Exercise 2. Building a Base Dataset of the San Marcos Basin

GIS in Water Resources
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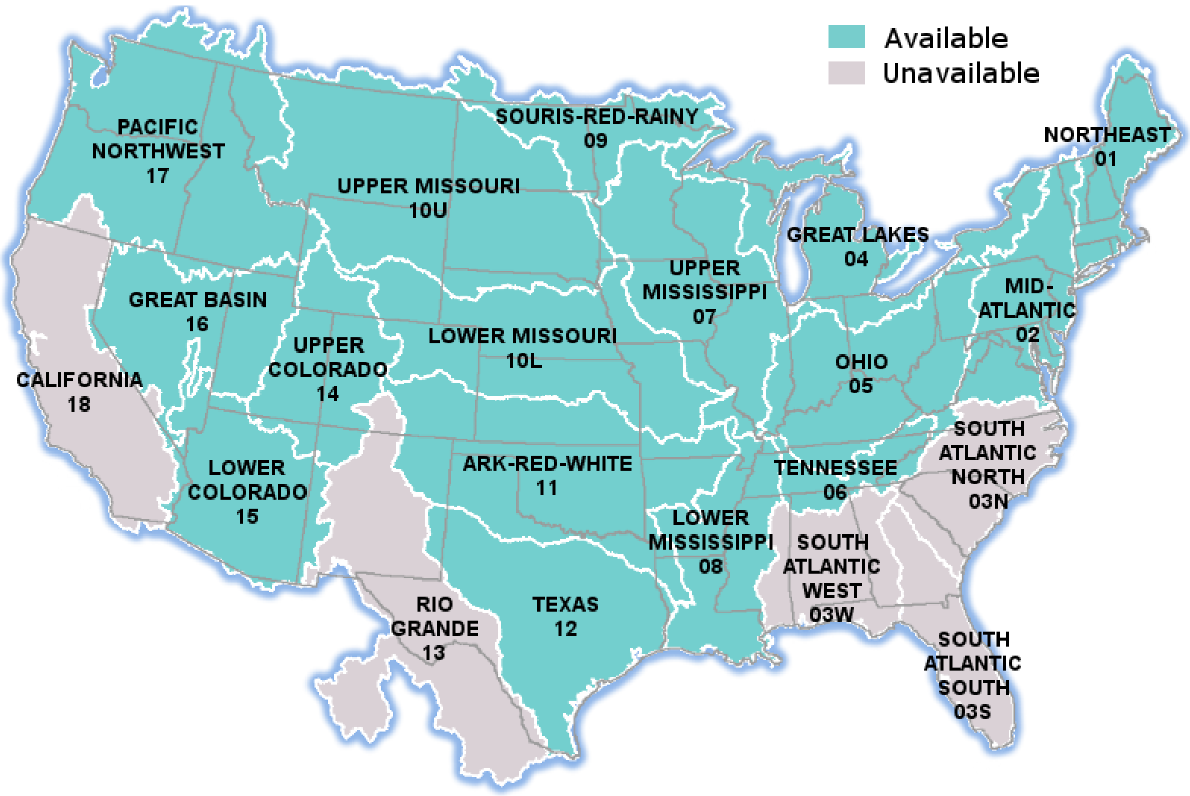
Goals of the Exercise

This exercise is intended for you to build a base data set of geographic information for a watershed using the San Marcos Basin in South Texas as an example. The base dataset comprises watershed boundaries and streams from the National Hydrography Dataset Plus (NHDPlus) and soils from the SSURGO soils database. A geodatabase is created to hold all these primary data layers. In addition, you will create a point Feature Class of stream gage sites by inputting latitude and longitude values for the gages in an Excel table that is added to ArcMap and the geodatabase. You also compare the locations of the San Marcos basin surface boundaries, and the Edwards aquifer subsurface boundaries.

Computer and Data Requirements

To complete this exercise, you'll need to run ArcGIS 10.1 from a PC. You will download map packages of hydrologic and soils information to do this exercise from ArcGIS Online. If you have trouble accessing these packages, there is a backup at http://www.caee.utexas.edu/prof/maidment/giswr2012/Ex2/Ex2Data.zip

NHDPlus data for the United States that can be downloaded over the internet: http://www.horizon-systems.com/nhdplus/ The current status of available information is depicted in this map:



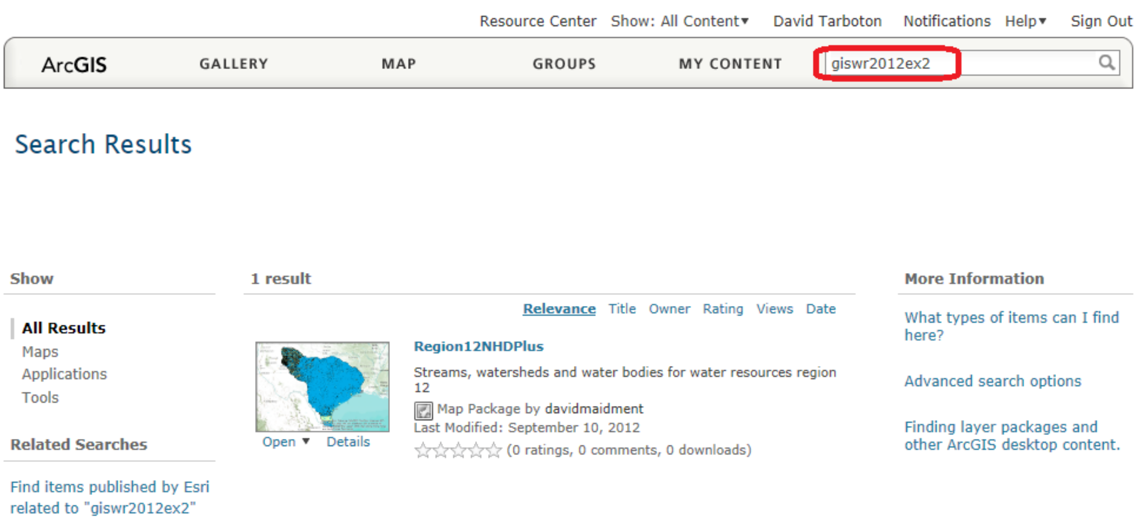
01 Northeast	02 Mid Atlantic	03N South Atlantic North
03S South Atlantic South	03W South Atlantic West	04 Great Lakes
05 Ohio	06 Tennessee	07 Upper Mississippi
08 Lower Mississippi	09 Souris-Red-Rainy	10U Upper Missouri
10L Lower Missouri	11 Ark-Red-White	12 Texas
13 Rio Grande	14 Upper Colorado	15 Lower Colorado
16 Great Basin	17 Pacific Northwest	18 California

In this instance, we need information from Water Resource Region 12 that covers most of Texas. We are going to use information from the **NHDSnapshot**, **NHDPlusAttributes**, and **WBDSnapshot** datasets.

http://www.horizon-systems.com/NHDPlus/NHDPlusV2_12.php

FTP	NHDPlusV21_TX_12_NHDPlusAttributes_03.7z
FTP	NHDPlusV21_TX_12_NHDPlusBurnComponents_02.7z
FTP	NHDPlusV21_TX_12_NHDPlusCatchments_01.7z
FTP	NHDPlusV21_TX_12_NHDSnapshot_02.7z
FTP	NHDPlusV21_TX_12_VogelExtension_01.7z
FTP	NHDPlusV21_TX_12_VPUAttributeExtension_02.7z
FTP	NHDPlusV21_TX_12_WBDSnapshot_01.7z

The needed files can be accessed as a Map Package called **Region12NHDPlus** that is indexed by the tag **giswr2012ex2** in ArcGIS Online. Make sure when you search for this, that you have "**Show:All Content**" rather than Show: Web Content Only in ArcGIS Online.

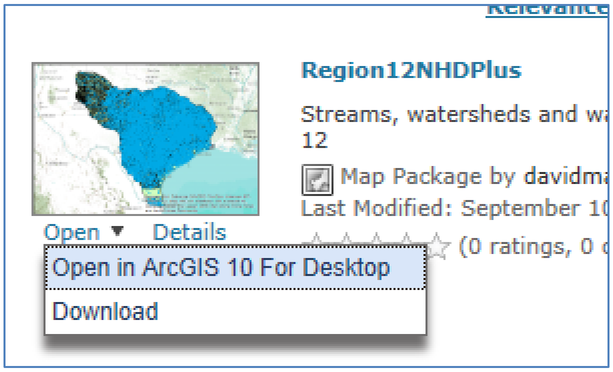


Procedure for the Assignment

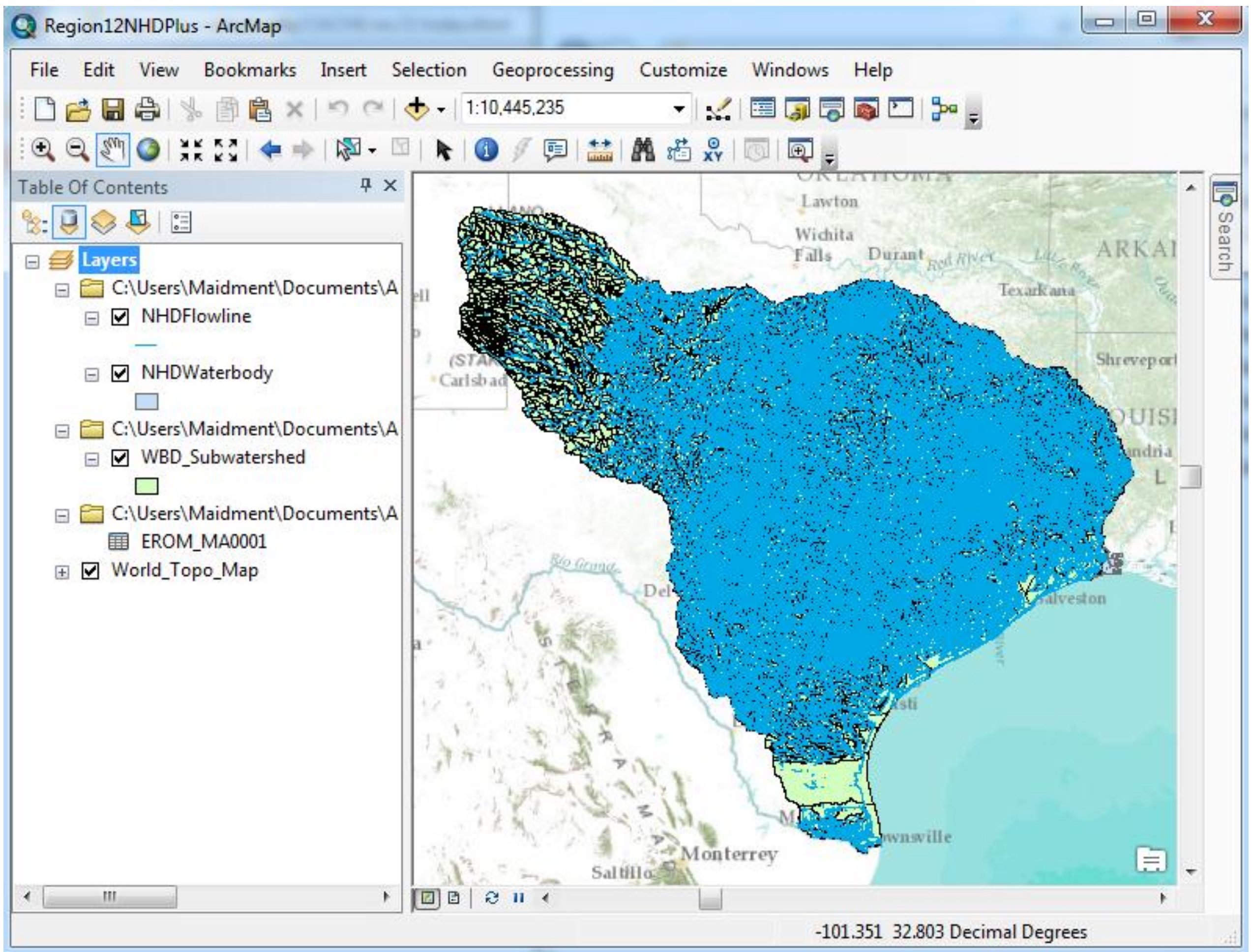
Getting Started

We'll begin by getting the input data for Water Resource Region 12, and creating a new, empty geodatabase into which you'll put data for the San Marcos basin, which is a small drainage area within this region.

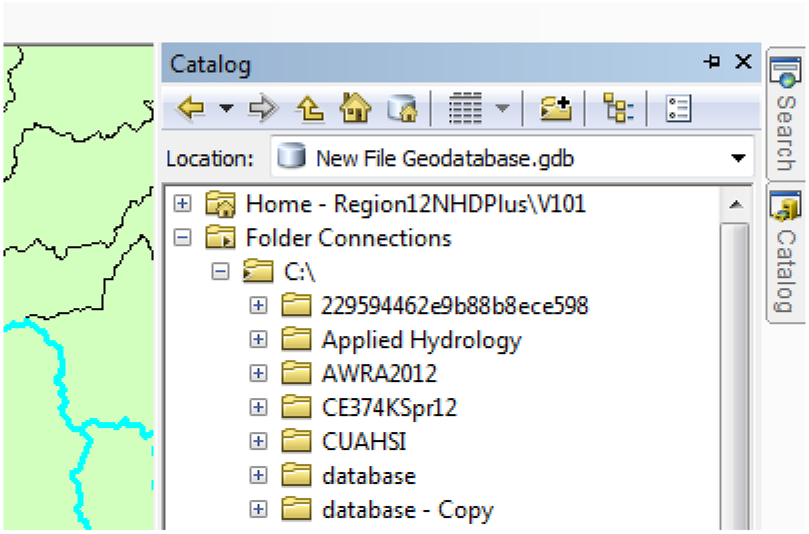
Once you have located the map package **Region12NHDPlus** in ArcGISOnline using the tag **giswr2012ex2** open it in ArcGIS



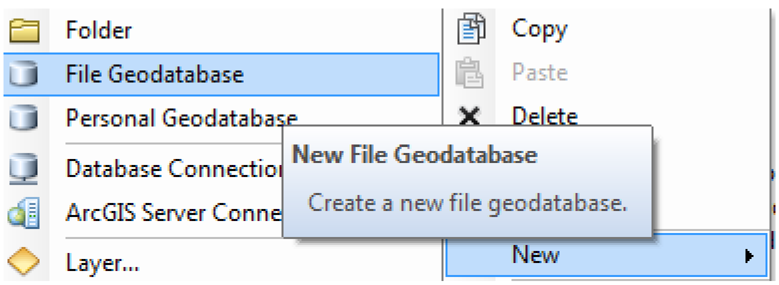
and you should see a display like this



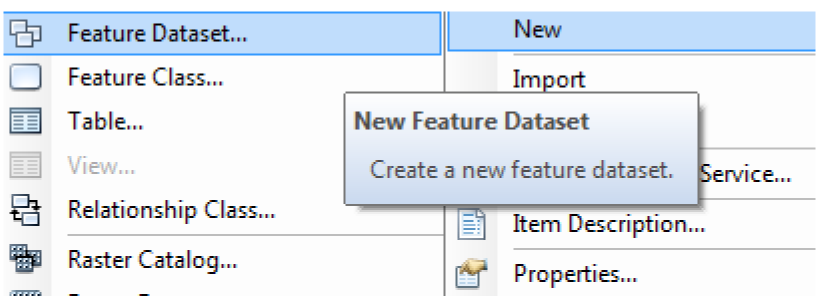
From ArcMap, open **ArcCatalog**, navigate through **Folder Connections** to a place where you want to have a workspace,



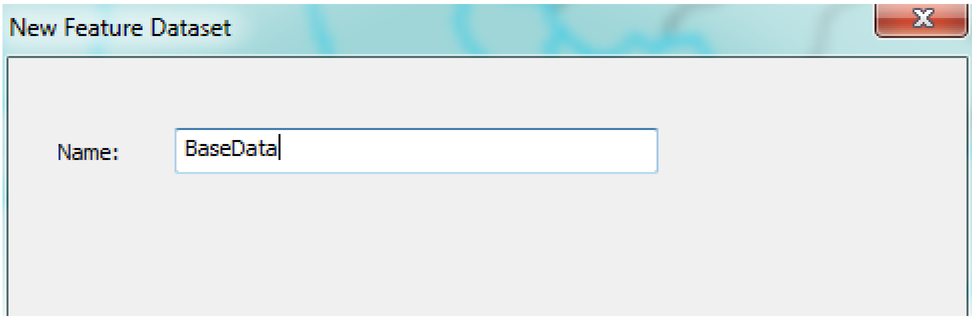
and create a new **File Geodatabase**:



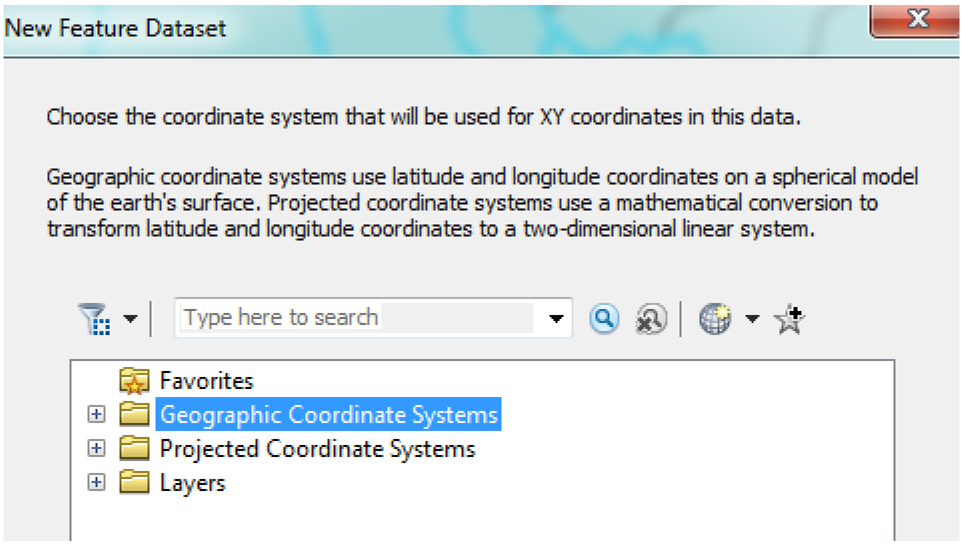
And call this **SanMarcos.**gdb.   Within this, create a new **Feature Dataset**



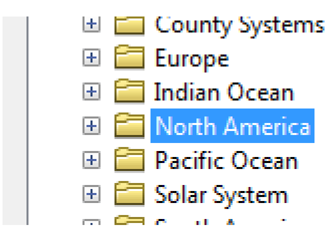
and call it **BaseData**



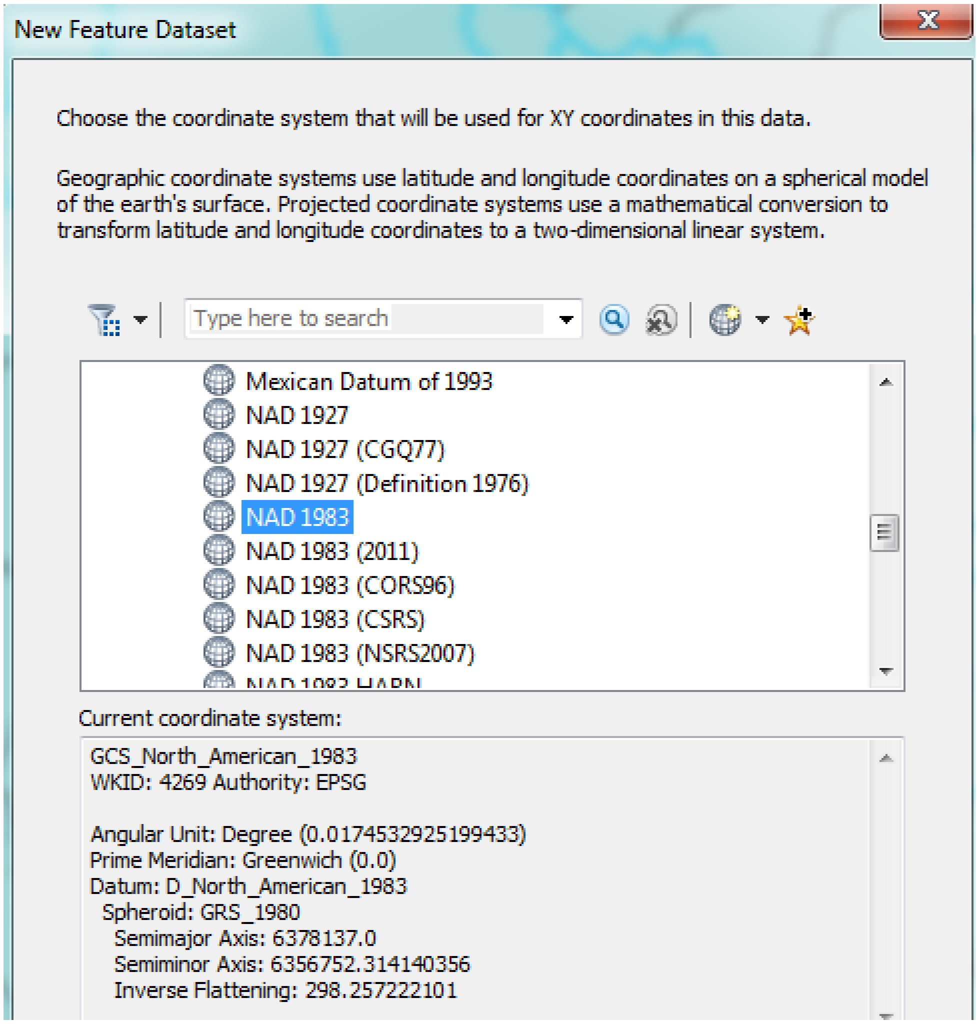
choose a Geographic Coordinate System



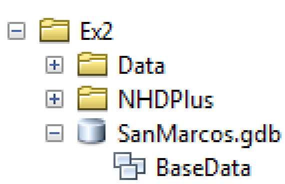
within North America,



select the NAD83 coordinate system



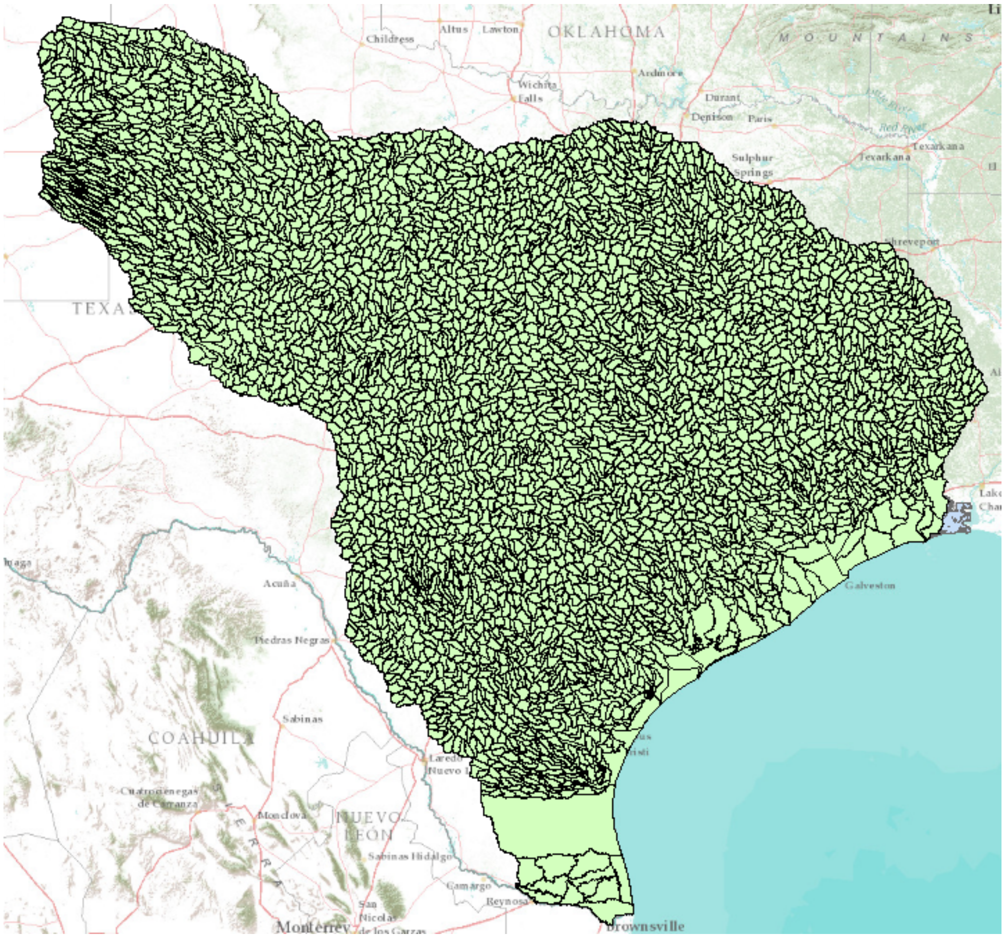
Hit **Next**, and **Next** again to bypass having a Vertical Coordinate system, and then **Finish** to complete creating the Feature Dataset, leaving the tolerance information at the default values.



