Introduction to GIS for geologists:

Supplementary Projects


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University of Leeds

For ArcGIS Pro 2.4
11th March 2020

Cover photograph acknowledgements

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Introduction

These supplementary projects are intended to give you a flavour of other ways in which you can use ArcGIS to work with spatial data, particularly in a geological context. The projects assume that you have already worked through the previous chapters in the workbook and have a basic idea of how to use ArcGIS.

The instructions are not as detailed as they are in the introductory workbook and you may need to refer back to previous chapters (don't forget the index). You may also need to work a few of the steps out for yourself. Have a go! If something doesn't work quite as you expected it to you can always delete or remove a layer, or start again!

You do not need to work through these exercises in order and there is some overlap between them. Start with whichever one looks most interesting, but still work through as many of them as you can.

The techniques and methods of analysis covered will work with various types of data so as you are going along try to think of ways in which you could apply them to other projects that you are working on, or may work on in the future.

This still isn't a definitive list of the tools in Arc: it is a very extensive suite! If you have any questions or any further ideas try searching in the ArcGIS Help to see whether there is a tool you could use. Or once you have a dataset in Arc try starting some of the tools within the Toolbox and see whether you can do anything interesting with them.

Enjoy yourself and make some colourful and informative maps!

Chapter 1

Working with height data: Mount St Helens before and after 1980

1.1 Introduction

On 18th
May 1980 the long dormant volcano, Mount St. Helens in the north west United States, erupted. Over the course of several weeks lateral blasts from the eruption destroyed the forested slopes and the volcano covered a large area in lava and ash. You can see more information about the eruption in a pdf from the USGS which can be downloaded from
`http://on.doi.gov/18jYFfl`
The link below goes to a lot more information and images of Mt St Helens from the Cascades Volcano Observatory including sections on Hazards; Monitoring; Geology and History.
`http://on.doi.gov/21kULb0`

In this exercise we'll use the tools in ArcMap and ArcScene to investigate the changes in the shape of the mountain caused by the eruption. We'll use USGS (United States Geological Survey) height data measured before and after the eruption.

Figure 1.1: The eruption of Mount St Helens in 1980

1.2 Obtaining data

Download the **MtStHelens.7z** file from Minerva. Save it to your file space and unzip it.
The data for this exercise has been obtained from [1] `http://bit.ly/1DWiPZc`
The data can also be found at `http://bit.ly/2grwsLe` [2]
The exercises are based on worksheets from the above URL and from ESRI Canada.

1.3 Setting up the map project

The 7zip file that you have downloaded and unzipped should include a file called **MtStHelens.aprx**.

[1](Website last visited: 8th December 2016)
[2]Website last visited: 8th December 2016

Open this now[3] and you should see that there isn't yet data on the map. If you check the Map Properties you should be able to see that the project has already been set up to use the correct coordinate system. In this case **NAD 1983 UTM Zone 10N**. NAD = North American Datum and UTM = Universal Transverse Mercator[4]. I've changed the Map frame name to show the coordinate system - this can be a very useful thing to do if you're likely to need to keep track of it through out your project.

- Add the **hbefore** and **hafter** files to the map from the `Folders` ▸ `MtStHelens` ▸ `Data` folder. These are ESRI grid format raster files.
- Switch the layers on and off to have a look at the changes between the before and after shapes as they are visible at the moment.

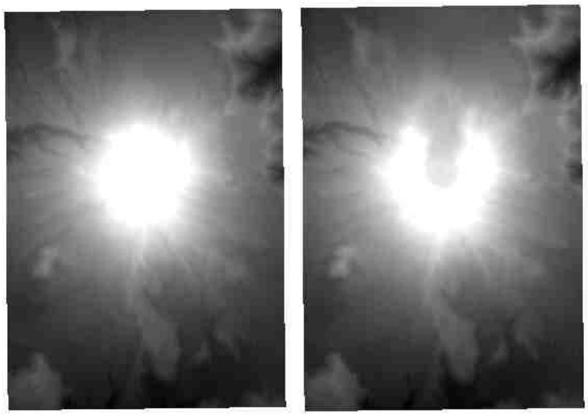


Figure 1.2: The original grid files: left: hbefore; right: hafter

1.3.1 Symbolising the raster layers

At the moment the height layers, the rasters that you have just added, will be coloured the default shades of grey. There are other colour ramps available which will make the elevation clearer.

- select the **hbefore** layer in the contents
- Go to the **Appearance** tab of the ribbon and click on **Symbology**
- In the symbology dialog check that the **Primary Symbology** is set to **Stretch**
- Drop down the list of choices next to **Color scheme**, click on **Show names** at the bottom, then select **Elevation #1** from the list.
- Click on the drop down next to **Stretch type** and select **Minimum Maximum** to use the full range of values in your raster. Figure 1.3 shows the settings.

Repeat the process above to symbolise the hafter elevation raster file.

You have on your map two layers which show similar data and which you may want to compare. To do this it would be useful to have the symbology, and also the legend later, set to the same scale. At the moment:

[3] If you double-click on the .aprx file it should open in ArcGIS Pro.

[4] There is a map showing the zones available online at `http://www.dmap.co.uk/utmworld.htm` (last viewed: 3rd February 2020)

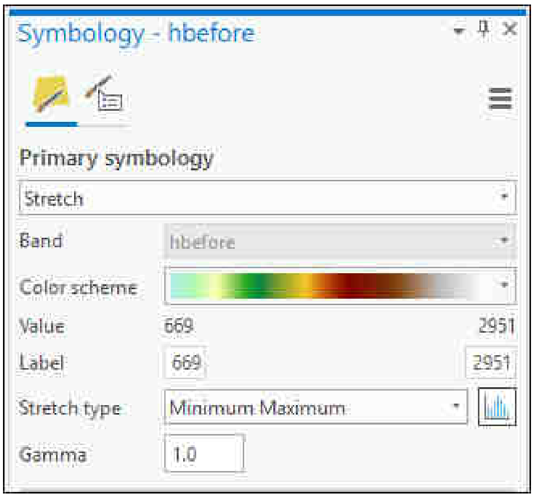


Figure 1.3: Setting stretched symbology for an elevation raster

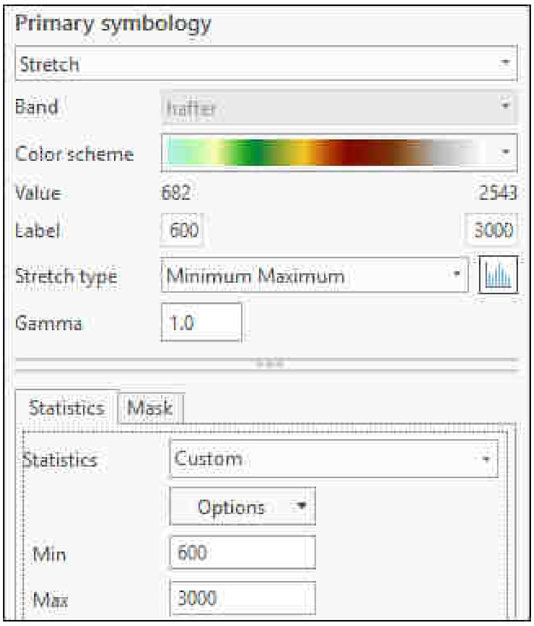


Figure 1.4: Changing the minimum and maximum for the symbology

- hbefore = 669 to 2951
- hafter = 682 to 2543

To put both elevations onto the same scale do the following:

- select the **hbefore** layer in the contents and go to the symbology panel
- Below the other settings there is a panel for **Statistics** - see figure 1.4
- Drop down the **Statistics** options and choose **Custom**
- The **Min** and **Max** boxes below should become editable
  - Change the **Min** to a round number which is less than the minimum of either dataset, e.g. **600**
  - Change the **Max** to a round number which is greater than the maximum of either dataset, e.g. **3000**

You should notice a change in the symbology of the layer. For some reason, the contents list will still give the same min and max, though[5]. So to update the legend and contents do the following

- in the Primary Symbology box above change the values in the boxes to your minimum and maximum values.

Repeat the above with the habove layer - putting the same minimum and maximum figures.

If you look at both layers on your map now you should be able to see the difference between before and after the eruption more clearly.

[5] Hopefully this is something which will be sorted out in a future version of ArcGIS Pro!

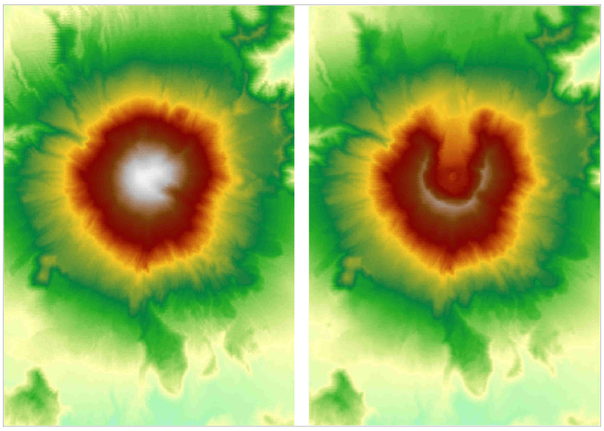


Figure 1.5: The symbolised grid files with minimum and maximum values altered to a common scale: left: hbefore; right: hafter

1.3.2 File formats

Grid files `hbefore` and `hafter` are examples of grid files. This is a **raster** file type which gives `z` (in this case *height*) values for each cell. If you zoom in close you will be able to see the individual "pixels".

TIN files - Triangulated Irregular Networks TINs are an alternative **vector** format for DEMs. TINs use triangles to represent surfaces. The sizes vary with triangles being smaller in more complex areas and larger in less detailed areas. TINs tend to be used for detailed larger scale applications, while Grids tend to be used for smaller, regional applications.

To convert a Grid to a TIN:

Open the Geoprocessing toolbox by clicking on **Tools** on the **Analysis** ribbon, then:

- Geoprocessing > 3D Analyst Tools > Conversion > From Raster > Raster to TIN
- Select **hbefore** as your input surface and choose a location and name for your output. Change the Z tolerance to **100** (Z tolerance controls the vertical accuracy of the resulting TIN. The closer the tolerance is to 0 the more points will be in the TIN - creating a larger file, so be careful not to set this too low). See figure 1.6.
- Click Run. The tool should run and add a new layer to your map - figure 1.7.

Repeat the same process using **hafter** as the input surface.

Have a close look at the resulting layers. Switch them on and off, zoom in close and pan around. You should be able to see the triangles and note how the ridges and valleys are shown.

TINs can be symbolised to show various types of surface.

- Go to the symbology tab[6] for one of the TIN layers
- Of the four icons at the top of the symbology panel click on the right-hand one. If you hover over it you should see that the tool-tip says **Symbolize your layer using a surface** (figure 1.8)
- Next to where it says **Draw using** drop down the box and select first the aspect and then the slope styles and have a look at the symbology to see what those are telling you about the landscape
- Also have a look at the options given by the other three icons, e.g. Under Edges, try drawing using **Edge Type**, click on the **More** button and select **Add all values**

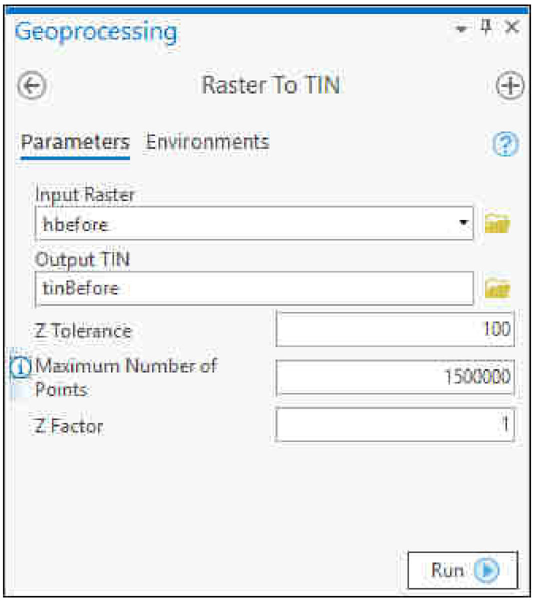


Figure 1.6: Converting a Raster to a TIN

Figure 1.7: The hbefore TIN showing the triangular mesh

When you have finished looking at them turn off or remove both of the TIN layers. For the rest of this chapter we'll be using the raster layers, but it's useful to know what TINs are, and how they can be used if you are downloading data and it comes in that format.

1.4 Creating hillshading

You should be able to see the original grid files again. It is possible to see from these some differences in the before and after topography, but they do not give a very clear view. Hillshades can give a much clearer picture of the topography of an area (and incidentally can give a better idea of the quality of your dtm).

- Geoprocessing » 3D Analyst Tools » Surface » Hillshade
- Fill in the dialog with **hbefore** as the input. Select where you want to save the output and give it a name. Leave the other fields as they are for now. See figure 1.9.
- Run. The tool should run and add a new layer to your map.

The resulting layer should show the shape of the land more visibly than the original raster layer (figure 1.10).

Repeat the hillshade process with the hafter raster file.

Have a look at both hillshade layers. The difference in the shape of Mount St. Helens before the eruption and after should be becoming clearer.

Incidentally, notice that the light source on the hillshade layer comes from the top-left of the image - which is usually the north-west, a direction from which the sun very rarely shines. This direction gives the best effect of 3D for an image. If you try turning a hillshaded map upside down so that the sun comes from the south-east, very often valleys will look like hills and hills will look like valleys.

[6] select the layer in the contents panel, then click on **Symbology** on the **Appearance** tab of the ribbon.

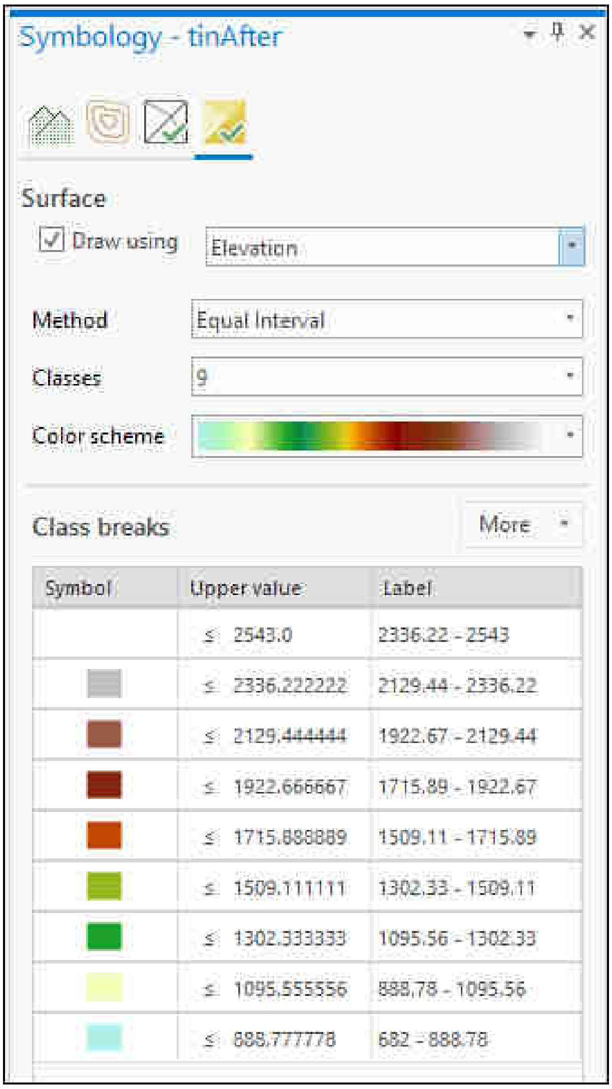


Figure 1.8: The symbology dialog for TIN layers - Symbolise your layer using a surface

1.4.1 Symbolising the hillshade

You could symbolise the hillshade directly to make a “prettier” map, but you often get a better result by symbolising the DEM, then putting the hillshade underneath it and making the DEM something like 40% transparent.

Make the “after” layers invisible and try symbolising the “before” layers first: If you haven’t already, symbolise the hbefore layer with a stretched colour ramp and set the before DEM layer to 40% transparency on the ?? tab (instructions are in section on page 7). Now try turning the hillshade layer on and off and look at how much difference it makes to how you can perceive the landscape!

If you still have the World Hillshade and Topographic Map layers on your map from the ESRI basemap you’ll also see how those interact with your data. Try turning those off and on too.

Try the same with the “after” layers. As usual - Experiment!

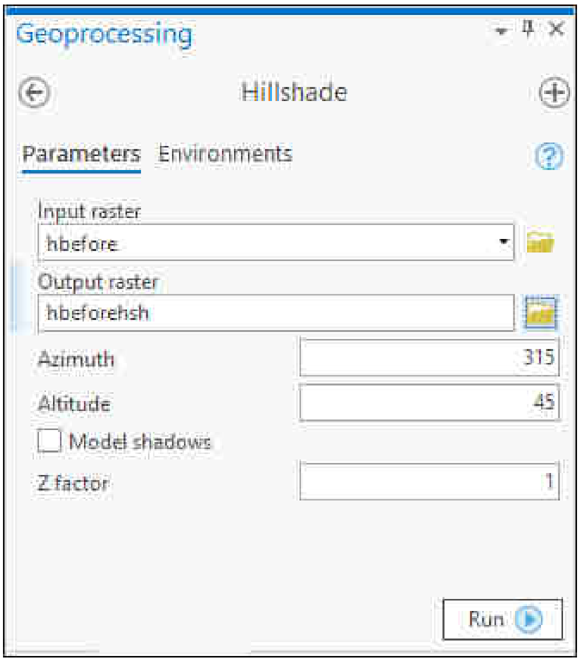


Figure 1.9: Creating a hillshade raster layer

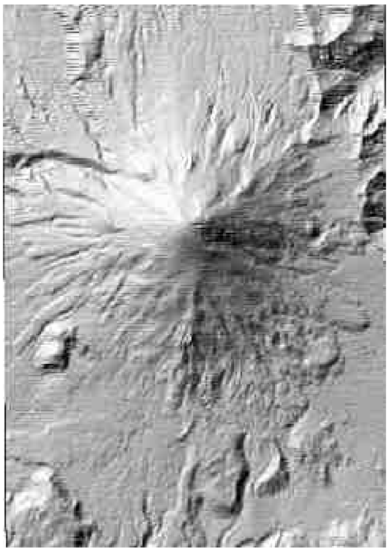


Figure 1.10: The hbefore hillshade layer

1.5 Area and volume calculations

It's good to be able to look at the differences - but what about actually doing some measurements and getting some figures out of the data? Arc's toolbox does give us the tools to be able to calculate the volume of Mount St Helens before and after the eruption.

- If you don't have the toolbox open already find it by going to the **Analysis** ribbon and clicking on **Tools**
- Geoprocessing > 3D Analyst Tools > Functional Surface > Surface Volume
- Fill in the dialog with **hbefore** as the input. Don't worry about saving the output this time - you'll make a note of it from the results window.
- The **Reference Plane** controls how the volume is measured - to see more click on the question mark symbol at the top of the tool dialog. The appropriate help page should open in your browser. In this case the page shows you the difference between setting the Reference Plane to either above or below. Return to Arc and set the **Reference Plane** to **Above the Plane**
- Having set this it is also a good idea to set the **Plane Height**. In this case set it to **669**, which is the lowest elevation in the hbefore DEM. See figure 1.11
- Run. Don't close the panel when the tool finishes running. Instead use the output window, which you can find by clicking on **View Details** at the bottom of the processing tool (figure 1.12) to make a note of the results below.

