

# UTILITY MAPPING

*For Surveyors, Utility Locators, and Engineers*

## How to Map & Manage Utility Data using FREE GIS Mapping Software

*“Learn how Surveying, Utility  
Locating, & Engineering Firms  
are Maximizing Revenue”*

A Step-By-Step Guide

CENTERLINE  
MAPPING 

# Utility Mapping *Bootcamp*

How To Map & Manage Utility Data using FREE GIS Mapping Software

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## What you'll learn

- Install Mapping Software
- Create GIS Shapefiles
- Symbolize Utility Data
- Import Field Data to QGIS
- Digitize and Map Utilities
- Publish Data Layers to Web
- Create a Web Map
- Build a Web Mapping Application

## Requirements

- Students should have 0 - 10+ years experience with Utilities, GPS, GIS, GPR, & AutoCAD.
- Students should be familiar with various data formats: KML, CSV, DXF, DWG, CAD.
- Students should be eager to learn how to map and manage critical utility data.

## Description

In response to the steep learning curve, high cost, and unlimited complexities of building custom GIS web mapping applications and deliverables, we have created this easy-to-follow, hands-on **Utility Mapping *Bootcamp*** training course. Following these steps, students will quickly learn how to map utilities and build GIS applications like a professional, without writing a single line of code.

In this course, you will learn how to install free mapping software, create and manage utility data using GIS, convert raw field data to GIS, export PDF maps, and build an interactive web application to visualize and share your maps and data online. You will learn industry-leading Best Practices for successful utility mapping and data management.

This **Utility Mapping *Bootcamp*** will get you up and running with GIS in a very short time.

By the end of the training, you will have the steps and process involved with using GIS software to map and manage utility data and generate cutting-edge GIS deliverables for new and existing clients.

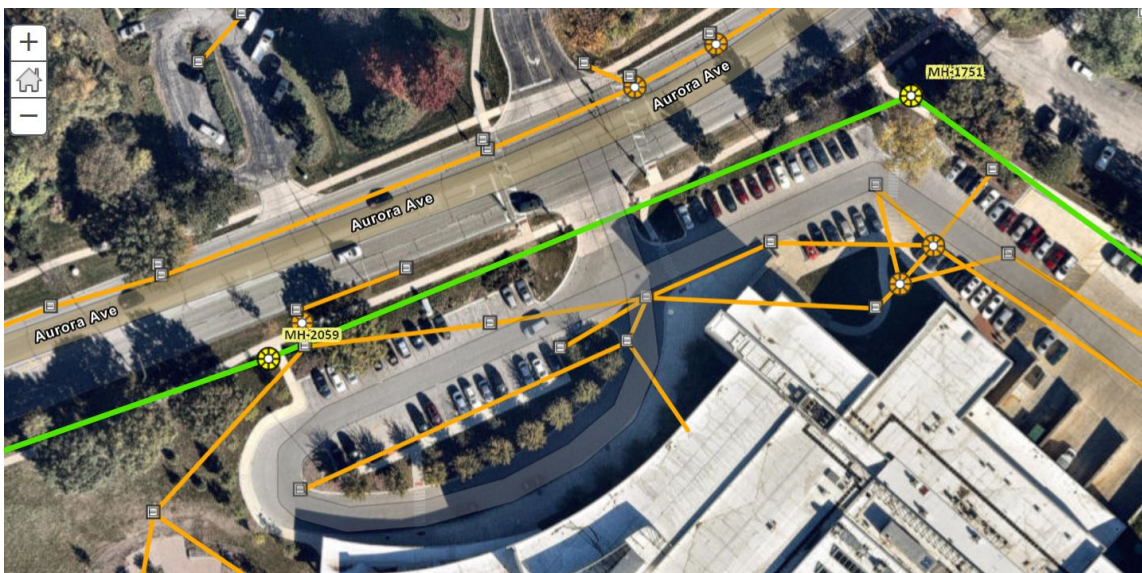
Utility Mapping *Bootcamp*

## Who this course is for?

- Utility Locators, GPR Technicians, CAD Drafters, Surveyors, GIS Technicians, GIS Analysts, Utility Engineers, Directional Drillers, high school students, and college students.
- This course is meant for those looking for hands-on experience mapping and managing utility data using GIS.
- This course is great for students interested in sharpening their GIS, utility mapping, and data management skills.
- This course is perfect for surveying, utility locating, and SUE firms that want to expand their deliverables and stand apart from the competition by offering GIS as a service.
- Anyone interested in learning how to map underground utilities using GIS.

## Course Contents

1. Introduction to GIS.....5
2. Install Mapping Software.....7
3. Create GIS Shapefiles.....9
4. Symbolize Utility Data.....17
5. Add GPS Field Data to Map.....20
6. Digitize and Map Utilities.....25
7. Upload Data to ArcGIS Online..33
8. Build Utility Map Viewer.....37
9. Explore ArcGIS Capabilities.....40



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Map and manage underground utility data using GIS mapping software at your own risk. Redistribution of this course content is unauthorized and prohibited.

# Course Content

## 1. Introduction to GIS

- What is GIS?
- Benefits of GIS

## 2. Install Mapping Software

- Download and install
- View user interface
- Browse various buttons
- (Zoom, Pan, Identify, Save, Measure)

## 3. Create GIS Shapefiles

- Add an aerial imagery map service
- Create point and polyline features
- Create attributes for utilities
- Reorder layers in Layer box
- View shapefile in windows explorer
- Save and Open the Map

## 4. Symbolize Utility Data

- Edit map layer colors and symbols
- Save maps and map layer settings
- Add flow arrows to polyline layers

## 5. Add GPS Field Data to Map

- Import and explore data (KML, CSV)
- Zoom to data after adding
- Edit, reorder, and symbolize data
- Explore attributes
- Use measurement tool

## 6. Digitize and Map Utilities

- Edit shapefiles using GPS data
- Map utilities and add attribute info
- Export data in various formats
- Create map labels

## 7. Upload Data to ArcGIS Online

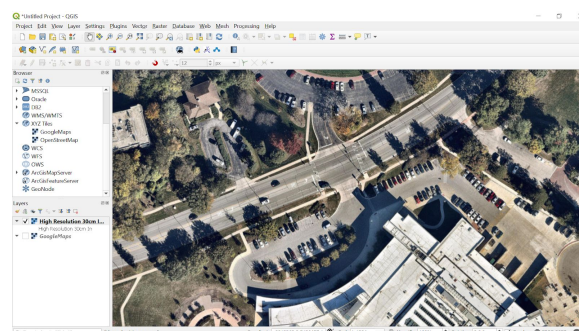
- Organize and zip shapefiles
- Upload data to a web map
- Create and save a web map

## 8. Build Utility Map Viewer

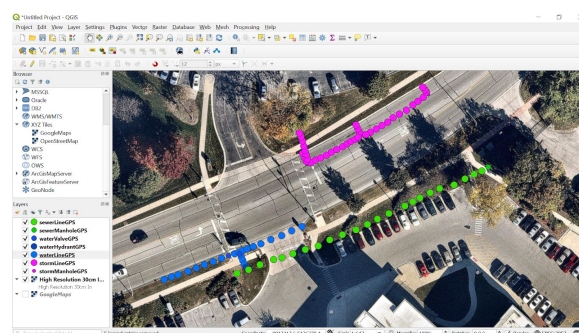
- Save web map as web application
- Edit settings of web applications
- Customize and view data

## 9. ArcGIS Capabilities

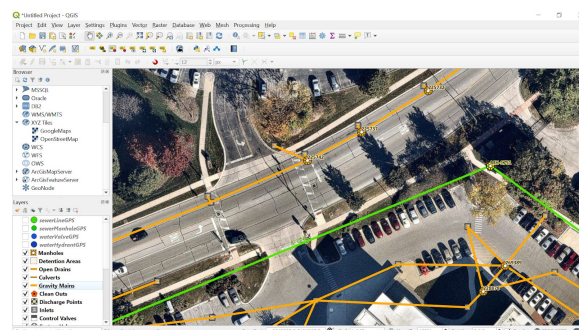
- Explore tools in Utility Map Viewer
- Print maps from the application



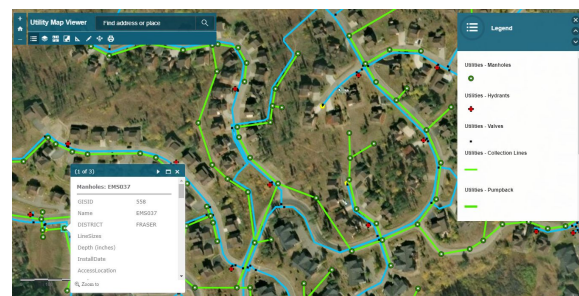
Learn how to add an aerial imagery map service to a map.



Learn how to use GPS & GPR data to digitize GIS data.



Learn how to map, export, and share utility data online.



Learn how to build interactive Utility Map Viewers.

# 1

## Introduction to GIS

A **GIS (Geographic Information System)** is a computer-based tool used for mapping, managing, visualizing, and analyzing various tabular and spatial information including underground and above ground utilities such as water, gas, storm, sewer, electrical, steam, telecommunication, sprinkler, condensate, and much more. GIS is a map tied to a relational database with analytical tools in-between. The value and capabilities of GIS for utilities are endless.

By using **GIS**, facilities and asset owners can better manage and operate reliable utility services using one central database of updated data, rather than a cabinet or local hard drive full of unorganized and outdated drawings. All of their data is stored in one location, accessible in a single interactive web-based mapping application accessible on any device, anywhere.

**GIS** is nothing new to the utility industry, in fact it's been around for decades. Due to new technology breakthroughs, **GIS** is no longer your single tool for mapping underground utilities; it's now a whole platform for understanding and optimizing system operations, performance, leak detection, and other maintenance activities.

**GIS** is used in the planning, construction, design, and maintenance aspect of operating and managing utilities. Engineers, surveyors, field crew, technicians, planners, and management personnel all contribute and benefit from the value of a well-implemented **GIS**.

**GIS** gives users the ability to create web-based maps, integrate additional software platforms (**SAP, SCADA, SharePoint**), visualize scenarios & risk potential, solve complicated problems, present powerful ideas, and develop effective solutions quickly and accurately. Utility locators and surveyors are at the front lines of this movement, locating and collecting the data to make Geographic Information Systems achievable.

## Benefits of GIS to Utility Departments & Facility Owners?

- Reduce Operational Costs
- Save Time Relocating Utilities
- Improve Utility Data and Asset Management
- Efficiently Manage New & Aging Infrastructure
- Achieve Maximum Productivity
- Boost Public Relations

**GIS** is important for the utility industry as people must know where their pipes, valves, pumps, meters, and other facilities are located and additional information regarding each asset. It's important to know where valves are located for scenarios such as gas and water main breaks, leak isolations, and excavation operations.

More and more utility departments and private facility owners are turning towards **GIS** to help manage and operate utility systems. **GIS** is becoming a requirement on several local, and federal RFPs, meaning Surveyors and Utility Locators are required to deliver these services and data formats. The good news is that it's not too late to begin learning and offering GIS as a service. At **Centerline Mapping**, we've created **Utility Mapping *Bootcamp*** to teach you.

## Benefits to Utility Locating, Surveying, and Engineering Firms?

- Win Multi-Million \$\$\$ GIS Contracts
- Win Repeat Business with Clients
- Blow Past Your Competitors
- Sharpen Your Business Blade
- Become the 'Go-To' Locating Firm
- Grow Your Business and Client Base

In summary, GIS is an extremely important tool used by asset owners and local gov't to help maintain infrastructure, deliver services, and inform the community.

Ready to learn how to map utilities using **FREE** GIS Mapping Software!?

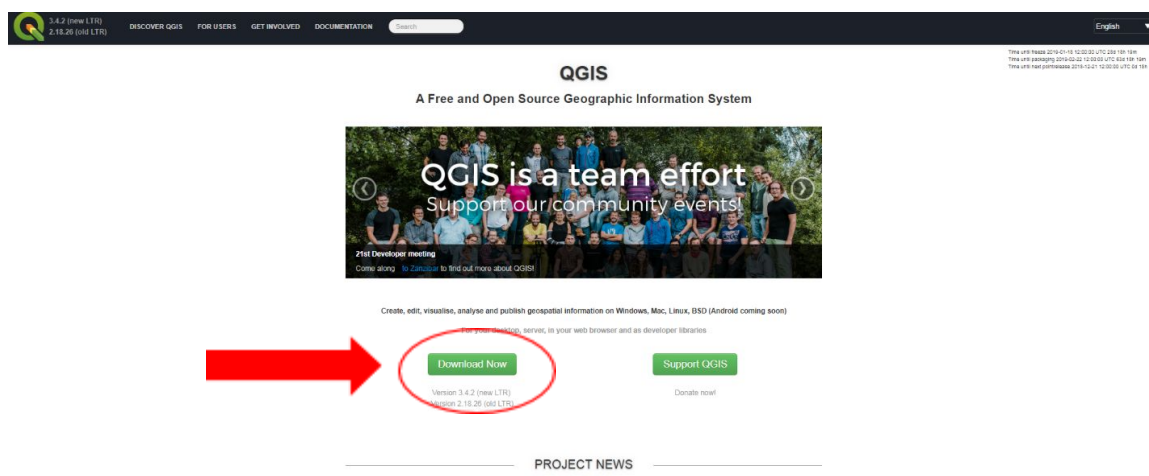
Let's get started!

# 2

## Install Mapping Software

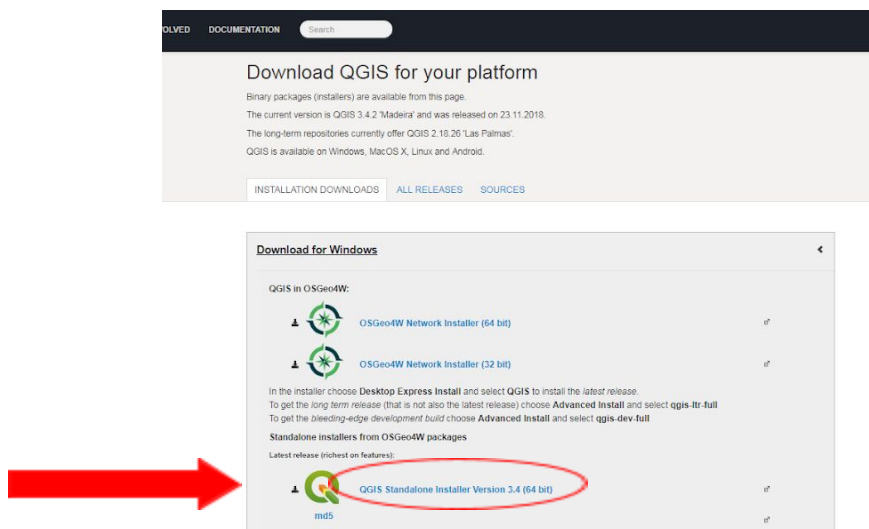
The first step in mapping and managing utility data is installing desktop GIS software. Today, you will install free, open source mapping software, called **QGIS**.

1. Browse to <https://qgis.org/> and click the green **Download Now** button to download a package for your platform (Mac OS, Windows, Linux, Android, etc.).



2. If you have a Windows 64 bit, download the latest package.

### ***QGIS Standalone Installer Version 3.4 (64 bit)***



3. Run the file. Click **Next** > Click **I Agree**. (accept the default destination path). Click **Next** > Click **Install** > Click **Finish**.

4. Open **QGIS**!

5. Click **Project** > click **New**.

**You have successfully installed FREE Open Source GIS mapping software!**

Let's move on to the next lesson and create GIS shapefiles to store spatial and tabular information for utility assets such as pipes, valves, hydrants, storm mains, laterals and attributes like pipe diameter, material, depth, etc.

Follow us to the next lesson below.



# 3

## Create GIS Shapefiles

Take a moment to get familiar with the QGIS graphical user interface. Hover your cursor over some of the buttons to get an idea of their functionality. Don't worry too much about all of those buttons, you will not use 95% of them in this course.

