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Georeferencing
In QGIS

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1. Intro to GIS

The aim of this section is to give you an introduction to GIS. You will understand what GIS is and who can use it. You will also get familiar with different types of data in GIS.

1.1. What is GIS

Esri defines GIS as a framework for gathering, managing, and analyzing data. Rooted in the science of geography, GIS integrates many types of data. It analyzes spatial location and organizes layers of information into visualizations using maps and 3D scenes. With this unique capability, GIS reveals deeper insights into data, such as patterns, relationships, and situations—helping users make smarter decisions. Thus, innovative professionals in any industry can take advantage of GIS technology including forestry, urban planning, and health and human services.

2.1. Different Types of Data

Raster data and vector data are two types of spatial data in GIS. The main difference between Raster and Vector Data is that the raster data represents data as a cell or a grid matrix while vector data represents data using sequential points or vertices. Points, lines, and polygons are three types of vector data. Raster data can be seen as digital aerial photographs, imagery from satellite, digital pictures, and scanned map.

2. Intro to QGIS

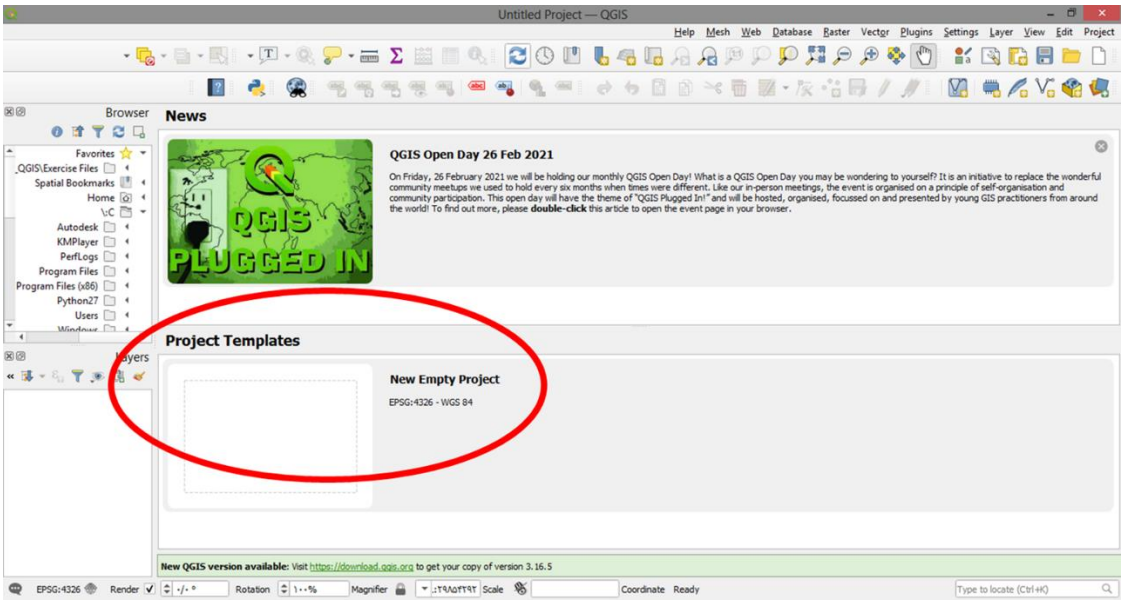
The aim of this section is to give you an introduction to QGIS. You will understand what QGIS is and how it is different from ArcGIS. You will also get familiar with the basic function of the program that you need to know for this workshop.

1.2. What is QGIS

The two most used desktop GIS programs by far are ArcGIS and QGIS. Both offer similar functionality but there are some major differences. For instance, QGIS is an open source and free program while ArcGIS is a close source and costs thousands of dollars.

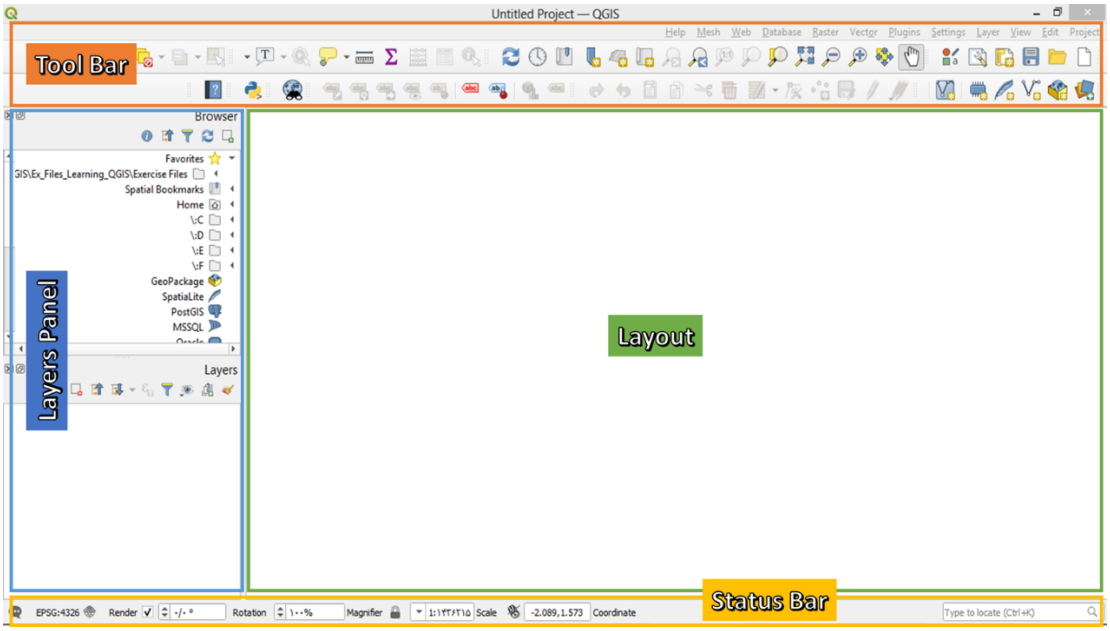
2.2. Basics of QGIS

To open QGIS, you just need to click on the  icon. Then, by clicking on “New Empty Project” under project templates, you will be in a new, blank document in QGIS.



