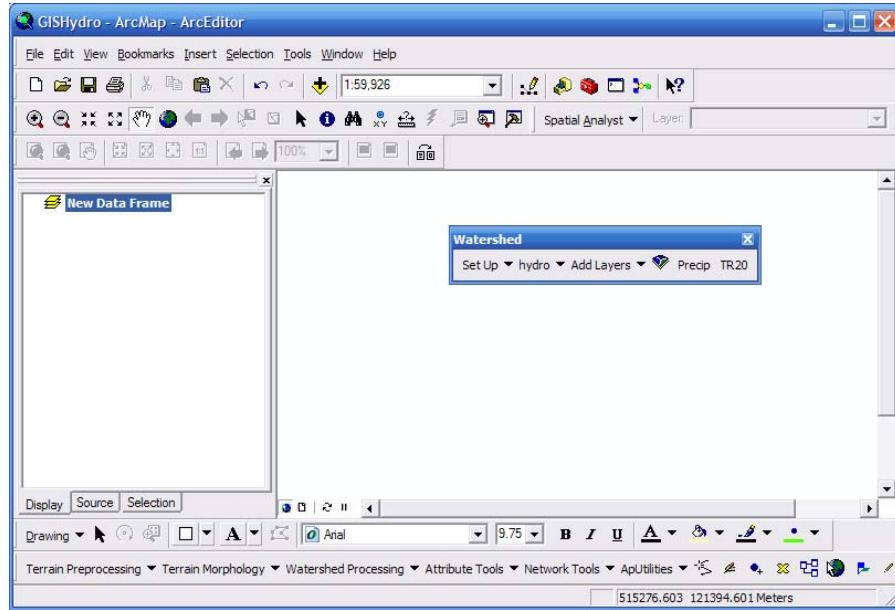
## TR20- (BUTTON)



This option becomes available after both basin statistics is ran and precipitation frequency and durations have been selected. This tool bring us the form for creating a WinTR20 input file.

## Step1 Getting Started

After opening GISHydro, select the Project button.



*Figure 1 Opening Screen*

After selecting the Project button, you will be prompted for information regarding the project.

Project Path: This should be the path of your GISHydro Program Folder.

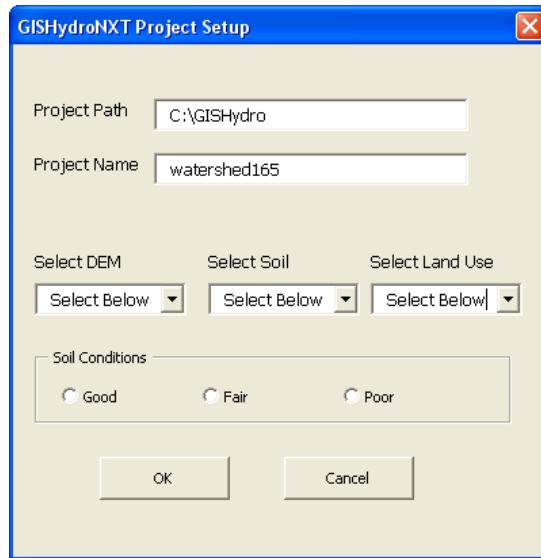
Project Name: Here you can name your project

Select DEM: Pick the DEM you wish to use for analysis

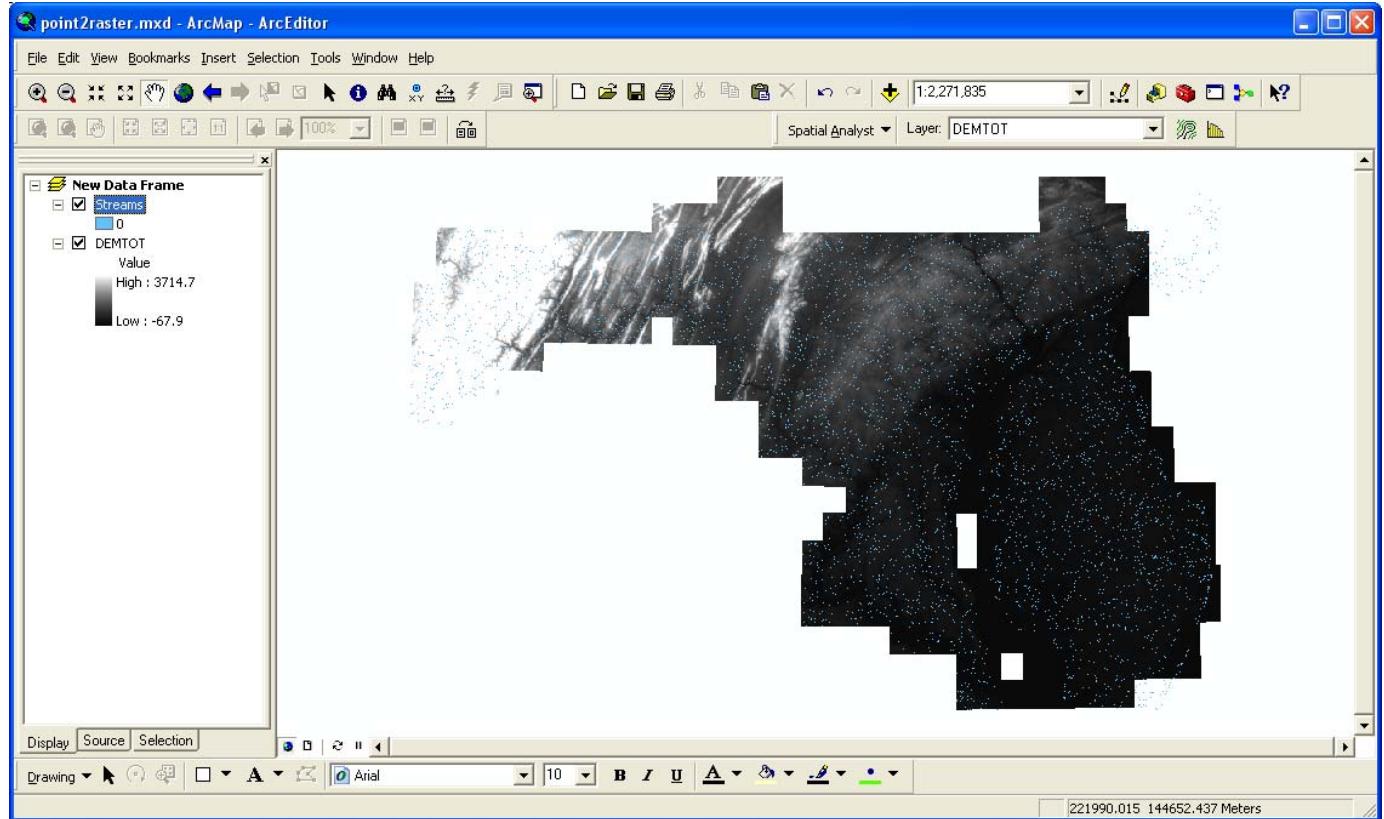
Select Land use: Pick the Land Use data base you wish to use for analysis

Select Soils: Pick the soils data base you wish to use for analysis

After, selecting a DEM, Land use and Soils pick OK.



