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Mapping 18th & 19th Century Land Surveys

General Formats

Various surveys from various people are in different units. The most common denominator is the unit of the surveyor's chain, or generally shortened to Chains. A chain is 20.1168 meters long, and there are 80 chains to the survey mile (Note that this is not a statute mile – although the two are very similar). Some surveys (more common in later surveys, which capture more detail) further break this down into links, which are each 1/100th of a chain.



Surveyor's Chain (Image courtesy of the Jordan Historical Museum)

Most land surveys of the time denote distance from a stated point in order to give position of features. The surveyor gives a feature to start from (Birch thicket, east of town, the heights by the creek, etc.), or a latitude and longitude, and then gives a bearing on which they will survey along. Depending

on the type of survey (e.g. initial survey, or later detail survey), the entire survey may be along a single line, on a broken line, where the survey will change direction, or along the square borders of a township.

As well, it is possible that the surveyor will have surveyed multiple lines, and this will be denoted, but it is vital that one reads the entire document first in order to gain an understanding of what has been surveyed.

After the chain, however, it becomes a matter of identifying the units and style used by the individual surveyor. In this case, it is vital to possess some cartographic knowledge of units of distance and position in order to identify the system used.

One common method for the initial surveys was to denote distance from a corner of a township in miles, followed by chains. A specific example is William Hambly's 1795 survey of Darlington Township, which denotes in this method.

Another method is to show distance in terms of which concession the surveyor was in. Since the township system is a grid of generally equal measures, this is a system that is relatively easy to follow. If the surveyor is moving along a north-south direction, the math to follow along is easy, since each concession is 100 chains long. In an east-west direction, this is somewhat harder to tell, as the distance can vary county to county. As such, the best practice is to find an NTS or similar map of the county and measure the distance manually. In this way, the measurements will be accurate.

There are also some surveys that give a latitude instead of a concession, and count up chains and links from there. The latitude will generally appear in the Notes column of the survey table.

Cadastral Surveys

Contemporary cadastral surveys are somewhat more confusing to reference without a map of the lots, as the lot size can vary between townships. An excellent reference in this case is a historical atlas of the area, as it will denote the lots, and even owners in most cases.

Boundary Surveys

Boundary Surveys were most often done as an initial survey of an area. Otherwise, they were performed as an initial step when surveying previously surveyed townships. A boundary survey is a survey of the vegetation around the perimeter of a given township or area. Depending on the time and the surveyor, they sometimes include lot numbers as the surveyor passed them, and most all of them include the concession numbers as the survey passes. An example with the lot number is included below in Figure 1, and an example without is given in Figure 2.

The notes will start with a description of the starting point of the survey. The surveyor would attempt to pick some permanent or semi-permanent feature, such as a dense clump of trees, a church, a house, or a crossroad if possible. These features would become the defining corner of each township.

