TUTORIAL 1 | MAPPING A CITY

General Notes

As you work through these tutorials, please keep in mind the following:

- *though we'll be doing these for the most part together in class, you will be expected to continue improving and finessing your maps outside of class*
- *the text in the tutorials is important to read thoroughly and understand; do not skip it*
- *if you notice a mistake or inconsistency between the text and image, please let me know. quality control is an ongoing process.*
- *pay attention to all requirements in the final steps of each tutorial, and in the tutorial assignments*

Tutorial 1 Goals

- Create a QGIS map of Roanoke using Open Street Maps data.
- Download natural features, urban features, and administrative boundaries.
- Stylize your city data.
- Gain familiarity with QGIS platform.

Introduction

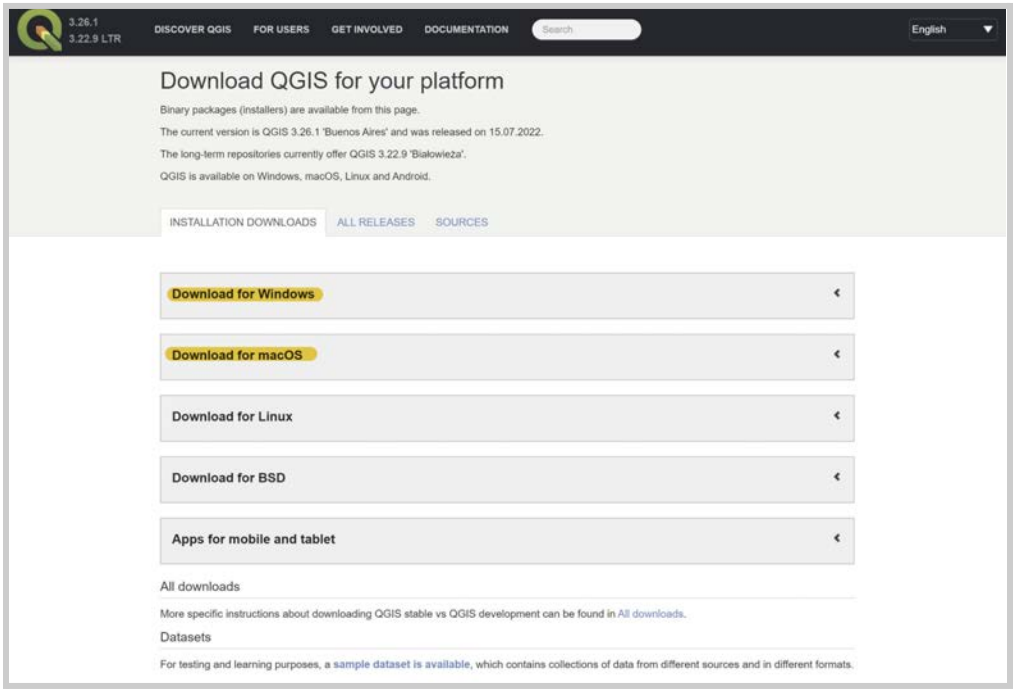
In this tutorial we'll go over the basics of using QGIS, which will be our primary application in this class. We'll be using QGIS because it is free and open-source, unlike the industry-standard software ArcGIS. This means 1) we're supporting an important and accessible resource, and 2) you can continue to use Q once you graduate. With QGIS, you can visualize physical geographic data like roads, rivers, and buildings, as well as data associated with geographic areas like census information. QGIS also has a powerful suite of spatial analysis tools, like the distance matrix which can compare proximities of different variables (for instance, the proximity of certain demographic groups to parks vs. industrial space). We'll only use a handful of QGIS's tools in this class, but if you're interested in learning more I recommend QGIS's tutorials: https://www.qgistutorials.com/en/ as a starting point.

First, you'll create a basic map of Roanoke in QGIS using **OpenStreetMap** data. OpenStreetMap (OSM) is another free, open-source resource which contains user-inputted geographic information (like a combination Google Maps-Wikipedia). Because anyone can contribute to the project, OSM has detailed geographic data in remote places like Tanzania, where NGOs partner with local teams to track indicators of public health, transportation access, living conditions, and other data that relies on accurate maps. By the same token, though, OSM data can be sparse in areas that haven't invested in developing it. You might notice, for instance, that only a few buildings have been included in OSM near Roanoke. To supplement OSM data, we'll use the Roanoke city's parcel data in Tutorial 3.

For this tutorial and the next, we'll focus on general trends visible in the city's urban and natural features. Once you've downloaded Roanoke's data, you will style it and create an exportable pdf map. QGIS has many data styling tools and options, which you'll explore in these tutorials.

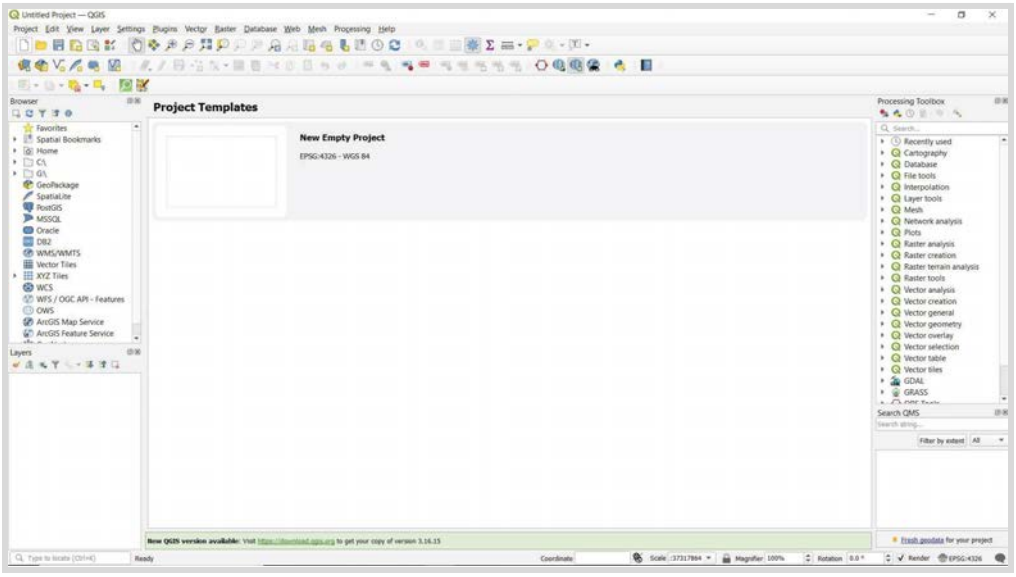
As with all future tutorials, you will be expected to continue refining your maps outside of class to develop an effective visual communication style. The maps you turn in should be complete, thoughtful, and attractive. ***You should not simply endeavor to copy the maps you see in the tutorial images, but should find your own aesthetic***. A successful map should communicate 1) the relevant information, 2) clearly, to your audience, and 3) beautifully, with careful color choice and line weights. Pay particular attention to color, which can easily overwhelm your map. The colors you choose should work together as a palette, and should reveal something about the mood or point of your map.

Step 1: Download and install QGIS 3.22, the most recent long-term release (LTR):
https://qgis.org/en/site/forusers/download.html#



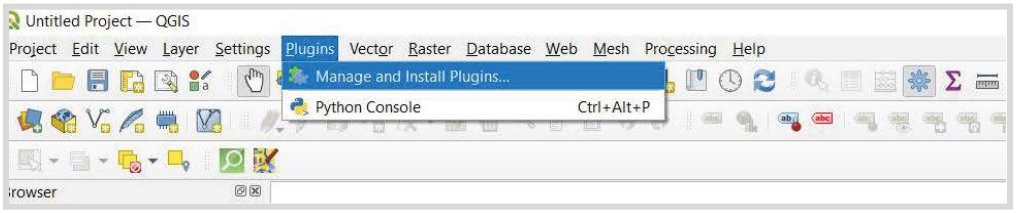
Step 2: Open QGIS and install the QuickOSM extension.

2a Click **New Project**...(you will see an empty white page)

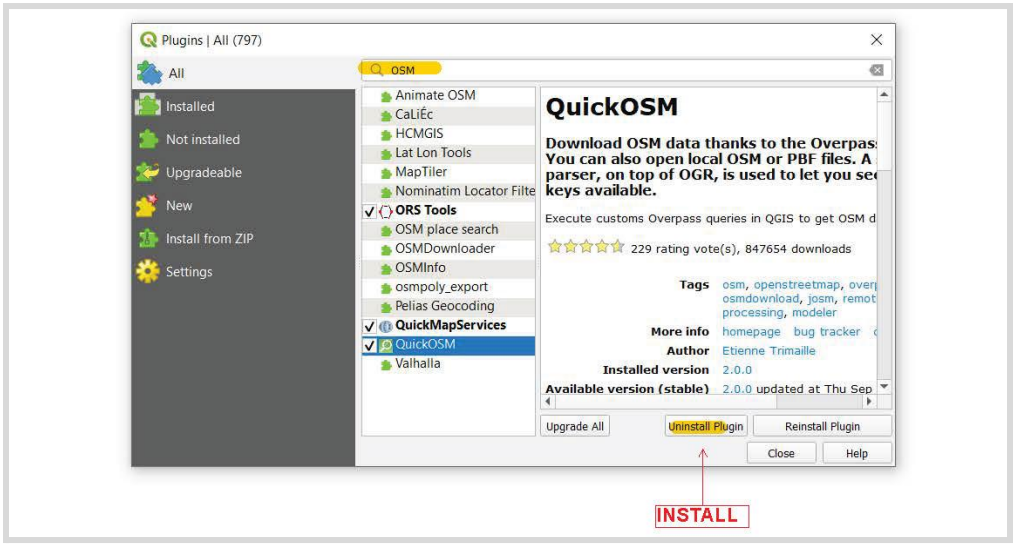


2b **Save** your project somewhere you will not lose it and where you will also store the geographic data that you'll be downloading. *In other words, not as a loose file on your desktop or (worse) in your downloads folder.*