*Figure 2 Project Setup*



*Figure 3 State View with Rivers*

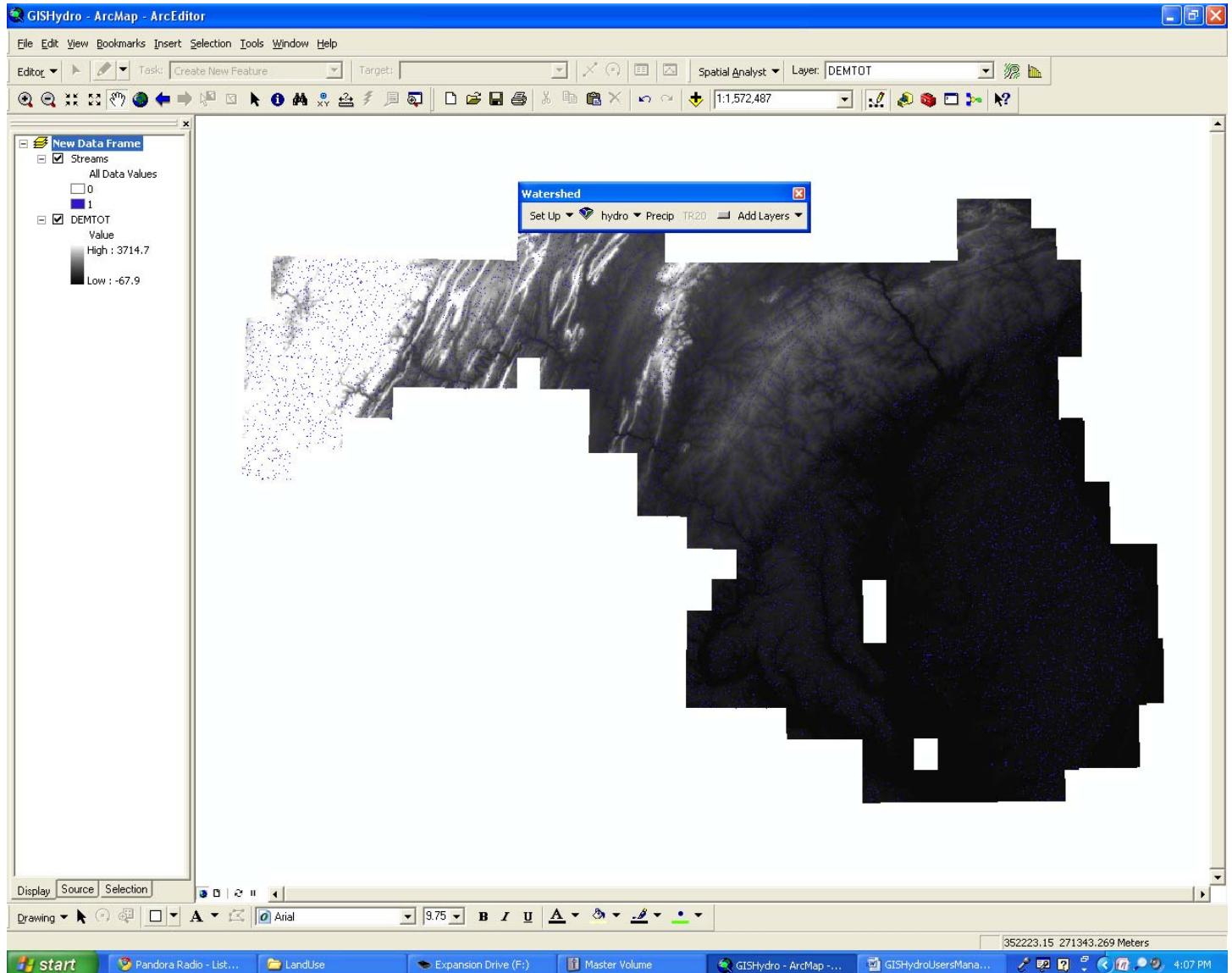
After selecting ok, the DEM and Inferred streams for the state will be displayed.

From here you can use zoom, to find your specific outlet location.

## Step 2 Creating your Watershed

Start by selecting the basin delineation button  on the watershed tool bar.

Zoom into a level where your mouse point is clearly on a single pixel.



*Figure 4 Starting your Watershed*

During the creation of your watershed you will be asked to confirm your watershed.

If the watershed looks similar to what you were expecting, select YES and

If the watershed is not what you were expecting select NO, you will then be instructed to use the restart button on the watershed tool, this will remove the watershed. Then Repeat Step 2, with a closer zoom.

