Roundabout Design - Vertical Geometry

This course is for the **2024 Release 2***version of:*

OpenRoads Designer

OpenRail Designer

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 **learning.bentley.com**
- This PDF file includes bookmarks providing an overview of the document. Click on a bookmark to quickly jump to any section in the file.
- Only Imperial files are included in the dataset.
- This course workbook uses the *Training and Examples* WorkSpace and the *Training-Imperial* 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.
- Prerequisites: Users should have completed the **Intersection Design-Horizontal & Vertical Geometry** course and the **Intersection Design-3D Model Detailing** course.

Have a Question? Need Help?

If you have questions while taking this course, you can submit questions to the *Civil Design Forum* on Bentley Communities where peers and Bentley subject matter experts are available to help.

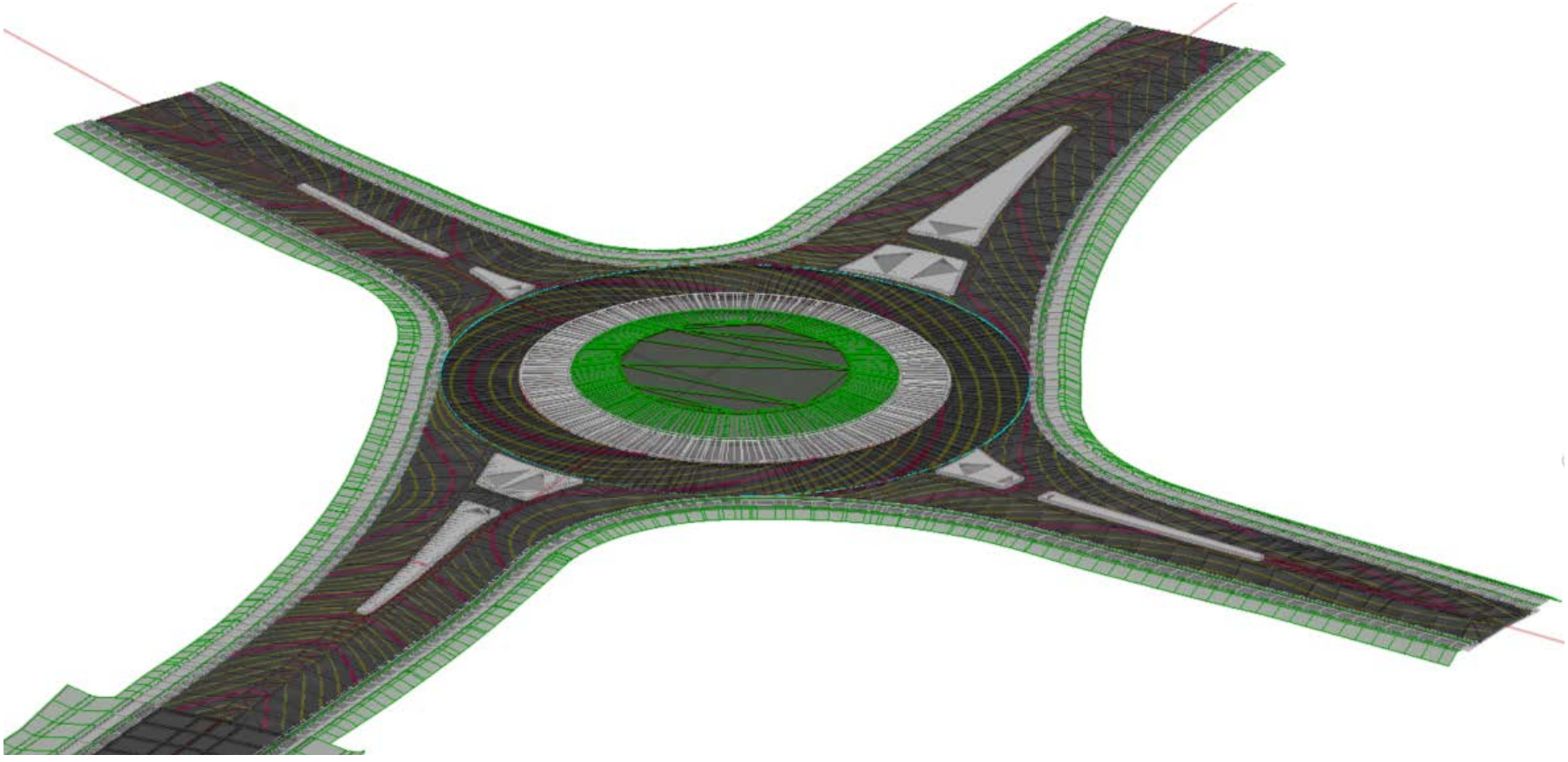
Bentley Institute

Edition: **02-02**

Course Level: **Advanced**

Course Overview

In this course we are going to cover the vertical design of a roundabout. The vertical design of a roundabout begins with the development of the central island and approach roadway profiles. The development of each profile is an iterative process that involves tying the elevations of the approach roadway profiles into a smooth profile around the central island. Since this is an iterative process and can be very time consuming we will only show the step by step details for one approach in this course. You can apply that same process for the other legs of the roundabout.



Design Requirements for Vertical Profiling of the Roundabout

The vertical design of a roundabout begins with the development of the central island and approach roadway profiles. The development of each profile is an iterative process that involves tying the elevations of the approach roadway profiles into a smooth profile around the central island.

Each approach profile should be designed to the point where the approach baseline intersects with the central island. A profile for the central island is then developed that passes through these four points (in the case of a four-legged roundabout). The approach roadway profiles are then readjusted as necessary to meet the central island profile.

It is generally not desirable to place roundabouts in locations where grades through the intersection are greater than 4%. At locations where a constant grade must be maintained through the intersection, the circulatory roadway may be constructed on a constant-slope plane. This means, for instance, that the cross slope may vary from +3% on the high side of the roundabout (sloped toward the central island) to −3% on the low side (sloped outward). On approach roadways with grades steeper than −4%, it is more difficult for entering drivers to slow or stop on the approach. At roundabouts on crest vertical curves with steep approaches, a driver's sight lines may be compromised, and the roundabout may violate driver expectancy

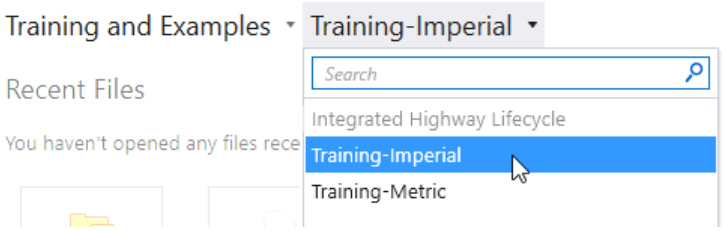
1. Start the software.
2. Set the WorkSpace and WorkSet.

   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 an existing file.

   a. Select **Browse**.

   b. Browse to *C:\Bentley Training\Roundabout Design - Vertical Geometry* or other folder where you unzipped the dataset files.

   c. Select the file **RAB Geometry-Start.dgn** and click **Open**.

Exercise 1: Creating Profiles on the Inner and Outer ICD

Description

In this exercise you will create a vertical profile on the Inner ICD and then project slopes across to the Outer ICD using a constant slope.

Skills Taught

- Open Profile Model
- Profile Intersection Point
- Vertical Geometry Tools
- Profile Slope from Element
- Set Active Profile

Profile the Inner and Outer ICD

A preliminary horizontal and vertical design for our roadways has already been completed and given to us. The first step in the vertical design of the roundabout will be to define the profile of the Inner and Outer ICD. In this section you will create the vertical design of the inner and outer ICD.

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1. The first step is to open a *Profile Model* of the **Inner ICD.**

   a. From the ribbon menu, Select > *Geometry* > *Vertical* > **Open Profile Model**

   b. *Locate Plan Element* > **Inner ICD**

   c. Select > **Select or Open View**

   d. From the *View Controls toolbar*, Select > **View 4**

   e. **Data Point** in the view

2. In the Profile View, display the locations of the four incoming centerline profile intersection points. We can use these points as a guide to help design the vertical alignment.

   a. From the ribbon menu, Select > *Geometry* > *Vertical* > *Profile Creation* > **Profile Intersection Point**

   b. Toggle **ON** *Process All Intersections*

   c. *Locate Element to Show Intersection* > **Inner ICD** (This needs to be selected in the Plan View)

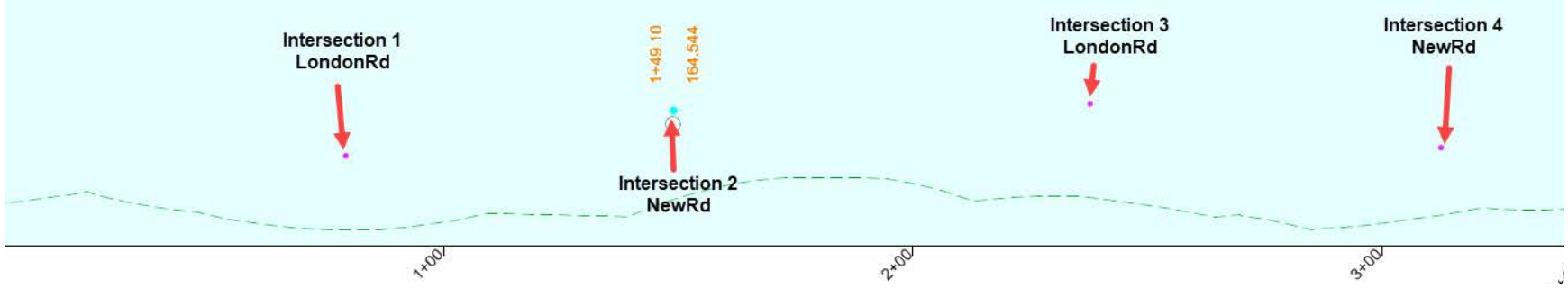
   d. *Locate Element which Intersects* > Select > **LondonRd** centerline

   e. Repeat the same process but this time use the NewRd centerline as the intersecting element.

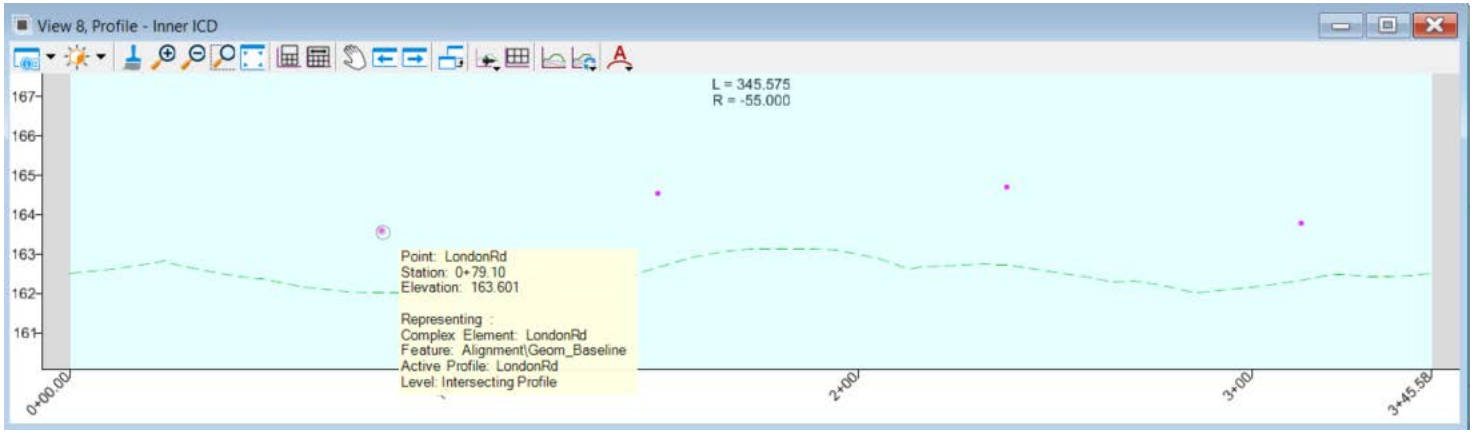
   f. *Locate Element to Show Intersection* > **Inner ICD**

   g. *Locate Element which Intersects* > Select > **NewRd** centerline

There should be four purple dots in the view, representing the elevations of the incoming centerlines. We have marked their locations just for reference.



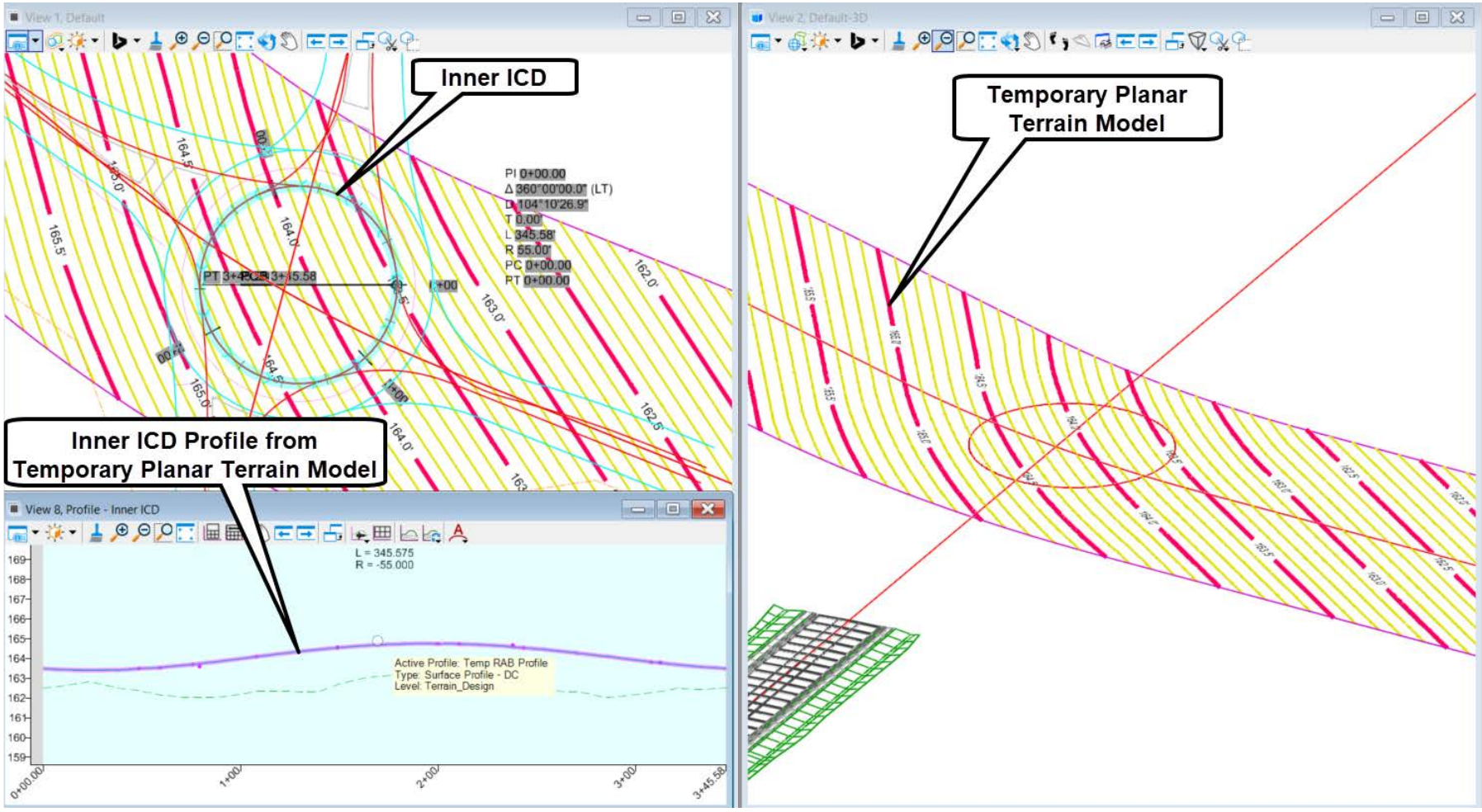
3. Hover your cursor over each intersecting point in the profile model view and review the station, elevation and associated intersecting alignment.



There are many methods to define the inner ICD vertical alignment. One approach to designing the inner ICD vertical alignment is to utilize the concept of a tilted plane (or surface).

In this concept, you would:

- Create a temporary planar terrain model surface that is sloped (or tilted) up or down.
- Display that surface onto the Inner ICD to use as a guide to design the vertical alignment.
- Use the Best-Fit Profile tool to create the vertical alignment.



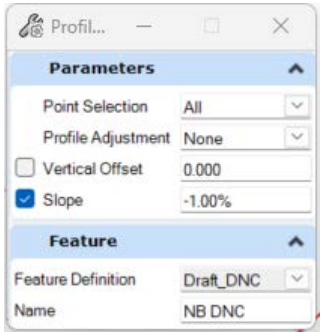
Now let's create the planar surface by first projecting slopes from the New Rd. alignment.

4. Project -1.0% slope from the **New Rd.** alignment to the **NB DNC** element.

   a. Select *Geometry* > *Vertical* > *Element Profiles* > **Profile By Slope from Element**

   b. Set the dialog as shown in the image to the right and then follow the heads up prompts:

      - *Locate First Element to Profile:* Select the **NB DNC**
      - Right click or Reset
      - *Locate Reference Element:* Select the **New Rd.** centerline
      - *Slope:* **-1.00%**



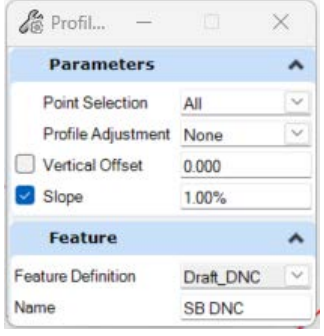
5. Project +1.0% slope from the **New Rd.** alignment to the **SB DNC** element.

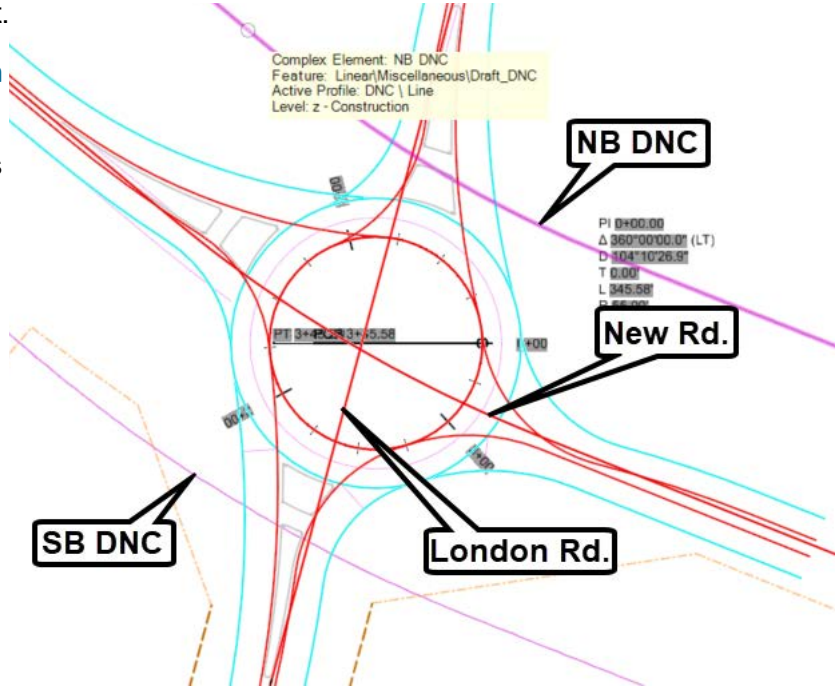
   a. Select *Geometry* > *Vertical* > *Element Profiles* > **Profile By Slope from Element**

   b. Set the dialog as shown in the image below and then follow the heads up prompts:

      - *Locate First Element to Profile:* Select the **SB DNC**
      - Right click or Reset
      - *Locate Reference Element:* Select the **New Rd.** centerline

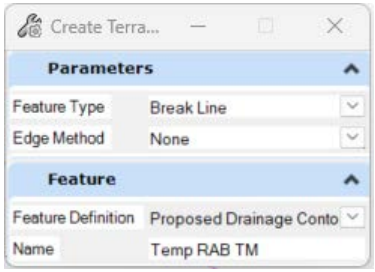
   c. *Slope:* **1.00%**



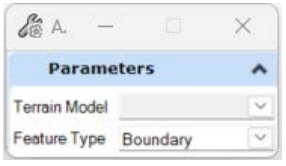


Now that we have these two elements defined, we can now create the tilted plane terrain model.

