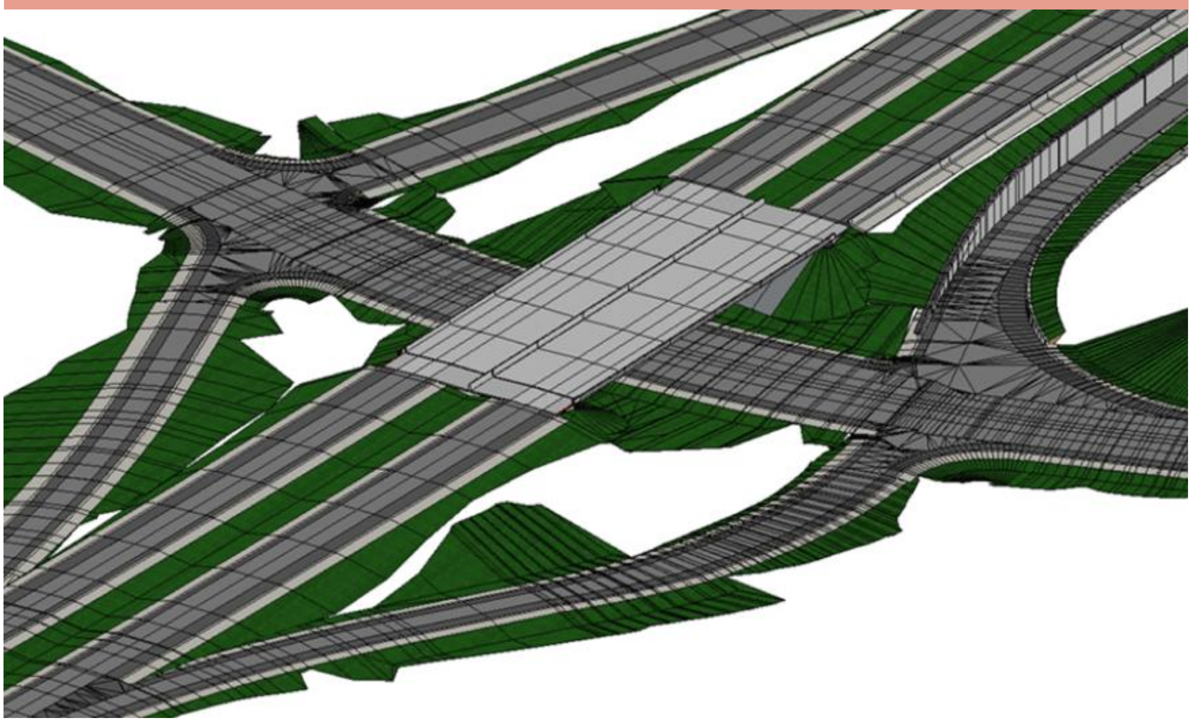
ROADWAY DESIGN II

OpenRoads Designer

CONNECT Edition



TDOT

Roadway Design Division

July 2023

TDOT Department of Transportation

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Preface

Purpose & Need

The ***ROADWAY DESIGN II*** OpenRoads Designer (ORD) Manual is the fifth document in a series of **six** training manuals released by the Tennessee Department of Transportation (TDOT). Bentley's ORD software is being adopted and implemented statewide by TDOT as the new **3D modeling** design software, which will ultimately replace both MicroStation V8i and Geopak (SELECT Series 2). This manual provides an introduction to more advanced workflows on the roadway and hydraulics side, such as civil cells, retaining walls, earthwork, bridges/box culverts, ramp gores, special ditches, and channel relocations.

For step-by-step instructions on creating a **TDOT plan set** in ORD utilizing the new workflows and updated CADD Standards, refer to the TDOT Requirements for Model-Centric Design document, which can be found on the TDOT CADD Support website under ORD Resources. For standardized naming convention methologies for ORD files, refer to the TDOT ORD File Naming Convention Standards document, which can also be found on the TDOT CADD Support website under ORD Resources.

Disclaimer

The ***ROADWAY DESIGN II*** Manual is developed based on OpenRoads Designer CONNECT Edition 2022 Release 1, Version **10.11.00.115**. The TDOT ORD workspace (**10.11.00.115_07.24.2023**) complies with the latest CADD standards and should be used in conjunction with this manual. It can be downloaded on the TDOT CADD Support website under ORD Resources. If you have any technical issues or recommendations for this manual, please contact TDOT CADD Support at TDOT.ORD@tn.gov.

Revisions

The ***ROADWAY DESIGN II*** Manual will be revised over time as a result of future ORD software releases and procedural & workspace updates. All revisions will be documented by WSP/TDOT and included on the **Revision History** page at the end of the manual. TDOT CADD support will announce updated manual versions when they become available via emailed announcements.

ORD Training Manuals

The ***ROADWAY DESIGN II*** Manual is one of **six** ORD training manuals available. Each manual has its own icon and color associated with it, which are maintained throughout the applicable manual and videos to help the user with wayfinding.

Chapter 1. Course Overview

Course Description and Objectives:

This course introduces users to the **advanced design** functionality of the OpenRoads Designer (ORD) CONNECT software, which is Bentley's current drafting and civil design platform that is being adopted for use by TDOT.

At the conclusion of this course, participants will be able to:

1. Set up the recommended TDOT user interface.
2. Model advanced items including intersections, underpass slope protection, ramp gores, and special ditches.
3. Leverage the advanced skills learned in the course exercises to model additional project related scenarios.

The topics covered in this class are:

1. User Interface Customization
2. Advanced Modeling
3. Placing Pavement Markings
4. Haul Roads
5. Civil Cells
6. Template Drop Transitions
7. Retaining Walls
8. Bridges
9. Underpass Slope Protection
10. Ramps and Gores
11. Box Culverts
12. Special Ditches
13. Channel Relocations
14. Earthwork
15. Item Types

Target Audience:

This course is designed for Project Development staff, or anyone using the advanced modeling tools for highway design. Chapters 4-11 are primarily focused on advanced roadway tools, while chapters 12-13 are more focused on advanced drainage tools. Chapters 3 and 14-16 are focused on generalized advanced topics.

Prerequisites:

- Familiarity with TDOT's design policies, procedures, and standards.
- A working knowledge of Windows 10.
- Completion and full comprehension of the Roadway Design I (ORD) Manual.

Chapter 2. User Interface Customization

The Bentley MicroStation products have always been highly customizable with respect to the workspace layout, and OpenRoads Designer (ORD) CONNECT Edition (CE) is no different. This chapter covers how to set up the TDOT recommended user interface.

2.1 Objectives

At the conclusion of this chapter, participants will be able to:

1. Customize the ORD user interface.
2. Set up the TDOT recommended layout in ORD.

2.2 Exercise: Set up the TDOT Recommended User Interface

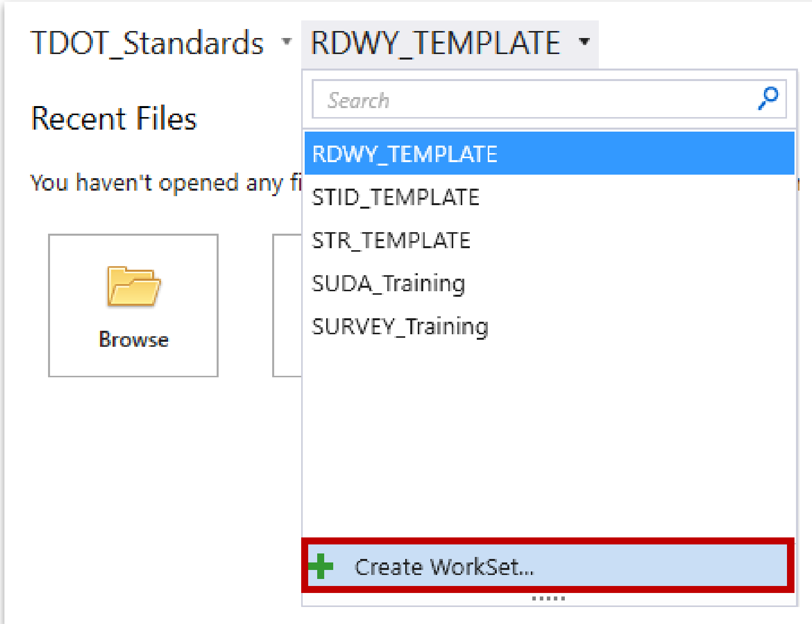
In this exercise, we will create a new ORD file and go through the steps to set up the user interface, as recommended by TDOT.

Take Note!

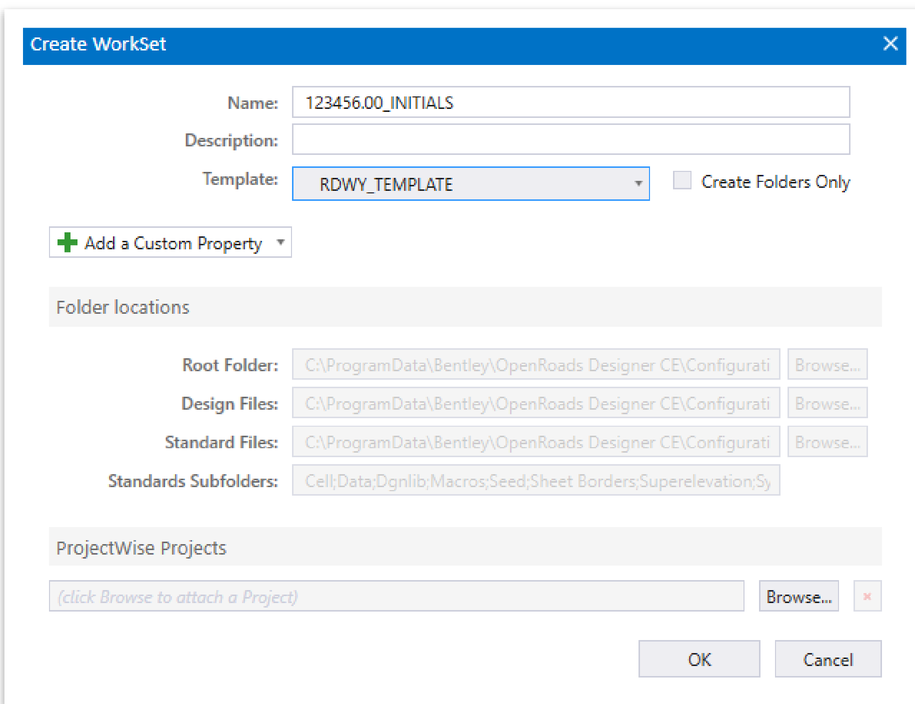
*On an actual project, remember to use the TDOT ORD naming convention when creating **all** design files. The file names used in this manual serve as general guidance for training purposes only. The procedures are intended to teach the necessary tools and TDOT's ORD workspace. For more information, refer to the TDOT ORD File Naming Convention Standards document.*

1. Launch **ORD CE – 2022 Release 1** and make sure the **TDOT_Standards** workspace is active. If you have previously copied your **123456.00_INITIALS** workset (created in the Fundamentals (ORD) training) to the following location: **C:\ProgramData\Bentley\OpenRoads Designer CE 10.11\Configuration\WorkSpaces\TDOT_Standards\WorkSets**, then skip to Step 8. If not, we will go through the steps to create the workset. We will be using this same workset for the duration of this manual. **Note:** If you are copying your workset over, make sure to copy the **123456.00_INITIALS** folder as well as the corresponding **cfg** and **dgnws** files.

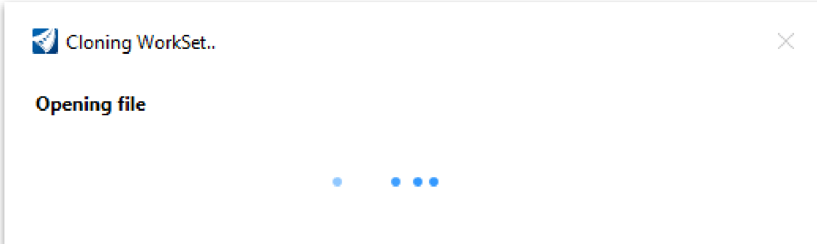
2. The software should default to the **RDWY_TEMPLATE** workset. Click on the drop-down and select **Create WorkSet**.



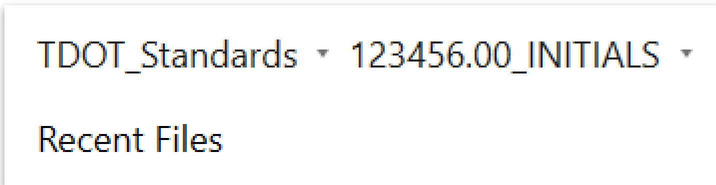
3. The **Create WorkSet** dialog will appear.
   a. Type in the name **123456.00_INITIALS** (enter your initials).
   b. Select the **RDWY_TEMPLATE** as the template. This sets up the correct sheet index folders per TDOT Roadway project standards.
   c. Leave the **Create Folders Only** option unchecked and click **OK**.



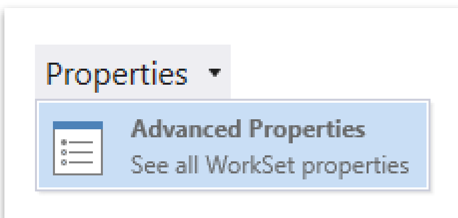
4. You will see a **Cloning WorkSet** window popup.



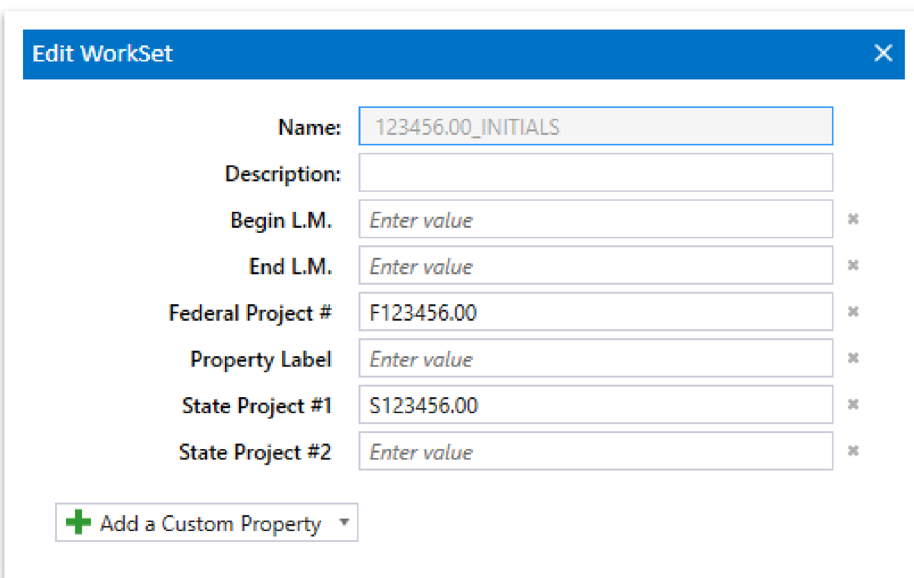
5. Notice your new project workset is now populated.



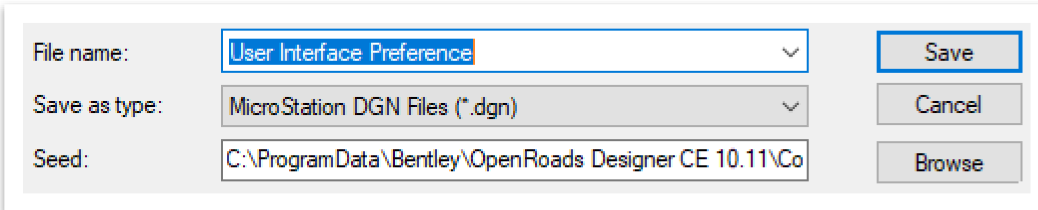
6. Let's now fill in the applicable workset properties. Open the Properties pull down menu and select **Advanced Properties**.



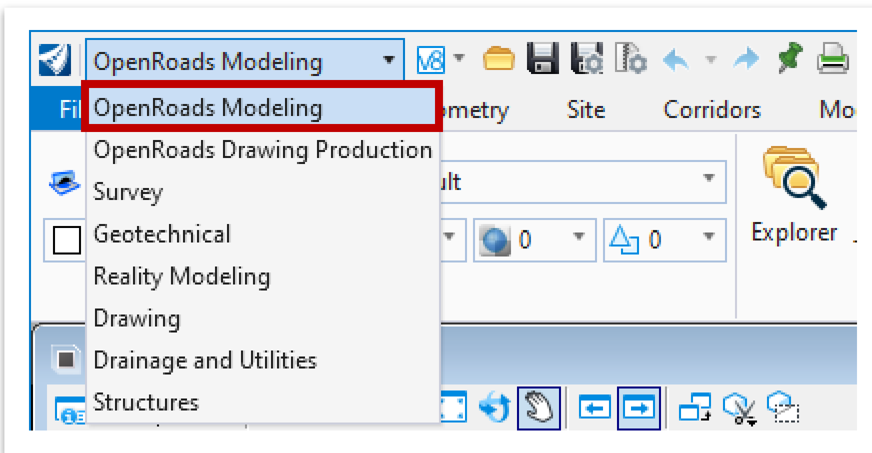
7. Enter the following data and then click **OK**.
    a. **Federal Project # 1:** F123456.00
    b. **State Project # 1:** S123456.00



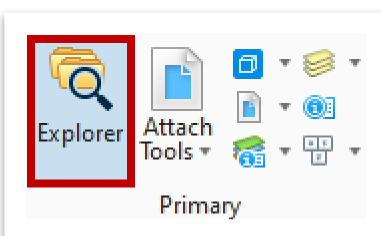
8. Now that we have created a workset, the applicable project folders have been created on the **C** drive. Go ahead and move the provided **class files** to the following location: **C:\ProgramData\Bentley\OpenRoads Designer CE 10.11 \Configuration\WorkSpaces\TDOT_Standards\WorkSets\123456.00_INITIAL S\dgn**. We will utilize them later in the class.
9. Create a new file and name it **User Interface Preference**. Select the **TDOTSeed 2D.dgn** and click **Save**.



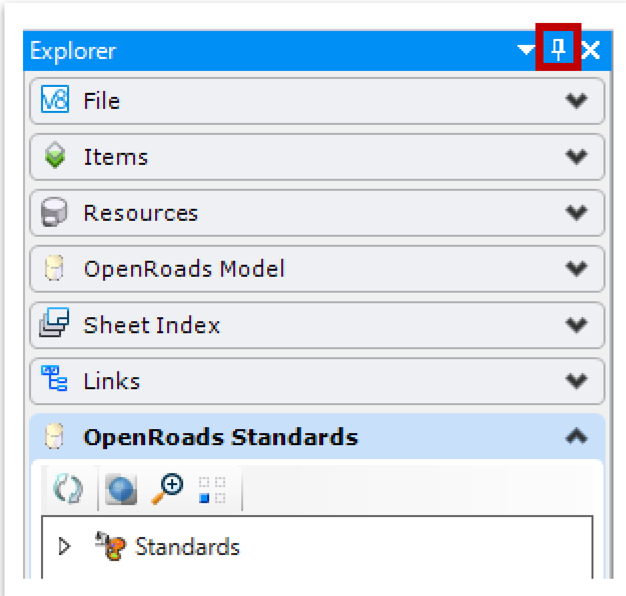
10. In the upper left corner, make sure the workflow is set to **OpenRoads Modeling**, if not already active.



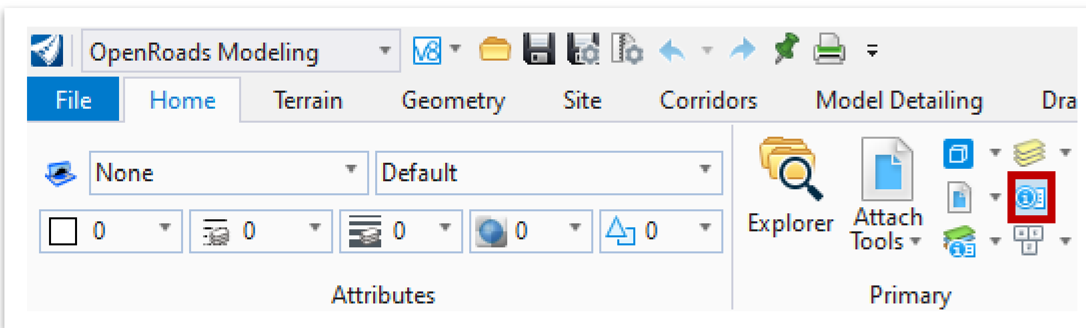
11. Now that the OpenRoads Modeling workflow is active, we will setup the recommended TDOT user interface which will ultimately assist in more efficient modeling efforts throughout this manual. Make sure the **Explorer** tool (**Open Roads Modeling >> Home >> Primary**) is docked/pinned on the left side of the screen. **Note:** It should automatically default to this location once opened.



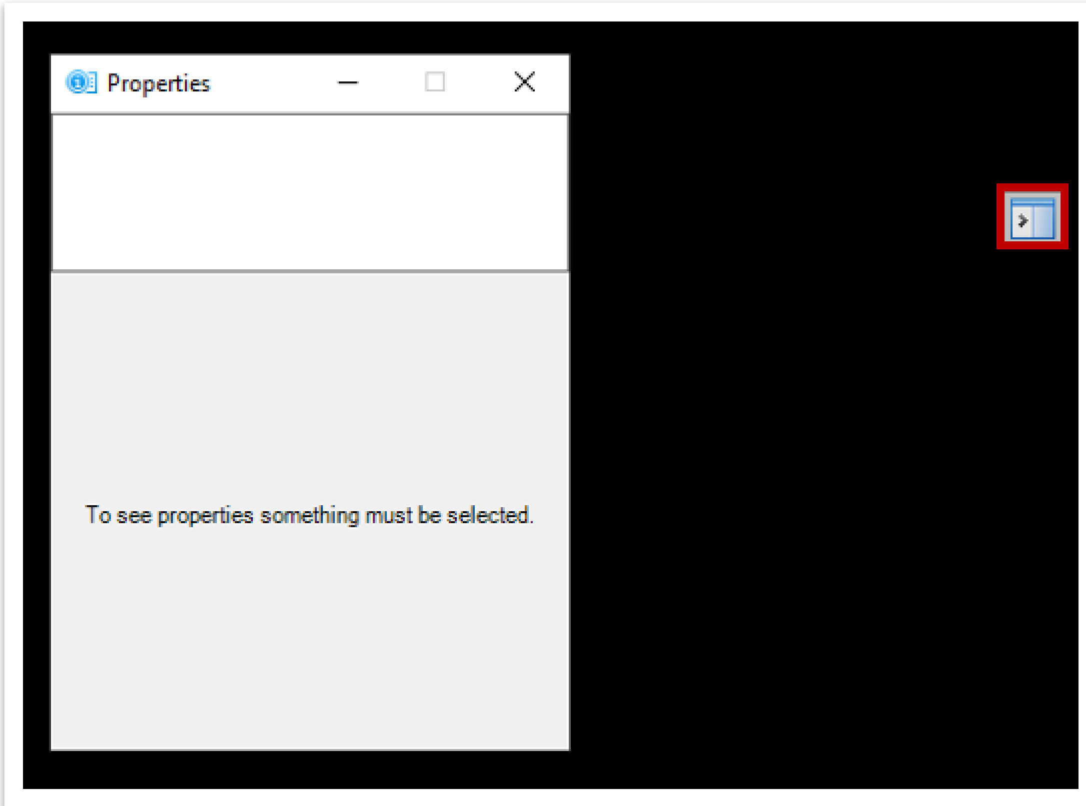
12. To unpin the **Explorer** but keep it docked on the left side of the screen, click the **Unpin** icon in the upper right corner of the **Explorer** header. This will allow you to have a larger visible drawing window. However, it is recommended that the **Explorer** stay pinned and fully visible during the modeling process.



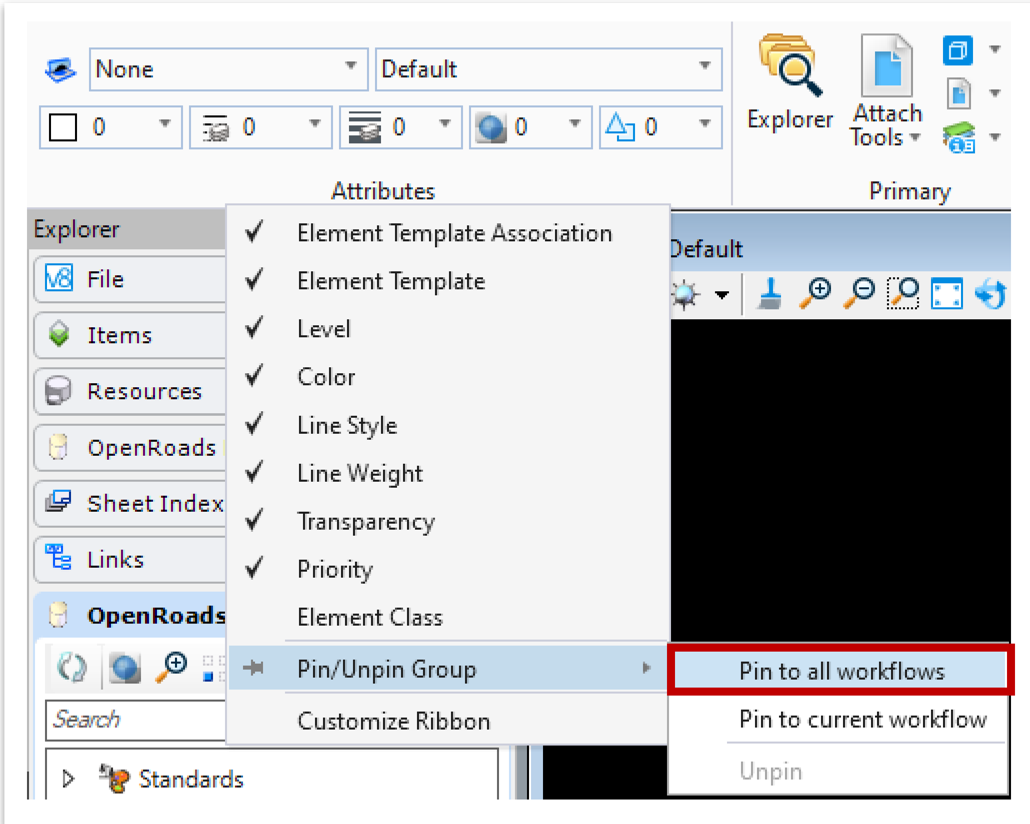
13. Next, go ahead and open the **Properties** tool (**OpenRoads Modeling >> Home >> Primary**).



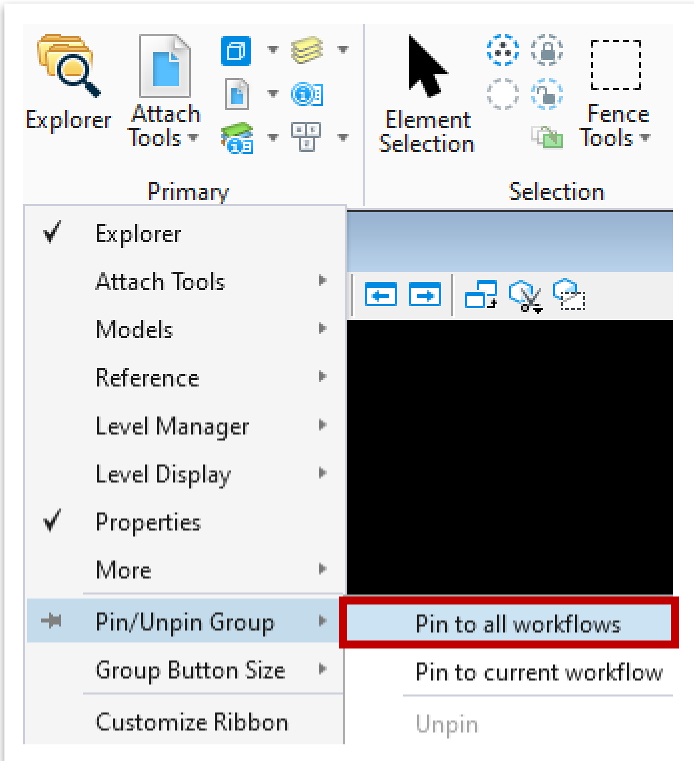
14. By default, it should dock/pin to the right side of your screen. If it does not, move the location by left clicking and holding the grey **Properties** header. Then, drag it to the pin box (outlined in red) on the right side of the screen and release. You'll notice there are also pin boxes in the middle of the screen, which also work to pin tools on the left and right sides.



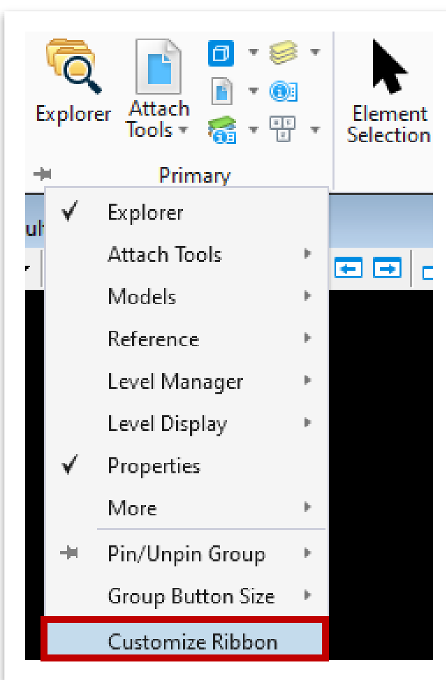
15. Now, let's pin the **Attributes** to all tabs and workflows as opposed to just the **Home** tab. **Right** click within the **Attributes** in the ribbon and select **Pin/Unpin Group >> Pin to all workflows**.



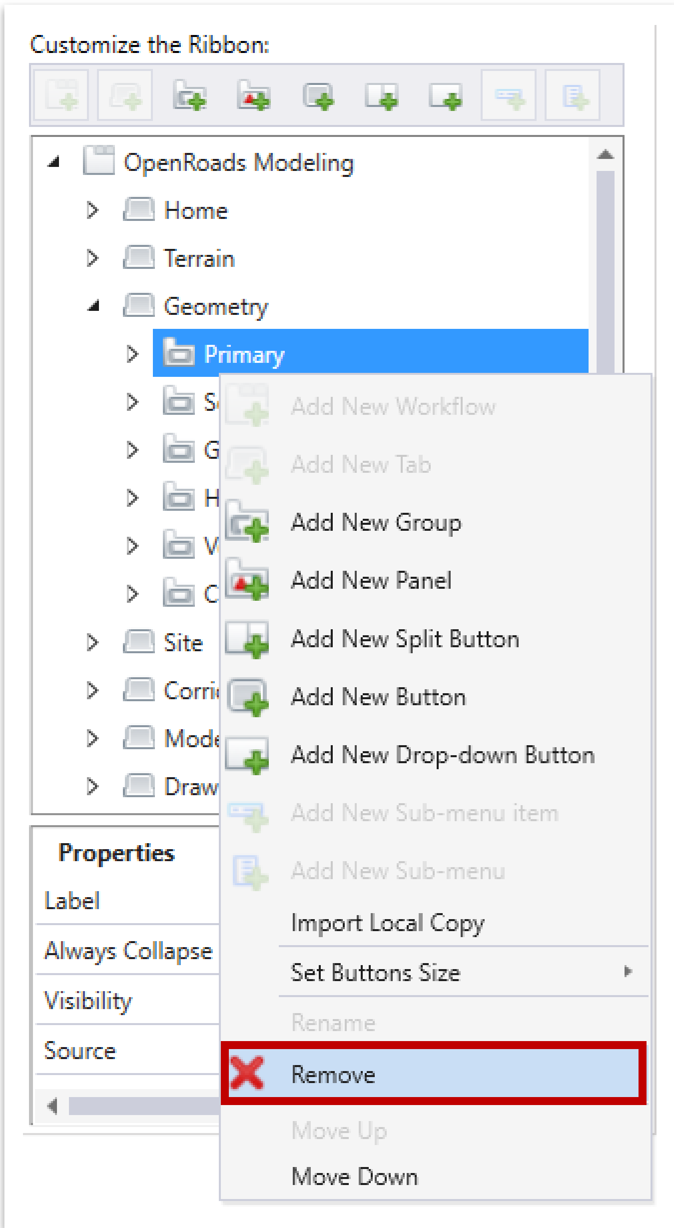
16. Go ahead and pin the **Primary** tool group to all tabs and workflows using the same method from the previous step.



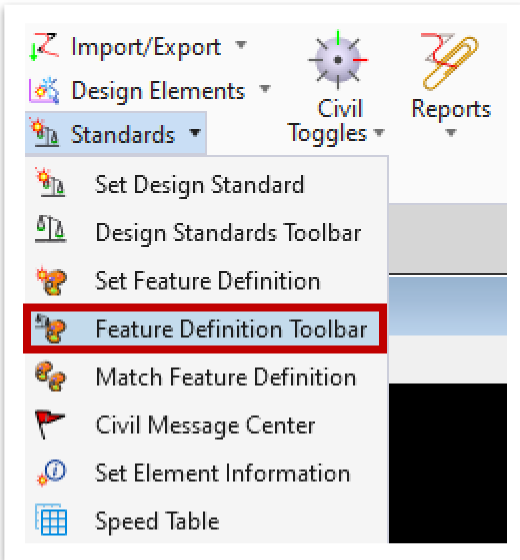
17. Now that the large **Primary** group is pinned to every tab, you can remove the simplified **Primary** tool group that was in most of the tabs by default. **Right** click on any tool group and select **Customize Ribbon**.

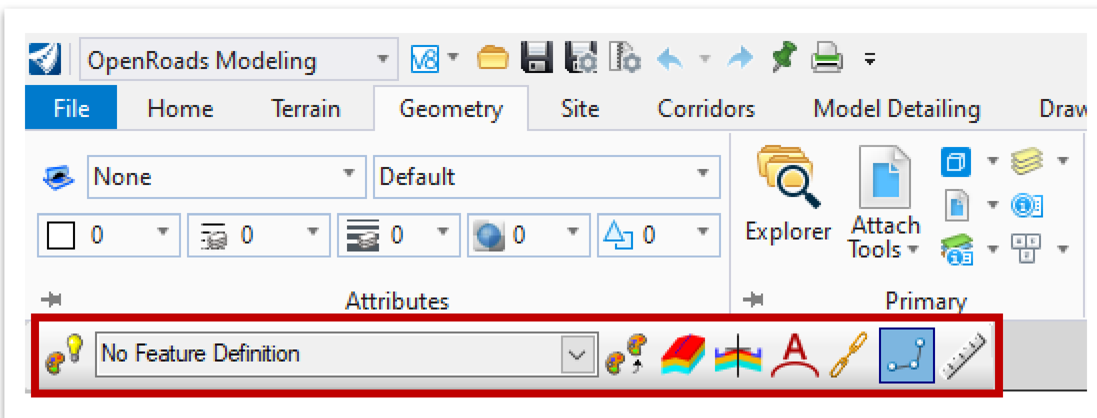


18. Within the **Customize Ribbon** window, go to the **Customize the Ribbon** section and **right** click on **Primary** (**OpenRoads Modeling >> Geometry**) and select **Remove**. Notice that the folder is now marked out indicating the simplified **Primary** tool group has been removed from the **Geometry** tab. Click **Apply** and then **Close** the **Customize Ribbon** window. Click on the **Geometry** tab and notice only one **Primary** tool group is shown. **Note:** You can apply this removal to other tabs if desired. For now, we will leave the simplified properties shown on the other tabs.

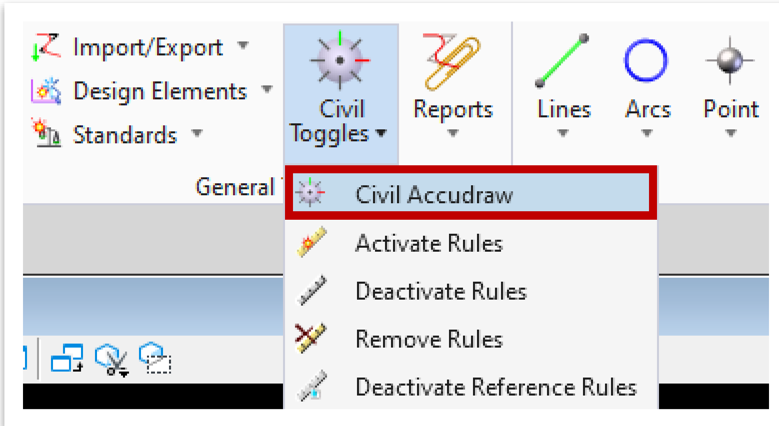


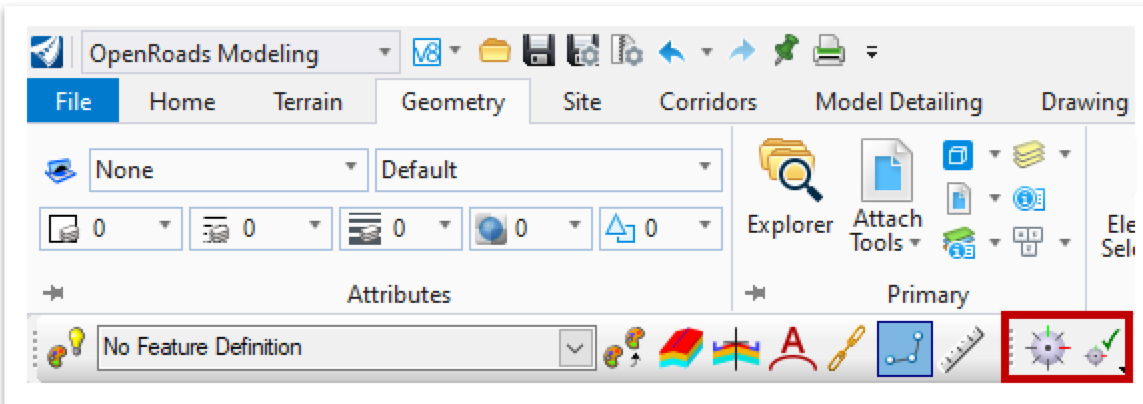
19. Next, open the **Feature Definition Toolbar** (**OpenRoads Modeling >> Geometry >> General Tools >> Standards**). **Left** click and drag the toolbar below the main ribbon to dock it, as shown below. **Note:** This tool, as well as others, can also be located by using the **Search Ribbon** in the upper right corner of the screen.



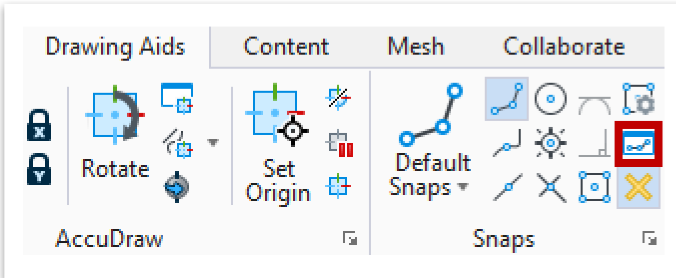


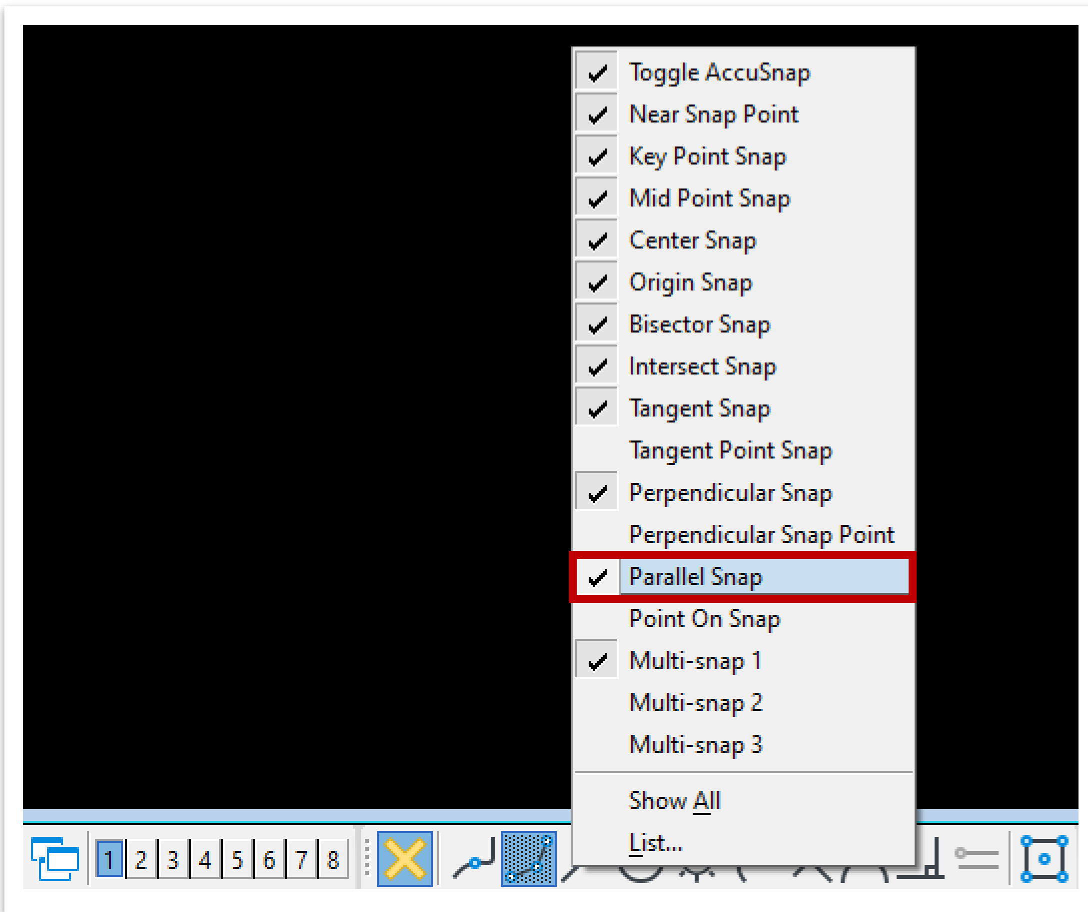
20. Now, open the **Civil AccuDraw** tool (**OpenRoads Modeling >> Geometry >> General Tools >> Civil Toggles**). **Left** click and drag next to the **Feature Definition Toolbar** to dock it, as shown below.



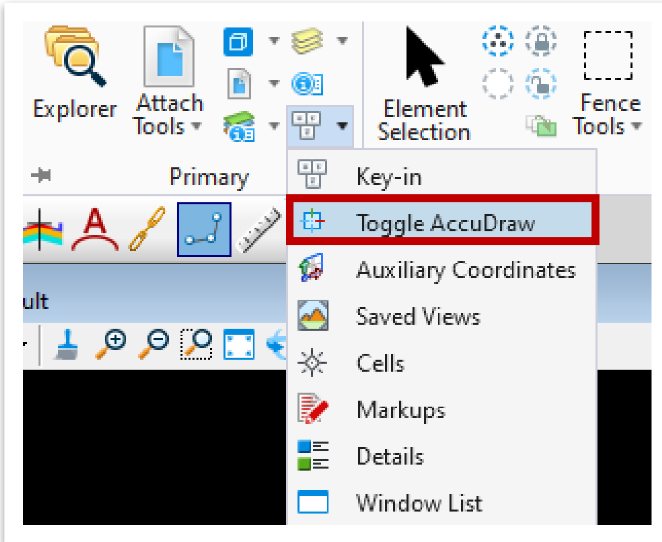


21. The **Snap Mode** toolbar should be docked by default. If not, you can switch to the **Drawing** workflow and access it under **Drawing >> Drawing Aids >> Snaps** or by searching for it in the **Search Ribbon**. Go ahead and dock it at the bottom of the screen by left clicking and dragging the toolbar. Toggle on the **Parallel Snap** option within the **Snap Mode** toolbar by right clicking within the toolbar.

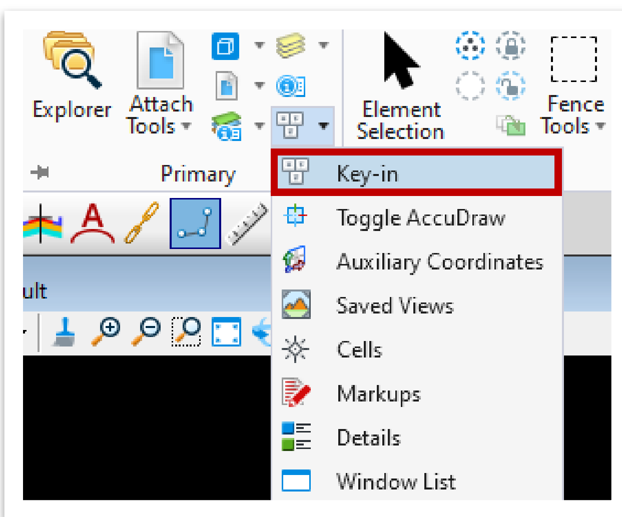




22. If you switched to the **Drawing** workflow in the previous step, go ahead and switch back to the **OpenRoads Modeling** workflow and open the **Toggle AccuDraw** tool (**OpenRoads Modeling >> Home >> Primary >> More**). **Left** click and drag next to the **Snap Mode** toolbar at the bottom of the screen. **Note:** The toolbar will disappear if **AccuDraw** is toggled off and reappears if turned back on.



23. Lastly, open the **Key-in** tool (**OpenRoads Modeling >> Home >> Primary >> More**). **Left** click and drag next to the **AccuDraw** toolbar at the bottom of the screen.



Chapter 3. Advanced Modeling

This chapter will discuss the available tools within ORD that are used to control anything modeled with a template drop.

3.1 Objectives

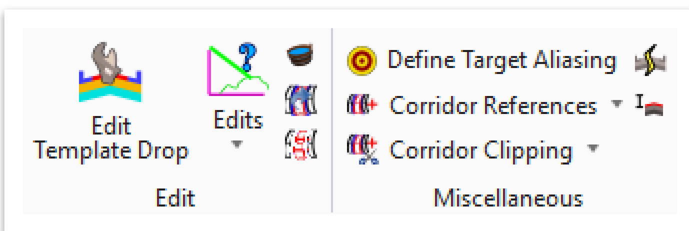
At the conclusion of this chapter, participants will be able to:

1. Understand model control.
2. Locate and manipulate model control tools.

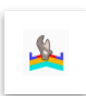
3.2 Lecture: Model Control

In general, roadway designers **should not** draw corridor and model elements by hand, but rather use **elements** and **constraints** to force the model to react as desired. Model control allows a user to manipulate a template to behave in certain ways in both **2D** and **3D** at the same time. The **Model Control** tools are located under the **Edit** and **Miscellaneous** tools located here: **OpenRoads Modeling >> Corridors** (Figure 1).

FIGURE 1. MODEL CONTROL TOOLS



The **Model Control** tools are discussed further below, including an example of each:

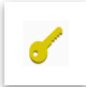


<u>Edit Template Drop</u>: Used to make edits that affect the entire template drop. This is the easiest form of model control.

- *<u>Example</u>: Changing the Horizontal Constraint on PSH_R from 4 feet to 8 feet to accommodate a buffered bike line on the shoulder.*

<u>Create End Condition Exception (located under the Edits tool)</u>: Used to manually control or replace an end condition along the template drop. It is based off a station range and can be either an override or a transition.

- *<u>Example</u>: Deleting the end condition from the template where a large cut exists, so you can model a proposed retaining wall.*



<u>Create Key Station (located under the Edits tool)</u>: Manually tells the software to process a cross section (template drop) at a specific location. In general, the template drop interval is **25** feet in tangent sections, and calculates off cord lengths in curves, so this tool is used to control things between those drops. Remember, everything between a template drop is an **extrusion**.

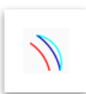
- *<u>Example</u>: Making a template end condition target a box culvert wingwall at the beginning and end of the wingwall.*

<u>Create Secondary Alignment (located under the Edits tool)</u>: Used to modify the direction of cross section processing, so they are orthogonal to the secondary alignment instead of the mainline alignment.

- *<u>Example</u>: Processing an exit ramp cross section on an interstate.*

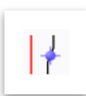
<u>Create Parametric Constraint (located under the Edits tool)</u>: To use this tool, a label must be placed on a specific constraint in the template drop. Then, specific values can be inputted to modify the template over a specific station range.

- *<u>Example</u>: Using the label LNA_R Width to change the width of a lane from 12 feet to 11 feet.*



<u>Create Curve Widening (located under the Edits tool)</u>: Runs on a preset table based on **design speed** and **curve radii**.

- *<u>Example</u>: Adding curve widening to accommodate certain design vehicles.*

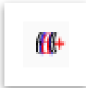


<u>Create Point Control (located under the Edits tool)</u>: To use this tool, a linear element must be drawn that is not constrained or related to the elements drawn by the template drop. This would create a recursive constraint.

- *<u>Example</u>: Adding a turn lane at an intersection by controlling the EOP_L point horizontally utilizing the feature definition Prop EOP - CTRL and a range of 20.*

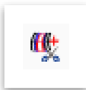
<u>Define Target Aliasing</u>: Used to constrain end conditions to one another and to prioritize the solution order of end conditions to multiple terrains or objects.

- *<u>Example</u>: For driveways, tying the driveways end condition to the proposed corridor first, and then the existing ground.*



<u>Corridor References (Add/Remove)</u>: Must be linear elements that **are not** related or constrained to the corridor. These must be tied to the exact feature definition that the template drop is searching for.

- *<u>Example</u>: For Guardrail Terminal Pad Slope creation, the roadway templates are set up on the EPD point with a horizontal feature constraint to search for the feature definition (Pad Slope Line Control). Once a linear element is drawn with this control and added as a corridor reference, the model will automatically update and follow the linear element.*



<u>Corridor Clipping (Add/Remove)</u>: Allows you to **trim** and **mask** parts of the corridor based on other elements. **Note:** Only the **3D** model is changed.

- *<u>Example</u>: Clipping the mainline corridor for an intersection civil cell.*

All **model control** feature definitions can be found under **Linear >> Roadway >> Model Control - 2D Plan**.

Chapter 4. Placing Pavement Markings

Within ORD, all **pavement markings** are drawn to scale with reference to the current TDOT and MUTCD standards. This chapter will discuss how to place the new pavement marking line styles, as well as, how to stencil them into the 3D model, if desired.

4.1 Objectives

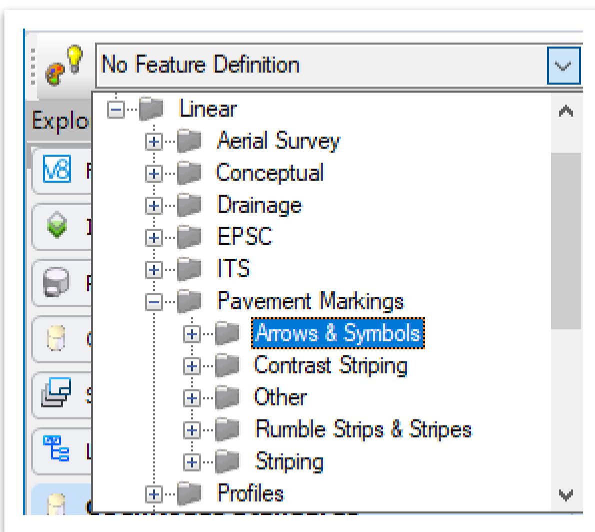
At the conclusion of this chapter, participants will be able to:

1. Place pavement marking feature definitions.
2. Stencil 2-D pavement marking elements into the 3-D model.

4.2 Lecture: Pavement Markings Overview

Pavement markings in ORD are set up using feature definitions to determine line styles and placement, including arrows and symbols (Figure 2). All pavement marking feature definitions are found under the **Linear >> Pavement Markings** folder. Within the folder, there are **five** subfolders (described below) containing the pavement marking line styles, which are all drawn to scale. These line styles align with the TDOT design standards and are setup to print black for plan production. If the user intends to print full color, there are pavement markings setup in the **Linear >> Conceptual >> Pavement Markings** folder.

FIGURE 2. PAVEMENT MARKING FEATURE DEFINITIONS



Arrows & Symbols: Contains arrow and symbol line styles that are setup to be placed at set distances defined by TDOT standard drawings.

Contrast Striping: Contains standard yellow and white striping line styles with black backgrounds, which meet the TDOT standards and spec that may be used on concrete surfaces.

Other: Contains pedestrian crossing, stop bar and yield bar line styles.

Rumble Strips & Stripes: Contains rumble strip and stripe line styles.

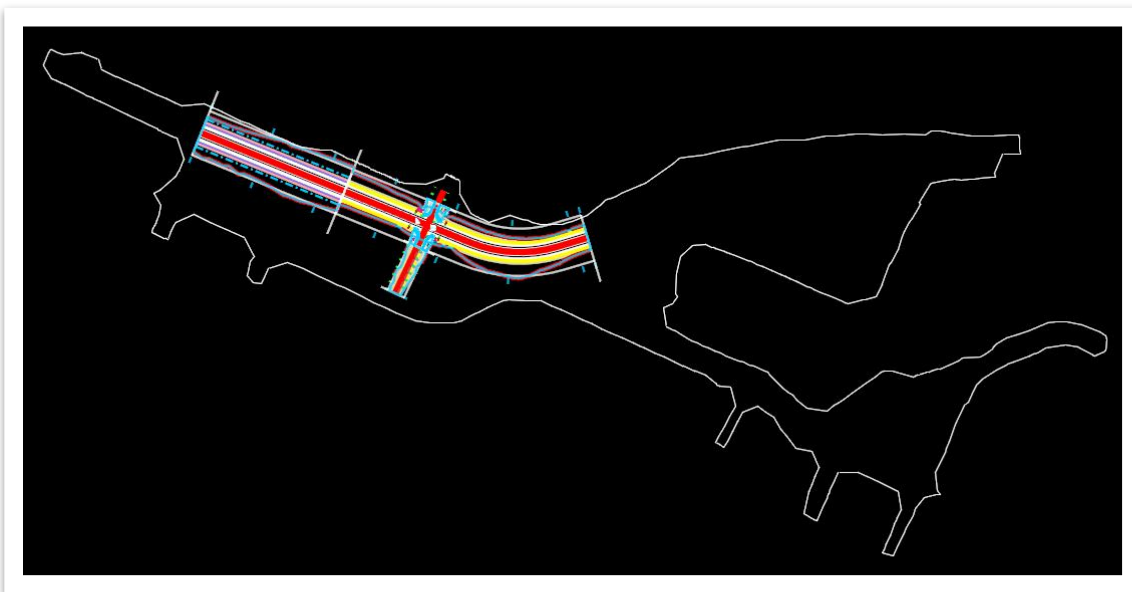
Striping: Contains all standard yellow and white striping line styles.

Pavement markings can be placed by using any of the horizontal geometry line tools. They are not required to be shown in the 3D model and will be submitted as a separate 2D file and referenced into the corridor file(s) like all other supporting files. Therefore, there is no need to profile pavement marking elements. If desired, 2D pavement markings may be stenciled to the surface of the 3D model.

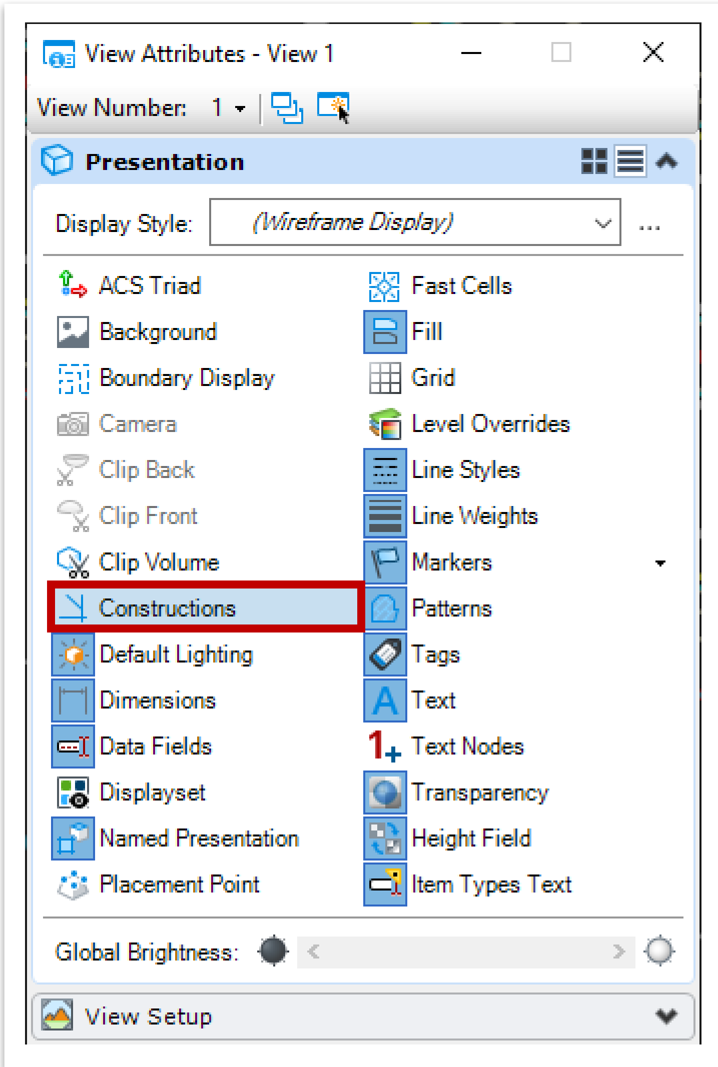
4.3 Exercise: Placing Pavement Markings

In this exercise, we will place the necessary pavement markings for the sample corridor (mainline eastbound lanes and southern intersection approach only).

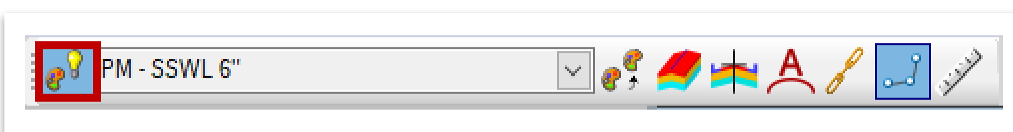
1. Open the **ROAD-II-PM.dgn** file within the dgn Chapter 4 subfolder. You should get a **WorkSet not found Alert**, which will occur anytime you open a class file for the first time since the files were not created under your unique workset. Select the **Use active Workspace "TDOT_Standards", WorkSet "123456.00_ *your initials*"** option and then click **Open**. **Note:** Remember to select this option for the other exercises in this manual when prompted.
2. Make sure that the **Default** view is active in the lower left corner. The following files should already be referenced in the 2D view.
   - ROAD-II-PM-Alignments.dgn
   - ROAD-II-PM-Corridor.dgn
   - ROAD-II-PM-Terrain.dgn
3. Click **Fit View** to see all elements within the reference files. Make sure the existing triangles are turned off on the terrain, if not already. The file should contain two corridors, each with a different type of template. The intersection should contain two civil cell T-intersections and curb ramp civil cells.



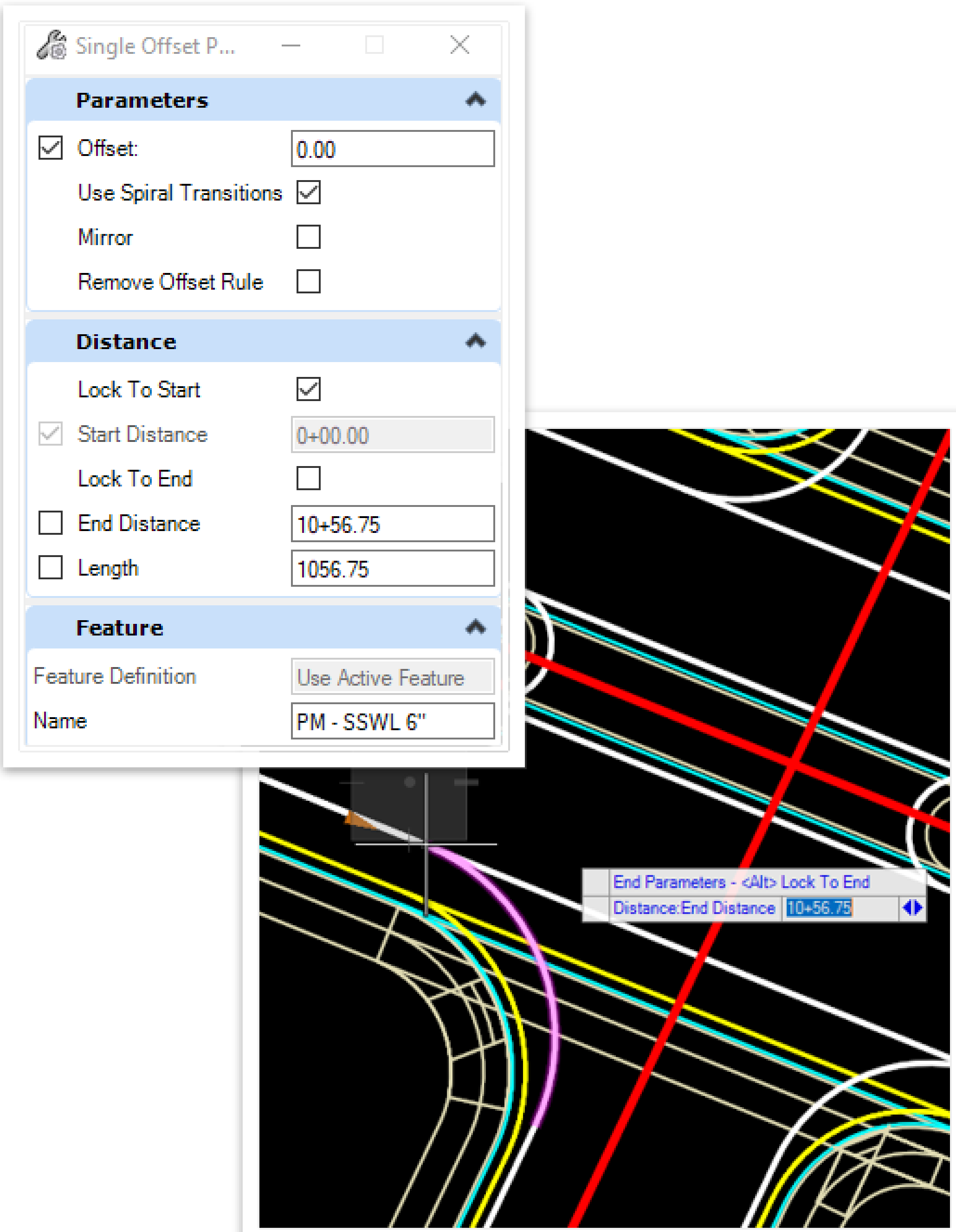
4. Open the **View Attributes** tool (**OpenRoads Modeling >> View >> Presentation**) or **CTRL + B** and turn off the **Constructions** option.



