

## Introduction to Spatial Data & GIS

### Learning objectives:

- To work with a raster base map within a GIS and overlay vector data.
- To learn how to use QGIS to display maps.
- To learn how to use QGIS to Geocode, georeference and create new spatial data.
- To understand maps as a visual display of underlying database information.

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### ***Basic Mapping: Adding point data to a raster base map.***

*We will create a map showing the location of secondary schools in Edinburgh. To provide some context and locate these data in the real world, we will overlay this point data on to an Ordnance Survey raster base map. We will then add in some detailed buildings data to see the outlines of some of the schools.*

### **Part 1: Bringing raster map data into QGIS**

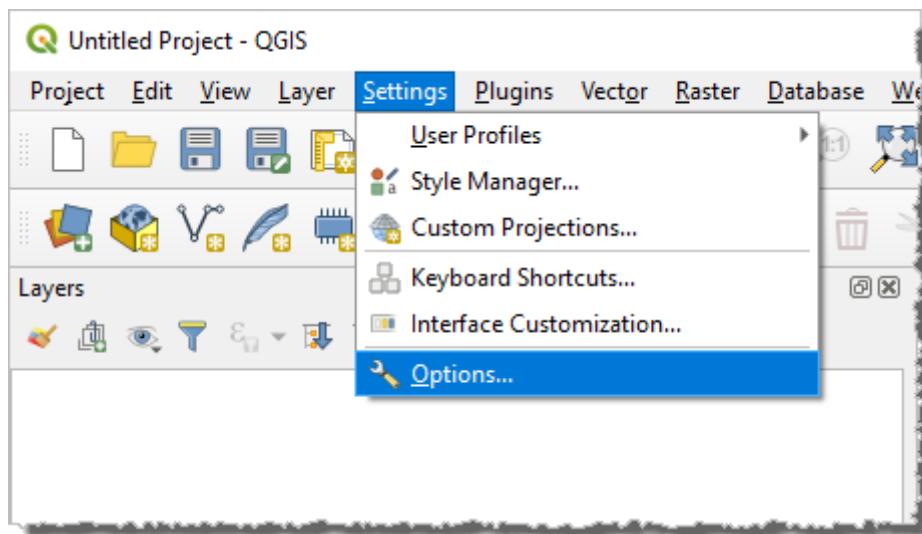
1. If you don't already have QGIS open, start the application.

**Start → QGIS 3.10 → QGIS Desktop 3.10.x**

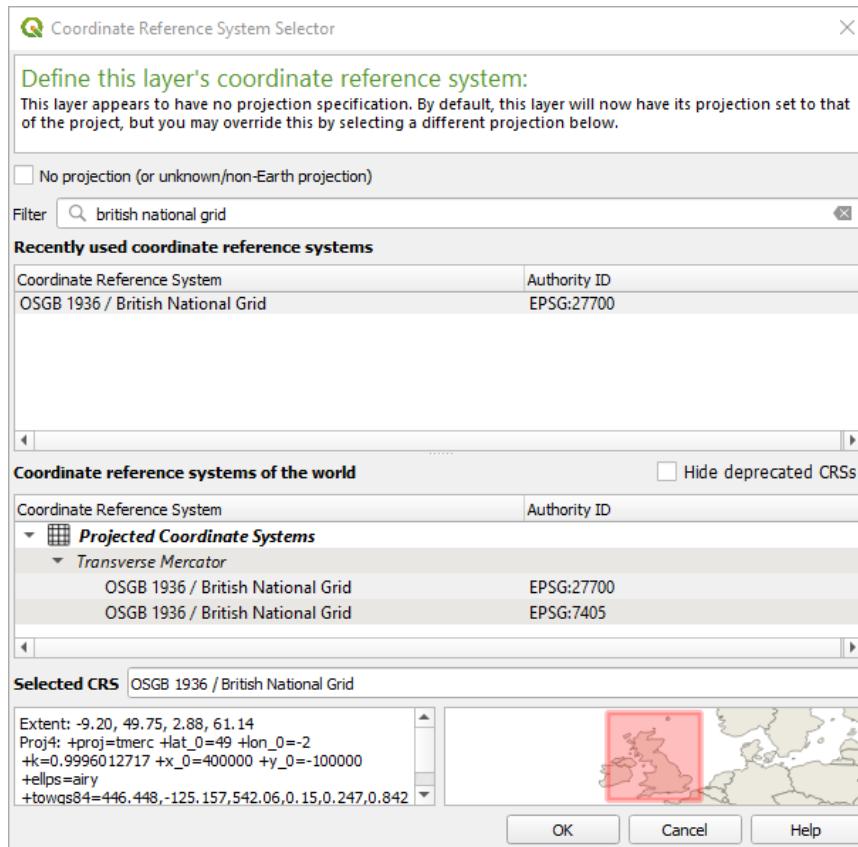
2. Click the **Maximize Window** icon  in the top right corner.

To ensure the data we are going to view in QGIS is located and scaled correctly we will need to set a coordinate system for the data layer. You can do this manually each time, but to save time you can set the default to the system you most commonly use:

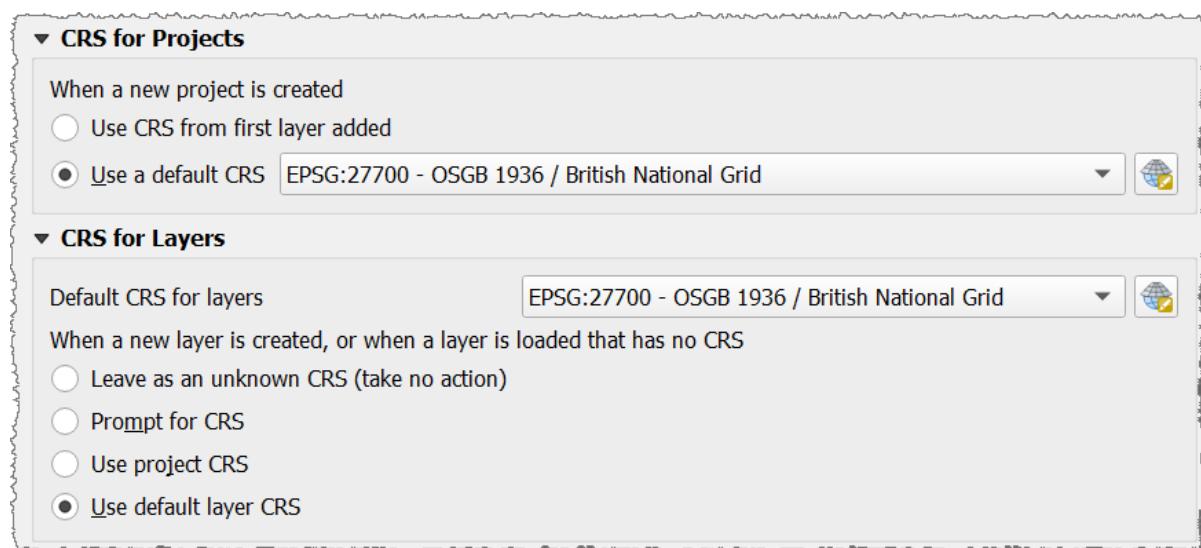
3. Click on the Settings → Options menu at the top of the screen.



4. Go to the **CRS** tab, in the first section **CRS for New Projects** click on the second radio button **Use a default CRS** and click on the **Select CRS** button to change the default CRS for new projects.
5. In the pop-up window type 'British National Grid' in to the **Filter** field and then select **OSGB 1936 / British National Grid** from the list.



6. Click **OK** to select the CRS.
7. In the second section **CRS for Layers** click on the **Select CRS** button  to change the **Default CRS for layers**, selecting **OSGB 1936 / British National Grid** as before, then click on the fort radio button **Use default layer CRS**.



8. Click **OK** to set British National Grid as the default CRS to use for new projects and layers.

9. Click on **Project → New** to open a new project using these settings

We now don't have to do this again until the software is reinstalled or updated. If you ever want to work in a different CRS simply click on the Coordinate Reference System (CRS) button at the bottom right of the map, where it says **EPSG:27700**:

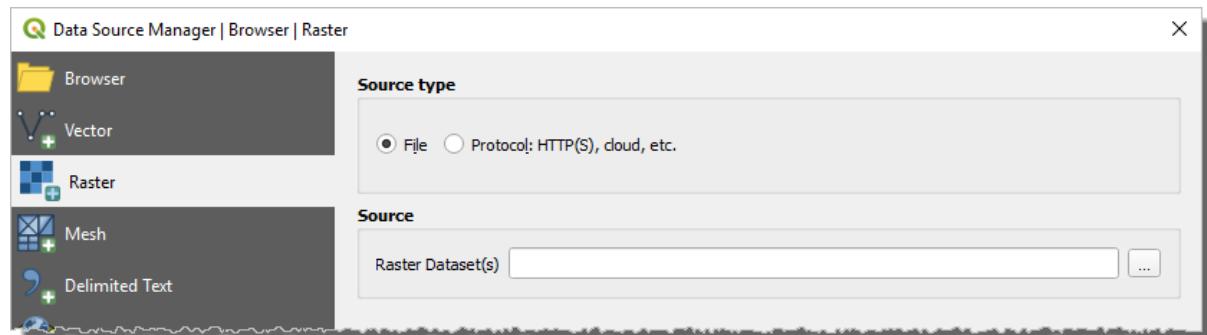


This will bring up **Project Properties | CRS** window where you can change to whichever system you need.

You can now begin to bring data in to QGIS using the **Data Source Manager**:

10. Click on the **Open Data Source Manager** button 

11. Click on the **Raster** tab on the left hand side.

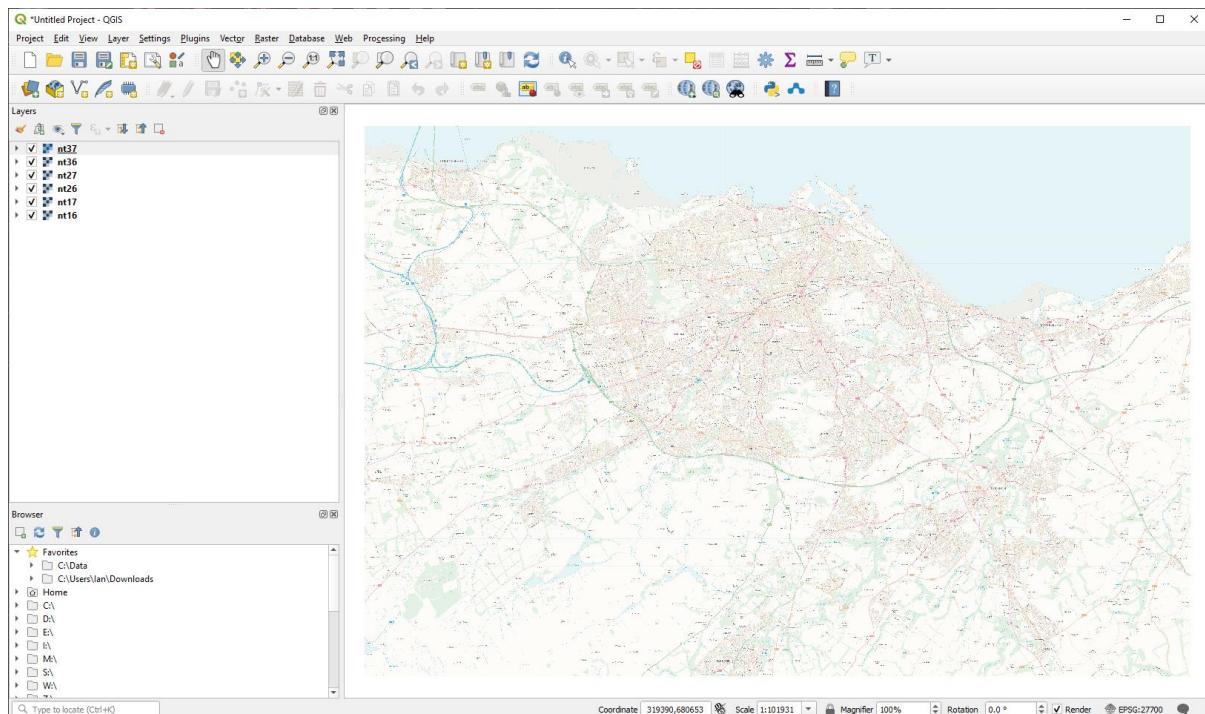


12. In the **Source > Raster Dataset(s)** field browse to the folder **Practical 1**, you instructor will tell you the location.

13. Six raster files with the suffix .tif should appear in the dialog box. **Ctrl-click** to highlight them all then click the **Open** button.

14. Click on the **Add** button to add the data to your map.

15. You may be asked to specify the CRS for each of the files you add. Choose **British National Grid** for each one and click **OK**.



You should now see the six raster tiles of Edinburgh and the surrounding area in your map window. The dataset we are using is product called **VectorMap® District Raster** (faded colour); this is an ideal backdrop map for overlaying your own data on. You can download it from the Digimap Ordnance Survey Collection (<https://digimap.edina.ac.uk/os>).

It is faded so any data you add on top stand out more; there is a full colour version if you need to show the topographic features more prominently. VectorMap District Raster is best viewed at a scale of 1:15,000 to 1:30,000.

**NOTE:** The **Layers** panel on the left shows the names of the files you have added. The datasets you have added are now referred to as layers within the data frame.

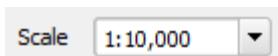
- \* The check boxes allow you to show or hide individual layers in the map window.
- \* Clicking on the arrow symbol next to each layer will show you the “legend” of each layer.

Now is a good time to get used to some of the controls for panning and zooming the data.

The main ones you will need are found in the tool bar above the map:



There is also the Scale drop down menu at the bottom of the map where you can pick from a list or manually type in the scale at which you want to view the data.



16. Click on the arrow next to the scale and select **1:10,000**.

17. You can use the **Scroll Wheel** on your mouse to zoom in and out on your current location.



18. The button allows you to drag a box round features you are interested in to zoom in on them.



19. The button changes your mouse pointer to a hand. This allows you to grab and pan the map.



20. The buttons allow you go back and forward between map views you have already seen.



21. Finally the button allows you to return to view where you can see all the data you have added to your map document.

At this point it is also a good idea to **save** our map; you do this in the usual way for a Windows program.

22. Click **Project** then **Save as...**

23. Save the file in the Practical 1 folder with the data

24. Give the file a suitable name such as **Practical1**



**IMPORTANT:** You are saving your document as a **.qgz** file. This is a list of instructions or behaviours for the data and any customisations to the interface. It will remember any symbology changes and selections you make to data and which tool bars are shown. It will **NOT** save any changes to the data files themselves and does **NOT** contain any data. The **.qgz** file won't work without the data files, so these need to be kept with it.

## Part 2: Add point data from spreadsheet

Now we have added our base map raster data we can now go through the steps needed to add some point data. The aim of the following exercise is to display a point on the map for each school. To do this we will need two data sources, one for the schools and one to provide the locations.

