# Intersection Design - Horizontal & Vertical Geometry

*This course is for the* **2021 Release 1** *version of:*

OpenRoads Designer CONNECT Edition

OpenRail Designer CONNECT Edition

**About this Practice Workbook...**

- This workbook is designed for use in Live instructor-led training and for OnDemand self study. OnDemand videos for this course are available on the *LEARNserver* and through *CONNECT Advisor*.
- This PDF file includes bookmarks providing an overview of the document. Click on a bookmark to quickly jump to any section in the file.
- Both Imperial and Metric files are included in the dataset. Throughout this practice workbook Imperial values are specified first and the metric values second with the metric values enclosed in square brackets.
  For example: *12.0′ [3.4m]*.
- This course workbook uses the *Training and Examples* WorkSpace and the *Training-Imperial* or *Training-Metric* WorkSet delivered with the software.
- The terms “Left-click”, “Click”, “Select” and “Data” are used interchangeably to represent pressing the left mouse button. The terms “Right-click” and “Reset” are also used interchangeably to represent pressing the right mouse button. If your mouse buttons are assigned differently, such as for left-handed use, you will need to adjust accordingly.

**Have a Question? Need Help?**

If you have questions while taking this course, search in *CONNECT Advisor* for related courses and topics. You can also submit questions to the Civil Design Forum on Bentley Communities where peers and Bentley subject matter experts are available to help.

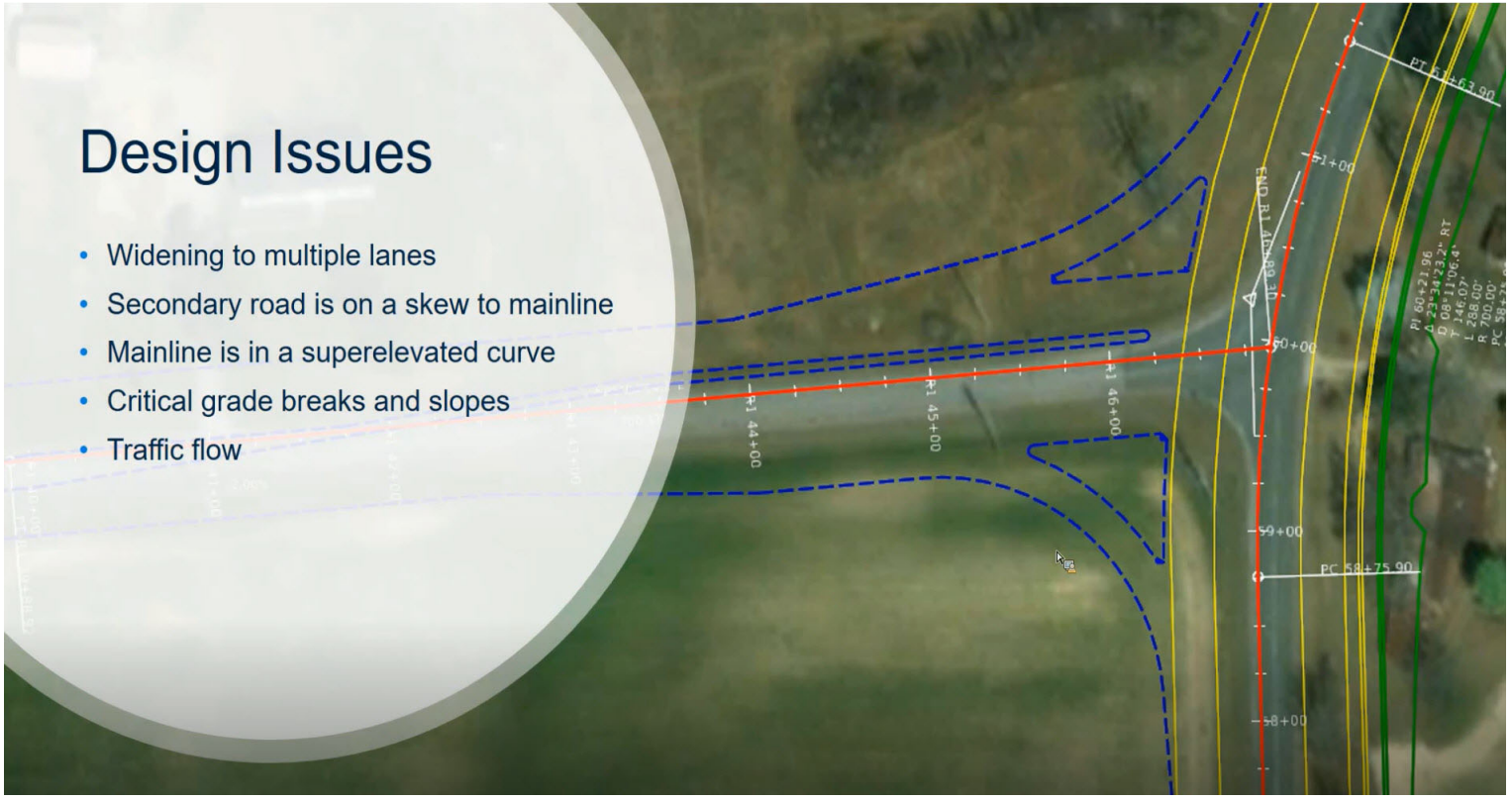
Edition: **04-01**

Course Level: **Intermediate**

## Course Overview

This course teaches tools and techniques that can be used to lay out a complex intersection. It will focus on the Horizontal and Vertical Geometry tools to create 2D and 3D geometric elements.

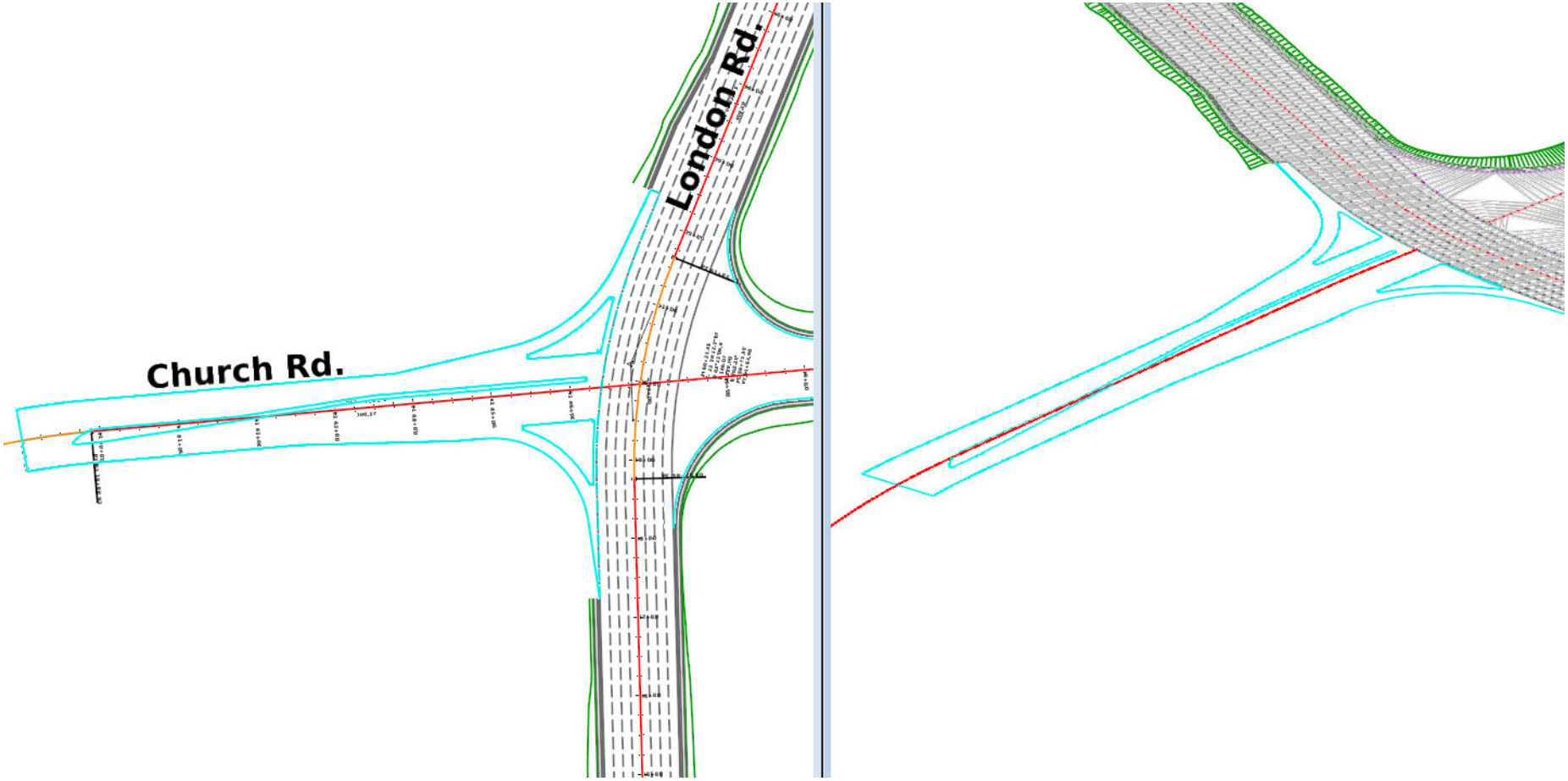
In this course, we will be designing a complex intersection that includes turn lanes, median islands and turn lane islands. There are also several design issues that we need to be aware of as shown below.



## Intersection Layout

The completed intersection layout is shown below in 2D and 3D. 2D horizontal geometry will be created using the Horizontal Geometry tools and Profiles and 3D elements will be created using the Vertical Geometry tools.

The objective is to create a terrain model of the proposed pavement surface and analyze the proposed drainage contours.



# Exercise 1: Create the Edge of Pavement Geometry

## Exercise Description

This exercise contains exercises teaching how to create the edge of pavement geometry.

## Skills Taught

- Review Reference Files
- Create horizontal geometry lines
- Create taper-arc-taper horizontal geometry
- Create geometry using the Single Offset Partial tool
- Create geometry using the Simple Arc tool

## Open Intersection Layout Design File

In this section you will open the intersection design file. All the necessary references have already been attached.

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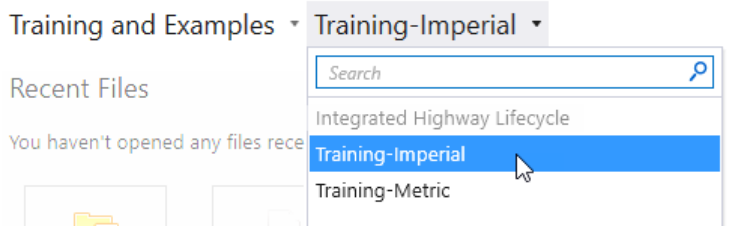
1. Start the software.
2. Set the WorkSpace and WorkSet

   The WorkSpace and WorkSet define standards that are used by the software, and the ones used for this training are installed during the software installation.

   Typically, the WorkSpace contains organizational standards and the WorkSet contains project standards.

   a. Select **Training and Examples** from the *WorkSpace* drop-down menu.

   b. Select **Training-Imperial** *[Training-Metric]* from the *WorkSet* drop-down menu.

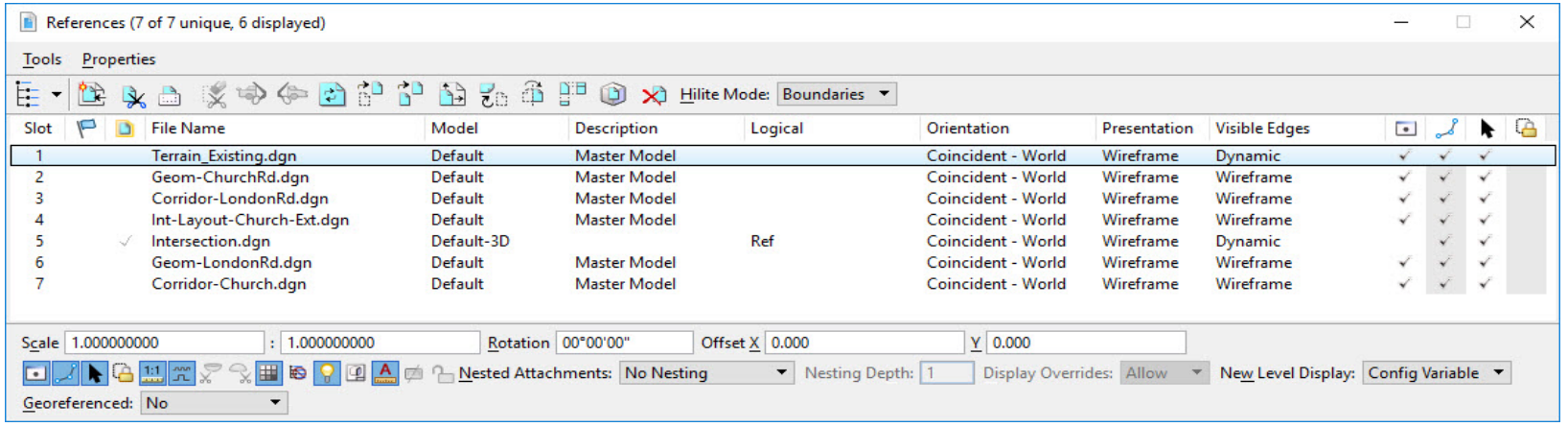



3. Open the intersection layout file.

   a. Browse to the folder where you unzipped the dataset files and select the design file **Intersection.dgn**.

4. Review the attached reference files.

   a. Select **Home > Primary > Attach Tools > References**




   b. Note that we have several files attached. We will be using these files as we progress through the course

   c. Close the References dialog.

5. Review the 2D and 3D views.

   - We will be creating horizontal geometry in the 2D view.
   - Note that the edge of pavement geometry will be tied into the Church Rd. corridor and the London Rd. corridor.
   - For time purposes we will only be creating horizontal and vertical geometry for the northern edge of pavement, northern island and center traffic median. The horizontal geometry and vertical geometry for the southern portion of Church Rd. is already complete.

## Create Edge of Pavement on the North Side of the Church Rd.

In this section you are going to create the edge of pavement elements for the intersection using the horizontal geometry tools. For time purposes the south side has already been completed.

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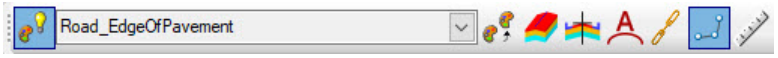
1. Set **Road_EdgeOfPavement** as the active feature definition.

   a. Select **Geometry > General Tools > Standards > Feature Definition Toolbar**

   b. Select **Linear > Pavement > Road_EdgeOfPavement**

   c. Select **Use Active Feature Definition** to set the feature definition active.




2. Create the Typical Edge of Pavement on the North Side of the Intersection

   a. Select the **Geometry > Horizontal > Offsets and Tapers > Single Offset Partial** tool.

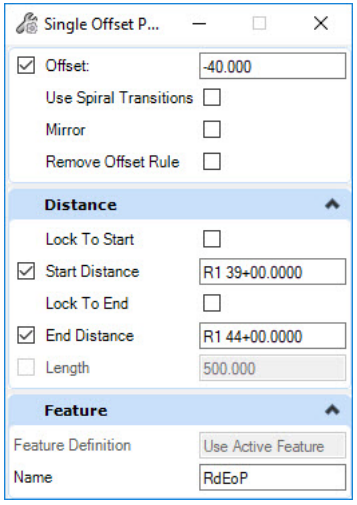
   b. On the dialog box, toggle off all the boxes to **UNLOCK** all the tool settings.

   c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

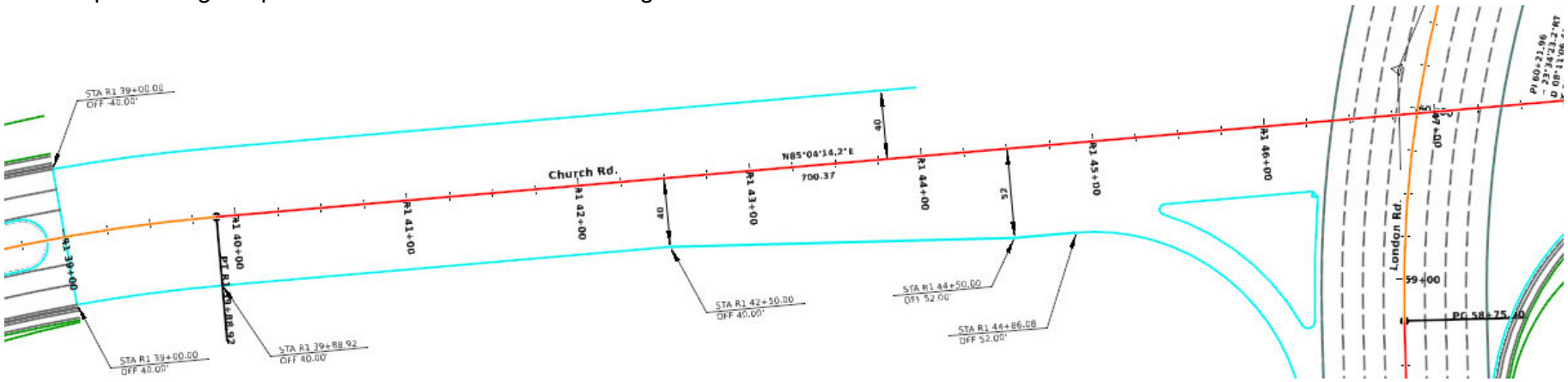
      - *Locate Element <ALT> to Pick element in complex:* Select the **Church Rd.** centerline geometry.
      - *Start Parameters - Offset:* **-40**, Press the **<Enter>** key to lock the value and move the cursor to the north side of the centerline.
      - Press the left or right arrow on the keyboard to cycle through the additional options.
      - *Start Parameters - Distance: Start Distance:* **39+00**, Press **<Enter>** to lock the value.
      - *End Parameters - Distance: End Distance:* **44+00**, Press **<Enter>** to lock the value.
      - *Mirror:* **No**

      **HINT:** Press the **<End>** key to unlock the key-in fields in the heads-up prompt.

   d. Click the **Element Selection** button to exit the command.



The completed edge of pavement should look like the image below.



## Create the Edge of Pavement around the Turn Lane

in this section you are going to learn how to create the taper-curve-taper for the north side turn lane.

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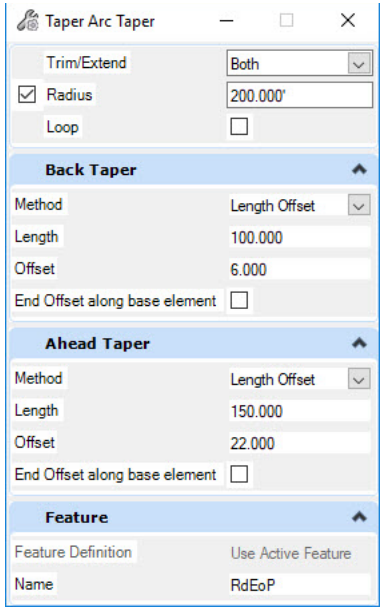
1. Create the Taper-Arc-Taper.

   a. Select **Geometry > Horizontal > Arcs > Arc Between Elements > Taper Arc Taper**

   b. *Locate the First Element*: Select the left edge of pavement element along **London Rd.** (*EOP_L* linear geometry, see image on next page).

   c. *Locate the Second Element:* Select the edge of pavement along the north side of **Church Rd.**

   d. Set the **Taper Arc Taper** dialog as shown below:




      - *Trim/Extend*: **Both**
      - *Radius*: **200**
      - *Back Taper Method*: **Length Offset**

      **Hint:** Press the left or right arrow on the keyboard to cycle through the other *Method* options.

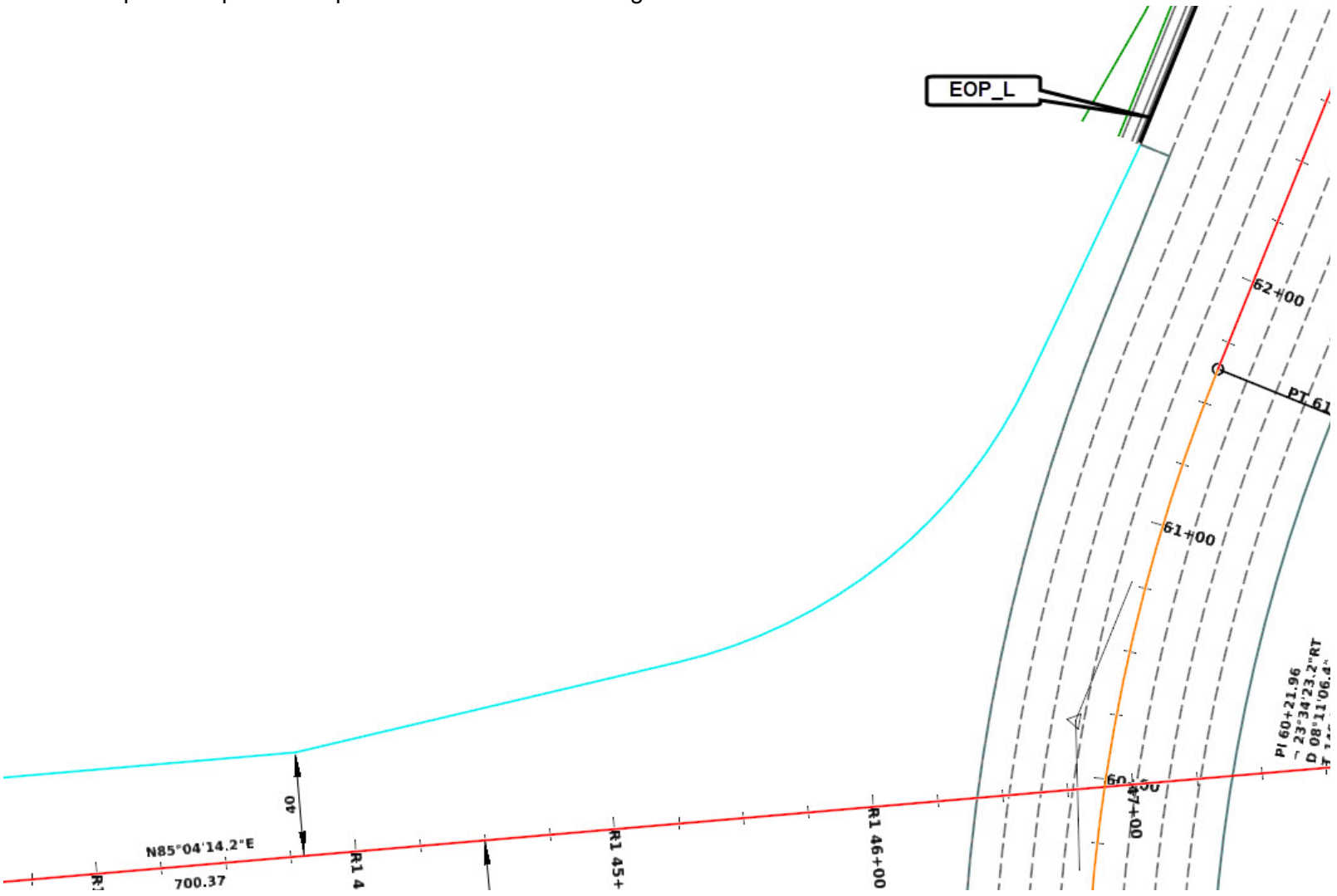
      - *Back Taper: Length*: **100**
      - *Back Taper: Offset*: **6**
      - *Ahead Taper Method*: **Length Offset**
      - *Ahead Taper: Length*: **150**
      - *Ahead Taper: Offset:* **22**

   e. Move the cursor into the proper quadrant.

   f. *Left-click* to complete.