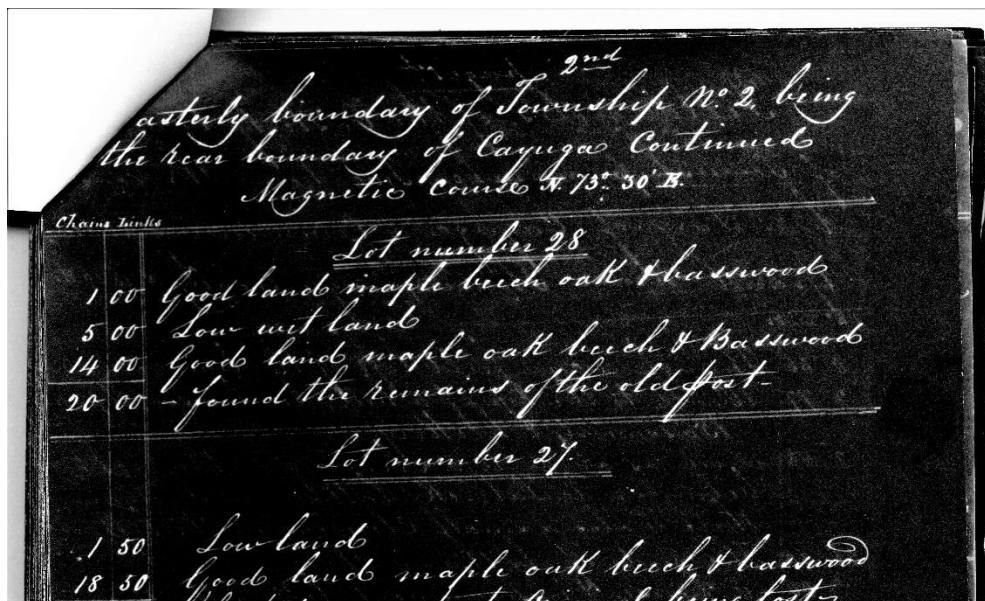


Figure 1: Boundary Survey with Lot numbers

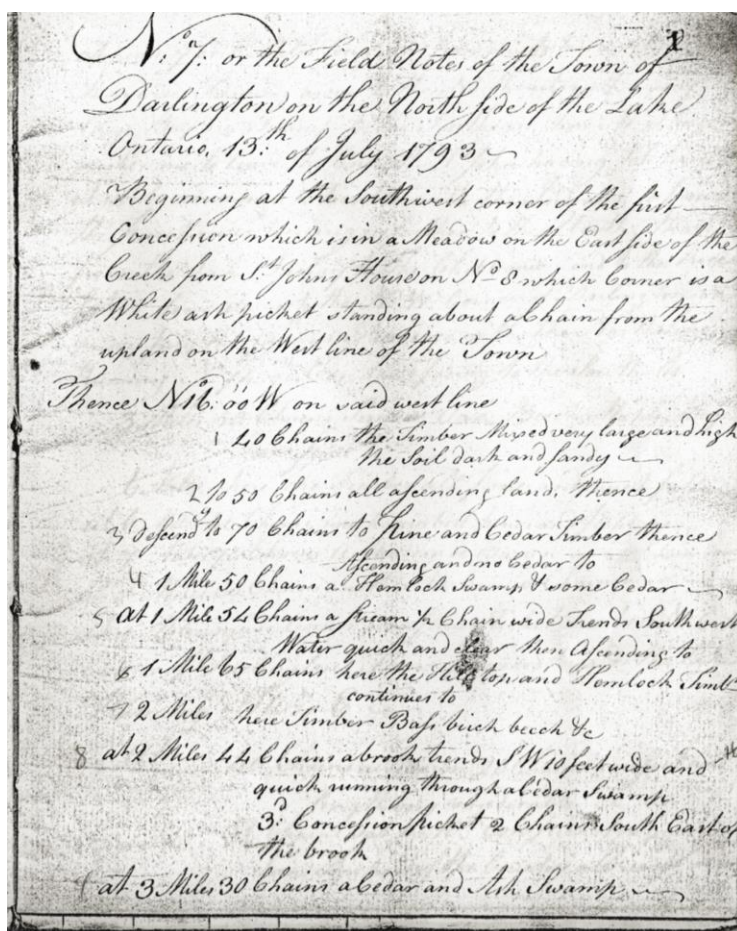


Figure 2 (Left): Boundary Survey without lot numbers

Interior Surveys

The other major type of survey was the survey of the interior of a township. This was often done in conjunction with a boundary survey, unless the entire survey was for a portion of the entire township.

These portional surveys will be given from either a set coordinate, or more likely from a landmark. As with other non-lot-based surveys, the features will be given as points along given distances on a given bearing.

Mapping

If more is desired from the survey than simple data, such as in the case of historical vegetation studies, then mapping is required. This falls into two broad categories: hand cartography, which is more

straightforward, but requires georeferencing to bring onto a computer; and GIS-based cartography, in which the data is drawn in a GIS such as ArcGIS or QGIS.

Mapping by Hand

In the case of mapping out older land surveys, it can be considered easier to draw by hand, given a protractor, ruler, plenty of paper, and a pencil. Because most surveys follow a straight line, and the oldest (the surveys directly after acquisition of the land) follow the boundaries of the township, they can be easily drawn without any spatial reference.

Having gained an understanding of the units and styles of the survey notes, it is time to begin mapping. There are two main methods to mapping the surveys by hand: the unreferenced and the fill-in method. Each has its application and use, and each is suited best to different data.

Unreferenced Method

The unreferenced method is the best method for surveys that are a regular shape, such as the initial boundary survey of a township, or a single-line survey (such as one re-surveying a boundary). The unreferenced method has the advantage of being easier and faster to perform than the fill-in method, but is more prone to error than the fill-in method, and thus surveys with multiple survey lines are better suited to the fill-in method.

Performing the Unreferenced Method

The first step in mapping out surveys using the UM is to determine which scale one wishes to map at. This choice depends on what level of detail is present in the survey, as well as what one wishes to do with the map once complete. Choosing a scale that matches topographic maps of the area being mapped is a good choice, as it allows one to overlay the mapped data over the topographic maps, and thus compare data and position. However, if one is planning on later scanning and georeferencing the map, the scale is not of great importance, so long as the scale is consistent.

Having chosen the scale, the units to draw with are the next concern. The easiest to use will likely be centimeters, as they make for easy math after the conversion, and centimeter rulers are easy to come by. As well, it is key to convert miles to chains at 80 chains to the mile first, and use the links as the decimal of the chains (there are 100 links in a chain). With these in mind the **conversion factor** for converting from chains is as follows:

Convert Chains -> Centimeters (change miles to chains at 80 chains to a mile first)

$$\text{Conversion Factor} = \frac{2011.68}{\text{Scale}}$$

Write this factor down, as you will use it extensively in the mapping process.

Finally, it is time to begin mapping! If the line you are drawing is unbroken, and does not change direction, then starting is easy: Determine the first and last points, and the distance between them (easy, since the distance in the notes is often the distance from the starting point), and draw a line in that scale distance on your paper(s). So, if the last point is 12 miles (a normal township) away from the first point, and you are drawing a map in 1: 25,000 scale, you can find the scale distance as follows:

$$12 \text{ miles} \times 80 = 960 \text{ chains}$$

$$\text{Conversion Factor} = \frac{2011.68}{25000} = 0.0804672$$

$$\therefore \text{Scale distance} = 960 \times CF = 77.25 \text{ centimeters}$$

Thus, you would draw a line 77.25 centimeters long.

