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Using QGIS in Mineral Exploration

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1: SUMMARY

QGIS has developed significantly in the past few years and is now a valuable tool for the mineral exploration industry. QGIS is now a viable alternative to the commercially available GIS packages. Although not specifically written for geological applications, QGIS can do most of the required GIS tasks required by today's geologists.

This manual examines QGIS and how QGIS can assist geologists to undertake these tasks in their day-to-day work. Accessing data from the internet via web map and web feature servers is illustrated to show how using this data can help with compiling available data for an area. Detailed aerial photography and Google Earth can be easily integrated with mapping data to allow the creation of accurate base maps for a variety of geological applications.

A wide range of vector and raster (grid and image) data formats can be easily imported into QGIS, as well as GPS gpx files which can be directly imported into QGIS.

The presentation options for point, line and polygon data are extensive and easily customised. Geological symbols and pattern fills can be applied to points, lines and polygons. Geochemical and geophysical data can be presented in a variety of display options. Basic 3D display of map data is also available via a plug-in.

QGIS has many plug-ins for specialised tasks and the semi-automatic classification plug-in (SCP) can be used to select, download and process ASTER, Landsat and Sentinel 2 satellite data.

Map production is easy in QGIS with the map composer allowing extensive options for the display and printing of maps.

This document is a working draft and in continuous development. There may be errors and omissions and these will be rectified as time permits.

2: INTRODUCTION

This document is aimed at the exploration geologist in Western Australia but the techniques outlined are easily transferrable to other areas. The author has been using QGIS since 2015 and the version used in this document is version 2.18.11.

The reader is encouraged to join the international online QGIS user forum at http://lists.osgeo.org/mailman/listinfo/qgis-user and the Western Australian QGIS user group (contact the author for details).

This document will not go into the detail that is covered by the QGIS User Manual and other reference books (e.g. Graser 2016) on QGIS on topics like editing etc., but will discuss those tools used particularly in geological mapping, mineral exploration and remote sensing.

3: ABOUT QGIS

QGIS is a user friendly Open Source Geographic Information System (GIS) licensed under the GNU General Public License and is an official project of the Open Source Geospatial Foundation

(OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities.

QGIS is a volunteer driven project. They welcome contributions in the form of code contributions, bug fixes, bug reports, contributed documentation, advocacy and supporting other users on their mailing lists and gis.stackexchange.com. If you are interested in actively supporting the project, you can find more information under the development menu and on the QGIS Wiki.

QGIS provides a continuously growing number of capabilities provided by core functions and plugins. You can visualize, manage, edit, analyse data, and compose printable maps.

This document will mainly deal with work flows for geologists but there are many other tools available in QGIS and worthy of some exploration of their functions. Currently QGIS does not have a downhole or cross section display option, but there are groups keen to crowd source the development of the drill hole plug-in. QGIS does not also handle all the various geophysical processing options, and again there is interest from various groups to develop plug-ins for geophysical processing.

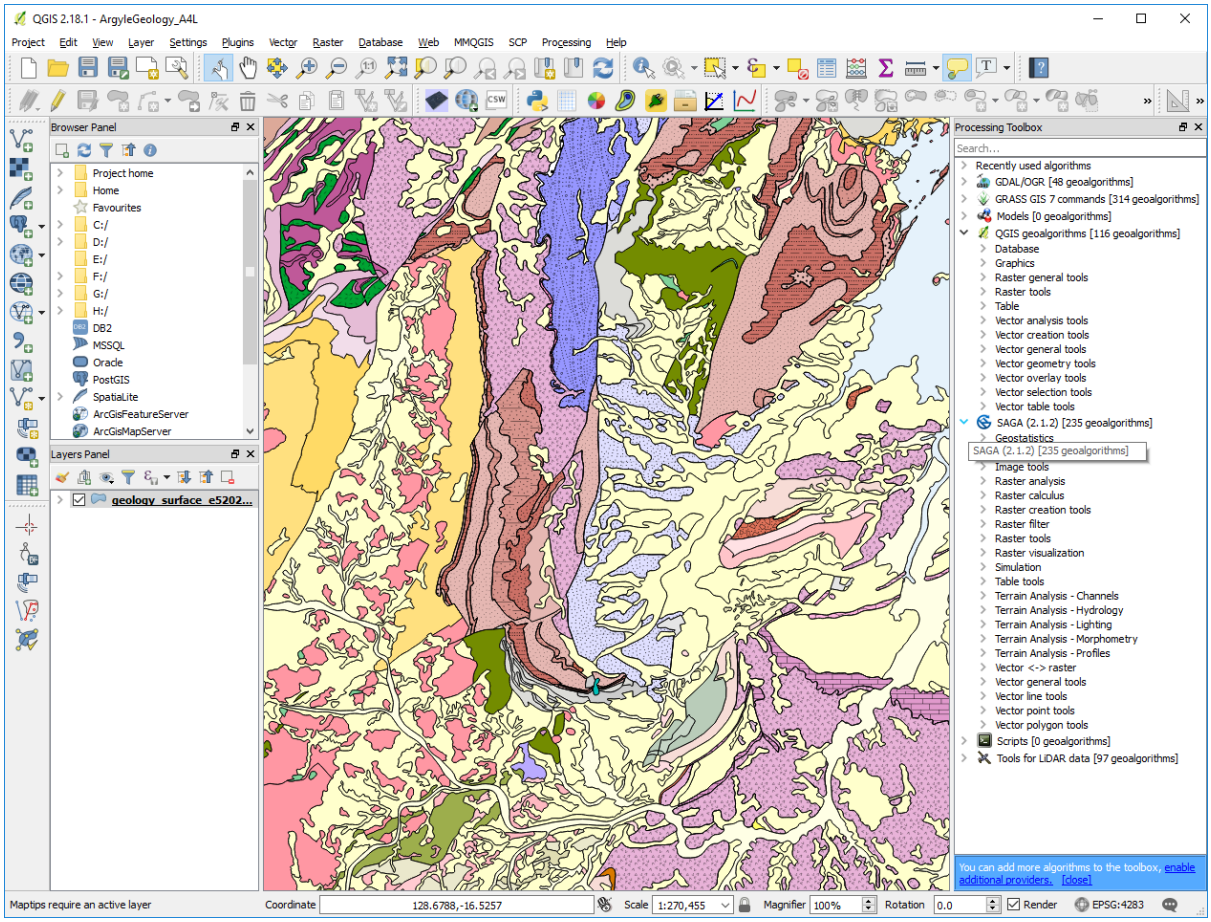
A complete revision of QGIS is nearing release, version 3, and should be available later in 2017.

4: THE QGIS DESKTOP

QGIS is not only a desktop GIS application, it also provides a spatial file browser, a server application, and web applications. The QGIS program can be downloaded from the QGIS Project website http://www.qgis.org/en/site/ and a choice can be made between 32 and 64 bit versions of the recent and current long term release version (2.18.12).

Once installed it is recommended to run the “QGIS Desktop 2.18.10 with GRASS 7.2.1” version which runs the GIS program and associated GRASS GIS functions.

The QGIS Browser panel allow users to preview and examine GIS directories.



The desktop is like other GIS applications with menu items along the top and numerous buttons/icons to make it easier to select various options without having to navigate menus. QGIS has operations to import vector and raster data from a variety of formats into QGIS, with excellent editing and analysis tools from the intergration of other GIS systems such as GRASS and SAGA. Some of these tools are illustrated in the right hand panel of the figure above.

5: PLUG-INS

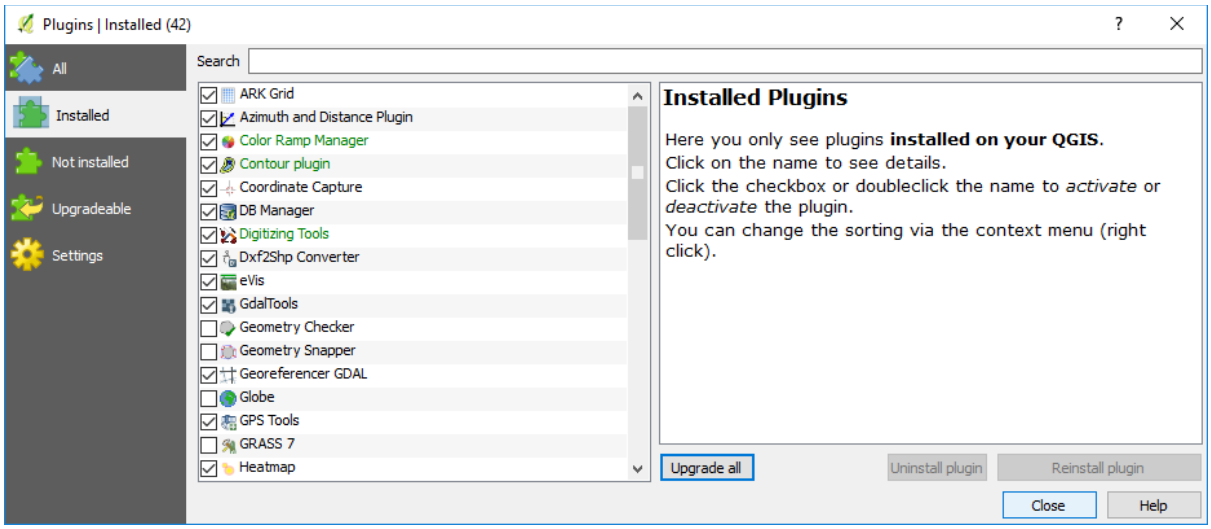
Plug-ins are small utility programs that greatly expand the capabilities of QGIS. There are currently 706 plug-ins available for download. These plug-ins are all free and have usually been written to solve a specific problem or task for users.

Seventeen plug-ins are installed by default in version 2.18.11 as are listed below.

Coordinate Capture
DXF2Shp Converter
eVis
Geometry Checker
Geometry Snapper
Georeferencer GDAL
Globe
GPS Tools
GRASS7
Heatmap
Interpolation plug-in
Offline Editing
Oracle Spatial GeoRaster

Raster Terrain Analysis plug-in
Road Graph plug-in
Topology Checker
Zonal Statistics plug-in

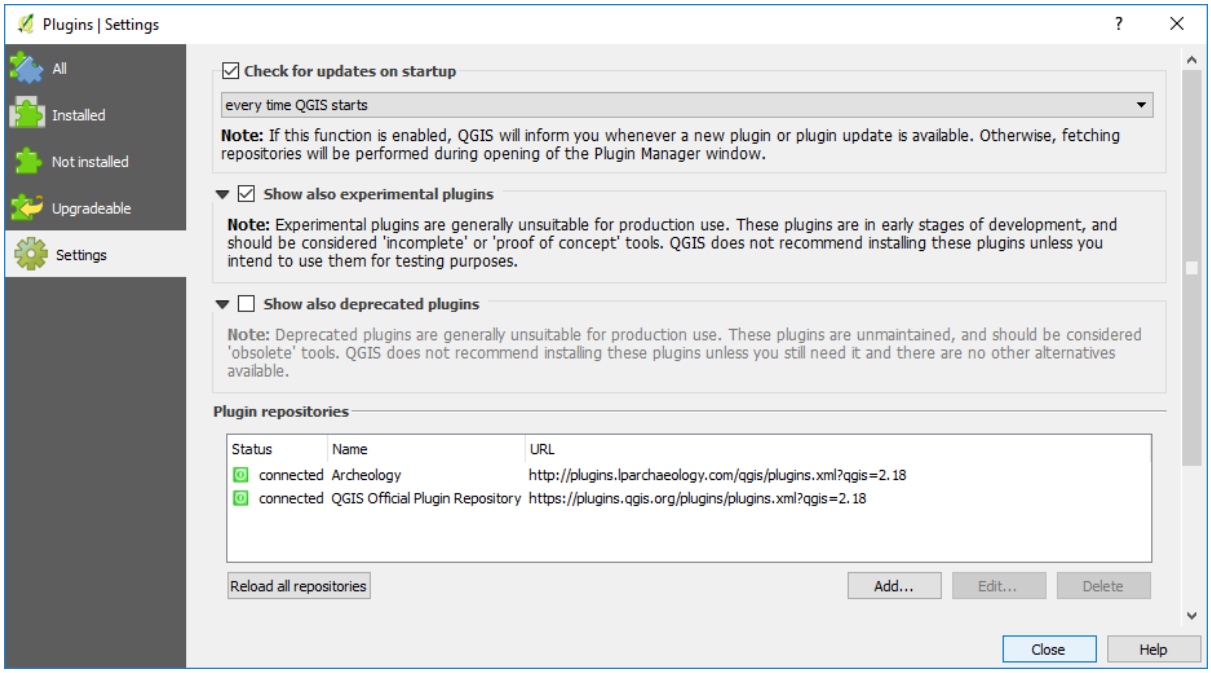
To use these plug-ins you may need to enable them in the Plug-Ins > Manage and Install Plug-Ins > Installed window. Enable the plug-ins by selecting the check box next to the plug-in.



Additional plug-ins that are recommended are as follows;

AusMap
Contour plug-in
MMQGIS (various selection and geocoding tools)
Numerical Vertex Edit (point editing)
Numerical Digitise (point editing)
Processing
QGIS2Threejs (3D visualisation)
QuickMapServices (raster maps and imagery, add extra services under settings)
Semi-Automatic Classification (satellite data selection and processing)
Spreadsheet Layers (import excel spreadsheet data)

In the Plug-Ins > Settings page, check the “Check for updates on start-up” and “Show also experimental plugins”.



Some managed IT systems block the loading of the repository data. Try selecting the Settings > Options > Network, and check the use proxy server. Try again to download the repository. If this loads the repositories, then uncheck this box and try to install the plugins.

6: DATA MINING AND PUBLIC DATASETS

QGIS has a large number of options to access on-line web datasets. These can be in the form of a WFS (web feature service – vector data), WMS (web map service – raster data) or as a WMTS (web map tile server – raster data). A large variety of raster maps can be sourced via the Web > QuickMapServices plug-in. You may need to enable extra services in the QuickMapServices plug-in by going to Web > QuickMapServices> Settings > More Services tab, then select "Get contributed pack". This will install numerous other options, including the Google Earth options.

Data can be downloaded for off-line use or can be used as live web based services providing you have a good internet connection. Satellite data for the ASTER, Landsat and Sentinel missions can be downloaded and processed via the Semi-Automatic Classification plug-in in QGIS and this is discussed below. Remote sensing data can also be downloaded via the USGS EarthExplorer and ESA (European Space Agency) websites.

The use of Spatialite database files can rapidly increase the speed of accessing large data sets. As an example, the entire 1:250 000 Geoscience Australia Australia-wide topographic vector data in zipped shapefile format is 1.01 Gb in size (GA file 64058.zip) and comprises many layers including road, rivers, etc. This file can be loaded into a Spatialite database file of about 3 Gb, but although a large file, the data is spatially indexed, and re-drawing of the data is very fast when panning from area to area.

6.1 GSWA (Geological Survey of Western Australia)

The Department of Mines, Industry Regulation and Safety (formerly the Department of Mines and Petroleum, http://www.dmp.wa.gov.au/) is home to the Geological Survey of Western Australia (GSWA) and this site contains a large number of data sets, most of which can be downloaded from the "Software and Data Centre" (https://dasc.dmp.wa.gov.au/dasc/). Raster and vector data can also be accessed live via their WMS and WFS services (http://geodownloads.dmp.wa.gov.au/downloads/dasc/Static/Resources/Map_Services/Image_Web_Service_definition.pdf and http://geodownloads.dmp.wa.gov.au/downloads/dasc/Static/Resources/Map_Services/Web_Map_Service_definition.pdf).

Registered raster files of the 100k and 250k geological map sheets have been mosaiced into 1:1 million map sheet areas and are in jp2 (jpeg2000) format registered in both GDA94 MGA coordinates. The "jp2" format contains the projection and registration data embedded in the file. Raster files of individual map sheets in either GDA94 lat/long or MGA can also be downloaded from the data centre.

The digital vector files for the 250k and 100k geology sheets vary in their data content depending upon the age of the map sheet edition. The GSWA use ArcView for their GIS system and many of their datasets contain "lyr" style and GeoMap "gmp" files. It has been requested that the data supplied by the GSWA also contain the colour and pattern information to allow users of other GIS systems (like QGIS) to style their maps similar to the GSWA style. This is a work in progress.

The GSWA have been testing a process by which they export layer styling into a MapInfo format file and they then use a python script to create a "qml" file for QGIS. This "qml" file contains all the colour styling information for polygon fills. This is work is evolving and hopefully this method can be used routinely for QGIS styling.

6.2 Landgate and Open Data WA

The WA government has made available a large variety of GIS datasets through their Open Data website (data.wa.gov.au). Searches can be made on this site and both vector data and web service links are supplied. More detailed datasets are available for WA from Landgate but they may require a subscription. Many datasets are however free and registration is required for either the free or subscription datasets.

Links to the web services are as follows;

WMS Links

Public: https://www2.landgate.wa.gov.au/ows/wmspublic?

Imagery: https://www2.landgate.wa.gov.au/ows/wmspublicimagery?

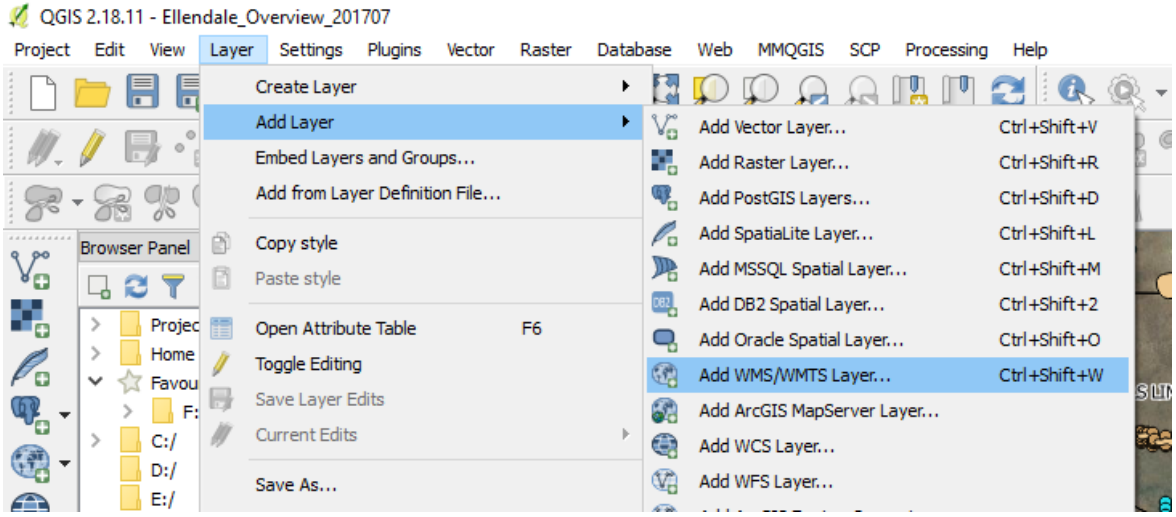
ABS: https://www2.landgate.wa.gov.au/ows/wmsabs?

WFS Links

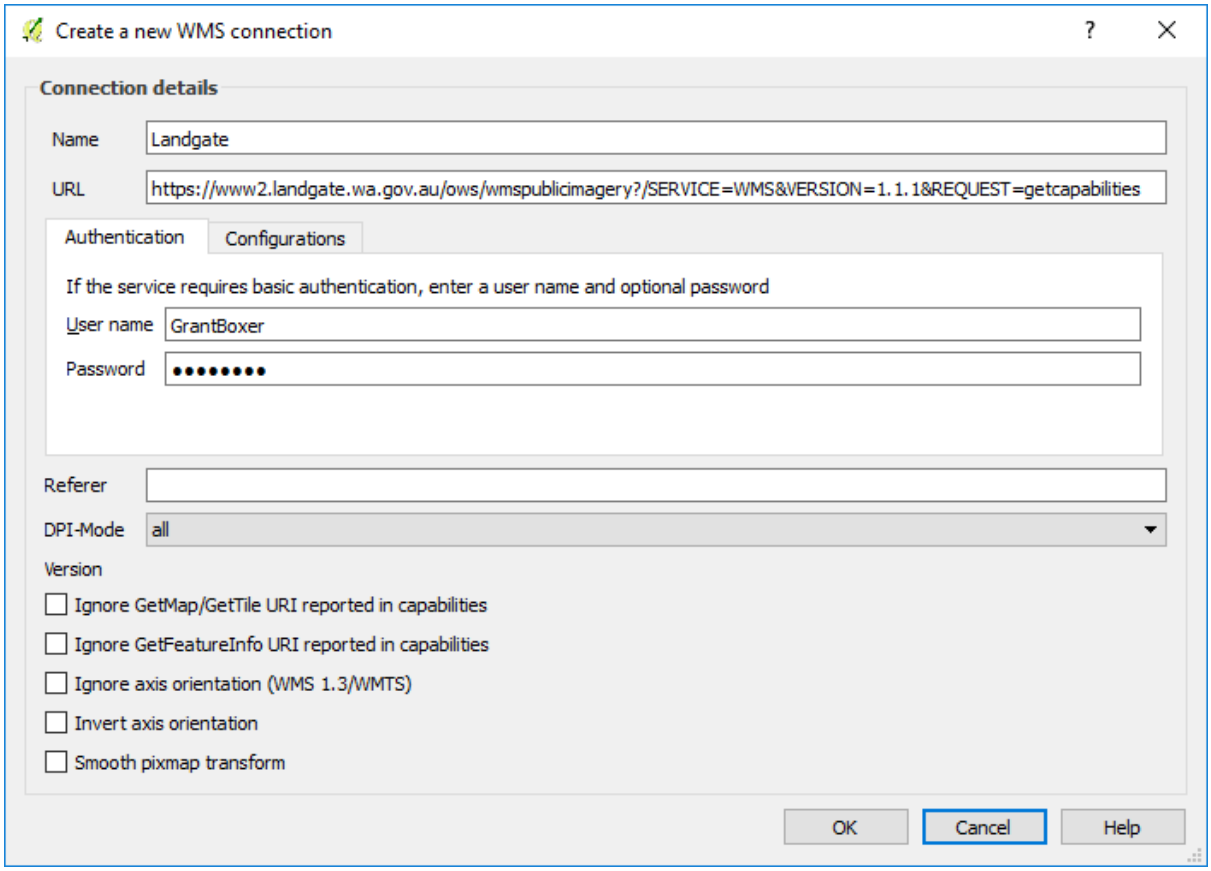
GDA: https://www2.landgate.wa.gov.au/ows/wfspublic_4283/wfs

ABS: https://www2.landgate.wa.gov.au/ows/wfsabs_4283/wfs

To add this data to QGIS, you use the Layer > Add Layer > Add WMS/WMTS Layer.

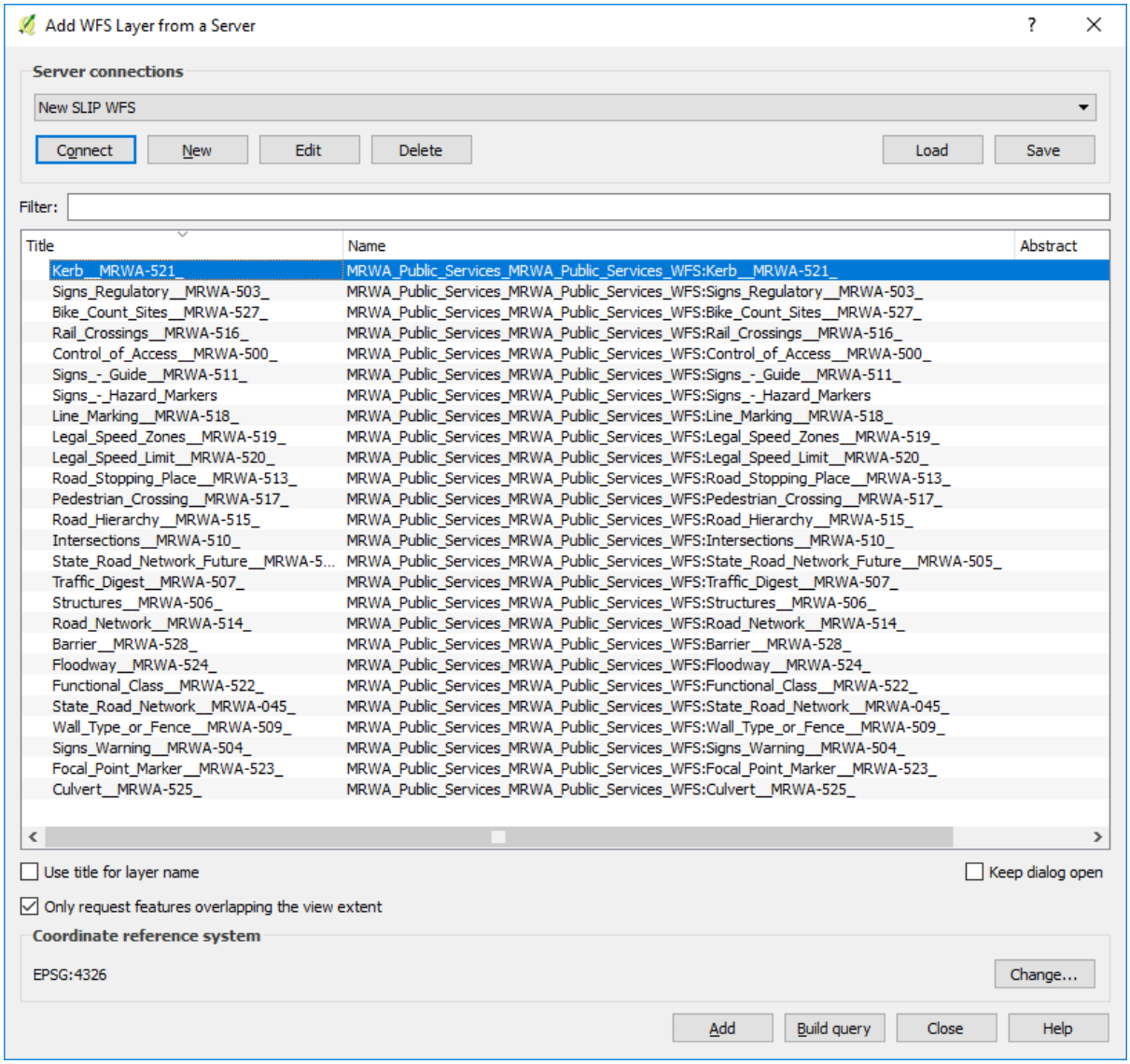


An example of linking to the Landgate imagery is shown below.



Some services will require you to register a username and password.

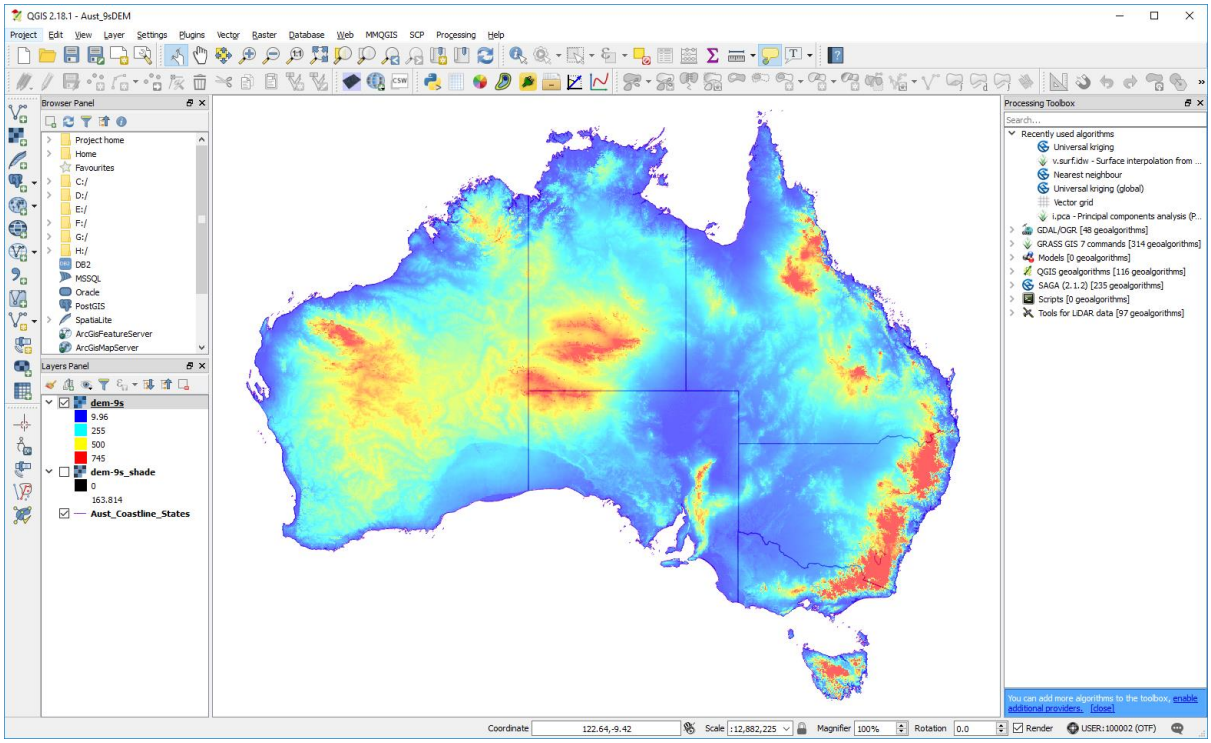
Access to vector data is via the add WFS option. See below for the list of publicly available data (no sign in required) from the Landgate SLIP server.



6.3 Geoscience Australia

Geoscience Australia (GA) provides an extensive array of national datasets (see this link for more information "data.gov.au/dataset").

Digital elevation data is also available across Australia from Geoscience Australia (http://www.ga.gov.au/elvis/) at a resolution of 1 arc second (approximately 30 m) and is available as a hydrologically conditioned and drainage enforced version (DEM-H). This is a 26 Gb zip file and can be downloaded and cut into UTM zones which are approximately 7 - 8 Gb in size each zone. Depending upon the speed of your PC/laptop, these may need to be further cut into 1:1 million map sheet areas. The 9 second DEM (approximately 250 m) is about 0.8 Gb in size, is also available.



Geoscience Australia, 9 second DEM

Many of these datasets are also available as web services – see this link http://services.ga.gov.au/.

Geophysical data incorporating magnetics, gravity, radiometrics and elevation data can be downloaded as vector (point data) or as grid files. Both national and individual survey data is available for data held by Geoscience Australia via the Geophysical Archive Data Delivery System (GADDS). The DMP will hold surveys flown for the GSWA. Data can be filtered by 1:250 000 map sheet area or by geographic coordinates. Check the projection of the dataset before you download, as it may default to geographic coordinates.

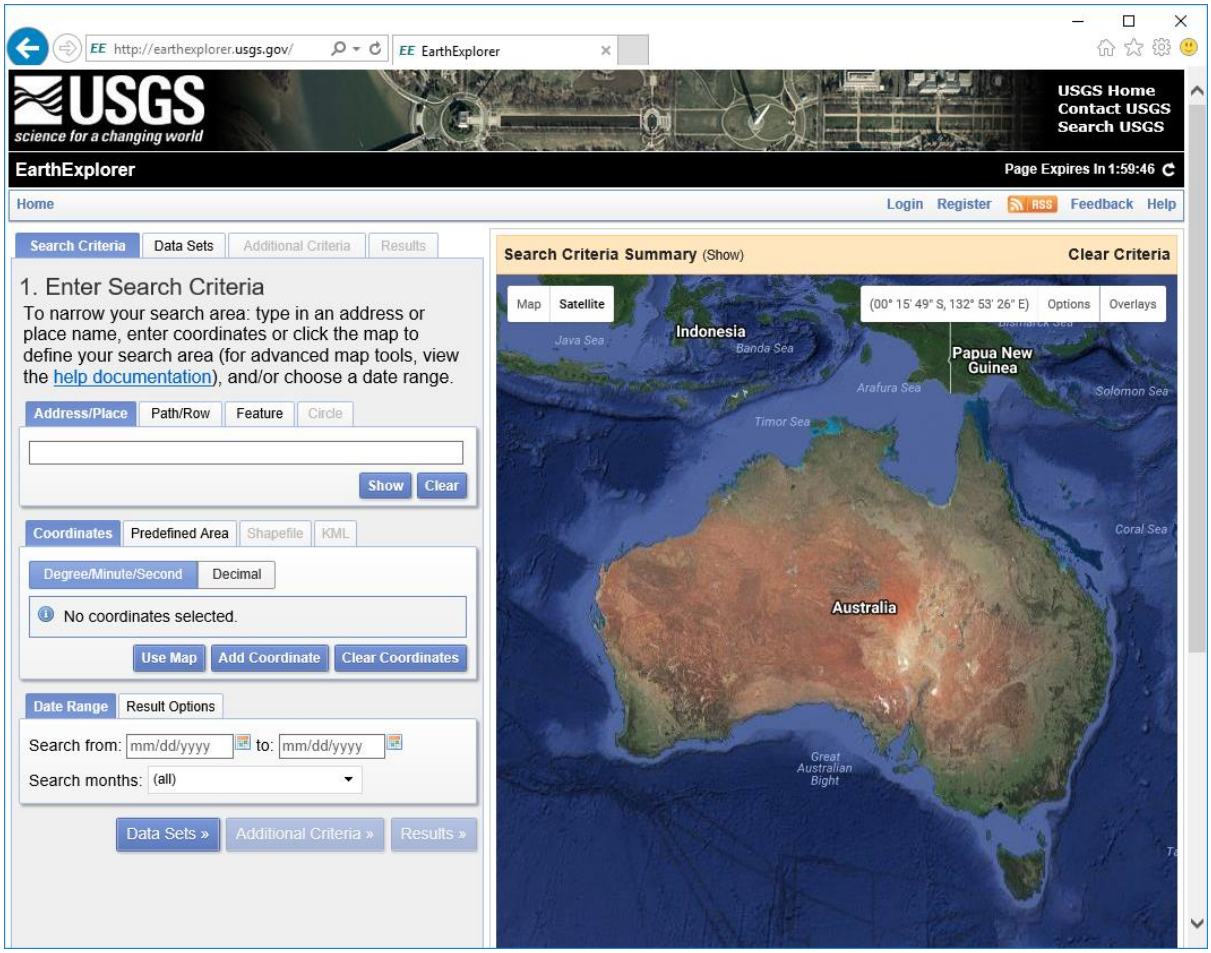
Geoscience Australia geophysical data portal.

GA have recently released a new Digital Earth Australia data portal at "eos.ga.gov.au". It currently holds "Water Observations from Space Data" but additional datasets are being developed to assist in land management (see http:/eos.ga.gov.au/geoserver/NFRIP-WOfS/wms?).

6.4 United States Geological Survey (USGS)

The USGS hold an enormous amount of free data, most of which is accessible via its EarthExplorer portal (http://earthexplorer.usgs.gov/). To download the data, you are required to register (free) and select a username and password.

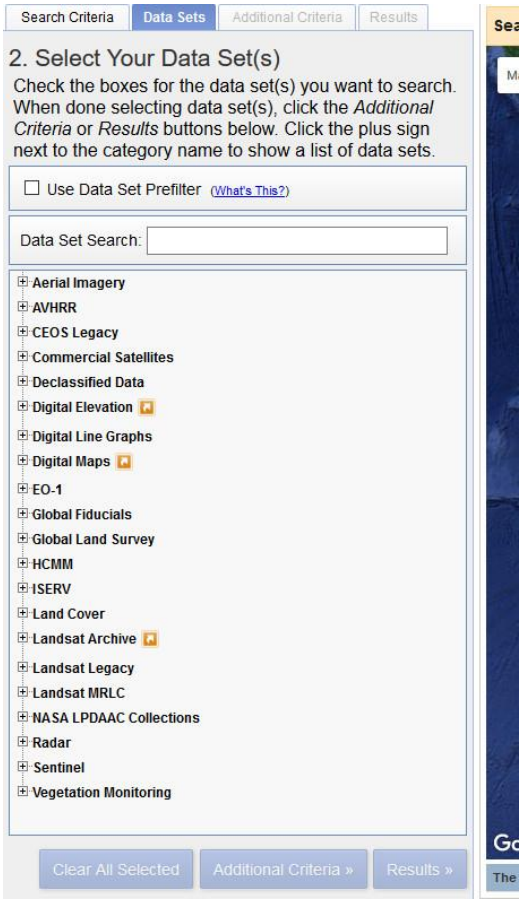
ASTER and Landsat data are two of the remote sensing datasets available from the USGS. These datasets are more easily accessed via the Semi-Automatic Classification plug-in in QGIS (see later). Digital elevation and Lidar data are also available from the USGS.



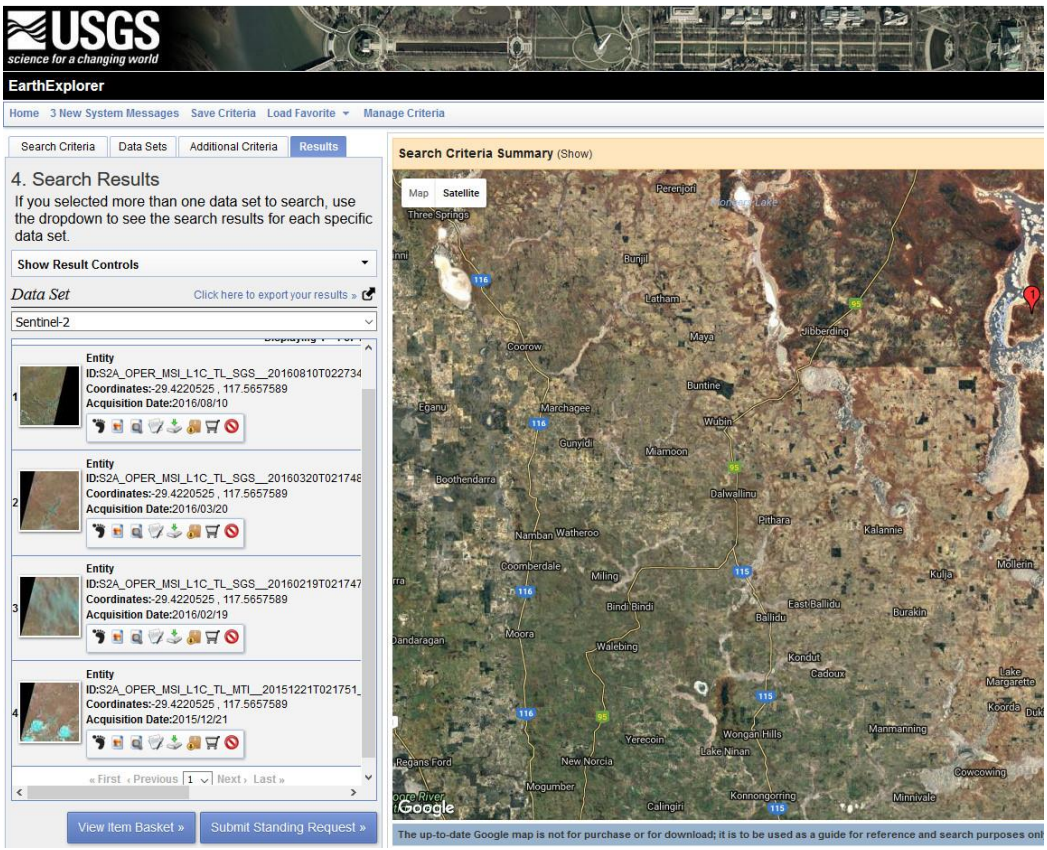
USGS EarthExplorer data portal.

Use the Register button to create a free account or log in if you have an existing EarthExplorer account. Logging in allows you to download datasets.

Enter the search criteria by using a Landsat path/row identifier, or by using the map or by a coordinate. Once you have selected an area, choose the data set you are seeking, add “Additional Criteria” if you want to filter your search, e.g. by date range.



Each of the data categories have a range of datasets available.



If there is data available from your search request, you can then examine the thumbnails of the scenes and select which dataset is the best one for your purposes. The footprint icon will show the area covered by the scene and notepad and pencil icon brings up a better view of the data including its metadata. Click on the download icon to download the data. The format of the data will depend on the data type and this needs to be researched by the user.

6.5 European Space Agency (ESA)

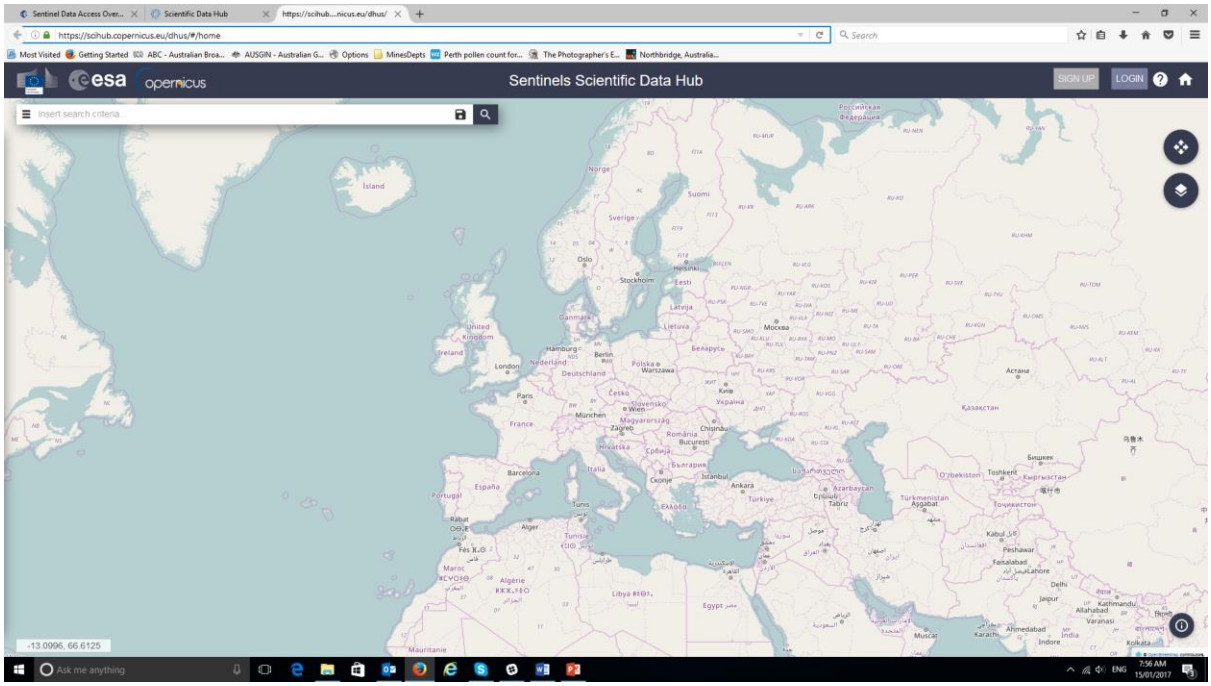
ESA has launched a number of satellites recently in their Sentinel series to observe the land and ocean areas for climate and monitoring purposes (see this site https://sentinel.esa.int/web/sentinel/home). The mission will monitor variability in land surface conditions, and its wide swath width and high revisit time (10 days at the equator with one satellite (2A), and 5 days with 2 satellites (2A and 2B) under cloud-free conditions which results in 2-3 days at mid-latitudes) will support monitoring of changes to vegetation within the growing season. The coverage limits are from between latitudes 56° south and 84° north (ESA). The second Sentinel 2 satellite (2B) has recently been launched and is undergoing commissioning tests.

The Sentinel 2 series A and B satellites are of relevance to geology as they have a high spatial resolution and 12 bands of spectral data. The multispectral imager (MSI) covers 13 spectral bands (443 nm–2190 nm) with a swath width of 290 km and spatial resolutions of 10 m (4 visible and near-infrared bands), 20 m (6 red-edge/shortwave-infrared bands) and 60 m (3 atmospheric correction bands). The Sentinel 2 satellites main applications are in monitoring agriculture, forests, land-use change, land-cover change; mapping biophysical variables such as leaf chlorophyll content, leaf water content, leaf area index; monitoring coastal and inland waters; risk mapping and disaster mapping.

Spectral bands for the SENTINEL-2 sensor

Band number	**Central wavelength** (nm)	**Bandwidth** (nm)	**Spatial resolution** (m)
1	443	20	60
2	490	65	10
3	560	35	10
4	665	30	10
5	705	15	20
6	740	15	20
7	783	20	20
8	842	115	10
8a	865	20	20
9	945	20	60
10	1380	30	60
11	1610	90	20
12	2190	180	20

The Sentinel data can be accessed via the Sentinel portal after registration (Sign Up button), see this link https://scihub.copernicus.eu/dhus/#/home.



After logging on to the portal, scroll to your area of interest and highlight a rectangle for your data search. This method of data selection is less intuitive than the USGS EarthExplorer data access portal.

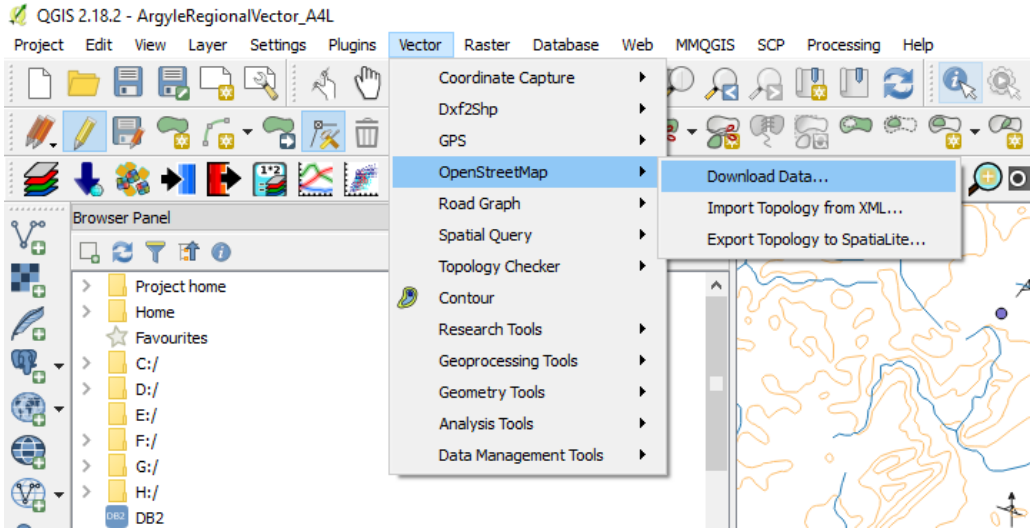
Sentinel data can also be accessed via the Amazon site (http://sentinel-pds.s3-website.eu-central-1.amazonaws.com/) and requires the user to know which data tile covers the area of interest.

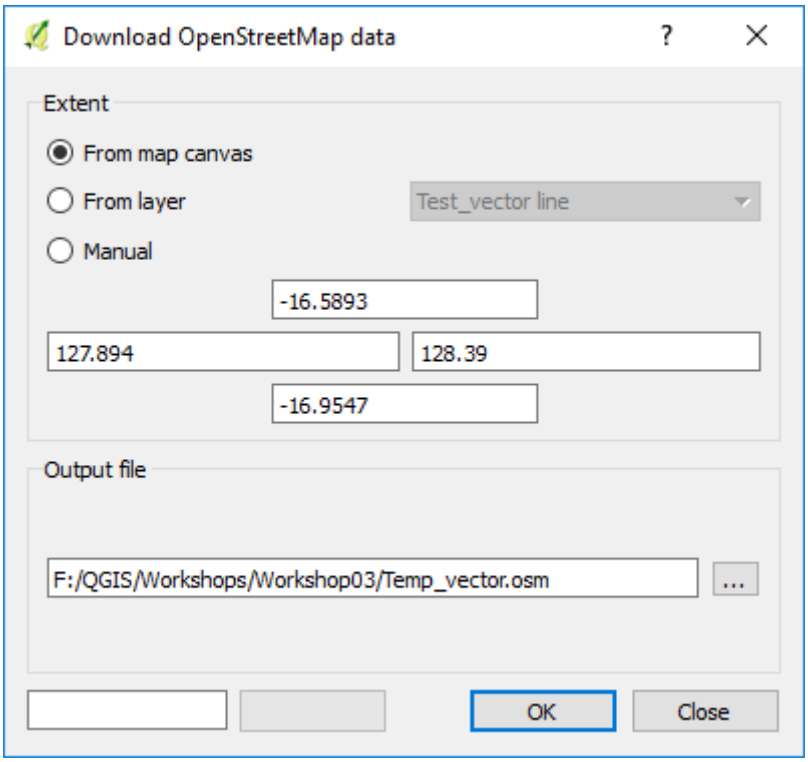
A Sentinel tile index covering the world can be downloaded as a shapefile from the ESA website.

The images are in jp2 (jpeg2000) format which have the image registration information incorporated in the file. QGIS reads and registers these images. To combine the bands into rgb images see the Hands-On Workshop 6 below.

6.6 Open Street Map Data

Open Street Map (OSM) is built by a community of mappers that contribute and maintain data about roads, trails, cafés, railway stations, and much more, all over the world. Data can be freely downloaded for any part of the world via the QGIS menu > Vector > OpenStreetMap > Download Data option. Data can be downloaded using the canvas/map extent or by coordinates.





Ensure you click on the "…" button to select a folder location, otherwise it may default to somewhere that does not allow write access, and you will get an error and no data will be downloaded. The OSM file is a vector file and can be opened via the open shapefile option. There will be several layers comprising point, line and polygon data.

7: GEOLOGICAL MAPPING

Geological mapping usually comprises the collection of points using a GPS, with lines and polygons commonly drawn as an overlay on aerial or satellite images. The following discussion covers a variety of tasks commonly associated with field data collection and interpretation. Detailed editing tasks will not be discussed as there are a number of resources available on the web and in QGIS books.

QGIS can sometimes have problems when digitising into layers with differing projections in the map window. It is recommended that digitising be done on layers in one projection at a time. The new file can be reprojected at a later date into a different projection if required.

7.1 Point Data

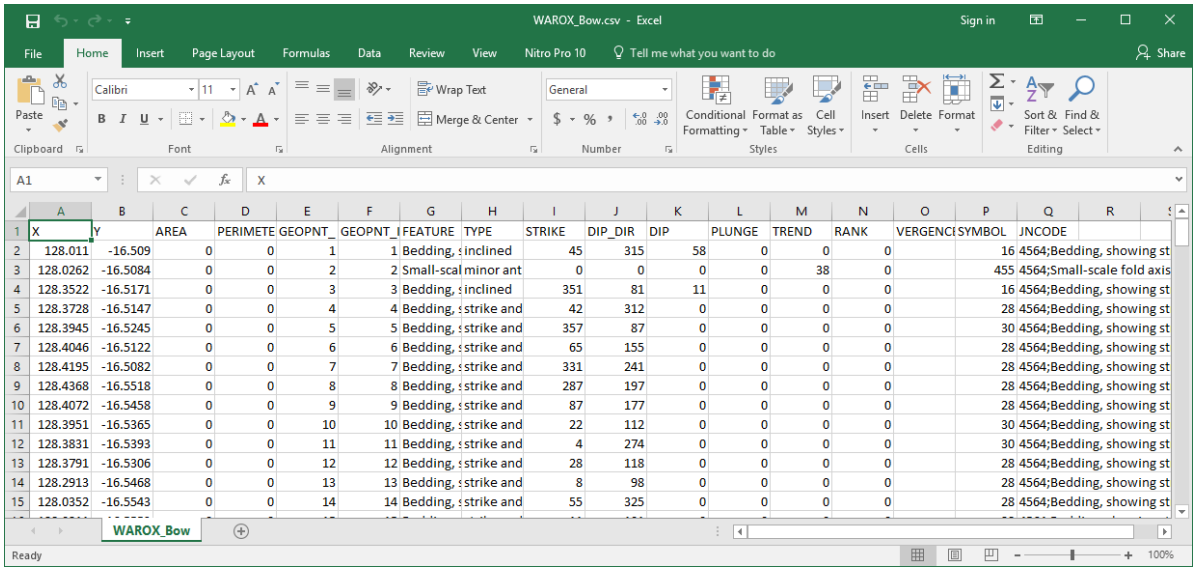
Field mapping data is collected by a number of methods. The most basic version and that used by the “old school” is to collect data in our field book and then enter it into a spreadsheet for import into a GIS. Field data collectors vary in their formats and so the user will need to determine what is the best option for data import. GPS points are easily brought in to QGIS by importing a GPS “gpx” file or in some cases direct download from the GPS. Tracks and waypoints downloaded from the GPS in *.gpx format are best imported via the “GPS Tools” icon located in the left menu bar or via the top menu Vector > GPS > GPS Tools menu. GPX files from Garmin GPS units are usually in WGS84 geographic coordinates (Longitude and Latitude, decimal degree format) by default.

Comma separated variable or “CSV” files are a good simple way to import point data and can be an alternative way to import spreadsheet data when there are problems importing Excel files. Export the Excel file in CSV format and import into QGIS.

Complex CSV files containing a variety of field types can be imported using CSV format files (*.csvt). QGIS can read field data types from an OGR CSV driver compatible "csvt" file. This is a file alongside the data file, but with a "t" appended to the file name extension. The file should just contain one line which lists the type of each field. Valid types are "integer", "real", "string", "date", "time", and "datetime". The date, time, and datetime types are treated as strings in QGIS. Each type may be followed by a width and precision, for example "real(10.4)". The list of types are separated by commas, regardless of the delimiter used in the data file. An example of a valid format file would be: "integer","string","string(20)","real(20.4)"

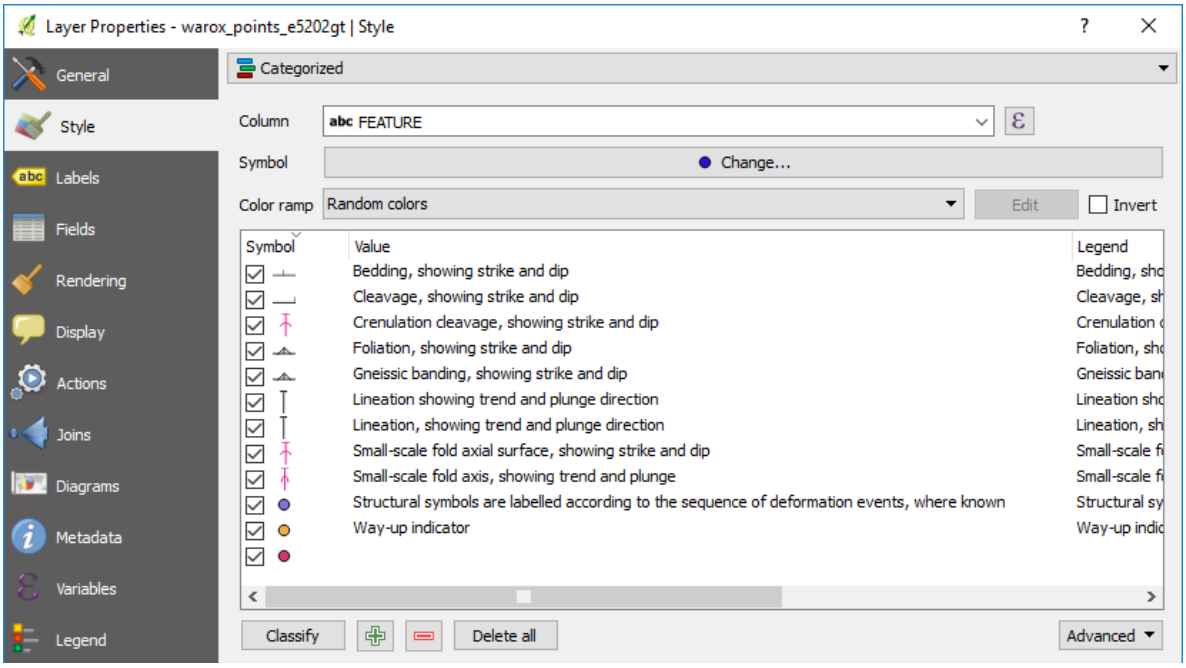
Another option for importing csv data is to load into Excel and check the field types for each field before importing.

Point geological mapping data such as bedding, joints and outcrop observations are best entered via a spreadsheet where columns can be created to cater for items such as coordinates, observations and photo references. Remember to always include the datum and map projection data in the file. Symbol file names can also be entered into the spreadsheet that will allow QGIS to select the correct symbol and then orientate it using a rotation angle for the correct strike or plunge. An example is shown below of the WAROX (mapping data, csv format) data from the GSWA Bow 1:100k geological map. Additional columns would be required with symbol file names to allow QGIS to select the appropriate symbol, or alternatively you can choose a “Categorise” symbol style option and edit the symbols for each category manually.

