Introduction

The 3-D Analyst is a software extension that's designed to accomplish different types of analysis such as making the map appear real and making it easy to comprehend. To use the ArcGIS 3D Analyst, it must be installed. The main function of the 3-D Analyst is to create elevation data and display it in three dimensions. The 3-D analyst can also perform slope, aspect, hillshade, surface area, volume calculation and viewshed to determine visibility from any point on a surface.

The 3-D Analyst in ArcMap also allows you to determine line of sight, allows you to create vertical profile, and also digitize 3D features and graphics.

ArcScene allows you to create a raster surface model and Triangulated Irregular Network (TIN) from different elevation input data such as (1) contour line, (2) GPS, and (3) survey points. You can also drape a vector or an image over the TIN or surface models.

The 3-D Analyst adds ArcScene to the ArcGIS application and allows you to integrate the data, visualize it in 3 dimensions, and navigate around it. You can also fly through your displayed data in 3-D perspective and make movies of your flight.

You can convert 2D points, lines, and polygons to 3D and the 3D work can be saved as an *.sxd* extension.

Z Values

To work with the 3-D Analyst you need a 3D data set that consists of (x, y, z). The x, y is the location and z represents a value in the attribute other than the location. The z could be elevation of points above sea level, chemical concentration of groundwater, precipitation, or any phenomenon that varies across a specific location. Table 17.1 shows that the x, y is the easting and northing, and the z could represent either the elevation, well depth, or salinity.

Raster

A raster is a way to represent digital images which has a wide range of formats, including the .gif, .jpg, .tiff, .png, .bmp and others. A Raster consists of a matrix of cells (grid) organized into rows and columns. The cell can represent a square kilometer (km^2), a square meter (m^2), or a square cm (cm^2). The square cm represents a more detailed raster with a higher resolution than the bigger cells. The higher the resolution of the raster, the larger the file space is that's taken up by the image.

When a raster image is created, the image on the screen is converted into pixels. Each pixel is assigned a specific value which determines its color. The raster image system uses the red, green, blue (RGB) color system. An RGB value of 0, 0, and 0 would be black, and the values go all the way through to 256 for each color, allowing the expression of a wide range of color values.

W. Bajjali, *ArcGIS for Environmental and Water Issues*, Springer Textbooks in Earth Sciences, Geography and Environment, https://doi.org/10.1007/978-3-319-61158-7_17

Table 17.1 Groundwater wells location and other information

Well_ID	Northing	Easting	Elevation	Depth	Salinity
840	3872.70	1027.00	626.99	17	456
841	3872.50	1024.20	663.03	38	567
842	3871.50	1021.80	662.91	58	435
843	3928.50	1358.20	662.73	14	289
846	3572.20	941.30	662.38	35	987
847	3554.10	2416.40	664.35	14	888
848	3038.90	964.70	663.61	16	846
853	2501.00	808.80	668.19	55	484
856	2133.00	2387.70	673.90	35	503
857	2129.10	2390.20	673.95	61	359

The x, y coordinates of the image are not stored in each cell, but they calculated from the x, y location of the upper-left cell in the raster. The cell stores only the z value that represents a category of phenomena or quantity such as elevation or salinity, or depth (Table 17.1).

Raster data can be divided into two categories

Image: represents the reflection of light or some other band in the electromagnetic spectrum and can be measured by camera or satellite.

Thematic: represents a category of phenomena or quantity such as elevation or salinity, and has to be measured by a human using an instrument such as a GPS (in terms of elevation). Several samples will be taken and then a surface model will be interpolated using a certain methodology such as statistics or mathematics.

Triangulated Irregular Network (TIN)

The TIN represents a surface as a set of irregularly located points, joined by a line which forms triangles of different sizes. Each triangle point (node) stores the x, y, and z values. The values in a TIN are interpolated from the collected sample points like a raster. The value on a TIN surface will be estimated using the x, y, and z values of each triangle. In addition, the slope and aspect of each triangle face will be calculated. The TIN takes more space, and therefore it is recommended to use them for small areas that require accurate modeling presentation.

3-D Features

The 3-D vector format is like the 2-D vector format, as it can represent any point, line, and polygon. The 3-D vector stores the z value along with x, y coordinate. Each point has only one z value and the line and polygon has many z values, one value for each vertex.

It is recommended adding the ArcScene icon into the desktop.

Lesson 1: Working with 3-D in ArcCatalog

Preview Raster (DEM) and Vector in ArcCatalog

1. Click Start menu/Point to All Programs/ArcGIS/click ArcCatalog
2. Customize menu/Extensions/check the box next to 3D Analyst
3. Close
4. Customize menu/Toolbars/check the box next to 3D View Tools

Result: The 3D Analyst extension and the 3D View Toolbar are loaded.

5. Click "Connect To Folder" icon navigate to the \\Ch17\ folder
6. Click the plus sign next to the **Q1** to open it
7. Q1 contains the DEM of "**Duluth.tif**" and shapefile "**Contour.shp**"
8. Click "**Duluth.tif** " in the Catalog tree and then click the Preview tab
9. The "**Duluth.tif**" is displayed in 2D
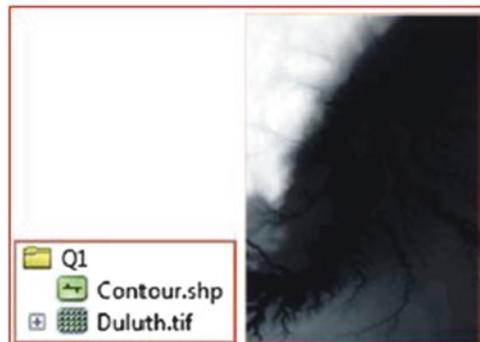
Note: 2D is called orthographic or planimetric view.

10. Click the arrow next to **Preview** at the bottom of the page/select 3D View
11. The DEM "**Duluth.tif**" is displayed in 3D (perspective view)
12. Click the Navigate tool

13. Place the cursor over the "**Duluth.tif**"
14. Hold down the left mouse button and move it in any direction
15. Click Full Extent icon on the 3-D toolbar to go back to the original position
16. To Pan, hold both left and right mouse button and drag the cursor in any direction
17. To Zoom in and out hold down the right mouse button and drag it down and up
18. Click "**Contour.shp**" in the Catalog tree, then click the preview tab
19. The "**Contour.shp**" is displayed in 3D View (Preview tab is already set to 3D)
20. Rotate, Zoom In, and Pan the "**Contour.shp**" as in the previous steps.

Does the Shapefile Contain 3D Features?

In order to know if the shapefile contain 3D feature do the following

21. Click "**Contour.shp**" in the Catalog tree again
22. Click in the Preview tab above the display map
23. Set the Preview menu at the bottom of the page to "Table"
24. You will notice that the Shape* field does not contain "**Polyline ZM**"

   Note: The "**Polyline ZM**" indicates that the "**Contour.shp**" is a 3D line feature.
   Result: The "**Contour.shp**" is not a 3D feature.