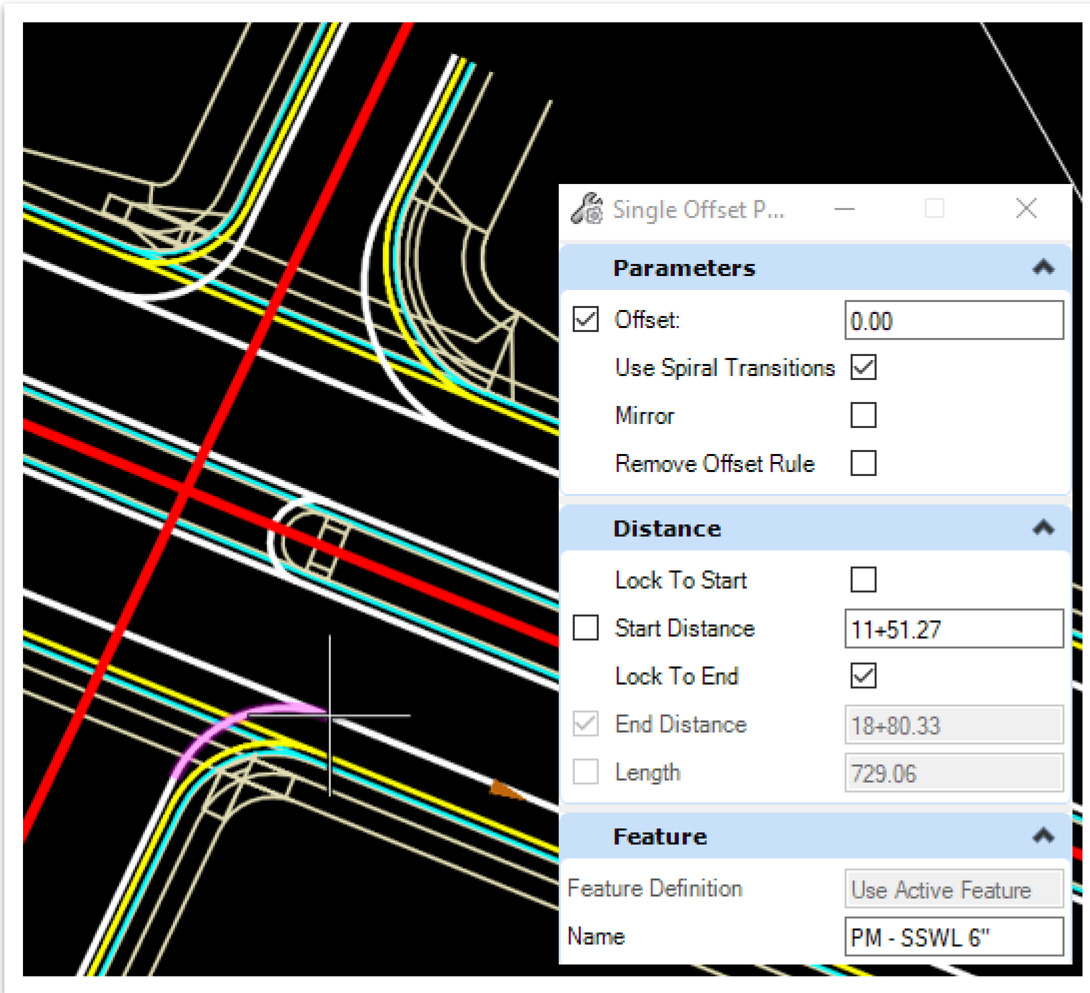
5. Open the **Level Display** and turn off the **DES - CORRIDOR GRAPHICS - Controls**, **DES - CORRIDOR GRAPHICS - Design**, **DES - MODEL - Lines - Cut Slopes**, and **DES - MODEL - Lines - Fill Slopes** levels within the **ROAD-II-PM-Corridor.dgn** file.
6. Now, we will place the lines that will go throughout the corridor. First, select the **PM - SSWL 6"** feature definition (**Linear >> Pavement Markings >> Striping**). Make sure to toggle on **Use Active Feature Definition**.



7. Open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and then select the **EOP_R** for the **mainline** corridor. Key-in an **Offset** of **0'** and toggle on **Lock To Start**. All other settings can remain as default. Then, snap to the intersection **EOP** with the **Side Road** corridor to determine the **End Distance**. **Note:** Ignore the **6" Lines** section (item type) within the dialog box.

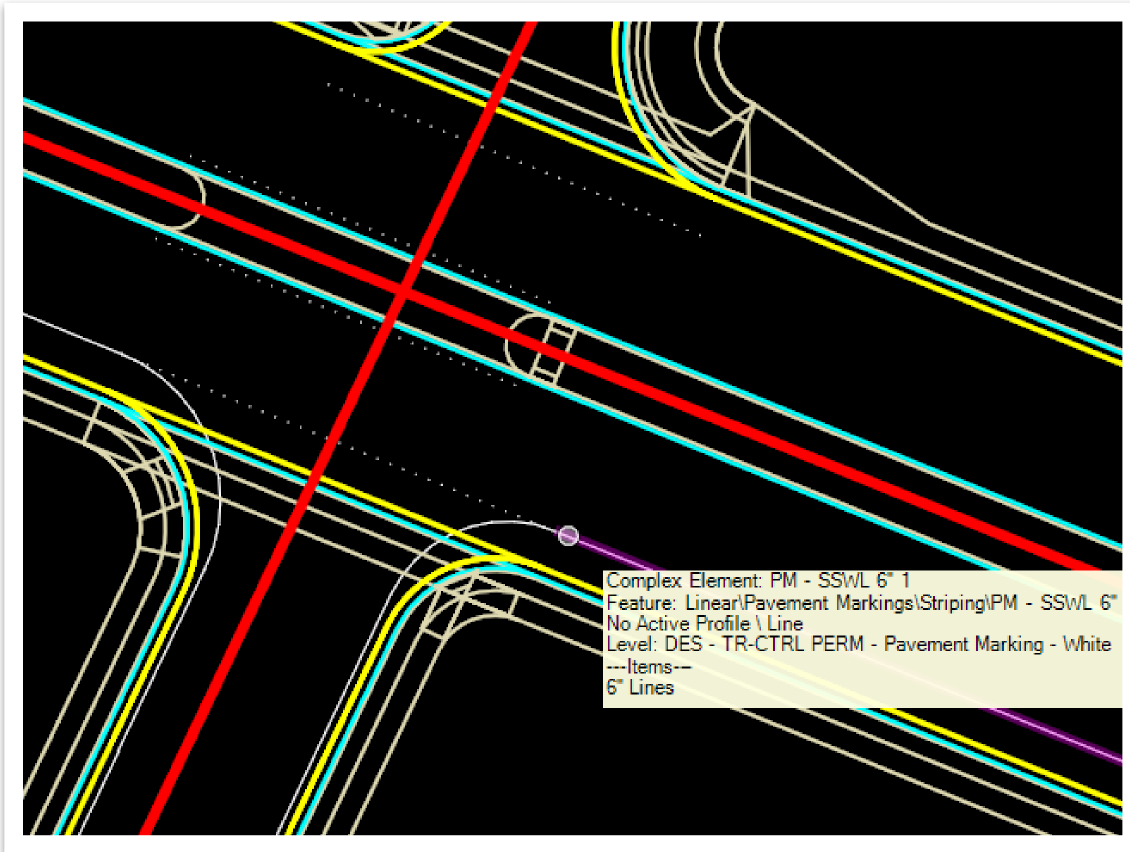


8. With the **Single Offset Partial** tool **still open** (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**),select the **EOP_R** line that was selected in the previous step. Snap to the other side of the intersection **EOP** line as the start, and then toggle on **Lock To End**.

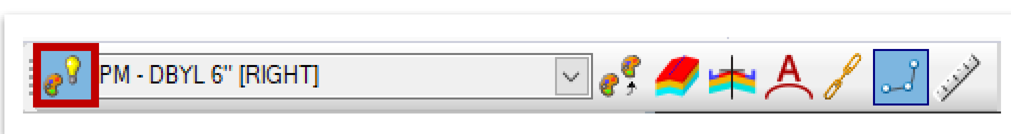


9. Next, open the **Single Offset Entire Element** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**). Set the **Offset** to **0** and select the two civil cell **EOP** lines and the side road template drop **EOP** lines to create the <u>white</u> striping on the sideroad. There should now be a total of **6** offset lines: two on the eastbound mainline outside edge, two for the south civil cell EOP's, and two for the south sideroad corridor EOP's.

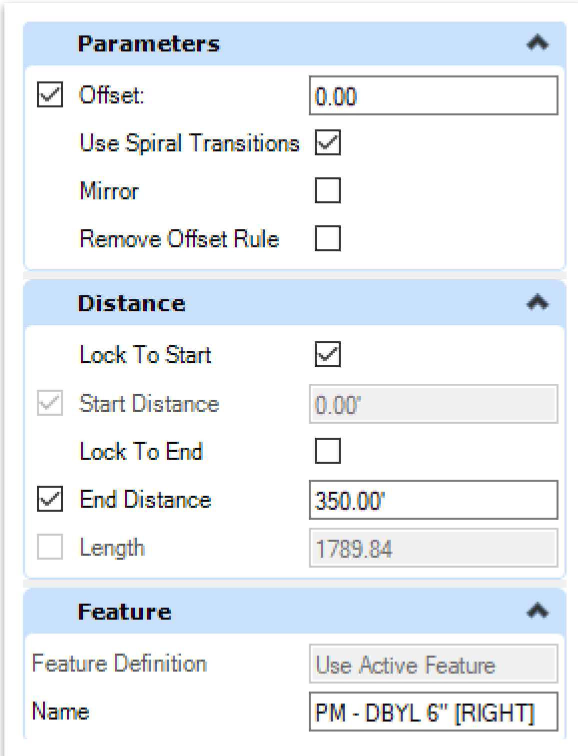
10. To check if all lines are properly placed, turn off the **EOP** level (**DES - MODEL - Lines - Pavement Edge**) within the **ROAD-II-PM-Corridor.dgn** reference file. **Note:** The placement of pavement markings is done in the **2D** model exclusively. The placement of these lines in 3D will not be done until all pavement markings have been placed.

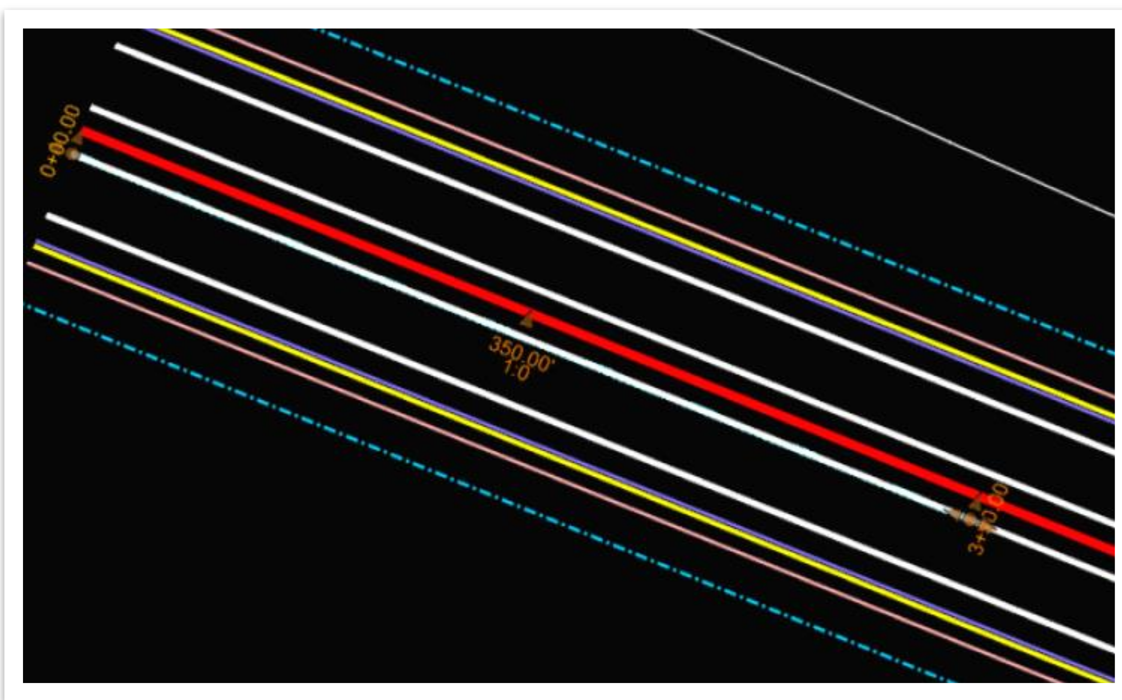


11. Go ahead and turn the **DES - Model - Lines - Pavement Edge** level back on. We are going to place the inside yellow lines along the eastbound lanes of the mainline corridor. First, locate the **5-lane** section of the main corridor at the beginning of the stationing. The first section of striping will be without the bi-directional markers. Select the **PM - DBYL 6" [RIGHT]** feature definition (**Linear >> Pavement Markings >> Striping**).

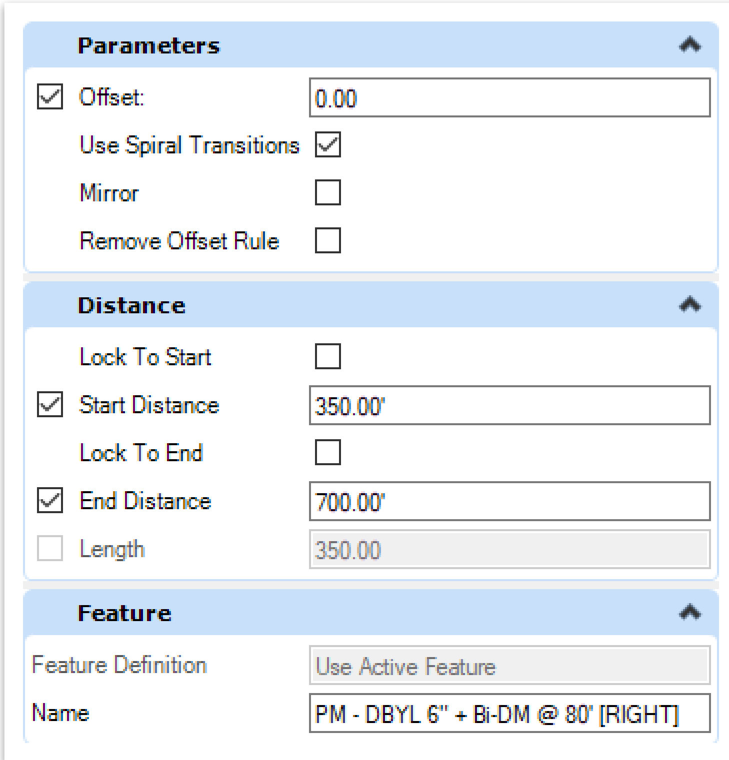


12. Open the **Single Offset Partial** tool once again. Set the **Offset** to **0'** and select the start of the inside **EOP** for the eastbound side of the corridor. Extend this line **350'** (halfway) down the corridor.

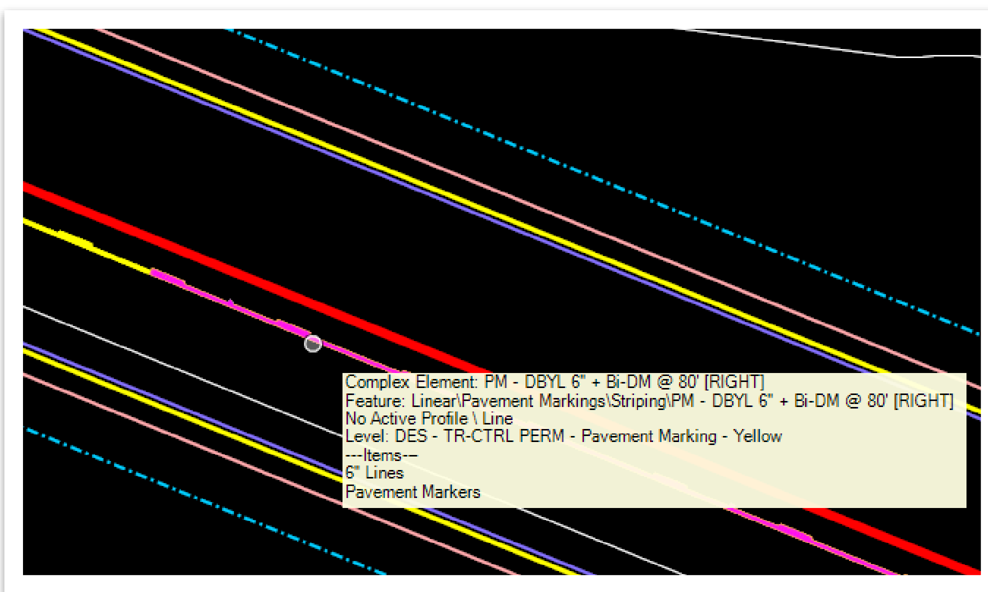




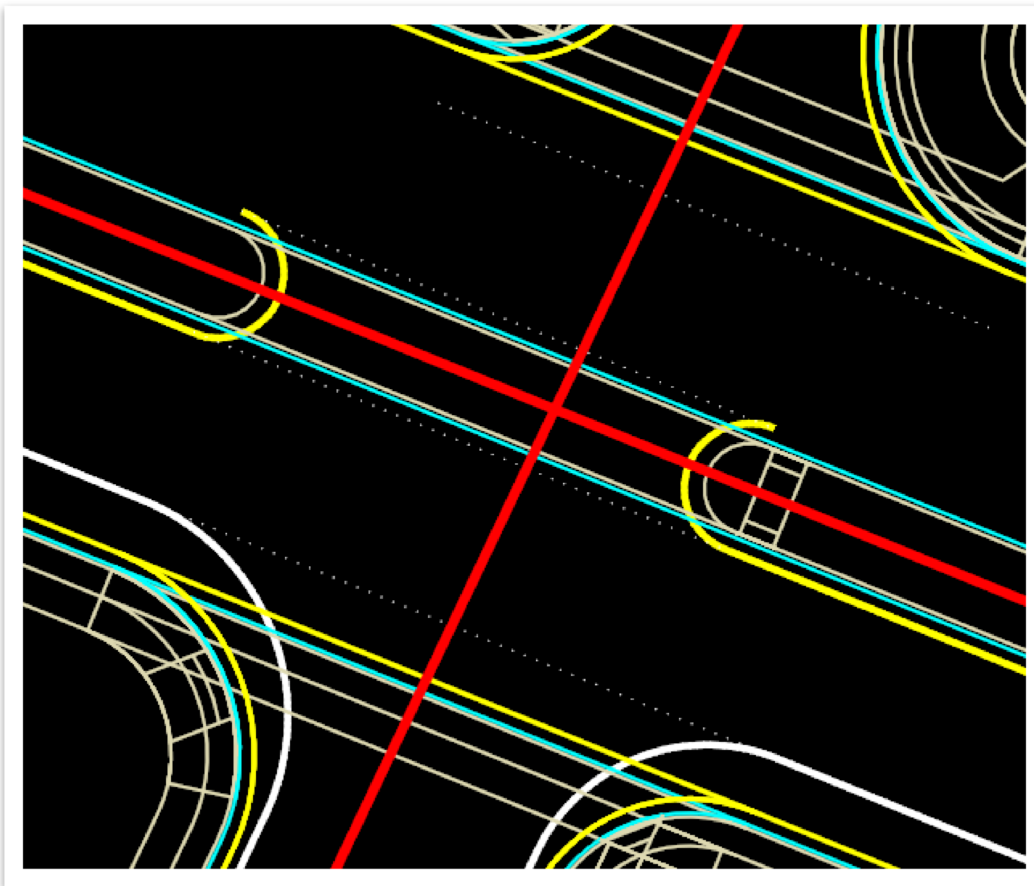
13. Now, select the **PM - DBYL 6" + Bi-DM @ 80' [RIGHT]** feature definition (**Linear >> Pavement Markings >> Striping**) and finish placing the remainder of the right inside yellow lines along the 5-lane section. You can determine the start and end location by entering **350'** in the **Start Distance** and **700'** in the **End Distance**. Notice that the line style now has the bi-directional marker embedded.



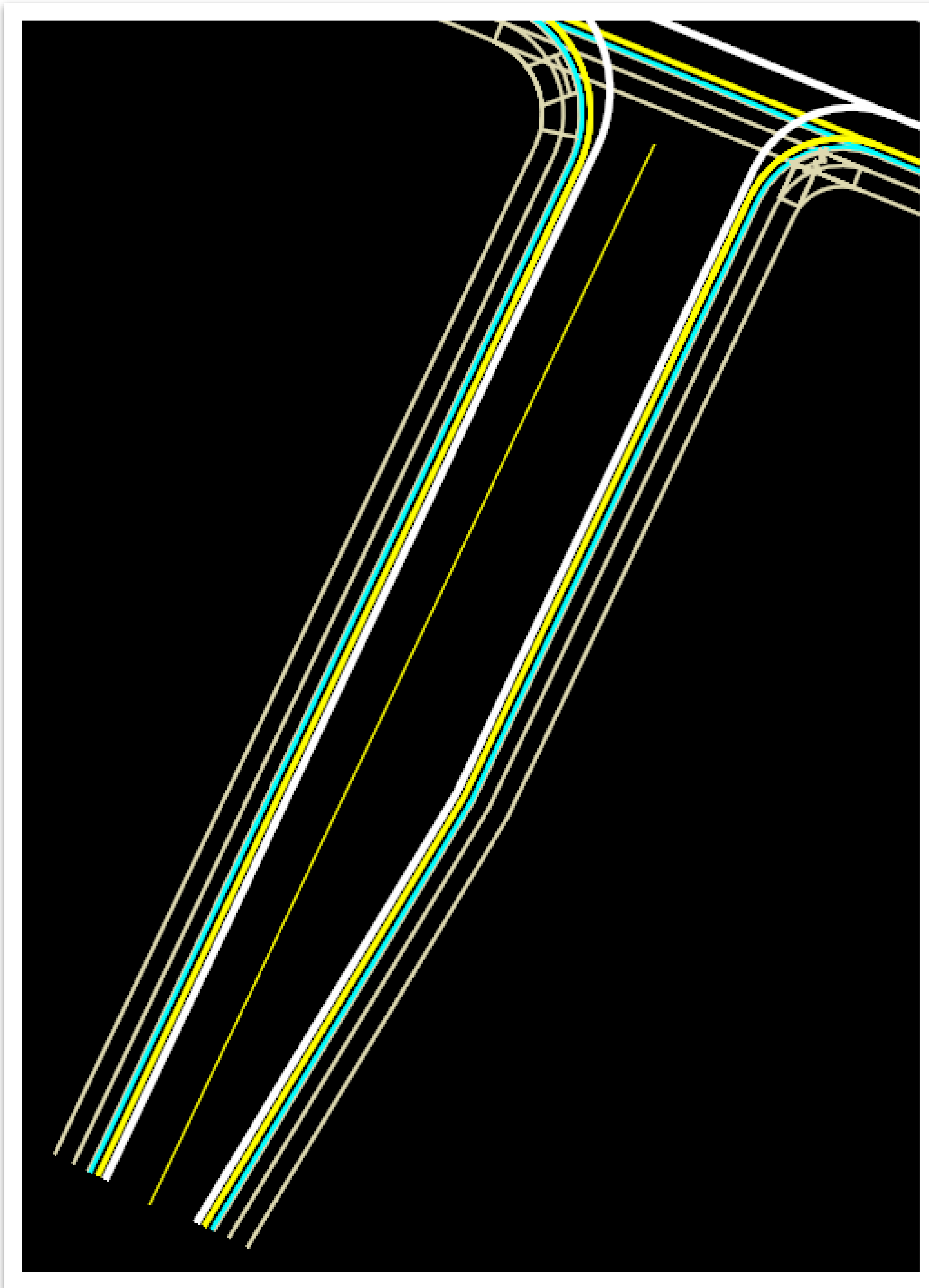
14. Turn off the **EOP** level (**DES - MODEL - Lines - Pavement Edge**) within the **ROAD-II-PM-Corridor.dgn** reference file to review the two lines just placed.



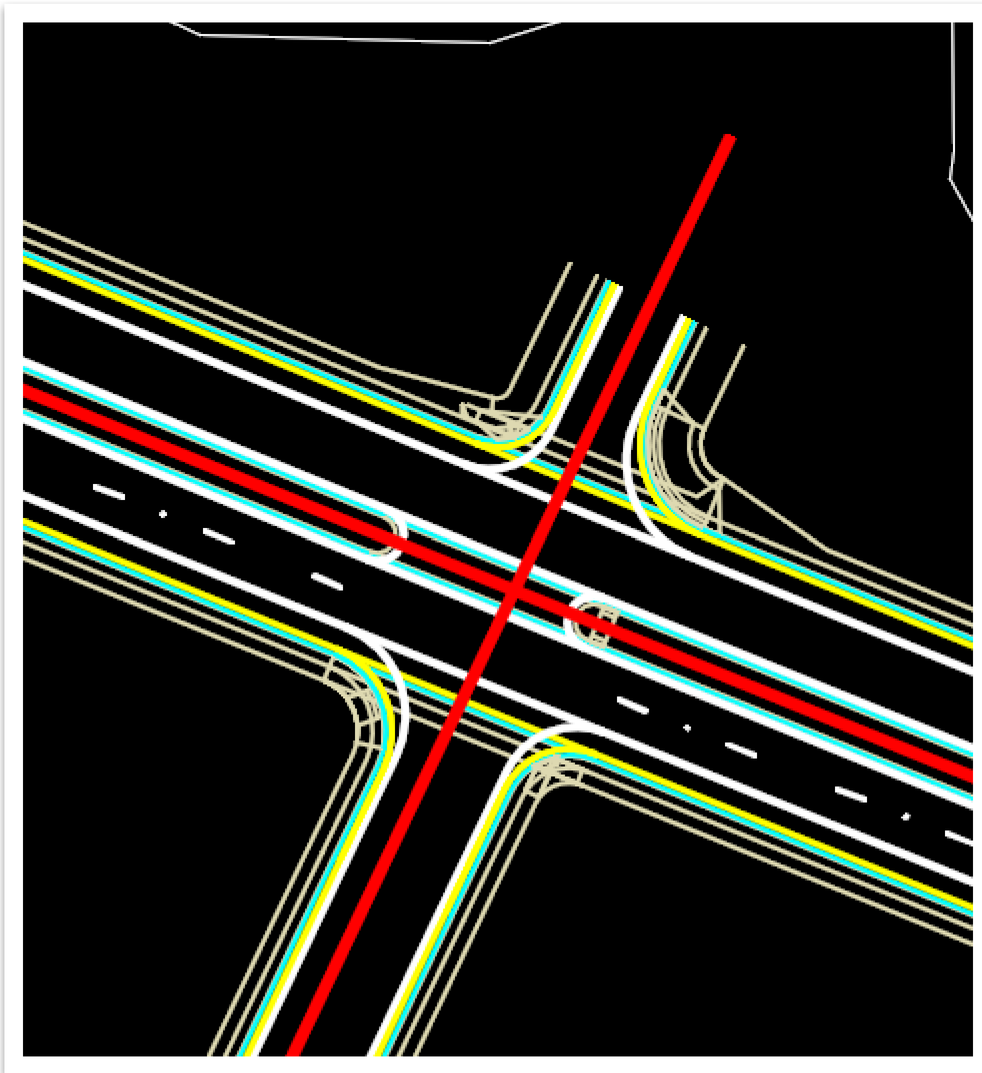
15. Turn the **DES - MODEL - Lines - Pavement Edge** level back on and then select the **PM - SSYL 6"** feature definition (**Linear >> Pavement Markings >> Striping**). Open the **Single Offset Partial** tool once again (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the inside **EOP** line, starting at the end of the 5 lane section and ending at the beginning of the median opening. Repeat the offset by starting at the end of the median opening and ending at the end of the corridor.
16. Next, open the **Single Offset Entire Element** tool once again (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the two **EOP** lines from the median opening. Turn off the **EOP** level (**DES - MODEL - Lines - Pavement Edge**) within the **ROAD-II-PM-Corridor.dgn** reference file to review the four lines just placed.



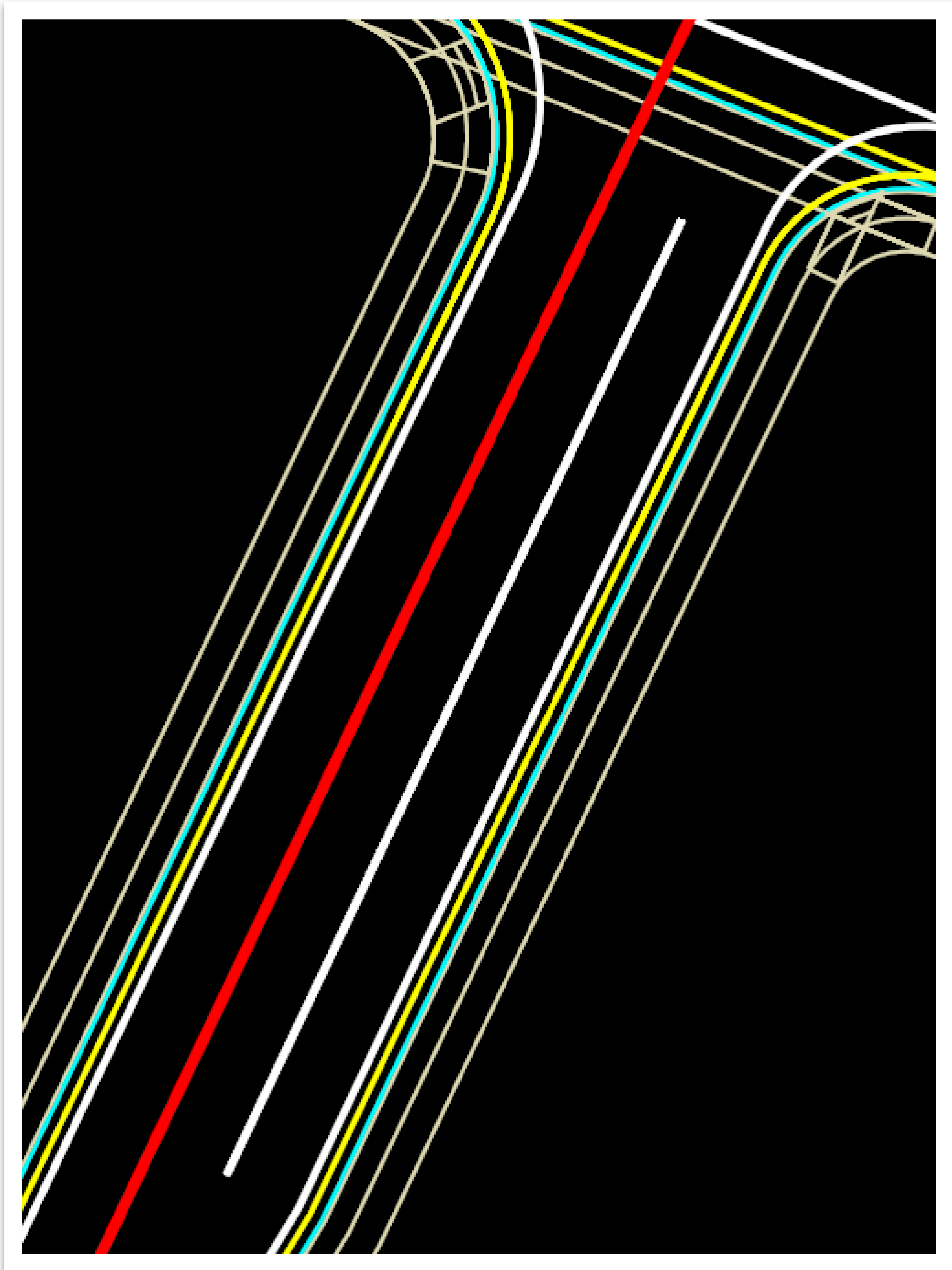
17. Turn the **DES - MODEL - Lines - Pavement Edge** level back on. We will now place the side road centerline striping for the southern approach. Select the **PM - DSYL 6"** feature definition (**Linear >> Pavement Markings >> Striping**). Use the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and offset the centerline of the sideroad alignment. Toggle on **Lock To Start** and key-in an **End Distance** of **2+80**. Turn off the **centerline** level (**DES - CL - Proposed**) within the **ROAD-II-PM-Alignments.dgn** reference file to review the line just placed.



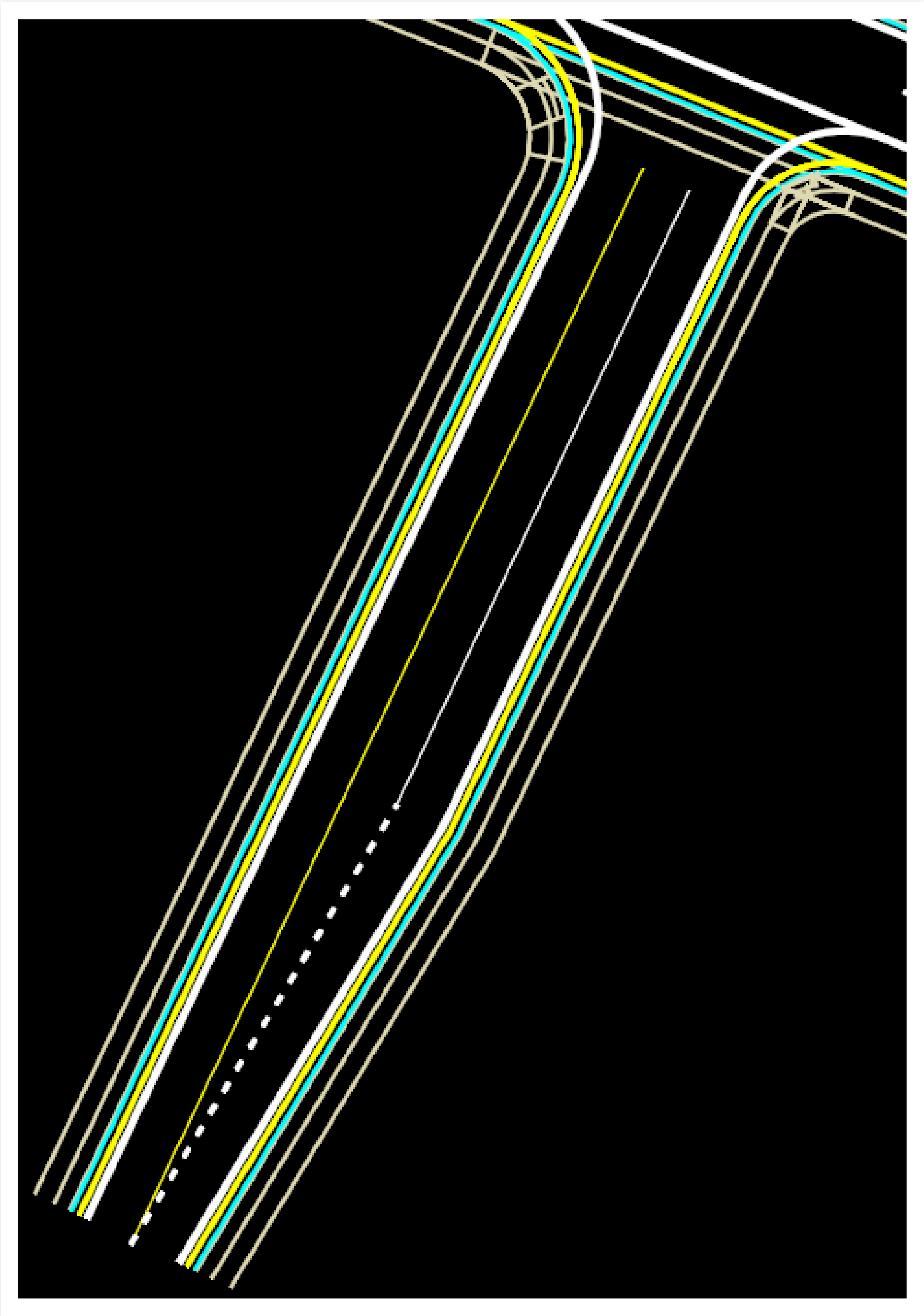
18. Turn the **DES - CL - Proposed** level back on. We will now place the lane markings on the eastbound lanes of the mainline corridor. Select the **PM - SBWL 6" + Bi-DM @ 80'** feature definition (**Linear >> Pavement Markings >> Striping**). Open the **Single Offset Entire Element** tool once again (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the outside solid white pavement markings placed earlier in the exercise for the base element. Set the **Offset** to **12'**.



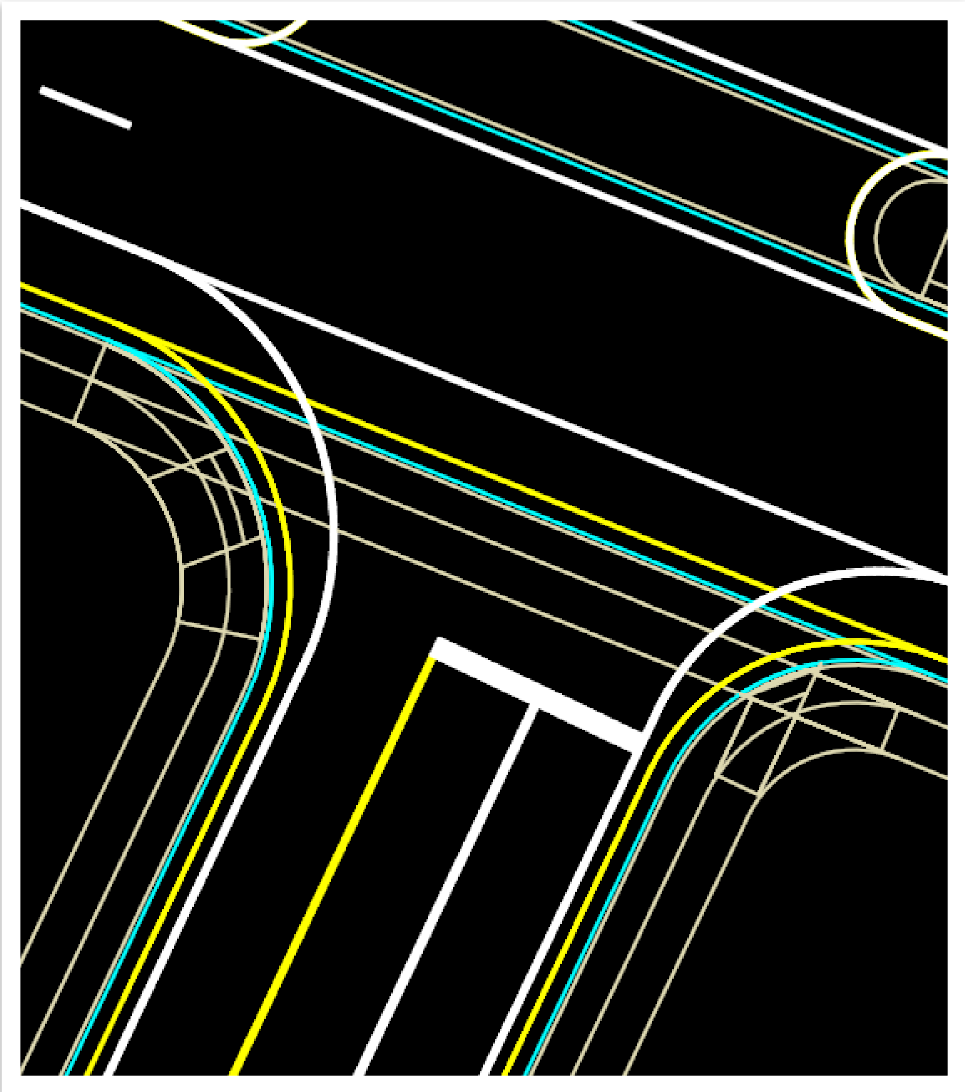
19. The side road (southern approach) is setup to have two lanes: a **left turn only** and a **straight/right turn**. Select the **PM - SSWL 8"** feature definition (**Linear >> Pavement Markings >> Striping**). Open the **Single Offset Partial** tool once again (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the centerline. Set the **Offset** to **12'** and set the **Start Distance** (Station **1+20**) and **End Distance** (Station **2+80**).



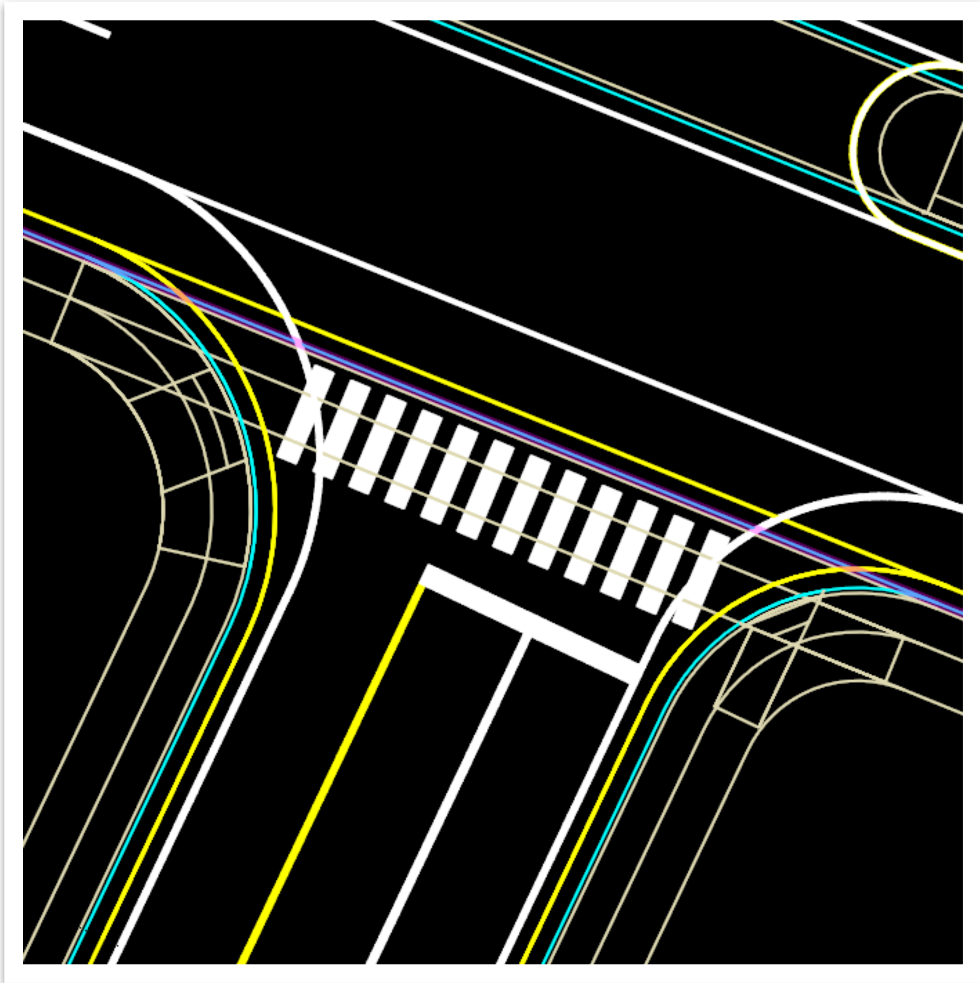
20. Next, select the **PM - SDWL 8" [2'-4']** feature definition (**Linear >> Pavement Markings >> Striping**) and open the **Variable Offset Taper** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**). Select the **Side Road** alignment as the reference. Set the **Start Offset** to **0'** and the **End Offset** to **12'**. Set the **Start Distance** (Station **0+00**) and **End Distance** (Station **1+20**). Turn off the **centerline** level (**DES - CL - Proposed**) within the **ROAD-II-PM-Alignments.dgn** reference file to review the line just placed.



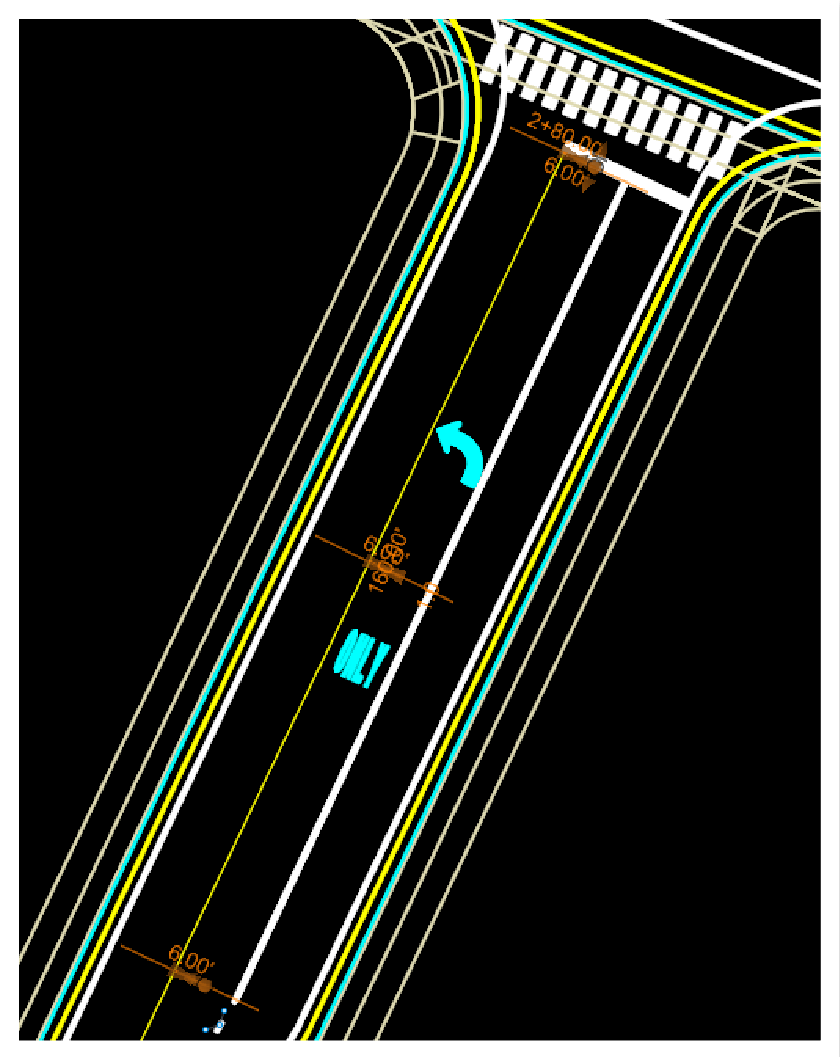
21. Now, we will place the stop bar at the intersection (southern approach). Select the **PM - Stop Bar** feature definition (**Linear >> Pavement Markings >> Other**). Open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and place the stop bar between the double yellow centerline and the right EOP, as shown below. After placement, you can select the stop bar and adjust it using the **Move** handles, if necessary.



22. Next, we will place a crosswalk across the southern approach of the intersection. Select the **PM - Cross-Walk Longitudinal** feature definition (**Linear >> Pavement Markings >> Other**). Using the **Line Between Points** tool, place the crosswalk, as shown below. **Note:** The curb ramps have already been placed.



23. Lastly, we will place a **left turn** arrow and the corresponding **ONLY** symbol on the side road (southern approach). Select the **PM - Left Turn Only** feature definition (**Linear >> Pavement Markings >> Arrows & Symbols**) and, using the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**), offset **6'** from the double yellow marking. Set the start location at the stop bar and end at the beginning of the turn lane. Notice how the symbol is the correct distance from the stop bar. **Note:** If you start at the beginning of the turn lane and end at the stop bar, the direction would be incorrect.



Take Note!

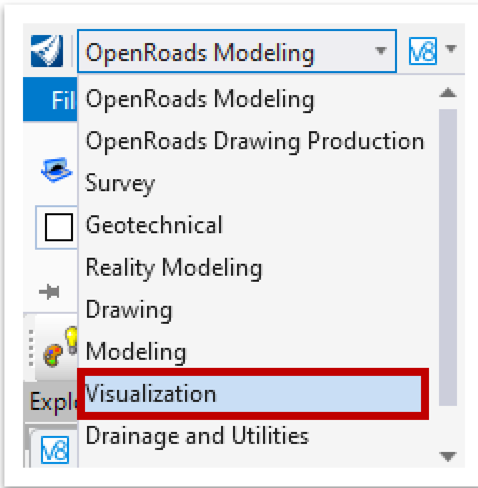
*All intersection arrows and symbols are setup to be drawn **from the stop bar**. This is because the TDOT standard drawings prescribe an offset distance from the stop bar to place pavement markings.*

24. The intent is that the user would utilize the tools in this exercise along with additional feature definitions to fully create the proposed striping for a given project.

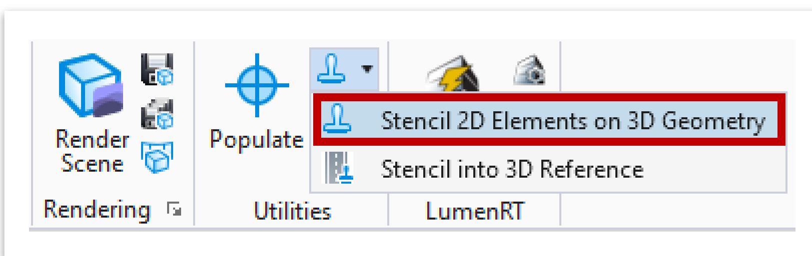
4.4 Exercise: Stenciling Pavement Markings in the 3D Model

In this exercise, we will stencil the pavement markings placed in the previous exercise into the 3D corridor model.

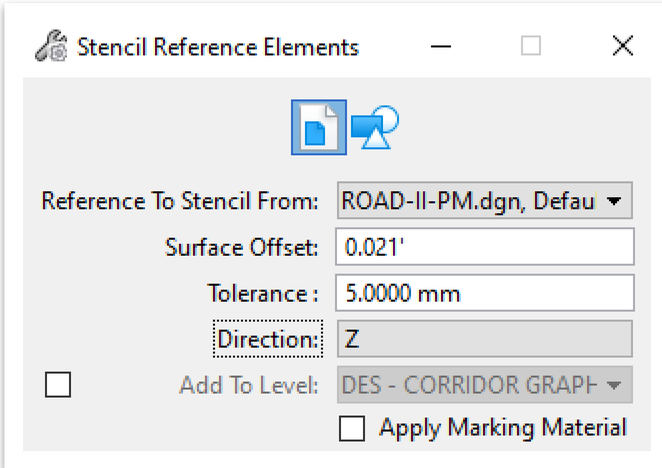
1. Open the **ROAD-II-PM-Corridor.dgn** file within the dgn Chapter 4 subfolder. By default, the 2D and 3D views should be open. Make sure that the **Default-3D** view is active. **Note:** Stenciling will not work if elements are selected within the 2D view.
2. Attach the **ROAD-II-PM.dgn** file as a reference file using the **Coincident World** attachment method. This file contains the 2D pavement markings added in the previous exercise. Make sure the **Default** model is referenced, not the Default-3D model.
3. Go ahead and change the workflow in the upper left corner to **Visualization**. **Note:** If you make the 2D view active, you will not see the Visualization workflow.



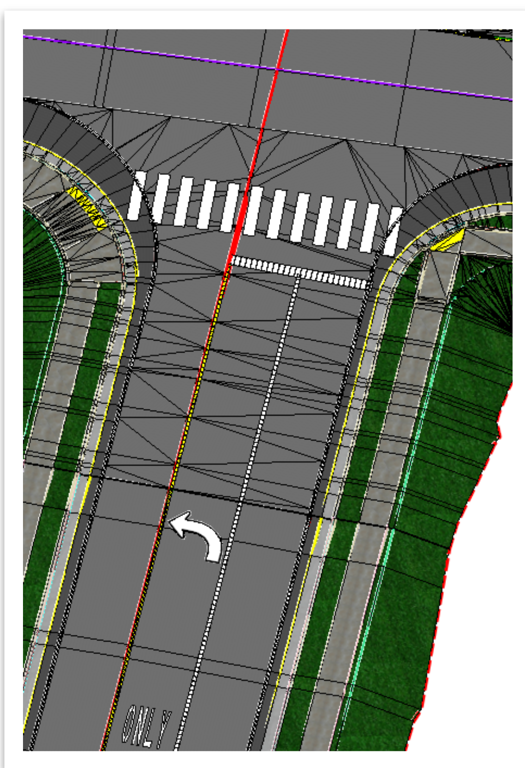
4. Open the **Stencil 2D Elements on 3D Geometry** tool (**Visualization >> Home >> Utilities**).



5. Within the **Stencil Reference Elements** dialog box, set the **Reference To Stencil From** to **ROAD-II-PM.dgn, Default**. Make sure the other settings match what is shown below. Then, **left** click anywhere within the 3D view to accept.



6. Notice the pavement markings now show up on the surface of the 3D model. Currently, Bentley has logged a defect where the surface offset is not applying. As a workaround, open the references for the **3D** model and change the stencil reference **Z** value to **0.1** to create an offset from the surface. **Note:** The construction display setting has been turned off in the screenshot below, which can be accessed in the **View Attributes** tool.



Chapter 5. Haul Roads

Occasionally, projects will require **haul roads** during construction. This chapter will discuss how to model a haul road in ORD.

5.1 Objectives

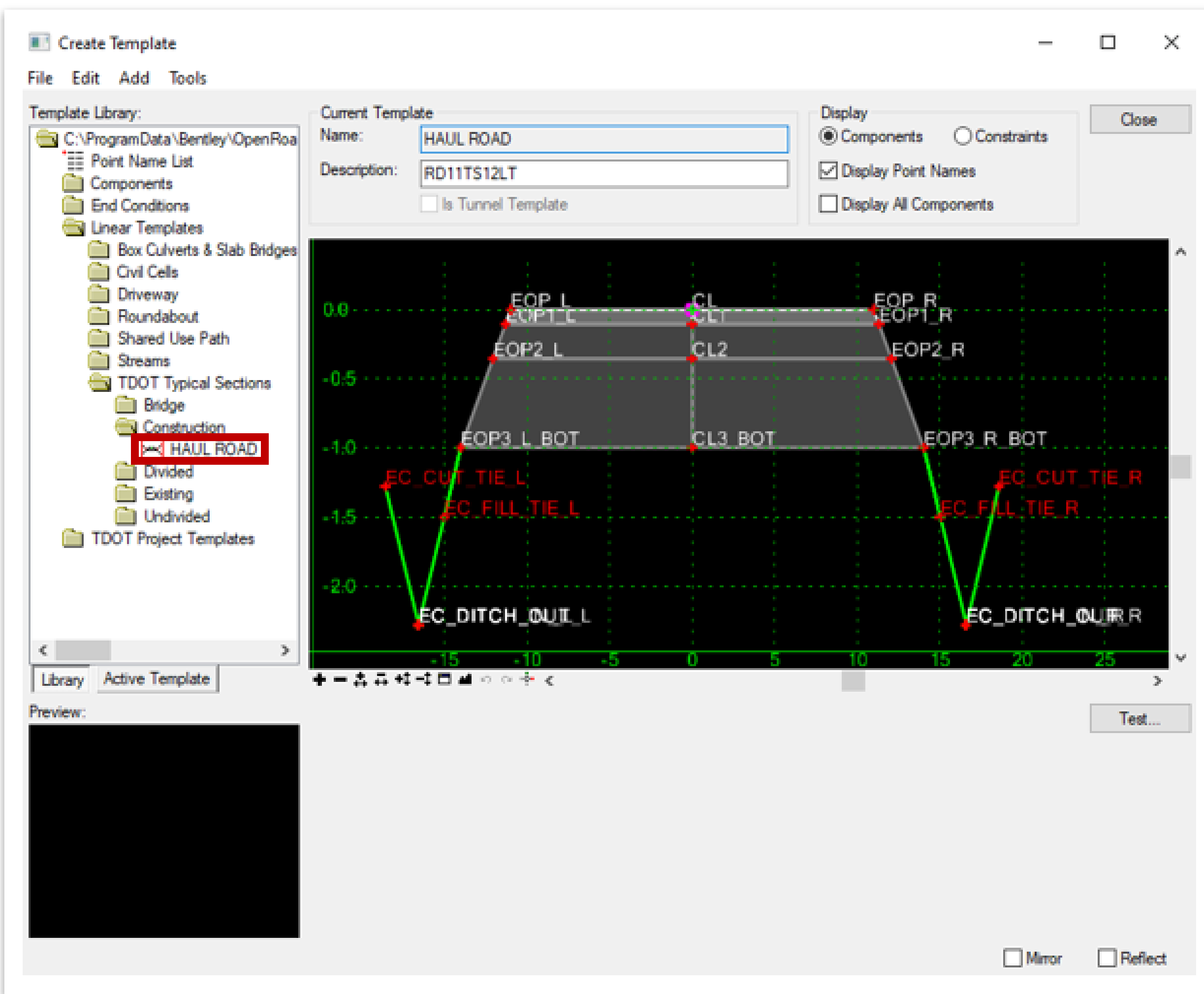
At the conclusion of this chapter, participants will be able to:

1. Model a haul road in ORD.

5.2 Lecture: Haul Roads Overview

Haul Roads are in the form of template drops that are placed along geometry, like any other corridor placement. The haul road must have both a **horizontal** and **vertical** alignment. The **HAUL ROAD** template (**Linear Templates >> TDOT Typical Sections >> Construction**) within the TDOT workspace provides a basic cross section which can be edited by the designer, as necessary, for each individual project (Figure 3).

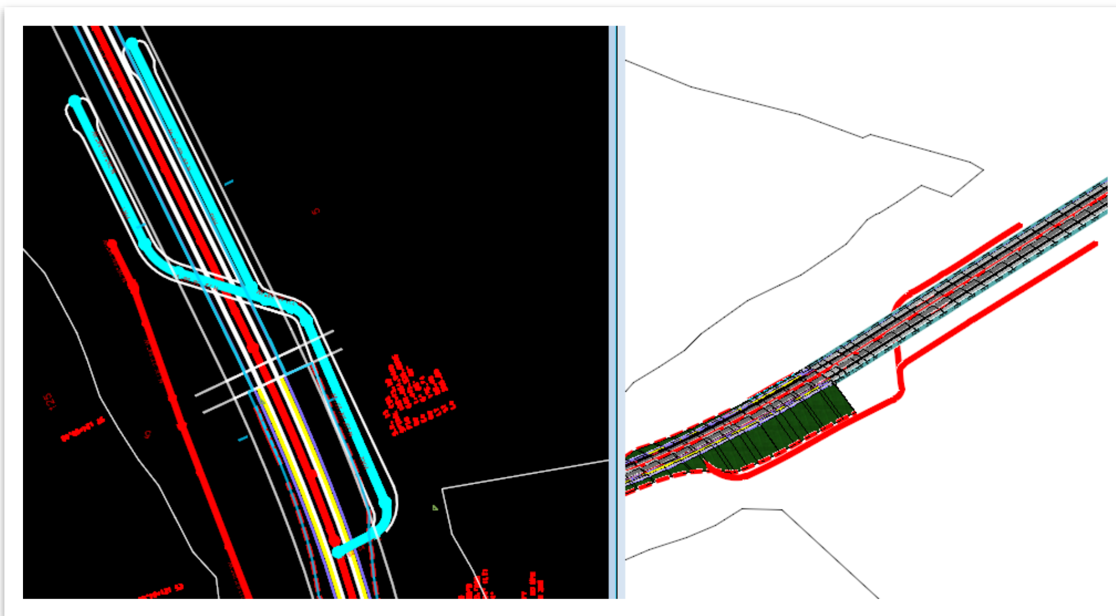
FIGURE 3. HAUL ROAD TEMPLATE



5.3 Exercise: Modeling a Haul Road

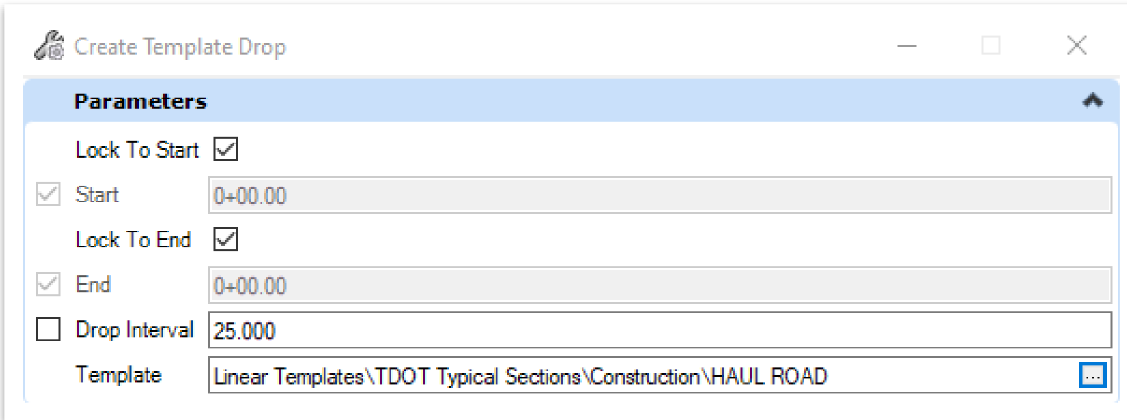
In this exercise, we will create a haul road using the ITL template and geometry tools, and then model the template to match the example project.

