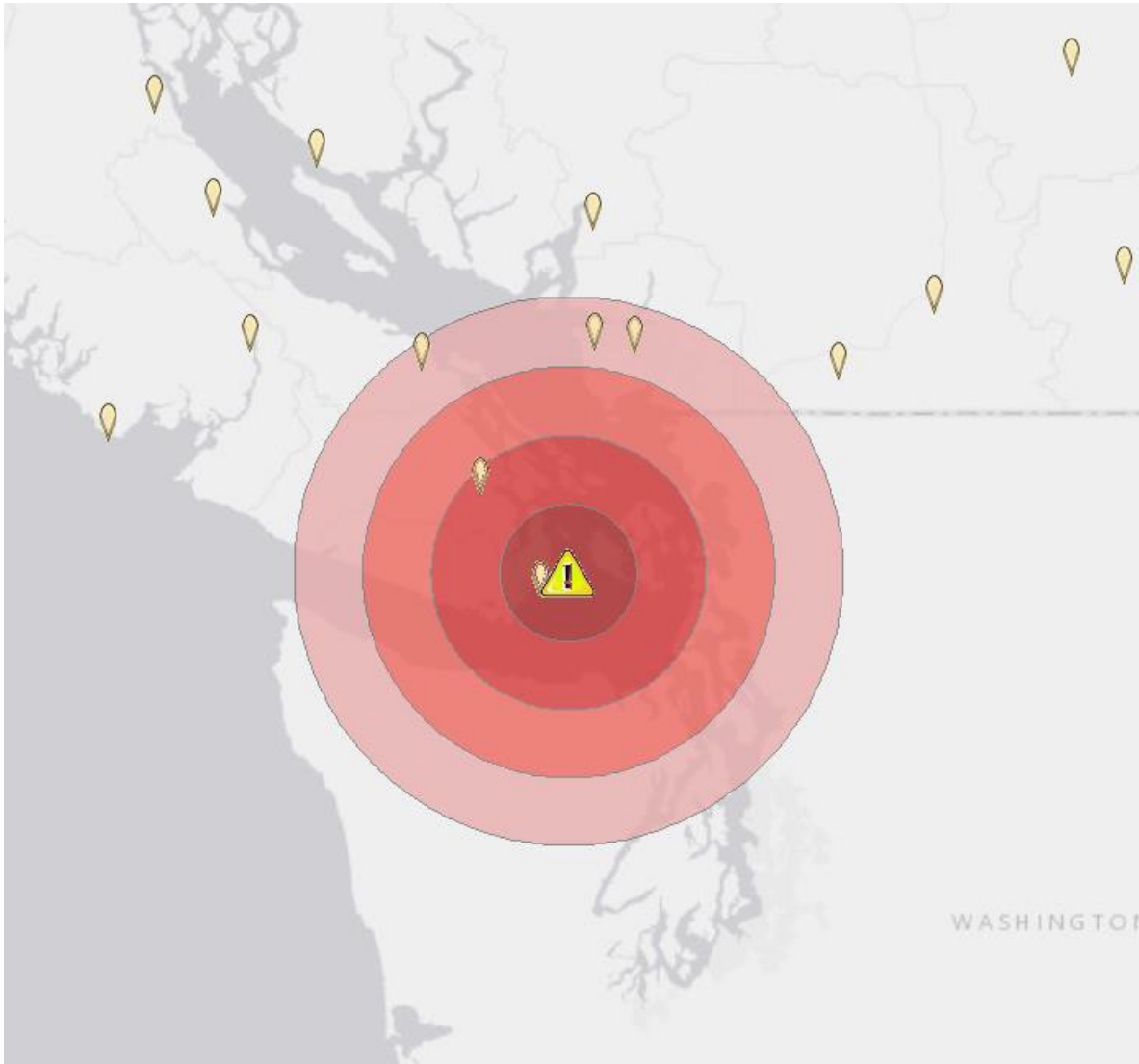


# Spatial Analysis Using ArcGIS

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**UNIVERSITY OF WATERLOO**

**GEOSPATIAL CENTRE**

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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 ArcMap. In the welcome window select “Start using ArcMap with:” **An Existing Map** and click **OK**.
2. Browse to the folder that you have unzipped this tutorial to and select buffering.mxd, and then click **Open**.

