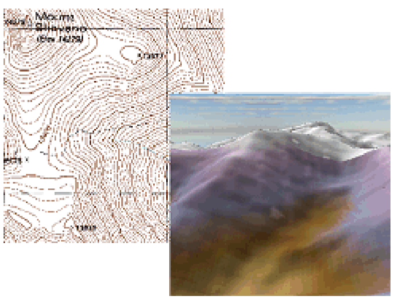
Workshop 2: Introduction to 3D Analyst

This exercise introduces the extension 3D Analyst for ArcGIS 9.1, and explores different ways to represent 3-dimensional surfaces, including TINs (Triangulated Irregular Network) and rasters (grids).

Most maps that we use are two-dimensional, whether they appear on a piece of paper or on a computer screen. For instance, if we go hiking in a wilderness area, we typically bring along a contour map that lies in a two-dimensional plane. While useful for visualizing the topography, two-dimensional maps have limitations. The 3D Analyst extension of ArcGIS 9.1 allows users to leap beyond the traditional 2D mapping environment and into the world of 3D visualization. In 3D Analyst, users can view surfaces, interact with data, and perform complex analysis.



Source: http://campus.esri.com

In terms of data, the difference between 2D and 3D is that three-dimensional data has z-values while 2D data has only x and y values. For instance, longitude and latitude might represent x and y, while altitude represents the z-value. 3D Analyst can be used with either (1) feature data (i.e., discrete points, lines, or polygons such as plants, trails, or buildings), or (2) continuous data such as rainfall, temperature, or evaporation. A couple of examples: the discrete boundaries of a parcel of land on the Hamakua coast can be viewed 3-dimensionally along the slope of Mauna Kea, or continuous rainfall data can be represented as a 3D surface over an area.

Overview

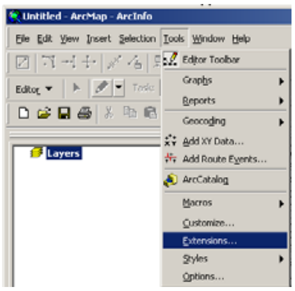
In this exercise, we will learn how to use ArcMap and ArcScene to create, represent and visualize 3D data. Working from a 2D digital contour map (elevation isolines), we will create TIN and raster surfaces. Then we will drape high-resolution images over these surfaces to create 3D representations of the landscape, perform fly-throughs, and produce animation files. Based on our work, we will produce one ArcMap layout showing various representations of the same area, and one ArcScene document useful for producing fly-throughs and animation files.

In our next workshop, we will discuss how to create surfaces from point features instead of lines, using the interpolation methods of Spatial Analyst and 3D Analyst.

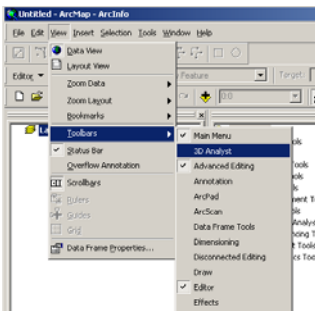
Getting Started

Before starting this exercise, create a new folder for your work on the **(Z:)** drive entitled “gis_workshop2”. The full path should be:

Z:\gis_workshop2



Next, start ArcMap 9.1 with a new empty map. Before going any further, you will need to enable the extension **[3D Analyst]**. To do so, click on the **[Tools]** menu and select **[Extensions]**. Tick the box next to **[3D Analyst]** and close the window. Next you will need to display the toolbar for **[3D Analyst]** by going to the **[View]** menu, choosing **[Toolbars]**, and then selecting **[3D Analyst]**. The **[3D Analyst]** toolbar should appear as below.



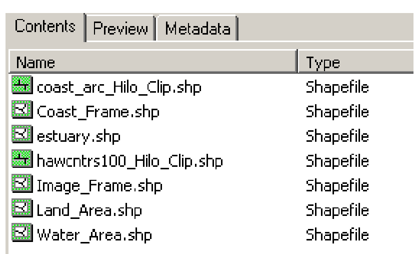
You can dock the toolbar anywhere within the ArcMap window. From the standard toolbar, click on the ArcCatalog icon  to launch ArcCatalog, or alternatively, open ArcCatalog from the **[Start]** button.

Most of the data for this workshop comes from DBEDT's website and is in the folder:

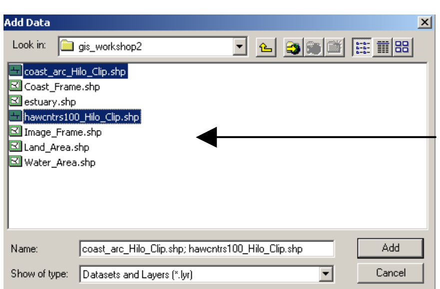
I:\GIS_Workshops\Workshop2\Data

Step 1: Assembling Data

First, let us copy the 7 shapefiles from the above (I:) drive location to our new folder on the (Z:) drive. Remember to copy the files using ArcCatalog to ensure that all the necessary files are transferred. Please refer to Workshop 1 if you have forgotten how to copy files in ArcCatalog. After copying the files, our new (Z:) drive folder should contain the following shapefiles:



Name	Type
coast_arc_Hilo_Clip.shp	Shapefile
Coast_Frame.shp	Shapefile
estuary.shp	Shapefile
hawcntrs100_Hilo_Clip.shp	Shapefile
Image_Frame.shp	Shapefile
Land_Area.shp	Shapefile
Water_Area.shp	Shapefile

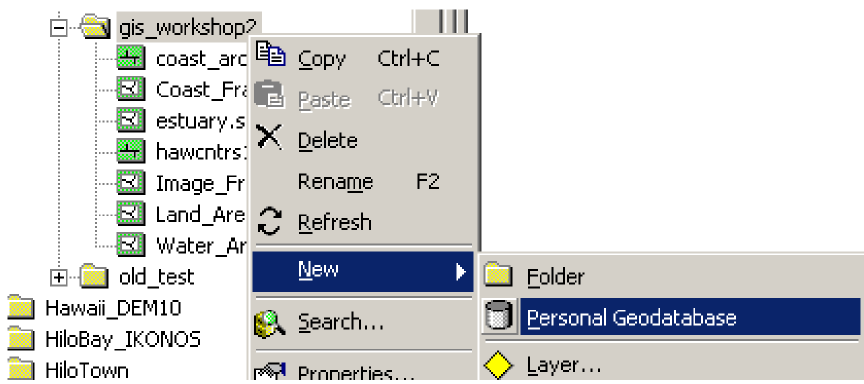


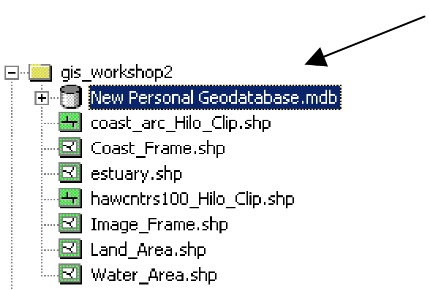
Switch to your ArcMap window, click on the **[Add Data]** button , and add **coast_arc_Hilo_Clip.shp** and **hawcntrs100_Hilo_Clip.shp** to your ArcMap document. For each shapefile, open the **[Layer Properties]** menu and click on the **[Source]** tab. Notice that both files have the same projected coordinate system: NAD_1983_UTM_Zone_4N. Now click on the

[Fields] tab for each file. Note that both shapefiles contain a field named "CONTOUR" that contains elevation data. Unfortunately, the contour data set does not include a zero-foot contour line. Thus, in order to create a more accurate elevation surface over the whole land area, we will want to use data from both the coast and contour shapefiles.

