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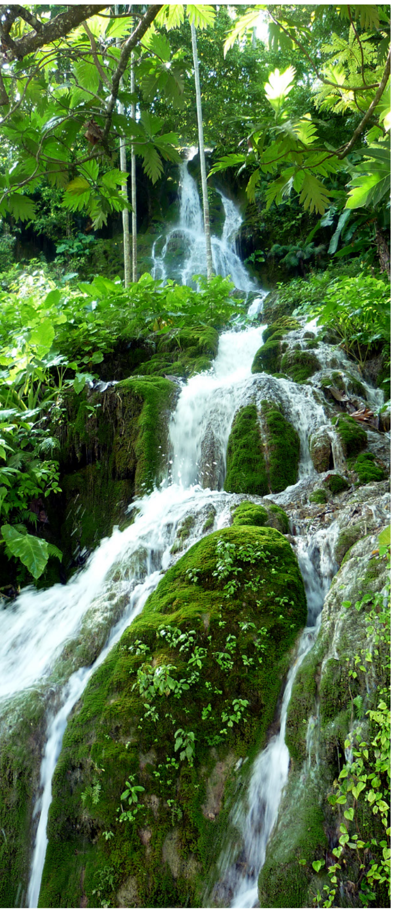

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GIS methods for hydrogeology mapping in Timor-Leste, QGIS version (free software)

Vulnerability assessment of climate change impacts on groundwater resources in Timor-Leste

Gerard Stewart, David Craven, Sam Dawson, Luke Wallace and Baskaran Sundaram

Australian AID

International CLIMATE CHANGE ADAPTATION Initiative

Prepared for the Australian Government Department of Climate Change and Energy Efficiency **July 2012**

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PREPARED FOR THE AUSTRALIAN GOVERNMENT DEPARTMENT OF CLIMATE CHANGE AND ENERGY EFFICIENCY

BY GEOSCIENCE AUSTRALIA

July 2012

by

Gerard Stewart[1], David Craven[2], Sam Dawson[1], Luke Wallace[1] and Baskaran Sundaram[1].

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Table of Contents

1. Introduction

1.1 PURPOSE

This document outlines some of the methods used by Geoscience Australia (GA) to symbolise the Geology and Hydrogeology map of Timor-Leste. It is designed to be used as a knowledge-sharing and educational tool by water resource management and geology technicians from Timor-Leste government agencies.

1.2 BACKGROUND

In August 2010 the Geoscience Australia Timor-Leste Groundwater project team collected numerous datasets from various government departments in Timor-Leste. These included several geology maps, however none of these maps had standard geological colours applied to them, including the one selected as a base for the hydrogeological map. Furthermore, the map GA used did not have any metadata attached to it, therefore there was no attributed creator. Despite several attempts we were unable to ascertain the makers of this map, and were therefore unable to consult them as to the colouring used when the map was created. It was decided that, for both ease of use and as an output to return to the country, standard geological colouring should be applied to this map. The following details the methods used to apply standard colouring to the map.

1.3 AUDIENCE

The intended readers of this document are GIS users from DNGRA, SERN, BESIK and other government departments and stakeholder groups in Timor-Leste.

1.4 USEFUL CONTACTS

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Email Luke.wallace@ga.gov.au

1.5 CONVENTIONS USED

The following table describes the instructional indicators of this GIS methods training manual.

DESCRIPTION	EXAMPLE	PURPOSE
Bold text	Click the **Add Data** button.	Indication to click a button or tool, or gain readers attention to what is important.
Keyboard button	Press the **<Enter>** button on your keyboard.	Indication to press the Enter key on your keyboard.
Diagram labels	A) Click here	Label used to visually indicate steps in the diagrams. A) B) C) etc indicate the order to complete a sequence of operations or procedures

1.6 NOTES

Training data and directory
The data required to complete the exercises described in this document include the following:

ET_geol UTM – a polygon shapefile describing characteristics of Timor-Leste's geology and hydrogeology.

ET_Towns UTM – a point shapefile defining the locations of Timor-Leste's main settlements (District and Sub District capitals)

Software
This document provides instructions and guidance for users of Quantum GIS 1.7.2 software. The Operating software used was Microsoft Windows XP Professional Service Pack 3.

All students will receive a CD containing copies of the software and the data used for the course.

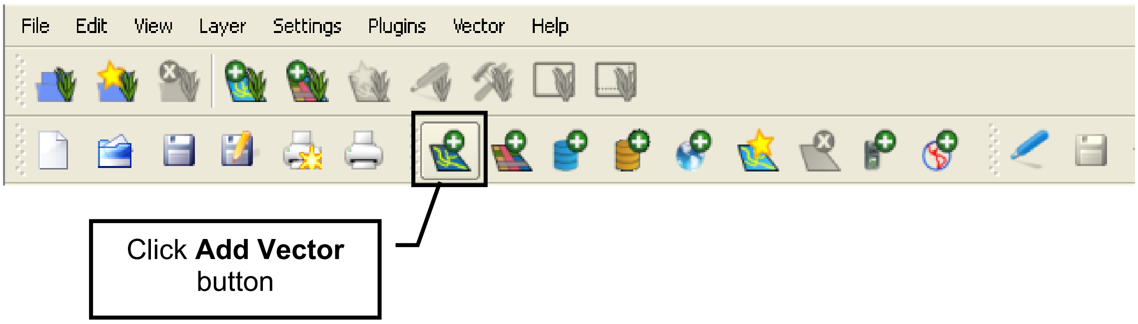
2 Editing Geological and Hydrogeological attributes

2.1 CREATING AND POPULATING A FIELD FOR STANDARD GEOLOGICAL MAP SYMBOLS

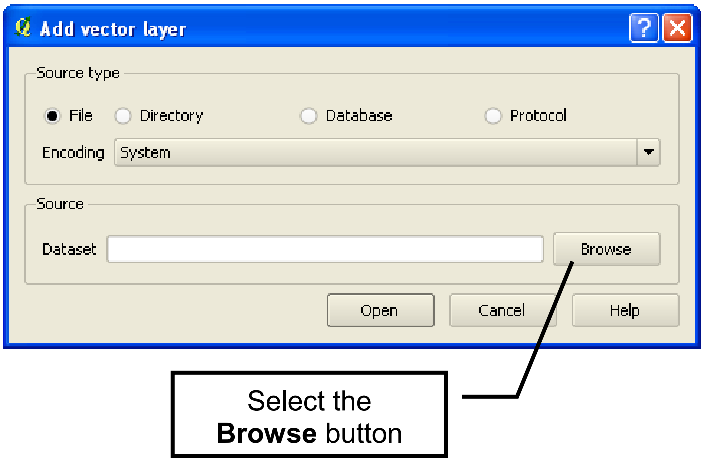
The task for this exercise is to change the geological map symbols recorded in the **ET_Geol UTM** attribute table. You will create a new field and populate that field with a new, standard symbol for each geological mapping unit.

1. Open **QGIS**.

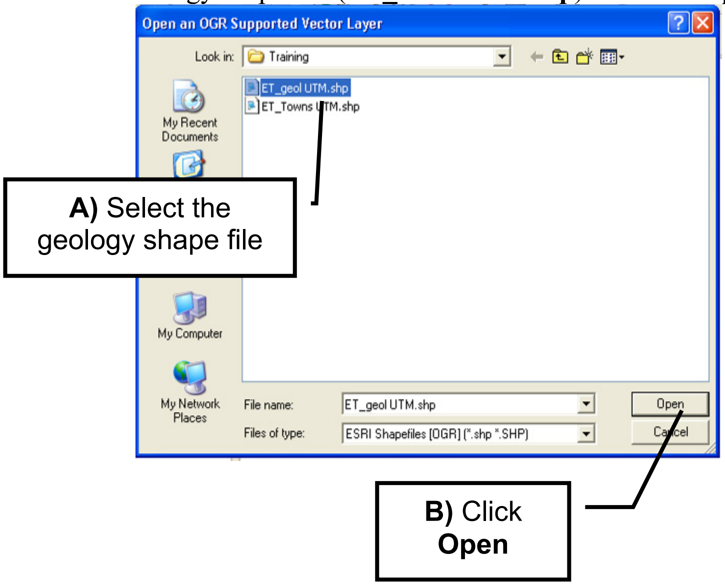
2. Click the **Add Vector Layer** button.



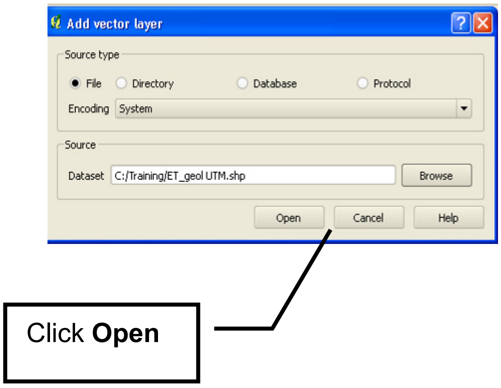
3. Click the **Browse** button and path to the directory of the Training folder.



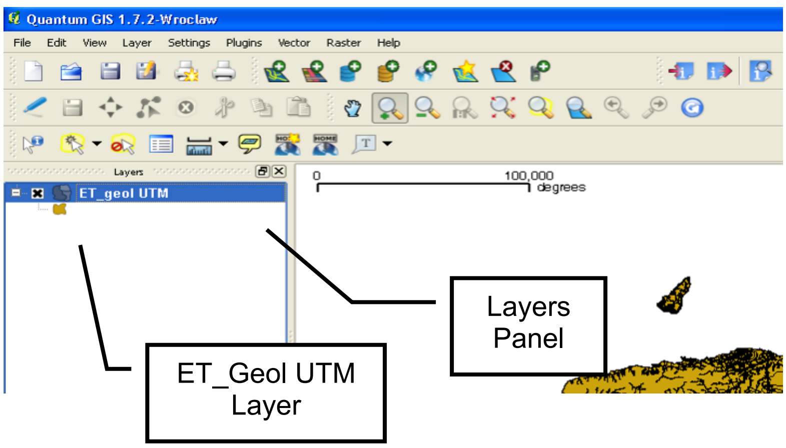
4. Select the Geology shape file (**ET_Geol UTM.shp**) and click **Open**.



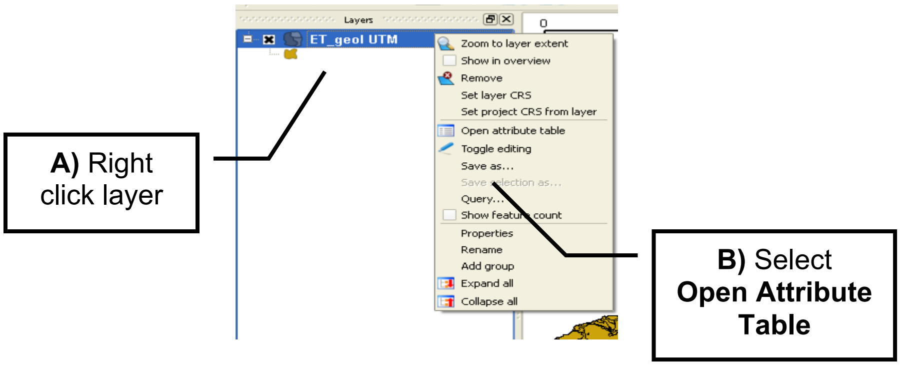
5. In the **Add vector layer** window, click **Open**.



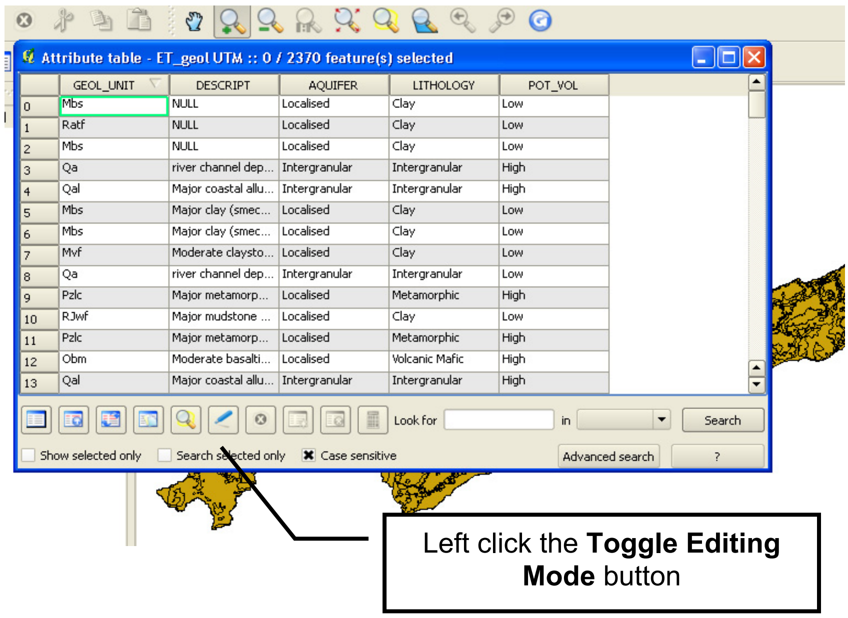
The geology file (**ET_Geol UTM**) is now displayed in the main window, it is also added as a layer in the **Layers** panel, left of the main window.



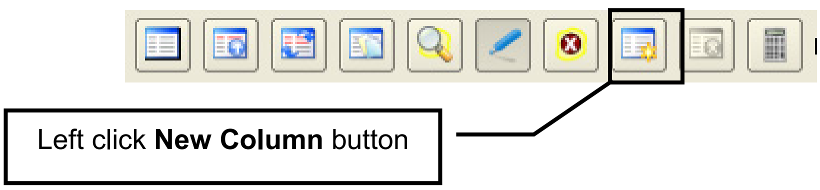
6. Open the attribute table of **ET_Geol UTM** in the layers panel by right clicking on the layer name within the table of contents and selecting **Open Attribute Table**.



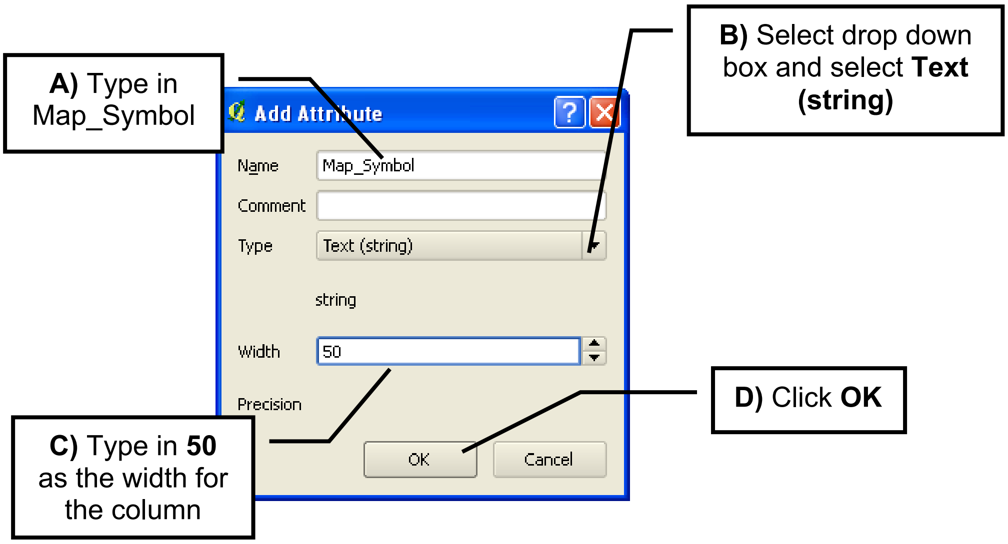
7. The attribute table of **ET_Geol UTM** will appear. At the bottom of the table, turn editing on by selecting the Toggle editing mode button. This will enable us to edit the feature.



8. Add another column/field to the attribute table by left clicking the **New Column** button.



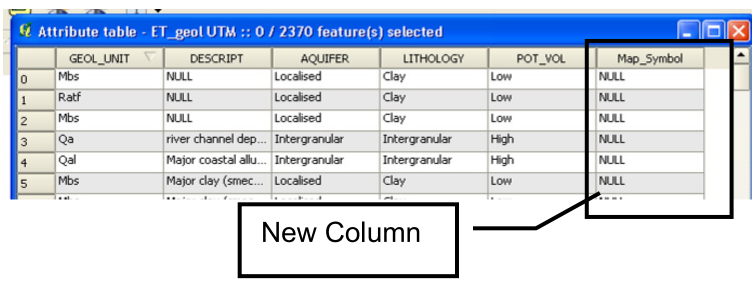
9. In the **Add Attribute** box, type **Name: Map_Symbol**, then under **Type,** use the drop down arrow and select **Text (string)** (this means that it will be text and not a number in the field. For the column **Width** type in 50.



> **Note:** Field names cannot have spaces, so we use _(underscores) for spaces.

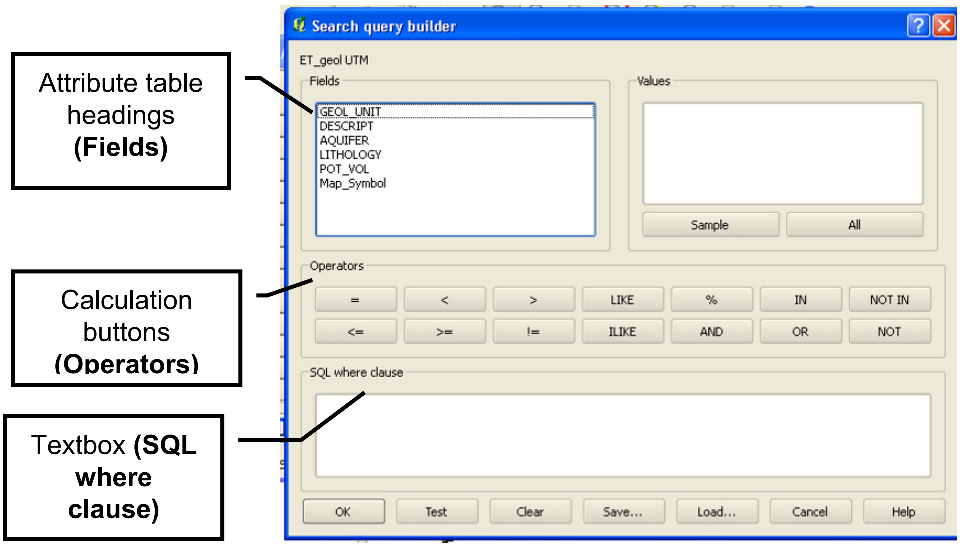
10. Click **OK**.

> **Result:** The Map_Symbol field appears as the last field in the attribute table. At this stage, the Map_Symbol value for all 2,370 features is 'NULL'.



11. In the attribute table, click the **Advanced search** button.

The **Search query builder** window appears with a list of the attribute table headings **(Fields)**, some calculation buttons **(Operators)** and a textbox at the bottom into which are typed search expressions **(SQL where clause)**.



12. In the list of attribute table headings (**Fields**) select the field you want to perform the operation on. In this case, we want to select features based on values in the geological unit field, so double click on **Geol_Unit**. The field name **Geol_Unit** will appear in the textbox.

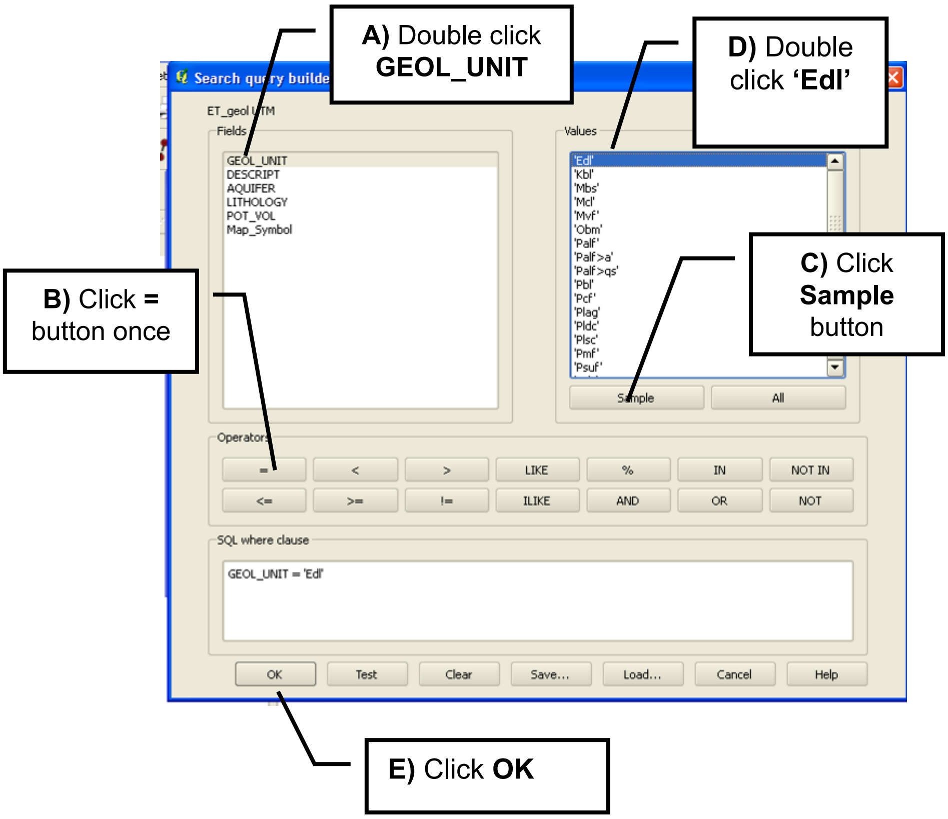
13. Click the = button once.

14. Click the **Sample** button once.

A list of the unique values in the **GEOL_UNIT** field will appear in the right-hand window. This is the list of values from which you need to pick to select features meeting your search criteria. First, select all the features whose geological code is defined as **Edl**.

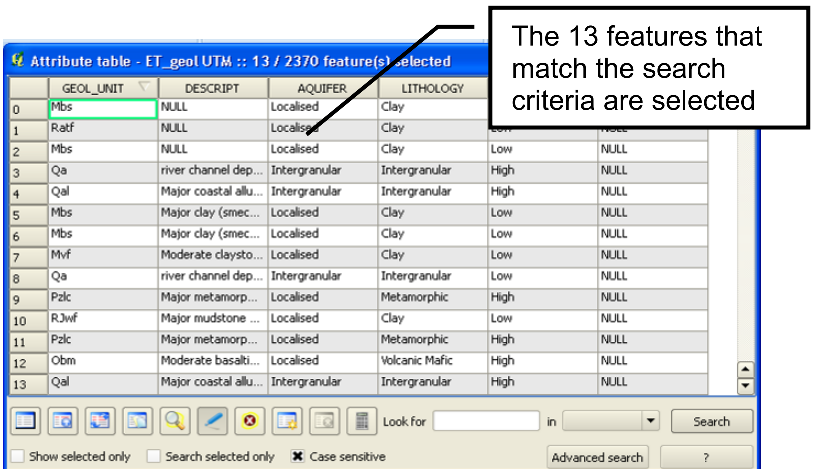
15. Double click **'Edl'**.

16. Click the **OK** button.

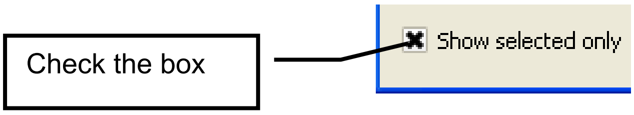


The **SQL where clause** (or search expression) in the illustration above is asking Quantum to select all the features whose **GEOL_UNIT** value is **Edl**

In this case, the notice at the top of the attribute table tells you that 13 features have GEOL_UNIT values of Edl (**13/2370 features selected**).



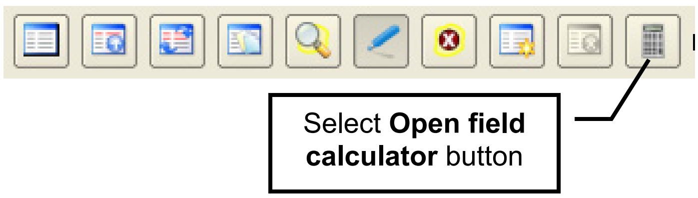
17. At the bottom of the attribute table, select the box of Show selected only.



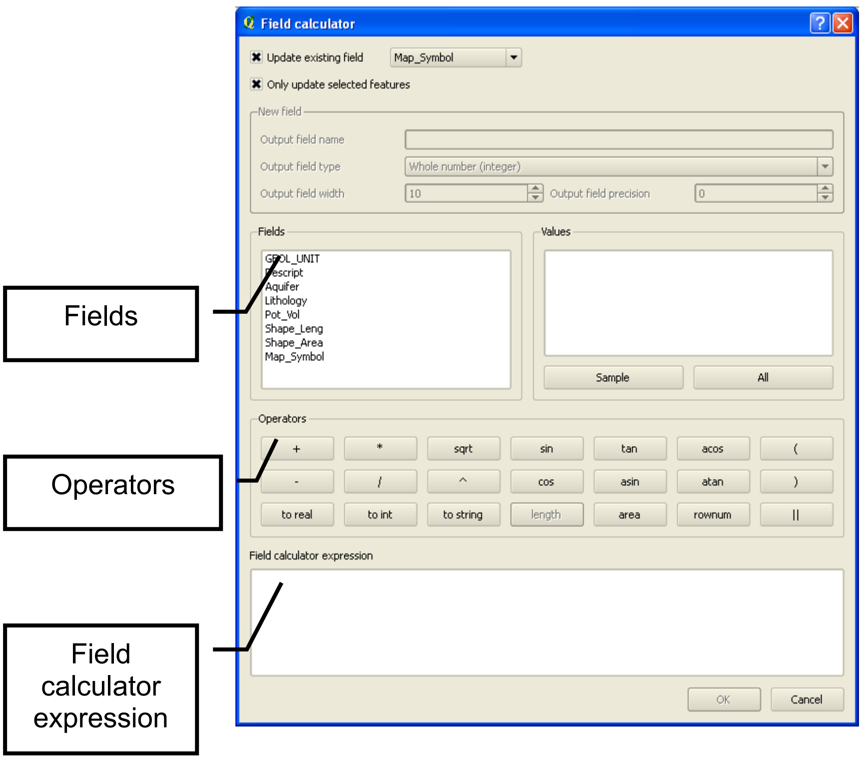
Note: The attribute table now displays records only for the 13 features that are selected.

