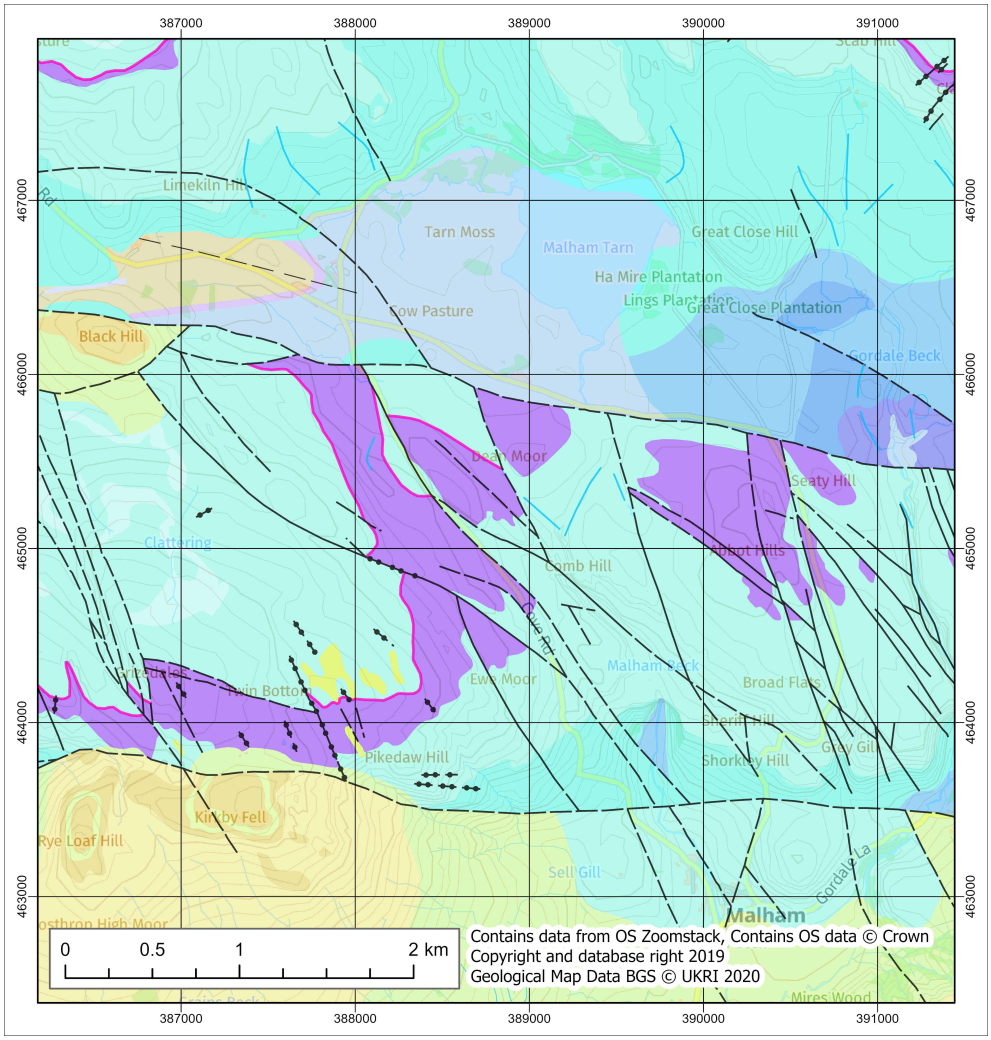
GIS for Geologists:
Digitising a geological map



© Clare Gordon
School of Earth & Environment,
University of Leeds

For ArcGIS Pro 2.4
3rd February 2020

Contents

Major changes to workbook

Major changes to the workbook with the date on which they were made are listed here. If you have been using an older version of the workbook, please check to see which sections have been changed. The date of the workbook will always be shown on the front cover.

Table 1: Major changes to workbook. Newest first.

Date of change	Section no.	Summary of change
January 2020	Whole workbook	Updated from ArcMap to ArcGIS Pro.

How to use this workbook

If you need this workbook in a different format, e.g. large print or a different font, please contact me - details at the end of this section.

It is worth reading through each little section before you start to follow the instructions. Certainly if you get stuck read the section fully to check that you haven't missed something!

The following conventions are used in this workbook to show things that you need to do:-

Tip boxes
Some handy tips and definitions have been put in tables through out the workbook. Check these for more information. You can find a list of these in the List of Tables at the beginning of the booklet.

Table 2: Tip boxes

Video Clip available in Minerva - Using the measure tool in ArcMap.
Direct link: `http://bit.ly/2h5ir8u`

This icon indicates that there is a video clip available for this task. The videos will be available in your module in Minerva. If you are not studying a particular module then the video clips are also available from the web page at `http://homepages.see.leeds.ac.uk/~earcej/VideoClips/index.htm`

Note that many of the video clips have sound - **on cluster machines these will require that you plug in your own headphones. Computers in clusters do not have speakers.**

Menu items are formatted as "buttons" so the following statement -

File › New… › Blank Document indicates that you should click on the **File** command on the toolbar, then click on **New…** then select **Blank Document**.

Keys that you should press are shown as follows: Esc means press the **Escape** key on the keyboard.

Where tool names in programs are mentioned these can usually be found by hovering over the buttons in Arc to activate **tool tips**.

Question 0.1. Questions that you need to answer or exercises that you need to do on your own are in boxes in large font. If a question is numbered, then a possible answer will be given in the answers section at the back of the workbook (check the contents list). If there is an empty box below use it as a space in which to record your answers.

Write your answer here!

Techniques that are covered in earlier chapters of the workbook will not be repeated in later chapters, but will be referred back to, so remember to bring the workbook to each practical so that you can refer back to it. The workbook will remain available in Minerva, but further printed copies will not be provided.

Contact Details

For further information about the contents of this booklet contact: Clare Gordon (Email: c.e.gordon@leeds.ac.uk)
Room 10.140b, School of Earth and Environment, University of Leeds

Chapter 1

Introduction to GIS with ArcGIS Pro

The background to GIS and an explanation of what it is will be covered in the lecture segment at the beginning of the class and the presentation and any other supporting materials will be available in Minerva. The lecture segment should help you to understand **why** you are doing these exercises. If you still aren't sure, please ask Clare.

1.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- demonstrate how to open a map project in ArcGIS
- select appropriate tools to navigate in a map document
- use layers to organise and display information on a map
- add information to a layout and prepare it for printing or display
- demonstrate different ways of finding help when using GIS

1.2 Introduction

As a GIS specialist you have been asked by the Field Studies Council to produce a geological map of the area around the Malham Tarn National Nature Reserve (NNR).

For this first exercise I have created a basic geological map of Malham Tarn so that you can explore the GIS application and get used to basic navigation and functions. In future sessions you'll be preparing the data and setting up the basics for yourself.

1.3 Obtaining and opening the sample map

The sample map is based on British Geological Survey data covering Malham Tarn in North Yorkshire and uses data from a number of sources with which you will become familiar during this module.

- download the **MalhamMinerva.7z** file from Minerva and save it on your M:/ drive.
- Create a new folder called **gis** on your M:/ drive and **unzip** the downloaded file to that folder (see table 1.1 on page 2 if you need instructions for unzipping files). **Never try to use the contents of a zipped file in Arc without extracting it first - it won't work.**

Unzipping files
Zipping files is a way of compressing them to save space and make it easier to store and download them. You'll frequently need to extract or unzip files during this module. Zip files may have extensions of either `.zip` or `.7z`, both will extract or unzip if you use the instructions here. • In **My Computer** right-click on the zip file. • 7-Zip ⟩ Extract files... select the location to save the files to OK Right-click and **Extract all** (which is the unzip utility provided by Windows) will usually work on `.zip` files, but occasionally doesn't extract **all** of the files in the archive. 7-zip seems to be more reliable and works for `.7z` too. 7-zip is also open-source so if you want to install a copy on your own computer you can - just download it from `http://www.7-zip.org/`

Table 1.1: Unzipping files

NOTE: for the purposes of this module always navigate to your M:/ drive directly via your username, then create a folder called **gis** at the top level, and use that for all of your GIS projects. Even though you end up in the same place as **My Documents**, for some reason Arc recognises this route as not having any spaces in the path, something to which it objects.

1.3.1 Open the sample map

- Open Arc by searching for **ArcGIS Pro** in the start menu of your computer and clicking on it. Be patient - Arc can open slowly sometimes!
- From the splash screen (figure 1.1) select to Open another project. If you don't have the splash screen use Project ⟩ Open....
- Navigate to the folder in which you unzipped the downloaded file and open **Malham.aprx**.
- Alternatively you can navigate to the folder to which you unzipped the downloaded data
- Go into the **Malham** folder and double-click on the **Malham.aprx** file - the map should open

Your ArcGIS window should look similar to figure 1.2 on page 5.

1.4 The map ribbon

The menu ribbon at the top of the window (figure 1.3) gives you a variety of tools. Hover over the buttons to see the tooltips that explain what each button will do.

Question 1.1. On the map ribbon look for each of the tools suggested in table 1.2 in turn and try them out to see what they do. Make notes for yourself in table 1.2 on page 3.

To see the basic navigation options hover over the Explore button on the ribbon.

(Remember that possible answers to questions in the workbook are given in appendix C starting on page 152)

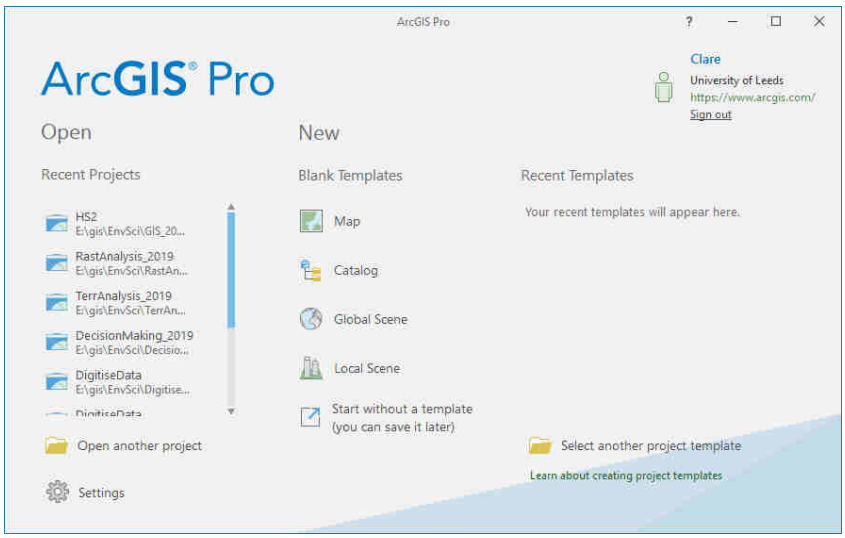


Figure 1.1: The ArcGIS Pro splash screen. If you have opened projects previously they will be available here. (Esri software graphical user interfaces are the intellectual property of Esri and are reproduced herein by permission. All rights reserved.)

Table 1.2: Map ribbon tools

Tool	**What it does**
Fixed zoom in - also try using the mouse wheel to zoom in and out	
Fixed zoom out	
Full extent	
Zoom to layer (this one isn't on the ribbon) Right-click on the title of the **BedrockGeol** layer in the contents pane Zoom To Layer[1]	
click the **Select** button then click and hold on the map, drag out a rectangle, and let go	
click the **Clear** button in the Selection group	
click on **Explore**, then click on one of the bedrock geology areas on the map. Also try some of the options found by clicking on the down arrow under the **Explore** button	

[1] **Zoom to layer** is a very useful tool. It can be particularly useful if you have zoomed in or out too far and can no longer see your map properly. **Zoom to layer** and you'll usually be able to see enough to find the bit of the map that you really want to see.

click on **Locate**, the locate pane should open on the right of your map. Type **Malham Tarn House** in the search box and select one of the results[2]	

1.4.1 Change scale

Instead of zooming with the mouse wheel you can change to a particular scale, e.g. 1:100 000, simply use the drop down box at the bottom of the window (figure 1.4) to select the scale you want. You can also type a scale in this box particularly if the scale you want isn't in the list, e.g. 50000 (note no punctuation), and it will change to that when you press **return**.

1.5 Spatial bookmarks

Spatial bookmarks enable you to go back to a view you have set up earlier. The map of Malham Tarn has a bookmark set up showing the area of the Malham Tarn National Nature Reserve (figure 1.5).

- Bookmarks » Malham Tarn NNR.

To set up your own bookmarks

- Pan the map to a different location
- Bookmarks » New Bookmark... type a name for your bookmark OK.
- The bookmark should be visible as a thumbnail when you click on Bookmarks again.

Video Clip available in Minerva - Spatial bookmarks in Arc.

Question 1.2. Change the scale of the map and pan to a different view, then go the bookmark that you have just set and check the scale again. How has the bookmark affected that?

The **Bookmark manager** allows you to view all of your spatial bookmarks, sort them, and remove any that you no longer need.

- Bookmarks » Manage Bookmarks...
- Try **creating** another bookmark in the manager
- Experiment with the options in the manager, including **Zoom To** and **Pan To**,
- **Remove** the last bookmark that you created.

[2] If nothing happens when you search, try the following: Click on the **Settings** tab above the search box. Click on **ArcGIS World Geocoding Service** - check it's Enabled, and move it to the top of the list (above XY provider). Go back to the **Locate** tab and hopefully the search will work now.

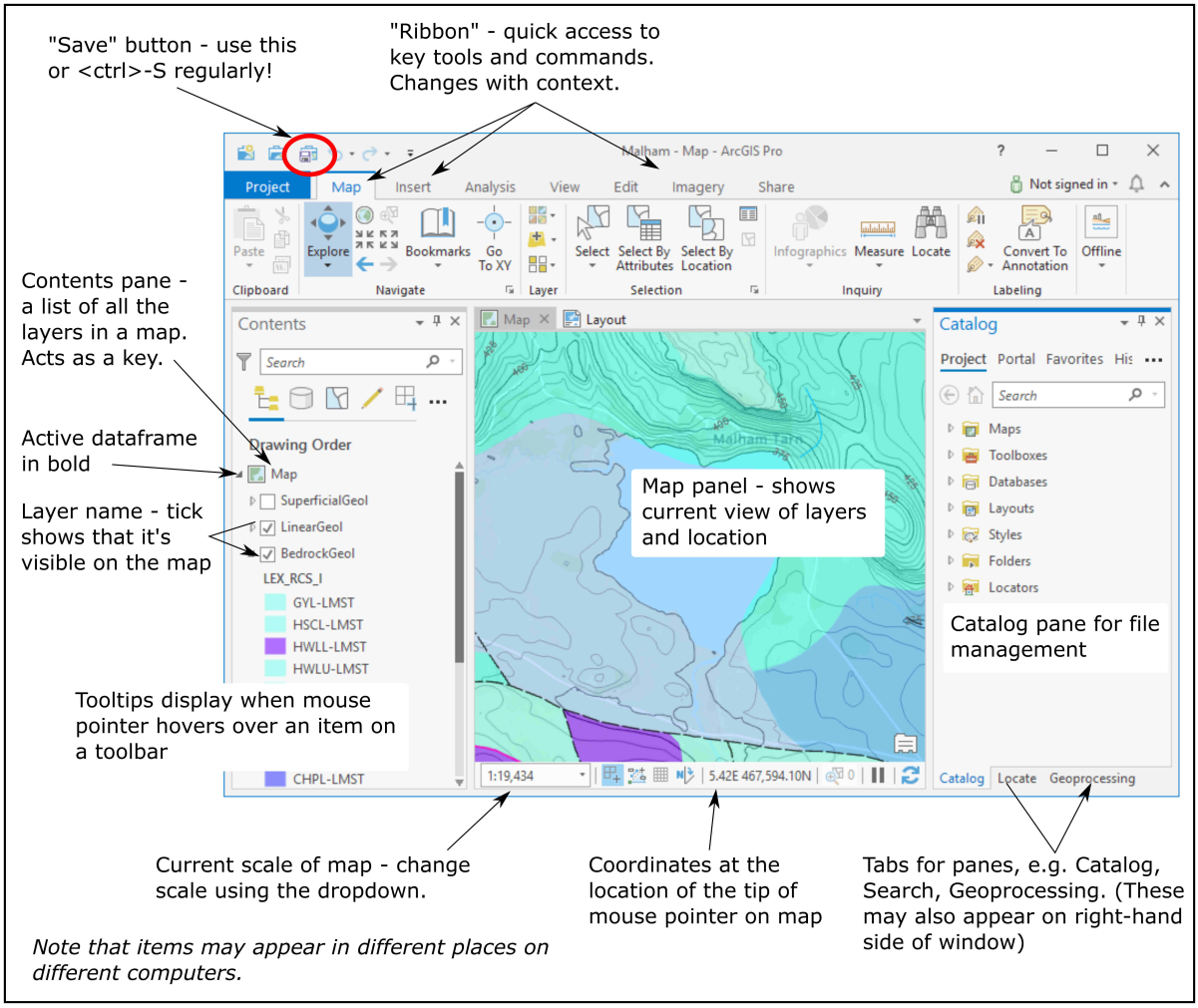


Figure 1.2: The ArcGIS Pro window (Esri software graphical user interfaces are the intellectual property of Esri and are reproduced herein by permission. All rights reserved.)

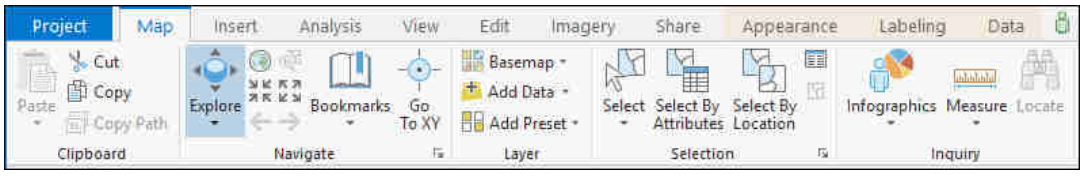


Figure 1.3: Part of the map “ribbon”

1.6 Catalog pane

The Catalog pane allows you to explore and find out more information about your data.

- If the catalog pane isn’t visible on the right of the window already, go to View > Catalog Pane on the ribbon to open it.
- Explore the tree in the Catalog pane by opening out all of the subheadings (click on the small arrows). You should end up with something like figure 1.6

The view that you’ve been working in shows a **Map** and this is available under the **Maps** heading in the Catalog. If you close it you can reopen it from here.

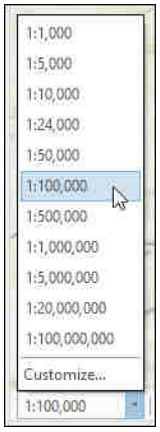


Figure 1.4: Scale dropdown box

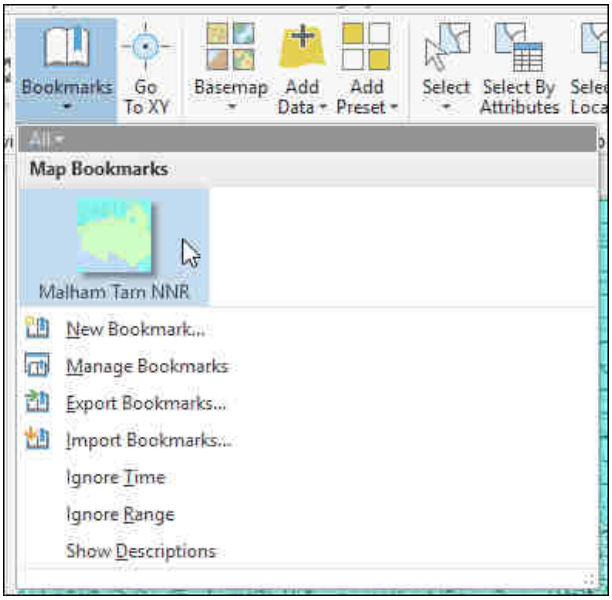


Figure 1.5: The bookmark menu showing the Malham Tarn NNR bookmark

The **Layouts** heading shows any print layouts that have been set up. You should already be able to see one, just called "Layout".

The heading for **Databases** shows the geodatabase which contains most of the information which makes up the map. If you open out the geodatabase **Malham.gdb** you can see the data feature classes that are stored within it.

There is another subheading for **Folders**. This has a "home" folder for this project - **Malham**. You can also add other folders here so that you can add data from outside of your project. See the tip box in table 3.2 on page 65 for how to do this.

1.7 Working with map layers

Layers are an essential part of any GIS. Each layer is a reference to a particular data source. In the Malham map file the layers include

- SuperficialGeol
- LinearGeol
- and contours

Question 1.3. What are the names of other layers in the Malham map?

Layers are controlled from the **contents pane** to the left of the map window.

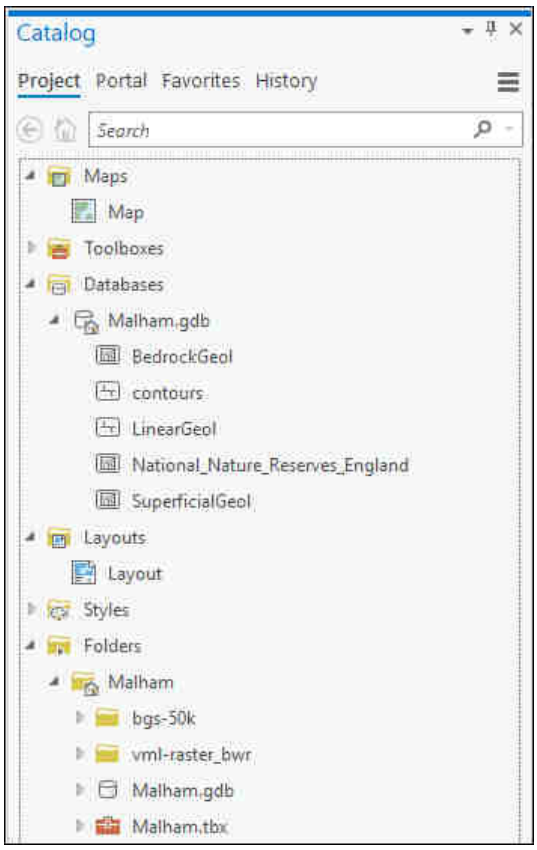


Figure 1.6: The Catalog pane with subheadings opened out to show contents of the project

Go to this module in Minerva and watch the video clip on "Working with layers in Arc". Then get used to working with layers by following the instructions below.

Video Clip available in Minerva - Working with layers in Arc.

1.7.1 Viewing contents of layers

In the contents pane:

- Click on the small arrow next to a layer to open and close the layer contents.
- The contents pane also acts as a key to your map and shows the symbols for map features.

1.7.2 Renaming layers in the contents pane

You can make the layer names more useful by changing them in the contents pane. This also means that names are clearer when you generate legends prior to printing or exporting maps.

Note that you are not renaming the original data file by doing this, but just how the name appears in Arc. It can be useful to get into the habit of doing this as it makes it easier to see what your layers contain.

- Select **BedrockGeol** in the contents pane and press F2 on the keyboard, or double-click slowly on the layer name.
- Type the new name, e.g. **Bedrock geology** (with a space) and then press Enter

1.7.3 Turn layers on and off

Once a layer is in the contents pane you can turn the layer on and off to view or work with other data without removing it completely.

- Click in the box next to the **Bedrock geology** layer title to turn the bedrock geology off on the map.
- Turn other layers on and off and see what the map looks like but finish with all of the current layers visible.

1.7.4 Add new layers

There are two simple ways to add new layers.

While it is possible to add data by dragging and dropping from Windows file explorer it really isn't a good idea to do that. It might look as if it has worked at first, but things can go horribly wrong...Instead use one of the following methods.

Video Clip available in Minerva - Adding new layers to Arc and Add Folder Connection

Add data command

- Map ribbon > Add data... navigate to the folder in which you unzipped the map - you'll need to start by going into `Folders` in the browse dialog, then go to the `Malham` ▸ `vml-raster_bwr` ▸ `sd` folder and add **sd86ne.tif**.
- When you add tif or jpg files to Arc as a layer for the first time it sometimes asks you whether you want to create **pyramids**. It's your choice, but usual advice is to create them. Pyramids can save time when you are zooming in and out of your map but take a while to create when you first load the file.[3]
- If you can't find the folder in order to add the image follow the instructions in the **Add Folder Connection** tip box (table 3.2).

This is an example of a VectorMap Local layer in black and white. The data is available in colour too, but as a background for a geological map black and white tends to be clearer. Zoom in closer and you'll be able to see more detail (if you can't see the layer make sure that it is above all the other layers in the contents pane - you can change the order by dragging layers around in the pane).

There are three other tif files in this folder too so to add those:

[3] If you want more information about how pyramids work, search for **raster pyramids** in the Arc Help.

- Go to Map ribbon › Add data... and make sure you are in the Malham ▸ vml-raster_bwr ▸ sd folder again.
- Click on one of the remaining three files then hold down the Shift key or the Ctrl key and select the other two.
- Click OK

In this way you can add as many files as you want in one go.

Drag and drop

Instead of clicking on add data, the alternative is to simply find the file in the **Catalog** pane and drag and drop it onto the map area or into the contents pane.

- The Catalog pane should be visible to the right of your map. If it isn't click the **View** tab on the ribbon and click on **Catalog pane** - see figure 1.7
- In the Catalog pane go to the **Folders** section, go into the Malham ▸ Malham.gdb folder and drag and drop **National_Nature_Reserves_England** on to your map. If you drag it over to the contents pane you can choose whereabouts in the layer structure it will appear - add it to the top so that you can see it.
- If you can't find the folder to add the data follow the instructions in the **Connecting to a folder** tip box (table 3.2).
- If you can't see the new layer (figure 1.8) try using **Zoom to layer** to make sure you are in the right place on the map.

National_Nature_Reserves_England, as it says, shows all of the National Nature Reserves in England, which includes the Malham Tarn National Nature Reserve (NNR).

You'll need the National_Nature_Reserves_England layer and background layers again so leave them visible on your map.

Adding a folder connection in the Catalog pane
If you can't see your M:/ drive or USB device in the list of folders when adding data or viewing the catalog you need to **Connect to folder**. • Right-click on the **Folders** subheading in the Catalog panel • **Add Folder Connection** (figure 3.9) and select your top level gis folder, or your M: drive then click OK. If you select the drive that you want, rather than navigating right to the file, you'll be able to navigate to any files within it. • Now select your files from the folders that you can see. On cluster machines you'll probably find that you have to repeat this each time you start work in Arc, unfortunately.

Table 1.3: Adding a folder connection in the Catalog pane

Add your M: drive to the Folders heading using the Add folder connection command now to check that you can do it.

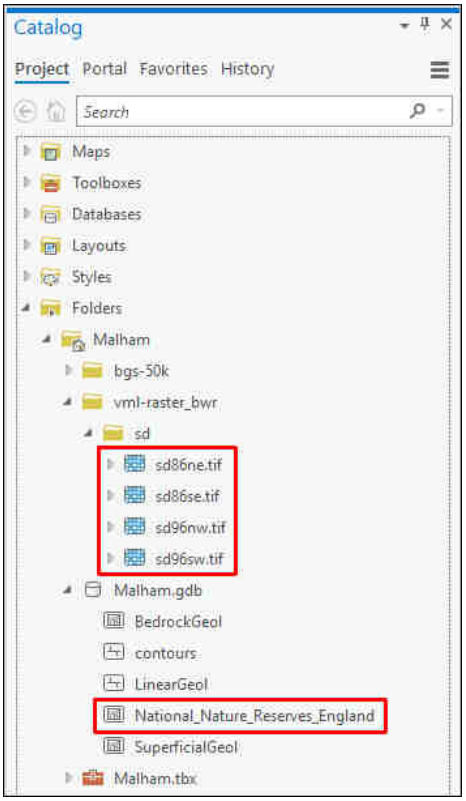


Figure 1.7: Finding the new layers in the Catalog

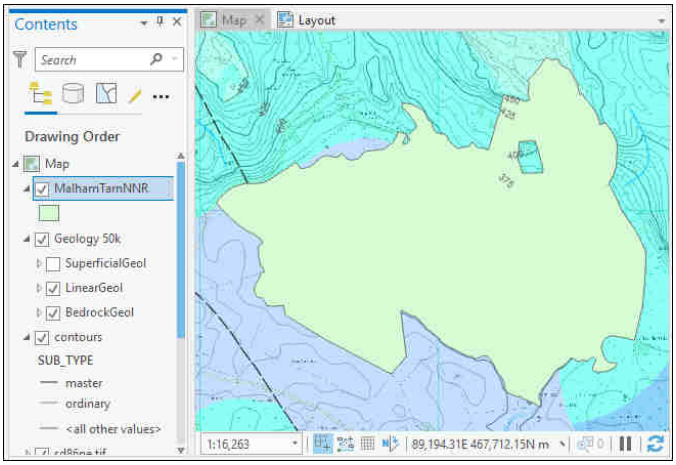


Figure 1.8: The geological map with the National Nature Reserves layer dropped on as the top layer in the contents pane. Your new layer will probably be a different colour but should look this shape.

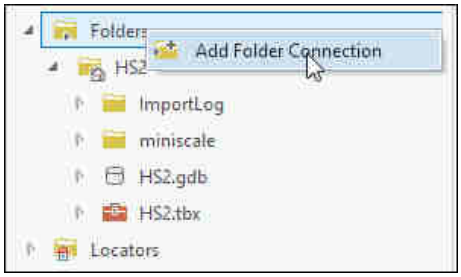


Figure 1.9: Add Folder Connection - found by right-clicking on the Folders subheading in Catalog

Video Clip available in Minerva - Add Folder Connection

1.7.5 Change the order of layers

Changing the order of layers is simple once you remember that they "stack up" in the order in which they appear on the contents pane. So the layers towards the top will cover up the layers lower down.

- To change the order of layers so that the **National_Nature_Reserves_England** layer is below one of the **Background** layers, simply use the mouse to drag the layer down to the bottom of the contents pane and drop it there.

You should find that the background layers cover up the National Nature Reserve layer so that it is no longer visible.

- Move the **National_Nature_Reserves_England** layer back up to the top of the contents so that you can see it again.
- Check where the **contours** layer is in the contents. If it is below the black and white tif layers that you added, move it so that it is above those.

1.7.6 Make layers transparent

Use the bookmark to go to the Malham Tarn NNR on your map[4]. You should be able to see that the polygon making up the reserve is symbolised in a solid colour which hides the detail of the base map underneath. We need to make the layer **transparent** so that it is still possible to see the detail of the layers below it in the contents pane.

- Start by making sure that you have the National Nature Reserves layer switched on, then select it in the contents pane. Try to have your contents pane looking something like figure 1.10
- Click to open the **Appearance** tab on the ribbon. The **Effects** group contains a slider to control transparency and a box showing percentage - see figure 1.11.
- 0% is fully opaque, 100% is fully transparent. Try several steps between 30 and 60% and see what difference it makes.

Using the above instructions move the layers around in the contents pane and change transparency for various layers, just to see what the possibilities are.

1.7.7 Grouping layers

The three geological layers are related to each other and could be grouped together to organise the map. Amongst other advantages this would make it easier to turn all of the geology layers on and off together.

- Right-click on the word **Map** in the contents pane. New Group Layer click on the New Group Layer that appears and give it a name such as **Geology** that tells you what the group is. Now use the mouse to drag the **SuperficialGeol; LinearGeol and BedrockGeol** layers so that they appear indented underneath the layer name.
- Try turning off the **Geology** group layer to check that all of your layers are actually together. Don't forget to turn them back on again!

You can also select several layers first and then group them as follows:

- Select the **contours** layer and the four black and white tif background layers using the Shift or Ctrl keys to allow you to select multiple layers
- Right-click on the selected layers and click on Group
- Now rename the group title to something like **Background map**

[4] See section 1.5 on page 4 if you need a reminder of how to use bookmarks.

Figure 1.10: Arrange your contents pane so that it looks like this before setting transparency for this exercise

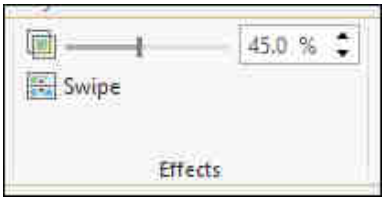


Figure 1.11: The Effects group on the Appearance tab of the ribbon. The slider and percentage show that the selected layer is set to 45% transparency.

1.7.8 Remove layers

You added four black and white background tif maps, but only two of those are actually needed for your final map. It can be a good idea to keep the amount of data in your project down to what you really need - though it makes more difference for a large area, or a large amount of data.

To remove the layers you don't need:

- Right-click on the **sd96sw.tif** layer in the contents pane then Remove.
- and do the same with the **sd86se.tif** layer

Note that this doesn't delete the data from your disk, it just removes the **link** to it from your map. Check this in the Catalog pane - the layers should still be available if you want to add them back in again.

1.7.9 Using Basemaps

The lowest layers on your map are probably called something like **World Topographic Map** and **World Hillshade**.

To make sure that you can see these layers turn off the layers above it by unticking the boxes. If you've grouped layers you should just be able to turn off the groups.

If you look at the **Source** for the World Topographic Map by double-clicking on the layer and choosing the **Source** heading, you'll see that it's **Data Type** is listed as **Vector Tile Service** - figure 1.12

The data type for the **World Hillshade** will be **ArcGIS Map Service**

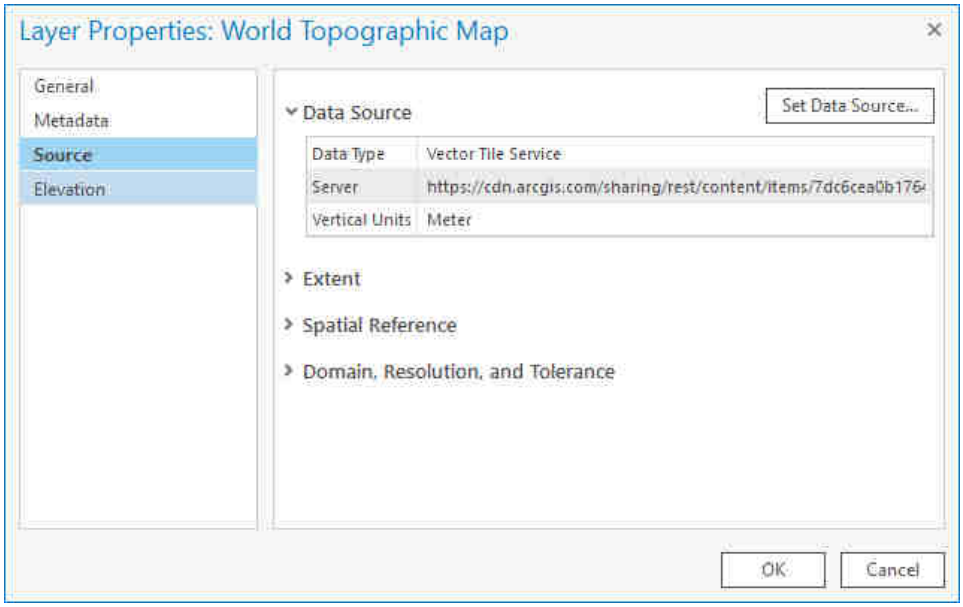


Figure 1.12: The Source information for the World Topographic Map layer - note the Data Type

When you create a new map in ArcGIS Pro you are automatically given a basemap of this type. It's useful as it gives you some idea of where you are. These layers are also very convenient as background maps, and it is possible to change the basemap that your map uses.

- On the **Map** tab of the ribbon click on the down arrow under **Basemap**
- from the list of alternatives click on **Imagery Hybrid** (this has the imagery with labels, roads, borders etc added)

Warning: ***You do have to wait a bit sometimes for these layers to load as they are downloading data over the internet, then reprojecting it to appear on your UK map. For this reason it is often not a good idea to rely on these maps.***

If you find that your maps are loading very slowly, or that you have to wait a long time for anything to display, turn off the ESRI background layers or, even better, remove them completely from your map. They can cause maps to become extremely unstable and start to crash.

Have a look at the Imagery Hybrid layer, then try out some of the others. When you've investigated turn this layer off as you will need to use the background black and white layer instead. Turn the rest of layers on your map back on.

Video Clip available in Minerva - Working with attribute tables in Arc.

1.8 Viewing an attribute table

Data for GIS is stored in tables as **feature attributes**. You can view the **attribute table** to get an overview of your data, and to carry out some useful operations.

- Right-click on the **Bedrock geology** layer in the contents pane and click on Attribute Table.

A pane similar to that in figure 1.13 should open at the bottom of your map window.

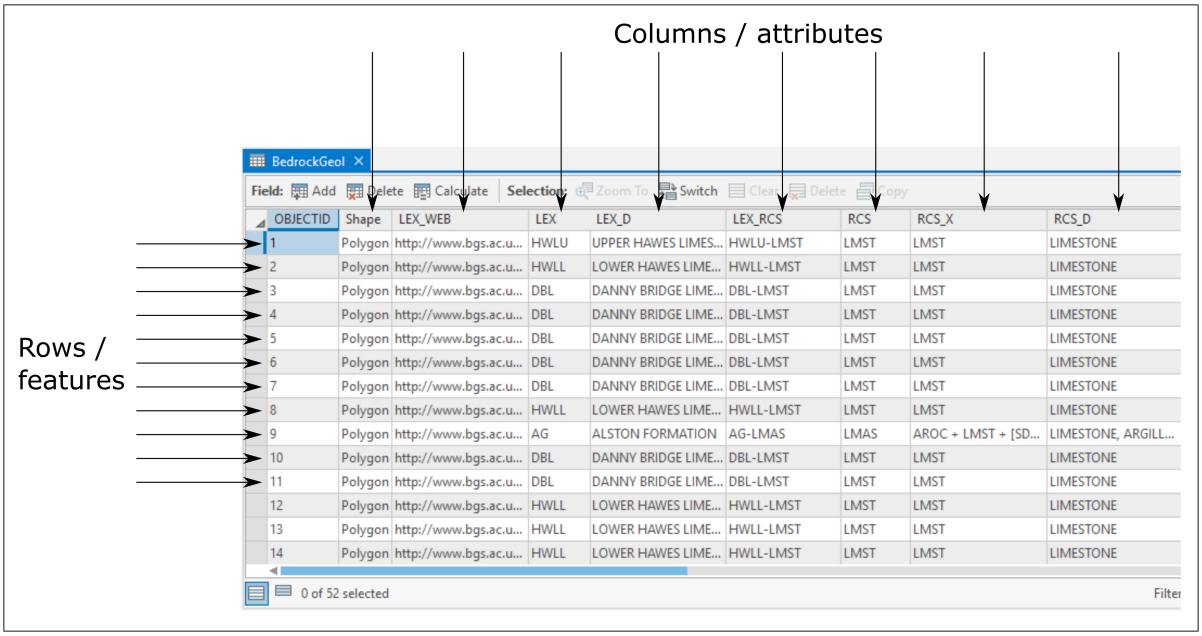


Figure 1.13: The attribute table for the Bedrock geology feature class

Have a look at the structure of the table -

- Each row contains one record - the details for one **feature** on the map.
- Each column is one field - or **attribute**. That is, related information for each feature, such as Label.
- If you are working with **polygon** features in a geodatabase[5], as you are here, the **Shape_Length** and **Shape_Area** fields will automatically be created and filled in with the length of the outline and the area of the polygon. Try scrolling across to see these fields in the Bedrock geology attribute table
- If you are working with **line** features in a geodatabase the **Shape_length** field will automatically be created and filled in with the length of the line.

The measurements will be in **map units** - find out what these are set to by right-clicking on **Map** (the title of the map frame) in the contents pane and going to Properties. Under **General** look at **Map units**

[5] You'll find out more about geodatabases later so don't worry too much about this for now.

Question 1.4. What are the map units of the current map? Make a note in the box below. This information will be useful later.

1.8.1 Selecting features in the attribute table

Video Clip available in Minerva - Selecting features with the attribute table.

- In the attribute table click on the little grey area to the left of the one of the records (see figure 1.14). The feature will be selected in the table, and will also be selected on the map.
- You'll probably need to right-click on the little grey area, then select Pan to. The map will move so that the selected feature is in the centre, and the selected feature will flash. Selected features are marked in a bright turquoise colour in the attribute table and a turquoise outline on the map.
- Use the **Select** tool from the Map tab of the ribbon to click on a bedrock feature on the map and notice that this selects the same feature in the attribute table.
- In the attribute table click in the grey area next to the first of the features that you can see. Now hold down the Ctrl key and click on the third feature. In this way you can select more than one feature at a time. ⇧ will also work.
- To view only your selections click on the Show selected records button at the bottom left of the attribute table pane. To view all records again click on Show all records. Remember that if you hover over a button you'll see a tooltip telling you what the button does.
- To clear selections click on the Clear button either on the attribute table top bar (figure 1.15), or on in the **Selection** group on the ribbon (figure 1.16).
- Right-click on the **Shape_Length** column heading and click on Sort Ascending. This will reorder the table from low to high by the length of the line feature, so the shortest at the top.

Play around with the attribute table and explore what else you can do.

When you've finished, clear all selections by clicking on **Clear** in the Selection group of the Map ribbon then **close** the attribute table pane by clicking on the cross on the tab at the top of it.

1.9 Finding help for ArcGIS

I've been throwing a lot of new terms at you here. Don't worry - most of them will become more familiar as the course goes on. Don't forget you will be able to look back at this workbook - and that there is an index in the back which will hopefully help you to find what you're looking for.

In addition you can make use of some resources provided by ESRI, the company who produce ArcGIS.

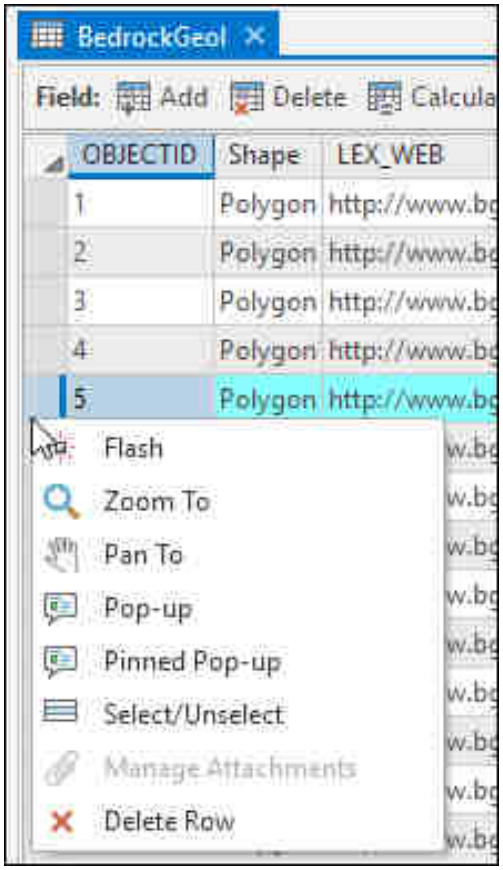


Figure 1.14: Selecting a feature in the attribute table - the "little grey area"

Figure 1.15: The "clear" button on the attribute table menu

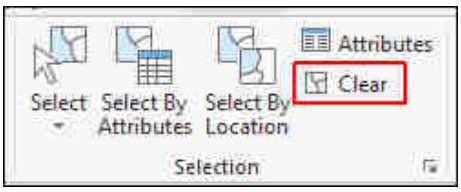


Figure 1.16: The "clear" button in the Selection group on the ribbon

ArcGIS Pro help is available at `https://pro.arcgis.com/en/pro-app/help/` You'll find this useful when you start using more advanced tools in Arc, but if you're not sure of something it's worth searching in the help.

In addition if you want to explore further ways to use GIS there are lots of lessons available at `https://learn.arcgis.com/en/`

1.9.1 ESRI GIS Dictionary

The Dictionary can be useful if you need to remember what a particular term means.

- Go to `https://support.esri.com/en/other-resources/gis-dictionary/`
- Type **attribute table** in the search box and press ↵
- The answer should match what you've already learnt in section 1.8 on page 14.

Practice using the dictionary by completing the exercises below.

"Raster" and "Vector" are the two main types of data structure used in ArcGIS and you will come across these many times during this course.

Use the GIS dictionary to find out what "Raster" and "Vector" mean and write definitions in the boxes below, using diagrams if it will help you to remember the difference.

Question 1.5. Raster:

Question 1.6. Vector:

1.10 Saving a map

IMPORTANT: Develop the habit of saving your map projects at regular intervals. Arc can crash when carrying out some operations and you don't want to lose all of your work. Crashes can also corrupt data files, so copy the whole of your gis folder to another location or drive at frequent intervals (i.e. create a **backup** copy). It can be useful to rename each backup folder with the date of the backup, then you can make sure you keep a couple of copies to go back to if there are problems.

To save your project:

- Either Project > Save from the menu
- or the save icon on the quick access toolbar at the top left
- or use Ctrl + S on the keyboard

1.11 Symbolising a layer

1.11.1 Symbolising a single symbol

At the moment the symbol for the National Nature Reserves is a polygon with a thin outline and a transparent fill. Let's change that so that the outline is thicker and there is no fill at all.

- Right-click on the **National Nature Reserves** layer and click on Symbology
- OR click on **Symbology** on the Appearance tab of the ribbon

The **Symbology** pane should open to the right of the map window. The layer is symbolised as a single symbol - a single random colour which is used for all polygons in the layer. See figure 1.19.

- click on the coloured "patch" next to **Symbol**
- The **Gallery** should open, if it doesn't click on the Gallery heading at the top of the panel.
- The gallery shows you lots of choices of symbology (figure 1.17), try some of them out but finish by clicking on **Black Outline (2 pts)** - you may need to hover over items to see the full names

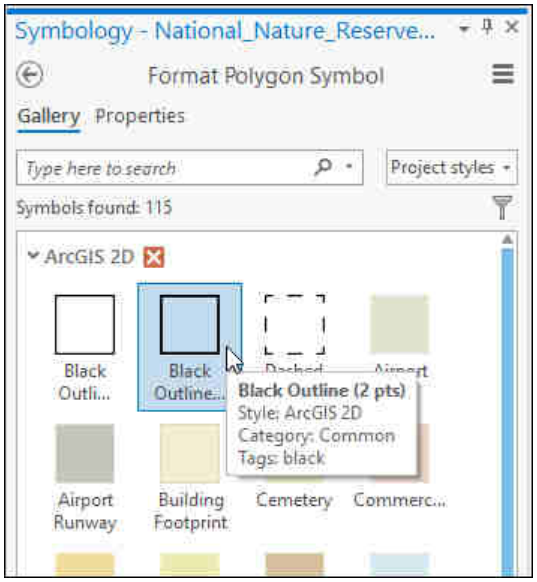


Figure 1.17: Formatting a polygon symbol from the Gallery

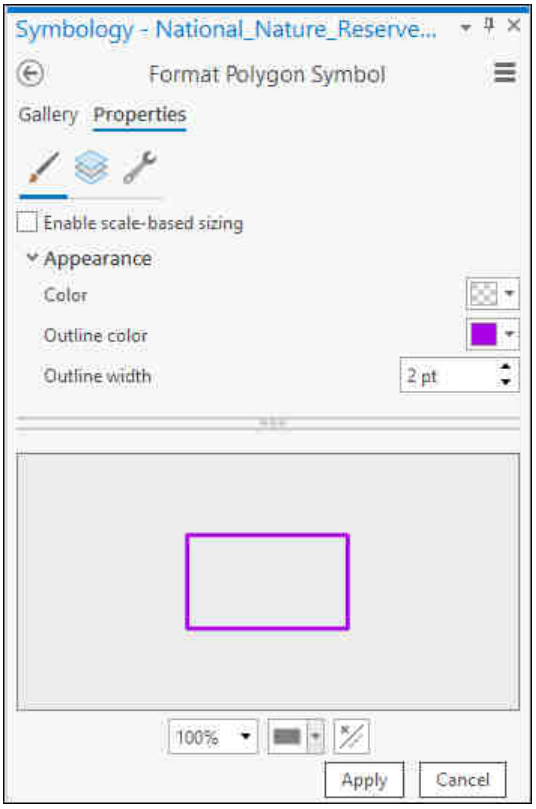


Figure 1.18: Formatting a polygon symbol in the Properties dialog

As soon as you click on a new symbol in the gallery the features on your map should change.