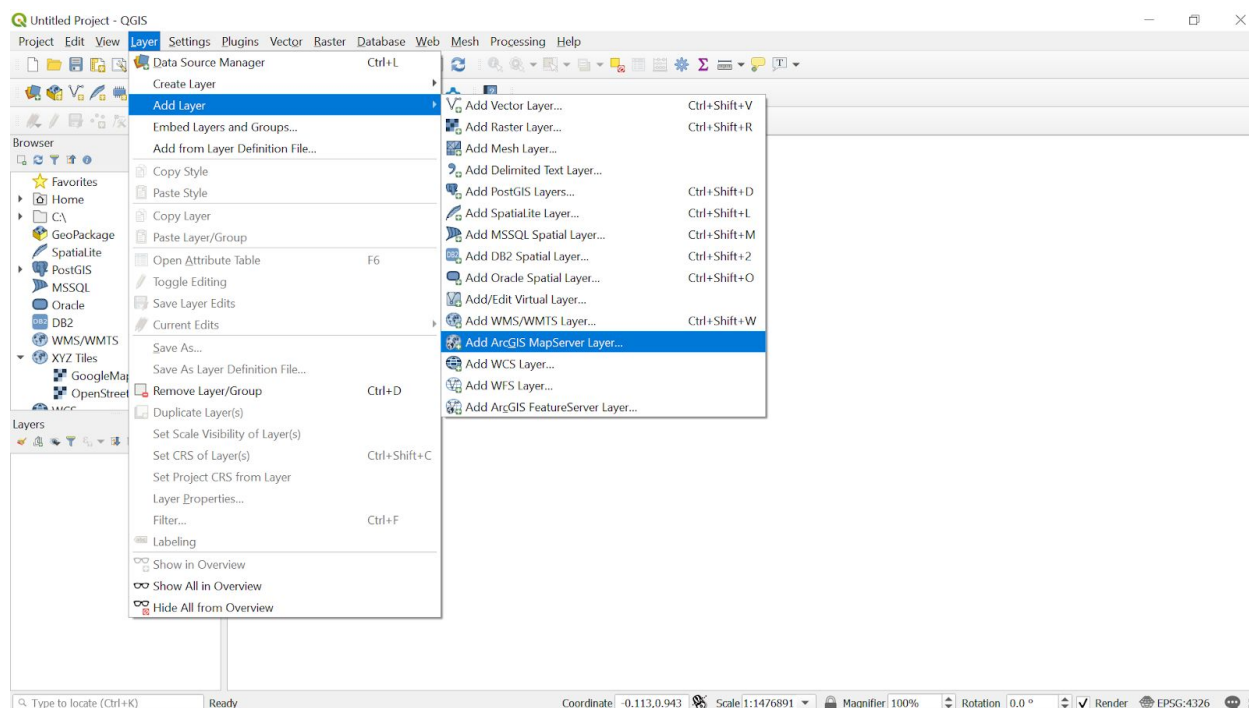
In this lesson, you will learn how to add aerial imagery to a map and create shapefiles to map and store the locations of underground utilities and assets.

For additional documentation on QGIS - [https://docs.qgis.org/3.4/en/docs/training\\_manual/index.html](https://docs.qgis.org/3.4/en/docs/training_manual/index.html)

Before you create shapefiles, add aerial imagery to the map as a basemap.

### Add Aerial Imagery

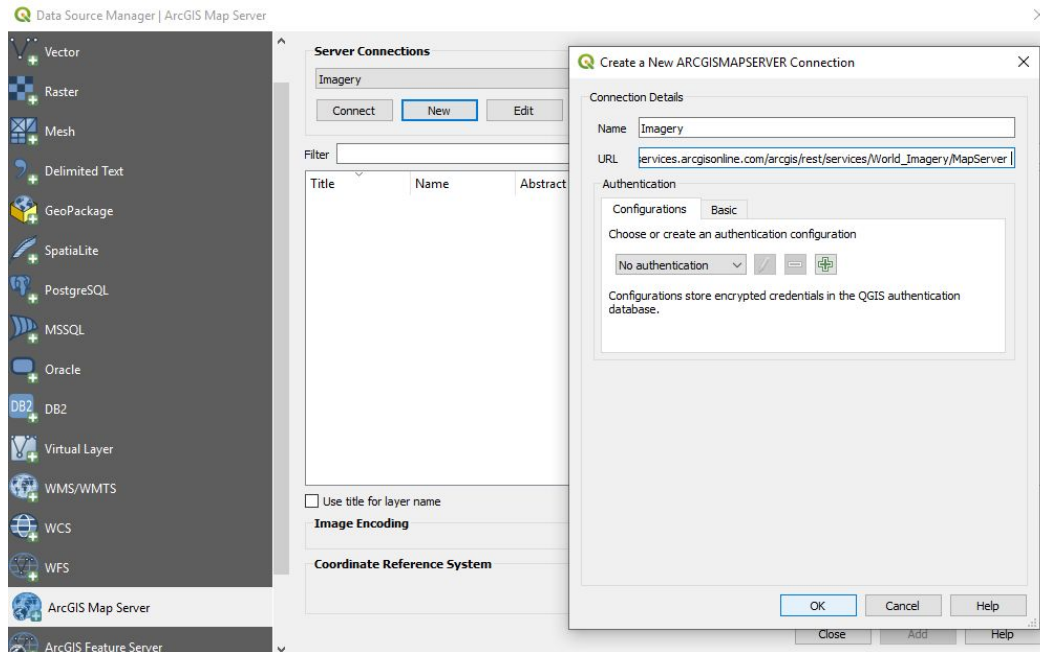
1. On the **Menu Toolbar**, click **Layer > Add Layer > Add ArcGIS MapServer Layer...**



2. Click **New** > Provide a Name and URL in the Connection Details Dialog Box. Use the Name and URL information below.

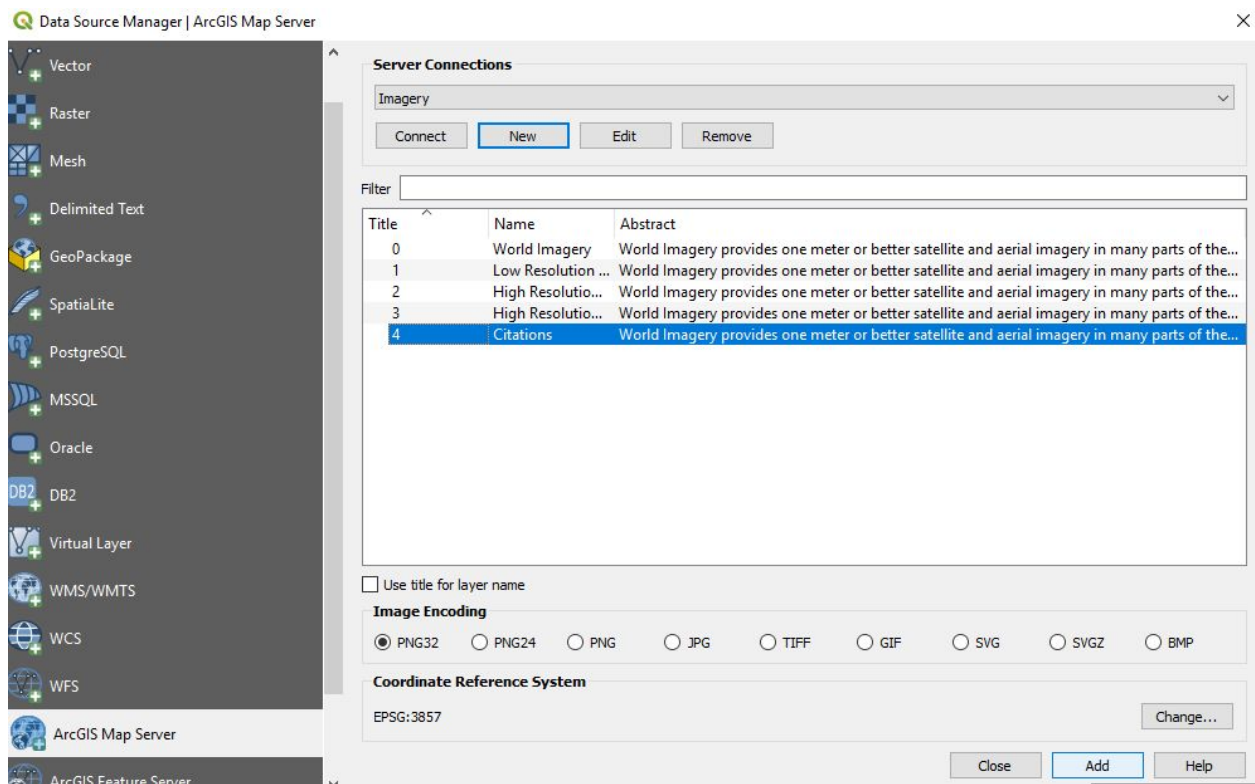
**Name:** Imagery

**URL:** [http://services.arcgisonline.com/arcgis/rest/services/World\\_Imagery/MapServer](http://services.arcgisonline.com/arcgis/rest/services/World_Imagery/MapServer)

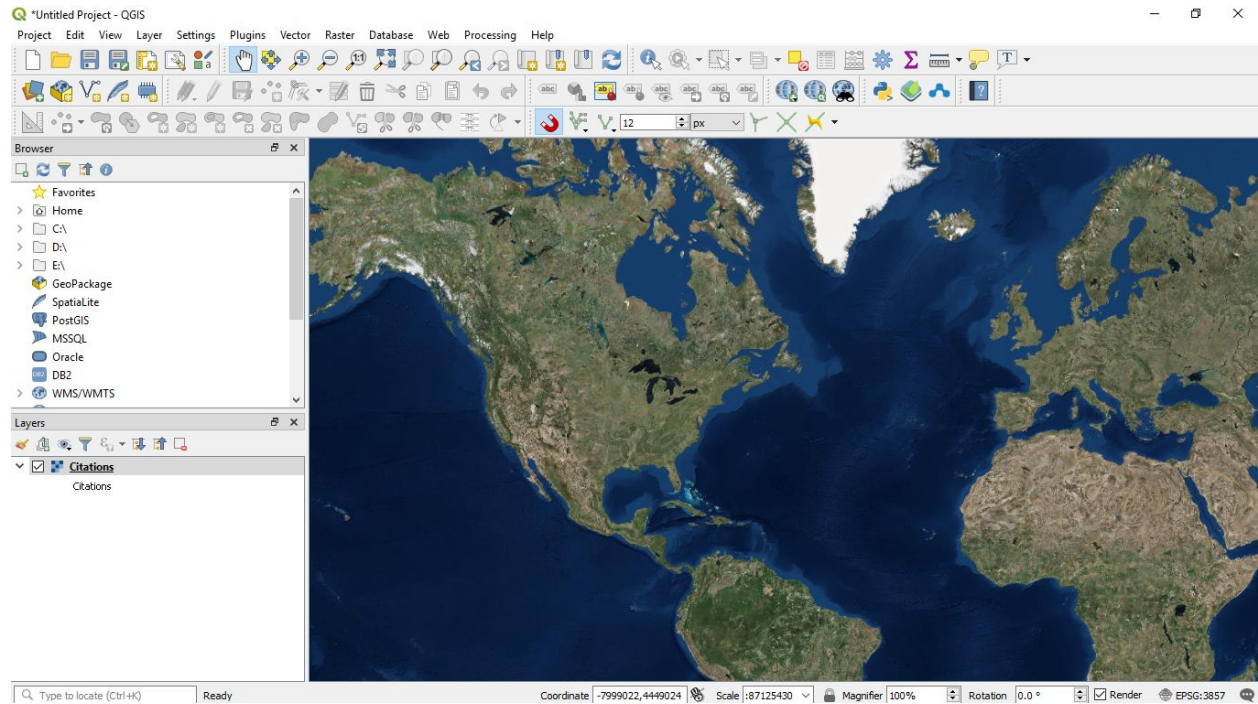


3. Click **OK** > Click **Connect** (internet connection is required for this step).

4. Keep all the defaults and click **Add**. Then click **Close** to close the dialog box.



You should now see aerial imagery in your map.



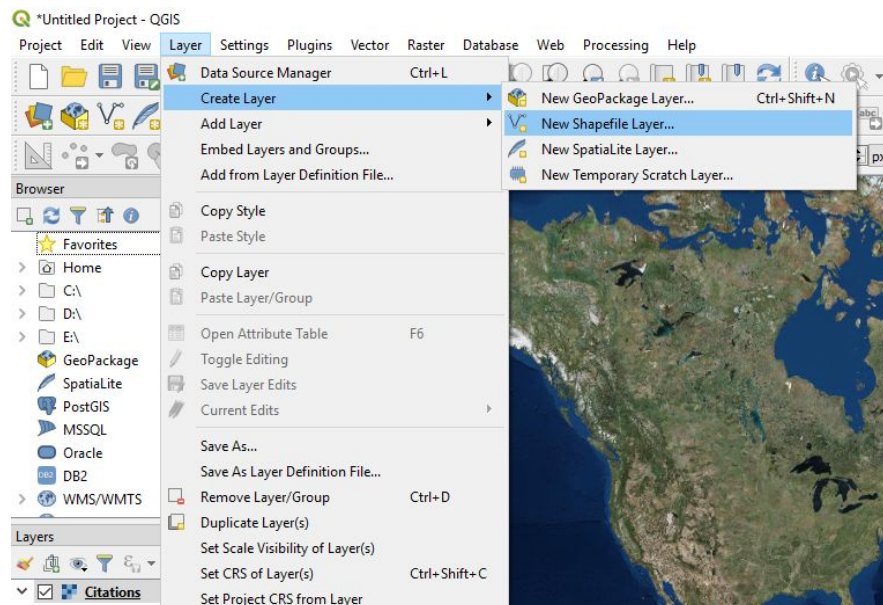
Move your mouse cursor over the map and use the mouse scroll to zoom in and out.

## Create Shapefiles

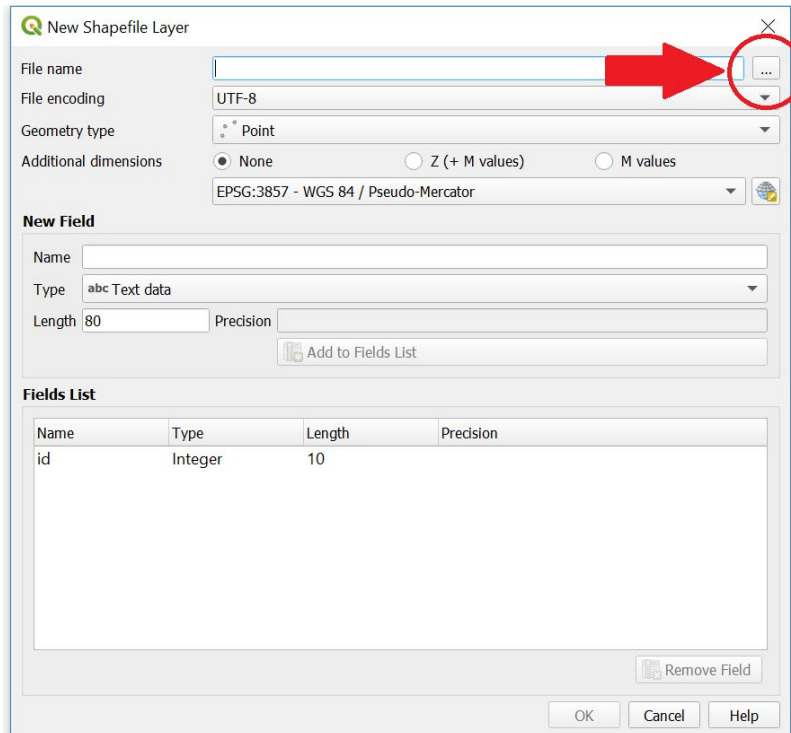
Create 3 shapefiles and 3 attributes for each shapefile, as shown below.

