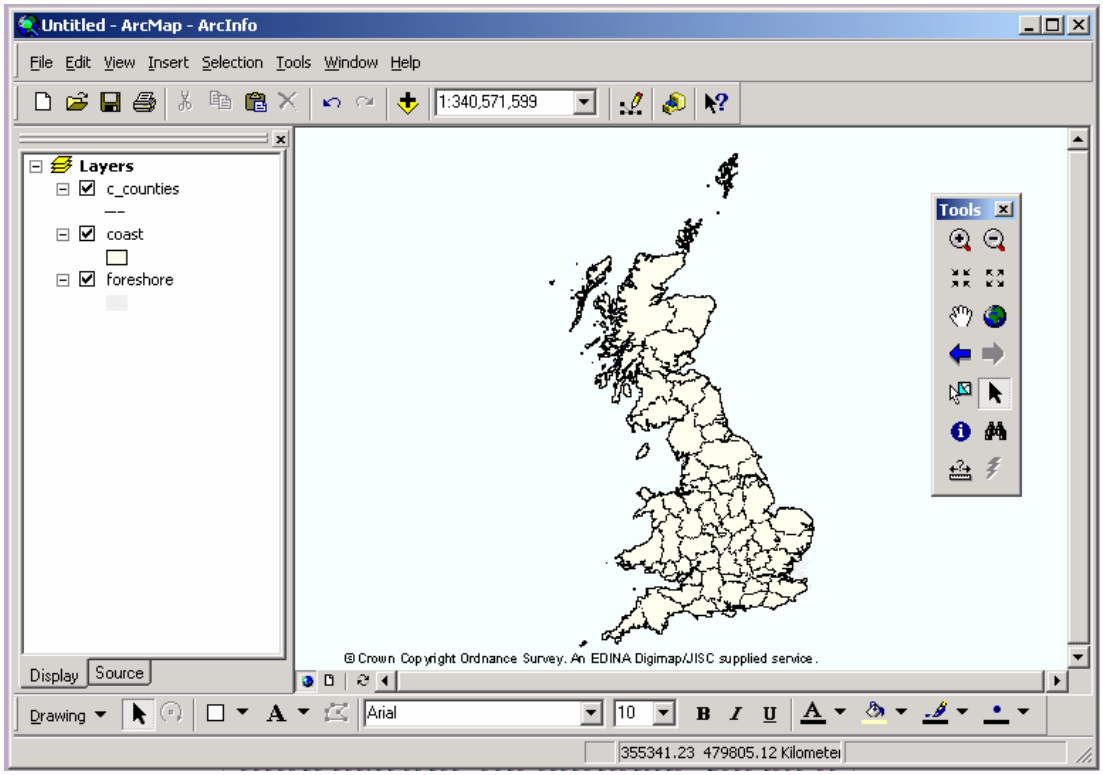
ITS Information Technology Service

Guide 37

Version 6.1

Introduction to GIS using ArcGIS



Durham University

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Conventions:

In this document, the following conventions are used:

- A typewriter font is used for what you see on the screen.
- A **bold typewriter font** is used to represent the actual characters you type at the keyboard.
- A ***slanted typewriter font*** is used for items such as filenames which you should replace with particular instances.
- A **bold font** is used to indicate named keys on the keyboard, for example, **Esc** and **Enter**, represent the keys marked Esc and Enter, respectively.
- A **bold font** is also used where a technical term or command name is used in the text.
- Where two keys are separated by a forward slash (as in **Ctrl/B**, for example), press and hold down the first key (**Ctrl**), tap the second (**B**), and then release the first key.

Contents

Introduction

Geographical Information Systems (GIS) are used to display, manipulate and analyse spatial (map) data. Spatial data are data that contain a reference to a place (in the case of this course, a place on earth).

ArcGIS is the main Geographical Information Systems (GIS) provided on ITS computers, and is used worldwide. ArcGIS is installed on both the UNIX and Networked PC services (NPCS).

This document covers using ArcGIS on the Networked PC service.

Part 1

1 Introducing ArcGIS

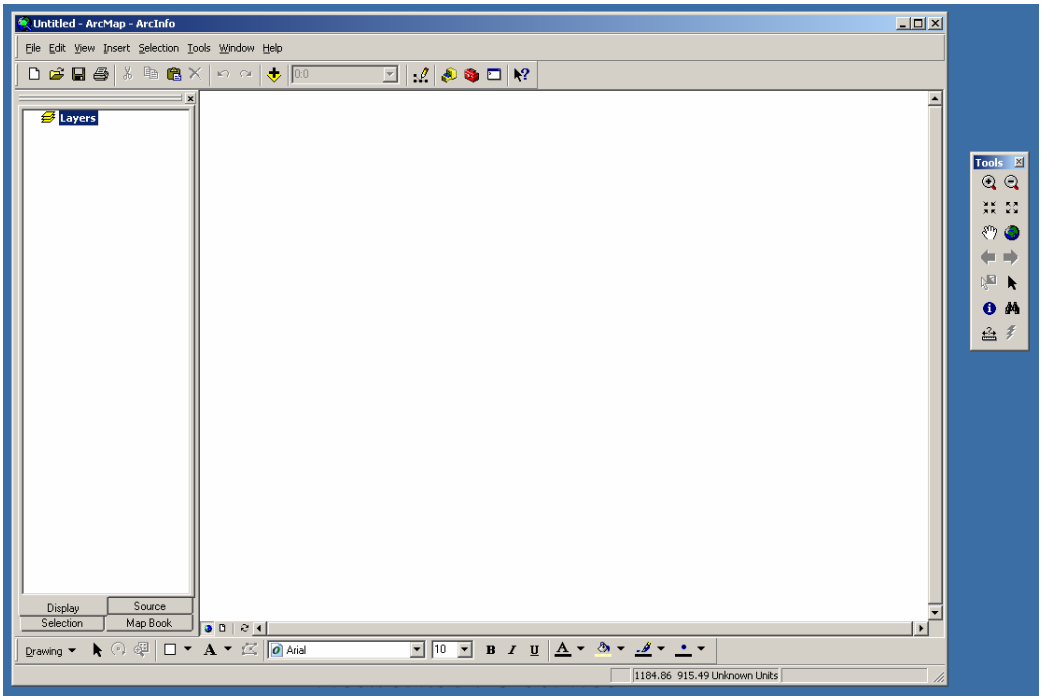
ArcGIS has four separate applications — ArcMap, ArcCatalog, ArcToolbox, ArcScene and ArcGlobe. Only ArcMap will be used in this section; ArcCatalog, ArcScene and ArcToolbox will be introduced later.

1.1 ArcMap

ArcMap is used to display map (spatial) data. It is also used to edit, query and analyse map data.

To start ArcMap select the menu item **Start | Programs | GIS | ArcGIS | ArcMap**

ArcMap will show a welcome screen. Click **OK**, and ArcMap will display an empty map as below:

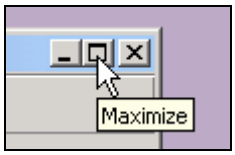


The following sections goes through adding data to a map, navigating around the map, and finally colouring and styling these.

1.2 Adding spatial data to ArcMap

Data added to a map in ArcMap are referred to as **Layers**. The steps below run through adding several layers to ArcMap.

Enlarge the ArcMap window by clicking the maximize icon in the top right corner:



To add a data source:

Click the **Add Data** icon  on the button bar,

or

Choose **File | Add Data** from the menu bar.

The **Add Data** dialog box will appear.

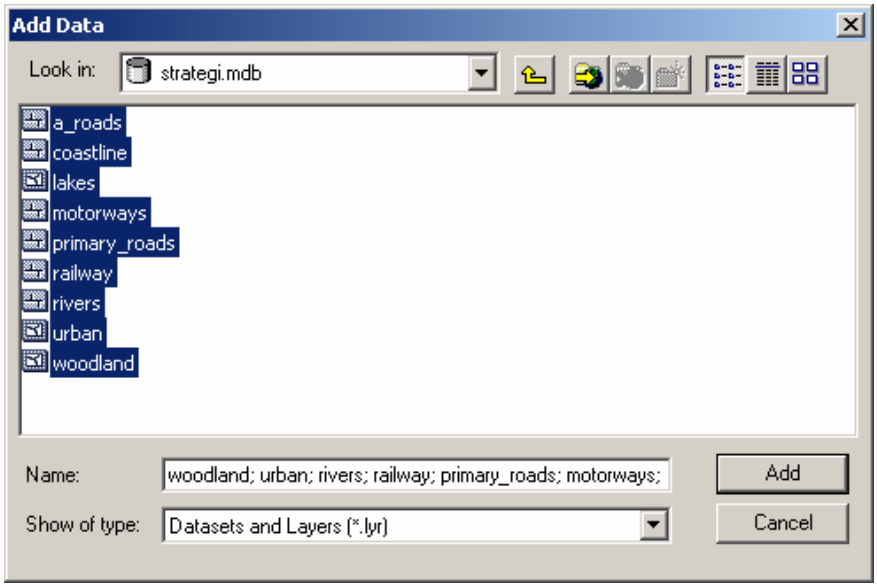
This session uses samples of the Ordnance Survey Strategi GB 1:250 000 scale data from South Wales. The required data files are stored in the folder **T:\its\gis** on the Networked PC service.