If the line is broken by the surveyor changing direction, you draw the first section as a complete line as described above, then you calculate the difference in bearing between the first and second segment of the line, and use your protractor to draw a line that is whatever difference in bearing off from the first segment, and draw the second segment as above, and so on and so forth.

If the path branches, simply start the branched line from the main segment as above.

Once your line is drawn, you can begin to plot the vegetation and features along it. This is fairly simple once the line has been drawn. For each successive entry, convert the distance, and plot along the line you have drawn. It may be helpful to shorten the names of vegetation; i.e. Beech to Be, Poplar to P, etc. A sample set used by the University of Waterloo Faculty of Environment in the 1970s is included in Figure 1.

Feature Type	Feature Abbreviation
Alder	Al
Ash	A
Ash black	Ab
Ash white	Aw
Basswood	Bd
Beech	B
Birch	B
Butternut	Bu
Cedar	Ce
Cherry	Ch
Chestnut	C
Cleared	Cl
Dogwood	Dg
Elm	E
Fallow	F
Fire	Fi
Hazel	Ha
Hemlock	He
Hickory	Hi
Hurricane	Hu
Improved Land	Imp
Maple hard	Mh
Maple Soft	Ms
Marsh	Ma
Meadow	Md
Mixed	Mi

Feature Type	Feature Abbreviation
Oak	O
Oak black	Ob
Oak red	Or
Oak white	Ow
Pine White	Pw
Plain	Pn
Poplar	Po
Sassafras	Sa
Sycamore	Sy
Tamarack	Ta
Thickets	T
Walnut	Wa
Wheat	Wh
Willow	W
Windfall	WF

Figure 1: Abbreviations for features

The features are generally listed with what they are, where they trend (if it is a hill or stream), and how big they are (width of stream in chains), as well as information about the nature of the feature (e.g. clear water, very tall trees, young trees, good soil, loamy ground, etc.). If there is something going on around them (fire, human activity, etc.) it will generally also be noted, although this depends on the surveyor.

Continue this process until the survey is complete. At this point, you can either overlay it on a same scale paper map and trace the features of the paper map, thus yielding a map showing the relative locations of the features once aligned correctly. In order to align correctly, one must determine the bearing upon which the survey started, and align the drawn map from the known starting point with the rest of the map. This can be checked by looking at the noted locations of more permanent features, such as creeks and large rocks, as well as by the knowledge that most surveyors remained on roads during their surveys. Alternatively, you can continue on to georeferenced or digitizing the map in a GIS, such as the paid ArcGIS or the free QGIS, for which there are directions in Appendix 1.

Fill-In Method

The fill-in method is a different approach to the map creation which involves tracing a pre-made map and drawing the features of a survey in. This method has the advantage of being more accurate than the unreferenced method, due to being constrained by an accurate dataset. This method has the downside of being somewhat time-consuming, and requiring both a paper map of the area in question, as well as appropriate tracing tools.

To begin, choose a map of the area that the survey you are interested is located within. The map should have enough detail that some or all of the features in the survey would be listed if the survey was made at the same time as the map. As such, 1: 25,000 NTS maps are a good choice, although you may require multiple, depending on the survey. If you have a historic map of the area in enough detail, that would be a good choice, provided you know the scale of the map.

With the map chosen, you can begin tracing features from the map onto your new map. Be sure to include attribution on your map of the original, and ensure that there are no restrictions on using the map as a source for features (insurance maps are not good sources for this reason. Provincial base maps and NTS maps are better choices). In tracing, ensure that your map is affixed somehow to the map you are tracing from, so as to ensure that there is no error in copying.

Trace key elements of the base map first, such as the concession and side line roads, which will serve largely as the basis on which you can locate surveyed features. Include rough outlines of large cities, and note any towns in the area. These should serve as a good starting point. If you wish to include clearly modern features, such as highways, you can, although they will likely not be relevant to the survey.

Drawing the map – line surveys & beginning a map

Drawing in the survey features in this method is much similar to that of the unreferenced method. Locate the starting point of the survey, which may be either a pair of coordinates, or may be a local reference that will require you to utilize air photos or Google Maps to locate. If the survey is the initial survey of a township, the starting point is generally a corner of the township, which is relatively easy to locate, but for other types of surveys it could be anything, but will be described.

Once the starting point has been located, the survey direction will be mentioned in the survey. This survey is generally along a road, so one can take advantage of this and find the road that most follows the direction given. To verify this is the correct direction, find a stream or other permanent feature in the survey and measure out the distance along the road to the stream on your map (or the traced map, if you did not include streams). If the feature is located where the surveyor wrote it was, you have the correct road.

Once you have the road you are drawing along, you can begin drawing features. Draw features along the road at the specified distance in the survey, converted to scale distance. To convert to scale distance, calculate as mentioned above, or as included below:

It is key to first convert miles to chains at 80 chains to the mile first, and use the links as the decimal of the chains (there are 100 links in a chain). With these in mind the **conversion factor** for converting from chains is as follows:

Convert Chains -> Centimeters (change miles to chains at 80 chains to a mile first)

$$\text{Conversion Factor} = \frac{2011.68}{\text{Scale}}$$

What follows is an example of conversion:

$$12 \text{ miles} \times 80 = 960 \text{ chains}$$

$$\text{Conversion Factor} = \frac{2011.68}{25000} = 0.0804672$$

$$\therefore \text{Scale distance} = 960 \times CF = 77.25 \text{ centimeters}$$

In this way, you can note any features mentioned in the survey, most easily by drawing a perpendicular line on the side of the road that the survey mentions (or both sides if none is mentioned), and noting the feature in abbreviated form, such as the forms shown in Figure 1.