- WaterLine > Diameter, Material, Depth
- WaterValve > Diameter, Manufacturer, ID
- WaterHydrant > Diameter, Manufacturer, ID

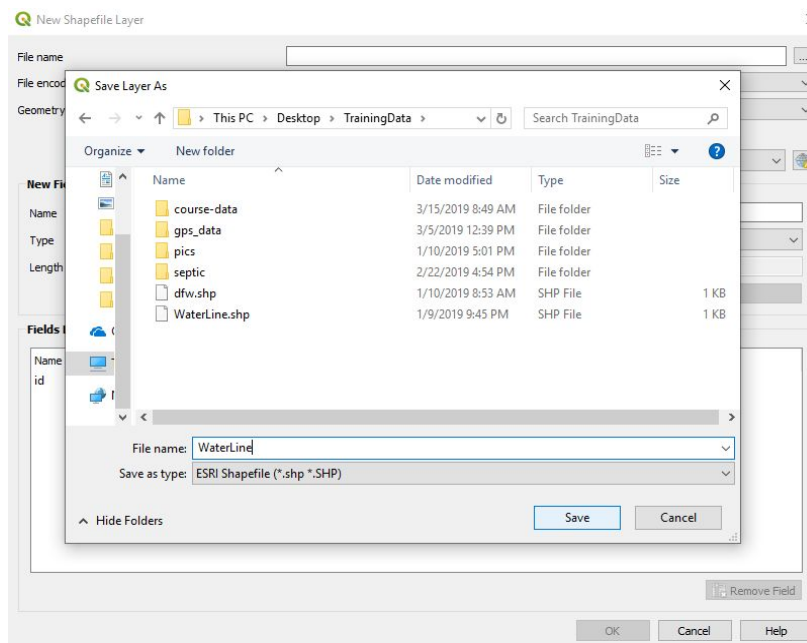
1. On the **Menu Toolbar**, click **Layer > Create Layer > New Shapefile Layer**.



2. In the **New Shapefile Layer** dialog box, for File name, click the small square with 3 dots (top right corner) to choose a location to store the new shapefile.



3. Browse to a location on your machine and enter **WaterLine** for File name. Click **Save**.



4. Next, within the **New Shapefile Layer** dialog box, for **Geometry Type** choose **Line**.

**New Shapefile Layer**

File name: WaterLine

File encoding: UTF-8

Geometry type: Line

☐ Include Z dimension ☐ Include M values

EPSG:3857 - WGS 84 / Pseudo-Mercator

**New Field**

Name:

Type: abc Text data

Length: 10 Precision:

Add to Fields List

**Fields List**

Name	Type	Length	Precision
id	Integer	10	
Diameter	String	10	
Material	String	10	
Depth	String	10	

Remove Field

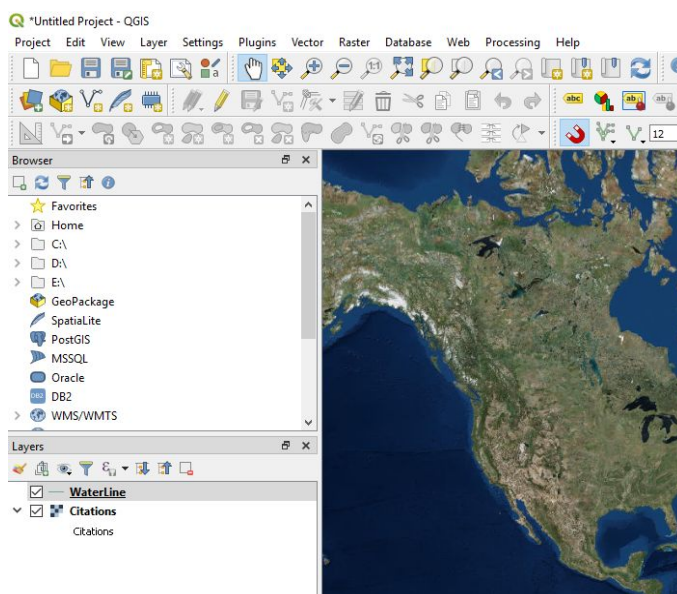
OK Cancel Help

5. In **New Field** section, enter **Diameter** for Name. Change Length to 10. Click **Add to Fields List**.

6. In **New Field** section, enter **Material** for Name. Change Length to 10. Click **Add to Fields List**.

7. In **New Field** section, enter **Depth** for Name. Change Length to 10. Click **Add to Fields List**.

8. Click **Ok**. You should see the layer added to the **Layers** dialog box to the left.



9. Follow the same steps above to create a **WaterValve** and **WaterHydrant** shapefile. Make sure to use **Point** for the **Geometry Type** for these 2 shapefiles.

10. To create a **WaterValve** shapefile - On the **Menu Toolbar**, click **Layer > Create Layer > New Shapefile Layer**

11. In the **Dialog Box**, enter **WaterValve** for **File name**. For **Geometry Type** choose **Point**. (Make sure to save this shapefile in the same location as the others.)

12. In **New Field** section, enter Diameter for Name. Change Length to 10. Click **Add to Fields List**.

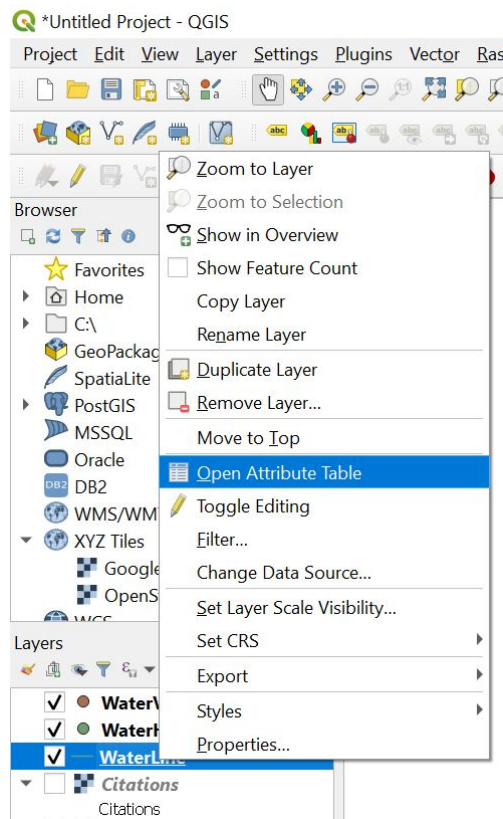
13. In **New Field** section, enter Manufacturer for Name. Change Length to 10. Click **Add to Fields List**.

14. In **New Field** section, enter Type for Name. Change Length to 10. Click **Add to Fields List**.

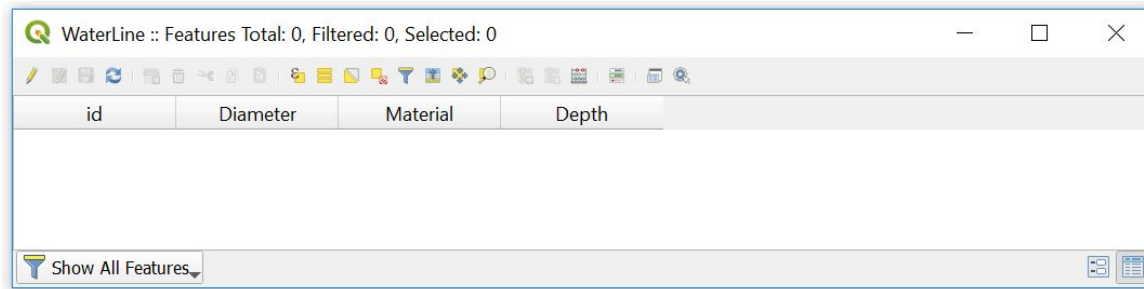
15. Click **Ok**. You should see the layer added to the Layer dialog box to the left.

16. Repeat this process for as many utilities you need to map (i.e. telecommunication, gas, stormwater, electrical, sprinkler, hydraulic, steam, condensate).

17. To view a map layer's attribute table, right click the map layer in the **Layers** dialog box to the left > click **Open Attribute Table**.

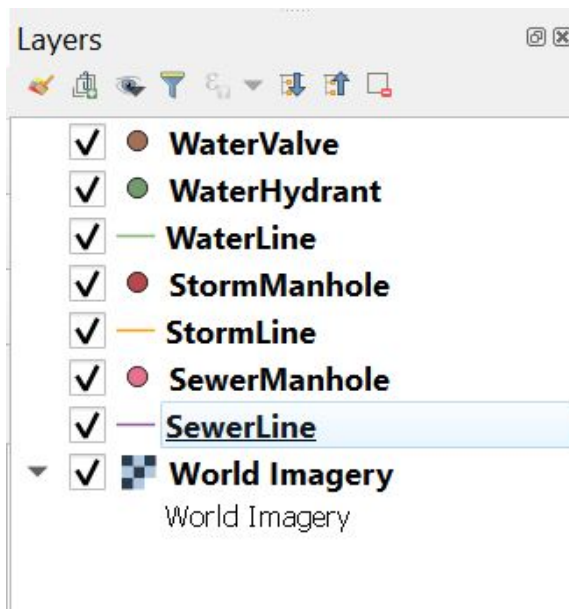


Notice there are no rows in the attribute table as you have not mapped and added attributes for any **WaterLines** yet.



### Reorder Map Layers in the Layers Dialog Box

To reorder map layers in the **Layers Dialog** box, you can simply left mouse click, hold, and drag the map layer above or below another map layer. The map layers are displayed in the map in the same order as they are displayed in the Layers Dialog box. If the aerial imagery map layer is above the shapefiles, you will not see your data as the aerial imagery will be on top of it. It's also a best practice to put your pipe map layers (line layers) below the valves, hydrants, fittings, manholes, etc (point layers). Notice for each utility system (Water, Stormwater, Sewer), the **Line** map layers are below the **Point** map layers. Also notice the World Imagery is below all other map layers, being used as a basemap.



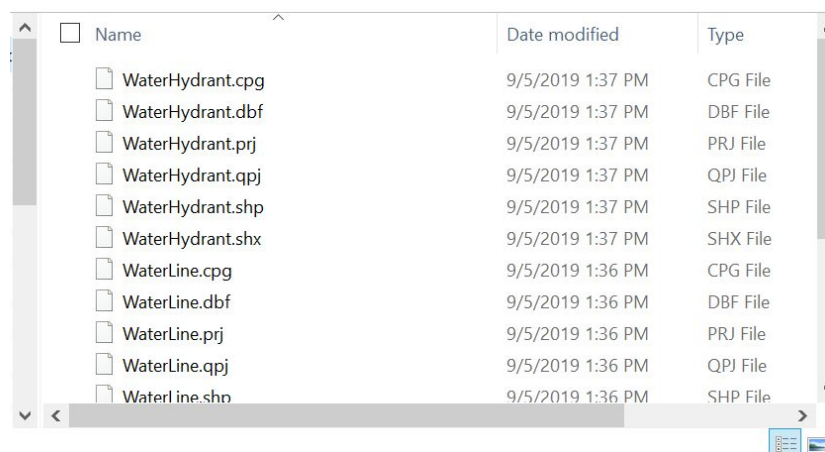
### Save Your Map

On the **Menu Toolbar** > click **Project** > **Save As**

This saves a QGIS Map file (qgz) to the location you choose. To open your map, simply double click the file where you saved it, and it will open your map with all of your last saved changes.

## View Shapefiles in Windows Explorer (on windows)

On your machine, browse to the location where you stored the shapefiles to view the shapefiles you created. Notice that a **WaterHydrant** shapefile consists of 6 individual files (cpg, dbf, prj, qpj, shp, shx). These all need to be stored and copied together if you move or rename them. When adding a shapefile to QGIS, you only need to select and add the **shp** file.



**Lesson Assignment:** Create 4 additional map layers and attributes for each.

- SewerLine > Diameter, Material, Depth
- SewerManhole > ID, Material, InvertElev
- StormLine > Diameter, Material, Depth
- StormManhole > ID, Material, InvertElev

*Note: for the purpose of time, we've included shapefiles in the course training data.*

In this lesson, you created shapefiles to map various utility systems and assets. In GIS, each utility system (Stormwater, Sewer, Water) consists of several different shapefiles. For example, a Water system consists of a shapefile for pipes, a shapefile for valves, a shapefile for hydrants, a shapefile for meters, etc. Each shapefile has a set of attributes in order to store information about each asset and create dynamic map labels. You might store different attributes and information about a water valve than a water meter or water hydrant. Attributes serve several purposes (symbolizing, labeling, utility networks, joins, relates) and are a beauty of GIS.

In the next lesson, you will learn how to symbolize shapefiles and add a cartographic touch to your maps and data.

# 4

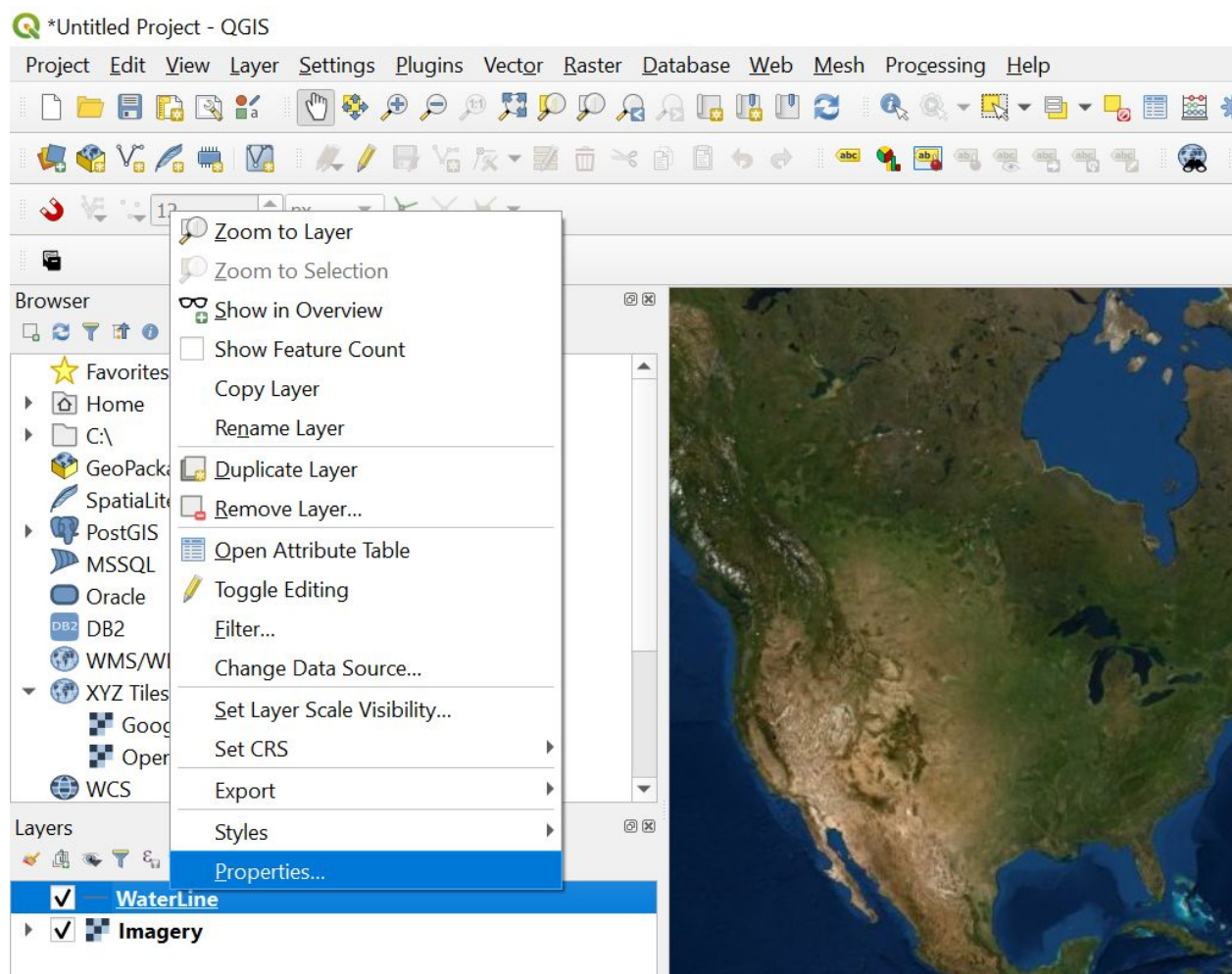
## Symbolize GIS Data

In this lesson, you will learn how to symbolize each map layer created in the previous lesson.