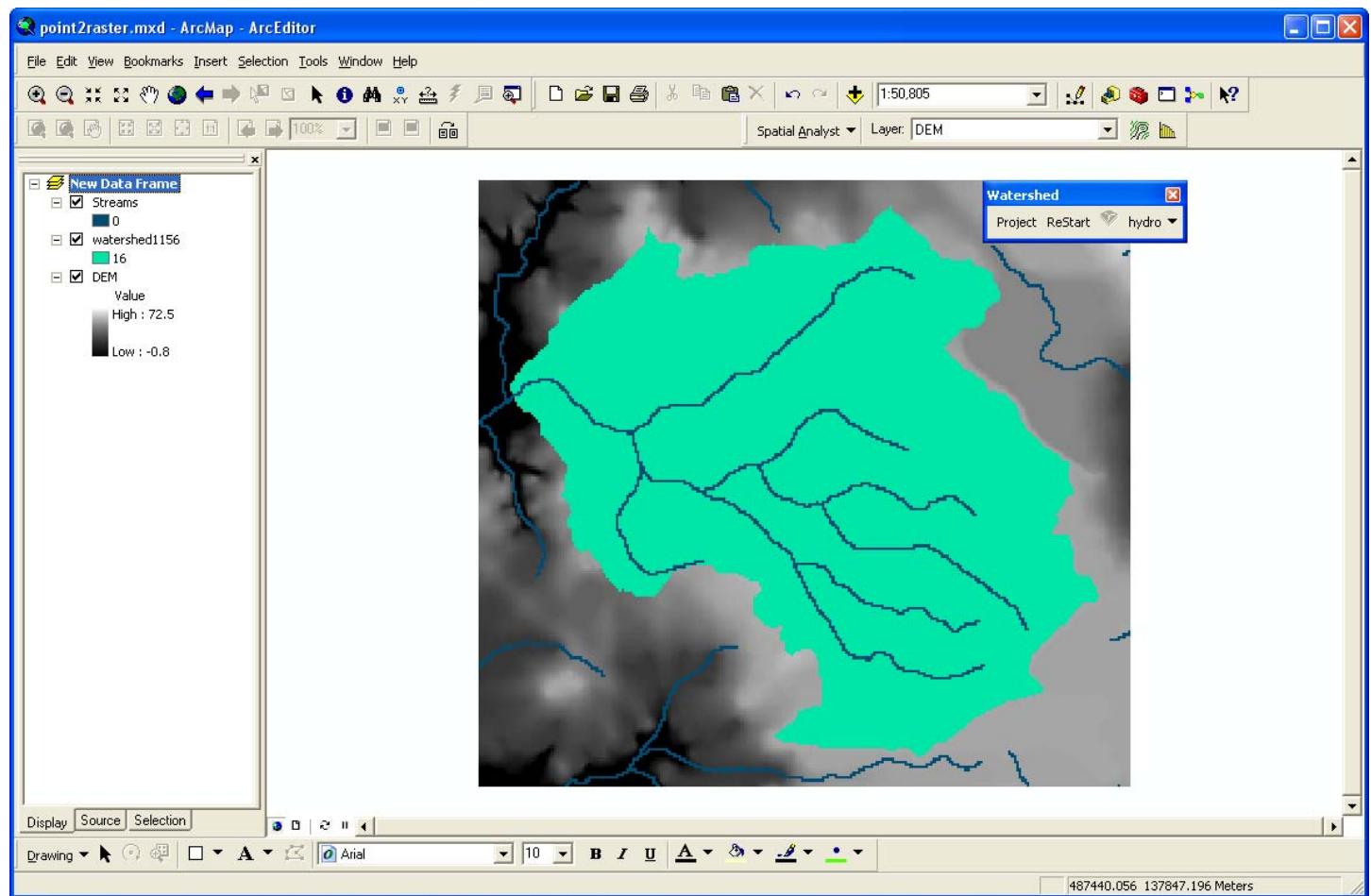
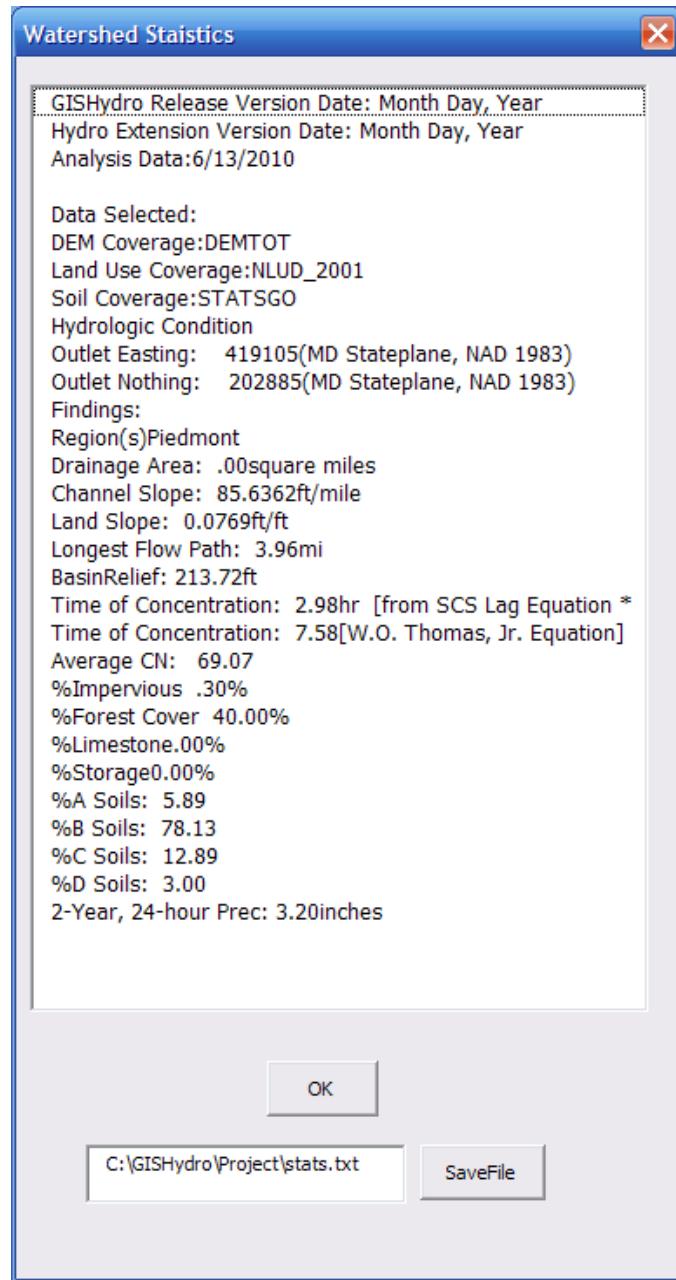


Figure 5 Watershed

## Step 3 Hydro Menu

Once you have created your watershed you can use the “hydro menu” to calculate Basin Statistics, Basin Composition., and calculate the peak discharges



*Figure 7 Basin Statistics*

| Attributes of CurveNumber_by_LandUse4 |    |                 |           |           |    |    |    |    |  |
|---------------------------------------|----|-----------------|-----------|-----------|----|----|----|----|--|
| OID                                   | LU | Land_Use        | Area      | Percent   | A  | B  | C  | D  |  |
| 0                                     | 11 | Open Water      | 1462810   | 0.533682  | 10 | 10 | 10 | 10 |  |
| 1                                     | 21 | Developed Open  | 3855617   | 1.406659  | 39 | 61 | 74 | 80 |  |
| 2                                     | 22 | Developed Low I | 1714684   | 0.625574  | 61 | 75 | 83 | 87 |  |
| 3                                     | 23 | Developed Mediu | 426249    | 0.15551   | 77 | 85 | 90 | 92 |  |
| 4                                     | 24 | Developed High  | 48437     | 0.017671  | 98 | 98 | 98 | 98 |  |
| 5                                     | 31 | Barren Land     | 368124    | 0.134304  | 77 | 86 | 91 | 94 |  |
| 6                                     | 41 | Deciduous Fores | 56148638  | 20.484909 | 30 | 55 | 70 | 77 |  |
| 7                                     | 42 | Evergreen Fores | 571561    | 0.208525  | 30 | 55 | 70 | 77 |  |
| 8                                     | 81 | Pasture/Hay     | 90442319  | 32.996395 | 72 | 81 | 88 | 91 |  |
| 9                                     | 82 | Cultivated Crop | 111464152 | 40.665866 | 72 | 81 | 88 | 91 |  |
| 10                                    | 90 | Woody Wetlands  | 3109681   | 1.134516  | 10 | 10 | 10 | 10 |  |
| 11                                    | 95 | Emergent Herbac | 4485303   | 1.636389  | 10 | 10 | 10 | 10 |  |

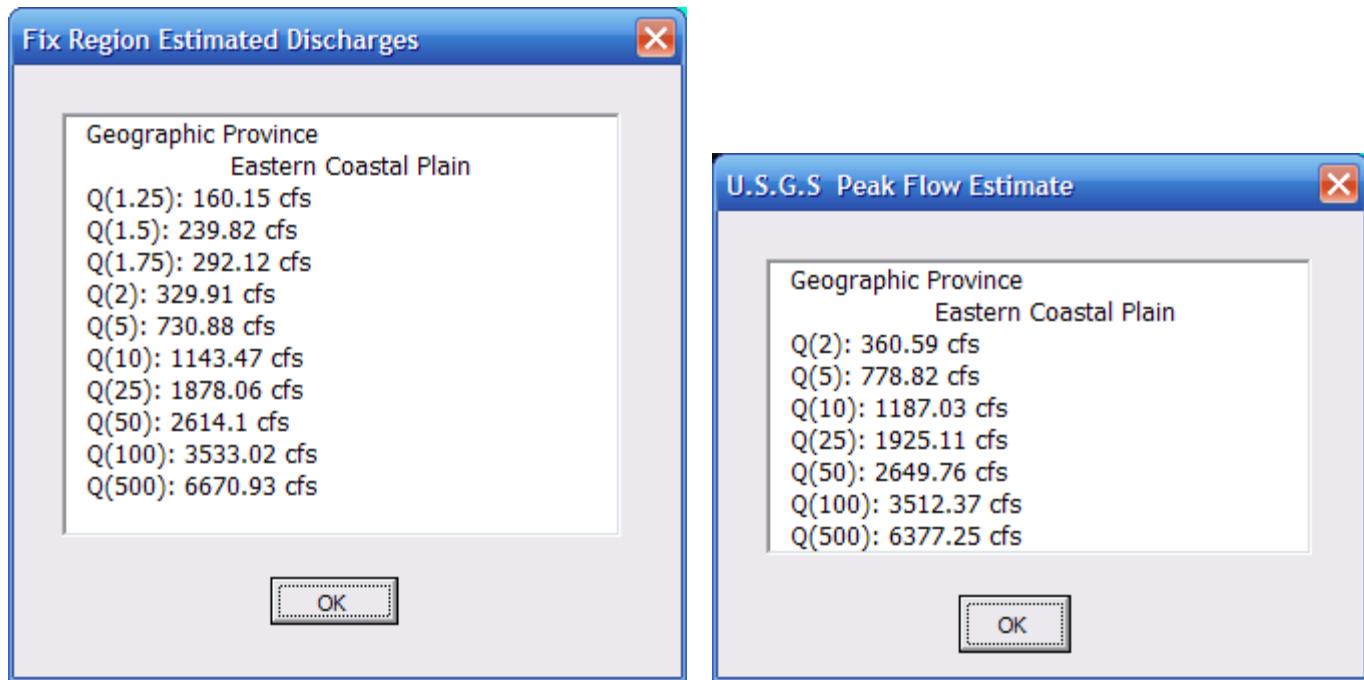
Record: 1 Show: All Selected Records (of 12) ▾