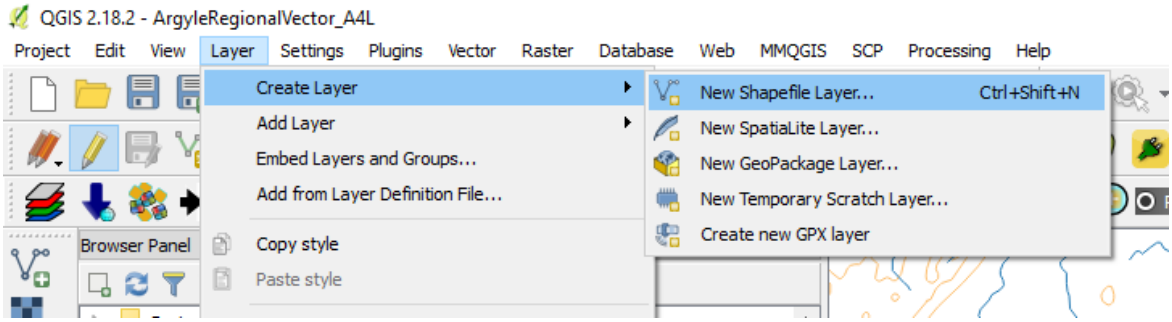


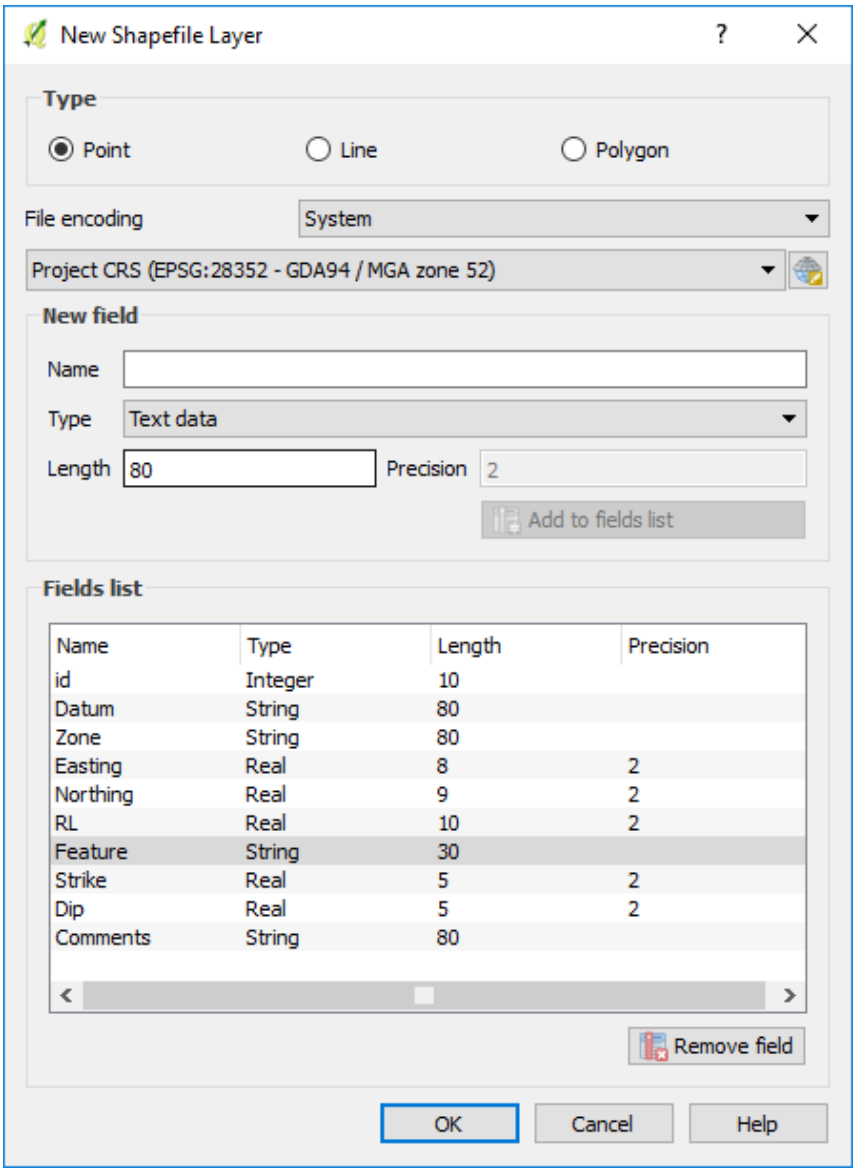
X	Y	AREA	PERIMETE	GEOPNT_	GEOPNT_I	FEATURE	TYPE	STRIKE	DIP_DIR	DIP	PLUNGE	TREND	RANK	VERGENCI	SYMBOL	JNCODE
128.011	-16.509	0	0	1	1	Bedding, s	inclined	45	315	58	0	0	0		16	4564;Bedding, showing st
128.0262	-16.5084	0	0	2	2	Small-scal	minor ant	0	0	0	0	38	0		455	4564;Small-scale fold axis
128.3522	-16.5171	0	0	3	3	Bedding, s	inclined	351	81	11	0	0	0		16	4564;Bedding, showing st
128.3728	-16.5147	0	0	4	4	Bedding, s	strike and	42	312	0	0	0	0		28	4564;Bedding, showing st
128.3945	-16.5245	0	0	5	5	Bedding, s	strike and	357	87	0	0	0	0		30	4564;Bedding, showing st
128.4046	-16.5122	0	0	6	6	Bedding, s	strike and	65	155	0	0	0	0		28	4564;Bedding, showing st
128.4195	-16.5082	0	0	7	7	Bedding, s	strike and	331	241	0	0	0	0		28	4564;Bedding, showing st
128.4368	-16.5518	0	0	8	8	Bedding, s	strike and	287	197	0	0	0	0		28	4564;Bedding, showing st
128.4072	-16.5458	0	0	9	9	Bedding, s	strike and	87	177	0	0	0	0		28	4564;Bedding, showing st
128.3951	-16.5365	0	0	10	10	Bedding, s	strike and	22	112	0	0	0	0		30	4564;Bedding, showing st
128.3831	-16.5393	0	0	11	11	Bedding, s	strike and	4	274	0	0	0	0		30	4564;Bedding, showing st
128.3791	-16.5306	0	0	12	12	Bedding, s	strike and	28	118	0	0	0	0		28	4564;Bedding, showing st
128.2913	-16.5468	0	0	13	13	Bedding, s	strike and	8	98	0	0	0	0		28	4564;Bedding, showing st
128.0352	-16.5543	0	0	14	14	Bedding, s	strike and	55	325	0	0	0	0		28	4564;Bedding, showing st

Below is an example of the “categorised” features of the WAROX data for the GSWA Lissadell 250k map sheet with features manually changed by clicking on each symbol. Once this has been done, save the symbols by using the “Style” button and “Save style” to a QGIS qml style file (e.g. GSWA_WAROX.qml). This style file can then be used to recall these styles. You can choose the “save as default”, which creates a qml file with the same file name as the shape file and when you open the shape file, the qml file will be used to determine the way the features are displayed for this layer.



To create a new empty points layer use the menu item Layer > Create Layer > New Shapefile Layer and select a point layer type. Add the required data columns and data types to attach to each point. Remember shapefile column names are limited to 10 characters and any names longer than this will be truncated. When creating a new vector layer to digitise data, ensure the layer is the correct type, i.e. point, line or polygon, that it has the correct map projection and add the necessary columns to be able to enter the relevant field data for each feature. Save the file with an appropriate file name. Note that additional fields can be added later if needed.

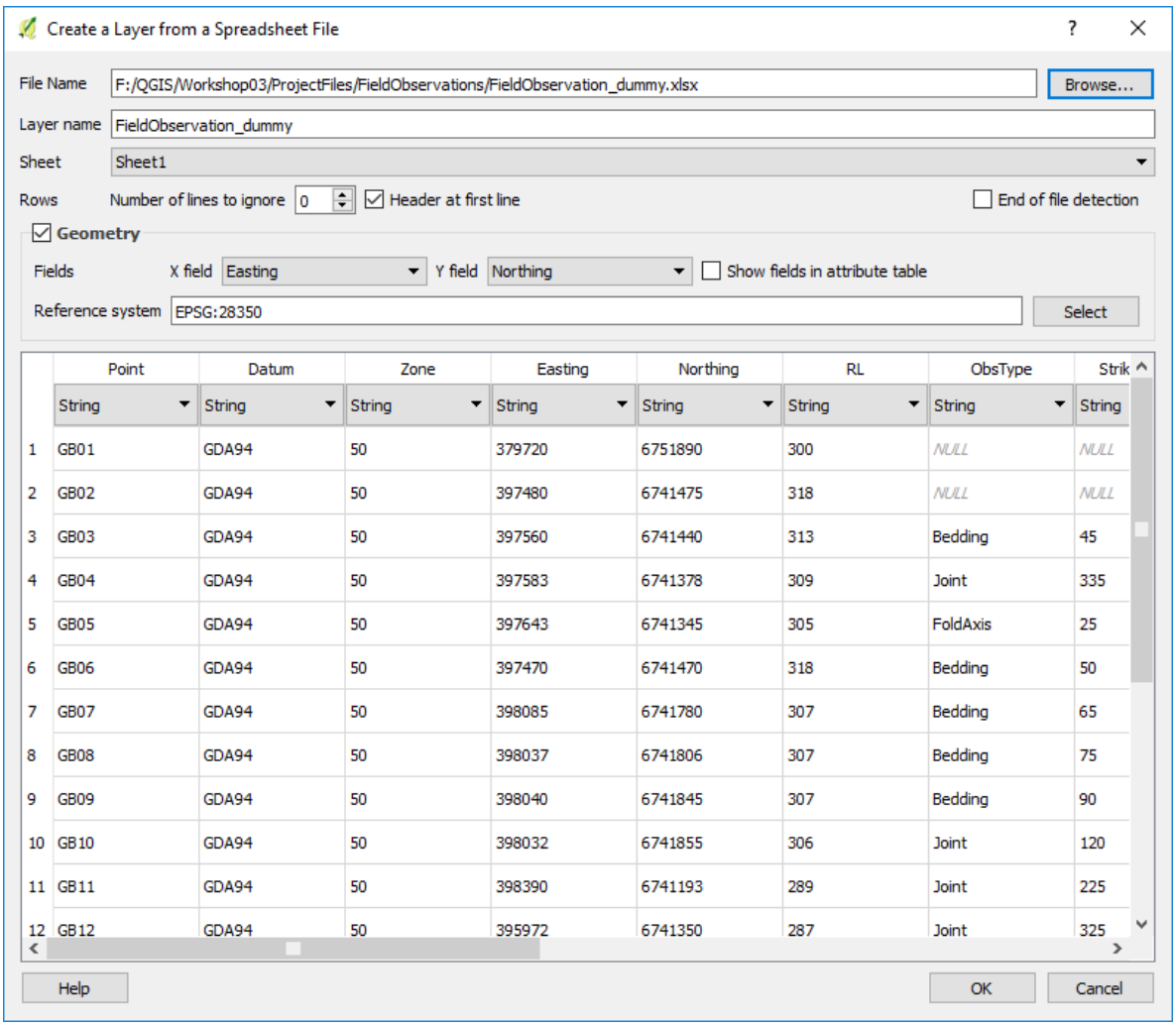




Note the Type “Real”, Length and Precision options where you can restrict the size of the data entered (e.g. UTM eastings length 9 - 6 figures, decimal point and two decimal places). Note that a negative sign, as per the dip, does not use a length, so the dip field in this example could have a length of 5 (00.00 to -90.00).

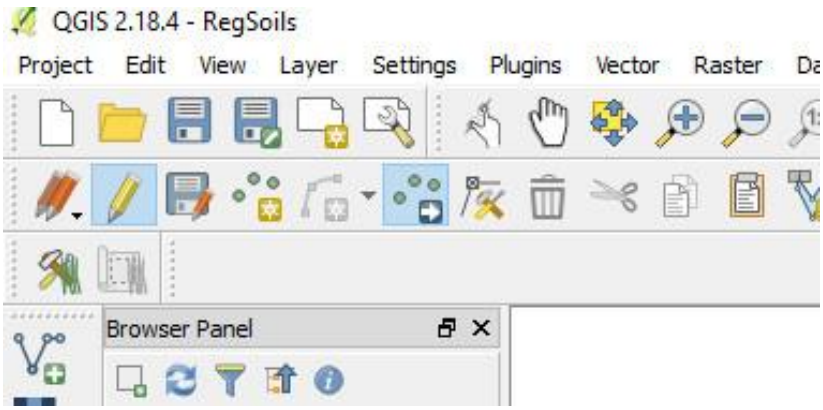
Point data can also be imported from a spreadsheet file using the “Spreadsheet Layer” plug-in. This allows the user to open an excel spreadsheet, select the require worksheet tab, and select

the “Geometry” to spatially locate the data. If QGIS has problems reading the file or spatial geometry, save the file as a csv file and import the csv file using the “Delimited Text Layer” file import option.



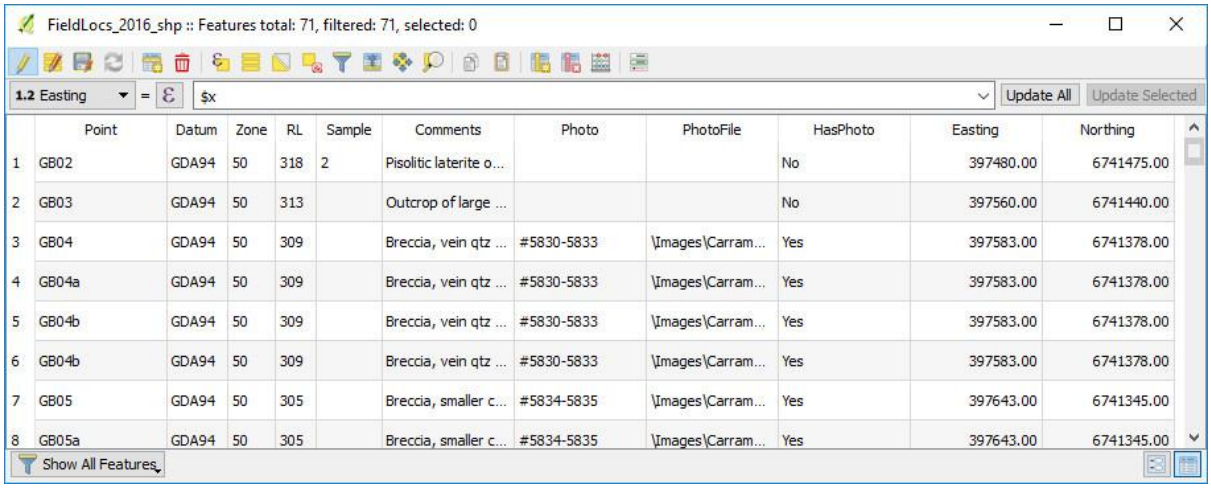
	Point	Datum	Zone	Easting	Northing	RL	ObsType	Strik
	String	String	String	String	String	String	String	String
1	GB01	GDA94	50	379720	6751890	300	NULL	NULL
2	GB02	GDA94	50	397480	6741475	318	NULL	NULL
3	GB03	GDA94	50	397560	6741440	313	Bedding	45
4	GB04	GDA94	50	397583	6741378	309	Joint	335
5	GB05	GDA94	50	397643	6741345	305	FoldAxis	25
6	GB06	GDA94	50	397470	6741470	318	Bedding	50
7	GB07	GDA94	50	398085	6741780	307	Bedding	65
8	GB08	GDA94	50	398037	6741806	307	Bedding	75
9	GB09	GDA94	50	398040	6741845	307	Bedding	90
10	GB10	GDA94	50	398032	6741855	306	Joint	120
11	GB11	GDA94	50	398390	6741193	289	Joint	225
12	GB12	GDA94	50	395972	6741350	287	Joint	325

Points can be moved in the map window by using the “Move Features” icon in the point edit menu. The layer requires to be set as editable. Note that the coordinates in the underlying table will not change and these coordinates need to be updated using the “Update Coordinates” option in the “Attribute Table”.



Move tool highlighted in editing toolbar.

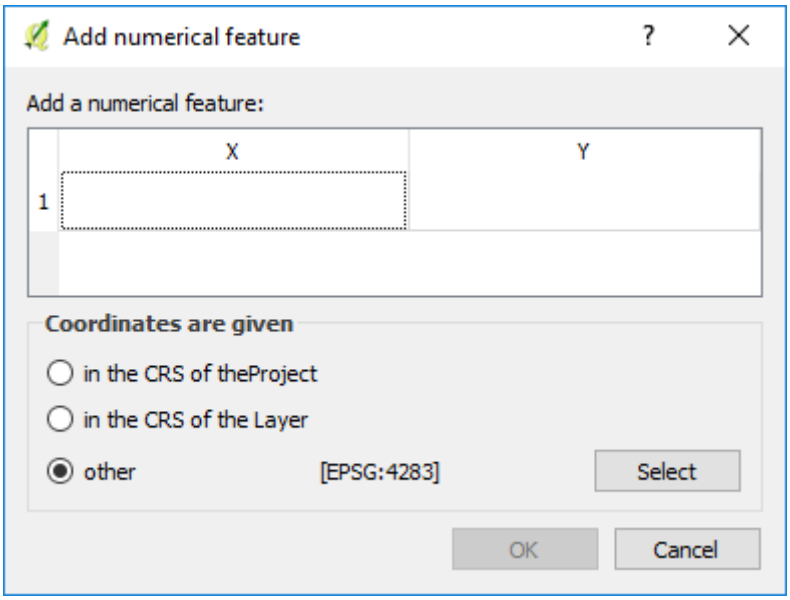
If you do move points, remember to update the Easting and Northing values in the table using the geometry operator “$x” for Easting and “$y” for Northing. Remember to select the correct column to update! If you fail to do this the coordinates shown in the table will be incorrect. Remember also that the updated coordinates will be in the project projection coordinates. Also remember to save your edits.



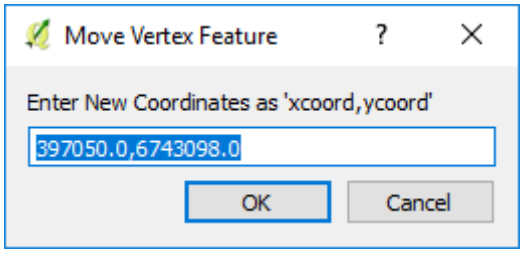
	Point	Datum	Zone	RL	Sample	Comments	Photo	PhotoFile	HasPhoto	Easting	Northing
1	GB02	GDA94	50	318	2	Pisolitic laterite o...			No	397480.00	6741475.00
2	GB03	GDA94	50	313		Outcrop of large ...			No	397560.00	6741440.00
3	GB04	GDA94	50	309		Breccia, vein qtz ...	#5830-5833	\Images\Carram...	Yes	397583.00	6741378.00
4	GB04a	GDA94	50	309		Breccia, vein qtz ...	#5830-5833	\Images\Carram...	Yes	397583.00	6741378.00
5	GB04b	GDA94	50	309		Breccia, vein qtz ...	#5830-5833	\Images\Carram...	Yes	397583.00	6741378.00
6	GB04b	GDA94	50	309		Breccia, vein qtz ...	#5830-5833	\Images\Carram...	Yes	397583.00	6741378.00
7	GB05	GDA94	50	305		Breccia, smaller c...	#5834-5835	\Images\Carram...	Yes	397643.00	6741345.00
8	GB05a	GDA94	50	305		Breccia, smaller c...	#5834-5835	\Images\Carram...	Yes	397643.00	6741345.00

To edit the coordinates of existing points, use the “Numerical Vertex Editor” and “Numerical Digitise” plug-ins. Remember to update the coordinates (as above) after moving any points to reflect their new locations. Points can also me moved using the mouse by enabling editing and using the node tool to highlight the point and then drag it to a new position.

Numerical Digitise is used to enter coordinates to locate points.

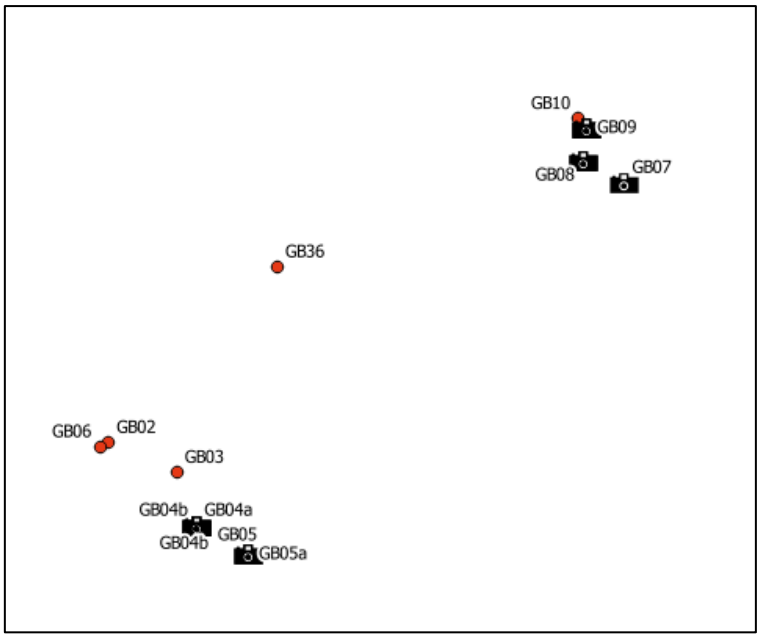


The Numerical Vertex Editor can be used to change the position of a point. Note that you must update the coordinate fields to correct the attribute table to reflect the new locations.

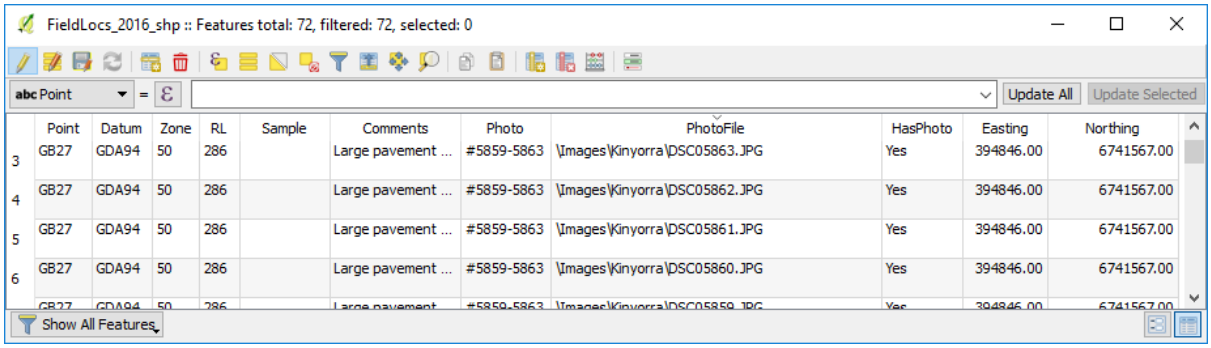


7.2 Outcrop Photographs

Photographs of outcrops and report pdf files can be attached to an observation point and allow a point and click to access the photo or report. Add extra columns in the file for “file location” so that QGIS can find the file and display it. The eVis plug-in can be used to display images and documents that are linked to points. eVis is located under the Database menu option on the top window menu. See the eVis documentation (evis_user_guide_v1.1.pdf) for detailed information on specifications of file locations and specifying the location of the pdf reader (if required). It is recommended that you also add a column to advise the user if there are photos available – such as a column named something like “PhotoYN”, with a yes/no answer so that you can display an icon indicating a photo is available for that location. Use the “Categorise” layer property option to show the yes-no options and change the “yes” data points to small camera icons.

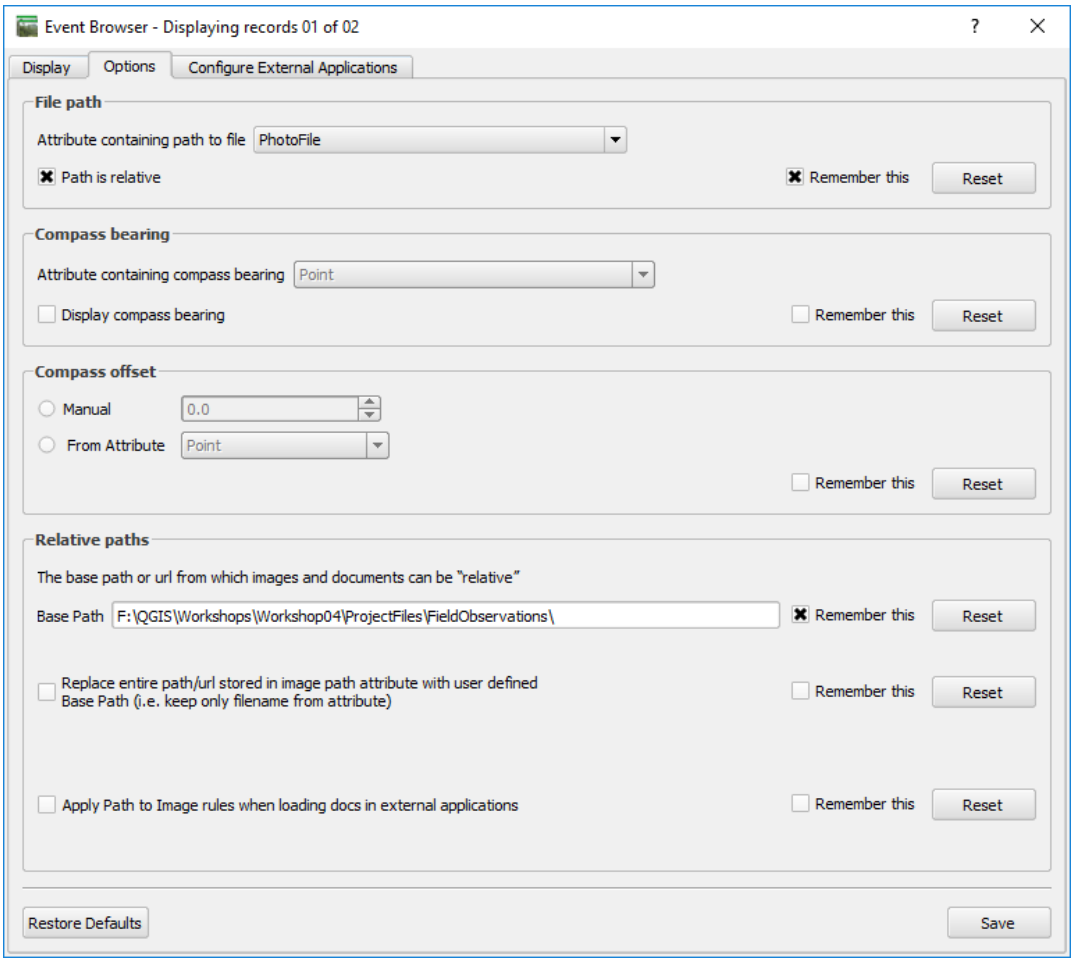


Example file showing relative file location for outcrop photographs.

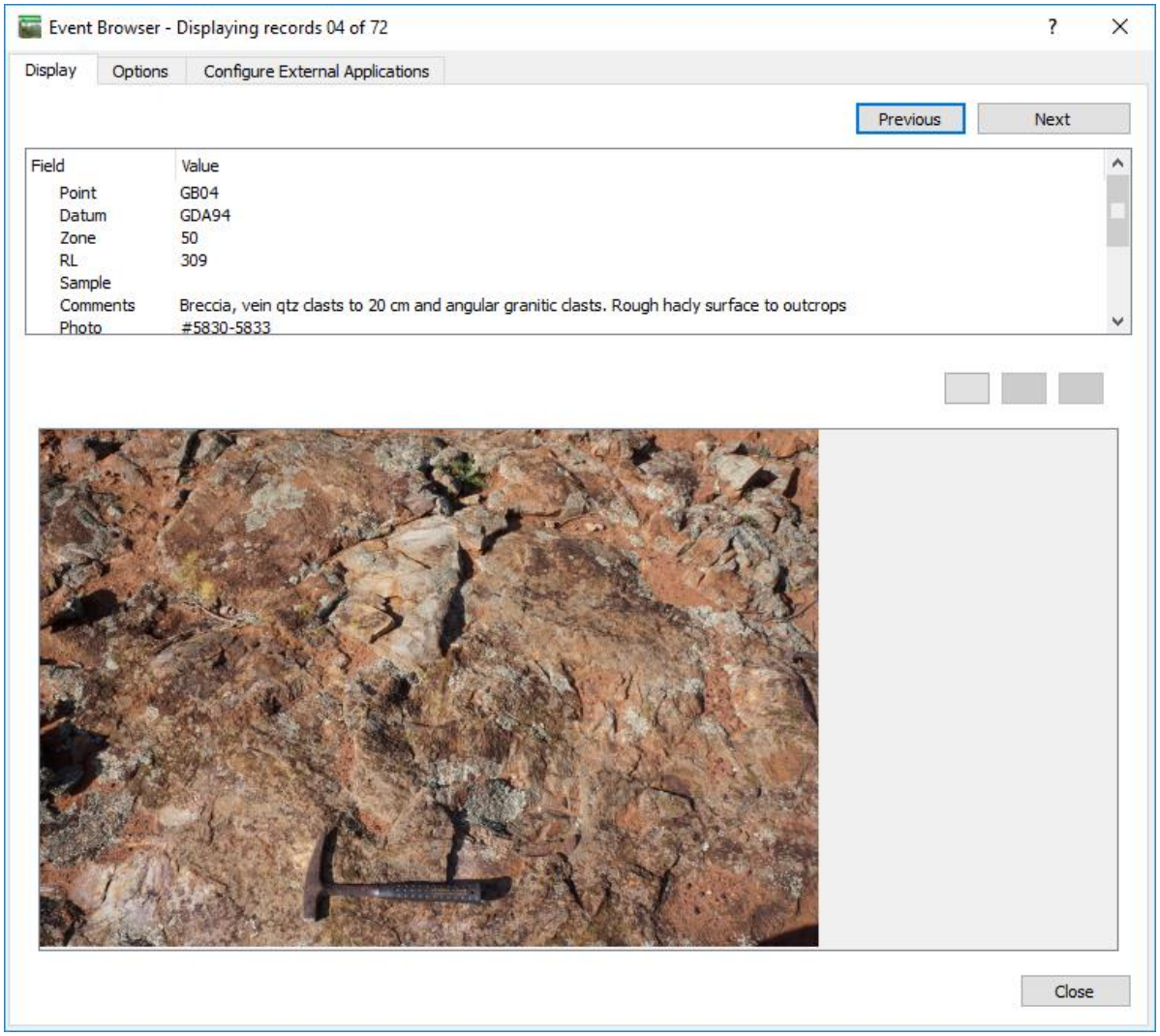


	Point	Datum	Zone	RL	Sample	Comments	Photo	PhotoFile	HasPhoto	Easting	Northing
3	GB27	GDA94	50	286		Large pavement ...	#5859-5863	\Images\Kinyorra\DSC05863.JPG	Yes	394846.00	6741567.00
4	GB27	GDA94	50	286		Large pavement ...	#5859-5863	\Images\Kinyorra\DSC05862.JPG	Yes	394846.00	6741567.00
5	GB27	GDA94	50	286		Large pavement ...	#5859-5863	\Images\Kinyorra\DSC05861.JPG	Yes	394846.00	6741567.00
6	GB27	GDA94	50	286		Large pavement ...	#5859-5863	\Images\Kinyorra\DSC05860.JPG	Yes	394846.00	6741567.00

It is recommended to use “relative” file paths (select “Path is Relative” in the eVis options panel), and provide the base directory, so that if you move files to a new directory, you can update the base directory and QGIS will find the files. Check the tick boxes on the “File Path” and “Relative Path” option so that QGIS remembers these settings for the other photos in the file.



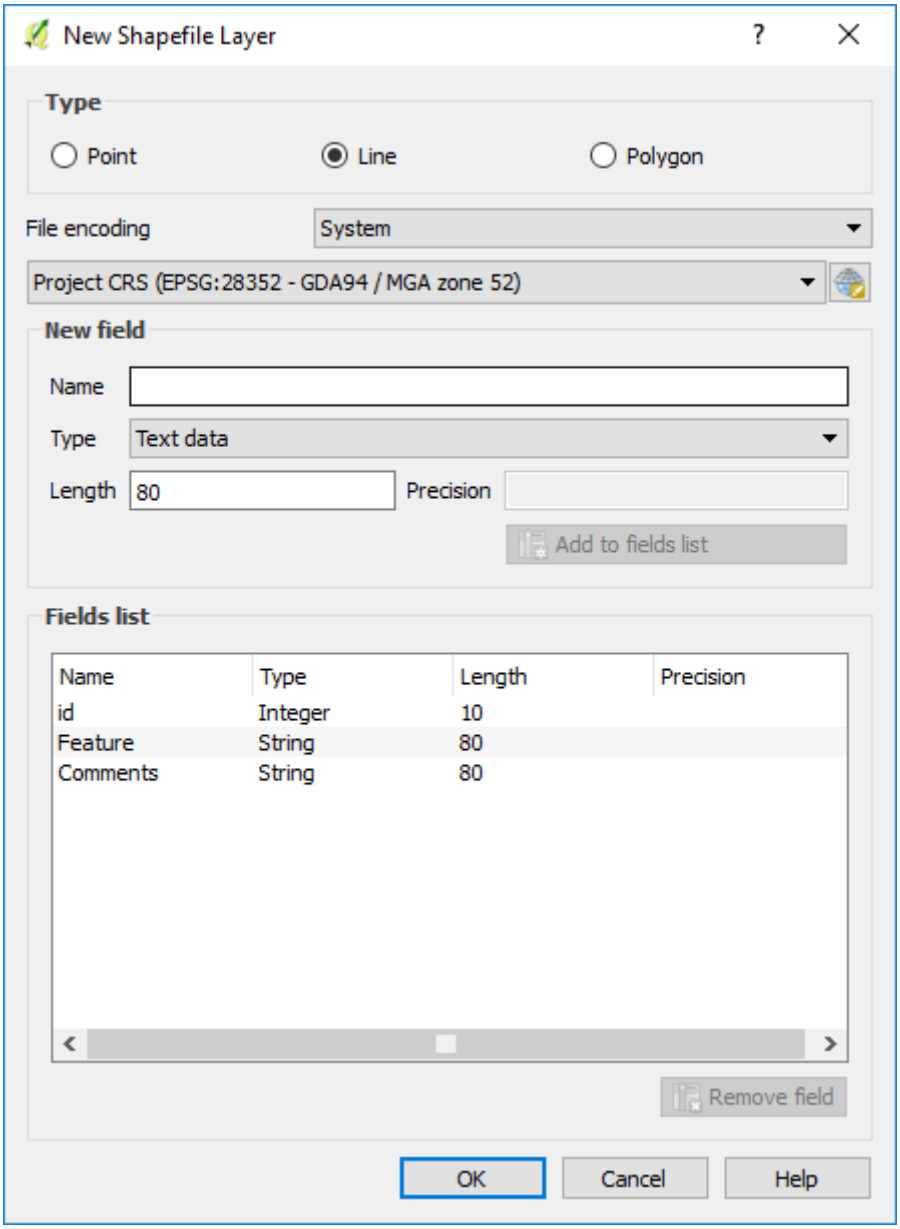
Other file types can also be linked, for example, pdf report files can also be attached to observation points (see the eVis user guide for more information).



7.3 Line Data

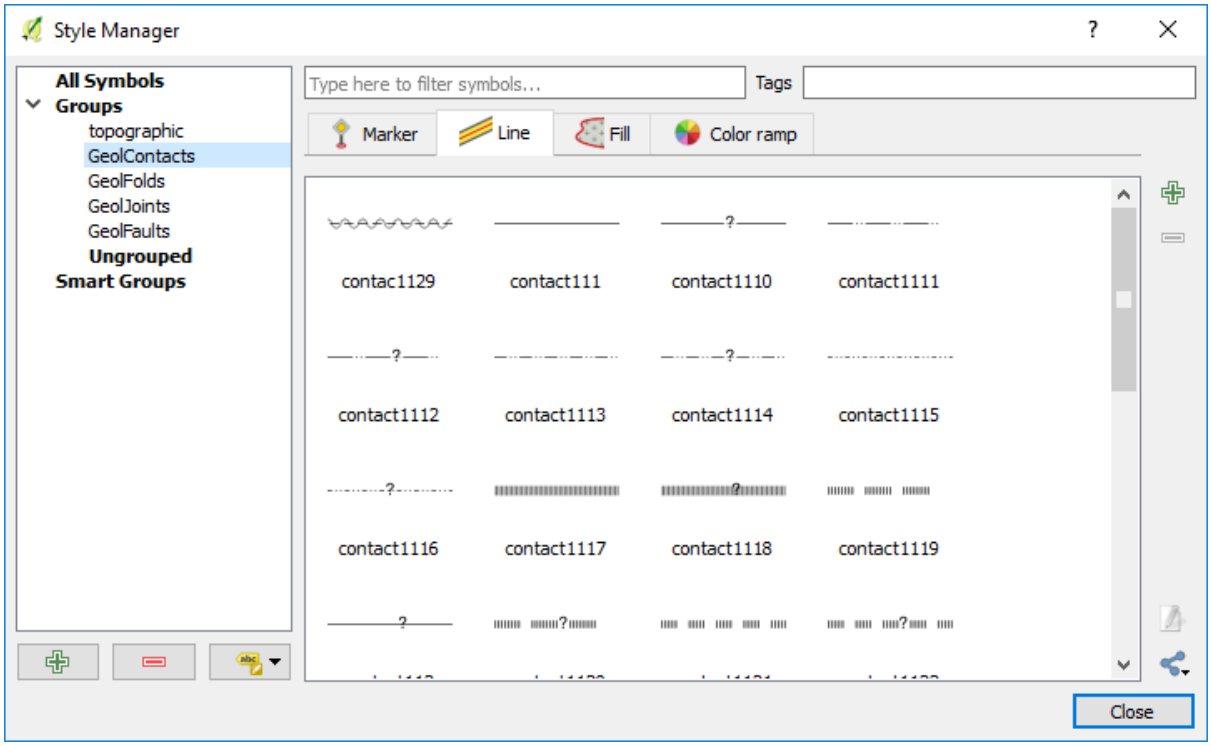
Line data includes such items as contacts, faults and trend lines and are usually plotted on aerial or satellite imagery overlays. Surface mapping data can be digitised by scanning in the hard copy photo overlay into QGIS (via raster registration) and tracing the linear features, or by direct digitising on screen using the field mapping data as a guide.

When creating a new vector layer to digitise the data, ensure the layer is the correct type, line type for example, has the correct map projection and add the necessary columns to be able to enter the relevant field data for each feature. Save the file with an appropriate file name.



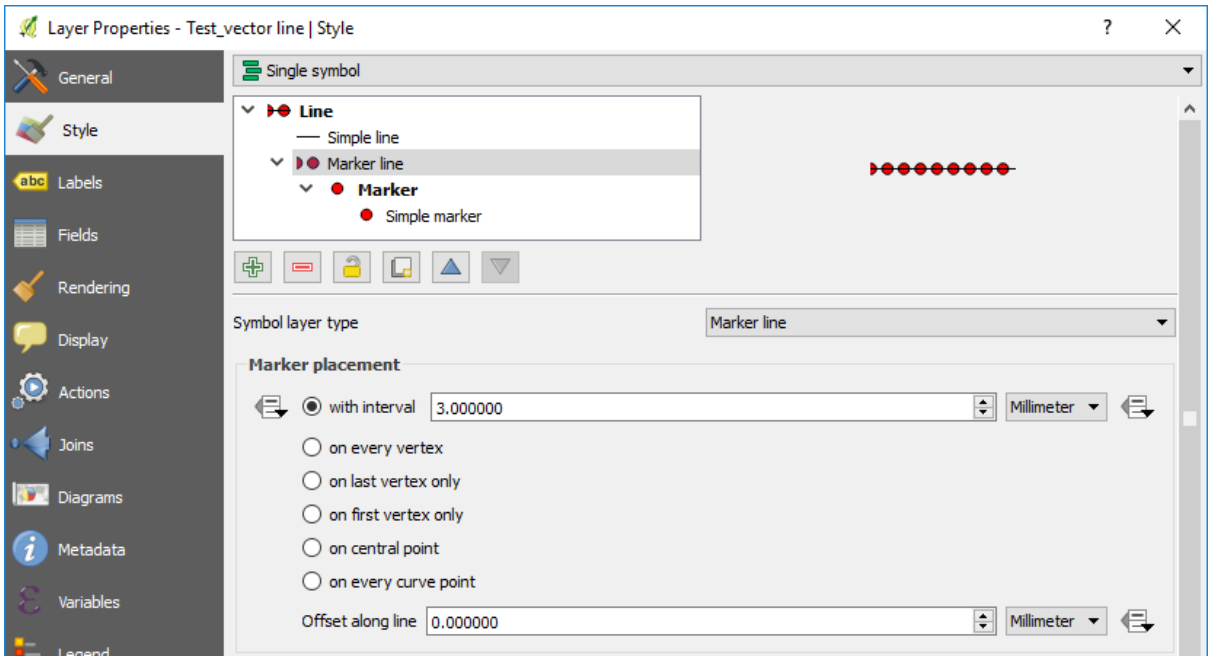
Note that each line should have a unique ID number as this will allow editing/deleting of discrete features.

Specific line styles can be added via the top menu Settings > Style Manager option. Geological line styles have been created as *.xml files and are imported using the “import” option, selectable from just above the Close button in the Style Manager dialog box. Import each style to a category, e.g. Contacts, so they are easier to locate.

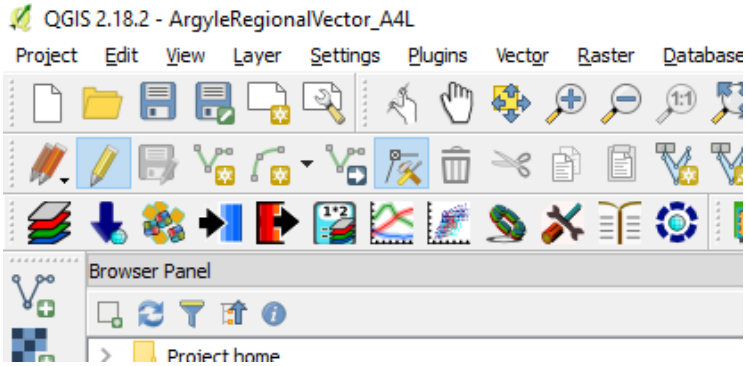


Line styles can also be created directly via the Style tab of the layer menu. Add an extra layer (using the green plus button) to combine lines and markers. There are a large number of styles and options to choose from. Remember to save the style using a qml or “Save as Default” option when finished editing the line style.

You can combine many line styles into the one vector line file, providing you have a column by which the lines can be classified, e.g. feature type “contact”.

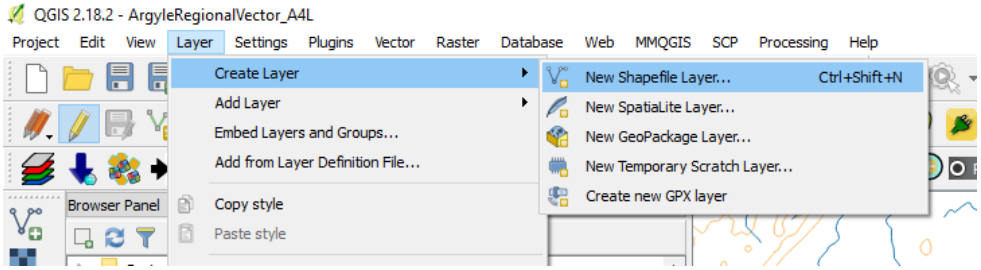


Lines can be edited by first highlighting the layer in the Layers panel and clicking the enable editing icon (pencil). A pencil symbol will then appear next to the layer being edited in the Layers panel. Remember to save your edits when exiting the edit mode. When the line is editable, there will be red crosses on the vertices. Click on the “node” tool (seventh button along from left, next to rubbish bin) then click near a vertex to highlight the vertices, select the vertex you want to move and simply drag. To add more vertices, simply double click anywhere along the line.

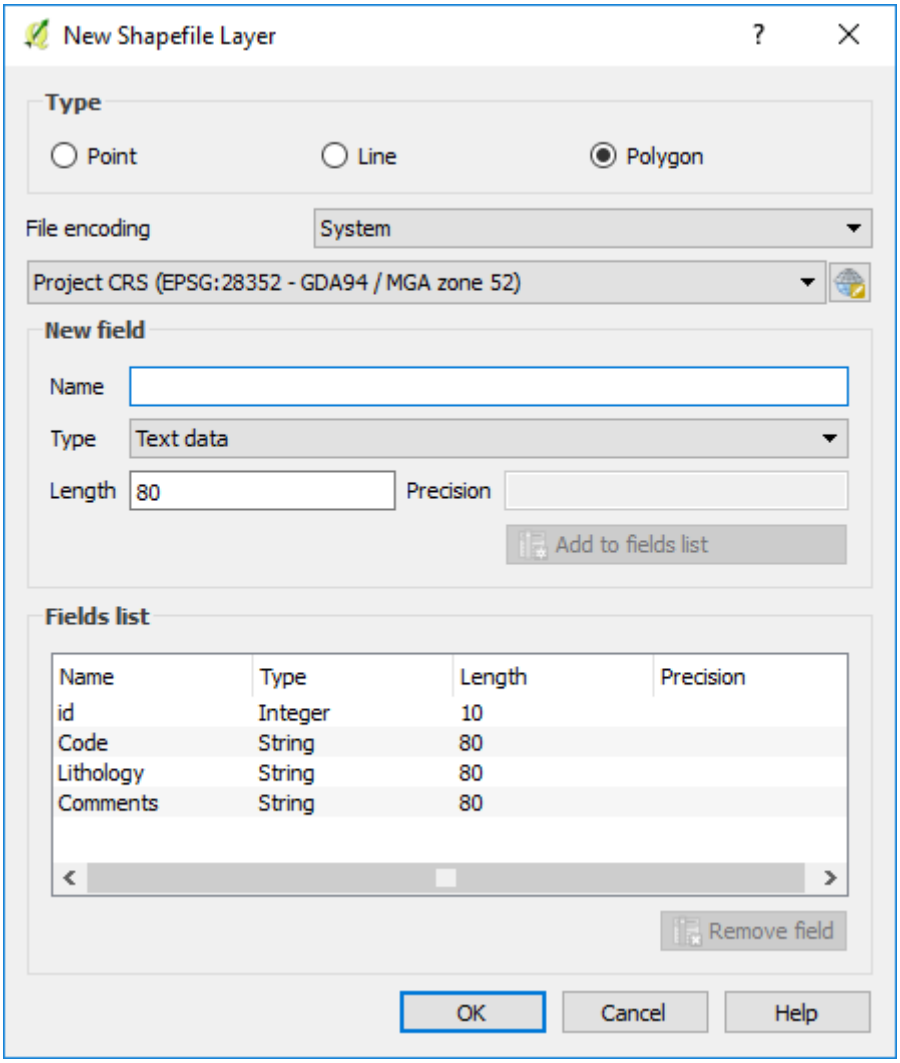


7.4 Polygon Data

Polygon data is added by creating a new polygon layer (Layer > Create Layer > New Shapefile Layer), selecting type “polygon”, set the projection information and enter the additional fields for the polygon file.

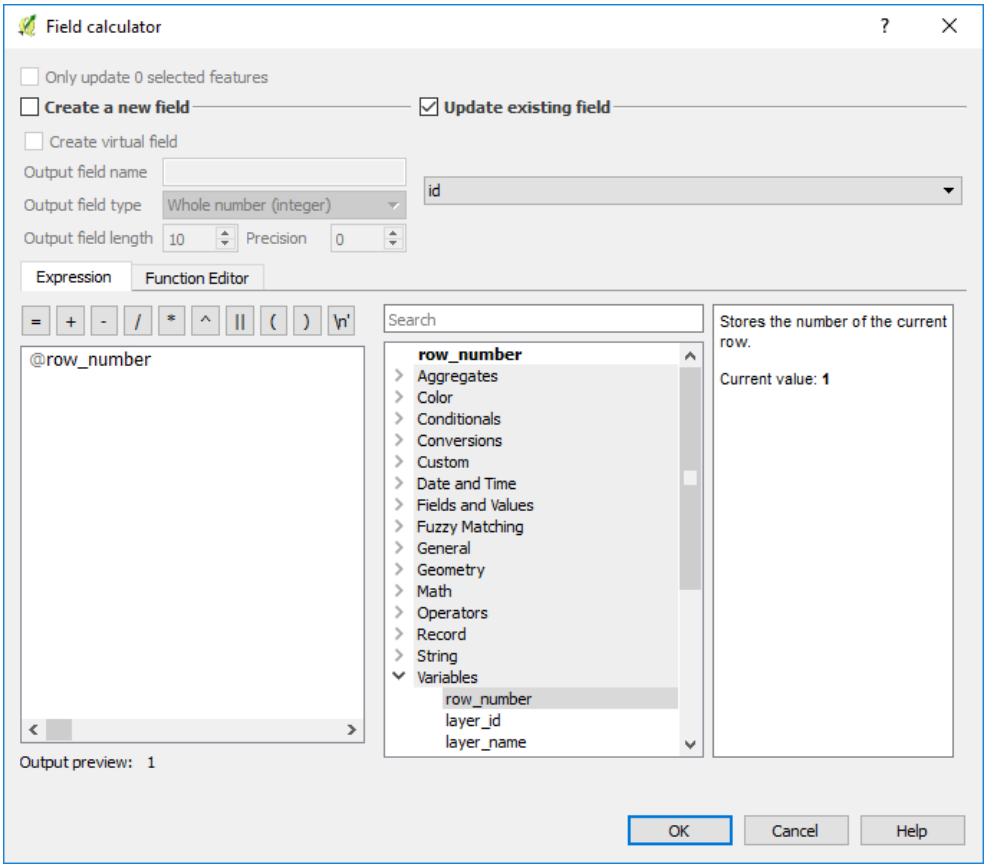


These additional columns might hold data such as geological code, geological descriptions, etc. Remember to select the correct field type (string, number and precision, etc) and also remember that field names are limited to a length of 10 characters in shapefiles.

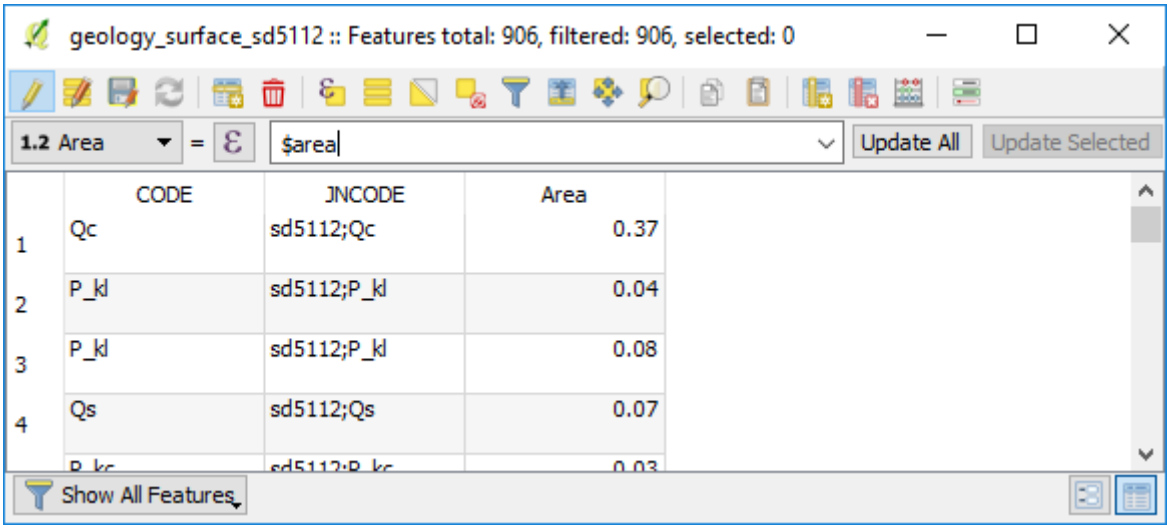


Every new polygon should be assigned a unique “id” number. If you keep these unique, then it is easier to select and alter polygons which can be then selected by their id. To add a new polygon, highlight the polygon layer in the Layers panel, and toggle the editing button (pencil icon). A number of polygon options are available - see the second row of menu. Hover over each icon for an explanation of the icon actions. If not all the digitising and advanced digitising options are not show, check the top menu View > Toolbars options.

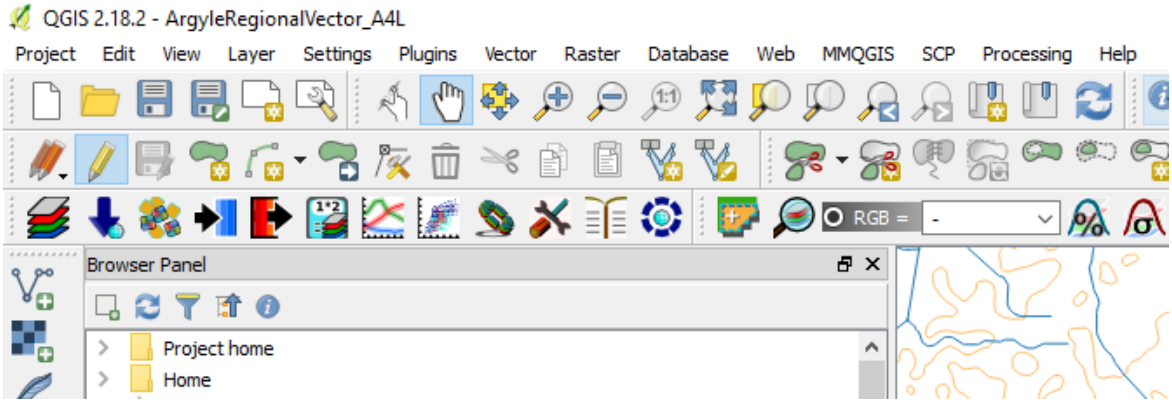
QGIS can automatically sign unique id numbers for each polygon. Open the Layer Properties > Fields, select the id field and click on the field calculator icon and choose “Update existing field”, select the id field, select the “row number” operator in the Variables list. Now when you save the file it will allocate a unique id to each feature. Thanks to Chris Franklin for noting this feature.



If you want to calculate areas of polygons, add an “Area” column to the polygon. Note you must set the projection to one in metres, e.g. UTM, not geographic degree units, and select your units in the Project Properties > General > Measurements dialogue box. You can then populate this field by using the calculation option in the Attribute Table option. Make the layer editable and then use the $area function to calculate the relevant field area.

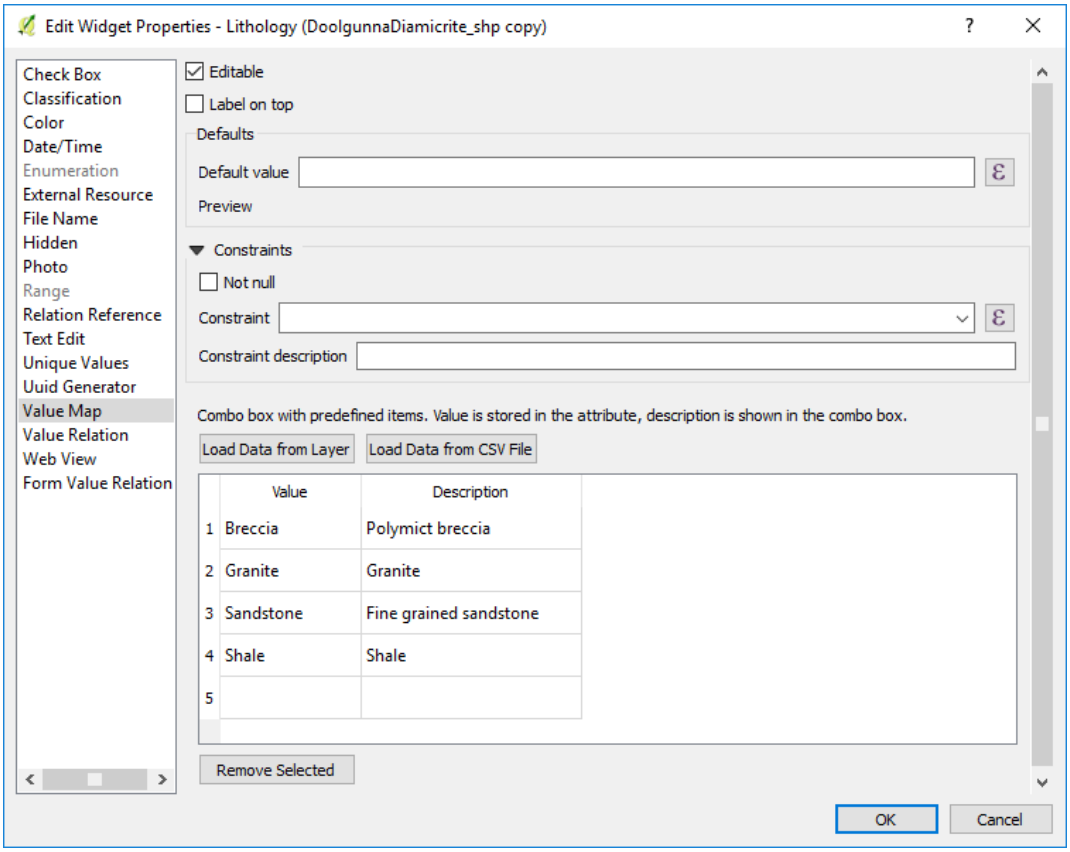


Note that the units of area are set in the Project Properties > General > Measurements dialogue box. These units can be changed on the fly but you need to refresh the values in the calculated area column to reflect the new units. The area can also be viewed by selecting the Layer Properties > Display > Field option so that the area can be displayed when you hover the mouse over the polygon when the Info Tool is activated.

