# Exercise

## Symbols and Scale

Section 3 Exercise 1

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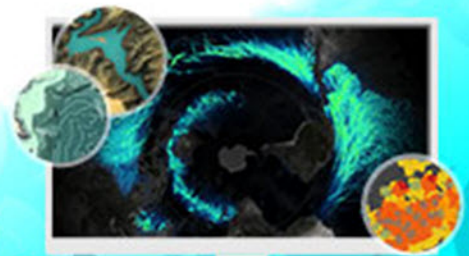
# Symbols and Scale

**Instructions**

Use this guide and ArcGIS Pro to reproduce the results of the exercise on your own.

*Note: The version of ArcGIS Pro that you are using for this course may produce slightly different results from the screen shots that you see in the course materials.*

**Time to complete**

Approximately 40-50 minutes

**Software requirements**

ArcGIS Pro 2.5

ArcGIS Pro Standard license (or higher)

*Note: The MOOC provides a separate ArcGIS account (user name and password) that you will need to use to license ArcGIS Pro and access other software applications used throughout the MOOC exercises. This account (user name ending with _cart) provides the appropriate ArcGIS Online role, ArcGIS Pro license, ArcGIS Pro extensions, and credits. We strongly recommend that you use the provided course ArcGIS account to ensure that you have the appropriate licensing to complete the exercises. Exercises may require credits. Using the provided course ArcGIS account ensures that you do not consume your organization's credits. Esri is not responsible for any credits consumed if you use a different account. Moreover, Esri will not provide technical support to students who use a different account.*

## Introduction

A map is a scaled representation of reality—scaled because whatever you are mapping is likely larger than the sheet of paper or computer screen that you want to show it on. So, you must reduce the size of the representations of reality in a deliberate way to make it fit the page or screen.

However, you must simplify some things and omit some others altogether to fit everything into this much smaller space while retaining clarity and the character of the area. The challenge is to make these subjective decisions intelligently to best retain the overall density and distribution of the mapped phenomena. This process is called generalization.

Generalization is necessary to make a multiscale map. A multiscale map shows different levels of detail at different scales. Multiscale maps help you navigate to a place by first orienting you

with a general overview of a large area and then allowing you to zoom in to a smaller area with more detail.

Generalization processes include elimination, reduction, simplification, exaggeration, displacement, and aggregation. The goal with generalization is to do it so well that your map reader does not notice your generalization choices at all, and the transition between scales feels seamless.

## What will you learn?

In the next few exercises, you will work with a map of New Zealand. It is a general reference map, like the one that you worked with for Massachusetts back in Section 1 Exercise 1: *Make a Map*. This time, though, the goal is to make a map that can be used as a basemap layer, not a static layout. That means it must work across multiple scales. You will need to manage the display of the data so that an appropriate representation of it is shown at each scale.

Making a map like this one takes time but has tremendous utility. It is unrealistic to go through the process for every layer within this exercise, so you will only work with a few examples of the entire workflow. When you are done, you can use the skills that you learn to further refine this map or find your own data and make a multiscale map of a different area. If you choose to find your own data, make sure to use data that has useful attributes that you can use for symbology, such as the data from OpenStreetMap. It is difficult to show distinctions between data that is only points, lines, or polygons with no other attributes.

### Expressing scale

The amount of resizing—or the *scale*—of a map is usually expressed as a ratio. The first number, the numerator, is usually 1. It represents a distance on the map. The second number, the denominator, represents how far that distance corresponds to in reality. For example, a map with a scale of 1:100,000 means that one linear unit on the map represents 100,000 of those same units in reality. Scale (https://bit.ly/2qlAiJF) is unitless. The ratio is true whether you measure in inches, centimeters, or furlongs (https://bit.ly/2OetKaB).

### Step 1: Download the exercise data file

In this step, you will download the exercise data file.

(a) Open a new web browser tab or window.

(b) Go to https://bit.ly/2YjvOpw and click Download to download the exercise data file.

*Note: The complete URL to the exercise data file is https://www.arcgis.com/home/item.html?id=0f9ef119a6804e5b8fb38c69708da0c2. The file is 186 MB.*

c  Save the file in a location that you will remember.

## Step 2: Open an ArcGIS Pro project

a  Start ArcGIS Pro and, if necessary, sign in using your provided course ArcGIS credentials (user name ending with _cart).

b  From the main ArcGIS Pro start page, click Open Another Project.

c  Browse to the location where you saved the exercise data file and open the ScaleAndGeneralization.ppkx project package.