      **TIP:** If the result begins to loop when moving your cursor, toggle off the **Loop** option Loop ☑ on the dialog box

The completed Taper-Arc-Taper should look like the image below.



## Create a Match Line (or Seam line) Along Left Side of London Rd.

In this section, you will create horizontal geometry that represents the left edge of pavement along London Rd. (We will assign a profile to this element later in the course).

---

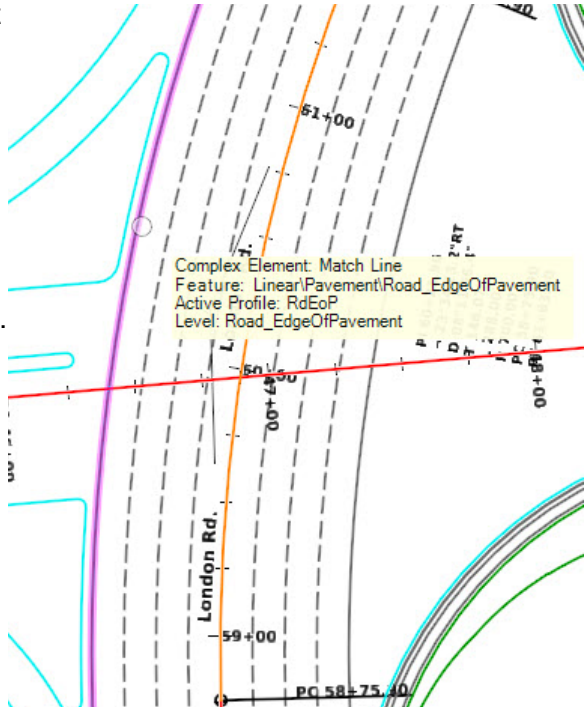
1. Use **Single Offset Partial** to create a match line (or seam line) that is offset 48 units to the left of London Rd.

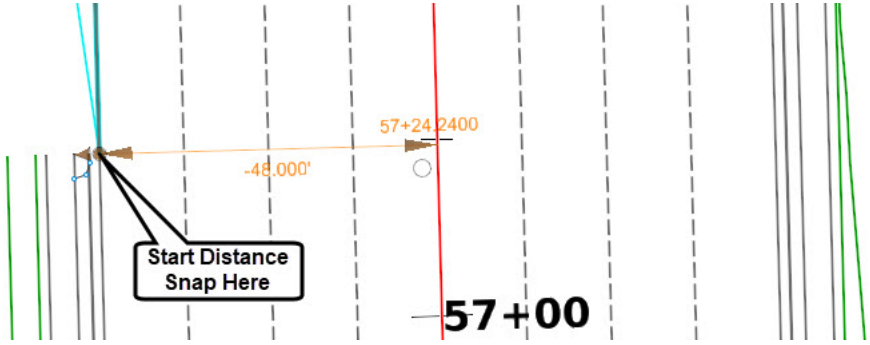
   a. Select the **Geometry > Horizontal > Offsets and Tapers > Single Offset Partial**.

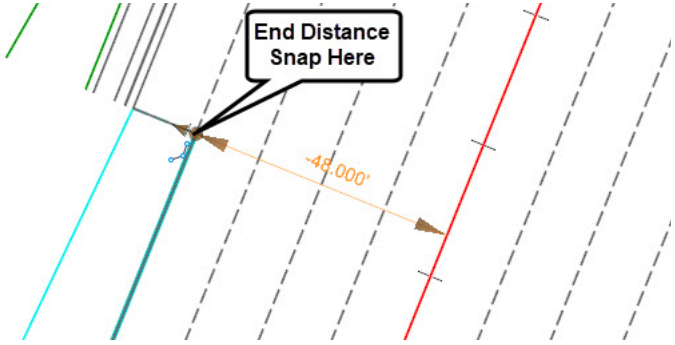
   b. On the dialog box, *UNLOCK* all the tool settings. Set the *Name* to **Match Line**

   c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - *Locate Element <ALT> to Pick element in complex:* Select the London Rd. centerline.
      - *Start Parameters - Offset:* **-48**, Press the **<Enter>** key to lock the value and move the cursor to locate the new element properly.
      - Press the right arrow key to advance to the next prompt.
      - *Start Parameters - Distance: Start Distance:* Snap to the beginning point of the southwest taper (use image below as a guide).
      - *End Parameters - Distance: End Distance:* Snap to the **EOP_L** is offset from the northwest taper (use image below as a guide).
      - *Mirror:* **No**



## Create the Edge of Pavement for the North Island

In this section we are going to create the horizontal geometry for the north island.

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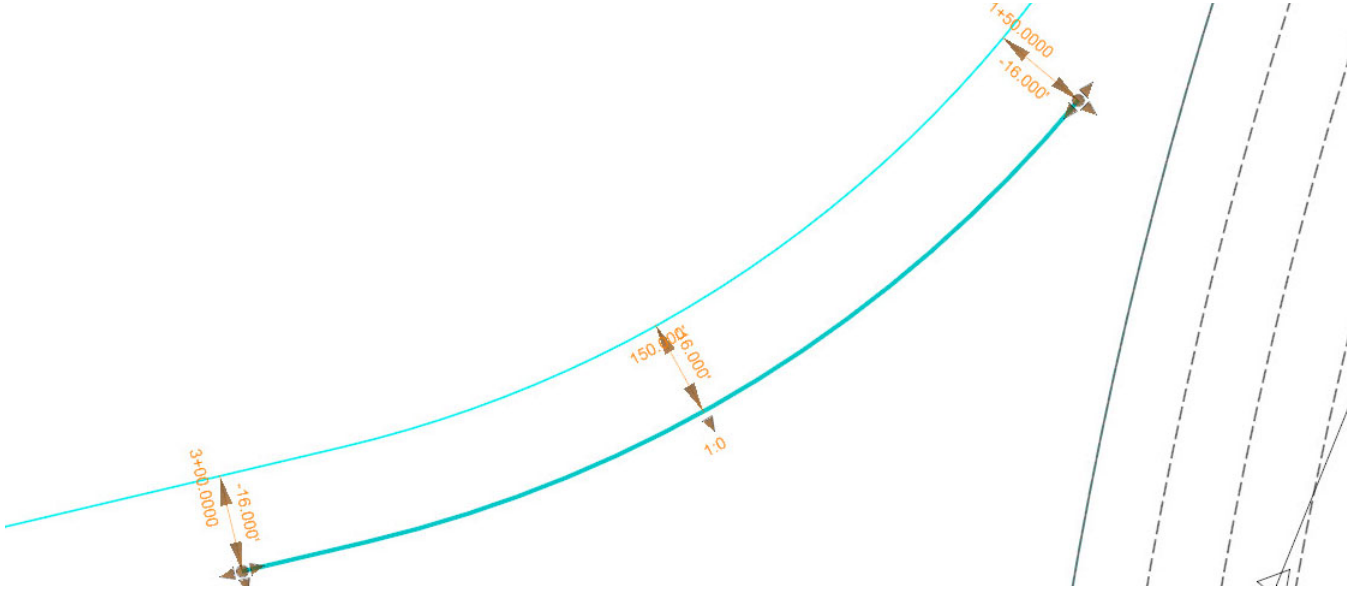
1. Create the northwest edge of pavement for the island, select the **Geometry > Horizontal > Offsets and Tapers > Single Offset Partial**
   a. On the dialog box, *UNLOCK* all the tool settings.
   b. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):
      - *Locate Element <ALT> to Pick element in complex:* Select the taper curve taper edge of pavement element.
      - *Start Parameters - Offset:* **-16**, Press the **<Enter>** key to lock the value and move the cursor to locate the new element properly
      - Press the right arrow key to advance to the next prompt.
      - *Start Parameters - Distance: Start Distance:* **1+50**, Press the **<Enter>** key to lock the value
      - *End Parameters - Distance: End Distance:* **3+00**, Press the **<Enter>** key to lock the value.
      - *Mirror:* **No**

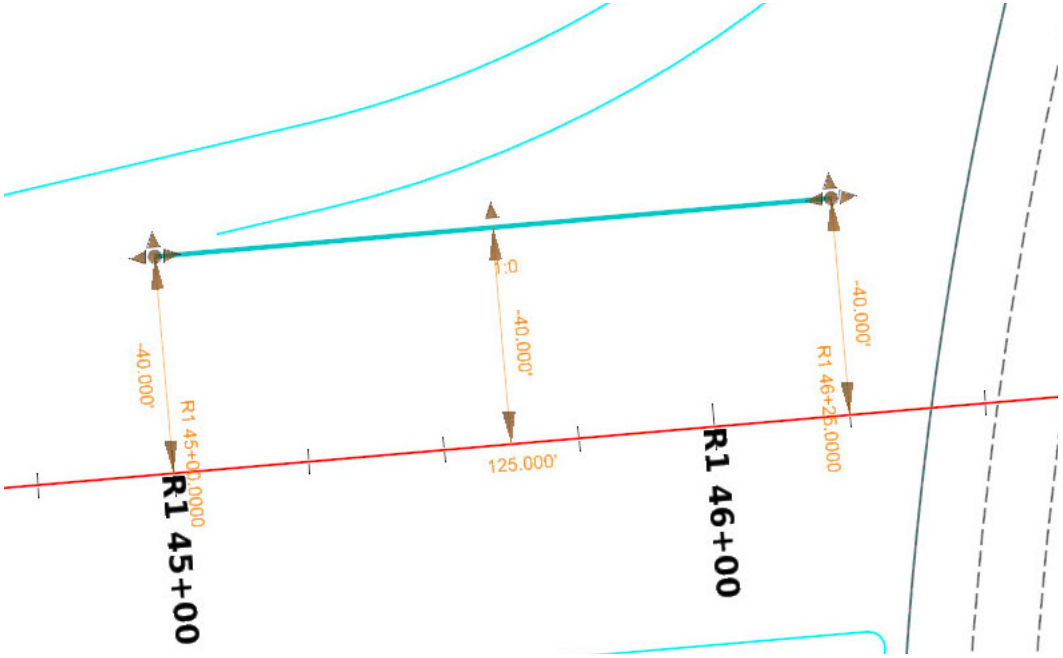


2. To create the southern edge of pavement for the island, select the **Geometry > Horizontal > Offsets and Tapers > Single Offset Partial**

   a. On the dialog box, *UNLOCK* all the tool settings.

   b. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

   - *Locate Element <ALT> to Pick element in complex:* Select the **Church Rd.** centerline geometry.
   - *Start Parameters - Offset:* **-40**, Press the **<Enter>** key to lock the value and move the cursor to locate the new element properly. Press the right arrow key to advance to the next prompt.
   - *Start Parameters - Distance: Start Distance:* **45+00**, Press the **<Enter>** key to lock the value
   - *End Parameters - Distance: End Distance:* **46+25**, Press the **<Enter>** key to lock the value.
   - *Mirror:* **No**

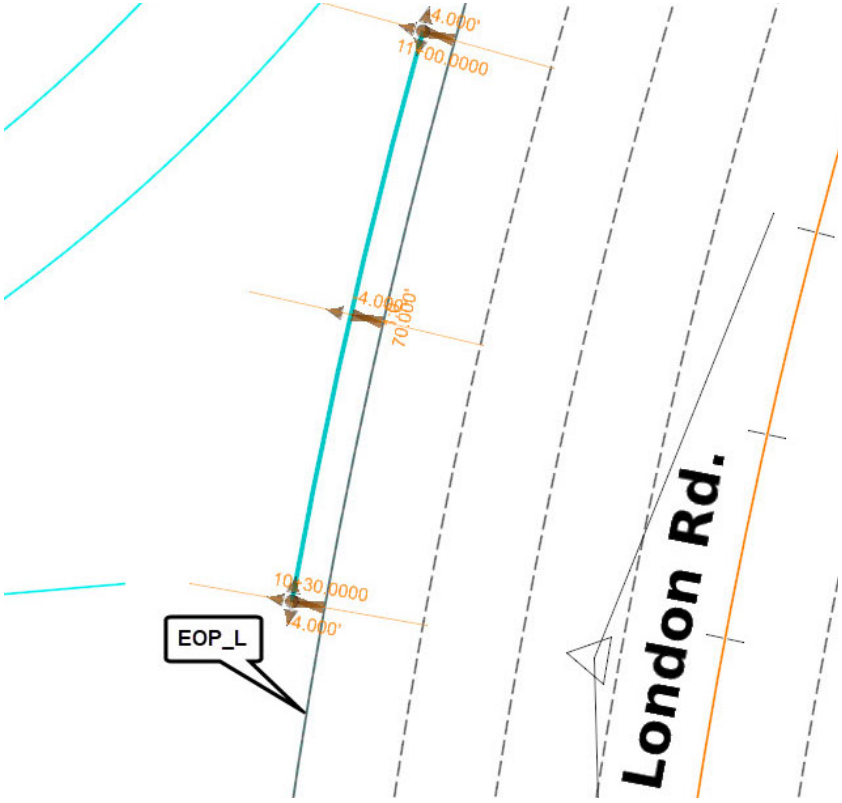


3. To create the eastern edge of pavement for the island, select the **Geometry > Horizontal > Offsets and Tapers > Single Offset Partial**

   a. On the dialog box, *UNLOCK* all the tool settings.

   b. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

   - *Locate Element <ALT> to Pick element in complex:* Select the **EOP_L** geometry along **London Rd**
   - **TIP:** *EOP_L* is a linear feature created in the London Rd. corridor design file.
   - *Start Parameters - Offset:* **-4**, Press the **<Enter>** key to lock the value and move the cursor to locate the new element properly. Press the right arrow key to advance to the next prompt.
   - *Start Parameters - Distance: Start Distance:* **10+30**, Press the **<Enter>** key to lock the value
   - *End Parameters - Distance: End Distance:* **11+00**, Press the **<Enter>** key to lock the value.
   - *Mirror:* **No**

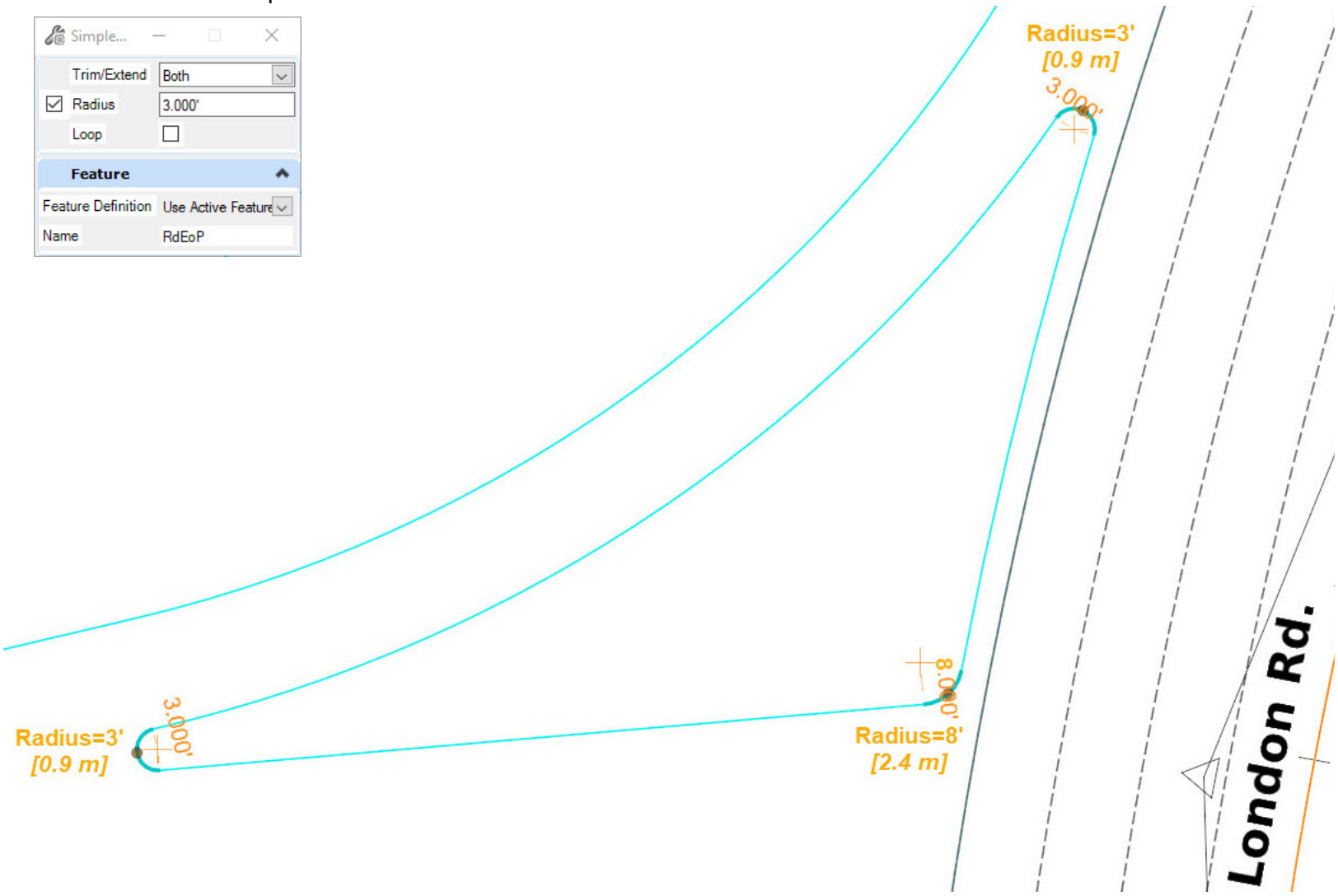


4. Create the island noses, Select the **Geometry > Horizontal > Arcs > Arc Between Elements > Simple Arc**

   a. Create the arcs using the radius values shown in the image below.

   b. Create the arcs between the previously created edge of pavement elements that make up the island.

   c. Set the *Trim/Extend* option to **Both** for all arcs.



# Exercise 2: Create Geometry for the Median

## Description

In this exercise, you will create the edge of pavement features along the median.

## Skills Taught

- Create geometry using the Single Offset Partial tool
- Create geometry using the Variable Offset Taper tool
- Create geometry using the Arc Between Points tool
- Create geometry using Arc From Elements tool
- Create geometry using Simple Arc tool
- Create geometry using Complex By Element

## Create the Eastern Portion of the Median Edges of Pavement

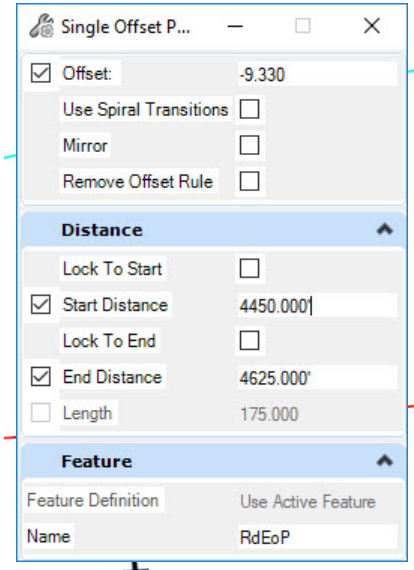
1. Create the inside edge of pavement for the median at an offset of **-9.33** units from the centerline

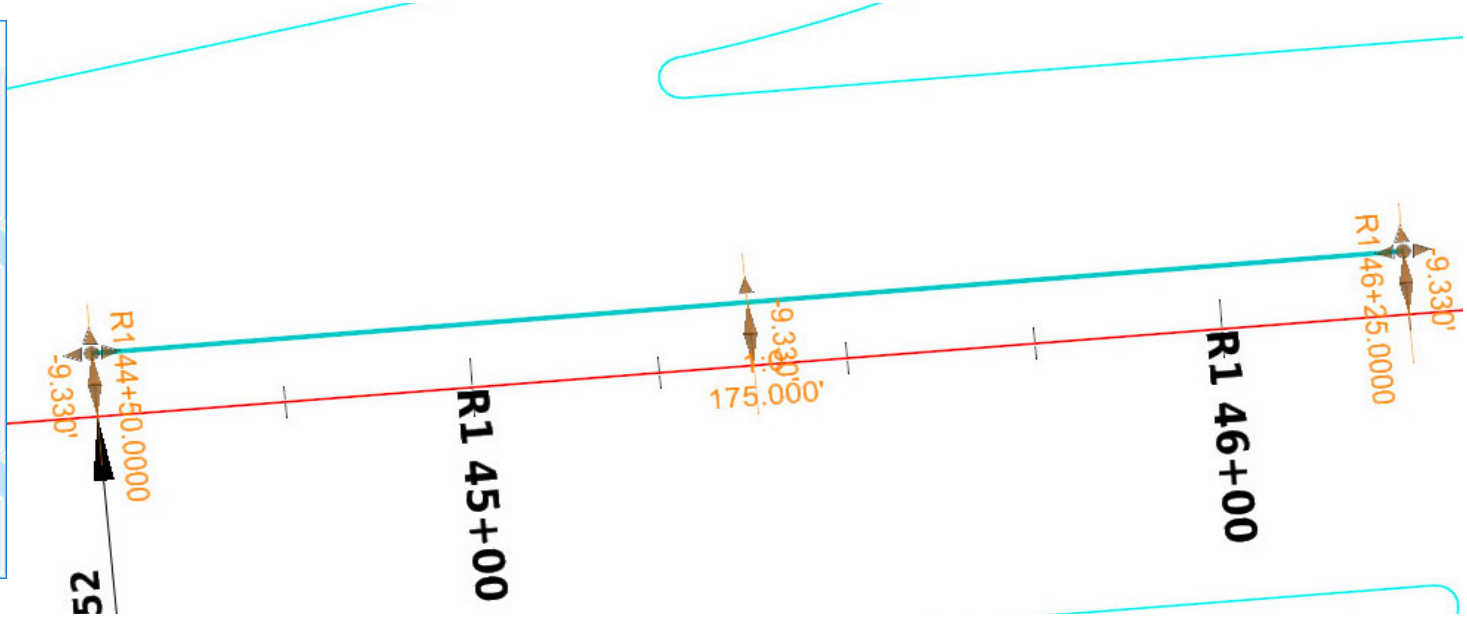
   a. select the **Geometry > Horizontal > Offsets and Tapers > Single Offset Partial**

   b. On the dialog box, *UNLOCK* all the tool settings.

   c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

   - *Locate Element <ALT> to Pick element in complex:* Select the **Church Rd.** centerline geometry.
   - *Start Parameters - Offset:* **-9.33**, Press the **<Enter>** key to lock the value and move the cursor to locate the new element properly. Press the right arrow key to advance to the next prompt.
   - *Start Parameters - Distance: Start Distance:* **44+50**, Press the **<Enter>** key to lock the value
   - *End Parameters - Distance: End Distance:* **46+25**, Press the **<Enter>** key to lock the value.
   - *Mirror:* **No**



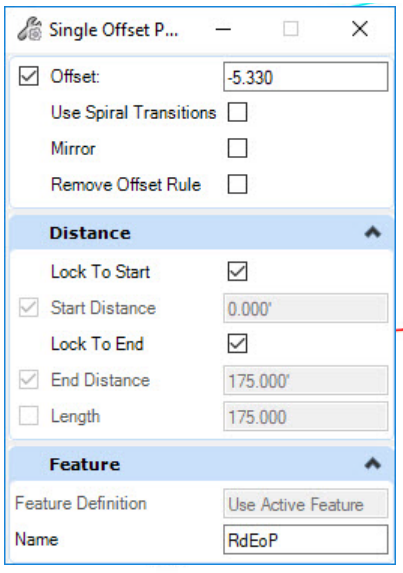
2. To create the outside edge of pavement for the median at an offset of **5.33** units from the median inside edge of pavement.

