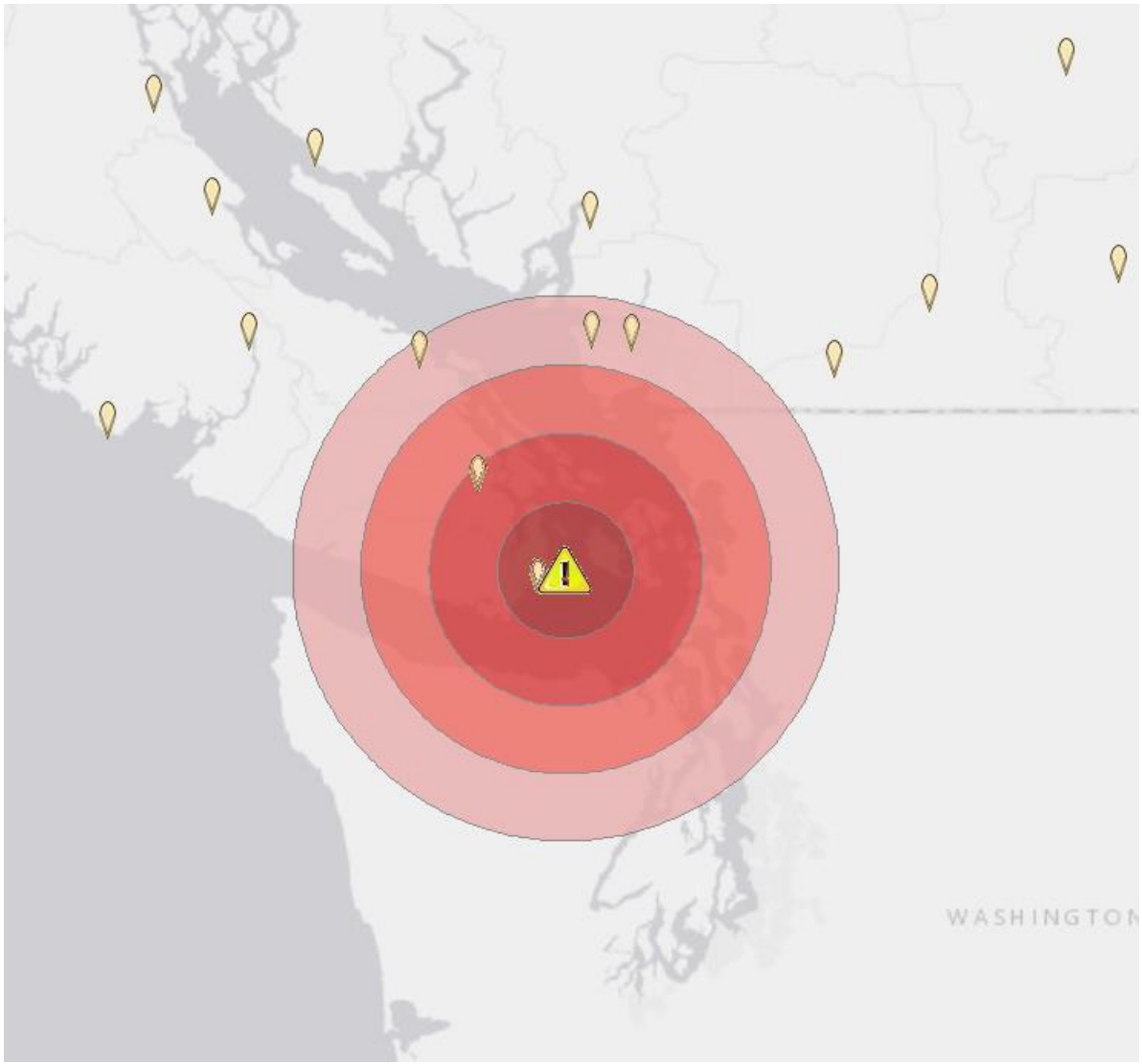
Spatial Analysis Using ArcGIS



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Background

Definition: Buffer Analysis is used for identifying areas surrounding geographic features. The process involves generating a buffer around existing geographic features and then identifying or selecting features based on whether they fall inside or outside the boundary of the buffer. Buffers are commonly used to assess and closely analyze environmental impacts, as you will see in this tutorial.

Briefing: In this tutorial you are going to use the data provided to highlight areas where earthquakes had the most profound impact on Canadians in 2002. You are going to use various **selection** and **buffering** techniques to establish areas where large earthquakes were located within a close proximity to populated places. First, you are going to use the **Select by Attribute** function to select places that had populations larger than 10,000 people, and all the earthquakes with magnitude greater than or equal to 5. Then you are going to use the **Select by Location** function to select populated places within 100km of a large earthquake. You will then use this information to create a series of buffers to assist you in some distance and population analysis.

By the end of this tutorial, you will have a clear map which demonstrates which earthquake had a significant impact on Canadians in 2002.

Overview

In this tutorial, you will learn how to:

- Change the projection
- Select features by definition query or their attributes
- Create a new shapefile
- Select features based on their location
- Use the buffer tool to create single or multiple ring buffers
- Perform a field calculation
- Label features

Getting Started

The data used in this tutorial includes three shapefiles:

- Quakes2002.shp – Information on earthquakes occurred in 2002
- Places.shp – Population of each geographical location
- Province.shp – Provincial and territorial boundaries

1. Start ArcGIS Pro. In the welcome window select “Open another project”.
2. Browse to the folder that you have unzipped this tutorial to and select bufferingpro.aprx, and then click **Ok.**

Fixing a "broken" APRX

If, when you open the APRX file, no layers appear and your Table of Contents pane looks like this (Figure 1), it is a very easy fix.