6. Create the terrain model.

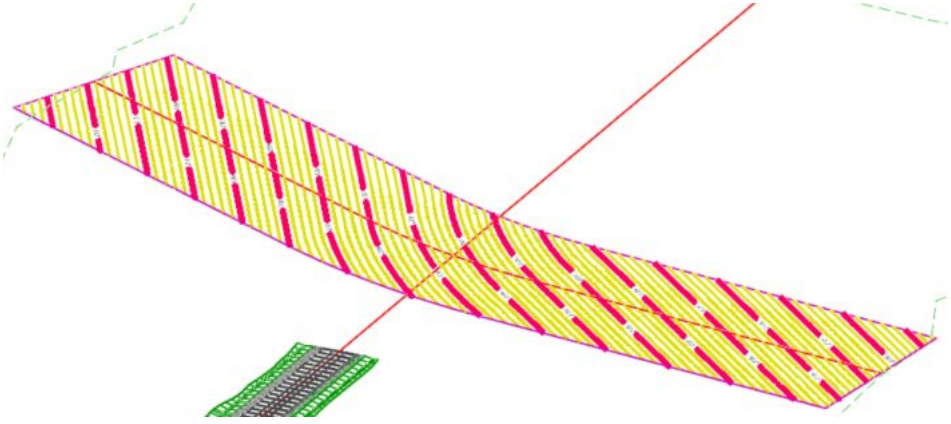


   a. Select *Terrain* > *Create* > **From Elements**
   b. *Feature Type:* **Break Line**
   c. *Edge Method:* **None**
   d. *Feature Definition:* **Proposed Drainage Contours**
   e. *Name:* **Temp RAB TM**
   f. Follow the heads up prompts:
      - *Locate Element to Add:* Select the **New Rd.** alignment
      - *Locate Next Element to Add - Reset when done:* Right click or reset
      - Left click through the prompts to complete
   g. Continuing in the command, in the toolbox, set the *Feature Type to* **Boundary**

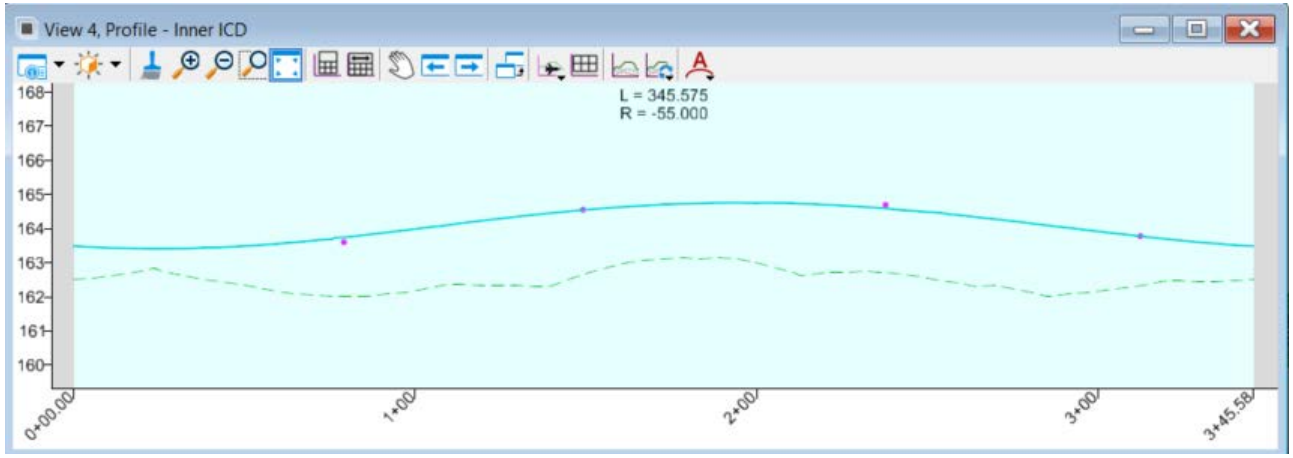


   h. Follow the heads up prompts:
      - *Locate Element to Add:* Select the **NB DNC** element
      - *Locate Next Element to Add - Reset When Done:* Select the **SB DNC** element
      - *Feature Type:* **Boundary**
      - Left click
      - Right click or Reset to complete

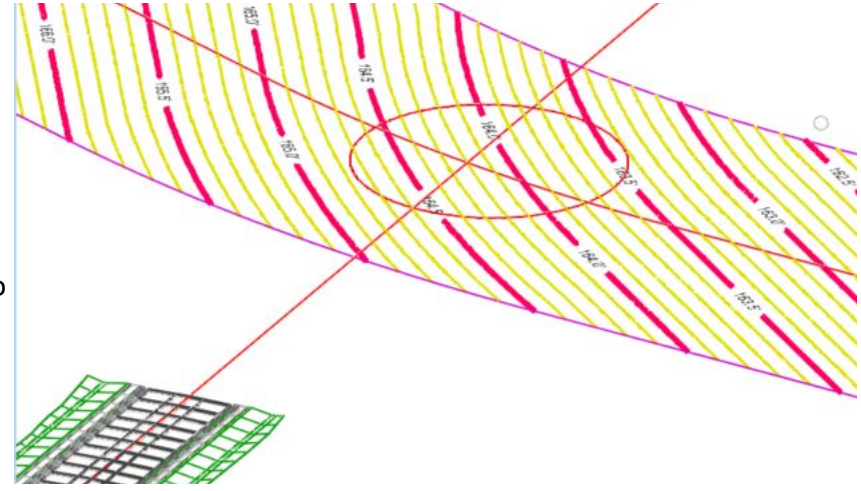
The completed terrain model can be seen in the image to the right.



7. Display the profile from the Temp RAB TM terrain model into the profile model for the Inner ICD.
   a. Select the profile model view in **View 4**.
   b. Select **Quick Profile from Surface**
   c. *Locate Reference Surface:* Select the **Temp RAB TM**
   d. *Locate Reference Surface or Reset to End:* Right click or reset



8. Set the Profile Active.
   a. Select the Inner ICD profile just created.
   b. From the *context sensitive toolbar* > **Set Active**
   c. **<ESC>** to Exit command



Once the profile has been set active, it will appear in the 3D View.

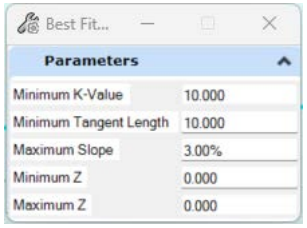
At his point, you now have a profile from the surface but it is a b-spline profile element. It is not a civil geometry element therefore you may want to create actual civil geometry elements.

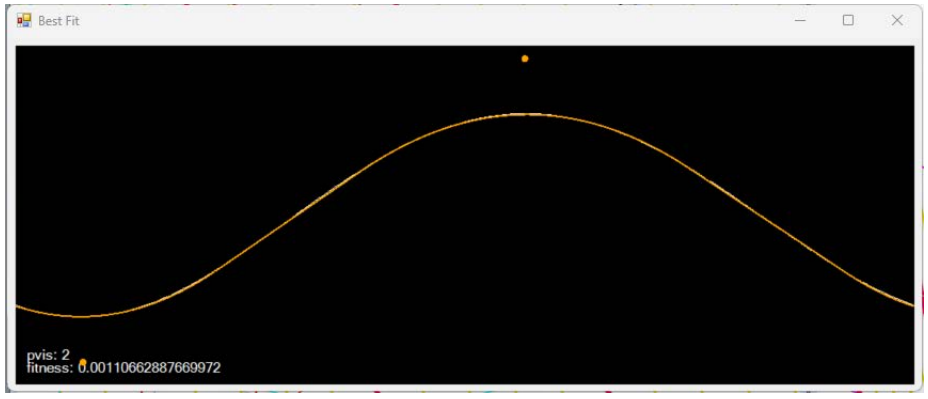
You can use the civil geometry tools to create individual civil geometry elements or apply a best-fit profile process to define the vertical alignment for the Inner ICD. We will choose the later.

9. Create the proposed vertical alignment for the Inner ICD by using the Best-Fit Profile command.

   a. Select *Site* > *Grading* > *Profiles* > **Best-Fit Profile**

   b. Set the dialog as shown.





   c. *Locate Element:* Select the Inner ICD profile

      The Best Fit window will appear and perform a best fit analysis on the profile and create a new proposed vertical alignment for the Inner ICD. The new alignment is made of civil geometry elements (tangents, curves, etc.)

   d. Close the *Best Fit* window.

   e. Review the newly "Best-Fit" vertical alignment. Note how closely it matches the profile that was defined from the terrain model surface. Also, note it does not have a name or feature definition. So, we will have to define a name and feature definition next.

10. Set the Name and Feature Definition

   a. Zoom in very close to the newly created vertical alignment.

   b. Select *Geometry* > *General Tools* > *Standards* > **Set Feature Definition**

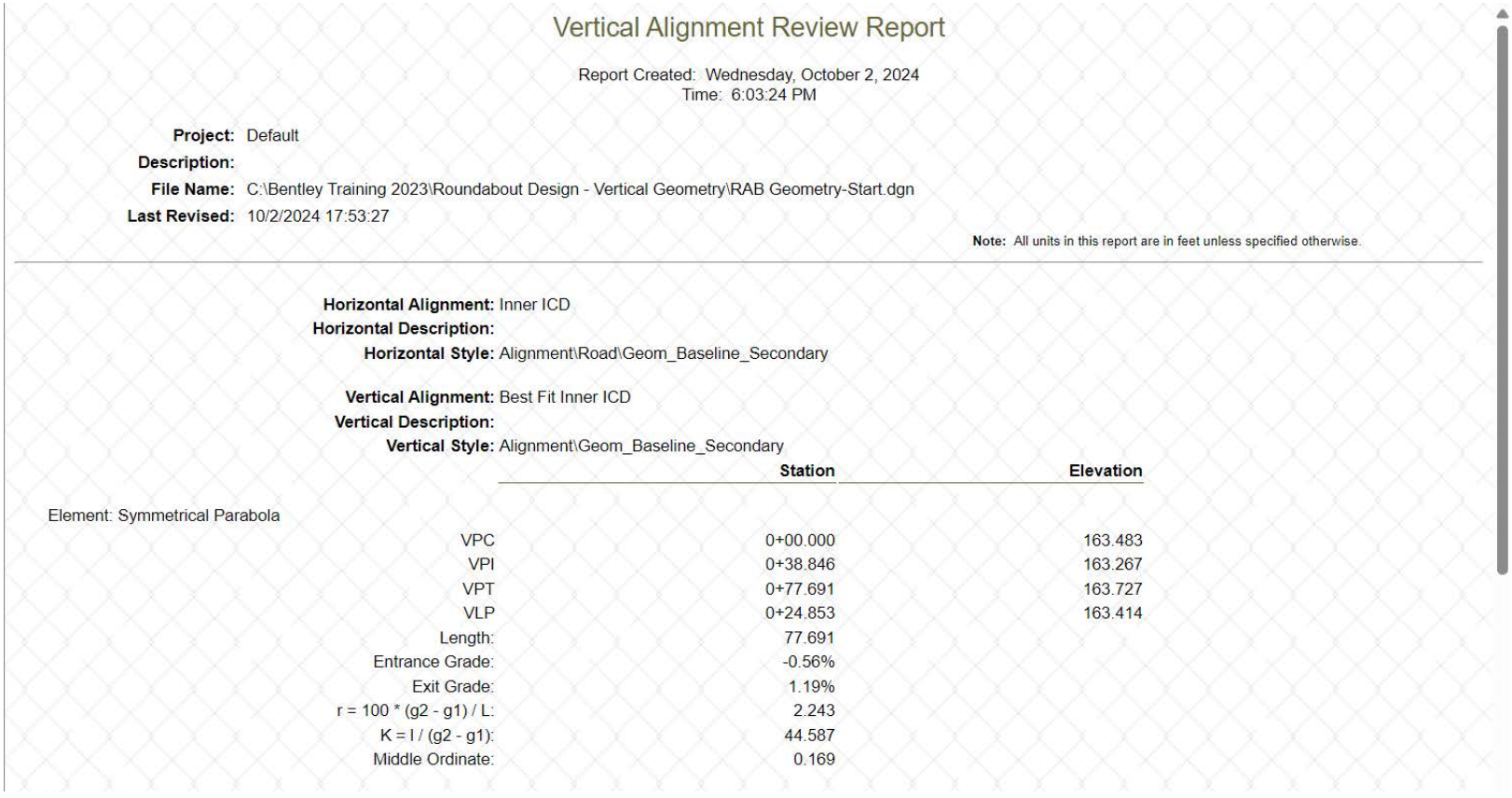
   c. *Feature Type:* **Alignment**

   d. *Feature Definition:* **Geom_Baseline_Secondary**

   e. *Name:* **Best Fit Inner ICD**

   f. *Locate Elements or Reset to Complete:* Select the best fit alignment

11. Set the Profile Active.
    a. Select the Inner ICD profile just created.
    b. From the *context sensitive toolbar* > **Set Active**
    c. **<ESC>** to Exit command
12. Review the best fit vertical geometry report to analyze the tangent lengths, grades, curve lengths and K-values.



Vertical Alignment Review Report

Report Created: Wednesday, October 2, 2024
Time: 6:03:24 PM

Project: Default
Description:
File Name: C:\Bentley Training 2023\Roundabout Design - Vertical Geometry\RAB Geometry-Start.dgn
Last Revised: 10/2/2024 17:53:27

Note: All units in this report are in feet unless specified otherwise.

Horizontal Alignment: Inner ICD
Horizontal Description:
Horizontal Style: Alignment\Road\Geom_Baseline_Secondary

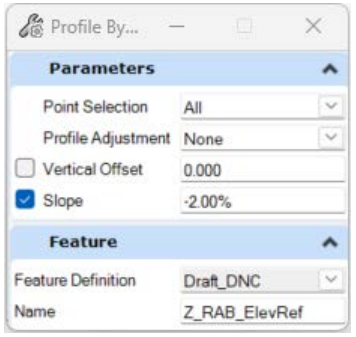
Vertical Alignment: Best Fit Inner ICD
Vertical Description:
Vertical Style: Alignment\Geom_Baseline_Secondary

		Station	Elevation
Element: Symmetrical Parabola			
	VPC	0+00.000	163.483
	VPI	0+38.846	163.267
	VPT	0+77.691	163.727
	VLP	0+24.853	163.414
	Length:	77.691	
	Entrance Grade:	-0.56%	
	Exit Grade:	1.19%	
	r = 100 * (g2 - g1) / L:	2.243	
	K = l / (g2 - g1):	44.587	
	Middle Ordinate:	0.169	

The next steps will be to define profiles for outer ICD elements.

13. Create a profile for the **Z_RAB_ElevRef** element by projecting a -2% slope from the Inner ICD.

a. Select, *Geometry* > *Vertical* > *Element Profiles* > **Profile By Slope from Element**



b. *Point Selection* > **All**

c. *Profile Adjustment* > **None**

d. *Vertical Offset* > **0**

e. *Slope* > **-2.000%**

f. *Feature Definition* > *Alignment* > *Road* > **Geom_Baseline**

g. *Name* > **Z_RAB_ElevRef**

h. *Locate First Element to Profile* > Select > **Z_RAB_ElevRef**

i. **Reset**

j. *Locate Reference Element* > **Inner ICD**

k. Follow Heads Up prompts and data point through the prompts to complete.

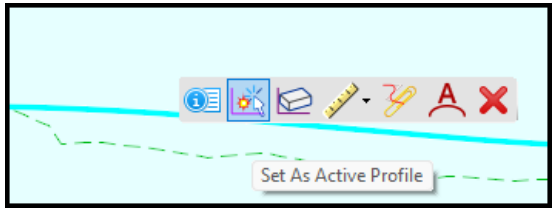
14. Set the Active Profile (if the Z_RAB_ElevRef) does not appear in the 3D View you will have to set the profile active).

a. Select, the **Z_RAB_ElevRef**

b. Wait for the *context sensitive toolbar* > Select, **Open Profile Model**

c. Select and *click* > **View 6**

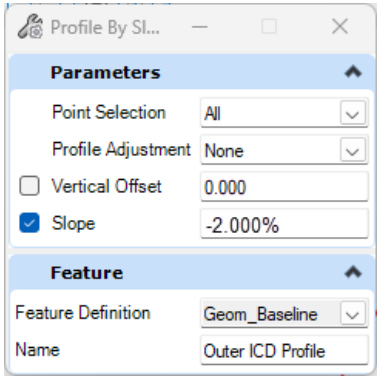
d. Select the Profile, wait for the *context sensitive toolbar* > **Set Active**



e. **Close** *View 6*

15. Create a profile for the Outer ICD by projecting a -2% slope.

a. Select, *Geometry* > *Vertical* > *Element Profiles* > **Profile By Slope from Element**



b. *Point Selection* > **All**

c. *Profile Adjustment* > **None**

d. *Vertical Offset* > **0**

e. *Slope* > **-2.000%**

f. *Feature Definition* > *Alignment* > *Road* > **Geom_Baseline**

g. *Name* > **Outer ICD Profile**

h. *Locate First Element to Profile* > Select > **Outer ICD**

i. **Reset**

j. *Locate Reference Element* > **Z_RAB_ElevRef**

k. Follow Heads Up prompts and data point through the prompts to complete.