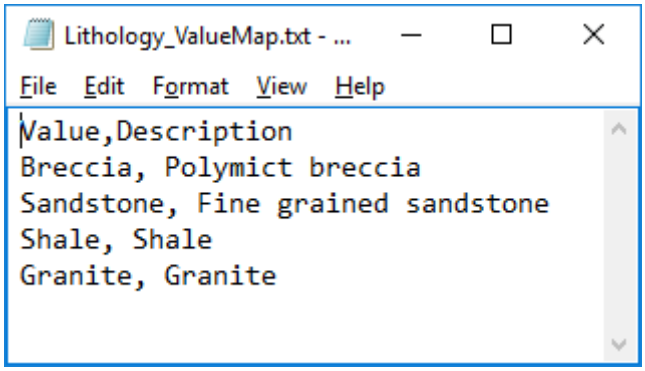


Digitise a polygon by making the layer editable and choosing the polygon icon. Click around the polygon and finish the polygon with a right mouse click. Nodes can be shifted and added-deleted using the node icon, as per the line editing options.

To restrict the values to be associated with a polygon, line or point, you can specify a “Value Map” which will create a drop-down list of acceptable values. Values can be entered two ways, one is via the Layer Properties > Fields > Edit Widget Properties dialog box where you directly enter the values and descriptions.



Values can also be loaded via a “csv” file with the format as shown below, with a Value field and a Description Field. The Value field will be assigned to the feature.

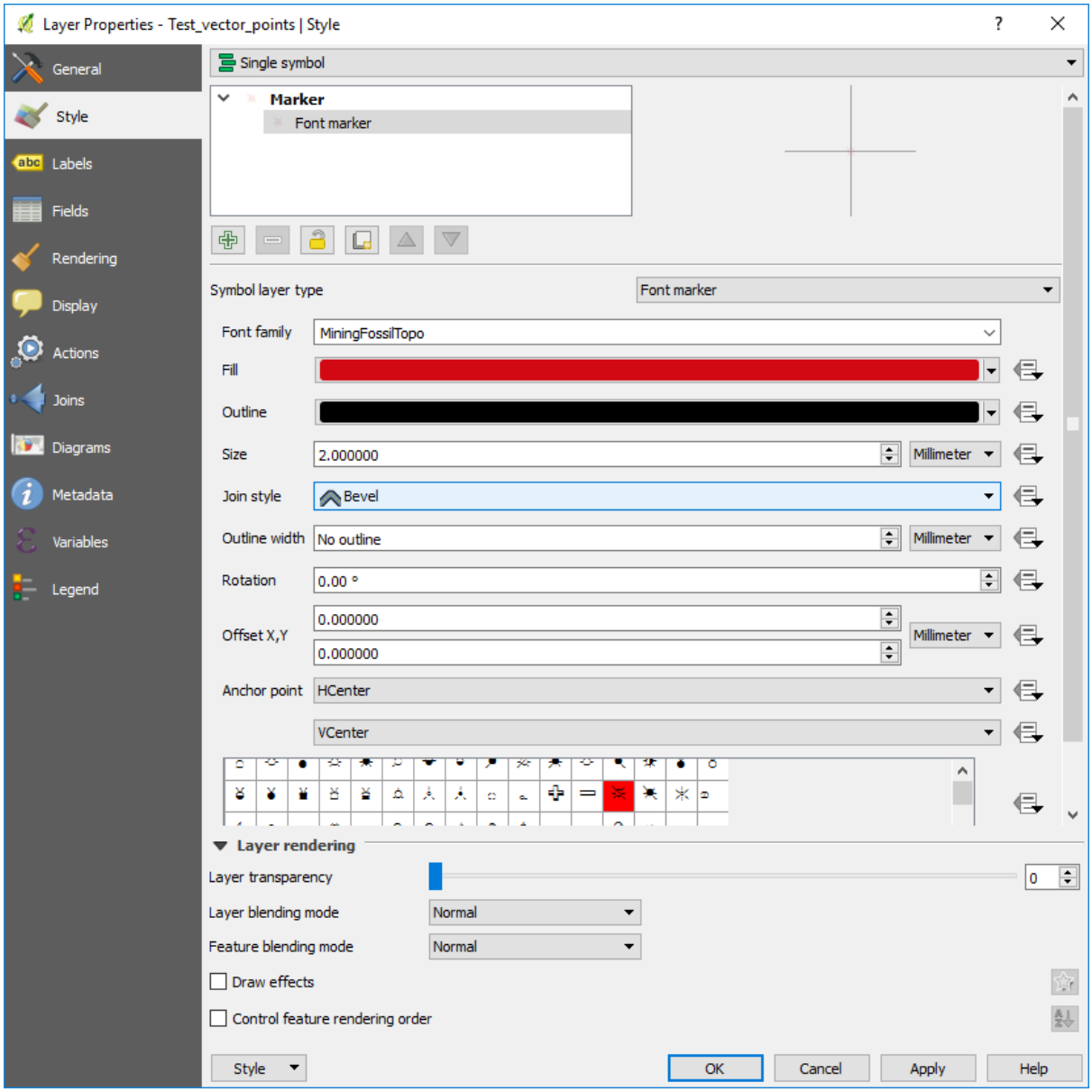


7.5 Geological Symbols and Geological Patterns

Geological symbols can be either specific geological fonts or represented by SVG (scalable vector graphic) symbols. Geological symbols can be downloaded from the internet for use in QGIS (https://github.com/GISsimbology/symbols). On Windows systems, geological symbol fonts need to be installed via the Windows – Control Panel. SVG files are usually stored in folders in the Program folder, for example C:\Program Files\QGIS “version”\apps\qgis\svg. It is recommended a separate folder is used for each symbol/pattern font.

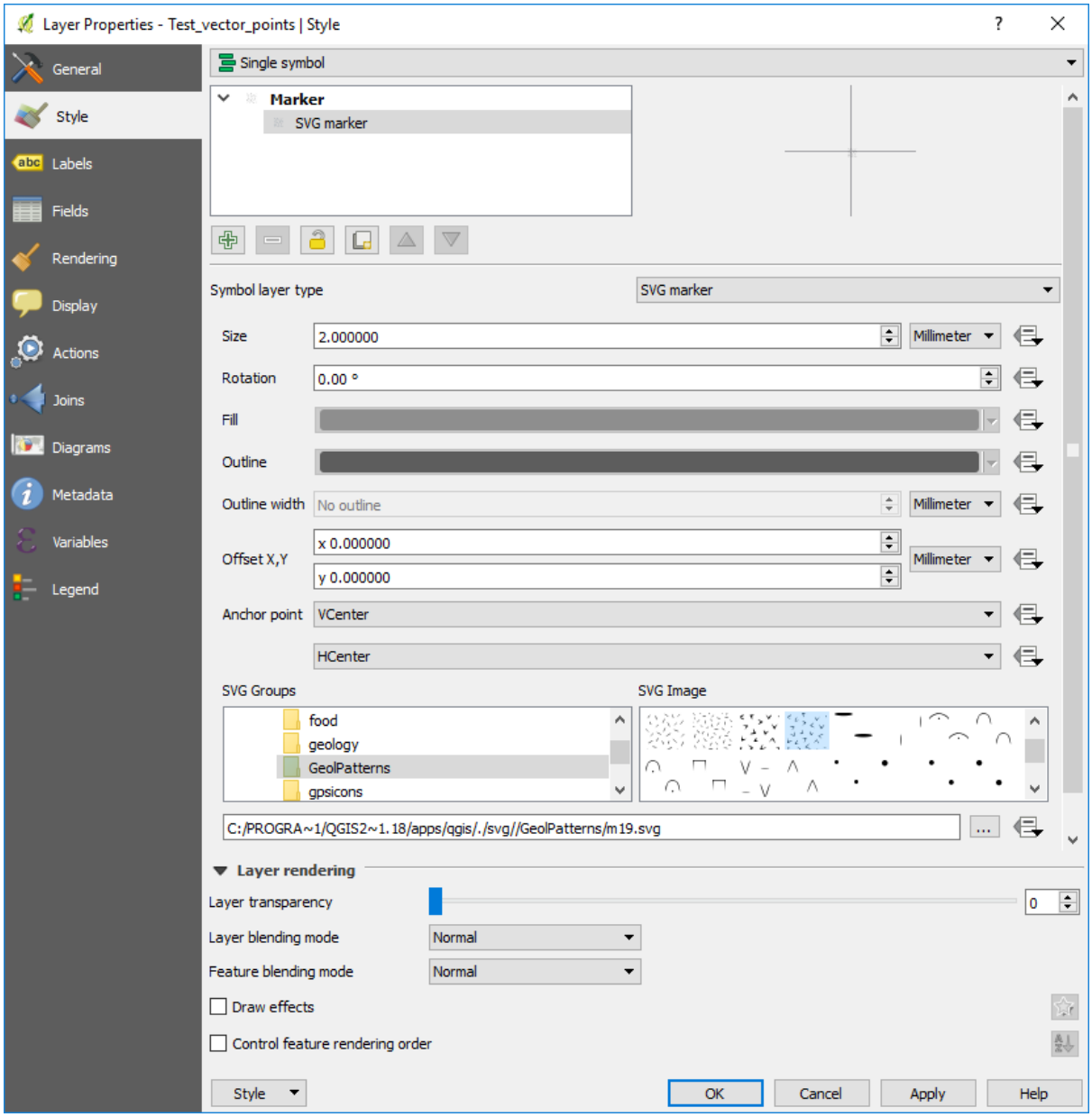
Four font sets are available from Geoscience Australia and include ESRI Geology AGSO 1 to 3 (esri_500.ttf, ESRIGA_0.ttf and ESRIGA_4.ttf), GeoscienceMining (GEOSM_.ttf) and MiningFossilTopo (MINIFT_.ttf). Other geological and cartographic fonts may also be available depending upon what other software you may have installed.

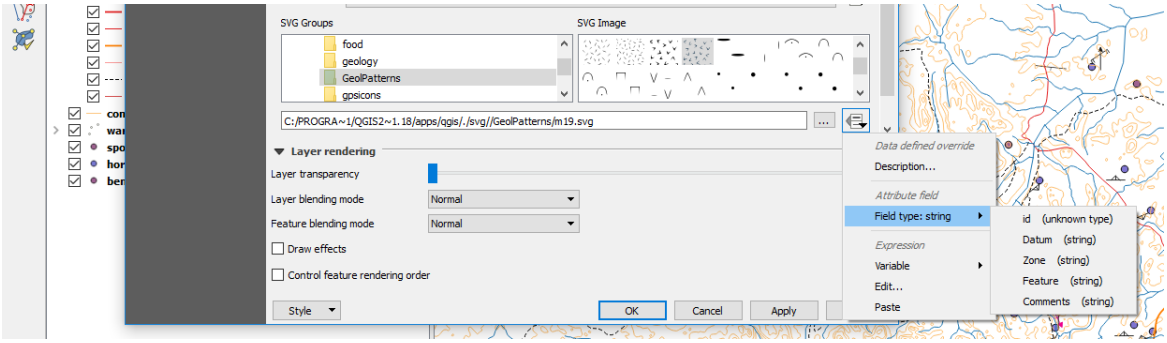
Geological font symbols are accessed via the Layer properties > Style tab and choose the symbol layer type as “font”. All the fonts install on your computer will be accessible and you will need to search through the installed fonts to find the relevant font file and then the relevant font symbol. Adjust the font size to suit.



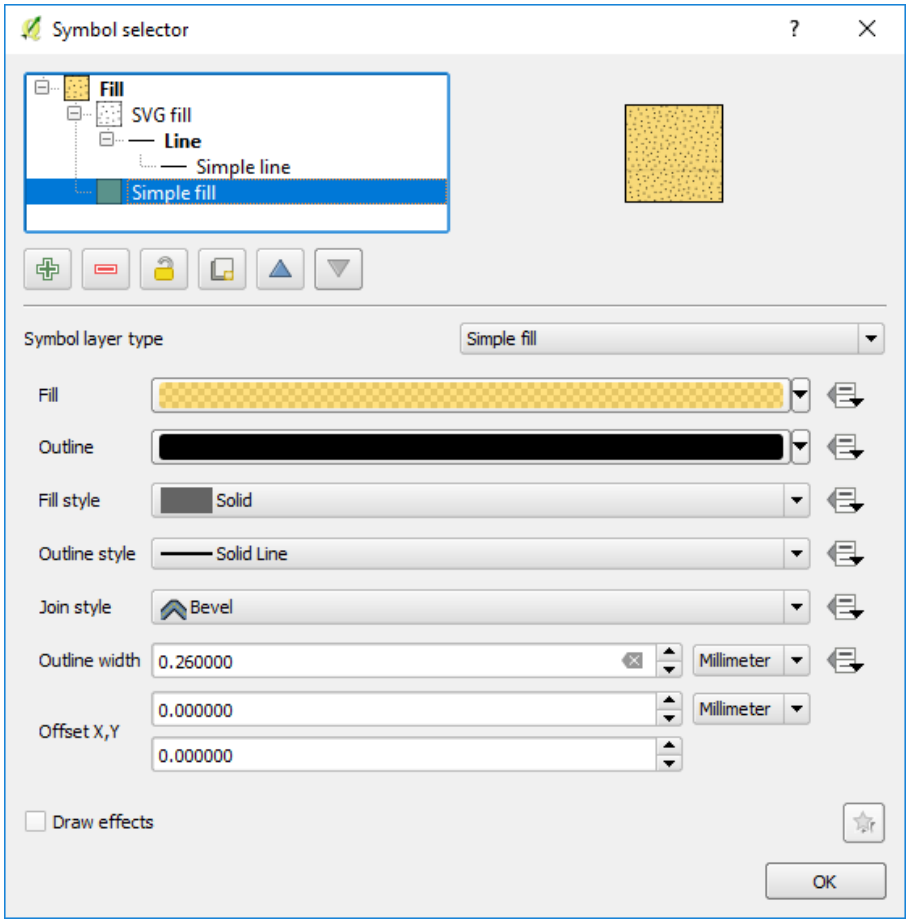
SVG symbols are accessed via the symbol layer type as “SVG marker”. SVG symbols can be stored anywhere but are usually in the C:\Program Files\QGIS “version” \apps\qgis\svg folder. If you cannot write to your Program Files directory, usually due to IT management profiles, then make a QGIS folder in a location where you have access and copy the files to that location. You can then instruct QGIS to search in alternative folders for the SVG files.

Note that you have options for size and rotation of the patterns or symbols. The SVG symbols and patterns have discrete file names which can be used to automatically assign symbols and patterns in the “Data Driven Override” of the layer properties file window (just above the “Layer Rendering” label).





Coloured backgrounds can be added to the polygon fill by adding another layer in the Symbol Selector dialog box. Add a new symbol layer by using the green plus symbol, and move it to the bottom using the down arrow key.

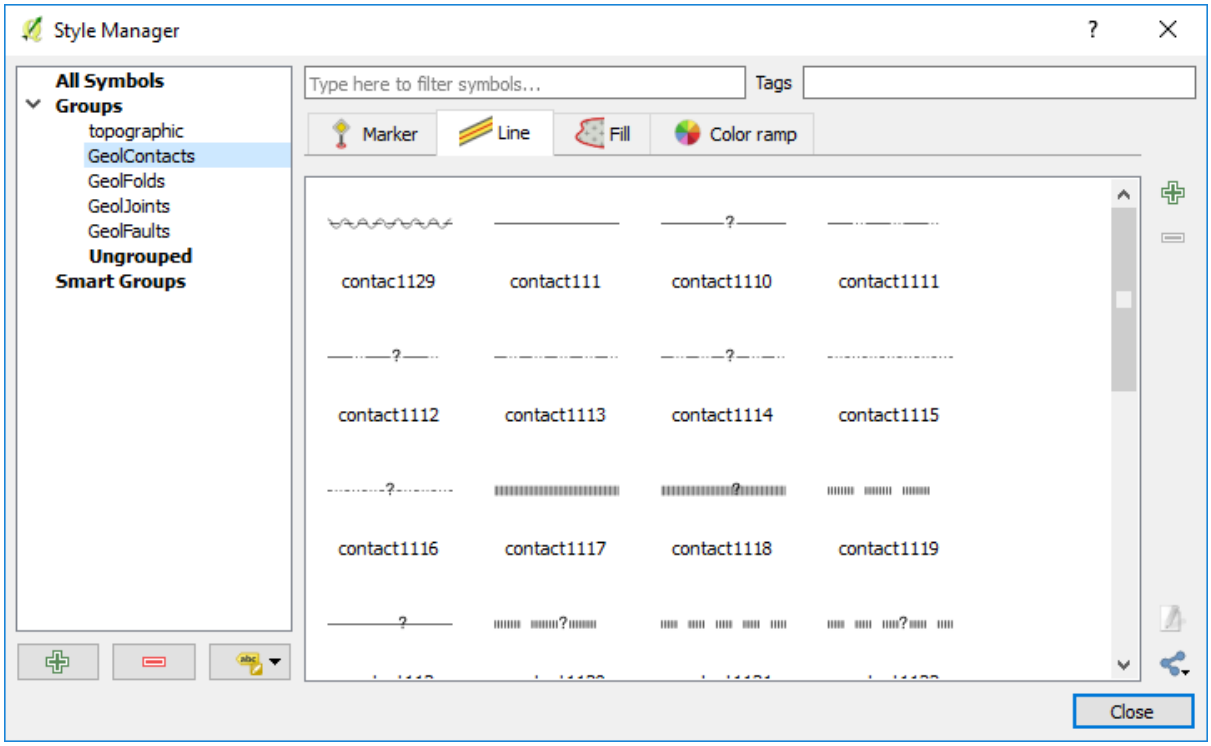


For assistance in selecting colours, go to the Color Brewer web site (http://colorbrewer2.org) where there is a vast array of colours and their specifications available. Colour specifications can be specified in QGIS via their hex, RGB or CYMK number.

7.6 Geological Line Styles

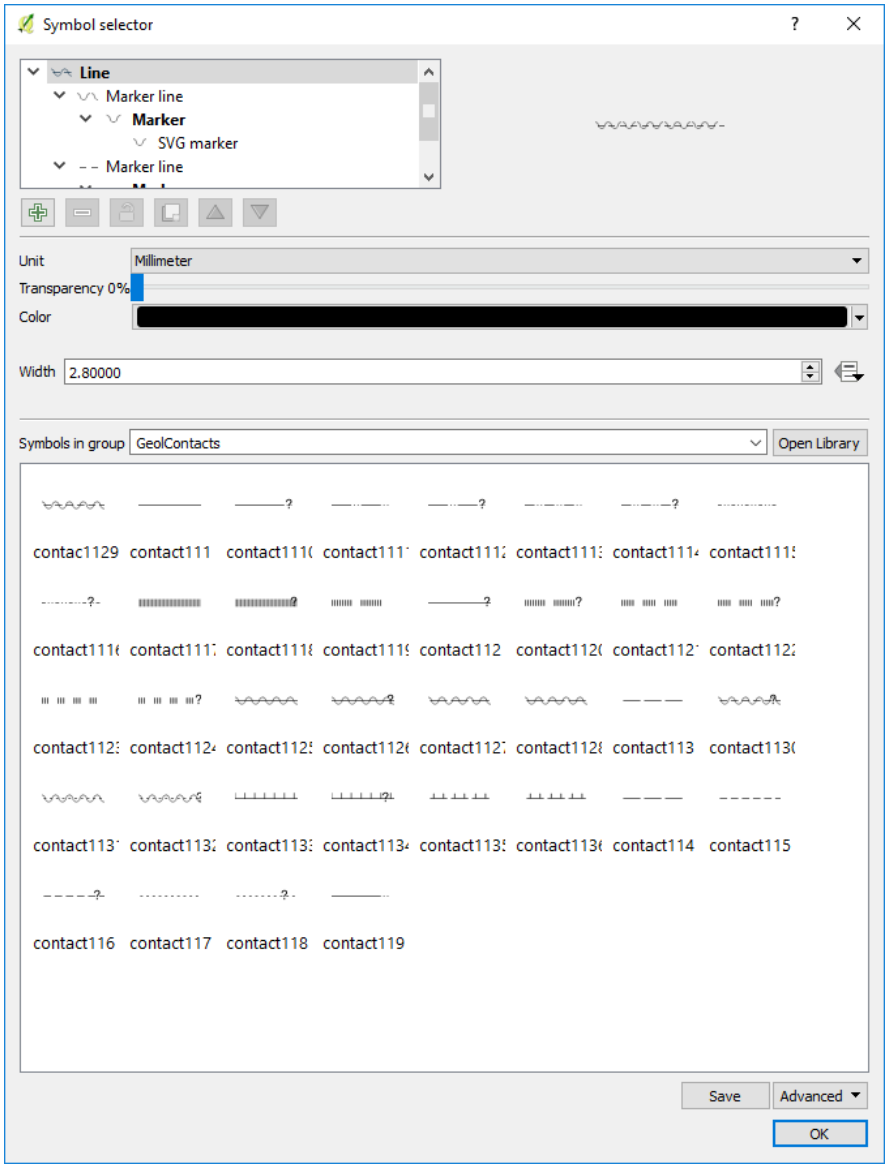
Linear geological features can be displayed by manually editing the line style in the Layer Properties > Style tab, or by using line styles set up in the top menu Settings > Style Manager window. Full details of how to construct various line styles can be found in a comprehensive document put out by the USGS and can be found here https://ngmdb.usgs.gov/fgdc_gds/geolsymstd/fgdc-geolsym-all.pdf.

Style (*.xml) and symbol (svg) files can be found here at Stefan Revett's site https://sourceforge.net/projects/qgisgeologysymbology/files/. On the main menu, go to Settings > Style Manager and select the Import option in the small box down on the lower right-hand side of the dialog box (looks like two blue lines with dots just above the Close button). Save each group with a name so that you can easily identify which line style group you want to display.



Navigate to where your line styles are stored. Import each one (contact, fold, fault and joint).

In the Symbols in group drop-down box, select GeolContacts (or whatever you called this line style group). Select the line style you want and hit OK. This method can be used to modify all the other line styles. To save these line styles remember to save the Style as default in the main Style tab window (under Style > Save as Default).



Any of these line styles can be edited manually by selecting the layer in the top window.

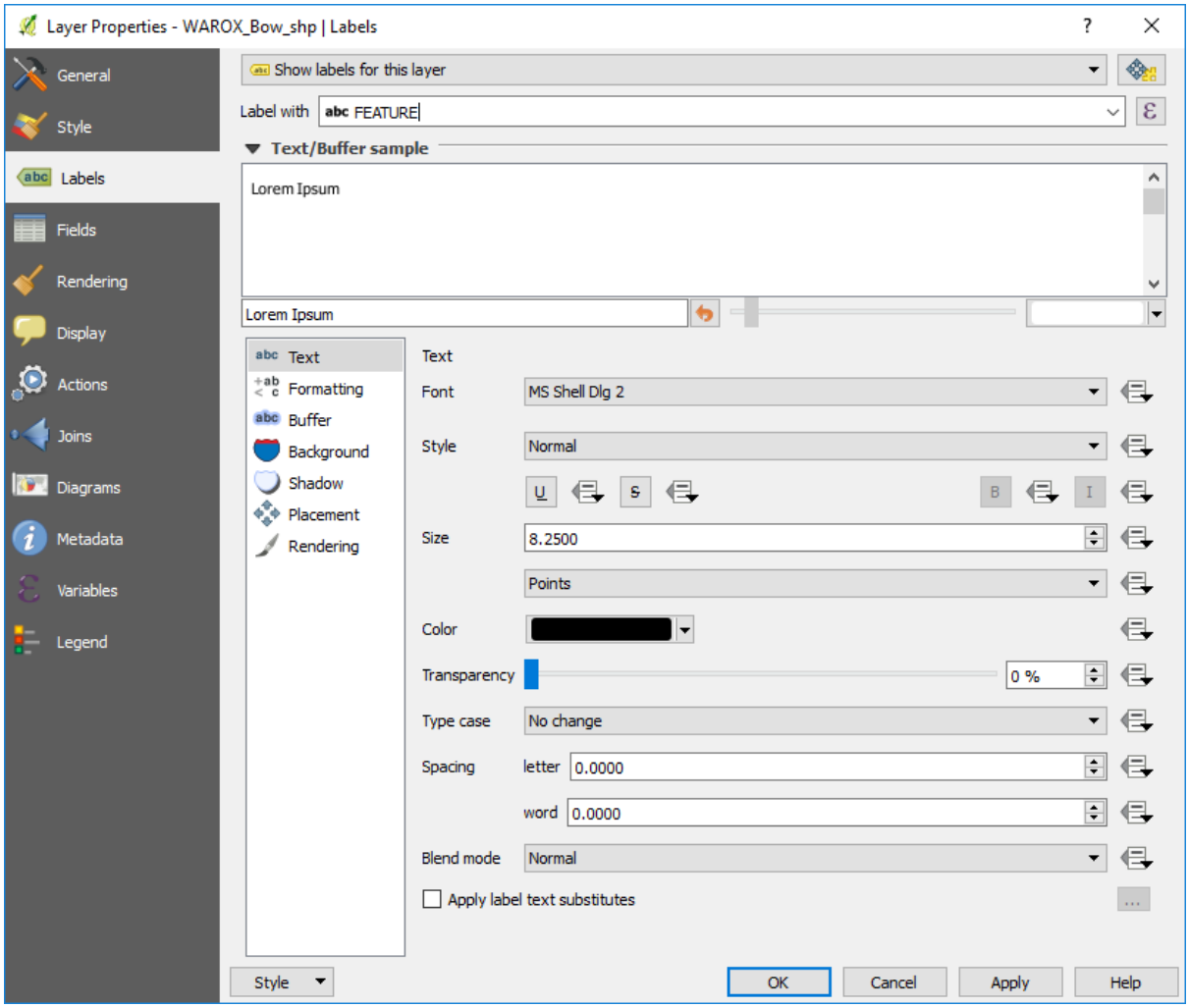
7.7 Labelling Features

Features can be labelled via the Labels tab in the Layer Properties window for each layer. There are many ways to place labels and format them. I will give some examples typically used in geological applications below but there are many other options which you are encouraged to explore (see QGIS User Guide – section 12.3.3 and Graser and Peterson 2016 – Part 2).

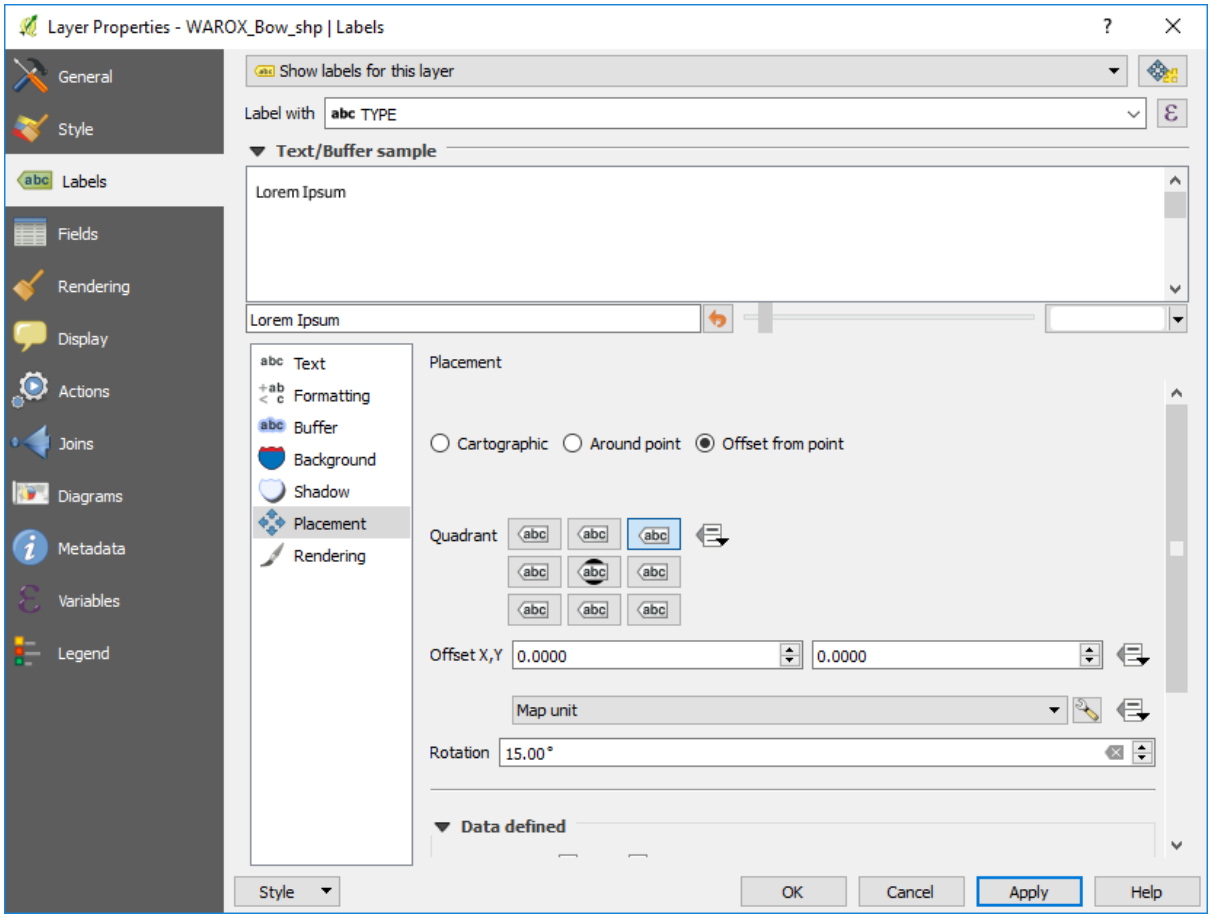
Labelling points

Data points can be for example drill hole id or sample numbers. The Labels tab shows a variety of labelling options such as font type and size, whether you want a halo around the label (buffer) which is useful when the labels are over a coloured background. The Formatting section allows you to specify multi-line labels and word wrap options. The Placement options allow you to test

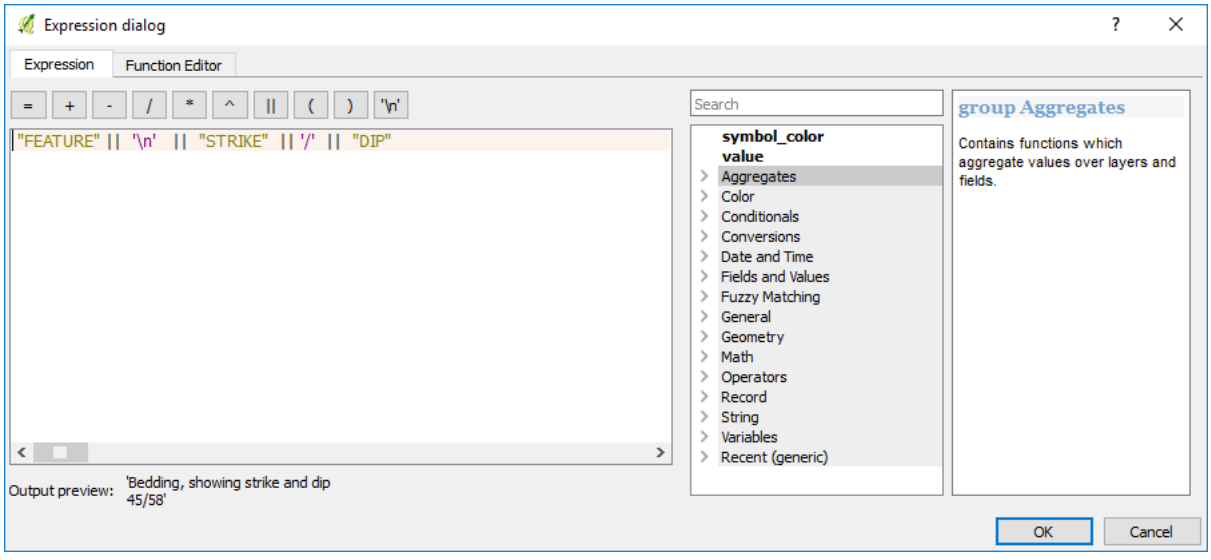
different ways to display your labels. Note that to manually move individual labels, you need the “Layer to Labelled Layer” plug-in. This plug-in creates additional fields and allows the user to manually move individual labels. I f you need to do this, it is recommended to do this as a last cosmetic clean-up before you finalise the map.

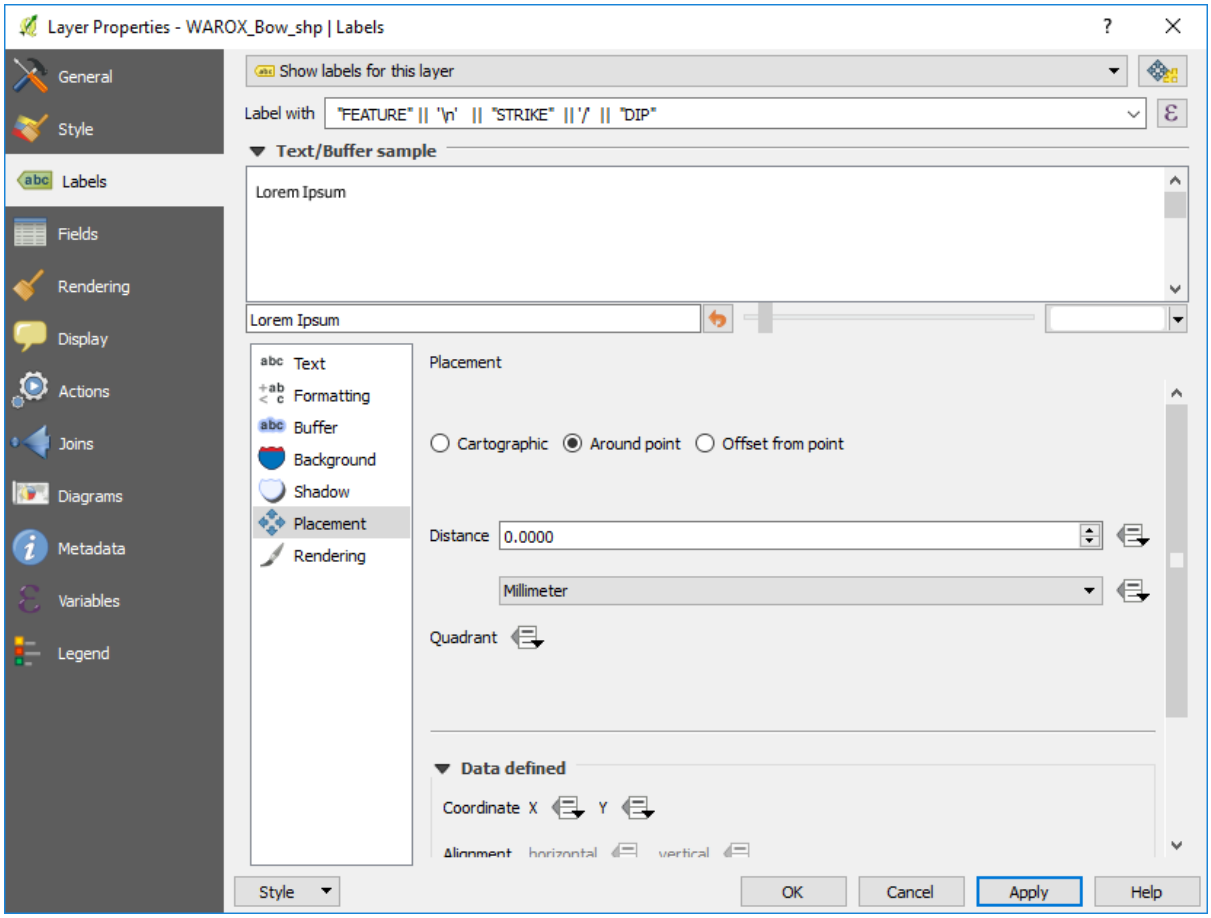


To rotate all the text labels, use the Labels > Placement > Offset from point > Rotation option. This option is useful for labelling drill holes along grid lines.

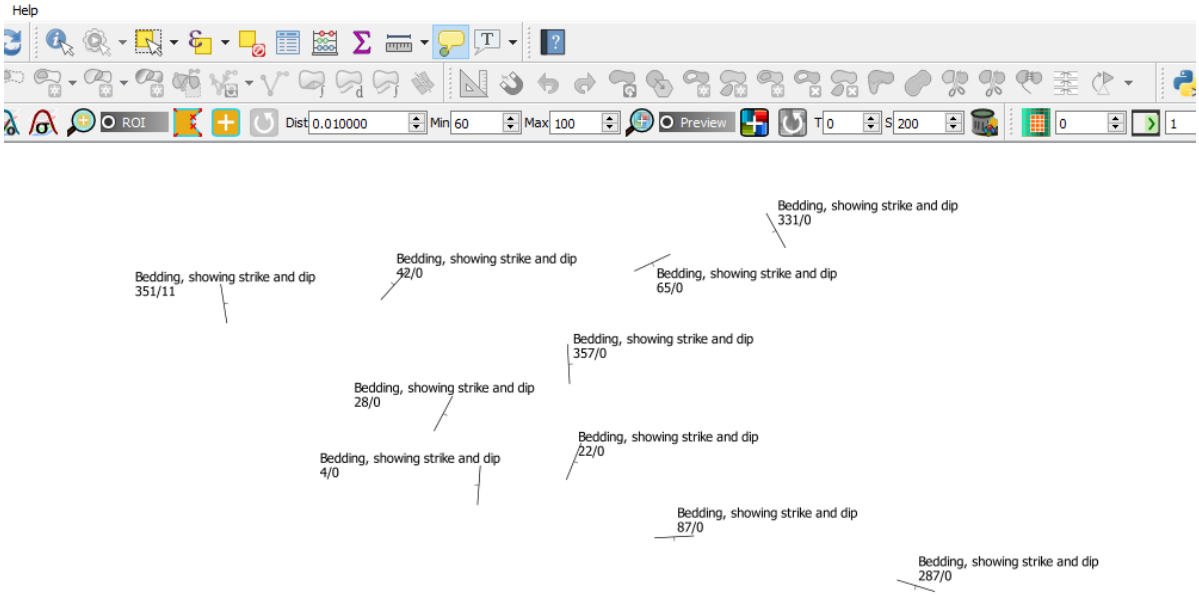


Multi-attribute labels can be created using the expression editor. Note the “Output Preview” in the lower left of the dialog box which shows how the labelling will appear.





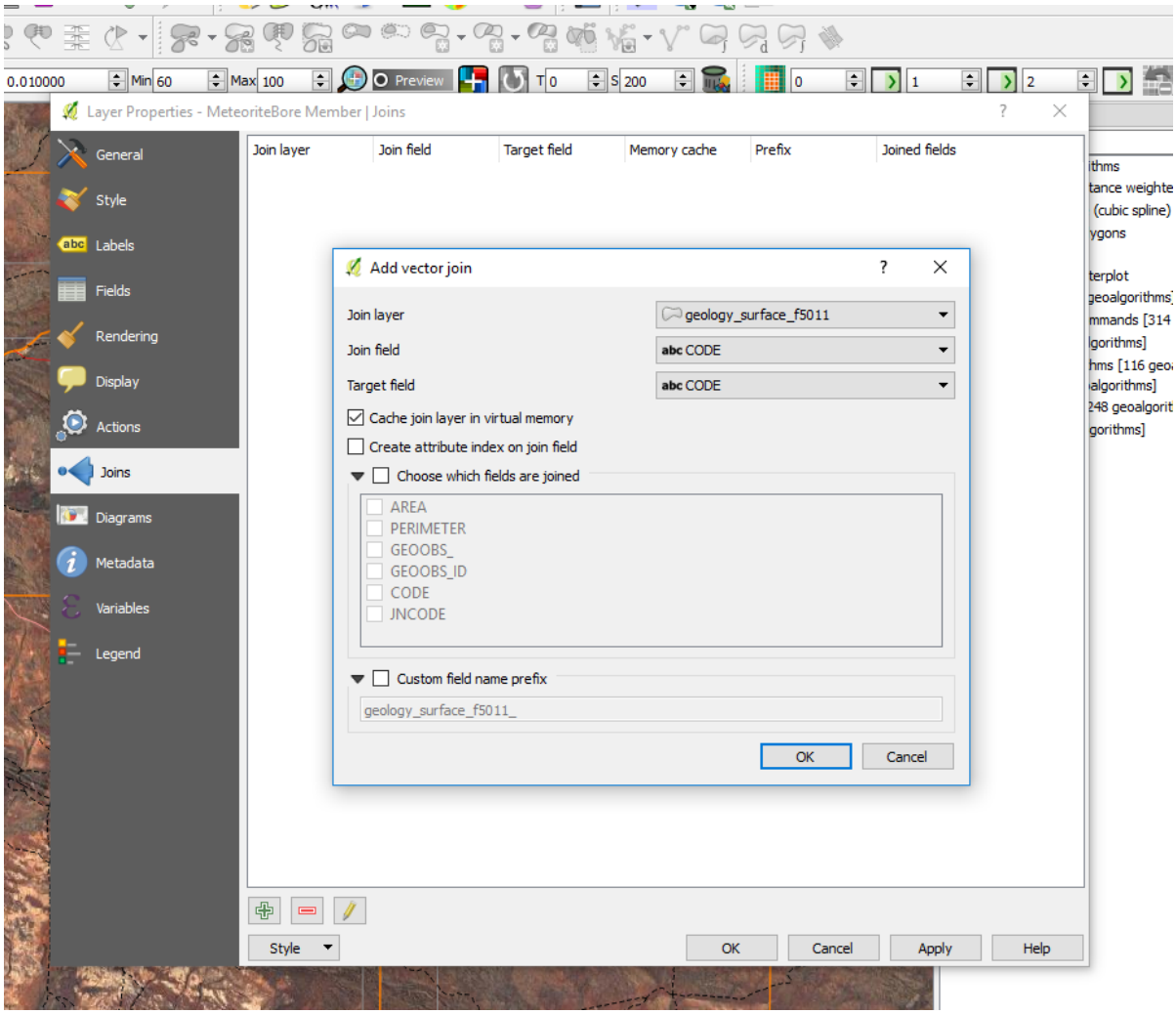
An example is shown below displaying the structure type with strike and dip.



7.8 Joining Spatial and Non-Spatial Data

Joins are done via the Layer Properties. Open both the spatial file (i.e.the layer that is spatially located) and the non-spatial file (without spatial data). The non-spatial file can be opened by the spreadsheet or text file import and with “No geometry” selected. The non-spatial layer will appear as a spreadsheet icon in the Layer properties panel. Select the spatial layer in the Layers panel you wish to join, open its Layer Properties > Join tab, select the join fields (which must have data in common in both layers to allow it to join).

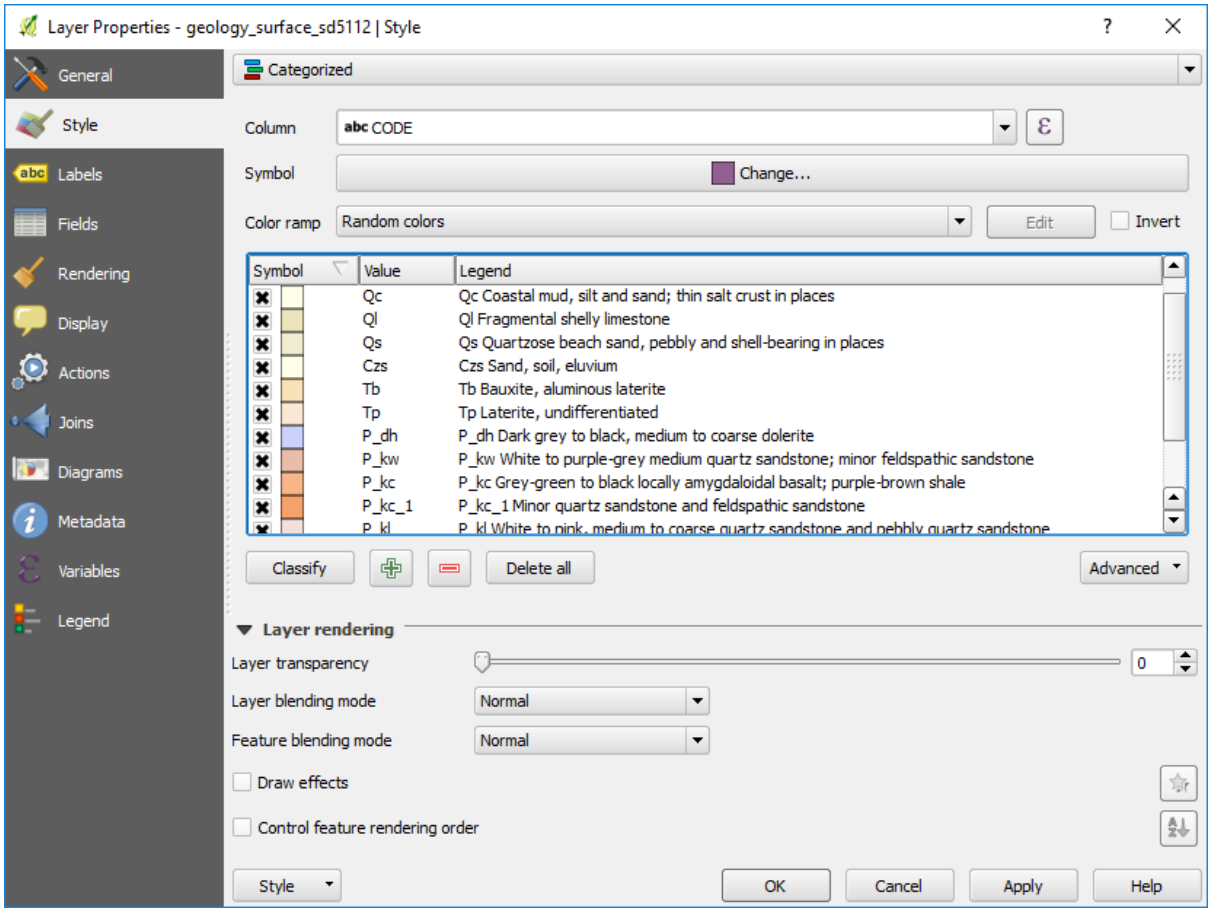
Individual fields can be selected for the join using the “Choose which fields are joined”. Select the “Custom field name prefix” and change it to a short abbreviation, remembering that shape files can only have a maximum field name size of 10 characters and this may cause problems later as field names may have been truncated.



After clicking “Apply”, examine the join results by opening the layer attribute table and ensuring the join has been successful. To make this a permanent join, use the “Save As” option by right-clicking on the layer name in the layers panel, and saving the file as a new shapefile layer. If you do not save this joined file, the join will not be permanent, as it is a virtual join only. An example of joining spatial and non-spatial data is discussed in the hands-on workshop task 5.

7.9 Geological Legends

The creation of automated geological legends in the current version of QGIS is limited. The best method to get detailed geological information into the legend is to edit the Legend data in the Layer Properties > Style tab.



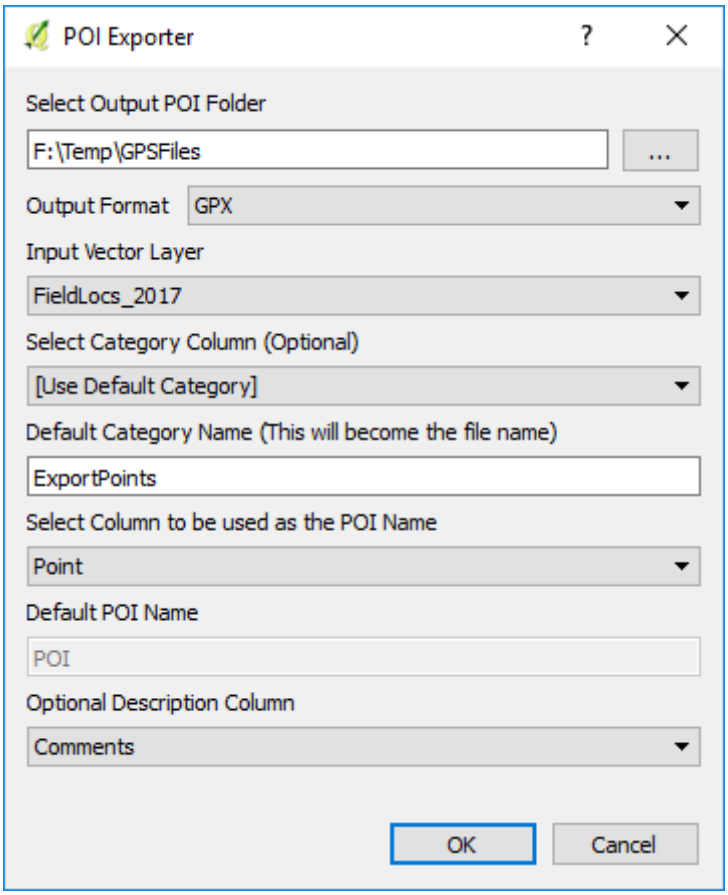
Usually when the “Categorised” option is selected, the Value and Legend columns only contain the code used for the categorisation, e.g. Tb or P-dh. The Legend column can be manually edited to add the required legend description. The polygon fills can also be modified. Remember to save the style as default when finished!

Work is in progress to automatically assign geological patterns and descriptions from the lyr (ArcGIS style files) via the GSWA using a python script to create a QGIS style file (qml). The GSWA are beginning to supply the polygon colouring information and pattern fills with the vector data for their digital maps.

7.10 Importing and Exporting GPS Data

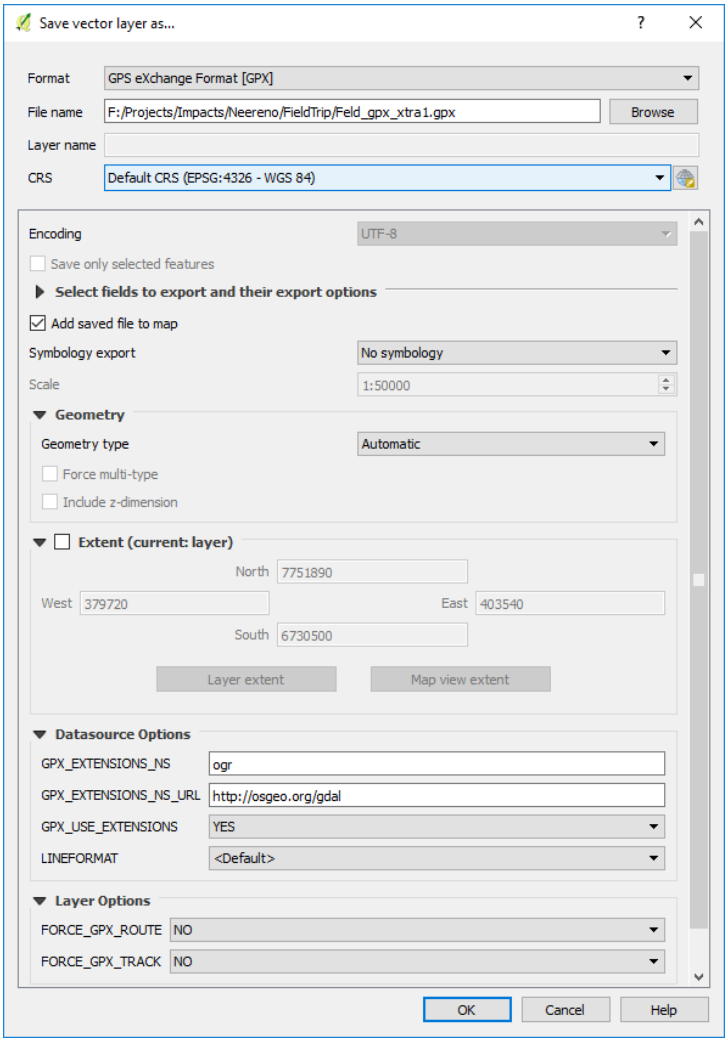
The quickest way to import point data into your GPS is via the POI plug-in. The plug-in allows you to select the layer you want to upload, the column containing the point names (or ids) and an optional comments column (up to 254 characters). The plug-in creates a gpx file which can then be easily uploaded to your gps via a direct file transfer or GPSBabel (for older models). The projection of the layer does not need to be in WGS84. Select the folder where you want the file to

go, select the layer to export as a gpx, enter the filename in the “Default Category Name” box, then select the column to be used as the “POI” name. The “Optional Description Column” can be used to upload other columns such as a site description into the “Comment” and “Description” fields of the gpx file.

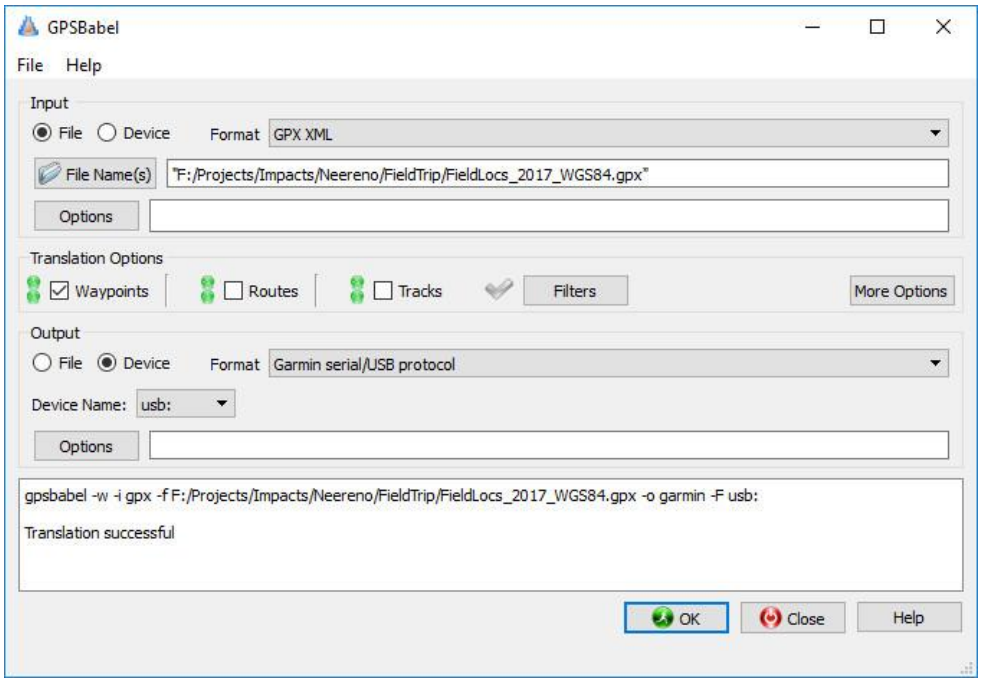


GPS data exported as a gpx file can also be directly read into QGIS via the add vector layer option. If there are problems importing the gpx files, try the GPS Tools under the Vector menu. If you continue to have problems with the gpx file, you can download the free GPSBabel utility (https://www.gpsbabel.org/) or purchase the GPS Utilities program (http://www.gpsu.co.uk/, US$60). The GPS Utilities program has a vast array for GPS formats that you can read or write. Remember to save the GPS layer as a shp file to allow for editing of the data.

Note that when uploading points to a GPS via a gpx file, you may need to save the shape file in a WGS84 (Lat/Long) projection and add two new text fields for “Name” and Desc”. Note that to include a long description in the DESC (Description) field, such as an outcrop observation, ensure you make the string length to be 254 characters. Note that some GPS units will only display a certain number of characters, for example the Garmin etrex Vista C only displays 30 of the 254 characters. Copy your point id’s from your location reference column into the “Name” field using the attribute table. Do the same to copy any comments into the “Desc” field. Save the shape files as a gpx file with GPX USE EXTENSION “YES” before uploading to the GPS. The point id’s will then appear as your waypoint names and the comments will appear in the notes section.



Open GPSBabel and select the gpx file to be uploaded, check Device “Garmin serial/usb” and device name “usb”.



The lower window will confirm if the upload has been successful.