## Fixing a “broken” MXD

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

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

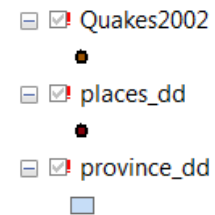


Figure 1 - MXD problems

## 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 **Layers** (the Data Frame) in the table of contents. This will bring up the Data Frame 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 1)
3. To confirm this is the coordinate system you wish to use, click on it to select it. Under the General tab change

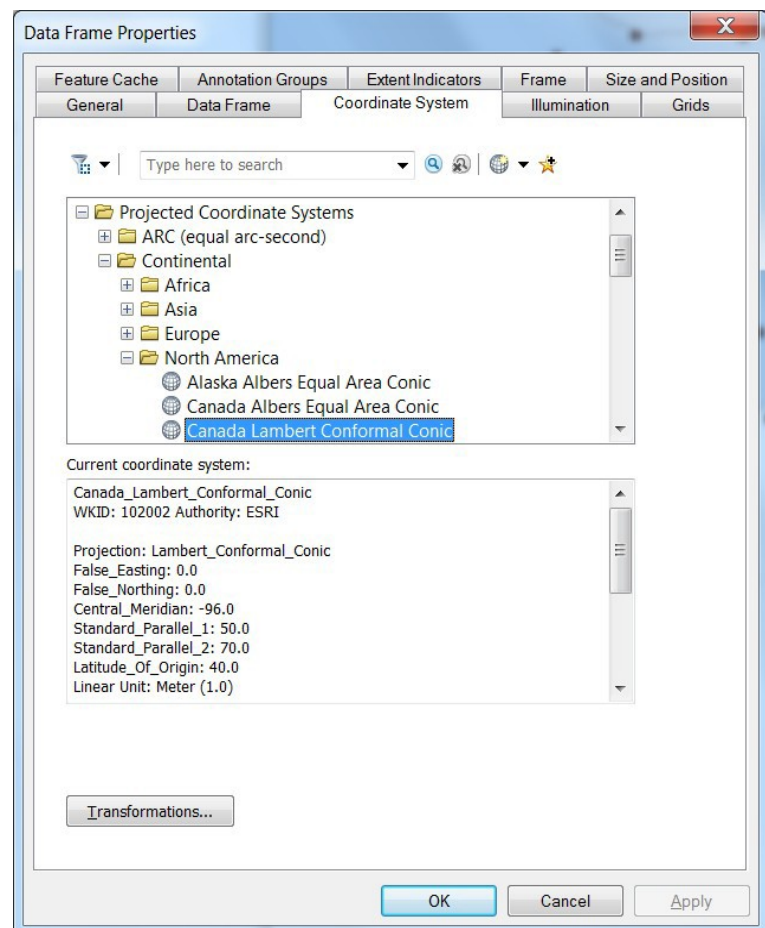


Figure 2 - Choosing a co-ordinate system.

the display unit to Kilometers. Click OK and if a warning occurs, simply click Yes until the warnings go away.

## 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 **Query Builder** button. This will bring up another 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. Scroll on the list of fields in quotation marks and double click on POP91 (Population in 1991). Click on the >= button (Greater than or equal sign), and then type 10000 (Don't put a comma in the number). Click OK to save the query and close the query builder window.