2c Open **Plugins > Manage and Install Plugins**…



2d Search for **QuickOSM**. Click **Install Plugin**

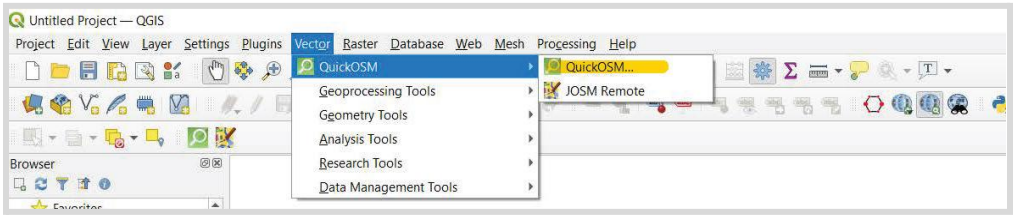


Step 3: Query OSM data

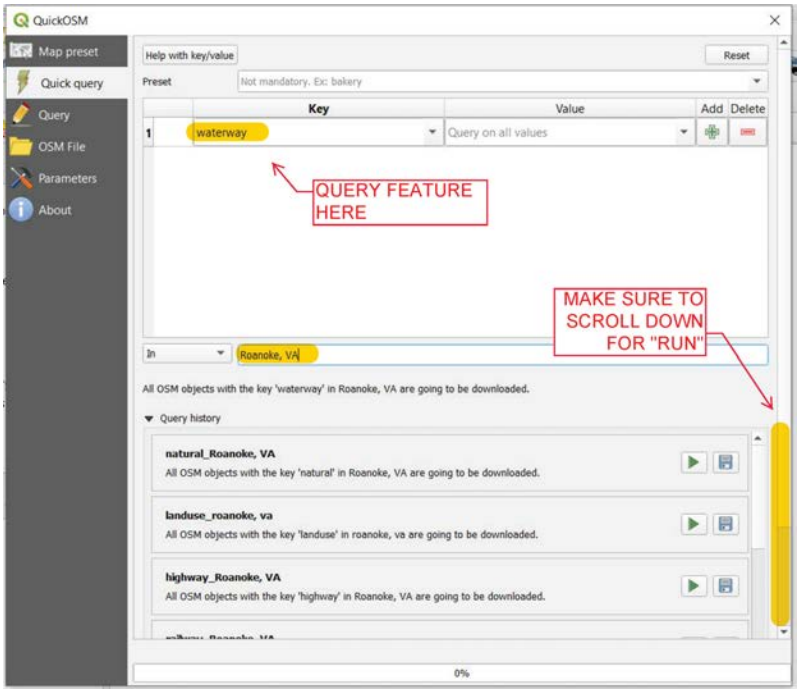
First off, you'll add some basic geographic data to your map with the OSM plugin. You'll query the "waterway", "highway" (this includes all roads and paths, but excludes waterway), "natural", and "administrative boundaries" data. Refer to https://wiki.openstreetmap.org/wiki/Map_features for more on OSM feature classification.

> Note: if you want to download a specific feature from OSM, it's often useful to visit OSM's website and query the feature (the arrow with a question mark on the right side toolbar). You can then choose the relevant feature from a list and see how it is classified, and how you might search for it through the OSM plugin.

3a Open **Vector > QuickOSM > QuickOSM**

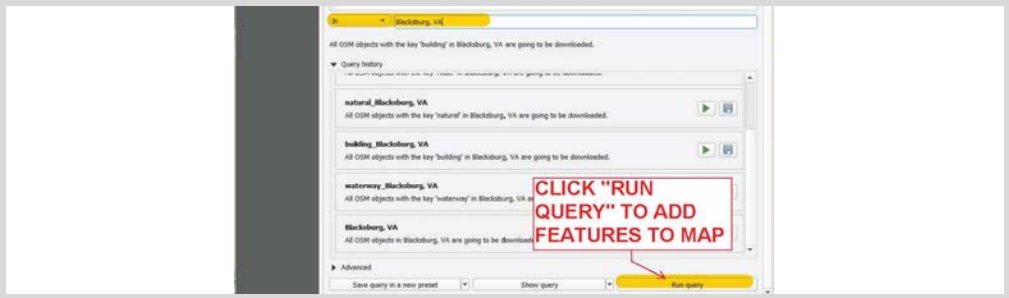


3b Search for each feature in the "**Key**" search bar: start with "**waterway**". **Type the city and state to the "In" field (in our case "Roanoke, Virginia").**



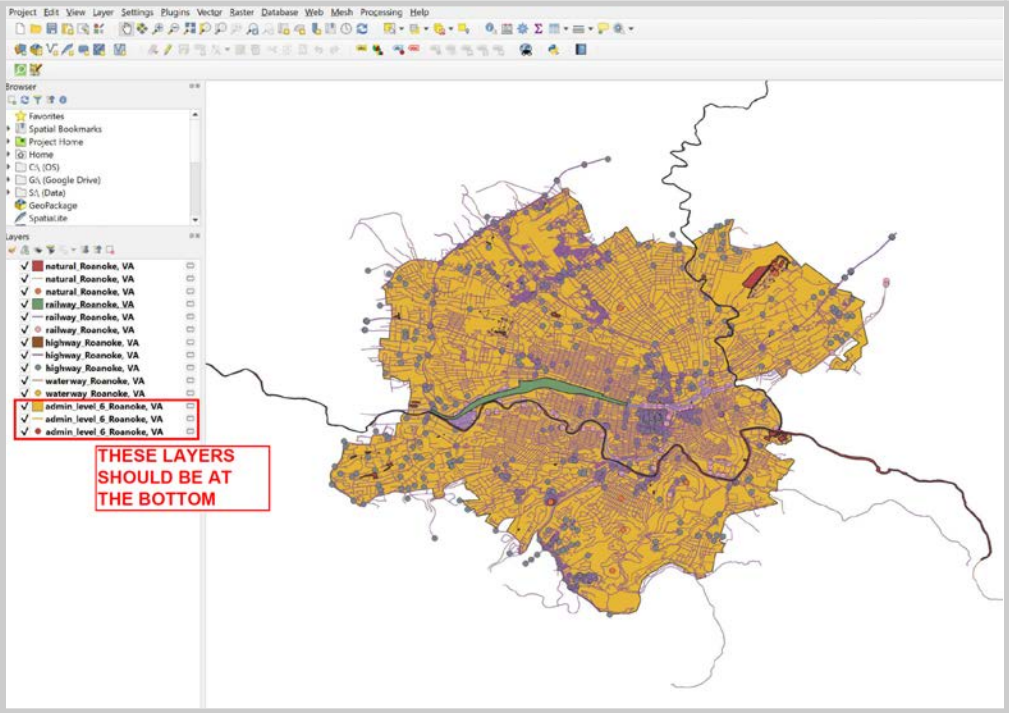
3c Scroll down, and click "**Run Query**" to automatically add the features to your map. Repeat step 3b for the "**highway**", "**railway**", and "**natural**" features.

NOTE: rather than "adding" a new feature line, simply delete the word "waterway" and type in the next word (highway, etc) and then re-click "run query".



3d Finally, download the boundary of Roanoke city by searching for "**admin_level**" in the key search bar, and then selecting "**6**" in the value bar. This will download the city boundary specifically, and not all administrative boundaries in the area.

Note: the admin layer polygon will hide your earlier layers. Drag it beneath the others to see all of your data.



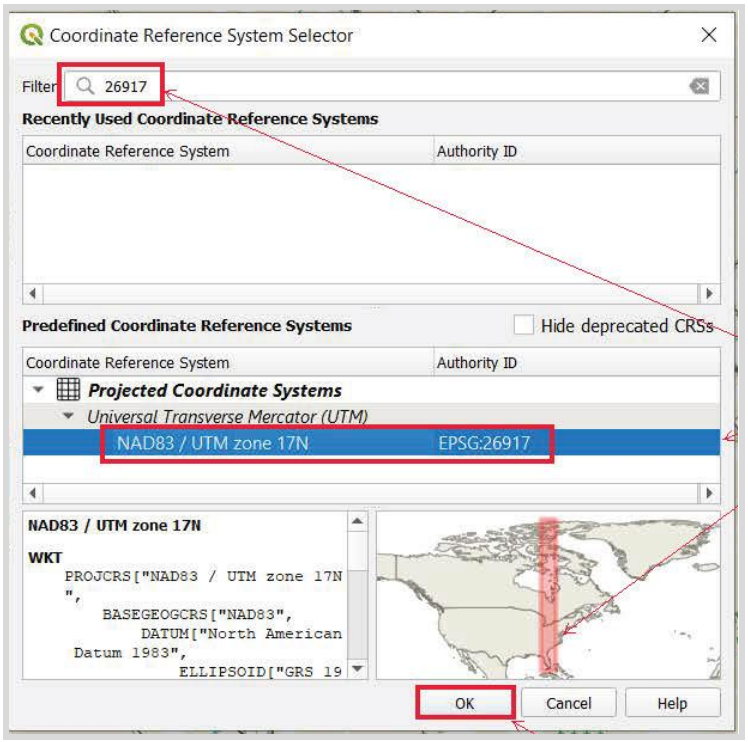
Step 4: Set your CRS in Project > Properties > CRS. This will be the first step of any new map.

Your map's **Coordinate reference systems** (CRS), which relates to a map's projection system, essentially defines which areas of the globe will be shown most accurately. Because the earth is spherical and maps are flat, maps necessarily distort geographic features. Generally, the more accurate a geography's shape is, the less accurate its size will be, and vice-versa. Think of how the familiar Mercator projection flattens the globe so that countries near the equator look too small relative to countries near the poles.

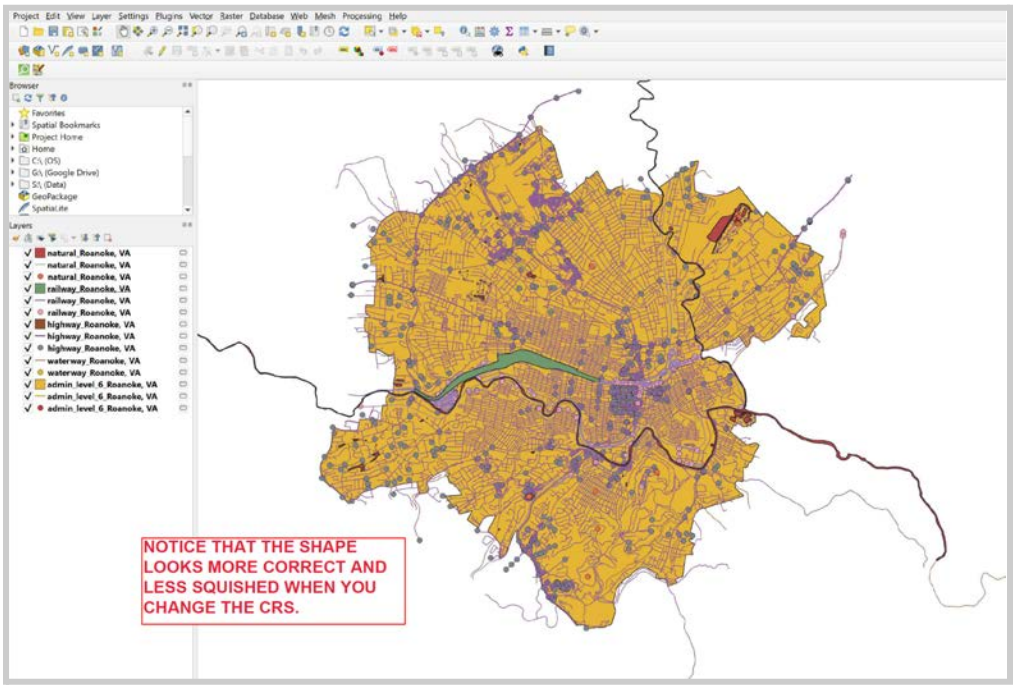
The CRS defines where the map's projection measures distortion from, based on a **latitudinal** reference (the equator), and a **longitudinal** reference (varies). QGIS's default CRS, called **WGS 84**, takes its longitudinal reference from the IERS Reference Meridian a.k.a. Prime Meridian, which runs north to south near Greenwich, England. So, the farther your Appalachian city is from England, the more distortion you'll see in measurements with WGS 84. Read more about it on QGIS's documentation.