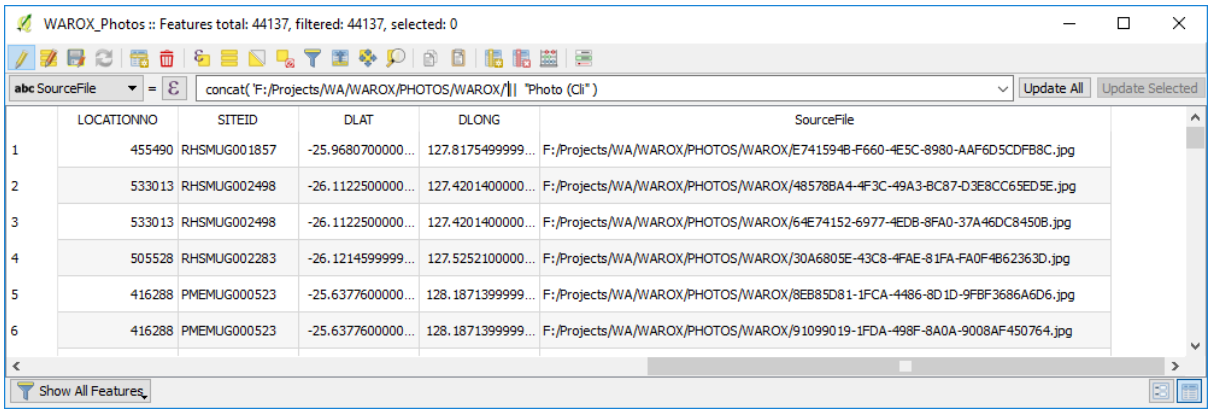
A live link to your GPS can be accessed via the View > Panels > GPS Information panel with various connection, display and digitising options.

7.11 Using the GSWA WAROX and WAMINES data

The WAROX database contains the GSWA field locations, sample sites, outcrop photos and petrography reports. The Microsoft Access database contains a number of queries to make it easier to access the data. The query “qry_photos_Locations” allows the user to extract the sites where photographs have been taken of outcrops. To import this data into QGIS, export the query as a csv (qry_photos_Locations.csv), ensuring you select the first row as field names, and then import this into QGIS via the CSV import option. Change the projection to GDA94 from the default WGS84.

In QGIS, open up the layers attribute table, make editable and add another column (called something like “SourceFile”) of type string (text) with width of 100 characters. Save this update. This “SourceFile” column will hold the file location and photo number that will allow QGIS to display the photo for this location. The next step will concatenate the directory path and photo file name into the “SourceFile” column.

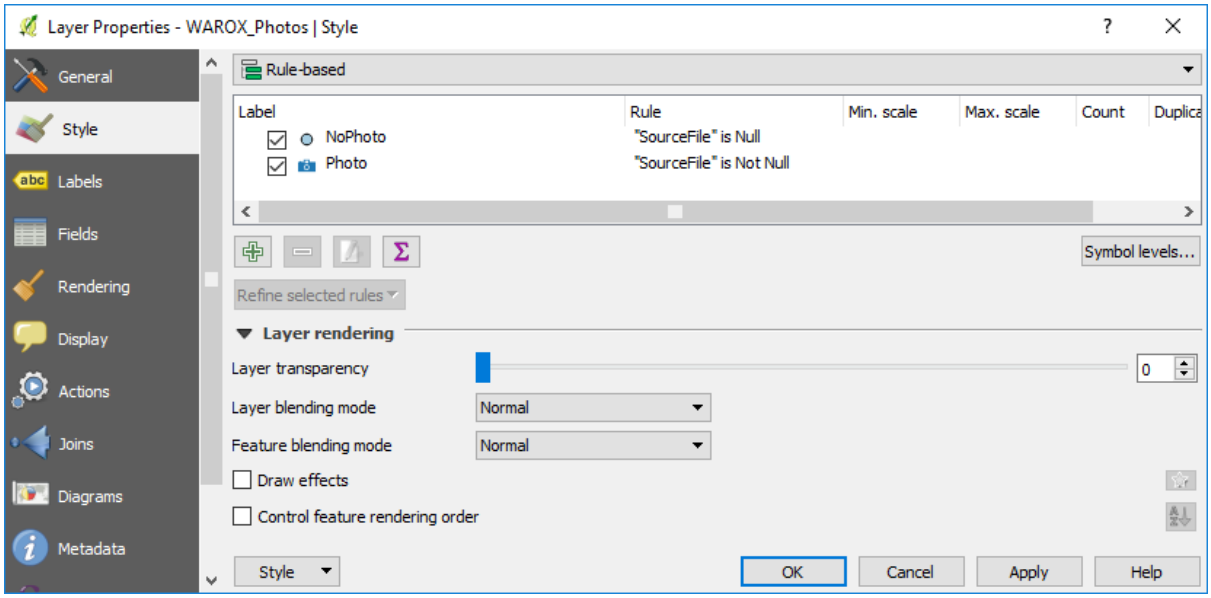
Click in the column selector to select the “SourceFile” column and then enter the following expression in the expression editor “concat(‘*directory location*’||”SourceFile”) substituting the directory location to point to where you have saved the WAROX photos. Note you have to change the default back slash (\) to a forward slash (/) in the directory path or you will get “?” replacing the back slashes. Save the file.



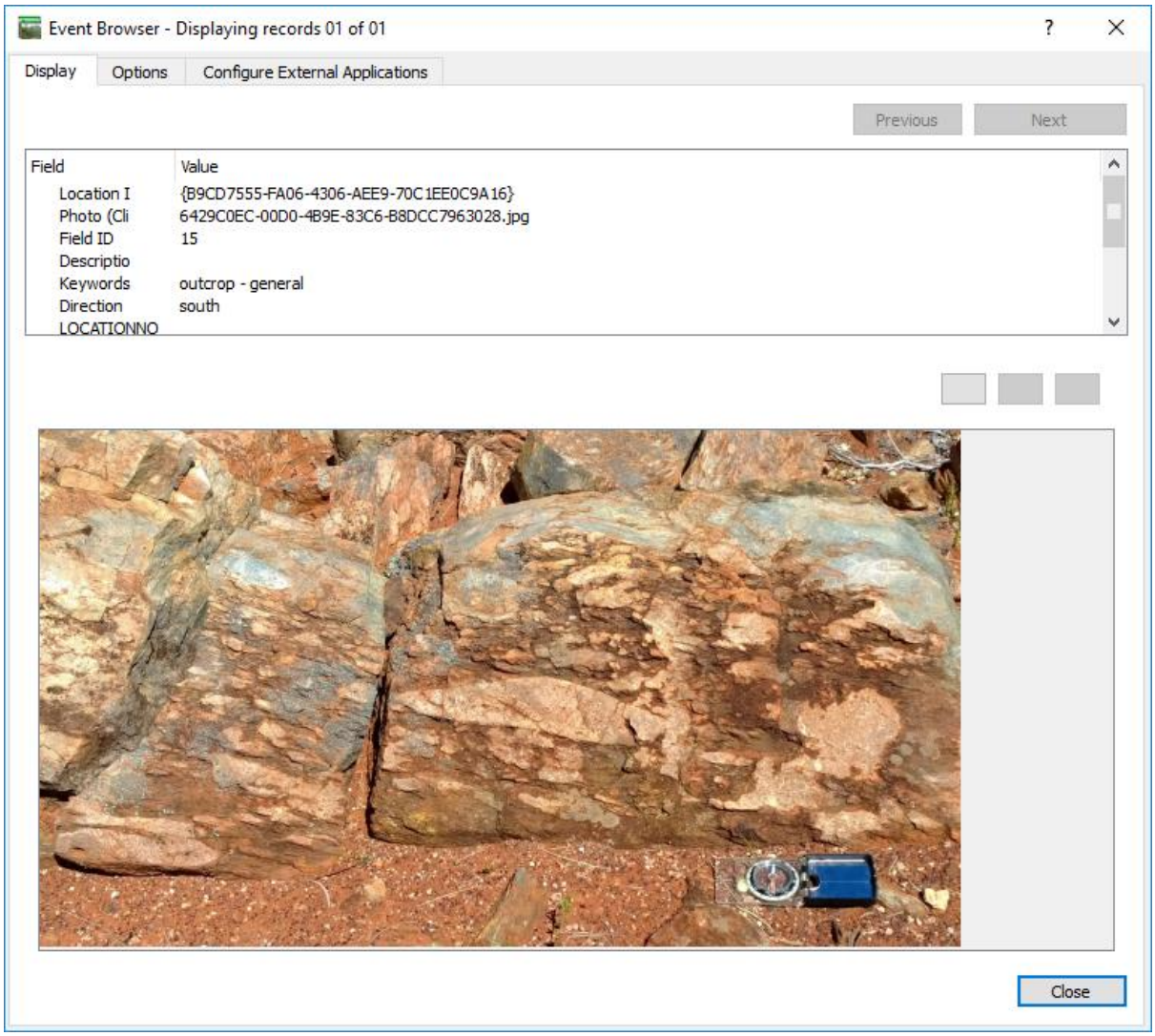
	LOCATIONNO	SITEID	DLAT	DLONG	SourceFile
1	455490	RHSMUG001857	-25.9680700000...	127.8175499999...	F:/Projects/WA/WAROX/PHOTOS/WAROX/E741594B-F660-4E5C-8980-AAF6D5CDFB8C.jpg
2	533013	RHSMUG002498	-26.1122500000...	127.4201400000...	F:/Projects/WA/WAROX/PHOTOS/WAROX/48578BA4-4F3C-49A3-BC87-D3E8CC65ED5E.jpg
3	533013	RHSMUG002498	-26.1122500000...	127.4201400000...	F:/Projects/WA/WAROX/PHOTOS/WAROX/64E74152-6977-4EDB-8FA0-37A46DC8450B.jpg
4	505528	RHSMUG002283	-26.1214599999...	127.5252100000...	F:/Projects/WA/WAROX/PHOTOS/WAROX/30A6805E-43C8-4FAE-81FA-FA0F4B62363D.jpg
5	416288	PMEMUG000523	-25.6377600000...	128.1871399999...	F:/Projects/WA/WAROX/PHOTOS/WAROX/8EB85D81-1FCA-4486-8D1D-9FBF3686A6D6.jpg
6	416288	PMEMUG000523	-25.6377600000...	128.1871399999...	F:/Projects/WA/WAROX/PHOTOS/WAROX/91099019-1FDA-498F-8A0A-9008AF450764.jpg

You may want to Categorise the points into those with and without photos using a “Rule based” styling using photo SourceFile is Not Null for points with photos (meaning there is a photo link), and no photo when SourceFile is Null (no photo link). I have used a photo icon to indicate if there is a photo available at a particular location.

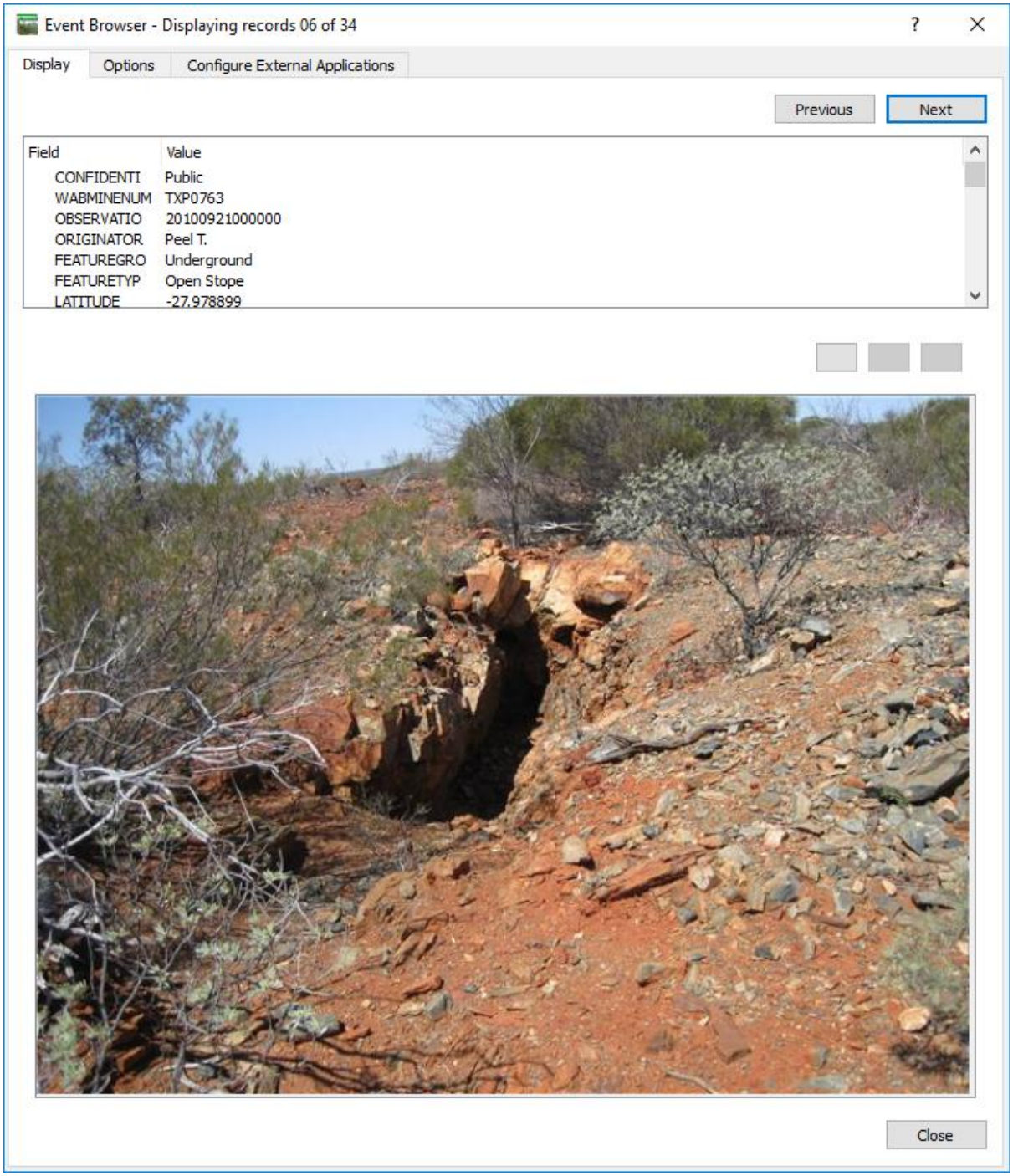
After saving the file, you can then use the eVis plug-in (Database > eVis > EVis event id tool) to click on and display photos linked to that site.


Layer Properties - WAROX_Photos | Style
General
Style
Labels
Fields
Rendering
Display
Actions
Joins
Diagrams
Metadata
Rule-based
Label
Rule
Min. scale
Max. scale
Count
NoPhoto
"SourceFile" is Null
Photo
"SourceFile" is Not Null
Symbol levels...
Refine selected rules
Layer rendering
Layer transparency
Layer blending mode
Normal
Feature blending mode
Normal
Draw effects
Control feature rendering order
Style
OK
Cancel
Apply
Help

eVis Window


Event Browser - Displaying records 01 of 01
Display
Options
Configure External Applications
Previous
Next
Field
Value
Location I
{B9CD7555-FA06-4306-AEE9-70C1EE0C9A16}
Photo (Cli
6429C0EC-00D0-4B9E-83C6-B8DCC7963028.jpg
Field ID
15
Descriptio
Keywords
outcrop - general
Direction
south
LOCATIONNO
Close

A similar process can be used to display linked petrographic reports and photos in the WAMINES database. See below an example from the WAMINES database.



8: DISPLAYING GEOCHEMICAL DATA

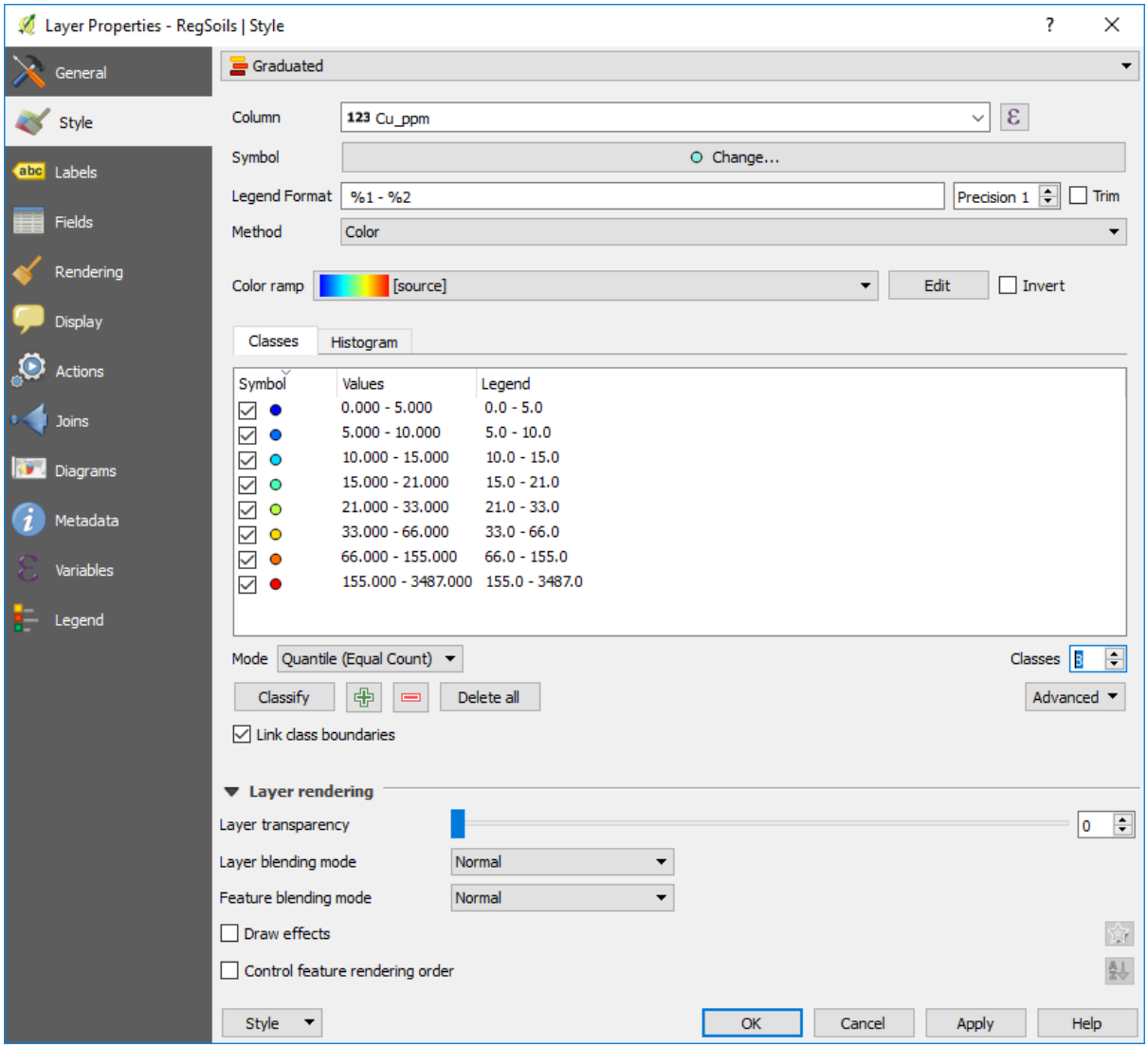
Geochemical data is usually in the form of an excel spreadsheet or as a text file. Open the file in QGIS via the "Spreadsheet Layers" or CSV file open options depending upon the format of your data. See section 6 above for opening spreadsheet and csv files, and the potential use of CSV format files (*.csvt) for large complicated csv files.

Another option for importing csv data is to load into Excel and check the field types for each field before importing. Ensure the data has been loaded into QGIS as the correct field type, i.e. as a number, not as a string (text) field. This can be checked using the layer's Layer Properties > Fields tab.

When the data has been imported into QGIS, make sure you check the correct coordinate system has been selected and the data is in the correct place. Google Earth, satellite imagery or open street map vector data can be used for this purpose. The simplest display is a series of points where the symbol can be displayed in different colours and sizes by sample value. Options for the display of geochemical point data is discussed in the Hands-On Workshop 3 below.

Geochemical point data can be displayed as points and can be coloured or sized according to value. Use the Layer Properties > Style tab to select the way you want the data displayed. The simplest way is to use the "Graduated" option and colour the point values. Note that this works on numeric values only. Select the column you wish to colour the points by and the desired colour ramp and hit the "Classify" button. Under the display window, you can also select the way the points are coloured. You can use a variety of methods. You can also manually edit the ranges in the display window.

If you select 8 classes and the "Quantile (Equal Count)" method this will calculate the 1st and 3rd quantiles as the second and seventh quantiles. For example, the displayed data set has a first quantile value of 10 and a third quantile value of 66. The Inter-Quantile Range (IQR) is therefore 56, and by calculation, the anomalous data threshold of "Cu_ppm" is 3rd Q + (1.5 * IQR) = 84. These values can be checked by using the Statistics Panel.



Statistics can be carried out on geochemical data in QGIS. Univariate statistics can be calculated using the View > Statistical Summary panel. This opens a panel under the browser panel, where you can select the layer and data field for which field you want to calculate statistics. The mean, standard deviation, first quantile, third quantile and the Inter Quartile Range (IQR) are among some of the calculated results. Note that the user must ensure their data has been verified and checked, so as not to introduce anomalous results caused by below detection assay results, e.g. “-5” as a replacement for below detection at a 5 ppm detection limit.

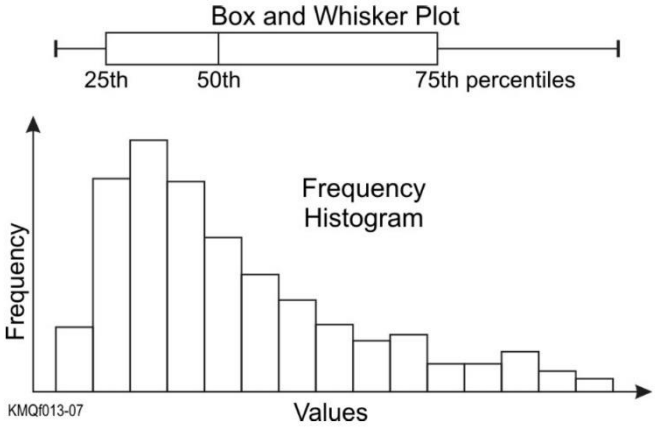
Statistics Panel

RegSoils

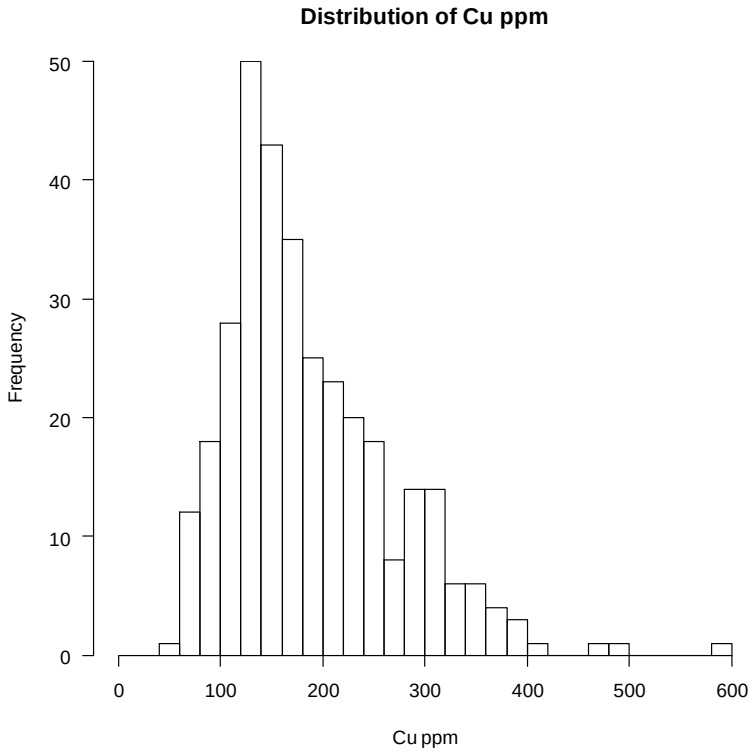
123 Cu_ppm

Statistic	Value
Count	4318
Sum	331453
Mean	76.7608
Median	21
St dev (pop)	179.932
St dev (sample)	179.953
Minimum	0
Maximum	3487
Range	3487
Q1	10
Q3	66
IQR	56
Missing (null) values	0

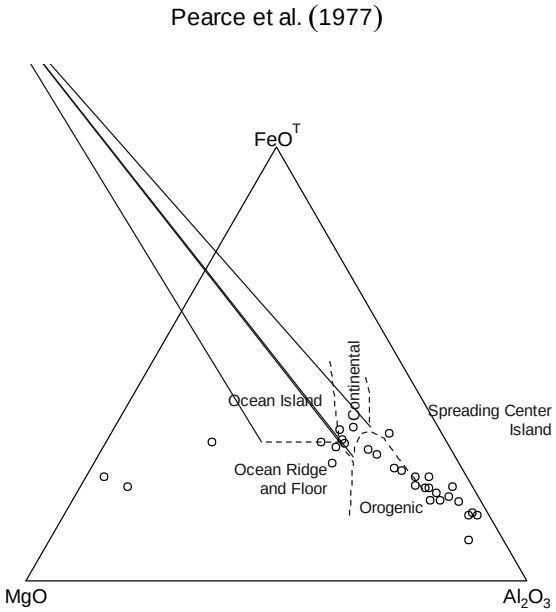
Selected features only



Users should also plot their data to examine its distribution. QGIS has plotting options (Processing Toolbox > R > Plots) but these require the installation of the free "R" open source program for statistical analysis. Various plot types are available including histograms, box (box and whisker) and cumulative frequency (QQPlots) plots. Some knowledge of R is required and further details are attached in appendix 2 (pending).



Whole rock geochemical analysis with rock classification diagrams are also possible using the GCDKit for R which is an add-on to the R program. Further details are attached in appendix 2 (pending).



Geochemists traditionally use “box and whisker” plots to display the mean, median, first and third quantile, interquartile range (IQR) and anomaly threshold level (third quartile plus 1.5 times IQR). The IQR is the difference between the third and first quantiles.

Gridding of geochemical data is common where there are a large number of approximately regular located sample points. Gridding can be done via the Raster > Interpolation, or Raster > Analysis > Grid (interpolation) options, but there are much more powerful gridding options in the SAGA menu of the Processing Toolbox (usually displayed on the far right hand side window). If this is not displayed go to the top menu Processing > Toolbox. SAGA has processing modules for cubic spline interpolation, inverse distance squared options and kriging. These options are discussed in the Hands-On Workshop 3 below.

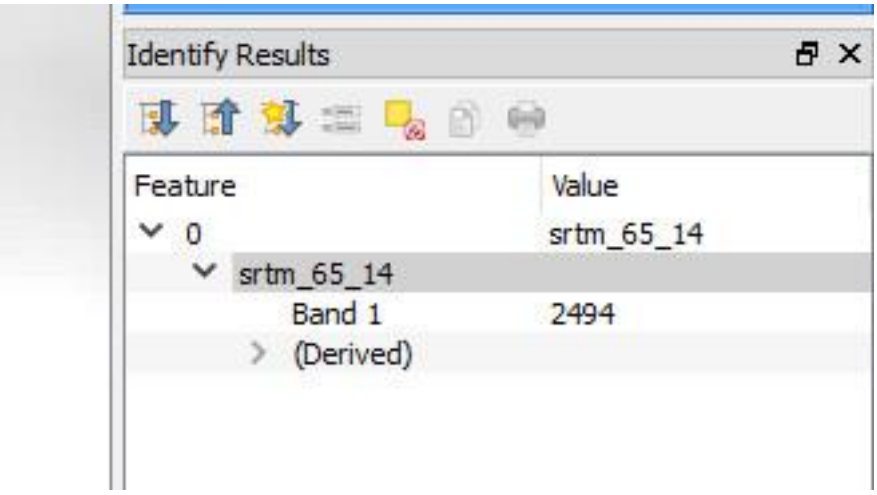
9: GEOPHYSICAL DATA IMPORT AND DISPLAY

Geophysical data usually comes as located data files (text) or grid files. QGIS can read many grid formats with *.ers, and *.tif (geotiff) files the most common. Geosoft *.grd files however require conversion to *.ers files via their free viewer Oasis Montaj program (available from www.geosoft.com).

When opening located data text files, remember that shape files can only have column names up to 10 characters in length. If your text files have longer column names, then it is suggested you use a text editor like Notepad++ (https://notepad-plus-plus.org/) to modify the column names.

Grid files are treated as raster files and are usually displayed as greyscale by default. To change the display, open the layer properties dialog and select “Style”. A variety of options are available including changing the colour ramps, colour stretch and display value limits. Manually entering the display limits is sometimes useful, particularly for first vertical derivative grids with values around zero.

Note that you can use the information to examine the values of a pixel or grid location. If the value is not displayed in the Identify panel, try minimising the left-hand side column, as sometimes the column width is too wide to display the cell value on the right-hand side of the panel.



If you open a grid file and have difficulties displaying the data, e.g. with 1VD images, zoom in to a small area of the grid and then “Stretch to Current Extent” (available as a right click on the layer name in the Layers panel) to stretch the data to something visible.

Examples of data import and display are discussed in Hands-On Workshop 3.

10: 3D IMAGE DISPLAY

For basic 3D image display, use QGIS2threejs plug-in. This plug-in allows the user to display a block model in a web browser where the model can be zoomed and rotated. The html file can be used by other users as a simple html web browser file.

Display options include the resolution of the block model, vertical exaggeration and an RL plane display. All layers displayed in the map window can be shown on the block model.

See the Hands-On Workshop 4 for an example of how this feature works. Note that some browsers will block the running of this plugin. If this happens, go to your internet browser settings/options tab and allow programs to run. In Internet Explorer it is located in the Settings > Advanced tab under Security – “Allow programs to run on this computer”.

11: REMOTE SENSING

The availability of free satellite and other remote sensing data has created unique opportunities for the display of remote sensing data to assist geological interpretation and analysis. QGIS can display the normal satellite images but it also has a powerful plugin, the Semi-Automatic Classification (SCP) plug-in, which can be used to source, select, download and process free satellite imagery. Video tutorials are available on the web (https://www.youtube.com/watch?v=GFrDgQ6Nzqs) and cover a variety of remote sensing applications including land cover classification.

An example of the use of the SCP plug-in is detailed in Hands-On Workshop 6 (below) as well as describing the process of creating RGB images from remote sensing data.

To download ASTER and Landsat data, you are required to register (free) at the USGS EarthExplorer portal. These registration details will be required to be entered into the SCP download window. Sentinel data download requires (free) registration at the ESA Sentinal data access portal. Note that it might take three or four days for your registration to become active.

11.1 ASTER Data

Details of the ASTER (Advance Spaceborne Thermal Emission and Reflection Radiometer) scanner bands are shown in the figure below (from Abrams and Hook 2016).

ASTER data is now freely available worldwide but note that the SWIR sensor (bands 4 to 9) became inoperable on 1st April 2008, and therefore only data acquired before this time will be suitable for mineral mapping.

ASTER Users Handbook

Subsystem	Band No.	Spectral Range (μm)	Spatial Resolution, m	Quantization Levels
VNIR	1	0.52-0.60	15	8 bits
	2	0.63-0.69		
	3N	0.78-0.86		
	3B	0.78-0.86		
SWIR	4	1.60-1.70	30	8 bits
	5	2.145-2.185		
	6	2.185-2.225		
	7	2.235-2.285		
	8	2.295-2.365		
	9	2.360-2.430		
TIR	10	8.125-8.475	90	12 bits
	11	8.475-8.825		
	12	8.925-9.275		
	13	10.25-10.95		
	14	10.95-11.65		

Table 1: Characteristics of the 3 ASTER Sensor Systems.

ASTER bands and band ratios for geological applications are shown in the tables below (from ASTERDataProcessing_GA7833.pdf available from Geoscience Australia).

Common ratio & band combinations

Features	Red	Green	Blue	Reference
Vegetation and visible bands**	3, 3/2, or NDVI	2	1	
AlOH minerals/advanced argillic alteration***	5/6 (phen)	7/6 (musc)	7/5 (kaol)	Hewson (CSIRO)
Clay, amphibole, laterite	(5x7)/6^2 (clay)	6/8 (amph)	4/5 (lat)	Bierwith
Gossan, alteration, host rock	4/2 (goss)	4/5 (alt)	5/6 (host)	Volesky
Gossan, alteration, host rock	6 (goss)	2 (alt)	1 (host)	
Decorellation (envi)	13	12	10	Bierwith
Silica, carbonate, basic degree index	(11x11)/10/12 (silica)	13/14 (carb)	12/13 (basic)	Bierwith
Silica, carbonate	(11x11)/(10x12)	13/14	12/13	Nimoyima
Silica	11/10	11/12	13/10	CSIRO
Discrimination for mapping	4/1	3/1	12/14	Abdelsalam
Discrimination in sulphide rich areas	12	5	3	
Discrimination	4/7	4/1	(2/3) x (4/3)	Sultan
Discrimination	4/7	4/3	2/1	Abrams (USGS)
Silica, Fe^{2+}	14/12	(1/2) + (5/3)	MNF Band 1	Rowan (USGS)
Enhanced structural features	7	4	2	Rowan (USGS)

*Comments by Hewson
**Equivalent to Landsat RGB 432
***Alunite/pyrophyllite, mica, kaolinite/dickite

Band rations are easily calculated in the SCP plug-in. My personal experience for using the ASTER data in Western Australia and Peru, is that the Discrimination ratios using ratio 4/7 (red), 4/3 (green) and 2/1 (blue) works well in most situations. The AlOH minerals/Advanced argillic alteration combination and the Alunite-Kaolinite-Pyrophyllite image also works well for detecting alteration associated with porphyry copper mineralisation. Remember the resulting images may have artefacts caused by low sun angles, clouds, etc. so be cautious in using the data. Remote sensing vendors are able to undertake more advanced processing and interpretation of this data, and the rough processing described above should be used with caution.

Commonly used ratios

Feature	Band or Ratio	Comments	Reference
Iron			
Ferric iron, Fe^{3+}	2/1		Rowan; CSIRO
Ferrous iron, Fe^{2+}	5/3 + 1/2		Rowan
Laterite	4/5		Bierwith
Gossan	4/2		Volesky
Ferrous silicates (biot, chl, amph)	5/4	Fe oxide Cu-Au alteration	CSIRO
Ferric oxides	4/3	Can be ambiguous*	CSIRO
Carbonates / Mafic Minerals			
Carbonate / chlorite / epidote	(7+9)/8		Rowan
Epidote / chlorite / amphibole	(6+9)/(7+8)	Endoskarn	CSIRO
Amphibole / MgOH	(6+9)/8	Can be either MgOH or carbonate*	Hewson
Amphibole	6/8		Bierwith
Dolomite	(6+8)/7		Rowan, USGS
Carbonate	13/14	Exoskarn (cal/dolom)	Bierwith, Nimoyima, CSIRO
Silicates			
Sericite / muscovite / illite / smectite	(5+7)/6	Phyllic alteration	Rowan (USGS); Hewson (CSIRO)
Alunite / kaolinite / pyrophyllite	(4+6)/5		Rowan (USGS)
Phengitic	5/6		Hewson
Muscovite	7/6		Hewson
Kaolinite	7/5	Approximate only*	Hewson
Clay	$(5x7)/6^2$		Bierwith
Alteration	4/5		Volesky
Host rock	5/6		Volesky
Silica			
Quartz rich rocks	14/12		Rowan
Silica	(11x11)/10/12		Bierwith
Basic degree index (gnt, cpx, epi, chl)	12/13	Exoskarn (gnt, px)	Bierwith, CSIRO
SiO2	13/12	Same as 14/12	Palomera
SiO_2	12/13		Nimoyima
Siliceous rocks	(11x11)/(10x12)		Nimoyima
Silica	11/10		CSIRO
Silica	11/12		CSIRO
Silica	13/10		CSIRO
Other			
Vegetation	3/2		
NDVI	(3-2)/(3+2)	Normalised difference vegetation index	

11.2 Landsat Data

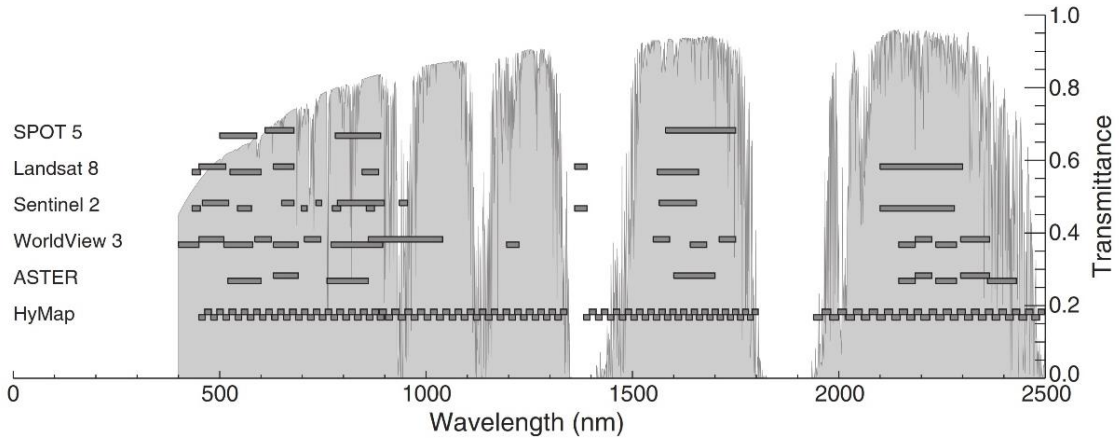
Landsat 8 data is collected over 11 bands as illustrated below.

Band Reference Number	Band Description	Band Center (nm)
1	Coastal Aerosol (Operational Land Imager (OLI))	433
2	Blue (OLI)	482
3	Green (OLI)	562
4	Red (OLI)	655
5	Near-Infrared (NIR) (OLI)	865
6	Short Wavelength Infrared (SWIR) 1 (OLI)	1610
7	SWIR 2 (OLI)	2200
8	Panchromatic (OLI)	590
9	Cirrus (OLI)	1375
10	Thermal Infrared Sensor (TIRS) 1	10800
11	TIRS 2	12000

Landsat 8 band combinations are usually bands 4, 3 and 2 in the R, G and B channels for an aerial photo type image, whereas the combination of bands 6, 4 and 2 typically enhances the geology. Band 8 is used to pan-sharpen the images to 15 m resolution. The SCP plug-in will automatically pan-sharpen the RGB images if selected.

11.3 Sentinel 2 Data

The Sentinel 2 satellites are designed for earth observation and the figure below illustrates the comparison with the other satellite data bands (from van der Meer et al 2014). The Sentinel satellite constellation has been launched by the European Space Agency (ESA) and the derived data is available free of charge. See ESA website (https://sentinel.esa.int/web/sentinel/home) for more detail on the available data and data access.



When using Sentinel 2 data, bands 4, 3 and 2 (for RGB) are used for the natural aerial photo type image and bands 12 or 11, 4 and 2 (for RGB) are used to enhance the geology. Users should experiment with various band ratios to find the most suitable for their application.

The figure below from van der Meer et al 2014 compares ASTER ratio mineral mapping to the equivalent bands in the Sentinel 2 data.

Sentinel-2 band ratios as an analogue of ASTER band ratios, used as proxies for mineralogy. Modified after Kalinowski & Oliver (2004). The table is limited to ratios that fall in the wavelength range of Sentinel-2.

Feature	ASTER	Sentinel-2
Iron		
Ferric Iron, Fe3+	2/1	4/3
Ferrous Iron, Fe2+	5/3 + 1/2	12/8 + 3/4
Laterite	4/5	11/12[a]
Gossan	4/2	11/4
Ferrous silicates (Biotite, chloride, amphibole)	5/4	12/11[a]
Ferric oxides	4/3	11/8
Carbonates/Mafic minerals		
Carbonate/Chlorite/Epidote	(7 + 9)/8	–
Epidote/Chlorite/Amphibole	(6 + 9)/(7 + 8)	–
Amphibole/MgOH	(6 + 9)/8	–
Amphibole	6/8	–
Dolomite	(6 + 8)/7	–
Silicates		
Sericite/Muscovite/Illite/Smectite	(5 + 7)/6	–
Alunite, Kaolinite, Pyrophyllite	(4 + 6)/5	–
Phengitic	5/6	–
Muscovite	7/6	–
Kaolinite	7/5	–
Clay	$(5 \times 7)/6^2$	–
Alteration	4/5	11/12[a]
Host rock	5/6	–
Other		
Vegetation	3/2	8/4
NDVI	(3 − 2)/(3 + 2)	(8 − 4)/(8 + 4)

[a] ASTER bands 5–7 fall within band 12 of Sentinel-2.

12: MAP PRODUCTION

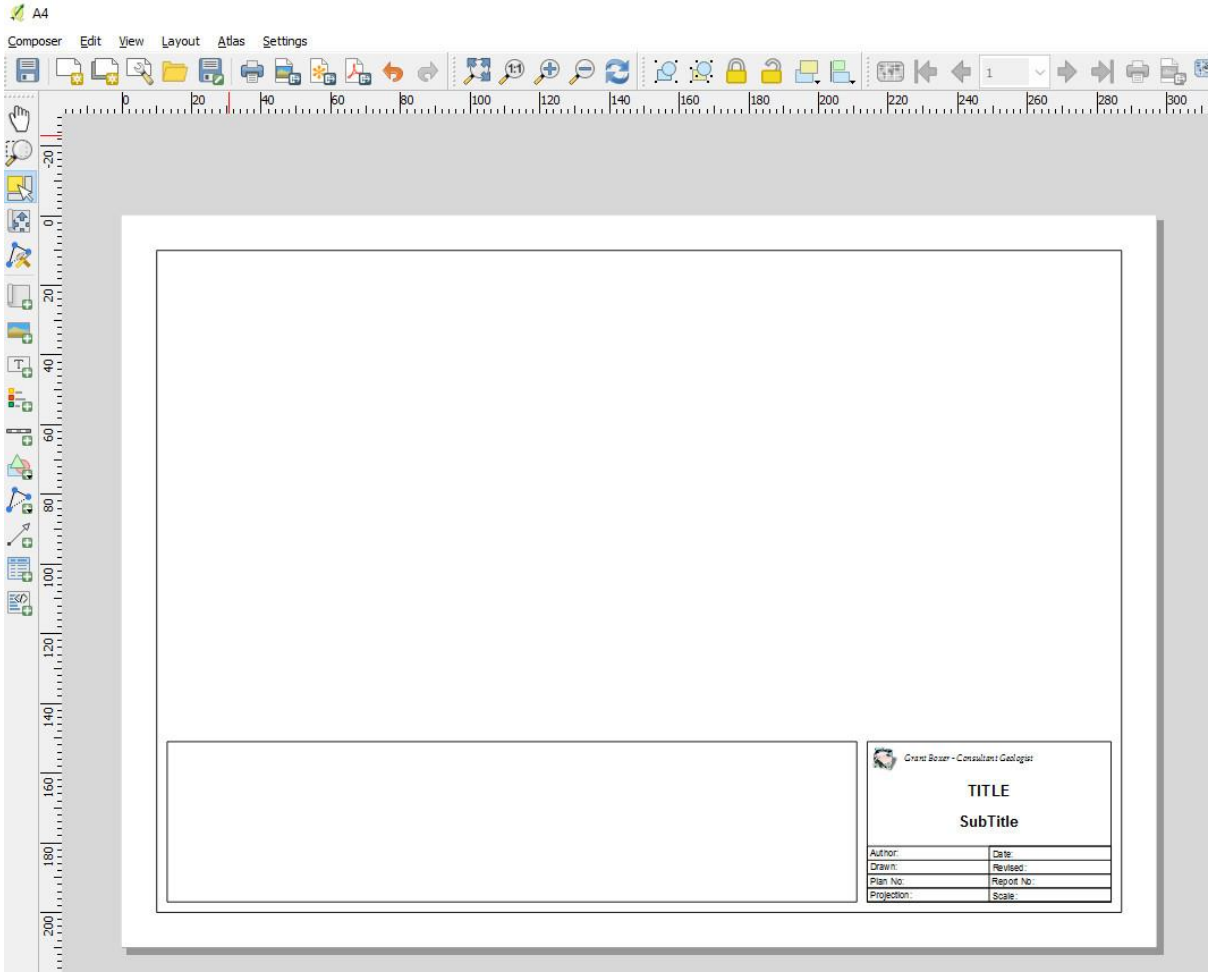
12.1 Map Composer

The Map Composer is the tool to produce maps for output. Various page sizes can be selected as well as creating custom page sizes. Everything to do with the final map design is done in the map composer. Map creation is described in Hands-On Workshop 1. If you lose tab views, click on the "Views" menu option in the Print Composer window and scroll down to Panels to reselect them for display.

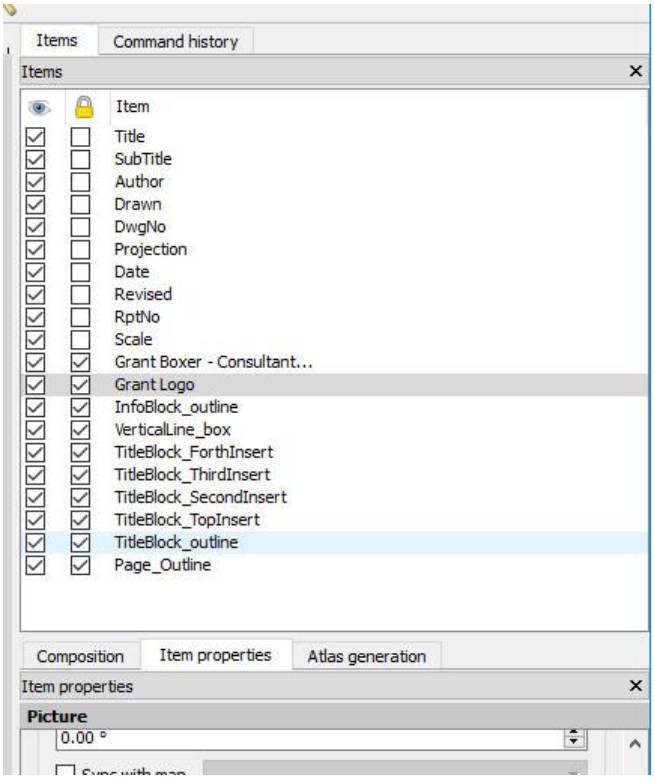
It is important to have the main map projection in a metres projection (i.e. UTM) and not in a geographic lat/long projection. I have had problems with the scale not being correct on map outputs when the main map window is in a lat/long projection.

12.2 Map Templates

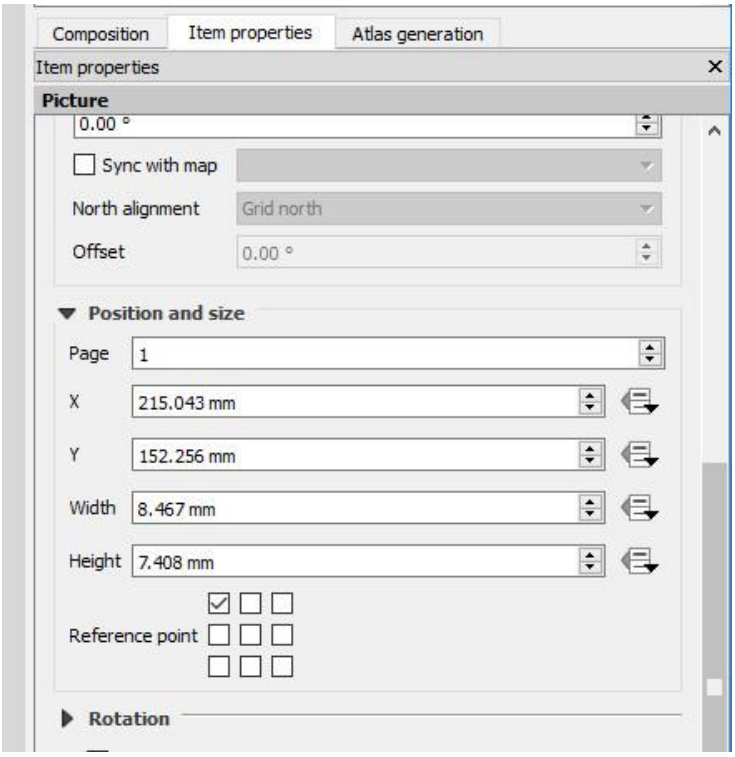
Templates can be constructed for use with a variety of map sheets sizes, e.g. A4, A3, A2, A1 and A0 in either landscape or portrait orientation. Frames and title blocks are simply constructed as rectangles and standard text boxes added into the rectangles. Shapes and text boxes are selected from along the left hand side margin of the map composer window. The figure below illustrates an example of a template complete with title block.



Each item of the template is listed in the Item panel and can be turned on or off and edited. Note that the position of the features can be set and adjusted using the “Position and Size” options in the item properties dialog box. Each item, e.g. page frame, insert box, logo, etc., has its own item properties and these can be varied independently.

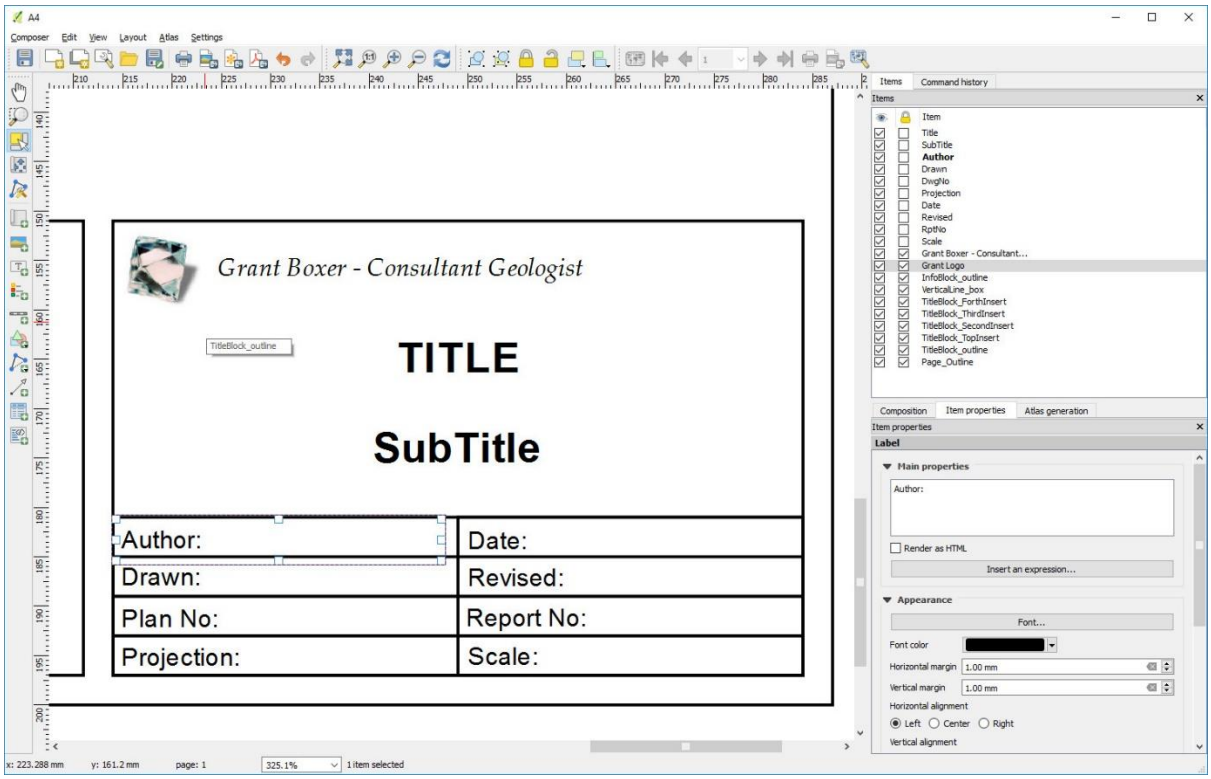


The image above shows all the items that map up the map frame.



The example above is the “Logo” item (diamond image on the layout) and its location is referenced to the top left hand corner of the page as shown in the 3 x 3 box array. It is located 215 mm to the right and 152 mm below the top left hand corner of the page, with a width of 8 mm and a height of 7 mm.

Each text box has a location and is edited as required in the Label > Main Properties window. The image below shows the “Author” field selected and the details can then be added to the existing text, or changed as required. If the text boxes require adjustment, use the position and size options attached to the item.



13: MISCELLANEOUS TRICKS AND TIPS

AusMap Plug-In

This is a new plug-in and has a variety of Australia wide datasets including the 1 second DEM grid data. This 1sec DEM can be used to assign elevations to points via the “Point Sampling Tool” plug-in. Note that both layers must be in the same projection. The 1 sec DEM is in GDA94 (lat/long).

AutoTrace Plug-In

This plug-in can be used to trace around polygons and shapes.

AutoSaver Plug-In

The Auto-Saver plug-in will save your project at regular intervals. I have had problems with this turned on during digitising and I recommend it is turned off when creating new files.

Bookmarks

Bookmarks are used to remember the extents of a map window and they are saved with the project data. When a bookmark is saved, the bookmark list panel is displayed.

Form Value Relation

The Form Value Relation is used to apply multiple nested dropdown boxes for use in pre-set data entry options. This is useful for entering specific rock types, geological codes or formation names.

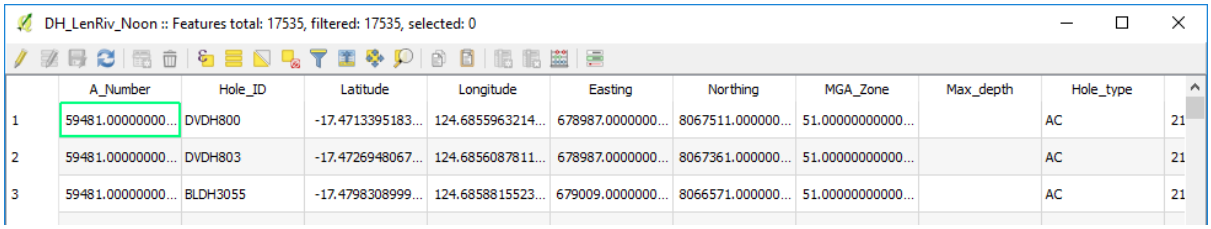
Colour Selection

To assist in selecting colours for maps, you can visit the ColorBrewer website (http://colorbrewer2.org) where rgb, hex and cymk values of a huge variety of colour options can be viewed and selected as required.

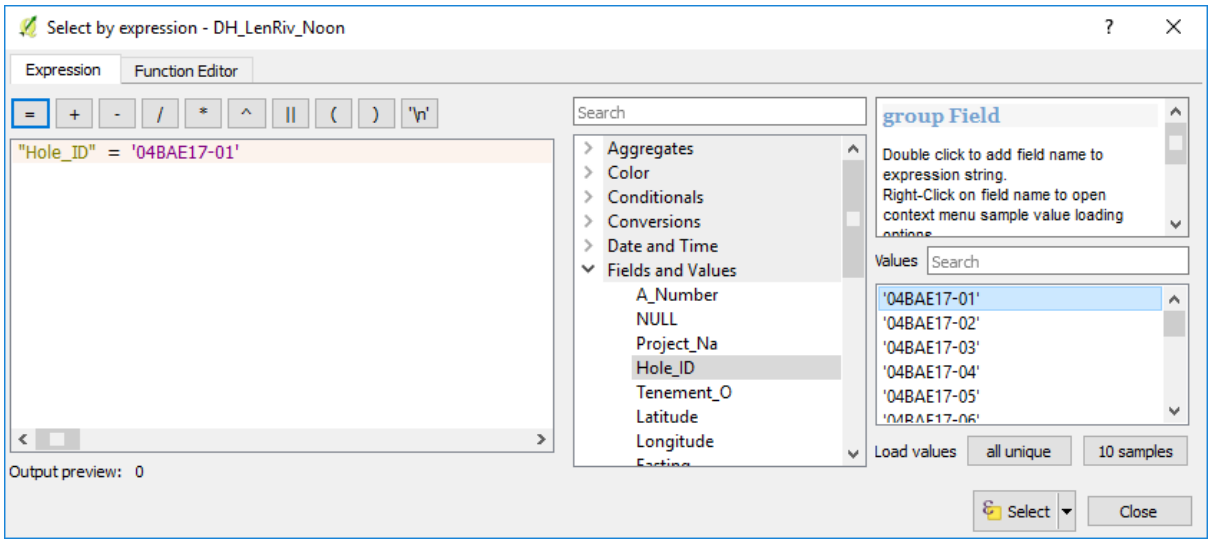
Data Searching

When searching large datasets, a number of options can be used. Spatial searches can be done in your map window but text searches are best done via the Expression form.