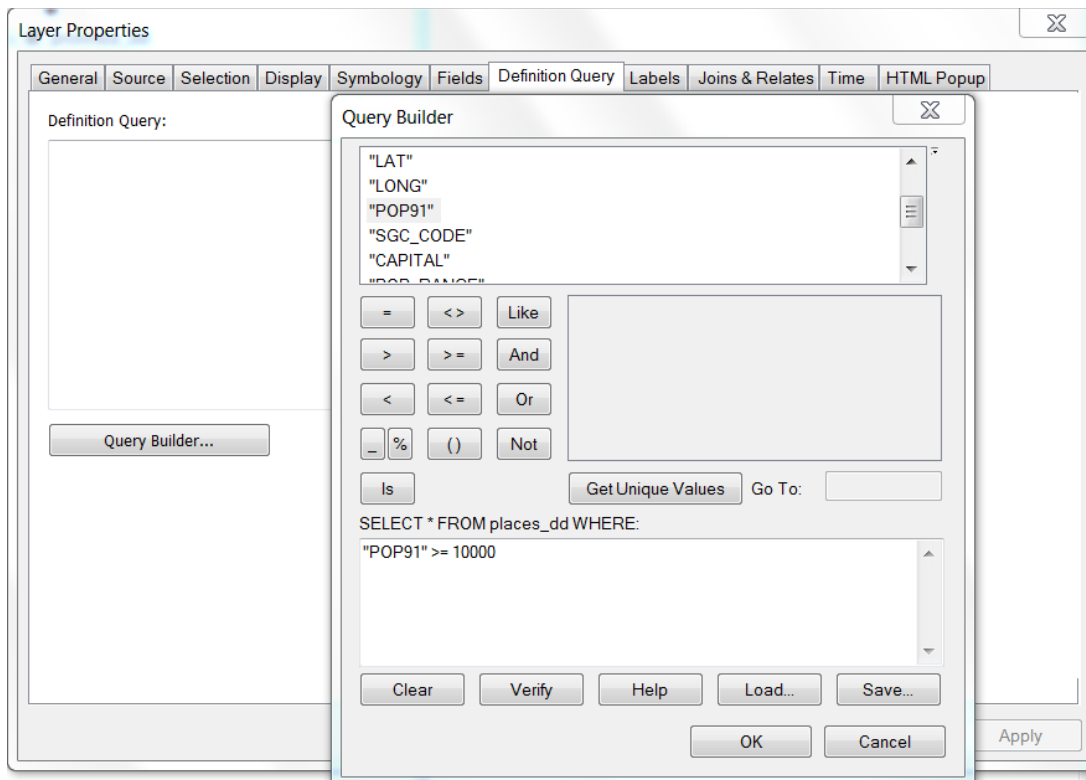


Figure 3 - QueryBuilder

3. Now we are going to label the cities. Click on the Labels tab, and check the box next to 'Label features in this layer'. Set the Label Field to NAME\_ENG (city name in English). Click on the 'Label Styles...' button under Predefined Label Styles and choose City. Then click OK and click OK again to close the Layer Properties window.
4. Now we are going to assign a symbol to the selected places. Double click on the dot below the layer name of Places in the Table of Contents. We want to emphasize these points, so change the symbol to Circle 2, size 4 to bring them out. Click OK to apply this change.

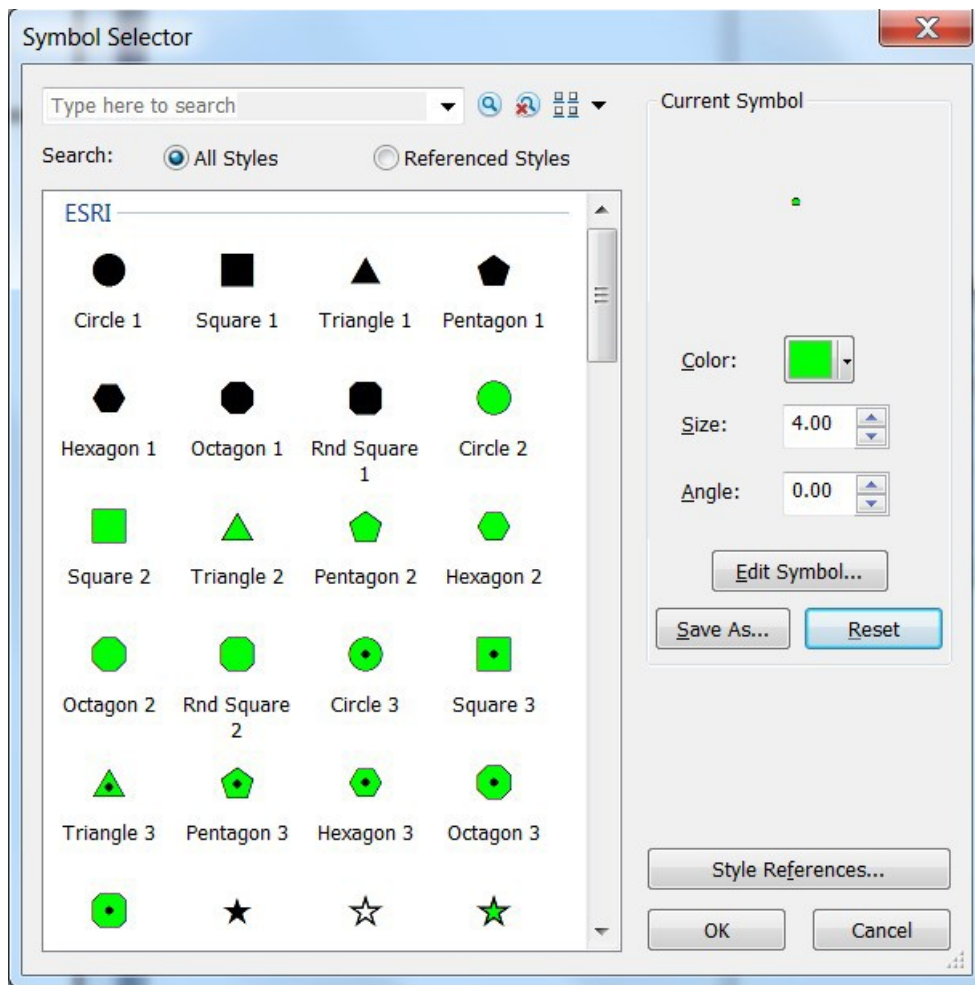


Figure 4 - SymbolSelector

### 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 table of contents and click **Open Attribute Table**. Have a look at the attributes in the table.