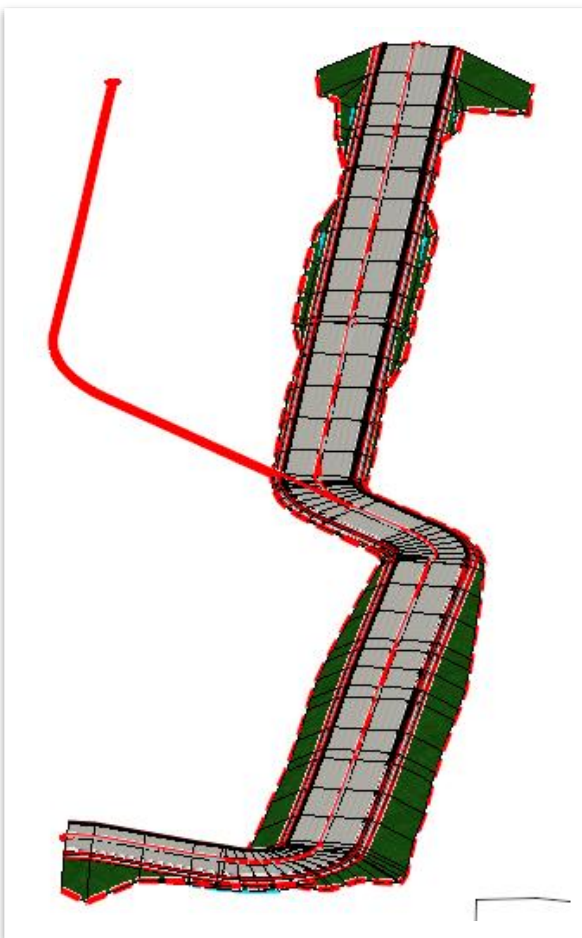
1. Open the **ROAD-II-HR.dgn** file within the dgn Chapter 5 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner. The following files should already be referenced in the 2D and 3D views.
    - ROAD-II-HR-Alignments.dgn
    - ROAD-II-HR-Corridor.dgn
    - ROAD-II-HR-Terrain.dgn (set terrain to active)
2. Locate the mainline alignment within the **2D** model, which also has an attached corridor, and then locate the haul road alignment on the southern approach to the bridge (**HR2**). The haul road alignment should already have an active profile. **Note:** If necessary, refer to Chapter 4, Exercise 4.4.9 and 4.5.9 in the Roadway Design I (ORD) Manual as a reference for how to create the horizontal and vertical civil geometry respectively.



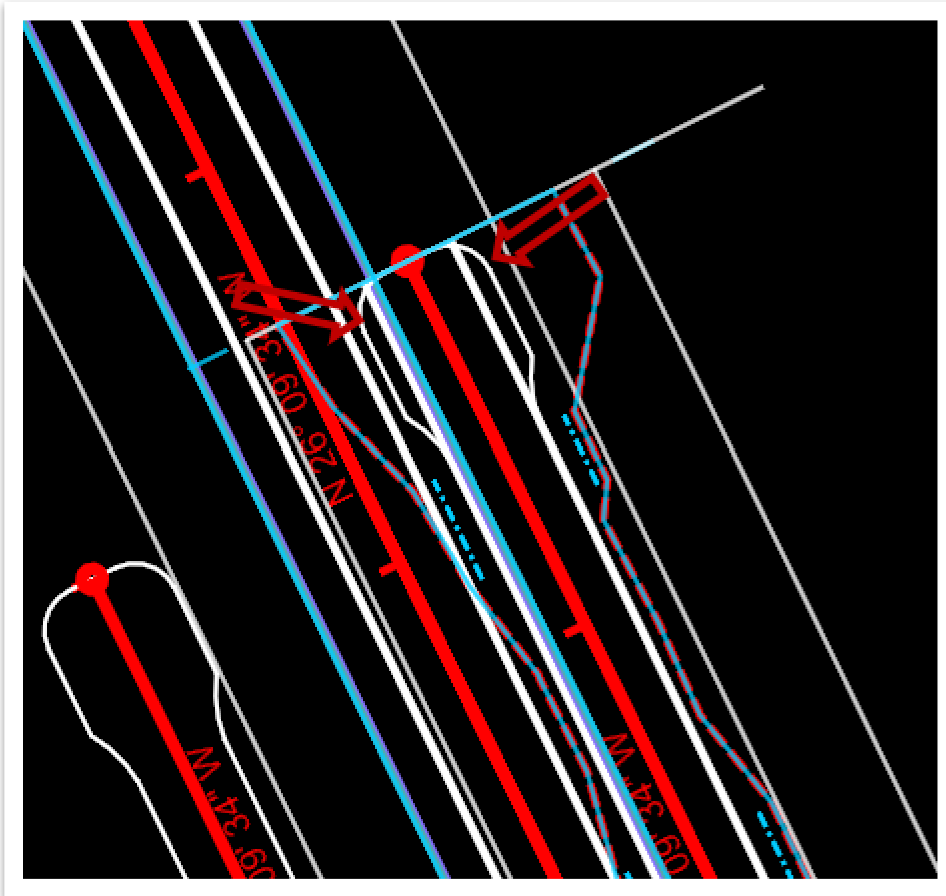
3. Now we can attach a **corridor** to the haul road. Go ahead and turn off the **ROAD-II-HR-Corridor.dgn** reference file in the **3D** view so we can easily see the haul road alignments. We will now place a **corridor** on the **HR2** haul road alignment. With the **2D** view active, open the **New Corridor** tool (**OpenRoads Modeling >> Corridors >> Create**) and select the **HR2** alignment. Set the corridor profile as the **Active** profile and then select the **Final Design** feature definition.

4. The **Create Template Drop** tool should automatically open. If it does not, open the **New Template Drop** tool (**OpenRoads Modeling >> Corridors >> Create**). Toggle on **Lock To Start** and **Lock To End** for the parameters. Then, open the template options by clicking on the 3 dots to the right of the **Template** path name.
5. Select the **HAUL ROAD** template (**Linear Templates >> TDOT Typical Sections >> Construction**) and then click **OK**. Click through the prompts to place the template.

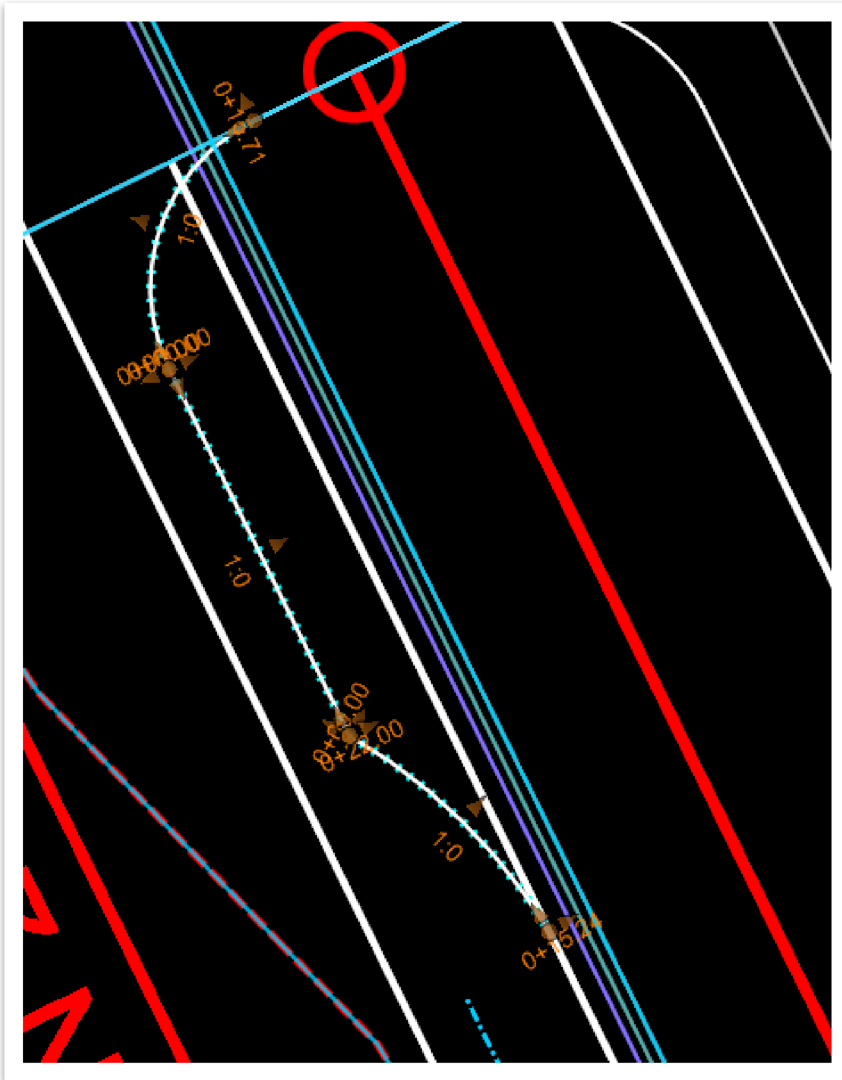




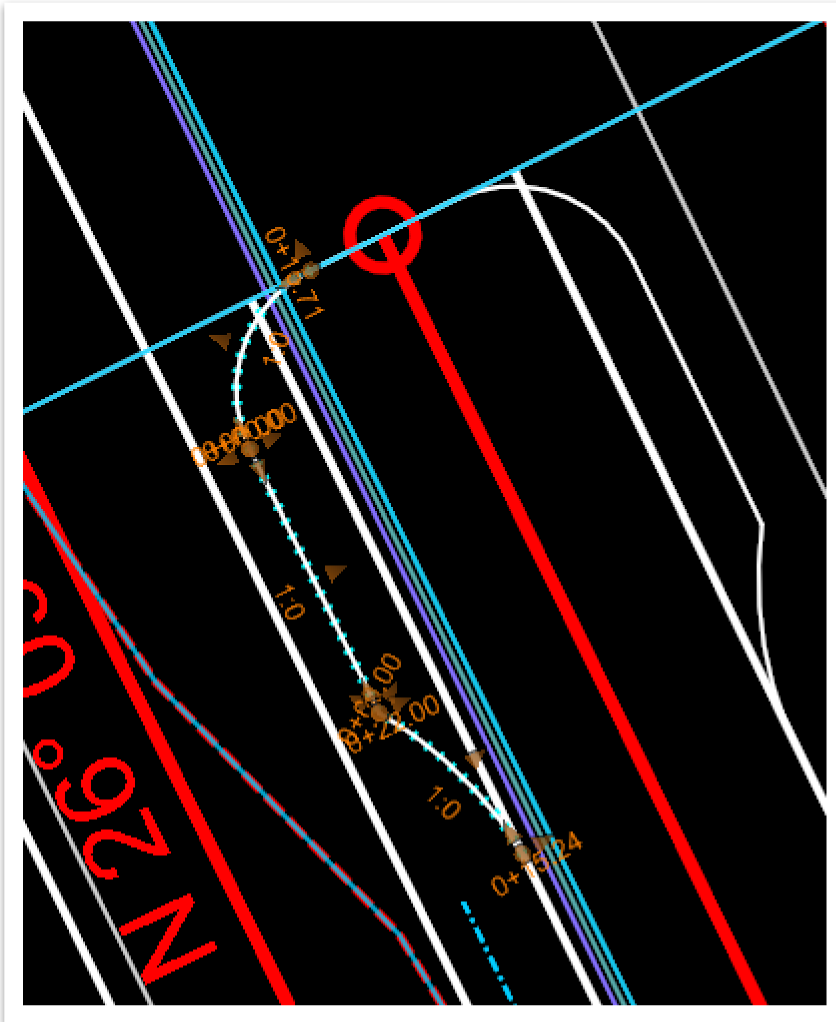
6. We must now create the **bulb outs** at the end of the haul road. Locate the bulb out lines in the **ROAD-II-HR-Alignments.dgn** reference file.



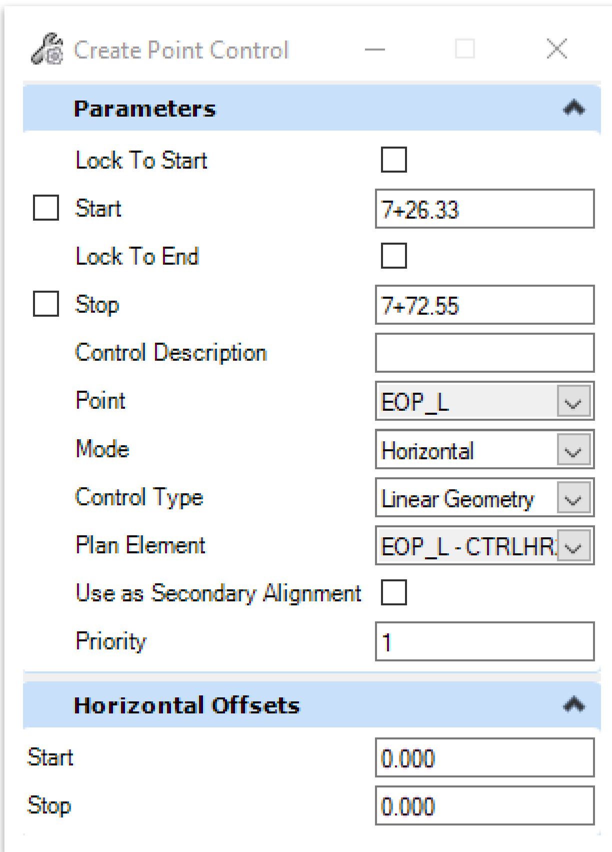
7. Select the **Prop EOP - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> EOP**) as the active feature definition and then use the **Single Offset Entire Element** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) with an offset of **0'** to copy the referenced bulb out lines on the left side of the road, as shown below.



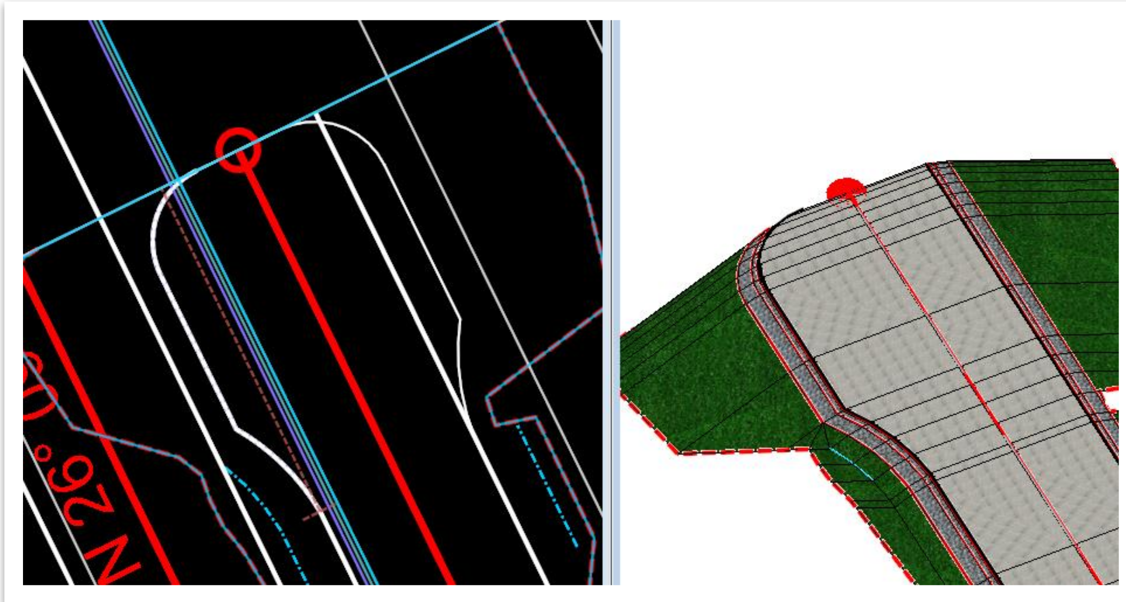
8. Complex the copied bulb out geometry using the **Complex By Element** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Complex Geometry**) and select the three lines that were just offset. Make sure that the elements are all complexed the same way. Name the complex element **EOP_L - CTRL_HR2**.



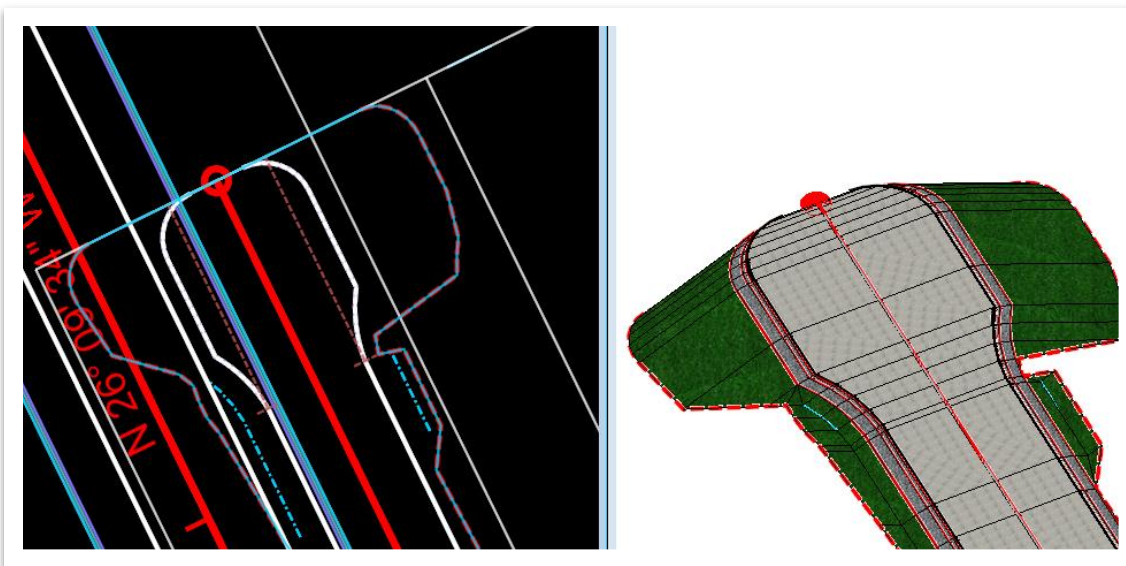
9. Next, open the **Create Point Control** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and select the **HR2** corridor. Key-point snap to the start and end points of the created geometry, which should correlate to the start and end points of the point control for each side of the centerline. **<u>Do not snap to any element drawn by the corridor, including using the intersection snap with elements in the corridor</u>**. If necessary, it may be easier to snap to the geometry if you turn off the **DES - MODEL - Lines - Pavement Edge** level, but it will need to be turned back on to locate the EOP_L. When prompted to **Locate Point**, click the **EOP_L** of the **HR2** corridor and set the **Mode** to **Horizontal**. For the **Control Type**, select **Linear Geometry** and then click on the created complex geometry when prompted. Click through the rest of the prompts to accept.



10. The **EOP** line should now follow the created geometry.



11. Repeat Steps 6-10 for the right side of the haul road. Once completed, you should have **two** point controls.



Chapter 6. Civil Cells

Civil Cells are pre-built cells intended to make standard and complex geometric configurations easier and more efficient for designers to model. Civil cells are not like traditional cells (e.g., STDS_NON-TRUE.cel, STDS_TRUE.cel, etc) that are placed with the place cell tool, nor do they behave like cells used in past design software. This chapter will discuss the basic steps and available tools to place and manipulate some of the civil cells within the TDOT library.

6.1 Objectives

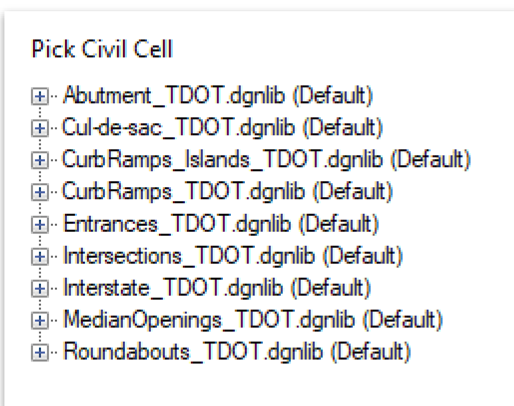
At the conclusion of this chapter, participants will be able to:

1. Place civil cells within a model.
2. Manipulate civil cells using the control handles.
3. Manipulate civil cells by editing the template drops.
4. Place ADA curb ramp civil cells in a corridor.

6.2 Lecture: Civil Cell Overview

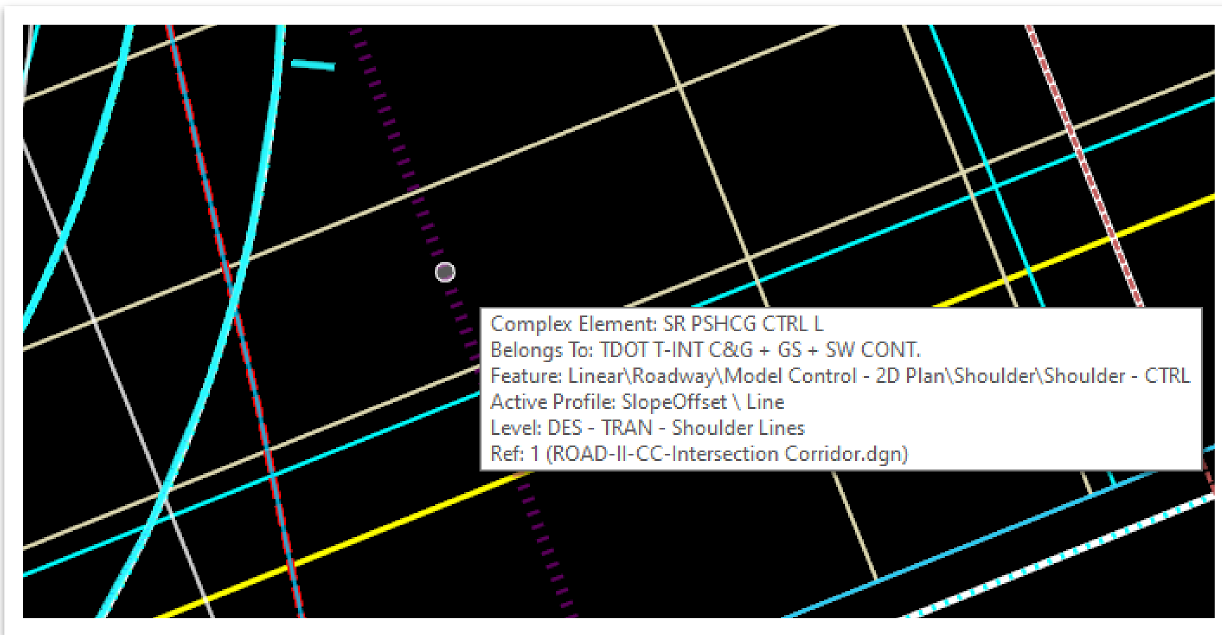
A **Civil Cell** is an intelligent and manipulatable group of modeling elements that places in both **2D** and **3D**, to model difficult, but repeatable items. Modeling elements would include driveways, curb ramps, intersections, and others. **Civil Cells** are civil geometry tools that allow users to place pre-built geometries into a corridor. The TDOT Civil Cell categories that meet the applicable standards are the following: **Abutment**, **Cul-de-sac**, **Curb Ramps_Islands**, **CurbRamps**, **Entrances**, **Intersections**, **Interstates**, **Median Openings** and **Roundabouts** (Figure 4).

FIGURE 4. CIVIL CELL DGNLIB'S



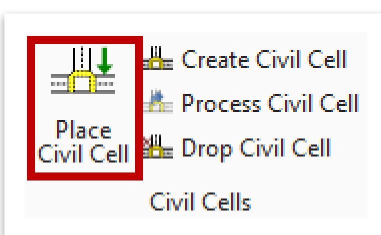
To work properly, civil cells require reference elements. When placing a civil cell, a prompt will appear directing the user to select the appropriate line to place the civil cell along. The **reference lines** serve as the base geometry of a civil cell. The next building block of civil cells is the **controlling geometry**, which are dashed construction lines that serve as the base geometry for **3D** elements (Figure 5). Almost all of these construction lines have a profile and are ruled back to the reference lines. Changing offsets, profiles, and other ruled geometry is how a civil cell's modeling elements are controlled to fit the users need. The final elements of a civil cell are the 3D **modeled elements**, which come in two types: **Linear Templates** and **Surface Templates**. Linear templates are placed on the construction geometry to create 3D modeled elements and act the same way a template works on a corridor. Surface templates work by having the construction geometry create a terrain, and a surface template draping the terrain. All civil cells in the TDOT library are highly modifiable to meet the constraints of a project and to stay within TDOT standards.

FIGURE 5. CTRL LINES



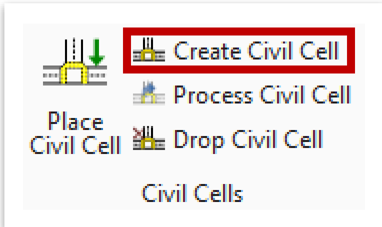
Civil Cells are placed using the **Place Civil Cell** tool (**OpenRoads Modeling >> Model Detailing >> Civil Cells**) (Figure 6).

FIGURE 6. PLACE CIVIL CELL TOOL



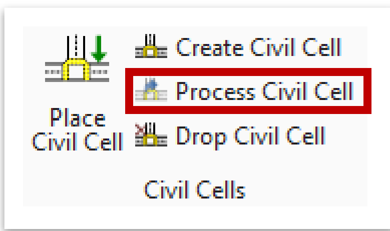
The creation of civil cells would be done using the **Create Civil Cell** tool (Figure 7), but it is extremely difficult to create a civil cell that works well. The TDOT CADD staff will handle any new civil cell creations in the future. If you have a suggestion, please submit it to the TDOT CADD staff.

FIGURE 7. CREATE CIVIL CELL TOOL



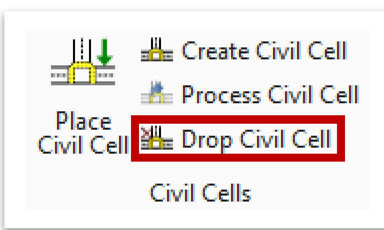
The **Process Civil Cell** tool (Figure 8) will re-process a civil cell like the **Process Corridor** tool. It updates the civil cell with any changes that have been made if it did not automatically update.

FIGURE 8. PROCESS CIVIL CELL TOOL



The **Drop Civil Cell** tool (Figure 9) will disassociate all geometry within the civil cell, allowing each line to be selected individually. <u>This is useful if the civil cell is going to be heavily edited and modified</u>. Once this tool has been used, elements will have to be **individually deleted**. Therefore, it is recommended to not drop a civil cell after placement unless absolutely required.

FIGURE 9. DROP CIVIL CELL TOOL



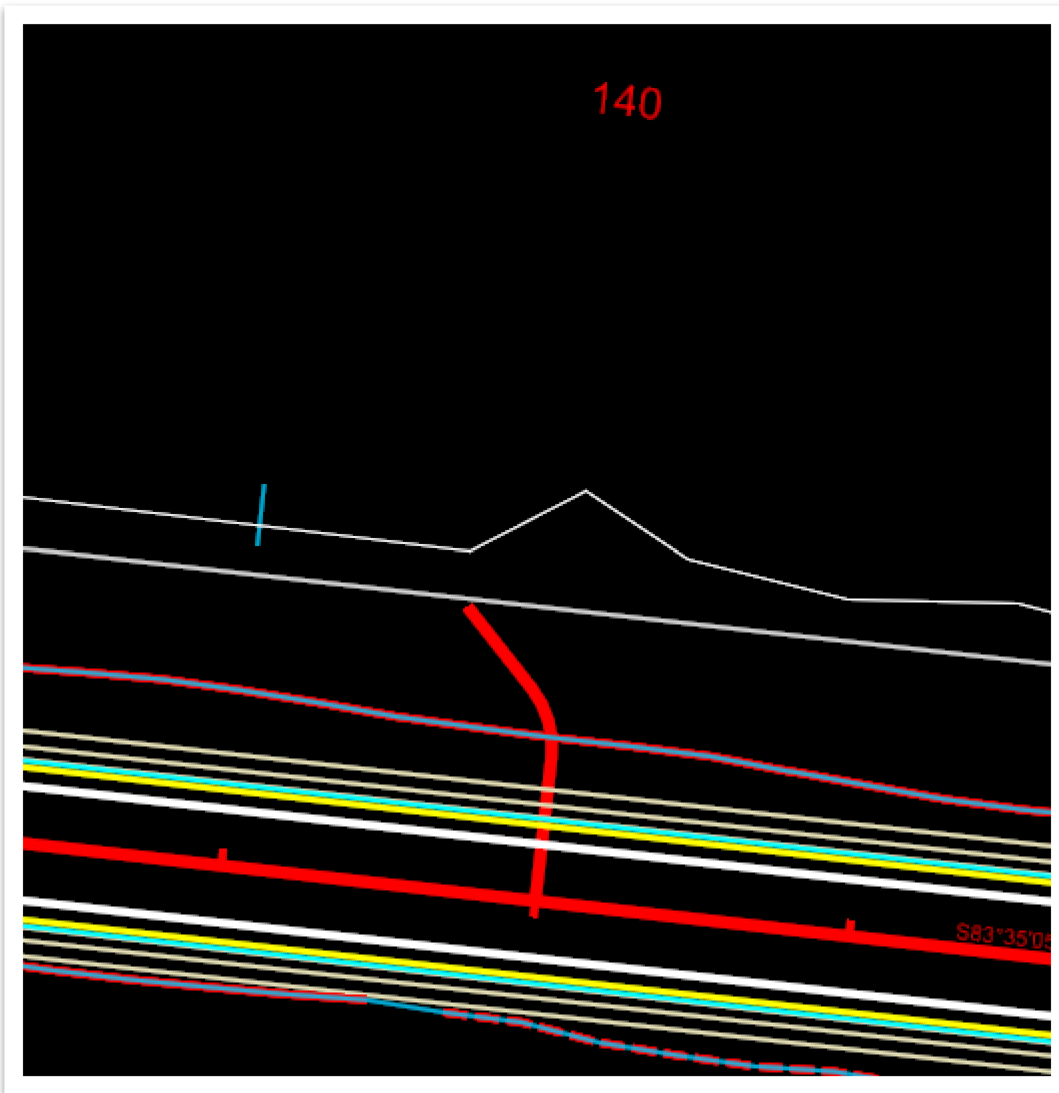
Take Note!

*If you make an error when placing a civil cell, you will need to delete it. **Do not hit the UNDO button**. Delete the civil cell in the Explorer or in the Heads Up Display. If you hit **UNDO**, it is possible that ghost elements, which are not easily selectable, will linger within the model.*

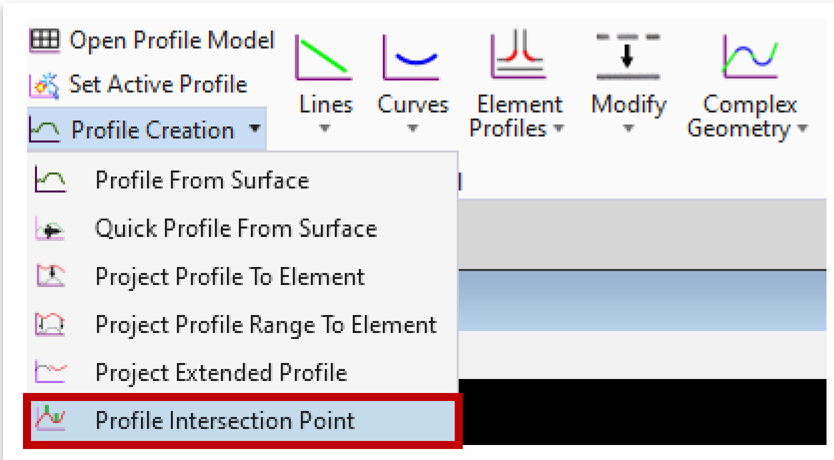
6.3 Exercise: Placing a Driveway Civil Cell

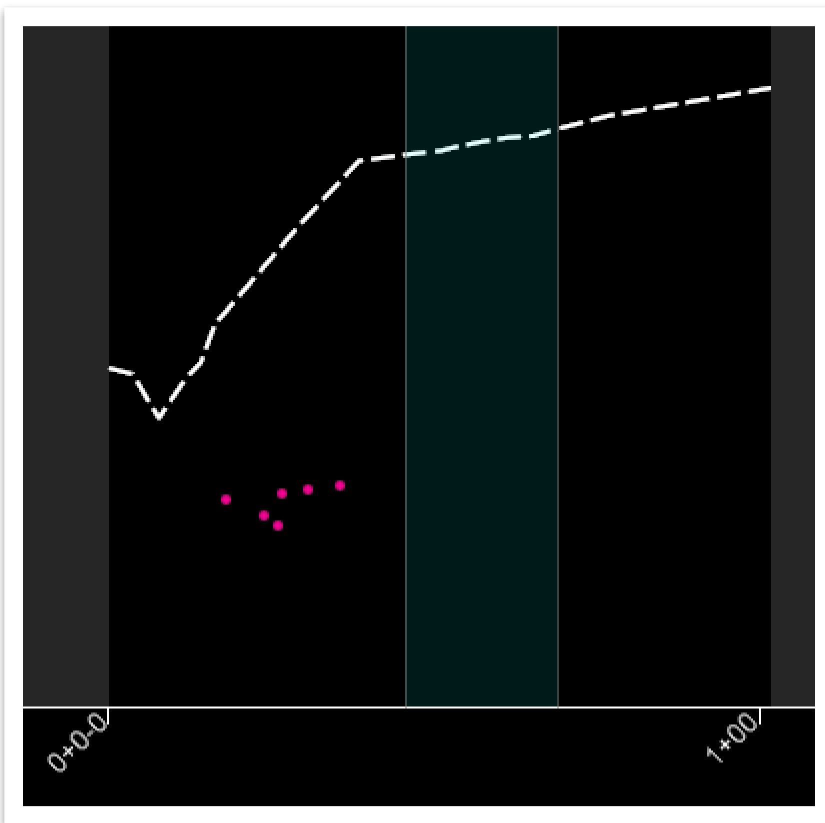
In this exercise, we will model a driveway and then place and manipulate a driveway civil cell.

1. Open the **Road-II-CC-Alignments.dgn** file within the dgn Chapter 6 subfolder. Make sure that the **Default** view is active in the lower left corner. The following files should already be referenced in the 2D view.
    - ROAD-II-CC-Corridor.dgn
    - ROAD-II-CC-Terrain.dgn
2. Locate the driveway at Station **140+00**. The horizontal geometry has been created, but we will now need to create the vertical geometry.



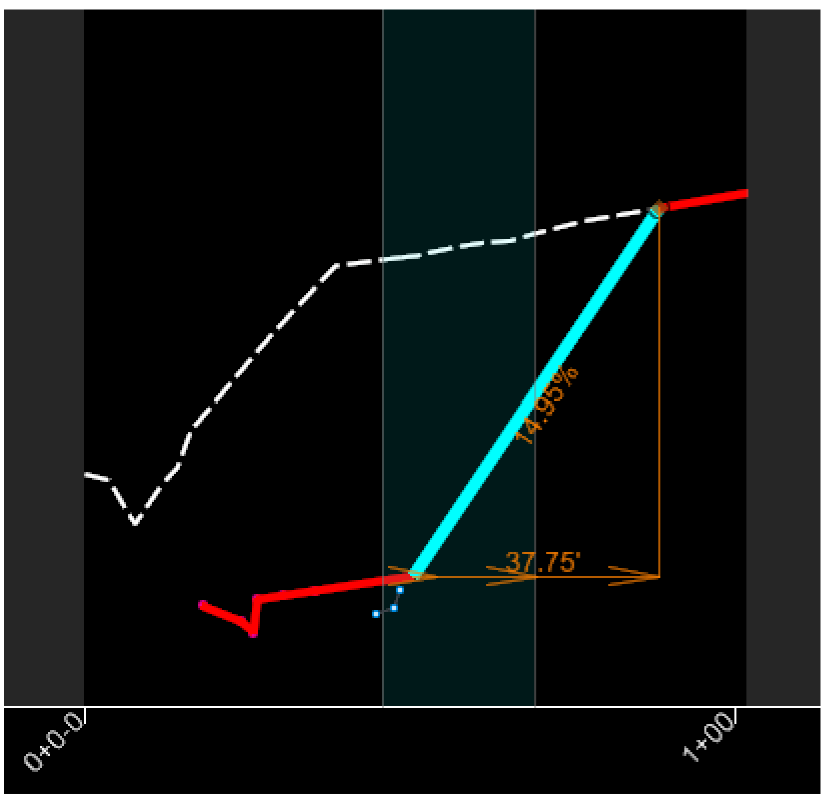
3. Make sure the existing terrain is active and then open the profile view of the driveway centerline. Now open the **Profile Intersection Point** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Profile Creation**). In the plan view, select the driveway **centerline** and then select the mainline **EOP_L**, **PSHCG_L**, **CR_FLOWLINE_L**, **CR_BACK_TOP_L**, **SW_FRONT_TOP_L** and **SW_BACK_TOP_L**.



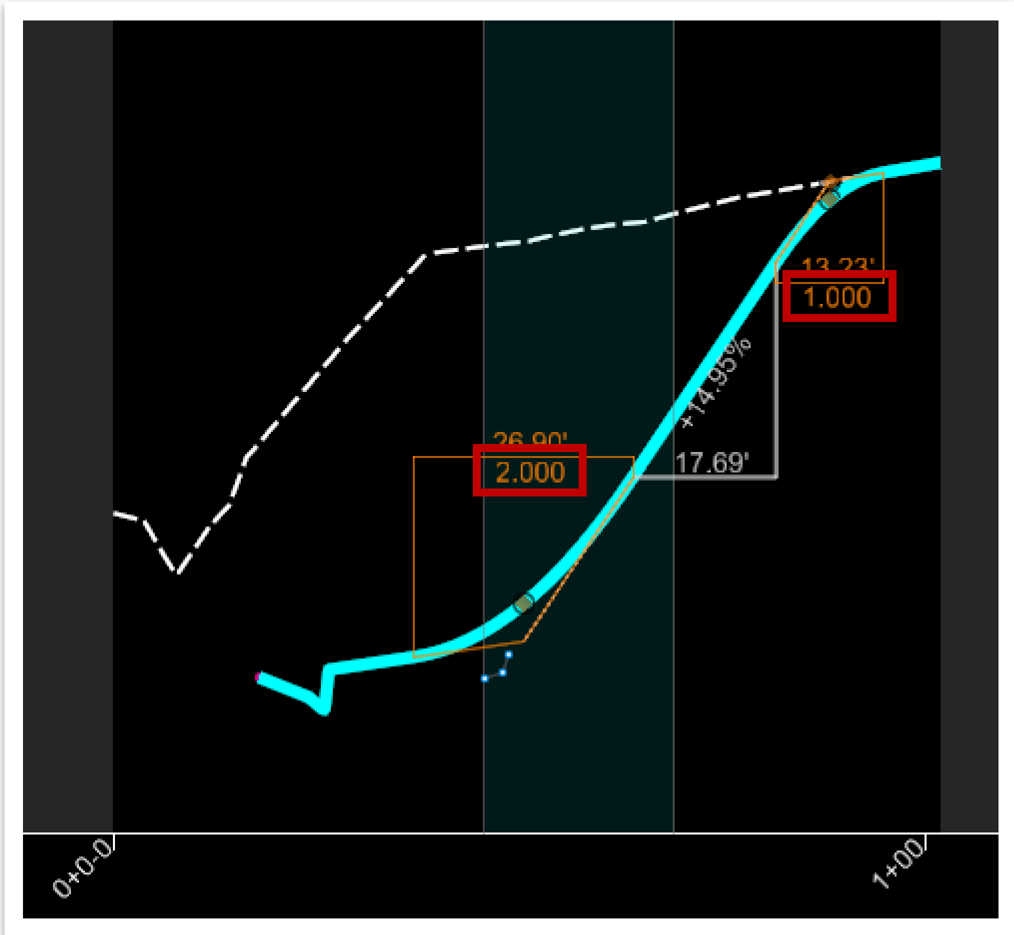


4. Next, select the **Prop VA Driveway** feature definition (**Linear >> Profiles >> Roadway >> Proposed**). Turn on the **Key Point Snap** and connect the points using the **Profile Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Lines**). From the **SW_BACK_TOP_L** intersection point, draw the first, second and third tangents, as listed below. The first tangent extension will keep the vertical curve outside the limits of the sidewalk. **Note:** Per the [TDOT Driveway Entrances Manual], the maximum slope allowed for a proposed driveway is **15%**.

Tangent #	Distance	Slope
1	15’	1.5%
2	37.75’	14.95% (to intersect existing ground)
3	13.49’	1.72% (along existing ground)

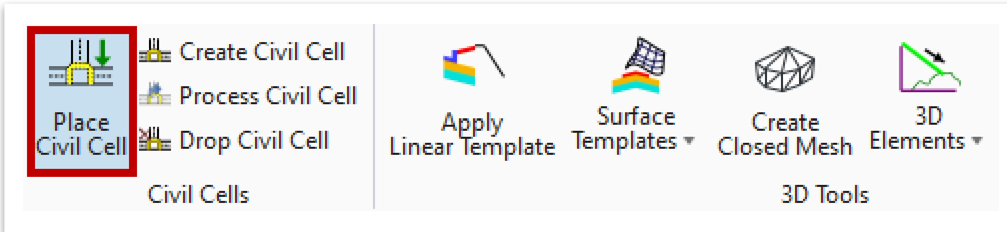


5. We need to insert vertical curves after the back of sidewalk. Go ahead and open the **Parabola Between Elements** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Curves >> Profile Curve Between Elements**) and set the **Trim/Extend** option to **Both**. Remember, per the TDOT Driveway Entrances Manual the minimum **K** values for **crest** and **sag** vertical curves are **1** and **2,** respectively. Complex the vertical geometry elements and make sure the new complex vertical profile is set to **active**.

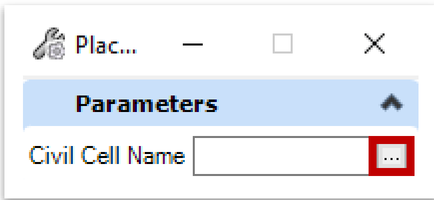


6. Now, open the **ROAD-II-CC-Corridor.dgn** file within the dgn Chapter 6 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner. The following files should already be referenced in the 2D view. **Note:** You should see your driveway alignment in the referenced geometry file. Also, for an actual project, the driveway civil cells should be in a separate file to keep the file size manageable. Civil cells contain a lot of data and quite often slow files down.
   - ROAD-II-CC-Alignments.dgn
   - ROAD-II-CC-Intersection Corridor.dgn
   - ROAD-II-CC-Terrain.dgn

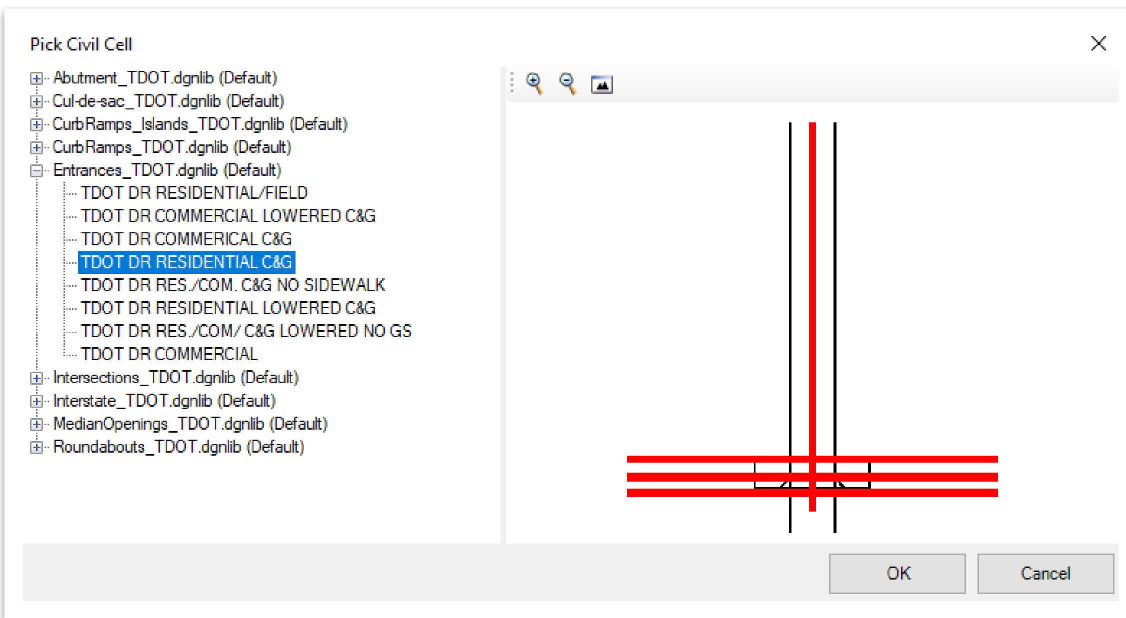
7. Next, we will place the applicable civil cell along the alignment. Open the **Place Civil Cell** tool (**OpenRoads Modeling >> Model Detailing >> Civil Cells**).



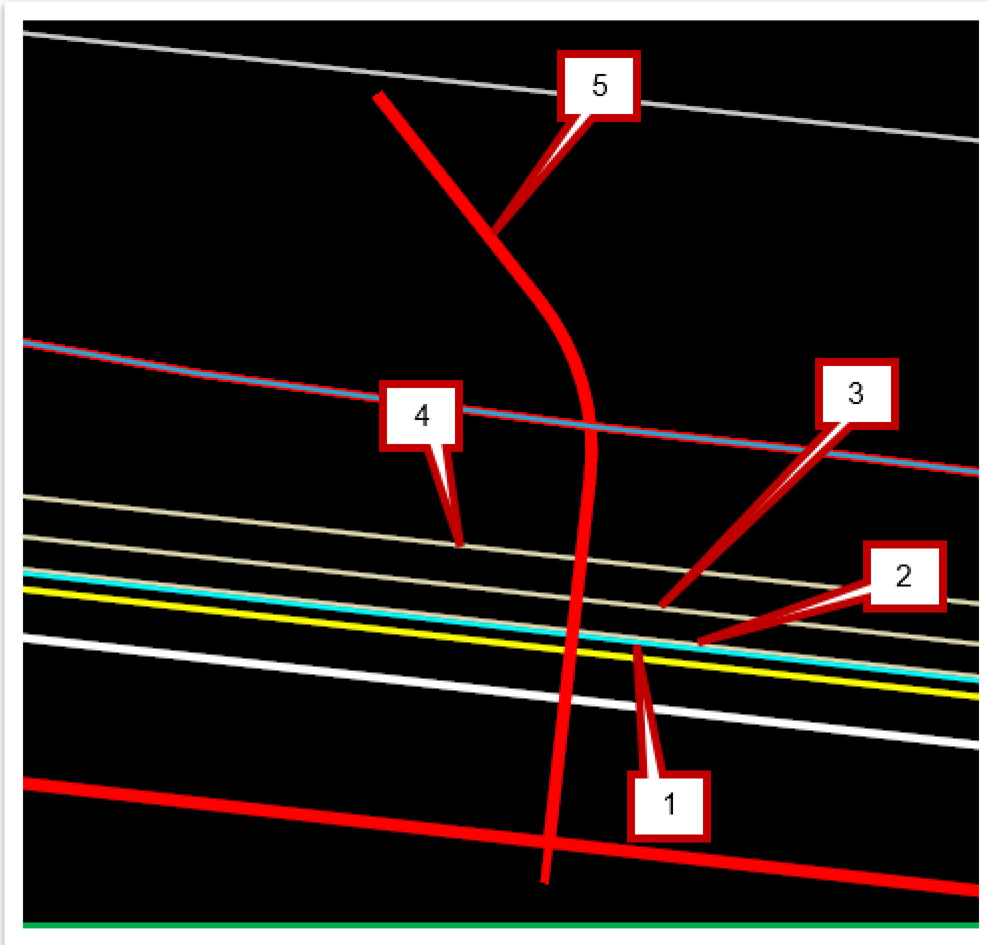
8. Within the **Place Civil Cell** dialog box, click the **3 dots** to open the **Civil Cell** folder. **Note:** Give the software a minute to open.



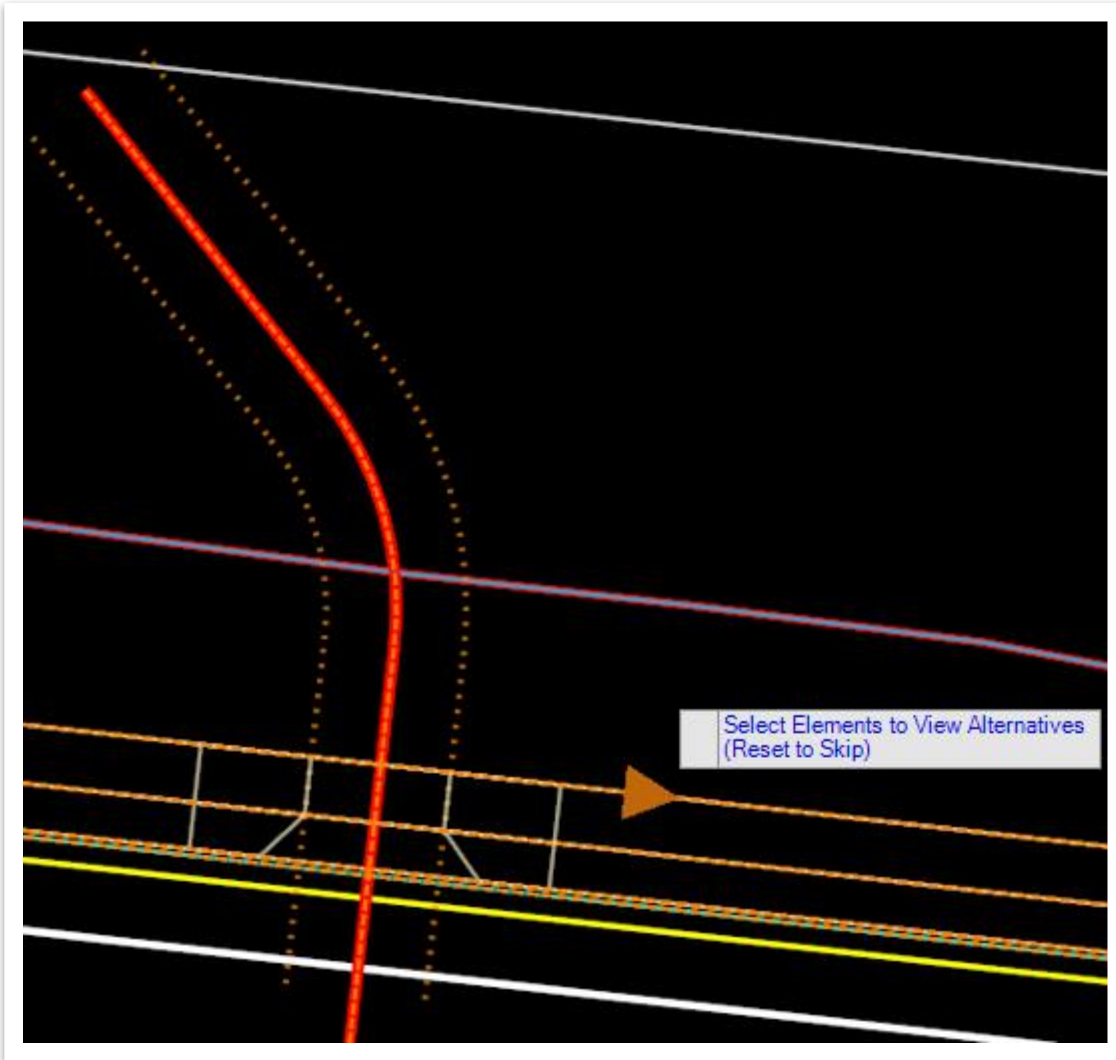
9. Select the **TDOT DR RESIDENTIAL C&G** civil cell under the **Entrances_TDOT.dgnlib** and click **OK**.



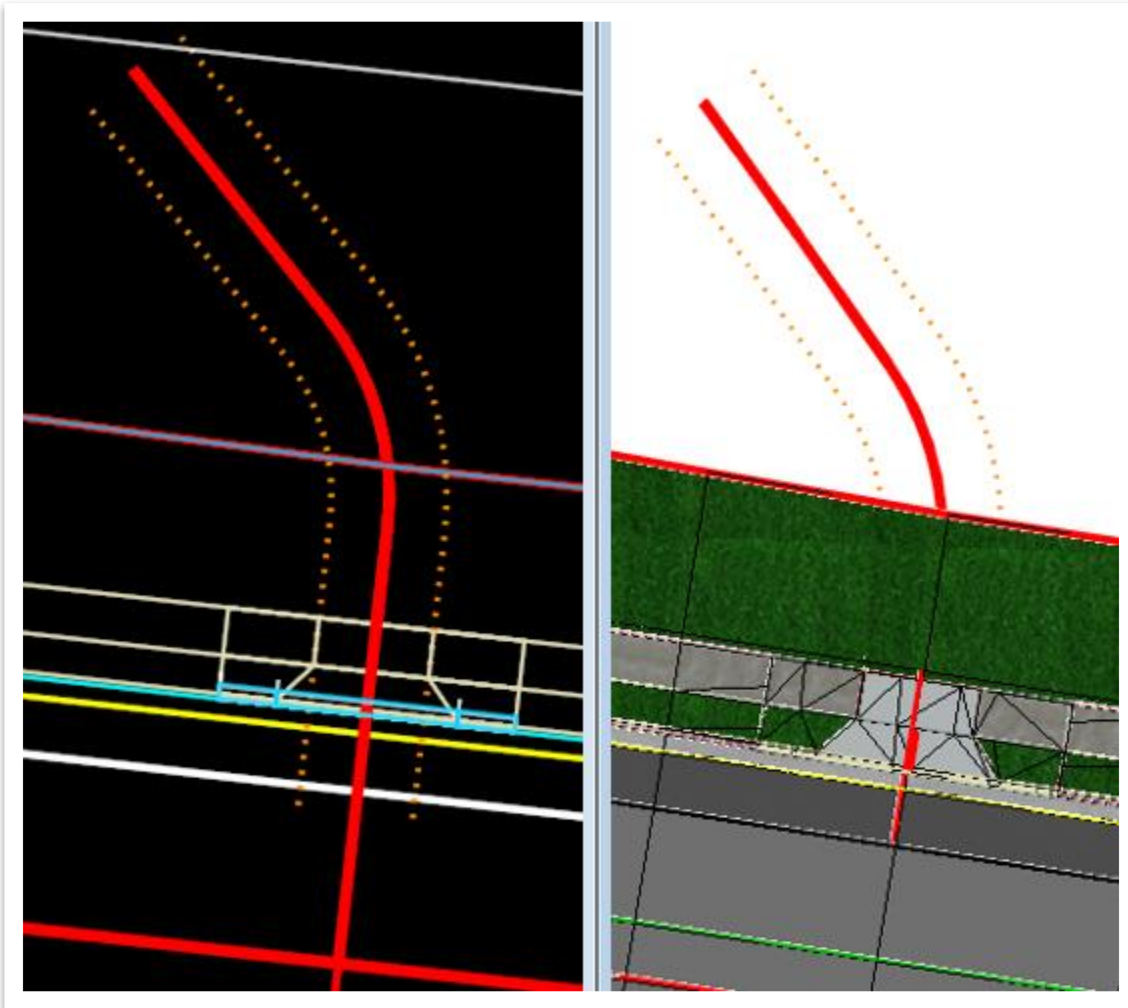
10. In the **2D** view, follow the prompts and select the **CR FLOWLINE** (**1**), **CR BACK TOP** (**2**), **SW FRONT TOP** (**3**), **SW BACK TOP** (**4**) and the **DRIVEWAY CL** (**5**).



11. A **2D** preview of the civil cell should now appear. You can switch the previously selected reference line directions by clicking on the reference lines until the civil cell preview looks correct. **Right** click to advance to the next prompt. **Note:** In this exercise, the civil cell should look correct, but if the cell was placed on the other side of the road, the reference lines would need to be reversed.

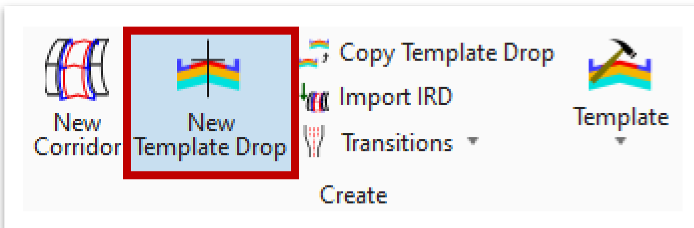


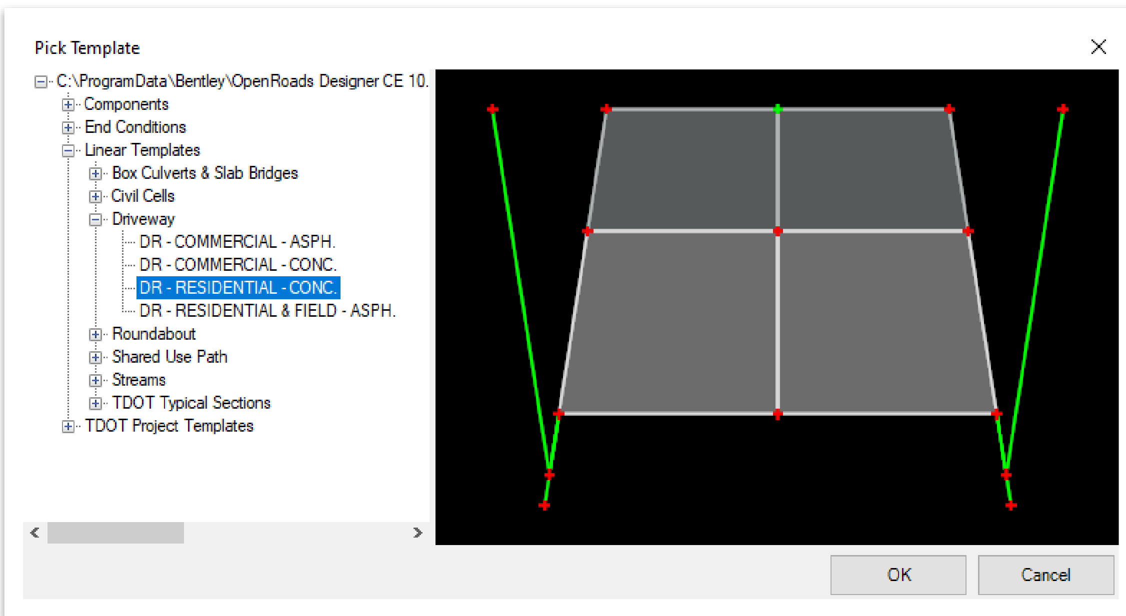
12. Select the corridor that will be clipped. For this exercise, it will only be the **mainline** corridor. To confirm the clipping, make sure the corridor graphics are highlighted. **Right** click, then **left** click to accept the civil cell placement. It should now be viewable in both the **2D** and **3D** views, as shown below. **Note:** You can only clip corridors that are in the active file. If the corridor was in a different file, you would need to open that file and then clip the corridor.



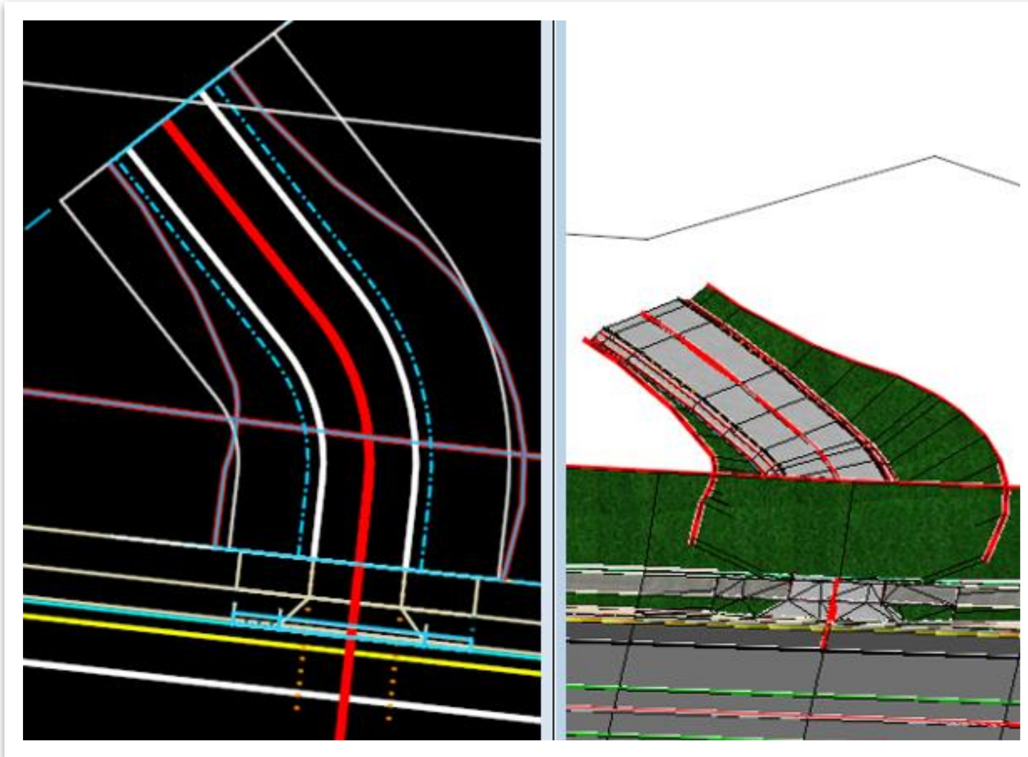
13. For this driveway civil cell, the software only models up to the **back of sidewalk**. To complete the rest of the driveway model, we will need to place a **corridor** along the alignment. We will use the **orange controlling elements** placed with the civil cell to control the edges of pavement.

14. Now open the **New Corridor** tool (**OpenRoads Modeling >> Corridors >> Create**). Note that there are two horizontal alignments to select: **DR2**, which is connected to the civil cell and only extends from the back of sidewalk to the end of the alignment, and **EXAMPLE DR**, which is the complex horizontal geometry that we created a profile for earlier in the exercise. Go ahead and select the **EXAMPLE DR** alignment for the corridor.
15. Once the alignment is selected, a prompt should appear asking to select the profile of the element. The active profile will be set, so **right** click to accept the active profile, and then **left** click to accept the name **EXAMPLE DR**.
16. The **Create Template Drop** tool should automatically open. If not, open the **New Template Drop** tool (**OpenRoads Modeling >> Corridors >> Create**) and place a **New Template Drop** on the corridor. Select the **DR - RESIDENTIAL - CONC** template (**Linear Templates >> Driveway**) as the template drop.