Before:

- ***2D area:***
- ***3D area[a]:***
- ***Volume:***

[a] 3D area takes the height into consideration so should give a greater number than simply measuring the area in 2D.

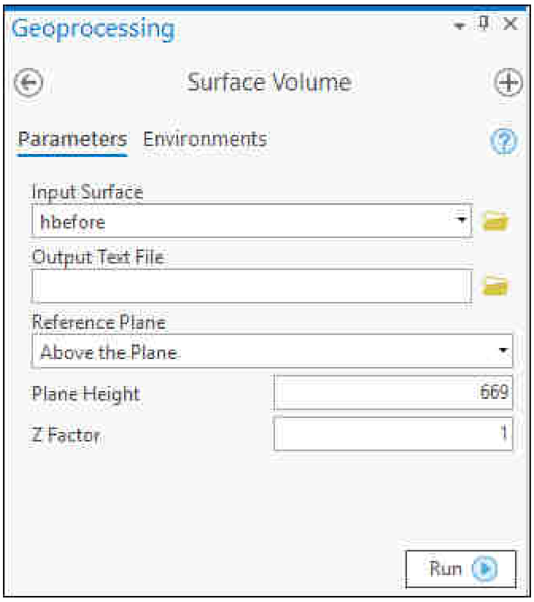


Figure 1.11: Obtaining surface volume and area

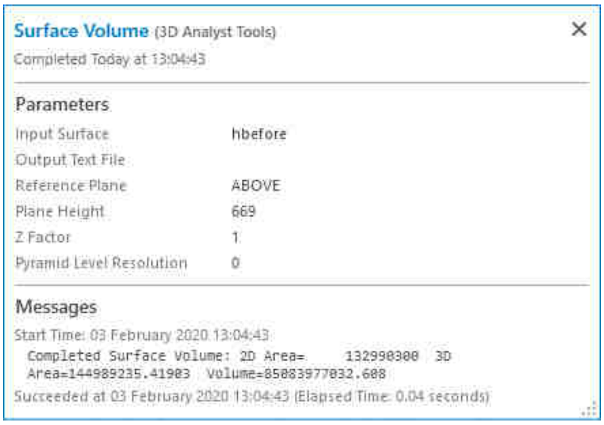


Figure 1.12: Result window for surface volume and area. Yours won't necessarily be the same as the results in this image, but should be similar.

The results will be in map units - check the units by going to the map properties and checking the **General** tab (figure 1.13). In this case it should be meters.

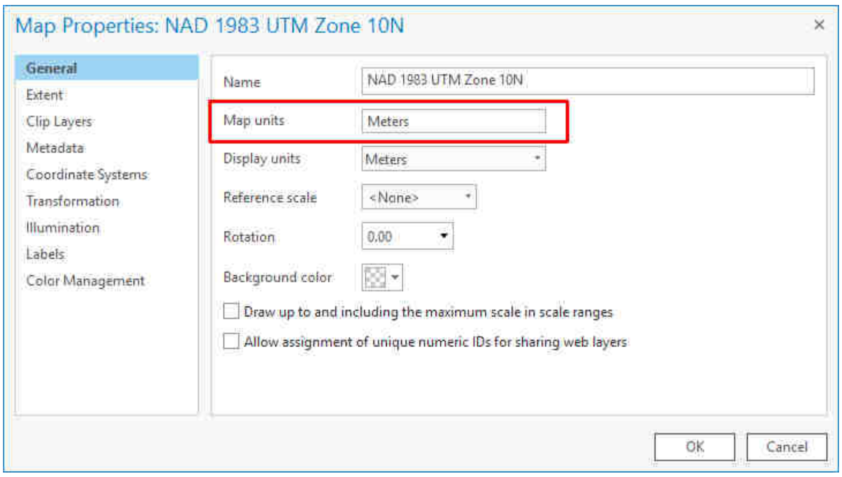


Figure 1.13: Checking the map units in the map properties window

Repeat the process for **hafter**, leaving the **Plane Height** as **669**, and again, make a note of the results below.

After:

- ***2D area:***
- ***3D area:***
- ***Volume:***

What differences are there? What can you say about the change in area/volume after the explosion?

1.6 Profile graphs

Another way to view topography is to draw a profile. This will allow you to see a profile along a line, and in this case allow you to view profiles for before and after the eruption.

- Start by creating a new line feature class in the geodatabase, making sure that the coordinate system matches the one used for the map, and drawing a line from north to south across the DEM. Check back to the main workbook if you need to remind yourself of how to do this.
- From the Analysis ribbon click on **Tools** and go to the **Interpolate Shape** tool - Geoprocessing > 3D Analyst Tools > Functional Surface > Interpolate Shape
- Fill in the dialog as in figure 1.14
  - The **Input surface** should be the Before DEM
  - **Input Features** is the line across the DEM that you have drawn
  - Give your **Output Feature Class** a name which reminds you that it is based on the Before layer
- The other defaults are fine, so click the Run button

Your new line feature class should be added to your map, if it isn't, then drag it across from the Catalog. Your map won't look much different.

To create the profile:

- Select the **Before** section line in the Contents and right-click
- Create Chart > Profile Graph

Arc should open a new panel below your map which contains the profile across the Before DEM - see figure 1.15.

If you click on **Properties** at the top of the panel you can change the format and the title, as well as other items.

By clicking on **Export** you can save the profile graph as a graphics file, e.g. svg, png or jpg.

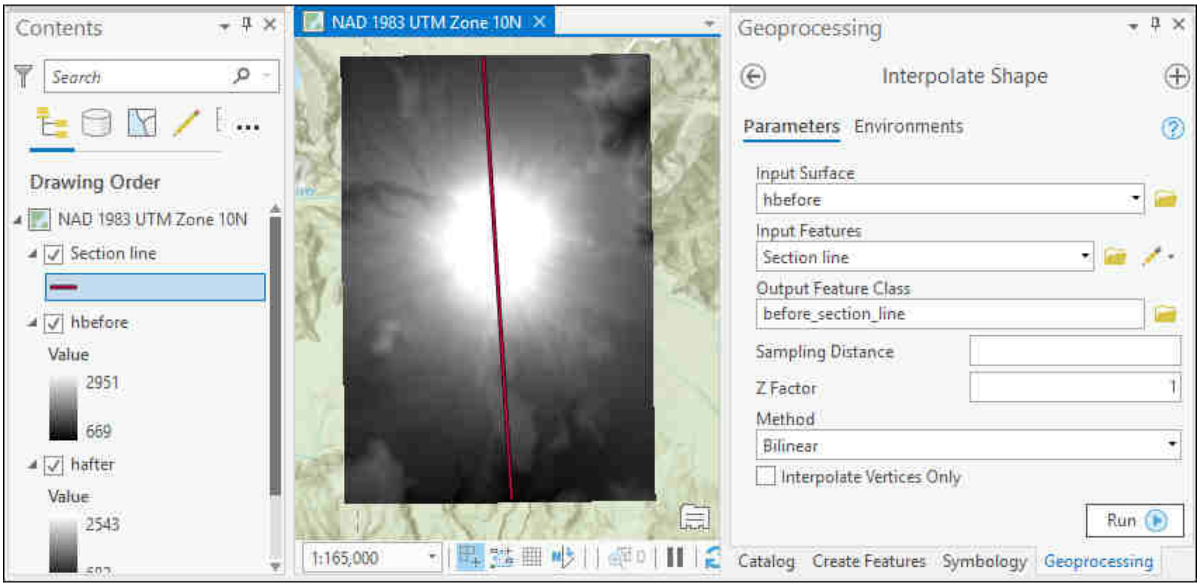


Figure 1.14: Using the Interpolate Shape tool to add height data from the hbefore layer to the Section Line

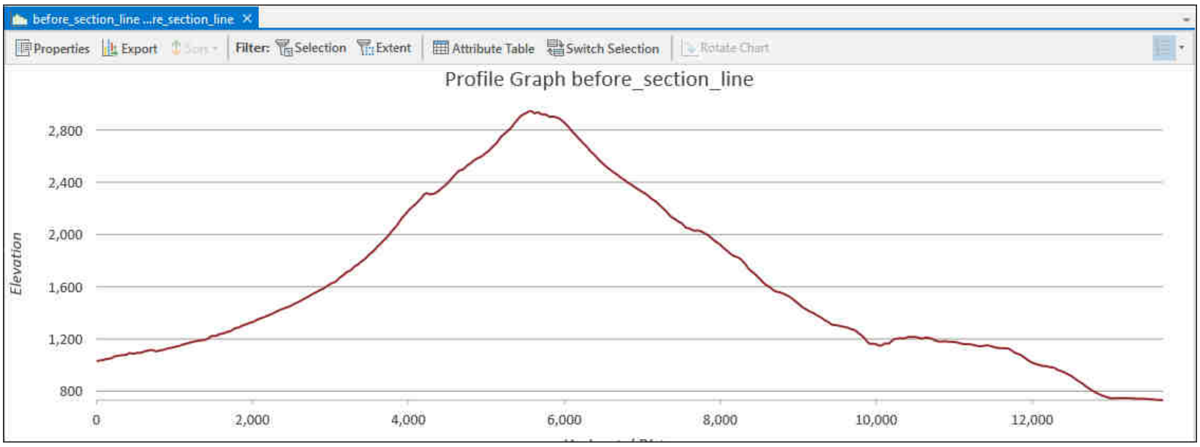


Figure 1.15: The profile graph across the before dem.

Repeat the process to create a profile graph for the DEM showing After the eruption.

Once you have created a graph it is listed in the Contents pane under the layer to which it applies. If you close it, you can open it again by clicking on the appropriate graph in the Contents.

Have a look at both of the graphs you have created. Resize them and use the properties to give them appropriate titles and axis labels.

1.7 Viewing your map in 3D

Within Arc it is possible to view your maps in 3D by creating a **Scene**. We'll look at this now with the data you have already, but it's something you can do with any data that you create in future too.

Video Clip available in Minerva - Viewing your map in 3D in ArcGIS Pro

1.7.1 Creating a Scene

To set up an empty scene within your existing Mount St Helens project:

- Go to the **Insert** tab of the ribbon
- Click on the down arrow under the **New Map** button
- Click on **New Local Scene**

Arc will create a new scene which currently looks very much like a new map - something like figure 3.11. Note that the new scene appears under the **Maps** subheading in the Catalog. In the Contents pane the Drawing Order view now shows layers divided into **3D Layers** and **2D Layers**.

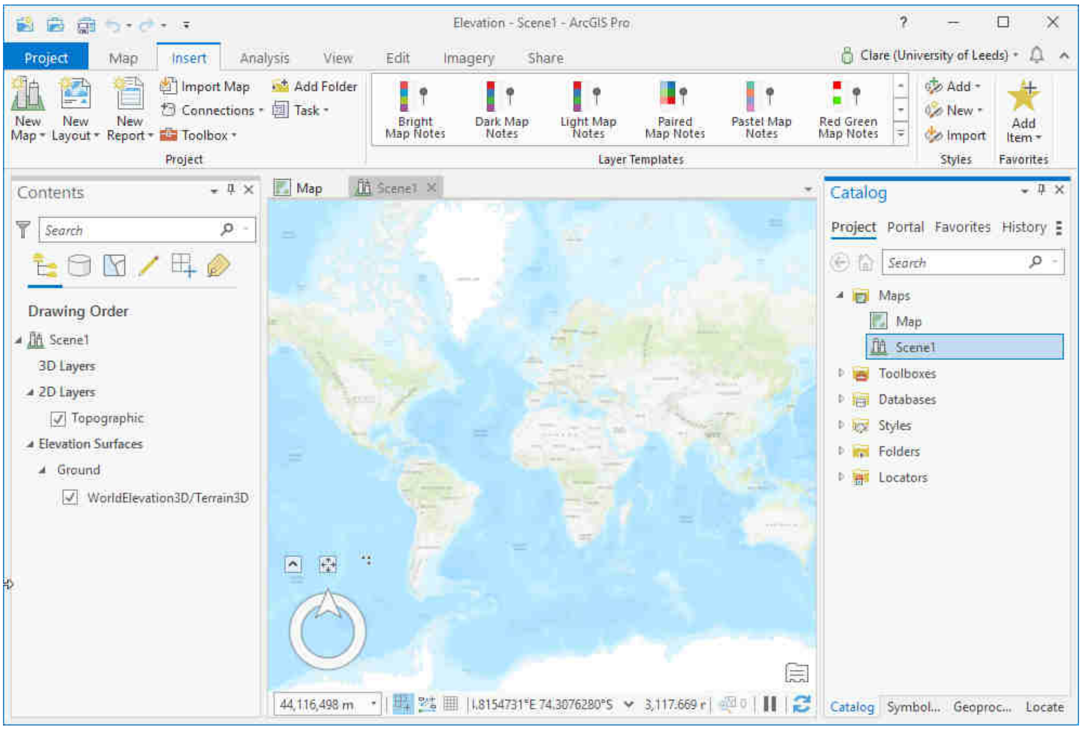


Figure 1.16: The initial view when you create a new local scene

1.7.2 Adding layers to a scene

You can add layers to a scene in exactly the same way as adding them to a map.

- Find your hillshade layers in your catalog pane and drag and drop them onto the scene

You should find that your scene zooms to the correct location for Mount St Helens and you can view the hillshade layers.

1.7.3 Navigating in a Scene

ArcGIS Pro Help has information on how to navigate in 3D at `http://bit.ly/32pZWOB`. The main difference from navigating in a map is that you can use the mouse wheel to "tip up" the map and rotate it, or use the navigation tool at the bottom left of the map to move around. Try this now.

It should quickly become obvious that the hillshade layers are draped over the landscape as it is now. For now turn off both hillshade layers so that you can see the basemap.

1.7.4 Changing the background layer

You can also change the **Basemap** in exactly the same way as you can change it in a map.

Change the basemap to Imagery now and use the navigation tools to zoom in to Mount St Helens and view the scene from a lower angle.

1.7.5 Controlling the elevation surface

You'll notice that Arc sets a default **elevation surface** - i.e. data which controls the terrain, or 3D surface. It is possible to make changes to this, and indeed to set your own elevation surface.

To change any of the properties of the elevation surface

- Select **Ground** under the **Elevation Surfaces** heading at the bottom of the contents panel
- Click on the **Appearance** tab on the ribbon to get the properties for the elevation surface - figure 3.12

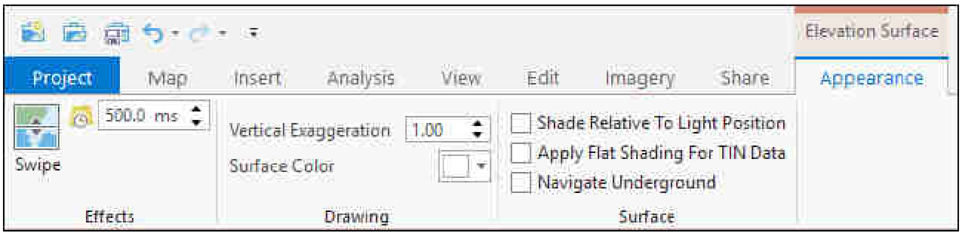


Figure 1.17: The properties for the elevation surface for the current scene

Vertical Exaggeration The default vertical exaggeration is **1.0** - which basically means as in reality. While scientifically this is usually the best setting to use, sometimes you need to exaggerate the terrain to show useful information.

- In the Scene Appearance tab, change **Vertical Exaggeration** to **4.0**
- You'll probably need to be patient again while the Scene redraws then zoom outwards so that you can see Mount St Helens again!

The difference between an exaggeration of **1.0** and an exaggeration of **4.0** should be pretty clear - see figures 3.13 and 3.14.

Return the exaggeration to **1.0** before continuing with the next task.

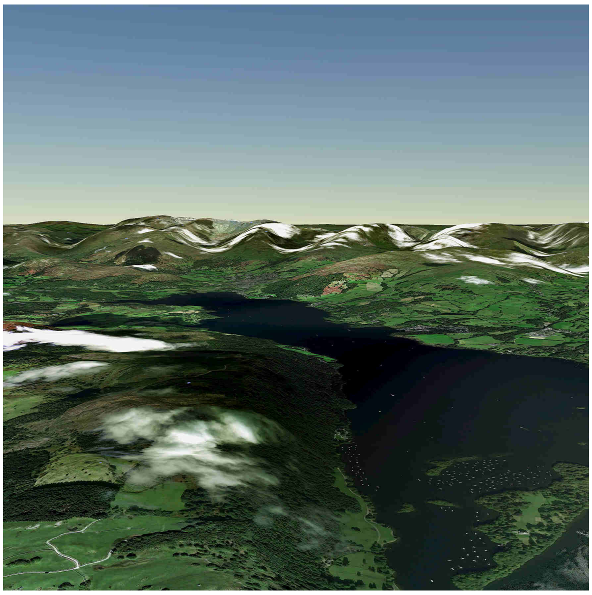


Figure 1.18: The view across Windermere with a vertical exaggeration of 1.0.

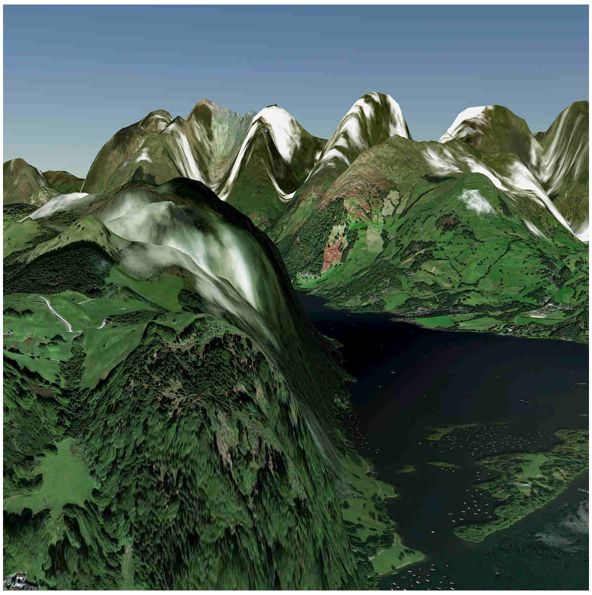


Figure 1.19: The same view across Windermere with a vertical exaggeration of 4.0.

Adding a custom elevation surface

Sometimes it is more useful to see your own data as the elevation surface. For example, we can add the DEM showing the shape of Mount St Helens *before* the 1980 eruption.

- Right-click on **Ground** under the **Elevation Surfaces** heading at the bottom of the contents panel
- Add Elevation Source and navigate to the data folder to select the **hbefore** raster dataset then click OK

This may look a bit odd as you'll still have the ESRI Imagery layer showing the current land surface, but the crater at the top of Mount St Helens should apparently have been filled in. Try turning on the hillshade layer showing the **before** data.

If you add a custom elevation surface, but leave the World Elevation layer on, then areas outside of your DEM will still have elevation.