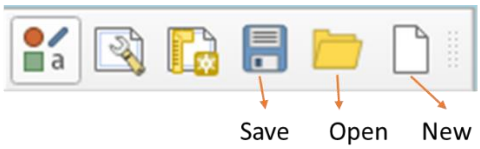
When you start QGIS you will see a simple interface with a menu and buttons at the top, some panels to the left, and a big area in the center right. At the bottom of the window there is a status bar with information and some input fields and tools.

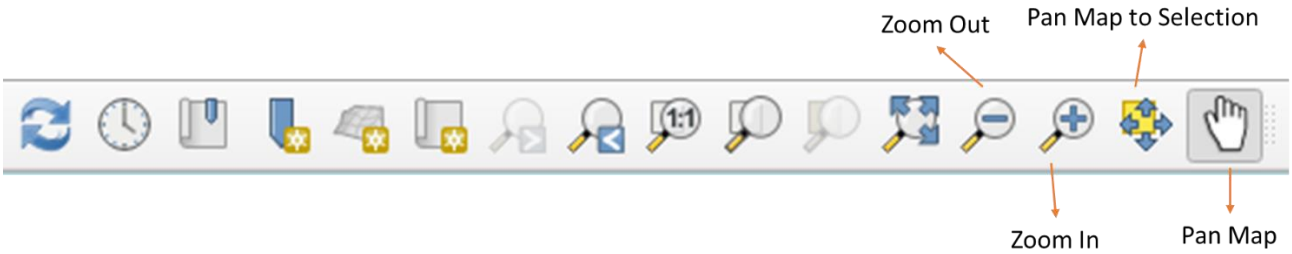
I am using version 3.16 today and depending on what version you are using things may look or work slightly different.



It is necessary to mention that you can change the way the QGIS looks by moving or hiding toolbars. To do that, you just need to right click on toolbar.

There are several buttons in the toolbar that you need to be familiar with for this workshop that you can see in the following picture.





3. Georeferencing

Georeferencing is the process of connecting your images (e.g. aerial photographs, scanned maps, satellite images) with their spatial locations on a reference dataset or so called “coordinate system”. This way we will be able to view, make queries and analyze our data with other geographic data.

Georeferencing is required only when the dataset has not been integrated to any coordinate system and does not have a defined extent. You can check those settings by right-clicking the .tiff file in the QGIS window, and selecting ‘Properties’. Relevant information can be found under the CRS section on the ‘Information’ tab.

Most of the raster datasets that you obtain from the government or commercial sources are already georeferenced, and they should be ready for you to use. However, your data will occasionally have a coordinate system different than the one you want to use. To prevent misalignment issues, you may need to re-project the data or adjust it.

To convert your raster data into GIS data, you need reference data that covers the same area as your target area or any other spatial information about your data (like known coordinates). Reference data is a layer with a known spatial reference that displays in the correct coordinates' space. Your raster data and the reference data must have some features in common that are visible in both datasets, such as hydrography, parks, roads, etc.

Georeferencing involves transformations, which convert an image from pixel space to a defined real-world coordinate system. Transformations are based on the ground control points on the raster and on the reference data. The reference data can be either in vector or raster format, as long as it covers the same area and has spatial information.

To understand how to georeference a raster data, I am going to define a project as an exercise:

Imagine your instructor asked you to explore how False Creek has changed during the history. To do that, you need to find an old map of False Creek and compare it with the current situation.

One of the passions of modern day information technologists is to convert the past to digital form and to put it on display. To this end the City of Vancouver completed a large project to digitize a large portion of its holdings.

The result includes 250,000 records from the old management database, 74,000 photographs, and most importantly for GIS enthusiast, 4,000 maps dating from the late 1700s to the present day.

Fortunately, I could find a map from the City of Vancouver Archives that belongs to 1877. The map can be found through One Drive.

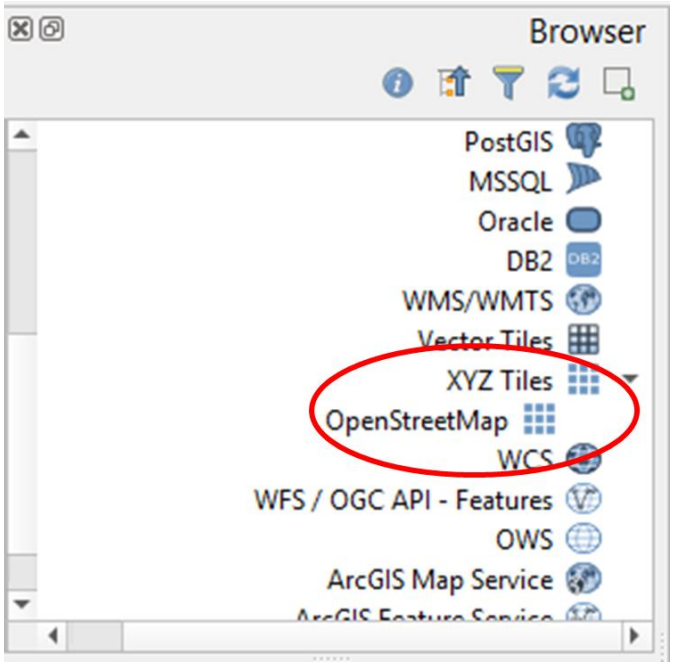
I need to georeference it to a modern day street map in order to compare the past with the present and gain insights into the future.

The process of georeferencing involves identifying a series of control points—known x,y coordinates—that link locations on the raster dataset with locations in the spatially referenced data (target data). Control points are locations that can be accurately identified on the raster dataset and in the geographic coordinate system. You then use those control points to build a transformation that will shift the raster dataset from its existing location to the spatially correct location. The connection between one control point on the raster dataset (the “from” point) and the corresponding control point on the aligned target data (the “to” point) is a link.