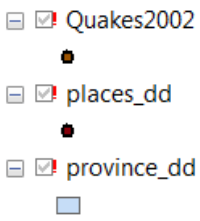


Figure 1 – APRX problems

1. Remove all the layers from your table of contents.
2. Click the Add Data button ( )
3. Navigate to the folder where this APRX file came from
4. Select the three files you see in the folder
5. Click Add.

Change the Projection

The original projection is in a geographic coordinate system (Latitude and longitude) which we will change to *Canada Lambert Conformal Conic.*

1. To change the coordinate system to a different projection, double click on **Map** in the Contents pane. This will bring up the Map **Properties** dialog box.
2. Select the **Coordinate System** tab and navigate to the Canada Lambert Conformal Conic, located under Projected Coordinate Systems → Continental → North America → Canada Lambert Conformal Conic (See Figure 2)
3. To confirm this is the coordinate system you wish to use, click on it to select it. Under the General tab change the display unit to Meters. Click OK and if a warning occurs, simply click Yes until the warnings go away.

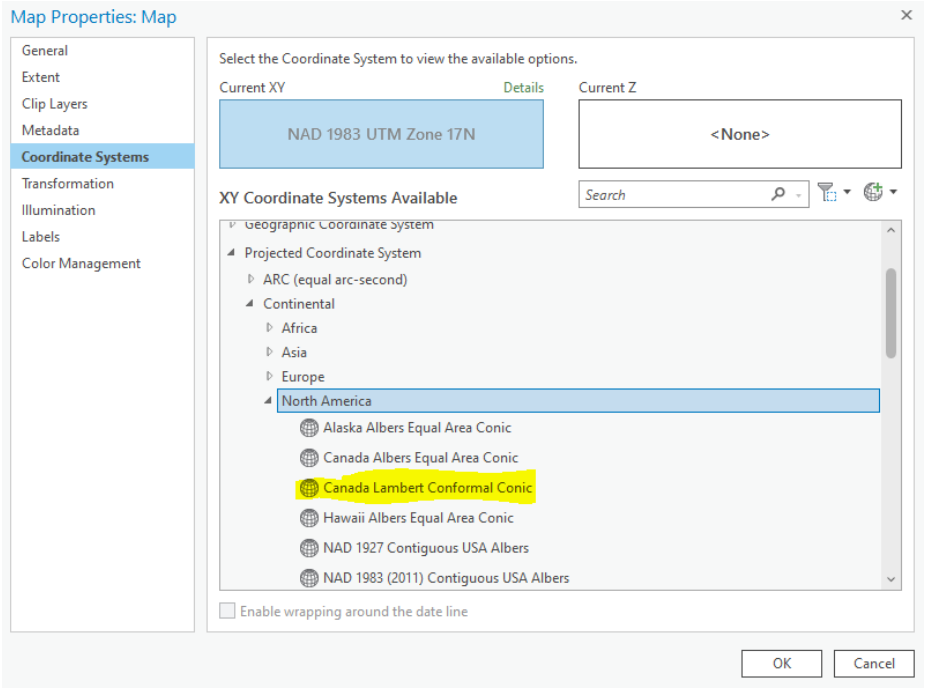


Figure 2 - Choosing a co-ordinate system.

Select features by definition query

Next, you are going to create a SQL query to select the features that you are interested in buffering. You are going to start by selecting places with populations greater than 10,000 people.

1. Double click on the point layer **Places.** This will bring up Layer properties. Under Layer Properties, choose Definition Query.
2. Click the **New Definition Query** button. This will open the definition queries window, in which we can very easily build an SQL query. We want to select all the cities that have a population greater than 10,000. Click on the first dropdown box and select POP91 (Population in 1991). Click on second dropdown box and select "is greater than or equal to". Click on the third dropdown box and type 10000 (Don't put a comma in the number). Alternatively, you can toggle the SQL switch and type in the query manually (POP91 >= **10000)**.
   Click OK to save the query and close the query builder window.