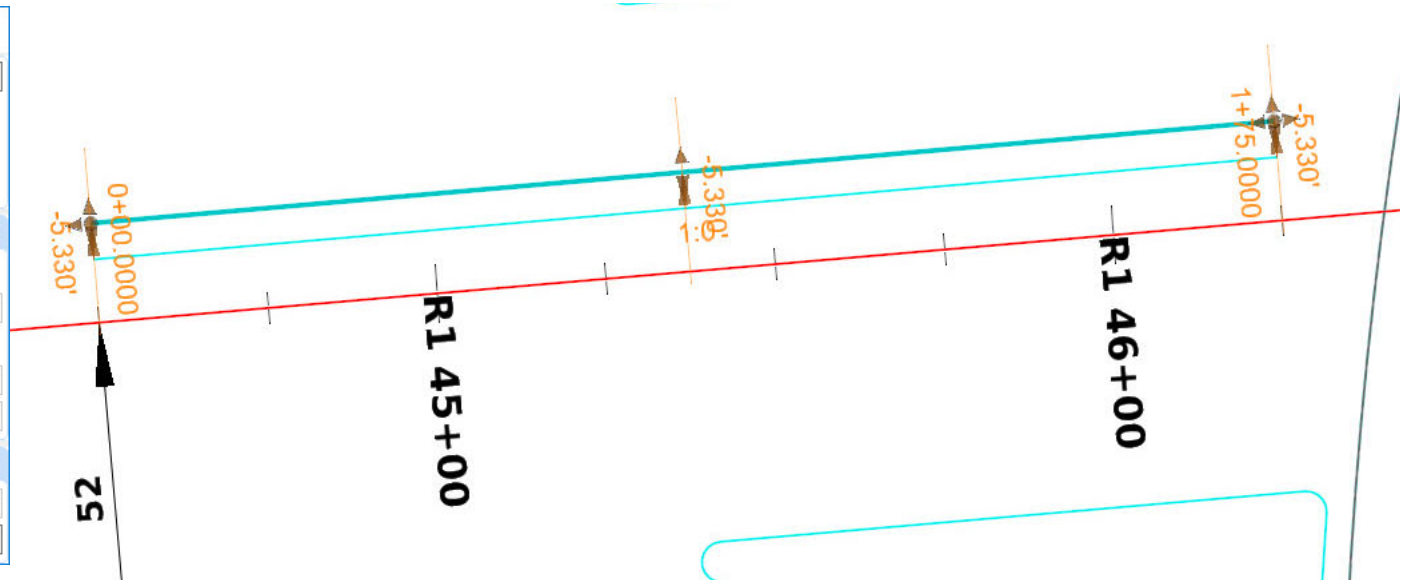
   a. Select the **Geometry > Horizontal > Offsets and Tapers > Single Offset Partial**

   b. On the dialog box, *UNLOCK* all the tool settings.

   c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - *Locate Element <ALT> to Pick element in complex:* Select the **median inside edge of pavement** created in the previous step.
      - *Start Parameters - Offset:* **-5.33**, Press the **<Enter>** key to lock the value and move the cursor to locate the new element properly.
      - *Start Parameters - Distance: Start Distance:* Press the **<ALT>** key to lock to the start.
      - *End Parameters - Distance: End Distance:* Press the **<ALT>** key to lock to the end.
      - *Mirror:* **No**



3. Create the edge of pavement around the Median Nose

a. Select the **Geometry > Horizontal > Arcs > Arc Between Points** tool.

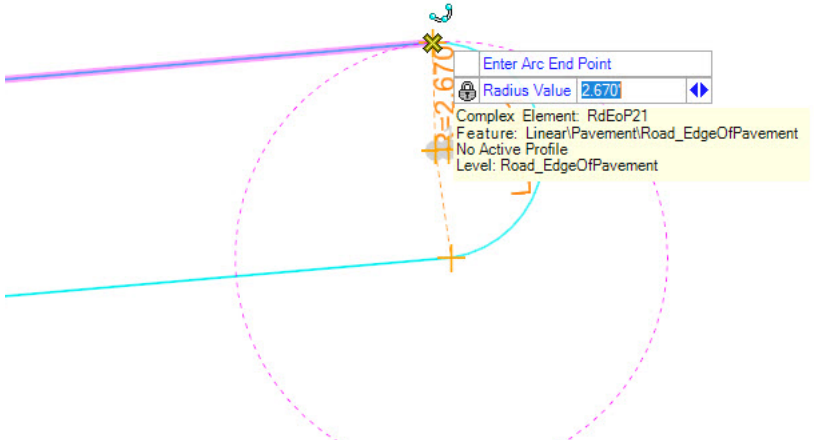
b. On the dialog box, set the *Placement Method* to **Start\Pass-through\End**

c. *Enter Arc Start Point*: **Snap** to the southern PC of the median's nose.


d. *Enter Arc End Point - Radius Value:* Key in the value **2.67**.

e. Press the **<Enter>** key to lock the value.

f. **Snap** to the northern PC of the median's nose.




g. Move your cursor to the right of the element, a temporary arc graphic will display showing the orientation of the arc.

h. Data point to place the arc.

## Create the Western Portion of the Median Edges of Pavement

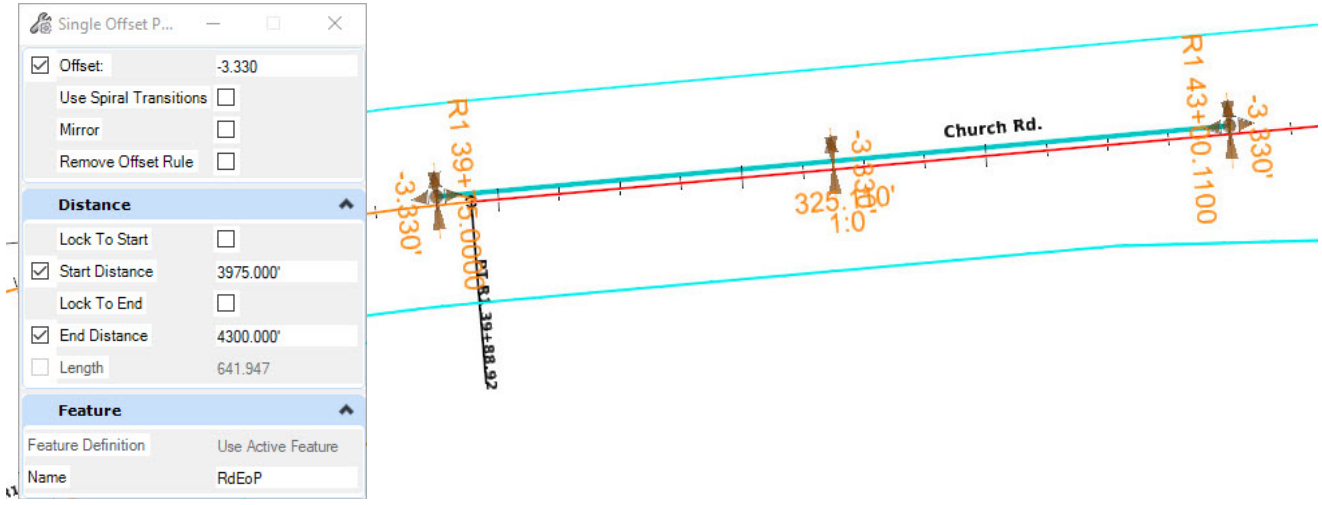
1. Create the western outside edge of pavement for the median at an offset of **-3.33** units from the centerline

   a. Select the **Geometry > Horizontal > Offsets and Tapers > Single Offset Partial**.

   b. On the dialog box, *UNLOCK* all the tool settings.

   c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

   - *Locate Element <ALT> to Pick element in complex:* Select the **Church Rd.** centerline geometry.
   - *Start Parameters - Offset:* **-3.33** units, Press the **<Enter>** key to lock the value and move the cursor to locate the new element properly. Press the right arrow key to advance to the next prompt.
   - *Start Parameters - Distance: Start Distance:* **39+75**, Press the **<Enter>** key to lock the value
   - *End Parameters - Distance: End Distance:* **43+00**, Press the **<Enter>** key to lock the value.
   - *Mirror:* **No**



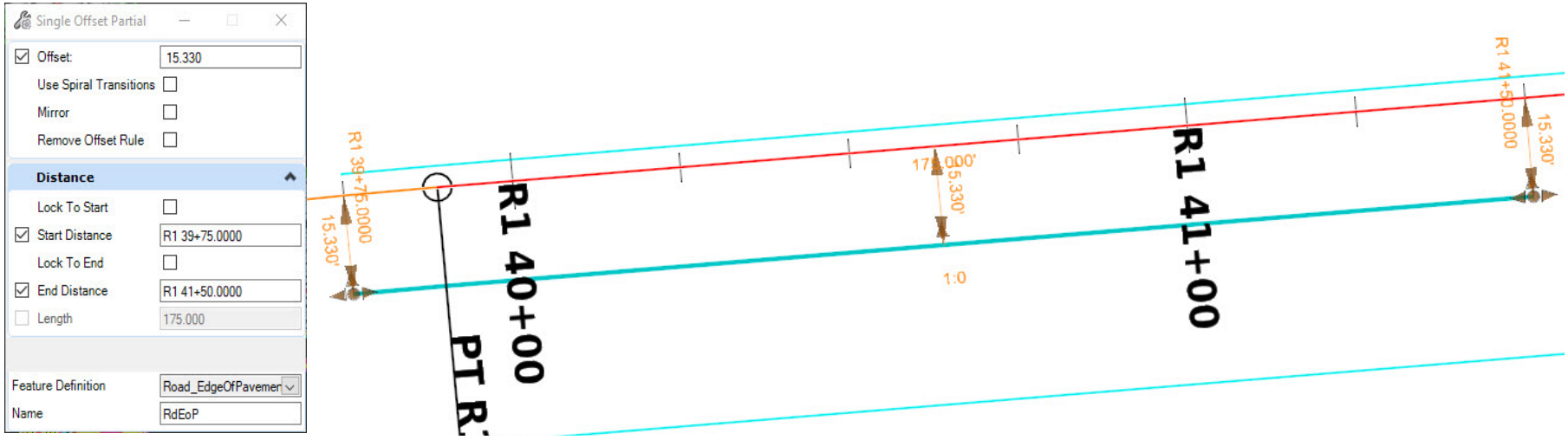
2. Create the inside edge of pavement for the median at an offset of **15.33** units from the centerline of Church Rd.

a. Select the **Geometry > Horizontal > Offsets and Tapers > Single Offset Partial**

b. On the dialog box, *UNLOCK* all the tool settings.

c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

- *Locate Element <ALT> to Pick element in complex:* Select the **Church Rd.** centerline geometry.
- *Start Parameters - Offset:* **15.33**, Press the **<Enter>** key to lock the value and move the cursor to locate the new element properly.
- *Start Parameters - Distance: Start Distance:* **39+75**
- *End Parameters - Distance: End Distance:* **41+50**
- *Mirror:* **No**



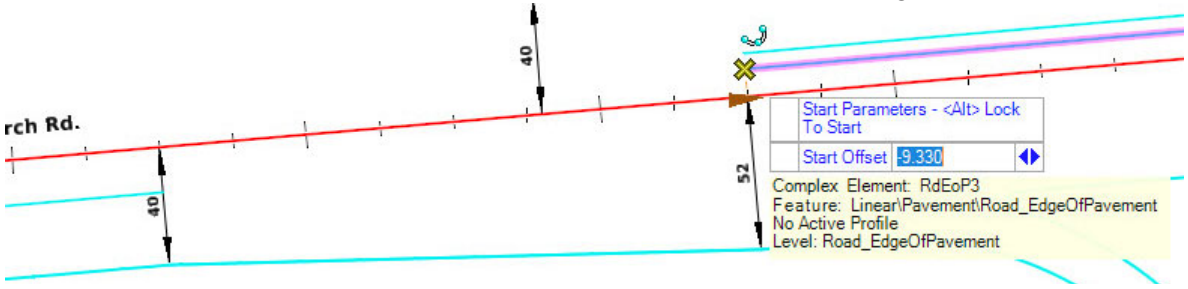
## Create the Median Tapers

1. Create a 15:1 taper for the median inside edge of pavement.

   a. Select the **Geometry > Horizontal > Offsets and Tapers > Ratio Offset Taper** tool.

   b. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - On the dialog box, *UNLOCK* all the tool settings.
      - *Locate Element <ALT> to Pick element in complex:* Select the **Church Rd.** centerline.
      - *Start Parameters - Start Offset:* **Snap** to the east end of the median inside edge of pavement to populate the *Start Offset* field.



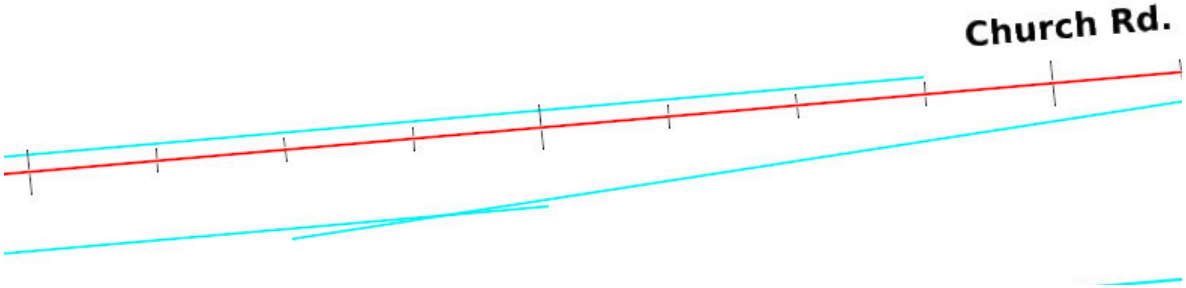

      - *Ratio:* **1:-15**, Press **<Enter>** to lock the value and then press the left or right arrow key to advance to the next prompt.
      - *End Parameters - Distance: End Distance:* **40+50**


   c. *Mirror:* **No**

   d. Data point to complete.

2. Trim the taper and inside median edge of pavement.

   a. Zoom to where the taper intersects the median inside edge of pavement.

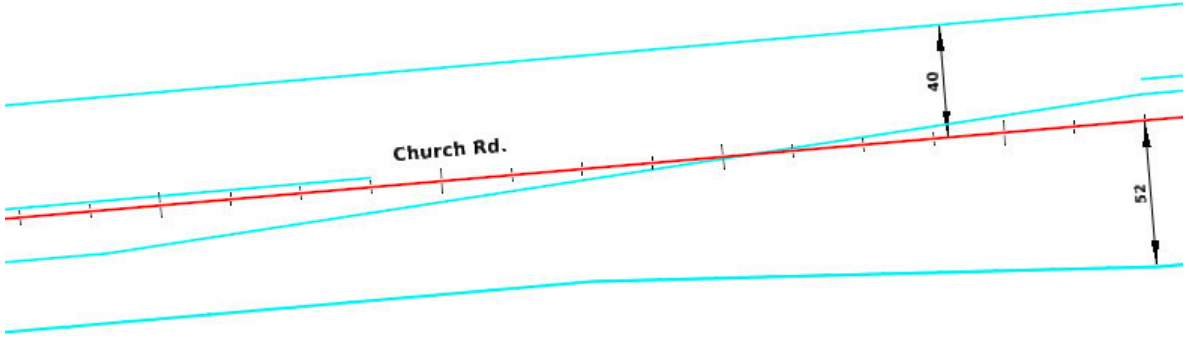



   b. Select **Drawing > Modify > Trim To Intersection**

   c. Follow the prompts at the lower left corner of the screen:

      - *Identify first element to modify:* Select the median inside edge of pavement element
      - *Identify second element to modify:* Select the taper element

      The completed taper should look like the image below.



3. Create the taper for the median outside edge of pavement.

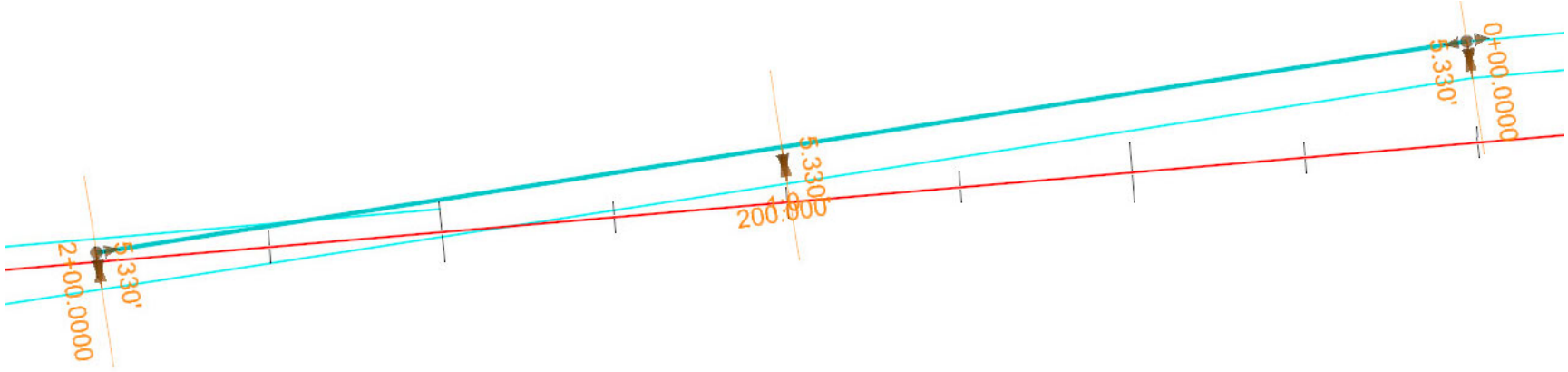
a. Select **Geometry > Horizontal > Offsets and Tapers > Single Offset Partial**

b. On the dialog box, *UNLOCK* all the tool settings.

c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

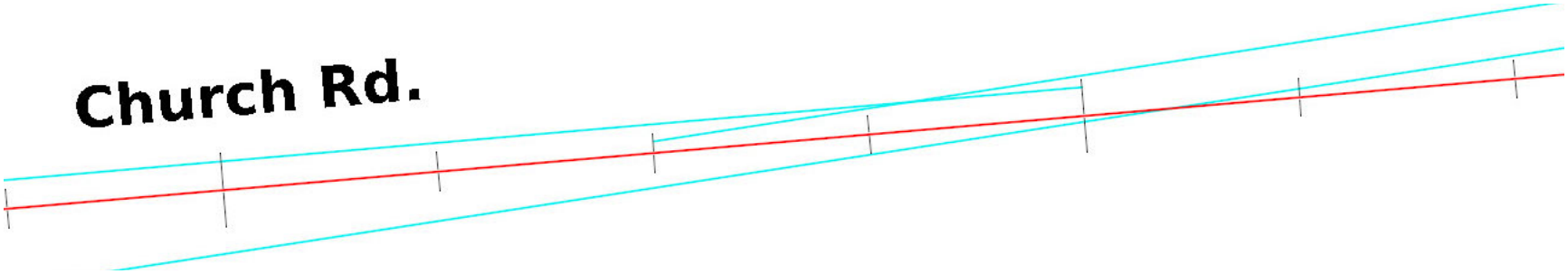
- *Locate Element <ALT> to Pick element in complex:* Select the taper element you created in the previous step.
- *Start Parameters - Offset:* **5.33**, press the **<Enter>** key to lock the value.
- *Start Parameters - Distance: Start Distance:* Press **<ALT>** to lock to Start.
- *End Parameters - Distance: End Distance:* **2+00**, press **<Enter>** key to lock the value.
- *Mirror:* **No**

d. Data point to complete.



4. Trim the taper and inside median edge of pavement.

   a. Zoom to where the taper intersects the median edge of pavement.