While there are a lot of symbols available, they may not always be quite what you need. For the NNR outline we'll change the colour of the line

- Click on the **Properties** heading at the top of the Symbology panel
- The properties options should look something like figure 1.18
- Change the **Outline color** to something bright which will stand out against the rest of your map.
- Because you selected just an outline in the gallery the **Color** choice is **No Color**. If you want to add a fill colour you can select it here.
- Press **Apply** to change the style of the features on your map.

1.11.2 Symbolising with multiple symbols (Unique Values)

Make the **SuperficialGeol** layer in the Malham map visible by clicking the little box next to it so that it is ticked. At the moment the layer is symbolised as a single colour. By using multiple colours, or classes, you can make your map much more informative.

- Open the attribute table for the **SuperficialGeol** layer and have a look at the data that it contains. The column headed **RCS_D** contains information on what type of unconsolidated deposits are shown by each feature. Make a note of the field name.

- Close the attribute table.
- Right-click on the **SuperficialGeol** layer and click on Symbology

The **Symbology** pane should open to the right of the map window. At the moment the layer is symbolised as a single symbol - a single random colour which is used for all polygons in the layer. See figure 1.19.

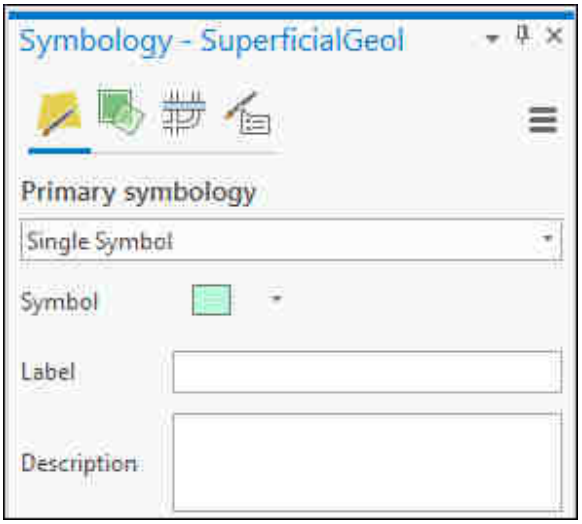


Figure 1.19: The Symbology pane showing single symbology for the superficial geology layer

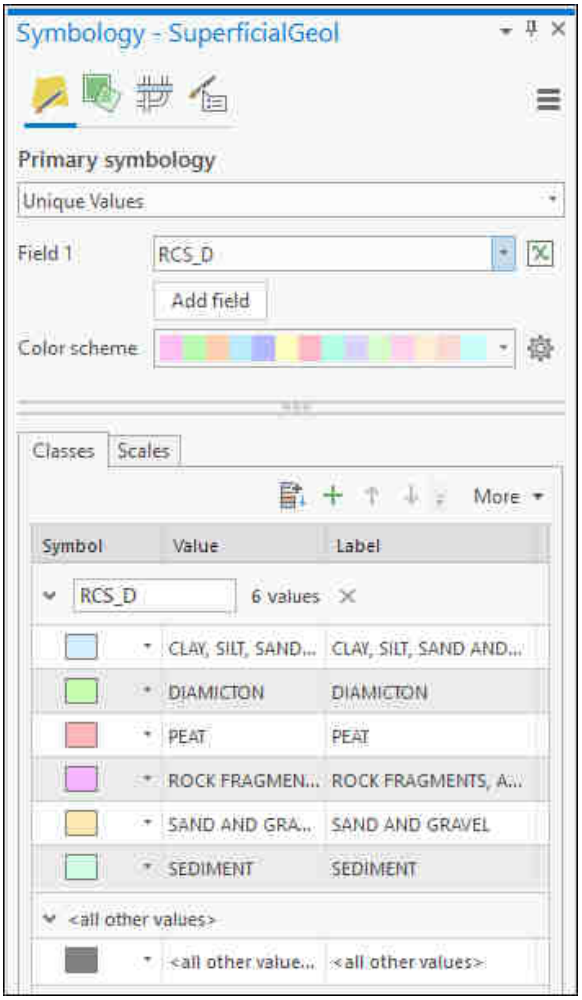


Figure 1.20: Setting symbols for a layer with unique values - or multiple categories

Video Clip available in Minerva - Symbolising a layer by unique values in ArcGIS Pro

To symbolise the layer as multiple colours by geology type:

- Select **Unique Values** in the dropdown box at the top of the Symbology pane
- in the **Field 1** box that appears select **RCS_D** - the field we were looking at earlier.

You should find that you get a list of the values of RCS_D to which Arc will have assigned random colours - figure 1.20.

- You can change the colours and thicknesses of the lines by clicking on each symbol in turn - click on the "patch" next to **PEAT** now.
  - If you click on the **Gallery** heading you'll get a choice of preset styles - click on one of them now, e.g. **Cultural**. You should see the new symbol appear for some of the features on your map [6]
  - As with the single symbology, in the **Properties** heading you can set up your own styles. Click on this heading and try making some of the line widths thicker, and change the colour of the symbol.
- This time you'll need to click on Apply to see the result on your map
- Click on the back arrow at the top of the pane to go back to the full list and try setting the other symbols too.
- You may find it easier to see what you are doing if you turn off all of the other layers in the contents pane.

1.12 Selecting and intersecting two different layers

Now that you have your data in a GIS, why not take advantage of its power? You can use GIS to select features which are within a certain distance of features in another layer. For example, which bedrock geology features appear within 2.5 km of, and in Malham Tarn NNR?

We'll use **Select by location** to select the bedrock geology features which are within 5 km of, and within the Malham Tarn NNR.

Make sure that both the bedrock geology and the National Nature Reserves layers are visible in your map.

1.12.1 Exporting a selection of a feature class

Zoom to layer on the NNR layer and you should be able to see that it covers the whole of England. To start with here we'll create a feature class which **just** includes the Malham Tarn NNR - this will make the next step simpler.

- Right-click on the layer containing the selection - the national nature reserves layer
- Data > Export features
- Choose to save the new Output feature class in the project geodatabase (Malham.gdb) - see figure 1.21 and give your output a name, e.g. **MalhamTarnNNR**
- To select just Malham Tarn NNR do the following:
  - Click on the New expression button
  - In the three boxes next to **Where** fill in
    * **NNR_NAME** - using the dropdown box
    * **contains the text** - again using the dropdown box
    * type in **Malham Tarn**
- then Run
- the new layer should be automatically added to your map

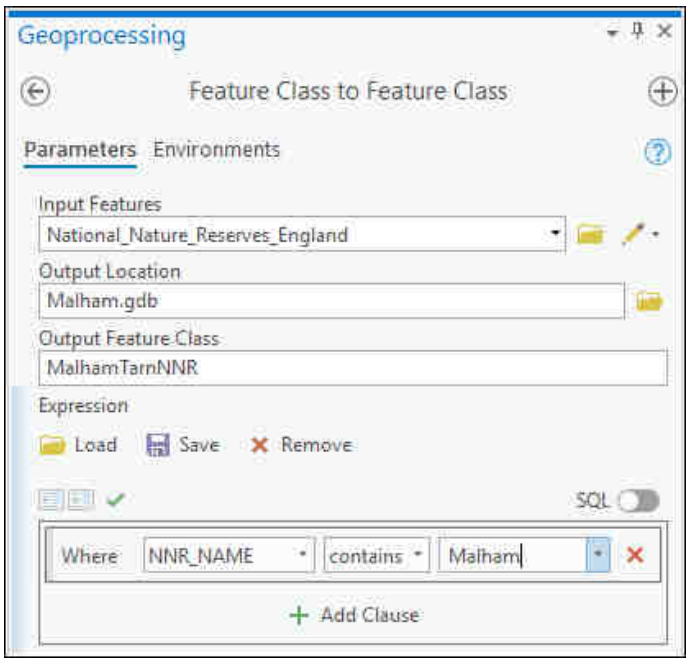


Figure 1.21: Exporting a subset of an existing layer using an expression

To check this has worked properly **Zoom to layer** on your new layer and check that the outline of the Malham Tarn NNR fills the map area.

Now **remove** the original national nature reserves layer from the contents list and you should be left with just the Malham Tarn Reserve which you had selected via the expression. Try symbolising the reserve as a single, green outline symbol.

1.12.2 Select by location

Video Clip available in Minerva - Select by location.

- From the **Map** tab of the ribbon click on the button to Select by Location
- The dialog should open in the Geoprocessing pane on the right. Fill it in following figure 1.22
  - **Input Features** should be the layer which contains the features that you wish to select, in this case the **Bedrock geology**
  - **Relationship** should be set to **Intersect** (but have a look at the other options which are available)
  - **Selecting Features** is the layer that indicates the location you want to select against, so the **Malham Tarn NNR**.
  - We'll also add a small margin so that nature reserves which have parts within 2.5 km of the nature reserve will also be selected, so enter the **Search distance** as **2500** meters.

[6] If you find the selection of symbols available rather limited, it is possible to add more styles from the ESRI Gallery - see table B.1 on page 146 for more details.

  - **Selection type** should be **New selection**
- Click on Run at the bottom of the pane

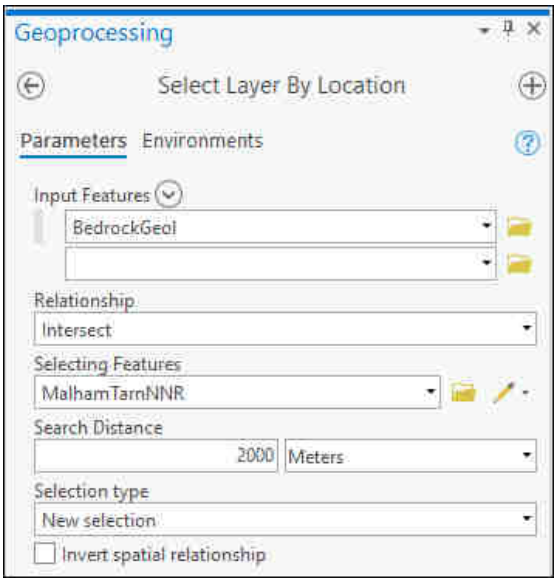


Figure 1.22: Filling in the Select by location dialog

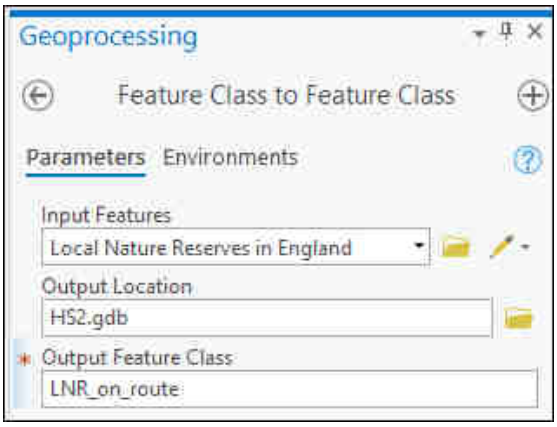


Figure 1.23: Exporting a selection to a new feature class. I haven't shown the whole tool panel - the defaults are fine in this case

---

Now your map should show the bedrock geology features which are within 2.5 km of the Malham Tarn NNR outlined in the selection colour - probably bright blue/turquoise in this case. You may need to zoom in a bit to see them properly!

Once you have selected the features you can make the selection permanent by exporting it to a new feature class.

- Right-click on the layer containing the selection - the bedrock geology layer
- Data > Export features
- Choose to save the new Output feature class in the project geodatabase (Malham.gdb) - see figure 1.23 and give your output a name, e.g. **MalhamGeology** - then Run
- The new layer should be automatically added to your map

Now **remove** the original bedrock geology layer and you should be left with just the features which you had selected.

Try symbolising them using Unique Values so that each type of bedrock geology is a different colour. Use **LEX_RCS_I** as Field 1.

Question 1.7. How many features are there in the new layer showing only the bedrock geology within 2.5 km of the Malham Tarn NNR? You should be able to tell by opening the attribute table for the layer.

1.12.3 Symbolising with a layer file

This section is an optional extra. If you want to colour the bedrock features in your new layer using the correct BGS colours try the following:

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

- Select the Malham geology layer in the contents list
- On the ribbon go to the **Appearance** tab and click on **Import** in the Drawing section
- In the **Apply Symbology From Layer** dialog (figure 1.24)
  - The **Input Layer** is the new bedrock geology layer
  - For the **Symbology Layer** click on the folder symbol and navigate to `Folders` ▸ `Malham` ▸ `bgs-50k` then click on `ew060_settle_bedrock.lyr` then on OK
  - Under **Update Symbology Ranges by Data** select **Update ranges** so that only the symbology that applies to your data is imported
- click Run

The colours of the new bedrock geology layer should update. You'll need to apply transparency again to be able to see the background map - see section 1.7.6 on page 11 for a reminder of how to do this.

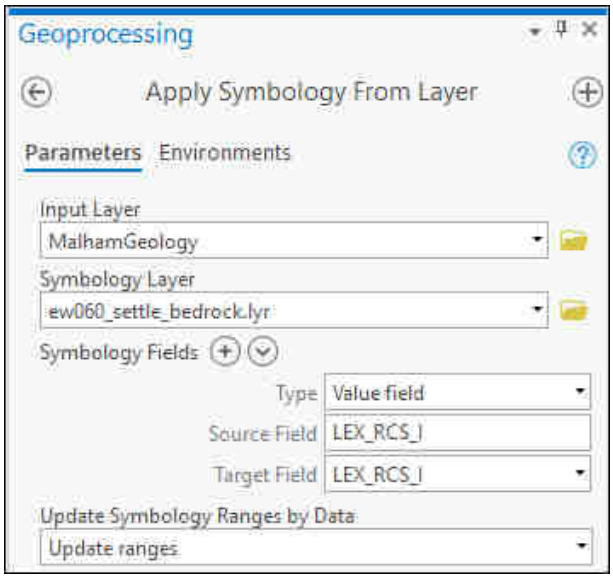


Figure 1.24: The Apply Symbology From Layer dialog

The .lyr files for the symbology for LinearGeol and SuperficialGeol have also been provided if you want to apply those.

1.13 Layout - laying out a map for print or export

So far we have been working in the **Map**. If you print the map from here you have little control over it's appearance. To produce a professional-looking map you need to use a **Layout**. The information

given here is just a quick introduction, you'll cover layout and presentation in more detail in a later chapter.

- In the Catalog pane open out the **Layouts** subheading and double-click on the **Layout**

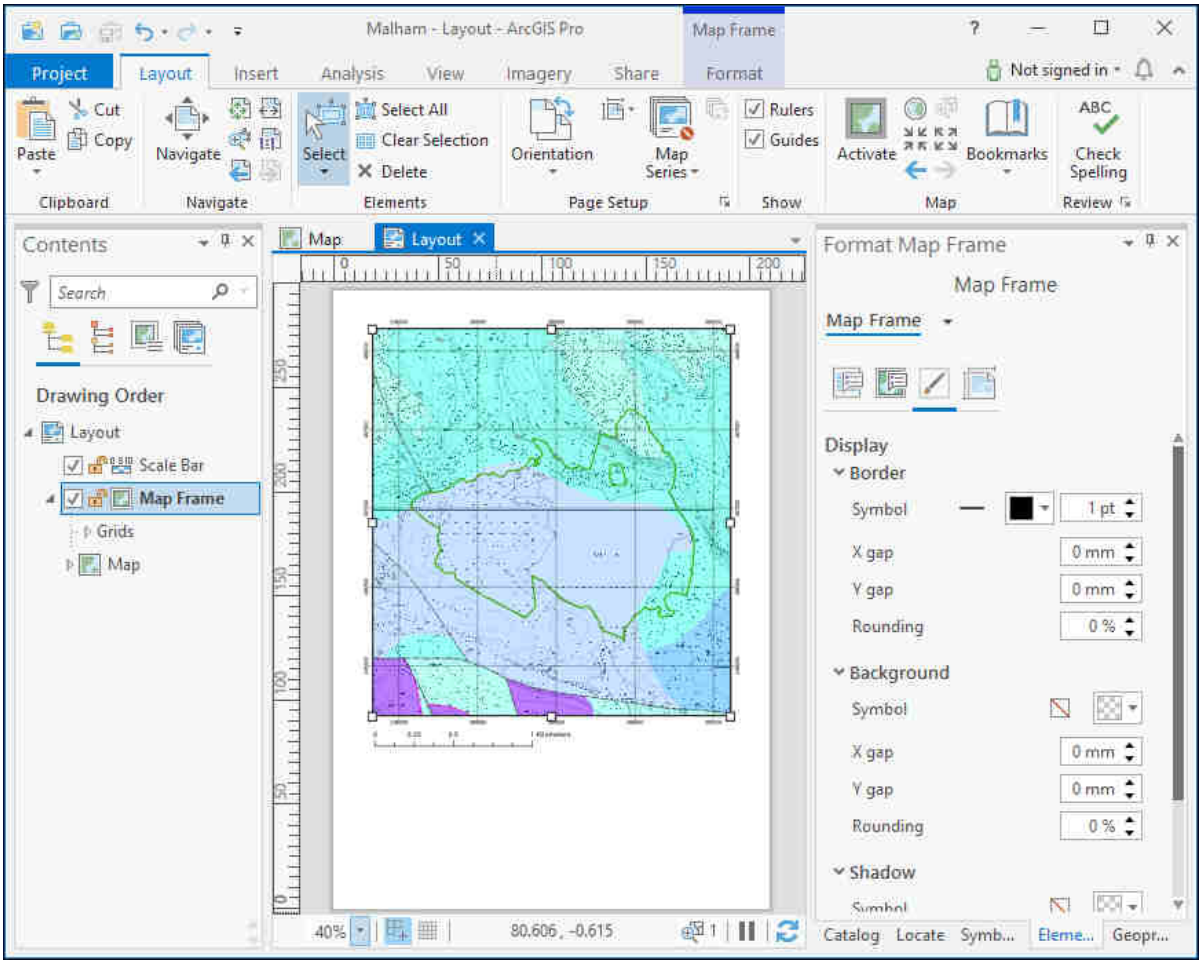


Figure 1.25: Layout view in ArcGIS Pro showing a layout with a single map frame.

The layout window (shown in figure 1.25) looks similar to the map window, but shows the layout as it will appear when printed. You still have the contents pane on the left of the screen and the ribbon at the top, but the ribbon will offer some different options.

- On the ribbon go to the **Layout** tab. Use the buttons in the **Navigate** group to zoom in and out of the layout and move around it.
- Try the tools in the **Map** group on the **Layout** tab in this view too.
- In addition you can open out the contents of the Map Frame in the Contents and **Zoom to Layer** on any of the layers just as you did in Map view (section 1.4 on page 2)
- To move the actual map, rather than the layout, you need to click on the **Activate** button in the Map group on the Layout tab. Once you've done that you can pan and zoom the area of the map using the mouse. Once you've finished click on the back arrow at the top of the Layout window to get back to the usual Layout view.

Question 1.8. What is the difference between zooming with the tools in the Navigate group of the Layout tab and with the tools in the Map group in layout view?

To get back to the original view use the **bookmarks** just as you did in section 1.5 on page 4. There should be a bookmark called **Malham Tarn NNR** that you can click on.

1.13.1 Adding objects to the layout

Most of the maps that you create will need to be printed out with additional content such as a title, a key or legend, a scale bar and some text. I've already added a measured grid and a scale bar to this layout. You'll add a title and copyright text to this map but you'll learn more about layout in a later chapter.

Video Clip available in Minerva - Adding a scalebar, title and text to a layout.

To add text

To add text to your layout:

- Go to the **Insert** tab on the ribbon
- In the **Text** group click on **Text** then select the top option - **Text**
- Click on the layout somewhere close to where you want the text to appear (you can move it later!)
- Type the text that you want to add - for now type the text below as a title - then click elsewhere to come out of the text box.

The geology of Malham Tarn National Nature Reserve

Formatting text You're likely to want to change the default text option. There are books about cartography on the reading list which give more information about font choices, but for now use the instructions below to play around with the options.

- If you select the text that you've just added a **Format Text** pane should open on the right of the window.
- Click on **Text Symbol** to get options to change the text appearance.
- As with symbology the **Gallery** gives you preset choices, or go to **Properties** to set your own.
- Investigate the options to set the text that you've just added as a title at the top of the page.
- You can see what the style will look like at the bottom of the pane. Once you're happy with it click Apply to change the style of your text.

Copyright acknowledgement is important! Always check the terms and conditions for any data that you use. Most will tell you the wording that you should use - though it can take a bit of finding sometimes! When you sign up to the Digimap service in chapter 2 you'll find out more about the correct acknowledgements you need to use for their data. For this map add the text below to your layout. If you are using an ESRI basemap the acknowledgement for that will automatically be added to your map.

> ***© Crown copyright and database rights 2020. Ordnance Survey (100025252). Geological Map Data BGS © UKRI 2020***

There is more information about adding text and copyright acknowledgements in section 7.7.2 on page 119.

1.14 Printing or exporting a map

To **print** your layout:

- If you need to change the paper size and orientation use the tools on the **Layout** ribbon **Page Setup** group.
- To print go to the **Share** tab on the ribbon and click on the printer button in the **Print** group.
- Set up the printer as you would usually then click to Print.

To **export** a map to pdf or an image:

- If you need to change the paper size and orientation use the tools on the **Layout** ribbon **Page Setup** group.
- To export go to the **Share** tab on the ribbon and click on the green arrow in the **Export** group.
- Select the format that you wish to export and give your file a name. Check the other options and change as appropriate (you may find that the defaults are OK) and then Export

1.14.1 Suggested layout

Your final map could look something like figure 1.26. It is unlikely to look identical as you should make your own decisions about where to place elements and how to display your map.

Print your final layout and bring it to the next class. I will try to speak to all of you individually during the course of the next practical and will give you feedback on this exercise. If you have any questions about what you have done you can ask them at any time during the session.

1.15 Recommended reading: Introduction to GIS

Many of the books in the reading list[7] have a general introduction to GIS which explain what it is and how it is used. Suggestions include the following:

[7] Reading list available from Minerva and from the library by searching for *SOEE2650* at `http://lib5.leeds.ac.uk/rlists/index.php`

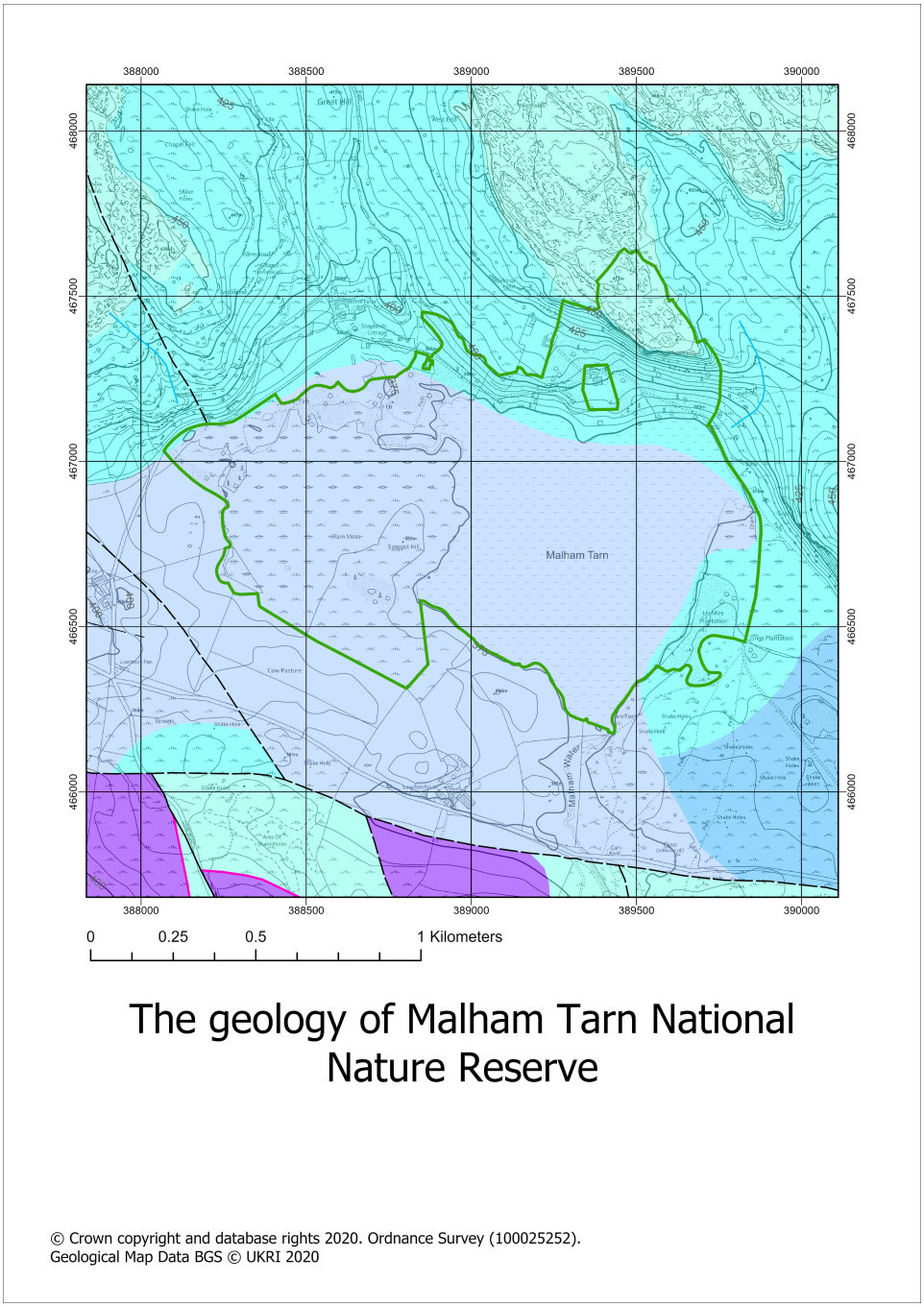


Figure 1.26: Possible layout for the Malham geological map. Your map probably won't look identical to this as you should make your own decisions about how to lay it out.

- Chapter 1: *What is GIS?* IN Heywood, I., Cornelius, S. and Carver, S. (2011), pp. 2-30.
- Chapter 1: *Systems, Science, and Study* IN Longley, P.A. et al. (2011), pp. 3-37.

In addition have a look at the other books under **Geography K-13** on level 9 in the Edward Boyle Library.

For more information about basic use of Arc look at the book by Kennedy, M. (2013). He specifically covers using ArcCatalog and ArcHelp - use the index to find the sections that you need.

1.15.1 Videos online

If you find videos helpful then search online for specific tasks in Arc. Make sure that you are viewing videos for ArcGIS Professional rather than Desktop, though.

Examples include:

Navigating ArcGIS Pro: The Basics Part 1 - `https://youtu.be/WDlUoDXQ_-o` - and other videos in the playlist from the University of Toronto Library

`https://youtu.be/soBtBP6aZ60` - quick start tutorials from ESRI which start with this video.

Chapter 2

Digimap

The background to using Digimap and an explanation of what you need to do will be covered in the lecture segment at the beginning of the class and the presentation and any other supporting materials will be available in Minerva. The lecture segment should help you to understand **why** you are doing these exercises. If you still aren't sure, please ask Clare.

2.1 Learning outcomes

When you have finished this chapter of the workbook you will

- be aware of the UK data available to you through the Digimap service
- understand how to use the Roam browser in the Digimap Collections to make a digital map displaying a selection of features
- know how to download images and pdf maps from the Digimap Collections for printing and use in other programs
- know how to use Data Download to download data from Digimap Collections for use in GIS programs

2.2 Introduction

Digimap is a service provided to Higher Education in the U.K. by EDINA at Edinburgh University. Digimap provides a front end to digital maps and data of Great Britain from the Ordnance Survey and the British Geological Survey. As a member of the University of Leeds you have access to maps and data for use as part of your studies.

2.3 Logging in to Digimap

2.3.1 Registering

If you have not used Digimap before you will need to register using your University id, that is the username and password that you use to access University systems. Full instructions for registering and logging in are on the Digimap help pages at

`http://bit.ly/1yQusPx`

Start by selecting **University of Leeds** and logging in with your usual University username and password. Please do not use any other email address to register - it will only cause you problems when it comes to obtaining data later.

You need to register for each collection separately, but can do it in one go. For this workbook you won't need to use all collections, but it is worth registering for all that are available to you so that you can explore them for yourself. The University of Leeds does not subscribe to Marine or Global Digimap[1].

In the **Purpose** dropdown select **Academic Works (coursework, projects, dissertations etc.)**

2.3.2 Logging in

To log in go to the Digimap Collections page (figure 2.1) at

`http://digimap.edina.ac.uk`

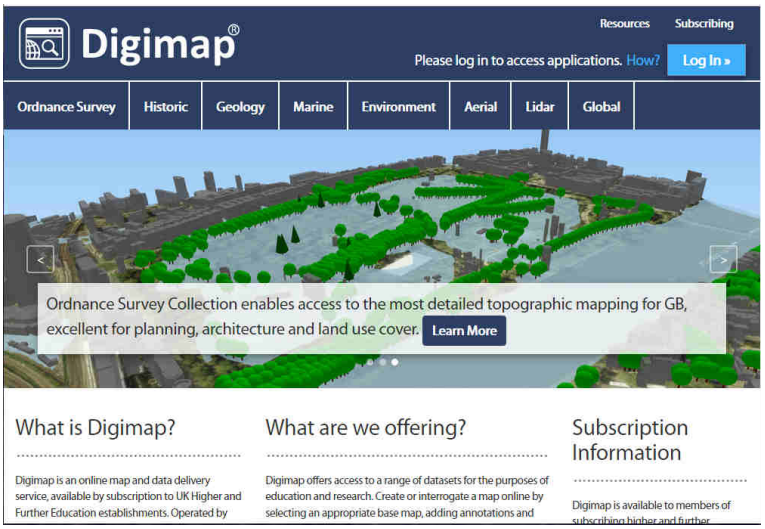


Figure 2.1: Digimap initial page

- Click the **Login** button at the top right of the screen and type **Leeds** in to the box and select the **University of Leeds** from the list of available institutions
- You should get the familiar University of Leeds login page, so type your **University username and password** into the appropriate boxes and then click the **Log in** button. If you are already logged in to Minerva you may find that you don't have to enter your login details again.

You should be taken to the Digimap initial page again (figure 2.2), but this time with your name at the top right.

The list includes options for a large number of collections. In this workbook we'll only be looking at the collections that are most relevant for creating the maps you'll need during your course, but if you are interested in any of the others feel free to explore them. Edina have worked to make all of the tools similar across each collection so just have a go!

[1] as of September 2018

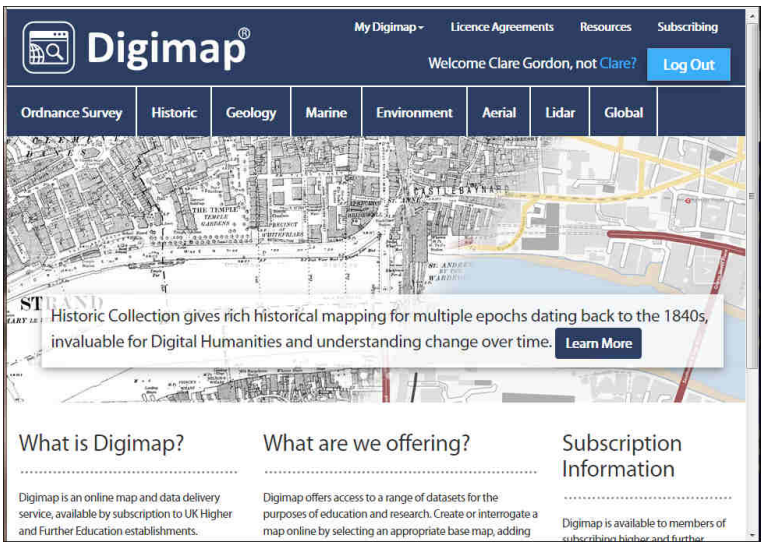


Figure 2.2: Choosing a data collection

2.4 Ordnance Survey Collection

We are going to start by looking at the **Digimap - Ordnance Survey Collection**. (Figure 2.3.) Click on the Ordnance Survey heading at the top of the screen and you'll be shown which services are available to you and information about the collection.

Figure 2.3: Ordnance Survey Collection

The list includes links to **Roam** and **Data Download**. We'll look at both of these in the sections below.

Roam and Download are fairly standard across all collections in Digimap (making allowances for the differences in the data) so once you've used them in the OS Collection you'll have a good idea of how they are likely to work for Geology, Aerial etc.

2.4.1 Digimap Roam

In this section you will learn how to use Roam to view and create maps using Ordnance Survey data.

- Click on the **Roam** heading.
- You may be presented with the copyright statement page.
- Read the copyright notice carefully and click on the **copyright terms and conditions link**. This launches the "Digimap: Ordnance Survey Data Sub-licence Agreement" page which shows the full terms and conditions. You signed up to these terms and conditions when you registered so make sure that you follow them. Click your browser's **back** button to return to the copyright notice, then click on the green button to acknowledge your agreement to the copyright statement.

Video Clip available - The Digimap video on Digimap Roam is available at `https://youtu.be/kSdO-2lnRGc` (this video has sound). Note that this video shows the beta version of Roam so there may be some differences.

Overview

Digimap Roam enables you to view and print maps using Ordnance Survey data at various predefined scales. PDF prints can be created in A4 or A3 size and landscape or portrait orientation. See figure 2.4 for an annotated overview of the Roam window.

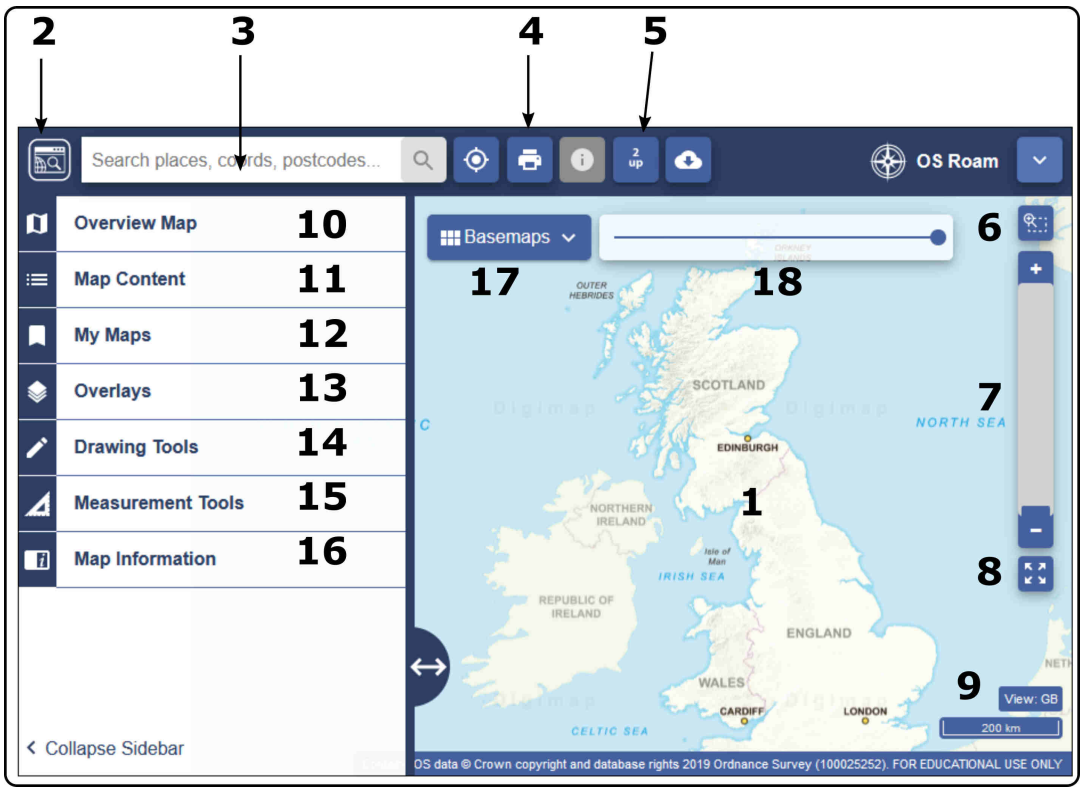


Figure 2.4: The Digimap Roam window

The service is being actively developed at the moment so keep an eye open for new buttons or headings and try them out.

1. = **Map window** - Where the maps are displayed

2. = **Home** - return to the Digimap home page
3. = **Search** - enter a place name, postcode or map coordinates here to search for them
4. = **Print** - produce a printable PDF file of your map
5. = **2 up** - open a second map window - allows you to look at two different maps of the same area side-by-side
6. = **Click and drag to zoom in** - as it says!
7. = **Zoom slider** - use to zoom in and out
8. = **Zoom to max extent** - Click to zoom out to full G.B. view
9. = **current view** and **scale bar** - shows current view type and the scale on the map
10. = **Overview map** - when you're zoomed in use this to show where in the country you are
11. = **Map content** - view map legend and customise map content when possible
12. = **My Maps** - previously saved map views and content
13. = **Overlays** - Enables hill shading at certain levels of zoom
14. = **Drawing tools** - Tools to create annotations, import your own data, or export data in various formats
15. = **Measurement tools** - Tools to measure distance and area
16. = **Map information** - current map product, data licence, date of map and other essential information
17. = **Basemaps** - Enables different map styles at certain levels of zoom
18. = **Opacity** - slider to change the transparency of the basemap

Searching for a location

You can search for a location in Roam by using a place name, postcode or grid reference.

To search using a **place name**:

- Type the place name (for this example type **Leeds**) in the search box and press Enter or click on the magnifying glass button.
- If there is more than one match for your place name the search results will be displayed below the search box - see figure 2.5. Click the place name that you are interested in to view it in the map window - in this case click on **Leeds (Leeds)**.

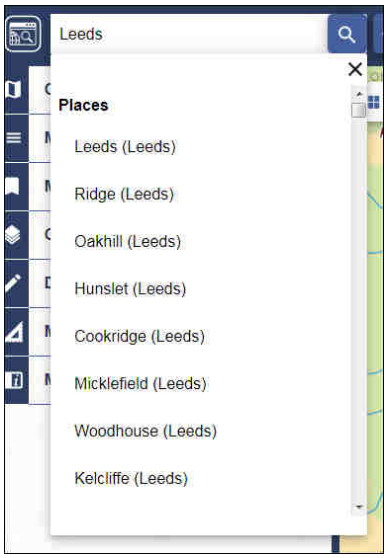


Figure 2.5: Search box and results of a search for "Leeds"

You'll need to click on the cross on the search results to close the list but when you do you'll lose the marker showing the centre of your search area.

To search using a **full postcode**:

- Try searching for the University postcode - **LS2 9JT**. Roam should take you straight to the centre of this postcode area.

To search using a **Grid Reference**:

- Type the grid reference, e.g. **SE4435** in the **Grid Reference** box and click **Find**. Roam will automatically navigate to that location.

Navigating in Roam

You can navigate in Roam by panning (moving the map in any direction by dragging it with the mouse) and by zooming in and out of the map.

To zoom in/out of the map you can:

- Double click to zoom in
- Use the zoom slider bar to zoom in or out either by clicking on the **+** and **-** signs or dragging the blue marker on the bar.
- Or click anywhere on the slider bar to zoom to that scale.

Map views

Roam has at least 13 pre-defined map scales, called **views**. The views consist of different Ordnance Survey map products which are appropriate for each view's scale (e.g. the Street view uses the VML (VectorMap Local) raster). once you have found your location of interest you can zoom in and out to find the appropriate view for your map.

The name of the view you are looking at appears in the bottom right of the map window, e.g. **City view**.

Search for the postcode LS2 9JT (The University).
Question 2.1. What view does Roam take you to when you click on "Find"?

Zoom in and out and notice the way that the map content changes between views. Pan around and explore an area of your choice.

Controlling map content and basemaps

In some of the views in Roam it is possible to customise which features are displayed on the map - e.g. display only A class roads and/or railways.

To customise the map view:

- Zoom to **Neighbourhood view** - the type of view is shown in the bottom right of the map.
- Click on **Basemaps** (top left of the map window) and select **VML Streetview**[2] See figure 2.6
- Click the **Map Content** tab in the task menu panel. The map content panel contains a list of the feature types that are included in the map so it can also function as a key.
- Switch features or groups of features (such as all roads) on and off by checking or un-checking the tick box next to the feature name.
- All features can be switched off by unchecking the **Clear/select all layers** tick box. **N**B: clearing all layers will result in a blank map, so remember to switch at least one layer back on!

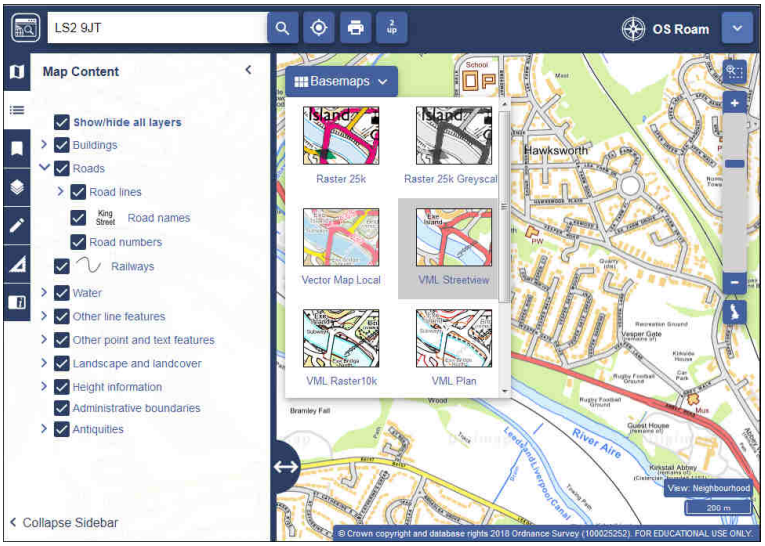


Figure 2.6: Choosing a basemap in Neighbourhood view in Roam. Note the tickboxes next to the features for the VML Streetview basemap.

Note: Many other views cannot be customised because the Ordnance Survey data used in these views are in raster data format which do not allow selection of features. You will still be able to see the features listed in the map content control panel but there won't be tick boxes next to them.

Question 2.2. Name some other view and basemap combinations besides Neighbourhood >> VML Streetview that allow you to select content?

[2]VML stands for VectorMap Local and refers to a particular Ordnance Survey product which is used in many of their web mapping applications.

Using the measuring tools

Roam provides tools for measuring distance and area.

- Click on Measurement Tools on the sidebar to open them (figure 2.7).
- Click on the first button - **Measure Distance**.
- Click on the map to start measuring, click for each corner, then double-click to stop measuring. The measurement in metres will appear on the toolbar as well as on an overlay on the map.

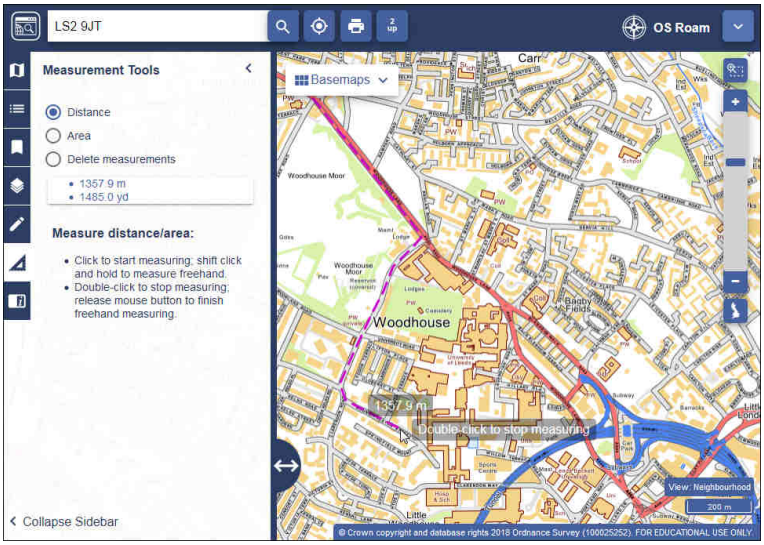


Figure 2.7: Measurement tools - click on the map to start measuring, double-click to stop

Question 2.3. Use the Measure Distance tool to measure your route to the University. How far away do you live?

In a similar way try out the **Measure Area** tool.

Try very roughly to measure the area of Woodhouse Cemetery (now disused and known as St George's Fields) which is just north of us here in Earth and Environment.

Question 2.4. What is the area of Woodhouse Cemetery?

Video Clip available - The Digimap video on Annotating maps with Roam is available at `https://youtu.be/GeFa2Er1Z9M` (this video has sound)

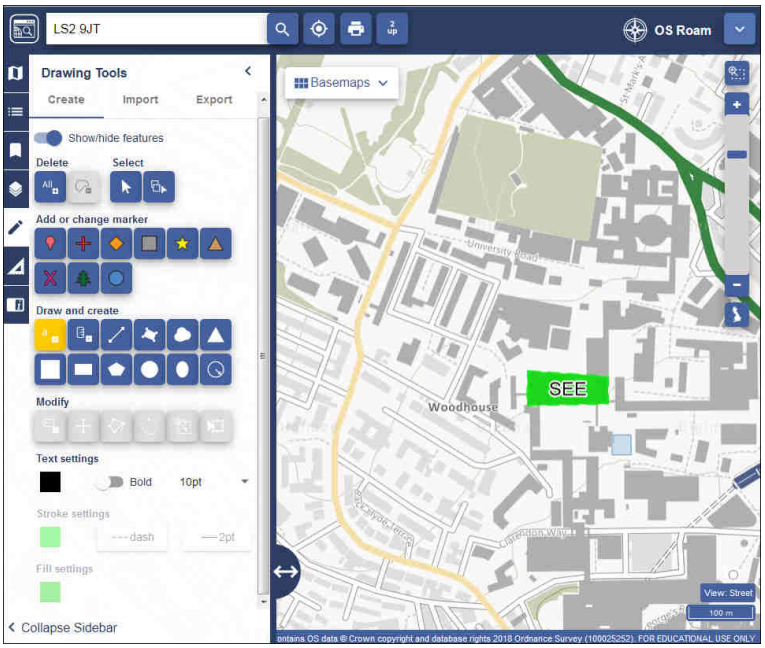


Figure 2.8: The Drawing Tools panel

Using the drawing tools

Roam has a set of drawing tools that allow you to draw on a map and add labels. This is particularly useful for marking up maps for reports or to show people where you are working.

- Click on Drawing Tools on the sidebar - the Drawing Tools panel should open (figure 2.8).
- Explore the tools and scribble all over your map! There is a **Delete All** button so you can clear everything when you have finished, or you can toggle visibility so that you can turn the annotations off without losing them.

Return to the University (LS2 9JT) and check that the view is set to Street View.

Use the drawing tools to draw a box with a red line around the Earth and Environment building (i.e. this building!) and label it "SEE" in bright green.

Exporting annotations

It is possible to save your annotations or drawings to file. This is particularly useful as one of the options is Shapefile which can be directly opened in ArcGIS, and another is kml which can be opened in Google Earth.

- Click on Export on the Drawing Tools panel, (figure 2.9) give your file a name that will help you identify it again later and select a file format:

  - **Shapefiles** can be opened in most GIS software
  - **KML** will open in Google Earth

- Then click on Export to save the file to disk

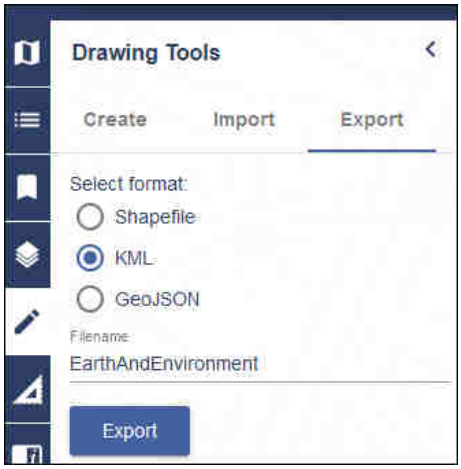


Figure 2.9: Saving annotations to file in Roam

Printing from Roam

Roam allows you to create printable PDF (Portable Document Format) maps or export jpg or png images in A4 to A0 size and in portrait or landscape layout. The image formats make it possible to import maps into Word or Powerpoint.