To make sure measurements and geometries in your map are accurate, you'll need to choose a local CRS. **UTM (Universal Transverse Mercator)** is a CRS with different longitudinal references around the globe from UTM 1 to UTM 60. Many countries favor UTM for its flexibility. You can find your city's UTM zone here. For Roanoke, VA you will use **NAD83/UTM zone 17N** (N for northern hemisphere; NAD83 for North American Datum).

Note: for some tutorials, you will use a projection system that is correct for the shapefile that you've downloaded. For instance, when working with census data, the correct projection system will be NAD83, not UTM. You can then **transform** the shapefile by selecting a new projection system when exporting its layer.



Nothing will change by changing the CRS, but at the bottom right corner of the screen, you will see that your file is set as EPSG:26917 now.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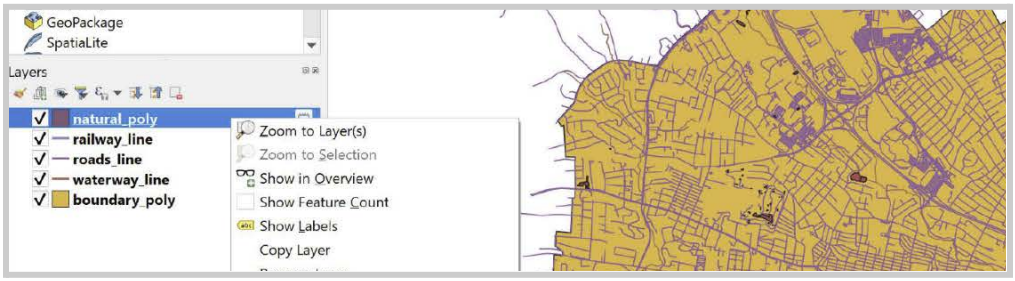
NOTICE THAT THE SHAPE LOOKS MORE CORRECT AND LESS SQUISHED WHEN YOU CHANGE THE CRS.

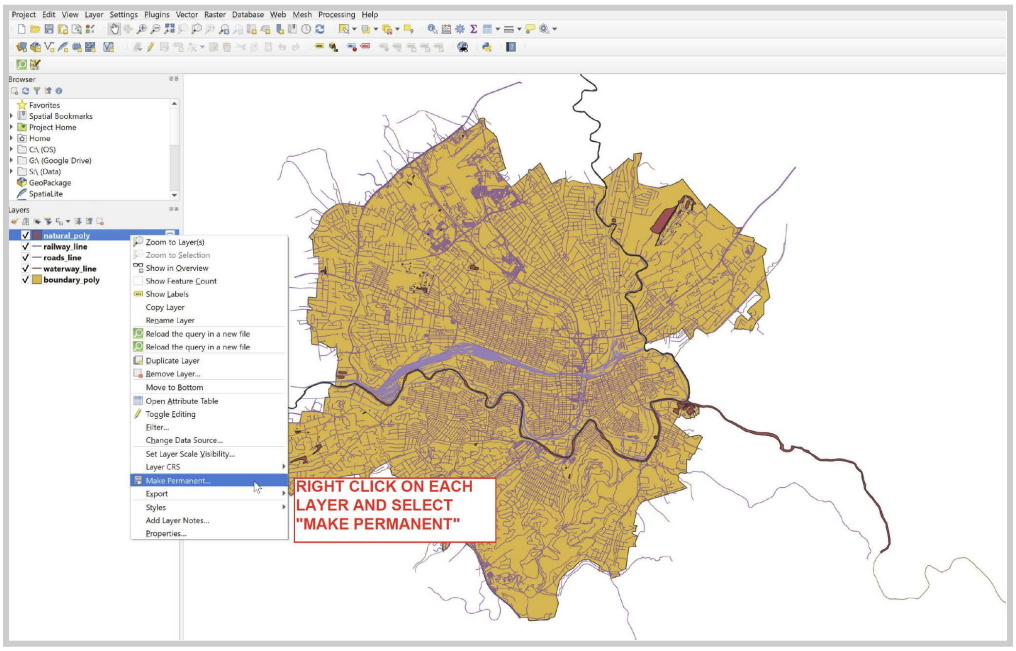
Step 5: Save your scratch layers as permanent layers. Save your file. NOTE: *if you save and close your file without saving the scratch layers, your map features will disconnect from OSM and you will lose your map.*

5a First, you can remove layers you won't be using, and rename the layers you'll keep.

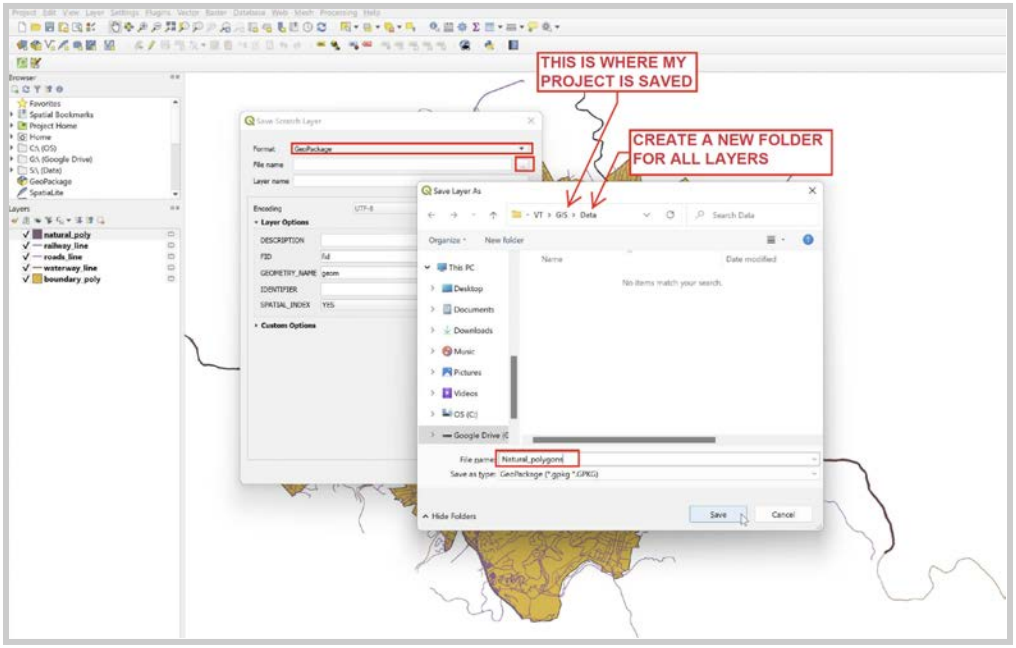
> **I usually remove all the multipoint (aka point, symbolized with dots beside the layer name) layers; remove the mulitpolygon (aka polygon) layers for highway, waterway, and railway; and remove the multiline (aka line) layer for natural and administrative boundary**. (Note: hover over layers to see their type.)
>
> As a best practice, you should keep your files clean and legible. Your layers should be named simply and clearly, without special characters or spaces. For example, "natural_Roanoke" or "natural-poly_Roanoke". To rename your layers (**right click > "Rename Layer"**).
>
> Reduced layers should look like this:



5b Look at the "Layers" window (lower left). The **gray rectangle symbol to the right of the layer name** means that it's a **scratch layer, or temporary layer.** The QuickOSM query pulls feature data from the internet, but doesn't save it to your computer. To **save your feature data**, right click on each layer and select "**Make Permanent**…"

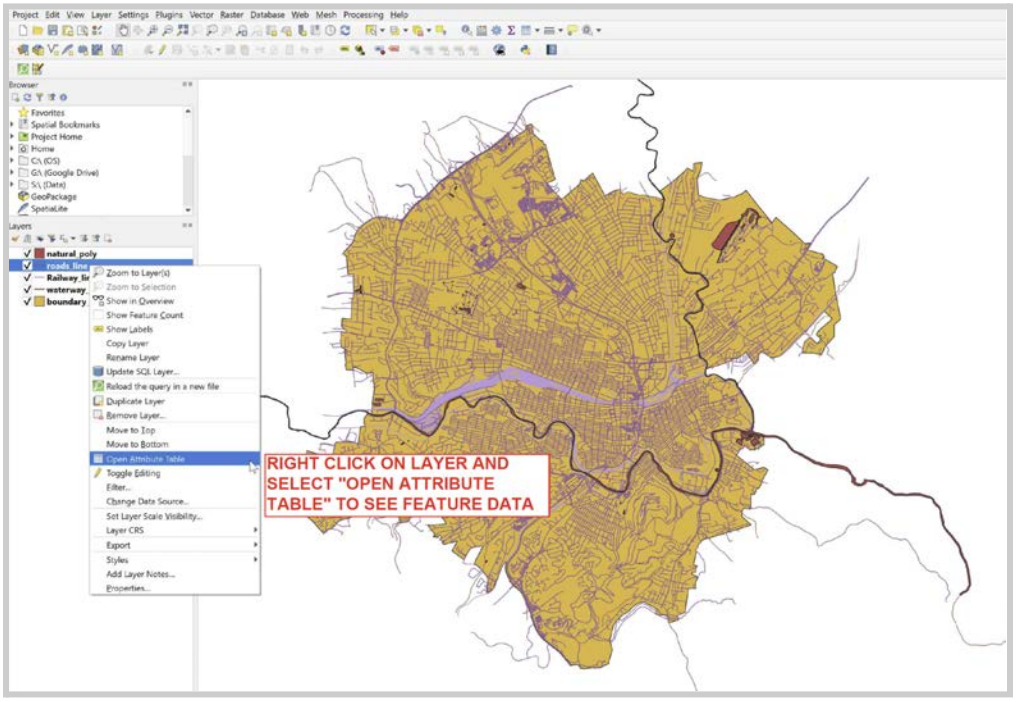


5c Set format to GeoPackage. Click on the ellipses (...) to the right of the “File Name” box. Navigate to the local folder **where you saved your QGIS file** and then **create a “Data” folder for your layers**. Name your layers clearly (for instance, “Waterways_lines” or “Natural_polygons”).