*Figure 8 Basin Composition, Curve Number by Land Use*

| Attributes of SoilType_by_LandUse11563 |    |                 |        |          |          |          |
|--|----|-----------------|--------|----------|----------|----------|
| OID                                    | LU | Land_Use        | A_Soil | B_Soil   | C_Soil   | D_Soil   |
| 0                                      | 11 | Open Water      | 0      | 736249   | 697499   | 29062    |
| 1                                      | 21 | Developed Open  | 0      | 1995621  | 1017185  | 842811   |
| 2                                      | 22 | Developed Low I | 0      | 920311   | 484374   | 309999   |
| 3                                      | 23 | Developed Mediu | 0      | 164687   | 222812   | 38750    |
| 4                                      | 24 | Developed High  | 0      | 19375    | 29062    | 0        |
| 5                                      | 31 | Barren Land     | 0      | 251874   | 58125    | 58125    |
| 6                                      | 41 | Deciduous Fores | 193750 | 32704935 | 13484973 | 9764980  |
| 7                                      | 42 | Evergreen Fores | 0      | 87187    | 474687   | 9687     |
| 8                                      | 81 | Pasture/Hay     | 426249 | 59858943 | 18909962 | 11247165 |
| 9                                      | 82 | Cultivated Crop | 155000 | 72084543 | 21273707 | 17950902 |
| 10                                     | 90 | Woody Wetlands  | 0      | 1695309  | 794373   | 619999   |
| 11                                     | 95 | Emergent Herbac | 0      | 2305620  | 1714684  | 464999   |

Record: 1 Show: All Selected Records (of 12) ▾ Options ▾

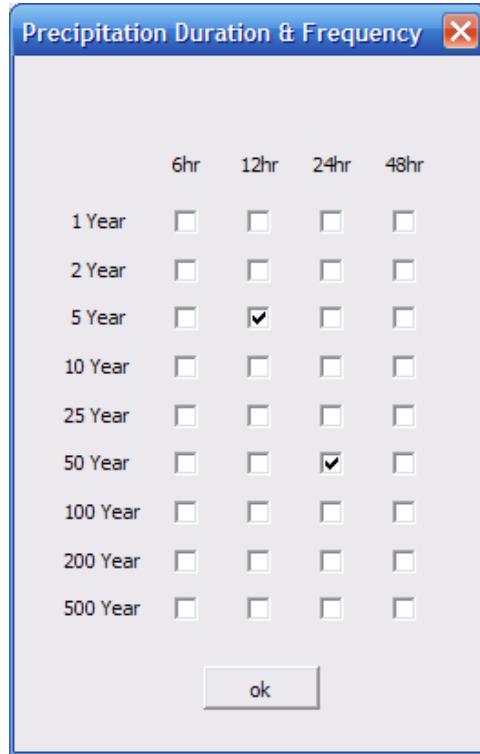
*Figure 9 Basin Composition, Soil Type by Land Use*



*Figure 10 Peak Discharges*

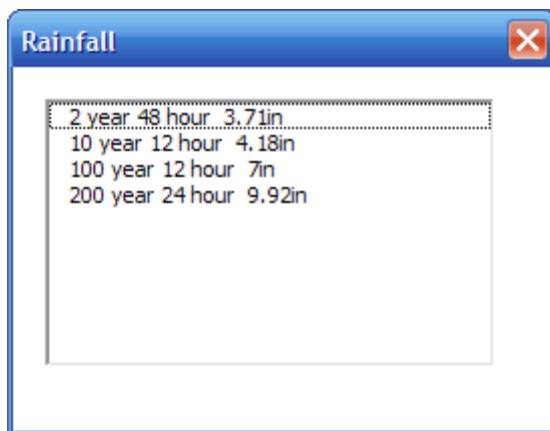
## Step 4 Precipitation Duration and Frequency Selection

From the menu bar, select the precip button. The following screen will appear, chose the event and select OK.



*Figure 11 Precipitation Frequency and Duration Selection*

The following screen will appear listing the depth of the selected event.



*Figure 12 Precipitation Frequency and Duration Output*

## Step 5 WinTR20

After running both Basin Stats and Precip the TR-20 option will appear. The WinTR20 Input Creator allows the user to select the time of concentration method and the desired precipitation event.

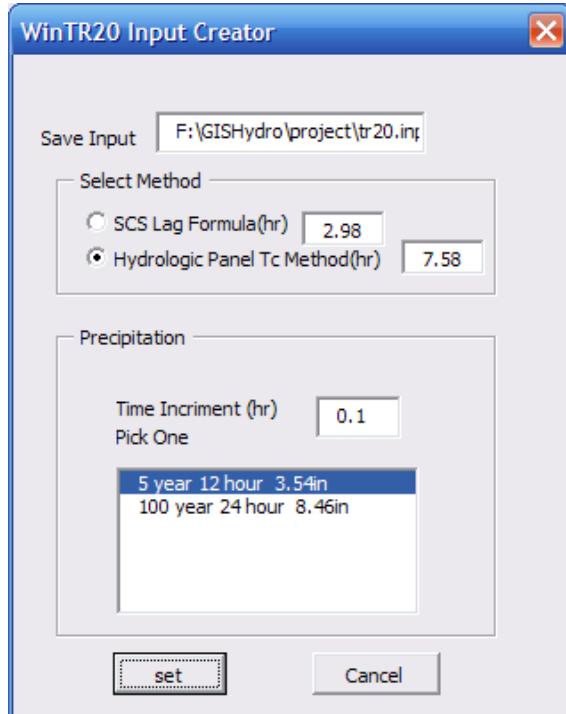


Figure 13 WinTR20 Creator

After running the WinTR20 Creator a message will appear indicating the file has been created. You can view the file in notepad (Figure 14) or proceed to WinTR20 (Figure 15)