To access this data we first have to connect to the folder containing the data:

1. Click on the **Connect To Folder** icon  , navigate to **T:\its\gis** and click **OK**.
2. Double-click on **strategi.mdb**.

A list of data layers will be displayed.

3. Select all the data layers by clicking once on each in the list in turn, whilst holding down the **Ctrl** or **Shift** key:

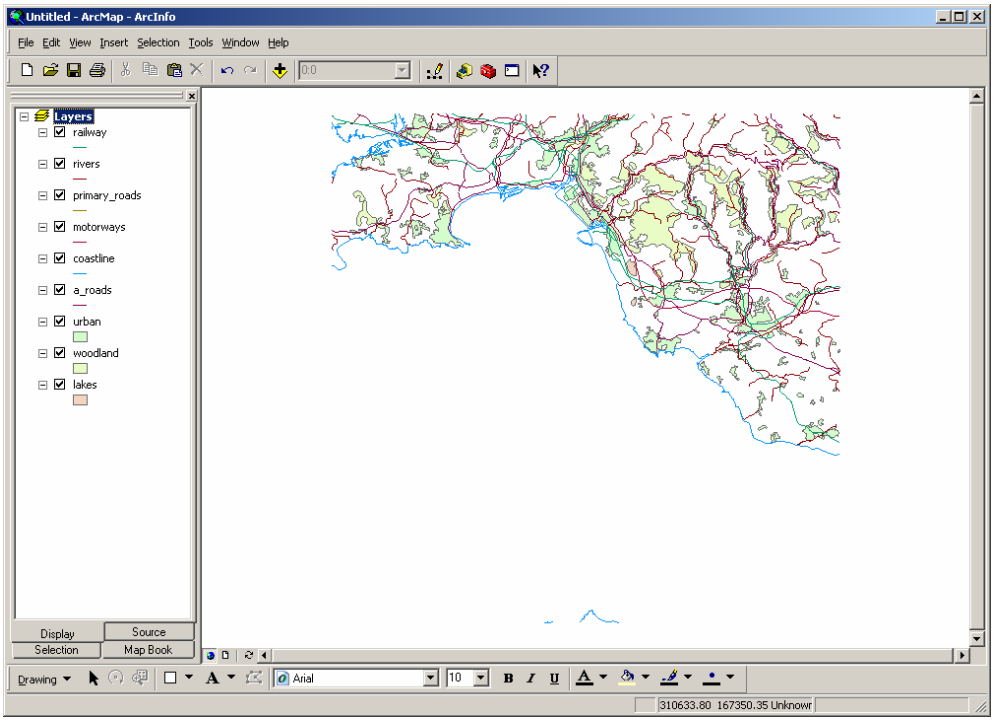


4 Once all required data files are highlighted click on **Add**

5 Ignore the message saying ‘One or more layers is missing spatial reference information’, and click **OK**.

1.3 Displaying spatial data in ArcMap

Each layer has an entry in the Table of Contents (TOC) displayed on the left-hand side of the window. There is a tick box alongside each layer entry which is used to turn the display of the layer on or off.



These datasets display quite quickly on the screen, but if you need to stop a screen re-draw, for example with large datasets, press the **ESC** key to cancel the re-draw.

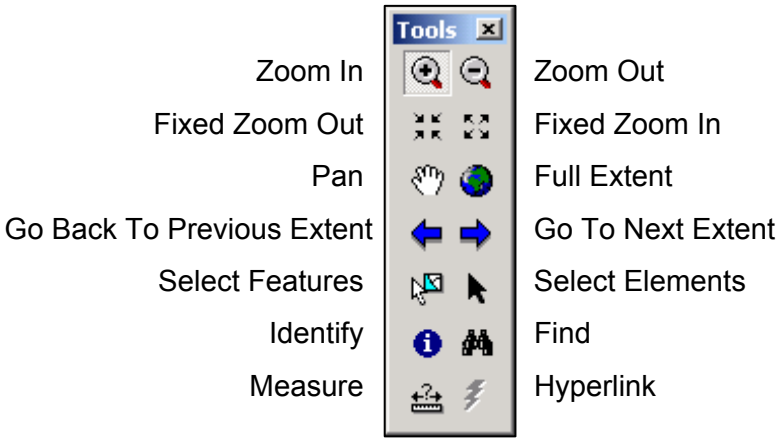
The position of a layer in the TOC determines the drawing order. ArcMap automatically orders these entries so that polygon layers (e.g. Woodland) are at the bottom of the TOC, with line layers above so that they are not obscured by polygons. Point layers would also display above polygons for the same reason.

It is possible to change the drawing order of layers. This will be covered later.

Types of data used so far are known as vector data. Vector data can be composed of point, line or polygon features and are commonly used for data that needs to display quickly, and for when a lot of control is required for setting feature colours and styles. Vector files sizes are also quite small.

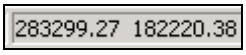
1.4 ArcMap navigation tools

ArcMap has a range of navigation tools that are located on the Tools floating toolbar displayed to the right of the ArcMap window:



Place the mouse cursor over each of these buttons in turn to get a brief description of its purpose (shown in the bar at the bottom left of the ArcMap window). Try using some of these tools.

Notice as you move the cursor around the ArcMap window that the cursor position is displayed at the bottom on the ArcMap window:



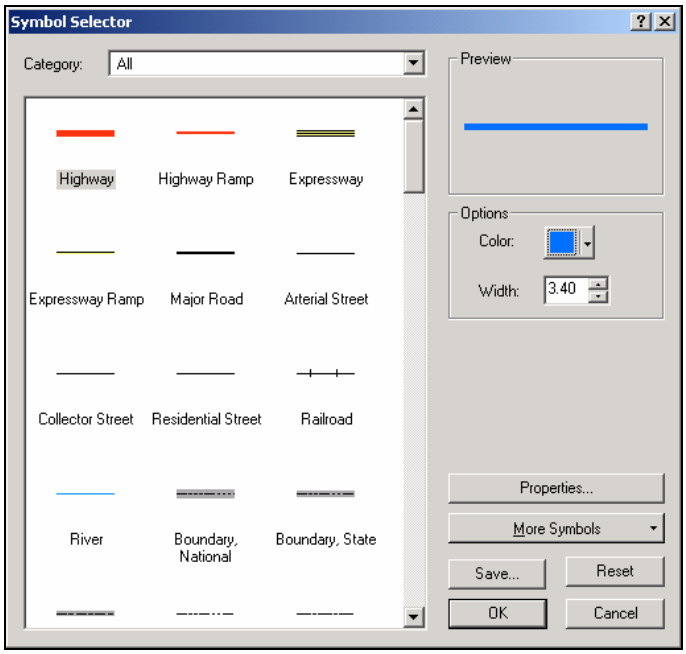
This is the real-world position of the feature on which the cursor is hovering over. The coordinates (in metres) shown for this Strategi data are the same as those that would be read off an Ordnance Survey paper map of the area i.e. the map data are displayed in Ordnance Survey Great Britain grid (OSGB).

1.5 Colouring and styling layers

ArcMap automatically assigns a random colour and style to each layer. These are rarely suitable, but can easily be changed using the **Symbol Selector**.

To change the display colour and style of a layer:

1 In the **TOC** click on the symbol you want to modify (e.g. **motorways** — the symbol appears **below** the motorways entry). The **Symbol Selector** dialog box appears**:**



2 Change the **Color:** and **Width:** to distinguish **motorways** from other layers.

3 Click **OK** when finished. The map will re-draw to reflect any changes made.

Now would be a good time to change the drawing order of the layers so that **motorways** are displayed above all other roads.

1 Click and hold the left mouse button on the **motorways** TOC entry — the layer will be highlighted.

2 Move the mouse up the TOC — a thick black line will be displayed where the layer is to be inserted — and release the mouse button when the black line is at the required position, i.e. above all other layers.

1.6 Labelling a layer

To display labels for a layer:

1 In the TOC right-click the layer you want to label and select **Properties** (do this for **a_roads**).

2 Click the **Labels** tab.

3 From **Label Field:** select the field to label with (**NU**). Note: NU is the name of the attribute field containing road numbers.

4 Click **OK**.

5 In the TOC right-click the **a_roads** layer and select **Label Features**.

Zoom into the map to view the labels.

1.7 Saving an ArcMap document

Display settings that have been defined during the current ArcMap session will be lost once ArcMap is exited. They can, however, be saved for future use by storing them as an ArcMap **map document**. At this stage it would be sensible to create a folder in which to keep this map document, and all other files used during the course.

1. Create a new folder called **giscourse** on your **J:** drive — use **Windows Explorer** or **My Computer** to do this.
2. In ArcMap choose **File | Save**, give the map document a name (e.g. **practical1.mxd**), and save it on your **J:** drive in the **giscourse** folder.