For each of those 13 features, we now want to add a new, standard map symbol value in the **Map_Symbol** field.

18. Select the Open field calculator button.



The Field calculator window will appear and there will be a list of field headings from the attribute table **(Fields)**, some calculation buttons **(Operators)** and a textbox at the bottom into which are typed the expression used to populate the field being calculated **(Field calculator expression)**.



Note: The Field calculator looks a lot like the Search query builder, but it has a different function.

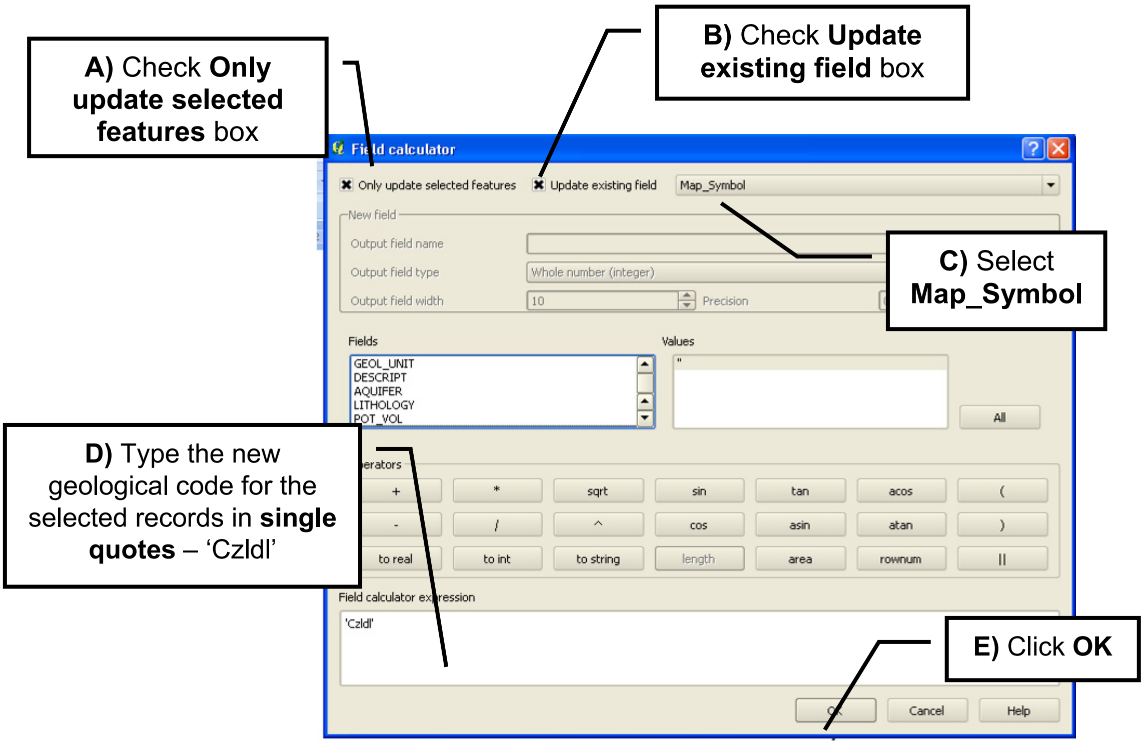
19. At the top of the window, check both the **Update existing field** and **Only update selected features** boxes.

20. Select **Map_Symbol** in the drop down box. This is the name of the existing field we want to calculate or update.

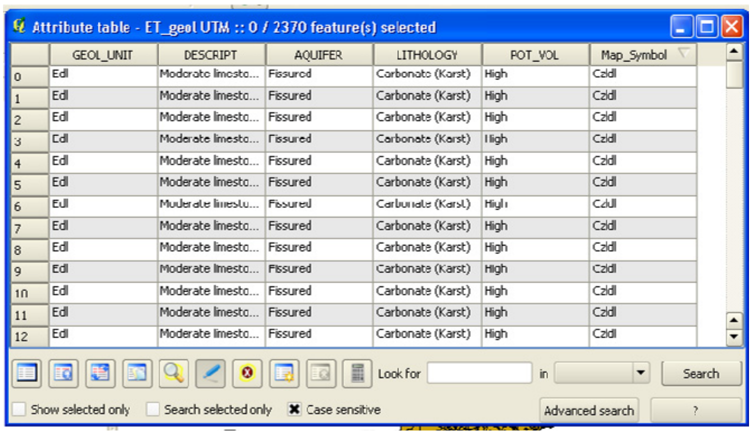
21. In the **Field calculator expression** textbox, type the text you want inserted into the **Map_Symbol** field. For the 13 features we have selected based on their **GEOL_UNIT** value of Edl, we want to enter Czldl as the **Map_Symbol** value. To do this, type **'Czldl'** in the **Field calculator expression** textbox.

> **Note:** You must use singe quotes around the text here – 'Czdl'. If you do not put in single quotes it will not work.

22. Click the **OK** button.



> ***RESULT:*** With steps 12 – 23 you have entered Map_Symbol values of 'Czldl' for the 13 features that have GEOL_UNIT values of 'Edl'.


Attribute table - ET_geol UTM :: 0 / 2370 feature(s) selected

	GEOL_UNIT	DESCRIPT	AQUIFER	LITHOLOGY	POT_VOL	Map_Symbol
0	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
1	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
2	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
3	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
4	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
5	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
6	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
7	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
8	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
9	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
10	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
11	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl
12	Edl	Moderate limesto...	Fissured	Carbonate (Karst)	High	Czdl

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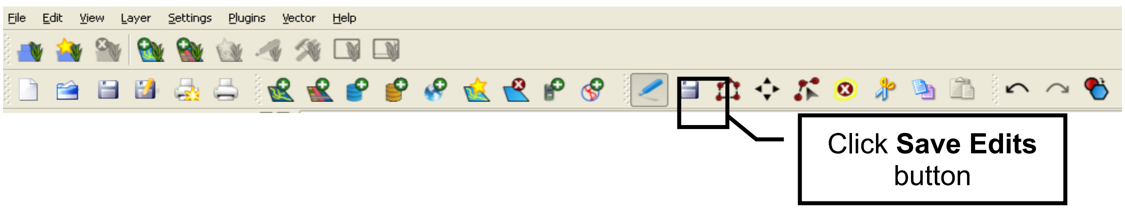
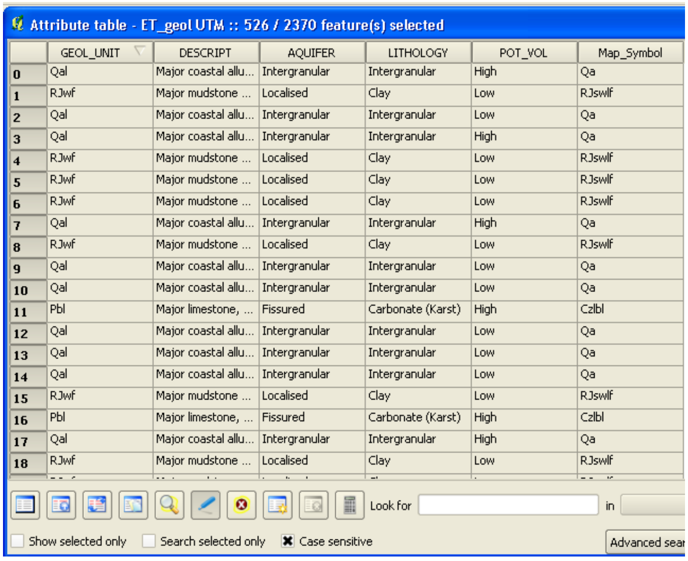
Show selected only Search selected only Case sensitive Advanced search ?

23. **Repeat steps 11 – 22** for more features in the ET_Geol UTM layer, selecting all the features in the attribute table with the following GEOL_UNIT values, calculating the corresponding values, and entering those values in the Map_Symbol field.

Note: Save your edits at regular intervals. To do this, go to the main toolbar located at the top of QGIS and click the **Save Edits** button.



RESULT: You will have entered new standard Map_Symbol values for 526 of the 2,370 features in the ET_GEOL UTM layer.


Attribute table - ET_geol UTM :: 526 / 2370 feature(s) selected

	GEOL_UNIT	DESCRIPT	AQUIFER	LITHOLOGY	POT_VOL	Map_Symbol
0	Qal	Major coastal allu...	Intergranular	Intergranular	High	Qa
1	RJwf	Major mudstone ...	Localised	Clay	Low	RJswlf
2	Qal	Major coastal allu...	Intergranular	Intergranular	Low	Qa
3	Qal	Major coastal allu...	Intergranular	Intergranular	High	Qa
4	RJwf	Major mudstone ...	Localised	Clay	Low	RJswlf
5	RJwf	Major mudstone ...	Localised	Clay	Low	RJswlf
6	RJwf	Major mudstone ...	Localised	Clay	Low	RJswlf
7	Qal	Major coastal allu...	Intergranular	Intergranular	High	Qa
8	RJwf	Major mudstone ...	Localised	Clay	Low	RJswlf
9	Qal	Major coastal allu...	Intergranular	Intergranular	Low	Qa
10	Qal	Major coastal allu...	Intergranular	Intergranular	Low	Qa
11	Pbl	Major limestone, ...	Fissured	Carbonate (Karst)	High	Czlbl
12	Qal	Major coastal allu...	Intergranular	Intergranular	Low	Qa
13	Qal	Major coastal allu...	Intergranular	Intergranular	Low	Qa
14	Qal	Major coastal allu...	Intergranular	Intergranular	Low	Qa
15	RJwf	Major mudstone ...	Localised	Clay	Low	RJswlf
16	Pbl	Major limestone, ...	Fissured	Carbonate (Karst)	High	Czlbl
17	Qal	Major coastal allu...	Intergranular	Intergranular	High	Qa
18	RJwf	Major mudstone ...	Localised	Clay	Low	RJswlf

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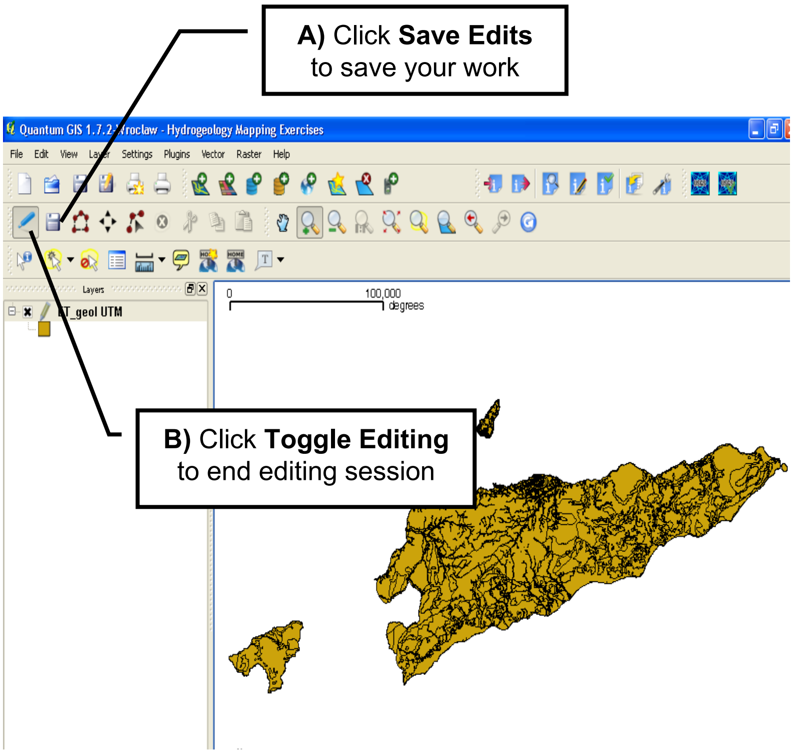
Complete the task by calculating Map_Symbol values for the remaining 1,844 features by **repeating steps 11-22** for each unique value in the GEOL_UNIT field. Refer to the **table in Attachment I (p. 59)** which shows corresponding Map_Symbols for all GEOL_UNIT symbols in the attribute table.

24. When you have finished calculating Map_Symbol values, save the changes by clicking the **Save Edits** button, and then close the editing session by clicking the **Toggle Editing** button.

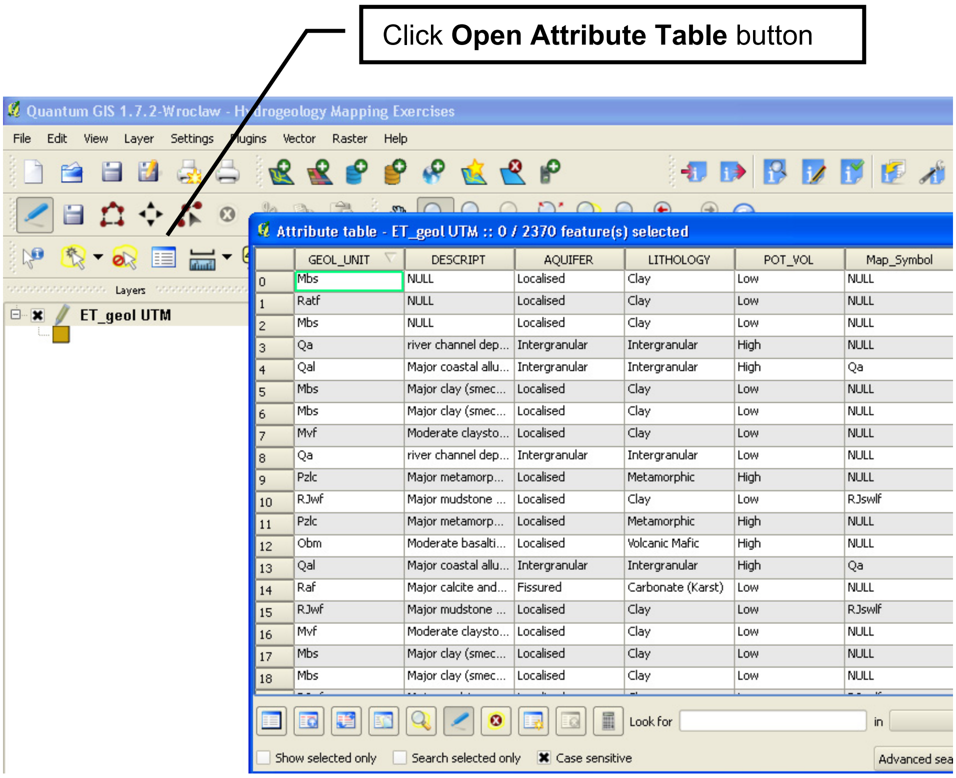


2.2 CALCULATING FEATURE GEOMETRY – AREA AND PERIMETER

The layer **ET_geol UTM** does not yet contain any feature geometry. To complete the exercise in Section 3.1.1 you will need to know the area of each individual feature (geological unit) in the layer. In this exercise (2.2) you will calculate the geometry of all 2,370 polygons in ET_geol UTM, and you will enter the data into two new fields – **Area** and **Perimeter**. You will then create two more new fields in which you will convert the area values from square metres to **Hectares** and **Square Kilometres**.

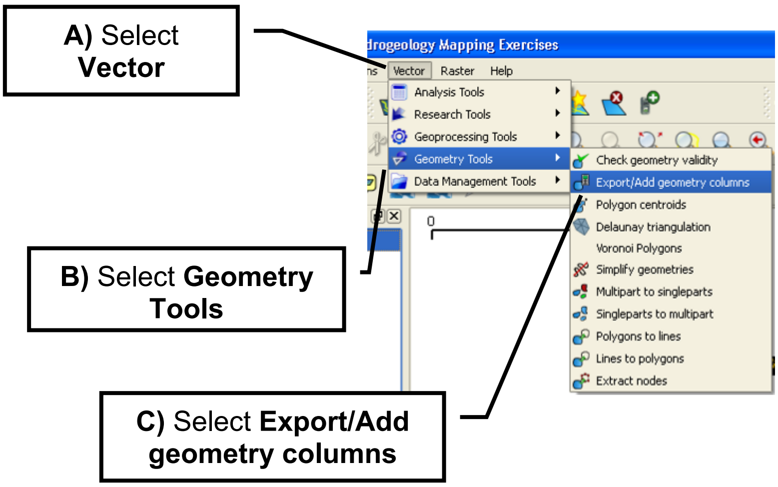
1. If it's not already running, open Quantum GIS and load **ET_geol UTM**

2. Click the **Open Attribute Table** button to open the ET_geol UTM attribute table.

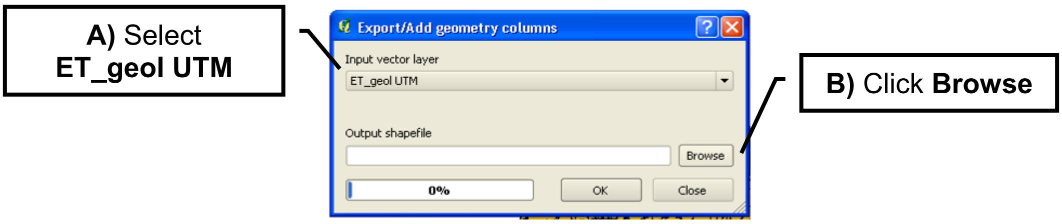


Note: The attribute table has 6 fields - GEOL_UNIT, DESCRIPT, AQUIFER, LITHOLOGY, POT_VAL and Map_Symbol, but it does not have an **Area** or **Perimeter** field.

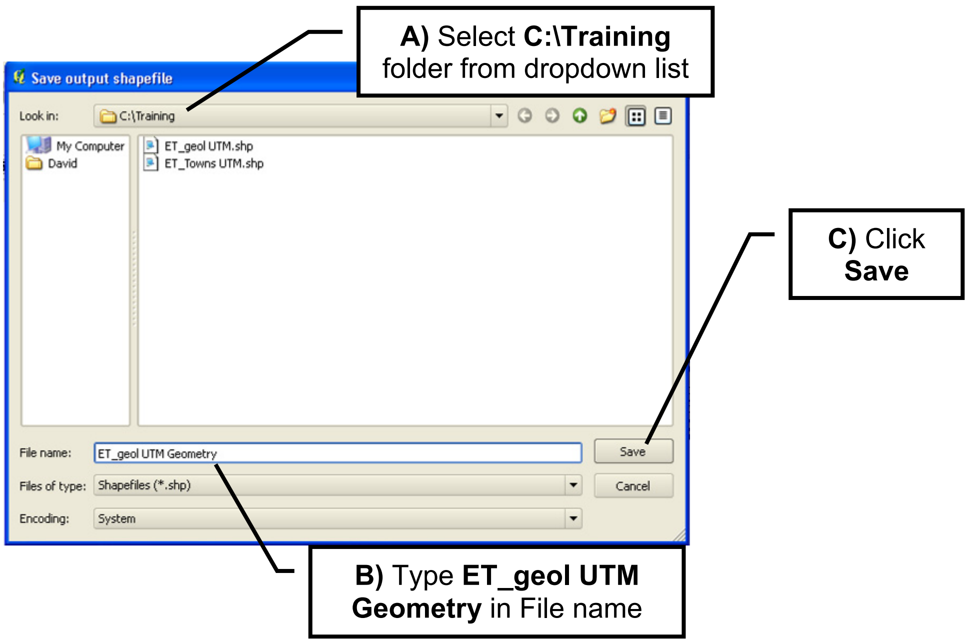
3. Close the attribute table, then, from the menu bar at the top of the main Quantum GIS window, select **Vector – Geometry Tools – Export/Add geometry columns.**



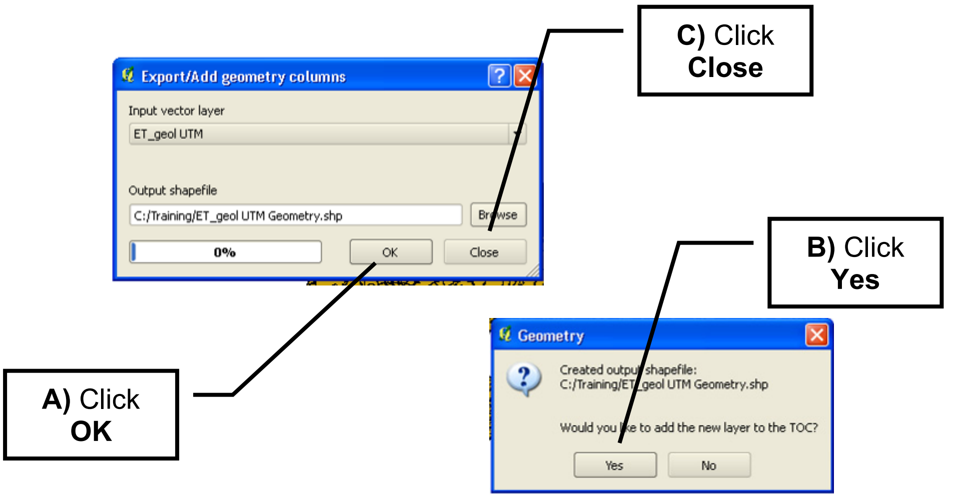
4. In the Export/Add geometry columns window, select **ET_geol UTM** from the drop down list as the Input Vector Layer (you have no choice because you currently have only 1 layer loaded in the Layers panel). Then click **Browse** to enter the name of the output shapefile.



5. In the Save output shapefile window, type **ET_geol UTM Geometry**. Be careful to save the new shapefile in the **C:\Training folder**. Then click **Save**.

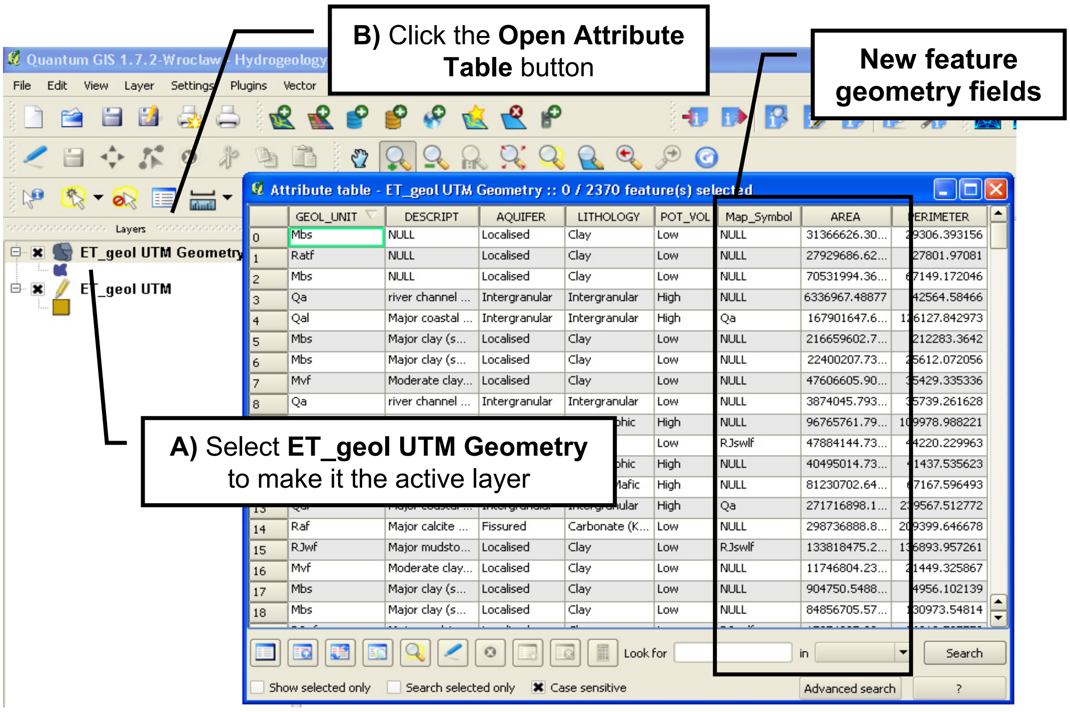


6. Click **OK** in the Export/Add geometry columns window and wait for Quantum to process the data. Then answer **Yes** to the question "Would you like to add the new layer to the TOC?" Then **Close** the Export/Add geometry columns window.



Result: You have created a new layer which has added the populated Area and Perimeter fields to the original ET_geol UTM layer.

7. To see your results, click **ET_geol UTM Geometry** in the Layers panel to make it the active layer, and then click the **Open Attribute Table** button. The Area and Perimeter fields appear at the right-hand side of the attribute table.