You won't be printing directly from Roam, really this is more of an **export** function.

Video Clip available - The Digimap video on Printing Roam maps is available from `https://youtu.be/mPZOyGp75h0` (this video has sound)

Using the map that you were looking at in the previous exercise create a pdf map which you'll save to your M:/ drive. You don't need to print it unless you particularly wish to.

- Click the **Print icon** at the top right to open the print options in a new browser window (figure 2.10).
- Enter a map title in the appropriate box.
- Click to add National Grid Lines.
- Select the page size and layout using the drop down menus.
- Look at the **Layout Preview** tab to check that the area that you want will be printed and move the map, or rescale it if you need to
- Click **Generate Print File**, depending on your choice this will either produce a PDF file which you can save or print, or an image file that you can include within other documents.

See section 2.7 on page 52 for information on how to print and edit PDF files.

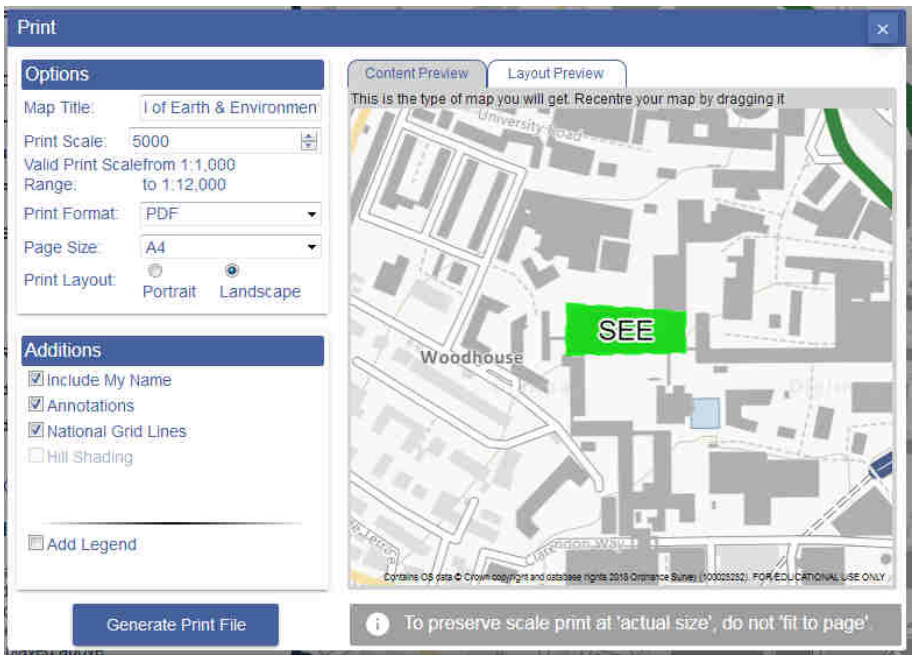


Figure 2.10: Printing to pdf or image file from Roam

Saving map views for future use

Once you have set up a view and, maybe, added annotations, Roam allows you to bookmark it so that you can go back to it later.

- Click on My Maps on the sidebar
- Click on Save and give your map a name that will help you to identify the map later then click Save on this screen.
- Next time you want to use that map click on Open and open it from the list that appears there - figure 2.11.

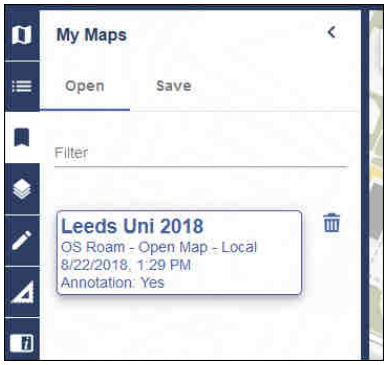


Figure 2.11: My Maps

2.4.2 Data Download

Data Download is a tool for downloading Ordnance Survey data for use in GIS or CAD software. The format that the data is delivered in will determine whether you will be able to open it directly in a software package or whether you will need to convert it.

We'll be using data from Digimap in ArcGIS later in the module so you need to know your way around this section. Instructions for converting, importing and viewing file types that need it will be given during the ArcGIS part of the course.

Selecting your Ordnance Survey data

- Go to the Digimap home page
- Click on **Ordnance Survey** in the menu at the top of the page
- From the Ordnance Survey page choose **Data Download** (Figure 2.12.)

Data download takes you to a map that looks very similar to Digimap Roam but with some important differences.

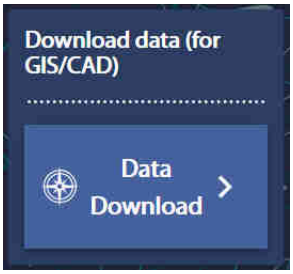


Figure 2.12: Data Download

Figure 2.13: Search for & select an area

Selecting an area

On the left there is a menu panel with options for selecting an area with a search box above it (figure 2.13).

- Click in the **Search** box and type **University Road, Leeds**, then press Enter or click on the magnifying glass to search.
- When you get the results click on **Roads (100+)** then select **University Road (University - Leeds)** to zoom in then close the search results.
- Under **Draw** click on the rectangle and use the mouse to draw a box around part of the University, clicking to start and finish the box. (Figure 2.14)

Note: The map that you see on the screen only shows the area that you will be downloading data for, **not** the actual data that you'll be downloading. You'll select the data separately so don't worry what it looks like for now.

Selecting data sets

Now that you've selected an area you have to select the data that you need.

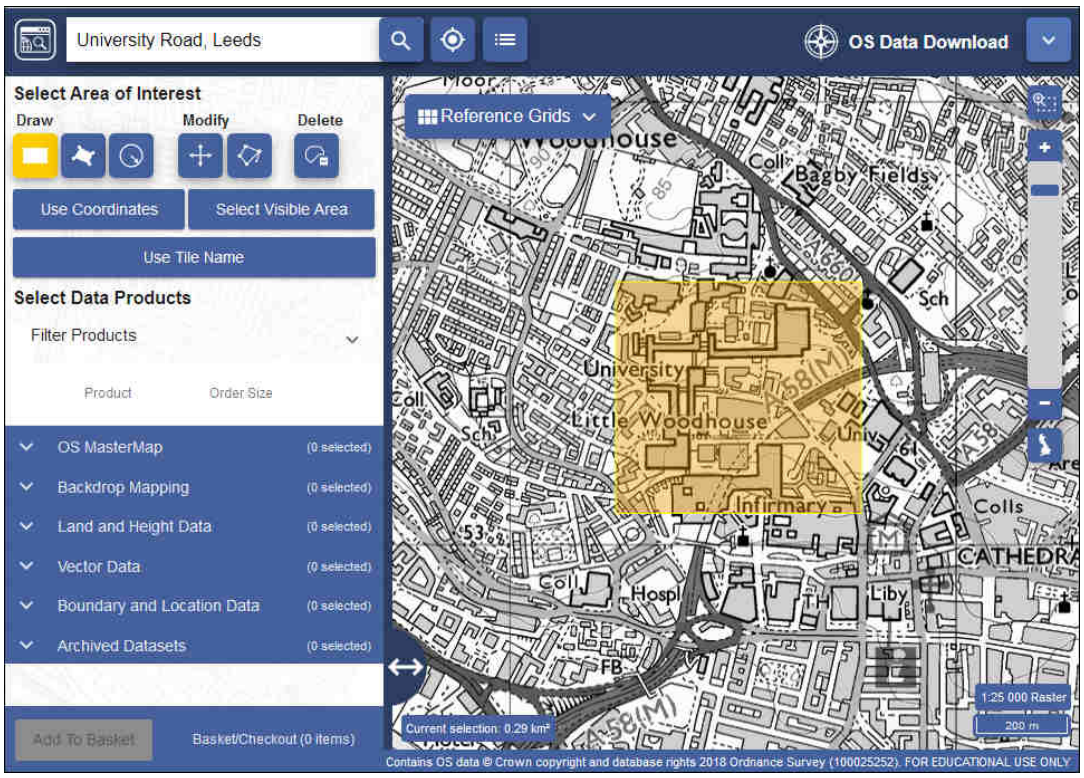


Figure 2.14: Selecting an area in Digimap Download

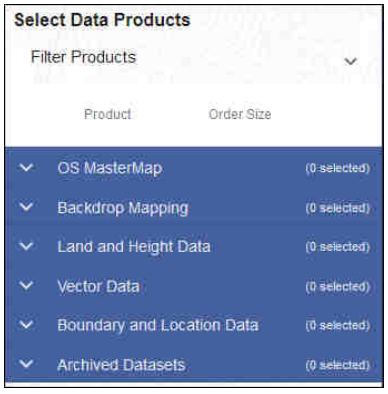


Figure 2.15: Select products from the list

- Back in the panel on the left, under **Select Data Products**, drop down each of the headings in turn. (Figure 2.15.)
- There are a lot of different data sets here and most of them won't mean anything to you. For now select the following datasets when you find them by putting a tick in the box next to them.

Backdrop mapping: VectorMap Local Raster
Land and Height data: OS Terrain 5 Contours

You can get more information about the datasets by clicking on the arrow next to them. This includes information on licences.

The figure on the right in brackets under **Order Size** shows how many tiles your selected area uses out of the maximum downloadable number.

- When you have selected the data you require click on **Add to Basket**. (Don't worry - despite the Shopping Basket and Checkout you won't be charged. The University has already paid the subscription!)

Your basket should appear with details of your order. (Figure 2.16.)

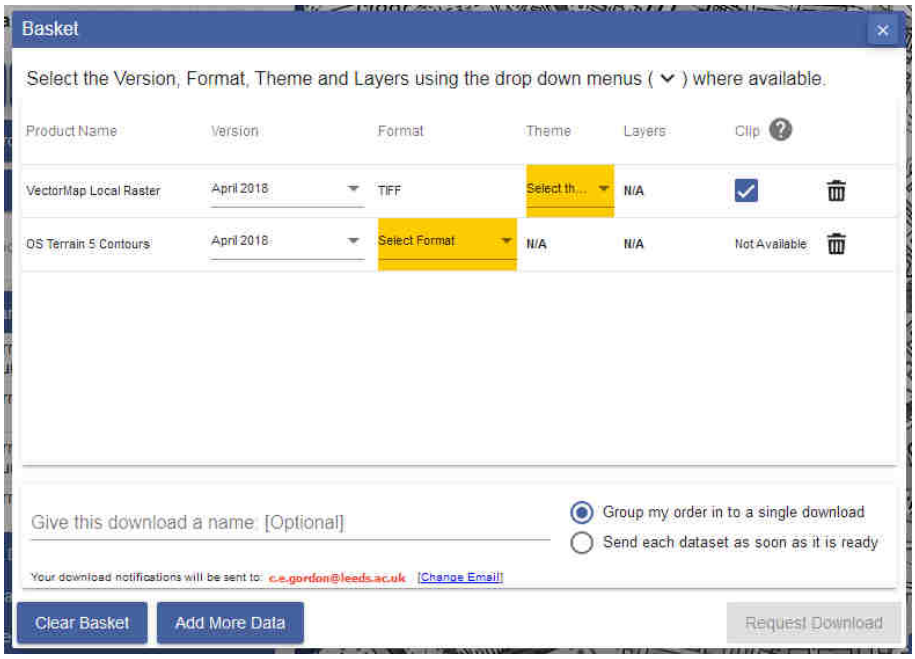


Figure 2.16: Details of your order in the Basket

- Some datasets will give you an option to change the format (highlighted in yellow). In this case click on **Select Format** next to the contours. The choices are **Shape**, **GML3** or **DWG**. Choose **Shape** in this case.
- You may also need to select a theme - for the VectorMap Local Raster there is a choice of themes - pick whichever one you like this time!
- Some items will have a **Clip** option. This means that the data will be sent to you clipped to the area outline that you requested. If you are really short of disk space this could be useful, but it doesn't usually hurt to have extra data around the outside of your study area. I prefer to untick this box and download full map tiles.
- Give the order a name, e.g. **Leeds**. This will be part of the file name of the zip file that you download so try to make it short but helpful!
- Click on **Request Download**.

Downloading your data

You'll receive an email confirming your order, then another with a download link. Make sure that you are still logged on to Digimap before you click on the download link (figure 2.17).

Once you have clicked on the link a window should open telling you that your order is ready to download (figure 2.18).

Figure 2.17: The download link in the email - click on this not on any of the other links in your email!

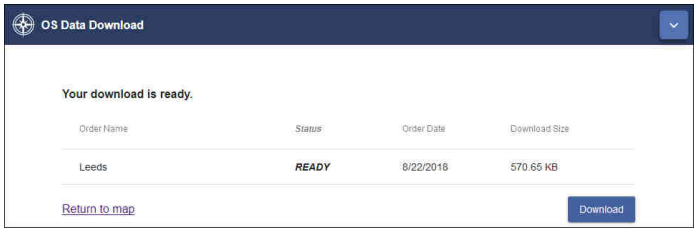


Figure 2.18: Order ready to download

- Click on **Download**.
- You'll download a zip file. **NOTE:** Don't run or open the file directly from your browser, and make sure that you **DON'T** save your zip file to a **temp** folder where you will probably be unable to unzip it.

Make sure that you remember where you have saved the zip file.

Now open **My Computer** and navigate to the location where you saved the zip file. Right-click on the compressed map data file that you downloaded and choose 7-zip ⟩ Extract files... . Select where you want to save the extracted files, and make a note of where you save them to. You should end up with a folder for each dataset that you requested.

Viewing your data

In this case the files that you have downloaded are either tiff graphics files or shapefiles. Navigate to the downloaded folder called something like `vml-raster_746810▸se` (your order number will be different) and look at the contents. Open one of the .tif files from the VectorMap Local Raster download by double-clicking on it. These files should open in a graphics program. In future classes we'll be using these in our own maps. Try opening one of the .shp files too. It's unlikely that you will be able to. These are a specific format for use in Arc and other GIS programs and we'll look at that in the ArcGIS sessions[3].

The download facility includes a lot of different formats and products, but the basic method of download is the same for all of them. The challenge tends to be in knowing how to use them once you have downloaded them and you'll be looking at that in future sessions.

2.5 Geology Digimap

Geology Digimap gives you access to British Geological Survey (BGS) data, if you use Geology Roam it is on a background Ordnance Survey maps.

2.5.1 Geology Roam

Geology Roam works in a similar way to the Digimap Ordnance Survey Roam so you may find that some of this seems familiar.

[3]Note that there may also be other files in the VectorMap Local folder with a **.tfw** extension. These won't open in any program but, if present, are essential for using the tif file in GIS programs such as ArcGIS, so make sure that you keep this together with the tif file.

Video Clip available - The Digimap video on Geology Roam is available at `http://bit.ly/1y191L7` (this video has sound). Note that this refers to an older version of Geology Roam.

If you are already in the Ordnance Survey section find the **Digimap home page** by clicking on **Digimap Home** at the top left of the screen.

From the Digimap home page click on the Geology heading and click on **Geology Roam**.

The Geology Roam map window (figure 2.19) is basically the same as the Ordnance Survey Roam window.

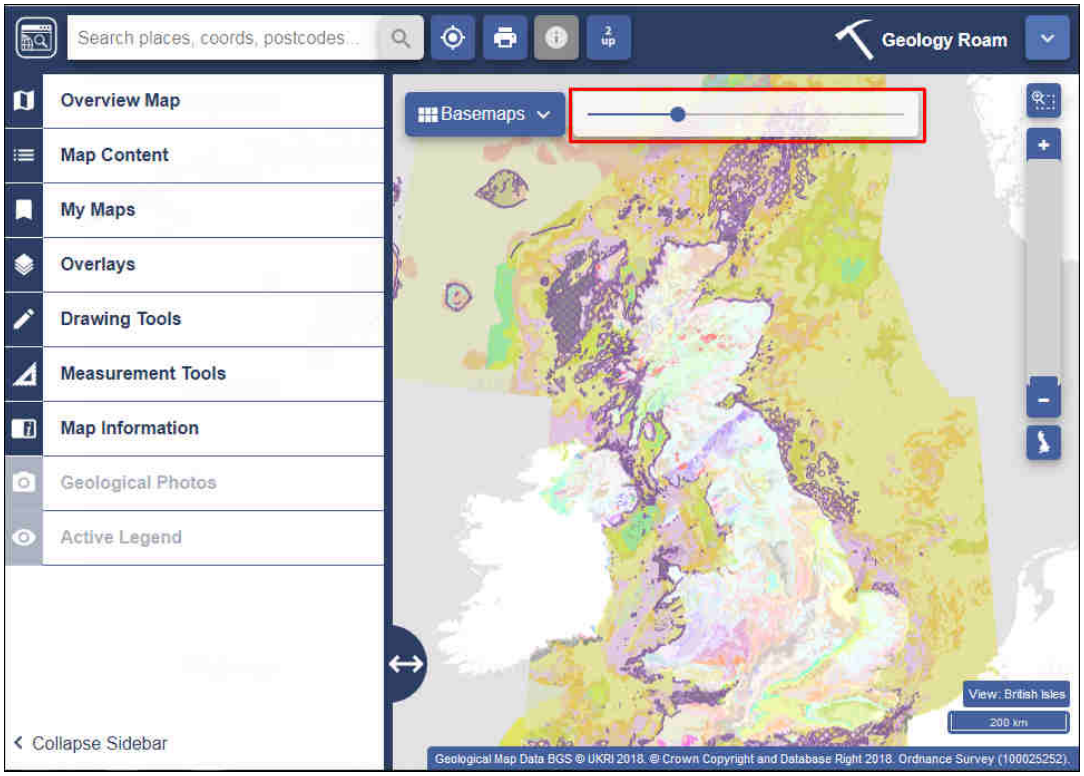


Figure 2.19: Geology Roam map window

Geology Roam is very similar in functionality to the Ordnance Survey Roam, so the buttons and task menu should be familiar to you from the previous sections.

- Open the **Search** menu and enter the University of Leeds postcode - **LS2 9JT** - into the postcode search box, then click on **Find**.
- As in OS Roam use the controls to change scale and level of detail.
- One feature that is different from OS Roam is the slider at the top of the map window (outlined in red in figure 2.19). Try sliding it and see its effect on the transparency of the geology over the topography.
- use the Basemaps menu to load different geology layers, for example, in the more zoomed in views try changing the 1:50 000 geology so that it shows **rock types** instead of **rock units**.

Controlling map content

- Once you have a geological map of the area you require click on the **Map Content Control** tab (figure 2.20). This will give you a key to the area shown in the current map and a way to control the visible layers.
- Try turning off the **Superficial Deposits** by unticking the box next to that heading and see what difference it makes to the map. You may have to be patient if you can't see the geology at all for a minute or so - it should return eventually! Try the same with **Artificial Ground**
- To find out what geology is present in a particular area click on the button for the **Feature Information** tool on the toolbar at the top...
- ...then click on the unit on the map that you want to find out more about. A box will appear showing basic details for all of the layers underneath the cursor (figure 2.21), plus the National Grid coordinates. The features selected in the list at the left of the box will be outlined on the map.

Figure 2.20: Map Content Control

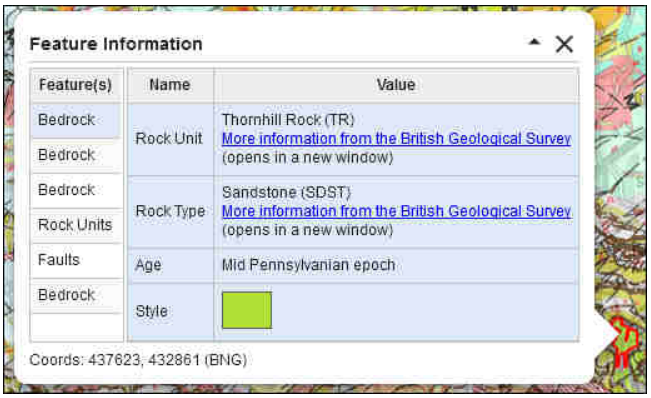


Figure 2.21: Feature information

Question 2.5. What is the Bedrock geology underneath the School of Earth and Environment?

Geological photographs

The geological photos panel adds icons that open photographs from the BGS photo archive. These include a caption with information about the geological features that they show.

Currently there are no geological photos available for the Leeds area. Search for and go to **Malham Cove** on the map and then click on Geological Photos in the side panel.

You should see lots of "camera" icons appearing on your map - figure 2.22.

Click on one of the icons to see a thumbnail. Click on that to see the large photo and more details (you may need to scroll down to see explanatory text).

Alternatively open out the **Geological Photos** list on the left-hand side of the screen and click on items in the list there.

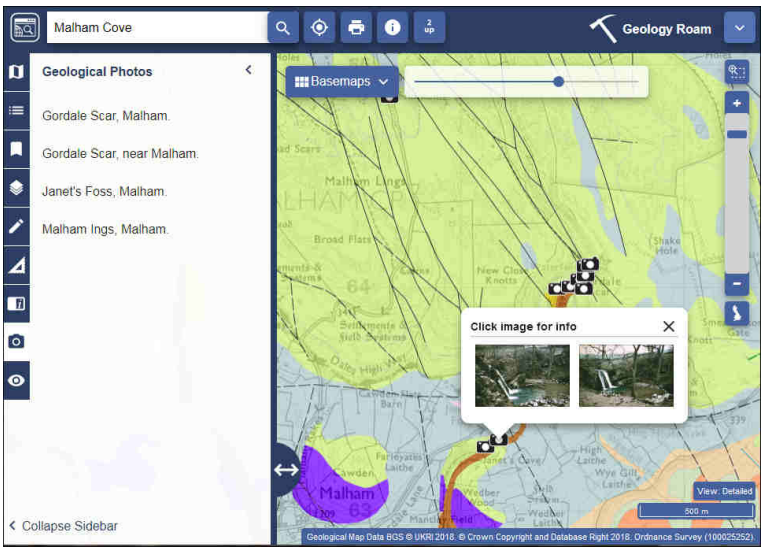


Figure 2.22: Viewing geological photographs

Printing from Geology Roam

Printing from Geology Roam means that you produce a file which you can save to print later if you wish, or include in another document.

- Click on the **Print** icon. The print dialog will open in a new window (figure 2.23).
- Fill in a map title
- Select the **print format** that you require - pdf for printing, png or jpg for importing into other documents - and whether you want to print in portrait or landscape format.
- Select the **Page Size** that you require.
- Note that the extent shown on the preview will not necessarily correspond with the extent that will actually print out - you can check that on the **Layout Preview** tab.
- Select whether you wish to include **National Grid lines** or **Rock Code Labels** (the labels are useful if you add a legend, but are rather obvious on the map).
- Select **Add Legend** if you want to generate a separate legend. If you choose this then your output will be two files inside a zip file.
- Click on **Generate Print File**, this will produce a file which you can then save or print.
- See section 2.7 on page 52 for information on how to print and edit PDF files.

Other features of Geology Roam

In addition to the features listed above Geology Roam allows you to make annotations, measure distance and area, save and open maps, and save annotations to file in exactly the same way as Ordnance Survey Roam. See the notes in section 2.4.1 from page 31 for more information.

2.5.2 Geology Download

Geology Digimap also gives you the opportunity to download tiles of geological data to add to your own maps. We'll download some data now, but it is delivered in a format that has to be opened in a GIS program and you'll find out how to do that later in the workbook.

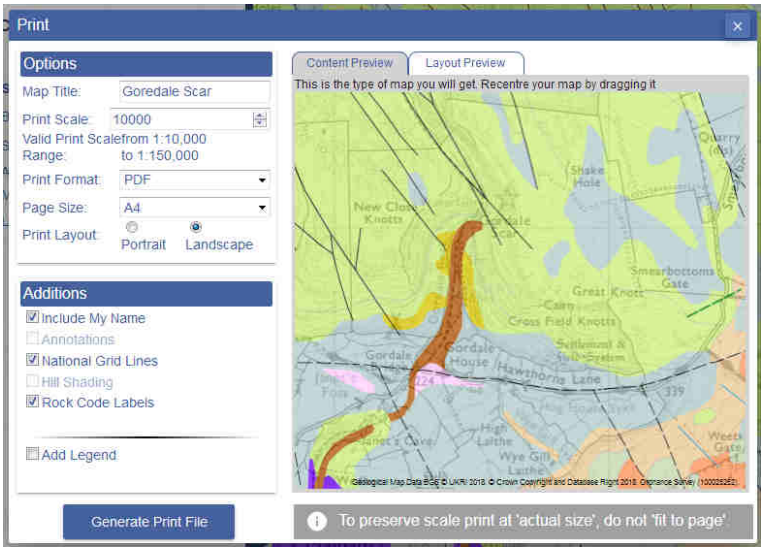


Figure 2.23: Geology print dialog

Video Clip available - The Digimap video on Geology Download is at `http://bit.ly/1xssnUC` (this video has sound), again, this refers to the older version.

- Click on the **Home** button in the top left-hand corner of the screen to return to the Digimap home page.
- Click on **Geology** in the menu at the top, then on **Geology Data Download** to bring up the map for selecting downloads.

Geology Download works in the same way as Ordnance Survey download, but of course, you have a different selection of layers to download. So start by selecting the area you require - using **search** and then the rectangle tool under **Draw** to outline the correct area.

Search for "Malham Cove" and outline a small area around that.

You then need to select the data sets that you are interested in from the panel on the left. Usually you'll want layers from the **Onshore Geology** section.

To find out whether there is 1:10 000 or 1:25 000 coverage of the area that you are interested in click on the grid symbol next to the layer in the Selection panel.

If there is data available the tiles will then be highlighted and you'll be able to see the tile names too. If you've zoomed to Malham Cove there won't be anything visible.

Click on the grid icon next to 1:50 000 Geology, then zoom out. You should reach a point where you can see the outlines of the tiles of data.

Question 2.6. What is the Tile Name for 1:50 000 data at this location?

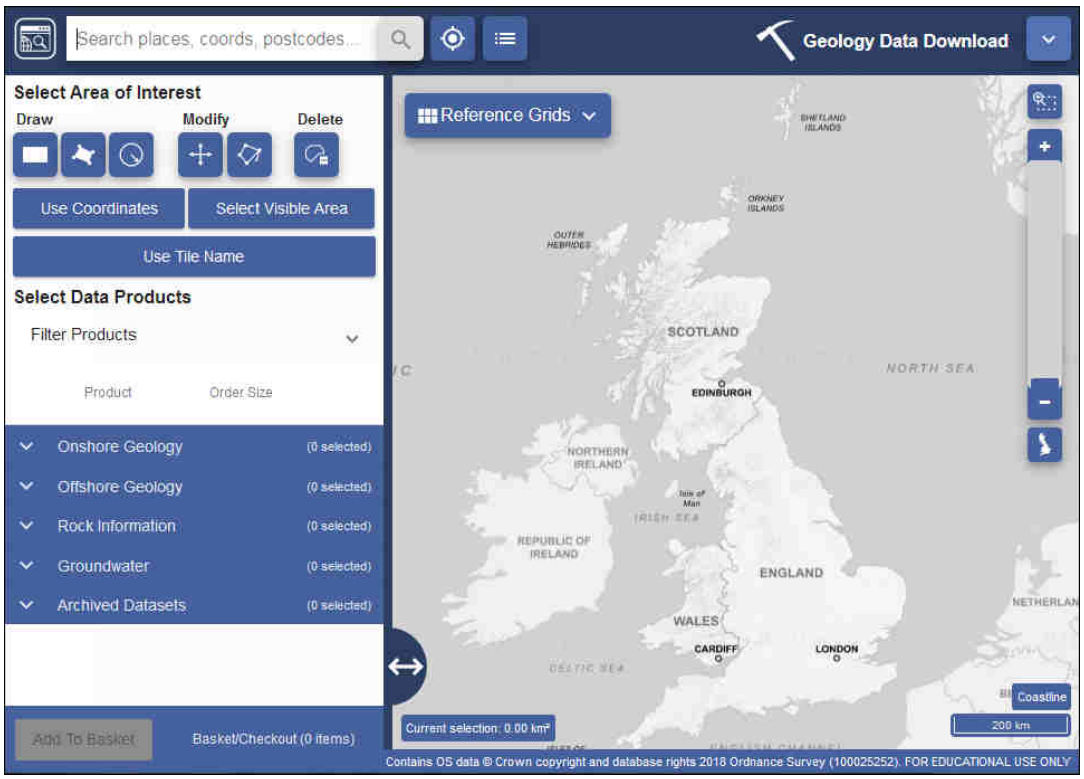


Figure 2.24: The Geology Download interface

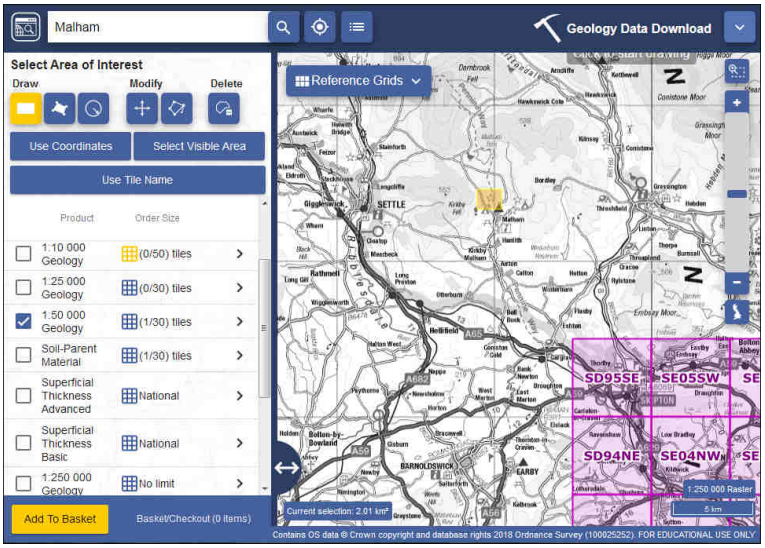


Figure 2.25: Finding out the availability of geological data: the shaded areas in the south east of the area around Skipton show 1:10 000 tiles which are available for this area. There is by no means full coverage of either 1:10 000 or 1:25 000

In this case

Select 1:50 000 Onshore data and don't forget to add it to your Basket. Once you've done that go to Checkout where you will be able to choose the format for your data, and when appropriate, the layers (figure 2.26).

The format choices will be either **SHAPE**, **MIFMID** or **TAB**. Shapefiles are opened in ArcGIS (and many other GIS programs) so once you have completed the rest of this module you will have the knowledge to open the downloaded files in Arc, but for now just be aware that the data is

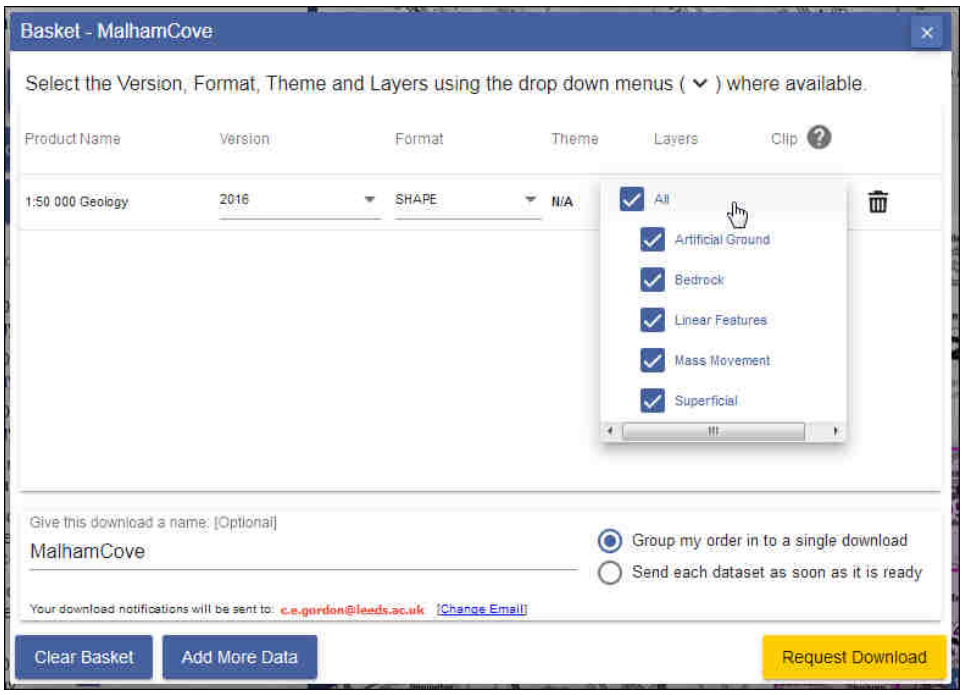


Figure 2.26: Format and layer options for downloading geological data

available. Mid/mif format opens in MapInfo - another GIS program which is also available within the university but which we won't be covering here.

2.5.3 Geological maps in the School of Earth and Environment

The geological maps that are available through Digimap are also available in paper form by speaking to Clare Gordon in the Kennedy Library (C.E.Gordon@leeds.ac.uk).

The paper geological maps still provide more information than the digital service, such as cleavage and bedding, and complete legends.

2.6 Aerial Digimap

Since 2016/2017 Digimap has given access to 25cm resolution aerial imagery from Getmapping. This is a fantastic resource and enables you to see a great deal of detail. It's well worth downloading imagery for your field areas. As in other collections in Digimap, you have a choice of Roam or Data Download and these work in a similar way, so refer back to the previous sections if you need a reminder, but there are inevitably some differences because of the different nature of the data.

2.6.1 Aerial Roam

From the Digimap home page click on the **Aerial** heading and then on **Aerial Roam**

The Aerial Roam map window is basically the same as the Ordnance Survey Roam window and the functionality is very similar so I won't go through it all here.

- Open the **Search...** menu and enter the University of Leeds postcode - **LS2 9JT** then click on **Search**

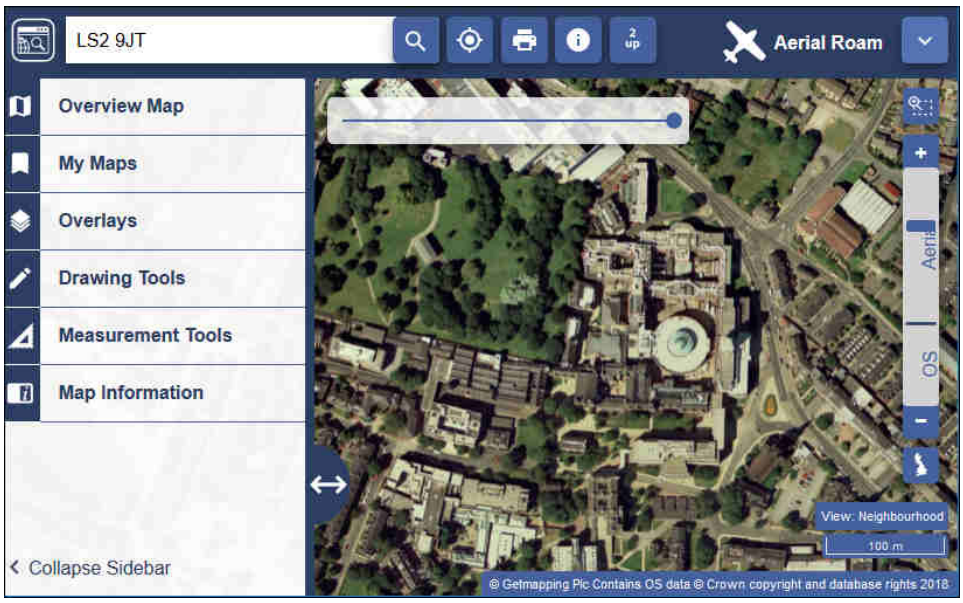


Figure 2.27: The Aerial Roam window

- You should be taken to a view which looks something like figure 2.27

Note that the imagery isn't available to browse at all zoom levels. Look at the bar on the right of the window (figure 2.27) and you'll see that the most zoomed out levels are labelled **OS**. As you zoom in closer the map will change to imagery.

Zoom in and out and move around the map to see what is available.

Opacity and viewing place names and roads

You can use the opacity slider at the top of the screen (above the zoom control) to allow the map to be shown through the aerial photograph.

If you don't want to make the aerial layer transparent, but do want to be able to see the names of places and the roads, click on Overlays > Road/Place names in the sidebar. This is a toggle, so do the same again to switch the names off.

Finding the date of the imagery

If you have searched for **LS2 9JT** and are looking at a view of the University, move the map so that you can see the SEE building. There is a lot of building work going on around the University so it would be useful to know when the imagery was taken to have some idea of how much is likely to have changed since. To find out the date it was flown do the following:

- Click on the **i** for information button at the top of the screen (next to the Overlays)
- Now click somewhere on the map, close to the SEE building.
- You should be shown a panel with the Tile name, Date Flown and the eastings and northings of the location that you clicked - see figure 2.28

In 2000 the company Getmapping flew aerial imagery for the whole of the UK - which is extremely impressive given that they were obtaining high resolution, cloud-free data. For how many days in the year is the UK completely cloud free?

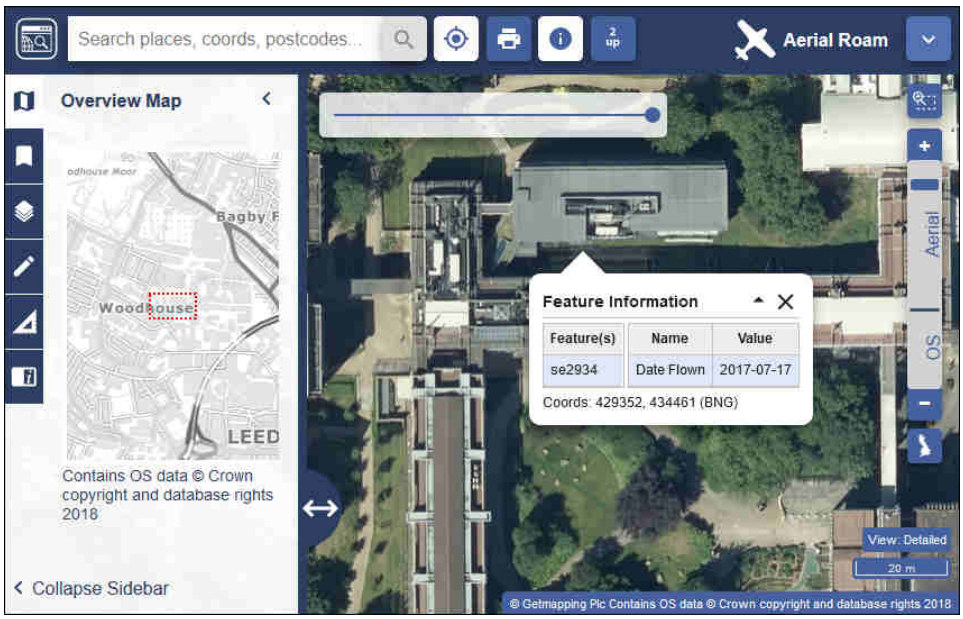


Figure 2.28: Information about the tile of aerial imagery, including the date that it was flown

Most of the data available in Aerial Digimap has been flown much more recently.

Note that when you click on the map for information you are also shown a red outline for the tile that you have clicked on. You may need to zoom out and move the Tile Name dialog out of the way to see this.

Search for the following British National Grid easting and northing using the search box:

- ***289576, 812418***

Question 2.7. What is the Tile Name at this location, and on what date was the aerial imagery at this location flown? As a bonus, what town is this point within?

2.6.2 Aerial Download

Return to **Digimap Home** and now select

- **Aerial** and **Aerial Data Download**

As with the other download interfaces the map that you see on the screen is only an indicator of the area that you will be downloading, it is not the actual data.

Use **Search** to go to British National Grid coordinates **254042, 271408**. You'll see that this is a coastal area of Wales with a rocky foreshore. Use the **Rectangle** tool to draw a rectangle around a small part of the rocky coast. These imagery downloads can be very large so for now just pick a very small area, at the bottom right of the map you can see the size of your current selection in km^2, try to go for something of about 0.25 km^2.

- Go to **Aerial Imagery (Latest)** in the panel on the left and put a tick in the box next to **High Resolution (25cm)**

- The number in brackets after this shows how many tiles you have selected to download out of the maximum of 100. If you have selected to download more than 4 files then I'd suggest that you outline a smaller area just for the purposes of this exercise.
- If you click on the arrow next to the dataset you are given more information about it, including the recommended copyright acknowledgement. Make a note of this and add it to any document or map that you create with this data.
- Now click on **Add To Basket** and give your download a name, then **Request Download**

This works in exactly the same way as OS and Geology download, so having requested the data you need to wait for an email which contains the download link. Once you have this, download the data, move it to your M: drive and **unzip it** (Right-click on the zip file - 7-zip ⟩ Extract here).

View the files in ArcGIS

You can open the jpg files in a graphics editor if you want a quick look at them, but for our purposes it makes more sense to add them to a map.

- Open ArcGIS, set up a new map and add the jpg file(s) that you have downloaded.
- You should be able to zoom in on an area of the rocky coast and have a look at the amount of detail that is available
- The files are georeferenced so can be used alongside map tiles from Digimap Ordnance Survey download
- If you are using this in a map for coursework or your dissertation, or indeed for showing to anyone else, don't forget to add the correct copyright acknowledgement.

Using aerial imagery for fieldwork

If you are setting up a map for geological fieldwork in an area of the UK it is well worth downloading this data and creating a set of aerial images too. Data may be available for other countries but it won't be downloadable via Digimap. If you can't find any aerial imagery for your area try searching for **World Imagery** in ArcGIS Online or the basemaps and add that to your map. It won't be as detailed as 25cm resolution, but will be better than nothing.

2.7 Printing and editing PDF files

2.7.1 To print

PDF files can be viewed and printed in any PDF reader, such as Adobe Acrobat Reader.

- From **My Computer** double-click on the pdf file and it should open automatically in the default reader.

For your own computer there are a lot of different programs that will read PDF files. See the list at

`http://en.wikipedia.org/wiki/List_of_PDF_software#Viewers_4`[4]

[4] Last accessed: 17th September 2019.

2.7.2 To edit

PDF files can be edited in Adobe software such as Photoshop and Illustrator, and in CorelDraw. It is also possible to edit files in Inkscape. Open the file as follows -

- File > Open > OK.

2.8 Copyright acknowledgements for Digimap data

Copyright is important. Remember that most data providers ask you to sign up to conditions that include an obligation to add a copyright acknowledgement to your map. Check what that copyright statement is and add it.

e.g. when you signed up to use the Digimap collections you agreed to add copyright acknowledgements whenever you created a map with the data. These do change from time to time so it's worth knowing how to check it for yourself.

- To find these copyright acknowledgements go to the **Digimap Resource Centre** (**Resources** at the top of the main Digimap page)
- Look for a link to **Digimap Licence Agreements** and click on it.
- Click on the End User or Sub-licence agreement for the data that you've used
- then look for the information under **In return, you must:** - that gives you the acknowledgement text.

For example, as of April 2019 when you use Ordnance Survey data obtained from Digimap you are expected to add the following text to your map.

> ***© Crown copyright and database rights*** `year`***. Ordnance Survey (100025252).***

Where *year* is replaced by the current year.

Remember that you do have to acknowledge each different dataset that you use and will have signed up to that when you registered.

Adding the copyright symbol to your text
To add the **copyright symbol** - ©- to your text • check that the Num lock is on on the keyboard • hold down the Alt key • use the number pad to type 0 + 1 + 6 + 9 • release the Alt key

Table 2.1: Adding the copyright symbol to your text

If you are *not* using U.K. Ordnance Survey data this is **not** the correct copyright acknowledgement to use, for example if you are using data for Spain or the United States, or indeed UK data that you

haven't downloaded from Digimap. You'll need to find the correct copyright acknowledgement for yourself. The web page[5] at `http://bit.ly/1ZSifnd` gives some information about how to cite GIS materials - including the software as well as the data. Have a look at that and follow the suggestions to cite non-Digimap data.

Advice on citing Digimap data, as opposed to the copyright acknowledgement is at `https://digimap.edina.ac.uk/webhelp/resources/citation/services.html`

2.9 Further help with Digimap

2.9.1 Additional Digimap collections

This booklet has only covered the basic collections from Digimap. The University of Leeds also subscribes to Geology, Aerial, Historic and Environment collections.

All of the collections have a Roam and a Data Download interface which work in a similar way to the examples you have used.

You have access to all of these collections, feel free to have a look at what is available and make use of any of the data or maps in your work.

2.9.2 Digimap Collections online help

Digimap help is available from both the Digimap Ordnance Survey and Geology home pages. Click on the links in the left hand menu for more information about how to use the services and file formats.

Alternatively use the Help links from within Roam or Download or use the videos that Edina have uploaded to YouTube at -

`http://www.youtube.com/user/EDINADigimap`[6]

If you want more detailed information Edina provide e-learning units which are linked from the main Digimap home page.

2.9.3 School of Earth and Environment

Clare Gordon can provide help and advice on using Digimap. Contact her in room 10.140b at the back of the Kennedy Library or on **c.e.gordon@leeds.ac.uk**.

The most up to date edition of this workbook will be available in Minerva for those modules on which it has been used.

[5] Last viewed: 18th September 2018
[6] Last accessed: 29th August 2019

Chapter 3

Creating a base map

The background to creating a base map and an explanation of what you need to do will be covered in the lecture segment at the beginning of the class and the presentation and any other supporting materials will be available in Minerva. The lecture segment should help you to understand **why** you are doing these exercises. If you still aren't sure, please ask Clare.

3.1 Learning outcomes

When you have completed this chapter you should be able to:

- Use the tools provided in ArcGIS Pro to prepare Ordnance Survey data for further use
- create a 1:10 000 topographic base map that is suitable to use for geological field mapping and as a base for digitising geological data
- demonstrate how to update symbology/styles and add basic labels to layers in your map

3.2 Introduction

Before you go out into the field, or before you start to digitise geological data, you need to set up a detailed base map. For the UK you will be able to download data from Digimap, and that is the method described in this chapter. If you are working outwith the UK you will need to source background data from elsewhere. Clare Gordon can advise on this - c.e.gordon@leeds.ac.uk

In the level one GIS class you will be creating a geological map of the area of the Waterfalls Walk north of **Ingleton** in North Yorkshire.

3.3 Opening a new map

For this exercise you'll need to set up the project for yourself from scratch.