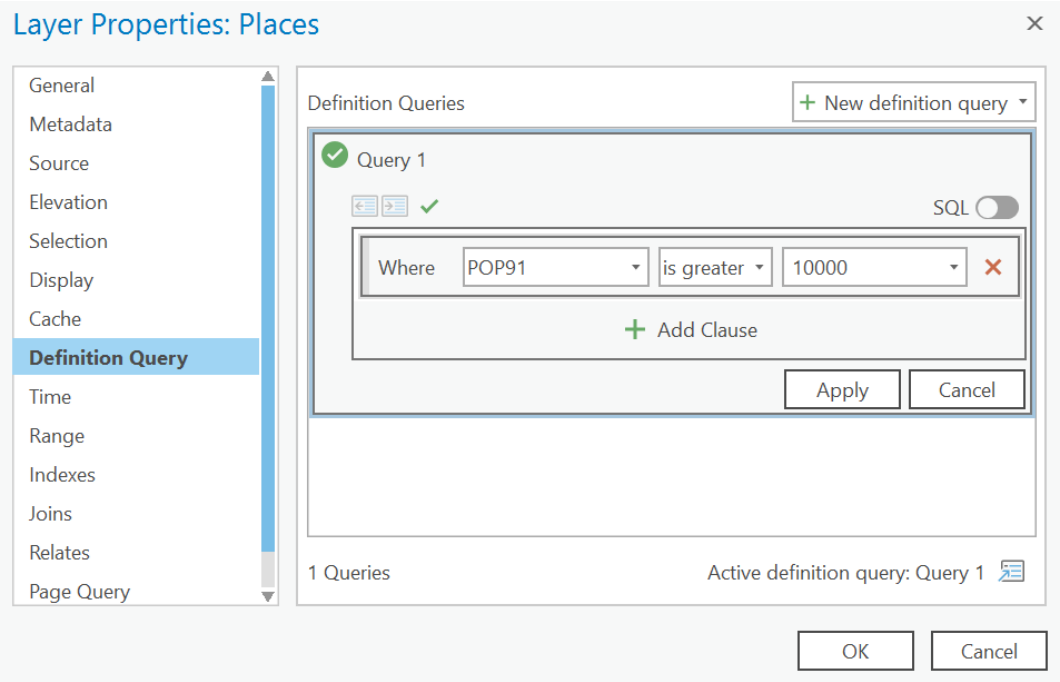


Figure 3 - Query Builder

3. Now we are going to label the cities. Right-click on the **Places** layer in the Contents pane and click 'Label'. The **Places** layer should now be labelled, but do they have the correct names? Right-click on the **Places** layer in the Contents pane again and click "Labeling Properties". Ensure the expression is "$feature.NAME_ENG." Close the Label Class pane.
4. Now we are going to assign a symbol to the selected places. Click on the dot below the layer name of Places in the Contents pane. We want to emphasize these points, so change the symbol to Circle 1 in the Gallery, size 4 (in the Properties) to bring them out. Close the Format Point Symbol pane.

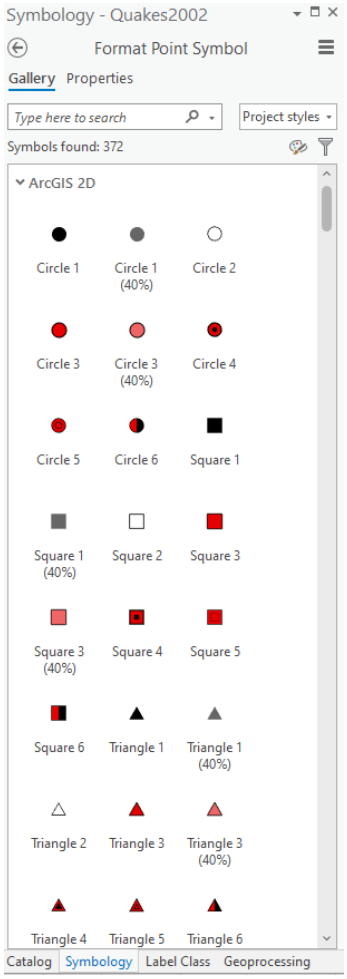


Figure 4 - Symbol Selector

Select by Attributes

You are now going to use a different technique to select **and display** the earthquakes with a magnitude of 5.0 or greater. The isolated big earthquakes will be used to create a new shapefile to use in the next table.

1. Right click on **Quakes2002** in the Contents pane and click **Open Attribute Table.** Have a look at the attributes in the table.

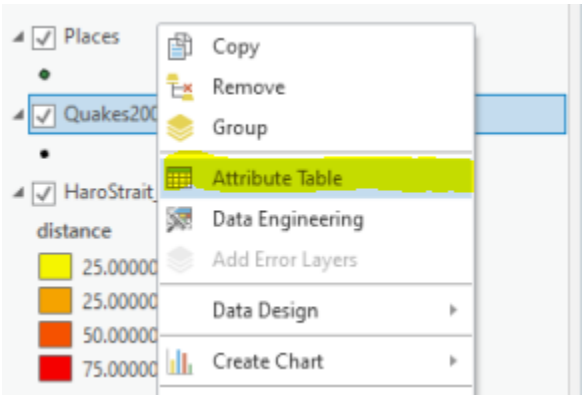


Figure 5 - Opening the attribute table

2. You are now going to select the earthquakes with a magnitude of 5.0 or greater in the **attributes of Quakes2002** table. Click Select by Attributes in the Selection options
3. In the **Selection Type** dialog box, ensure that the method is **New selection**.
4. Add a new expression by clicking "New expression".
5. Click on the first dropdown box and select **MAGNITUDE.** Click on second dropdown box and select "**is greater than or equal to**". Click on the third dropdown box and type **5**. Alternatively, you can toggle the SQL switch and type in the query manually (MAGNITUDE >= 5).
6. Click **Ok** to execute the query.
7. You can toggle between viewing all records and only the selected layers using these buttons:  . There should be 10 of 1188 records selected.
   Is there a pattern of where the big earthquakes are located?
8. Close the **Attributes of Quakes2002** table.

Creating a new shapefile

To simplify your map, you are going to create a new shapefile of the Magnitude of earthquakes greater than 5.0. The new shapefile can be created from selected records using the function called *Export*.

1. Right click on the **Quakes2002** layer in the table of contents and choose **Data -> Export Features**.

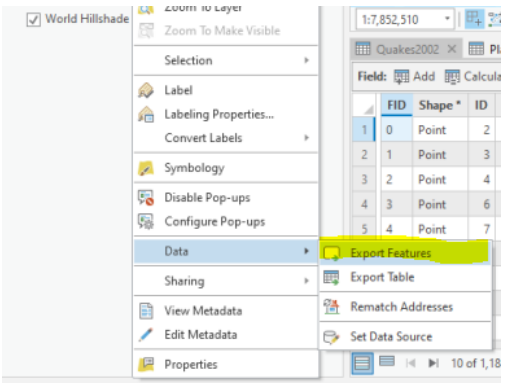
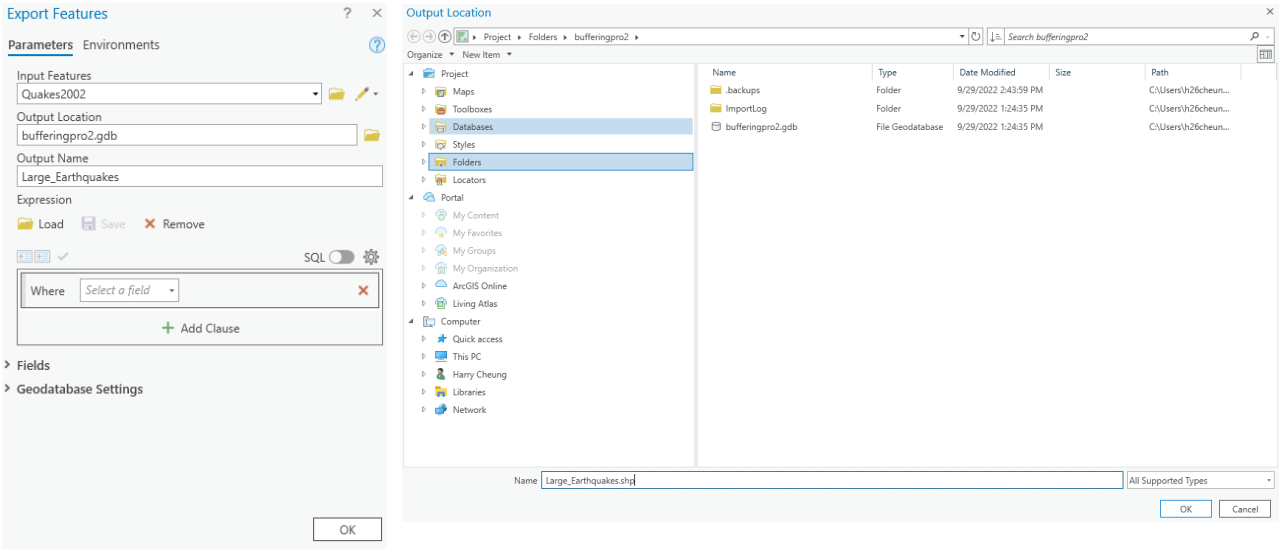


