CE 365K Hydraulic Engineering Design **Spring 2016**

Designing a Detention Pond using FlowMaster, ArcGIS and HEC-HMS

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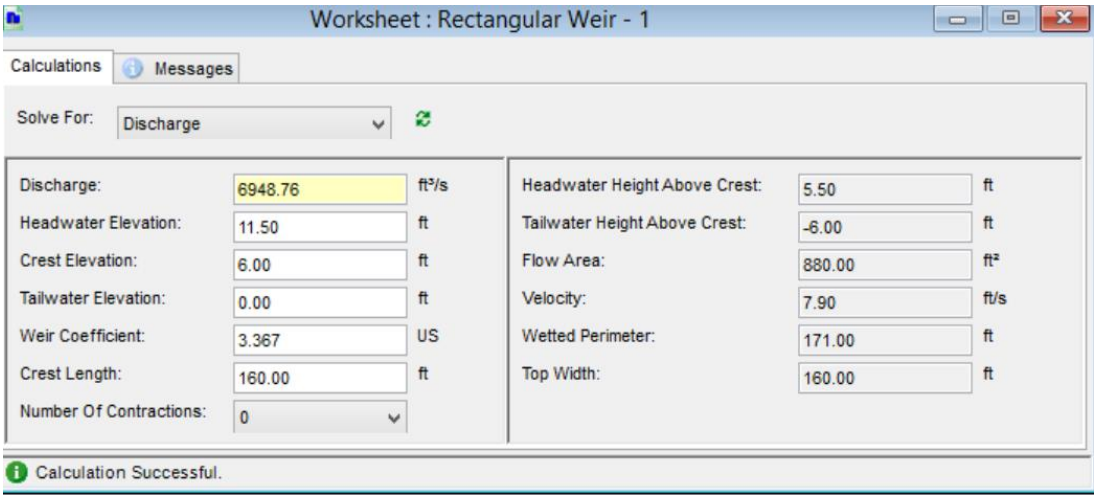
This example follows the pond using in Question 3 of the Second Exam for a pond located in the Boggy Creek Greenbelt with an outlet structure which is a rectangular weir.

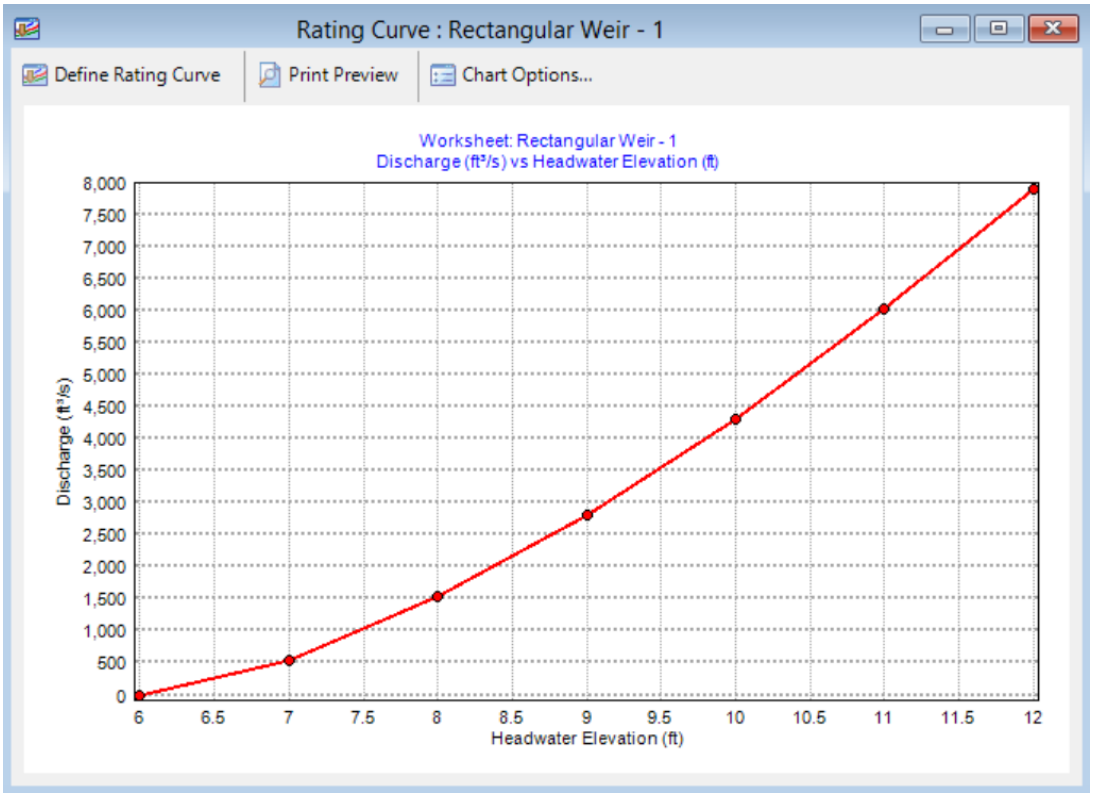
Contents

Outlet Structure

Assume a rectangular weir with width 160 ft, and crest elevation 6 ft. Compute discharge for headwater elevation of 11.50 ft (important to use discharge as the variable to be found so that you can get the rating curve later).



Compute a rating curve for the weir



Produce a report on the rating curve

Rating Curve for Rectangular Weir - 1

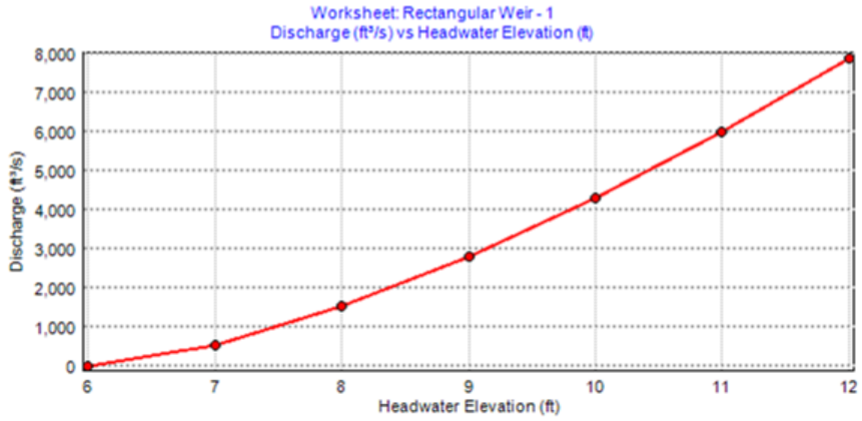
Project Description

Solve For	Discharge

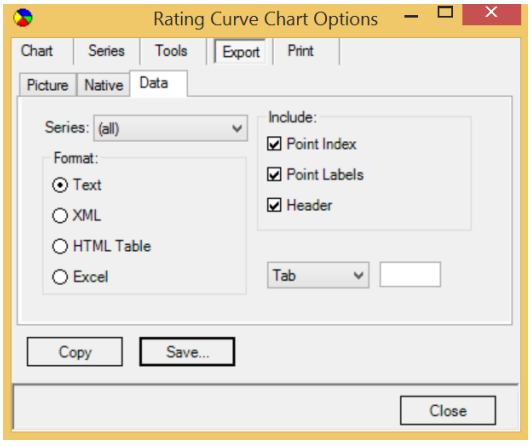
Input Data

Headwater Elevation	11.50	ft
Crest Elevation	6.00	ft
Tailwater Elevation	0.00	ft
Weir Coefficient	3.367	US
Crest Length	160.00	ft
Number Of Contractions	0	

Rating Curve Plot



Export the chart as Text (include “Point Index” to get value from both axes)



Here is the exported output file

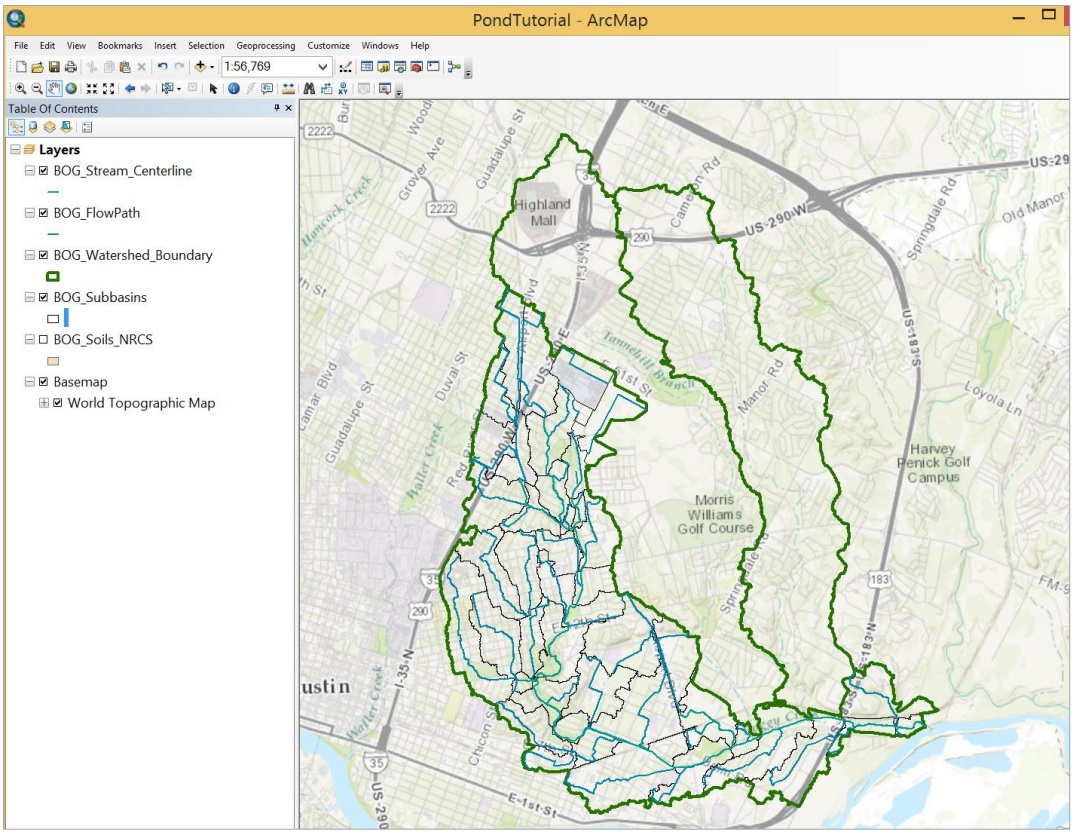
	A	B
1	Index	0
2	0	0
3	1	538.72
4	2	1523.73
5	3	2799.271
6	4	4309.76
7	5	6023.073
8	6	7917.535