*Note: It may take some time for the map to load. In the bottom-right corner, the Refresh indicator spins while the map is loading.*
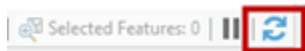


A small-scale map of New Zealand opens.

d  Save your project with a name such as **ScaleAndGeneralization_<your first and last name>**.aprx in the folder on your computer where you are saving your work.

e  In the map, zoom in and out, and as you zoom in and out, keep an eye on the scale control at the bottom of the map.
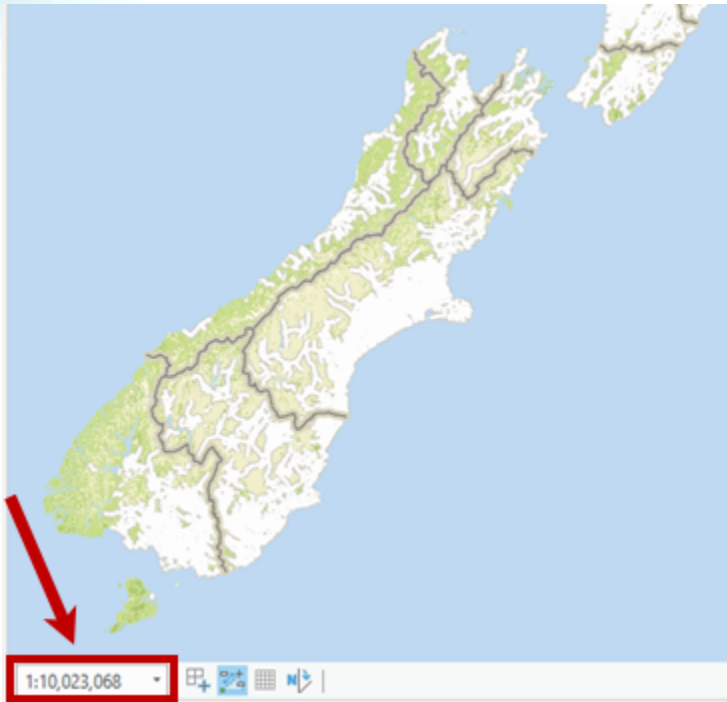
Because scale is expressed as a ratio, a map with a small numeric scale (a ratio with a large denominator) is considered a *small-scale* map of a large place, with limited detail. A map with a large numeric scale (a ratio with a small denominator) is a *large-scale* map of a small place with high detail.

*Note: You can type directly into the scale control box to get to an exact scale.*

## Step 3: Examine map content and symbology

To make an effective multiscale map, you typically begin by showing all the data that you have at all scales. As you inspect the map, you will make note of which layers become too complex and detailed as you decrease scale. The goal is to always show as much detail as the map can handle at each scale with clarity. Adequate feature attribution can be helpful to filter data.

a  Starting at the largest scale and working outward to the smallest scale, zoom out at different areas across New Zealand.

*Note: Pick a variety of places to zoom—urban areas, rural areas, inland areas, coastal areas, and so on. In the scale control box at the bottom of the map, notice how the numerical scale ratio changes as you zoom.*

Notice at what point the amount of map information is too detailed or dense to retain map clarity and legibility.

## Step 4: Use a definition query to limit building display

In this step, you will define a query expression to select a subset of features for the layer to display.

(a) If necessary, on the ribbon, click the Map tab.

(b) In the Navigate group, click Bookmarks and click the Wellington bookmark.

(c) Zoom in further and pan the map as necessary to see some buildings.



As you explore the map, you will notice that the Buildings layer is very detailed in some areas. Different kinds of structures are shown. Perhaps not all of these structures are necessary on this map. Next, you will use a definition query to filter out a few kinds of buildings to clear up your map at all scales.
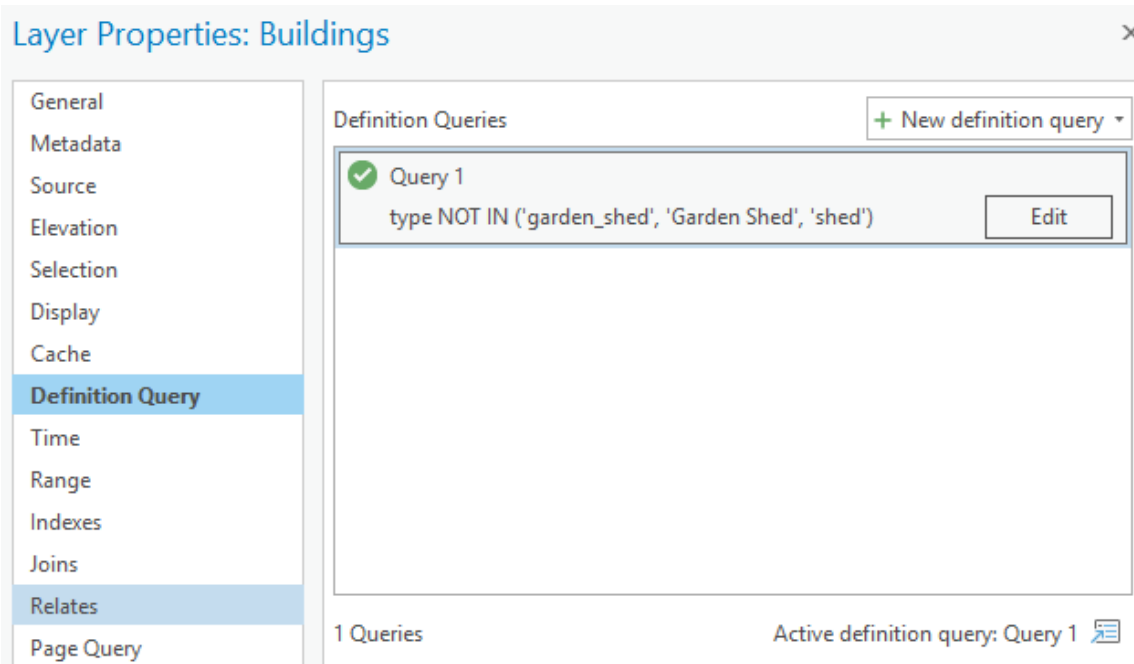
(d) Open the layer properties for the Buildings layer, and then click the Definition Query tab.

