Creating Maps in QGIS: A Quick Guide

Overview

Quantum GIS, which is often called QGIS, is an open source GIS desktop application. Comparing to ArcGIS, QGIS can be installed on various operating systems, such as Windows, Mac OS X, Linux (Ubuntu), and Unix, while ArcGIS only has Windows version. More importantly, QGIS is FREE and has many plugins, adding different functions. However, since QGIS mainly relies on community support and voluntary developers, it does not have abundant documents and sometimes is not intuitive to use. Hence, making maps in QGIS needs some explanation. The two major steps, browsing data and making maps, are divided into five parts shown in the following table:

No.	Steps	Sections to check	Difficulties
1	Load Geospatial Data into QGIS	1.1	Data formats
2	Identify the features and attributes to present	1.2	Layer order, feature selection, and (briefly) frequent-used projections
3	Define how to show the data	2.1	Transparency (raster and vector), data classification, and layer file
4	Add maps components	2.2	Geospatial data references
5	Export maps	2.3	File formats

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Note: This document can be read in a "non-linear" manner:

- *Possible problems are covered in coloured regions*: Knowing how to address these problems are not quite relevant to the main process, but might be useful in practise. Hence, they are covered in coloured regions, which *you can skip when you want to go through the process* and no error pops up. You can come back whenever you meet problems;
- *Section number and title is shown at the top of every page*: If you have known what kind of problem you have, you can "jump" to the section where discusses it.

1. Browse Geospatial Data

1.1. Load data

To launch QGIS, click: **Start -> All Programs -> QGIS -> QGIS**. QGIS normally adds the version number after "QGIS", which is currently 1.5.0 (code name Tethys). The main windows of QGIS can be divided into three regions shown in Figure 1.

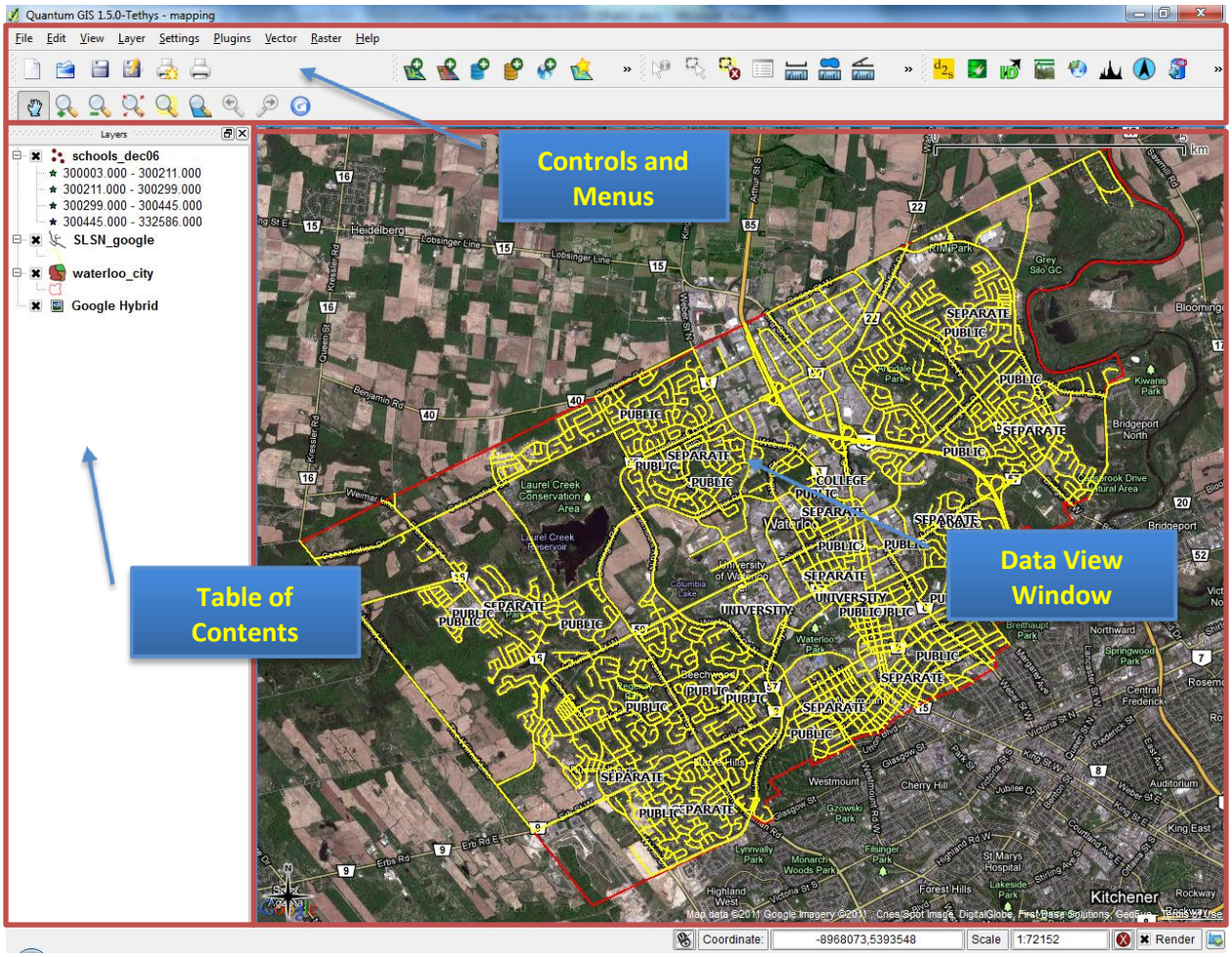


Figure 1. The Main Window of QGIS showing Regions

1.1 Load Data

Click the **Add Vector Layer** button to add geospatial data (Figure 2), which opens a window (Figure 3).