The screenshot shows a Windows Notepad window titled "tr20 - Notepad". The content of the file is as follows:

```
File Edit Format View Help
WinTR-20: Version 1.11
Single Basin for GISHydro
0 0 1. 0

SUB-AREA:
area1 outlet A 00000.0 69.1 7.58

STORM ANALYSIS:
5y 12 h A 3.54 yr005 2 3.1

RAINFALL DISTRIBUTION:
yr005 0.1
0.0 00.011 00.022 00.034 00.045
00.056 00.067 00.078 00.089 00.101
00.112 00.123 00.134 00.145 00.157
00.168 00.179 00.190 00.201 00.212
00.224 00.235 00.246 00.257 00.268
00.280 00.291 00.302 00.313 00.324
00.335 00.347 00.355 00.383 00.401
00.419 00.437 00.455 00.473 00.492
00.510 00.528 00.546 00.564 00.582
00.600 00.618 00.636 00.654 00.672
00.690 00.727 00.764 00.800 00.837
00.874 00.953 01.031 01.110 01.274

GLOBAL OUTPUT:
1 YYYYYY NNNNNN
```

Figure 14 WinTR20 Input File

Open WinTR20 and from the file menu choose “Open Existing WinTR-20 File”

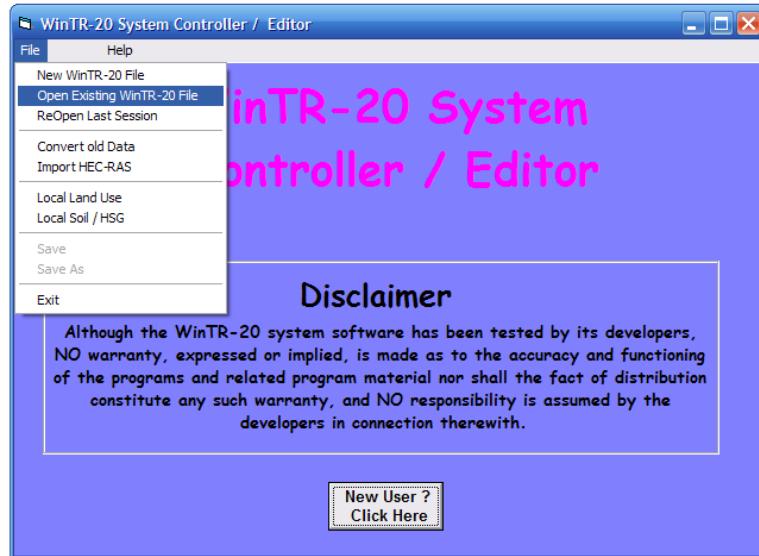
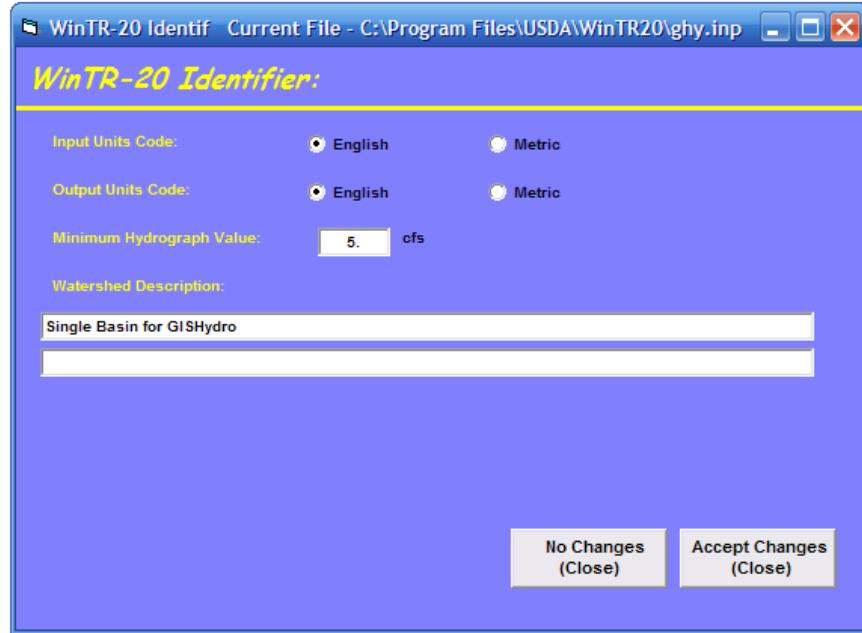


Figure 15 WinTR-20

Leave in English units, you can edit description if you desire. Chose “Accept Changes and Close”. From the file menu choose save. After saving the “run” option will appear on the menu bar. Choose run.



*Figure 16 Accept Changes*

The screenshot shows the 'WinTR-20 Printed Page File' window. It displays a hydrograph for a 'Single Basin for GISHydro' storm event. The header includes 'Name of printed page file: C:\Program Files\USDA\WinTR20\ghy.out' and 'STORM 10y 12 h'. The data table has columns for Area or Reach Identifier, Drainage Area, Rain Gage ID or Location, Runoff Amount, Elevation (ft), Time (hr), Peak Flow Rate (cfs), and Peak Flow Rate (csm). Below this is another table for flow values over time increments of 0.514 hr, with columns for Start Time (hr), Flow Values (cfs), and (cfs).

| Area or Reach Identifier | Drainage Area | Rain Gage ID or Location                 | Runoff Amount | Elevation (ft) | Time (hr) | Peak Flow Rate (cfs) | Peak Flow Rate (csm) |
|--------------------------|---------------|--|---------------|----------------|-----------|----------------------|----------------------|
| reach1                   | 3.600         | Upstream                                 | 2.777         | 312.09         | 10.00     | 906.99               | 251.94               |
| <hr/>                    |               |  |               |                |           |                      |                      |
| <hr/>                    |               |  |               |                |           |                      |                      |
| Line Start Time          | -----         | Flow Values @ time increment of 0.514 hr | -----         | (cfs)          | (cfs)     | (cfs)                | (cfs)                |
| (hr)                     | (cfs)         | (cfs)                                    | (cfs)         | (cfs)          | (cfs)     | (cfs)                | (cfs)                |
| 3.634                    | 9.5           | 21.0                                     | 40.4          | 72.0           | 131.1     | 219.3                | 323.9                |
| 7.433                    | 445.4         | 582.2                                    | 719.4         | 823.8          | 885.8     | 907.0                | 892.6                |
| 11.032                   | 856.4         | 790.4                                    | 716.1         | 635.5          | 545.9     | 452.5                | 375.9                |
| 14.630                   | 318.6         | 270.2                                    | 229.9         | 197.1          | 168.4     | 142.1                | 120.4                |
| 18.229                   | 102.9         | 87.4                                     | 74.2          | 62.9           | 53.6      | 45.1                 | 38.5                 |
| 21.828                   | 32.7          | 27.9                                     | 23.8          | 20.3           | 17.2      | 14.6                 | 12.3                 |

*Figure 17 TR-20 Output*

## Download

1. Go to <http://www.gishydro.umd.edu.edu>
2. Click on the “Download” link along the left margin. If you have not already registered, please do so. (Registration is free).
3. Once you have registered, you will be at the GISHydro download page. You will need to download several (5) zip files and the GISHydro.mxd project file (see screen capture below).
4. Create a directory called “c:\gishydro\” on your local machine.
  - a. Create three sub-directories off the “c:\gishydro\” directory called “BaseFiles”, “Project”, and “Temp”.
  - b. Unzip the zip files from Step 3 above to the “c:\gishydro\BaseFiles” sub-directory
  - c. Place the “GISHydro.mxd” file in the “c:\gishydro” directory.