- Open ArcGIS Pro by searching for it in the Windows start menu. Make sure that you open **ArcGIS Pro**, not any other version of Arc!
- You should get a start screen which looks something like figure 3.1. Though your recent projects will be different.
- Under **Blank Templates** pane click on Map

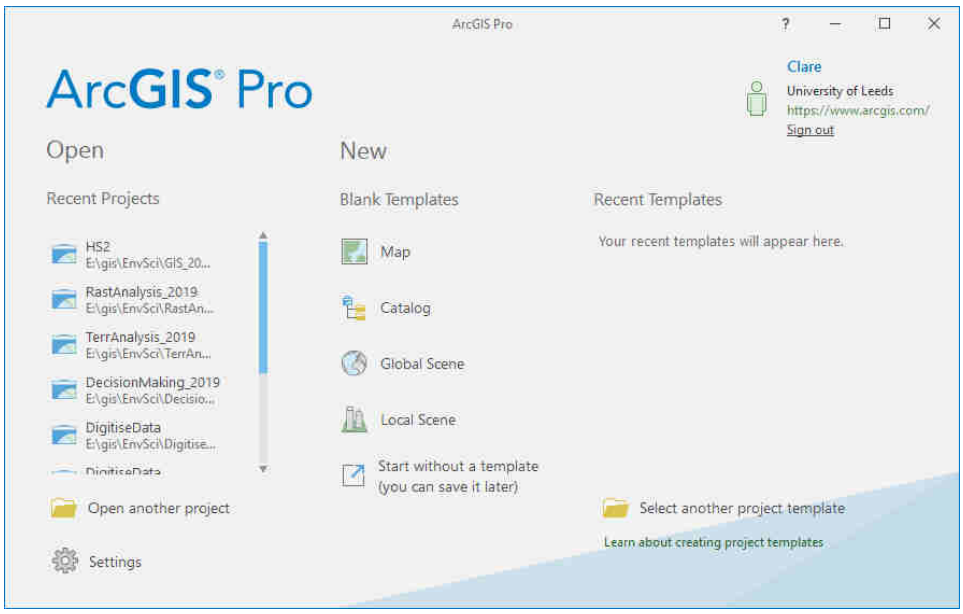


Figure 3.1: The start screen when you open ArcGIS Pro

- You'll get a dialog box like the one in figure 3.2 which you should fill in as follows:
  - For the name enter the name of the project - so in this case maybe **Ingleton**. In future use the name of your own study area (remember no spaces etc)
  - For the location navigate to the folder where you want to store the project. You can use the default setting if you want to or click on the folder icon to navigate to another location
  - Check that **Create a new folder for this project** is unticked if you are saving the project to an existing folder with the name that you gave your project above, otherwise make sure that it is ticked to create a new folder.
  - Click OK to create your new project

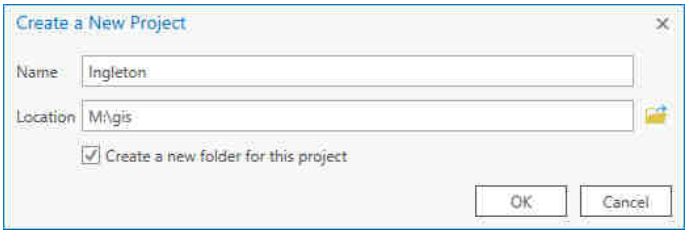


Figure 3.2: Creating a new project to contain all the work for the Ingleton study area. Note there are no spaces in either the folder names or the project name

ArcGIS Pro creates the new project folder and sets up the component parts automatically. As you are working on your projects make sure that you save all of your data into the project folder so that it all stays together even if you move the project to another drive, e.g. by backing it up to a USB stick.

You should find yourself with something similar to figure 3.3, with only the background layer as you haven't added any data yet. Arc will have set up a map view and added a topographic basemap, which will show a default area, e.g. the whole of the UK.

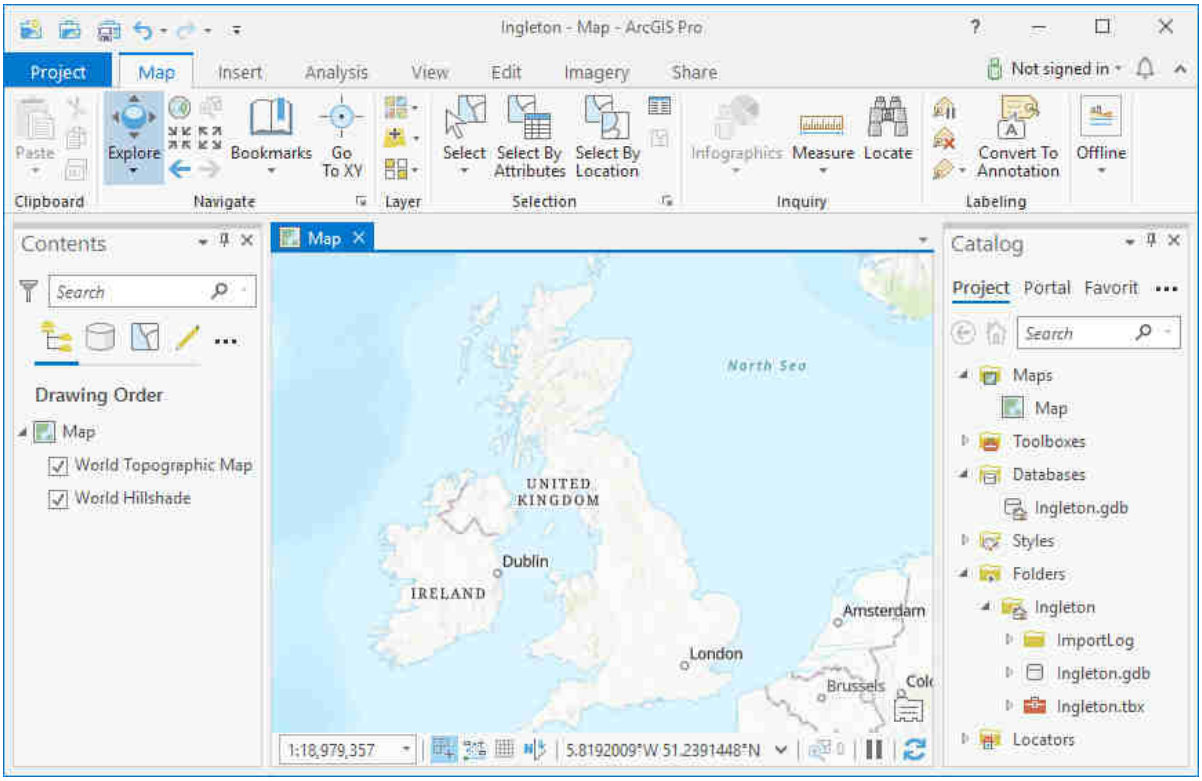


Figure 3.3: Your new ArcGIS Pro project showing default catalog contents and an ESRI background map (Esri software graphical user interfaces are the intellectual property of Esri and are reproduced herein by permission. All rights reserved.)

Open out some of the subheadings in the Catalog pane. You should see that Arc has created some empty content for you. Most notably a geodatabase for data storage with the same name as your project and an extension of .gdb. This geodatabase will have a little house icon on it to show that it's the "home" geodatabase.

3.4 Data to download

ESRI has provided a base map for you, and there is a selection of others available, but these do not provide enough detail for a 1:10 000 geological or field map, and can also cause problems with your project running very slowly and crashing.

Instead you will need to download topographic data from Digimap before you can create a base map in Arc. For a 1:10 000 map we will need to download the raster topographic maps and the vector contour files separately as Digimap does not provide these as one file.

Download the following datasets from Digimap using the Ordnance Survey download service (section 2.4.2 on page 39) (NOT Geology download).

Search in Digimap Download to go to your field area - in the class it will be Ingleton (North Yorkshire), not Durham - and make sure that you select to download data for a larger area than you think you need - it will save having to go back and download more data later.

For the Ingleton area download data for at least the area in figure 3.4.

Save the zip file to your project folder then unzip the downloaded data using 7zip.

- ***VectorMap Local Raster - TIFF format. See table 3.1 for information on which Theme to download. For the Ingleton exercise download Black and white.***
- ***OS Terrain 5 contours (NOT 50) - SHAPE NOT GML***

Figure 3.4: The minimum area for which to download data for Ingleton

Note on colour choices for background map
When you download the raster topographic maps for the UK from Digimap the basket gives you a choice of colour formats between black and white; faded; and full colour. It's worth downloading and trying them all. • If you are creating a fieldslip to take into the field and map onto then you can choose which will be the best background for your markings, colours etc. This varies from area to area so you may want to discuss this with your mapping supervisor (show them examples!) • For your final top copy map with the digitised geology on top use the **Black and white** version so that the geology shows clearly. On a BGS published geological map the topography is a grey layer behind the geology. You can "fade" a background that is too dark by making the layer transparent.

Table 3.1: Note on colour choices for background map

3.5 Adding contour data

ArcGIS Pro sets the coordinate system of your map to the coordinate system of the first layer that you add. When downloading data from Digimap the raster layers don't always have coordinate system information, so it makes sense to start by adding the contour layers.

If you have more than one tile of data for the contours the first thing you'll need to do is **Merge** them into one layer.

Merging contour shapefiles

Video Clip available in Minerva - Creating a base map with OS data:
1. Merging contour shapefiles

- From the Analysis tab of the ribbon find **Merge** in the Tools group
- OR go to the Analysis tab of the ribbon, click on **Tools** to open the toolbox panel on the right, then Toolboxes > Data Management Tools > General > Merge
- Add all contour shapefile tiles as the input by clicking on the folder icon to the right.
  - You may need to include files from more than one sub-folder. Remember that you only need to add the **line** shapefiles, not the point. See figure 3.5
  - to add more than one file at a time use the Ctrl key and then click on each file
- Save the output to the project geodatabase, that is the file with the same name as your project and an extension of **.gdb**, and give output dataset a name such as **contours** that will help you to identify it again later
- Leave the rest of the fields as the defaults
- Run - Arc should merge your shapefiles, add them to the geodatabase and then zoom in and display them on your map

If Arc doesn't take you to the correct location for your data, remember that you can **Zoom to layer** by right-clicking on the contours layer and selecting **Zoom to Layer** from the context menu.

You should end up with something like figure 3.6 with a random choice of a single colour for all of your contours.

If you need to save disk space, or even just tidy up your data, you can now delete the folder containing the original contour data. If you need it again you can either unzip the file that you downloaded from Digimap again, or just redo the download.

3.5.1 Checking the coordinate system of the map

To check that the map coordinate system has been set correctly - in this case to British National Grid

- In the Contents pane right-click on the map title, e.g. where it says **Map**
- click on **Properties** and select the **Coordinate Systems** subheading on the left
- the current coordinate system of your map is shown under **Current XY**
- If this isn't correct you can change it by selecting a new coordinate system from the choices below. The easiest way to find British National Grid is to search for **British** in the search box.

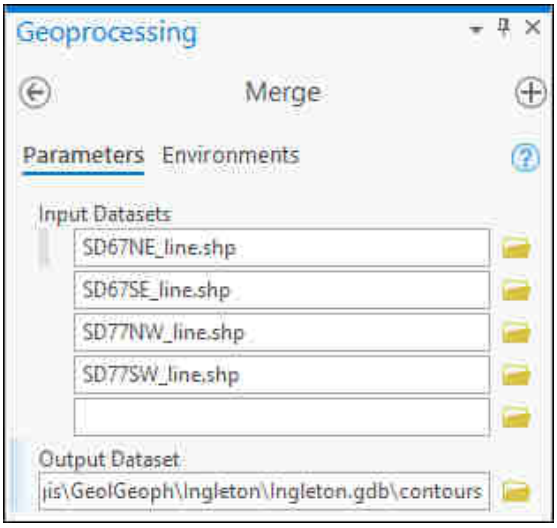


Figure 3.5: Merging multiple contour shapefiles into a single geodatabase feature class

Figure 3.6: The merged contour output

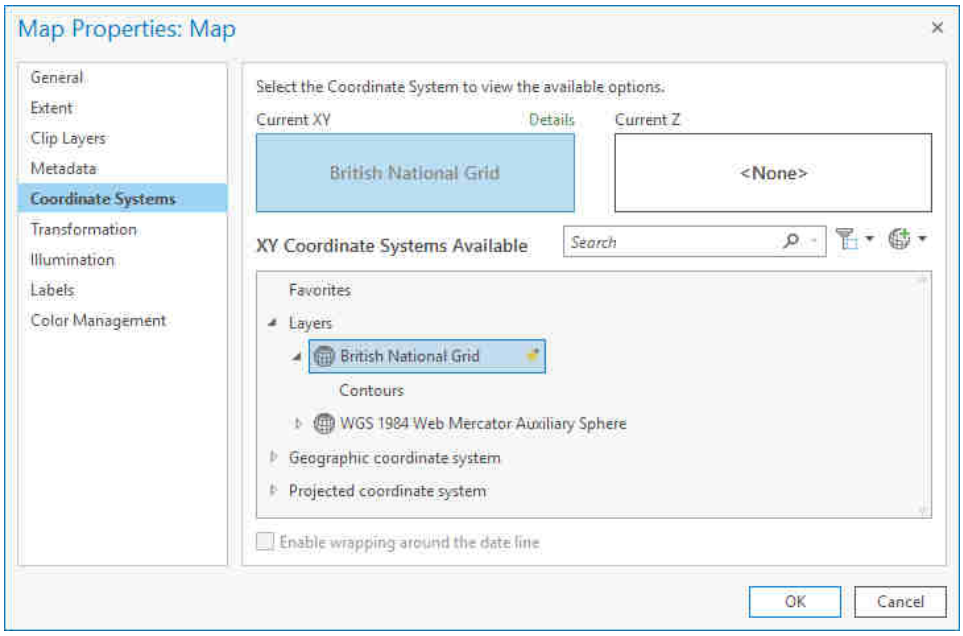


Figure 3.7: The map properties showing the current coordinate system (British National Grid) and the coordinate system of each layer in the map

3.6 Setting the reference scale

Before you start symbolising and labelling your layers it is a good idea to set the reference scale to the scale at which you are intending to print the map. You are most likely to be wanting to print a field slip or top copy map at either 1:10 000 or 1:5 000. Setting the reference scale will ensure that when you choose symbology or label size it will look the same as it will once your map is printed.

- Start by setting the scale of your map to, for example, 1:10 000, using the dropdown be-

low the map view

- In the table of contents right-click on the title of your map - usually **Map**
- Click to **Set Reference Scale**

You can reset the reference scale just by going to a different scale and doing the same, or you can clear the reference scale completely if you wish to.

3.7 Symbolising the contours

Now that the contour lines are in your project you need to symbolise them so that they look professional. For this take inspiration from the British Geological Survey published maps.[1]

Video Clip available in Minerva - Symbolising a layer by unique values in Arc

- Select your contours layer in the contents pane then click on the **Appearance** tab of the ribbon and click on the **Symbology** button to open the Symbology pane on the right of your map.

3.7.1 Symbolising as unique values

It is good practice to symbolise your contours so that most are of a standard width, but contours at a regular interval are made slightly thicker. To do this try the following:

Check the attribute table for your contour feature class (right-click on the layer in the contents pane and Attribute table) - for OS data there will be a column which divides the contours into master and ordinary. If your area is on the coast you may also have high and low water mark.

Question 3.1. What is the name of the column that divides the contours into master and ordinary?

- In the symbology pane change the dropdown under **Primary symbology** to **Unique Values**
- Dropdown the box next to **Field1** and change it to the column that you made a note of above

Arc should automatically classify your data as the number of different sub-types in your feature class and give them a random colour - figure 3.8. You will also end up with a value labelled **all other values**. You don't need it for this map, so get rid of it as follows:

[1] I have lots of paper copies in my office (room 10.140b in SEE) which you are welcome to come and look at. Otherwise have a look at the scanned maps on the BGS website. You can find them at `https://www.bgs.ac.uk/data/maps/` (last viewed: 22nd January 2020). Try to make sure that you look at a recently published example, such as the 1:25 000 Ardnamurchan Central Complex map published in 2009 - `https://www.bgs.ac.uk/data/maps/maps.cfc?method=viewRecord&mapId=11475`

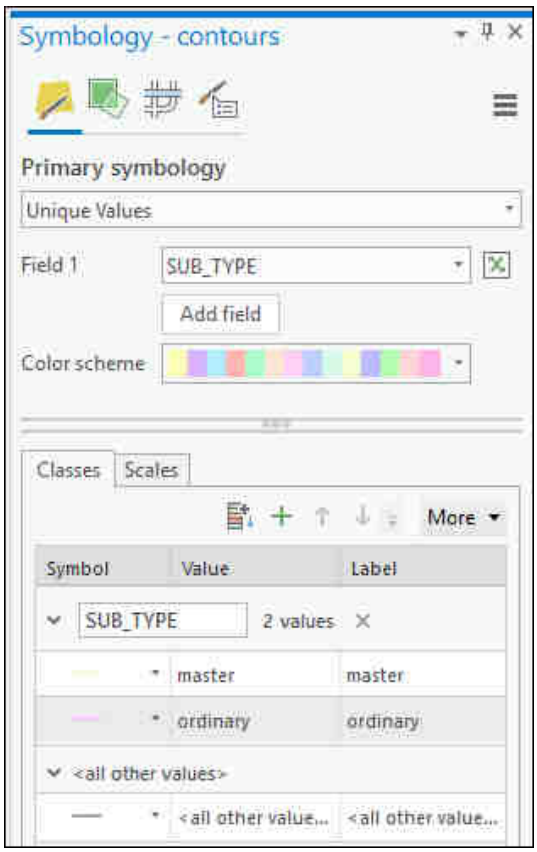


Figure 3.8: Unique values used to symbolise contours - the colours are still random

- On the **Classes** tab click on the More button which has a little down arrow.
- Untick **Show all other values**

You shouldn't notice any difference on your map, but it will tidy up your contents pane, and if you were going to add this layer to a map legend it would stop that showing there too.

3.7.2 Styling the contour lines

Remember there is more information about styling and symbology in section 1.11 on page 17.

The automatic styling of the contour lines is unlikely to be satisfactory. To style the two different types of line

- Click on the symbol to the left of one of the line types
- Check that you are on the **Properties** tab of the next panel, not the Gallery
- Change the colour and line width as suggested below - you can play around with the settings when you see what they look like later
- Go back to the symbology pane between each value

3.8 Labelling the contours

It's essential to add labels to the contour lines to show the height. Without labels contour lines are basically worthless.

For a black and white / greyscale map:

- Color = **Grey 40%**
- Line width
  - Master / index contour = **0.8 pt**
  - Standard contour = **0.4 pt**
- Click Apply

For a faded colour map:

- Color = **Seville Orange** (hover over the colour patches to see their names!)
- Line width
  - Master / index contour = **0.8 pt**
  - Standard contour = **0.4 pt**
- Click Apply

Video Clip available in Minerva - How to add labels to layers in Arc

Have a look at the attribute table of the contours feature class again.

Question 3.2. What is the name of the column which holds the information about height above sea-level?

- Select the contour layer in the contents panel
- Click to go to the **Labeling** tab of the ribbon
- Click on the **Label** button to the left of the ribbbon

Labels will appear, but they are unlikely to be the labels that you actually need.

To change the content of the labels

- In the **Label Class** group of the labeling tab use the **Field** dropdown to select the field that you made a note of above - the one which holds the information about the height of the contour.

The labels should change to the height. But if you have a closer look at the contours you should notice that the labels don't actually appear on top of the lines to which they refer. You need to change the **Label Placement**

- in the **Label Placement** group of the labeling ribbon use the arrow on the right to find the **Contours** setting.
- if you click on the little arrow in the bottom right corner of the group you should open the Position tab of the Label Class pane. Drop down the **Placement** subheading and you should be able to check the settings there.

The Contour placement should set your labels so that they are on top of the lines and curved. Now you need to change how the text looks.

- Click on the **Symbol** tab of the Label Class dialog
- Drop down the **Appearance** subheading
- From there you'll most likely need to set a smaller font size, e.g. 8 pt, and change the colour of the text symbol to match the colour of the contours
- Click Apply to see what your settings look like. You may need to wait a bit while Arc applies them - labelling contours can slow things down rather.

You can try out alternatives to see what looks best. Remember that the contours and their labels need to be present and visible so that they can be used, but not so large that they dominate the map. If in doubt check OS or BGS published maps as suggested at the start of this section.

3.9 Adding the background raster map

So far you have been working with one of the ESRI Basemaps as the background to your contours. These basemaps are useful for general maps, but you need a detailed map for fieldwork and as a background to your top copy geological map. You should have downloaded VectorMap Local Raster tiles from Digimap and these will be a suitable background.

Video Clip available in Minerva - Creating a base map with OS data:
2. adding raster background maps

To add the raster tiles

- Find the files in the **Folders** subheading of the Catalog Pane. If you don't have them in your project, either move them there using the Windows file manager or follow the instructions in table 3.2 to add a new folder connection.
  - If you downloaded data from Digimap and unzipped it then the files should be under **vml-raster-bwr**
  - and have names or a name like **vml-raster....tif**
- then simply drag and drop the raster file(s) from the Catalog pane to the Contents pane so that they are placed below the contour layer. Don't forget that you may have files in more than one folder.
- If you are offered the choice of creating **Pyramids** say Yes[2]

Your raster maps may appear rather bad quality, this is usually just an onscreen problem. When you print your map, or zoom in close, it should be fine.

Check that the background map looks right with your contours, e.g. that the contours don't go straight through the middle of lakes, or that streams don't appear to flow uphill.

If you think the black and white background is too dark you can always fade it a bit by using **Transparency** - see section 1.7.6 on page 11.

[2] Pyramids take a moment to create when you first load the file, but make it much quicker to move around once they are loaded.

3.9.1 Removing the ESRI background layers

This is a good point at which to **Remove** the ESRI basemap layers, e.g. World Topographic Map and World Hillshade, so that they don't cause problems later.

- Right-click on each of the basemap layers in turn
- Remove

Adding a folder connection in the Catalog pane
If you can't see your M:/ drive or USB device in the list of folders when adding data or viewing the catalog you need to **Connect to folder**. • Right-click on the **Folders** subheading in the Catalog panel • **Add Folder Connection** (figure 3.9) and select your top level gis folder, or your M: drive then click OK. If you select the drive that you want, rather than navigating right to the file, you'll be able to navigate to any files within it. • Now select your files from the folders that you can see. On cluster machines you'll probably find that you have to repeat this each time you start work in Arc, unfortunately.

Table 3.2: Adding a folder connection in the Catalog pane

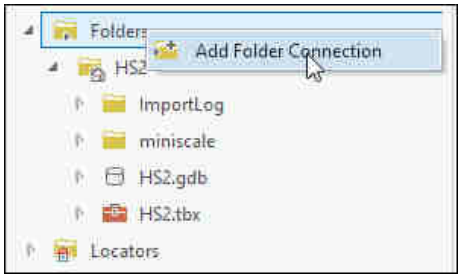


Figure 3.9: Add Folder Connection - found by right-clicking on the Folders subheading in Catalog

Video Clip available in Minerva - Add Folder Connection

3.10 Creating a layout for printing

You will need to add various map elements to a layout for your field slip. Chapter 7 on page 114 gives more information about setting up a layout and adding elements such as a measured grid, north arrows, copyright information and a scale bar.

For now:

- Go to the **Insert** ribbon and click on **New Layout**

- Select ISO - Portrait » A4
- On the ribbon click on the arrow under **Map Frame** and select your map
- Now click on the page, and draw out a “box” - don’t worry too much about the area for now
- At the bottom of the screen change the scale to **1:10 000** to zoom in to your map.
- With the map still selected click on **Grid** on the ribbon then select Measured Grid » Black Vertical Label Grid to add grid references around the outside of your map
- Click on **Scale Bar** in the **Map Surrounds** group and select any of the **Metric** scale bars
- Use the instructions in section 11 on page 26 to add copyright text for the Ordnance Survey data that you have used.

You can play with the settings for the elements you have added, but we’ll be looking at layout and presentation in more detail in Chapter 7 on page 114.

Your final map should look something like figure 3.10.

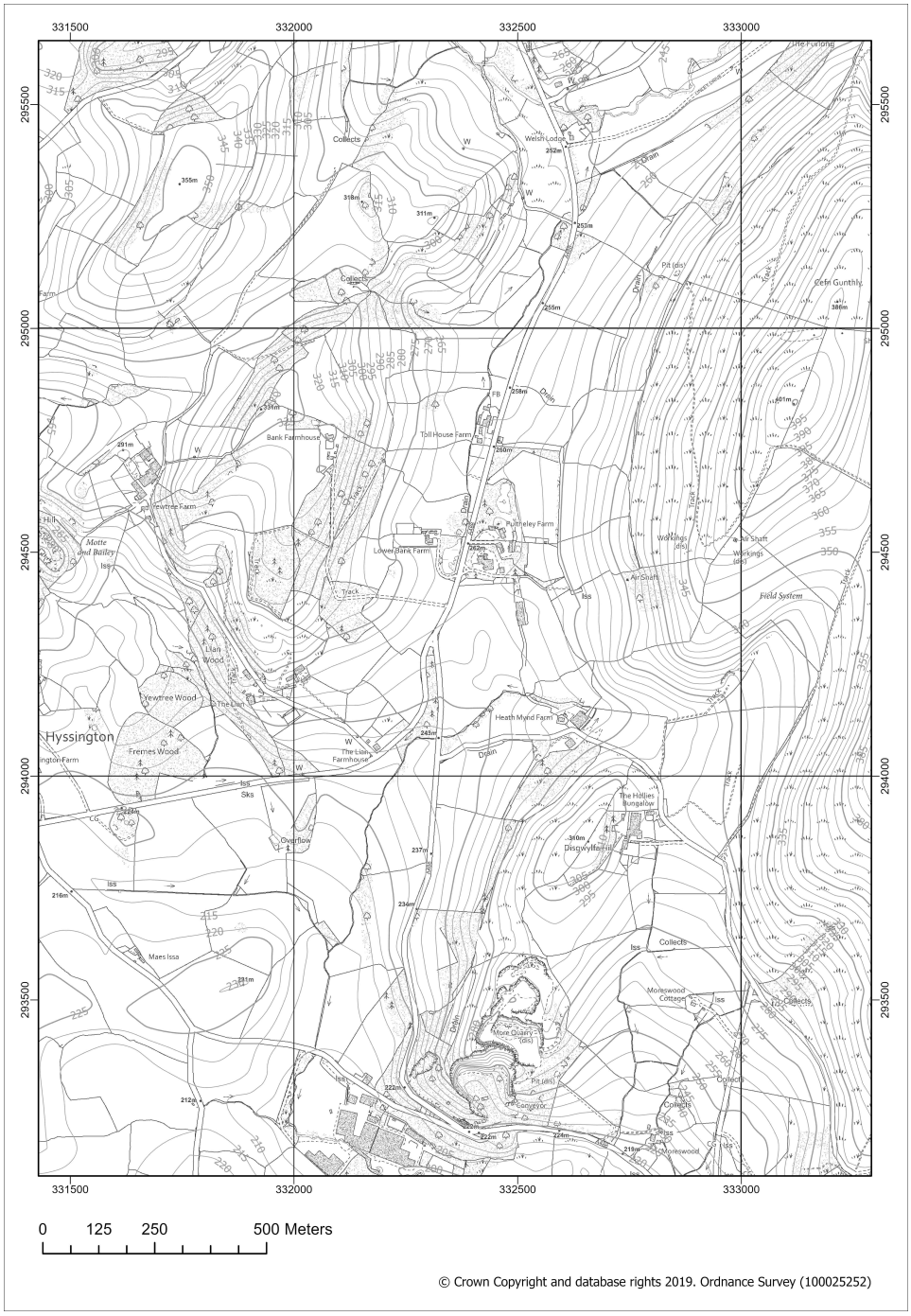


Figure 3.10:
A basemap ready for field mapping or as a background for a top copy geological map

Chapter 4

Georeferencing a scanned map

The background to georeferencing and an explanation of what it is will be covered in the lecture segment at the beginning of the class and the presentation and any other supporting materials will be available in Minerva. The lecture segment should help you to understand **why** you are doing these exercises. If you still aren't sure, please ask Clare.

4.1 Learning outcomes

When you have completed this section of the workbook you should be able to:

- understand what is meant by georeferencing
- demonstrate how to import a scanned map into ArcGIS and use georeferencing tools to place it in the correct geographical / spatial relationship to your base map

4.2 What is georeferencing?

Having created a base map, printed it out, and used it to collect data in the field, you then have returned with hand drawn markings on the printed map. Somehow you need to get these printed maps in to ArcGIS.

You will start with a scanned copy of your field slip. Despite being electronic that file has no **spatial reference** to tell Arc where in space the map belongs. You can see that information from the map, but in effect that scan is just a picture. You will need to **georeference** the scanned map so that the electronic information about location is coded into the file. Once you have done that the map will appear in the correct place overlaying your base map.

4.3 Scanning your field slip

For the level one GIS module you can download a copy of a fieldslip for **Ingleton** from Minerva.

Otherwise, if you don't yet have a digital copy of your field slip you will need to scan it before you start. Taking a photograph will not work - however careful you are the image will be distorted in some way.

All of the printers in clusters around the university will scan. The default format appears to be pdf, which won't open in Arc. Either change the settings so that the output is **tif**, **jpg** or **png**[1], or use `http://smallpdf.com` to convert the pdf to jpg.

[1] Tif, jpg and png are all acceptable formats for georeferencing. Tif will be the best quality, but also the largest file sizes. Jpg will have smaller file sizes, but may lose some quality.

4.4 Add a scanned map to ArcGIS

The first step is to add the scanned map to Arc without worrying about its location.

Make sure that you've saved the scanned map to the project folder which also contains the base map in ArcGIS which you originally printed as your field slip.

- Start by opening the map that you created for your base map
- Add your scanned field slip to the map by dragging and dropping it from the Folders sub-heading of the catalog pane
- If you are asked whether you want to build pyramids say Yes

The file should appear in the contents pane, but is unlikely to be visible in the map. Because there is no spatial information in the scanned map Arc doesn't know where to put it, so has probably added it at grid coordinates 0,0. Don't worry about this for now!

4.5 Georeferencing with known grid coordinates

If you are georeferencing an image which has known grid references for particular points, e.g. if you are georeferencing a map with a measured grid in the same coordinate system as your background map, then you can type in the figures rather than having to look for identical points on the basemap.

If the map or image that you are georeferencing does not have known grid references then go straight to section 4.6 on page 73 for instructions on how to georeference using identifiable points.

Video Clip available in Minerva - Georeferencing a scanned map in ArcGIS: 1: using grid intersections.

You'll be adding **control points** and typing in the grid reference for each point, so it may help if you start by marking some points at corners of grid squares on a print out of the field slip, e.g. figure 4.1 on page figure 70, and write down the full 12 figure grid reference, being very careful to get the x and y coordinates the correct way round[2].

- Select the layer to be georeferenced in the contents pane - if you haven't already right-click and **Zoom to Layer**
- On the ribbon go to the **Imagery** tab and click on the **Georeference** button. The ribbon should change to show the Georeferencing tools - figure 4.2
- Double-check that you have the correct layer selected - georeferencing another layer by mistake is not a good thing to do. The georeferencing information panel in the top right of the map window (figure 4.4) will show you which layer Arc thinks is being georeferenced.
- Click on **Add Control Points** on the ribbon then zoom in close to one of the points that you marked to georeference - preferably an intersection of two grid lines[3]
- left-click on the grid intersection or point as accurately as you can, then right-click
- in the box that opens (figure 4.3) enter the x and y coordinates for that point and click OK

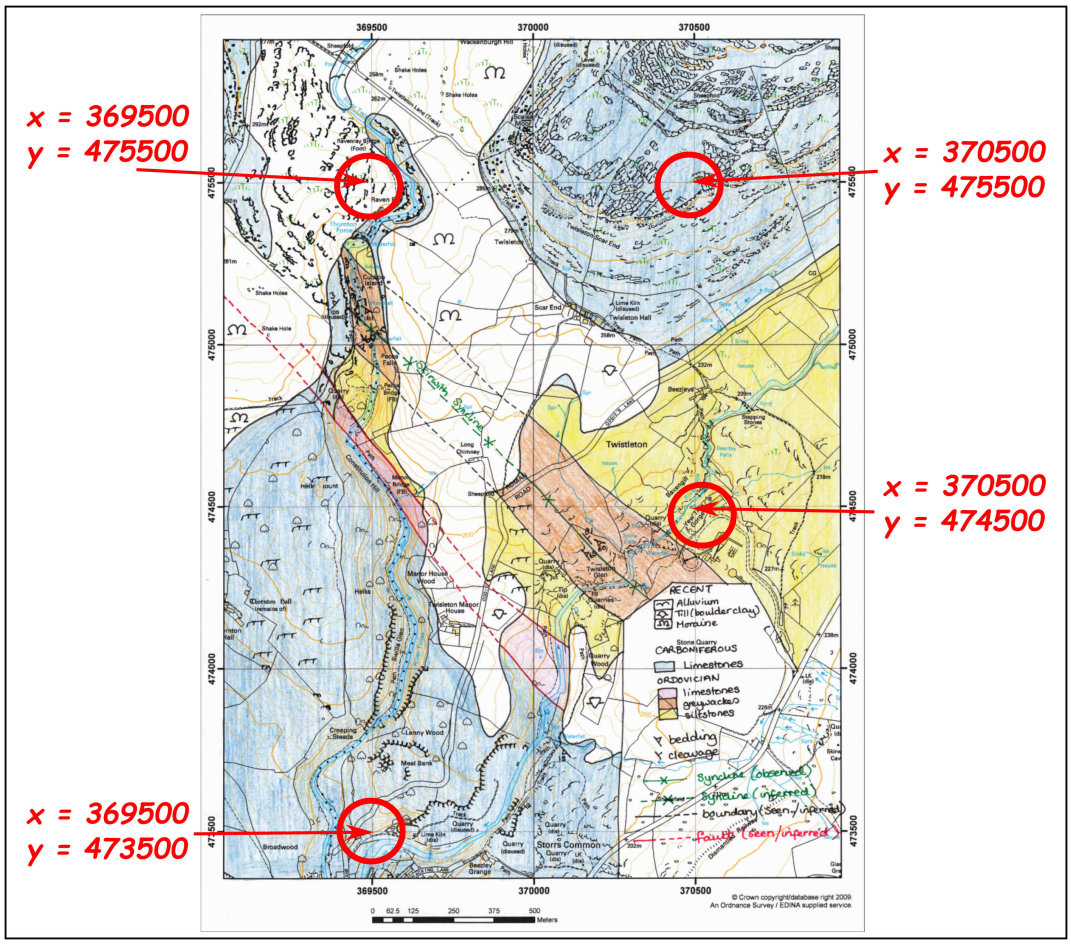


Figure 4.1: A geological field slip marked with control points and their national grid values ready for georeferencing

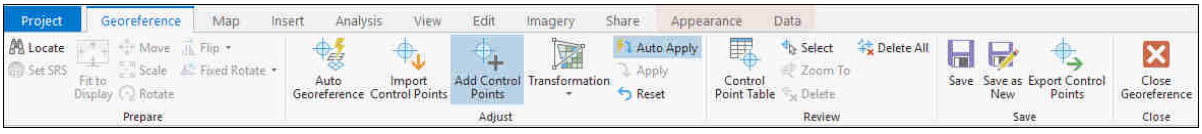


Figure 4.2: The georeferencing tools on the ribbon

The result is slightly alarming as your map should disappear. Don't worry! Arc has moved it from completely the wrong place to somewhere approximating the correct place.

- Right-click on the field slip in the contents pane and again **Zoom to Layer**

Things may still look rather odd - at the moment Arc knows vaguely where your map belongs, but you haven't yet given it enough information to be able to scale your map correctly.

- Add another point at another corner of the map in exactly the same way as above.
- Again, click OK
- and again, **Zoom to Layer**

[2] A useful way of remembering can be "Along the corridor and up the stairs" - so start with the numbers along the bottom (or top) for x, then the numbers on the sides for y.

[3] Avoid using the corners of the map - you have no guarantee that they are accurately numbered

Figure 4.3: Entering x and y coordinates for a point

Your field slip should be starting to look as if it fits the background map now.

- Add a minimum of another two points in the same way, spread as widely across your map as you can manage. You need at least 4 points for a transformation.

4.5.1 Checking your points

Your points should show on your map as a red circle with a cross through it (figure 4.4). Once you have four points stop and look at the little semi-transparent information panel at the top right of the map - figure 4.4. This shows the type of transformation that you are using and the amount of error that you have in map units. It's good to aim for less than one, but that can vary depending on the scale of your map, the required accuracy, and how well the original printed map matches the background map.

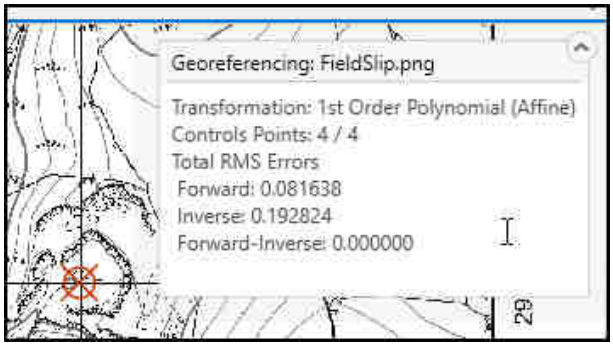
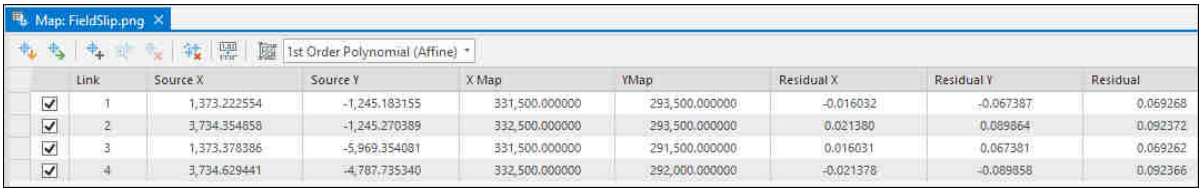


Figure 4.4: The information panel at the top right of the map - if you hover over it with the cursor it will show up better.

The other way to check your points is to use the **Control Point Table**

- Click on the **Control Point Table** button on the Georeferencing ribbon
- The table should open below your map - 4.5
- Have a look at the information available to you. The Control Point Table has a line for each point that you've added.
  - The X Map and Y Map columns show the coordinates that you entered. If you have made a mistake you can double-click on the numbers and change them.
  - There is a Residual error for each point - if one is too high try unticking the box on the left to see what difference it makes to the total residual error
  - You can use the buttons at the top of the table to delete any points which are particularly bad!

You should also inspect your georeferencing visually - does the field slip line up correctly with the background map? Check that roads run in the right place and buildings are in the same place on each map.



	Link	Source X	Source Y	X Map	YMap	Residual X	Residual Y	Residual
☑	1	1,373.222554	-1,245.183155	331,500.000000	293,500.000000	-0.016032	-0.067387	0.069268
☑	2	3,734.354858	-1,245.270389	332,500.000000	293,500.000000	0.021380	0.089864	0.092372
☑	3	1,373.378386	-5,969.354081	331,500.000000	291,500.000000	0.016031	0.067381	0.069262
☑	4	3,734.629441	-4,787.735340	332,500.000000	292,000.000000	-0.021378	-0.089858	0.092366

Figure 4.5: The Control Point Table showing x and y coordinates and the residual error

4.5.2 Saving your georeferenced scan

Once you are happy with the result you are ready to save it. This is the most crucial step - forget this and you'll have to go through it all again!

- To save the current version of the scan as a georeferenced file Click on **Save** on the georeference ribbon
- To save the result as a new file click on **Save as New** on the georeference ribbon.
  - Fill in the **Export Raster** dialog which opens on the right to save the file with a new name
  - Arc should add the new file to your map on top of the original file

Failure to do this step will mean that you have lost your carefully added links next time that you open the map and the scanned image probably won't show.

Once you save georeferencing Arc will add extra files to the same folder as the scanned map - rather like those in figure 4.6. These files contain the world information for geographical location, the equivalent of the tfw files with the O.S. tif files. Make sure that you keep these files and the scanned map together and don't delete them by mistake.

Figure 4.6: The original tif file and the extra files resulting from georeferencing and creating pyramids

4.5.3 Preventing georeferencing by mistake

To ensure that you don't georeference any other raster layers by mistake, once you've finished georeferencing

- Click to Close Georeference on the ribbon to return to the usual ribbon.

4.5.4 Solving georeferencing problems

If you have problems with your georeferenced image after you have saved the georeferencing you will probably have to start again from scratch. In this case remove the layer from your map, then delete all of the extra files that have been created such as .tfw, .jgw or .aux. That is, anything with the same name as your original tif, jpg, or png file except for the file itself. You'll need to use the Windows file manager to do this, not the catalog pane.

Then add the image back into your map as a layer and start the georeferencing process again.

4.6 Alternative method: georeferencing using identifiable points

Identifiable points here means that you will be using, for example, corners of field boundaries and road junctions as landmarks to add your georeferencing points. This tends to be necessary if you are using historic maps, satellite images with no grid, or similar.

If you have been able to georeference your scanned map using grid lines, as in the previous section, then you don't need to use this section now. Just be aware that it is possible as you may need this in the future and then carry on to the next chapter.

Video Clip available in Minerva - Georeferencing a scanned map in ArcMap: 2: Using identifiable points.

I strongly recommend that you view the video clip that shows how to georeference a scanned map before you start this section. It can be a difficult concept to grasp at first, but once you know what you are doing it becomes fiddly rather than difficult.

This method of georeferencing is more fiddly than using known grid references but you may find that you need to use it if you don't have a grid on your scanned map. This should be an extra incentive to you to make sure that you remember to put one on your base map for field work!

You need to be able to spot identifiable points on the background map of the scanned map and relate them to the base map in Arc.

Suggestions for identifiable points to look for when georeferencing
You need to look for features that you can spot and click on accurately on both maps. Look for features such as • Look for features such as – road junctions – corners of buildings – fence/wall junctions – bench marks • If you are using two different editions of a map, be careful to choose points that are unlikely to have changed between the two maps. E.g. streams tend to move around over time! You can still use the zoom and pan tools, so zoom in close to be as accurate as possible.

Table 4.1: Choosing identifiable points when georeferencing

- Select the layer to be georeferenced in the contents pane
- On the ribbon go to the **Imagery** tab and click on the **Georeference** button. The ribbon should change to show the Georeferencing tools - figure 4.2
- Double-check that you have the correct layer selected - georeferencing another layer by mistake is not a good thing to do. The georeferencing information panel in the top right of the map window (figure 4.4) will show you which layer Arc thinks is being georeferenced.
- On your background map navigate to the general area in which your scanned map belongs then click on **Fit to Display** on the ribbon

- Click on **Add Control Points** on the ribbon then look for a point on the scan that you can also identify accurately on the background map
- left-click on the point as accurately as you can, then turn off the scanned map in the contents pane and click on the same identifiable point on the background map

The layers should immediately adjust. Switch the scanned map back on and **repeat the process at least three more times**, preferably more, spreading the points out as far as you can.

- if you make a mistake you can cancel the previous point by pressing Esc
- To check the accuracy of the georeferencing, in addition to making a visual check use the **Control Point Table** - see section 4.5.1 on page 71.

4.6.1 Saving your georeferenced scan

Once you are happy with the result you are ready to save it. This is the most crucial step - forget this and you'll have to go through it all again!

- To save the current version of the scan as a georeferenced file Click on **Save** on the georeference ribbon
- To save the result as a new file click on **Save as New** on the georeference ribbon.
  - Fill in the **Export Raster** dialog which opens on the right to save the file with a new name
  - Arc should add the new file to your map on top of the original file

Failure to do this step will mean that you have lost your carefully added links next time that you open the map and the scanned image probably won't show.

Once you save georeferencing Arc will add extra files to the same folder as the scanned map - rather like those in figure 4.6. These files contain the world information for geographical location, the equivalent of the tfw files with the O.S. tif files. Make sure that you keep these files and the scanned map together and don't delete them by mistake.

4.6.2 Preventing georeferencing by mistake

To ensure that you don't georeference any other raster layers by mistake, once you've finished georeferencing

- Click to Close Georeference on the ribbon to return to the usual ribbon.

4.6.3 Solving georeferencing problems

If you have problems with your georeferenced image after you have saved the georeferencing you will probably have to start again from scratch. In this case remove the layer from your map, then delete all of the extra files that have been created such as .tfw, .jgw or .aux. That is, anything with the same name as your original tif, jpg, or png file except for the file itself. You'll need to use the Windows file manager to do this, not the catalog pane.

Then add the image back into your map as a layer and start the georeferencing process again.

Chapter 5

Digitising geological data

The background to digitising data and an explanation of what it is will be covered in the lecture segment at the beginning of the class and the presentation and any other supporting materials will be available in Minerva. The lecture segment should help you to understand **why** you are doing these exercises. If you still aren't sure, please ask Clare.

5.1 Learning outcomes

When you have completed this section of the workbook you should be able to:

- explain what a geodatabase consists of and why it is used to store GIS data
- set up organised storage for GIS data
- use the tools in ArcGIS to create and edit map features

5.2 Introduction

Now that you have a base map, and your field slip is in the correct location, you can start to digitise, or draw, your geological data.

The process of tracing or drawing in GIS is known as "digitising".

For these exercises you'll be **digitising** polygons, points and lines by tracing over geological features on your field slip. The next chapter will show how to change how the data looks, so don't worry about that for now.

The techniques explained here for creating geological maps with ArcGIS are of necessity rather generalised. Each map that you create will have different requirements, e.g. you may not need to add symbols or lines to particular maps.

Try out the techniques listed here and use the ones that you need. Experiment. You may well find better ways of doing things. As ever in computing there is more than one way to do most things and you may find that a different way gives you better results or seems simpler to you.

5.3 Setting up storage

You will store your data in a **file geodatabase**. This is a way of storing multiple files together in a format that is spatially-enabled. Within a file geodatabase you can create a **feature dataset** to store

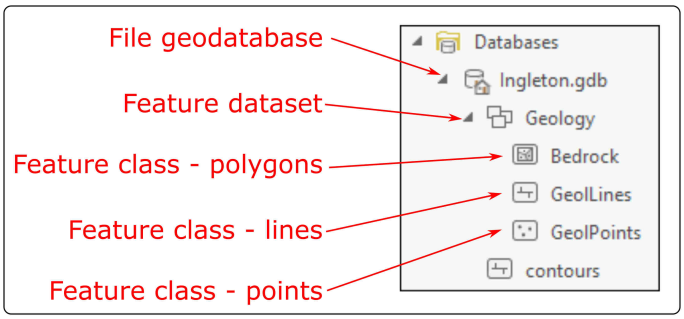


Figure 5.1: Example of the structure of a file geodatabase as seen in the catalog pane

multiple, related, **feature classes**. Feature classes can also be stored directly in the geodatabase. See figure 5.1 for an example of the structure of a file geodatabase in the Catalog pane.

You will have come across shapefiles as another form of storage - file geodatabases are recommended as being more robust and better for handling large amounts of data.

Start by having a look at your field slip. The key to that will show the geological symbols that you've used and you need to begin by planning how you are going to digitise those.

Make a list in the space below showing all of the symbols that you think you will need to digitise, how you could group them, e.g. bedrock symbols, structural symbols etc. and whether they will be point, line or polygon symbols. You can make changes to the structure of your geodatabase later, but it can save time if you have planned well and don't need to change too much.

It is up to you to arrange your storage in a way that you think will be useful, though knowing what you prefer will become easier as you learn more about the process. For now maybe try the scheme I suggest in the instructions below.

5.3.1 Setting up your file geodatabase

If necessary open the map project that you were working on in the previous chapters - the one with the background map and the georeferenced field slip.

When the project was set up Arc automatically included a **geodatabase** within it which will have the same name as your project. You should be able to find this under the **Databases** subheading in the contents pane. You'll use this to store your data.

Set up a feature dataset

- In the Catalog pane go to the **Databases** subheading and open it out. There will be a geodatabase with the same name as the project / folder
- Right-click on your geodatabase
- New > Feature Dataset
- Enter a name that describes the information that it will contain, in this example it could be **Geology**.
- Set your projection - if you are working in Britain it is most likely to be British National Grid so select Projected Coordinate Systems > National Grids > Europe > British National Grid. For other areas check!
- Run

Set up a feature class

Still in the catalog pane

- Right-click on the feature dataset that you've just set up (in this example the one called **Geology**
- New > Feature Class
- Fill in the geoprocessing dialog as follows:
  - Give your feature class a name that explains what it shows - with no spaces or punctuation, e.g. in this case **Bedrock**
  - The **Feature Class Alias** is the name that will appear in the contents pane - this can include spaces
  - Choose the correct **Geometry Type** - it's important to get this right as it isn't possible to change this once you've created the feature class. For the Bedrock layer select **Polygon**
  - If you are storing the feature class in a dataset which already has a spatial reference set you shouldn't need to fill that in again.
- If you click on Next you'll get an opportunity to add fields and other information
  - add a text field called **Type**
  - and another text field called **Label**
- If your feature class is **not** inside a feature dataset you'll also need to set the XY coordinate system
- Click Finish to create the new feature class

The feature class should be added to your feature dataset, and also added to the contents pane of the map that is open. If it isn't automatically added to the contents pane just drag and drop it across.

Set up further feature classes as follows:

- ***A line class called GeolLines with text fields for Type and Label***
- ***A point class called GeolPoints with a text field for Type, and a field with a data type of Short Integer called Rotation. Any type of number field should work, but Short integers hold numbers with no decimal points.***

Note that if you forget to change the feature type when you are creating a feature class it can't be changed later. All you can do is delete the feature class and create a new one.