This **BaseData** feature dataset within the **SanMarcos** geodatabase will hold the data that you create for the San Marcos Basin.

Selecting the Watersheds in the San Marcos Basin

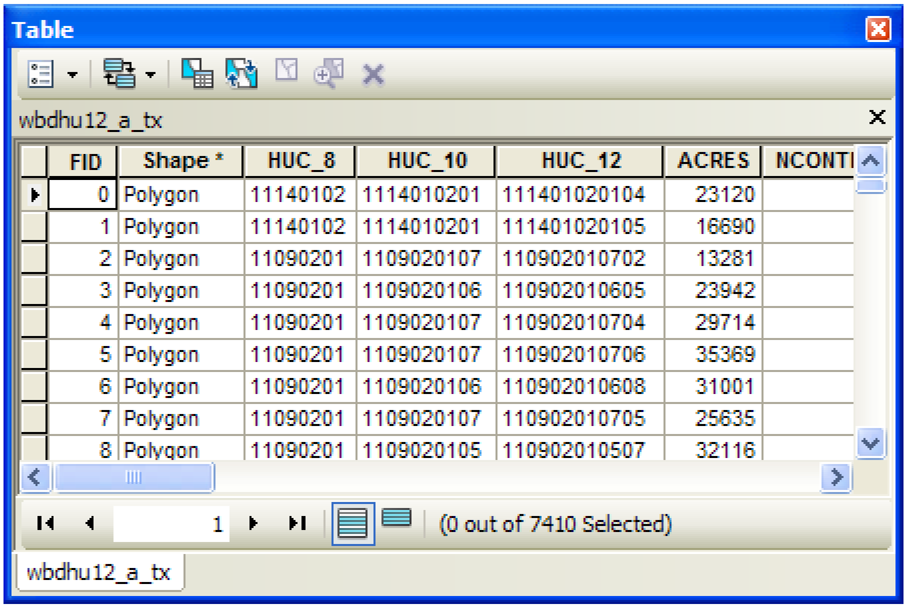
Turn off all the layers except the Watershed Boundary Dataset (**WDB_Subwatershed**)



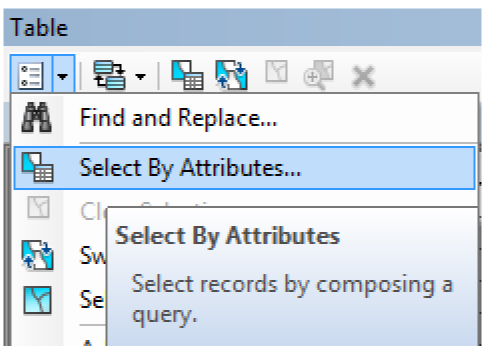
Let’s zoom into the San Marcos basin.

We want all the HUC12 subwatersheds that lie within the San Marcos subbasin, which has a HUC8 value of [HUC_8 = 12100203].

Open the Attribute Table of the Watershed Boundary Dataset (**WDB_Subwatershed**)



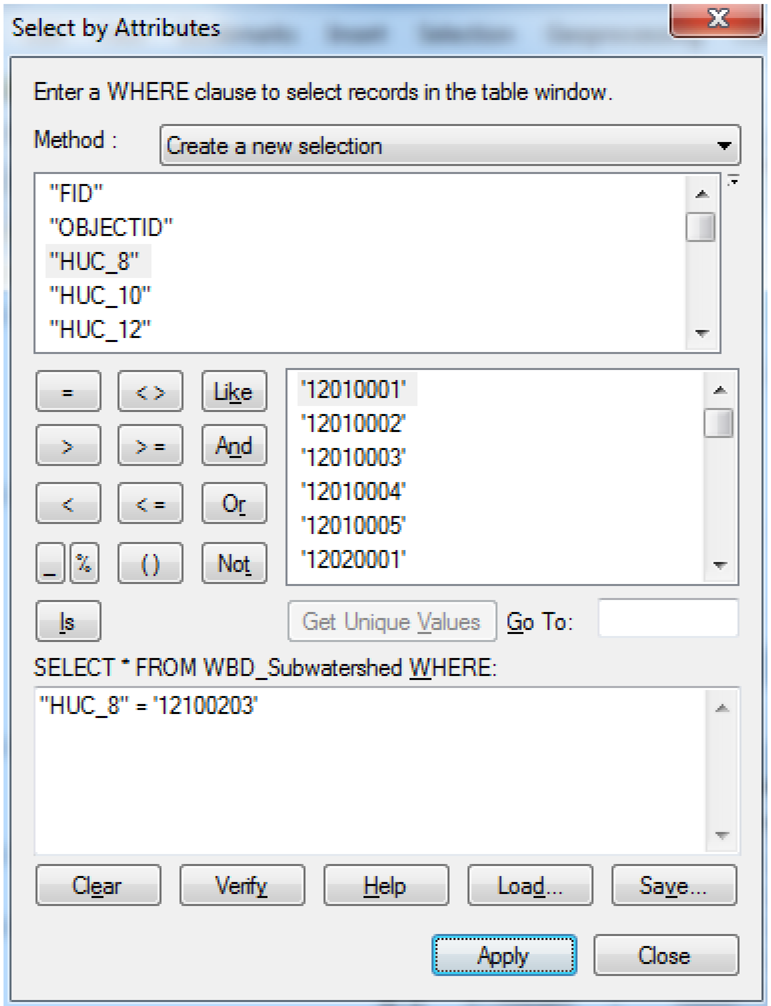
At the top left corner of the **Table**, click on the **Select by Attributes** tool



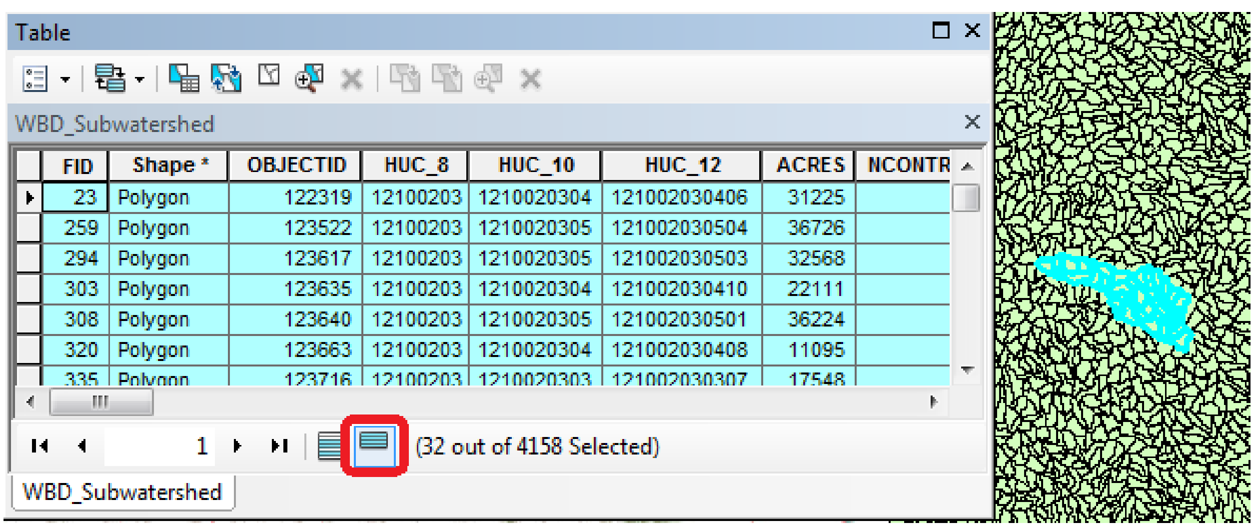
Click on "HUC8", "=", **Get Unique Values** and then type 12100203 in the **Go To** box, double click on the resulting '12100203' to form the expression

"HUC_8" = '12100203'

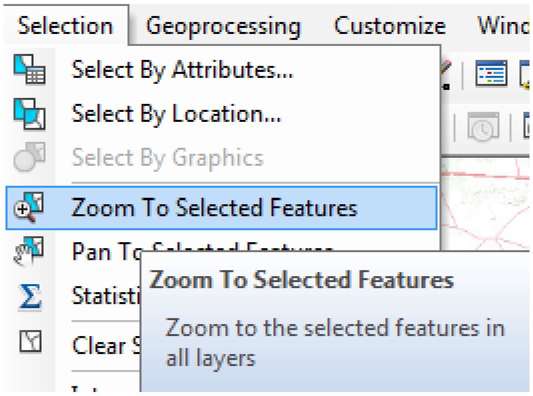
In the selection window. Be careful about how you do this since the form of the expression is important. Click **Apply** and **Close** the Select by Attributes window**.**



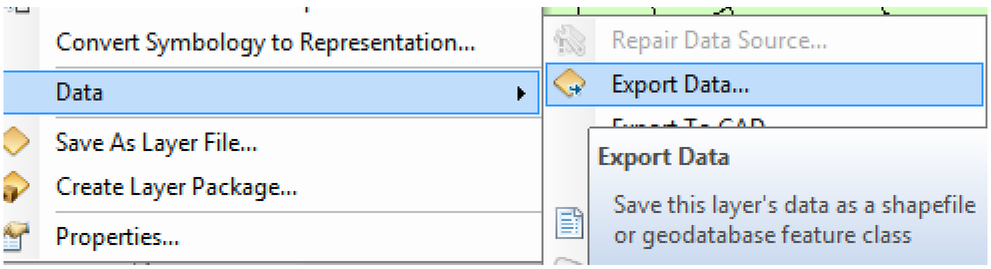
You'll see that this selects 32 of the HUC-12 Subwatersheds that lie within the San Marcos basin (one HUC-8 Subbasin). If you hit the **Selected** button at the bottom of the Table, you'll see the selected records, and also their highlighted images in the map.



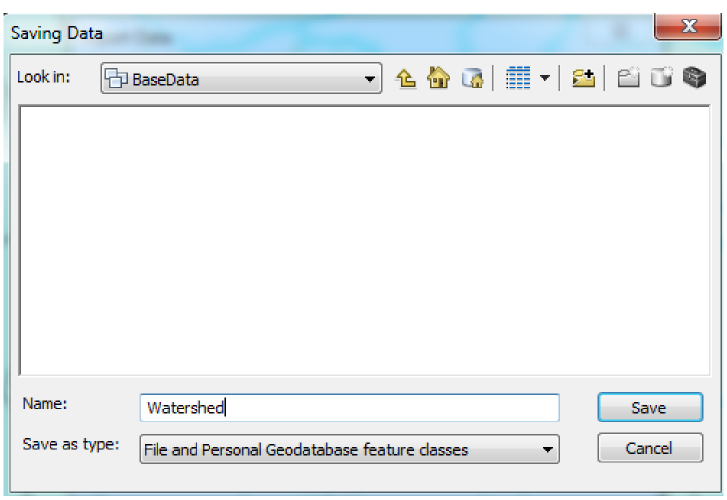
Use **Selection/Zoom to Selected Features**:



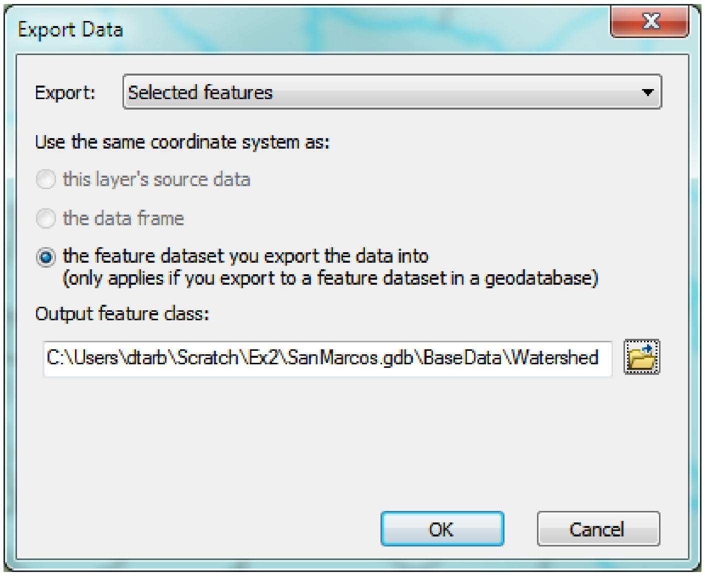
Close the **WBD_Subwatershed** table to get it out of the way. Right Click on the watersheds layer (**WBD_Subwatershed**) and select **Data/Export Data** to produce a new Feature Class.



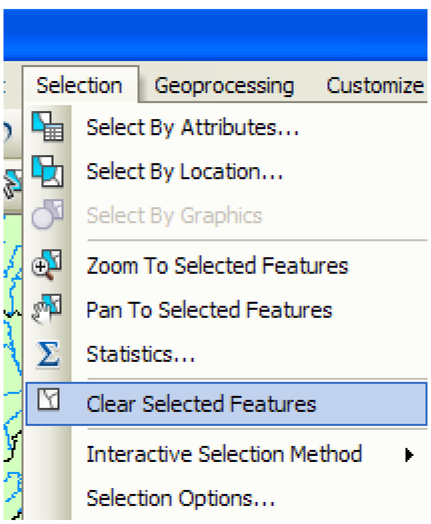
Be sure to navigate to where you established the SanMarcos geodatabase earlier and don't just accept the default geodatabase presented to you, which is somewhere deep in the file system that you may never find again! Browse inside the SanMarcos geodatabase you created to the **BaseData** Feature dataset and name this new feature class as **Watershed** and click **Save**. (Note that you may have to change the Save as Type to File and Personal Geodatabase feature classes).



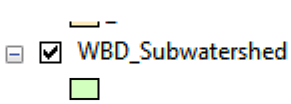
At the next screen click OK



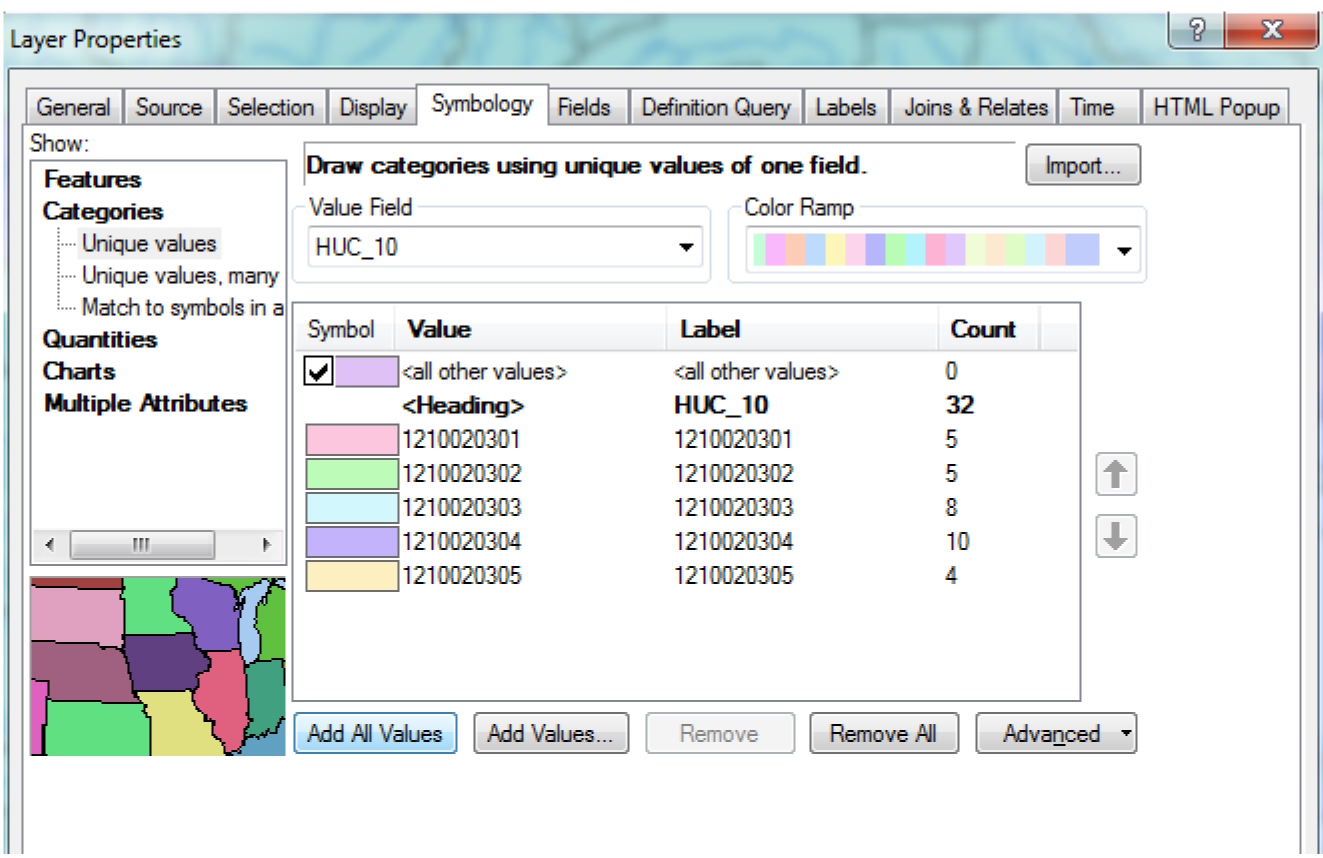
You will be prompted to whether add this theme to the Map, click **Yes**. In ArcMap, Use **Selection/Clear Selected Features** to clear the selection you just made.



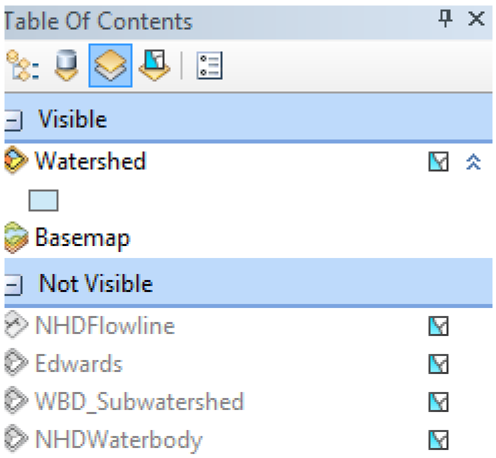
And then Zoom to Layer to focus in on your selected Watersheds. You can click off the little check mark by the **WBD_Subwatershed** layer and **Basemap** so that you just see the watersheds displayed.



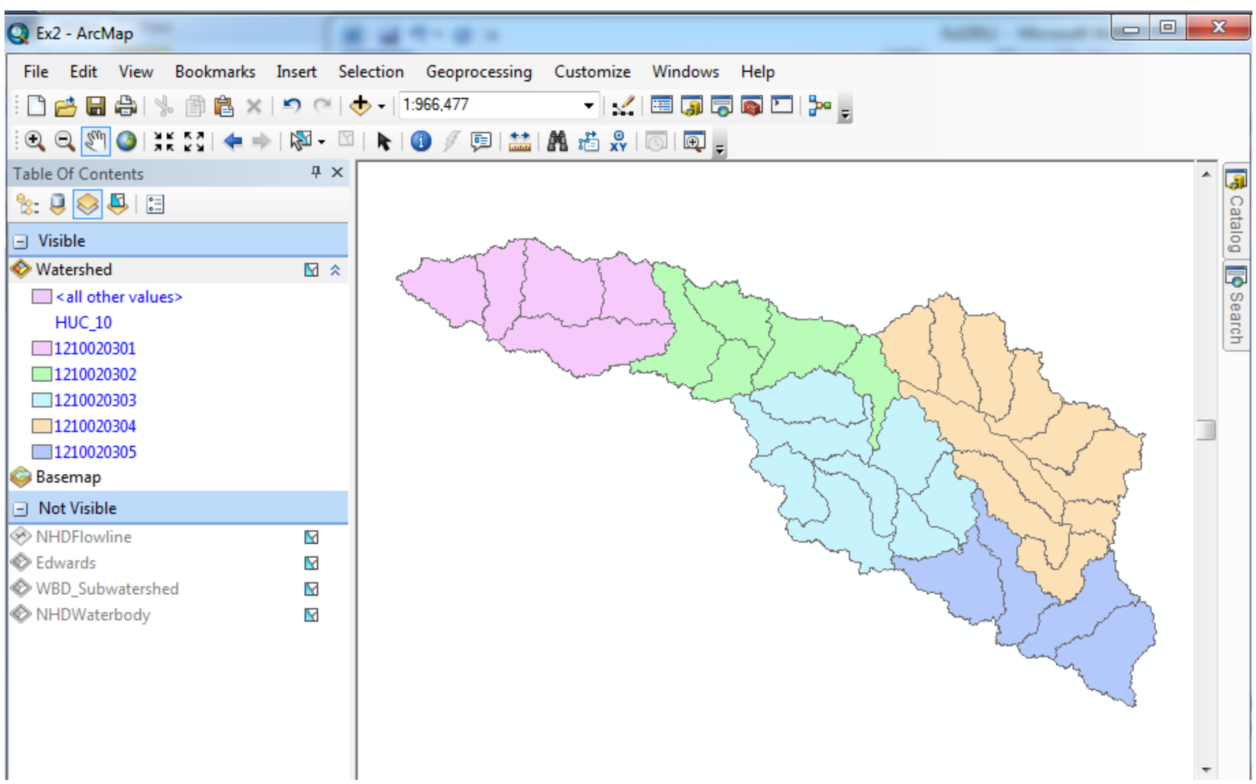
Lets make our basin a bit more interesting.   Right click on the Watershed feature class, and select Properties/Symbology. Select Categories Unique values and use HUC-10 as the Value Field, hit Add All Values to give each HUC-10 watershed a different color. Hit **Apply** and **OK** to get this color scheme applied to the map.



Lets focus on the Watersheds feature class by turning off the display of the other feature classes using the check box in the Table of Contents.

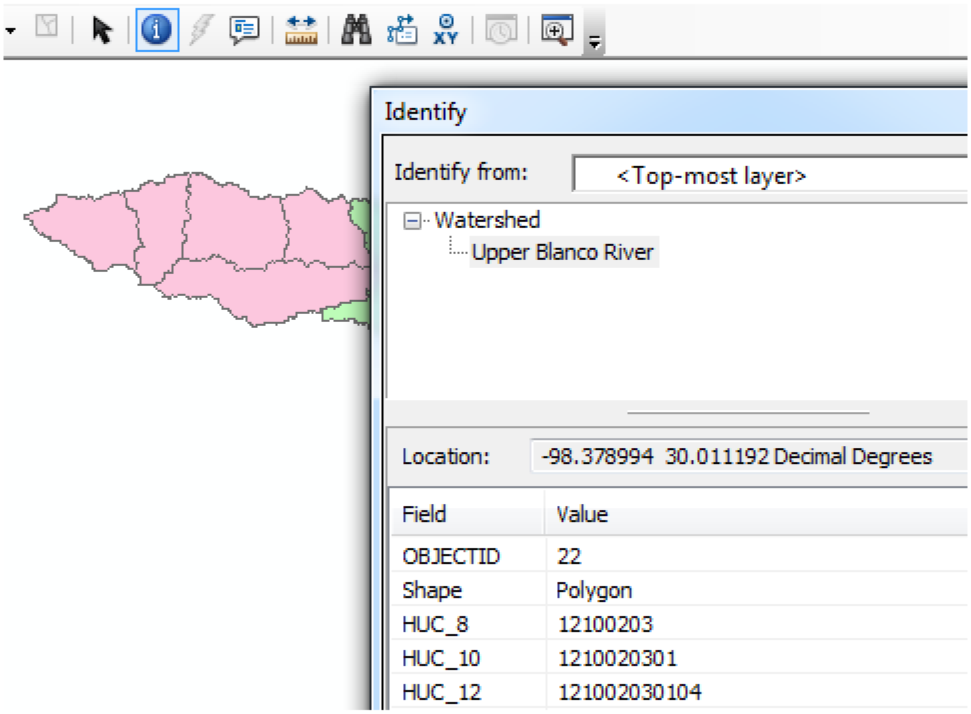


And you'll get this nicely colored map of the watersheds and subwatersheds of the San Marcos basin.



Notice that the 32 HUC-12 *subwatersheds* have been grouped into five *watersheds* within the San Marcos *subbasin* (I am here using the Watershed Boundary Set nomenclature to refer to the drainage area hierarchy in its formal sense).