The screenshot shows a Windows Internet Explorer window with the title "Download Page - Windows Internet Explorer". The address bar contains the URL "http://www.gishydro.umd.edu/download.asp". The menu bar includes File, Edit, View, Favorites, Tools, and Help. The toolbar has icons for Back, Forward, Stop, Home, and Favorites. Below the toolbar is a status bar with "Download Page". The main content area features the "GISHydro@Maryland" logo, which includes the University of Maryland crest and the text "GISHydro@Maryland". To the right of the logo is a red circular "SHA" seal. Below the logo, a red banner states: "A Collaboration between the Department of Civil and Environmental Engineering and the Maryland State Highway Administration, Office of Structures (OOS)". The main text on the page is titled "GISHydroNXT Download Section". It describes the availability of GISHydroNXT as a beta-trial program, compatible with ArcGIS 9.3.1, and provides instructions for installation and file extraction. A bulleted list details the download links for "GISHydroNXT data files" (DEM.zip, LandUse.zip, Precip.zip, Soils.zip, ancillary.zip) and the "GISHydroNXT project file" (GISHydro.mxd). The "GISHydro.mxd" link is highlighted in blue.

**GISHydroNXT Download Section**

GISHydroNXT (compatible with ArcGIS 9.3.1) is now available as a beta-trial program. Please see report (including user's manual on "Documentation" page. Installation should be to the "c:\gishydro" directory with three immediate sub-directories named: "BaseFiles", "Project", and "Temp". Download each of the zip files below and unzip these files with the contents extracted to the BaseFiles sub-directory.

- **GISHydroNXT data files** (to be unzipped in "c:\gishydro\BaseFiles" sub-directory).
  - **DEM.zip:** (~563 MB, Updated:06/20/2010)
  - **LandUse.zip:** (~114 MB, Updated: 06/20/2010)
  - **Precip.zip:** (~236 MB, Updated: 06/20/2010)
  - **Soils.zip:** (~10 MB, Updated: 06/20/2010)
  - **ancillary.zip:** (~2 MB, Updated: 06/20/2010)
- **GISHydroNXT project file** (to be placed in "c:\gishydro\BaseFiles" sub-directory).
  - **GISHydro.mxd:** (~5 MB, Updated:06/20/2010)

## File System

C:\GISHydro

**GisHydro.mxd**

### BaseFiles

- **DEM**
  - Demtot
  - Flowacc
  - Flowlenup
  - Flowdir
  - Rivers
  - Info
- **Precip**
- **LandUse**
  - LUD
  - LandUse\_Key\_NLUD.txt
  - landuse\_names.dbf
  - imp (impervious area)
- **Soils**
  - Ragan
  - Ssurgo
  - Statsgo
- **Limestone**
- **MDProv**
- **Mjr\_rdsstpm**

**Project** – stores watershed and other important data from program

**Temp** – stores information necessary to run program

## Regression Equations

*Fixed Region Equations, Thomas (Moglen, et al., 2006)*

### Piedmont Region

$Q1p25 = 202.9 * DA^{0.682} * (F + 1)^{-0.222}$   
 $Q1p5 = 262 * DA^{0.683} * (F + 1)^{-0.217}$   
 $Q1p75 = 308.9 * DA^{0.679} * (F + 1)^{-0.219}$   
 $Q2 = 349 * DA^{0.674} * (F + 1)^{-0.224}$   
 $Q5 = 673.8 * DA^{0.659} * (F + 1)^{-0.228}$   
 $Q10 = 992.6 * DA^{0.649} * (F + 1)^{-0.23}$   
 $Q25 = 1556 * DA^{0.635} * (F + 1)^{-0.231}$   
 $Q50 = 2146 * DA^{0.624} * (F + 1)^{-0.235}$   
 $Q100 = 2897 * DA^{0.613} * (F + 1)^{-0.238}$   
 $Q200 = 3847 * DA^{0.603} * (F + 1)^{-0.239}$   
 $Q500 = 5519 * DA^{0.589} * (F + 1)^{-0.242}$

#### Piedmont urban

$Q1p25 = 17.85 * DA^{0.652} * (IA+1)^{0.635}$   
 $Q1p50 = 24.66 * DA^{0.648} * (IA+1)^{0.631}$   
 $Q1p75 = 30.82 * DA^{0.643} * (IA+1)^{0.611}$   
 $Q2 = 37.01 * DA^{0.635} * (IA+1)^{0.588}$   
 $Q5 = 94.76 * DA^{0.624} * (IA+1)^{0.499}$   
 $Q10 = 169.2 * DA^{0.622} * (IA+1)^{0.435}$   
 $Q25 = 341.0 * DA^{0.619} * (IA+1)^{0.349}$   
 $Q50 = 562.4 * DA^{0.619} * (IA+1)^{0.284}$   
 $Q100 = 898.3 * DA^{0.619} * (IA+1)^{0.222}$   
 $Q200 = 1413 * DA^{0.621} * (IA+1)^{0.160}$   
 $Q500 = 2529 * DA^{0.623} * (IA+1)^{0.079}$

### Western Coastal Plain

$Q1p25 = 18.62 * DA^{0.611} * (IA + 1)^{0.419} * (SD + 1)^{0.165}$   
 $Q1p50 = 21.97 * DA^{0.612} * (IA + 1)^{0.399} * (SD + 1)^{0.226}$   
 $Q1p75 = 24.42 * DA^{0.612} * (IA + 1)^{0.391} * (SD + 1)^{0.246}$   
 $Q2 = 26.32 * DA^{0.612} * (IA + 1)^{0.386} * (SD + 1)^{0.256}$   
 $Q5 = 42.64 * DA^{0.607} * (IA + 1)^{0.347} * (SD + 1)^{0.34}$   
 $Q10 = 58.04 * DA^{0.603} * (IA + 1)^{0.323} * (SD + 1)^{0.382}$   
 $Q25 = 86.25 * DA^{0.582} * (IA + 1)^{0.295} * (SD + 1)^{0.421}$   
 $Q50 = 111.5 * DA^{0.584} * (IA + 1)^{0.27} * (SD + 1)^{0.457}$   
 $Q100 = 143.56 * DA^{0.586} * (IA + 1)^{0.26} * (SD + 1)^{0.469}$   
 $Q200 = 185.15 * DA^{0.58} * (IA + 1)^{0.243} * (SD + 1)^{0.488}$   
 $Q500 = 256.02 * DA^{0.573} * (IA + 1)^{0.222} * (SD + 1)^{0.51}$

### Blue Ridge and Great Valley

$Q1p25 = 57.39 * DA^{0.784} * (LIME + 1)^{-0.19}$   
 $Q1p50 = 81.45 * DA^{0.764} * (LIME + 1)^{-0.193}$   
 $Q1p75 = 96.33 * DA^{0.755} * (LIME + 1)^{-0.194}$   
 $Q2 = 107.2 * DA^{0.75} * (LIME + 1)^{-0.194}$   
 $Q5 = 221.28 * DA^{0.71} * (LIME + 1)^{-0.202}$   
 $Q10 = 336.84 * DA^{0.687} * (LIME + 1)^{-0.207}$   
 $Q25 = 545.62 * DA^{0.66} * (LIME + 1)^{-0.214}$   
 $Q50 = 759.45 * DA^{0.641} * (LIME + 1)^{-0.219}$   
 $Q100 = 1034.7 * DA^{0.624} * (LIME + 1)^{-0.224}$   
 $Q200 = 1387.6 * DA^{0.608} * (LIME + 1)^{-0.229}$   
 $Q500 = 2008.6 * DA^{0.587} * (LIME + 1)^{-0.235}$