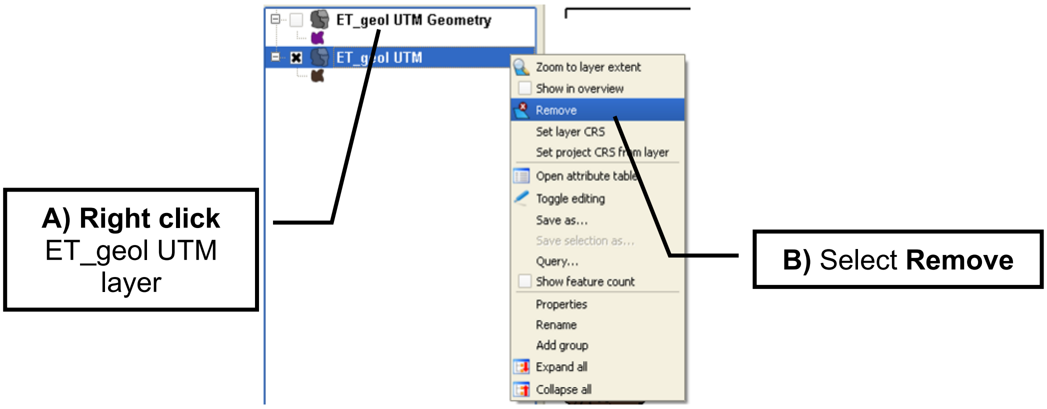


Note: The geometry parameters are reported in **square metres** for Area and **metres** for Perimeter. They are also reported to six decimal places, a **very high level of precision** that can be misleading in national level datasets that are highly generalized, such as the Timor-Leste geological dataset we are using here.

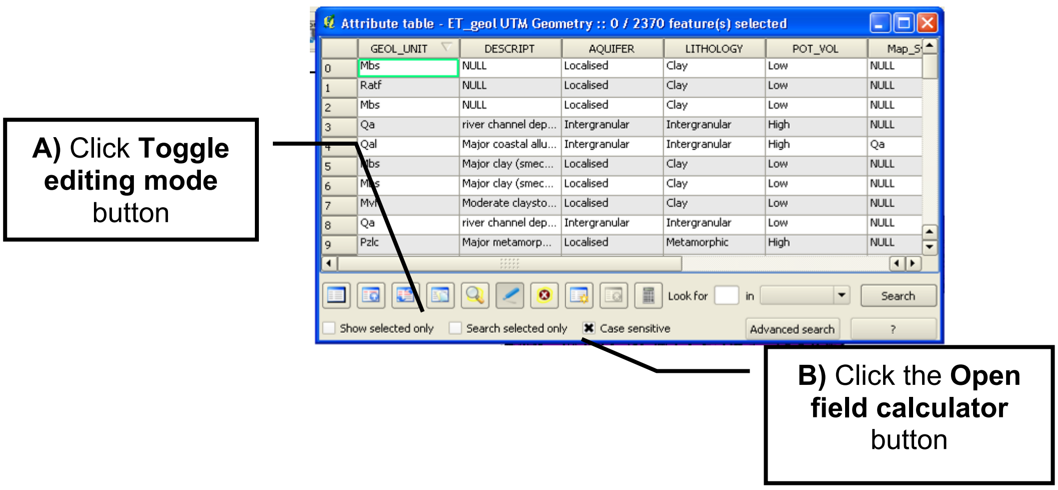
We will convert the area data to **hectares** and **square kilometres** and we will reduce the level of precision to **1 decimal place**, presenting our data in more familiar units and reducing false precision.

First, remove the ET_geol UTM layer from the Layers panel as we will not be using it any more during this course.

8. **Right click ET_geol UTM** in the Layers panel and select **Remove.**

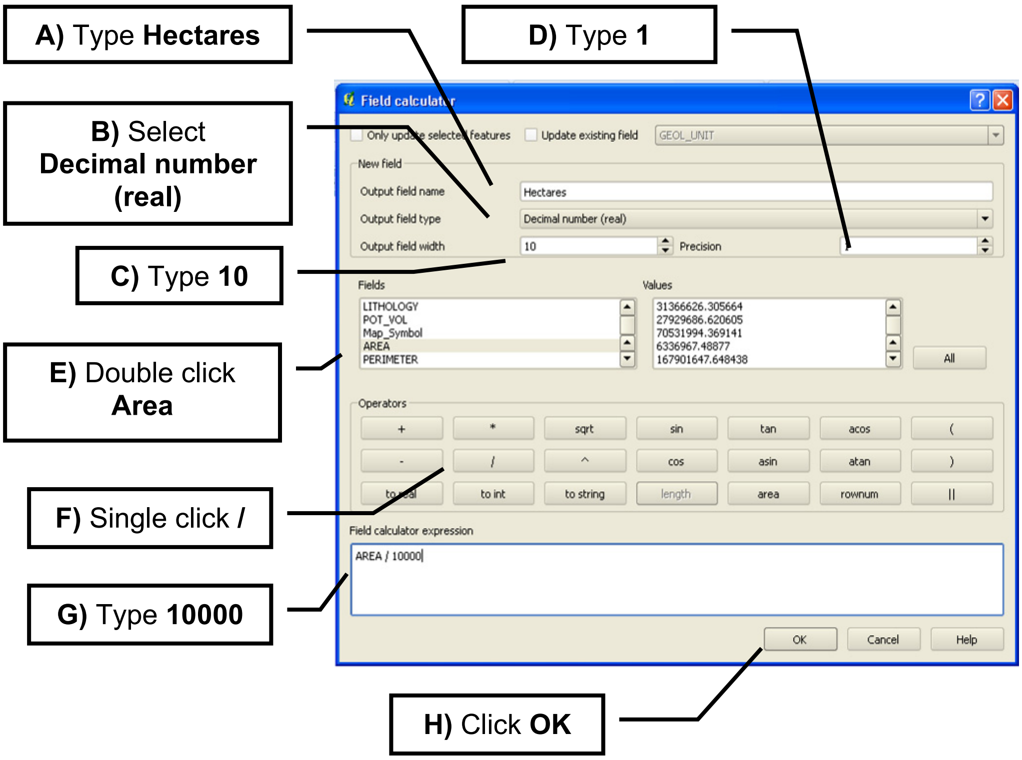


9. Open the attribute table for ET_geol UTM Geometry and activate editing mode by **clicking the Toggle editing mode** button. **Click the Field calculator** button. We will use the Field calculator to create two new fields, **Hectares** and **Sq Km**, and at the same time perform the calculations needed to populate those fields.

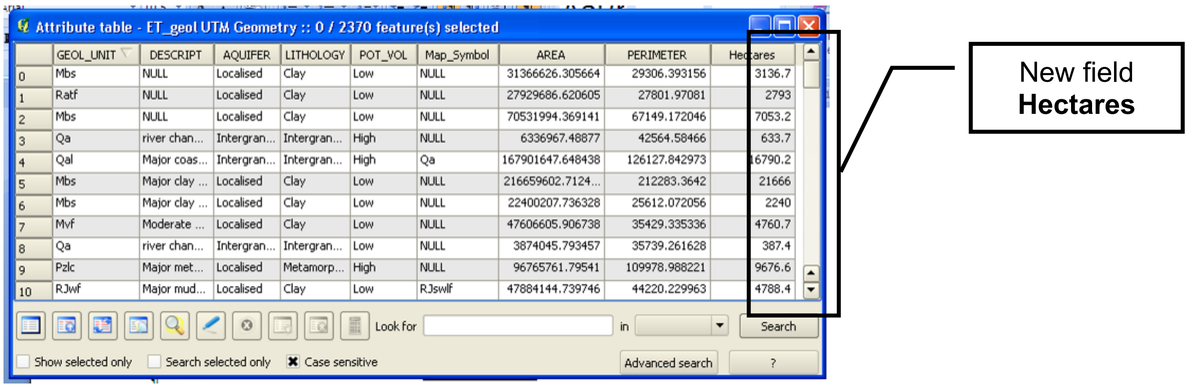


10. In the **New field** section of the Field calculator, **type Hectares** for the Output field name, **select Decimal number (real)** from the drop down list for Output field type, define the Output field width to **10** characters, and set the Precision level to **1**.

11. In the Field calculator expression box, enter the expression **AREA / 10000.** This expression tells Quantum for each feature in the ET_geol UTM Geometry layer, take the number of square metres from the Area field, divide it by 10,000, and enter the result in the corresponding cell of the Hectares field. To enter this expression, **double click AREA** in the Fields box, **single click** / in the Operators box and **type 10000** after the / in the Field calculator expression box. Then **click OK.**

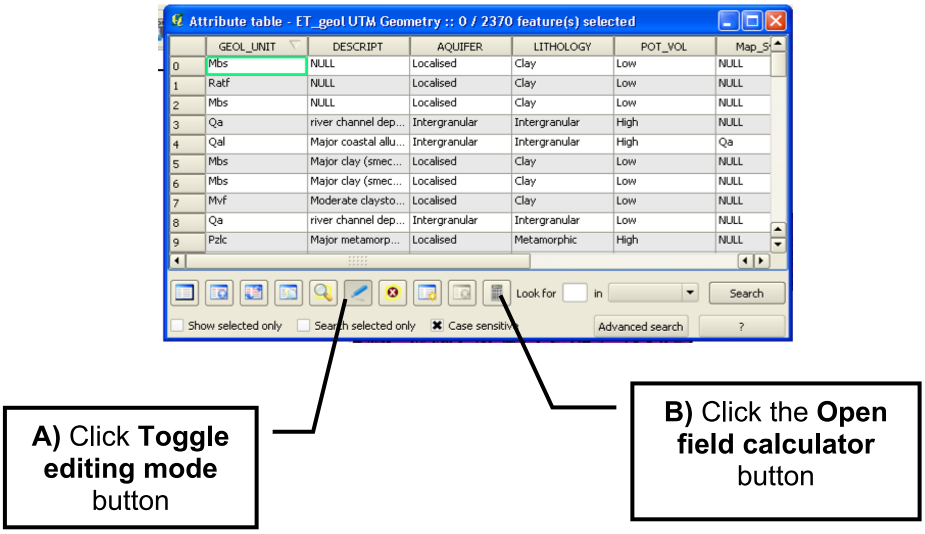


Result: You have created a new field in the attribute table called **Hectares**. This field records the size of every geological unit in ET_geol UTM Geometry, in hectares, to a level of precision of 1 decimal place.



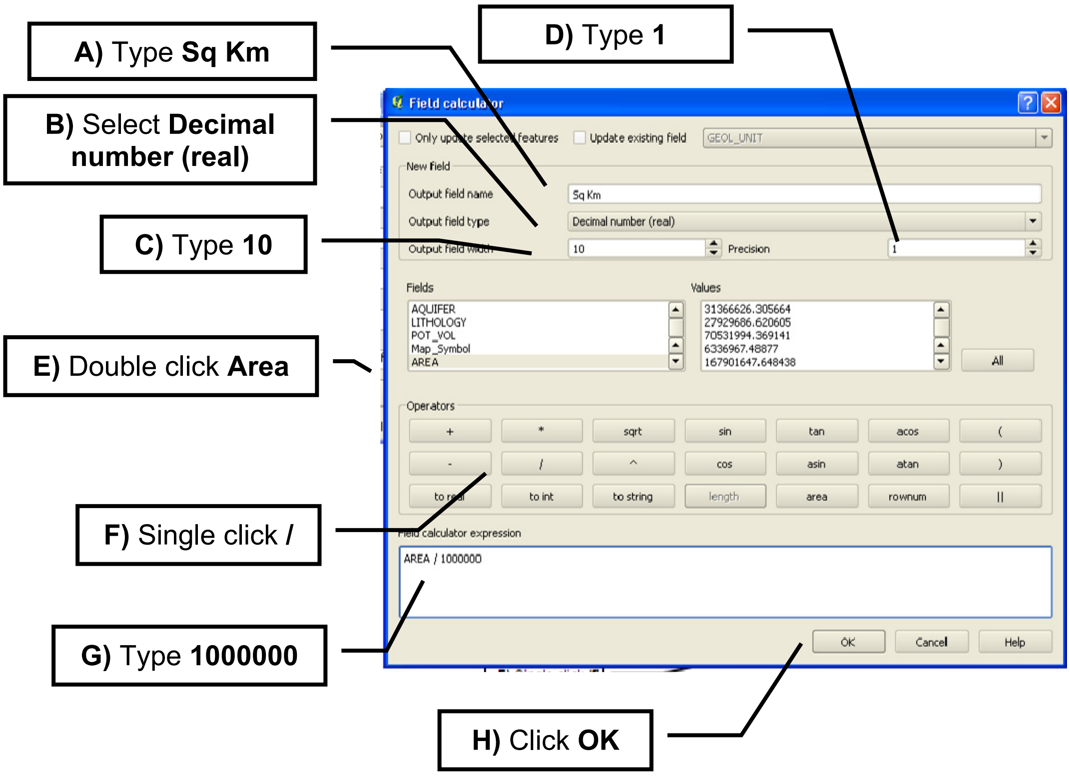
Following the procedures outlined in Steps 9, 10 and 11, create another new field, this one recording the area of each geological unit in square kilometres.

12. Open the attribute table for ET_geol UTM Geometry and activate editing mode by **clicking the Toggle editing mode** button. **Click the Field calculator** button.

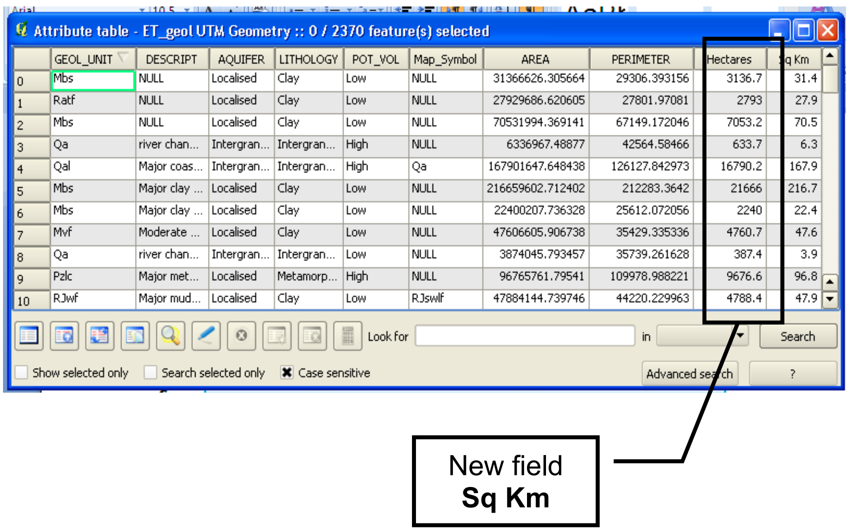


13. In the **New field** section of the Field calculator, **type Sq Km** for the Output field name, **select Decimal number (real)** from the drop down list for Output field type, define the Output field width to **10** characters, and set the Precision level to **1**.

14. In the **Field calculator expression** box, enter the expression **AREA / 1000000**. This expression tells Quantum for each feature in the ET_geol UTM Geometry layer, take the number of square metres from the Area field, divide it by 1,000,000, and enter the result in the corresponding cell of the Sq Km field. To enter this expression, **double click AREA** in the Fields box, **single click** / in the Operators box and **type 1000000** after the / in the Field calculator expression box. Then click **OK**.



Result: You have created another new field, this one called **Sq Km**. This field records the size of every geological unit in ET_geol UTM Geometry, in square kilometres, to a level of precision of 1 decimal place.

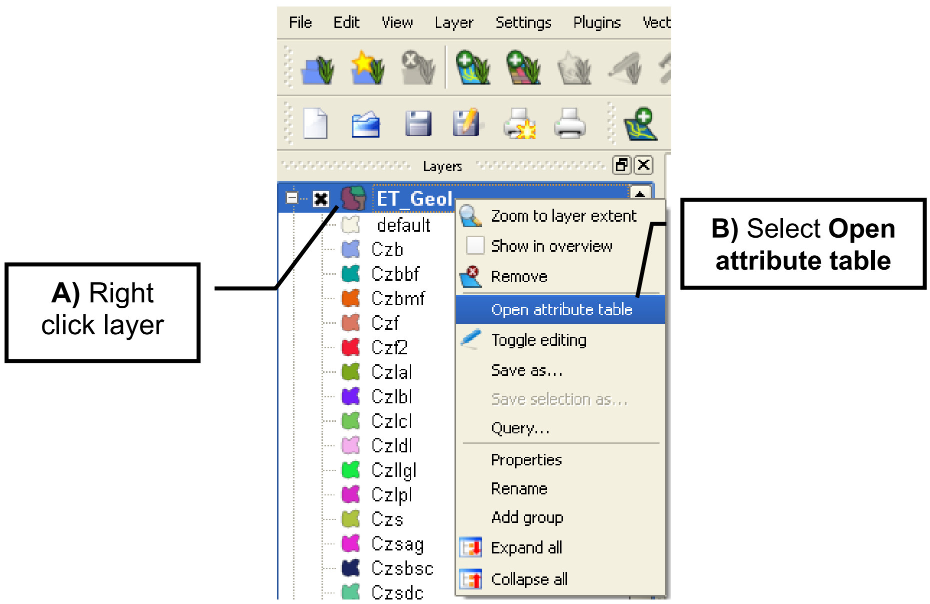


2.3 CREATING AND POPULATING THE HYDROGEOLOGICAL POTENTIAL FIELD

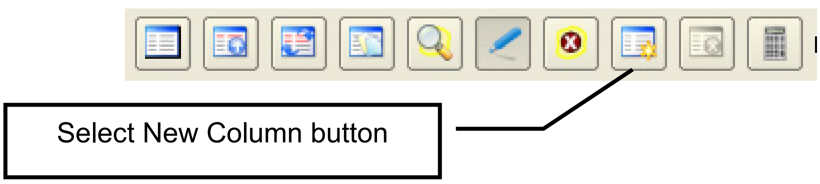
One more change is needed in the attribute table before we are ready to start symbolizing the data and viewing it cartographically. To allow us to symbolize hydrogeological potential effectively on a map, we need to express both the type of aquifer and the potential volume of groundwater in a single field. To do this we'll merge the values in the **Aquifer** field with the values in the **Pot Vol** (potential volume) field, and record the results in a new field called **Aqu_w_PV**

1. Turn editing on by selecting the Toggle editing mode button.

2. Open the attribute table of ET_Geol UTM by right clicking on the layer name within the table of contents and selecting **Open Attribute Table**.

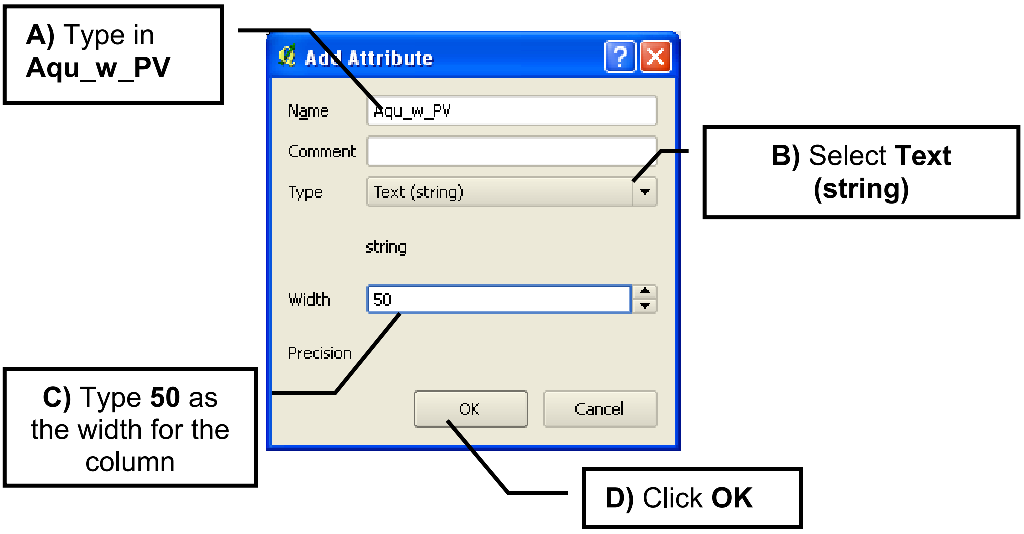


3. Add another column/field to the attribute table by selecting the **New Column** button.

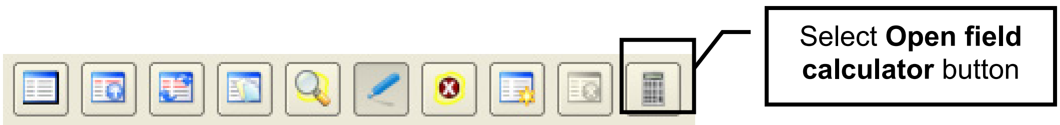


4. In the **Name:** text box, type **Aqu_w_PV**, then for **Type,** use the drop down arrow and select **Text (String)**. For the column **Width** type in 50.

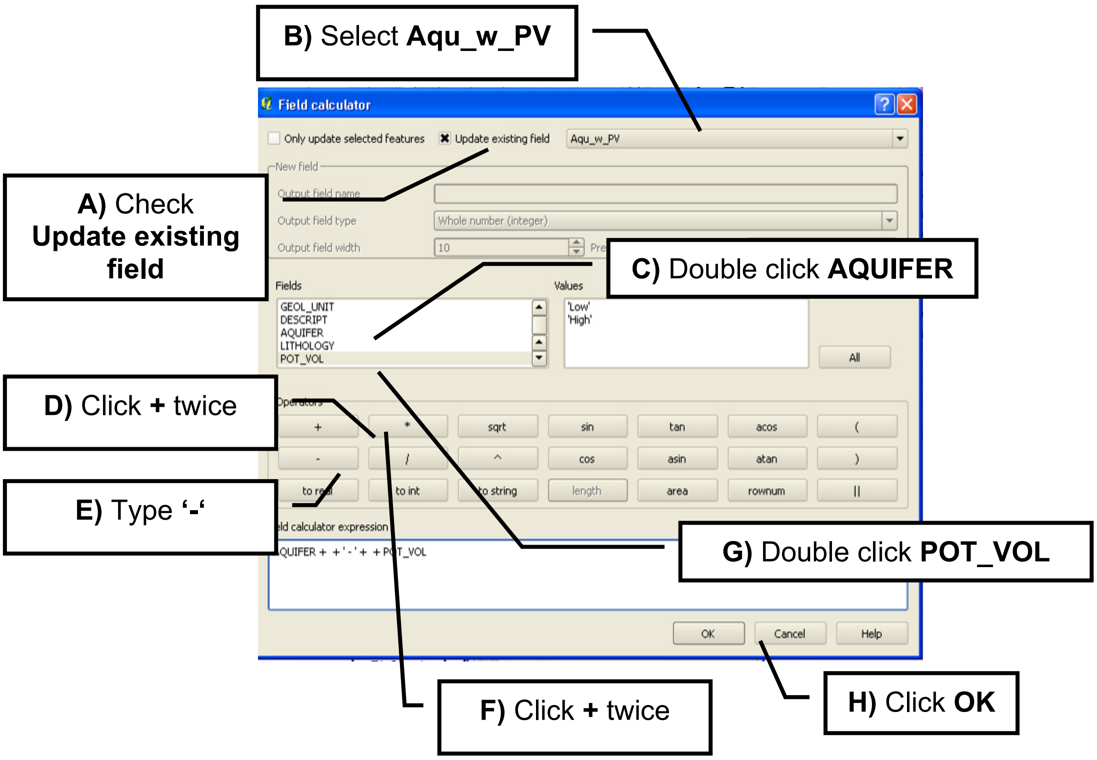
5. Click **OK**.



6. In the attribute table of ET_Geol UTM, select the Open Field Calculator button.

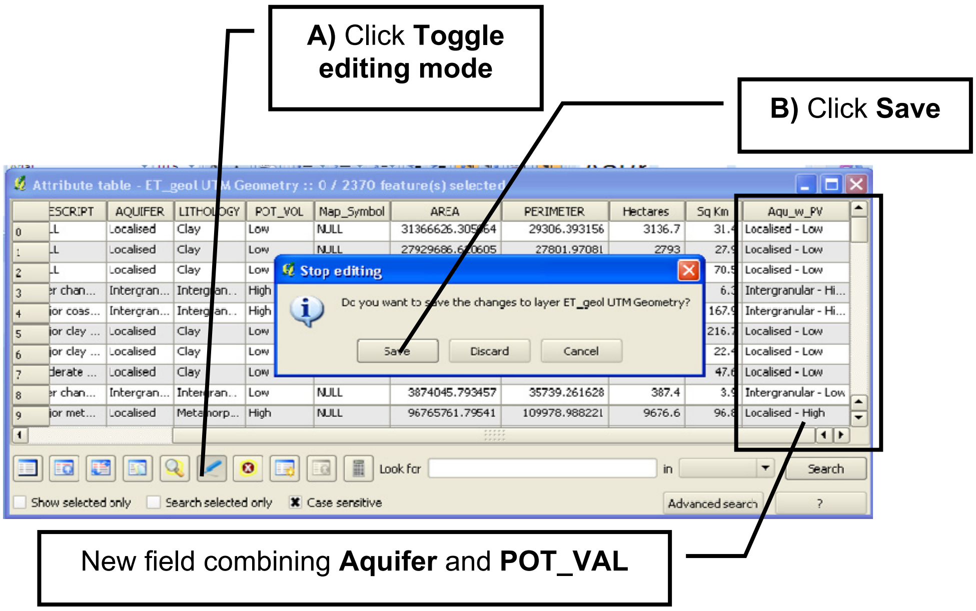


7. To configure the **Field calculator** and enter the expression into the **Field calculator expression** textbox, follow the steps in the diagram below. It is important that these are done in the order shown, from A to H.