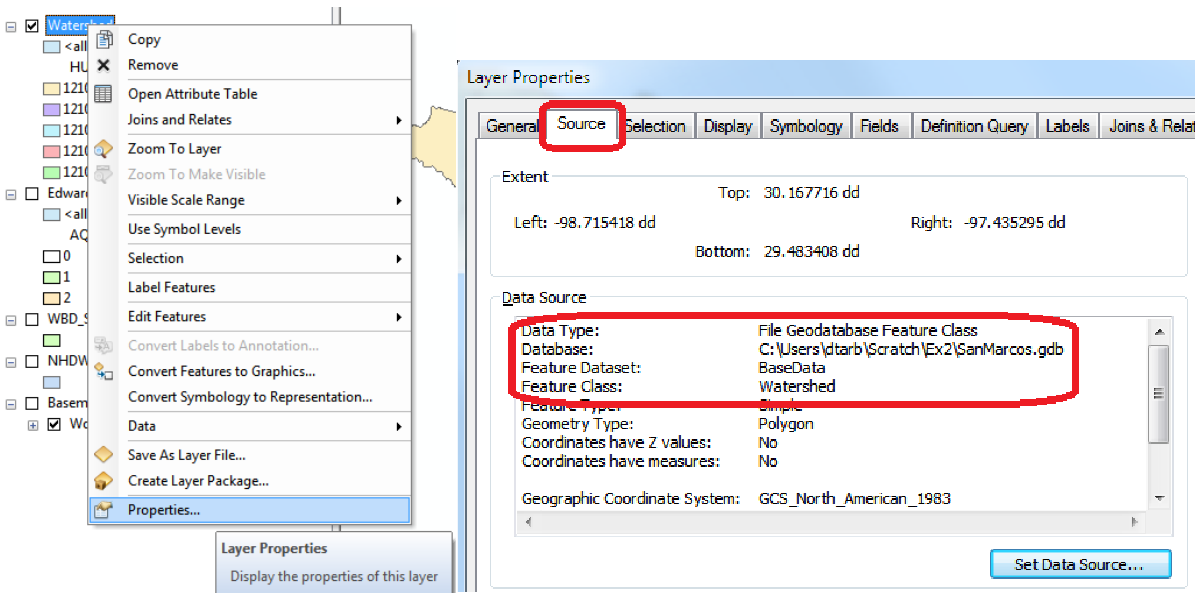
Select the **Identify** tool, go up near the top of the San Marcos Basin, and click on one of the HUC-12 subwatersheds. You'll see its attributes pop up. Notice the hierarchy of numbers for the HUC_8, HUC_10, and HUC_12 attributes.



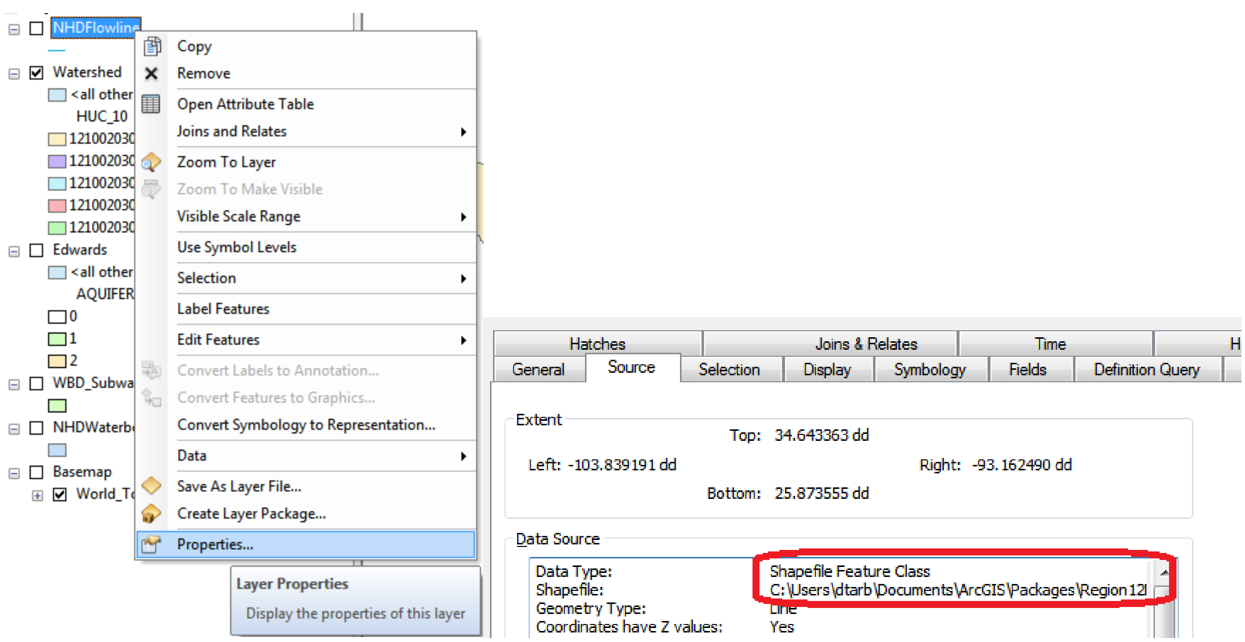
Use **File/Save As** to save your map file as Ex2.mxd with the new information that you've created (and to keep it distinct from the Map Document Region12NHDPlus.mxd opened from ArcGIS Online).

Where is My Stuff

Right click on Watershed and select Propeties and select the Source tab. Notice that this Feature Class you created is in the BaseData Feature Dataset in the SanMarcos.gdb Geodatabase in the location where you created it.

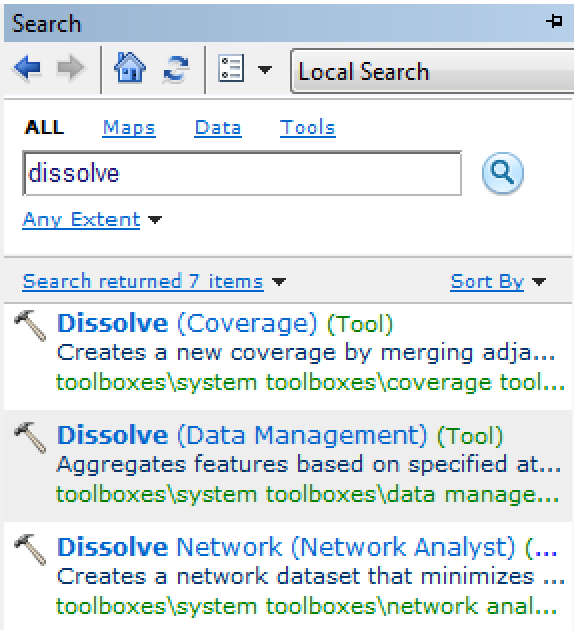


Now right click on NHDFlowline and select Propeties and select the Source tab. This is one of the layers from the Map Document Region12NHDPlus.mxd opened from ArcGIS Online. Notice that this is a Shapefile stored in your Documents\ArcGIS\Packages folder. This is where stuff goes when you download a map document from ArcGIS Online. This becomes important if you want to move your map document to another computer. This downloaded data will not go along with your map document automatically so its keeping needs to be managed.

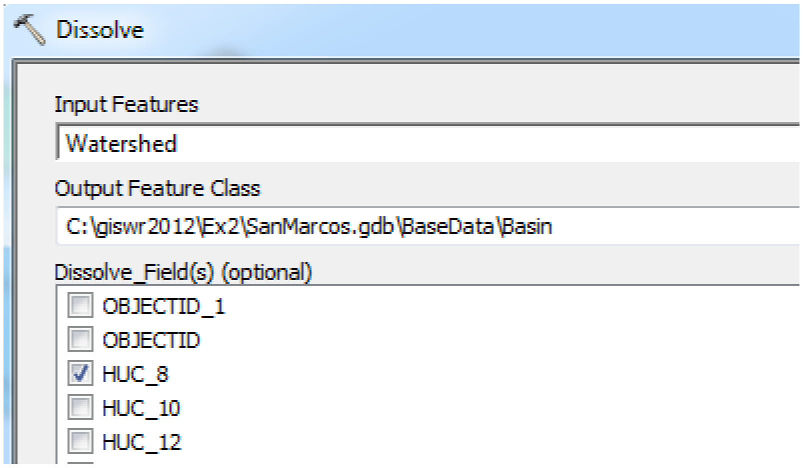


Creating a San Marcos Basin Boundary

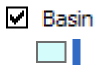
It is useful to have a single polygon that is the outline of the San Marcos Basin. Click on the **Search**  button in ArcMap and within the Search box that opens up on the right hand side of the ArcMap display, click on **Tools** and then type **Dissolve**. You will see the autocomplete tool gives you several options and select **Dissolve (Data Management)**



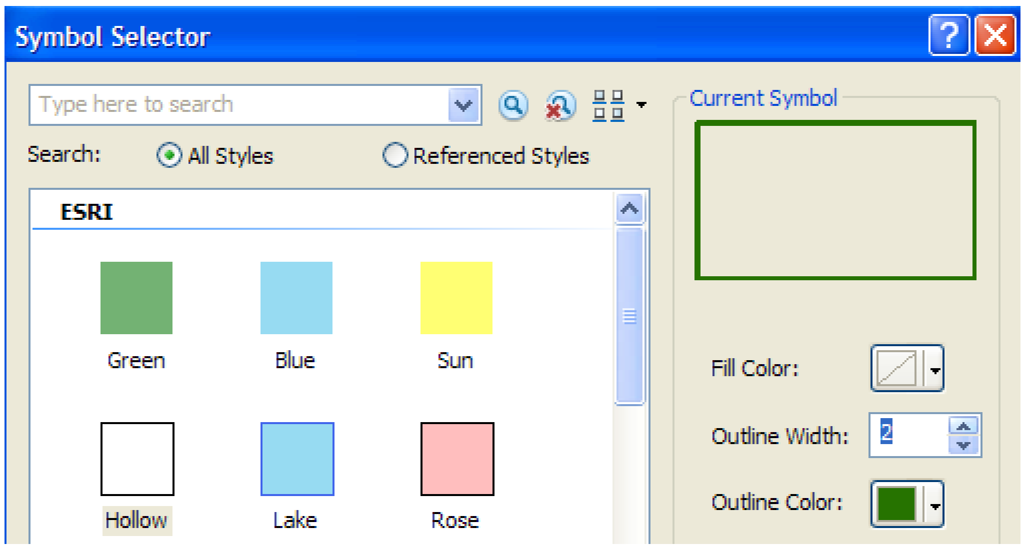
You'll see a **Dissolve** tool window appear. You can drag and drop the **Watershed** feature class from the Table of Contents into the **Input Features** area of this window. For the **Output Feature Class**, navigate to the BaseMap feature dataset and type **Basin** as the name**.** Click on **HUC_8** as your **Dissolve_Field**. This means that all Watersheds with the same HUC8 number (12100203) will be merged together. Hit Ok to execute the function.



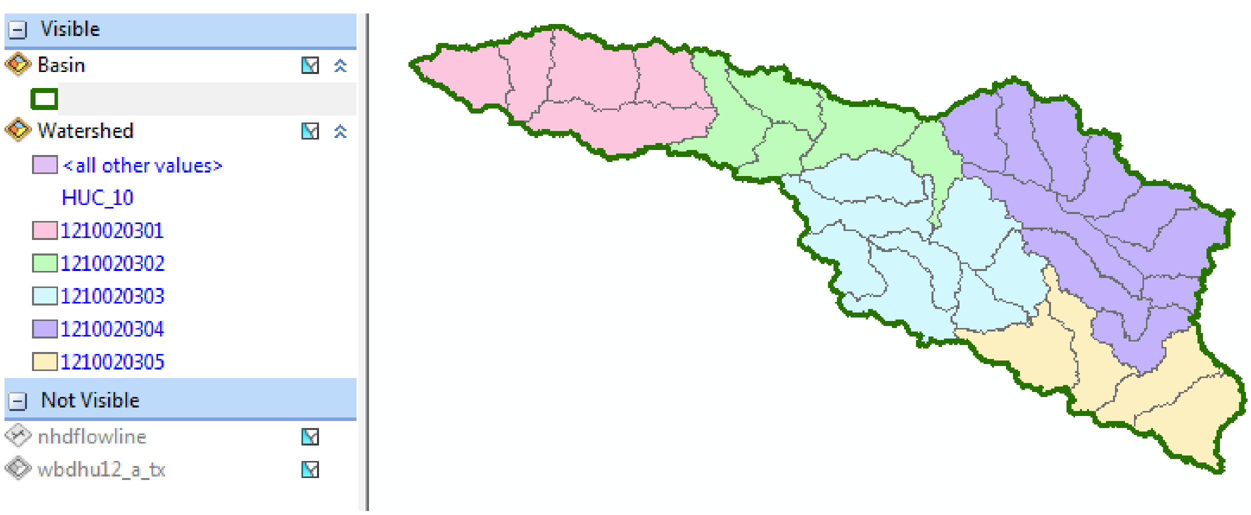
There'll be no apparent activity for a while and then you'll see some blue scrolling text at the bottom right and a pop up indicating completion and the Basin feature will appear.

Lets alter the map display to make the Basin layer just an outline. Click on the Symbol for the Basin layer 

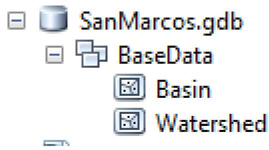
and select **Hollow** for the shape, Green for the **Outline Color** and 2 for the **Outline Width**.



And you'll get a very nice looking map of the San Marcos Basin with its constituent subdrainage areas.



Click on the **Catalog** window in ArcMap and navigate to your **BaseData** feature dataset. Notice how you've now got the **Watershed** and **Basin** feature classes that you've just created stored inside it.

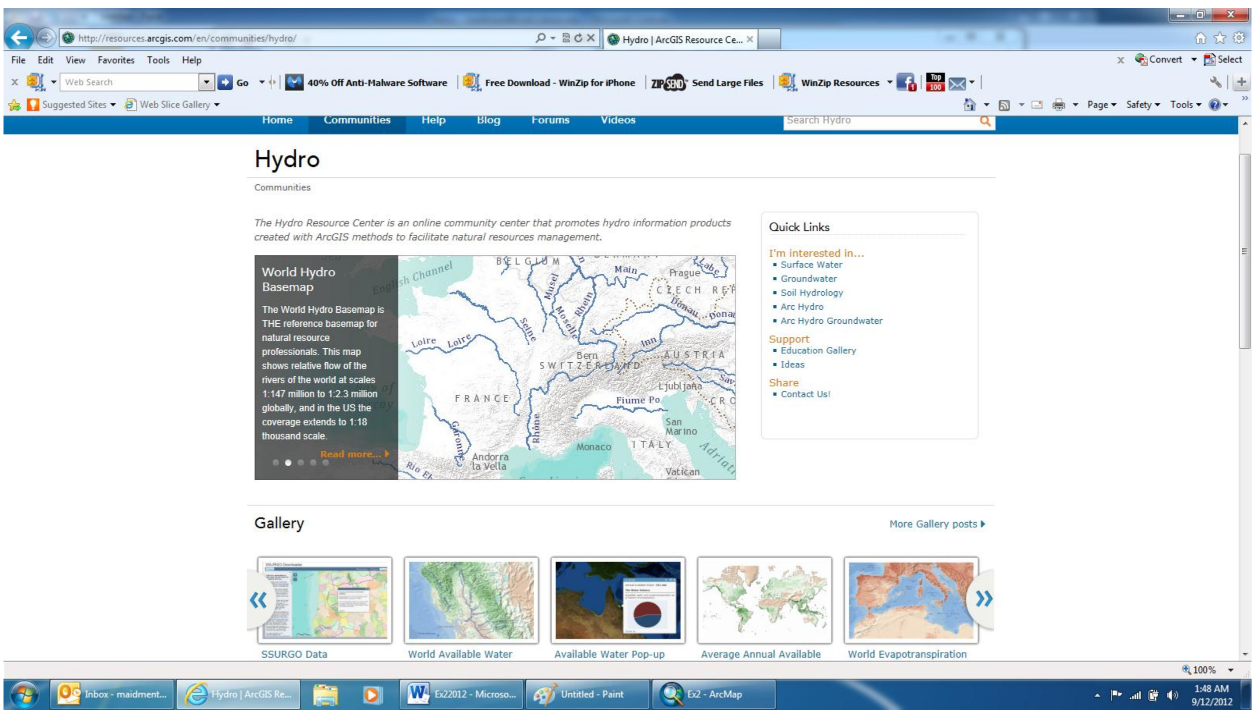


Save your ArcMap document to the file **Ex2Basin.mxd.** Note that this is a different name than used earlier, so you can retrieve the former configuration or this one separately. **Close ArcMap.**

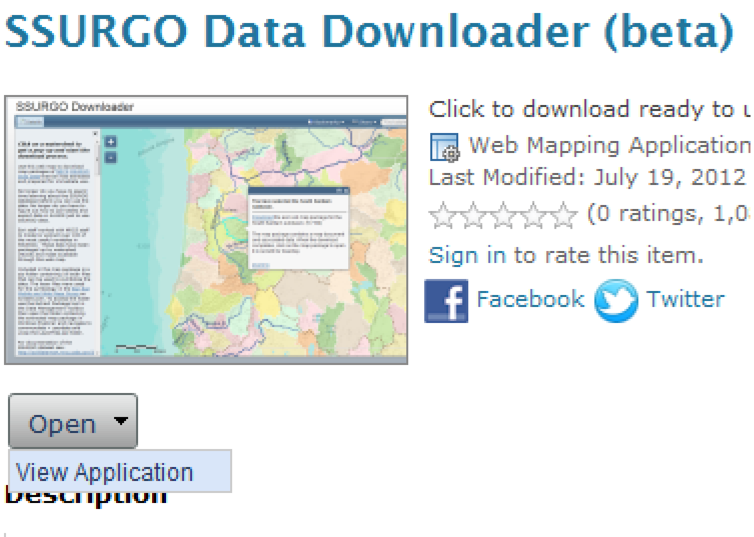
To be turned in: A screen capture of the San Marcos basin with its HUC-10 and HUC-12 watersheds and subwatersheds.

Soil Information for the San Marcos Basin

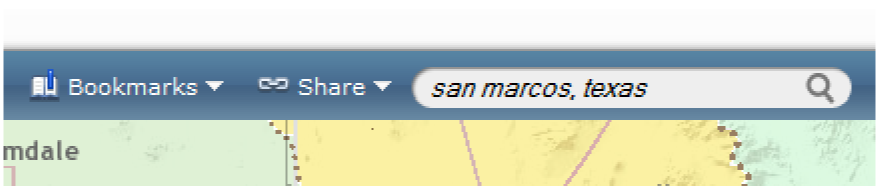
Go to the Hydro Resource Center on ArcGIS.com http://resources.arcgis.com/en/communities/hydro/ (Use the **Firefox** or **Chrome** browser as this application does not work properly in Internet Explorer). Scroll across the Gallery at the bottom of the page until you see the **SSURGO Data** map (left end of the Gallary ribbon below).



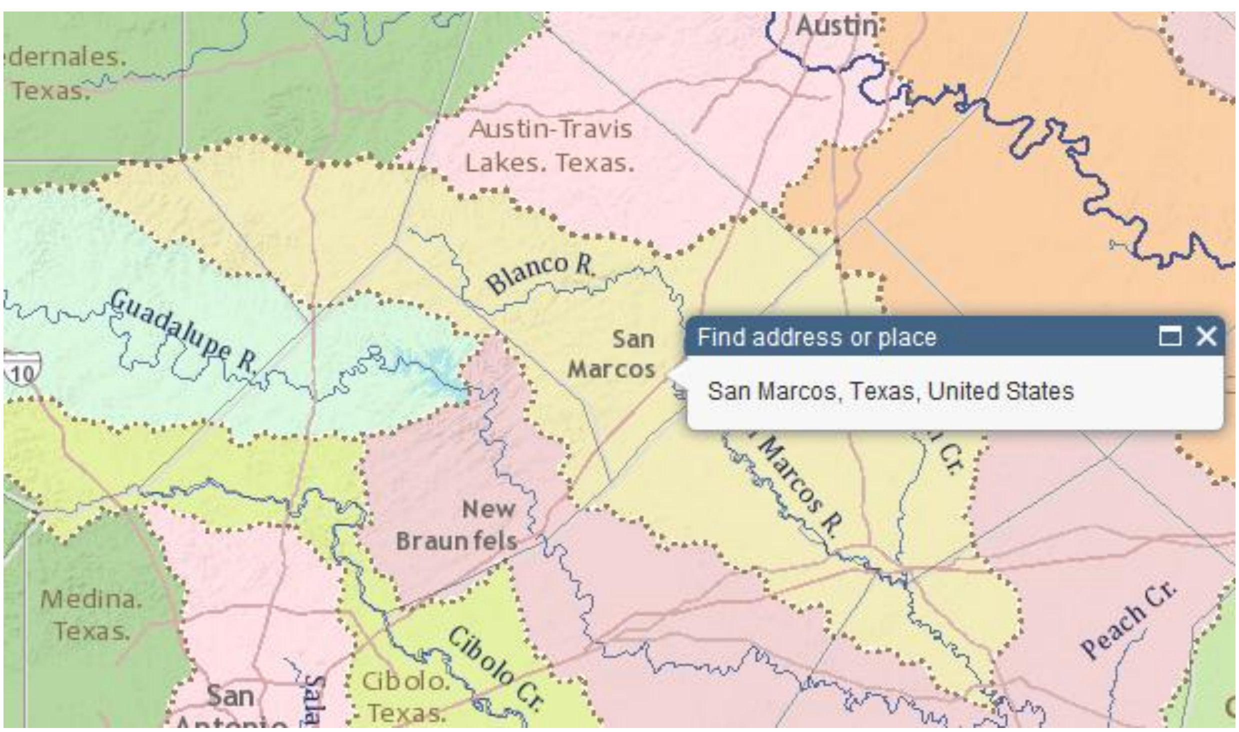
Open the SSURGO Data Downloader (beta) application



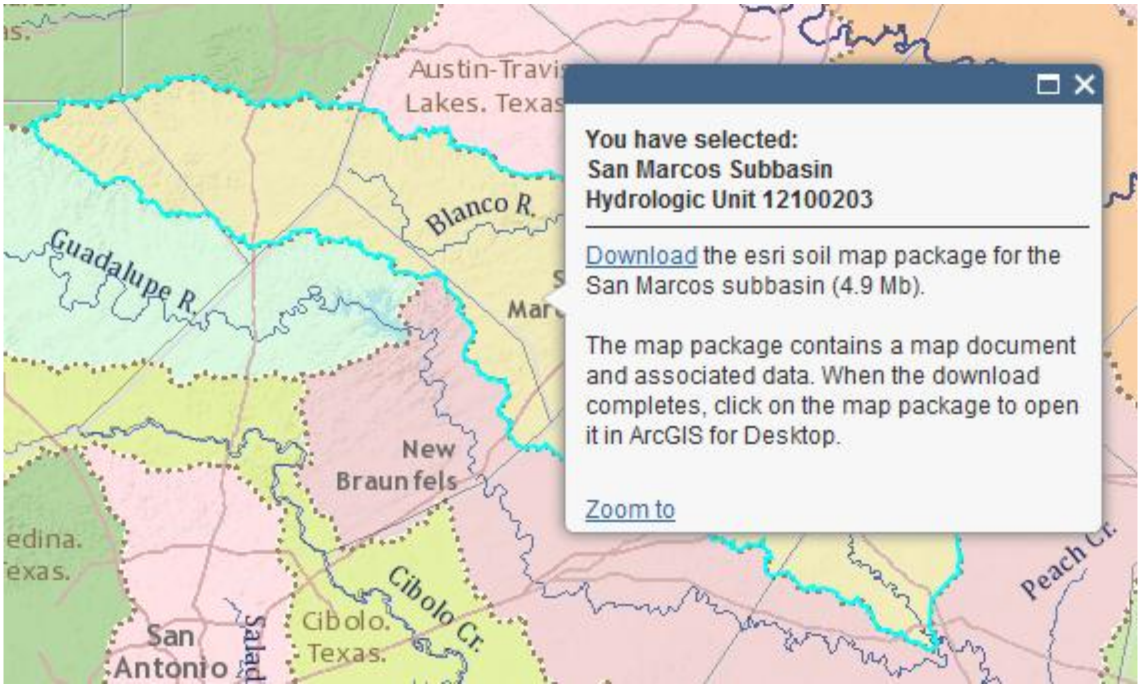
In the map that appears, enter San Marcos, Texas as the place to search in the top right corner



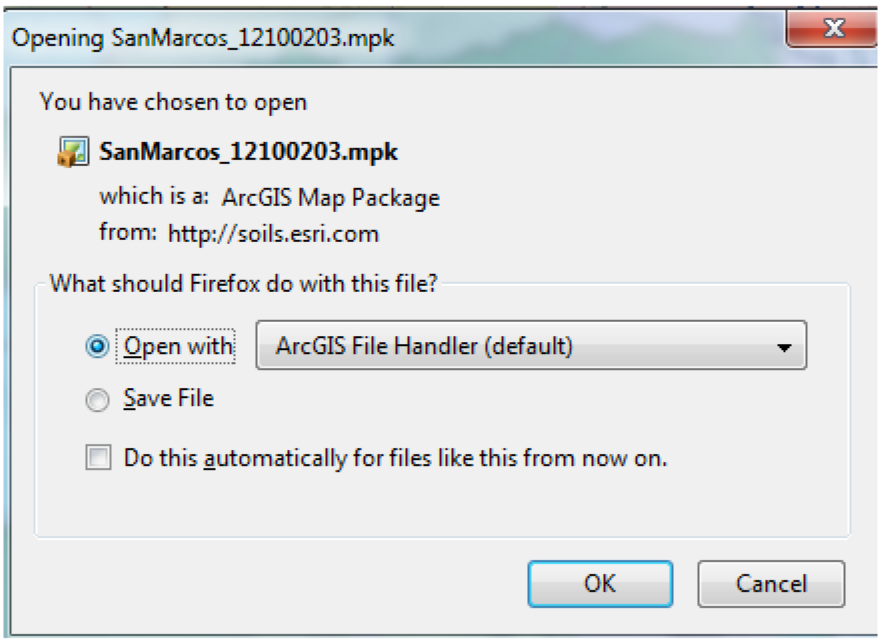
Zoom back a bit and you'll see the San Marcos Basin. Pretty nice map!