*Hint: In the Contents pane, double-click the Buildings layer to open the Layer Properties dialog box.*

(e) Click New Definition Query to create a query and set the following parameters:

- From the first drop-down list, choose Type.
- For the operator, choose Does Not Include The Value(s).
- From the third drop-down list, check the box for Garden Shed, garden_shed, and shed.

Because OpenStreetMap includes user-contributed data, standardization in attribution is sometimes missing, which is why you see variations in capitalization and punctuation. This happens often when you are creating maps—data may not be perfect, so you may have to adjust to make sure that you include all the necessary information in a query. You may be able to spot other values in the data that should be included in this definition query.

(f) Above the expression, click the green check mark ✔ to verify that the expression is valid.

(g) Click Apply.

**Layer Properties: Buildings**                                               ✕

| General | Definition Queries | + New definition query ▾ |
|---|---|---|
| Metadata | | |
| Source | ✅ Query 1 | |
| Elevation | type NOT IN ('garden_shed', 'Garden Shed', 'shed') | Edit |
| Selection | | |
| Display | | |
| Cache | | |
| **Definition Query** | | |
| Time | | |
| Range | | |
| Indexes | | |
| Joins | | |
| Relates | 1 Queries | Active definition query: Query 1 ▣ |
| Page Query | | |

(h) Click OK to close the Layer Properties dialog box.

This definition query gets rid of a handful (about 4,000 across the whole map) of relatively insignificant features. However, if you inspect the large concentrations of buildings in the populated places, you will see that many very small building features are still shown. Many of these features have no value for the Type field.