Convert this to an Elevation-Discharge Curve, remembering that the crest elevation of the rectangular weir is at 480 ft above geodetic datum, and that the base elevation of the detention pond is 474 ft above geodetic datum

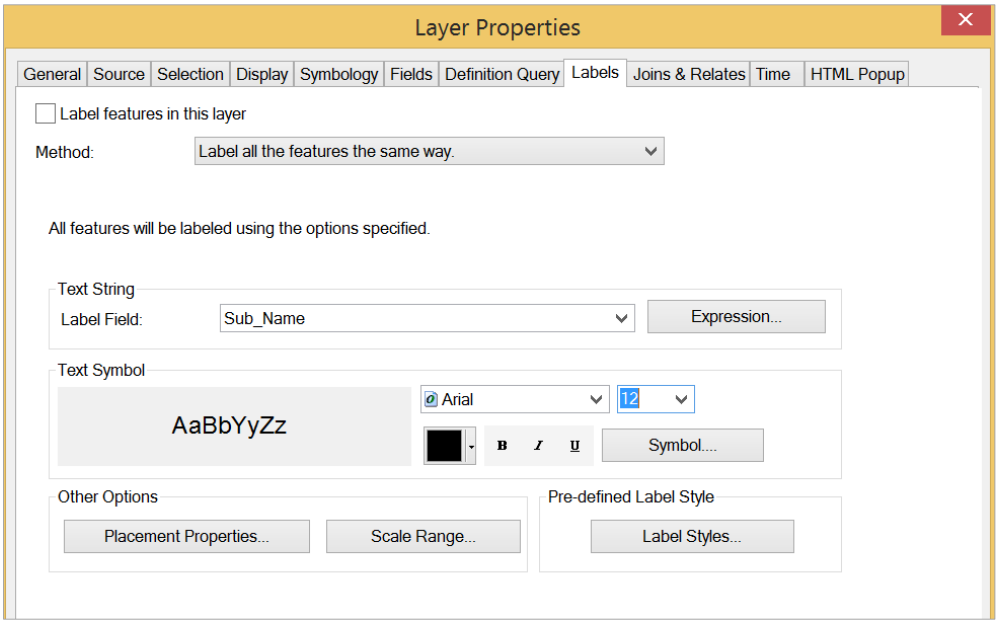
Elevation	Discharge
474	0
475	0
476	0
477	0
478	0
479	0
480	0
481	539
482	1524
483	2799
484	4310
485	6023
486	7918

Detention Pond

Open the Hydrology Spatial files for the watershed in ArcMap, recolor the themes appropriately and save the ArcMap document in the folder you want to use for the project data. Add a Topographic base map for spatial context.

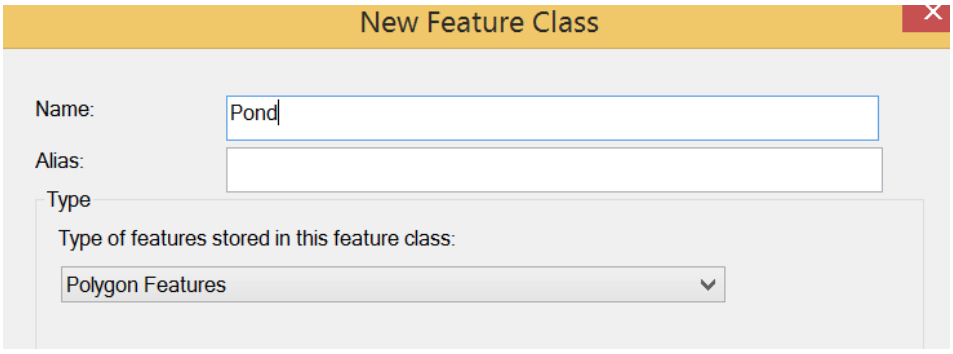


Right click on the **Subbasin** feature class, select **Properties** and set the Label field as **Subname** with size **12**. Right click on the Subbasin feature class again and select Label Features so you can see which subbasins you are dealing with.

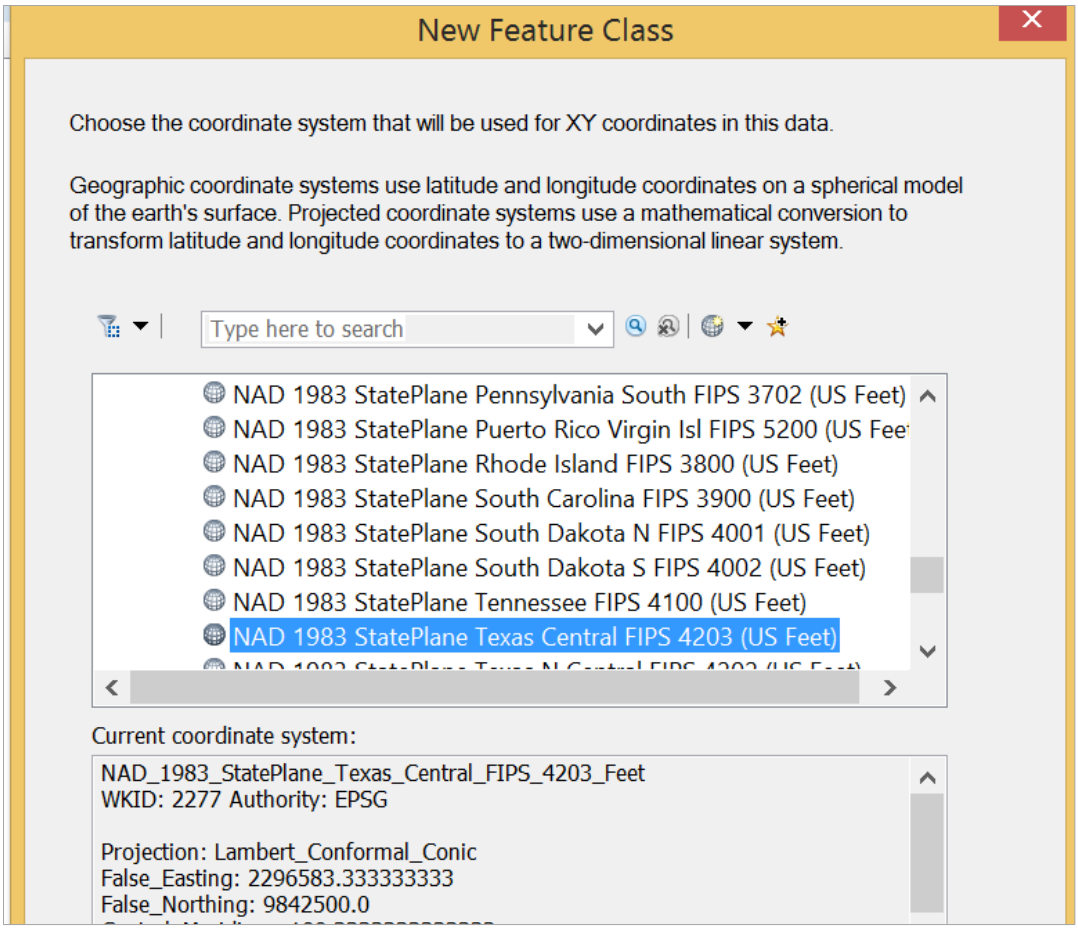


Zoom in to the area where you want to define a detention pond.

In the ArcCatalog tab on the right hand side of the ArcMap display, right click on the folder where your data are stored and select a New Geodatabase and call this **DesignProject**. Right click on the file geodatabase and select New Feature Class and call it **Pond**.