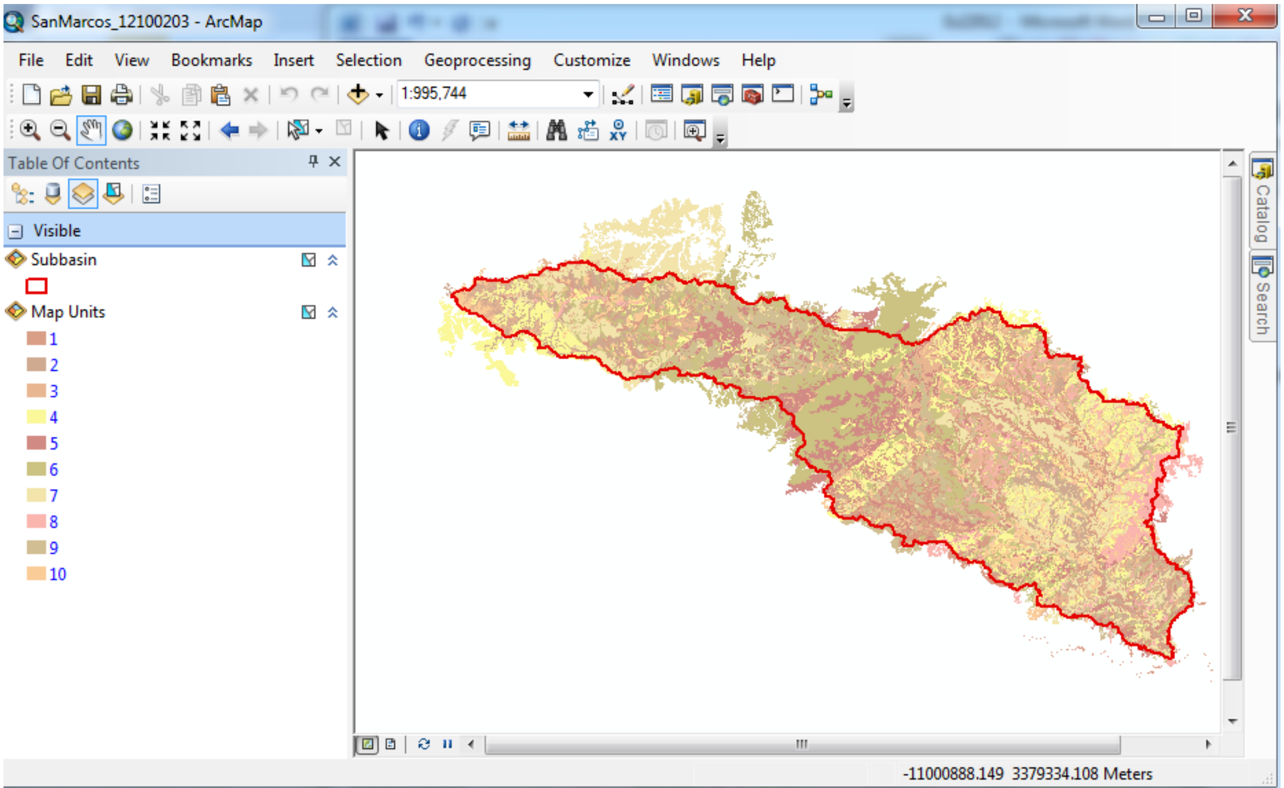
Click on the San Marcos Basin to highlight it, and select **Download** to get the soil map package for this basin



Select **Open with the ArcGIS File Handler** (make sure ArcMap is closed before you do this).

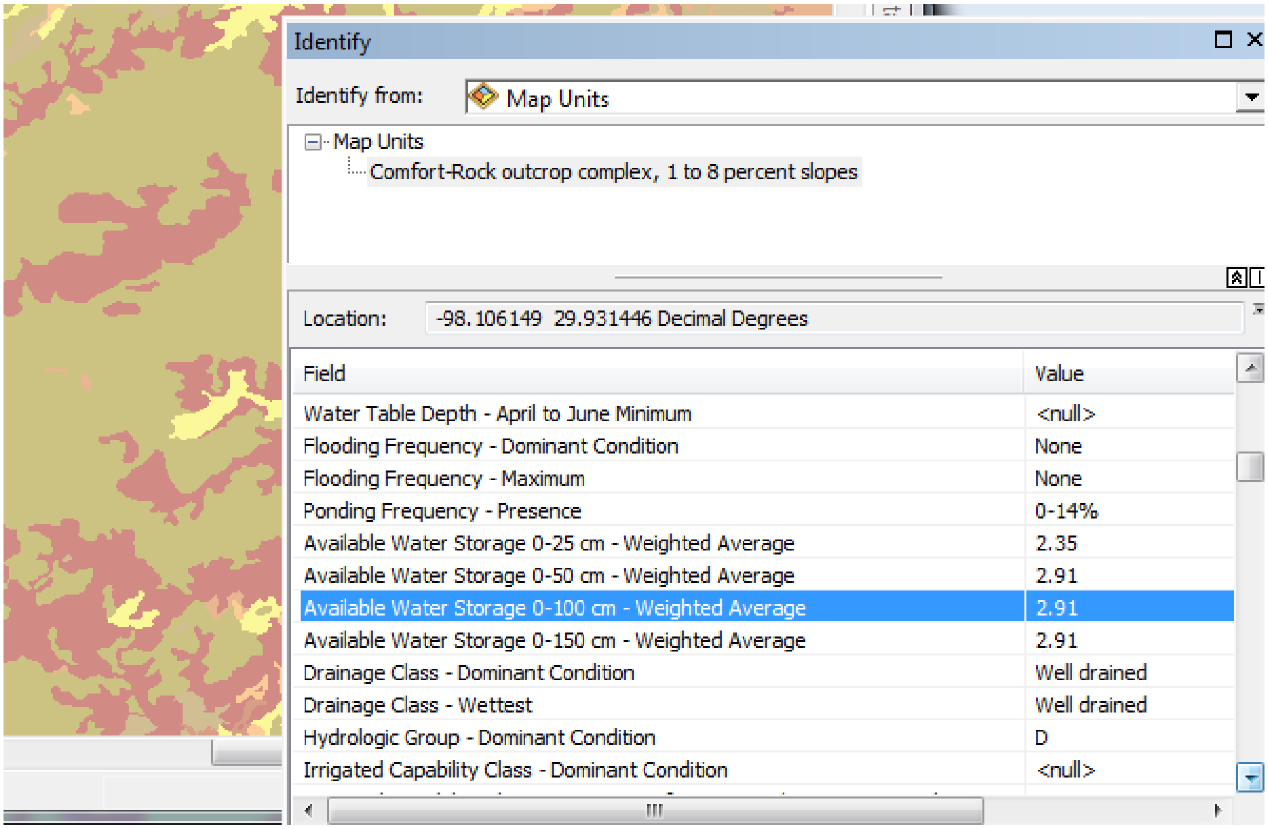


ArcMap will open and you'll get a map that shows SSURGO soil map data for this basin. ESRI has simplified access to the SSURGO soil database produced by USDA and made a map package like this for each HUC-8 Subbasin in the US.

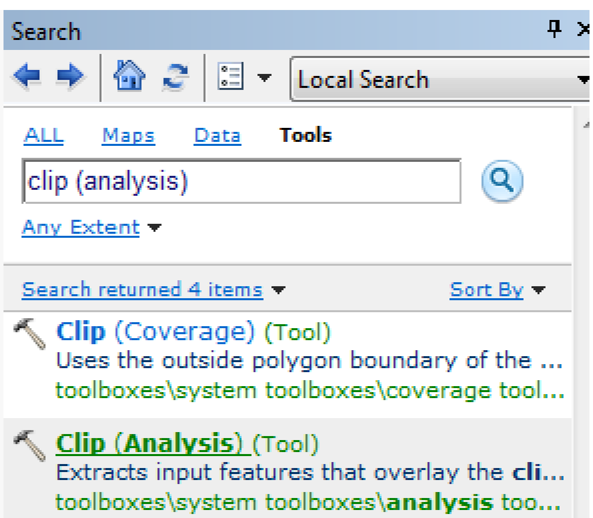


The numbers 1-10 refer to different soil classes in the basin.

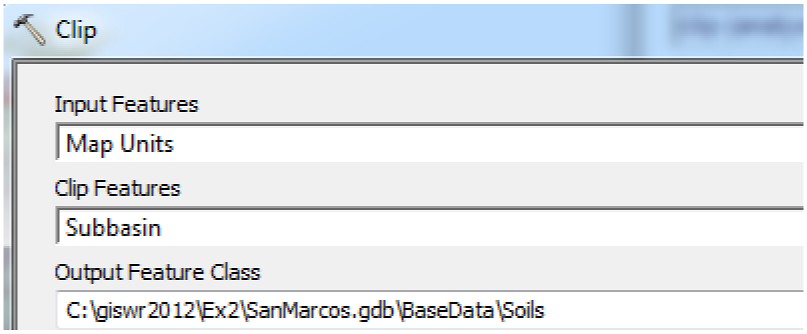
If you use the Identify button, zoom into a particular area in the map, make Map Unit the layer to be identified and query some features, you can see some characteristics of the soils. Make the Identify window wider if you can't see any numerical values. We are going to focus on one attribute, **Available Water Storage 0-100cm – Weighted Average** This specifies the number of cm of water that can be stored in the top 1m of soil, only 2.91 cm in the example shown below. Wow! We have really thin soils overlying shallow surface rocks at this location!



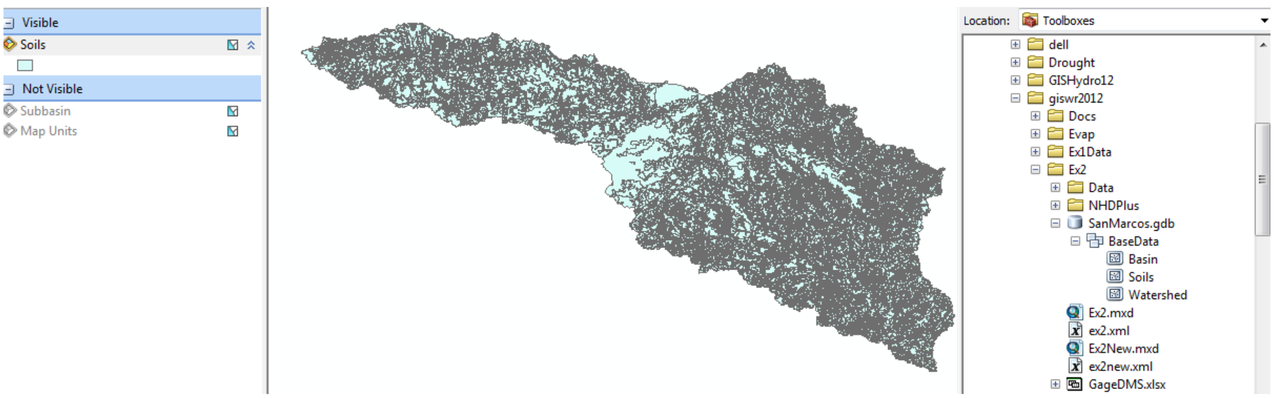
Select the Clip (Analysis) tool (using Search as before)



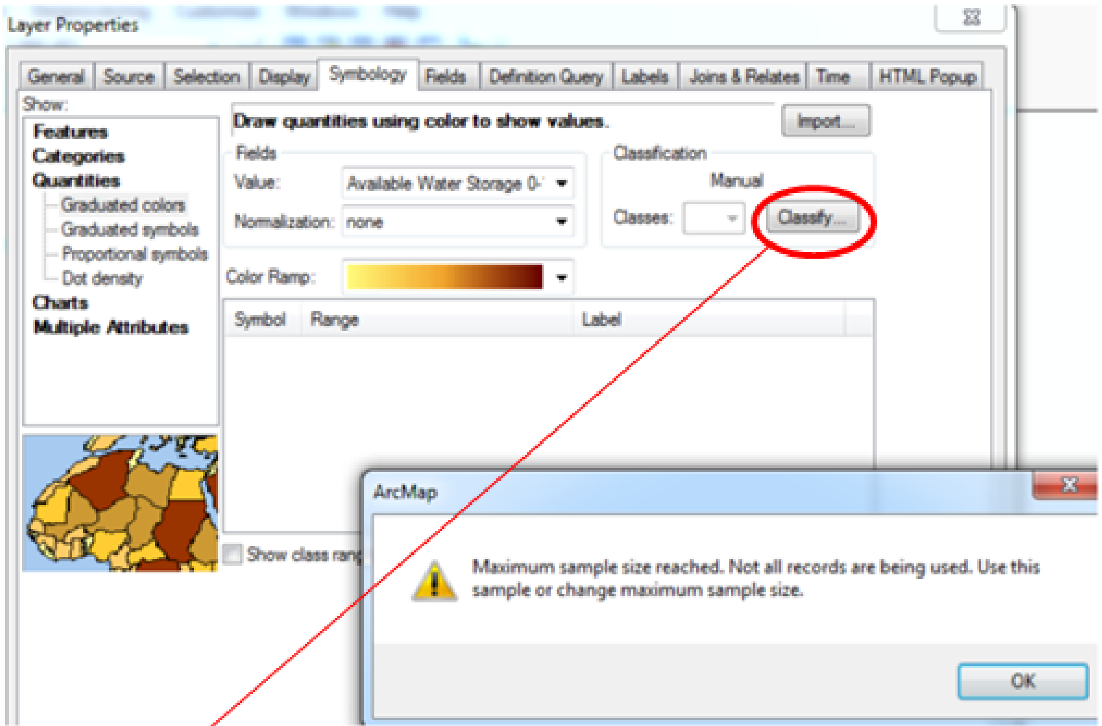
With input features **Map Units**, clip features **Subbasin**, and output features **Soils** in your BaseData feature dataset for the San Marcos Basin.



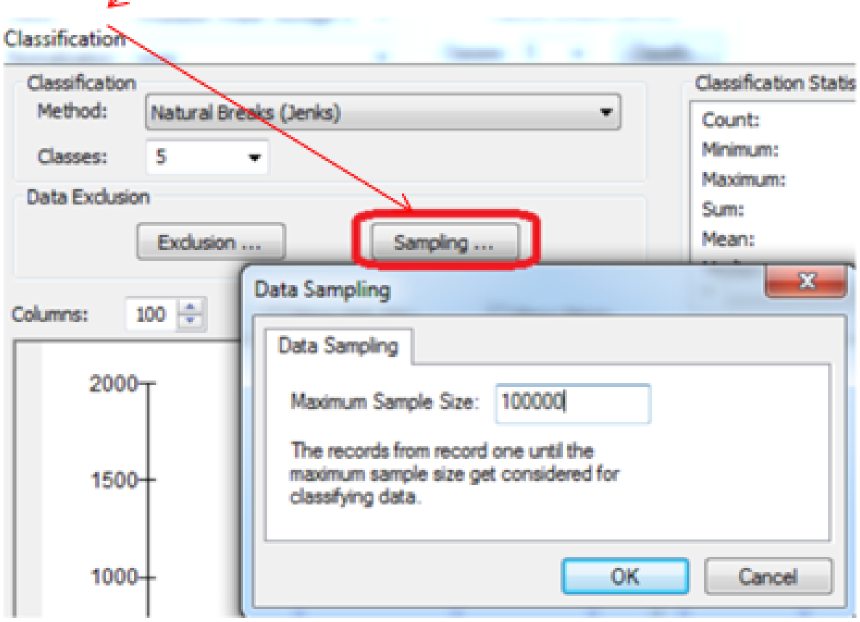
And if you make invisible all the layers except for Soils and open the Arc Catalog, you'll see that you've now got a feature class of soil information in the San Marcos Basin. Pretty cool!



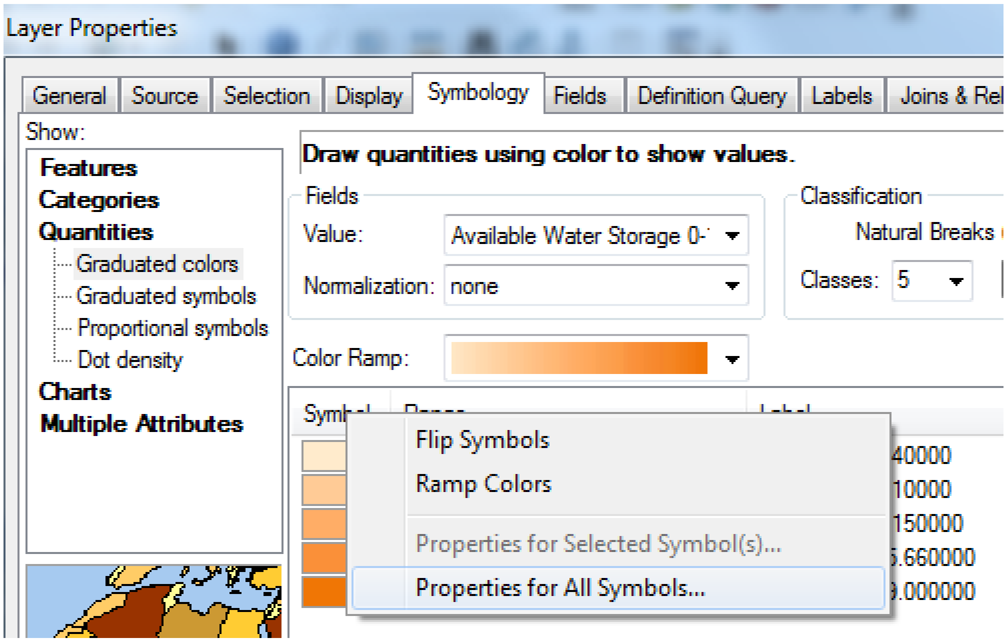
If we want to make a map of the San Marcos basin **Available Water Storage 0-100 cm - Weighted Average**, you'll find there are too many features to symbolize with the default settings



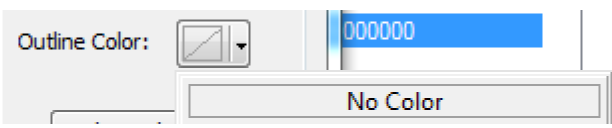
So under **Classify/Data Sampling** increase the Maximum Sample Size to 10000



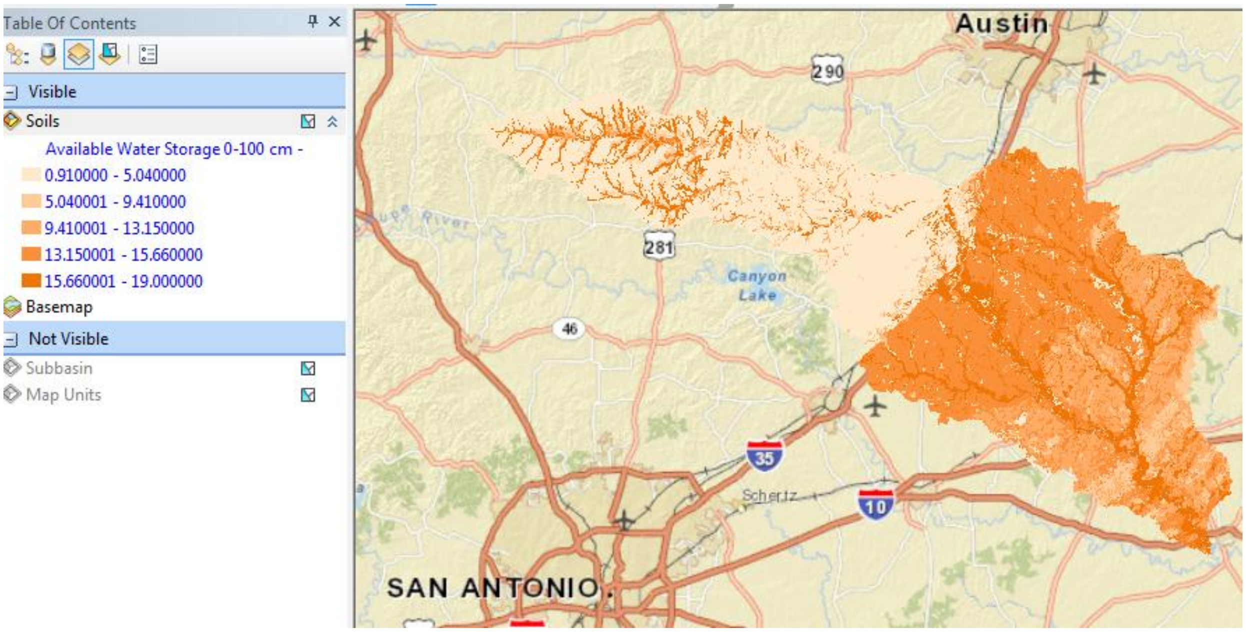
And put "No color" in all the Outline symbols, by clicking on **Symbol/Properties for All Symbols**



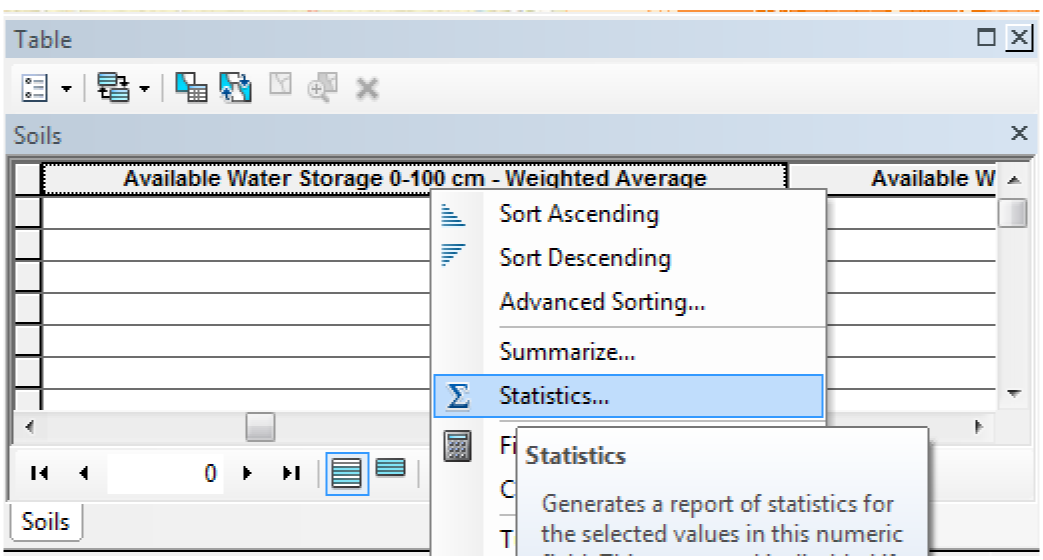
And select **Outline Color** as **No Color**



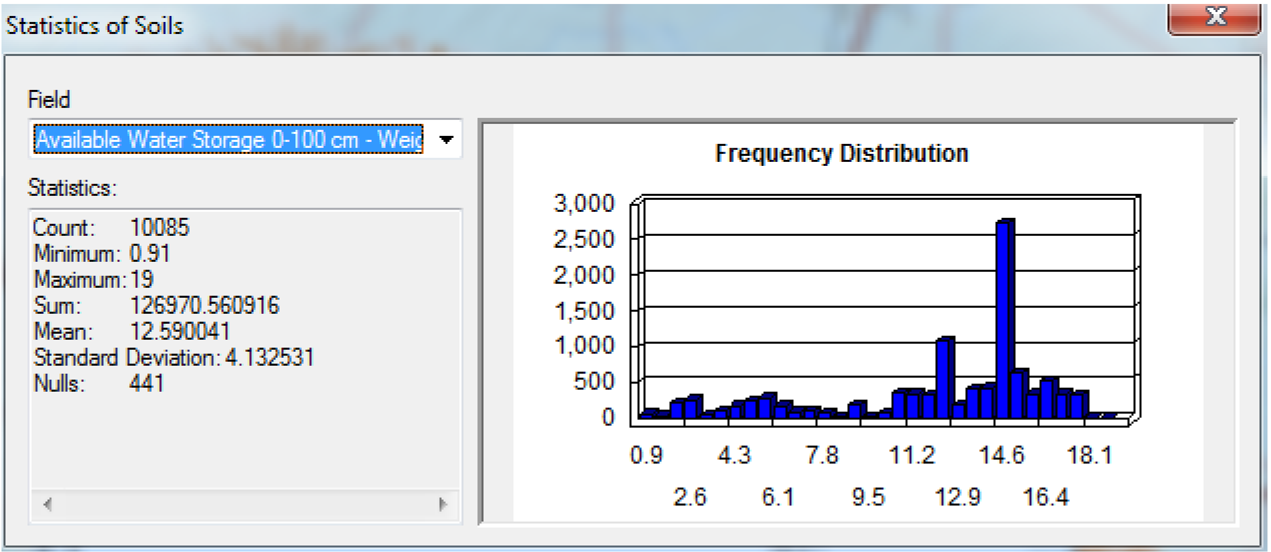
you'll get a really remarkable map that shows how the Available Water Storage increases significantly as you go east in the basin across IH-35 and off the thin rocky soils of the Balcones Escarpment to the west and in the deeper more agriculturally productive soils to the the east. You can also see the presence of the streams in the eastern side of the basin and the deeper more alluvial soils that have been deposited around them. I've added the Roads Basemap to highlight the demarcation of soil properties along IH-35 ☺



If you open the attribute table of the Soils feature class, right click on the 0-100 cm Available Water Storage field and select Statistics



And you'll get a summary of the Statistics of this field.