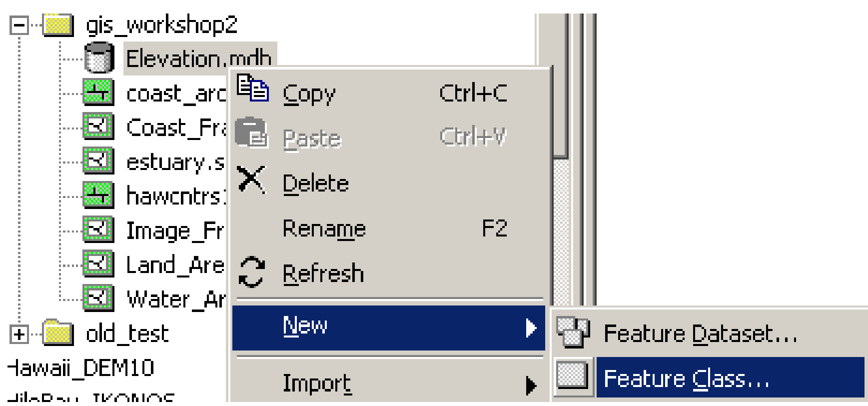
At this point we have a choice in how to proceed: (a) combine the coast and contour data into one data set and create a TIN from that data set, or (b) create the TIN directly from the two separate shapefiles. Let us choose the former option to give us some practice with personal geodatabases.

In your ArcCatalog window, right click on your folder "gis_workshop2" and select **[New] > [Personal Geodatabase].**



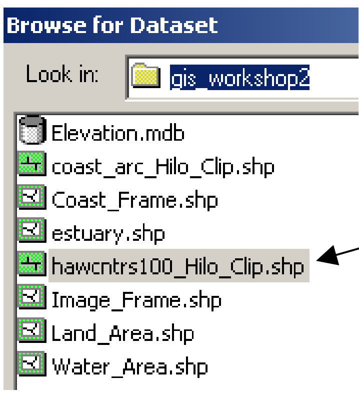


ArcCatalog will create a new Access database for us. Single click on the default title "New Personal Geodatabase" and rename it to "Elevation". Now right-click on "Elevation" and select **[New]** > **[Feature Class].**



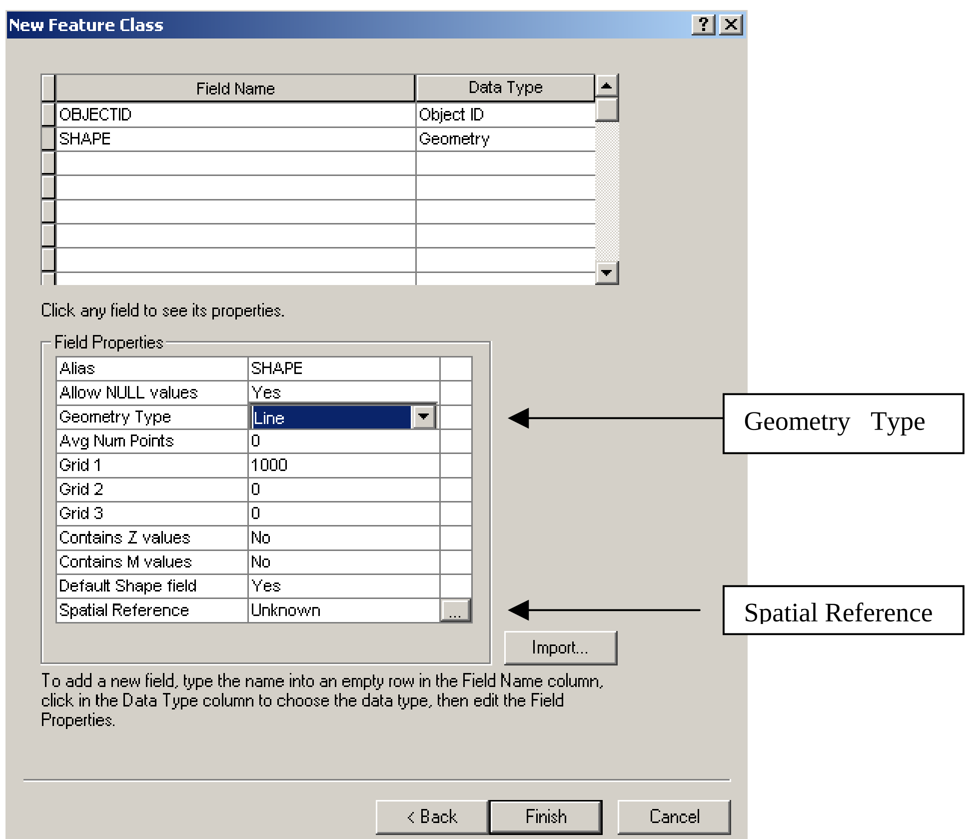
Name the new feature class "CONTOUR100" and press **[Next].** Press **[Next]** again in the second **[New Feature Class]** dialog box.

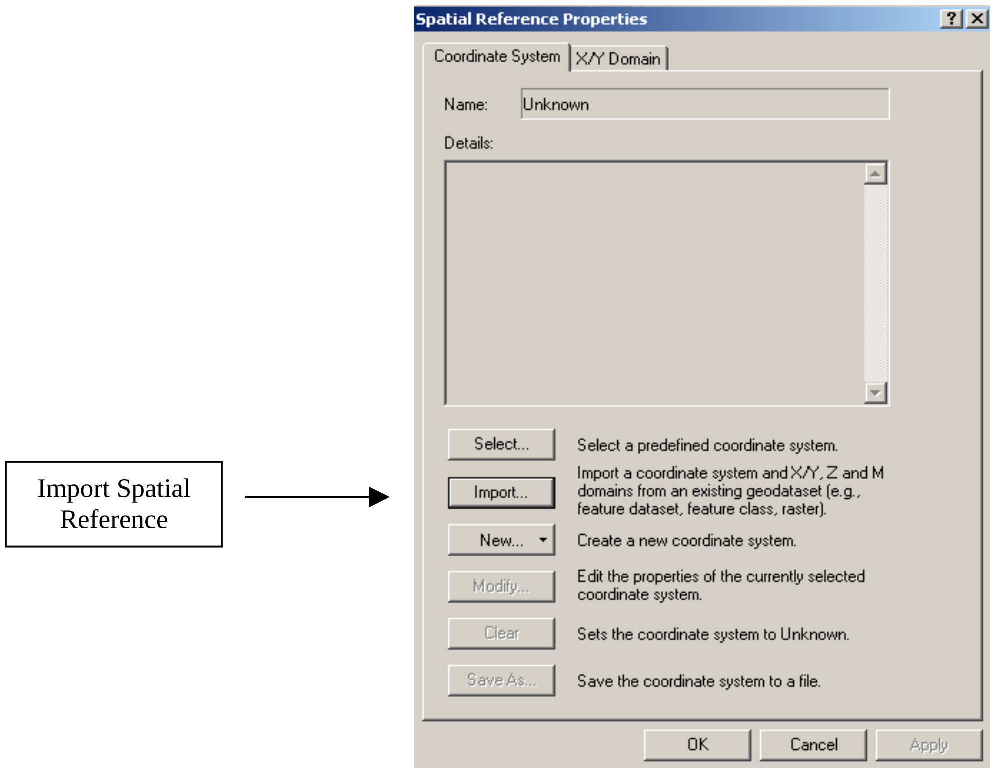
In the third dialog box, we need to define three things:



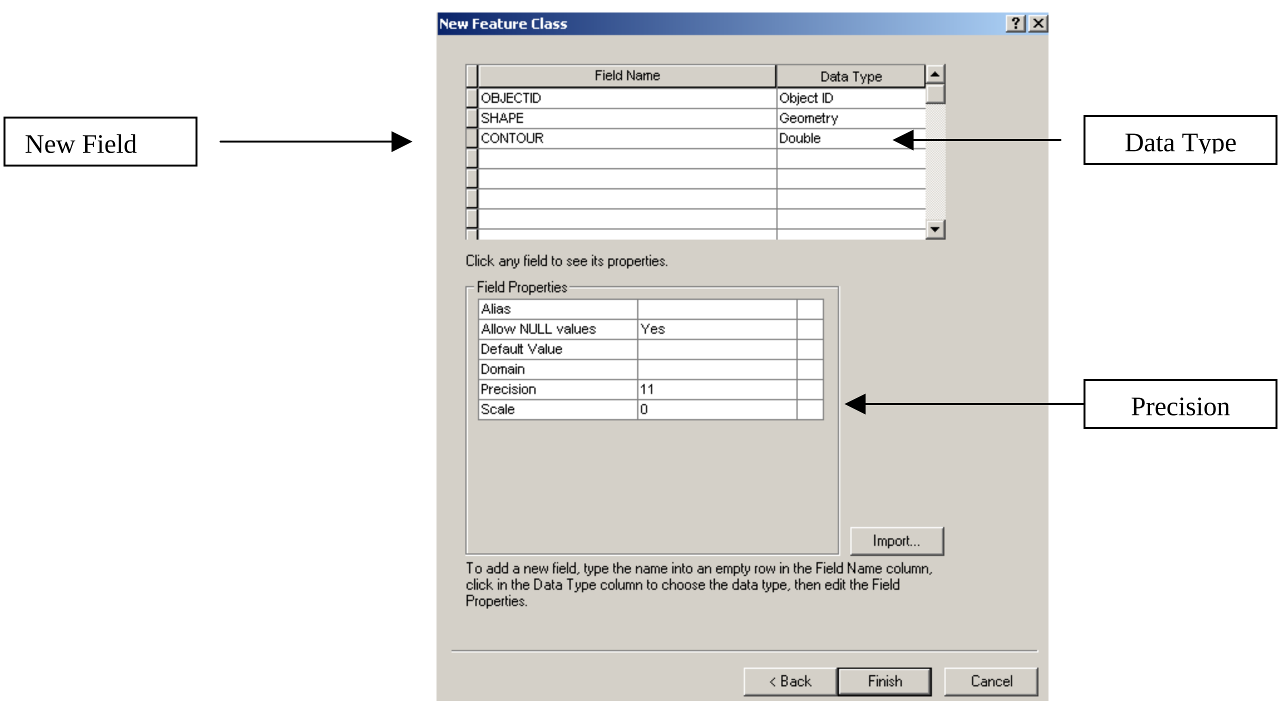
(1) Single click on the "SHAPE" field in the top box, and set the Geometry type to "Line".

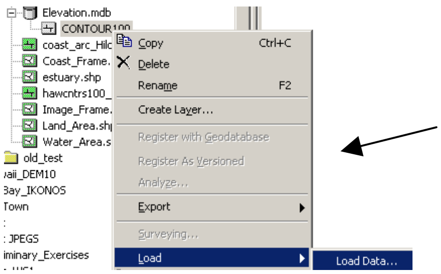
(2) Click on the [...] button in the lower right corner, across from the Spatial Reference field. When the **[Spatial Reference Properties]** box appears, press the **[Import]** button, and browse to the shapefile: **hawcntrs100_Hilo_Clip.shp.** Click **[Add]** and then **[OK].** Your Spatial Reference will now be set to NAD_1983_UTM_Zone_4N.



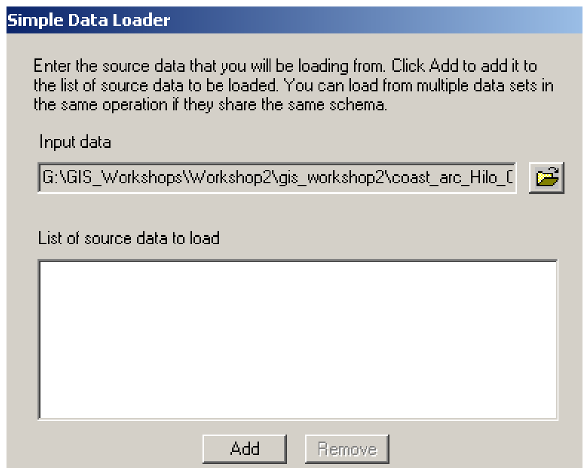


(3) Lastly, create a new field called "CONTOUR" by typing "CONTOUR on line 3 of the "Field Name" column. Set the "Data Type" to "Double" and "Precision" to "11". Now click **[Finish]** to return to the main ArcCatalog menu.





Now that the feature class properties are set, we can load the coast and contour data sets into the feature class "CONTOUR100". Right-click on CONTOUR100 and select **[Load] > [Load Data].** Click **[Next]** once. Browse and open **coast_arc_Hilo_Clip.shp** and press **[Add].** Press **[Next]** multiple times to select the default choices and then press **[Finish]**. ArcMap will load the coast shapefile into our new feature class, mapping the original values for CONTOUR to the new field CONTOUR.

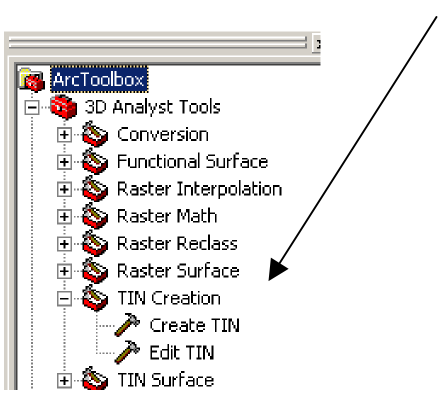


Repeat the above process, this time loading data from **hawcntrs100_Hilo_Clip.shp** into CONTOUR100.