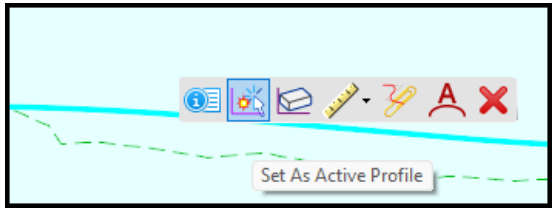
16. Set the Active Profile (if the Outer ICD does not appear in the 3D View you will have to set the profile active).

a. Select, the **Outer ICD**

b. Wait for the *context sensitive toolbar* > Select > **Open Profile Model**

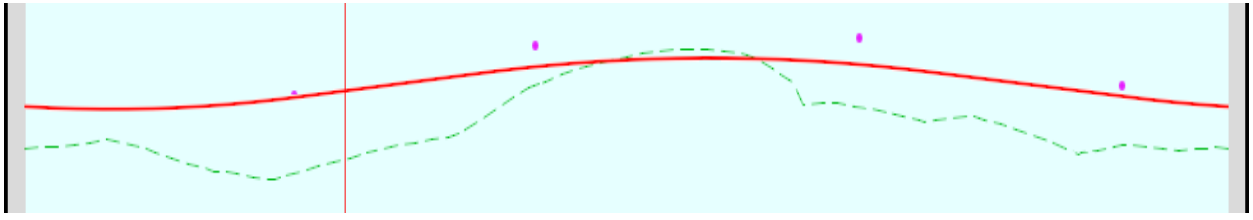
c. Select and *click* > **View 5**

d. Select the Profile, wait for the *context sensitive toolbar* > **Set Active**



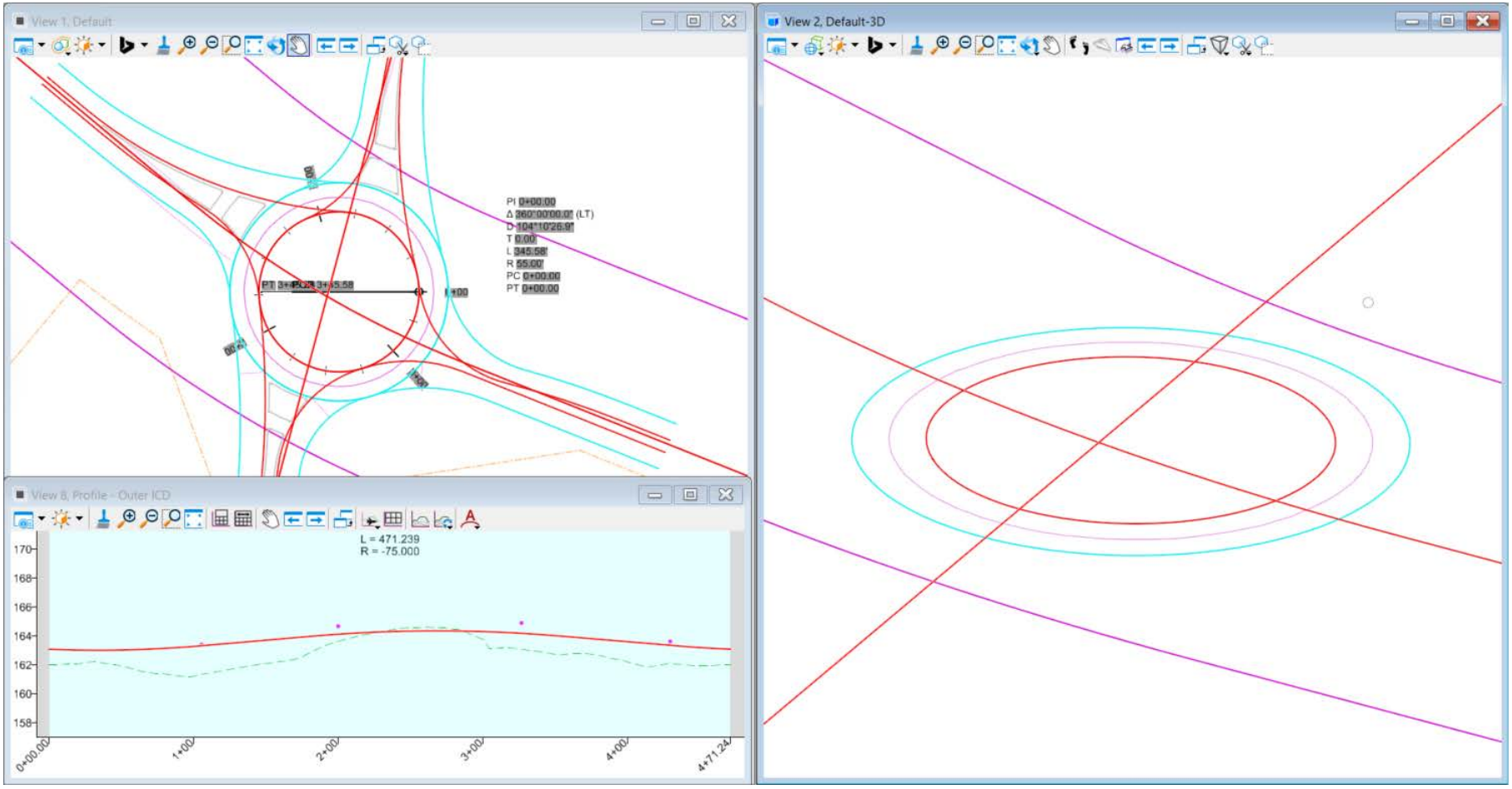
e. **Close** *View 5*

17. Using the *Profile Intersection Point* tool, place the intersection points for the incoming centerlines LondonRd and NewRd in the Outer ICD Profile View.



18. Change the display of the **TEMP RAB TM** terrain model to **Proposed Boundary**.
    a. In the 3D view, select the **TEMP RAB TM** terrain model.
    b. From the context sensitive toolbar, select *Properties*.
    c. Change the *Feature Definition* to **Proposed Boundary**.

    The 3D model should now look like the image below.



There are many different ways to handle the vertical design of the roundabout this is just one method to consider. Every roundabout design is different and may require different methods or workflows.

Exercise 2: Creating Profiles for the Northbound Entry and Southbound Exit

Description

In this exercise you will create profiles for the Northbound Entry and Southbound Exit lanes.

Skills Taught

- Open Profile Model
- Profile By Constant Slope from Element
- Set Active Profile
- Profile by Variable Slope from Element
- Profile Intersection Point

Create the Southbound Exit Edge of Pavement Profile (SB Exit EOP-1)

1. Open the Profile Model view for **SB Exit EOP-1**.

   a. Select the **SB Exit EOP-1**

   b. From the *context sensitive toolbar* Select > **Open Profile Model**

   c. Open *View 5* > **Data Point**

2. Display the Inner ICD, Outer ICD and London Rd. elevation points into the profile model.

   a. From the ribbon menu, Select > *Geometry* > *Vertical* > *Profile Creation* > **Profile Intersection Point**

   b. *Locate the Element to Show Intersection* > **SB Exit EOP-1** (This needs to be selected in the Plan View)

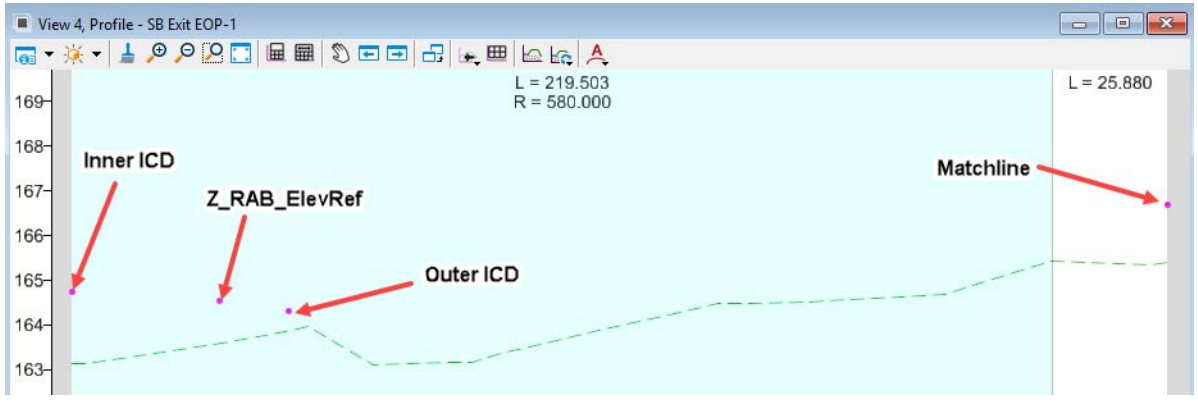
   c. *Locate Element Which Intersects*: Select **Inner ICD Profile**

   d. *Locate Element For Next Intersection*: Select **Outer ICD Profile**

   e. *Locate Element For Next Intersection*: Select **Z_RAB_ElevRef**

   f. *Locate Element For Next Intersection*: Select the **Matchline LondonRd** element (this element is located at the end of the London Rd. corridor).

   g. Right click or reset to complete



You should now have 4 magenta points displayed in the profile model view. We will use these to help define the vertical geometry.

3. Create first tangent between the Inner ICD and Outer ICD points. This will enable us to see the slope or grade we need to match to begin the vertical geometry.

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

   b. *Feature Definition:* **Draft_DNC**

   c. *Enter Start Point:* **Snap to the Inner ICD point**

   d. *Enter End Point:* **Snap to the Z_RAB_ElevRef point**

4. Review the slope.

   a. *Select* the line just placed and notice the slope is **-0.56%**.

   b. *De-select* the line.

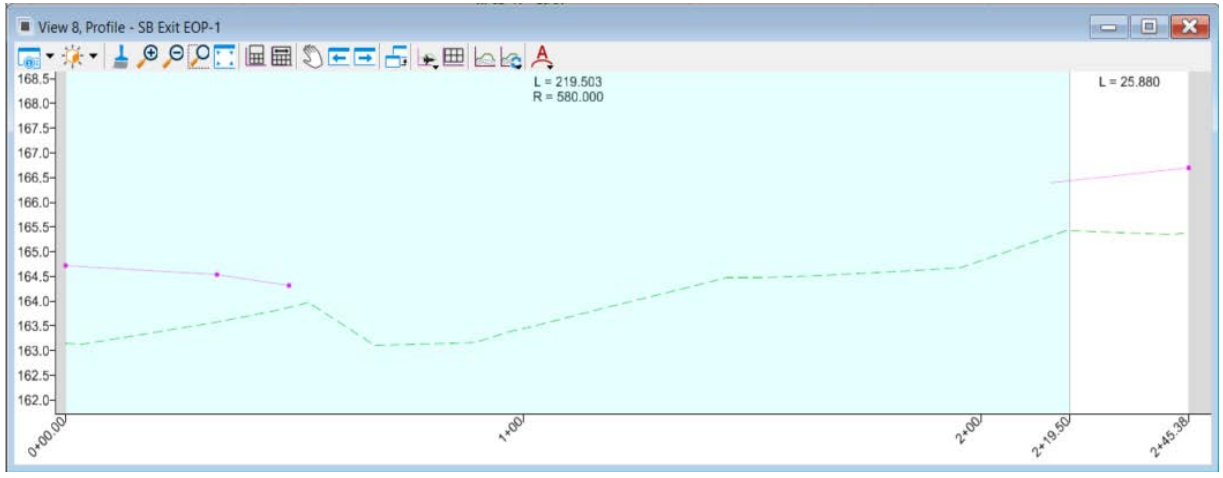
5. Using the **Profile Line Between Points**, create another vertical tangent line between the **Z_RAB_ElevRef point** and the **Outer ICD point.**

6. Review the slope.

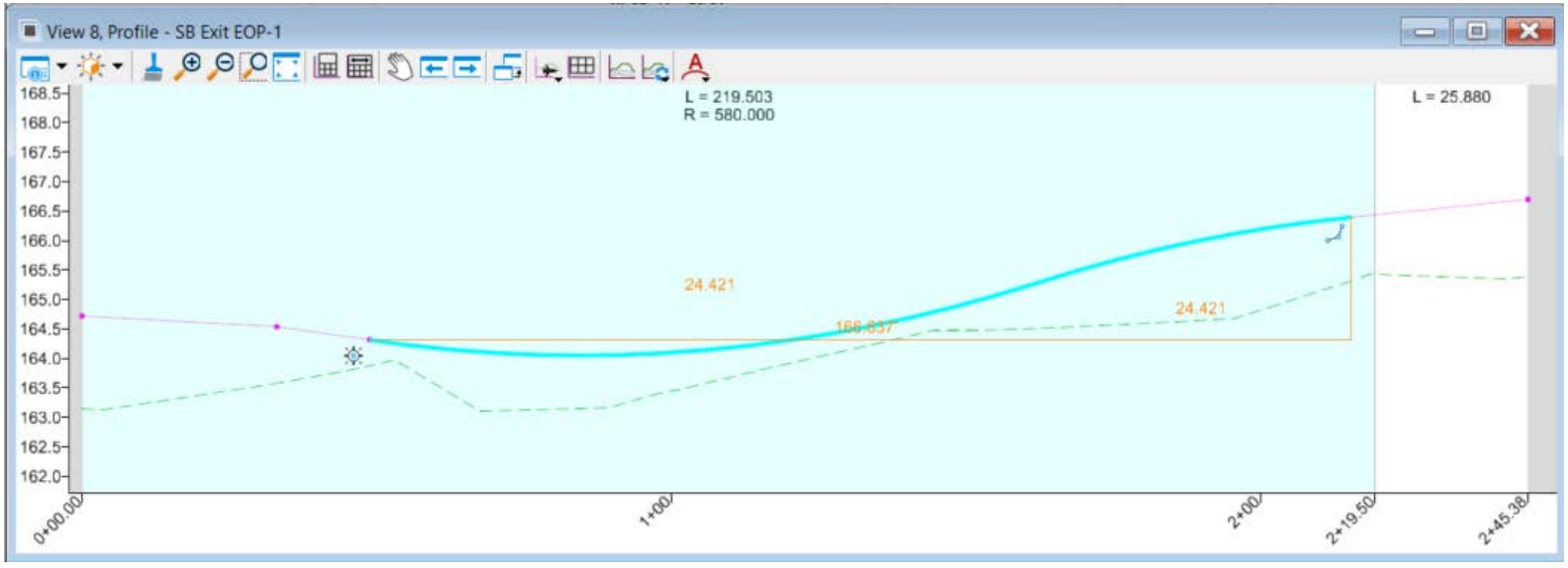
   a. *Select* the line just placed and notice the slope is **-1.47%** (this will be the starting slope for the vertical we are going to design).

   b. *De-select* the line.

7. Create the ending tangent coming off the London Rd. intersection point.
   a. Select, *Geometry* > *Vertical* > *Lines* > **Profile Line Between Points**
   b. *Feature Definition:* **Draft_DNC**
   c. *Enter Start Point:* **Snap** to the **LondonRd intersection point**
   d. *Length:* **-30** (Negative because we are placing it to the left)
   e. *Slope:* **1.0%** (This slope is 1.0% because the profile grade line for London Rd. has a slope of 1.0% so it must match)

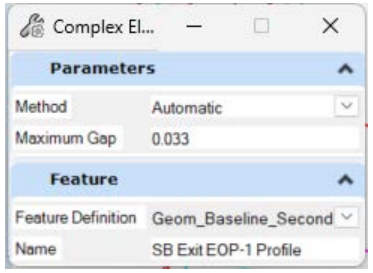


8. Create a reverse profile transition.
   a. Select *Geometry* > *Vertical* > *Complex Geometry* > **Profile Reverse Transition**
   b. *Feature Definition:* **Geom_Baseline_Secondary**
   c. *Locate First Element:* **Select the tangent line between the Z_RAB_ElevRef point and Outer ICD point**
   d. *Back Vertical Offset:* **0**
   e. *Locate Second Element:* **Select the ending tangent line**
   f. *Ahead Vertical Offset:* **0**
   g. *Enter Start Point:* **Snap to the Outer ICD profile intersection point**
   h. Press the right arrow key to move to the *Enter End Point* prompt: **Snap to the start point of the ending tangent line**
   i. *Trim/Extend:* **Both**
   j. Left click to complete.



9. Create the vertical alignment.

a. Select, *Geometry* > *Vertical* > *Complex Geometry* > **Profile Complex by Elements**



b. *Method* > **Automatic**

c. *Maximum Gap* > **0.033**

d. F*eature Definition* > **Geom_Baseline_Secondary**

e. *Name* > **SB Exit EOP-1 Profile**

f. *Locate First Element* > **Select Start of Profile**

Make sure you start the complex element at the Outer ICD Intersection point

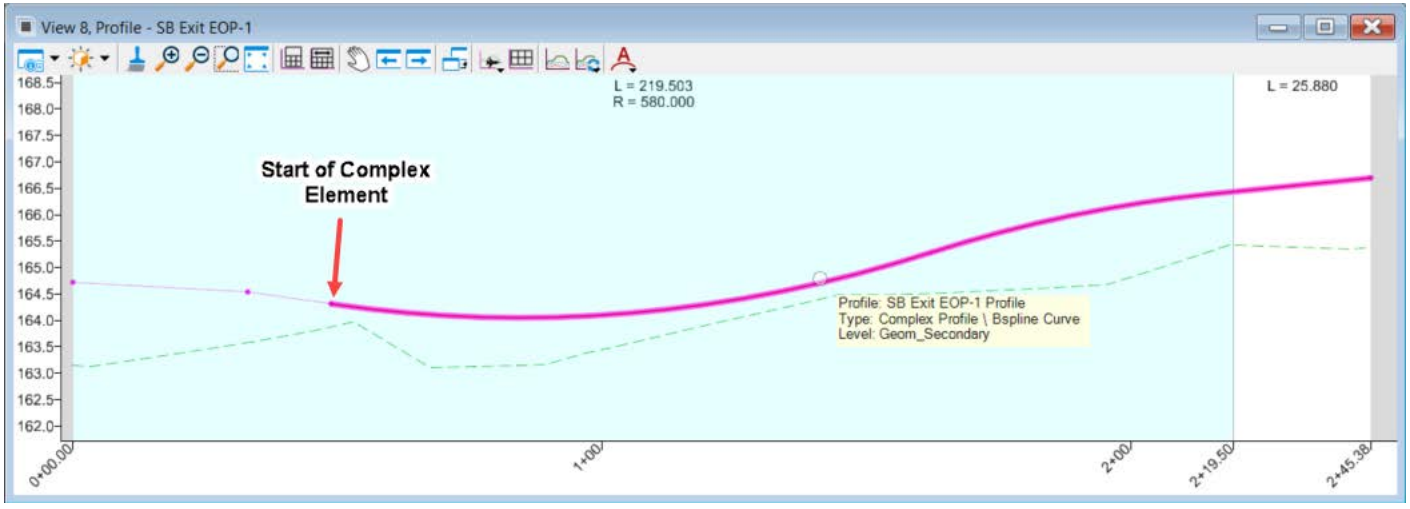
g. **<ESC>** to Exit command

10. Set the Profile Active

a. Select the Profile > **SB Exit EOP-1 Profile**

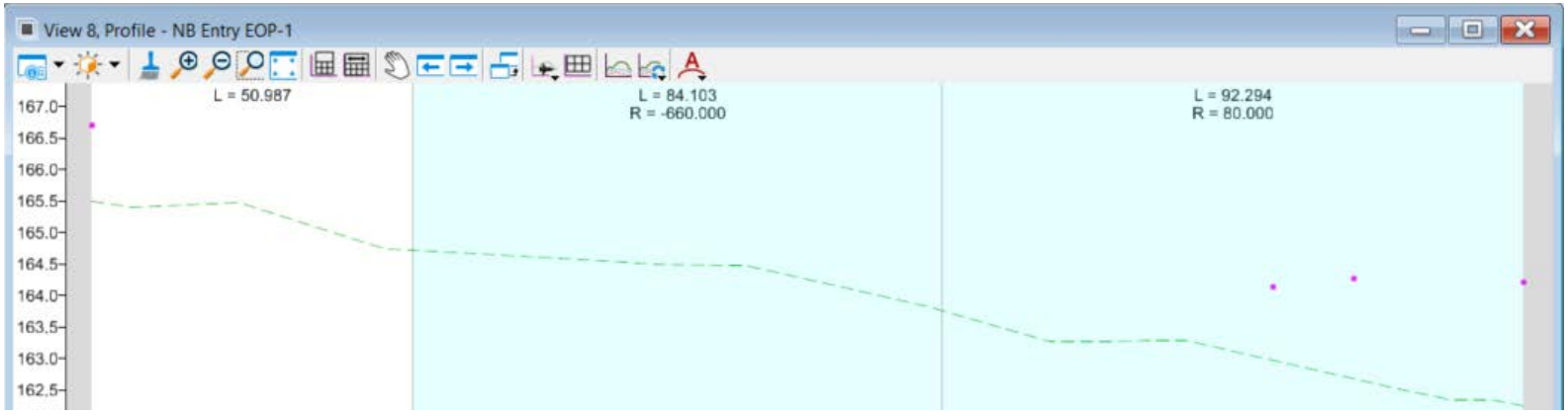
b. From the *context sensitive toolbar* > **Set Active**

c. **<ESC>** to exit the command.



Create the Northbound Inside Edge of Pavement Profile (NB Entry EOP-1)

1. Open the Profile Model view for NB Entry EOP-1.
   a. Select the **NB Entry EOP-1**
   b. From the *context sensitive toolbar* Select > **Open Profile Model**
   c. Open *View 5* > **Data Point**
2. Display the Inner ICD, Outer ICD and London Rd. elevation points into the profile model.
   a. From the ribbon menu, Select > *Geometry* > *Vertical* > *Profile Creation* > **Profile Intersection Point**
   b. *Locate the Element to Show Intersection* > NB Entry EOP-1 (This needs to be selected in the Plan View)
   c. *Locate Element Which Intersects*: Select **Inner ICD Profile**
   d. *Locate Element For Next Intersection*: Select **Z_RAB_ElevRef**
   e. *Locate Element For Next Intersection*: Select **Outer ICD Profile**
   f. *Locate Element For Next Intersection*: Select the **Matchline LondonRd** element
   g. Right click or reset to complete



You should now have 4 magenta points displayed in the profile model view. We will use these to help define the vertical geometry.

3. Create the ending tangent between the Z_RAB_ElevRef and Inner ICD points.

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

   b. *Feature Definition:* **Draft_DNC**

   c. *Enter Start Point:* **Snap to the Z_RAB_ElevRef point**

   d. *Enter End Point:* **Snap to the Inner ICD point**

4. Continuing with the **Profile Line Between Points** command, create the tangent line between the **Outer ICD point** and the **Z_RAB_ElevRef point.** This will enable us to see the slope or grade we need to match and tie into.

