GIS I - Exercise 3 (AV9.2) - Map Rainfall in 3D with Spreadsheets *(v2d, Jun 2010)*

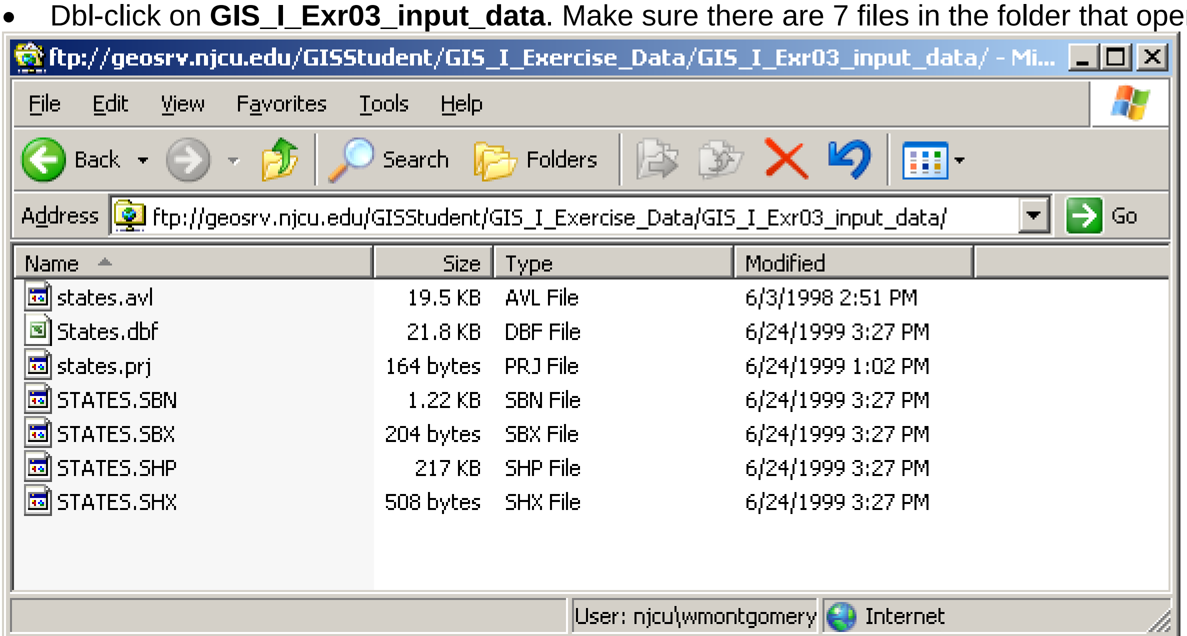
Desired Learning Outcomes:

- Retrieve a set of state boundaries from pre-packaged ESRI data
- Use the query builder to reduce the state set to New Jersey
- Make a new Theme of points (hypothetical rain gauge stations located on a lat-long grid in New Jersey) both manually (OSD) and automatically (Add Event Theme)
- Join an external spreadsheet with rainfall amount to the attribute table of the rain gauges
- Label the points with the rainfall amounts
- Create a 3D model and contour map of the rainfall with ESRI's 3D Analyst Extension

Before Proceeding – Create a separate folder for Exercise 03 titled ***_Exr03** (where *= your name), within your own personal GIS I class folder, in order to keep your files well-organized. **Make sure** that you download and/or save new themes to this folder. *Failure to do this could result in software failure and/or loss of your data.*

Part I – Build a map and add point shapefiles through "OSD" and "Add Event Theme"
Step 1 - Copy GIS data to your folder
Discussion - This exercise will begin with a theme (aka shapefile) of U.S. states that you will reduce to just NJ by means of "querying". To prevent corruption or disruption of these data files, you **MUST** first copy these files to your own ***Exr03*** folder. ***NOTE:*** you **MUST** copy **ALL** components of GIS themes, not just the *.shp component.
Procedure –
- Make sure your own Exr03 folder is visible on your computer screen.
- If you are **onsite (GIS Lab)**, scroll to **gisstudent\GIS_I_Exercise_Data\gis_I_exr03_input_data**.
- If you are **online**, open Internet Explorer; use our **FTP protocol** to connect to the NJCU server and scroll to ftp://geosrv.njcu.edu/GISStudent/GIS_I_Exercise_Data. *NOTE:* You cannot click on the preceding "ftp:" line and use it as a complete link because the server is secure. If the line does act as a link, finish the FTP sign-in procedure per "FTP protocol" to access the folder.

- Dbl-click on **GIS_I_Exr03_input_data**. Make sure there are 7 files in the folder that opens:



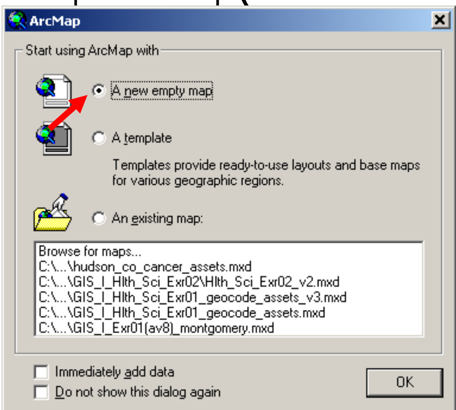
- **Copy (*DO NOT CUT!*)** and **Paste** all of the contents of this folder to your own ***Exr03*** folder.

NOTE: One GIS student working long-distance said she was unable to select all the files and Copy>Paste them all at the same time. *She had to copy and paste each one of these files separately.*

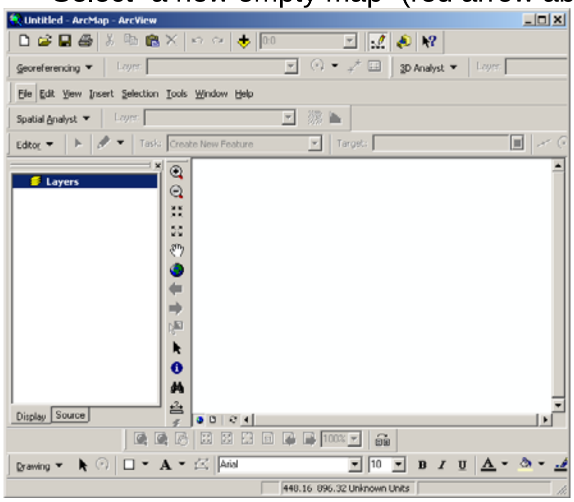
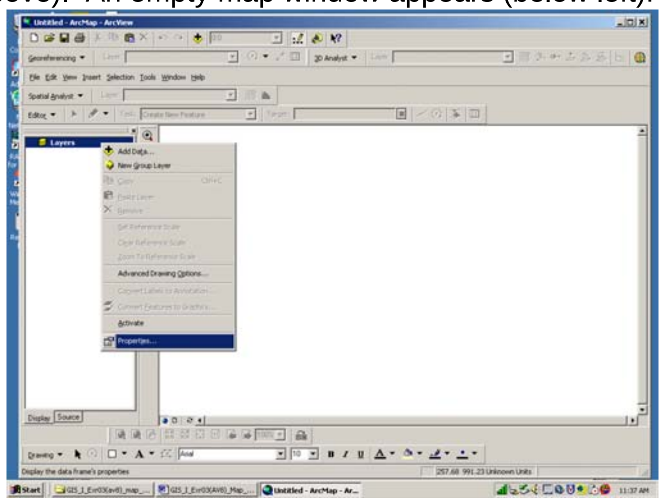
Step 2 - Start ArcMap, set Layer properties

Procedure:

- Open Arcmap **(Start > ArcGIS > ArcMap)**. An ArcMap window appears:

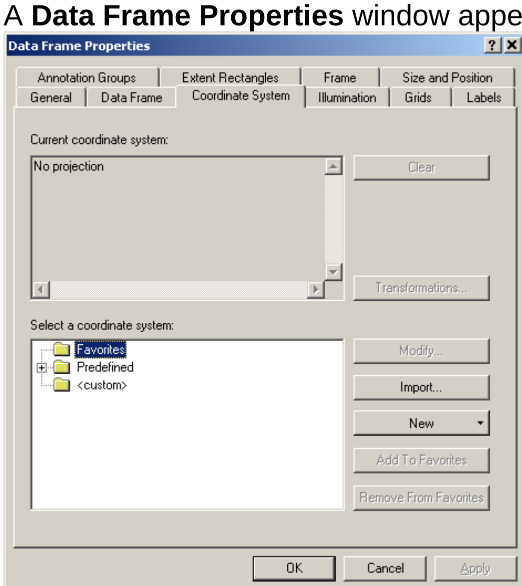


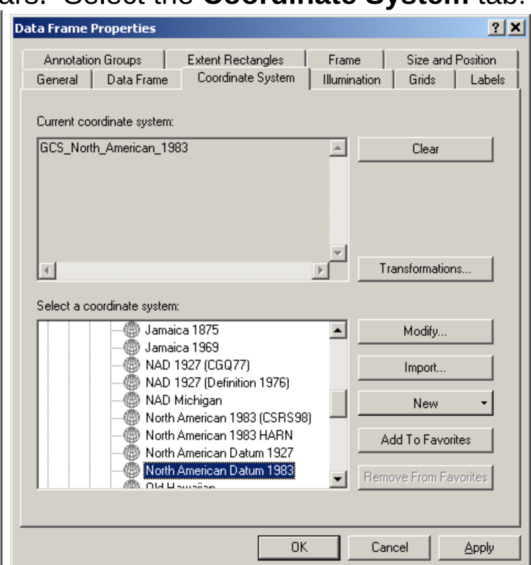
- Select “a new empty map” (red arrow above). An empty map window appears (below left):

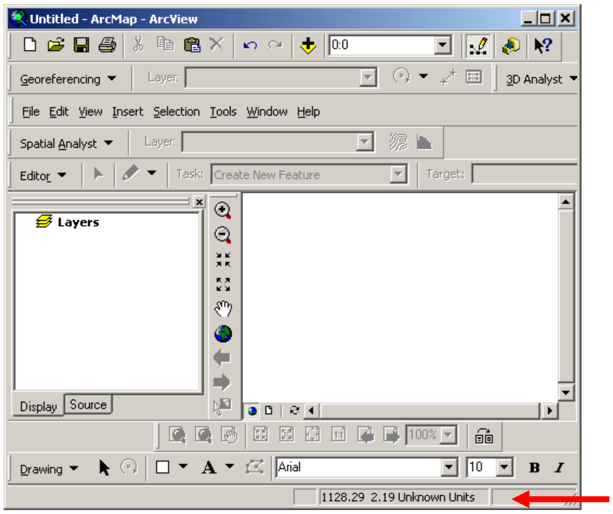
- Rt-click on **Layers** in the Table of Contents (ToC); select **Properties** (above right):

A **Data Frame Properties** window appears. Select the **Coordinate System** tab:





- Under “Select a coordinate system” (above left), select **Predefined** > **Geographic Coordinate Systems** > **North America > North American Datum 1983** (above right)
- Press **Apply**, **OK**. The ArcMap Data View re-appears:

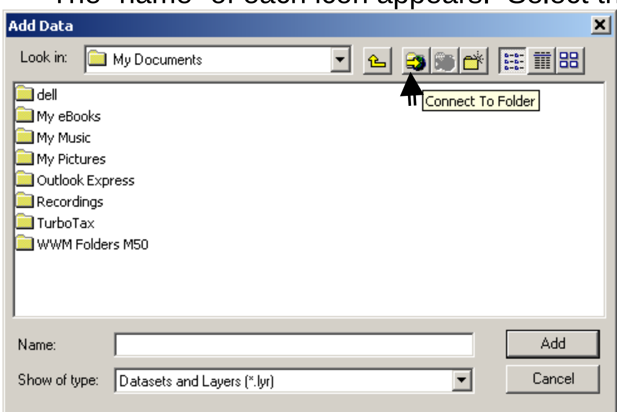


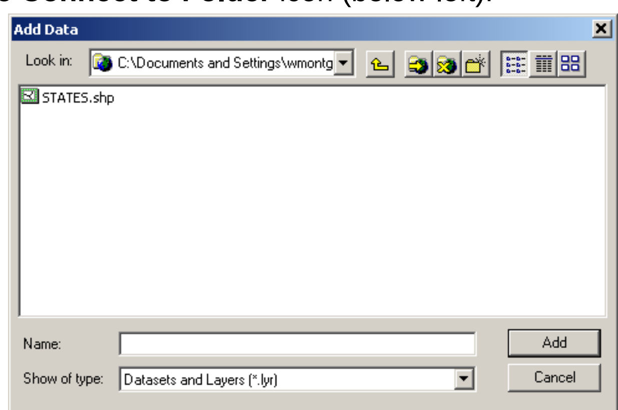
Move your mouse around in the map window. X,Y coordinate values (possibly expressed in unknown units) in the lower RH portion of the ArcMap window (red arrow above) change as you move the mouse N,S,E,W in the window. We will specify decimal degrees (DD) for these coordinates after we add the *states* theme.

Step 3 - Bring the states theme into ArcMap, isolate New Jersey as a new layer

Procedure:

- Press the **Add Data** button  in ArcMap. An Add Data window appears with icons across the top. Take your mouse pointer and let it rest on each of these icons for a few moments. The "name" of each icon appears. Select the **Connect to Folder** icon (below left):



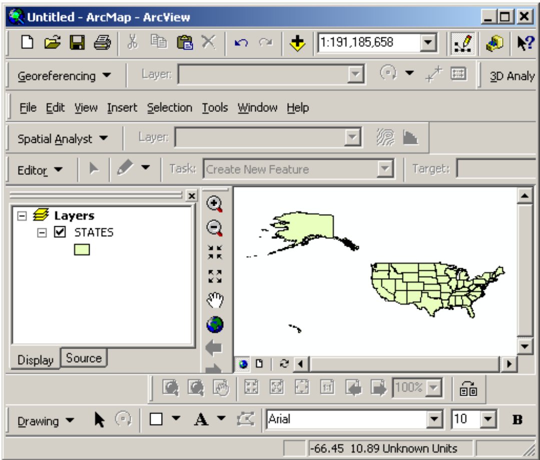


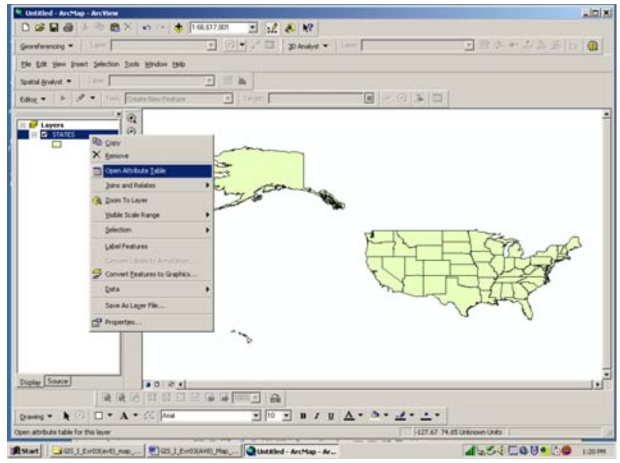
- Scroll to your Exr03 folder via the Connect to Folder window. When you reach your folder, press the OK button to actually open the folder (I have been unable to open the folder by double-clicking). The *states.shp* file will appear (above right):

Discussion: ***Note:*** Do NOT Panic if you only see the "*.shp" file, rather than the 7 that you copied into this folder earlier. The reason that you see only this component is because this is the "feature" component of the theme (showing the actual point, line, or polygon), and is the only component that automatically appears in the Data View window. The only other component that can be made visible is the attribute table ("*.dbf" file), and that component appears only when you "open attribute table".

Procedure:

- Select *states.shp* one of two ways: single click and press Add, or double-click. *States.shp* should appear in the ArcMap window. Notice that all the US states are shown:

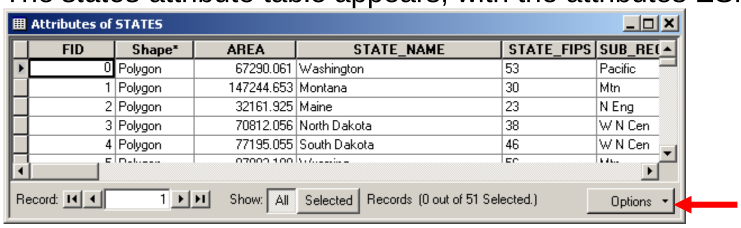




We don't need all the states. But we do want the outline of NJ as our map area.

- Rt-click *States* in the Table of Contents (ToC) (above right); Select **Open Attribute Table**:

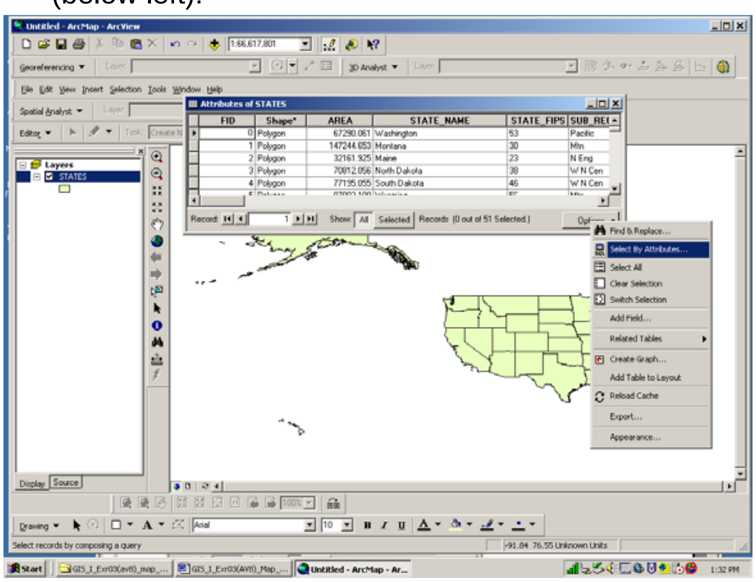
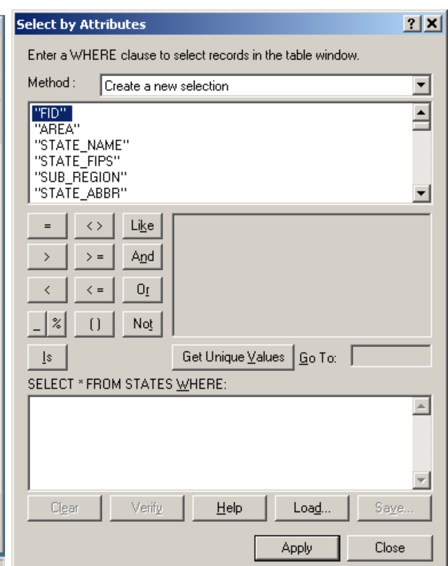
The *states* attribute table appears, with the attributes ESRI has included as pre-installed data.



Discussion: You will use the *states* attribute table and a query to isolate New Jersey.

Procedure:

- From the *states* attribute table, press **Options** (red arrow above) > **Select by Attributes** (below left):

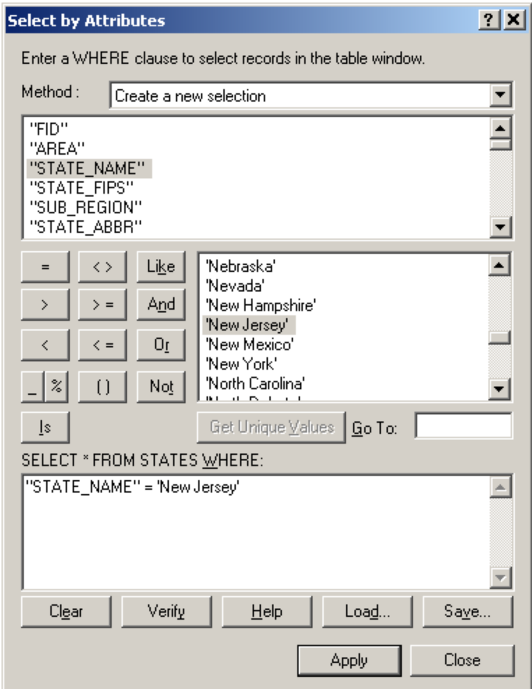



The "Select by Attributes" window appears (above right):

You will create a query to separate New Jersey from the rest of the states:

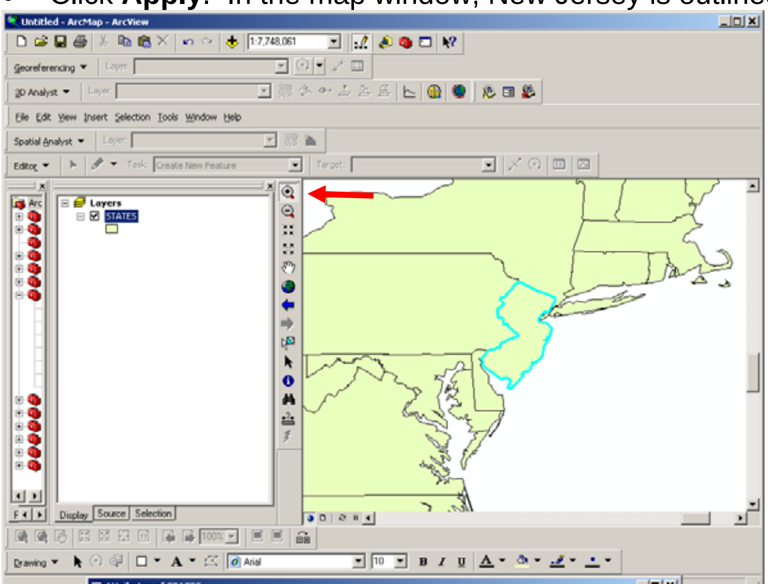
- In the "Method": window, select "**Create a new selection**"
- In the "Select * from States Where": window, build your query **with your mouse** as follows:
  - Dbl-click on "State_Name" in the Fields: window.
  - Single-click the = button.
  - Press "Get Unique Values", scroll to and select, "New Jersey" from the list that appears.