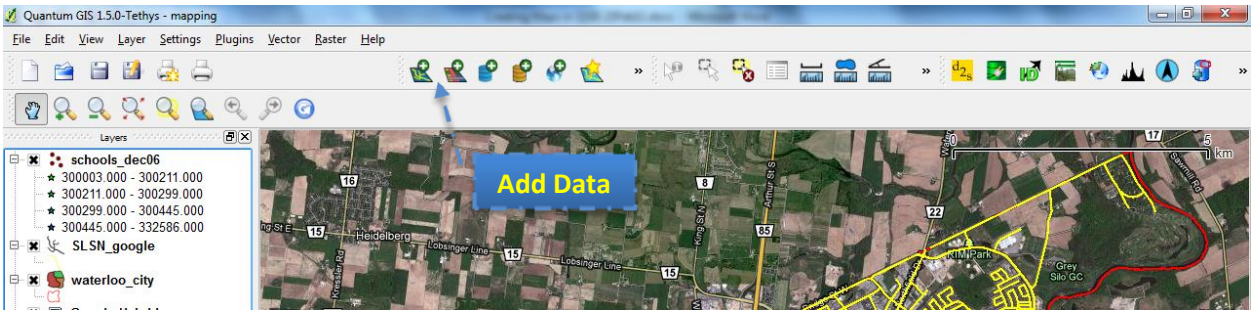


Figure 2. The Main Window : Add Vector Layer button

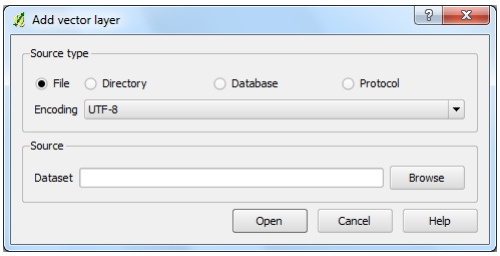


Figure 3. The Pop-up Window to "Add Vector Layer"

Then you can browse to the file you want to work with by clicking the **Browse** button just like any other file explorer dialogs in Windows. You can open multiple files at one time by holding the **Ctrl** or **Shift** button when you are clicking the mouse button to make selections. The by-default file filter is *.shp file (Figure 4). But there are many other choices, such as *.kml (Google Earth) and *.tab (MapInfo), much broader than ArcGIS.

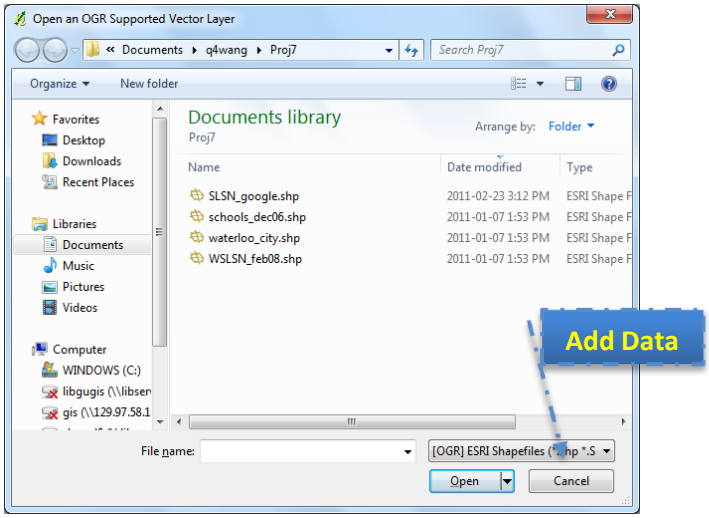


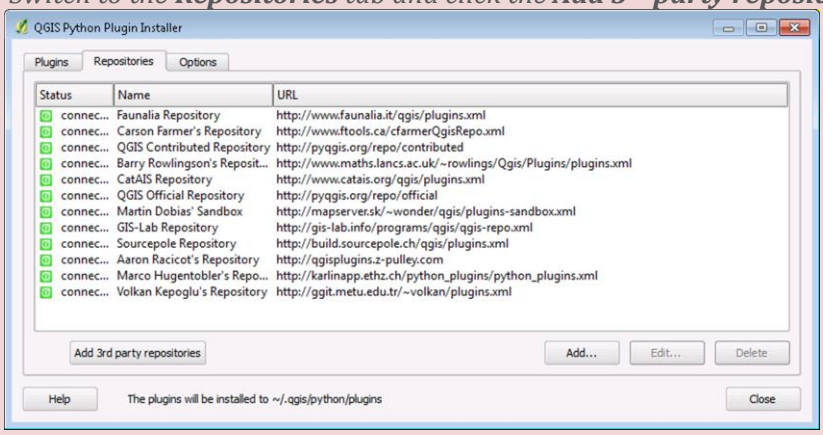
Figure 4. The File Open Dialog with File Filters

Load all data listed in Figure 4 into QGIS.

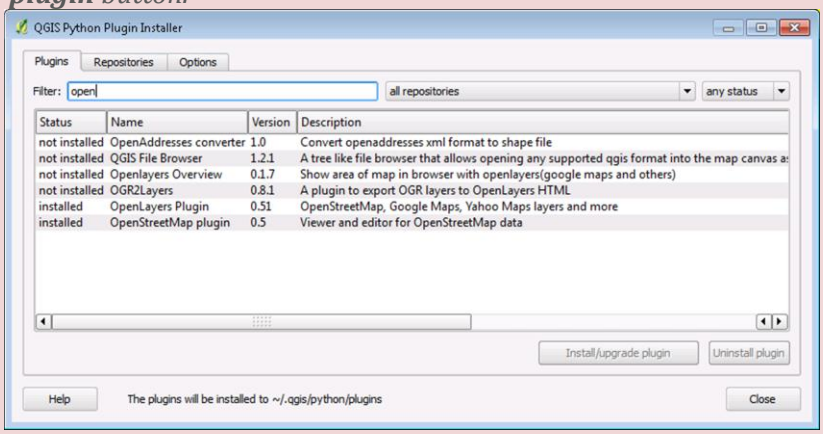
Load Google Maps.

QGIS provides the flexibility of using Google (or Yahoo) Satellite images as a background layer in your map. To do so, follow the steps below:

0. *Install the OpenLayers plugin into QGIS:*
   a. *Go to **Plugins -> Fetch Python Plugins**, which leads to a dialog.*
   b. *Switch to the **Repositories** tab and click the **Add 3rd party repositories** button.*



   c. *Switch back to the **Plugins** tab and search for Openlayers (you can type in "openlayers" in the filter), then select the "Openlayers plugin" and click the **Install plugin** button.*



1. *Add Google Maps as the background layer: Go to the menu **Plugins -> Openlayers plugin ->Add Google Hybrid Layer.***