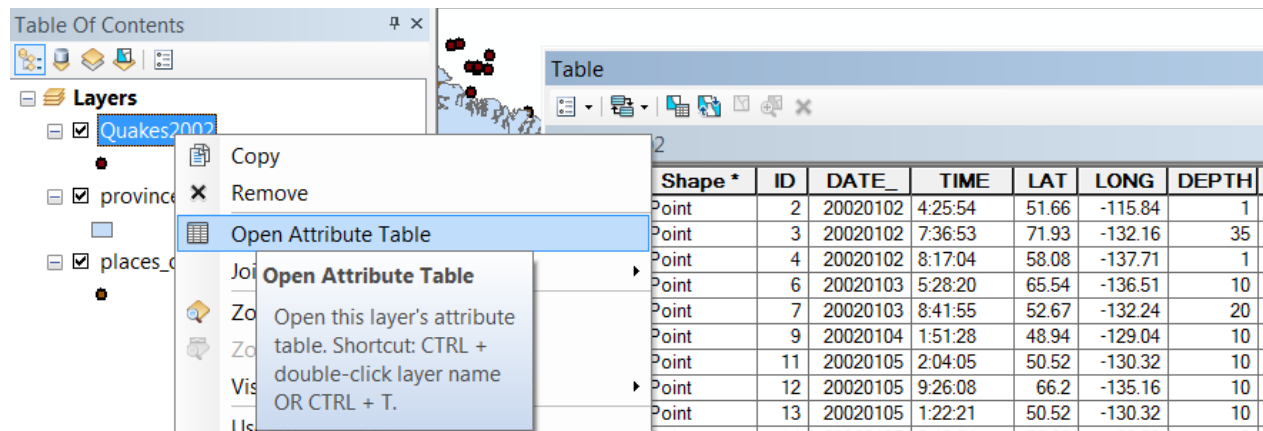


Figure 5 - Opening the attributetable

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.
3. In the **Select by Attributes** dialog box, ensure that the method is **Create a new selection**.
4. Double click **MAGNITUDE** in the query builder, click '>=' and then type **5**.
5. Click **Apply** to execute the query and **Close** to close the **Select by Attributes** dialogbox.
6. 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?*
7. Close the **Attributes of Quakes2002** table.

## Creating a new shapefile

In order 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 Data**.

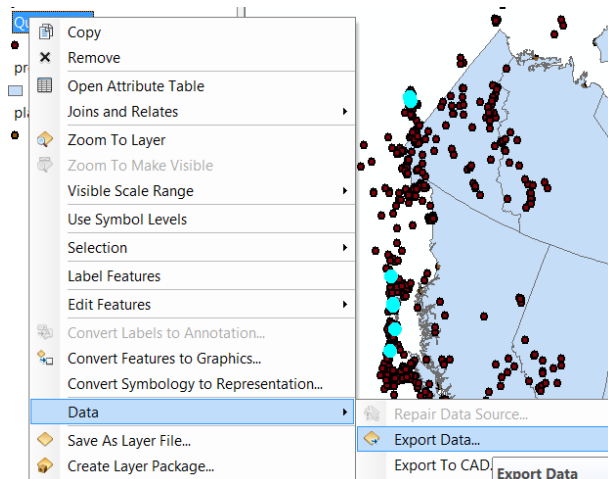
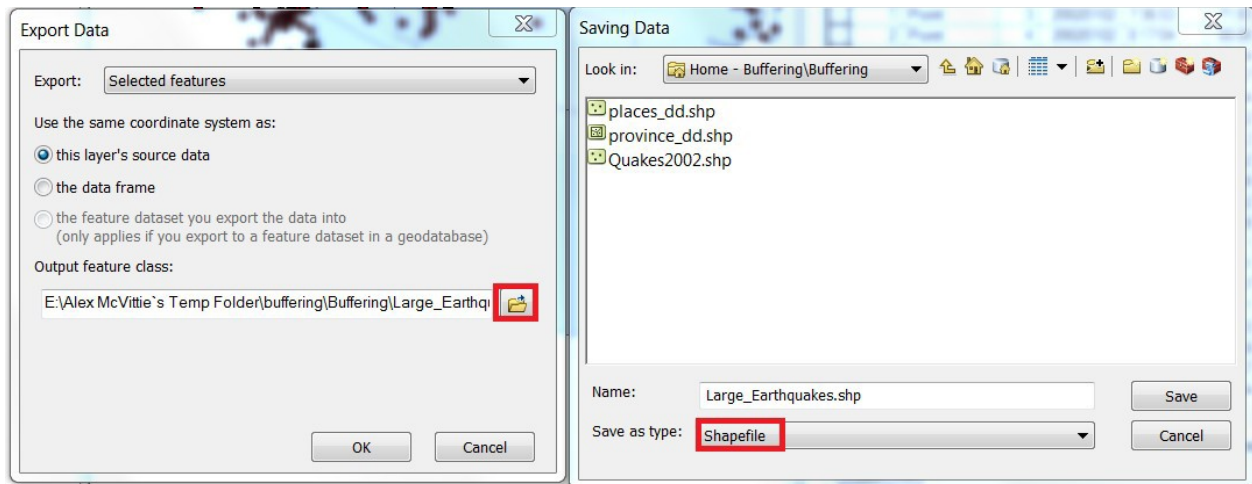