The window should look as below:



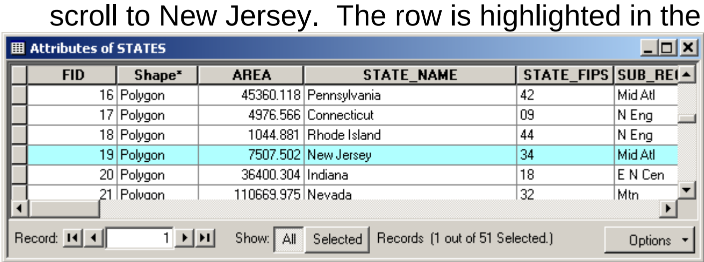
NOTE: If there are elements missing, re-do the query until it reads as above.

- Click **Apply**. In the map window, New Jersey is outlined in bright aquamarine blue:



If you can't see NJ, select the  magnifying glass from your tool bar (red arrow above) and magnify NJ until you can see it.

- Activate the attribute table (make the upper header of the table blue by selecting it), and scroll to New Jersey. The row is highlighted in the bright blue outlining NJ on the map:

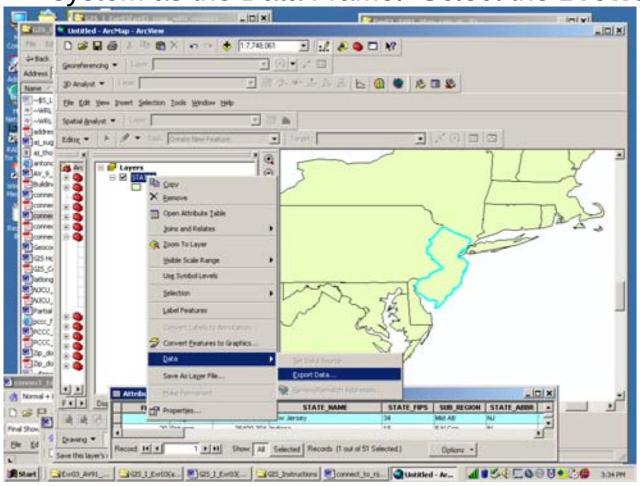
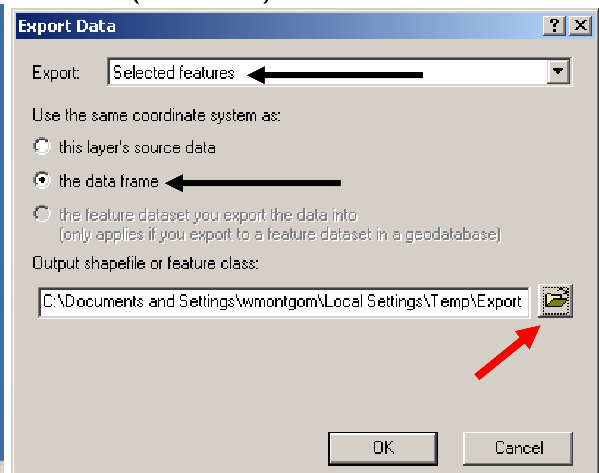

Attributes of STATES

FID	Shape*	AREA	STATE_NAME	STATE_FIPS	SUB_RE(
16	Polygon	45360.118	Pennsylvania	42	Mid Atl
17	Polygon	4976.566	Connecticut	09	N Eng
18	Polygon	1044.881	Rhode Island	44	N Eng
19	Polygon	7507.502	New Jersey	34	Mid Atl
20	Polygon	36400.304	Indiana	18	E N Cen
21	Polygon	110669.975	Nevada	32	Mtn

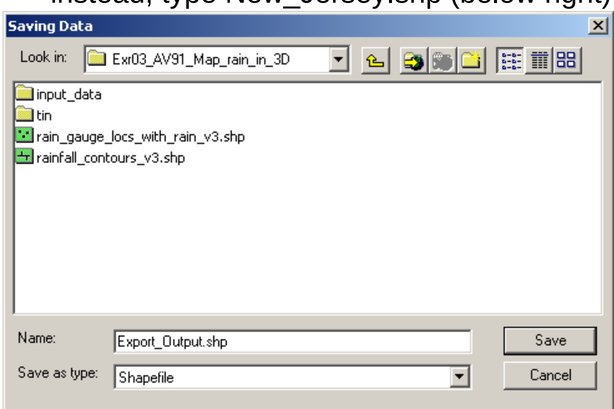
Record: 1 Show: All Selected Records (1 out of 51 Selected.) Options

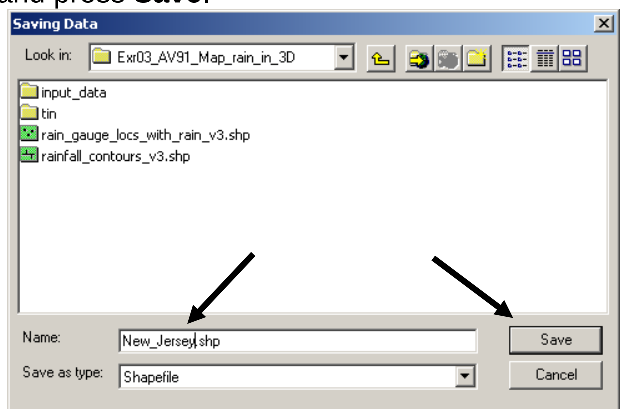
ArcView provides an intuitive message to the user: This highlighted row of data is associated with the map object (the polygon representing New Jersey) that is highlighted in the same color.

- Rt-click on *States* in the ToC; select **Data > Export Data** (left below). An Export Data screen appears (below right); you want to Export Selected Features, using the same coordinate system as the Data Frame. Select the **Browse** button (red arrow).

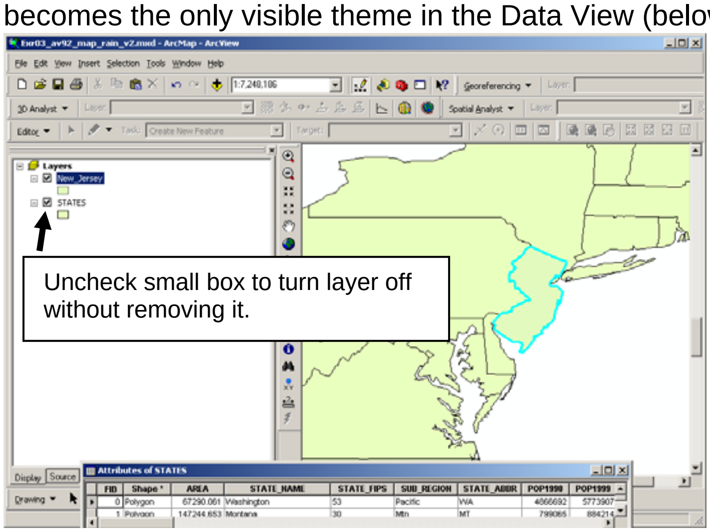
- Scroll to your Exr03 folder (below left). DO NOT use the Export_Output.shp default name; instead, type New_Jersey.shp (below right) and press **Save**.

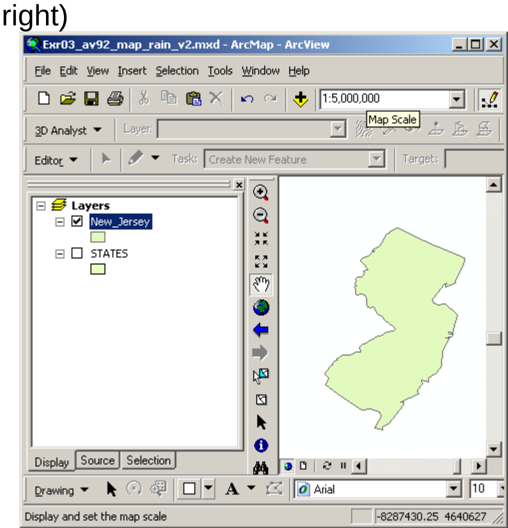




- When the Export Map window returns (not shown), press **OK**; press **Yes** to add the data.

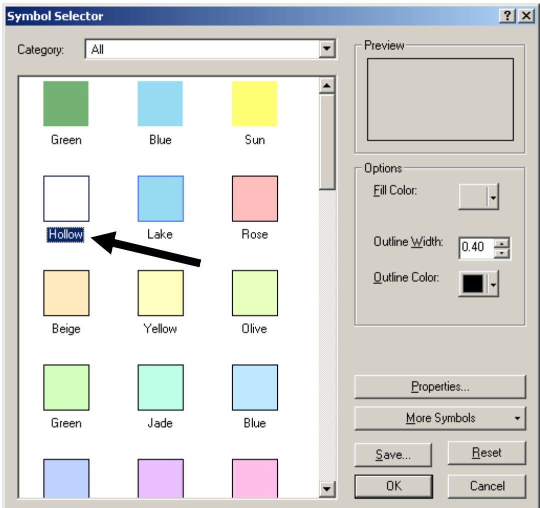
A new theme, entitled *New_Jersey* appears in the ToC and in the map window (below left). Turn off *States* (uncheck the small box in the ToC); *States* becomes invisible and *New_Jersey* becomes the only visible theme in the Data View (below right)

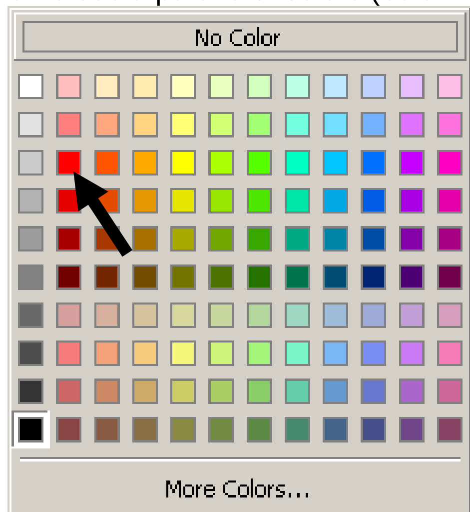




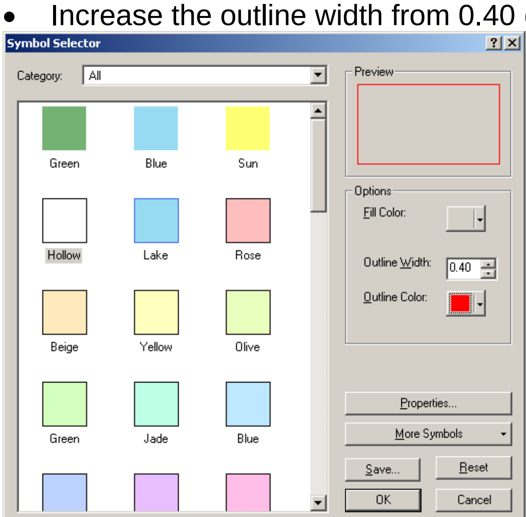
Discussion: We want to change New Jersey from a solid polygon to an outline.
Procedure:

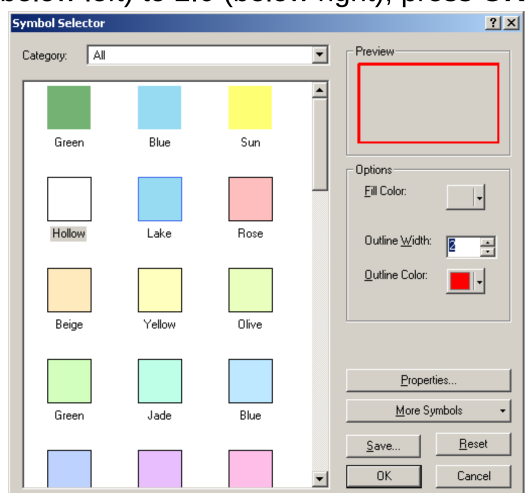
- Left-click the **polygon** below *New_Jersey* in the ToC. Select **Hollow** in the table that opens (left below); notice that "Fill color" becomes blank, but there is still an outline color. Select the arrow next to the outline color in order to see a palette of colors (below right), select red.



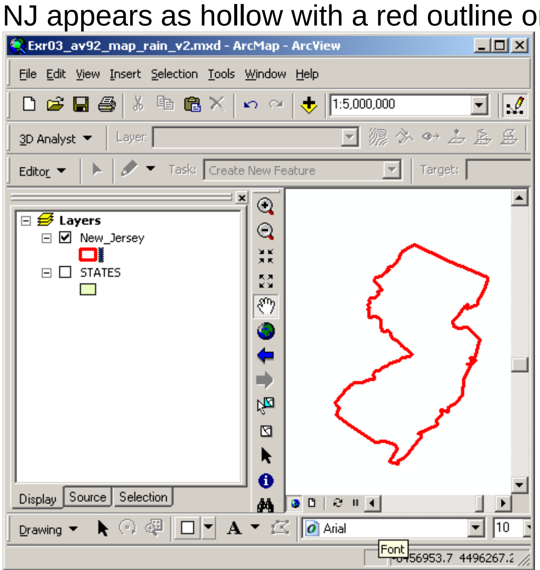


- Increase the outline width from 0.40 (below left) to 2.0 (below right); press **OK**.





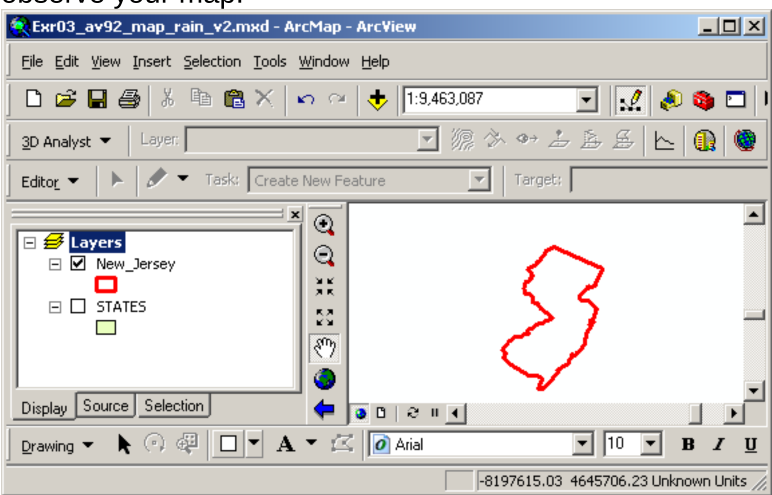
NJ appears as hollow with a red outline on the map (below).



- If you have not yet done so, select **File** > **Document Properties** > **Data Source Options** > Store relative path names to data sources . Also, check, "make relative paths the default…"; press **OK**, twice.
- Select **File** > **Save As;** Scroll to your folder and name your mxd something memorable, like ***Yourname_Exr03***. Press **Save**.

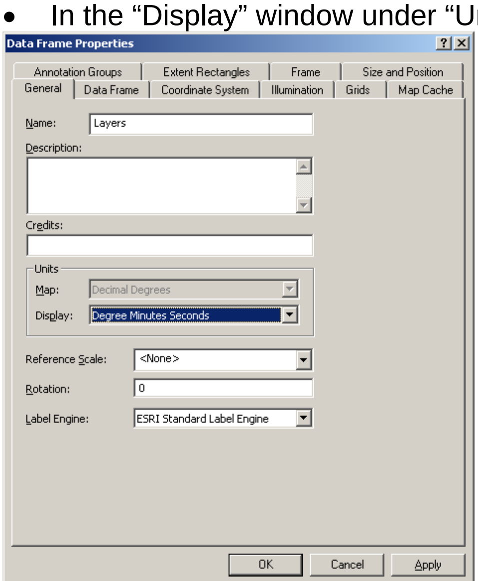
Step 4 - Set the View Units from Degrees-Minutes-Seconds to Decimal Degrees.

Discussion – Because data sets frequently are in different coordinate systems, GIS users need to be aware of different coordinate systems and how they relate to each other. For example, an analogy for degrees-minutes-seconds (DMS) and decimal degree (DD) coordinate systems can be drawn from a clock. You can write 6:30 A.M. as 06:30:00 (i.e., 6 hours, 30 minutes, zero seconds). Another way to express 6:30:00 could be 6.50 (in decimal hours). One system uses hours-minutes-seconds, while the other uses decimal fractions of hours, but the **actual time remains the same**. Likewise, either a DMS or a DD coordinate system can be used to locate the **same point in space**. Let's use ArcMap to look at an example. First, observe your map:



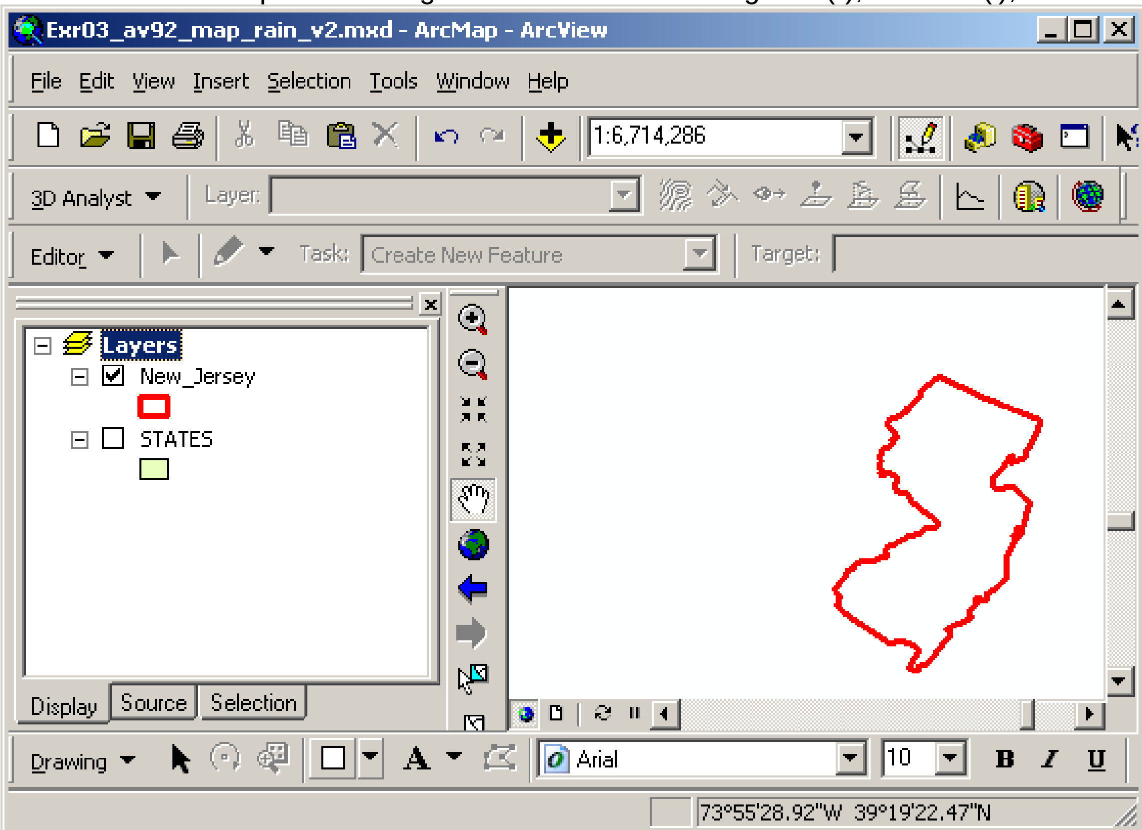
Note the "Unknown Units" on the bottom right of the map window.