Turn off the before layers for both hillshade and the elevation surface before continuing with the next section.

1.7.6 Cut-fill analysis

Cut-fill analysis looks at how much material is lost or gained in an area by comparing two surface models - one before the change and one after. It could be used to look at deposition in a lake or changes in groundwater over time, for example. Here we'll use it to look at the difference in the land surface before and after the 1980 eruption of Mount St Helens.

- On the **Analysis** ribbon click on **Tools**
- in the Geoprocessing toolbox go to 3D Analyst Tools > Raster Surface > Cut Fill

- Fill in the dialog as shown in figure 1.20
  - For **Input before Raster Surface** use the folder button on the right to select the before DEM
  - For **Input after Raster Surface** use the folder button on the right to select the after DEM
  - Give the **Output raster** a name you'll remember and put it in one of the folders in your project
- Click on Run

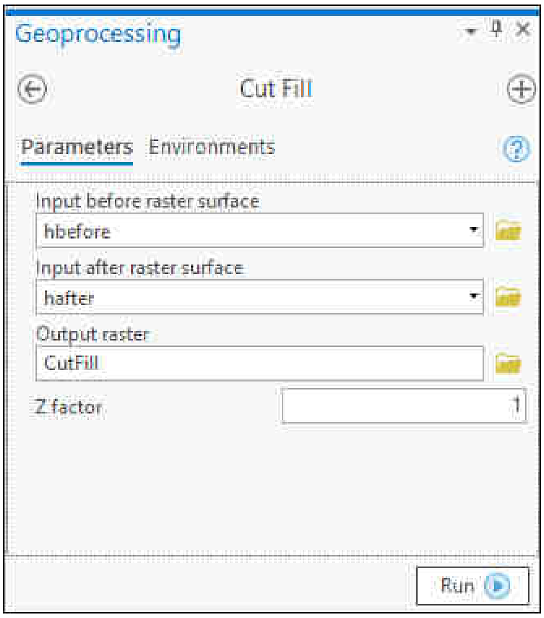


Figure 1.20: Filling in the Cut Fill tool

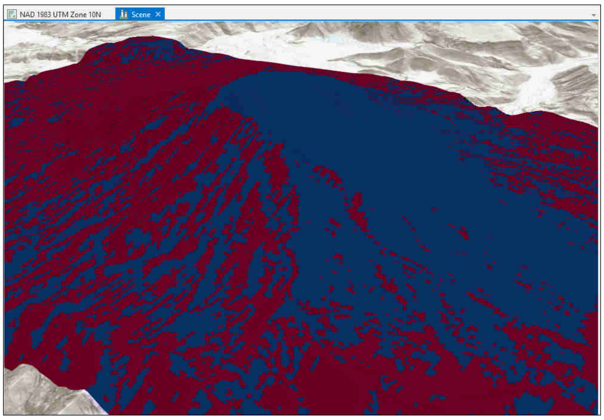


Figure 1.21: The output of the cut fill tool draped over the scene

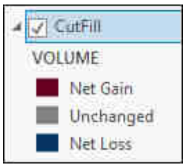


Figure 1.22: The key to the result of the cut fill tool

Figure 1.21 shows the result of the cut fill tool draped over the landscape in a scene. The red areas show a net gain, the blue a net loss, any grey areas would be unchanged. This layer could complement the volume measurements that you gained in section 1.5 on page 8.

1.7.7 Including a scene in a layout

It is possible to include your scene in a layout in exactly the same way that you can include a map.

From within a layout

- click on the arrow underneath **Map Frame** button on the **Insert** tab of the ribbon
- In the list that appears choose a **Scene**
- then wait a while for it to appear on your layout!

You can move the scene around and resize it on the layout in exactly the same way that you can move and resize a map frame.

- If you want to change the view then you need to right-click on the **Map Frame** which contains your scene and **Activate**, exactly as you would for a flat map.
- Once you've done this you can use the usual 3D navigation tools to move the view around.
- When you've finished click on **Layout** at the top left of the layout to return to the layout view.

To export or print the layout use the instructions in the Layout and Presentation chapter of the main workbook.

1.7.8 Exporting a 3D view

Once you have a useful view in Scene you can export it as an image to import into other programs, such as Word or Powerpoint.

- Go to the **Share** tab of the ribbon
- Click on the **Map** button in the **Export** group
- choose where you want to save the output, and what format you want (png or jpg will import into Word or Powerpoint)
- Check the Resolution - higher gives higher quality, but a bigger file - experiment but don't go higher than 600 without being very careful. 300 is usually enough.
- Export

1.8 Other suggestions for analysis

Arc contains a large number of tools for working with data. Try out some of the following and think about how you could use them with other datasets.

If you are not sure what information you need to enter in a particular field in a tool dialog click on information symbol which comes up when you hover over a field. That will give you a brief explanation. If you are still stuck then try clicking on the question mark at the top of the tool and you should be taken to the full information in online Help.

1.8.1 Creating contours

Try creating contours for the before and after DEMs of Mount St. Helens.

Hint: Geoprocessing > 3D Analyst Tools > Raster Surface > Contour

This can be very useful if you have a DEM but no contours and want to create a base map for mapping.

1.8.2 Viewshed analysis

Viewshed analysis shows which parts of a scene an observer at a particular point would be able to see.

Try creating a point feature class and placing a point somewhere on the map of Mount St. Helens. Then Geoprocessing > 3D Analyst Tools > Visibility > Viewshed.

1.8.3 Slope and aspect

Both of these tools produce an output raster. Slope shows the angle of slope or steepness of each part of the map. Aspect shows in which direction the slope is facing.

Both are under Geoprocessing › 3D Analyst Tools › Raster Surface.

1.9 Layout suggestions

You have created a lot of output in this exercise try and think about ways in which you can create an attractive layout showing the effect of the 1980 eruption on the shape of Mount St. Helens.

- Try putting together a layout that includes the before and after hillshades symbolised with the DEMs.
- Export a 3D view from the Scene and include it as an image in your layout.
- Include before and after profiles taken across the same line from north to south.
- Add an extent rectangle making use of an outline country map from `https://www.naturalearthdata.com/`. Show the location of Mount St. Helens within the United States.

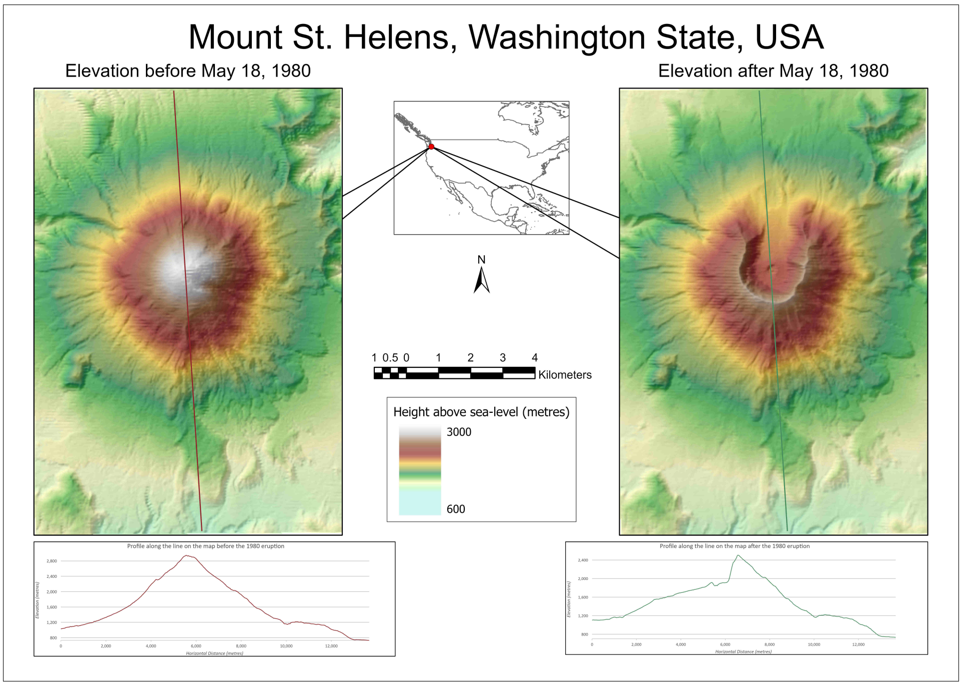


Figure 1.23: Example layout for the Mount St Helens map

Chapter 2

Working with 3D datasets: Dunes in the Paraná River

2.1 Introduction

This exercise is based on data collected by Dan Parsons[1] from the Paraná River on the border between Argentina and Paraguay. Dan's research interests include the sedimentology of large rivers and this dataset shows the form of the sediments close to the confluence of the Paraná and Paraguay Rivers. Dan is interested in the dynamics of these dune bedforms and how they build up units of deposits in larger bars and channels over longer periods of time.

Figure 2.1: Parana River. ANDY ABIR ALAN [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

2.1.1 Data

The data was collected using multibeam echo sounding and consists of a grid of point measurements that you will import into Arc and use to create a surface that shows the form of the river bed. The area covered is approximately 1200 m by 400m. We'll convert the feature class to a **raster** file and then use raster functions in Arc to explore the data further in both 2 and 3D.

[1] If you would like to find out more Dan's web page is at `https://www.hull.ac.uk/faculties/staff-profiles/daniel-parsons.aspx`. Dan was a member of staff here in Leeds before he moved to Hull. Details about the project, and more photographs of the Paraná River, are at `http://about.brighton.ac.uk/parana/`

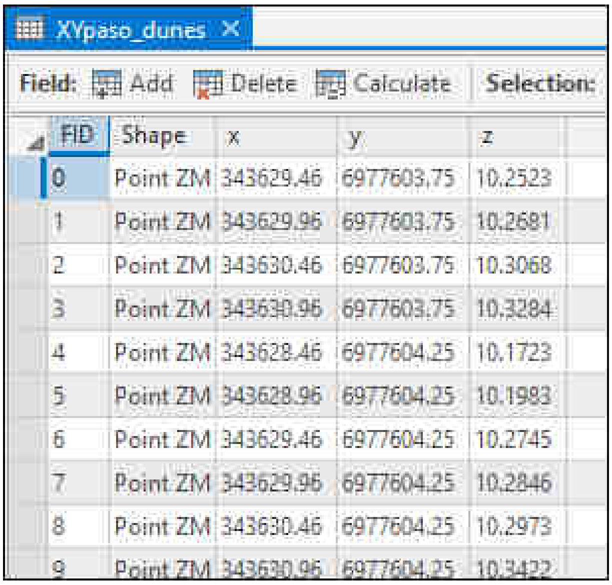
2.2 Setting up your map

Start by adding the data to your map.

- Open ArcGIS Pro and create a new map project in your gis folder
- Download the data for this exercise from Minerva and unzip it to the project folder
- add the **XYpaso_dunes** feature class from the unzipped data to the new map

> ***Have a look at the data you have just added by zooming in very close, e.g. 1:50, and have a close look at it. What can you see? Use the Explore tool[a] to click on a few points and have a look at the attributes.***
>
> ***Zoom back to the layer extent.***
>
> [a]Check the main workbook if you need a reminder about this tool.

The data that you have just added to your map is a point feature class which has x,y and z columns for each point. x and y are the coordinates for each point, z is **height** in metres - see a small portion of the attribute table in figure 2.2.



FID	Shape	x	y	z
0	Point ZM	343629.46	6977603.75	10.2523
1	Point ZM	343629.96	6977603.75	10.2681
2	Point ZM	343630.46	6977603.75	10.3068
3	Point ZM	343630.96	6977603.75	10.3284
4	Point ZM	343628.46	6977604.25	10.1723
5	Point ZM	343628.96	6977604.25	10.1983
6	Point ZM	343629.46	6977604.25	10.2745
7	Point ZM	343629.96	6977604.25	10.2846
8	Point ZM	343630.46	6977604.25	10.2973
9	Point ZM	343630.96	6977604.25	10.3422

Figure 2.2: Part of the attribute table of XYpaso_dunes showing the x, y and z fields. There are a total of 2,276,612 points in this feature class.

2.3 Converting a feature class to Raster

The layer we have added first is a feature class, so it is vector. For the rest of the analysis that you will be doing the layer needs to be converted to a **raster** layer.

- On the **Analysis** ribbon click on the **Tools** button to open the **Geoprocessing** panel
- Toolboxes > Conversion Tools > To Raster > Feature to Raster.
- Select the feature class as the **Input features** and for **field** choose **z** - the height field.

- **Output raster** - choose where you want to save the output (not the default geodatabase!) and give it a name.
- Output cell size at 1 (see figure 2.3)
- then click Run. Be patient - there are over 2,000,000 data points and it can take a while to process.
- Arrange the layers so that you can see the new raster surface and turn off the **XYpaso_dunes** feature layer so that it doesn't redraw (slowly!) on each screen update.

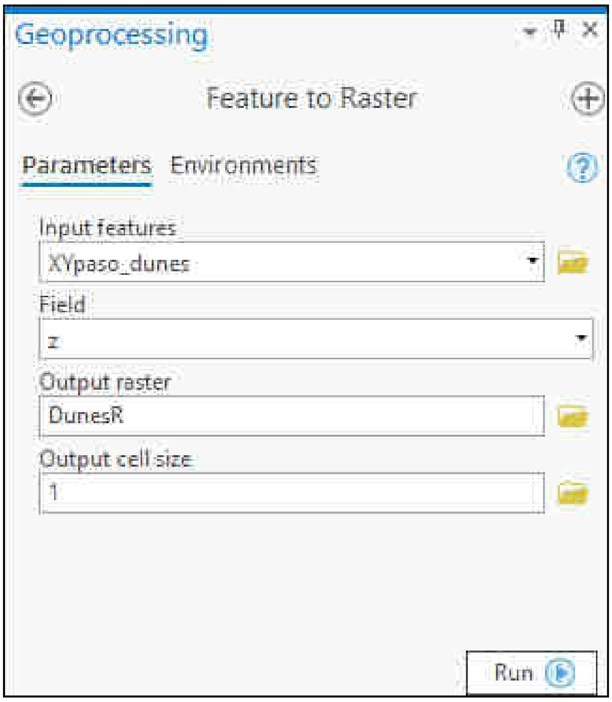


Figure 2.3: Converting a feature class to raster

Check the Coordinate System of the map by going to the map properties Coordinate Systems tab, and make a note of it below. It should have been set automatically because the first layer that you added was a vector feature class.

2.4 Symbolise surface

Arc may have automatically classified your data into discrete classes and symbolised it accordingly. In this case we have a continuous surface so it makes more sense to symbolise the layer as continuous - or **Stretched**.

- Right-click on your new layer and go to Properties > Symbology.
- Check that the type of symbology has been set to **Stretched** and if it hasn't change it now.

- Change the **Color scheme** to a colour version of your choice using the dropdown list.
- Scroll down and change **Stretch Type** to **Min-Max**.

The map should update automatically to your new colour scheme. Once you have a scheme you are happy with you should be able to see a 2D planform map, such as figure 2.4, of the dunes on a part of the bed of the Paraná River. The colours represent surface height - look at the layer in the table of contents to see what heights they show.

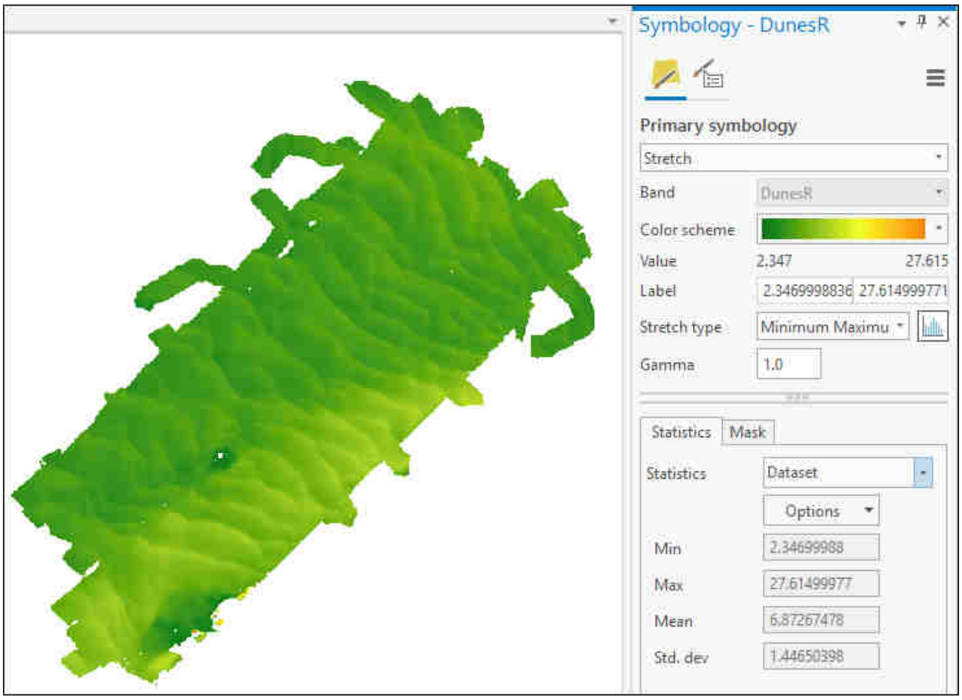


Figure 2.4: The Paso dunes layer with a stretched symbology applied - uses minimum and maximum from the dataset. You won't necessarily have chosen the same colour scheme.

Because there are outliers in the data (towards the southern corner) most of your layer will be towards the lower end of the colour scheme. To show the lower values better:

- Go to the symbology for the layer again
- In the panel below the choice of stretch type go to **Statistics** and change to **Custom**
- Edit the min and max boxes below that to read
  - **Min** = **3.5**
  - **Max** = **11**
- The legend in the Contents panel doesn't update, but the map itself should, so go up to where there are two boxes next to **Label** and enter the same min and max values in there - figure 2.5

Again, zoom in very close, e.g. 1:50. Now what can you see?

Use the Explore tool to have a close look at the data by clicking on several locations. How does this compare to the original dataset?

Zoom back to the layer extent.