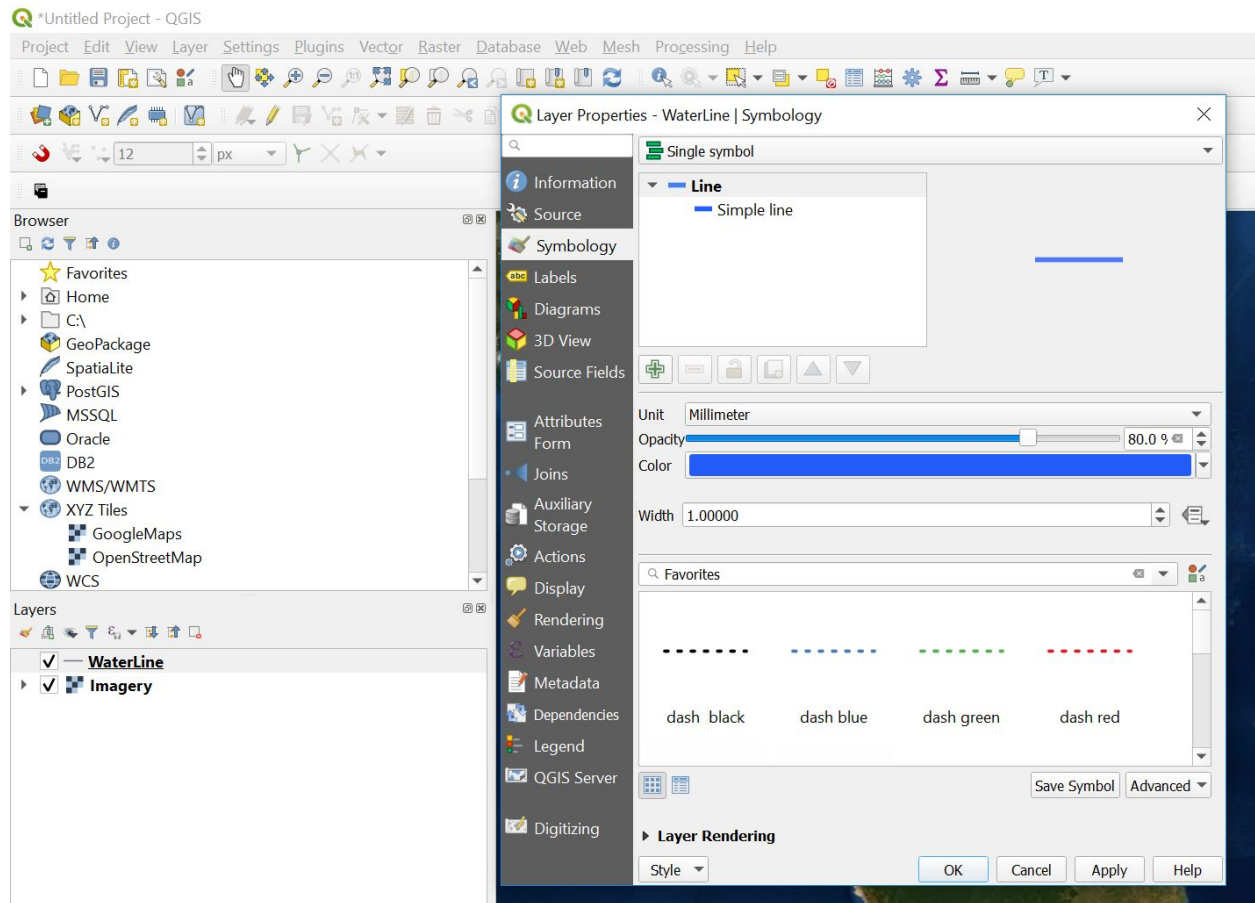
### Symbolize Shapefiles

First, symbolize the **WaterLine** map layer.

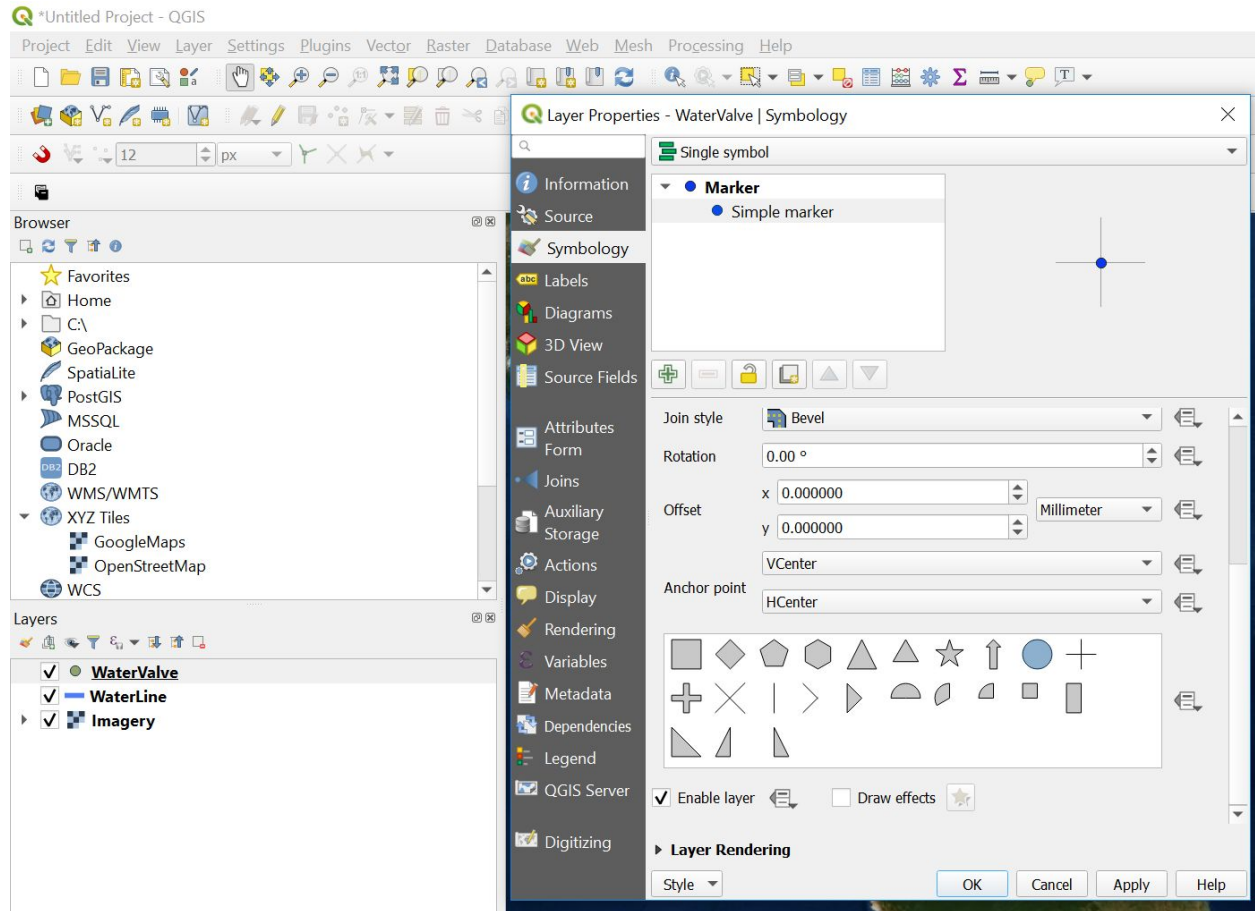
1. Right click the **WaterLine** map layer to the left under **Layers** and click **Properties**.



2. To the left, under **Symbology**, change the **Opacity** to 80.0%, then change the **Color** to Blue, then change the **Width** to 1.0, Click **Ok**.



3. Next, symbolize the **WaterValve** map layer. Symbolize valves with a blue circle.
4. Right click the **WaterValve** map layer to the left under **Layers** and click **Properties**.
5. Click **Simple Marker** > Scroll down until you see a dialog of shapes. Click the **Circle** icon.
6. Adjust the **Offset x** to 0 and **y** to 0. Scroll up and change the **Fill color** to blue.



**Lesson Assignment:** *Symbolize the shapefiles you created in the previous lesson.*

- *Sewer Lines > Change the Color to Green.*
- *Sewer Manhole> Change the Shape to a Circle and Color with a Green Fill and Black outline.*
- *Storm Lines > Change the Color to Brown.*
- *Storm Manhole > Change the Shape to a Circle and Color with a Brown Fill and Black outline.*

*Feel free to change the color and symbology to meet your needs and preferences.*

In this lesson, you symbolized map layers to distinguish various utility systems and features.

In the next lesson, you will learn how to import and add GPS data to the map. GPS data can be imported in the form of various types of vector file formats.

# 5

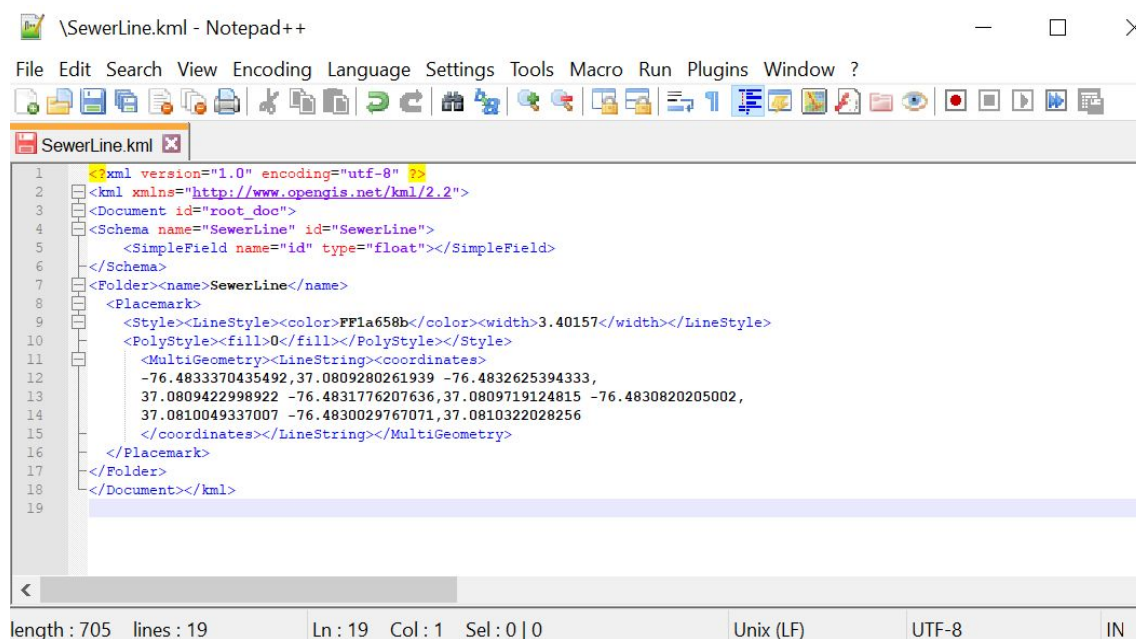
## Add GPS Field Data to Map

In this lesson, you will learn how to quickly import GPS/GPR field data to a QGIS map. KML is a standard file format exported from RD8100 and GPR utility locating equipment. Utility data comes in various file formats including: DWG, DXF, XML, KML, CSV, & GPX. The good news is QGIS supports over +100 different vector and raster file formats and importing data is usually a piece of cake.

### Sample Data

1. To get started, browse and view the sample data contained in the training package you received and downloaded. ([Utility\\_Mapping\\_Bootcamp.zip](#))
2. The **Course\_Data** folder includes sample GPS data (KML and shapefiles) and public data from the city of Naperville, IL.

Below is an example of KML data in a code editor (Notepad++). KML is an XML format for storing and displaying geographic information within internet applications and 2D/3D maps. When you create a KML file in QGIS, the software is writing this file behind the scenes. You can edit the file manually to modify the contents then save it, though it is usually easier to let QGIS do that for you.



```

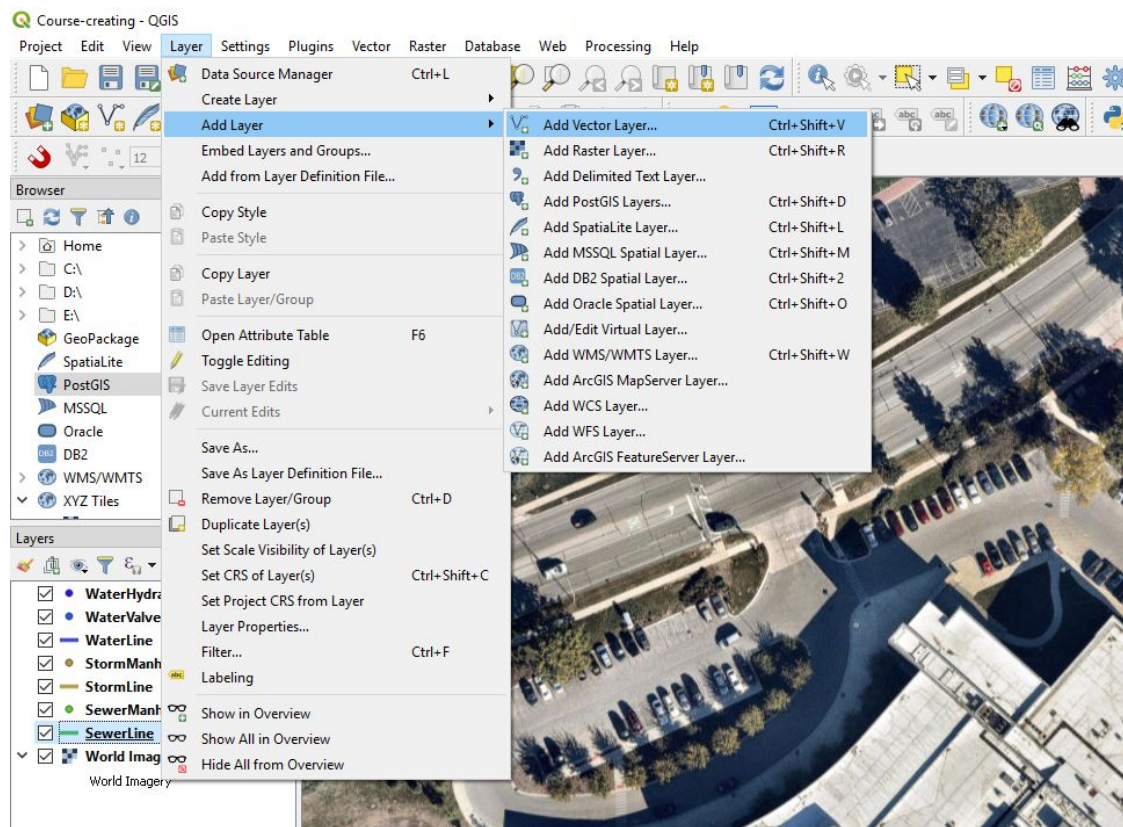
1  <?xml version="1.0" encoding="utf-8" ?>
2  <kml xmlns="http://www.opengis.net/kml/2.2">
3  <Document id="root_doc">
4  <Schema name="SewerLine" id="SewerLine">
5    <SimpleField name="id" type="float"/></SimpleField>
6  </Schema>
7  <Folder><name>SewerLine</name>
8    <Placemark>
9      <Style><LineStyle><color>FF1a658b</color><width>3.40157</width></LineStyle>
10     <PolyStyle><fill>0</fill></PolyStyle></Style>
11     <MultiGeometry><LineString><coordinates>
12       -76.4833370435492,37.0809280261939 -76.4832625394333,
13       37.0809422998922 -76.4831776207636,37.0809719124815 -76.4830820205002,
14       37.0810049337007 -76.4830029767071,37.0810322028256
15     </coordinates></LineString></MultiGeometry>
16   </Placemark>
17 </Folder>
18 </Document></kml>
19
length: 705 lines: 19 Ln: 19 Col: 1 Sel: 0 | 0 Unix (LF) UTF-8 IN
  
