Exercise 3: Perform analysis in ArcGIS Pro

The Northridge earthquake caused around $20 billion in damage because of the duration of the shaking (10 to 20 seconds) and the speed at which the ground shook. The quake occurred in a major population center.

In this exercise, you will use a hillshade raster to investigate how the location of the faults in the area affects the geology of the San Fernando Valley. You will also determine the approximate distance that the shaking traveled through the surrounding area in the first minute after the quake started. Finally, you will analyze rasters showing how quickly the ground shook, and you will visualize the amount of damage that occurred.

1. Start ArcGIS Pro and sign in using your ArcGIS Online organizational account credentials.
2. Click Open Another Project.
3. In the Recent Projects section, click the Browse button.
4. Browse to C:\Esri\ArcGIS Pro\Projects and select **Exercise3.ppkx**.

Packages are unpacked in the <User Documents>\ArcGIS\Packages folder rather than the ***C:\Esri\Projects*** folder. You will save this package in the correct location.

1. On the ***Project*** tab, click **Save As**.

In the Save Project As window, browse to ***C:\Esri\ArcGIS Pro\Projects*** and save the project as **Exercise3**.

2. Return to the **Map** tab in ArcGIS Pro.

For this earthquake project, you will use data that is not contained in the ArcGIS Pro project structure. You will create a connection to its location so that you can work more efficiently.

3. In the ***Project*** pane, right-click Folders and click **Add Folder Connection**.
4. Create a **Folder** connection to ***C:\Esri\ArcGIS Pro\Data\Exercise3***.
5. Add a **Database** connection to ***C:\Esri\ArcGIS Pro\Outputs\Exercise3.gdb***
6. If necessary, click the ***Northridge2D*** tab at the top of the view area to return to the 2D map view.
7. In the ***Contents*** pane, turn off the Stations, Earthquakes, and BuildingDamage layers.

Step 1: Use a raster processing function to create a hillshade

Like many other Southern California locations, the San Fernando Valley is surrounded by earthquake faults, which have shaped the local landscape. With the data already in your project, you can see where the faults lie and observe their relationship to the topography in the area. But a higher-resolution view of the local elevation will give you a better sense of how the faults and the landforms interact. You will use an elevation raster to create a hillshade on the fly.

1. In the ***Contents*** pane, turn on the **Elevation** raster.
2. If necessary, zoom to the extent of the Elevation raster (right click layer then select **Zoom to Layer**).
3. Make sure that the Elevation raster is selected in the Contents pane.

The Analysis tab contains three groups. The Geoprocessing group lets you search for tools, create models and Python scripts, and set the geoprocessing environments for the project. In the Analysis group, you can choose the most common analysis tools from a gallery. Finally, in the Raster group, you can access raster functions. You will use those raster functions in this step.

4. On the ***Analysis*** tab, in the ***Raster*** group, click ***Raster Functions***.

Note: The Raster Functions pane contains many functions designed for raster analysis. You will search for the function you want.

5. In the ***Raster Functions*** search box in the ***Raster Function*** pane, type *Hillshade*.
6. Click the **Hillshade** function, the ***Hillshade Properties*** pane opens.
7. Keep all the defaults for the Hillshade function.
8. Click ***Create new layer***, then close the ***Raster Function*** pane.
9. Turn off the **Elevation** raster.
10. Turn on the **MajorFaults** feature class.

The new, higher-resolution hillshade makes it easier to see the relationship between mountains and earthquake faults.

11. **Save** your project.

Step 2: Add and symbolize a layer

To run some of the analysis tools in this exercise, you must be able to easily identify the point that represents the main shock of the Northridge earthquake. To save time, the epicenter of the quake has been added to a separate feature class, which you will add to the map and symbolize in this step.

1. In the ***Project*** pane, browse to **Folders** > **Exercise3** > **Database** > **Northridge.gdb**.
2. Add the **Epicenter** feature class by dragging it to the map.

Now you will symbolize the epicenter of the earthquake.

3. In the ***Contents*** pane, click the **Epicenter** symbol to open the ***Symbology*** pane.
4. Choose the **Triangle 4** symbol.
5. In the ***Symbology*** pane, click **Properties**.
6. Increase the symbol size to **12** point.
7. Click **Apply**.
8. **Save** your Project.