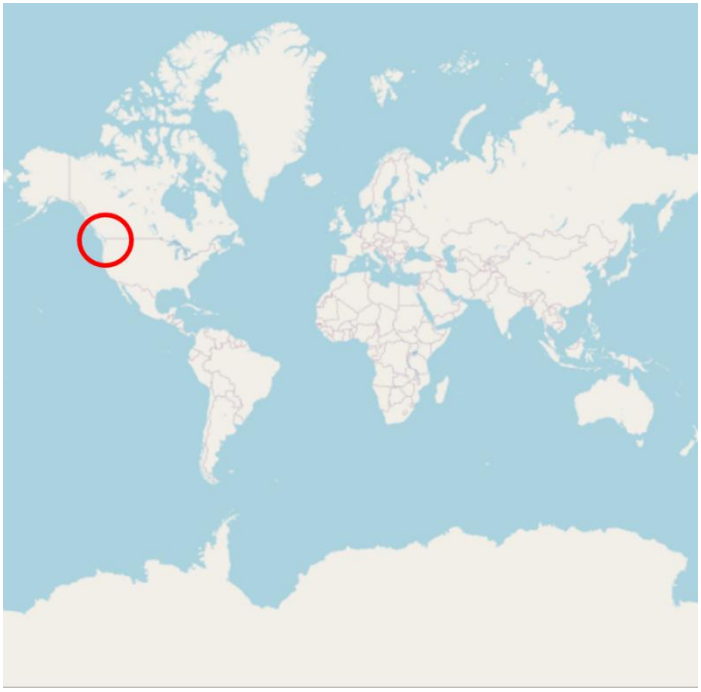
In this exercise I am using the OpenStreetMap as a reference data. As you remember I talked about plugins in QGIS and how useful they are. The QGIS OpenStreetMap Plugin is a plugin for the desktop GIS application QGIS. It adds support for OpenStreetMap raw vector data, bringing it in as a layer. To import OpenStreetMap data in to QGIS you need to:

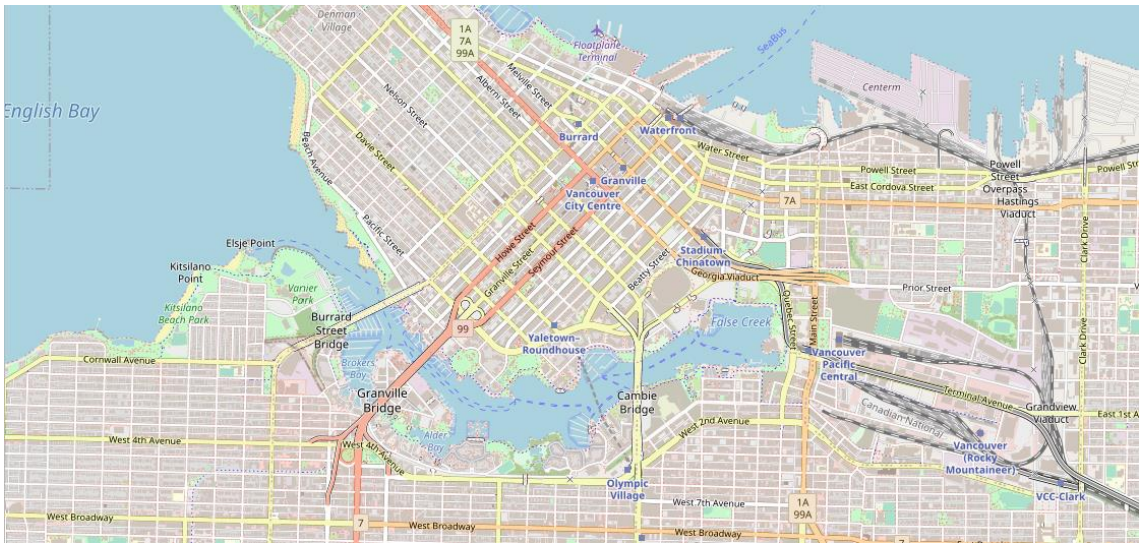
- Click on Plugins on the menu bar
- Click on manage and install plugins
- Search QuickOSM
- Click on install plugin

Then you can find OpenStreetMap under XYZ Tiles on the Browser section.



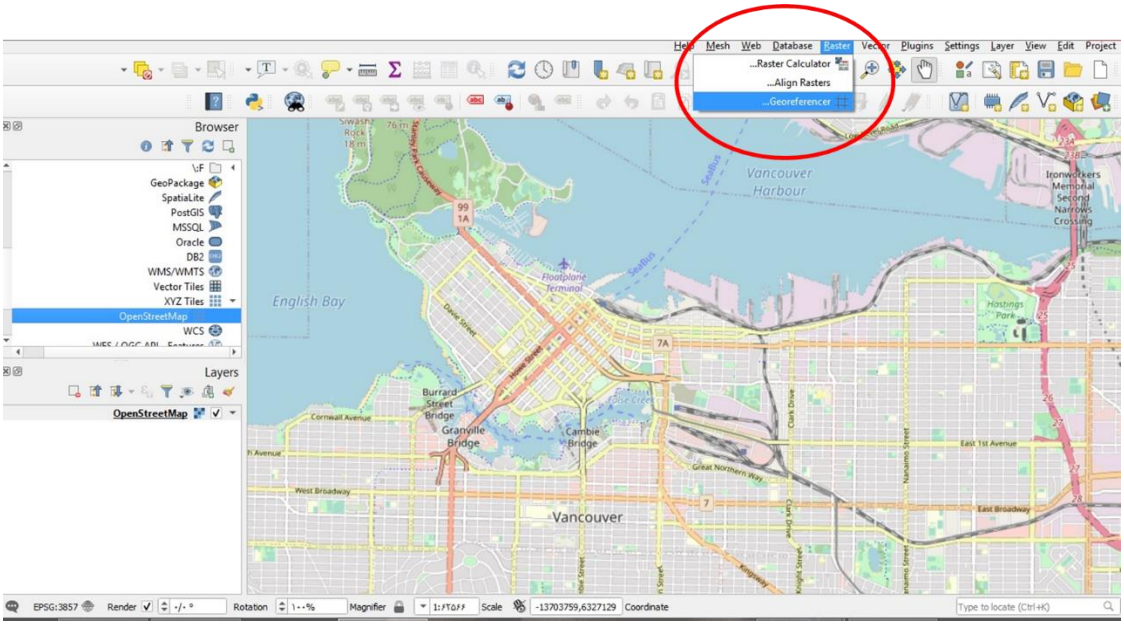
By double clicking on OpenStreetMap, the map will be appeared in the layout section. Then by zooming in you can find Vancouver and False Creek.