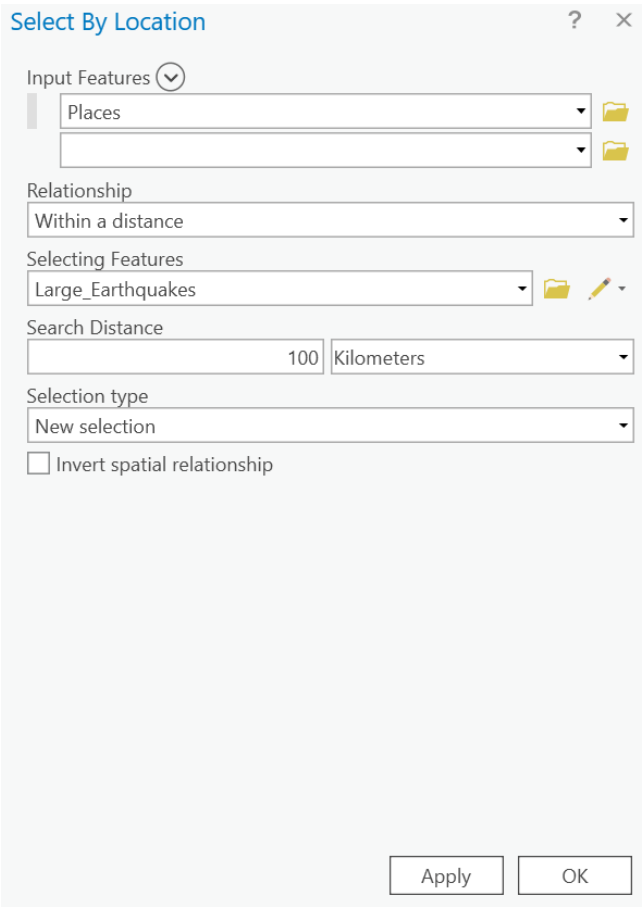
Figure 6 – Exporting Data



2. Click on the Folder button next to the output path to choose where you wish to save the shape file. Ensure that you save it to the same folder as the rest of the shape files. For ease of access, name the new shape file "Large_Earthquakes.shp".
3. Click 'Yes' when asked to add the shapefile as a new layer to the map. Customize the new shapefile to have a bold, noticeable icon.

Select by Location

You are now going to use the **Select by Location** function to find out if there are any **places** with 10,000 people or more that are within 100 km of an earthquake with magnitude 5.0 or greater in 2002. This seems like a daunting query, but using some built in tools in ArcGIS Pro, this becomes a simple task.



1. From the **Selection** options, choose **Select by Location**.
2. In the **Select by Location** dialog box, specify the **Places** layer as the input features. Specify the relationship as "Within a distance" from the dropdown. In 'Selecting Features', choose the layer created earlier (Large_Earthquakes), and apply a search distance of 100 kilometers.
3. Close the table and right click on the **Places** layer in the Contents pane and choose **Selection -> Zoom to Selection**.
4. From the **Selection** options, choose **Clear.**

Select Location using Selected Features Tool

You are going to select out the earthquake that occurred in the **Haro Strait**. Around this, you are going to create a multiple ring buffer. To accomplish this, ensure that you avoid selecting features in other layers and select the big earthquake that occurred in Haro Strait near Victoria by doing the following:

1. In the Contents pane, uncheck all the layers except for the **Large_Earthquakes** layer.
2. Click the **Select** tool in the Selection options and pick one of the options to draw a box around the big earthquake that occurred in **Haro Strait** near Victoria.

The selected earthquake is now ready to create a multiple ring buffer.

Create multiple ring buffers using the Multiple Buffer tool

You are going to create a multiple ring buffer using the **Multiple Ring Buffer** tool. The buffer will have four concentric rings spaced out at 25km helping illustrate the proximity of each place to the earthquake. The places located closest to the earthquake are susceptible to the greatest amount of

damage. To locate this tool, open the **Geoprocessing toolbox** in the **View tab** and search for **Multiple Ring Buffer**.

1. For the input of this tool, choose the **Large_Earthquakes** as an input feature, and set the output feature class to be **HaroStrait_Buffer.shp**. The output feature class is a new shapefile that is generated because of the buffer analysis.

2. You are going to create 4 rings at intervals of 25, 50, 75, and 100km. In the distances field, type in **25** and click (+) **Add another**. Continue to type and add **50**, **75**, and **100**. In the Distance Unit field, select **Kilometers**. Click **OK** and in a couple of minutes, your buffers will be created.