5. Review the slope. Select the line just placed and notice the slope is +1.07%. De-select the line.

6. Create the tangent coming off the London Rd. intersection point.

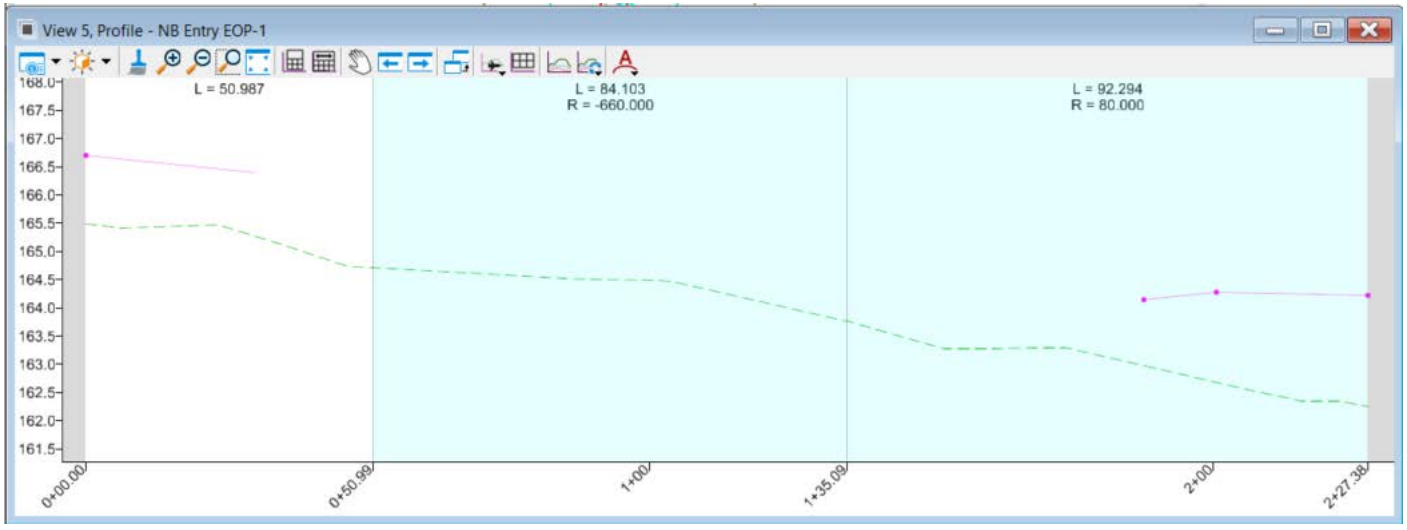
   a. Select, *Geometry* > *Vertical* > *Lines* > **Profile Line Between Points**

   b. *Feature Definition:* **Draft_DNC**

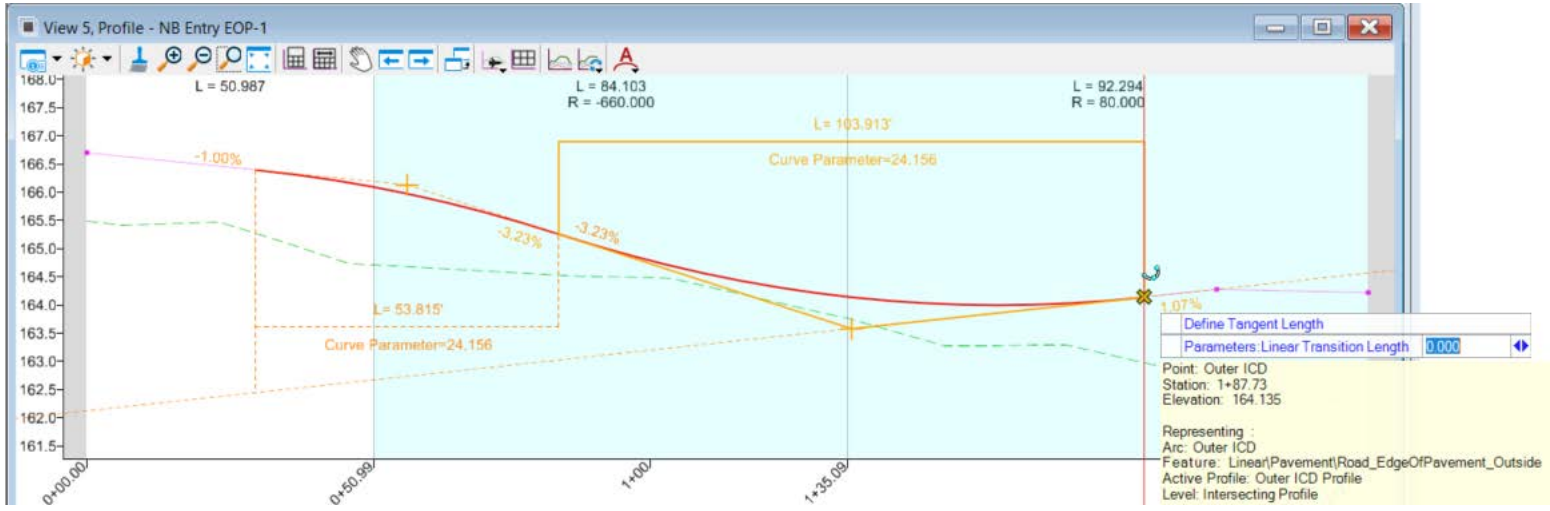
   c. *Enter Start Point:* **Snap to the LondonRd intersection point**

   d. *Length:* **30**

   e. *Slope:* **-1.0%** (This slope is -1.0% because the profile grade line for London Rd. has a slope of 1.0% so it must match)

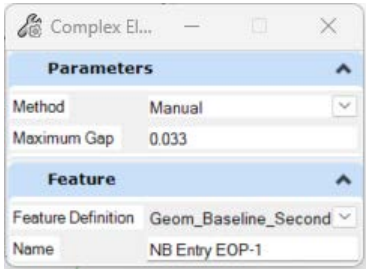


7. Create a reverse profile transition.
   a. Select *Geometry* > *Vertical* > *Complex Geometry* > **Profile Reverse Transition**
   b. *Feature Definition:* **Geom_Baseline_Secondary**
   c. *Locate First Element:* **Select the beginning tangent line**
   d. *Back Vertical Offset:* **0**
   e. *Locate Second Element:* **Select the tangent line between the Outer ICD and Z_RAB_ElevRef points**
   f. *Ahead Vertical Offset:* **0**
   g. *Enter Start Point:* **Snap to the end point of the beginning tangent**
   h. Press the right arrow key to move to the *Enter End Point* prompt: Snap to the Outer ICD point.
   i. *Trim/Extend:* **Both**
   j. Left click to complete



8. Create the vertical alignment.

a. Select, *Geometry* > *Vertical* > *Complex Geometry* > **Profile Complex by Elements**



b. *Method* > **Manual**

c. *Maximum Gap* > **0.033**

d. F*eature Definition* > **Geom_Baseline_Secondary**

e. *Name* > **NB Entry EOP-1**

f. *Locate First Element* > **Select the first tangent**

g. *Locate Next Element* > **Select the reverse profile element**

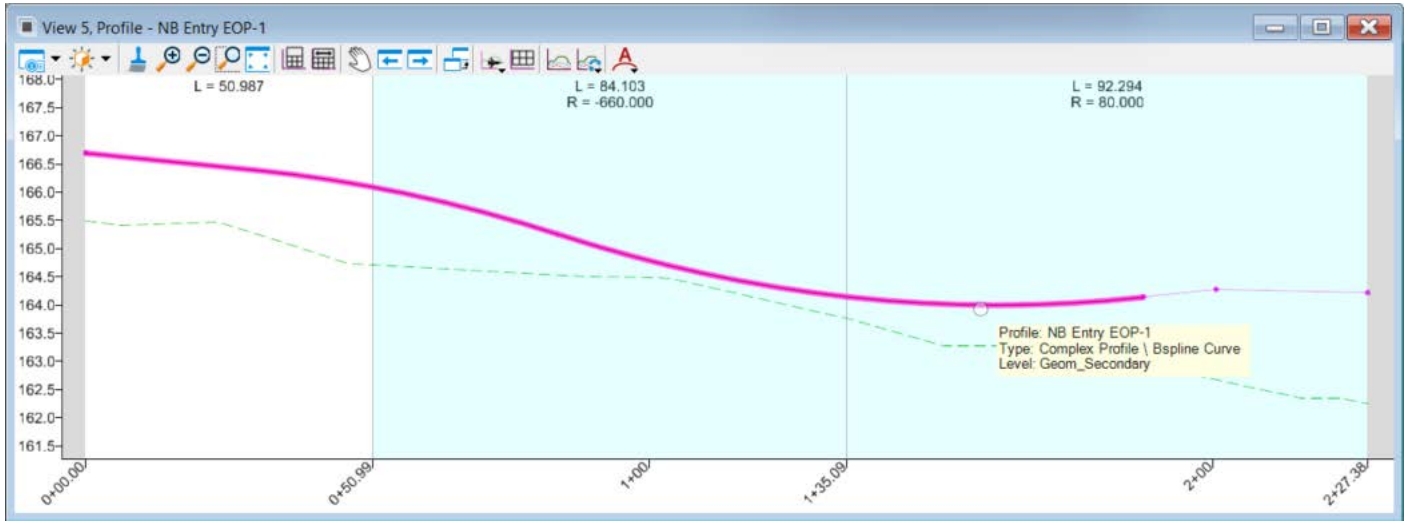
h. **<ESC>** to exit command

9. Set the Profile Active

a. Select the Profile > **NB Entry EOP-1 Profile**

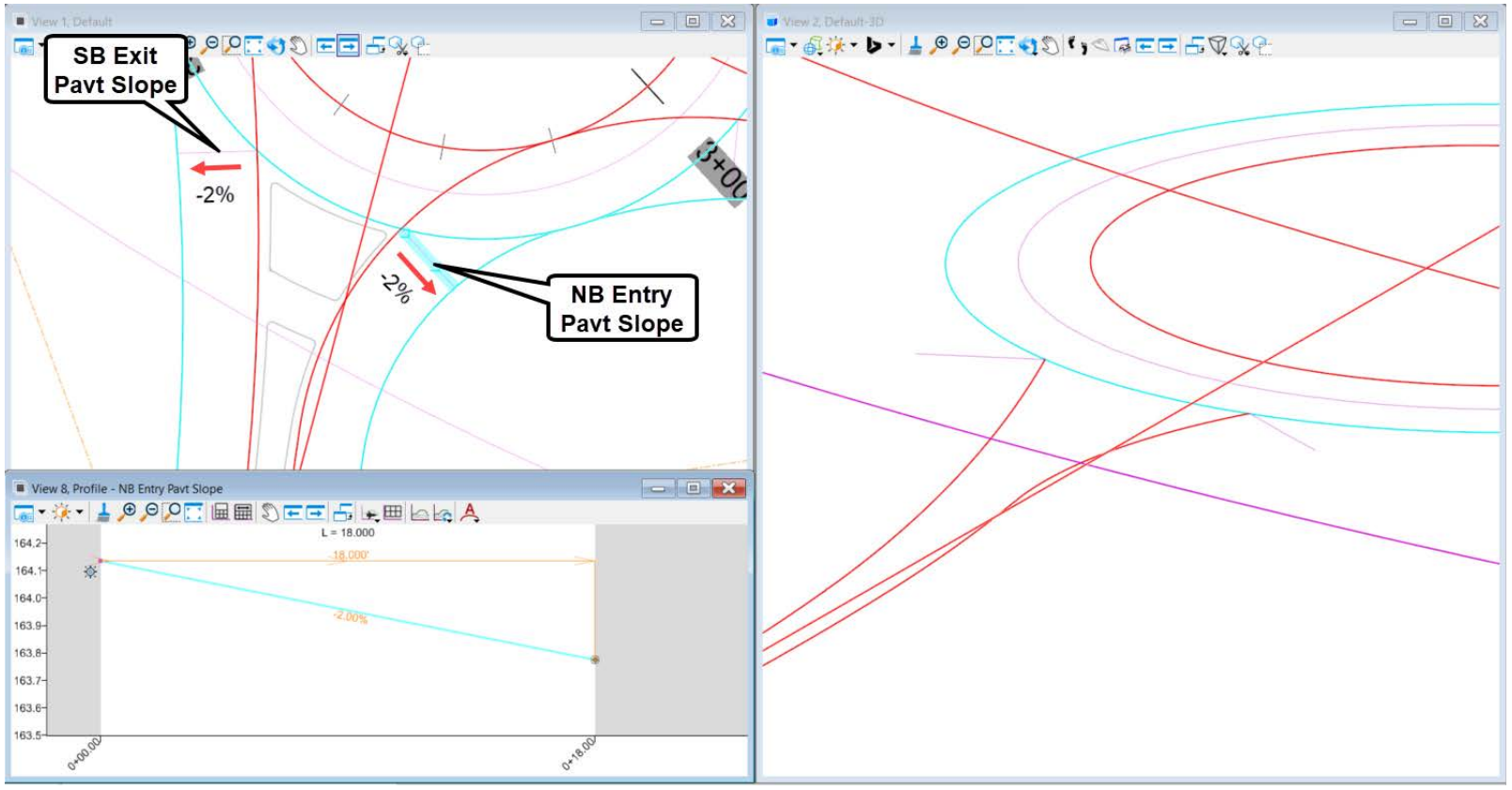
b. From the *context sensitive toolbar* > **Set Active**

c. **<ESC>** to exit command



Create Pavement Slope Profiles

In this section you will create pavement slope profiles along the entry and exit width elements. These will be used as a reference for creating the outside edge of pavement profiles. We will also be using these later as breaklines for cross slope transitions to and from the roundabout.



1. Open the Profile Model view for NB Entry Pavt Slope
   a. Select the **NB Entry Pavt Slope** element
   b. From the *context sensitive toolbar* Select > **Open Profile Model**
   c. Open *View 5* > **Data Point**

2. Display the **NB Entry EOP-1** intersecting elevation into the profile model.

   a. From the ribbon menu, Select > *Geometry* > *Vertical* > *Profile Creation* > **Profile Intersection Point**

   b. *Locate Element to Show Intersection* > **NB Entry Pavt Slope** (This needs to be selected in the Plan View)

   c. *Locate Element Which Intersects*: Select **NB Entry EOP-1** or **Outer ICD Profile**

   d. Right click or reset to complete

3. Create a -2.0% tangent line.

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

   b. *Feature Definition:* **Draft_DNC**

   c. *Name:* **NB Entry Pavt Slope**

   d. *Enter Start Point:* **Snap to the NB Entry EOP-1 or Outer ICD Profile profile point**

   e. *Length:* **18**

   f. *Slope:* **-2.0%** Tip: You may need to adjust this slope later if you notice the profile is too slope or grades become too steep.

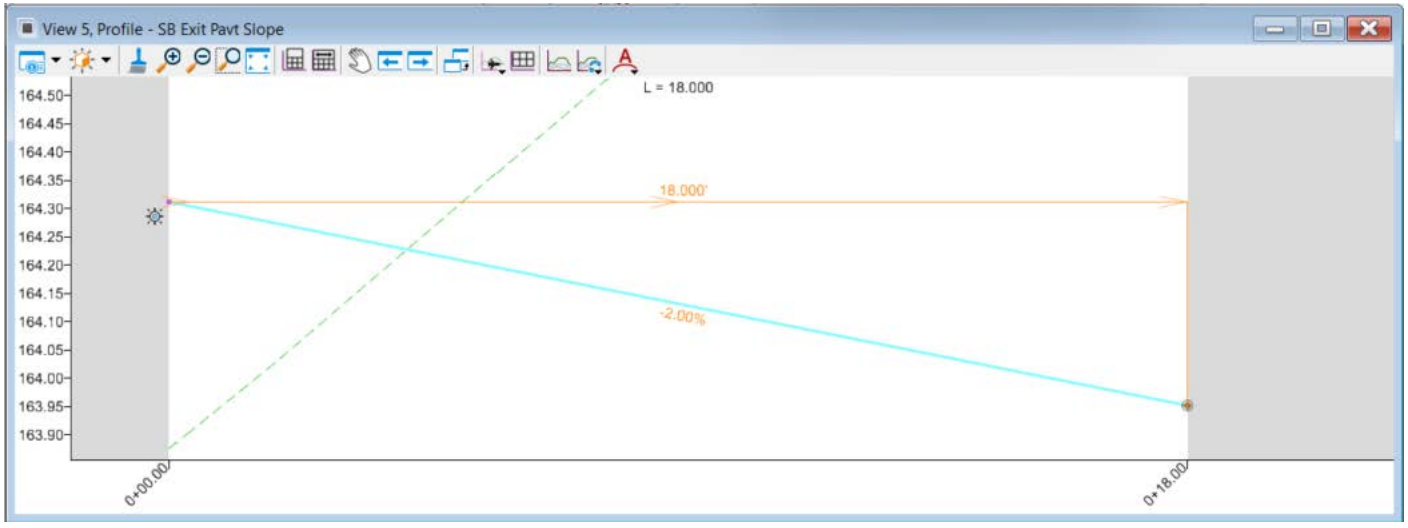
4. Set the Profile Active.

5. Review the slope and 3D model.

   a. Select the line just placed and make sure the slope is **-2.0%.**

   b. De-select the line.

6. Repeat these same steps for the SB Exit Pavt Slope.



7. Set the Profiles Active

   a. Select the Profile > **NB Entry Pavt Slope**

   b. From the *context sensitive toolbar* > **Set Active**

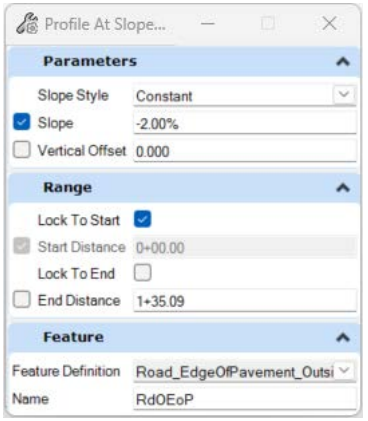
   c. Repeat for **SB Exit Pavt Slope**

8. **<ESC>** to exit command

Create Profiles along the outside NB Entry EOP and outside SB Exit EOP

At this point you could create corridors along the NB and SB inside EOP's or we can opt to project slopes to the outside edges of pavement. We will choose the later to further reinforce using the slope projection tools.

1. We are going to start with the outside **NB Entry EOP-2** element.
   a. Select, *Geometry* > *Vertical* > *Element Profiles* > **Profile By Variable Slope From Element**
   b. Set the Feature Definition to *Feature Definition* > **Road_EdgeOfPavement_Outside**
   c. Following the Heads Up prompts:
      - *Slope Style:* **Constant**
      - *Locate Plan Element to Profile*: **NB Entry EOP-2**
      - *Locate Reference Element*: **NB Entry EOP-1**
      - *Start Distance:* **Press ALT to lock to start or key-in 0+00**
      - *End Distance:* **1+35.09 or Snap to the beginning of the radius return**
      - *Slope:* **-2.0%** Tip: You may need to adjust this slope later if you notice the profile is too slope or grades become too steep.
      - *Offsets*: **0.000**



2. View the profile model for **NB Entry EOP-2**
   a. Select **NB Entry EOP-2**

   b. From the *context sensitive toolbar* Select > **Open Profile Model**
   c. Open *View 5* > **Data Point**

3. Display the Outer ICD profile elevation in the profile model and display the NB Entry Pavt Slope elevation in the profile model.