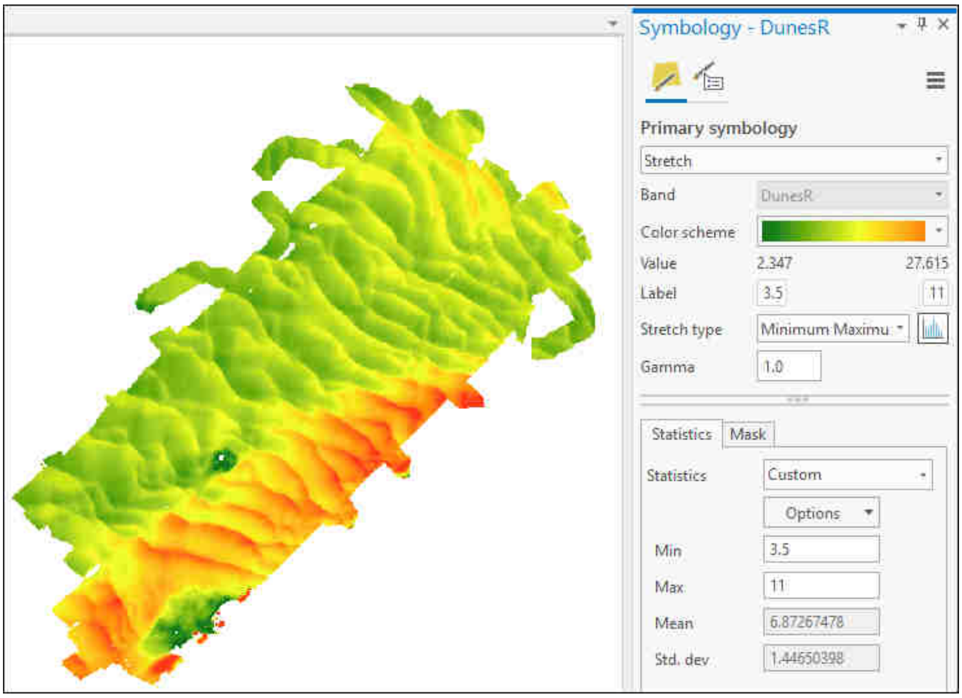


Figure 2.5: The Paso dunes layer with a stretched symbology applied which uses your custom minimum and maximum values. This should give a clearer view of the shape of the dunes - compare it with figure 2.4. Note the Statistics settings. You won't necessarily have chosen the same colour scheme.

2.5 Profile graphs

Another way to view topography is to draw a profile. This will allow you to see a profile along a line, and in this case allow you to view profiles for various parts of the dataset.

First you have to create a line feature which contains height data from the dunes layer:

- Start by creating a new line feature class in the geodatabase, making sure that the coordinate system matches the one used for the map, and drawing a line from north-east to south-west across the Dunes dataset. Check back to the main workbook if you need to remind yourself of how to do this.
- From the Analysis ribbon click on **Tools** and go to the **Interpolate Shape** tool - Geoprocessing > 3D Analyst Tools > Functional Surface > Interpolate Shape
- Fill in the dialog as in figure 2.6
  - The **Input surface** should be the dunes raster layer
  - **Input Features** is the line across the dunes that you have drawn
  - Give your **Output Feature Class** a name which reminds you that it is based on the dunes layer
- The other defaults are fine, so click the Run button

Your new line feature class should be added to your map, if it isn't, then drag it across from the Catalog. Your map won't look much different.

To create the profile:

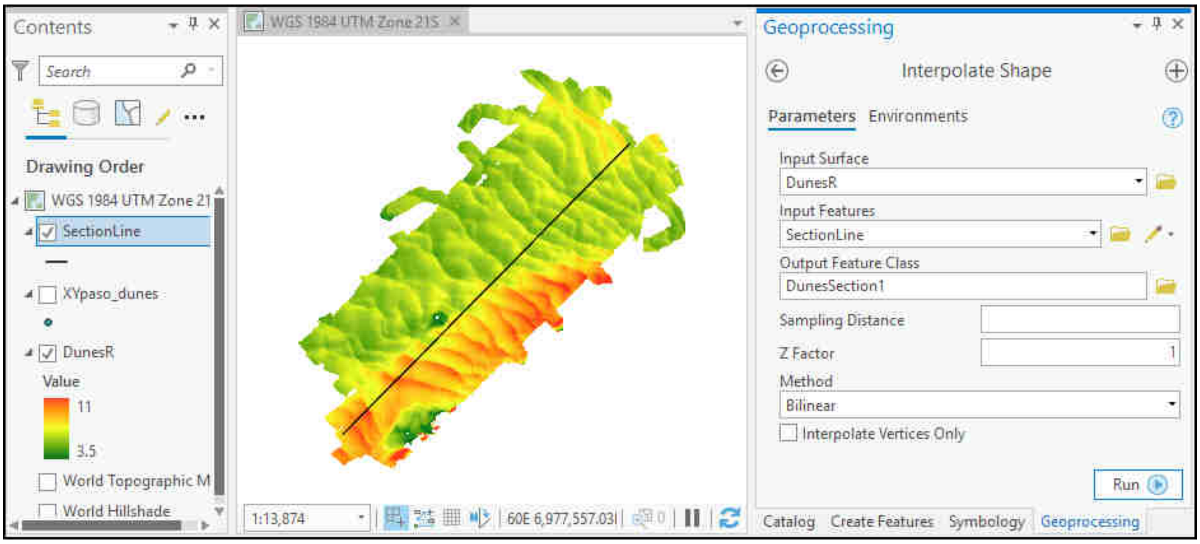


Figure 2.6: Using the Interpolate Shape tool to add height data from the dunes layer to the Section Line

- Select the **dunes** section line in the Contents and right-click
- Create Chart ❯ Profile Graph

Arc should open a new panel below your map which contains the profile across the dunes layer - see figure 2.7. This will probably be very vertically exaggerated!

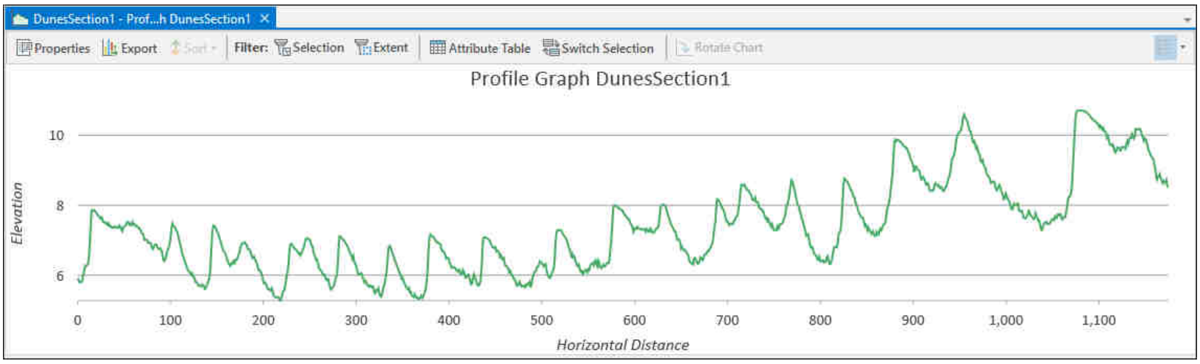


Figure 2.7: The profile graph across the dunes layer - very vertically exaggerated! Try using the graph to measure the distance between the dunes.

If you click on **Properties** at the top of the panel you can change the format and the title, as well as other items.
By clicking on **Export** you can save the profile graph as a graphics file, e.g. svg, png or jpg.

> ***Repeat the process to create a profile graph for a different part of the dunes layer.***

Once you have created a graph it is listed in the Contents pane under the layer to which it applies. If you close it, you can open it again by clicking on the appropriate graph in the Contents.

> ***Have a look at both of the graphs you have created. Resize them and use the properties to give them appropriate titles and axis labels.***

2.6 Cell resolution

Repeat the process in section 2.3 to create another raster file from the feature class, but this time enter the Output cell size as **10 m**.

As usual, have a look at the new layer in detail. What is the difference between this one and the first one that you created?

Why do you think this is? Use the Swipe Layer tool (from the Appearance tab of the ribbon)[a]) to compare the layers.

[a]The **Swipe Layer** tool allows you to "roll back" a layer so that you can see the layer below. Select the layer that you want to swipe; then select the swipe tool; Use the mouse to "roll" the layer up and down or side to side.

You should see from this that the **Output cell size** controls the *resolution* of your data. The first layer was converted as 1 metre cells, this one was converted as 10 metre cells. It means that the resulting layer will load, and display much faster, but will contain much less detailed information. When you are converting large datasets you have to decide what resolution to work at depending on the power of your computer and the disk space that you have available, but also keep in mind the amount of data that you need for your analysis.

2.7 Add context with satellite imagery

ESRI, the company who own ArcGIS, provide a lot of data via the web. It is really simple to use in ArcGIS via ESRI Basemaps, though it can have some limitations!

Warning: adding online data can slow Arc down significantly, or cause it to crash completely. If you are having trouble with a map try removing any online/basemap layers.

- From the **Map** tab of the ribbon click on **Basemap**
- From the list of options choose **Imagery**

Be patient while the layer loads. If it won't load and complains of lack of memory you will need to close Arc then open it again - the previous operations will have been very memory intensive!

Zoom out to look at the wider geographical context of the dune field. Make sure that your raster layer showing the dunes is above the imagery layer so that it is still visible.

What can you tell about the geomorphology of the Paraná River from the view you are looking at?

2.8 Viewing your map in 3D

Within Arc it is possible to view your maps in 3D by creating a **Scene**. We'll look at this now with the data you have already, but it's something you can do with any data that you create in future too.

Video Clip available in Minerva - Viewing your map in 3D in ArcGIS Pro

2.8.1 Creating a Scene

To set up an empty scene within your existing project:

- Go to the **Insert** tab of the ribbon
- Click on the down arrow under the **New Map** button
- Click on **New Local Scene**

Arc will create a new scene which currently looks very much like a new map - something like figure 3.11. Note that the new scene appears under the **Maps** subheading in the Catalog. In the Contents pane the Drawing Order view now shows layers divided into **3D Layers** and **2D Layers**.

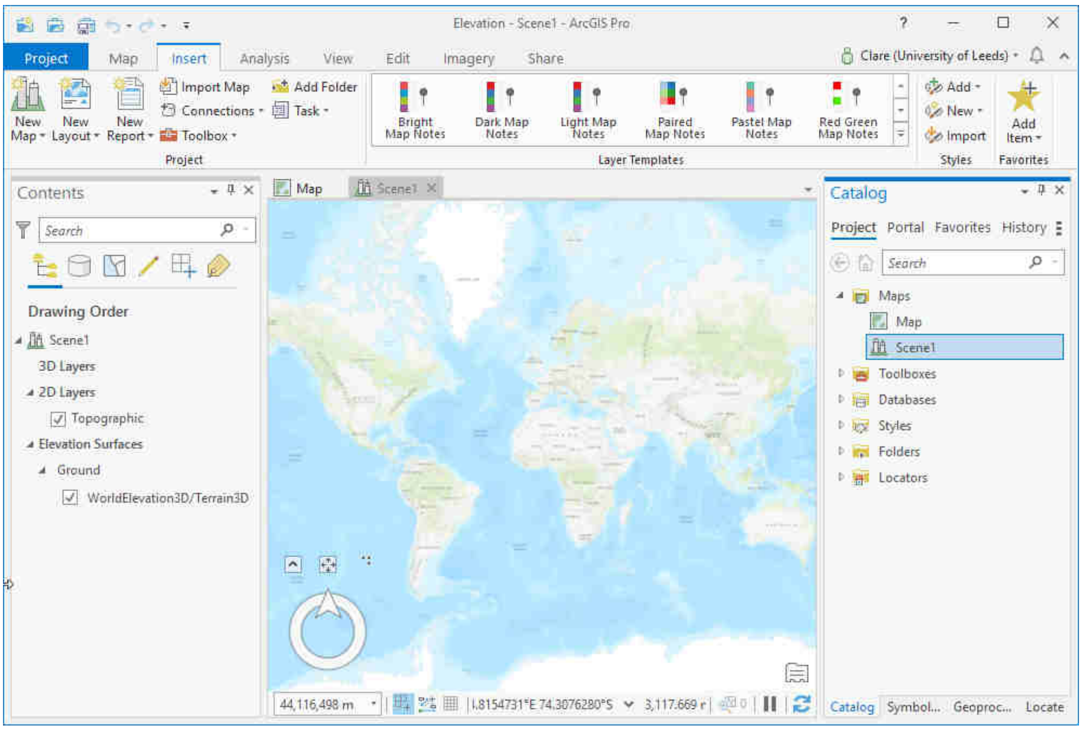


Figure 2.8: The initial view when you create a new local scene

2.8.2 Adding layers to a scene

You can add layers to a scene in exactly the same way as adding them to a map.

- Find your **dunes raster layer** in your catalog pane and drag and drop it onto the scene

You should find that your scene zooms to the correct location, but your data will be symbolised as the default again. To add the data with the symbology preserved from the map try the following:

- Go to the map view and right-click on the raster dunes layer in the Contents pane - **Copy**
- Return to the scene and right-click on the **Scene** title at the top of the Drawing Order in the Contents, now select **Paste**

Hopefully you'll now see the same symbology that you set in the map.

2.8.3 Navigating in a Scene

ArcGIS Pro Help has information on how to navigate in 3D at `http://bit.ly/32pZWOB`. The main difference from navigating in a map is that you can use the mouse wheel to "tip up" the map and rotate it, or use the navigation tool at the bottom left of the map to move around. Try this now.

It should quickly become obvious that the dunes layer is draped over the landscape as it is now.

2.8.4 Changing the background layer

You can also change the **Basemap** in exactly the same way as you can change it in a map.

> ***Change the basemap to Imagery now and use the navigation tools to zoom in and view the scene from a lower angle.***

This is a flat landscape so you can't see much elevation, but it should become clear that your dunes layer is completely flat on the top of the river.

2.8.5 Controlling the elevation surface

You'll notice that Arc sets a default **elevation surface** - i.e. data which controls the terrain, or 3D surface. It is possible to make changes to this, and indeed to set your own elevation surface.

To change any of the properties of the elevation surface

- Select **Ground** under the **Elevation Surfaces** heading at the bottom of the contents panel
- Click on the **Appearance** tab on the ribbon to get the properties for the elevation surface - figure 3.12

Vertical Exaggeration The default vertical exaggeration is **1.0** - which basically means as in reality. While scientifically this is usually the best setting to use, sometimes you need to exaggerate the terrain to show useful information.

- In the Scene Appearance tab, change **Vertical Exaggeration** to **4.0**
- You'll probably need to be patient again while the Scene redraws then zoom outwards so that you can see the dunes again!

The difference between an exaggeration of **1.0** and an exaggeration of **4.0** should be pretty clear - see figures 3.13 and 3.14.

Return the exaggeration to **1.0** before continuing with the next task.

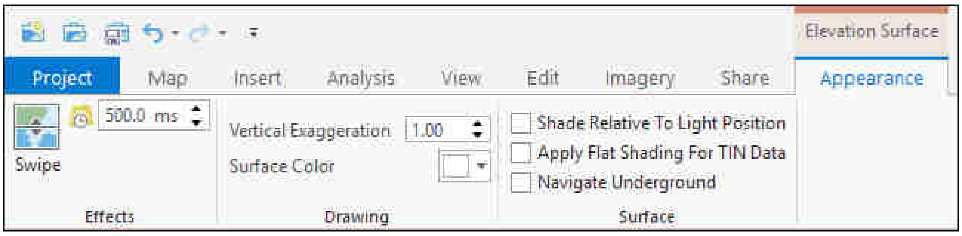


Figure 2.9: The properties for the elevation surface for the current scene

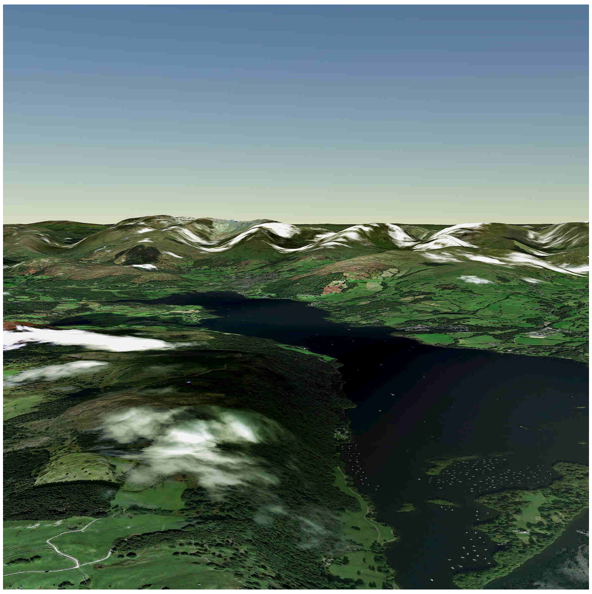


Figure 2.10: The view across Windermere with a vertical exaggeration of 1.0.

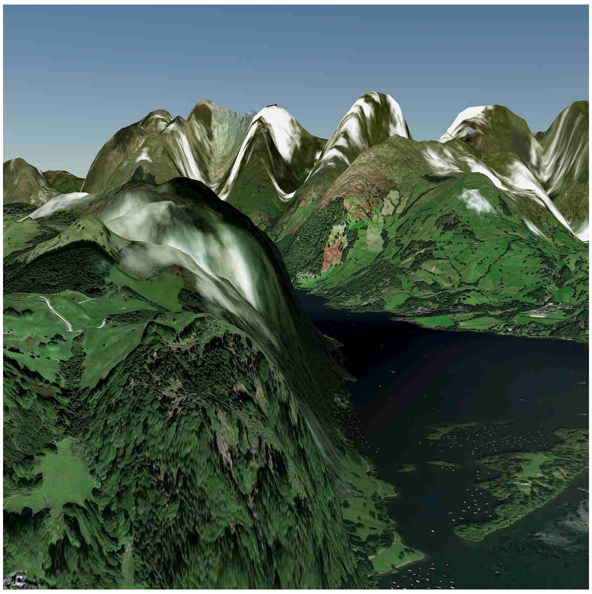


Figure 2.11: The same view across Windermere with a vertical exaggeration of 4.0.

Adding a custom elevation surface

Sometimes it is more useful to see your own data as the elevation surface. For example, we can use the dunes layer as an elevation surface to see the shape of the dunes.

- Right-click on **Ground** under the **Elevation Surfaces** heading at the bottom of the contents panel
- Add Elevation Source and navigate to the data folder to select the **dunes** raster dataset then click OK

This may look a bit odd as you'll still have the ESRI Imagery layer showing the current land surface but the dunes will appear as a "hole" in the river!

If you add a custom elevation surface, but leave the World Elevation layer on, then areas outside of your DEM will still have elevation.

Explore the dunes layer from various angles and try changing the vertical exaggeration again.

What happens if you right-click on the WorldElevation3D/Terrain3D layer and Remove it?

2.8.6 Including a scene in a layout

It is possible to include your scene in a layout in exactly the same way that you can include a map. From within a layout

- click on the arrow underneath **Map Frame** button on the **Insert** tab of the ribbon
- In the list that appears choose a **Scene**
- then wait a while for it to appear on your layout!

You can move the scene around and resize it on the layout in exactly the same way that you can move and resize a map frame.

- If you want to change the view then you need to right-click on the **Map Frame** which contains your scene and **Activate**, exactly as you would for a flat map.
- Once you've done this you can use the usual 3D navigation tools to move the view around.
- When you've finished click on **Layout** at the top left of the layout to return to the layout view.

To export or print the layout use the instructions in the Layout and Presentation chapter of the main workbook.

2.8.7 Exporting a 3D view

Once you have a useful view in Scene you can export it as an image to import into other programs, such as Word or Powerpoint.

- Go to the **Share** tab of the ribbon
- Click on the **Map** button in the **Export** group
- choose where you want to save the output, and what format you want (png or jpg will import into Word or Powerpoint)
- Check the Resolution - higher gives higher quality, but a bigger file - experiment but don't go higher than 600 without being very careful. 300 is usually enough.
- Export

2.9 Suggested elements to add to a layout in Arc

The final step of the project is to present the various elements that you have created in an Arc layout as a presentation for colleagues to view. There are some ideas below and also have a look at figure 2.12. As usual, you can make your own choices about layout - the example is not the only possibility.