Create a Layer File for the DEM of Duluth in ArcCatalog

This exercise is to create a layer file (.lyr) in order to see the Duluth DEM in 3D. The layer file is not a raster data but a copy of the display instruction.

1. Click "**Duluth.tif**" in the Catalog tree and then click the preview tab
2. Make sure that the Preview menu is set to 3D View
3. R-click "**Duluth.tif**" DEM and point to Create Layer
4. Save it as "**Duluth.lyr**" in the \\Ch17\Result folder
5. Highlight the "**Duluth.lyr**" in the Catalog tree and select Preview tab/select 3D View
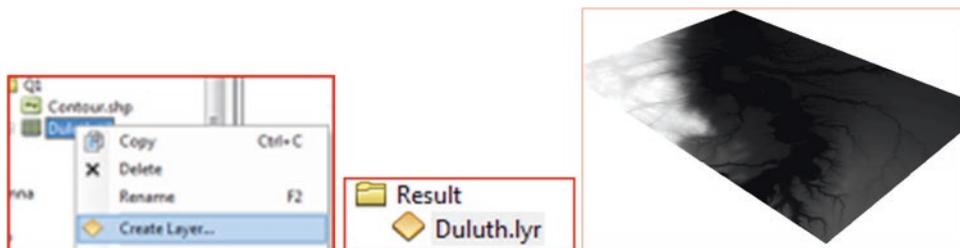
Display Duluth.lyr in 3D Using the Base Height of Duluth DEM

The next step is to display the "**Duluth.lyr**" in 3D to see the overall elevation of Duluth.

Base Height for Duluth DEM
6. R-click "**Duluth.lyr**"/Properties/click Base Height tab
7. Choose *Floating on a Custom Surface*

8. This step will use the elevation values from the Duluth DEM \\Q1\Duluth.tif
9. Below change the custom to 5 (will apply exaggeration to the elevation)/OK
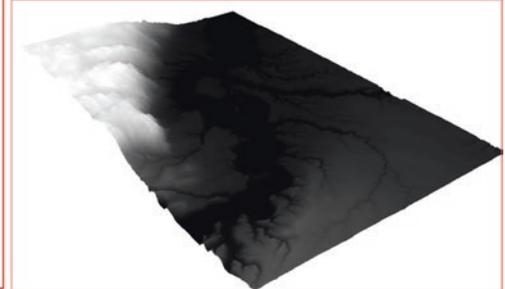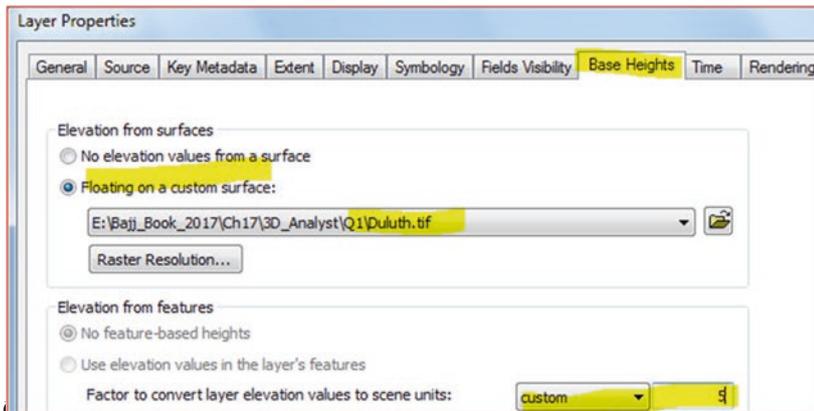
Result: The Duluth file layer is displayed in 3D with exaggeration.

Change the Color of the Duluth Layer File

11. R-click "**Duluth.lyr**"/Properties/Symbology tab
12. Under Shows: make sure Stretched is selected
13. R-click in the Color Ramp window and Uncheck the Graphic View
14. Click the drop-down list and scroll down to select Elevation # 1/OK
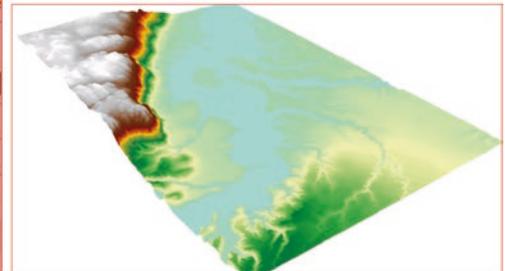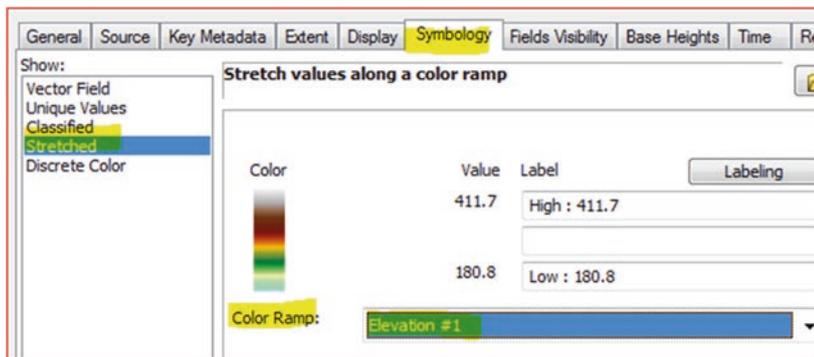
Result: A color added to the Duluth layer.

Add Shading to the Duluth Layer File

16. R-click "**Duluth.lyr**"/Properties/click Rendering tab

Note: The Rendering tab consists of **Visibility**, **Effects**, and **Optimize** frames.