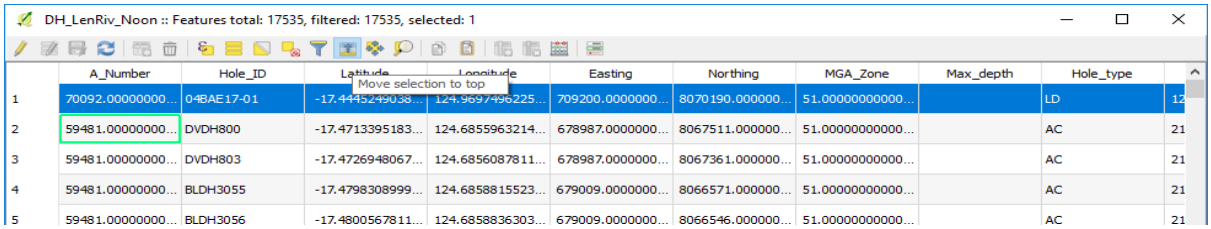
Highlight the layer in the Layers panel, bring up its attribute table and click on the “Select Features Using an Expression” button.



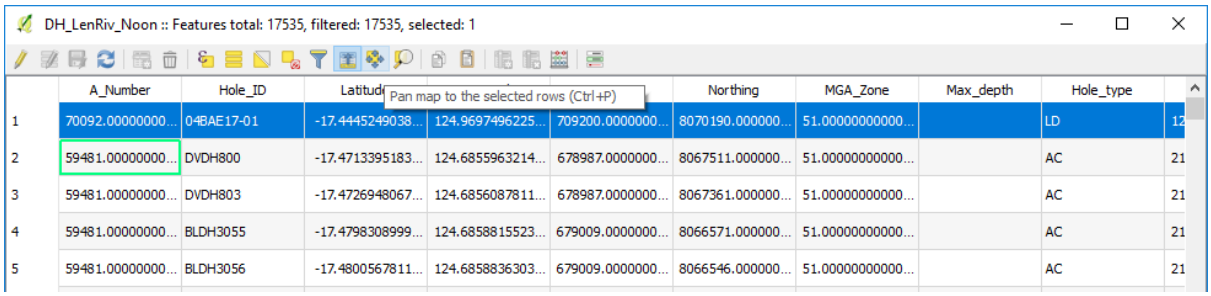
This will bring up the expression editor window. Click on the central panel to select the field to search in, then press “all unique” in the lower right hand side of the dialog box to show all the entries in this field. You can filter by entering values into the “Values” window. Double click the field name to enter it into the left hand panel. Use the function button to add a function, e.g. “=” and then double click on the value to search for in the right hand panel. Hit select to run the query.



Go to the attribute table and select the “Move selection to top” of the table. This may take a little while in large datasets but it will display the selected record(s) at the top of the table and highlight them.



To show these on the map, select the “Pan map to selected rows” icon and the map will pan to the area of the selected features.



Point Sampling Tool

This plug-in tool is handy if you want to sample points in a grid, e.g. drill hole collar elevations using a digital elevation grid. The point and grid layers need to be in the same projection.

Profile Tool

This plug-in allows the user to put a line across a grid and obtain a profile along the line.

QConsolidate

The QConsolidate plug-in allows the user to create a project file with an associated folder holding all the relevant layers for that project.

Spatialite Databases

A Spatialite database is a simple, single file database structure that can hold very large files but with the advantage that the data is spatially referenced. The spatial referencing allows the data to be quickly displayed when panning across a map. This is very useful for data such as the 250k vector data (from GA) for Australia or the large GSWA open file drill hole database.

Refractor Process

The refactor utility is located in the Processing Toolbox and can be used to rename and reorder fields within a table, and has replaced the Table Manager plug-in.

Stereonet Plotting

The stereonet plug-in is used for plotting structural data on equal angle or equal area stereonets.

Vector Transform Plug-In

Pending

14: REFERENCES

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USGS. 2006. FGDC Digital Cartographic Standard for Geologic Map Symbolization (PostScript Implementation). US Geological Survey.

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QGIS FOR GEOLOGISTS WORKSHOP NOTES

No Internet Required

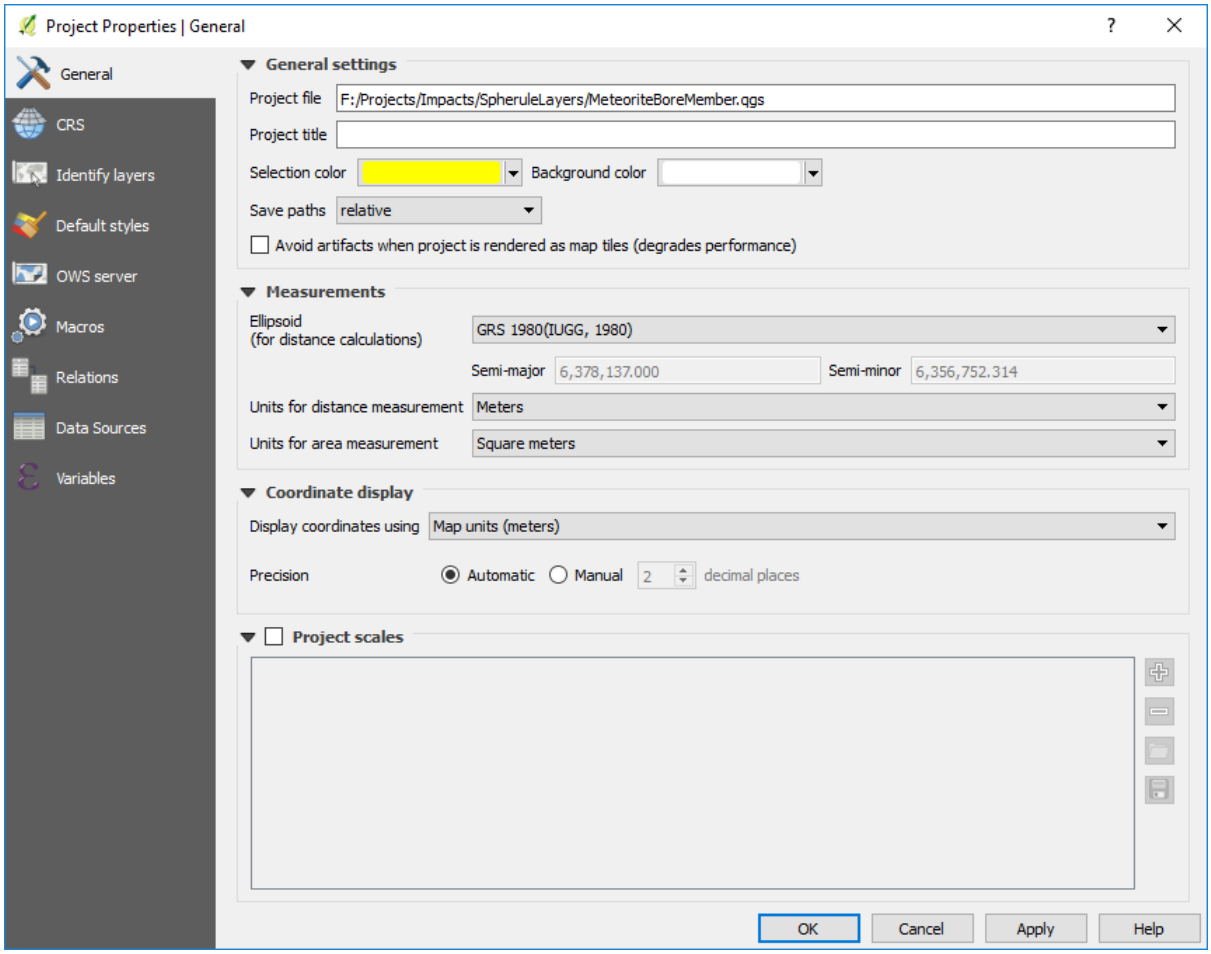
G Boxer

November 2017

Hands-On Session 1 – Preferences and Making a Base Map

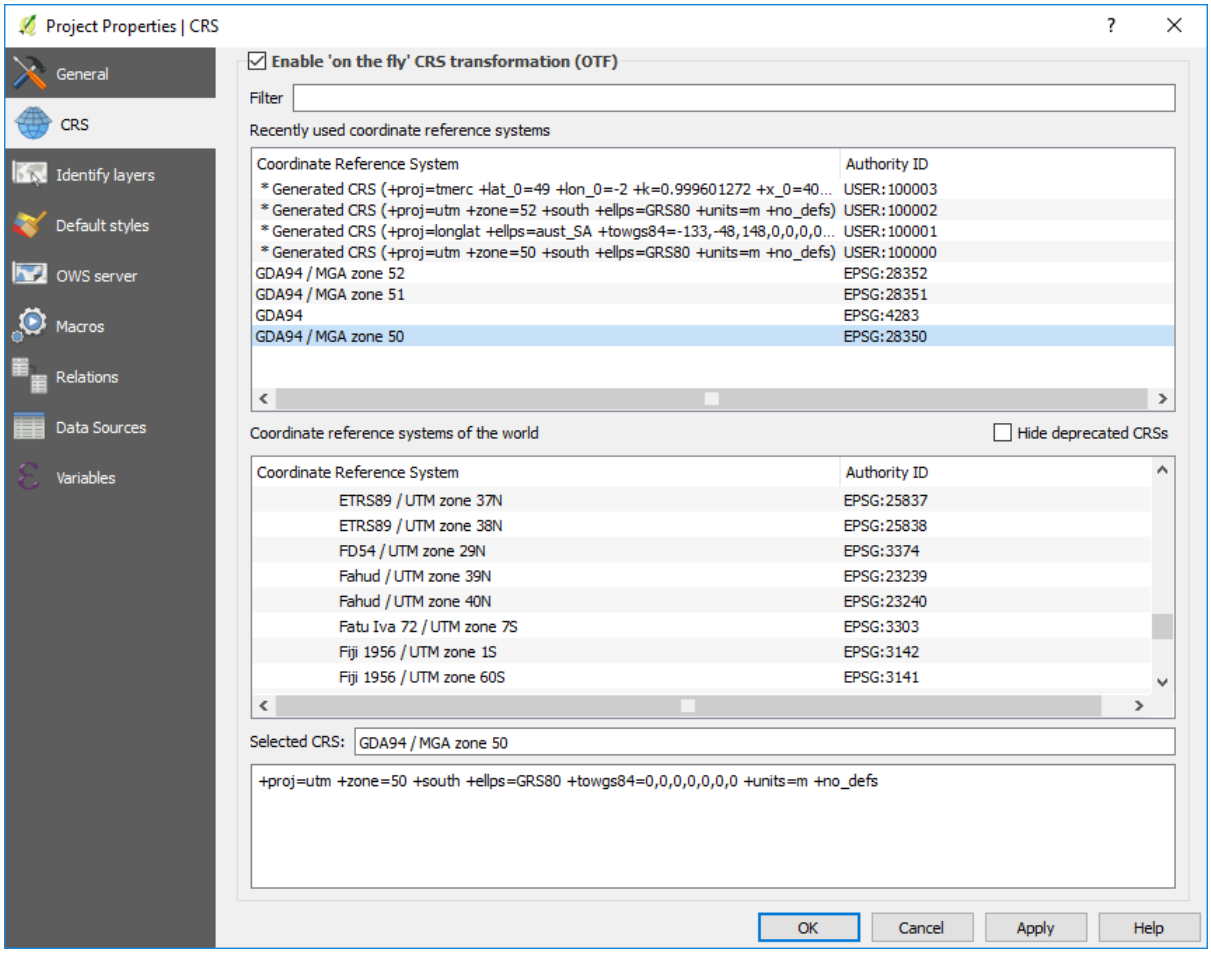
Getting started and preamble.

Run QGIS and using the top left-hand menu item “Project”, open-up the “Project Properties”. This is where you can select various defaults for your project.



I would typically leave everything as the default values. Note that the units for area measurement are in square metres. This indicates that if you calculate a polygonal area, the result will be in in square metres. It can be changed to hectares or square km, but be aware that it might not immediately refresh the values if done after project generation.

In the “CRS” tab, the Coordinate Reference System (CRS) can also be set and On-The-Fly (OTF) projection can be enabled.

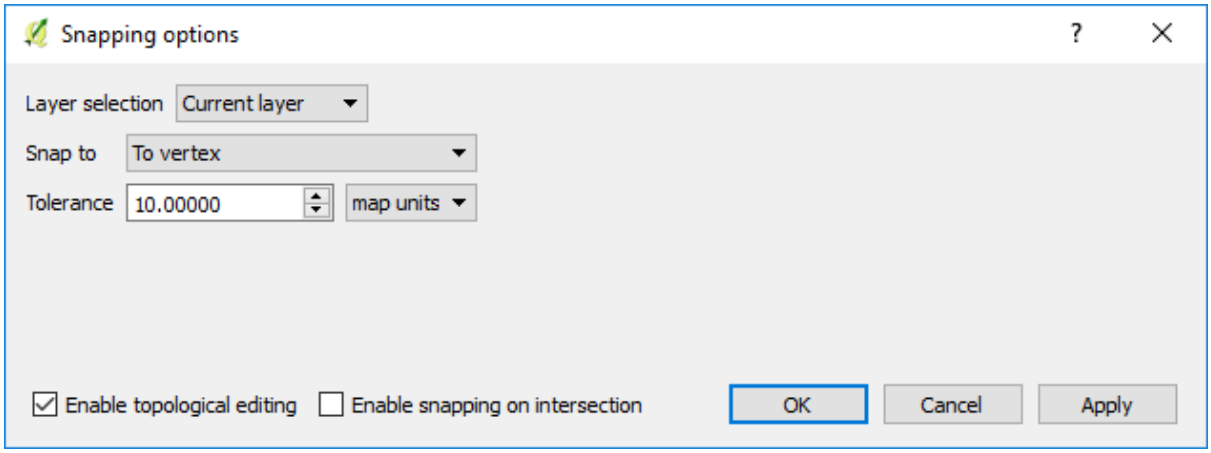


Geological symbols can be either “fonts” or “svg” (scalable vector graphics) files. Fonts are added to the PC operating system and will be available to all programs that use fonts. In Windows 10, highlight the fonts to be added, right-click, and select INSTALL.

SVG files require them to be added to the “C:\Program Files\QGIS 2.18.x\apps\qgis\svg” folder in 64 bit systems or to the equivalent folder in 32 bit systems. Add the folders “geology”, Geol_Patterns” and GeolPat_colour” to the svg folder.

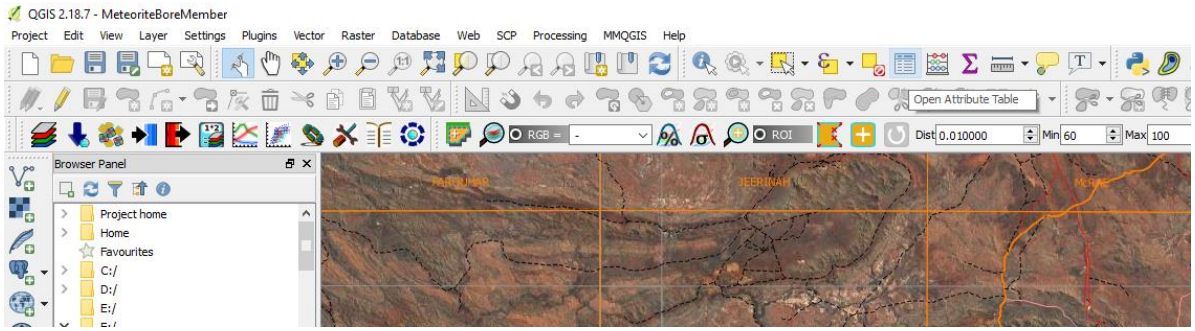
Both font files and svg graphics files are included in the USB of workshop data and should be done prior to doing the Hands-On Workshop 2.

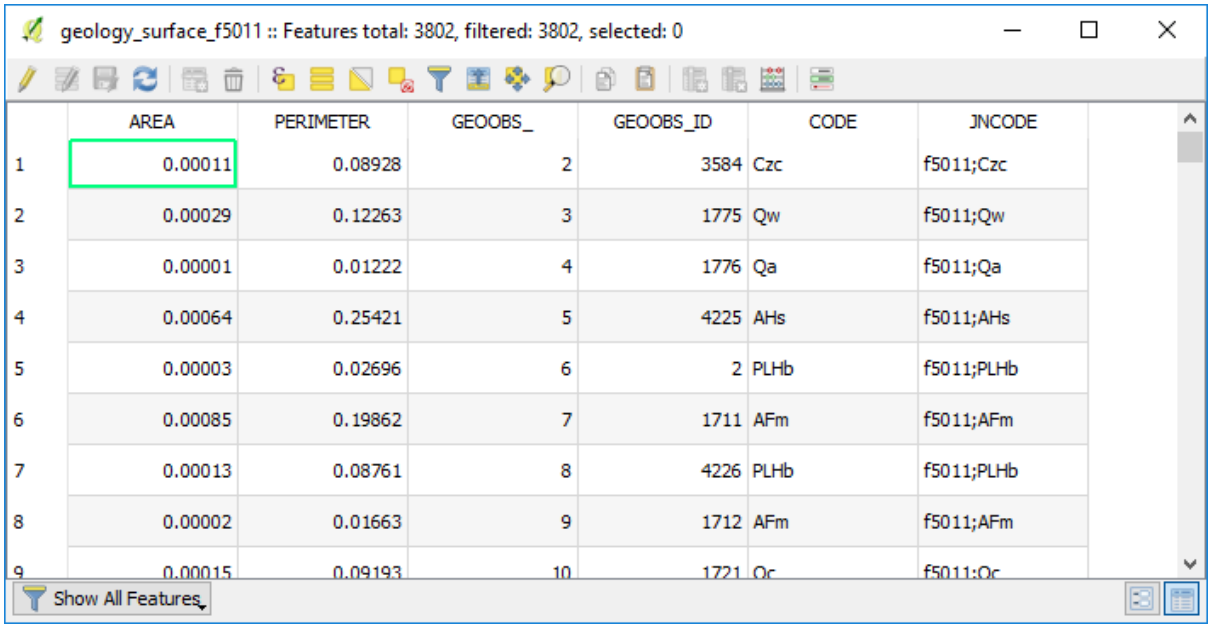
Other settings that should be examined are under the top menu “Settings”. Here can be found a variety of customisation options and the “Snapping Options” settings. Open-up the Snapping Options and tick on the topological editing check box. Select the “snap to” vertex option and enter “10” into the tolerance box. This indicates that snapping will occur when you are within 10 m (map units) from a vertex.



If an information panel, eg, the browser window is not open, you can select the top menu item View > Panels or for toolbars View > Toolbars to turn these on or off.

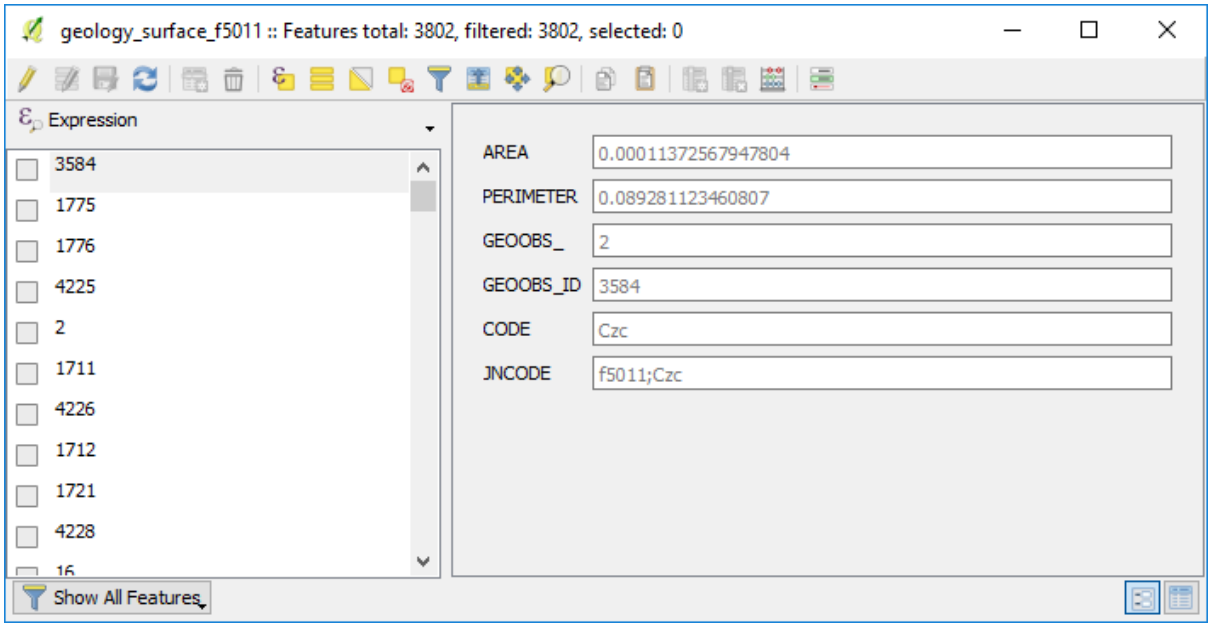
Examining table data can be done via the top menu icon “Open Attribute Table”.





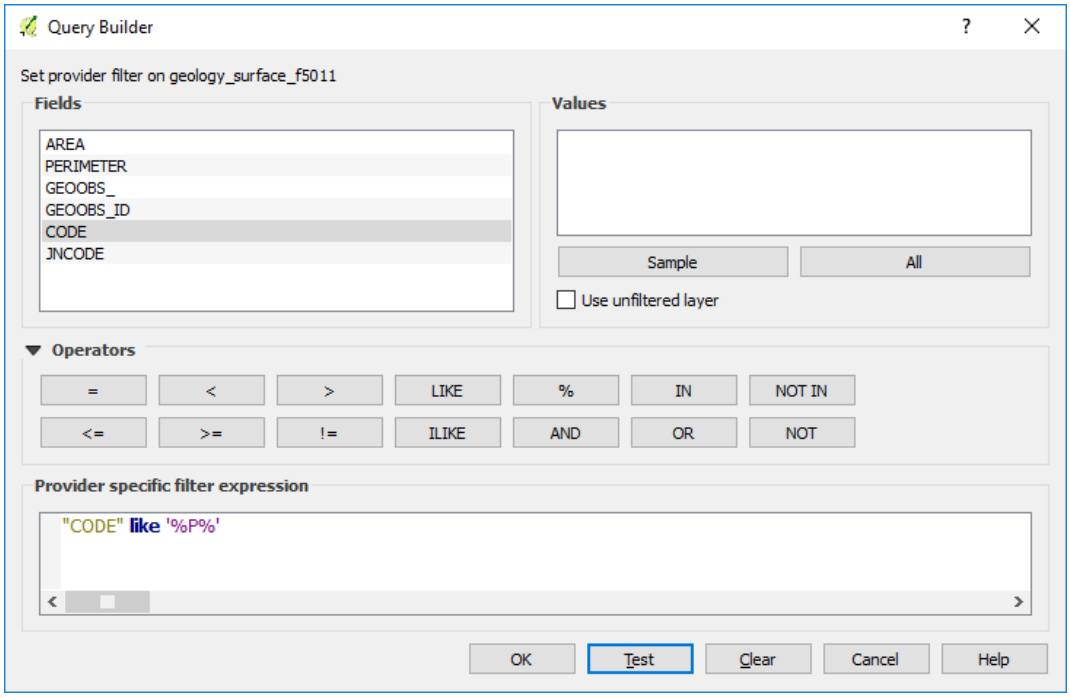
	AREA	PERIMETER	GEOOBS_	GEOOBS_ID	CODE	JNCODE
1	0.00011	0.08928	2	3584	Czc	f5011;Czc
2	0.00029	0.12263	3	1775	Qw	f5011;Qw
3	0.00001	0.01222	4	1776	Qa	f5011;Qa
4	0.00064	0.25421	5	4225	AHs	f5011;AHs
5	0.00003	0.02696	6	2	PLHb	f5011;PLHb
6	0.00085	0.19862	7	1711	AFm	f5011;AFm
7	0.00013	0.08761	8	4226	PLHb	f5011;PLHb
8	0.00002	0.01663	9	1712	AFm	f5011;AFm
9	0.00015	0.09193	10	1721	Qc	f5011;Qc

The table can be displayed as list (above) or in form view (below) by clicking on the icons in the lower right hand side of the window.



New columns can be created in the attribute window by enabling editing (pencil icon – toggle on and off) and using the “Create Field” and “Open Field Calculator” icons in the attribute window.

A table can be filtered to show only certain attributes by using the Layer > Filter options. This can be useful if you have a large dataset and only wish to display part of it.



If you have problems with QGIS crashing, it may be that there are problems with QGIS doing on-the-fly projections with large images or datasets.

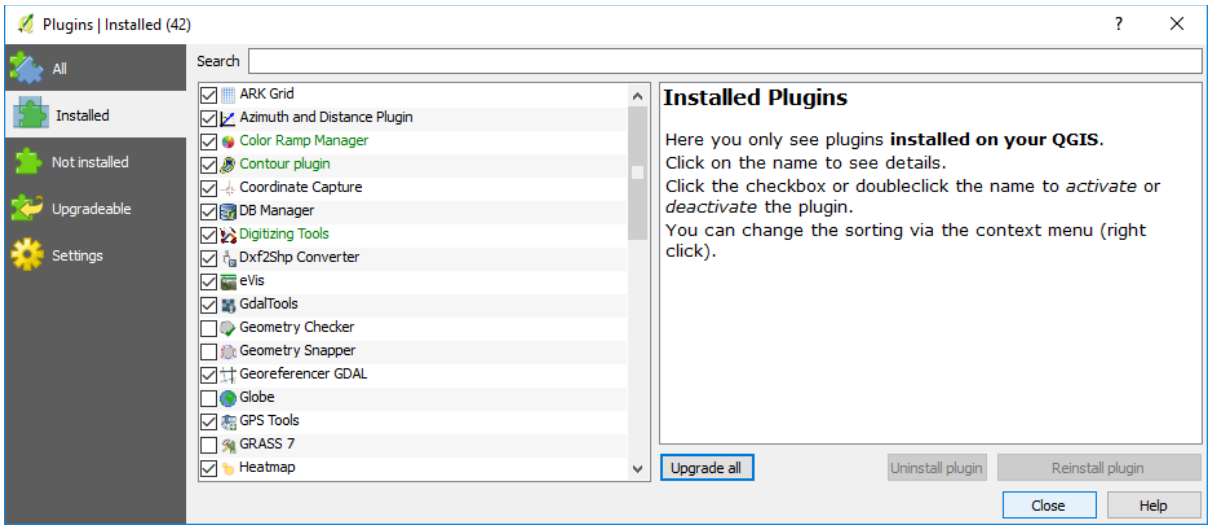
It is also recommended users install the following plug-ins.

Plug-ins are small utility programs that greatly expand the capabilities of QGIS. There are currently over 700 plug-ins available for download. These plug-ins are all free and have usually been written to solve a specific problem or task for users.

Seventeen plug-ins are installed by default in version 2.18.10 as are listed below.

Coordinate Capture
DXF2Shp Converter
eVis
Geometry Checker
Geometry Snapper
Georeferencer GDAL
Globe
GPS Tools
GRASS7
Heatmap
Interpolation plug-in
Offline Editing
Oracle Spatial GeoRaster
Processing
Raster Terrain Analysis plug-in
Road Graph plug-in
Topology Checker
Zonal Statistics plug-in

To use these plug-ins you may need to enable them in the Plug-Ins > Manage and Install Plug-Ins > Installed window.

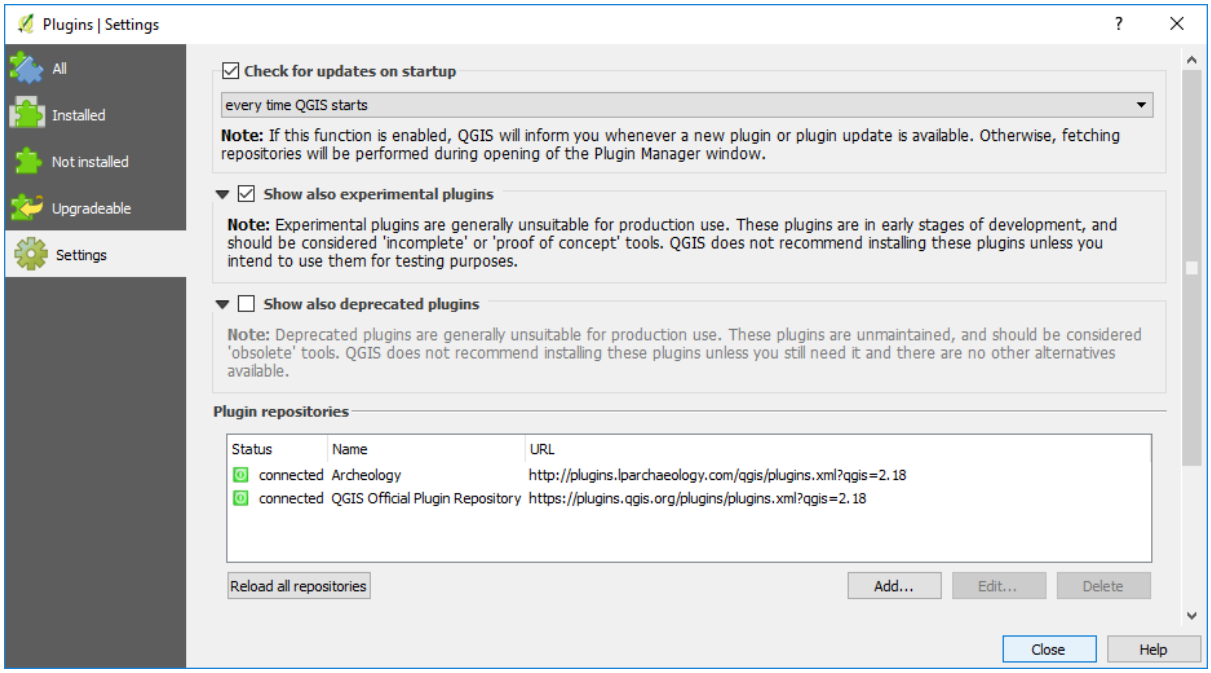


Additional plug-ins that are recommended are as follows;

AusMap plug-in
Contour plug-in
Digitising Tools
MMQGIS (various selection and geocoding tools)
Numerical Vertex Edit (point editing)
Numerical Digitise (point editing)
Point Sampling Tool
Processing
QGIS2Threejs (3D visualisation)
QuickMapServices (raster maps and imagery), go to settings > more services and add the extra data to allow display of Google Earth plus other imagery.

Semi-Automatic Classification (satellite data selection and processing)
Spreadsheet Layers (import excel spreadsheet data)

In the Plug-Ins > Settings page, check the “Check for updates on startup” and “Show also experimental plugins”.



Some managed IT systems block the loading of the repository data. Try selecting the Settings > Options > Network, and check the use proxy server. Try again to download the repository. If this loads the repositories, then uncheck this box and try to install the plugins.

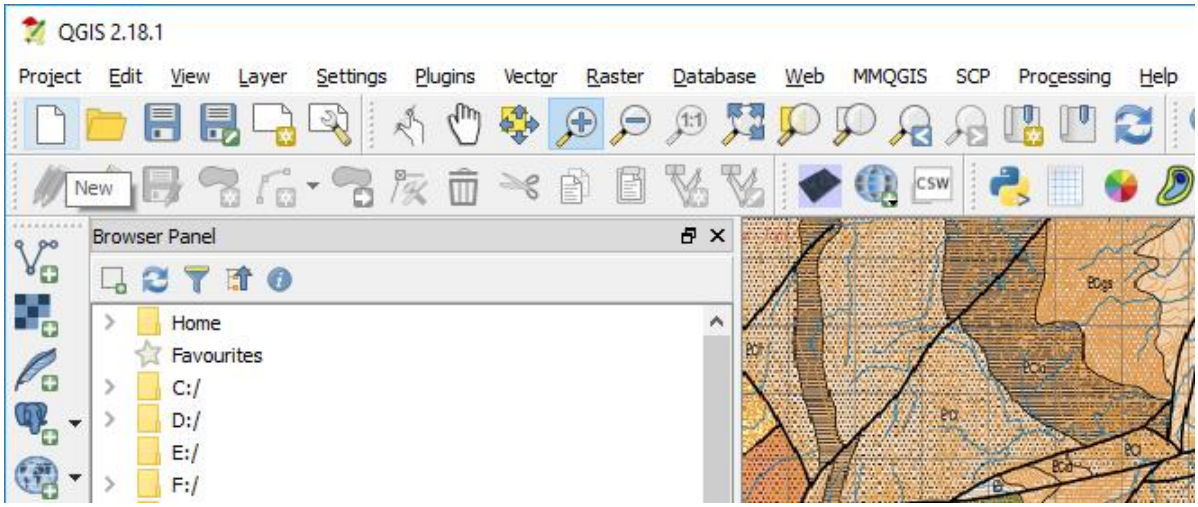
Bookmarks

If you want QGIS to remember the current window extent, use the View >New Bookmark and this will add a new bookmark into the bookmarks panel. The bookmarks are saved with your Project.

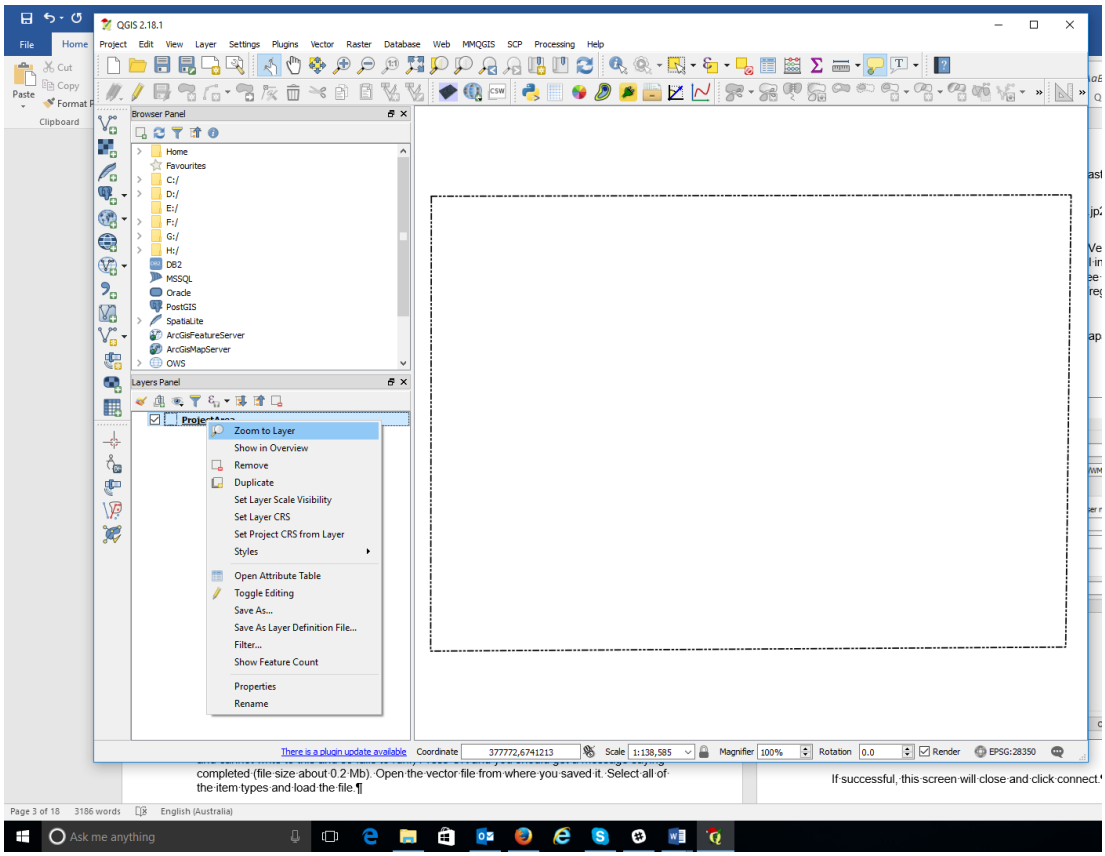
Favourites

To display a particular directory for ease of access, display the directory you want as a favourite, right click on it, and then select “Add as a Favourite”. This will then display that directory in the “Favourites” tab in the Browser panel.

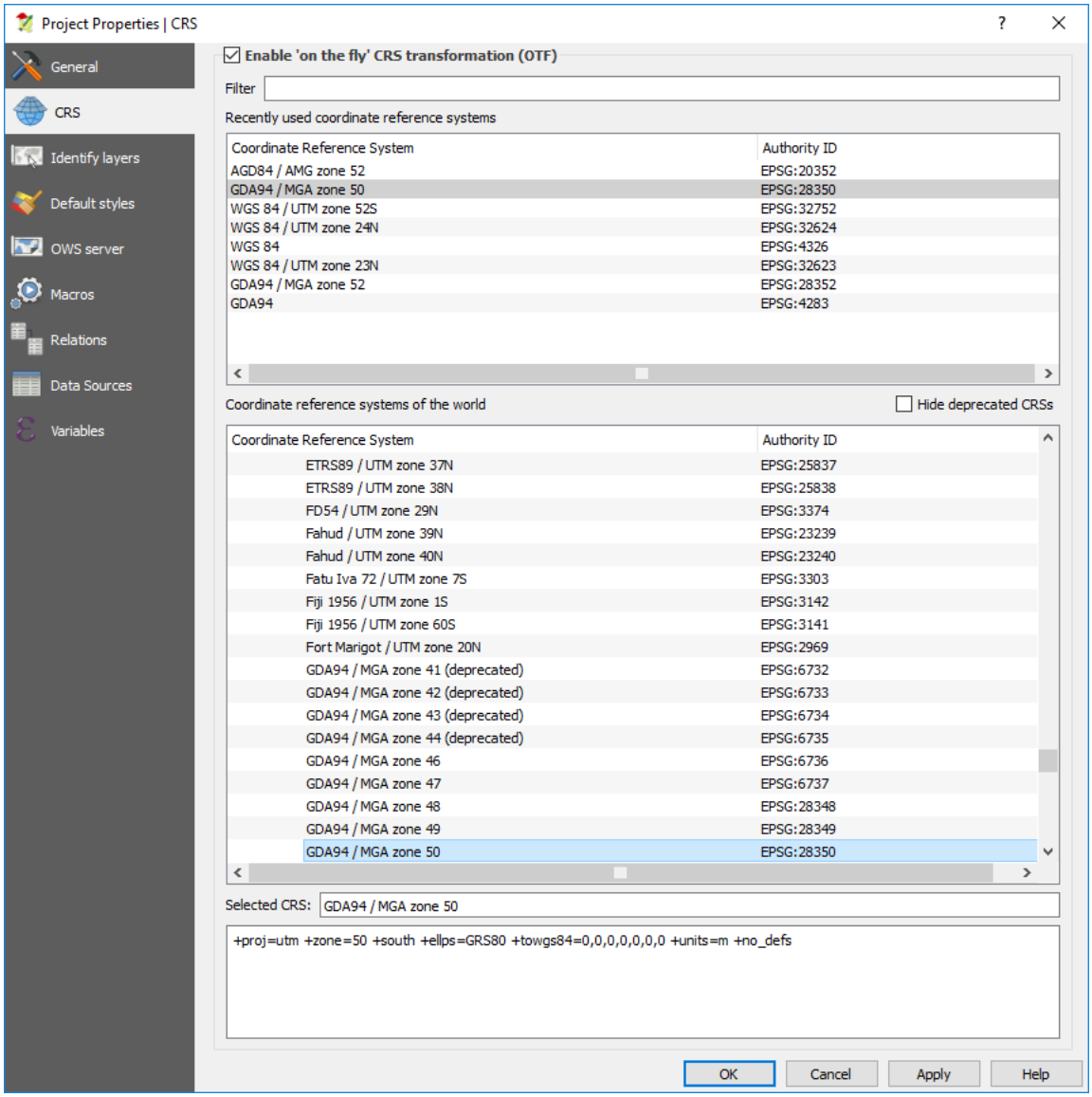
Task 1.1 - Open a new Project and load the “Project Area” shp file (“ProjectArea.shp”) located in the Project Files directory. Note that you can add a folder to your by right-clicking on the folder name in the Browser panel and “add to favourites”. This can then be quickly accessed via the favourites tab in the browser panel. Do this for the workshop directory so it is easy to access.



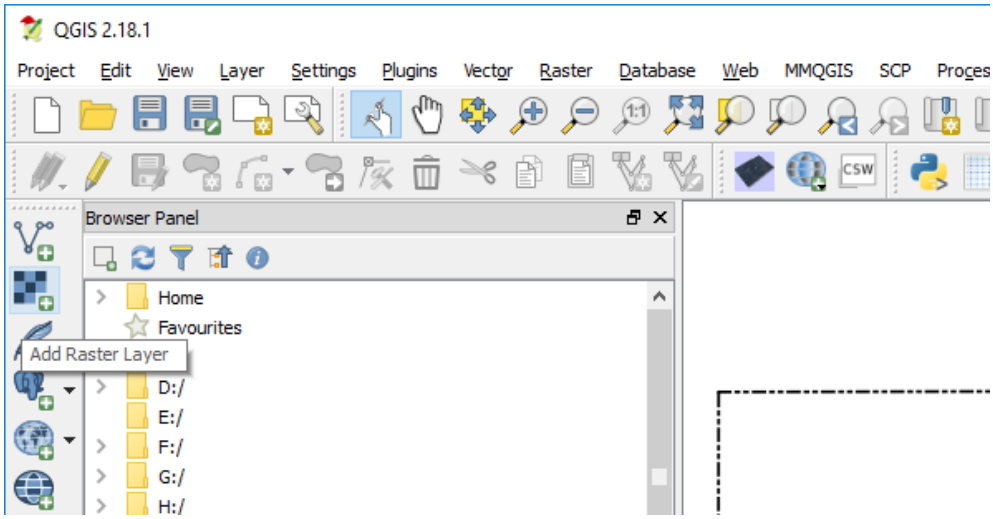
Task 1.2 - Zoom to full extent of layer by right click on the file name in the layers panel and select "Zoom to layer".



Click the projection button (World symbol, near to the EPSG info) and check map projection, it should be GDA94 zone 50, and turn on the On-The-Fly (OTF) projection, the coordinates should display in metres.



Task 1.4 - Open the 250k topography raster file (Perth_SH50.jp2), using “Add Raster” (checkerboard symbol on top left hand side of desktop), and the file is located in the Project Data > Topography folder. The jpeg2000 file format contains the image registration information and will be opened and positioned by QGIS. Move this layer down to the bottom of the layers list in the Layer Panel by click and dragging it to the bottom of the list. Note the black line that will appear when dragging – this shows where the layer will move to.



Task 1.5 - To create a map, open up the Map Composer and enter a page name like A1L. In the "Composition" tab, set the page size to A1 and Landscape. Use the Zoom Full button to see the entire page. Use the Composition/Extents tab to align the Map view with Composer view or visa versa.

Task 1.6 - Select "Composer" menu item and "Add Items from Template". Navigate to where your templates/frames are stored. Add the A1L template which will load it into the map composer. **It is important to set the map size and orientation before you import the template, otherwise QGIS will not be able to display the template correctly.**

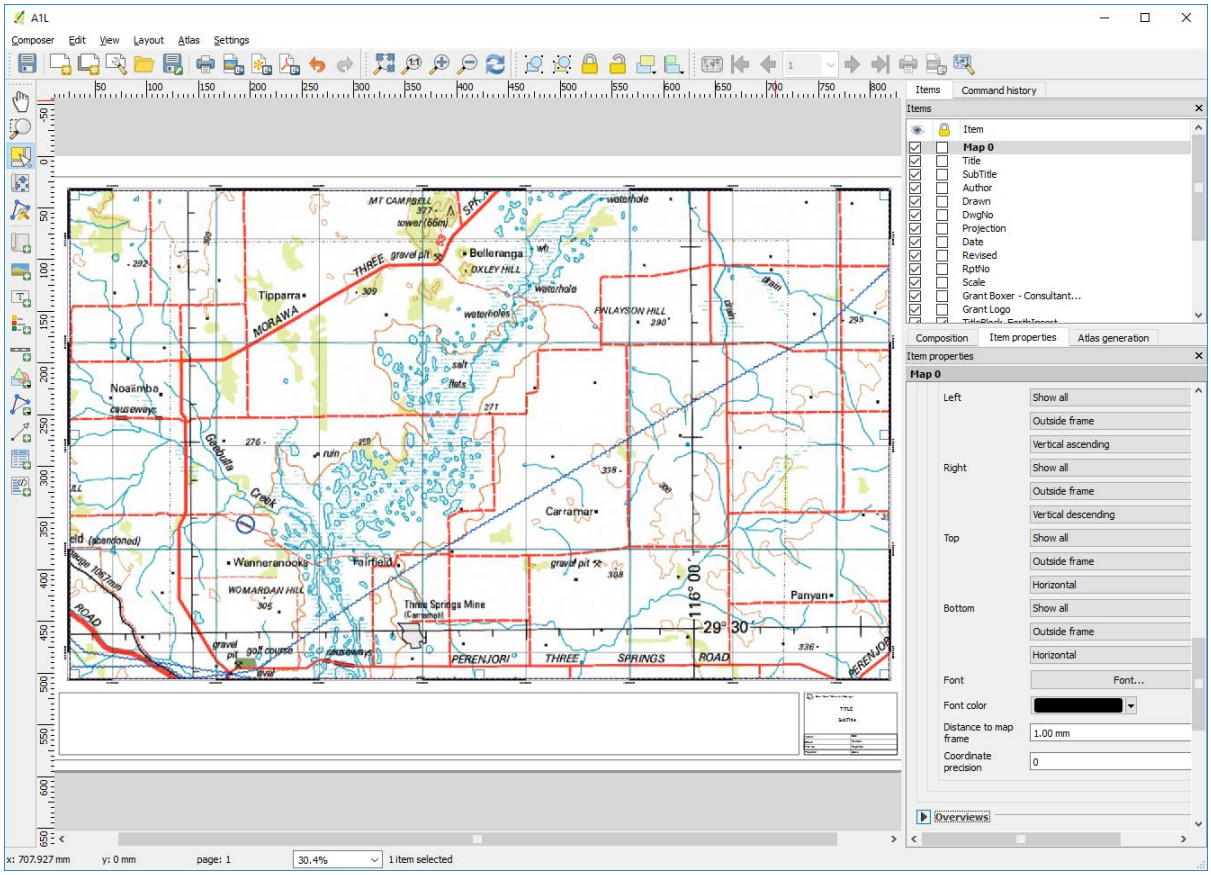
Task 1.7 - Before you add the map to the composer, turn off any Google Earth Imagery or WMS layers. This will speed up the next few steps as it won't need to reload the imagery whenever you alter the composer window. Click on the "Add New Map" icon, and click and drag a window in the map composer. Resize as necessary. Use the "Move Item Content" button to move the image in the window to suit.

Note that if you are creating a map in a metre projection, like UTM, ensure the main map window is in the correct projection for the style of grid you wish to display. Overlaying a metre grid on a lat/long map can sometimes cause problems in drawing the grid.

Task 1.8 - Highlight "Map0" in the Items browser, and in the Item Properties tab below, set the scale to suit, say 1:50 000. Scroll down to "Grids" and hit the green cross to add a grid. Select grid "Interval" as 5000 on both the X and Y. Scroll down to select Grid Frame style to "zebra". Scroll down to "Draw Coordinates" and tick on. Select "Decimal with suffix", then "format", "Left", "Vertical Ascending" (third box down) and then "Right", "Vertical Descending". Scroll a bit further down the coordinates section and set "coordinate precision" to "0."

All these changes occur "on-the-fly" so you can immediately see the effects of changes. Some tools adjust the map composer instantly, others may require a click outside the item box to apply.

Task 1.9 - On the Items browser, select the "Title" item. Note that the item in the map composer will be selected and you can usually move it around using the mouse and red guide lines will be displayed to assist centering and alignment.



In the Item Properties window, you can now edit the Title. The same process is used to change all the other text boxes in the template. Note that if the item cannot be moved using the mouse, use the “Position and Size” options for the item.

Task 1.10 - To add additional text to the map, choose the “Add New Label” icon and click and drag where you want the label, and a new text edit window will open, where you can add text.

Task 1.11 - Add a legend by clicking on the Legend tool. The various items can be deleted if not needed – un-select to Auto-Update tick box. If you need to change the legend descriptions, do this in the Layer Properties > Style window under the Legend column.

Task 1.12 – To a north arrow, use the “Add Image” icon, then select the “Search Directories”, usually found in your C drive > Program Files > QGIS > apps > qgis > svg folder under “Arrows”. Under the “Main Properties”, select the resize mode to “Zoom and Resize Frame” option. This will allow resizing of the image without clipping. You may need to zoom to 1:1 to re-size the image box so that it displays correctly.

The variety of available arrows are shown below.

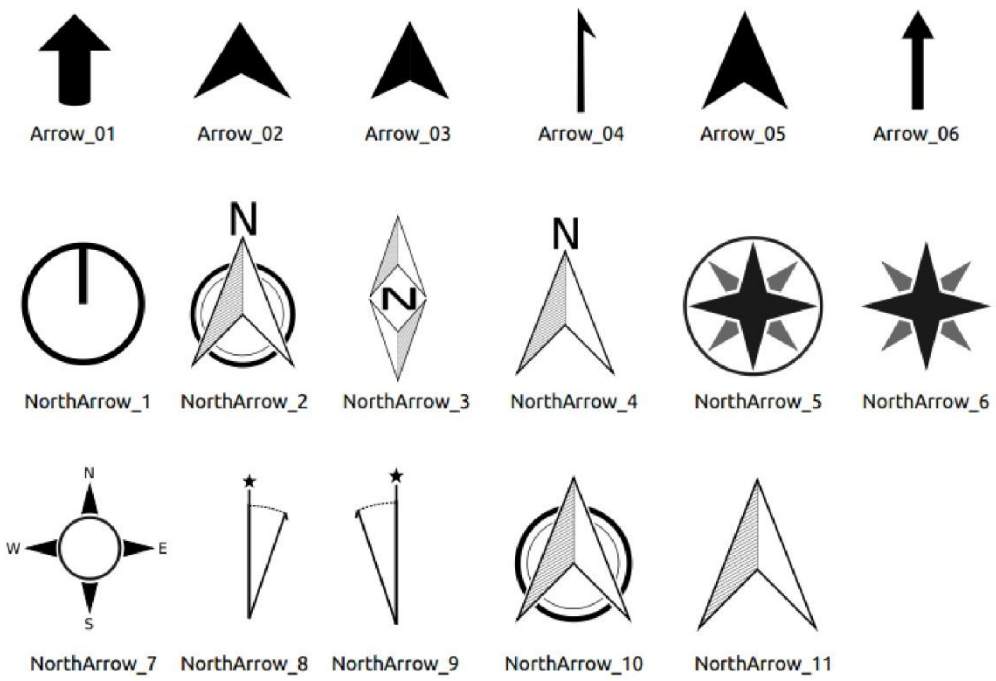


Figure 14.42: North arrows available for selection in provided SVG library

Task 1.13 – Add a scalebar by clicking on the scalebar icon and clicking where you want the scalebar to be displayed. Adjust the “Segments” fixed width to suit.

Task 1.14 - When you are happy with the result, turn the WMS imagery back on (in the main map window), and click the “refresh” button in the map composer. This should then redraw the map with the imagery. Sometimes if the server or internet is slow, and you may need to refresh again to download all the imagery tiles.

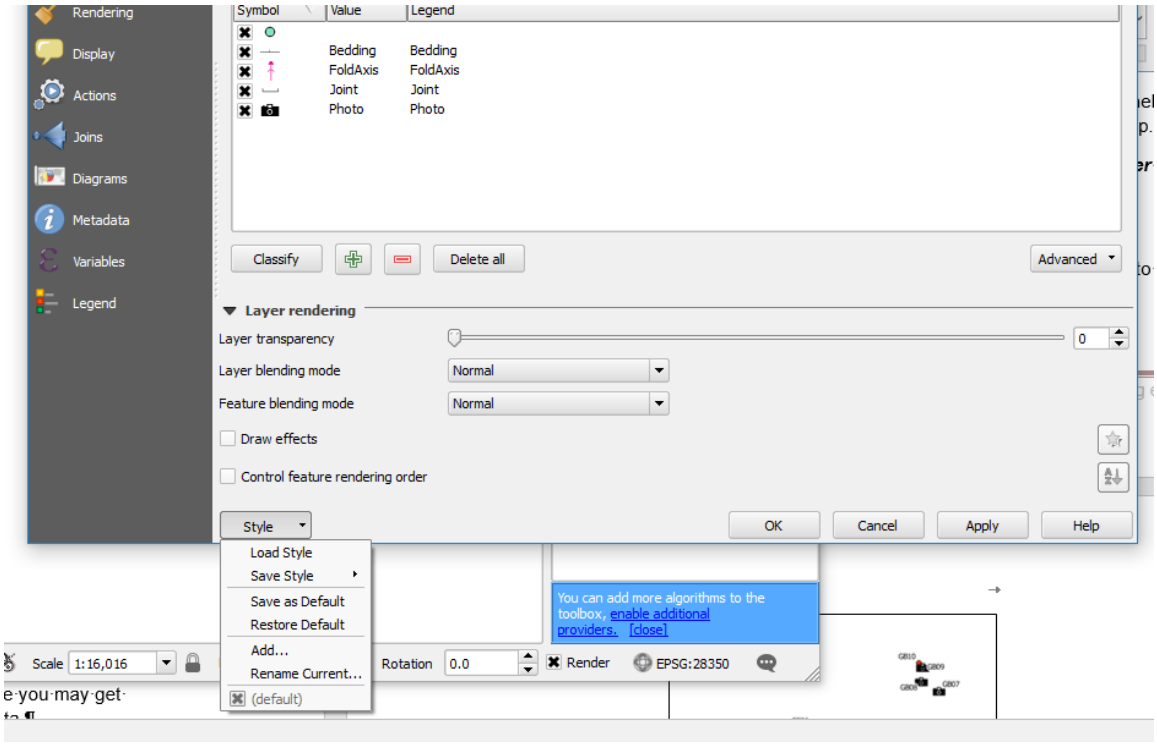
Task 1.15 - Save the project by going to the main map window and selecting “Save As” and choose a suitable file name. QGIS project files have a “qgs” file extension. Note the map composer windows are saved with the project. Do not close the project as we will use this area for the next task.

This map can now be printed to a plotter or pdf file as required. There are options along the top menu bar of the map composer window for printing to a printer/plotter, an image or pdf file.

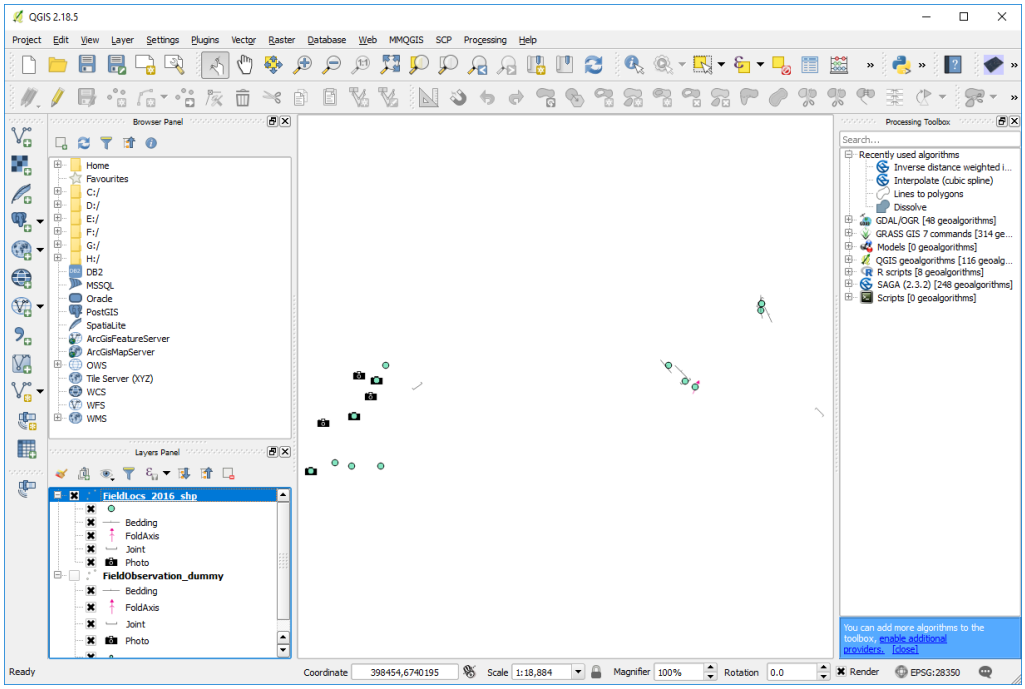
Hands-On Session 2 – Adding Field Data

Task 2.1 – Open up the structure data file "FieldLocs_2016" (in the Project Files > Field Observations folder) using the add vector layer icon. In the Layers panel, right-click on the layer name and "Zoom to Layer". Turn off the topography layer.

