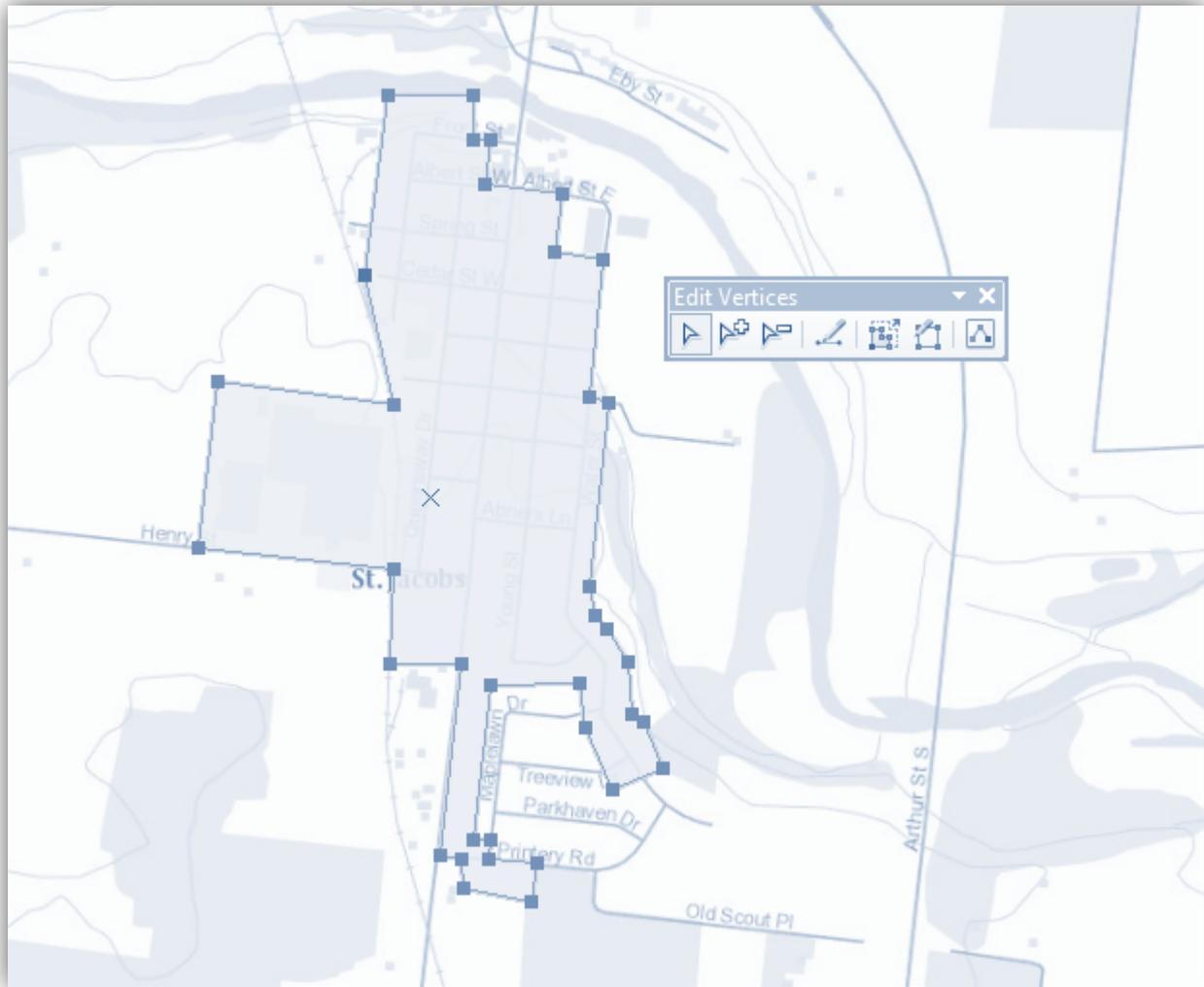


Editing with ArcGIS



UNIVERSITY OF WATERLOO

GEOSPATIAL CENTRE

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This tutorial is designed to introduce you to the basic editing tools used in ArcMap for the both the creation and modification of geospatial data. Editing is an essential skill for GIS users that helps build spatial awareness and a broader understanding of topological relationships. This tutorial will cover several common editing functions and workflows using the Feature Template editing environment in ArcGIS 10.x.

Note: If you are completing this tutorial independently, the data and files you will need are found in the zipped folder that you downloaded for this document.

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Coordinate Systems and Projections

In order to represent data on the earth's surface, a coordinate system is needed to define locations on that surface. In GIS, there are two types of coordinate systems: geographic and projected. **Geographic coordinate systems** use a spherical surface to plot those defined locations, which are referred to as lines of latitude (also known as the y-axis) and longitude (the x-axis) as illustrated in Figure 1. **Projected coordinate systems** use a flat surface onto which a portion (or all) of the spherical earth is *projected* (Figure 2).



Figure 1 - The earth represented as a sphere with lines of latitude (running east-west) and longitude (running north-south).

Since the earth is not a perfect sphere but more elliptical, its shape is referred to in geography as a spheroid, or ellipsoid. However, even a spheroid does not account for the irregularities of the earth's surface. Therefore, geographic **datums** have been developed to define the position of a spheroid relative to the centre of the earth. This in turn provides a frame of reference for measuring locations and distances on the surface of the earth.

The terms *datum* and *geographic coordinate system* are technically not the same thing (a datum is one part of a geographic coordinate system); however, they are nevertheless used interchangeably, so it's good to be aware of that usage. In North America, the most commonly used datums are the North American Datum of 1927 (NAD 1927 or NAD 27) and of 1983 (NAD 1983 or NAD 83); and the World Geodetic System of 1984 (WGS 1984 or WGS 84).

Projected coordinate systems are always based on a geographic coordinate system, and there are many different types (for North America alone, there are hundreds of projections); however, one of the more common ones is the Universal Transverse Mercator (UTM), based on the NAD 83 datum. This projected coordinate system is broken down further into the various UTM Zones.

Although we cannot cover all there is to know about coordinate systems and projections in this tutorial, these basic concepts will be useful as you work through the exercises and become familiar with GIS.