Next time you use ArcMap choose **File | Open** to retrieve your saved ArcMap map document.

Note: An ArcMap map document only contains display settings — it does not include the actual data. Only references to data are stored, so if all the data referenced in the project is on the T: drive, next time the project is opened it will fetch the data from the T: drive again. If you need to back-up, or send a map document to a colleague, both the map document and associated data must be included.

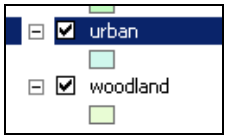
2 Attribute data and spatial querying

2.1 Accessing attribute data in ArcMap

Individual features on a map have associated information held in tabular format. These are known as attribute data.

There are two ways to access attribute data in ArcMap — using the identify tool, or by displaying the whole table for a layer.

1. First, select the **urban** layer in the Table of Contents by clicking on it with the left mouse button (the layer name will highlight):

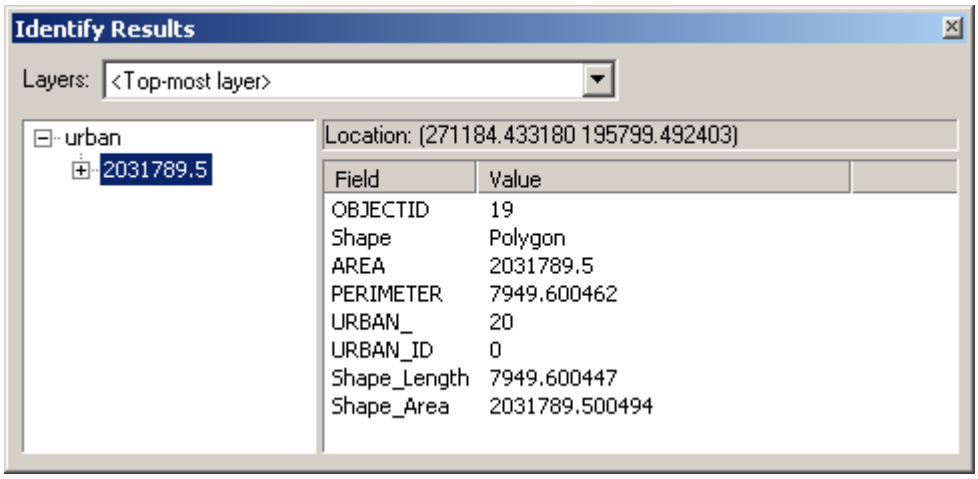


2.1.1 Using the Identify tool

1. Click on the **Identify** button on the Tools floating toolbar,

   then on a feature on the map within the highlighted layer (i.e. urban).

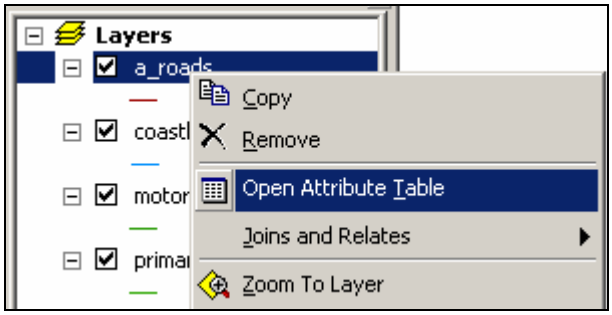
Attribute data on the layer will appear in the **Identify Results** dialog box:



2 Do the same for the **a_roads** layer and look at the field column — the **NU** value entry contains the road name (these were used earlier for labelling roads).

2.1.2 Displaying a complete table

The complete attribute table for a layer can be accessed by right-clicking on the TOC entry for the layer and selecting **Open Attribute Table** from the menu. Do this for the **a_roads** layer:



Close the table when finished.

2.2 Querying attribute data

2.2.1 Using Select By Attributes

An attribute table can be queried (i.e. search for records) using the **Select By Attributes** menu.

1 Choose **Selection | Select By Attributes** from the menu bar. The **Select By Attributes** dialog box appears.

For example, choose to select all **a_roads** that are named **A48** by entering the field to search in "**NU**", and **'A48'** as the text to search for.

To do this, in the Select By Attributes dialog box that appears:

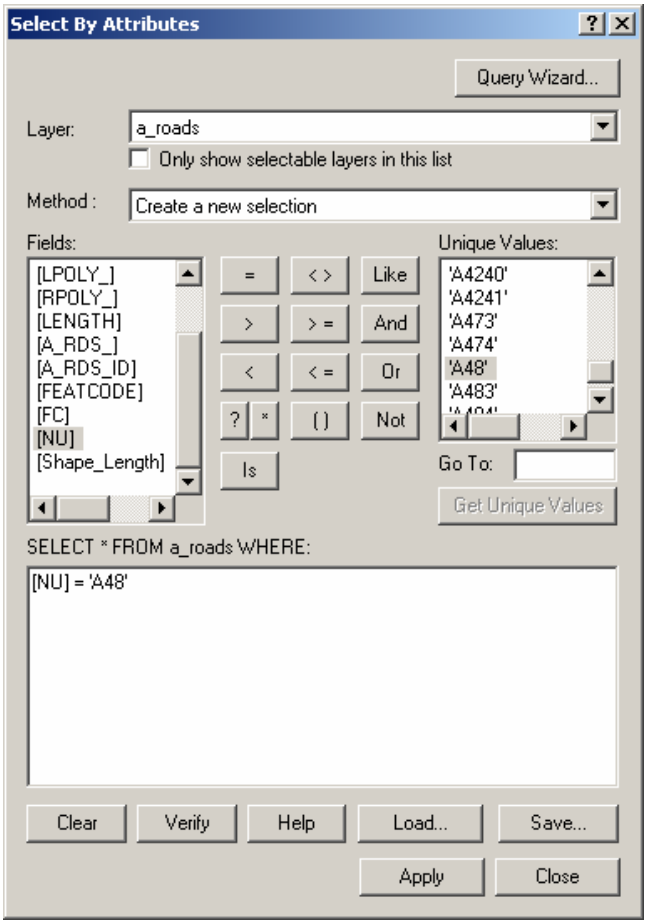
2 Check that **Layer:** is set to **a_roads**.

3 In the **Fields:** list on the left of the dialog box click **"NU"**, then double-click **'NU'** to paste it into the select box at the bottom.

4 Click the **=** icon, click **Get Unique Values** below the '**Unique values'** box on the right then double-click **'A48'** from the resultant list.

When finished the dialog box should be filled out as below.

5 Click the **Apply** button and then **Close**.



All a_roads containing **A48** in the **NU** field will now be highlighted in light blue on the map.

1 To zoom to the selected features on the map select the menu **Selection | Zoom to Selected Features**.

2 Open the attribute table (right-click on **a_roads** in the TOC and select **Open Attribute Table**).

All the associated records are also highlighted in the table.

1 To view only the selected records in the list, press the **Selected** button.

2 To switch the Table selection to all records that do not have **NU = A48** click **ALL**, then the **Options** button and **Switch Selection** from the menu.

3 Close the table.

2.2.2 Using Find

Find can be used as an alternative to Select By Attributes. Find searches all attribute data and returns a list of matches.

1 Press the **Find** button on the Tools toolbar, and enter **A4222** in the **Find:** box.

2 Press **Find**.

All occurrences of A4222 will be displayed in a box at the bottom of the dialog box. Right-click on one of these rows to **Flash feature**, **Zoom to feature,** etc. You may need to zoom out to the extent of the map (use the **Full Extent** button on the **Tools** toolbar) to see the features flash.

Close the Find dialog box when finished and choose the menu **Selection | Clear Selected Features**.

2.3 Performing a spatial query

One of the important features in a GIS is the ability to carry out spatial queries, i.e. queries on the relative position of features. This differentiates GIS from a pure mapping application.