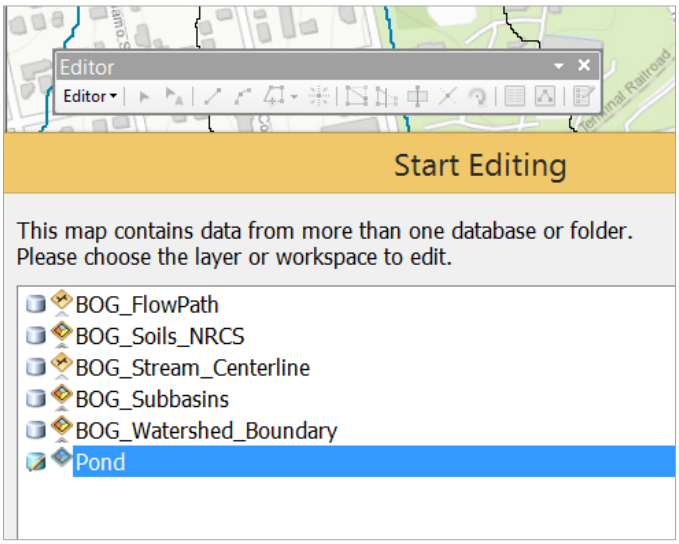


Use Texas State Plane Central Zone as XY Coordinate System

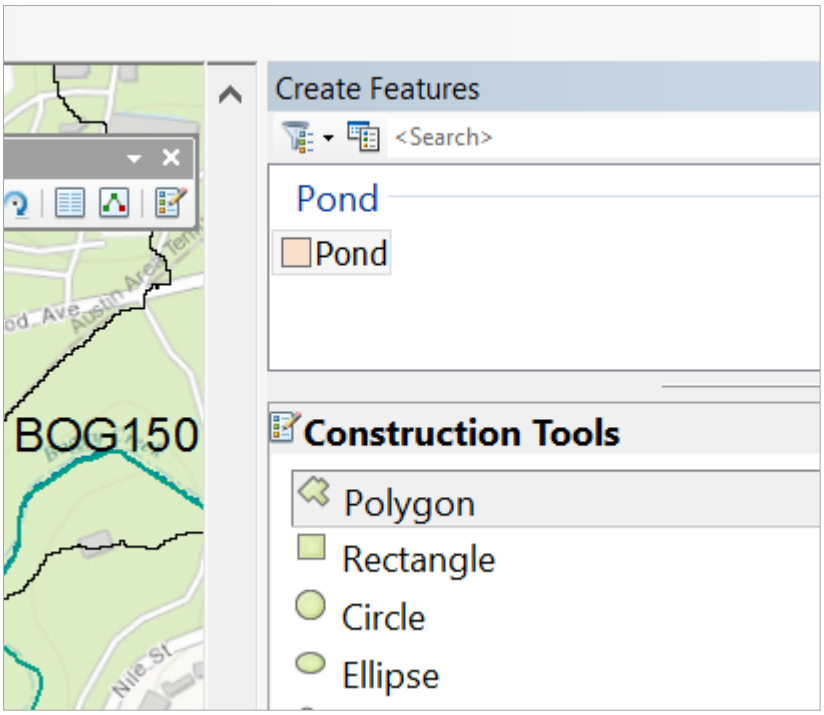


And click ok to all the rest of the questions to finish creating the feature class. This is just a holder to contain the outline of your pond, which we'll now digitize.

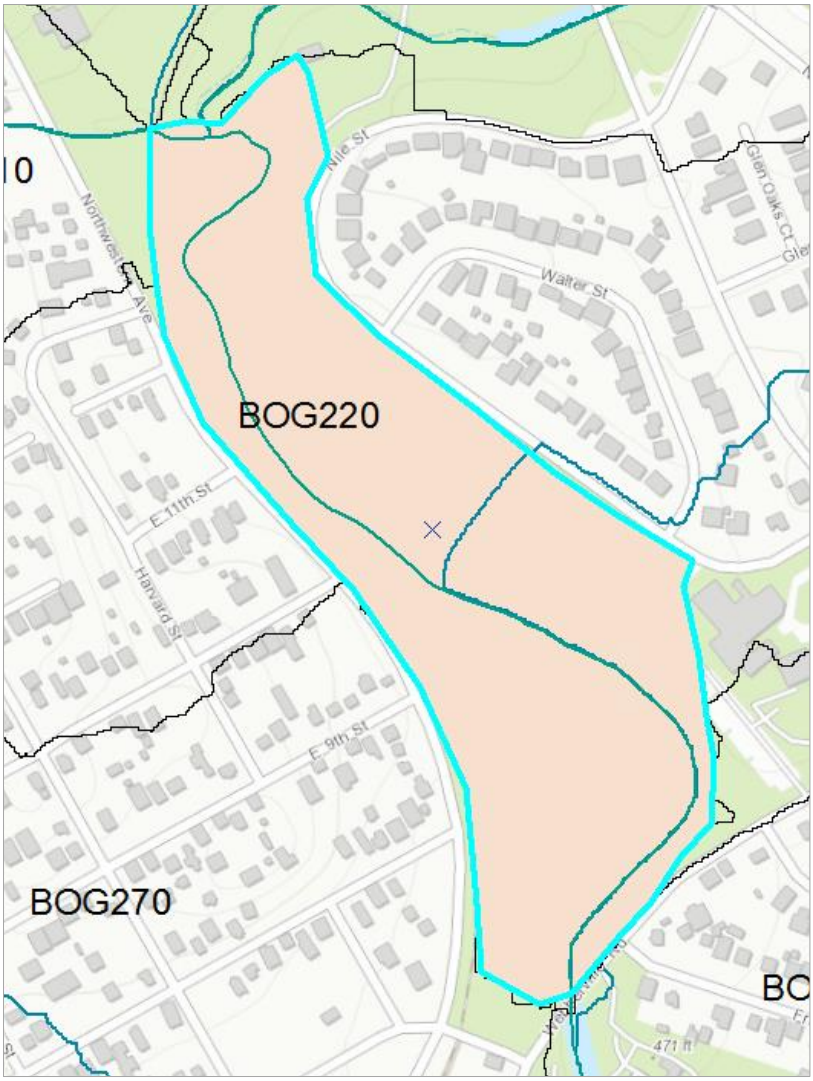
Click on **Customize/Toolbars** and select the **Editor** Toolbar. Start Editing and select the Pond feature class



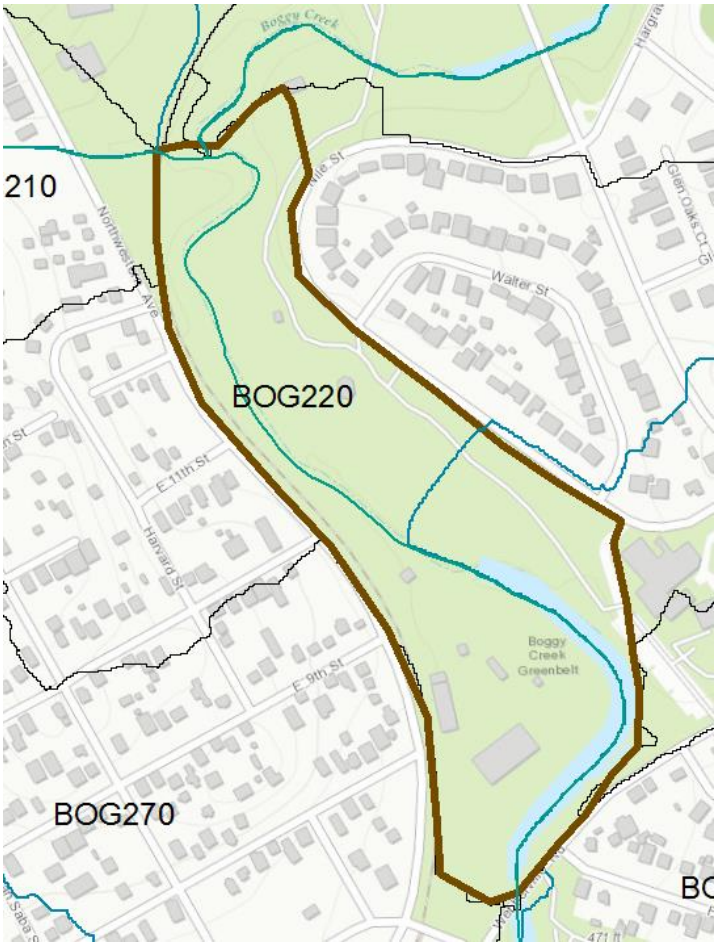
Click on the “Create Features” icon  at the right hand end of the Editor toolbar and select the Polygon option.



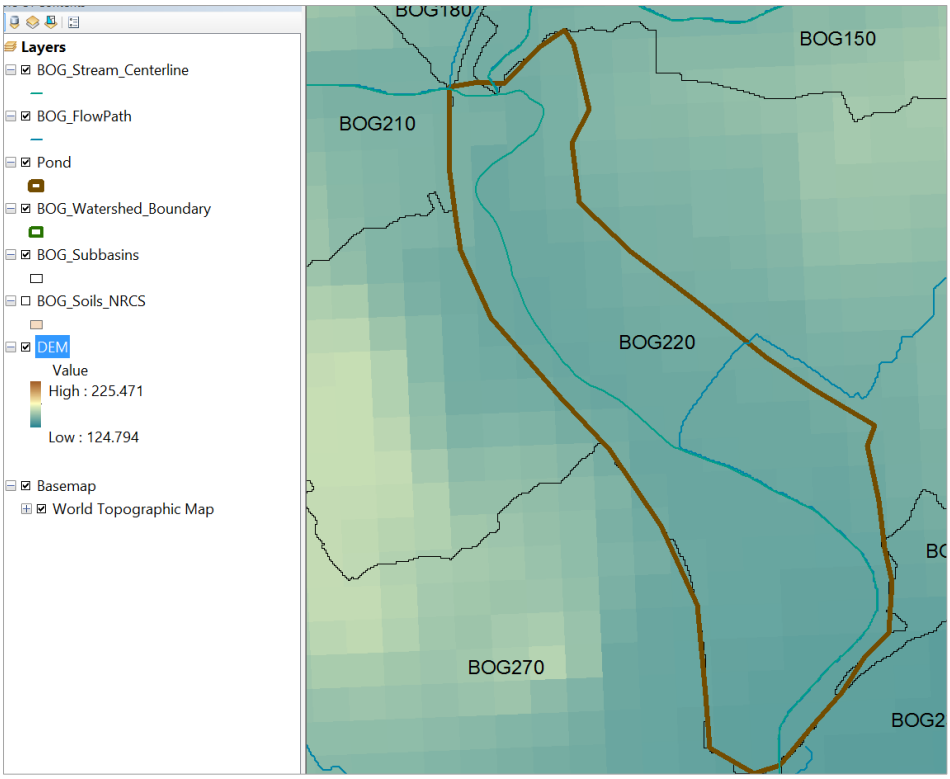
In this case, I followed the boundaries of the greenbelt and of the subbasin.



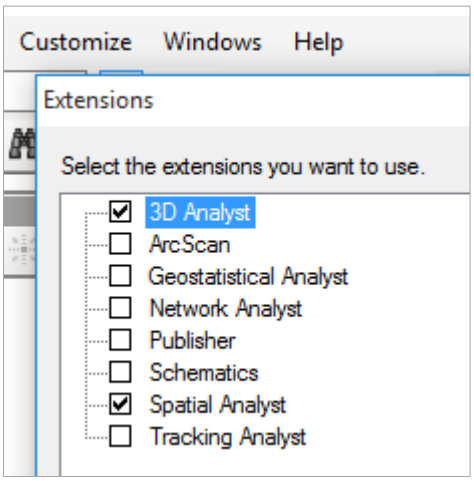
Stop editing and save edits. Now you have a Pond feature. Recolor it so you can see through the outline.