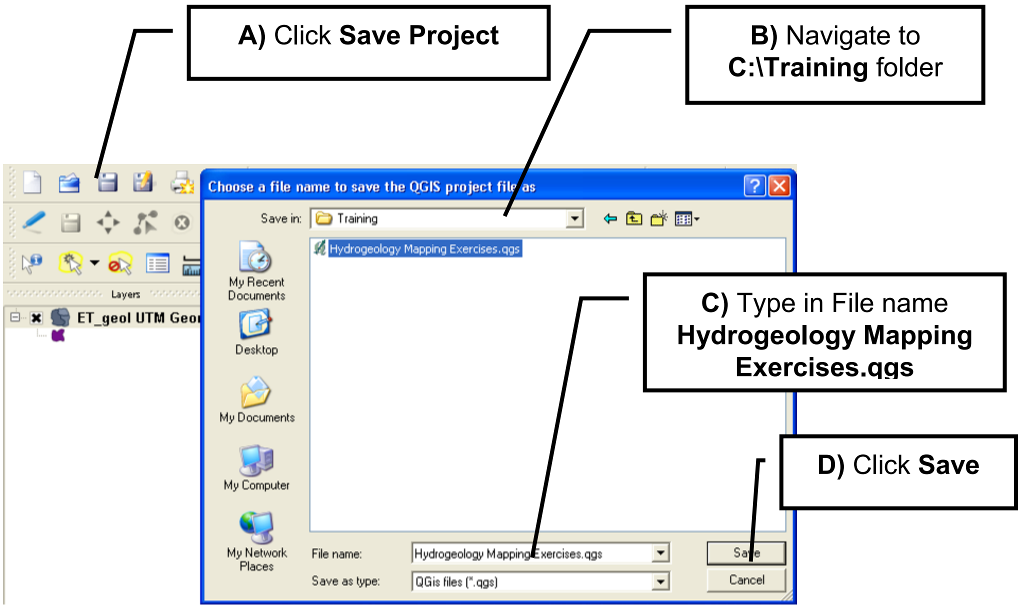


Result: You have created the new field **Aqu_w_PV** and populated it with the **Aquifer** and **Pot_Vol** field values merged together and separated by a dash (-).

8. Click on **Toggle editing mode** to end the editing session. When you are asked "Do you want to save the changes to layer ET_geol UTM Geometry", click **Save.**



9. Click the **Save Project** button and save your project as **C:\Training\Hydrogeology Mapping Exercises.qgs**



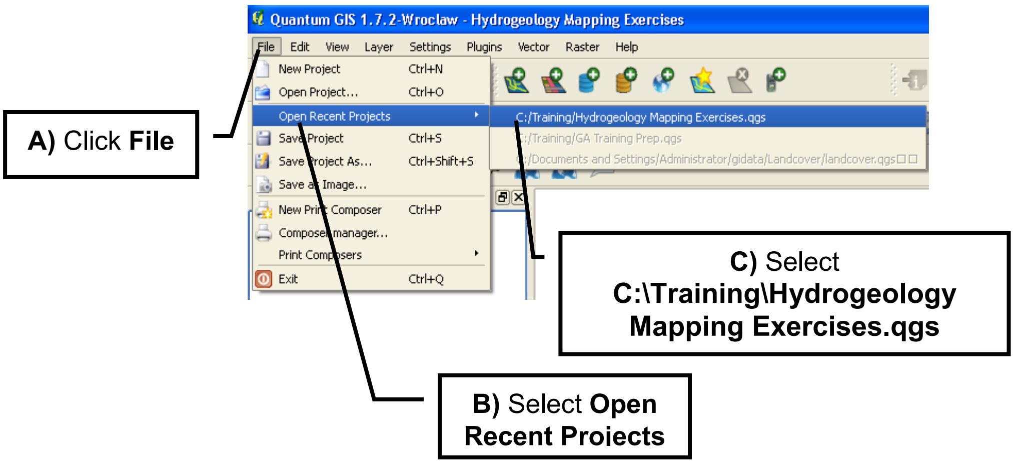
You have now completed the modifications to the attribute table. The changes you made are necessary preparation for the next set of exercises in which you will symbolize different geological and hydrogeological characteristics on maps, and for the spatial analysis exercises that follow.

3 Symbolizing Geological Characteristics

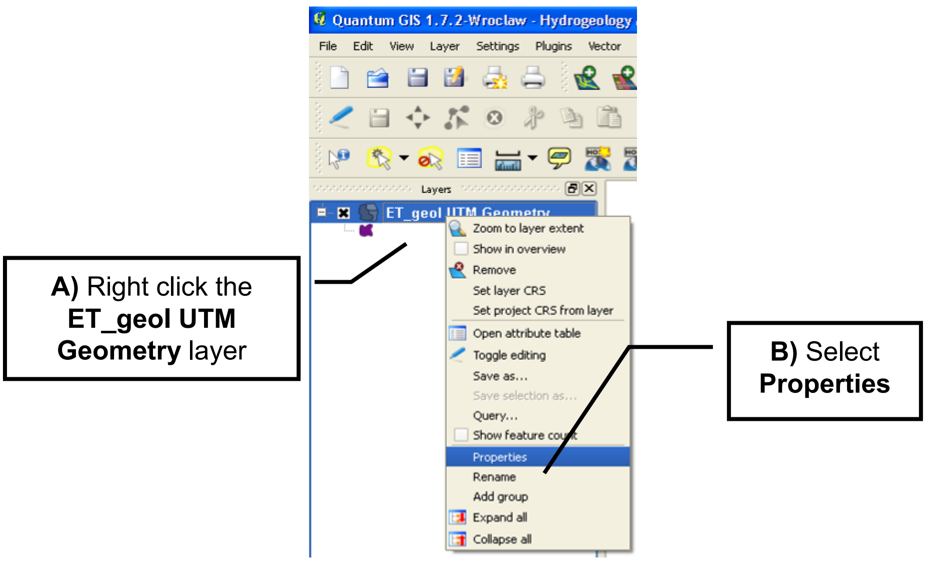
3.1 SYMBOLIZING GEOLOGY WITH INTERNATIONAL STANDARD COLOURS

Assuming you have completed entering Map_Symbol data for all the features in the ET_geol UTM Geometry layer, you will now display the data with the standard colours used for symbolizing geological units.

1. Start Quantum GIS and open **C:\Training\Hydrogeology Mapping Exercises.qgs**, the project file you saved at the end of the previous exercise.



2. Right click the **ET_geol UTM Geometry** layer in the table of contents and select **Properties**.

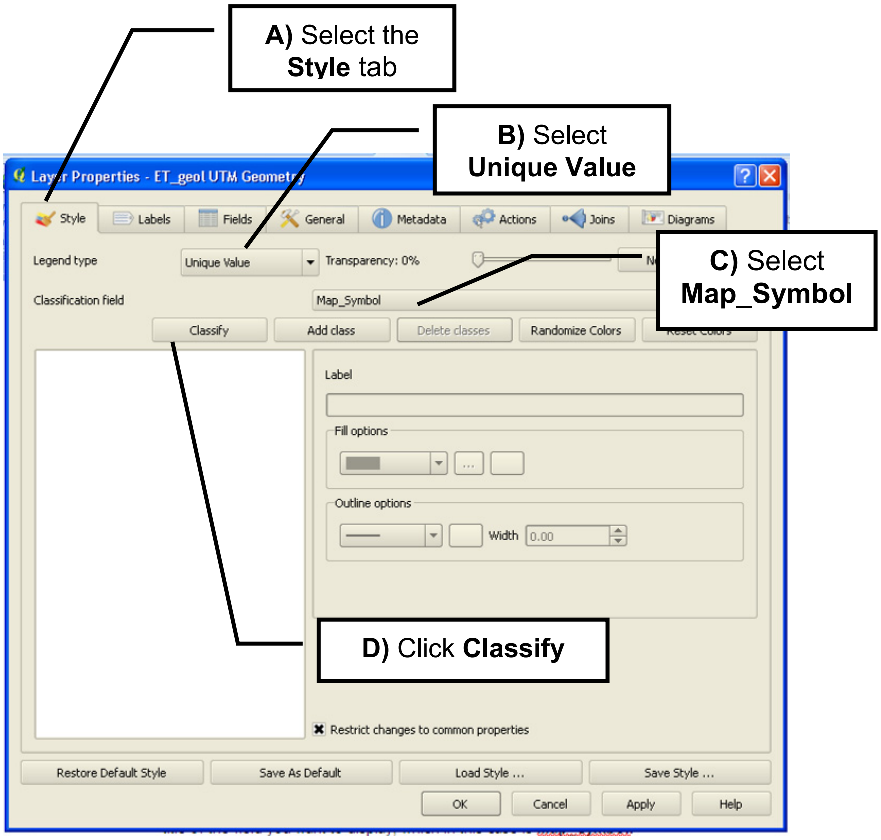


3. In the window that opens **select** the **Style** tab.

4. Under **Legend type**, select **Unique Value** from the drop down list**.**

5. Under the **Classification field**, select the name of the attribute field you want to symbolize on your map, which in this case is **Map_Symbol**.

6. Click the **Classify** button.



This will display a list of classes, one for each unique value from the **Map_Symbol** field. Each class is assigned a colour symbol. Unless specific colours are selected, QGIS will randomly assign colours, one for each class.

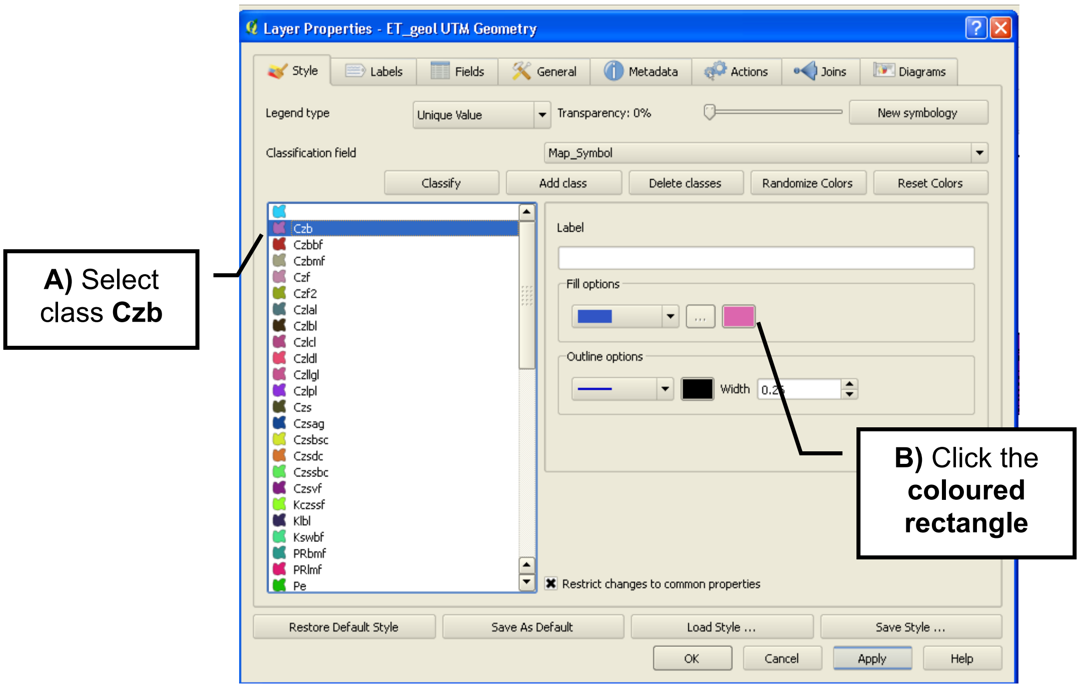
We don't want to display our geological classes with randomly assigned colours, so we will apply **standard colours used for geological mapping**.

We do this by assigning specific red, green and blue (RGB) values to each class. The values to use are presented in the Geology RGB **Table in Attachment II (p. 58).**

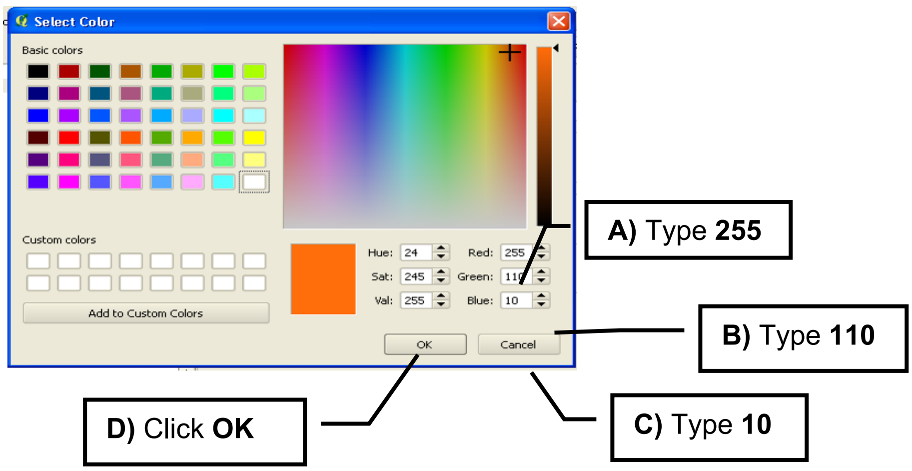
7. Select **Czb**, the first in the list of Map_Symbol classes. The properties of the Czb symbol are displayed to the right. The properties are **Label**, **Fill options** and **Outline options**.

There are two coloured rectangles under Fill options. The one on the left specifies the **pattern of the symbol** (solid, diagonal lines, cross hatching, etc); the one on the right specifies the **colour of the symbol**

8. **Click the rectangle on the right** to change the colour of the symbol for the Czb class.



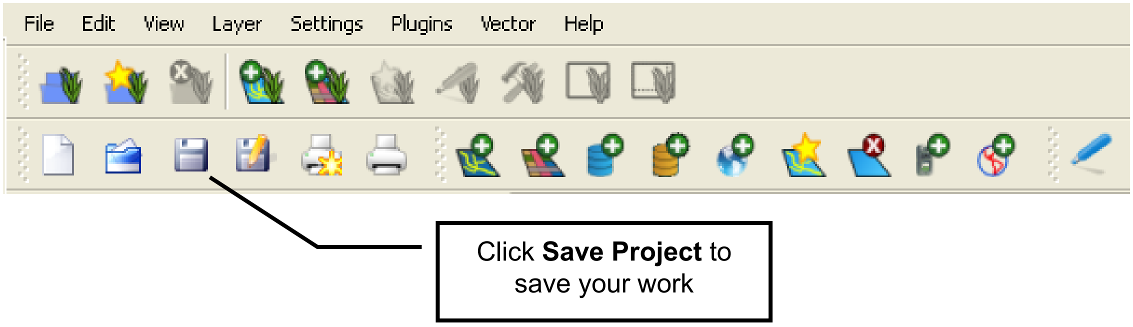
The **Select Colour** window will appear.



9. Referring to the Geology RGB Table in Attachment II (p. 58), **type in the Red, Green and Blue values** for the Czb class into the appropriate boxes.

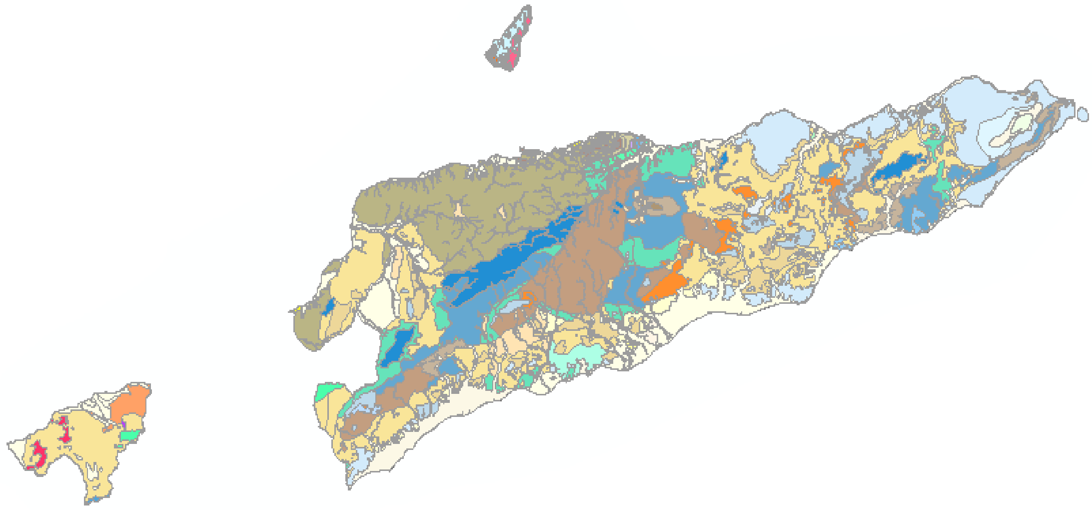
10. Click **OK**.

11. **Repeat steps 7 to 10** for each geology class in the list. Click the **Save Project** button at regular and frequent intervals to save your work and ensure changes are not lost.



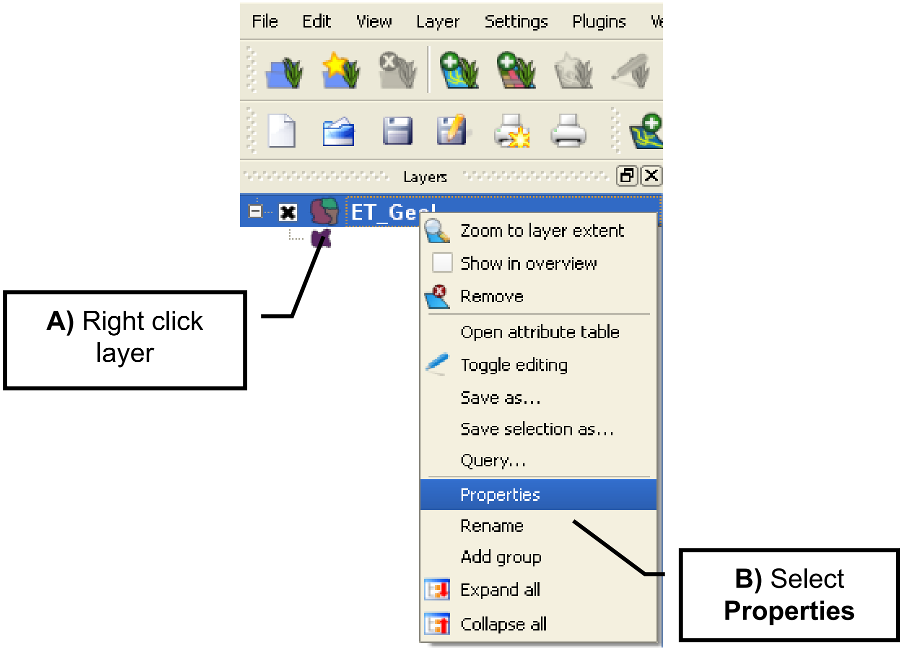
12. Click **OK** on the Layer Properties window**.**

Your map should look something like this.

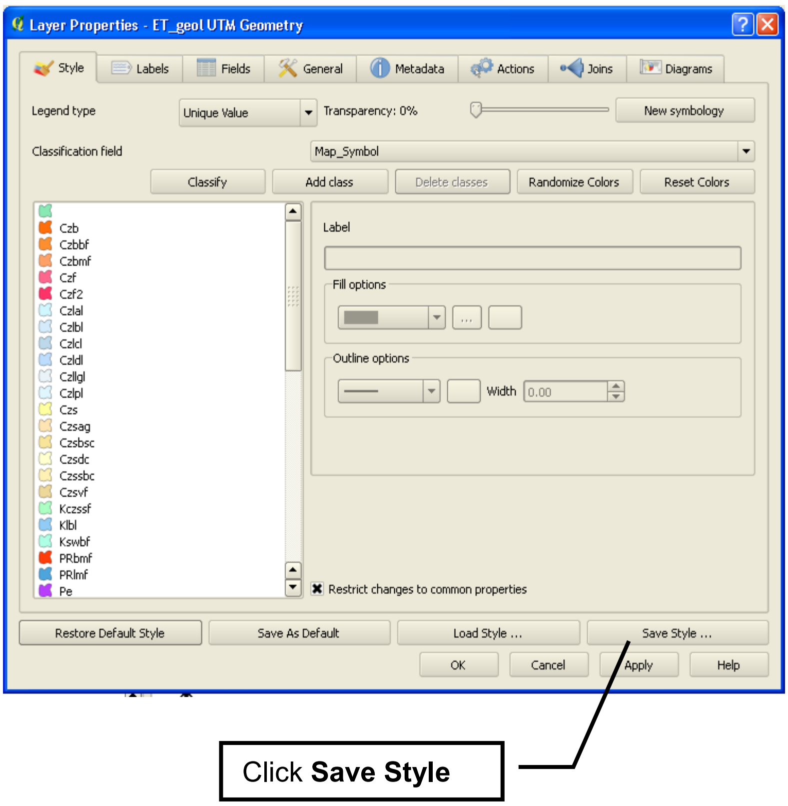


Once you have specified the RGB values of the standard symbols for all the geological classes, save the symbol properties in a Style File with a .qml extension as shown below. By applying a Style File, you will be able to automatically assign the standard symbols to your ET_geol UTM Geometry layer, thus avoiding the procedure of re-entering all the RGB values manually each time you load it.

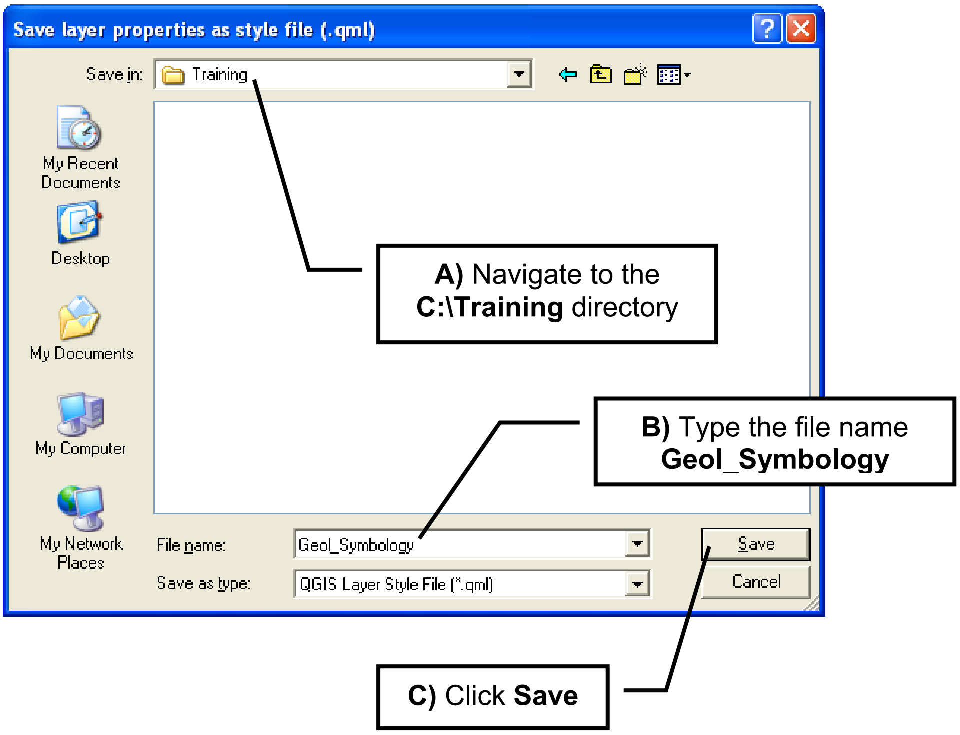
13. Right click **ET_geol UTM Geometry** in the layers panel and select **Properties**.



14. In the Layer Properties window click the **Save Style** button.



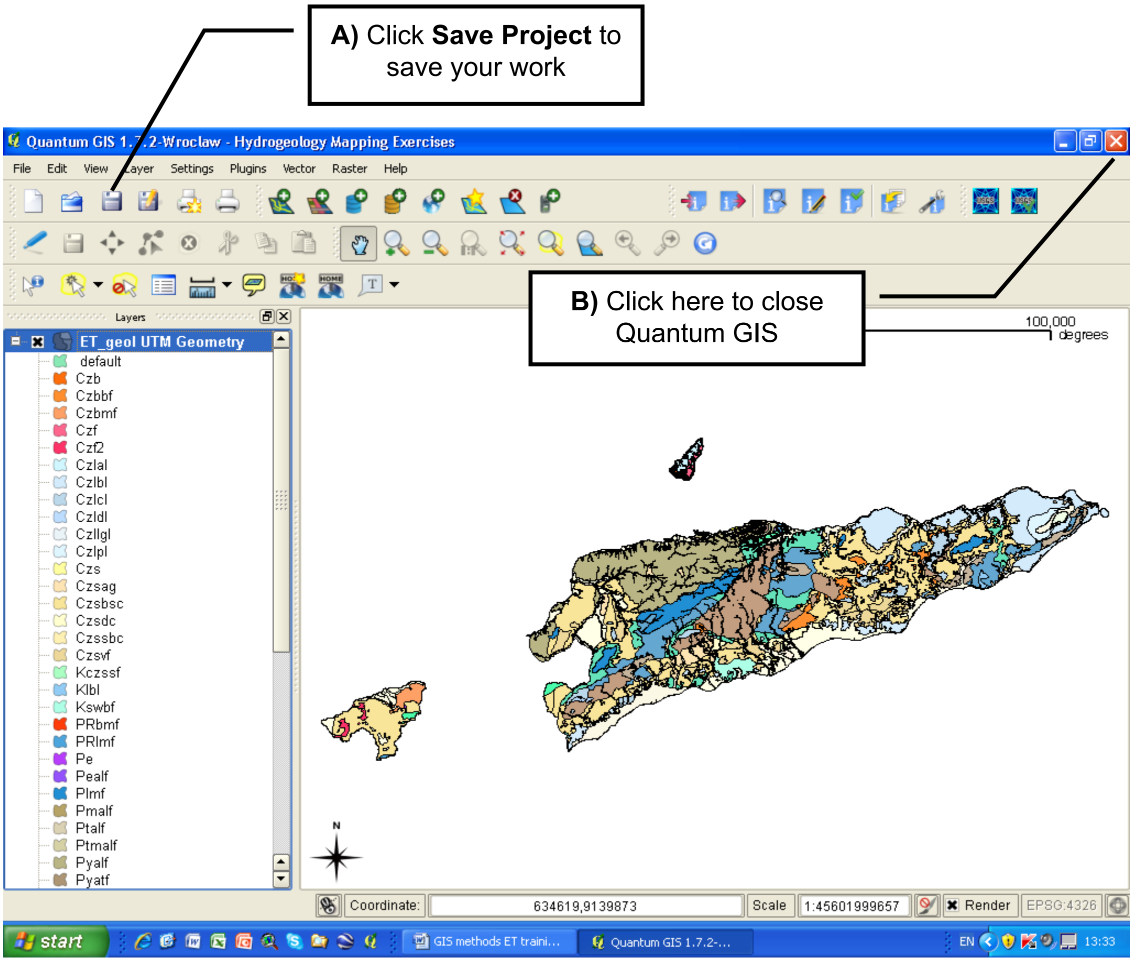
15. In the window that appears, navigate to the training folder, type in the file name **Geol_Symbology** and click **Save**.