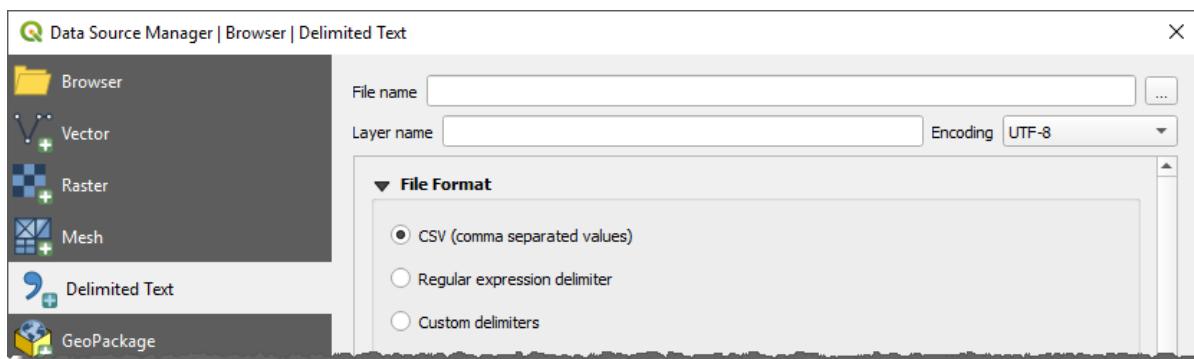
We will be using two files:

1. **schools.csv** – contains the names of non-denominational secondary schools in Edinburgh, with their address and postcode (obtained from Edinburgh City Council: <http://data.edinburghcouncilmaps.info>).
2. **postcodes.csv** – is a list of the postcodes in Edinburgh that has been downloaded from Digimap (a dataset called Code-Point Open). This file contains the geographical co-ordinates for centre of each postcode which can be added to the base map created above.

For both datasets, spaces were removed from the postcode fields.

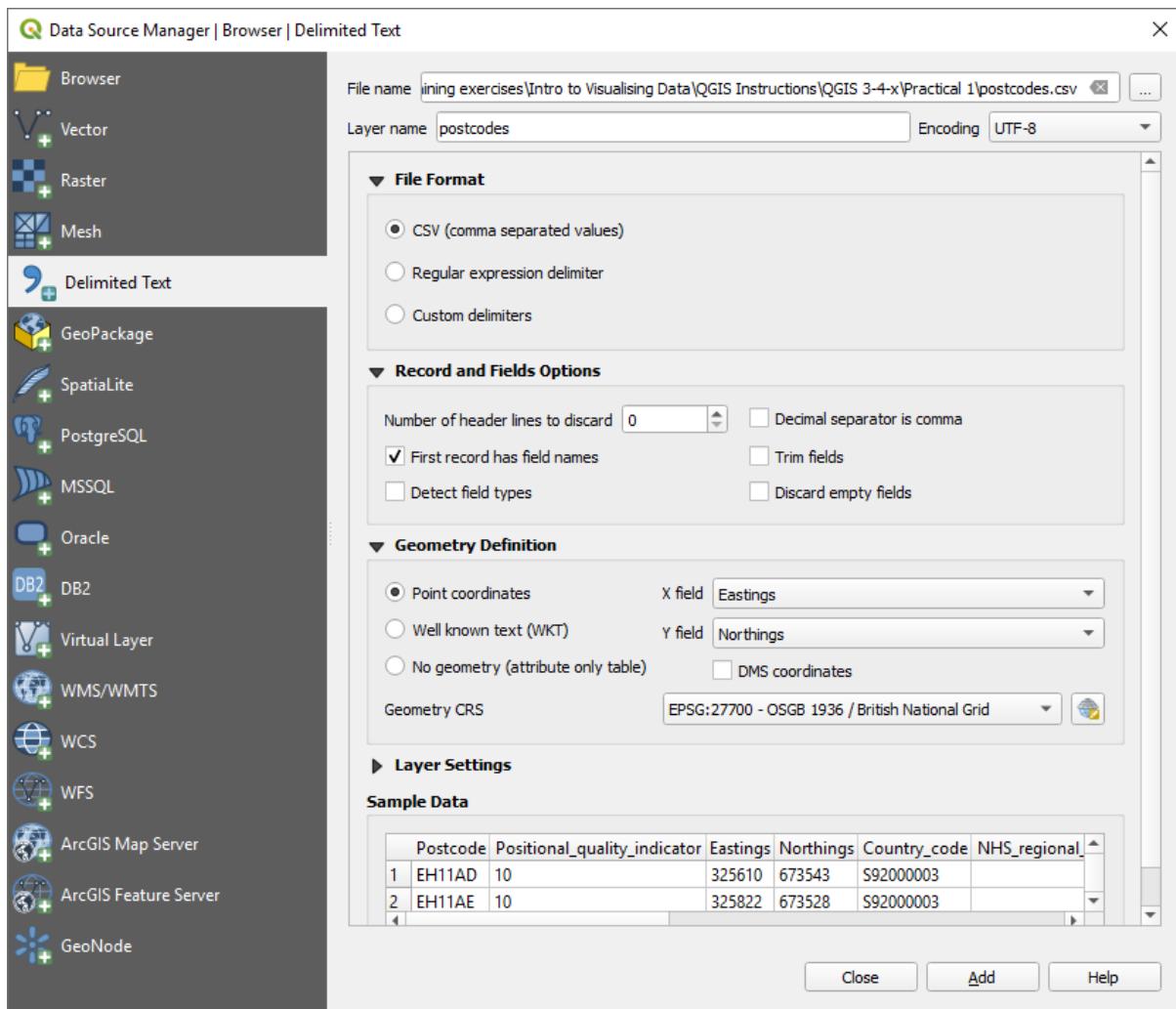
First, we need to add the csv files to QGIS:

3. Open the **Data Source Manager** 
4. Click on the **Delimited Text** tab to the left hand side:



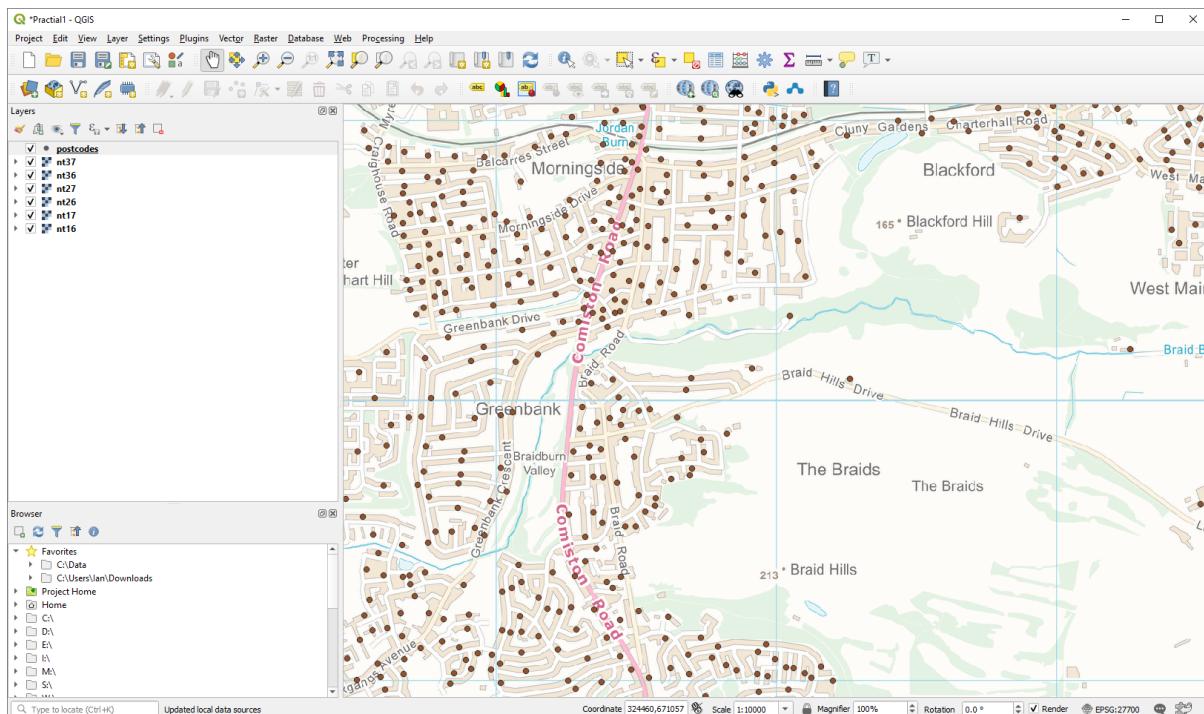
We will first add the postcode list which has the coordinates in it.

5. Click on the button to browse to the **postcodes.csv** file:



QGIS will automatically detect the settings but in case it gets it wrong please ensure the following:

6. **File Format** is set to **CSV**.
7. **Number of header lines to discard** is set to **0**.
8. **First record has field names** is checked.
9. **Geometry Definition** is set to **Point coordinates**.
10. **X field** is set to **Eastings** and **Y field** is set to **Northing**.
11. **Geometry CRS** is set to **EPSG:27700 - OSGB 1936 / British National Grid**.
12. Click **Add** then **Close**.



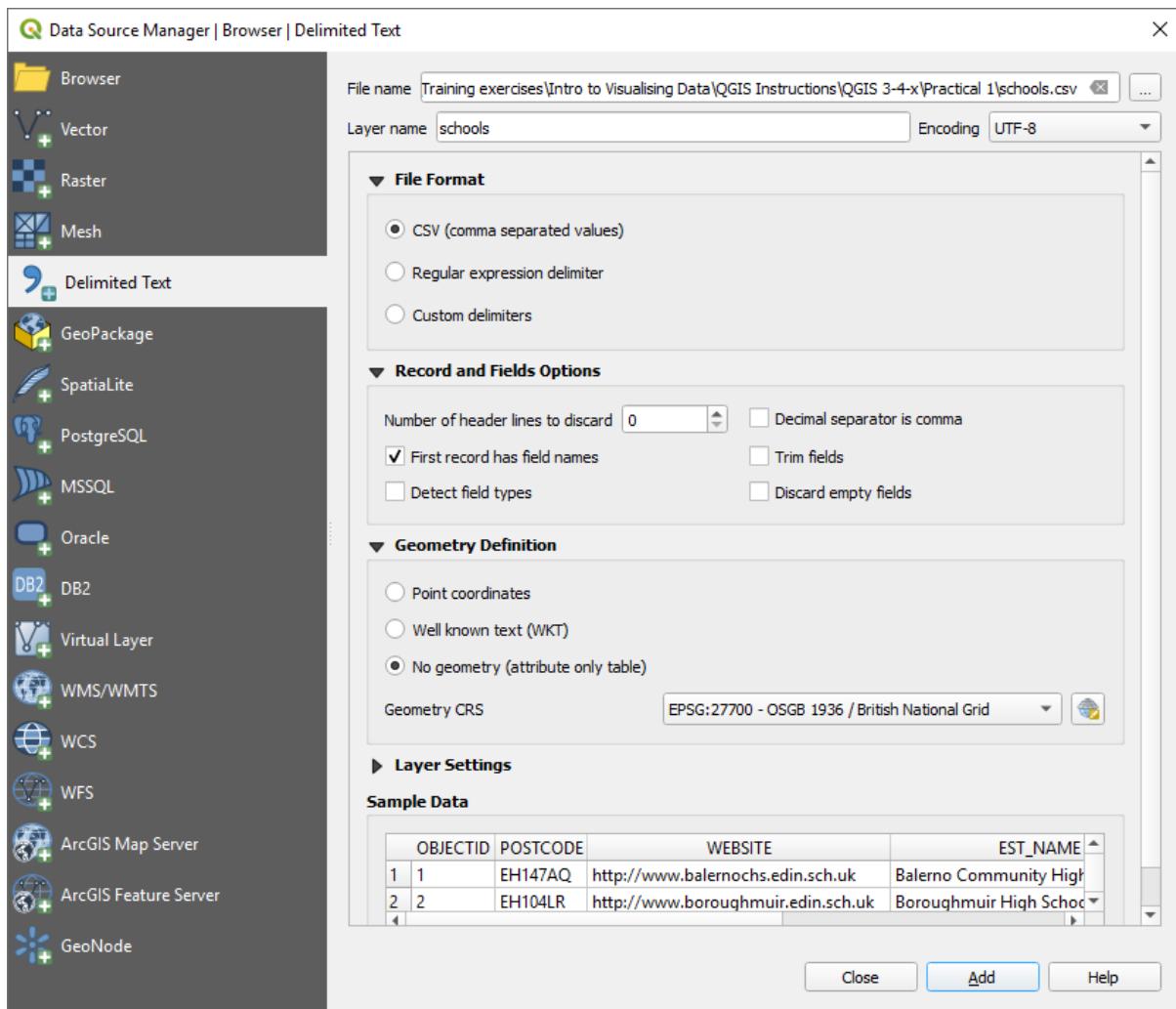
You will now see point locations for every postcode area in Edinburgh displayed on the map and a new entry in the layers panel on the left hand side called **postcodes**.

Next we need to add the **schools.csv**, this is different as it doesn't have any geometry columns it is just attribute information.

13. Open the **Data Source Manager** 

14. Click on the **Delimited Text** tab to the left hand side.

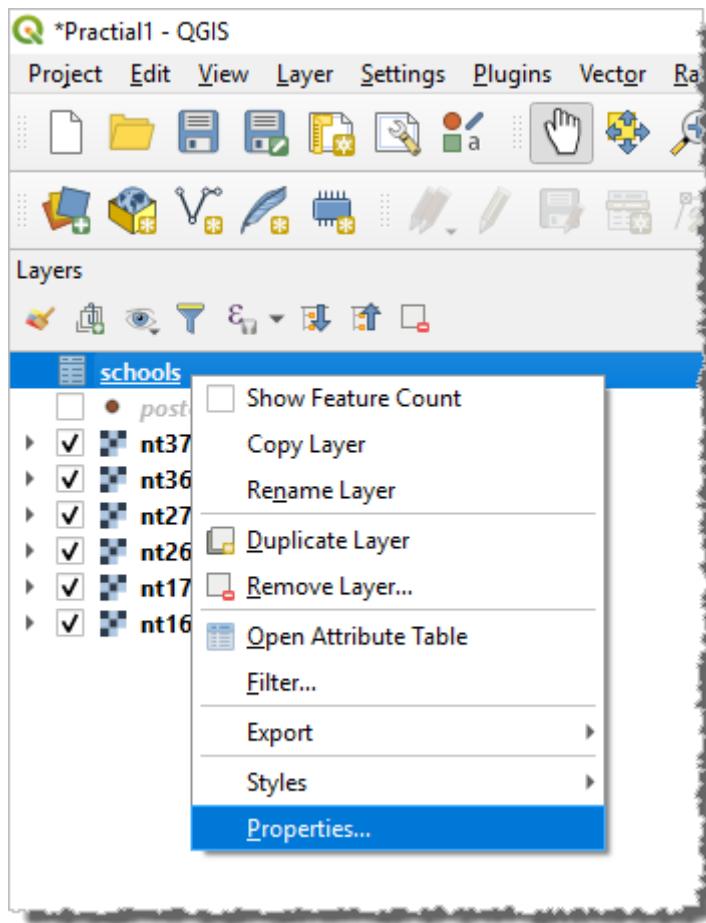
15. Click on the button to browse to the **schools.csv** file:



16. Click **Add** when you are happy that the settings are the same as the image above, you will probably need to select the **No geometry (attribute only table)** option.