1.1 Load Data

***Frequently-used File Formats in QGIS**:*

- *Feature Data: Feature data are usually organized as points, lines, and polygons in vector format.*
    - ***Shapefile**: The most commonly used geospatial data format. Although it appears to be one file in ArcMap, shapefile includes **multiple files** with the same file name, but different extensions. *.shp, *,dbf, and *.shx are must-have.*
    - ***Personal Geodatabase**: These files are based on Microsoft Access (*.mdb). From user perspective, all kinds of geodatabase are the same, which include multiple layers (different geospatial data) in one geodatabase.*
    - ***MapInfo files:** The following three are legendary geospatial file formats. MapInfo is the first desktop GIS software for Windows. Its files (*.tab) are widely used.*
    - ***MicroStation files:** MicroStation files have the extension of *.dgn, whose vendor is GE. Electricity plants often use it.*
    - ***ArcInfo:** ArcInfo is the previous generation of ArcGIS. Its file (*.e00) are supported in QGIS as well.*
    - ***Google Earth:** *.kml and *.kmz (zipped KML) are Google Earth file formats, which are popular in Location-Based Service now. Many websites support kml and kmz files.*
    - ***GML and GeoJSON:** Open source geospatial data standard, which is also popular in online applications.*
    - ***GPS:** The track of GPS records can be imported into QGIS as *.gpx files. This function is very useful in surveying.*
    - ***CSV:** *.csv files stands for comma separated value, which can be regarded as a legendary spreadsheet file format.*
    - ***US Census TIGER:** US census publishes its data in tiger format, which belongs to "directory" source type rather than "file".*
- *Raster Data: Raster data uses grid to represent a region with values as a "field". Images explicitly have the parameter of resolution. Typical raster data is:*
    - ***GeoTIFF**: They have the file extension of *.tif. The key difference between normal TIFF file and GeoTIFF is that GeoTIFF has projection information. Hence, normal TIFF files cannot be correctly added to the desired location.*
    - ***GeoJPEG**: Similar to GeoTIFF, but they have *.jpg extension.*
    - ***Usage**: Raster data can be air photos, satellite images, elevation data (DEM). But raster data tends to be huge and slow to load.*
- *Stronger Database Support:*

  One major advantage of QGIS over ArcGIS lies in its superior support of different database vendors. Almost all types of relational database management system (RDBMS) are supported.

1.2. Browse Geographic Features

Most controls to browse data are located in two tool bars (Figure 5), which are also available under the **View** menu. If you cannot find this toolbar, go to **View** -> **Toolbars** and check the **Map Navigation** on.

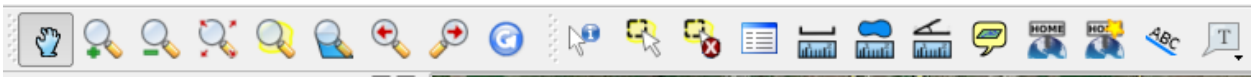


Figure 5. The Toolbar with Data Browsing Controls

Most icons are intuitive and self-explained. If you are not sure what function it has, hover your mouse over that icon. A pop-up text will show with further explanations.

One difference between QGIS and ArcGIS is the layer related operations. In QGIS, all layer related operations must be conducted after the target layer has been selected, such as feature identification, feature selection, and attribute table operations.

To open the attribute table, you can either right-click at the layer and select "Open attribute table", or click the open attribute table button in the toolbar (Figure 6).

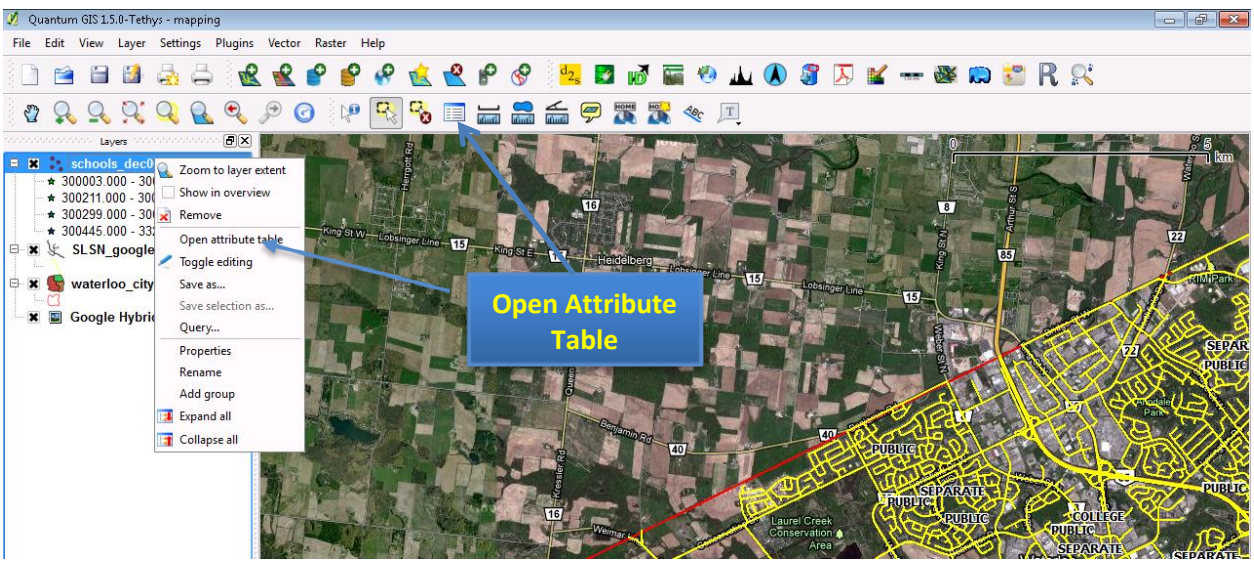


Figure 6. The Pop-up Window with Options on a Layer

The feature selection function in QGIS is not as powerful as ArcGIS. There are two ways to choose a subset of features. One is "select by dragging a rectangle" by clicking  . The other is by right-clicking the layer, then selecting "**Query**" (Figure 7). You can form SQL statements to select features based on attributes.

1.2 Browse Geographic Features

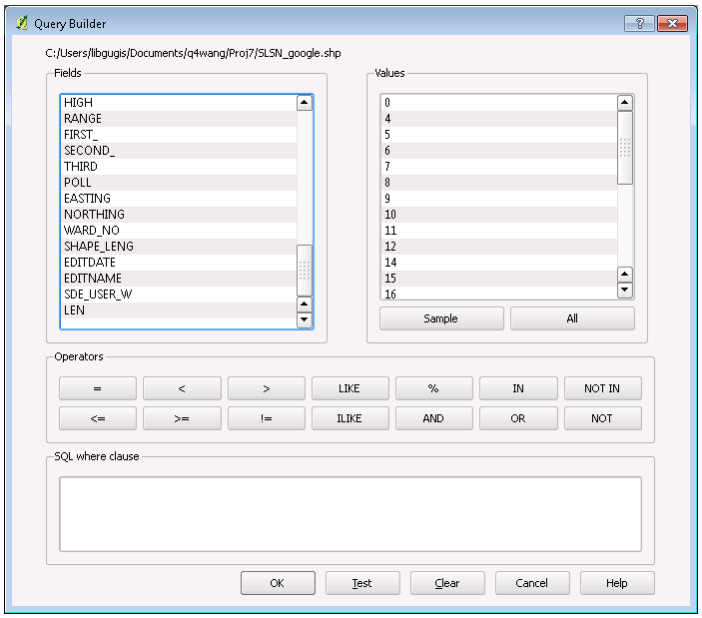


Figure 7. The Query Builder Window

Another interesting feature is "Zoom to layer extent" shown in Figure 6. Sometimes you may lose sight of your map display. If so, you can zoom back to the desired region by clicking **Zoom to layer extent**.