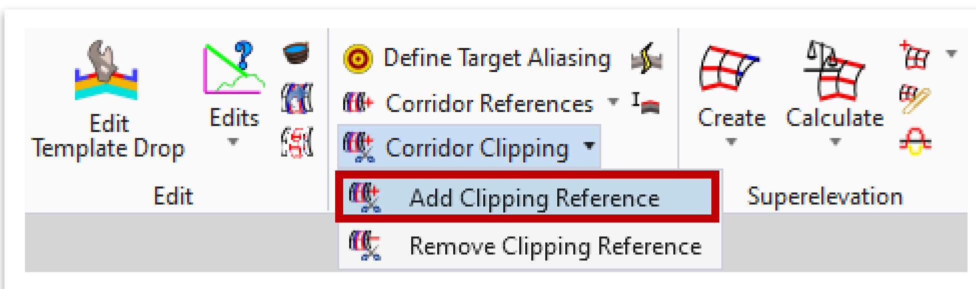




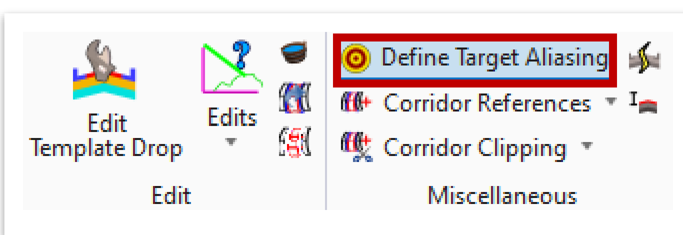
17. For the template extent, start at the **back of the sidewalk** (Station **0+35.50**) and then extend to the end of the corridor.



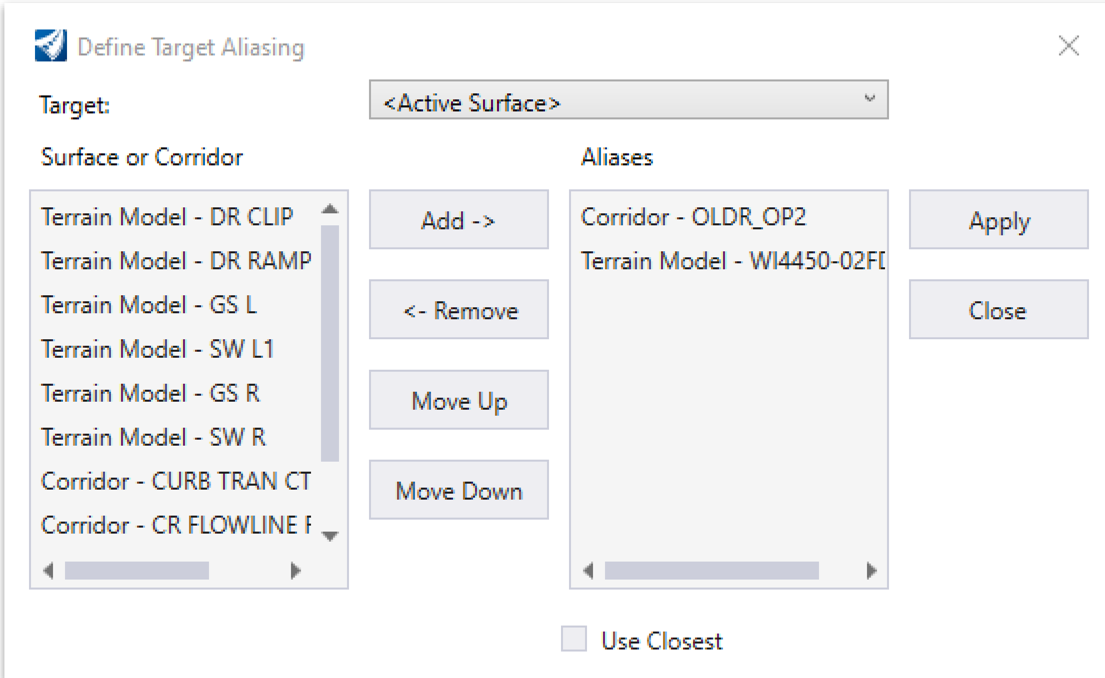
18. Notice that the mainline corridor is **overlapping** with the driveway corridor. Open the **Add Clipping Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor Clipping**). Select the mainline corridor and then the driveway corridor as the clipping reference. **Right** click to complete the clipping.

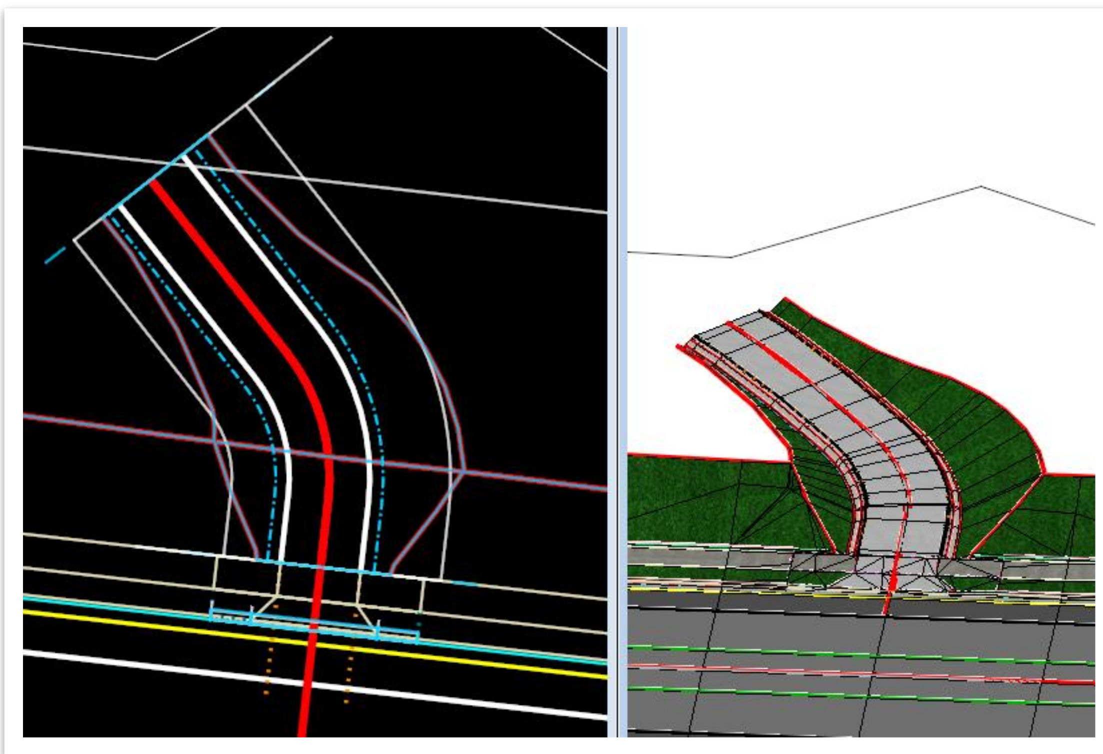


19. Next, open the **Define Target Aliasing** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous**) and select the driveway corridor.

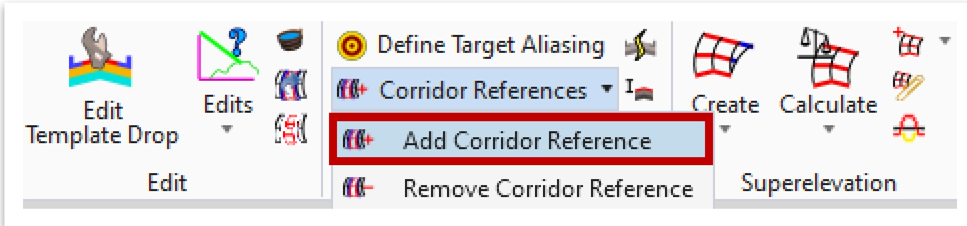


20. Add **Corridor - OLDR_OP2** and click **Apply**. Then, add **Terrain Model - WI4450-02FDTM** (the existing terrain) and click **Apply** and notice that the intersecting corridors have been resolved.

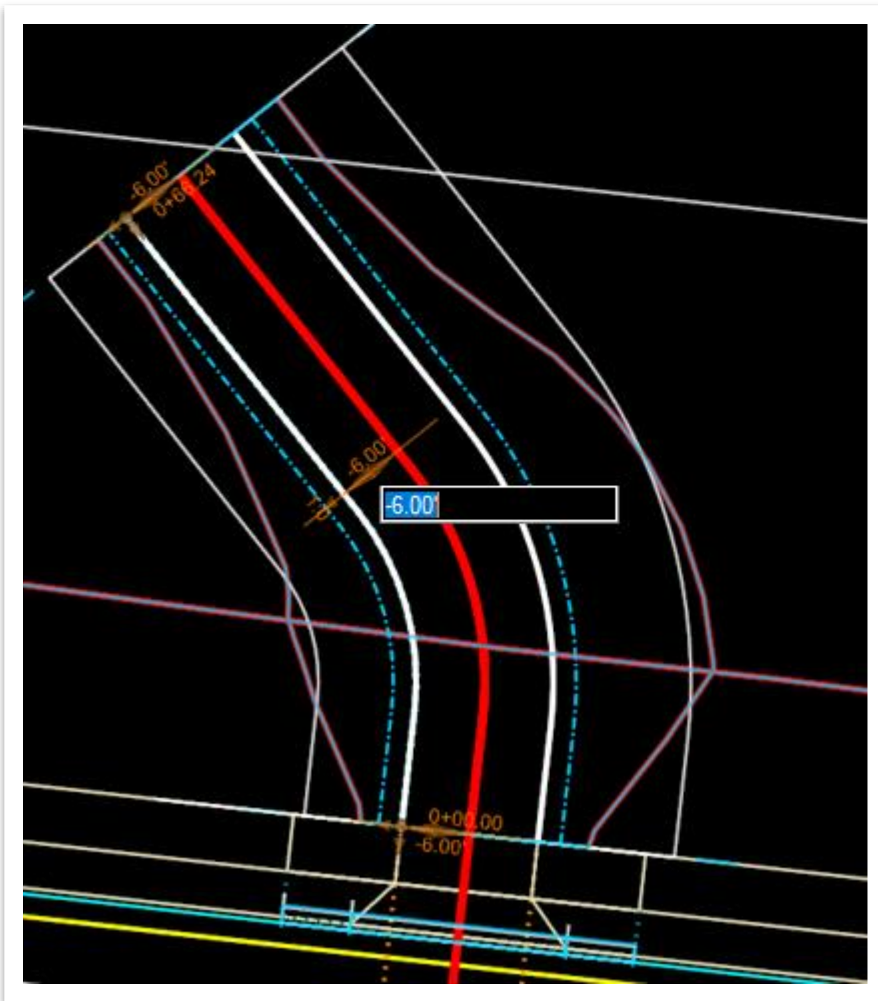




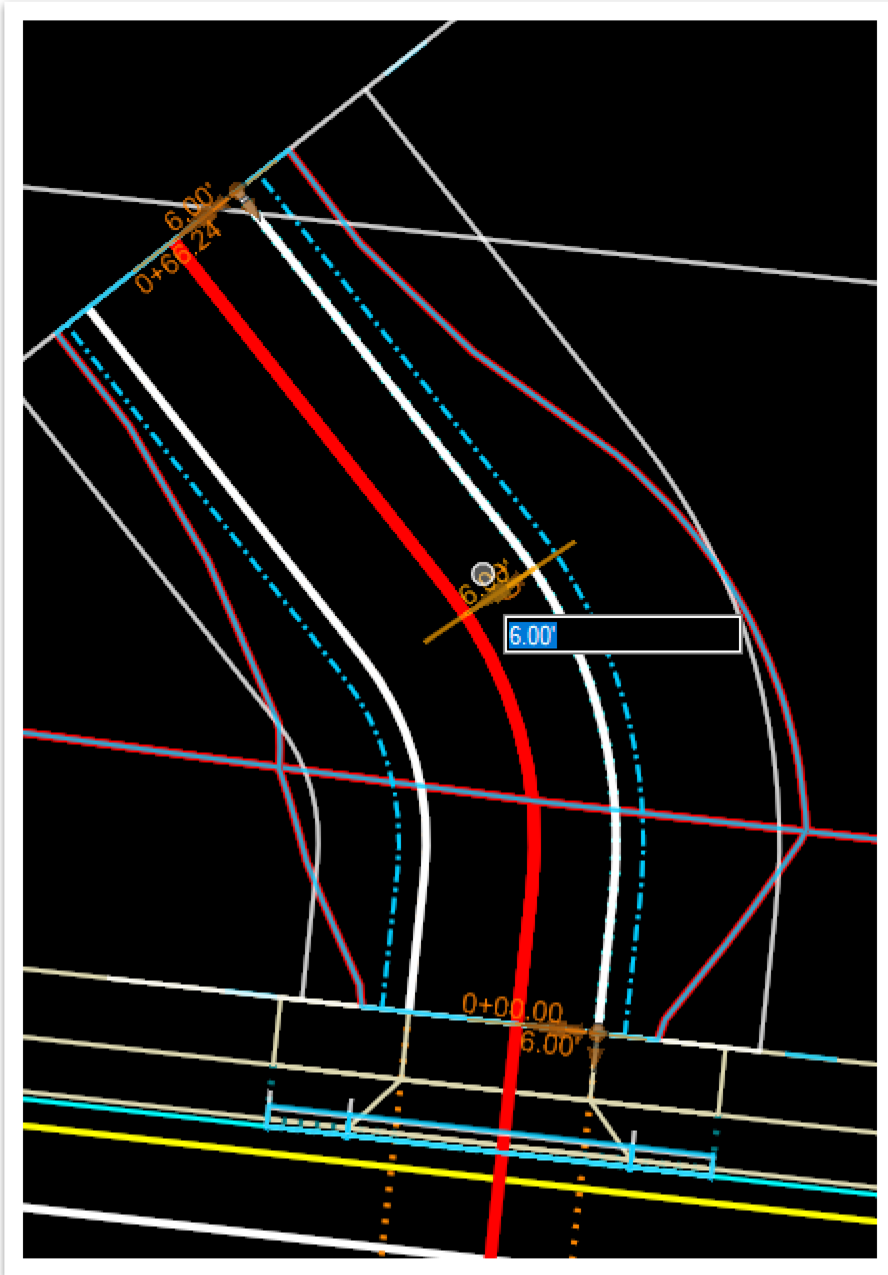
21. We now need to add **two** corridor references to the driveway corridor from the driveway ramp civil cell (area from the flowline to the back of sidewalk). Open the **Add Corridor Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor References**) and select the driveway corridor. Then, select the **DR EOP L CTRL1** line (under the left EOP line of the driveway) on the driveway civil cell and **right** click to accept.



22. Next, change the width of the **DR EOP L CTRL1** line (under the left EOP line of the driveway) from -6' to -**8'** by selecting the line. Edit the width in the orange midpoint offset manipulator to revise both ends of the control line. The driveway corridor should now move in conjunction with the width of the driveway civil cell.

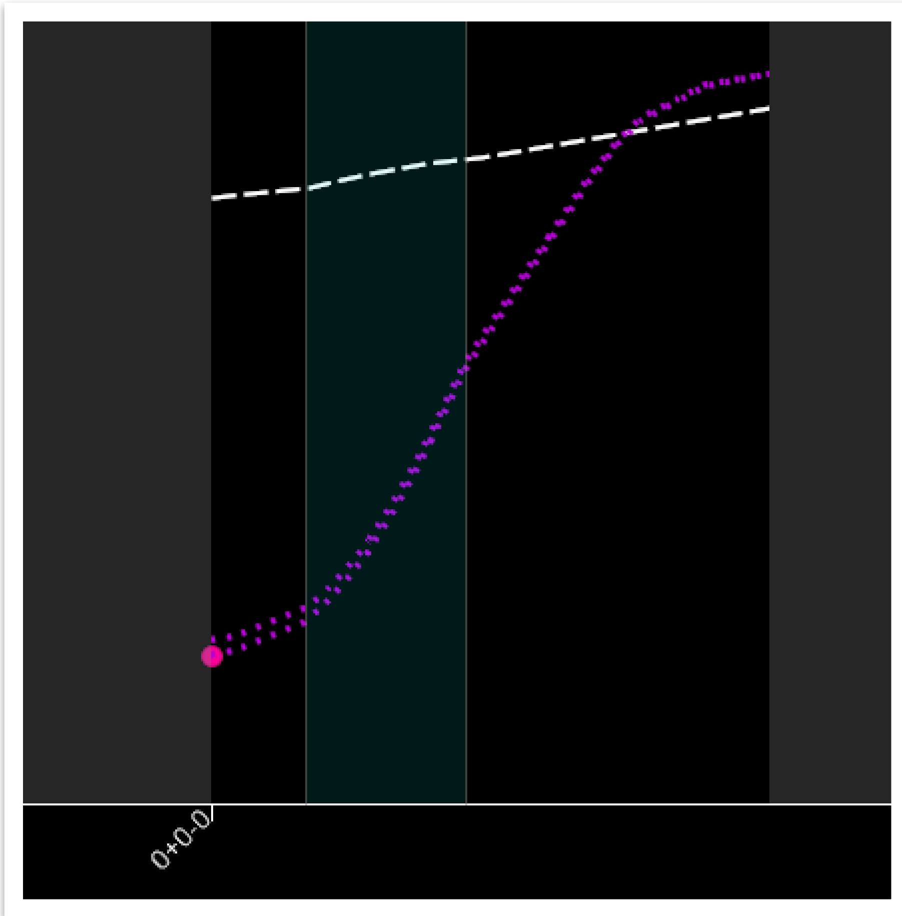


23. Repeat the previous two steps but select the **DR EOP R CTRL1** line instead of the DR EOP L CTRL 1 line, and then change the width to **8’**.



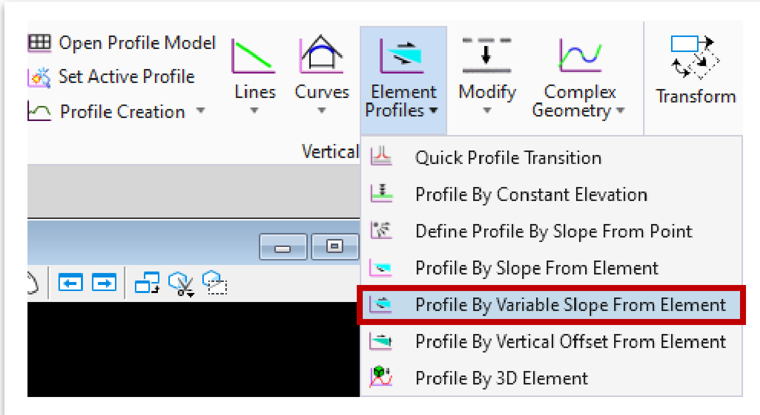
24. The corridor now needs to be adjusted to make sure the driveway cross slopes mirror the profile grade of the mainline corridor. Open the **DR EOP L CTRL1** profile. **Note:** This is only done so that the model aligns. A PDF set of plans will not show this level of detail.

25. Within the profile, there will be two lines: **DR PROFILE EOP L** is the current profile of the driveway, assuming that the cross slope of the line is **0.00%**, and **VARIABLE SLOPE L**, which can be adjusted as a secondary profile of the line if needed. There will also be a pink dot in the profile, which indicates the elevation of the sidewalk back top of the driveway civil cell. Through an iterative process within the **VARIABLE SLOPE L** properties, it has been determined that the slope of the mainline sidewalk at this point is **-2.22%.**

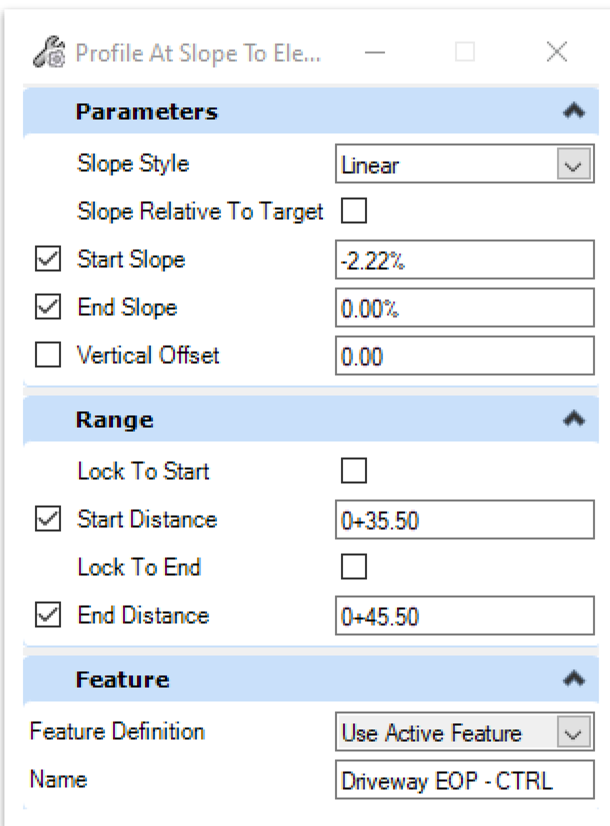


26. Currently the driveway EOP's do not intersect with the sidewalk back top of the driveway civil cell. We will need to transition the driveway EOP's profile to line up with the sidewalk back top. Go ahead and select the **Prop EOP - Driveway - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D plan >> EOP**).

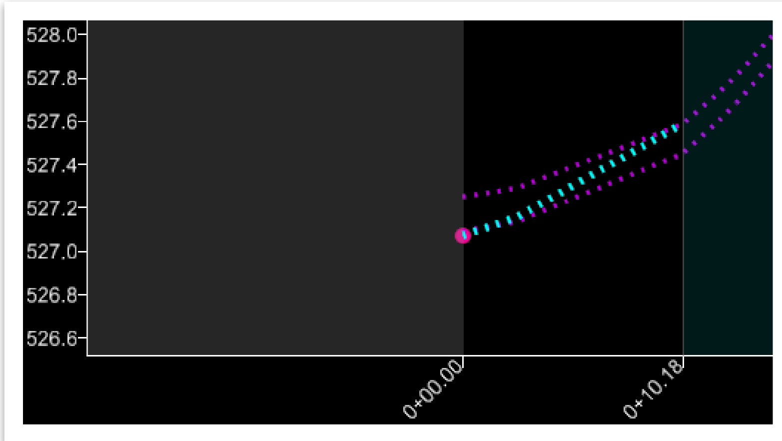
27. Then, open the **Profile By Variable Slope From Element** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Element Profiles**).



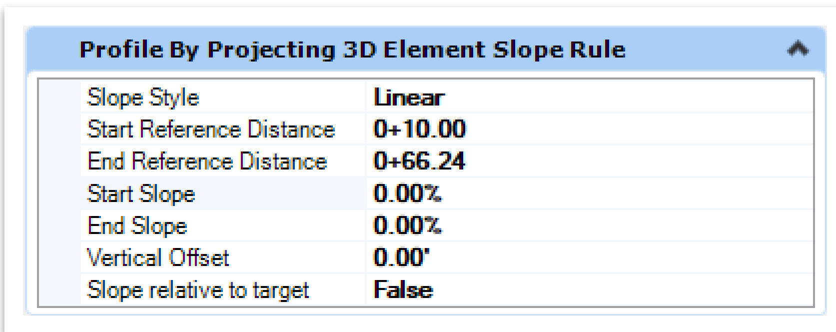
28. Set the **Slope Style** to **Linear**, and then select the **DR EOP L CTRL1** line in plan view as the line we want to profile, which is located under the driveway EOP_L (turn off the **DES - MODEL - Lines - Pavement Edge** level to make it easier to select). Select the driveway centerline (**EXAMPLE_DR**) as the reference line. Set the **Start Slope** to **-2.22%** (determined previously in the exercise) and the **End Slope** to **0.00%**. Set the **Start Distance** (Station **0+35.50)** and **End Distance** (Station **0+45.50**), which is the transition range from the mainline slope to the driveway cross slope. Click through the remaining prompts to create the profile.



29. Notice that a new line within the **DR EOP L CTRL1** profile now appears. The line should be transitioning from the pink dot to the **DR PROFILE EOP L** profile.

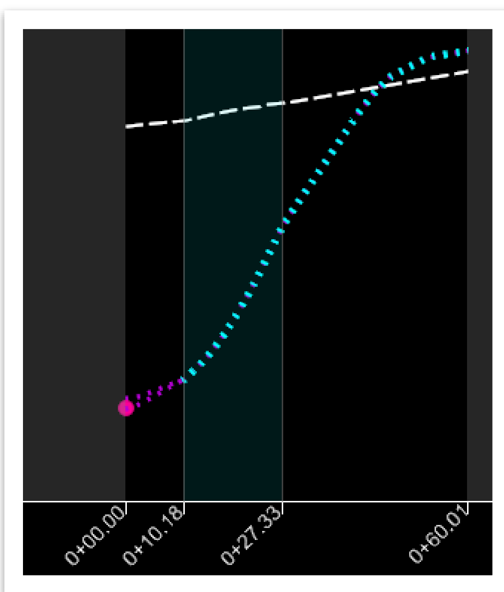


30. Now select the **VARIABLE SLOPE L** profile line and open the **Properties**. Within the properties under the **Profile By Projecting 3D Element Slope Rule** header, change the **Start Reference Distance** to Station **0+10.00** and the **Start** and **End Slopes** to **0.00%**.

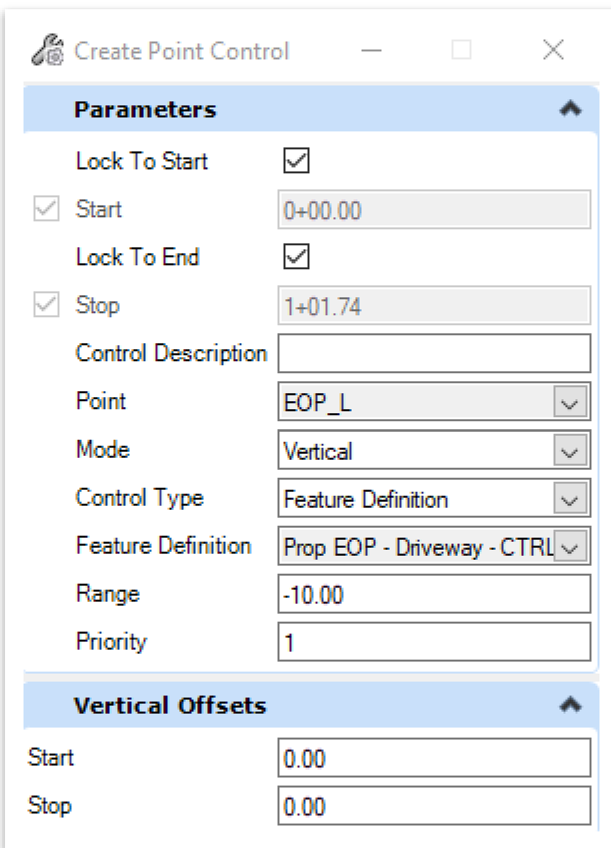


Profile By Projecting 3D Element Slope Rule

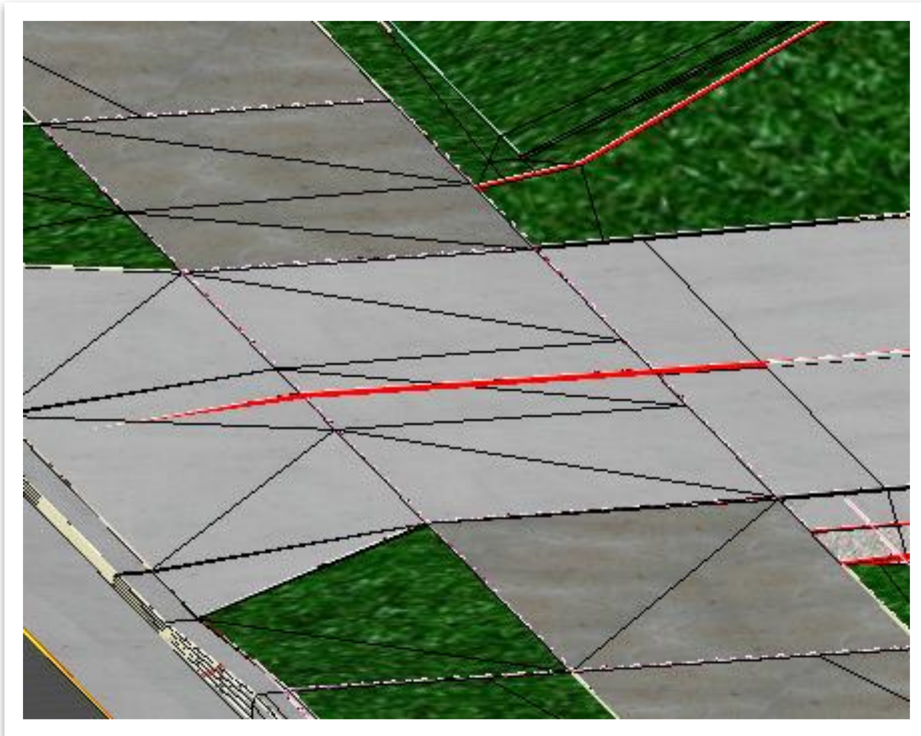
Slope Style	Linear
Start Reference Distance	0+10.00
End Reference Distance	0+66.24
Start Slope	0.00%
End Slope	0.00%
Vertical Offset	0.00'
Slope relative to target	False



31. Complex the **projected line** and the **VARIABLE SLOPE L** together to create a new profile for **DR EOP L CTRL1**, and then set that line as the **active** profile.
32. For the slope to place properly, we need to create a point control. Open the **Create Point Control** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and select the driveway corridor and then select the following settings.
    a. **Lock To Start:** On
    b. **Lock To End:** On
    c. **Point:** EOP_L
    d. **Mode:** Vertical
    e. **Control Type:** Feature Definition
    f. **Feature Definition:** Prop EOP - Driveway - CTRL (Linear >> Roadway >> Model Control - 2D Plan >> EOP)
    g. **Range:** -10.00
    h. **Priority:** 1
    i. **Start:** 0.00
    j. **Stop:** 0.00



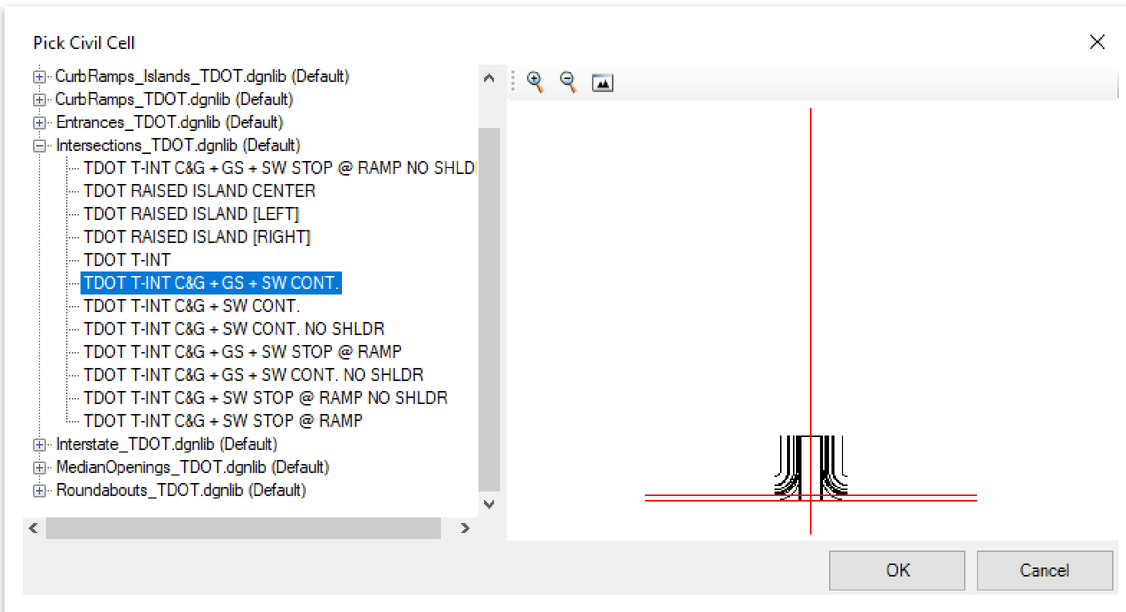
33. When prompted to select point, select **EOP_L** on the driveway corridor and then click through the rest of the prompts to accept. The driveway should now be flush with the edge of the sidewalk on the left side.
34. Repeat Steps 24-33 for the right side of the corridor. The slope of the sidewalk for the right side is positive **2.22%**.
35. Once both sides of the driveway have been updated, the driveway should now be flush with the sidewalk.



6.4 Exercise: Creating an Intersection

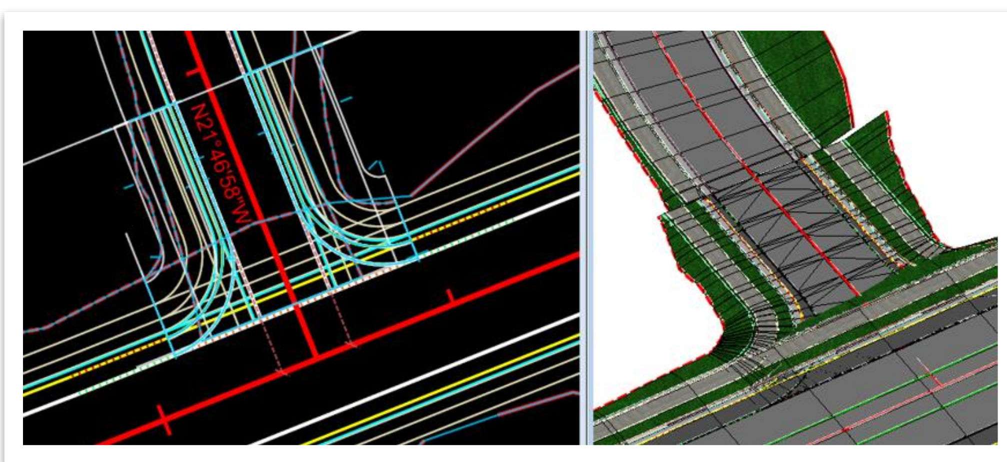
In this exercise, we will create an intersection with a civil cell and then modify the intersection to add a turn lane.

1. Open the **ROAD-II-CC-Intersection Corridor.dgn** file within the dgn Chapter 6 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner. Notice there is a side road corridor between Station **125+00** and **126+00**, which has superelevation attached to it. You may turn on the **ROAD-II-CC-Intersection Superelevation.dgn** reference file to view the superelevation.
    2. First, we will place a **T Intersection** civil cell along the side road. Open the **Place Civil Cell** tool (**OpenRoads Modeling >> Model Detailing >> Civil Cells**) and select the **TDOT T-INT C&G + GS + SW CONT.** civil cell under the **Intersections _TDOT.dgnlib** and click **OK**.

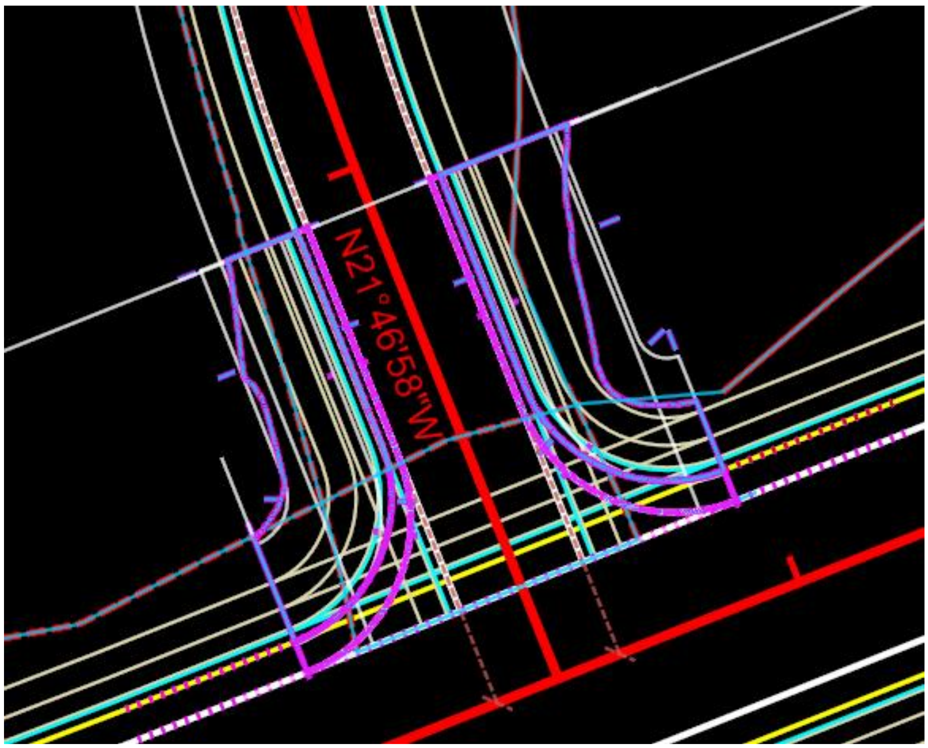


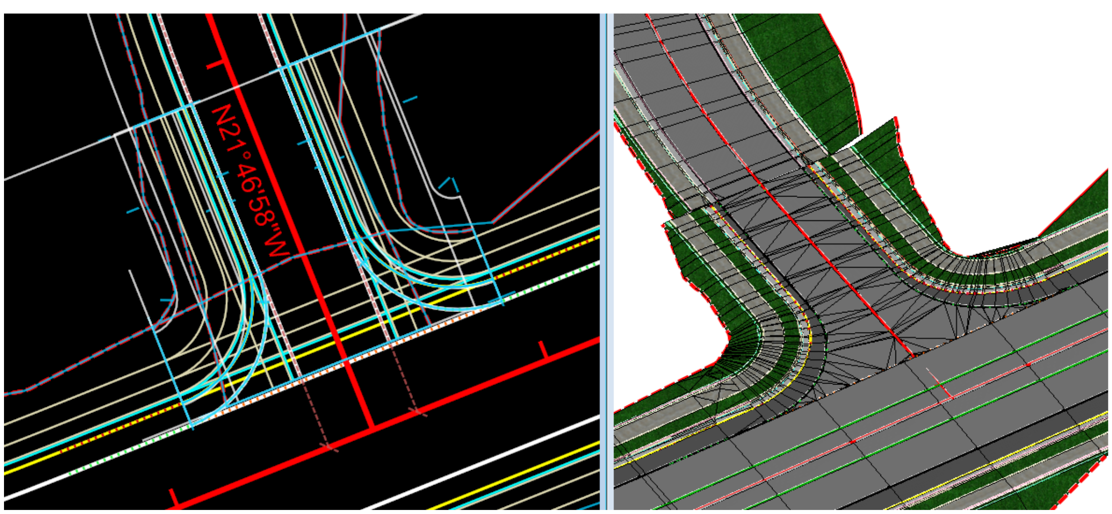
3. Select the **MAINLINE EOP** (**1**), the **MAINLINE PSHCG** (**2**) and then the **SIDEROAD CL** (**3**) to place the civil cell.

4. Make sure the placement looks correct by clicking on the **control lines**. In this exercise, there should be no need to reverse the direction of the reference lines. **Right** click to accept line directions. Next, select the Side Road corridor to clip and then **right** click to accept. Lastly, **left** click to accept the civil cell placement.

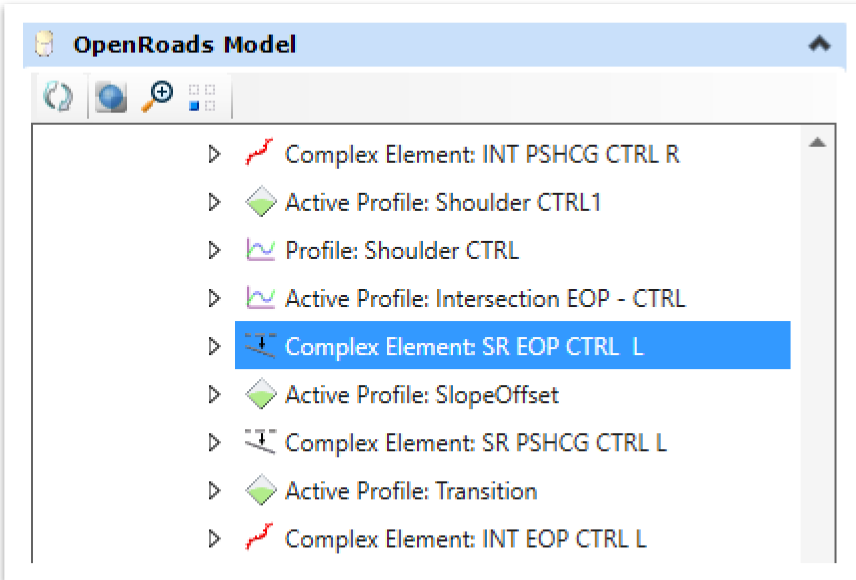


5. Since referenced corridors cannot be clipped, we need to open the **ROAD-II-CC-Corridor.dgn** file to clip the mainline corridor with the intersection civil cell. Reference the side road corridor file (**ROAD-II-CC-Intersection Corridor.dgn**) if not already referenced.
6. Open the **Add Clipping Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor Clipping**). Select the mainline corridor and then select the civil cell corridor graphics (which will turn purple) and **right** click to accept.

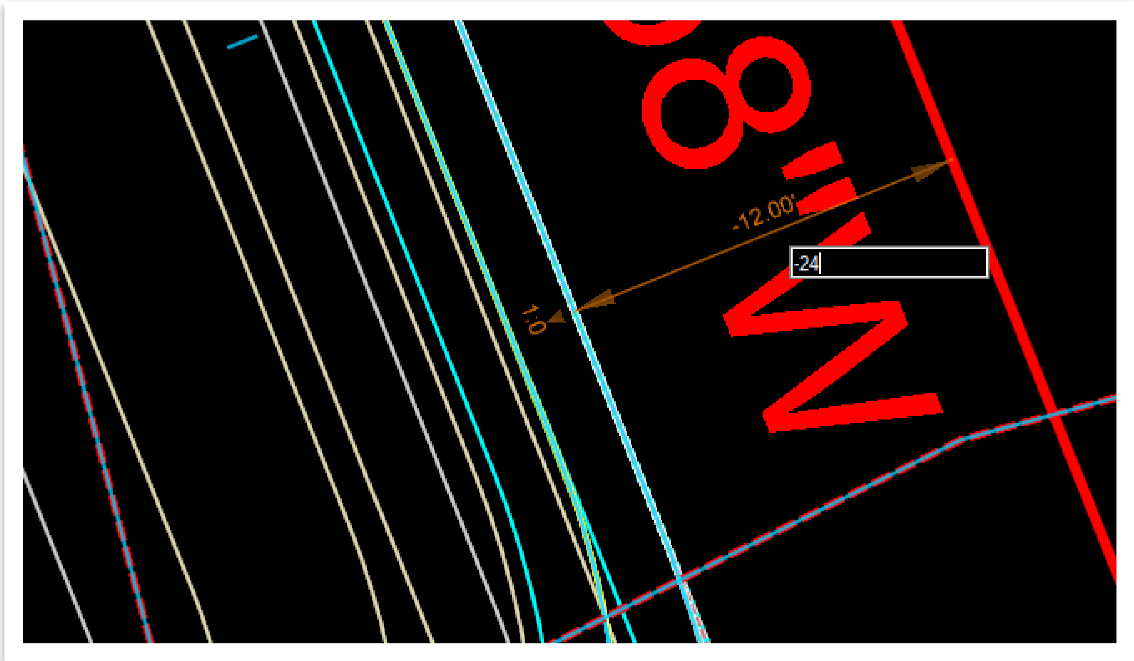




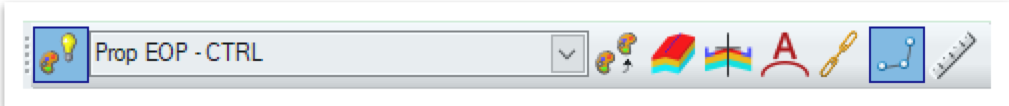
7. Now let's open the **ROAD-II-CC-Intersection Corridor.dgn** file back up. We need to add a **turning lane** to the civil cell and the side road corridor. Within the **Explorer** open the civil cell just placed under the **OpenRoads Model** tab (**OpenRoads Model >> Civil Cells >> Civil Cell TDOT T-INT C&G + GS + SW CONT. >> Dependent Elements**) and select the complex element **SR EOP CTRL L**. The element will then highlight in the **2D** view (only when the 2D view is active). This element could also have been selected in the 2D view, but it would have been a **ghost** element that would not be visible until it was hovered over.



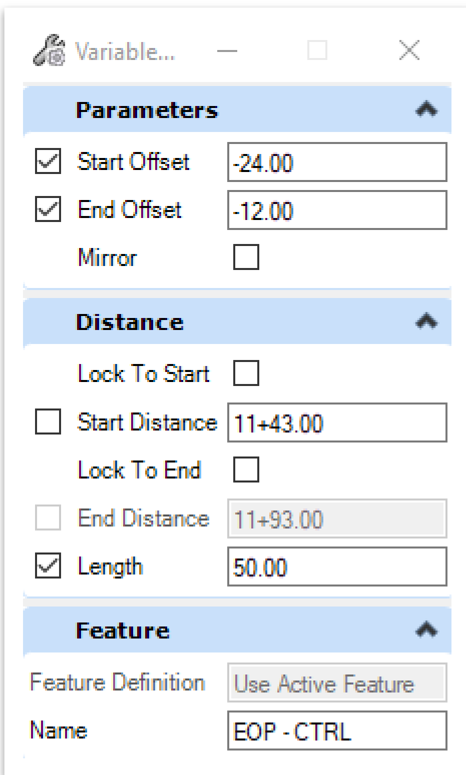
8. There will be **three** element control handles (beginning, middle and end). To change the offset of the entire element, update the middle width control value from -12' to -**24**'. **Note:** Updating the values at the beginning or end does not control the whole element. It is instead treated as a transition. Also, you may have to reclip the side road corridor using the **Corridor Clipping** tool that was used to clip the mainline.



9. Now, we will use a **point control** to add a turning lane to the side road corridor. Select the **Prop EOP - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> EOP**) and set the feature to active.

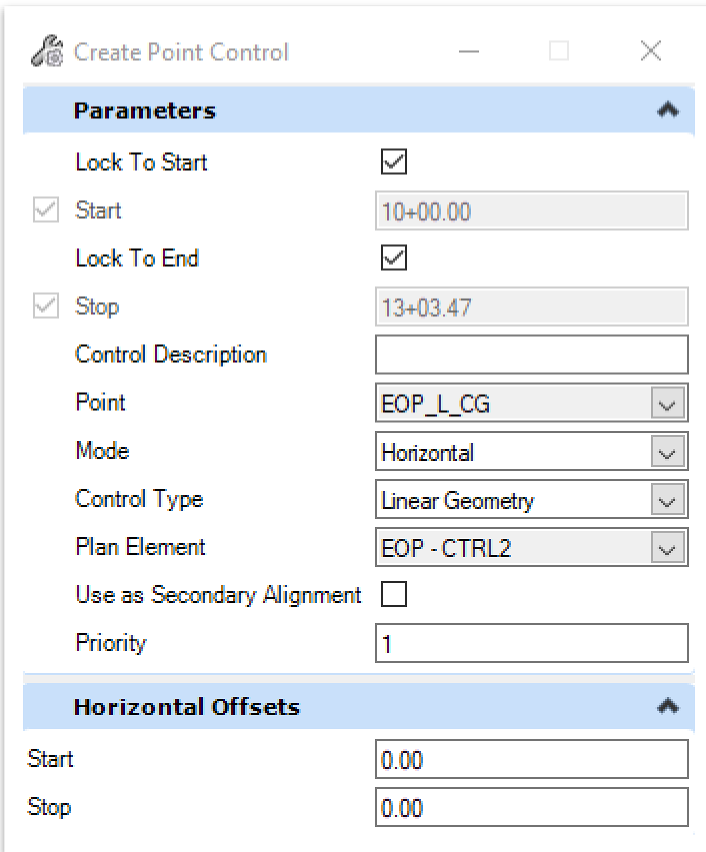


10. Open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**). Offset a line **24'** from the side road centerline with a length of **50'** starting where the civil cell ends (Station **10+93**). **Note:** You must select the side road **centerline** to offset and not the side road EOP, otherwise this would be a recursive constraint because the EOP element is being placed by the corridor we are trying to control.
11. To complete the horizontal geometry, open the **Variable Offset Taper** tool (**OpenRoads Modeling >> Geometry >> Horizontal > Offsets and Tapers**). Snap to the end of the last offset and then add a **50'** taper from that point to the intersection corridor EOP. Again, the offset reference must be the side road centerline and not an element placed in the template drop.

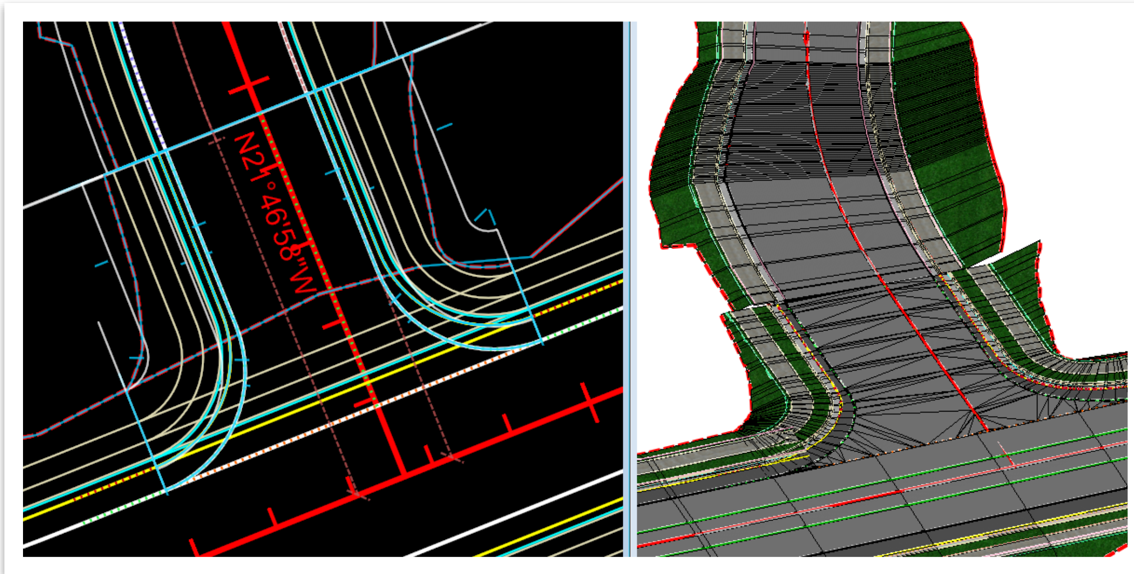


12. Go ahead and **complex** the horizontal geometry that you created for the turn lane.

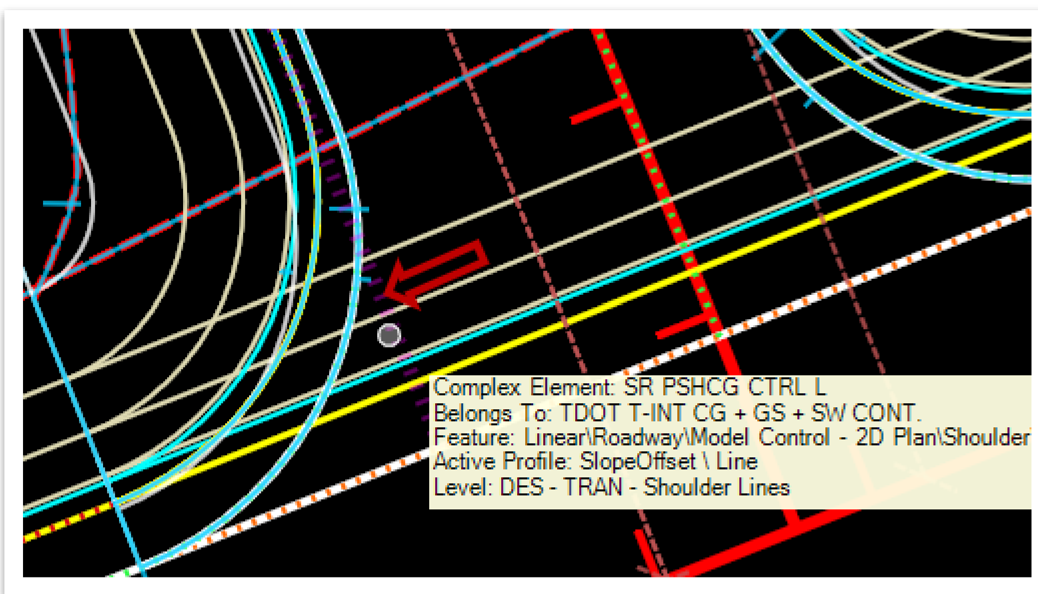
13. Next, open the **Create Point Control** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and select the side road corridor. Within the **Create Point Control** dialog box, select the following settings (leave all others as default) and then **left** click to accept the prompts.
    a. **Locked To Start/End:** On
    b. **Point:** EOP_L_CG
    c. **Mode:** Horizontal
    d. **Control Type:** Linear Geometry
    e. **Plan Element:** EOP - CTRL2



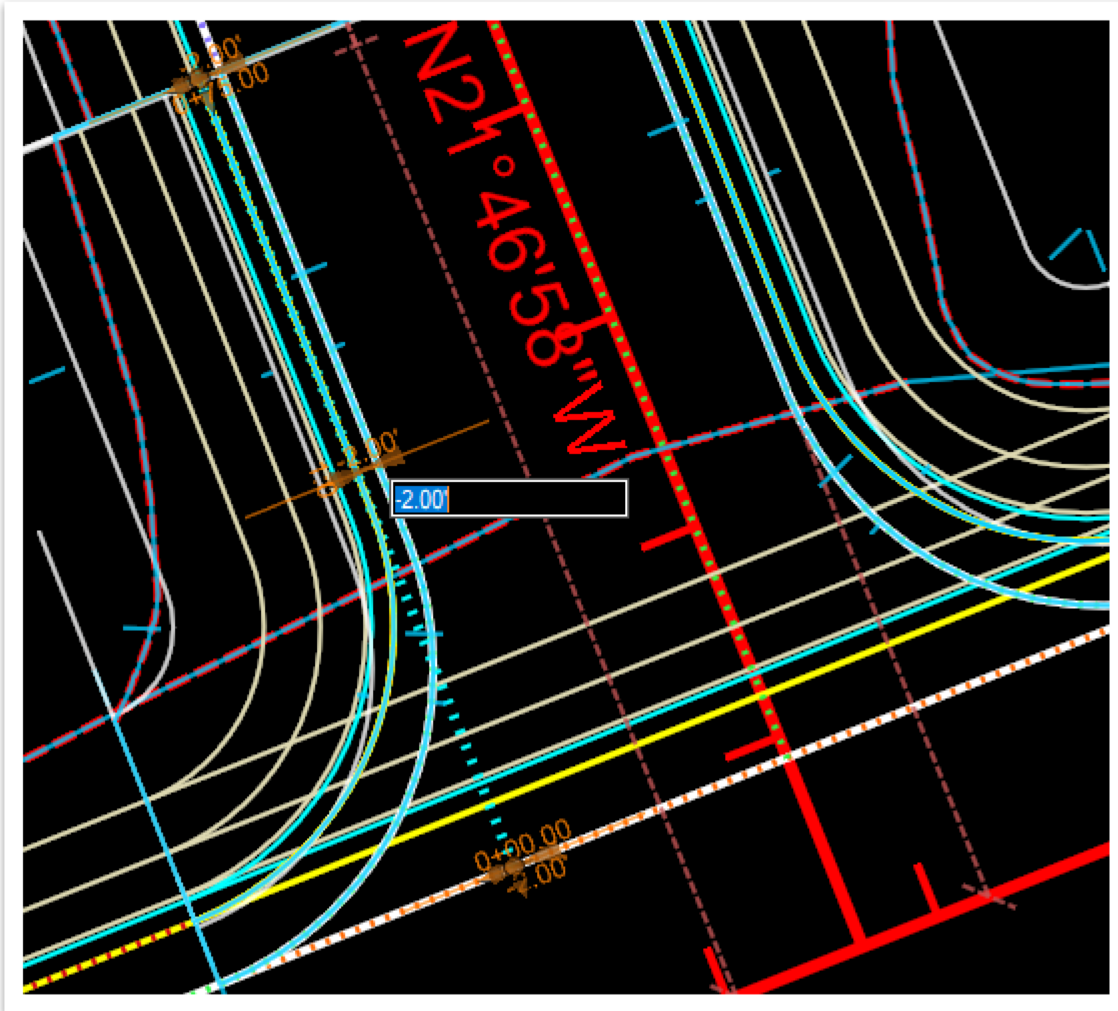
14. The **EOP** should now follow the **control line**, as shown below. To clean up the intersection, we will now move the sideroad template drop to Station **10+93.00**, which is where the civil cell ends.



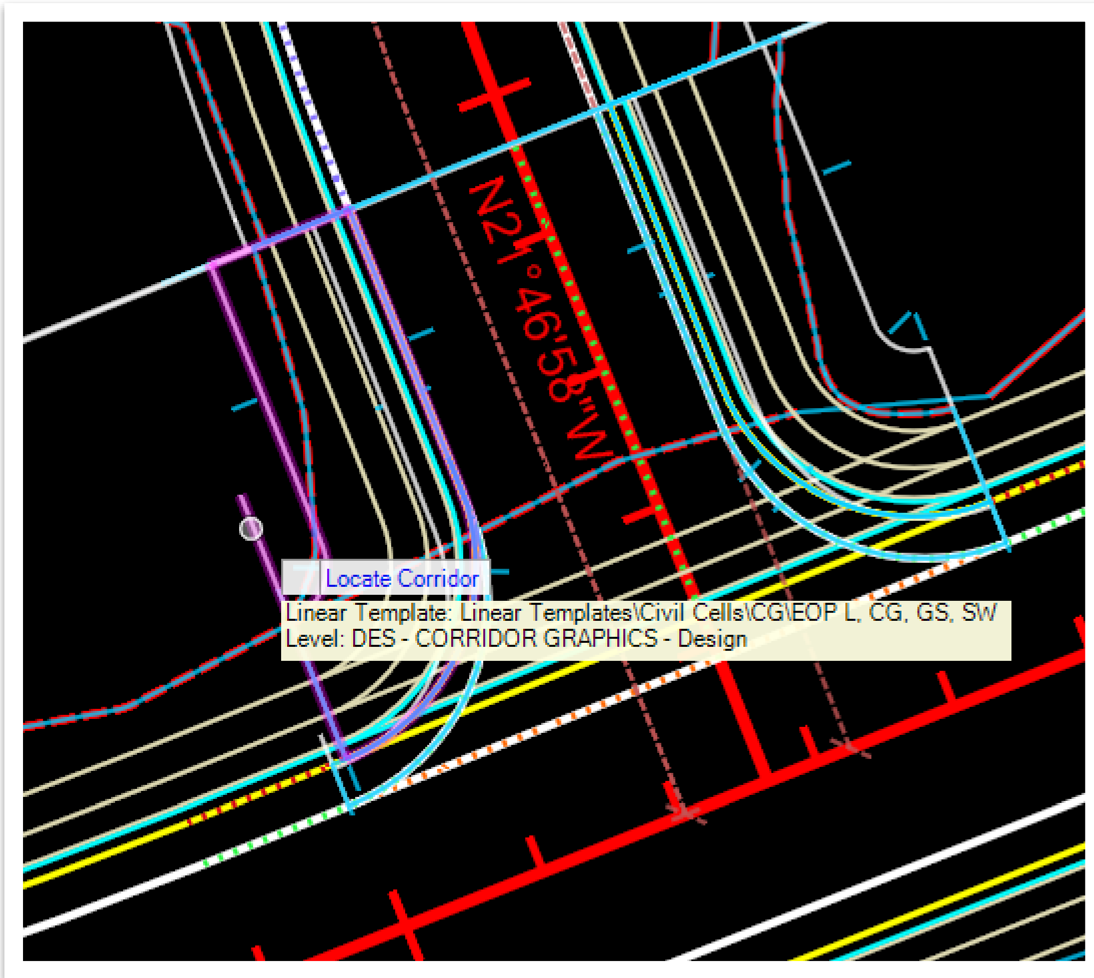
15. Notice that the civil cell automatically lined up with the mainline **PSHCG**, but it did not line up with the side road shoulder. To fix this, first locate the **SR PSH CTRL** line. The easiest way to find the line is to locate the area in the curb return where the line is hidden but is not underneath any other elements. Move the cursor to where the arrow is pointing in the screenshot below so that the line appears and then select the line.



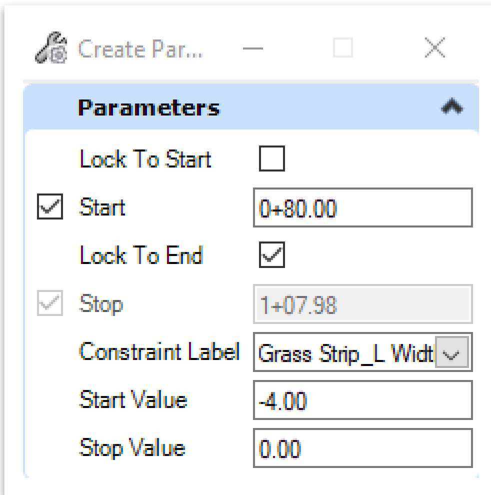
16. Once the line is selected, click the middle offset and change it from -2' to **0**'. Do this for both the left and right **SR PSH CTRL** lines.



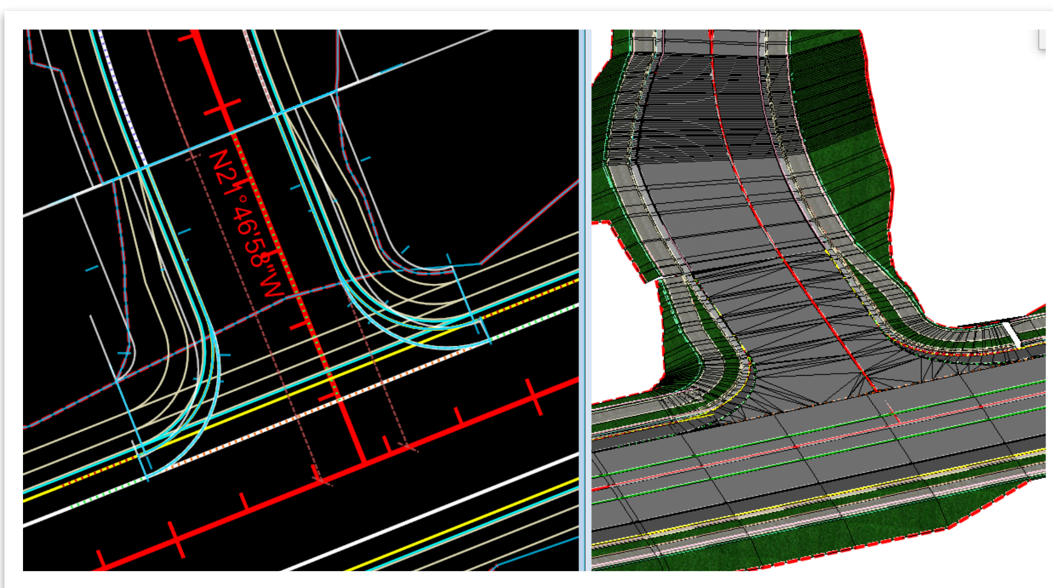
17. Now, we will modify the **grass strip** on the intersection civil cell so that it will taper down to match the side road corridor. Open the **Create Parametric Constraint** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**). Select the left intersection civil cell linear template (not the shoulder template). **Note:** It might be easiest to select the template drop that is as far from the **EOP** around the civil cell for this selection.