The final database structure for the Ingleton field area should be something like that in figure 5.1 on page 76.

Arc should have automatically added the new feature classes to your table of contents. If it hasn't add them now.

5.4 Digitising polygons

The instructions in this section show how to do the basic digitisation of polygon features. If you are following the level one GIS module there are other techniques you need to try before you digitise the whole map, so go through these instructions for one bedrock polygon, then move onto section 5.6 on page 80 to find out how to digitise further polygon areas without having gaps and overlaps between them.

Video Clip available in Minerva - Digitising in Arc Part 1: Starting and finishing, and creating polygon features.

- To start editing simply click on the **Edit** tab of the ribbon.
- Click on the **Create** button in the **Features** group
- A **Create Features** pane should open on the right-hand side of the window showing the editable layers in your map - see figure 5.2
- Click on the layer that you want to digitise into, in this case the bedrock layer, and select the **Polygons** tool - the one on the left. As usual if you hover over icons you'll get a tooltip.

Start by zooming in to the area of bedrock that you want to digitise.

- To create a polygon left-click along the edges of the bedrock shape. Each click creates a **vertex**, or corner - see figure 5.3.
- To finish a polygon double-click on the last point or press the F2 key on the keyboard. The polygon should be outlined by the selection colour, e.g. turquoise, once you've done this.
- To add attributes (information) about the area you've just digitised, click on the **Attributes** button on the ribbon to open the Attributes panel
  - add the rock type etc to the **Type** field e.g. **Ordovician Siltstone**
  - and add a short abbreviation for the rock type which you'll use to label the map later e.g. **OS** - figure 5.4.

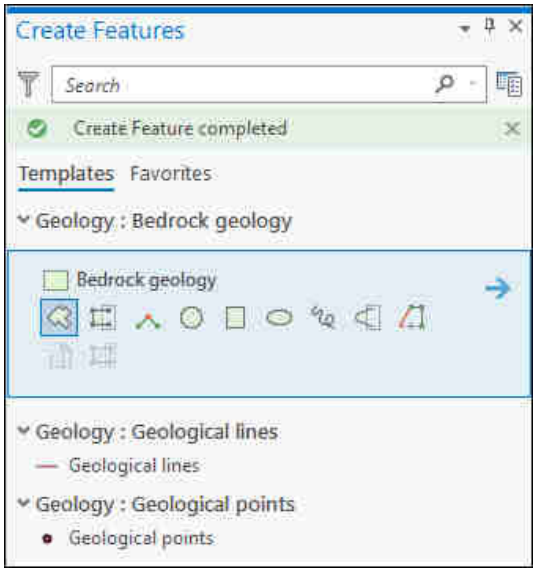


Figure 5.2: The Create Features pane showing editable layers

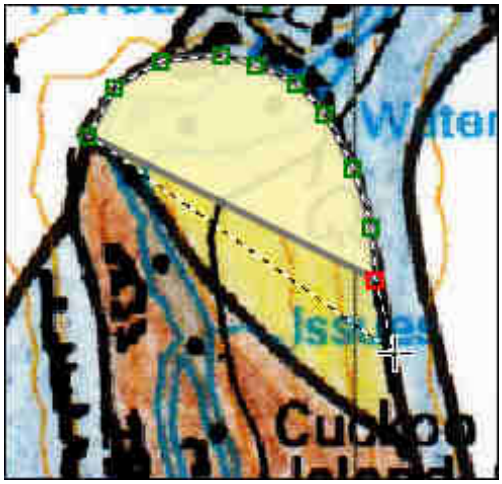


Figure 5.3: Clicking around a polygon outlines to create vertices - the red vertex is the last one that was placed

- You can continue straight on to digitise another area if you wish to but remember to save your edits regularly - see the next section - section 5.4.1. You should also check section 5.6 for tips on avoiding gaps and overlaps before you continue digitising, particularly if you are following the level one GIS module.

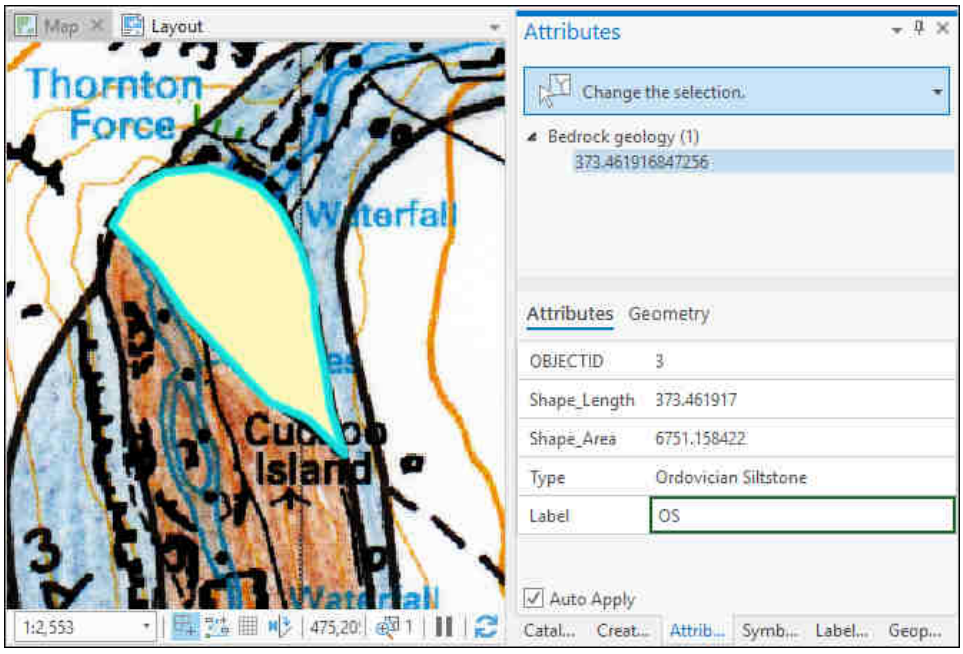


Figure 5.4: Adding attributes to a newly created polygon. Note the turquoise outline that shows that the polygon is still selected

You can also try out some of the other edit tools available to you, but from experience tools such as **Freehand** don't work as well as you would hope. It might be worth trying this if you have a digitising tablet, but otherwise it is very difficult to get smooth, accurate outlines.

5.4.1 Saving your edits

- To save your edits click Save on the Edit tab of the ribbon. If you don't want to save your edits click Discard instead.

It is important to save your edits on the Edit toolbar - they are not being stored in the map, but are being written to the external feature class that you have set up. If you closed Arc without saving the edits, even if you save the map, they wouldn't be there next time you opened it.

Once you've finished adding items it isn't obvious how to stop!

- Click on the **Map** tab of the ribbon
- Click on the **Explore** button from the Navigate group.

5.5 Transparency

When you are creating multiple features it can become difficult to see what you are doing. To make it a bit easier remember that you can make a layer transparent:

- Select the layer you want to make transparent, in this case the Bedrock
- Click on the **Appearance** tab of the ribbon
- in the **Effects** group of the ribbon there is a slider which is set to 0.0%, change that to, for example, **30%**.

Try different settings to see what helps you most.

5.6 Suggestions for avoiding gaps and overlaps

Some of the polygons that you need to add share edges with others and you'll need to use techniques to make sure that these polygons neither overlap or have gaps between them. Once you've set transparency overlaps will show clearly! Gaps and overlaps between polygons and lines that don't follow the edges of polygons make your map look inaccurate and as if you haven't taken care with your digitising.

Try the following suggestions to make it easier to avoid gaps and overlaps while efficiently digitising the shapes.

You should continue on to add the other bedrock and superficial polygon features on the map, remembering to check which feature class you are editing. Once you've added a feature to the wrong feature class it is not possible to move it to the correct one.

5.6.1 Snapping

Snapping allows new edits to connect exactly to existing lines and nodes. You may find this particularly useful if you want lines such as faults to line up accurately with the edges of geological formations. Note that this works with points, lines and polygons.

It is worth being aware of snapping, even if you decide you don't want to use it in editing, as it can cause you issues when digitising. In particular, it can be useful to switch off contours, as those can become very irritating when digitising.

Video Clip available in Minerva - Digitising in ArcGIS: Avoiding overlaps and gaps Part 2. snapping.

- Select a layer and start editing
- From the Edit tab of the ribbon click on the **Snapping** button to switch snapping on. This toggles, so to switch snapping off click on the button again.
- Click on the arrow below the snapping button to get up more options - see figure 5.5. These control exactly what your cursor will snap to. For now check that snapping is on, and that the first four buttons in the line below are selected, as shown in the image.

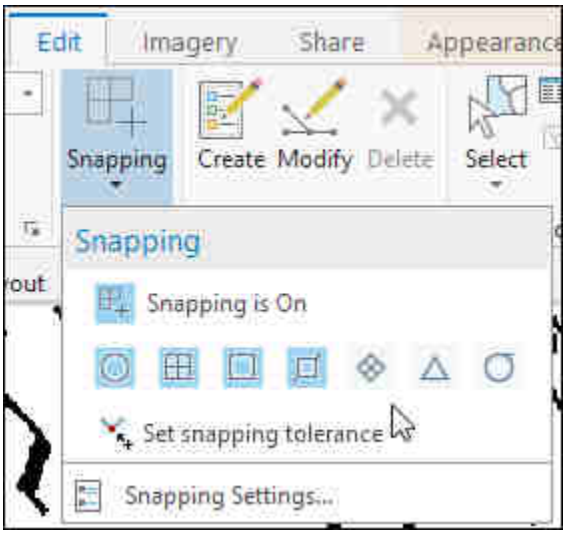


Figure 5.5: The snapping options from the button on the ribbon. As usual, hovering over the buttons shows the tool tips.

Snapping tolerence

Snapping tolerence sets how close the cursor has to be to an edge, end or vertex before it **snaps**, or jumps, to it.

- From the options under the **Snapping** button click on **Snapping Settings...**
- The default setting is probably **10 pixels**. This is quite large and may stop you from putting vertices where you want to, but you can then experiment to get this set to your satisfaction once you start digitising.

- ***Set the XY snapping Tolerence to 100 pixels - very large but it will show you how it works.***
- ***Click OK to close the Snapping Settings.***
- ***Start editing a new polygon - move the mouse cursor close to an existing polygon - it should jump to the edge.***

This gives you an idea of how snapping works, but 100 pixels is very difficult to work with so change it back to 10 pixels before continuing.

Controlling selections

If you have overlapping layers it can be difficult to select just the feature that you want, either to find the details for it, or to edit it.
When you click on your map to select a feature it is possible to select the correct one from the little dialog which pops up (figure 5.6), but this isn't always convenient.
To control which layers can be selected from, and which can't, try the following:

- From the top of the Contents pane click on the **List By Selection** button - remember the tool tips appear if you hover over the buttons
- In the view of your layers which appears ensure that
  - the layer or layers that you want to be able to select from are ticked
  - the layer or layers that you **don't** want to be able to select from are **not** ticked.
- It's a good idea to go straight back to the **List by Drawing Order** view of your layers or it's easy to get confused later

Table 5.1: Controlling selections

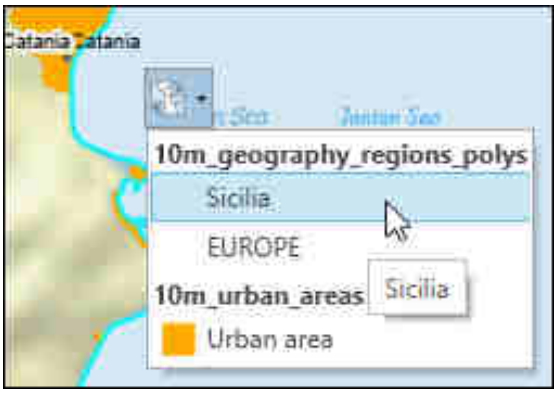


Figure 5.6: Choosing a single feature from the overlapping selections pop up

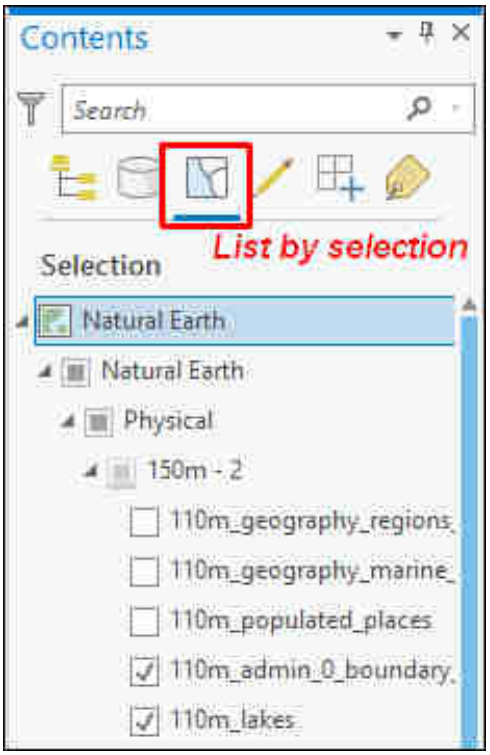


Figure 5.7: The Contents pane showing List by Selection view. Layers with no ticks can't be selected, layers with ticks are still selectable.

Video Clip available in Minerva - Selection tools and stopping layers from being selectable. It can be useful to prevent other layers from being selectable as if more than one feature is selected you won't be able to make the changes.

5.6.2 Clipping features

Clipping will remove the portion of one polygon that overlaps another - figure 5.8. Note that clipping has no effect on line features. If you are drawing multiple polygons you can leave big overlaps then clip later - it can be quicker than having to be careful to get edges to match.

Video Clip available in Minerva - Digitising in ArcGIS: Avoiding gaps and overlaps Part 3. clipping.

- Select the feature you want to use to clip, i.e. the one that is the correct shape - figure 5.9. If you're having trouble selecting features from the layer that you need without selecting features from other layers too have a look at the tips in table 5.1 on page 82.
- On the Edit tab of the ribbon go to the **Tools** group and use the arrows to the right to scroll down until you find Clip. This will open the Clip panel - figure 5.10
- Leave the buffer distance as **0**.
- Click to Discard (Remainder) > Clip.

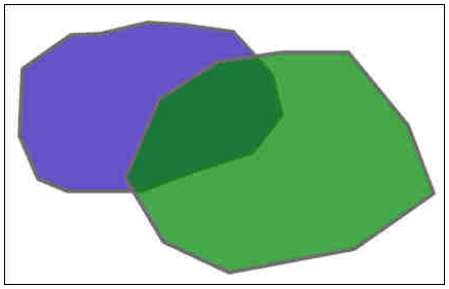


Figure 5.8: Transparency allows it to be seen that these two polygons are overlapping each other

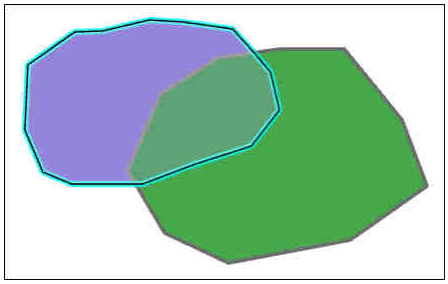


Figure 5.9: The turquoise outline shows that the polygon which is the correct shape is selected

The clipping may happen so quickly that you don't notice it! Your polygons should now match rather than overlap. Click each polygon to view the selection outline, or change their order in the table of contents to check.

You will find that you often need to clip against more than one polygon.

5.6.3 Merging features

If you have drawn two separate polygons which overlap each other and want to join them together as one, you need to **merge** them. The polygons must be from the same layer, e.g. Bedrock.

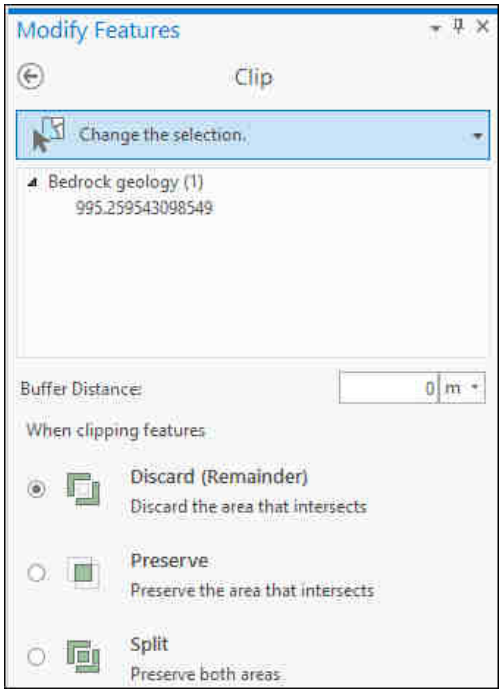


Figure 5.10: The Clip tool

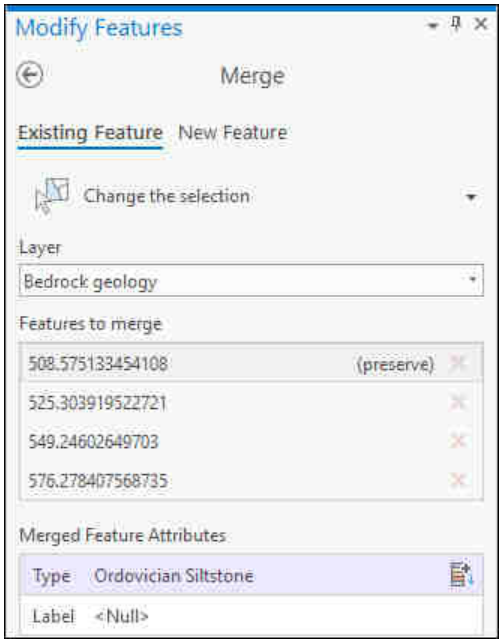


Figure 5.11: The Merge tool

Video Clip available in Minerva - Digitising in ArcGIS: Avoiding overlaps and gaps Part 4: merging.

This can be particularly useful if you are tracing a large or complex shape and want to create it in small portions, or if you get interrupted. See figure 5.12 for an example.

- Use the **Select** tool to select both/all of the polygons that you want to merge, hold down the ⇧ key while you do
- On the Edit tab of the ribbon go to the **Tools** group and use the arrows to the right to scroll down until you find Merge. This will open the Merge panel - figure 5.11
- Check that the details are correct, and if you have attributes in the feature class check that they are correct for the final merged polygon
- Then click Merge

You should find that the end result is a combined polygon - such as figure 5.13.

5.6.4 The trace tool

This tool can be used successfully with both polygons and lines. It can be a little difficult to use at first, but once you've got used to it can make tracing a lot easier and quicker.

- Whilst editing as usual select the **Trace Tool** instead of the polygon tool from the choices in the **Create Features** panel.

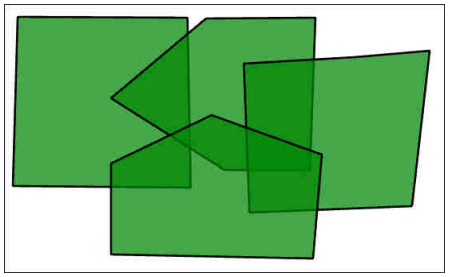


Figure 5.12: Transparency allows it to be seen that these four polygons are overlapping each other

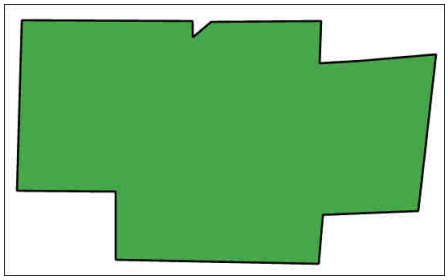


Figure 5.13: The four polygons have now been merged into one - there are no internal outlines visible

Video Clip available in Minerva - Digitising in ArcGIS: Avoiding overlaps and gaps Part 1. the trace tool.

- Click on the selected polygon for the first vertex of the edge that you want to draw, then, without clicking, follow around the edge of the selected polygon. The edge you are drawing should appear along the line that you are tracing.
- If you want to continue a line or edge away from the edge that you are tracing simple click to create a vertex, then click back onto the **Straight Segment Tool** (or which ever you are using) on the edit toolbar and continue as usual.
- To finish your line double-click or press F2 as usual.

Continue to digitise so that you have polygons for all of the bedrock geology areas. Remember to save your new polygons. Remember to use the techniques in section 5.6 to avoid gaps and overlaps between polygons.

Add attributes as you go along to save confusion later. For the Ingleton exercise your attribute table should end up looking something like figure 5.14. Don't worry if the information in the OBJECTID, Shape_length and Shape_area columns is different.

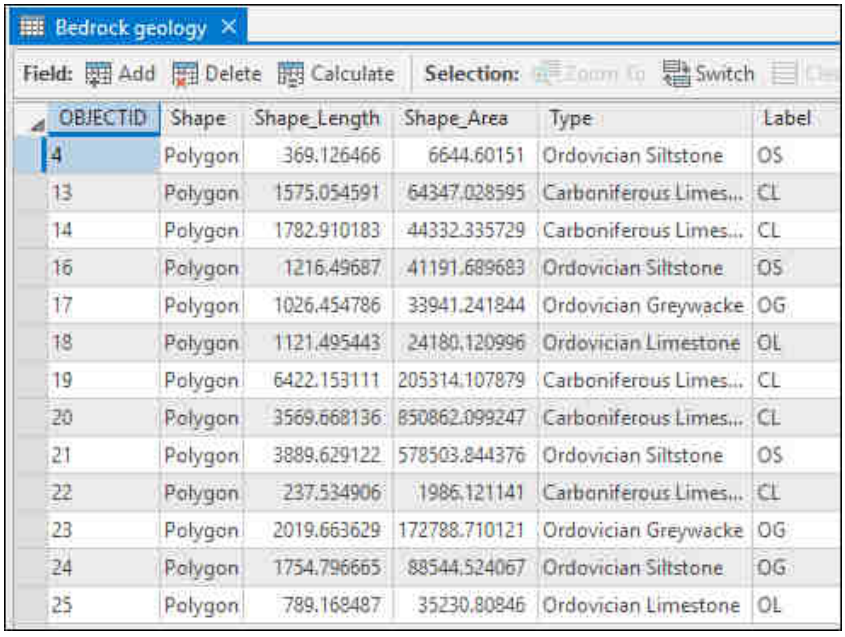
5.7 Digitising lines and points

Once you understand how to digitise polygons digitising lines and points is very similar.

Setting up feature classes to store lines or points is the same as setting them up for polygons - see section 5.3.1 on page 77 for a reminder of how to do this, but you do need to remember to set the data type correctly as you can't change it once the feature class has been created.

5.7.1 Adding line features

To digitise a line feature you can basically use the same instructions as you did for digitising polygons (section 5.4 on page 78), but of course you won't have to "close" lines or clip them.



Bedrock geology

Field: Add Delete Calculate Selection: Zoom To Switch Cle

OBJECTID	Shape	Shape_Length	Shape_Area	Type	Label
4	Polygon	369.126466	6644.60151	Ordovician Siltstone	OS
13	Polygon	1575.054591	64347.028595	Carboniferous Limes...	CL
14	Polygon	1782.910183	44332.335729	Carboniferous Limes...	CL
16	Polygon	1216.49687	41191.689683	Ordovician Siltstone	OS
17	Polygon	1026.454786	33941.241844	Ordovician Greywacke	OG
18	Polygon	1121.495443	24180.120996	Ordovician Limestone	OL
19	Polygon	6422.153111	205314.107879	Carboniferous Limes...	CL
20	Polygon	3569.668136	850862.099247	Carboniferous Limes...	CL
21	Polygon	3889.629122	578503.844376	Ordovician Siltstone	OS
22	Polygon	237.534906	1986.121141	Carboniferous Limes...	CL
23	Polygon	2019.663629	172788.710121	Ordovician Greywacke	OG
24	Polygon	1754.796665	88544.524067	Ordovician Siltstone	OG
25	Polygon	789.168487	35230.80846	Ordovician Limestone	OL

Figure 5.14: The completed attribute table for the Ingleton bedrock layer

Use the instructions on **snapping** in section 5.6.1 on page 80 to ensure that the ends of the lines join each other where necessary, and that the lines follow the edges of polygons where appropriate. The **trace tool** (see section 5.6.4 on page 84) can also be very useful when a line needs to follow the edge of a polygon.

Video Clip available in Minerva – Digitising in Arc Part 2: Creating line features.

If you need to create lines which have varying symbology along their length then you need to create multiple lines so that later you can set the symbology to Unique Values.

For example, if you are digitising a fault, but some parts of the line for the fault need to be solid, because you actually observed them, and other parts need to be dashed because they are inferred. You'd draw this line as a series of lines, one for each section, making sure that each one **snaps** to the end of the previous one, and put an attribute in a field to differentiate each type of line. Then you can symbolise each line type appropriately. See figure 5.15 for further explanation.

Note that if you need to create a dashed or dotted line, you'll be doing it via the symbology. Don't actually draw the dashes at this stage, just draw a solid line.

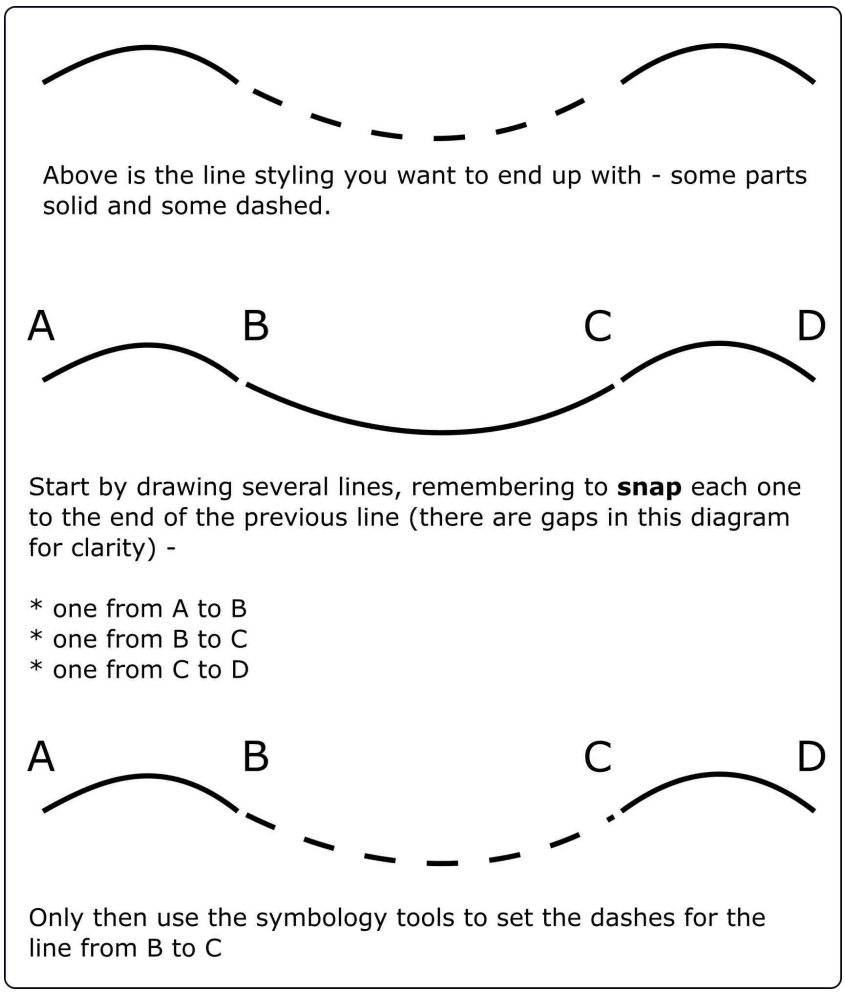


Figure 5.15: Drawing a line which has varying symbology along it's length

For the Ingleton map digitise all of the geological lines into the GeolLines feature class. From looking at the key on the fieldslip you should be able to work out that you need to add the following line types:

- ***Fault - inferred***
- ***Fault - observed***
- ***Geological boundary - inferred***
- ***Syncline fold axis - inferred***
- ***Syncline fold axis - observed***

Note that sometimes you need to outline the geological polygons because they won't always be the same type of line all the way round. In that case you would probably need a "Geological boundary - observed" type too. For the Ingleton map, so save some time, the outlines are part of the polygon formatting.

5.7.2 Adding point features

Points on maps can include symbol markers to show types of lines, such as anticlines and synclines (useful if you can't find a line symbol with appropriate "decoration"), direction of dip and

strike for field observations, locations of particular features, or a way of adding symbols for particular rock types. You can also use points to create labels that aren't attached to any other particular feature. Figure 5.16 shows some examples of uses of point symbols.

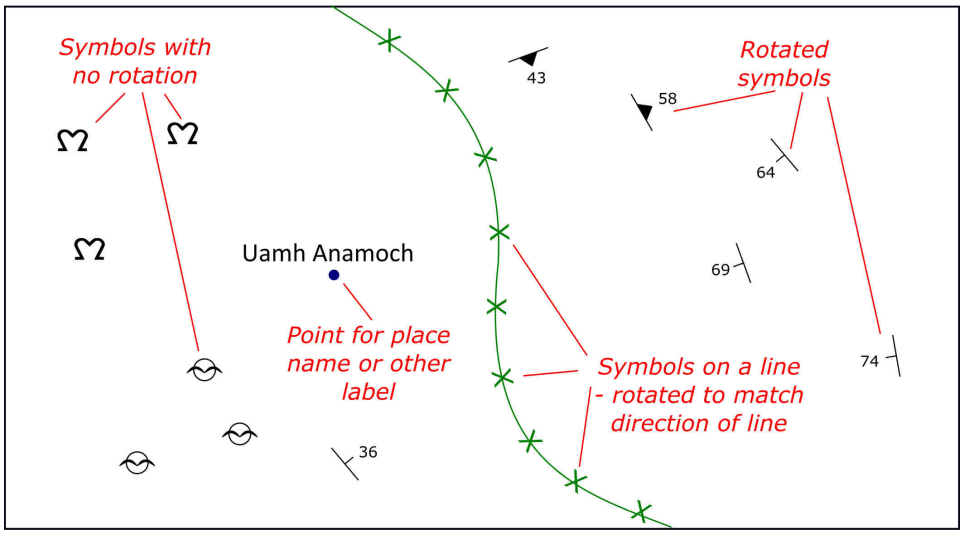


Figure 5.16: Examples of the uses of point symbols on maps

This section shows you how to create point features by editing a feature class. Section 5.10 on page 91 shows you how to create a point feature class by importing a spreadsheet or csv file.

Try out both methods of adding point data so that you know how to do them. When it comes to adding your own data in future it will be up to you which method you decide to use for which types of point data. If you have bedding, cleavage, etc on your fieldslip, the simplest way will probably be to add the points by editing a feature class rather than by pulling them all into a spreadsheet first. For the Ingleton exercise, though, you'll use the import technique to add the bedding and cleavage symbols.

Adding points by editing

You can add points to a feature class in a similar way to adding lines and polygons, but this time by selecting a point layer. Of course, for points you only need to click once on the map. Use the instructions in section 5.4 on page 78 to digitise any point features.

Video Clip available in Minerva - Digitising in Arc Part 3: Creating point features

For the Ingleton geological map edit the GeolPoints layer to add the points for alluvium, till and moraine. In addition add points to the lines to show the syncline symbol. You'll find out how to symbolise these with the correct symbols later in the workbook, for now just pick a random dot or shape.

5.8 Modifying existing features

If you want to edit a polygon, point or line to change or move it once you have created it you can do so as follows:

Video Clip available in Minerva - Digitising in Arc Part 4: Editing features.

- Select the layer which contains the features that you want to modify
- Go to the **Edit** tab of the toolbar and click on the **Modify** button

The Modify Features panel (figure 5.17) should open on the right and contains a wide range of potential tools.

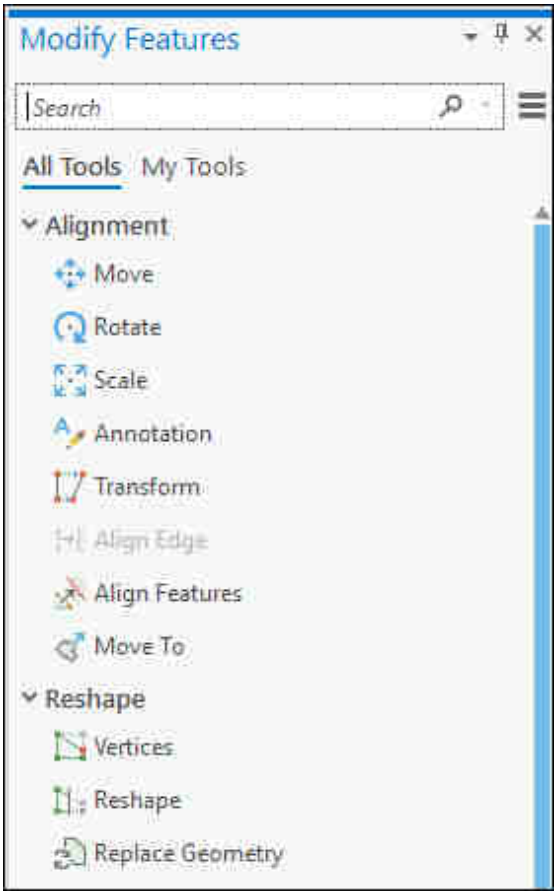


Figure 5.17: The Modify Features panel showing some of the tools available

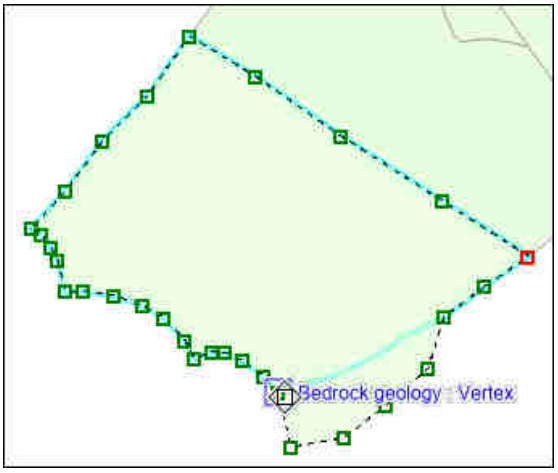


Figure 5.18: In the process of modifying vertices on a polygon. Note the vertices are small green and red boxes which can be moved with the cursor.

- To start with click on the **Vertices** tool under the **Reshape** subheading
- A new panel will open and give you a chance to select the feature that you want to change - just click on the feature now

- Your feature should look something like figure 5.18 with the start/finish vertex as a red box, and the other vertices as green boxes.
- Use the mouse to hover over one of the vertices, then hold the left mouse button down and move the vertex.
- You're editing the **Edit sketch**, not the actual line or edge, so the feature itself won't change until you finish it either by clicking F2 on your keyboard, or click the **Finish** button on the editing menu at the bottom of the screen.
- When you've finished editing remember to click the **Save** button on the Edit tab of the ribbon or your modifications won't be written to disk!

The tools will work in exactly the same way for lines and points. Try out some of the other tools to see how they can help you too.

5.9 Adding attributes to a feature class

As is usual with GIS there is more than one way to add attributes to a feature class, but first you do need to have the fields set up to add them to.

5.9.1 Adding new fields

In section 5.3.1 on page 77 I showed you how to add fields to a feature class as you are creating it. That is probably the best time to do it, but sometimes you forget, or you need to add another field later. This section shows you how to add attributes to an existing feature class. These instructions are the same for point, line or polygon feature classes.

For example, for the Ingleton exercise try adding a new field called **Period** to the Bedrock geology feature class.

Video Clip available in Minerva - Adding a new field to a feature class

- Select the feature class you want to add fields to in the contents pane, in this case **BedrockGeol** and open the attribute table (right-click and **Attribute table**
- At the top of the attribute table you'll have a few buttons - click on the one which says **Add**
- This opens a list of the existing fields in the feature class with a new field at the bottom - see figure 5.19.
  - enter a descriptive **field name** - short with no spaces, e.g. **Period**
  - an **alias** allows spaces so can be natural English
  - Choose the **data type** - this can't be changed later! For this example it will be **Text**
  - If you are adding a text field you can enter a **Length**, e.g. **50**
- To add any more fields click at the bottom where it says **Click here to add a new field**
- otherwise click **Save** on the Fields tab of the ribbon - it's easy to forget to do this as you won't necessarily be able to see the correct tab!
- The fields dialog will have opened as a new panel - close this by clicking on the cross on the tab to return back to the attribute table view.

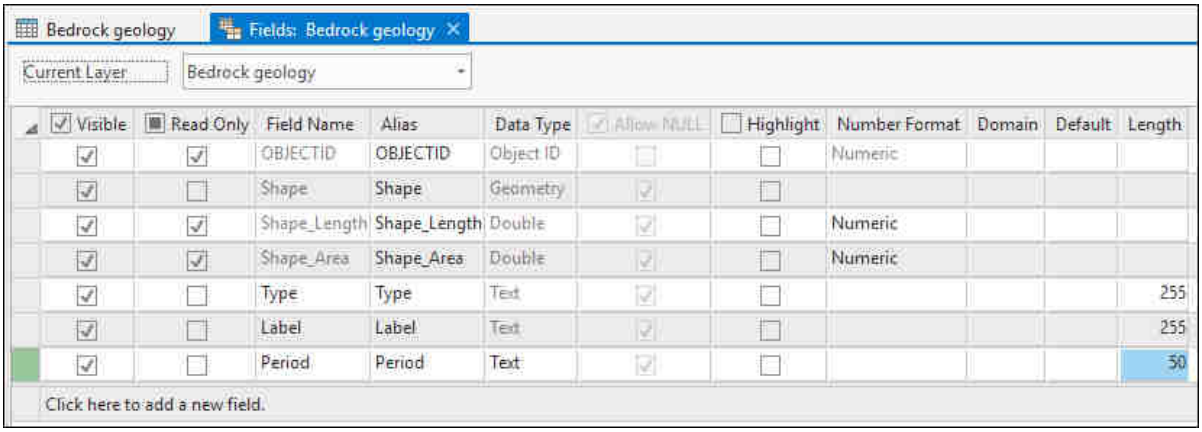


Figure 5.19: Adding a new field to a feature class

5.9.2 Adding attributes

Now you're ready to add information, or attributes, to your new field.

Video Clip available in Minerva - Adding attributes to the attribute table.

You can do this either as you add features to your feature class (this is often the easiest way and you've already seen how to do this in section 5.4 on page 78):

- digitise your feature then to add attributes (information) about the feature you've just digitised, click on the **Attributes** button on the Edit tab of the ribbon to open the Attributes panel, then add your information there.
- Click on **Apply**, or select to **Auto Apply** so you don't have to remember it again!
- Click on **Save** on the Edit tab to write your feature to disk.

OR within the attribute table for existing features:

- Open the attribute table for your feature class if it isn't open already.
- find the feature that you want to add attributes to - maybe by selecting it on the map
- Click in a field on that row and enter the data that you need to add, then press ↵ (enter)
- Repeat this for other fields, and other features then Don't forget to press **Save** on the Edit tab of the ribbon. If you forget this, you'll lose your information.

5.10 Creating point features by importing

Point data can be added either by editing the map, as in the section above, or by importing it from a spreadsheet or text file. When you are working with your own data you will have all of these measurements on your field slip and in your notebook. So the first step would be to collate the measurements that you want to include in your top copy map into a table. For this

reason you may find it much simpler just to digitise the measurements by digitising using the instructions in the previous section. If you have geochemical readings, for example, they may be in a spreadsheet anyway, so this will be the method to use.

It is completely up to you which method you use but have a go at both before you decide.

Xyz files can be either comma separated value text files or Excel spreadsheets. They contain point data which includes coordinates for a geographic location either in two dimensions (x and y) or three (x, y and z). The example we'll use is an Excel spreadsheet. When you are creating your own maps you could either create the file for yourself from a field notebook or create from GPS-related data.

5.10.1 Creating xyz files and preparing for import

For the Ingleton exercises, in Excel open the **strikedip.xls** file that you can download from Minerva and have a look at the data (Figure 5.20). We're using bedding and cleavage data as an example, but the same techniques will apply to any point data, such as lead concentrations in soil samples, gravity measurements, rainfall totals etc.

Note If you have trouble importing an excel file, try saving it as .csv instead.

Arc can also import xyz data from **.csv** (comma-separated value) files either saved from Excel or created in a text editor such as Notepad++ (Not Word!) see figure 5.21.

I6

	A	B	C	D	E	F	G
1	site	100kgrid	eastings	northings	type	strike	dip
2	1	SD	69388	75125	bedding	220	3
3	2	SD	69487	75103	bedding	122	61
4	3	SD	69471	74991	bedding	310	60
5	4	SD	70171	74404	cleavage	322	81
6	5	SD	70207	74392	bedding	107	60
7	6	SD	70168	74356	bedding	321	65
8	7	SD	70101	73749	bedding	137	18
9							

Figure 5.20: Excel file containing x and y point data

strikedip.csv

```
site,100kgrid,eastings,northings,type,strike,dip
1,SD,69388,75125,bedding,220,3
2,SD,69487,75103,bedding,122,61
3,SD,69471,74991,bedding,310,60
4,SD,70171,74404,cleavage,322,81
5,SD,70207,74392,bedding,107,60
6,SD,70168,74356,bedding,321,65
7,SD,70101,73749,bedding,137,18
```

Figure 5.21: The same file containing x and y point data, this time saved as .csv and opened in a text editor

IMPORTANT NOTE: Column headings must be short and contain no spaces or non-standard characters - so text and numbers only. Edit your table before you try importing it to check that this is the case.

Notice the **eastings** and **northings** columns - in effect x and y. These are in **British National Grid 1m coordinates**. We'll need to do some work to make these suitable for importing into Arc, though. Note the column headed **100kgrid** - that tells you which 100km grid square the references are in, **SD** in this case. Unfortunately Arc won't read these, and if you import the eastings and northings as they are your data will end up in the wrong place.

5.10.2 British National Grid 100km squares

British National Grid references are most commonly given in the form NN60052674, with grid **letters** at the start to give the 100km grid square. These letters need to be replaced by numbers if the grid references are to be read by ArcGIS.

Plotting structural geology data in GIS: Leeds method vs Right hand rule
When you take structural readings you will be recording them using the Leeds method as (for example) 010/18NW, with the strike being between 0 and 180, but when you then plot them in GIS, which uses the right hand rule, the tick mark will be in the wrong direction for some of your measurements. The problem isn't with your measurements, but with the way that Arc is able to handle them. Have a look at appendix A on page 134 for more information on how to deal with this. **Once you have imported the points into Arc have a close look to make sure that they agree with your symbols on the field slip.** This is a general tip - when you've added any data to GIS you should always check that it looks correct. **The data you have been provided with for Ingleton is already converted so that you don't need to worry about this step.**

Table 5.2: Plotting structural geology data in GIS

If you are given a reference that does not include the grid letters but consists entirely of numbers it is worth checking whether the grid numbers make sense. Of course, it may just mean that the person who created the references forgot about the letters, in this case the reference could refer to any of the 100km squares covering the UK - not helpful!

The instructions with figure 5.22 show you how to convert from grid letters to numbers. Study this and then practice using the examples below.

Question 5.1. Using the instructions with figure 5.22 on page 94 convert the following grid references to British National Grid numbers with 6 figures for each number so that Arc will be able to read them and write them in the space next to each reference then check your answers in appendix C

1. ***NH 3395 3196 =***

2. ***SP 727 499 =***

3. ***TM 2753 3952 =***

If you look at the corners of a published hardcopy Ordnance Survey map such as the Landranger (pink covers) or Explorer (orange covers) series you'll be able to see these numbers as small figures on the labels of the grid lines - only at the corners, though, not right around the edges. The grid letters will appear in the corner of the published maps too.

Look at your spreadsheet or table and work out what numbers you need to add to the eastings and northings columns to make the numbers correct for the relevant grid square.

Edit any spreadsheet x and y coordinates so that all of the eastings and northings have the correct number at the beginning. Every number should consist of 6 figures when you have finished.

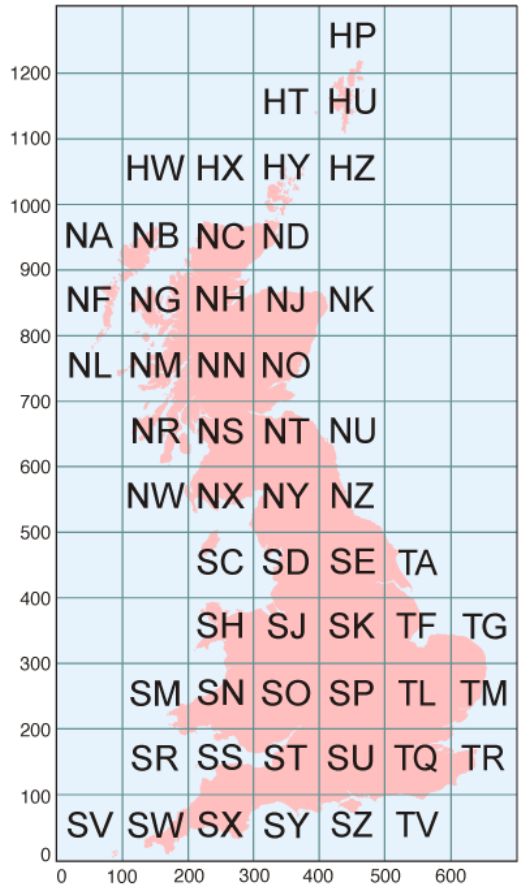


Figure 5.22: British National Grid 100 km squares

To replace grid letters with numbers as is required when importing British National Grid coordinates into Arc:
Using the example **NN 6005 2674** (This is not Ingleton!)

- find the number of the line **to the left** of the grid square (i.e. one of the numbers from the line at the bottom) in figure 5.22 - for **NN** this is "2".
- This number will apply to all of the references in the eastings column of the spreadsheet.
- then the number of the line **below** the grid square (i.e. one of the numbers to the left) - in this case "7".
- This number will apply to all of the references in the northings column of the spreadsheet.
- So in this example, grid reference **NN 6005 2674** would become **26005 72674**.
- In addition, x and y numbers all need to be six figures to appear in the correct place in Arc, so if, as in the example, there are fewer digits then add zeros to the end of each so make it correct.

Finally the grid reference above will become **260050 726740** and at this point will be ready to enter into Arc.

5.10.3 Converting .xls or csv to a feature class

In the Catalog pane in Arc:

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.

- For an Excel spreadsheet
  - click on the down arrow next to the Excel file to show the contents (figure 5.23)
  - 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. To be able to do that you need to convert it to a feature class.

- Open the Geoprocessing tools by clicking on the **Tools** button on the **Analysis** tab of the ribbon
- Toolboxes > Data Management Tools > Features > XY Table to Point
- Fill in the tool as shown in figure 5.24
  - 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

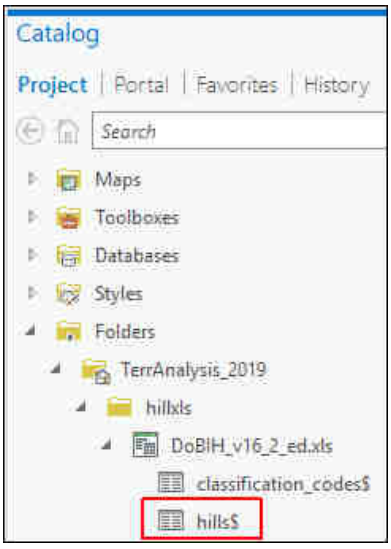


Figure 5.23: Excel file in Catalog opened out to show contents

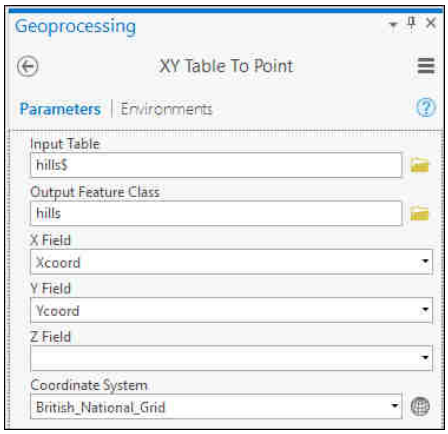


Figure 5.24: Creating a feature class from an XY Table (your field and file names probably won't be the same as this)

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.