(i) With the Explore tool ⊕ active, zoom in and click a building to see a pop-up window with its attribute values.
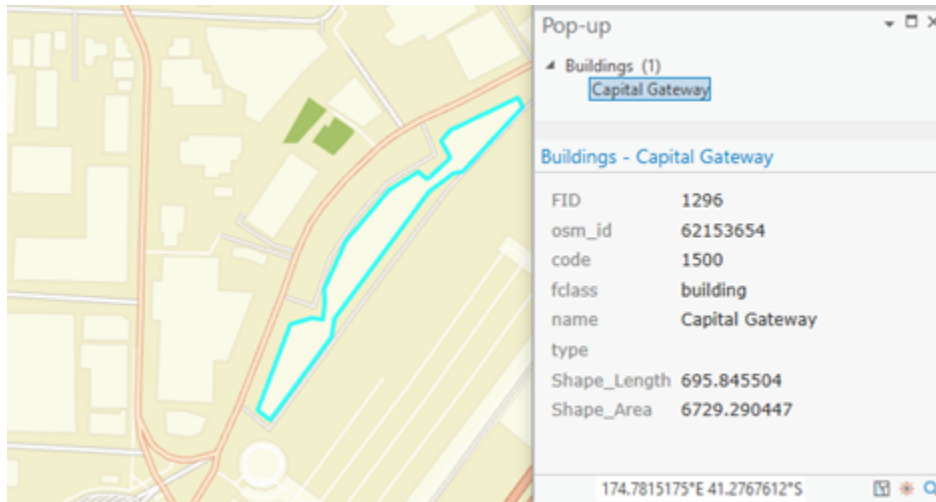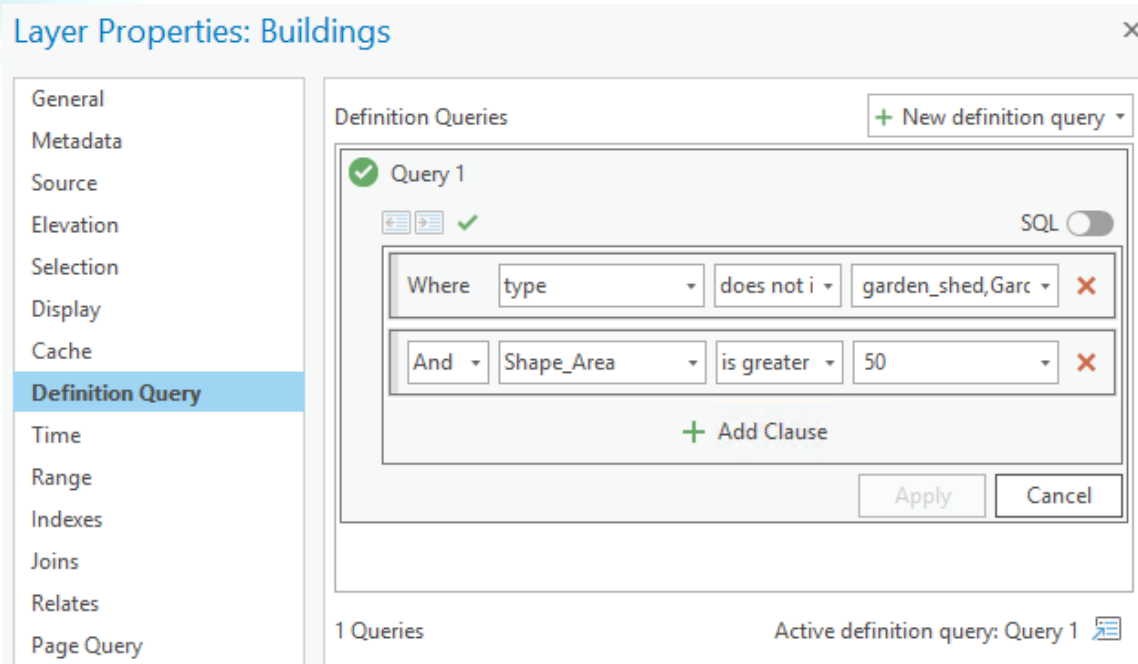


Next, you will add to the definition query to eliminate very small buildings, also based only on their size.

(j) If necessary, close the pop-up window.

(k) Open the Buildings layer properties again.

On the Definition Query tab, the definition query that you added is still active. It currently contains one clause. You will add an additional clause to this active definition query.

(l) Click Edit, and then click Add Clause.

(m) Create the following expression: `And Shape_Area Is Greater Than`**50** .

*Hint: Type the number 50 rather than using the drop-down list, and then add a space to remove any extra digits.*

**Layer Properties: Buildings**

Definition Queries          + New definition query ▾

✓ Query 1

Where  type  ▾  does not i ▾  garden_shed,Gar ▾  ✕

And ▾  Shape_Area  ▾  is greater ▾  50  ▾  ✕

+ Add Clause

Apply    Cancel

1 Queries          Active definition query: Query 1

**n** Verify that the expression is valid, and then click Apply.

**o** Click OK to close the Layer Properties dialog box.

Adding this clause filters about 83,000 building features from the original data set, but the overall character, distribution, and density of the buildings are still visually apparent.

## Step 5: Limit the scale range of a layer

In addition to limiting the features that appear in a layer with a definition query, you can also limit the scales at which a layer is visible on a map, which is known as the scale range (https://bit.ly/3bc5CAk). This is another way to ensure that only an appropriate amount of detail is shown at smaller scales. The Buildings layer is an obvious choice for imposing this sort of limit. The buildings are very detailed and do not add much to the smaller-scale views of the country. Also, the map already includes an Urban Area layer for a general overview of where the inhabited places are.

So, in addition to having thinned many insignificant structures from the Buildings layer, you will now remove all buildings at the smaller scales of your map using a scale range. Scale ranges can be open on either end of the range ("*only show this layer at smaller scales than this*" or "*only show this layer at larger scales than this*") or can be constrained on both ends.

**a** In the Contents pane, ensure that the Buildings layer is selected.

**b** If necessary, collapse the Roads layer.
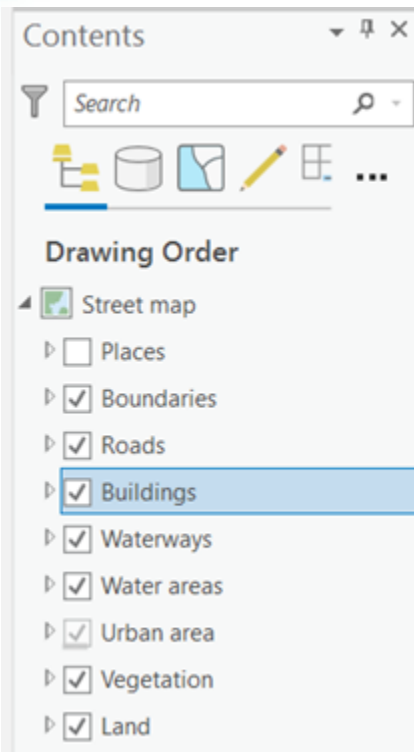


*Note: You will use the Appearance tab, which is contextual. This means that the tab only displays under certain circumstances. This tab in particular only appears if a layer is selected in the Contents pane.*