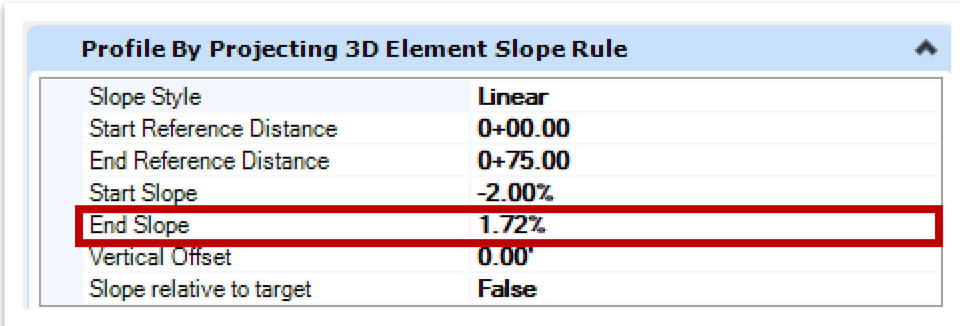
18. Within the **Create Parametric Constraint** dialog box, select the following settings and then **left** click to accept the prompts.
    a. **Start:** 0+80.00
    b. **Lock To End:** On
    c. **Constraint Label:** Grass Strip_L Width
    d. **Start Value:** -4.00
    e. **Stop Value:** 0.00



19. Repeat the previous step for the right grass strip (**Grass Strip_L Width**) by selecting the right intersection civil cell linear template. The start station will be **0+92.00**. Notice the updates once the **Parametric Constraint** has been added. **Note:** Since the civil cell has two identical template drops on each **PSH CTRL** line, the line and parametric constraint names are the same (i.e., the grass strip name is the same for the right side template drop).



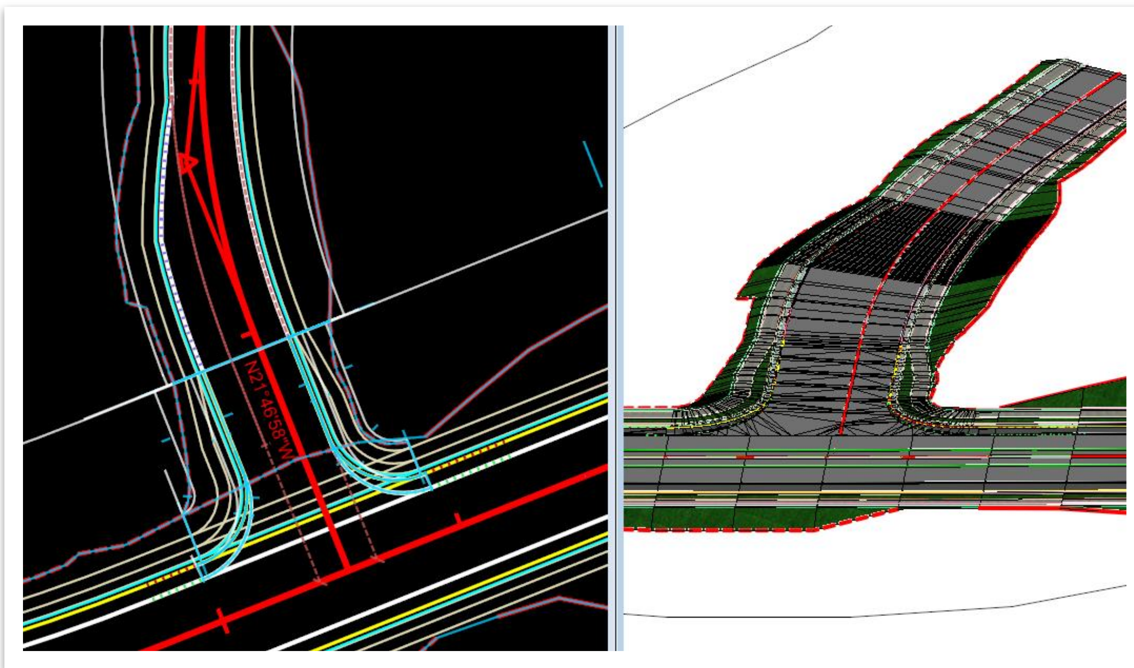
20. Since the side road corridor is superelevated, the civil cell cross slope does not automatically match the cross slope of the side road. Select the **SR EOP CTRL L** line and then within the **Properties**, change the **End Slope** from -2.00% to **1.72%**. The civil cell and the side road cross slopes should now align. **Note:** It might be easiest to select this line within the **Explorer** under the **OpenRoads Model** tab (**OpenRoads Model >> Civil Cells >> Civil Cell TDOT T-INT C&G + GS + SW CONT. >> Dependent Elements**).



Profile By Projecting 3D Element Slope Rule

Slope Style	Linear
Start Reference Distance	0+00.00
End Reference Distance	0+75.00
Start Slope	-2.00%
End Slope	1.72%
Vertical Offset	0.00'
Slope relative to target	False

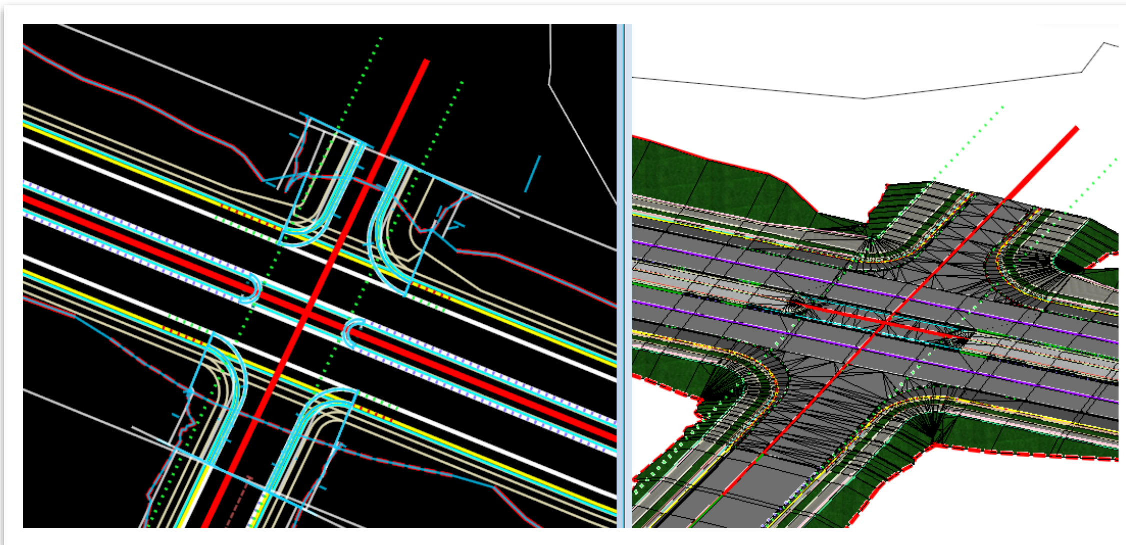
21. The civil cell is now complete. If the mainline is not clipped correctly, go back to the mainline file (**ROAD-II-CC-Corridor.dgn**) and reclip the corridor with the civil cell.



6.5 Exercise: Placing ADA Curb Ramps

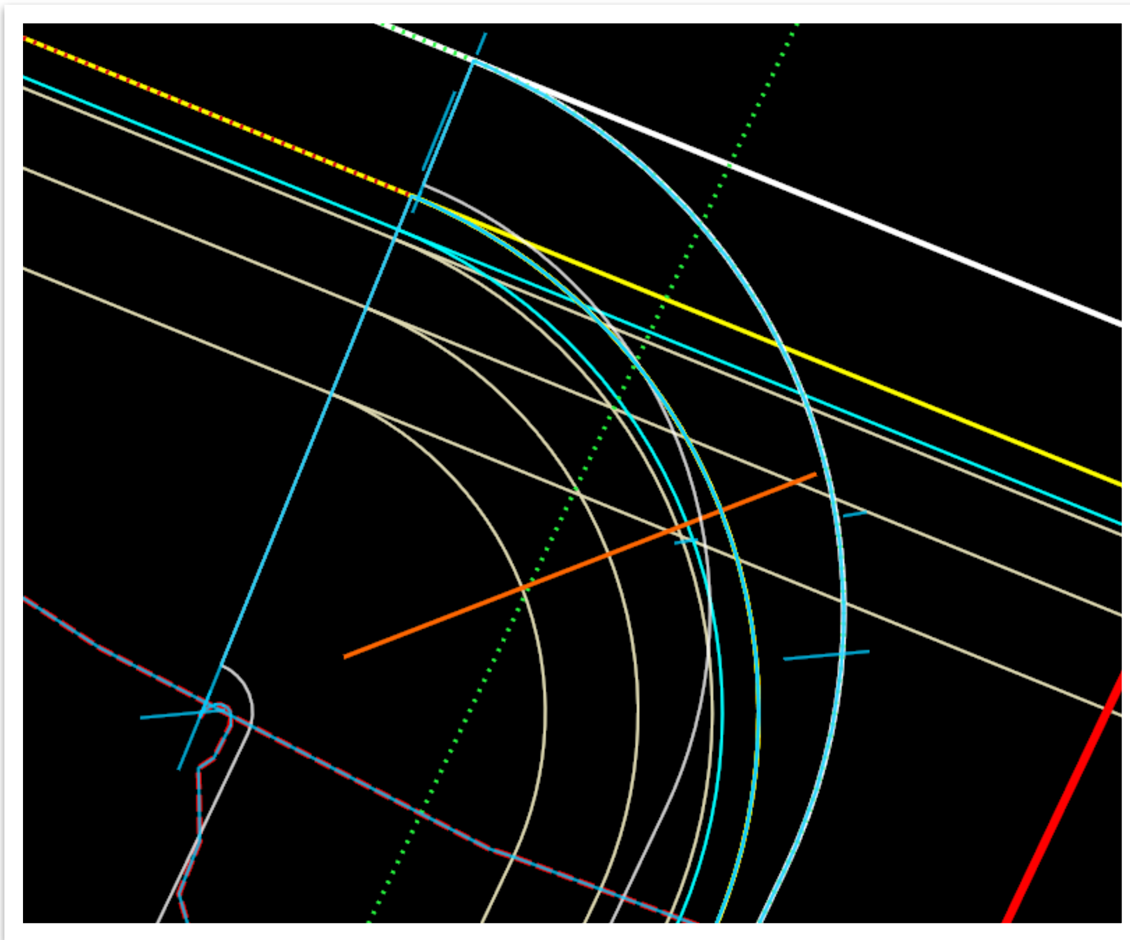
In this exercise, we will place five different ADA curb ramps within a model: four at an intersection and one in the median.

1. Open the **ROAD-II-CC-ADA Corridor.dgn** file within the dgn Chapter 6 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner. The following files should already be referenced in the 2D view.
    - ROAD-II-CC-ADA Alignments.dgn
    - ROAD-II-CC-ADA Terrain.dgn
2. Notice there is a mainline corridor with a 4-way intersection. Zoom in to the **southern** approach with the side road corridor.

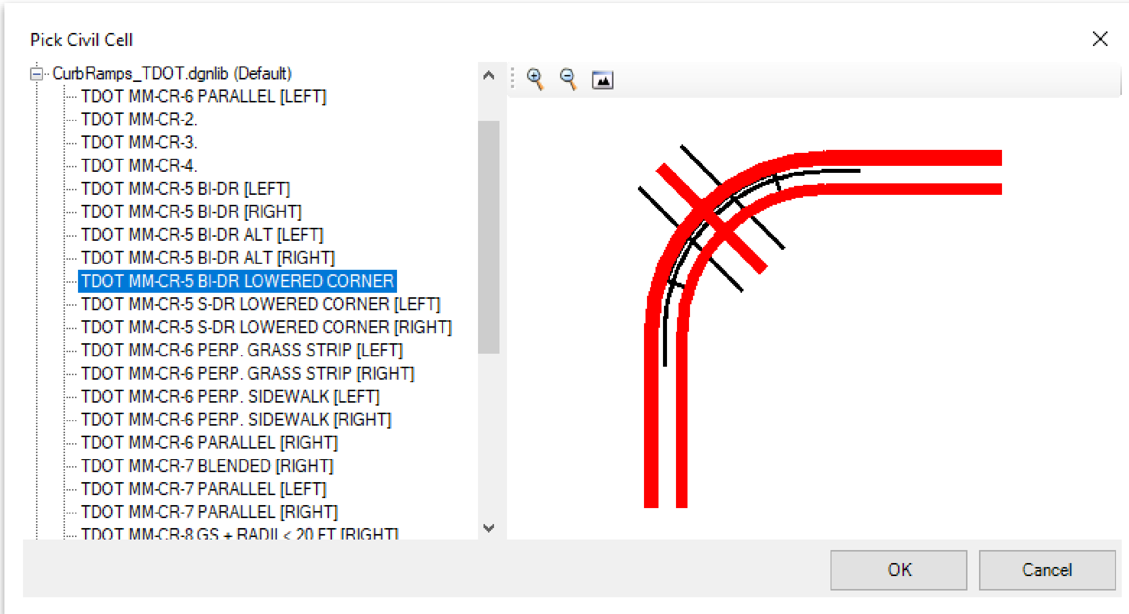


3. Select the **Ramp CL - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Sidewalk**) and set it to active.

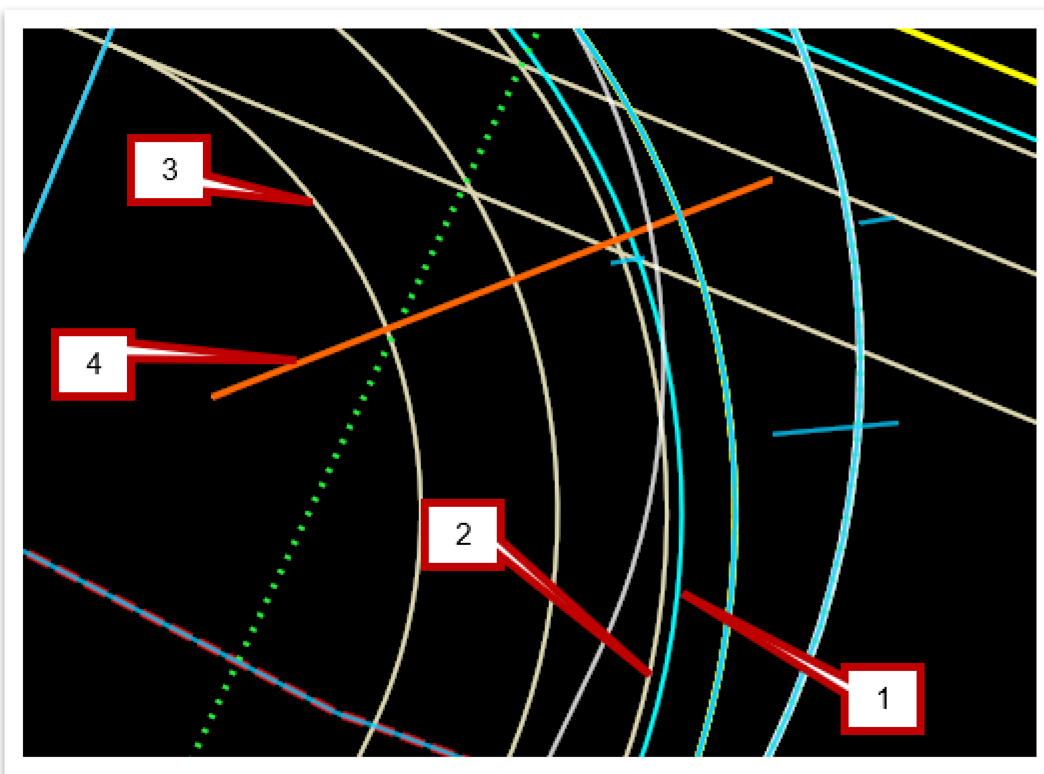
4. Turn on **AccuSnap** and open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**). Locate the southwest corner of the intersection. Snap to the **midpoint** of the flowline (**CR_FLOWLINE_L**) and then use the perpendicular snap to draw a line to the back of sidewalk (**SW_BACK _TOP_L**). Then, extend that line further out in both directions with the **Move** tools so that it bisects all lines in that corner of the intersection and extends past them, as shown below. This centerline and all curb ramp centerlines **do not** need a profile attached to them or will ignore the automatically created profile. The civil cell will automatically profile the curb ramp.



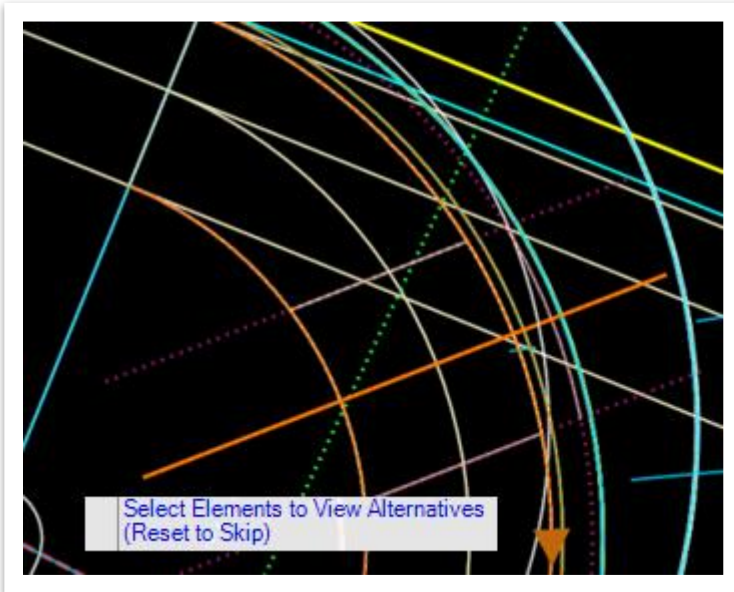
5. Now, open the **Place Civil Cell** tool (**OpenRoads Modeling >> Model Detailing >> Civil Cells**) and select the **TDOT MM-CR-5 BI-DR LOWERED CORNER** civil cell under **CurbRamps_TDOT.dgnlib** and click **OK**.



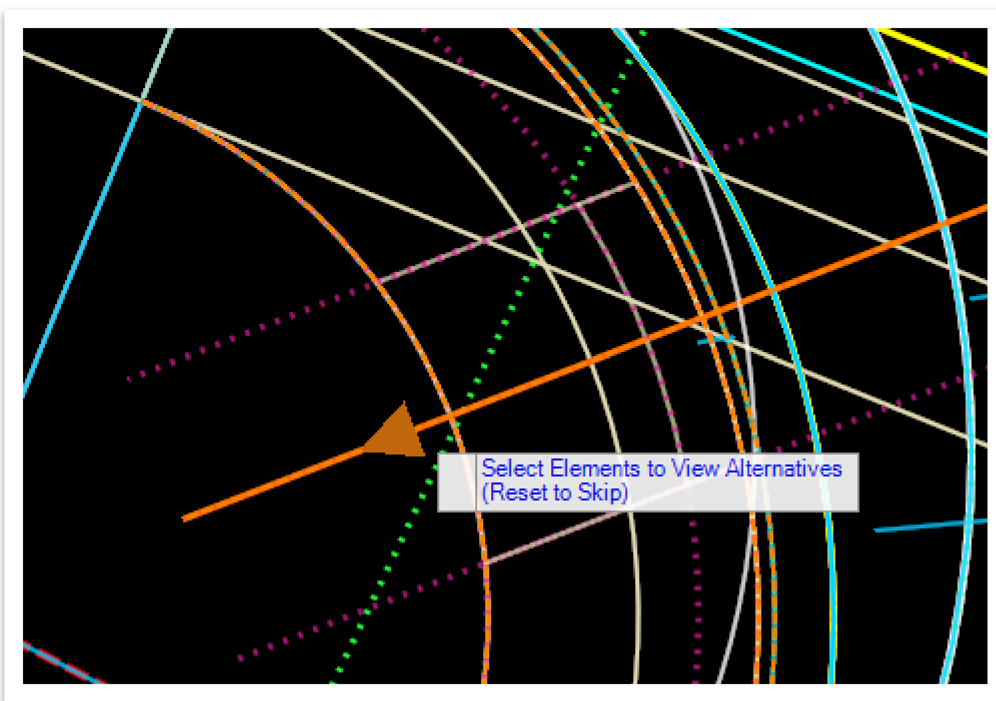
6. Follow the prompts and select the **CR Flowline** (**1**), **CR BACK TOP** (**2**), **SW BACK TOP** (**3**) and then the **Ramp CL** (**4**), which is the line that was just drawn.



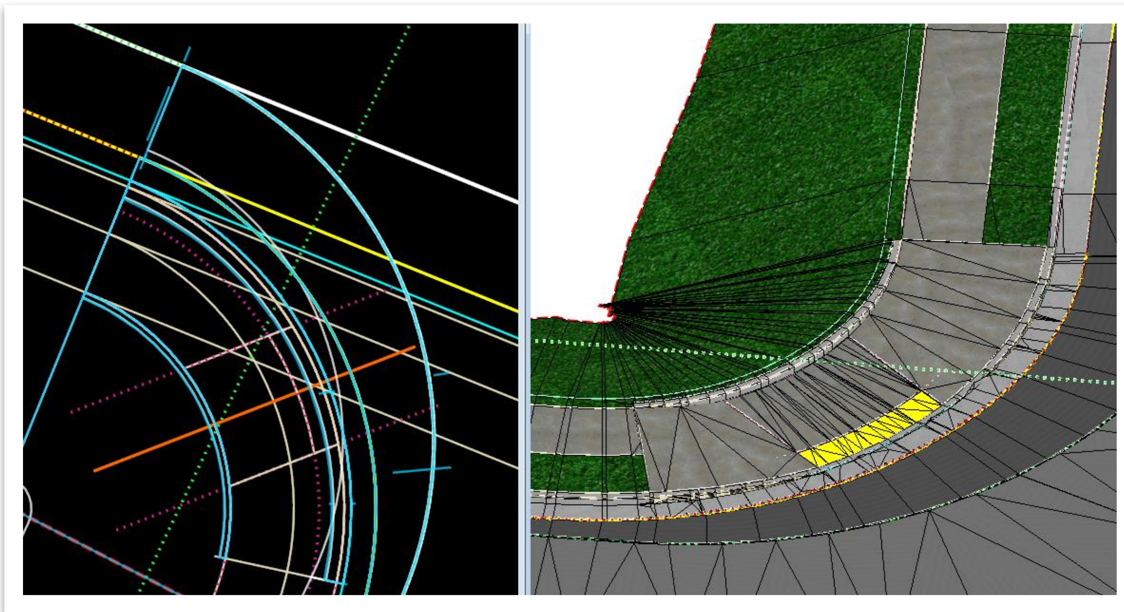
7. The civil cell preview should be close to what's expected but notice that the detectable warning surface controlling lines are placed on the outside of the **CR** flowline. This is because the cell was not built in this direction and therefore without changing the reference lines, the cell would be broken when placed. Many of the civil cells will still work when all reference lines are reversed.



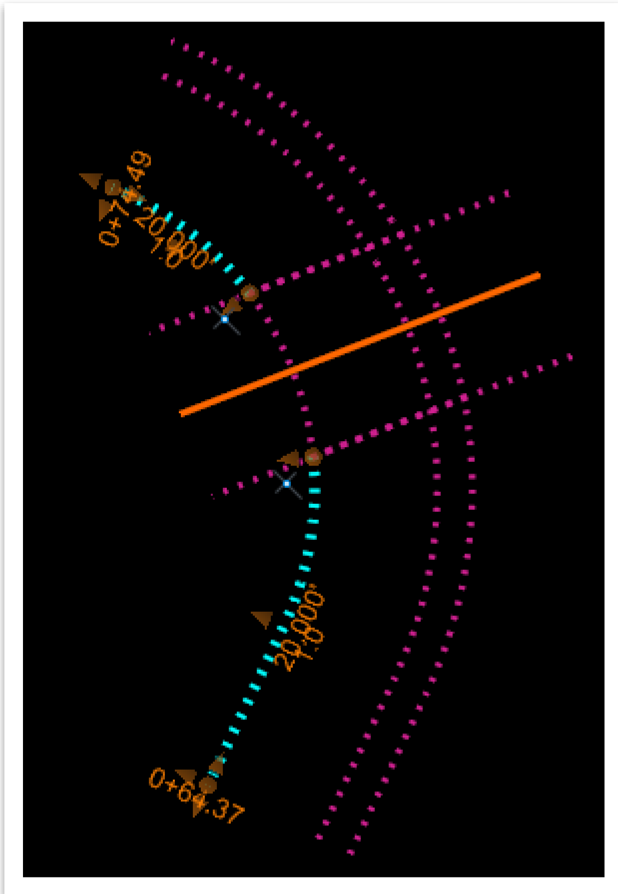
8. To fix the civil cell, we need to reverse all the reference line directions. Click on all four of the **orange** lines to change their direction, and then the civil cell preview should be correct.



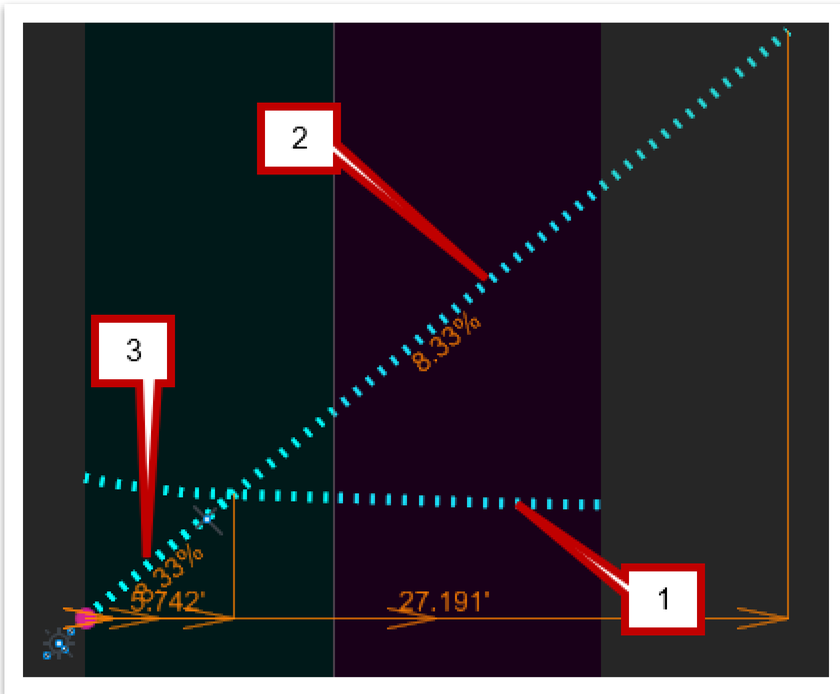
9. Go ahead and **right** click to the next prompt, which asks for the corridors that this civil cell will clip. Select the intersection civil cell that this civil cell is placing on. **Right** click to advance and then **left** click to accept the civil cell placement. **Note:** For this curb ramp civil cell, only the intersection civil cell is being clipped. The curb ramp cannot extend onto the mainline corridor since none of the reference lines are from the mainline. Make sure to check that the ramp slopes tie back into the intersection civil cell. In this exercise, the ramp towards the mainline does not successfully tie back. The user will need to adjust the radius of the curb return or extend the civil cell template drop along the mainline. We will leave the civil cell as is for now.



10. Currently, the ramp slopes of this civil cell are set to **8.33%**, which is the allowable maximum. To change this ramp slope, open the profile model by selecting the pink dashed line (**RAMP SLOPE CTRL**). There is a **RAMP SLOPE CTRL L** and **RAMP SLOPE CTRL R** along the back of the ramp on the left and right sides of the curb ramp civil cell. To access the ramp control lines more easily, turn off all levels other than the **DES - TRAN - Sidewalk** level.

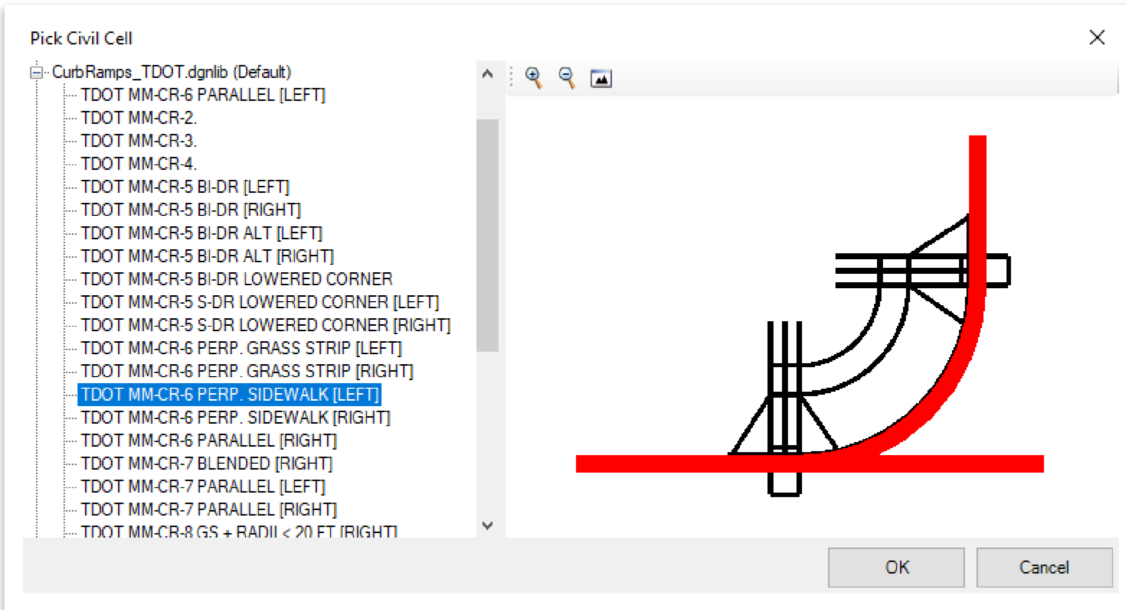


11. Let's open the **RAMP SLOPE CTRL R** profile to see how the profiles are created. The arced line (**1**) is the base sidewalk profile from the intersection civil cell. The pink dot is the intersection of the lowered ramp right line. The line extending up (**2**) is the slope control line where the slope of this ramp is controlled. There is a third line (**3**) that uses the intersection of the arced sidewalk line and the controlling line to determine where the ramp stops. Many ramp profiles that are controllable are set up like this, but some ramps have a more complex setup to ensure the civil cell does not break.

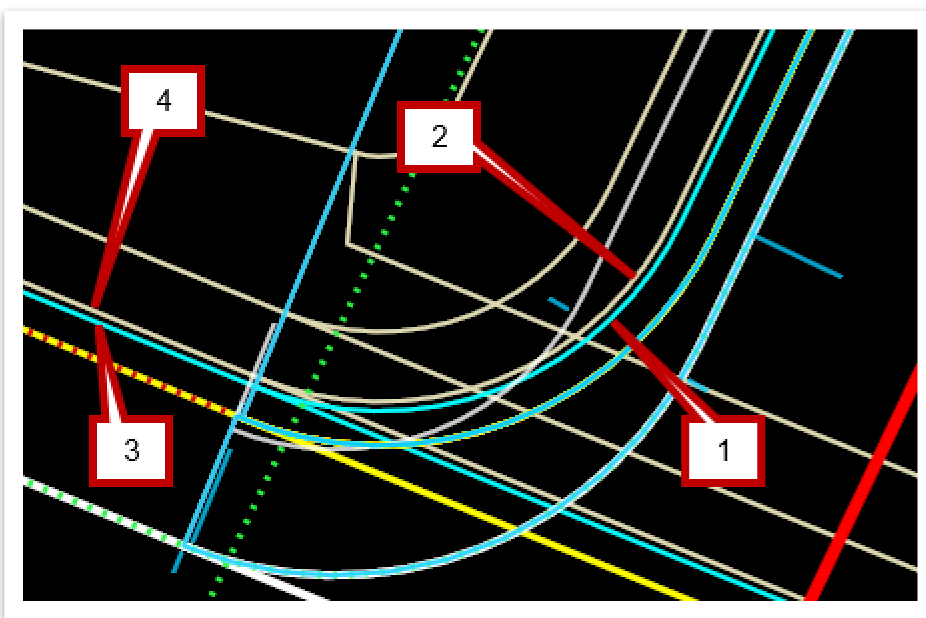


12. Go ahead and change the slope of **line 2** to **6%**, which will update the slope of the right ramp, and then turn all levels back on.

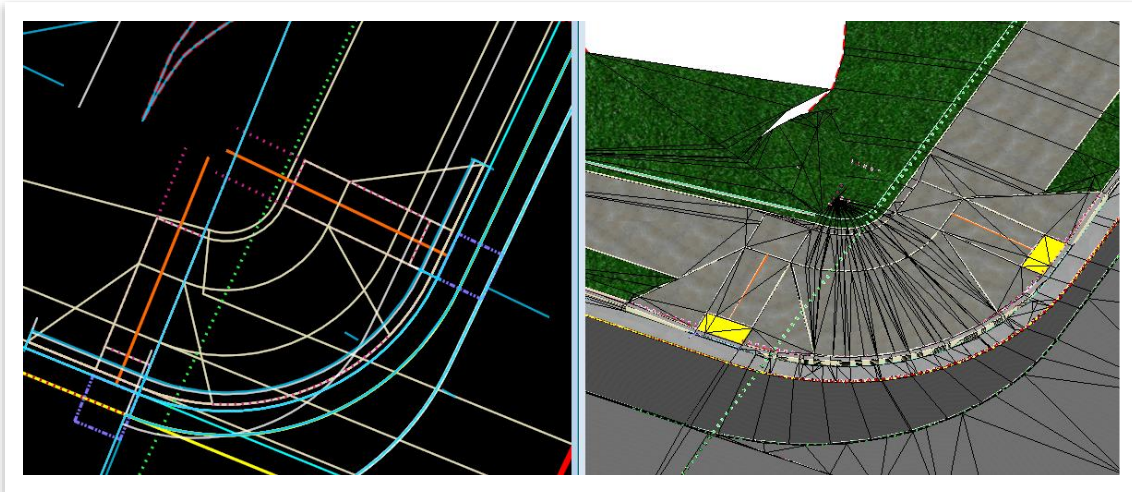
13. Next, locate the northwest corner of the intersection. This curb ramp will not require a ramp centerline. Open the **Place Civil Cell** tool once again (**OpenRoads Modeling >> Model Detailing >> Civil Cells**) and select the **TDOT MM-CR-6 PERP. SIDEWALK [LEFT]** civil cell under **CurbRamps_TDOT.dgnlib** and click **OK**. **Note:** Not all curb ramp civil cells need a designated centerline. In this scenario, the civil cell can successfully build the curb ramps by simply knowing where the mainline, the curb return flowline, and the curbs are located.



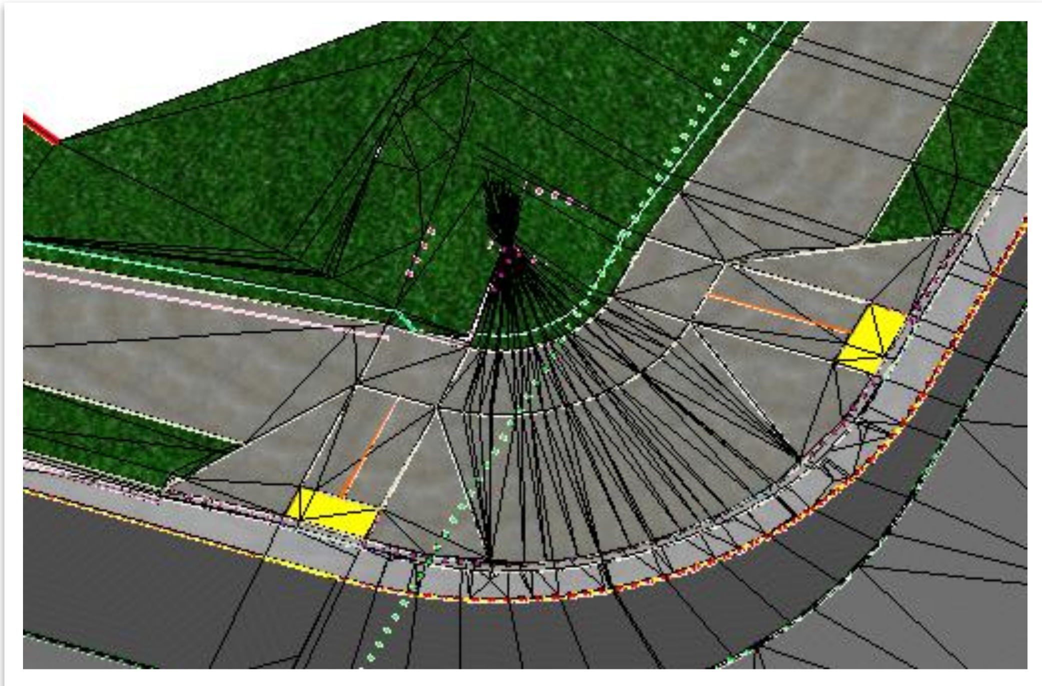
14. Select the following reference lines in order: the intersection (curb return) **CR Flowline** (**1**), the intersection (curb return) **CR Back Top** (**2**), the mainline **CR Flowline** (**3**), and the mainline **CR Back Top** (**4**).



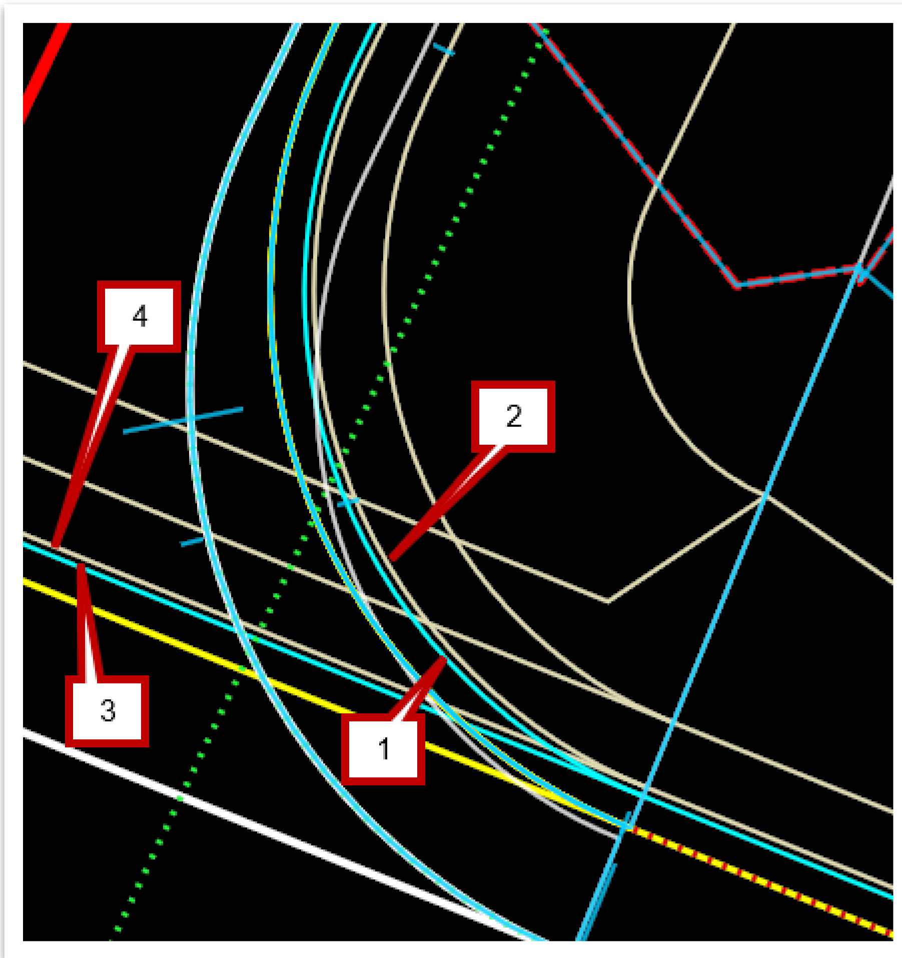
15. The preview should be correct. **Right** click to advance, then select both the intersection and the mainline corridors to clip. **Right** click to advance and then **left** click to accept the civil cell. **Note:** Because these curb ramps have a **[LEFT]** or **[RIGHT]**, the preview should be correct. In this exercise, the **left** will work for the top left (NW) and bottom right (SE), and the **right** will work for the top right (NE) and the bottom left (SW).



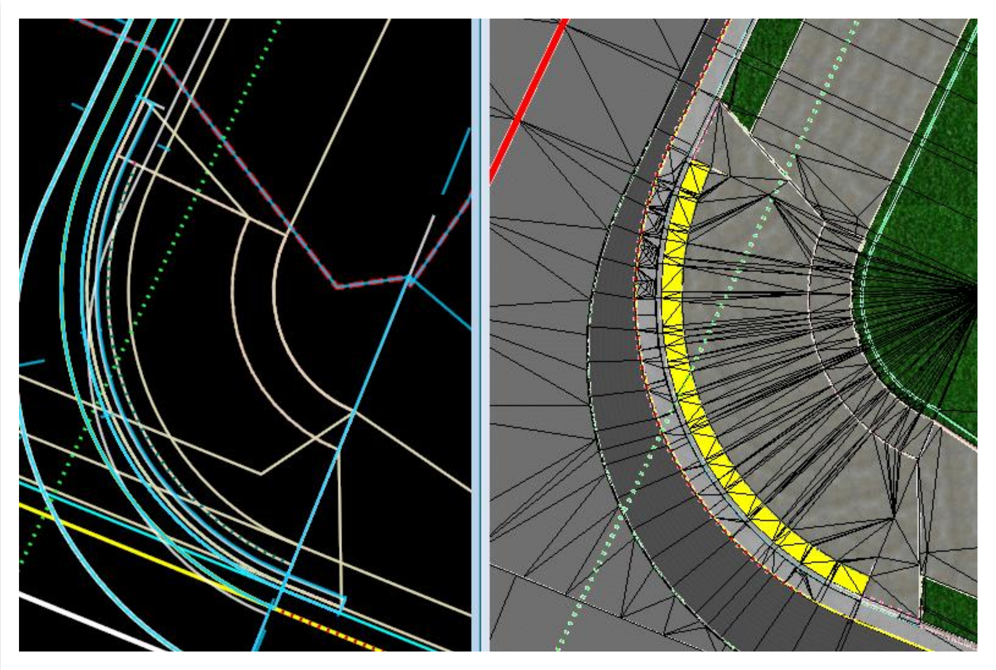
16. Zoom in and notice that the sidewalks have been tapered and adjusted to meet the back of the civil cell ramps. This is because the civil cell is built with the maximum slope of **8.33%** and the sidewalk needs to be widened to match the civil cell max slope. **Note:** For all civil cells that have two ramps that wrap around the radius, the civil cell will not work well if the ramps are two different slopes.



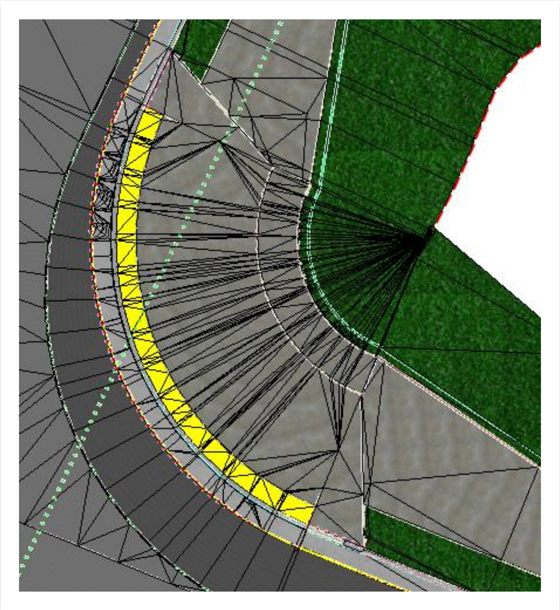
17. Continuing clockwise, now locate the <u>northeast</u> corner of the intersection. Open the **Place Civil Cell** tool once again (**OpenRoads Modeling >> Model Detailing >> Civil Cells**) and select the **TDOT MM-CR-7 BLENDED [RIGHT]** civil cell under **CurbRamps_TDOT.dgnlib** and click **OK**.
18. Follow the prompts and select the intersection (curb return) **CR Flowline** (**1**), the intersection (curb return) **CR Back Top** (**2**), the mainline **CR Flowline** (**3**) and the mainline **CR Back Top** (**4**).



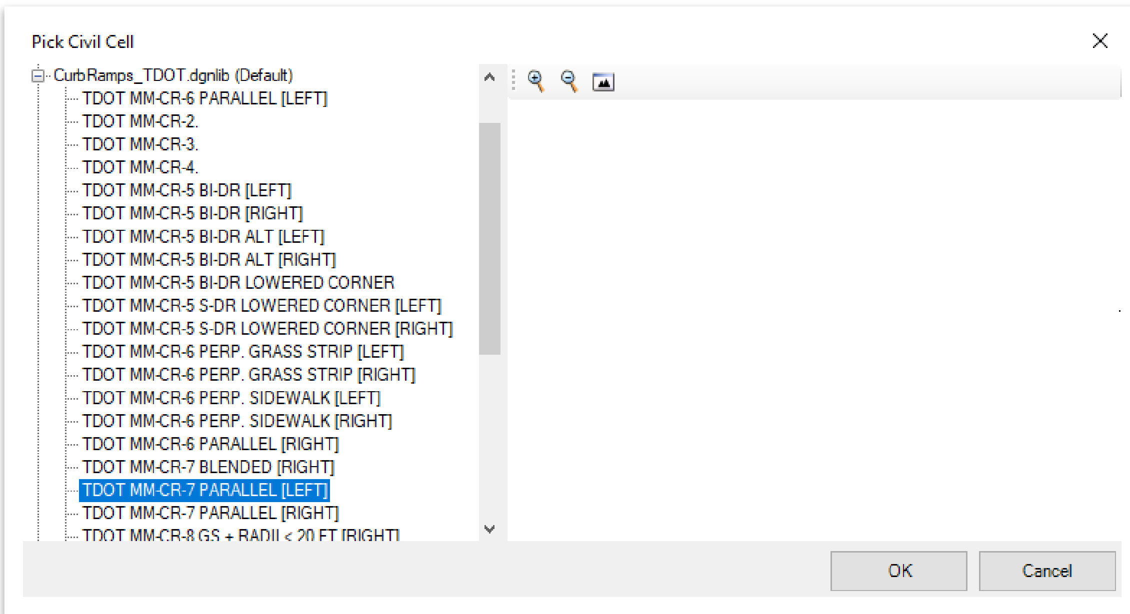
19. The preview should be correct. **Right** click to advance, then select both the intersection and the mainline corridors to clip. **Right** click to advance and then **left** click to accept the civil cell.



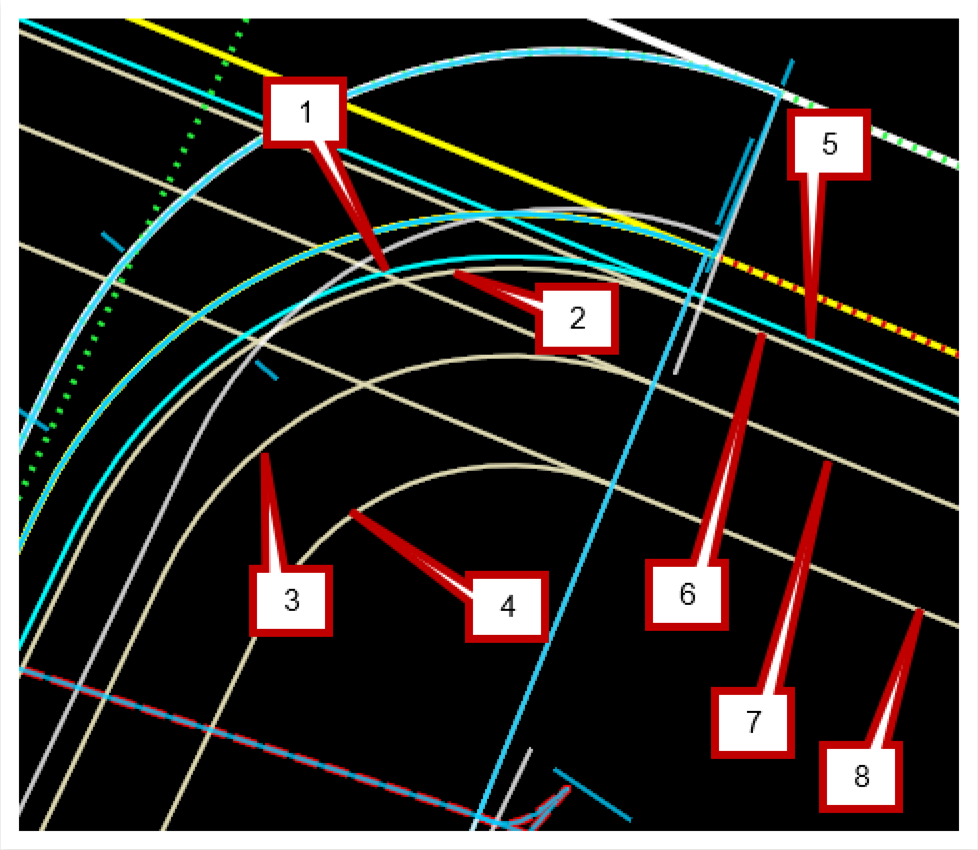
20. Zoom in and notice once again that the sidewalks have been tapered and adjusted to meet the back of the civil cell ramps. This is because the civil cell is built with the maximum slope of **8.33%** and the sidewalk needs to be widened to match the civil cell.



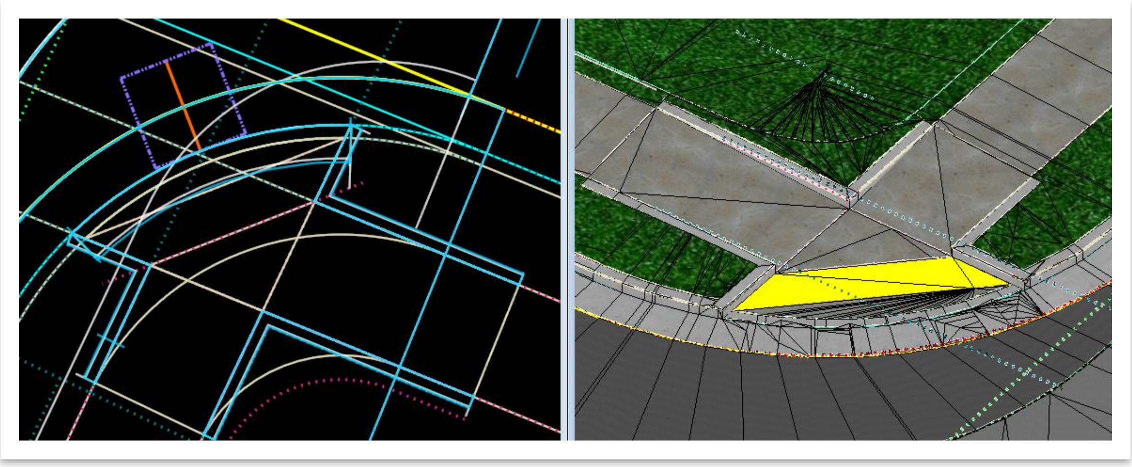
21. Continuing clockwise, now locate the southeast corner of the intersection. We will now place the **MM-CR-7 Parallel** civil cell, which is the most complicated curb ramp civil cell in the library. It requires **8** different reference line selections. **Note:** This civil cell can only be used where the intersection curb return radius is relatively small. If the radius is too large, the civil cell will break and not display correctly.
22. Open the **Place Civil Cell** tool once again (**OpenRoads Modeling >> Model Detailing >> Civil Cells**) and select the **TDOT MM-CR-7 Parallel [LEFT]** civil cell under **CurbRamps_TDOT.dgnlib** and click **OK**. **Note:** This civil cell, as well as a few others, do not show a preview within the **Pick Civil Cell** window. This is a bug in the software and Bentley has logged a defect.



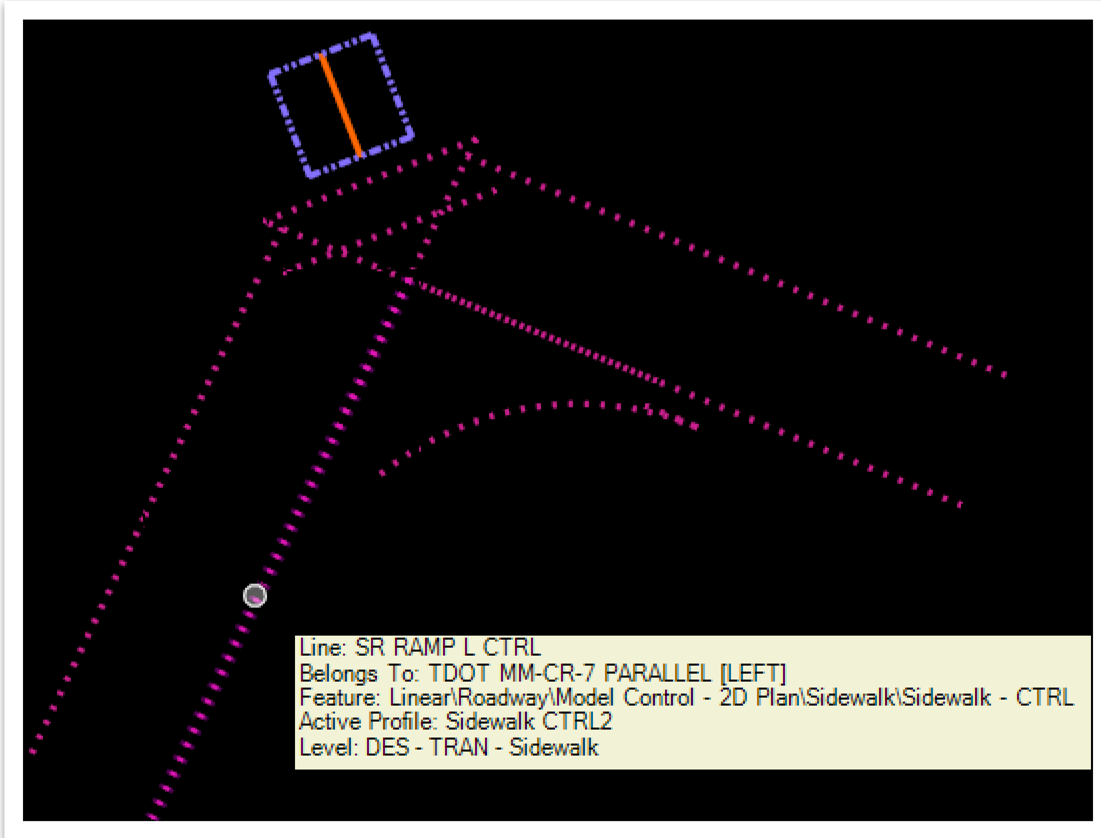
23. Follow the prompts and select the intersection (curb return) **CR Flowline** (**1**), the intersection (curb return) **CR Back Top** (**2**), the intersection (curb return) **SW Front Top** (**3**), the intersection (curb return) **SW Back Top** (**4**), the mainline **CR Flowline** (**5**), the mainline **CR Back Top** (**6**), the mainline **SW Front Top** (**7**), and the mainline **SW Back Top** (**8**).



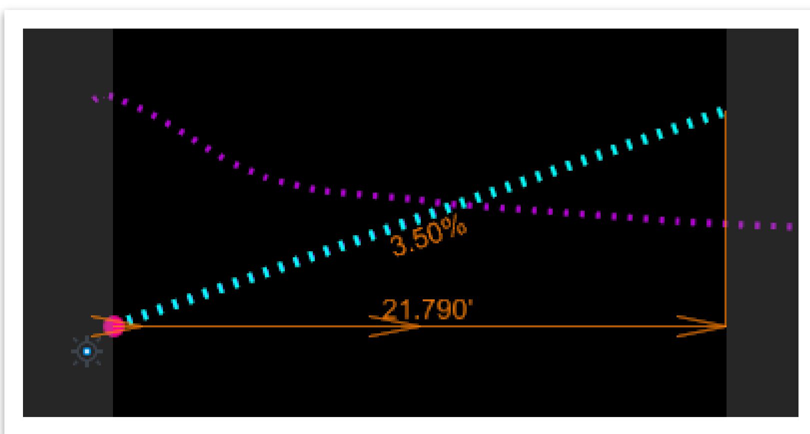
24. The preview should be correct. **Right** click to advance, then select both the intersection and the mainline corridors to clip. **Right** click to advance and then **left** click to accept the civil cell.



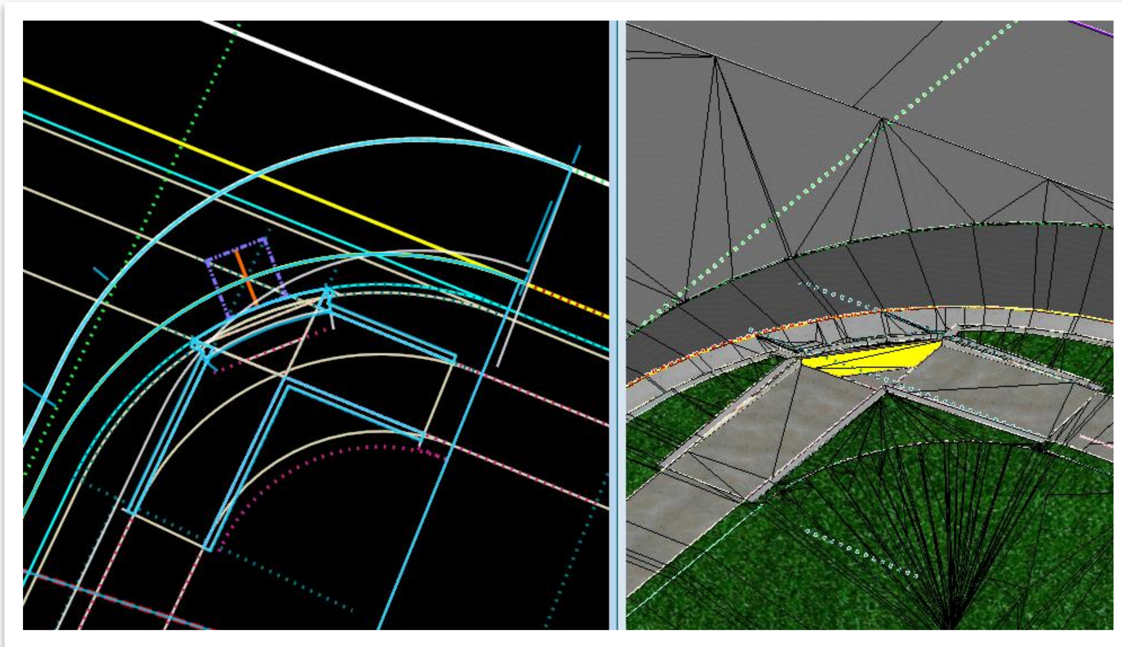
25. We will now change the ramp slope. First, turn off all levels other than the **DES - TRAN - Sidewalk** level and then open the profile of the pink dashed line (**SR RAMP L CTRL**).



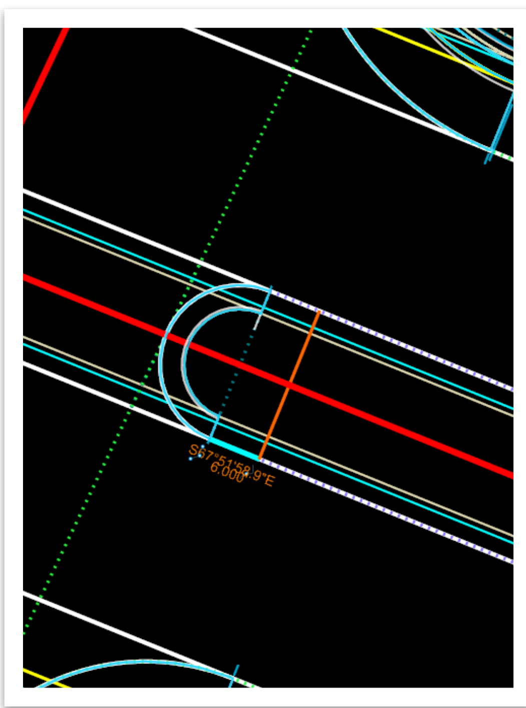
26. Go ahead and change the slope of the profile from 8.33% to **3.5%**. Notice the ramp has extended but the **R** side of the ramp is still sloped at 8.33%. This is because of the complexity of the civil cell, where both **CTRL** element slopes will need to be manually adjusted. The slopes need to be the same, but this civil cell is one of the exceptions where the mainline and sideroad ramp slopes <u>can be</u> different.