5.11 Conclusion

Use the techniques in this chapter to finish digitising all of the geological features from your fieldslip.

By using the techniques in this workbook so far you should now have a basic map which shows geological polygons, lines and points on a topographic background. Your map may look similar to figure 5.25, though your colours are likely to be different.

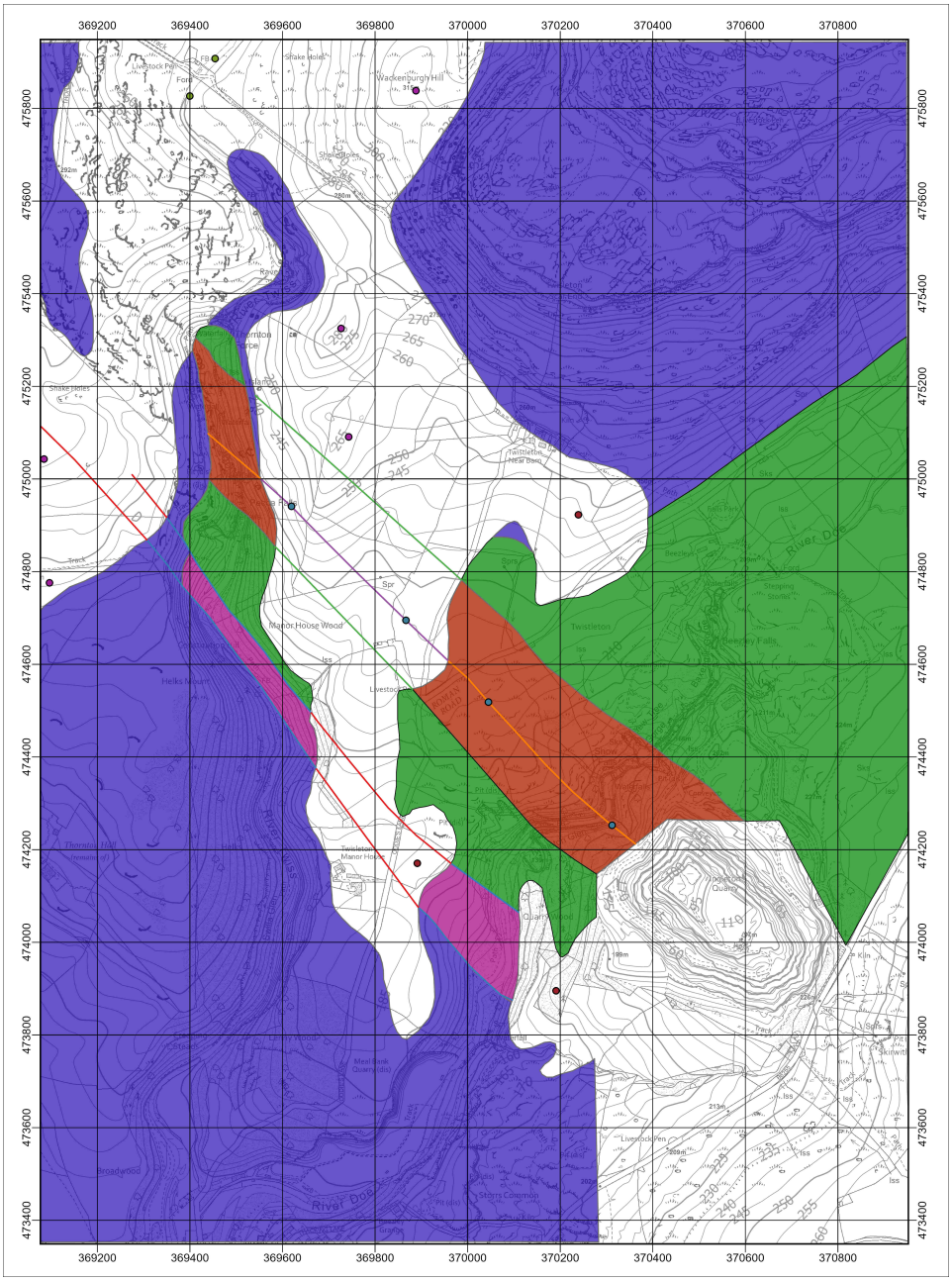


Figure 5.25: A basic digitised map of the Ingleton Waterfalls Walk. This is now ready to have symbology and labels applied.

Chapter 6

Symbolising and labelling data

The background to symbolising and labelling data and an explanation of what it is will be covered in the lecture segment at the beginning of the class and the presentation and any other supporting materials will be available in Minerva. The lecture segment should help you to understand **why** you are doing these exercises. If you still aren't sure, please ask Clare.

6.1 Learning outcomes

When you have completed this section of the workbook you should be able to:

- explain how to symbolise a map so that it displays the data clearly and informatively
- demonstrate how to add appropriately located labels to the features on your map

6.2 Introduction

In the previous chapters you'll have created your data and added information to the attribute tables. Now you'll see how to style, or symbolise, and label that data to make a more informative map.

When you first add a vector feature class to a map, Arc symbolises it with a single, random colour, and doesn't add any automatic information about what the features show. You need to apply **symbology** to your data to differentiate them, and probably labels to show your audience what each feature indicates.

The sections below show the general principles. You will need to decide how best to symbolise and label each of your layers.

6.3 Symbolising layers

Symbology is the ArcGIS term for styling your data. In this section you'll be changing colours, the style of lines, e.g. solid or dashed, and the symbols for your points.

If you add a key to your map (you'll be shown how to do this in section 7.7.3 on page 121), it will show the colours and styles that you have set for your layers.

To bring up the symbology pane:

Choosing colours for polygons
There is a lot of advice in the books on the reading list about choosing colours for maps. In addition try the Color Brewer web site at `http://bit.ly/1OiBt3w` - it lets you play with colour combinations and is specifically aimed at people creating maps. Note that if you are going to be making a layer transparent then you will probably find that it is best to choose strong colours, such as Steel Blue, for your polygons. They will fade when you apply transparency. *(If you hover over a colour in the Symbol Selector a tool tip will tell you the name of that colour.)*

Table 6.1: Choosing colours for polygons

- In the contents pane select the layer that you want to symbolise, e.g. the Bedrock geology layer on the Ingleton map
- either right-click and click on **Symbology**
- or go to the **Appearance** tab of the ribbon and click on **Symbology**

Now try some of the methods of setting symbology below...

6.3.1 Setting a single symbol for a layer

This is the simplest type of symbology, and the one Arc applies to your layers by default.

You may find this does what you want if you have, for example, set up separate layers for each rock type on a geological map. You can then set each feature class to a single symbol.

Video Clip available in Minerva - Symbolising a layer as a single symbol in Arc

- Check that the correct layer is selected at the top of the symbology pane - figure 6.1, if not click on the correct layer in the contents pane
- To change the symbol click on the coloured symbol next to **Symbol**
- The pane will usually initially show the **Gallery** - try selecting something from here - your layer should change to whatever you select
- To have more control over the symbol click on the **Properties** tab at the top of the pane.
  - In the Properties dialog try changing the colour of your feature and the outline colour and width.
  - This time you'll need to click on Apply at the bottom of the pane to make your map change

6.3.2 Setting unique values for a layer

Setting unique values for a layer allows you to categorise your data. For example, if you have a single bedrock polygon layer, and within that you have multiple rock types, as you will have if you followed the instructions for setting up storage for the Ingleton map, you can set each rock type as a category and symbolise each with a different colour.

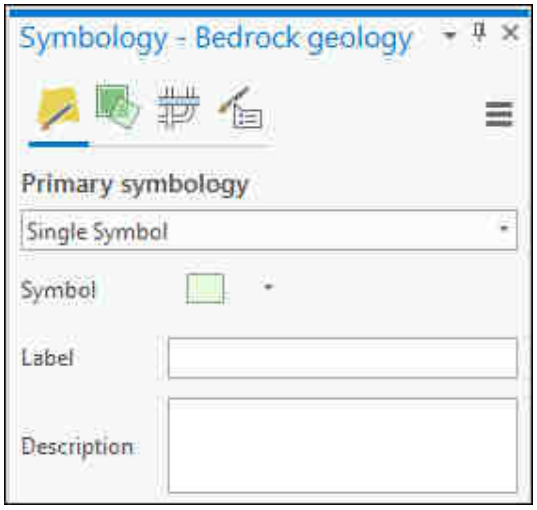


Figure 6.1: The symbology pane showing the setup for a single polygon symbol

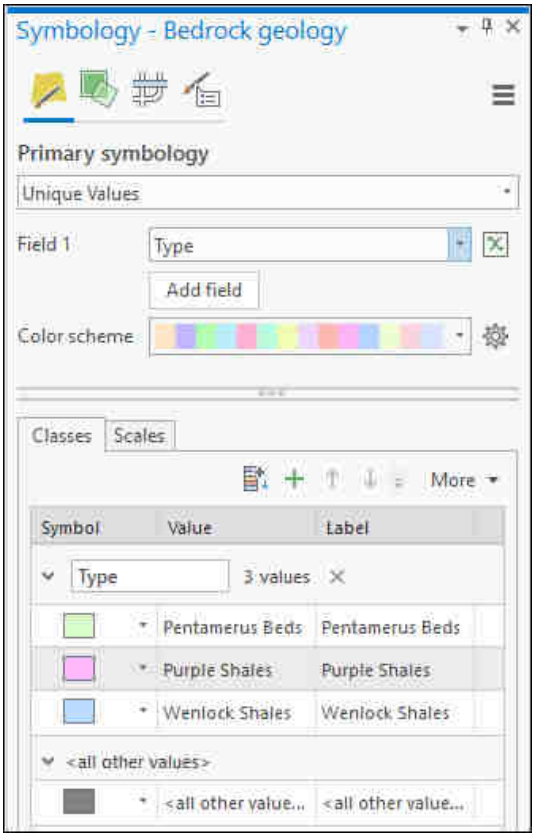


Figure 6.2: The symbology pane showing the set for multiple categories, or Unique Values

Video Clip available in Minerva - Symbolising a layer by unique values in Arc

- Check that the correct layer is selected at the top of the symbology pane, if not, click on the correct layer in the contents pane
- To change the Primary Symbology, drop down the box at the top of the pane and change to **Unique Values** - figure 6.2
- Arc will usually use the first field in your feature class to categorise the data, which is unlikely to be the right one, so change **Field 1** to the field you want to use for the unique values, e.g. the **Type** field in the Ingleton bedrock geology.

Arc should automatically set a colour scheme and give a colour to each category.

To change the colours and symbols:

- To change the colour scheme for all the colours at once, use the **Color Scheme** drop down and pick another - clicking on **Format color scheme** takes you to the Color Scheme Editor.
- To have more control over your symbols you can change them individually - click on each symbol in turn in the **Classes** table

This takes you to the pane for formatting the symbol in the same way that it does on the Single Symbol dialog. Again you can swap between the gallery and properties and make changes as required.

To make a fill transparent without making the outline transparent too do the following:

- Click on the patch next to the type of symbology you want to change
- Go to the **Properties** tab and click on the **Layers** item - hover over the symbols to use the tool tips to find this
- There you should see that you can click on either the **Solid stroke** or **Solid fill** to edit them separately. Click on the **Solid fill**
- Click on **Appearance** to see the **Color** setting then click on that to go to the list of colours
- next click on **Color properties...** at the bottom to open the **Color Editor** - figure 6.3
- There you can alter the **Transparency**, e.g. set it to **40%** and see what difference that makes when you click OK > Apply. You should be able to see the background map through the fill now.

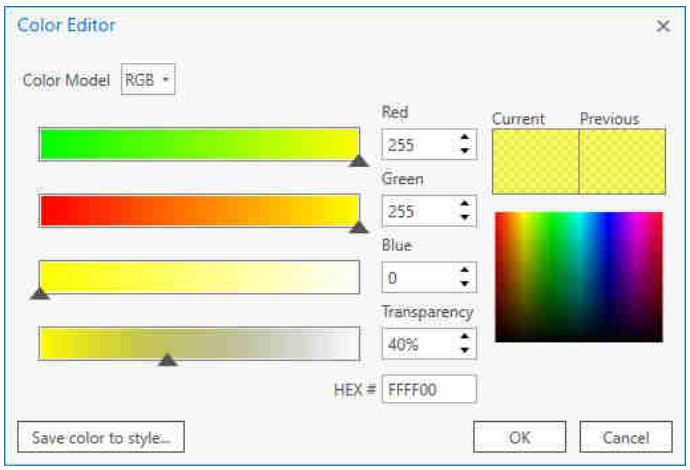


Figure 6.3: Setting colour and transparency in the Color Editor

This works best if you choose stronger colours for the fills and then apply the transparency.

Once you've finished changing a particular symbol use the arrow at the top of the pane to go back to the list of classes.

> ***Use the tools in the Unique Values to symbolise the bedrock geology polygons to match the colours in the Ingleton fieldslip. Make sure that you set the fill to transparent so that the background map shows through. Any outlines shouldn't be transparent for this map.***

6.3.3 Removing the All other values heading

To remove the **all other values** entry from the list, the contents pane, and in any legends you create:

- In the classes pane click on More above the table
- Deselect **Show all other values**

6.3.4 Symbolising line features

Symbolising line features is basically the same as symbolising polygon features so refer back to the instructions in sections 6.3.1 and 6.3.2 too, but there are some extra things to think about in addition to choosing colours for fill and outline.

Start by symbolising your line feature classes as either **Single symbol** or **Unique values** as appropriate then apply the following techniques as required.

For the Ingleton map you should have multiple line types in one feature class, so select **Unique Values**.

Finding and using additional ArcGIS Pro Styles
There are only a relatively limited range of symbols available in ArcGIS Pro and sometimes you'll need more. ESRI provide further styles via a gallery at `https://esri-styles.maps.arcgis.com/home/gallery.html` Unfortunately it doesn't seem to be possible to preview the symbols, but there are symbol sets such as **Ordnance Survey** and **Geology 24K** which should be helpful. To install a style in your project: • Download a style from the Gallery by clicking on it. You should end up with a `.stylx` file. • copy or move the stylx file into your map project folder • Go to the **Insert** tab of the ribbon and click on **Add** in the **Styles** group and select to **Add Style** • Navigate to where you saved the `.stylx` file and select it. You may get a message about the style not being the correct version, if you do click to allow it to update. The style should be added to your project and next time you symbolise a vector layer you'll see the extra symbols and be able to select from them. Unfortunately you do seem to need to do this for each project so it is probably worth keeping the `.stylx` files that you download for future use.

Table 6.2: Finding and using additional ArcGIS Pro Styles

Symbolising dashed lines

You may well need to set dashed lines on your map, e.g. for inferred geological boundaries. There are a couple of ways to do this. The first is the simplest, and probably the most reliable:

- Select the symbol next to the line type that needs to be dashed
- in the **Format symbol** dialog select the **Gallery**
- scroll down and hopefully you'll find a series of **Dashed** styles, e.g. **Dashed 4:4**. If you don't find these dashes you may need to import a new style to ArcGIS. Follow the instructions in table B.1.
- Select the one you require
- If you need to change the colour or thickness you can then click on the **Properties** tab and change as required. Don't forget to click Apply if you do this

The second method involves setting up the dashes manually (figure 6.4):

- in the **Format symbol** dialog go to the **Properties** tab
- click on the **layers** button - you'll need to use the tooltips to find this
- drop down **Dash effect** to see the options, and select a **Dash type** from the drop down list
- Now you can change the numbers in the **Dash template** to alter the spaces and dashes for your lines - the first number applies to the length of the dash, the second to the spaces.

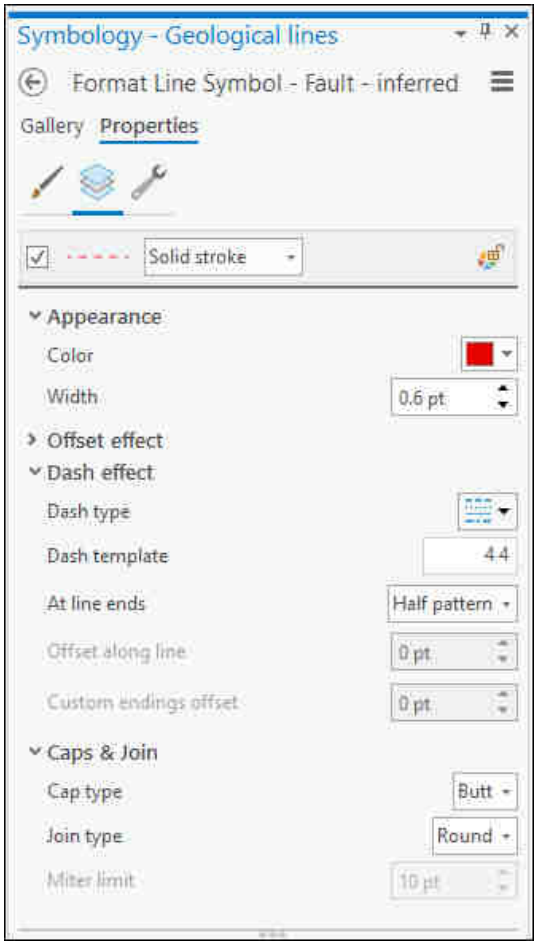


Figure 6.4: Setting up dashed lines in the Format Line Symbol dialog

In the Ingleton map you'll need to set the inferred faults, boundaries and synclines to dashed lines. Do this now and set the colour of the lines to match the fieldslip.

The observed faults, boundaries and synclines should all be solid lines, but set to the same colours as their equivalent dashed lines.

Symbolising lines with "decoration"

Decorations on lines can include

- the "ticks" to show downthrow on faults

- the little triangles or “barbs” which show thrust faults
- crosses or arrows to show fold axes
- etc!

The simplest way to apply these is to check for existing line styles in the gallery. If you can’t find what you want try downloading extra styles from ESRI and see if that helps - see table B.1 on page 146 for how to do this.

If you can’t find the symbol you need then you’ll need to set it up for yourself.

Using a marker layer This works well for generic decorations, such as the tick for downthrow. In this example we’ll symbolise a fold axis as a syncline, as shown by the fieldslip for Ingleton:

- Open the **Format line symbol** pane and go to the **Properties**
- Click on the spanner symbol - if you hover over it you’ll see that it’s **Structure**
- Click to Add symbol layer > Marker layer - this adds a symbol on top of your line.
- To change the symbol click on the **Layers** button (use tooltips!) and check that the **Shape marker** is selected at the top.
- For this example click on Font..., but you could use a Style... instead
  - The font should be set to something like **ESRI Default Marker** subset **Basic Latin**
  - Look for a cross symbol (if you hover over and see the number **68** - that’s a decent choice for a syncline)
  - OK
- Click Apply to see the result so far. You should see lots of crosses across the lines.
- Use the **Size** setting to make the crosses larger or smaller
- To change the spacing of the crosses on the line
  - Drop down the **Marker Placement** subheading
  - Change the **Placement template** number, e.g. make it larger to spread the symbols out.
  - try out some of the other settings to see if they help (figure 6.5)
- Once again, Apply to see the result of your changes

Feel free to play with some of the other settings to see what happens, or try with different styles or fonts.

Flipping line features

If you are using a “decoration” on one particular side of the line, e.g. the tick to show downthrow, you’ll need it to be consistent on all of your lines. This depends on the direction in which you digitised the line. If you find that some of your lines are incorrect you can flip, or **reverse** them.

- Select the line you want to flip
- go to the **Edit** tab of the ribbon and click on **Modify**
- in the **Modify features** pane click on **Vertices**

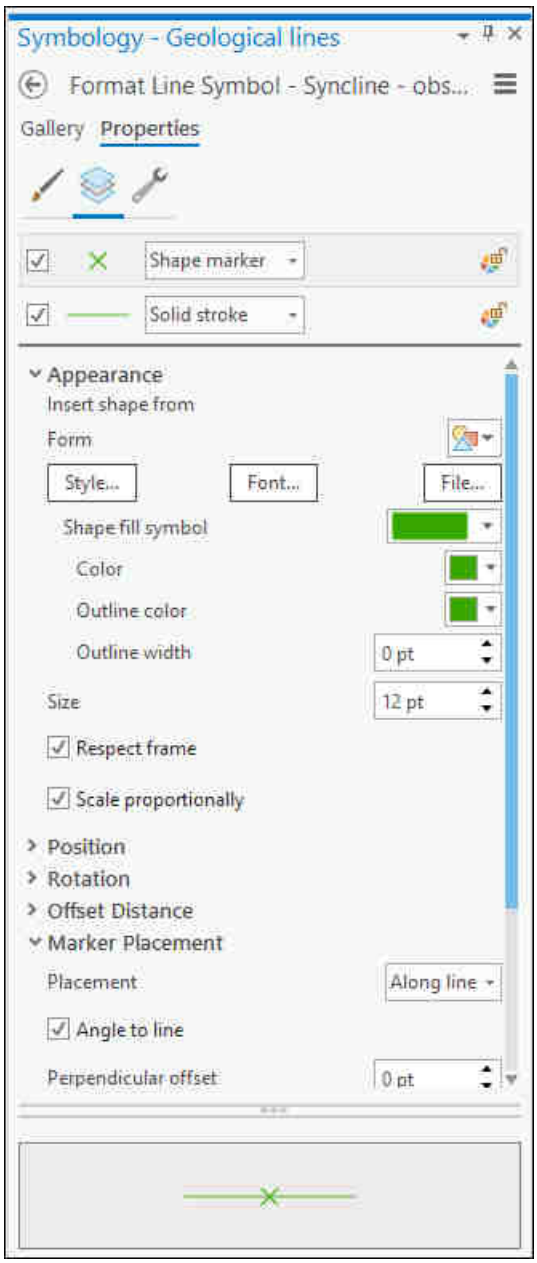


Figure 6.5: Setting up a shape marker on top of a line

Video Clip available in Minerva - Flipping line features

- Right-click on the line and select **Reverse Direction** - you should see the red vertex, which indicates the end of the line, change to the other end
- Don't forget to press F2 or **Finish**
- and don't forget to **Save** your edits

The symbols should now appear on the opposite side of the line.

6.3.5 Symbolising point features

Symbolising point features is basically the same as symbolising polygon features so refer back to the instructions in sections 6.3.1 and 6.3.2 too. Start by symbolising your points as either **Single symbol** or **Unique values** as appropriate then apply the following techniques as required.

The simplest way to apply these is to check for existing point styles in the gallery. If you can't find what you want try downloading extra styles from ESRI and see if that helps - see table B.1 on page 146 for how to do this.

If you're looking for symbols for bedding, cleavage etc then download and add the **Geology 24k** style from the link in the table. The symbols are those used by the United States Geological Survey so vary a bit from the symbols that you will be used to, but if you browse you should find most of what you need.

> ***For the Ingleton exercise symbolise the points for the cleavage and bedding readings now, but don't worry about rotating them to strike yet. These will be the points that you imported from an Excel spreadsheet.***
>
> ***If you install the Geology 24k styles you should be able to find appropriate styles. Try:***
>
> - ***Inclined bedding - showing strike and direction of dip***
> - ***Inclined foliation in layered gneiss - showing strike and direction of dip***

If you can't find the style you need, e.g. for the Quaternary symbols, then you'll need to set it up for yourself as follows:

Creating and importing your own symbols

If you can't find the symbols that you need, then you can create your own. It is possible to use Inkscape, or a similar vector graphics program to create svg images and these can be used as Shape markers, or create a bmp, jpg, or png image and import them as marker symbols

To create your own symbols:

- On this occasion I've created some example svg and png files for you, so download them from Minerva and unzip to your M:/ drive - **GeolSymbolsMinerva.7z**[1]
- You'll usually have to start by using Inkscape or CorelDraw to create the symbol you need. If you need to do this:
  - Set the page or drawing size as **512 X 512 pixels** and use the whole space.
  - if using Inkscape save the file as `.svg` - this should be better quality in ArcGIS than a png would be.
  - if using CorelDraw **export** the symbol as a **.png** file.

We'll start by setting up the symbol for **till** but other symbols will be imported in the same way.

If you have svg images:

- select the geological points layer and go to **Symbology**

[1] I have based these symbols on the BGS Symbols Index v.3 which can be downloaded from `http://www.bgs.ac.uk/reference/symbols/home.html` (Last accessed: 5th October 2017). The codes in the filenames refer to this document.

- Click on the point symbol next to **Till** and go to the **Properties** tab of the **Format Point Symbol** pane
- Go to the **Layers** tab - use tooltips to find it!
- The dropdown at the top should show **Shape marker** - if it doesn't select that now
- underneath click on the File... button and navigate to where you have stored your svg files
- select an svg file and OK
- it usually appears to be a good idea to tick **Scale proportionally**
- check the symbol in the preview window at the bottom and change the **size** if necessary
- click Apply to apply it to your map

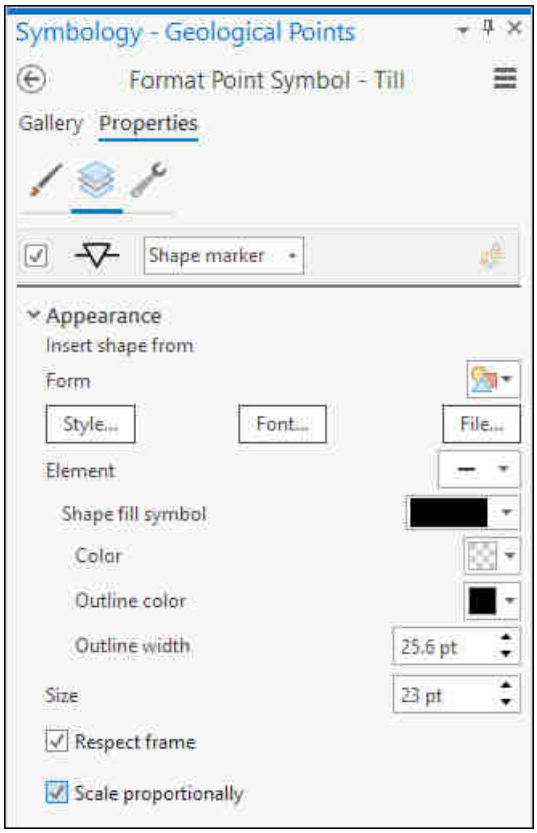


Figure 6.6: Filling in the dialogue to add a point symbol from an svg file - in this case Till

If you have png, jpg, or bmp images:

- Go to the **Properties** tab of the **Format Point Symbol** pane
- Go to the **Layers** tab - use tooltips to find it!
- Change the drop down at the top to show **Picture marker**
- Click on File... to select your image
- Set **Quality** as **Picture**
- Change the **Size** as necessary
- Apply to see the result on your map

Rotating point symbols

For some symbols you need to apply rotation which is different for each symbol, e.g. the strike for bedding or foliation. The rotation angle will be available as a number in your attribute table.

Video Clip available in Minerva - Rotating point symbols in Arc.

If you are adding bedding, foliation etc measurements, there should already be a field for strike which has a numerical data type e.g. **Short** and you will use this as the rotation field.

If you wish to rotate symbols which don't have strike you will need to set up a numerical field in your feature class to hold the rotation information, e.g. you could create a field called **Rotation**. See section 5.9.1 on page 90 for instructions on how to add a new field/column and don't forget that it must be **Short** data type.

- Open the **Symbology - Points** pane for the symbol you need to rotate, e.g. bedding
- go to the **Properties** tab
- at the top click on the menu button (three horizontal lines) next to **Format Point Symbol - bedding** and select to **Vary symbology by attribute**
- Under the **Rotation** subheading choose the appropriate attribute as the **Field** e.g. Strike
- Click the **Geographic** Rotation style.

As long as there are rotation values in that field your symbols should now rotate.

> ***For the Ingleton exercise apply rotation to the bedding and cleavage symbols using the Strike attribute as the rotation value.***

If you don't have values in the field and want to add them manually, do the following:

- You do already need to have carried out the previous instructions to set up a field for Arc to put rotation values into
- Click on **Modify** on the Edit tab of the ribbon
- Select the point feature that you want to rotate
- In the **Modify features** panel click on **Rotate**
- Your symbol should now have a large "wheel" around it which you can rotate with the cursor
- As usual, once you have it at the correct angle press F2 or **Finish** to complete the edit sketch
- then **Save** on the edit tab to write your changes to disk

If you check the attribute table you should see that the rotation angle has been set in the correct field.

6.3.6 Finish symbolising your data

You should now be able to use the techniques in the first part of this chapter to fully symbolise all of your data, so go ahead and check that everything looks as you want it to. The next task is to add labels where appropriate.

6.4 Labelling features

If you look at any map you'll be able to see that attributes from the attribute table have been used to add **labels** which are essential to the understanding of the map.

Once you have information in your attribute tables it is really easy to add labels to your features. You may not need to add them to all layers, but they can really help interpretation. For example, if you look at British Geological Survey maps they add symbols to each rock polygon which are then included in the key and make it easier to spot which symbol is which. Points can be labelled to show location names, or dip angle, names can be added to lines, such as "Moine Thrust" on the appropriate thrust fault.

6.4.1 Adding simple labels

In section 5.4 on page 78 I suggested that you put a short abbreviation in the **Label** field of the attribute table for each rock type. We'll use this text to label the bedrock layer.

Video Clip available in Minerva - How to add labels to layers in Arc

- Select the layer you wish to label in the contents panel - as an example choose the **BedrockGeol** layer
- Click on the **Labeling** tab of the ribbon - figure 6.7
- Click on the **Label** button on the left of the ribbon

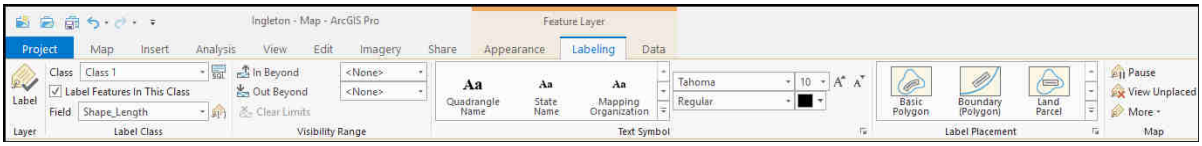


Figure 6.7: The labeling ribbon

Arc will add labels but they'll be from the first field in your feature class, which is unlikely to be the correct one and could just be a load of apparently random numbers! To select the correct field:

- Use the dropdown next to **Field** on the ribbon to select the field you wish to use, in this case **Label**

The labels should instantly change to the contents of the field that you selected, so for the Ingleton Bedrock you should now have a short label on each polygon.

Once you have the basic labels you can use the other tools on the Labeling ribbon to change the font, size, colour, or placement. Try some of these options now.

You can also open a **Label class** pane by clicking on one of the little arrows under Text Symbol or Label Placement on the ribbon. This gives you more options which show up when you click on Apply.

Try changing the font of your labels and making them smaller or larger. Change the colour to a dark grey instead of black.

From the Label Class pane try adding a Halo or Shadow to your labels.

It's usually best to keep the label styles simple - you're aiming for readability not fancy - but a narrow **halo**, or a **Callout** can be useful techniques for making labels clearer if used in moderation.

6.4.2 Labelling structural symbols with dip angle

As shown in figure 6.8, the default label positioning isn't great when it comes to adding the dip angle to structural symbols such as bedding and cleavage. The options on the **Position** tab of the Label Class panel allow you to change this.

Video Clip available in Minerva - Labelling structural symbols with dip angle

- If the **Label Class** panel isn't already open on the right of the map go to the Labeling tab of the ribbon, and click on the little arrow at the bottom right of the **Label Placement** group.
- Click on the **Position** tab
- Fill in the dialog as shown in figure 6.10
  - **Measure offset from** should be set to **Feature geometry**
  - Drop down the **Rotation** option and set the **Rotation field** to the same field that the symbols are rotated by, in the case of the Ingleton exercise this should be **strike**
  - **Additional rotation** probably needs to be set to **270°**
  - **Rotation type** should be **Geographic**
  - **Alignment type** should be **Horizontal**
  - Tick the box next to **Keep label upright (may flip)**

These changes should be updated automatically on your map and the final result should look like figure 6.9.

6.4.3 Using label classes

Label classes refer to the ability to add labels to a subset of features in your feature class, or different labels for different features.

Video Clip available in Minerva - Using label classes to label subsets of features

An example is restricting the number of labels you use for your contours by only labelling the master or index contours, not the standard contours too. This is particularly in mountainous or very hilly areas with a lot of contours. You should have labelled your contours using the instructions in section 3.8 on page 62.

To set up label classes:

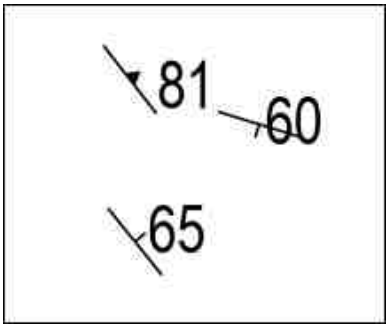


Figure 6.8: Default labelling applied to the dip angle on structural symbols

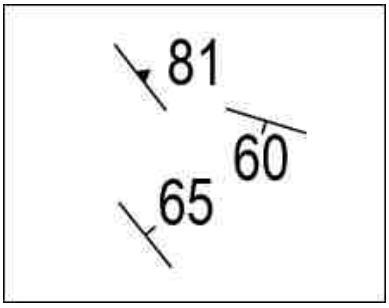


Figure 6.9: The altered positioning for the dip angle on structural symbols

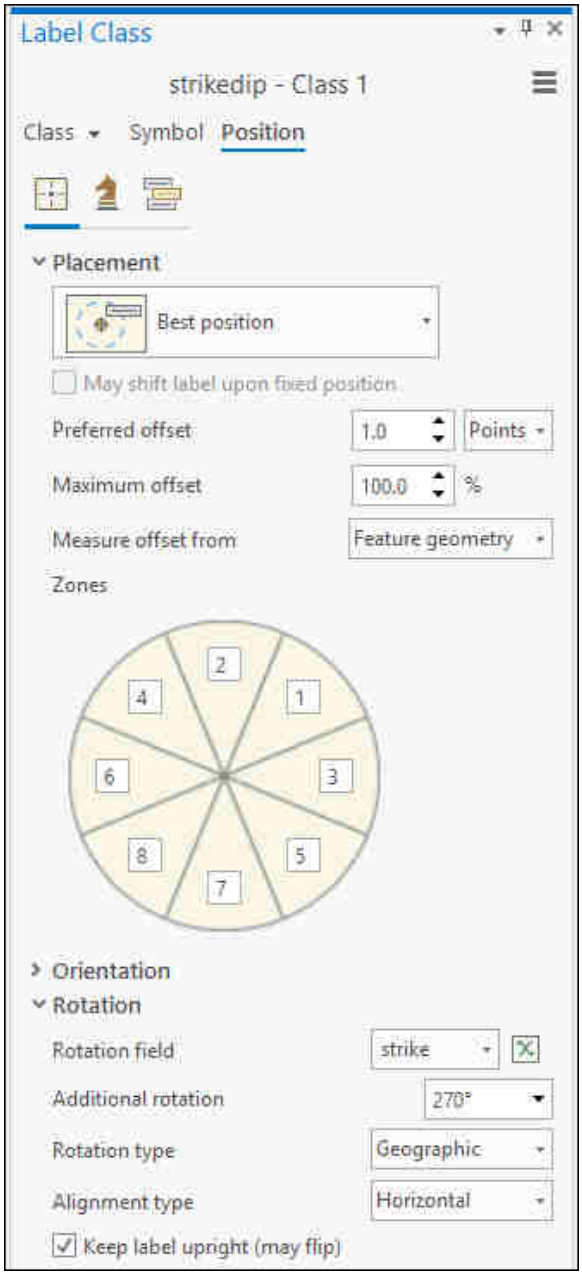


Figure 6.10: Settings for dip labels on structural symbols

- Select the **Contours** layer in the contents pane
- click on the down arrow next to **Class** on the Labeling ribbon
- Select **Create new label class** and give your new class a name, e.g. Master contours
- You'll probably need to set the **Field** again
- click on the **SQL** button next to **Class** to go to the **Label Class** pane
- Click on the New expression button and use the dropdowns to create an expression, such as `subtype is equal to master`
- Click Apply and hopefully now just your master contours will be labelled. If they aren't you need to go back up to the ribbon, set the **Class** to **Class 1** and untick **Label Features in this**

Class

You'll probably need to symbolise the labels again to make sure that they appear on top of the contour lines and aren't too large or too dark. Remember the full instructions for contour labels are in section 3.8 on page 62.

6.4.4 Converting labels to annotation

You can convert the contour labels to annotation so that they can be treated like any other layer and moved around manually. This gives you a way to neaten your map by placing the contour labels underneath the geology layers in the layer order, rather than on top of them. This gives a neater finish so that the labels are still visible but not dominant.

Annotation also means that if you are not happy with the automatic placement of the labels on any layer you can convert them to annotation and then move them around individually using the editing tools.

Note that the instructions below only work properly if your data is in a geodatabase. If your contours are in a shapefile then you can convert them to annotation, but you won't have the full flexibility.

Video Clip available in Minerva - Converting labels to annotation

To convert labels to annotation:

- Right-click on the labelled layer in the contents pane - for this example the **Contours** layer
- select **Convert Labels to Annotation** to open a pane on the right
- the form should be filled in to convert your current layer - see figure 6.11
  - **Input Map** will be the name of your current map
  - check that **Convert** is set to **Single layer**
  - **Feature Layer** should be your current layer
  - Set the **Conversion scale** to the scale you'll be printing the map at - e.g. 1:10 000
  - Set the **Output Geodatabase** to your project geodatabase
  - Dropdown the choices next to **Extent** and select **Union of Inputs**
  - Check that **Create feature-linked annotation** is not ticked
  - Give your **Output layer** a name, eg **AnnoContours**
- Click Run

The new annotation layer should be added to the top of your contents pane and you can now move it down to just above the contours layer. If you turn this layer off the contours will no longer be labelled - you can always relabel them if you wish.

Editing annotations

It should now be possible to use the editing tools to move annotations around or change them manually. Be careful doing this as it does mean that they are no longer being generated automatically.

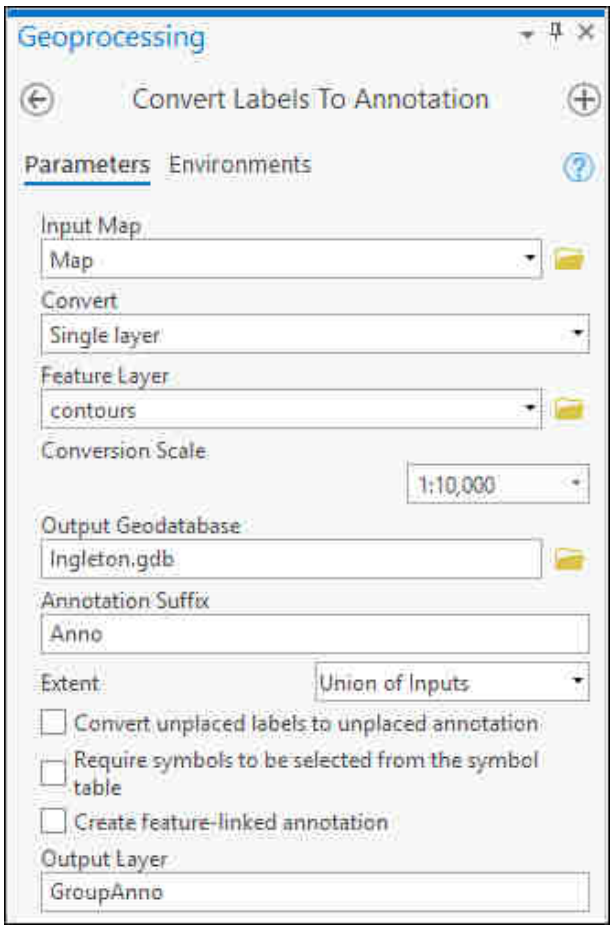


Figure 6.11: Converting labels to annotation

- Go to the Edit ribbon and click on **Modify**
- The **Annotation** tool will allow you to change the font or the size
- Other tools will allow you to move, scale etc the annotation.
- As usual, once you have it at the correct angle press F2 or **Finish** to complete the edit sketch
- then **Save** on the edit tab to write your changes to disk

Use the labelling techniques in this section to label all appropriate layers in your map. For the Ingleton map, in addition to the layers described above, label the Skirwith Syncline (see the fieldslip). You don't need to label lines as "Fault" or "Fold" as these generic names will be added via the key.

6.5 Conclusion

Your final map with all layers symbolised and labelled where necessary should look something like figure 6.12.

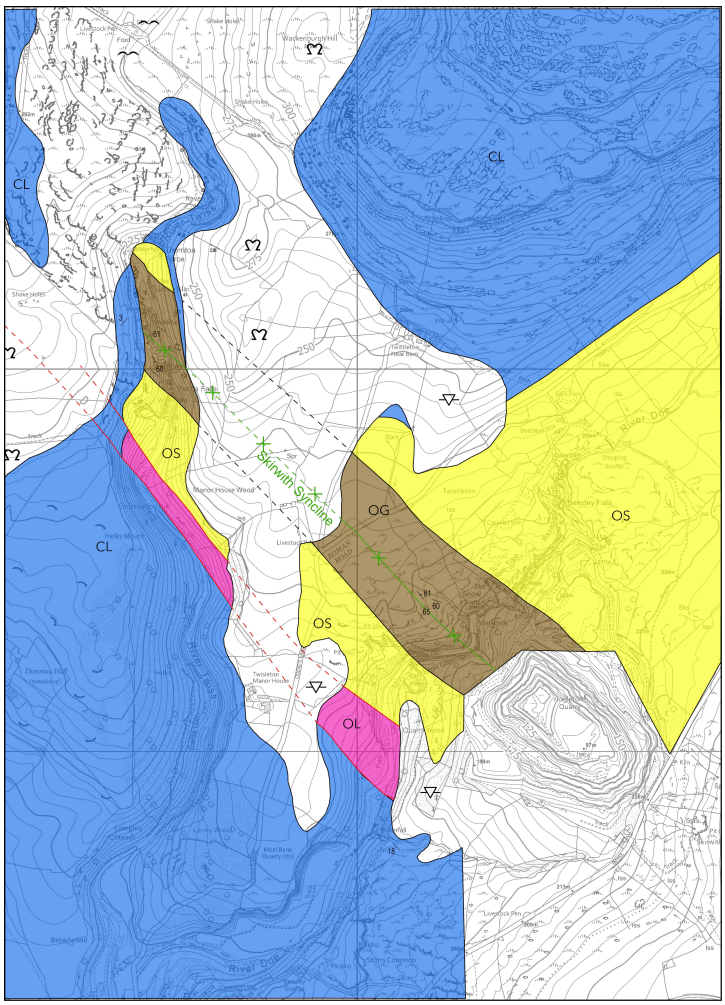


Figure 6.12: The Ingleton map with layers symbolised and labelled as appropriate. Your map may well look different to this as you should have made your own choices.

Chapter 7

Layout and presentation

The background to laying out and presenting your data and maps will be covered in the lecture segment at the beginning of the class and the presentation and any other supporting materials will be available in Minerva. The lecture segment should help you to understand **why** you are doing these exercises. If you still aren't sure, please ask Clare.

7.1 Learning outcomes

When you have completed this section of the workbook you should be able to

- layout a map in such a way that it effectively communicates the content and purpose of your work to a user
- select map elements to include in a layout and set their properties to match the requirements of your map
- print or export your map to show it to it's best advantage

7.2 Introduction

Once you've put in all of the hard work to produce a map of your field area or project, it is worth making the extra effort to ensure that you lay it out clearly and print it, or export it in a professional fashion. Make sure that you allow the time to do this. Care and patience can make the difference between a scruffy, unimpressive map that loses you marks, and a clear, professional map that gives a good first impression.

Don't underestimate the time that the final details can take and don't leave this until the last hour before a deadline!

You won't need to use all of the elements and features outlined here for every map. Equally, this is not an exhaustive list of possible elements. You should already have some idea of what elements are useful, and should be able to make a decision for each case based on your existing knowledge of maps. If you think that you need to add something that is not listed here, e.g. a report based on a table, then use the extra information available in the bibliography, further information and on-line to find out how to add it.

So this chapter isn't necessarily for working through in order. Make sure that you are aware of the contents and of what Arc is able to do, and then make your own decisions about what you need to include based on the principles that will be covered in class.

7.3 Viewing a map layout

In Arc a **layout** allows you to control the format and scale at which you print your map, and lay out additional elements to complete the final product.

- Open any map that you have created in the previously in Arc
- Add a layout by going to the **Insert** tab of the ribbon and clicking on **New Layout**
- You'll be given a choice of paper sizes - for this map select **A4 portrait**
- A new layout will open as a new tab over the map with a blank layout, and the ribbon will change to give you options relevant to layout - see figure 7.1

In this view you will see your map laid out as it will be when it is finally printed or exported with the page outlined on screen and the content on top of it - figure 7.1.

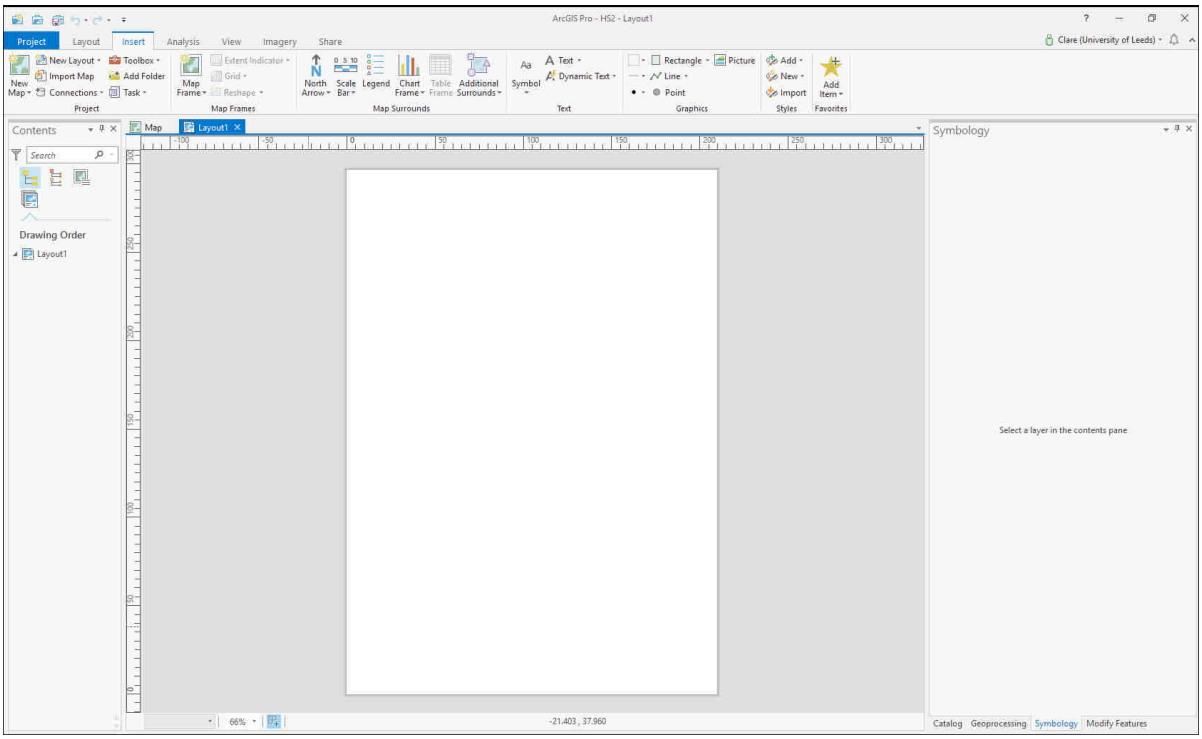


Figure 7.1: Layout view showing the initial blank layout

7.4 Adding a map frame to a blank layout

To add a map to a blank layout:

- Click on **Map Frame** on the **Insert** tab of the ribbon
- If you just click on the button you'll be given a World map.
- If you click on the arrow underneath **Map Frame** you'll be given some options which in include any spatial bookmarks that you have set up[1] and the map views in your project.