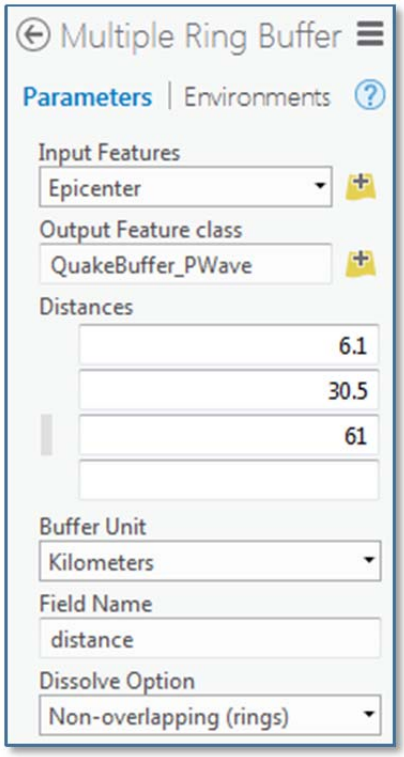
Changing the symbology makes the main earthquake more visible on the 2D map.

Step 3: Use geoprocessing to create a multiple ring buffer

The shaking from an earthquake is not actually a single continuous event, although it can feel that way. In fact, two different types of waves travel through the earth that create shaking: P-waves (or primary waves) are pressure waves, and will travel through any material (liquids, solids, or gases). They travel much faster S-waves, the second type of seismic wave. Seismograph stations usually register P-waves first. In this step, you will examine the distance that the Northridge quake P-waves traveled.

1. If necessary, click the ***Analysis*** tab on the ribbon.
2. In the **Geoprocessing** group, click Tools.
3. In the ***Geoprocessing*** pane, search for and open the **Multiple Ring Buffer** tool.

You will create buffer rings for ***6.1***, ***30.5***, and ***61*** *kilometers* from the quake's epicenter. The buffer rings represent the approximate distance that P-waves would have traveled in one, five, and ten seconds after the shaking started.



4. In the ***Geoprocessing*** pane, click **Environments**.
5. For Output Coordinate System, choose **Earthquakes**.
6. Click **Parameters**.
7. For **Input Features**, choose **Epicenter**.
8. For **Output Feature Class**, browse to the ***Exercise3*** geodatabase in the **Databases** connection and enter the name: ***QuakeBuffer_PWave***.
9. For Distances:
   - In the first field, type **6.1** and then press Enter.
   - In the second field, type **30.5** and then press Enter.
   - In the third field, type **61**.
10. For **Buffer Unit**, choose ***Kilometers***.
11. Click **Run**.

Note: Do not close the geoprocessing pane.

12. Zoom to the extent of the **QuakeBuffer_PWave** layer

The buffer rings represent the approximate distance that the initial P-waves from the main shock traveled in the first second, five seconds, and ten seconds after the earthquake started.

Step 4: Symbolize the multiple ring buffer output

1. In the ***Contents*** pane, make sure that the **QuakeBuffer_PWave** layer is selected.
2. On the ***Appearance*** tab, click the **Symbology** down arrow and choose ***Graduated Colors***.
3. On the **Symbology** pane, change the color scheme to ***Cyan To Purple***.

4. Under ***Class Breaks***, click **More**.
5. Click **Symbols** > **Reverse Order**.
6. Close the ***Symbology*** pane.
7. On the ***Appearance*** tab, change the transparency to **40%**.

Step 8: Run the multiple ring buffer again

S-waves (secondary or shear waves) travel more slowly than P-waves, and usually have greater amplitude, meaning that they generally cause more damage. S-waves travel at approximately 60 percent of the speed of P-waves, and will not move through liquids or gases.

The average speed of S-waves is 3.5 kilometers per second through solid ground. For this step, you will determine the approximate distance the S-waves traveled in the first 10 seconds after the earthquake started.

1. In the ***Contents*** pane, turn off the **QuakeBuffer_PWave** layer.
2. Activate the ***Geoprocessing*** pane.

Note: The Multiple Ring Buffer tool is still open in the Geoprocessing pane, and all the parameters you set earlier are still present. You will change some of the variables and run the tool again.