- Rt-click on **Layers** in the Table of Contents (ToC) > **Properties** > **General** tab. In Data Frame Properties, notice that the Units > "Map" window contains a grayed-out **Decimal Degrees**, reflecting the predefined map units that are embedded in this theme.
- In the "Display" window under "Units:" select **Degrees Minutes Seconds**; click **Apply**:

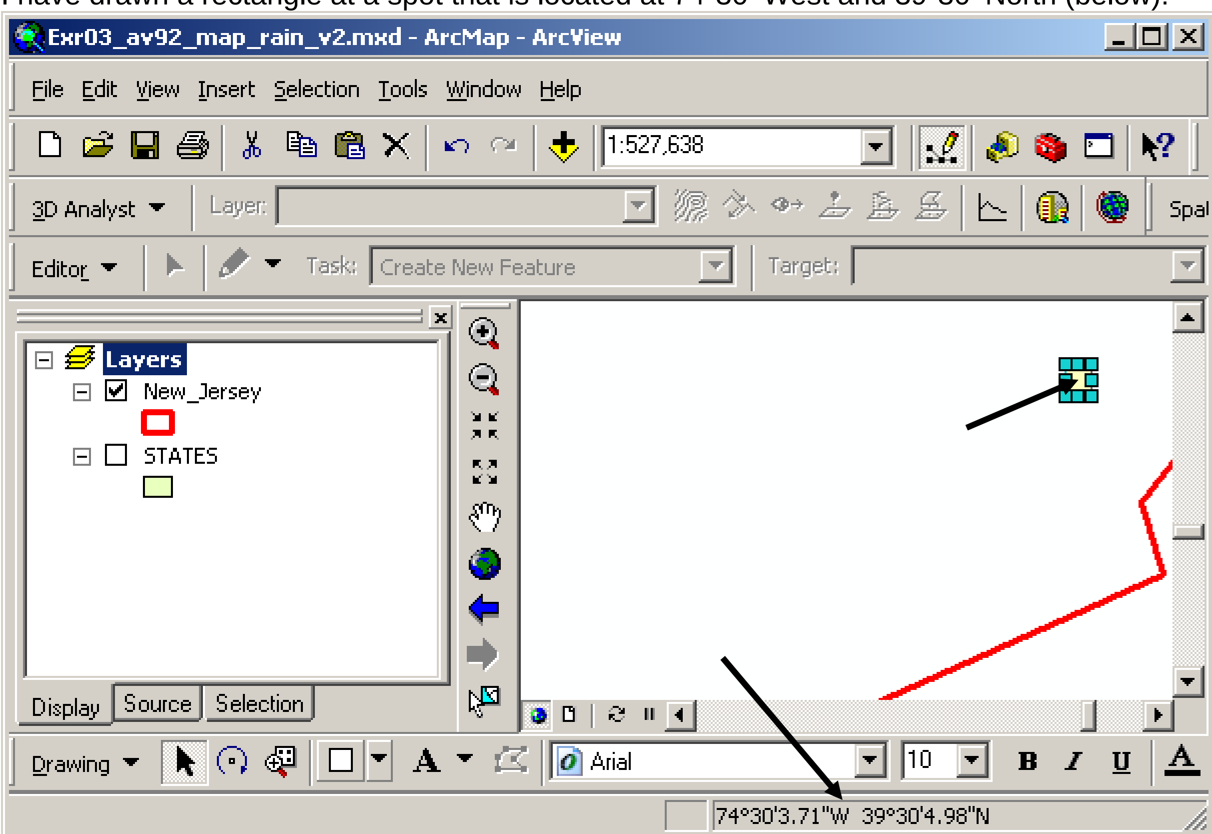


Press **Apply**, **OK**.

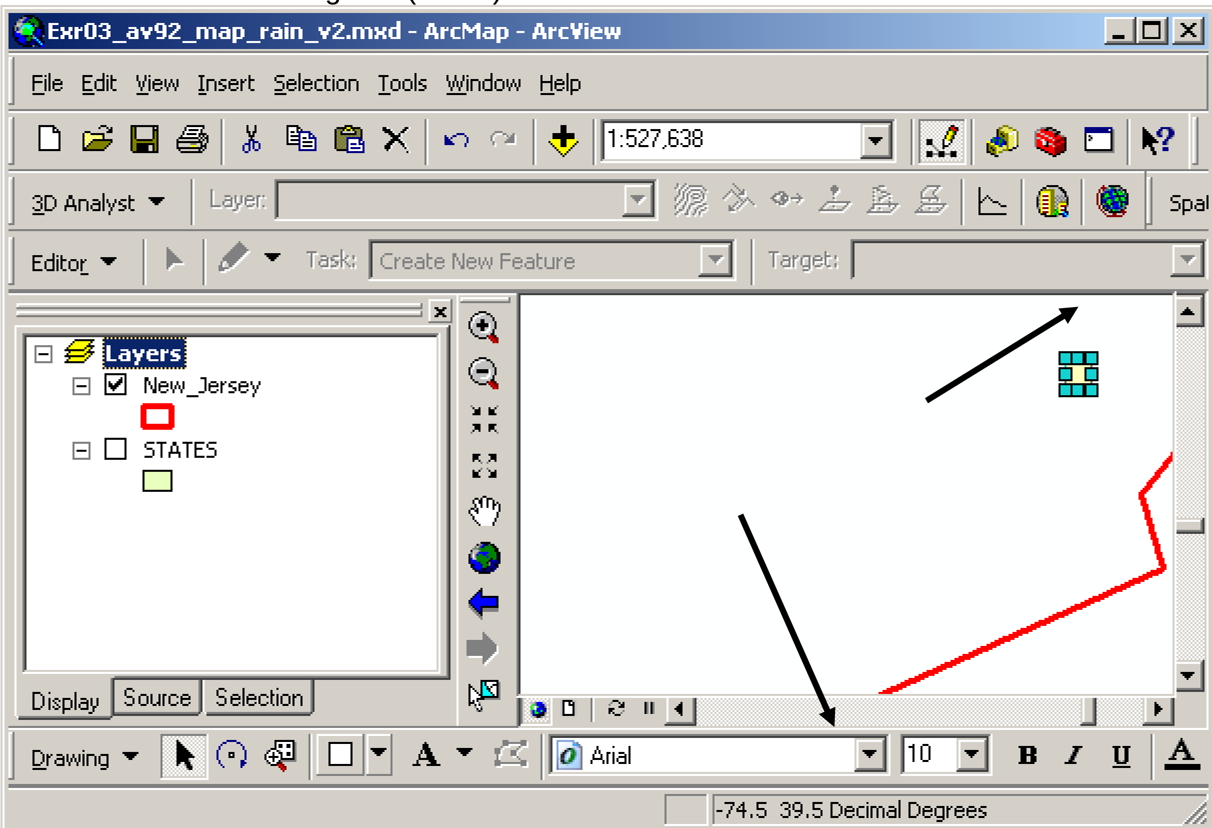
The units on the map have changed from Unknown to Degrees (^{o}), Minutes ('), Seconds ("):



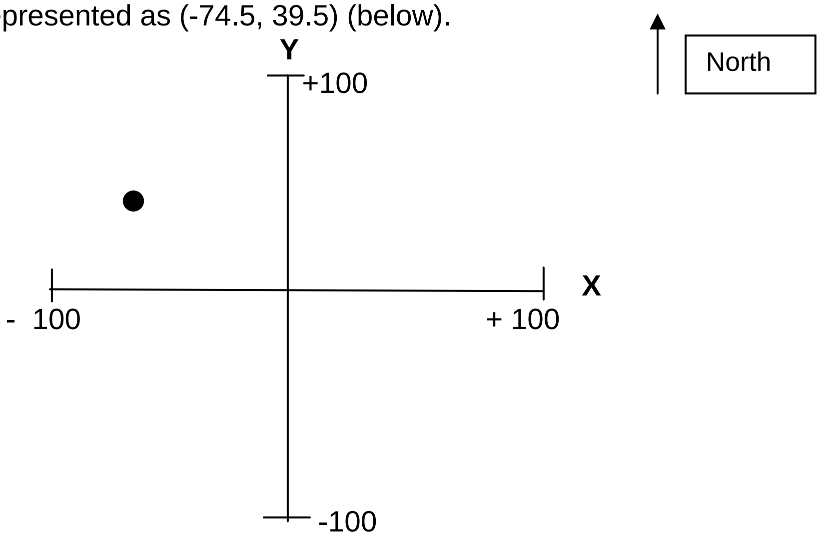
I have drawn a rectangle at a spot that is located at 74^{o}30' West and 39^{o}30' North (below):



When I change the coordinate system to DD (Decimal Degrees), the same point is now located at -74.5 39.5 Decimal Degrees (below).



On an X-Y graph, -74.5 would be the X-coordinate, and 39.5 would be the Y-coordinate, and the (X,Y) pair would be represented as (-74.5, 39.5) (below).



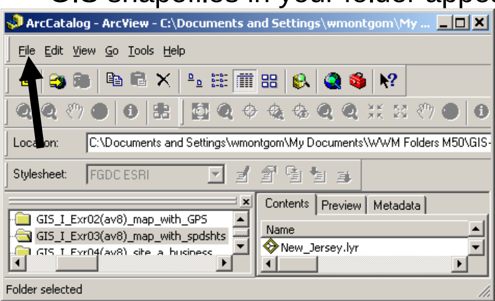
Set your map coordinate system units to be Decimal Degrees. Move the mouse over New Jersey. Note that the coordinates are now in decimal degrees. Why is it that the X coordinate is negative? The answer lies in what you (hopefully) learned in middle school geometry class: all the numbers above and to the right of (0,0) in a Cartesian coordinate system are positive, whereas all the numbers to the left and below (0,0) are negative. Degree designation in GIS makes sense when you define the intersection of the Equator and the Prime Meridian as (0,0). The Prime Meridian (PM) runs through Greenwich, England. New Jersey is west of the PM, to the left of it in map view. Therefore, any units of measurement along the X-axis (longitude) in NJ are negative.

Step 5 - Create a new attribute table and point theme for rainfall gauging stations -

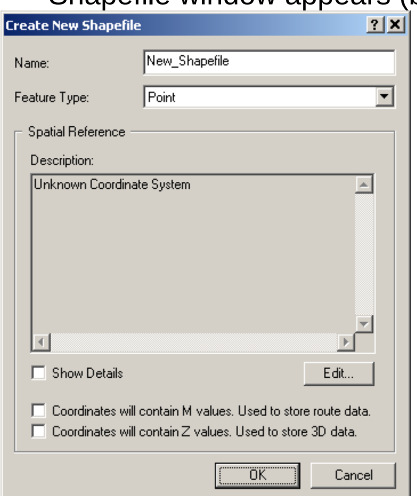
Discussion: You will now perform onscreen, manual digitizing of 10 points to create a new theme that represents the locations of 10 rainfall measurement gauges in New Jersey. You will learn how to do this in a faster, more automated manner later in the exercise.

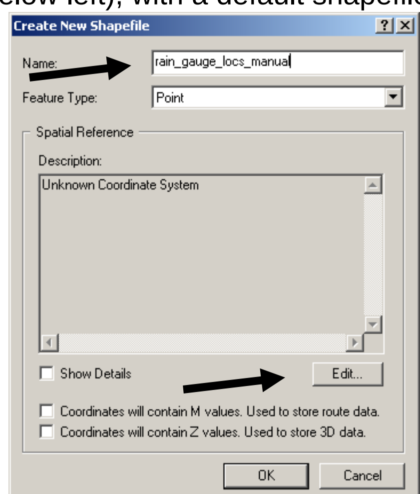
Procedure: Recall from Exr01 that you must use **ArcCatalog** to create (and name) an empty shell of a shapefile before you start filling it with points.

- Open ArcCatalog by dbl-clicking on the yellow file cabinet at the top of ArcMap, or by going to **Start > Programs > ArcGIS > ArcCatalog.** A Windows Explorer-style window opens. Using the left window, scroll to your Exr03 folder; double-click on it to open it. Your current GIS shapefiles in your folder appear in the RH window:

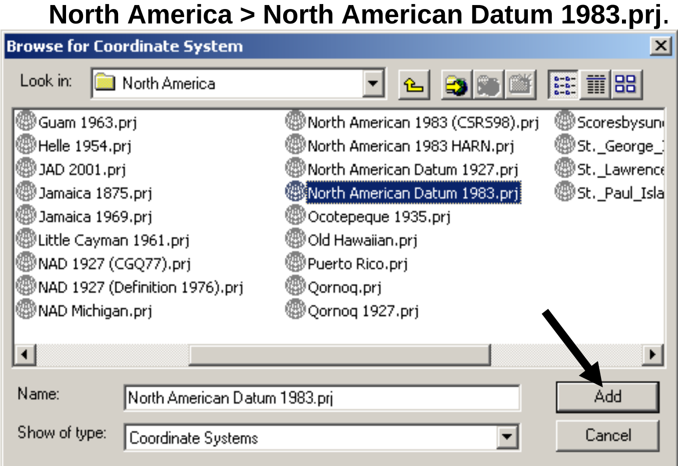


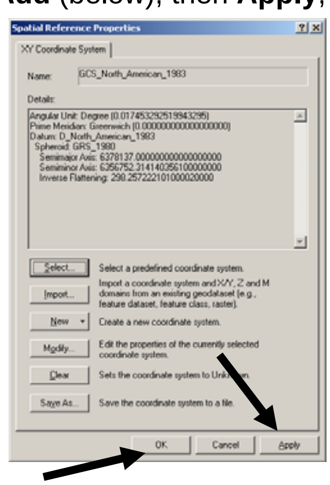
- At the top bar of ArcCatalog, select **File > New > Shapefile** (above left). A Create New Shapefile window appears (below left), with a default shapefile name in the Name: window:



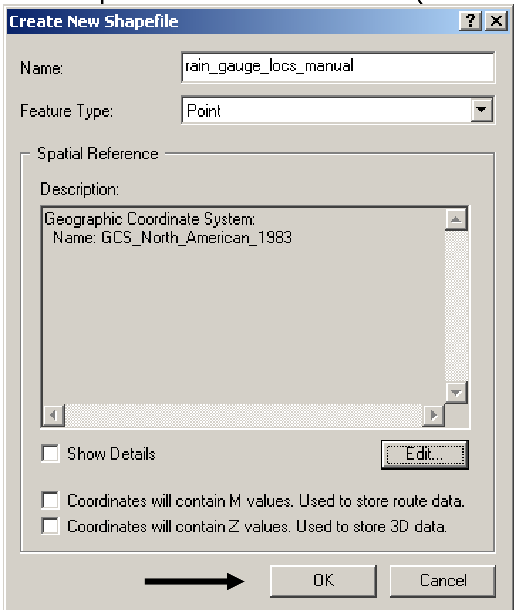


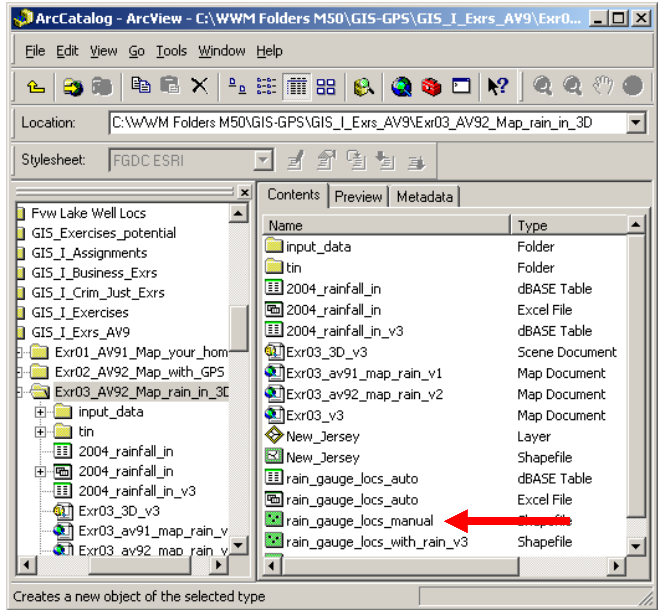
- Type ***rain_gauge_locs_manual*** in the Name: window (above, right). Feature type = ***point***. Select **Edit** button and set the coordinate system to: **Geographic coordinate systems (GCS) > North America > North American Datum 1983.prj**. Press **Add** (below), then **Apply**, **OK**.



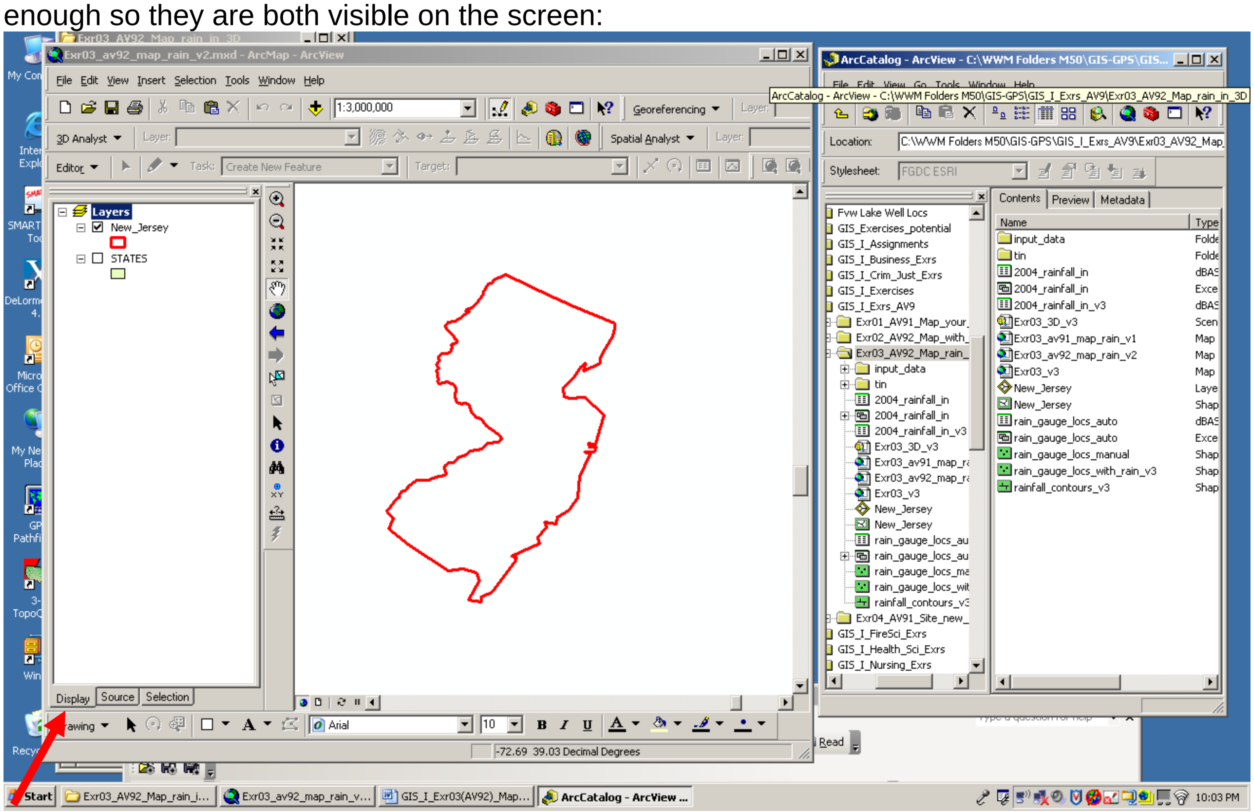


Press **OK** when the Create New Shapefile window returns (below left). ArcCatalog returns, with the shapefile in the RH window (below right)





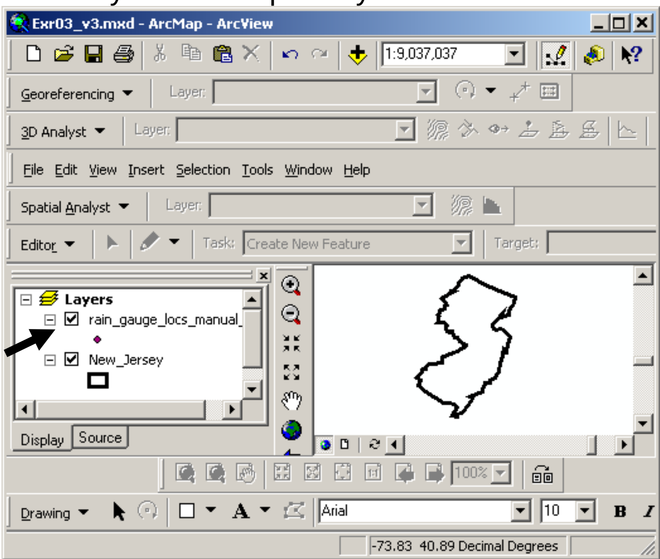
Discussion: Make sure you have both the ArcCatalog and ArcMap windows open, small enough so they are both visible on the screen:



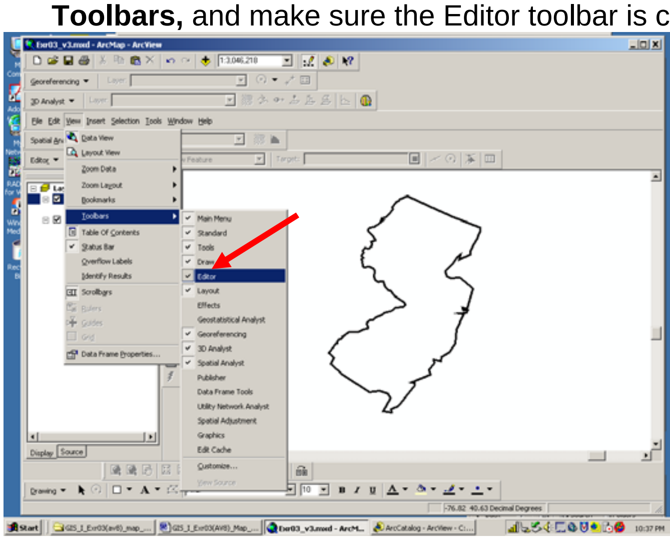
Make sure that the "**Display**" tab (**NOT** "Source" tab) at the bottom of the ToC is active.

- Copy and paste (or drag) the *rain_gauge_locs_manual.shp* icon from ArcCatalog into the ToC of ArcMap. If a "one or more layers are missing spatial reference information" window appears, it means that you did not set the coordinate system in the new shapefile properly. Repeat the above steps to correctly set the shapefile's coordinate system to GCS NAD 1983. Consult your instructor if you are unable to get past this step.