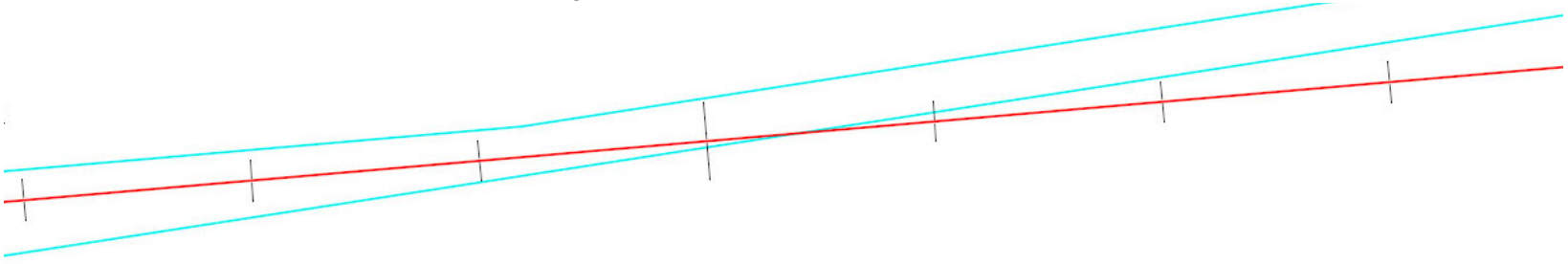



   b. Select **Drawing > Modify > Trim To Intersection**

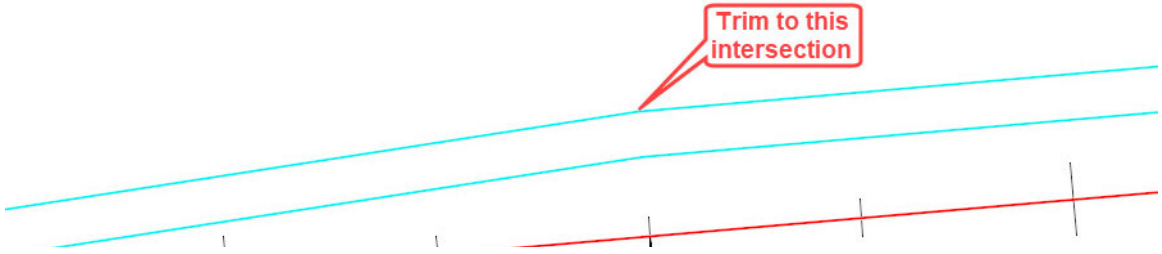
   c. Follow the prompts at the lower left corner of the screen:

      - *Identify first element to modify:* Select the median inside edge of pavement element
      - *Identify second element to modify:* Select the taper element

   The completed taper should look like the image below.



5. Use **Trim to Intersection** to trim where the begin taper meets the median edge of pavement end point.



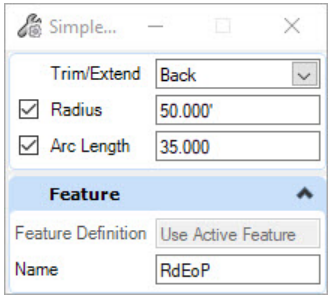
6. Create the western median nose.

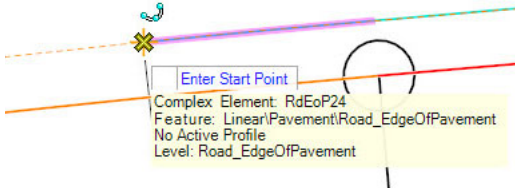
a. Select the **Geometry > Horizontal > Arcs > Arc From Element > Simple Arc From Element** tool.

b. On the dialog box, *UNLOCK* all the tool settings.

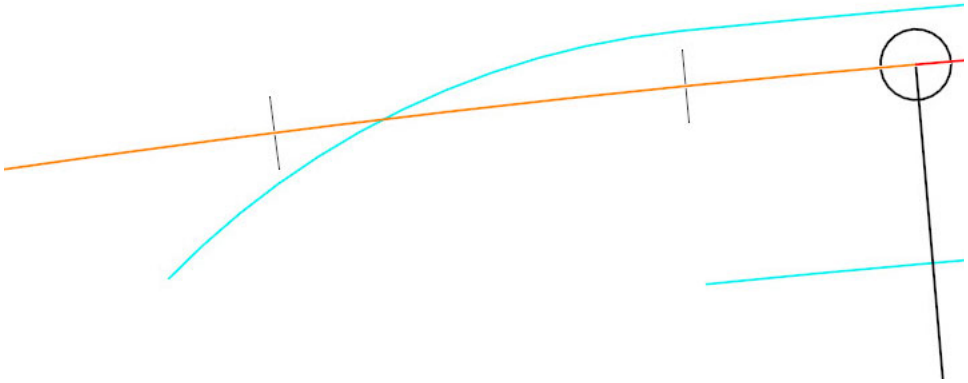
c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

- *Locate Element <ALT> to Pick element in complex:* Select the **north median edge of pavement**
- *Enter Start Point:* **Snap** to the end point of the median outside edge of pavement.
- *Radius:* **50**, **<ENTER>** to lock the value.
- *Arc Length:* **35**, **<ENTER>** to lock the value.
- *Trim/Extend:* **Back**




d. Data point to place the arc.



7. Place a Simple Arc to close off the median nose.

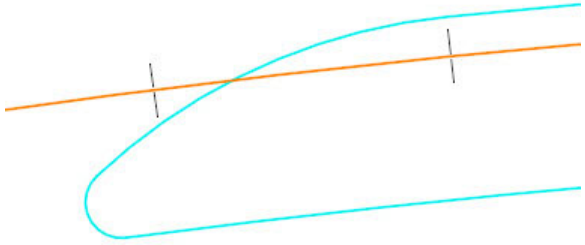
a. Select the **Geometry > Horizontal > Arcs > Arc Between Elements > Simple Arc**

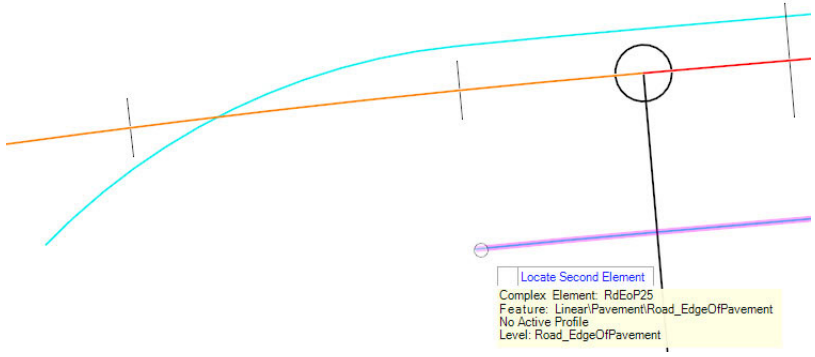
b. On the dialog box, *UNLOCK* all the tool settings.

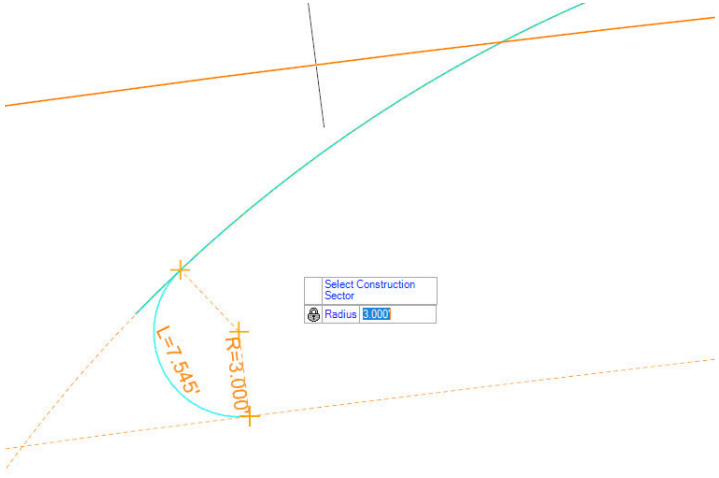
c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

- *Locate First Element <ALT> to Pick Component of Complex:* Select the previously created arc.
- *Locate Second Element:* Select the median inside edge of pavement
- *Radius:* **3**, **<ENTER>** to lock the value.
- *Trim/Extend:* **Both**

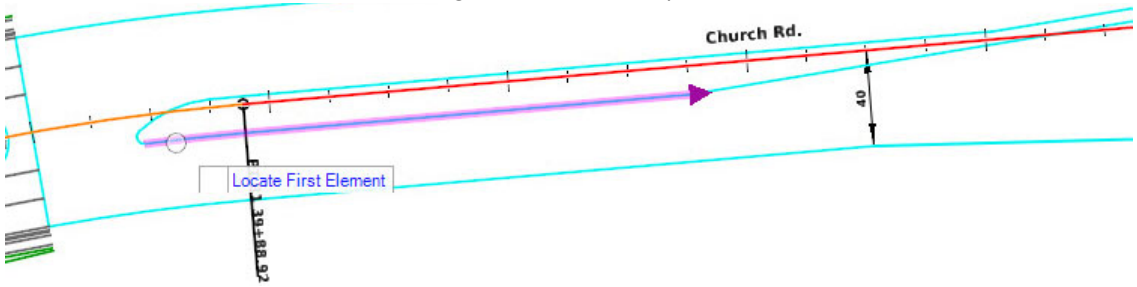
d. Data point to place the arc.



8. Join together all of the median edges of pavement using Complex By Element.
   a. Select **Geometry > Horizontal > Complex Geometry > Complex By Element**
   b. *Method:* **Automatic**
   c. *Maximum Gap:* **0.033**
   d. *Name:* **Median EOP**
   e. *Locate First Element:* Select the south inside median edge of pavement (be sure the directional arrow is pointing to the east).




   f. *Accept Complex:* **Data point**

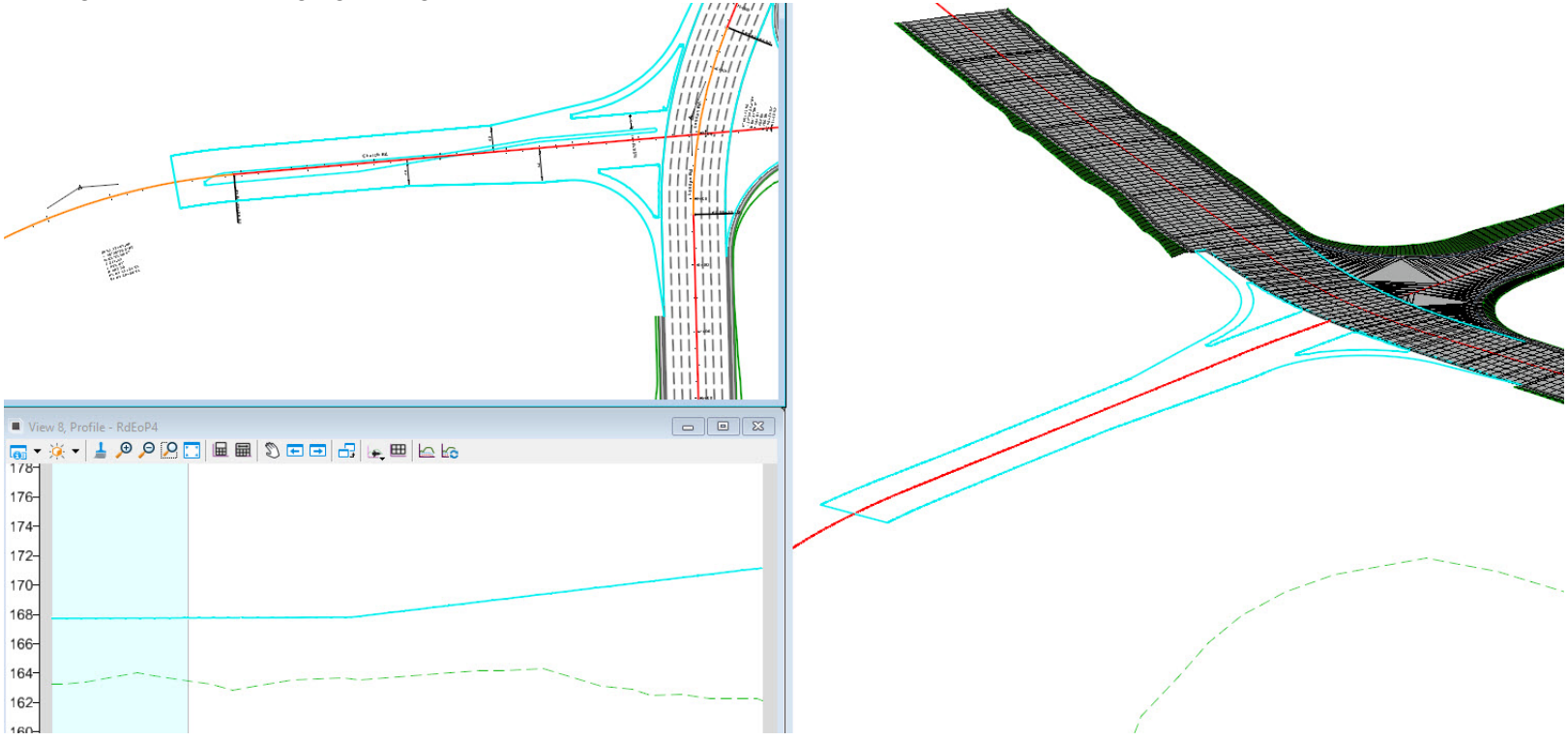
# Exercise 3: Create Vertical Geometry Along Horizontal Geometry Elements

## Description

In this exercise you will learn the tools used to create profiles for the horizontal geometry elements that make up the intersection design.

## Skills Taught

- Create profile for the edges of pavement based on a defined cross slope
- Create horizontal geometry for the match line
- Assign a profile to the match line
- Use of design intent in managing changes to civil profile elements



## Profile the Edges of Pavement Along the Proposed Roadway

In this exercise, you will define the vertical geometry for the edges of the pavement along the new roadway. You will apply the typical cross slope for the proposed roadway to create the profile of the edges of pavement.

---

1. Profile the North Edge of Pavement by projecting slopes from the centerline. The pavement cross slope transitions from **+3.8%** to **-2.0%** beginning at **39+00** and ending at **41+00**, so we will use the **Profile By Variable Slope From Element** tool to create the profile along the edge of pavement.

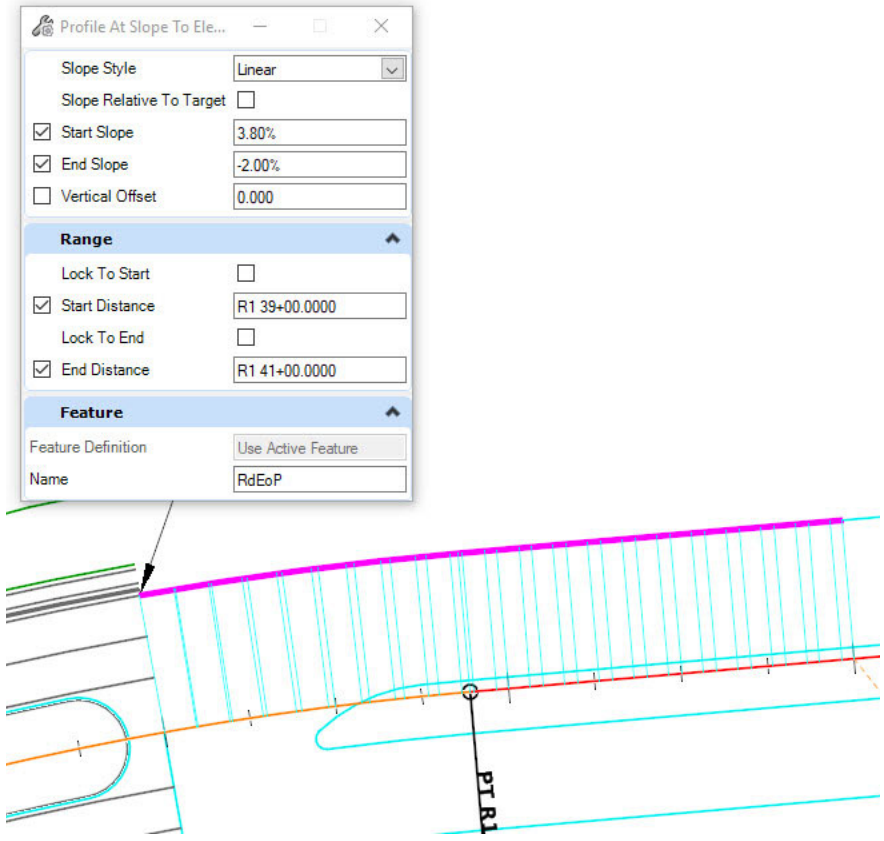
   a. Set *View 1* active.

   b. Select **Geometry > Vertical > Element Profiles > Profile By Variable Slope From Element**

   c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - *Slope Style:* **Linear** (Use the up or down arrow key to toggle the *Slope Style* options).
      - *Locate Plan Element To Profile:* Select the north edge of pavement
      - *Locate Reference Element:* Select the **Church Rd.** centerline
      - *Start Distance - <ALT> Lock To Start:* **39+00**, Press **<ENTER>** to lock the value.
      - *End Distance - <ALT> Lock To End:* **41+00**, Press **<ENTER>** to lock the value.
      - *Start Slope:* **3.8**
      - *End Slope:* **-2.0**
      - *Vertical Offset:* **0.0**

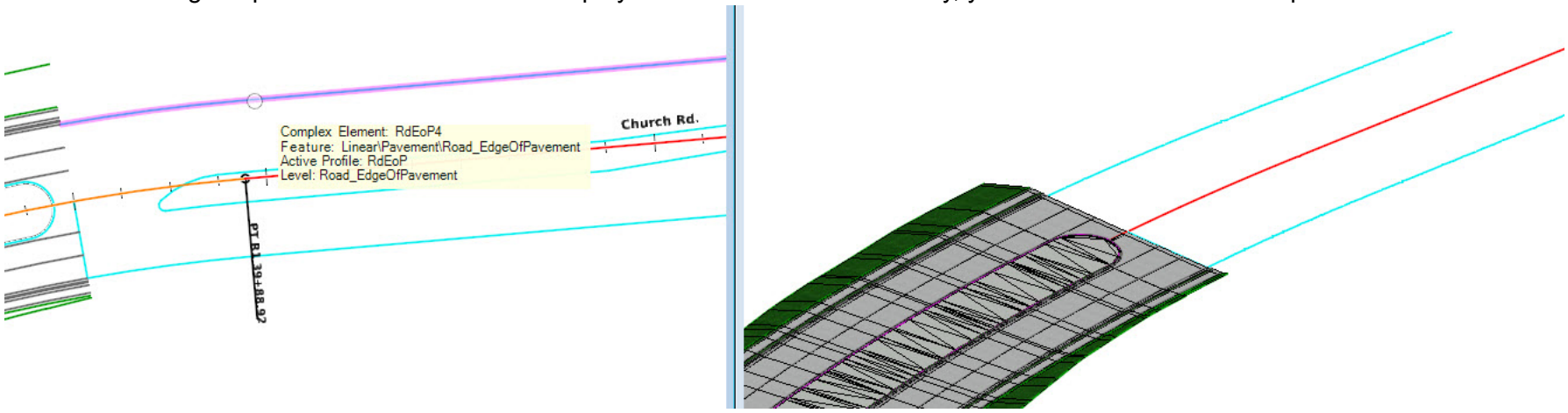
   d. Data point to complete.



A profile along the edge of pavement is now created and assigned to the horizontal geometry. The edge of pavement 3D feature is also displayed in the 3D model.

The 3D model displays the active profile of each element. You'll notice that the 3D model will update automatically as you set or change the active profile of an element.

**NOTE:** If the edge of pavement feature doesn't display in the 3D view automatically, you will need to set the new profile active.




2. Open the Profile Model and Review the edge of pavement profile. Set it active (if not already active).

   a. In *View 1*, select the north edge of pavement geometry.

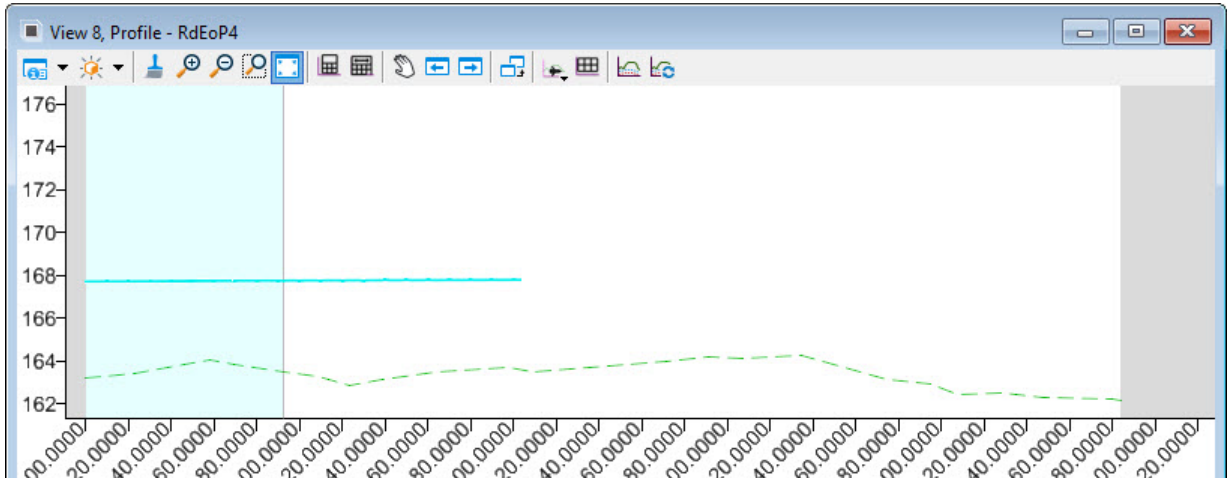
   b. Continue to hover the cursor at the selection point until the context sensitive menu appears.

   c. Select the **Open Profile Model** tool.

   d. If not already open, Open **View 8** by selecting the respective button at the bottom of the screen. Profiles can be displayed in any view.


   e. Left-click in **View 8** to place the profile.

The profile model opens. If the profile did not display in the 3D model. You need to set it active.




3. Set the Profile Active (you can skip this step if the profile element is already displayed in the 3D Model view).

   a. Select the profile element.

   b. Continue to hover the cursor at the selection point until the context sensitive menu appears.

   c. Select **Set As Active Profile**.

      The profile will now be displayed in the 3D model.

      Up to this point we have only created a portion of the profile along the edge of pavement. We will now continue building the remaining portion of the profile by once again projecting slopes from the centerline of Church Rd.