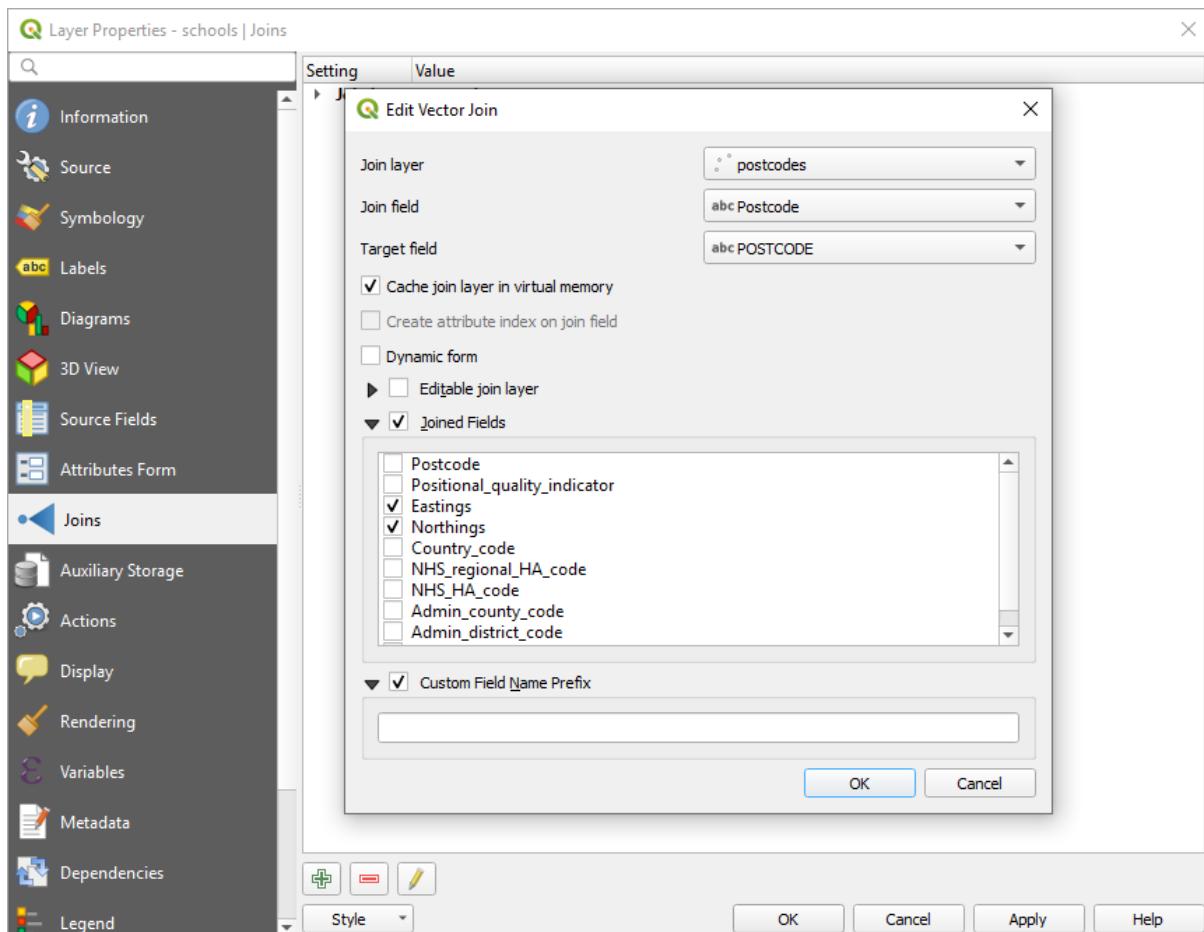
Now we have the data in QGIS we can **Join** the datasets to add the location information from the Postcodes to the Schools.

17. Right-click on **schools** in the **Layers** panel and select **Properties**:

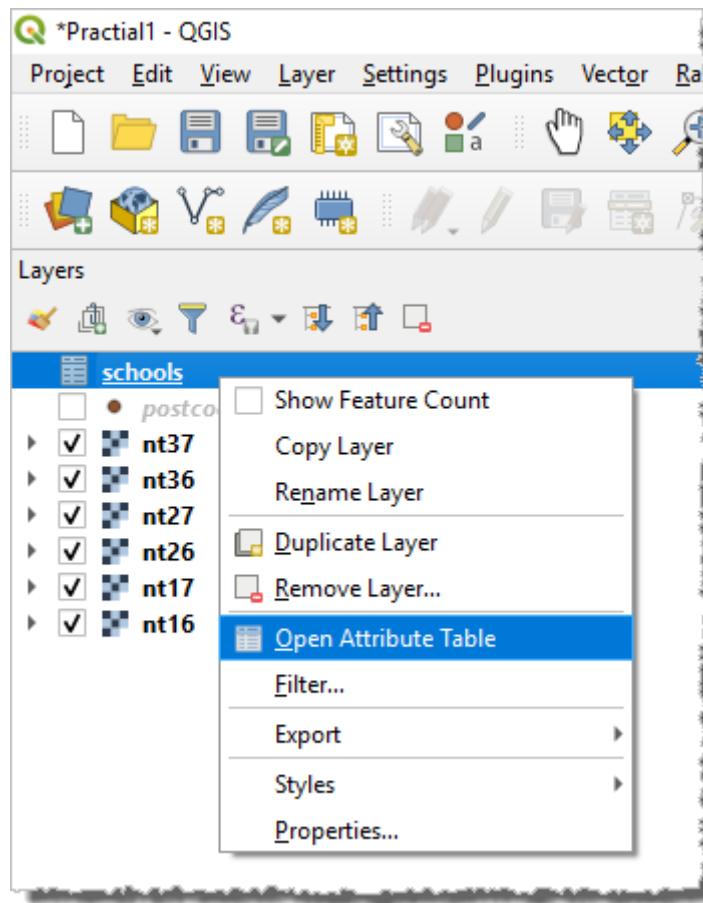


18. Click on the **Joins** option in the **Properties** window:

19. Click on the **Green Plus** button to add a new Join.



20. Select **postcodes** as the **Join layer**.
21. Select **Postcode** as the **Join field**.
22. Select **POSTCODE** as the **Target field**.
23. Check the **Joined Fields** box and select **Easting** and **Northing**.
24. Check the **Custom Field Name Prefix** and remove it so it's a blank value.
25. Click **OK**: your tables are now joined.
26. To view the joined data, **right-click** on the **schools** layer and select **Open Attribute Table**:

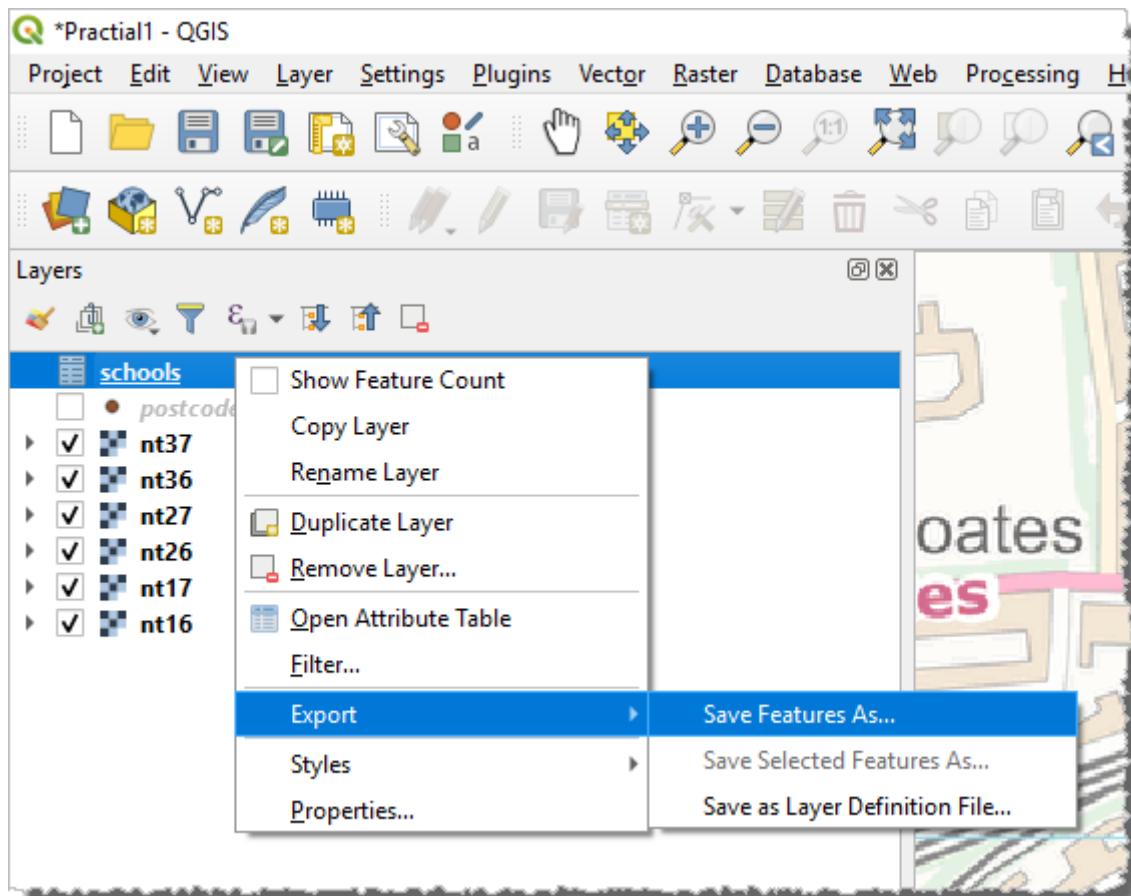


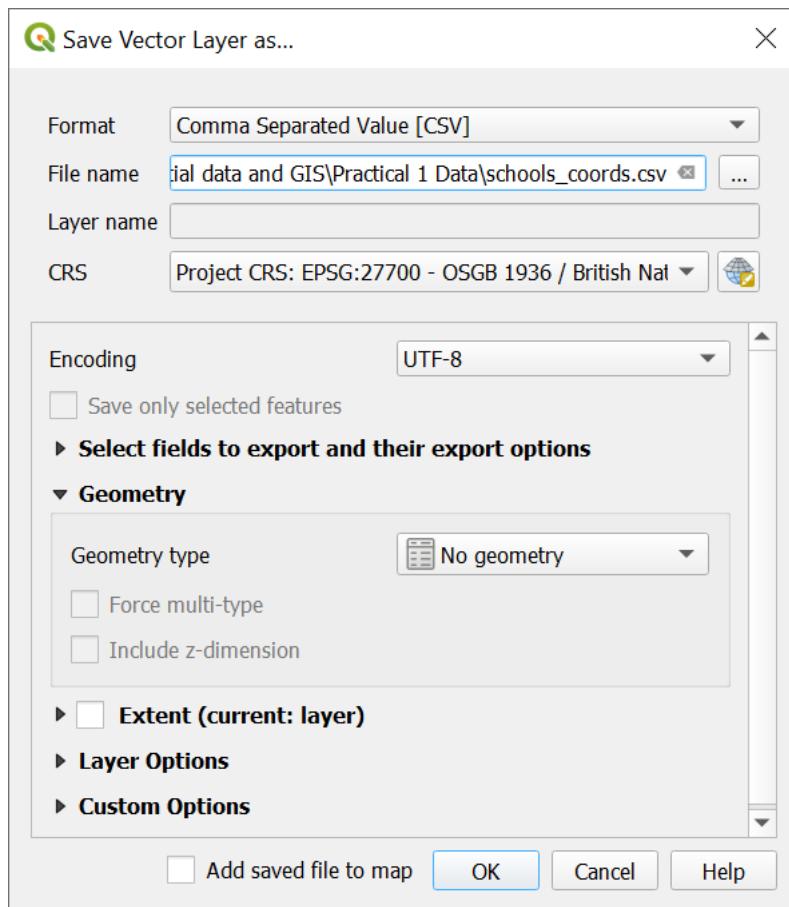
The additional attributes of Easting and Northing have been added to the end of the table:

	OBJECTID	POSTCODE	WEBSITE	EST_NAME	ADD_1	TOWN	TELEPHONE	Eastings	Northings
1	1	EH147AQ	http://www.bal...	Balerno Community High School	5 Bridge Road, ...	Edinburgh	477 7788	316300	666655
2	2	EH104LR	http://www.bor...	Boroughmuir High School	Viewforth	Edinburgh	229 9703	NULL	NULL
3	3	EH41EG	http://www.bro...	Broughton High School	29 East Fettes A...	Edinburgh	332 7805	323810	674859
4	4	EH164DP	http://www.cas...	Castlebrae High School	2A Greendykes ...	Edinburgh	661 1282	329157	671402
5	5	EH128NH	http://www.cra...	Craigmount High School	59 Criags Road	Edinburgh	339 6823	318419	673374
6	6	EH44NL	http://www.cra...	Craigroyston Community High School	67 Pennywell R...	Edinburgh	477 7801	321829	676334
7	7	EH145RD	http://www.cur...	Currie Community High School	31 Dolphin Ave...	Edinburgh	449 2165	317637	667788
8	8	EH74BS	http://www.dru...	Drummond Community High School	41 Bellevue Place	Edinburgh	556 2651	325699	674834
9	9	EH141DP	http://www.firr...	Firhill High School	9 Oxbgangs Roa...	Edinburgh	441 4501	322725	669774
10	10	EH129AE	http://www.for...	Forrester High School	212 Broomhouse...	Edinburgh	334 9262	319513	671633
11	11	EH166TZ	http://www.gra...	Gracemount High School	136 Lasswade R...	Edinburgh	664 7440	328026	668719
12	12	EH91DD	http://www.ja...	James Gillespie's High School	57 Lauderdale S...	Edinburgh	447 1900	325144	672183

Now we have added geographic coordinates to each school in the table we can visualise these on the map. To do this we need to export the data as a new file then add it back in again.

**27. Right-click on schools in the Layers panel and select Export > Save Features As...**

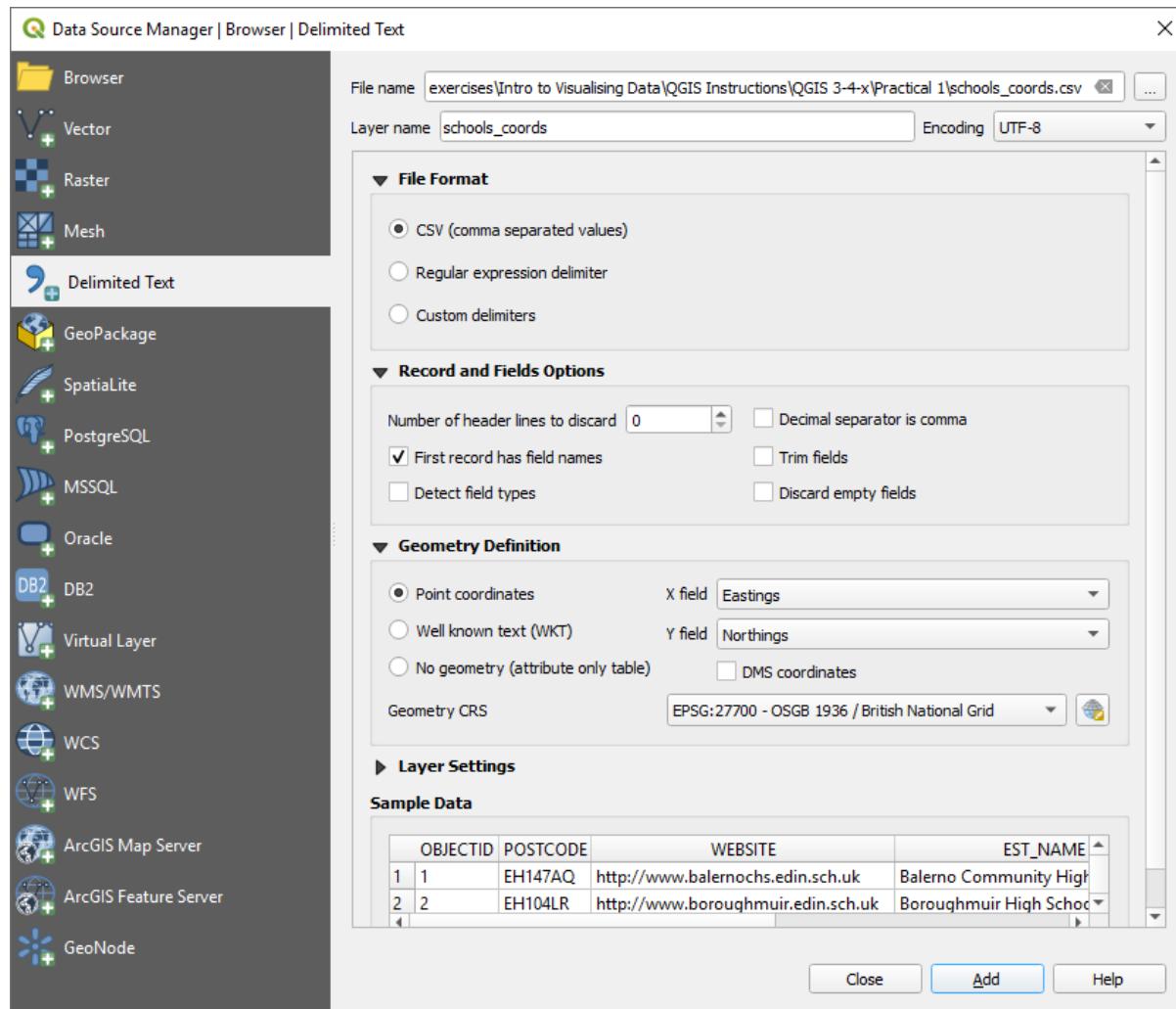




28. Save the data as a new CSV file called **schools\_coords.csv** in the **Practical 1** folder.
29. Select **British National Grid** as the CRS.
30. Under **Geometry type** select **No geometry**.
31. Uncheck the **Add saved file to map** checkbox.
32. Click **OK** to create the file.