The **Select By Location** menu choice allows us to carry out a spatial data search. For example, we may want to view all urban areas that have a motorway running through them:

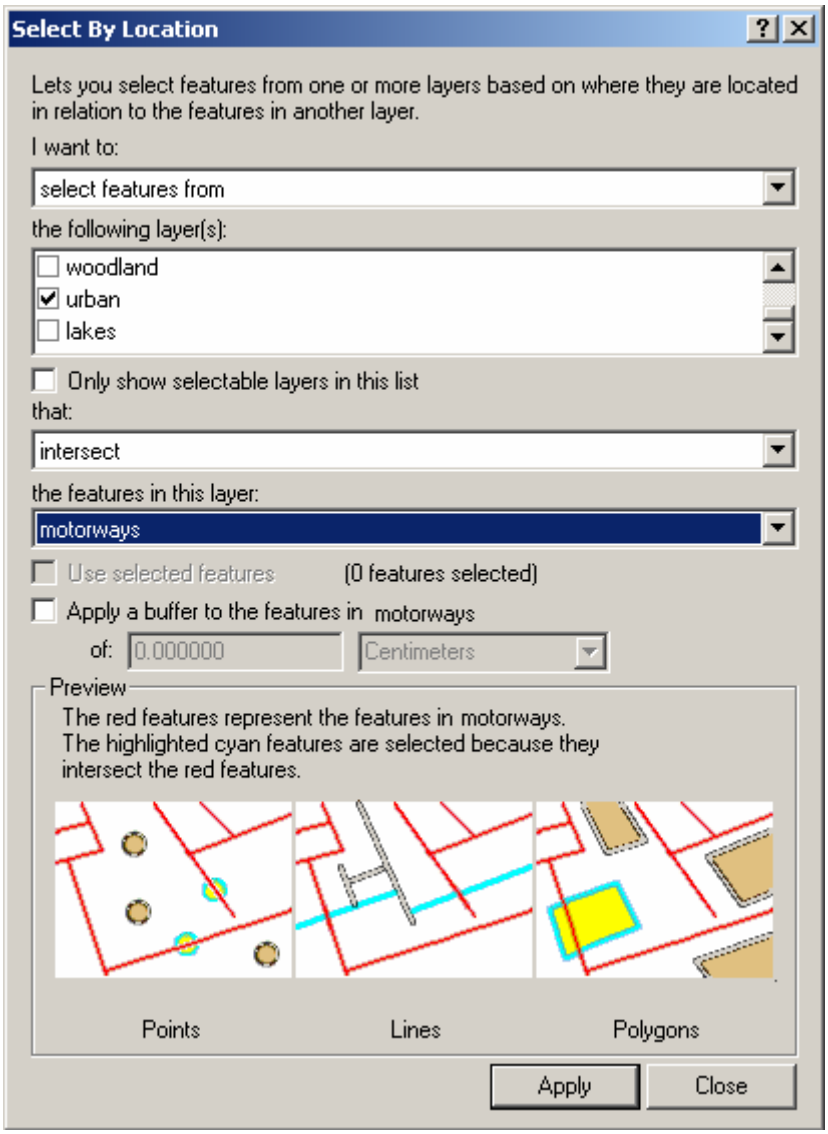
1 Choose the menu **Selection | Select By Location**.

2 Make sure **Select features from** is chosen in the first box.

3 Tick **Urban** in the second box.

4 Select **intersect** from the third box.

5 Select **motorways** from the fourth box:



6 Finally, click **Apply** and then **Close**.

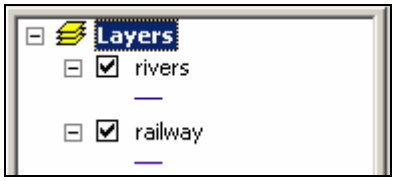
7 Selected urban areas will be shown in light blue on the map.

8 To zoom to the selected features, choose the menu **Selection | Zoom To Selected Features**.

3 Data Frames

As well as overlaying data in a map, we can create multiple Data Frames to display data from different geographical areas or to group related datasets together.

The default Data Frame is called **Layers**. It is this Data Frame we have used so far:



1. To add a new Data Frame, select the menu **Insert | Data Frame**.

The active Data Frame is shown in bold in the TOC.

2. To make a Data Frame active right-mouse click the **Data Frame** name in the TOC and select the menu item **Activate**.
3. To change the name of a Data Frame right-mouse click the Data Frame name, select **Properties** and change the **Name:** field.

   Rename New Data Frame to **Codepoint Data**.

The layer to show in this new Data Frame will be added in the next section.

4 ArcCatalog — managing data

ArcCatalog is another ArcGIS application and is used for accessing and managing data. Specifically, it can be used to move, rename and copy datasets, and preview geographic and attribute data. It is particularly useful for backing up data.

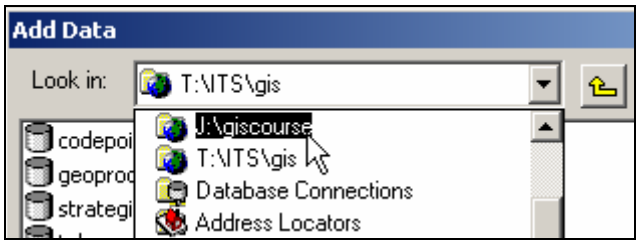
ArcCatalog is used here to view and copy a sample layer that will be used to demonstrate ArcGIS concepts and functionality in this, and following sections.

1. Open ArcCatalog by selecting **Start | Programs | GIS | ArcGIS | ArcCatalog**
2. Click on the connection **T:\its\gis** on the panel on the left of the ArcCatalog window **(**You may have to create a Data Connection by clicking on the **Connect to Folder** icon ).
3. Click the plus icon beside **T:\its\gis** and double-click **codepoint.mdb** on the left screen and highlight **codepoint_durham**.
4. Click the **Preview** tab to display a preview of **codepoint_durham**. The data are postcode unit boundaries for Durham City. Change **Preview:** at the bottom of the screen to **Table** to display the associated attribute data.

Use ArcCatalog to copy **codepoint.mdb** to your **J:\giscourse** folder:

5. Right-click **codepoint.mdb** in the pane on the left and select **Copy**.
6. Use the **Connect To Folder** icon to set a connection to **J:\giscourse** if one does not already exist.
7. Navigate to **J:\giscourse**, right-click in the pane on the right (make sure the **Contents** tab is selected) and select **Paste**. **Codepoint.mdb** will be copied into this folder.

In ArcMap add **codepoint_durham** from **J:\giscourse\codepoint.mdb** to the **Codepoint Data** Frame. Select **J:\giscourse** from the pull-down menu first:



The unit postcode boundaries will be displayed in ArcMap. A unit postcode is also known as the full postcode e.g. DH1 3LE. Look at the attribute data for codepoint to see the postcodes.

Add the file **T:\its\gis\durham50k.tif** into ArcMap. This is a 1:50 000 raster map of Durham which provides some detail to the codepoint data. Make the codepoint_durham data transparent so that it does not obscure the raster map (In the **TOC** click on the symbol **below** the codepoint_durham entry and set the Fill Color: to No Color, Outline Width: to 2 and Outline Color: to Blue).

5 Database management

ArcMap is also used for database management. This section will introduce joining databases together using common fields, altering record values and creating and automatically populating new fields using the codepoint data used above.

5.1 Database join

A database containing additional attribute information can be appended to a layer using a common field. For example, with the codepoint_durham layer additional attributes such as number of delivery points can be appended. There needs to be a common field to ensure that each postcode polygon is matched to the correct delivery point data.

The following example works through the steps to join a file, **dh.csv** to the **codepoint_durham** layer using the common field **postcode**.

1. Open **T:\its\gis\dh.csv** in Excel to view the data (when opening set **Files of type:** to **All Files (*.*)**). Note the first column contains postcodes. Look at the other columns headings to see what they contain.
2. Close Excel.
3. In ArcMap right-click **codepoint_durham** in the TOC and select **Open Attribute Table**.
4. Move the attribute table and ArcMap window so that both can be seen on the screen, then right-click **codepoint_durham** in the TOC and select **Joins and Relates | Join**.

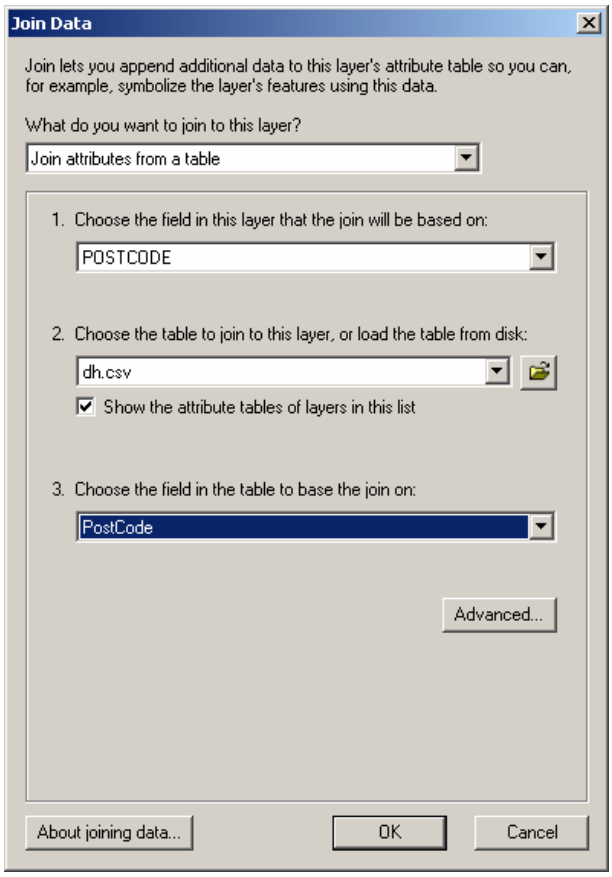
5 In the **Join Data** dialog box make sure the top box is set to **Join attributes from a table**.

6 Set drop-down box **1.** to **POSTCODE**. This is the join, or common field.

7 Click on the open button beside drop-down box **2.**, navigate to **T:\its\gis**, highlight **dh.csv** and click **Add**.