17. Under **Visibility** frame, make sure "Render layer at all times" is checked
18. Under **Effects** frame check "Shade areal features relative to the scene's light position"
19. Under **Optimize** frame, make sure "Cache layer for fastest possible rendering speed"
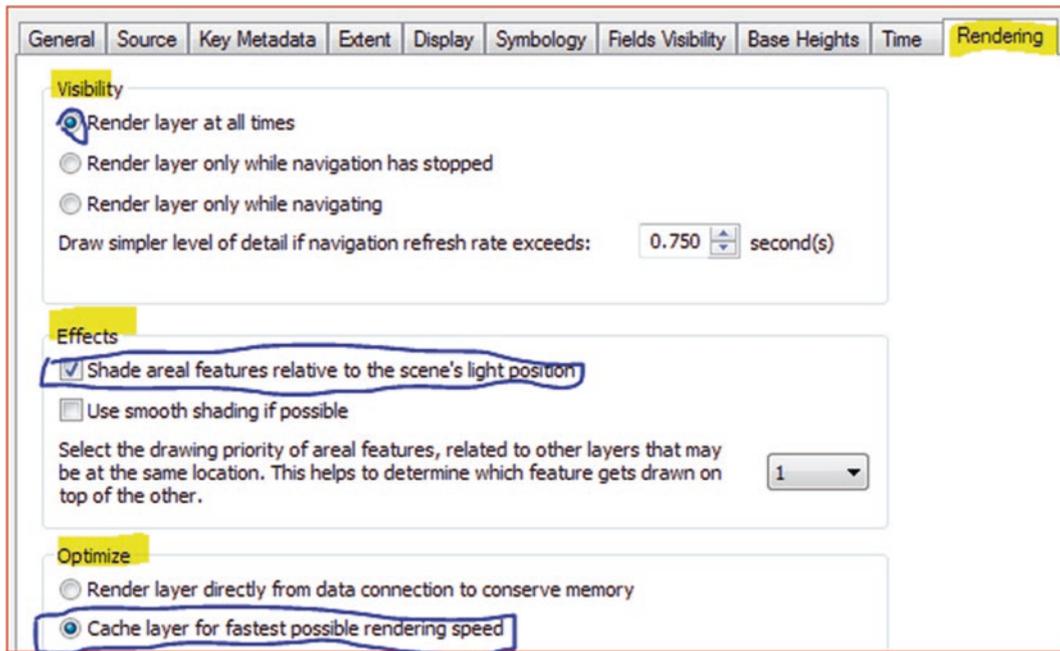
20. Click OK
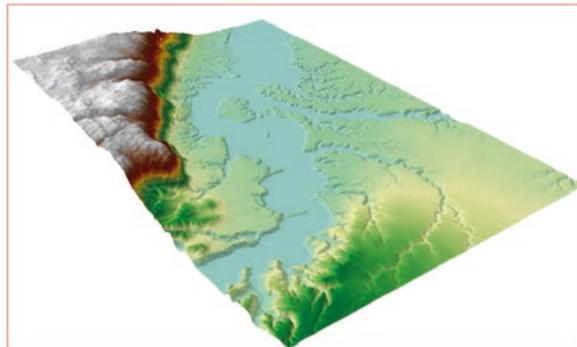
   Result: The elevation of the Duluth layer is better presented now.

Create a 3D Thumbnail to the Duluth Layer File

21. In the Catalog tree, click the "**Duluth.lyr**"
22. Select the Preview tab above the display map
23. Click the Create Thumbnail button on the 3D toolbar

24. Make sure the Preview tab at the bottom is set to 3D
25. Click the Content tab
26. The Duluth Layer File thumbnail is added
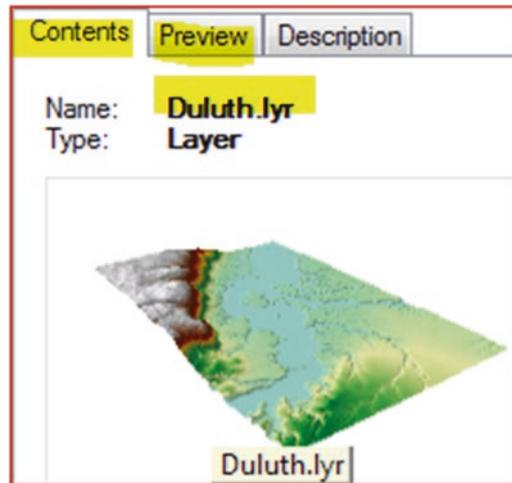
Lesson 2: Working with 3-D Toolbar in ArcMap

You can access 3D Analyst toolbar in ArcMap, but make sure that the 3D Analyst extension is enabled. The Toolbar contains tools you can use on 3D surfaces to perform different functions such as create a contour line, interpolate heights for digitized points, lines, and polygons and much more. These tools work with TIN, terrain dataset, LAS dataset surfaces, and DEM.

While using the 3-D Toolbar, you will perform the following:

- Create Single Contour
- Interpolate Points
- Interpolate Line

1. Launch ArcMap and rename the Layer data frame "**Duluth Height**" Customize menu/Toolbars/3D Analyst
2. Click Add Data and browse to \\Ch17\Data\Q2 folder and integrate City.shp, Duluth.tif, RainStation.shp, and Stream.shp layers
3. Change the symbols, size, and color of the City.shp, RainStation.shp, and Stream.shp layers based on your taste
4. Change the Symbology of the Duluth.tif and apply the Elevation1
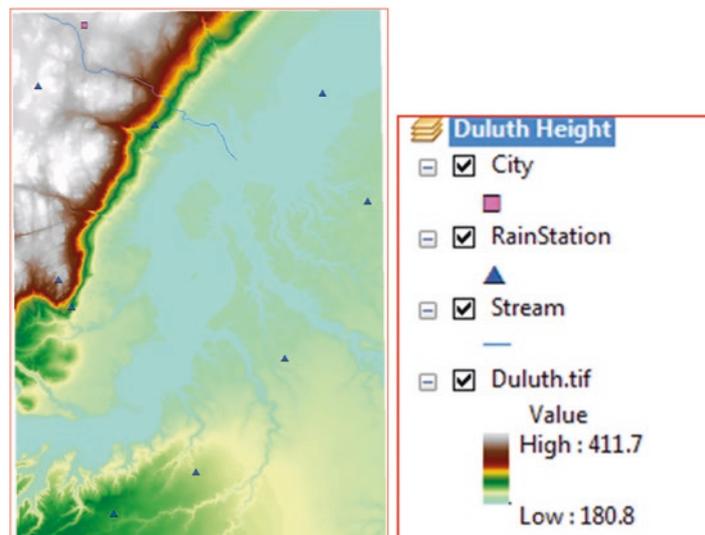
**Result**: The layers will be displayed and they are symbolized.

Create Single Contour

Contour lines are representing surface elevations on maps. A contour is a line that connect all points with equal height (or other values such as population, chemical parameter).

You can create contour lines for a raster, TIN, or DEM.

In this exercise, you are going to create contour line for the city layer

1. Click the Create Contours ![icon] button on the 3-D Analyst Toolbar.
2. Click the surface at the City layer to create a layer
3. The contour is added as a 3D polyline graphic.
4. The height of the City layer is 380.587 meters (It is written to the status bar).


Contour elevation: 380.587
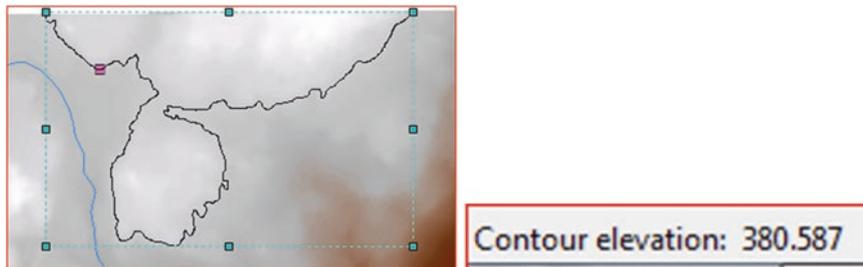
Find the Elevation of the Rain Stations Using the "Interpolate Point"

The tool create a 3-D point by interpolating the elevation from the DEM of Duluth image. In this exercise you want to find the elevation of the RainStation layer using the DEM of Duluth.