- Insert a layout, add the map frame and resize it so that there is space for a picture and the profile graph.
- Add the profile graph that you created earlier
  - With the layout open check that the section line for the profile is ticked in the Contents so that it is visible
  - On the **Insert** tab of the ribbon click on the arrow under **Chart Frame**
  - Select the required section from the list provided and then click on your layout
  - You can resize and move the chart frame as required
  - Annotate the graph with the space between the dunes that you measured earlier.
- Add other elements to your layout such as a scale for the map, a title, an extent indicator and acknowledgement of the sources of the data to produce an informative handout.

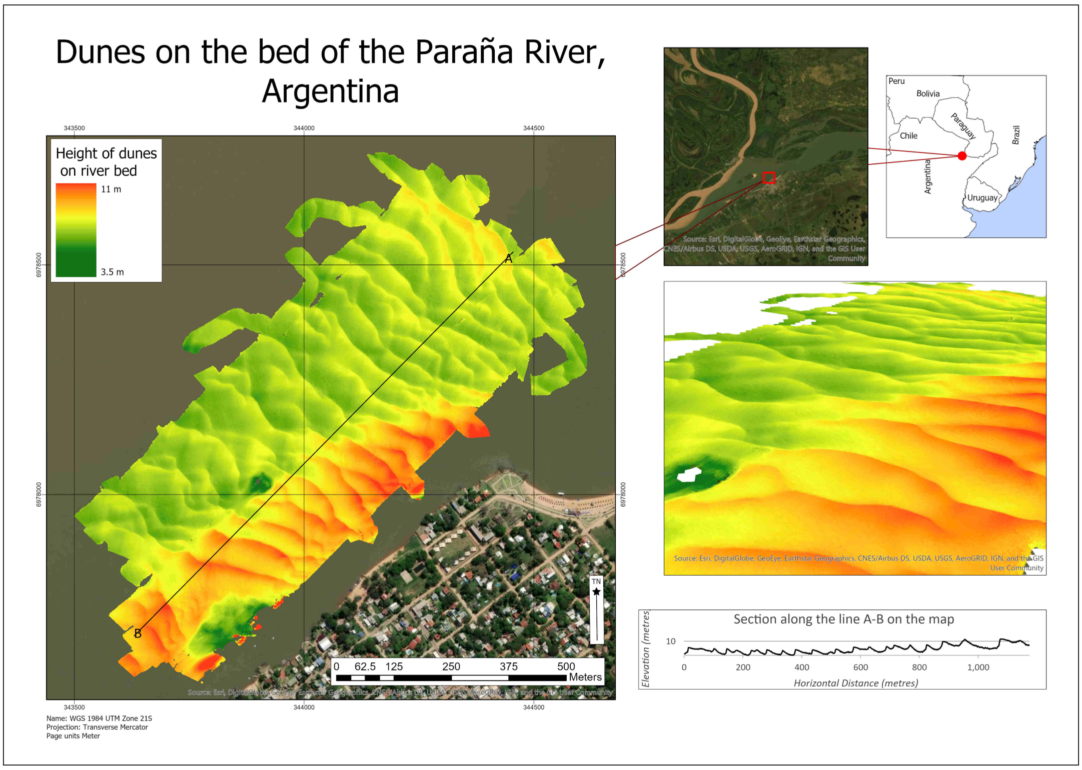


Figure 2.12: Example layout for the Paso Dunes exercise

Chapter 3

Working with point sampled data: Lead concentrations in Cononish, Scotland

3.1 Introduction

The glen of the River Cononish near Tyndrum in Scotland has historically been a lead and gold mining area. You may have seen news about the reopening of a gold mine in the area recently. Using data from stream and soil samples we will look at ways of processing and displaying the data in ArcGIS to investigate possible lead contamination. The techniques in this chapter could be applied to all sorts of point sampled data, not just geochemical.

3.1.1 Data

The data was collected as part of a student project in 2009 and is presented as an Excel spreadsheet which gives you details of the locations of the stream and soil samples and the lead concentration (in parts per million - ppm) in each sample. The spreadsheet and a shapefile which outlines the study area can be downloaded from Minerva - the **Cononish.7z** file under "Data for supplementary Exercises".

3.2 Setting up your map

Open ArcGIS Pro and create a new project called **Cononish**.

Using **Digimap** download the following data:

Search for *Cononish* ***in the download section to find and download the following dataset for at least the area shown in figure 3.1:***

- ***OS 1:25 000 Raster***

- Add the **1:25 000 raster** tile(s)) to your map.
- Remember that it can be a good idea to **remove** the default ESRI base map layers - probably **World Topographic Map** and **World Hillshade**. These can cause your map to slow down and/or crash.

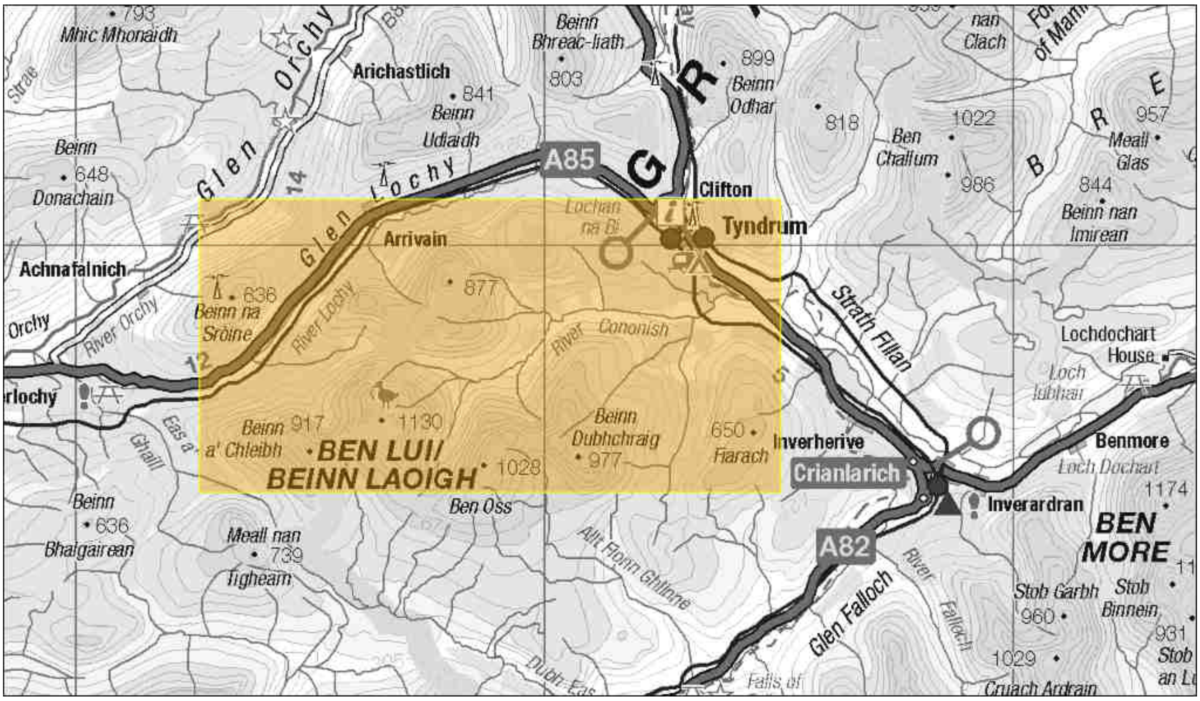


Figure 3.1: Download data for at least the area marked in orange on this map.

3.3 Importing xy data

Download the **Cononish.7z** file from Minerva, unzip it and open the Excel spreadsheet to have a look at the data.

You have a file which includes grid references for the British National Grid converted into 12 figure grid references (columns headed **x** and **y**) and lead concentrations from soil and stream samples in parts per million (ppm).

Close the spreadsheet and make sure that your Cononish map is open in Arc.

3.3.1 Converting .xls or csv to a feature class

This works for either Excel files or csv (**c**omma-**s**eparated **v**alue) files. Indeed, **if you are having trouble loading an Excel file**, try saving it as csv in Excel[1], then import it to Arc using the instructions below. It often works much better than the Excel file.

In the Catalog pane in Arc:

- For an Excel spreadsheet
  - click on the down arrow next to the Excel file to show the contents (figure 3.2)
  - You should be able to see at least one layer with a name which ends with with a **$** sign.
- For a csv file
  - work with the file directly, there won't be layers underneath it

[1]Save from Excel to csv as follows: File > Save As choose a location then under **Save as type:** choose **CSV (Comma delimited) (*.csv)**.

If you add the file to Arc as it is you won't be able to view it on a map - though you can see the grid references these currently don't mean anything to Arc. To be able to view the data on a map you need to convert the table to a feature class. As part of this process you'll be telling Arc where to find the grid reference of each point is so that it can place it on the map.

- In the Catalog pane right-click on the data sheet to be imported and go to Export » Table to point feature class...
- This will open the geoprocessing tool, fill it in as shown in figure 3.3
  - Select either the excel spread sheet or the csv file by clicking on the folder icon next to **Input table**
  - Choose a location and name for the **Output Feature Class** - the best place is probably inside the project geodatabase
  - Fill in the X and Y Fields using the spreadsheet columns which show the coordinates in British National Grid. You don't need to worry about the Z field.
  - Click on the icon next to Coordinate System and select **British National Grid**
- Run the tool

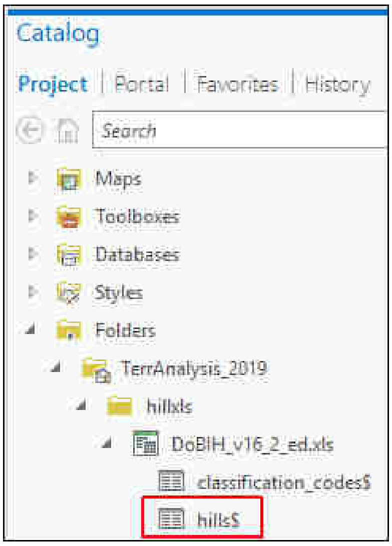


Figure 3.2: Excel file in Catalog opened out to show contents

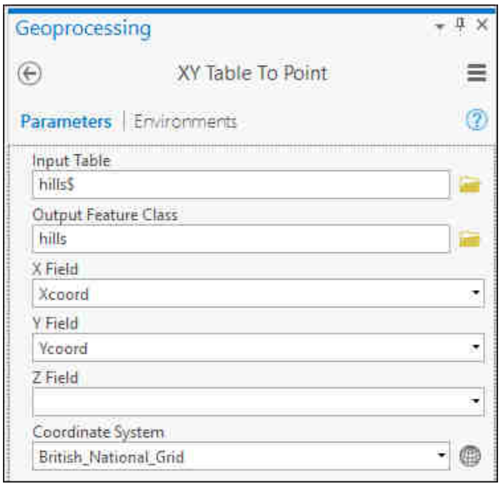


Figure 3.3: Creating a feature class from an XY Table (your field and file names probably won't be the same as this)

The output feature class should be added to your map automatically. If it isn't, in the Catalog browse to the location that you chose to save it and drag and drop it on to your map.

3.3.2 Reviewing the data

- Zoom in to the new layer with **Zoom to Layer** and look at the area it covers. Each point is the location of a sample reading.
- Zoom in further and have a look at the 1:25 000 map that you added in section 3.2, particularly noting the locations of mines.
- Open the attribute table and have a look at it. How does it compare to the original Excel spreadsheet?

- In the attribute table sort the **concentration** column (right-click on the column header and select either **Sort ascending** or **Sort descending**) and make a note of the highest and lowest values in the box below. This information will be useful later.

Highest:

Lowest:

3.4 Visualising the data

Now that you have the points from the spreadsheet imported into Arc you can start symbolising them to visualise the data in a more user-friendly fashion.

3.4.1 Symbolising points

We'll start with the simplest way of showing different concentrations on the map - graduated point symbols.

- Select the **Pb Concentration** layer in the contents then go to the **Appearance** tab of the ribbon.
- Click on the down arrow under **Symbology** and choose **Graduated Symbols**
- The Symbology pane should open on the right of your map.
- Set the **Field** to **concentration**.

The resulting symbols should vary in size depending on the lead concentration at that location (figure 3.4).

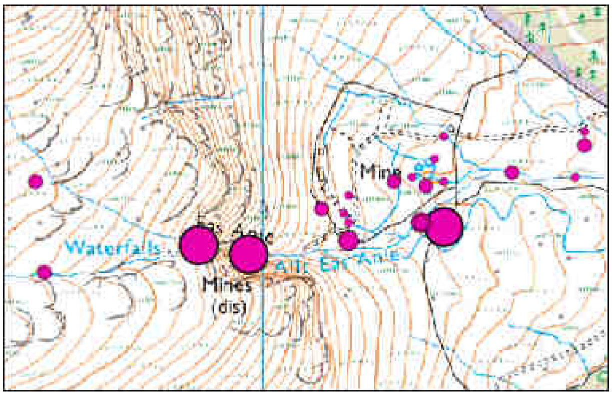


Figure 3.4: Lead concentrations symbolized as graduated sizes

- Try changing some of the other options on the symbology pane, such as the number of classes or the symbol. Try different **methods** of classifying the data, such as Quantile or Equal Interval. Each time have a look at the changes on the map and think about how this shows the range of your data.

- In addition try setting the symbology type to **Proportional Symbols** rather than **Graduated symbols**. You'll need to select the correct field name again. With this symbology you should also see a histogram below the symbology dialog which gives information on how many data points are in each class.

> ***At a quick look, do these ways of symbolising your data show any correlation between lead concentrations and mine locations?***

3.4.2 Interpolating a surface

This shapefile shows the lead concentration at each particular point. What do you do if you want to know the potential concentration at any other point between those points, or over an area? Arc gives you the tools to **interpolate** point data and calculate *z* values, or **totals**, for the spaces between the points. Inevitably the accuracy of the surface will increase if you have more data points in a particular area, but it still works if your points are widely spaced.

There are different methods of interpolation available in Arc. The instructions below use Inverse Distance Weighted (IDW) as that works well for this geochemical data, but try Spline, Natural Neighbor and Kriging too and have a look at the differences. Different methods work best for different data. There is more information in ArcGIS Help - search for **Raster interpolation**. Also see ArcUser for a useful article which is freely available online - `http://www.esri.com/news/arcuser/0704/files/interpolating.pdf`

Video Clip available in Minerva - Interpolating surfaces from point data.

We'll perform interpolation on a section of the data defined by a polygon layer. Otherwise 3D Analyst interpolates an area based on the extent of the point layer.

- Download the **ConoonishArea** zip file from Minerva, unzip and add the resulting shapefile to Arc. Symbolise so that the outline is visible but the polygon has no colour.
- Tell Arc that you only want to process data for the area within the ConoonishArea polygon by going to the **Analysis** tab of the ribbon then Environments › Processing Extent › Same as Layer › ConoonishArea.[2]
- Now carry out the interpolation - on the **Analysis** tab of the ribbon click on the **Tools button** then go to Toolboxes › 3D Analyst Tools › Raster Interpolation › IDW Enter the settings as in figure 3.5
  - The **Input point features** are your lead concentration layer
  - The **Z value field** is the field which holds the concentration values
  - Give the **Output raster** a name which means something to you, e.g. IDW_PbConc
  - Set the **Output cell size** to **5**
- Then Run.

The surface should be automatically added to your map - figure 3.6, but you may need to change it's location in the table of contents so that it is visible.

Try symbolising your layer to make it clearer:

[2]This can be a really useful way of saving time, disk space and processing power. It means you're only running a process and generating data for the area you actually want, not for lots of extra space.

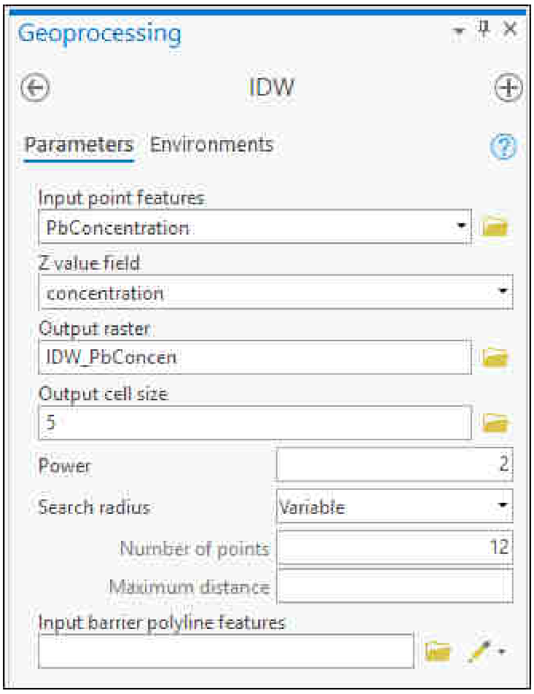


Figure 3.5: IDW tool dialog

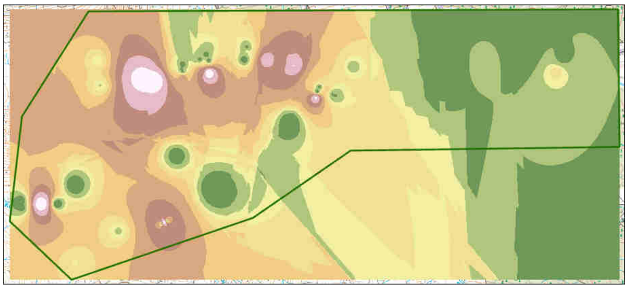


Figure 3.6: The interpolated layer when it is first added to your map. The outline is the CononishArea shapefile.

- Arc may have automatically set the symbology to **Stretch**. If not, select that now.
- Click on the colour ramp and select Show names then choose **Slope** or **Yellow to Red** from the list. Try some other colour ramps too.
- Try playing around with the other symbology settings and see what difference they make to the surface. For example, increase the number of **classes** or try different **Methods**.

Repeat the interpolation but this time choose first **Spline**, then **Natural Neighbor**, then **Kriging**. Have a look at the difference results and think about why they are different based on the article from ESRI. In particular note the high and low values for the interpolated surfaces compared to the original data (you should have made a note of these values in section 3.3.2 on page 32), and the differences in distribution of highs and lows.

Having looked at the interpolated layers select the one that you feel is most representative of the data you started with. Make sure that you make that layer transparent so that the base map is visible, and then remove the other three layers from your map. You'll use your chosen layer to carry out the rest of the tasks in this chapter.

3.4.3 Deriving contours from a surface

Once you have created a surface you can use Arc to derive contours to display the surface in 2D.

- Click on **Tools** on the **Analysis** tab of the ribbon then Toolboxes › 3D Analyst Tools › Raster Surface › Contour. (See figure 3.7.)
- Set **Input surface** to the surface from which you want to derive contours, e.g. the IDW raster surface.