Warning:
A Style File (.qml) ***<u>is not</u>*** *a shapefile or feature class, it does not store the data or shape of the polygons, it only stores and dictates the way a map is coloured and displayed. It refers back to the original shapefile/featureclass for all its information.* ***<u>If you move or delete the original shapefile/feature class the layer file will no longer work</u>****. If the original shapefile/featureclass is not in the same place next time you open the layer file it will not display.* ***<u>If the original shapefile is deleted there is no way to make the layer file work unless you have another copy of the EXACT SAME shapefile.</u>***

RESULT: You are now able to compile a geology map of Timor-Leste using a widely recognised standard set of colours and map symbols.

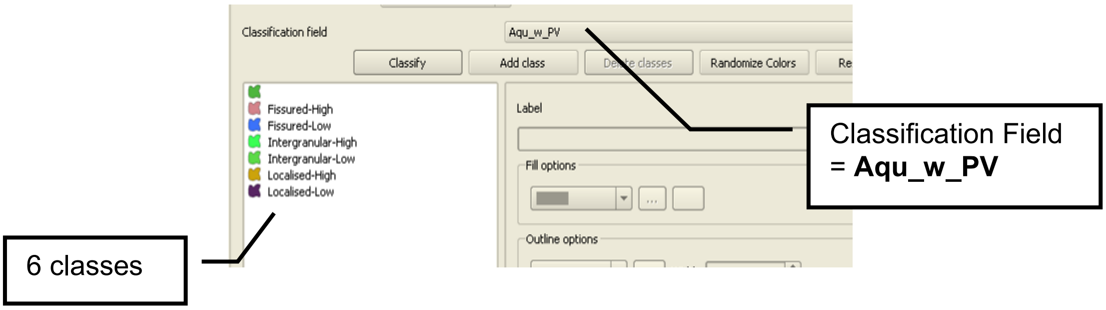
16. Click the **Save Project** button to save your work and close Quantum GIS by clicking the cross in the red box at top right.



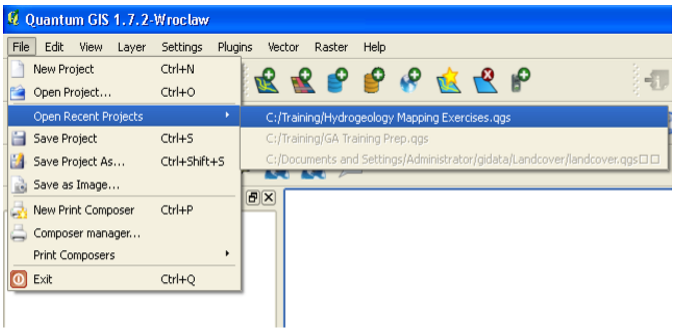
3.2 SYMBOLIZING HYDROGEOLOGY WITH INTERNATIONAL STANDARD COLOURS

In terms of GIS methodology, the process for making the hydrogeology map is similar to the process used above to create the geology map. The reasoning and justifications for the hydrogeology classifications are discussed elsewhere in other reports and will not be covered here.

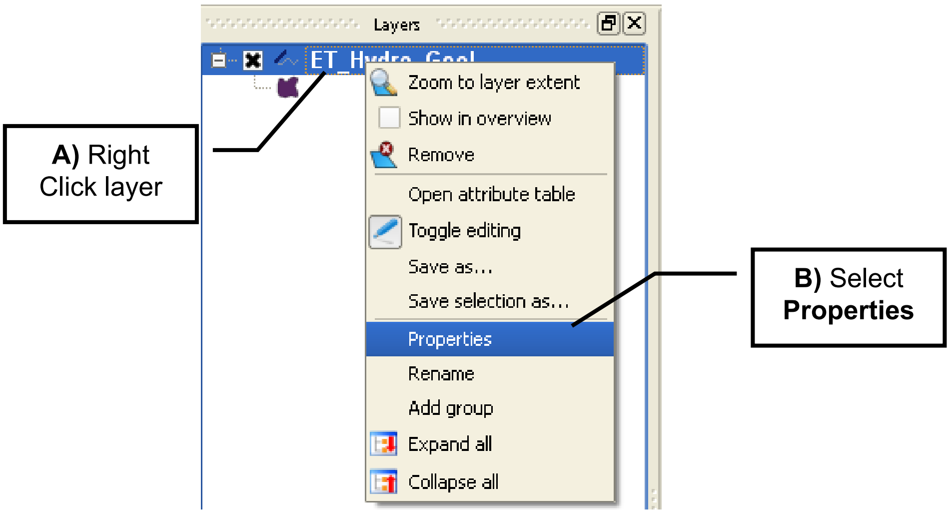
What we are going to do in this exercise is **assign RGB values for standard colours** used to represent the 6 classes in the Aqu_w_PV field:



1. Open Quantum GIS and load your project file by selecting **File – Open Recent Projects – C:\ Hydrogeological Mapping Exercises**.**qgs**



2. Right click **ET_geol UTM Geometry** in the Layers panel and select **Properties**.

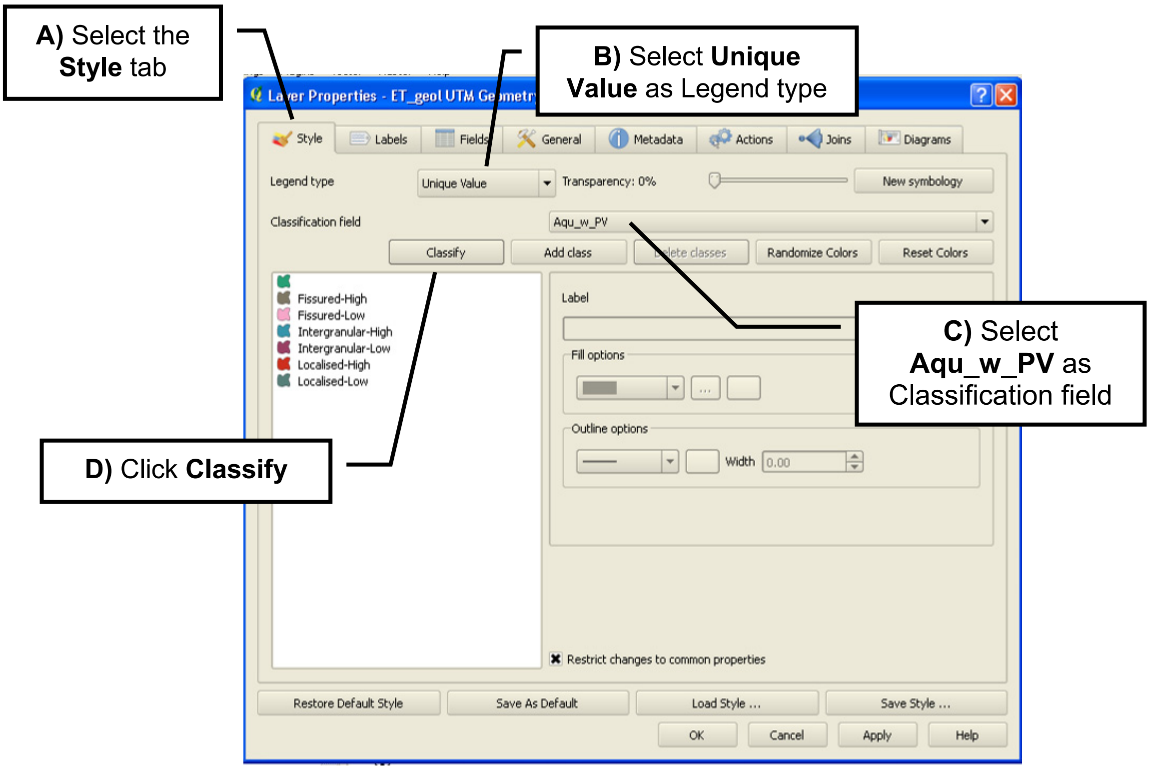


3. In the window that opens select the **Style** tab.

4. Select **Unique Value** as the Legend type.

5. Under the Classification Field there is a drop down menu. Select the title of the field you want to classify, which in this case is **Aqu_w_PV**.

6. Click the **Classify** button. This will display the symbols assigned to the 6 unique classes of Aqu_w_PV.

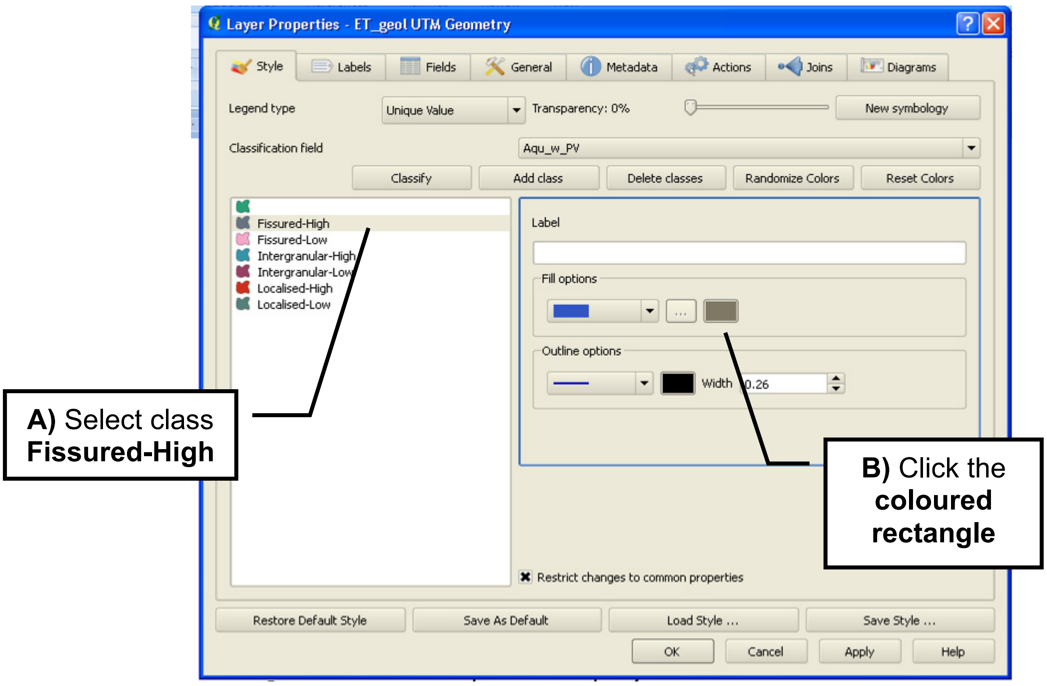


The hydrological potential of each geological mapping unit is now displayed in a randomly assigned colour based on the 6 classes in the **Aqu_w_PV** field**.** You will now apply international standard colours by entering RGB values for each class from the Hydrogeology Symbol table in Attachment II (p. 60).

7. **Select Fissured – High,** the first in the list of Aqu_w_PV classes. The properties of the Fissured - High symbol are displayed to the right. The properties are **Label**, **Fill options** and **Outline options**.

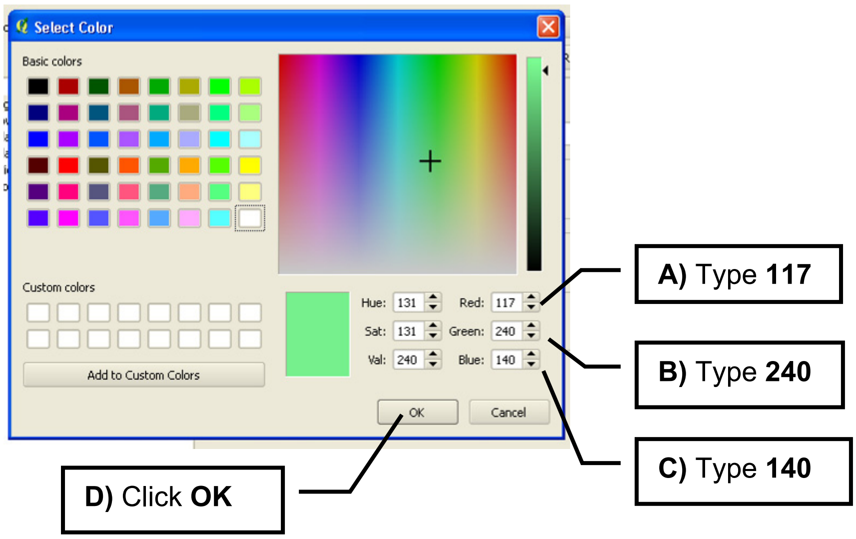
There are two coloured rectangles under Fill options. The one on the left specifies the **pattern of the symbol** (solid, diagonal lines, cross hatching, etc); the one on the right specifies the **colour of the symbol**.

8. **Click the rectangle on the right** to change the colour of the symbol for the Fissured - High class.

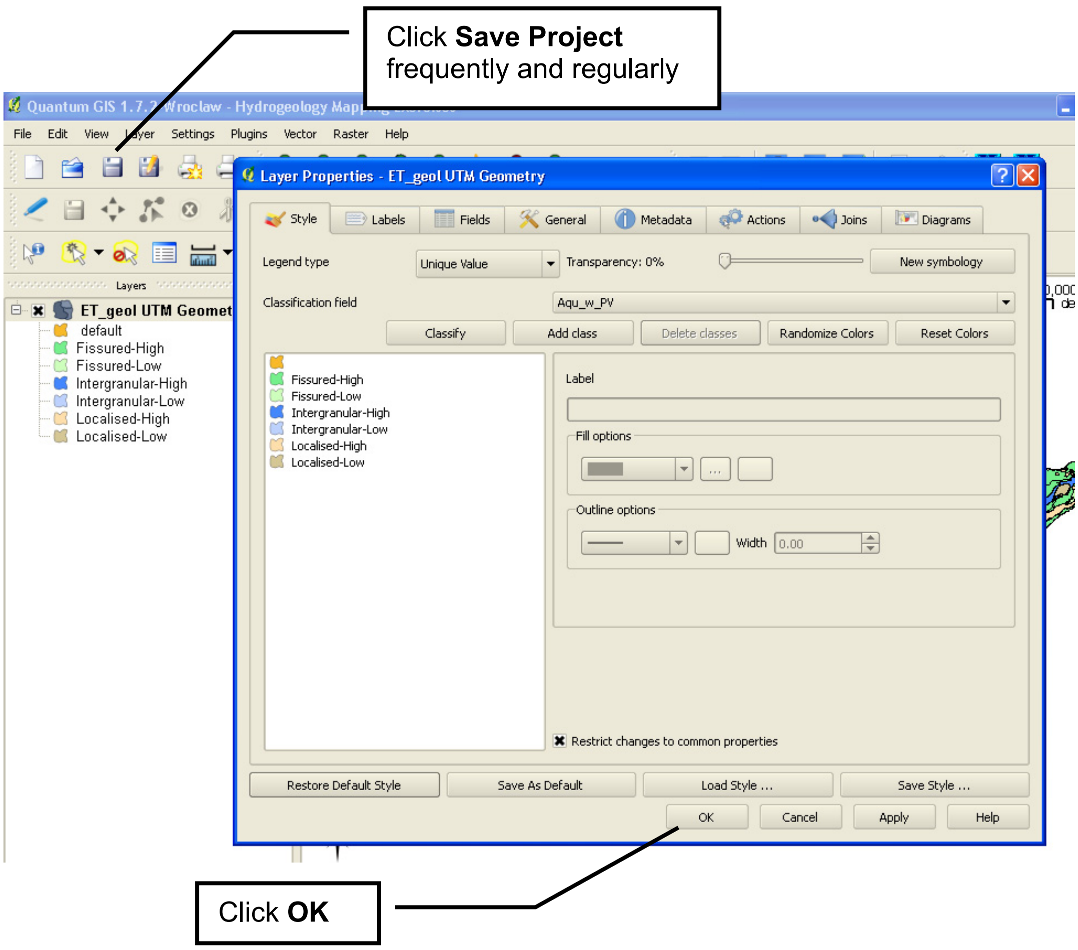


The **Select Colour** window will appear.

9. Referring to the Geology RGB Table in Attachment II (p. 58), **type the Red, Green and Blue values for the Fissured - High class** into the appropriate boxes. Click **OK**.

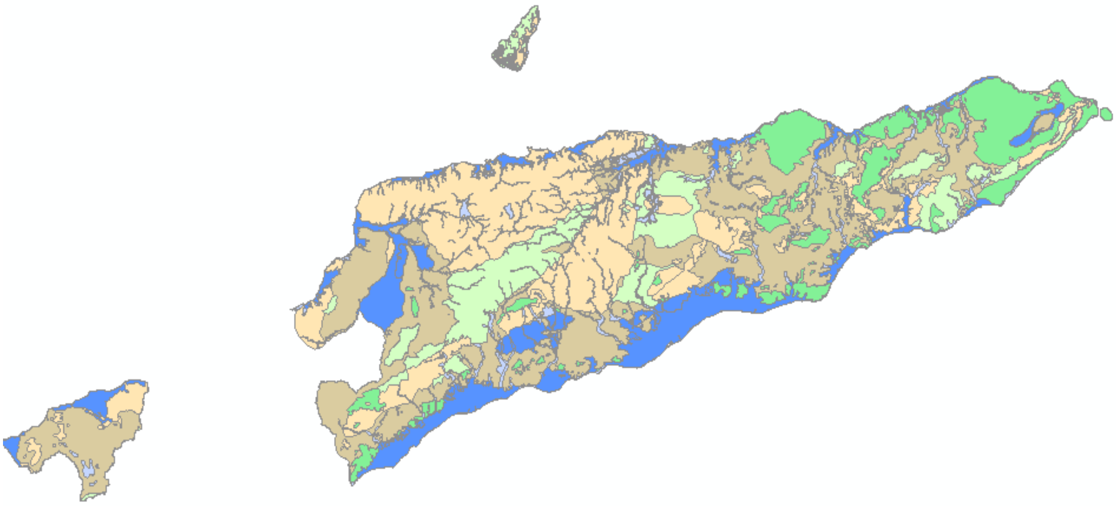


10. **Repeat steps 7 to 9** for each hydrological potential class in the list. Click the **Save Project** button at regular and frequent intervals to save your work and ensure changes are not lost.



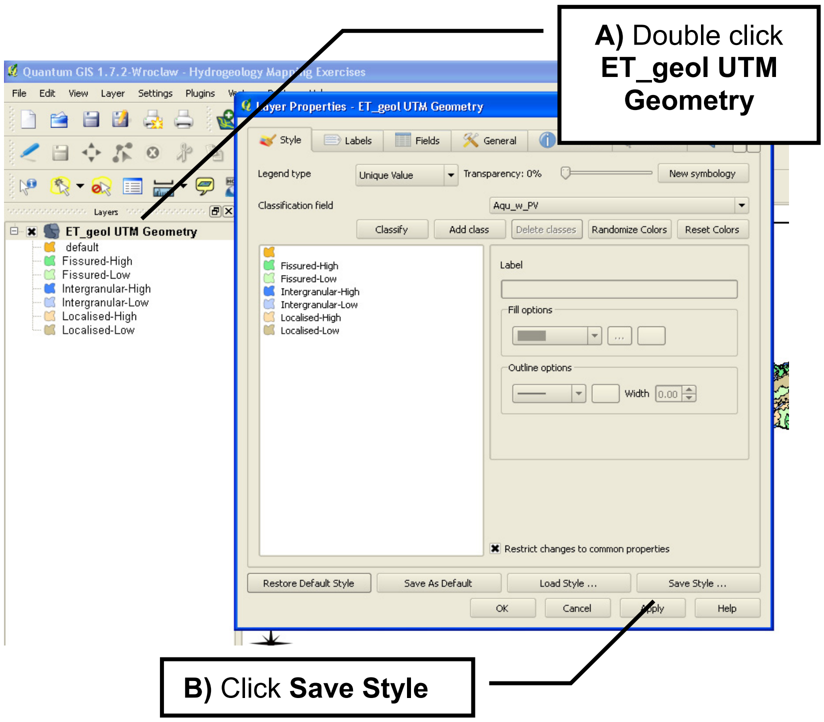
11. Click **OK** in the Layer Properties window.

> ***RESULT:*** You are now able to compile a hydrogeological potential map of Timor-Leste using the internationally recognized set of colours



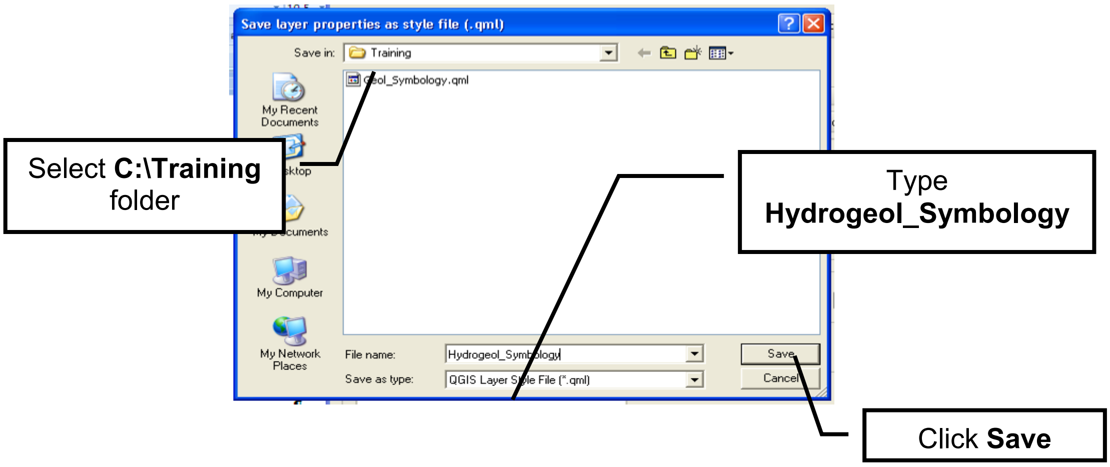
Just as you saved the international standard symbols you specified for the classes in your geology map, save the symbols you have just specified for the hydrogeological potential classes. Again, you do this by saving a Style File (.qml).

12. Double click on **ET_geol UTM Geometry** in the Layers panel. This is another way of opening the Layer Properties window.



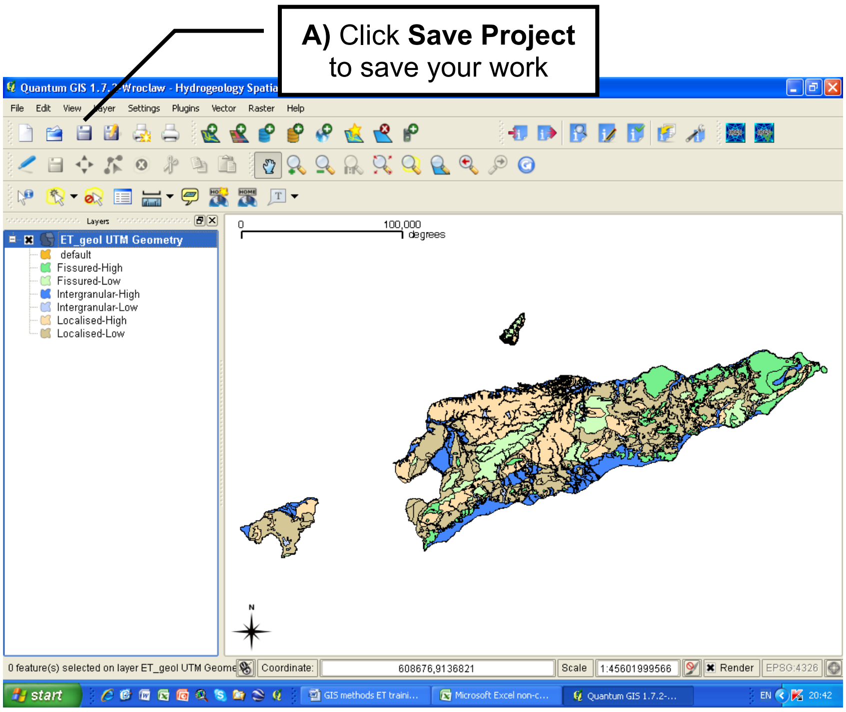
13. In the Layer Properties window click the **Save Style** button.

14. In the Save layer properties as style file (.qml) window, type **Hydrogeol_Symbology** as the File name and navigate to the **C:\Training** folder in the Save in drop down menu. Click **Save**.



15. Click **OK** in the Layer Properties window.

The map that now appears in the main window of Quantum GIS shows Timor-Leste's hydrogeological potential in internationally recognized colours.