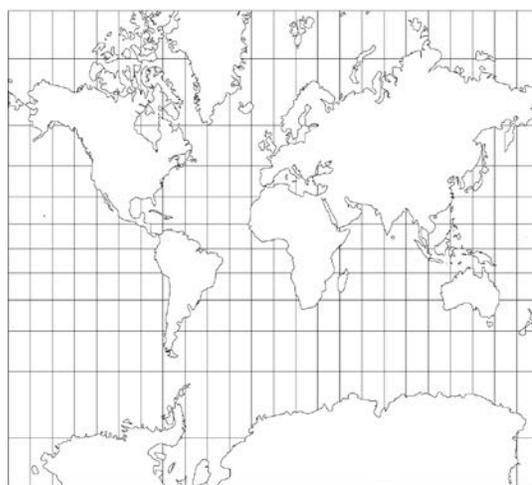


Figure 2 - The earth flattened, or projected, onto a two-dimensional surface (note the distortion of size and shape, particularly at the poles).

Creating New Features

In this section, you will learn how to create a new shapefile and start an edit session, wherein you'll begin adding features to your new layer. You will also learn how to map xy coordinates from a table of locations.

New Shapefile

Shapefiles and other data types are typically planned out before they are created. The planning process includes identifying the attributes of the features you will be adding to the layer as well as any subtypes or domains (these are subsets of a layer that provide users with more control over their data). This method of creation is normally done in ArcCatalog.

Because we don't have time to plan out the layer in this tutorial, we will create the shapefile in ArcMap first and add attribute fields later (this will also demonstrate the process of adding fields to a shapefile, because even planned layers sometimes need extra fields added).

1. Navigate to the **Editing Exercises** MXD in the tutorial data folder and double-click to open it.
2. In the Catalog tab, right-click on the **Home** folder and create a new folder named **Editing**.
3. Right-click the newly created folder and choose **New > Shapefile...**
4. Name the shapefile **Towns** and change the Feature Type to **Polygon**.
5. Click **Edit** to assign the coordinate system (which is currently unknown) and type "utm zone 17n" in the search box or navigate to **Projected Coordinate Systems > UTM > NAD 1983 > NAD 1983 UTM Zone 17N**.
6. Click **OK** and note that the Description now includes the "NAD_1983_UTM_Zone_17N" projected coordinate system, which is based on the "GCS_North_American_1983" geographic coordinate system.
7. Click **OK** to finish creating your shapefile, which is automatically added to your map.

The shapefile you just created is only a shell at the moment because it contains no features. But perhaps more importantly, it only has three attribute fields. In order to give the features meaningful information, we need attribute fields where we can store that information.

1. Open the **Attribute Table** of Towns.
2. From the Table Options dropdown menu, select **Add Field**
3. Type **Name** in the Name field, change the Type to **Text** and click OK.
4. Repeat steps 2 and 3 to add the following fields and types: **Township / Text; Founded / Date; Population / Long Integer**
5. Close the attribute table, move it aside, or dock it to one of the sides of your screen.

Digitizing

With attribute fields in place, we are now ready to begin editing the layer, or digitizing features. This process is often done using coordinate geometry (COGO) derived from land surveys, plat maps, and other field-generated sources, such as global positioning systems (GPS). However, that type of data entry introduces a whole new set of tools and workflows, which are not needed for basic editing. Therefore, to create features in our new layer, we will be performing what is known as heads-up digitizing, which uses a basemap (usually some kind of aerial image) as the source for tracing features.

1. From the Bookmarks menu, select **St. Jacobs**.
2. On the Editor toolbar (turn this on if needed), click the dropdown menu and select **Start Editing** to begin an edit session.

Note: You can also start editing by right-clicking the layer you want to edit in the Table of Contents and selecting Edit Features > Start Editing.

3. When you start an edit session for the first time, the **Create Features window** should appear (if it doesn't, go the dropdown menu on the Editor toolbar, go to Editing Windows and select Create Features).
4. Click on Towns in the Create Features window and note the **Polygon construction tool** is selected (you can also draw polygonal features using the other Construction Tools).

5. Making sure your cursor has changed to a cross on the map, pick a starting point at one of the corners of the city boundary for St. Jacobs (beige color surrounding the city blocks) and click to **add a vertex** (Figure 3).



6. Finish outlining the city boundary by adding vertices (vertexes) at any point where the angle of the line changes; when you get to the last vertex of your drawing, **double-click to finish the sketch**

Figure 3 - The starting vertex for digitizing the city boundary of St. Jacobs (note the leading vertex is always colored red, while previously added vertices change to green).

(alternatively, you can also single-click to add the last vertex—offers more control than a double-click—then right-click on that vertex and select Finish Sketch or simply hit the F2 key).

7. From the Editor dropdown, go to **Editing Windows > Attributes** (the window may automatically dock itself on the side of the Data Frame).

Note: You may wish to “pin down” certain windows and Auto Hide others; use the pushpin icon in the upper right-hand corner of any window to toggle between the two.

8. With your new feature still selected (the default after finishing a sketch), open the Attributes window and enter the following values for each attribute:

Name	St. Jacobs
Township	Woolwich
Founded	2/6/1852
Population	1891

9. At this stage, it’s a good idea to **Save Edits**. Saving your edits frequently will prevent you from losing work if ArcMap crashes, which is known to happen on occasion. As a safeguard, if there are any unsaved changes when you Stop Editing, ArcMap will prompt you to save your edits (this is also true when you try to close ArcMap).
10. For now, we’re going to Stop Editing (from the Editor dropdown menu) and move on to another method of creating features.

Adding XY Data

A very common scenario for creating features is the desire to plot xy, or lat-long, coordinates on a map. ArcMap has tools for this, but what many people don’t realize is that not all xy data is created equal. For this reason, we are going to briefly explore the typical problem that people encounter when trying to add xy data, and then we’re going to walk through the correct procedure.

1. Using the Add Data button (or the Catalog tab if you prefer), navigate to the **Bridges_xy_data.csv** file in the tutorial data folder and add it to the map.
2. Open the attribute table and note the three records: **Arthur St, King St, CN Railway**. These records contain the latitude-longitude coordinates (in decimal degrees) for the

middle point of each bridge, all of which cross the Conestoga River near St. Jacobs (you can see the crossings on the north and east sides of the town).

3. Right-click on the CSV in the Table of Contents and choose **Display XY Data...**
4. Remember that our **x-axis is the longitude**, and our **y-axis is the latitude**. These are easily confused, probably for two reasons: one, we say lat-long and xy, which can easily lead to linking lat with x and long with y; two, although the lines of longitude run north-south, they mark positions along the x-axis, east or west of the prime meridian.
5. Verify that the **X Field** and **Y Field** are set to the correct field from the table (they should be by default) and click OK.
6. A warning message pops up indicating that the **“Table Does Not Have Object-ID Field”** and you therefore won’t be able to interact with the features in the layer, but you can export it to a shapefile or feature class afterward in order to spatially enable the points.
7. Click OK and note that a new **“Events” layer** is created and appears in the Table of Contents. However, the points are not showing on the map where they ought to be.