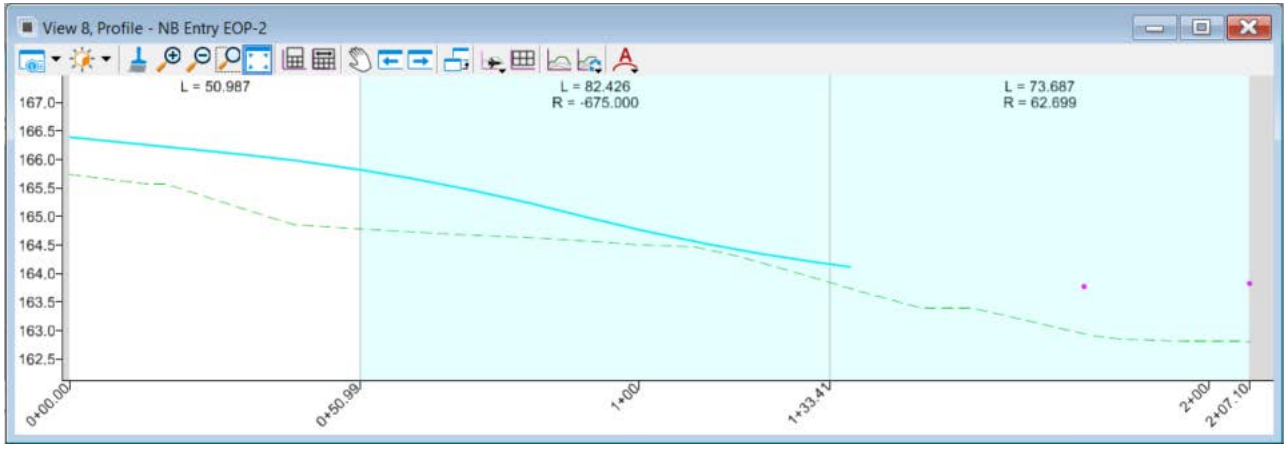
   a. From the ribbon menu, Select > *Geometry* > *Vertical* > *Profile Creation* > **Profile Intersection Point**

   b. *Locate Element to Show Intersection:* Select **NB Entry EOP-2** (This needs to be selected in the Plan View)

   c. *Locate Element Which Intersects*: Select **Outer ICD Profile**

   d. *Locate Element for Next Intersection-Reset to Complete:* Select the **NB Entry Pavt Slope** element

   e. **Reset** to Complete



4. Create the first tangent coming off the Outer ICD.

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

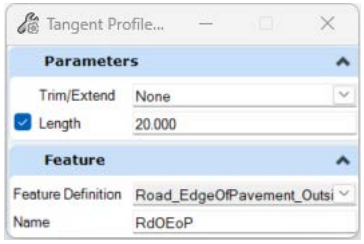
   b. *Feature Definition: Linear* > *Pavement* > **Road_EdgeOfPavement_Outside**

   c. *Enter Start Point:* **Snap the Outer ICD intersection point**

   d. *Enter End Point:* **Snap to the NB Entry Slope intersection point**

5. The projected profile of NB Entry EOP-2 ends with a -1.25% slope. So, we need to create a -1.25% tangent to match.

a. Select, *Geometry* > *Vertical* > *Lines* > *Profile Line From Element* > **Tangent Profile Line from Element**



b. *Feature Definition* > **Road_EdgeOfPavement_Outside**

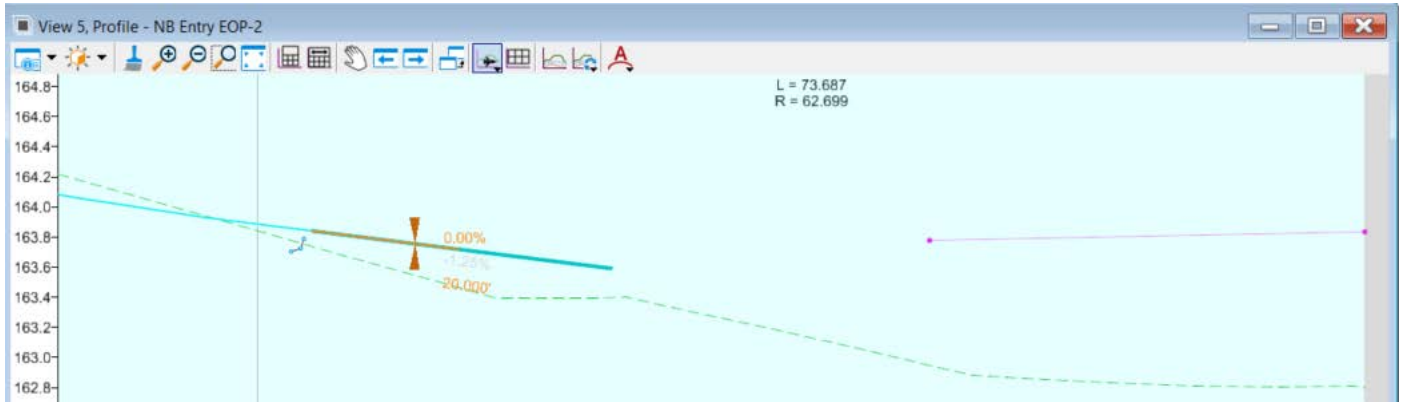
c. *Locate Element <ALT> to Pick Complex Only* > **Select the projected profile element**

d. *Start Point* > **Snap to the end point of the projected profile element**

e. *Length* > **20**

f. *Trim/Extend* > **None**

g. **Data Point** to accept



6. Create a vertical curve between tangents.

a. Select, *Geometry* > *Vertical* > *Curves* > *Profile Curve Between Elements* > **Parabola Between Elements**

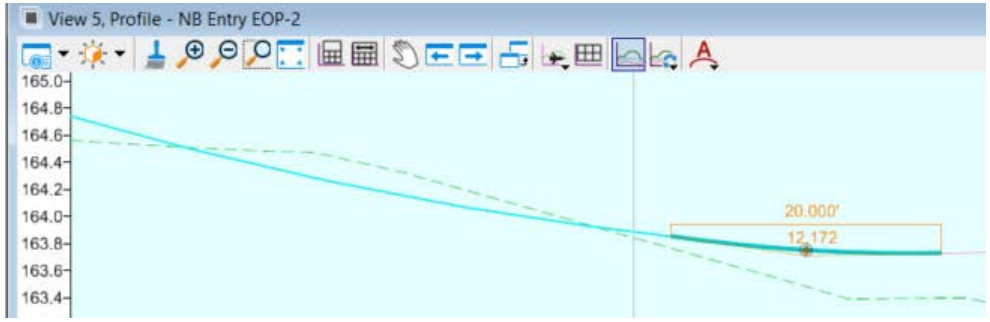
b. *Feature Definition* > **Road_EdgeOfPavement_Outside**

c. *Locate First Profile Element:* **Select first tangent**

d. *Locate Second Profile Element:* **Select second tangent**

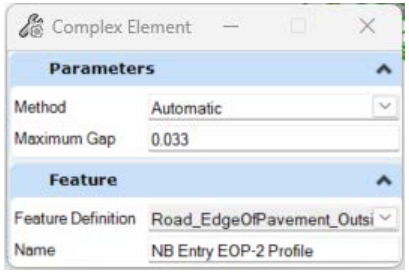
e. *Length:* **20**

f. *Trim/Extend:* **Both**



7. Create the vertical alignment.

a. Select, *Geometry* > *Vertical* > *Complex Geometry* > **Profile Complex by Elements**



b. *Method* > **Automatic**

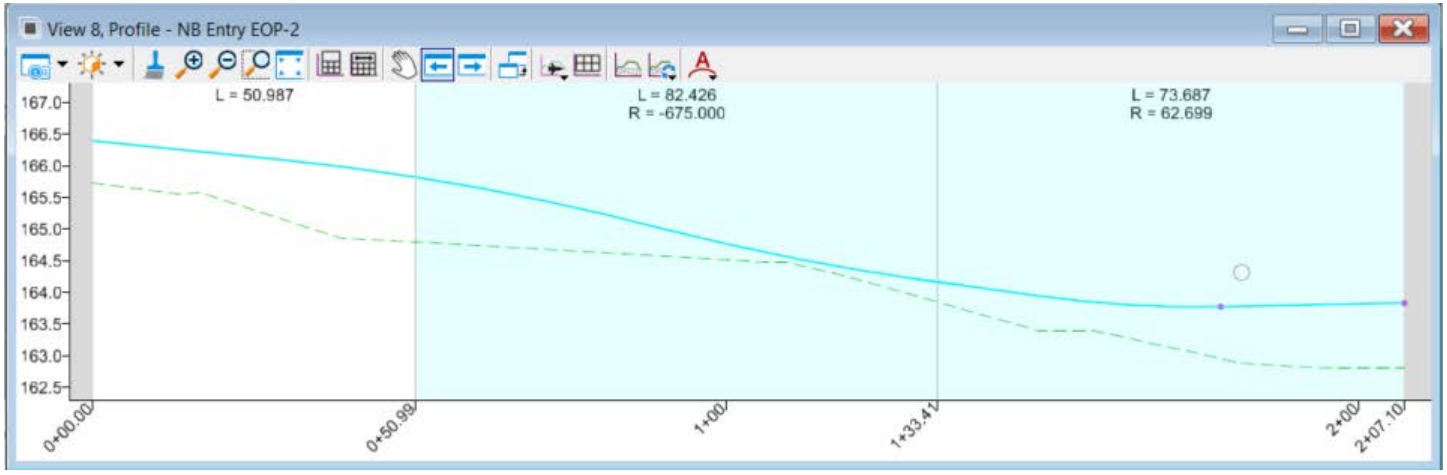
c. *Maximum Gap* > **0.033**

d. *Feature Definition> Linear > Pavement >* **Road_EdgeOfPavement_Outside**

e. *Name* > **NB Entry EOP-2 Profile**

f. *Locate First Element* > **Select Start of Profile**

g. **<ESC>** to Exit command



8. Set the Profile Active

a. Select the Profile > **NB Entry EOP-2 Profile**

b. From the *context sensitive toolbar* > **Set Active**

c. **<ESC>** to Exit command

9. We are now going to create a vertical alignment of the SB Exit EOP-2 using the same process.

   a. Select, *Geometry* > *Vertical* > **Profile By Variable Slope From Element**
   b. Set the Feature Definition to *Feature Definition* > **Road_EdgeOfPavement_Outside**
   c. Following the Heads Up prompts:
      - *Slope Style:* **Constant**
      - *Locate Plan Element to Profile*: **SB Exit EOP-2**
      - *Locate Reference Element*: **SB Exit EOP-1**
      - *Start Distance:* **1+10.98 (SB Exit EOP-1)**
      - *End Distance:* **Press ALT to lock to End**
      - *Slope:* **-2.0%**
      - *Offsets*: **0.000**

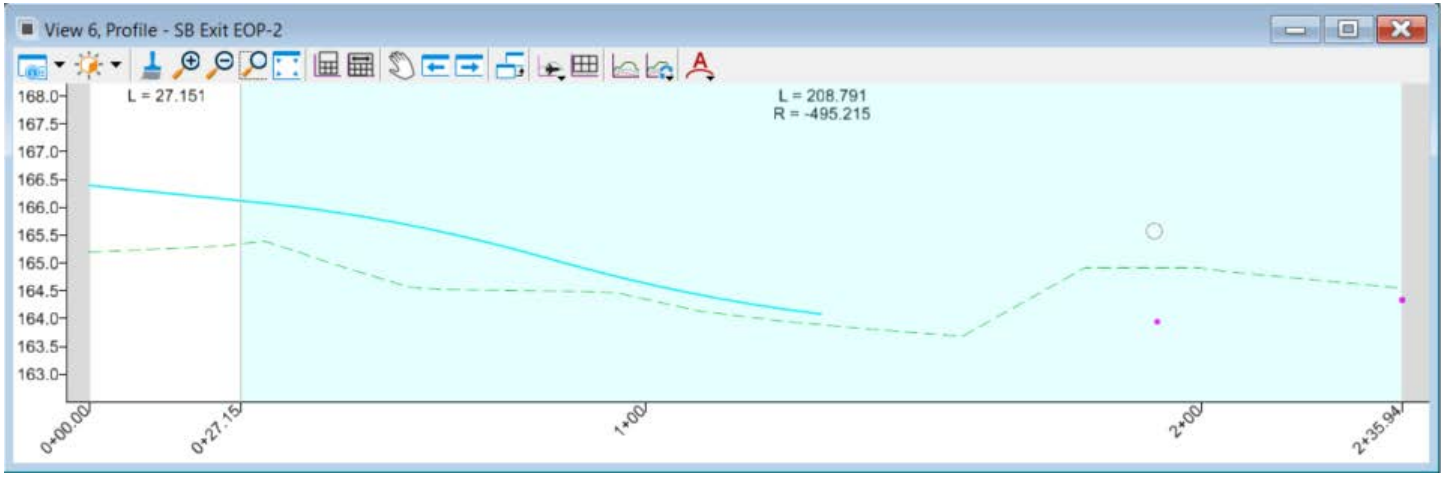
10. Display Outer ICD profile elevation in the profile view.

   a. Select **SB Exit EOP-2**
   b. From the *context sensitive toolbar* Select > **Open Profile Model**
   c. Open *View 6* > **Data Point**

11. Display Outer ICD and SB Exit Pavt Slope profile elevation in the profile view.

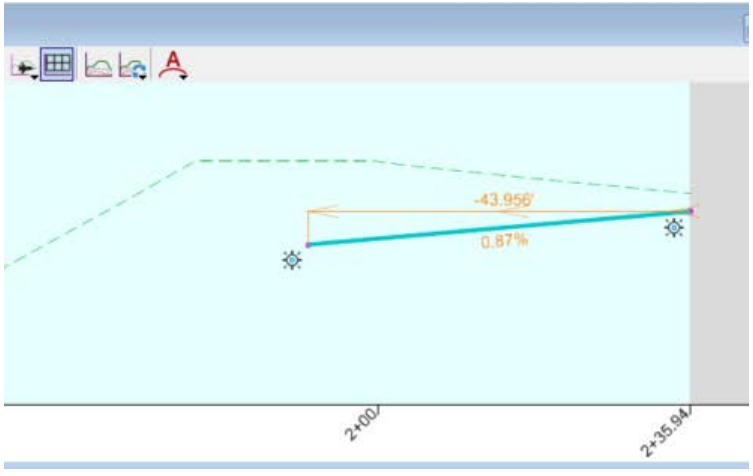
   a. From the ribbon menu, Select > *Geometry* > *Vertical* > *Profile Creation* > **Profile Intersection Point**
   b. *Locate Element to Show Intersection* > **SB Exit EOP-2** (This needs to be selected in the Plan View)
   c. *Locate Element which Intersects*, Select > **Outer ICD Profile**
   d. *Locate Element for Next Intersection-Reset to Complete:* Select the **SB Exit Pavt Slope** element
   e. **Reset** to complete.

Completed SB Exit EOP-2 profile



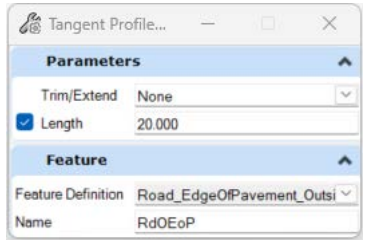
12. Create the first tangent between the Outer ICD point and SB Exit Slope point.

   a. Select, *Geometry* > *Vertical* > *Lines* > **Profile Line Between Points**
   b. *Feature Definition: Linear > Pavement* > **Road_EdgeOfPavement_Outside**
   c. *Enter Start Point:* **Snap the Outer ICD intersection point**
   d. *Enter End Point:* **Snap to the SB Exit Slope intersection point**



13. The exit grade of the projected profile is -1.19%. We will need to create a tangent line to match.

a. Select, *Geometry* > *Vertical* > *Lines* > *Profile Line From Element* > **Tangent Profile Line from Element**



b. *Feature Definition >* **Road_EdgeOfPavement_Outside**

c. *Locate Element <ALT> to Pick Complex Only* > **Select the projected profile element**

d. *Start Point* > **Snap to the end point of the projected profile element**

e. *Length >* **20**

f. *Trim/Extend >* **None**

g. **Data Point** to accept

14. Create a vertical curve between tangents.

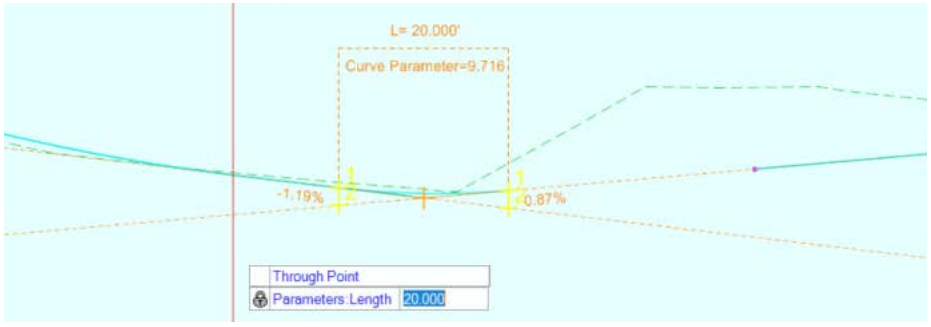
a. Select, *Geometry* > *Vertical* > *Curves* > *Profile Curve Between Elements* > **Parabola Between Elements**

b. *Locate First Profile Element:* **Select first tangent**

c. *Locate Second Profile Element:* **Select second tangent**

d. *Length:* **20.00**

e. *Trim/Extend:* **Both**



15. Create the **SB Exit EOP-2** vertical alignment

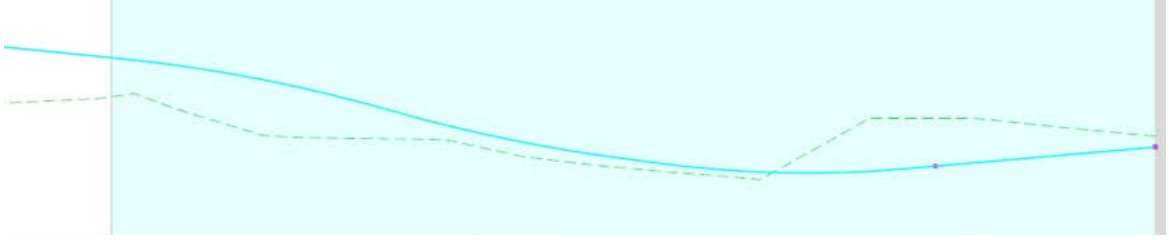
a. Select, *Geometry* > *Vertical* > *Complex Geometry* > **Profile Complex by Elements**

b. *Method*: **Automatic**

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

d. *Feature Definition*: **Road_EdgeOfPavement_Outside**

e. *Name*: **SB Exit EOP-2 Profile**



f. *Locate First Element* > **Select Start of Profile**

g. *Accept Complex* > Data point to accept.

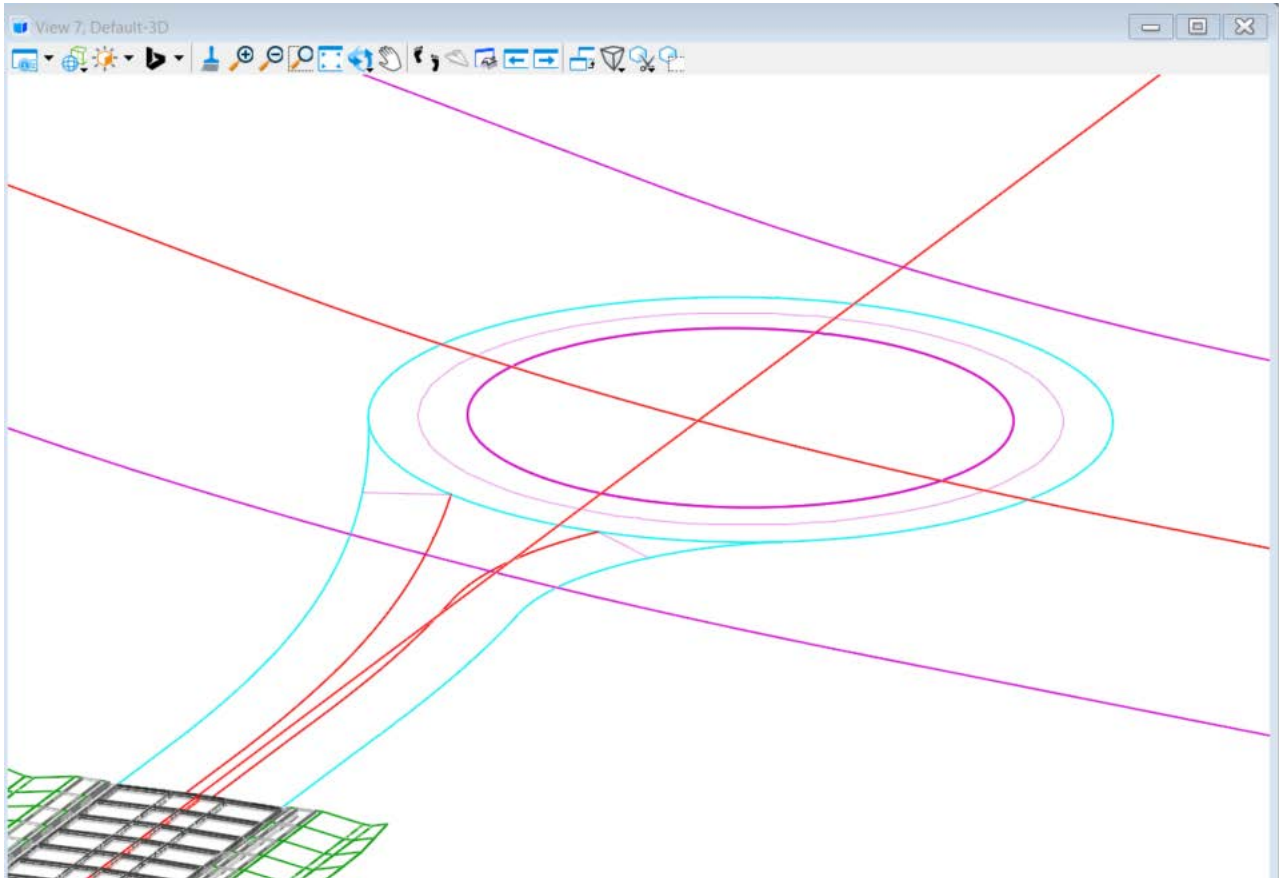
16. Set the Profile Active.

    a. Select the Profile > **SB Exit EOP-2 Profile**

    b. From the *context sensitive toolbar* > **Set Active**

    c. **<ESC>** to Exit command

    Once the profiles have been set active they will appear in the 3D View.