3. For Input Features, keep Epicenter.
4. Change the **Output Feature Class** to ***QuakeBuffer_SWave*** (make sure it is saved to the Exercise3 geodatabase in the **Databases** folder).
5. Change the **Distances** to the following values:
   - **3.5**
   - **17.5**
   - **35**
6. For **Buffer Unit**, keep *Kilometers*.
7. Run the tool and close the ***Geoprocessing*** pane.

Use what you have learned to symbolize the **QuakeBuffer_SWave**:

8. Symbolize the layer with **Graduated Colors**.
9. Change the color scheme to **Yellow To Red**.
10. Reverse the order of the colors so that 3.5 is red (**Class Breaks** > **More** >> **Symbols** > **Reverse Order**).
11. Close the ***Symbology*** pane.
12. Change the **transparency** of ***QuakeBuffer_SWave*** to 40%.

13. In the ***Contents*** pane, turn on the ***QuakeBuffer_PWave*** layer.

Compare how much farther the P-waves traveled in the first ten seconds of the earthquake than the more dangerous S-waves.

The Northridge earthquake itself lasted between 10 and 20 seconds, so the outer buffer ring is about how far the waves traveled before the earth even stopped moving.

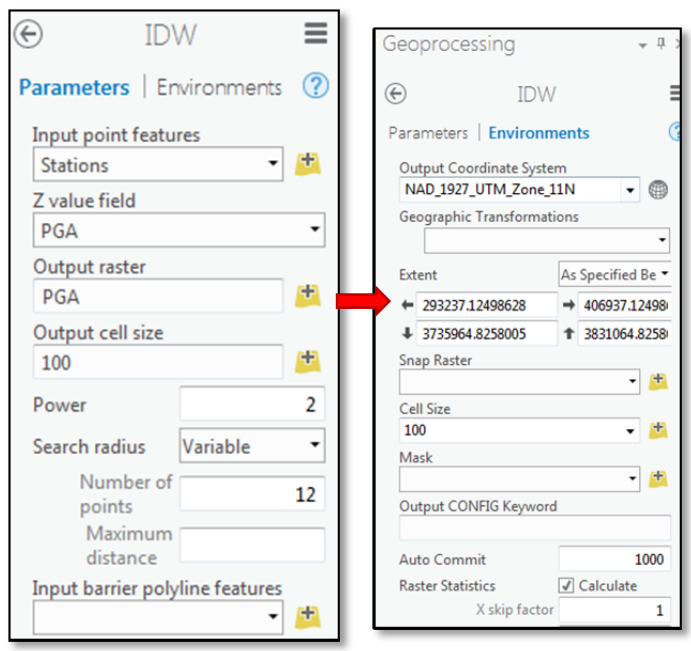
14. **Save** your project.

Step 5: Run a geoprocessing tool to create a raster

To complete this step, you must have access to either the 3D Analyst or the Spatial Analyst extension.

You will start by creating a raster representing the peak ground acceleration that was recorded at each of the earthquake stations in the area of the Northridge earthquake.

1. Turn **off** the *Epicenter*, the two ***QuakeBuffer***, and the ***Hillshade*** Layers
2. Turn on the ***Elevation*** layer.
3. Zoom to the extent of the ***Elevation*** layer.
4. In the ***Geoprocessing*** pane (***Analysis*** pane > **Tools**), search for and open the **IDW tool** from the *Spatial Analyst Tools*.
5. Click **Environments** and set the geoprocessing environment:
   - Output Coordinate System: **Elevation**
   - Extent: **Same As Layer Elevation**
   - Cell Size: **Same As Layer Elevation**
   - Keep all other defaults
6. Click **Parameters** and set the **IDW** tool parameters:
   - Input Point Features: **Stations**
   - Z Value Field: **PGA**
   - Keep the Output Raster location (C:\Esri\ArcGIS Pro\Outputs\Exercise3.gdb), name it **PGA**.
   - Keep all other defaults
7. Click **Run**.



The tool creates a surface for peak ground acceleration.

8. **Save** your project.

Step 6: Run a geoprocessing tool to create another raster

Now you will create a surface of peak ground velocity.

