Watersheds in GIS

Definition (Hydrologic): A watershed is a contiguous region of land that all drains to a single location called the watershed outlet.

Definition (GIS): A watershed is the set of al pixels whose downstream flowpath passes through a selected (outlet) pixel.

Why is the watershed concept important?

Just as control volumes or free-body diagrams in physics and engineering mechanics were powerful concepts because they focussed all attention on "the system", in hydrology, the watershed is the "system" of interest. Points (pixels) outside of the watershe are not of concern when calculating a hydrologically relevant quantity like water flow, contaminent concentration, or % forest cover.

How do I use the GIS to delineate a watershed?

The ArcView syntax for delineating a watershed is:

```
'
' Overhead Commands
'
theView = av.GetActiveDoc
theDisplay = theView.GetDisplay
'
' Get User Defined Watershed Location
'
thePoint = theDisplay.ReturnUserPoint
mPoint = MultiPoint.Make({thePoint})
'
' Get Flow Direction Grid
'
FlowDir = theView.FindTheme("Flow Direction").GetGrid
SrcGrid = FlowDir.ExtractByPoints(mPoint,
     Prj.MakeNull, FALSE)
'
' Delineate Watershed
'
ShedGrid = FlowDir.Watershed(SrcGrid)
'
' Add delineated watershed to the View
'
ShedTheme = GTheme.Make(ShedGrid)
ShedTheme.SetName("A Watershed")
theView.AddTheme(ShedTheme)
```

which is a lot to swallow all at one time. The above syntax, after performing some "overhead" calculations is doing two basic tasks. It is getting a user defined point from the display (this is the boldface "**ReturnUserPoint**" command) which is the watershed outlet. Then it is determining the actual watershed in the other boldface line where the **ShedGrid** is a grid that stores the delineated watershed. The final lines of code add the watershed grid to the view as a grid theme.
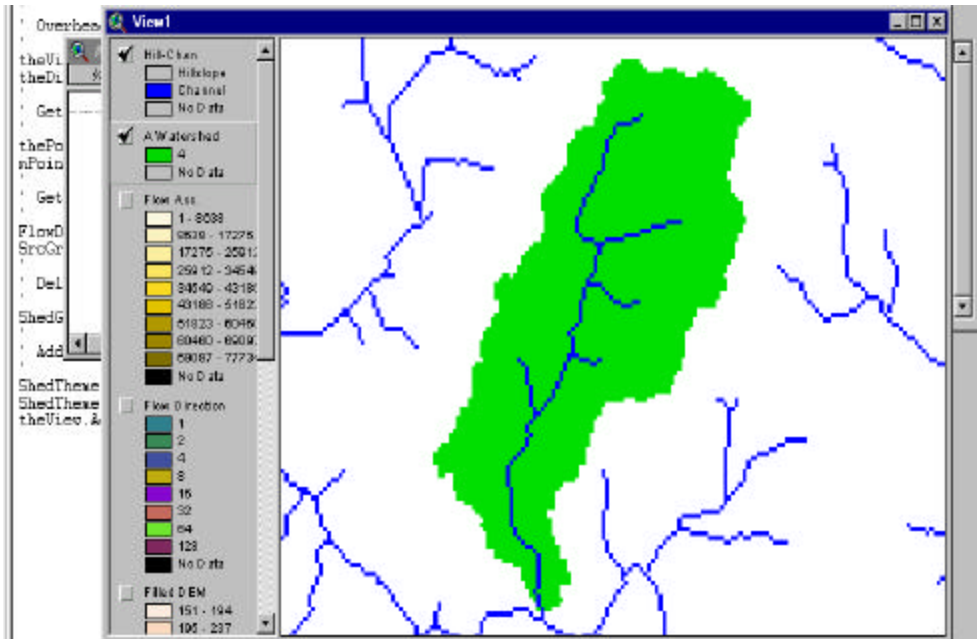

The above picture shows an isolated watershed and the drainage network overlying it. Note that the "A Watershed" theme shows two values (4, and No Data). Every pixel within the watershed is identified by the number "4".