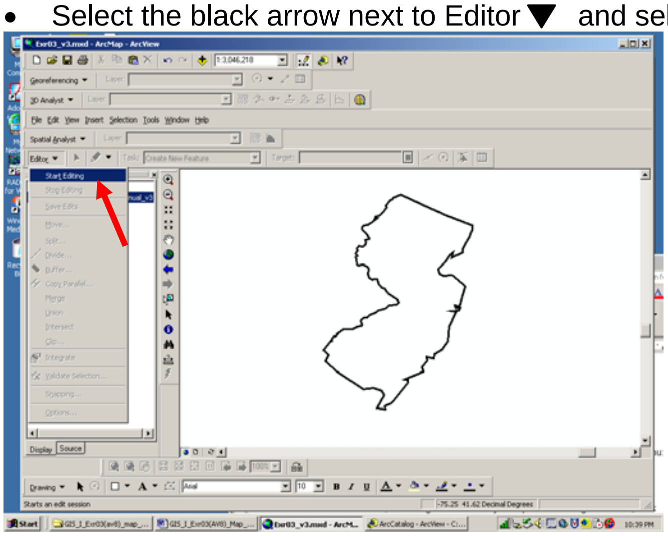
- Once you have copied the *rain_gauge_locs_manual.shp* over to ArcMap, close ArcCatalog.
- If necessary, drag the *rain_gauge_locs_manual.shp* to the top of the ToC to ensure your ability to see the points you create:



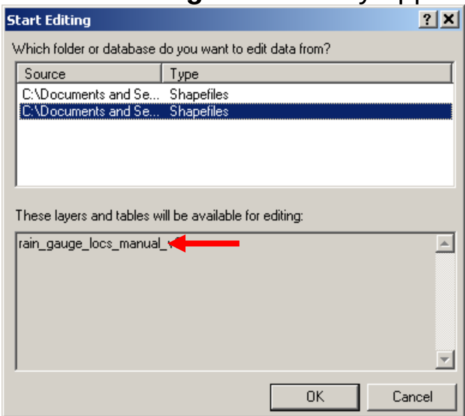
- Select *rain_gauge_locs_manual.shp* (it will turn dark blue in the ToC). Go up to **View-Toolbars,** and make sure the Editor toolbar is checked ☑ (red arrow below):



- Select the black arrow next to Editor ▼ and select **Start Editing** from the drop-down menu:



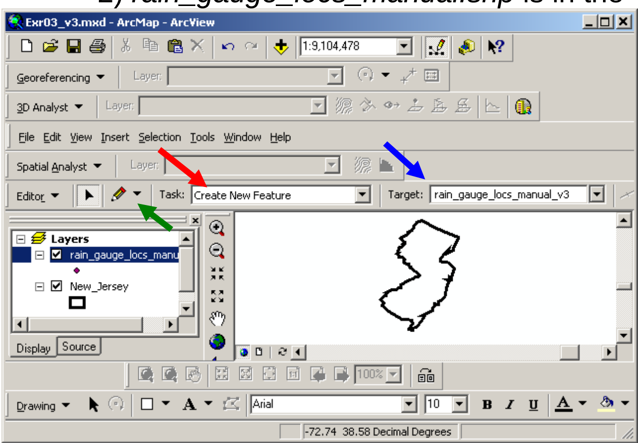
A **Start Editing** window may appear that asks which folder or database you want to edit:



- Select the folder that contains *rain_gauge_locs_manual.shp* (red arrow above); click **OK**.

Before going any further, MAKE SURE that:

1) **Create New Feature** is in the "**Task**" window (red arrow below) and
2) *rain_gauge_locs_manual.shp* is in the "**Target**" window (blue arrow below):



- Click on the black arrow ▼ to the right of the red & yellow pencil to the right of Editor (green arrow above):
- Click on the pencil again if it appears in a small box. This puts AV into "create a new feature" mode and will enable you to use the pencil to draw a point that will be saved as a feature on the map and in the *rain_gauge_locs_manual.shp* attribute table.

Step 6 - Perform onscreen digitizing of 10 points

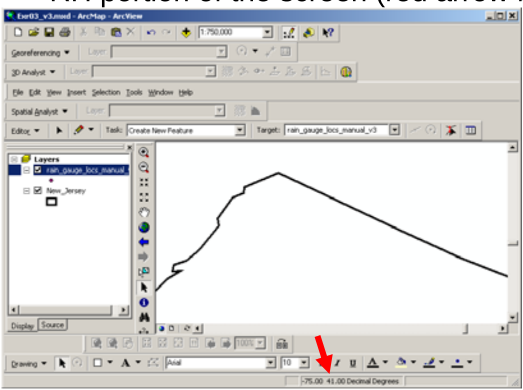
- **Discussion:** You will now manually perform "onscreen digitizing" (OSD) of the following 10 rain gauge stations by using a point to locate each station. Each time you digitize a point, you will also type in the ID number for that point in the ID column of the attribute table.

ID	Longitude(^{o}W)	Latitude(^{o}N)
1	-75.00	41.00
2	-74.50	41.00
3	-74.00	41.00
4	-75.00	40.50
5	-74.50	40.50
6	-74.75	40.75
7	-74.25	40.75
8	-74.75	40.25
9	-74.25	40.25
10	-75.00	40.00

Procedure:

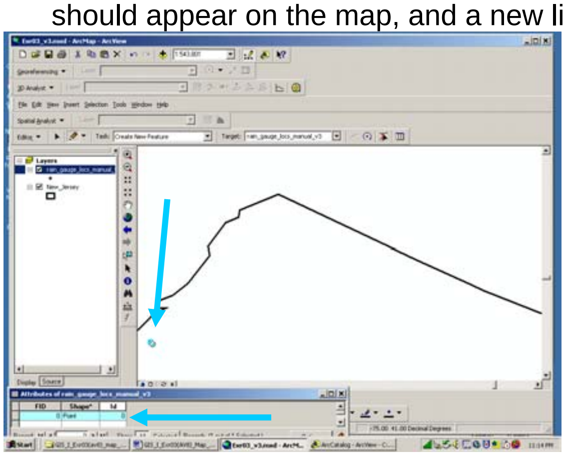
- Open the *rain_gauge_locs_manual.shp* attribute table (right-click on the theme name in the ToC > **Open Attribute Table**). The attribute table already has FID, Shape, and ID fields:

- Set the map scale to 1:500,000 or even larger (smaller number) if necessary. Use the mouse to find the location of the first point by following the lat-long coordinates in the lower RH portion of the screen (red arrow below):

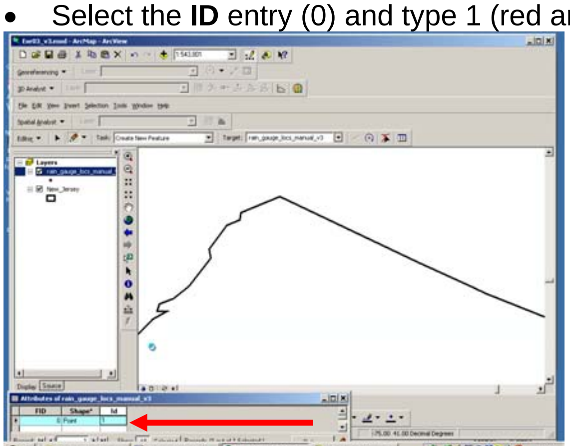


Select the hand on the toolbar and drag the map to a new location if necessary. Click on the red & yellow pencil to re-enter the editing mode.

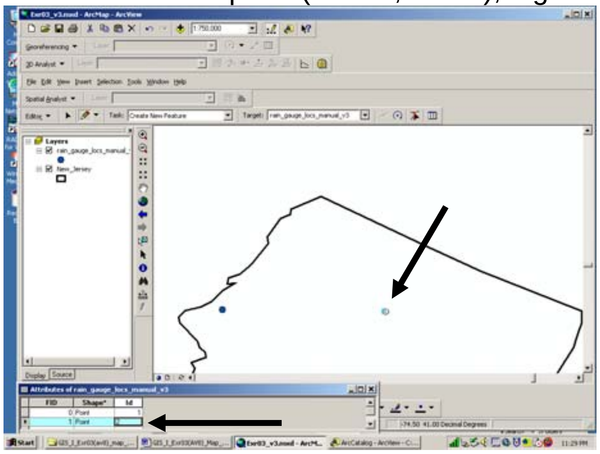
- Move the mouse to your first point (-75.00, 41.00) and left-click. A bright, aqua-blue point should appear on the map, and a new line in bright blue should appear in the attribute table:



- Select the **ID** entry (0) and type 1 (red arrow below):



Press **Enter** on your keyboard to save the ID entry.
Move to the next point (-74.50, 41.00), digitize the point and enter the ID value (2) in the AT:



Select **Editor > Save Edits** periodically during the digitizing process. When you have finished all 10 points, select **Editor > Save Edits** and finally **Editor > Stop Editing**.

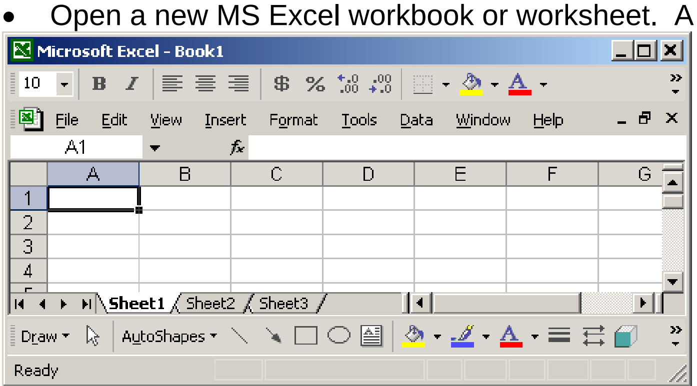
- **File > Save** to save your project.

Step 7 - Create 30 rain gauge station points in MS Excel

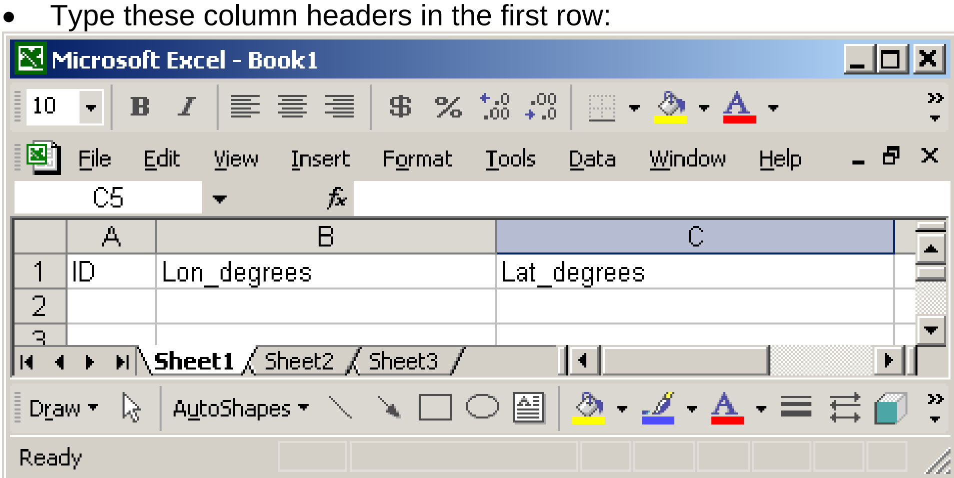
Discussion: Arcview can recognize columns of X,Y data in tables and automatically plot points, which can be a much faster way to create a large number of points than manual digitizing. You will create a table of 30 rain gauge data points in MS Excel and save it as an .xls (Excel) file. You will then save it as a .dbf (dBase) file because ***AV can not read MS Excel***.

Procedure:

- Open a new MS Excel workbook or worksheet. A blank spreadsheet appears:

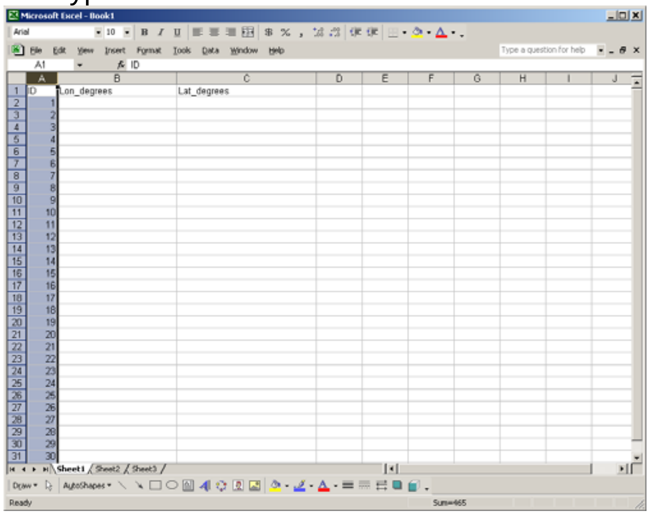


- Type these column headers in the first row:



***NOTE:* No empty columns or rows in this spreadsheet!** If names are too long for an initial column width, simply make the column wider (use Help if necessary).

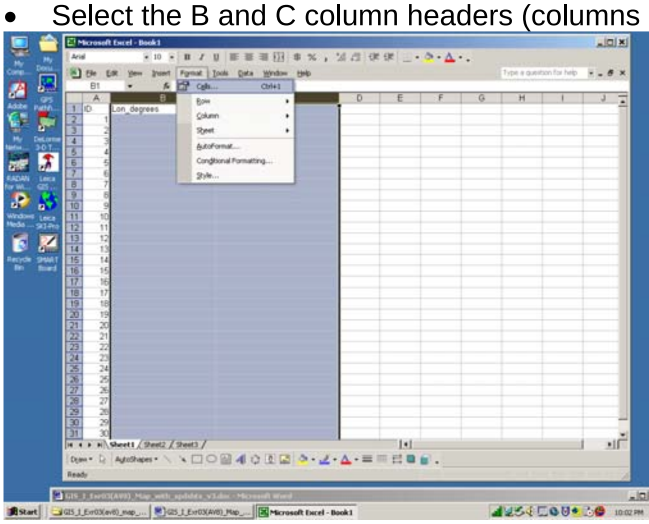
- Type in values from 1 to 30 in the ID column:



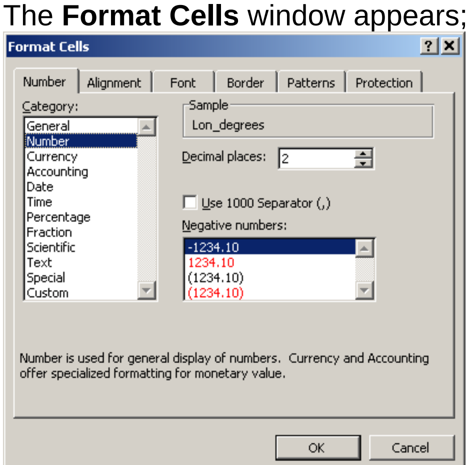
Discussion: It is ***CRITICAL*** to format the latitude and longitude columns for **2 decimal places**. Otherwise, the lat-long values will be automatically rounded by Excel to whole numbers, which will cause a number of points to "overplot" on top of each other.

Procedure:

- Select the B and C column headers (columns selected in blue); select **Format** > **Cells**



The **Format Cells** window appears; select **Number** under "Category:" and **2** in "Decimal places"

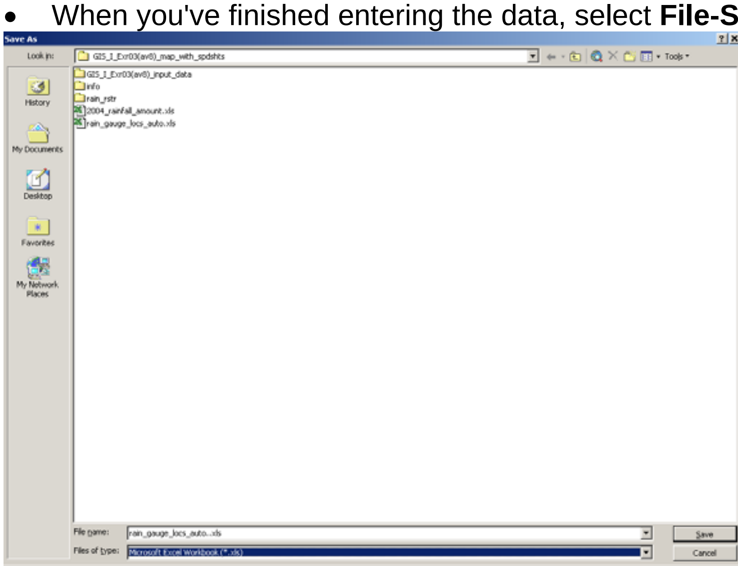


- Press **OK**

- Enter the following latitude and longitude data into the spreadsheet:

ID	Lon_degrees	Lat_degrees
1	-75.00	41.00
2	-74.50	41.00
3	-74.00	41.00
4	-75.00	40.50
5	-74.50	40.50
6	-74.75	40.75
7	-74.25	40.75
8	-74.75	40.25
9	-74.25	40.25
10	-75.00	40.00
11	-74.50	40.00
12	-75.25	39.75
13	-74.75	39.75
14	-74.25	39.75
15	-75.00	39.50
16	-74.50	39.50
17	-74.75	41.00
18	-74.25	41.00
19	-75.00	40.75
20	-74.50	40.75
21	-74.75	40.50
22	-74.50	40.25
23	-74.75	40.00
24	-74.25	40.00
25	-75.00	39.75
26	-74.50	39.75
27	-75.25	39.50
28	-74.75	39.50
29	-75.00	39.25
30	-74.75	39.25

- When you've finished entering the data, select **File-Save As;** A **Save As** window appears:



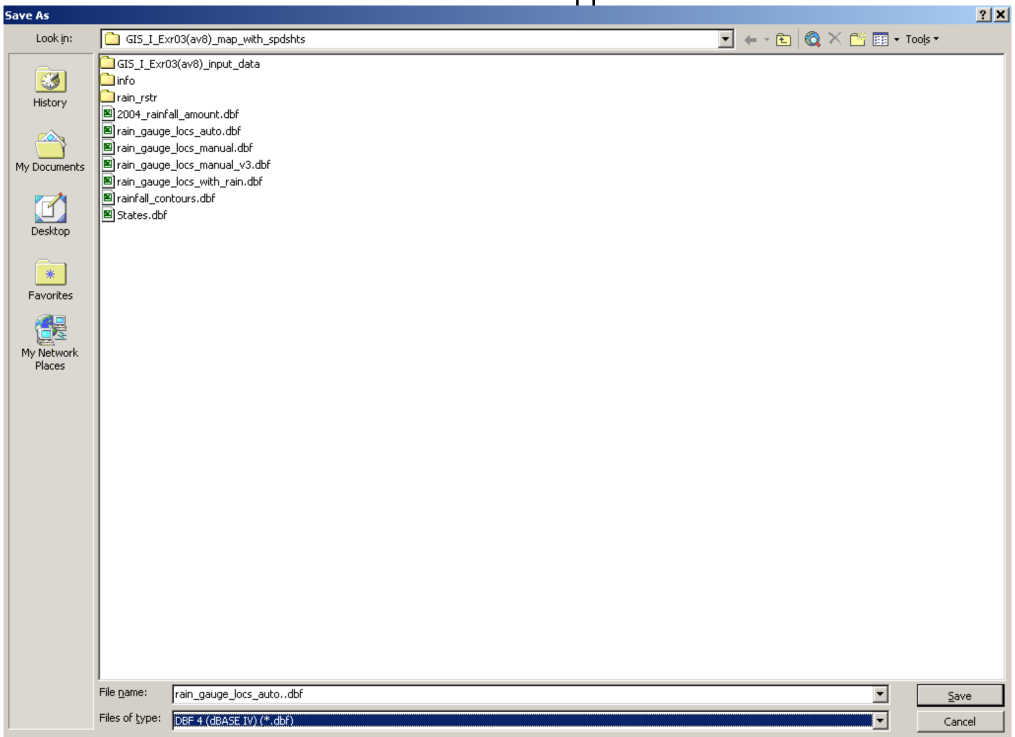
Fill it in as follows:

  - **Save in:** (browse to your Exr03 folder on your computer or on the server)
  - **File name:** *rain_gauge_locs_auto.xls*
  - **Save as type:** Microsoft Excel Workbook

IMPORTANT:

1) **Make sure** you save this Excel spreadsheet **inside** your Exr03 folder!
2) **Use underscores (_)** between file name words to avoid error messages later.

Discussion: Since Arcview may not read Excel files, you now need to re-save this Excel file in dBase IV (.dbf) format. **Make sure you first select an active cell in the worksheet** (e.g., A2). Select **File – Save As**. A Save As window appears:

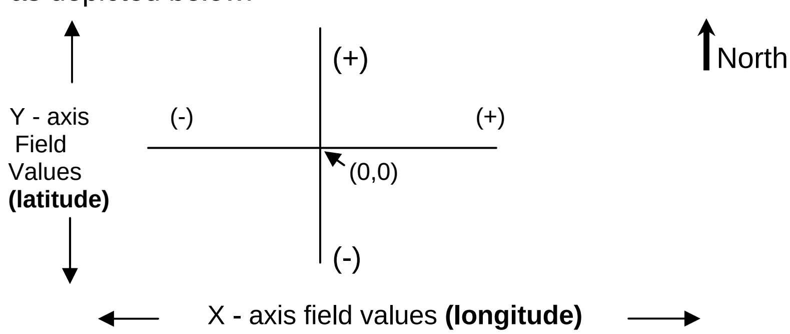


- In the upper "Save In: "window, make sure you browse to **inside** your Exr03 folder.
- In File Name:, leave the same file name (*rain_gauge_locs_auto)*
- In the lower window, **Save As Type**, scroll to and select **dBase IV**, then click **SAVE**. Excel will present a warning:
  "The selected file type does not support workbooks that contain multiple sheets. To save only the active sheet; Click OK ". Click **OK**.

  Excel presents another warning: *"rain_gauge_locs_auto.dbf may contain features that are not compatible with DBF 4. Do you want to keep the workbook in this format?*" Click **Yes**. Click **X** in the upper RH corner of the spreadsheet to close your .dbf file. Excel will ask *"Do you want to save the changes you made? "* Click **NO** (you already saved the file).