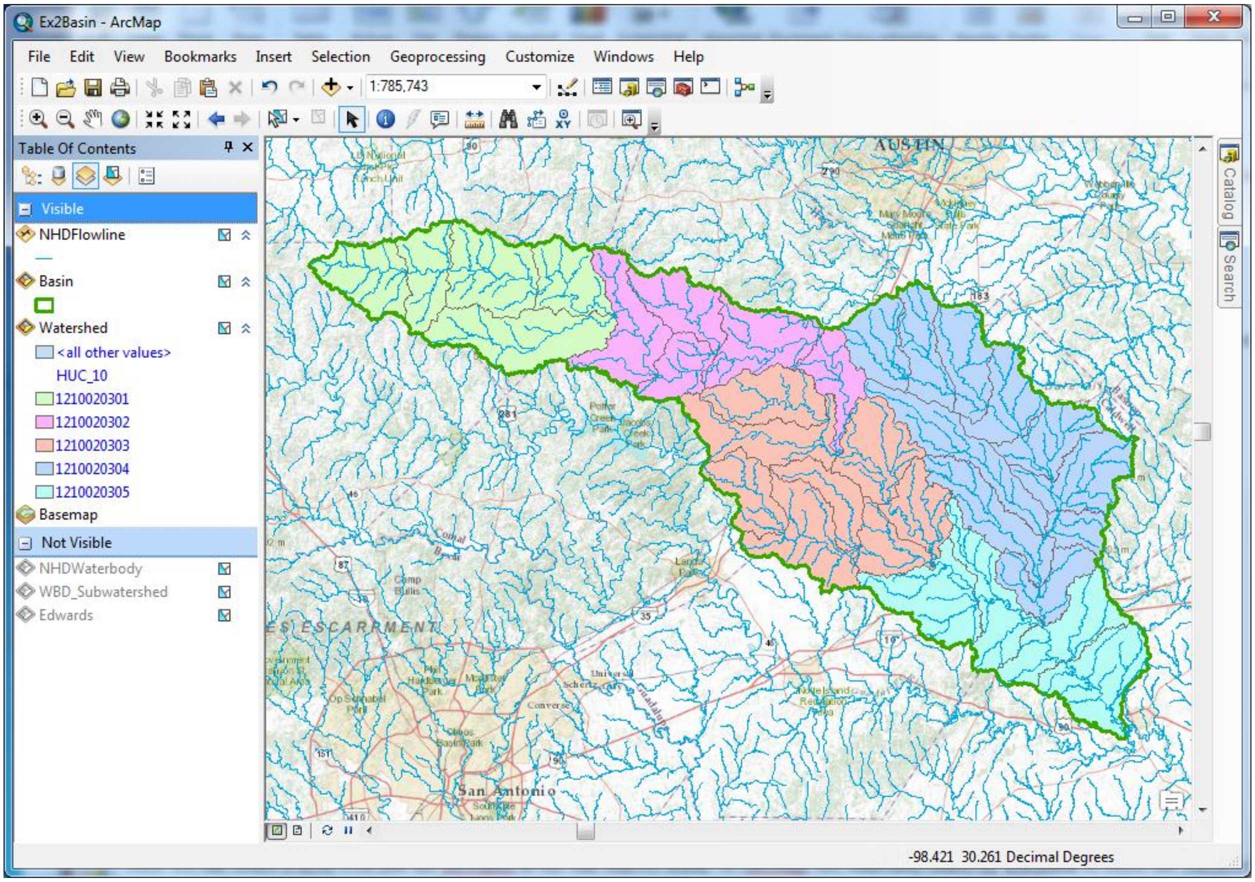
Note that care is needed in interpreting these statistics as the soil polygons involved have different sizes. To be really precise about the computation below we should area-weight the polygons rather than just computing the statistical average. Lets just use the statistical average for now.

Save your map as Ex2Soils.mxd and close ArcMap.

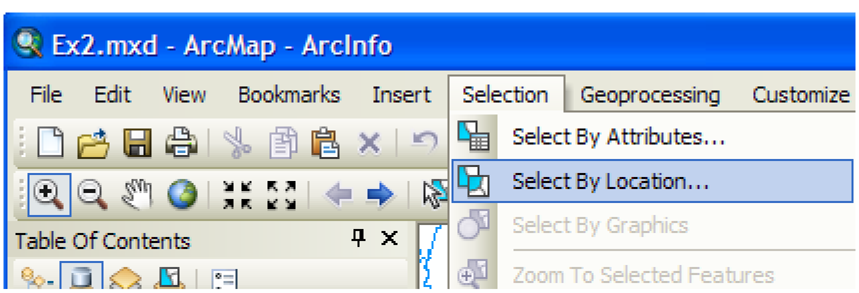
To be turned in: What is the average available water storage (cm) in the San Marcos basin? If the area of the basin is 3520 square kilometers, what volume of water (km^3) could potentially be stored in the top 1m of soil in the San Marcos basin if the soil were fully saturated with water?

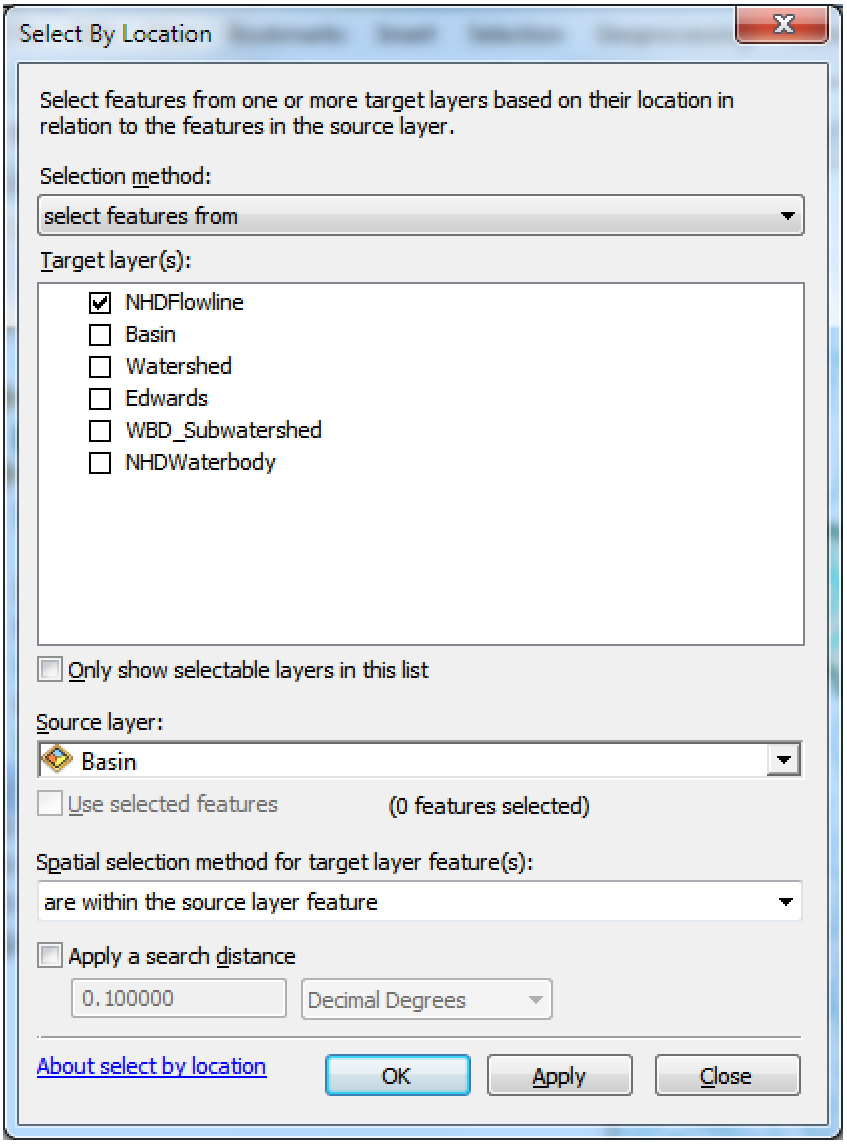
Selecting the San Marcos Flowlines

Open ArcMap using the **Ex2Basin.mxd** file that you saved earlier. Click on the symbol to the left of **nhdflowline** in the Table of Contents to make the flowlines visible again.



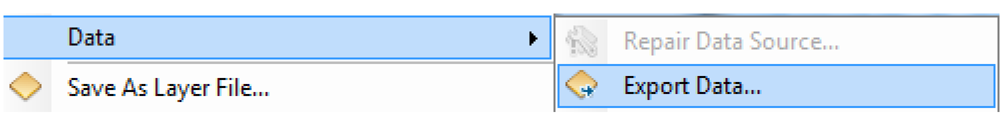
Now we can create a layer with just the flowlines in the San Marcos Basin. In ArcMap, use **Selection/Select by Location** to select the features from **nhdflowline** as the Target Layer and **Basin** as the Source Layer, and use the Spatial Selection Method "Target layer(s) features are within the Source layer feature". This selects all the streams in the San Marcos Basin.



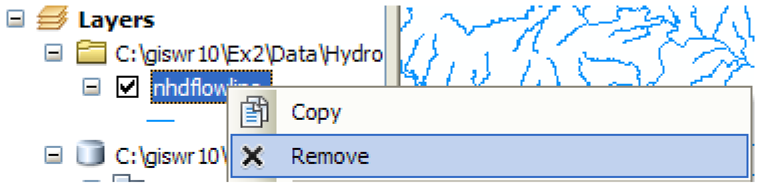


Hit **OK** and you'll see the flowlines within the basin selected.

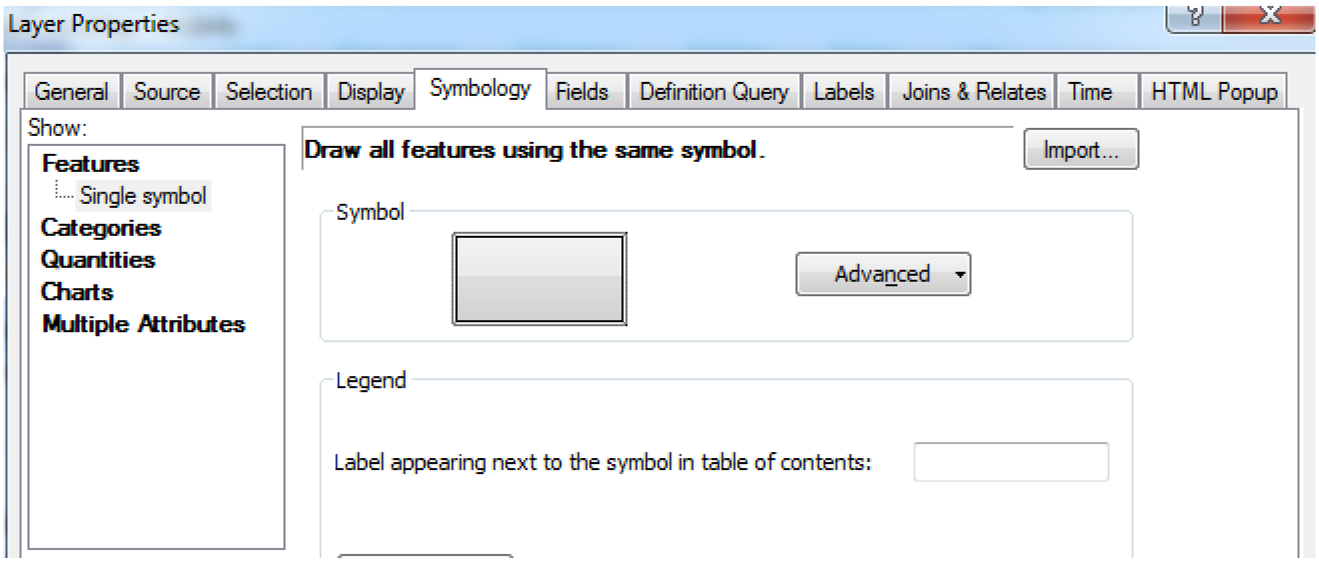
Right click on the **NHDFlowline** feature class and select **Data/Export Data**



Save the selected features as **Flowline** in the BaseData feature dataset and add it as a layer to the map. Remove the old **NHDFlowline**, **WBD_Subwatershed** and **NHDWaterbody** themes from your map display by right clicking on the Layer name and selecting **Remove**.

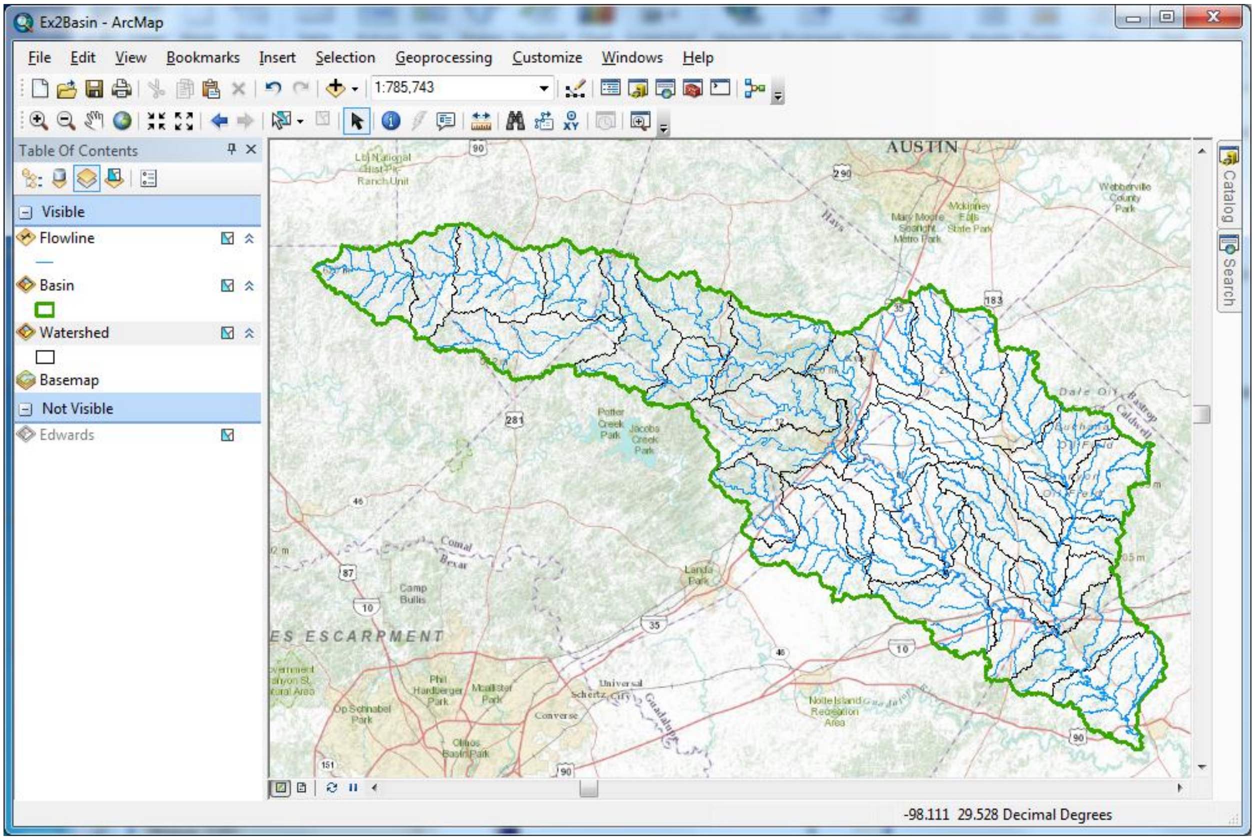


Right click on the **Watershed** feature class and under **Properties/Symbology**, assign a **Single Symbol** for the features and select that Symbol to be **Hollow**



If necessary, change your symbology so that your flowlines are colored in blue. We want to have our streams looking liking real map streams!

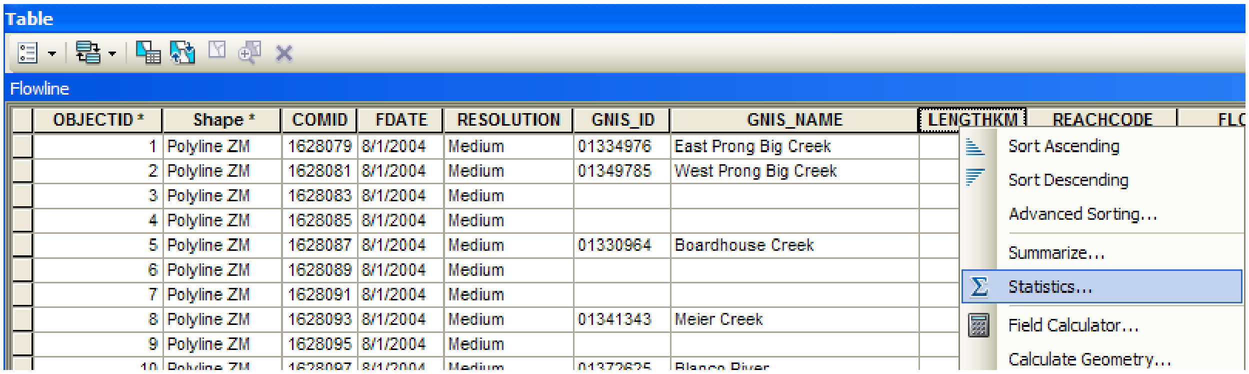
Now you've got a map where you can see your flowlines within the areas they drain. Very nice!

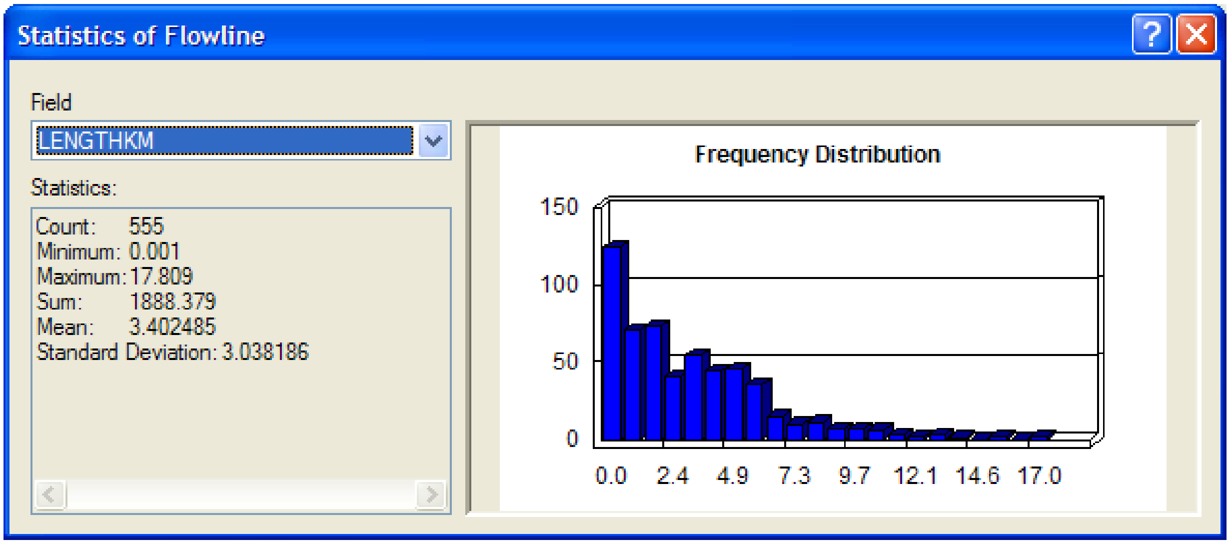


That looks very cool!! You can see how the slope of the topography changes between the east and west of IH-35. East is flatter and West is steeper. This is another reflection of the different underlying geology of the two parts of the basin that you saw earlier reflected in the soil map properties.

Save the **Ex2Basin.mxd** file again.

Now let's look at some summary statistics of the **flowlines**. Open the Attribute table Right click on the **LengthKm** field and select **Statistics**





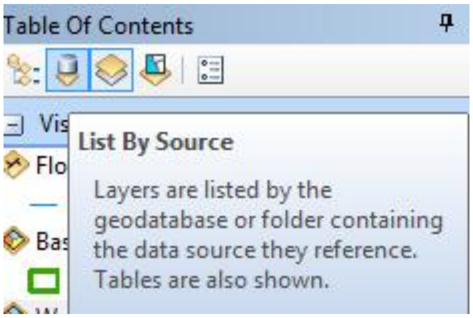
From this display, you can see the statistics of the LengthKm of the Flowlines. There are 555 flowlines whose average length is 3.40 km and the total length is 1888 km. You can do the same query on the Acres attribute of the Watershed feature class to get watershed areas. (1 acre = 0.0040469 km^2).

To be turned in: How many HUC12 subwatersheds are there in the San Marcos Basin? What is their average area in acres and in km^2? What is the total area of this basin in km^2? What is the ratio of the length of the streamlines to the area of the HUC12 subwatersheds (called the drainage density) in km^{-1}?

Adding Attributes to the Flowlines

Now we will use the flowline attributes table to symbolize the flowlines based on their mean annual flow.

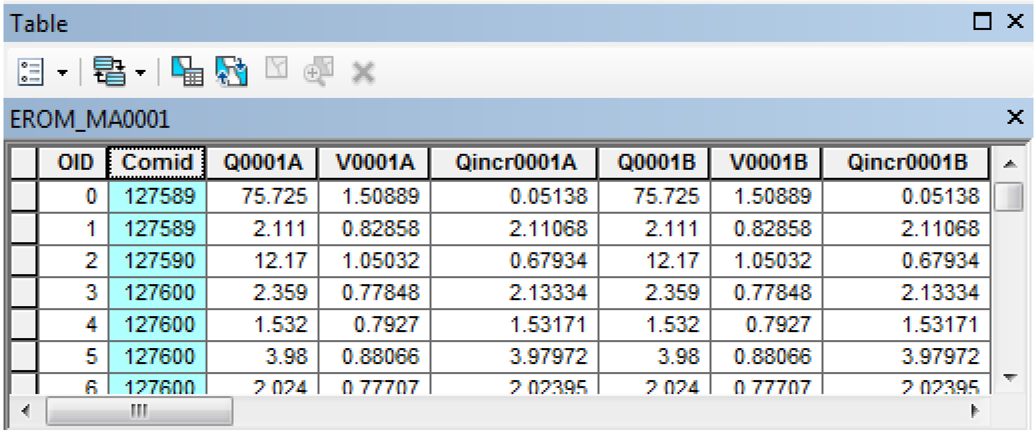
Change the Table of Contents display to **List by Source**



And you'll see that you've got a table near the bottom of the set of listed layers called **EROM_MA0001**. EROM stands for "Extended RunOff Method" and contains data from a fairly complicated method of estimating mean annual flow on the NHDFlowlines that you can read details about in the NHDPlus Version 2 User Guide if you are keen to understand this

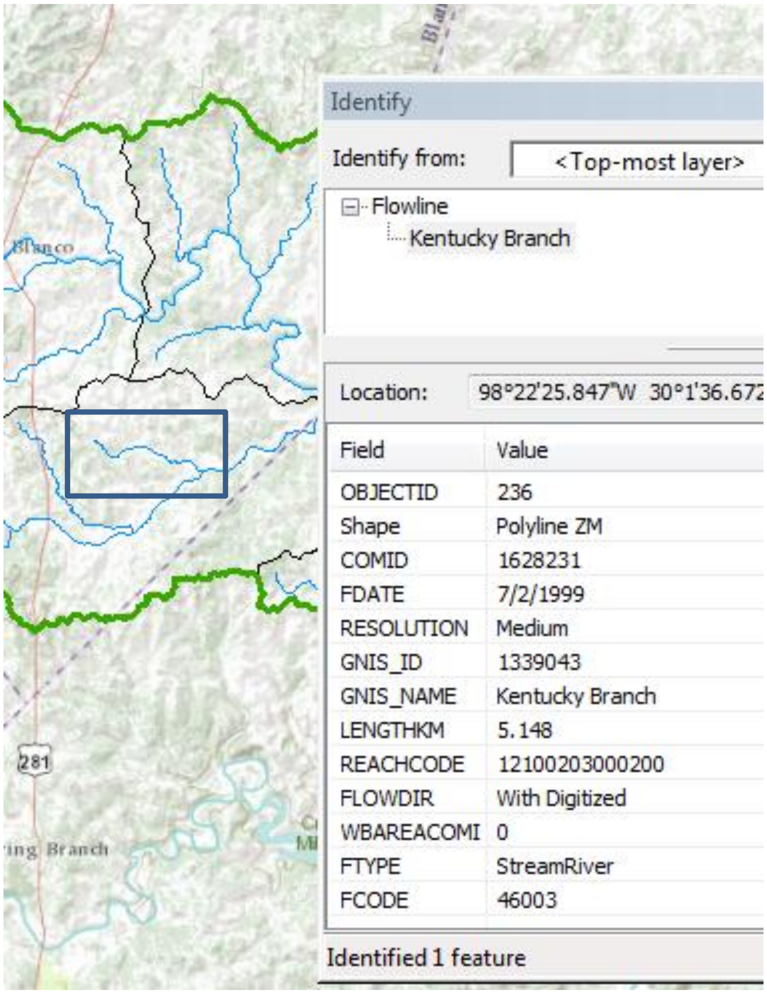
further.
ftp://ftp.horizon-systems.com/NHDPlus/NHDPlusV21/Documentation/NHDPlusV2_User_Guide.pdf

Right click and Open the table **EROM_MA0001**. You'll see there is a field for COMID which is a key field identifying each NHDPlus flowline feature and enabling it to be linked to attributes of that feature held in separate tables, such as this one.