Once the file has been created, we just need to add it to the map view, this time specifying the new attributes as the coordinate values.

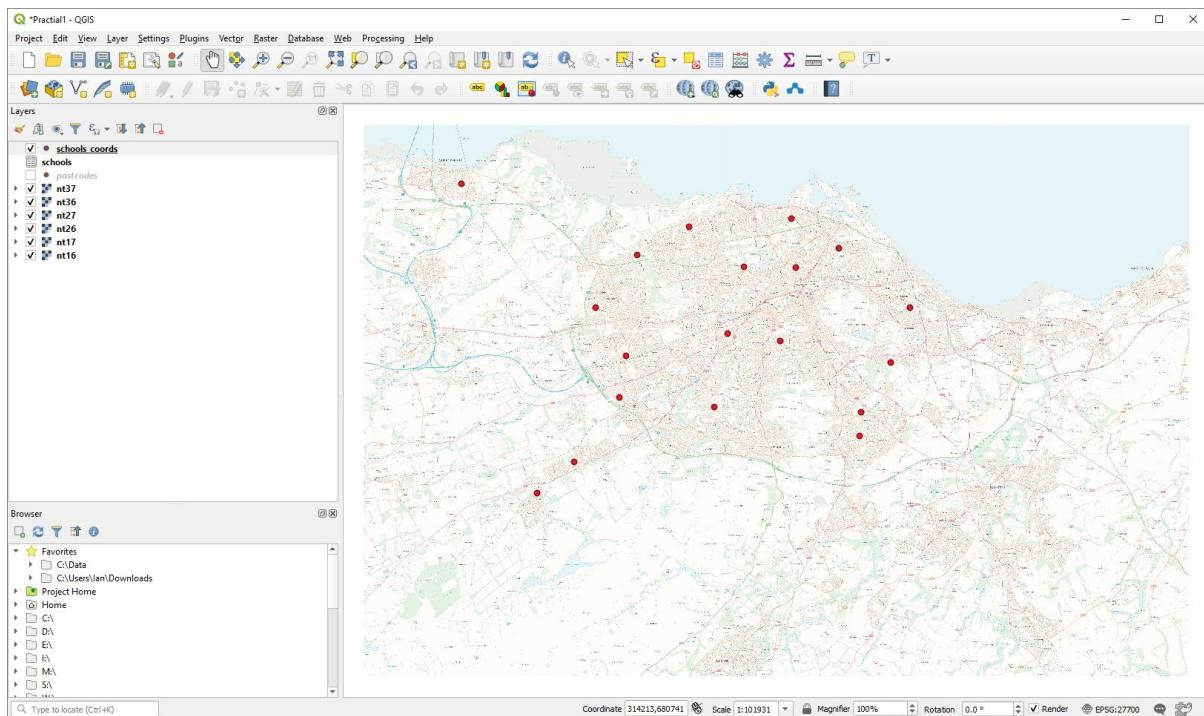
33. Open the **Data Source Manager** and select the **Delimited Text** tab on the left hand side.



34. Browse to the newly created **schools\_coords.csv** file and set the options as shown above (check that **Geometry Definition** is set to **Point coordinates** with the **Easting** and **Northing** fields selected).

35. Click on **Add** then **Close** to add the school data to the map.

The schools are now visible on the map. If they're still enabled, turn off the **postcodes** layer that contains all the postcodes so you can see the schools more clearly:

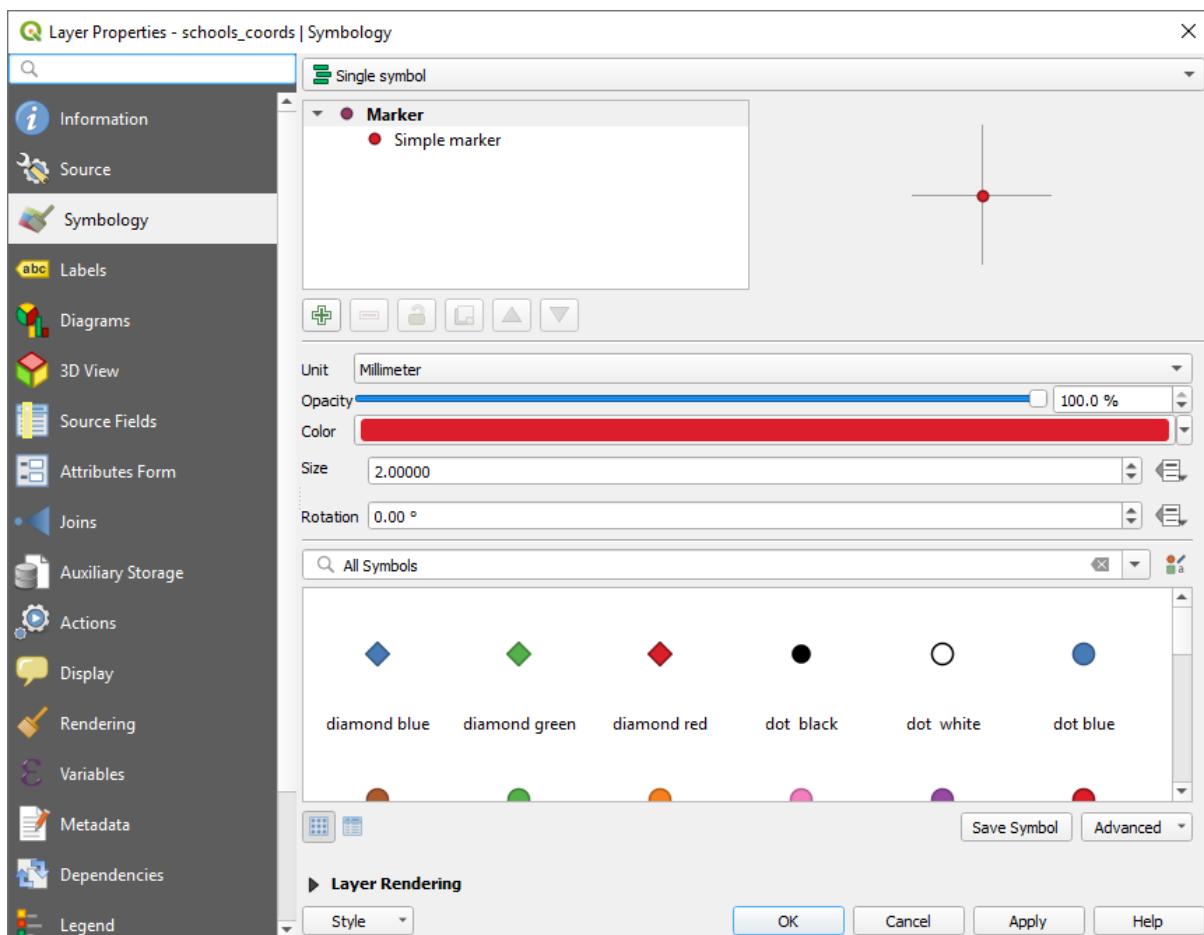


36. **Save** your work and then move on to the next section.

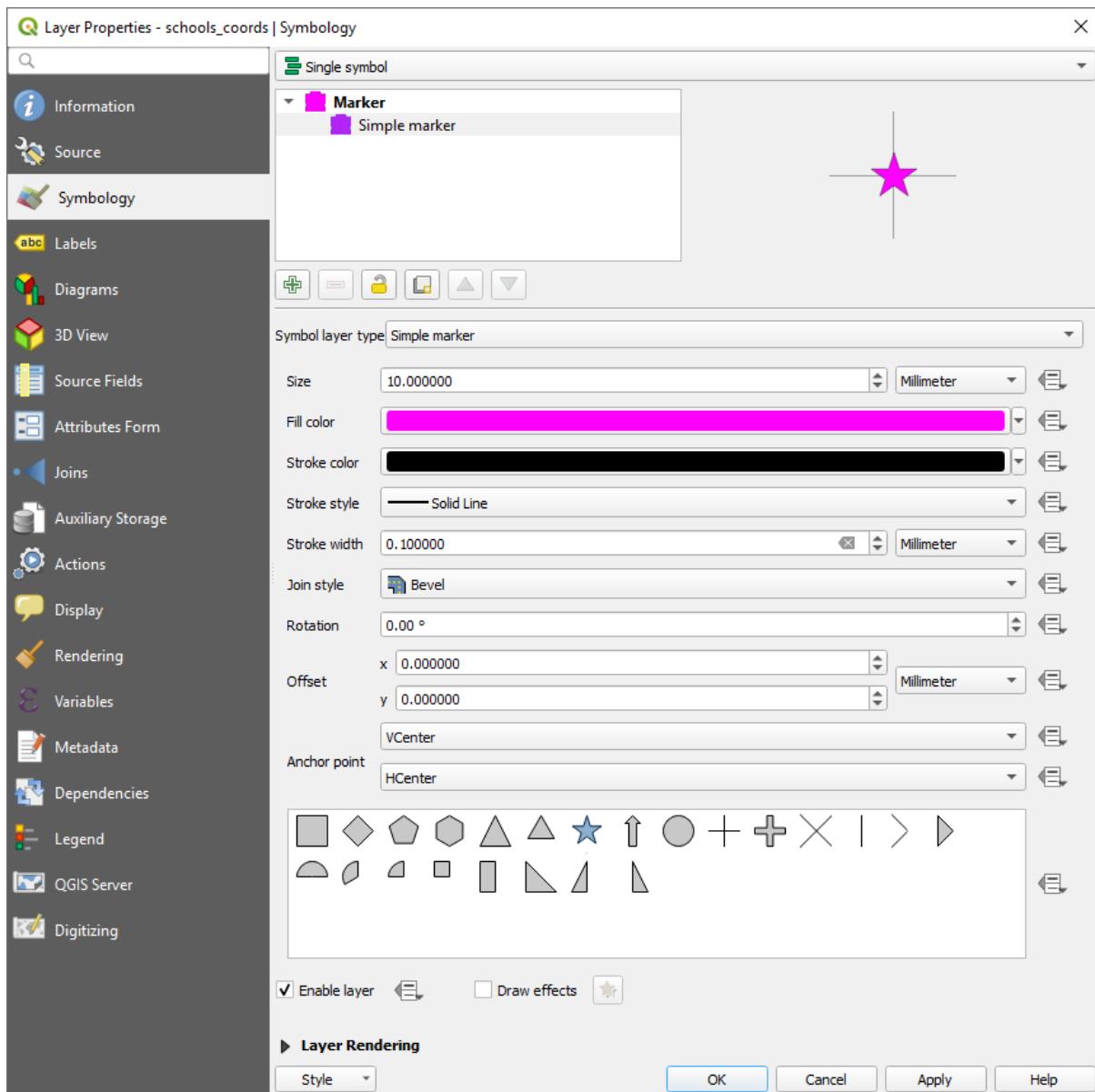
## Part 3: Changing the point display

The schools are easily visible on this faded map, but they can be harder to see on busier background mapping. QGIS chooses its legend colours at random so the chance that you will need to intervene to make the map more aesthetically pleasing is high.

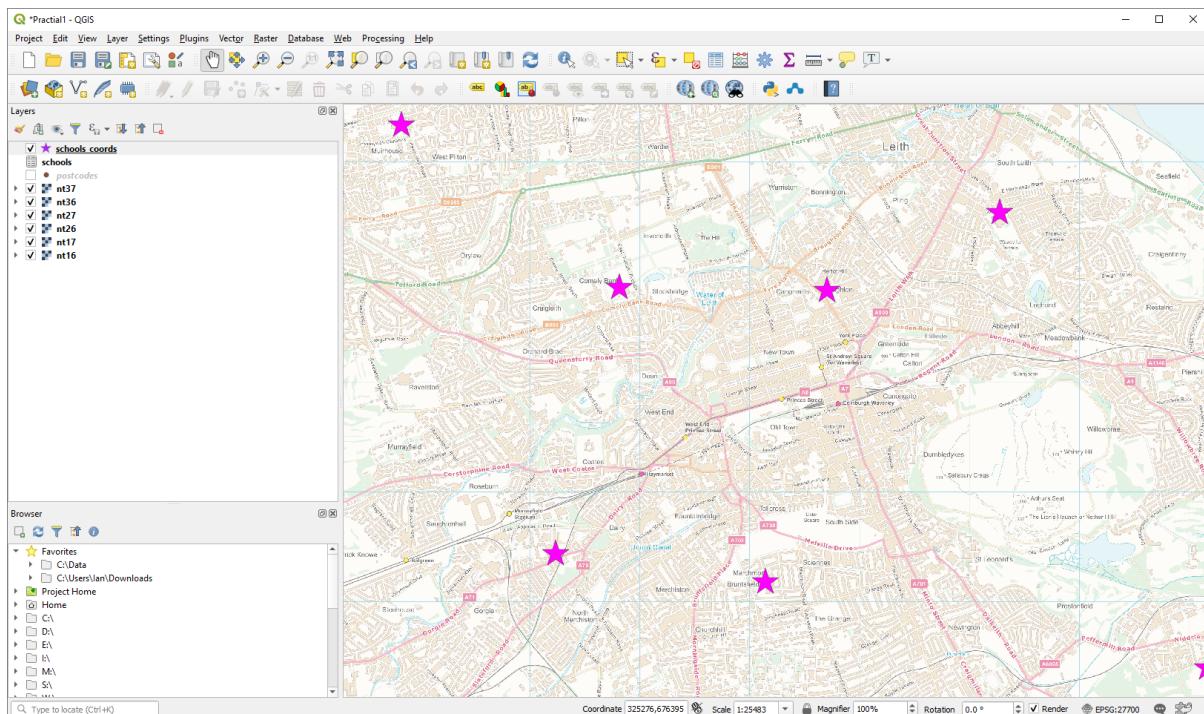
1. Double-click on the point next to **schools\_coords** in the **Layers** panel.
2. The **Symbology** page of the layer's properties will open:



3. Click on **Simple Marker** to see the options. Pick a **Colour** that will stand out, change the **Size** to around **10** and choose a **Shape** that will be more noticeable like a **star**.