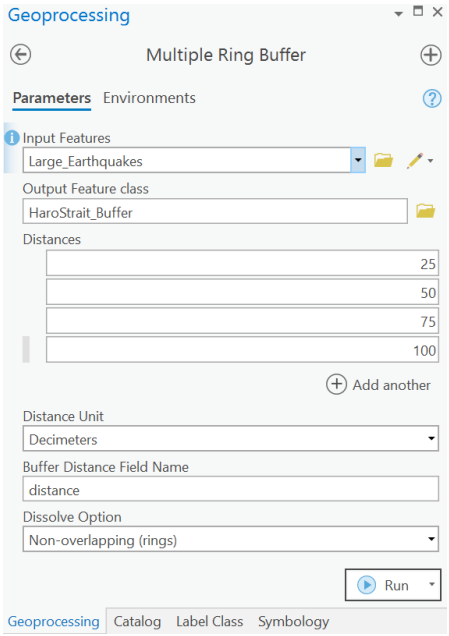


Figure 7 – Multiple Ring Buffer Tool

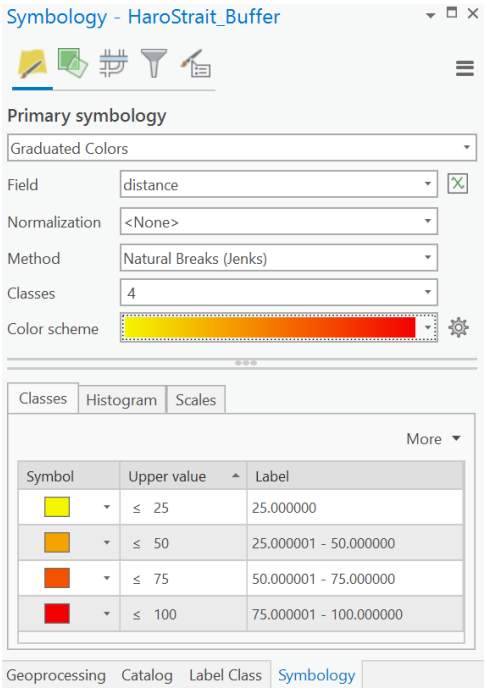


Figure 8 - Symbology tab

3. Right-click the **HaroStrait_Buffer** layer you have just created in the Contents pane and navigate to the **Symbology** pane. Select Graduated Colors from the Primary symbology dropdown and set the Field dropdown to be **distance.** Choose a color ramp that is one of the color changing shades, not a multi-color ramp (i.e., light red to dark red). Once you have chosen a color scheme that works for you, open the Color Scheme Editor by clicking "Format color scheme…" under the Color scheme dropdown and select "Reverse color scheme"

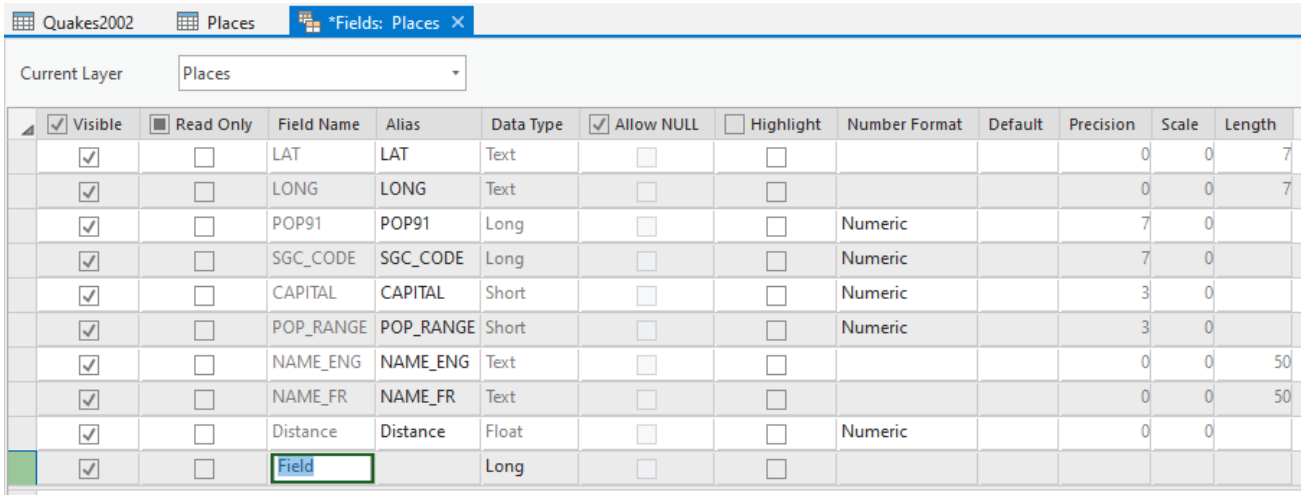
Figure 9 – Flipping a color ramp

By applying this reverse color ramp, it will give the visual effect that a darker shade is equal to more damage from the earthquake. Turn on all the layers again.

Performing a field calculation

The other major factor that determines the impact of an earthquake is the size of the populated places nearest to it. The point of this exercise is to create a faked distance field which is the physical representation of each populated place weighted by population. The attribute you are going to use, POP91 field (total population in 1991) is not a measurement of length. It is important to remember the faked field value **does not** represent the real distance each populated place extends outward.