Brief introduction to geographic information:

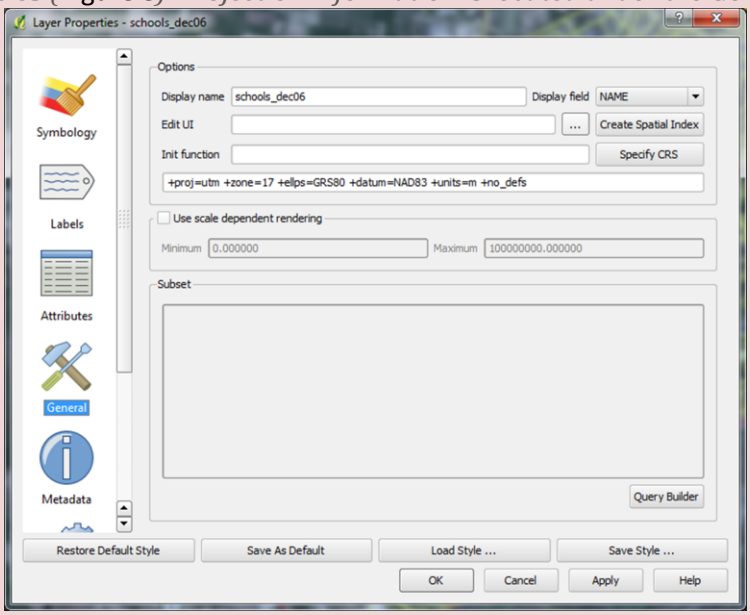
- *Vector Data: Vector data contains two parts: a geographic feature on the map (i.e. bus stops) and an associated record in the table with all its attributes (i.e. routes, arriving times, etc). The separation of attribute table and geographic feature is critical, because most operations in ArcGIS are organized based on this classification.*
- *Raster Data: Raster data is a set of cells with values, which is normally added as reference background in mapping or included for further analysis. Normally, users will not identify or modify raster data for mapping purpose.*
- *Networks: A kind of typical networks is roads. Finding the nearest way to a destination via roads is a frequently used operation. Please find more in the further reading if interested.*
- *Further Reading: Michael Zeiler, Modeling Our World, ESRI Press, 2nd Edition, 2010.*

Add Raster Data: QGIS explicitly differentiates vector and raster data format. To add raster data, the ***Add Raster Layer*** *button*  *should be clicked. The main reason is that raster data is supported via another open source module called GDAL, which adds powerful operations or raster data processing.*

1.2 Browse Geographic Features

Geospatial Data Projections:

- *The globe is not flat, but a map is. Any kind of projection used to make the map distorts the reality in some way. Hence, when Google maps or any other third party layer is included, different projections are likely to be used, leading to a problem of mismatch.*
- *To obtain the projection information of a layer (and the map) right-click on the layer, then select* ***Properties*** *(Figure 8). Projection information is located under the* ***General*** *tab.*



- *You can specify (check the projection code) by clicking the* ***Specify CRS*** *button. Frequently used projections are:*
  - *WGS 84: Used in GPS systems with longitude/latitude measurement. You can find it using either ESPG code 4326 or CRS ID 3452;*
  - *Google Mercator: Used by major online mapping services, including Google, Microsoft, and OpenStreetMap. Its ESPG code is 900913, while CRS ID 3644;*
  - *UTM zone system: UTM system is often employed in northern country mapping. Waterloo, Ontario, Canada belongs to UTM zone 17N, which can be found wit ESPG: 26917 and CRS ID 2294.*
- *If different layers cannot combine, go to the menu* ***Settings -> Project Properties****, and specify a project in the* ***Coordinate Reference System (CRS)*** *tab of the pop-up window. Check all layers' projections if there are still problems. Mismatch is usually caused by incorrect use of projections.*

2. Mapping

2.1. Key Options of Geospatial Data Representations

Main options of changing geospatial data representations include layer order, layer transparency, symbology, label, and annotation. Apart from the first one (layer order) and last one (annotations), all the rest are located in the pop-up window (Figure 8) when you right-click the layer you want to modify and select **property** (Figure 9). They are under either the **symbology** or **labels** tab.

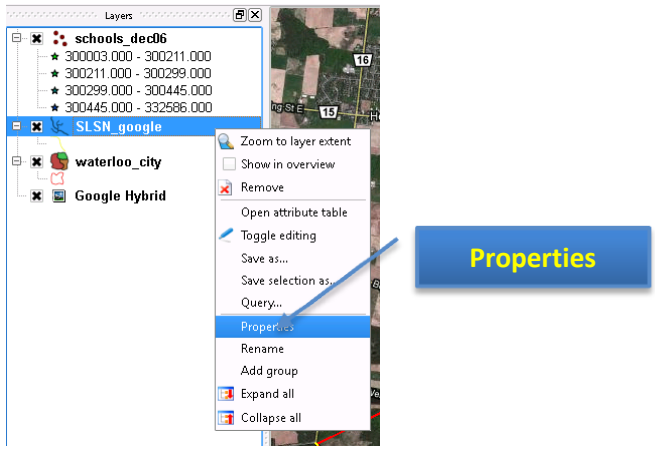


Figure 8. The Pop-up Window of a Layer's Property

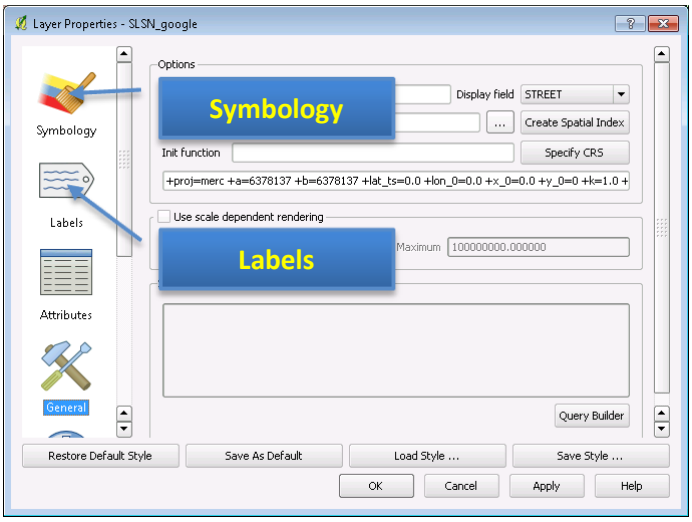


Figure 9. The Property Window

All options will be introduced as subsections in the following.