The symbols will show up against most data sets now. Generally, it is always best to pick a colour that doesn't feature too heavily on the base map if you want your points to stand out. Having a different shape and a larger size can help too, but you may want to consider how closely spaced your points are before making the symbols very large.

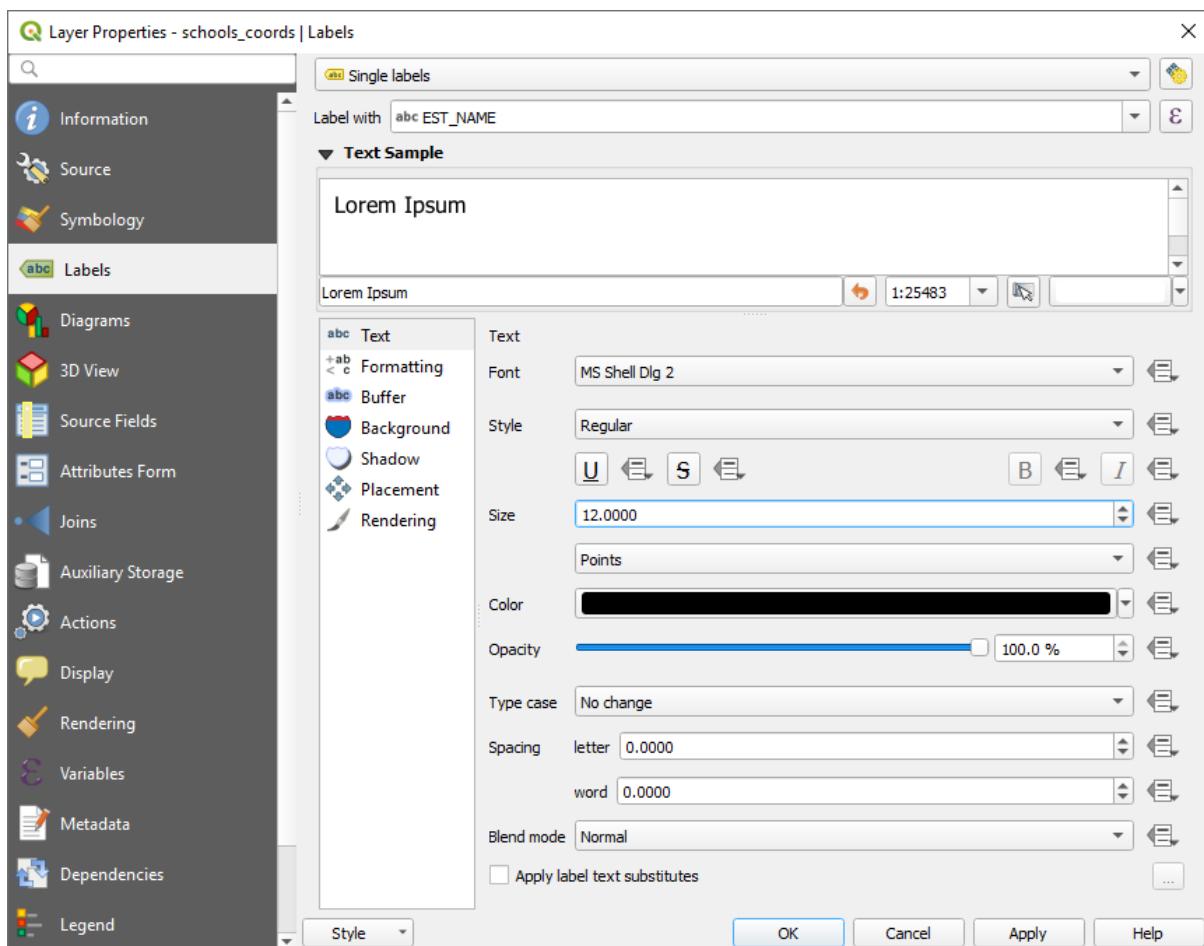


4. Save your work and then move on to the next section.

## Part 4: Labelling features

You can use QGIS to label the Schools with the names given in the attribute table:

1. Right-click on **schools\_coords** and select **Properties**.
2. Select the **Labels** option.
3. In the drop down select **Single labels**.
4. In the **Label with** field select **EST\_NAME** (this is the name of the school)
5. Increase the **Size** to **12**.

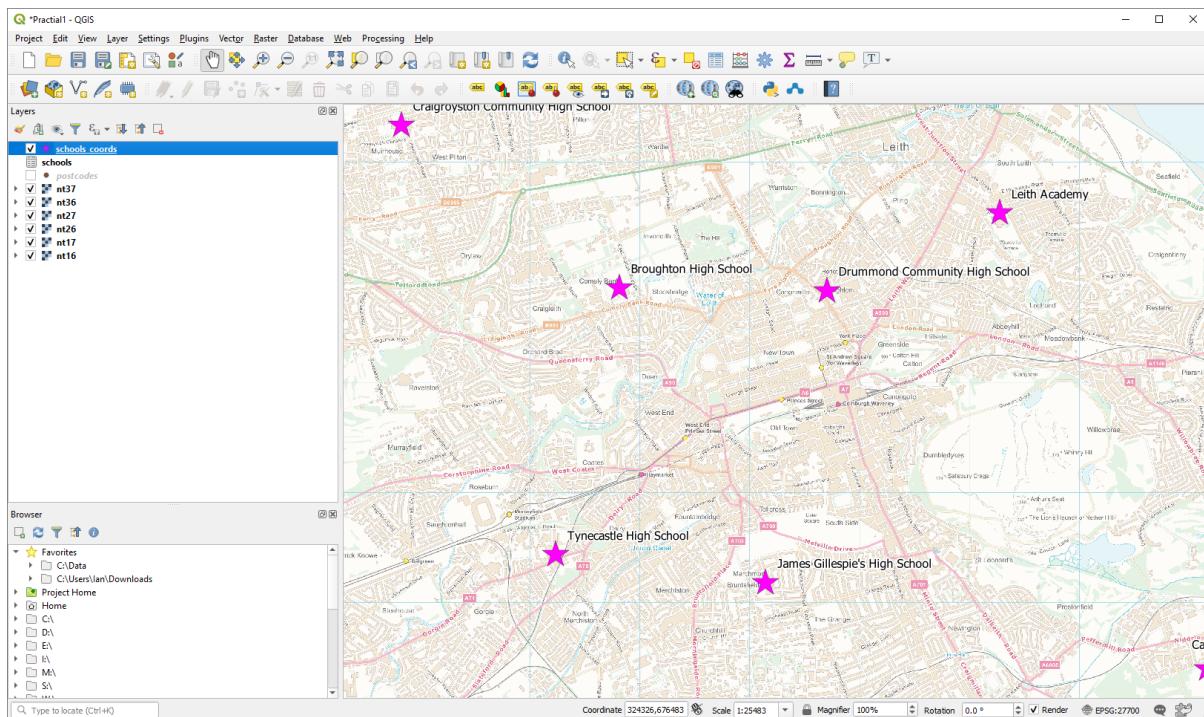


6. Click on **Buffer** and Check the **Draw text buffer** option, the default size one is OK.

The buffer puts a white background to the text preventing the map details from making it difficult to read.

7. Click on **Placement** and change the **Distance** to be **6** (more than half the size of the marker which is 10) to prevent the label overlapping the marker.
8. Click **OK** to close the **Layer Properties** window

You should now have labels on your schools that clearly stand out from the map:

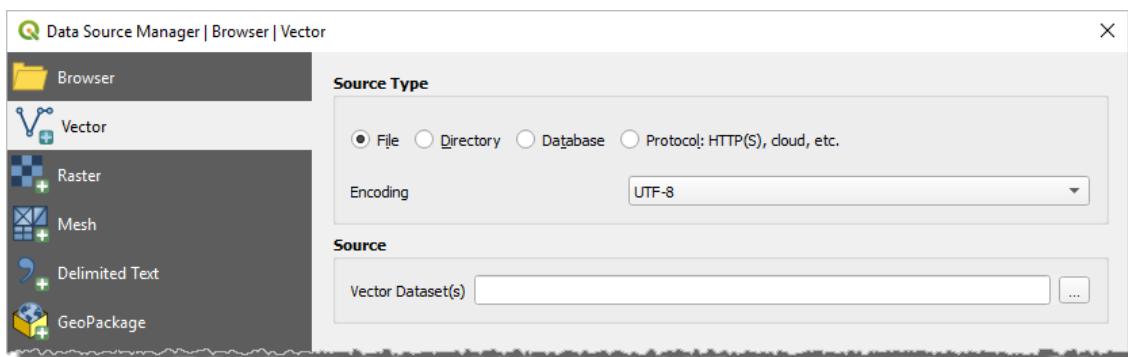


## Part 5: Adding Vector Data

The map we have created looks OK but the backdrop mapping is very generalised, it provides a good overview but we can't see detail. We can add some new data to see more detail, we have some building outlines from OpenStreetMap, which should enable us to see the detail of the schools.

1. Click on the **Open Data Source Manager** button 

2. Click on the **Vector** tab on the left hand side.



3. Add the **Edinburgh Buildings.shp** file to the map.

 Edinburgh Buildings.cpg	10/03/2017 14:52	CPG File	1 KB
 Edinburgh Buildings.dbf	10/03/2017 16:21	OpenOffice.org X...	255 KB
 Edinburgh Buildings.prj	10/03/2017 14:52	Text Document	1 KB
 Edinburgh Buildings.qpj	10/03/2017 14:52	QPJ File	1 KB
 Edinburgh Buildings.shp	10/03/2017 14:53	AutoCAD Shape S...	4,796 KB
 Edinburgh Buildings.shx	10/03/2017 14:53	AutoCAD Compil...	186 KB

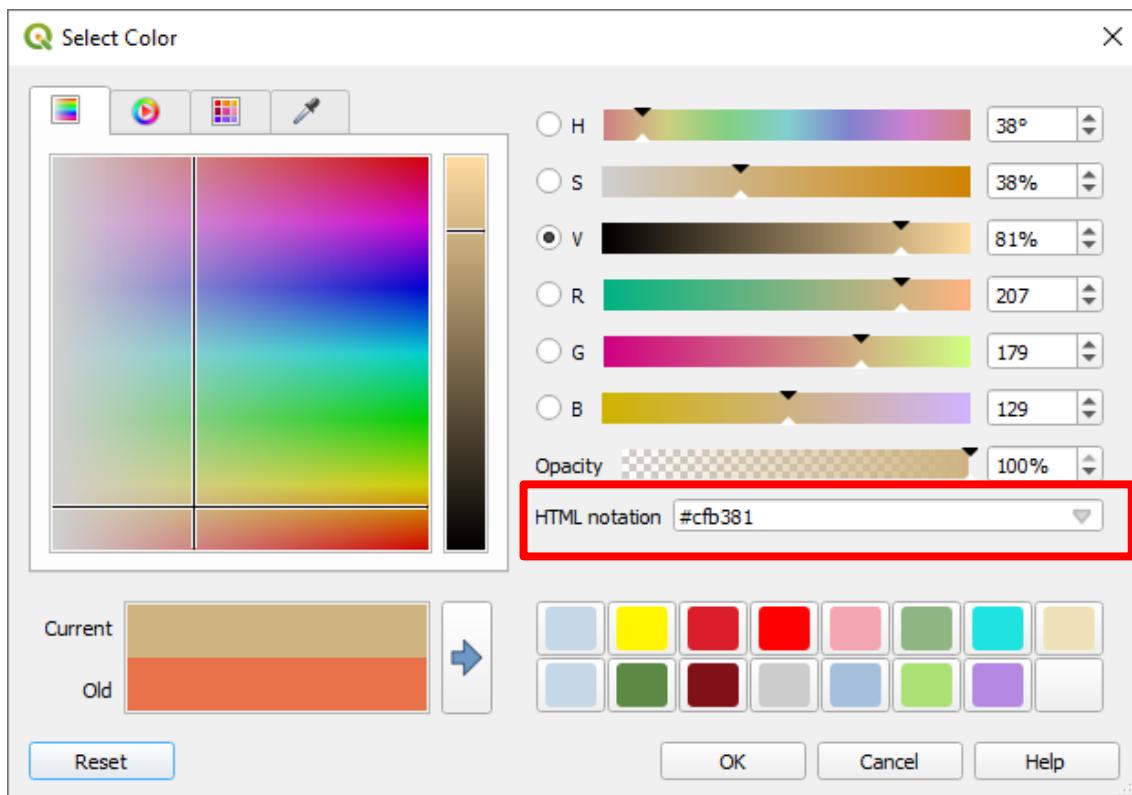
**NOTE:** Shapefiles are made up of several component files, they all need to be in the same folder with the same name for the "Shapefile" to work.

The buildings will be added to the map with a random colour assigned to them, you may also need to drag the layer below the **schools\_coords** layer in the **Layers** panel.

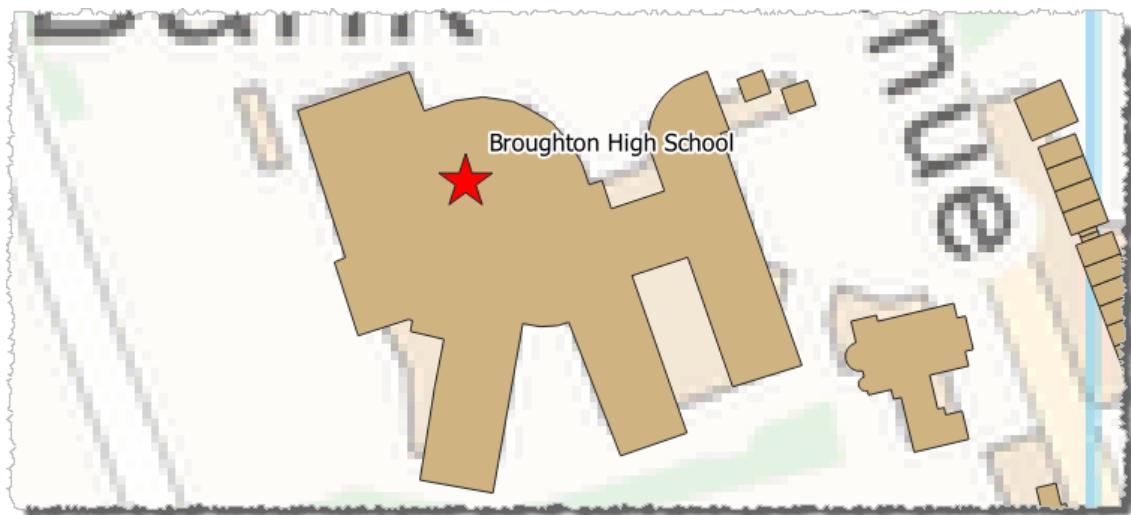
4. If the **Edinburgh Buildings** appears above the **schools\_coords** in the **Layers** panel, **click and hold** on the name and drag it below.
5. **Right Click** on the **Edinburgh Buildings** layer in the **Layers** panel and select **Properties**.
6. Go to the **Symbology** tab.

A sandy colour is standard for buildings on more detailed map data so we will change to this from the random one assigned by QGIS.

7. On the symbology tab click on the **Color** area to change it, there are multiple ways to change colour in this interface. Use the **Select Color** window to pick your colour, we have chosen a colour with the html notation: **#cfb381**.



8. Zoom in to see the detailed outlines of the schools marked on the map:



You have now completed the first part of the workshop!