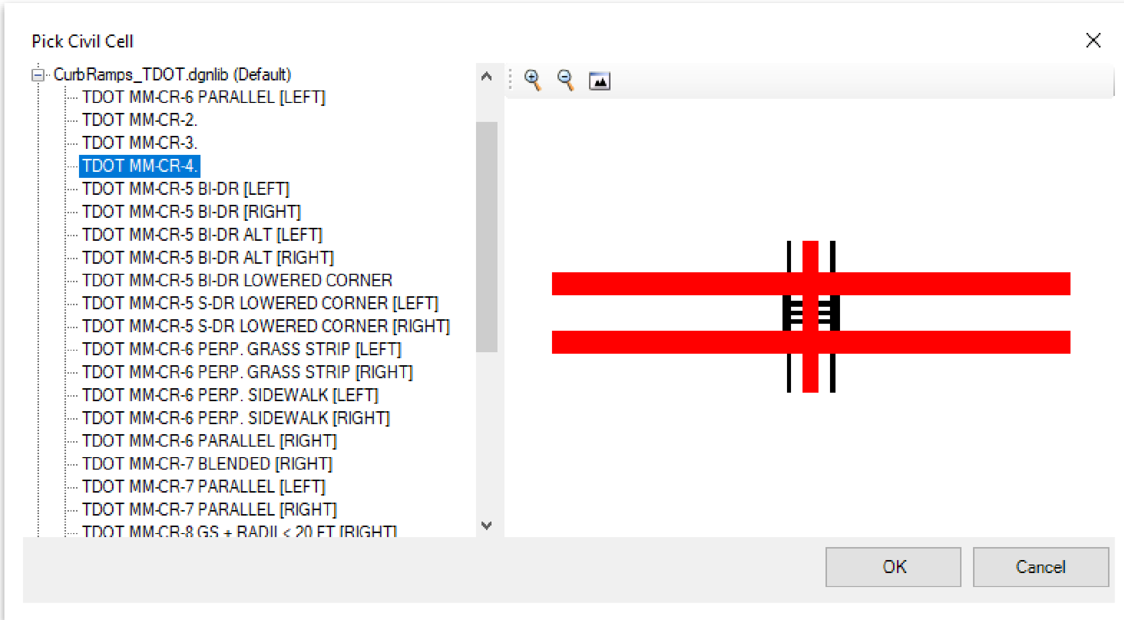
27. Repeat the same change in the profile slope for the **SR RAMP R CTRL** line and then notice the update. Turn all levels back on to see the updated **2D** geometry after the adjustments to the civil cell have been made.



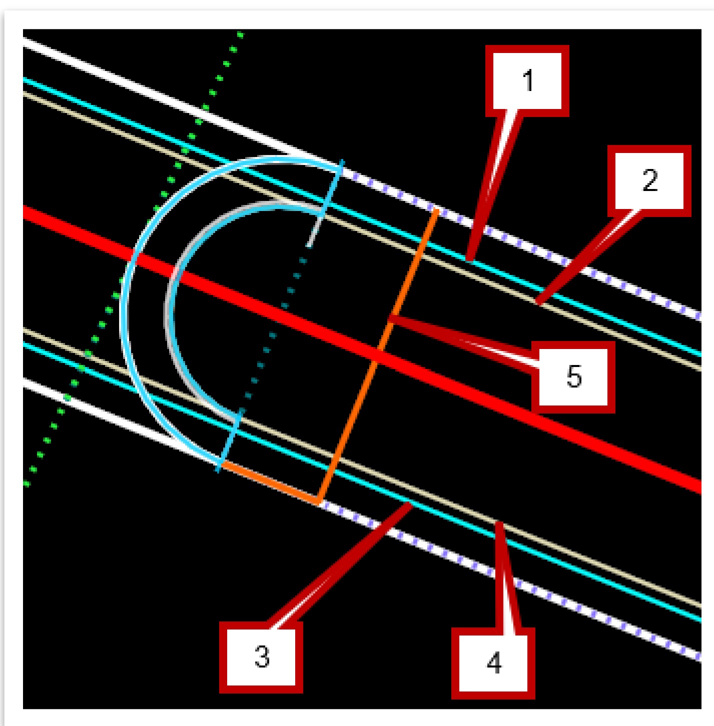
28. Next, locate the <u>east</u> median opening between the two **CR-7** curb ramps placed earlier in the exercise. With the **Ramp CL - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Sidewalk**) still active, draw a geometry line **6** feet off the back of the median opening nose, perpendicular to the **EOP** lines.



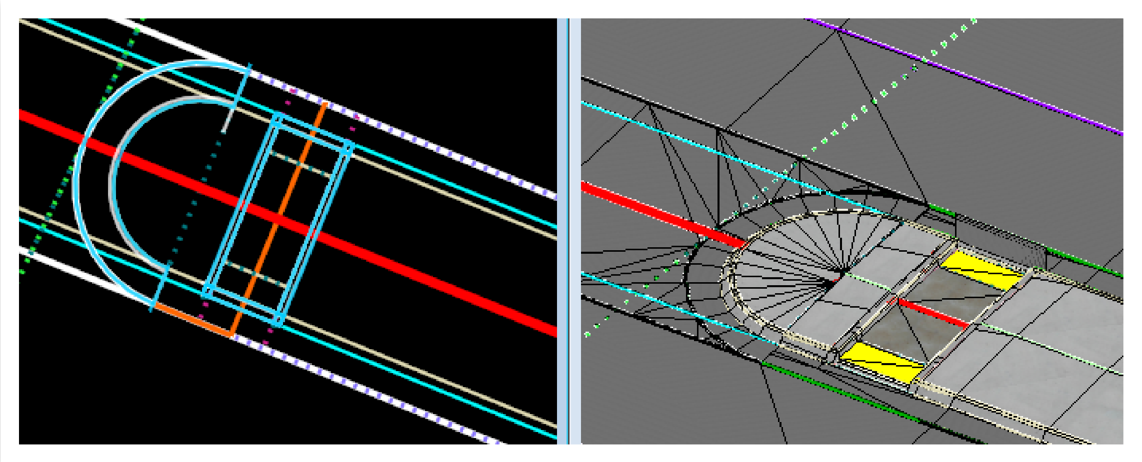
29. Open the **Place Civil Cell** tool one more time (**OpenRoads Modeling >> Model Detailing >> Civil Cells**) and select the **TDOT MM-CR-4** civil cell under **CurbRamps_TDOT.dgnlib** and click **OK**.



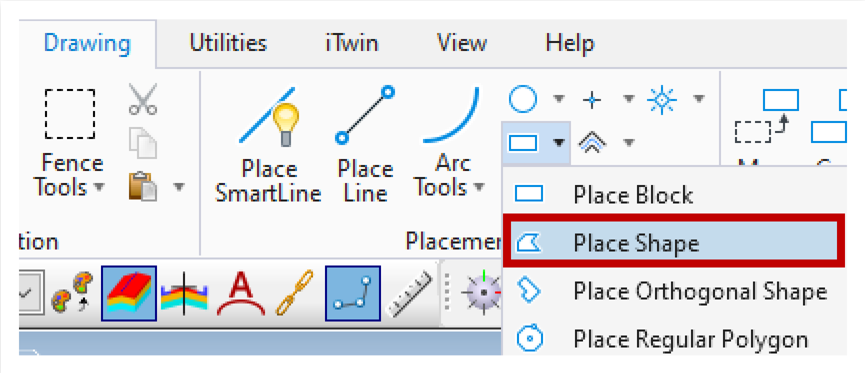
30. Follow the prompts and select the top **CR Flowline** (**1**), the top **CR Back Top** (**2**), the bottom **CR Flowline** (**3**), the bottom **CR Back Top** (**4**), and then the orange **Ramp Centerline** (**5**).

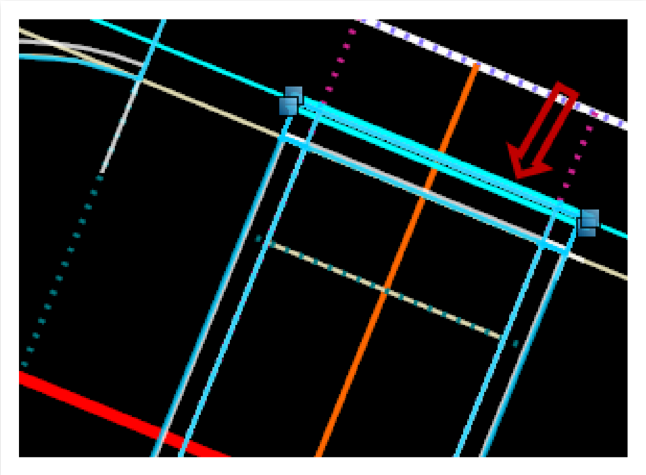


31. The preview should be correct. **Right** click to advance, then select the mainline corridor to clip. **Right** click to advance and then **left** click to accept the civil cell.

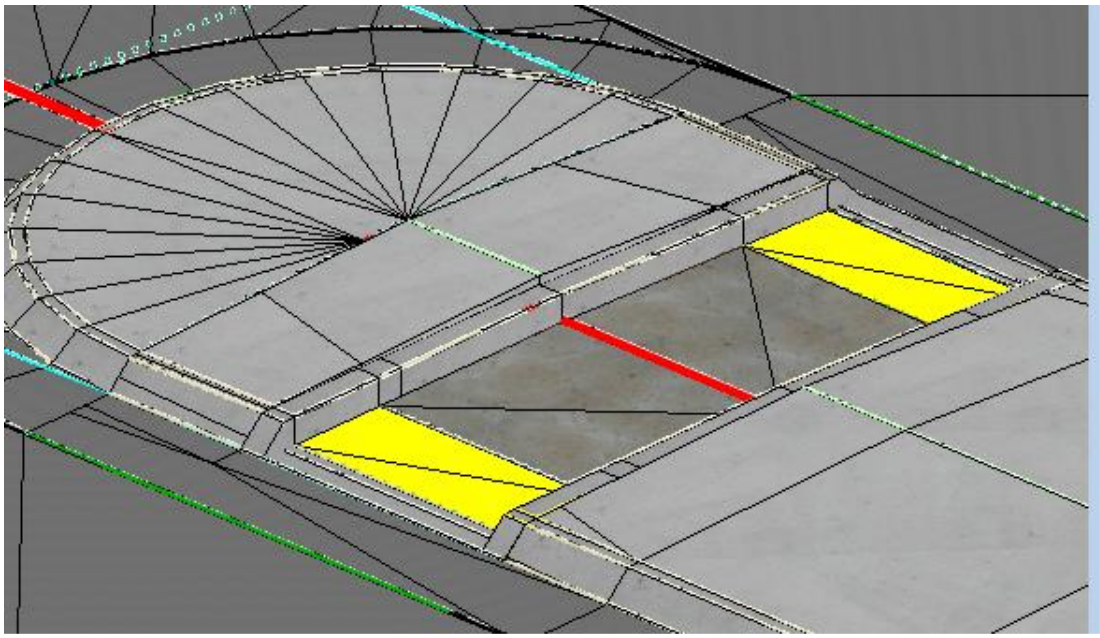


32. Notice that there is a clipping issue with the mainline (the vertical gray rectangle on the top side of the curb ramp). To fix the issue, open the **Place Shape** tool (**OpenRoads Modeling >> Drawing >> Placement**) and place a small shape around where the clipping issues are in the **2D** view. The shape should cover the median flowline (blue line) across where the civil cell is.





33. Then, open the **Add Clipping Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor Clipping**), select the mainline corridor, and then select the shape that was just drawn. If the clipping does not go away, adjust the shape until the clip works. This completes the placement of the curb ramp civil cells.



Take Note!

There is an additional civil cell exercise in Appendix A.1, which involves creating a Cul-De-Sac.

Chapter 7. Template Drop Transitions

Whenever a template drop (typical section) changes within a corridor, designers will have to model the **transition** between the two template drops. This chapter will discuss the applicable tools available to model transitions between template drops.

7.1 Objectives

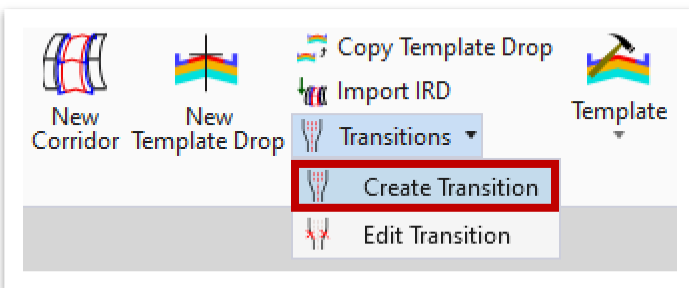
At the conclusion of this chapter, participants will be able to:

1. Create a transition from a 3-lane typical section to a 4-lane typical section with a raised median.

7.2 Lecture: Template Drop Transitions Overview

Template drop transitions allow the model to accurately transition between different template drops within the same corridor. The **Create Transition** tool (**OpenRoads Modeling >> Corridors >> Create >> Transitions**) creates a transition between two template drops (Figure 10). While this tool is useful for the more complicated transitions, it is not the only way to transition between templates. The user may want to use an easier transition method (e.g., point controls, parametric constraints or display rules) for certain scenarios.

FIGURE 10. CREATE TRANSITION TOOL



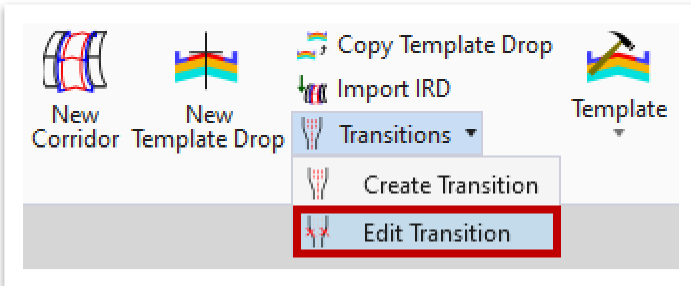
Transitions work by targeting points of the same name between the two template drops selected. The template will automatically connect points of the same name when a new transition is created. However, the transition will need to be edited due to one of the two reasons listed below:

- There are new points being introduced or removed from one template drop to another.
- The consistent points have horizontal and vertical constraints attached to them that need to be removed, so the transition between the two templates functions correctly.

The **Edit Transition** tool (**OpenRoads Modeling >> Corridors >> Create >> Transitions**) allows the user to edit the transitions placed within a corridor (Figure 11). The two main functions are to:

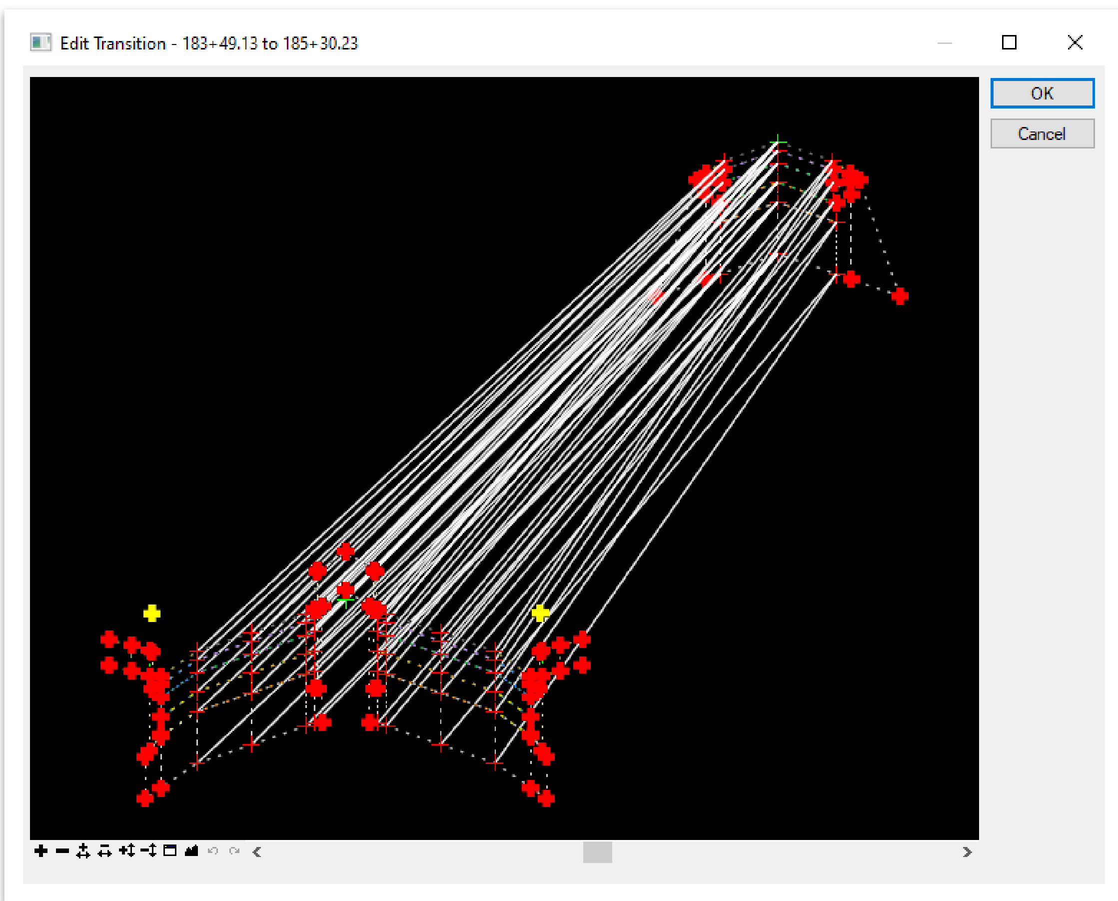
- Connect points from one template drop to the other that were not connected automatically.
- Edit point constraints within the transition.

FIGURE 11. EDIT TRANSITION TOOL



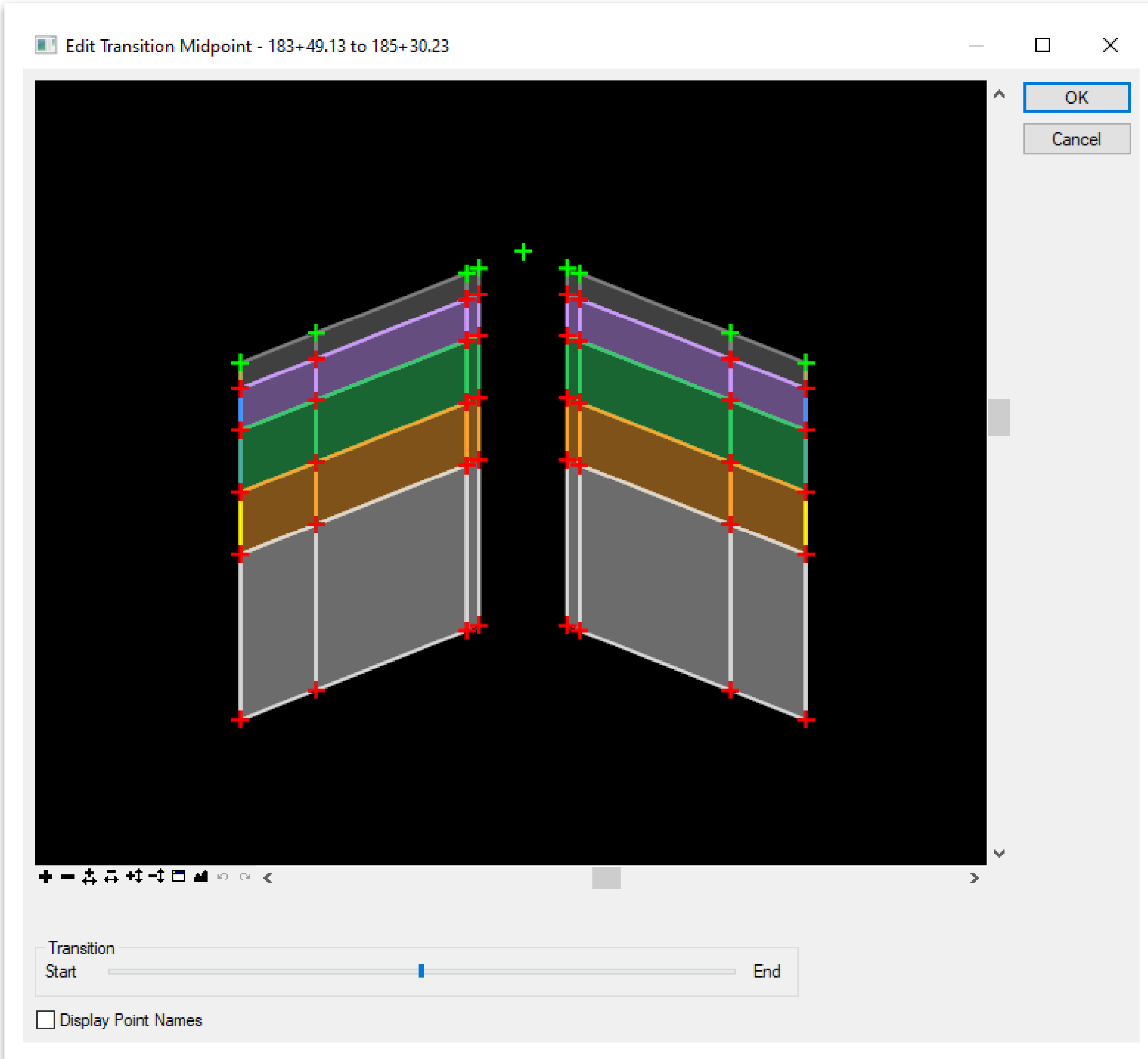
Within the **Edit Transition** tool, the **first window** allows you to delete automatic links and create new links between points in the two template drops (Figure 12).

FIGURE 12. EDIT TRANSITION TOOL – FIRST WINDOW



The **second window** within the **Edit Transition** tool is where points can be edited (Figure 13). Point constraints can be added and deleted. This window also serves as a preview for how the transition will function. The slider at the bottom of the window can be moved accordingly to view different cross sections within the transition.

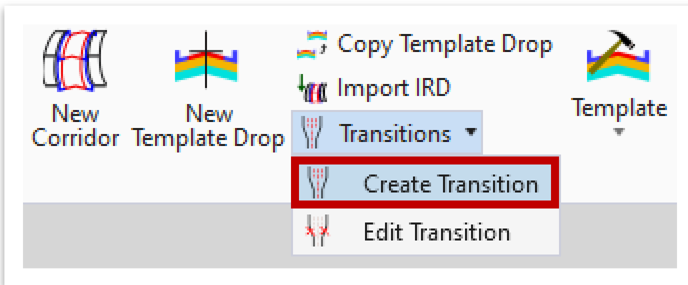
FIGURE 13. EDIT TRANSITION TOOL – SECOND WINDOW



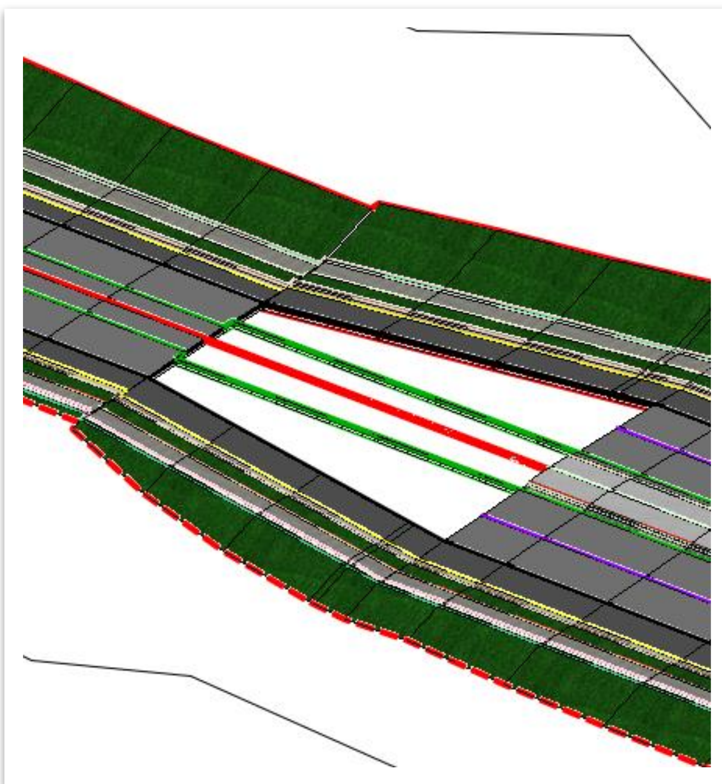
7.3 Exercise: 3-Lane to 4-Lane With Median Transition

In this exercise, we will create a transition from a 3LN to a 4LN typical section using the transition tool. Then, we will use a surface template to model what the transition tool does not create.

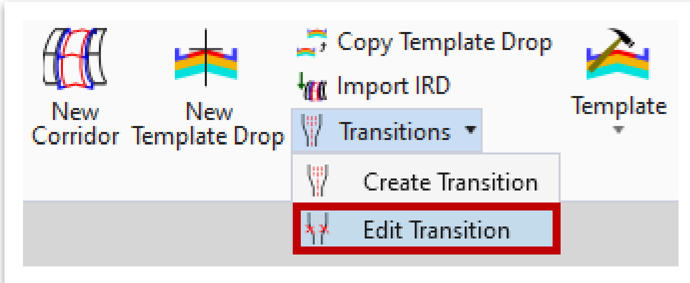
1. Open the **ROAD-II-TDT-Corridor.dgn** file within the dgn Chapter 7 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner. Notice there is a corridor with three different template drops.
2. First, locate the area between the first two templates (Station **140+00.00 - 140+85.00**) and then open the **Create Transition** tool (**OpenRoads Modeling >> Corridors >> Create >> Transitions**).

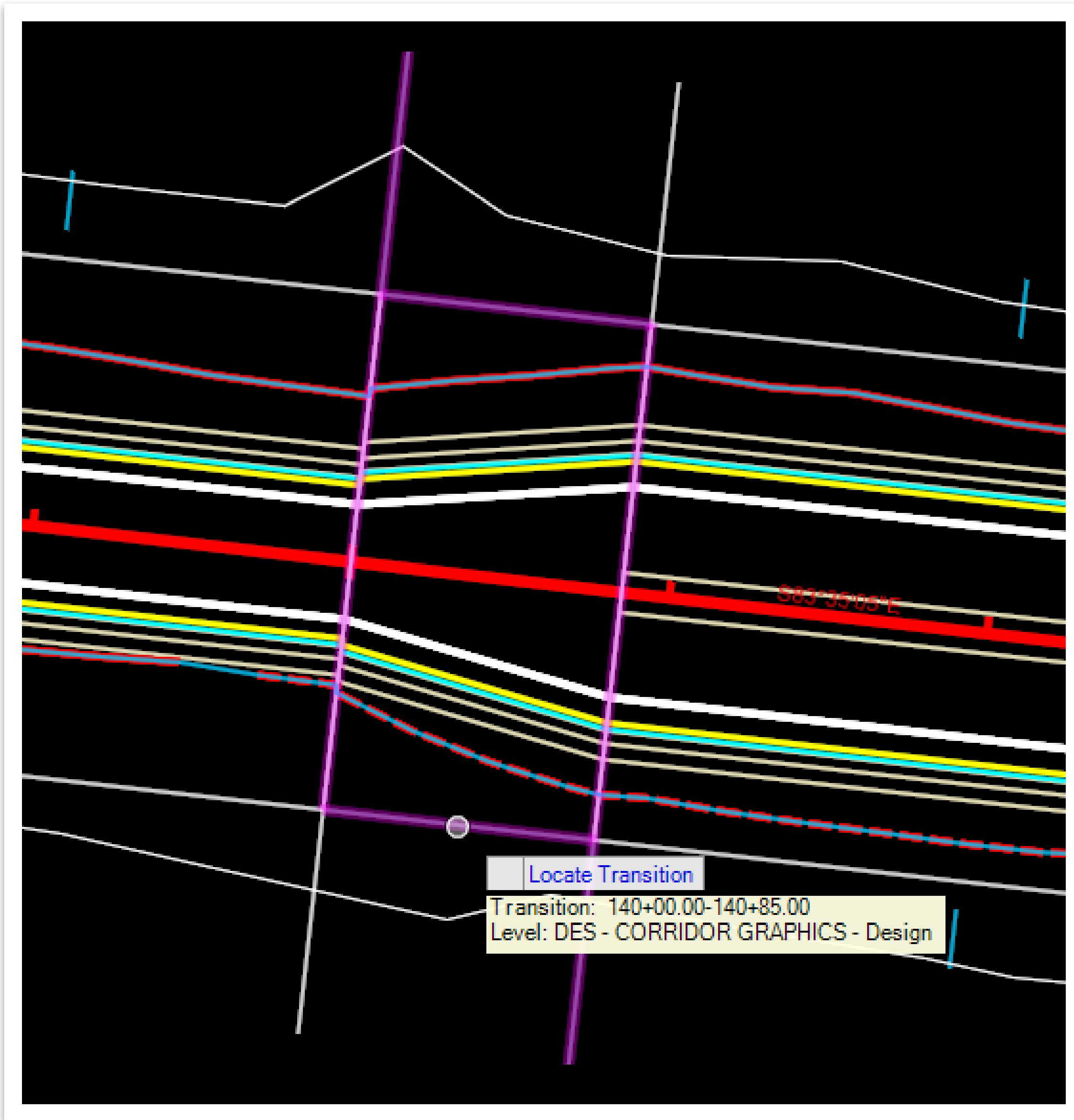


3. Select the two template drops in the **2D** plan view. The **2D** and **3D** model will both render a **transition**. Notice that the pavement lanes are not transitioning, and the curb and sidewalk are not aligning with one of the templates correctly.

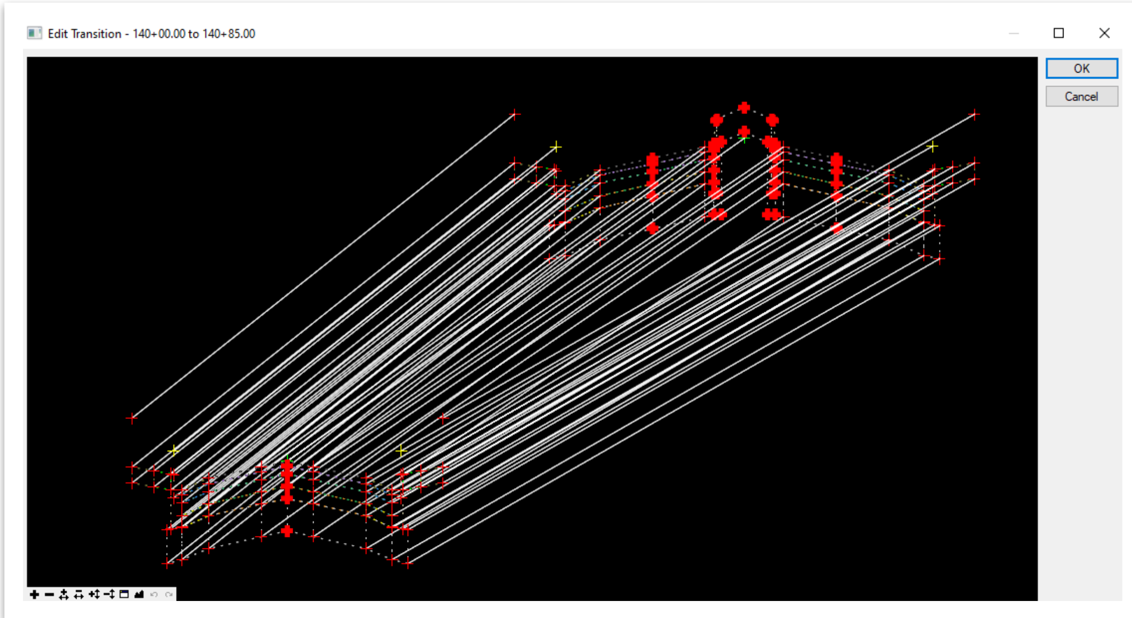


4. To edit the transition, open the **Edit Transition** tool (**OpenRoads Modeling >> Corridors >> Create >> Transitions**) and then select the transition handle.

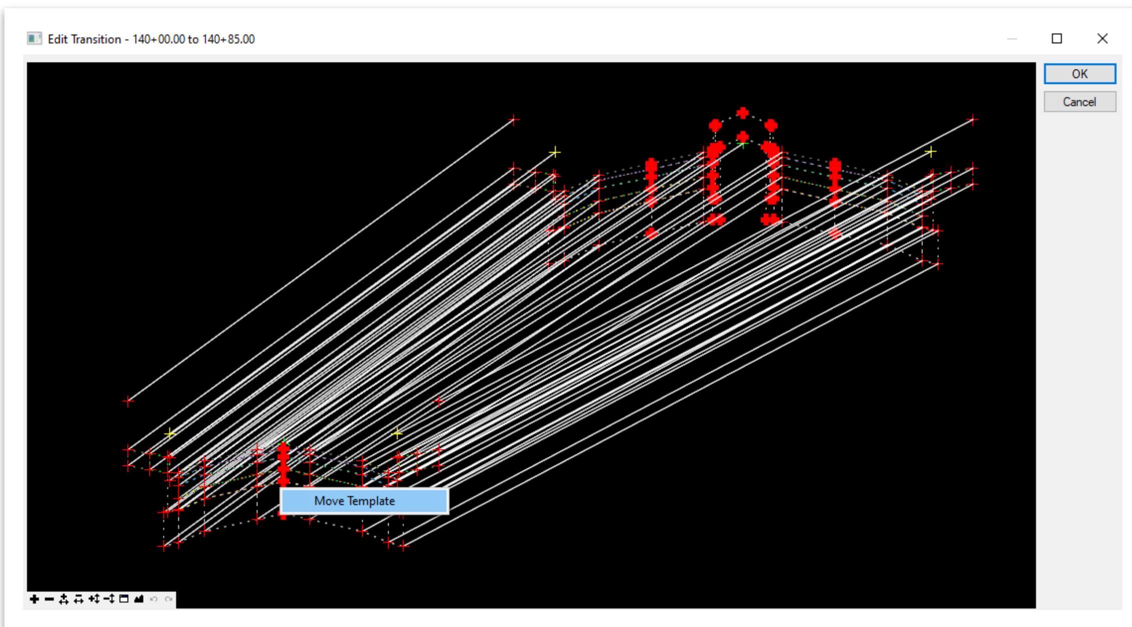




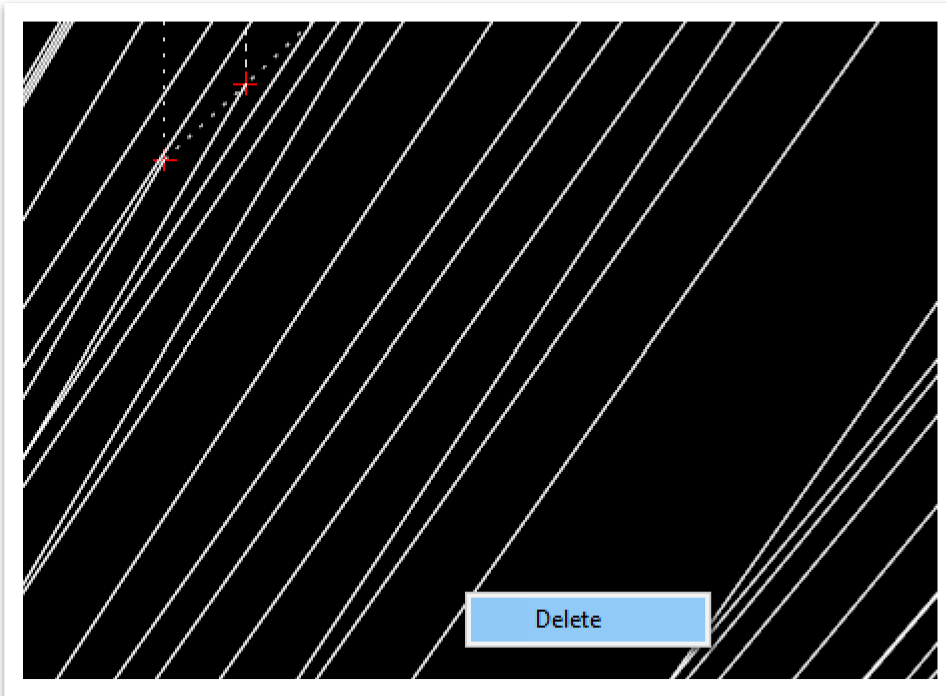
5. An **Edit Transition** window should open. Within this window, you can zoom in and out with the mouse wheel and see what points in the template have automatically been linked to each other. This will happen if the points in both templates have the same name. The **bold crosses** represent the points that have not been linked.



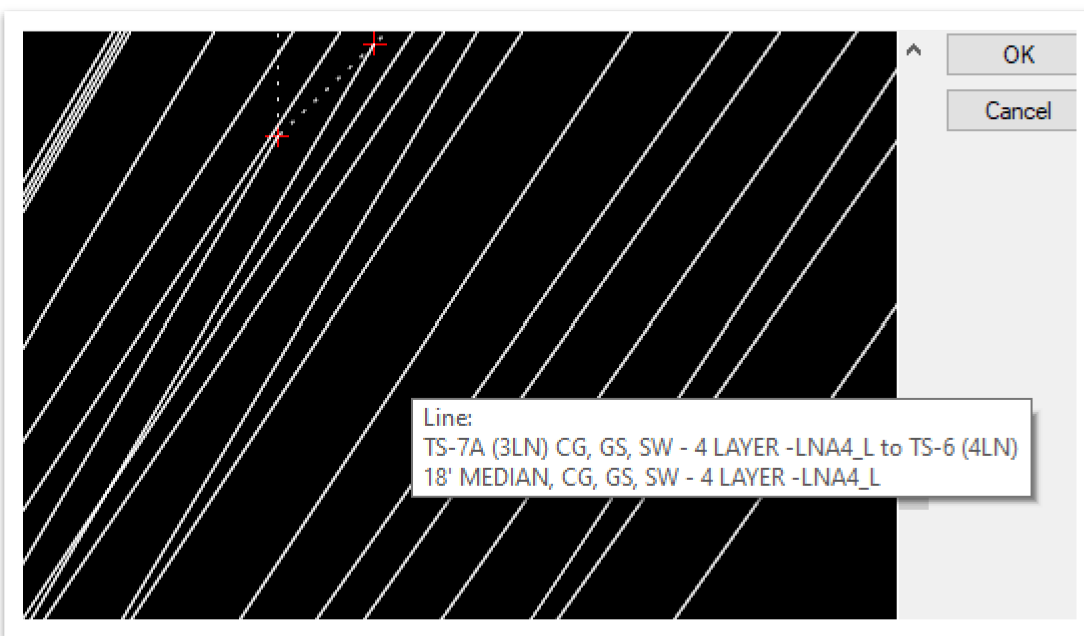
6. **Right** click on one of the template ends and notice a **Move Template** prompt appears. This allows the selected template to be moved around within the window to see a better view of what is linking.



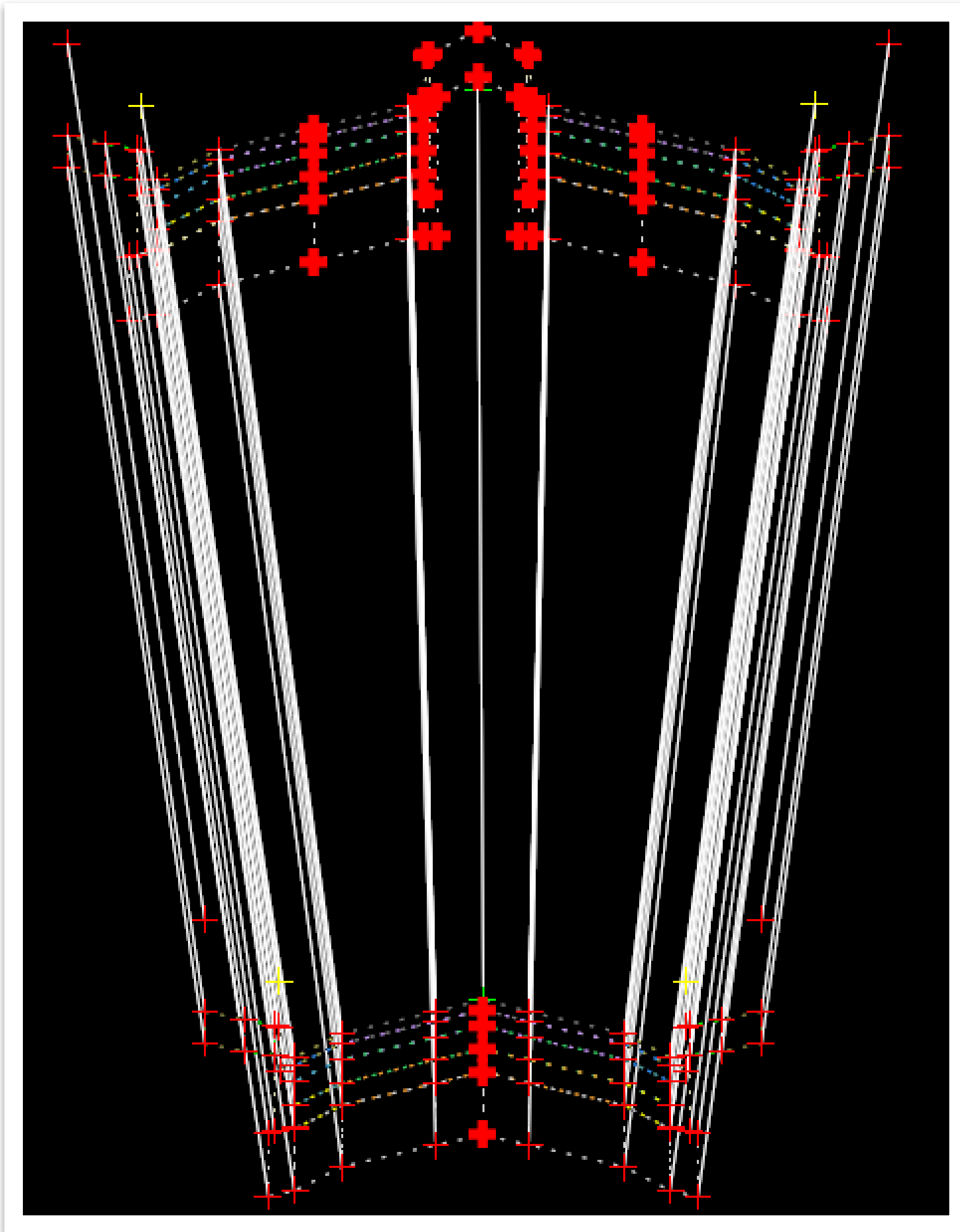
7. Zoom in and **right** click on any line and notice a **Delete** prompt appears. This is how you would delete a link between two template points. **For this exercise do not delete any links that were already placed**.



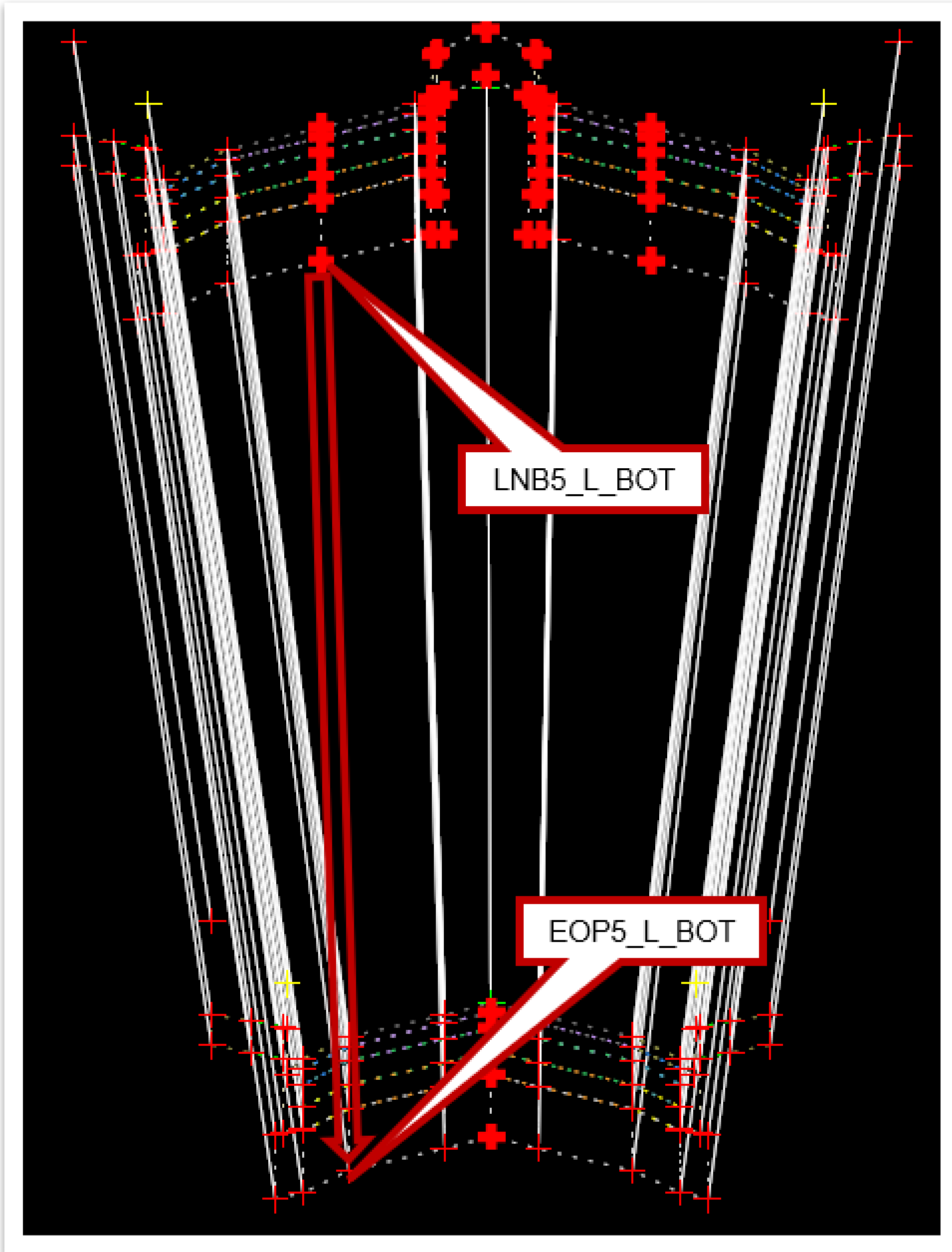
8. To see what a **point** is or what a **link** is linked to, hover over the point or the line and a text box will appear showing the description. Hover over some of the lines and notice that all the lines are connecting to points that have the same name, as shown below.



9. The recommended workflow for connecting points from one template to another is to work from left to right, bottom to top. It is not necessary to connect every point, but this enhances the ability to properly model a transition. To navigate the lines more easily, it is beneficial to align the templates vertically to each other by right clicking and selecting **Move Template** (reference Step 6). Go ahead and align based on the screenshot below.

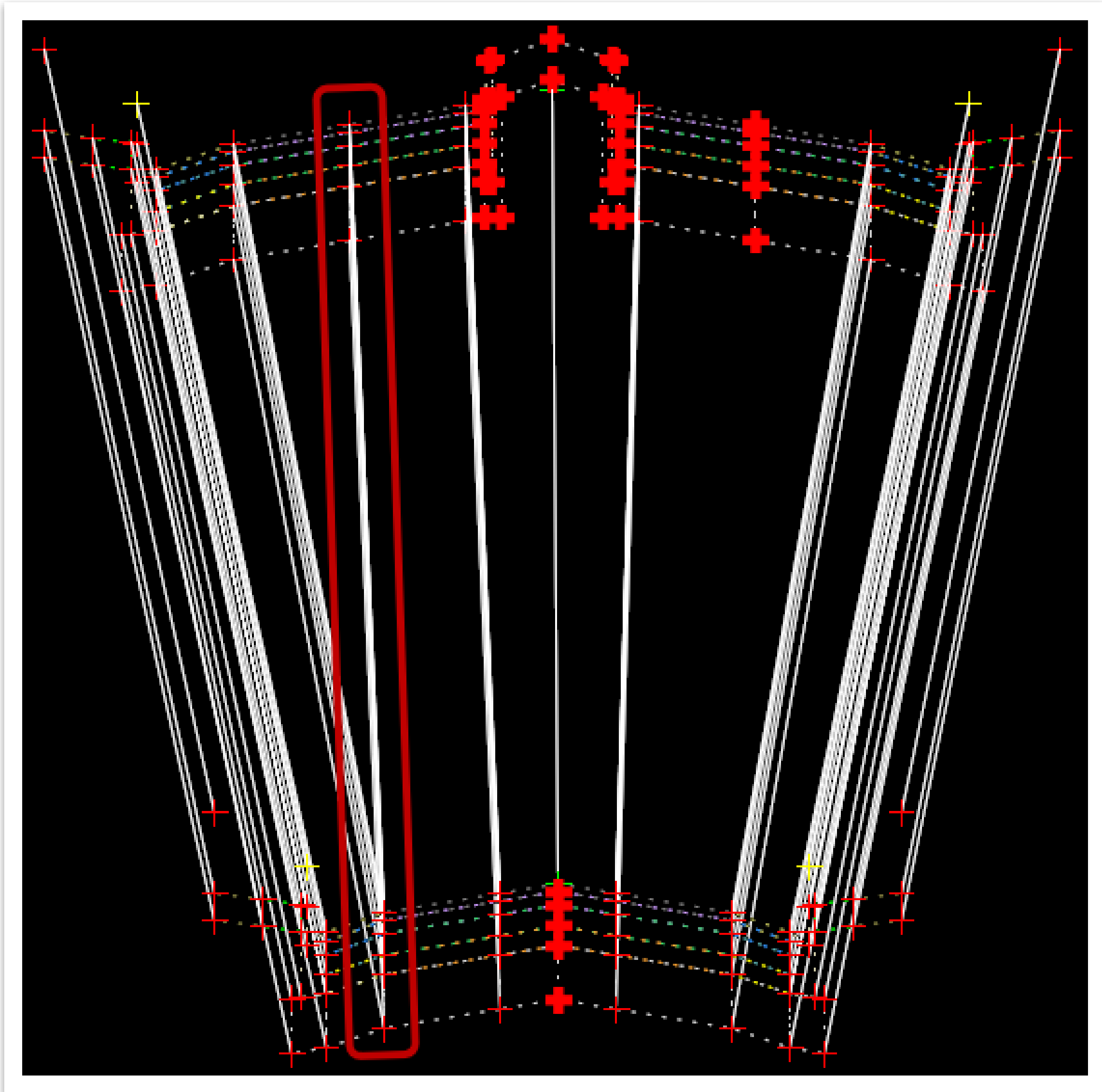


10. To create the new lane on the outside, connect the **LNB5_L_BOT** points on the **4-lane** template to the **EOP5_L_BOT** points on the **3-lane** template. To do this, select the **LNB5_L_BOT** point (bold), and then click the **EOP5_L_BOT** point to finish the connection. **Note:** Only bold points will be able to be selected.

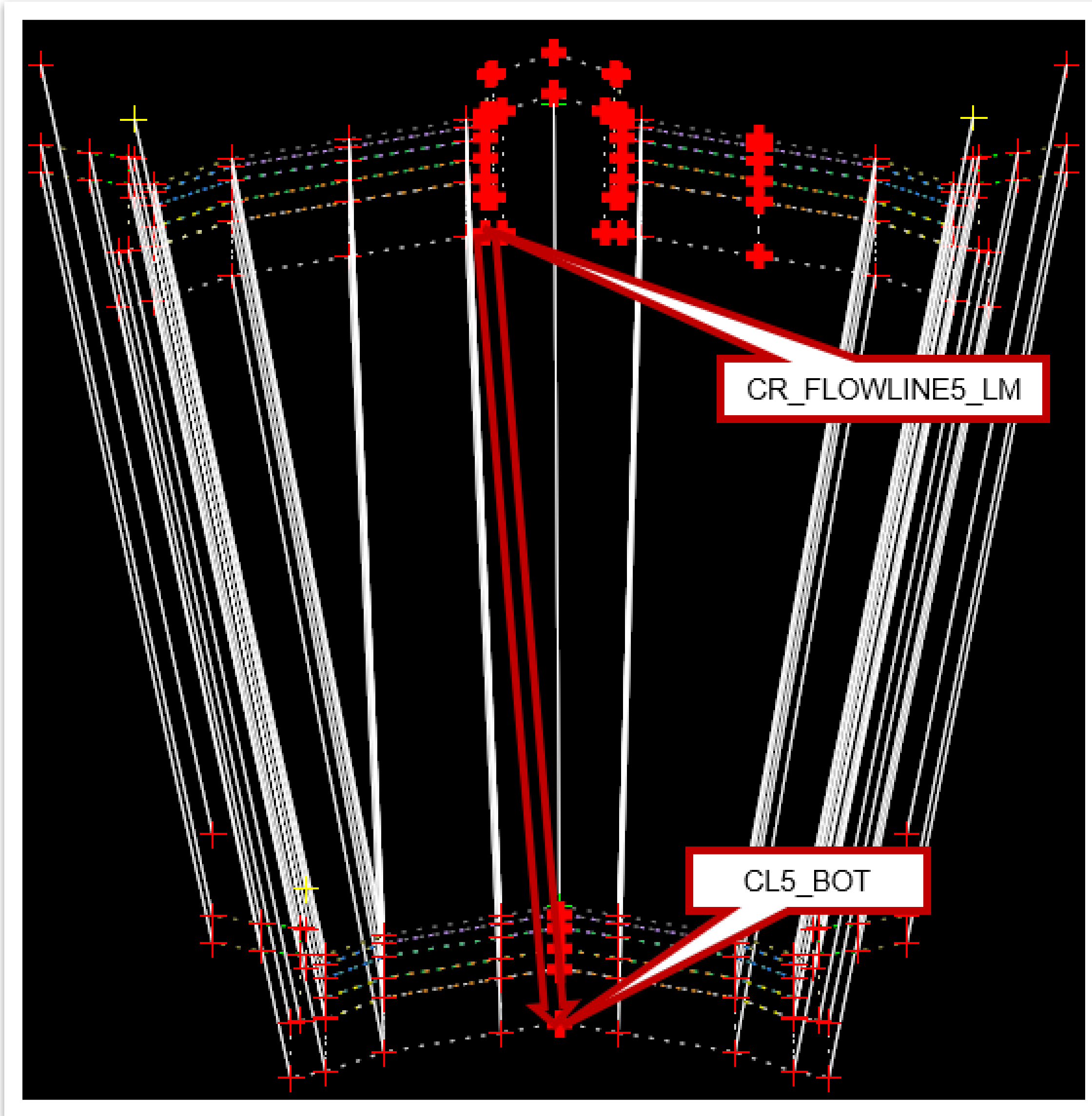


11. Repeat the process for the points above this line. The table below lists the points that need to be connected.

4 Lane Template Point	3 Lane Template Point
LNB4_L	EOP4_L
LNB3_L	EOP3_L
LNB2_L	EOP2_L
LNB1_L	EOP1_L
LNB_L	EOP_L



12. Next, connect the **CR_FLOWLINE5_LM** points on the **4-lane** template to the **CL5_BOT** points on the **3-lane** template.



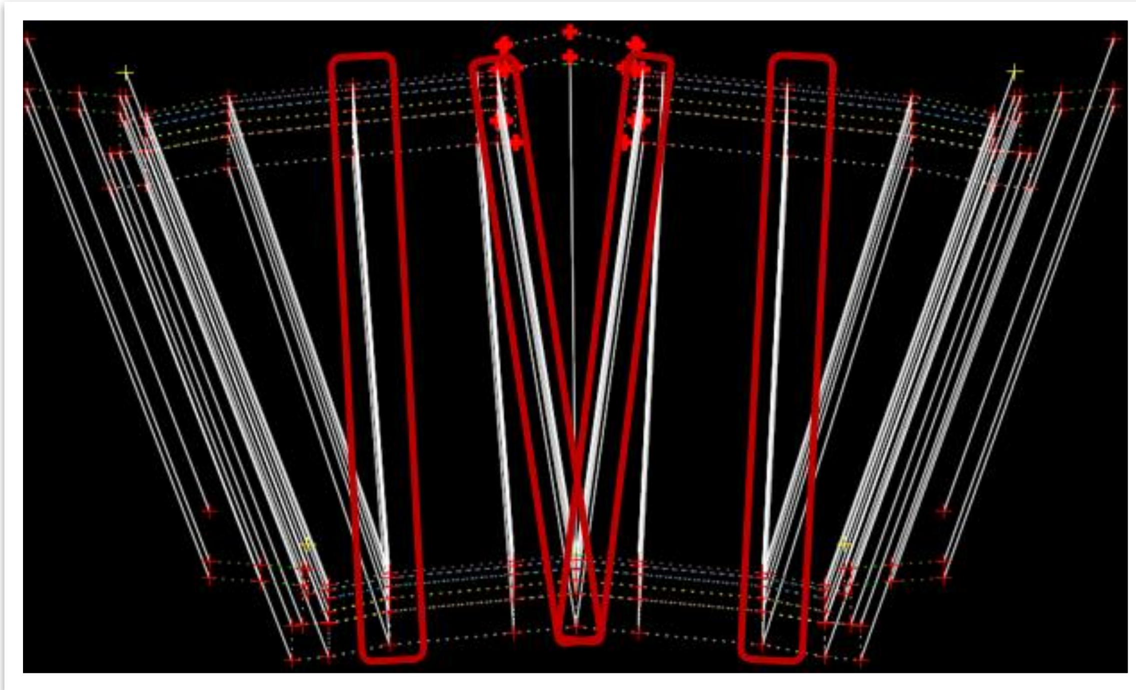
13. Repeat the process for the points above this line. The table below list the points that need to be connected.

4 Lane Template Point	3 Lane Template Point
CR_FLOWLINE4_LM	CL4
CR_FLOWLINE3_LM	CL3
CR_FLOWLINE2_LM	CL2
CR_FLOWLINE1_LM	CL1
CR_FLOWLINE_LM	CL

14. The left side of the template has been updated with links. We will now repeat the steps for the right side. The table below list the points that need to be connected.

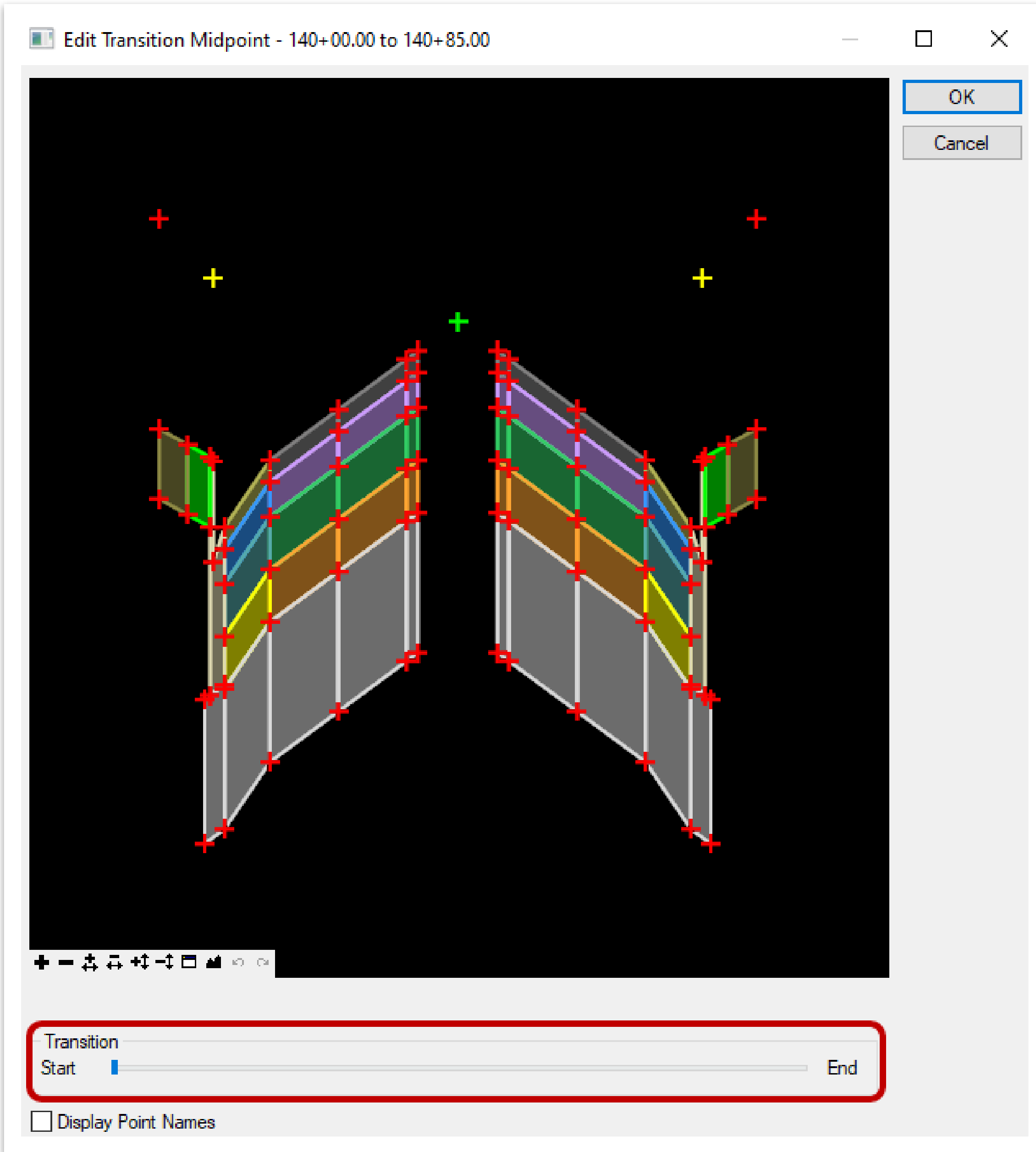
4 Lane Template Point	3 Lane Template Point
CR_FLOWLINE5_RM	CL5
CR_FLOWLINE4_RM	CL4
CR_FLOWLINE3_RM	CL3
CR_FLOWLINE2_RM	CL2
CR_FLOWLINE1_RM	CL1
CR_FLOWLINE_RM	CL
LNB5_R_BOT	EOP5_R_BOT
LNB4_R	EOP4_R
LNB3_R	EOP3_R
LNB2_R	EOP2_R
LNB1_R	EOP1_R
LNB_R	EOP_R

15. The final additional connections should be made in the **four** vertical areas shown below.

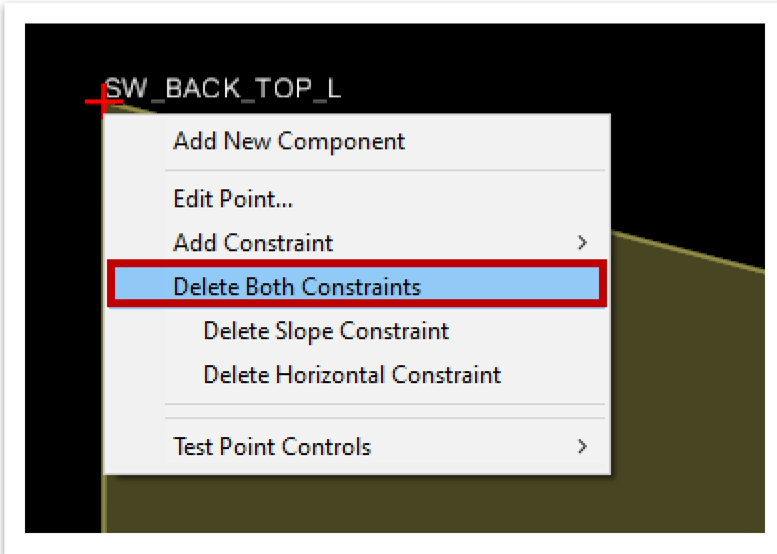


16. Notice that several lines are not connected, and the median has not been connected to anything. The median will be created later in the exercise. Click **OK** and a prompt should appear saying that for the transition to properly apply, constraints must be removed. Click **OK**.