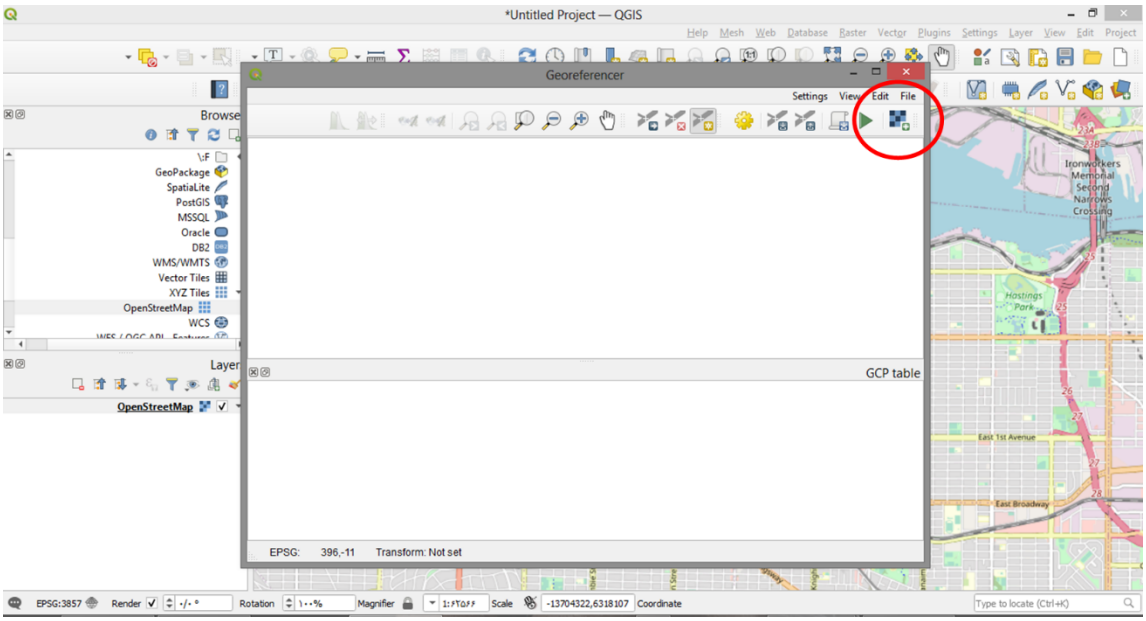


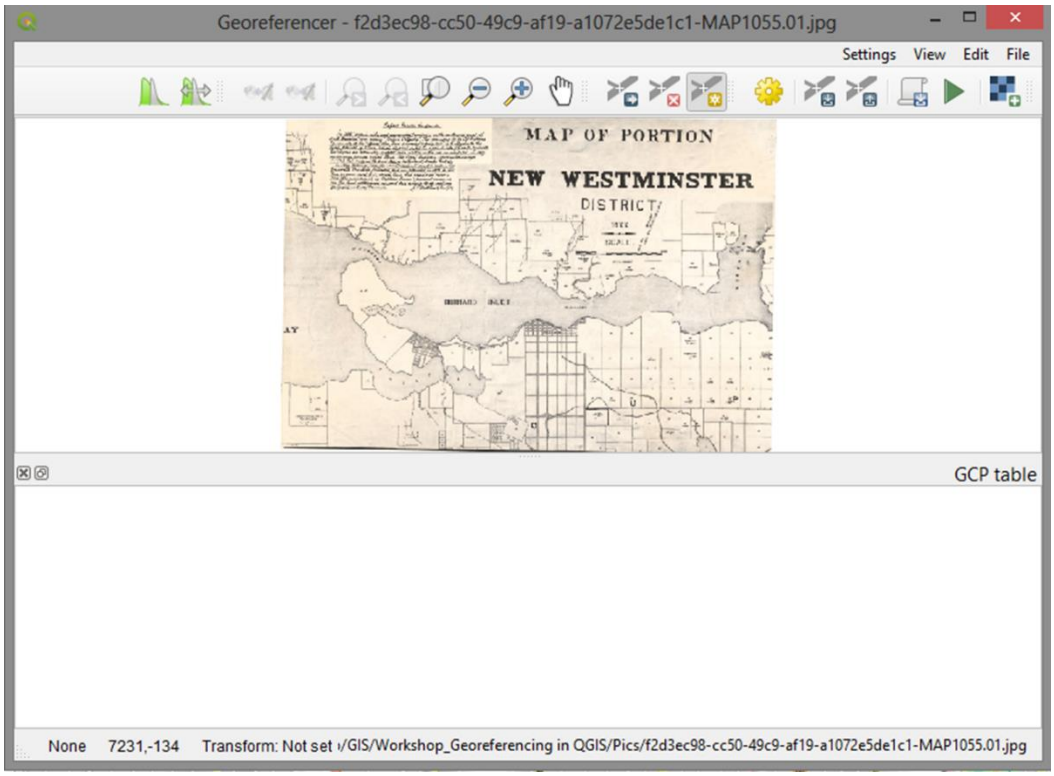


Now it is the time to start georeferencing our old scanned map based on this OpenStreetMap. To do that you need to:

- Click on Raster on the menu bar
- Click on Georeferencer
- Click on Open Raster
- Navigate to the place where you have saved your image and you can open your image which is a scanned map here





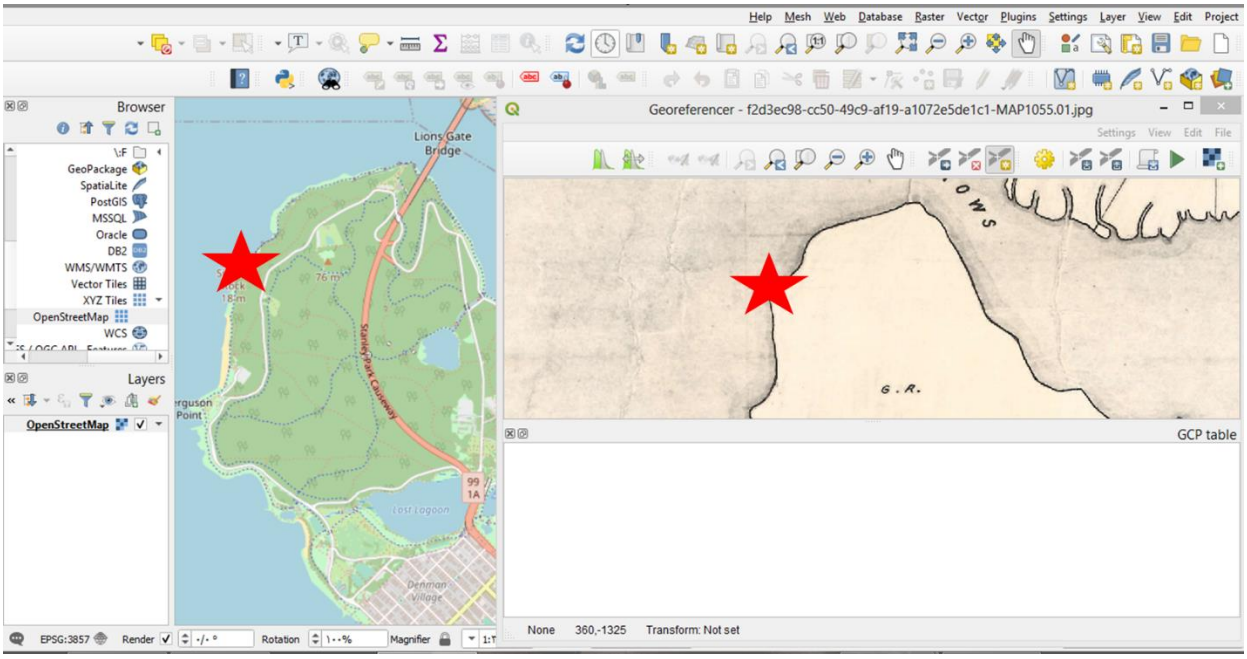


You can see that by scroll wheel you can zoom in and out and even pan it around using your mouse wheel.

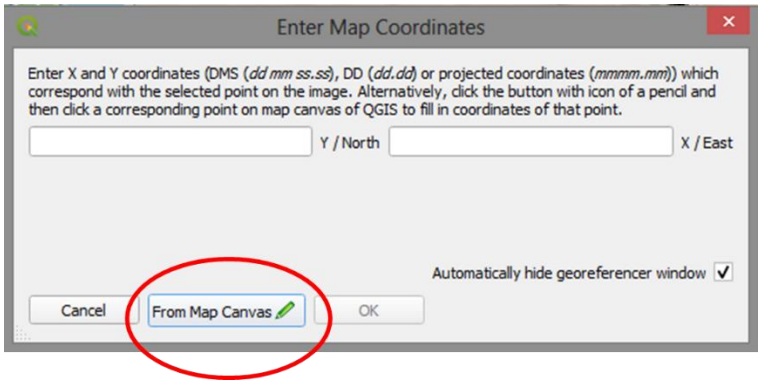
In the lower left side you can see that there is one option called GCP table (Ground Control Points table) which is basically an empty table as per now.

This GCP stands for ground control points. So, we're going to provide the coordinates of points which we can accurately identify on this open street map as reference points to enable the process of georeferencing.

To add a control point, it is necessary to designate a point on the scanned map. How about Siwash Rock, a famous geological feature in Vancouver's Stanley Park? That has probably not moved too far since 1877.