#### "Appalachian Plateau"

$Q1p25 = 70.25 * DA^{0.837} * LSLOPE^{0.327}$   
 $Q1p50 = 87.42 * DA^{0.837} * LSLOPE^{0.321}$   
 $Q1p75 = 96.37 * DA^{0.836} * LSLOPE^{0.307}$   
 $Q2 = 101.41 * DA^{0.834} * LSLOPE^{0.3}$   
 $Q5 = 179.13 * DA^{0.826} * LSLOPE^{0.314}$   
 $Q10 = 255.75 * DA^{0.821} * LSLOPE^{0.34}$   
 $Q25 = 404.22 * DA^{0.812} * LSLOPE^{0.393}$   
 $Q50 = 559.8 * DA^{0.806} * LSLOPE^{0.435}$   
 $Q100 = 766.28 * DA^{0.799} * LSLOPE^{0.478}$   
 $Q200 = 1046.9 * DA^{0.793} * LSLOPE^{0.525}$   
 $Q500 = 1565 * DA^{0.784} * LSLOPE^{0.589}$

### Eastern Coastal Plain

$Q1p25 = 19.85 * DA^{0.796} * BR^{0.066} * (SA + 1)^{-0.106}$   
 $Q1p50 = 20.48 * DA^{0.795} * BR^{0.156} * (SA + 1)^{-0.14}$   
 $Q1p75 = 20.81 * DA^{0.799} * BR^{0.197} * (SA + 1)^{-0.146}$   
 $Q2 = 20.95 * DA^{0.803} * BR^{0.222} * (SA + 1)^{-0.144}$   
 $Q5 = 25.82 * DA^{0.793} * BR^{0.368} * (SA + 1)^{-0.19}$   
 $Q10 = 31.17 * DA^{0.777} * BR^{0.439} * (SA + 1)^{-0.215}$   
 $Q25 = 40.26 * DA^{0.751} * BR^{0.511} * (SA + 1)^{-0.242}$   
 $Q50 = 50# * DA^{0.732} * BR^{0.549} * (SA + 1)^{-0.261}$   
 $Q100 = 63.44 * DA^{0.711} * BR^{0.576} * (SA + 1)^{-0.279}$   
 $Q200 = 79.81 * DA^{0.689} * BR^{0.601} * (SA + 1)^{-0.296}$   
 $Q500 = 108.7 * DA^{0.66} * BR^{0.628} * (SA + 1)^{-0.316}$

DA Drainage Area

BR Basin Relief

IA Percent of Impervious Area

F Percent Forest

LIME Percent Limestone

SA Percent Soil Type A

SD Percent Soil Type D

## USGS Regression Equations (Dillow 1996)

### Appalachian Plateaus and Allegheny Ridges region

$Q_2 = (106 * A^{0.851} * (F + 10)^{-0.223} * BR^{0.056})$   
 $Q_5 = (109 * A^{0.858} * (F + 10)^{-0.143} * BR^{0.064})$   
 $Q_{10} = (113 * A^{0.859} * (F + 10)^{-0.106} * BR^{0.072})$   
 $Q_{25} = (118 * A^{0.858} * (F + 10)^{-0.072} * BR^{0.087})$   
 $Q_{50} = (121 * A^{0.858} * (F + 10)^{-0.051} * BR^{0.099})$   
 $Q_{100} = (124 * A^{0.858} * (F + 10)^{-0.033} * BR^{0.111})$   
 $Q_{500} = (127 * A^{0.859} * (F + 10)^{0.004} * BR^{0.14})$

### Blue Ridge and Great Valley region

$Q_2 = (4260 * A^{0.774} * (LI + 10)^{-0.549} * BR^{-0.405})$   
 $Q_5 = (6670 * A^{0.752} * (LI + 10)^{-0.564} * BR^{-0.354})$   
 $Q_{10} = (8740 * A^{0.741} * (LI + 10)^{-0.579} * BR^{-0.326})$   
 $Q_{25} = (12000 * A^{0.73} * (LI + 10)^{-0.602} * BR^{-0.295})$   
 $Q_{50} = (15100 * A^{0.723} * (LI + 10)^{-0.62} * BR^{-0.276})$   
 $Q_{100} = (18900 * A^{0.719} * (LI + 10)^{-0.639} * BR^{-0.261})$   
 $Q_{500} = (31800 * A^{0.712} * (LI + 10)^{-0.686} * BR^{-0.241})$

### Eastern Coastal Plain region

$Q_2 = (0.25 * A^{0.591} * (RCN - 33)^{1.7} * BR^{0.31} * (F + 10)^{-0.464} * (ST + 10)^{-0.148})$   
 $Q_5 = (1.05 * A^{0.595} * (RCN - 33)^{1.74} * BR^{0.404} * (F + 10)^{-0.586} * (ST + 10)^{-0.498})$   
 $Q_{10} = (3.24 * A^{0.597} * (RCN - 33)^{1.71} * BR^{0.436} * (F + 10)^{-0.667} * (ST + 10)^{-0.694})$   
 $Q_{25} = (13.1 * A^{0.597} * (RCN - 33)^{1.66} * BR^{0.457} * (F + 10)^{-0.77} * (ST + 10)^{-0.892})$   
 $Q_{50} = (35 * A^{0.594} * (RCN - 33)^{1.62} * BR^{0.465} * (F + 10)^{-0.847} * (ST + 10)^{-1.01})$   
 $Q_{100} = (87.6 * A^{0.589} * (RCN - 33)^{1.58} * BR^{0.47} * (F + 10)^{-0.923} * (ST + 10)^{-1.11})$   
 $Q_{500} = (627 * A^{0.573} * (RCN - 33)^{1.49} * BR^{0.478} * (F + 10)^{-1.1} * (ST + 10)^{-1.29})$

A Area

RCN Runoff Curve Number

BR Basin Relief

F Percent Forest

ST Percent Storage

LI Percent Limestone

### Piedmont

$Q_2 = (451 * A^{0.635} * (F + 10)^{-0.266})$   
 $Q_5 = (839 * A^{0.606} * (F + 10)^{-0.248})$   
 $Q_{10} = (1210 * A^{0.589} * (F + 10)^{-0.242})$   
 $Q_{25} = (1820 * A^{0.574} * (F + 10)^{-0.239})$   
 $Q_{50} = (2390 * A^{0.565} * (F + 10)^{-0.24})$   
 $Q_{100} = (3060 * A^{0.557} * (F + 10)^{-0.241})$   
 $Q_{500} = (5190 * A^{0.543} * (F + 10)^{-0.245})$

### Western Coastal Plain

$Q_2 = (1410 * A^{0.761} * (F + 10)^{-0.782})$   
 $Q_5 = (1780 * A^{0.769} * (F + 10)^{-0.687})$   
 $Q_{10} = (1910 * A^{0.771} * (F + 10)^{-0.613})$   
 $Q_{25} = (2000 * A^{0.772} * (F + 10)^{-0.519})$   
 $Q_{50} = (2060 * A^{0.771} * (F + 10)^{-0.452})$   
 $Q_{100} = (2140 * A^{0.77} * (F + 10)^{-0.391})$   
 $Q_{500} = (2380 * A^{0.765} * (F + 10)^{-0.263})$