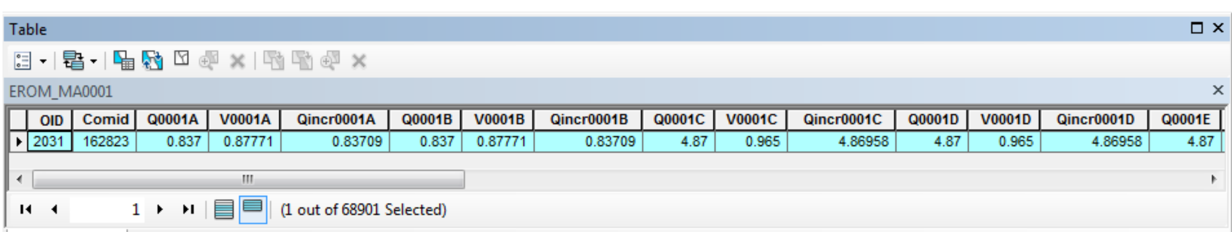


OID	Comid	Q0001A	V0001A	Qincr0001A	Q0001B	V0001B	Qincr0001B
0	127589	75.725	1.50889	0.05138	75.725	1.50889	0.05138
1	127589	2.111	0.82858	2.11068	2.111	0.82858	2.11068
2	127590	12.17	1.05032	0.67934	12.17	1.05032	0.67934
3	127600	2.359	0.77848	2.13334	2.359	0.77848	2.13334
4	127600	1.532	0.7927	1.53171	1.532	0.7927	1.53171
5	127600	3.98	0.88066	3.97972	3.98	0.88066	3.97972
6	127600	2.024	0.77707	2.02395	2.024	0.77707	2.02395

Lets zoom into our Flowlines and use the **Inquiry** button  in the **Tools** menu to see the attributes of one of them. You'll also see there the **COMID** that uniquely identifies each flowline feature in the NHD. In this case, COMID = 1628231. You'll also see the **ReachCode** = 12100203000200 in this case. This means that this is segment 200 within HUC8 Subbasin = 12100203. You'll also see reference here to **GNIS**, which is the Geographic Names Information System, the official set of names for things in the United States. We have systems for everything!



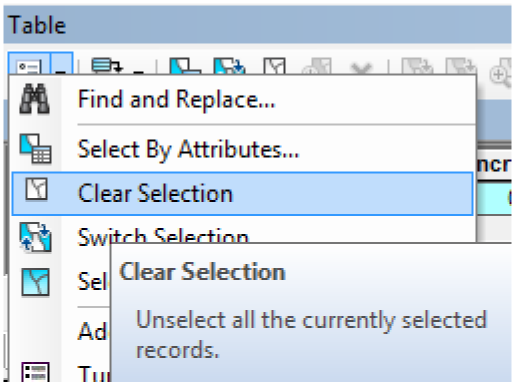
We'll use COMID as a key field to link the two attribute tables and transfer mean annual flow attributes to the Flowline feature class. Just for fun, I've use the "Select by Attributes" tool in the Table to select the record in the **EROM_MA0001** table that tells us more about this particular stream with 'COMID' = 1628231. It has a Mean Annual Flow of (Q0001E) of 4.87 cfs. This is very useful for water flow computations. The other estimates (A, B, C, D, etc refer to earlier steps in the Mean Annual Flow estimation process).



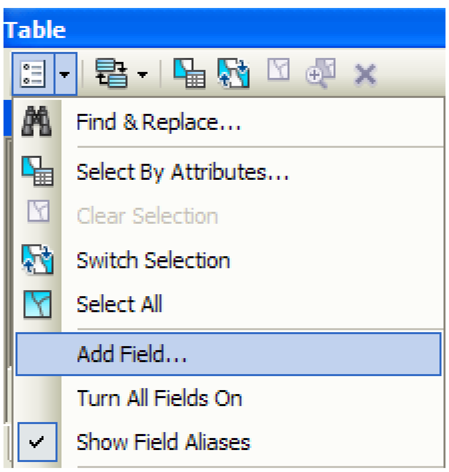
OID	Comid	Q0001A	V0001A	Qincr0001A	Q0001B	V0001B	Qincr0001B	Q0001C	V0001C	Qincr0001C	Q0001D	V0001D	Qincr0001D	Q0001E
2031	162823	0.837	0.87771	0.83709	0.837	0.87771	0.83709	4.87	0.965	4.86958	4.87	0.965	4.86958	4.87

Notice that there are 68,901 records in the **EROM_MA0001** table. This corresponds to the attributes for all the blue lines streams in the water resource region 12 in Texas, and that is a lot more than what we need to describe flow just in the San Marcos basin. What we'd like to do is to transfer the information about Mean Annual Flows from the **EROM_MA0001** table to the Flowline feature class just for those flowline features within the San Marcos basin.

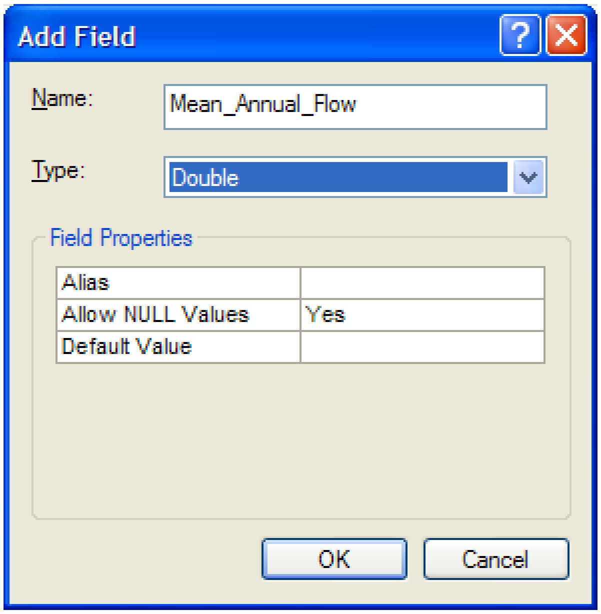
In the Table, use **Clear Selection** to unselect the record that we've been looking at.



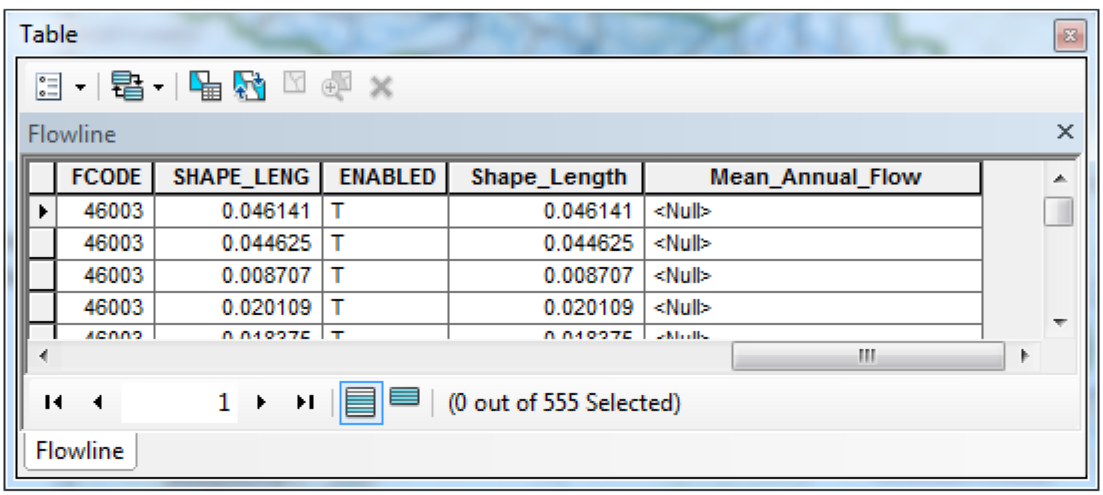
Open the attribute table for the feature class **Flowline** and select **Table Options/Add Field.**



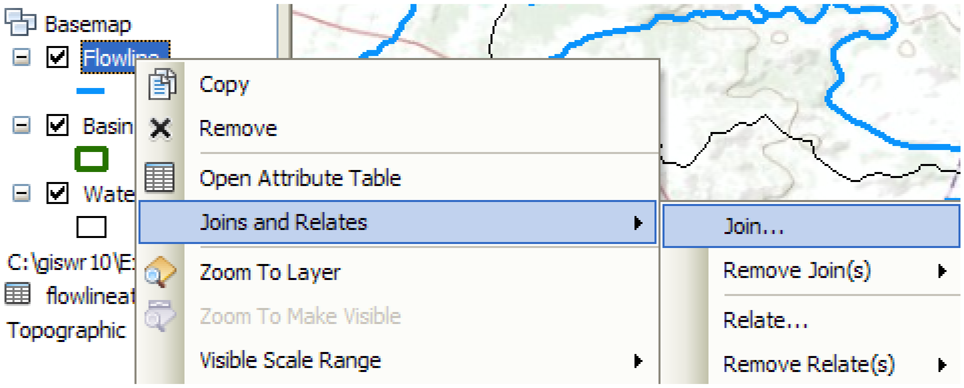
Name the field **Mean_Annual_Flow** and make it of the type **Double** and click **OK**.



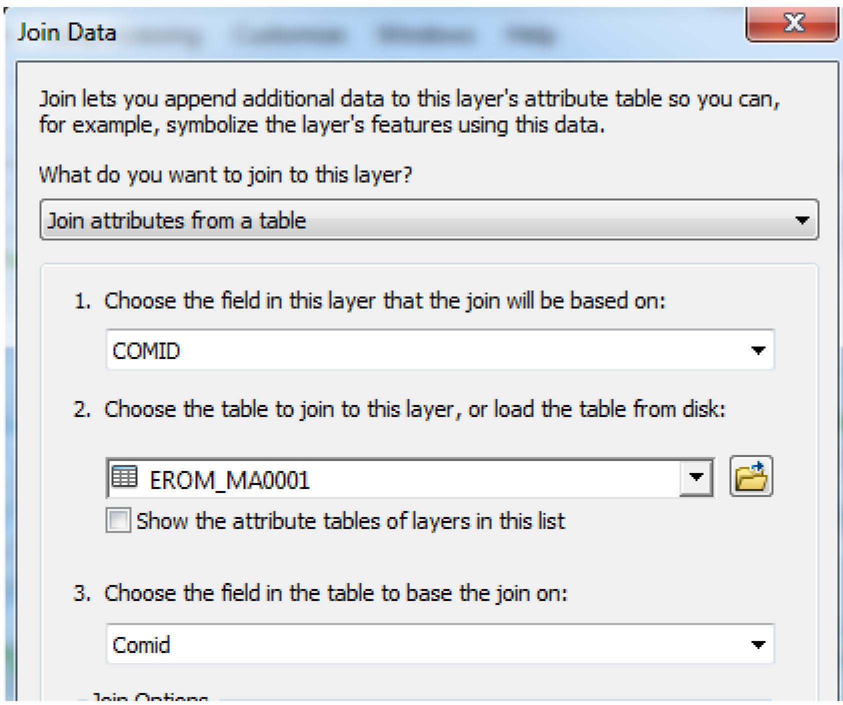
This creates a new field at the right hand end of the attributes table that has <null entries> in it for the moment. Notice that there are 555 features in the **flowline** feature class.



Now we will join the **Flowline** layer with the **EROM_MA0001** table based on COMID. Right click on the **Flowline** layer and select **Joins and Relates/Join.**

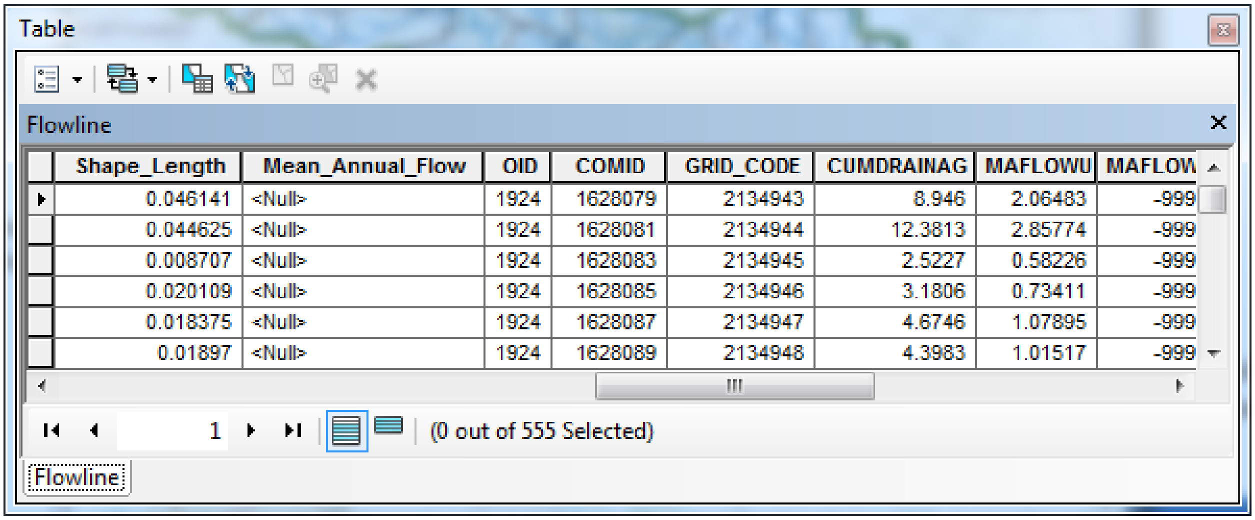


Select the COMID field and the **EROM_MA0001** table as the one you are going to join to



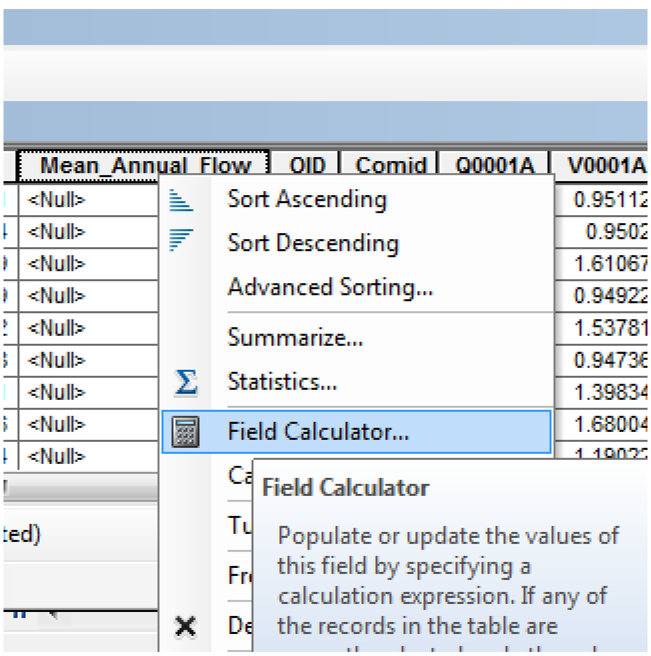
Say no to creating an index.

Now when you open the **Flowline** attribute table, at the right hand end of the table, you will find the information contained in the EROM_MA0001 table has been joined to the existing features. Scroll over to the column labeled Q0001E. This field contains the Mean Annual Flow for each reach that we are going to use. It is estimated by averaging the mean annual runoff over the drainage area above this reach. Notice that in this joined table, we've only got 555 records with flow values in them, not the 68,901values we had earlier.

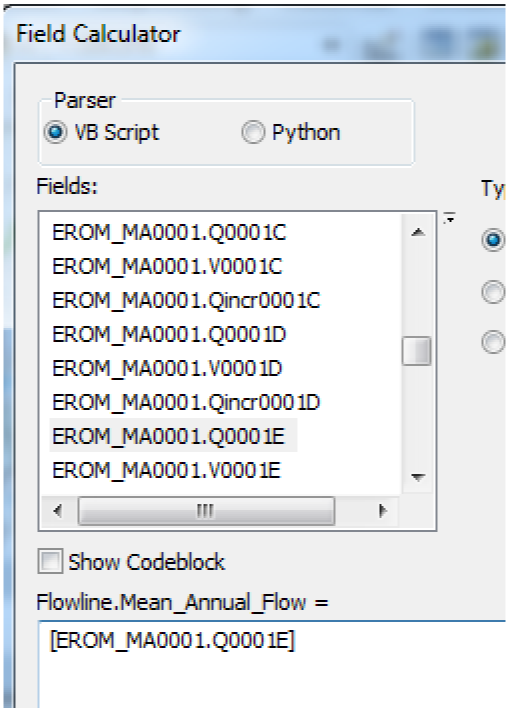


Shape_Length	Mean_Annual_Flow	OID	COMID	GRID_CODE	CUMDRAINAG	MAFLOWU	MAFLOW
0.046141	<Null>	1924	1628079	2134943	8.946	2.06483	-999
0.044625	<Null>	1924	1628081	2134944	12.3813	2.85774	-999
0.008707	<Null>	1924	1628083	2134945	2.5227	0.58226	-999
0.020109	<Null>	1924	1628085	2134946	3.1806	0.73411	-999
0.018375	<Null>	1924	1628087	2134947	4.6746	1.07895	-999
0.01897	<Null>	1924	1628089	2134948	4.3983	1.01517	-999

We can set the value of our new field Mean_Annual_Flow by using the field calculator. Scroll back to the column we created, called **Mean_Annual_Flow**, and right click on the column label to select the field calculator.

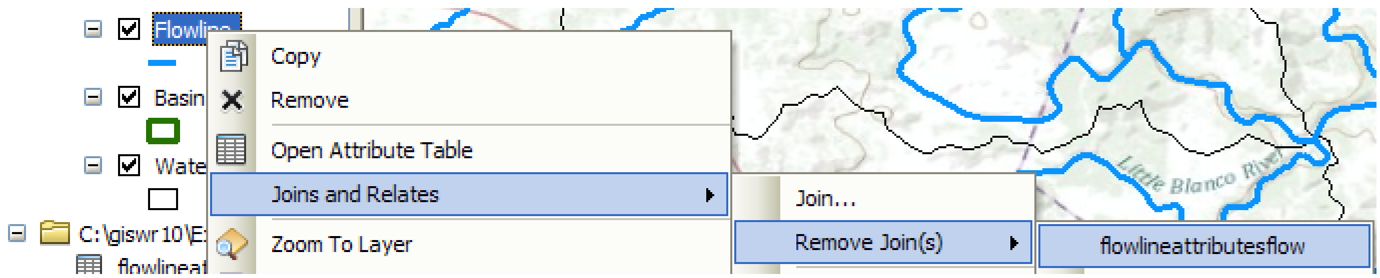


Click **Yes** to the warning. Scroll down the Fields list and double click on **[EROM_MA0001.Q0001E]** to set the entry in the **Flowline.Mean_Annual_Flow=** box

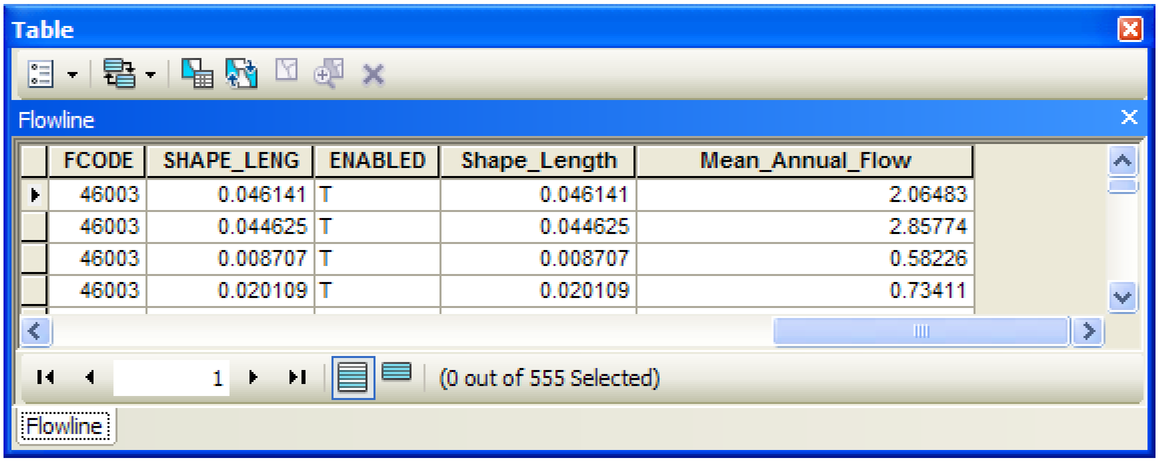


Click **OK**. This populates the Mean Annual Flow field with the appropriate value.

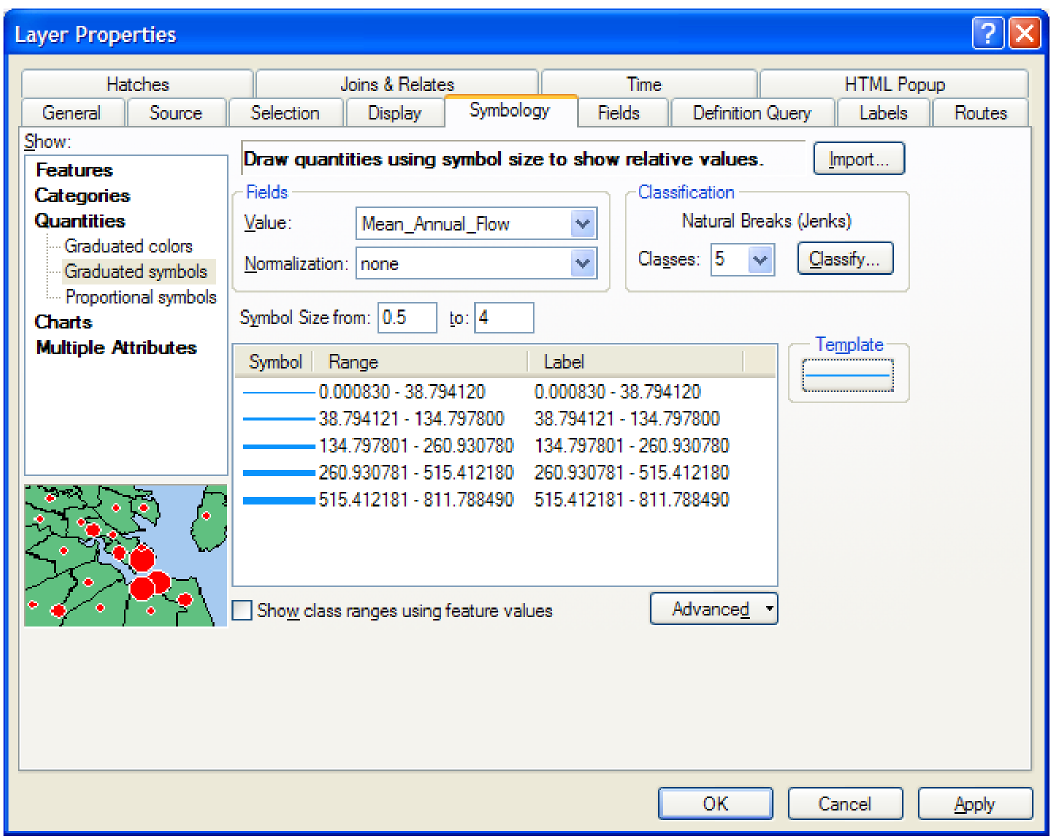
Now we can remove the join by right clicking on the **Flowline** feature class and selecting **Joins and Relates/Remove All Joins**.



Now our attribute table for SanMarcos_flowlines has a field called Mean_Annual_Flow with the values populated.