Click on any of the options to add a map frame to your layout. If you have a map showing the World you can zoom in to the area of your data.

[1] See section 1.5 on page 4 if you need a reminder about spatial bookmarks

7.5 The contents pane for a layout

As when you're working on your map, layout view makes use of the Contents pane on the left of the window. Click on the little arrows next to the headings to see the contents - figure 7.2.

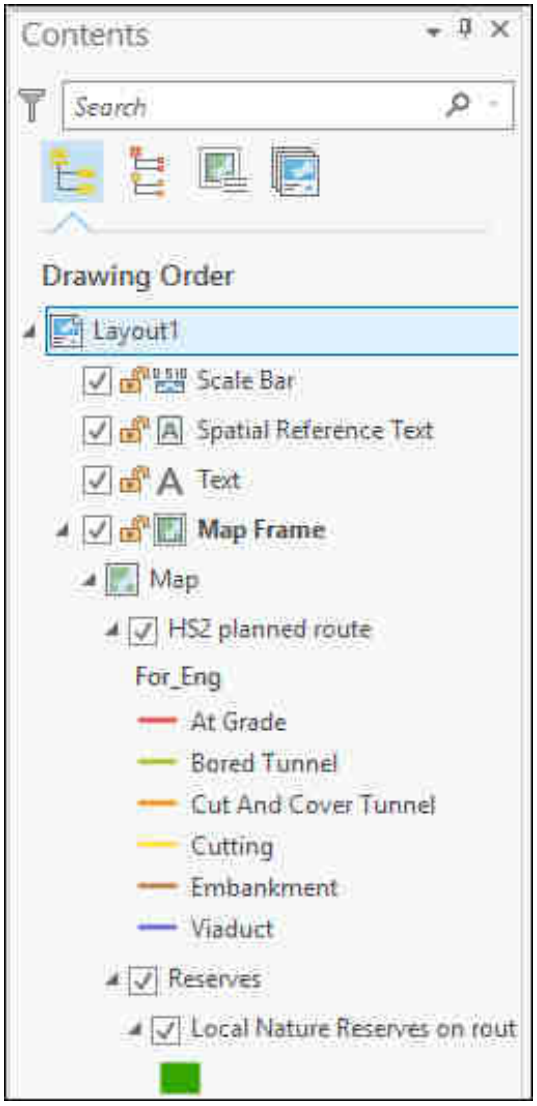


Figure 7.2: The contents pane in a layout with the elements and layers opened out

The top layer is the layout itself. Within that you'll find all of the elements on your page. This includes any map frames (there can be more than one), but also scale bars, legends, text etc.

As with the contents pane on a map, elements are drawn in the order they appear here. So if you want something to appear above something else, make sure that it is above it in the table of contents.

You can select any element within the contents list and move it on the layout or edit its properties in the pane on the right.

An element can be "locked" in place by clicking on the padlock symbol next to its name

7.6 Size and scale of a layout

7.6.1 Page size and scale

Note: Changing the size of the page can sometimes change the scale, so each time you alter this check the scale of your map again!

- Click on the **Layout** tab of the ribbon

Video Clip available in Minerva - Setting the size and scale of a map layout.

- the **Orientation** button allows you to change between portrait and landscape orientation
- the small button to the right of that one is for **Size** - hover over it to see the tool tip. This allows you to choose from a wide range of standard sizes, or use **Custom page size...** if you need something different.

Change your page orientation and size to A3 landscape. This will give you more space to experiment with adding other elements to your page.

7.6.2 Resizing the map frame in a layout

When you first set up a layout the size of the map frame that you see will not necessarily be the the size you want. Changing the size of the map frame is easy, but can take a little experimentation. You will also need to look at this in conjunction with the instructions on changing paper size in the previous section.

Video Clip available in Minerva - Resizing the map frame in a layout.

- Make sure that the map frame is selected in the layout by clicking on it
- When the map frame is selected you should be able to see that it small boxes at the corners and on each side - see figure 7.3.
- Use the boxes as "handles" to resize the map frame by dragging
- Keep an eye on the scale dropdown! You may need to put this back to your required scale and then resize the map frame again
- If you need to move the map itself you need to **Activate** the map by right-clicking on it and selecting Activate.
  - Move the map as appropriate
  - then go to the top of the layout window, where there is an arrow pointing to the right (see figure 7.4), and click on **Layout** to get back to the previous view
- Keep repeating this until the size/extent and scale of your map are correct

Warning: this process can take patience to get the map frame the correct size for the scale and area. There don't appear to be any short cuts so just stick with it and keep repeating the process!

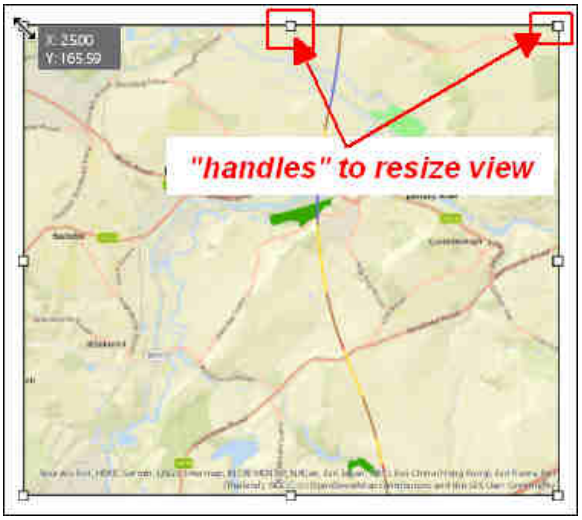


Figure 7.3: Using the “handles” on each corner and side of a map to resize a map frame in a layout

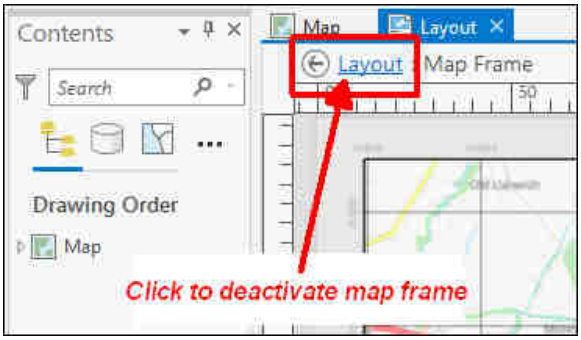


Figure 7.4: Top right of the layout window, showing where to click to deactivate a map frame

7.6.3 Setting a fixed extent

It is possible to set the view to show a particular extent, but be warned that if you do this it then becomes impossible to change the scale of your map in either map or layout view, and you won’t be able to resize the map frame in a layout or pan your map in map view. **If you’ve been asked to produce a map at a particular scale this won’t be a good idea!**

- In a layout click on the **Map Frame** in the Contents
- In the **Format Map Frame** panel on the right of the window go to the second button across - if you hover over it, it will say **Display Options**
- Use the dropdown box under **Constraint** to select your choice, e.g. **Fixed Extent** and set the **Location Settings as appropriate**
- To get back to the default of being able to pan etc, just set the **Constraint** back to **None**

It is also possible to set the dropdown to Fixed Scale, which can be useful, but does mean that if you are still working on your map it isn’t possible to zoom in and work on details.

7.7 Adding elements to a layout

The information below includes details on adding many different elements to a layout. Not all of these will be appropriate to every layout, it is up to you to decide which elements to use depending on the purpose and audience of your map and any guidelines specified for assessments or reports. Some of the references in the cartography section of the reading list should help you with this. See section 7.10 on page 131 for suggestions.

Remember that **Arc Help** will provide you with plenty of extra information on how to add map elements to a layout.

Most elements are added to a layout in a similar way to each other using the Insert tab of the ribbon. In most cases you’ll then be presented with a properties dialog which allows you to make changes to the element.

Once they have been added to the page you can move the elements around. If you need to change properties then click on an element in the contents pane.

Video Clip available in Minerva - Adding a scalebar, title and text to a layout.

7.7.1 Scale bar and text

Some indication of scale should always be added to both printed and screen maps. A scale bar is a useful convention for both. Scale text (e.g. 1:50 000 or 1cm = 1km) is only relevant for printed maps, not for maps on screen where someone can zoom to any scale. If you add scale text you must also ensure that you print the map at the correct scale.

To add a scale bar:

- Click on **Scale Bar** on the **Insert** tab of the ribbon
- Select an appropriate scale bar from the list - if you are working in a projected coordinate system such as British National Grid and the map units are metres, then use a metric scale bar.
- You can make changes to the format of the scalebar in the properties pane on the right
- To change things such as the number of divisions and the units make sure that the scale bar is selected then go to the **Design** tab on the ribbon

To add scale text:

- Click the little arrow next to **Dynamic Text** on the **Insert** tab of the ribbon
- Select **Scale** from the choices provided

Arc will add text to your map which will automatically update if you change the scale of your map.

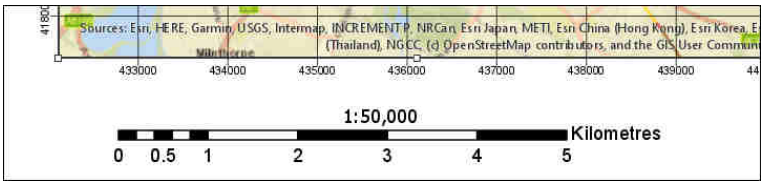


Figure 7.5: Scale bar and scale text on a layout. Note that the divisions and length of the scale bar relate to the measured grid on the map.

It's worth having a look at what other text elements can be added via Dynamic Text too, e.g. information about the spatial reference.

7.7.2 Title and text

Maps need an informative title so that people looking at them know what they are supposed to show. You should use the insert text command to add a title, or further text, such as your name (or for an assessment your student ID) as creator of the map, a copyright statement, acknowledgements, and further explanation.

To add text:

- From the **Insert** tab of the ribbon click on the little arrow next to the **Text** button and select a form of text. **Rectangle** works best, particularly if you're likely to want to add a background.
- Click on the layout, or click and drag for rectangle, and type your text
- You can use the **Format text** pane on the right to change the text
- The **Text symbol** dialog will allow you to change the font, and font size - it's worth exploring all of the options

Copyright acknowledgements

Copyright is important. Remember that most data providers ask you to sign up to conditions that include an obligation to add a copyright acknowledgement to your map. Check what that copyright statement is and add it.

e.g. when you signed up to use the Digimap collections you agreed to add copyright acknowledgements whenever you created a map with the data. These do change from time to time so it's worth knowing how to check it for yourself.

- To find these copyright acknowledgements go to the **Digimap Resource Centre** (**Resources** at the top of the main Digimap page)
- Look for a link to **Digimap Licence Agreements** and click on it.
- Click on the End User or Sub-licence agreement for the data that you've used
- then look for the information under **In return, you must:** - that gives you the acknowledgement text.

For example, as of April 2019 when you use Ordnance Survey data obtained from Digimap you are expected to add the following text to your map.

> ***© Crown copyright and database rights*** `year`***. Ordnance Survey (100025252).***

Where *year* is replaced by the current year.

Remember that you do have to acknowledge each different dataset that you use and will have signed up to that when you registered.

Adding the copyright symbol to your text

To add the **copyright symbol** - ©- to your text

- check that the Num lock is on on the keyboard
- hold down the Alt key
- use the number pad to type 0 + 1 + 6 + 9
- release the Alt key

Table 7.1: Adding the copyright symbol to your text

If you are *not* using U.K. Ordnance Survey data this is **not** the correct copyright acknowledgement to use, for example if you are using data for Spain or the United States, or indeed UK data that you

haven't downloaded from Digimap. You'll need to find the correct copyright acknowledgement for yourself. The web page[2] at `http://bit.ly/1ZSifnd` gives some information about how to cite GIS materials - including the software as well as the data. Have a look at that and follow the suggestions to cite non-Digimap data.

Advice on citing Digimap data, as opposed to the copyright acknowledgement is at `https://digimap.edina.ac.uk/webhelp/resources/citation/services.html`

7.7.3 Adding a key / legend to your layout

You'll have added various data to your map, and it is necessary for you to explain to anyone looking at your map what those layers and symbols show. To do this you'll need to add a legend or key.

Start by using the default options to create a legend. Once you have the basic legend it is possible to make alterations later

Video Clip available in Minerva - Adding and editing a map legend.

- Click on **Legend** on the **Insert** tab of the ribbon
- then click close to where you want the legend on your map

Arc will automatically add all of your layers to the legend, including those you don't want to include.

- Use the Contents pane to view the layers which are included in your legend by clicking on the arrow next to its heading
- To remove a layer from the legend just untick it in the Contents - figure 7.7

As an aside - the ESRI blog has a short discussion at `http://arcg.is/2eD2Kk2` about the use of singular and plural nouns for legend items which you might find informative.[3]

It is very likely that you will want to change the legend in some way to make it clearer. Do as much as you can while it is still being generated automatically.

- Make sure that all the symbology is correct
- Rename layers in the map contents pane so that they are in plain English, e.g. no unexplained abbreviations, or strange characters, such as underscores.
- On the example in figure 7.6 the heading `For_Eng` either needs to be removed or written in full as something like `Type of engineering required`.
- To change the format of an item right-click on it in the Layout contents pane and select **Properties** then try changing the options there.

Once you have all the basic information in your legend you can convert it to a graphic and you will have more flexibility to rearrange items. Note that once you have converted a legend to a graphic it will no longer change automatically if you change symbology or layers on your map, you will have to generate a new legend. So leave this step until you are happy with everything else on your map.

[2] Last viewed: 18th September 2018
[3] Last viewed: 18th September 2018.

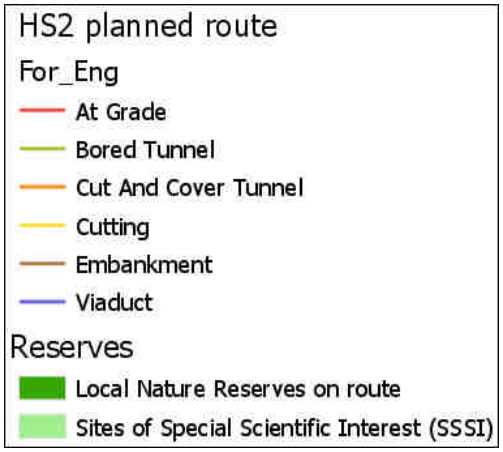


Figure 7.6: An example of a basic legend or key. It needs some work on it now!

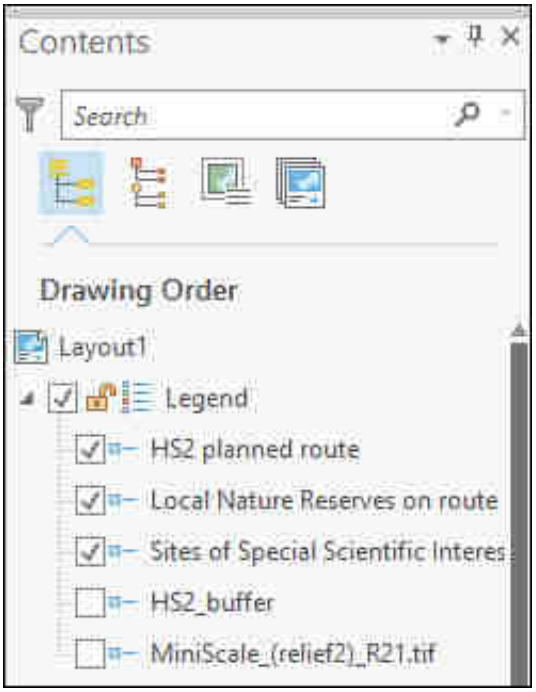


Figure 7.7: Selecting the layers which should appear in the legend

Converting a legend into a graphic

- Right-click on the legend Convert to Graphics.
- Right-click on the legend again Ungroup.
- Repeat the last step again as necessary on each part of the legend

Now you should be able to select individual parts of your legend and move them around or delete them.

> ***For example if you have lines with symbols that have been added as points: in your legend move the point symbol so that it is positioned on top of the appropriate line then delete any text that was associated with the symbol.***
>
> ***Add any extra text that you want to add by using the Text button on the ribbon, or remove text that you don't need.***
>
> ***The default legend styles in Arc will not necessarily group features in a way that is most helpful for your map. You can add headings yourself using the Text tool and then rearrange the entries under those headings manually.***

Make sure that your key covers all of the information that you have added to your map, but doesn't include any symbology that doesn't appear on your map. (Do you want a viewer to waste time sitting there wondering where that symbol is on your map?)

7.7.4 Adding a measured grid

Measured grids add labelled grid lines to a layout. If you are using Ordnance Survey or other UK data projected in British National Grid then you can easily add National Grid lines and numbers to your map. The O.S. raster tiff files already have grid lines marked, but adding a measured grid allows you to include coordinates around the edge of your map - making it possible to read grid references.

Video Clip available in Minerva - Adding a measured grid to a map.

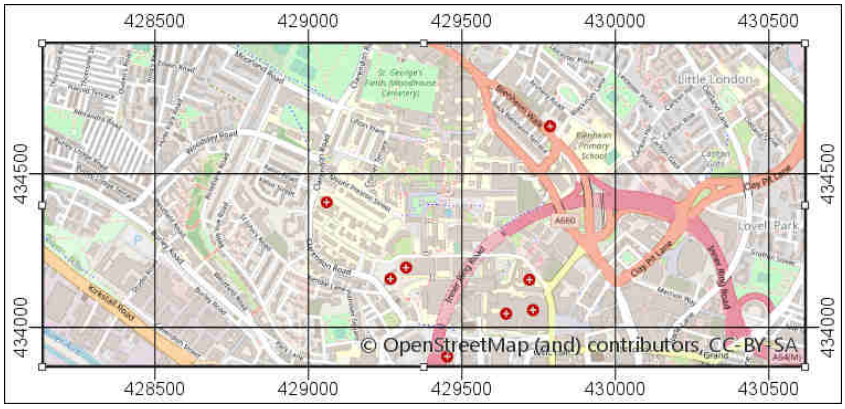


Figure 7.8: A map with a measured grid that shows British National Grid coordinates on a 500 m grid

- With the map frame selected, from the **Insert** tab of the ribbon click on **Grid**
- You should be presented with a selection of choices. For a map in a projected coordinate system such as British National Grid you will want to choose one of the **Measured Grids**, and probably **Black Vertical Label Grid**
- You can make changes to the grid in the **Format Map Grid** pane to the right of the window when the Grid is selected in the Contents pane
- check that the intervals are suitable to the scale of the map, you don't want the lines to be too dense, but you do want to have enough to make it possible to see measurements between them. To change the intervals
  - In the **Options** tab untick **Automatically adjust** under **Interval**
  - Go to the **Components** tab and change the intervals for Labels, Ticks and Gridlines.

Note that the grid that Arc adds is fully numeric, you may be more used to seeing grid letters for 100 km grid squares, e.g. our current grid reference is similar to SE 2934 3444, our current grid coordinates are similar to 42934 43444. It is the latter that will appear on a measured grid generated by Arc. For more information on this and a diagram to help you to change from one to the other, see section 5.10.2 on page 92.

7.7.5 Adding north arrows

Before adding a north arrow to your layout stop and think about how you need to indicate north on your map. If you look at the technical information on an Ordnance Survey Landranger (1:50

000) map you'll see a diagram showing Grid north, True north and Magnetic north. The information given there shows how to plot the difference of magnetic north from grid north. Adding this to your own maps can also be useful, particularly if you, or anyone else, are going to be using the map in the field.

If you are taking strike and dip measurements in the field you should have corrected your compass-clino for declination (the horizontal angular difference between true north and magnetic north) anyway. When you plot the measurements on your map it isn't worth worrying too much about whether you are plotting against grid or true north as the difference on any grid, not just the British National Grid, is unlikely to be that big. Figure 7.9 shows the different types of north and the declination.

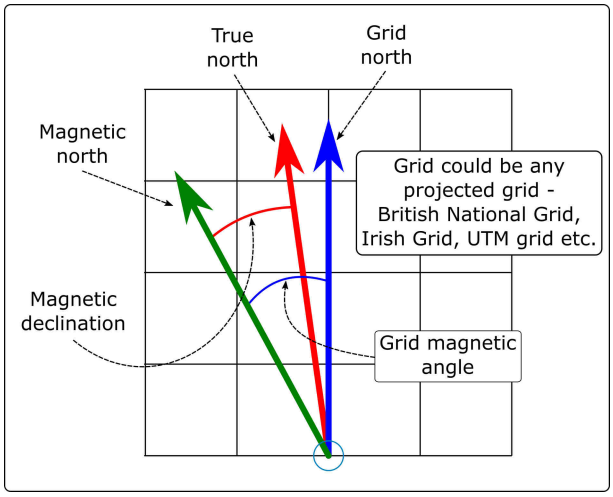


Figure 7.9: The different types of North that you'll find on a map set to a projected coordinate system, such as British National Grid

If you add any north arrows to your layout do remember to label them in some way which shows which version of north each one is showing.

Video Clip available in Minerva - Adding north arrows to a layout.

North arrow: Grid north / Map north

If a map is in a projected coordinate system Arc will automatically lay it out aligned with the grid. So for example, any map set to British National Grid will be aligned to grid north.

In this case it isn't strictly necessary to add a north arrow to show grid north if you also include a measured grid on your map, but it doesn't hurt.

In layout view:

- From the **Insert** tab of the ribbon click on the down arrow under the **North Arrow** button
- select an arrow style (it's usually much better not to go for something too fancy!)
- Double-click on the arrow to open the **Format North Arrow** pane that opens to the right and check that **Type** is set to **Map North**

If you check this against your measured grid lines you should find that it matches exactly.

North arrow: True north

True north is the direction from the area of your map to the North Pole. In the east/west centre of a grid, such as that set for the British National Grid, it may well be the same as grid north, e.g. in Leeds the difference is extremely slight. As you go further east or west towards the edges of an area covered by a grid the difference becomes more noticeable, e.g. at Lands End in Cornwall, or in Norfolk.

The ArcGIS Pro Help describes True North as "The north arrow angle points to geodetic north (to the north pole) as calculated by the coordinate system of the associated map frame, at the center of the map."[4]

In layout view:

- From the **Insert** tab of the ribbon click on the down arrow under the **North Arrow** button
- select an arrow style (it's usually much better not to go for something too fancy!)
- Double-click on the arrow to open the **Format North Arrow** pane to the right and check that **Type** is set to **True North**

If you check this north arrow against your measured grid lines you may well find that the north arrow is slightly tilted.

North arrow: Magnetic north calculated by grid magnetic angle

Magnetic north is the direction from the area of your map to the magnetic North Pole. This is the number that is given on the corner of Ordnance Survey maps and the one geologists need for setting their compass-clinos in the field, so it is worth making a note of this on your map too.

Since version 2.4 of ArcGIS Pro setting a north arrow to magnetic north has become simple, but if you do need to work out the declination for yourself the website below will give you the calibration angle for anywhere in the world.

BGS Geomagnetism Group at `http://bit.ly/2uGMfdp`. Use the map to select your area and click to retrieve the data. Make a note of the figure shown as **degrees east** and round it to the nearest two decimal places. The key to the table you are given is underneath the map.

To set magnetic north automatically - in layout view:

- From the **Insert** tab of the ribbon click on the down arrow under the **North Arrow** button
- select an arrow style (it's usually much better not to go for something too fancy!)
- Double-click on the arrow to open the **Format North Arrow** pane to the right and check that **Type** is set to **Magnetic North**
- The properties will give the **Calculated Angle**. It's a good idea to add this and the current date to your magnetic north arrow as magnetic north changes with time.

If you check this north arrow against your measured grid lines you will probably find that the north arrow is slightly tilted. Note that at the moment the line where magnetic north and grid north are the same is passing across the UK so you may find that there is no, or very little difference[5].

If you need to set the angle manually with the declination from the site above, enter the value into the **Calibration Angle** box. Note that due to the way Arc calibrates the angle, if your figure is negative you need to add it as positive, if positive, put a minus sign in front of it! The arrow on the preview should change to reflect the magnetic angle.

[4] `https://pro.arcgis.com/en/pro-app/help/layouts/north-arrows.htm` Last visited: 10th October 2019.

[5] See blog post from the Ordnance Survey - `https://www.ordnancesurvey.co.uk/blog/2019/03/magnetic-north-continues-its-march-to-the-east/` Last viewed: 10th August 2019.

7.7.6 Adding extra map frames

It can be very useful to be able to place more than one map or map view on a single layout, either so that you can show a different area, or a different zoom level for the same area. You can also use this to set up an automatic extent indicator which marks your study area on a larger map. To do all of this you need to add extra map frames.

Video Clip available in Minerva - Adding extra map frames to a layout.

Showing a different area of the same map

If you just want to add another frame showing a different area of the same map, and using the same data layers then the process is simple and is basically repeating what you did to add the first map frame.

- Click on **Map Frame** on the **Insert** tab of the ribbon
- If you just click on the button you'll be given a World map.
- If you click on the arrow underneath **Map Frame** you'll be given some options which in include any spatial bookmarks that you have set up[6] and the map views in your project.

Click on any of the options to add a map frame to your layout. If you have a map showing the World you can zoom in to the area of your data.

You can move each map frame separately, but if you turn data layers on or off on one of them, they will be turned on or off on both.

Create a new map frame using different data

Adding another map frame which uses different data layers is a bit more involved.

- Start by setting up another map - from the **Insert** tab of the ribbon click on **New Map**
  - It's a good idea to rename the maps so that you can remember what each one shows. Do this by bringing up the **Map Properties** and changing the **Name** field.
  - Set this map up with the data you need and symbolise as required then return to your layout.
- Click on **Map Frame** on the **Insert** tab of the ribbon
- If you just click on the button you'll be given a World map.
- If you click on the arrow underneath **Map Frame** you'll be given some options which in include any spatial bookmarks that you have set up[7] and the map views in your project.

Click on any of the options to add a map frame to your layout. If you have a map showing the World you can zoom in to the area of your data. See figure 7.10 to get an idea of how the map frames and the contents pane will look (your data and areas will of course be different).

Once you have two map views on your layout you can copy and paste layers between the two if necessary and symbology will be preserved.

[6] See section 1.5 on page 4 if you need a reminder about spatial bookmarks
[7] See section 1.5 on page 4 if you need a reminder about spatial bookmarks

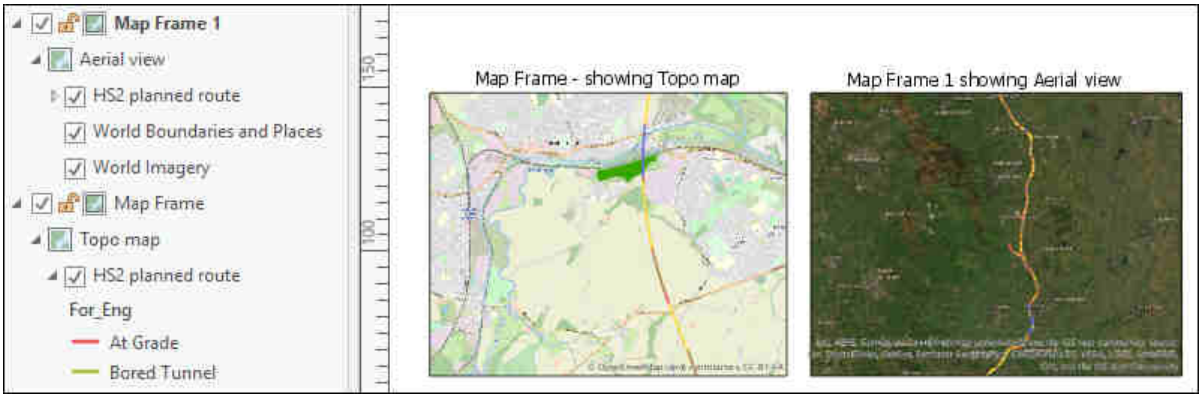


Figure 7.10: A layout showing two map frames containing different data

7.7.7 Adding an extent indicator

For some maps, particularly large scale (detailed) maps of very small areas, it is useful to show a small scale map of the general area with the area of the main map marked (see figure 7.11). To do this you need to obtain small scale data and then add it to a second map frame in Arc. You really only need a general map, even just an outline of a whole country, so it can be best to use data from Natural Earth[8].

Note that using a screenshot from Google Maps or Google Earth (or similar) with a marker on it doesn't look good, and should be avoided. Not least it is suprisingly easy to end up with the marker in the wrong place.

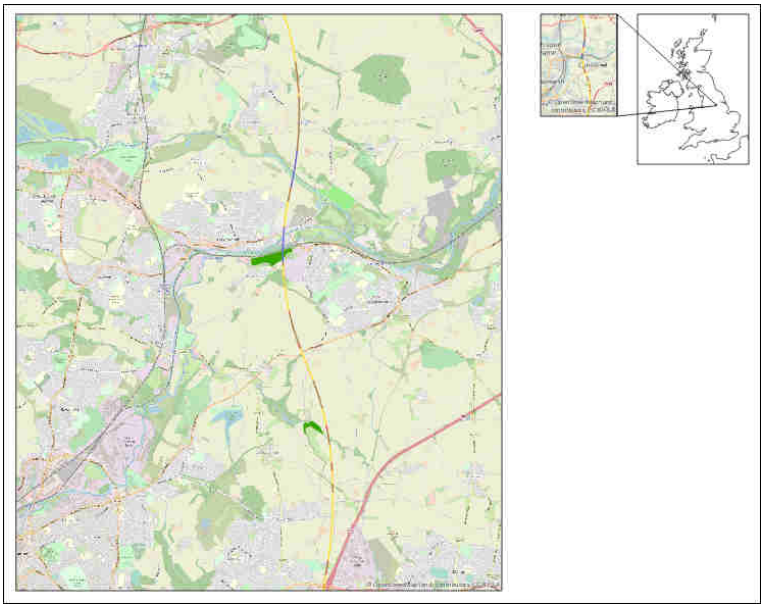


Figure 7.11: An extent indicator on a layout: using a smaller map to show the general area of the main map. In this example the main map has been duplicated and shrunk down, but set to cover the same extent as the main map. The extent is then shown on an outline map of the UK. You can also make the extent straight from the larger map. Note that the indicator does not need to be large, but should be a small map which doesn't take up too much space on the layout.

Start by adding a new map frame to your map as shown in section 7.7.6 on page 126 and add

[8]Download from `https://www.naturalearthdata.com/` Last visited: 13th August 2019. Look for Downloads › Large scale data › Cultural › Download Countries. Don't forget you'll need to reference this data.

your choice of map layers, e.g. the Natural Earth Data countries, to the new map and symbolise appropriately.

Set up the extent indicator

- Resize and relocate the map frame and set it to an appropriate scale (e.g. start with 1:1 000 000) and the area of the country of your main map.
- Select the outline map (the one that is going to be the extent indicator)
- Click on **Extent Indicator** on the **Insert** tab of the ribbon
- From the dropdown select the map frame of the more detailed map that you want the extent indicator to show the area for
- Arc should add a dot to the map at the correct location. You can now use the **Format Extent Indicator** pane on the right to set the properties, e.g. try changing the symbol, or use the dropdown under **Leader** and try out the options there

You should now have a map with a marker showing the area covered by your main map and with a line or lines leading to it as in figure 7.11 on page 127.

If you use a smaller map, as in the example, select that map, and in the **Format Map Frame** pane choose **Linked map frame extent** under **Constraint** so that it continues to show the same area as the main map.

Try moving and rescaling both maps (remember you have to Activate the frame you want to pan and zoom in) - the marker on the extent indicator should resize and relocate to reflect your changes.

You can change the style of the box and the leader line by selecting the correct extent indicator under **Extent Indicators** in the contents pane, then editing the properties in the **Format Extent Indicator** pane on the right.

7.7.8 Inserting photographs and images

Following some experimentation I would recommend that if you are including diagrams produced in either CorelDraw or Inkscape you **export/save as...** your diagram as **png** format and then insert the result into Arc. It may not look quite right on screen (gradients can be a bit odd and the image can look very pixelated/blurry) but looks fine when actually printed. Jpg files tended to have problems with colours changing when they are exported from CorelDraw.

- In a layout select **Picture** from the graphics group of the **Insert** tab on the ribbon
- Click on your layout and then browse for the image you want.
- Move the image as required. Try not to resize it unless you absolutely have to. You'll get better quality if you resize vector images in Inkscape/CorelDraw before you export them, rather than resizing them in Arc once they've been saved as rasters.

Remember, if the image doesn't look quite right, try exporting to pdf or printing a copy of your layout before you worry about it (see section 7.8.1 on page 129). What you see on screen isn't always how the final result will look.

7.8 Checking your map

A very important stage but one that can easily be forgotten if you are in a hurry!

In addition to the points below have a look at Darkes (2017) which gives lots of quick tips on map layout and presentation. On pages 92 and 93 Darkes includes a section with quick wins for improving your map before publication if you have 5, 15 or 50 minutes. In addition, check the reading list for other references - there is plenty of information available to help you to present better maps.

- ***Check spelling. Even better - get a helpful (and reliable!) friend to proof-read your text for spelling mistakes. It's very easy to miss something obvious in your own work. In particular check geological and geographical names and any technical terms.***
- ***Check that you have included everything that you need to include - if this is an assignment reread the instructions and check that you haven't forgotten to do anything.***
- ***Check that your map doesn't include anything that you don't want to include! Did you add some experimental polygons when you were editing, then forgot to delete them? Have you clicked on the Add text button too many times, but then not removed the resulting text?***
- ***Look at the article on the ESRI blog at*** `http://bit.ly/SZyDiC` [a]***. Read about what makes a map great, then click on the link to the checklist and use the questions there to evaluate your own map. Have you included everything you need to include, or do you have a good reason if something is not on your map? Have you taken care with your presentation?***

[a] Last viewed: 18th September 2018

7.8.1 Printing a copy to pdf to check

Inevitably you'll notice something not quite right with your map after you have printed it. To minimize the chances of this happening when the (expensive) big version is printed it is a good idea to print your map at A3 and have a close look at it first! (This isn't such an issue if your map is only A3 or A4 when full size.)

- Export your map as a pdf file following the instructions in section 7.9.2 on page 130.
- Open your pdf map file in Acrobat reader, or your usual pdf program (instructions below are for Acrobat).
- File » Print…
- Choose your printer and use the printer properties to set the paper size to A3 then choose to print in colour.
- In the **Page Handling** section set **Page Scaling** to **Fit to Printable Area**. In Acrobat this should show you a small preview of how your file will print.
- When you are happy with the settings - OK

7.9 Printing and exporting maps from Arc

When you have finished creating your map in ArcGIS you will usually need to export it to pdf for printing. The following instructions should help to ensure that your map is the correct size and scale.

7.9.1 Printing a map from Arc

The best quality output is obtained by printing directly from Arc, though this isn't always possible. If it is, print as follows:

- Start by checking that the page size and scale are correct (section 7.6 on page 116)
- Whilst in a layout go to the **Share** tab of the ribbon and click on the **Print** icon
- Set up the printer as you usually would (this is system specific so I can't include exact instructions here)
- then click to print

7.9.2 Exporting a map for printing

These instructions show you how to export the map to pdf - the format that is usually required by print shops etc. There are other options in the dropdown list if you need to export an image or another format and the instructions are very similar.

- Whilst in a layout go to the **Share** tab of the ribbon and click on the **Export** icon
- Select **PDF(*.pdf)** in the **Save as** type. **(Do not select the 'Production PDF' option, if you have it - it causes all sorts of problems.)**
- Set the resolution - minimum 300dpi for printing. Higher is better, but too high and it will be impossible to export the file, particularly if it is a large map.
- Set **Image Quality** to **Best**.
- Give your file a name and choose where to save it (checking first that you have enough disk space - some exported maps can be very large[9]).
- Export - be patient! For a large map this can take a long time.

Important note on printing your final copy

If you are printing your final copy from pdf double-check in the pdf reader you use that the **Page Scaling** or **Zoom** is set to **Actual Size...** or **None** (the actual terminology depends on which pdf application you are printing from). This is important to ensure that your map is printed at the scale at which you intend it to be printed. Major problems can be caused by the tiny amount that your map will be reduced by otherwise.

[9] If you think that you may be short of disk space you can save the export to the c: drive or the desktop of the computer in the first place, but do make sure that you then move the file to your m: drive or a USB stick. Forget and you'll lose it.

7.9.3 Exporting a map to import to other programs

You can also export the Arc layout to include in programs such as Inkscape, CorelDraw, Word or Powerpoint. The instructions here show how to do the latter.

- To start with set up your Arc layout as required
  - check that the page size, and the scale/size of the map frame are correct - you'll lose quality if you resize them outside of Arc
  - If you want to include a legend in the final layout it is a good idea to create it in Arc and export it with the map as then the colours and sizes of the symbols will match the map.
- Export the map using the instructions in section 7.9.2 on page 130 but this time choose the appropriate output format (see below) and set the resolution - to **600 dpi** if you have the disk space
- Choose a location then Export

If you basically want a good quality image to import into Word, Powerpoint, CorelDraw, Inkscape etc, then **png** or **jpg** are both fine. Be aware that if you import png or jpg and then resize them you are likely to end up with blurred final result - double-check before printing.

You can also import **pdf** or **svg** into Inkscape and CorelDraw and do some limited further editing.

Whichever format you choose, if your map is going to be part of a bigger presentation where scale is important, such as the Geological Sciences final dissertation map, import to either Inkscape or CorelDraw without changing scale/size/proportions (check instructions for those programs) and then double-check the scale of the main map by drawing a horizontal line of known length and checking it against the lines of the measured grid. For example, for a map at 1:10 000, a line of 10 cm will be the same length as the space between the 1000 m (1 km) grid lines.

7.10 Recommended reading: layout and presentation

The module reading list[10] includes a full section on layout and presentation. In particular have a look at "Designing better maps" by Cynthia Brewer, but for a quick overview look at the article by Frye (2001) or the small book by Darkes and Spence (2017). For examples and ideas look at Brewer (2008) and the ESRI Map Book Gallery.

[10] Reading list available from Minerva and from the module catalogue at `http://webprod3.leeds.ac.uk/banner/dynmodules.asp?M=SOEE-2650`

7.11 Suggested final map layout

Figure 7.12 shows a suggested layout for your final map. Once you have finished working through chapter 7 you will be able to pick the most appropriate elements to add to your maps. This is the stage where you present your map in the clearest possible way so that your audience can "read" the information that you are trying to give to them.

Try setting your map up on an A3 layout rather than the A4 shown here. It will give you more space to try things out. Remember too, don't be afraid of white space, so don't make elements larger just to fill the space available to you.

Your map should not look identical to this as you will have made your own decisions as to what to include and where to put the elements. For example, you could add a small extent indicator to this to show where Ingleton is located within the UK; you could add a north arrow (remember to give the details if you do); you should include your name, or at least Student ID, as the creator of the map.

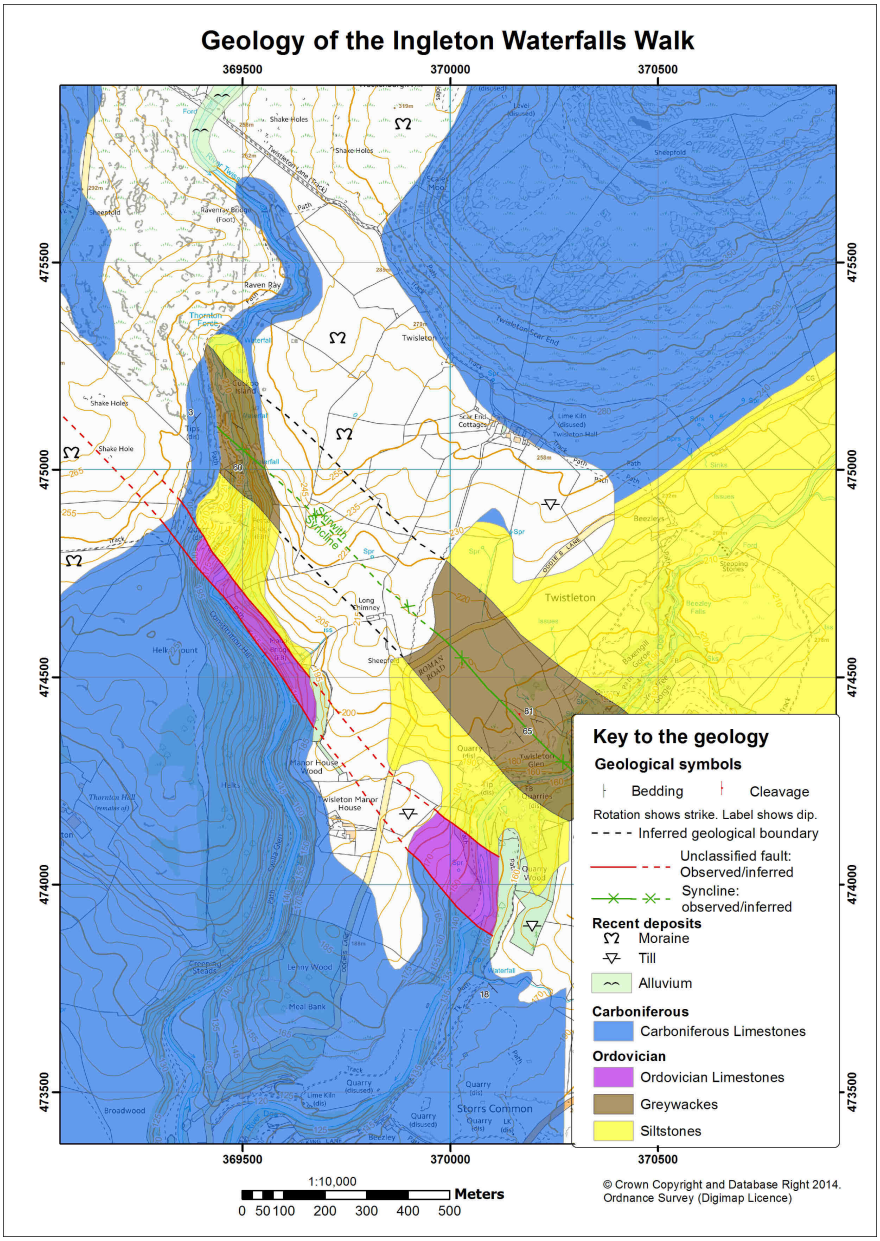


Figure 7.12: Suggested final layout for the Ingleton geological map

Appendix A

Changing Leeds method strike and dip to the Right Hand Rule for GIS

The information in this appendix was provided by Ph.D. student Josh Wolstenholme, to whom many thanks.

Remember that you can also add strike and dip measurements to your map by digitising the points directly from your fieldslip. You do not have to add them via a spreadsheet.

A.1 Introduction

The right hand rule (RHR) is a notation for geological measurements adopted by some of the geological world, including software such as ArcGIS and Stereonet 9. The right hand rule essentially states that the 'dip tick' (using bedding strike and dip as an example) must always be on the right of the strike line as in figure A.1.

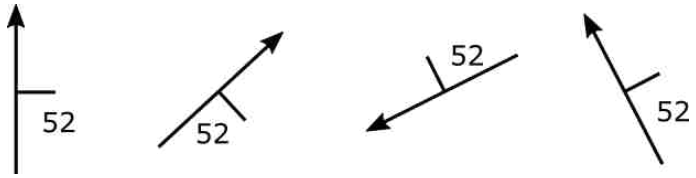


Figure A.1: Right hand rule vs Leeds Notation

In figure A.1, an indicator arrow has been placed along the strike as a reference to keep the dip on the right hand side of the strike. You may find it easier to comprehend by drawing a strike and dip on a piece of paper and rotating it yourself. This helps to visualise what is happening.

A.2 Data preparation in Excel

When importing any data into Excel it is always a good idea to make it clear what each row/-column represents. For example, when working with large datasets it's worthwhile adding in a 'Type' column alongside a unique 'ID' and any 'Notes' you may have. This is helpful when referring back to data and when importing it into software such as ArcGIS and Stereonet 9.

a		b		c		d	
Leeds	**RHR**	**Leeds**	**RHR**	**Leeds**	**RHR**	**Leeds**	**RHR**
000/52E	000/52	048/52SE	048/52	063/52NW	243/52	153/52NE	333/52

A.2.1 Converting dip direction into RHR

Essentially if your dip direction is between just above west (271°) and just below east (089°) you will need to create a new strike. If you refer back to figure A.1, measurements a and b have a dip direction between 090° and 270°; whereas c and d are between 271° and 089°.

In Excel, a simple (but complex looking!) formula can calculate this all for you. It utilises the operators `=IF` and `=OR` [1] to determine whether your measurement needs converting or not. **N.B. It is always worth double checking your measurements are displaying how you would expect them to.**

The formula we will use is as follows (note code should all be on one line):

```
=IF(OR([@[Dip Direction]]="
    N",[@[Dip Direction]]="NE",[@[Dip Direction]]="NW",[@[Dip Direction]]="NNE",[@[Dip
    Direction]]="NNW",[@[Dip Direction]]="E"),[@[Strike/Azimuth]]+180,[@[Strike/Azimuth]])
```

This essentially states that if any of the values within the Dip Direction column are equal to any of the following: "N","NE","NW","NNE","NNW","E" there will be 180° added to the Strike/Azimuth in a new cell. If condition is not met (i.e. Dip Direction does not equal any of the aforementioned), then the original strike is preserved and placed in a new cell. An alternative way of doing this is to use an actual dip direction in degrees. This is more accurate and a quicker formula to write, however requires more data collection or processing:

```
=IF(OR([@[Dip
     Direction]]>270,[@[Dip Direction]]<90),[@[Strike/Azimuth]]+180,[@[Strike/Azimuth]])
```

This takes the reading from the Dip Direction column (i.e. the direction the dip is pointing), and tests if it is either >270 (North West → North) or <90 (North East). If so, 180° is added to the Strike/Azimuth in a new cell. If condition is not met then the original strike is preserved and placed in a new cell.

N.B. The `[@[Name]]` notation refers to a column within a formatted table. It is perfectly fine to use an individual cell reference such as `G38` (for example).

A.3 Excel document with examples

There is an associated Excel document with this workflow, which makes use of the first example of code with arbitrary data which can be found at this link:

`http://homepages.see.leeds.ac.uk/~earcej/downloads/RHR_Example.xlsx`

[1] see `https://support.office.com/en-gb/article/if-function-69aed7c9-4e8a-4755-a9bc-aa8bbff73be2` and `https://support.office.com/en-us/article/or-function-7d17ad14-8700-4281-b308-00b131e22af0` for more information respectively

Appendix B

Creating data for GIS: Point data and GPS

B.1 Learning outcomes

When you have completed this section you should be able to

- collect your own spatial data for use in GIS
- discuss the problems that can affect data for GIS
- suggest ways in which to minimize error and uncertainty in spatial data

B.2 Introduction

The previous chapters should have given you some idea of the variety of data that is available for you to use, but there is nothing to replace going out and collecting your own data and it is very likely that you will be using GPS units for fieldwork at some point.

In this chapter you will collect waypoints using a GPS unit. Once you have collected waypoints you will look at how to import the data from the GPS units into Arc.

Waypoints collected using a GPS receiver can be downloaded and opened in ArcGIS in a variety of ways depending on the software provided with your receiver. Instructions in this section will of necessity be vague in places as it is impossible to know about every combination of hardware and software. You may need to use instruction booklets and help files provided with your setup.

If you are new to GPS and would like to find out more about the background and technology there is a beginners guide at:

Garmin:

`http://www8.garmin.com/aboutGPS/index.html`[1]

B.3 Prerequisites

- GPS receiver with cables to connect to computer
- **OR** GPS enabled mobile device either with cables to download data or wifi connection.
- Base map - these instructions will show you how to use ArcGIS Online as a base, but use the most suitable base map for your area.

[1] Last visited: 18th September 2019

B.4 Collecting data with a GPS

You will be divided into small groups. Each group will have a GPS unit (probably a Garmin eTrex 10), a brief quick start guide and a fieldslip (see section B.11). The official Quick Start manual for the Garmin eTrex 10 is available online[2] at

`https://support.garmin.com/en-US/?productID=87768&tab=manuals`

B.4.1 Setting up the GPS

This is best done once you are outside and the gps can find satellite signals. Wait for me at the location I tell you, and we will check that you all have a gps which works, and know how to do the basics before you continue with the exercise.