Figure 6 - Exporting data

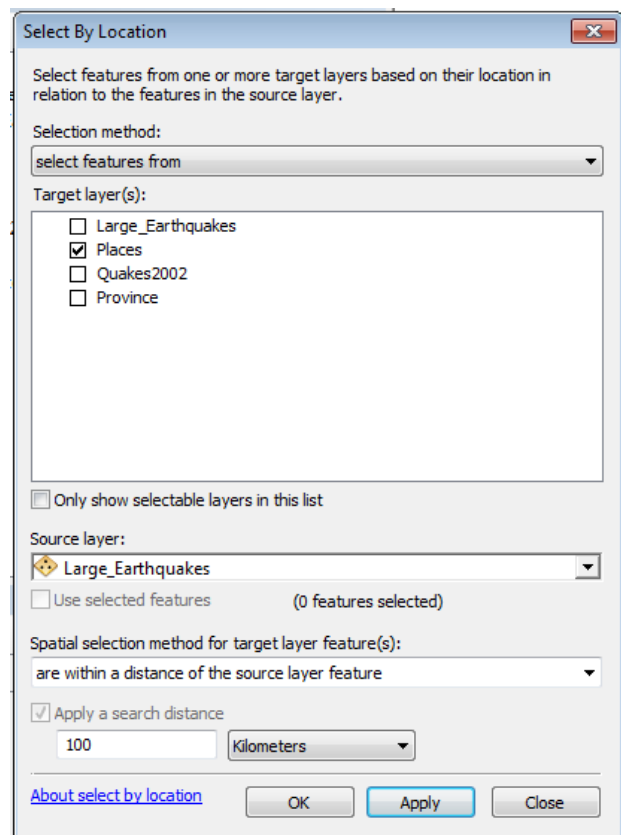


2. Click on the Folder button next to the output path to choose where you wish to save the shape file. Ensure that you save it to the same folder as the rest of the shape files, and that the file type is set to Shapefile (Default is personal/file geodatabase).
3. Click 'Yes' when asked to add the shapefile 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 ArcMap, this becomes a simple task.


1. From the **Selection** drop down menu, choose **Select by Location**.
2. In the **Select by Location** dialog box, choose "Select features from" (default). Check off the **Places** layer, and choose "are within a distance of the source layer feature" from the dropdown. In 'Source layer', choose the layer created earlier (Large\_Earthquakes), and apply a buffer of 100 kilometers.
3. Close the table and right click on the **places** layer in the table of contents and choose **Selection -> Zoom to Selected Features**.
4. From the **Selection** drop down menu, chose **Clear Selected Features**.






## 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.

1. You will need to set the selectable layers to avoid selecting features in other layers. In the Table of Contents, uncheck all the layers except for the **Large\_Earthquakes** layer.
2. Click the **Select Features**  tool and draw a box around the big earthquake that occurred in **Haro Strait** near Victoria.

The selected earthquake will be used 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, click the **Search** button (  ) 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 as a result 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 (+)**. Continue to type and add **50, 75, and 100**. In the optional Buffer unit, select **Kilometers**. Click **OK** and in a couple of minutes, your buffers will be created.
3. Open the Properties of the **HaroStrait\_Buffer** layer you have just created and navigate to the **Symbol** tab. Open the **Quantities** option and set the Value to be the **distance** field. Choose a colour ramp that is one colour changing shades, not a multi-colour ramp (ie light red to dark red). Once you have chosen a colour scheme that works for you, click on the **Symbol** header (May be slightly cut off and read Sym...) and select **Flip Symbols**.