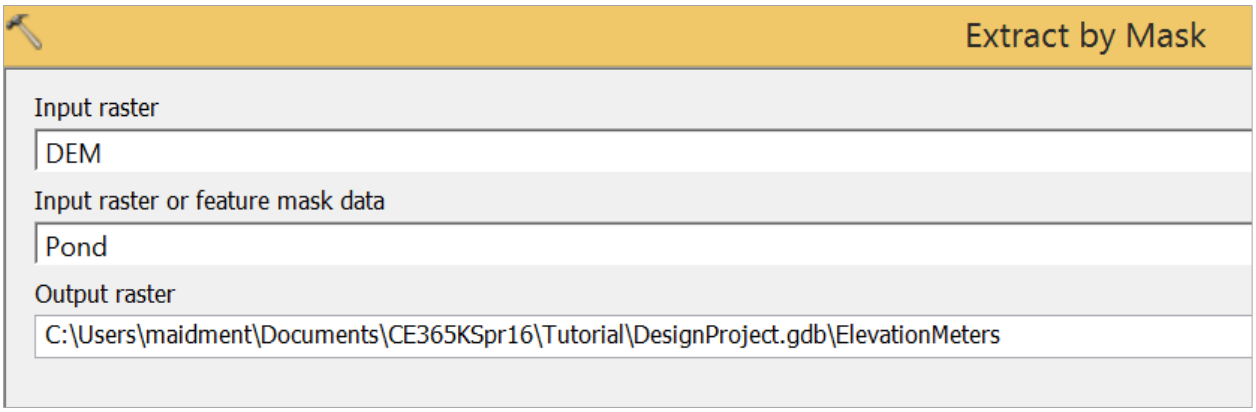
Add the **DEM** file that you got from applying the GetData function in HMSPrePro or from the WatershedData set that I supplied earlier. This elevation dataset has elevations in meters and has cells that are 30m x 30m in size. We'll work in metric units to be consistent with these data and then convert them to feet later.



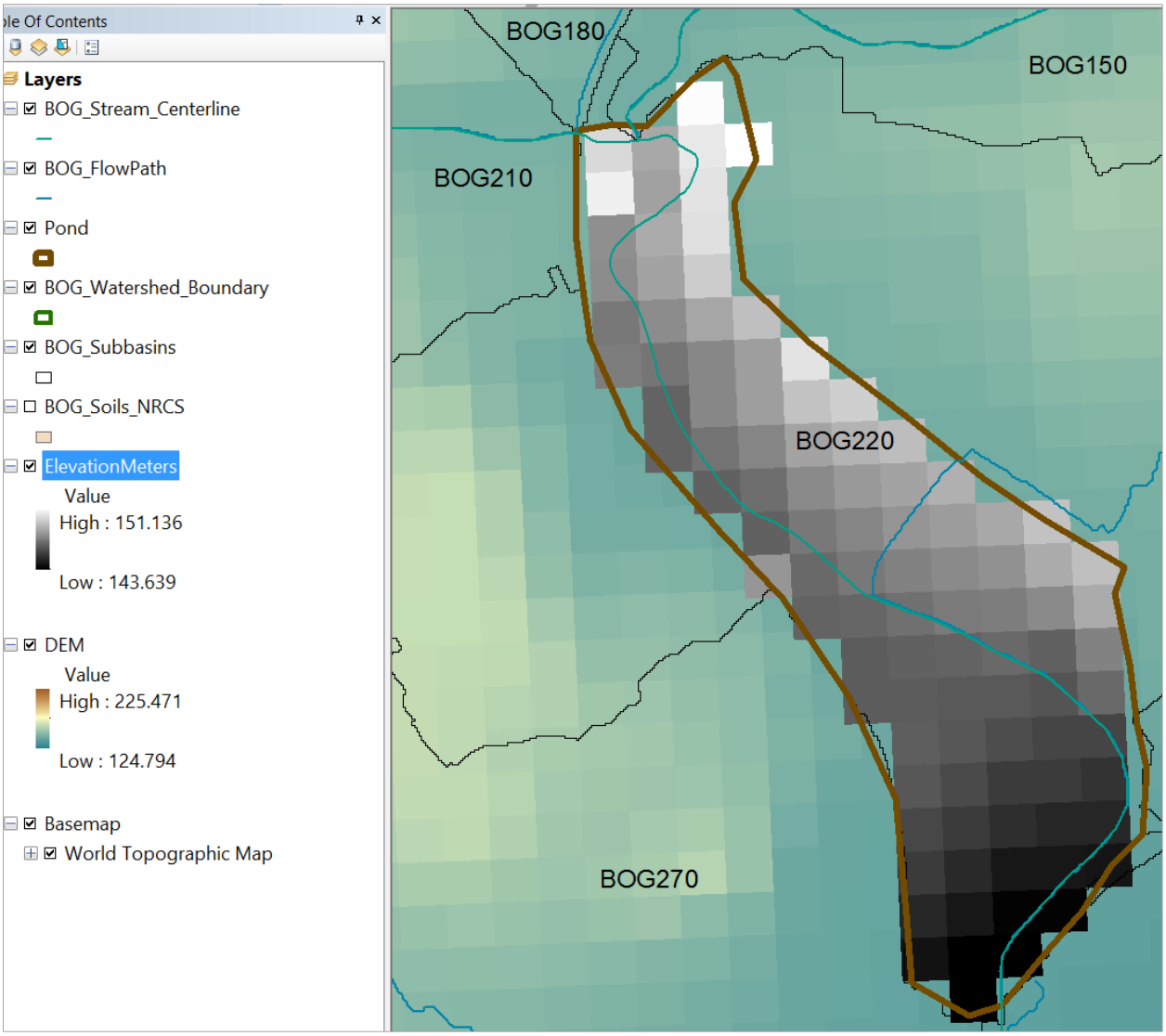
The next step requires that you have the Spatial Analyst extension of ArcGIS enabled. In ArcMap, use Customize/Extensions to open the Extensions window and then make sure that the box next to Spatial Analyst is checked on.



In the Search Tab on the right hand side of ArcMap, search for “Extract by Mask”, and enter the inputs as below, storing the result in your DesignProject geodatabase under the title **ElevationMeters.**

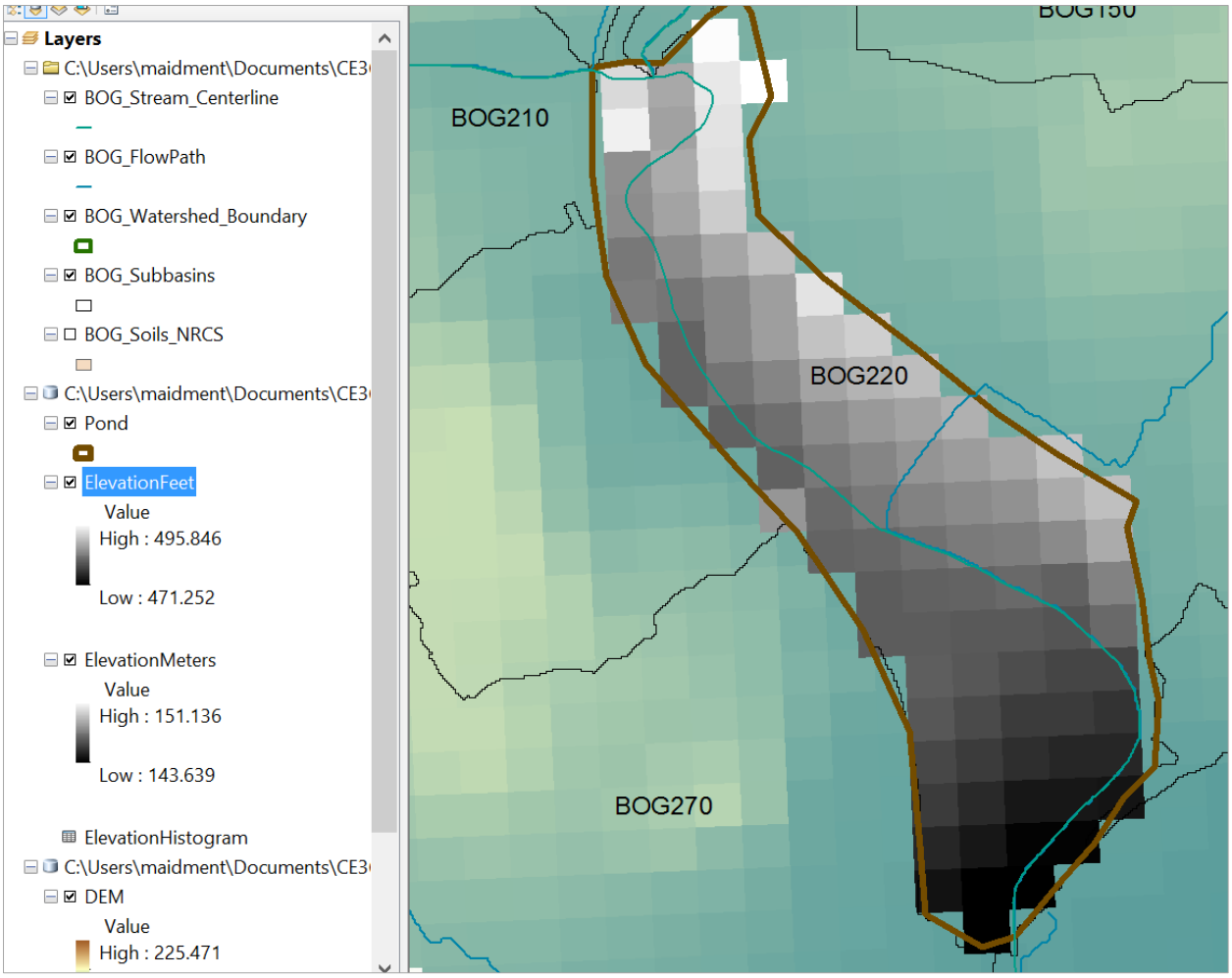


The extracted elevation data are shown below



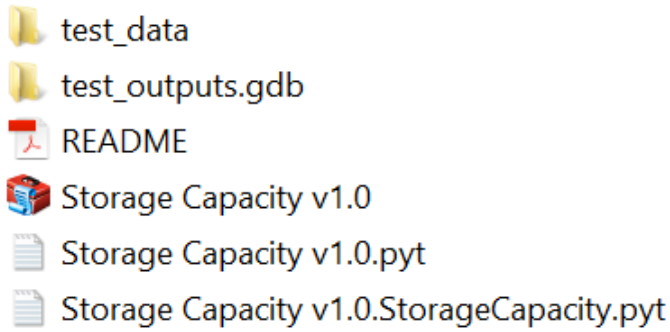
This is an elevation model with cells that are 30m x 30m in size and elevations in meters. Lets convert the elevations into feet. Search for “Raster Calculator” under the Search Tab in ArcMap, create the expression “DEM” * 3.2808 and store the results as **ElevationFeet**, as shown below.