For the next section we will be starting a new map document.  
Save your work and we can then move on to Practical 2.

## **Creating data in QGIS: Georeferenceing a scanned map and creating a new Shapefile**

*In this section we will add a little contextual mapping and use this to georeference a scan of a historic map of Scotland. We will then create a new blank dataset and use the historic map to create a set of points marking the locations of towns and cities in Scotland.*

*Finally, we will use the points along with a historical counties dataset to create multiple new datasets using spatial selection queries.*

### **Part 1: Adding the contextual mapping**

1. Open a “new map file” by clicking on the  icon in the top left corner of the interface.

You cannot have two map files open at the same time in QGIS so if you have still got Practical 1 open it will ask you to save changes and close it.

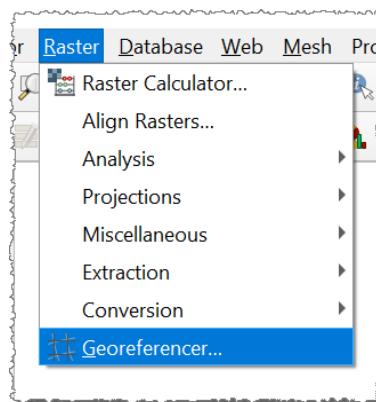
2. Click on the **Open Data Source Manager** button 
3. Click on the **Vector** tab on the left hand side.
4. Click **Browse** and navigate to the **Practical 2** folder.
5. Add the **Scotland.shp** file to the map.

You can change the style of the map if you want but we are just using it to get an outline so that we can georeference the scanned map. The map we will be using is William MacKenzie's 1846 map from his Gallery of Geography.

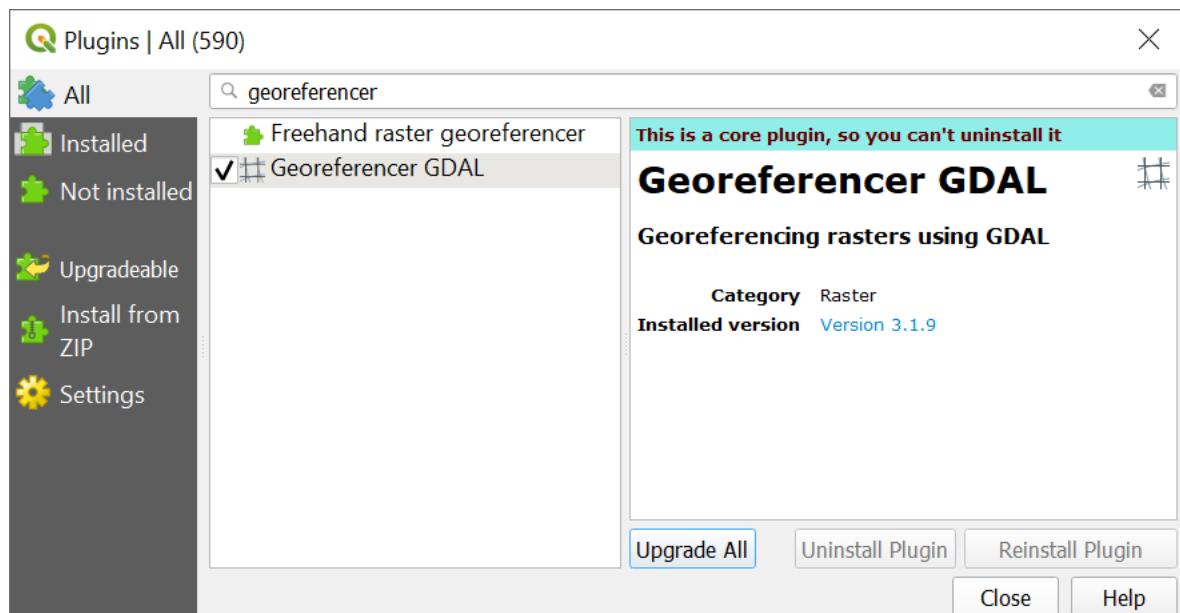
## Part 2: Georeferencing

Georeferencing means to associate something with locations in physical space. The term is commonly used by GIS people to describe the process of associating a physical map or raster image of a map with spatial locations. This allows the GIS software to locate the map in the right place in relation to other geographic data layers.

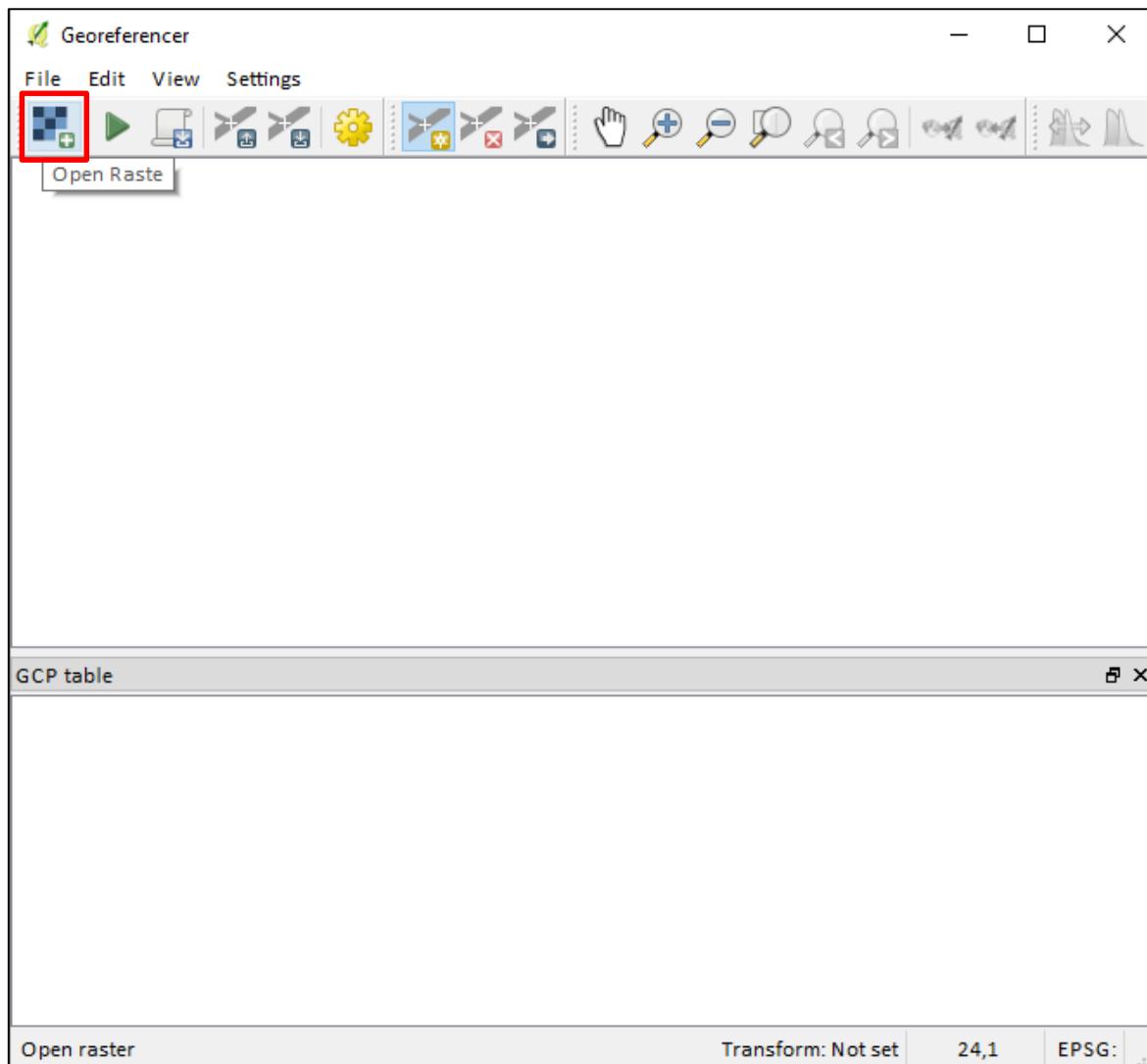
1. Start the georeferencer interface by **clicking** on the **Raster** menu at the top of the screen and selecting **Georeferencer...**



**Note:** if the **Georeferencer** option is not present in the **Raster** menu, you will need to enable it via the **Plugins** menu. Select **Plugins > Manage and Install Plugins**, search for ‘georeferencer’ and select the checkbox next to the **Georeferencer GDAL** entry:



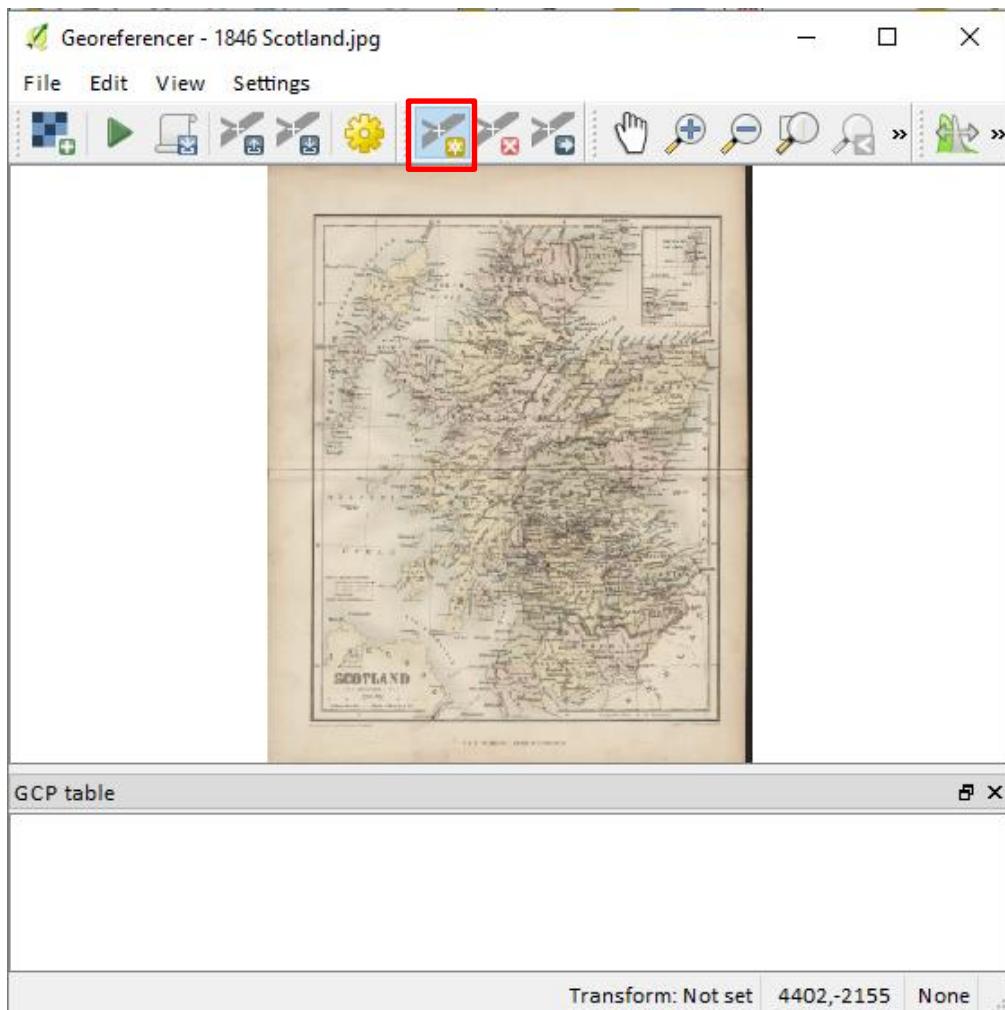
2. The interface will look like the image below, click on the **Open Raster** button to load in the scanned map.



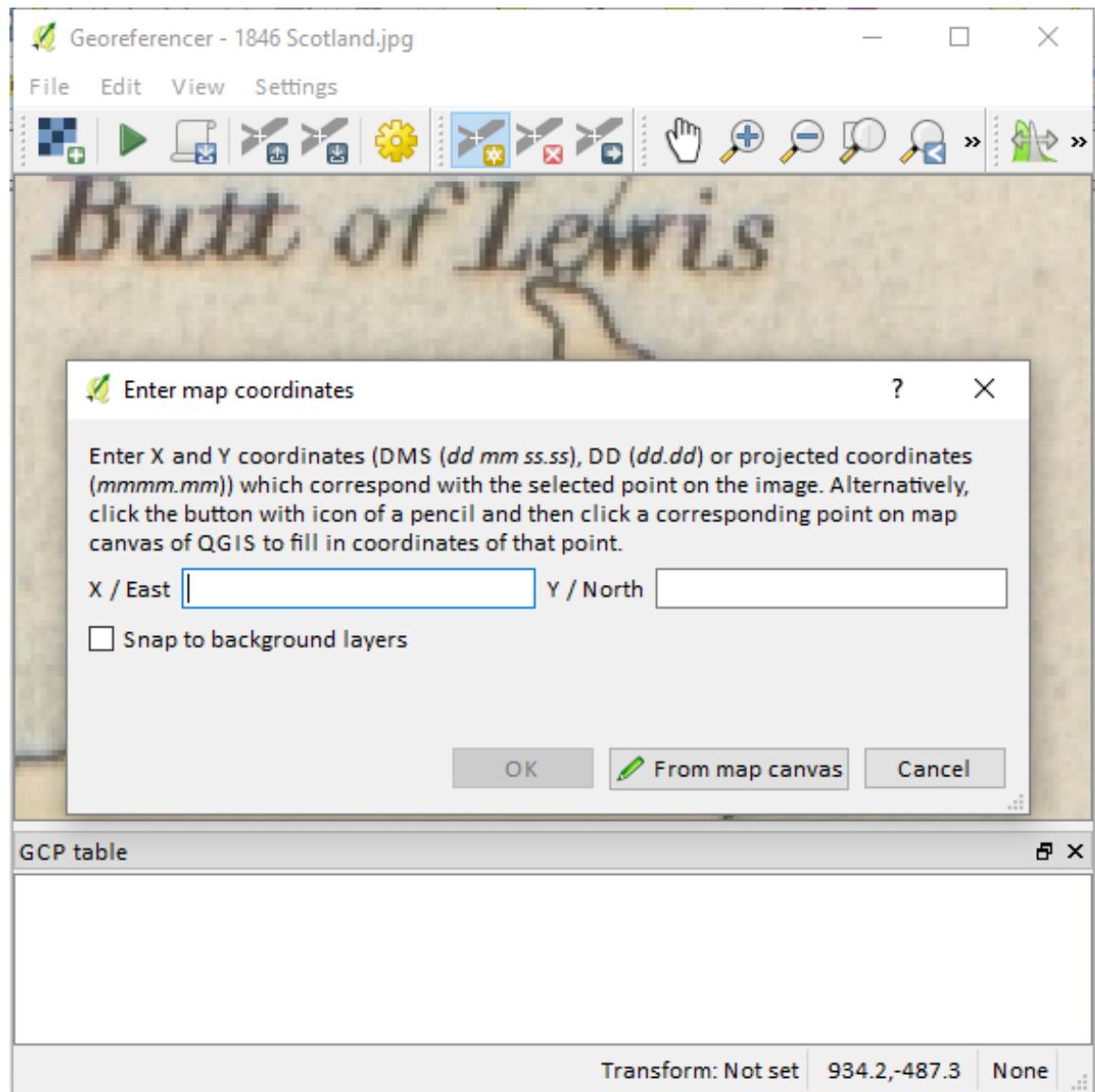
3. Navigate to the **1846 Scotland.jpg** file and click **Open**.
4. Specify the coordinate system **as OSGB 1936 / British National Grid** as we did before and click **OK**.