4. Project a constant **-2.0%** slope from the centerline to the edge of pavement.

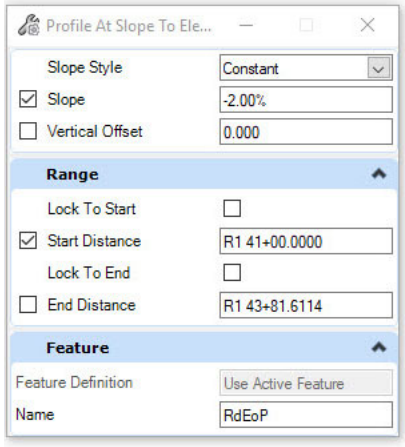
   a. Set *View 1* active.

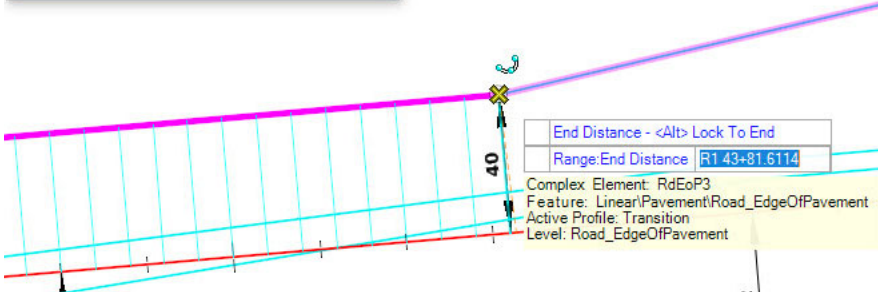
   b. Select **Geometry > Vertical > Element Profiles > Profile By Variable Slope From Element**

   c. On the dialog box, *UNLOCK* all the tool settings.

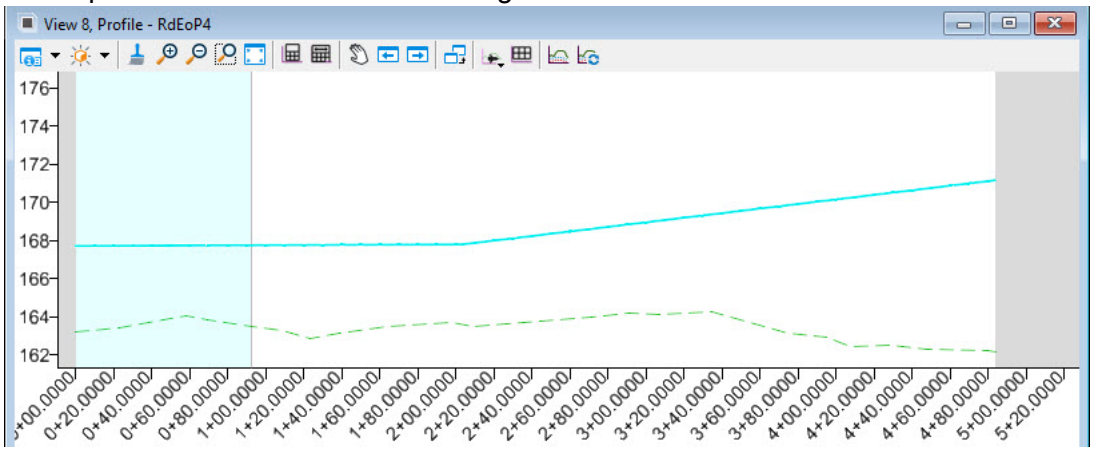
   d. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

   - *Slope Style:* **Constant** (Use the up or down arrow key to toggle the *Slope Style* options).
   - *Locate Plan Element To Profile:* Select the north edge of pavement
   - *Locate Reference Element:* Select the **Church Rd.** centerline
   - *Start Distance - <ALT> Lock To Start:* **41+00**, Press **<ENTER>** to lock the value.
   - *End Distance - <ALT> Lock To End:* Snap to the end point of where the taper-curve-taper begins.
   - *Slope:* **-2.0**
   - *Vertical Offset:* **0**



e. Data point to complete. The profile will now look like the image below.




5. Set the Profile Active (you can skip this step if the profile element is already displayed in the 3D Model view).

   a. Select the profile element you just created.

   b. Continue to hover the cursor at the selection point until the context sensitive menu appears.

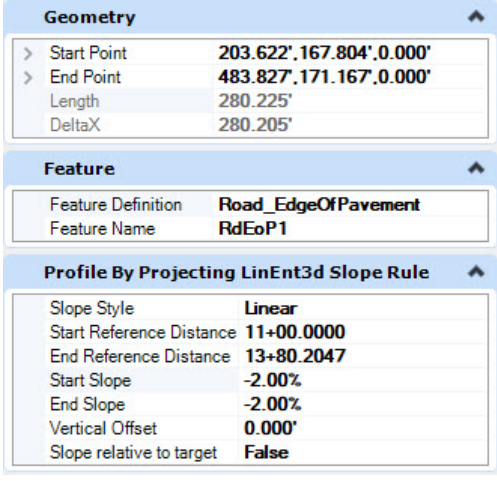
   c. Select **Set As Active Profile**. The profile will now be displayed in the 3D model.

The edge of pavement has now been profiled and ruled. By creating the edge of pavement with slopes defined from other design elements, you have not only created the edge of pavements in Profile and 3D, but you have conveyed your design intent to them. The relationship for each of these features and its reference elements will be maintained until you change it.

You may modify any of the values in the *Properties* pane at any time. For example, to change the slope:

- Open the profile model of the element
- Select the profile element and open the *Properties*
- Change the slope

**Note:** When profile elements have been complexed together you will need to access the base element in order to see the full properties.



At this point we have 2 independent profiles. Since only one profile can be set active at one time we will join these two profiles together.

6. Join the profiles using **Create Profile By Complex Elements**

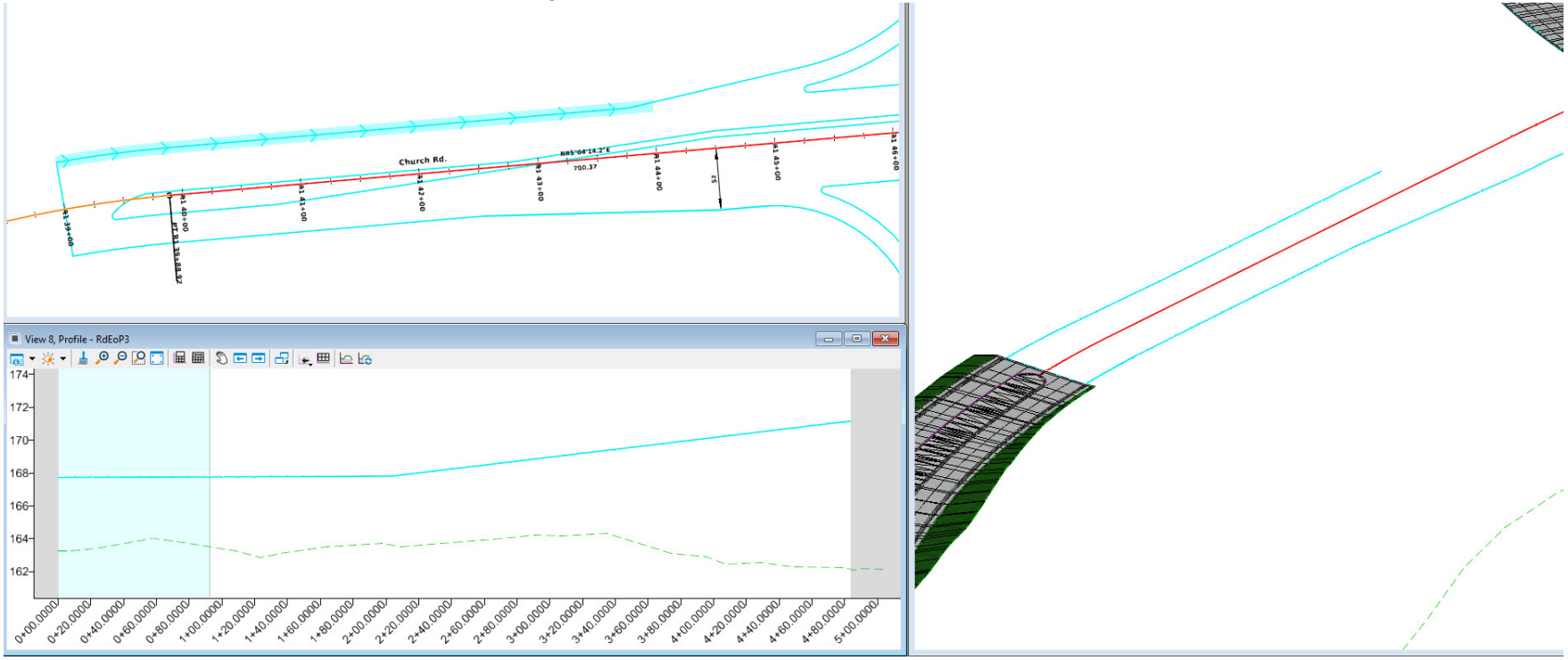
a. Select **Geometry > Vertical > Complex Geometry > Profile Complex By Elements** tool.

b. Set the *Method* to **Automatic**

c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

- *Locate First Element:* Select the first profile element (be sure to select it near its beginning point).
- *Accept Complex:* Left-click

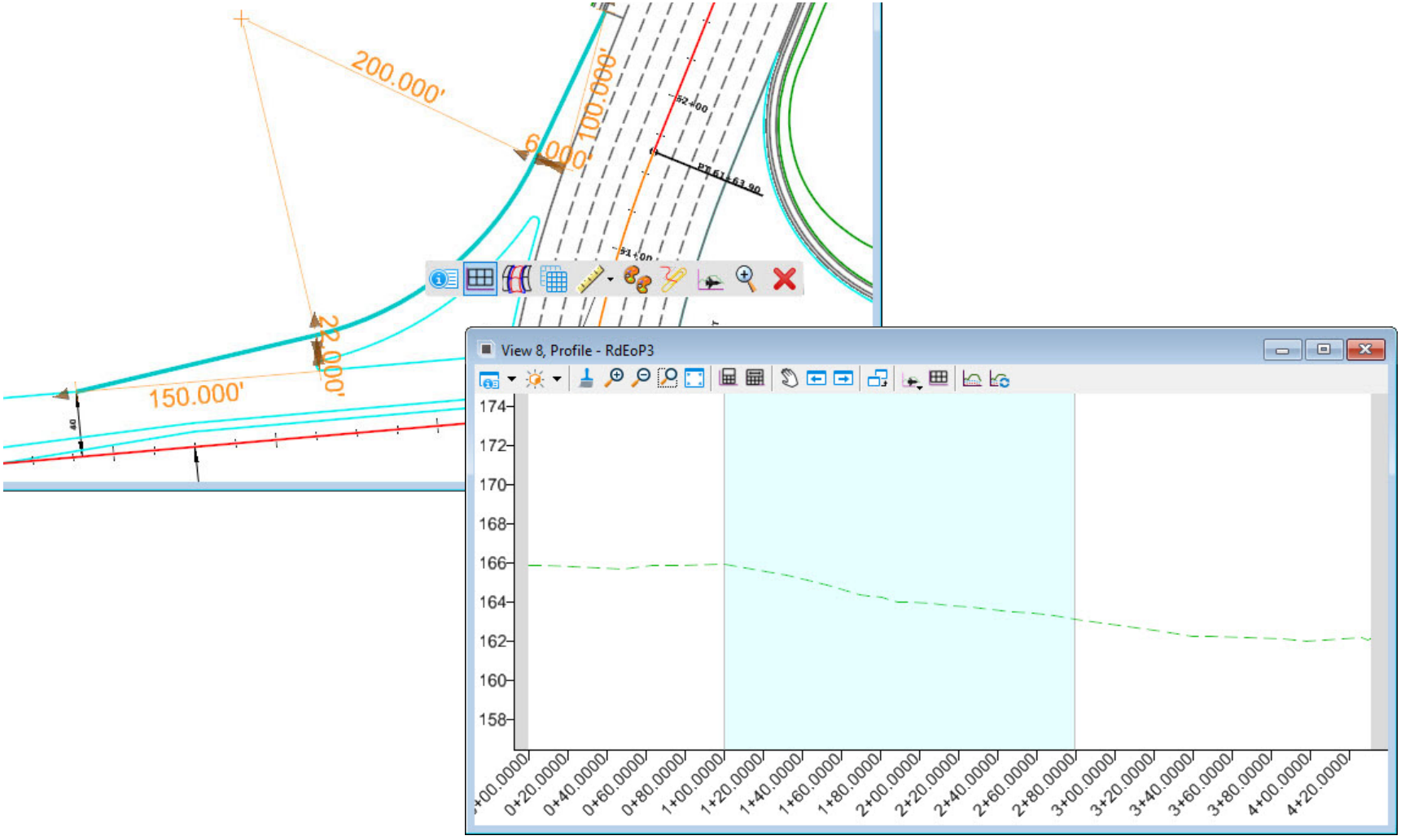
The two profiles will now be joined together as one. If the newly created profile does not display in the 3D model you will have to set it active. The completed profile should like the image below.



## Profile the Northwest Edge of Pavement

In this exercise, you will create a profile along the taper-curve-taper.

1. Set *View 1* active.
2. Open the profile model of the taper-curve-taper along the north west edge of pavement within the intersection.



3. Create a profile along the taper-curve-taper.

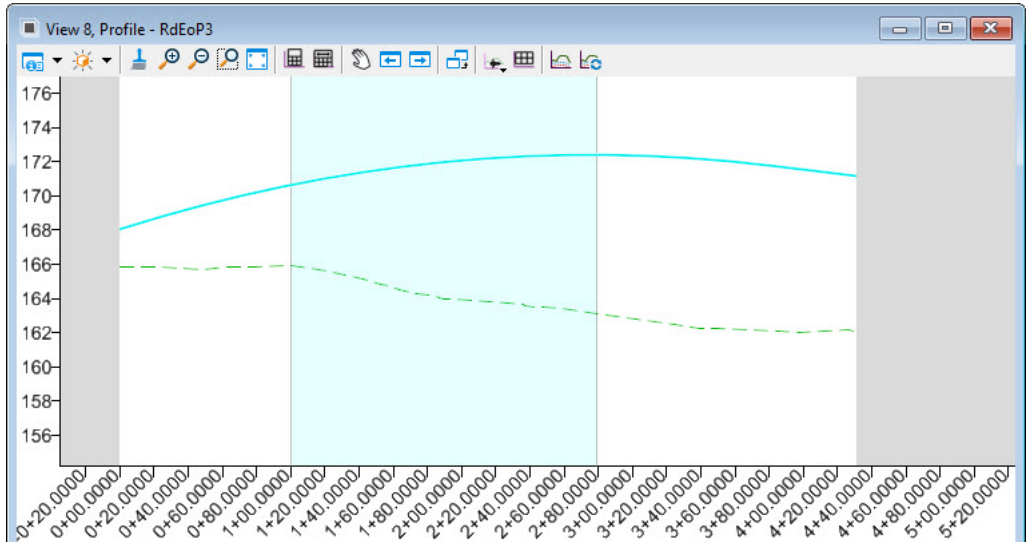
The new roadway edges of pavement have now been “profiled” or assigned a vertical definition. We will now profile the edge of pavement along the northwest edge of the intersection. We will create a profile to transition the edge of pavement between Church Rd. and London Rd.

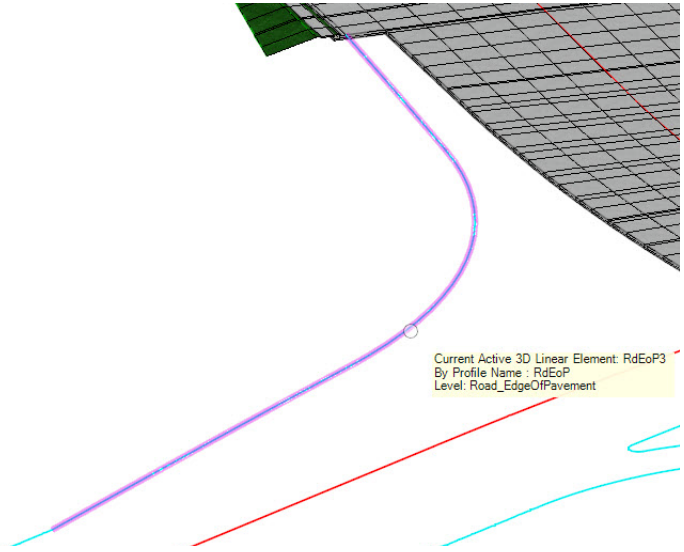
a. Select **Geometry > Vertical > Element Profiles > Quick Profile Transition**

b. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

- *Quick Transition Method:* **Parabolic**
- *Locate What to Define*: Select the taper-curve-taper element

The edge of pavement is now profiled with a parabolic vertical definition.




The vertical is displayed in the profile model and may be displayed in the 3D view. If the profile is not displayed in the 3D model, you must set the vertical profile active and it will be displayed in the 3D model.

**NOTE:** Use the Quick Profile Transition command to assign a linear or parabolic profile to an element by matching the slope and elevation of adjoining elements. Depending on the configuration of adjacent elements, either a single crest/sag curve is created or a reverse transition.

## Review and Verify the Entrance and Exit Grades

After creating the profile along the taper-curve-taper it's always a good idea to check the entrance (incoming) and exit (outgoing) grades along the edge of pavement to ensure the profile that was created matches up to those grades properly. A good way to do this is by using the **Project Extended Profile** tool to display the incoming and outgoing tangents onto the profile.

---

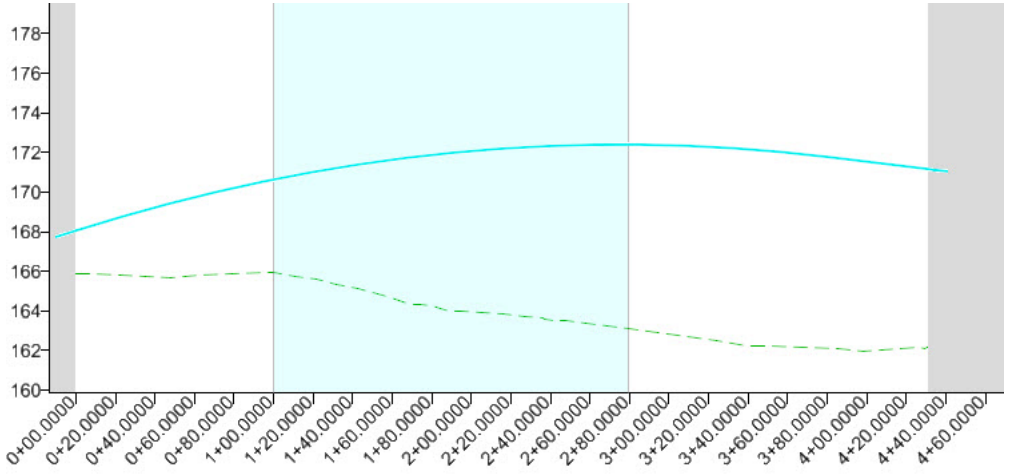
1. Display the incoming and outgoing tangent elements onto the profile.

   a. Select **Geometry > Vertical > Profile Creation > Project Extended Profile**

   b. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

   - *Select Element to Project Onto:* Select the taper-curve-taper profile element.
   - *Locate Back Extended Distance: Start:* **10**, press **<ENTER>** to lock the value.
   - *Locate Ahead Extended Distance: End:* **10**, press **<ENTER>** to lock the value.

   The back and ahead tangent elements are now graphically displayed on the profile.



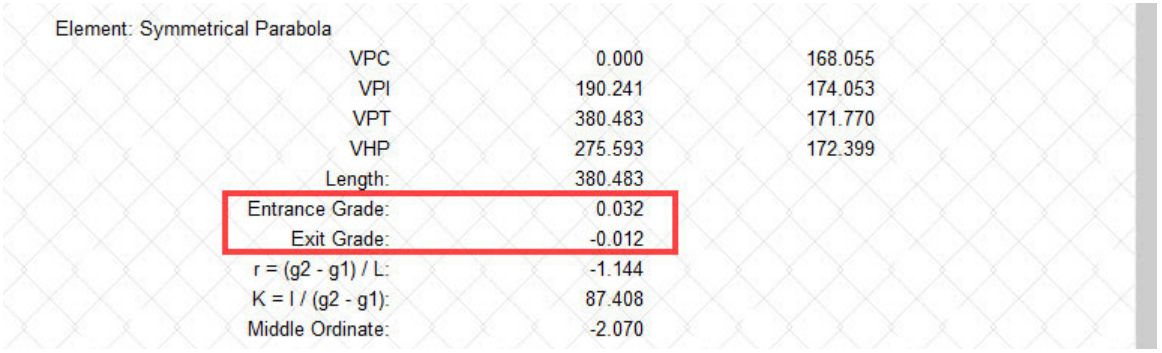
2. Use the **Profile Report** tool to verify the Entrance and Exit grades.

   a. Select the taper-curve-taper profile element.

   b. Continue to hover the cursor at the selection point until the context sensitive menu appears.

   c. Select **Profile Report**

   d. Review and make a note of the **Entrance Grade** and **Exit Grade** listed in the report.



| Element: Symmetrical Parabola | | |
|---|---|---|
| VPC | 0.000 | 168.055 |
| VPI | 190.241 | 174.053 |
| VPT | 380.483 | 171.770 |
| VHP | 275.593 | 172.399 |
| Length: | 380.483 | |
| Entrance Grade: | 0.032 | |
| Exit Grade: | -0.012 | |
| r = (g2 - g1) / L: | -1.144 | |
| K = l / (g2 - g1): | 87.408 | |
| Middle Ordinate: | -2.070 | |

   e. Close the report browser.

   f. Select the back profile element (or entrance profile element).

   g. Continue to hover the cursor at the selection point until the context sensitive menu appears.

   h. Select **Profile Report**

   i. Review and make a note of the **Entrance Grade**, it should match the **Entrance Grade** of the taper-curve-taper profile element.

   j. Close the report browser.

   k. Repeat the steps above by selecting the ahead profile element (or exiting profile element).

## Create a Profile Along the Match Line (or Seam line)

In this section, you will learn to create the vertical geometry that represents the left edge of pavement along London Rd.