Now we have an elevation raster with values from Elevation 471 to 495 ft

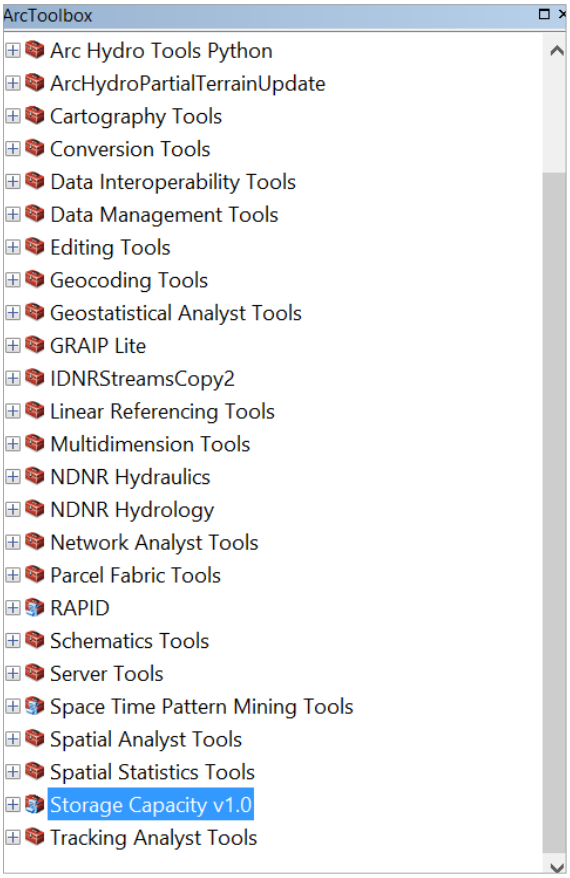


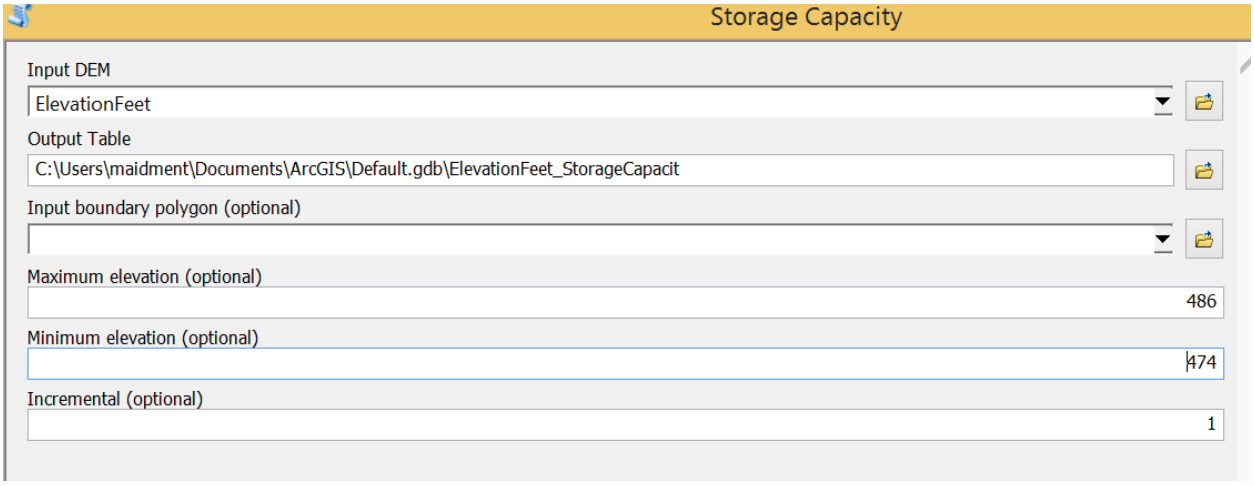
Nawajish Noman of ESRI has programmed a special tool for the elevation-area-storage called "Storage Capacity" (Thanks Noman!) Get the Storage Capacity toolkit at http://www.caee.utexas.edu/prof/maidment/CE365KSpr16/Detention/StorageCapacity.zip and unzip it.

Open Arc Toolbox, right click in the clear area to the right hand side of the tool box, select "Add Toolbox" and navigate to where the Storage Capacity v 1.0 toolbox is located.



Add this to Arc Toolbox (it will take a moment or two to show up).



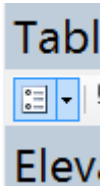


Open the resulting Storage Capacity table and you'll see Area in m^2 and Volume in m^2-ft as shown below indexed by 1 foot increments of elevation as we need.

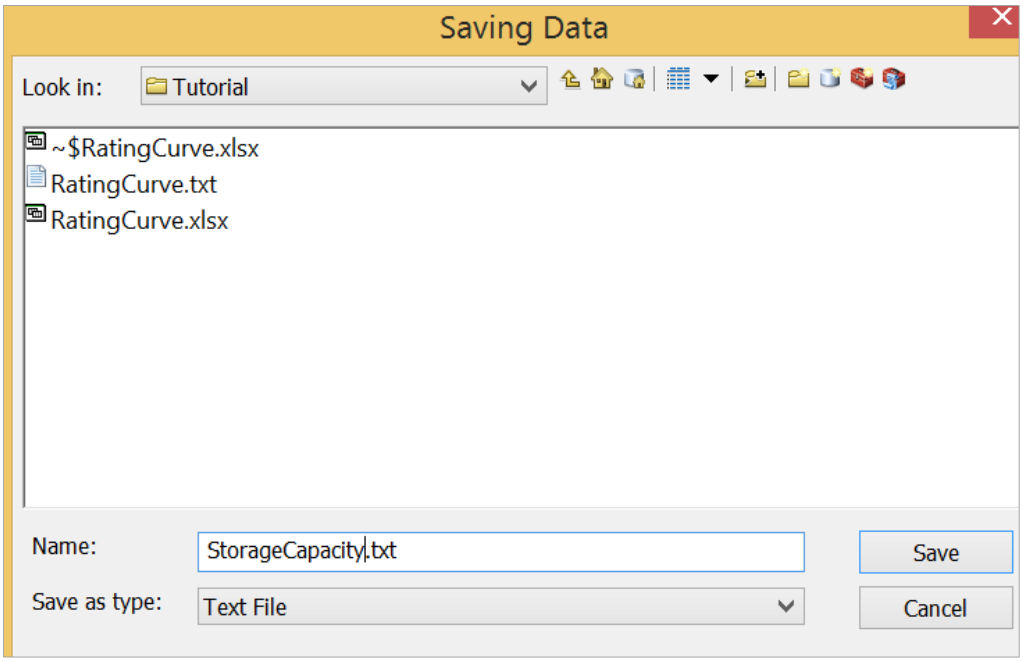
Table

ElevationFeet_StorageCapacit

OBJECTID *	Elevation	Area	Volume
1	475	9561.750795	20415.831224
2	476	14342.626193	33072.161006
3	477	19123.50159	48704.684002
4	478	21992.026829	68555.378906
5	479	24860.552067	92191.390569
6	480	36334.653022	122348.891275
7	481	43984.053658	163979.716287
8	482	51633.454294	211777.781049
9	483	59282.85493	266405.470689
10	484	66932.255566	329996.844761
11	485	71713.130964	399179.385111
12	486	81274.881759	475667.323857



Right click on the **Table Options** button and select **Export.** Choose export as .txt and store the StorageCapacity.txt file in your project workspace.