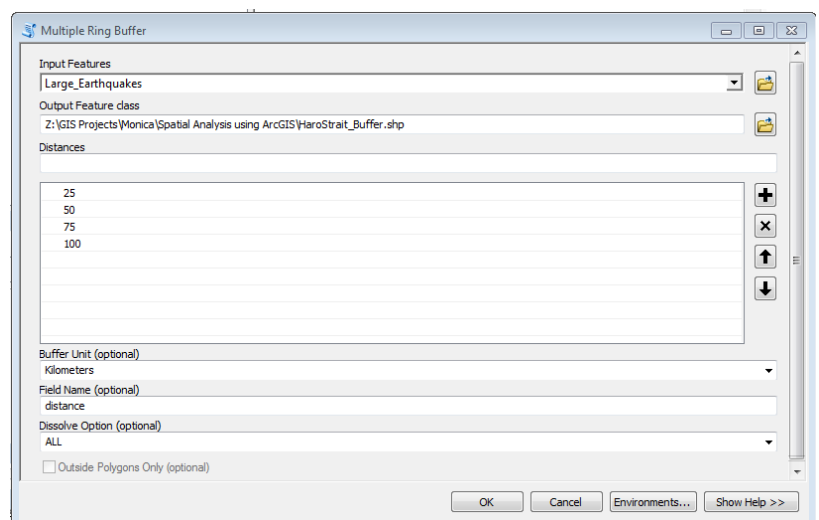


Figure 7 - Multiple Ring Buffer tool

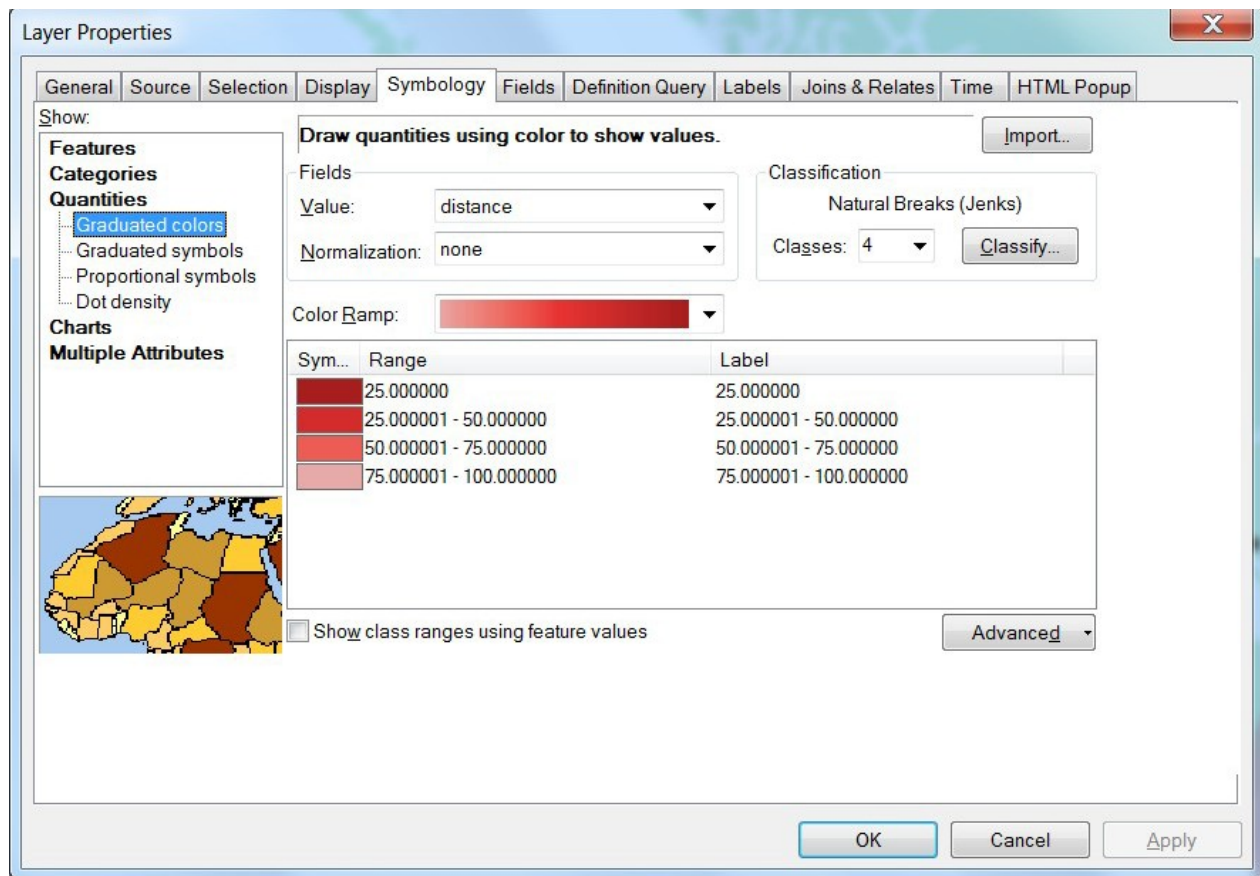


Figure 8 - Symbology tab

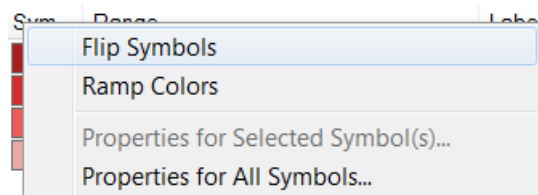


Figure 9 - Flipping a colour ramp

By applying this reverse colour 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 **"Open attribute table"**. Click **Options** and select **Add Field**.