- Set **Output feature class** to the location where you want to save your feature class, e.g. the project geodatabase, and give it a name that means something to you.
- Set the **contour interval** appropriately by looking at the number of units on the surface you are contouring in the contents panel, e.g. for the IDW surface 25 will probably be suitable.
- Supply a **base contour** if required, that is the lowest contour that will be generated. Check the lowest value in your data from the table of contents. It's a good idea to keep the contours as rounded numbers so if your lowest data value is, for example, `-12.43` and your contour interval is 25, put in `-25` as your base contour.
- The **z-factor** is optional. It is used to adjust the units of the data. So a z-factor of 3.28 would convert data in meters to a result in feet. We don't need to do any conversion here so leave it as **1**.
- Run

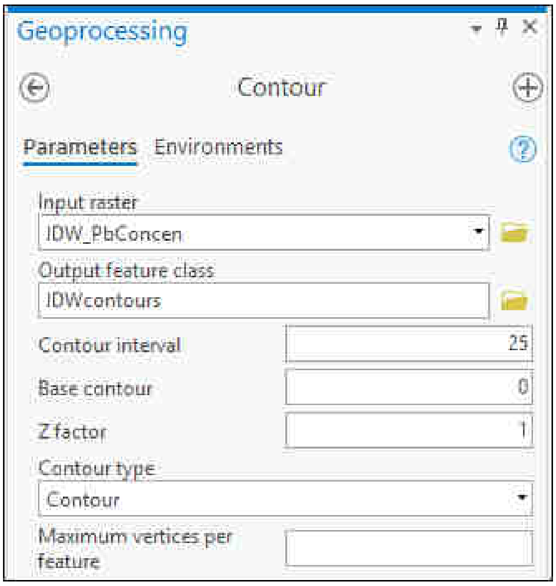


Figure 3.7: Creating contours with the toolbox

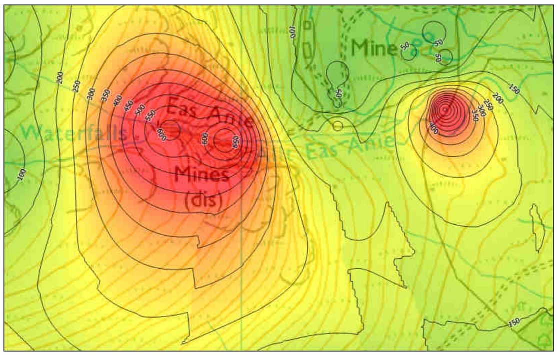


Figure 3.8: Contours generated from the IDW surface at 50 unit intervals. The units in this case are ppm.

Arc should generate contours and add them as a layer to your map. Try running the tool again a couple of time, using a different contour interval each time. Have a look at all of the results and see which gives the best view of your data - e.g. enough contours to show the changes in your data, but not so many that they look crowded.

The contours can be symbolised and labelled in the usual manner if required - though preferably not to the same colours etc. as the existing topographic contours!

3.4.4 Buffering to display distance from mines

It is possible to see some of the sites of former mines on the topographic base map. We'll set up a shapefile and digitise these points, then it will be possible to create buffers around the points that show the distances from the main mining activity. Once you've done this it should be possible to look at your map and see how far from the possible source contamination has travelled.

- Create a new point feature class (preferably a feature class in the project geodatabase) called **Mines**.

- Add the feature class to your map and edit it to add points at the locations of any mines or related sites that you can find within the outlined area on the map. There are only a few. Note that the buildings at Cononish itself are also mine-related.
- Remember to **Save** your edits!
- **Clear** any selections
- Open the tools and Toolboxes > Analysis Tools > Proximity > Multiple Ring Buffer.
- Fill in the dialog box as shown in figure 3.9.
  - The **Input features** are the Mines layer
  - Choose a location to save the **Output feature class**, e.g. the project geodatabase, and give the output a name that makes sense to you, e.g. **MinesBuffer**
  - You'll need to add the distances for the width of each ring by typing each one in the **Distances** box. Add widths at 500 m intervals from 500 to 3000.
  - With **Buffer Unit** set to `default` the units should be the same as the map: if your project is in British National Grid this should be metres. If you want to be sure you can set this in the dialog, though.
  - Change **Dissolve Option** to **Overlapping (disks)** so that each buffer is a solid feature from 0 to the distance requested.
- Run the tool

You should end up with a new layer in your table of contents and concentric shapes covering your map - see figure 3.10. Change the symbology so that each distance buffer is a different colour. Set **transparency** of this layer to something like **40%**.

Feel free to change the distance and number of rings to settings that you feel are more useful. Experiment! The distances may be different each time you do this.

Make sure that your symbolised point layer for lead concentrations is visible and have a look at how the concentrations compare to the distance to the mining area. How far have the high levels of lead travelled? Remember that, if you used the distances that I suggested, each ring is 500 m further from the mines than the previous one.

3.5 Viewing your map in 3D

Within Arc it is possible to view your maps in 3D by creating a **Scene**. We'll look at this now with the data you have already, but it's something you can do with any data that you create in future too.

Video Clip available in Minerva - Viewing your map in 3D in ArcGIS Pro

3.5.1 Creating a Scene

To set up an empty scene within your existing Cononish geochemistry project:

- Go to the **Insert** tab of the ribbon

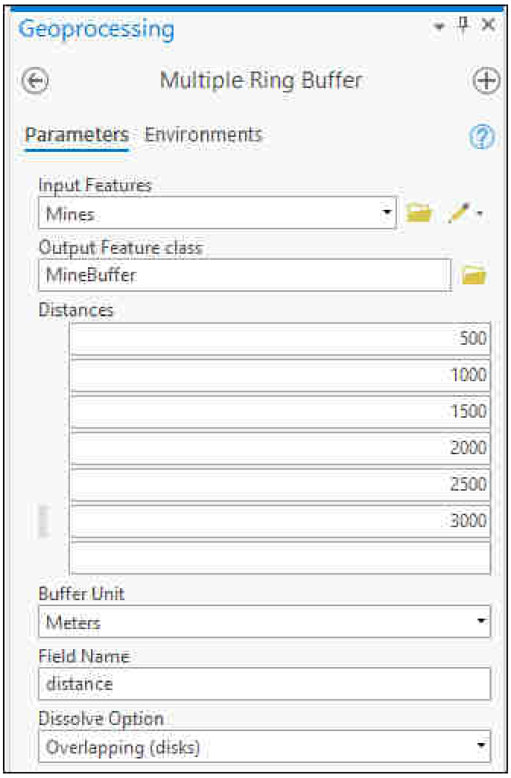


Figure 3.9: Multiple Ring Buffer Tool

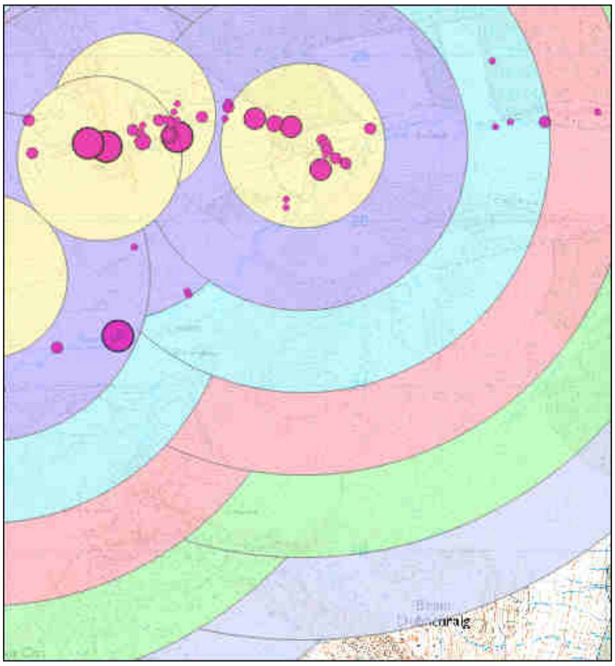


Figure 3.10: The multiple buffers on your map overlain by the symbolised lead concentrations point layer

- Click on the down arrow under the **New Map** button
- Click on **New Local Scene**

Arc will create a new scene which currently looks very much like a new map - something like figure 3.11. Note that the new scene appears under the **Maps** subheading in the Catalog. In the Contents pane the Drawing Order view now shows layers divided into **3D Layers** and **2D Layers**.

3.5.2 Adding layers to a scene

You can add layers to a scene in exactly the same way as adding them to a map.

- Find your Mines point layer in your catalog pane and drag and drop it onto the scene
- You already have your Pb Concentration interpolated surface symbolised in your map, so
  - go back to your map
  - Right-click on the interpolated concentration raster layer in the contents pane
  - Select **Copy**
  - Return to the Scene
  - Right-click at the top of the contents where it says **Scene** and **Paste**

You should find that your scene zooms to the correct location for Cononish and you can view the layers that you added. Because you copied it across the raster surface should have kept the symbology that you gave it in your map.

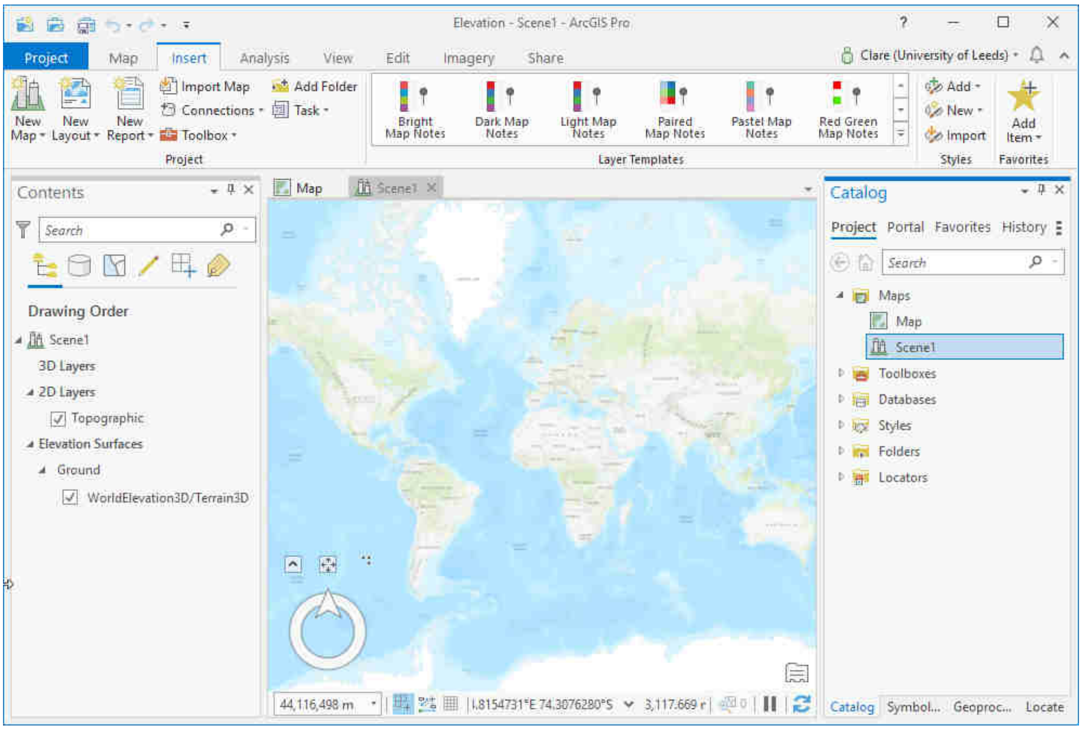


Figure 3.11: The initial view when you create a new local scene

3.5.3 Navigating in a Scene

ArcGIS Pro Help has information on how to navigate in 3D at `http://bit.ly/32pZWOB`. The main difference from navigating in a map is that you can use the mouse wheel to "tip up" the map and rotate it, or use the navigation tool at the bottom left of the map to move around. Try this now.

It should quickly become obvious that the hillshade layers are draped over the landscape as it is now. For now turn off both hillshade layers so that you can see the basemap.

3.5.4 Changing the background layer

You can also change the **Basemap** in exactly the same way as you can change it in a map.

> ***Change the basemap to Imagery Hybrid now and use the navigation tools to zoom in to Cononish and view the scene from a lower angle.***

3.5.5 Controlling the elevation surface

You'll notice that Arc sets a default **elevation surface** - i.e. data which controls the terrain, or 3D surface. It is possible to make changes to this, and indeed to set your own elevation surface.

To change any of the properties of the elevation surface

- Select **Ground** under the **Elevation Surfaces** heading at the bottom of the contents panel
- Click on the **Appearance** tab on the ribbon to get the properties for the elevation surface - figure 3.12

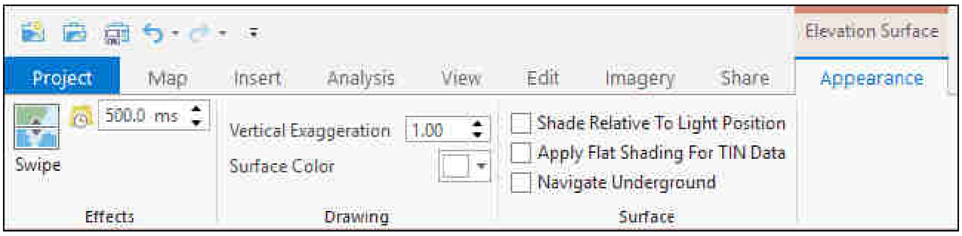


Figure 3.12: The properties for the elevation surface for the current scene

Vertical Exaggeration The default vertical exaggeration is **1.0** - which basically means as in reality. While scientifically this is usually the best setting to use, sometimes you need to exaggerate the terrain to show useful information.

- In the Scene Appearance tab, change **Vertical Exaggeration** to **4.0**
- You'll probably need to be patient again while the Scene redraws then zoom outwards so that you can see Cononish again!

The difference between an exaggeration of **1.0** and an exaggeration of **4.0** should be pretty clear - see figures 3.13 and 3.14.

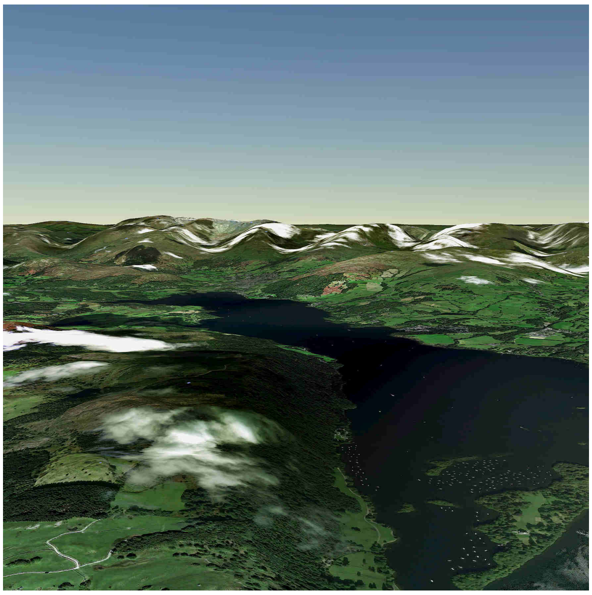


Figure 3.13: The view across Windermere with a vertical exaggeration of 1.0.

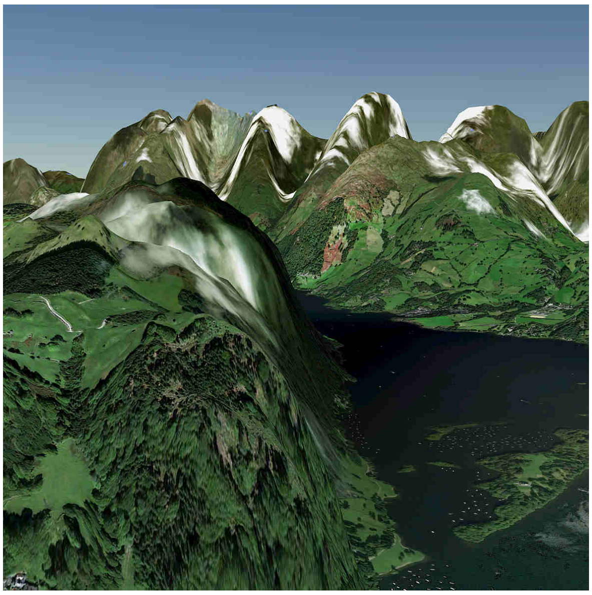


Figure 3.14: The same view across Windermere with a vertical exaggeration of 4.0.

Return the exaggeration to **1.0** before continuing with the next task.

3.5.6 Download dtm files from Digimap

Sometimes it is more useful to set your own data as the elevation surface. The data used by ESRI looks fine, but isn't as detailed as the Ordnance Survey elevation data you can download from Digimap.

DTM stands for **Digital Terrain Model**. You may also see **DEM** meaning **Digital Elevation Model** or **DSM** meaning **Digital Surface Model**. These are raster files which contain points with height data for the land surface.

Use Digimap O.S. Data Download to search for "Cononish" and download Land and Height Data - OS Terrain 5 DTM files in .asc format. Unzip and save the downloaded files to your Cononish folder. See figure 3.15 for the approximate area to download.

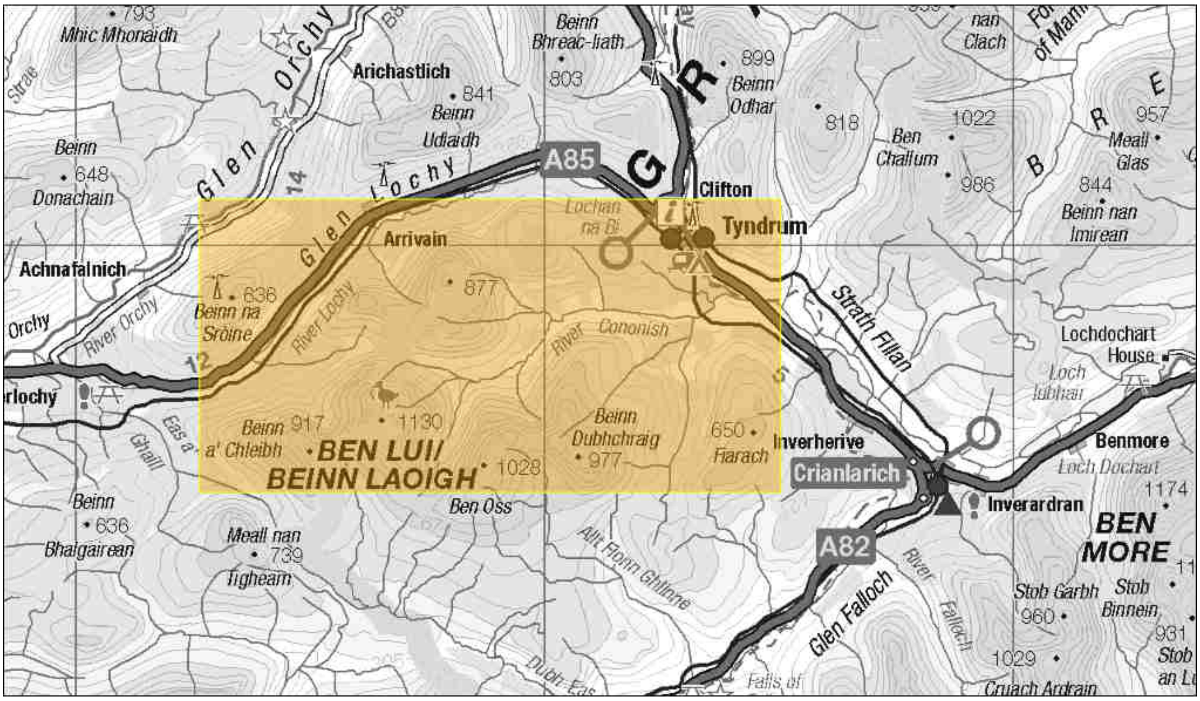


Figure 3.15: Download data for at least the area marked in orange on this map.