1. To create a new field, right click on the **Places** layer and select **"Attribute table"**.
2. Click **Add.** 



Visible	Read Only	Field Name	Alias	Data Type	Allow NULL	Highlight	Number Format	Default	Precision	Scale	Length
☑	☐	LAT	LAT	Text	☐	☐			0	0	7
☑	☐	LONG	LONG	Text	☐	☐			0	0	7
☑	☐	POP91	POP91	Long	☐	☐	Numeric		7	0	
☑	☐	SGC_CODE	SGC_CODE	Long	☐	☐	Numeric		7	0	
☑	☐	CAPITAL	CAPITAL	Short	☐	☐	Numeric		3	0	
☑	☐	POP_RANGE	POP_RANGE	Short	☐	☐	Numeric		3	0	
☑	☐	NAME_ENG	NAME_ENG	Text	☐	☐			0	0	50
☑	☐	NAME_FR	NAME_FR	Text	☐	☐			0	0	50
☑	☐	Distance	Distance	Float	☐	☐	Numeric		0	0	
☑	☐	Field		Long	☐	☐					

Figure 10 – Creating a field in an attribute table

2. Create a new field, name it as "Distance" and set the type as "Float". Right-click and select save. When you add a field to a table in a shapefile, the field is created as a specific data type. In this example, you are going to add a single-precision floating point number column to the existing table, often referred to as a **float**.

3. Scroll down to the **Distance** field (far right), right click under the **Distance,** and select **Calculate Field**.
4. In the Calculate Field tool, enter Distance = **[POP91]/40** (Total population is divided by 40) and click **"OK"**. This value 40 was chosen through trial and error based on how well the distance value was able to display the relative size of the population at each place.

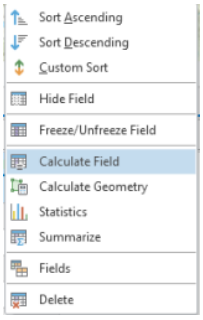


Figure 11- Calculating the fields

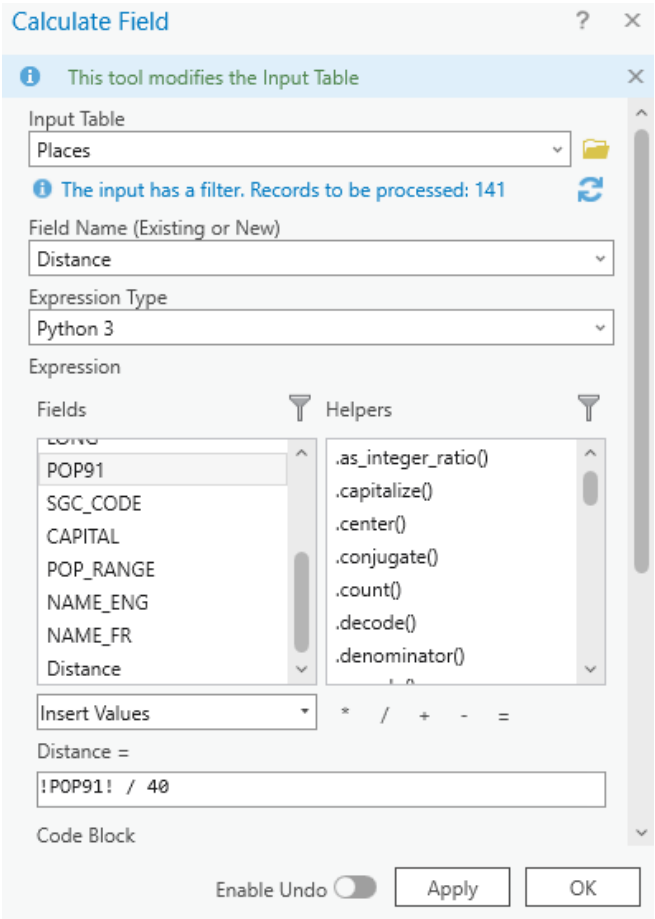


Figure 12- Calculate Field Tool

Creating a buffer based on distance from a table attribute

The next step is to create single ring buffers based on the faked distance.

1. Select all places within 100km of the **Haro Strait** earthquake again (Refer back to page 7)
2. Click the Geoprocessing menu and select the Buffer tool.
3. In the Buffer pane, set Input Features as **"Places"**, Output Feature Class where you have this tutorial data, named Places_Buffer.shp. In the Distance parameters, specify "Field" and "Distance". The numeric values in the field will become the buffer distances.