Since the process to define the vertical geometry for the other legs of the roundabout is going to be the same we are not going to create the other parts. Feel free to use what you have learned so far to define the vertical geometry for the other legs.

Exercise 3: Profile the Splitter Islands

Description

In this exercise you the profile the splitter islands.

Skills Taught

- Profile by Variable Slope from Element
- Profile by Slope from Element
- Profile Intersection Point
- Profile Line between Points
- Open Profile Model
- Set Active Profile
- Quick Profile Transition

Profile the Northbound Splitter Island

In this section you will create the vertical profiles for the Splitter Island. To do this we are going to project slopes from the Entry and Exit lanes using constant slopes. Then we will profile the crossing features of the splitter island that represent the pedestrian crossings and then make a vertical alignment to join all the pieces together.

---

1. Project the slopes onto the Splitter Island flowlines. Start with NB Entry.

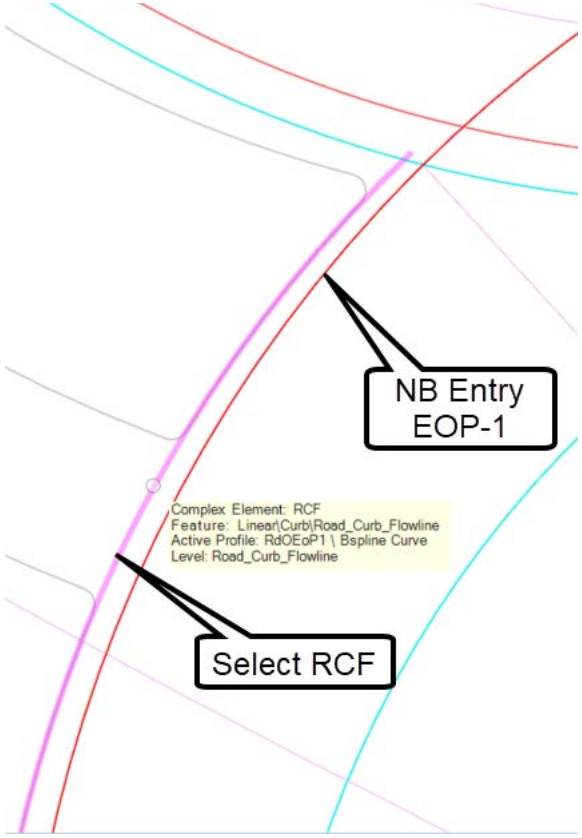
   a. Select, *Geometry* > *Vertical* > *Element Profiles* > **Profile by Variable Slope from Element**

   b. Set the dialog as follows:

      - *Slope Style* > **Constant**
      - *Slope* > **2.00%**
      - *Vertical Offset* > **0.000**
      - *Feature Definition: Linear* > *Curb* > **Road_Curb_Flowline**
      - *Name* > **RCF Profile**

   c. Follow the heads up prompts:

      - *Locate Plan Element to Profile* > **RCF** (Select this feature from it's pre-trimmed location, this is the base element)
      - *Locate Reference Element* > **NB Entry EOP-1**
      - *Start Distance* > **Lock to Start of RCF**
      - *End Distance* > **1+83.61** (The end is the start of the splitter island curb return)
      - **Data Point** to Accept *Start* and *End Slopes*



2. We are now going to project slopes from the other side of the splitter island using the same process as before.

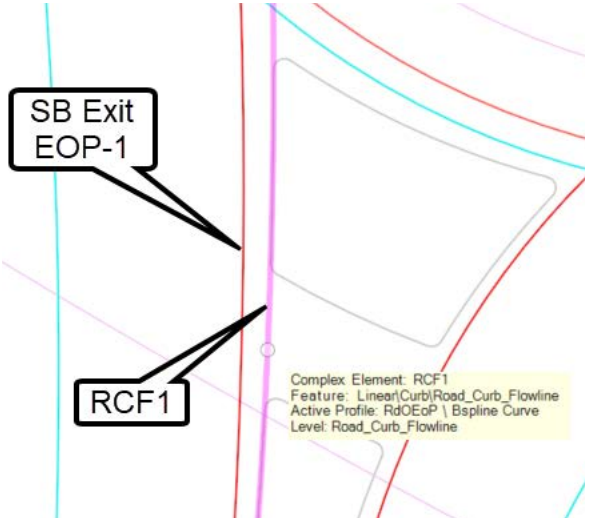
   a. Select, *Geometry* > *Vertical* > *Element Profiles* > **Profile by Variable Slope from Element**

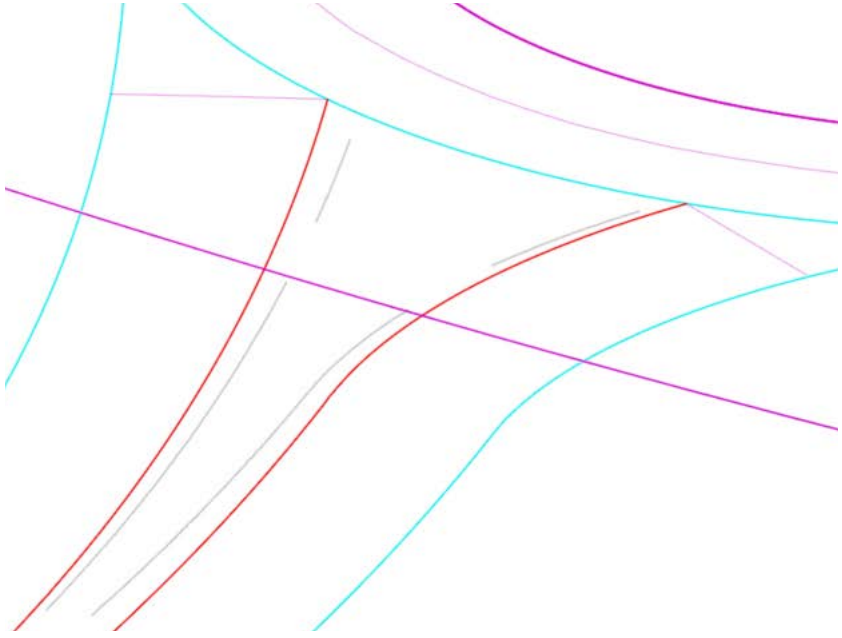
   b. On the dialog:

      - *Slope Style* > **Constant**
      - *Slope* > **2.00%**
      - *Vertical Offset* > **0.000**
      - *Feature Definition: Linear* > *Curb* > **Road_Curb_Flowline**
      - *Name* > **RCF1 Profile**

   c. Follow the heads up prompts:

      - *Locate Plan Element to Profile* > **RCF1**
      - *Locate Reference Element* > **SB Exit EOP-1**
      - *Start Distance* > **0+57.12**
      - *End Distance* > **1+64.53**
      - **Data Point** to Accept *Start* and *End Slopes*

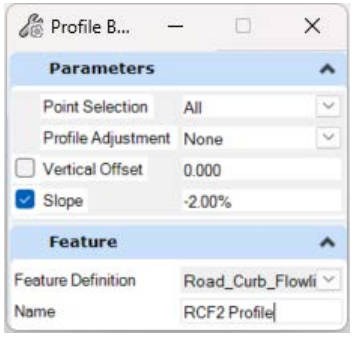




3. Review the 3D model to ensure the 3D features have been displayed. **If not, be sure to set the profiles active and they will then be displayed.**

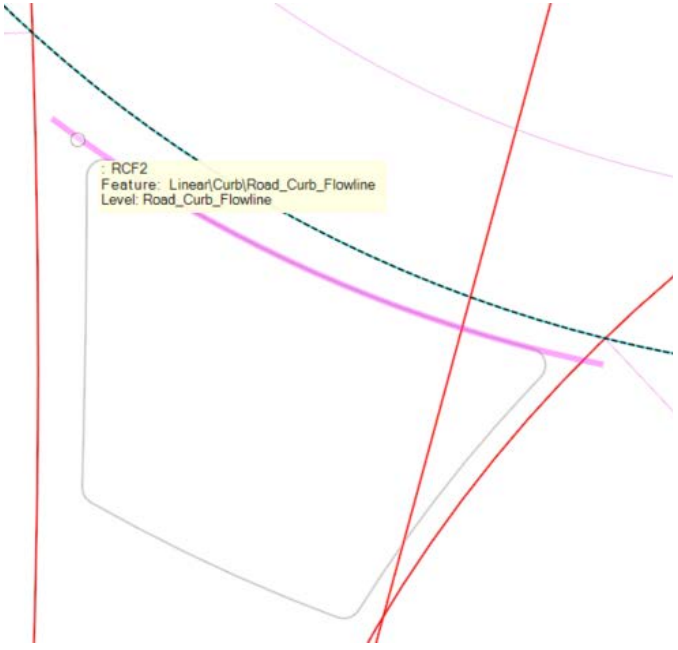
4. We are now going to project slopes from the Outer ICD flowline to the splitter island elements using a constant slope.

   a. Select, *Geometry* > *Vertical* > *Element Profiles* > **Profile by Slope from Element**



   b. On the dialog:
      - *Point Selection* > **All**
      - *Point Adjustment* > **None**
      - *Slope* > **-2.000%**
      - *Vertical Offset* > **0.000**
      - *Feature Definition* > **Road_Curb_Flowline**
      - *Name* > **RCF2 Profile**

   c. Follow the heads up prompts:
      - *Locate First Element to Profile* > **RCF2**
      - *Locate Next Element to Profile - Reset to Complete* > **Reset**
      - *Locate Reference Element* > **Outer ICD**
      - Just locate the station range so that is covers the feature RCF2 by snapping to the start and end



5. All the profiled elements should now appear in the 3D View. **If not, be sure to set the profiles active and they will then be displayed.**

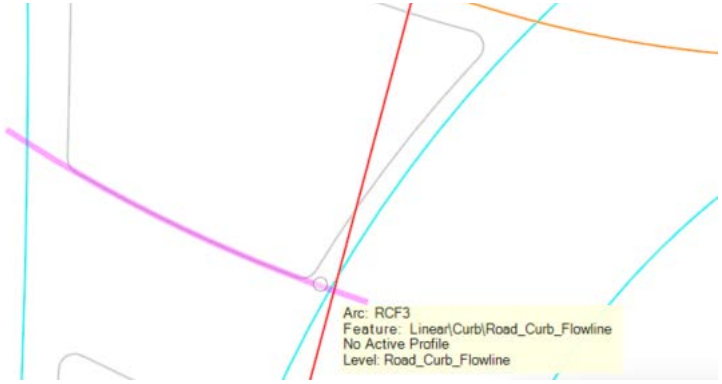
6. Next will be the pedestrian crossing area. As these features have to tie in with the splitter island flowlines, we are going to create vertical alignments for them.

   a. Select Feature > **RCF3** (the untrimmed line)

   b. Wait for the *context sensitive toolbar* and Select > **Open Profile Model**

   c. Select a **View** from the *view toolbar*

   d. **Click** in the *View*



7. Display the intersecting elements elevations in the profile model view.

   a. Select, *Geometry* > *Vertical* > *Profile Creation* > **Profile Intersection Point**

   b. *Locate Element to Show Intersections* > **RCF3**

   c. *Locate Elements which Intersect Select* > **RCF1**

   d. *Locate Next Element to Intersect* > **RCF**

   e. **Reset to Complete**

   In the Profile View there should be 2 purple dots indicating the intersections.

8. Create a tangent line between the 2 points.

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

   b. *Feature Definition* > **Road_Curb_Flowline**

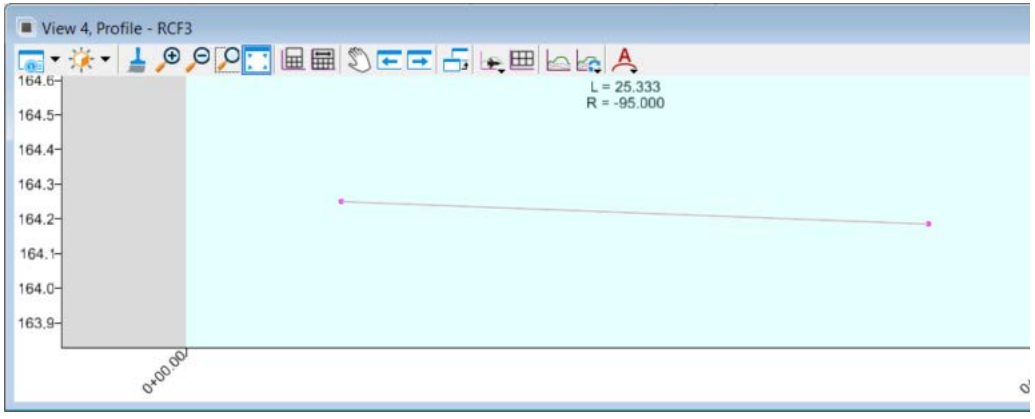
   c. *Start Point* > Select **First Point**

   d. *End Point* > Select **Second Point**

   e. Select **RCF3** in the *Profile View*

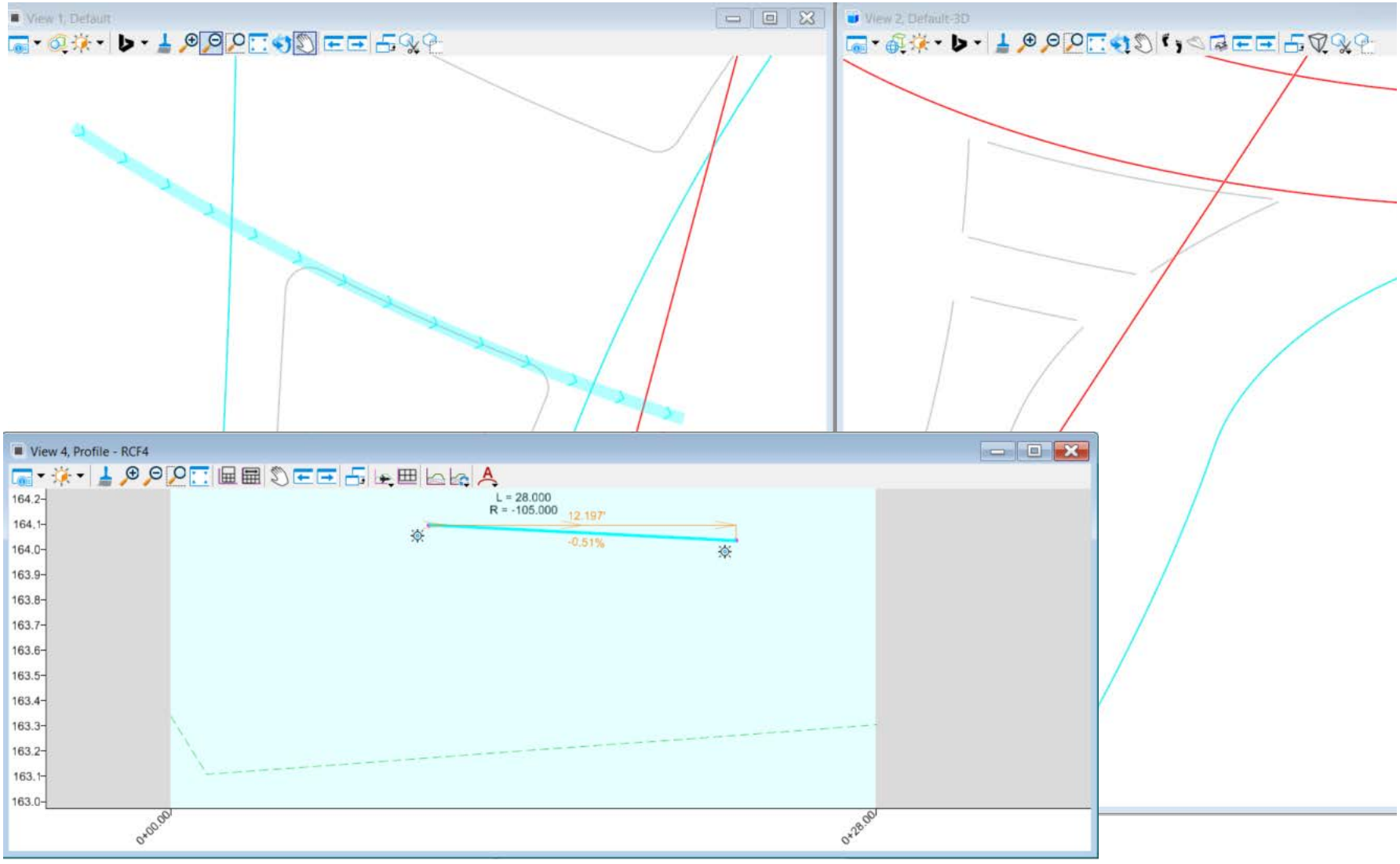
   f. Wait for the *context sensitive toolbar*

   g. **Set the Profile Active**



9. Repeat the process for the other pedestrian crossing **RCF4.**

All the profiled elements should now appear in the 3D View. **If not, be sure to set the profiles active and they will then be displayed.**



Profiling the Curb Returns to the Northbound Splitter Island

In this section we are going to create profiles for the splitter island curb returns.

---

1. Starting in the North-West corner of the Northbound splitter island. Define the profiles along the northbound splitter island.