Returning to ArcMap, add the feature class "CONTOUR100" to your map. Notice that CONTOUR100 contains all the contour lines including the coastline. This feature class will be the input for our first TIN. We can remove all other layers at this point.

Note: If you could not complete Step 1, you can use ArcCatalog to copy **I:\GIS_Workshops\Workshop2\Data\Elevation.mdb** to your working folder, and then add CONTOUR100 to your map document.

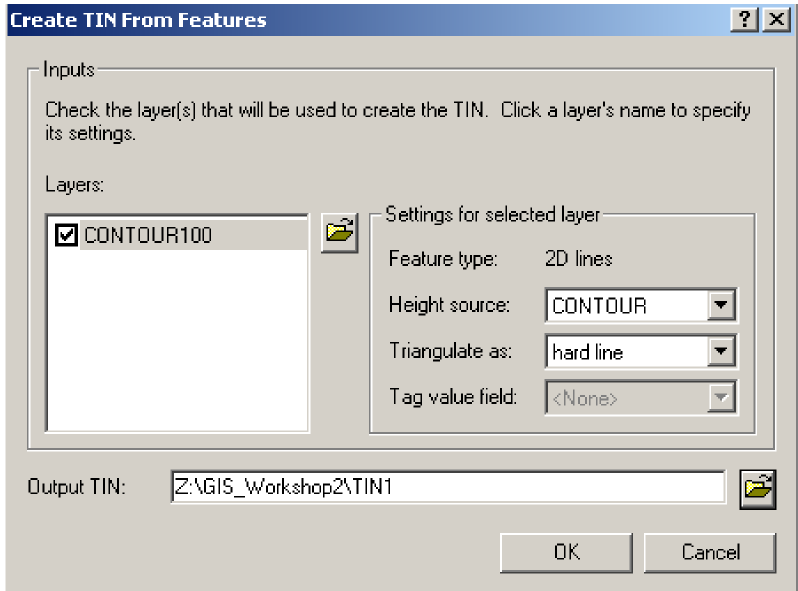
Step 2: Creating a TIN



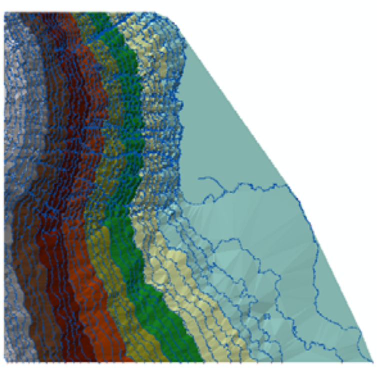
In ArcGIS we can create a TIN using either the 3D Analyst toolbar or ArcToolbox. ArcToolbox offers more flexibility and control, but is not as easy to use. Let us create a TIN using the 3D Analyst toolbar, and then we can modify it using ArcToolbox.

Pull down the 3D Analyst toolbar and select **[Create/Modify TIN]** > **[Create TIN From Features]**.

In the dialog box, tick the box next to CONTOUR100, set the Height Source equal to "CONTOUR", choose to triangulate as "hard line", and name the output file as Z:\gis_workshop2\TIN1.



TIN1



Selecting hard break lines forces ArcMap to draw triangles that do not cross break lines. This option ensures a change in slope at the break lines. Hard lines are useful for modeling ridges, streams, roads, and shorelines, while soft lines are better for features such as rolling hills. I arbitrarily chose hard break lines for this example to ensure a more accurate representation of the coastline, although the other contour lines might be modeled more accurately using soft lines.

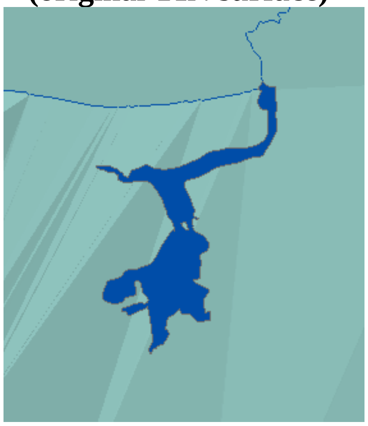
ArcMap adds TIN1 automatically, using an arbitrary line symbol for the hard edges and an equal-interval color ramp for elevation.

Before continuing, please save your ArcMap document in your working folder. Remember to save your work frequently!

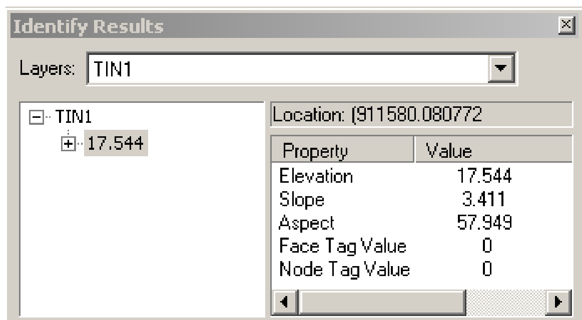
Step 3: Editing a TIN

ArcMap allows you to edit TINs in a variety of ways. You can (a) insert additional break lines, (b) replace polygons with flat surfaces (e.g., to represent lakes or terraces), (c) clip or erase polygons, or (d) fill polygons with attribute data. We will demonstrate two types of editing. First we will create a flat area on our TIN to represent Wailoa estuary, and second we will clip out a portion of our TIN to match the extent of our satellite imagery.

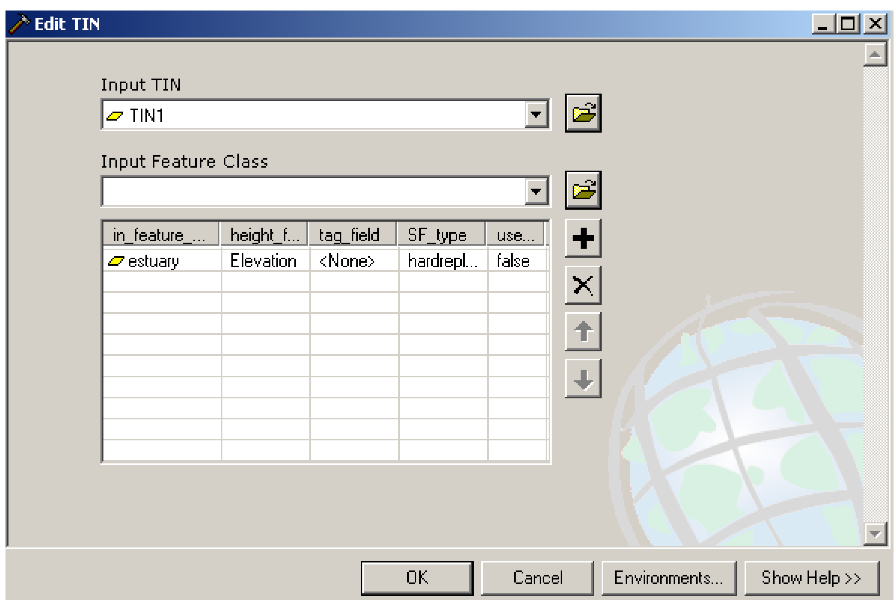
TIN1 and Estuary.shp (original TIN surface)