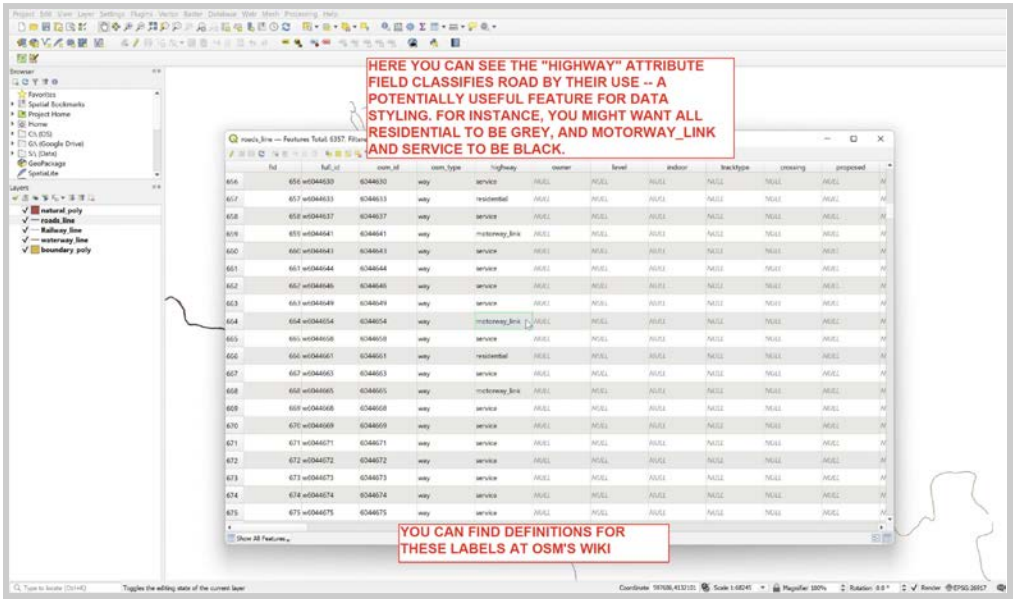


Step 6: Open the data table and see what information is available about different feature types.

6a Right click on any of your layers and select "**Open Attribute Table**" to see the data associated with features in that layer. The attribute table is the spreadsheet of information associated with each geographically-pinned feature (the points, polylines, and polygons).

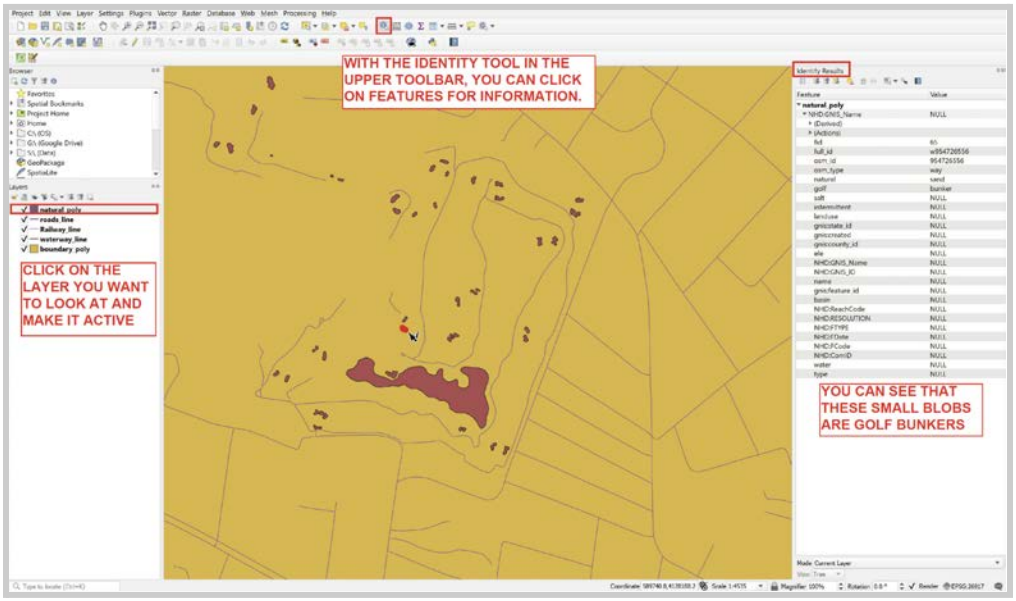


6b **OpenStreetMaps** has a TON of fields, most of which aren't used for every feature. "NULL" means the field has no information for that particular feature. You can find specific definitions for the labels OSM uses like "apartment" and "motorway" in the OSM Wiki. Note that because OSM is an open-source, community-driven project, the feature information isn't always accurate (but the shape, location, and size of features are generally right).



6c Use the “**Identify**” tool (arrow with blue circle “i”) in the top toolbar to identify features by clicking on them. This tool can help you understand unusual or unexpected features, especially once you style them and outliers stand out. For instance, you might see a building classified as a hospital in an unexpected location, or a plot of land that is unusually expensive. With “identify”, you can understand what you’re looking at.

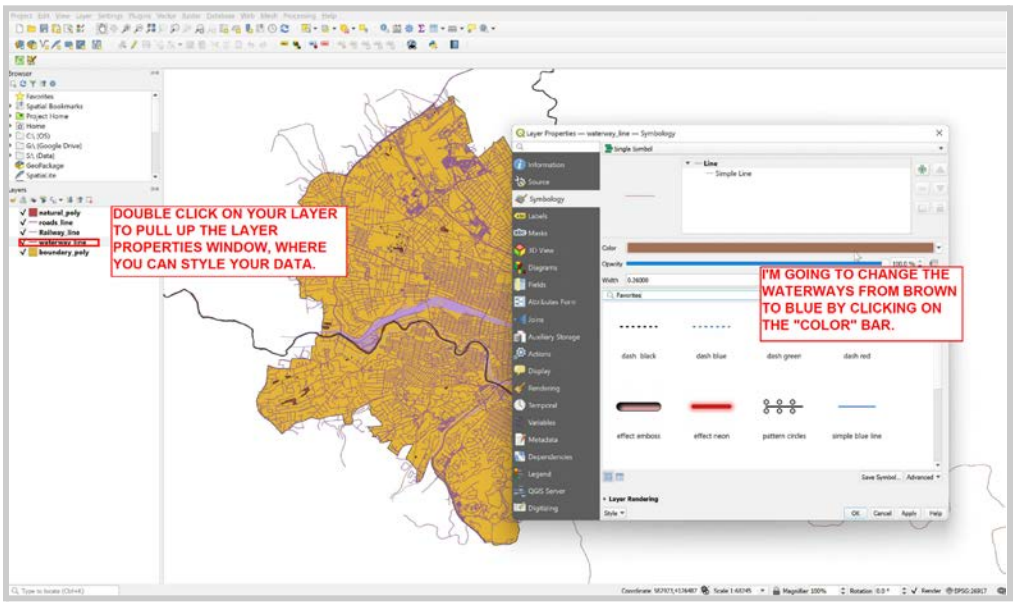
Note: Make sure to select the layer that the feature is on (eg. “natural”) before you click on it. The identify tool only queries the selected layer’s features.

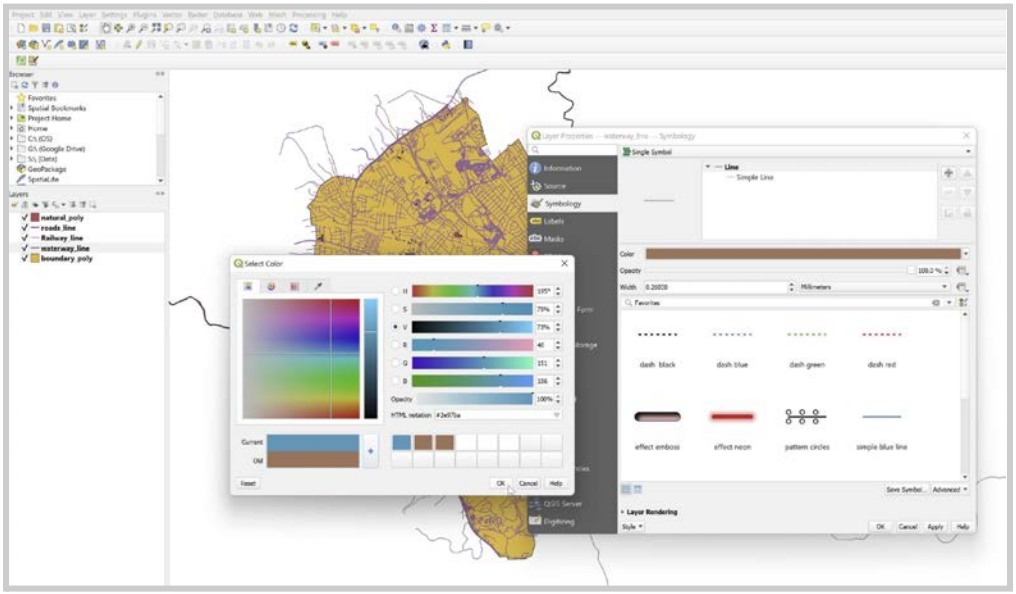


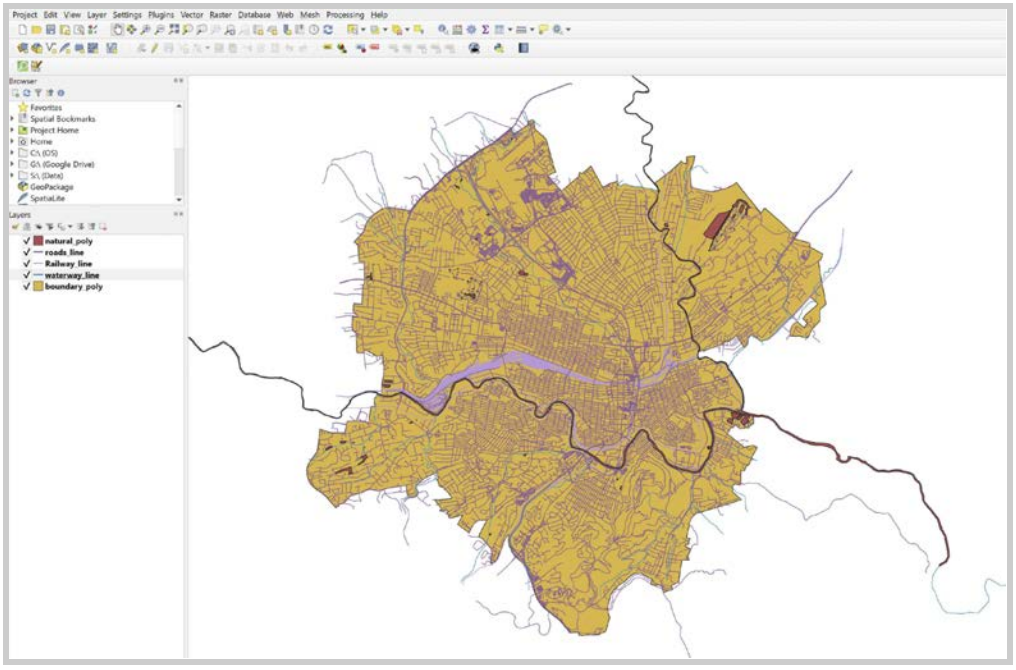
Step 7: Style data by color and “category”.

7a Double click on the layer to pull up the **Layer Properties** dialogue. Select the **Symbology** tab. Here, you can see the features’ color and linetype. Note that properties are nested, so you need to click on the inner layer (eg the one called “Simple Line”) to see and edit all properties. To change a property, click on the box displaying it.