2.1.1. Layer Order and Transparency

QGIS displays geospatial data according to the order in the table of contents: the bottom layer will be drawn on the screen first and covered by upper layer. Hence, the layer on the top in the table of

contents will be displayed as the top layer in the map**. Unlike ArcMap, QGIS will not order layers automatically.**

When a point-feature layer is put under a polygon-feature layer, the point-feature one is covered and invisible. You can change layer visibility by switching the checkboxes left to the layer name in table of contents (Figure 10). And the display order can be changed by simply dragging the layer toward or away from the top.

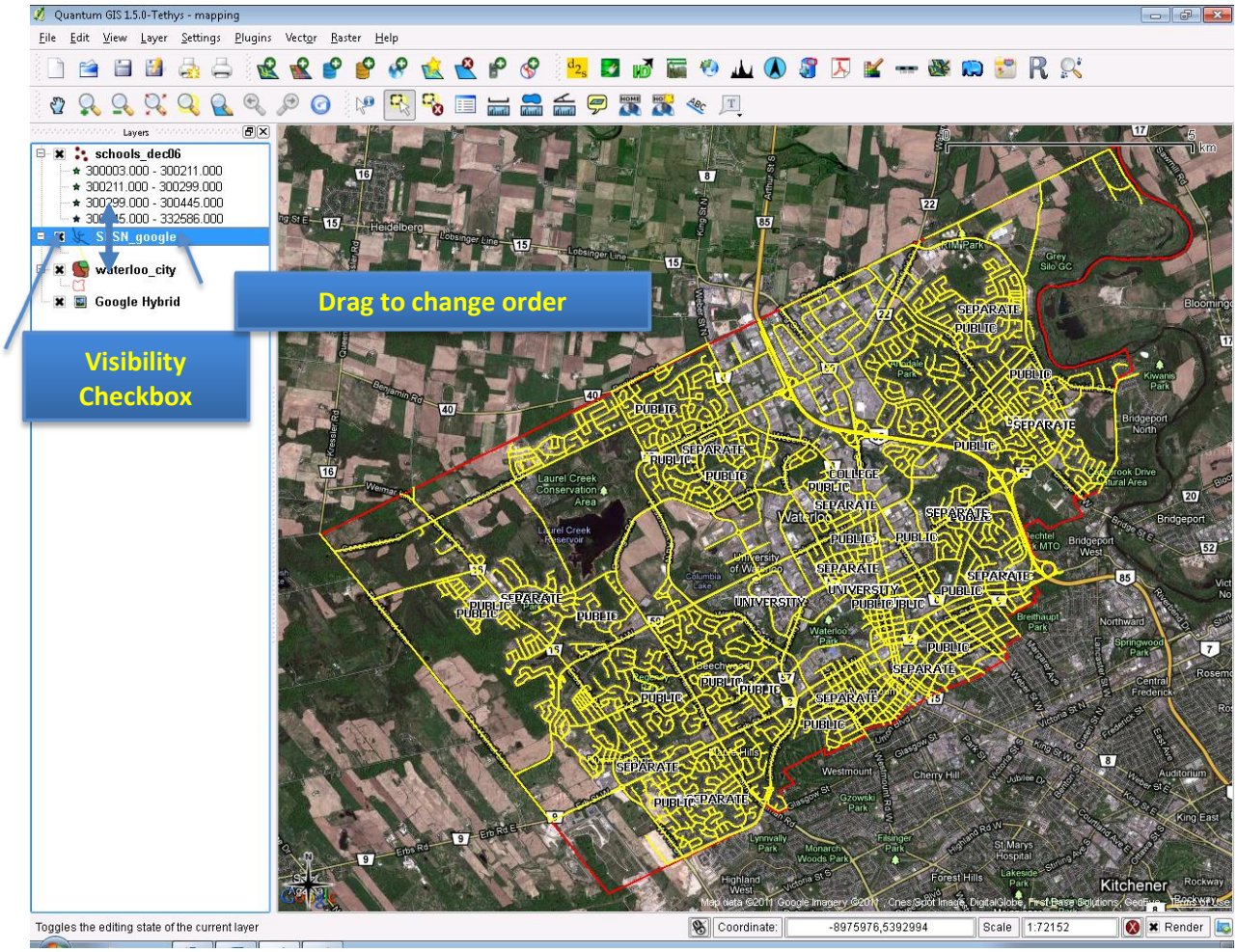


Figure 10. Layer Visibility and Order Control

When a polygon layer, such as buildings or parcels, is added over an image, the content on image under the building is often invisible. But sometimes users like to only show the parcel's boundary and keep the image displayed. In this case, layer transparency and hollow symbology can help.

To do so, **right-click on the polygon layer** and select **Properties** first (Figure 8). Then switch to the tab **Symbology** and click on the symbol itself (Figure 11). You can make polygons hollow by changing **Fill options** from solid to **none**. Alternatively, you can change the **Transparency** ratio as well.