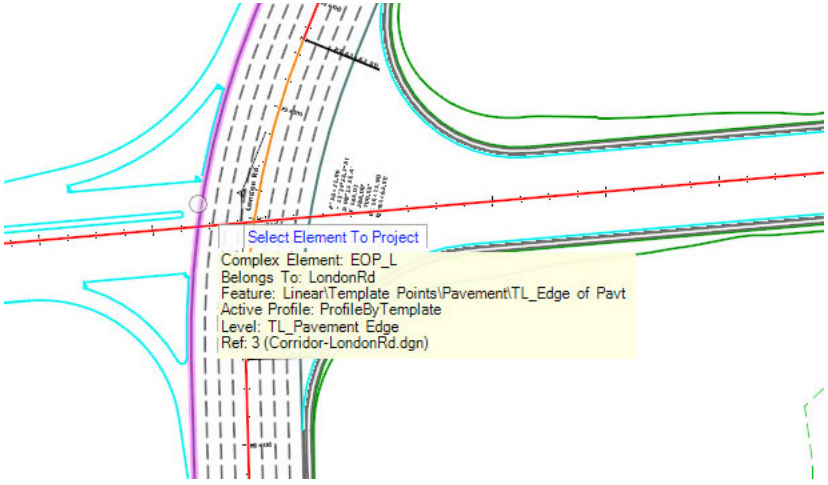
---

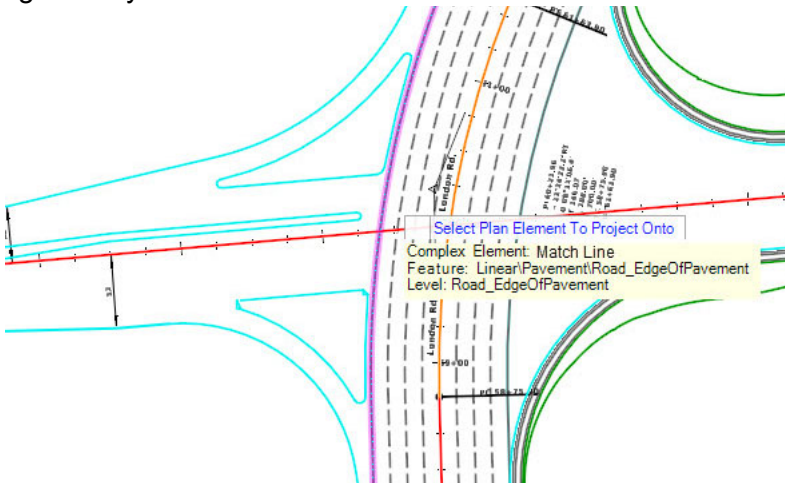
1. Use **Project Profile To Element** to create the profile for the match line (or seam line).

   a. Select **Geometry > Vertical > Profile Creation > Project Profile To Element**

   b. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - *Select Element To Project:* Select the London Rd. **EOP_L** feature.
      - *Select Plan Element To Project Onto:* Select the **Match Line** geometry.



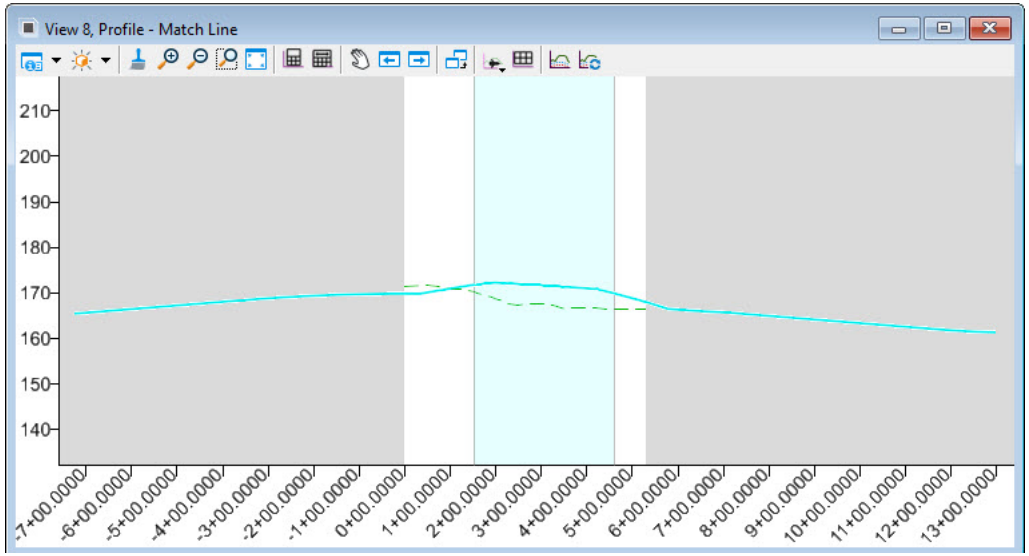



2. Open the profile model and Review the Profile.

   a. Select the match line geometry in **View 1.**

   b. Open the *Profile Model*.

   c. Review the profile.




The vertical is displayed in the profile model and may be displayed in the 3D view. If the profile is not displayed in the 3D model, you must set the vertical profile active and it will be displayed in the 3D model.

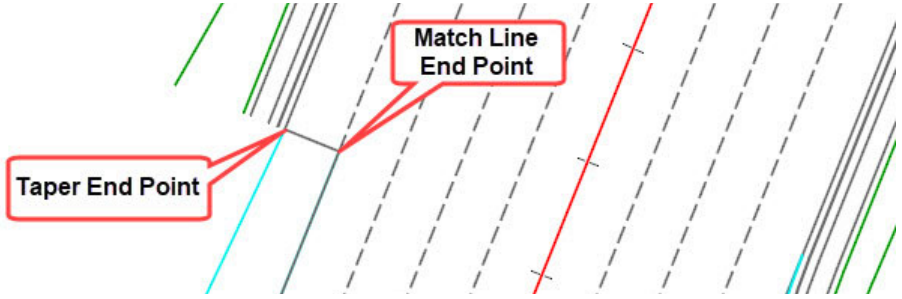
## Create Horizontal and Vertical Geometry for Boundary Elements

In this section, you will create horizontal and vertical geometry for the boundary elements of the intersection. These elements will be used later in the course to build a proposed terrain model.

---

1. Place a line between the end of the northwest taper-curve-taper and the end point of the match line geometry.

   a. Zoom in toward the end of the taper-curve-taper.




   b. Select **Geometry > Horizontal > Lines > Line Between Points**

   c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - *Enter Start Point:* Snap the end point of the match line geometry.
      - *Enter End Point:* Snap to the end point of the northwest taper-curve-taper geometry.

2. Display the match line edge of pavement elevation and the taper elevation on the profile.

   a. In **View 1**, Select the geometry placed in the previous step.

   b. Open the Profile Model.

   c. Select **Geometry > Vertical > Profile Creation > Profile Intersection Point**

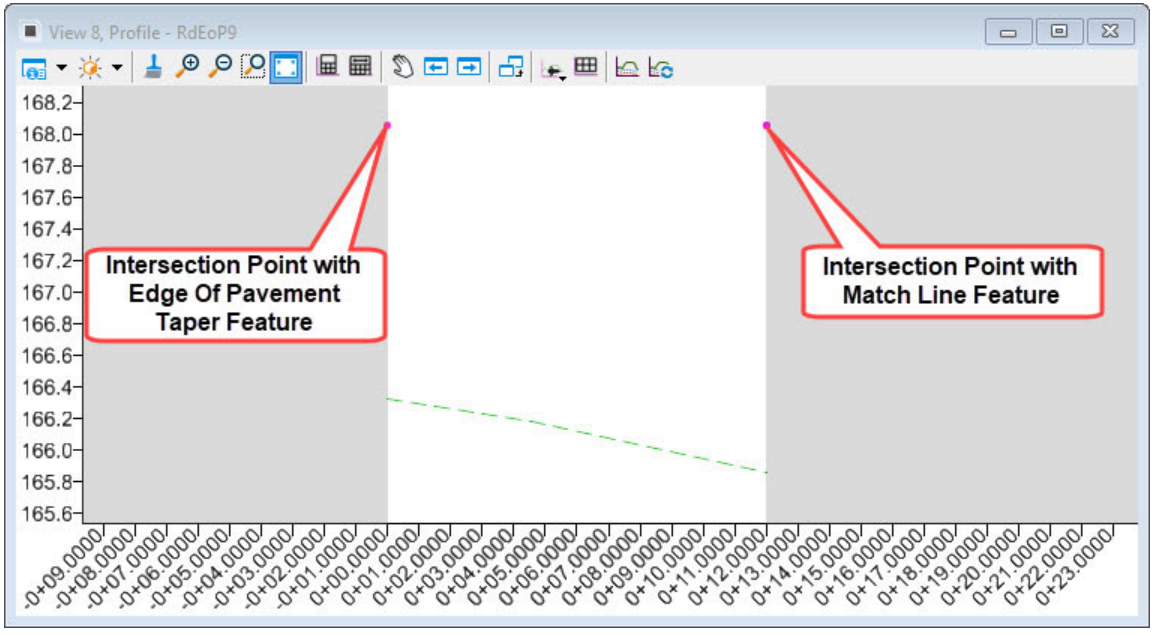
   d. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - *Locate Element to Show Intersection:* Select horizontal geometry created in the previous step.
      - *Locate Element Which Intersects:* Select the match line element.
      - *Locate Element For Next Intersection - Reset To Complete:* Select the taper element

   e. *Right click* or *Reset* to complete.

   f. *Fit* the profile view.

   2 dots appears in the profile model at the station and elevation where the boundary element intersects the match line feature and the taper edge of pavement feature.

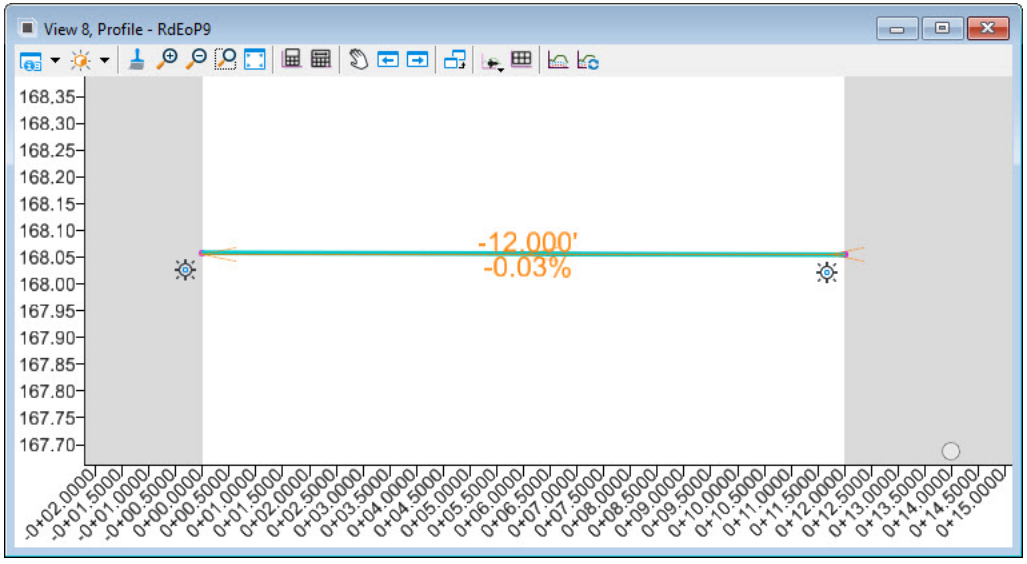


3. Create a Vertical Line Between the two intersection points.

a. Select **Geometry > Vertical > Lines > Profile Line Between Points**

- *Enter Start Point*: **Snap** to the intersection point to the left.
- *Enter End Point:* **Snap** to the intersection point to the right.

Note the slope is going to be pretty flat since there is superelevation transition happening on the pavement in the London Rd. Corridor.




b. Select the profile element.

Note the Snap icons, they indicate that the begin and end points of the vertical geometry has snap rules that are associated to the intersection points.

When you snap to the intersection points, the vertical geometry will be ruled and associated to the features. If the features change, the intersection points will update and so will the vertical geometry.

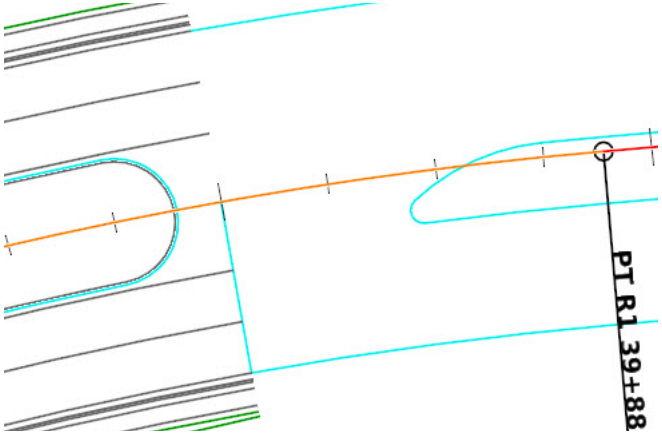
c. Set the new profile **Active** and make sure it is displayed in the 3D model.

4. Create the Boundary Element Across Church Rd.

   a. Zoom to the western end of Church Rd.

   b. From the *Feature Definition Toolbar,* select **Create 3D Automatically**.

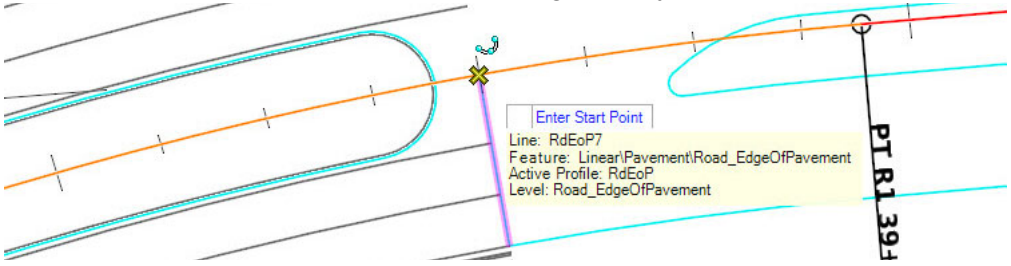
**Note:** Create 3D Automatically will generate a profile and 3D element automatically when defining horizontal geometry. This only works if the element being created is adjacent to other geometry elements which have a defined profile.



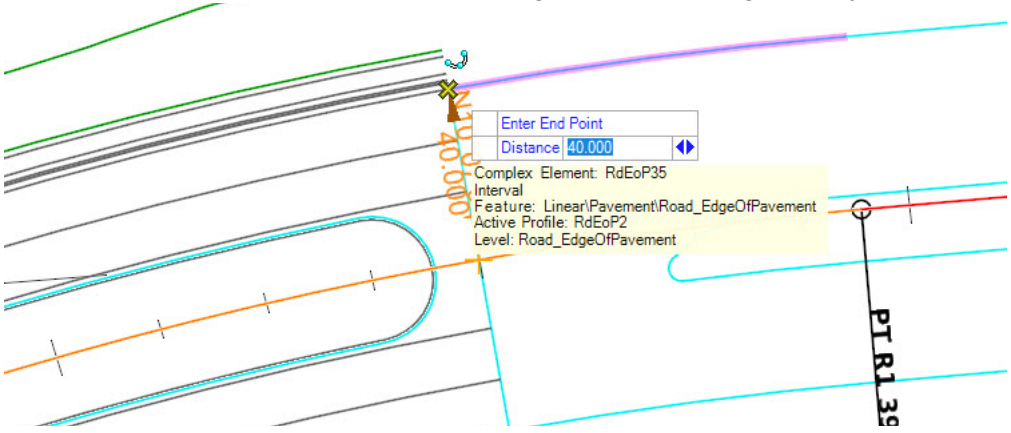

   c. Select **Geometry > Horizontal > Lines > Line Between Points**

   d. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

   - *Enter Start Point:* Snap to the end point of the **RdEOP7** geometry element.

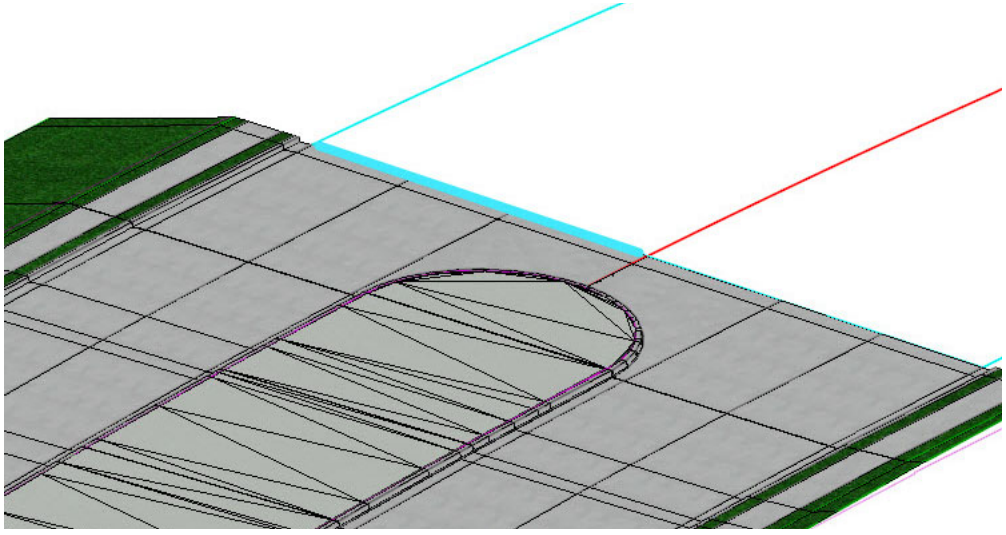



   - *Enter End Point:* Snap to the start point of the north edge of pavement geometry.



e. Turn Off **Create 3D Automatically**.

A line will be placed in 2D and 3D. A profile and 3D feature will be created automatically since **Create 3D Automatically** was activated.

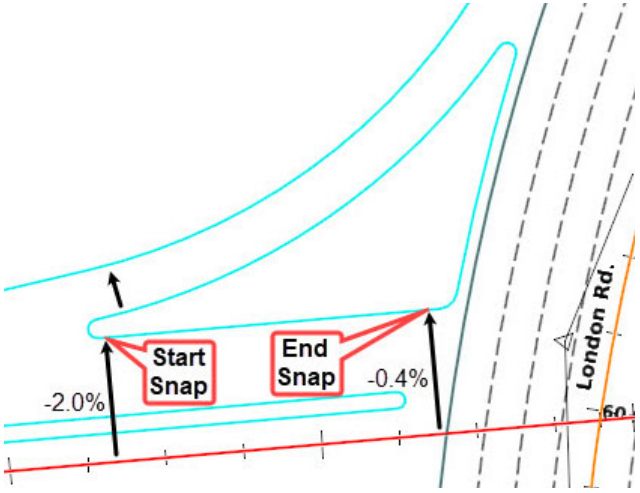


## Create Profiles Along the North Island Edge of Pavement

In this section, you will create the profiles for the islands.

---

1. Create the profile for the south edge of pavement for the north island.
   a. Zoom to the north island.
   b. Set **View 1** active.
   c. Select **Geometry > Common Tools > Simplify Geometry***
      - *Locate Element:* Select **ALL** of the edge of pavement elements **(do not select the arcs)** that represent the north island.
      - Data point to complete.
   d. Select **Geometry > Vertical > Profile Elements > Profile By Variable Slope From Element**
   e. On the dialog box, *UNLOCK* all the tool settings.
   f. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):
      - *Slope Style:* **Linear** (Use the up or down arrow key to toggle the *Slope Style* options).
      - *Locate Plan Element To Profile:* Select the south edge of pavement on the north island.
      - *Locate Reference Element:* Select the **Church Rd.** centerline.
      - *Start Distance - <ALT> Lock To Start:* Snap to the start of the edge of pavement.
      - *End Distance - <ALT> Lock To End:* Snap to the end of the edge of pavement.
      - *Start Slope:* **-2.0**
      - *End Slope:* **-0.4**
      - *Vertical Offset:* **0.0**
   g. Data point to complete.

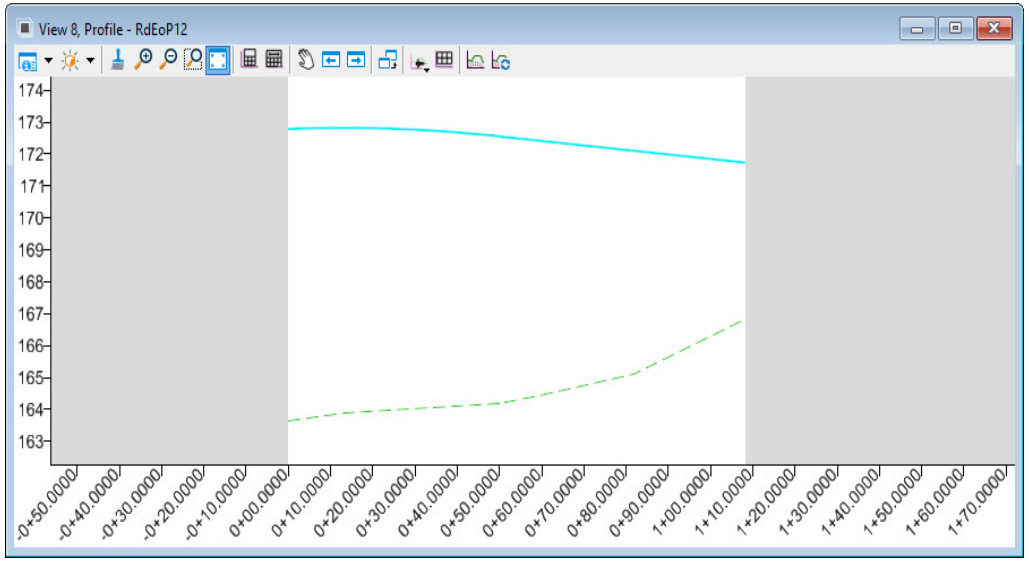


2. Open the Profile Model and Review the edge of pavement profile.

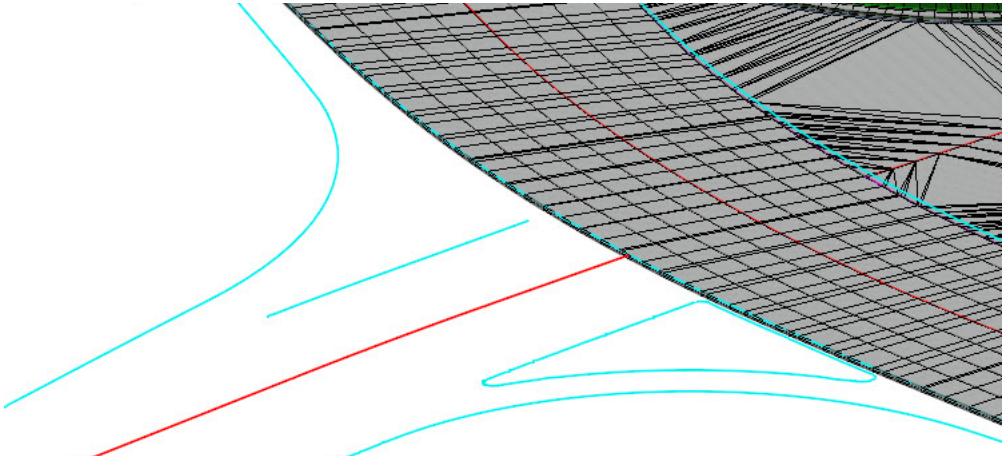
   a. In *View 1*, select the south edge of pavement geometry.

   b. Continue to hover the cursor at the selection point until the context sensitive menu appears.

   c. Select the **Open Profile Model** tool.




   d. If not active, set the new profile **Active** and make sure it is displayed in the 3D model.