## Curve Number Tables

### GOOD CONDITIONS

| NLCD ID | Land Use Name                                | A   | B   | C   | D   |
|---------|--|-----|-----|-----|-----|
| 11      | Open Water                                   | 100 | 100 | 100 | 100 |
| 12      | Perennial Ice/Snow                           | 100 | 100 | 100 | 100 |
| 21      | Developed, Open Space                        | 39  | 61  | 74  | 80  |
| 22      | Developed, Low Intensity                     | 61  | 76  | 84  | 88  |
| 23      | Developed, Medium Intensity                  | 68  | 80  | 86  | 89  |
| 24      | Developed, High Intensity                    | 81  | 88  | 91  | 93  |
| 31      | Barren Land (Rock/Sand/Clay)                 | 77  | 86  | 91  | 94  |
| 32      | Unconsolidated Shore* -                      | 77  | 86  | 91  | 94  |
| 41      | Deciduous Forest -                           | 30  | 55  | 70  | 77  |
| 42      | Evergreen Forest -                           | 30  | 55  | 70  | 77  |
| 43      | Mixed Forest -                               | 30  | 55  | 70  | 77  |
| 51      | Dwarf Scrub –                                | 35  | 56  | 70  | 77  |
| 52      | Shrub/Scrub –                                | 35  | 56  | 70  | 77  |
| 71      | Grassland/Herbaceous.                        | 49  | 69  | 79  | 84  |
| 72      | Sedge/Herbaceous                             | 49  | 69  | 79  | 84  |
| 81      | Pasture/Hay -                                | 67  | 78  | 85  | 89  |
| 82      | Cultivated Crops -                           | 67  | 78  | 85  | 89  |
| 90      | Woody Wetlands -                             | 100 | 100 | 100 | 100 |
| 91      | Palustrine Forested Wetland*                 | 100 | 100 | 100 | 100 |
| 92      | Palustrine Scrub/Shrub Wetland*              | 100 | 100 | 100 | 100 |
| 93      | Estuarine Forested Wetland*                  | 100 | 100 | 100 | 100 |
| 94      | Estuarine Scrub/Shrub Wetland*               | 100 | 100 | 100 | 100 |
| 95      | Emergent Herbaceous Wetlands                 | 100 | 100 | 100 | 100 |
| 96      | Palustrine Emergent Wetland<br>(Persistent)* | 100 | 100 | 100 | 100 |
| 97      | Estuarine Emergent Wetland*                  | 100 | 100 | 100 | 100 |
| 98      | Palustrine Aquatic Bed*                      | 100 | 100 | 100 | 100 |
| 99      | Estuarine Aquatic Bed*                       | 100 | 100 | 100 | 100 |

## FAIR CONDITIONS

| NLCD ID | Land Use Name                             | A   | B   | C   | D   |
|---------|---|-----|-----|-----|-----|
| 11      | Open Water                                | 100 | 100 | 100 | 100 |
| 12      | Perennial Ice/Snow                        | 100 | 100 | 100 | 100 |
| 21      | Developed, Open Space                     | 49  | 69  | 79  | 84  |
| 22      | Developed, Low Intensity                  | 66  | 79  | 86  | 89  |
| 23      | Developed, Medium Intensity               | 86  | 91  | 94  | 95  |
| 24      | Developed, High Intensity                 | 95  | 96  | 97  | 98  |
| 31      | Barren Land (Rock/Sand/Clay)              | 77  | 86  | 91  | 94  |
| 32      | Unconsolidated Shore* -                   | 77  | 86  | 91  | 94  |
| 41      | Deciduous Forest -                        | 36  | 60  | 73  | 79  |
| 42      | Evergreen Forest -                        | 36  | 60  | 73  | 79  |
| 43      | Mixed Forest -                            | 36  | 60  | 73  | 79  |
| 51      | Dwarf Scrub -                             | 48  | 56  | 70  | 77  |
| 52      | Shrub/Scrub -                             | 48  | 56  | 70  | 77  |
| 71      | Grassland/Herbaceous.                     | 54  | 74  | 84  | 87  |
| 72      | Sedge/Herbaceous                          | 54  | 74  | 84  | 87  |
| 81      | Pasture/Hay -                             | 70  | 80  | 87  | 90  |
| 82      | Cultivated Crops -                        | 70  | 80  | 87  | 90  |
| 90      | Woody Wetlands -                          | 100 | 100 | 100 | 100 |
| 91      | Palustrine Forested Wetland*              | 100 | 100 | 100 | 100 |
| 92      | Palustrine Scrub/Shrub Wetland*           | 100 | 100 | 100 | 100 |
| 93      | Estuarine Forested Wetland*               | 100 | 100 | 100 | 100 |
| 94      | Estuarine Scrub/Shrub Wetland*            | 100 | 100 | 100 | 100 |
| 95      | Emergent Herbaceous Wetlands              | 100 | 100 | 100 | 100 |
| 96      | Palustrine Emergent Wetland (Persistent)* | 100 | 100 | 100 | 100 |
| 97      | Estuarine Emergent Wetland*               | 100 | 100 | 100 | 100 |
| 98      | Palustrine Aquatic Bed*                   | 100 | 100 | 100 | 100 |
| 99      | Estuarine Aquatic Bed*                    | 100 | 100 | 100 | 100 |

## POOR CONDITIONS

| NLCD ID | Land Use Name                             | A   | B   | C   | D   |
|---------|---|-----|-----|-----|-----|
| 11      | Open Water                                | 100 | 100 | 100 | 100 |
| 12      | Perennial Ice/Snow                        | 100 | 100 | 100 | 100 |
| 21      | Developed, Open Space                     | 68  | 79  | 86  | 89  |
| 22      | Developed, Low Intensity                  | 76  | 84  | 89  | 91  |
| 23      | Developed, Medium Intensity               | 79  | 86  | 91  | 92  |
| 24      | Developed, High Intensity                 | 88  | 91  | 94  | 95  |
| 31      | Barren Land (Rock/Sand/Clay)              | 77  | 86  | 91  | 94  |
| 32      | Unconsolidated Shore* -                   | 77  | 86  | 91  | 94  |
| 41      | Deciduous Forest -                        | 45  | 66  | 77  | 83  |
| 42      | Evergreen Forest -                        | 45  | 66  | 77  | 83  |
| 43      | Mixed Forest -                            | 45  | 66  | 77  | 83  |
| 51      | Dwarf Scrub -                             | 48  | 67  | 77  | 83  |
| 52      | Shrub/Scrub -                             | 48  | 67  | 77  | 83  |
| 71      | Grassland/Herbaceous.                     | 58  | 78  | 88  | 91  |
| 72      | Sedge/Herbaceous                          | 58  | 78  | 88  | 91  |
| 81      | Pasture/Hay -                             | 72  | 81  | 88  | 91  |
| 82      | Cultivated Crops -                        | 72  | 81  | 88  | 91  |
| 90      | Woody Wetlands -                          | 100 | 100 | 100 | 100 |
| 91      | Palustrine Forested Wetland*              | 100 | 100 | 100 | 100 |
| 92      | Palustrine Scrub/Shrub Wetland*           | 100 | 100 | 100 | 100 |
| 93      | Estuarine Forested Wetland*               | 100 | 100 | 100 | 100 |
| 94      | Estuarine Scrub/Shrub Wetland*            | 100 | 100 | 100 | 100 |
| 95      | Emergent Herbaceous Wetlands              | 100 | 100 | 100 | 100 |
| 96      | Palustrine Emergent Wetland (Persistent)* | 100 | 100 | 100 | 100 |
| 97      | Estuarine Emergent Wetland*               | 100 | 100 | 100 | 100 |
| 98      | Palustrine Aquatic Bed*                   | 100 | 100 | 100 | 100 |
| 99      | Estuarine Aquatic Bed*                    | 100 | 100 | 100 | 100 |