```

## Import Data

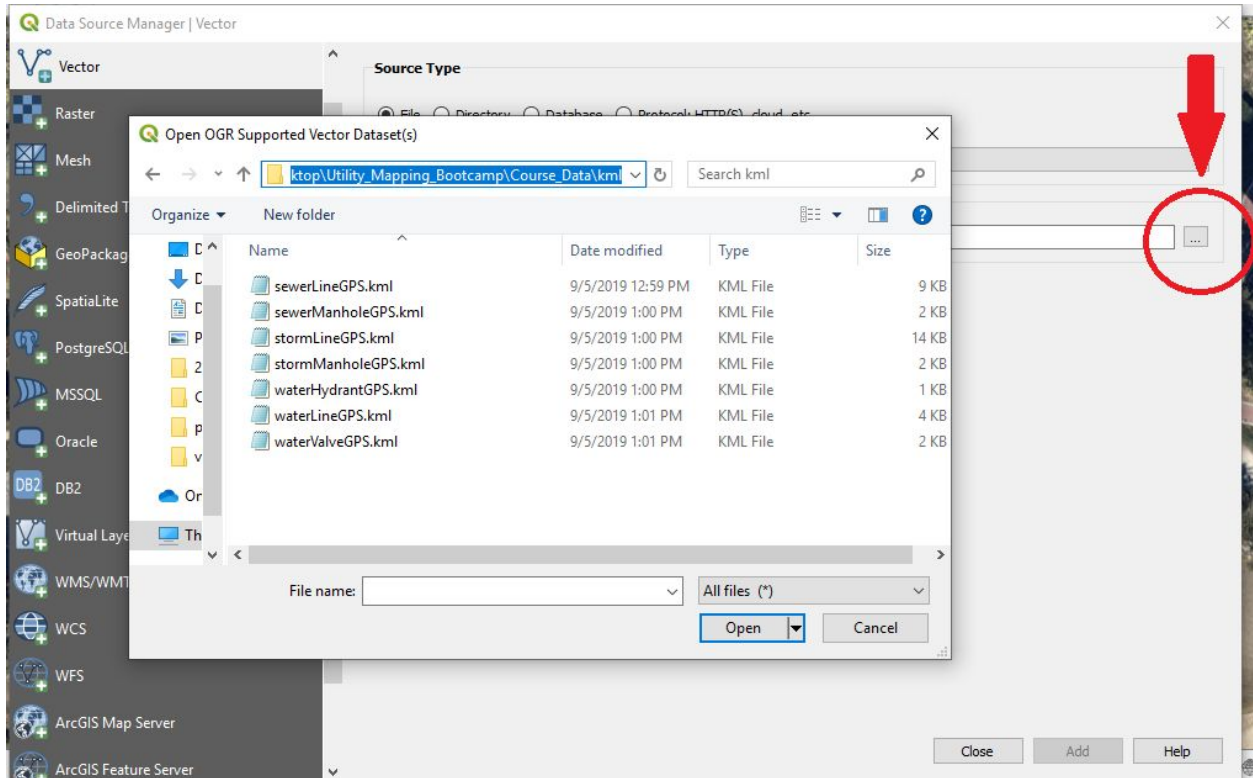
Import the following KML files to your map. (Utility\_Mapping\_Bootcamp\Course\_Data\kml).

- sewerLineGPS.kml
- sewerManholeGPS.kml
- stormLineGPS.kml
- stormManholeGPS.kml
- waterLineGPS.kml
- waterValveGPS.kml
- waterHydrantGPS.kml

1. To add KML files to the map - On the **Menu Toolbar**, click **Layer > Add Layer > Add Vector Layer**.



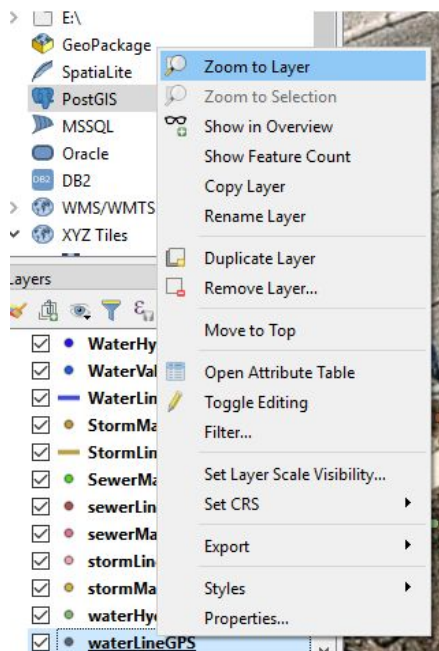
2. Choose **File** for **Source Type** > For **Source**, click the small square with three dots > Browse for the location where you saved the course training data.



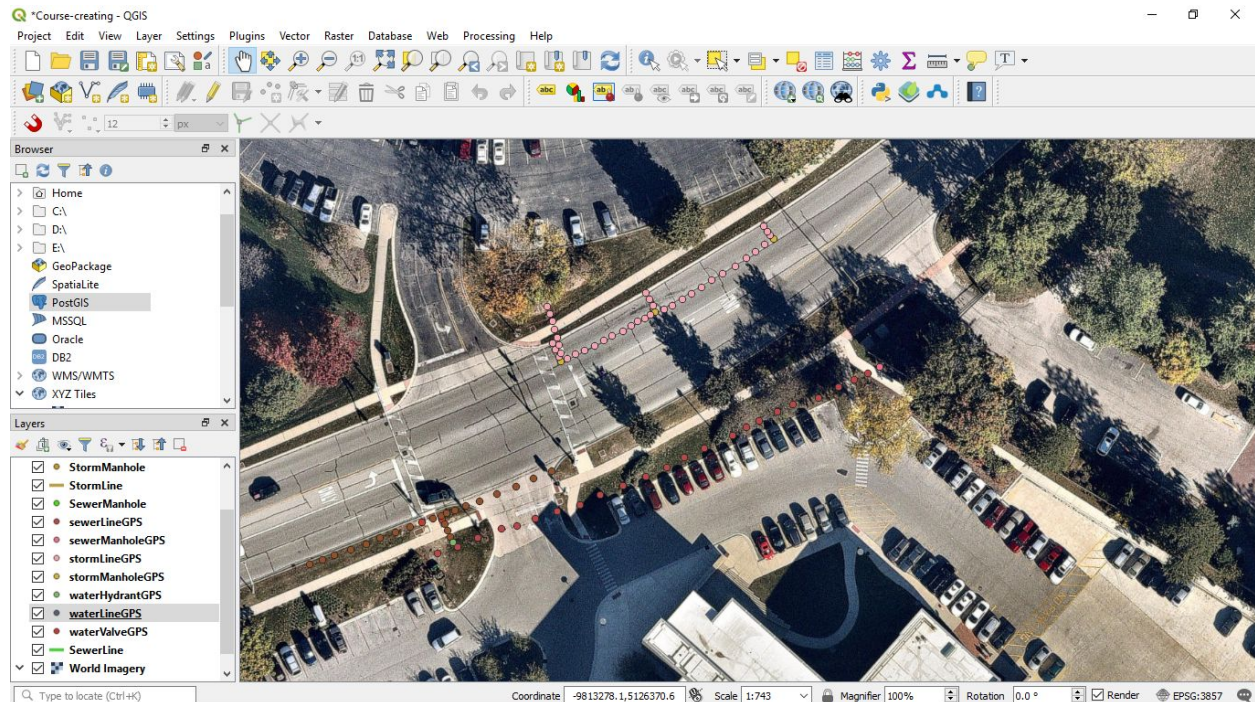
3. To select and add all the KML files to the map at once, select the top KML file (sewerLineGPS.kml), hold down the **Shift** key on the keyboard, and click on the bottom file (waterValveGPS.kml). After all KML files are selected, click **Open** > click **Add** > click **Close**.

You should see the layers added to the **Layer** dialog box to the left.

4. **Right Click** one of the kml map layers you just added, **waterLinesGPS**, and click **Zoom To Layer**. This zooms the map to the extent of that layer.

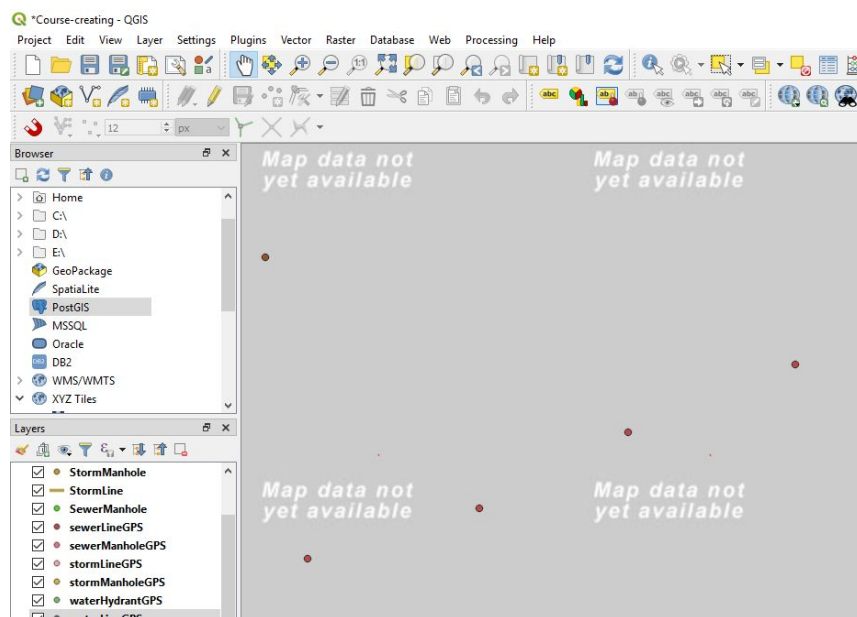


You should now see aerial imagery and GPS data in your map (small point features). This GPS data represents the location of underground storm lines, water lines, and sewer lines. Also captured are the location of manholes, water valves, and a hydrant.



If you do not see GPS data you may want to make sure the imagery map layer is below the GPS layers in the **Layers** box.

If you are not seeing aerial imagery after you zoom to the extent of the waterLineGPS kml file, it may be that you are zoomed in too far. The aerial imagery will not show if you are zoomed in beyond a certain point. You will see *"Map data not yet available"*.



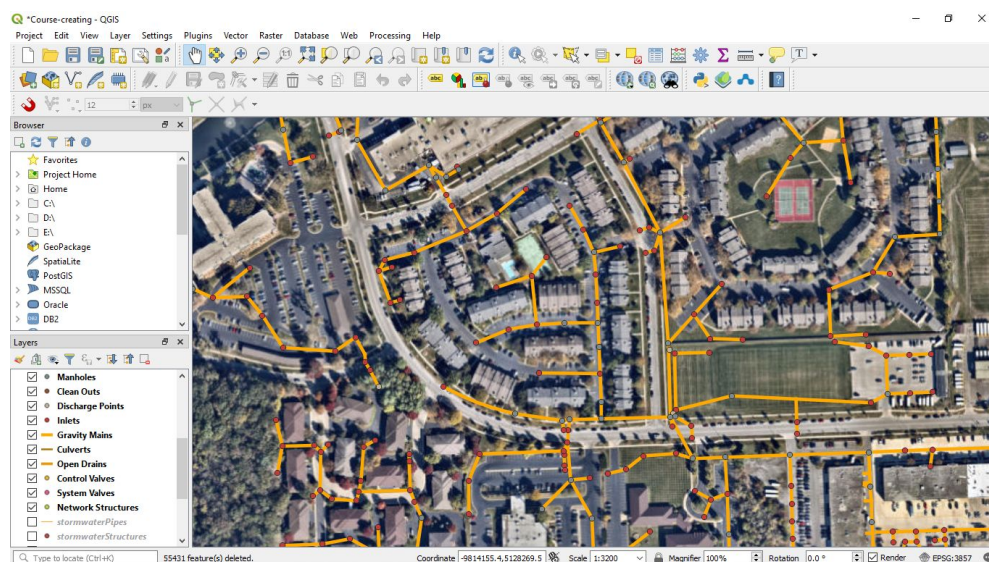
**Lesson Assignment:** Import open public data from the City of Naperville, IL.

You can find data in this location (*Utility\_Mapping\_Bootcamp\Course\_Data\Naperville\_data*).

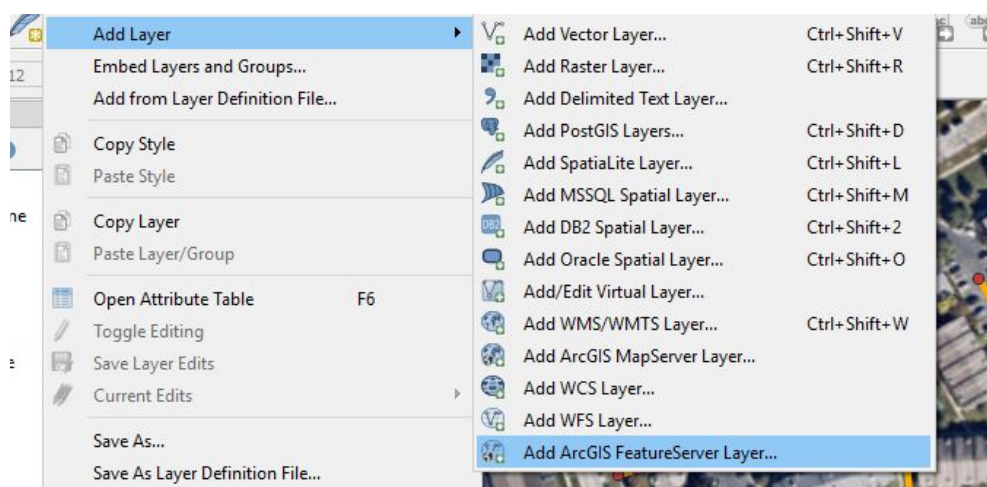
Add an ArcGIS Feature Server to the map.

[https://services.arcgis.com/ue9rwulloeLEI9bj/arcgis/rest/services/Stormwater\\_Network\\_FIDA/FeatureServer](https://services.arcgis.com/ue9rwulloeLEI9bj/arcgis/rest/services/Stormwater_Network_FIDA/FeatureServer)

This Feature Server consists of a Stormwater Network of Naperville, IL. After adding all of the map layers, you can select them in the **Layers** dialog box, right click, and select **Group Selected**.



*Hint: Add this the same way you added the aerial imagery to the map. Instead of choosing MapServer, choose FeatureServer.*



In this lesson you learned how to import and add GPS field data to QGIS.

In the next lesson, you will learn how to digitize utilities and add data to your empty GIS shapefiles. You will add geometry (spatial information) and attributes (tabular information).

# 6

## Digitize and Map Utilities

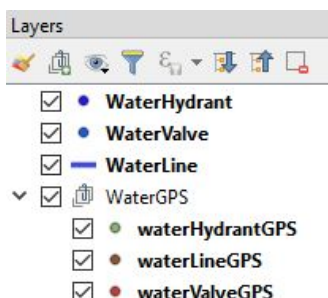
In this lesson, you will learn how to digitize and convert raw utility GPS data (KML files) to quality GIS data deliverables (shapefiles).

You will edit the GIS shapefiles and add data to the GIS shapefiles by manually tracing the GPS data collected in the field and exported from RD8100 locator equipment. You will use the KML data as a reference to map and digitize utility data. You can then add attributes to the pipe features, such as Diameter = 12in, Material = Ductile Iron, Depth = 2ft. Attributes will be used for labels and symbology in later sections.