Figure 4 - Anticipated bridge-point locations.

8. Using the image in Figure 4 as a reference, zoom to the **Bridges_xy_data.csv Events** layer and note that the points line up in the correct position relative to one another, but they appear to be in the middle of nowhere.
9. From the Bookmarks menu, select **Points Location** to see where the points were placed relative to southern Ontario.

As previously mentioned, xy coordinates are not created equal, meaning when xy data is collected in the field or manually from a mapping program or application like Google Earth or Bing Maps, it is done in a specific coordinate system. And you'll recall that there are hundreds of different coordinate systems to choose from. Therefore, it is important that you know what coordinate system the data is based on in order to properly display your points on the map.

1. Launch a **new ArcMap window** and open a new Blank Map.
2. In the Table of Contents, open the Properties of the Layers Data Frame and go to the **Coordinate System tab**.
3. Navigate to the **WGS 1984** coordinate system (Geographic Coordinate Systems > World > WGS 1984), select it, and click OK.

*Note: If you compiled your xy data using an online mapping application, chances are the coordinates are based on WGS 1984, which is one of the most common datums for the global scale. Another common coordinate system coming into greater use is the **Web Mercator (auxiliary sphere)**, which is based on the WGS 1984 datum but is actually a projected coordinate system, not a geographic one.*

4. Add the Bridges_xy_data.csv table to the map and **repeat the steps** for displaying xy data.
5. Once the points have been displayed on the map, add the **Topographic Basemap** to verify that the points are now in their proper locations.
6. Right-click on the Events layer and choose **Data > Export Data....**
7. Under "Use the same coordinate system as:" choose **the data frame** (we set this to WGS 1984, which displayed our data correctly, so we want to maintain that).
8. Navigate to the Editing folder where the Towns layer is located, name this layer **Bridges**, click OK to export the data, then click **Yes** to add the exported data to the map as a layer.
9. Now add the new Bridges layer to the Editing Exercises map document (you can do this using the traditional Add Data method or you can drag and drop it from the Untitled map document).

10. When the layer is added to the map, you will get a Geographic Coordinate Systems Warning explaining that the Bridges layer (which is in GCS_WGS_1984) is different from the current map's coordinate system (which is set to NAD_1983_UTM_Zone_17N). This is okay, because ArcMap will project the data "on-the-fly" so that it lines up with the map's coordinate system. Click Close.

You will now see that the Bridges layer lines up with the Basemap in St. Jacobs (Figure 5), which means the on-the-fly projection worked. When working with tabular xy data, there are two important things to remember. First, you have to start with a new map and before adding any data, **set the coordinate system** to whatever the source data was collected in. Second, when preparing your table for import, **ensure your coordinates are in a numeric format** (like decimal degrees as in this example). ArcMap cannot read the degrees-minutes-seconds (DMS) format from a table (i.e. 43° 32' 28" N, 80° 33' 31" W), so you will encounter errors as a result. If you need to convert your coordinates from DMS to a numeric format, there are many free conversion tools available online.

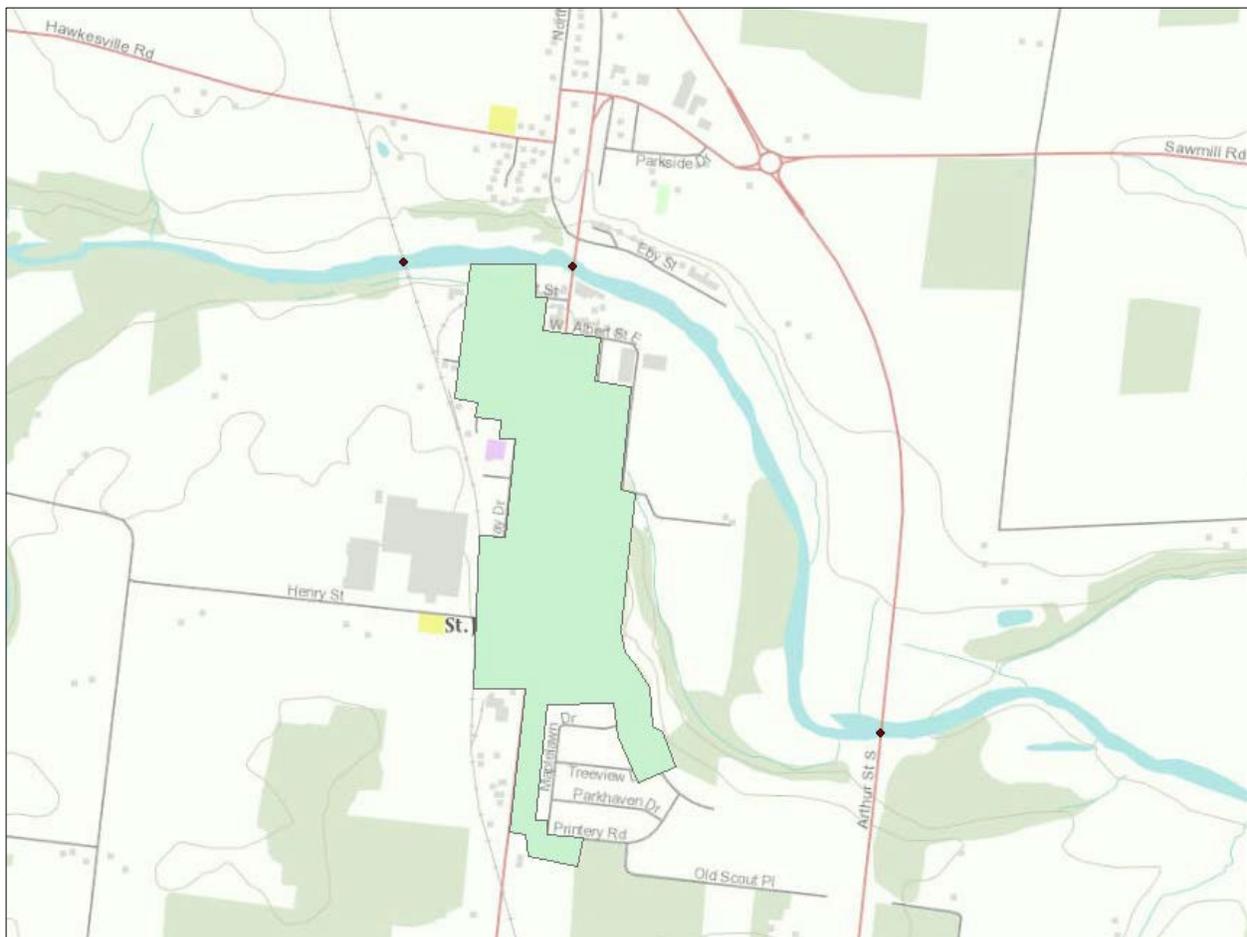


Figure 5 - Corrected bridge locations based on the source data's coordinate system.