3.5.7 Producing "seamless" datasets from more than one tile of dtm data

Often data is provided as tiles, each covering a small part of the total area. If you have more than one tile of dtm data for the area that you need follow the instructions below to combine the multiple files into one "seamless" dataset, a process that involves creating a mosaic. This will make it possible to use the files as a continuous surface in maps and 3D scenes. During this process we will also convert the multiple ascii or tiff files into one single **Grid** file.

Note that this only applies when each tile contains data for a small part of the area. If the raster data tiles that you have all cover the same area then mosaicking them will not work.

This will work with various formats of dtm files including tiff and asc.

If you only have a single tile of dtm data you don't need to create a seamless mosaic. Just continue with the next section.

Video Clip available in Minerva - Creating a seamless mosaic from multiple DEM tiles.

- If you don't already have a map, create or open one now
- In Map view go to the **Analysis** tab of the ribbon

- set the extent for carrying out geoprocessing operations - Environments > Processing Extent set to Union of Inputs and click OK.
- click on the **Tools** button on the ribbon
- Then use the geoprocessing toolbox to open the correct tool - Data Management Tools > Raster > Raster Dataset > Mosaic to New Raster.

Fill in the dialog that opens as shown in figure 3.16. You'll need to add all of the .asc files that you downloaded, and save the result to the geodatabase in the project. Your file names will be different to the ones used here.

- Select all of your ascii dtm tiles under **Input Rasters** (you may need to look for them in more than one folder if your area covers parts of more than one 100km grid square)
- The **Output Location** is a folder or a geodatabase NOT a file name. For this example click on your file geodatabase to select it, but don't double-click to enter it
- Under **Raster Dataset Name with Extension** enter a file name without an extension to create an ESRI grid. Make sure you call it something that means something to you, e.g. *mosaicdtm*.
- Set the **Spatial Reference for Raster** to the one that applies to the original files using the button to the right of the field. (You can check this in the properties of one of the original files if you need to). If your final map needs to be a different coordinate system you will set this later - see section 3.5.8 on page 42.
- **Pixel Type** should be set to the same as the original files - have a look at the properties in the Catalog pane if you haven't made a note of this already.
  - If you understand what the pixel type indicates it can help you to check your data. Check the properties of the layer, but also use the **Explore** tool to click on the layer when it is displayed on your map and check what values the file contains. Table 3.1 gives a summary of the type of data that each pixel type will store.
  - For OS Terrain 5 and OS Terrain 50 files from Digimap this should work out as **32_BIT_FLOAT** from the list under **Pixel Type** in the tool.
- Cellsize can be left blank, alternatively check this in the properties for your data.
- **Number of Bands** should be **1** to create a monochrome raster.
- Run

Pixel type	Decimal places?	Negative numbers?
Unsigned	no	no
Signed or short	no	yes
Floating point	yes	yes

Table 3.1: A digression on pixel type

Arc should process your tiles, then add the result to your map. You should have a single tile which is coloured continuously rather than as a separate section for each individual tile (figure 3.17 - yours will look different to this one).

3.5.8 Changing spatial reference for output mosaic

If the spatial reference of your original files is not the same as your map project then you need to change the coordinate system. If you are working with terrain data from Digimap you won't need to do this step **unless** you are creating a map that isn't in British National Grid.

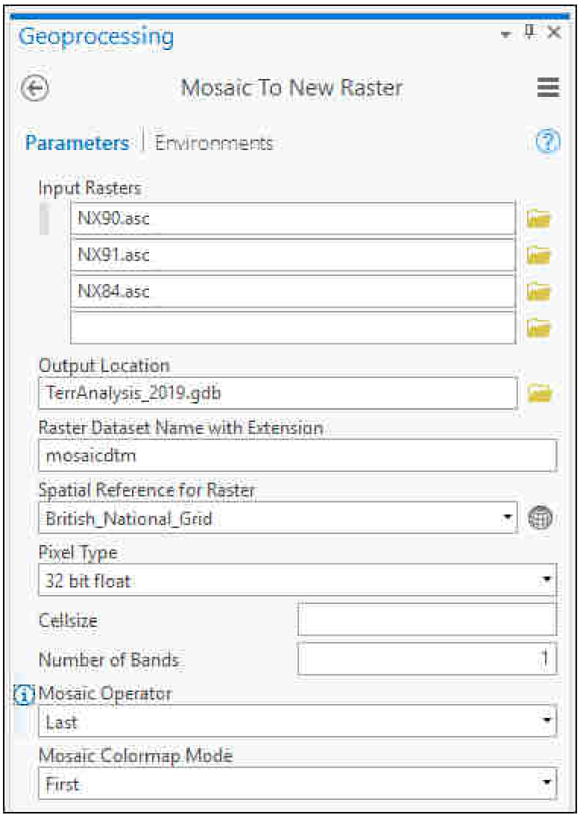


Figure 3.16: The Mosaic to New Raster tool. Note that the details for your data may be different to those shown here, in particular check the Pixel Type - this is crucial to running the tool successfully. Remember to include **all** of your input rasters - only a small number are shown here for convenience.

Figure 3.17: Grid file mosaic made by combining smaller tiles. Note that yours probably won't look identical to this one as it will cover a different area.

- From the geoprocessing toolbox select Data Management Tools > Projections and Transformations > Raster > Project Raster
- Add the mosaic (you can drag it from the catalog into the appropriate box on the dialog)
- Select... and choose the coordinate system that your final map project needs to be in, e.g. British National Grid.
- Arc will probably set the **Transformation** automatically if necessary, but if it doesn't select one from the drop-down list. e.g. WGS84 to British National Grid is usually **OSGB_1936_To_WGS_1984_Petroleum**

3.5.9 Adding a custom elevation surface

Now to add the new data as the elevation surface.

- Right-click on **Ground** under the **Elevation Surfaces** heading at the bottom of the contents panel
- Add Elevation Source and navigate to the data folder to select the **mosaicked OS terrain 5** raster dataset then click OK

If you add a custom elevation surface, but leave the World Elevation layer on, then areas outside of your DEM will still have elevation.

If you explore your scene now you should find that there is more detail in the 3D effect, e.g. where streams are running from the mountains.

3.6 Extruding a point layer

Your original point layer shows actual lead concentration measurements at particular points. It is possible to add this to the scene and "extrude" the points to show comparative concentration in a more 3D way.

- Add your Pb Concentration points layer to the scene.
- The layer will probably appear in the 2D layers section of the contents panel. Drag it up to appear under the **3D Layers** section
- Select the points layer in the contents then go to the **Appearance** tab on the ribbon
- In the **Extrusion** group click on the arrow under **Type** and choose **Base Height**. This means that the extrusion will be added to the elevation surface.
- In the **field** dropdown select the **concentration** field
- The **Unit** field should already be set to **Meters**, if not, set that now.

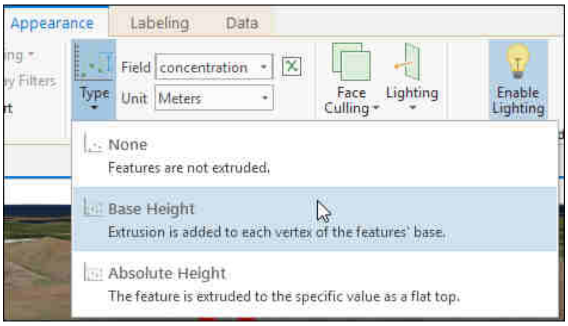


Figure 3.18: Setting up extrusion for a layer

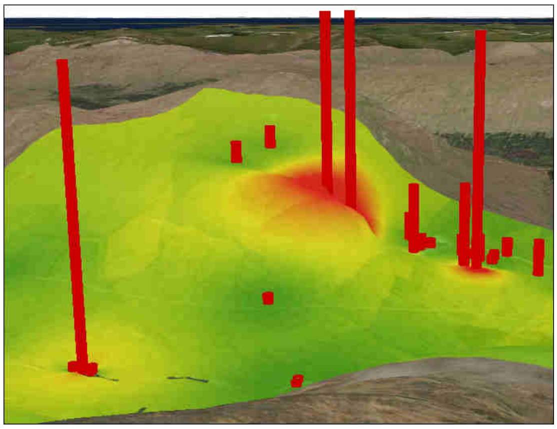


Figure 3.19: Extruded points in a Scene

3.7 Adding geology layers from Digimap

Use the instructions in chapter 4 on page 46 to download and add 1:25 000 geological data to your map and to symbolise it according to BGS styles.

Have a close look at the geology - the Explore tool[a] can be useful for this. How does it relate to the locations of the mines?

[a] Click on the Explore button on the Map tab of the ribbon, and then click on the feature that you want to identify. You may need to be careful of selections.

3.8 Layout suggestions

Figure 3.20 shows one suggested layout in Arc, but as usual, it is only a suggestion.

- Create a layout in Arc showing the lead concentrations, the topography and the geology. You'll have to balance transparency very carefully and you'll probably need to layout more than one map - don't try to show too much on one map.
- Add the 3D scene to your layout.
- If you want to add an extent indicator you can download an outline map of the countries of the world from Natural Earth Data - `https://www.naturalearthdata.com/`.
- Don't forget to include any necessary copyright acknowledgements.
- Using your map and scene have a look at how the topography, the geochemistry and the geology relate to each other. Write some notes on your observations and add them to your layout.

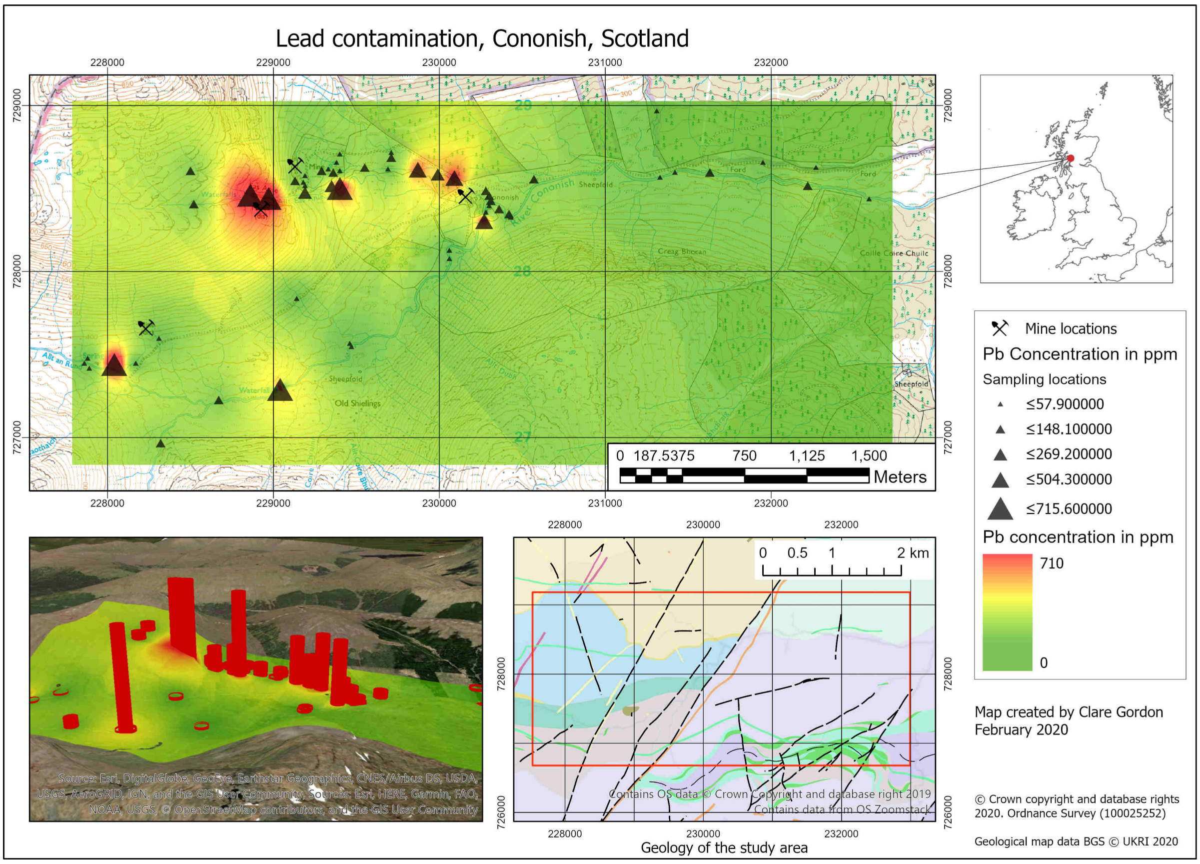


Figure 3.20: Example layout for the Cononish geochemistry map

Chapter 4

Using BGS geology shapefiles downloaded from Digimap

4.1 Introduction

It is possible to download shapefiles containing British Geological Survey (BGS) data at various scales from the Digimap service. These can be added to a map in Arc in the usual way. Once data has been added to ArcGIS symbolising the data can be an issue. These notes give some suggestions for how to display the data. Please refer to the Digimap chapter of your workbook for more information about downloading data from Geology Digimap.

IMPORTANT: Please note that the information in this section is written so that it can be used with a variety of BGS datasets. Take care to follow the sections that apply to the data that is suitable for your map. If you are not sure about this, please ask.

For example: if you are a geophysicist following the exercises which use gravity data for Llanbedr then download 1:50 000 data and go to section 4.2 on page 46 for instructions on what to do next.

If you are a meteorologist following the exercises which use rainfall data for North Wales then download 1:250 000 data and go to section **??** on page **??**.

Log in to Digimap and go to Geology download to download tiles of geological data in shapefile format. Choose data to cover your area at an appropriate scale. For example, the scale at which you are intending to print your map. Note that 1:25 000 and 1:10 000 data are not available for all areas of the UK so if you are printing a 1:10 000 map you may just have to use the 1:50 000 and make your audience aware that this was the best data available.

Unzip the layers that you download.

4.2 Styling shapefiles with a layer file

4.2.1 Obtaining layer files

1:250 000 data

The 1:250 000 shapefiles do not have a layer file in the data that you downloaded, but you can download them from the BGS instead. Go to:

https://www.bgs.ac.uk/products/digitalmaps/DiGMapGB_250.html

Download the **Sample map** and unzip it. This download should include files called

- gb_250k_bedrock.lyr
- gb_250k_lines.lyr

These are the files you will use to symbolise your downloaded geological data.

1:50 000 data

The 1:50 000 shapefiles have a layer file with the extension .lyr associated with them when you unzip them.

1:10 000 and 1:25 000 data

The 1:10 000 and 1:25 000 shapefiles provided by Digimap have another zipped file within the download which contains layer files - look for it within the **docs** folder. These layer files can be used to apply BGS standard symbology.

For the 1:25 000 and 1:10 000 data start by unzipping the layer files

- for 1:10 000 scale data unzip `Geology_10k_Layer_Files.zip` to your local drive.
- for 1:25 000 scale data unzip `Geology_25k_Layer_Files.zip` to your local drive.

4.2.2 Using the layer files

There are two possible ways to use layer files to symbolise the shapefiles and it is your choice which one you use. Both will give the same final result.

Video Clip available in Minerva - Symbolising a layer with a layer file (.lyr).

Add the layer file first

- Open Arc and add data as usual, but this time add the layer files (.lyr extension - see figure 4.1) to your map rather than the shapefiles

You'll probably find that you can see the layer title in your table of contents but it has the "dreaded" red exclamation mark next to it (figure 4.2) and you can't see the geology on your map. This is because the layer file is still trying to find the data in the place it was on the computer of the person who originally set up the file, so you need to tell it where to find the data on **your** computer. Use the instructions in table 4.1

If it works immediately and you can see the geology on your map that's a bonus and you don't need to repair the data source!

The layer should appear on your map symbolised according to BGS categories as in figure 4.5.

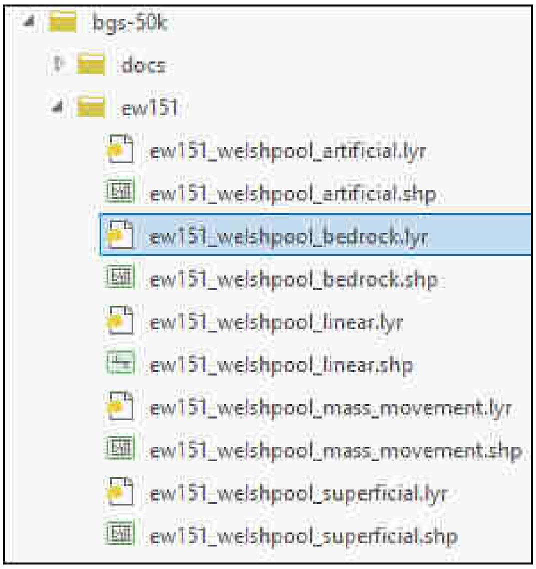


Figure 4.1: The bedrock layer file is selected here. Add this to your map rather than the shapefile. The name will of course vary depending on the location of your data.

Repairing broken file links
If you use absolute file paths and you have to move the files from one location to another, or if you have a project folder set up by someone else, you may find that the broken links are marked by a red exclamation mark next to the layer name (as in figure 4.2). This can also happen if you are adding .lyr files for symbology. To check the name of the file that you'll need to locate: • Open the layer properties and go to the Source tab • Under **Data Source** you will see which file Arc is looking for - see figure 4.3 Once you know where the file you need is located, do the following to repair the link: • From the layer properties source tab • Set Data Source... • Navigate to the file that you need OK 〉 OK. If you're lucky all of the missing layers will appear, but if you're not you'll need to repeat the process for each layer.

Table 4.1: Repairing broken file links

Add the data layer first

An alternative to the previous section is to add the data layer first -

- Add a shapefile to your map as usual. It will appear but will be all one colour
- Select the layer in the contents, then click on the **Symbology** button on the **Appearance** tab.
- Click on the menu icon at the top right of the Symbology panel and select **Import symbology...** to open the geoprocessing tool - figure 4.4

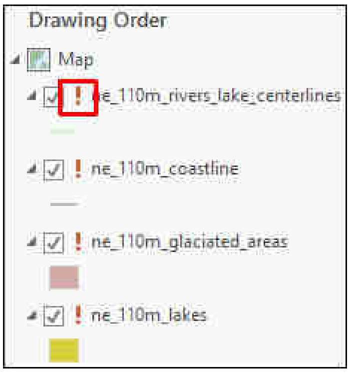


Figure 4.2: The red exclamation mark showing that the links to the data for these layers is broken

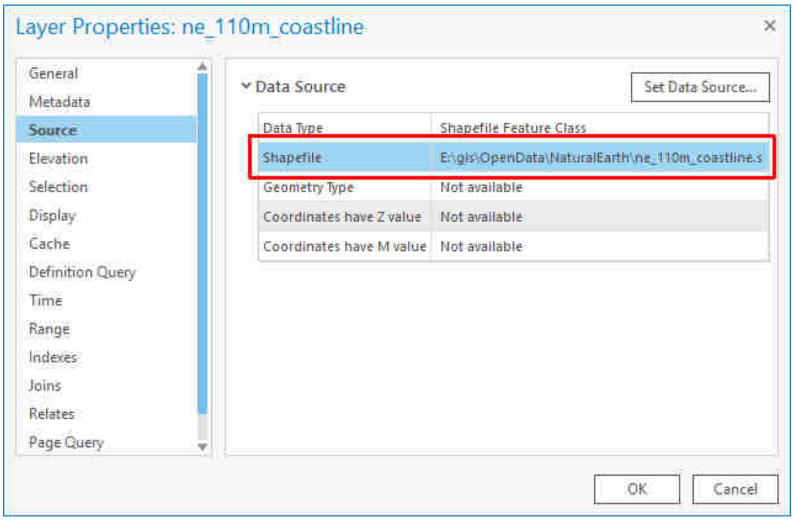


Figure 4.3: The Layer Properties for the missing layer, showing where Arc is actually looking for the data. Note the file name - this is what you need to look for in your file system.