4 Spatial Analysis

4.1 CALCULATING AREAS OF HYDROGEOLOGICAL POTENTIAL CLASSES

Objectives: Find the answers to the following questions by analysing your hydrogeological data for Timor-Leste:

1) What is the total land area of Timor-Leste?
2) What is the area of each of the 6 hydrogeological potential classes?
3) What proportion of Timor-Leste's total land area does each class represent?

Record your answers in this table:

		Area (sq km)	**% Timor-Leste**
Fissured - High			
Fissured - Low			
Intergranular - High			
Intergranular - Low			
Localised - High			
Localised - Low			
Timor-Leste			

Create a new project for this exercise – do not open the project you saved your earlier work in.

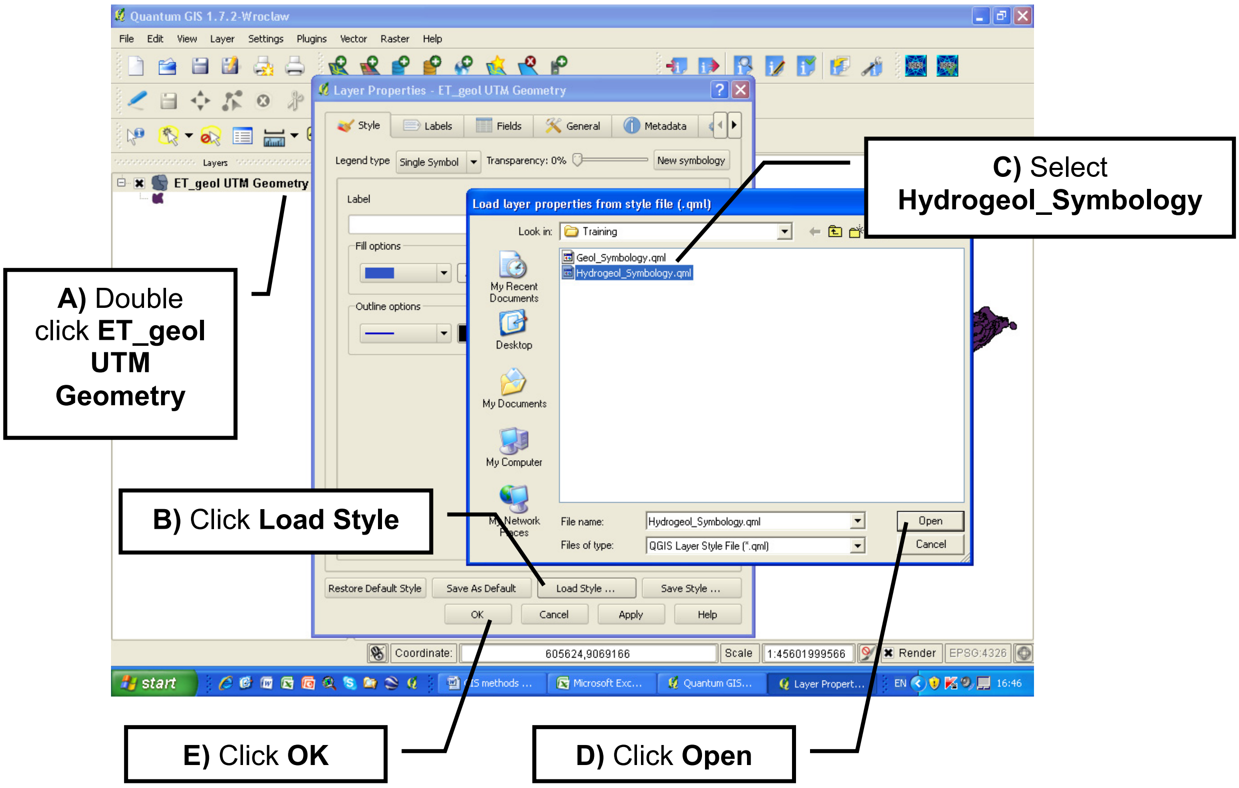
1. **Start Quantum GIS** and **load the vector layer ET_geol UTM Geometry**. You will notice the layer is represented with a single symbol – it is not classified yet.

2. **Double click the name of the layer** in the Layers panel to open the Layer Properties - ET_geol UTM Geometry window.

3. Click **Load Style** in the Layer Properties box

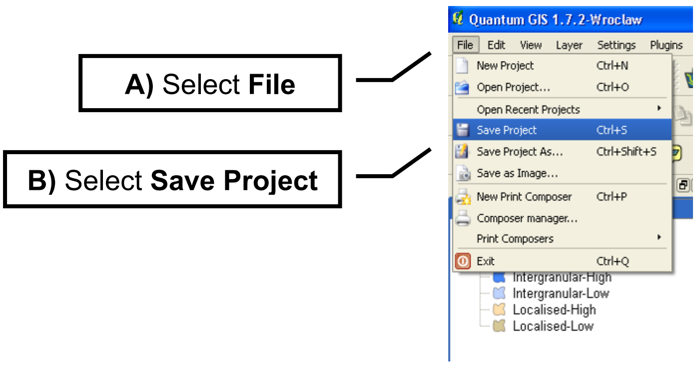
4. Select **C:\Hydrogeol_Symbology.qml** from the Load Layer properties from style file window, then click **Open**

5. Click **OK**

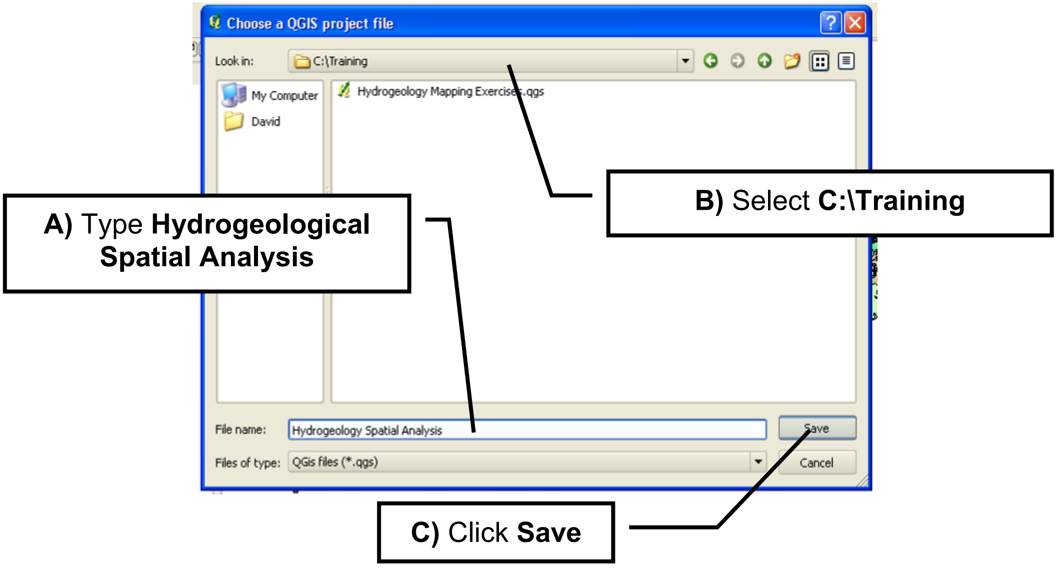


The map will show Timor-Leste's hydrogeological potential, symbolized according to the international standards you specified in the previous exercise.

6. Create a new project file by selecting **File – Save Project**

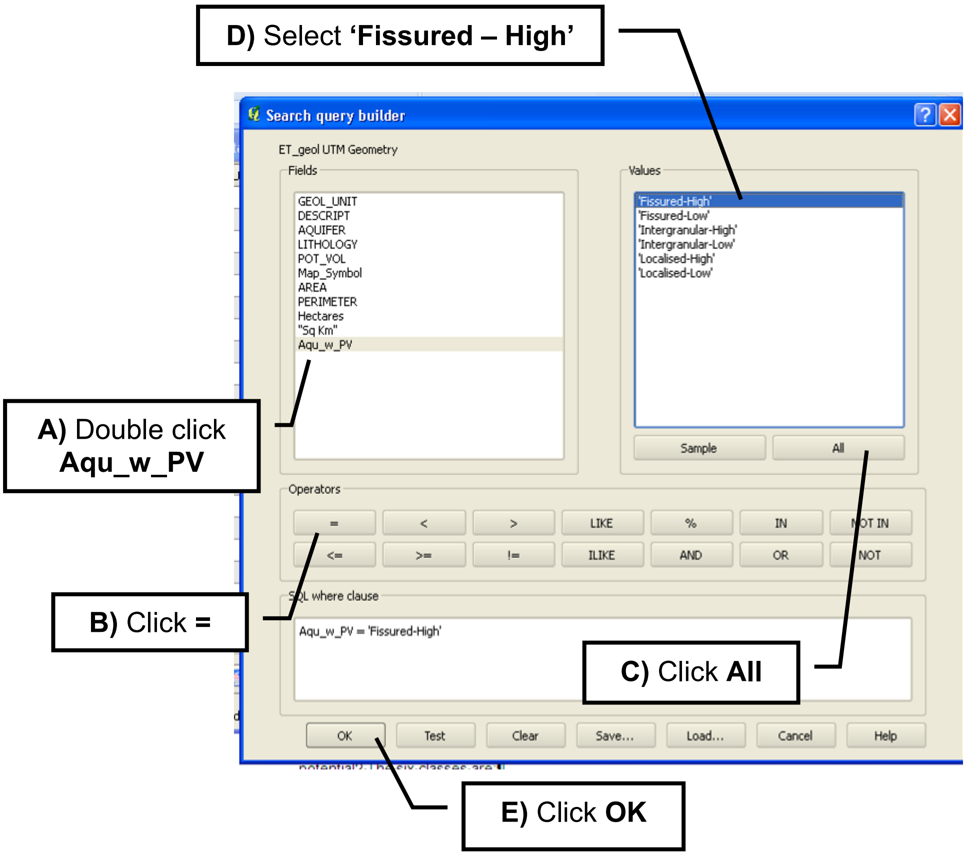


7. Type **Hydrogeological Spatial Analysis** as the file name, make sure **C:\Training** is the folder selected to save the project file in, then click **Save.**



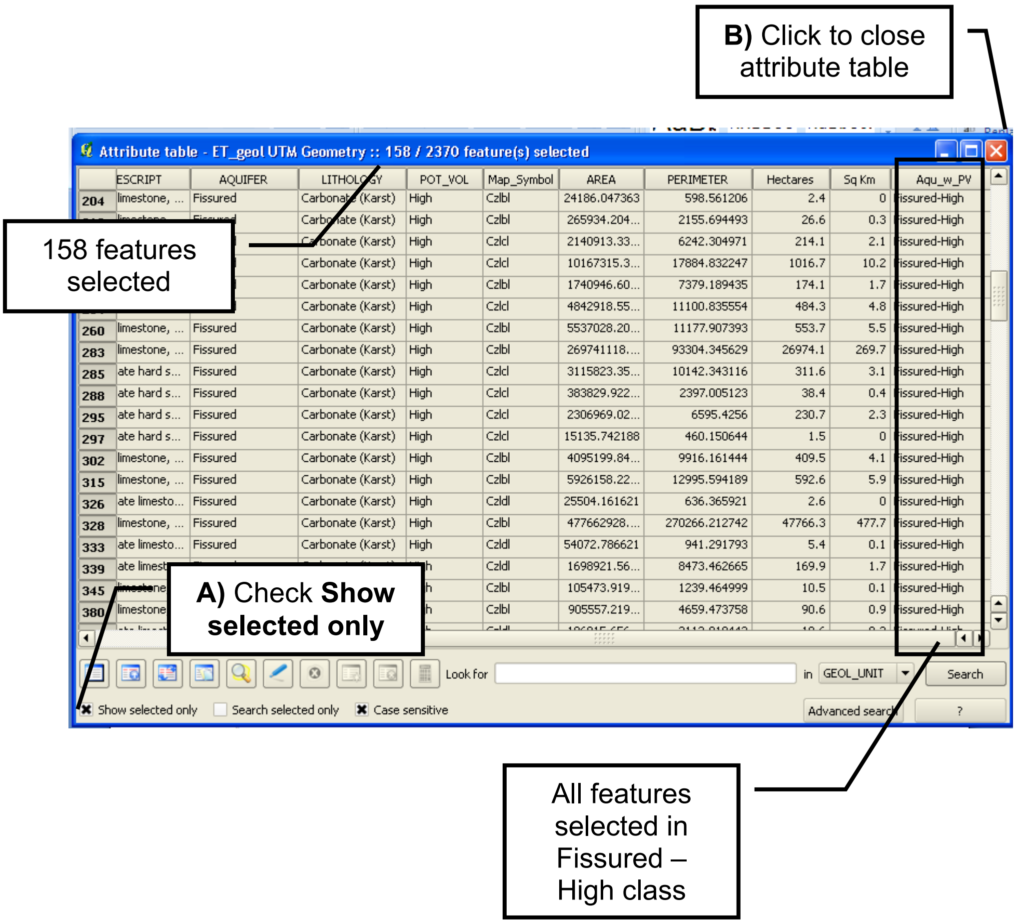
8. **Open the attribute table** of ET_geol UTM Geometry and click **Advanced Search.**

9. In the Search query builder window, build the expression **Aqu_w_PV = 'Fissured – High'** by double clicking **Aqu_w_PV** in Fields, single clicking the Operator **=,** clicking **All** and selecting **'Fissured – High'** in the Values box, then clicking **OK**.



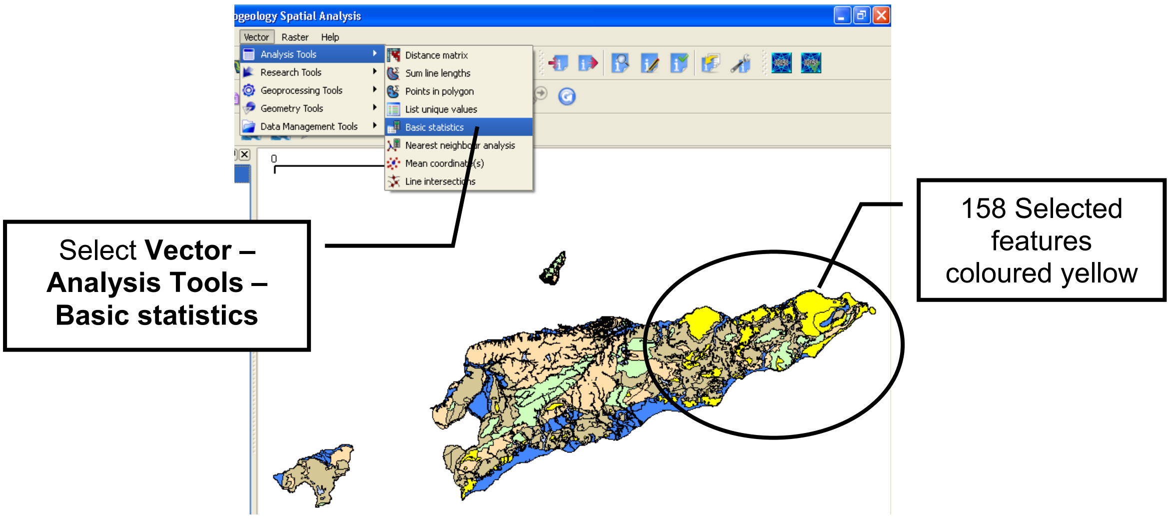
158 features are selected in the attribute table.

10. In the attribute table, check **Show selected only**. The table now displays only the records for the 158 features that have Fissured – High values in their Aqu_w_PV fields.

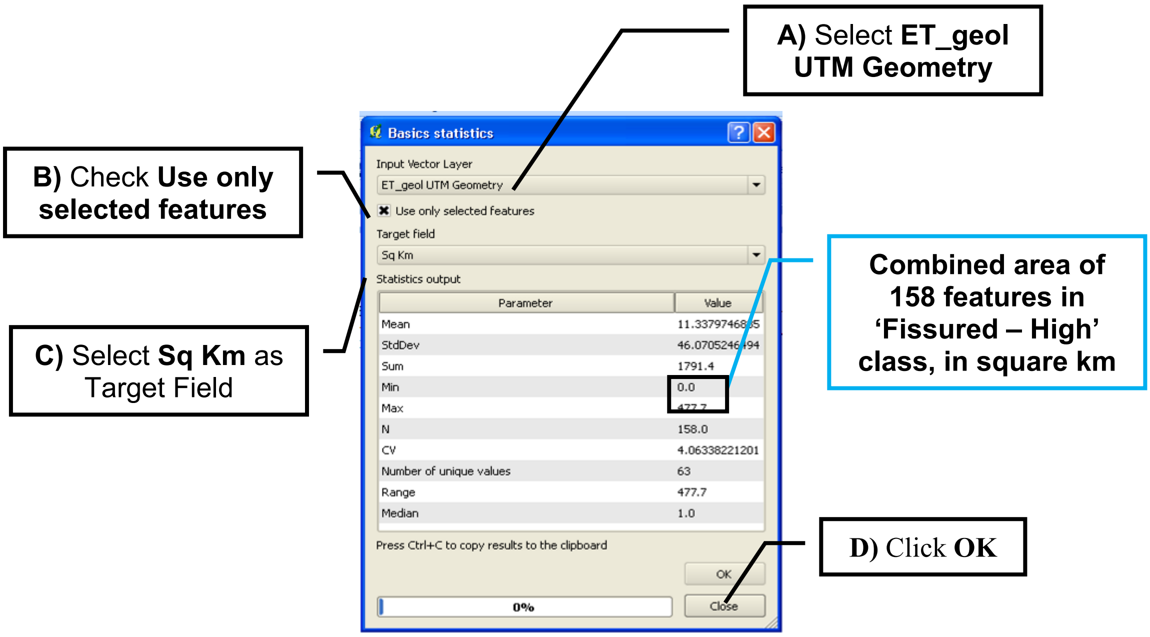


11. Close the attribute table to return to the main Quantum GIS window. Notice some polygons on the map are coloured yellow. These are the 158 features you just selected.

12. Select **Vector – Analysis Tools – basic Statistics** from the main menu bar.



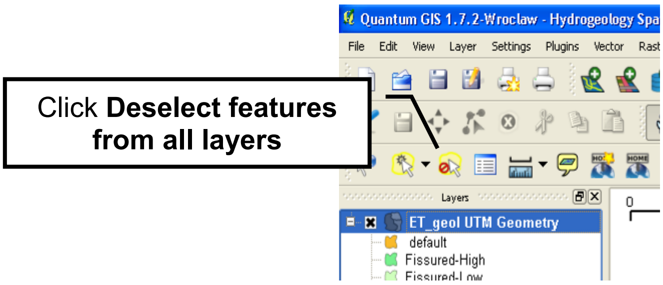
13. In the Basic statistics window, select **ET_geol UTM Geometry** as the Input Vector Layer, check the box for **Use only selected features**, select **Aqu_w_PV** as the Target Field and click **OK.**



RESULT: The Statistics output presents basic statistical measures for all the features in the 'Fissured – High' class. The statistics include the number you are looking for – the total area of land of the 158 selected features, which in this case is **1,791.4 square kilometres.**

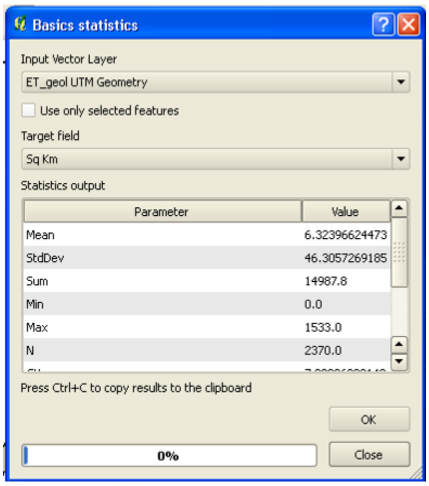
14. Write the area of the 'Fissured – High' class in the table on Page 37.

15. Click **Deselect features from all layers** to deselect the 158 features for which you have just calculated basic statistics. The yellow highlights on your map will disappear and the attribute table will report **0/2370 feature(s) selected**



16. **Repeat steps 8 – 14** for the other 5 hydrogeological classes, and write the total area of each class in the table on **Page 37**.

17. To calculate the total area of Timor-Leste, follow the Vector - Analysis Tools – Basic statistics procedure with **no features selected**. Do not check the Use only selected features box.



In this case, the Statistics output box reports Sum = 14,987.8 and N = 2,370. This tells you that the combined area of all 2,370 features in the layer is 14,987.8 square kilometres.

18. **Write the area of Timor-Leste** in the appropriate box in the table on **Page 37**.

19. Close the **Basic statistics** window and **any attribute tables** that are open.

20. Click the **Save Project** button to save your work

21. Continue to the next exercise; **DO NOT** close the project or exit Quantum GIS

4.2 EXPLORING THE RELATIONSHIP BETWEEN HYDROGEOLOGICAL POTENTIAL AND POPULATION CENTRES

Objective: To examine the population distribution of Timor-Leste in relation to the potential availability of groundwater by answering questions such as:

- What is the groundwater potential for Timor-Leste's main centres of population?
- How many population centres are located in each of the 6 hydrogeological potential classes?
- Which towns might be concerned that their groundwater resources may be inadequate to meet future needs?

For this exercise you will research spatial relationships between 2 layers of geographic data – **ET_geol UTM Geometry** (hydrogeological potential) and **ET Towns UTM** (population centres).

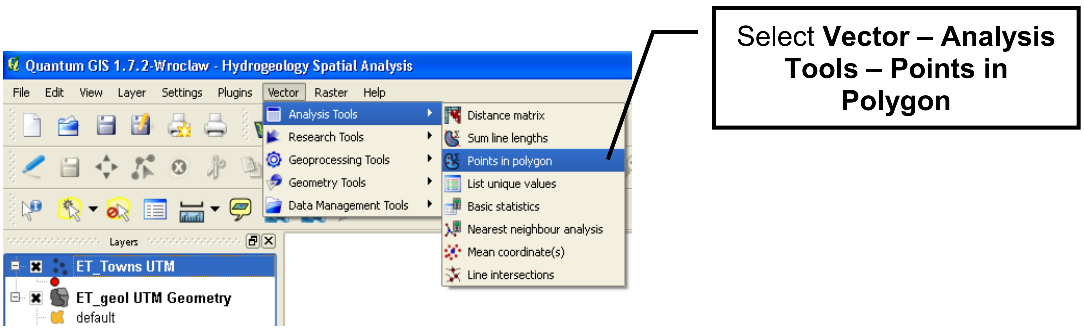
1. ET_geol UTM Geometry is already loaded into Quantum GIS. Now load vector layer **ET Towns UTM** into the same project window. This layer is also stored in the C:\Training folder.

2. Change the symbol used for ET Towns UTM to **red dots** to make it easier to see them.

We can **see** the relationship between hydrogeological potential and towns by looking at the map, but we're going to make it easier to understand, analyse and report by performing two standard GIS overlay analyses – **point-in-polygon** and **intersect**.

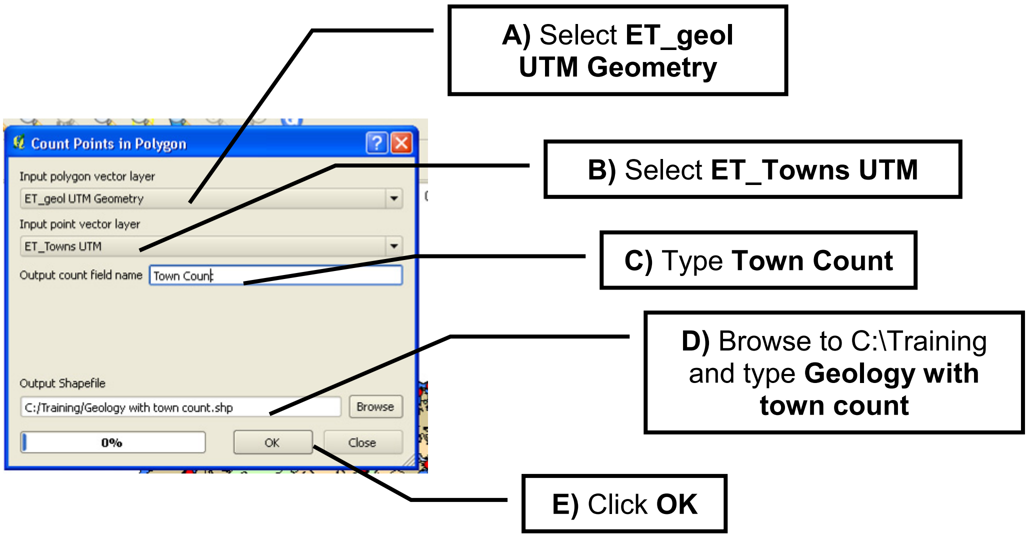
Point-in-polygon will calculate how many population centres are located on each of the 2,370 geological mapping units. It will record the data in a new field in the attribute table for ET_geol UTM Geometry.

3. From the main menu bar at the top of the Quantum GIS main window, select **Vector – Analysis Tools – Points in polygon**.

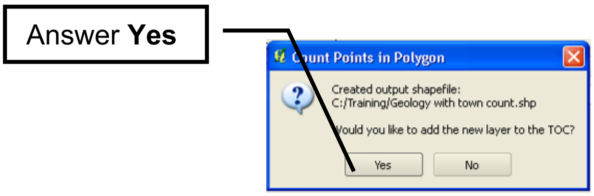


4. In the Count Points in Polygon window, select **ET_geol UTM Geometry** as the Input polygon vector layer, select **ET_Towns UTM** as the Input point vector layer, and type **Town Count** as the Output count field name.