Using the Layer Properties > Style tab, select the Style drop down (in the bottom part of the panel) and select "Load Style". Open the "FieldLocs_2016_structure" qml file. This will then apply selected styles to the points.

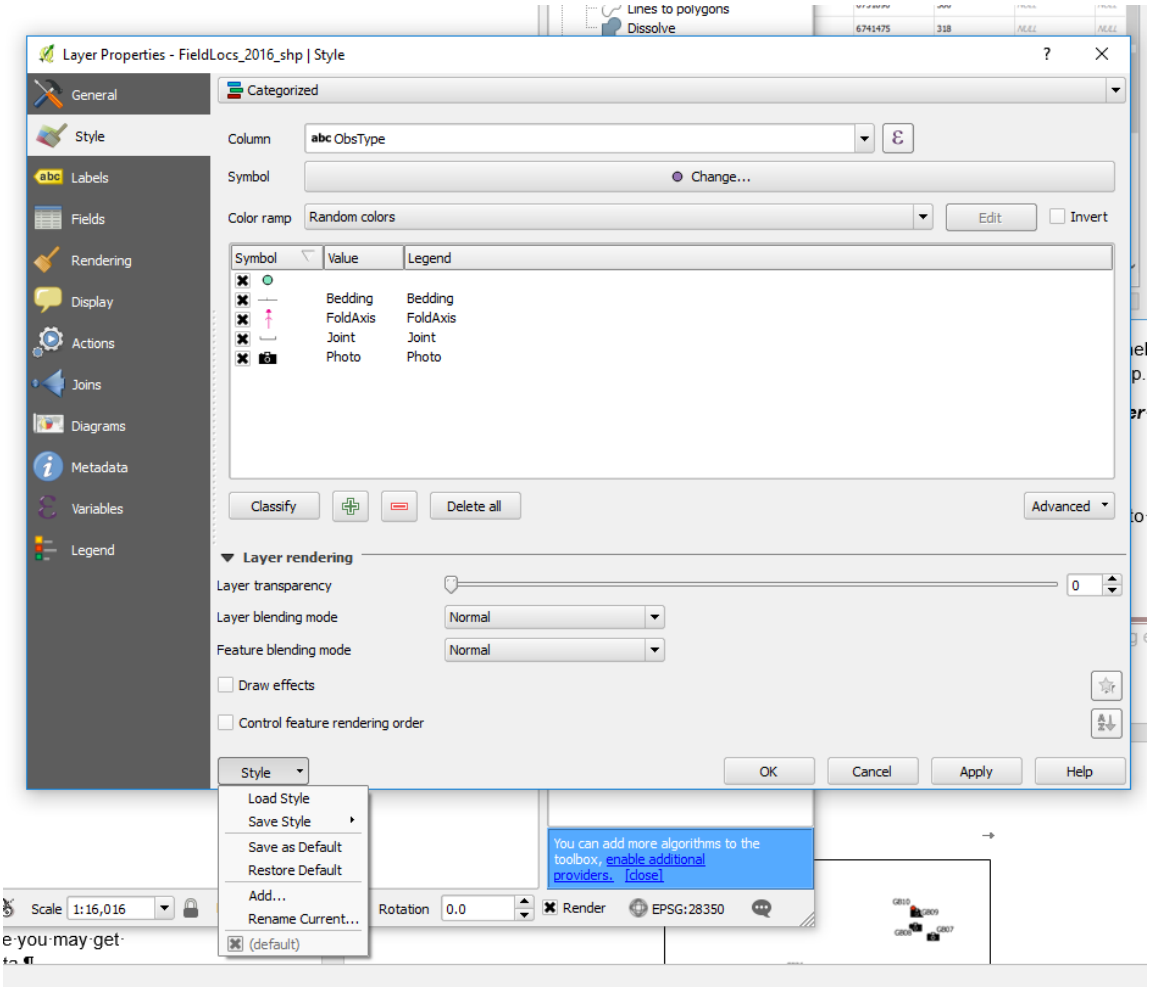


The points should appear as camera icons, joints and bedding symbols.



If you get question marks for symbols, then QGIS cannot find the structure symbols. Check that the svg “Geology” files are in the correct folder (e.g. C drive > Program Files > QGIS > apps > qgis > svg).

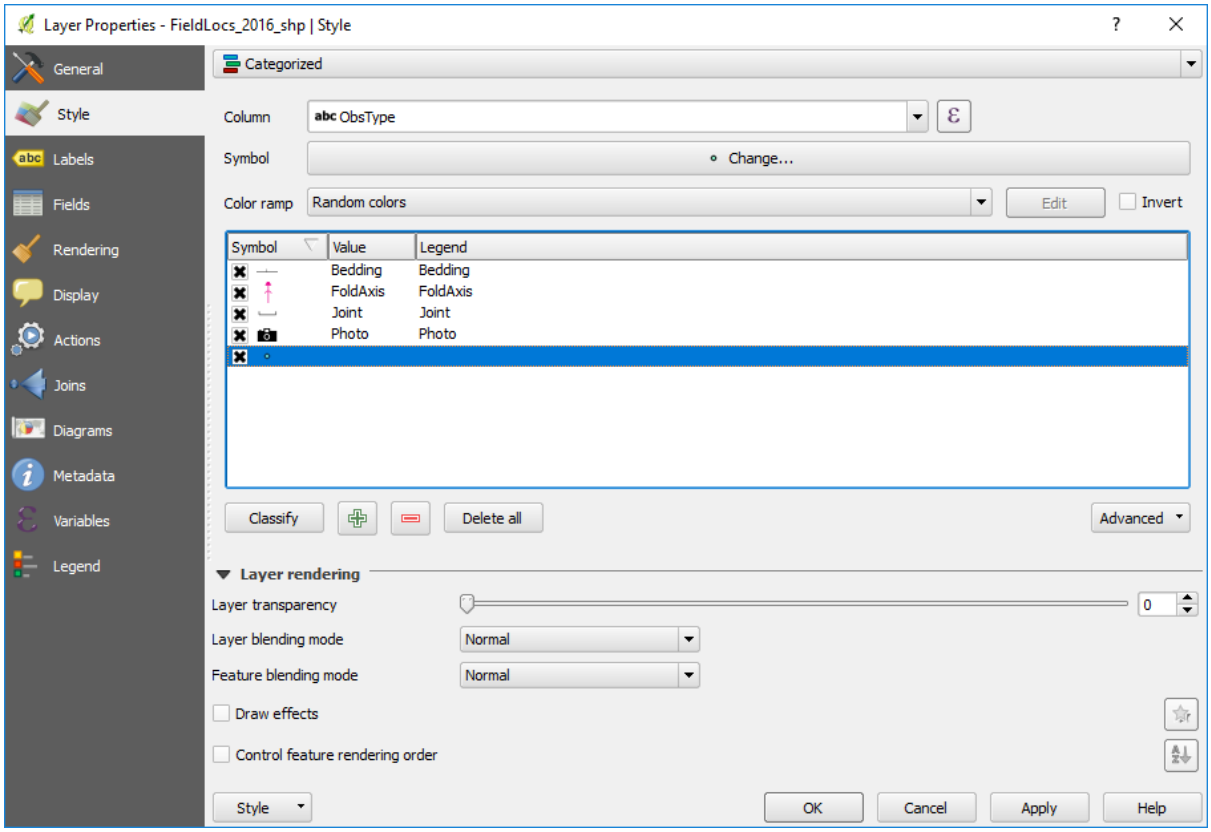
Task 2.2 – In the Layer Properties > style tab, you will see the layer has been split into “Categories” and these have had specific symbols applied. QGIS knows what to plot because we have previously saved a style file. If the style file is located in the same directory as the file and has the same name as the file, it will automatically be loaded when we open the file. All styling information for QGIS is stored in these style files. They are XML text files and can be read and edited in any text editor.



Demonstrate eVis and photos.

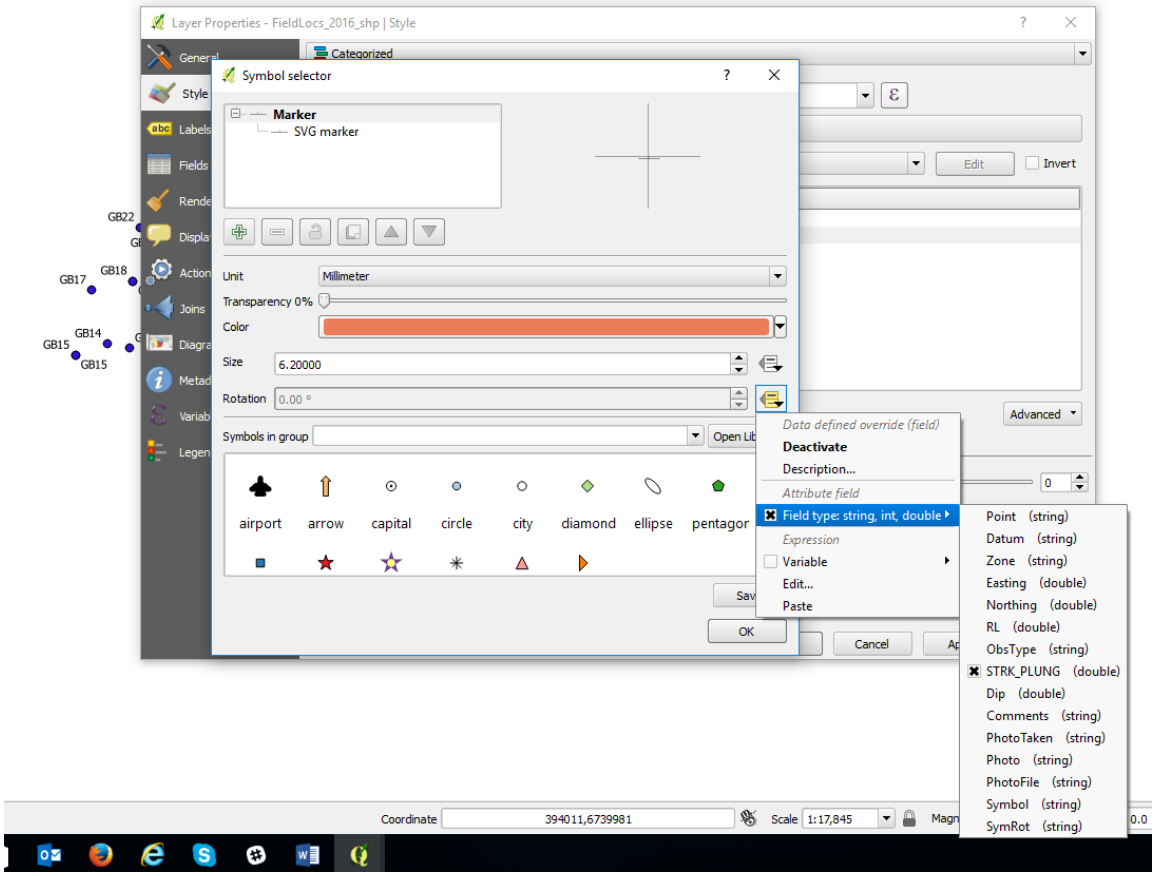
Demonstrate Landgate imagery.

Task 2.4 - In the Layer Properties > Style tab, click on the point symbol (circle) and drag it to the bottom of the list and make it 1 mm in size (by double clicking on the symbol).

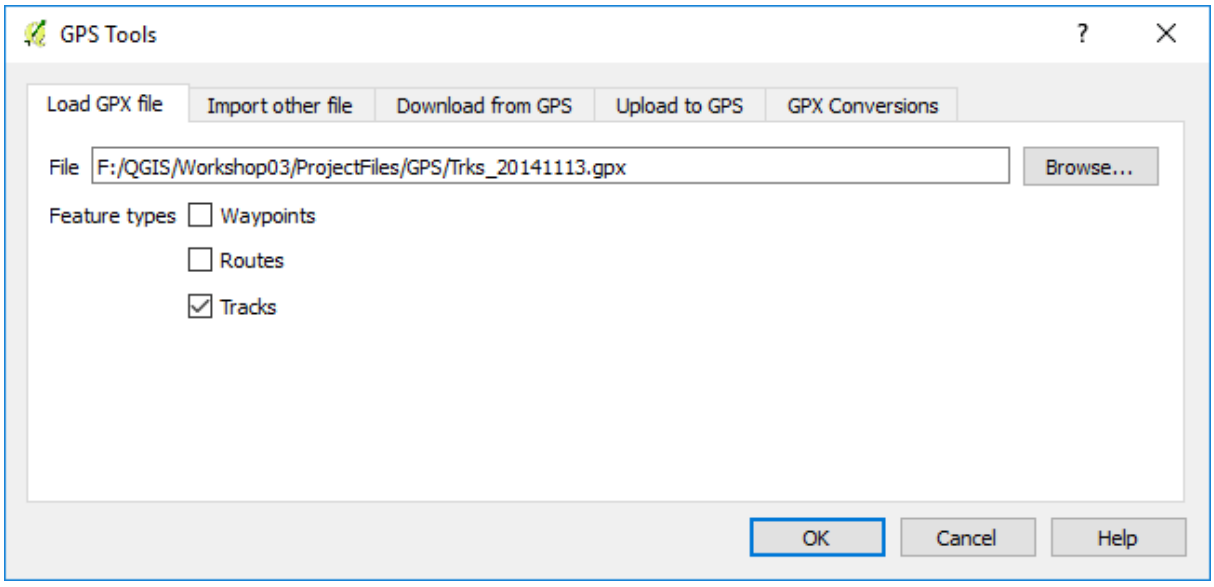


Note that on the map the bedding and joint symbols have been rotated by their azimuth directions. This is controlled by the style (qml) file creating a “Data Driven Override” option on the rotation field for the symbol. This rotation is specified in the file by using the azimuth field value.

Task 2.5 – Double-click on the bedding symbol to bring up its properties. Note that the “Data Driven Override” option at the far right of the “Rotation” field is shaded yellow and is therefore “active”. This has been activated by the style file and instructed to use the “Strike-Plunge” field for the rotation amount.



Task 2.6 - Import a GPS gpx file via the Vector > GPS Tools button and add a gpx track file (Project Files > GPS > Trks_20141113.gpx), select tracks only.

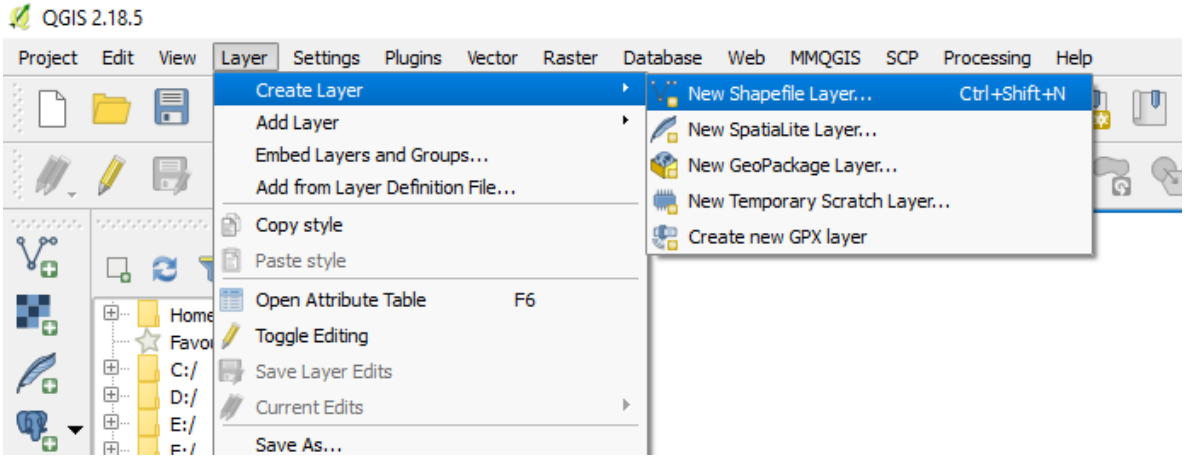


If the GPSTools option is not displayed in the Vector menu, go to the Plug-Ins > Manage and Install Plug-Ins > Installed, and tick on the GPSTools plug-in. When you have imported the gpx

file, “Save As” a shape file (so it becomes editable) by using the Layer Panel, highlight the layer, right click and “Save As”. It is necessary to save the gps file as a shape file, otherwise you may get unpredictable results when zooming and panning the gpx file data.

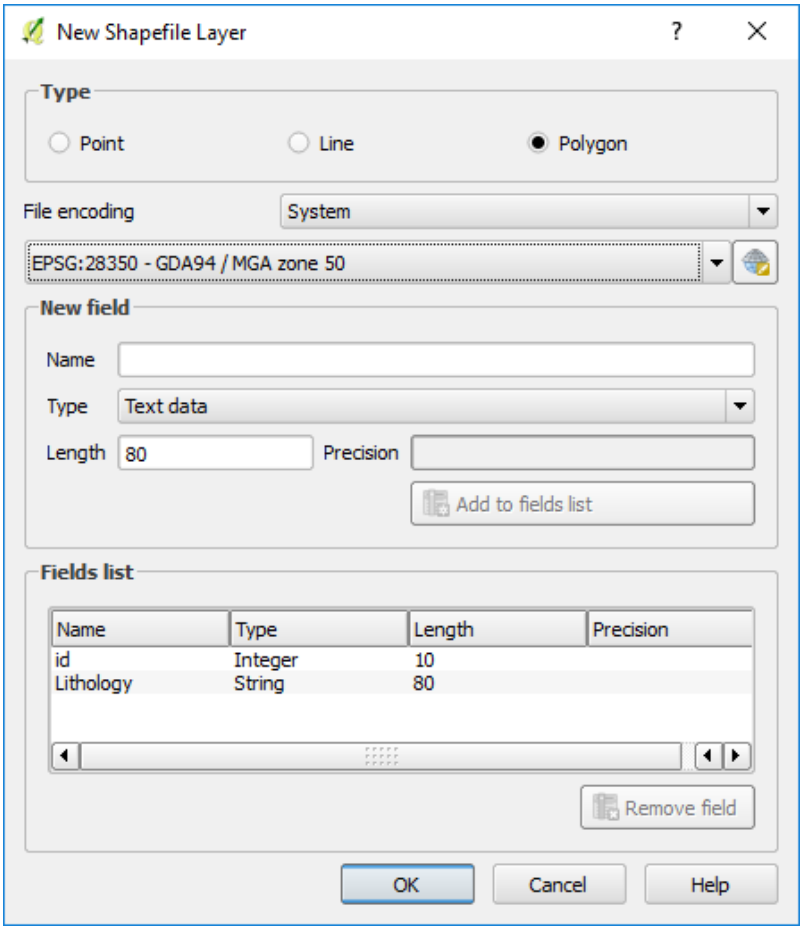
Task 2.7 - The new gps track file should now be displayed on the map. Close the original imported gpx file. You should now see tracks around the area. Double click the tracks layer in the layer panel to open up the Layer Properties. Select “Style” and change the line style to something more readable and then select the Style button in the lower part of the Style tab, and save the selected line style as the default.

Task 2.8 – We will now create some geological polygons. Create a new shape file layer (using Layer > Create Layer > new shape file layer) – polygon type – add an additional text field called “Lithology”, the id field is automatic but needs an integer number, save as Geology in your “Project Files” folder.



When creating the new shape file layer, it is important to note that you can have only one vector file type, i.e., line or point or polygon in a shape file. Ensure you select the coordinate reference system in which you want the layer to be created, and use the “add fields” to add fields into the table, and being sure to make the fields of the correct type (text, whole number, decimal or date).

Select GDA94/MGA zone 50 for the coordinate system (CRS). Add a lithology text/string field with a length of 80 characters. Make sure you click the “Add to fields list”!Then click OK.



Task 2.9 - Make the "Geology" layer editable (click the pencil symbol) and add a large polygon. To create a polygon, use the left mouse key to create nodes and right click to close and complete polygon. Give the polygon an id of 1 (a dialog box will appear when you complete each polygon and you need to add an integer which will be a unique identifier for that polygon) and in the "Lithology" field, enter Breccia. Save the edits and turn off editing.

Note that you can use a "Value Map" (accessible via the Layer Properties > Fields option) to create lists of acceptable data, to ensure the geologist selects specific fixed terms or codes.

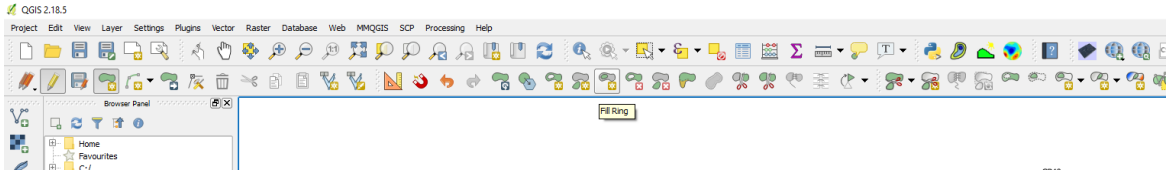
Demonstrate value map in Layer Properties > Fields >Edit Widgets tab.

Task 2. 10 - Fill the polygon with a geological pattern using the Style > Simple Fill > SVG > select the Geological Pattern folder and select a suitable pattern (breccia-like). Note you may need to select the search directories to bring up the svg folders and the svg patterns. Save the edits (button next to edit toggle button).

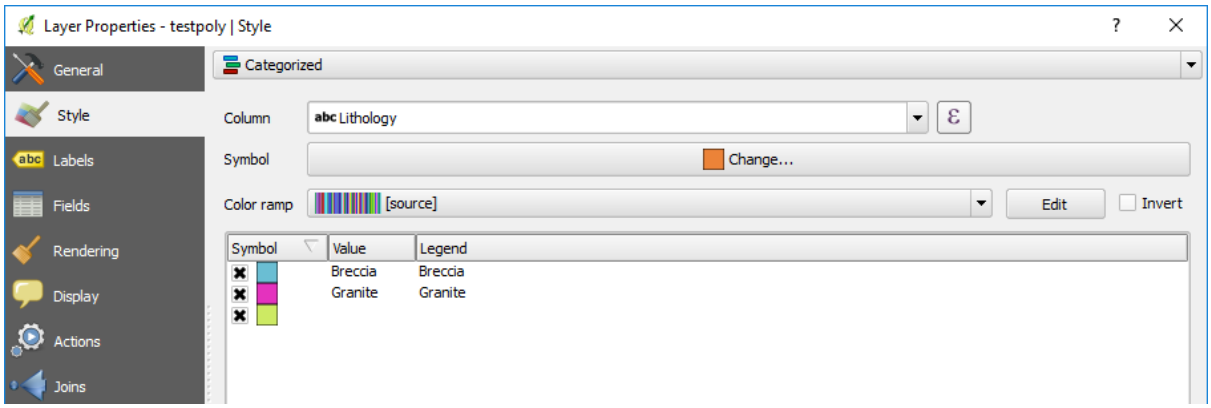
The geological patterns are in the form of svg (scalable vector graphics) files. SVG files require them to be added to the "C:\Program Files\QGIS 2.18.x\apps\qgis\svg" folder in 64 bit systems or to the equivalent folder in 32 bit systems. Add the folders "geology", Geol_Patterns" and GeolPat_colour" to the svg folder from the "Software_Symbols\Fonts_Patterns" folder.

Both font files and svg graphics files are included in the USB of workshop data.

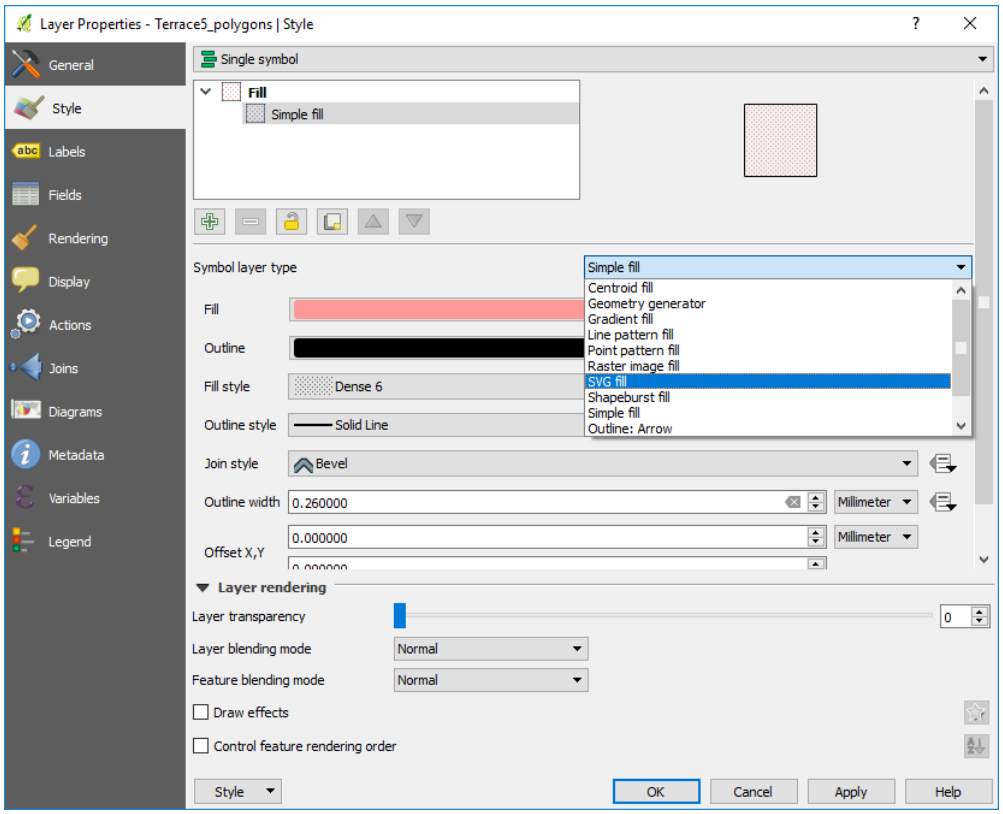
Task 2.11 - In the Advanced Editing tools, use the “Fill Ring” tool to put a polygon inside your Breccia outcrop. Name the inserted polygon id 2 and lithology “Granite”. “Add Ring” can also be used if you want to cut a hole in a polygon. Save the edit.

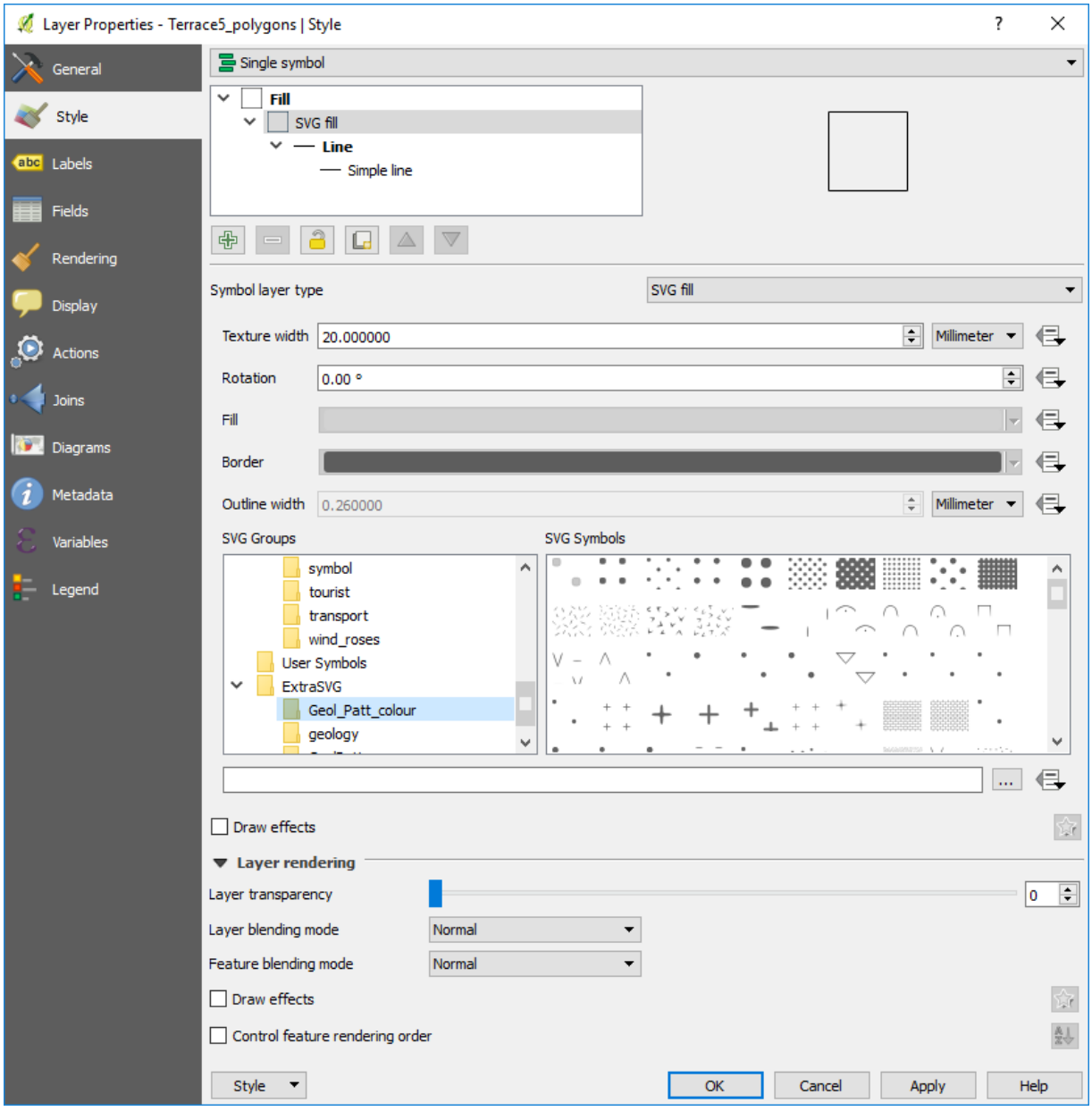


Task 2.12 - Open the Layer Properties for the geology layer and select the Style tab. Select “Categorise” in the top drop down menu and use the Lithology column to classify the polygons. You should see two or three listings by lithology, breccia, granite and maybe blank.



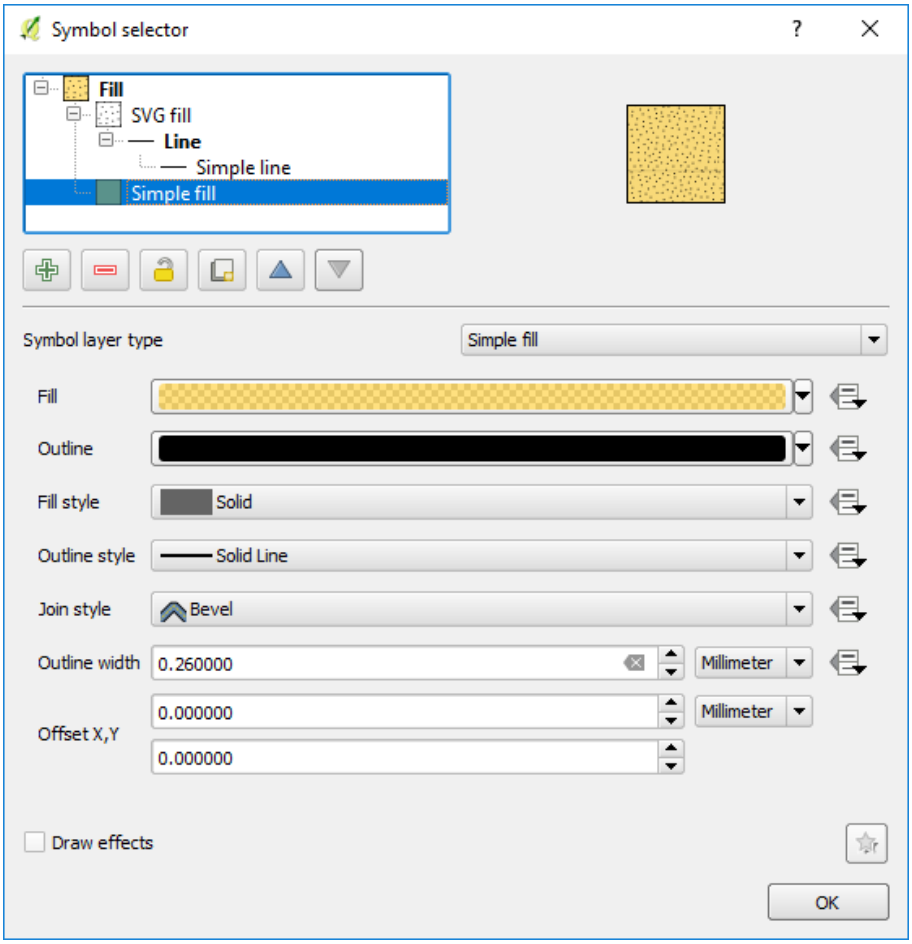
Double click the small square next to the “Granite” classification and change Simple Fill to something Granite-like using the SVG “GeoPatt_Colour” folder.



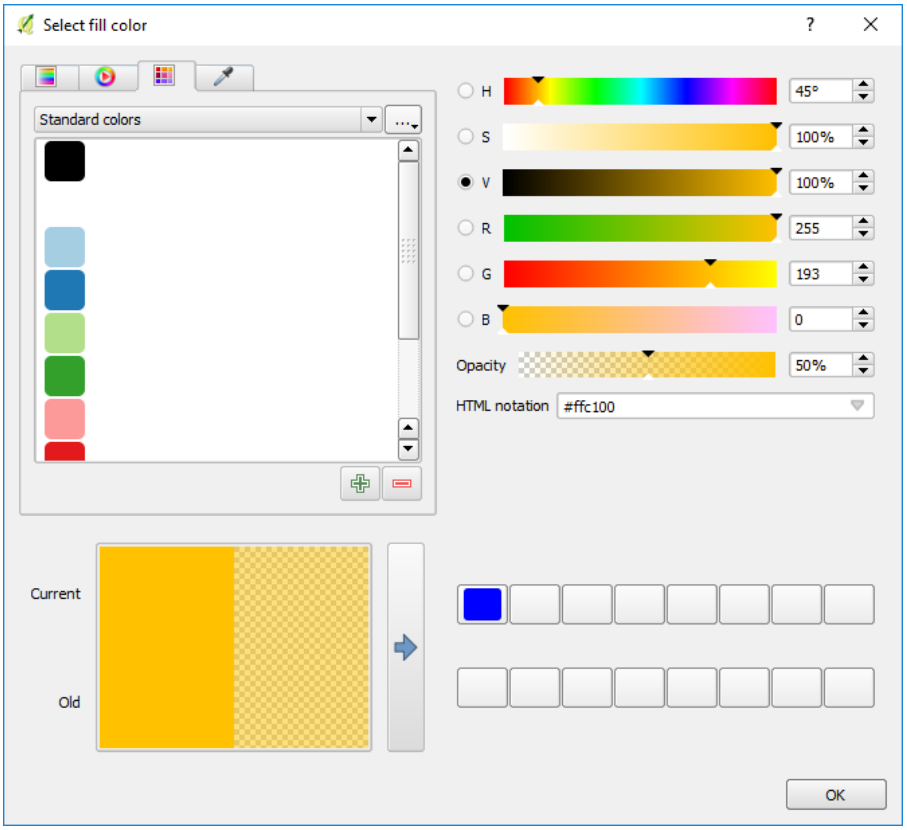


The pattern colour, size and orientation can be adjusted using the “Fill”, “Texture Width” and “Rotation” options.

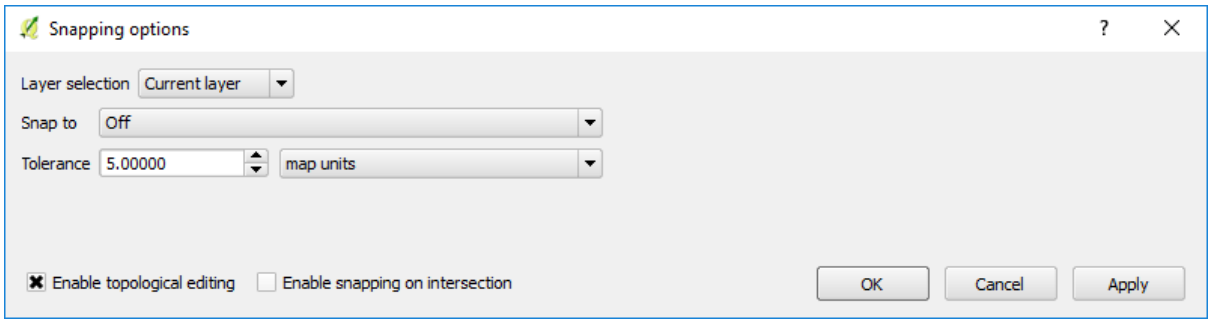
To add a polygon fill as a background to the symbols, use the green plus symbol to add another layer and move it down using the down arrow button (down pointing triangle). Select a suitable background colour, set the opacity to 50%. Save style as default. Saving the styles to default creates a qml file (QGIS style file) in the same folder as the shp file (and has the same name as the shp file) that will be used whenever this file is opened.



Discuss svg and background polygon colours – opacity.



Task 2.13 -You should now have two geological polygons; a granite surrounded by a breccia. If you want to change the granite-breccia contact so that changes will fill gaps, go to the main menu > Settings > Snapping Options and check the “Enable Topological Editing”. Adjust the tolerance to suit your application and note this tolerance can be map units or pixels.



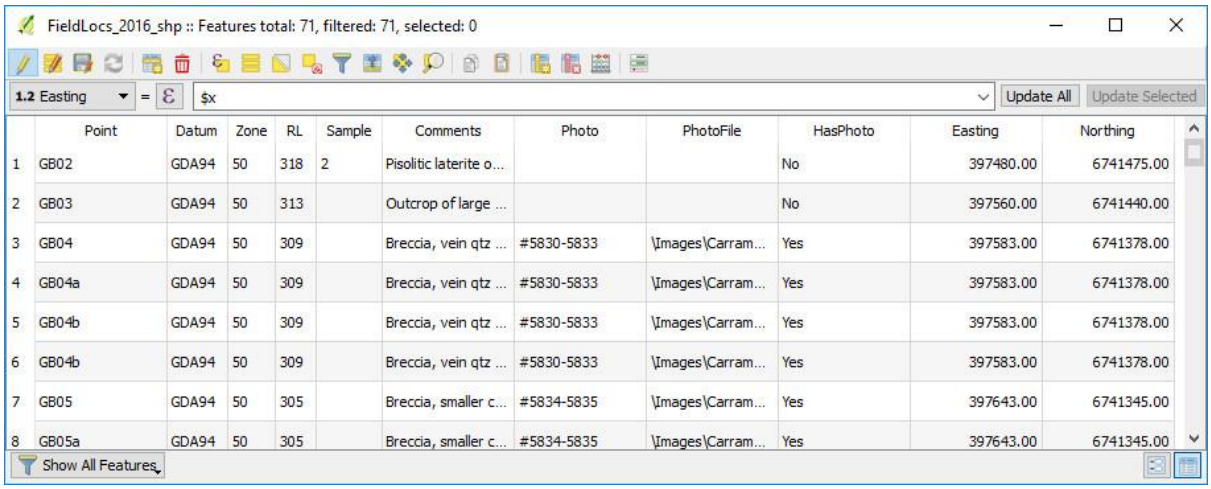
Any changes to the granite-breccia boundary will then change both the polygons and will not leave gaps.

Task 2.14 - To modify the geological polygons, make the layer editable, and you should see little red crosses at the vertices/nodes. To edit a node activate the “Node Tool” (next to the red bin), click in the polygon and all the nodes should become highlighted. To move a node simply click and drag. To delete a node click on it, it should become black, then hit delete. To add a node, simply double click on the line where you want another node.

To modify multiple vertices in a polygon, left click and draw a rectangle around the vertices to be modified, then move or delete as required.

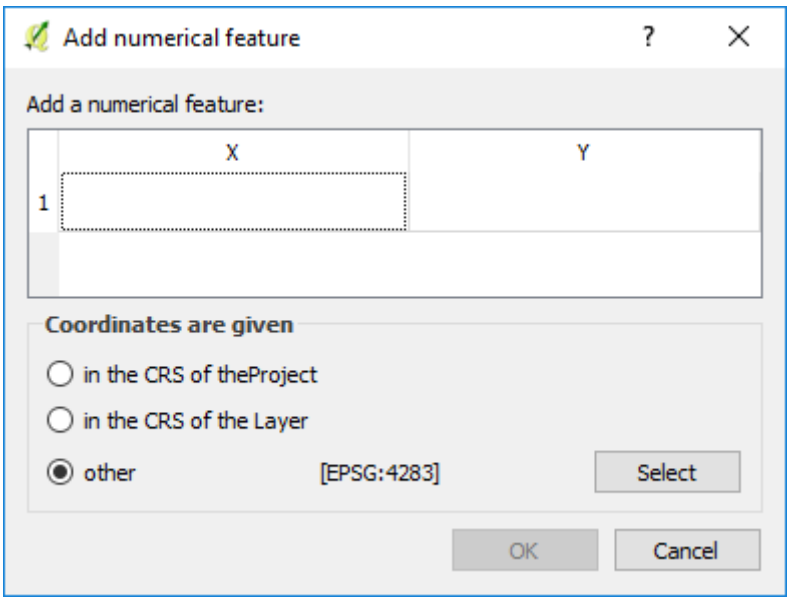
Task 2.15 - To move a point using the mouse, make the Field Observations layer editable, enable the Node Tool, then select any point and move. ***Note that the coordinates in the file will not change.***

Task 2.16 - To update the coordinates in the file, open the layer Attribute Table, click edit (pencil icon), select the field in the drop-down menu and then enter an expression into the expression box ($x for Easting and $y for the northing), select Update All or Update Selected to update all or selected points for that field.

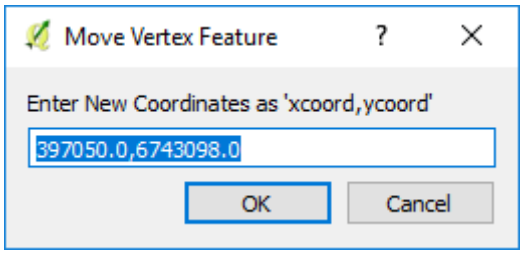


	Point	Datum	Zone	RL	Sample	Comments	Photo	PhotoFile	HasPhoto	Easting	Northing
1	GB02	GDA94	50	318	2	Pisolitic laterite o...			No	397480.00	6741475.00
2	GB03	GDA94	50	313		Outcrop of large ...			No	397560.00	6741440.00
3	GB04	GDA94	50	309		Breccia, vein qtz ...	#5830-5833	\Images\Carram...	Yes	397583.00	6741378.00
4	GB04a	GDA94	50	309		Breccia, vein qtz ...	#5830-5833	\Images\Carram...	Yes	397583.00	6741378.00
5	GB04b	GDA94	50	309		Breccia, vein qtz ...	#5830-5833	\Images\Carram...	Yes	397583.00	6741378.00
6	GB04b	GDA94	50	309		Breccia, vein qtz ...	#5830-5833	\Images\Carram...	Yes	397583.00	6741378.00
7	GB05	GDA94	50	305		Breccia, smaller c...	#5834-5835	\Images\Carram...	Yes	397643.00	6741345.00
8	GB05a	GDA94	50	305		Breccia, smaller c...	#5834-5835	\Images\Carram...	Yes	397643.00	6741345.00

Task 2.17 – To add individual points by coordinates requires the “Numerical Digitise” plugin. Make the required points layer editable, select the Numerical Digitise tool and enter the coordinates (for example 397000 for x and 6743000 for y).

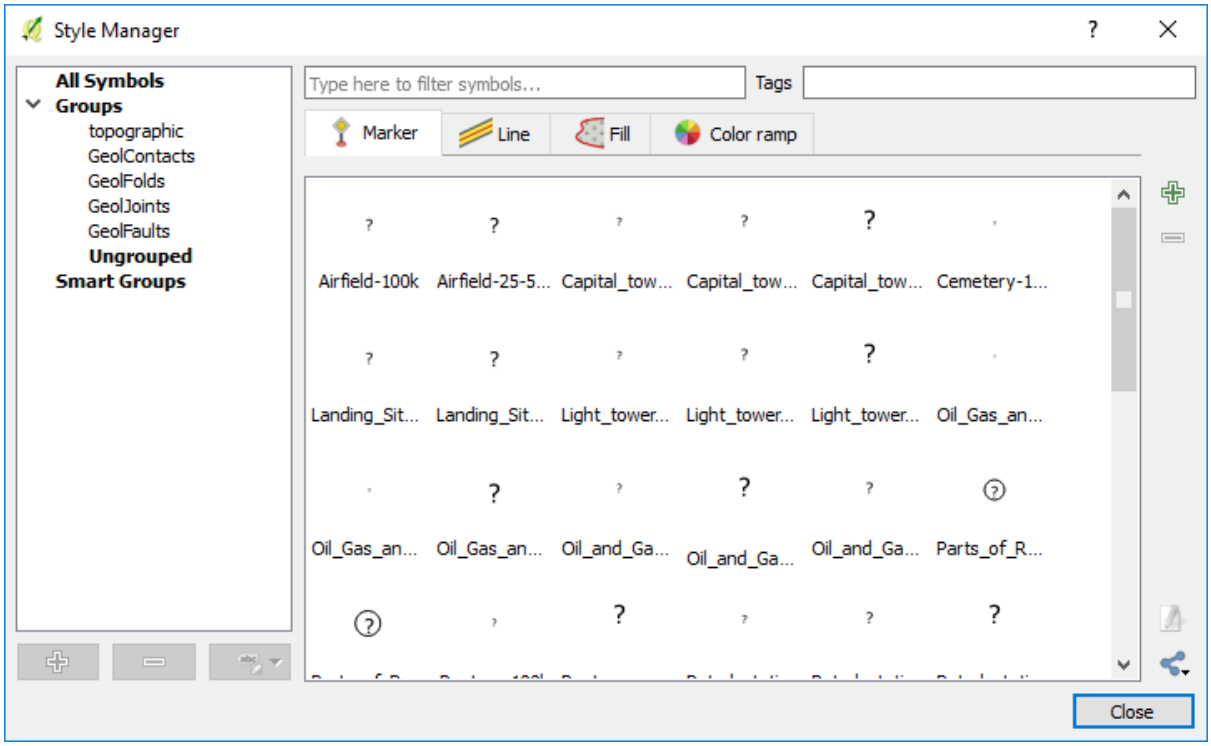


Task 2.18 - To modify the location of a point by adjusting its coordinates use the “Numerical Vertex Editor”. Ensure the relevant layer is selected and made editable, then select the “Numerical Vertex Editor” icon (plug-in), select the point then edit the coordinates. Note you may need to turn-on the snapping options in the Settings > Snapping Options on the map window main window.

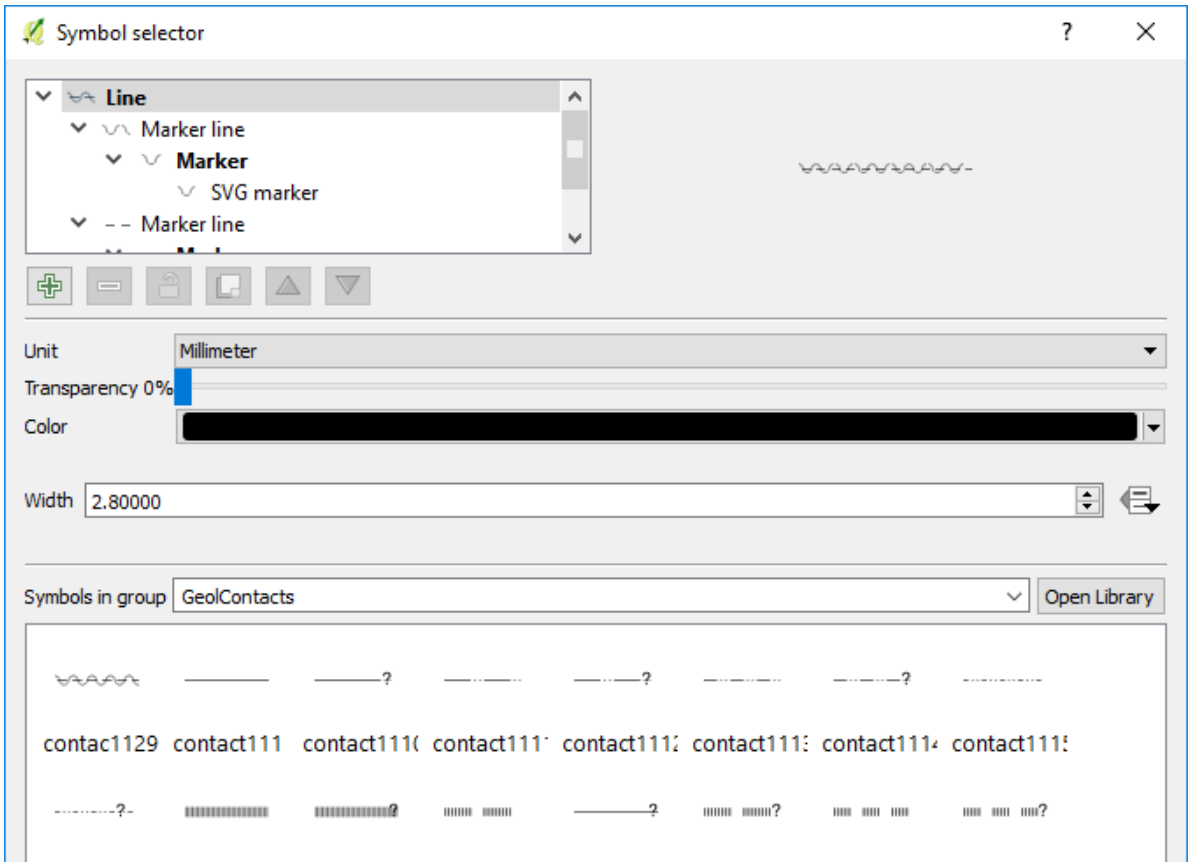


Task 2.19 - Create a new shapefile layer of type “Line”, make sure the projection is GDA94 z50, call it something like “testlines”, make editable and add a couple of lines to the map (use left click to create the line nodes and right click to finish the line). Give each line a unique ID number so we can change their line styles independantly by their ID number using the categorise option. Save edits.

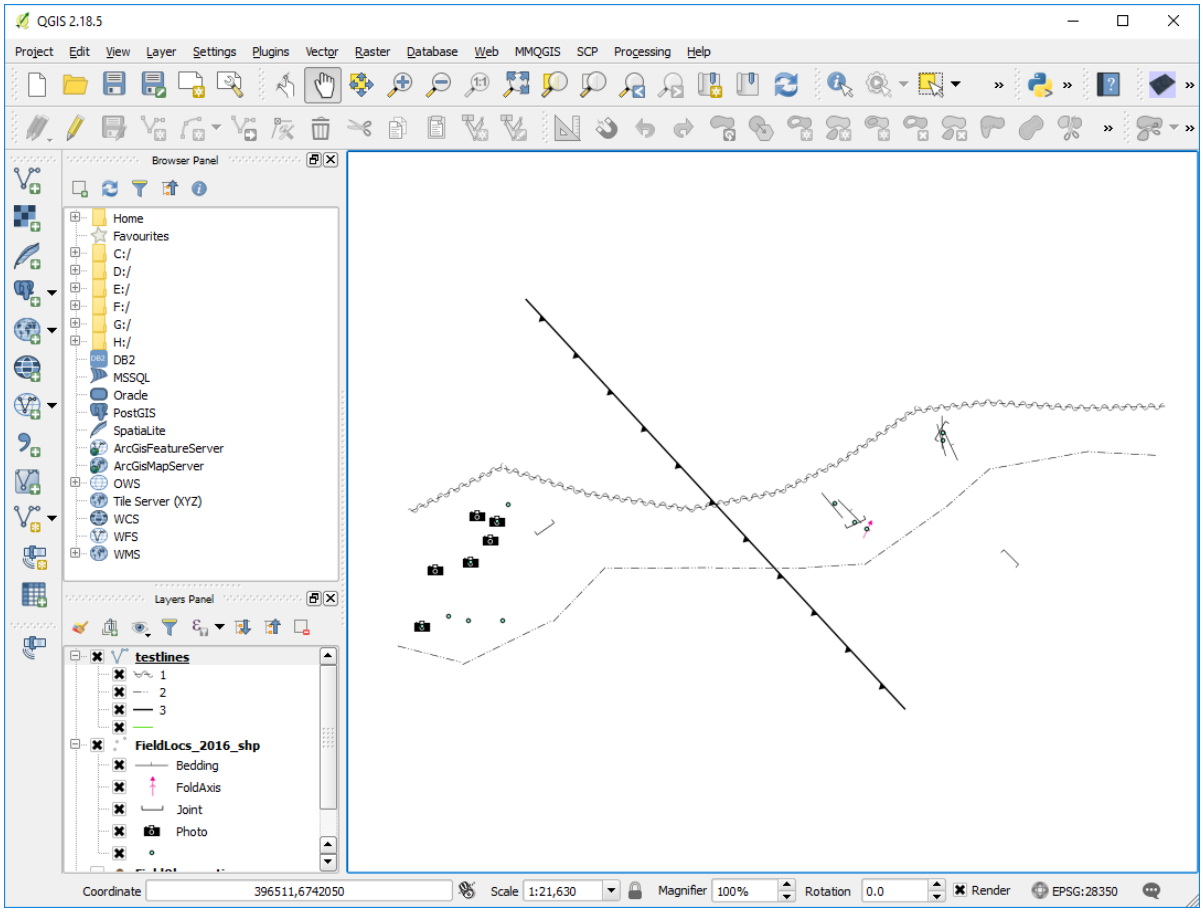
Task 2.20 - On the main menu, go to Settings > Style Manager and select the Import option in the small box down on the lower right hand side of the dialog box (looks like two blue lines with dots).



Navigate to where your line styles are stored (from the workshop USB) and in this exercise, they are found in the Software_Symbols\Fonts_Patterns\LineStyles folder. Import each one individually (i.e. contact, fold, fault and joint). Next go to your test lines layer and in the Layer Properties, Style tab, use the categorise option. This should then apply different colours to each of the different ID numbers of the lines. Click on the line symbol and a Symbol Selector window should pop-up.



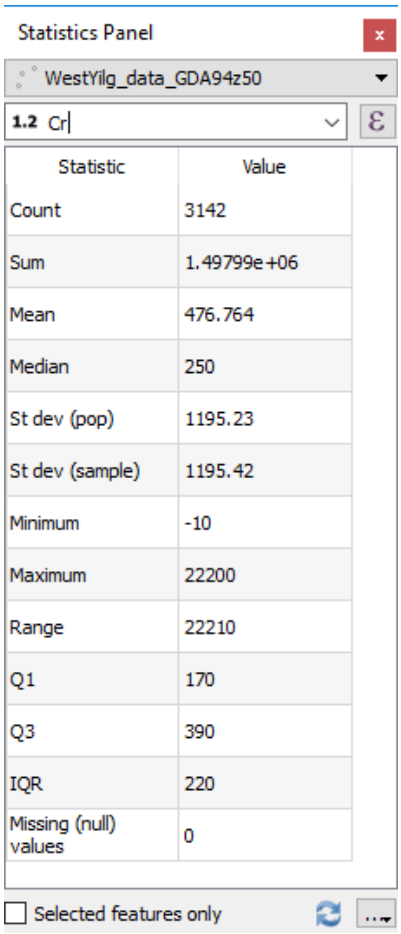
In the Symbols in group drop-down box, select GeolContacts (or whatever you called this line style group). Select the line style you want and hit OK. This method can be used to modify all the other line styles. To save these line styles remember to save the Style as default in the main Style tab window (under Style > Save as Default).



Hands-On Workshop 3 – Import and Display of Geochemical and Geophysical Data

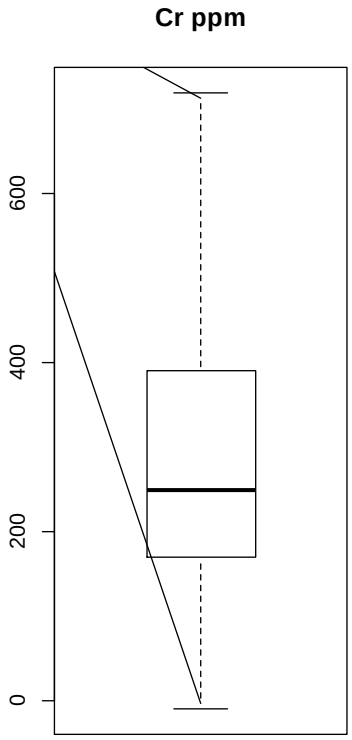
Task 3.1 - Create a new Project, discard the old one if you have one displayed. Open up the vector file "WestYilg_data_GDA94z50.shp" located in the Project Files > Geochemistry folder. This is the GSWA laterite sampling of the Western Yilgarn area.