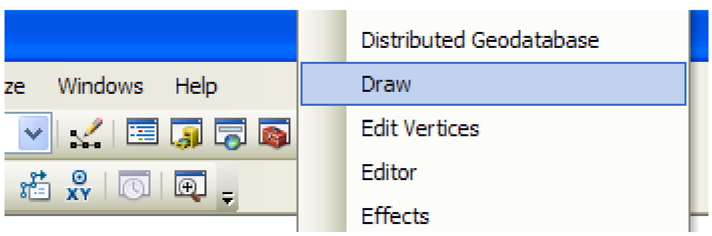
We can use this field to symbolize the flowlines. Right click on **Flowline** and select **properties**. In the properties menu, select the **Symbology** tab. Change the Symbology to display **Quantities/graduated symbols** with **Mean_Annual_Flow** for the Value field**.** Click on the Template symbol to change the color of the lines from the arbitrary one selected by the symbol editor to blue and hit **OK**.



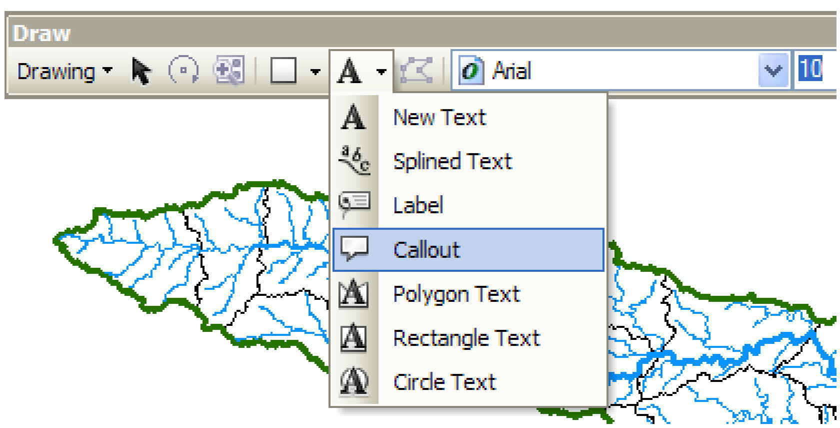
The result is a map displaying the relative flow of the streams and rivers in the San Marcos basin.   This is a much more instructive map that shows the main rivers of the San Marcos basin, the Blanco, San Marcos Rivers along the main steam, and Plum Creek, a tributary coming in from the North near the downstream end of the basin.

Use the **Inquiry** tool to find out the names of the various rivers in the map display.

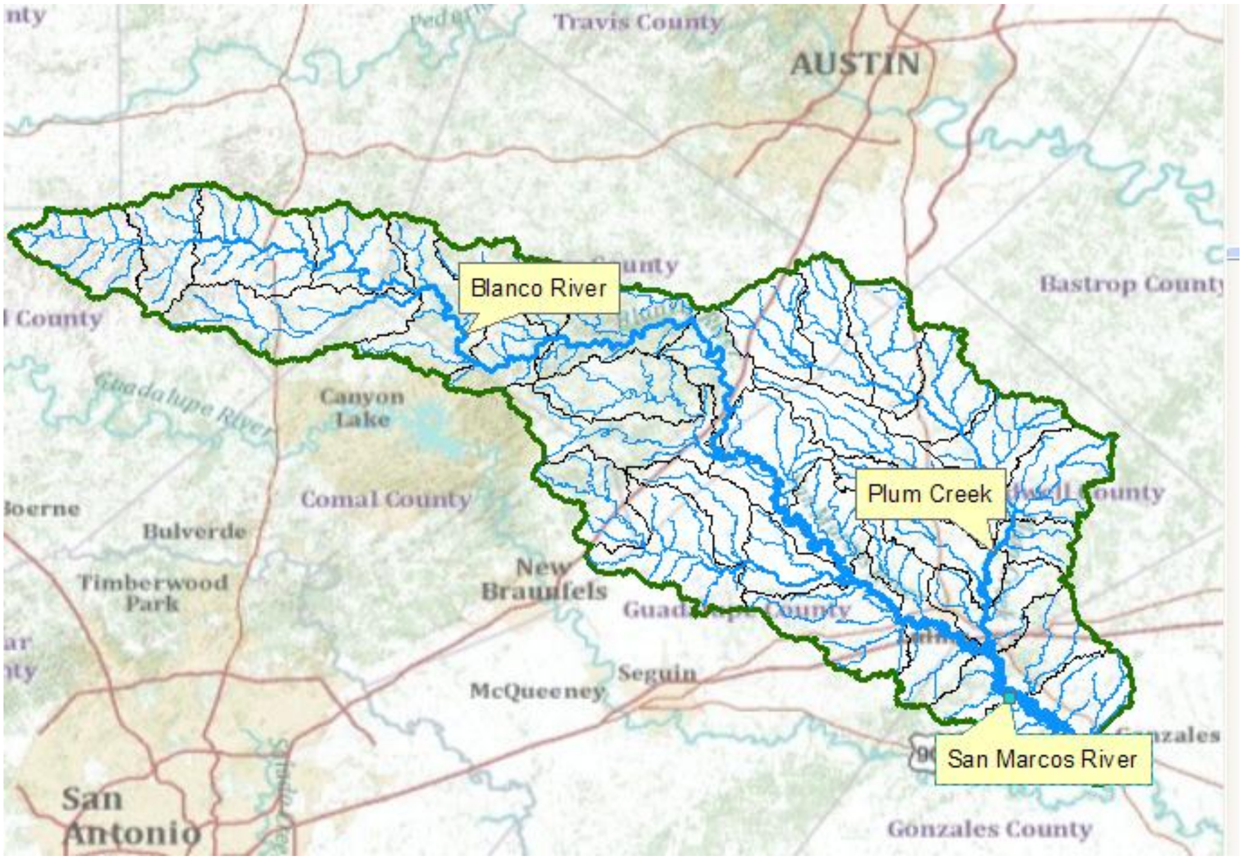
Right click in the grey area to the right of the existing toolbars to open the **Draw** toolbar



and select a label:



And add a label to show Plum Creek:



To be turned in: A map (a screen capture is ok) of the San Marcos Basin and streams. Add labels to show the San Marcos River, the Blanco River and Plum Creek.

Resave your **Ex2Basin.mxd** file.

Creating a Point Feature Class of Stream Gages

Now you are going to build a new Feature Class yourself of stream gage locations in the San Marcos basin. I have extracted information from the USGS site information at http://waterdata.usgs.gov/tx/nwis/si

SiteID	SiteName	Latitude	Longitude	DASqMile	MAFlow
08171000	Blanco Rv at Wimberley, Tx	29º 59' 39"	98º 05' 19"	355	142
08171300	Blanco Rv nr Kyle, Tx	29º 58' 45"	97º 54' 35"	412	165
08172400	Plum Ck at Lockhart, Tx	29º 55' 22"	97º 40' 44"	112	49
08173000	Plum Ck nr Luling, Tx	29º 41' 58"	97º 36' 12"	309	114
08172000	San Marcos Rv at Luling, Tx	29º 39' 58"	97º 39' 02"	838	408
08170500	San Marcos Rv at San Marcos, Tx	29º 53' 20"	97º 56' 02"	48.9	176

(a) Define a table containing an ID and the long, lat coordinates of the gages

The coordinate data is in geographic degrees, minutes, & seconds. These values need to be converted to digital degrees, so go ahead and perform that computation for the 8 pairs of longitude and latitude values. This is something that has to be done carefully because any errors in conversions will result in the stations lying well away from the San Marcos basin. I suggest that you prepare an Excel table showing the gage longitude and latitude in degrees, minutes and seconds, convert it to long, lat in decimal degrees using the formula

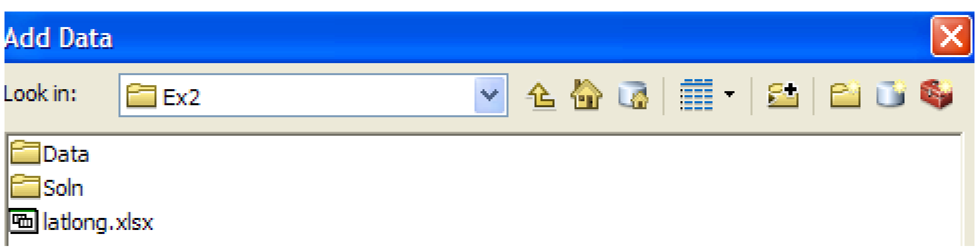
Decimal Degrees (DD) = Degrees + Min/60 + Seconds/3600

Remember that West Longitude is negative in decimal degrees. Shown below is a table that I created. **Be sure to format the columns containing the Longitude and Latitude data in decimal degrees (LongDD and LatDD) so that they explicitly have Number format with 4 decimal places using Excel format procedures. Format the column SITEID as Text or it will not retain the leading zero in the SiteID data**. Add the additional information about the USGS SiteID, SiteName and Mean Annual Flow (MAF). Note the name of the worksheet that you have stored the data in. I have called mine **latlong.xlsx**. Close Excel before you proceed to ArcMap.

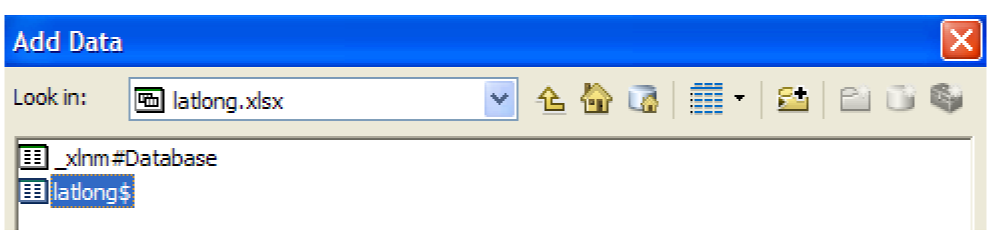
SiteID	SiteName	Latitude	Longitude	LatDeg	LatMin	LatSec	LongDeg	LongMin	LongSec	LatDD	LongDD	DASqMile	MAFlow
08171000	Blanco Rv at Wimberley, Tx	29° 59' 39"	98° 05' 19"	29	59	39	98	5	19	29.9942	-98.0886	355	142
08171300	Blanco Rv nr Kyle, Tx	29° 58' 45"	97° 54' 35"	29	58	45	97	54	35	29.9792	-97.9097	412	165
08172400	Plum Ck at Lockhart, Tx	29° 55' 22"	97° 40' 44"	29	55	22	97	40	44	29.9228	-97.6789	112	49
08173000	Plum Ck nr Luling, Tx	29° 41' 58"	97° 36' 12"	29	41	58	97	36	12	29.6994	-97.6033	309	114
08172000	San Marcos Rv at Luling, Tx	29° 39' 58"	97° 39' 02"	29	39	58	97	39	2	29.6661	-97.6506	838	408
08170500	San Marcos Rv at San Marcos, Tx	29° 53' 20"	97° 56' 02"	29	53	20	97	56	2	29.8889	-97.9339	48.9	176

(b) Creating and Projecting a Feature Class of the Gages

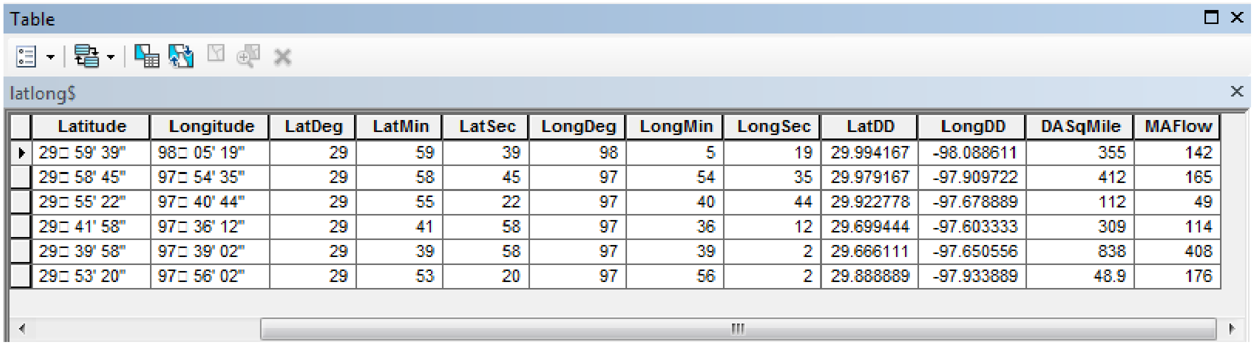
(1) Open **ArcMap** and the **Ex2.mxd** file you created in the first part of this exercise. Select the add data button and navigate to your Excel spreadsheet



Double click on the spreadsheet to identify the individual worksheet within the spreadsheet that you want to add to ArcMap (it's a coincidence that they have the same name in this example and that is not necessary in general).



Hit **Add** and your spreadsheet will be added to ArcMap. Pretty cool!! Its always been a struggle to add data from spreadsheets before and it seems like at ArcGIS 10, they have gotten this right.



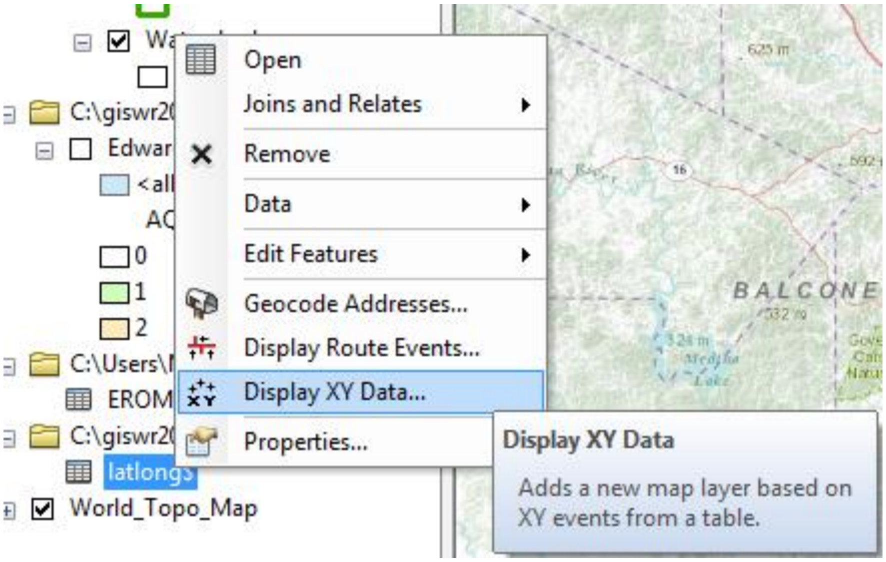
Table

latlong$

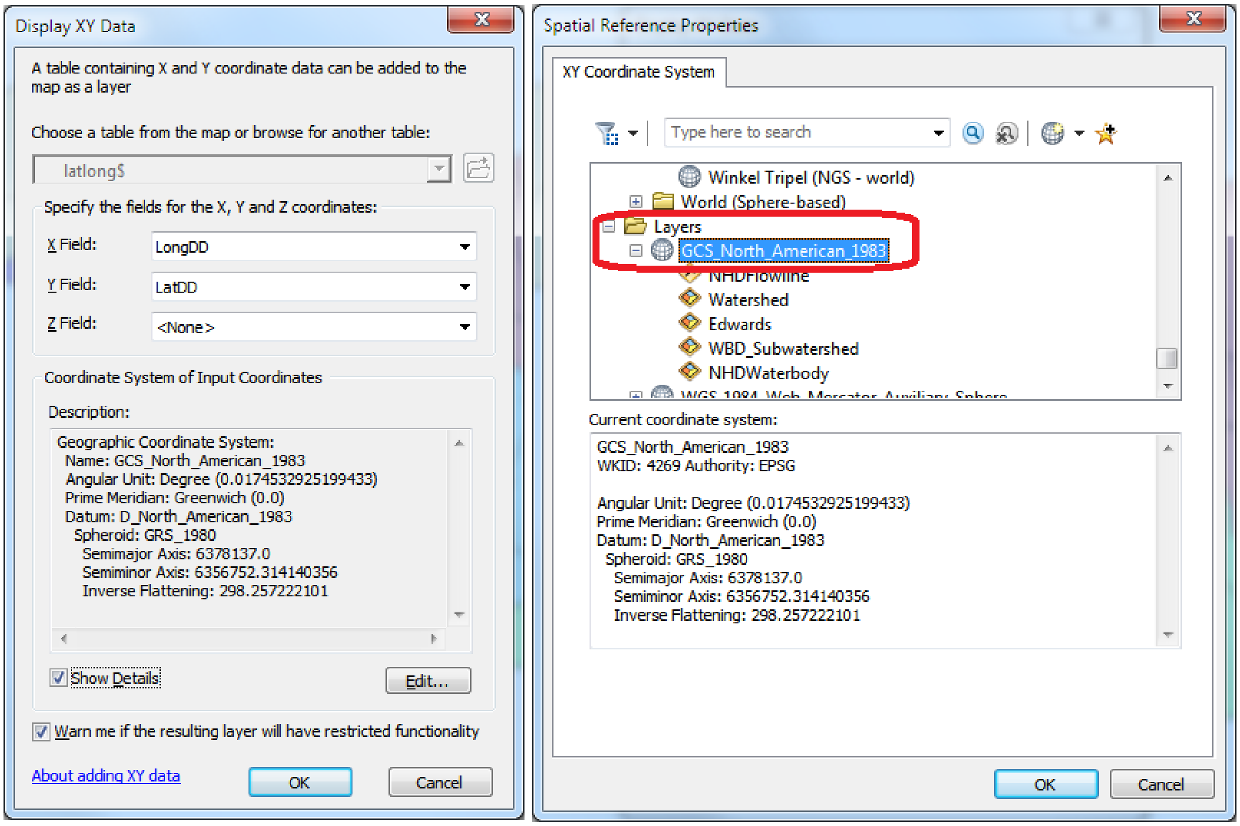
Latitude	Longitude	LatDeg	LatMin	LatSec	LongDeg	LongMin	LongSec	LatDD	LongDD	DASqMile	MAFlow
29□ 59' 39"	98□ 05' 19"	29	59	39	98	5	19	29.994167	-98.088611	355	142
29□ 58' 45"	97□ 54' 35"	29	58	45	97	54	35	29.979167	-97.909722	412	165
29□ 55' 22"	97□ 40' 44"	29	55	22	97	40	44	29.922778	-97.678889	112	49
29□ 41' 58"	97□ 36' 12"	29	41	58	97	36	12	29.699444	-97.603333	309	114
29□ 39' 58"	97□ 39' 02"	29	39	58	97	39	2	29.666111	-97.650556	838	408
29□ 53' 20"	97□ 56' 02"	29	53	20	97	56	2	29.888889	-97.933889	48.9	176

Now we are going to convert the tabular data in the spreadsheet to points in the ArcMap display.

(2) **Right click** on the new table, **latlong$**, and select **Display XY Data**



(3) Set the X Field to **LongDD (or Longitude)**, the Y Field to **LatDD (or Latitude)**, Hit **Edit** to change the spatial coordinate system. Scroll to the folder **Layers** at the bottom of the list to see the Spatial References of the Layers in the Map. Expand the folder to see that NHDFlowline, Watershed and other layers have the Spatial Reference **GCS_North_American_1983**. Click on this and hit OK. Don't use the default spatial reference system that initially shows up, because it's the Web Mercator Projection of the basemap and that is a projected not geographic coordinate system.



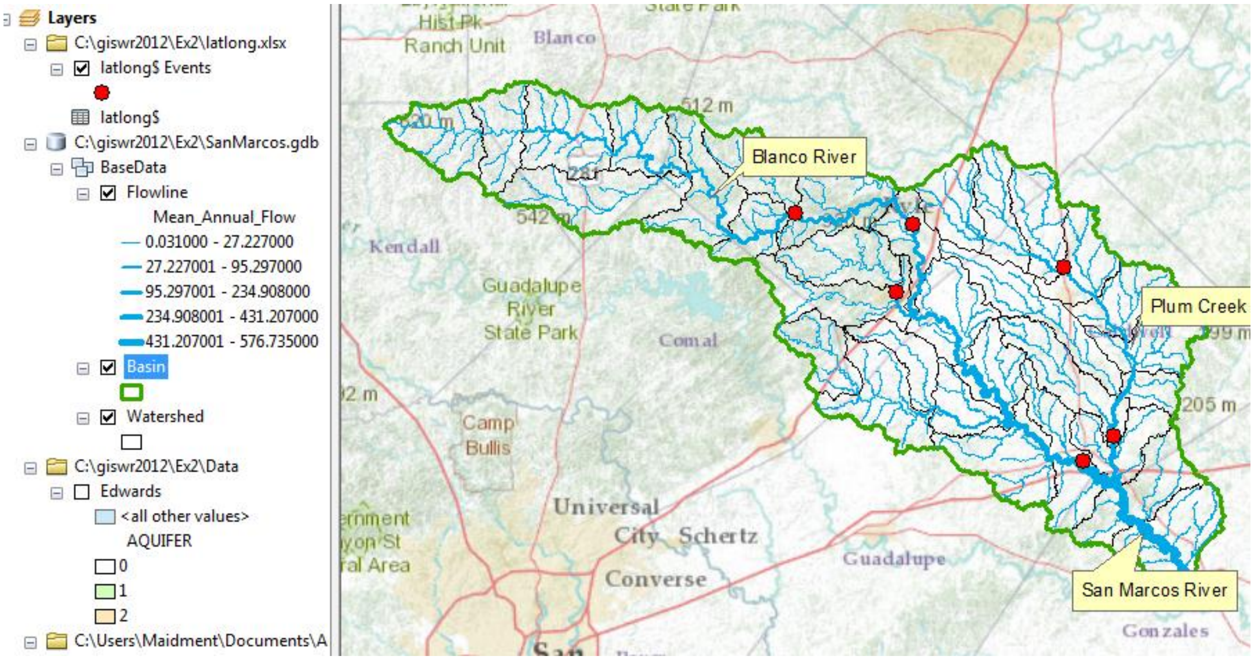
Click on the Show Details button to see details of the Geographic Coordinate System. We'll learn about these in our next lecture!

Hit **OK**, to complete it and you'll get a warning message about your table not having an ObjectID. Just hit Ok and and voila! Your gage points show up on the map right along the San Marcos River just like they should. Magic. I remember the first time I did this I was really thrilled. This stuff really works. I can create data points myself! If you don't see any points, don't be dismayed. Check back at your spreadsheet to make sure that the correct X field and Y field have been selected as the ones that have your data in decimal degrees.

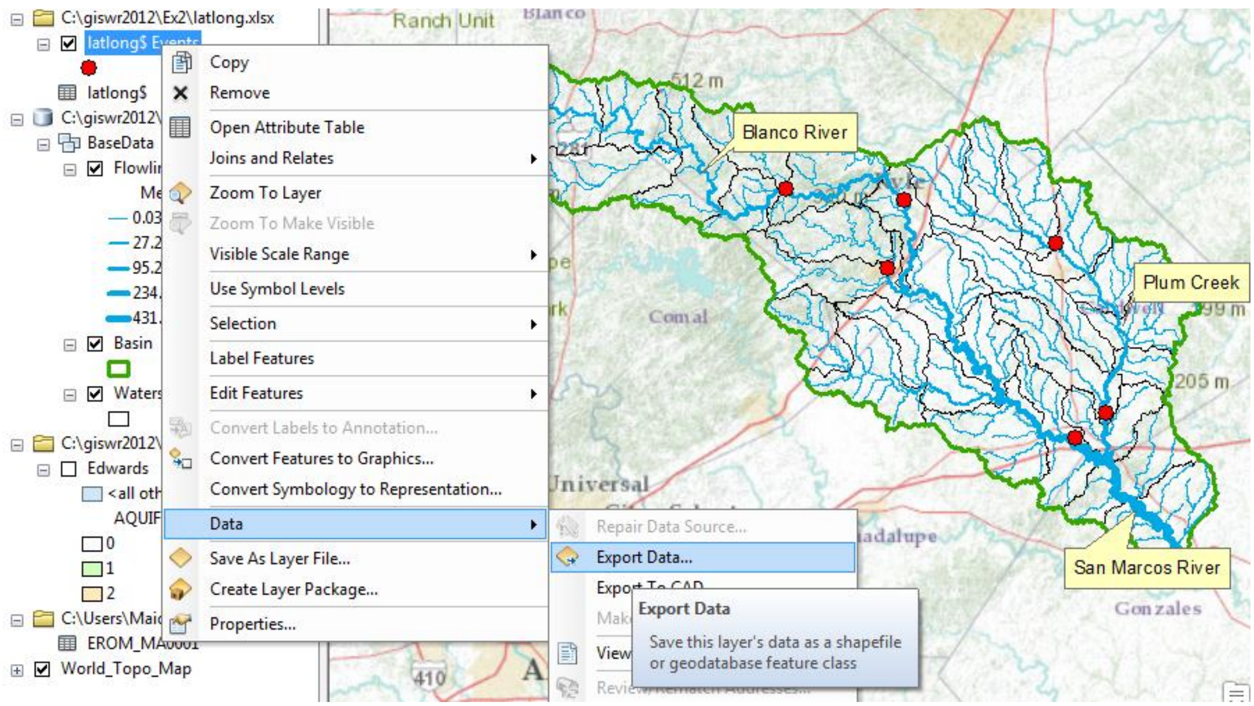
Click on the point symbol under the legend label **latlong event** and recolor and resize the points so that they show up more clearly. You'll see that you have 3 sites on Plum Creek, 3 sites on the San Marcos River, and two sites on the Blanco River, an upstream tributary of the San Marcos River.