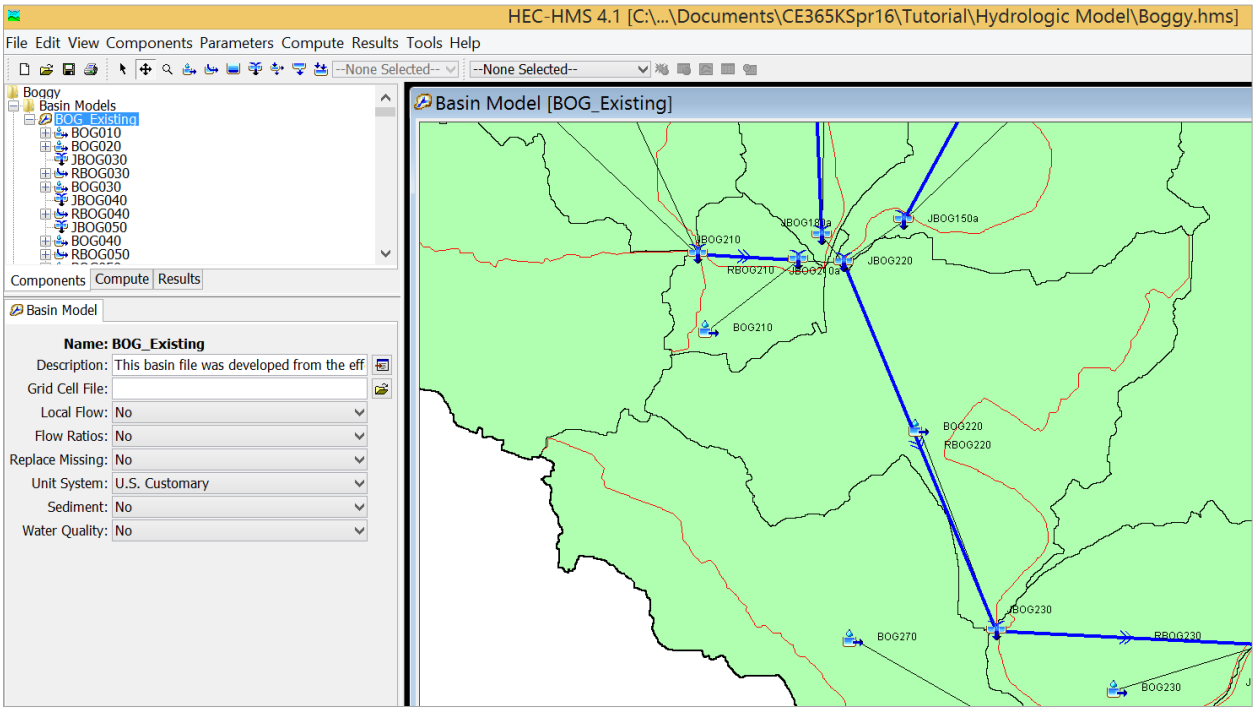
Convert the units of square meters to square feet by multiplying by 10.7639 and convert cubic feet to acre-ft by dividing by 43560. This gives the elevation – storage curve for the pond. I have added a set of zero values at elevation 474 ft to indicate that this is the base elevation of the pond. We will use the elevation in ft and area in acres in our analysis.

OBJECTID	**Elevation**	Area	Volume	Area (ft2)	**Area (Ac)**	Storage (ft3)	Storage (Ac-ft)
	474	0	0	0	**0.00**	0	0.00
1	**475**	9562	20416	102922	**2.36**	219754	5.04
2	**476**	14343	33072	154383	**3.54**	355985	8.17
3	**477**	19124	48705	205843	**4.73**	524252	12.04
4	**478**	21992	68555	236720	**5.43**	737923	16.94
5	**479**	24861	92191	267596	**6.14**	992339	22.78
6	**480**	36335	122349	391103	**8.98**	1316951	30.23
7	**481**	43984	163980	473440	**10.87**	1765061	40.52
8	**482**	51633	211778	555777	**12.76**	2279555	52.33
9	**483**	59283	266405	638115	**14.65**	2867562	65.83
10	**484**	66932	329997	720452	**16.54**	3552053	81.54
11	**485**	71713	399179	771913	**17.72**	4296727	98.64
12	**486**	81275	475667	874835	**20.08**	5120036	117.54

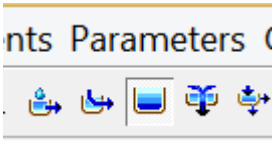
Flow Routing in HEC-HMS

Copy the "Hydrology Model" folder for the watershed to your project workspace and open the HEC-HMS project there. Zoom in to the project location at the downstream end of Subbasin Bog_220. You'll see

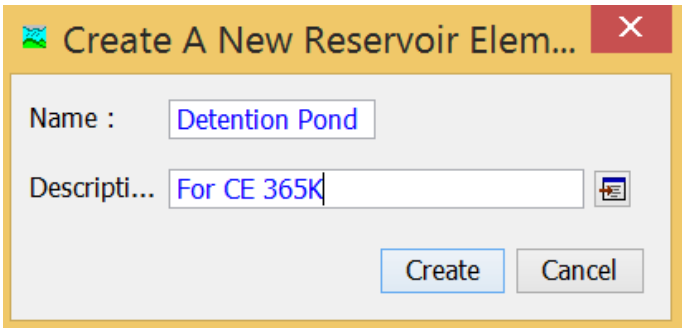
that there is a Junction there called JBOG230. We are going to replace this junction in the model with a Detention Pond.



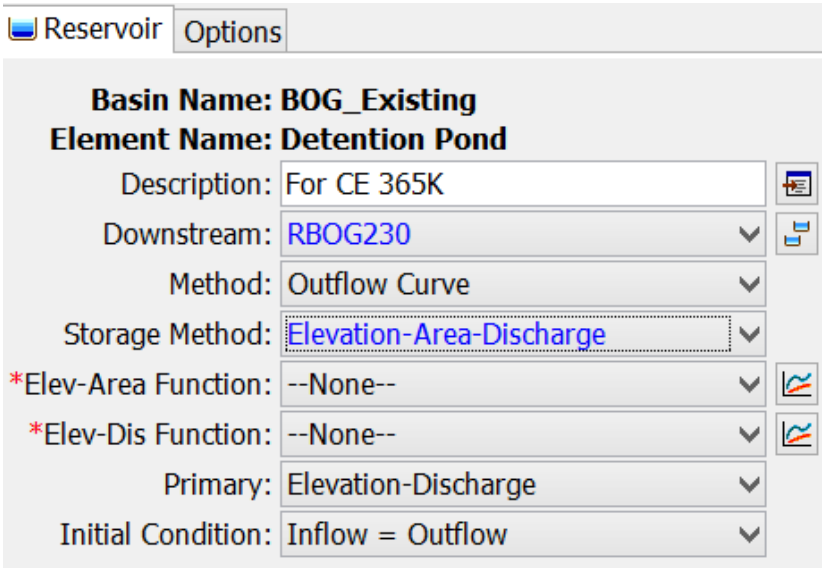
Right click on the JB230 junction and select **Cut Element**. In HEC-HMS select the Create Reservoir Tool



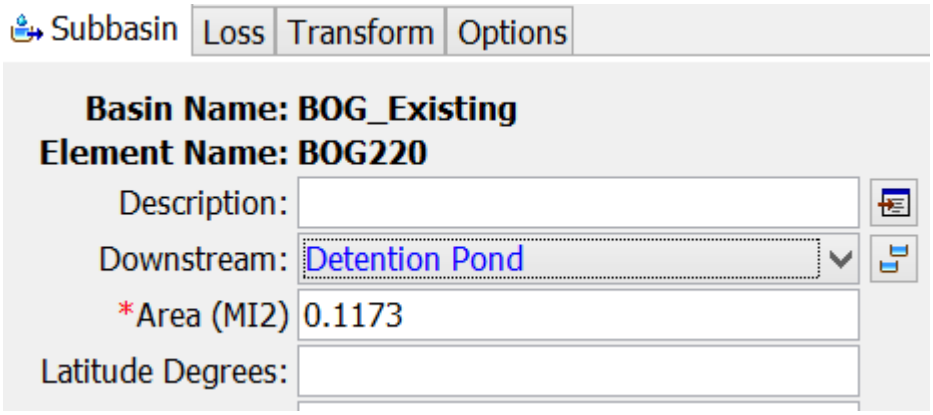
And create a new reservoir at the same location.



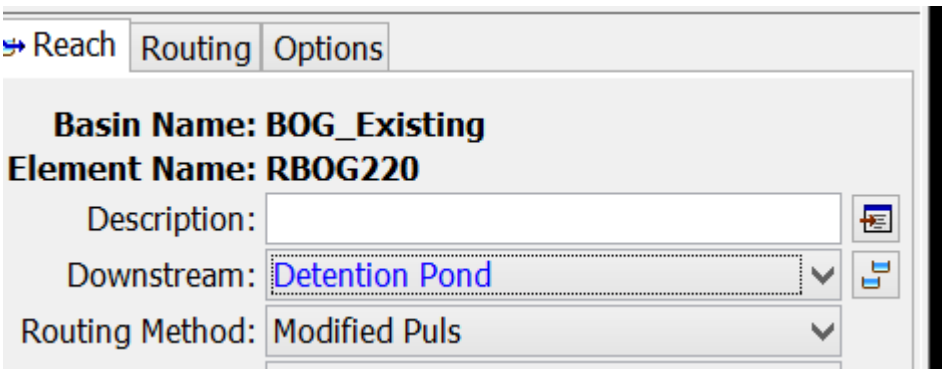
To make sure we have this reservoir connected to its downstream element, select Downstream and put in RBOG230 as the reach which is next downstream of the reservoir.



Similarly, for the BOG220 Subbasin, select Detention Pond as the Downstream Element.