Geocoding

Another very common feature people want to plot on a map is addresses. The process of taking a tabular list of addresses and plotting them on a map is known as geocoding. Using an address locator, the geocoder runs the list of addresses against the locator to find matches, which are then plotted on the map. This functionality is becoming more and more popular as people realize the potential of visualizing their location data on a map.

1. Using the Bookmarks, zoom back to St. Jacobs and **turn off the Towns layer** in the Table of Contents.
2. Check to ensure the **Geocoding toolbar** is turned on and then click the Geocode Addresses icon (mailbox on a post).
3. In the “Choose an Address Locator to use...” dialog, click Add and navigate to the **ONrds** locator in the tutorial data folder.
4. With that locator selected, click OK to continue setting up your geocoder. For the Address table, browse to the **HistoricSites.csv** file, also in the tutorial data folder.
5. Ensure the **Street or Intersection** input field is set to Address, then save the “Geocoding_Result.shp” to the Editing folder where the Towns and Bridges are located and click OK.

6. The results of the geocode operation are displayed (Figure 6), and in this case, of the 5 addresses in the table, 3 were Matched, 2 were Tied, and none were Unmatched.

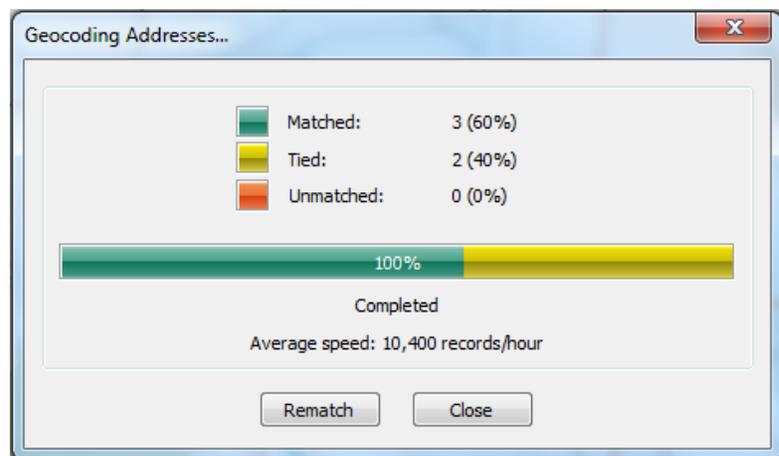


Figure 6 - Geocoding match results.

7. Click Rematch to open the **Interactive Rematch** dialog, where you can examine the results and try to manually determine why some addresses tied or were unmatched. You will also want to examine or spot check the matched results, because sometimes those are not what you'd expect.

8. 37 NORTHSIDE DR., ST. JACOBS, ON

- a. The first record has a Status of M for matched, but the Score is 66, which means it was not a perfect match (score of 100).
- b. Looking at the Match_addr[ess] field shows us that the closest match is a 37 NORTHSIDE DR, WOOLWICH (not St. Jacobs).
- c. In the list of Candidates below (there should be 11 for this record), right-click on the top candidate that was used to match and select **Flash** (the point for that candidate is flashed on the map).
- d. Based on its location just outside of St. Jacobs, we can confirm this as a match and move on to the next record.

9. 1395 KING ST., ST. JACOBS, ON

- a. This record has a Status of Tied, and once again the closest match has a score of 66 and uses a city other than St. Jacobs.
- b. The fifth candidate from the top has WOOLWICH for the city, and adds a suffix direction to the street address.
- c. Flash this candidate and note that based on its location, this is probably the correct address.
- d. Since it was tied, we need to **click on Match** at the bottom of the dialog window to interactively match the record.

11. 878 WEBER ST. N, ST. JACOBS, ON

- a. The next record has a Status of Matched and a Score of 66, and it also found the address in WOOLWICH.
- b. This address is not visible in the current extent of the map, so right-click it and choose **Pan To**.
- c. Again, this is just a few kilometers south of St. Jacobs, so we can confirm it as a match.

12. 15 CEDAR ST. EAST, ST. JACOBS, ON

- a. The next record is Tied with over 200 candidates and has an entirely different city listed (KAPUSKASING) than what we've encountered.
- b. But recall that our King Street address had a suffix direction; and if we look at the map (go back one extent or use the St. Jacobs Bookmark), we can see that there's a "Cedar St W" labeled near the north end of town.
- c. To the left of the Candidates list is the original address we're trying to match. Click in the address box and **add the suffix "WEST"** after "CEDAR ST.", then hit Enter.

- d. Nothing changes, but Cedar Street does cross over the main road through town (King Street), so let's try changing "WEST" to "EAST" and see what happens.
- e. A candidate with a Score of 66 and a WOOLWICH address appears, and we probably have a match. Flash to confirm the point is in St. Jacobs and then click Match.

13. 24 QUEENSWAY, ST. JACOBS, ON

- a. The last record says it is matched, but another foreign city (ESSEX) is listed as the match candidate.
- b. Also note that the address is for QUEENSWAY ST, but the original address had no street suffix at all.
- c. Since we've seen that with this locator, the rest of our addresses are given WOOLWICH for the city instead of St. Jacobs, we can look through the list of candidates and find that there is a 24 QUEENSWAY DR, WOOLWICH that might be a good candidate.
- d. Flashing the point confirms this, and we can match our last address. **Go to the Matched Addresses Bookmark** to see all the points (Figure 7).

Geocoding with ArcGIS has changed recently so that the locators that were once provided with the software are no longer available for free use. Instead, they have been superseded by the World Geocode Service (ArcGIS Online), which is a highly sophisticated locator that requires an ArcGIS Online subscription to use it within ArcMap. The exception to this is the ArcGIS Online web platform, which allows users with a free public account (not the subscription) to geocode up to 100 addresses at a time. The points can then be saved as a layer and imported into ArcMap.