**c** Under Feature Layer, on the Appearance tab, in the Visibility Range group, for Out Beyond, choose 1:36,112.
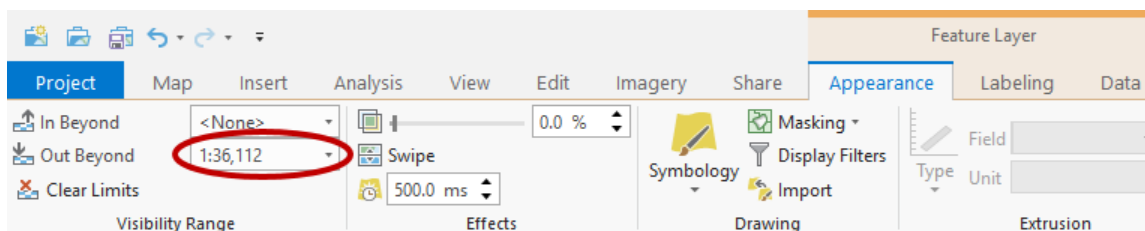


This limits the display of the buildings to scale ranges smaller than 1:36,112.

*Note: These numbers are not round numbers because they relate to a tiling scheme. You will learn more about tiling schemes in another exercise.*

**d** Zoom in and out on the map to see when buildings are visible and when they are not.

*Note: In the Contents pane, the check box next to the Buildings layer will become gray when you are zoomed outside of the scale range that you specified.*

(e) Save your project.

## Step 6: Work with display filters

Cartographers commonly make multiple copies of a feature layer in a map. They then combine these two techniques—definition queries and scale ranges—to get more control over which features are shown at which scales. A unique definition query and a scale range are set on each layer copy so that it displays differently at different scales.

While this can be an effective approach, it is cumbersome to maintain multiple layers of the same features as it involves a lot of duplicated effort and data. There are two other approaches to use to avoid this duplication of layers: display filters and scale-based symbology.

In the case of the buildings, the way that they are currently filtered (using a definition query) is independent of how they are symbolized. The buildings are all symbolized the same way, with the symbol defined using single symbol symbology (https://bit.ly/3d7myto). In this case, instead of making duplicate layers with unique scale ranges and definition queries, you can set up display filters (https://bit.ly/2rtdKal) to get more control over which buildings are shown at which scales. Display filters allow you to specify the query in clauses the same way as definition queries but also specify a scale range, all on a single layer.

Next, you will use display filters to control the display of buildings at three different scales.

(a) Clear the scale range and definition query that you previously established on this layer.

> *Hint:*
> - *Scale range: In the Contents pane, select the Buildings layer, and then on the Appearance tab, in the Visibility Range group, click Clear Limits* ![icon]*.*
> - *Definition query: In the Contents pane, double-click the Buildings layer, and then in the Layer Properties dialog box, on the Definition Query tab, point to the query and click the Remove Definition Query* ✕ *button.*

You will start by setting a scale range on the layer so that none of the buildings will display at smaller scales.

(b) In the Contents pane, ensure that the Buildings layer is selected.

(c) On the Appearance tab, in the Visibility Range group, for Out Beyond, choose 1:144,448.
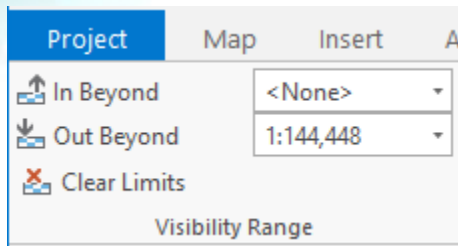
d　On the Appearance tab, in the Drawing group, click Display Filters.

The Symbology pane opens.

e　In the Symbology pane, click the option to Enable Display Filters.

You will start by naming the display filter.

f　Double-click <all features> to select it, and then type **1:18,056 and larger scale** and press Enter.
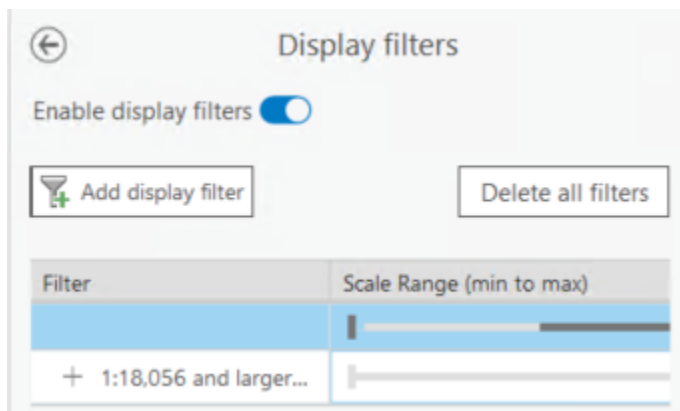


g　To the left of the filter text, click the plus sign ➕ to create a query for this filter.