The map has now been added to the interface and we can start capturing control points. We will need at least 4 for a good fit. It is best to have them regularly spaced around the map to give the best possible result. We have only got a coastline to go on in this example so we'd suggest 6 points one near to each corner of the map and 1 more on each side roughly in the middle of the map. As there could be more discrepancy between high and low tide in bays and estuaries look for prominent headlands to select points on.

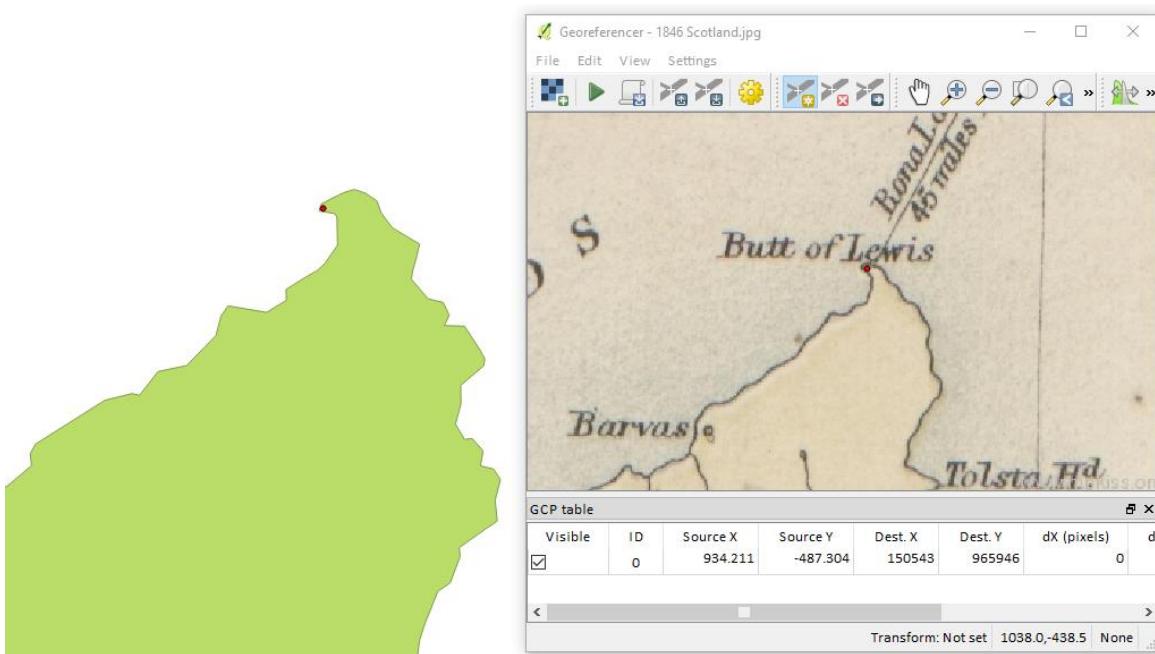
5. The Add Control Point button should be highlighted after adding the map, click on it to start the process.



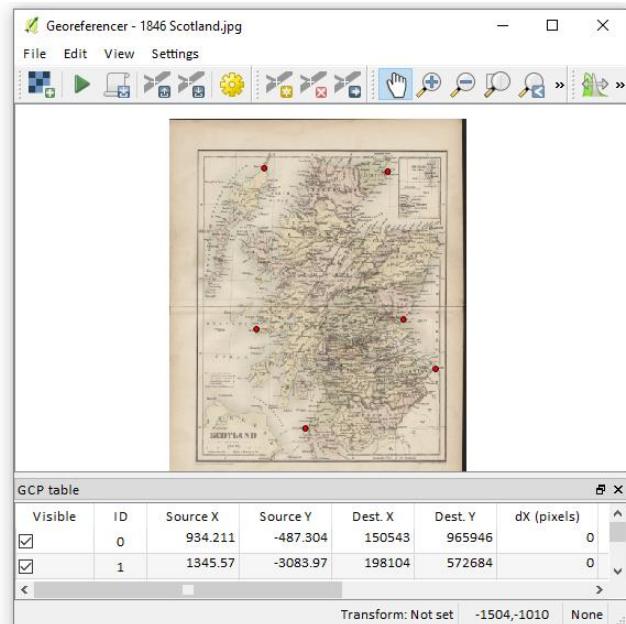
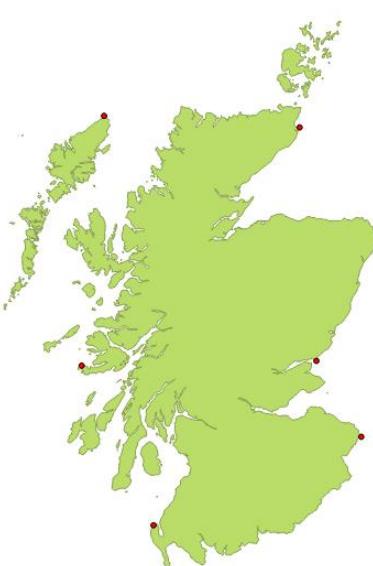
6. **Zoom** in using the mouse wheel and centre the map using the pan **Hand** to on the **Butt of Lewis** and click on the add control point button and then click on the map precisely on the tip of the land.



7. Rather than entering the coordinates as suggested click on the **From map canvas** button to click on corresponding locations on the coastline map we added to QGIS earlier.
8. Use the mouse wheel to zoom to the Butt of Lewis in QGIS and click on the precisely the same location as you did on the scanned map. This can be tricky and you can't use the pan hand in QGIS without stopping the georeferencing process.
9. When you select your location the Georeferencer reappears with the coordinates filled in. **Click OK** and you will see your control point displayed on both maps.



10. Repeat this process until you have at least points near the 4 corners. We used the following extra points; the top of Iona, Coursewell point near Stranraer, Berwick, Buddon Ness near Dundee, and Noss Head near Wick.

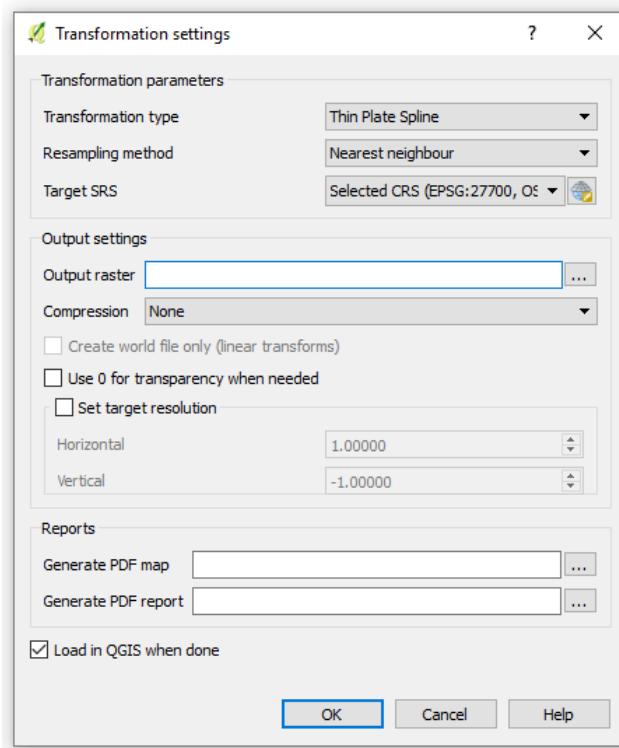


Before we can use the control points to georeference the map we need to make a few settings to ensure the software uses the right parameters.

11. Click on the yellow **Settings Cog** button above the map:

12. Select the following options:

- a. Transformation type: **Thin Plate Spline**
- b. Resampling Method: **Nearest neighbour**
- c. Target SRS: **EPSG: 27700 (British National Grid)**
- d. Output Raster: Browse to our Practical 2 folder, the default name is fine
- e. Ensure that **Load into QGIS when done** is ticked on.

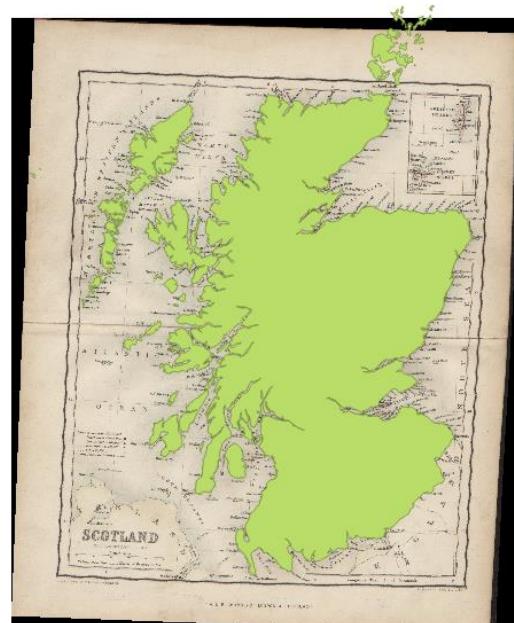


13. Click OK to keep the settings

14. Click the Green Arrow to start Georeferencing 

15. When the georeferenced map appears in the main QGIS window you can **close** the georeferencing interface. You may want to **save** your control points in case you have to redo any.

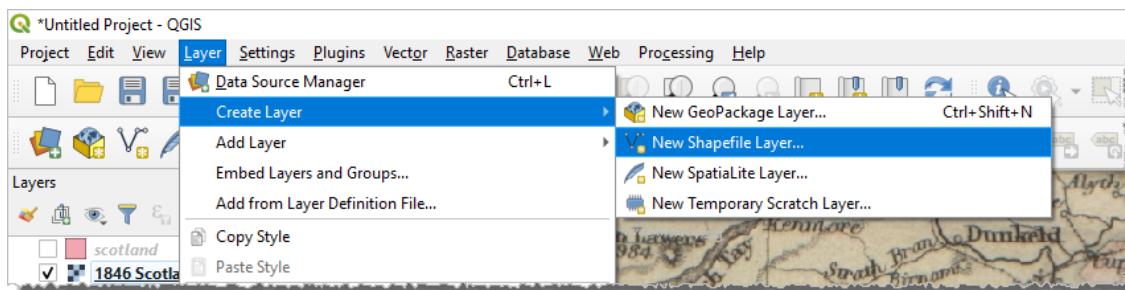
16. In the **Layers** panel drag the new map below the Scotland map and you should have something that looks like this:



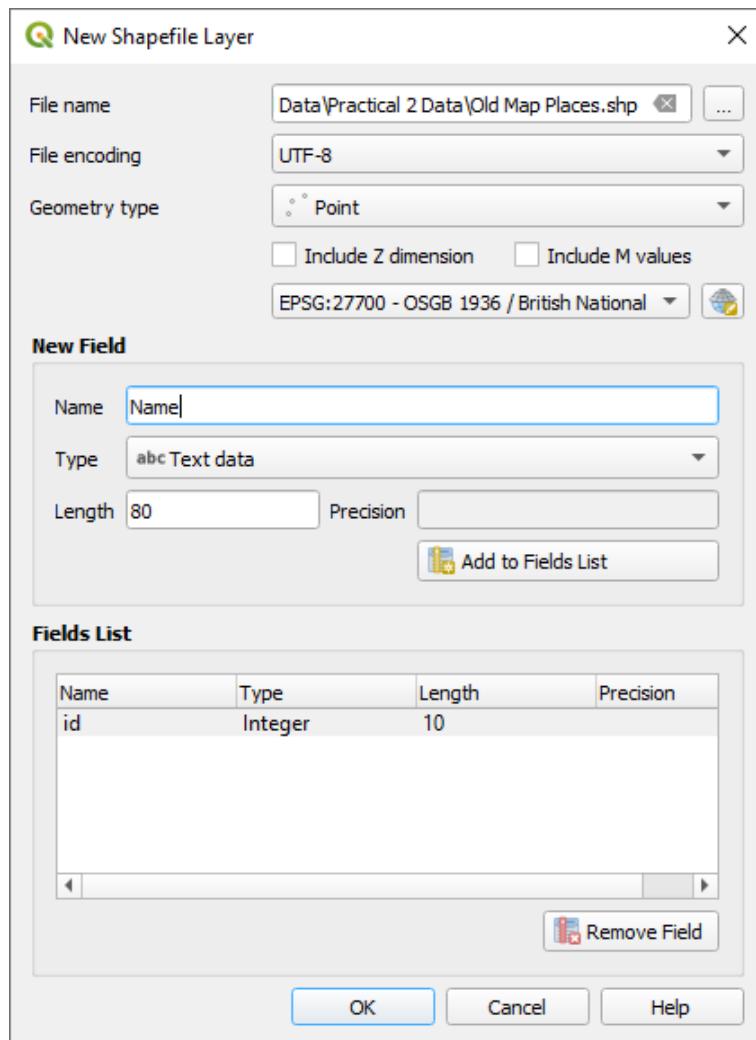
## Part 3: Creating a new Shapefile

In this part of the practical we will create a new Shapefile and collect data points from the scanned map. The idea we are looking at here is using raster data sources to create new vector information.

1. Turn off the **Scotland** outline layer by **un-checking** it in the **Layers** panel.
2. Click on **Layer** in the top menu bar and select **Create Layer → New Shapefile Layer:**



3. Call the new file **Old Map Places** and save it in your Practical 2 folder.
4. In the window that opens ensure the following:
  - a. Type: **Point**
  - b. CRS: **(EPSG:27700 – OSGB 1936 / British National Grid)**
5. Create a New Field:
  - a. Name: **Name**
  - b. Type: **Text Data**
  - c. Length: **80**
6. Click **Add to fields list**
7. Click **OK**



Your new shapefile has been created but it has no data in it. We can now start adding data to the new file by starting an **Editing** session.

## Part 4: Editing a Shapefile (Digitising)

Editing sessions can be used to add data to a file or to change the data that already exists.

1. First, **click once** on the **Old Map Places** layer in the **Layers** panel so that it is highlighted in blue. When you start editing you can only edit the layer highlighted in the **Layers** panel.

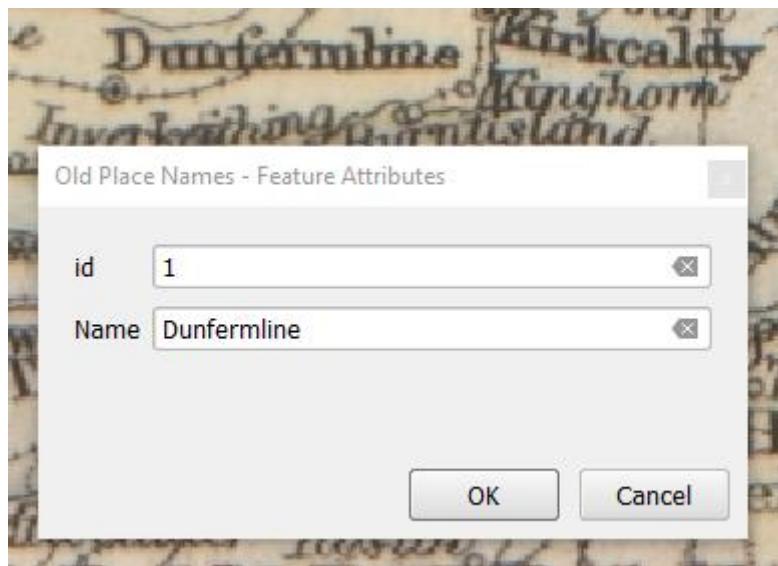


2. Now start an editing session by **clicking** on the **pencil icon** in the top menu:
3. **Zoom** in to the map so you can see a few place names and the circles marking their locations clearly.