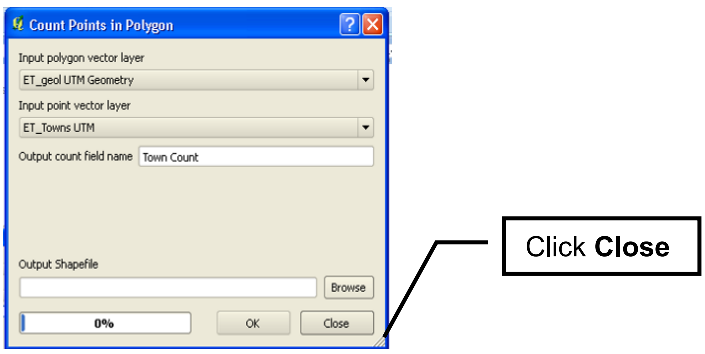
5. This procedure generates a new shapefile, so you need to specify a name for it. Browse to **C:\Training** and type in the Output Shapefile name **Geology with town count**



6. Answer **Yes** to the question, Would you like to add the new layer to the TOC?

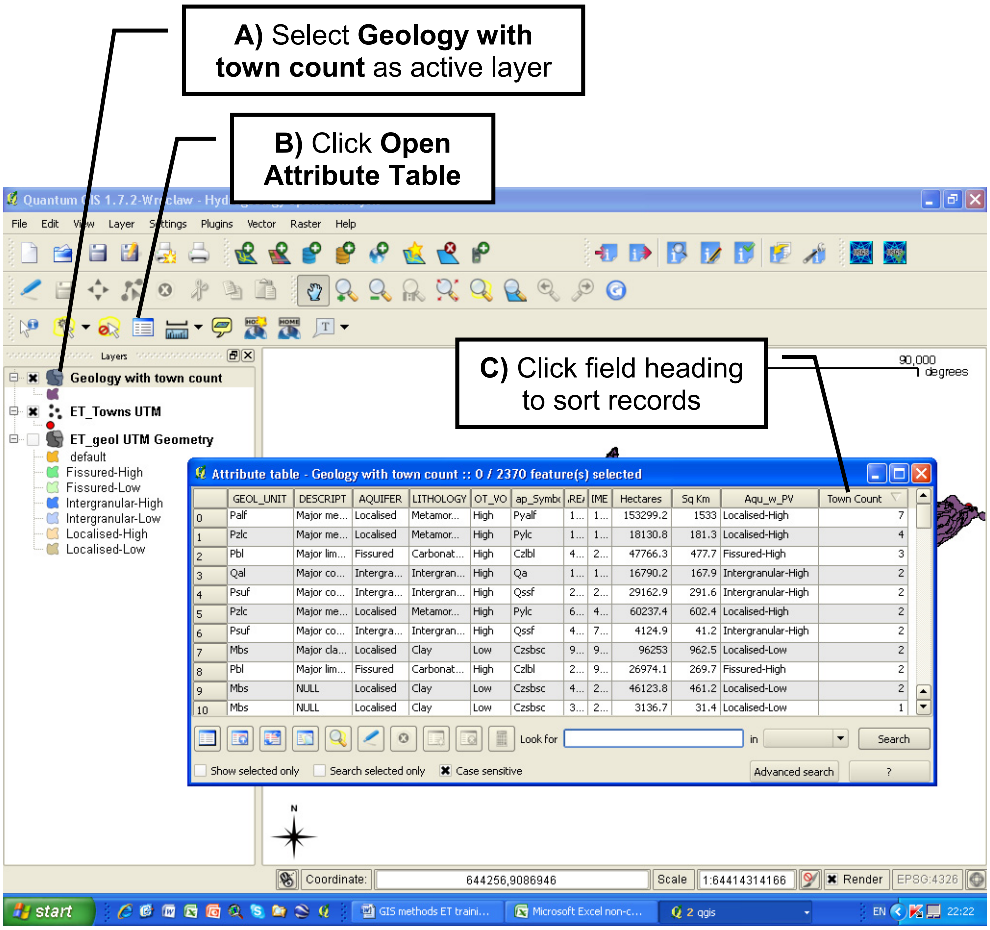


7. **Close** the Count Points in Polygon window



8. The new layer, **Geology with town count**, will load into Quantum GIS and appear in the Layers panel. Select Geology with town count to make it the active layer, and then click the **Open Attribute Table** button. **Scroll** all the way to the right-hand side. The new field you just created is appended next to the Aqu_w_PV field.

9. **Click on the field heading Town Count** to sort the data based on the values in this field. Click once to sort from low to high; click a second time to sort from high to low.

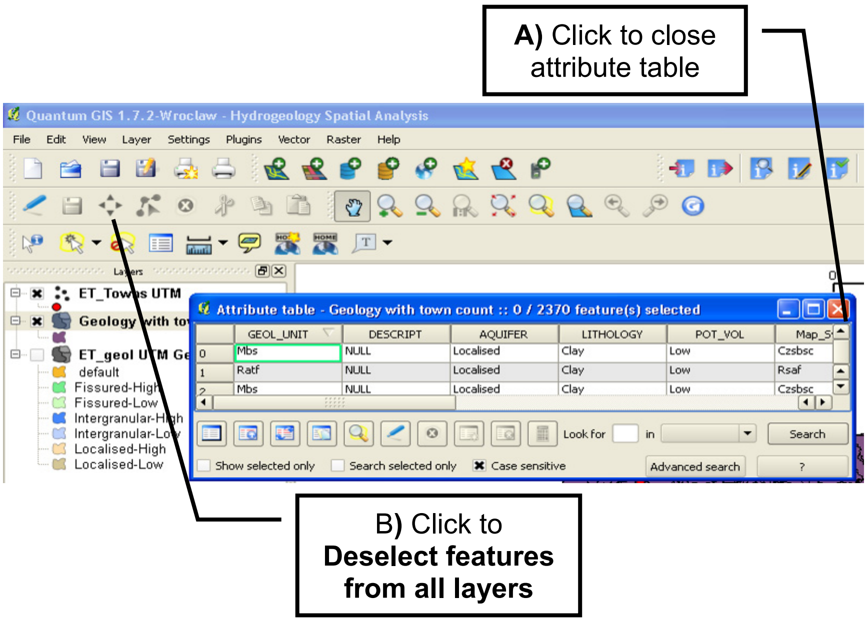


Observations and Interpretation:

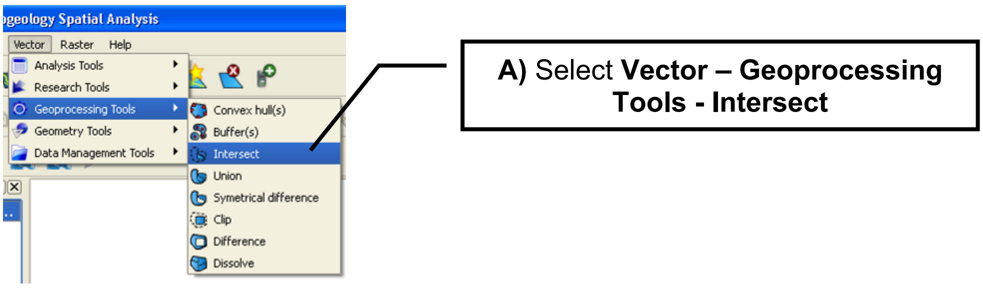
- Of the Ten geological mapping units with 2 or more settlements on them, 8 have high potential groundwater volume and 2 have low potential groundwater volume.
- Of the total of 2,370 geological mapping units, 51 have towns on them. Of these 51 units, 27 have high potential groundwater volume and 24 have low potential volume.
- Of the 51 geological mapping units with towns on them, 9 are fissured, 22 are intergranular and 20 are localized.

Intersect will determine which geological mapping unit each of the 69 towns is located on. It will then append the corresponding attribute values from ET_geol UTM Geometry to each record in the ET Towns UTM attribute table.

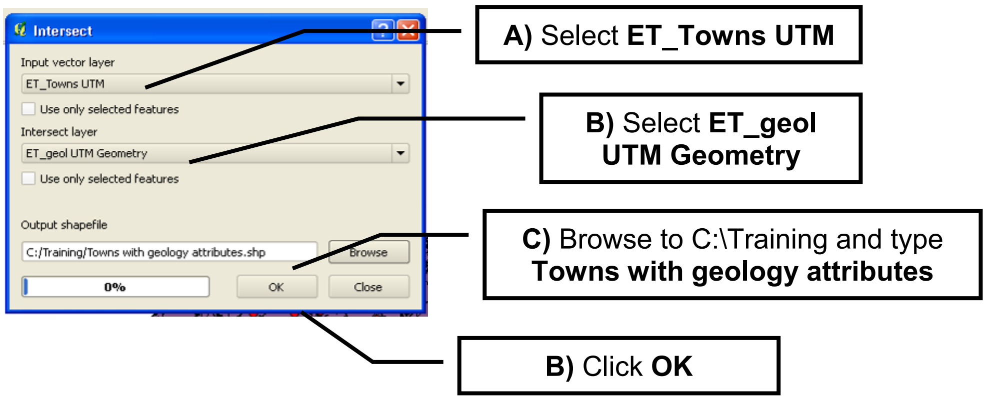
10. **Close** the Geology with town count attribute table and click **Deselect features from all layers**



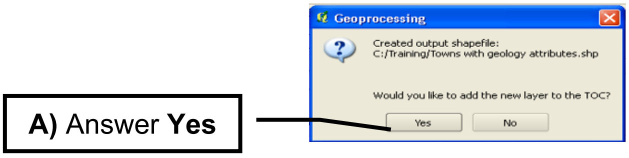
11. From the main menu of the main Quantum GIS window, select **Vector – Geoprocessing Tools - Intersect**

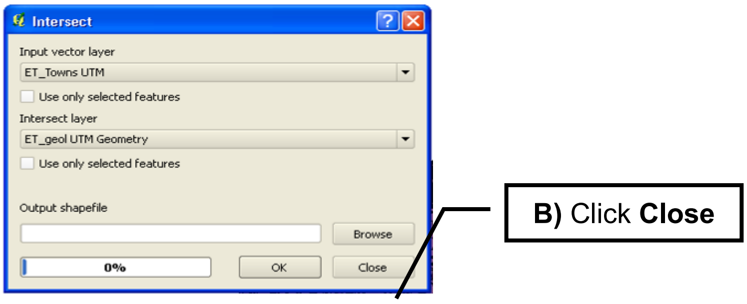


12. In the Intersect window, select **ET_Towns UTM** as the Input vector layer and **ET_geol UTM Geometry** as the Intersect layer. Browse to **C:\Training** and type **Towns with geology attributes** as the name of the Output shapefile.

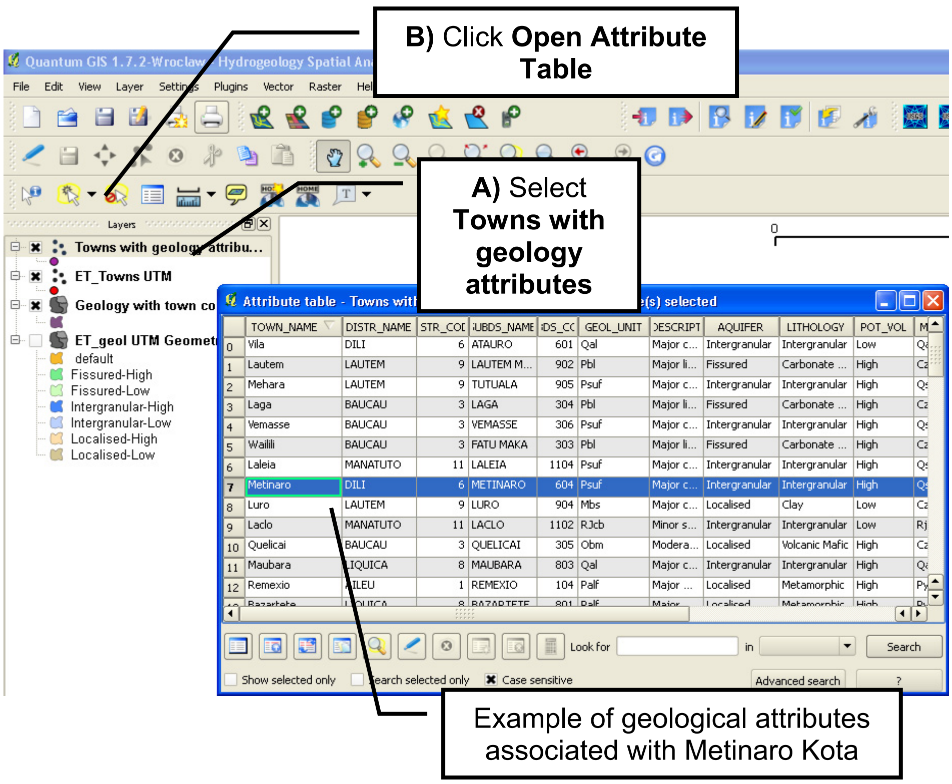


13. Answer **Yes** to the question, Would you like to add the new layer to the TOC? Then **Close** the Intersect window.





14. The new layer, Towns with geology attributes, will load into Quantum GIS and appear in the Layers panel. Select **Towns with geology attributes** to make it the active layer, and then click the **Open Attribute Table** button. Scroll all the way to the right-hand side. The new field you just created is appended next to the Aqu_w_PV field.



Observations and Interpretation:

- The new layer, **Towns with geology attributes**, has 69 features, representing Timor-Leste's District and Sub District capitals. Attributes from the underlying geological mapping unit are appended to each town's record in the attribute table. This means we can now easily access and learn about the hydrogeological characteristics of the land each of the country's major settlements sits on, directly from our GIS database. For example, we can see that Metinaro Kota is located on major coastal alluvial deposits (Qssf) and that it is on an intergranular aquifer with potential for high volumes of groundwater.
- Of the 69 towns, **43** are on geological units with **high** potential groundwater volume and **26** are on geological units with **low** potential groundwater volume.
- Many of the largest towns in the country – Dili, Baucau, Maliana, Los Palos, Gleno, Suai and Aileu **-** are on geological units with high potential groundwater volumes.
- Large towns that are on geological units with low potential groundwater volumes include Viqueque, Manatuto, Ainaro, and Maubisse. As their populations expand, towns such as these might have cause to be concerned about meeting their requirements for water in the future.

Through spatial analyses you have created two new datasets that are informative, easy to access and manipulate, and structured in a way that makes them powerful sources of information for research, analysis and reporting.

This completes the spatial analysis. We will now switch our attention to metadata.

5 Metadata

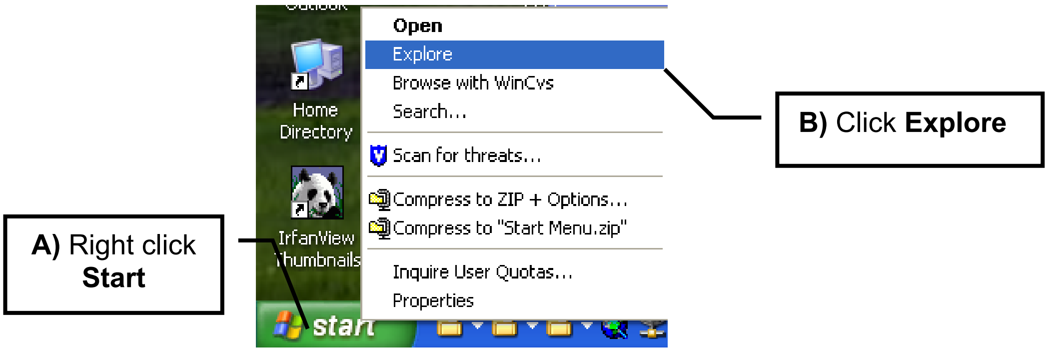
The objectives of this exercise are to a) show you how to expand Quantum GIS's functionality by installing a metadata management plug-in, b) explain to you what metadata is and why it is important; and c) give you the opportunity to enter and then access some simple examples of metadata. This exercise is a very basic introduction to the concept of metadata. It is not possible during this short training course to provide you with comprehensive, accurate metadata for all the geographic data we have used. Time is limited, datasets are generally poorly documented, and in many cases we simply do not know the provenance of the data we are using.

In its original form, the data provided to you for this training course has no metadata attached to it. In the steps below, we will show you how to enter metadata using the Metatools plug-in for Quantum GIS. The FGDC (Federal Geographic Data Committee) standard will be used.

5.1 INSTALLING THE METATOOLS PLUGIN

To install the plug-in you will need to copy the **metatools** folder (located in the training folder) into the QGIS install directory.

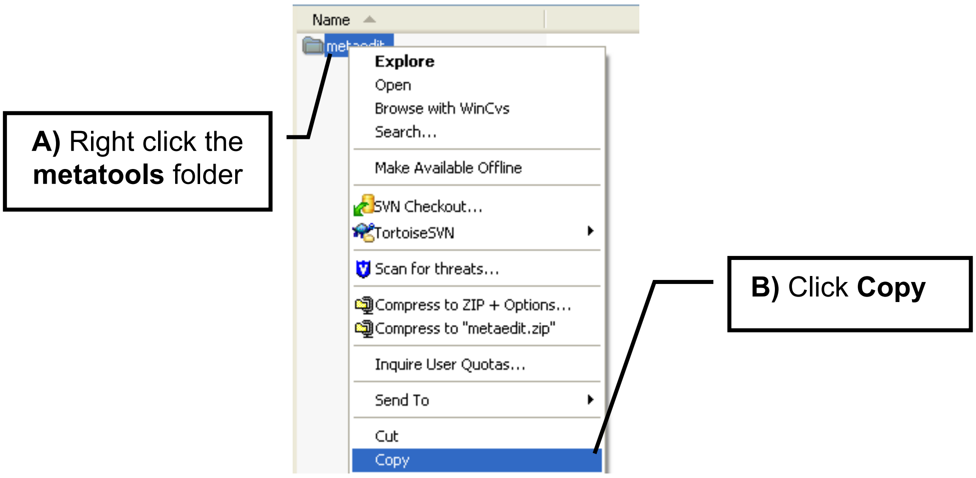
1. On the Windows Desktop, right click the **Start** button and click **Explore**.



2. In the window that appears, navigate to where the **Training** folder is located and into the folder **plugins**.

Within the plugins folder is a folder called **Metatools**.

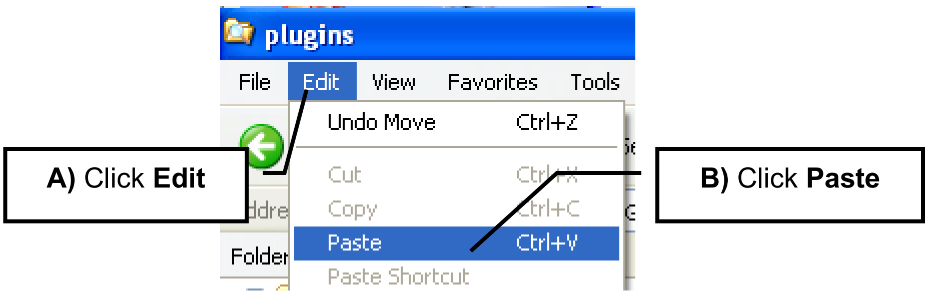
3. Right click the **Metatools** folder and click **Copy**.



4. Navigate to the directory;

   C:\Program Files\Quantum GIS Wroclaw\apps\qgis\python\plugins

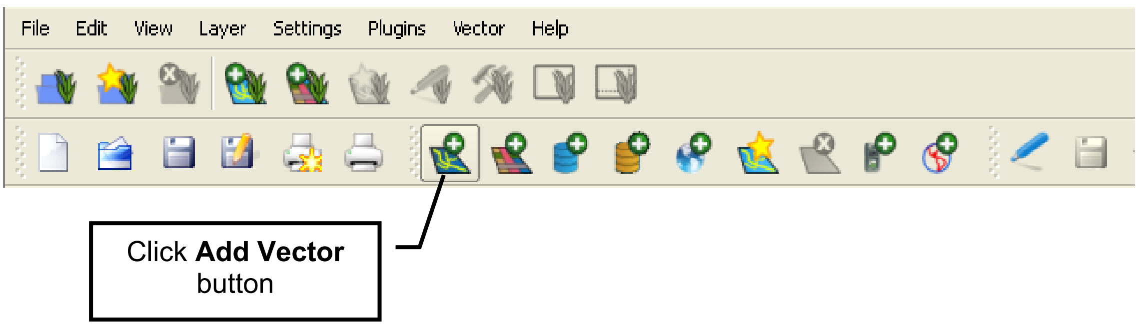
5. Paste the **Metatools** folder into this directory by clicking the menu **Edit > Paste**.



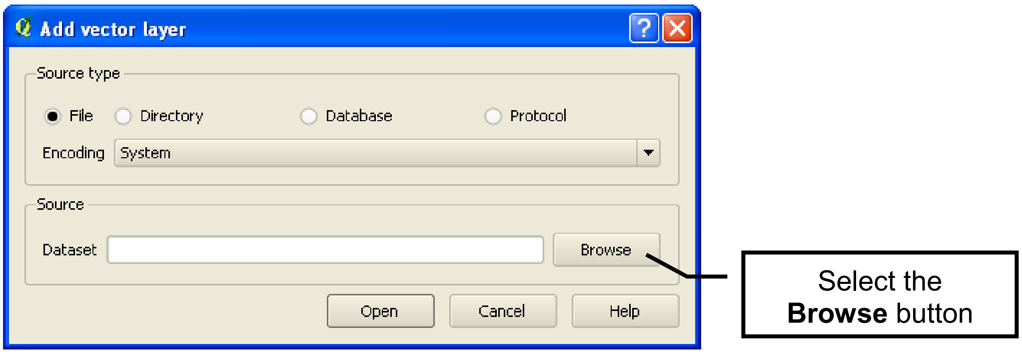
The **Metatools** folder should now appear in the **plugins** folder.