If we click on the table for the watershed theme we get:

Which shows that this theme has only one value (4), and that there are 4802 pixels with this same value. This means that there are 4802 pixels within the watershed. With the flow accumulation theme active, the "identify" tool selecting the outlet pixel gives:
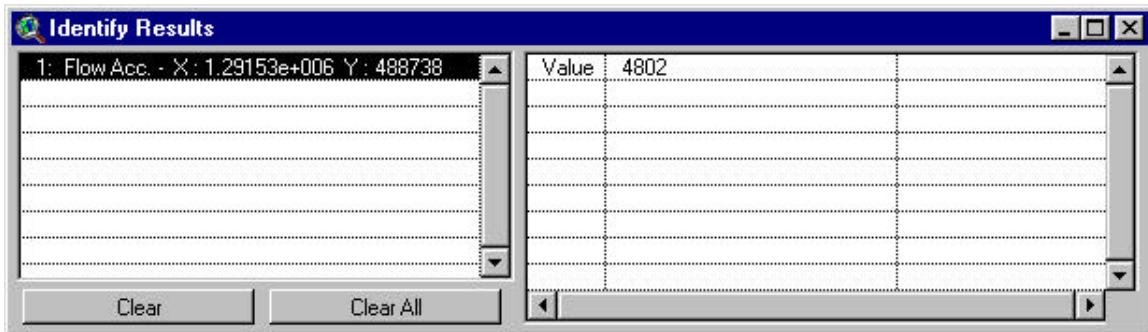

This confirms that the watershed area is equal to the flow accumulation at the watershed's outlet, an important fact to remember.

Another way to look at a watershed is to examine its flow paths.
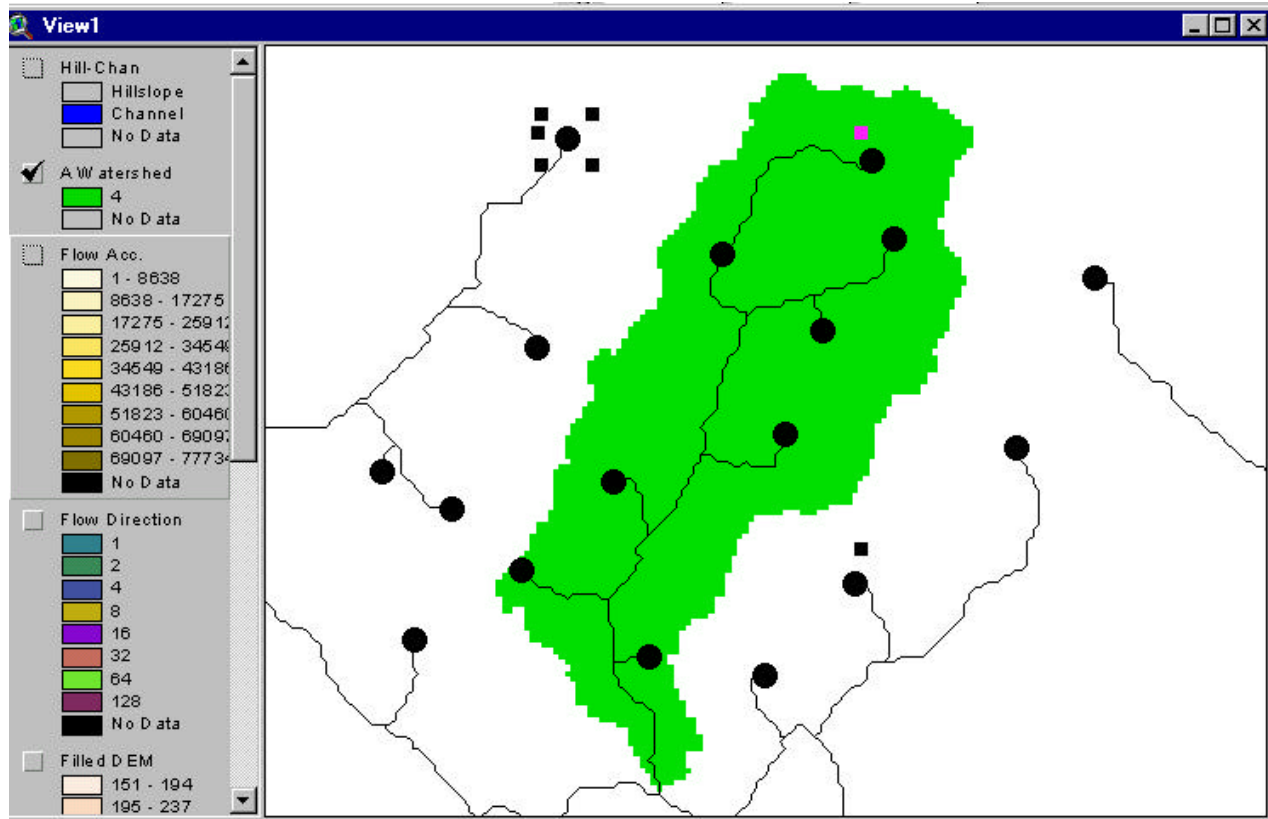
The above view shows the result of clicking using the "Raindrop Tool" in and around our watershed. The large circles indicate the point that was clicked on, and the black lines trailing from the circles indicate the downstream flow paths. You should notice that all black circles within the watershed hove downstream flow paths through our watershed's outlet. All other Black circles downstream without passing through the selected watershed outlet.