3. Create the profile for the east edge of pavement for the north island.

   a. Set **View 1** active.

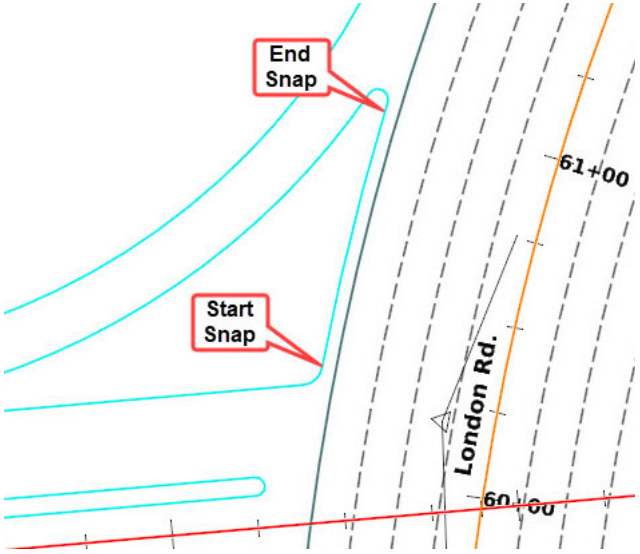
   b. Select **Geometry > Vertical > Element Profiles > Profile By Variable Slope From Element**

   c. On the dialog box, *UNLOCK* all the tool settings.

   d. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - *Slope Style:* **Constant** (Use the up or down arrow key to toggle the *Slope Style* options).
      - *Locate Plan Element To Profile:* Select the east edge of pavement.
      - *Locate Reference Element:* Select the match line geometry.
      - *Start Distance - <ALT> Lock To Start:* Snap to the start of the edge of pavement.
      - *End Distance - <ALT> Lock To End:* Snap to the end of the edge of pavement.
      - *Slope:* **2.0**
      - *Vertical Offset:* **0.0**

   e. Data point to complete.

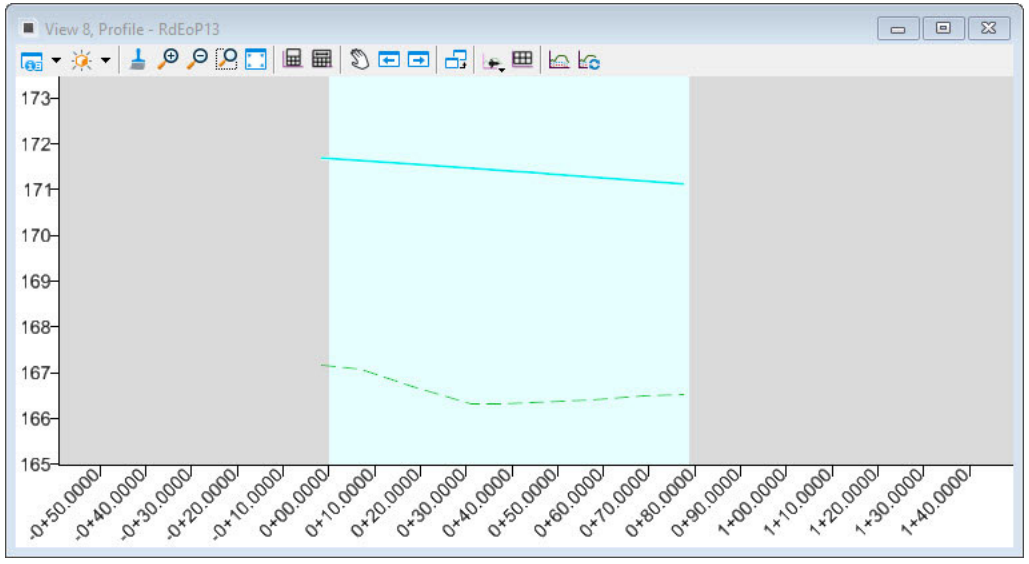


4. Open the Profile Model and Review the edge of pavement profile.

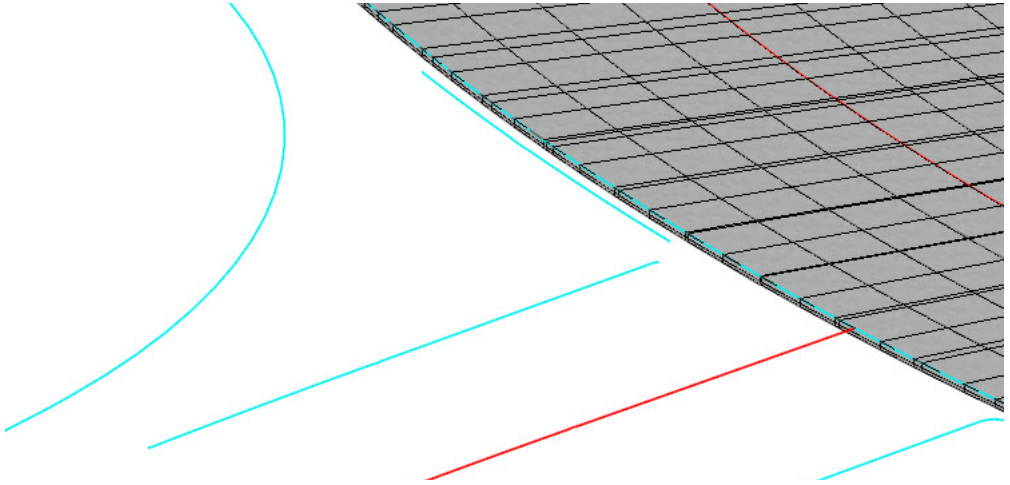
   a. In *View 1*, select the east edge of pavement geometry.

   b. Continue to hover the cursor at the selection point until the context sensitive menu appears.

   c. Select the **Open Profile Model** tool.




   d. If not active, set the new profile **Active** and make sure it is displayed in the 3D model.



5. Create the profile for the north edge of pavement for the north island.

   a. Set **View 1** active.

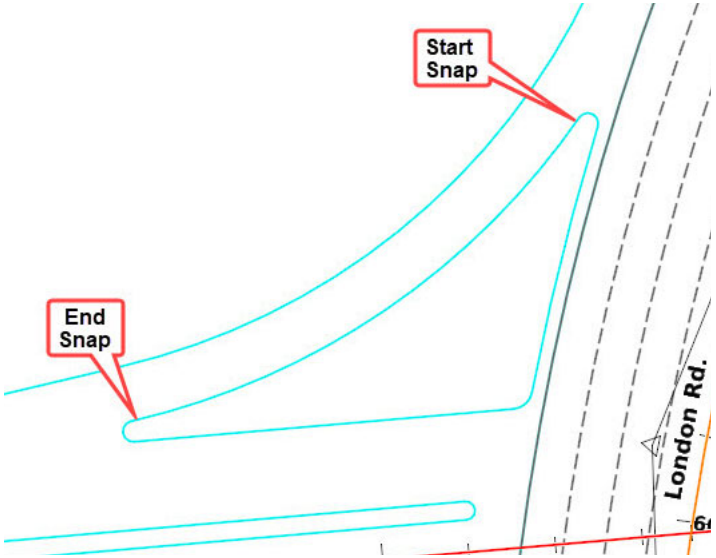
   b. Select **Geometry > Vertical > Profile Elements > Profile By Variable Slope From Element**

   c. On the dialog box, *UNLOCK* all the tool settings.

   d. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - *Slope Style:* **Constant** (Use the up or down arrow key to toggle the *Slope Style* options).
      - *Locate Plan Element To Profile:* Select the north edge of pavement.
      - *Locate Reference Element:* Select the taper-curve-taper element.
      - *Start Distance - <ALT> Lock To Start:* Snap to the start of the edge of pavement.
      - *End Distance - <ALT> Lock To End:* Snap to the end of the edge of pavement.
      - *Slope:* **2.0**
      - *Vertical Offset:* **0.0**

   e. Data point to complete.

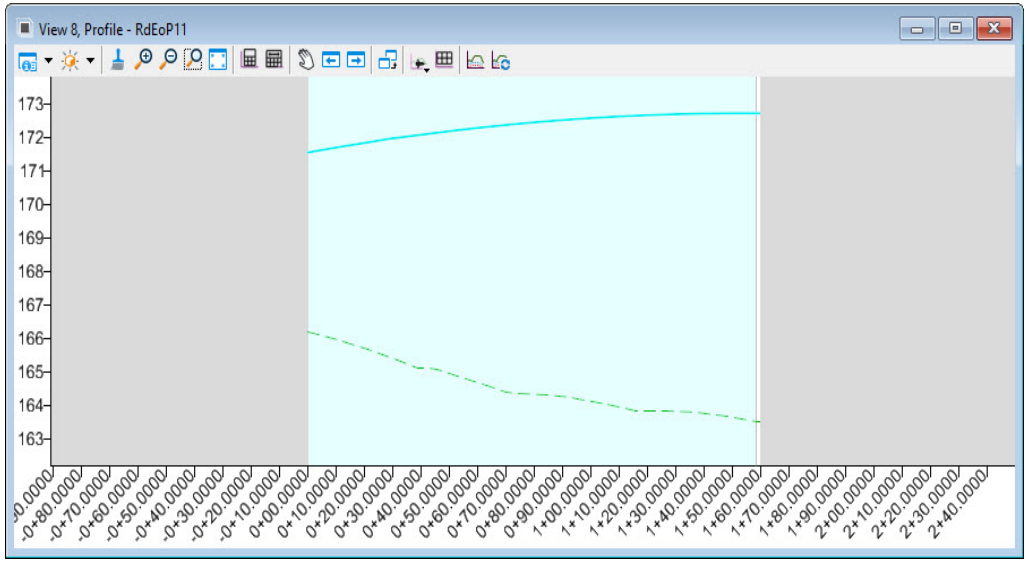


6. Open the Profile Model and Review the edge of pavement profile.

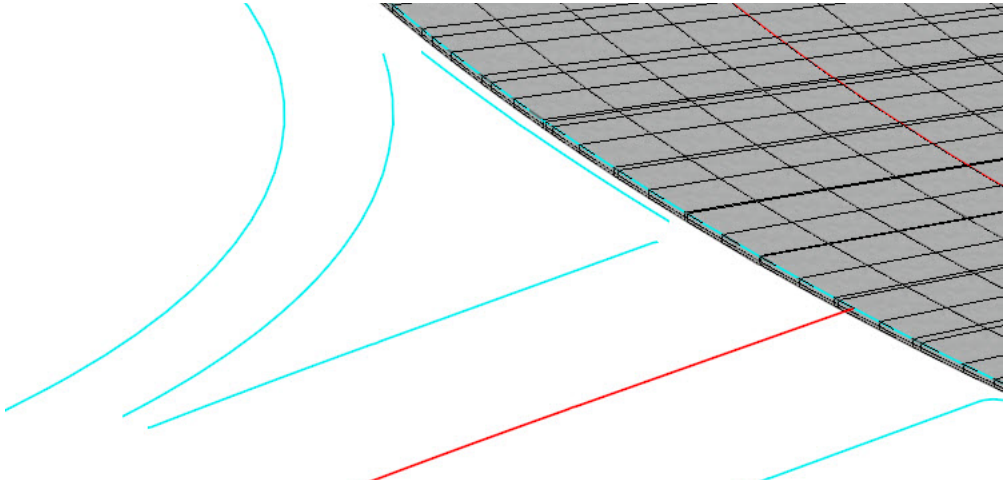
   a. In *View 1*, select the north edge of pavement geometry.

   b. Continue to hover the cursor at the selection point until the context sensitive menu appears.

   c. Select the **Open Profile Model** tool.




   d. If not active, set the new profile **Active** and make sure it is displayed in the 3D model.



7. Create the profiles for the island noses.

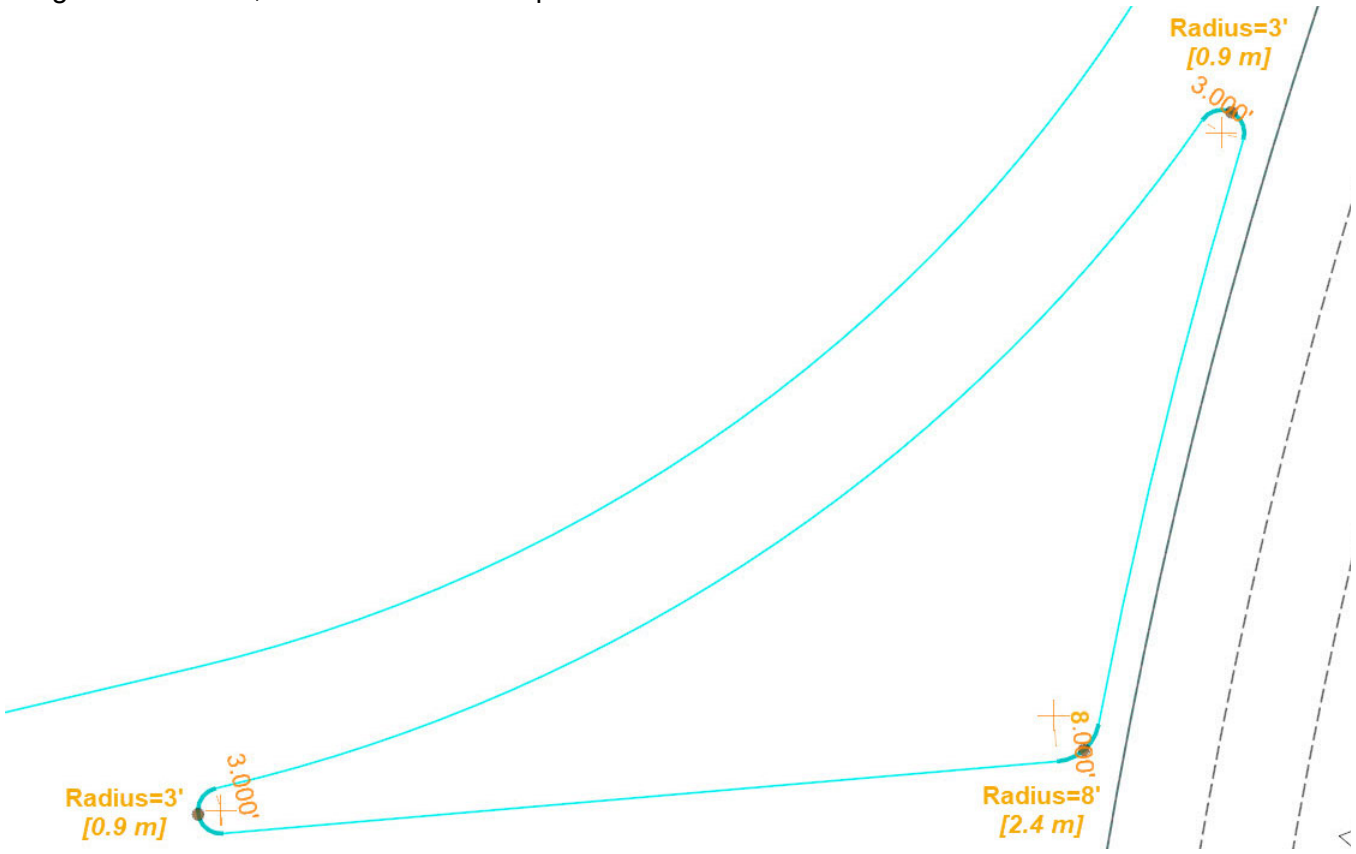
a. Select **Geometry > Vertical > Element Profiles > Quick Profile Transition**

b. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

- *Quick Transition Method:* **Parabolic**
- *Locate What to Define*: Select the arc with the **8** unit radius.

The profile transition is created.

c. Without leaving the command, continue and create profiles for the other island noses.




d. If the profiles are not displayed in the 3D model, you must set the profiles active and they will be displayed in the 3D model.

Now that the horizontal and vertical elements for the north island have been defined it's typically a good idea to join them together. Joining them together will be helpful for when you have to do the model detailing of the island.

8. Join together all of the north island edges of pavement using Complex By Element.

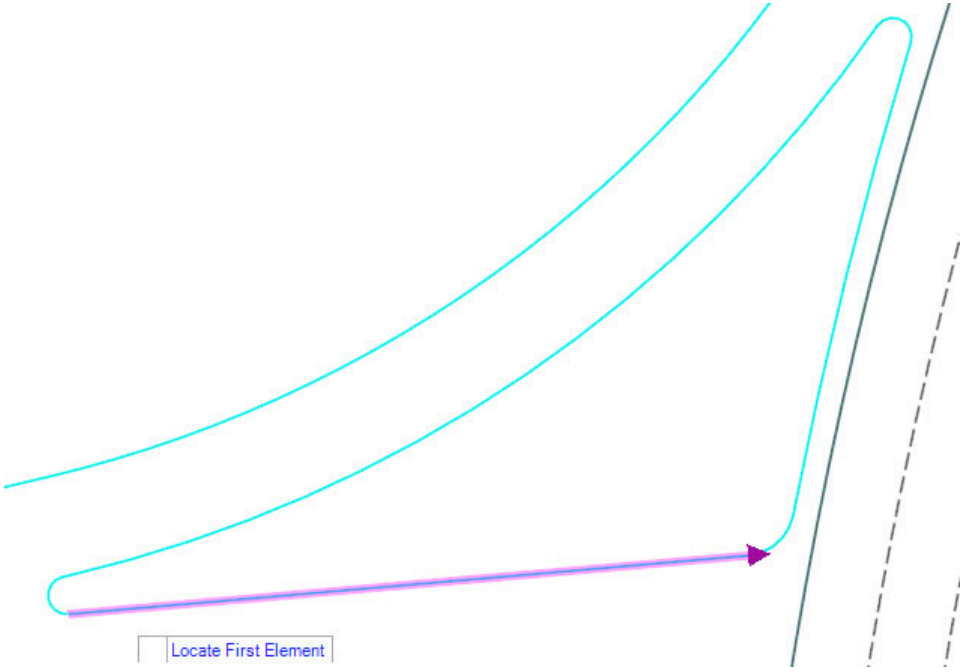
   a. Select **Geometry > Horizontal > Complex Geometry > Complex By Element**

   b. *Method:* **Automatic (may have to set to Manual and select each element separately)**

   c. *Maximum Gap:* **0.033**

   d. *Name:* **North Island**

   e. *Locate First Element:* Select the south edge of pavement on the north island (be sure the directional arrow is pointing to the east).




   f. *Accept Complex:* **Data point**

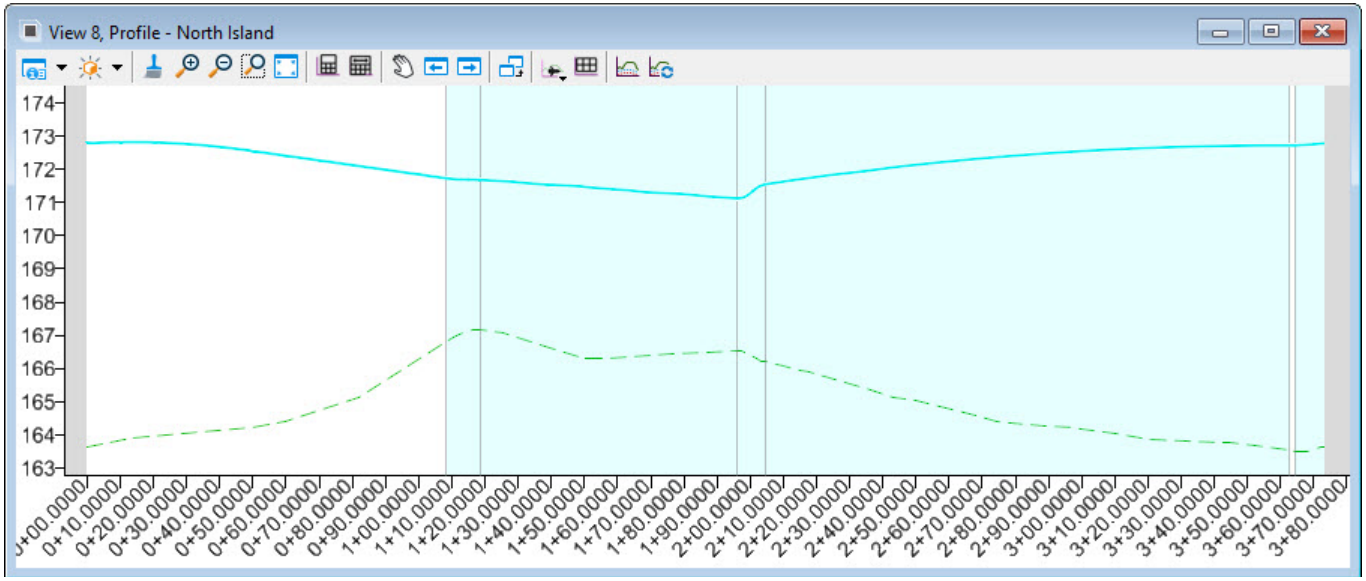
   Now that the horizontal elements are joined together lets take a look at the profile. When the horizontal elements are joined together individual profiles of the original elements exist and should be joined together as well.

9. Review the profile for the North Island.

   a. In *View 1*, select the north island geometry.

   b. Continue to hover the cursor at the selection point until the context sensitive menu appears.

   c. Select the **Open Profile Model** tool.




10. Join the profiles using **Create Profile By Complex Elements**

   a. Select **Geometry > Vertical > Complex Geometry > Profile Complex By Elements** tool.

   b. Set the *Method* to **Automatic**

   c. *Maximum Gap:* **0.033**

   d. Set the *Name* to **North Island**

   e. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - *Locate First Element:* Select the first profile element (be sure to select it near its beginning point).
      - *Accept Complex:* Left-click

11. Set the new profile **Active** and make sure it is displayed in the 3D model.

# Exercise 4: Create a Terrain Model of the Proposed Intersection Roadway Surface

## Description

In this exercise you will learn to create a terrain model of the proposed intersection roadway pavement surface.