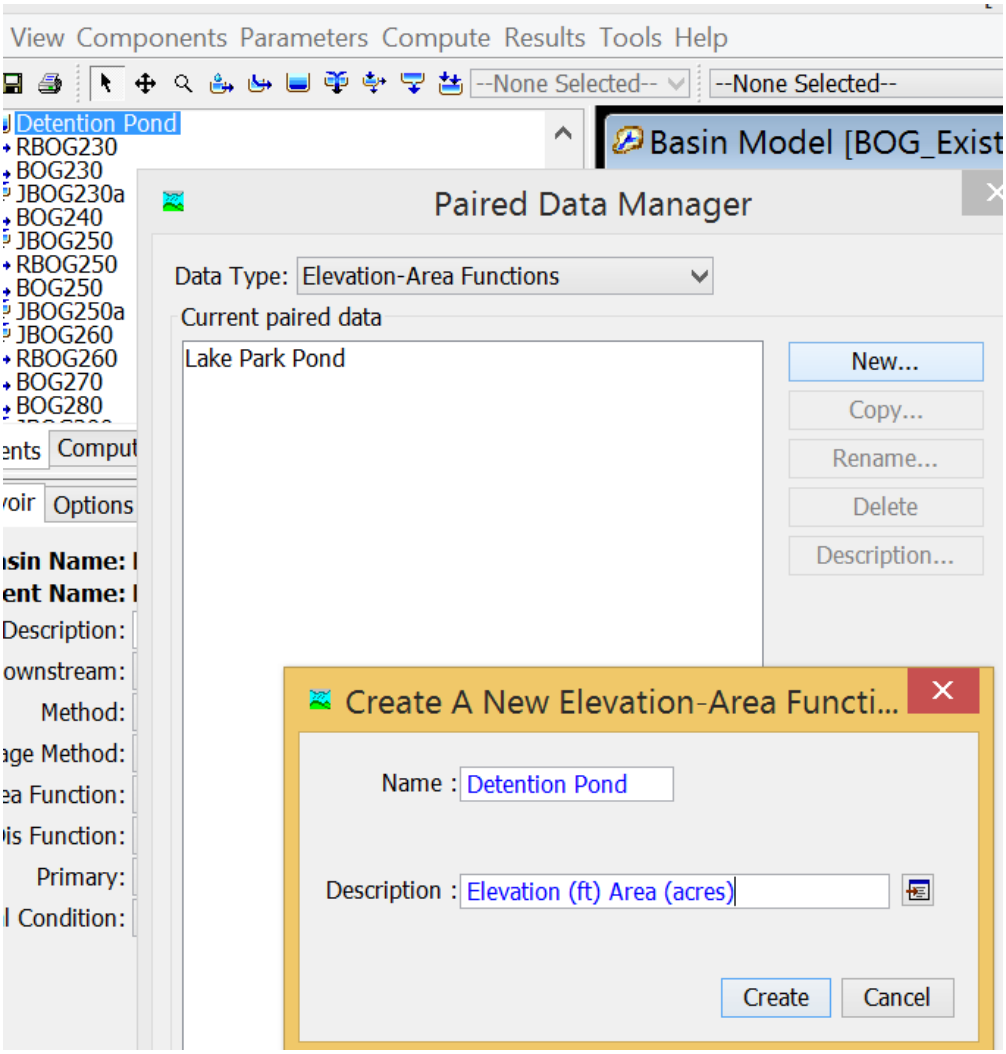
And similarly for the upstream reach RBOG220, select Detention Pond as the Downstream Element.



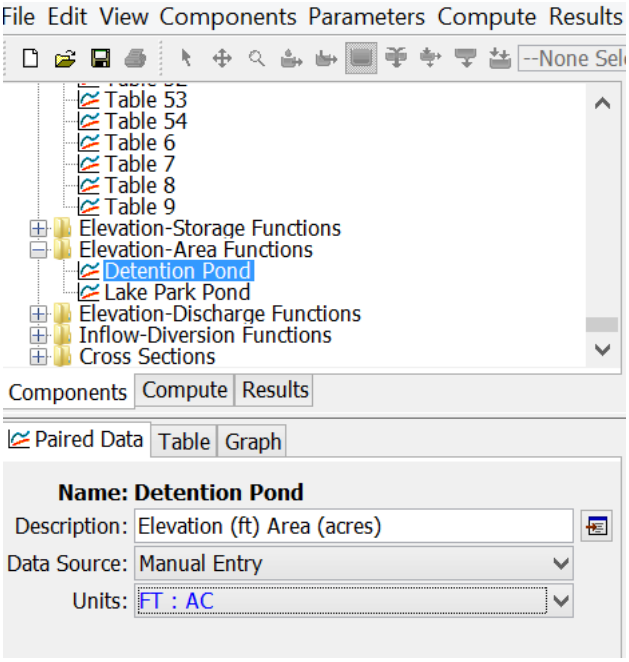
Now you have all the upstream elements flowing into the Detention Pond and the Pond discharging into the downstream reach as it should.

Now we have to specify the data describing the Detention Pond

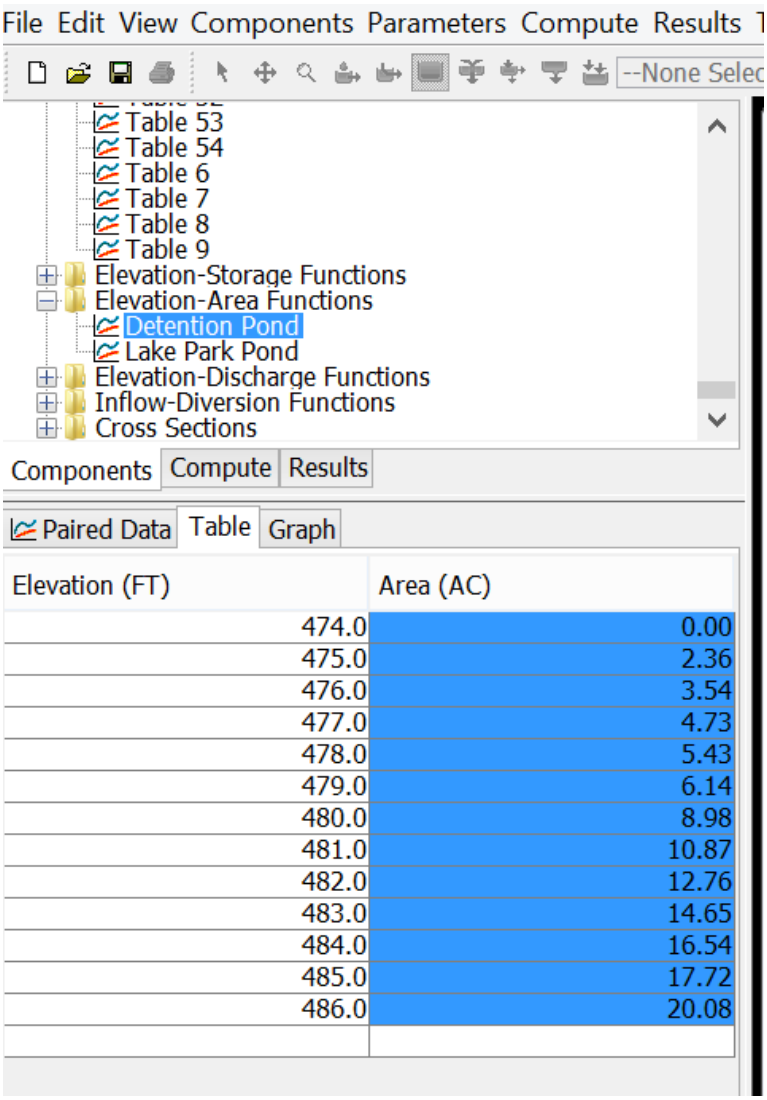
Under **Components** in HEC-HMS, select **Paired Data Manager,** and within this, select **Elevation-Area** functions and create a new table called **Detention Pond**



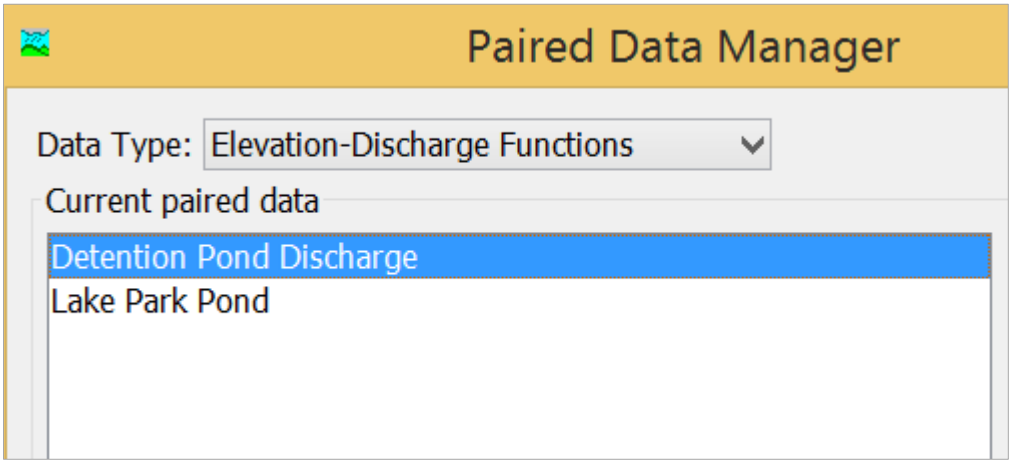
You'll now have a new Paired Data table called Detention Pond. In the **Component Editor** for this table, make sure that the data source is set for Manual Entry units are set for ft and acres.



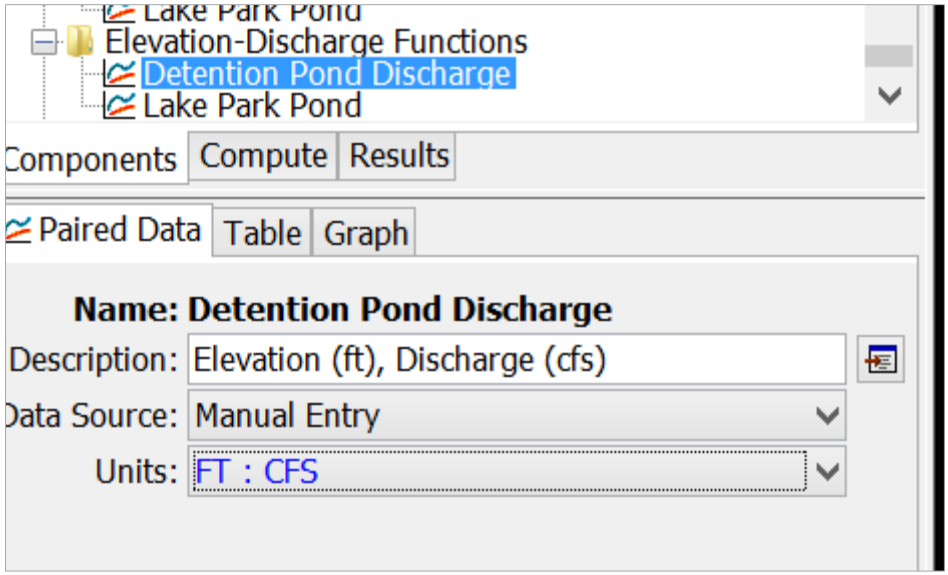
Then you can copy and paste your data from Excel into the columns of this table