Step 8 - Add X-Y (lon-lat) data and automatically create a new point theme

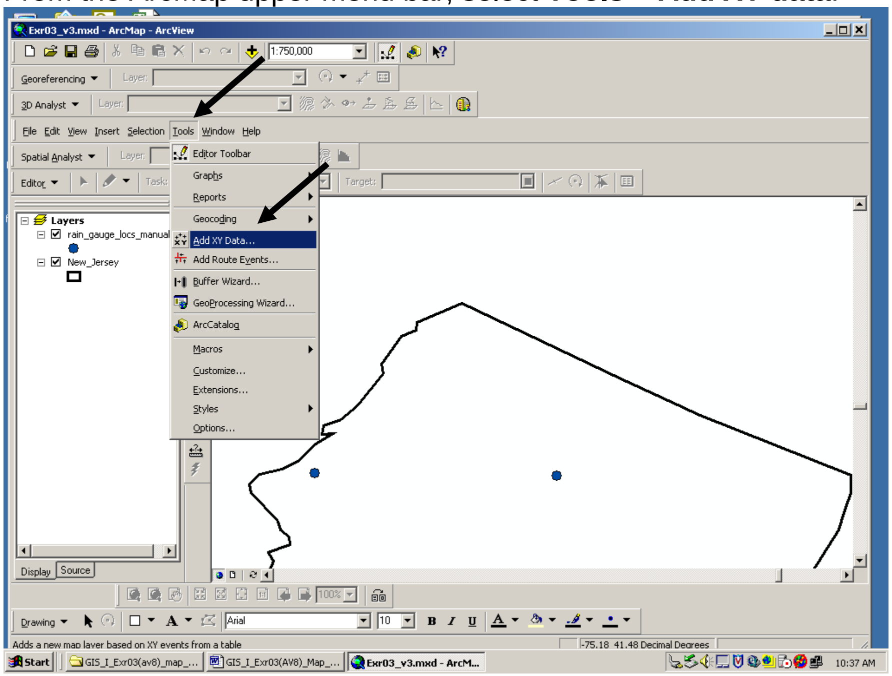
Discussion: In ArcMap, longitude and latitude are interpreted as "X" and "Y" values in a coordinate system, as depicted below:



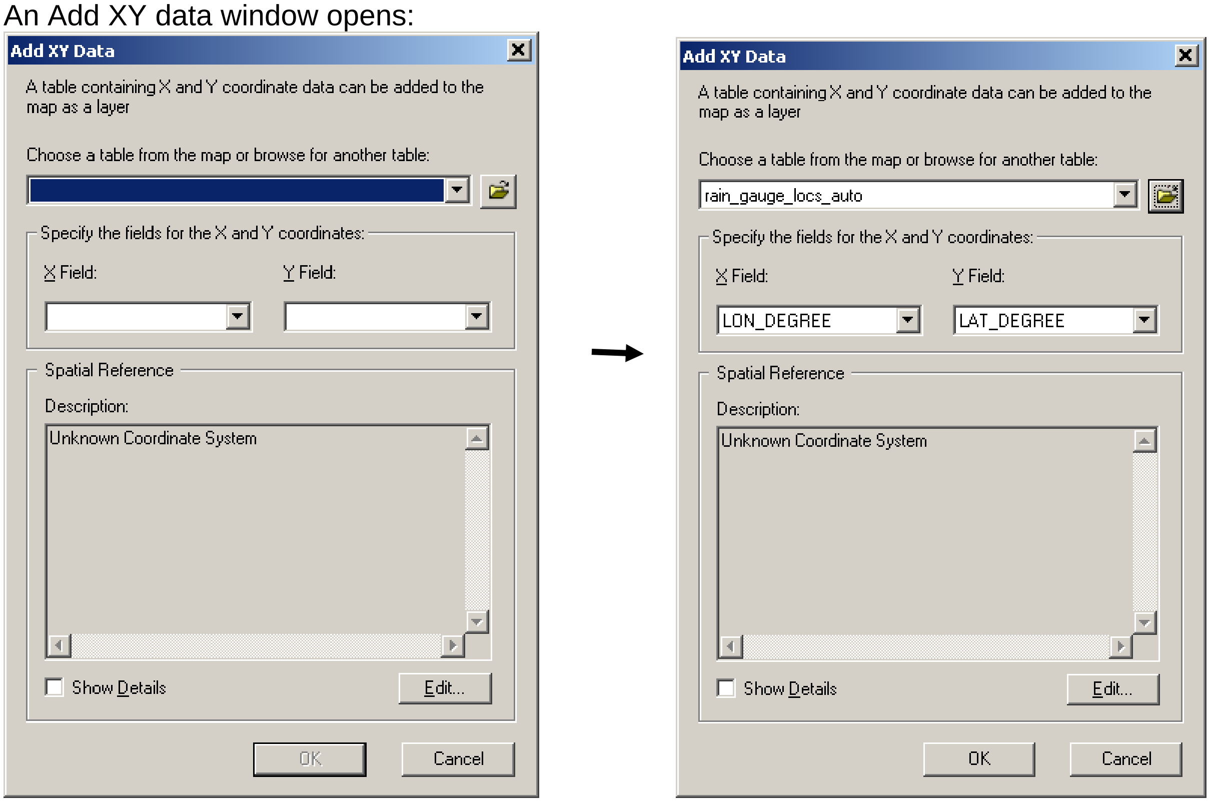
ArcMap can read the longitude-latitude values from *rain_gauge_locs_auto.dbf* and automatically plot those values on a map much faster than you can plot manually.

Procedure:

- From the ArcMap upper menu bar, select **Tools > Add XY data**:

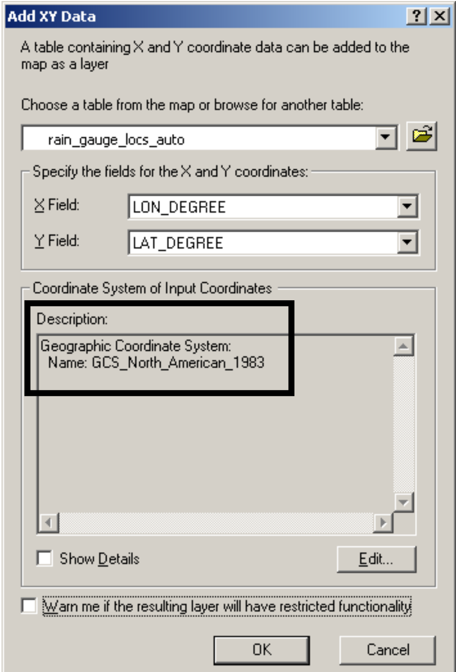


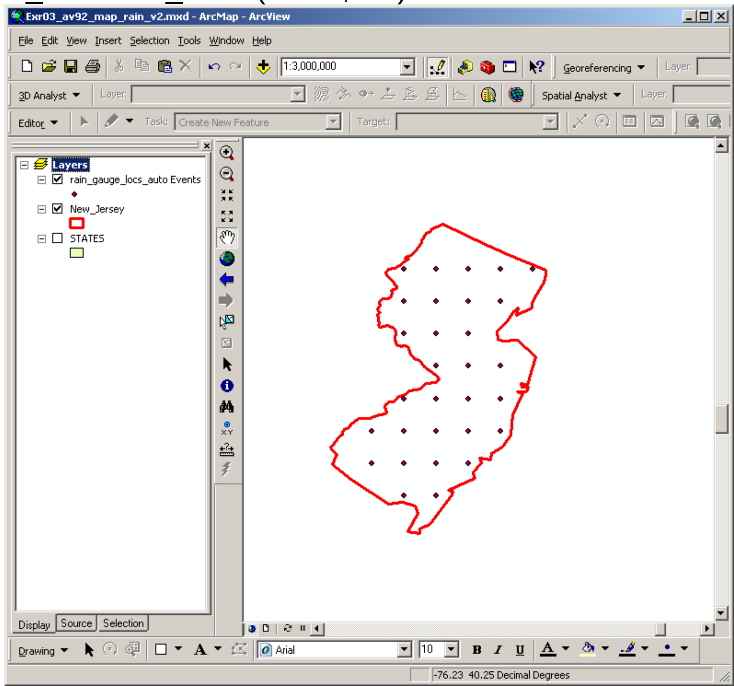
An Add XY data window opens:



- Select the folder on the RH side of the "Choose a table…" window and browse to your Exr03 folder and select *rain_gauge_locs_auto.dbf*. The **Add XY Data** window returns: ***rain_gauge_locs_auto*** is in the "Choose a table…" window, **LON_DEGREE** is the X field, and **LAT_DEGREE** is the Y field. Notice that the Description says the file has an "unknown coordinate system". Select **Edit** and set the coordinate system to **GCS North American Datum 1983.prj** (as you did earlier when adding *rain_gauge_locs_manual.shp*). Click **Apply**, **OK**.

The coord system is now GCS_North_American_1983 (below, left). Press **OK**.





A layer of 30 points, *rain_gauge_locs_autoEvents* appears (above, right).

NOTE: If there are **NOT** 30 points, or the points do not appear EXACTLY in the positions shown, you either mis-entered data or formatted the lat-long columns of the original Excel spreadsheet incorrectly. You must return to that step and perform it correctly.

- Rt-click on *rain_gauge_locs_autoEvents* > **Open Attribute Table**. It appears with Latitude, Longitude, FID, ID, and Shape columns (below):

Attributes of rain_gauge_locs_auto Events

OID	ID	LON_DEGREE	LAT_DEGREE	Shape*
0	1	-75	41	Point
1	2	-74.5	41	Point
2	3	-74	41	Point
3	4	-75	40.5	Point
4	5	-74.5	40.5	Point
5	6	-74.75	40.75	Point
6	7	-74.25	40.75	Point
7	8	-74.75	40.25	Point
8	9	-74.25	40.25	Point
9	10	-75	40	Point
10	11	-74.5	40	Point
11	12	-75.25	39.75	Point
12	13	-74.75	39.75	Point
13	14	-74.25	39.75	Point
14	15	-75	39.5	Point
15	16	-74.5	39.5	Point
16	17	-74.75	41	Point
17	18	-74.25	41	Point
18	19	-75	40.75	Point
19	20	-74.5	40.75	Point
20	21	-74.75	40.5	Point
21	22	-74.5	40.25	Point
22	23	-74.75	40	Point
23	24	-74.25	40	Point
24	25	-75	39.75	Point
25	26	-74.5	39.75	Point
26	27	-75.25	39.5	Point
27	28	-74.75	39.5	Point
28	29	-75	39.25	Point
29	30	-74.75	39.25	Point

Record: 1 Show: All Selected Records (0 out of 30 Sele

Don't panic if the X and Y values do not all show 2 decimal places; AV has chopped off unnecessary zeroes. If you formatted the original Excel sheet correctly to 2 decimal places, each one of the 30 points will plot correctly, as in the map above.

- Use **File** > **Export** to create a JPG of your map, and send it to your instructor. **END PART I.**

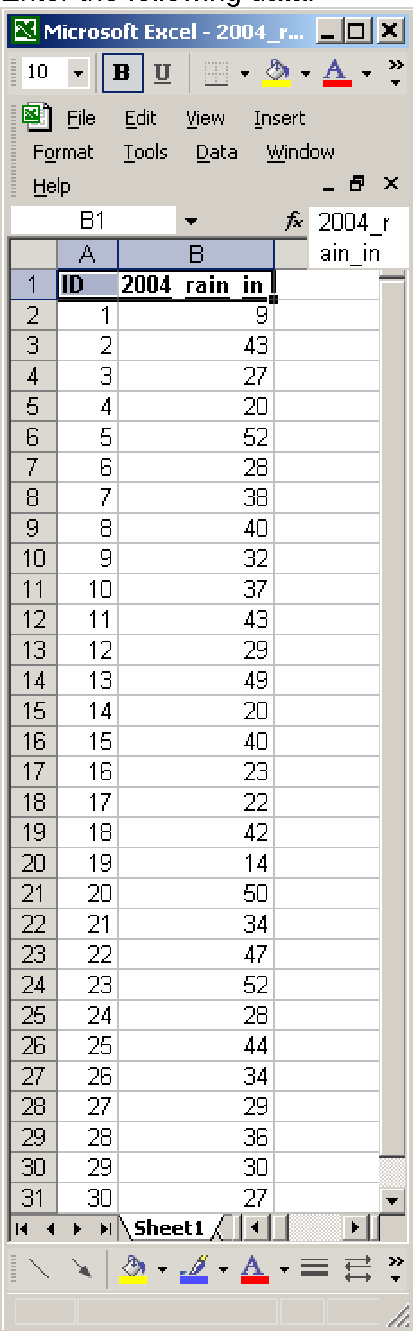
Part II – Perform a "Table Join" and create both a map (mxd) and 3D image (sxd)

***Step 1 - Create an external "rainfall" spreadsheet to join to** "rain_gauge_locs_auto"*

Discussion: One of the most powerful features of a GIS is its ability to "join" external spreadsheets and databases to internal attribute tables. This enables mapping ALL the attributes from the "joined" table, even though this table is not "in" a GIS per se. In this next step, you will create a spreadsheet of measured rainfall data taken from each of the 30 rain gauge stations that you just plotted.

Procedure:

- Open MS Excel, and set up a spreadsheet with two columns of data - **ID** and **2004_Rain_in**.
- Enter the following data:



ID	2004_rain_in
1	9
2	43
3	27
4	20
5	52
6	28
7	38
8	40
9	32
10	37
11	43
12	29
13	49
14	20
15	40
16	23
17	22
18	42
19	14
20	50
21	34
22	47
23	52
24	28
25	44
26	34
27	29
28	36
29	30
30	27

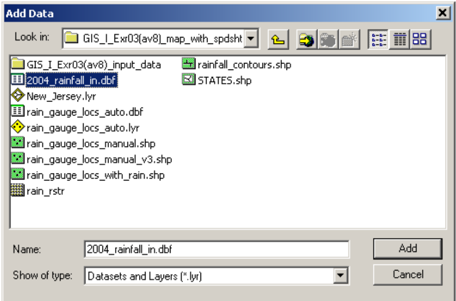
When you are done entering the data, save this table first in **.xls** and then in **.dbf** format, like you did earlier for *rain_gauge_locs_auto*. Refer to those steps if necessary. Save the tables in your Exr03 folder with a name you can remember, such as *2004_rainfall_in*.

Step 2 - Join rainfall data to the rain gauge locations

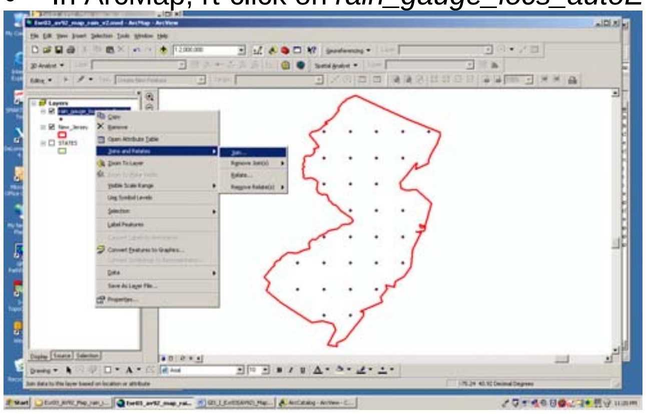
Discussion: In order for one table to be joined to another, the tables must share a common field (column) known as the "primary key". There are various types of joins, but the one you want to perform here is "one-to-one", because you want one 2004 rainfall amount value to be associated with one (and only one) rain gauge. The primary key will be **ID**.

Procedure:

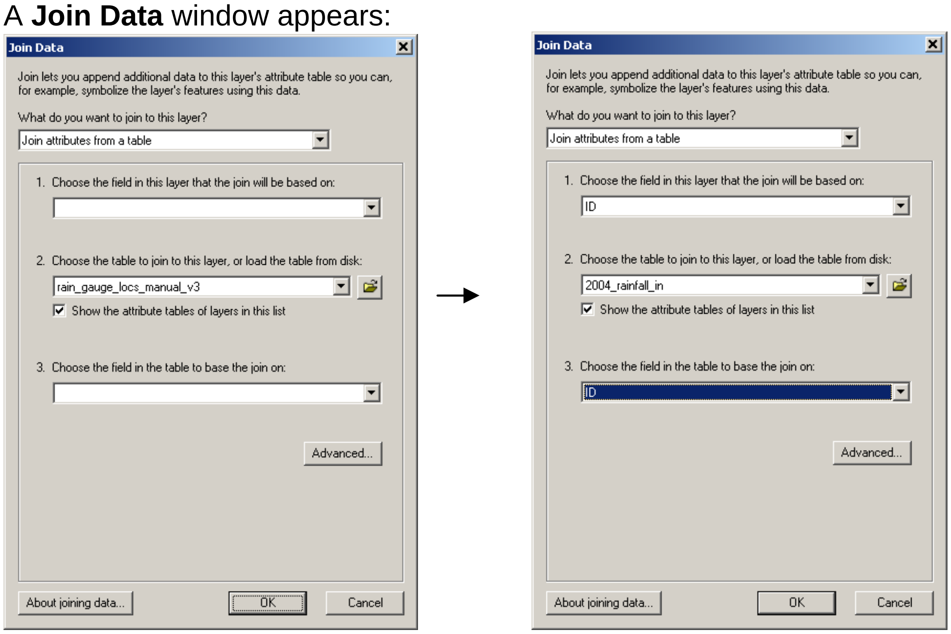
- In ArcMap, select the **Source** tab at the bottom of the ToC.
- Select **File** > **Add Data**, scroll to your Exr03 folder, and add *2004_rainfall_in.dbf*:



- In ArcMap, rt-click on *rain_gauge_locs_autoEvents* > **Joins and Relates** > **Join**:



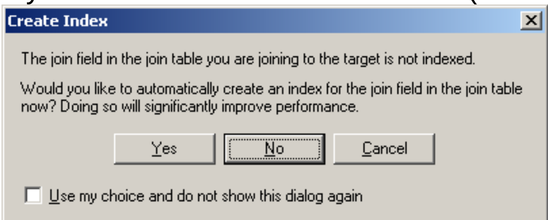
A **Join Data** window appears:



Fill in the blanks: "What do you want to join to this layer?" **Join attributes from a table**

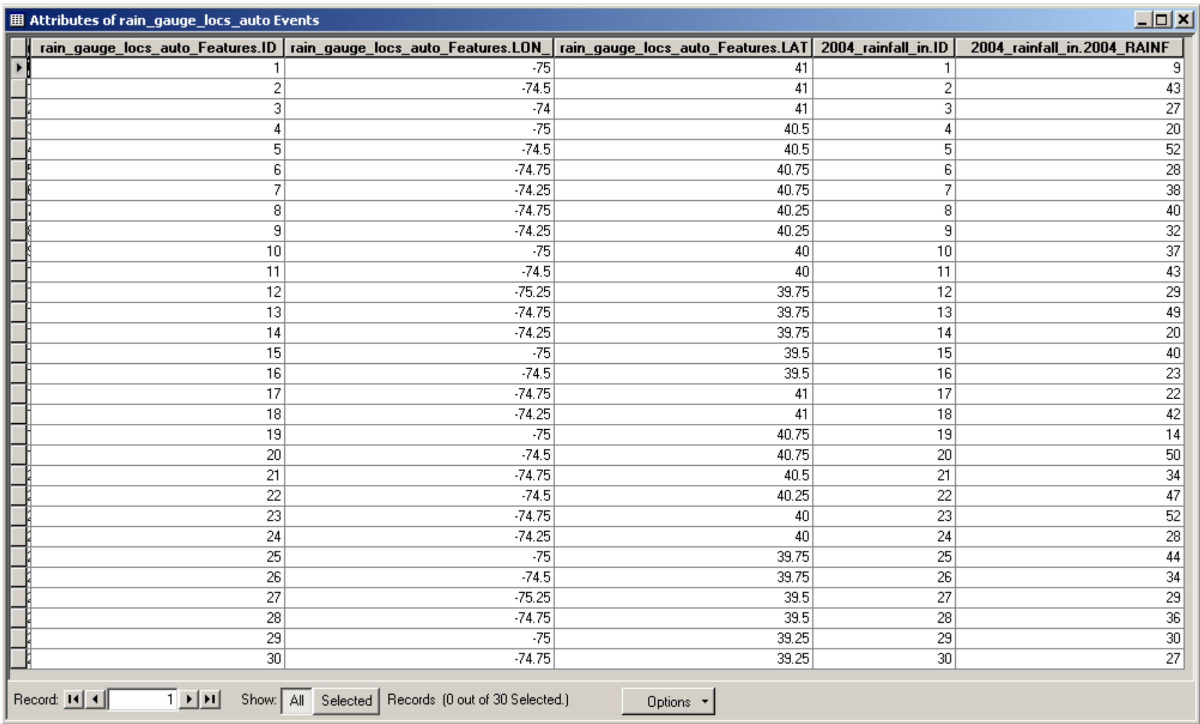
1. Choose the field in the layer that the join will be based on: **ID**
2. Choose the table to join to this layer: **2004_rainfall_in**
3. Choose the field in the table to base the join on: **ID**. Click **OK.**

If you are asked to Create an Index (below), say No (but it probably does not hurt to say Yes).



- In ArcMap, rt-click on *rain_gauge_locs_autoEvents* in the ToC > **Open Attribute Table**.