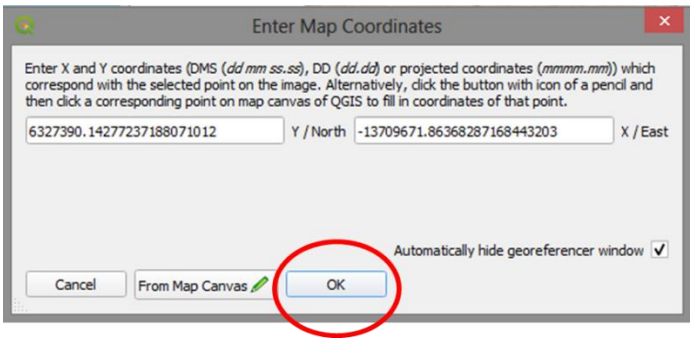


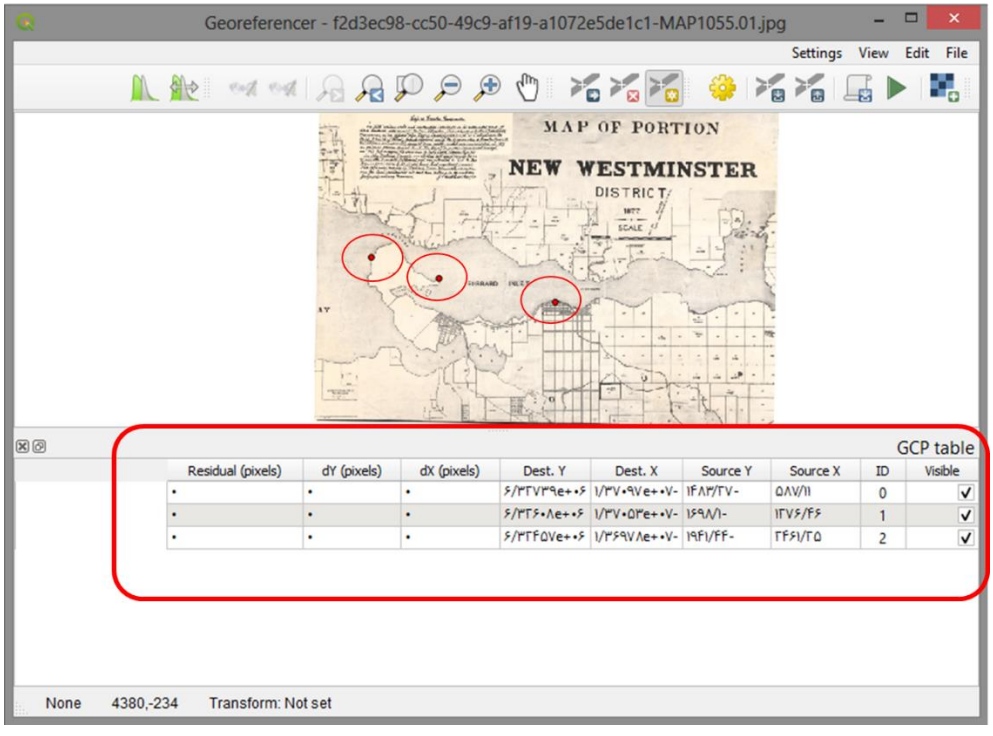
An "Enter map coordinates" dialog box appears asking for the matching coordinates for this point on the map in the QGIS window. However it is not necessary to manually enter these, an easier alternative is to click the from map canvas button on the dialog box.



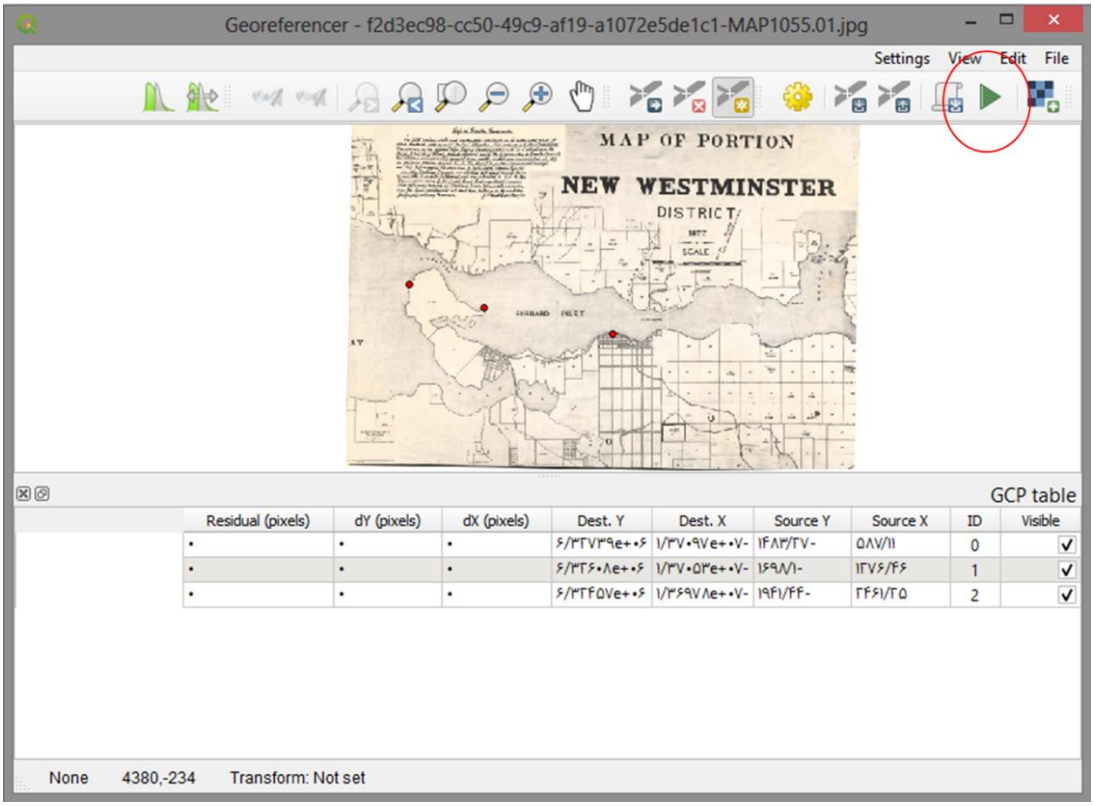
Clicking on Siwash Rock in the OpenStreetMap on the QGIS canvas creates points in both the scanned map and in the OpenStreetMap. The GCP table in the lower half of the Georeferencer tool also records the point.

We can continue and find other points. In this exercise I am using three points and I think it should be sufficient. But you can always tweak in case if when you do the georeferencing and if you find that the map has not been georeferenced properly. In such situation you can always come back and maybe increase the number of points or even you do have any points which you are not really sure about. Then you can actually get rid of those points.

