OUTLINE

GIS Tools for Hydrology and Hydraulics

INTRODUCTION

Good afternoon! Welcome and thanks for coming.

I once heard GIS described as a high-end Swiss Army knife: lots of tools in one little package

The problem is that GIS has SO many tools and SO many are just obscure, that

You don't know what some of the tools are and
The ones you can find, you don't always know what they do

So today, what we want to do is to open up some of the tools that we use in ArcGIS for H&H…

Well, actually, mostly hydrology
And let you have a look

Unfortunately, we can't teach you how to USE the tools, because that would take an all-day training,

but at least we can take a look at them and hopefully begin to see how they can be used.

SO, THE FIRST QUESTION IS, WHAT KIND OF TOOLS ARE OUT THERE?

Well, let me clarify one thing first: by "tools" I don't just mean stuff can click in GIS, but I also am going to include data into the category of "tools"

And in fact, most of the "tools" we will discuss today will be data… so what do we got?

A. One of the primary tools that we use is a State-wide digital elevation model

1. If you are like me, you see the letters DEM and don't even think about what they mean

2. But it is important to understand what a DEM is…

   A DEM is a raster file - Oh, yeah, like that helps…

   Basically, it is like a grid – and every opening in the grid has a number which is an elevation

So, the whole state of Indiana has been divided into a 1.5 x 1.5 meter (5x5 foot) grid and there is an elevation assigned to each space in that grid

3. Many of you may have heard this called LIDAR data, and that is basically correct…

   Indiana gathered LiDAR data for the entire state from 2011 - 2013

   And that raw LiDAR (LAS) data had to be processed in order to derive the DEM data

   The LiDAR data has things like trees, buildings and even barrier rails in it so if you want an actual GROUND elevation some processing has to happen

   Since that processing had to have been automated, you will need to evaluate the DEM data carefully since you don't necessarily know how good that processing actually was.

B. One of the primary tools used for working with DEM data is "3D Analyst"

   1. This is a tool that will allow you to work with DEM data in bulk.

   2. It is possible to query individual spots on the grid to get the elevation, but this is cumbersome, 3D Analyst will allow you to get what you need from the DEM data much more quickly.

   3. Note that 3D Analyst is an add-in and requires a separate license.

      INDOT does not have a lot of them!

C. Another tool / data that we have at our disposal is a GIS layer that we call "hillshade"

   1. Essentially, this uses a display effect to show which way the ground slopes

   2. The hillshade data we use is based on a DEM that was done in 2005 which is much more generalized that the 2011 – 2013 data

   3. Even the actual 2005 elevation data is not that useful for our purposes, the more generalized hillshade makes this layer much more useful than a hillshade based on a 5-foot grid.

D. Now, soil data is something we use frequently in doing hydrology computations

   1. If you are an old dinosaur like me, you always used to get this information from the old paper County Soil Reports.

2. Now we have GIS layers which recreate these old county soil maps

3. The good part about this is that these soil maps have an "attribute table" which provides all of the information for a specific blob on the maps

4. This means that you can now use the information tool in GIS and to understand important things like the hydrologic soil group of the soil

5. We will see later how that is useful for us.

E. Now, any time you are doing anything in GIS, you need a background map and in Hydraulics, we always use aerial photography for this purpose…

1. Typically, we will use two different maps: one based on 2005 orthophotography and the other based on the 2011 – 2013 orthophotography.

2. The 2005 orthophotography is useful, because it apparently places less demand on my computer and I can navigate through the map very quickly with it

3. On the other hand, the 2011 – 2013 orthos, for some reason, really want to bog my computer down.

4. However, it is very useful to compare the two sets of orthos for clarity when they are zoomed in. Different features on the ground show up differently…

OK, SO THERE ARE SOME TOOLS / DATA THAT YOU CAN USE FOR H&H, NOW LET'S LOOK AT THE KINDS OF THINGS WE CAN DO WITH THEM…

A. We said before, that these tools are used mostly for hydrology, if and we want to do hydrologic computations, there are at least three types of data we need:

Drainage area, Curve Number and Time of Concentration

B. So, there are lots of things in GIS that will help us figure out a drainage area

1. As we said before, one of the tools we use is the 2005 hillshade layer.

This is especially useful in flat areas in central and northern Indiana where there are lots of flat areas.

Helps me figure out where the depressional areas will spill once they fill up.

2. There are also a number of things we can do with the Statewide DEM data:

   One of the primary things is that we can use 3D Analyst to create contours.

   Obviously, this helps a lot in figuring out a drainage area, but one of the other things you can do is use something called “Map tips” to have the elevation of a contour line displayed by hovering the mouse.