Notice that there are additional fields in the attribute table:



Attributes of rain_gauge_locs_auto Events

rain_gauge_locs_auto_Features.ID	rain_gauge_locs_auto_Features.LON	rain_gauge_locs_auto_Features.LAT	2004_rainfall_in.ID	2004_rainfall_in.2004_RAINF
1	-75	41	1	9
2	-74.5	41	2	43
3	-74	41	3	27
4	-75	40.5	4	20
5	-74.5	40.5	5	52
6	-74.75	40.75	6	28
7	-74.25	40.75	7	38
8	-74.75	40.25	8	40
9	-74.25	40.25	9	32
10	-75	40	10	37
11	-74.5	40	11	43
12	-75.25	39.75	12	29
13	-74.75	39.75	13	49
14	-74.25	39.75	14	20
15	-75	39.5	15	40
16	-74.5	39.5	16	23
17	-74.75	41	17	22
18	-74.25	41	18	42
19	-75	40.75	19	14
20	-74.5	40.75	20	50
21	-74.75	40.5	21	34
22	-74.5	40.25	22	47
23	-74.75	40	23	52
24	-74.25	40	24	28
25	-75	39.75	25	44
26	-74.5	39.75	26	34
27	-75.25	39.5	27	29
28	-74.75	39.5	28	36
29	-75	39.25	29	30
30	-74.75	39.25	30	27

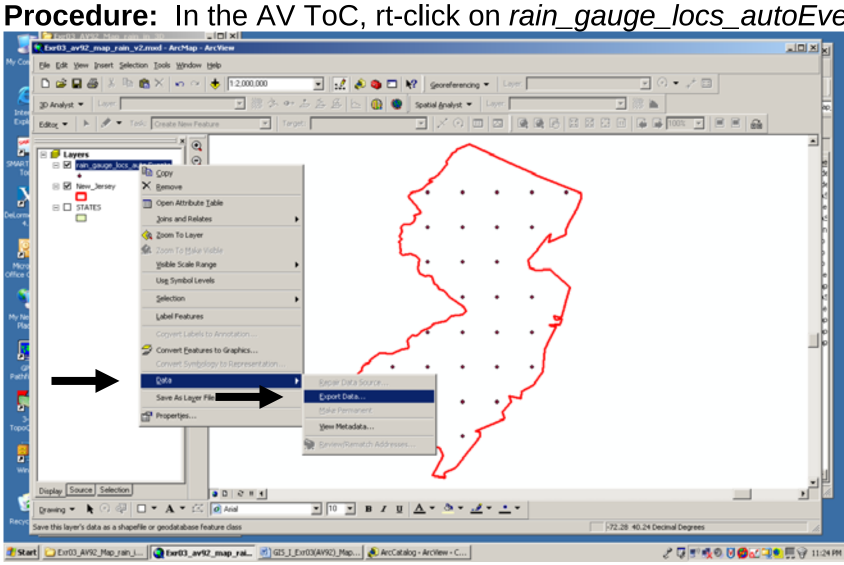
Record: 1 Show: All Selected Records (0 out of 30 Selected.) Options

The source of the field can be determined by the prefix (rain_gauge_locs_auto_Features and 2004_rainfall_in). The unique identifying number that is the same for each row is **ID**.

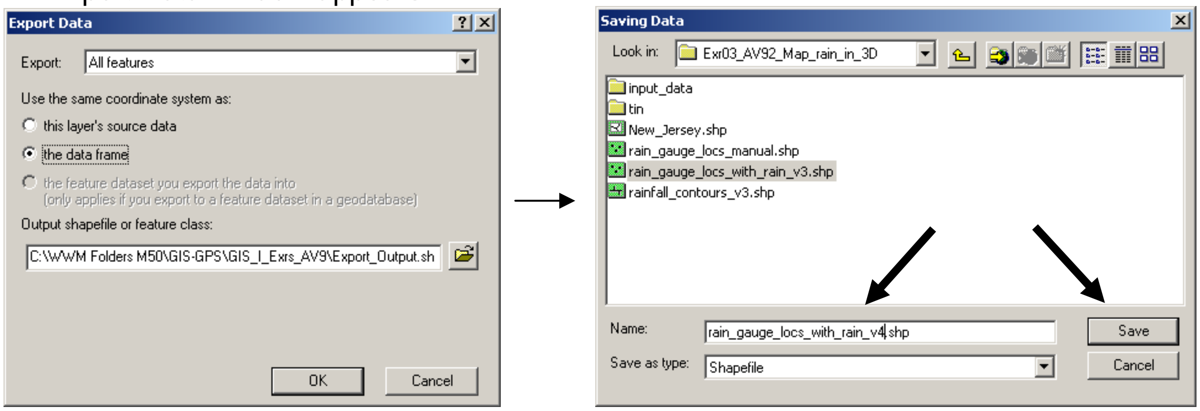
Step 3 - Convert rain_gauge_locs_auto Events to a shapefile

Discussion: To preserve your points, it is wise to convert this "events" theme to a shapefile.

Procedure: In the AV ToC, rt-click on *rain_gauge_locs_autoEvents* > **Data** > **Export Data**:

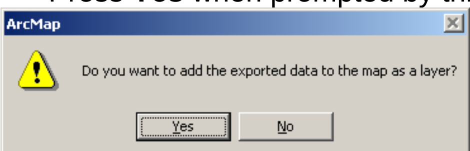


An Export Data window appears:

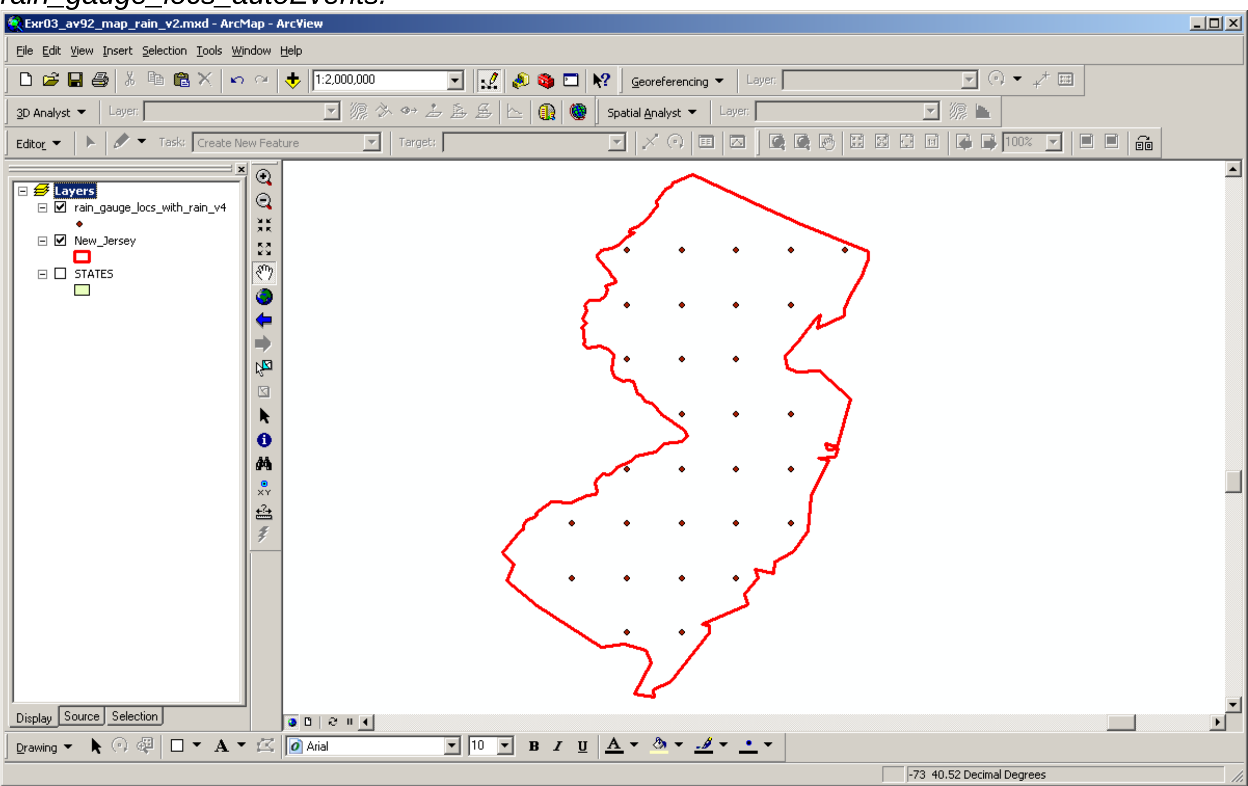


In the Export Data window, select **All Features**, and "Use the same Coordinate System as: the data frame". In the "Output shapefile or feature class" window, browse to your Exr03 folder, and type *rain_gauge_locs_with_rain.* Press **Save**. Press **OK** when the Export Data window returns.

- Press **Yes** when prompted by this window:



The points should directly overlie those of *rain_gauge_locs_autoEvents*; if so, rt-click > **Remove** *rain_gauge_locs_autoEvents.*



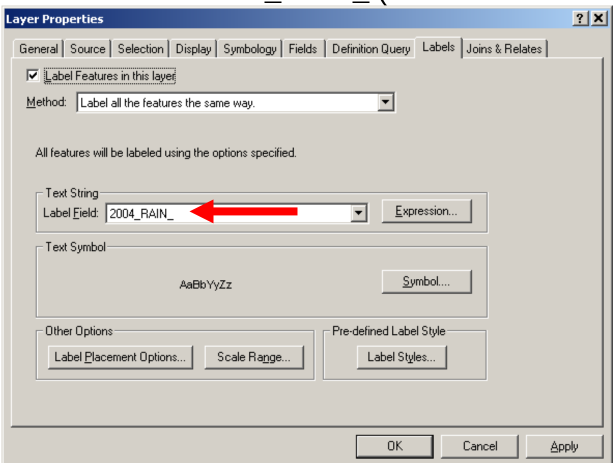
- **File** > **Save** your project.

Step 4 - Label each rain gauge station with 2004_rainfall_in

Discussion: Prior to construction of a 3D model and contour mapping of rainfall, it is wise to label each gauging station with the 2004 rainfall recorded at that location, since this is the data that will be used to construct the model and create the contours.

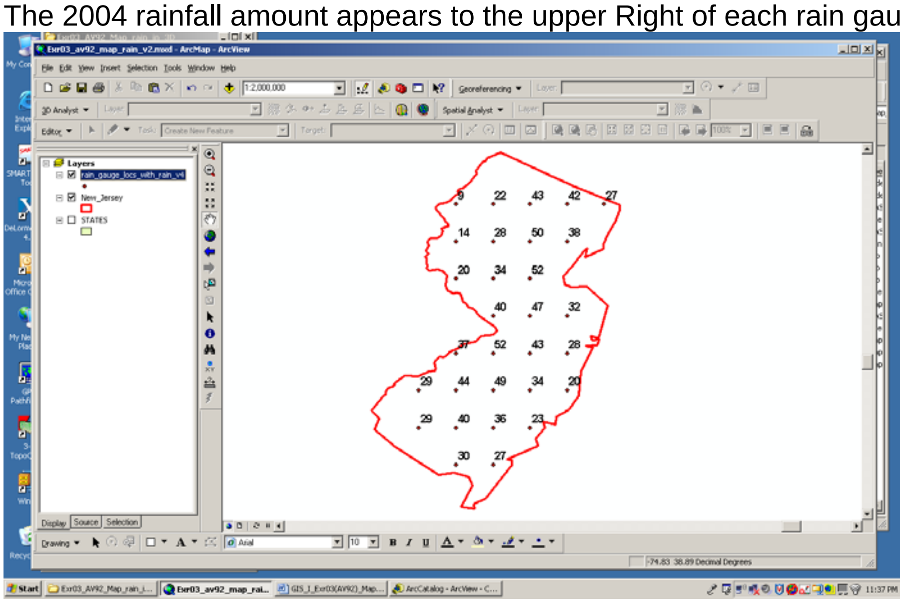
Procedure: Rt-click on *rain_gauge_locs_with_rain* in the ToC **> Properties.** Select the **Labels** tab and fill in the **Layer Properties** window with the following information:

- Check "Label features in this layer".
- Method: **Label all features the same way**
- Label field: **2004_RAIN_** (AV truncates *2004_rain_in* to 10 characters maximum)



- Click **Apply**, **OK.**

The 2004 rainfall amount appears to the upper Right of each rain gauge station point:



- **File** > **Save** your project to your Exr03 folder

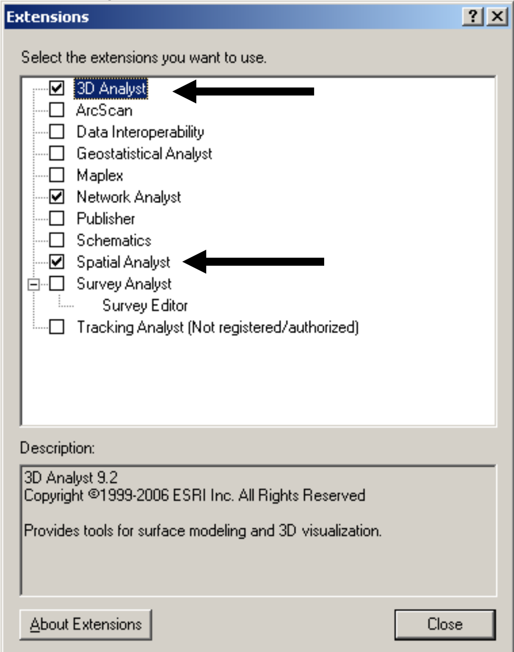
Step 5 - Create a triangulated irregular network (TIN) with 3D Analyst

Introduction: 3D visualization of "continuous surfaces" and the companion ability to represent these 3D surfaces in 2D are very useful skills because they allow you to interpret ("map") data and communicate those interpretations to a wide audience. An example of a continuous surface is the Earth's surface, which is 3D in nature. This 3D surface can be represented in 2D by creating a map of points, each with an attribute of elevation above sea level, and then drawing "isolines" ("iso" means equal) to connect equal elevation values. Hills and mountains are typically contoured as "closed highs" extending above sea level, whereas ocean basins are "closed lows" extending below sea level. In the same manner as you represent the Earth's surface in 3D or 2D, you can represent New Jersey's 2004 rainfall by creating a 3D model and creating a 2D contour map. If you need further background on continuous surfaces and contour mapping, consult your text, use Google, or ask your instructor to show you a U.S. Geological Survey topographic quad map.

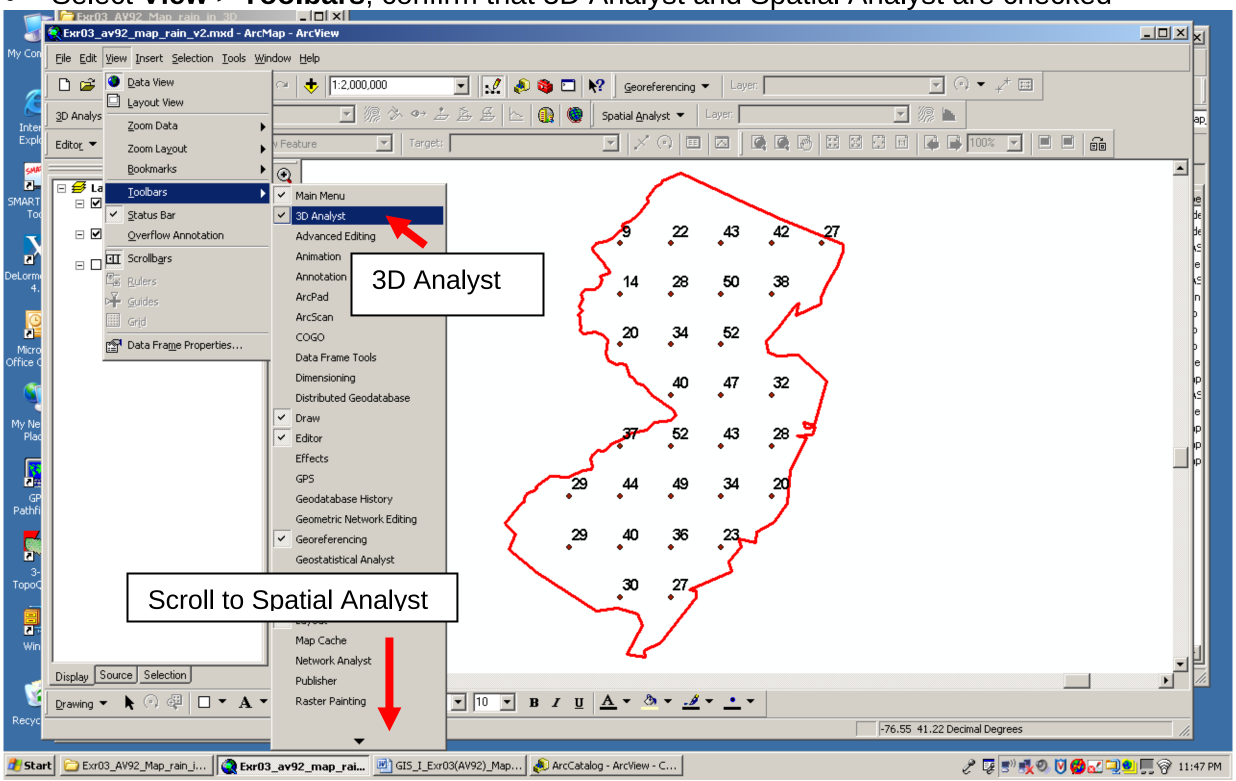
Discussion: Triangulated Irregular Networks (TINs) are models of 3D surfaces that AV creates from vector point data. AV treats a user-defined attribute (e.g., elevation above sea level or 2004_rain_in) as a "z-value" ("elevation value") in X-Y-Z space, then it uses the simplest forms of planes (triangles) to connect these z-values together into a continuous surface. The TIN can then be displayed in 3D. It also serves as a surface which can be contoured in 2D.

Procedure:

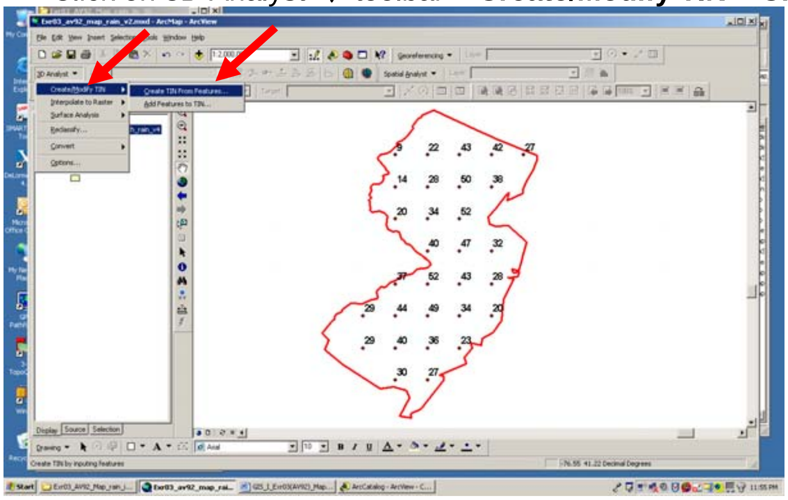
- Select **Tools** > **Extensions**. On the window that appears, make sure that 3D and Spatial Analysts are checked. Press **Close**.