1. Display the ***Geoprocessing*** pane, if necessary.
2. The same **IDW** tool should appear in the Geoprocessing window, if not Search for and open the **IDW** tool.

3. Change some of the tool parameters (Refer to Step 5 above if parameters have been cleared):
   - Z Value Field: **PGV**
   - Output Raster: **PGV**
   - Keep all other defaults
4. Click **Run**.
5. The tool creates a **PGV** layer in the ***Contents*** pane.
6. **Save** your project.

Step 7: Symbolize a raster layer for visual analysis

In most earthquakes, the ground shakes much more than it actually moves. Therefore, the damage a building sustains during an earthquake does not usually come from the actual displacement of the ground beneath it, but from being forced to move quickly.

The speed at which the ground shakes during an earthquake is a measure of its velocity. As you have learned, the highest velocity reached during an earthquake is called the peak ground velocity (PGV). The more quickly the ground reaches this maximum velocity, the greater its acceleration. The peak ground acceleration (PGA) is the largest acceleration recorded during an earthquake.

These raster layers **PGA** and **PGV** represent the peak ground acceleration and peak ground velocity recorded at the various earthquake stations during the main shock of the Northridge earthquake.

1. If necessary, turn off the **PGV** layer.
2. In the ***Contents*** pane, click the **PGA** layer.
3. On the ***Appearance*** tab, click **Symbology** > **Stretch**.
4. Apply symbology:
   - Color Scheme: **Yellow To Red**
   - Stretch Type: **Standard Deviation**
   - Number Of Standard Deviations: **2.5**
5. On the **Appearance** tab, change the transparency of the **PGA** layer to **40%**.
6. If necessary, turn on the **Hillshade** layer
7. If not already, move the **PGA** layer so that it is just above the **Hillshade** layer.

In the PGA layer, yellow areas indicate lower acceleration rates. Orange and red areas show higher acceleration rates, and indicate where more damage is expected.

Step 8: Symbolize another raster layer for visual analysis

1. Turn on the **PGV** layer.
2. With the **PGV** layer active, click the ***Appearance*** tab > **Symbology** > **Stretch**.
3. Apply symbology:
   - Color Scheme: Cyan To Purple

- Stretch Type: **Standard Deviation**
- Number Of Standard Deviations: **2.5**

4. On the ***Appearance*** tab, change the transparency of the **PGV** layer to **40%**.
5. If necessary, in the ***Contents*** pane, move the **PGV** layer directly above the **PGA** layer.

The cyan areas indicate the lowest peak ground velocity rates during the earthquake. Darker purple and fuchsia areas indicate the highest ground velocity rates.

6. **Save** your project.

Step 9: Compare building damage to rasters

Evaluating where the ground velocity and acceleration are highest can help predict where the worst damage will be reported, but it is not infallible. Other factors—for example, older buildings not built according to modern standards, or the ground on which a structure is built (known as site response)—can also affect the amount of damage that occurs.

In your project, the **BuildingDamage** layer is symbolized by the number of buildings that were damaged in each block group. For this step, you will visually compare the building damage with the PGA and PGV rasters that you symbolized earlier.

1. In the ***Contents*** pane, turn on the **BuildingDamage** layer.
2. Turn off the Earthquakes Layer.
3. With the **BuildingDamage** layer selected, click the ***Appearance*** tab.
4. In the Effects group, click Swipe.

Note: The Swipe tool allows you to view the **PGV** layer under the BuildingDamage layer without having to turn the **BuildingDamage** layer on and off in the Contents pane.

5. Use the Swipe tool by clicking and dragging the cursor back and forth across the map.

Question: Where on the map does there seem to be a lot of damage with relatively low ground velocity?

Answer: _____

_____

6. In the ***Contents*** pane, turn off the **PGV** layer and turn on the **PGA** layer.

Use the Swipe tool to compare the **BuildingDamage** layer with the **PGA** layer.

Question: Where on the map do there seem to be discrepancies between peak ground acceleration and the number of damaged buildings?

Answer: _____

_____

7. **Save** your project.

In this exercise, you used geoprocessing tools and visual analysis methods to investigate fault lines, topography, damage, PGA, and PGV associated with the Northridge earthquake.

1. Close **ArcGIS Pro.**

End Exercise 3