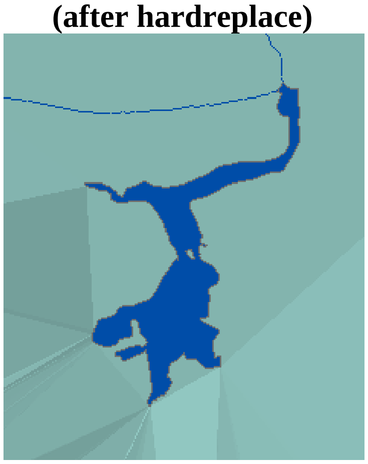
Let us start by adding the shapefile **Z:\GIS_Workshop2\estuary.shp** to our document. Symbolize the estuary in dark blue, click next to the symbol in the Table of Contents, and label the symbol "Wailoa". Zoom in closely on the estuary. Notice that several triangles intersect the estuary polygon. Use the identify tool  to examine the TIN1 elevations within the estuary polygon. You will need to set the layer to TIN1 within the [Identify Results] box. According to our TIN1 surface model, the estuary has an elevation range of over 50 feet.



For the sake of this exercise, let us suppose we want to represent the estuary as a flat surface with an elevation of zero. To edit TIN1, click the ArcToolbox icon . Double click on the Edit TIN tool under **ArcToolbox > 3D Analyst Tools > TIN Creation.**



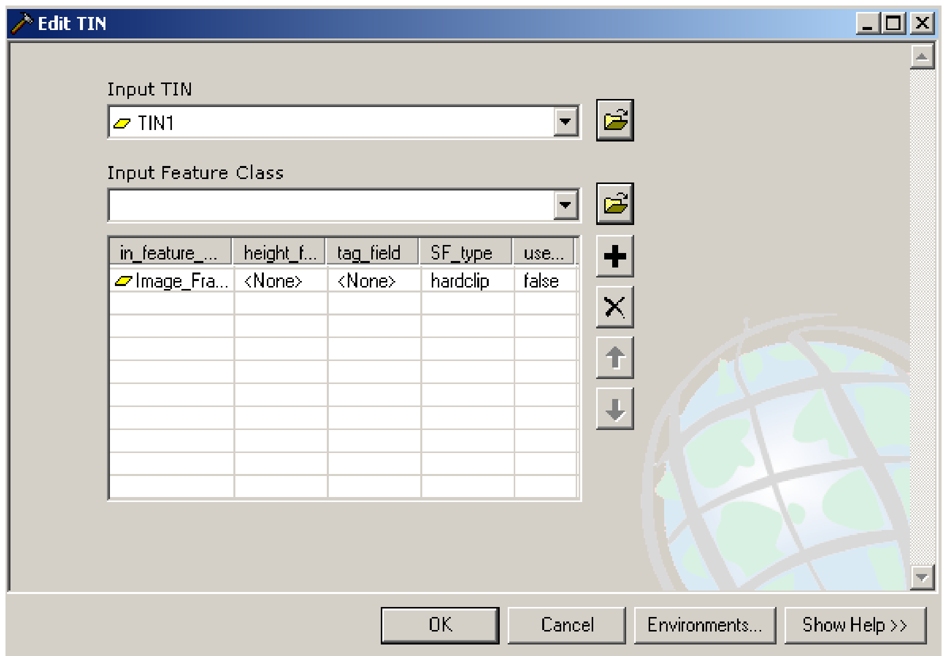
TIN1 and Estuary.shp (after hardreplace)



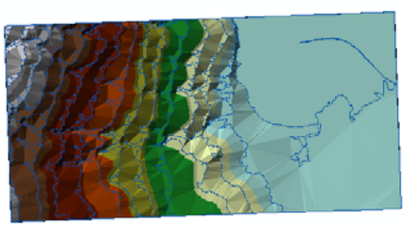
Choose TIN1 as the input (using the down arrow), estuary as the input feature class, elevation as the height field, and hardreplace as the SF (surface feature) type. Click **[OK].**

Using the identify tool, examine the new estuary elevation. The estuary surface should have a constant elevation of zero.

For our second editing task, let us clip out a rectangular polygon that corresponds to the extent of our satellite imagery. Return to the full extent . Add the image boundary from the shapefile **Z:\GIS_Workshop2\Image_Frame.shp**, and symbolize it with the hollow symbol. Open the  tool again, choosing TIN1 as the input, Image Frame as the input feature class, <None> as the height, and hardclip as the SF type. Click **[OK]**.



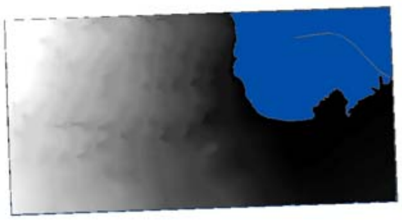
TIN3



After this tool executes, untick the layer CONTOUR100. Notice that TIN1 now has the same boundaries as Image Frame.

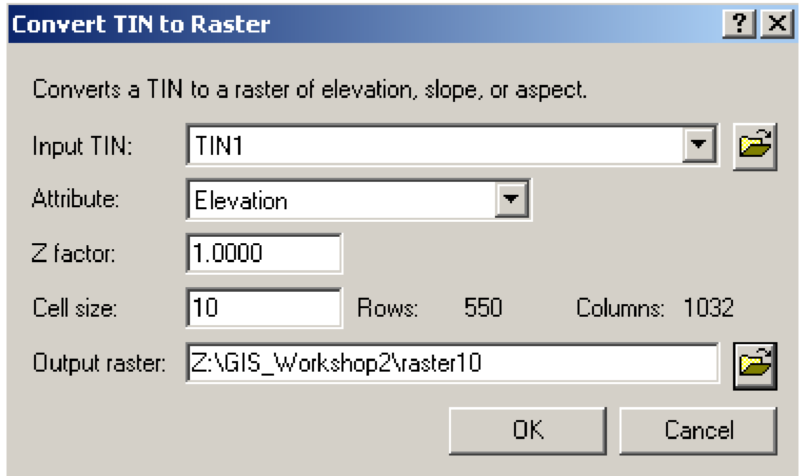
Step 4: Creating a Raster

Before we switch to ArcScene, let us create a raster surface (or grid) from our TIN. We can convert any TIN to a grid using the 3D Analyst toolbar. Pull down the 3D Analyst toolbar menu and select **[Convert] > [TIN to Raster]**. In the dialog box, choose TIN1 as the Input TIN, “10” as the cell size, and “raster10” as the output raster. Click **[OK]** and ArcMap will compute the raster and add it to your map. This sort of elevation grid is known as a Digital Elevation Model (DEM). To make the coastline more visible, we can add the shapefile **Z:\GIS_Workshop2\ Water_Area.shp** to our map**,**