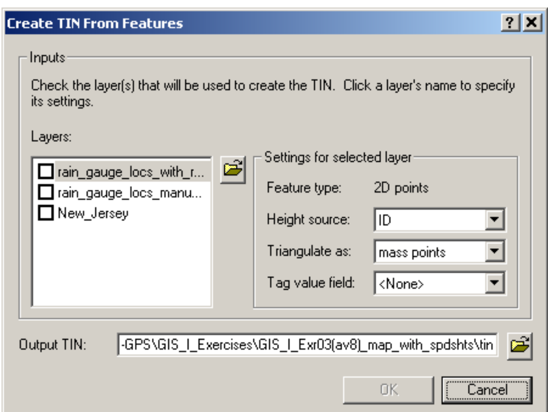
- Select **View** > **Toolbars**; confirm that 3D Analyst and Spatial Analyst are checked

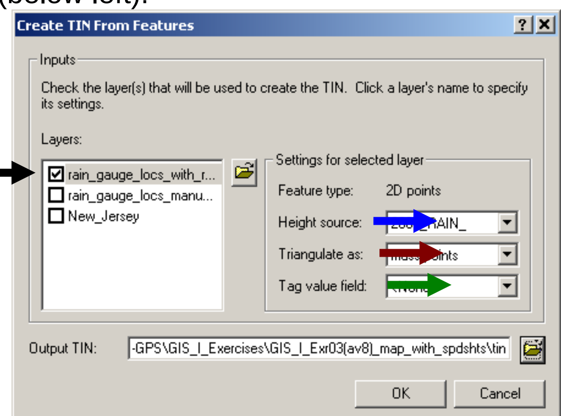


- Click on 3D Analyst ▼ toolbar > **Create/Modify TIN** > **Create TIN from features**:



- A “Create TIN from Features” window appears (below left):





Make the following changes (above, right), to the window:

- Check ✓ the box next to *rain_gauge_locs_with_rain.*

In the Settings for Selected Layer panel, choose the following settings:

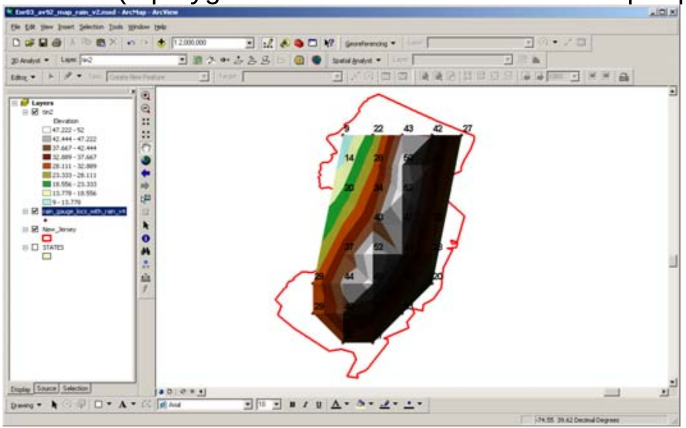
  - Height Source: **2004_RAIN_**
  - Triangulate as: **Mass points**
  - Tag value field: **ID**

- In the Output TIN window, **NOTE the following departure from protocol:**

Many users have reported trouble in creation and display of TINs. In-lab GIS students rarely have trouble. My own (limited) experience suggests that if there is a space ANYWHERE in the directory path from the drive letter (e.g., C: or G:) to the tin folder, the TIN will not be created. Therefore, I suggest that **online** GIS students place the tin in the main C drive folder of their home computer:

- Press **Save.**

The TIN (a polygon with different colors in a "stripe" pattern) should appear:



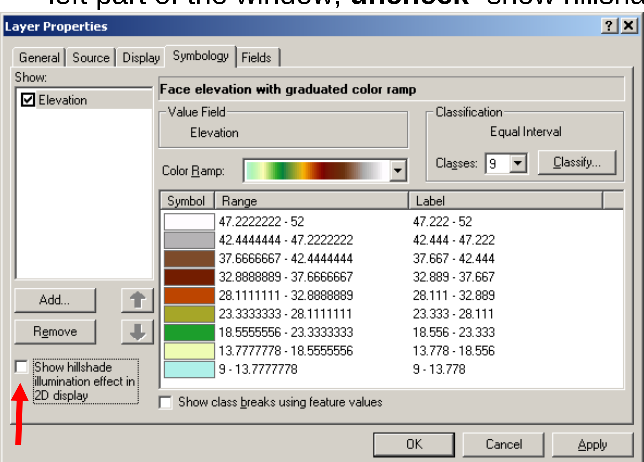
If not, check your settings and directory path. If the settings and path look OK, contact your instructor right away, rather than spend hours (literally) trying to troubleshoot the problem.

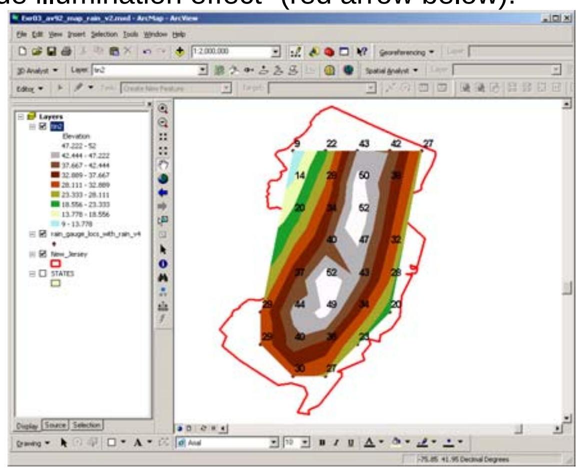
Step 6 - Modify the class breaks on the TIN to correspond with contour values.

Discussion: The TIN is a 3D model that uses colored bands to distinguish ranges of values, in this case, 2004 rainfall.

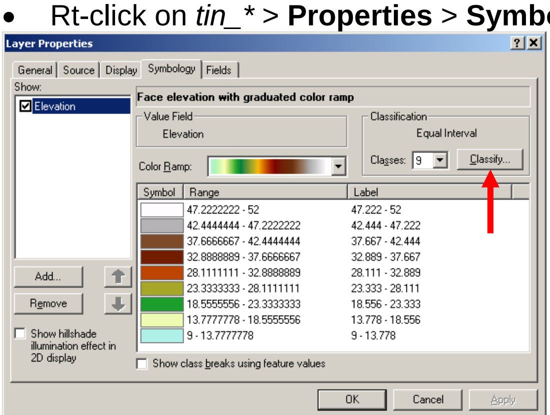
Procedure:

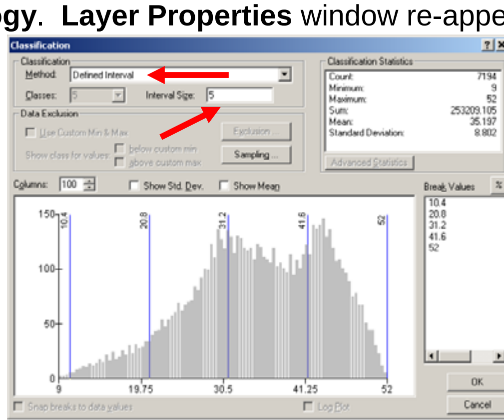
- Rt-click on *tin_** (where * is your name) in the ToC > **Properties** > **Symbology**. In the lower left part of the window, **uncheck** "show hillshade illumination effect" (red arrow below):





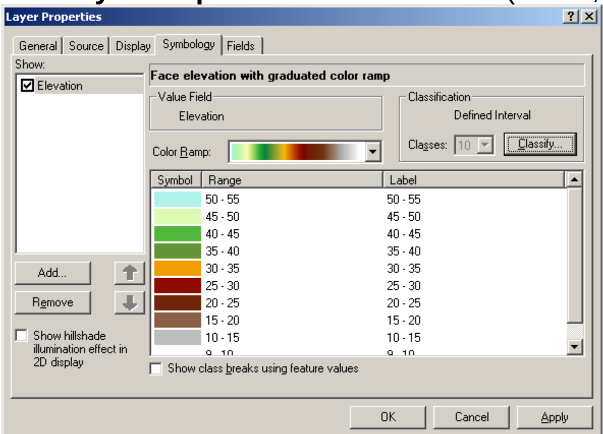
- Press **Apply**, **OK**. You now see the full range of TIN colors in the Data View (above right)
- Rt-click on *tin_** > **Properties** > **Symbology**. **Layer Properties** window re-appears:

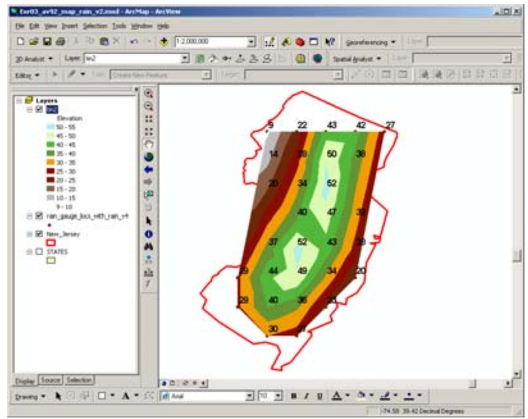




In the upper RH Classification window, select the **Classify** button (red arrow above left). A Classification window opens (Right above.) In the "Method" window, select **Defined Interval**, and set the "Interval Size" to **5**. Click **OK** in the lower RH corner of the window.

The **Layer Properties** window returns (below, left).





The breaks that separate the colors are now in increments of 5 inches of rainfall. If you don't care for the default colors, select a "Color Ramp" that is pleasing to you. Press **Apply**, **OK**. The Data View returns with the TIN color-coded according to your specifications (above, right).

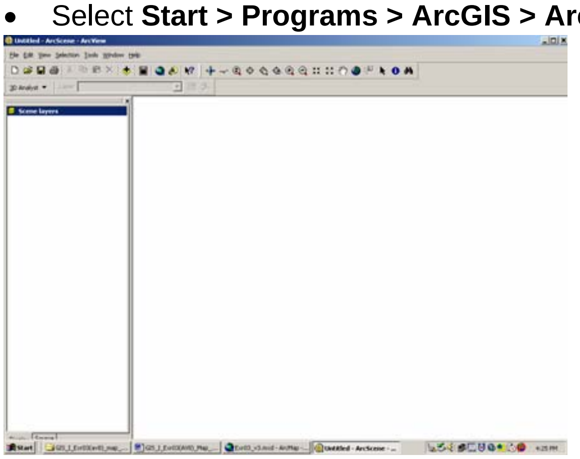
- **File** > **Save** your project.

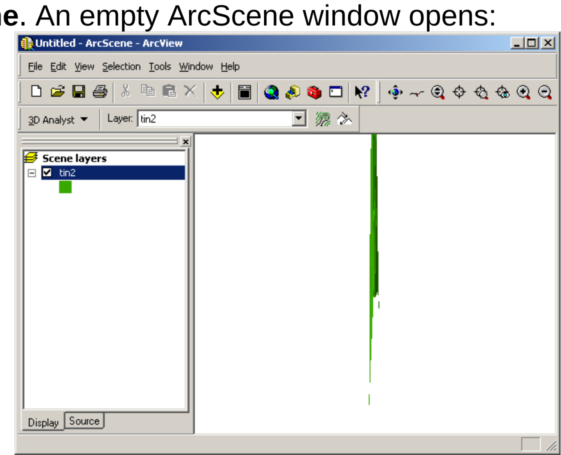
Step 7 - Display the TIN in 3D in ArcScene

Discussion: ArcScene is part of the ArcView package (along with ArcCatalog and ArcMap). It enable you to bring 3D files into a view, then manipulate them in order to aid 3D visualization.

Procedure:

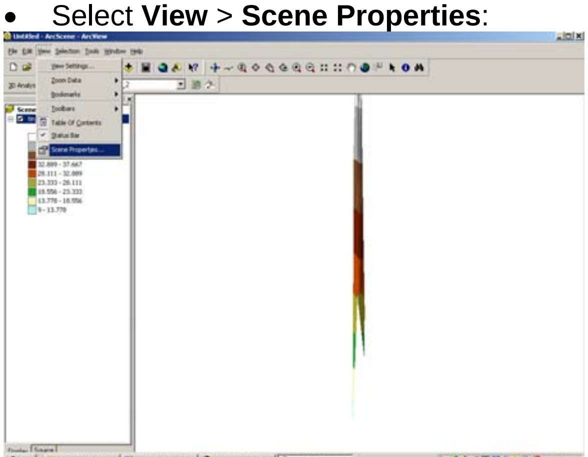
- Select **Start > Programs > ArcGIS > ArcScene**. An empty ArcScene window opens:



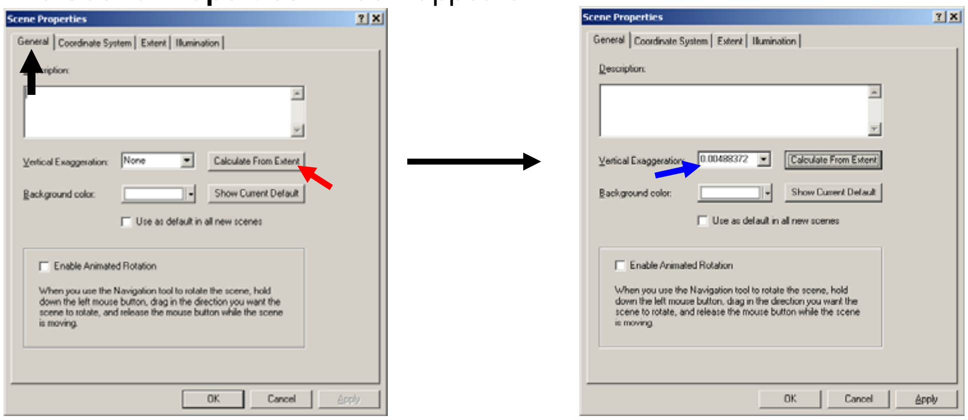


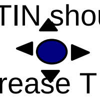
Select **File** > **Add Data** or press the **Add Data** button. Scroll to your *tin_** folder and select it. The TIN appears, but in a very distorted manner (see above right).

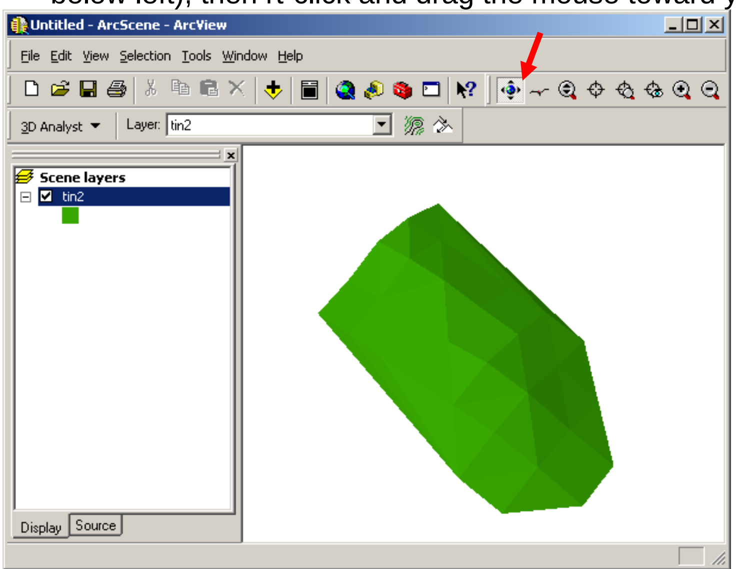
- Select **View** > **Scene Properties**:



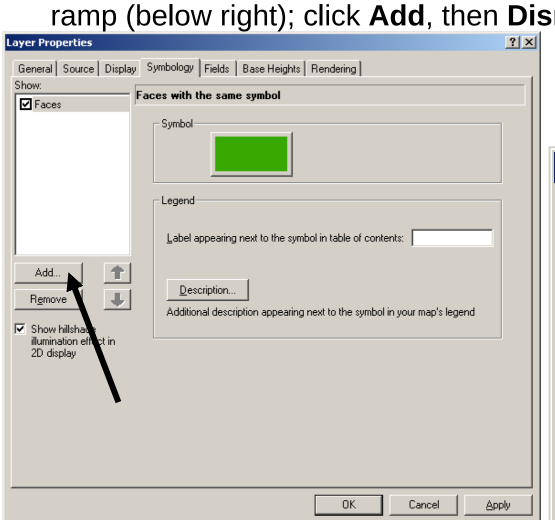
The **Scene Properties** window appears:

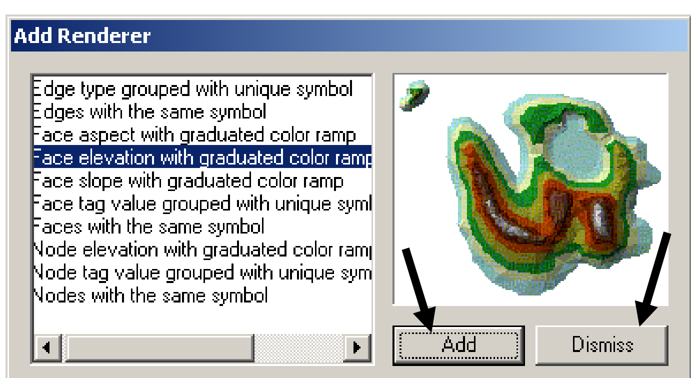


- Select the **General** tab (above, left). Next to the "Vertical Exaggeration" window, press **Calculate from Extent** (red arrow above left). A number will appear in the "Vertical Exaggeration" window (blue arrow, above right). Press **Apply**, **OK**. The TIN should look 3D in ArcScene (***NOTE:*** you will probably have to select the **Navigate** button  (red arrow below left), then rt-click and drag the mouse toward you in the View to increase TIN size.

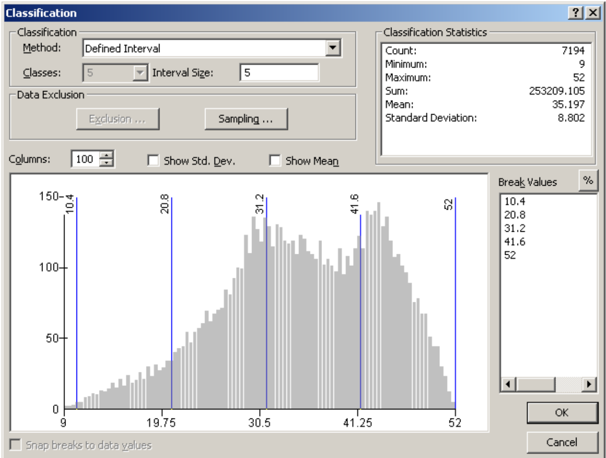


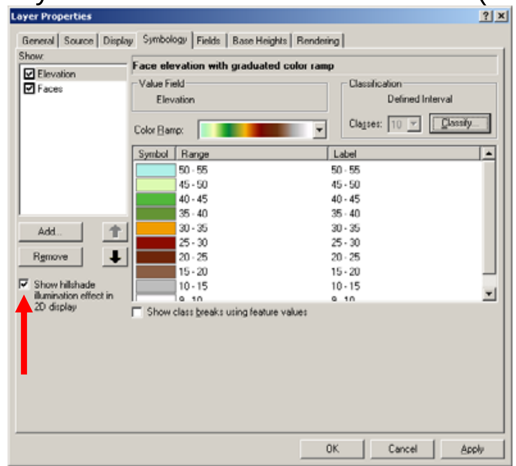
- Rt-click on the TIN in the ToC > **Properties** > **Symbology**. In the **Layer Properties** window (below left), select **Remove** > Faces, then select **Add** > Face elevation with graduated color ramp (below right); click **Add**, then **Dismiss**



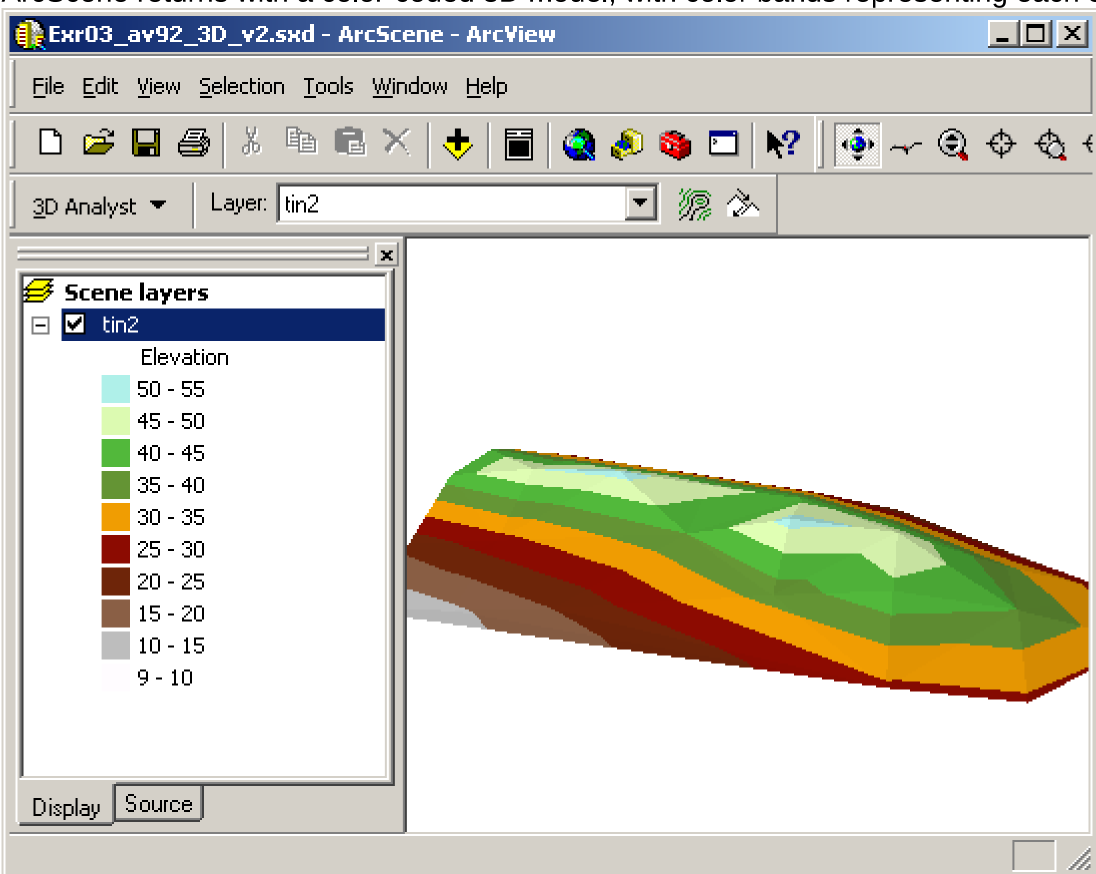


As you did earlier, press the **Classify** button, and you are taken to a second screen (below).