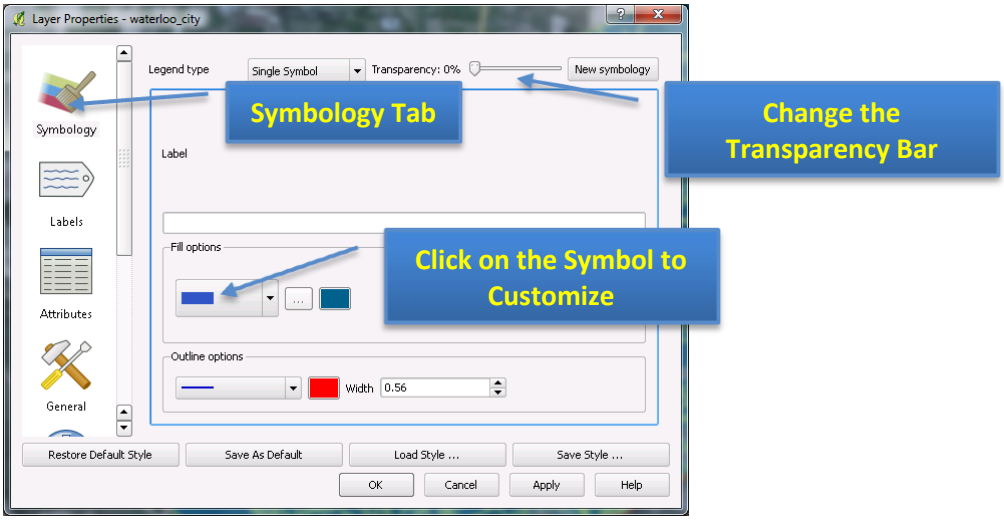


Figure 11. Properties of Symbology

2.1.2. Symbology and Label

Symbology is critical in making maps, which are classified into four **Legend type** in QGIS (on the top of Figure 11). Due to its complexity, these four categories and their normal usages will be briefly introduced in the note region with further reading. We will only focus on symbol customization and classification symbols, which are mostly used.

Unlike ArcMap, QGIS does not hold a large library of professional symbols. In fact, only point-feature layers can have different symbols (Figure 12), while line and polygon layers can only change line and fill options.

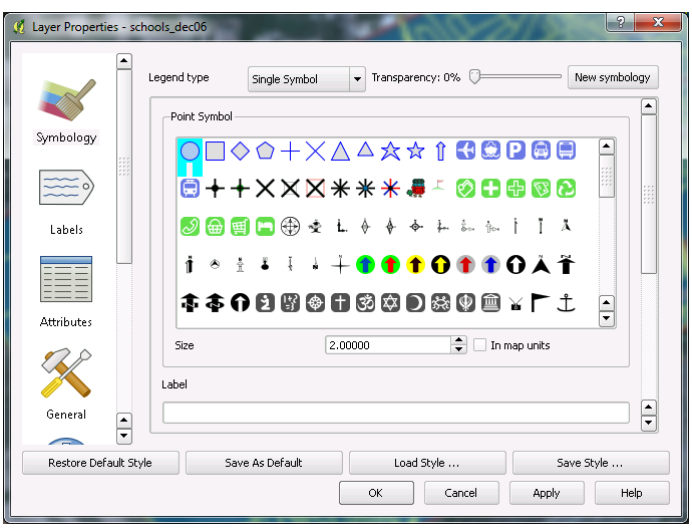


Figure 12. The Symbology Customization Window

2.1 Key Options of Geospatial Data Representations

Depending on the type of the feature (point, line, or polygon), the options in Figure 12 changes accordingly. For polygons, it has the most options: fill color, boundary width, and boundary color. For lines, only color and width show up. Points also have two options (color and size).

There are cases when you want to differentiate features in a layer based on some attribute. For instance, I want to know which schools are public, separate, or for higher education in the schools layer, which is the top layer in Figure 10. Different types will be marked in colors. To do so, we should **right-click** on the school layer, select **properties**, and go to the **symbology** tab, which is the same as shown in Figure 11. But, instead of by-default **Features** option, we should click and select the **categories** option (Figure 15). The steps to follow are also shown in Figure 15:

1. Click on the **Legend type** first and make sure the "**Unique Value**" is chosen;
2. Pull down the dropbox of the **Classification field**, and select TYPE as the classification attribute;
3. Click on the **Classify** button to add all distinct values under the TYPE attribute into consideration;
4. (**Optional)** Click on the **Randomize** dropbox and change colors.

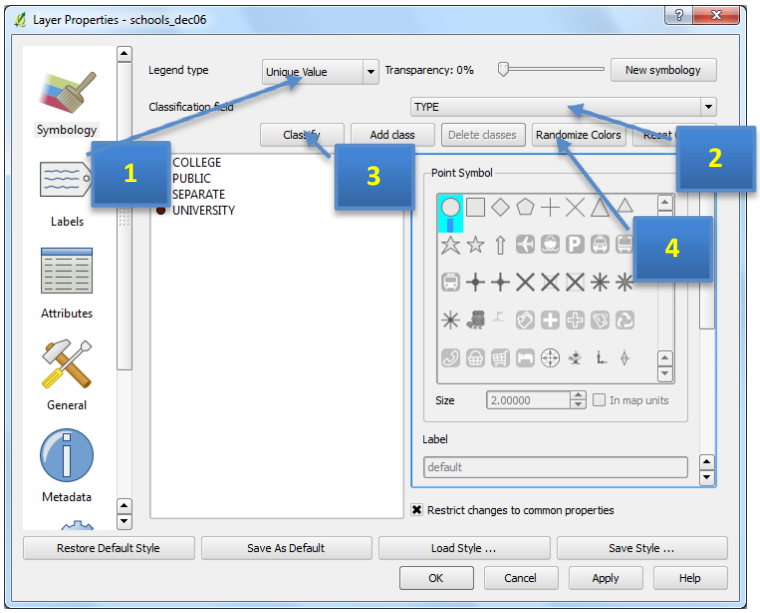


Figure 13. Classifying Features using Colors

Note that you can still customize individual symbols for each category (size, shape, etc) by double clicking the corresponding class on either the left pane or the line in symbology window (Figure 13).

The labels are an important feature of a map. By marking some property up on the map, for instance the name of the marked location, labels can make your map more useful, informative, and visually appealing.

To add labels to your map, **right-click** on the layer that you want to add marks on and select **Properties** (Figure 8). Then follow the steps below:

1. Select the **Labels** tab and check on (off by default) "Display labels".

2. Choose the attribute you want to display on the map in the dropbox of **Field Containing label** (Figure 14).
3. Change Font, so that it is clearly shown on the map.
4. You can click on the **Apply** button to see the effect until it is satisfactory. Then click **OK** to save your setting and exit.
5. (**Optional**) If you think the added labels are not distinct on the map background, you can make a buffer background around the texts. Please scroll down and check **Buffer labels**, which has the same effect of "mask" in ArcMap.