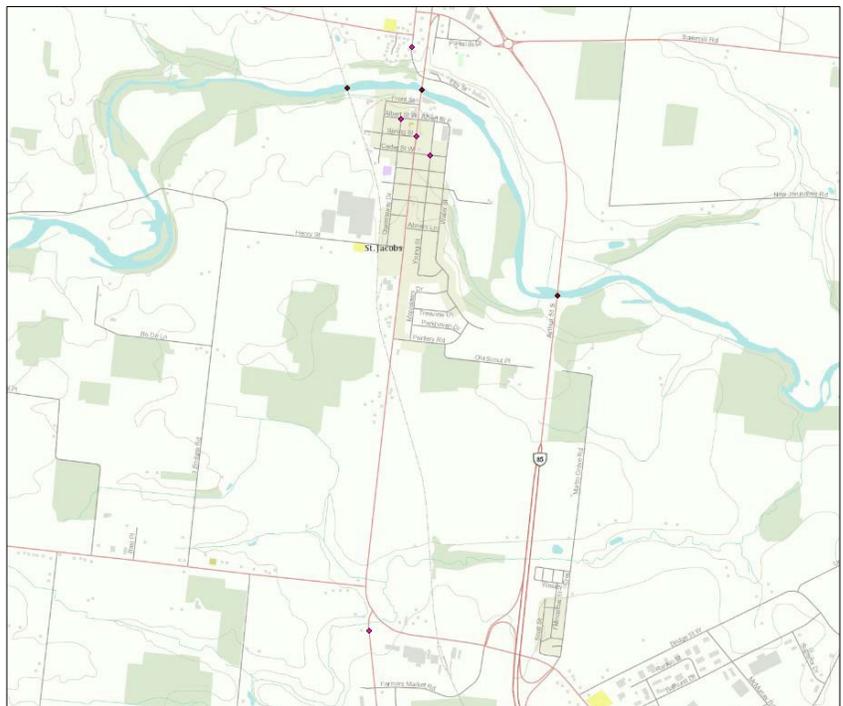


Figure 7 - Plotted xy data for bridges and geocoded addresses of historic sites in St. Jacobs, Woolwich Township, Ontario.

Editing Existing Features

Now that we've created some features using three different methods, let's take a look at the ins and outs of editing existing features. This section will be mostly explanatory, elaborating on the tools you've already used and introducing some new ones as well.

Layer-Based Editing Environment

The idea behind layer-based editing is that it **maintains the layer properties**, including symbology. You may have noticed that the Towns layer in the Create Features editing window (Figure 8) had the same symbol associated with it as the layer in the Table of Contents. As

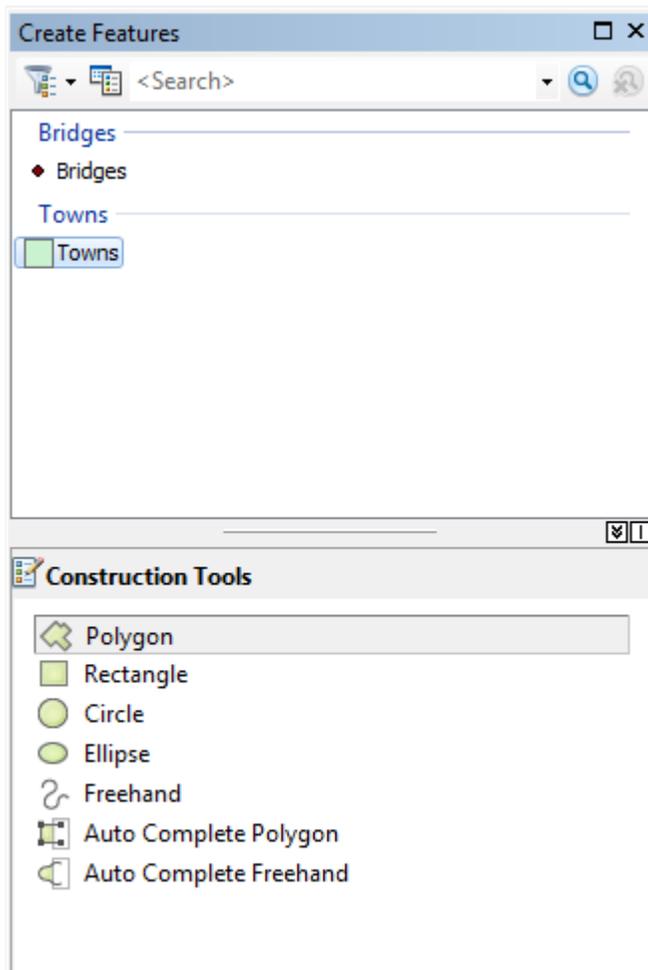


Figure 8 - The Create Features editing window.

editable layers are added to the map, they also appear in the Create Features dialog with all their properties intact.

Another aspect of layer-based editing that helps improve workflows is the ability to choose which features you want to **edit by layer or by stored location**. Start an edit session and note that unlike before when there was only one editable layer (Towns), you now have a list of layers to choose from as well as the option to choose a folder or geodatabase location where all the layers you want to edit are stored.

Also, returning to the concept of coordinate systems, you may be prompted with a warning letting you know that the data you about to **edit data that is in a different coordinate system** than the data frame. This warning is useful because editing layers that are being projected on-the-fly may lead to errors in how the data is stored or displayed.

Feature Templates

For GIS users and technicians who do a lot of editing on the same layers (usually as part of keeping municipal layers up-to-date such as roads, parcels, hydrants, etc.), the Feature Templates allow them to set up default properties for a layer so that every time they edit the