In the Method window, select **Defined Interval** and set the Interval Size = **5**. Press **OK**. Uncheck “Show hillshade illumination effect…” (red arrow above right). Press **Apply**, **OK**. The ArcScene returns with a color-coded 3D model, with color bands representing each 5” of rainfall:



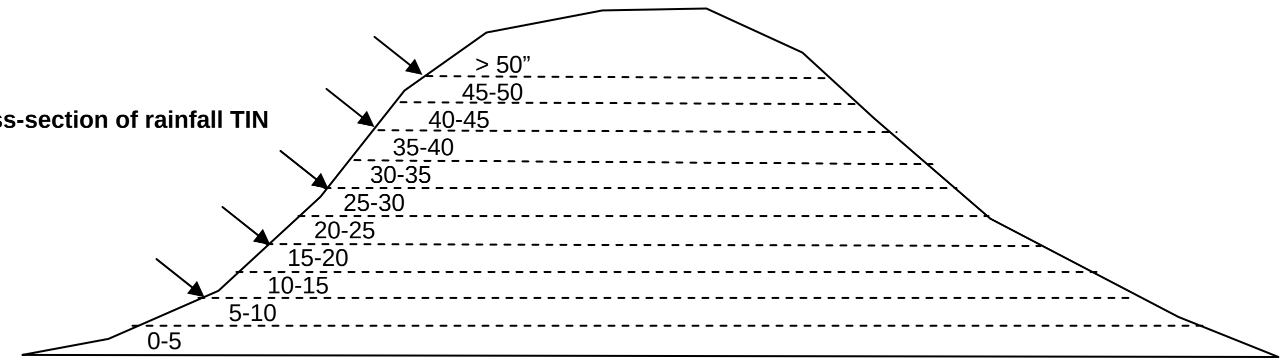
To maximize the 3D effect, select the Navigator button, then press and hold the Right mouse button and pull the mouse toward you. The image gets larger. Press and hold the Left mouse button and the image will start rotating about various axes, allowing you to move the image around in 3D space. Move the image to a position where you are looking at the side of the TIN, with the lines separating the 5-inch intervals approximately horizontal. This will help you see how contour lines are created in the next step.

- Select **File** > **Document Properties** > **Data source options** > **Store relative path names**; click **OK**, **Apply**, **OK**
- Select **File > Save As**, scroll to your Exr03 folder and save the Scene as ***Exr03_3D.sxd.***

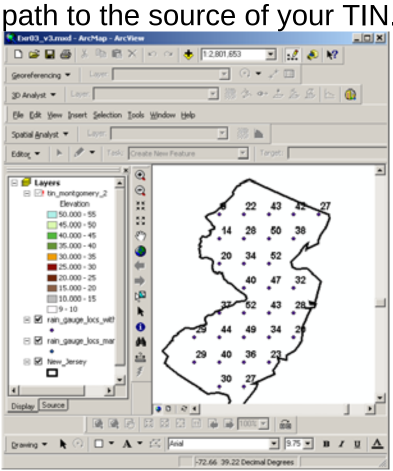
Step 8 - Create contours of NJ rainfall with 3D Analyst based upon the rainfall TIN

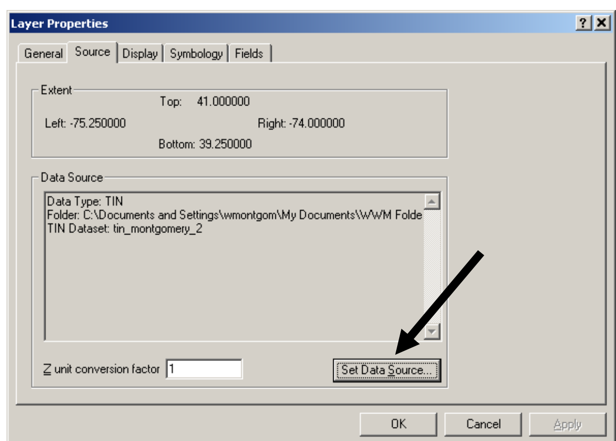
Discussion: The color breaks at every 5” of rainfall on the TIN wrap all the way around the TIN, except for the north end. You can see these breaks easily in 3D in ArcScene. In ArcMap, you can only view the TIN from a “map” view (directly from above). From above, the only places you see color changes are where the 5-inch increments intersect the outer surface of the TIN. To illustrate this, arrows are placed at a spacing of every 10” of rainfall on the cross-section below, at the spot where the line representing a certain value of rainfall (e.g, 20”) intersects the outer surface of the TIN. These “isolines” are **contour lines**, drawn around the outer surface of the TIN. An isoline connects equal values of measurement on any continuous surface. In this exercise, you are going to create isolines at a contour interval (C.I) = 10”, and then overlay those contours on the 3D TIN of rainfall. This will give you a better understanding of how contour mapping allows you to represent 3 dimensions in 2D.

Cross-section of rainfall TIN

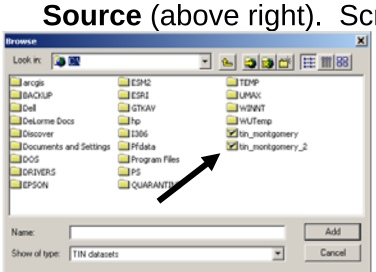


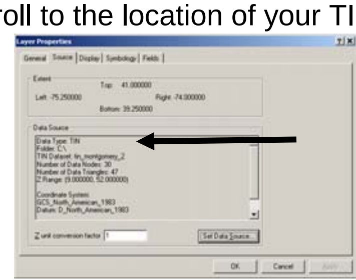
Procedure: Re-open your ***Exr03_map*** in ArcMap (not ArcScene). If you did not set your Document Properties > Save relative paths earlier, you may see a red exclamation point (**!**) to the left of the TIN in the ToC (see below); this indicates that you need to re-set the directory path to the source of your TIN.





- Rt-click on the tin_* (* = your name) in the ToC > **Properties** > **Source** > Select **Set Data Source** (above right). Scroll to the location of your TIN (below, left).



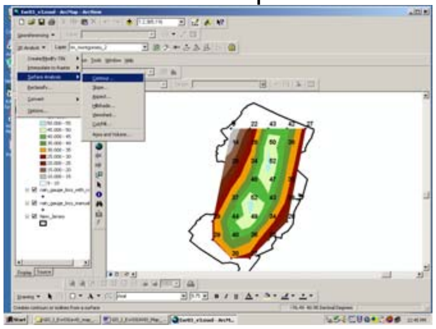


.

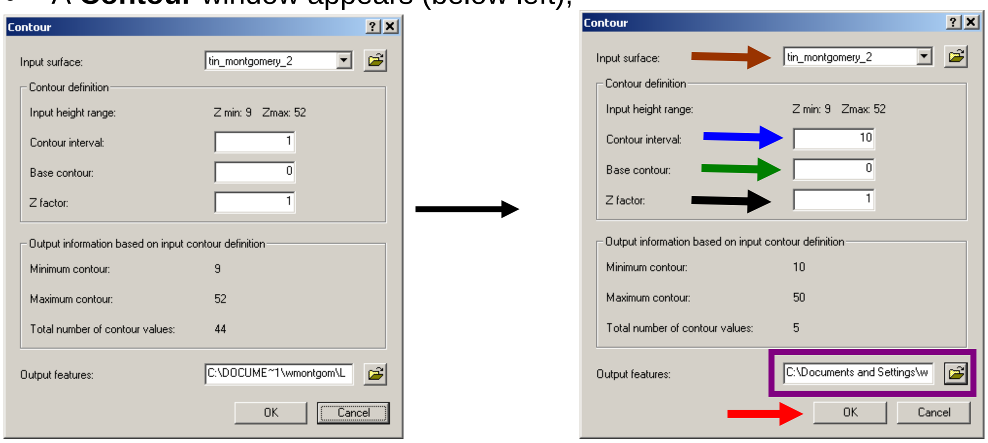
- Select your TIN (above left); the **Layer Properties** window re-appears (above right)
- Press **OK**.

The Data View re-appears with the TIN visible.

- Click on the drop-down arrow ▼ on the 3D Analyst menu > **Surface Analysis** > **Contour**:



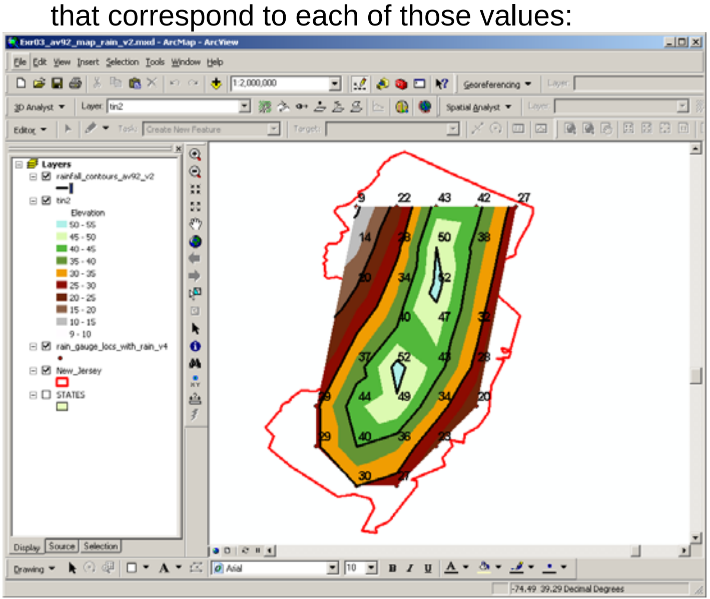
- A **Contour** window appears (below left),



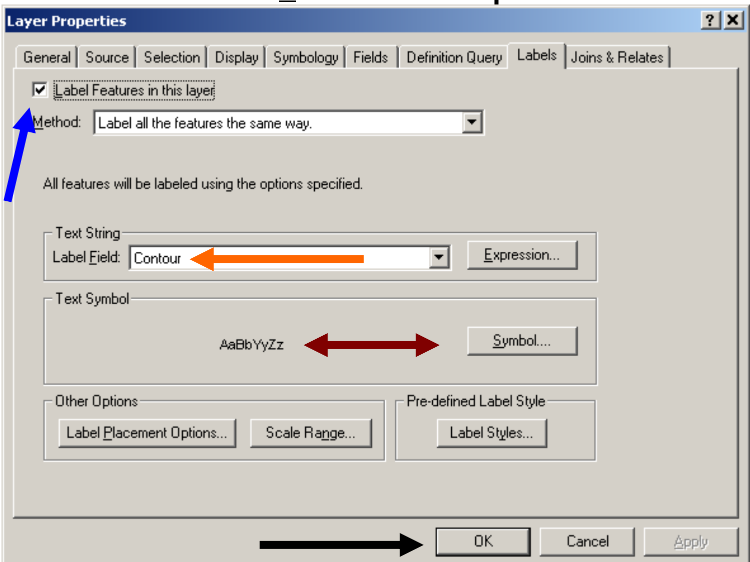
Select the following parameters (above, right):

- o Input surface : **tin_*** (* = your name)
- o Contour Interval: **10** (1 line for every 10” of rain)
- o Base Contour: **0** (this will be the first, lowest contour line)
- o Z factor: **1** (a measure of vertical exaggeration)
- o Output features: Use the folder button to set the directory path to your Exr03 folder, and **Save** the contour map as *rainfall_contours* in your folder.
- o Press **OK** on the bottom of the **Contour** window (above, right)

- The *rainfall_contours* shapefile should appear in your map window and in your ToC. The default black lines should overlay the TIN at 10, 20, 30, 40, and 50”, at the breaks in color that correspond to each of those values:

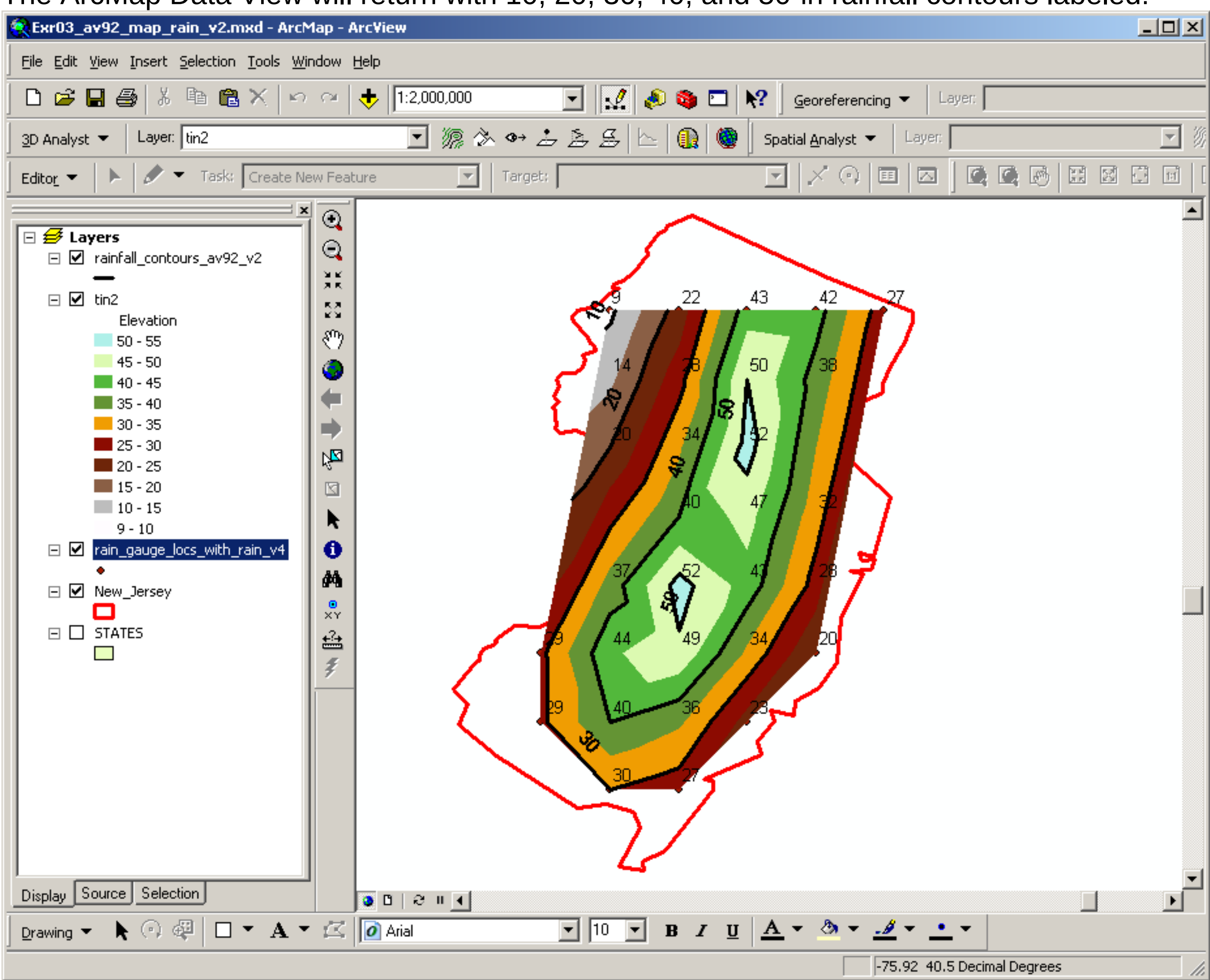


- Rt-click on *rainfall_contours* > **Properties** > **Labels** tab ; **Layer Properties** appears:



- **Checkmark** "Label Features in this layer".
- In the "Label field:" window, select **Contour**; you may also want to change the font to Bold using **Symbol**.
- Click **Apply** (if you changed the font), then **OK.**

The ArcMap Data View will return with 10, 20, 30, 40, and 50-in rainfall contours labeled:



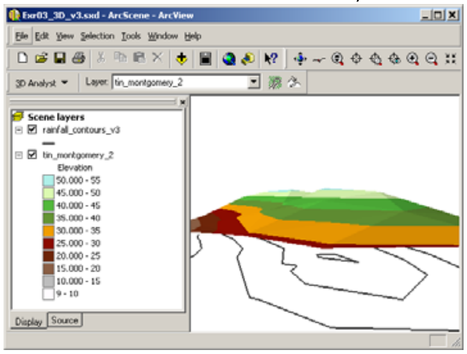
- Select **File** > **Save**

Step 9 - Open ArcScene, add rainfall contours to the 3D view

Discussion: You will use ArcScene to look at the relationship between a TIN and Contour map.

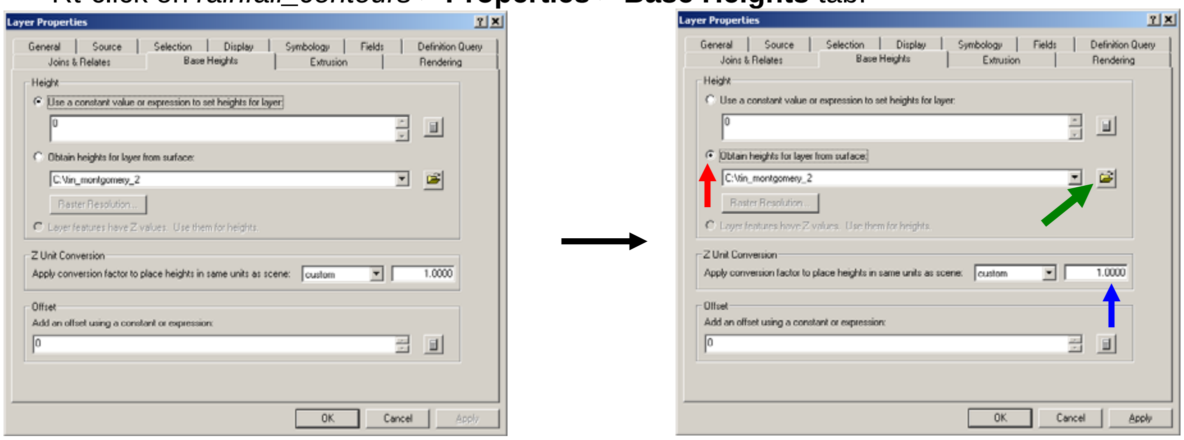
Procedure:

- Re-open your ***Exr03_3D.sdx*** file.
- Select **File** > **Add Data**, scroll to your Exr03 folder, and select *rainfall_contours.shp*:

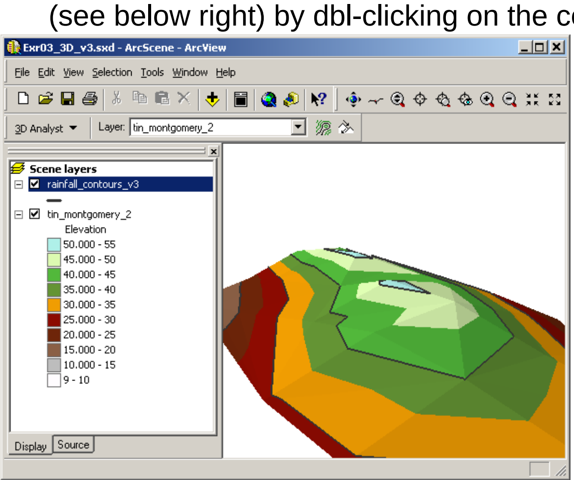


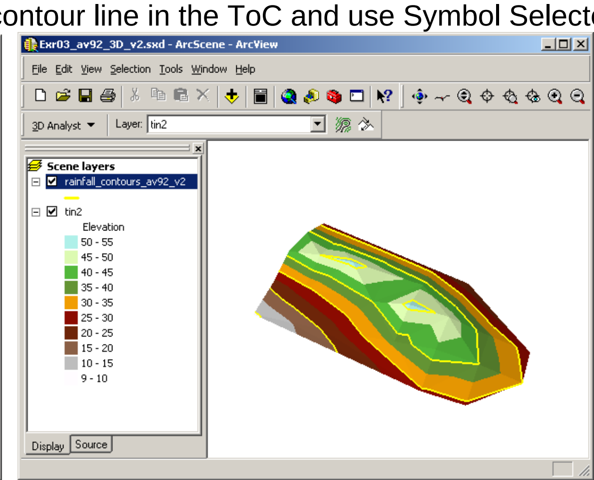
The contours are displayed in a flat plane, underlying the TIN. You must instruct ArcMap to "drape" line features **on top of** the TIN.

- Rt-click on *rainfall_contours* > **Properties** > **Base Heights** tab:



- Under "Height:" select **Obtain heights for layer from surface** (red arrow above right). Use the Browse button (Green arrow) to scroll to your **tin_*** (* = your name); press **Add**.
- Leave the Z-init conversion at 1 (blue arrow above right).
- Do not add an offset.
- Click **Apply, OK** when the Layer Properties window returns. The contours "rise" into position at the breaks between colors (below left). You may wish to change their color and thickness (see below right) by dbl-clicking on the contour line in the ToC and use Symbol Selector.





- Select **File > Save**.

Step 10 - Evaluate the rainfall TIN and contours in 3D and 2D

Discussion: Spend some time moving the *TIN_** and *rainfall_contours* around in ArcScene.

- Rotate the image to the cross-sectional view portrayed in the exercise instructions above, and make sure you see how the contours wrap around the outside of the TIN, connecting equal values together (all the 10s, 20s, 30s, 40s, and 50s).
- Take the image to “map view” (as though you are directly overhead)) and note its similarity to ArcMap - now it is a 2D view. Can you see how contours can represent 3D images in 2D?

Contouring is perhaps the most powerful quantitative mapping tool in existence. Even non-spatial thinkers, managers, and your bosses can see “highs”, be they for elevation, contamination, or number of crimes per day. If you learn how to use this tool, your analytical capabilities will improve immensely, along with your abilities to share your analyses with others.

Step 11 - Embed ArcMap and ArcScene views into your write up of this exercise.

- Create a layout in ArcMap, at a scale of about 1:2,000,000; **Export** it as a jpg.
- Create a view of ArcScene (it is not capable of creating layouts);**Export** it as a jpg.
- Open MS Word and begin your exercise writeup. During the course of your writeup, use **Insert** > **Picture** > **From file** and Insert both the ArcMap jpg and ArcScene jpg into your document.
- In about 250 words, indicate:
  - what you learned about table joins, 3D viewing, and contouring
  - what you liked and disliked about the exercise
  - how you'd like to see this exercise changed in the future, if at all.

Due Date: Approximately two weeks from the date the exercise was assigned. Consult your syllabus or WebCT calendar for the current semester.