Drawing the map – Cadastral surveys

In the case of cadastral, or property, surveys, the features are generally listed under each property. In this case, it is vital to have contemporary property maps or atlases of the area in the survey, as the division of lots will not always be clear. If you have a scale-listed map and a contemporary map, but without scale, you can convert as follows:

$$\text{Length Conversion Ratio: } \frac{\text{Non – scale distance between concessions}}{\text{Scale map distance between concession lines}}$$

$$\text{Width Conversion Ratio: } \frac{\text{Non – scale distance between side lines}}{\text{Scale map distance between side line roads}}$$

$$\text{Scaled map lot dimension: } \frac{\text{Non – scale lot dimension (x or y)}}{\text{Relevant conversion ratio}}$$

Then, simply draw in the lots at the appropriate dimensions, and label by number according to the contemporary map (not by name, there's a good chance the surveyor used the numbers as well). If you do not have numbers, attempt to figure the number system out using topographic features listed in the survey and cross-reference with the base map.

Once you have the lots labelled, you can begin to fill in features. This is just a matter of matching lots and measuring out what distances are mentioned in some entries in the survey notes.

Mapping in a GIS

Mapping in ArcGIS

Mapping the survey data in a GIS is very similar to the fill-in method listed above in that everything is done with reference to base materials. However, there are some advantages and disadvantages to mapping in a GIS. The chief advantage is the applicability of the data once mapped. Once mapped in a GIS, it is easy to compare historic data to current data, and paint a picture of change over time. The chief disadvantage is the need for accuracy and the difficulties in drafting common with GIS, as well as the need for underlying GIS knowledge, not to mention the costs in acquiring some GIS software.

Step 1: Acquiring Data

To map the survey data, unless precise coordinates are given, you will need some other data to create your map. Luckily enough, most of this data is publicly available. The main datasets you will need are the roads and the geographic township data, both of which can be acquired from the Province of Ontario's Open Data website (<https://www.ontario.ca/data/>). Ensure that the first data you add is in a projected coordinate system. This is important, as ArcMap will force all your other data into a GCS if the first data is not projected, and will be unable to convert units or edit properly.

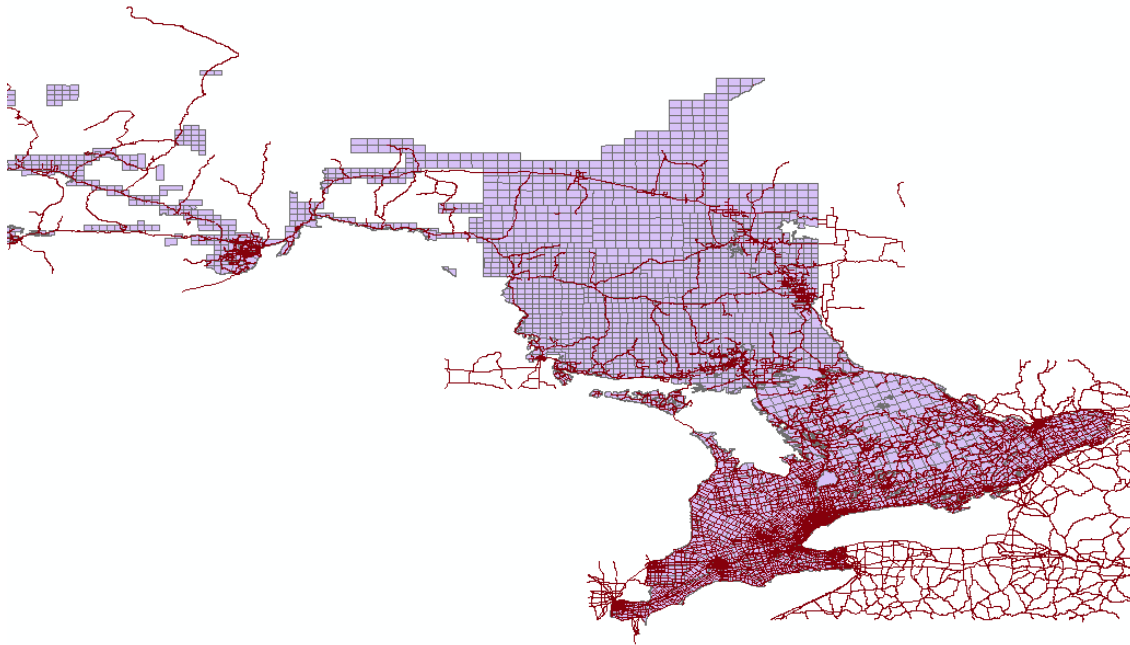


Figure 2: Open Data in default configuration

The data, once added to ArcMap, will look something like what is shown in Figure 2 above. In order to make the map easier, use the Select By Features tool to select the township(s) you are interested in. Once you have selected your townships, right click on the layer in the Table of Contents and export the selection as a shapefile under the Selection submenu. As you add data, you will want to clip them to the township(s) you have selected.