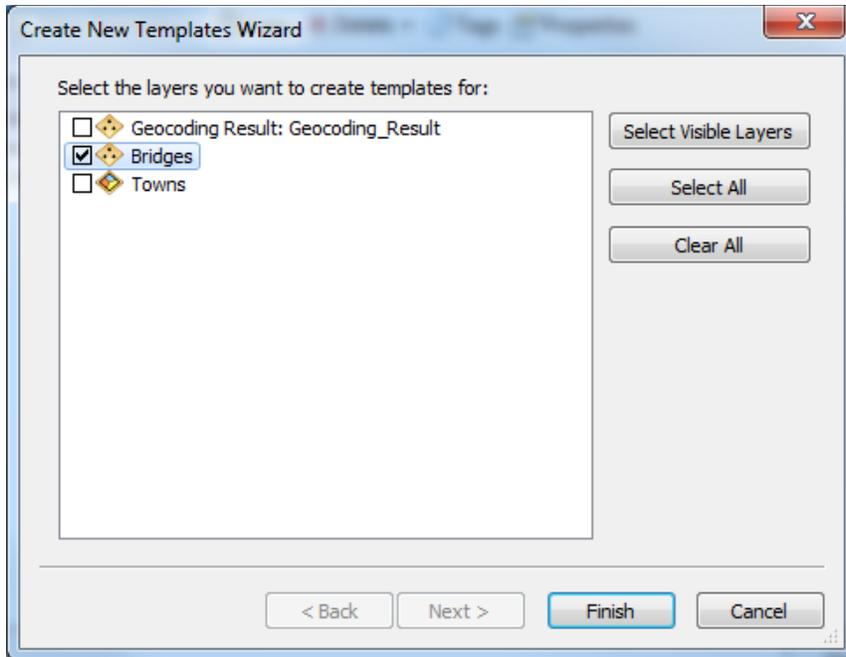


Figure 9 - Create New Templates Wizard, used for creating Feature Templates.

layer, they can get started with their editing right away without having to set up the defaults over and over again. The Create New Templates Wizard (Figure 9) is where Feature Templates are created.

For example, if you were going to create the city boundaries for all of the towns in Woolwich Township, you could create a template as follows:

1. In the Create Features window, click on the Organize Templates button to the left of the Search box.
2. Click on New Template and make sure Towns is the only layer checked, then click Finish.
3. Click on Towns in the Layers section of the dialog, select the top template, and click Properties.
4. Change the properties to reflect Figure 10 to the right.

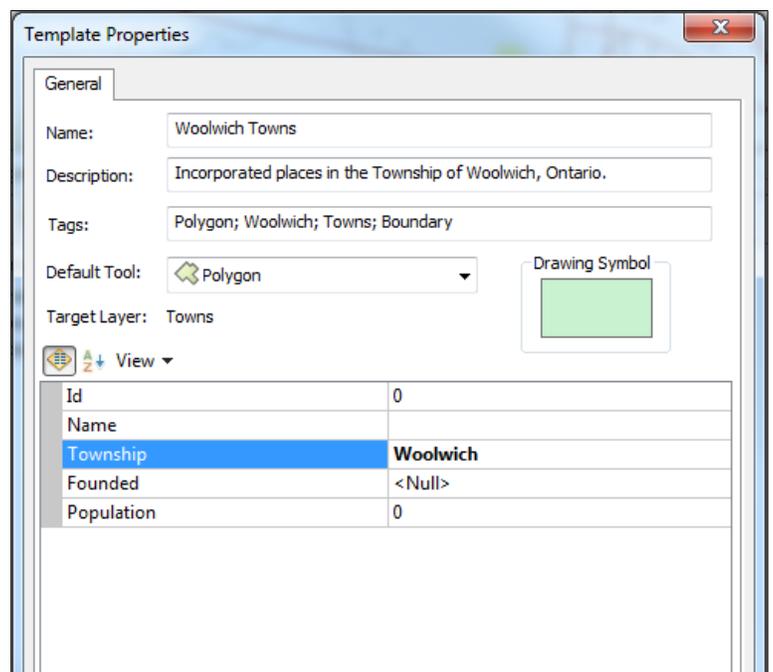


Figure 10 - Feature Template properties for Woolwich Towns.

Snapping Environment

ArcGIS uses a function called snapping to help editors ensure they are clicking precisely on a given feature and not just really close to it. This saves time not only during the edit session but also down the road by eliminating gaps and overlaps that then need to be fixed.

The basic tenet is that when you want to connect your line segments together (whether for a line feature or to close a polygon), or you want to create a point somewhere along a line (or vice versa: a line that crosses over a point), you move your cursor toward the feature you want to connect with and when it gets within a certain distance, your cursor snaps to that edge or vertex.

Snapping is enabled by default in ArcMap. However, it can be temporarily **disabled by holding down the space bar** on your keyboard. This can be useful (and sometimes necessary) in order to draw or edit features that are very close to each other without necessarily snapping to them. It will help to test it out for yourself.

1. With one of the layers selected from the Create Features window, slowly move your cursor toward one of the bridges on the map.
2. As you get within the **snapping tolerance** (set to 10 pixels by default), your cursor jumps, or snaps, to the feature. A tool tip appears telling you what layer you are snapping to and what feature type (again, useful when multiple points are in close proximity to one another).
3. Now hover your cursor over one of the edges of Towns and notice how it snaps to the edge of the feature. With polygons, your cursor can be snapped to either **an edge or a vertex**, and again, the feature type will be shown in the tool tip.

Vertex Editing

Sometimes it is necessary to change the shape of a feature, but only minimally. Suppose we learn that the town of St. Jacobs has annexed several properties on the west side of town. This means the boundary needs to be updated. Using the Edit Vertices toolbar, we can add, move, or delete vertices associated with the Towns layer.

1. Turn on the Towns layer in the Table of Contents; select the **Edit Tool** from the Editor toolbar (small black arrowhead) and double-click the St. Jacobs polygon on the map.

2. This displays all of the vertices for that feature and pops up the **Edit Vertices toolbar** (Figure 11), which pops up automatically when needed and hides itself when not.