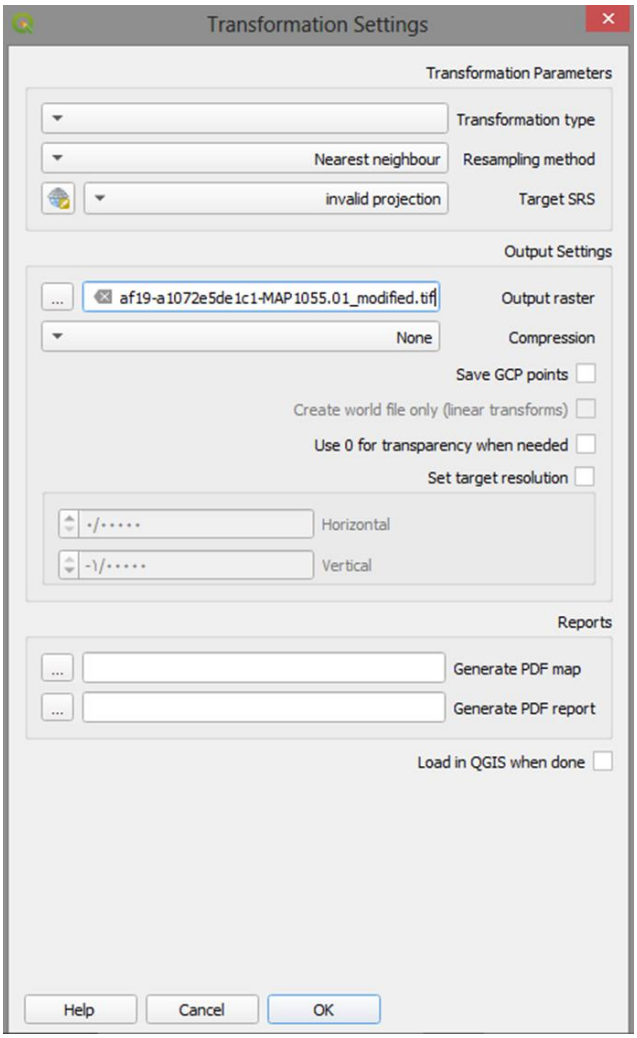




Once you have done that you can simply go ahead and click on the start georeferencing triangle button in order to begin the georeferencing process.



As soon as you click on this button you will get the dialogue box in which you will be actually able to select the transformation type and the resampling method and also set the corresponding coordinate reference system.



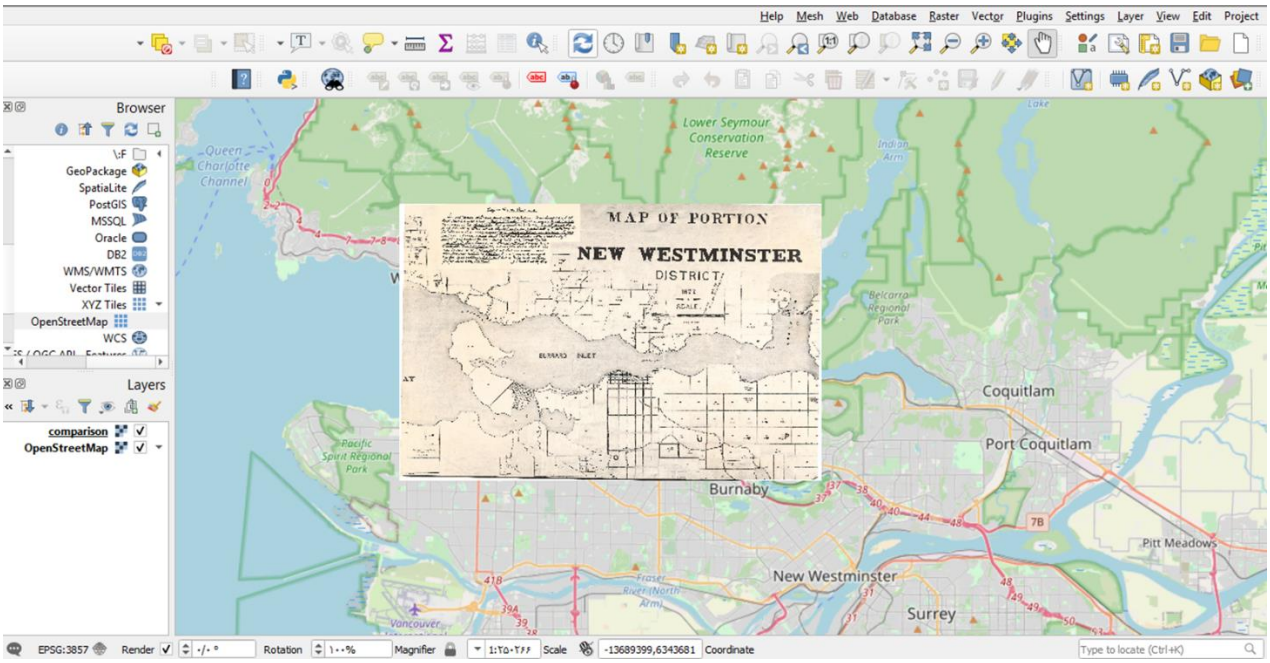
There are different transformation types and one can actually differ from the other depending on the algorithms that they use. For this exercise I'm going to go with:

- Linear transformation type
- Nearest neighbor resampling method

I'm also going to use the same reference coordinate system which this OpenStreetMap layer was in. In front of the output button you can specify a name for the output raster. I'm going to name this one as Comparison.

For the comparison type I'm going to leave it as none and of course after you're done with this you would like to load the layer into QGIS. So, you can go ahead and put a tick over the blank button and after that you can click on ok and finally for the process to begin you can simply click on start georeferencing button again.

You can go ahead and close the window.