You will create a query in the same manner that you created the definition query earlier.

h　Click New Expression and build the first query as follows: `Type Does Not Include The Value(s) Garden Shed, garden_shed, shed`.

i　Click Add Clause and build the second part of the query as follows: `And Shape_Area Is Greater Than` **50** .

*Note: You may need to expand the Symbology pane to see the entire query.*

j　Click Apply.

Your display filter should look like the following graphic.

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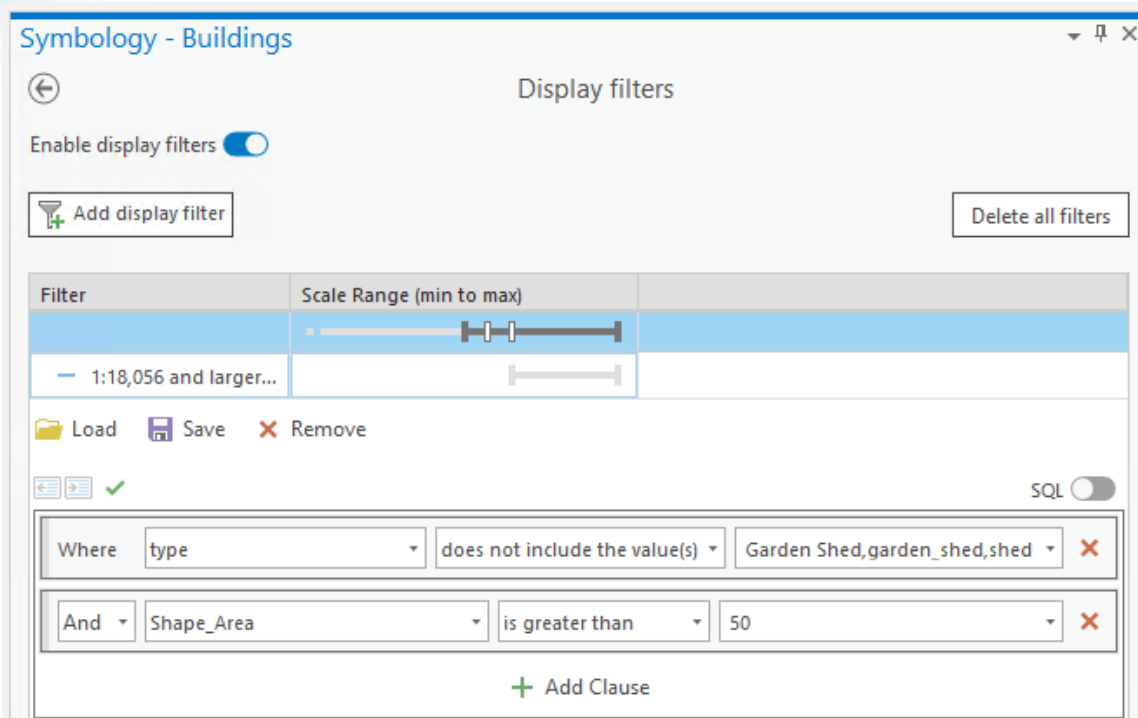
k   Near the top of the Symbology pane, click Add Display Filter twice to add two additional display filters.

Two new display filter entries are added to the grid near the bottom of the Symbology pane.

l   Using what you have learned about display filters, set up the filter names and their display filter clauses as specified in the following table.

| Display filter name | Display filter clause |
|---|---|
| Between 1:18,056 and 1:72,224 scale | Show all buildings that are larger than 250m$^2$ |
| Between 1:72,224 and 1:144,448 scale | Show all buildings that are larger than 500m$^2$ |

When you are done, the display filters should look like the following graphic.

m  After you have verified the naming of each display filter and the clauses, collapse each filter.

*Hint:  Click the minus sign to the left of each display filter name.*

Now you will set the actual scale range for each of the filters.

At the top of the grid that lists the display filters that you created is a dark gray bar with four sliders (also called "stops") on it. The sliders represent the visibility range for each of the display filters. The solid gray slider on the far right represents the largest scale that the map will display at, and the hollow slider to its immediate left represents the smallest scale that the first display filter will show.