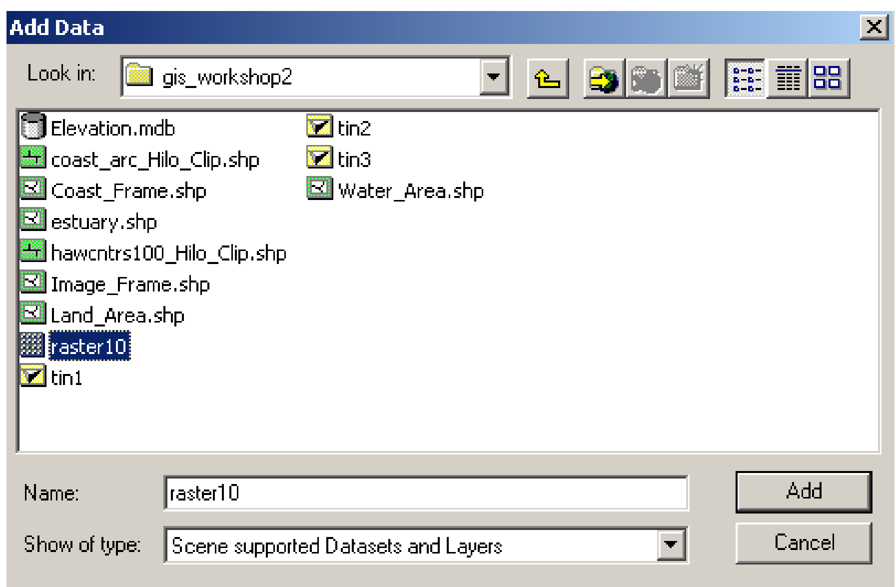
ArcMap view of raster10

and symbolize it in dark blue.

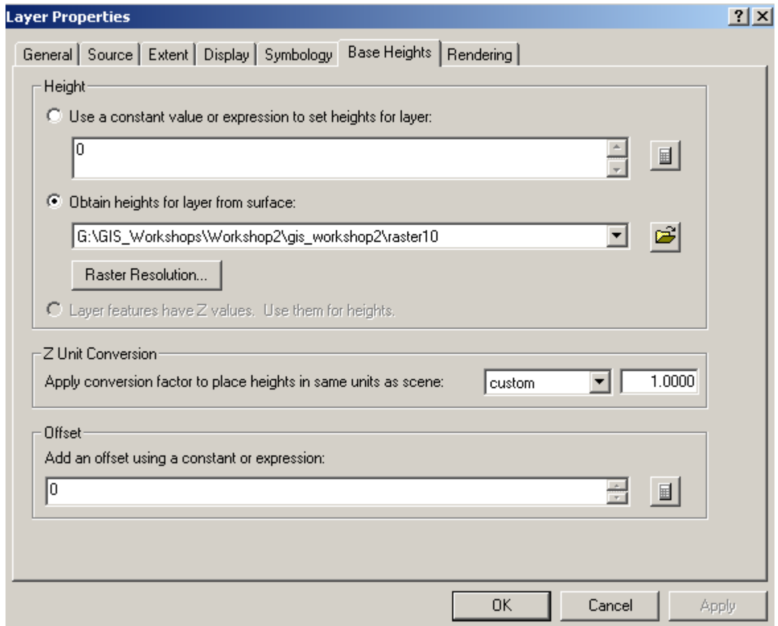


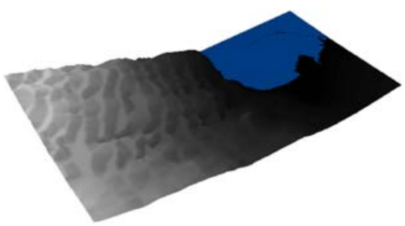
Step 5: ArcScene

Up to this point, we have been working with and creating 3D surfaces; however, we have been viewing these surfaces in the 2D map display area of ArcMap. Let us open ArcScene and see how our data looks in 3D. From the 3D Analyst toolbar in ArcMap, click on the ArcScene icon . Once the ArcScene window opens, click on the **[Add data]** button , browse to raster10, and press **[Add].**



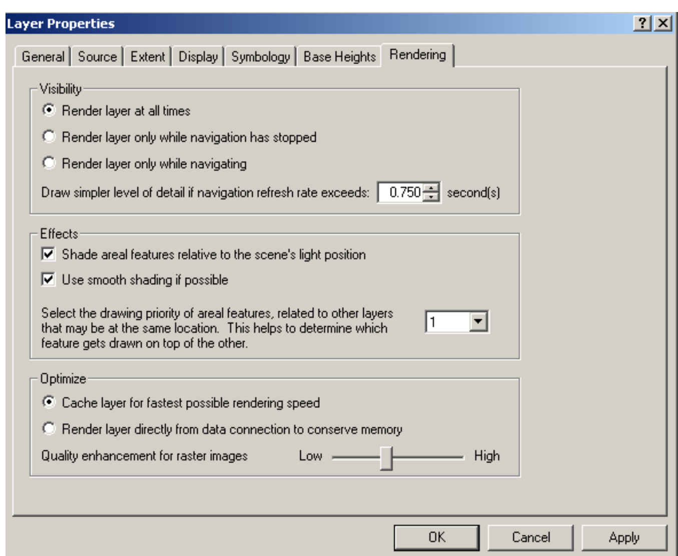
Once again to distinguish the coastline, add the shapefile **Water_Area.shp** and symbolize it in blue. To make the scene 3D, double click on the layer raster10 to display the **[Layer Properties]** menu. Under the **[Base Heights]** tab, press the circular button next to "Obtain base heights from surface". This option instructs ArcMap to display raster10 using its z-values. Note that from this dialog box, you can display surfaces with constant values, expressions, scaling factors , or offsets.

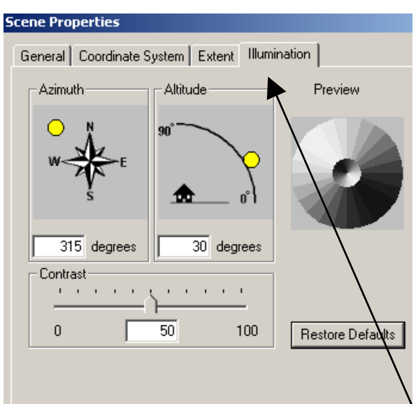




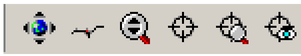
ArcScene view of raster10

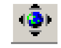
Now select the **[Rendering]** tab and tick the box next to "Shade areal features relative to the scene's light position". Press **[OK].**





Like in ArcMap, you can adjust the sun's position by right-clicking on Scene layers in the Table of Contents and selecting the **[Scene Properties] > [Illumination]** tab.