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

   b. When the toolbar appears **Dock** it at the top of the display

   c. On the toolbar, *Set the Feature Definition* > *Linear* > *Curb* > **Road_Curb_Flowline**

   d. *Set the Feature Definition* > **Use Active Feature Definition**

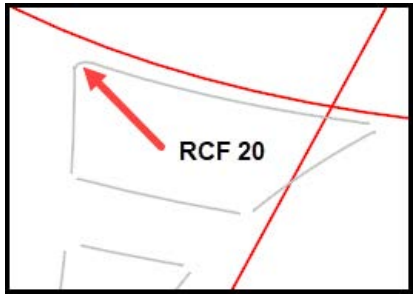
2. Define the profile along the RCF20 element

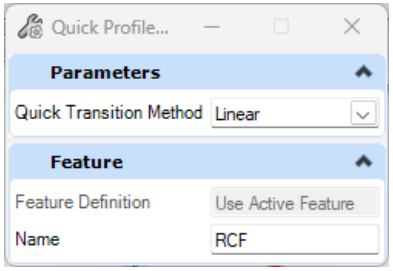
   a. Select > *Geometry* > *Vertical* > *Element Profiles* > **Quick Profile Transition**

   a. *Quick Transition Method* > **Linear**

   b. *Name* > **RCF** (the name will increment)

   c. *Locate What to Define* > **RCF20** (Curb Return)





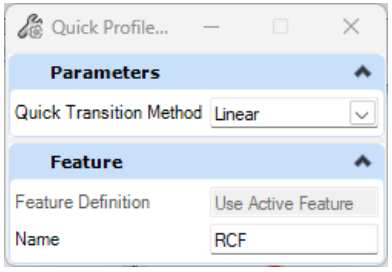
3. Moving South to the next element RCF23 to create a curb return

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

   a. *Quick Transition Method* > **Linear**

   b. *Name* > **RCF** (the name will increment)

   c. *Locate What to Define* > **RCF23** (Curb Return)



4. Moving South to the next element RCF25 to create a curb return.

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

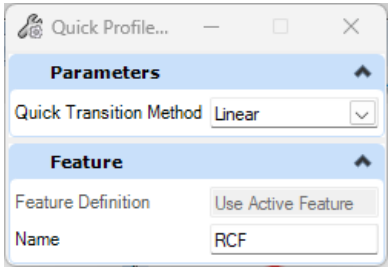
   a. *Quick Transition Method* > **Linear**

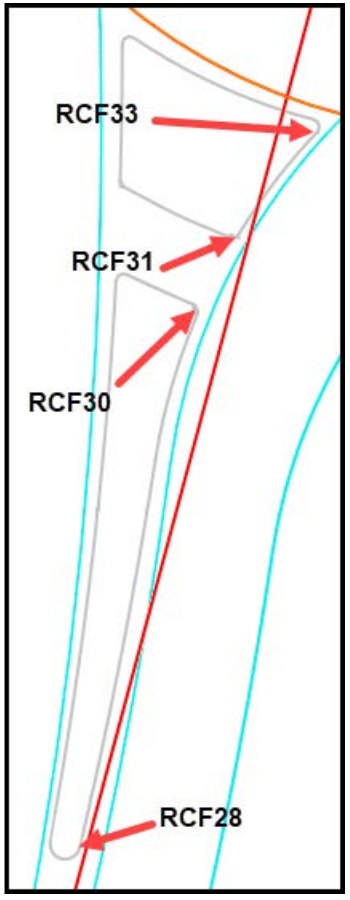
   b. *Name* > **RCF** (the name will increment)

   c. *Locate What to Define* > **RCF25** (Curb Return)

5. Repeat the process for Curb Returns: **RCF28, RCF30**, **RCF31** and **RCF33**

   All the profiled elements should now appear in the 3D View. **If not, be sure to set the profiles active and they will then be displayed.**





6. Create a horizontal alignment for the first Northbound Splitter Island.

a. Ensure *View 1* is active.

b. Select, *Geometry* > *Horizontal* > *Complex Geometry* > **Complex By Element**

a. *Method* > **Automatic**

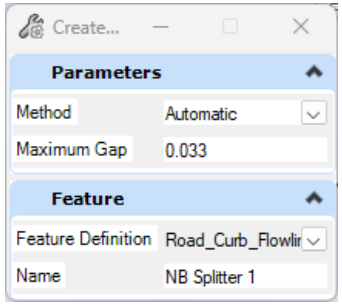
b. *Maximum Gap* > **0.033**

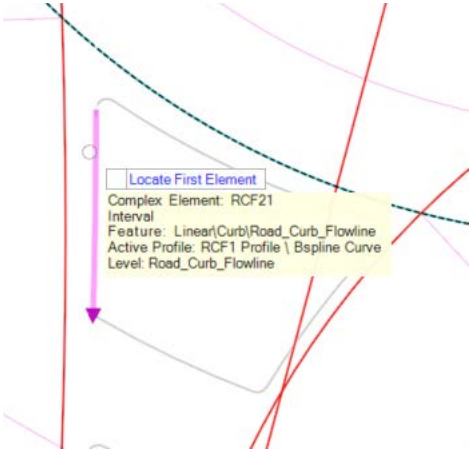
c. *Feature Definition* > **Road_Curb_Flowline**

d. *Name* > **NB Splitter 1**

e. *Locate First Element* > **RCF21**

f. **Data Point** to *Accept Complex*





7. Create the vertical alignment for the first Northbound Splitter Island.

   a. Select the New *Complex Chain* **NB Splitter 1**

   b. Wait for the *context sensitive toolbar*

   c. Select > **Open Profile Model**

   d. **Data Point** in *View 7*

   e. Select, *Geometry* > *Vertical Complex Geometry* > **Profile Complex by Elements**

   f. *Feature Definition* > *Road_Curb_Flowline*

   g. *Name* > **NB Splitter 1 Profile**

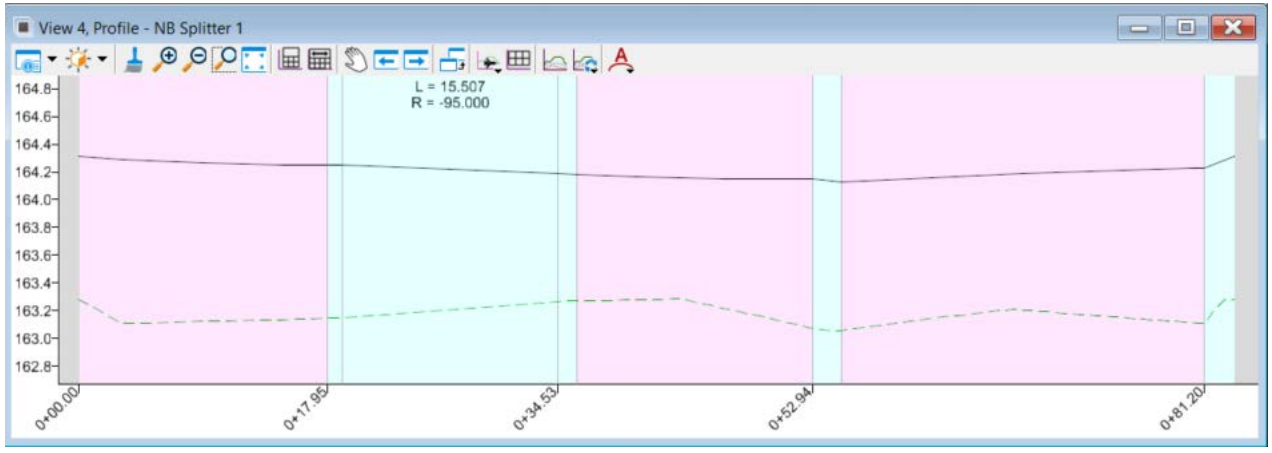
   h. *Locate the First Element* > **Start of the Profile**

   i. **Data Point** to Accept

   j. *Select Profile* > **NB Splitter 1 Profile**

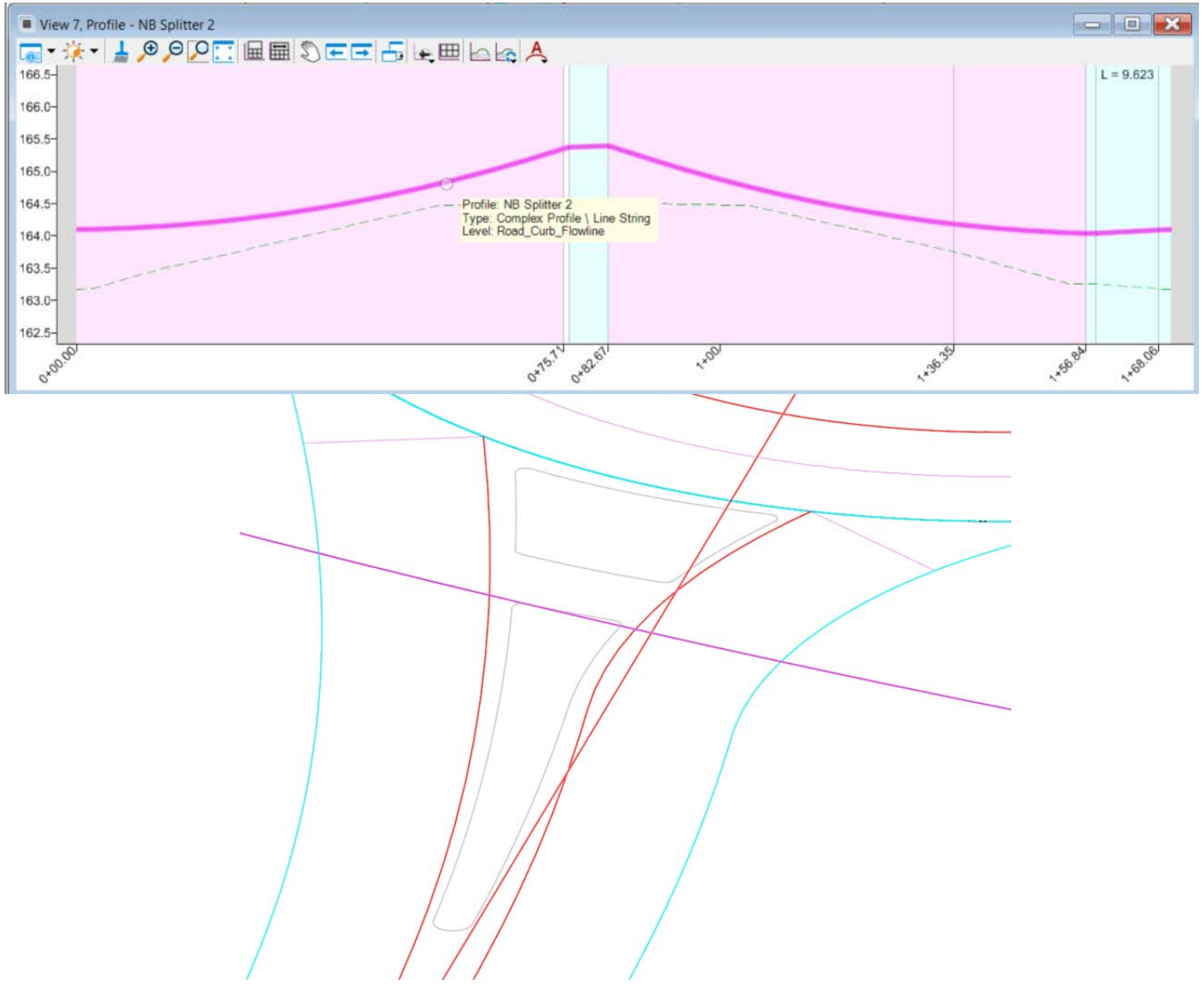
   k. Wait for the *context sensitive toolbar*

   l. Select > **Set as Active Profile**



Note: You may want to apply a best-fit profile to smooth out the vertical. Remember, this is our first iteration and the design may not be perfect on the first try.

8. Repeat Steps **6** and **7** for the other splitter island, and name it *NB Splitter 2*. If for some reason your profile does not look like the image below, check the profiles for each element to ensure they were defined correctly.



NB Splitter Islands Complete

Exercise 4: Creating a Terrain Model of the Roundabout and 3D Model Detailing

Description

In this exercise you will create a terrain model of the Roundabout and Pavement Approaches.

Skills Taught

- Create Terrain From Elements
- Create a Terrain Model Roundabout Rotary
- Create a Terrain Model of the Approaches
- Create the 3D Model
- Display Terrain Model Contours
- Analyze the Terrain Model Slopes

Create a Terrain Model of the Roundabout Rotary

Now that the vertical design is complete, we need to create a terrain model of our roundabout so that we can analyze the drainage contours and then a create detailed 3D model. In this section, you learn how to create a terrain model of the roundabout.

---

1. Open an existing file.

   a. Select **Browse**.

   b. Browse to *C:\Bentley Training\Roundabout Design - Vertical Geometry* or other folder where you unzipped the dataset files.

   c. Select the file **RAB Terrain Model.dgn** and click **Open**.

2. Create a Terrain Model for the Roundabout Rotary.

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

   b. On the *Create Terrain Model* dialog:

   c. *Feature Type* > **Boundary**

   d. *Edge Method* > **None**

   e. *Feature Definition* > **Proposed Drainage Contours**

   f. *Name* > **RAB Rotary TM**

   g. From the Heads Up prompts:

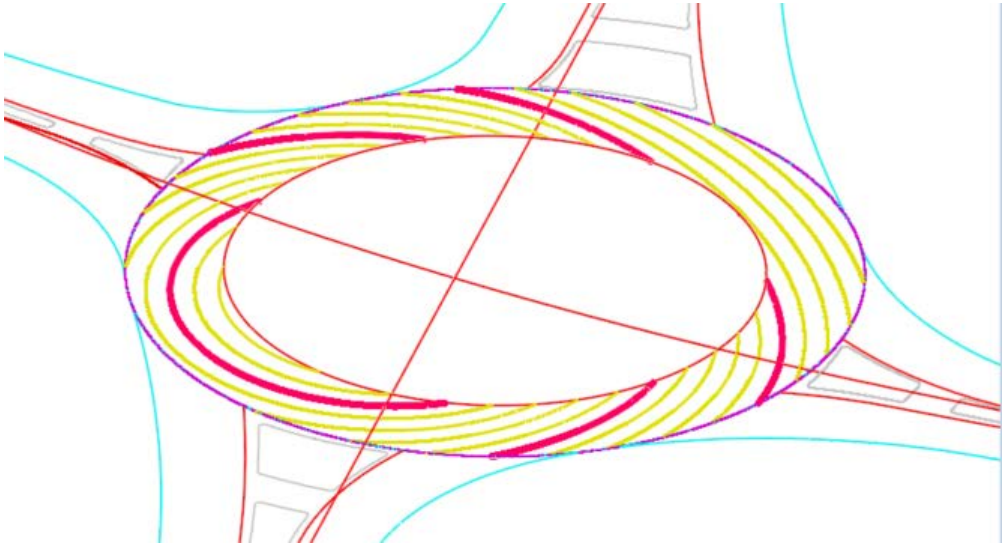
      - *Locate Element to Add* > Select the **Outer ICD**
      - *Locate Next Element to Add - Reset When Done* > **Reset** to complete.

   h. Continue to follow the prompts to add a Break Line.

      - In **Add Features** toobox, set the *Feature Type* to **Break Line**
      - *Locate Element to Add* > Select **RAB_ElevRef** element

i. Continue to follow the prompts to add a Hole.

- Set the *Feature Type* to **Hole**
- *Locate Next Element to Add - Reset When Done* > Select the **Inner ICD** element



Create a Terrain Model for the Pavement

1. Create the Terrain Model for the NB pavement approach Boundary Elements.

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

   b. On the *Create Terrain Model* dialog:

   c. *Feature Type* > **Boundary**

   d. *Edge Method* > **None**

   e. *Feature Definition* > **Proposed Drainage Contours**

   f. *Name* > **NB Pavt Approach TM**

   g. From the Heads Up prompts:

      - *Locate Element to Add* > Select the NB Entry EOP-2, SB Exit EOP-2, LondonRd Matchline and NB Approach Matchline
      - **Reset** when complete
      - Follow the prompts to create the terrain model

2. Add the **Breakline** elements (NB Entry EOP-1, SB Exit EOP-1, NB Entry Pavt Slope, SB Exit Pavt Slope) to the terrain model.

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

   b. From the Heads Up prompts:

      - *Locate Terrain Model To Add Elements* > Select the **NB Pavt Approach TM**
      - *Feature Type* > **Breakline**
      - *Locate Element to Add* > Select the **NB Entry EOP-1, SB Exit EOP-1, NB Entry Pavt Slope, SB Exit Pavt Slope**
      - **Reset** when complete

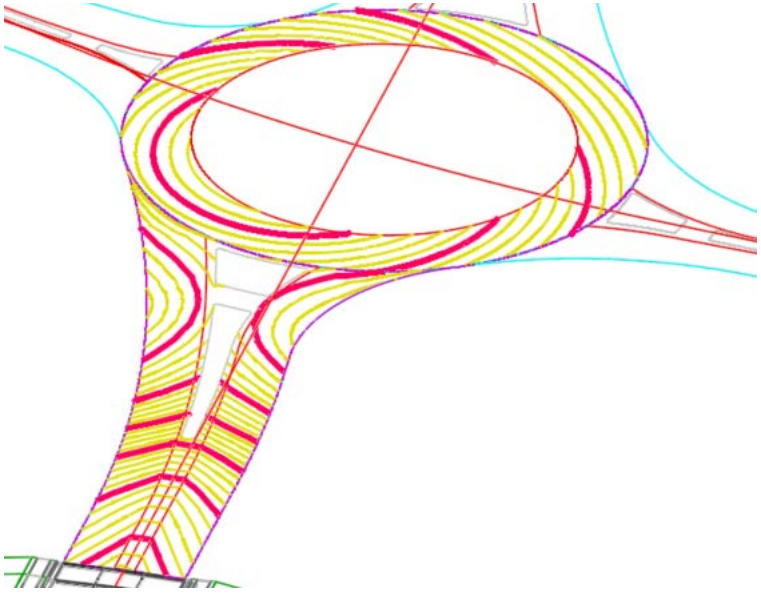
3. Add NB Splitter 1 and NB Splitter 2 elements as **Holes**.

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

   b. From the Heads Up prompts:

      - *Locate Terrain Model To Add Elements* > Select the **NB Pavt Approach TM**
      - *Feature Type* > **Breakline**
      - *Locate Element to Add* > Select the **NB Splitter 1** and **NB Splitter 2**

   c. **Reset** to complete. The terrain is now complete.



4. Review the contours and overall design.

   - Whenever you are designing roundabouts and intersections it is a best practice to review the contours to verify the drainage, slopes of the terrain and the incoming/outgoing grades of the geometric elements.
   - At this point, is when you would start to refine the design and make adjustments to your geometric elements. Remember, designing a roundabout is an iterative and time consuming process and it may take several adjustments to complete the final design.
   - For purposes of this training course we will continue with our initial design.

Create the 3D Model Details

In this section, we will create the 3D model details of the roundabout.

---

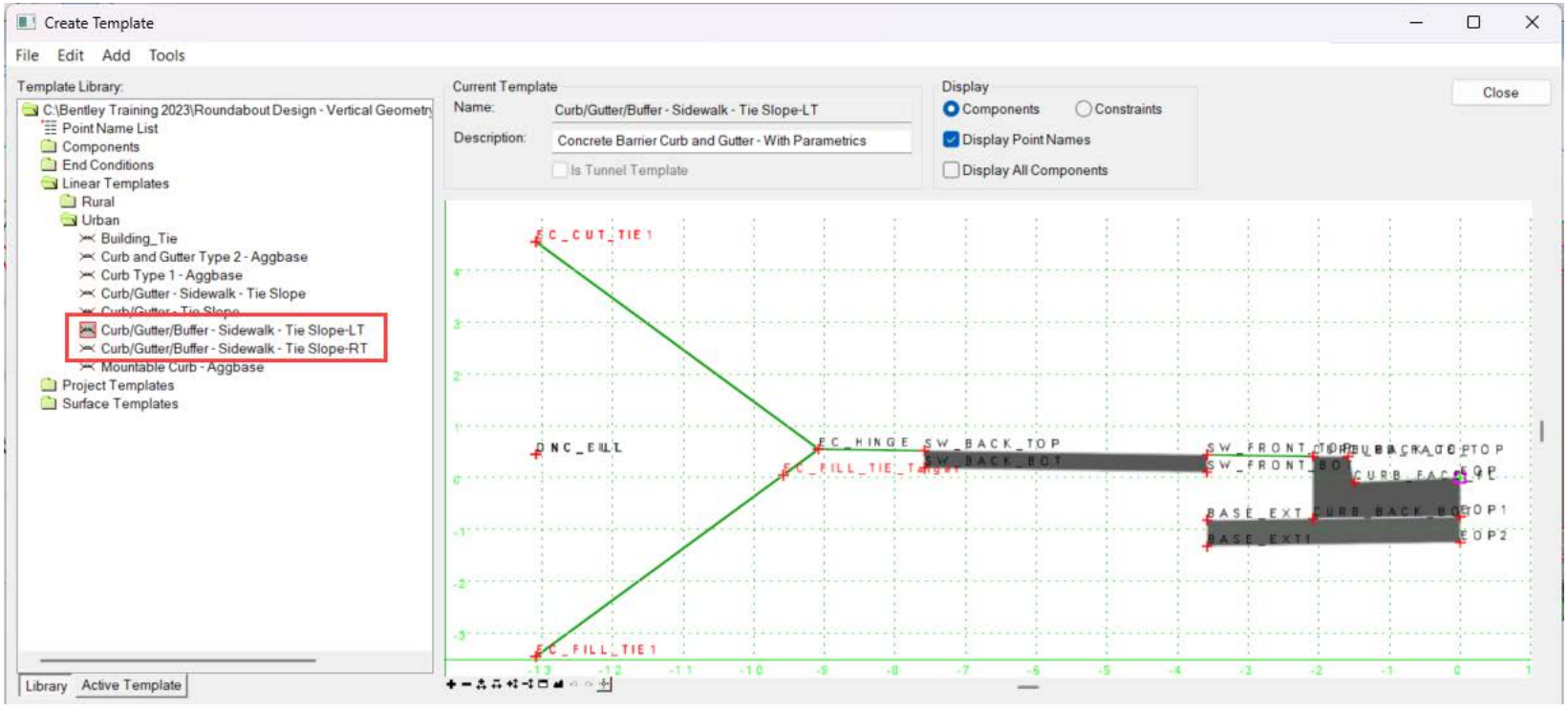
1. Open an Existing File.

   a. Select **Browse** and browse to *C:\Bentley Training\Roundabout Design - Vertical Geometry* or other folder where you unzipped the dataset files.

   b. Select the file **RAB Model.dgn** and click **Open**.