At this point, you are ready to begin drawing most surveys, although you may wish to acquire stream data, or symbolize roads based on size. If the area you are mapping has higher quality data available on the county or region open data site, it is highly recommended that you use that data instead, as the provincial data is often not complete in terms of local side line roads, as shown in the example township of Darlington in Figure 4, below, where the base line road, which is necessary to locate the start of the township, is not included.

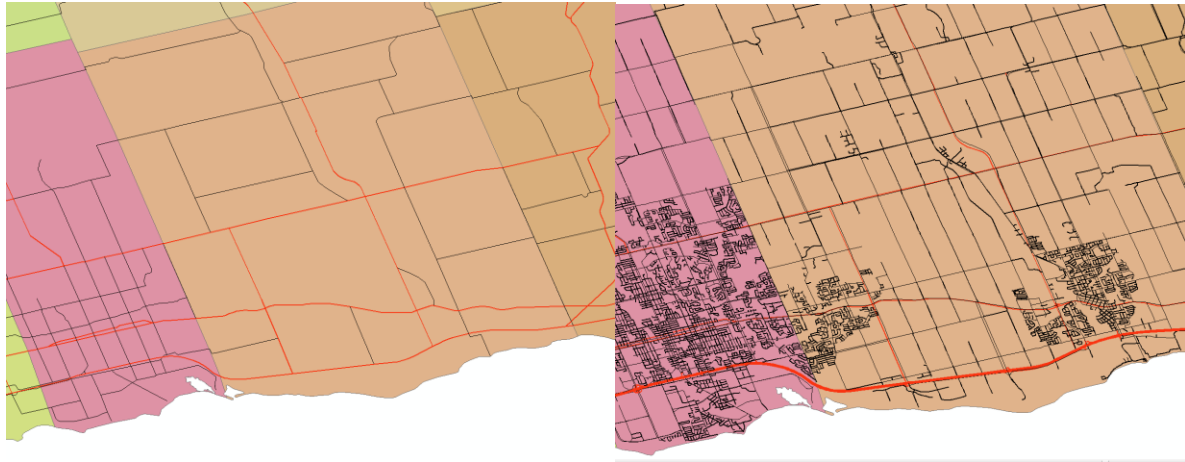


Figure 4: Missing roads – compare left (province open data) and right (county open data)

Mapping

To begin mapping, locate the start of the survey. Use the relative or absolute reference the surveyor uses to locate this, and acquire more data if necessary. In this tutorial, the first line of the 1795 boundary survey of Darlington Township by William Hambly will be mapped. As such, Mr. Hambly states that the survey

“[began] at the Southwest corner of the first Concession which is in a Meadow on the East Side of the Creek from St. John House on No. 8 which Corner is a White ash thicket standing a Chain from the upland on the West line of the Town.”

This is a relatively easy location to find, even though Mr. Hambly was quite verbose in his description. Often, older surveys describe the area at the beginning in great detail, so as to make location on the ground easy for future readers. However, with the great volumes of data available to us, it is easy to locate the southwest corner of the First Concession. Given that townships are laid out in a regular fashion, the southwest corner of the first concession is the point at which the baseline road meets/would meet the next township over. It is necessary to specify the baseline road, as there is often a section of shoreline around lakes that is included as an extra portion of the township, but is not included in the grid.

Using the Identify Features tool, we can find which road is the baseline road fairly easily, as shown in Figure 5. Once found, we can find the connection point using a ruler on the screen, or an Arc ruler and create a point at the location with the Editing Toolbar. To do so, we will first use the tool Create New Feature Class, which can be found by searching for it using the search tool in Geoprocessing. Make the new layer a Point layer, and put it somewhere relevant. Give it a reasonable name, and then add the Editing Toolbar to your ArcMap window, by right clicking anywhere on the toolbars at the top. Click the Editor dropdown menu, and Start Editing. Use the Create Features window to create a point where the start of the survey is. Click Save Edits and Stop Editing after you create the point. You may have to add the Create Features window, pictured in Figure 6, if it is not there already.