One of the powerful concepts in GIS is that of "masking". The watershed theme can be thought of as a pattern that acts like a "cookie-cutter" selecting data intersecting the mask and setting everything outside of the mask to "nil" (No Data). Once a theme has been "masked" by the watershed, calculations on the remaining, non-zero data can be performed unimpeded by the data external to the watershed.
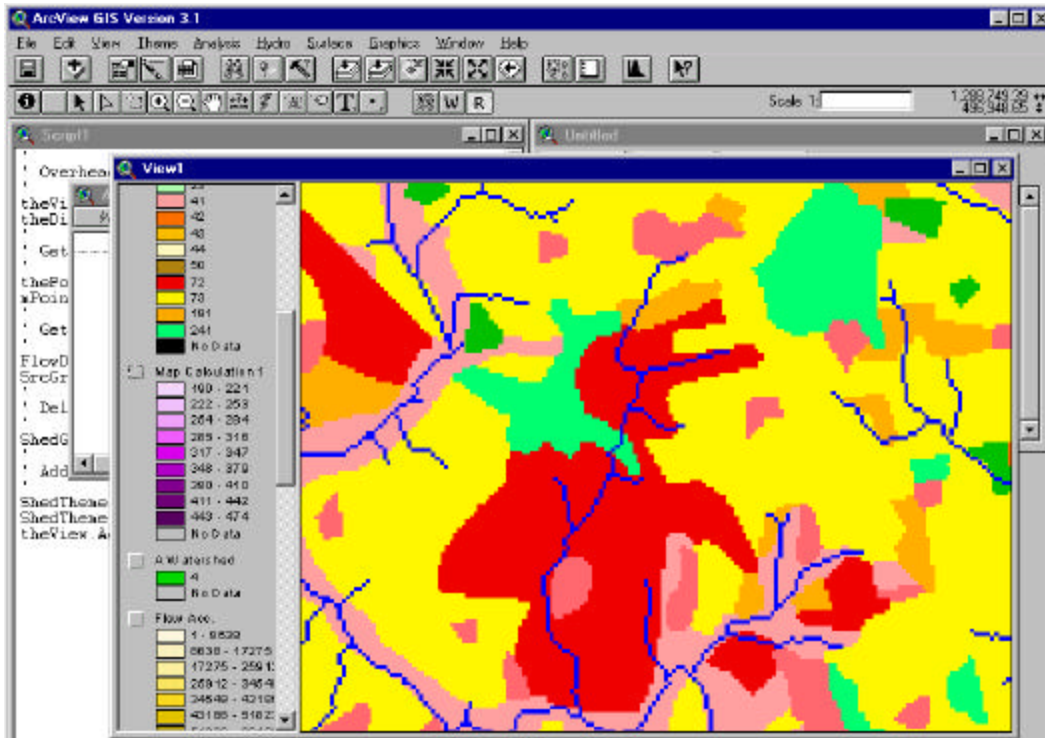
Overall Land Use coverage in vicinity of study watershed.
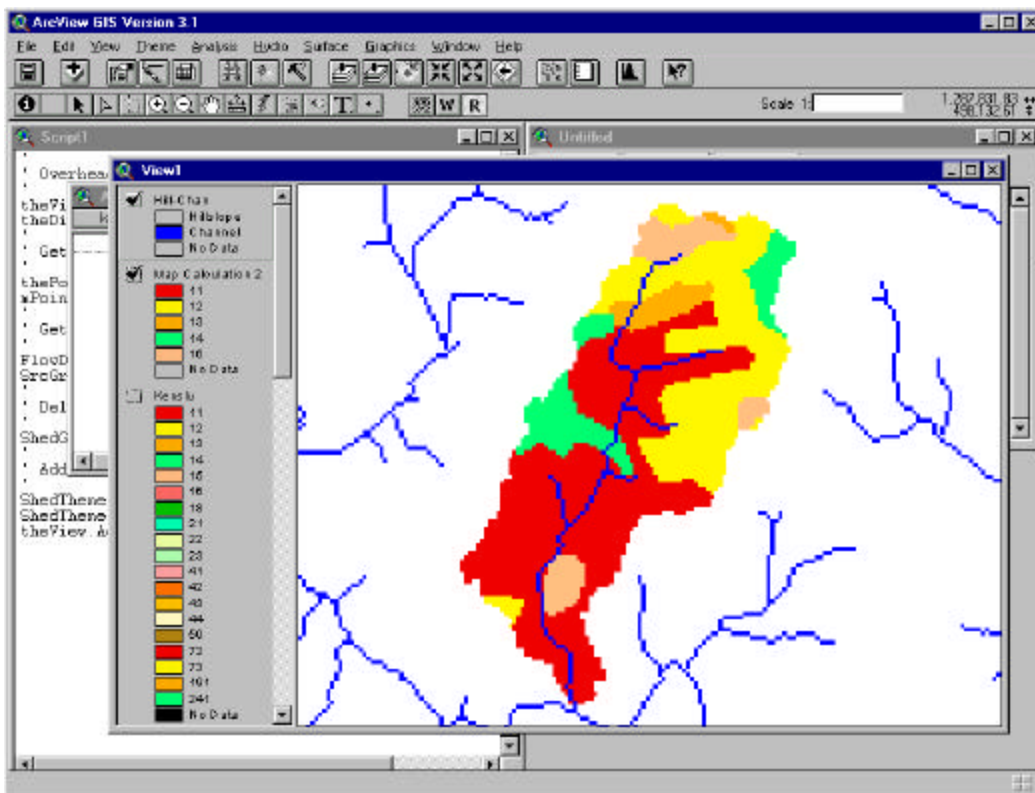
Masked Land Use coverage within watershed.

