**Exercise 03**
**Creating and Editing Shapefiles**
**Assigned Feb. 2, 2018**
**Due Feb. 9, 2018**

On the class website I've posted an **exercise_03_data.zip** file which contains a USGS 7.5' quad map of Laramie (as **laramie_quad_usgs_1963.tiff**) plus two **gpx** files -- one with a track around campus and the other with waypoints on the track. In this exercise we'll import those files, examine and adjust the CRS (coordinate reference system) associated with them, then create some simple overlay shape files. Before class on Feb. 9 use QGIS to import the tracks, waypoints, and base map, create the shape files, then, as described at the end, turn in your map and shapefiles next Friday by email.

Use the documentation given in the links on the class website. You can reach the on-line QGIS manual either via that links page or from the QGIS Help menu. Most of the relevant parts in the main manual are under "Working with Vector Data". On the class reference page I've also added a link to a tutorial "A Gentle Introduction to GIS". In particular look at the "Vector Data" section. Finally, within QGIS, if you let the mouse hover over an icon, after a second or two a "tip" should appear. Send me an email if you encounter difficulties.

First, download the **exercise_03_data.zip** file from the class website and extract it into a local or H: drive folder. Start a new QGIS Desktop session.

## Part I. GPS Data, Maps, and Coordinate Reference Systems.

Use the menu entry **Layer / Add Layer / Add Vector Layer** and in the file dialog box navigate to your copy of the exercise_03 data directory and select **exercise_03_track.gpx**. Select the **tracks (Geometry Type= MultiLineString25D)** option and click OK. The track should appear in QGIS. Double click on this line in the **Layers Panel** to open the **Properties** dialog and change the line color and width to something that is easy to see. While there click on the **General** tab which among other things will show you the **CRS** (Coordinate Reference System) being used for this data. It should show WGS 84 (also known as EPSG:4326. There are European Petroleum Survey Group (EPSG) codes for a very large number of different possible CRS's).

Repeat the above steps to import the **exercise_03_waypoints.gpx** file but in the final step select **Waypoints (Geometry Type = Point25D)** for those. When you create a new shapefile (which is what you are indirectly doing when you import the gpx data) you need to specify the Geometry Type of those shape files. You could, for example, have imported the track

file as a set of discrete points (as we did in exercise 1) rather than as a connected linestring.

With the Pan tool selected (the hand-like icon) move around the image -- but without clicking. You should see longitude (about -105) and latitude (about 41) displayed at the bottom. The tentative "Project" CRS, adopted from the first layer you created, is WGS84 latitude and longitude.

Now import the Laramie Map by selecting **`Layer / Add Layer / Add Raster Layer`** and selecting **`laramie_quad_usgs_1963.tiff`**. The map will probably cover up the GPS information. In the **`Layers`** panel drag the map down so you can see the GPS points above it. *(Bug-workaround: Sometimes the map does not appear as it should. If this happens you need to remind QGIS to actually use the map CRS that was contained in the tiff file and should already be associated with this layer. Right click on the map in the* **`Layers`** *panel and select* **`Set Layer CRS`**. *A dialog box will open. Don't change anything there. Just click* **`OK`**. *The map should now appear.)*

The real track I recorded actually started and ended near the front entrance to Geology, but you will probably see that the track appears offset by about half the width of the building. While the map tiff file contained some information about the coordinate reference system, apparently it wasn't enough. Either the datum recorded in the file was wrong or QGIS misinterpreted that information. Unfortunately this is a common occurrence in GIS systems. Although it's nice when it "just works", you really need to test imports by recording waypoints at known locations and double-checking that they import as expected.

In this case the fix is to force QGIS to use correct CRS information for the map. I've saved that information in the **`laramie_quad_usgs_1963_crs.txt`** file. Open that file with any text editor (such as notepad or wordpad) and copy the full text to the clipboard. If you look at that text, the proj keyword says this is a polyconic projection. The other keywords tell about the origin of the coordinate system, the assumed size and shape of the earth (Clark 1866) and the datum. QGIS is smart enough to do "on-the-fly" projection" to display both this polyconic projection and the "geographic" coordinates from the GPS on a common screen, but datum details matter. Back in QGIS right click on the Laramie map in the **`Layers`** panel and select **`Set CRS`**. You should see near the bottom of the dialog window an entry which looks almost like what is in the text file, but is missing the NAD information. The system ALMOST knows the right CRS, but has the wrong datum. For the moment back out of this dialog by hitting **`Cancel`**. From the main menu chose **`Settings / Custom CRS`** and in the dialog window which opens click the + sign to add a new **`CRS`**. In the parameters field paste the text you copied from the **`txt`** file. In the name

field enter **Laramie_Map**, then click OK. Back in the QGIS **Layer Panel** once again right click on the map layer, select **Set Layer CRS**, and in the CRS dialog window which appears, in the middle panel, scroll down till you see **Laramie_map**, select it, then click **OK**. When you do that the map should jump slightly, and the track should align with the front door of Geology.

At this point, in case of error, you should use **Project / Save As** to create a project file which records the information about which layers you have loaded, and what CRS's those layers use. If you have to restart, then you can just load the project file.

## Part II. Creating shapefiles

Create the three shapefiles described below (Points, Walkways, and Building), by selecting from the QGIS Menu **Layer/Create Layer/New Shapefile Layer** then specifying the appropriate shapefile type (point, line, or polygon) in the dialog which appears. You can keep the default parameters for most of the entries. In the "spreadsheet" we will create we need an index **attribute** (think of **attributes** as spreadsheet columns) for each feature we enter. For the first two files, keep the default integer **ID** attribute, and give each building and walkway a number. We'll do something different for the buildings.