Task 3.2 - To examine the statistics of the data, use the View > Statistics Panel and select Cr.



Statistic	Value
Count	3142
Sum	1.49799e+06
Mean	476.764
Median	250
St dev (pop)	1195.23
St dev (sample)	1195.42
Minimum	-10
Maximum	22200
Range	22210
Q1	170
Q3	390
IQR	220
Missing (null) values	0

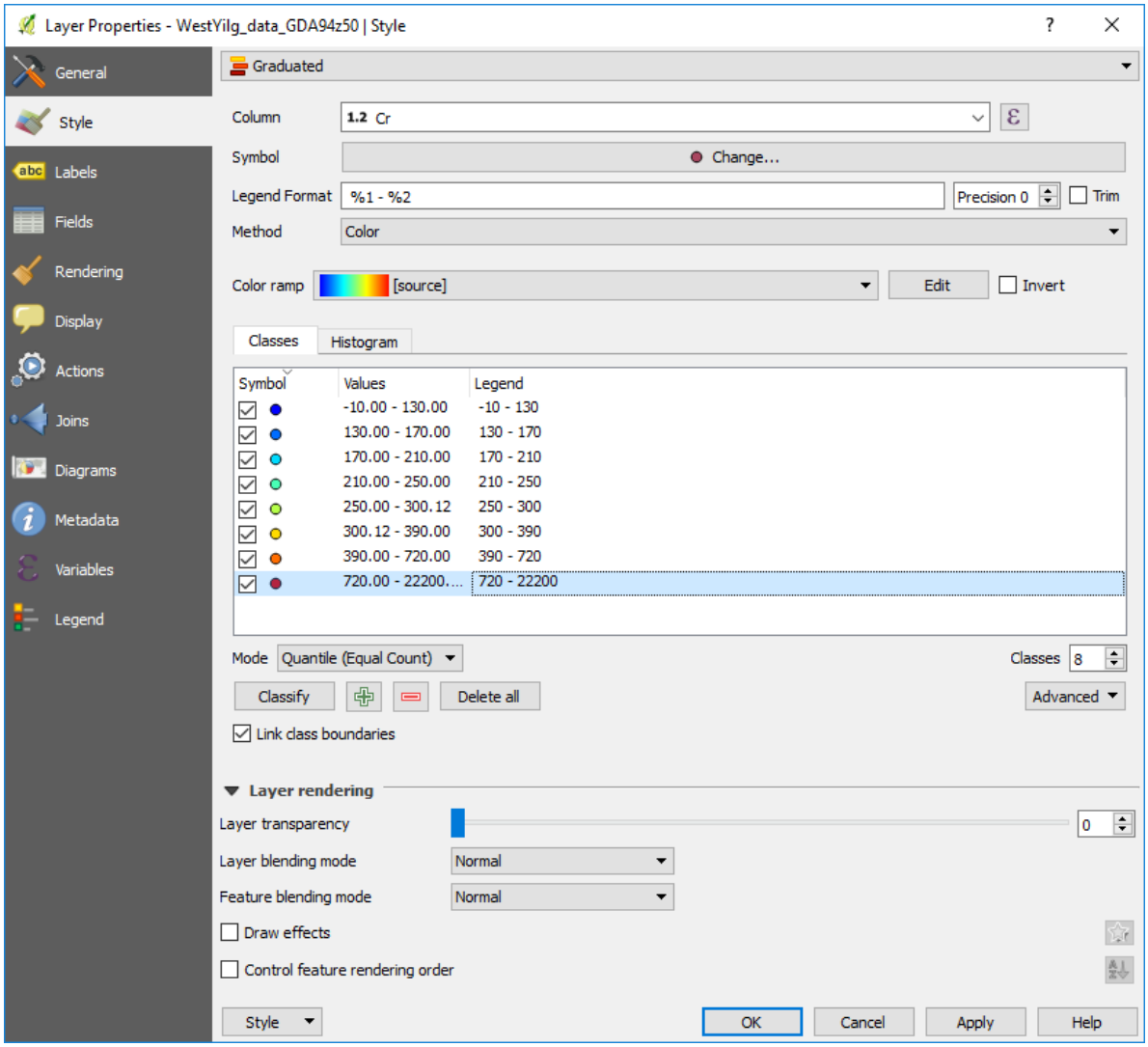
Selected features only



The boxplot (on the right) was generated using the plotting functions in R via the QGIS Processing Toolbox (more on this if we have time).

Note that the first and third quantiles are 170 and 390 ppm Cr with an IQR of 220. Any values over 720 ppm Cr (Q3 + (1.5 * IQR) are anomalous.

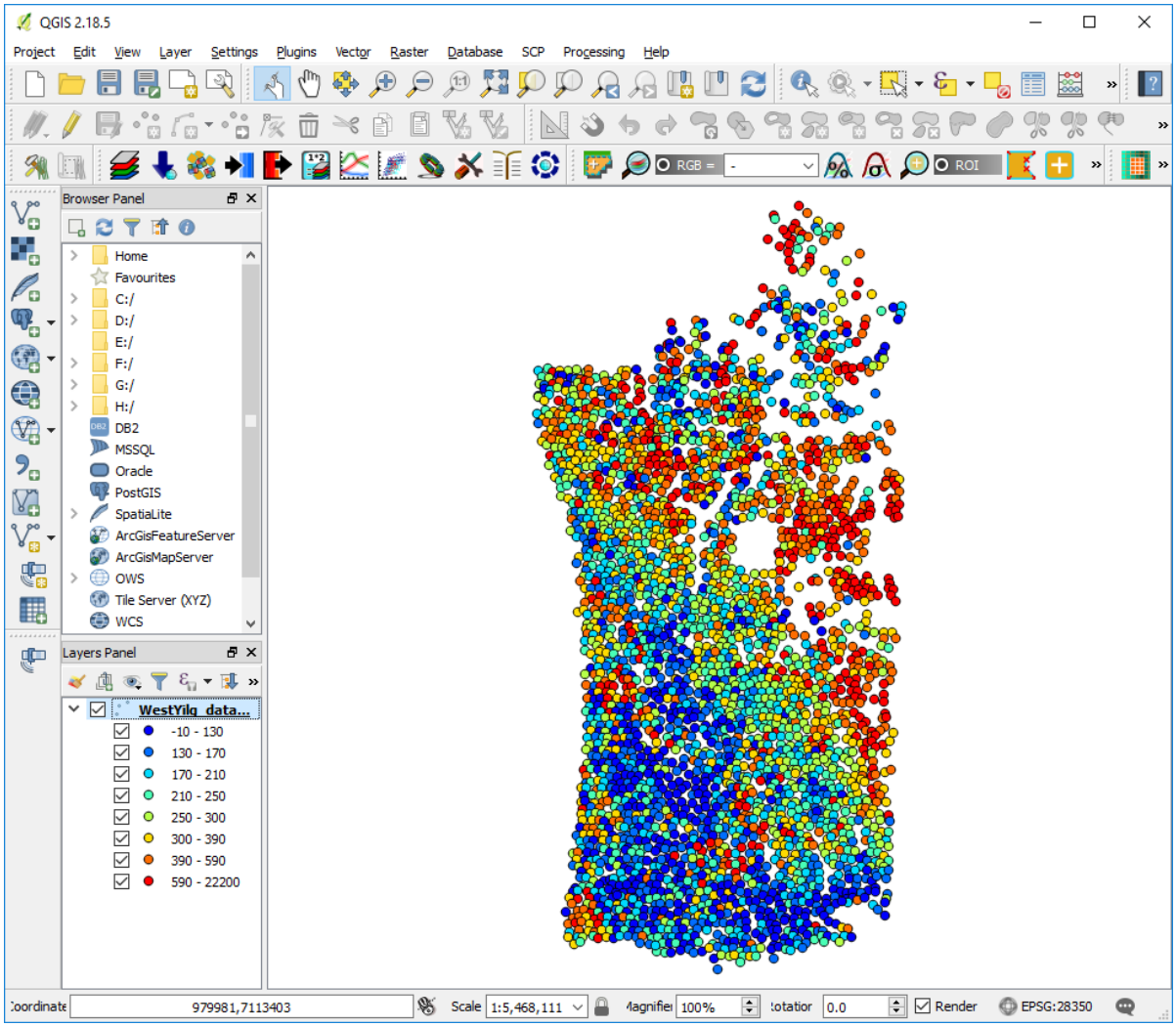
Task 3.3 - Bring up the Layer Properties > Style window. Select the Graduated option. Select "Cr" as the field to be displayed. Select a suitable "colour ramp", select Mode "Quantile (Equal Count)", change Classes to 8, hit "Classify" (if you forget to hit Classify you will not any colours!). You will note that the boundary between the second and third quantile is 170 ppm (Q1) and the boundary between the sixth and seventh range is 390 ppm (Q3).



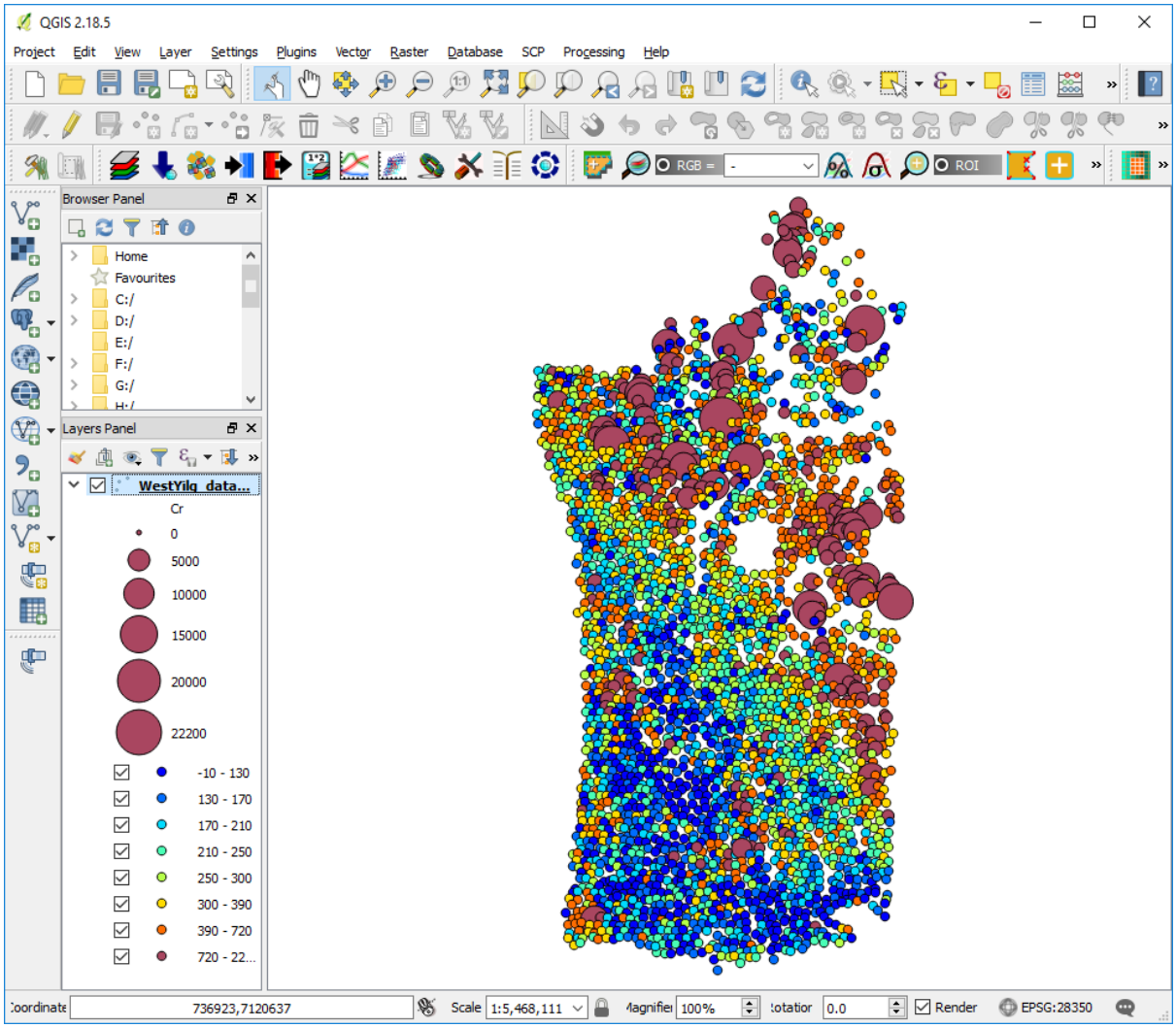
The top two classes are below 170 ppm (25th percentile) and the bottom two classes are greater than 390 ppm (75th percentile). You can manually edit the second last range so that it's upper value is 720 ppm (anomaly threshold) and it will automatically update the eighth data range.

Other options are available for the display of the data – see the "Mode" drop-down box.

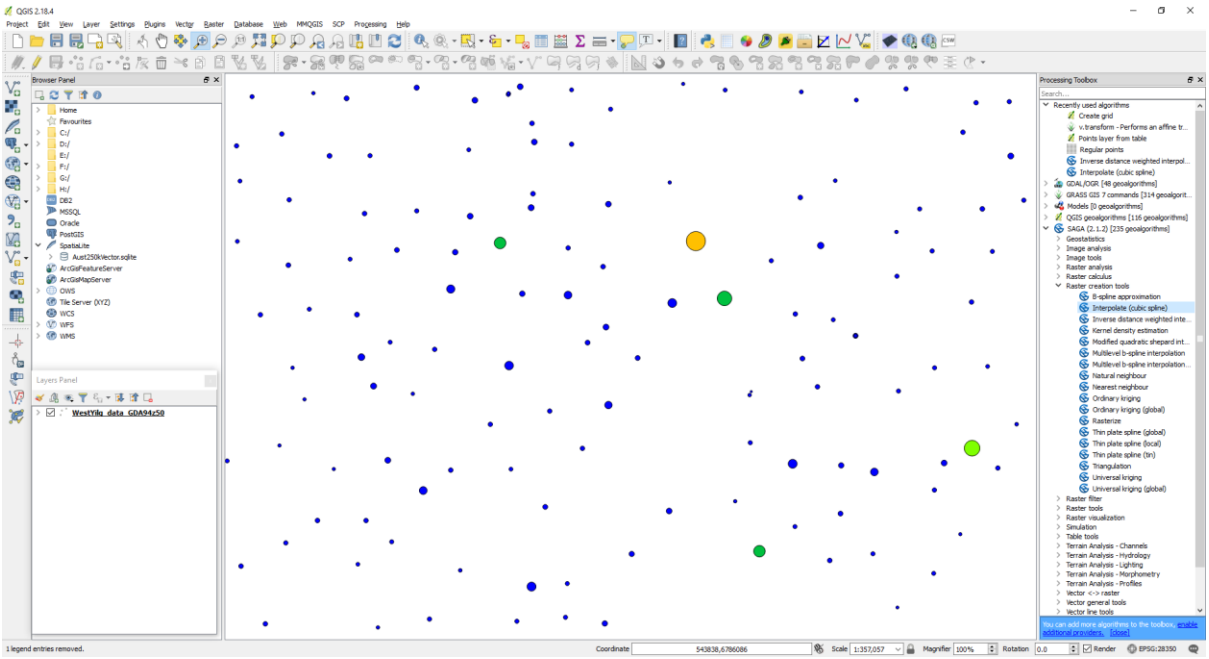
Note you can vary the displayed number of decimal places in the legend by using the "Precision" option in the dialog box.

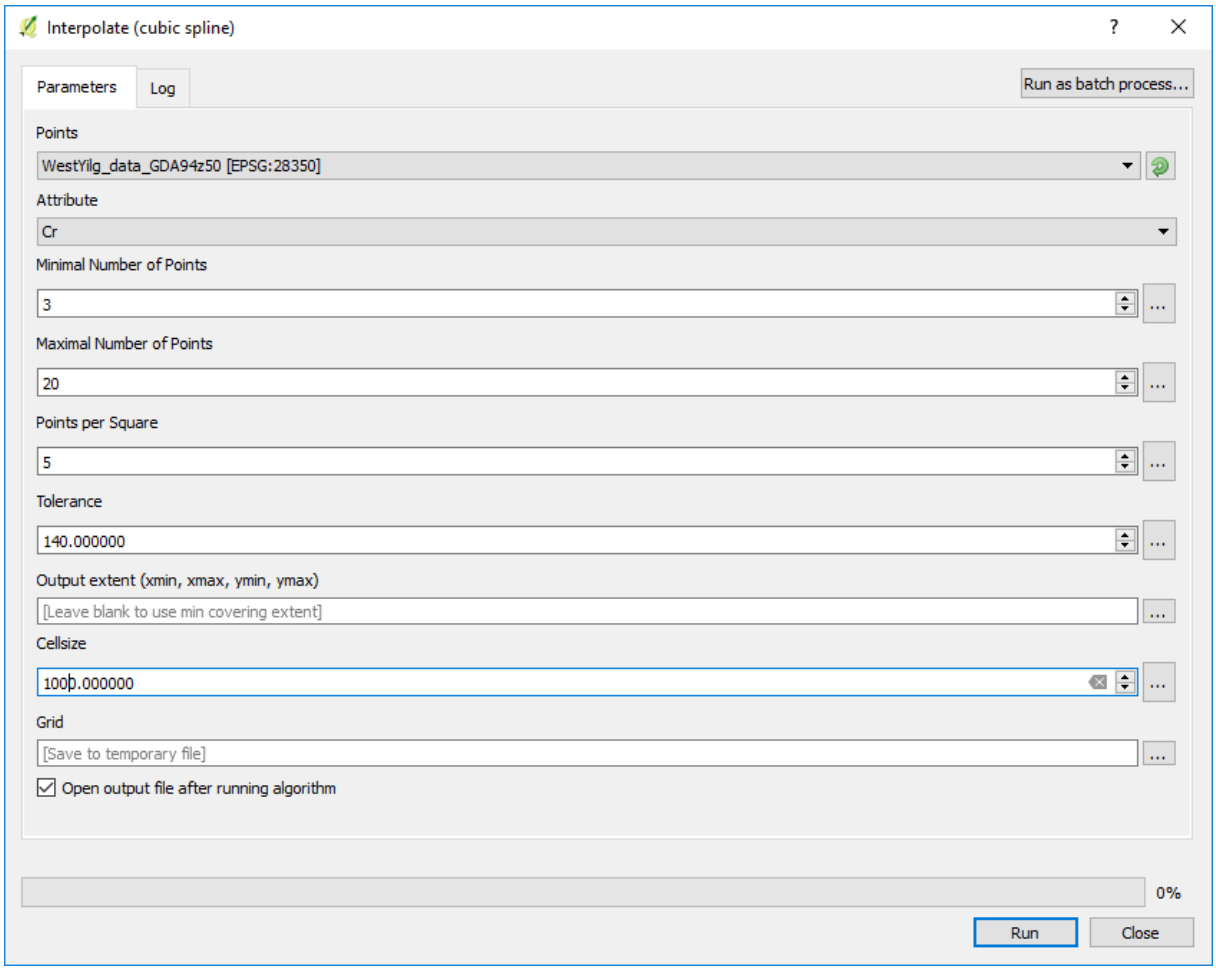


Task 3.4 - Points can be classified by colour and/or size. We can do a classification by both size and colour by clicking in the Symbol box (where it says “change”) which will bring up the symbol selector window. Highlight the “Simple Marker” layer in the top left, then click on the far right hand side of the Size options where there is a little square box with a down arrow. This is the “Data Driven Override” button. Click on this and scroll down to “Size Assistant” where you can select the symbol size by the field “Cr”. Click OK to apply. Close the layer properties window.



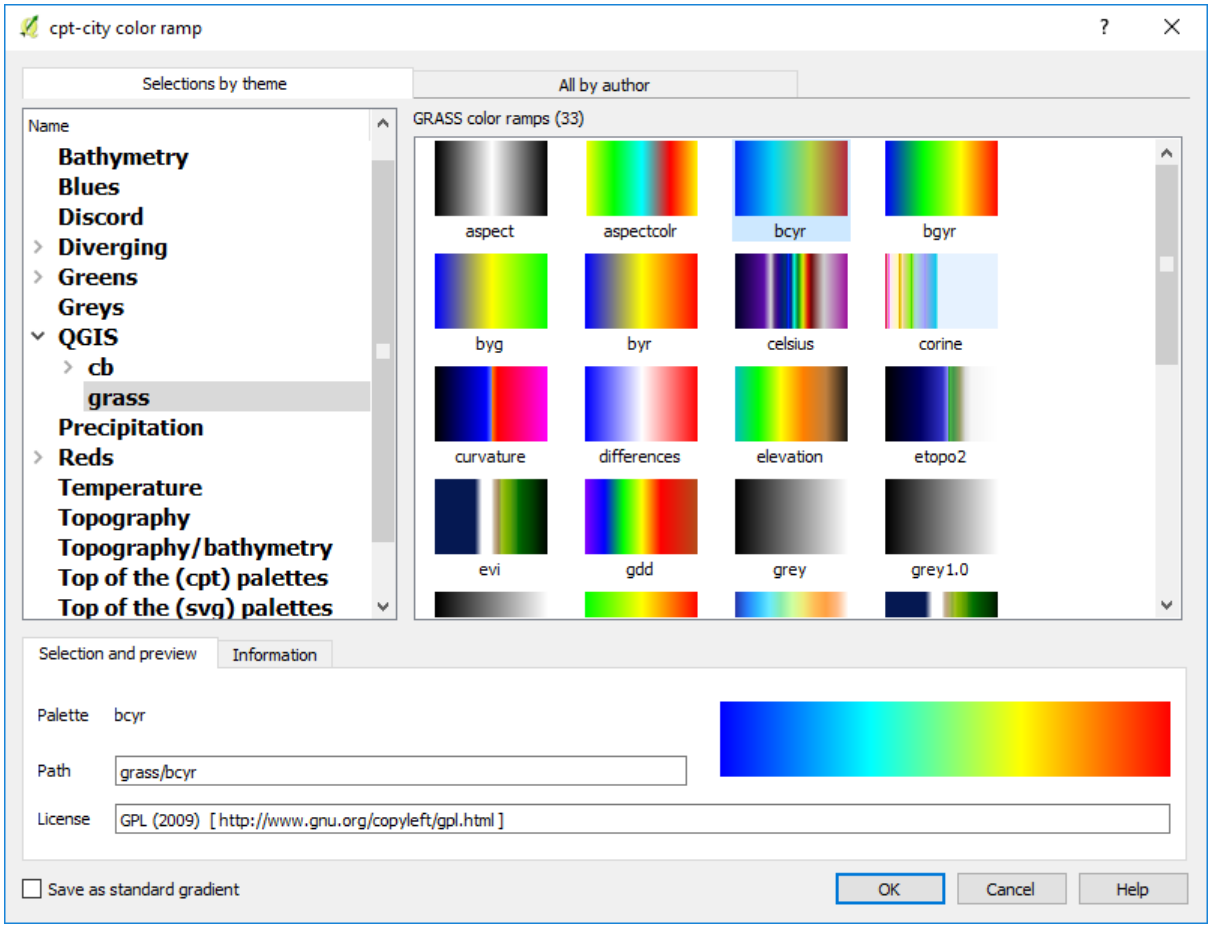
Task 3.5 – To create a grid of the data, zoom to an area of data and go to Processing Toolbox (right hand side window) > SAGA > Raster Creation Tools > Interpolate (Cubic Spline). Select Cr as the field to grid and click select and enter a file name (if you want) and location to where you want to write the grid file. **It is important to make sure QGIS can write to the folder (not the default Program Files folder), otherwise the operation will fail.**



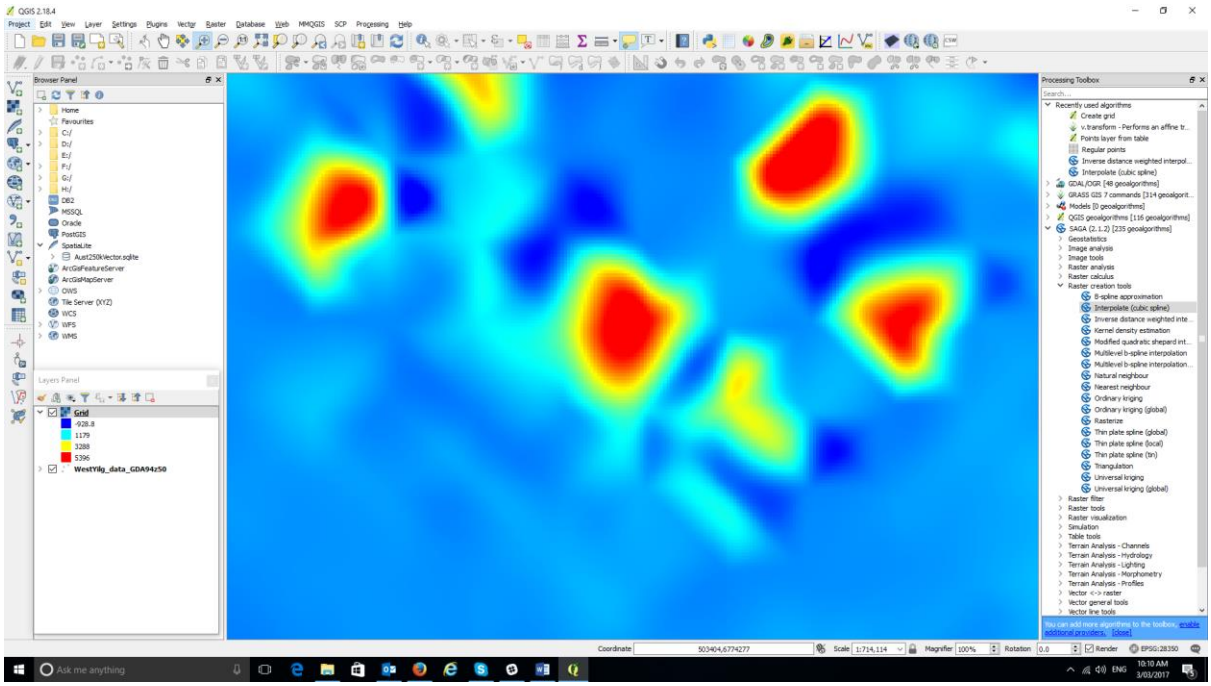


A grey scale grid should appear.

Task 3.6 - The default colouring is greyscale. To add colour to the grid, open the Layer Property > Style tab and select pseudo colour as the render type. If you can't see the desired colour ramp, scroll to the bottom of the colour ramp display box and select "New Colour Ramp", then Colour Ramp Type "cty-city". A large range of colour ramps can then be selected.



I usually use the QGIS > grass "bcyr" colour ramp.



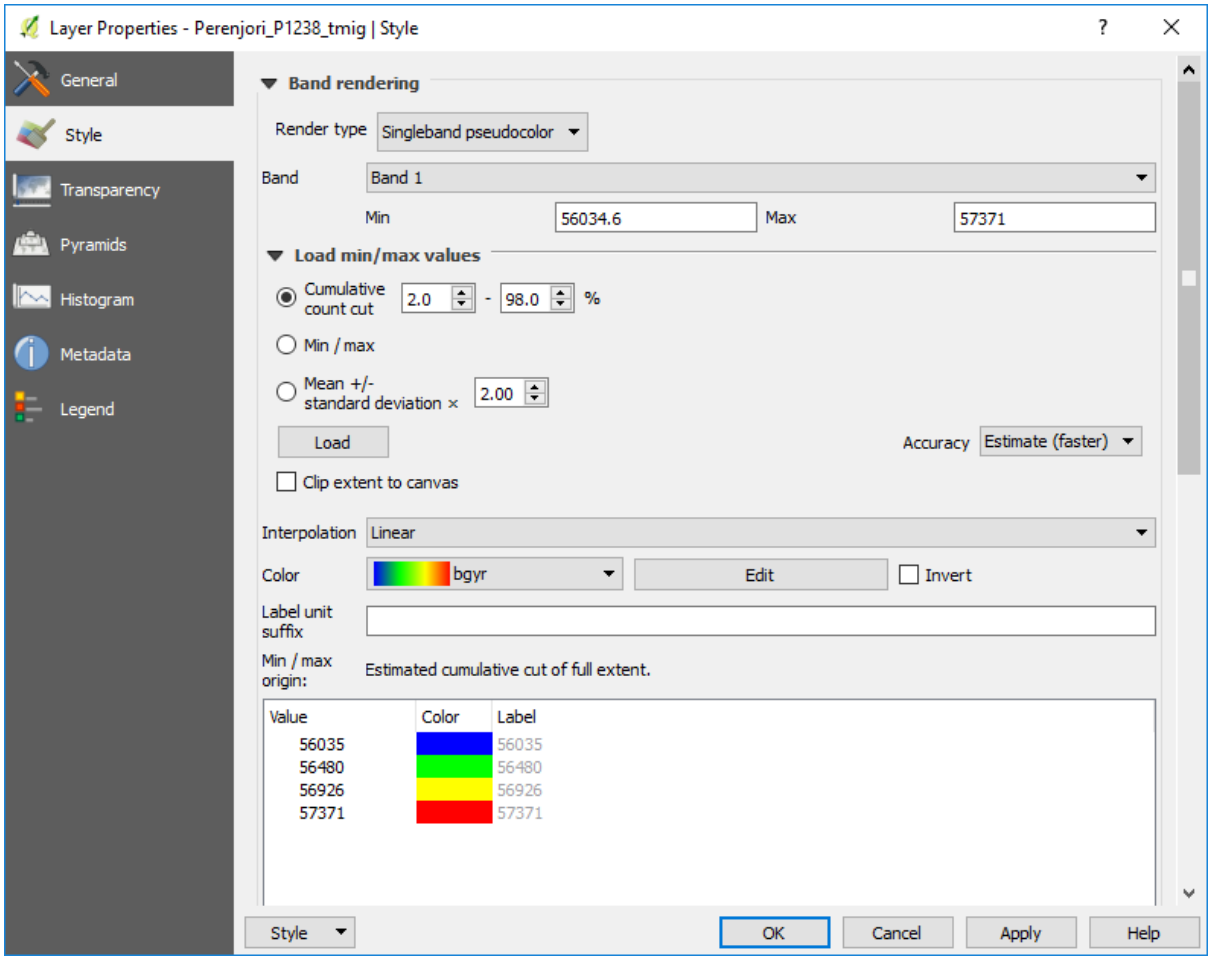
There are a variety of gridding option in QGIS (see menu item raster > interpolation) but I have found the SAGA gridding tools, which includes inverse distance and kriging, to be the best for geochemical data.

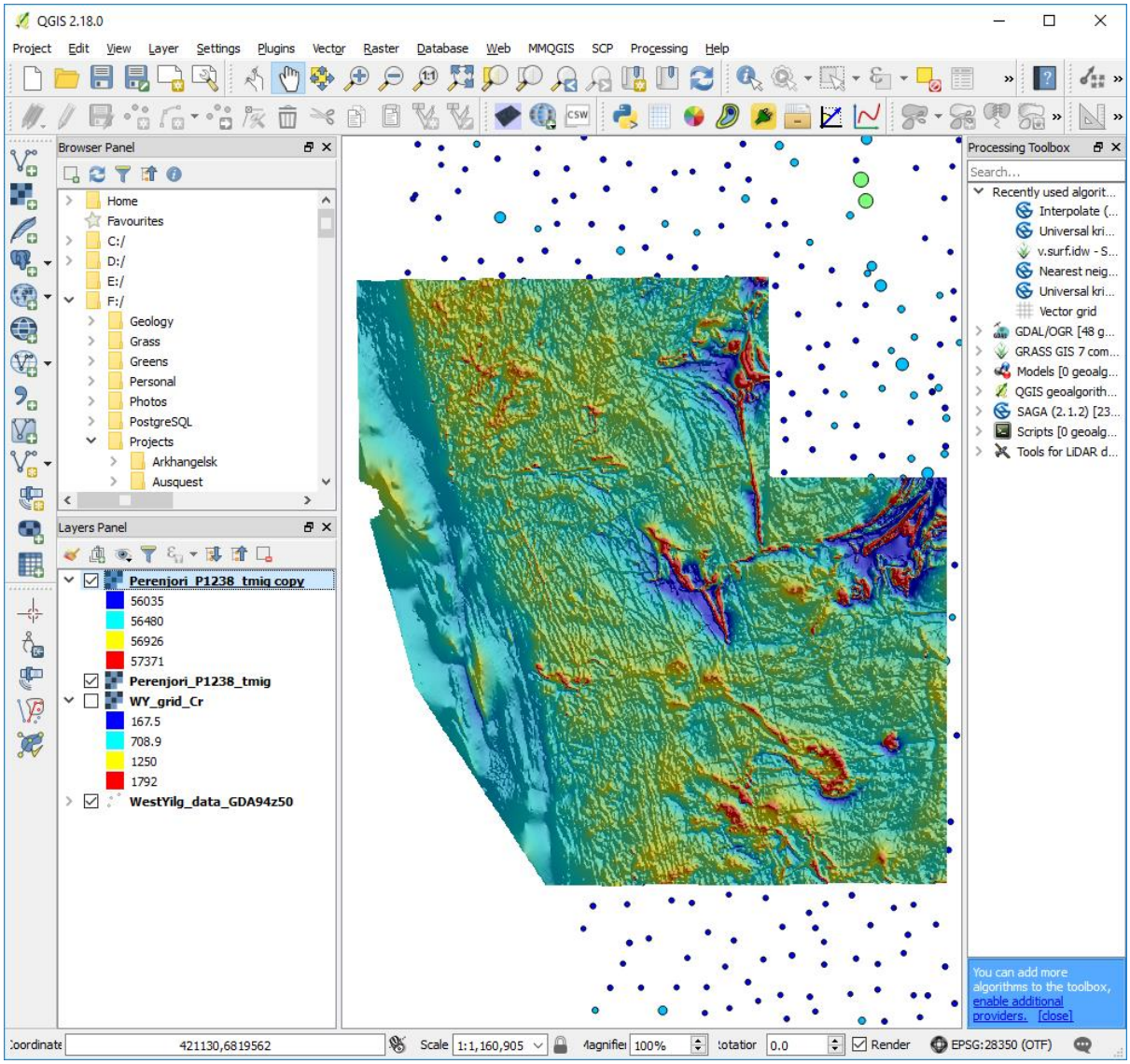
Task 3.7 - Geophysical data grids can be opened via the raster menu for *.ers files for example (note that ers files are not visible in the Browser panel). Geosoft grids (*.gid) need to be converted to *.ers files to be opened by QGIS (the free Oasis Montaj viewer can do this). Open the file “Perenjori_P1238_tmig.ers” in the Geophysics > Perenjori folder, and zoom to layer (use the right click and zoom to layer option in the Layers window). Change the layer properties for the layer to style > pseudocolour and change transparency to 50%.

Task 3.8 - Use the Layer window to duplicate the magnetics layer and name it “Hillshade”. Open the Layer Properties for the new Hillshade layer, and in the style tab, select hillshade option (suggest lighting from north east). The shaded tmi should then be visible through the partially transparent coloured tmi.

Note: If you open a grid file and have difficulties displaying the data, e.g. with 1VD images, zoom in to a small area of the grid and then “Stretch to Current Extent” (available as a right click on the layer name in the Layers panel) to stretch the data to something visible.

Adjusting the values for the display of the colour ramp can be modified by putting values in the Min or Max windows. To return to the default input values just press the “Load” button.


Layer Properties - Perenjori_P1238_tmig | Style
General
Style
Transparency
Pyramids
Histogram
Metadata
Legend
Band rendering
Render type
Singleband pseudocolor
Band
Band 1
Min
56034.6
Max
57371
Load min/max values
Cumulative count cut
2.0
98.0
%
Min / max
Mean +/- standard deviation ×
2.00
Load
Accuracy
Estimate (faster)
Clip extent to canvas
Interpolation
Linear
Color
bgyr
Edit
Invert
Label unit suffix
Min / max origin:
Estimated cumulative cut of full extent.
Value
Color
Label
56035
56480
56926
57371
Style
OK
Cancel
Apply
Help

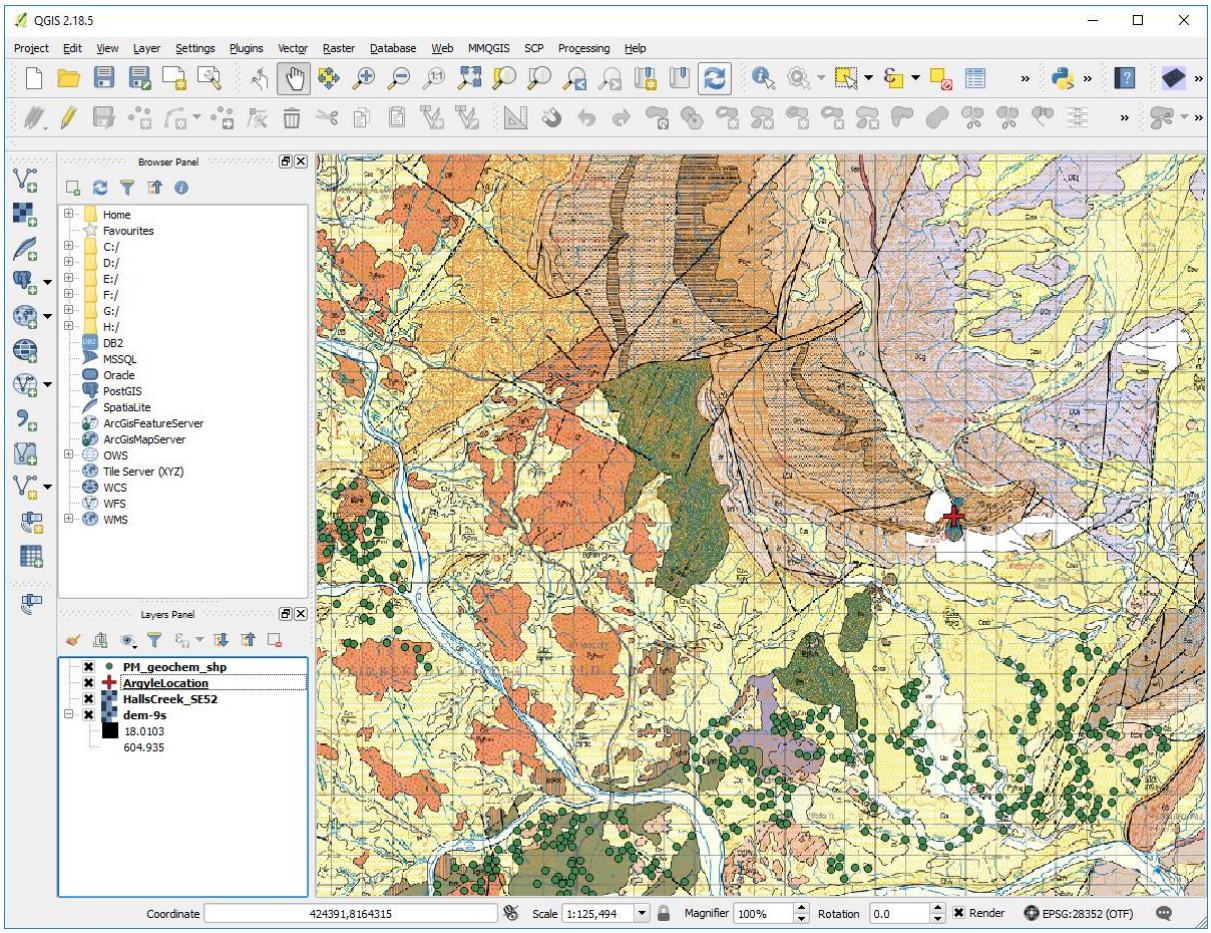


If you have a requirement to load located data, use the CSV file load option and select the delimiter option to suit the file. Note that shape file field names are limited to 10 characters and may require editing the data file to create suitable field names.

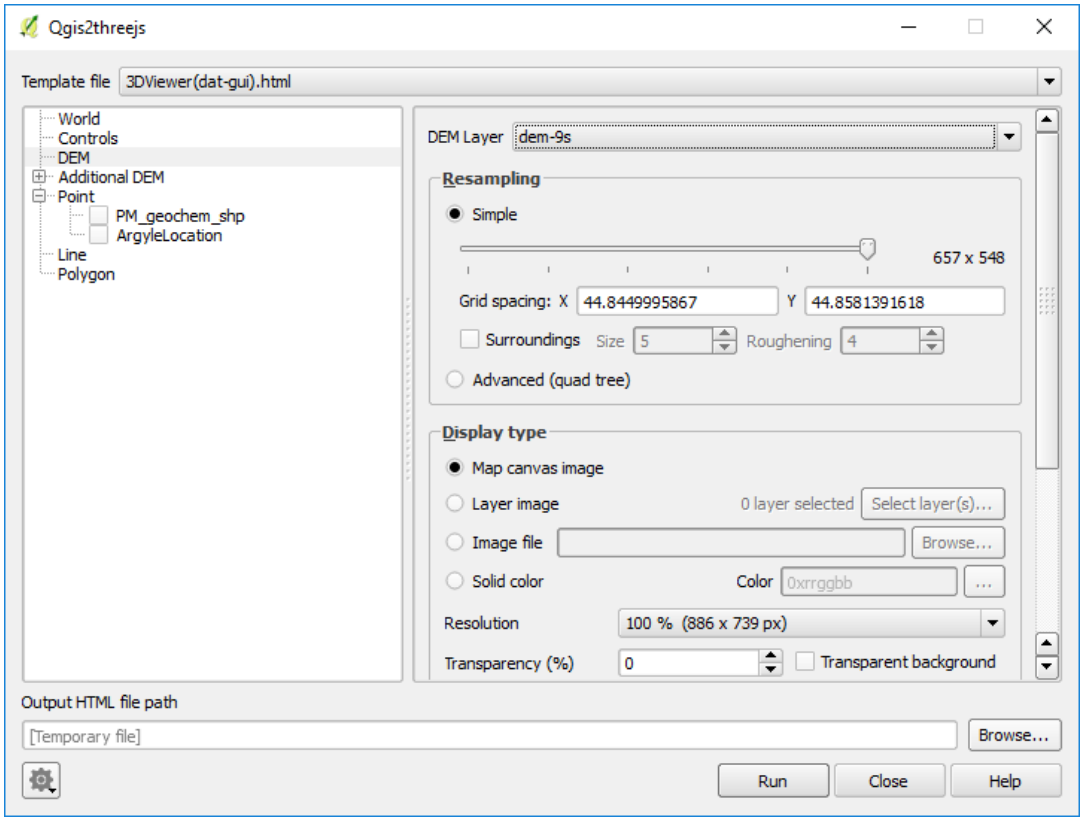
Hands-On Workshop 4 – 3 D!

Task 4.1 - Create a new blank project. Load the raster files “HallsCreek_SE52.jp2” and “DEM-0s.ers” from the Example3D folder. Move the DEM layer underneath the Halls Creek geology layer. Add the vector layer “PM_geochem_shp.shp” and make sure it is the top layer.

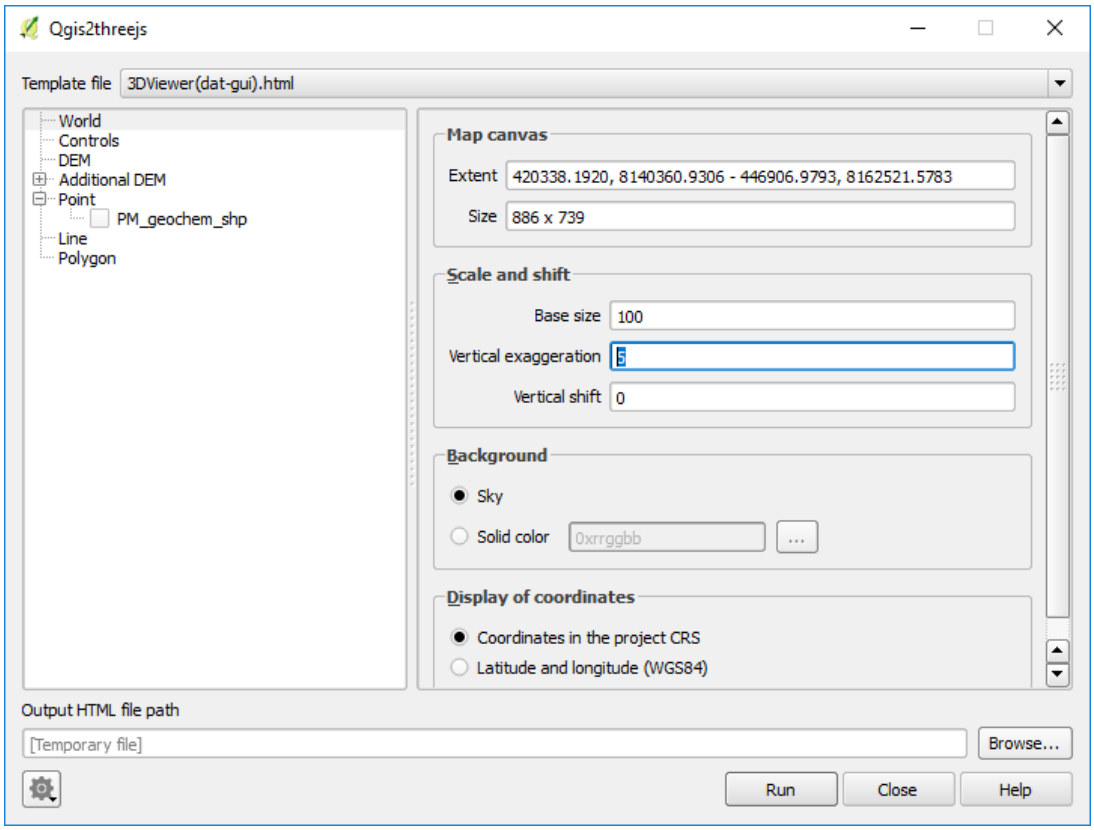
Task 4.2 - Zoom into the area around the Argyle diamond mine – top right hand corner of geology image (centred approximately on 343771 mE and 8152161 mN).



Task 4.3 - On the top menu bar go to Web > QGIS2threejs plugin.

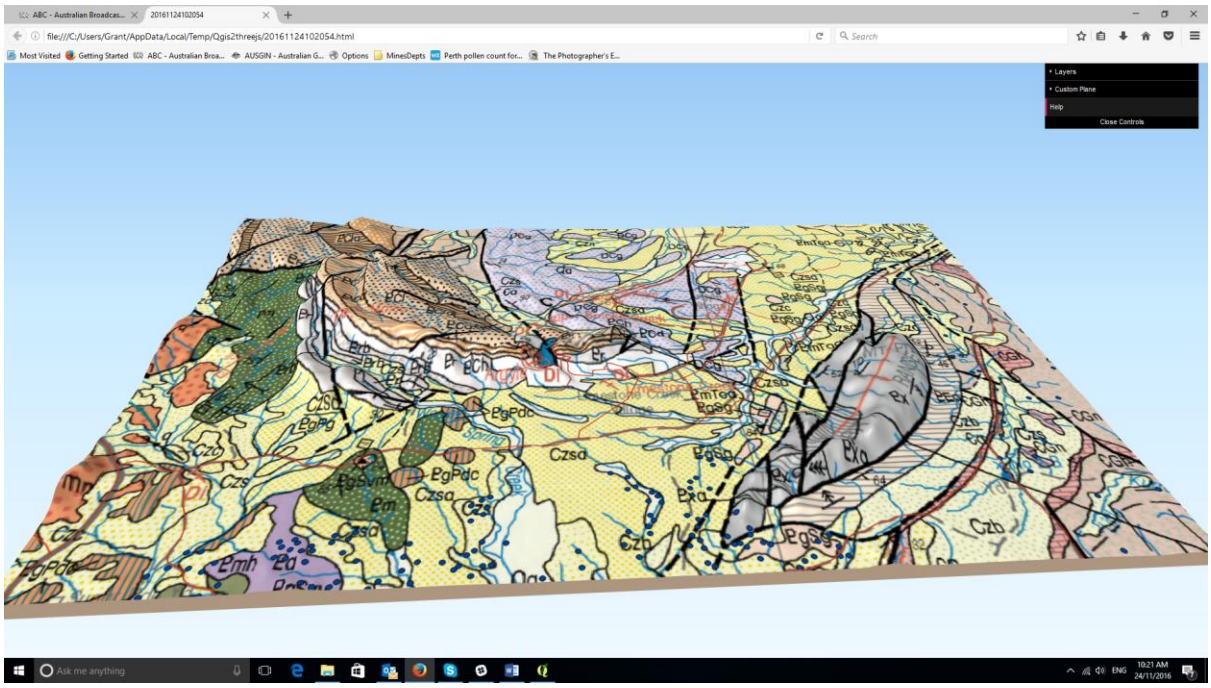


Ensure the DEM layer (DEM-9s) is in the DEM Layer window. Move the Resampling – Simple to the far right (maximum resolution). Click on the "World" layer (left side window) and change the Scale and Shift to a vertical exaggeration of 5.



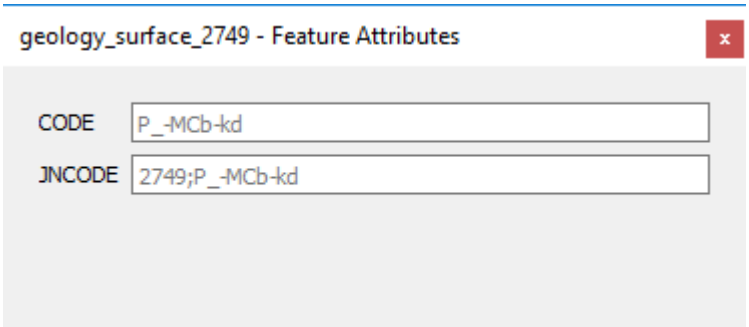
When you hit run, you should see a new Internet Browser window appear with the 3D rendering of the image in the map window. If the browser does not appear, it may be being blocked by a pop-up blocker and you will need to adjust your browser settings.

The 3D image can be zoomed and rotated as required. The html file and its folders can be copied and any user with an internet browser can then open this file.

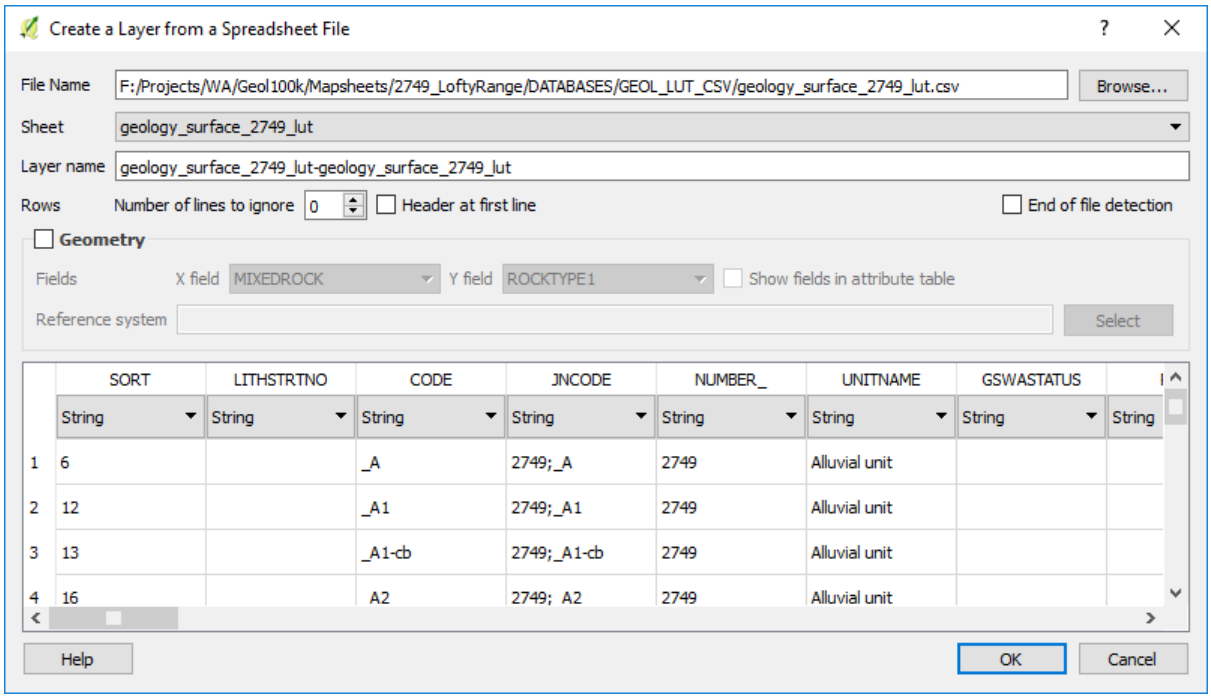


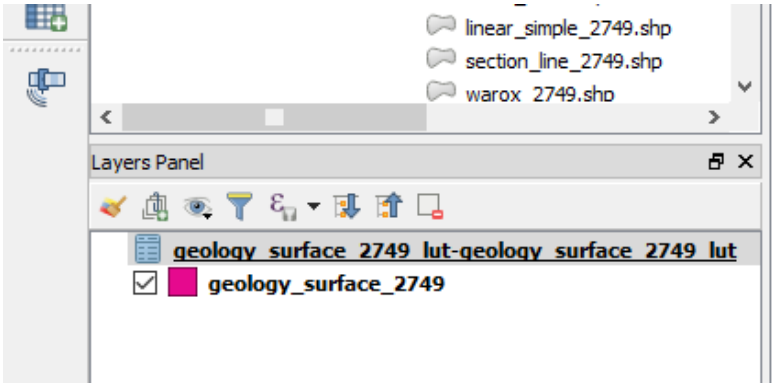
Hands-On Workshop 5 – Joining Spatial and Non-Spatial Data, and Colouring a Geological Map

Task 5.1 - Create a new blank project. Load the vector file “geology_surface_2749.shp” located in the “ProjectFiles\Geology\2749_LoftyRange\ARCMAP” folder. This will load the 1:100 000 vector polygons of the surface geology for the Lofty Range map sheet. They are all displayed in the one colour. Clicking on any polygon will show limited data attached to these polygons.

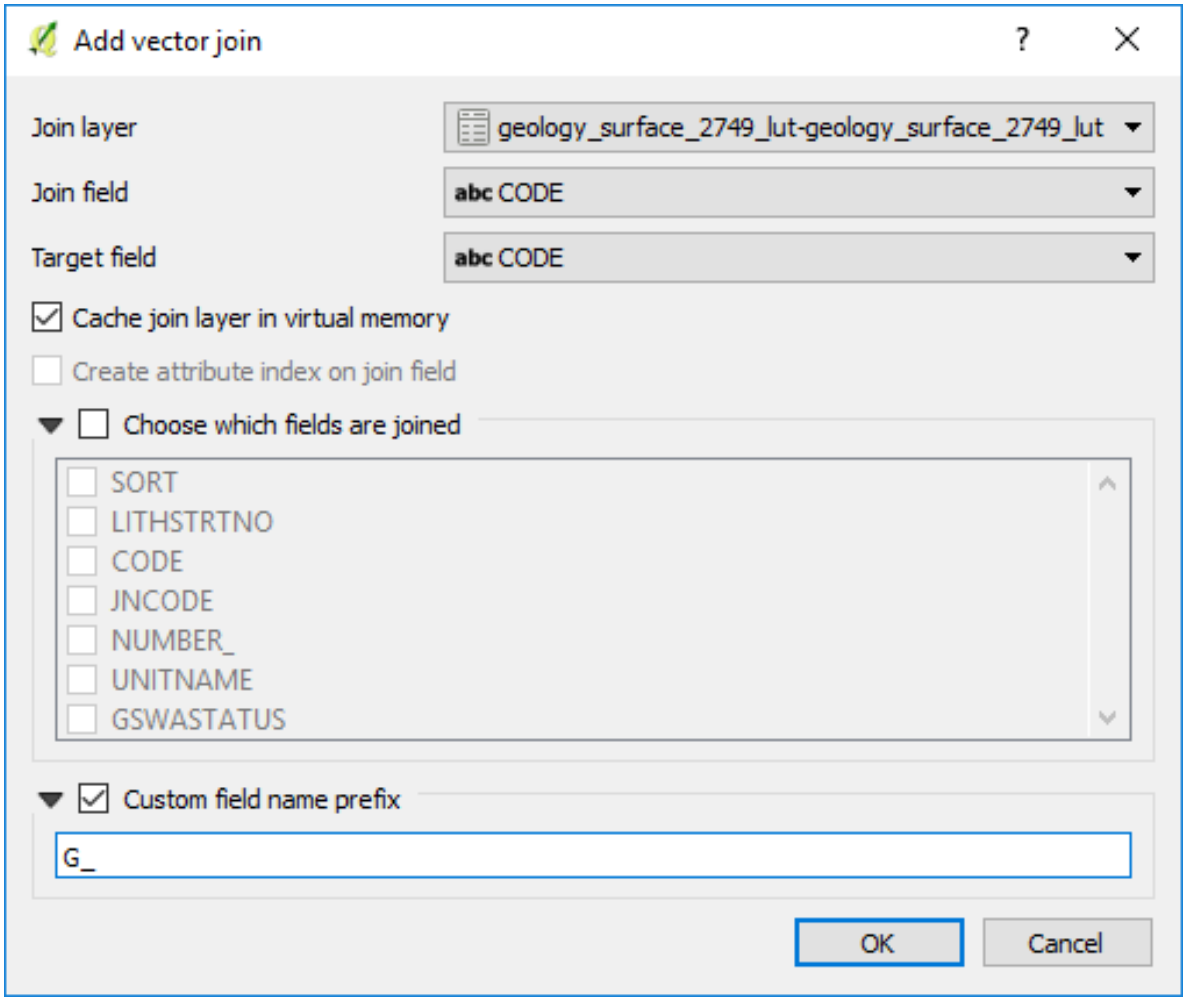


Task 5.2 - We will join the geological description to the geological codes to make the layer more useful. The geological data is in the “geology_surface_2749_lut.csv” file located in the “ProjectFiles\Geology\2749_LoftyRange\DATABASES\GEOL_LUT_CSV” folder. Open this file using the “Spreadsheet Layers” open option. This will create a non-spatial file as there is no geometry attached to this file.