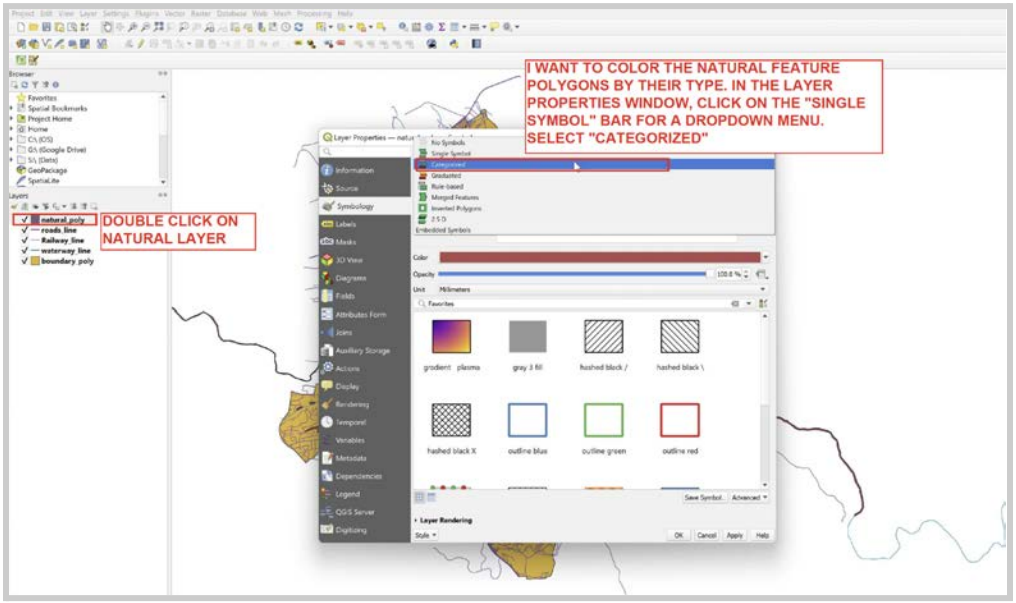
7b For example, I will change all the waterway lines from default color to blue. Pull up the Layer Properties for the waterways layer, and click the color box under Symbology. change the color to blue. Make sure to click **“Apply”**.



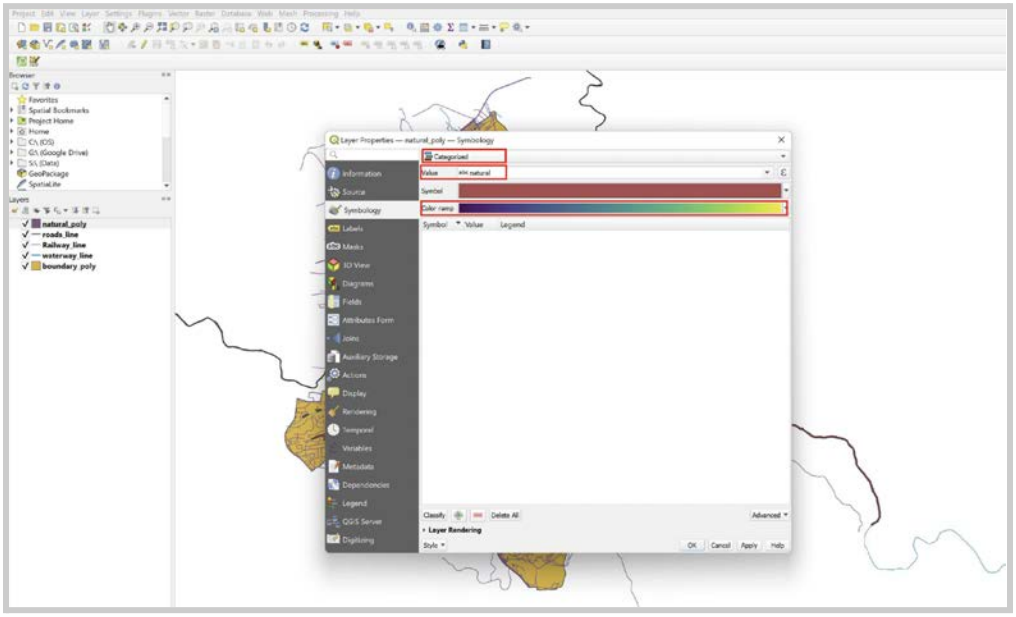




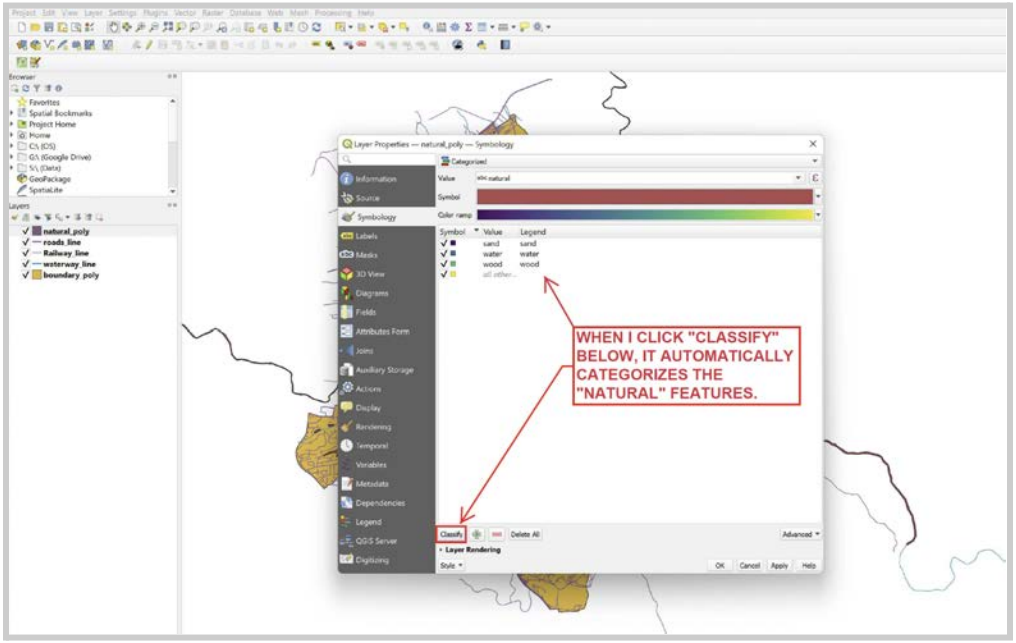
7c Next, let's color features differently according to their attributes (the information in the Attribute Table). For instance, I want to color the natural features according to their properties as water, forest, rock, and so on. First, open the Layer Properties for the **natural features polygon** layer. Click on the "**Symbology**" tab, then click "**Single Symbo**l" at the top to see the dropdown menu of available styling options. The main style options we'll use in the class are Single Symbol (entire layer is one color), Categorized (color determined by text property), and Graduated (color determined by number property).



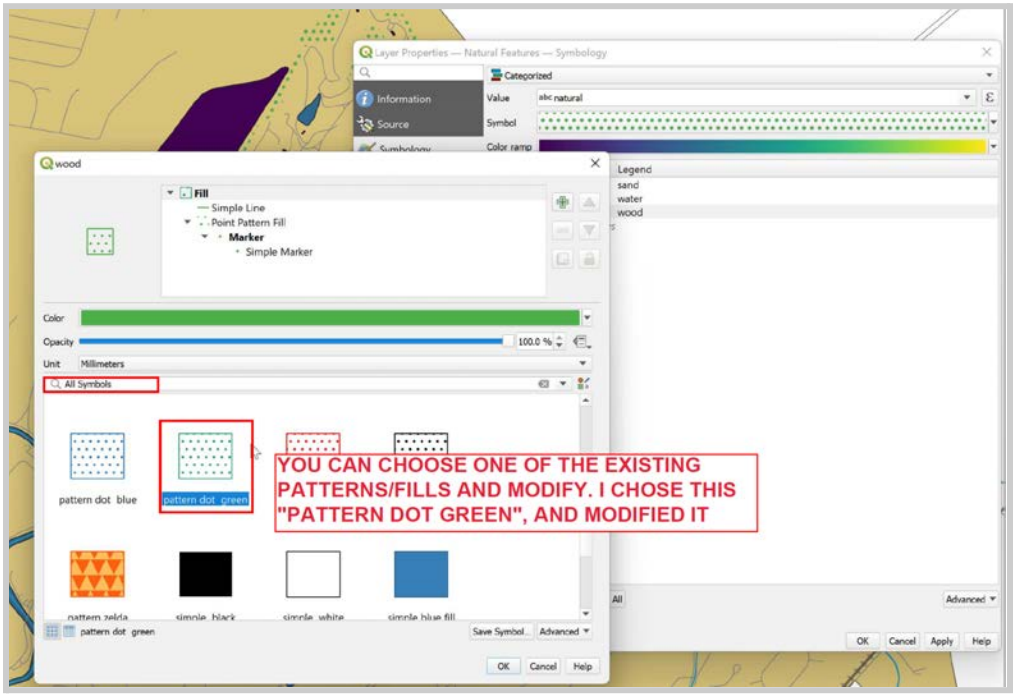
7d Choose “**Categorized**” from the dropdown menu. In the top “**Value**” bar, you’ll select the attribute that you want to define feature color. Refer to the “Fields” tab (left, below “Diagrams”) to see the layer’s available fields, or open its Attribute Table (spreadsheet) to see what kinds of values it contains for each field. I’m going to select “natural”, which contains values like“water”, “woods”, “wetlands”, etc. Then, I’ll select a **“Color ramp”** that has a range of natural-looking colors (in this case, I chose the blue to yellow spectrum called ‘Viridis’).