**n** Click the hollow (white) slider that is farthest to the right and drag it until the ToolTip says 1:18,056.

*Note: You can also use the drop-down list that appears when you click the slider to specify the scale.*

*Hint:  You work only with the stops on the main slider, but the subsliders below the main slider give you a visual understanding of the scale ranges for each of the filters.*

The scale ranges are set from a single slider because display filters must be mutually exclusive and coincident. Their ranges cannot overlap and cannot have gaps.

**o** Click the hollow slider on the left and specify a scale of 1:72,224.

When you are finished, the grid should look like the following graphic.



**p** Move the minimum scale stop (the left-most solid slider) to 1:144,448.

Now the scale ranges for each display filter are set to match their names.

The final grid should look like the following graphic.

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You have set up a total of four ways to control how the features in the Buildings layer display, using a combination of visibility ranges and display filters. The following table summarizes the work that you did in this step.

| Type | Scale range | Description/query clause |
|------|-------------|--------------------------|
| Scale range | Smaller than 1:144,448 scale | Do not show buildings |
| Display filter | Between 1:72,224 and 1:144,448 scale | Show all buildings that are larger than 500m$^2$ |
| Display filter | Between 1:18,056 and 1:72,224 scale | Show all buildings that are larger than 250m$^2$ |
| Display filter | 1:18,056 and larger scale | Show all buildings larger than 50m$^2$ that are not sheds |

q  Zoom in and out on the map.

Observe how display filters control visibility of features in the map at different scale ranges based on the queries that you just created.

## Step 7: Work with scale-based symbol classes

Another approach to limit the amount of detailed data displayed at smaller scales without having to make multiple versions of a layer, each with a different definition query, is called scale-based symbology. When a layer is symbolized with either unique-value or graduated-color symbology, you can specify the visible scale range for each symbol class.

In your map, roads are symbolized by road class. In this case, you can set scale ranges directly on the symbol classes.

a  In the Contents pane, if necessary, turn on the Roads layer and expand the layer to see its symbology for the different types of roads in the data.

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b Zoom in and out in various areas (including urban areas) to see how additional road classes appear as you move into larger scales.
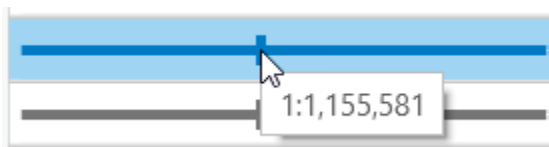


c Open the Symbology pane for the Roads layer.

*Hint: Right-click Roads and choose Symbology.*

d Investigate the way that the road classifications are designed and symbolized.

e In the Symbology pane, click the Scales tab.
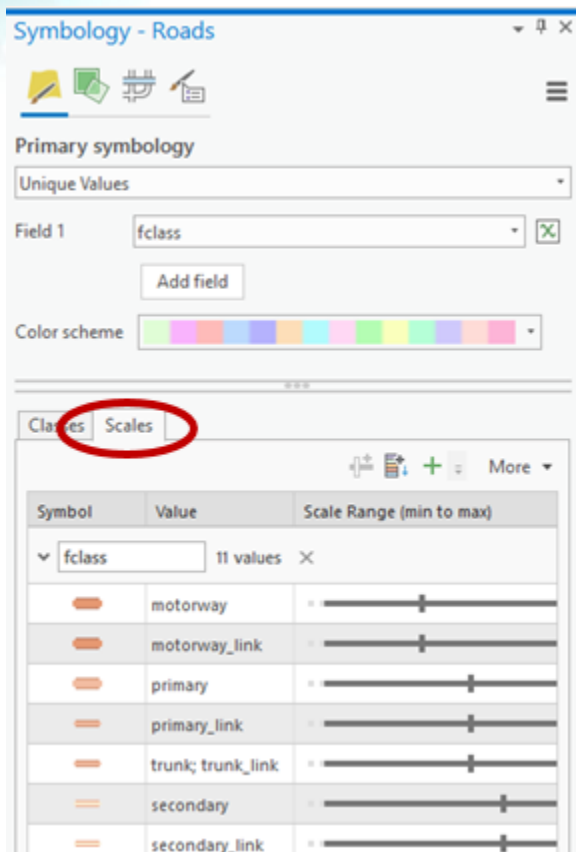
(f) Investigate the scale ranges on each road class by pointing to each stop to see the scale range boundaries.

⚠ Do not click or move the stops.



*Note: In the Scale Range column in the grid, point to the stops (vertical bars) on the slider to view the values. You may need to expand the width of the Symbology pane or scroll to the right to see the slider.*

Note that the Residential road class (third from the bottom) is set to show at all scales. This setting is too much detail at smaller scales and is inconsistent with the way that the other road symbol classes are defined.

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**g** Use the scale stops on the slider to adjust the scale range of the Residential roads so that they appear only from 1:144,448 to infinity (none) at the largest scales.