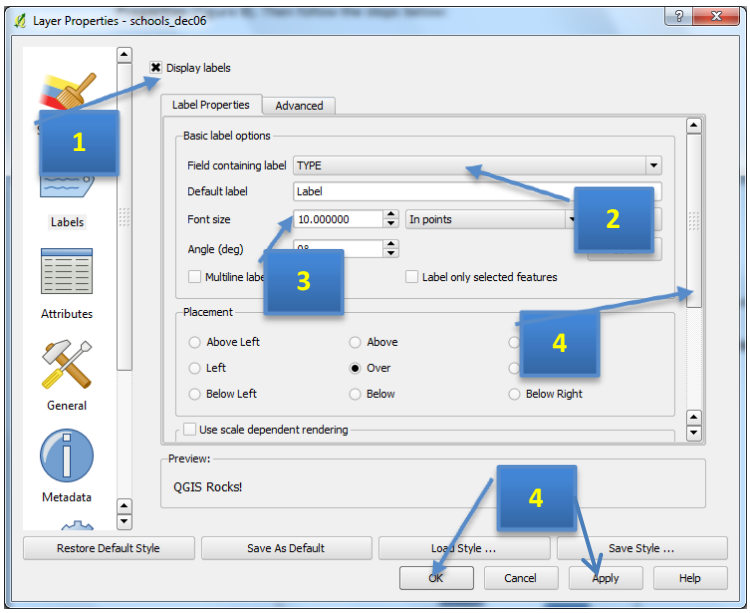


Figure 14. Label Setting Window

Note: Alternatively, you can accomplish most jobs by clicking shown in Figure 5. Only the "buffer" function is missing.

Symbology Types and Their Normal Usage:

- *Single Symbol: Mainly used when you just want to mark geographic features on a map.*
- *Graduated Symbol: Graduated symbol marked attributes with decretive numbers in a statistical way, which can only applied to attributes with numbers.*
- *Continuous Color: Continuous color can represent continuous values, such as population density, elevation, and so on.*
- *Unique Value: Unique value gives every possible value of an attribute a distinct symbol (mainly based on colors). Unique value can be applied to all kinds of attributes.*
- *Diagram Overlay: Unlike ArcMap, QGIS places multiple attribute mapping into an independent tab called **diagram overlay**. Information like the percentage of populations in different age intervals at different locations can be easily shown in this way.*

2.1.3. Annotations

Annotations look like labels. The key difference is that annotation can be any text you want to add on the map, regardless to whether the information has been included in the geospatial data.

For instance, if you want to add a point at the entrance of uWaterloo, which is not in the geospatial data, Simply click  on the toolbar shown in Figure 5.

2.2. Map Components

When the geospatial data and its representations are satisfactory, you can add other map components in another window via **File** -> **Print Composer** (Figure 15). You can manage multiple composers via **File** -> **Composer Manager**. Key components include:

- The title of the map;
- The scale of the map;
- The North Arrow (Orientation);
- The Legend (how to interpret the map);
- (Optional) The reference (where you obtain the data).

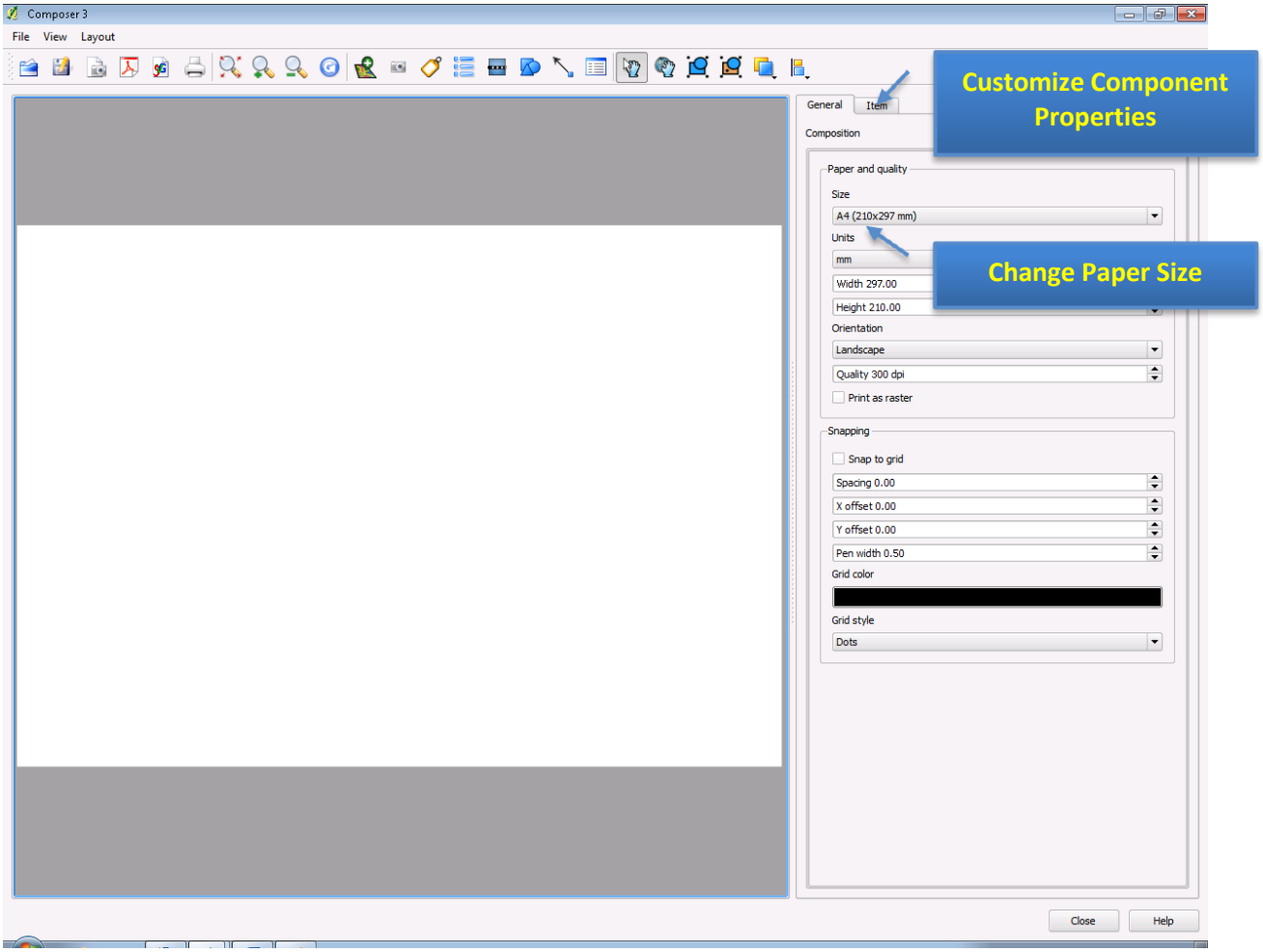


Figure 15. The Map Composer Window

Firstly, please note that, unlike ArcMap, the by-default page size is A4 (not letter size). Since letter size is more popular in North America, you might want to change to letter size, which is called "**ANSI A**" in QGIS.