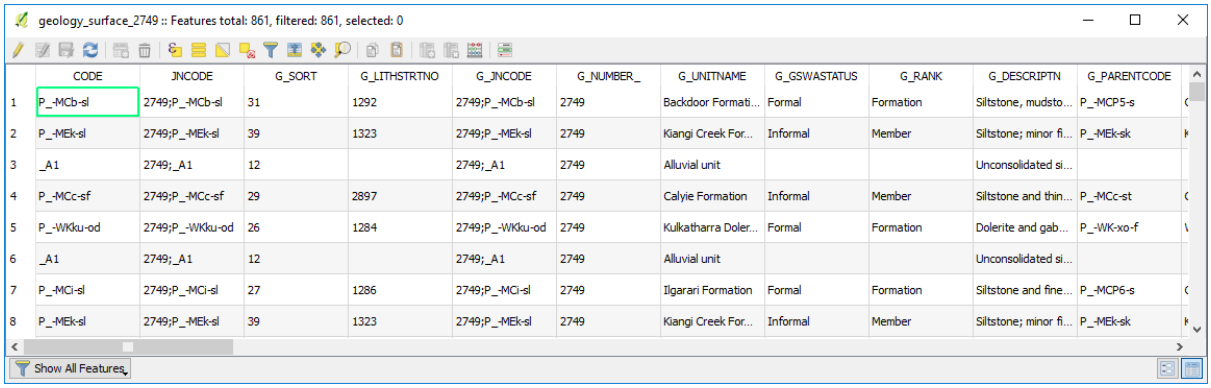




Task 5.3 - To attach the geological details to the geological polygons, we use the join option located in the Layer Properties of the spatial layer "geology_surface_2749", and select the Join tab. Click on the green plus symbol to add a new join. The vector join dialog box will display and add the details as below into the box. Note that all the fields will be selected in the non-spatial layer and joined to the geological polygons. The custom field name prefix has also been modified to limit the size of the resulting joined field names – remember that shp files have a limited field name size of 10 characters.

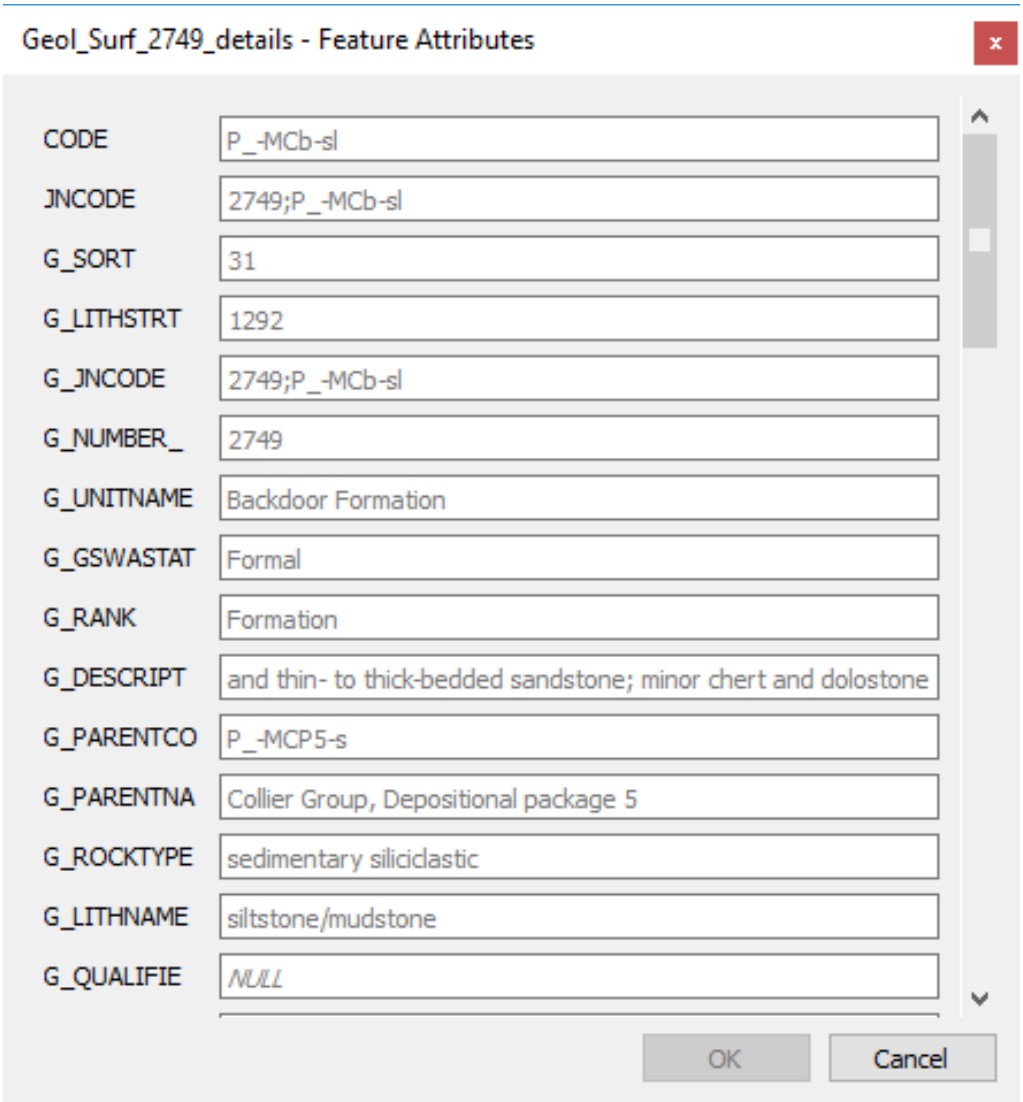


Click on Apply and then check the join has been successful by opening the layer attribute table.

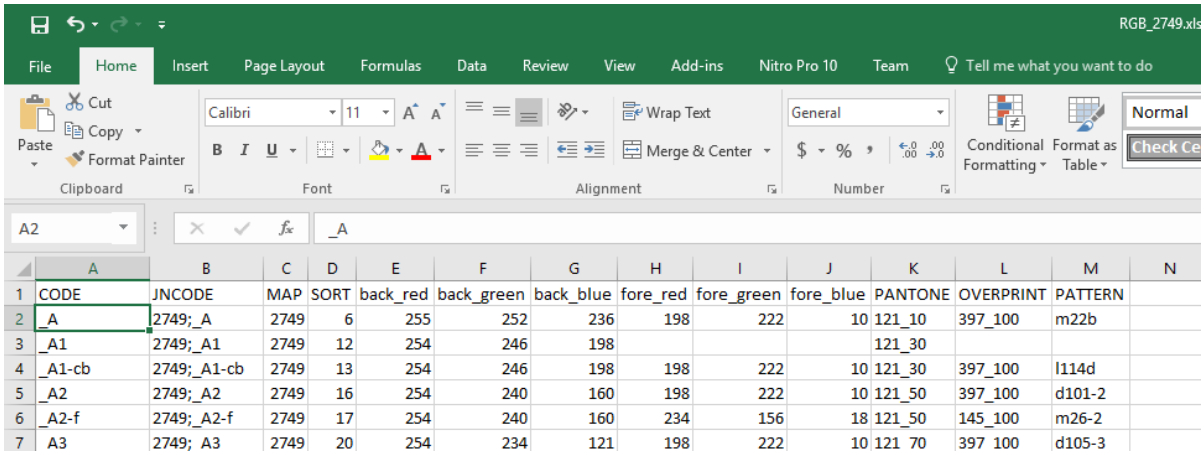


	CODE	JNCODE	G_SORT	G_LITHSTRTNO	G_JNCODE	G_NUMBER_	G_UNITNAME	G_GSWASTATUS	G_RANK	G_DESCRIPTN	G_PARENTCODE
1	P_-MCb-sl	2749;P_-MCb-sl	31	1292	2749;P_-MCb-sl	2749	Backdoor Formati...	Formal	Formation	Siltstone, mudsto...	P_-MCP5-s
2	P_-MEk-sl	2749;P_-MEk-sl	39	1323	2749;P_-MEk-sl	2749	Kiangi Creek For...	Informal	Member	Siltstone; minor fi...	P_-MEk-sk
3	_A1	2749;_A1	12		2749;_A1	2749	Alluvial unit			Unconsolidated si...	
4	P_-MCc-sf	2749;P_-MCc-sf	29	2897	2749;P_-MCc-sf	2749	Calyie Formation	Informal	Member	Siltstone and thin...	P_-MCc-st
5	P_-WKku-od	2749;P_-WKku-od	26	1284	2749;P_-WKku-od	2749	Kulkatharra Doler...	Formal	Formation	Dolerite and gab...	P_-WK-xo-f
6	_A1	2749;_A1	12		2749;_A1	2749	Alluvial unit			Unconsolidated si...	
7	P_-MCi-sl	2749;P_-MCi-sl	27	1286	2749;P_-MCi-sl	2749	Ilgarari Formation	Formal	Formation	Siltstone and fine...	P_-MCP6-s
8	P_-MEk-sl	2749;P_-MEk-sl	39	1323	2749;P_-MEk-sl	2749	Kiangi Creek For...	Informal	Member	Siltstone; minor fi...	P_-MEk-sk

Task 5.4 - To make this join permanent, save as “Geol_Surf_2749_details”. Note this will load the new layer into the map window. Close the original file. Now when you click on a polygon with the information tool you will get all the geological detail.

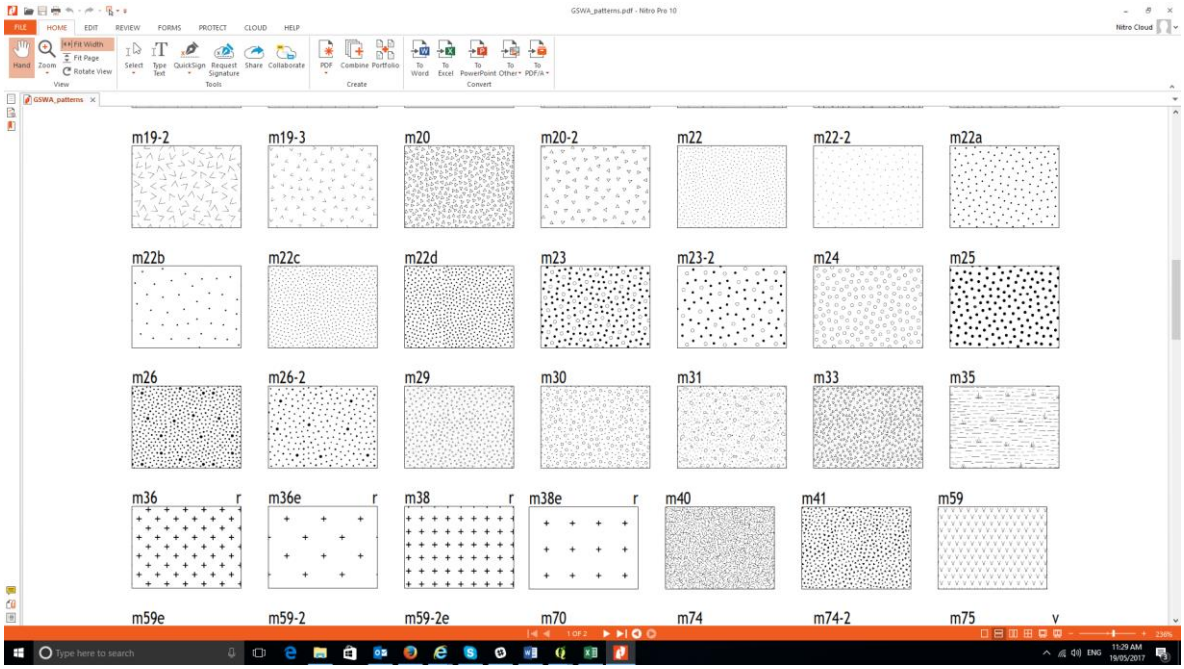


Task 5.9 - To obtain a suitable legend, you need to edit the polygon fill data in the Layer Properties > Style tab. The details of the polygon colours and fills are in the RGB_2749.xls file.



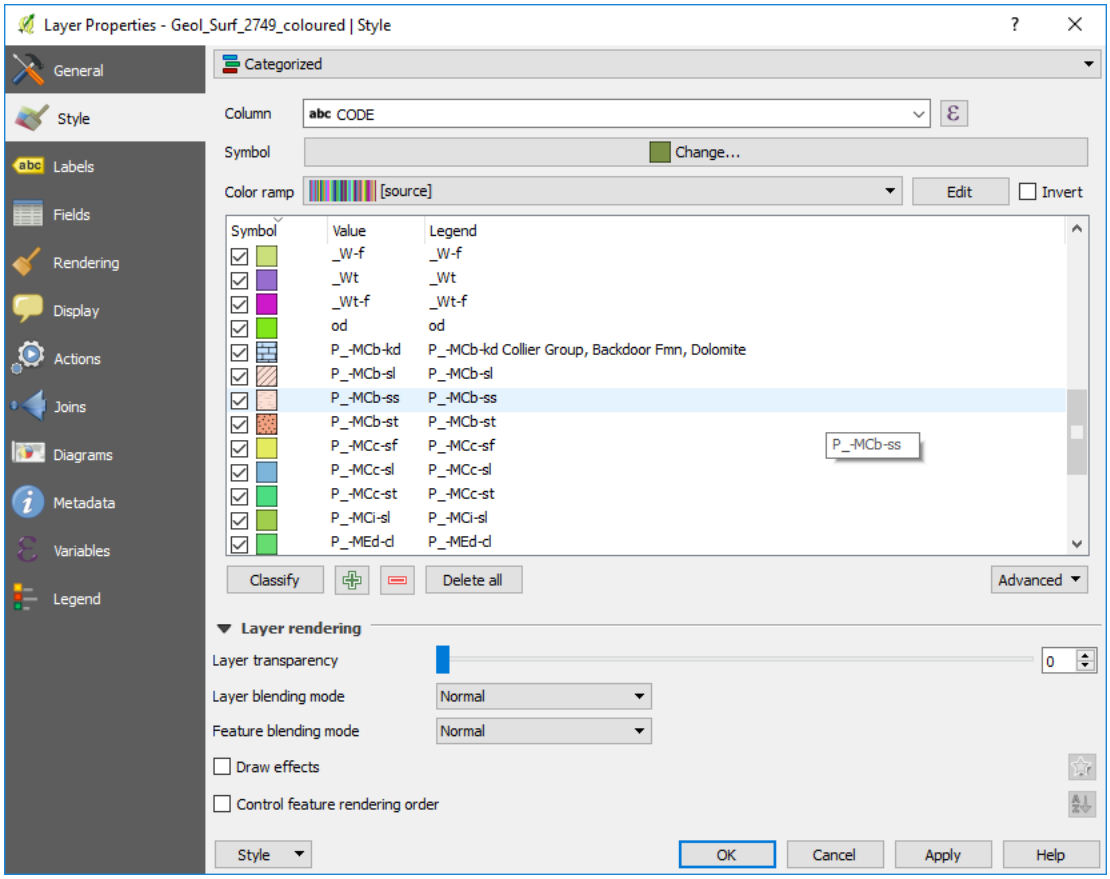
	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	CODE	JNCODE	MAP	SORT	back_red	back_green	back_blue	fore_red	fore_green	fore_blue	PANTONE	OVERPRINT	PATTERN	
2	_A	2749;_A	2749	6	255	252	236	198	222	10	121_10	397_100	m22b	
3	_A1	2749;_A1	2749	12	254	246	198				121_30			
4	_A1-cb	2749;_A1-cb	2749	13	254	246	198	198	222	10	121_30	397_100	l114d	
5	_A2	2749;_A2	2749	16	254	240	160	198	222	10	121_50	397_100	d101-2	
6	_A2-f	2749;_A2-f	2749	17	254	240	160	234	156	18	121_50	145_100	m26-2	
7	A3	2749; A3	2749	20	254	234	121	198	222	10	121 70	397 100	d105-3	

Each geological code (“CODE”) will have a background RGB colour for the polygon, and a foreground colour for the overprint pattern. The pattern type is shown in the PATTERN field and users are referred to the “GSWA_patterns.pdf” located in the “Workshop\ProjectFiles\Geology\2749_LoftyRange\DOCUMENTS\SYMBOLOGY” folder.

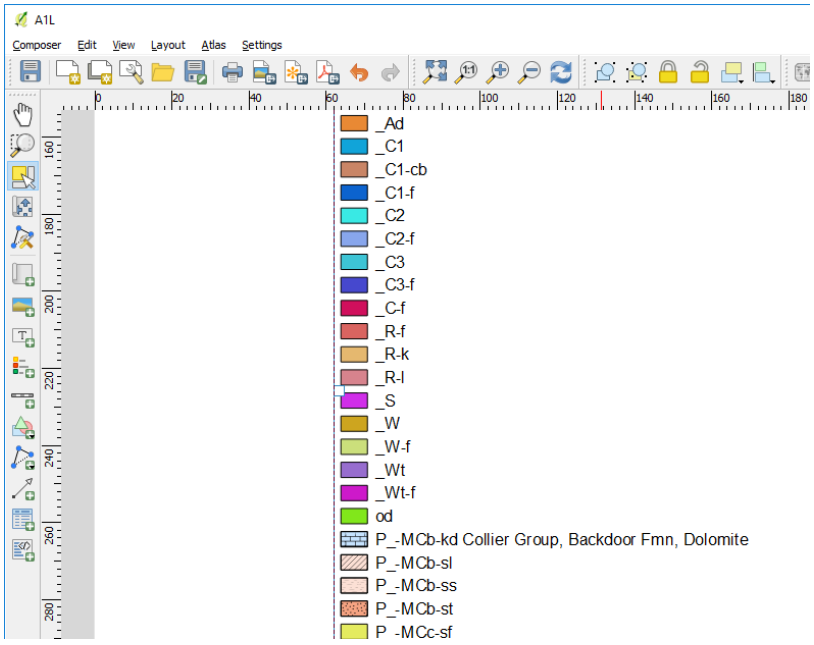


These pattern numbers correspond to pattern numbers in the geological patterns folders in the svg folder.

The text that appears in the legend can be edited in the Layer Properties > Style tab to include the Formation names and rock types as required. The information in the “Legend” column will be displayed in the legend. Double click on the entry in the “Legend” column to edit this data.



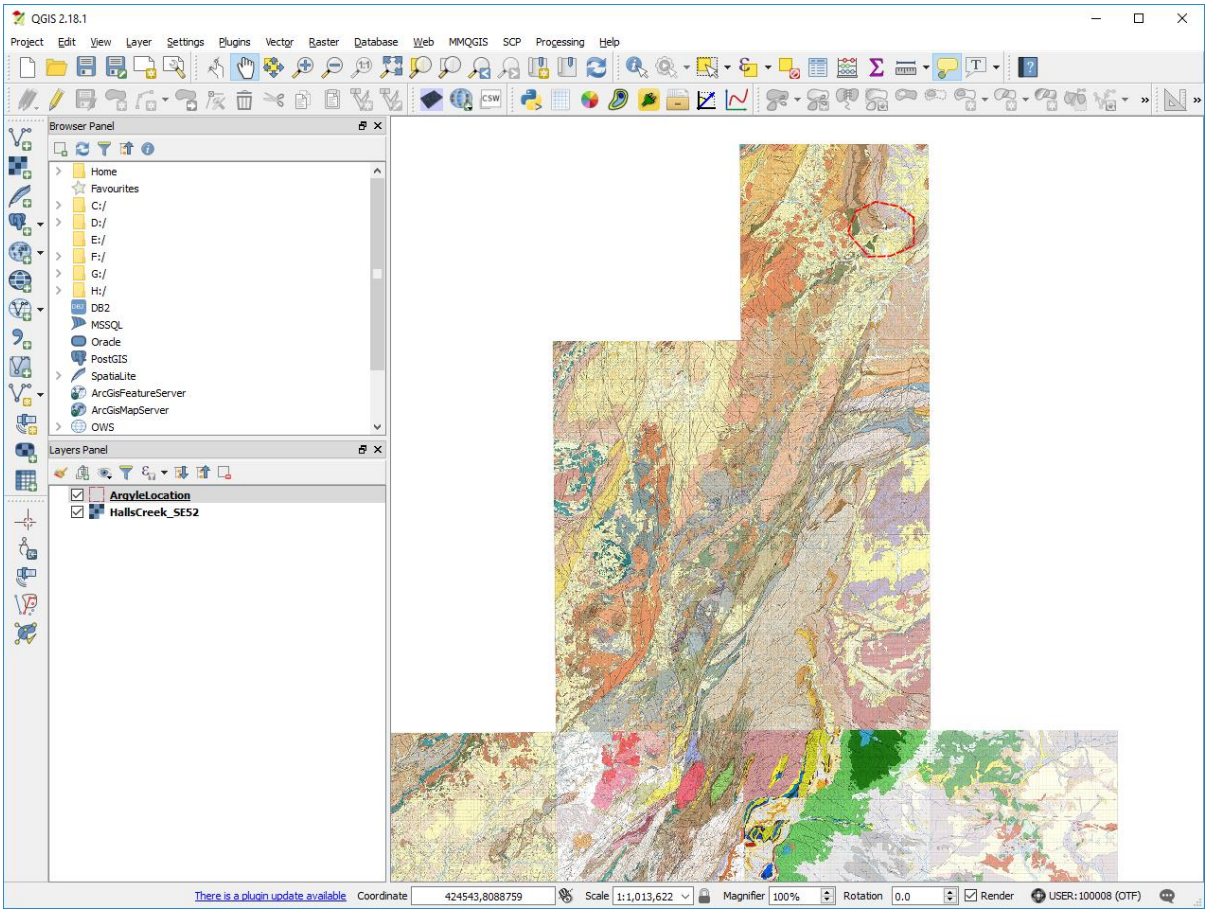
Double click on the geological pattern in the Symbol column of the Style tab, and select the pattern and colour required for each geological type (see section xx above). The legend would appear in the map composer as below.



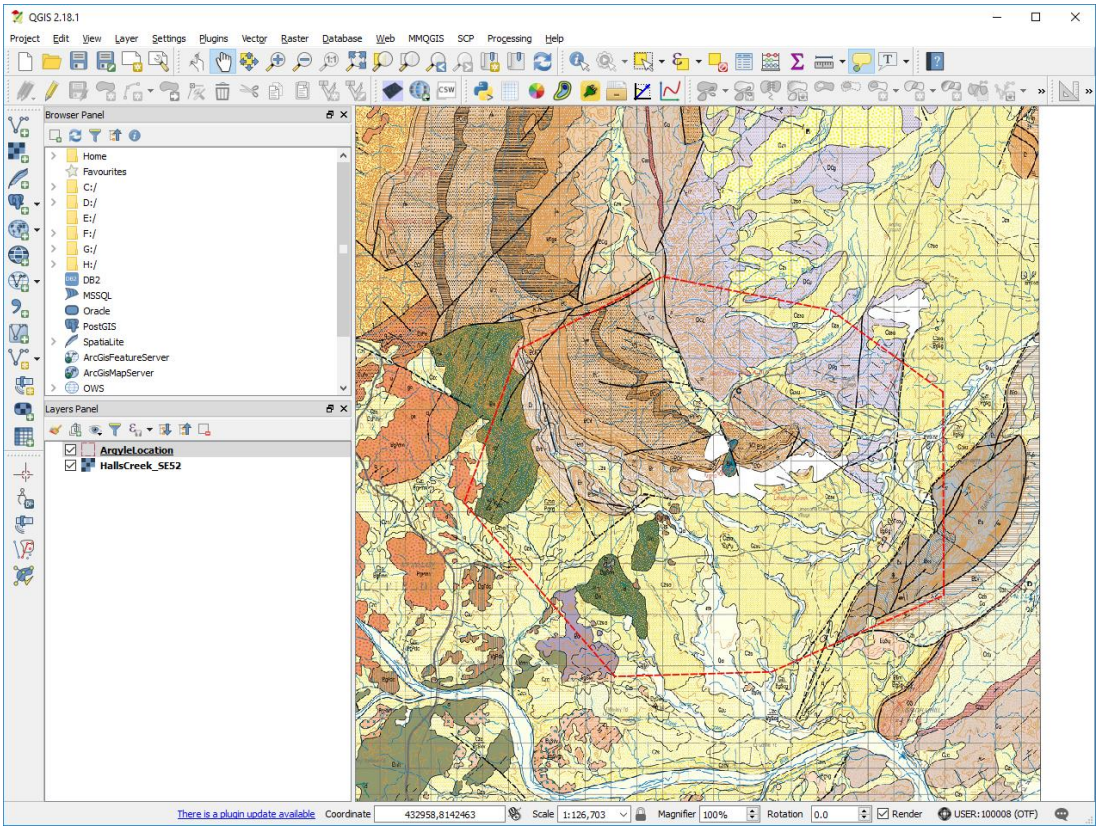
Work is currently pending to automate this process from data supplied by the GSWA.

Hands-On Workshop 6 – Creating coloured raster data for ASTER, Landsat and Sentinel Satellite Data

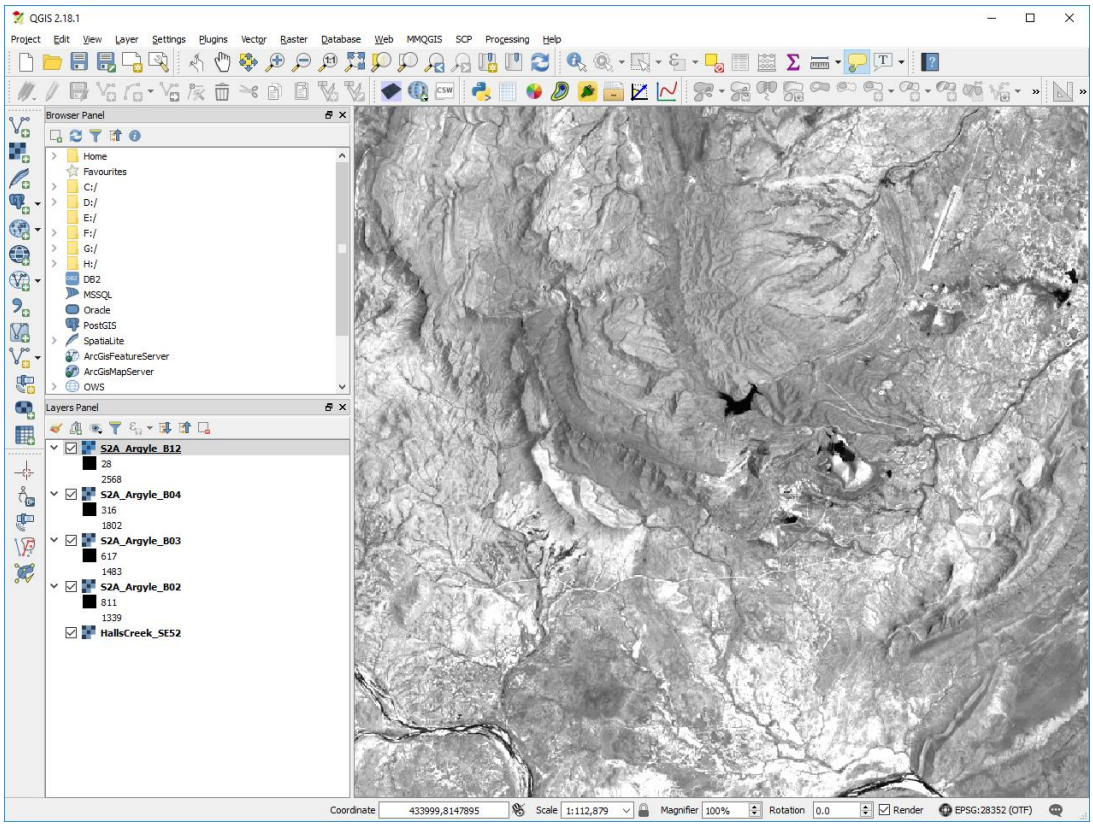
Task 6.1 - Create a new blank project and load the raster file “HallsCreek_SE52.jp2” and the “ArgyleLocation.shp” vector file. Zoom into the area around the Argyle diamond mine which is in the top right-hand corner of geology image.



The view should look something like the one below.

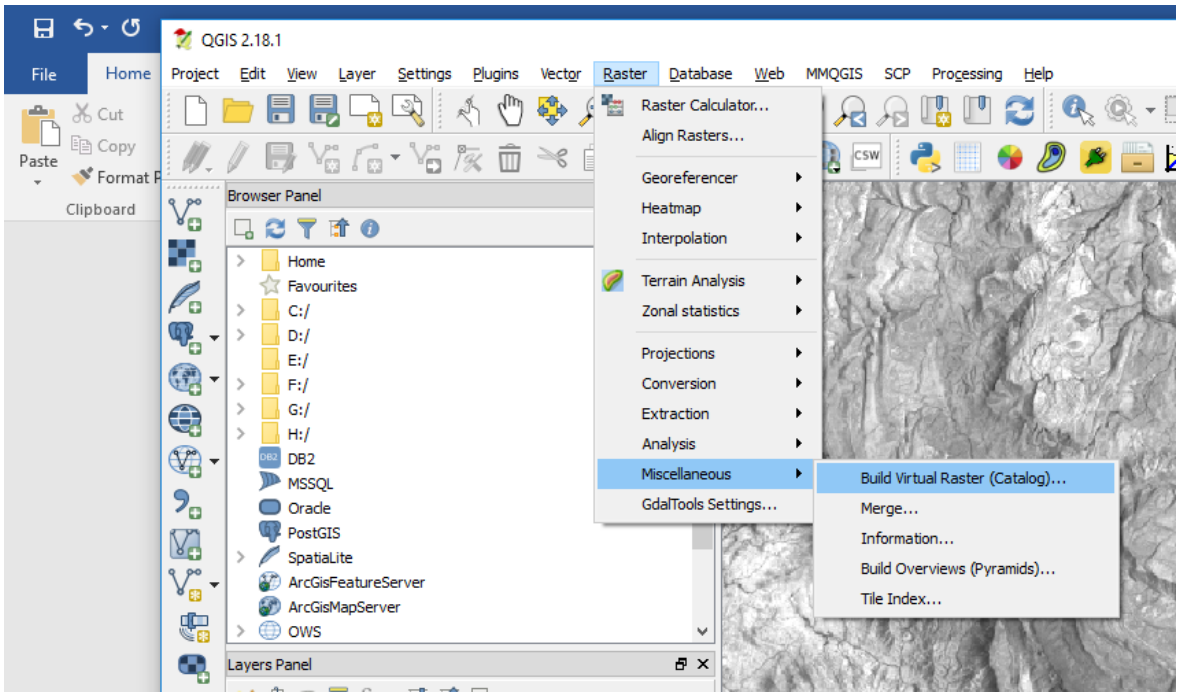


Task 6.2 – Load the four jp2 raster images from “Workshop\ProjectFiles\SatelliteData\Sentinel”. There are four images comprising Sentinel satellite data for bands 2, 3, 4 and 12. We will create rgb images of this data.

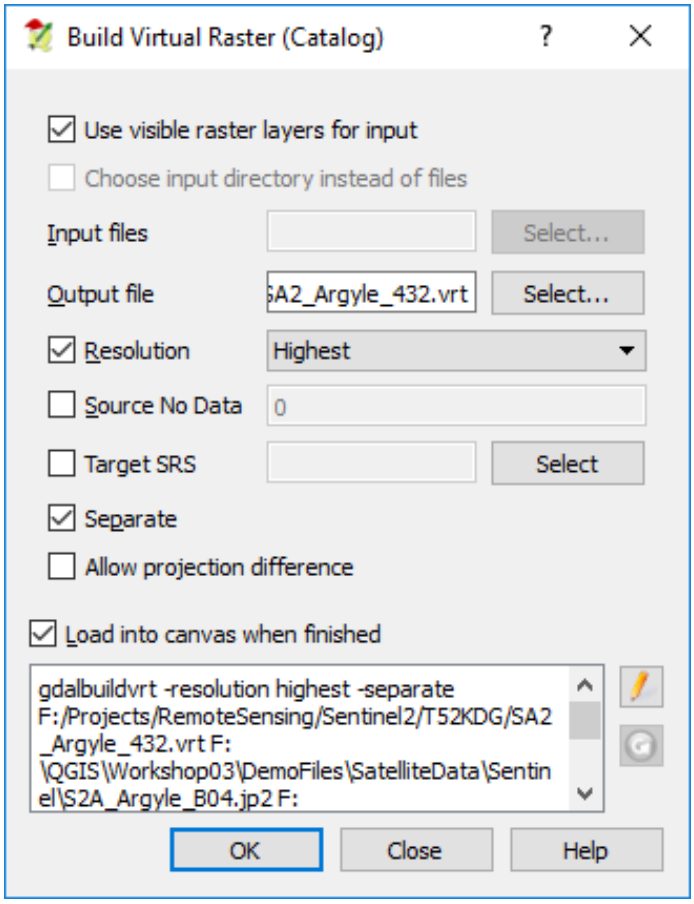


Note that when each band is loaded into the window and the min-max values are automatically calculated and shown for each layer. If when bringing in raster or grid data the screen is black, it indicates that QGIS has not correctly stretched the data. Zoom in to a small part of the image and re-stretch by highlighting the layer in the Layers panel, right click, and “Stretch Using Current Extent”.

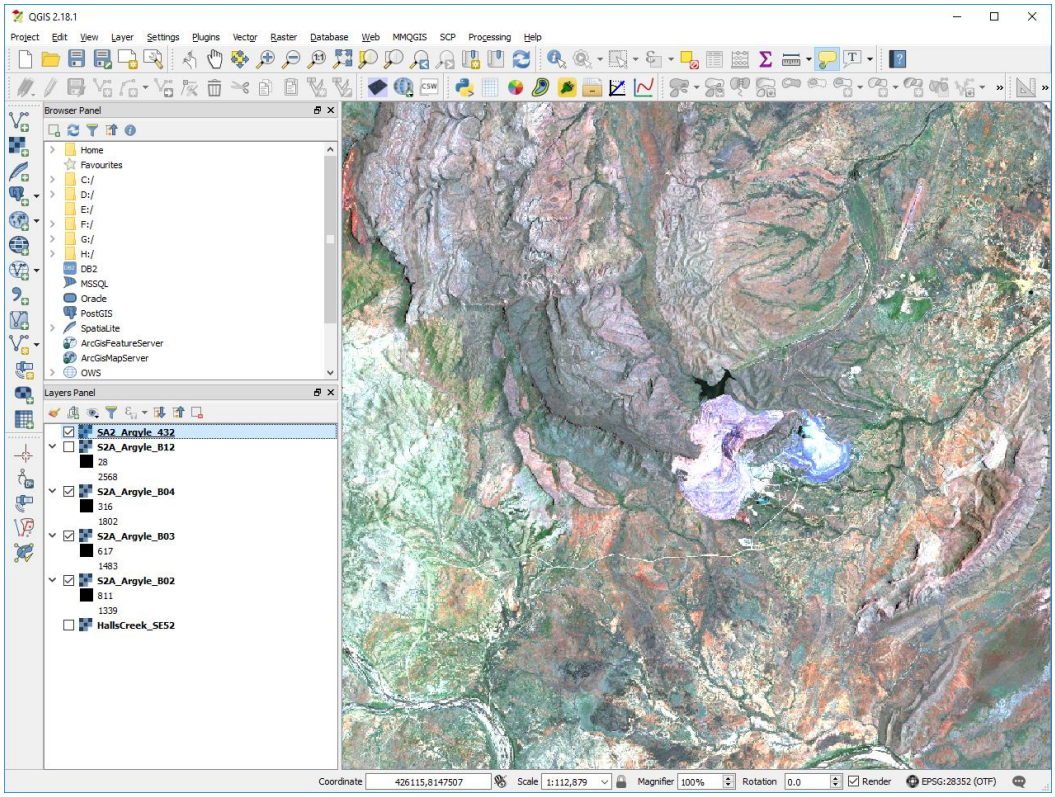
Task 6.7 - To create a coloured image (“rgb”) of the data, use the Raster > Miscellaneous > Build Virtual Raster.



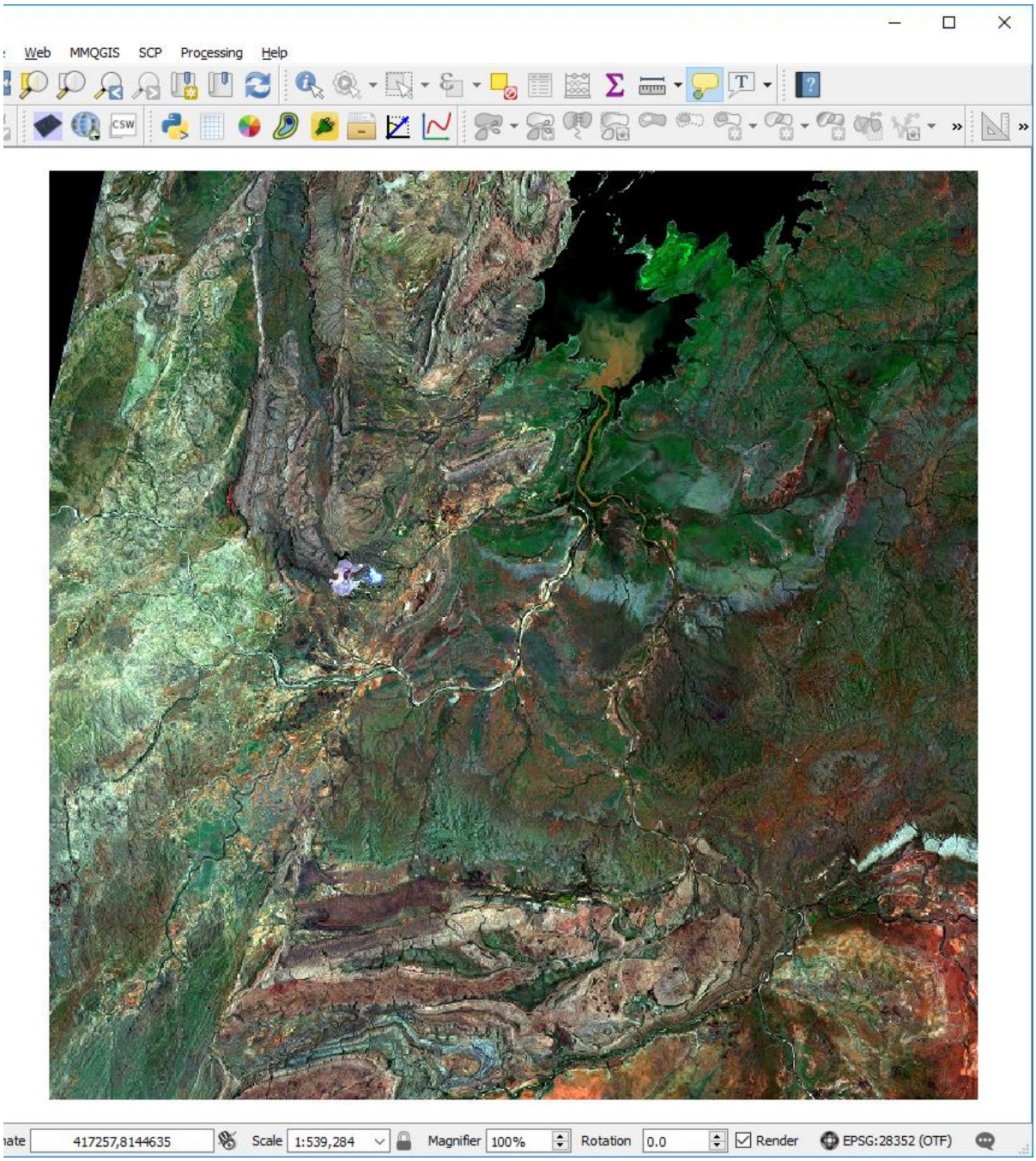
Note that in the Layers panel, I usually only have the three bands visible for which I want to create the rgb image. This simplifies the process for creating the rgb image. This makes it easier to select the correct images for the colour composite. Click on the “Select” button to find a location where you can save the files (note: QGIS may default to a directory you cannot write to – so it is important to go via the Select button – otherwise the process may fail). Tick the “Resolution” box and select “Highest”. This will ensure the image is produced with the highest available resolution (similar to “pansharpening”). It is important to select the “Separate” tick box so that the program separates the output into three bands that can be allocated to red, green and blue. If your image comes out grey, it usually means this “Separate” option was not selected.



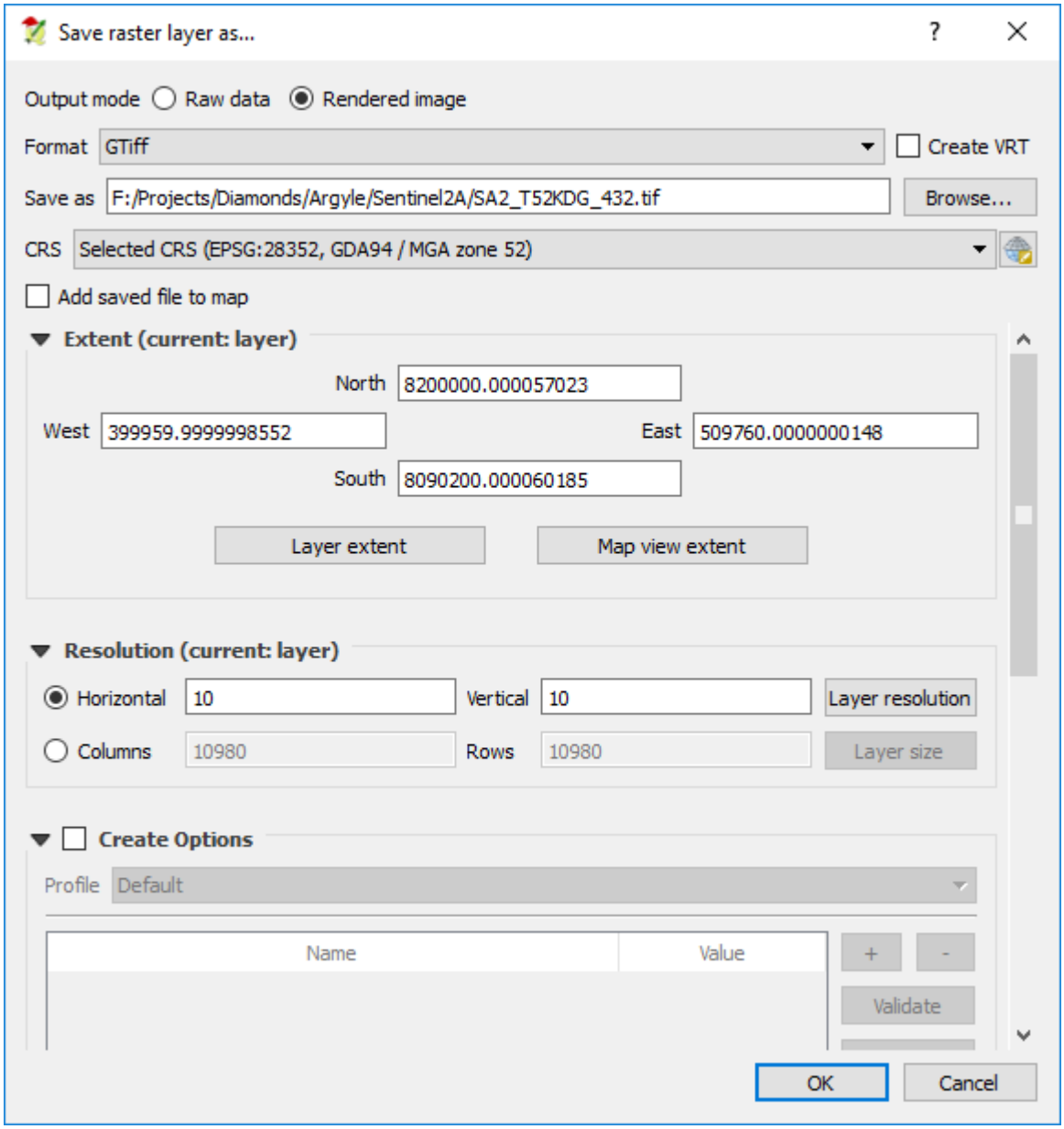
Click OK and after a little while an rgb image should be produced. Note to close this dialog box, press “Close” NOT OK.



Task 6.8 - To change the colour stretch, zoom into a part of the image where you want to see more detail and then use the Layer panel to right click on the rgb layer and select “Stretch using current extent”. This can be done multiple times until you get the desired result (see below for example).



Task 6.9 - The rgb image is currently only a “virtual file”. To create a permanent image, right click on the image layer in the Layers panel and select “Save As” Select the “Rendered Image” option, click the “Browse” and select the folder and required file name. Change the coordinate system if required. When all is OK, click OK. It may take some time to create the tiff file depending upon the size of the image and the speed of your computer.



Other rgb band combinations can be produced using the same method. If you want to do band arithmetic/ratios, use the “Band Calc” tab in the SCP plug-in.

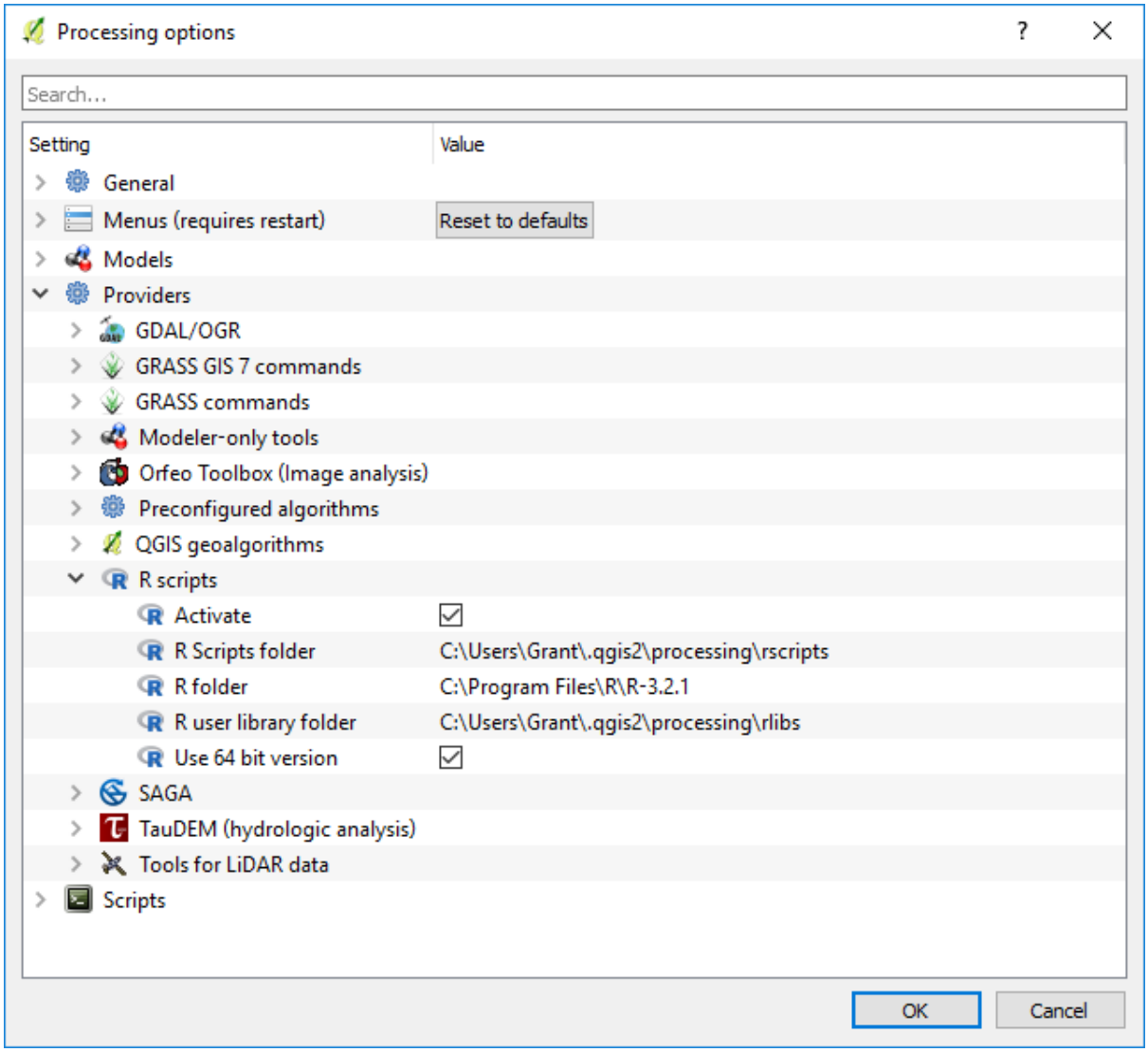
A good RGB blend to enhance geological features is the band combination 12, 4 and 2

Similar processes can be used for ASTER and Landsat data

APPENDIX 2

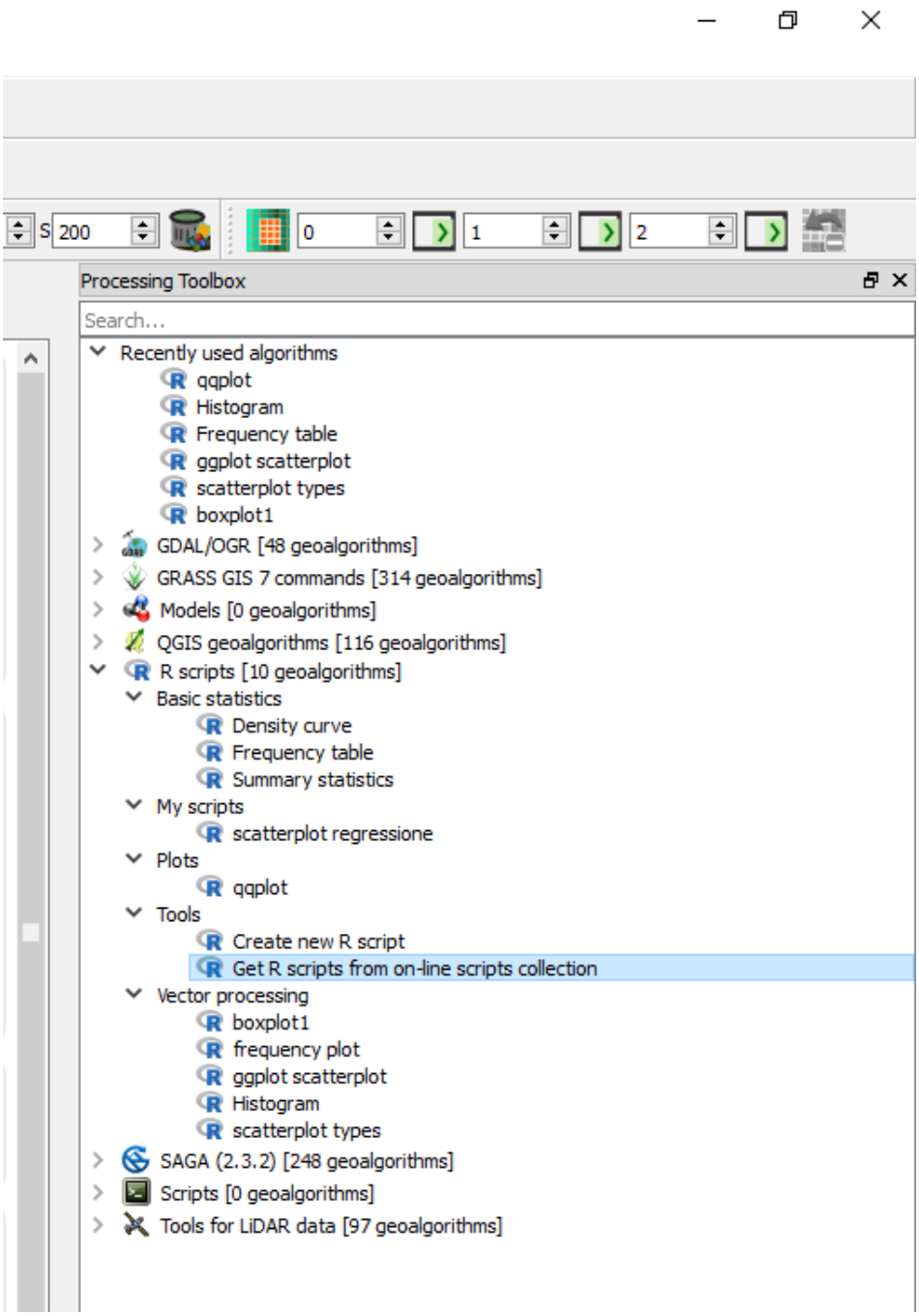
PLOTTING GEOCHEMICAL DATA

Geochemical data can be plotted in QGIS using the R program. R is an open source statistical package which, like QGIS, has many add-ons to increase its flexibility. To use R in QGIS, you are required to install R (https://www.r-project.org/) and then set the options in the Processing Toolbox so that QGIS can find the program.

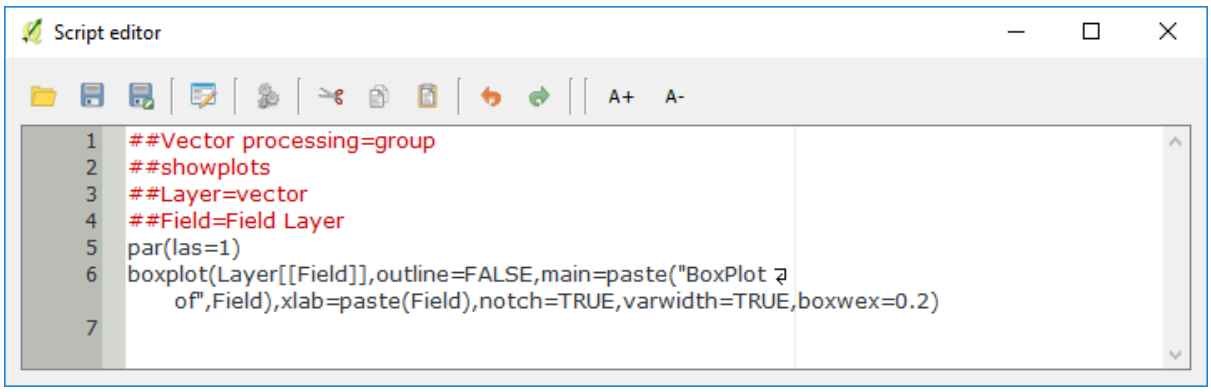


To use the graphing functions in R, it is recommended to load the “sp”, “rgdal”, Rcmdr, “ggplot2”, and “raster” packages via the Packages > Install Packages option. Select a local mirror site from the displayed list (Curtin Uni for Perth) and select the packages from the list. Run R and then load the “Rcmdr” package. This brings up a new window for the selection and loading of data and a variety of other functions.

Histogram, box plots and cumulative frequency (QQplots) can also be run from the QGIS > Processing Toolbox > R > scripts toolbox. Select the “Get R scripts from on-line scripts collection” and this will allow you to select which scripts to download. Initially download the “frequency plot”, “histogram” and “qqplot” scripts. These basic scripts can be modified to create “boxplots”.



An example plot script is shown below to produce box plots.



The Geochemical Data Toolkit (GCDkit) for R is a program running in R that allows for the plotting of a variety of geochemical plots including binary and tertiary plots, Harker diagrams, spider plots, several dozen classification and geotectonic discrimination diagrams (Janousek et al 2006). GCDkit current only runs under version 3.2.1 of R, so this version must be used to run GCDkit. This currently doesn't run under QGIS.