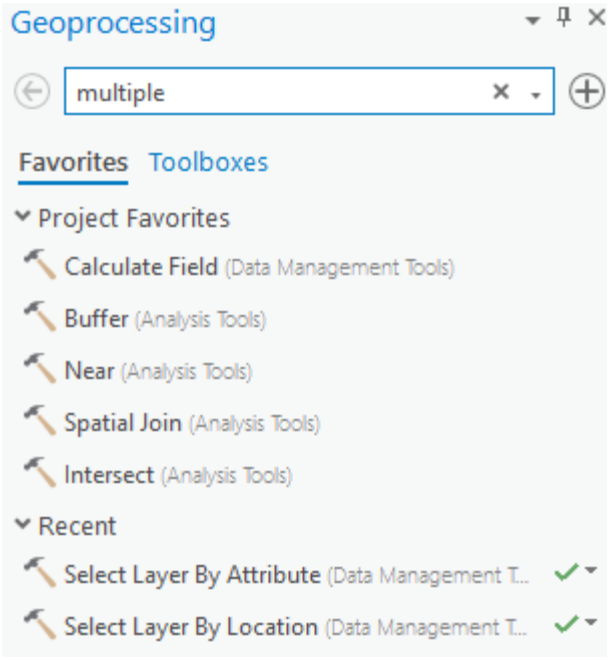


Figure 13 – Accessing tools through a Geoprocessing menu

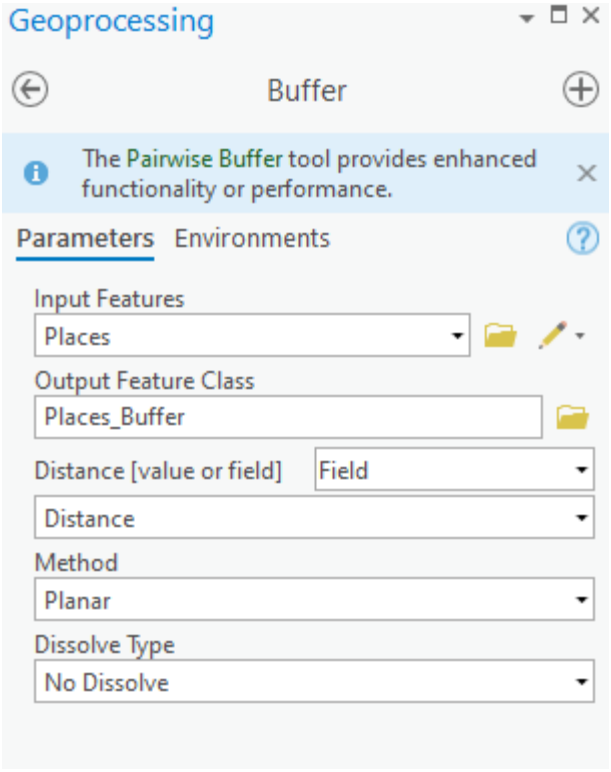


Figure 14 – Buffer tool

4. Click **Environments** to make some changes to the Buffer Tool environment settings (Tab next to Parameters)
5. In the Environment Settings dialog box, click on the Output Coordinates text if not already expanded to expand the coordinate settings.
6. In these settings, make a change to the Output Coordinate System to **Current Map [Map]**. The field should populate with the Canada Lambert Conformal Conic coordinate system.

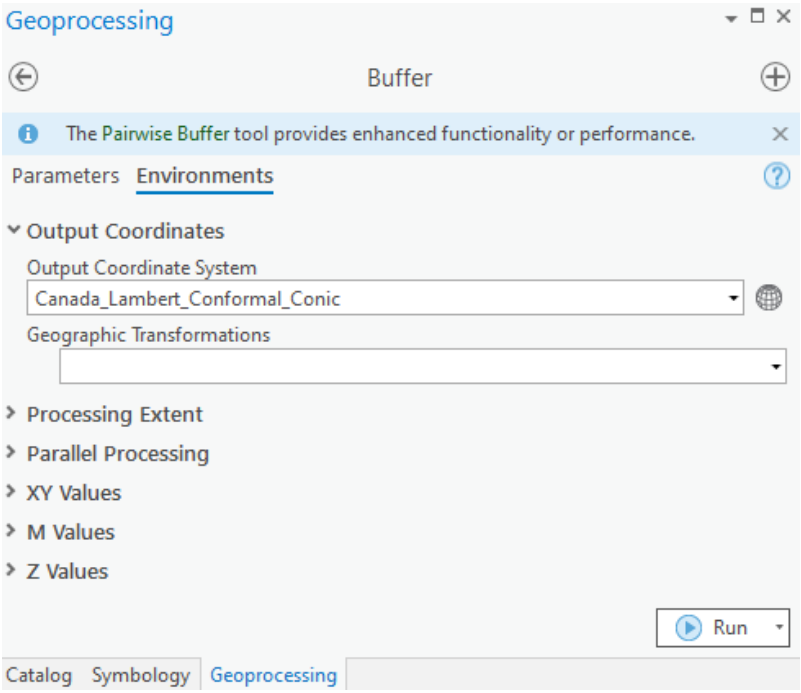


Figure 15 – Environment Settings

The input feature's (Places) coordinate system is in a geographical coordinate system (Latitude and Longitude), which cannot be used to create a valid buffer. Therefore, the

display coordinate system, which is a Projected Coordinate System (Lambert Conformal Conic), will now be used with the change in environment.

1. Return to the Parameters tab in the Buffer pane. Click Run to perform the buffer operation.
2. Click on the "Places_Buffer" symbol in the Contents pane. This will bring up the **Symbolology pane.** Change the fill color to **Grey 30%**. Close the pane.
3. Go to the **Selection** menu and click **Clear.**

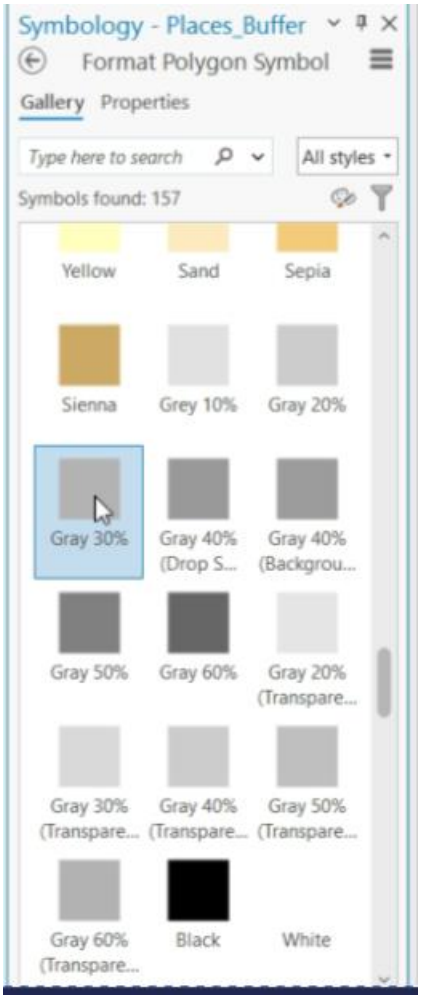


Figure 16 – Symbology pane

After selecting all places within 100km of the Haro Strait earthquake, you have used a distance representing the relative size of population to create buffers. Then you have assigned a grey color to the buffer rings.

Figure 17 – Grey buffer rings

Labelling the Buffer

Next, you are going to label the buffer distances. The easiest way to do this is to label the features by right clicking on the layer in the Table of Contents and clicking on Label Features. Make sure to put "$feature.Distance" in the "Expression" box of "Labeling Properties".