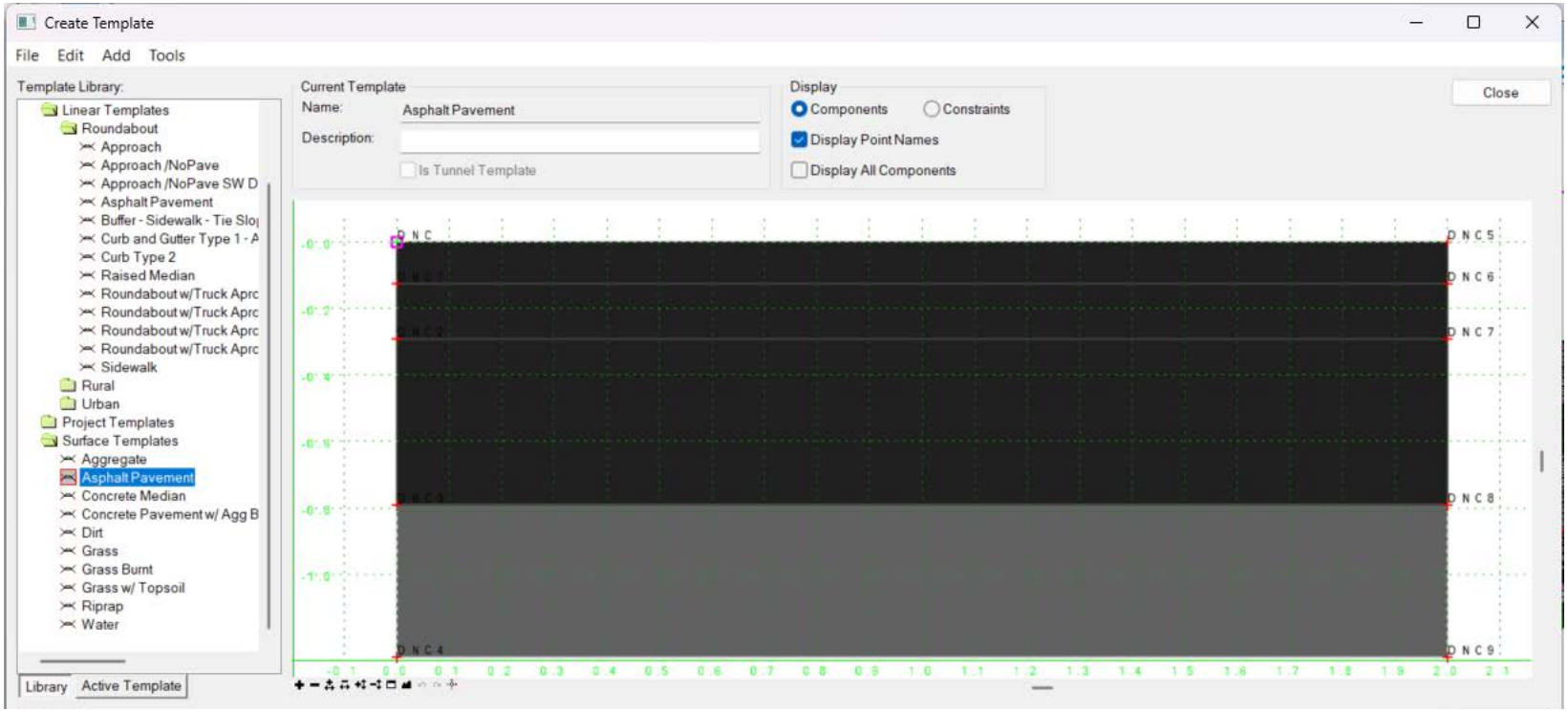
      Note: This file has the geometry and terrain already attached as references.

2. Create the curb, sidewalk and grading by defining corridors along the NB and SB outside edges of pavement using the templates shown below. Use the templates shown below. The templates can be found in the **LondonRd-Imperial.itl** template library delivered with the course dataset. Use the *Feature Definition* named **Final** and a *Template Drop Interval* of **5**.



3. Create the Pavement using the **Apply Surface Templates** tool.

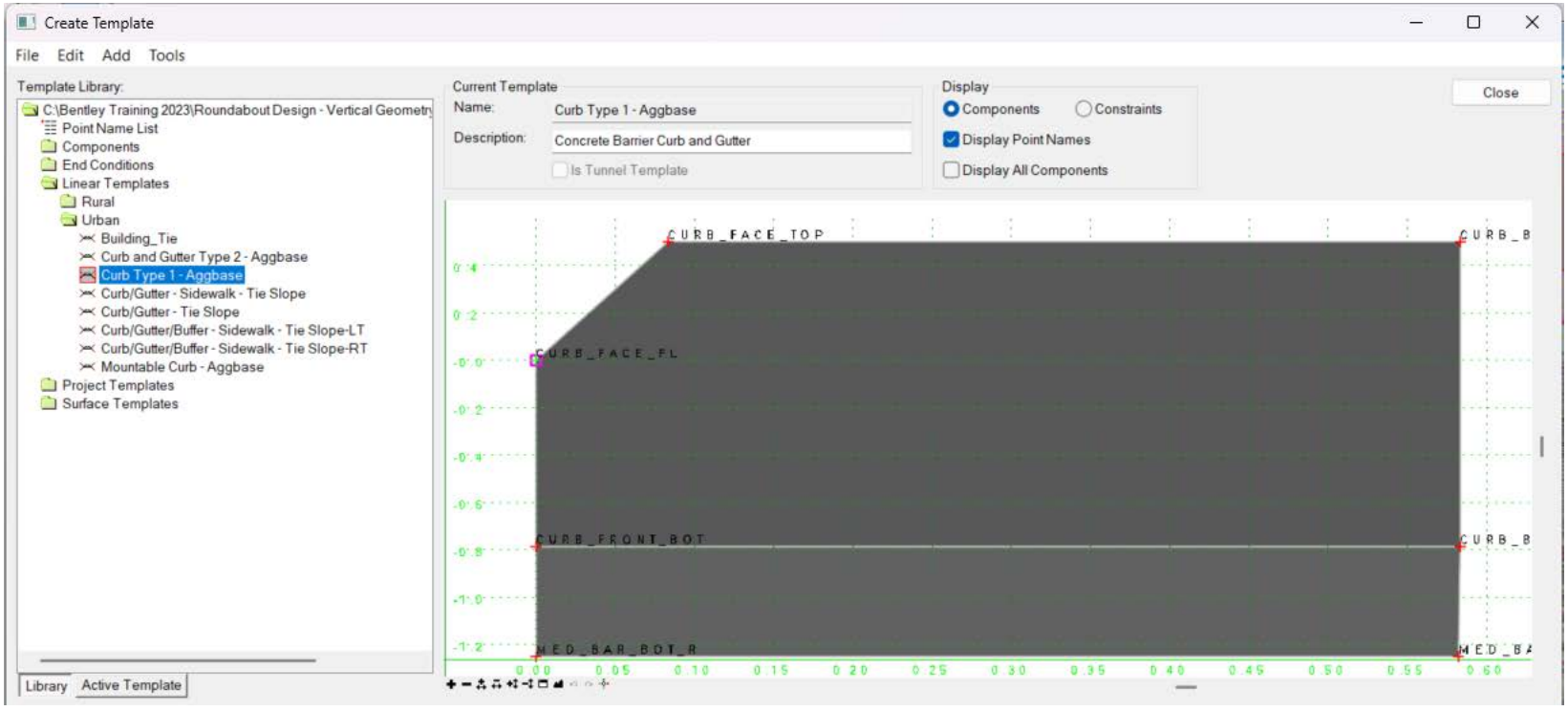
   - Use the **Asphalt Pavement** template.
   - Apply the **Asphalt Pavement** template to the **NB Approach TM** and the **RAB Rotary TM**



Note: An alternative method of creating the roundabout 3D model would be to create corridors rather than use surface templates. Creating corridors would give you more control if the design were to change, however there would be slightly more work involved if creating corridors, such as point controls etc...

4. Create the Curb for the NB Splitter Islands.

   - Use the **Apply Linear Template** tool to create the curbs for the NB Splitter Islands.
   - Use the template named: **Curb Type 1 - Aggbase** and *Feature Definition:* **Final**

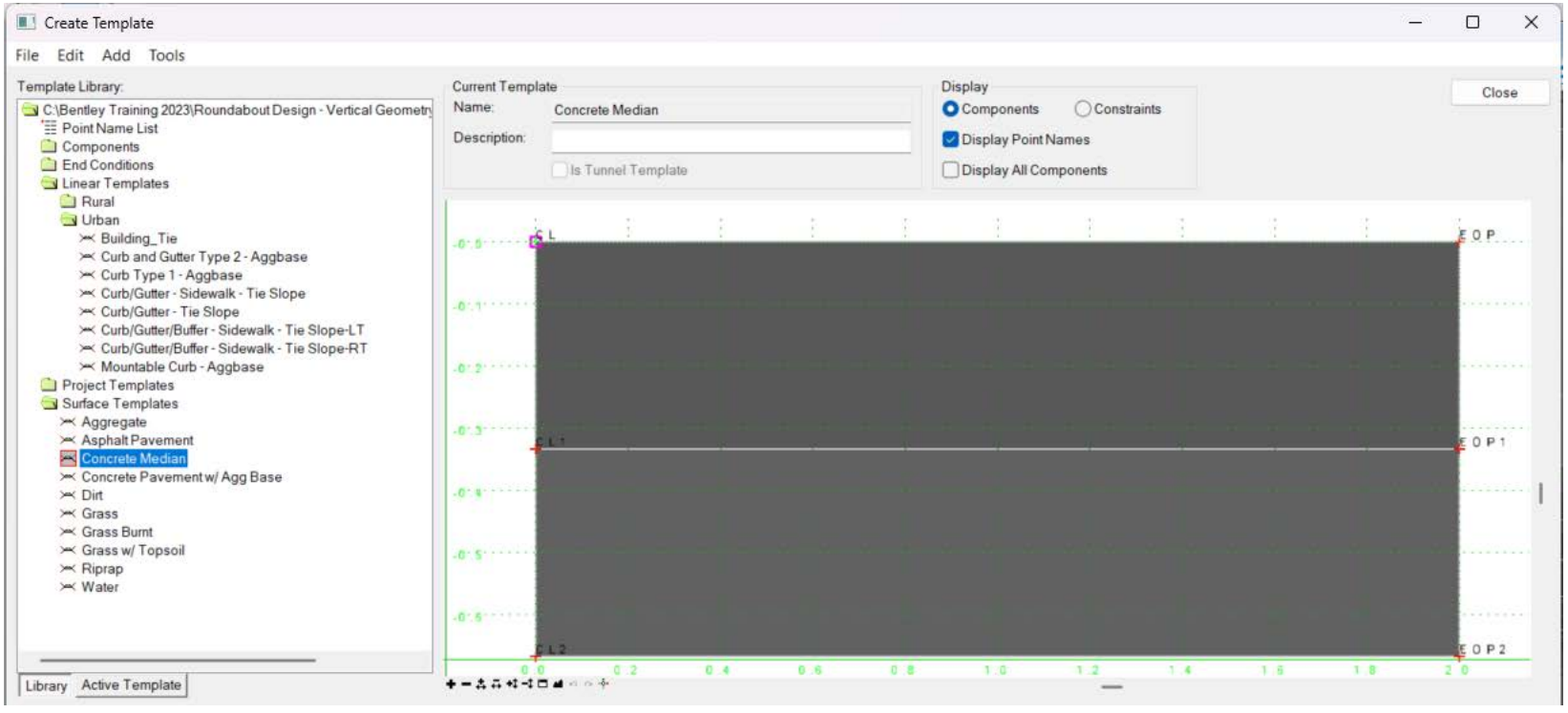


5. Create the Truck Apron for the Inner ICD Island.

   - Use the **Apply Linear Template** tool to create the curbs for the Inner ICD.

Use the template named: **Truck Apron/No End Condition-RT** and *Feature Definition:* **Final**

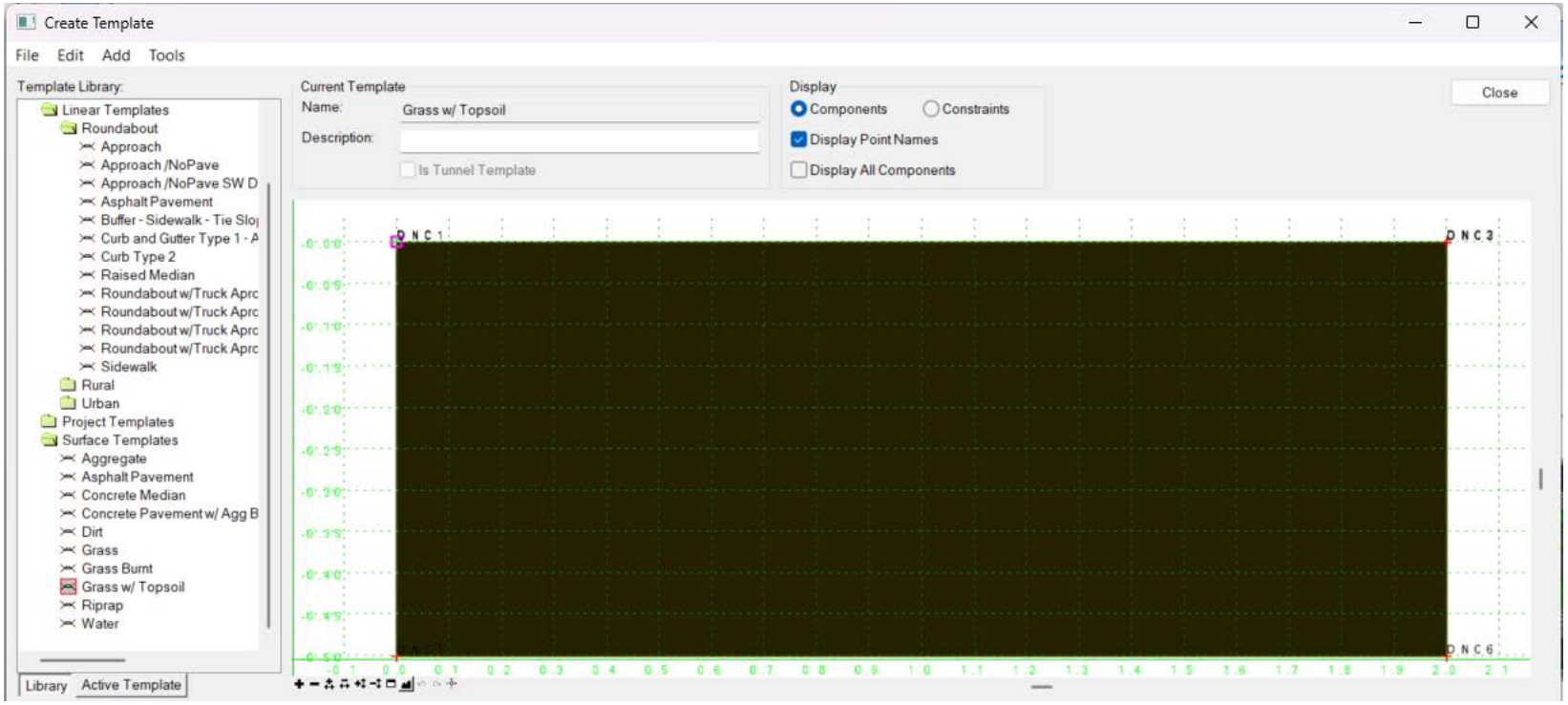
6. Create terrain models for the NB Splitter Island Caps. This will be used to apply surface templates.
   - Use the **CURB_BACK_TOP** as the 3D element
   - Set the *Feature Type* to **Boundary**
7. Create the Concrete Median for the splitter island caps.
   - Use the **Apply Surface Templates** tool.
   - Use the **Concrete Median** template.



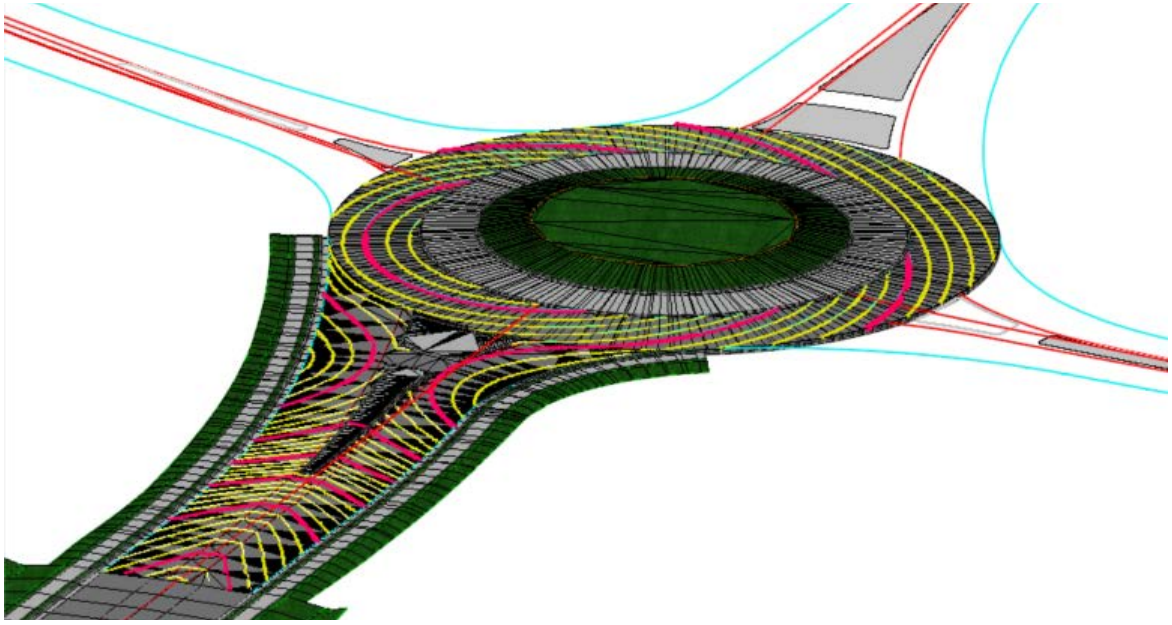
8. Create the Curb for the Outer Pavement Edges to the Approaches
   - Use the **Apply Linear Template** tool to create the curbs, verges, sidewalks and side slopes.

Use the template named: **Buffer - Sidewalk - Tie Slope-RT** and *Feature Definition:* **Final**

9. Create a terrain model for the roundabout center island area. This will be used to apply surface templates.
   - Use the **ES_OUT_TOP_R** as the 3D element
   - Set the *Feature Type* to **Boundary**
10. Create the roundabout center island area.
   - Use the **Apply Surface Templates** tool
   - Use the **Grass w/Topsoil** template



Completed 3D model.



Now that the roundabout rotary and northbound approach is done. Complete the other legs of the roundabout using the same steps.

Summary

In this course we covered the vertical design of a roundabout. The vertical design of a roundabout begins with the development of the central island and approach roadway profiles. The development of each profile is an iterative process that involves tying the elevations of the approach roadway profiles into a smooth profile around the central island. Since this is an iterative process and can be very time consuming we will only show the step by step details for one approach in this course.