2.2 Map Components

The main part, map, can be added by clicking in Figure 15, and then drag a rectangle on the paper to define display area and extent.

Map titles can be added as a text box by clicking and then click on the spot where you want to place the title at. Please note that, **in print composer, you can customize the properties of all components by switching to the ITEM tab.** So, for instance, if you want to change the font of the title, click the title first (so that it is selected) and change to the **ITEM** tab. There is a button called **Font** where you can find all properties there.

Add scale bar is also intuitive: click on and then click where you want to add it. You can change **Unit label** and **Style**. The scale bar style can be numeric, i.e. 1:5,000,000, or different bar/line forms. All options are intuitive and can be tested by changing it back and forth.

North Arrow can be added as an arrow. The options of a north arrow in QGIS are very limited.

Legend can be added in the same way as others (click on). QGIS has better organization of legend properties than ArcMap (Figure 16). The major options are located under **Legend items**. You can fine tune in **Item Options**.

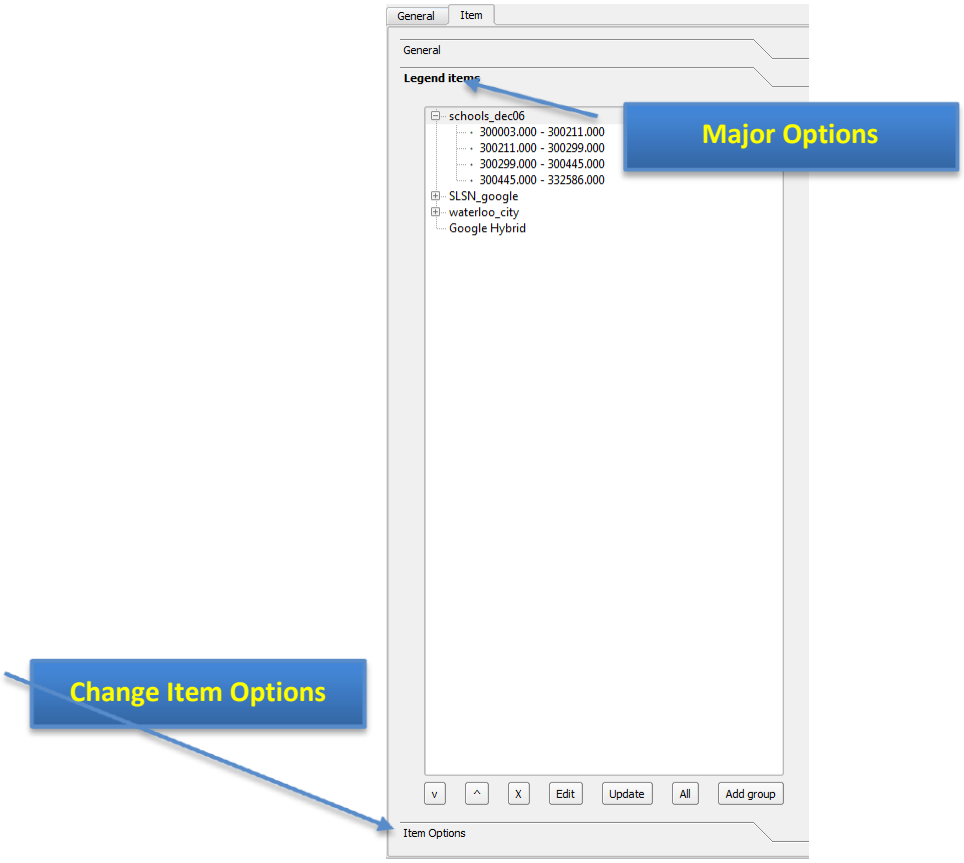


Figure 16. The Legend Property Window

2.2 Map Components

The initial generated legend looks like Figure 17. We can find that there are several obscure layer names. For instance, ordinary users will not know the meaning of “SLSN_google”. To change the name, you can select the layer “SLSN_google” first; then click the **Edit** button and change its name to “Roads” in the pop-up window. Other options are intuitive, enabling you to change the order, remove unwanted layer in legend, and group layers in a more meaningful way, and so on.

Figure 17. An Example of Generated Legend

Some Components that are also frequently added:

- *<u>Author of the Map</u>: Users may want to know who creates the map;*
- *<u>Date Saved</u> (Created/Modified): The more frequent a region changes, the more important it is for users to know when the map is created;*
- *<u>Coordinate System</u>: The globe is not flat, but a map is. Any kind of projection used to make the map distorts the reality in some way. Hence, it is critical for users to know how reliable their measurements on the map are, especially for pilots and navigators.*

2.3. Export Maps

When you are satisfied with everything on the map and are ready to deliver, you can export your map as images, PDF, SVG, or print a hard copy. All options are under the **File** menu.

You can specify the directory and file name of the map in this dialog. But, most importantly, you need to choose an appropriate file format by clicking on the **Save as type** dropbox. The most frequent-used formats are JPEG and PDF. JPEG is a popular graphic file format, which is easy to be inserted into word as a graph, while PDF is best used for sharing. The printed copy of PDF will be identical regardless of your computer (and printer) environment.

Brief Explanation of Graphic File Formats:

- *SVG file: Scalable Vector Graphics, an open-source vector graphic standard. It is becoming more and more popular and can be accepted by many vendors;*
- *BMP file: BitMap file, which is a mature loss-less uncompressed raster format. The quality is great. But its file size tends to be huge. It can be used if you need both high-quality output and compatibility ;*
- *PNG file: Portable Network Graphics, which is an open-source standard designed to replace BMP and GIF. It is a true-color loss-less raster file format. PNG file is slightly larger than JPEG (compressed with quality loss). And some old browsers and operating systems do not support PNG files;*
- *TIFF file: Tagged Image File Format. A major raster graphic file format provided by Adobe (AI for vector). Best to be used for raster file editing on Adobe Products, such as Photoshop;*
- *GIF file: Graphics Interchange Format. An uncompressed raster file format with 256-color limitation. Hence, if your map contains only a few colors (vector-based data), GIF is a good candidate.*