5. R-click RainStation layer in the TOC/Label Features

6. Click the Interpolate Point ![icon] button on the 3-D Analyst Toolbar.

7. Click the symbol of the RainStation that has a label 1
8. A point appears above the symbol and the height of the Rainstation is 397.234 meters written to the status bar.
9. Continue identifying the elevations of the RainStation layer and fill the table below

| RainStation No	Elevation (m)
1	397.234
2	
3	
4	
5	
6	
7	
8	
9	

Point Z: 397.234
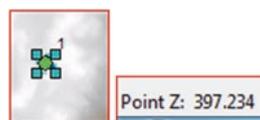
Create a Profile Graph for the Stream Using the "Interpolate Line"

The Interpolate tool allows you to create a 3-D graphics on a DEM using the "Interpolate Line" on the 3-D Analyst

10. Insert Data Frame and call it "Vertical Profile"
11. Drag the Duluth.tif and Stream layer from the Duluth Height data frame into the "Vertical Profile" data frame
12. Make the width of the Stream layer 2
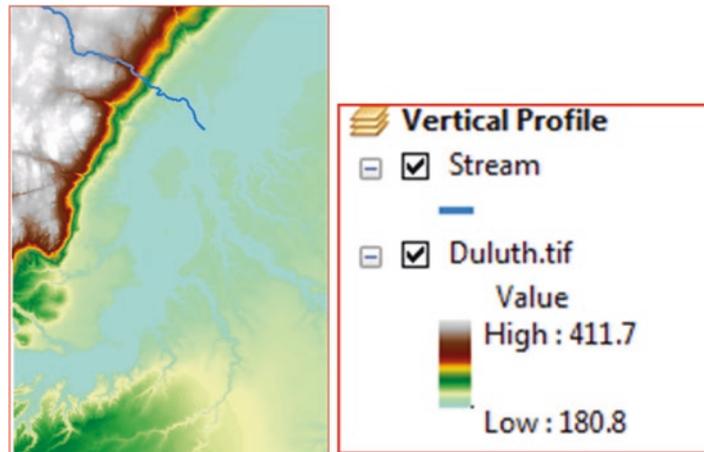
13. Click the Interpolate Line [button icon] button
14. Then click the upper end of the Stream layer and digitize a line along the Stream flow
15. When you are finished adding vertices to the line, double-click to stop digitizing.

16. Then click the "Create Profile Graph" [button icon] button.
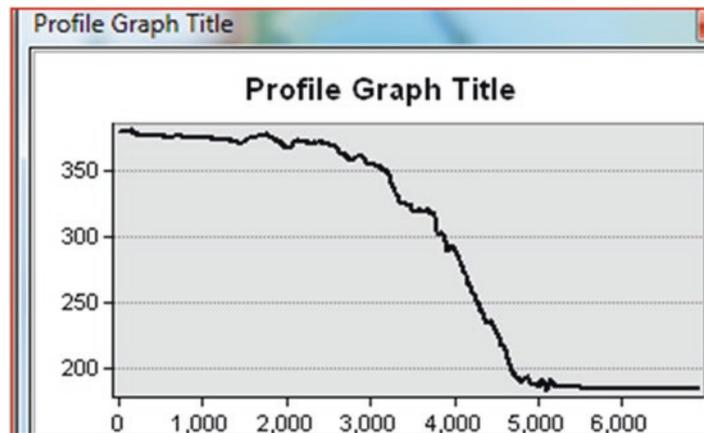
Result: The vertical profile display.

Lesson 3: Working with ArcScene

ArcScene is a 3D visualization application that allows you to view your GIS data in three dimensions. It allows the user to integrate many layers of data into a 3D environment. Data can be displayed in 3D by using height information from raster elevation or a field in the attribute table. Data with different spatial references will be projected to a common projection, or data can be displayed using relative coordinates only. ArcScene also has the capability to utilize many analytical tools and functions.

Scenario 1: You have been asked by your advisor to integrate various types of data and create a TIN in order to provide a presentation about the water resources in Dhuleil area in 3-D setting.
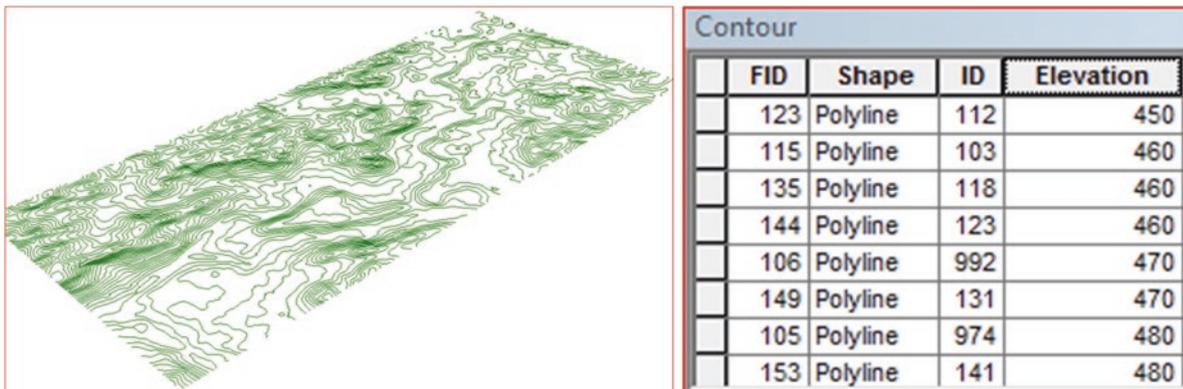
Create TIN from Contour Line

A triangulated irregular network (TIN) is a digital data structure used in GIS for the representation of a surface. The TIN is a vector-based digital data and is constructed from features, such as points, lines, and polygons that contain elevation information. There are different methods of interpolation to form these triangles, such as Delaunay triangulation or distance ordering. ArcGIS supports the Delaunay triangulation method.

   ArcScene can be launched from the Start menu and it reside in ArcGIS and you can start the program also from the

ArcScene button on the 3D Analyst toolbar in ArcMap
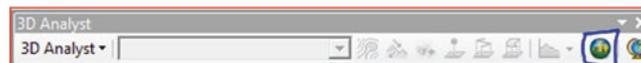
1. Click Start menu
2. Point to program then ArcGIS
3. Click on ArcScene to launch it
4. Click Add Data button, and browse to \\Data\Q3 folder and integrate **Contour.shp**
5. R-click the **Contour** layer and Open Attribute Table

Contour			
FID	**Shape**	**ID**	**Elevation**
123	Polyline	112	450
115	Polyline	103	460
135	Polyline	118	460
144	Polyline	123	460
106	Polyline	992	470
149	Polyline	131	470
105	Polyline	974	480
153	Polyline	141	480

   Note: The table has an "Elevation" field that will be used to create the TIN.