You will be given a quick reference sheet which you can take outside with you to use during the exercise.

Take a short while to familiarise yourself with the GPS and work out how to add waypoints (use the quick reference leaflet to see how to do the basics). Please ask if you can't work anything out.

- Start by turning the GPS on!
- Use the thumbstick to navigate the menu. Press it to select.
- Use the **Waypoint manager** to delete all existing waypoints (hint: use the **Menu** button!)
- Use the **Track manager** to clear the current track
- For this exercise go to Setup » Position Format and check that the format is as follows:
  - **Position format:** British Grid
  - **Map Datum:** Ord Srvy GB
  - **Map Spheroid:** Airy
- If the position format isn't correct, reset it.[3]
- Check that you know how to record a **Waypoint**

Now you should be ready to go.

B.4.2 Collecting data: warnings

Accuracy

It is possible check how many satellites your GPS receiver can see (**Satellite** in the initial menu). The more satellites there are within view, the more accurate your readings will be.

When you get outside, keep an eye on this from time to time.

[2] Last visited: 18th September 2019

[3] It is often best to have the coordinate system set to the same as a paper map that you are using in the field. If this isn't possible set the format to WGS84, which is a standard geographic coordinate system and can be **transformed** into another system later:

- **Position format:** hddd.ddddd degrees
- **Map Datum:** WGS84
- **Map Spheroid:** WGS84

Figure B.1 shows the satellite information screen on the eTrex 10. In this case it is showing that it has picked up four of the satellites that it is expecting, although it only has a full-strength signal from three of them. The accuracy is +/- 34 m, hopefully yours will be better than that!

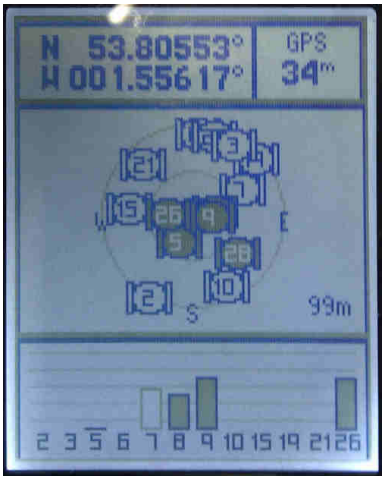


Figure B.1: Garmin eTrex 10 satellite information screen

Make a note on your sheet of the number of satellites that there are in view when you first switch on the GPS and of the stated level of accuracy which should be in metres (ask for help if it is in feet).

The general advice is to turn on your GPS well in advance of starting to work, and leave it on for the whole of the working day. This gives it a chance to find and track the maximum number of satellites. Even under ideal conditions, when your receiver has found several satellites, due to the nature of the system accuracy still won't be 100%. Under **Satellite** you should be able to find out what the current level of accuracy is - it will be a measurement in metres. Be aware of this when using the readings. According to the O.S. website "Positional accuracy with a single receiver, to civilian users approximately equals 5 m to 10 m, 95% of the time." [4]

It is particularly worth noting that GPS data can give an *illusion* of extreme accuracy. The readings tend to show figures with lots of decimal points which could lead you to assume that a reading is accurate to 1 m or less. Given the statement above that is very unlikely to be the case.

For this reason it is still important to know how to locate yourself accurately on a paper map without the use of GPS, and most navigation experts will say that with practice you can be far more reliable and accurate than a GPS unit. Not least, you should have the intelligence to recognise when the point where you are standing is at the top of a cliff, not off it!

Elevation

Don't use elevation measurements from your GPS. For various reasons obtaining accurate height readings with GPS is much more difficult than obtaining accurate horizontal readings. The OS website has an explanation of how best to do this, but it involves specific equipment and readings taken over at least 24 hours.

B.4.3 Data to collect

Go out to the area indicated in the class (probably Chancellors Court or St Georges Fields) taking a copy of the data sheet or map with you and collect a series of point readings. You will be

[4] `http://bit.ly/1cPJkCw` [Last accessed: 18th September 2018]

given a time limit - try quickly to collect points which are spread out across a fairly wide area. When you are doing field work you will collect data in your field notebook and/or on a field slip but for now mark items on the field slip provided.

Suggested features to take a reading for are: Trees; Seats; Rocks; Rubbish bins; Memorials; Sign posts; Planters; Maps. But add any other features that you think are appropriate.

Fill in the fieldslip with the number of the waypoint, and the type of feature, e.g. seat.[5]

Make sure that every member of the group has a turn with the GPS and try to work quickly and efficiently.

Once you have at least the recommended number of points, return to the computer cluster and continue following these instructions to download the data.

B.5 Downloading files from the GPS

Start from here once you get back into the cluster from collecting data.

To download data directly from the GPS unit you will have a USB lead (if you're in class you should sign one out from the demonstrator).

- Connect the USB lead to a USB port on the computer.
- Lift the "weather cap" from the port near the top of the back of the gps unit and plug the other end of the USB lead in to that
- The gps unit should appear as a removable drive in **My Computer**
- navigate to `Garmin▸GPX` and download the gpx (gps exchange format) file - `Waypoints_`*`current_date`*`.gpx`

You won't be able to open the file directly, but **copy it to your working folder** so that you don't lose it when you remove the gps.

Make sure that every member of your group has a copy of the gpx file on their own drive so that you can all work through the remaining exercises independently.

When you've finished make sure that the gps is turned off - the batteries are not rechargeable!

B.6 Converting gps files for ArcGIS

Open a new map in ArcGIS Pro - you should get a world map don't worry about that for now!

Start by investigating the contents of the gpx file that you have created, by opening it in a text editor such as Notepad or Notepad++ (right-click on the file in the windows file explorer and Open with... . You may need to set the text to wrap around if the whole thing appears on a single line - in Notepad++ go to View > Word wrap.

It will look rather confusing - this is a form of xml - but don't panic! Look for a line that begins `<wpt lat= ...`(see figure B.2). This line shows the **latitude** and **longitude** of a waypoint and

Video Clip available in Minerva - Converting gps files to display in Arc.

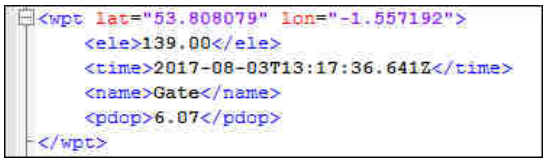


Figure B.2: This is how a waypoint looks in Notepad++ - note the line beginning **<wpt lat=** . Also note that the coordinates will be in lat and long even if you had the GPS unit set to British National Grid.

Figure B.3: This is the same file as figure B.2 but with all of the data on one line. It's harder to see what is happening, but the information is the same. Just look for **<wpt lat =** still.

demonstrates that, even if your gps unit was set to British National Grid, for example, a gps unit will still **store** the data in a coordinate system called **WGS84**.

You'll use one of the tools in the geoprocessing toolbox to convert the gpx file. The geoprocessing toolbox gives you the opportunity to do a lot of very advanced processing tasks without needing to use a command-line interface.

- Click on **Tools** on the **Analysis** tab of the ribbon to open the geoprocessing toolbox. Be patient, it can be slow to open - it should look something like figure B.4 once it does.
- You can either browse for the correct tool by going to **Toolboxes** then Conversion Tools ▸ From GPS or search for **GPX to Features**. Either way double-click on GPX to Features to open the tool (figure B.5).
- Fill in your **Input GPX File** and then click on the folder symbol next to **Output Feature class** to save your output to the project geodatabase and give your output feature class a name, e.g. `Waypoints`
- Click Run

The tool should run and add a point feature class to your map.

Before adding your data to a map you need to stop and think about coordinate systems - the coordinate system of your data needs to match the coordinate system of your map.

If you followed the instructions above then the coordinate system will be **WGS1984** by default. We'll start by adding the data to a map with that coordinate system.

- Add your converted Waypoints feature class to the map, if it hasn't been added automatically.
- Check the coordinate system of the map frame (double-click on the map frame title (usually **Layers**) to open the properties, then go to the **Coordinate System** tab) - it should be WGS84. If it isn't, set it to that now (`Geographic Coordinate Systems▸World▸WGS84`)

[5] It is possible to use the GPS unit to add notes, such as the type of feature, to each waypoint, but the GPS doesn't have a touch keyboard and entering text is very long-winded and fiddly. It is much easier to collect the points on the GPS, make notes on paper, then add the notes to the data on computer.

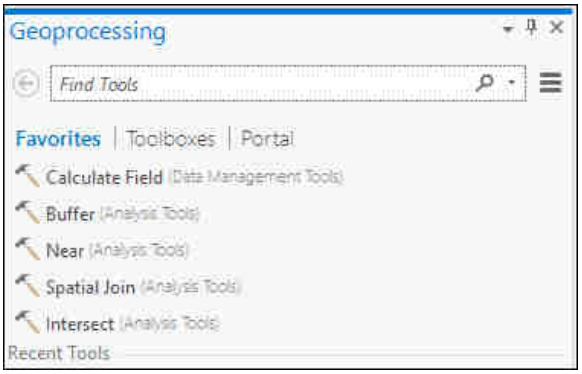


Figure B.4: Geoprocessing toolbox - showing GPS to Features selected

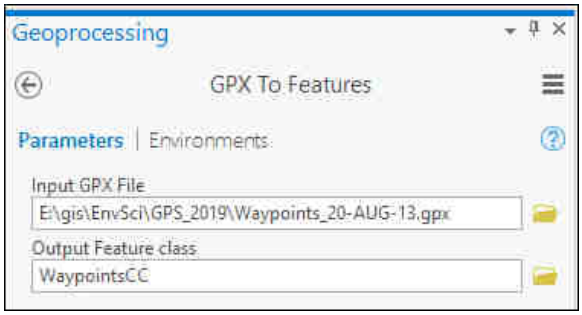


Figure B.5: The filled in GPS To Features tool

- also check that the waypoints are set to WGS84 by going to the layer properties and looking for the **Geographic Coordinate System** heading under **Data Source**. If that says `<unknown>` you'll need to set the projection:
  - use the toolbox to **Define** the projection of the Waypoints feature class to WGS84. (Toolbox > Data Management Tools > Projections and Transformations > Define Projection and set the **Coordinate System** to `Geographic Coordinate Systems▸World▸WGS84`)

B.6.1 Changing to a different basemap

By default ArcGIS Pro maps are usually set up with a topographic basemap. It would be useful to change this to a satellite imagery layer instead.

- On the **Map** tab of the ribbon click on **Basemap**
- Click to load the **Imagery with Labels** layer.

The imagery should replace **Topographic** as the basemap for your map. The other layers in this menu can be very useful too - it's worth investigating what is available.

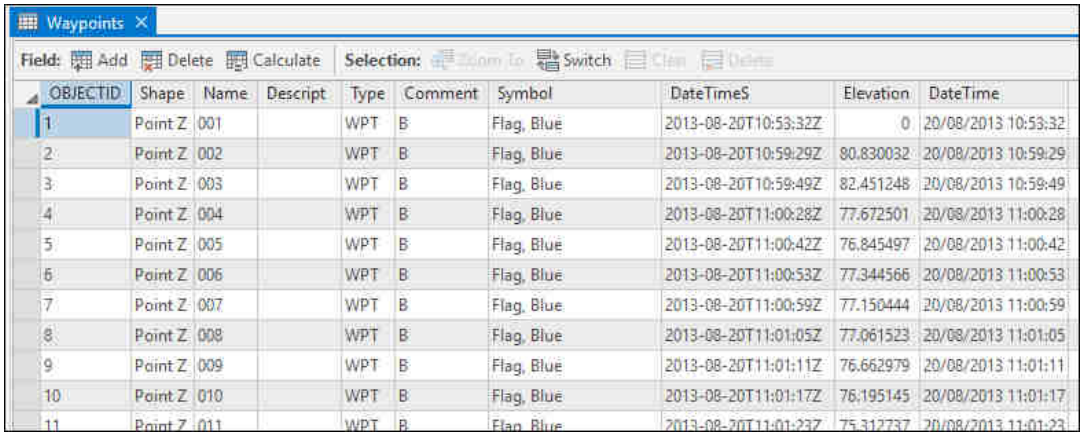
B.6.2 Checking your data

Have a look at your map and zoom in and out a bit. Take particular note of where your gps points are. How accurate do you think the locations are? What problems can you spot based on your memory of collecting the data? How do you think you could increase accuracy of data collection?

B.6.3 Adding extra data to feature classes

Have a look at the attribute table of the new layer

- right-click on the layer in the table of contents
- select Attribute Table. It should look something like figure B.6



OBJECTID	Shape	Name	Descript	Type	Comment	Symbol	DateTimeS	Elevation	DateTime
1	Point Z	001		WPT	B	Flag, Blue	2013-08-20T10:53:32Z	0	20/08/2013 10:53:32
2	Point Z	002		WPT	B	Flag, Blue	2013-08-20T10:59:29Z	80.830032	20/08/2013 10:59:29
3	Point Z	003		WPT	B	Flag, Blue	2013-08-20T10:59:49Z	82.451248	20/08/2013 10:59:49
4	Point Z	004		WPT	B	Flag, Blue	2013-08-20T11:00:28Z	77.672501	20/08/2013 11:00:28
5	Point Z	005		WPT	B	Flag, Blue	2013-08-20T11:00:42Z	76.845497	20/08/2013 11:00:42
6	Point Z	006		WPT	B	Flag, Blue	2013-08-20T11:00:53Z	77.344566	20/08/2013 11:00:53
7	Point Z	007		WPT	B	Flag, Blue	2013-08-20T11:00:59Z	77.150444	20/08/2013 11:00:59
8	Point Z	008		WPT	B	Flag, Blue	2013-08-20T11:01:05Z	77.061523	20/08/2013 11:01:05
9	Point Z	009		WPT	B	Flag, Blue	2013-08-20T11:01:11Z	76.662979	20/08/2013 11:01:11
10	Point Z	010		WPT	B	Flag, Blue	2013-08-20T11:01:17Z	76.195145	20/08/2013 11:01:17
11	Point Z	011		WPT	B	Flag, Blue	2013-08-20T11:01:23Z	75.312737	20/08/2013 11:01:23

Figure B.6: The attribute table for the converted gps data

Amongst many other attributes there should be one for **Name** which should include the label or name of each waypoint as stored by the GPS unit, in this case the number of each point. There is a set of important information missing from this file, though. What do you think it is?

Hopefully you spotted that you still need to add the details of each feature to the feature class, i.e. what type of feature it is, such as seat or signpost. You should still have a copy of this information. This is the point at which you add that information to the attribute table. You could use the existing **Descript** field, but for experience here you can add a new field.

Adding a new field to a feature class

This can also be referred to as adding a new column or a new attribute field.

Video Clip available in Minerva - Adding a new field to a feature class.

- Right-click on the **Buildings** layer in the Contents pane and open the **Attribute table** if it isn't already open
- To add a new field click on the **Add** button on the attribute table toolbar - see figure **??**
- The attribute table will change to **Field** view - showing more information about the data types and formats - figure **??**
- Fill in the details to create a new field called **FType**[6]
  - The **Field Name** should be short and contain no spaces or strange characters

[6] To denote **Feature type** - field names need to be short with no spaces

  - **Alias** is how the name will be displayed and can include spaces - it's still a good idea to keep it short
  - Set the **Data Type** to **Text**
  - Set the **Length** to **100** - that's the number of characters you'll be able to use in a name.
- Once you've filled in that click on Save on the ribbon.

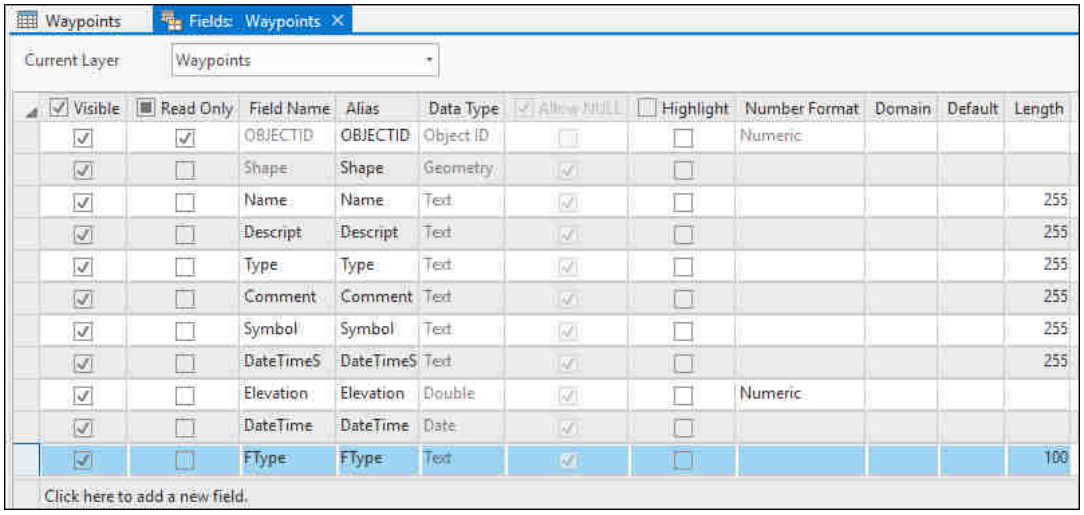


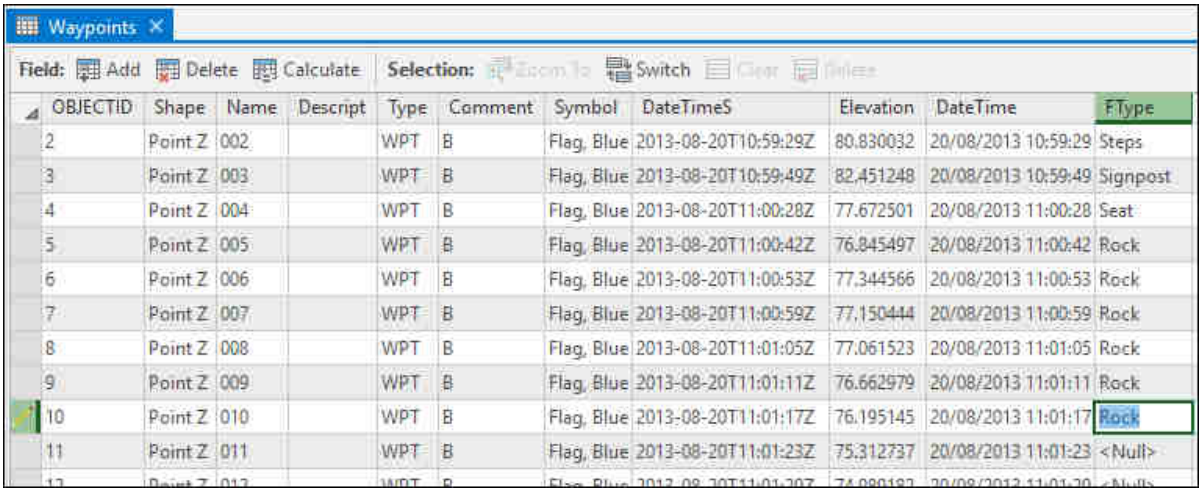
Figure B.7: Adding a field to a feature class attribute table

B.6.4 Adding feature attributes to a feature class

Now you're ready to add information, or **attributes**, to your new field.

- Start by opening the attribute table for the waypoints layer, if it isn't already open, by right-clicking on the layer in the contents pane and click on **Attribute Table**
- If you have any features that you don't need, e.g. if you haven't written down any information for one, you can delete it by right-clicking in the little grey box on the left of the attribute table next to that record and **Delete Row**
- Click in the first box of the `FType` field - check that the `Name` field matches the number in your notes, and add the type of feature. Try to be consistent, so all features of the same type have exactly the same text - check spelling and if you use upper case to start one, use it for all.
- go through the list and add all the feature types, see figure B.8.
- then save your edits by clicking the **Save** button on the **Edit** tab of the ribbon - it's easy to forget this but you don't want to lose your work!

Video Clip available in Minerva - Adding attributes to the attribute table in ArcGIS Pro



OBJECTID	Shape	Name	Descript	Type	Comment	Symbol	DateTimeS	Elevation	DateTime	FType
2	Point Z	002		WPT	B	Flag, Blue	2013-08-20T10:59:29Z	80.830032	20/08/2013 10:59:29	Steps
3	Point Z	003		WPT	B	Flag, Blue	2013-08-20T10:59:49Z	82.451248	20/08/2013 10:59:49	Signpost
4	Point Z	004		WPT	B	Flag, Blue	2013-08-20T11:00:28Z	77.672501	20/08/2013 11:00:28	Seat
5	Point Z	005		WPT	B	Flag, Blue	2013-08-20T11:00:42Z	76.845497	20/08/2013 11:00:42	Rock
6	Point Z	006		WPT	B	Flag, Blue	2013-08-20T11:00:53Z	77.344566	20/08/2013 11:00:53	Rock
7	Point Z	007		WPT	B	Flag, Blue	2013-08-20T11:00:59Z	77.150444	20/08/2013 11:00:59	Rock
8	Point Z	008		WPT	B	Flag, Blue	2013-08-20T11:01:05Z	77.061523	20/08/2013 11:01:05	Rock
9	Point Z	009		WPT	B	Flag, Blue	2013-08-20T11:01:11Z	76.662979	20/08/2013 11:01:11	Rock
10	Point Z	010		WPT	B	Flag, Blue	2013-08-20T11:01:17Z	76.195145	20/08/2013 11:01:17	Rock
11	Point Z	011		WPT	B	Flag, Blue	2013-08-20T11:01:23Z	75.312737	20/08/2013 11:01:23	<Null>

Figure B.8: The attribute table for the converted gps data with the feature type added manually in the FType field

B.7 Symbolising a layer

So far you have a single coloured dot representing every point. Your map would be much more informative if each type of feature had it's own symbol.

Open the attribute table for your new point feature layer again and have another look at the data that it contains. In the previous section you created a column called **FType** or something similar and added attributes to show what type of feature each record contained. In Arc it is easy to colour, or **symbolise** the features so that you can differentiate what they refer to.

- Close the attribute table.
- Select your waypoint layer in the contents pane
- Go to the **Appearance** tab of the ribbon and click on **Symbology** to open the Symbology pane on the right of the window

Video Clip available in Minerva - Symbolising a layer by unique values in Arc.

At the moment the layer is symbolised as a single symbol - a single random colour which is used for all features (figure B.9).

- In the symbology pane select **Unique Values** in the dropdown at the top
- in the **Value Field** box that appears select **FType** - or whatever you called the field that you added attributes to.

You should find that you get a list of the values of FType to which Arc will have assigned random coloured symbols - figure B.10.

- You can change the symbols by double-clicking on each symbol in turn - have a go now. If you search through the possible symbols in the symbol selector you may find appropriate symbols for rocks, plants etc. You may need to follow the instructions in table B.1 on page 146 to add extra symbols to find what you need
- You may find it easier to see what you are doing if you turn off the base map layers.

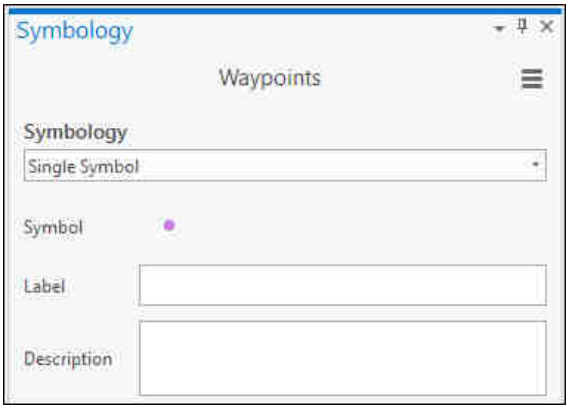


Figure B.9: The waypoints layer symbolised as a single symbol

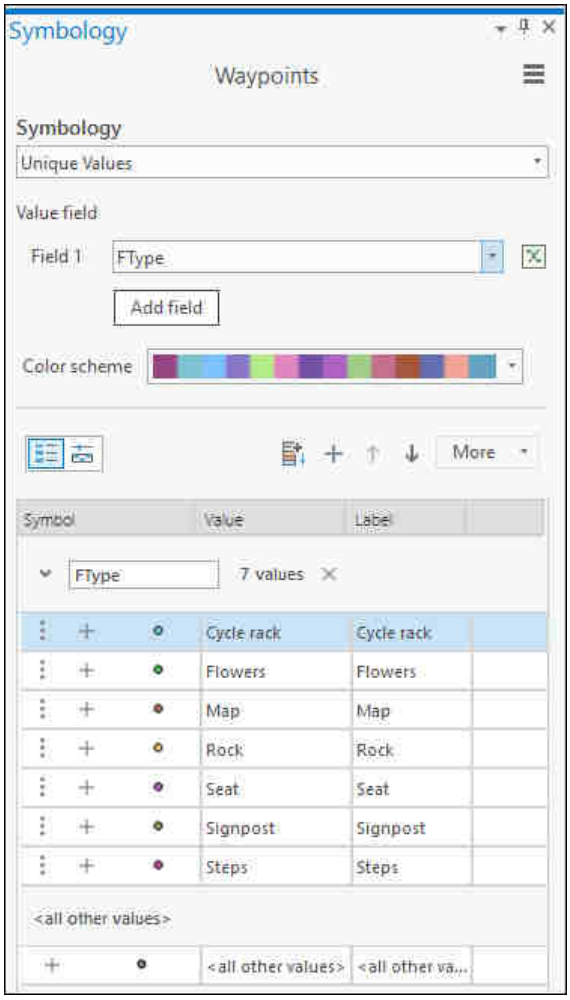


Figure B.10: Setting symbols for a layer with unique values based on the FType field

B.8 Data frame reference scale

When you print your map you will want the symbols and labels to be a particular size at a particular scale. If you set a **map frame reference scale** to the scale at which you are intending to print the map then you can set the size of the symbols and labels at this scale.

Question B.1. Zoom in to 1:500 and then zoom out to 1:25 000. What happens to the size of the symbols you have just created when you zoom in very close or zoom out?

- Scale the map to the scale that you will be printing it at by using the **scale drop down** at the bottom of the map window. In this case set the scale to **1:1 000** (you can just type **1000** into the box).

Finding and using additional ArcGIS Pro Styles
There are only a relatively limited range of symbols available in ArcGIS Pro and sometimes you'll need more. ESRI provide further styles via a gallery at `https://esri-styles.maps.arcgis.com/home/gallery.html` Unfortunately it doesn't seem to be possible to preview the symbols, but there are symbol sets such as **Ordnance Survey** and **Geology 24K** which should be helpful. To install a style in your project: • Download a style from the Gallery by clicking on it. You should end up with a `.stylx` file. • copy or move the stylx file into your map project folder • Go to the **Insert** tab of the ribbon and click on **Add** in the **Styles** group and select to **Add Style** • Navigate to where you saved the `.stylx` file and select it. You may get a message about the style not being the correct version, if you do click to allow it to update. The style should be added to your project and next time you symbolise a vector layer you'll see the extra symbols and be able to select from them. Unfortunately you do seem to need to do this for each project so it is probably worth keeping the `.stylx` files that you download for future use.

Table B.1: Finding and using additional ArcGIS Pro Styles

- Right-click on the **map frame title** in the contents pane.
- Reference Scale > Set reference scale. Arc will set the reference scale to the current map scale.

Question B.2. Zoom in to 1:500 again - what happens to the size of the labels now? And what happens to them when you zoom out to 1:25 000?

When you use the symbology settings to set the size of your symbols now, you will be setting the size that they print out at your reference scale. You may find that you do need to resize the symbols so that they don't look to crowded once you have set this.

- To remove the reference scale completely use Reference Scale > Clear Reference Scale.
- To change a reference scale set your map to the correct scale then use Reference Scale > Set Reference Scale again.

B.9 Changing the coordinate system of data

The GPS data that you have collected is in the WGS84 geographic coordinate system, but often you will need to use the data in a local projected coordinate system. The obvious example

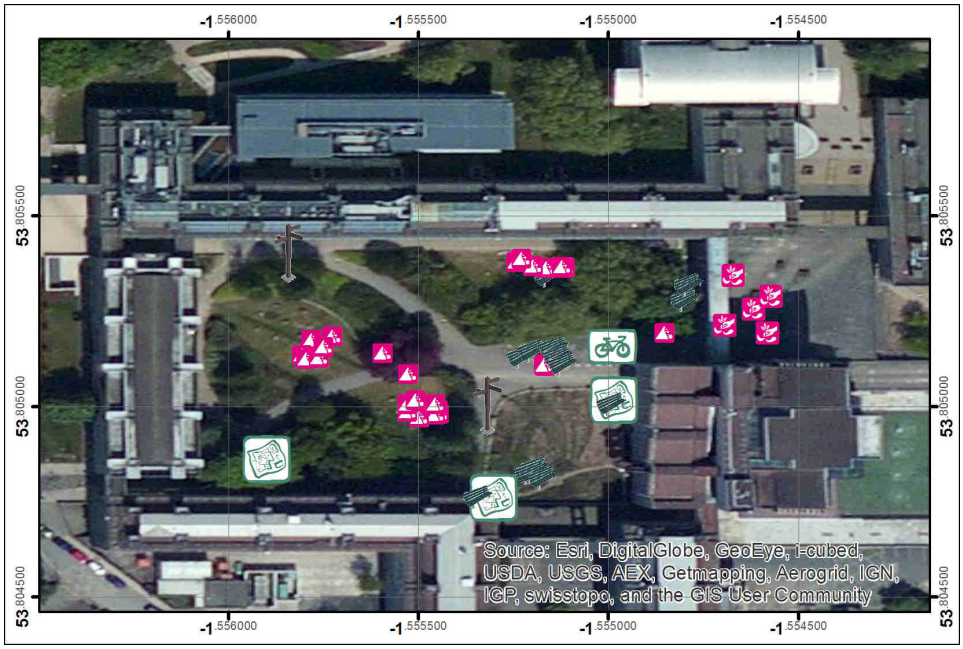


Figure B.11: An example of symbolised waypoints for Chancellors Court (WGS84 coordinate system)

is if you are using Ordnance Survey maps from Digimap in the same project. This is the example that we'll use now, but the same situation can arise if you are, for example, mapping in Spain or Eire.[7]

- Open a new map in Arc by going to the **Insert** tab of the ribbon and clicking on **New Map**
- add the **LocationBNG** shapefile that you can download from Minerva as **GPS_data.7z**. Remember that the first layer that you add to a map frame automatically sets the coordinate system.
- Change the basemap to **Imagery with labels**
- Now try adding your **Waypoints** layer.

Arc should show your waypoints layer in the correct location above the polygon for the area you have surveyed - either Chancellors Court to the south, or St Georges Fields to the north.

Have a look at the coordinate system of your map -

- Right click on the name of the map in the contents pane
- Properties > Coordinate Systems
- Make a note of the **Current XY** coordinate system below

Now check the coordinate system of the waypoints layer that you've just added:

[7] If you want to find out more about coordinate systems and projections have a look at Heywood (2006) pp. 44-51 for a general introduction. The books in the Coordinate systems and projections section of the module reading list give more detailed information.

- Right-click on the Waypoints layer
- Properties > Source > Spatial Reference
- Make a note below of the coordinate system which is given, and whether it is geographic or projected

Are the two the same? You should find that the waypoints layer is in a geographic coordinate system called **GCS WGS 1984**, while the map is in **British National Grid**.

If you were going to do any analysis or measurements on your data you would need to make sure that the two match. In this case, you want to end up with a map in **British National Grid**, which is a projected coordinate system, so you need to **reproject** the waypoints layer to match the map.

If you want to project a layer permanently, particularly if you want to do analysis on it, you have to use the **Project** tool which you find from Geoprocessing > Data Management Tools > Projections and Transformations. There are separate tools for feature classes and raster layers, in this case you would select Feature > Project

Video Clip available in Minerva - Reprojecting a feature class with the geoprocessing toolbox.

If you haven't already try changing the basemap to Imagery with Labels again (instructions in section B.6.1 on page 141) and switch off the LocationBNG layer.

Look at both of your maps from this chapter in turn and it should become obvious that changing the projection doesn't just have an effect on how your layers line up with each other, but also on the "shape" of your data.

B.10 Finally...

Question B.3. Have another close look at the gps layer. How accurate do you think the locations of the points are? What problems can you spot based on your memory of collecting the data? Compare the points you collected with the base imagery that you've added. How do you think that you could increase accuracy of data input?

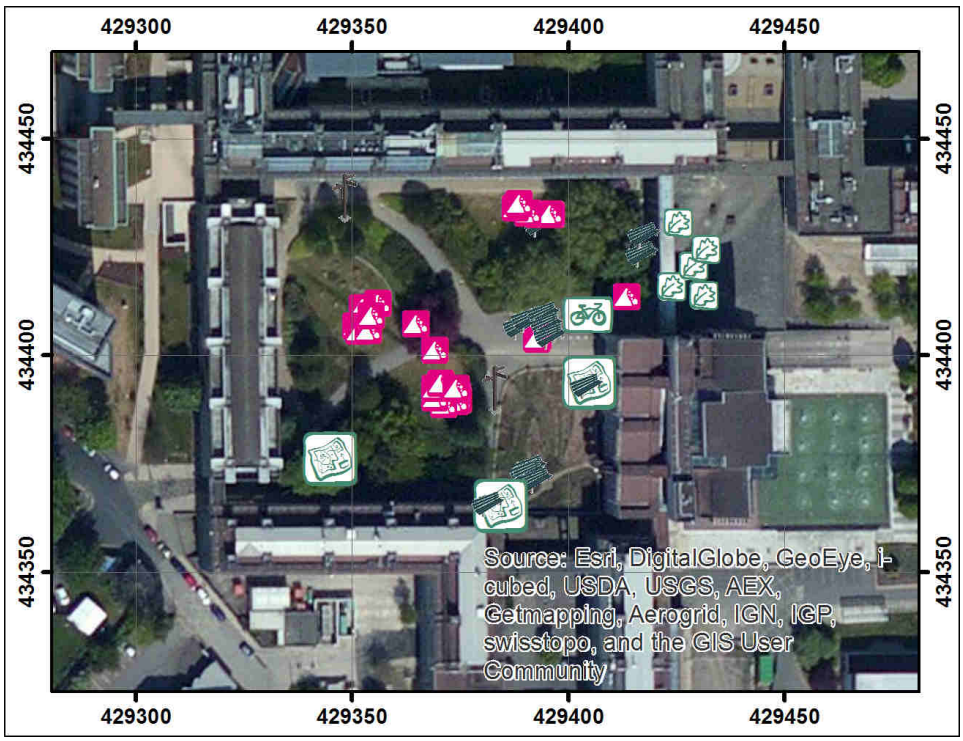


Figure B.12: An example of symbolised waypoints for Chancellors Court in British National Grid coordinate system. Compare with figure B.11 on page 147, which is in WGS 1984.

When you are mapping in the field you can use a gps receiver to locate your measurements and keep a record in your field note book. But remember the issues with accuracy (section B.4.2 on page 137) and make sure that you can also locate yourself accurately using a paper map. The advice of professional mappers is often to check the location given by your gps unit against a map every time that you take a reading!

B.11 Recommended reading: collecting data with GPS

For more detailed information have a look at the following references from the module reading list[8].

Chang (2016), Section 5.4. on creating new data includes information on GPS.

Garmin (a major gps unit supplier) has some information about GPS on their website[9] - `https://www8.garmin.com/aboutGPS/`

Heywood, I. (2011), Chapter 10 covers data quality issues, including accuracy.

[8] Reading list available from Minerva and from the module catalogue at `http://webprod3.leeds.ac.uk/banner/dynmodules.asp?M=SOEE-2650`

[9] Last visited: 18th September 2019

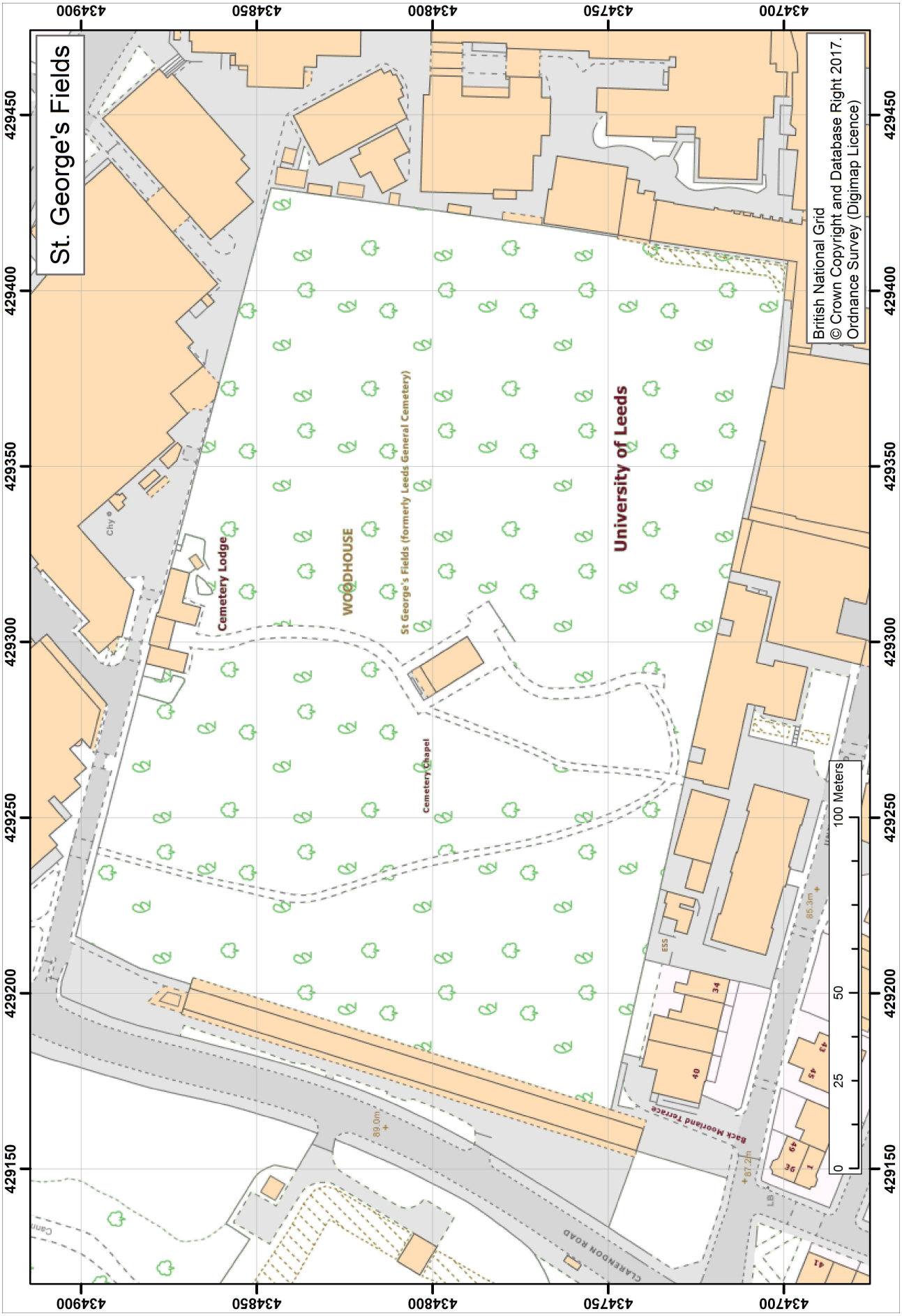


Figure B.13: Field slip for St George's Fields

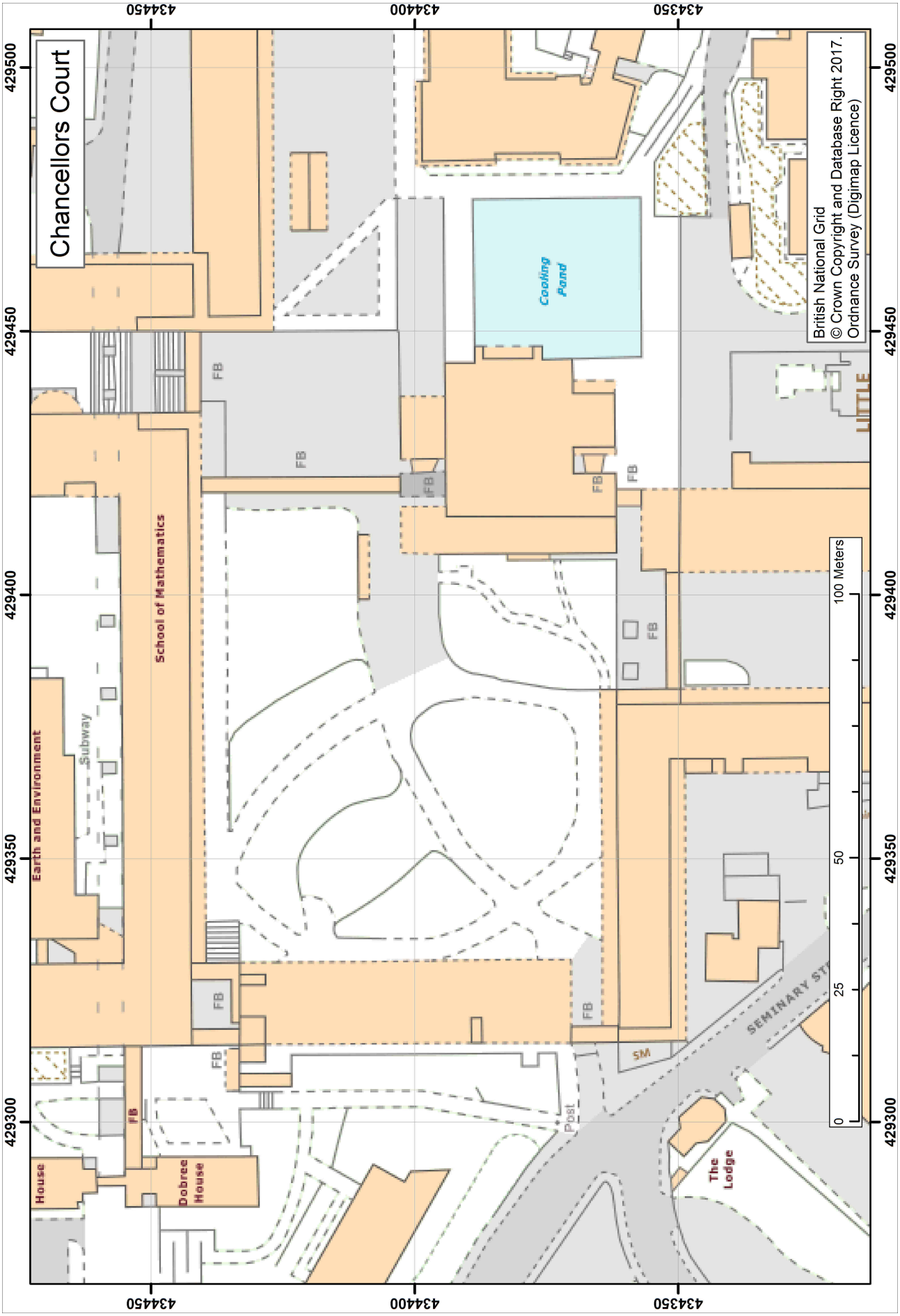


Figure B.14: Field slip for Chancellors Court

Appendix C

Answers to questions in text

These are suggested answers to the questions asked in the text. Check your answers against them but be aware that in many cases there is more than one correct answer. If you don't understand why a particular answer has been given please ask module staff or demonstrators for more information.

Chapter 1: Introduction to ArcMap

Question 1.1: On the map ribbon look for each of the tools suggested in table 1.2 in turn and try them out to see what they do.

Tool	What it does
Fixed zoom in	*Moves the view closer in to the map so that you are viewing a smaller area in more detail*
Fixed zoom out	*Moves the view out from the map so that you are viewing a larger area in less detail*
Full extent	*Zooms right out so that all of the data in your map is visible.*
Zoom to layer (this one isn't on the ribbon. Right-click on the title of a layer in the contents pane zoom to layer)	*Zooms to the extent of the data in the layer you clicked on*
click the **Select** button then click and hold on the map, drag, and let go	*Select particular features, or items from the selected layer*
click the **Clear** button in the Selection group	*This clears all of the selections that you made with the previous tool*
click on **Explore**, then click on one of the nature reserves on the map	*The explore tool should enable you to find out more about the features at a particular point on the map.*
click on **Locate**, the locate pane should open on the right of your map. Type **Sheffield** in the search box and select one of the results	*Locate should allow you to zoom straight to a place that you've searched for. If you right-click on one of the search results you'll get options to zoom or pan to that location.*

Question 1.2: How has the bookmark affected the scale of the map?
The scale should have returned to the scale that had been set when you created the bookmark.

Question 1.3: What are the names of other layers in the Malham map?
The other layers are called BedrockGeol; World Topographic Map; World Hillshade.

Question 1.4: What are the map units of the current map?

The map units should be set to meters[1]

Question 1.5: A possible definition of raster format.

A file format consisting of cells of data with each cell defined by x and y coordinates.

Question 1.6: A possible definition of vector format.

A file format consisting of paths and points which are located by x and y coordinates, and which can be joined to create lines and polygons.

Question 1.7: How many features are there in the new layer showing only the bedrock geology within 2.5 km of the Malham Tarn NNR?

There should be about 175 bedrock geology features - check the numbers by opening the attribute table for each layer and looking at the bottom left.

Question 1.8: What is the difference between zooming with the tools in the Navigate group of the Layout tab and with the tools in the Map group in layout view?

You should find that the zoom in the Navigate group changes the zoom of the layout so that you are zooming on the "sheet of paper", while the zoom in the map group changes the zoom level of the map itself without changing the size of the paper.

Chapter 2: Digimap

Question 2.1: What view does Roam take you to when you click on "Find"?

Street View - look in the bottom right of the map view to see which view you are looking at.

Question 2.2: Name some other view and basemap combinations besides **Neighbourhood** >> **VML Streetview** that allow you to select content?

Possible combinations include the following:

- Street >> Vector Map Local
- Street >> VML Plan
- Detailed >> Full Colour
- District >> Mid-scale (2016)
- City >> Strategi (2016)

There are other combinations which also allow you select. Note that none of the basemaps marked as Raster allow you to select, neither do the most zoomed out Views.

Question 2.2: Use the Measure Distance tool to measure your route to the University. How far away do you live?

Of course, I can't tell you the answer to this one. Make sure that you include the units of the measurement in your answer - which should be either metres or kilometres.

Question 2.4: What is the area of Woodhouse Cemetery?

The area is approximately 36450 m^2

[1] The spelling of words such as metres and colour are Americanised in Arc.

Question 2.5: What is the bedrock geology underneath the School of Earth and Environment?.

You'll probably need to click on the Bedrock tab to see that the bedrock unit is Pennine Lower Coal Measures Formation, and the rock type is Mudstone, Siltstone and Sandstone. The Age is listed as Langsettian Sub-Age.

Question 2.6: What is the Tile Name for 1:50 000 data at this location?

Once you've zoomed out a fair way, you should be able to see that Malham Cove is covered by a tile called "EW060". This means that it is covered by the map sheet for England and Wales with the number 60 - which matches the paper maps produced by the British Geological Survey.

Question 2.7: What is the Tile Name at this location, and on what date was the aerial imagery at this location flown? As a bonus, what town is this point within?

*This point is in Aviemore (switch on Overlays - Road/Place Names to be able to see this) and the Tile Name is **nh8912**. The date that the imagery was obtained was **2015-10-01** (as of 1st August 2018).*

Chapter 3: Creating a base map

Question 3.1: What is the name of the column that divides the contours into master and ordinary?

*The relevant column should be **SUB_TYPE***

Question 3.2: What is the name of the column which holds the information about height above sea-level?

*The relevant column should be **PROP_VALUE**, presumably indicating Property Value*

Chapter 5: Digitising geological data

Question 5.1: Using the instructions with figure 5.22 on page 94 convert the following grid references to British National Grid numbers with 6 figures for each number, then write them in the space below

The grid numbers should be as follows

1. NH 3395 3196 = 233950 831960
2. SP 727 499 = 472700 249900
3. TM 2753 3952 = 627530 239520

Index