Map the **Water** system first using the course sample data.

You will edit the **WaterLine**, **WaterValve**, and **WaterHydrant** shapefiles you created earlier by tracing the **waterLineGPS**, **waterValveGPS**, and **waterHydrantGPS** kml layers.

1. In the **Layers** dialog box to the left, uncheck all of the map layers except the water layers (**waterValveGPS**, **waterLineGPS**, **waterHydrantGPS**, **WaterLine**, **WaterValve**, **WaterHydrant**) and group the Water GPS kml layers. Name the group WaterGPS.



2. Right click the **WaterLine** layer, click **Toggle Editing**.

3. Right click the **WaterValve** layer, click **Toggle Editing**.

4. Right click the **WaterHydrant** layer, click **Toggle Editing**.

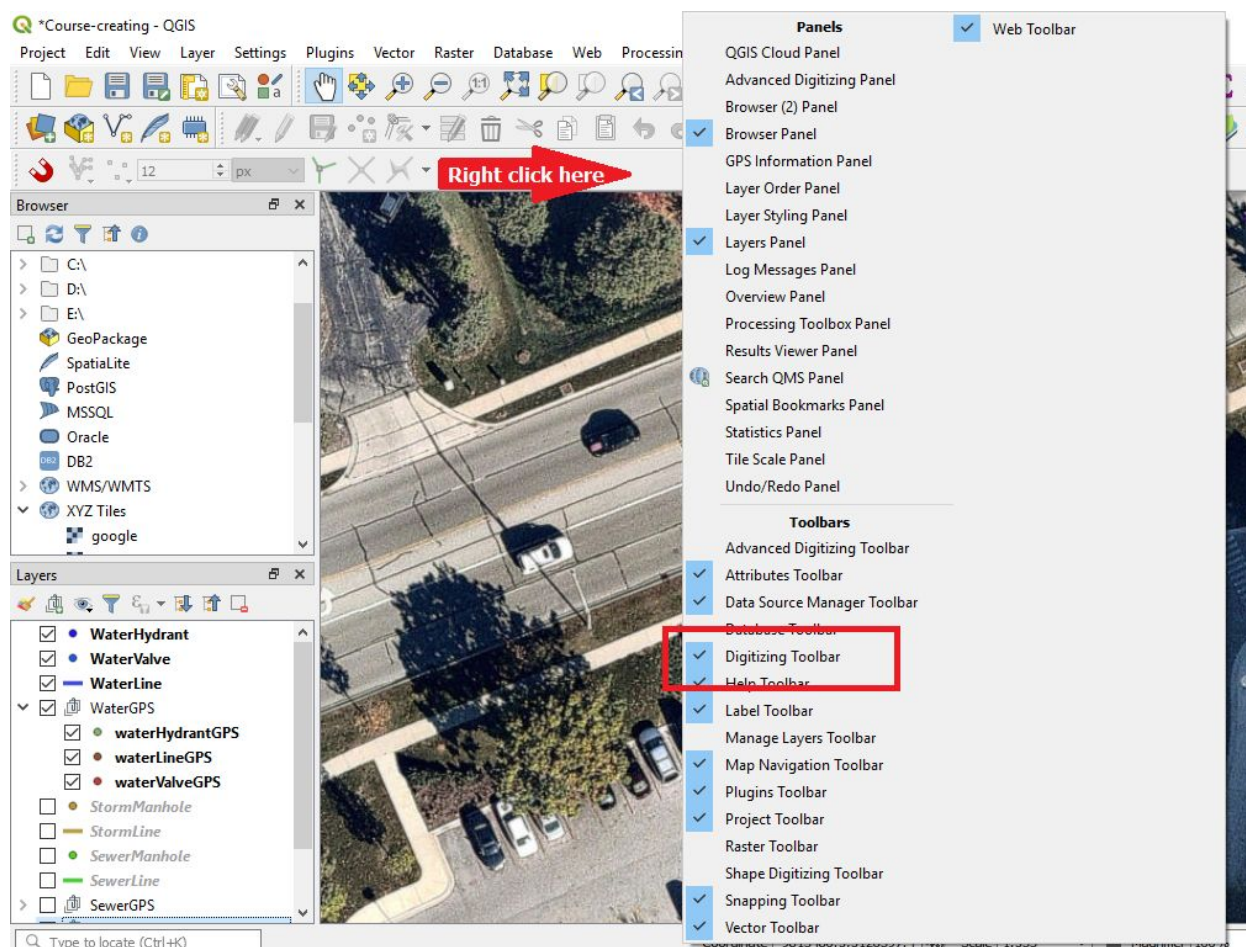
This allows you to edit the map layers. Think of those two layers as being in “editor mode.” If you incorrectly edit or delete data, you can choose not to save the edits and start over.

5. In the **Layers** box to the left, select the **WaterValve** layer (left click so that it is highlighted). The layer that is selected in the **Layers** box is the layer that you will be editing. Although all 3 map layers are in “editor mode”, you need to select a layer in the **Layers** box to add, edit, or remove features.

6. In the **Digitizing Toolbar**, look for the **Add Point Feature** button.



*Note: In order to open the **Digitizing Toolbar**, right click in the gray area above your map, and choose **Digitizing Toolbar** from the list of toolbars. This should show the **Digitizing Toolbar** and related tools.*



7. Click the **Add Point Feature** button on the **Digitizing Toolbar**, then left click on the map where you want to add a Valve feature. Add a valve where you see a valve in the **waterValveGPS** map layer.

8. After you add the valve, enter the following attributes in the dialog box that appears.

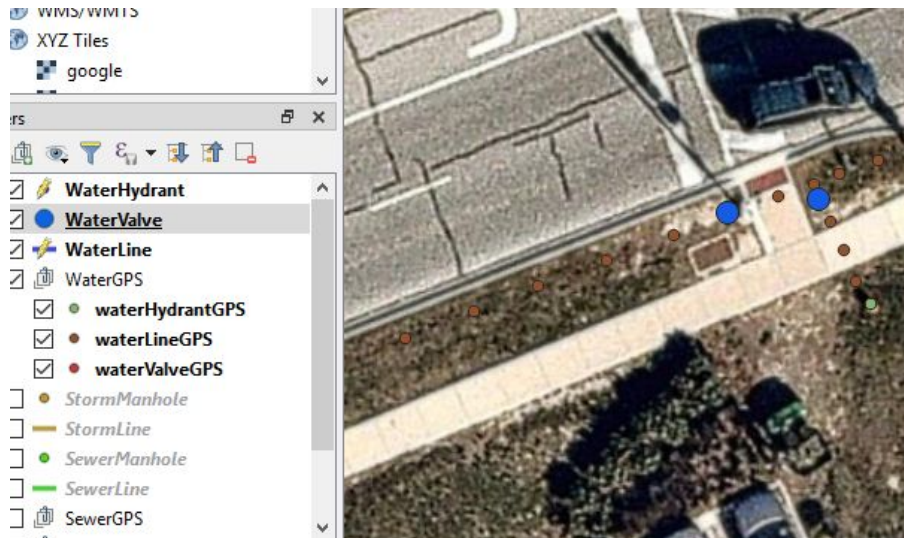
**Diameter** = 2 **Manufacturer** = Apollo **ID** = 1A

9. Add a total of 2 valves for each of the valves located in the **waterValveGPS** layer.

Use this attribute information for the 2nd valve. **Diameter** = 2 **Manufacturer** = Apollo **ID** = 1A

10. After adding the 2 valves, right click the **WaterValve** layer in the **Layers** box to the left, click **Toggle Editing** > click **Save**.

You should see 2 blue circles in the map and 2 rows in the **WaterValve** attribute table with the attributes you entered.



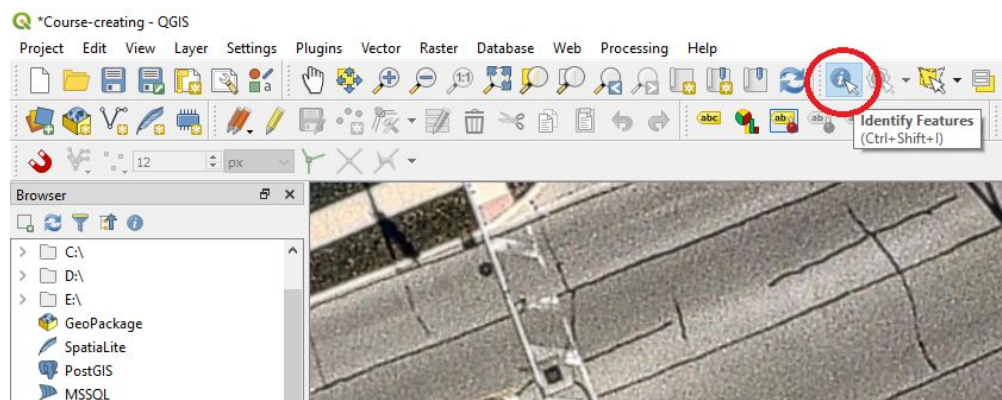
Right click the **WaterValve** layer > click **Open Attribute Table** to view the attributes.

WaterValve :: Features Total: 2, Filtered: 2, Selected...

	id	Diameter	Manufactur	ID_1
1		2	Apollo	1A
2		2	Apollo	1B

Show All Features

Another way to view attributes for features in the map is to use the **Identify Features** tool. Click the **Identify Features** button in the **Menu Toolbar** and then click on a valve in the map. The **Identify Features** tool is a tool on the **Attributes Toolbar**. If you don't see this toolbar, follow the same steps to show this toolbar that you did to show the **Digitizing Toolbar**.



Next, let's map the water lines using the **WaterLine** layer.

11. In the Layers box to the left, select the **WaterLine** layer (left click so that it is highlighted).

12. In the **Digitizing Toolbar**, look for the **Add Line Feature** button.



*In order to open the **Digitizing Toolbar** right click in the gray area above your map, and choose **Digitizing Toolbar**. This should show the **Digitizing Toolbar** and related tools.*

Before you trace the water lines, make sure to enable snapping. Snapping is an editing and digitizing feature that “snaps” your mouse cursor to points, line end-points, and line vertices when digitizing to make it easier to add a point to the exact same location as another point (i.e. a valve, fitting, or hydrant to the end of a pipe). This feature helps enforce data topology rules, network connectivity, and quality data. More information on utility networks in another course.

*In order to open the **Snapping Toolbar** right click in the gray area above your map, and choose **Snapping Toolbar**. This should show the **Snapping Toolbar** and related tools.*

13. Click the **Enable Snapping** button on the **Snapping Toolbar**.



14. Click the **Add Line Feature** button on the **Digitizing Toolbar** to begin digitizing the first pipe segment.

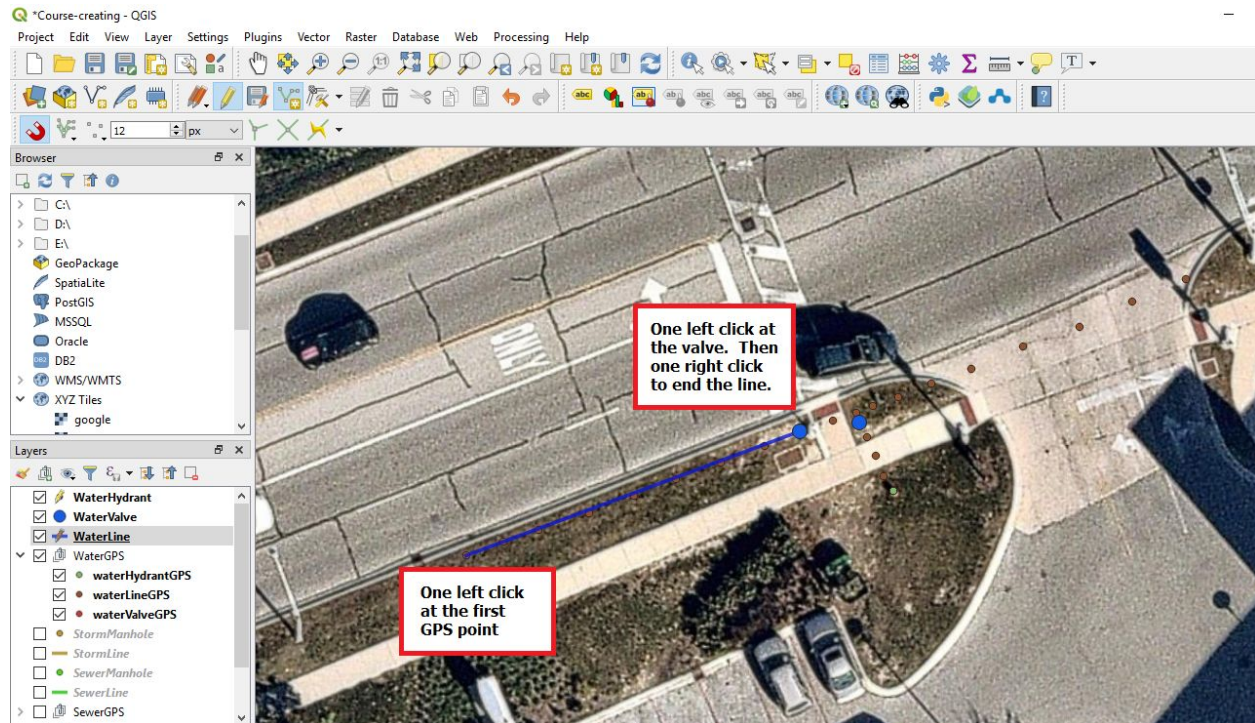


15. Left click at the end of a located line, where the locator stopped locating the water pipe, likely at the edge of the survey project boundary. You are going to digitize a line from the end of the water line at the edge of the survey project boundary to the first valve.

16. Left click again at the nearest Valve or Tee, ensuring to roughly connect the points shown in the **waterLineGPS** layer. If snapping is enabled correctly, your cursor should “snap” to a valve.

17. Right click to end the tracing of a pipe and then enter the following attributes in the dialog box that appears for that particular pipe segment. Enter this attribute information for all pipes.