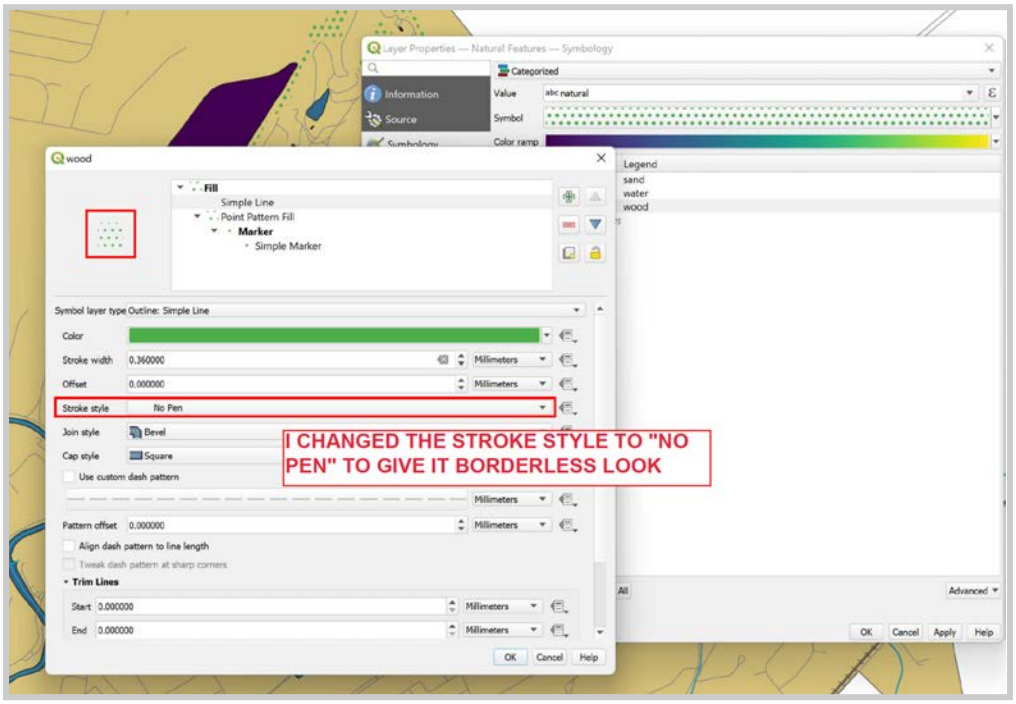


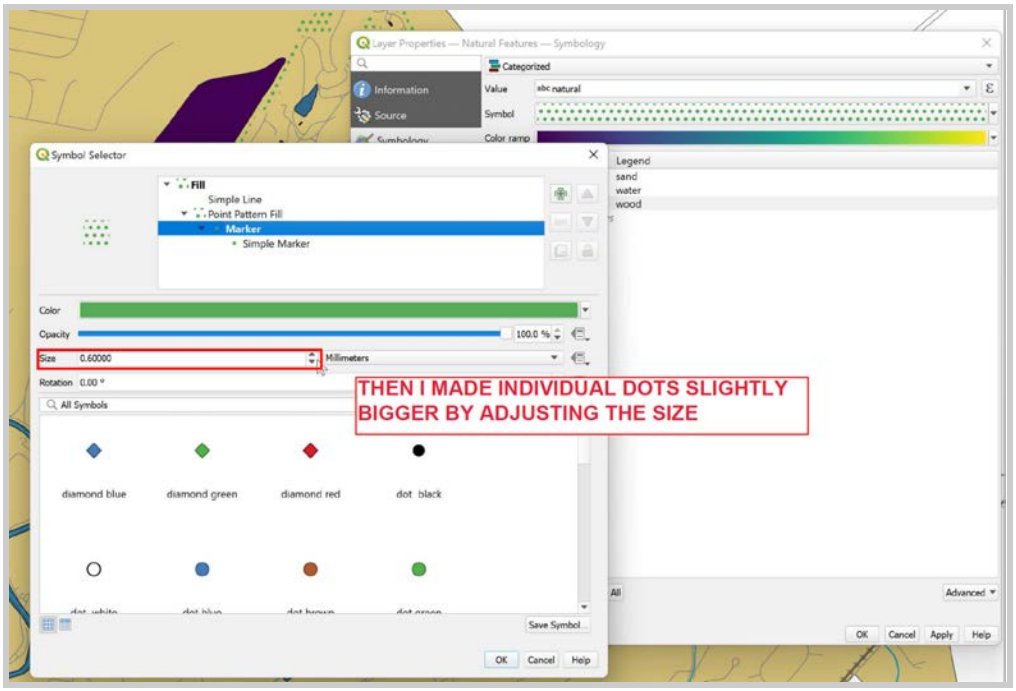
7e Next, click “**Classify**” at the bottom. Q will automatically divide the Color ramp into “steps” and assign one to each value in the selected field. In this case we have six different values, and “all others” (which usually means “NULL”). You can change the color of each value by clicking the box beside it (to change, say, water to blue, and woods to green). You can also **group values** (for instance, if you want “wetland” and “water” to be the same color) by selecting both words (shift+click) and right clicking to **“Merge Categories”**. To see the new style, click “**Apply”.**

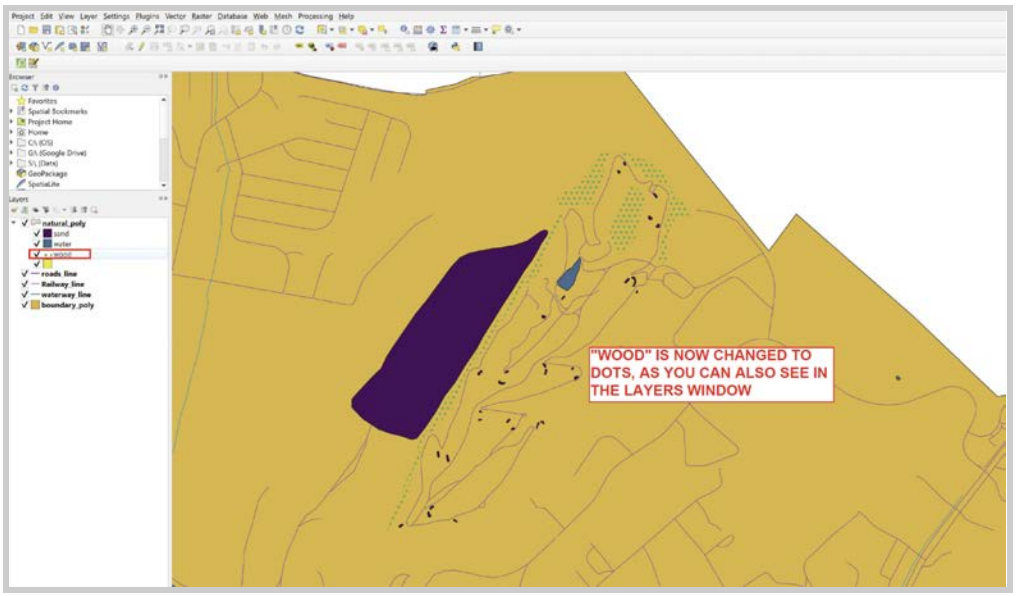


You can also try selecting **patterns** instead of colors. For instance, I changed my woods polygons from solid green to little green dots, to mimic trees:





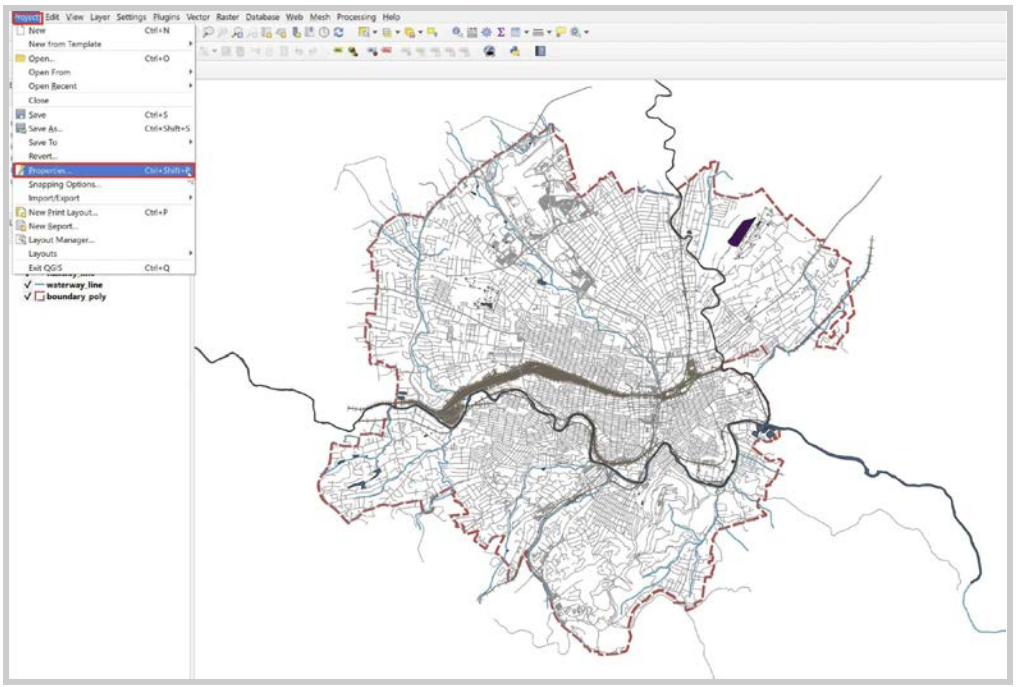




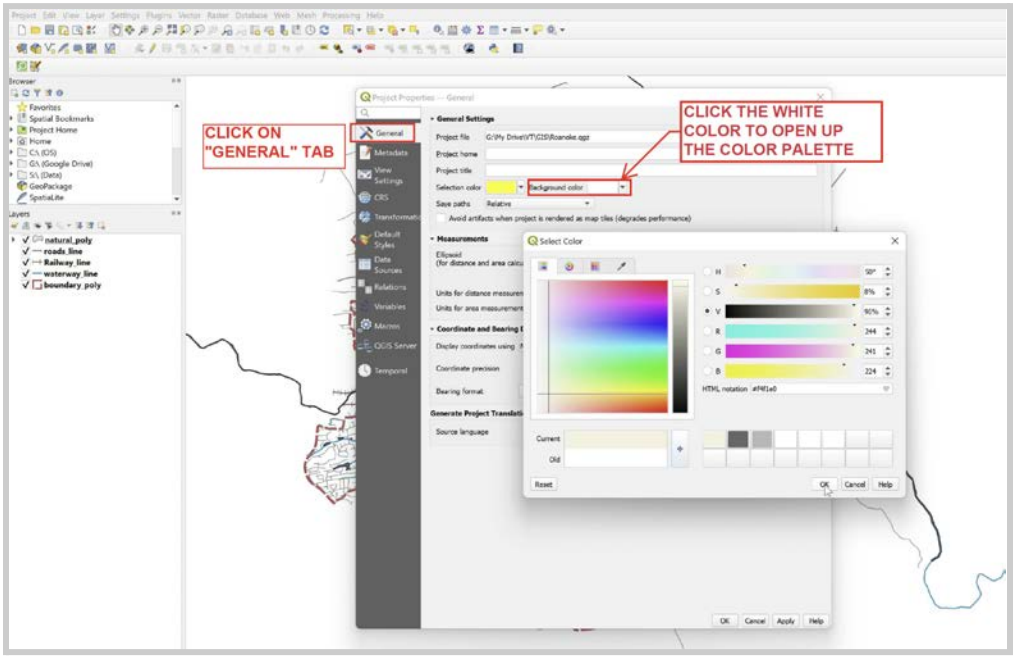
7f Repeat these steps for your other layers; make sure that your data looks like what you are showing, or otherwise expresses something about the place. See how you can cleanly show the different layers to make a cohesive map.