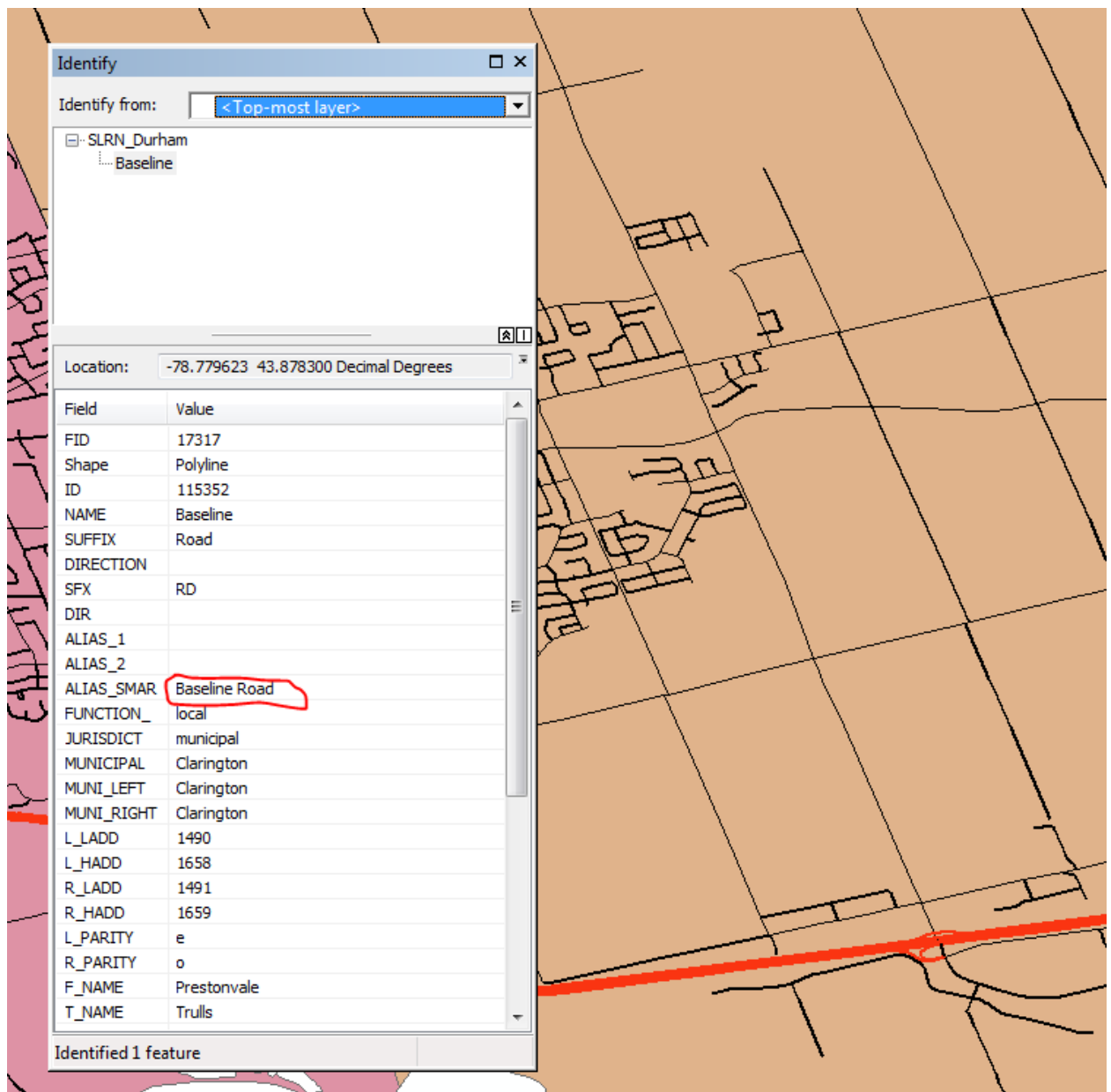


Figure 5: Baseline Road



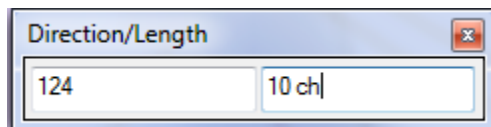
A note about creating lines in ArcMap:

Direction given at the bottom of the screen is measured counterclockwise from East by default. Check before you begin.

If you create a specific length line, units are in map units.

Figure 6: Create Features Window

The next step is to draw a line along which the surveyed points will fall. If the survey occurred along the township boundary, then this step is not necessary, as you can simply place points along the boundary, however if this is not the case, the process is a little more involved. Create a new Feature Class using the tool as before, and begin editing. Create a line that is as long as the survey you are mapping, along the direction of the survey. As noted above, ArcMap provides direction counterclockwise from East. Distance at the bottom while editing is given in map units, and distance when created specific length lines is in map units by default. If you press Ctrl-G, you can enter an exact bearing (clockwise from East) and a distance, which you can provide a unit for, as shown below:



At this point, you will likely want to make a list of the points you will be drawing, and convert them to map units. Since you are not creating a physical map, you do not have to convert scale. Thus, if your map units are meters, you simply multiply a chain value by 20.1168 meters.

Next, using either the Direction/Length tool and the Point at End of Line tool in Create Features, or using the Measure tool, you can start placing your points. You can either edit the attributes of points as you go, or edit them after you have finished placement. Note that if you use the Point at End of Line tool, you can forgo the creation of the survey line in the previous step.

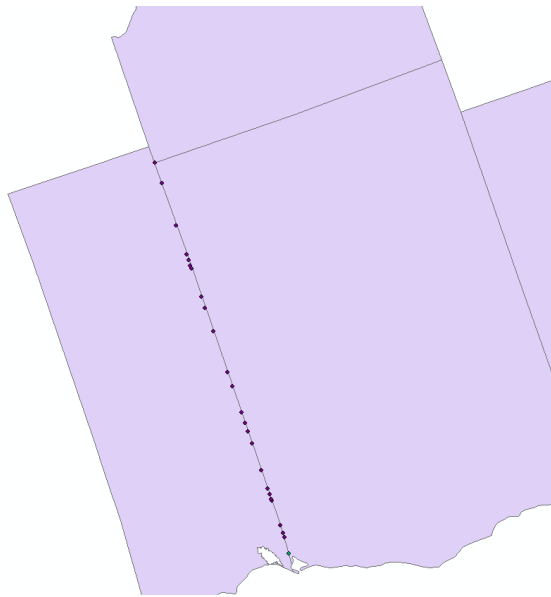


Figure 7: Survey Points

Editing Attributes

When adding attributes to your points, you may want to take one of two approaches to classification. The first is to use a numbered system, in which each number is coded to a feature value. This is preferable if you are within a geodatabase, as coded values can be used as a domain. Another possibility, and the one used in the example, is to use text based classification. In either, case, you will need to create one or more additional fields outside of the edit session, by opening the attribute table of your survey points, and adding the fields. Depending on your use for the data, you will want to change this form of representation. If you are doing this at the Geospatial Centre, and use a text system, the Centre has a script that changes a series of points, each with multiple 2 letter codes (e.g. one point has AbAlMh) into a new series of points, each with only one form of vegetation.