8 Set drop-down box **3.** to **PostCode**. This is the join, or common field.

9 The completed dialog box should look as below when complete. Click **OK**:



10 The additional fields from dh.csv will now be displayed at the end of the codepoint attribute table. The field names from codepoint_durham will be pre-fixed codepoint_durham.

To permanently join this new data to codepoint the layer must be exported and given a new name. If this is needed right-click on codepoint_durham in the TOC and select Data | Export Data. Do not do this now, but remove the join by right-clicking **codepoint_durham** in the TOC and select **Joins and Relates | Remove Join(s) | Remove all Joins.**

5.2 Updating attribute data

Data, or attributes in a database table can be updated manually, or semi-automatically. The example below demonstrates how to do this manually and the subsequent section shows a semi-automated method.

To alter attributes in a table it first has to be made editable:

1. Turn on the Editor toolbar through the ArcMap menu **View | Toolbars | Editor**.
2. Select the **Editor** menu from the left-hand side of the Editor Toolbar and choose **Start Editing**.
3. Alter some of the data in the postcode field by clicking and typing in a cell in the attributes of codepoint_durham table. Press the **Enter** key to confirm changes.

These changes will be permanent once saved, which we do not wish to do now. Choose **Stop Editing** from the **Editor** menu and select **No** to confirm these changes are not to be saved.

5.3 Creating and updating new fields

New fields can be added to an attribute table in ArcMap. Add a field called **poly_size** and enter values into this:

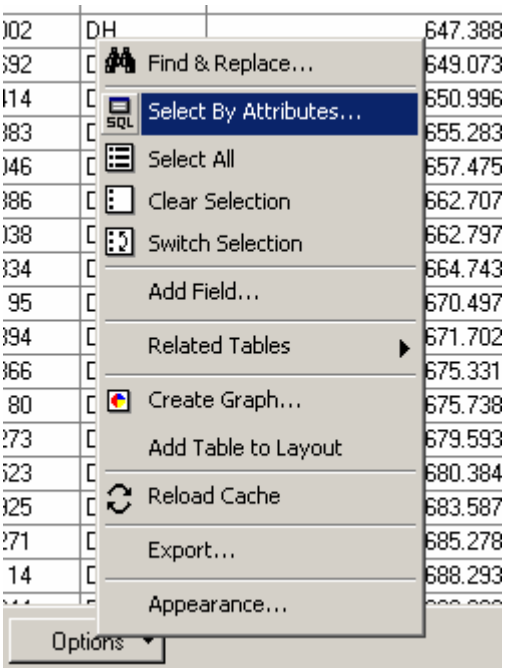
1. Click the **Options** button at the bottom right of the attribute table and select **Add Field**. If an 'Add Field Failed…' error message is given close ArcCatalog first.
2. Type **poly_size** in the **Name:** field and set **Type:** to **Text**.
3. Under **Field Properties** set **Length** to **5**.
4. Click **OK**.

This new field can be updated based on a query on the **Shape_Area** field:

- All postcode polygons with an area value between 0 and 600 are to be classified as **small**.
- All polygons with an area value greater than 600 are to be classified as **large**.

Select polygons with an area value between 0 and 600:

1. Select **Options | Select By Attributes**:



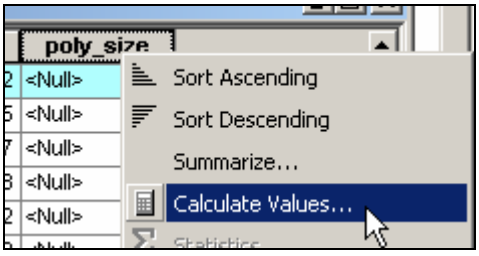
2 In the **Select by Attributes** dialog box that appears, use the Fields and operator buttons to enter the following in the lower white panel:

[Shape_Area] >0 AND [Shape_Area] <=600

3 Click **Apply** and 105 selected records will be shown highlighted.

For these highlighted records the poly_size field needs the text **small** entering:

1 Right-click on the title bar of the poly_size field, and choose **Calculate Values**:



2 Click **Yes** to the warning message shown, and in the field calculator dialog box enter "**small"** in the lower panel and click **OK**. Note: do not forget the quotes.

The text **small** will be entered into all the selected records. Do the same for the second criteria ("Shape_Area" > 600) and enter **large** as the text.

Close the Select By Attributes dialog box.

6 ArcGIS Help

The ArcGIS online Help provides in-depth help on using the software. To access it, go to **Start | Programs | GIS | ArcGIS | Desktop Help**.

There is also a full set of digital manuals provided with the software. These are available at **Start | Programs | GIS | ArcGIS | Digital Books**. The books are very comprehensive and provide tutorials on all the ArcGIS applications.

7 Exiting ArcMap

Save the map document (**practical1.mxd**) before you close ArcMap. This will be used again in Part 2. Close ArcMap using the menu **File | Exit**.

Part 2

This part builds on the work done in the Part 1 and covers importing GPS data, using raster data and creating a printable map.

Before starting open the map document **practical1.mxd** from the previous session:

1. Start ArcMap.
2. In the dialog box that appears select **An existing map** then click **OK**.
3. Navigate to **J:\giscourse**, select **practical1.mxd**.
4. Click **Open**.

8 Importing Ordnance Survey and GPS data

This section will demonstrate importing Ordnance Survey Land-Line data downloaded from Digimap and displaying this together with data captured with a GPS unit.

8.1 Using Land-Line compressed (zipped) data

The Ordnance Survey Land-Line data are contained in a zip file on the T: drive. It is common to compress files into a zip archive. They are smaller and provide a far more efficient method for backing-up data, e-mailing attachments, or downloading data from a web-site.

> Create a new Data Frame and call it **Durham Science Site** (select the menu **Insert | Data Frame** and right-mouse click the Data Frame name, select **Properties** and change the **Name:** field.)

Power Archiver is installed on the Networked PC service to manage zip files:

1. Start Power Archiver from **Start | Utilities | Power Archiver**.
2. Click on the **Open** button, navigate to **T:\its\gis**, highlight the file **science_site.zip** and click **Open**.
3. The contents of the zip file will be displayed.
4. Select all the files using **Edit | Select All**, and click on the **Extract** button.
5. Enter **j:\giscourse** in **Extract to:,** and click **Extract**. The uncompressed files will appear in j:\giscourse.
6. Close Power Archiver.

Use Windows Explorer or My Computer to view the contents of J:\giscourse.

The extracted files (landline.*) are Ordnance Survey Land-Line data at 1:1250 scale in shapefile format. They have been downloaded from

Digimap in NTF format and converted to shapefile using a conversion program called Map Manager.

There is also one extra file called **gps_pts.txt**. This will be used later.

Now add the Land-Line Layer (landline.lyr) into the empty Data Frame **Durham Science Site** using the Add Data icon  . You will need to add a new connection (using the **Connect to Folder** icon ) to **J:\giscourse**.

Navigate around the data to orientate yourself.

8.2 Importing GPS data with ArcCatalog

GPS (Global Positioning System) is a collection of 27 NAVSTAR satellites orbiting the earth. Signals from these satellites can be collected by GPS receivers to determine the 3D position of the receiver. The cheapest handheld receivers can collect data at better than 10m accuracy. High-end receivers, combined with Differential GPS (combination of a roaming receiver and a fixed receiver at a known location) can improve accuracy to the sub-metre level.

The file **gps_pts.txt** also extracted from the zip file to **J:\giscourse** contain co-ordinates of points collected by GPS from the Science Site. These data will be added into ArcMap to overlay the Land-Line data.

To display the **gps_pts.txt** we first have to import the data using ArcCatalog:

1. Start ArcCatalog if it is not already running.
2. Navigate to **J:\giscourse**, and double-click on **gps_pts.txt** to view the file in Notepad. (Make sure the **Contents** tab is selected in the right-hand pane). If the file is not visible select the menu **View | Refresh**.

gps_pts.txt is simply a text file containing a comma-separated list of latitude, longitude, altitude and time values.

3. Close Notepad.
4. In ArcCatalog right-click on **gps_pts.txt** and select **Create Feature Class | From XY Table**.
5. Make sure **X Field:** is set to **Longitude**, and **Y Field:** is set to **Latitude**
6. The GPS points are in latitude/longitude coordinates. This must be specified so that they are imported correctly:

   Click the **Spatial Reference of Input Coordinates** button, click **Select**, double-click **Geographic Coordinate Systems | World** and select **WGS 1984.prj**. Click **Add** then **OK**.
7. In the **Output** section at the bottom ensure Output Shapefile is set to: **J:\giscourse\XYgps_pts.shp** then click **Advanced Geometry Options**.

To get the GPS points to overlay data already in the data frame **Durham Science Site** the projections must match. Currently the gps_pts.txt data are in latitude/longitude — they must be converted to Ordnance Survey Great Britain grid to match. To do this the following Output option must be set:

8 Click **Edit |Select | Projected Coordinate Systems | National Grids | British National Grid.prj,** then **Add,** then **OK,** then **OK**.