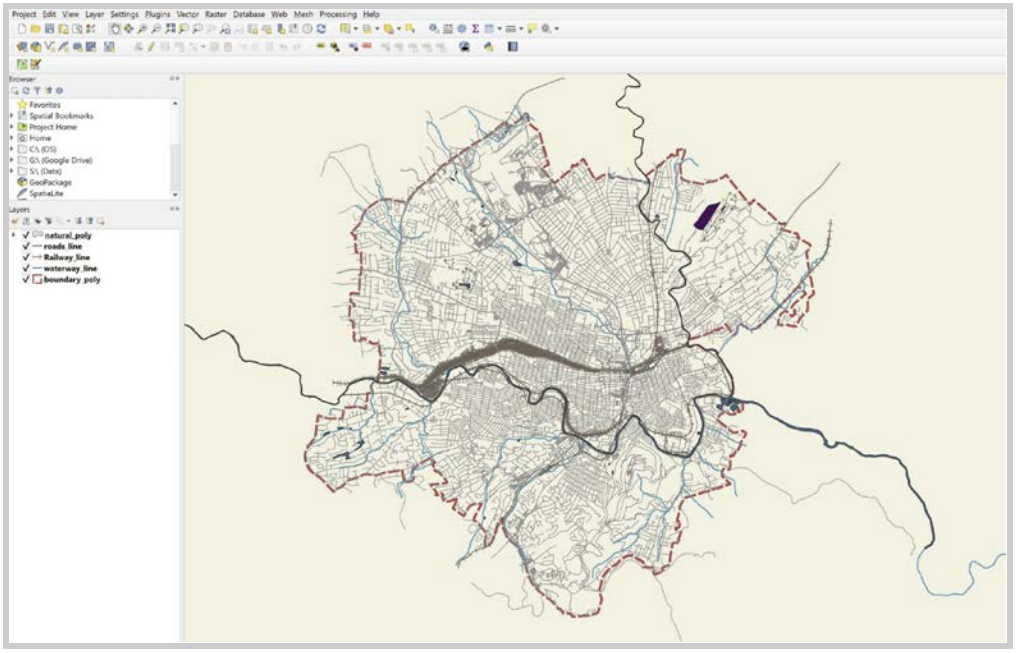
Step 8: You can also change the background color of your map.

8a Go to “**Project**” > “**Properties**”.



8b Click on “**General**” tab on the left, and in the fourth line, you will see ‘**Background color**”. Click on the color, and a palette will appear. Choose your color, and click OK, then OK in the Project Properties window.

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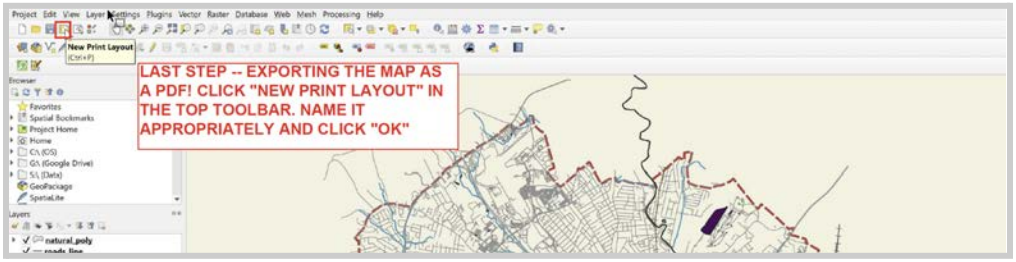
S:\ (Data)
GeoPackage
SpatiaLite
Layers
natural_poly
roads_line
Railway_line
waterway_line
boundary_poly

Step 9: Export map as 11x17 pdf, with title, legend, scale, and north arrow. Include a byline with your name, date, and data sources.

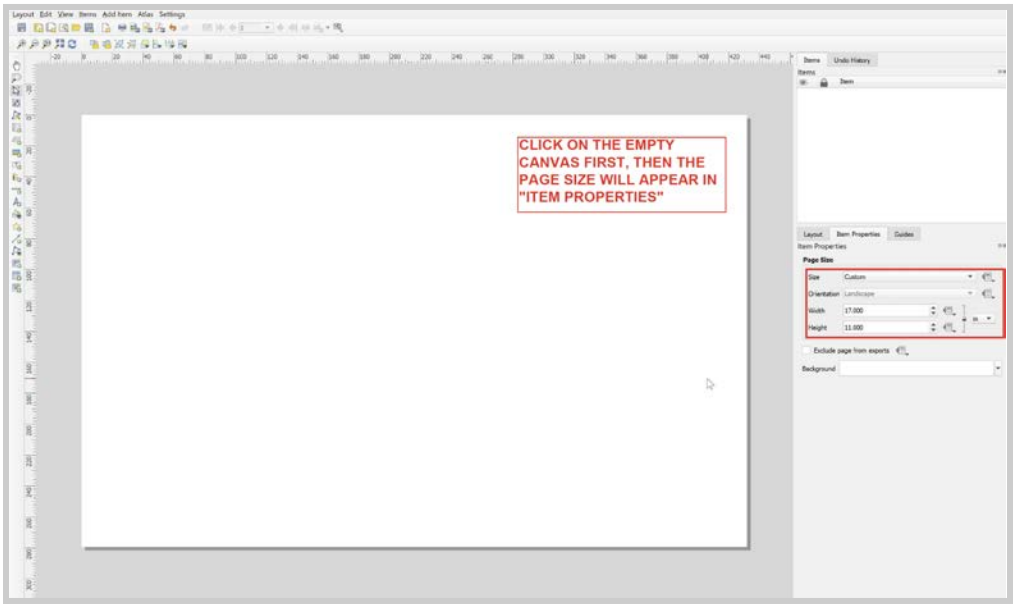
> **Note:** *All static maps in this class should include these elements. Leaving them off will impact your grade.*

In QGIS, like in AutoCAD, data and layout are treated as separate pieces. The geographic vector data stays in one window, while you develop the layout that you want to share (the map proper) in another. In QGIS, the layout window is called **"Print Layout"**. This is where you can add things like margins, annotations, and legends. You can also add multiple maps to a single print layout. Say you have different data layers that you want to turn on and off, or different geographic scales that you want to show. You might, for instance, include an inset map that shows the state of Virginia with a red dot for Roanoke, and then a larger map of Roanoke itself. Or you might include two side-by-side maps, one showing man-made features and the other showing natural features of the city.

9a In the upper toolbar, select "**New Print Layout**." Name your layout and click "Ok".

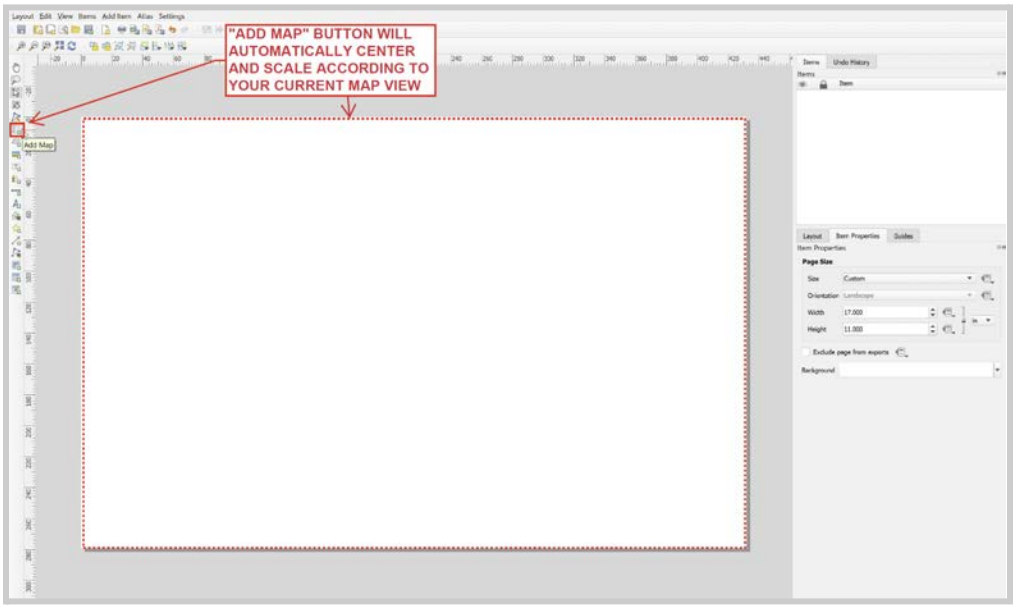


9b First, adjust your canvas page size. Right click on the empty canvas and select "**Page Properties**". In the right window, select "Custom" size, and then "in" (inch) as your unit and set the width to 17 and height to 11.

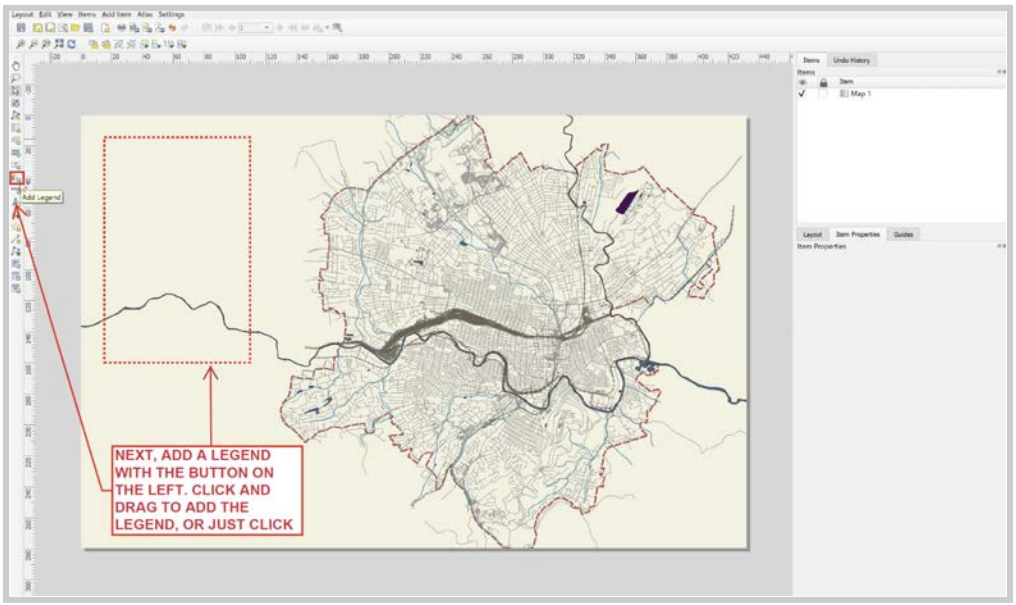


9c Next, select “**Add Map**” from the left toolbar to add your map. It will default to your current location and zoom level.

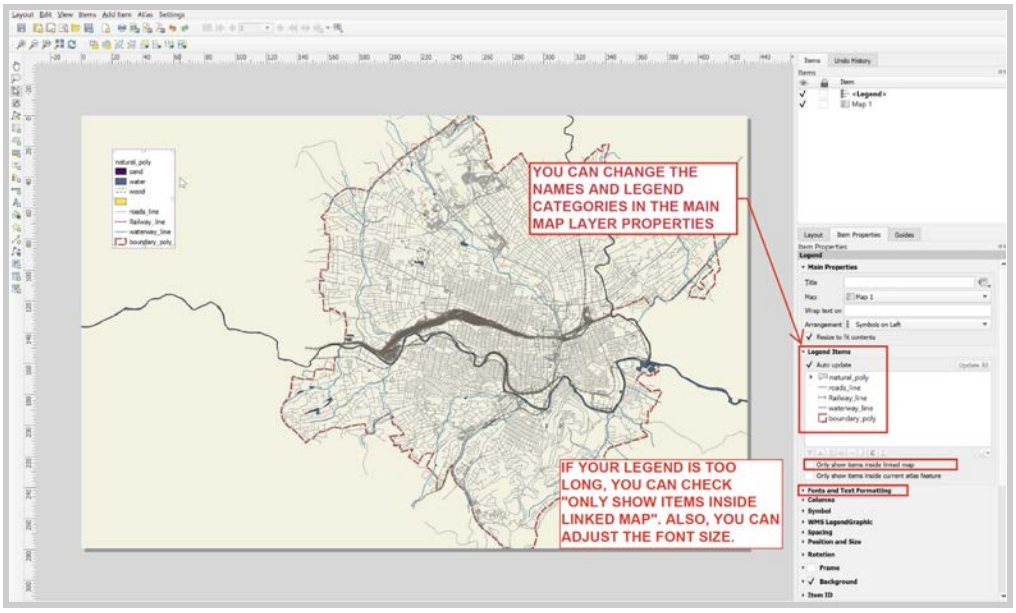
> **Note:** the maps in your Print Layout will automatically adjust as you move or edit the maps in your data view. To freeze a print layout map, select it and see the “Item Properties” tab on the right. This will have an option to lock the map view.