6. Close the Contour attribute table Click on the ArcToolbox button on the Standard Toolbar to launch it

7. Click ArcToolbox/3D Analyst tools/Data Management/TIN
8. D-click Create TIN
9. Fill the Create TIN dialog box as follow:
10. Output TIN: \\Ch17\Result\Dhuleil_TIN
11. Coordinate System browse to \\Data\Q3 and import from Contour.shp/OK
12. Input Feature Class: Contour
13. Make sure the Height Field is **Elevation** and SF Type is **Hard_Line**
14. Click OK
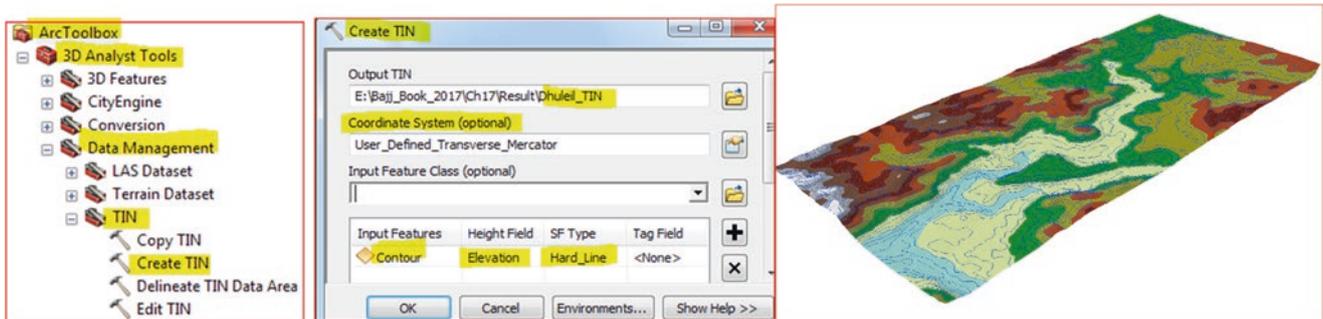
Result: **Dhuleil_TIN** is created and added to TOC.

Change the Symbols of the TIN

15. In the TOC/R-click "Dhuleil_TIN"/Properties/Symbology/
16. Under Show: uncheck Edge types and Elevation and click Add button
17. Highlight "**Faces with the same symbol**"/click Add then Dismiss
18. Click the Symbol color and click Dawn Ivory/OK/OK
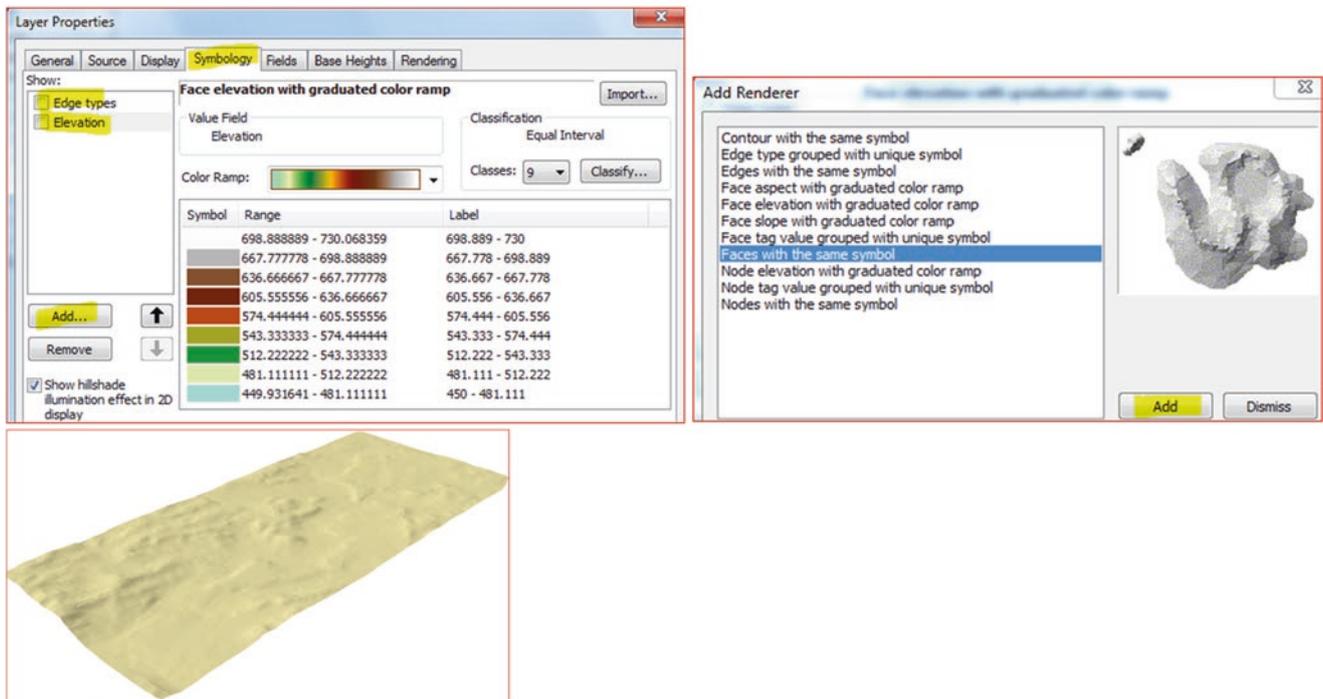


Result: **Dhuleil_TIN** has now one color.

Drape and Extrude Layers onto Dhuleil_TIN

In this exercise, you will drape the different layers over the TIN. The layers don't have an elevation field in their attribute tables, so you will take the base height from Dhuleil_TIN and apply them to the layers.