9 Finally, click **OK** to import to convert gps_pts.txt.

10 Once complete go to ArcMap and add **J:\giscourse\XYgps_pts.shp** to the **Durham Science Site** data frame.

The GPS points will appear overlain on the University science site.

11 Before finishing this section save the map document with the menu **File | Save** and close down ArcMap using **File | Exit**.

9 Raster data

All the data used so far has been vector data (i.e. point, line or polygon features). Another important type of data used in GIS are raster data, where features are broken up into individual cells, or pixels. Raster files can be quite large, but offer a wide range of analysis options.

The following sections go through the process of converting vector data to raster, and then carrying out analysis on this data.

9.1 Add Geology vector data

1 Start ArcMap up again, but do not open your previously saved Map document (practical1.mxd). Use the default blank document that is shown on start-up

2 In ArcMap rename the default **Layers** data frame to **Raster Analysis** (click once on the **Layers** label, then click again to edit the label).

3 Click the **Add Data** button.

4 Navigate to **T:\its\gis** and highlight **tahoe_geol.lyr**. Click **Add**.

tahoe_geol.lyr is geology data of Tahoe in the US.

9.2 Using Spatial Analyst

Advanced functionality in ArcMap is provided in Extensions, one of which is Spatial Analyst.

ArcMap will display raster data, but Spatial Analyst must be used for modelling and analysing raster data. We will use it first to convert the vector **tahoe_geol** data to raster format.

Extensions have to be turned on by adding a new menu bar to the ArcMap window:

1. Turn Spatial Analyst on by ticking its entry under **Tools | Extensions** then turn on its menu on by selecting **View | Toolbars** and left-mouse click the **Spatial Analyst** entry.
2. The Spatial Analyst menu appears in the ArcMap window.

9.3 Converting vector data to raster

To convert the vector data **tahoe_geol** to raster format:

1. From the Spatial Analyst menu bar choose **Spatial Analyst | Convert | Features to Raster**.
2. In the **Features to Raster** dialog box make sure **Input Features:** is set to **tahoe_geol.lyr**, **Field:** is set to **GEOLOGY** (NOT Geology_) and **Output raster:** is set to **J:\giscourse\tahoe_raster**
3. Click **OK**.

When the vector to raster conversion has finished the new raster data **tahoe_raster** will appear in the **Raster Analysis** Data Frame. Turn off the **tahoe_geol** vector layer first as it obscures layers below it. ArcGIS Raster data are in GRID format.

Navigate around **tahoe_raster** and use the identify tool to query cell values. The data contains the same geology attribute data as the vector data equivalent. Zoom into the data to see the individual cell pixels.

9.4 Digital Elevation Model — raster data

A Digital Elevation Model (DEM) is a raster representation of height data. In this example the heights are of land above sea level.

Add in a DEM of upper Tahoe to the Data Frame containing geology data:

1. Click on the **Add Data** button.
2. Navigate to **T:\its\gis**, highlight the **tahoe_dem** and click **Add**.

Turn off **tahoe_raster** if it obscures **tahoe_dem**.

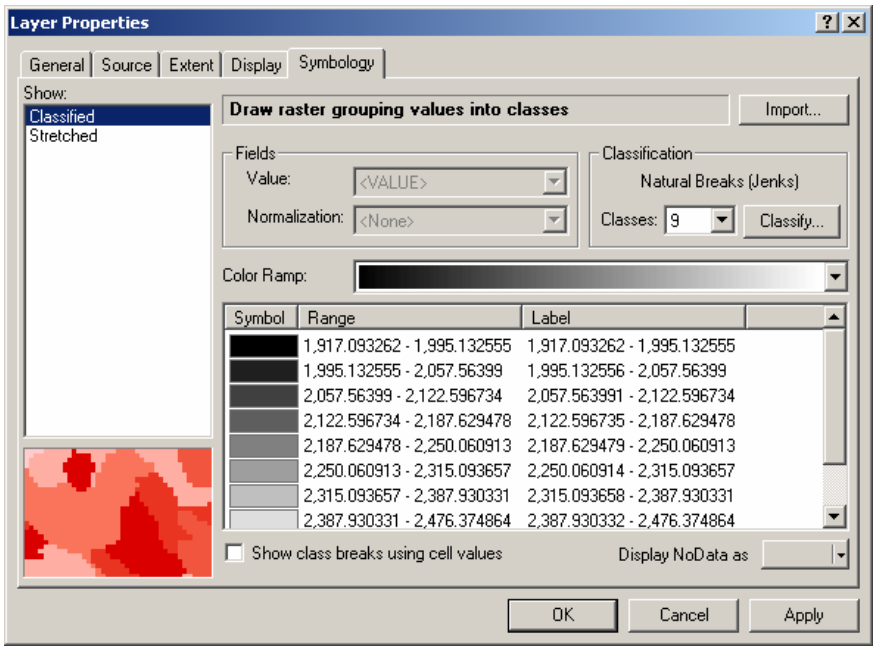
ArcMap automatically assigns a stretched colour ramp scheme to **tahoe_dem**.

Navigate around **tahoe_dem** and use the identity tool to query grid cell values. The values are in Feet above sea level.

9.5 Change classification of raster data

The stretched colour ramp automatically assigned by ArcMap is not always appropriate. This can be changed using Layer Properties:

1. Open the **Layer Properties** dialog for the **tahoe_dem** layer by double-clicking on its entry in the TOC.
2. Make sure the **Symbology** tab is selected. To change to a classified scheme, click **Classified** on the left-hand side and change **Classes:** to 9:



The colour used can be changed from the **Color Ramp:** drop-down menu.

The individual values used for each class can be changed by clicking on the **Classify** button and altering the **Break** values for each class.

3 Click **OK** to accept changes.

9.6 Create slope map

Using a DEM, it is straightforward to create a raster showing the slope:

1 From the Spatial Analyst menu make sure that the **Layer:** is set to **tahoe_dem** then choose the menu **Spatial Analyst | Surface Analysis | Slope**.

2 Click **OK** on the **Slope** dialog box.

A slope layer called **Slope of tahoe_dem** is created, with slope values in degrees.

9.7 Integrating Raster data

It is now possible to use **Slope of tahoe_dem** and **tahoe_raster** layers together to carry out suitability analysis.

Imagine the scenario where these data are to be used to find suitable locations for the siting of a granite quarry. We need to find areas of Cretaceous intrusives (i.e. Granite) that are on relatively flat land. So, from the slope layer we need to select areas that have a slope of less than 3 °, and from the **tahoe_raster** layer we want to select areas only containing Cretaceous intrusives as the surface geology.

Using Spatial Analyst functionality we can combine these conditions from both layers to create a suitability map:

1. Select **Spatial Analyst | Raster Calculator** from the menu.
2. Use the **Layers** entries and buttons to put the following formula into the query box at the bottom of the dialog box:

   [Slope of tahoe_dem] < 3 & [tahoe_raster] == 1

   The value 1 from tahoe_raster corresponds to Cretaceous intrusives (granite).
3. Click Evaluate.

The resulting layer **Calculation** shows where the slope is less than 3 degrees, and granite is present. Calculation is coded with 0 = false, and 1 = True (i.e. suitable – the criteria is satisfied with granite located in areas with slope < 3).

To view the layers under Calculation double-click it's entry in the TOC and under the **Display** tab set transparency to 30%.

The calculation is not permanent and will be automatically deleted when ArcMap is closed down. To make this calculation permanent save it to the J: drive and call it s**uitability**:

1. Right-click on **Calculation** and select **Make Permanent**.
2. Navigate to J:\giscourse and enter **suitability** in the **Name:** field.
3. Click **Save**.
4. This layer can be renamed in the Table of Contents – click once on the Calculation label in the TOC and click again to edit it – rename it Suitability.

These three criteria may not be sufficient to base a decision on. Further analysis could include combining information on, for example, protected areas where quarrying may be not allowed or ease of access by road.

Before starting the next section save the map document as **j:\giscourse\rasterdata.mxd**.

10 Producing final output — The Layout View

The suitability layer produced in the previous section will now be used to create a presentation-quality layout ready for printing.

10.1 Creating a Layout

Although printing can be done directly from the Data View, for final map output the Layout View is recommended. The Layout View is used to display the map along with a north arrow, scale bar, legend, graphs, explanatory text etc.

Create and print a Layout View from the Suitability layer:

1. First, remove all layers except **suitability** from the **Raster Analysis** data frame. To do this right-click each layer in turn in the TOC, and select **Remove**.
2. Select **Layout View** from the icon just below the bottom left of the map: 

As default a neat line is added around the map.