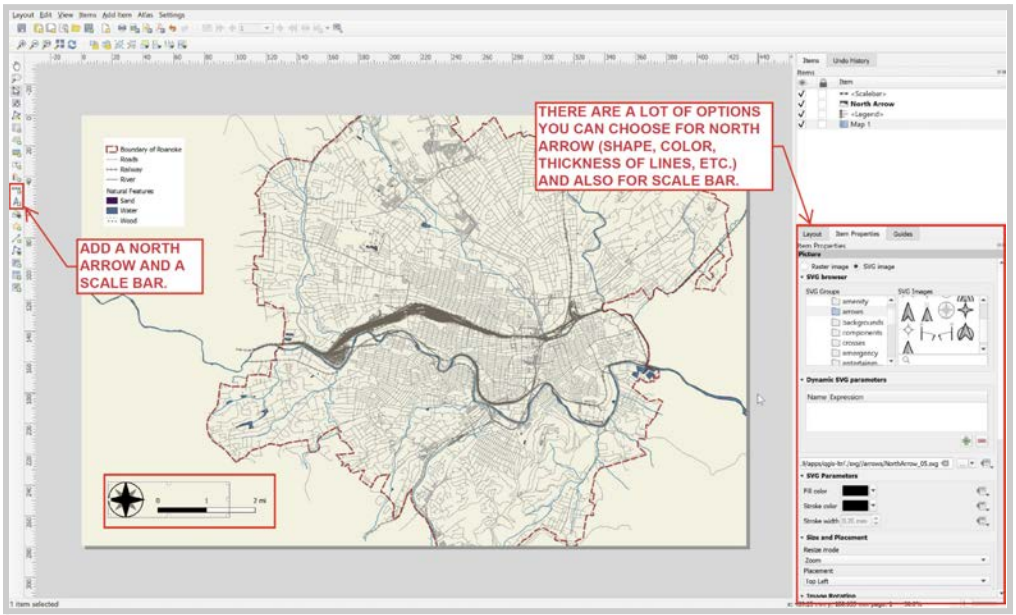
9d Now select “**Legend**” from the left toolbar. Like mine, yours might be way too long to fit on the page.



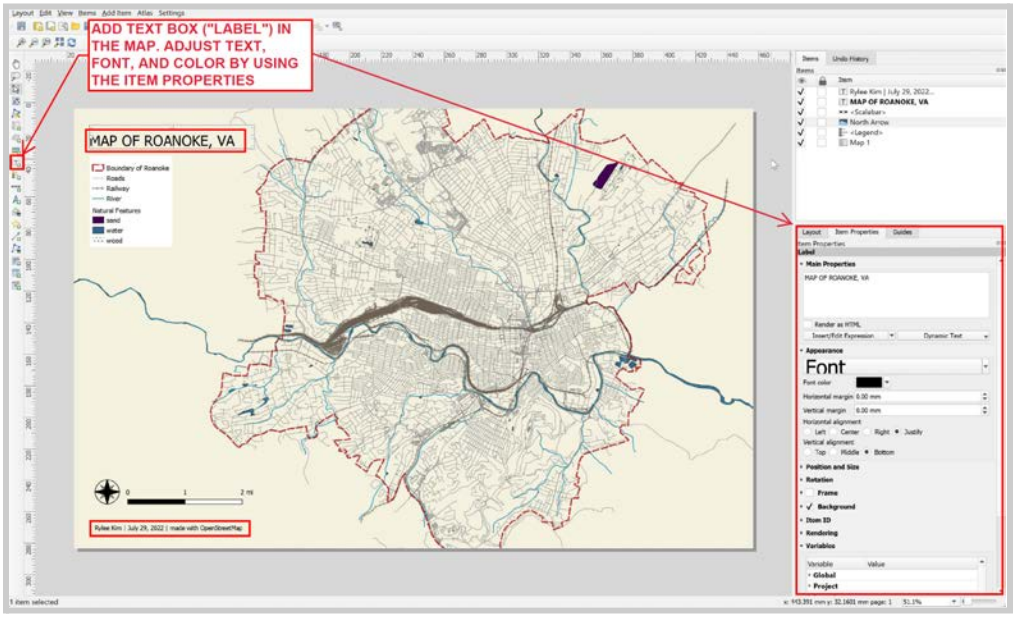
To change the names and categories, adjust in the main map layers and click “**Update All**”. If the legend is too long, first check off “**Only show items inside linked map**” in the right “Item Properties” window. This hides the legend items not visible on the current map. Second, we can adjust the font size in “**Fonts and Texts**”. Third, we can uncheck “**Auto update**” and manually edit and simplify the legend text in Item Properties.



9e Add a **north arrow and scale** to your map from the left toolbar. You can adjust the graphics of these, and the units of the scale, in the “Item Properties” window.

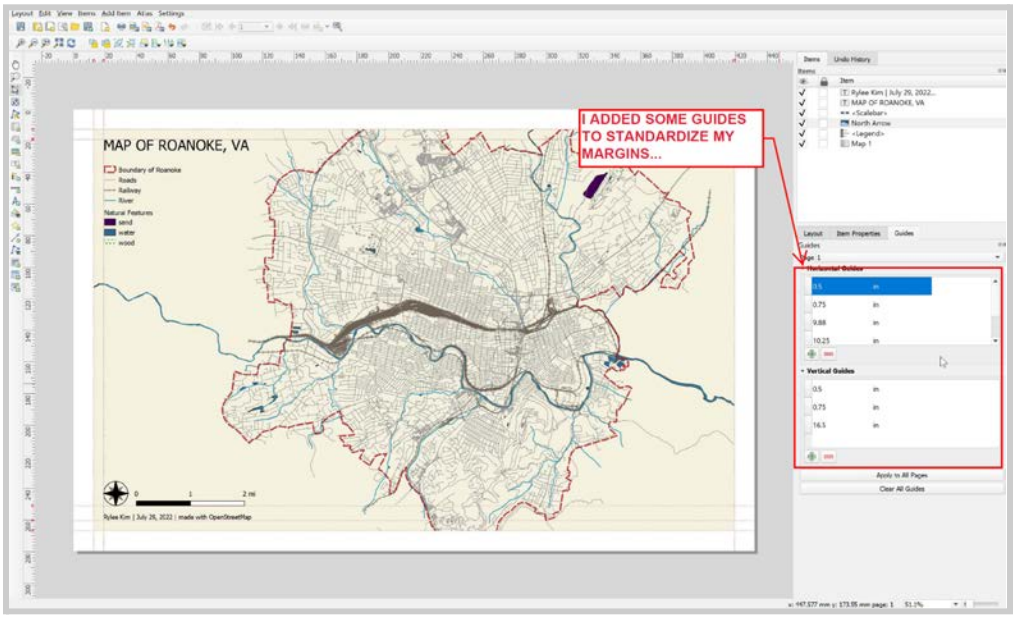


9f Add a title and byline (**with your name, date, and data sources**) using the **text box** tool.

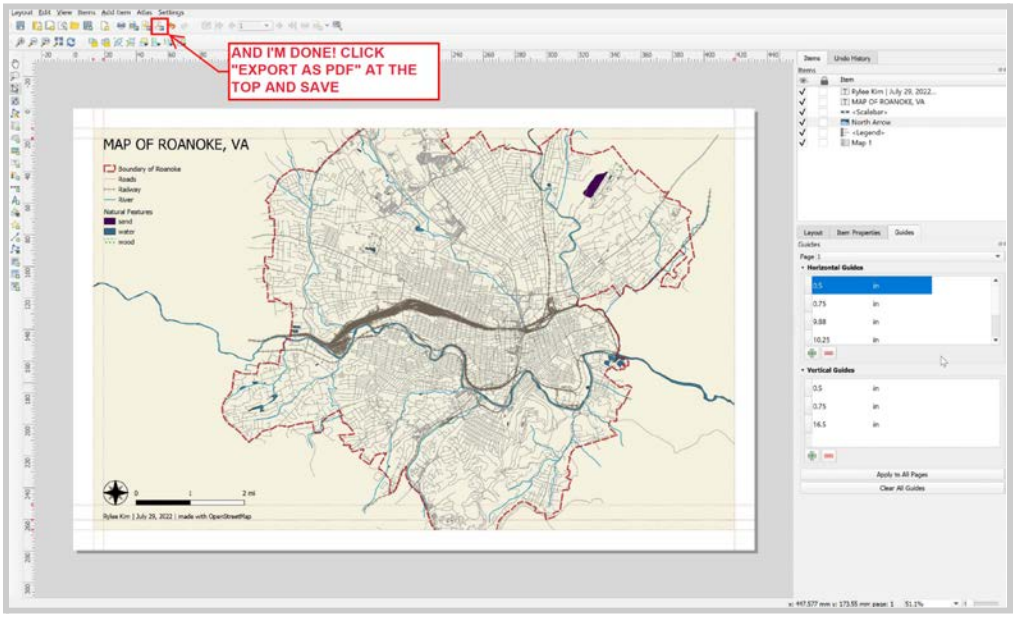


9g Adjust your map content and add margins using the "**Guides**" tab (lower right window, beside "Item Properties"). You can drag your map boundaries to fit inside the guidelines.

> Note: the map elements in Print Layout can be adjusted as window elements (adjusting the boundaries of what is shown, like looking through a window) or as map elements (panning or zooming within the map itself) using the "**Select / Move Item**" tool (third from the top) and "**Move Content**" tool (fourth from the top) respectively.



9h Lastly, save your layout. Then click “**Export as PDF**” in the upper toolbar to export your finished map.



- Bonus -

Step 10: Add a context map (aka “inset map”) of Virginia, showing the location of Roanoke on the map. You will need to download the administrative boundary for the state of Virginia through OSM or from the state of Virginia GIS portal. You can add a dot for Roanoke in the Print Layout.

- Your context map (inset) should be on top of your larger Roanoke map, in an additional map box.
- Make sure to lock the layers in your base map (uncheck “update map” in item properties)
- Turn on the appropriate layers in your context map and uncheck “update map” there as well

Step 11: Export your new map(s) as pdf with legend and include them in your Tutorial 1, 2, & 3 submission.