Since we can keep all the default parameters for the first (points) file just click OK, and choose a filename like **uw_points** in the dialog window which opens. (Double check this is going into a reasonable directory.) A new line should appear in the **Layers Panel**. Select it, then click on the **Pencil** icon to enable editing. (Again, if you hover over an icon, it should, after a couple seconds, give help information. It will take practice to learn which icons correspond to which tools.) Click on **Add Features** which is probably two icons to the right of the pencil. The cursor should change to a target. Proceed around campus adding points which for the moment represent buildings. Do this for at least 6 buildings. Each time you add a new one a dialog box opens, asking you to enter an ID, which should be an increasing count of integers. If you make a mistake you can either delete points, or open the attribute table and correct the numbers. When you are done adding points click the **Pencil** icon again to toggle off editing. It will ask you if you are sure you want to save the changes. Do save it. If we wanted, after we finished adding points we could edit the attribute table to add columns with additional information about each building. We'll do that with our final shapefile.

Repeat the above, but now add a **uw_walks** shapefile which will contain linestrings -- connected sets of points. Other than changing the shapefile **Type** to **Line**, you can again use the default parameters. Note the **Add Feature** icon changes to show a string rather than an isolated point. When you click it the target cursor again appears, and each time

you left click on the map it adds a new vertex (ie. point or node) along the string. When you have added the last vertex you want, right click then enter the requested ID number. Add at least 3 lines representing different walkways on campus.

For the third (**uw_buildings**) shapefile, choose **Type=Polygon**. In addition, remove the **ID** attribute by clicking on it then selecting **Remove**. Create a new **BldgName** attribute with the default 80 character. (An annoying limitation of shapefiles is that you need to specify the size of the attribute fields when you create them.) Using the map as a guide, add polygons representing at least six buildings. Once again each left click adds a vertex or "node". Right click after the final one. As you create the individual features, give each building a name. Try making deliberate mistakes in a couple, then go back and correct those mistakes using the **Node Tool** (a hammer next to a node). Click near a node to select that node, then drag the node to move it. The documentation discusses more sophisticated editing of nodes.

**Entering and Calculating Attribute Table Columns**

Once you have created the **uw_buildings** file, and saved it, right click on the **uw_buildings** line in the **Layers** panel, and select **Open Attributes Table.** You should see a table, with one line per building. Click on the **Toggle Editing Mode** icon at the left within the **Attribute Table** window. Several other icons which were grayed out become active. Select the **New Column** icon, which will probably be second from the right. Add a column named **NR**, with a comment field set to **Rough Guess**, with **Type** set to **Decimal,** with **Width** set to 3, and with **Precision** set to 0. Note that the column is initially filled with **NULL**. Fill in a rough guess of the number of rooms in each building.

Finally, click on the **Field Calculator** button -- which looks like an abacus -- at the far right. This opens a dialog box which by default will add a new column, calculated based on the others. In the dialog box name the new column **NStudents**, set the **output field type** to **Decimal**, the **length** (or **output field width** in older versions) to 10, and the **Precision** to 2. We'll estimate the total students in each building by assuming each room contains on average 12.5 students. In the middle lower panel scroll down till you see **Fields and Values**, double click on it to expand the list of all column names. Double click on **NR**. That **"NR"** should appear in the expression box at the left. Then simply type ***12.5** and it should show an **Output preview** at the bottom of that panel which matches the number of rooms times 12.5, for the first row in the table. If this looks right, click on **OK** to add the new column. Note in this case we added an actual numerical new column which although initially filled in with the calculated value, can also be edited cell by cell. We could also add a "virtual column" which is always calculated from the formula we specify.

Explore the calculator to see what other options are available. Once again you will need

to toggle off editing to save the results.

**Labels**

Back in the main QGIS window (i.e. after closing the attribute table) you can label the buildings you've marked by first toggling on editing, then clicking on the `Label` icon  . A dialog window will open which will initially show `No labels` at the top. Click on that drop-down list and select `Show labels for this layer`. In the next drop-down list select the `BldgName` column as your label. You can also adjust fonts, spacing, positioning, etc. Your map should now show those building labels.

**Saving an image of your map**

Save an image of your map (for example for inclusion in a report) by selecting from the main QGIS menu `Project/Save as Image,` double check the default directory it wants to use is reasonable, then give it a file name. Select jpg type output. If you examine the files created you will see it has created not only filename.jpg, but also filename.jpgw. The latter is a "world file" which contains the geographic location information information for your image, useful for importing it back into QGIS or another GIS program. But to be useful you need to know the Coordinate Reference System (CRS) assumed in the numbers in jpgw. In this case, that is the CRS inherited from our first layer, which was WGS84 Geographic.

**Saving the Project**

Once again save the project file, to record the information about what layers are included and how they are displayed.

If you saved this or your layer files on the local ESB1006 machine, be sure to copy the files back to permanent storage on your (network) H: drive or a thumb drive before you log off.

**Turning in the files next Friday**

You will turn in the files you created next Friday. To make that simple, try to have all the relevant files (the shape files, the project file, the image jpg and jpgw files, but not the large original map tiff) in a single folder on your machine. On Friday I'll show you how to package all of them into a single zip file named `exercise_03_lastname_firstname.zip` then submit that to the "homework drop" folder.