6. **Start Quantum GIS**

7. Click the **Add Vector Layer** button.

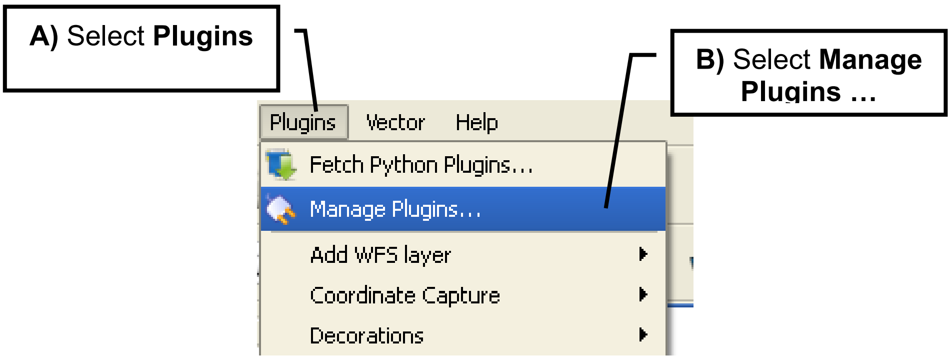


8. Click the **Browse** button and navigate to the **C:\Training folder.**



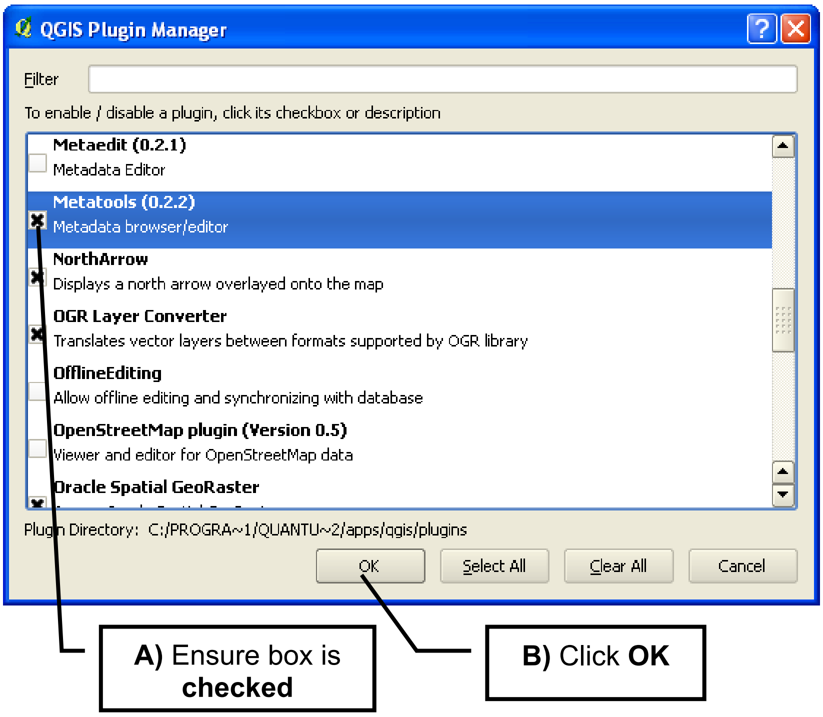
9. Select the geology shape file (**ET_geol UTM Geometry.shp**) and click **Open.**

10. From the main menu, select **Plugins - Manage Plugins …**

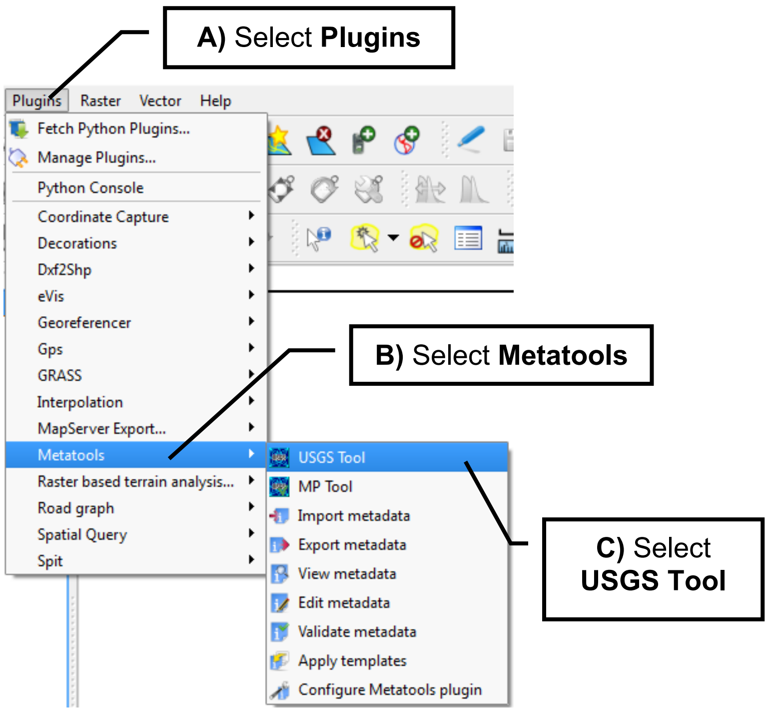


11. In the **QGIS Plugin Manager** window, check the box next to **Metatools (0.2.2)**.

12. Click **OK**.



13. From the main menu, select **Plugins - Metatools - USGS Tool**



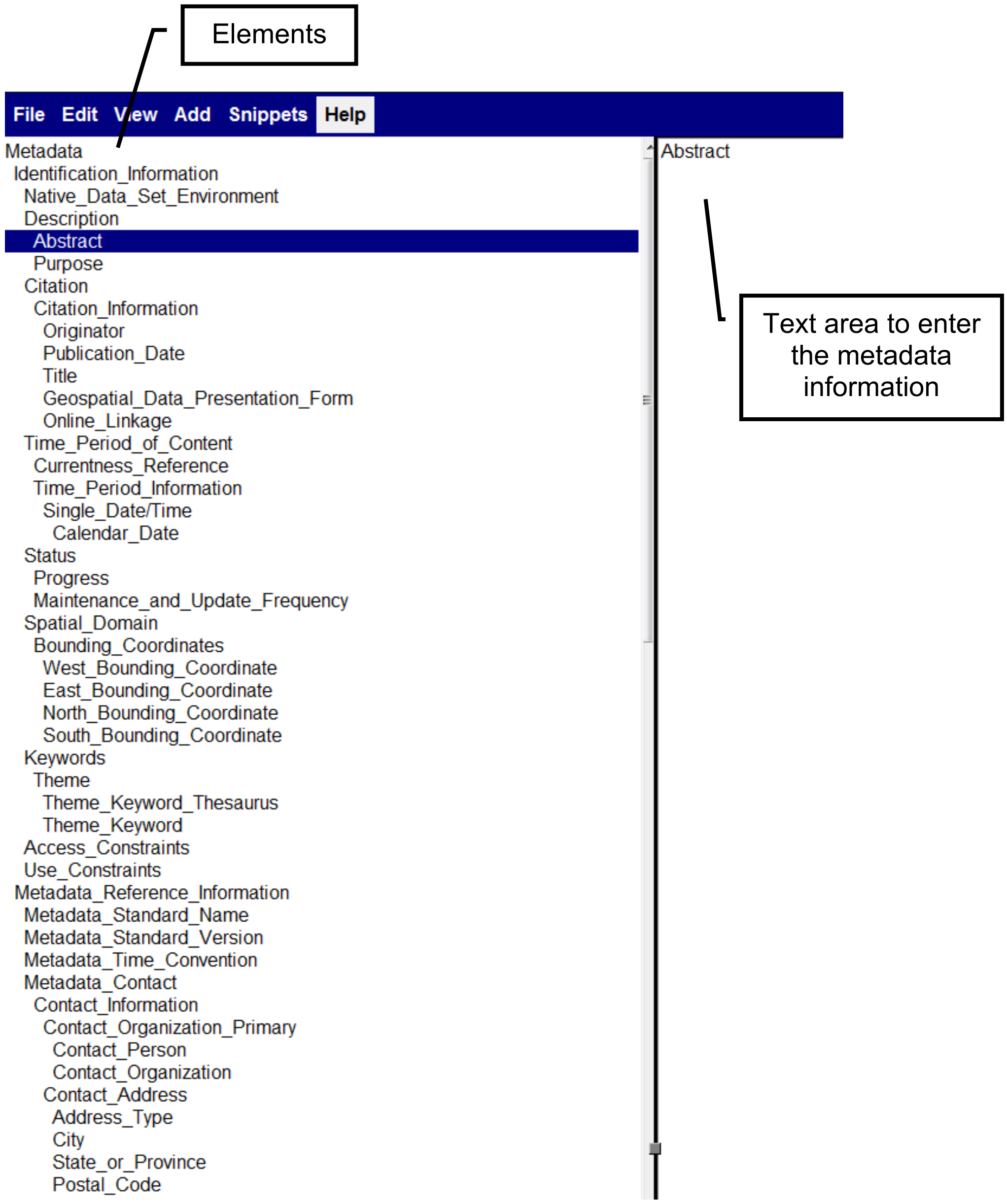
5.2 ENTERING METADATA

The **USGS** window will appear. Here is where we will enter our metadata.

The left hand panel contains the different metadata elements or categories. To populate an element, simply select it and type in the information in the right hand panel.

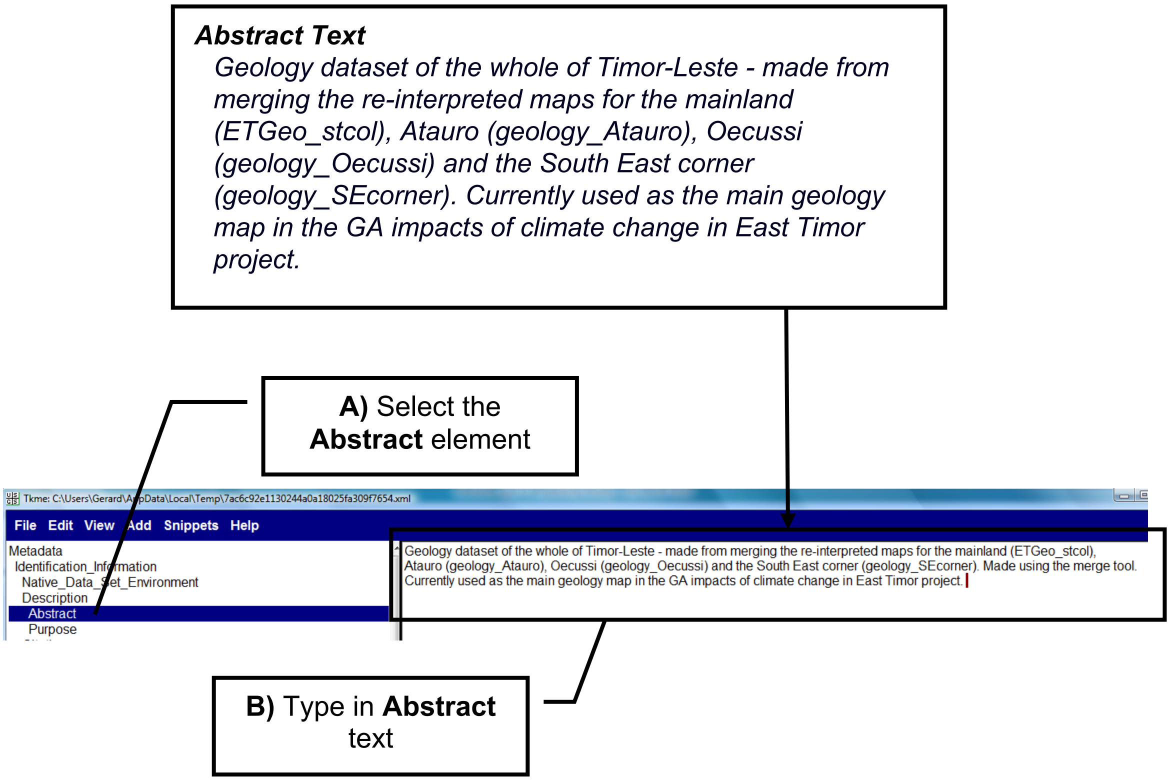
For this training exercise we will update the elements;

- Abstract
- Purpose
- Use_constraints
- Contact_person
- Contact_organization
- Address_type
- City
- State_or_Province
- Postal_Code
- Contact_Voice_Telephone



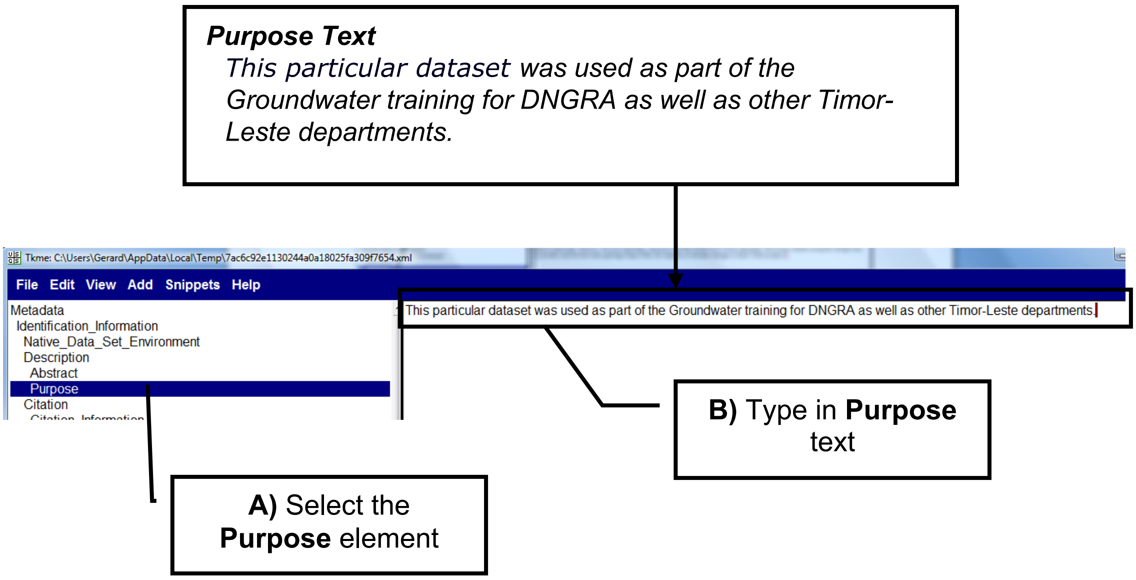
1. Click on the **Abstract** Element.

2. In the right hand panel type in the following text.



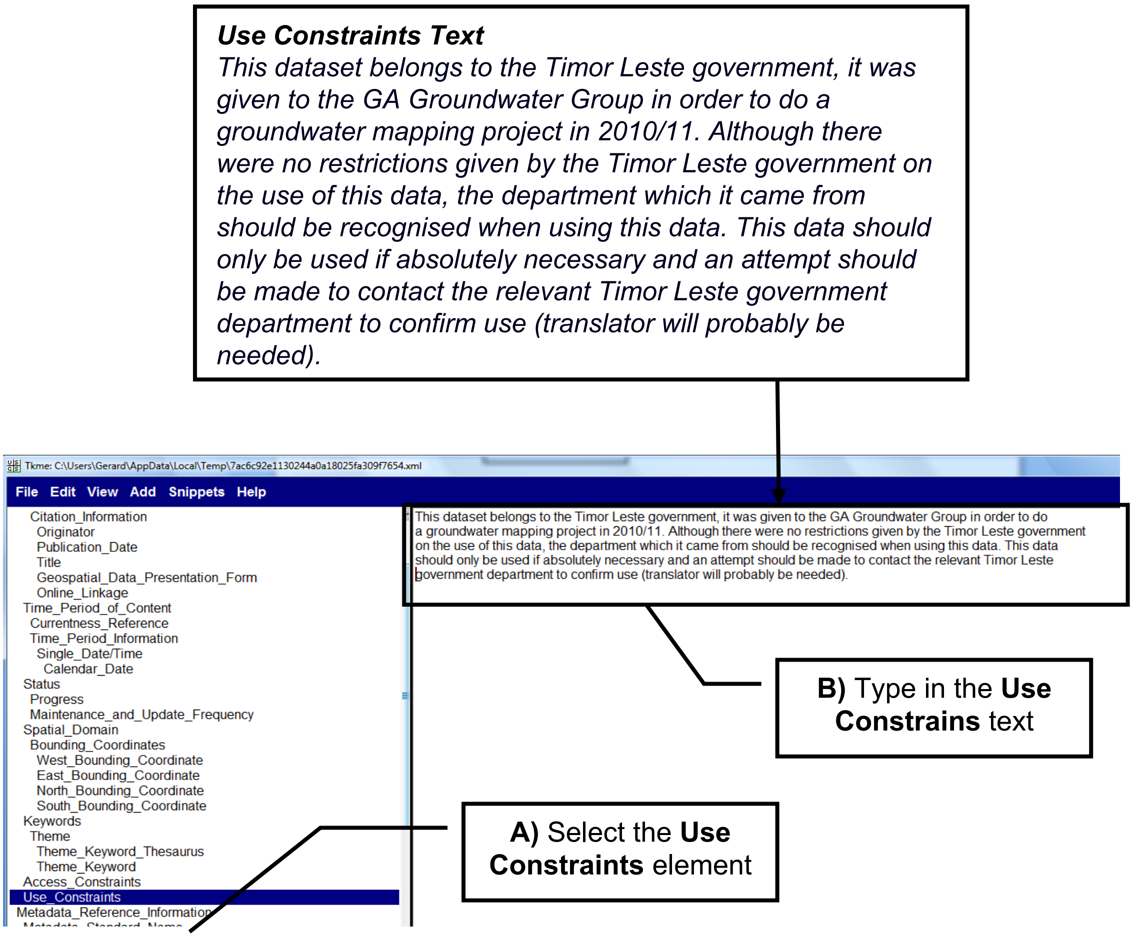
3. Click on the **Purpose** Element.

4. In the right hand panel type in the following text.



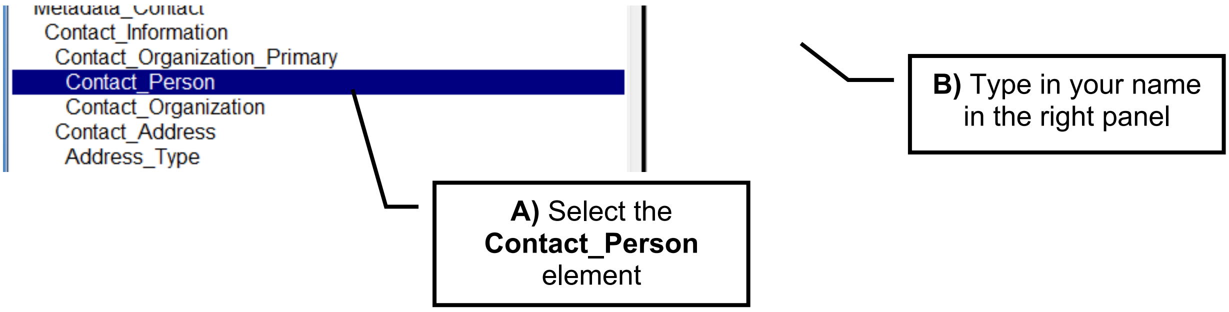
5. Click on the **Use Constraints** element.

6. In the right hand panel type in the following text.



7. Click on the **Contact Person** element.

8. In the right hand panel type in your name as the contact person.

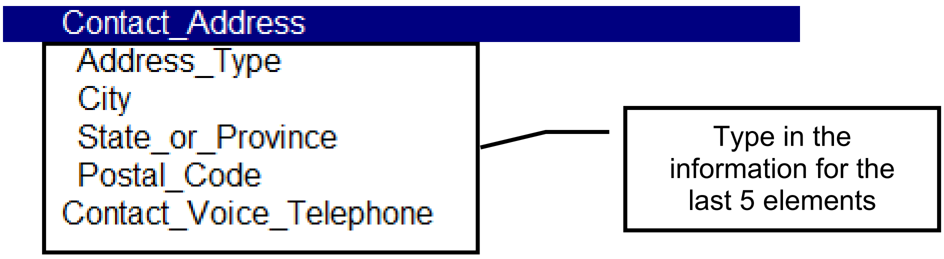


9. Click on the **Contact_Organization** element.

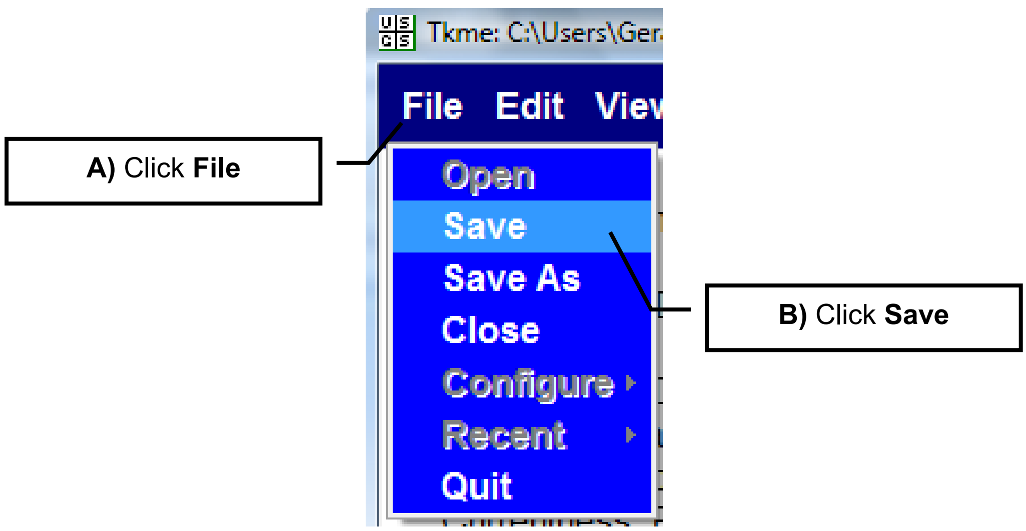
10. In the right hand panel type in the name of your organization.

11. Continue this process for the last 5 elements;

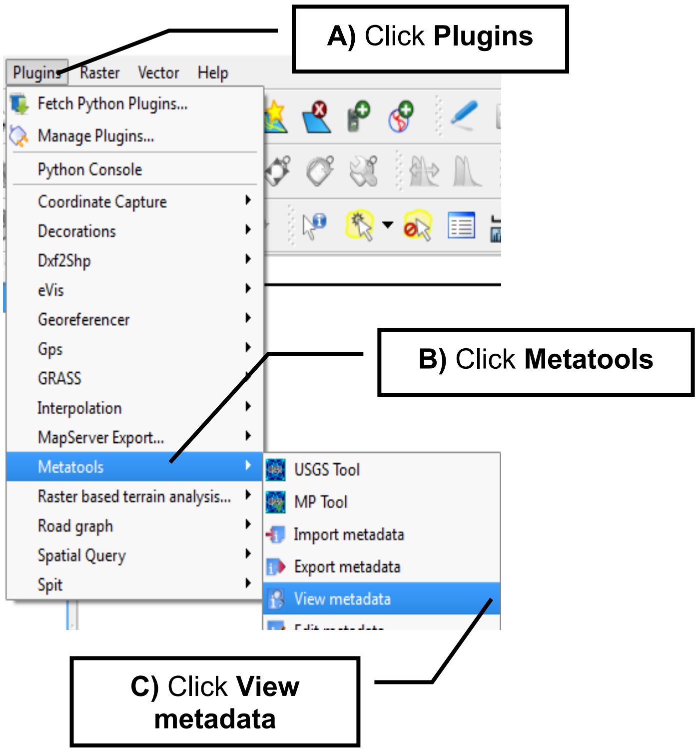
- Address type
- City
- State_or_Province
- Postal_Code
- Contact_Voice_Telephone



12. Once you have entered the information for the above elements, in the top left hand corner click the menu **File** > **Save** to save your metadata.

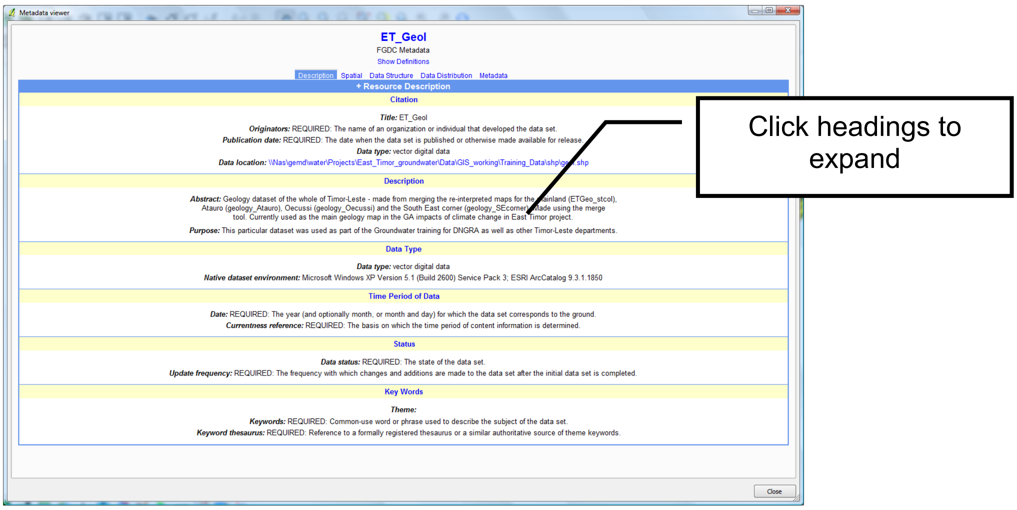


13. In QGIS click on the menu **Plugins > Metatools > View metadata**.



The metadata viewer window will appear displaying the metadata you have entered.

You will need to click on each heading to expand it and see the underlying information.



You have now completed entering some sample metadata. Obviously if you had more information you would try and update as many elements as possible.

14. Close the metadata viewer and close QGIS.

ATTACHMENT I - GEOLOGY MAP SYMBOL CONVERSION GUIDE

MAP_SYMBOL	ORIGINAL GEOL_UNIT
Czb	Qvba
Czbbf	Obm
Czbmf	Tmm
Czf	Qvd
Czf2	Ted
Czlal	1a
Czlbl	Pbl
Czlcl	Mcl
Czldl	Edl
Czllgl	Mlgl
Czlpl	Ppl
Czs	W
Czsag	Plag
Czsbsc	Mbs
Czsdc	Pldc
Czssbc	Plsc
Czsvf	Mvf
KCzssf	KTsf
Klbl	Kbl
Kswbf	Kwf
Pe	Ub
Pealf	Palf>v
PJewlf	RJwf>s
Plmf	Pmf
Pmalf	Palf>m
PRbmf	TRmv
PRlmf	TRPm
Ptalf	Palf>a

MAP_SYMBOL	ORIGINAL GEOL UNIT
Ptmalf	Palf>as
Pyalf	Palf
Pyatf	Patf
Pycf	Pcf
Pylc	Pzlc
Pysalf	Palf>qs
Qa	Qal
Qa2	Qt
Qdc	Qb
Qs	Qa
Qssf	Psuf
Qt	Ql
RJb	RJlb>v
RJewlf	RJwf>s
RJl	RJlb>l
RJl2	RJlb>lb
RJls	RJlb
RJrwlf	RJwf>hp
RJs	RJcb
RJswlf	RJwf
RJszwlf	Shear
RJtwlf	RJwf>p
Rlaf	Raf
Rsaf	Ratf

ATTACHMENT II - STANDARD RGB VALUES FOR GEOLOGY & HYDROGEOLOGY SYMBOLS

GEOLOGY SYMBOL	R	G	B
Czb	255	110	10
Czbbf	255	143	46
Czbmf	255	161	102
Czf	255	102	142
Czf2	255	51	104
Czlal	208	246	255
Czlbl	211	235	251
Czlcl	188	217	235
Czldl	188	221	255
Czllgl	233	243	248
Czlpl	223	246	255
Czs	255	255	160
Czsag	255	228	179
Czsbsc	249	229	153
Czsdc	255	255	208
Czssbc	255	241	179
Czsvf	237	215	153
KCzssf	171	255	194
Klbl	144	204	245
Kswbf	173	255	229
PJewlf	169	133	255
PRbmf	255	60	10
PRlmf	77	165	221
Pe	184	61	255
Pealf	148	82	255
Plmf	33	143	212
Pmalf	183	163	102
Ptalf	219	209	179
Ptmalf	214	210	166
Pyalf	186	181	133
Pyatf	174	150	116

GEOLOGY SYMBOL	R	G	B
Pycf	198	180	156
Pylc	195	158	128
Pysalf	174	140	128
Qa	255	255	231
Qa2	245	255	230
Qdc	255	255	42
Qs	255	246	230
Qssf	252	248	230
Qt	240	255	230
RJb	255	80	35
RJewlf	201	169	255
RJl	144	193	222
RJl2	122	188	229
RJls	100	184	241
RJrwlf	223	195	195
RJs	94	255	179
RJswlf	102	227	186
RJszwlf	114	255	181
RJtwlf	211	175	167
Rlaf	100	168	209
Rsaf	74	255	171

HYDROGEOLOGY SYMBOL	R	G	B
Fissured - High	117	240	140
Fissured - Low	207	255	189
Intergranular - High	69	135	255
Intergranular - Low	190	210	255
Localised - High	255	227	171
Localised - Low	214	199	150