If we examine the theme tables for our Land Use and our Masked Land Use (corresponding to the pictures on the previous page) we find:

Attributes Of Map Calculation 2		
Value	Count	
11	2420	
12	1366	
13	186	
14	482	
16	348	

Attributes Of Kenslu		
Value	Count	
11	27670	
12	61694	
13	10421	
14	9434	
15	91	
16	7738	
18	8841	
21	1878	
22	2567	
23	671	
41	23537	

Where we can see that the number of pixels of land uses 11 through 16 is significantly diminished in the Map Calculation 2 theme (this is the masked land use theme) as compared to the Kenslu theme (the unmasked land use theme).

Finally, some comments on performing some of the functions described within this document:
1. You can write scripts to isolate watershed (and you will!) but for now, you can add a new extension (called CE465Hydro) just as you added the spatial analyst extension earlier in the semester. This will add two tools to your view functions, a "W" tool which delineates watersheds when clicking on outlets, and an "R" tool which traces flow paths downstream from a raindrop landing point.
2. This extension is already loaded on the PC's in the construction lab, and can be downloaded from my web site at
   http://www.ence.umd.edu/~moglen/ce465/ce465hydro.avx
   If you want this to work in your glue account, simply copy this file in your root directory.
3. All other calculations shown here were done using the map calculator facility.