19. Click Add Data button and browse to \\Data\Q3 and add **Farm**, **ObserbationWell**, **Street**, **SupplyWell**, **Valley,** and **WWTP** layers
20. In TOC/R-click **SupplyWell**/Properties/click Base Heights tab
21. Under "Elevation from Surfaces" check "Floating on a custom surface"
22. Choose Dhuleil_TIN
23. Click the Extrusion tab/check "Extrude features in layer"
24. Click the Calculator and enter the following expression "**[Height] *10**"
25. Click Ok/Apply/OK
26. Change the symbol of SupplyWell into "Dot 4" and select Cretan Blue color/click OK
27. Repeat the previous steps for the ObservationWell
28. Change the symbol of ObservationWell and into "Dot 4" and select Apatite Blue color
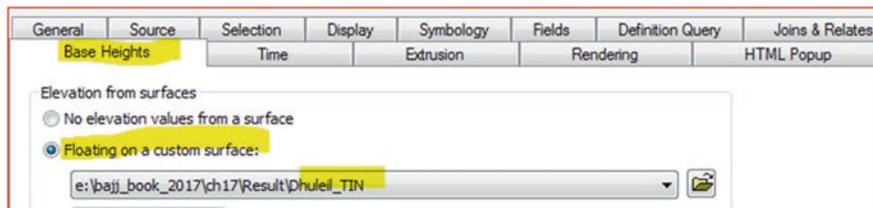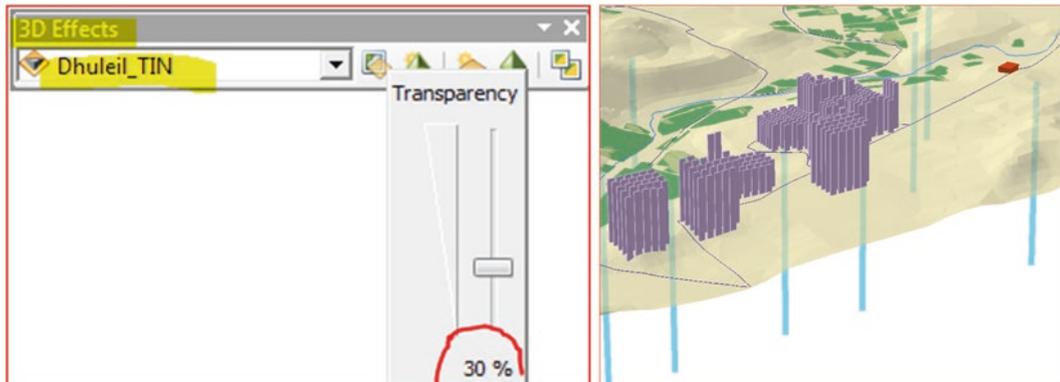

29. In TOC/R-click **Valley**/Properties/click Base Heights tab
30. Under "Elevation from Surfaces" check "Floating on a custom surface"
31. Choose Dhuleil_TIN
32. Change the **Valley** to the River symbol and make the width 2
33. Repeat the previous step for the **Farm**, **Street** and **WWTP** and change the color into Light Apple, Black and Ultra Blue respectively
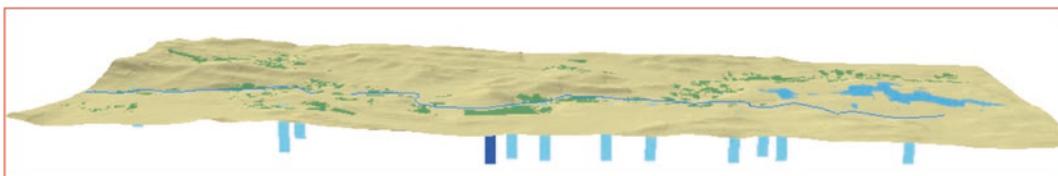
34. Click Add Data button and browse to \\Data\Q3 and add **Building**, **GasStation**, and **Tree** layers.
35. In TOC/R-click **Building**/Properties/click Base Heights tab
36. Under "Elevation from Surfaces" check "Floating on a custom surface"
37. Choose Dhuleil_TIN

38. Click the Extrusion tab/check "Extrude features in layer"
39. Click the Calculator and enter the following expression "**[Height] *20**"
40. Click Apply/OK
41. Repeat the previous step for the GasStation and extrude it by multiply the height by 10.
42. In the TOC/uncheck the Contour layer
43. D-click anywhere in the blank area of a toolbar and click 3D Effects/Close
44. On the 3D Effects toolbar/click the Layer-drop-down and select "**Dhuleil_TIN**"

45. Click the Layer Transparency [button] button to change the it to 30%

46. Zoom to the building and GasStation layers

Result: The 3D Effects toolbar will be displayed, and the Layer Transparency will be changed to 30%.

Applying the 3D Symbol to the Tree Layer

Points in ArcScene can be symbolized as 3D markers and you can choose the 3D markers from the existing styles in ArcScene.

47. In TOC/R-click **Tree**/Properties/click Base Heights tab
48. Under "Elevation from Surfaces" check "Floating on a custom surface:
49. Choose Dhuleil_TIN
50. Click Symbology tab/click the Symbol button/click Style References button/select 3D Trees/click OK/select the Pine symbol/make the size 25/click OK/OK
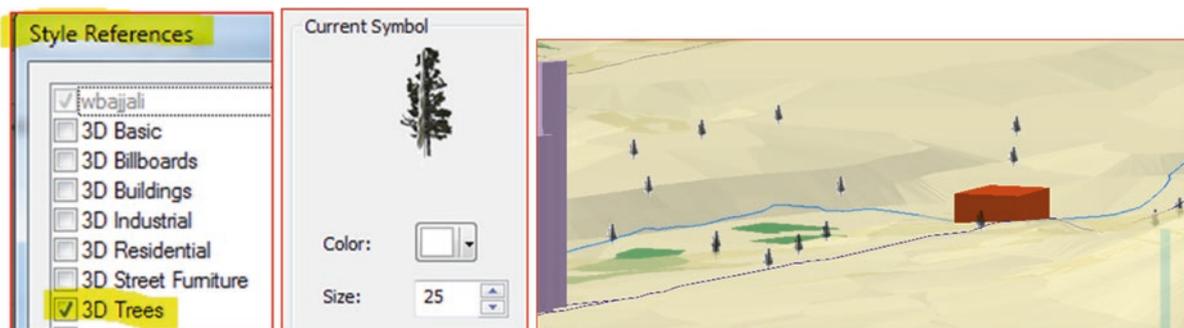
Vertical Exaggeration

ArcScene allows the user to exaggerate the vertical appearance and also change the elevation of the surface by any number. The exaggeration can provide a better visual effect and smooth the look of the surface, but does not affect the analysis.

51. R-click Scene Layers/Scene Properties dialog box display
52. Change the Vertical Exaggeration onto 2
53. Apply/OK
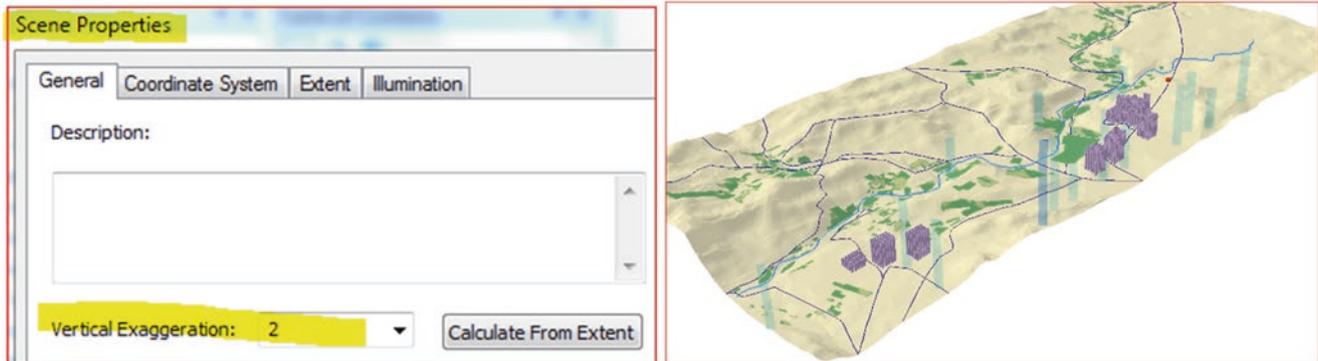
Navigate and Fly