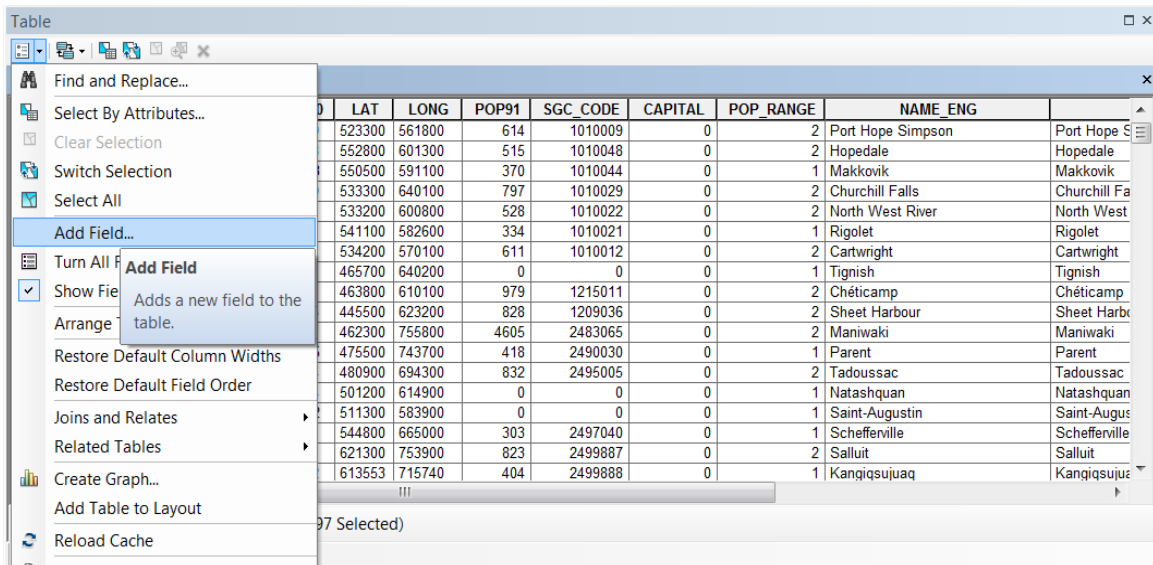


Figure 10 - Creating a field in an attribute table

2. Create a new field, name it as "Distance" and set the type as "Float". Click **OK**. 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 **Field Calculator**.
4. In the Field Calculator, enter  $\text{Distance} = [\text{POP91}]/40$  (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.

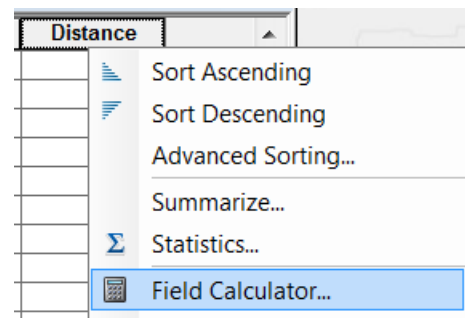


Figure 11 - Accessing the field calculator

### Creating a buffer based on distance from a table attribute

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

1. Select the 496 populated 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 dialog box, set Input Features as "**Places**", Output Feature Class where you have this tutorial data, named Places\_Buffer.shp. Next, choose Field as "Distance". The numeric values in the field will become the buffer distances.