## Skills Taught

- Create a terrain from the 3D elements
- Create the profile for the median
- Review the contours and pavement cross slopes
- Modify the pavement cross slope

## Create Terrain Model of the Pavement Surface and Profile the Median Edge of Pavement

To define the profiles along the median edge of pavement we need to create a terrain model of the intersection pavement surface. The median profiles and 3D elements will be created by “draping” the 2D median geometry onto the terrain model. Once the terrain model is created we will then analyze the drainage patterns by displaying the contours and adjust the model to correct some grading issues.

---

1. Create the temporary pavement surface Terrain Model from Edge of Pavement Boundary Elements.

   a. Select **Terrain > Create > Create From Elements**

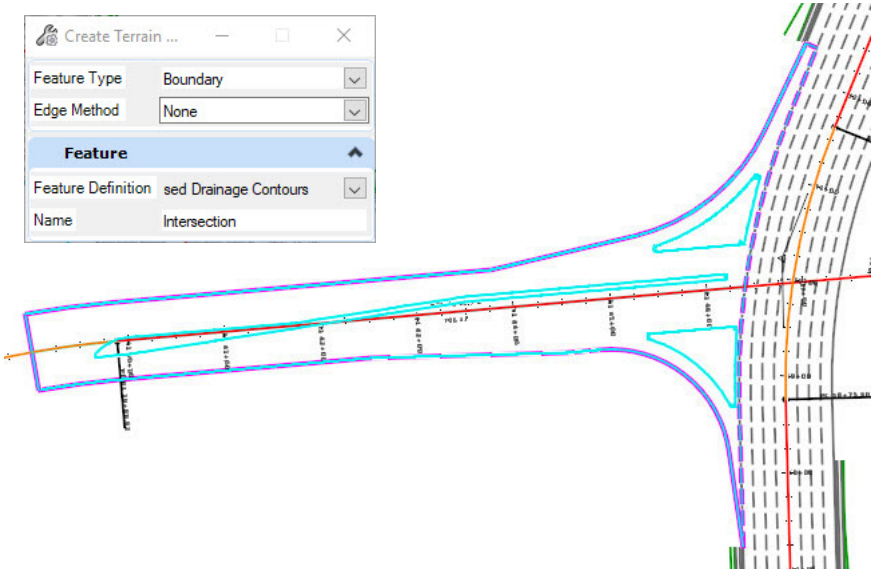
   b. In the *Create Terrain From Elements* dialog set the *Feature* as follows:

      - *Feature Definition:* **Terrain > Proposed > Proposed Drainage Contours**
      - *Name:* **Intersection**

   c. Following the heads up prompts (after each prompt, **Left click** to accept values and move to next prompt):

      - *Locate Element to Add:* Select all of the edge of pavement boundary elements (use image below as a guide).
      - *Locate Next Element to Add - Reset When Done:* **Right click**
      - *Locate Next Element to Add - Reset When Done:* **Right click** or **Reset**.
      - *Feature Type:* **Boundary**
      - *Edge Method:* **None**

   d. Data point to complete.



2. Add the Centerline as a Break Line feature.

   a. Select **Terrain > Edit > Feature Management > Add Features**

   b. Set the *Feature Type* to **Break Line**

      - *Locate Terrain Model To Add Elements:* In the **3D View**, select the intersection terrain model.
      - *Locate Element to Add:* In the **3D View**, select the centerline of **Church Rd.**
      - *Locate Next Element to Add - Reset When Done:* **Right click** or **Reset**.

   c. Data point to complete.

3. Add the Islands as Voids (or Holes).

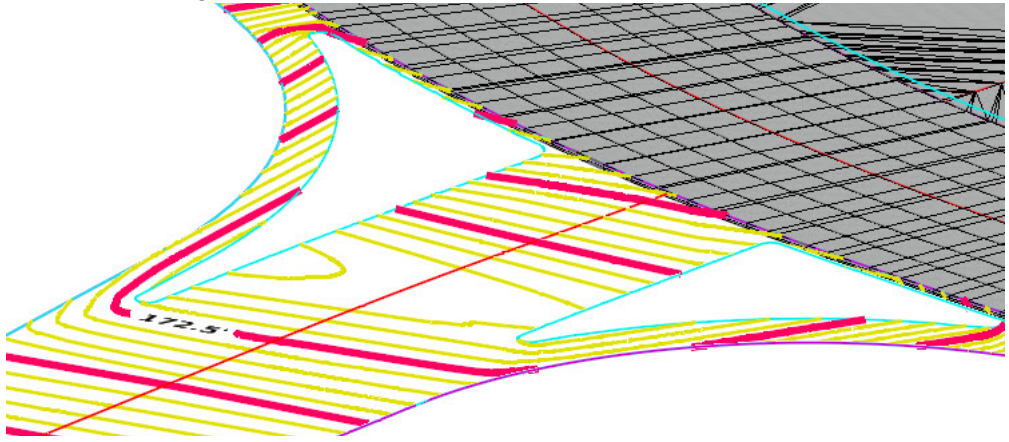
   a. Select **Terrain > Edit > Feature Management > Add Features**

   b. Set the *Feature Type* to **Void** (or Hole).

      - *Locate Terrain Model To Add Elements:* In the **3D View**, select the intersection terrain model.
      - *Locate Element to Add:* In the **3D View**, select the **north island** complex element.
      - *Locate Next Element to Add - Reset When Done:* Select the **south island** complex element.

   c. Data point to complete.

   The island voids should look like the image below.



4. Create the profile for the Median Edge of Pavement geometry.

   a. Select **Geometry > Vertical > Profile Creation > Quick Profile From Surface**

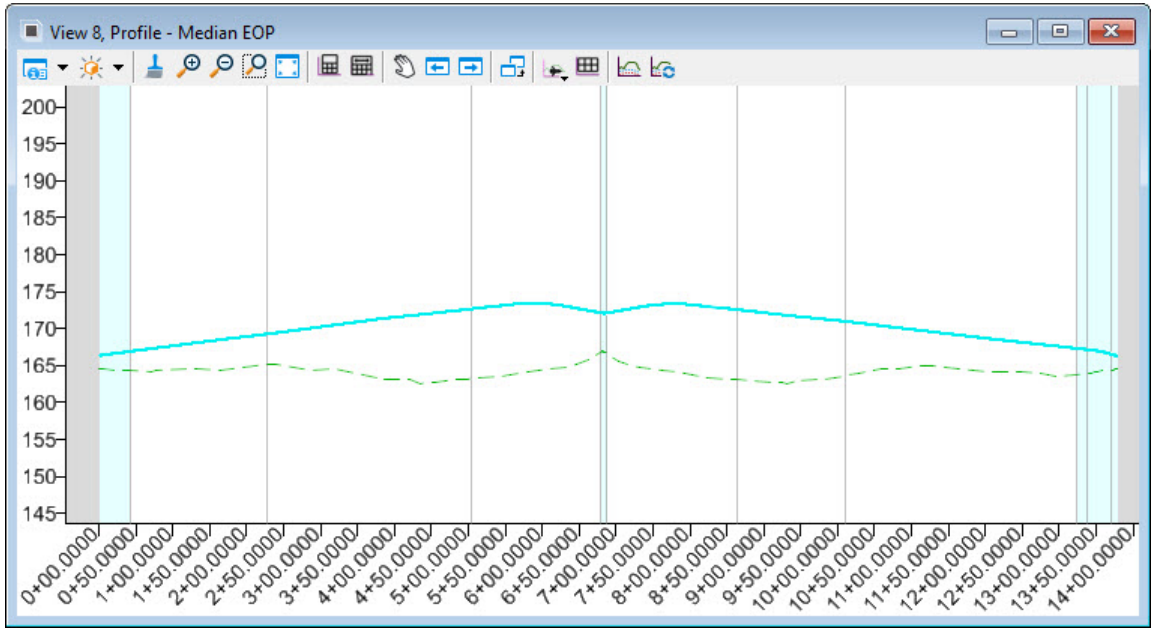
   b. *Locate Reference Element:* Select the Median Edge of Pavement geometry.

   c. *Locate Reference Surface:* Select the intersection terrain model.

   d. *Locate Reference Surface or Reset to End:* **Right click** or **Reset**

      Doing this is essentially draping the elements onto the terrain model. This process creates profiles and 3D elements of the median 2D geometry.

5. Open the Median Edge of Pavement Profile Model and Review the profile that was created.




   Since the resulting profile was created from the terrain model we cannot just add this profile's 3D feature directly to the terrain model. The software will not allow a circular dependency. To get around this we will remove the rule from the 3D feature.

6. Set the profile active so that it displays the 3D feature into the 3D model.

7. Remove the Rule from the Profile. In the profile model, select the median profile element.

   a. Hover your cursor over the profile element until the context menu appears.

   b. Select **Remove Rule** (see note about removing rules below).

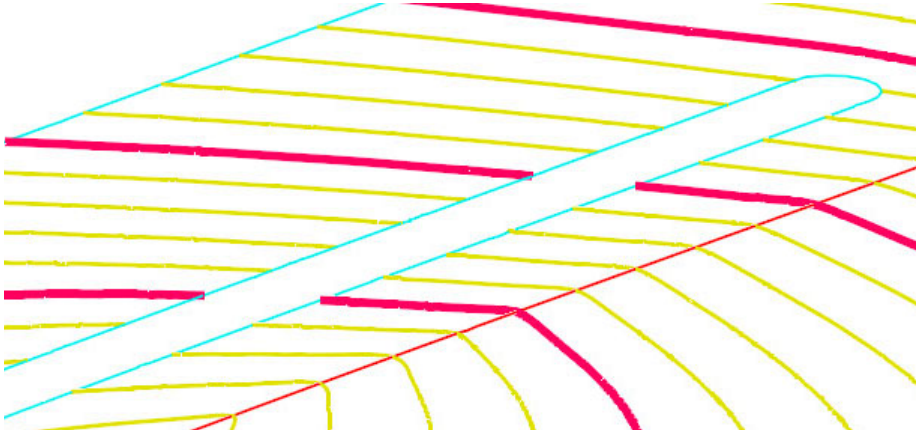
8. Add the Median Edge of Pavement 3D feature to the intersection terrain model.

   a. Select **Terrain > Edit > Feature Management > Add Features**

   b. Set the *Feature Type* to **Void** (or Hole).

      - *Locate Terrain Model To Add Elements:* In the 3D View, select the intersection terrain model.
      - *Locate Element to Add:* Select the median edge of pavement complex element.
      - *Locate Next Element to Add - Reset When Done:* **Right click** or **Reset**.

   c. Data point to complete.



**TIP:** If you do not want to remove the rule from the median profile, an alternative workflow would be to create a new file and reference in the intersection geometry and build a temporary terrain model that represents the pavement surface from the referenced intersection geometry. You could then use that terrain model to define the median profile in the intersection.dgn.

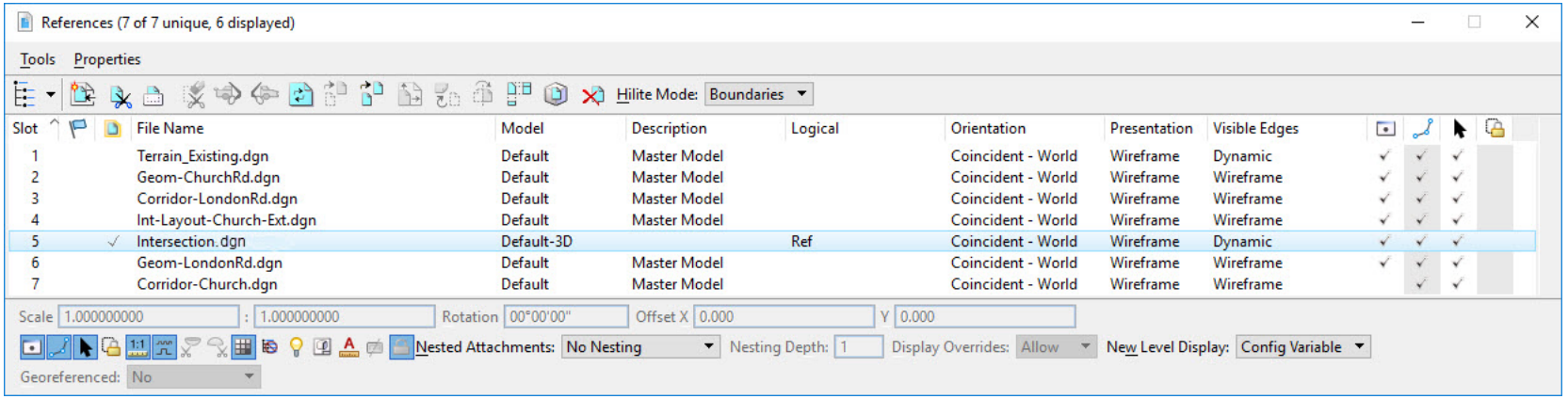
9. View the Contours in 2D. Turn ON the Default-3D model in the 2D view.

   a. *Left-click* in **View 1** to make it active.

   b. Select **Home > Primary > Attach Tools > References**.

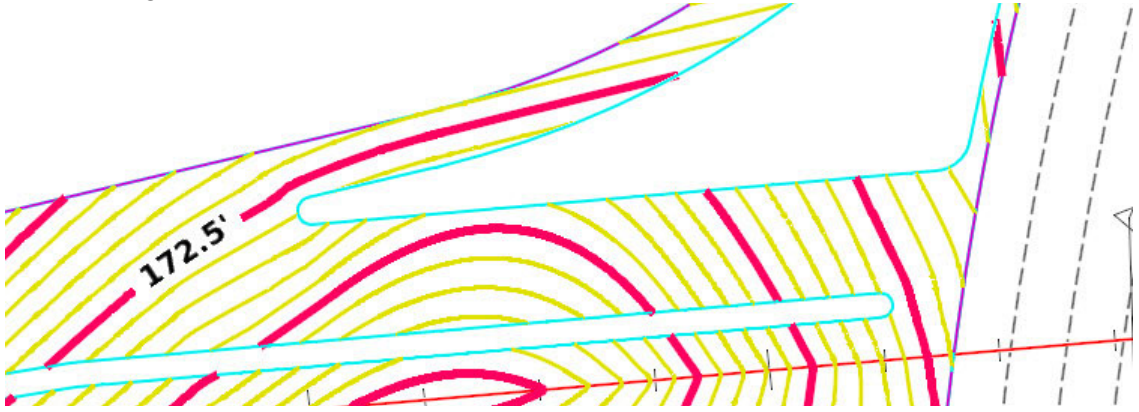
   c. Select **Intersection.dgn**.

   d. Select the **Display** button.




   e. Close the *References* dialog. The terrain model contours will now be displayed in the 2D view.

   f. Zoom in near the south edge of pavement for the north island.

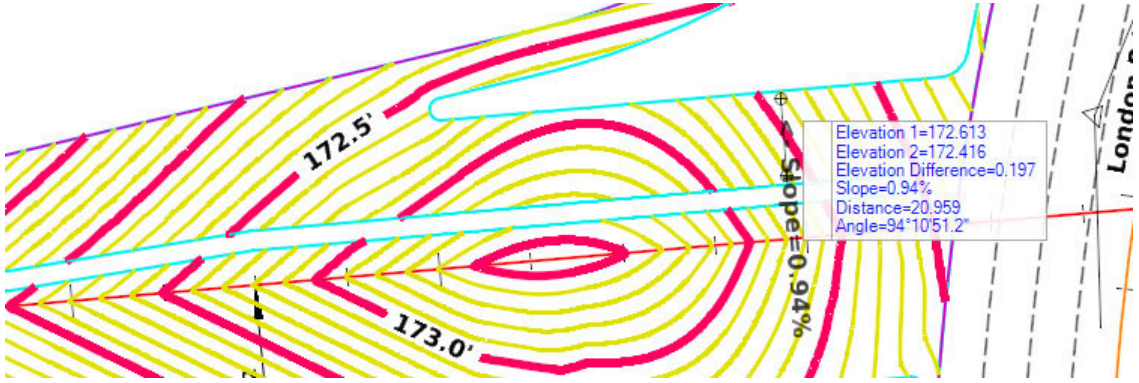



Recall, to create the profile along the south edge of pavement we projected a -2.0% slope to the start point and -0.40% slope to the end point of this element from the centerline.

10. Analyze Pavement Cross Slopes using the **Analyze Between Points** tool.

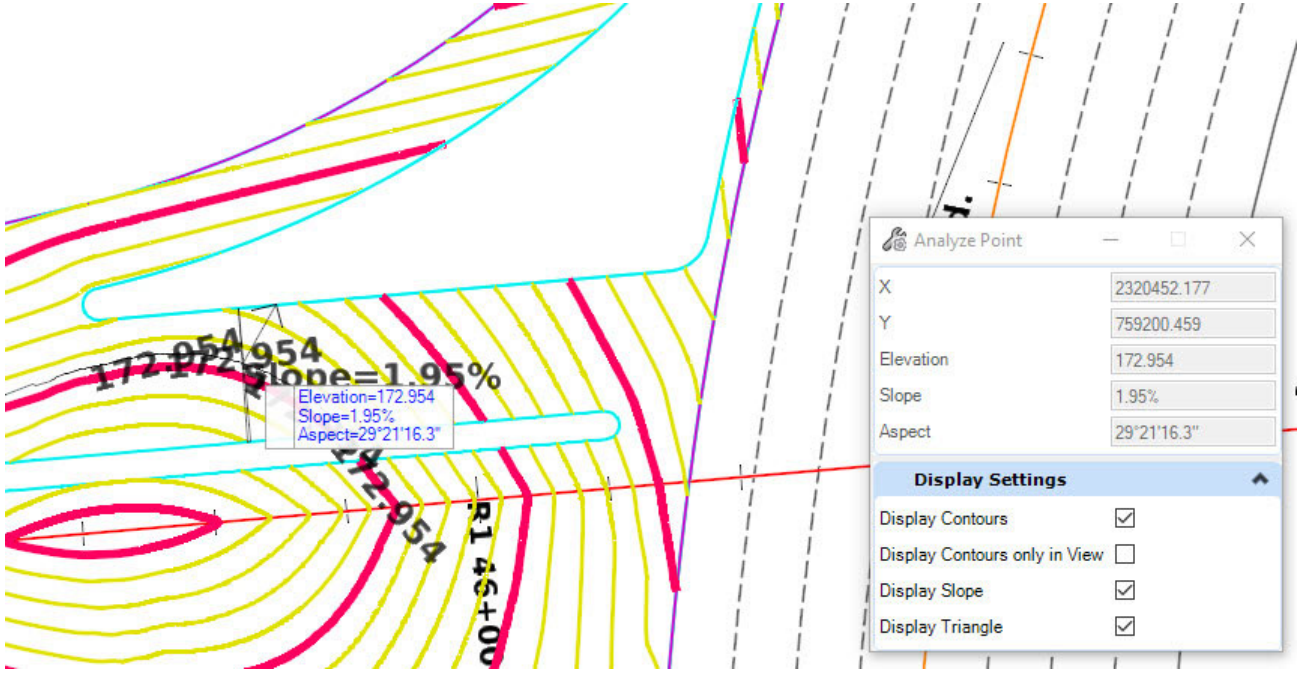
a. Select **Home > Model Analysis and Reporting > Civil Analysis > Analyze Between Points**

- *Select Terrain Model Element:* In the 2D view, select the terrain model.
- *Start Point:* Pick a point near the edge of median.
- Move your cursor toward the south edge of pavement for the north island. The heads-up display will appear displaying elevation and slope information as you move the cursor within the surface of the terrain model.




b. Data point near the south median edge of pavement. The slope text will be graphically placed in the 2D view.

11. Use the **Analyze Point** tool to check slopes and direction of drainage flow.
    a. Select **Terrain > Analysis > Points > Analyze Point**
    b. At the *Select Element To Analyze Point* prompt, in 2D, select any terrain contour.
    c. Move your cursor anywhere within the boundary of the terrain model and notice the slope, elevation and drainage flow arrow are graphically displayed as you move around the terrain.




This tool is very useful for checking slopes and elevations of a terrain model.

## Skills Assessment

The questions below will test your retention of the skills covered in this course.

---

1. Which tool can be used to create offset edge of pavement horizontal geometry?
   a. Single Offset Partial
   b. Offsets and Tapers
2. Which tool would be best to use if you need to create profiles along edge of pavement horizontal geometry where the projected cross slope needs to transition from -2% to -0.4%?
   a. Profile By Slope From Element
   b. Quick Profile From Surface
   c. Profile By Variable slope From Element
3. Only the active profile is displayed in the 3D model.
   a. True
   b. False
4. The quick profile transition tool only creates parabolic transitions.
   a. True
   b. False
5. Drainage Contours can be analyzed using the following tools (pick 2):
   a. Analyze Between Points
   b. Analyze Point
   c. Profile Report
   d. Analyze Volume

## Skills Assessment - Answers

The answers to the skills assessment questions are highlighted below.

---

1. Which tool can be used to create offset edge of pavement horizontal geometry?
   a. **Single Offset Partial**
   b. Offsets and Tapers
2. Which tool would be best to use if you need to create profiles along edge of pavement horizontal geometry where the projected cross slope needs to transition from -2% to -0.4%?
   a. Profile By Slope From Element
   b. Quick Profile From Surface
   c. **Profile By Variable Slope From Element**
3. Only the active profile is displayed in the 3D model.
   a. **True, although you can have multiple profiles defined for a single element, only the active profile is displayed in the 3D Model.**
   b. False
4. The quick profile transition tool only creates parabolic transitions.
   a. True
   b. **False, the tool can create both linear and parabolic transitions.**
5. Drainage Contours can be analyzed using the following tools (pick 2):
   a. **Analyze Between Points**
   b. **Analyze Point**
   c. Profile Report
   d. Analyze Volume

## Summary

In this course you have now learned the tools and techniques that can be used to layout the horizontal and vertical elements of a complex intersection.

You have learned:

- How to create horizontal and vertical geometry for the edges of pavement, median and islands.
- How to create a terrain model that represents the proposed pavement surface.
- How to analyze contours and make adjustments to the slopes.

The intersection design process does not stop here, the next step is to create a 3D solids model of the roadway intersection. To learn about creating the 3D model of the roadway intersection take the continuation of the this course called: **Intersection Design - 3D Model Detailing**