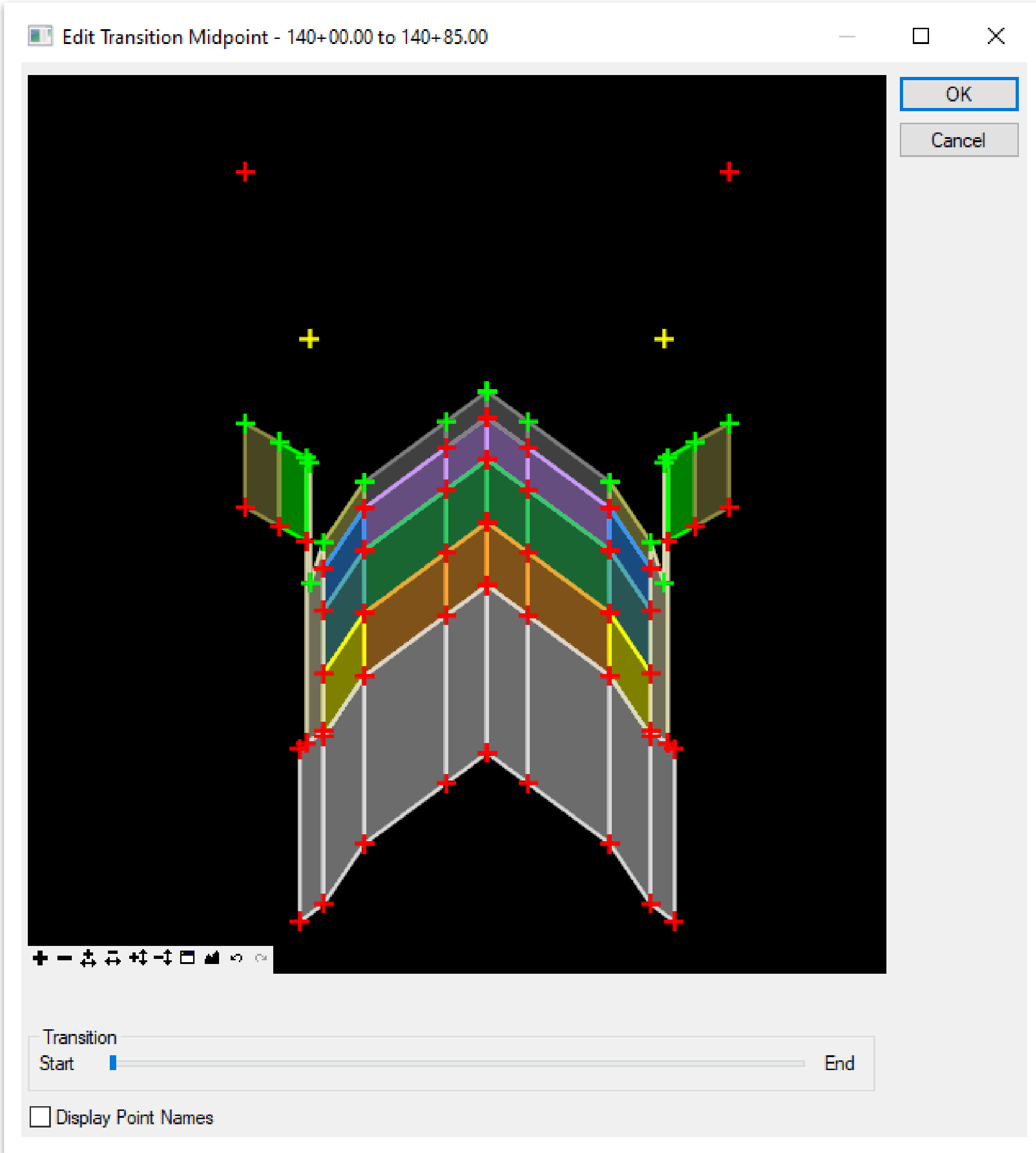
17. A new **Edit Transition Midpoint** window now appears in the **Edit Transition** tool, which allows you to view the cross section of the transition and edit the points in it. Notice at the bottom of the window, there is a slider that can be used to move from the **start** to the **end** of the transition. If you move the slider, the template does not change because the points are still constrained.



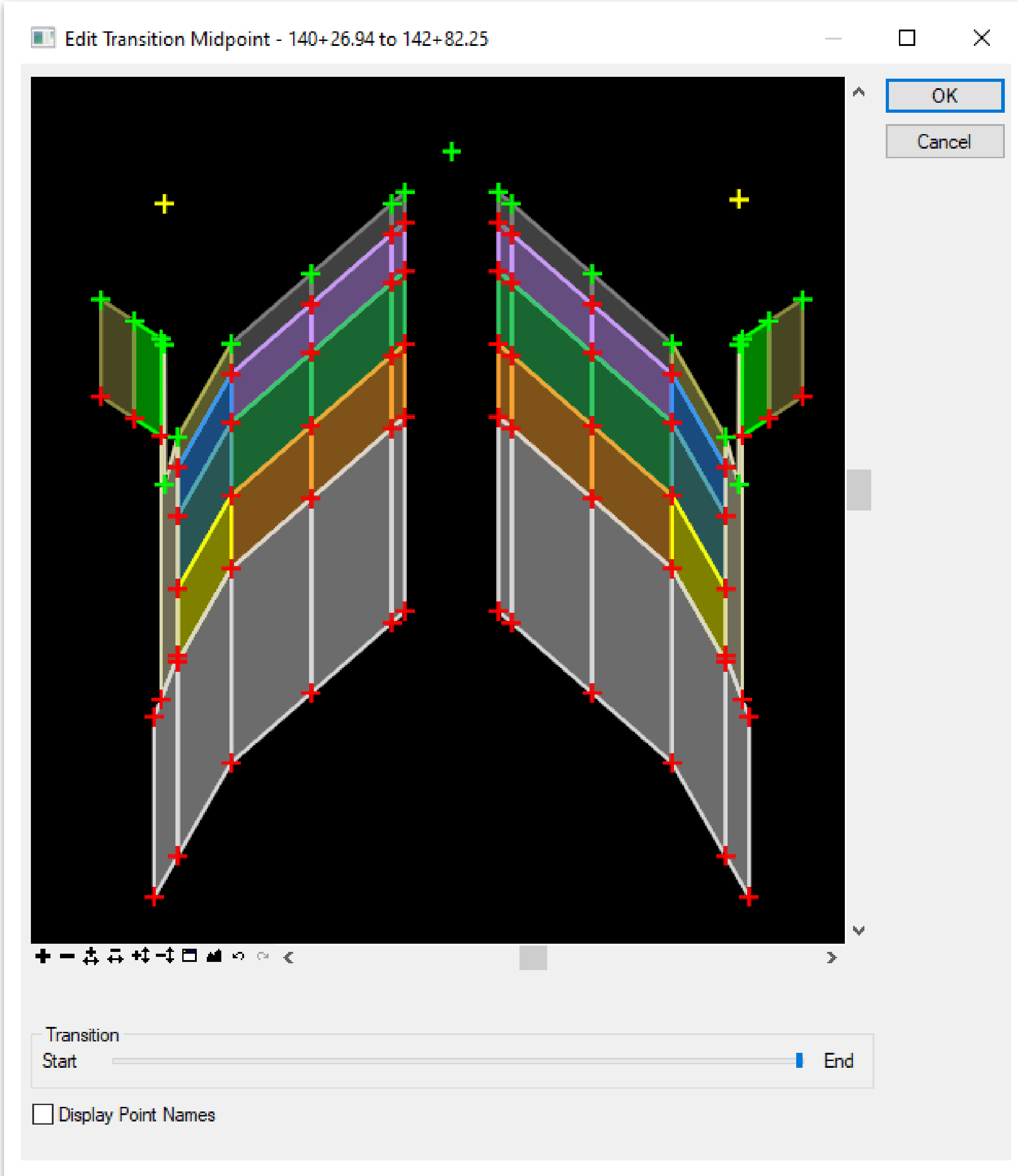
18. Not all the points need to be unconstrained. Most are **constrained** to the point above it. Therefore, only the points at the top of the template need to have their constraints removed. Starting from the left, delete the constraints of **SW_BACK_TOP_L** and then move towards the right across the top of the template. **Right** click on the point and select **Delete Both Constraints**.



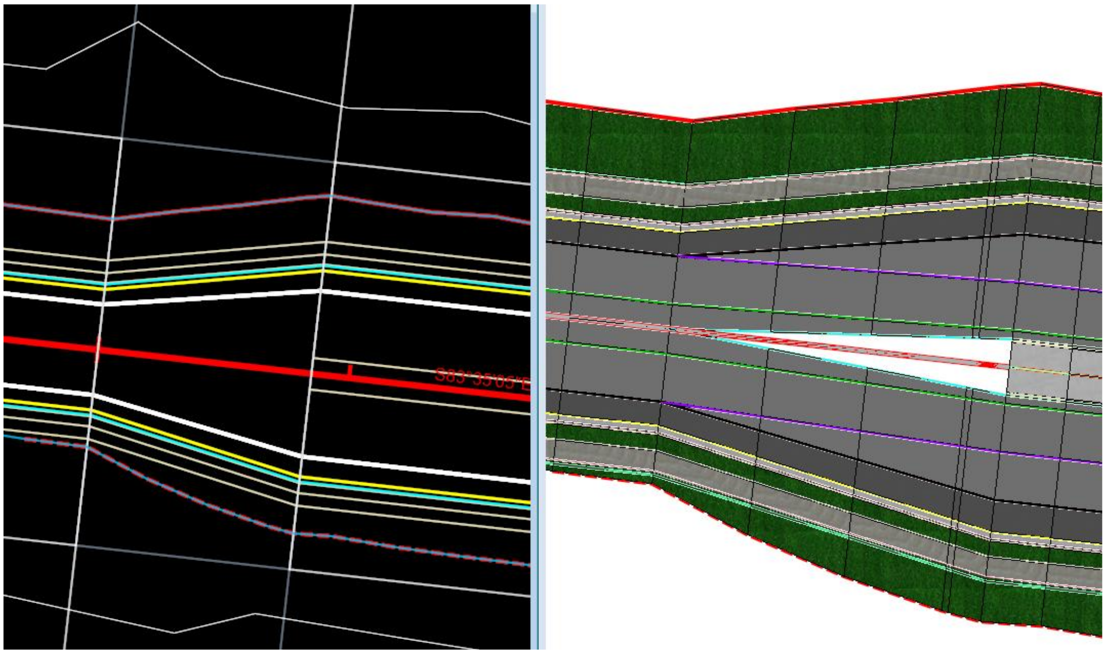
19. The model will start to look strange until all points are **unconstrained**, but you can change the **Transition** slider to **End** to help with this. Unconstrained points turn **green** to help keep track. If in doubt, delete the constraint and the point will follow the links created in the last window.



20. Now, as the slider moves from **Start** to **End**, the template should adjust to create a median and a second lane in each direction.

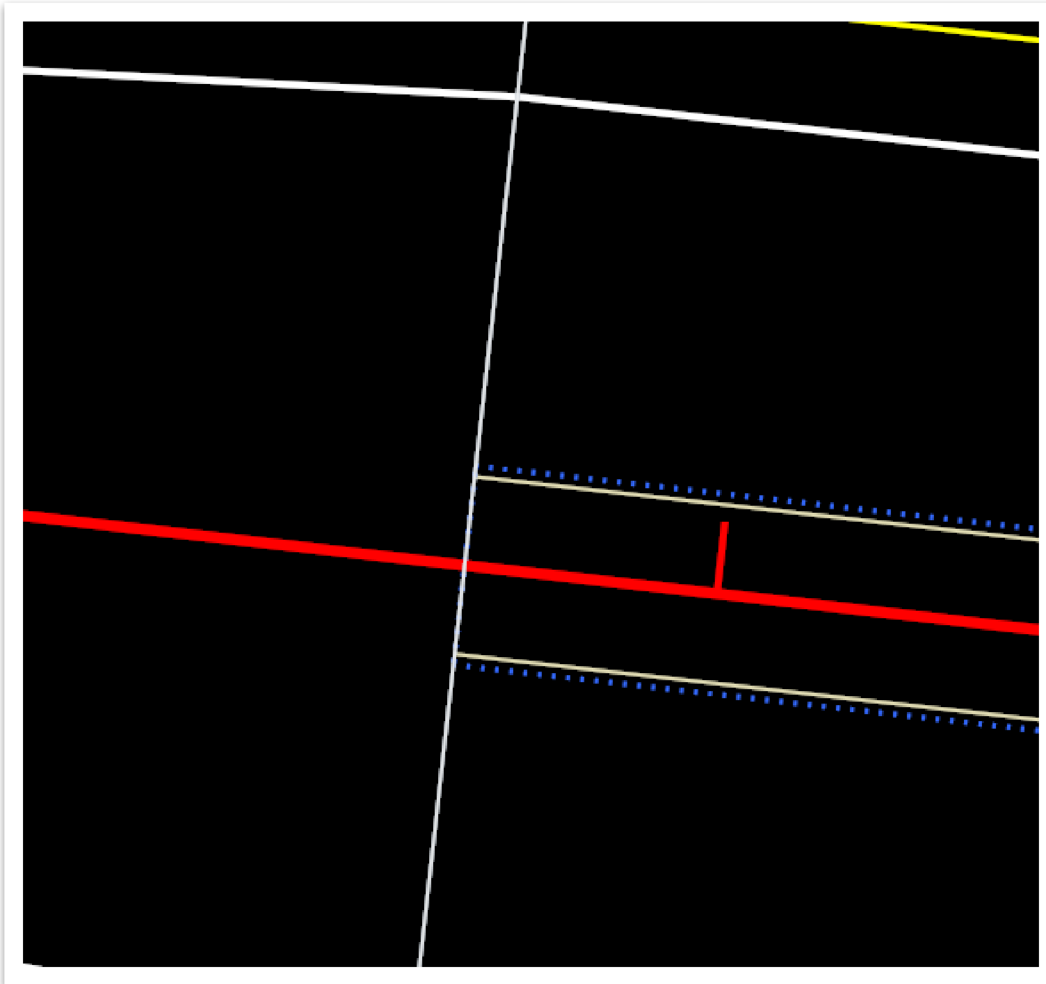


21. Click **OK** and the **2D** and **3D** models will update to fill in the lanes and align the curb and sidewalk.

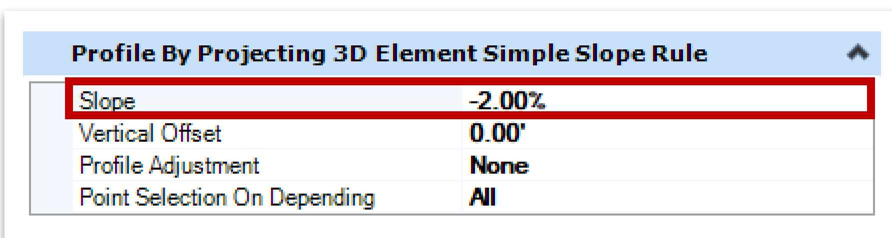


22. Next, we need to add a **surface** for the area that did not fill in from the transition and add a **median nose**. Select the **C&G Flowline - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Curb and Gutter**) and set it active. Make sure **Create 3D Automatically** is toggled on.

23. Open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**). Create a partial offset from the CL of the corridor **7**’ to the outside of the roadway, from the start of the 4-lane section (Station **140+85.00**) to the end of the 4 lane section (Station **183+50.00**). Do this on both sides of the centerline.

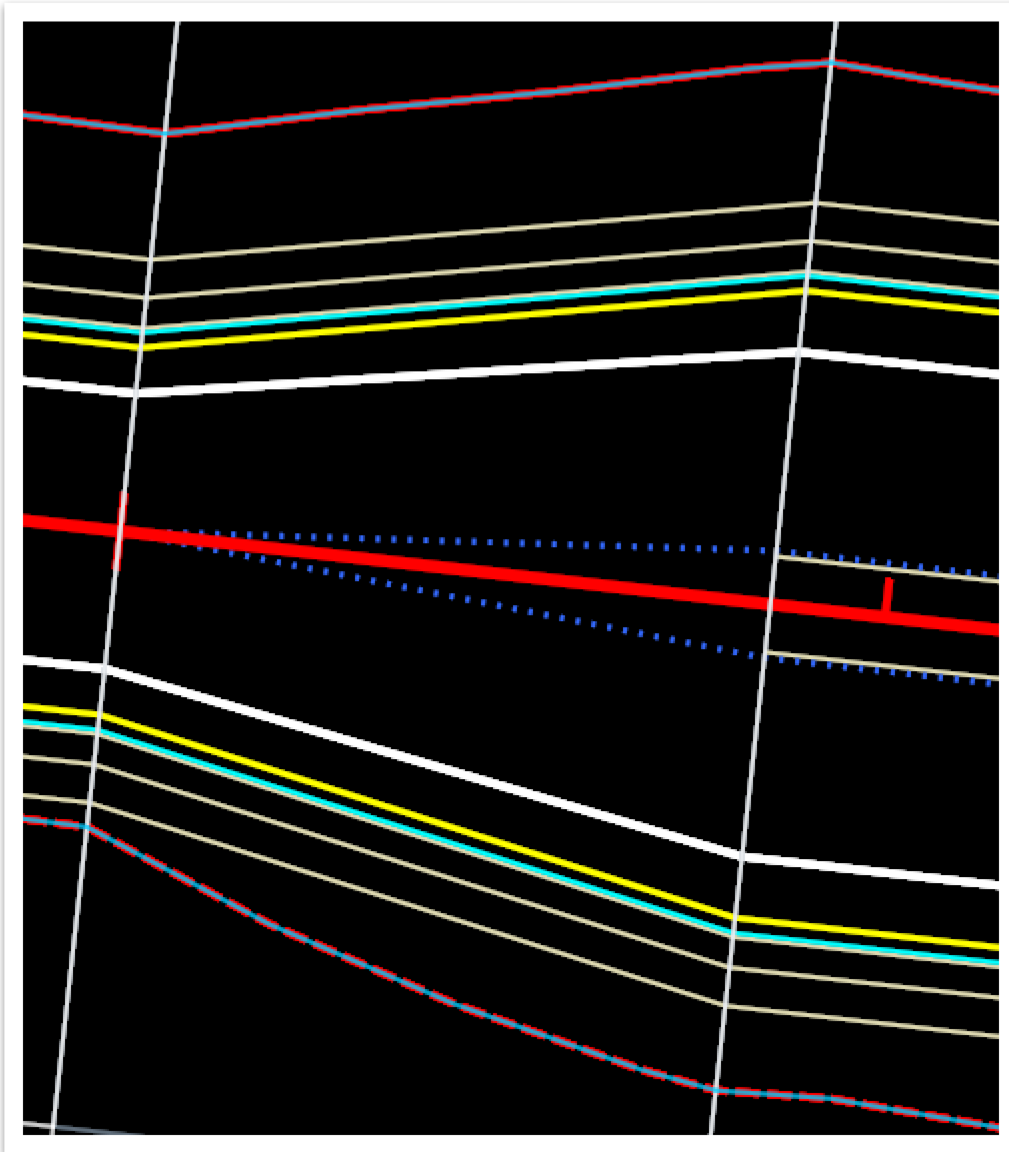


24. Select the **CTRL** lines that were just placed and open the **Properties**. Within the properties under the **Profile By Projecting 3D Element Simple Slope Rule** header, change the **Slope** to **-2.00%**.

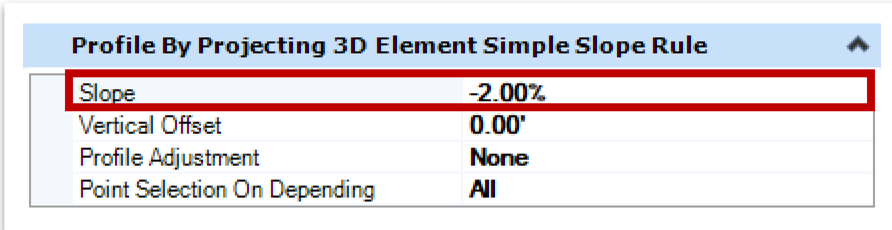


Profile By Projecting 3D Element Simple Slope Rule	
Slope	-2.00%
Vertical Offset	0.00'
Profile Adjustment	None
Point Selection On Depending	All

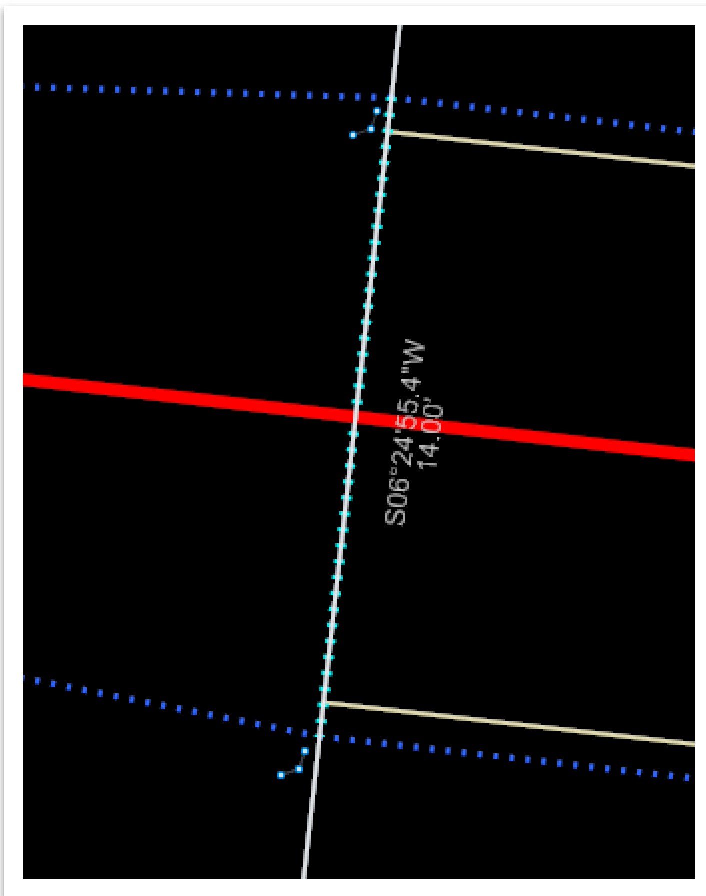
25. Now, open the **Variable Offset Taper** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the centerline. Set the **Start Offset** to **0** and the **End Offset** to **7'**. Set the **Start Distance** at the start of the transition (Station **140+00.00**). Snap to the **flowline control** for the end (Station **140+85.00**). Repeat this process for the opposite side.



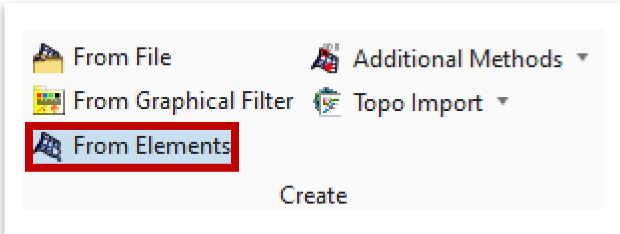
26. Select the **tapers** that were just placed and open the **Properties**. Within the properties under the **Profile By Projecting 3D Element Simple Slope Rule** header, change the **Slope** to **-2.00%**.



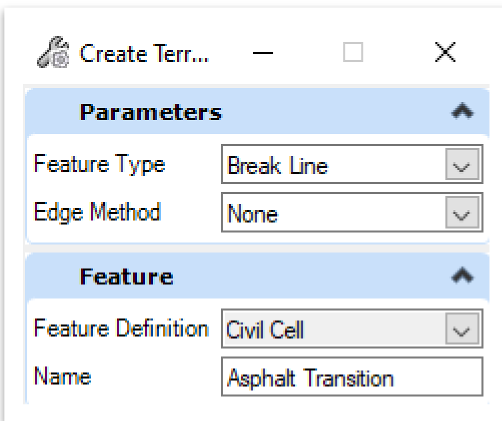
27. Next, open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and connect the two tapers at the median. The median transition should now be a closed shape.



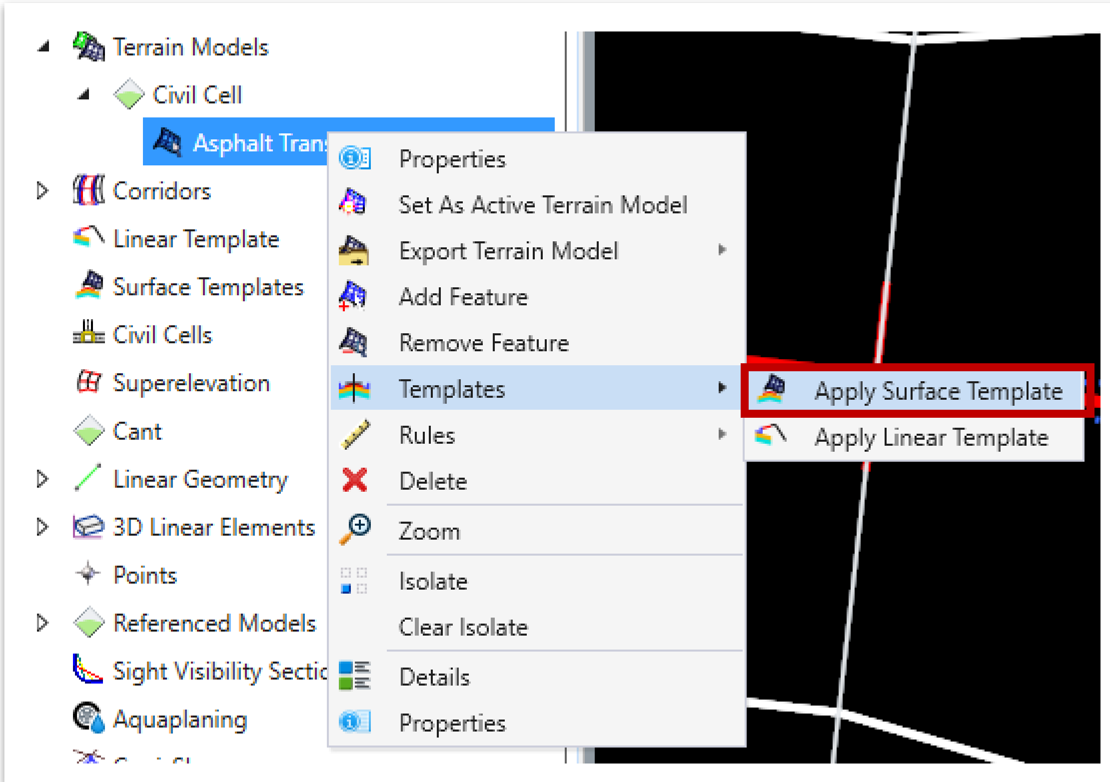
28. Then, open the **Create Terrain Model From Elements** tool (**OpenRoads Modeling >> Terrain >> Create**) and select the three lines that were just placed to make up the closed shape in the median transition.



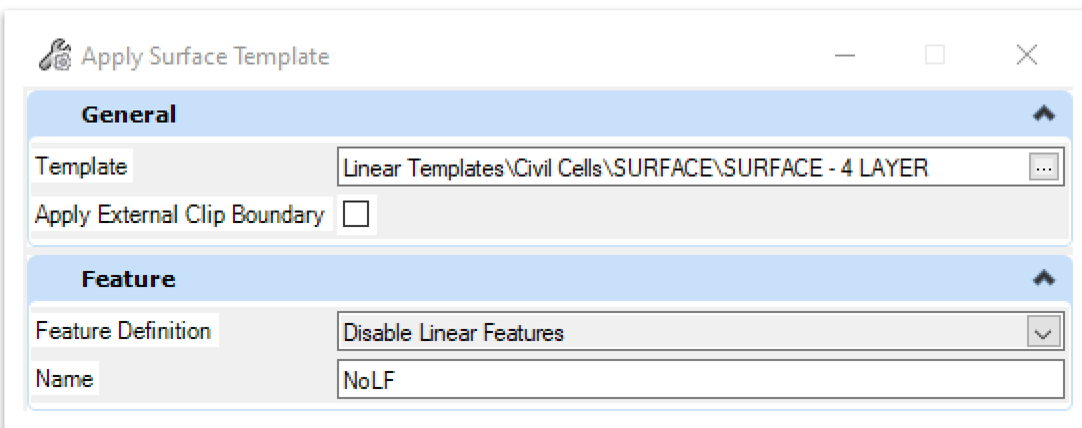
29. Within the **Create Terrain Model From Elements** dialog box, select the following settings and then **left** click to accept the prompts.
    a. **Feature Type:** Break Line
    b. **Edge Method:** None
    c. **Feature Definition:** Civil Cell
    d. **Name:** Asphalt Transition



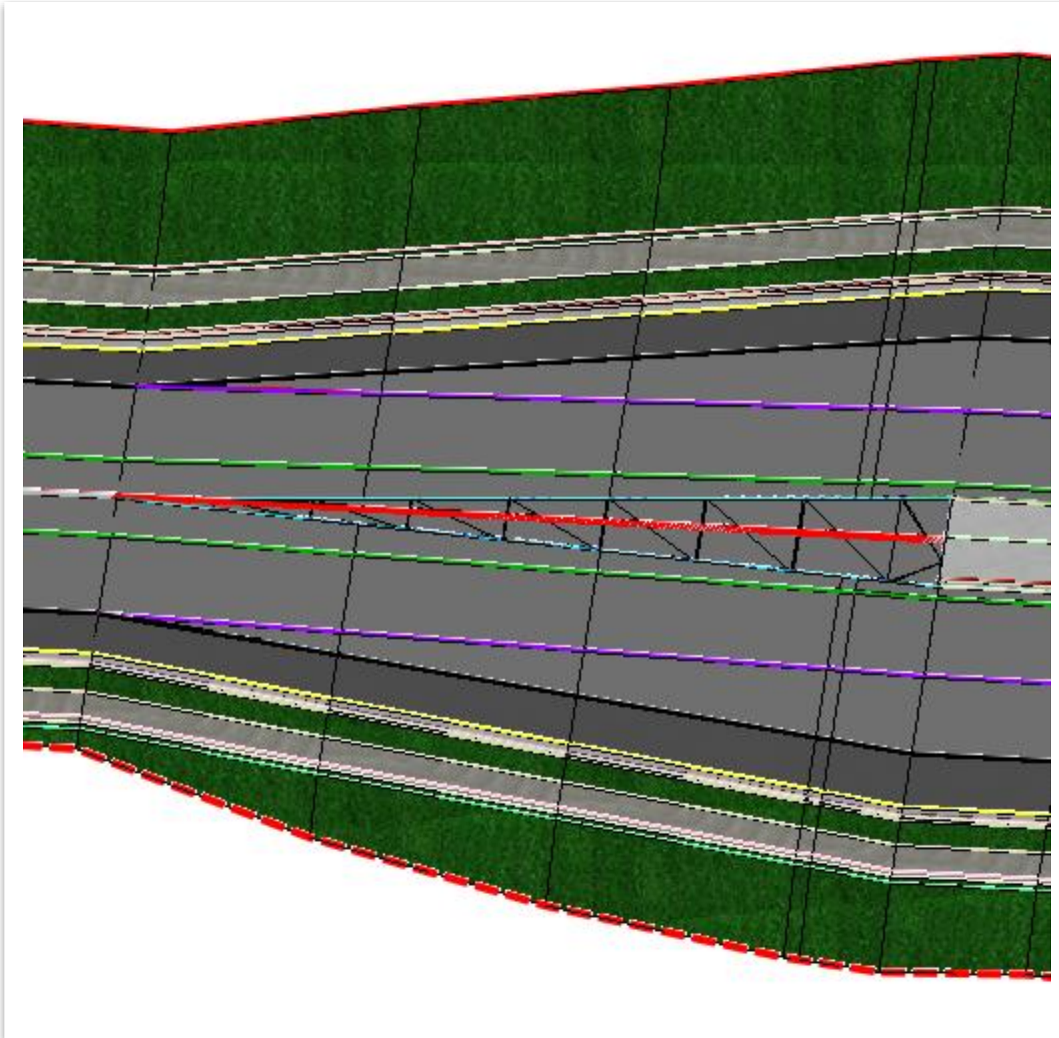
30. Within the **Explorer**, **right** click on the **Asphalt Transition** terrain just created (**OpenRoads Model >> Terrain Models >> Civil Cell**) and select **Apply Surface Template**.



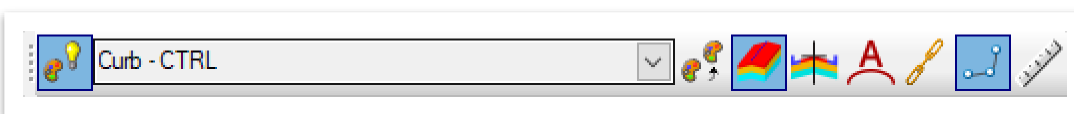
31. Select the **SURFACE - 4 LAYER** template (**Linear Templates >> Civil Cells >> Surface**) and **left** click through the prompts to accept.



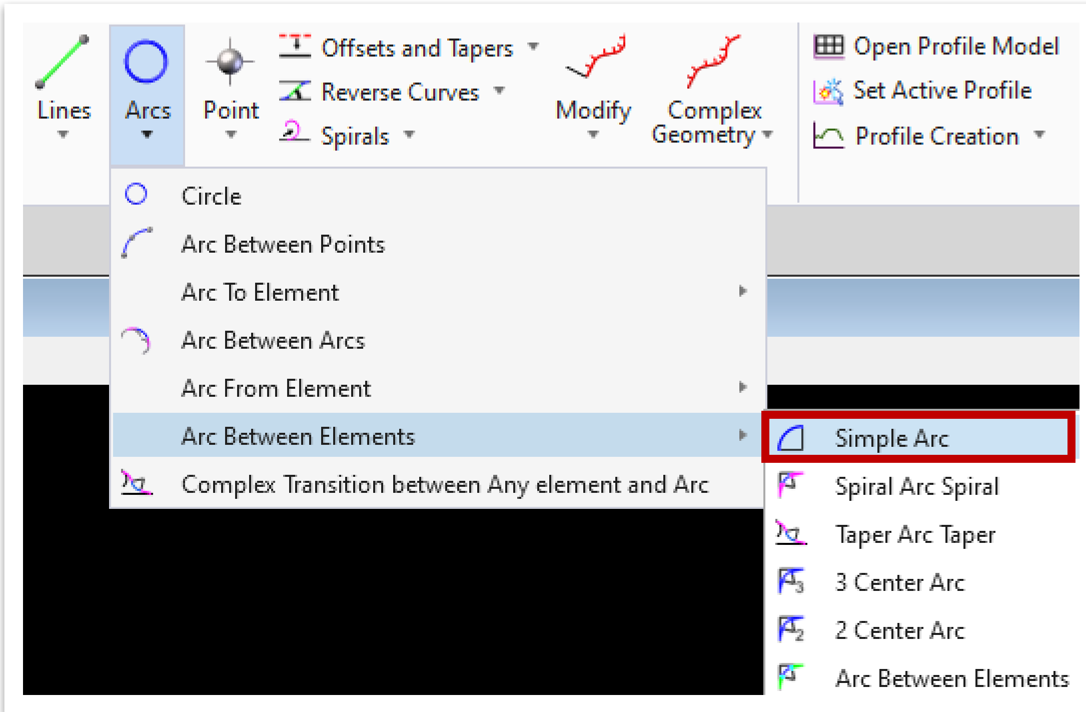
32. Review the **3D** model and notice the median transition should now have a surface.

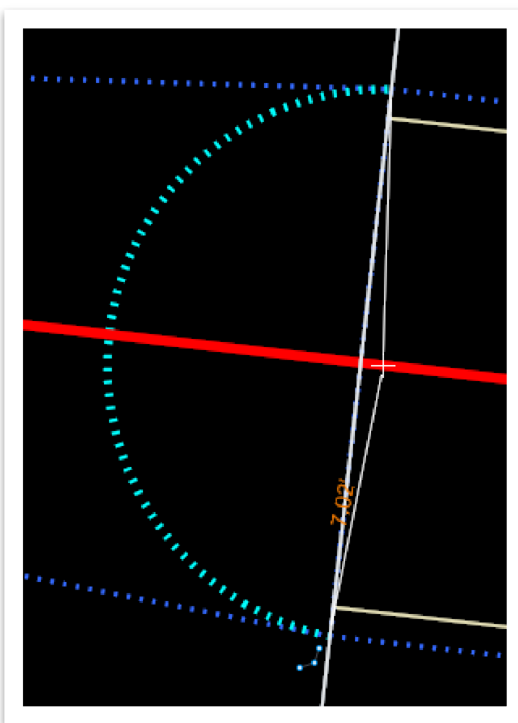


33. Next, select the **Curb - CTRL** feature definition (**Roadway >> Model Control - 2D Plan >> Curb and Gutter**).

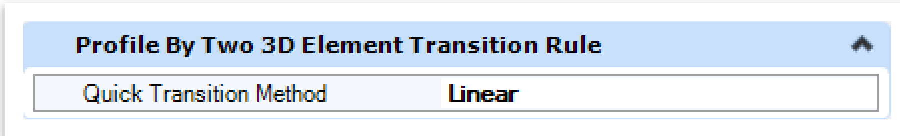


34. Open the **Simple Arc** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Arcs >> Arc Between Elements**). Select the **C&G Flowline - CTRL** bottom taper in the median transition, and then the **C&G Flowline - CTRL** top taper in the median transition. Snap to the end of the bottom taper to place the arc. Set the **Trim/Extend** option to **None**.

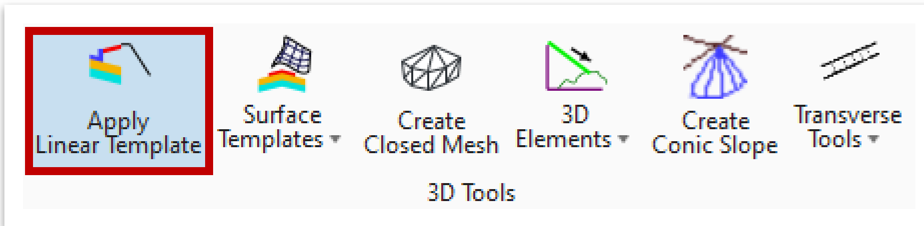




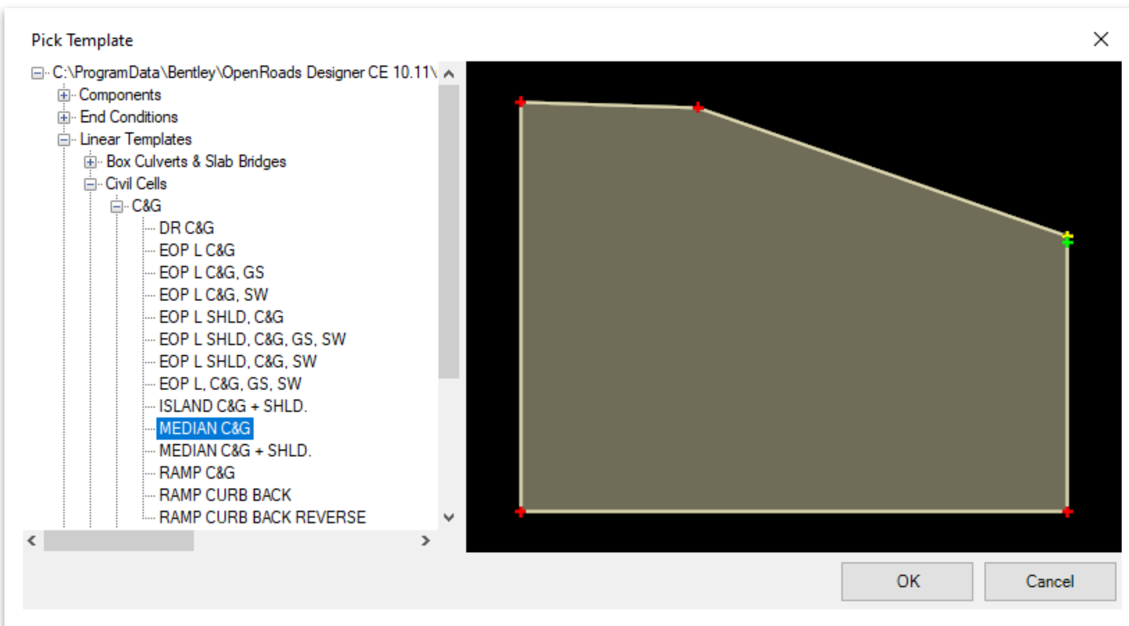
35. Now, select the arc that was just placed and open the **Properties**. Change the **Quick Transition Method** to **Linear** under the **Profile By Two 3D Element Transition Rule** header.



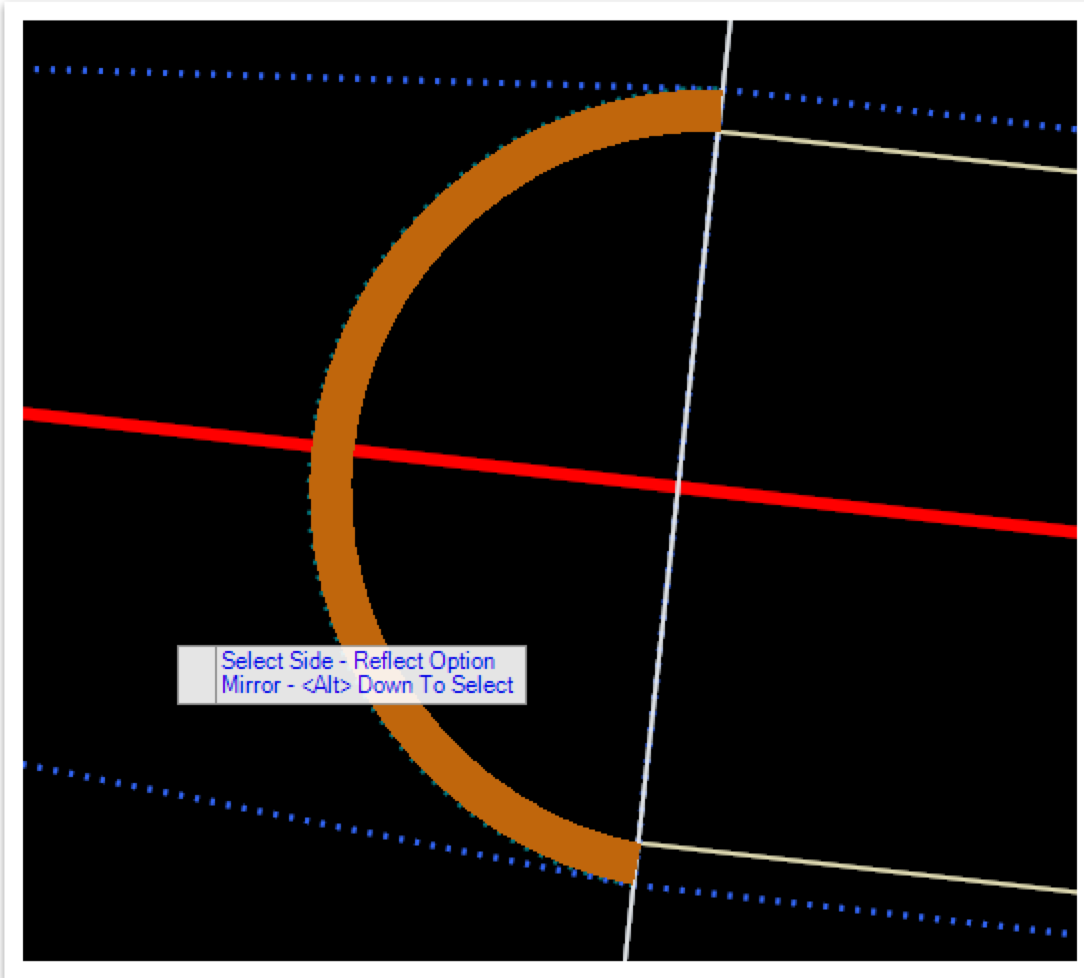
36. Next, open the **Apply Linear Template** tool (**OpenRoads Modeling >> Model Detailing >> 3D Tools**) and select the arc.



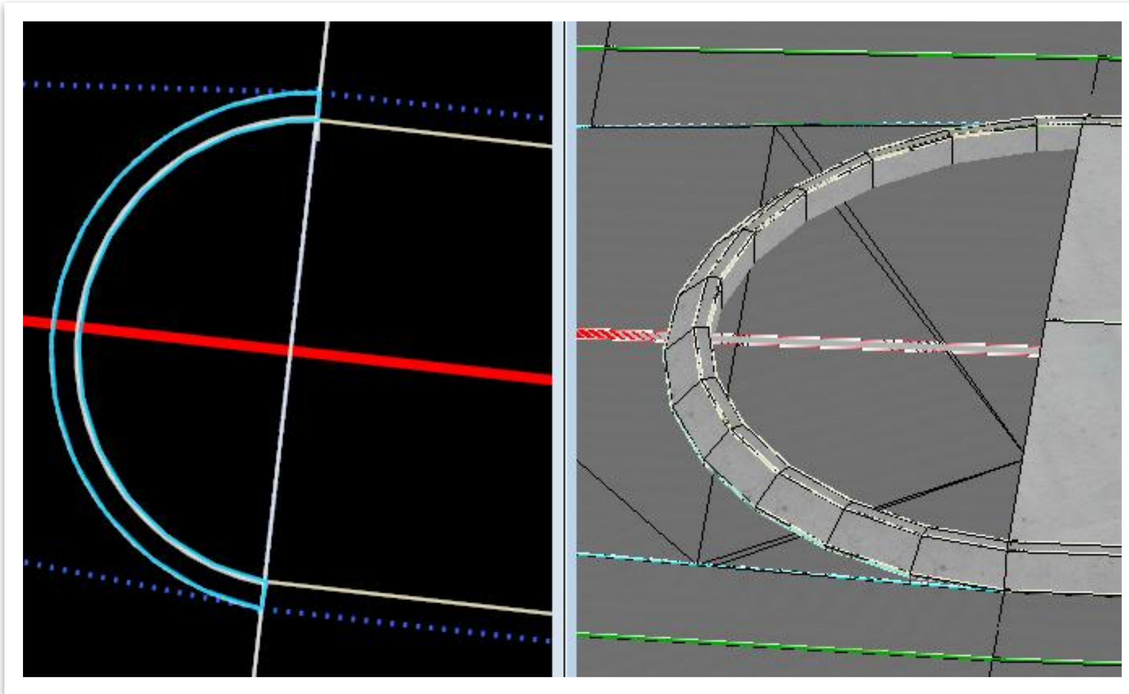
37. Select the **Median C&G** linear template (**Linear Templates >> Civil Cells >> C&G**) and click **OK**.



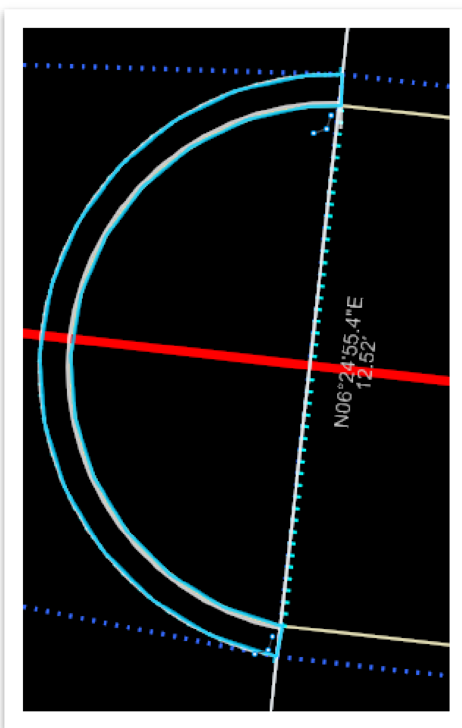
38. **Lock to Start** and **End** and place the **orange** preview on the **inside** of the arc by moving the cursor to the left, outside the arc.



39. Click through the prompts to accept placement and notice the linear template shows up in both **2D** and **3D**.



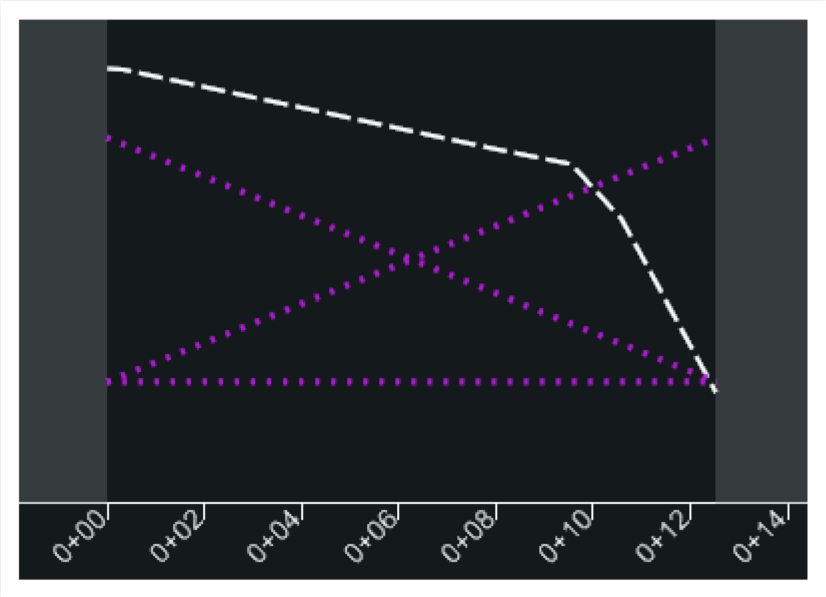
40. Open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and draw a line from the inside edge of the linear template to the other, snapping to the arc (**CR_BACK_TOP_RM**).



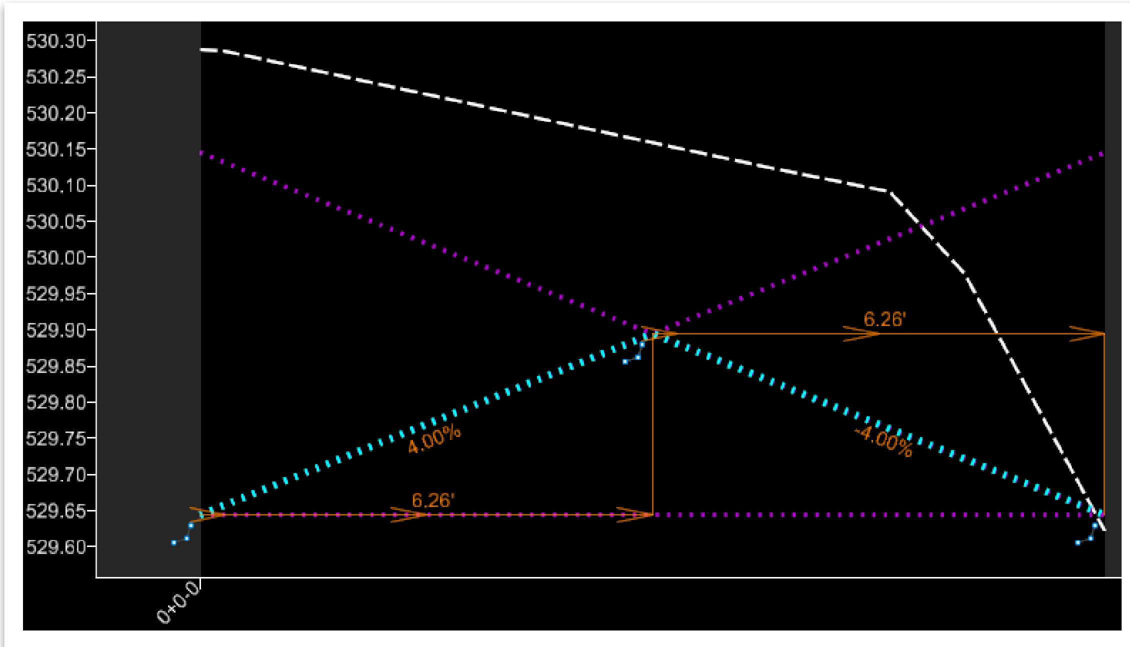
Take Note!

*The TDOT standard drawing for a raised median is **crowned** along the centerline of the roadway. Therefore, we need to replicate the crown in the profile of the line so that it matches up correctly with the template drop. The end of the element in plan view is represented by where the black area meets the dark grey area in the profile view. This area can be snapped to with the **Key Point** snap if you hover over the imaginary line between the black and dark grey area.*

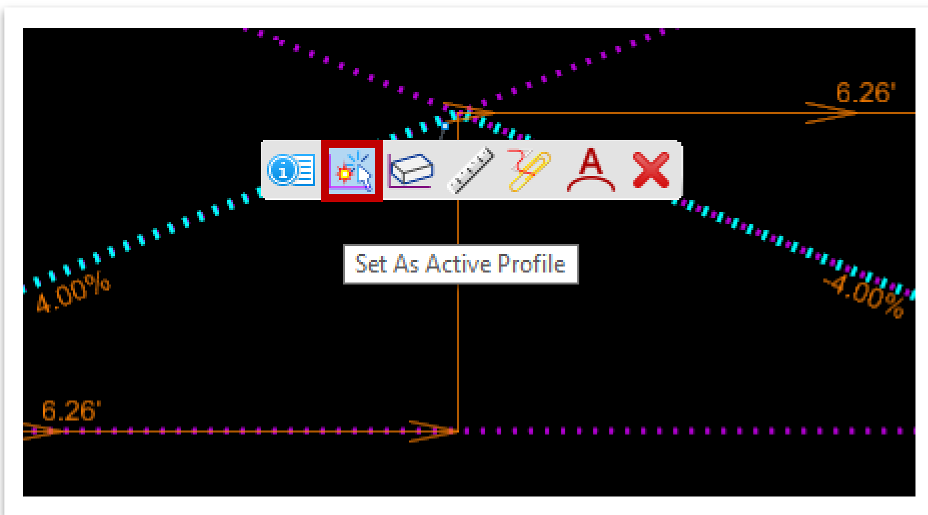
41. Go ahead and open the **profile** view of the line that was just placed. Using the **Key Point** snap, draw a line from the left end of the horizontal purple dotted line and snap to the end of the black area in the profile view. Before left clicking to accept the snap to the end of the black area, tab through the inputs until you see the **slope** input and key-in **4**. This should lock the element into a **4% slope**. Repeat this procedure starting with the right end and key-in -**4** this time for the slope.



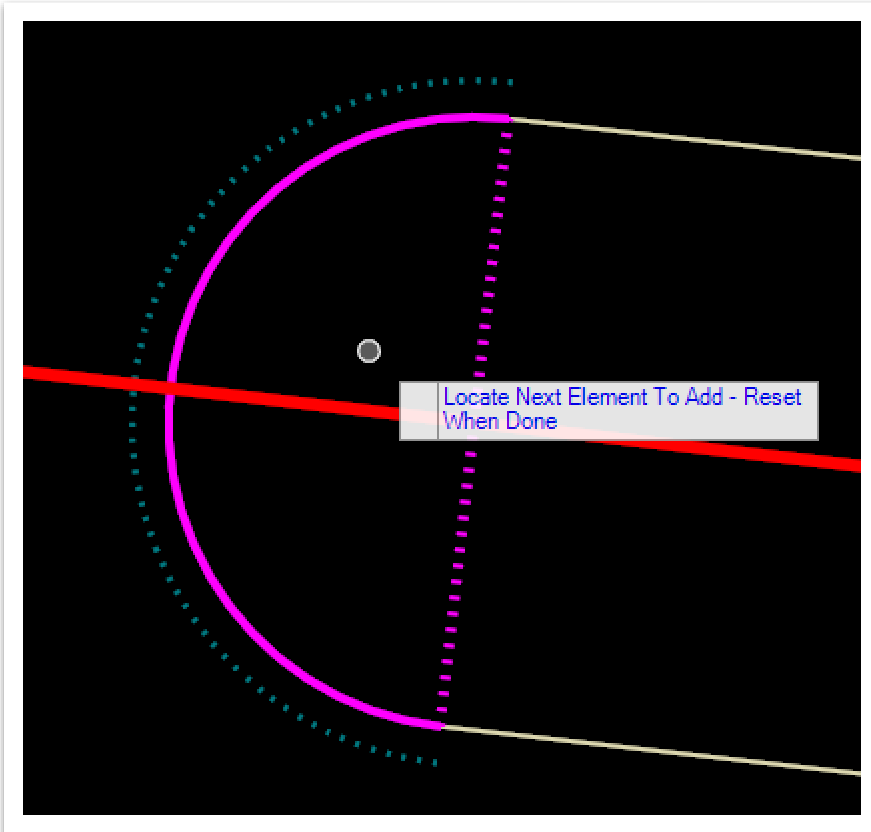
42. Now, trace the **positive 4%** line starting from the left end and terminating at the intersection of the two 4% slope lines. Then, trace the **negative 4%** line starting with a key snap to follow the element just created that terminates at the intersection of the two 4% lines and key snap to the right at the end of the -4% line. Lastly, complex those two elements together. **Note:** It can be helpful to set the feature definition to **none** before completing this step so you can easily tell the difference between the controlling elements and the following elements.



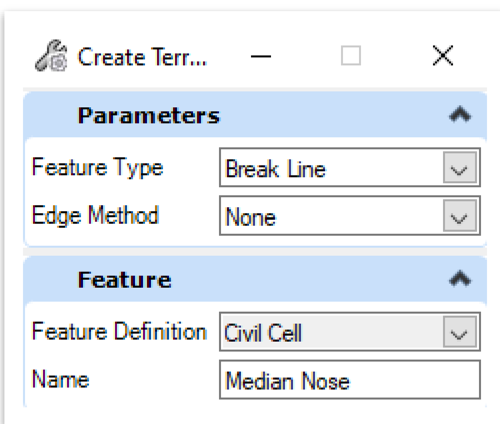
43. Go ahead and set the complex geometry to **active**.



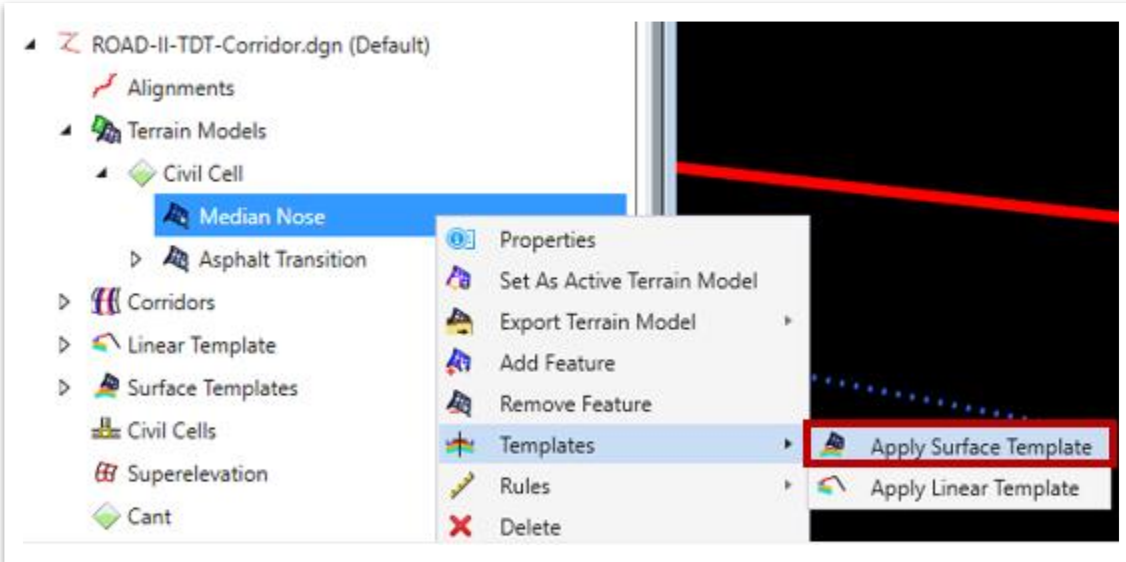
44. Next, we will create another terrain. Open the **Create Terrain Model From Elements** tool (**OpenRoads Modeling >> Terrain >> Create**). Turn off the **DES - CORRIDOR GRAPHICS - Design** and **DES - MODEL - Lines - Curb Flowline** levels to make it easier to select the two lines. Select the **Curb** line with the new profile and then select the **CR_BACK_TOP_RM** line.



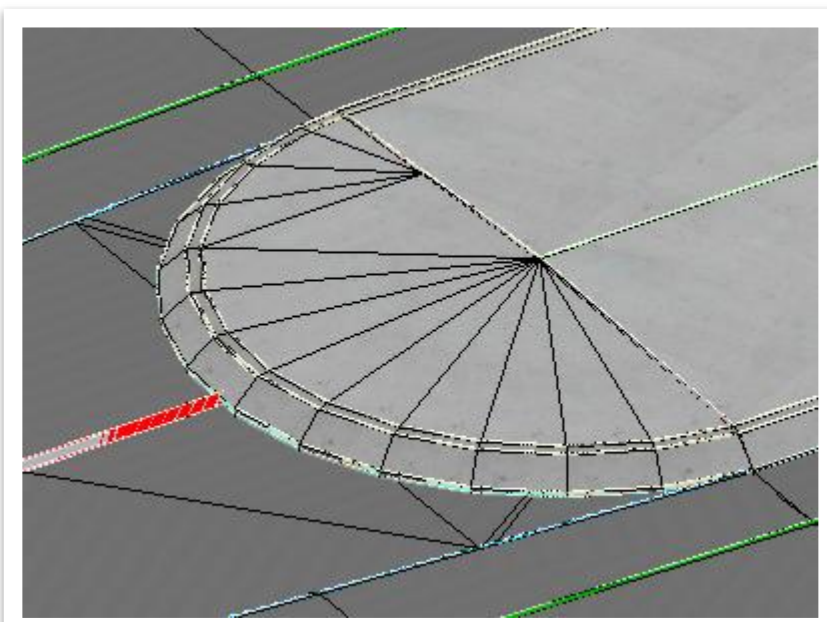
45. **Right** click to accept those two lines, and then make sure the **Feature Type** is set to **Break Line**, the **Edge Method** is set to **None,** and the **Feature Definition** is a **Civil Cell**. Name the terrain **Median Nose**. **Left** click through the prompts to accept.