Edinburgh and Glasgow are marked with squares being the main cities, other important places are named in bold and have a dot in a circle to mark their location. We are going to try and capture as many of these as time allows.



4. **Click** on the **Add Feature** button: Note the cursor turns into a cross-hair.
5. **Click** on the map putting the **cross-hair** dead centre on the location markers.



6. Fill in the **id** and **Name** in the box that appears then click **OK**.
7. A coloured dot will appear every time you create a location, try to make sure each one has a unique ID number. Repeat this process for at least 5 more points if you have time.
8. **Click Save Edits** when you have finished then click off edit mode to see your results.



## Part 5: Selecting Data

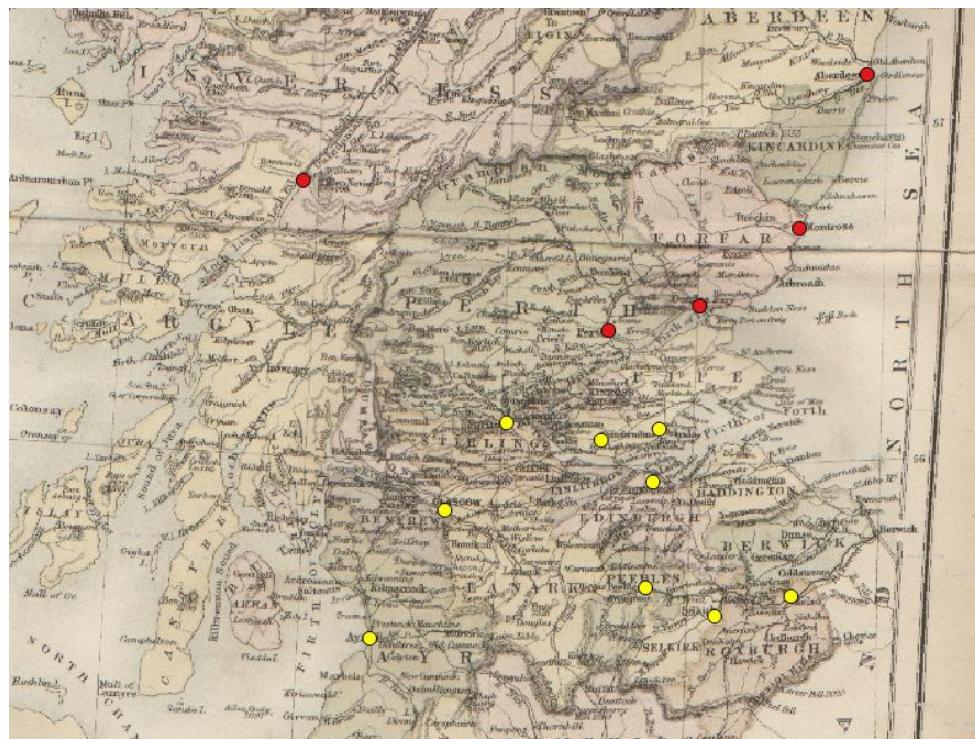
It is possible to take samples of your data by selecting out certain features. These selections can then be saved as new datasets. You can select data in a number of ways, by drawing an area on the map with the select tool, by querying the attributes of the data points, or by using the spatial features of one dataset to define the features to select from another.

### Selecting with the Selection tool.

1. Click on the drop down arrow next to the **Select Feature(s)** tool: 
2. You can now see the options for drawing the area to select features by:



3. Using the first option you can drag a box over the features you want to select.
4. Zoom in to the map and use the tool to try and select the features in southern Scotland, they will highlight yellow when selected.



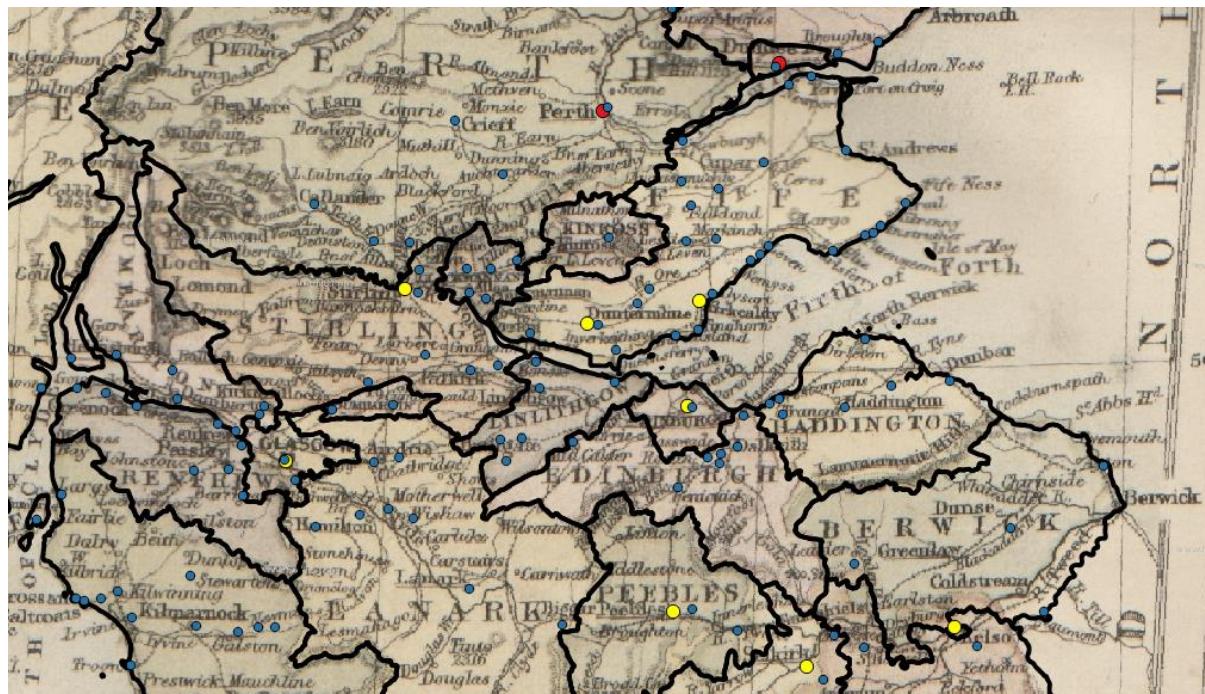
This is very easy and you can be precise when the points are scattered however when the points are more densely packed or the area you want is more complex then you may need to

use the polygon or free hand tool. However when you need real precision it is best to use the features of another layer.

### Selecting using another layer

1. Use the **Open Data Source Manager** button and go to the **Vector** tab to bring in some new data, browse to the Practical 2 folder and add the **scotland historic counties.shp** and **scotland towns and cities.shp** files.
2. Right-Click on the **scotland historic counties.shp** and click on **Properties...**
3. Click on the **Symbology** tab and then where it says **Simple Fill** at the top.
4. Change the **Fill** to be **Transparent** and the **Outline width** to be **1**.

The map should now have a lot more point and the boundaries of the historical counties marked on it.

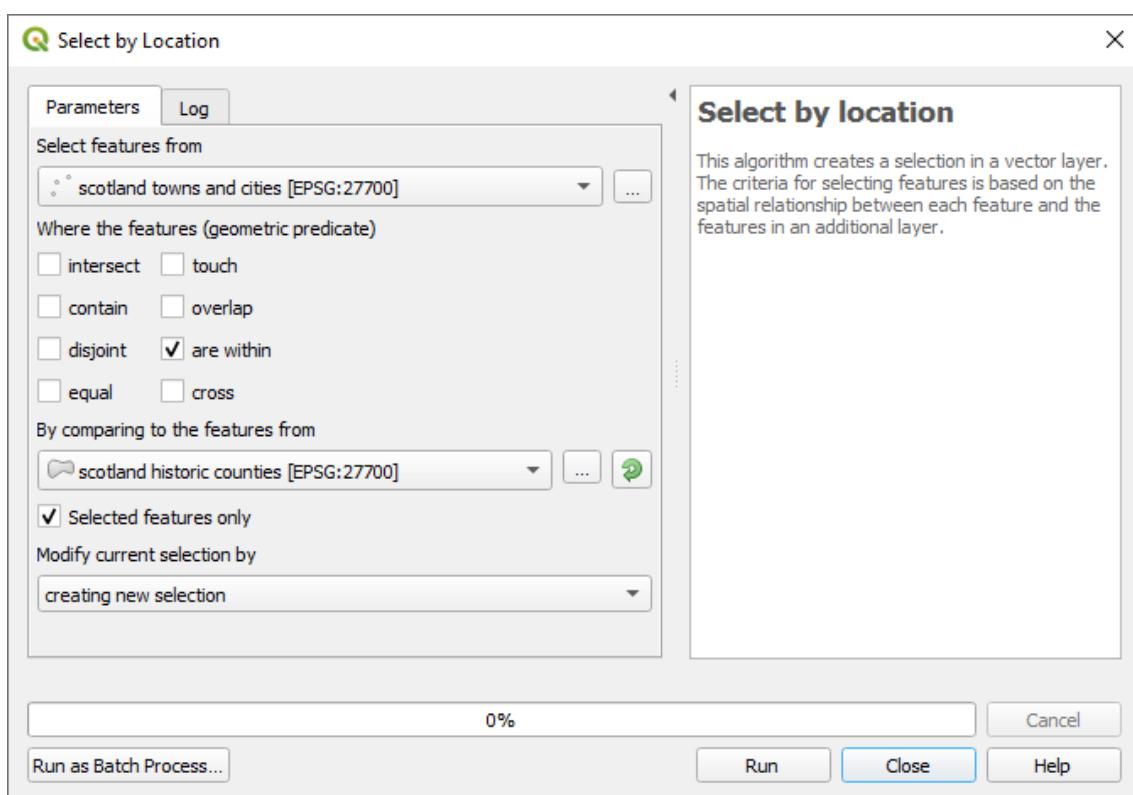


We are now going to use these datasets to select all the settlements in a county.

5. First click on the **clear selected features** button, to clear any of your previous selections:
6. Now **click once** on **scotland historic counties.shp** in the **Layers** panel, so it is highlighted blue. When we make selections now it will only affect this layer.
7. **Click on the Select features by area tool** and click on the **Linlithgowshire County** so it is highlighted yellow.

We can now set up a spatial query to select the towns and cities in Linlithgowshire:

8. Click on the **Vector** menu at the top of the screen and select **Research Tools > Select by Location...**
9. Select **Scotland towns and cities** as the layer to select features from.
10. For **Where the feature** section, change to **are within**.
11. Set **features from** to **Scotland historic counties**
12. Ensure that the box is **checked** for **selected features only**, this will ensure it only selects the features within Linlithgowshire.
13. The final option should be set to **creating new selection**.



14. Click **Run** and the settlements in Linlithgowshire will be selected.

### Selecting by Attribute

The final way we are going to select data is by their attributes. The towns and cities we just added have some attributes we can use to distinguish them so we can use a database query to select the ones we are interested in.

- First click on the **clear selected features** button, to clear any of your previous



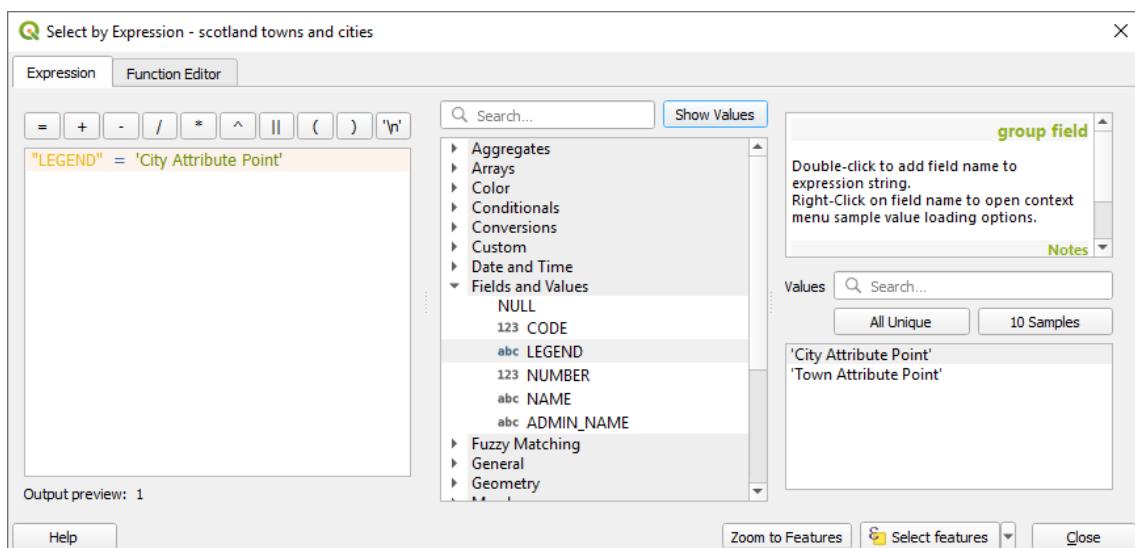
- Now **click once** on **scotland towns and cities.shp** in the **Layers** panel, so it is highlighted blue. When we make selections now it will only affect this layer.

- Click on the **Select features by expression** button:



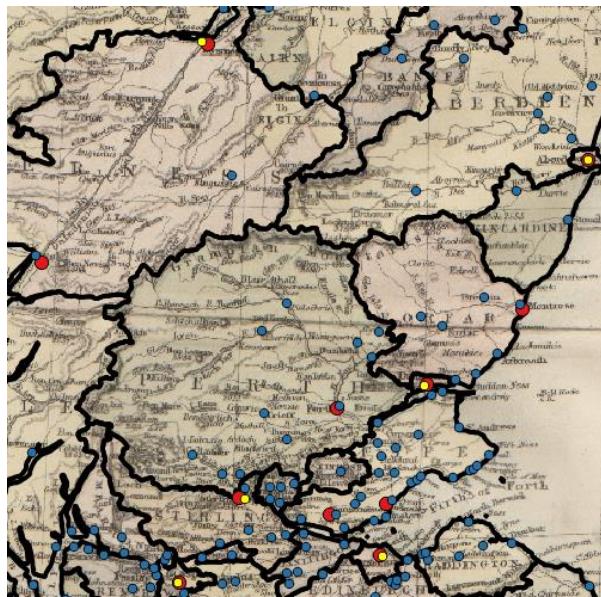
We can now build an expression to select all the cities from the data and not the towns. The Legend field in the attribute contains the values we need so we will query based on this info. We will be using SQL to build our expression, this is the Standard Query Language for databases.

- Click the drop down arrow** next to the **Fields and Values** in the second column.



- Double click on Legend** and it will appear in the expression builder.
- Click on the All Unique** button at the bottom of the last column, it will be populated with all the unique values for this attribute, there should be two.
- Click on the = above the expression builder box** then double click on the **City Attribute Point**.
- When the query looks like the above picture click **Select features** then **Close**.

The Scottish Cities should now be highlighted. We can now save them as a new dataset.



9. Right-Click on the **scotland towns and cities** layer in the **Layers** panel and select **Export > Save Selected Features As...**
10. Set the **Format** to be **ESRI Shapefile** and **Browse** to the Practical 2 folder and name the file **Scotland Cities.shp**
11. The **CRS** should be **EPSG:27700**
12. Ensure the **Save only selected features** checkbox is selected.
13. The remaining defaults are fine. **Click OK**.

The new layer will be added to the map, feel free to style these points differently to the others, perhaps using Squares.



You have now completed the whole workshop!

Thank you for attending.