Set the Data Frame units to feet so that the scale bar is correct:

1. Select the menu **View | Data Frame Properties**.
2. On the **General** tab under **Units** set both **Map:** and **Display:** to **Feet**.
3. Click **OK**.
4. Select the menu **Insert | Scale Bar**, choose **Properties** and set **Division Units** to **Feet**.
5. Click **OK** and **OK** again.
6. Insert a title, legend and north arrow from the menu **Insert**.
7. Move the elements to appropriate places on the map by clicking and dragging with the mouse.,
8. Finally, insert a text box and include a copyright note:

When using data it is very important to acknowledge the copyright holder. In this case the map has been created from ESRI data, so the note should say:

Copyright ESRI

10.2 Printing the map

Printing from ArcMap is relatively straightforward:

1. To print the Map, select **File | Print** from the menu bar.
2. The default printer is the **Self Service** black and white laser printer. If this is not suitable, click on **Setup** and choose a printer from the drop-down list below **Name:**
3. Click **OK** and **OK** again to print.

There are a range of printers available, including A4, A3 and A0 Black & White and Colour - for a full list look at:
www.dur.ac.uk/its/services/printing/

11 Exporting maps to use in other applications

Maps are commonly placed into other applications, for example a Microsoft Word document or for inclusion in a web page.

To export a map choose **File | Export Map** and choose **JPEG** or another format as the **Save as type**. Enter a **File Name** and click **Save**.

To use a JPEG file in Microsoft Word, select **Insert | Picture | From File**, select the JPEG file and click on **Insert**.

To paste a Layout into Word highlight the Layout in ArcMap, select **Edit | Copy**, open Word and select **Edit | Paste**.

Finally, save the map document (**rasterdata.mxd**) and select **File | New** from the menu to create a Blank Document.

12 ArcToolbox

ArcToolbox provides access to advanced geoprocessing functionality and will be used here to alter vector data.

Turn on the ArcToolbox window on by selecting **Window | ArcToolbox**.

12.1 Dissolve

This example shows how to dissolve polygon data based on an attribute. The data are regions of France which are to be dissolved to create a country boundary:

1. Add in **T:\its\gis\geoprocessing_data\Level_1_Provinces\France_regions**
2. From ArcToolbox select **Data Management Tools | Generalization | Dissolve**.
3. Click **Show Help** to understand what Dissolve does.
4. Select **France_regions** from the drop-down box under Input features.
5. Under **Output Feature Class** enter **J:\giscourse\France_dissolve.shp**.
6. Tick the correct attribute under **Dissolve_field(s)** (i.e. the attribute to dissolve on which is CNTRYABBR). This attribute will be the same for each region i.e. the country name, France.
7. Click **OK**.

Once dissolve is complete the output file will be added to ArcMap. Look at what has happened. Also look at the CNTRYABBR in the attribute table of the original data to understand what Dissolve has done.

12.2 Clip

Data often covers an area far larger than that required, which can slow down analysis and mean file sizes are too large. Clip allows data to be ‘cookie-cut’ to the required study area. The following show how to clip out an area from the data created in the last example.

1. Remove all layers from the currently active data frame except the dissolved layer.
2. Add in **T:\its\gis\geoprocessing_data\ Level_1_Provinces \study_area**
3. This new layer is a polygon which defines the limit of a hypothetical study area.
4. Select **ArcToolbox | Analysis Tools | Extract | Clip**.
5. **Show Help** describes the clip tool.
6. Select the **France_dissolve** layer under **Input Features**.
7. Select **study_area** as the polygon clip layer under **Clip Features**.
8. Enter an **Output Feature Class** name.
9. Click **OK**.

Turn off study_area and France_dissolve to see the output from Clip.

12.3 Union

Union will combine multiple layers into a single one. This example shows how to merge two layers; one containing the country boundary of Norway, the other of Sweden:

1. Create a new Data Frame and add in **T:\its\gis\geoprocessing_data\countries\norway** and **sweden**.
2. Select **ArcToolbox | Analysis Tools | Overlay | Union**.
3. Select **View Help** for an explanation of Union.
4. Select norway and sweden in turn from **Input features**.
5. Set **Output feature Class** to **c:\temp\norswe.shp**. Do not save to your J:\ drive as the output file is large. Note: all files in c:\temp are deleted when logging off an NPCS machine.
6. Click **OK**.
7. The new merged layer will be added to the map.
8. Turn off the existing norway and sweden layers and confirm that Union worked correctly in the new file.

Look in the Index tab at the bottom of the ArcToolbox window for other commands e.g. Intersect and Merge.

Part 3

Part 3 covers creating and editing data and introduces the extensions Geostatistical Analyst, ArcScene and 3D Analyst, Tracking Analyst, Survey Analyst and ArcScan.

13 Digitising and editing data

All the data used in this Guide has been pre-prepared, and in digital format. However, it is quite possible that for a particular project data is not available in digital format, but only on paper maps. Data from paper maps can be input into a GIS by a process of digitising; either digitising from paper maps laid on a digitising table where features are traced manually using a 'mouse', or by heads-up digitising where a paper map is first scanned and features are then traced from this image on-screen with the mouse. The example below goes through the steps to do heads-up digitising.

For more information on digitising look in the ArcGIS Desktop Help under **Editing in ArcMap**.

13.1 Creating and editing a geodatabase in ArcMap

Geodatabases have been used for most of this course. A geodatabase is an ESRI format based on a Microsoft Access database that can contain both geographic and attribute data.

For this section an empty geodatabase must first be created in which the data can be added by digitising.

ArcMap Editor is used to edit a geodatabase, and will be used here to digitise polygons from a land parcel map.

Use ArcCatalog to create a personal geodatabase in **J:\giscourse\:**

1. In ArcCatalog set up a connection to **J:\giscourse.**
2. Right-click in the white space of the Contents tab for J:\giscourse and select **New | Personal Geodatabase**. Name this digitising.mdb.
3. Double-click digitising.mdb then right-click and select **New | Feature Class.**
4. Enter **land_boundaries** as the **Name:**
5. Click **Next** twice and before pressing Finish check to see that the new feature class will contain polygons (highlight **Shape** at the top of the dialog box and make sure the Geometry Type field property is set to Polygon). Click **Finish**.
6. In ArcMap open **j:\giscourse\practical1.mxd**, create a new Data Frame and name it **Digitising**.
7. Press the **Add Data** button and double-click on **J:\giscourse\ digitising.mdb**. Highlight **land_boundaries** and click **Add**.

The display will remain blankas land_boundaries currently contains no features.

8 Press the **Add Data** button and add **t:\its\gis\DigitizingFeatures.tif**

DigitisingFeatures.tif is a scanned image of a paper map. Zoom to this by right-clicking on its entry in the TOC and choose **Zoom to Layer**.

Task: digitise some of the land parcels.

9 Turn on the toolbar for editing by selecting the menu **View | Toolbars | Editor**, and from this toolbar select **Editor | Start Editing**.

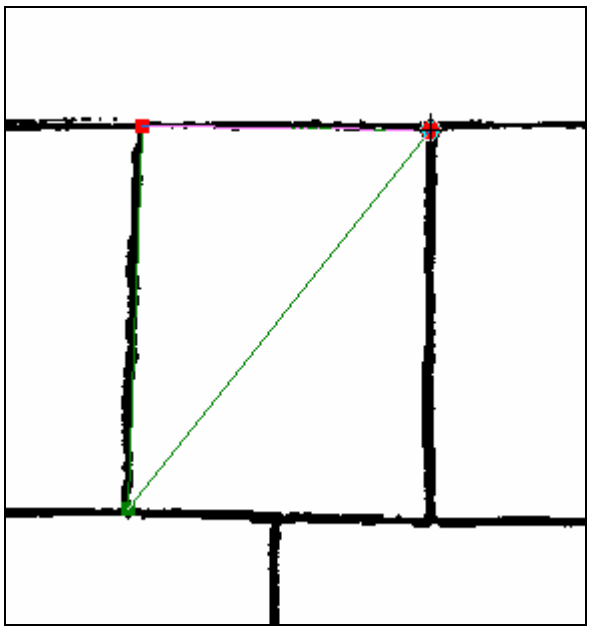
10 From the Editor toolbar select **Editor | Snapping** and tick **Vertex, Edge and End** for **land_boundaries**. These setting ensure that coincident features 'snap' together correctly avoiding the creation of sliver polygons. Close the Snapping box.

11 From the **Task:** dropdown arrow on the Editor toolbar, make sure **Create New Feature** is selected.

12 Zoom into the first of the land parcels that need adding


Sketch Tool

13 Click the **Sketch Tool** button from the Editor toolbar and click once with the left mouse button over one corner of a land parcel. A node will be added. Click on the other corner of the polygon, and finally click on the remaining corners of the polygon you are adding. Double-click when adding the final node to complete the polygon.



14 Do the same for a number of the other polygons, ensuring that the cursor snaps to the nodes of adjacent polygons.

When you are happy with how the process works stop editing. Select **Editor | Stop Editing** and confirm **Yes** to save edits.

If attribute data need adding follow the steps covered in previous sections.

14 Geostatistical Analyst

The Geostatistical Analyst extension is used for exploratory spatial data analysis. This example shows how Geostatistical Analyst can be used to create a map of ozone concentration by interpolating between individual point recordings of ozone levels.