   Also, 3D Analyst provides a 3D line tool that lets me cut a cross section along a line

   This is very useful in flat areas where I am trying to figure out where the slope actually breaks

   [in this example, looking at the approximate profile of a side ditch. Know that there is a break somewhere…]

3. Believe it or not, even the orthophotography can help a lot in figuring a drainage area…

   There are several times that the photography will show a culvert or other kind of drainage structure that will alter how we delineate the drainage area.

   Many times, a road becomes a drainage divide just because of the side ditches, so the ortho’s can help us identify the presence of ditches as well as the road alignment.

   Sometimes, even the presence of dark soils will help us figure out which way the water is moving through a watershed.

4. There is another type of tool worth mentioning, even though they are not exactly GIS tools…

   One is the USGS Streamstats application and the other is the Purdue L-THIA Online Watershed Delineation tool (OWL).

   Both of these tools will do an automated drainage area delineation for you, but both may need to be evaluated carefully.

   I know that Streamstats is based on the 2005 DEM data, but am not sure about the Purdue delineations, except that it very likely is also based on comparatively old information.

   That means that those delineations are best used for general information, especially for smaller watersheds.

C. One of the other important inputs for hydrology computations is the curve number

1. As you know, the two things we need for the CN are soil information and land use.

2. One of the very useful things you can do with the soil information is set the symbology to reflect the hydrologic soil group.

   Once you have done that, you can set the transparency so that the land use in the orthophotography is visible under the soil data.

   You can use this set to estimate your CN just by estimating the proportion of each combination of land use and HSG.

3. If you need (or want) to be more accurate than that, you can actually clip the soils data to the drainage area

   This allows you to use the "calculate geometry" tool to compute the area of each blob in the drainage area

   This then can be exported to Excel so that you can compute the number of acres of each hydrologic soil group in the watershed. [show example]

4. Ultimately, there should be a way to combine land use and HSG within GIS, but a really accurate way of doing this may be some time in the (distant) future…

D. The third piece of hydrologic data that GIS can help you with is the time of concentration

1. For this, we again turn to 3D Analyst…

   As we mentioned before, 3D Analyst offers a tool that will allow us to get a profile along a line we draw on DEM data

   This gives use the flow length and fall data we need to compute a TC

2. If you don't have a license for 3D Analyst, the process is more cumbersome, but could be accomplished by using the information tool in GIS

E. All of the things we have discussed so far have had to do with hydrology. Is there anything that would help us with HYDRAULIC analysis?

1. Well, it case it is not obvious, you could use 3D Analyst with the DEM data to get road profiles

and cut cross sections of streams.

Then, we can get a plot,
go to the advanced properties,
copy to the clipboard,
paste into Excel, and do some analysis for inputs to your H&H model

2. But you do need to be careful…

3. Here is an example of a road profile cut on I-164 in Vanderburgh County. The black dashed line is the DEM data and the red line is a profile based on the old road plans, adjusted for datum.

   See anything interesting about this?

   First of all, there is a fair amount of "noise" in the DEM data

   But – look at the Y-axis on this plot, the "noise" is possibly 0.2 – 0.3 feet

   This is processed information, right? But as one person I know said, you don't know how much of this is just cars

   Second, there are some places where the LiDAR don't appear to be that accurate

   Now, does this mean the project didn't get built according to plans? I don't know, but this sort of deviation seems to be quite common.

4. Another area were the DEM data requires careful evaluation is in getting channel cross sections…

   Here is a channel cross section obtained from DEM data – Look OK to you?

   Here is the DEM cross section compared to a surveyed channel cross section – how much difference is there in the channel bottom elevation?

   Remember that the DEM elevations are averaged on a 5-foot square grid. This means that you are going to lose definition in a small to medium stream channel

   Even if you have a large enough stream channel, the LiDAR data will not penetrate beneath the water surface elevation, so you still don't have a complete channel.

   Bottom line: There is no substitute for survey.

5. Now this doesn't mean that you should not use the DEM data out on the overbanks of the floodplain, and we frequently do. Essentially, we will copy the data into a spreadsheet along with survey data and use a graph to combine the two.

OK – SO FINALLY, AND BRIEFLY, LET'S TALK ABOUT WHERE TO FIND THE DATA THAT WE HAVE BEEN DISCUSSING…

1. First, if you are an INDOT employee, you have access to a host of GIS coverages not only through our servers, but also through the Government Information Office

   Now, to get access to those on an INDOT computer, you will need to have a configuration file installed on your computer

   If you don't have that, you will need to contact IOT and have them work with the INDOT INDOT MIS section.

2. If you are NOT an INDOT employee, you can still get this data on the internet

   Check out the Indiana Map at the address on the slide

   And look at the IU [sorry – I can't say those two letters here…] Spatial Data Portal which has all of the 2011 – 2013 LiDAR data, including the DEM's.

ALL RIGHT! THANKS FOR SITTING WITH ME THROUGH ALL OF THIS. DO WE HAVE TIME FOR QUESTIONS?