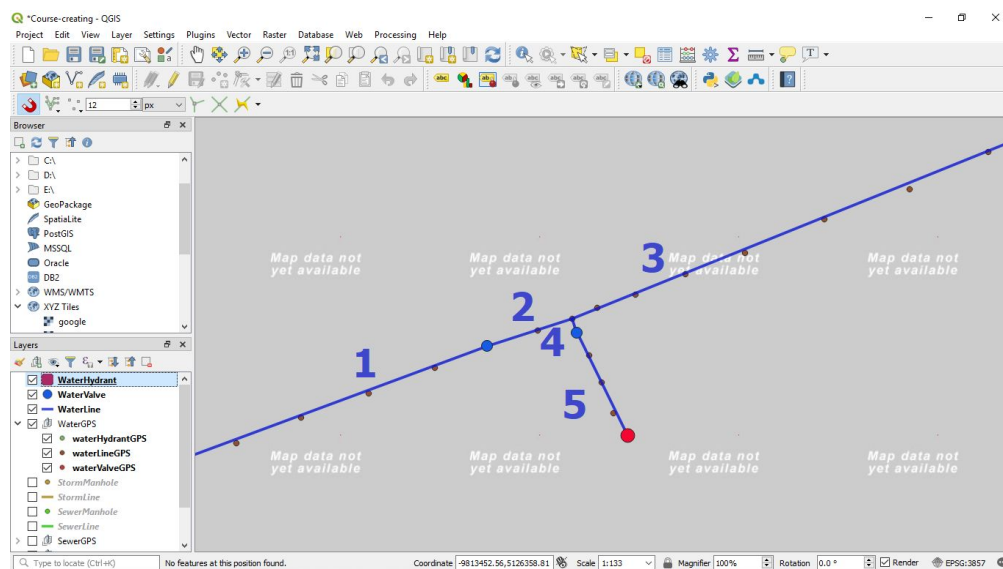
**Diameter = 2 Material = HDPE Depth = 3 (ft)**

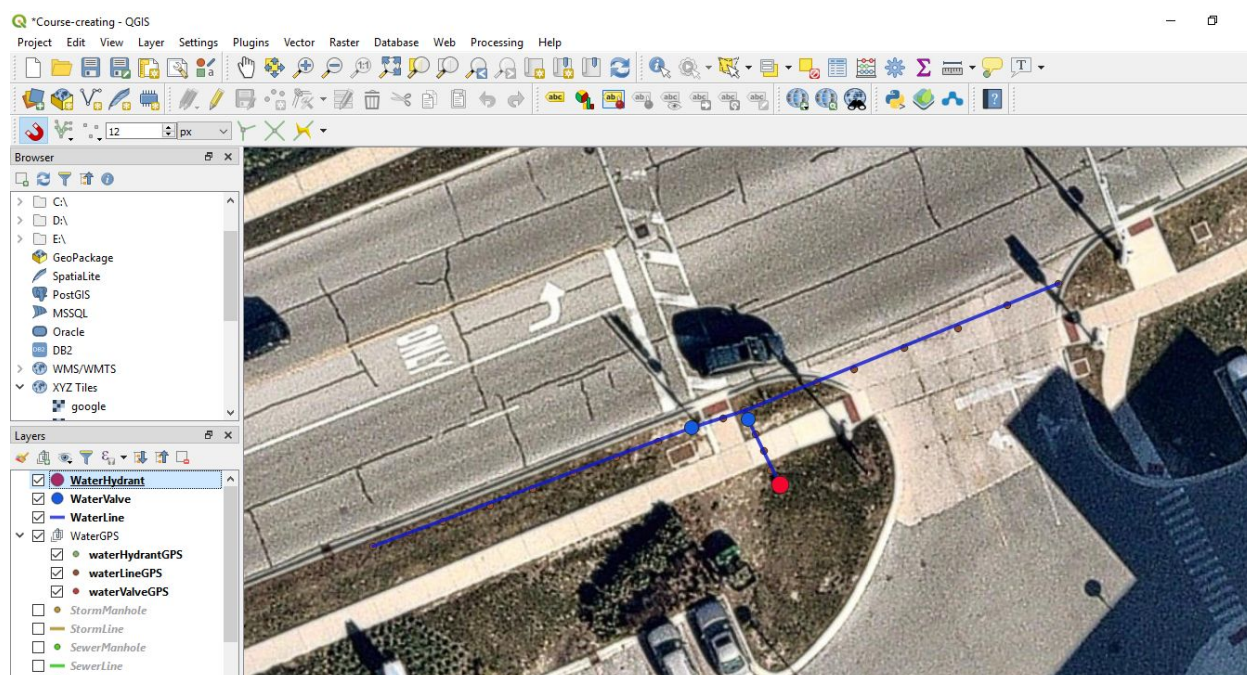


You have digitized the first WaterLine pipe.

18. Digitize a total of ~5 pipe segments for the **WaterLine** layer.

The first segment is from the left side of the survey boundary to the first valve. 2nd is from the valve to the Tee. The 3rd is from the Tee to the right side of the survey boundary. 4th is from the Tee to the 2nd valve. The 5th segment is from the valve to the red hydrant.





To delete a pipe segment, use the **Select Features by Polygon** tool on the **Identify Features Toolbar**.



19. Select and highlight the **WaterLine** layer in the **Layer** dialog box, click the **Select Features by Polygon** button, select the pipe segment so that it is highlighted and selected in the map, and push **Delete** on your keyboard.

Remember to select the correct map layer. If both **WaterValve** and **WaterLine** map layers are in “editor mode”, and you have the **WaterValve** layer selected, you could delete those features instead of the **WaterLine** features.

## Export Data to Various File Formats

To export your shapefiles to different data formats, right click on the map layer **WaterLine** in the **Layers** box, click **Export** > click **Save Feature As**.

For **Format**, choose the file format you would like to export the data as > choose **Keyhole Markup Language [KML]**.

For **File name** > click the small square with 3 dots, browse to a location, give the file a name > click **Save** > click **OK**.

You just exported the **WaterLine** shapefile to a KML file.

You can now view the data in **Google Earth** or **Google Maps API**.

## Create Map Labels

To create map labels for the **WaterValve** map layer, right click **WaterValve** > **Properties**.

On the left side > click **Labels** > at the top choose **Single Labels**.

For **Label with** > choose the **Diameter** field > Click **OK**.

You should see a valve diameter label on the map next to the valves.

Try adjusting the colors, sizes, and label placement settings to meet you needs.



**Lesson Assignment:** Map and digitize the Storm and Sewer systems using the same steps and process used to map the Water system.

Use the following attributes for these systems.

Storm (**Diameter** = 18 **Material** = RCP **Depth** = 2) Total pipe segments = 6 Total manholes = 3

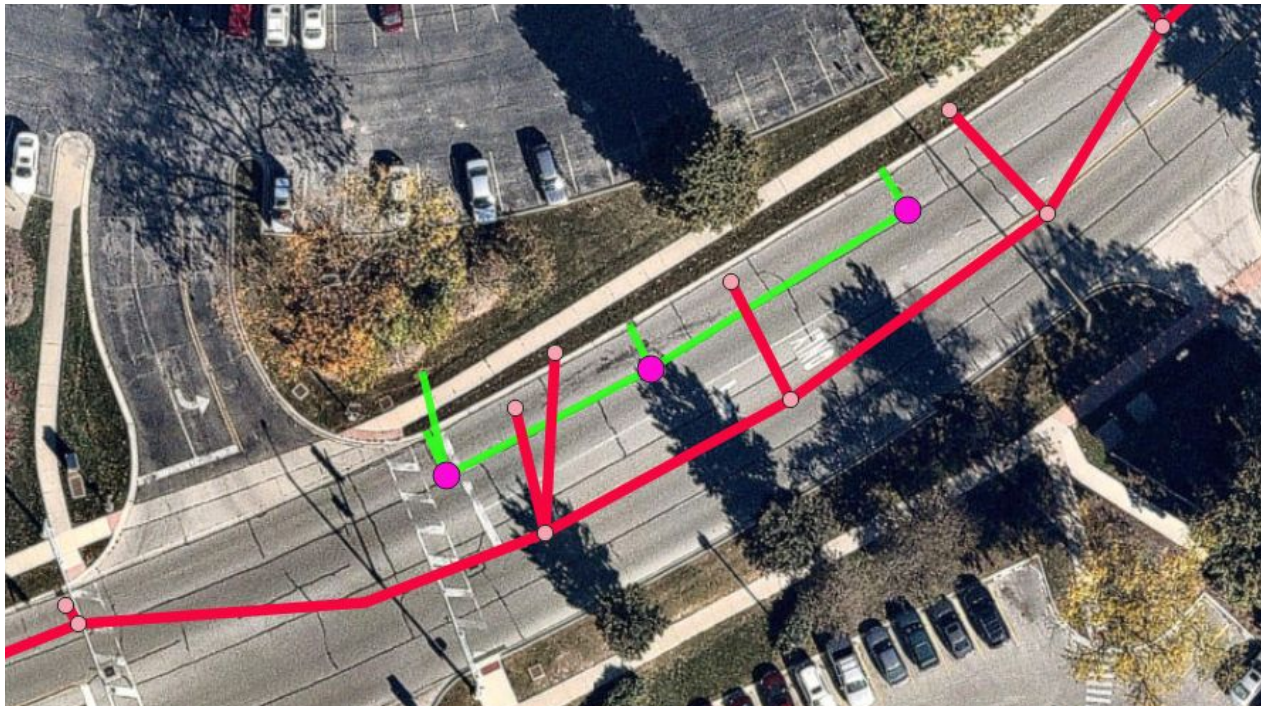
Sewer (**Diameter** = 8 **Material** = RCP **Depth** = 5) Total pipe segments = 1 Total manholes = 1

**Next assignment:** the city has hired you to update their stormwater shapefiles. Their stormwater data is a bit out of place from where it was recently located and they have asked you to fix it for them. The green lines in the map below show where it was located and where it is located, and the red lines are where their maps and data shows it. They have sent you the shapefiles and asked you to fix it for them.

Here are the shapefiles in the training data.

**\Utility\_Mapping\_Bootcamp\Course\_Data\Naperville\_data\Stormwater\shapefile**

Remember, you only need to select and add the (.shp) files when adding the data to the map.



Add both the **stormwaterPipes.shp** and **stormwaterStructures.shp** to the map to edit the geometry.

Edit these shapefiles to match where the (green) GPS data shows the stormwater pipes and structures are located.

*Hint: you can delete the inaccurate red lines and structures and draw new ones using the GPS data as a reference.*

In this lesson, you used GPS data to digitize GIS data using shapefiles created in an earlier lesson. You also added attributes for various utility features such as pipes and valves.

This lesson is where lots of work is involved and various procedures and standards are used for storing attributes and representing a utility system. For example, we did not map any fittings in this course. You may consider using fittings to represent known fitting connections to store valuable information about a system. Storing information about elbows, tees, and reducers along a system can be very helpful for engineers and maintenance teams, while mapping every single coupling fitting along a 30 mile stretch of 12" water pipe can be a bit excessive to a GIS program and bog down storage systems.

In the next lesson, you will learn how to upload your data to ArcGIS Online and create a web map. There are several different cloud GIS platforms to choose from depending on your needs, requirements, and budget including Mango Map, GIS Cloud, QGIS Cloud, & ArcGIS Online. In this course, you will use ArcGIS Online.

# 7

## Upload Data to ArcGIS Online

In this lesson you will learn how to upload utility data to ArcGIS Online and create maps to share on the web. This lesson uses a free public ArcGIS Online account. Please read and agree to our Legal Disclaimer and Terms of Use in the beginning of this document before proceeding with this lesson. Also, please read and agree to Esri's Terms of Use before using ArcGIS software. Ok, now that you have read and agree to the terms, let's continue.

1. Sign up for a public account here (<https://www.arcgis.com/index.html>). We highly recommend keeping this software on your radar!

The first step is to create your account. The second step is to zip your shapefiles. We will zip each utility system's shapefiles separately.

The following files are available for uploading to ArcGIS online.

- Shapefile (ZIP archive containing all shapefile files)
- CSV or TXT files with optional address, place or coordinate locations (comma, semicolon or tab delimited)
- GPX (GPS Exchange Format)
- GeoJSON (open standard format for simple geographical features)

2. First, create a folder called **WaterLines** and copy all of the **WaterLine** files to this folder. Right click the folder and Choose 7-Zip or WinZip. (or whatever Zip software you have installed).

3. These 6 (total) **WaterLine** files shown below make up the **WaterLine** shapefile and they all should be copied to the folder. Copy all 6 files to the new **WaterLines** folder you created.

- WaterLine.cpg
- WaterLine.dbf
- WaterLine.prj
- WaterLine.qpj
- WaterLine.shp
- WaterLine.shx

4. Create a separate folder called **WaterValves** and copy all of the **WaterValve** files to this folder.

5. Right click the folder and Choose 7-Zip or WinZip. (or whatever Zip software you have installed).

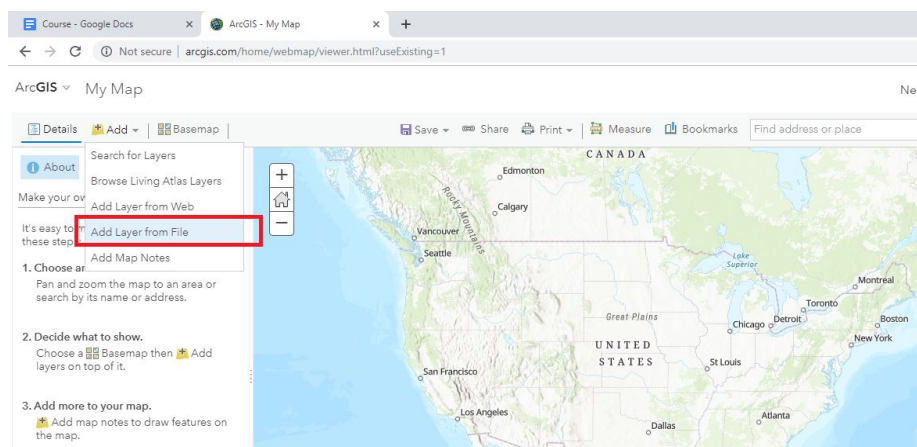
6. Repeat those steps for the **WaterHydrant**, Sewer (manhole, lines), and Stormwater (manhole, lines) shapefiles. You should have 7 zipped folders once complete.

- **WaterLines.zip**
- **WaterValves.zip**
- **WaterHydrants.zip**
- **StormLines.zip**
- **StormManholes.zip**
- **SewerLines.zip**
- **SewerManholes.zip**

7. Sign In to your ArcGIS Online account, and at the top of the screen, click **Map**.



8. Click the **Add** button in the top left and choose **Add Layer from File**.

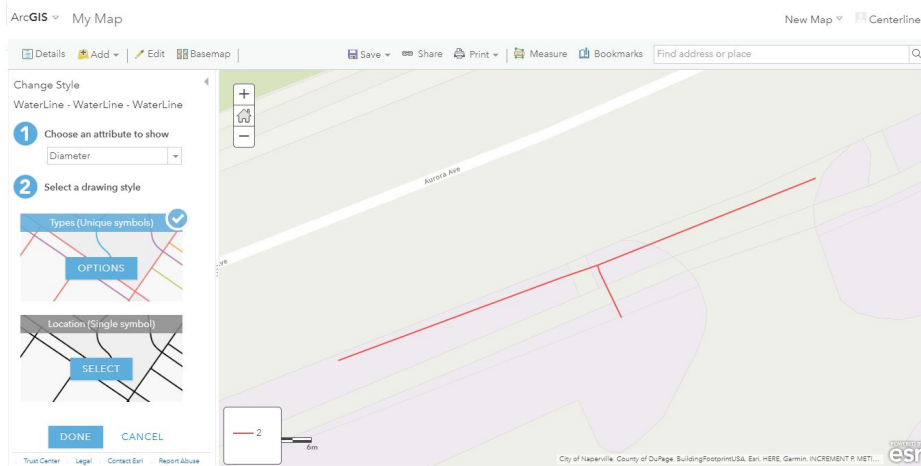


9. Browse to your zipped **WaterLine.zip** folder and select that folder.

**Make sure the Keep original features radio button is selected.**

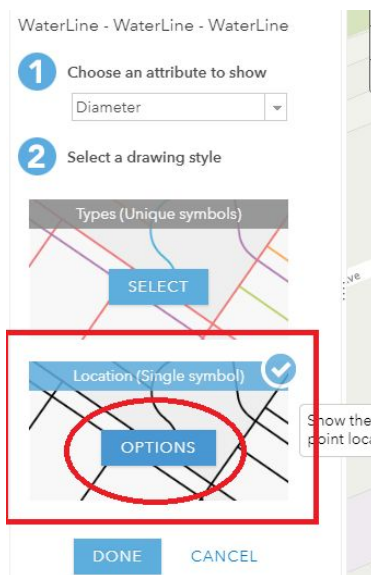
10. Click **Import Layer**.

You should see your **WaterLines** added to the Content section on the left, and to the map.