What you have created is called an "event" which means that it is a graphical display in the ArcMap window of latitude and longitude points that are stored in a table. It is not a real feature class yet.

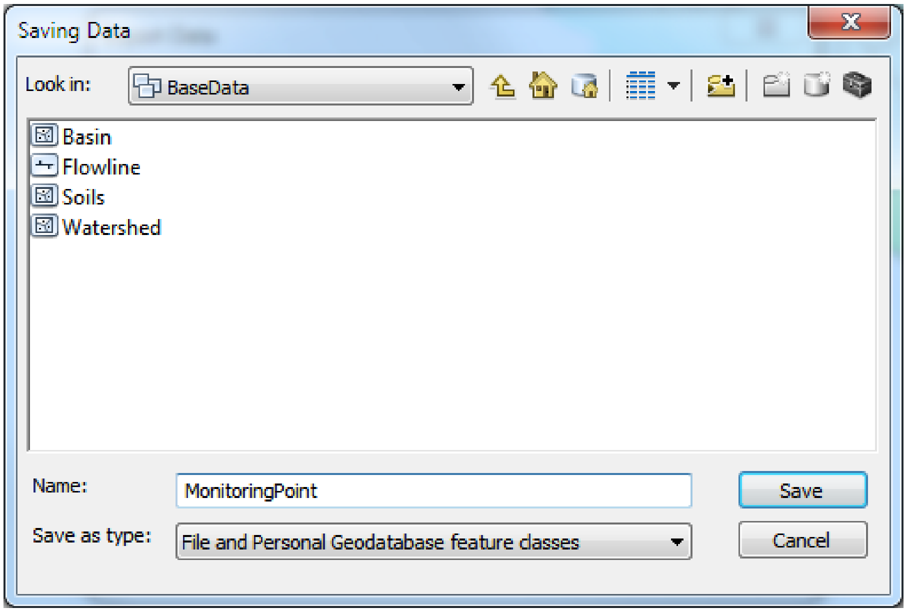
Resave your **Ex2Basin.mxd** file.



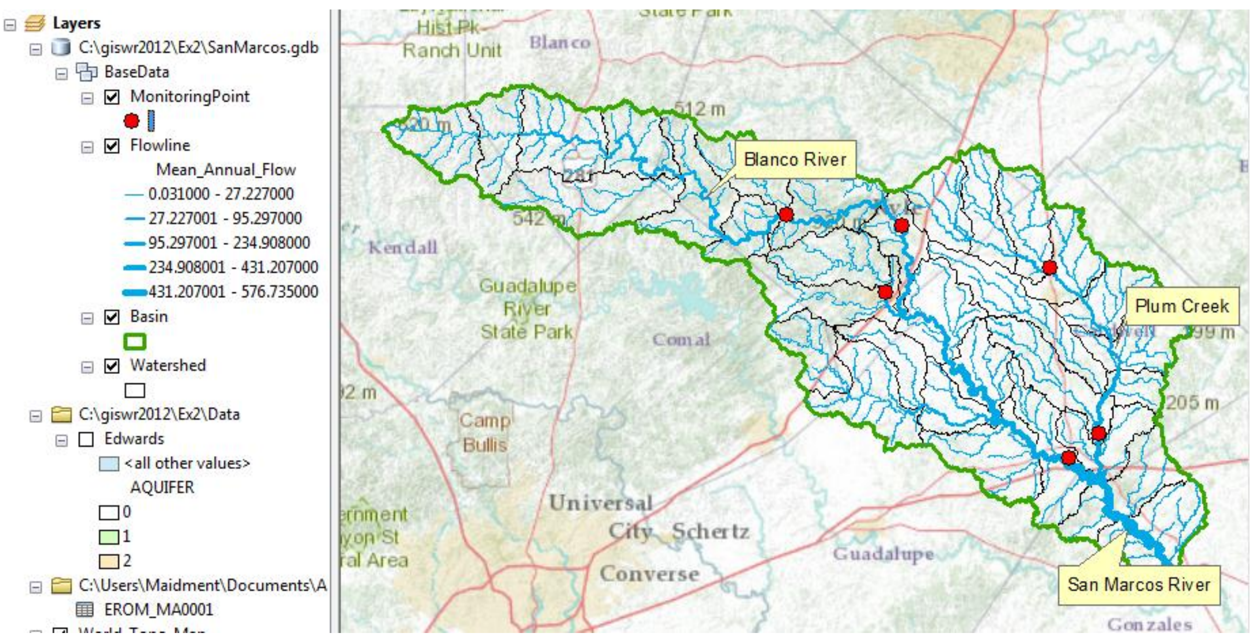
(4) Now, we'll make a feature class out of the points. Right click on the **latlong$ Events** layer



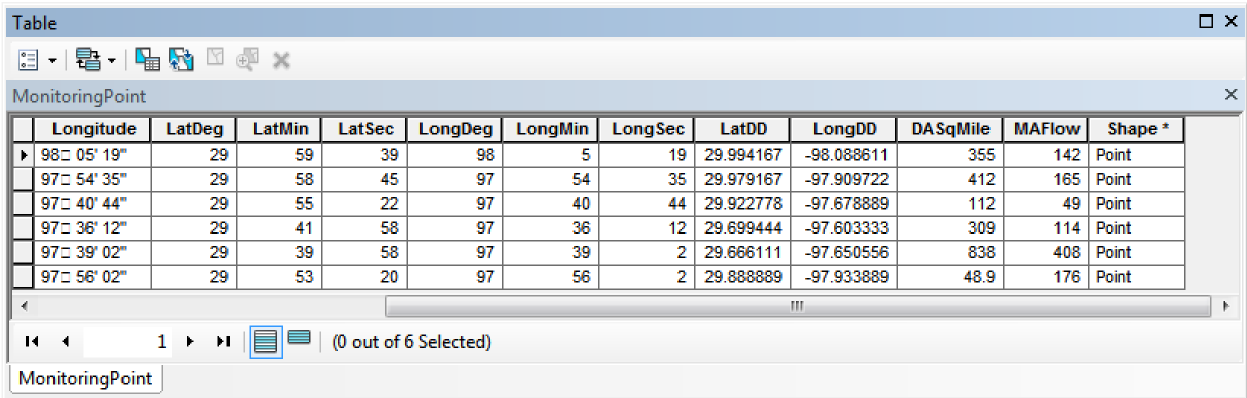
And export the data into the **BaseData** feature dataset as the feature class **MonitoringPoint.** Say Yes when you are asked if you want to add the points to your map, and now you've got a new feature class in the BaseData feature dataset with your points in the same projection as the other features in BaseData (ArcGIS does the map projection automatically as part of the data export process).



Remove the Latlong table and the Latlong Event layers from the ArcMap display and recolor and resize the MonitoringPoint features so that you can see them easily.



Open the attribute **Table** of the new MonitoringPoint feature class, and you can see on the right hand side, a new field called **Shape** that was added when the feature class was formed. This is where the geographic coordinates of the points are stored in a way that ArcMap can readily visualize them.



Table

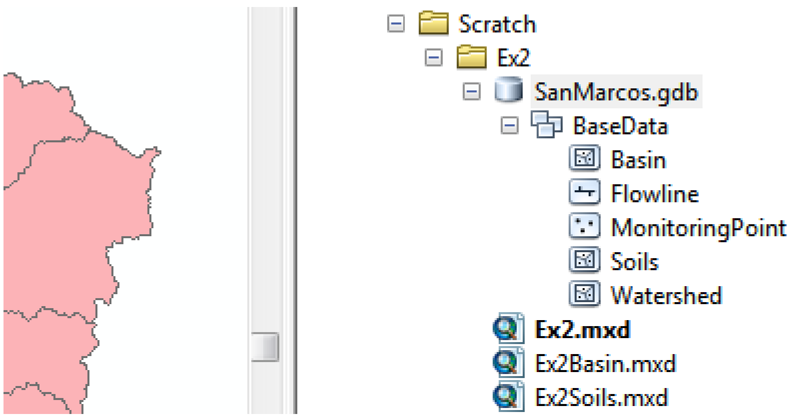
MonitoringPoint

Longitude	LatDeg	LatMin	LatSec	LongDeg	LongMin	LongSec	LatDD	LongDD	DASqMile	MAFlow	Shape *
98□ 05' 19"	29	59	39	98	5	19	29.994167	-98.088611	355	142	Point
97□ 54' 35"	29	58	45	97	54	35	29.979167	-97.909722	412	165	Point
97□ 40' 44"	29	55	22	97	40	44	29.922778	-97.678889	112	49	Point
97□ 36' 12"	29	41	58	97	36	12	29.699444	-97.603333	309	114	Point
97□ 39' 02"	29	39	58	97	39	2	29.666111	-97.650556	838	408	Point
97□ 56' 02"	29	53	20	97	56	2	29.888889	-97.933889	48.9	176	Point

1 (0 out of 6 Selected)

MonitoringPoint

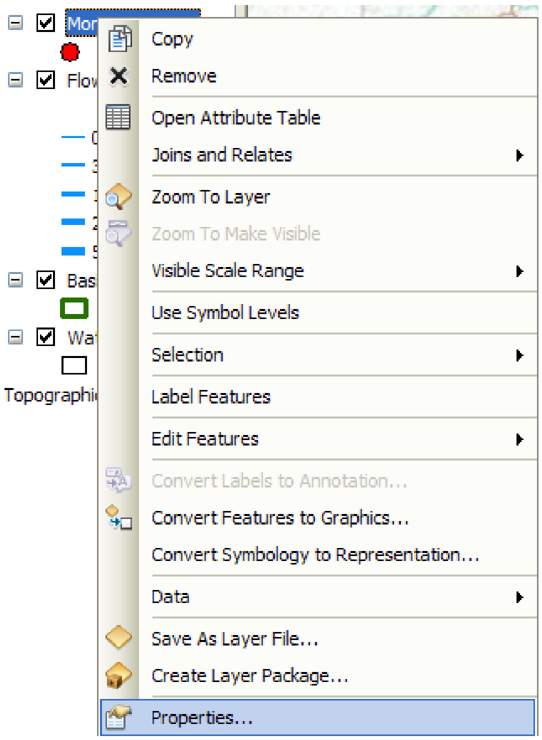
In ArcMap, open an ArcCatalog window using the button and expand the contents of your BaseData feature dataset. The **MonitoringPoint** feature class now resides there.



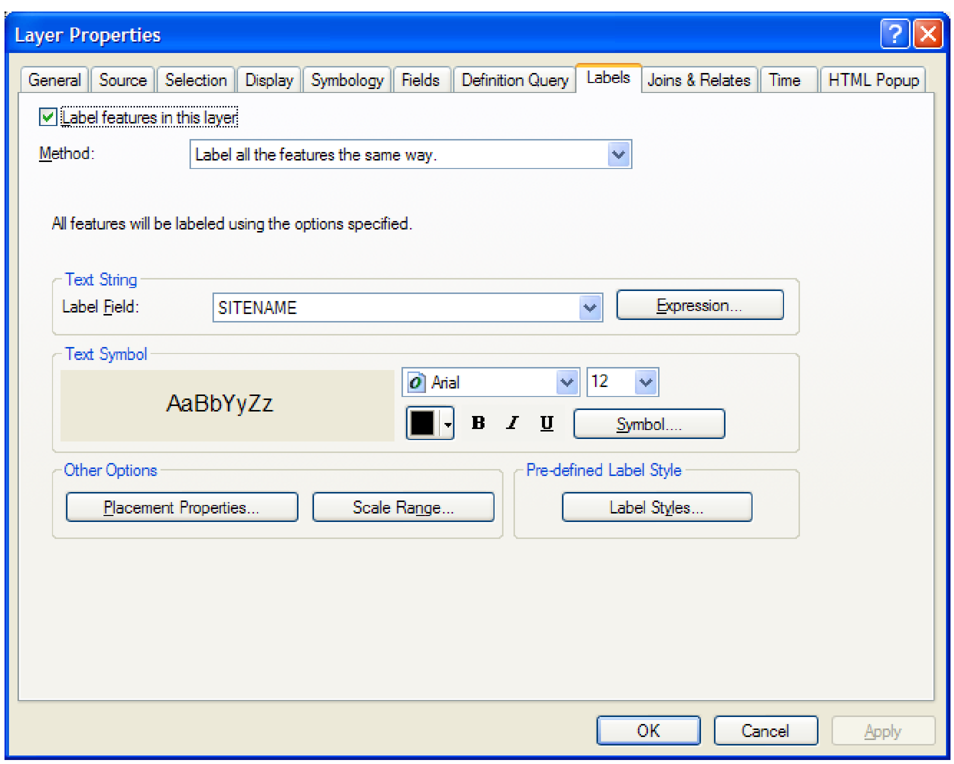
(5) Save your **Ex2Basin.mxd** ArcMap document.

Labeling the Gages in View

Right click on the **MonitoringPoint** feature class and select **Properties**.

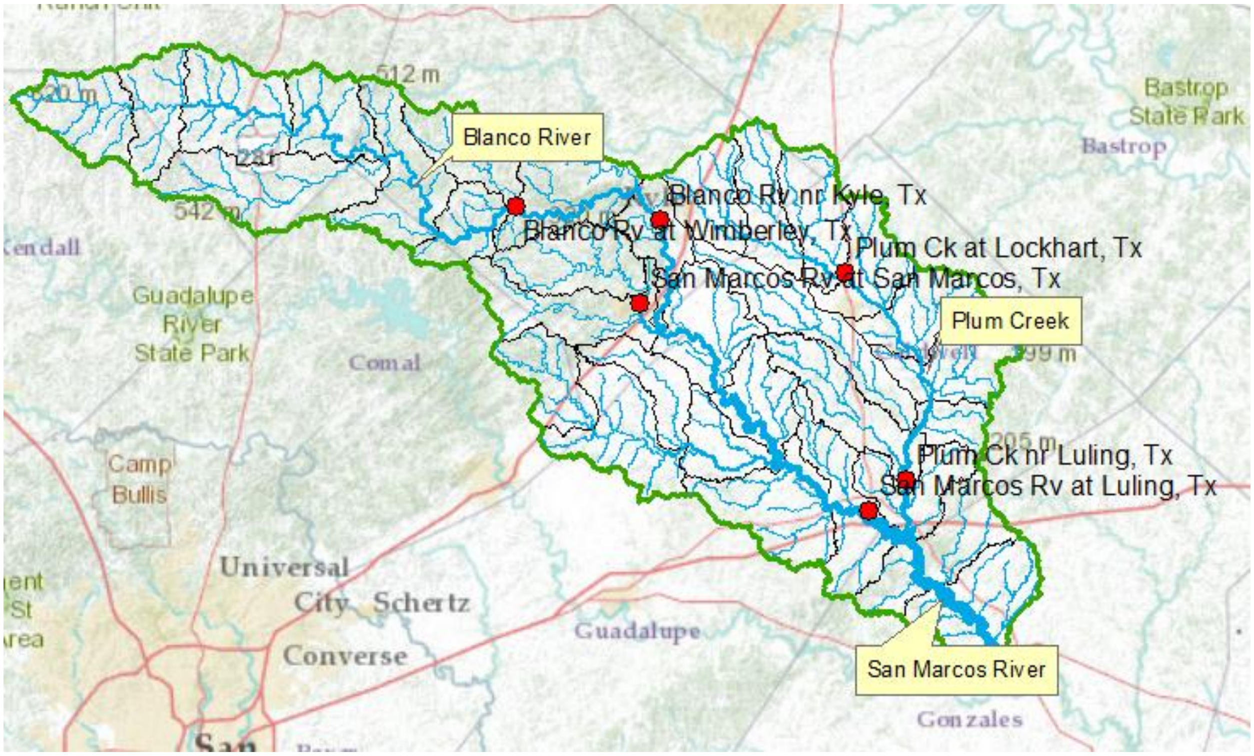


Click on the **Labels** tab and from the drop down menu select the label field name to be **SiteName.** Change the size of your font to 12 point type.



Right click on the **MonitoringPoint** feature class again and select **Label Features**.

You can now create a view like this:



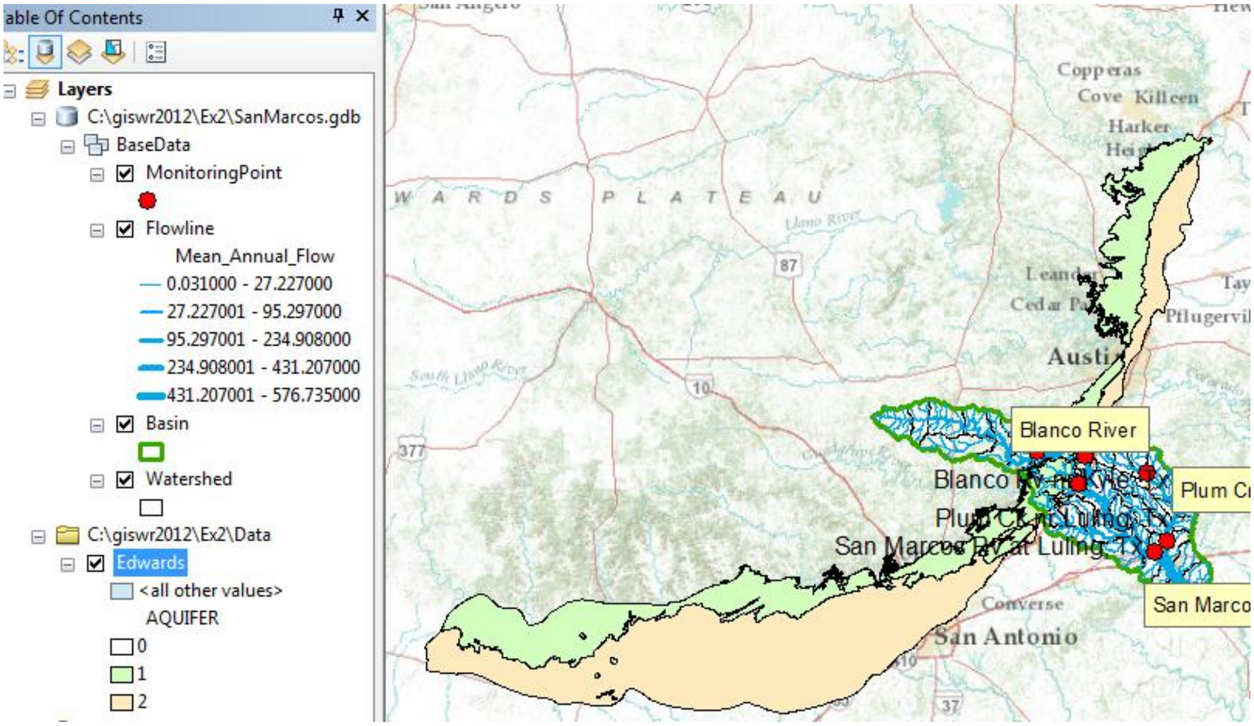
Resave your **Ex2Basin.mxd** file.

To be turned in: a map showing the labeled streams and streamgages for the San Marcos Basin

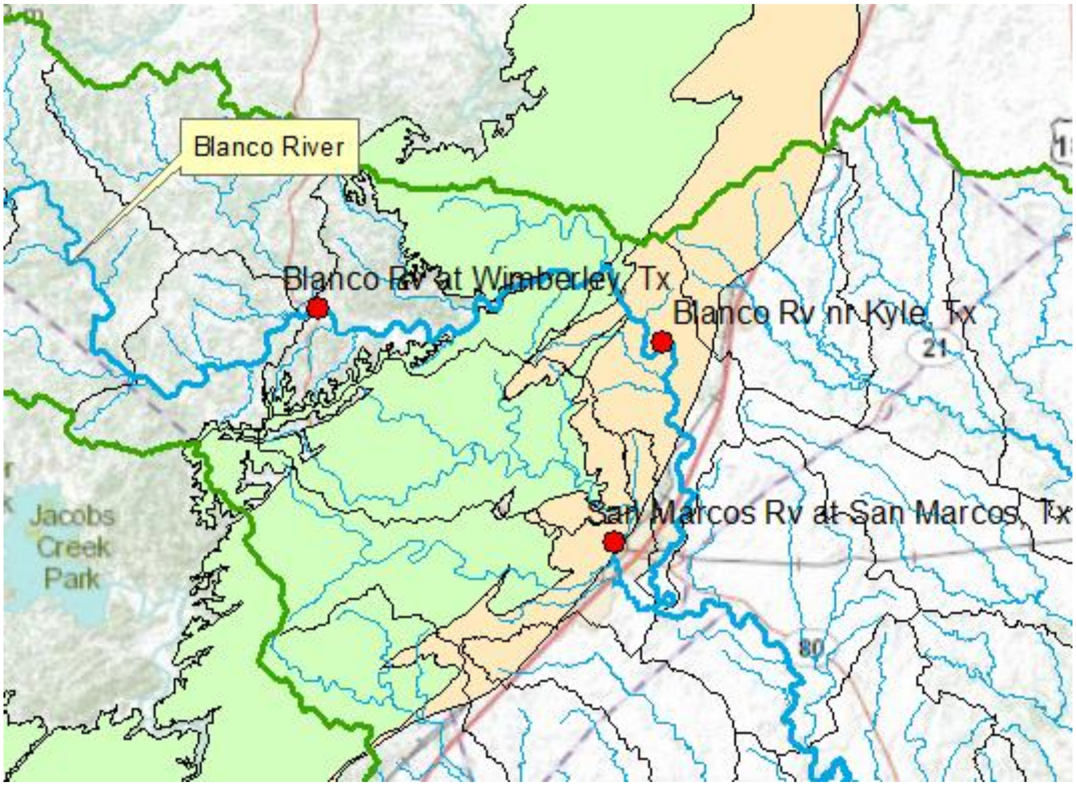
Overlaying the Edwards Aquifer

The Edwards aquifer is one of the most critical water resources of Central Texas. It is the main source of water supply for San Antonio, the 10th largest city in the United States. The Edwards aquifer is recharged by infiltration from rivers crossing its outcrop area. To determine where the San Marcos River crosses, the outcrop area, I obtained a coverage of the Edwards aquifer from the [Texas Natural Resource Information System](http://www.tnris.state.tx.us/) (http://www.tnris.state.tx.us/)

The Edwards aquifer coverage from TNRIS is in Decimal Degree coordinates. This is contained in the map package that you downloaded from ArcGIS Online at the beginning of the exercise. Click on the layer name **Edwards** to display the aquifer and **Zoom to Layer** to see the extent of the Edwards Aquifer.



You'll see that as the San Marcos River flows South East towards the Gulf Coast and it crosses first the outcrop (the green portion labeled 1) and then the downdip portions of the Edwards aquifer (the brown portion labeled 2). The downdip region is where the aquifer dips below the land surface and is shielded from the surface rivers by overlying hydrogeological units of low permeability. The Edwards is a fissured limestone aquifer whose fissures lie along its Southwest to Northeast orientation, so its flow moves in that direction, transverse to the direction of flow in the San Marcos basin. It is thus quite possible for water to drain from the San Marcos river into the Edwards aquifer and then reappear as a spring further North in another river. Zoom in to the region where the aquifer crosses the San Marcos basin for a closer look.



You can see that the gaging stations that you've put on the map lie at different, and very important locations with respect to the Edwards Aquifer. The Blanco River flows over the outcrop area of the Edwards Aquifer between the gaging stations at Wimberley and Kyle. The San Marcos River at San Marcos records from a very large artesian spring that arises from the downdip area of the Edwards Aquifer. Later on in the class, we'll use a new USGS tool called NWIS Snapshot, to download flow data from the USGS and study the properties of the water at these locations. http://txpub.usgs.gov/snapshot/

Resave your **Ex2Basin.mxd** file.

To be turned in: A map showing the Edwards aquifer and the San Marcos basin

Summary of Items to be Turned in:

1. *A screen capture of the San Marcos basin with its HUC-10 and HUC-12 watersheds and subwatersheds.*
2. *What is the average available water storage (cm) in the San Marcos basin? If the area of the basin is 3520 square kilometers, what volume of water (km^3) could potentially be stored in the top 1m of soil in the San Marcos basin if the soil were fully saturated with water?*
3. *How many HUC12 subwatersheds are there in the San Marcos Basin? What is their average area in km^2? What is the total area of HUC12 subwatersheds in this basin in km^2? What is the ratio of the length of the streamlines to the area of the HUC12 subwatersheds (called the drainage density) in km^{-1}?*

4. *A map (a screen capture is ok) of the San Marcos Basin and streams. Add labels to show the San Marcos River, the Blanco River and Plum Creek.*
5. *A map showing the labeled streams and streamgages for the San Marcos Basin*
6. *A map showing the Edwards aquifer and the San Marcos basin*