Now that you have your fields, start an Edit session, and open the Attributes task pane. Next, using the Edit tool, you will want to select each point in turn, and add the data from the survey notes.

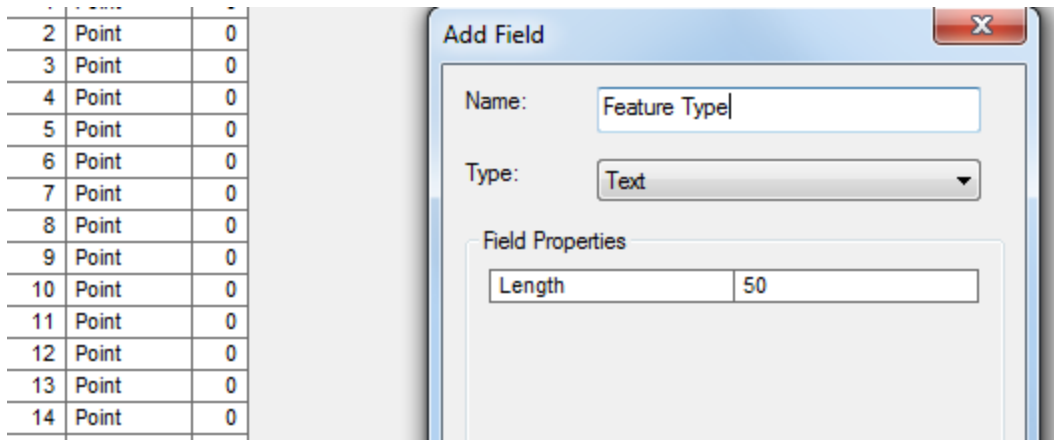


Figure 8: Creating fields

FID	Shape	Id	FeatureType	FeatName
0	Point	0	Veg	Mi
1	Point	0	Oth	Asc
2	Point	0	Veg	PCe
3	Point	0	Veg	HelMaCe
4	Point	0	Feat	St
5	Point	0	Veg	He
6	Point	0	Veg	Be
7	Point	0	Feat	St
8	Point	0	Veg	CeAMa
9	Point	0	Null	Null
10	Point	0	Feat	Desc
11	Point	0	Feat	St
12	Point	0	Feat	St
13	Point	0	Veg	Mh
14	Point	0	Feat	St
15	Point	0	Feat	St
16	Point	0	Feat	St
17	Point	0	Feat	Lev
18	Point	0	Feat	Pond
19	Point	0	Null	Null
20	Point	0	Feat	St
21	Point	0	Null	Null
22	Point	0	Null	Null
23	Point	0	Veg	Be
24	Point	0	Veg	Aw

Figure 9: Filled Fields

As shown in Figure 9, you may not be able to get detailed data for each point. As such, you could assign a vegetation data value based on the nearest known vegetation, or leave without.

Mapping in QGIS

QGIS is an open-source GIS software, which comes with the obvious advantage of being free for anyone to acquire. As such, it is ideal for small companies, and single users, as the lack of the complete analysis suite of ArcGIS is of no issue. There are various advantages to either ArcGIS or QGIS that do not merit being brought into this guide.

Step 1: Acquiring Data

To map the survey data, unless precise coordinates are given, you will need some other data to create your map. Luckily enough, most of this data is publicly available. The main datasets you will need

are the roads and the geographic township data, both of which can be acquired from the Province of Ontario's Open Data website (<https://www.ontario.ca/data/>). Unlike ArcGIS, when adding each layer, you can choose which projection to display it in, and can also change the projection of the whole map by right clicking on a layer with the projection you want.