1. Start ArcMap and add the shapefiles **ca_ozone_pts.shp** and **ca_outline.shp** from **I:\licence\arcgis9\ArcTutor\Geostatistics** into a new data frame.

ca_ozone_pts.shp are points containing the ozone sample values, whilst **ca_outline.shp** is the outline of the State of California.

2. Turn Geostatistical Analyst on by ticking its entry under **Tools | Extensions** then turn on its menu on by selecting **View | Toolbars** and left-mouse click the **Geostatistical Analyst** entry.
3. From this new toolbar select **Geostatistical Analyst | Geostatistical Wizard**
4. Set **Input Data:** to **ca_ozone_pts** and **Attribute:** to **OZONE** and click **Next**.
5. You can preview the surface that will be created by selecting **Surface** from the **Preview type:**
6. There are many options available in this dialog box, but for this example click **Next** to accept the default settings.
7. Click **Finish** and **OK** to run the wizard.
8. To allow all layers to be viewed move the newly created **Inverse Distance Weighting** surface to the bottom of the Table of Contents and set **ca_outline** to display with no fill (left mouse click on the colour symbol below this layer and in the **Symbol Selector** dialog box that appears set **Fill Color:** to **No Color**. Click **OK)**.
9. Use the Identify tool to check that the surface interpolation has worked correctly.

15 ArcScene and 3D Analyst

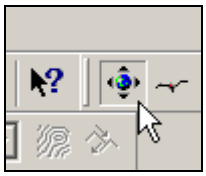
3D Analyst is an ArcMap extension used for analyzing 3D data. It is commonly used together with the application ArcScene for viewing 3D data.

Use 3D Analyst together with ArcScene to view 3D data, and carry out volumetric calculations:

1. Start ArcScene using **Start | Programs |GIS | ArcGIS | ArcScene**
2. Click on the **Add Data** icon and map a new connection to **Z:\licence\esri\AV_GIS30 \AVTUTOR\3D\site2**
3. From this new connection highlight **dtm_tin** and **ortho.lan** (use the **Ctrl** key) and click the **Add** button.

4 **dtm_tin** is a digital terrain model that can be displayed in 3D. **ortho.lan** is an aerial photograph of the same area. To make the display easier to navigate increase the vertical exaggeration: From the menu choose **View | Scene Properties**, set **Vertical Exaggeration** to 5 and click **OK**.

5 **dtm_tin** is now displayed in 3D. Use the navigate tool (half-way along the toolbar) to move around and investigate the data (hint - use a combination of the left, right and middle mouse buttons):



The aerial photograph can be draped over the terrain model using its height values:

6 Right-click on **ortho.lan** in the TOC and select **Properties**.

7 Click the **Base Heights** tab and select the option **Obtain heights for layer from surface:** This will automatically be set to **dtm_tin**.

8 Click **OK**.

9 The aerial photograph will now display in 3D — turn off **dtm_tin** in the TOC before navigating around the data.

3D Analyst can be used to carry out volumetric calculations. For example, the amount of material in a quarry can be calculated. Use **dtm_tin** and calculate the volume of material above a certain height:

1 Turn off **ortho.lan** and turn on **dtm_tin**.

2 In ArcScene from the **3D Analyst** menu select **Surface Analysis | Area and Volume**.

3 Set the **Height of plane:** to **300** and click the **Calculate statistics** button lower down on the dialog box.

4 Values will display at the bottom of the dialog box for 2D area, Surface area and Volume above the 300ft plane. Click **Done** when finished.

3D Analyst can also be used to create viewsheds to analyse visibility. These can be useful for gauging the visual effect on surrounding areas of, for example, a new wind farm development.

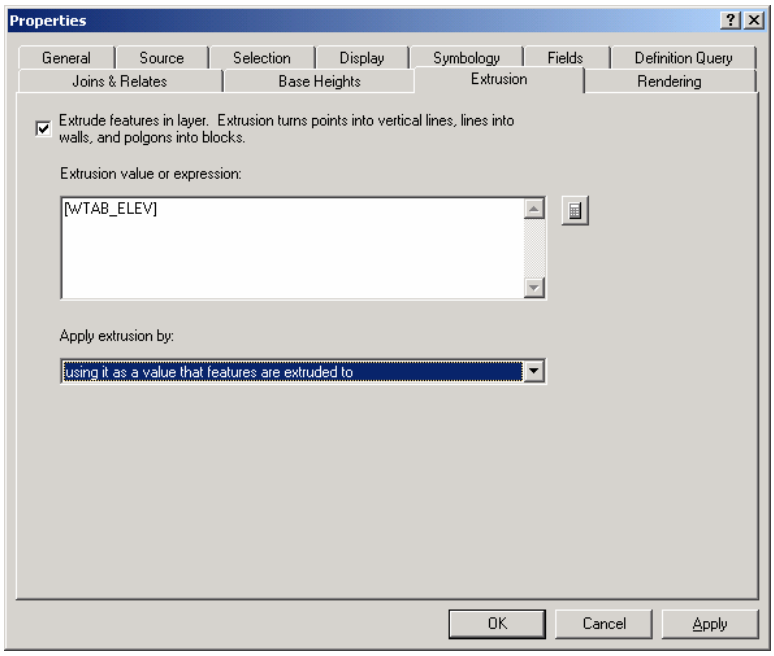
ArcScene can also be used to investigate borehole data:

1 Click on the **Add Data** icon.

2 Select **wells.shp** from the **Z:\licence\esri\AV_GIS30 \AVTUTOR\3D\site2** connection.

wells.shp contains the location and depth of boreholes drilled in the area. These can be displayed on the 3D scene using the well depth included in the attribute data:

1. Right-click on **wells** in the TOC and select **Properties**.
2. In the **Properties** dialog box select the **Base Heights** tab and make sure **Obtain heights of layer from surface:** is selected. This will automatically be set to dtm_tin, and ensures that all wells start at the land surface.
3. Click on the **Extrusion** tab, tick the **Extrude features in layer...** tick box, click on the **Calculator icon** below, double-click **WTAB_ELEV** from the **Fields** box and click **OK**. This field contains the depth of each borehole.
4. Change **Apply extrusion by:** to **using it as a value that features are extruded to**. The dialog box should be the same as below when finished:



5. Click **OK** to apply these changes

The well data will appear on the **dtm_tin** surface where they were bored, and a vertical line is drawn below each well to the depth of the well.

If the well data included geology information the vertical lines could be colour-coded according to the rock type down through the well.

16 Other extensions

There are a range of other extensions available for ArcMap. Below are three which are installed on the Networked PC Service. Read through their descriptions and if they are of interest follow the exercise mentioned.

16.1 Survey Analyst

Survey Analyst provides tools for using and analysing survey measurement and coordinates.

To try this extension open the book 'Using_Survey_Analyst' from **Start | Programs | GIS | ArcGIS | ESRI_Library** and follow any of the exercises from Chapter 2. Sample data referred to in the book are at I:\licence\arcgis9\ArcTutor\Survey_Analyst.

16.2 ArcScan

ArcScan allows raster to vector data conversion.

To try this extension open the book 'Using_ArcScan_for_ArcGIS' from **Start | Programs | GIS | ArcGIS | ESRI_Library** and follow any of the exercises from Chapter 2. Sample data referred to in the book are at I:\licence\arcgis9\ArcTutor\ArcScan.

17 Where next?

Having completed this course the following information may be useful for your future work with GIS.

17.1 Virtual Campus

Members of the University are eligible to free access to any of the ESRI authored online courses provided on their Virtual Campus. Courses include:

- Learning ArcGIS 9
- Customizing ArcGIS 9
- Learning ArcGIS Spatial Analyst 9
- Understanding Map Projections and Coordinate Systems

For a full list of courses go to: **http://www.dur.ac.uk/its/software/gis/** and click the relevant link under Training Courses.

If you would like an access code for any of the courses contact the ITS Helpdesk.

17.2 Durham GIS web pages

A list of WWW links to other GIS resources and information on GIS discussion lists and newsgroups can be seen on the ITS GIS web pages at: **www.dur.ac.uk/its/software/gis/**

There is also an FAQ section for ArcGIS – click the link under **GIS software at Durham**, select **ArcGIS** and click the **ITS FAQs about this application** link.

17.3 ESRI Support Center

ESRI, the makers of ArcGIS provide good online support for users via a knowledge base and user forums. If the ArcGIS help or manuals do not provide an answer this is generally the best port-of-call to find solutions to

problems. Go to **support.esri.com** and enter your query in the 'Search our Site' box at the top left of the screen. Select a particular software product to limit the search.

Some hits will require you to register and create a personal ESRI Global Account before the solution can be displayed. Click on the Create Account link on the left of the screen to register.

17.4 Help and advice

For questions and advice about GIS, ITS Helpdesk is available:

- by personal contact in the Helpdesk in the Computer Centre.
- by telephone (41515).
- by electronic mail to **helpdesk@durham.ac.uk**. Messages are normally answered during the same day.

Opening times are listed at **http://www.dur.ac.uk/its/helpdesk/**