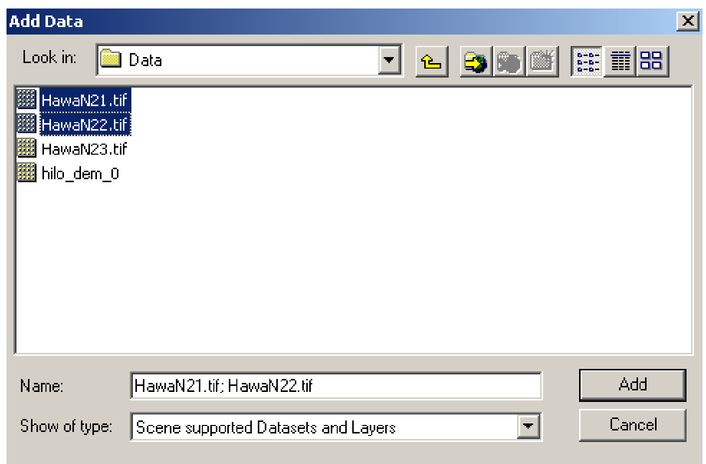


Within ArcScene, you can negotiate the display area with a wider range of tools than in ArcMap. The adjacent tools allow you to navigate, fly, zoom, center, target, and set observers. Experiment with them, especially the navigate tool  which allows you to adjust your perspective.

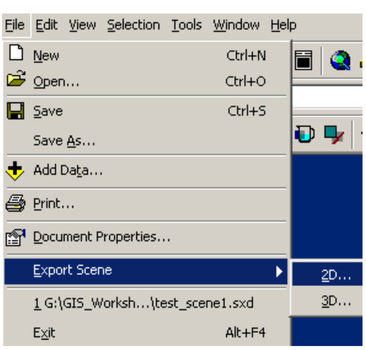
Within ArcScene, we could view our TIN using the same method as above. To save time, we will move on to draping photos over a surface.

Step 6: Draping Imagery

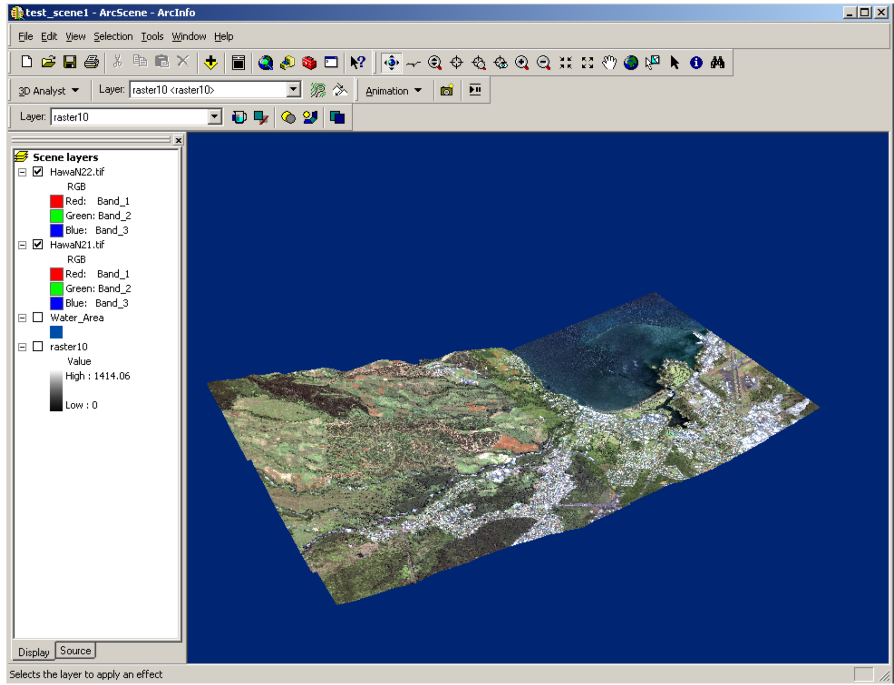
First we need to add two image files to our ArcScene document. Click the **[Add Data]** button , browse to the folder **C:\ITER_GIS_Workshops_Fall2005\Fly_Demo\Data,** and add the images **HawaN21.tif** and **HawaN22.tif**. This may take a while since the images are large (154 MB each).



Notice that ArcMap adds the images in a horizontal plane, as the base heights are set to a constant value of zero by default. Let us reassign these values. For each of the image files, open the **[Layer Properties]** menu, select the **[Base Heights]** tab, and choose to obtain the heights from the surface raster10. In the Table of Contents, untick the boxes next to raster10 and water area, so that only the two images are visible. Now open the **[Scene Properties]** menu, and set the vertical exaggeration to 1.5 and the background color to navy blue. Your scene should resemble the one on the next page.



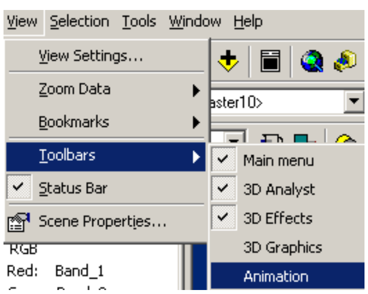
Before we continue, let us export this image as a JPEG file. Then we can paste it into an ArcMap layout at a later time. Under the **[File]** menu, select **[Export Scene]** > **[2D]**. Browse to your working folder, name the file **Satellite view,** and set the file type to JPEG. We will use this exported file in Step 8.



Step 7: Fly-Throughs and Animation

In workshop 1, we learned how to use the Fly tool to fly over our scene. Refer back to workshop1 to refresh your memory of how this tool works. You may want to use the Navigate Tool to adjust your perspective. Also, if you want to start flying from the same point every time, you can create a bookmark from the **[View]** menu and return to it at any time. Here is a partial list of other useful commands for flying:

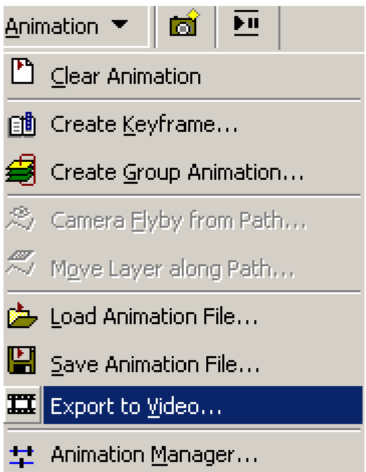
Left-Click	Zoom In (fly speed = 0, 1, 2, 3 etc.)
Right-Click	Zoom Out (fly speed = 0, -1, -2, -3, etc.)
Up Arrow	Fine Tune Zoom In
Down Arrow	Fine Tune Zoom Out
ESC	Freezes Flight



After a bit of practice, you should be ready to record a flight. We can capture a flight in two ways: (1) by recording the flight directly, or (2) by building an animation file from key frames. Let us start with the first method.

Before we begin, we need to open the **[Animation]** toolbar from the **[View]** menu. Then press the button on the end of the toolbar to view the **[Animation Controls]** window. Lastly, press the **[Options]** button to see more animation controls.