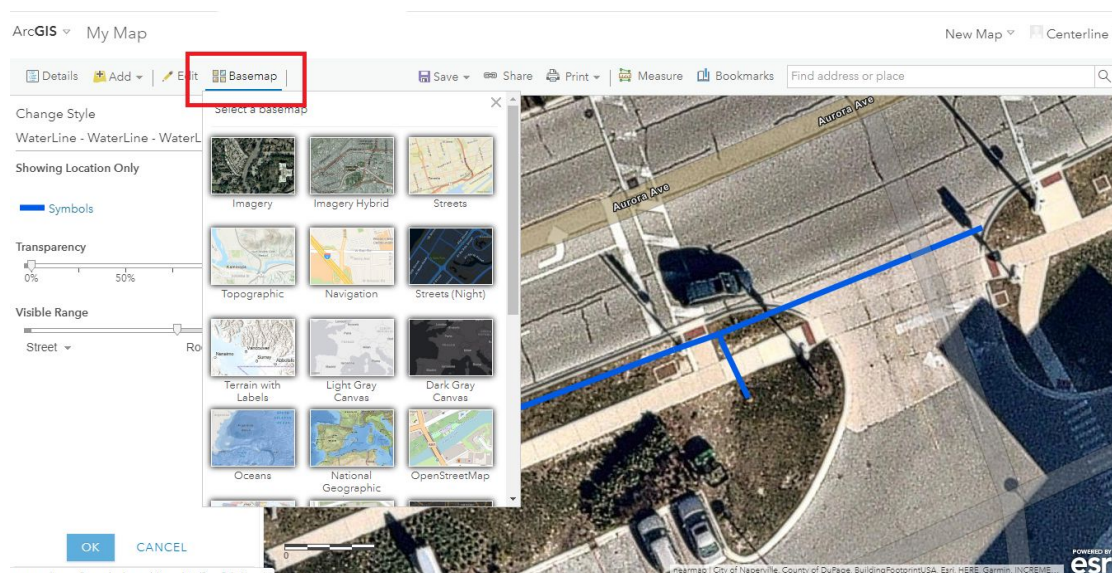
You can now change the Style and Color of your water lines.

11. In the left dialog box under the **2 - Select a drawing style** > Choose **Location (Single symbol)**, click the blue **SELECT** button > click **OPTIONS** (the same button).



12. Click the **Symbols** button to change the water line symbol. Choose a color, line width, transparency to meet your needs. Click **Ok** > Click **Ok** > Click **Done**.

To change the basemap, click **Basemap** and choose the basemap you would like to see.



14. At the top of the map, click **Save** > click **Save As** to save your map, layer settings and symbology. You can close ArcGIS Online and Log Out at anytime and start off where you last saved your map. To open your map, when you sign-in, instead of clicking **Map**, click on **Content**, and this is where you can open your saved map. ArcGIS Online stores all of your maps, data, and content in their cloud.

**Lesson Assignment:** Add the WaterValves, WaterHydrants, StormManholes, StormLines, SewerManholes, SewerLines shapefiles to your map. Change the symbology for each of the shapefiles to fit your needs and color standards. Remember to Save your map often and frequently. We have zipped the shapefiles and included them in the course data.

In this lesson, you created an ArcGIS Online account and added utility data to a web map. You also changed the map layer symbology. There are several layer settings and web map capabilities for you to explore now. Feel free to take some time to explore the capabilities of ArcGIS Online and the various mapping features built-in (Print, Measure, Bookmarks). Notice how you can edit the WaterLine map layer by clicking the **Edit** button, next to **Basemap**.

Now that you have a **Web Map**, you can create a **Utility Map Viewer** to access and share your utility maps and data online. A Utility Map Viewer is an out-of-the-box Web Mapping Application that is accessible online, on any device, anywhere (as long as you have an internet connection). Next, let's build a **Utility Map Viewer** without writing a single line of code!

# 8

## Build Utility Map Viewer

In this lesson you will learn how to share your Web Map and build a Utility Map Viewer.

1. First, sign-in to your ArcGIS Online account, and click **Content** at the top.
2. Find the Web Map you saved in the previous lesson and click to open it. Then in the top right of the next page, click **Open in Map Viewer**.

This is the Web Map you will use to build a Utility Map Viewer application. You can always open this Web Map to change symbology, pop-ups, basemaps, and attribute settings to update your Utility Map Viewer application. Remember to save the web map after making changes.

It is important to note that the Utility Map Viewer is an out-of-the-box application that uses the web map. When you make changes to your web map, they are automatically updated in the application (once you reload the application).

So what's the difference between the Web Map and Utility Map Viewer?

The Utility Map Viewer is how you view the web maps and data, and what you share with your clients, and team members in the field.

The Web Map is where you upload and edit data, adjust layer settings, apply labeling, and apply filters. You may have one or two people responsible for editing and creating Web Maps, while hundreds of customers are using the Utility Map Viewer.

3. At the top of your Web Map, click **Share**, then click **CREATE A WEB APP**.

### Share

Choose who can view this map.

Currently, only you can view your map. Before you can link to it or embed it, you need to allow others to view your map.

☐ Everyone (public)

Link to this map

<http://arcg.is/DCDID>

☒ Share current map extent

Embed this map

EMBED IN WEBSITE

CREATE A WEB APP

Now you should see a list of templates to use for your Web App. These templates highlight various information and tools depending on your specific mapping needs and industry.

4. Click the **Basic Viewer** option in the top left (but feel free to explore other options), click **Create Web App**.

5. Fill out the form and provide a **Title, Tags, Summary**, and choose the default Save in folder option.

6. Check the checkbox to share the app. This is basic metadata about your web app.

7. Scroll down and click **DONE**.

The next page is the configuration page for your application. This is where you update configuration settings about the application such as the **Title, Colors, Theme, Widgets, Labels**, and web map to load. You can change this information later by going to your Content, click your Web Application, click **CONFIGURE APP**.

8. First, under the **General Tab**, provide an application title.

You can add a Splash screen that will popup when you first open the Application to provide background information, disclaimers, and anything you want to share before someone uses the application.

9. Next, click **Theme** at the top. This is where you can style your application using various layout, color, and logo options. Make sure to click **Save** after making updates.

10. Click the **Options** tab. This is where you can add and configure specific out-of-the-box widgets, also known as mapping tools.

Available widgets:

- Basemap Gallery
- Legend
- Map Details
- Measure Tool
- Overview Map
- Share Tools

11. Once you are ready and happy with your application template, coloring, and widget configuration, click **Save**, and then click **Launch**.

This will build and launch your very own **Utility Map Viewer** in a web browser.

Remember, if you have to make changes to the application, you can browse to your web application under **Content**, make changes, and **Save**.

To make changes to symbology, pop-ups, layer names, and map settings, browse to your web map under **Content**, make changes, and **Save**.

Remember, you created a Web Map, and a Web Application (two separate things).

You do not need to configure an app every time you make changes to the Web Map. Next time you load your application, you will see changes to the web map in the web application.

As a test, change the color of the WaterLines to red, save your map, reload the web application and notice the **WaterLines** are now red. You didn't change or save anything to the web application, just the web map.

You should now have a **Web Map**, and a **Web Application** in your contents page in ArcGIS Online.

To download and host the application on a private server, at step 3 of this lesson, instead of clicking **CREATE WEB APP**, you would click **DOWNLOAD**. This downloads all the source code necessary to host the application on another server. Your application will still use the Web Map you build and save on ArcGIS Online, but the application will be hosted on another server.

You WILL need to do some HTML and JavaScript coding to get the application up and running on a private server.

In this lesson you learned how to share your Web Map and build a web-based and GPS-enabled Utility Map Viewer.

In the next and final lesson, you will learn more about ArcGIS capabilities and strategy.

# 9

## Explore ArcGIS Capabilities

**ArcGIS Online** is a cloud-based GIS mapping software that is being used widely around the globe. More and more organizations and utility departments are finding the value in having GIS information and data accessible on the web (in the cloud). Organizations no longer need to send entire databases via email and FTP to share a few records of information.

Now, with GIS, they can just share a URL to a web mapping application. All of the information is stored in a secure central database and utility departments spend less time finding the most recent and updated site plan about City Water in an old filing cabinet.

When the utility information needs updating (after several years of project work), we have an analyst update the GIS and maps, and everyone can see the changes in real-time within the Utility Map Viewer. Every time a utility locating, surveying firm provides data or as-builts, we input the information in the GIS. Over-time, the client, the owner of the utility assets, has an accurate and updated picture of their utilities, accessible on any device, anywhere.

Data can be converted back to CAD files for engineering and surveying purposes as well. PDF maps can be printed from GIS software as needed for redlining and field visits. ArcGIS Online supports 3D map viewers in case your organization is moving into 3D modeling. ArcGIS also provides a number of tools geared towards utilities such as valve and network tracing. These tools give users the ability to determine customers affected during outages, and closest upstream valves to isolate a leak. Data plugs directly into these tools and they are accessible through your Utility Map Viewer.

Esri provides APIs and SDKs in order to integrate additional tools and functionality within your applications. Esri (the company that owns ArcGIS) provides additional software that comes with your ArcGIS online license called Collector for ArcGIS. This is a mobile application that allows you to collect and update information in the field. Now, your workforce can use Android, iOS, and tablets to connect to your central database and provide real-time data updating (upload pictures, add attribution, verify IDs, valve numbers, etc).

## Key GIS Terminology

**GIS** - a geographic information system (GIS) is a computer system for viewing, editing, and analysis of geospatial data.

**GPS** - a global positioning system (GPS) is a navigation system that provides location and time information anywhere on or near the Earth where there is an unobstructed line of sight to satellites.

**GPR** - a ground-penetrating radar(GPR) is a geophysical method that uses radar pulses to image the subsurface.

**QGIS** - a free and open-source cross-platform desktop GIS that supports viewing, editing, and analysis of data.

**Open-source software** - software for which the original source code is made freely available to users.

**Open-data** - data that is free and open to use by the public.

**Basemap** - a collection of GIS data and/or imagery that form the background setting for maps and data.

**Map Service** - a map service is a standard web protocol for serving maps, images, features, and attribute data to many different client applications. When you add aerial imagery in Lesson 3, you are using a map service.

**Map Layer** - a map layer is used to display a specific dataset in GIS. Map layers represent vector data (points, lines, polygons) or raster data (digital elevation models, aerial imagery). In GIS, water pipes are usually stored in one map layer, while water valves are stored another map layer.

**Geospatial data** - any data that has a geographic component to it. This means that records in a dataset have geographic data tied to them in the form of coordinates, address, city, zip, etc. Geospatial data can be represented on a map.

**Vector data** - discrete data composed of and represented using points, polylines, and polygons. Pipes are an example of vector data as we use polylines to represent them. A valve is an example of vector data as we use points to represent valves.

**Raster data** - continuous data composed of and represented using pixels and individual cells in a grid format. Digital elevation models are an example of raster data. Aerial imagery is an example of raster data.

**Digital Elevation Model** - DEMs are a form of raster data used to represent ground elevations and topography of a given area.

**Aerial imagery** - photographs of the earth from satellites, drones, airplanes, etc. This imagery is then georeferenced and added to a GIS usually as a basemap for referencing additional data such as utilities, light poles, property lines, etc.

**Georeference** - a geoprocess used to apply coordinate and spatial information to information in a database.

**Digitize** - a process of converting geographic data from scanned images, hardcopy drawings, or other reference data into vector data by tracing the features.

**Shapefile** - a shapefile is a common data format used in GIS software and applications to store spatial and attribute information of geographic features. Shapefiles consist of 6 separate files (cpg, dbf, prj, qpj, shp, shx)

**KML file** - KML (Keyhole Markup Language) uses XML (eXtensible Markup Language) to represent and store geographic data by storing points, polylines, polygons, shapes, images, in XML.

**CSV file** - CSV (Comma-Separated Values) file is a common file used to store tabular data. CSV files can also store geospatial data in the form of coordinates, addresses, zip codes, and more.

**DWG file** - DWG file is a drawing file format used for storing two and three dimensional data commonly used and exported from CAD and used in GIS.

**DXF file** - DXF (Drawing eXchange Format) file is used for graphic image formats commonly used in CAD and GIS software to represent utilities.

**Geodatabase** - a geodatabase is a file format used to store geospatial information in one large file which can contain points, polylines, and polygons. Rather than create and store hundreds of shapefiles separately, a geodatabase is used to store and organize data in one container.

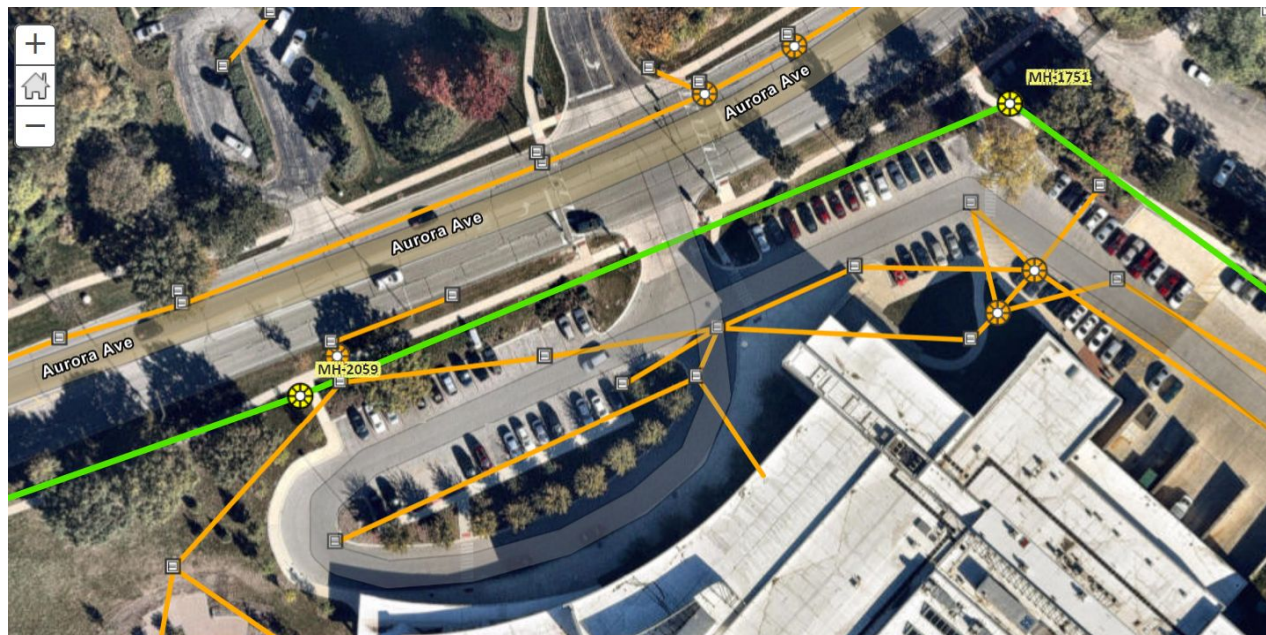
**Extent** - the geometry extent of a feature is the minimum and maximum X and Y coordinates of the feature.

**Spatial information** - location information about a feature that is stored as coordinates, addresses, zip codes, etc. Spatial information about a water valve could be -76.4343, 36.3343.

**Tabular information** - this is attribute information stored about each record in a database. Tabular information about a water pipe could be the Size, Diameter, Material, Depth, Install Date, etc.

**Topology** - topology is defined as the spatial relationships between adjacent or neighboring features. In GIS, features such as pipes, and valves can share the same coordinates in order to meet specific topology rules and reduce errors in data.

**Snapping** - snapping is an editing tool in GIS that allows users to easily create and edit features that connect to each other and apply standard topology rules and behavior so that edits are more accurate with few errors. When digitizing utilities, we use snapping to ensure that valves are “snapped” to the end points of pipes.



## About

This **Utility Mapping *Bootcamp*** training is an independent initiative from the Virginia registered entity Centerline Mapping LLC and Tyler Bristow.

Tyler is a certified GIS Professional (GISP) and has more than 10 years of experience with GIS supporting contracts for U.S. Fish and Wildlife Service (USFWS), Huntington Ingalls Industries, National Aeronautics and Space Administration (NASA), U.S. Air Force (USAF), U.S. Federal Aviation Administration (USFAA), and U.S. Coast Guard (USCG).

Tyler also volunteers and provides professional GIS mapping services to GISCorps.




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### **Utility Mapping *Bootcamp***

Centerline Mapping LLC

[www.centerlinemapping.com](http://www.centerlinemapping.com)

[tyler@centerlinemapping.com](mailto:tyler@centerlinemapping.com)