Video Clip available in Minerva - Repairing broken file links.

- Click on the folder button next to the **Symbology Layer** drop down and navigate to the location of your layer files. There should be a layer file that matches your shapefile, the name will vary depending on the data you are using
- click on the lyr file and OK
- It is a good idea to set **Update Symbology Ranges by Data** to **Update ranges** so that only the symbology you actually need is used. This will make creating a legend much simpler!
- Then Run the tool.

The data should now be symbolised according to BGS categories as in figure 4.5.

4.3 Copyright notice

All maps produced from BGS data downloaded from Digimap must carry the following copyright acknowledgement:

Geological Map Data BGS © UKRI 20(yy)

Where (yy) is replaced by the current year.

Maps that also include OS data must **in addition** carry the OS copyright acknowledgement[1].

© Crown Copyright and database rights 20(yy). Ordnance Survey (100025252).

Where (yy) is replaced by the current year.

[1] Note that the text for this copyright acknowledgement changed in October 2014

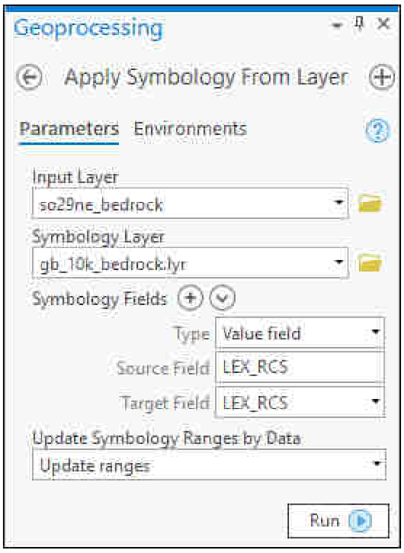


Figure 4.4: Filling in the Apply Symbology from Layer dialog.

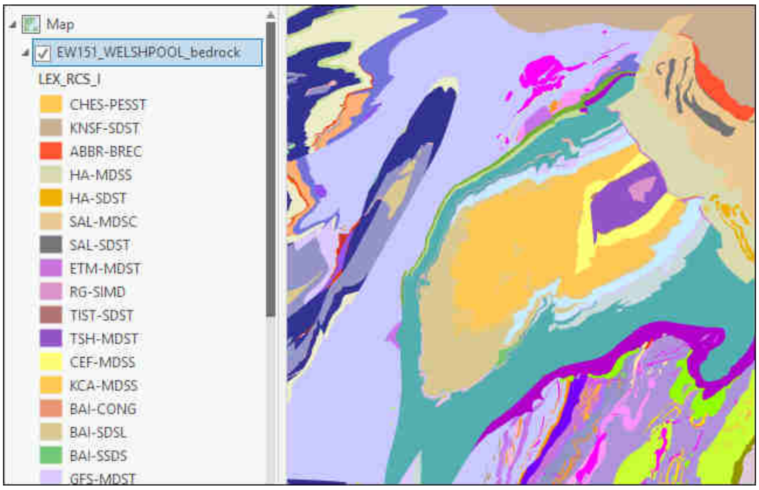


Figure 4.5: BGS geology shapefile with symbology, also showing the classification in the table of contents

Create a geological map of your area using the geological data that you processed above and an Ordnance Survey base map at a suitable scale. You'll need to set transparency[a] for the geology so that the topography is visible underneath to give location information.

The examples above all show just the bedrock geology, try adding and symbolising the other layers provided too, particularly the linear features (fold axes, faults etc).

[a] Check the workbook index for **Transparency** if you need a reminder of how to do this.

Chapter 5

Changes with time: Coastal erosion in E. Yorkshire

5.1 Introduction

Figure 5.1: View of Mappleton cliffs

The East Yorkshire coast around Hornsea is historically prone to rapid coastal erosion. The EDINA Digimap service allows us to obtain mapping from the end of the Nineteenth Century, the middle of the Twentieth, and current mapping. Using this it is possible to investigate the speed of coastal erosion of a small area around Mappleton and Great Cowden to the south of Hornsea. The coastal erosion in this area is still continuing despite the measures that have been put in place over the years - see stories such as the one at `http://bbc.in/1SzscGl` from August 2015.

5.2 Historic data from Digimap

Log in to Digimap and go to the Download for Historic Data. Historic Download works in a very similar way to OS and Geology Downloads so it should look familiar.

- *Search for Mappleton. Both of the alternatives that come up are in the East Riding, so select either to go to the correct area.*
- *Draw a rectangle around at least the area shown in figure 5.2*
- *in the menu on the left select the following datasets (You can check availability by using the Show Availability Grid tab on the right)*
    - *County Series 1:10 560 (1846-1969) - select all 4 editions/revisions*
    - *National Grid 1:10 560 (1948-1992) - only the 1st edition is available for this area so select that*
    - *National Grid 1:10 000 (1958-1996) - only the Latest is available so select that*
- *You should have selected 6 layers. Add them to your basket.*
- *For the layers that give you a choice select the Theme to be National Grid Tiles then click to Request Download*

As usual, you'll be notified by email when your data is ready to download.

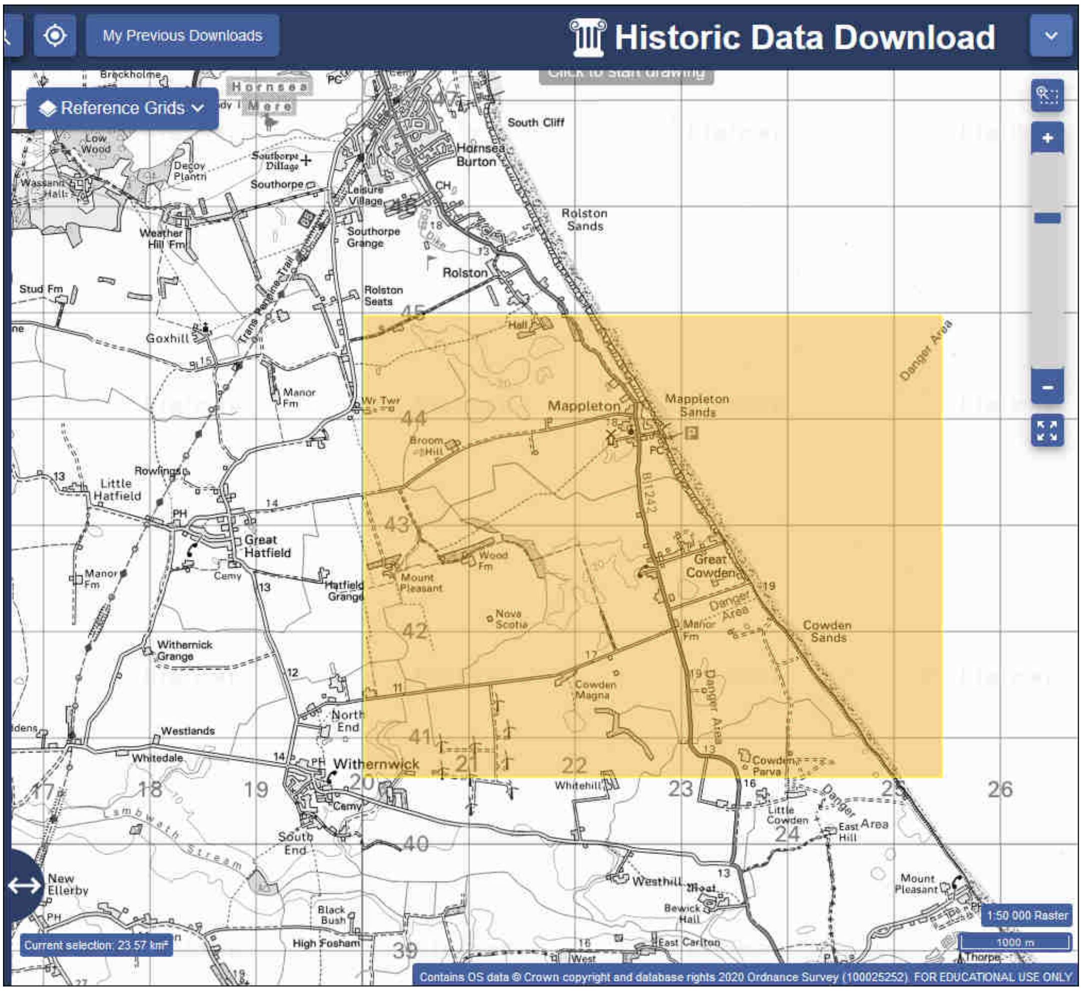


Figure 5.2: Selecting map tiles from Digimap Historic download

In addition, go to the usual Ordnance Survey Download and download two VectorMap Local raster layers for the same area.
It is possible to choose an older version in the basket, so

- ***add the VectorMap Local Raster data to the basket twice***
- ***set one copy to the latest version, as of February 2020 this is 2019 data, and one to the oldest available, which is probably January 2014[a].***

[a]EDINA have an archive of all the data they have held since Digimap started and this is available via the basket.

Yes, this is all rather fiddly and repetitive. Getting hold of the data is often the hardest and most time consuming part of a GIS project but just has to be done!

5.2.1 Staying organised

Staying organised with the data for this project is not completely straightforward. Start by making sure that you know which data set is which, and making a note of what year each tile of data refers to. When you unzip your downloads there will be a **contents_order.txt** file with each one and this lists each tile of data in that download and gives the edition and the year of publication. One solution is to add the tiles one at a time, and make a note in the table of contents of the year of publication of each tile as you go along - as in figure 5.3. If you have more than one tile for an area, group them and label the group with the year.

5.3 Tracing the coast line

Create a geodatabase feature dataset for the area and then a **line** feature class to hold tracings of the historical shore lines.

Digitize (that is, trace) the coastline on each sheet in turn using the cliff line on the historical mapping and the high-water mark on the most recent maps. Don't forget to include some way of showing what date that coast line indicates - either use a different feature class for each year, or a single feature class with the year as an attribute which can be used to symbolise by category later e.g. see figure 5.4.

Suggested limits of tracing are -

- ***North west: GR 522500, 444500***
- ***South east: GR 524500, 442000***

It can be useful to set up a polygon feature class to show this study area. Once you've created a polygon you can Modify and use the Vertices to enter accurate grid coordinates.

Symbolise and label the lines appropriately so that you can differentiate the coast for each set of data.

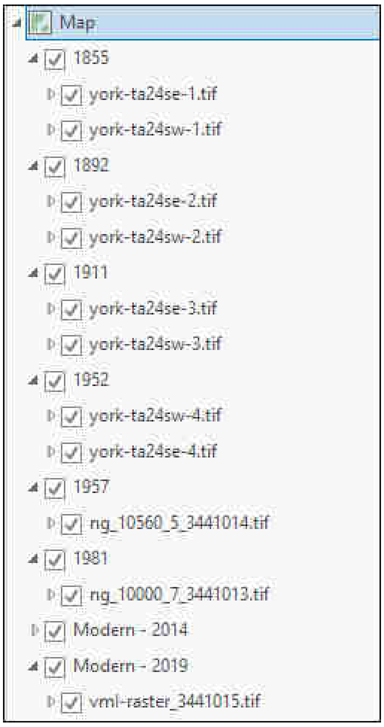


Figure 5.3: Keeping track of the years in the table of contents

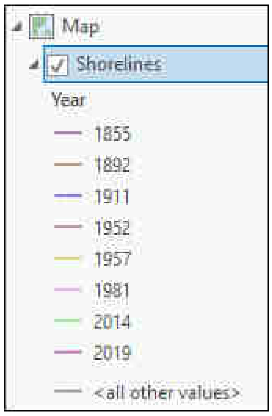


Figure 5.4: Shorelines is a single feature class with each year as an attribute. It has then been symbolised by category so each is a different colour.

5.4 Finding out more

Draw 3 lines across the coast perpendicular to the shore line - suggested profile locations are below, but feel free to decide for yourself. Measure how much erosion there has been between each pair of years for which you have data (i.e. each coastline that you have drawn) and make a note of it.

Suggested profile locations:

1. ***Grid ref: 522600,444000 to 523100,444300***
2. ***Grid ref: 523000,443300 to 523500,443600***
3. ***Grid ref: 523600,442400 to 524100,442700***

Put your results into an Excel spreadsheet. You can then add your spreadsheet to your layout by doing the following:

- Add your spreadsheet table to your map by dragging and dropping it from the catalog. Remember you need to drag across the spreadsheet from within the Excel file. It should be added to a section called **Standalone Tables** at the bottom of the contents - see figure 5.5
- Go to your Layout and select the map frame which holds your table data
- On the **Insert** tab of the ribbon go to the **Map Surrounds** group and click on **Table Frame**
- Click on the layout in the location you want the table to appear. If you get an empty table frame

– Double-click on the element, or right-click and go to **Properties**
– Select your table in the **Table** drop down. Note that you can also include the attribute tables of data layers in this way.

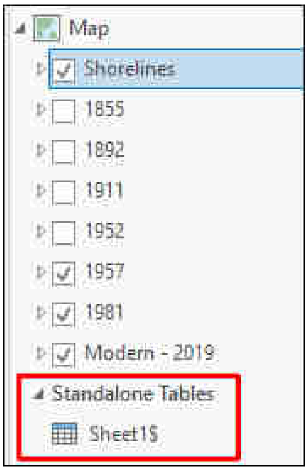


Figure 5.5: A spreadsheet from an Excel file in the contents pane

Your table should be visible now but the formatting is likely to be unsatisfactory. Use the Properties dialog to neaten it up. I found that going to the field properties and unticking **Auto width** immediately allowed all of the data to show.

Play around with the properties until you are happy with the appearance of the table.

Look at your results and think about what is happening. Are there differences in rates of erosion at different locations and at different times? Why is that likely to be?

Use the Coastal Explorer from East Riding council[1] to find out more information about this area -

`https://www.eastriding.gov.uk/coastalexplorer/`

Detailed maps are available through the **Coastal Mapper** link. Note that this map interface appears to work best in Internet Explorer. In Firefox and Chrome there are no menus.

Go to Great Cowden again and look at the data the council provide. For example, look at the Cumulative Change in Beach Level from 2008-2015.

The **Beach Profile** data allows you to download pdf files containing historic profiles.

There is lots of information on the site. Look at documents in the download section to see more information on how council collect the data for these maps - yes, some of it is by tracing shore lines from old maps as you've just done.

5.5 Displaying your data

Suggestions for laying out a map to present your findings:

- Include all historic coast lines on a modern map - see figure 5.6 for an example.

[1] Last visited: 3rd March 2020.

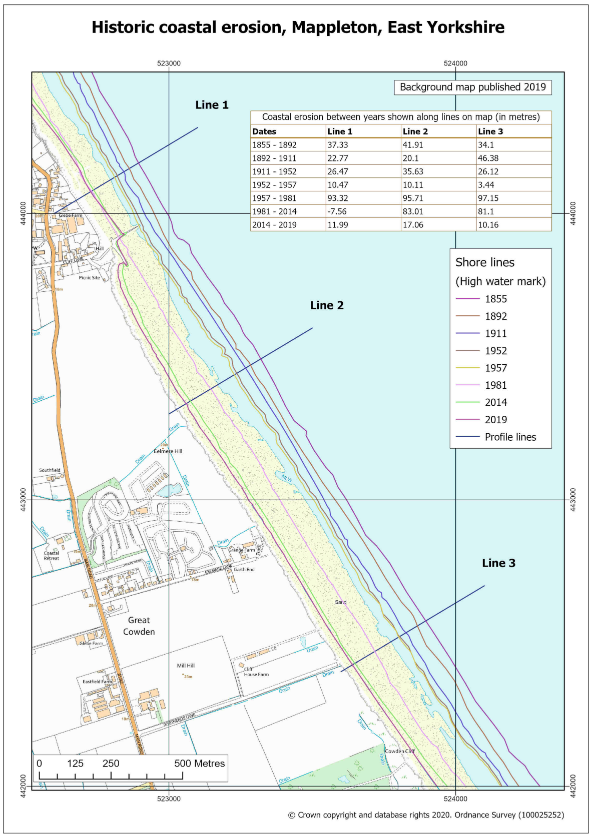


Figure 5.6: Example layout: Mappleton 2019

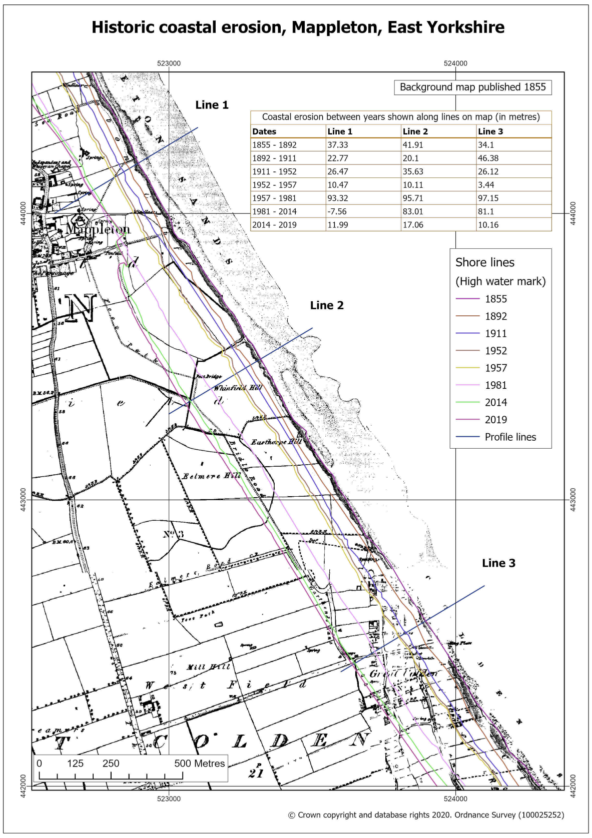


Figure 5.7: Example layout: Mappleton 1855

- Include all historic coast lines on the earliest map - showing the details of the settlement that has been destroyed. See figure 5.7 for an example.
- Include your Excel spreadsheet (with an explanation of what it shows) and a legend for the coast lines showing which years you have digitised.
- Don't forget to reference/acknowledge all of your sources

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