Now we are ready to record a flight. Follow these steps: (a) press the record button, (b) conduct a flight, (c) press the **[Esc]** key to freeze the scene, and then (d) press the stop button to end the recording. You can review your flight using the play button. Note that you can reassign the length of the animation, choose a time interval to play, and select the mode of play (forward, backward, etc.).



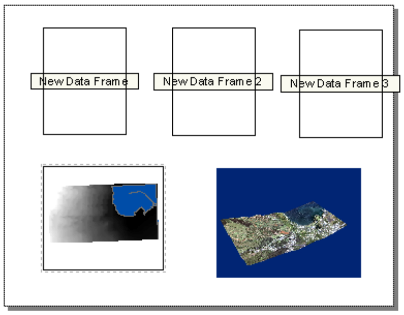
The second way to record an animation is using key frames. Under the animation toolbar, select **[Clear Animation]**. Then press the full extent button. Now we will use the camera button to capture a series of keyframes that ArcScene will link into a video. As a demonstration, let us create a video of our scene rotating 360 degrees. Press the camera button to capture the starting frame. Now using the navigate tool rotate the scene clockwise approximately 30 degrees and press the camera button again. Continuing rotating and pressing the camera button periodically until you return to the original view, facing approximately east downslope. To view your video, simply press the play button in the **[Animation Controls].**

We can export our video by selecting the **[Export to Video]** option under the toolbar. Then others can view it using video software such as Real Player, Quick Time, or Windows Media Player. Note that under the animation toolbar menu, the **[Animation Manager]** option allows us to edit our videos. We can save and close our ArcScene document now.

Step 8: Producing a Layout

For review, let us summarize what we have done in an ArcMap layout. We can create a simple layout depicting the following five data frames: (1) the original contours, (2) the TIN symbolized as Delaunay triangles, (3) the TIN elevations symbolized with a color ramp, (4) the raster surface, and (5) the satellite imagery in 3D.

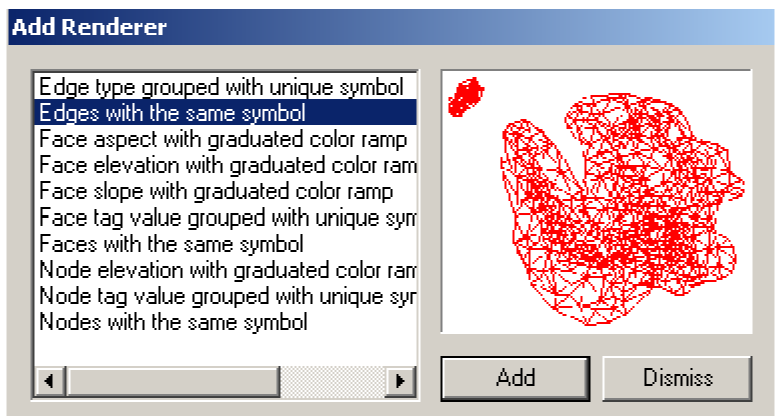
Returning to your ArcMap document, maximize the ArcMap window and close ArcToolbox. Pull down the **[Insert]** menu and insert three new data frames. Press the layout button in the lower left corner of the map display area to switch to layout view. Under the **[File]** menu, select **[Page and Print Setup]** and change the orientation to landscape. From the **[Insert]** menu, insert the JPEG file from Step 6 **(Z:\gis_workshop2\satellite_view.jpg).**



In the layout view, you will have to click and drag your data frames, so that they are not superimposed. At this point, your layout might resemble the one to the left. All we need to do move layers to the empty data frames, symbolize them appropriately, and add some cartographic elements.

In the first new data frame ("New Data Fame"), copy the layers Image Frame and CONTOUR100, and insert a legend.

In "New Data Frame 2", copy these three layers: water area, estuary, and TIN1. For TIN1, open the **[Layer Properties]** menu and click on the **[Symbology]** tab. Press the **[Add]** button and choose "Edges with the same symbol". Press **[Add]** again and then **[Dismiss].** Untick the boxes for "Edge Types" and "Elevation", and press **[OK].** With this data frame activated, insert a legend.



In "New Data Frame 3", copy the same layers as data frame 2, except this time symbolize elevation using a graduated color ramp. Untick the box next to "edge types".

The final data frame entitled "Layers" (by default) has all our original layers in it already. We simply need to tick the boxes next to the layers water_area, estuary, and raster10, placing them in that order. Depending on your cartographic choices, your layout should resemble the one on the next page.

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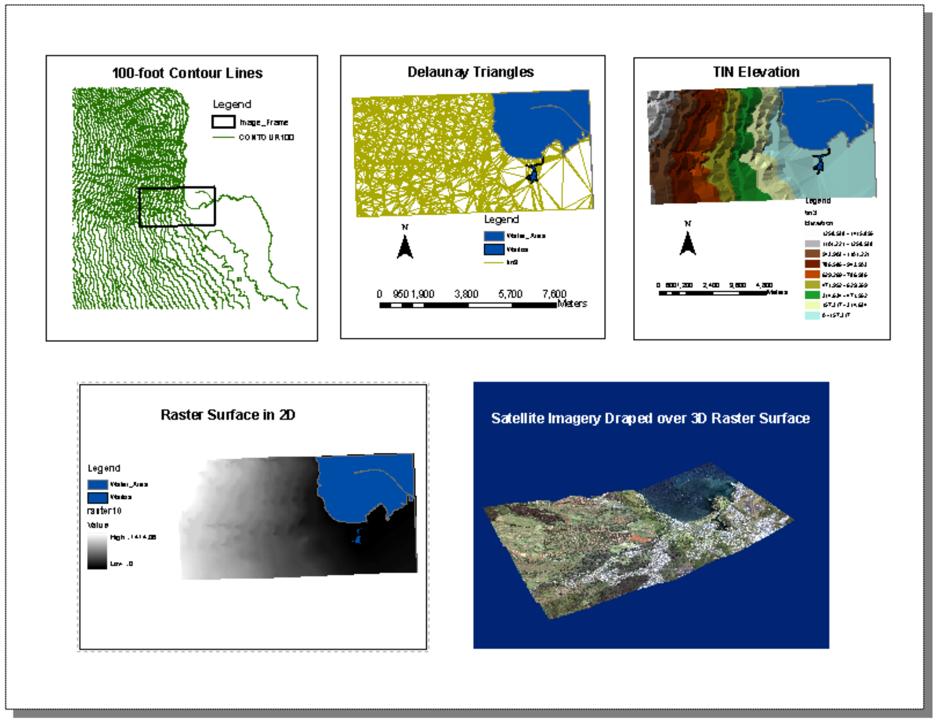
100-foot Contour Lines
Legend
Image_Frame
CONTOUR100
Delaunay Triangles
Legend
N
0 950 1,900 3,800 5,700 7,600 Meters
TIN Elevation
N
Raster Surface in 2D
Legend
raster10
Value
Satellite Imagery Draped over 3D Raster Surface