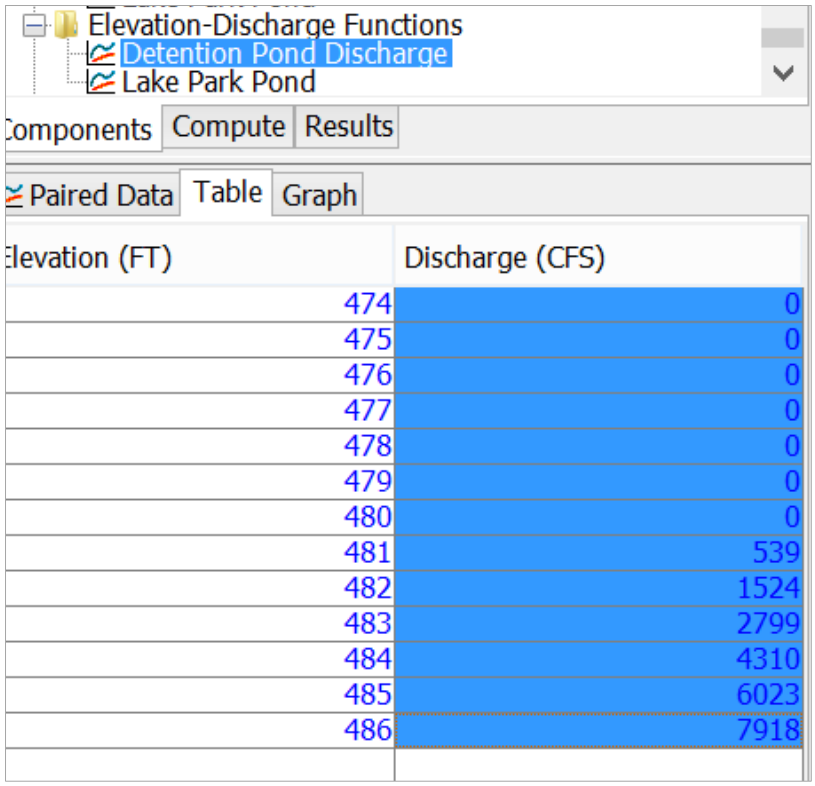
Lets do the same thing for the Elevation-Discharge function that we worked out in FlowMaster. Create an Elevation Discharge function using the Paired Data Manager



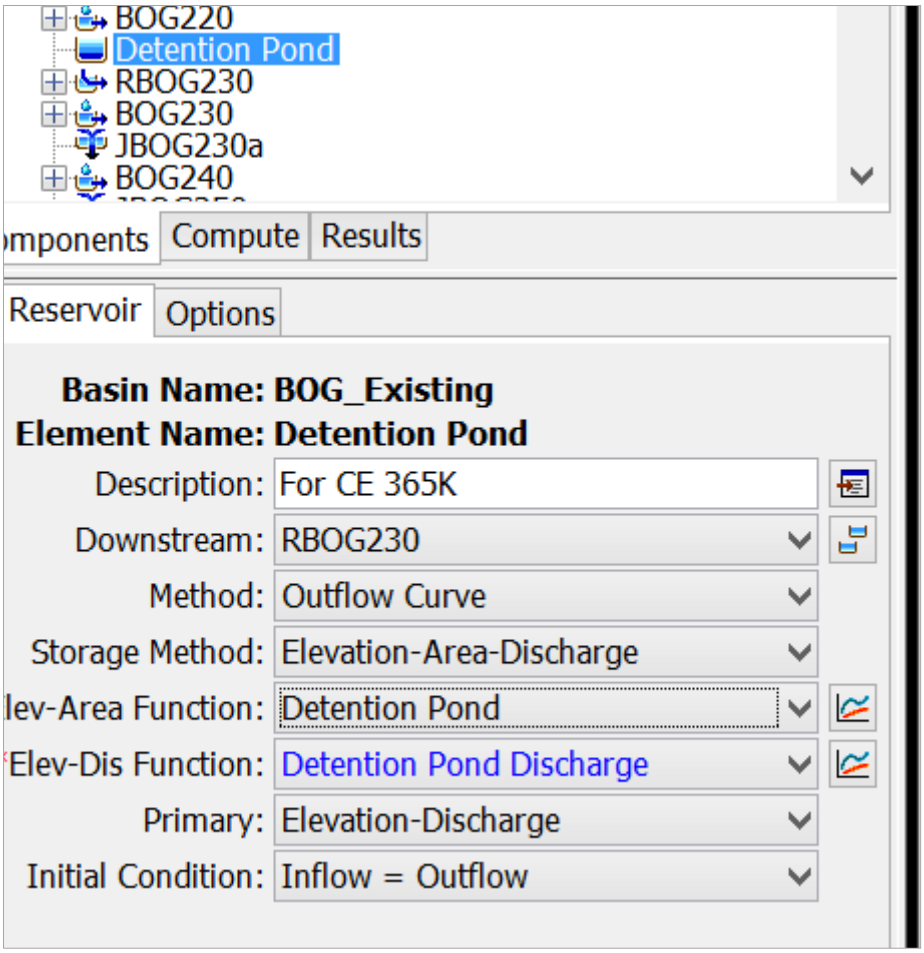
Set the units to be ft and cfs



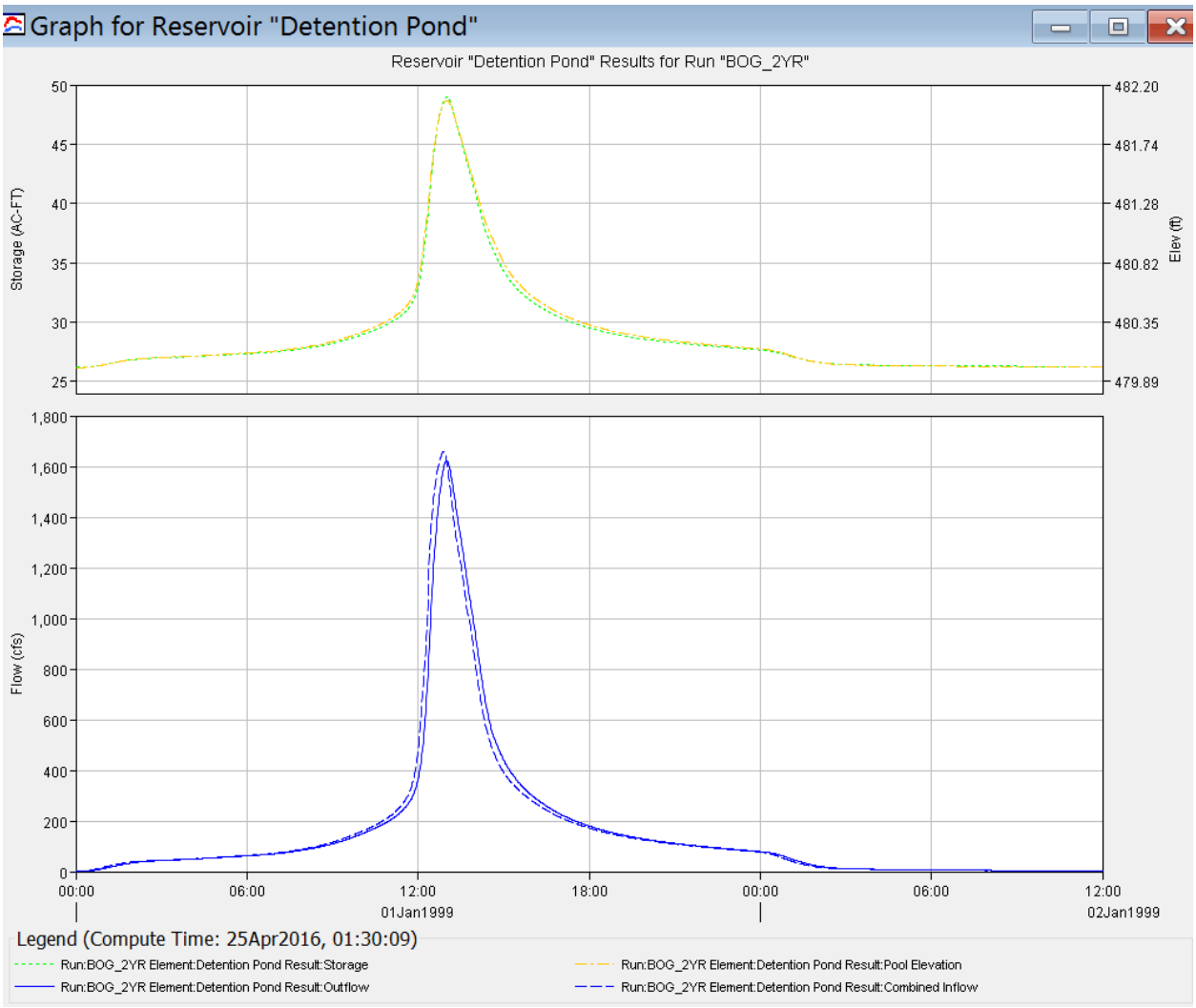
Add the data by copying and pasting from Excel



In your Detention Pond Element, make sure that the appropriate Paired Data Tables have been selected for the Elevation-Area and Elevation-Discharge functions



Now if you save the model and run HEC-HMS you can see the effect of the detention pond on various storm intensities. You can change the outlet structure design and see if this has an effect. When I first ran this modified model it did not work but I closed HEC-HMS and reopened it and ran the model and it worked fine.


Graph for Reservoir "Detention Pond"
Reservoir "Detention Pond" Results for Run "BOG_2YR"
Storage (AC-FT)
Elev (ft)
50
45
40
35
30
25
482.20
481.74
481.28
480.82
480.35
479.89
Flow (cfs)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
00:00
06:00
12:00
18:00
00:00
06:00
12:00
01Jan1999
02Jan1999
Legend (Compute Time: 25Apr2016, 01:30:09)
Run:BOG_2YR Element:Detention Pond Result:Storage
Run:BOG_2YR Element:Detention Pond Result:Outflow
Run:BOG_2YR Element:Detention Pond Result:Pool Elevation
Run:BOG_2YR Element:Detention Pond Result:Combined Inflow