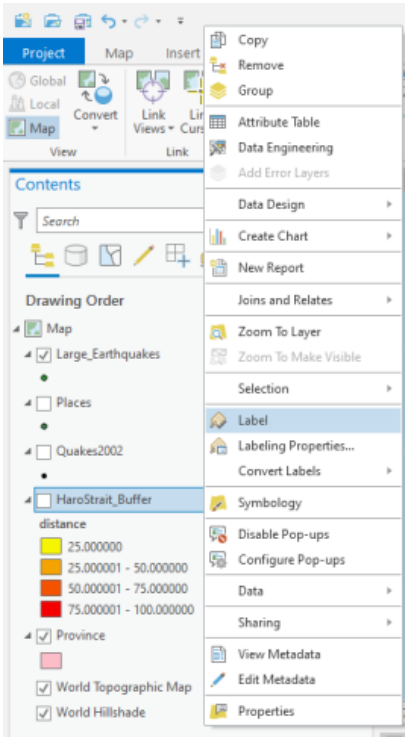


Figure 18 – Labelling Features

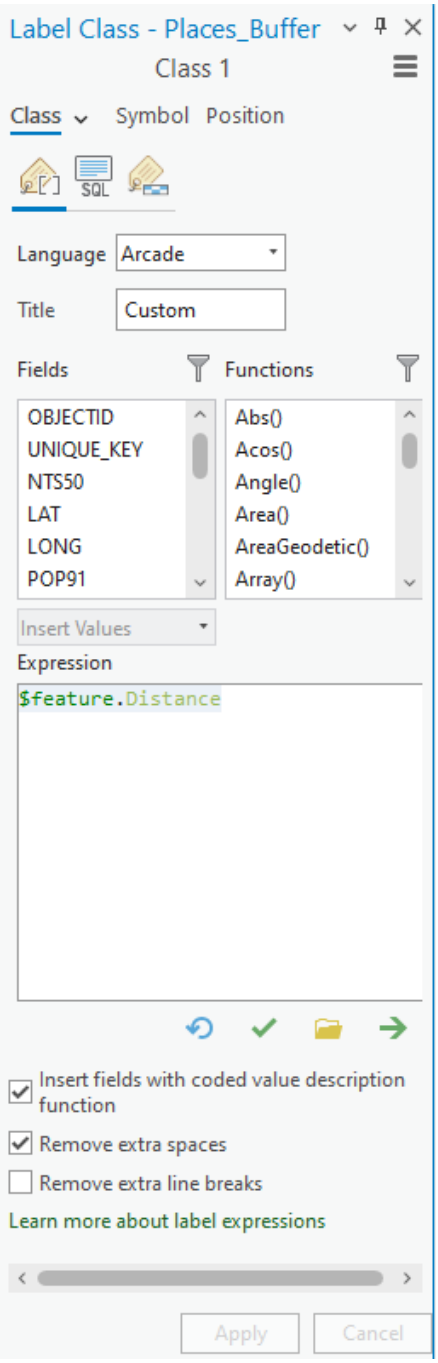


Figure 19 – Labelling Properties Expression

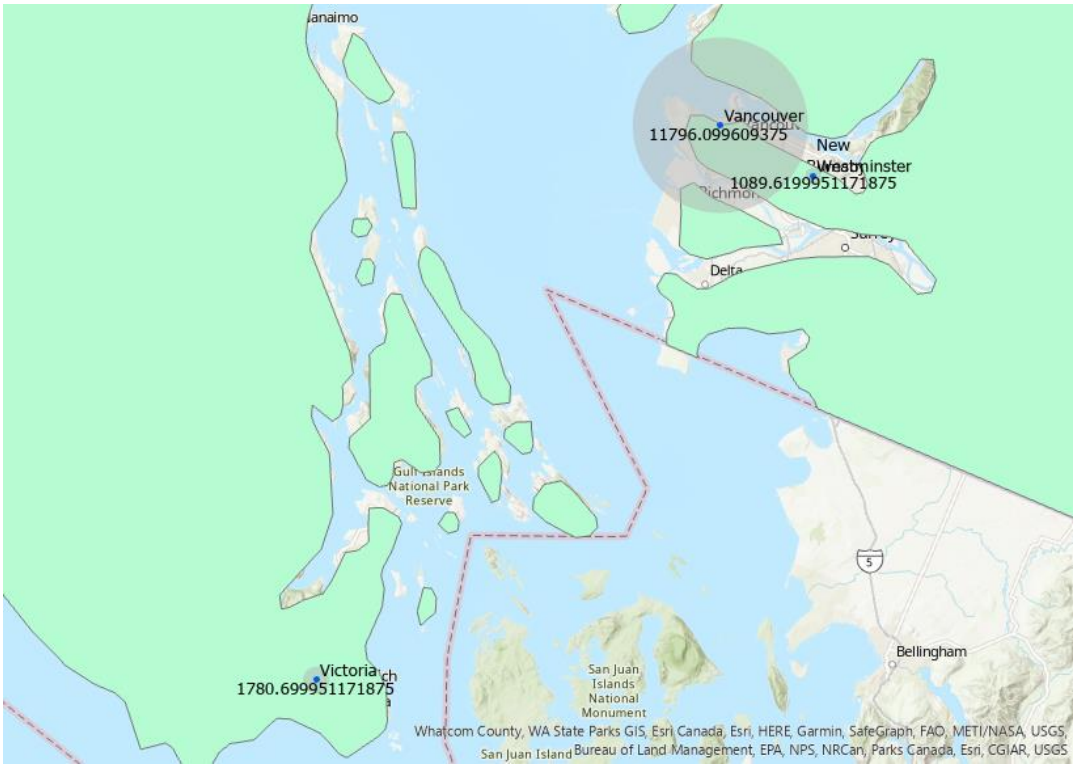


Figure 20 – Grey buffer rings with buffer distance

Congratulations! You have successfully created buffers using a variety of selection methods!

Updated by Martin Trang, August 2023