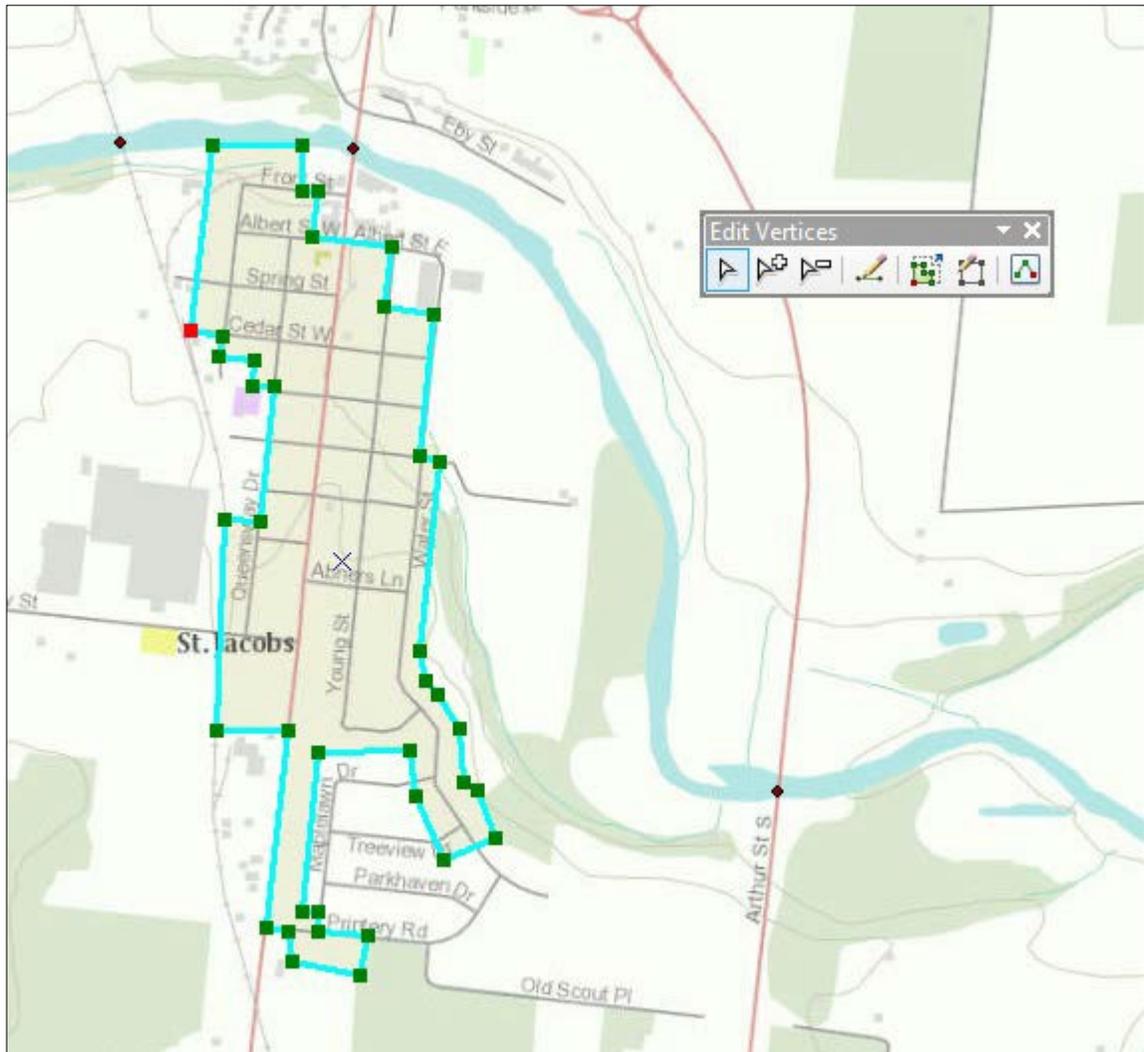


Figure 11 - Feature vertices and the Edit Vertices toolbar.

3. Select the **Add Vertex** tool (white arrowhead with a plus sign) and add three new vertices anywhere along the western border of the city boundary where it intersects with Henry St.
4. Now switch back to the standard **Modify Sketch Vertices** tool and hover your cursor over the bottom vertex of the three you just added. Notice how the cursor changes to multi-directional arrows, which allows you to click and drag the vertex to a new position.

5. **Move the three new vertices** so they encompass the buildings as shown in Figure 12 (remember that you are extending the existing lines when you move a vertex, so be aware of where and how those lines are moving as you adjust vertices).
6. Now select the **Delete Vertex** tool, which can be used to click on vertices and delete them one at a time or to drag a box around a cluster of vertices and delete them at the same time.

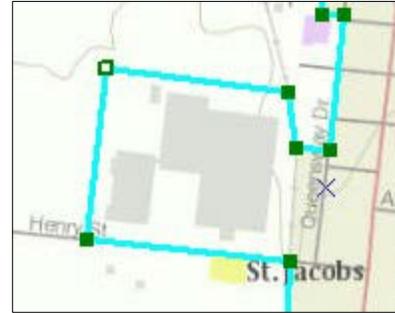


Figure 12 - Adding and moving vertices (note the white square inside a vertex indicates that it is currently selected).

7. Using one or both methods, delete the selected vertices shown in Figure 13, then click the **Finish Sketch** button (polygon outline with a pencil on top) on the Edit Vertices toolbar. You can also click on the map outside of the selected feature to deselect it and

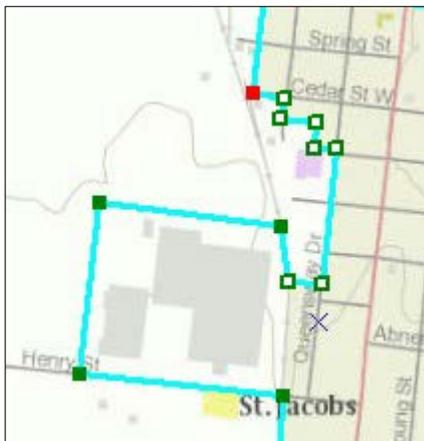


Figure 13 - Deleting multiple vertices at once (this method is a considerable timesaver compared to deleting one vertex at a time).

thereby finish the sketch (if the Add or Delete Vertex tool is selected, the first click outside the feature will disable the tool; the second click outside the feature will deselect the feature and finish the sketch).

The other tools on the Edit Vertices toolbar offer more functionality for various editing scenarios. The **Continue Feature** tool (line with a pencil) lets you continue drawing from the last vertex, or end point, of the feature (the red vertex). The **Sketch**

Proportionately tool is a toggle switch that when turned on moves all vertices in proportion with the one you are moving. And finally, for the most precision and control over your vertex editing, the

Sketch Properties tool is a dialog showing the xy positions of all the vertices in the selected feature, which allows you to manually change the xy values of your vertices as well as add z-values (elevation) and m-values (environment settings).

Georeferencing

People tend to take aerial imagery for granted, meaning because they are using an online mapping application, they can safely assume the image is in the correct position. However, it didn't start out that way, and when you add static images (rasters) to ArcMap, unless their

spatial information has been added and included already, they will not know where to line themselves up. This is where the Georeferencing toolbar can be used to make your aerial images line up properly.

1. From the Imagery folder, add the **1963_4360_131.tif** image file to the map (you will receive a warning telling you that the data is missing spatial reference, which in this case is precisely what we are going to give it). Click OK.
2. You will not see the image at first, because without that spatial reference, it doesn't know to put it on the earth's surface as depicted on your map. To see the image, you could use the Zoom to Layer function, but for this exercise, there's a handy function on the **Georeferencing toolbar** that makes things much easier. Open the toolbar if not already open.
3. From the Georeferencing dropdown menu, choose **Fit to Display** and watch the image come into view on the page. This is useful because we won't have to switch back and forth between the image's original location and St. Jacobs as we set the Control Points to line it up.
4. Turn off the Towns layer and set the image's **Transparency to 50%** so we can see what's underneath on the basemap.