54. Click Full Extent button on the Tools toolbar

55. On the Tools toolbar/click the Navigate button (1st icon)

56. Click on Dhuleil_TIN and drag the map to view the scene from different positions

57. Click the Zoom In button and zoom in to a small area around the Building layer

58. Click the Full Extent button
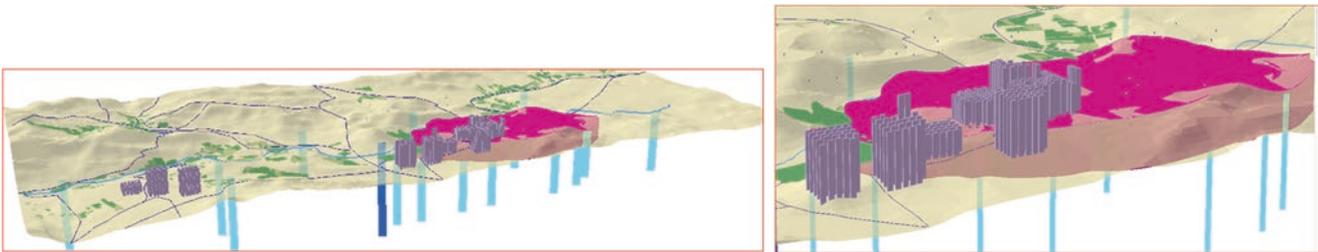
59. From the Tools toolbar/click the Fly button
60. Click in the middle of the map with the Fly button and click again to start a flight
61. Slowly move the mouse up, down, to left, and to right in order to move the map to these directions
62. Click the left mouse to increase the speed, the right mouse to decrease the speed
63. Press ESC key on the keyboard to stop the flight
64. Zoom to Full Extent

Create an Animation and Video

65. D-click in the blank area of a toolbar
66. Check the Animation and click Close button
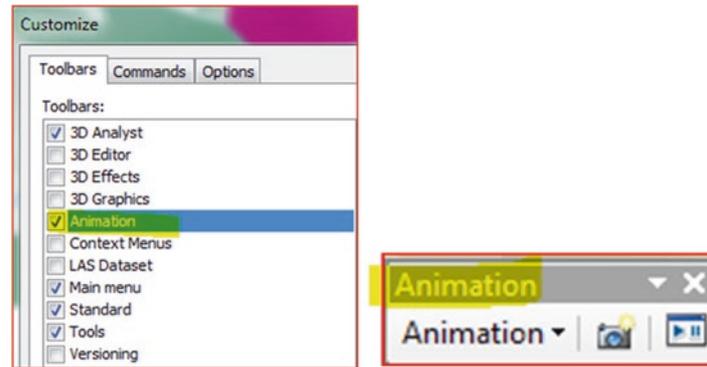
67. On the Animation toolbar/click the Open Animation Control button

Result: The Animation Controls toolbar display.

68. Zoon In in the Middle of the Scene
69. Click the Record button

70. Click the Play button

71. Click the Fly button and create a fly through the whole study area and when finish click the ESC key to stop the flight

72. On the Animation toolbar/click Animation/Save Animation File
73. Browse to \\Result folder and save the animation as **Dhuleil.asa**/click OK
74. On the Animation toolbar/click Animation/Load Animation File/
75. Browse to \\Result folder, highlight **Dhuleil.asa** and click Open
76. From the Animation Controls toolbar/click Play button

77. Zoom to Full Extent
78. On the Animation toolbar/click Animation/Export Animation
79. Browse to \\Result folder and save the animation as **Dhuleil.avi**/click Export
80. The Video Compression dialog box display
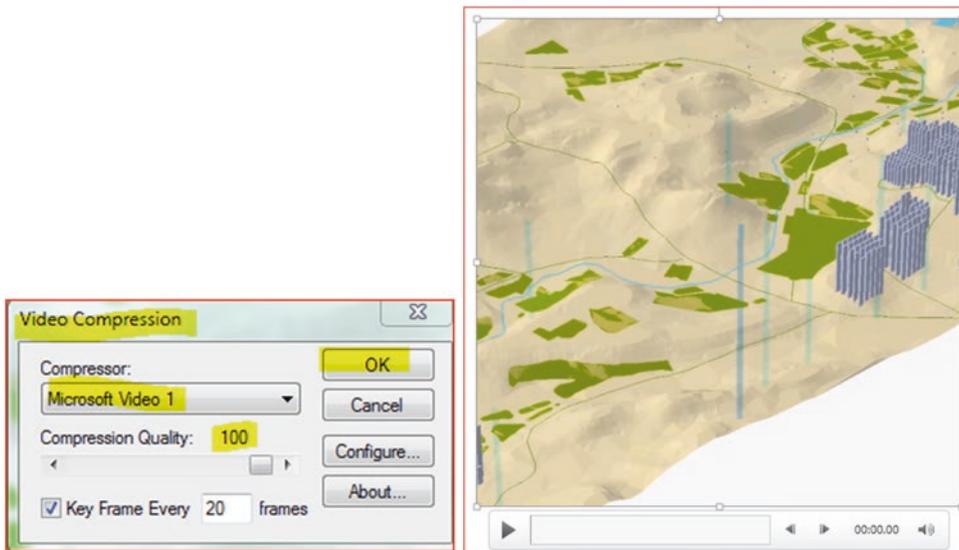   a. Compressor: Microsoft Video1
    b. Compression Quality: 100
81. Click OK
82. Launch PowerPoint
83. Insert menu/Video/Video on my PC browse to \\Result
84. Highlight Dhuleil.avi/Insert
85. In PowerPoint/Click play to watch the video

Time Tracking

Time tracking is a visual representation that uses the time field to show how the events are changing over time. The Plume attribute table layer contains a time field, which allows user to visualize the events at various locations over time.