*Hint: Click and drag only the left slider to adjust this scale range.*
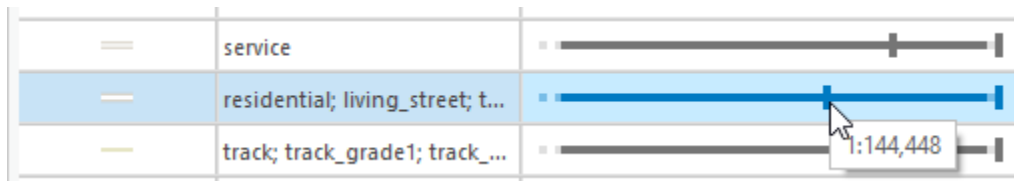


**h** On the Map tab, in the Navigate group, click Bookmarks and click the Wellington bookmark.

Note that there is a range of scales from 1;144,000 to 1:72,000 where it would be nice to show the residential roads, but they are too detailed as cased roads. They would be better as simple single solid lines. You can modify the symbol class symbology to accomplish this.

**i** In the grid near the bottom of the Symbology pane, click the Residential roads class to select it.

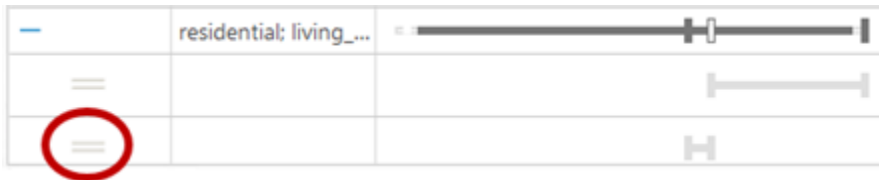**j** Click the Add Alternate Symbol button  ⊣⊢ .

Now there are two identical symbol classes, each with different scale ranges.
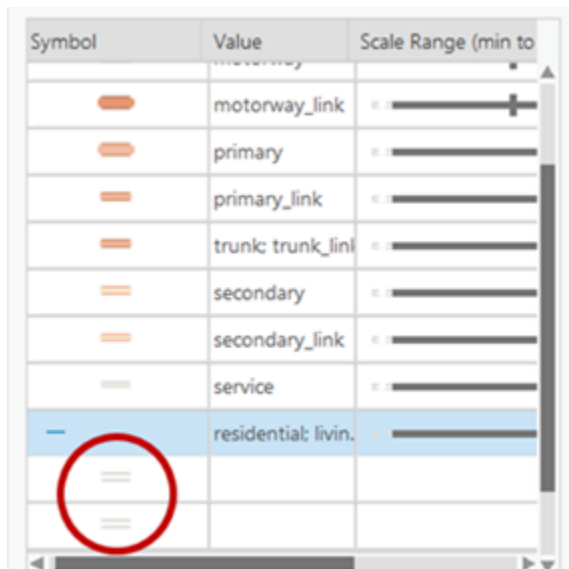


**k** If necessary, adjust the scale boundary between these two by dragging the white scale stop to 1:72,224.

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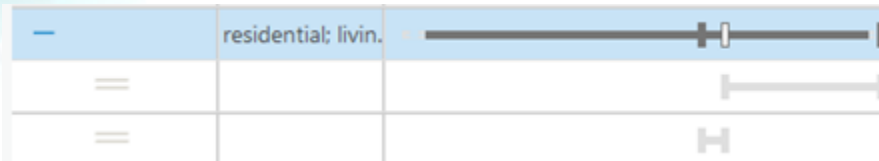
l Click the symbol of the second duplicated class to change it. (This is the one that is set to a 1:144,448 to 1:72,224 scale.)



m Click the Properties tab, and then use the options to change the symbol so that it has only a solid stroke layer that is 1 pt wide and colored Gray 30%.

*Hint: Use the Structure tab* 🔧 *to delete one of the two stroke symbol layers, and then use the Layers tab* 📚 *to adjust the properties of the remaining stroke symbol layer.*

n Click Apply, and then click the Back arrow ⊕ to return to the Scales tab of the Symbology pane.

Your symbol classes should look like the following graphic.

○ Zoom in and out on the map through the scale ranges and note how the residential roads are drawn with a different symbol at different scales.

Notice how the same road features are symbolized differently depending on the scale. At the largest scales, they are cased roads; at medium scales, they are a simple gray line; and at the smallest scales, they are not drawn at all.

p Close the Symbology pane.

q Save your project.

So far, managing which features are shown at which scales with which symbols got you to a decent multiscale map. (Ideally, you will eventually work this magic on all the map layers, not just the Roads and Buildings layers. See the Stretch Goals section at the end of Section 3 Exercise 3: *Vector Tiles.*)

r If you are continuing to the next exercise now, leave ArcGIS Pro open.

s If you will continue to the next exercise at a later time, exit ArcGIS Pro.