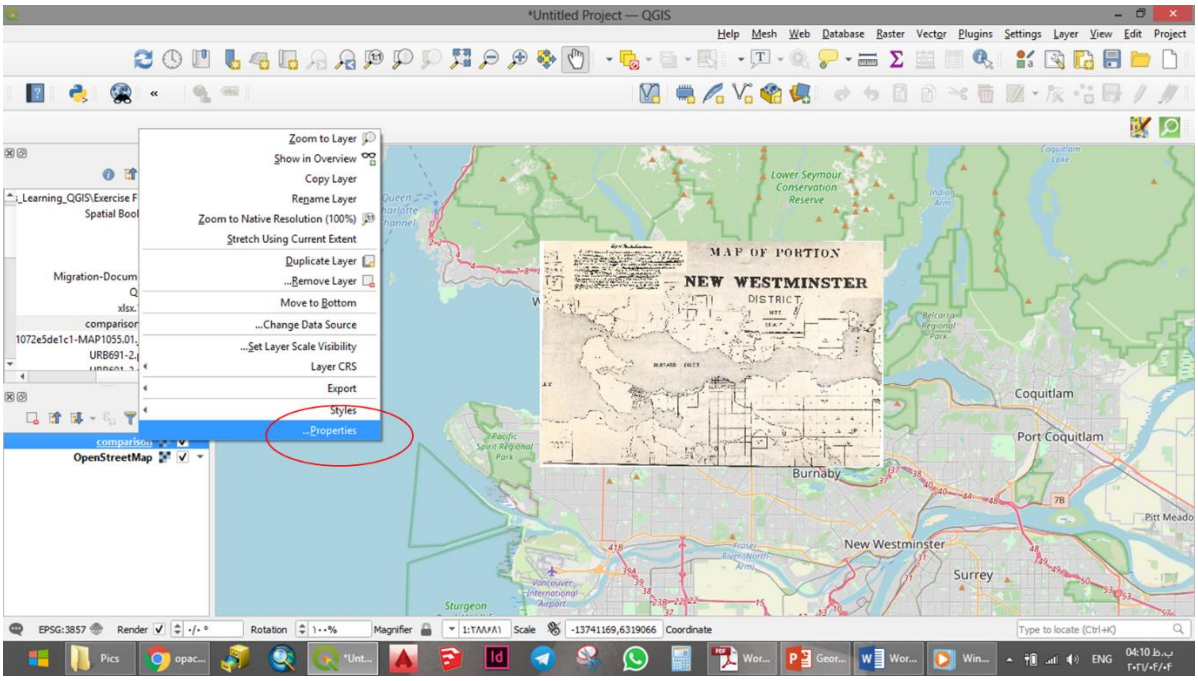


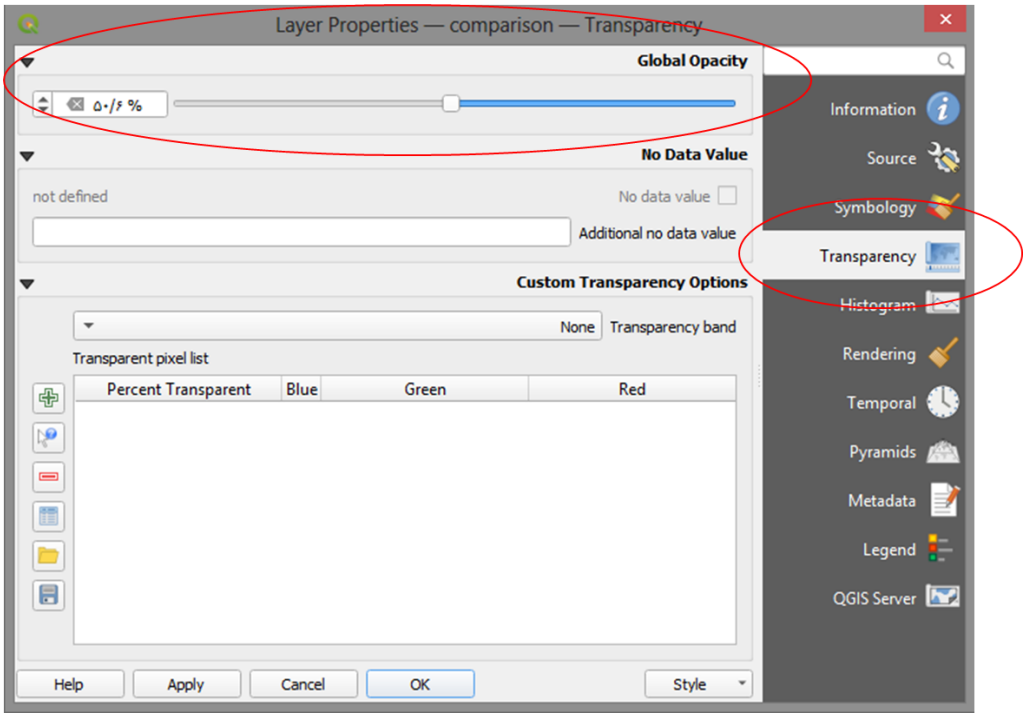
As you can see our picture which was a scanned map has been exported into as GeoTIFF which is now a raster which is fully georeferenced. You can see that the False Creek fits quite nicely over here to this base map.

If I navigate back to the place where I have saved this file, we can see that this is a georeferenced file and in case if you drag and drop it to the layout or add it through browser, you can see it got georeferenced.

Now it is the time to do what the instructor asked us: How False Creek has changed during the history. To have a good comparison, we can change the transparency of our georeference file. To do that:

- Right click on the georeferenced file
- Click on properties
- Change the transparency under the global opacity in the transparency section.


*Untitled Project — QGIS
Zoom to Layer
Show in Overview
Copy Layer
Rename Layer
Zoom to Native Resolution (100%)
Stretch Using Current Extent
Duplicate Layer
...Remove Layer
Move to Bottom
...Change Data Source
...Set Layer Scale Visibility
Layer CRS
Export
Styles
...Properties
OpenStreetMap
MAP OF PORTION
NEW WESTMINSTER
DISTRICT
Coquitlam
Port Coquitlam
Burnaby
New Westminster
Surrey


Layer Properties — comparison — Transparency
Global Opacity
No Data Value
not defined
No data value
Additional no data value
Custom Transparency Options
None
Transparency band
Transparent pixel list
Percent Transparent
Blue
Green
Red
Help
Apply
Cancel
OK
Style
Information
Source
Symbology
Transparency
Histogram
Rendering
Temporal
Pyramids
Metadata
Legend
QGIS Server

By changing the transparency we can see that much of the False Creek today was originally water. Granville Island also is a man-made structure. These facts are known to City of Vancouver planners, but such a map can help the City explain to the public the importance of taking steps now to avoid coastal flooding in the future. With the oceans predicted to rise 1-2 meters in the next hundred years, it is prudent to take action now.