Note: You may need to change the Transparency to suit your level of viewing comfort, in which case, if you cannot see the basemap underneath, you'll need to toggle the imagery layer on and off to see where and how things line up.

5. On the aerial image, find the intersections of **King St/Henry St** and **King St/Printery Rd**, keeping in mind that the image may not be rotated with north up. Once you have found those intersections on the image, you can now begin to line them up with the basemap.
6. On the Georeferencing toolbar, select the **Add Control Points** tool (green cross connected to a red cross) and beginning with the image as your bearing, click on the intersection of King & Henry, followed by the corresponding intersection on the basemap.
7. Now add another control point at King & Printery and connect it to the corresponding intersection on the basemap. These two connectors have **rotated the image** so that it lines up perfectly with the basemap (Figure 14), so there's no need to add more control

points. However, in some cases, it is necessary to add additional control points in order to properly line up the image.

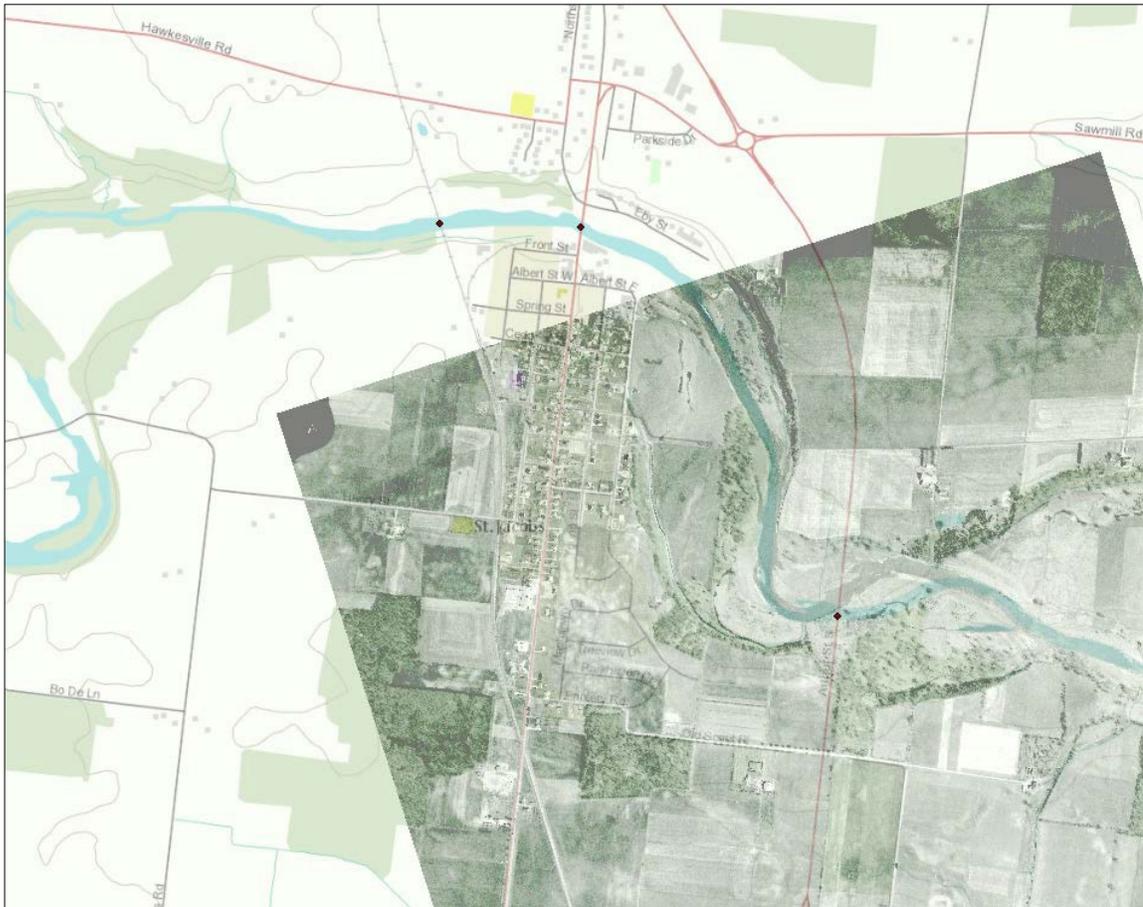


Figure 14 - Georeferenced orthoimage of St. Jacobs, Ontario, 1963.

8. To set this orientation and write the spatial information to the image file, select **Update Georeferencing** from the dropdown menu. With the process complete, we can now look at the Properties of the image layer to see what we've added.
9. Under the Source Tab of the Properties window, scroll down to the **Extent and Spatial Reference** nodes. The extent (bounding box) of the image is determined using the units of measurement from the map (in this case, meters). The spatial reference is similarly determined by the Data Frame Properties (in this case, NAD_1983_UTM_Zone_17N)
10. Click OK to close the Properties dialog and repeat this process with the **1963_4360_133.tif** file to get full coverage of St. Jacobs from the 1963 aerial imagery.

Data Sources

The pre-existing data used in this tutorial (i.e. not the data created in the exercises) was generated manually from online sources as cited below.

Google, Inc. Google Maps. *Lat-long coordinates for dropped-pin sites*. Generated by Talsan Schulzke for the University of Waterloo Geospatial Centre;
<<https://www.google.ca/maps/@43.5360111,-80.5519841,15z?hl=en>> (June 2014).

National Air Photo Library. *Kitchener-Waterloo 1963*. Scale 1:11,950. Ottawa: Natural Resources Canada, 1963.

Ontario Roads Locator. CanMap Streetfile 2013. Markham, ON: DMTI Spatial, 2013. Available: University of Waterloo Geospatial Centre Controlled Access DATA PC
Z:\Canada\DMTI\2013\CanMapStreetFile\CanMapStreetFile\CanMap
Streetfiles\ON\Streets (June 2014).

St. Jacobs Country. stjacobson.com. *Select historic sites*. Compiled by Talsan Schulzke for the University of Waterloo Geospatial Centre; *St. Jacobs Self Guided Historic Walking Tour*. St. Jacobs, ON: St. Jacobs Country, 2011;
<http://www.stjacobs.com/sites/default/files/SELFGUIDEDHISTORICWALKINGTOURWeb_000.pdf> (June 2014).

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