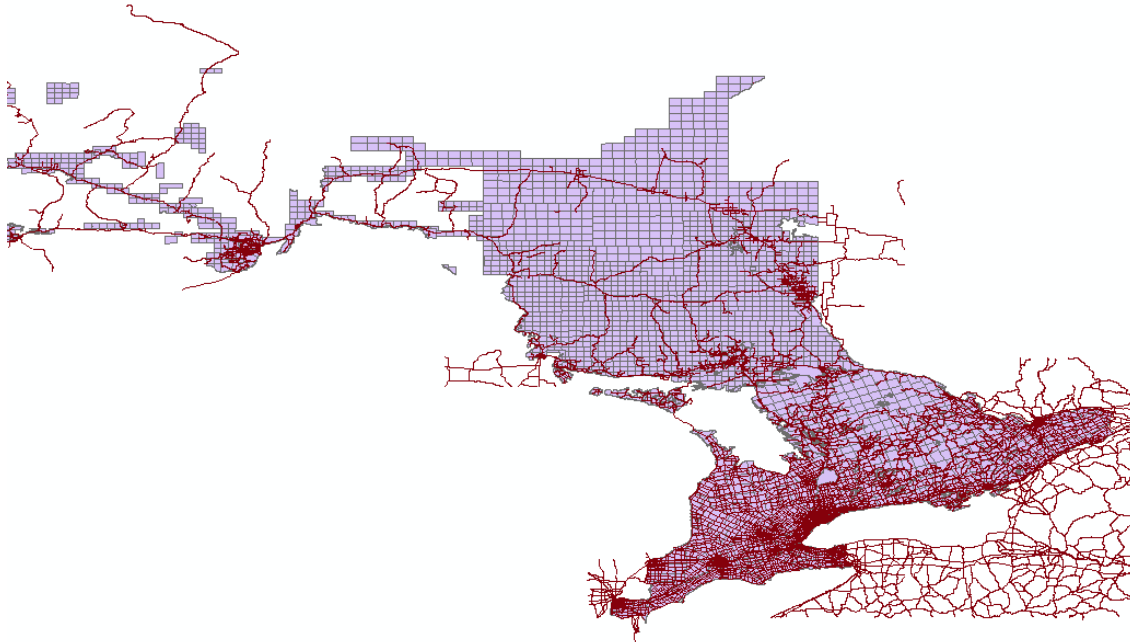


Figure 2: Open Data in default configuration

The data, once added to QGIS, will look something like what is shown in Figure 2 above. In order to make the map easier, use the View->Select->Select By Expression tool to select the township(s) you are interested in from the tool's Fields and Values submenu. Once you have selected your townships, right click on the layer in the Table of Contents and export the selection as a shapefile using Save As. As you add data, you will want to clip them to the township(s) you have selected.

At this point, you are ready to begin drawing most surveys, although you may wish to acquire stream data, or symbolize roads based on size. If the area you are mapping has higher quality data available on the county or region open data site, it is highly recommended that you use that data instead, as the provincial data is often not complete in terms of local side line roads, as shown in the example township of Darlington in Figure 4, below, where the base line road, which is necessary to locate the start of the township, is not included.

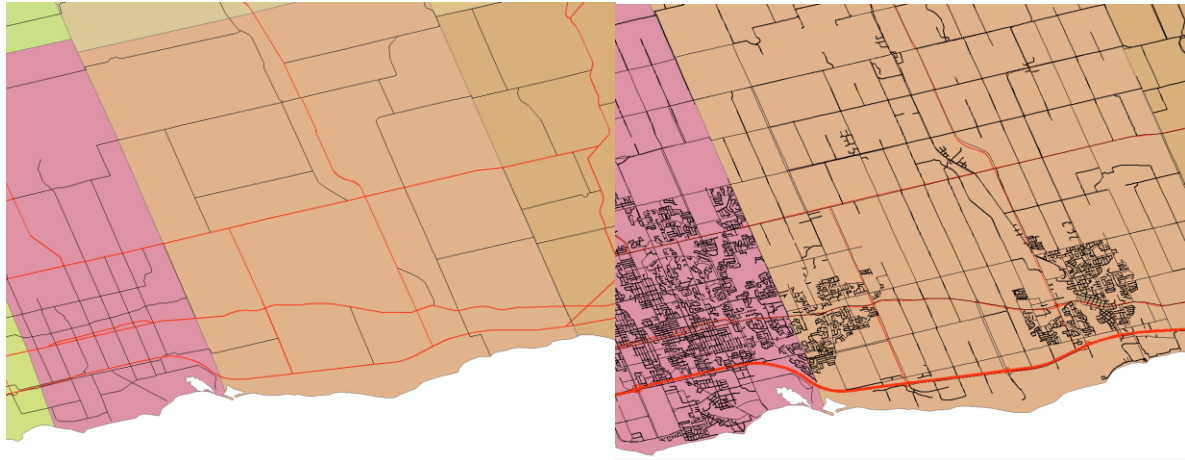


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Using the Identify Features tool, we can find which road is the baseline road fairly easily, as shown in Figure 5. Once found, we can find the connection point using a ruler on the screen, or the Measure Tool and create a point at the location with the Editing Toolbar. To do so, we will first go to Layer->New->New Shapefile. Make the new layer a Point layer, and put it somewhere relevant on your computer. Give it a reasonable name. Click the yellow marker to start editing. Use the Add Feature tool to create a point where the start of the survey is. Click Save Edits and the yellow marker to stop editing after you create the point.

Next, for actual mapping of points, you will want to use the Distance/Azimuth plugin for QGIS. If you do not already have it installed, you can acquire it through the Manage Plugins tool, under Plugins. With this tool, you can use the From Map button to set the initial reference, and then enter in the

azimuth the points fall along, and then give a distance (in map units, generally meters). Unlike ArcGIS, you are limited to default units. Once you have entered your numbers, click Add To Bottom, and then click Draw. This should add the point to the map. Continue this process by clicking on each successive point. If this encounters an error, it may still draw a line, but you will have to add a point using the add feature tool at the end of the line.

As you add points, QGIS should prompt you for attribute information. If it doesn't, you can add attributes after easily in the attribute table, or by selecting each point in turn.

This concludes the tutorial on the mapping of historical survey notes in paper form, ArcGIS, and QGIS.