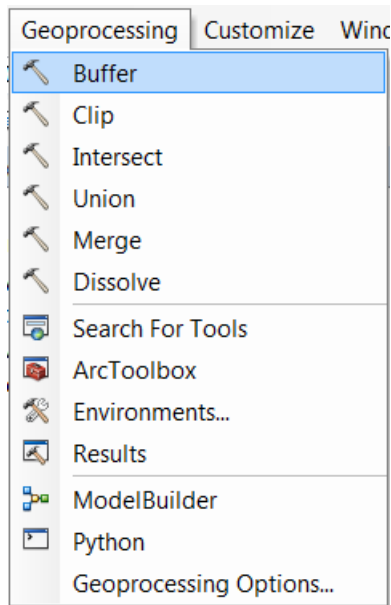


Figure 12 – Accessing tools through the Geoprocessing menu

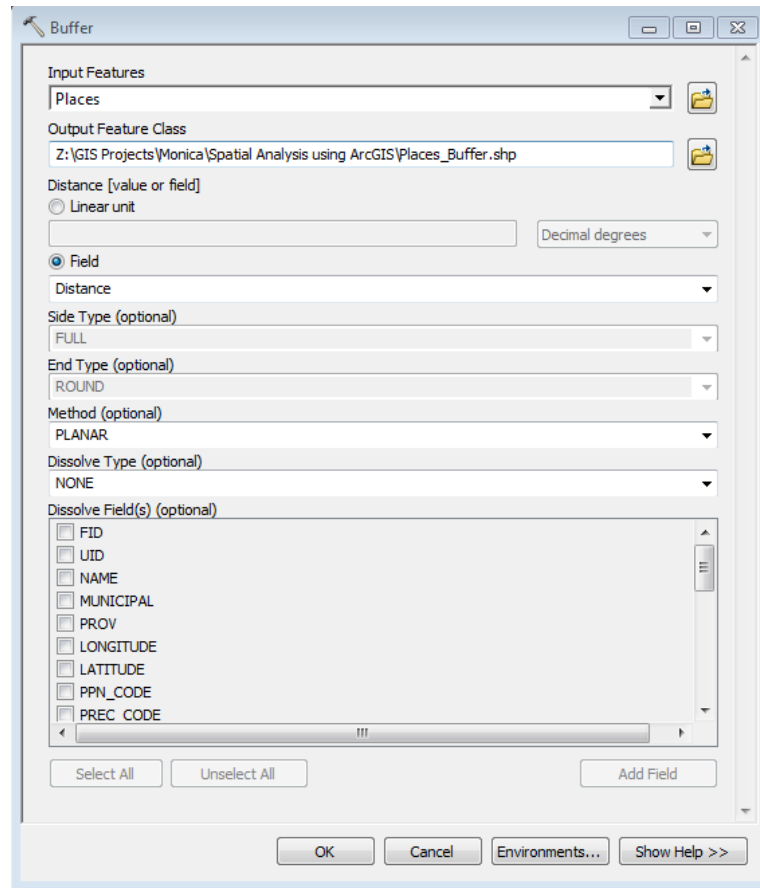


Figure 14 – Buffer tool

4. Click **Environments** to make some changes to the Buffer Tool environment settings (Bottom right hand corner of the Buffer tool window)
5. In the Environment Settings dialog box, click on the Output Coordinates text to expand the coordinate settings.
6. In these settings, make a change to the Output Coordinate System to **Same as Display**. The default is “Same as Input”, and click OK.

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

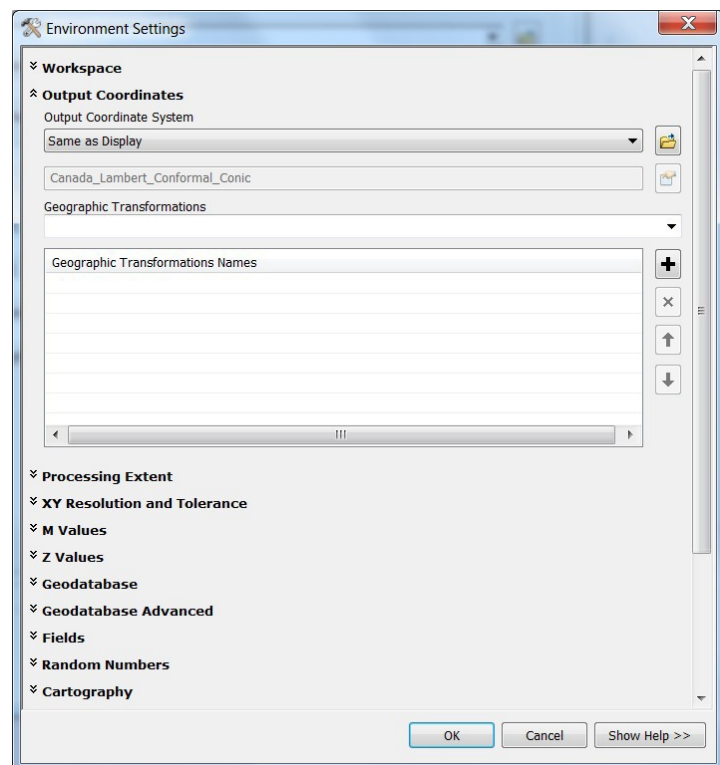


Figure 13 – Environment Settings

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

7. Back to the buffer tool dialog box, click OK to perform the buffer operation.
8. Double click on the “Places\_Buffer” symbol. This will bring up the **Symbol Selector** and change the fill color to **Grey 30%**. Click OK to apply the change.
9. Go to the **Selection** menu and click **Clear Selected Features**.

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.

## 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.

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

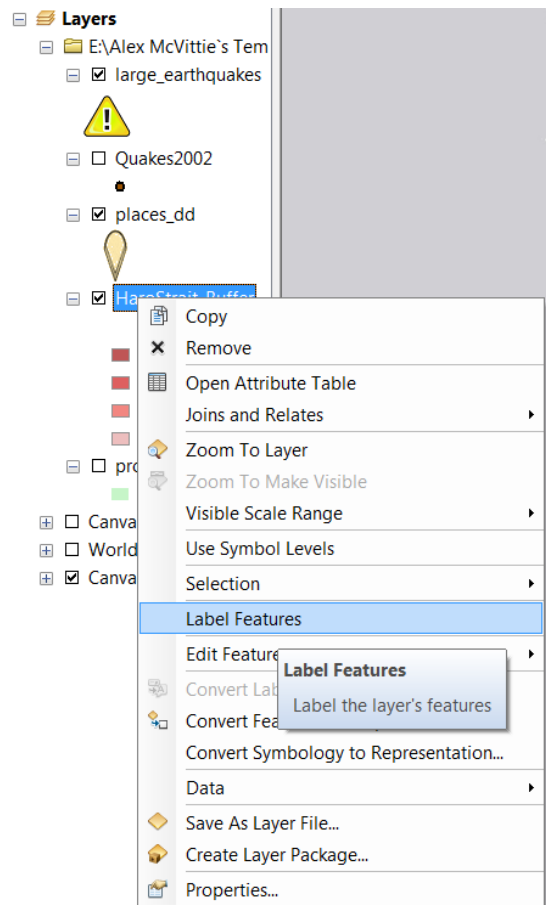


Figure 15 - Labelling features

*Modified from the 2010 spatial analysis tutorial and the ESRI Canada K12 buffering tutorial.*

*Updated by Alex McVittie, February 2015*

*Updated by Monica Varga, September 2016*