86. Activate ArcScene and Zoom to Full Extent
87. Add Data and browse to \\Data\Q4 folder and add **Plume** layers.
88. In TOC/R-click Plume/Properties/click Base Heights tab
89. Under "Elevation from Surfaces" check "Floating on a custom surface"
90. Choose Dhuleil_TIN and click OK
91. Change the Color of Plume to "Mars Red"
92. OK
93. R-click Plume/Properties/Time tab
    a. Check "Enable time on this layer"
    b. Layer Time: Each feature has a single time field
    c. Time Field: Coll_Date
    d. Click Calculate
    e. Time Step Interval: change it into "1 Year"
    f. Check Display data cumulatively
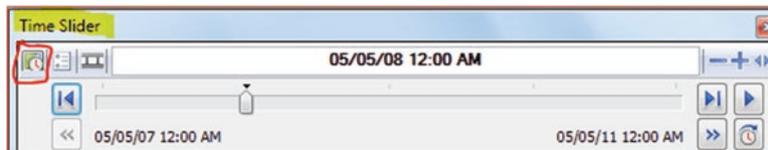94. OK
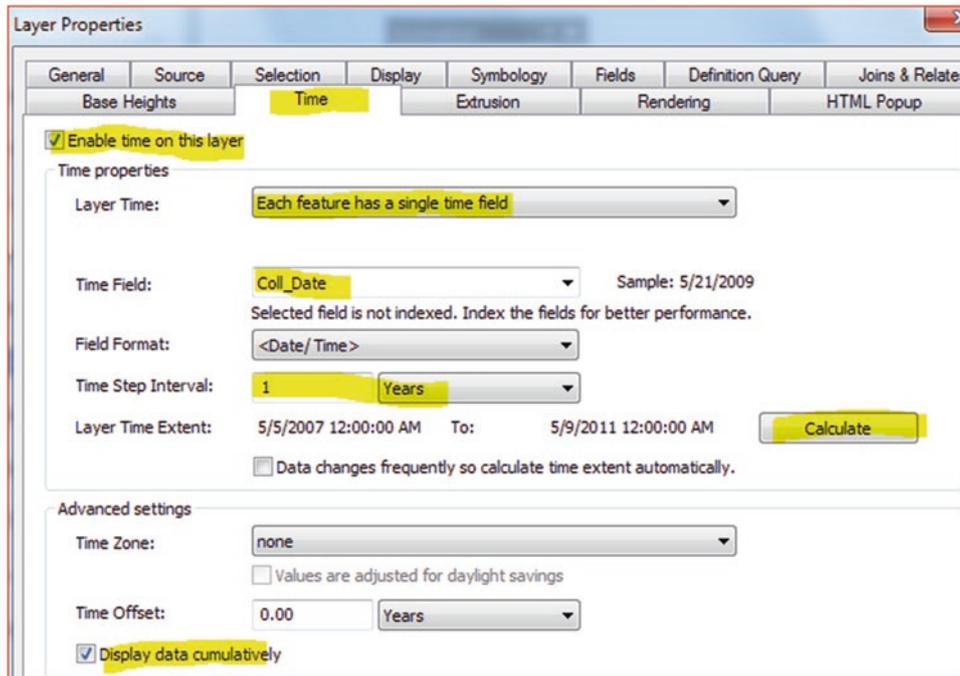
Note: Once you clicked OK the Time Slider on the Tools toolbar will be activated.

95. Click on the Time Slider button on the Tools toolbar

96. The Time Slider display

 97. Click on Disable time on map button (1st icon on Time Slider

 98. Click on the Options button (2nd icon)
 99. Click Time Display tab/Change it as follow
100. Time Step Interval: 1 Year
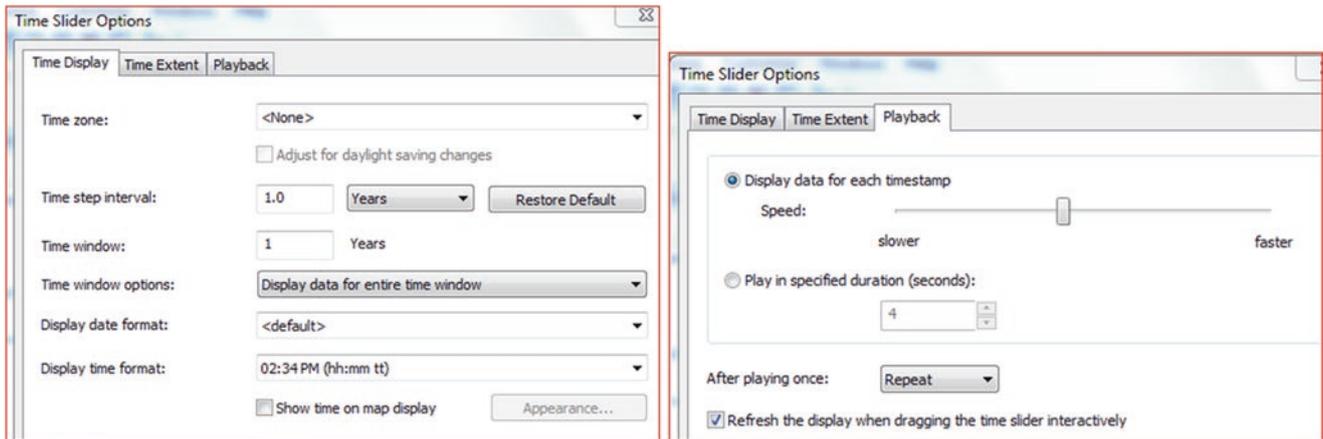101. Time window: 1.0 Year
102. Click Playback tab
103. Check "Display data for each timestamp"
104. Speed: move the speed selector to the middle between slower and faster
105. After playing once: Repeat
106. Check Refresh the display when dragging the time slider interactively
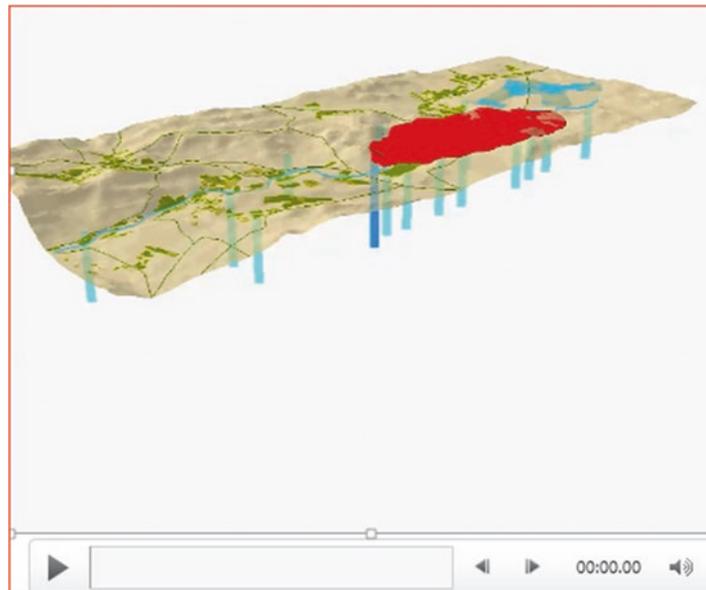107. OK

108. Click Play icon

109. Click the Export to Video button (3rd icon) on the Time Slider toolbar

110. Save it in \\Result folder as **Plume.avi** then click Export

111. Accept the default and click OK

112. Launch PowerPoint

113. Insert the **Plume.avi** and play it as in the previous section

Result: The video will play.