46. Within the **Explorer**, **right** click on the **Median Nose** terrain just created (**OpenRoads Model >> Terrain Models >> Civil Cell**) and select **Apply Surface Template**.



47. Select the **SURFACE - CONC. MISC.** template (**Linear Templates >> Civil Cells >> Surface**) and **left** click through the prompts to apply the surface template.



Take Note!

There is an additional template drop transition exercise in [Appendix B.1](#), which involves transitioning from a 4-Lane with Median to a 3-Lane.

Chapter 8. Retaining Walls

Retaining walls are a common component in roadway design. This chapter will discuss how to model retaining walls in cut and fill scenarios, as well as, how to set up a template to automatically place walls within a criteria-based model.

8.1 Objectives

At the conclusion of this chapter, participants will be able to:

1. Place a retaining wall in a cut and a fill scenario.
2. Place a retaining wall within a template and use display rules to determine when it is placed.

8.2 Lecture: Retaining Walls Overview

Within the TDOT workspace, **retaining walls** have been set up to run with two linear templates: **cut** (Figure 14) and **fill** (Figure 15 on next page). Both templates meet the criteria set forth in TDOT standard drawing **W-CIP-1**. The retaining wall templates do not have sidewalks within them. They will be placed along a given corridor adjacent to templates that already contain a sidewalk component <u>or</u> with templates where a sidewalk is not required.

FIGURE 14. RETAINING WALL – CUT TEMPLATE

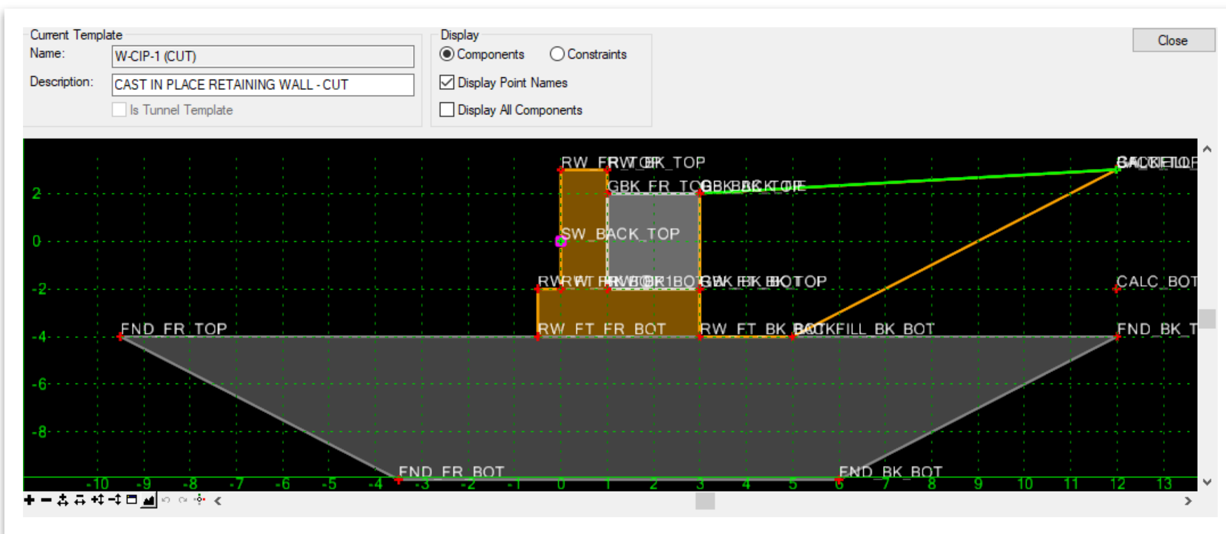
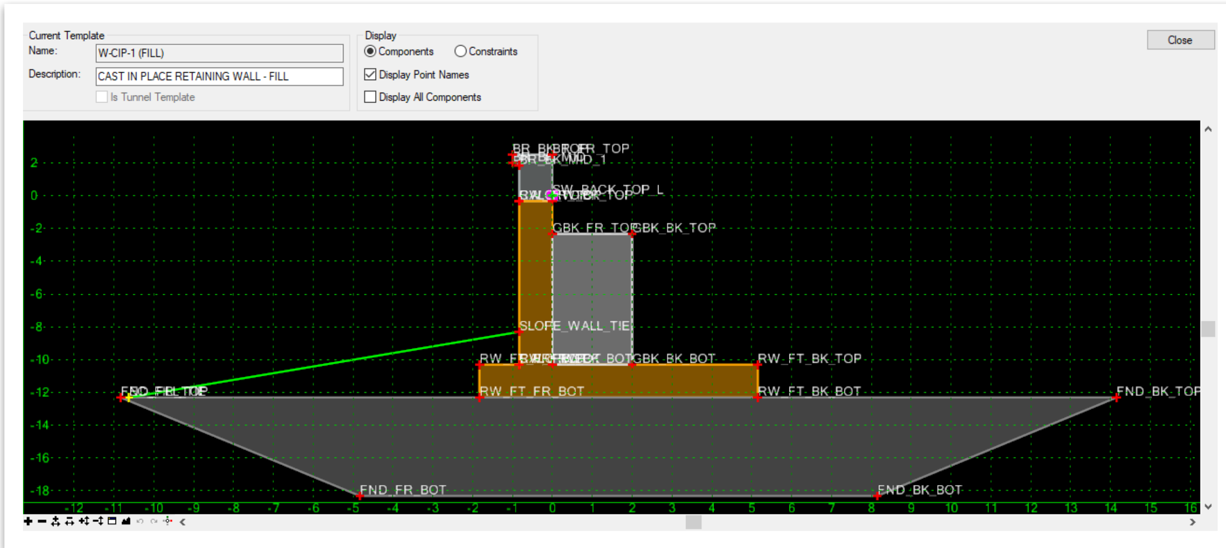


FIGURE 15. RETAINING WALL – FILL TEMPLATE



There are **two** methods for placing retaining walls:

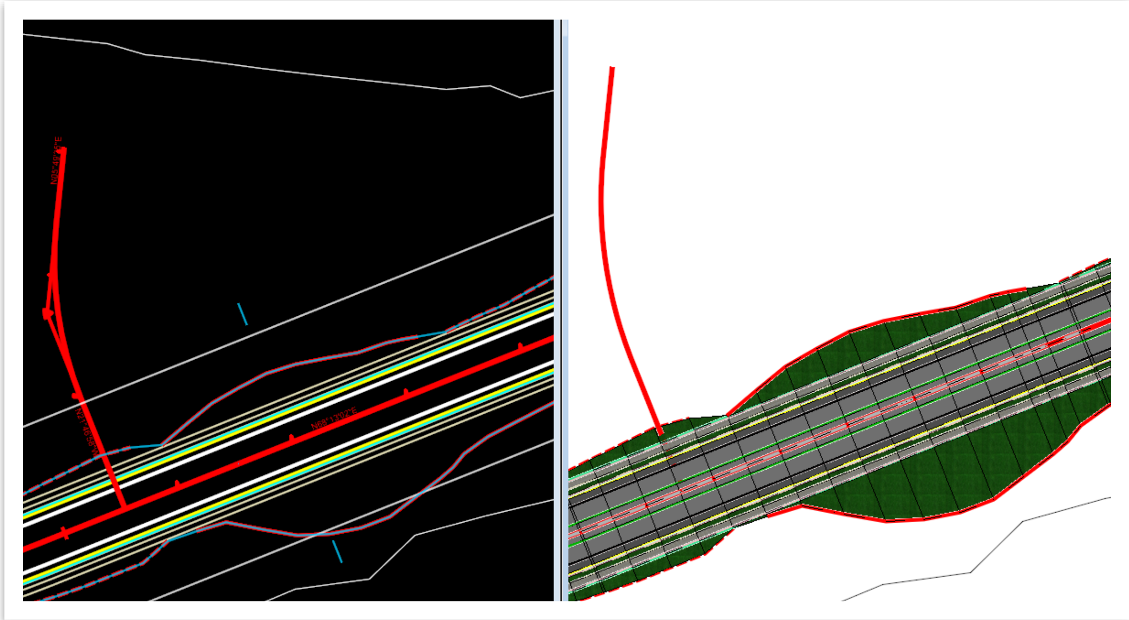
- Apply a **linear template** to the model. Then, create an **end condition exception** to remove the original end condition from the model where the retaining wall will be placed. This method will be shown in Exercise 8.3.
- Create a **new linear template** and use **display rules** to determine when a retaining wall will be placed. This method will be shown in Exercise 8.4.

By default, both templates are set to target the existing ground and automatically adjust the wall height and all associated dimensions as necessary. If the user wants more control of the wall height, **point controls** can be used to manually override the point targeting the existing ground.

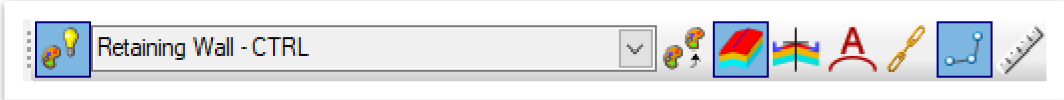
8.3 Exercise: Placing Retaining Walls Along a Corridor

In this exercise, we will place two retaining walls (one cut and one fill) along a corridor using the linear template tool.

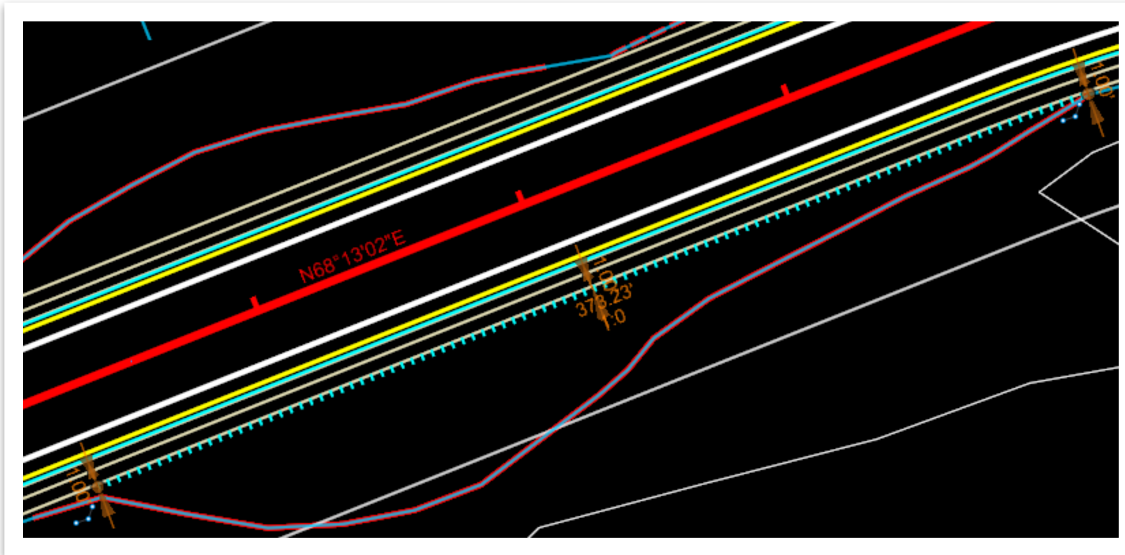
1. Open the **ROAD-II-RW-Corridor.dgn** file within the dgn Chapter 8 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner. Locate the large cut section directly after the **PAGE** side road alignment, around mainline Station **127+00.00 RT**.



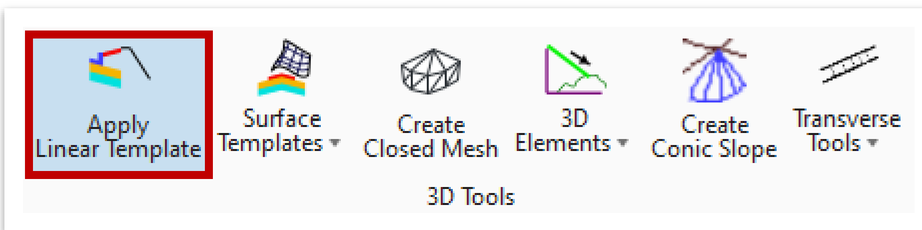
2. Select the **Retaining Wall - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Barrier**).



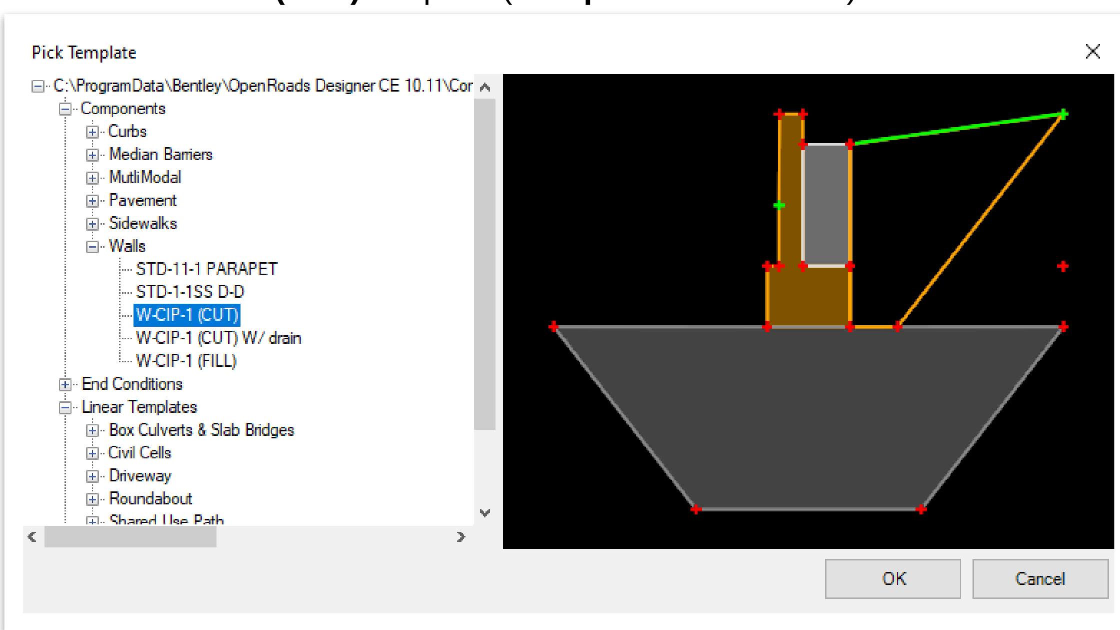
3. Next, open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and offset a line **1**' from the **SW_BACK_TOP_R** within the large cut section (Station **26+40.28** to Station **30+13.51**).



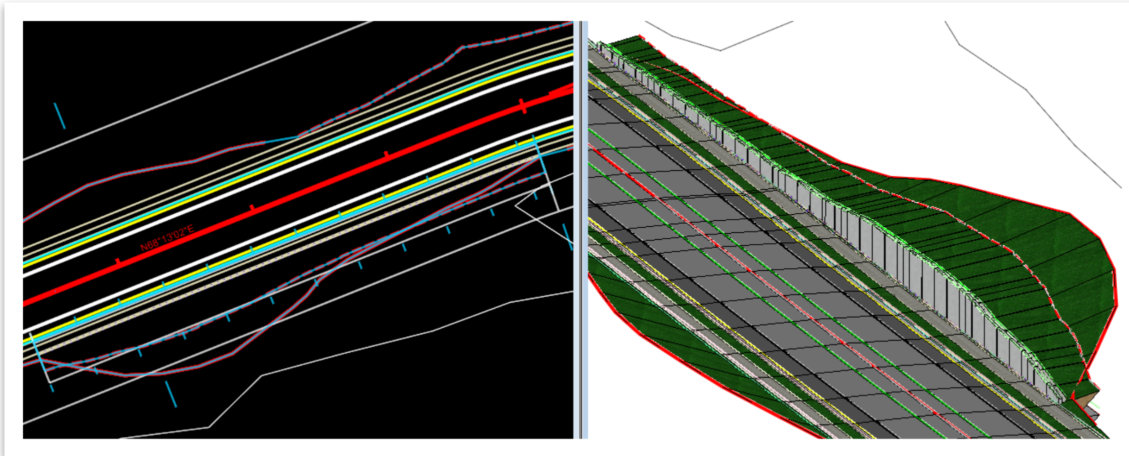
4. Now, open the **Apply Linear Template** tool (**OpenRoads Modeling >> Model Detailing >> 3D Tools**) and select the line that was just placed.



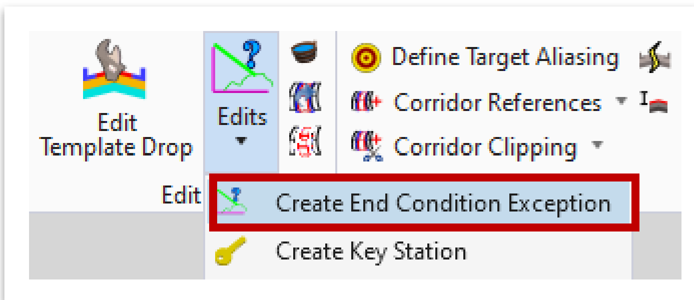
5. Select the **W-CIP-1 (CUT)** template (**Components >> Walls**).



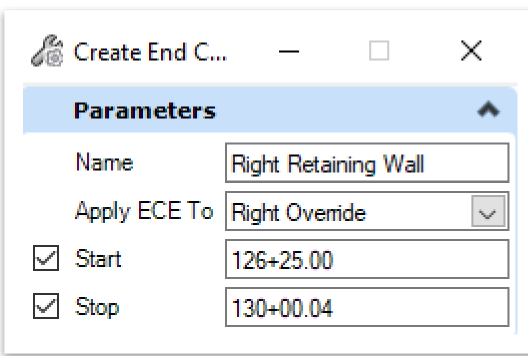
6. **Lock** to **start** and **end** and place the orange object on the **outside** of the road and click through the prompts to accept.



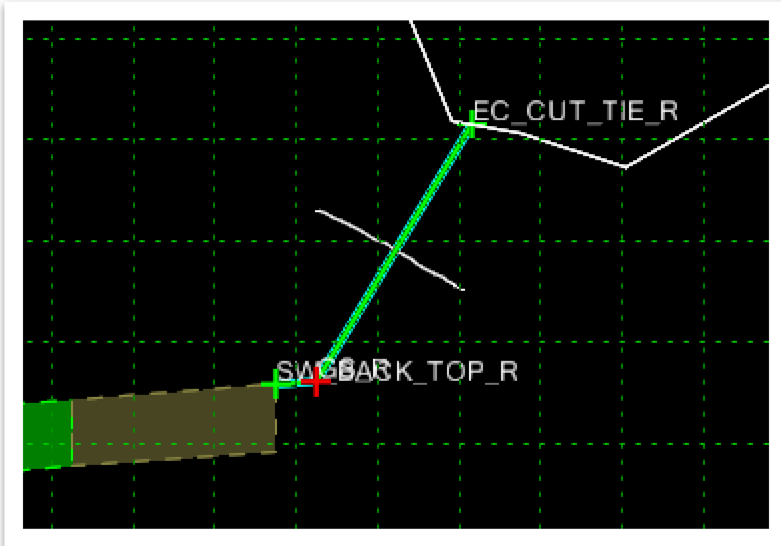
7. Next, open the **Create End Condition Exception** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**).

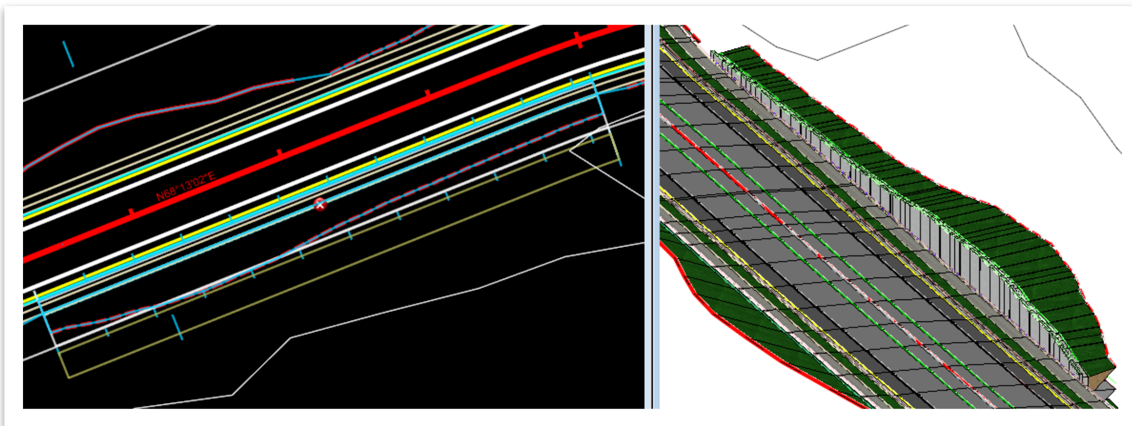


8. Select the mainline corridor and then select **Right Override** for where to apply the **End Condition Exception** (ECE) to. Set the start and stop locations around the start and end of the retaining wall. Try to get as close as possible but <u>do not snap to the line created</u>.

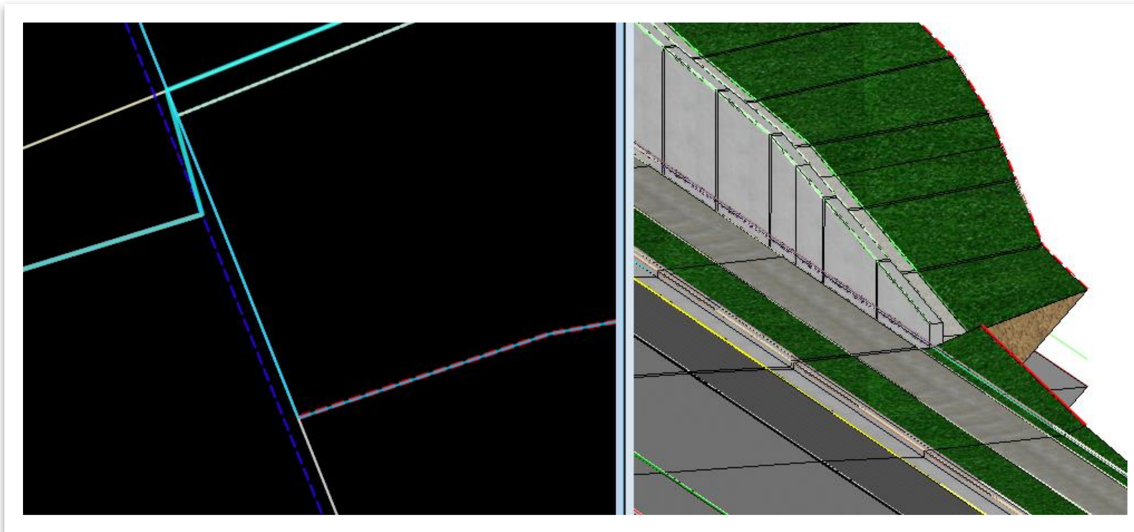


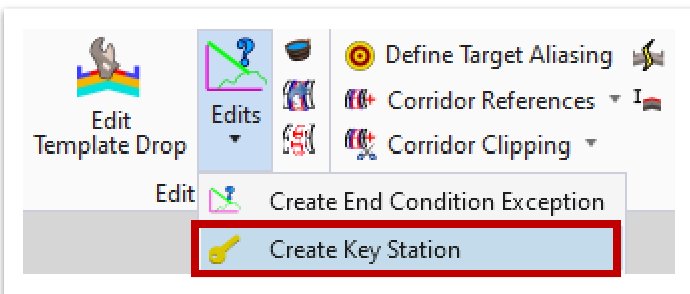
9. The **Right Override** window should open. **Right** click in space and select **Delete Components**. Draw through the **EC_CUT_TIE_R** line and click **OK**, and then notice the update in plan view.



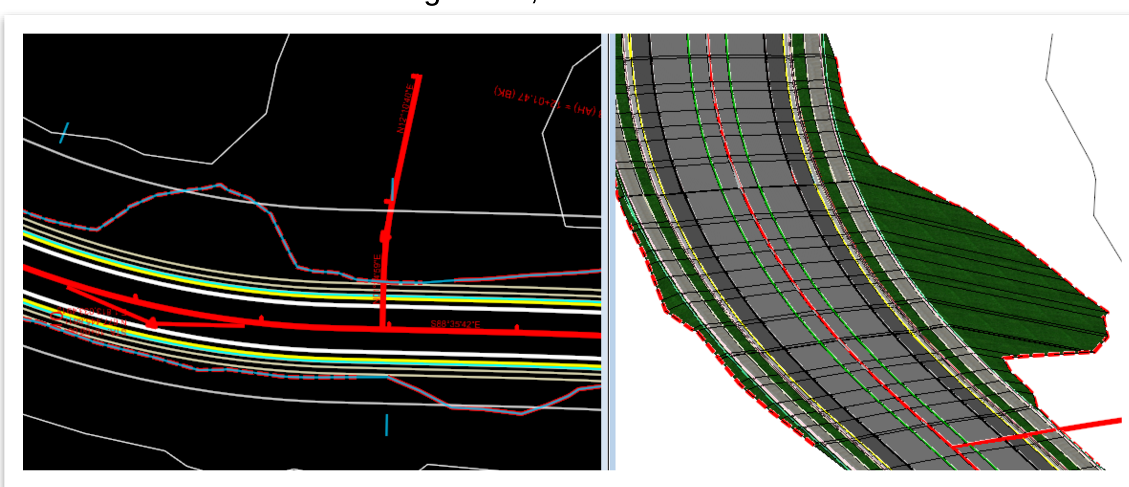


10. Notice there is an issue with the gap between the mainline corridor and the retaining wall at the start and end of the end condition exception. This is because the mainline template will not start the end condition until the next template drop. To fix this issue, open the **Create Key Station** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**). Select the mainline corridor and place the key stations just outside the start and end of the retaining wall (approximate Station **126+24.50** and Station **130+00.54**).

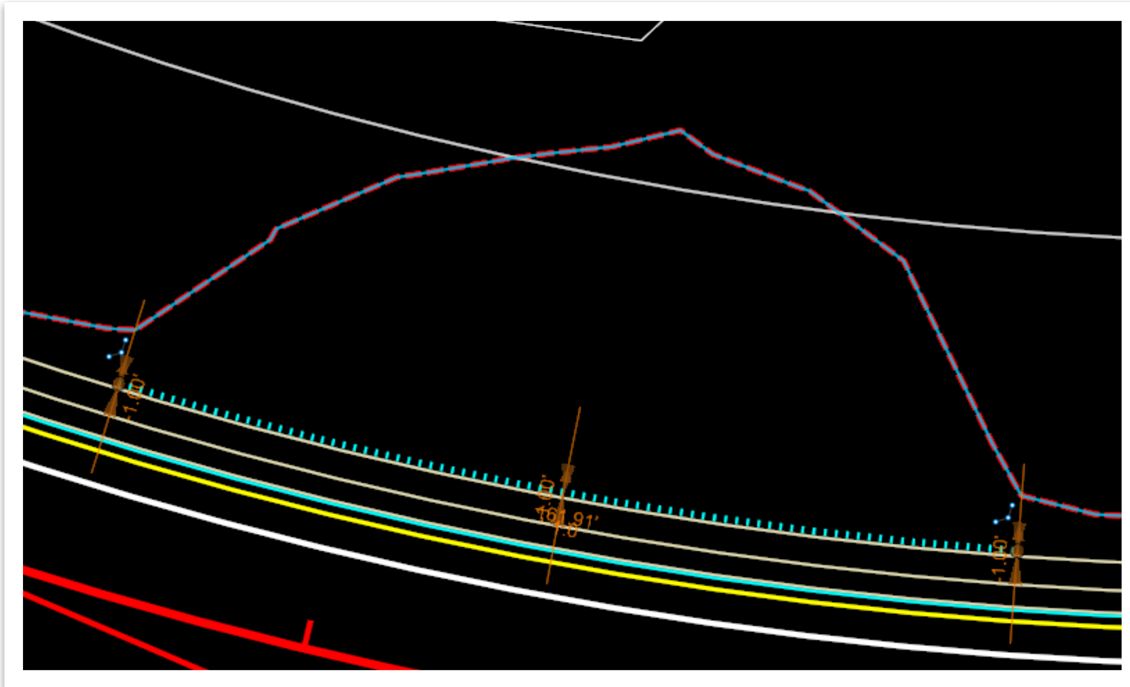




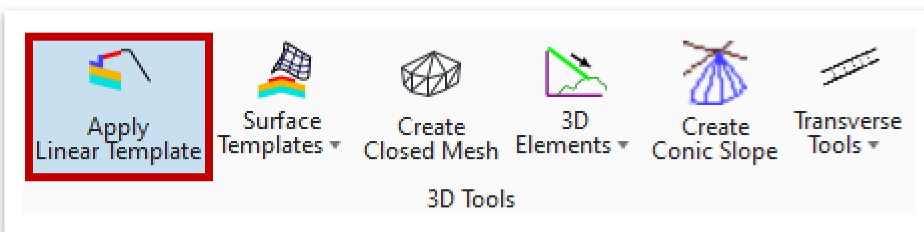
11. Now, let's place a **fill** retaining wall. Locate the large fill section just before the **JACKSONTRAIL** side road alignment, around mainline **Station 191+50.00 LT**.



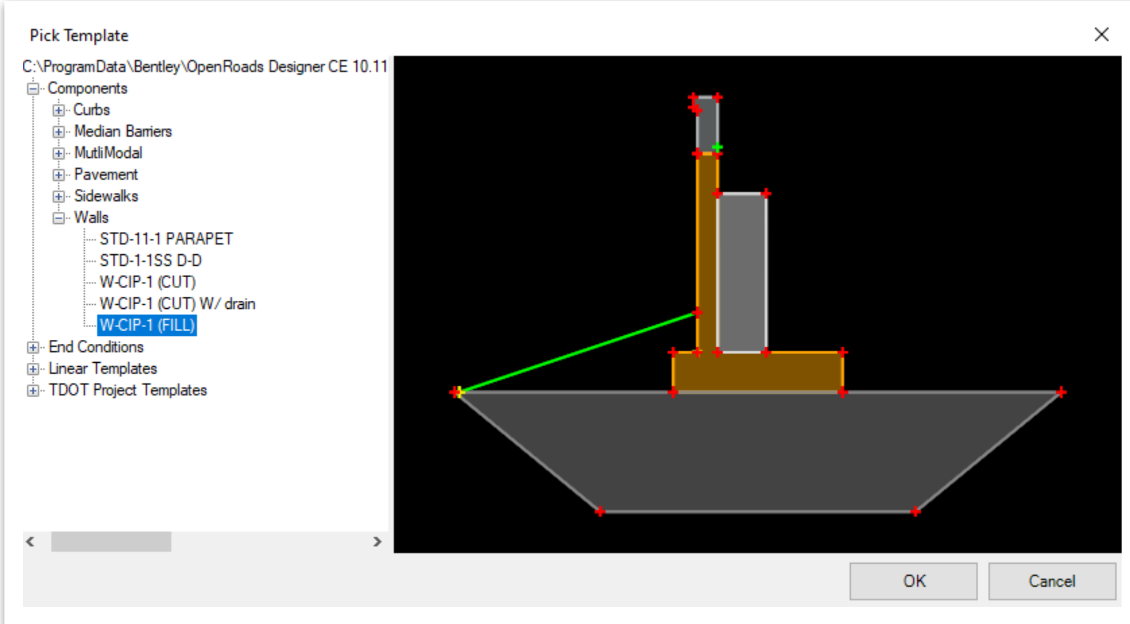
12. Open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and offset a line **1**' from **SW_BACK_TOP_L** within the large fill section (Station **90+63.81** to Station **92+25.73**) using the **Retaining Wall - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Barrier**).



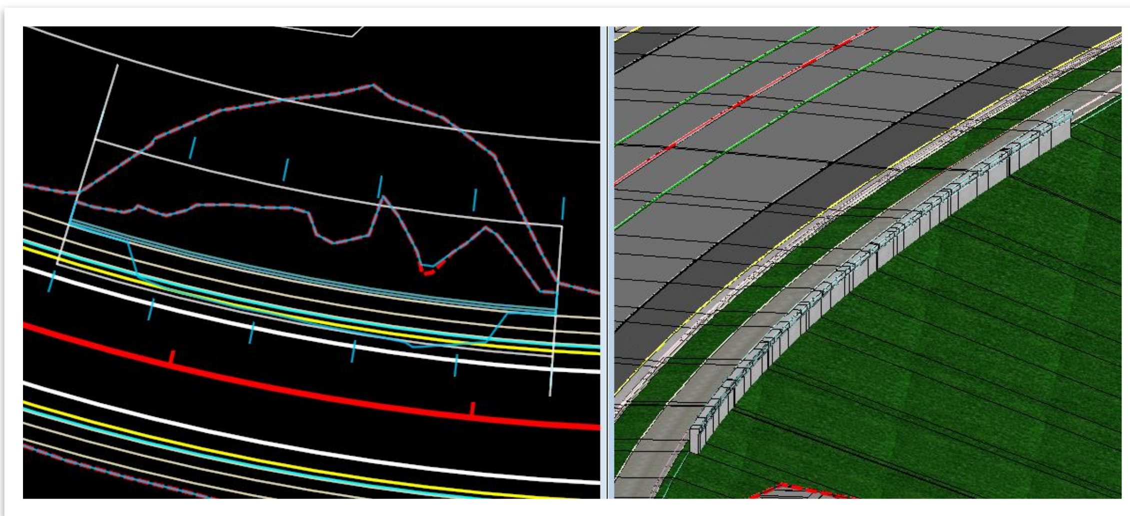
13. Next, open the **Apply Linear Template** tool (**OpenRoads Modeling >> Model Detailing >> 3D Tools**) and select the line that was just placed.



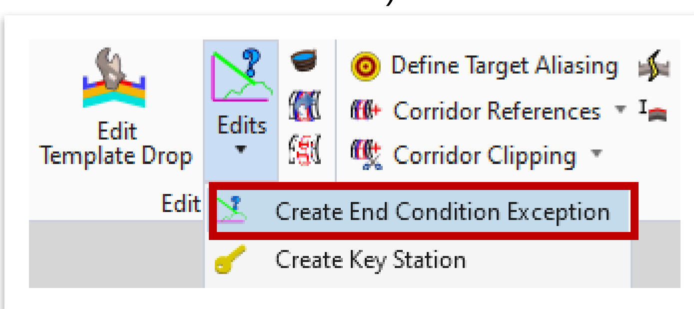
14. This time select the **W-CIP-1 (FILL)** template (**Components >> Walls**).



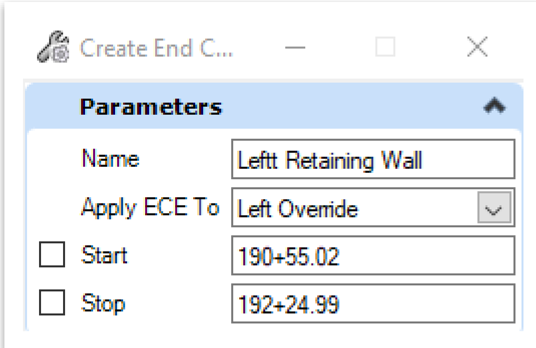
15. **Lock** to **start** and **end** and place the orange object on the **inside** of the road and click through the prompts to accept.



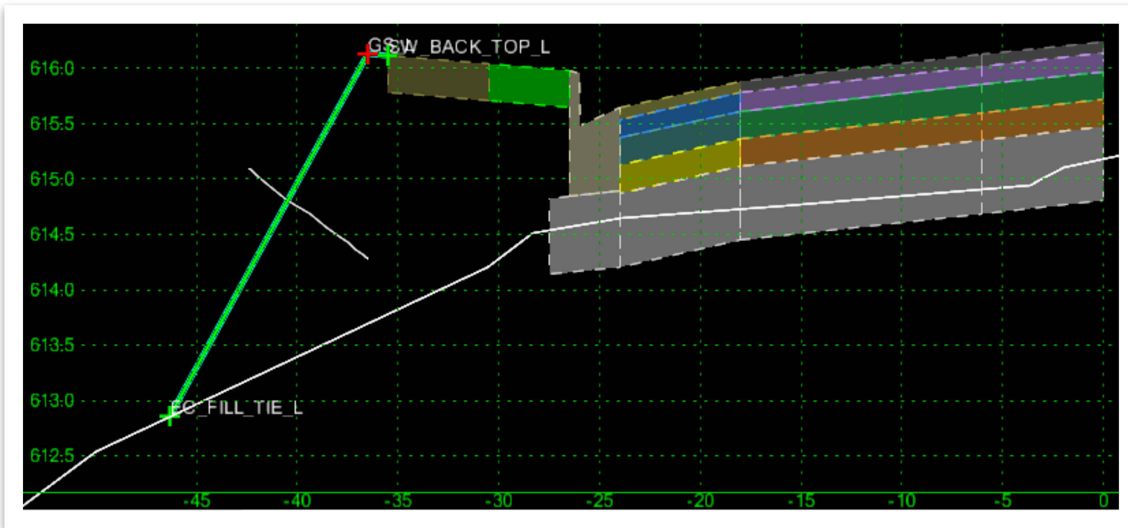
16. Now, open the **Create End Condition Exception** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**).



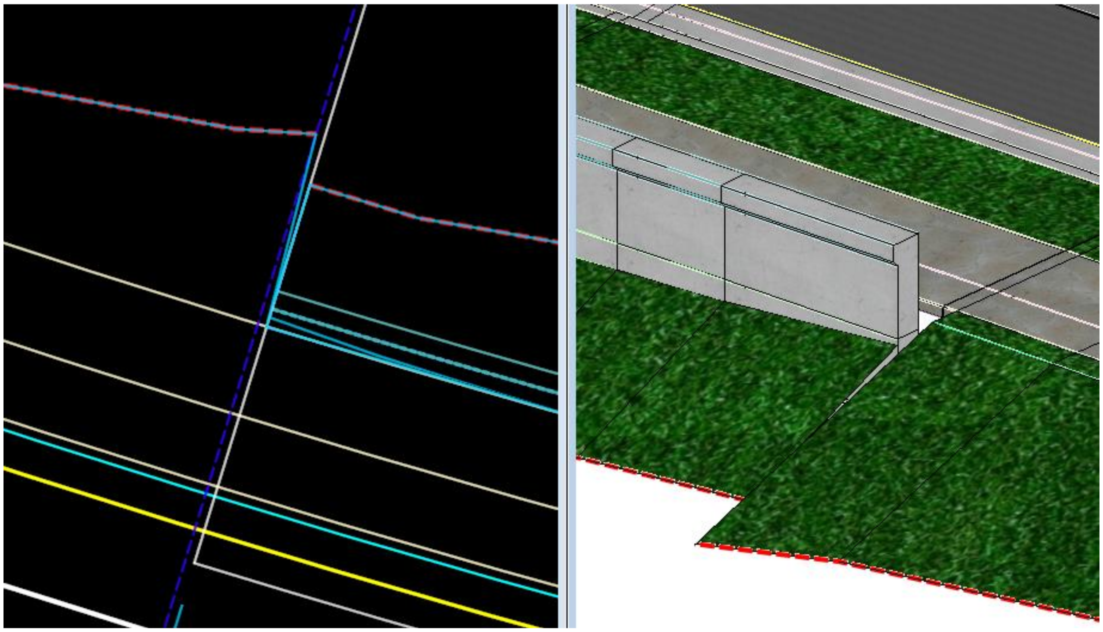
17. Select the mainline corridor and then select **Left Override** for where to apply the **End Condition Exception** (ECE) to. Set the start and stop locations around the start and end of the retaining wall. Try to get as close as possible but do not snap to the line created.

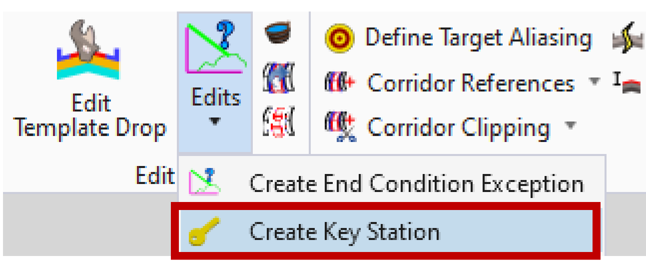


18. The **Left Override** window should open. **Right** click in space and select **Delete Components**. Draw through the **EC_FILL_TIE_L** line and click **OK**.



19. If there is still an issue with the gap between the mainline corridor and the retaining wall at the start and end of the end condition exception, open the **Create Key Station** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**). Select the mainline corridor and place the key stations just outside the start and end of the retaining wall (approximate Station **190+54.52** and Station **192+25.49**), which should fix the issue.

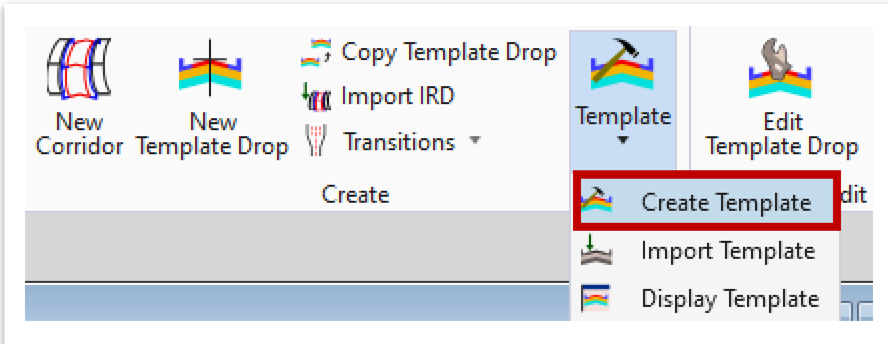




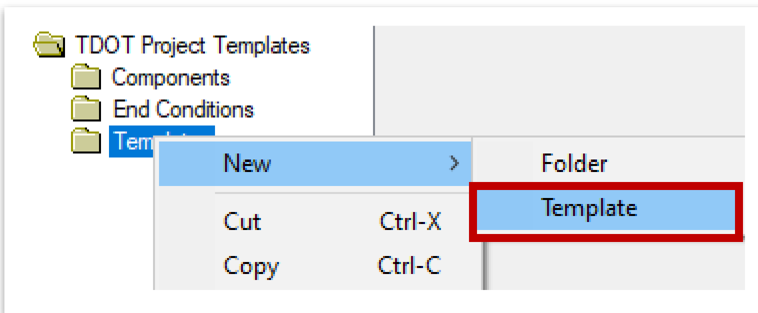
8.4 Exercise: Placing a Retaining Wall Within a Template Using Display Rules

In this exercise, we will place a retaining wall template using **Display Rules** within the corridor ITL. We will continue to utilize the same **ROAD-II-RW-Corridor.dgn** file.

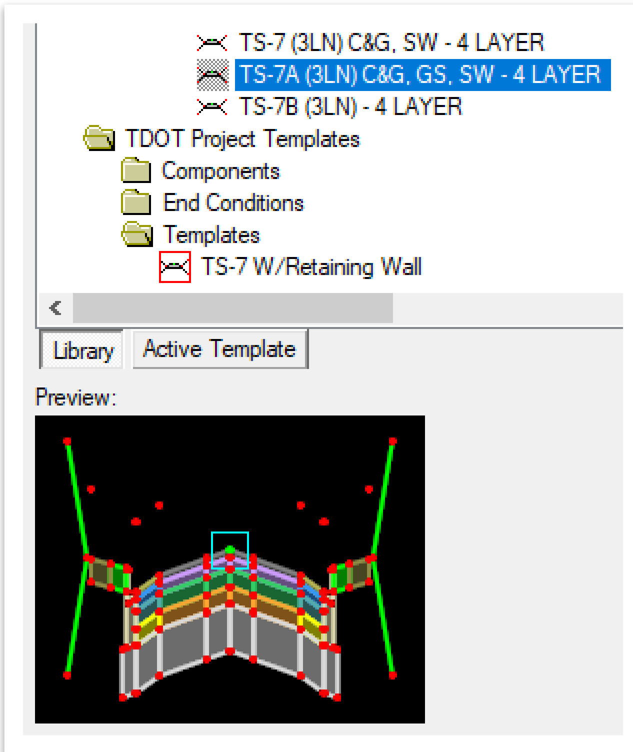
1. Open the **Create Template** tool (**OpenRoads Modeling >> Corridors >> Create**).



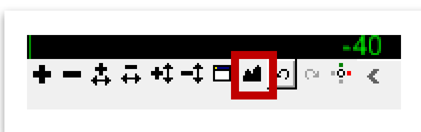
2. Under the **TDOT Project Templates** folder, **right** click on the **Templates** subfolder and select **New >> Template**. Name the new template **TS-7 W/ Retaining Wall**.

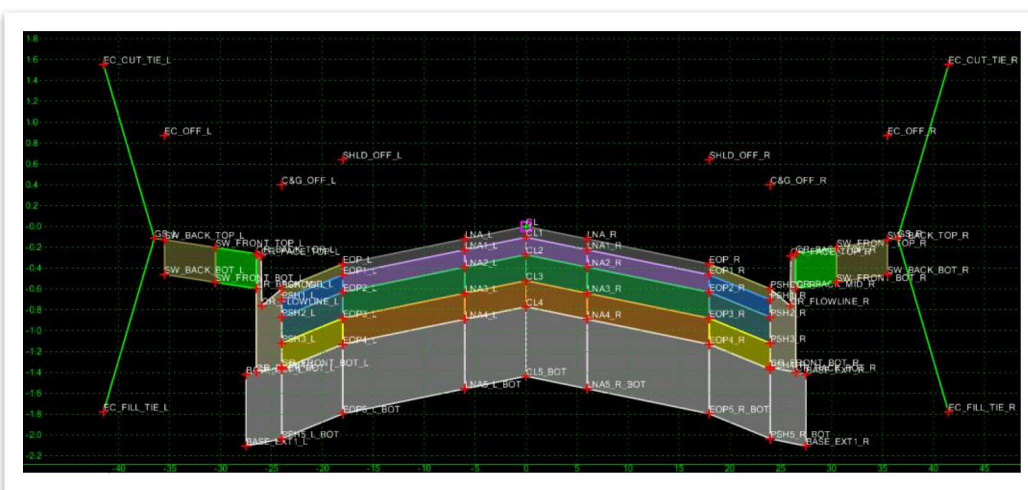


3. An empty template should now appear. Scroll up and select the **TS-7A (3LN) C&G, GS, SW - 4 LAYER** template (**Linear Templates >> TDOT Typical Sections >> Undivided**). Click on the template once so that the preview shows up in the bottom left corner.

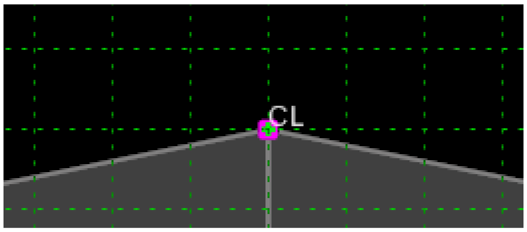


4. Next, **left** click and hold in the bottom preview window and drag the template over into the empty template. Click **View Extent** to see the full template.

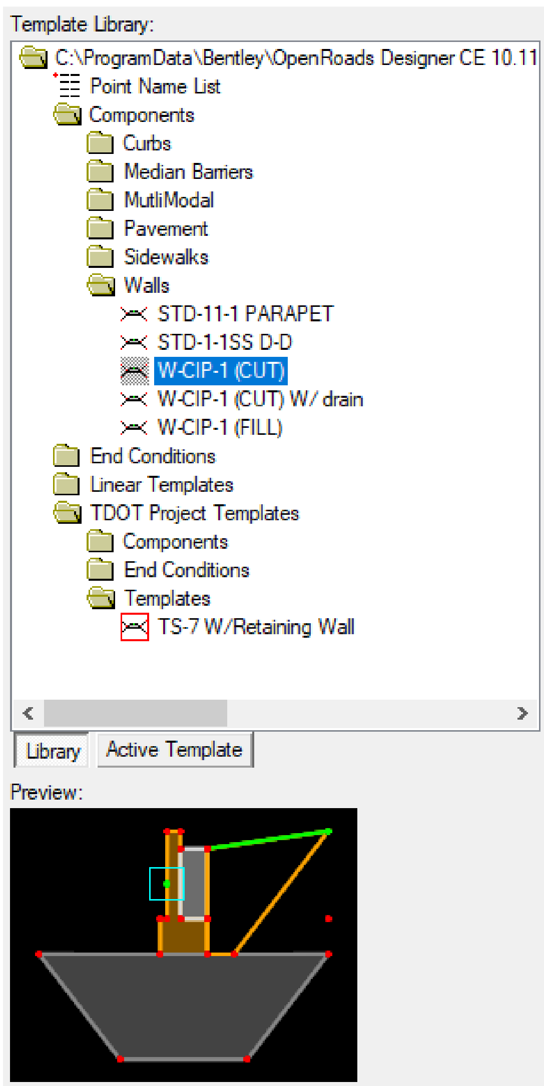




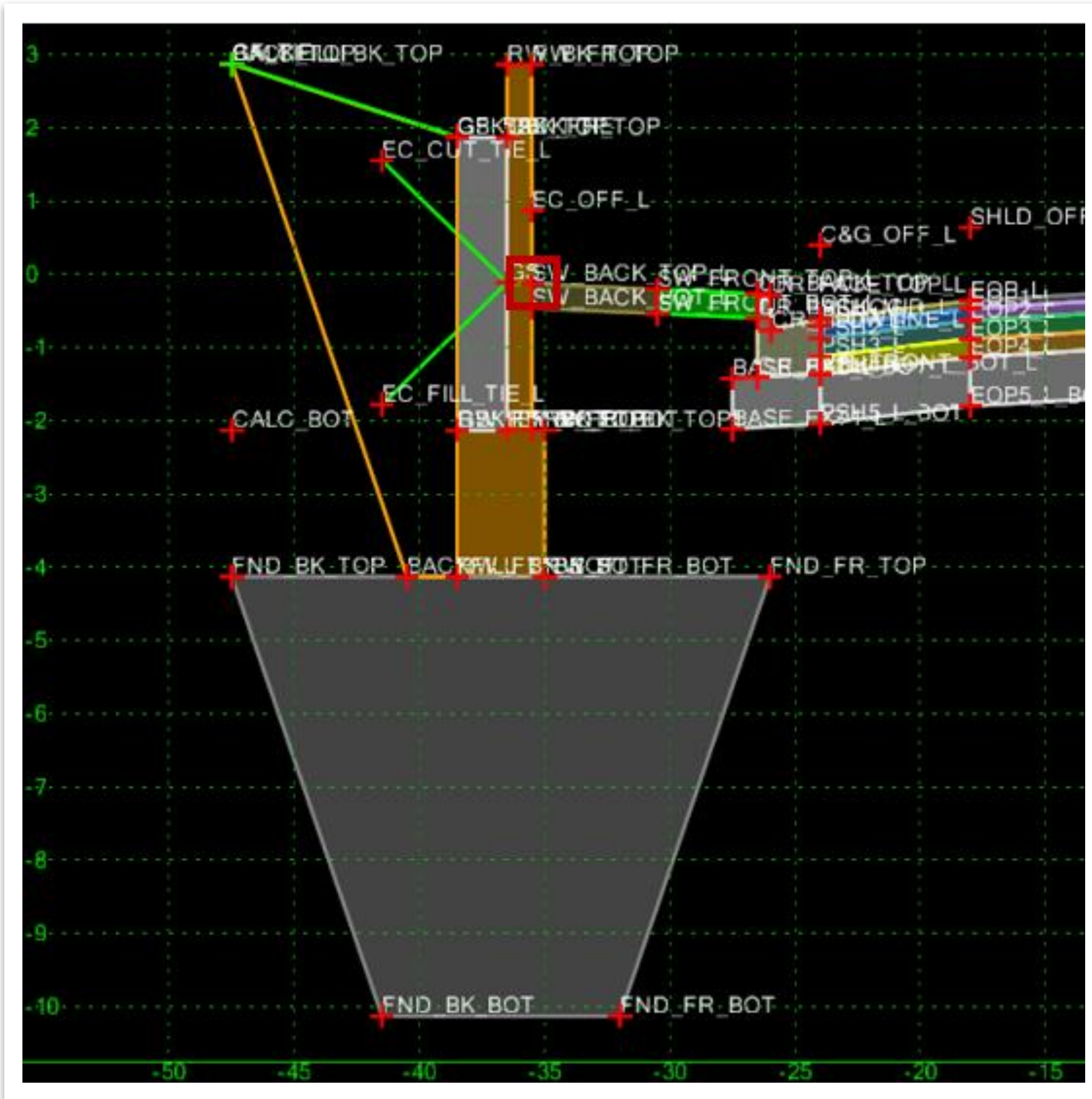
5. **Right** click within the **Create Template** window and select **Change Template Origin**. Select the **CL** point and the template origin will change to **CL**.



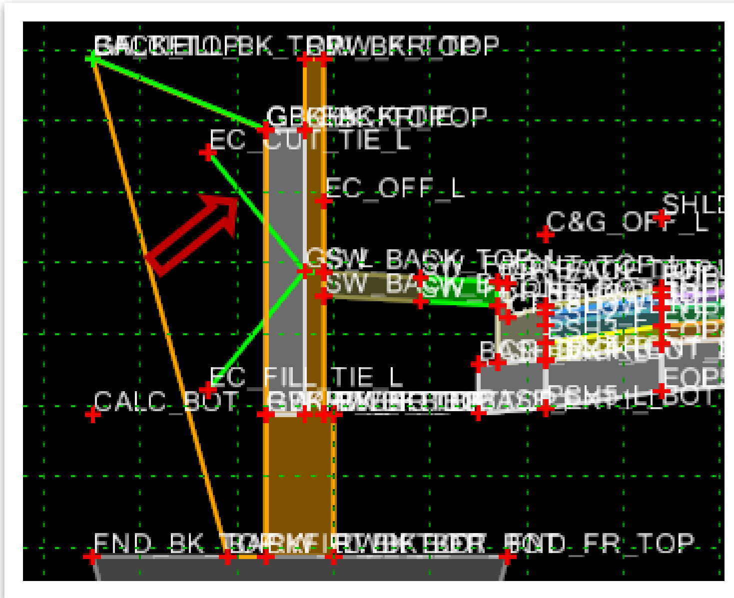
6. Now, select the **W-CIP-1 (CUT)** template once (**Components >> Walls**). Make sure the blue box in the preview window is drawn around the **SW_BACK_TOP** point. **Note:** If the blue box is drawn around another point, go ahead and select the **SW_BACK_TOP** point in the preview window.



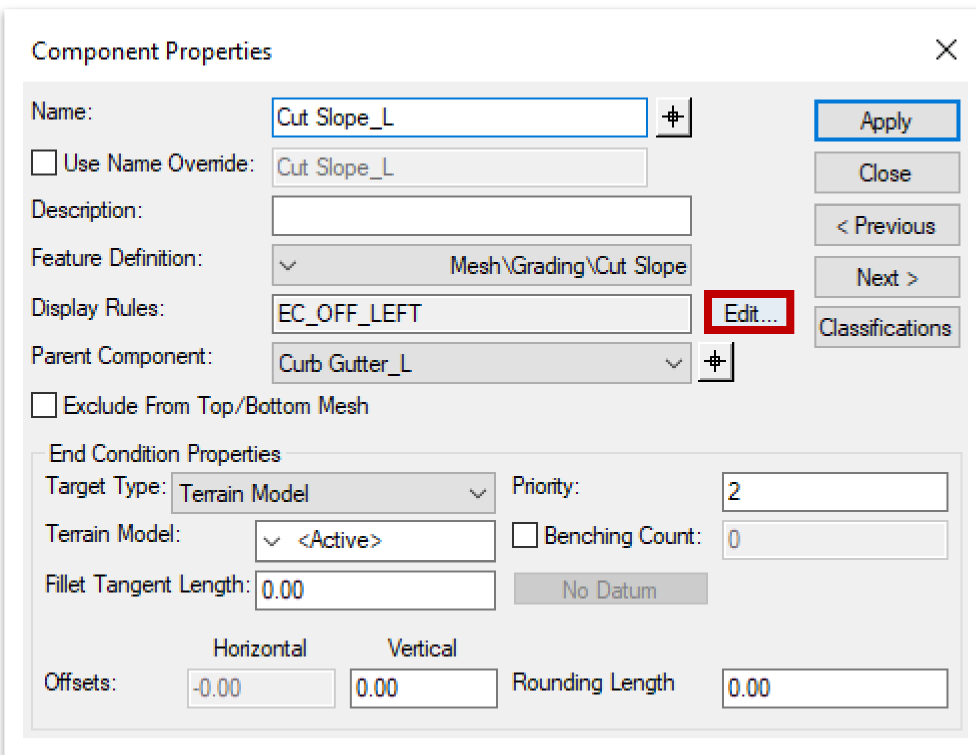
7. Once again, **left** click and hold in the bottom preview window and drag the wall template component over into the main template. While holding the left click button down within the template window, **right** click and select **Reflect**. Place the retaining wall point on the **SW_BACK_TOP_L** point (highlighted in red).



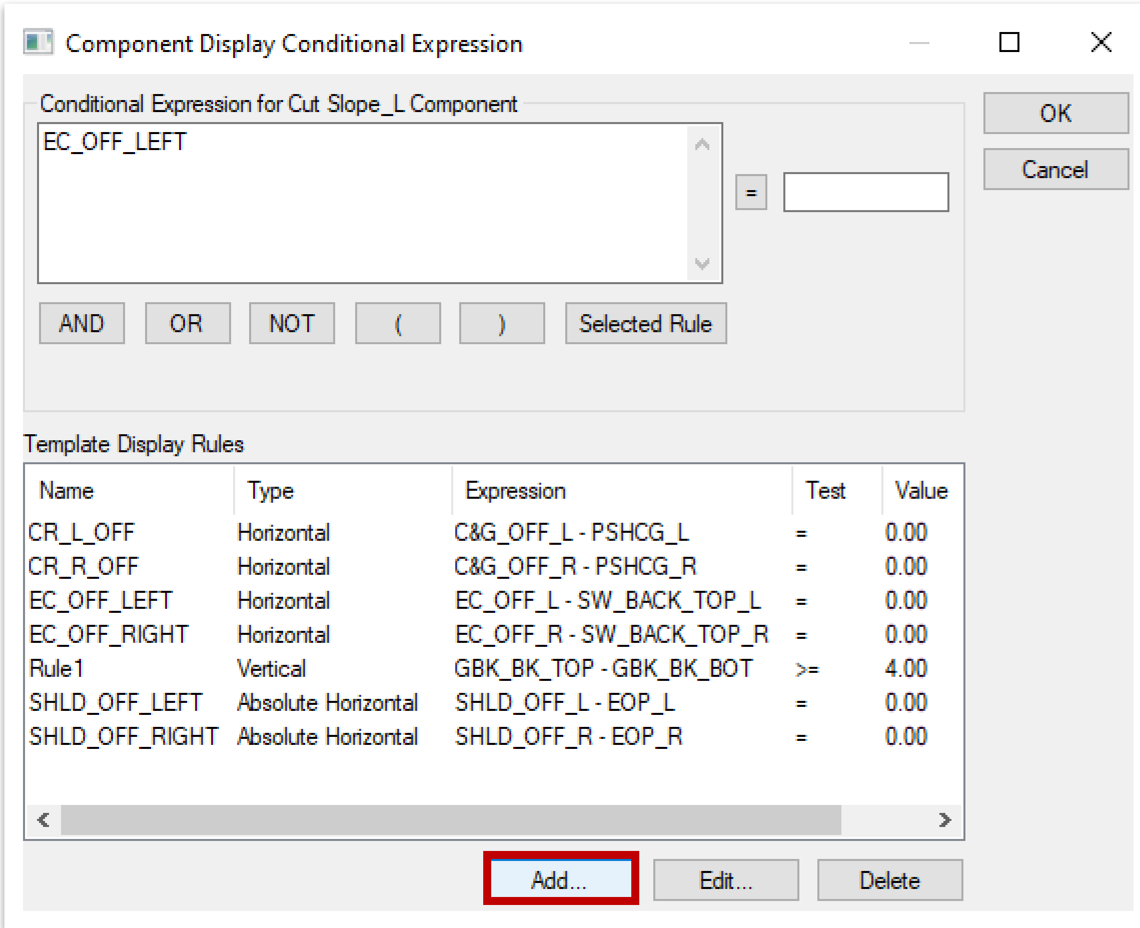
8. We will now use **Display Rules** to control what does and does not show in the template drop. We will make the retaining wall appear when the cut slope line is **longer** than 12 feet and make the cut slope turn off. Likewise, when the cut slope is less than 12 feet or if the template is in fill, the retaining wall needs to turn off. Go ahead and select the **Cut Slope_L** component by double clicking it.



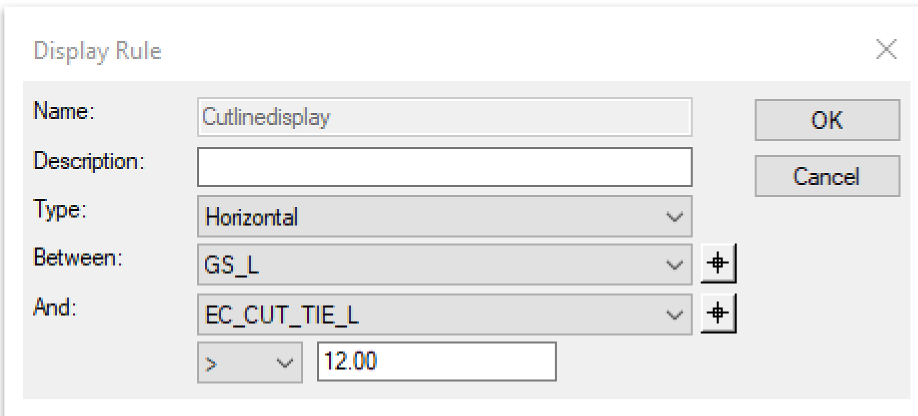
9. Within the **Component Properties** window, click the **Edit** button next to **Display Rules**.



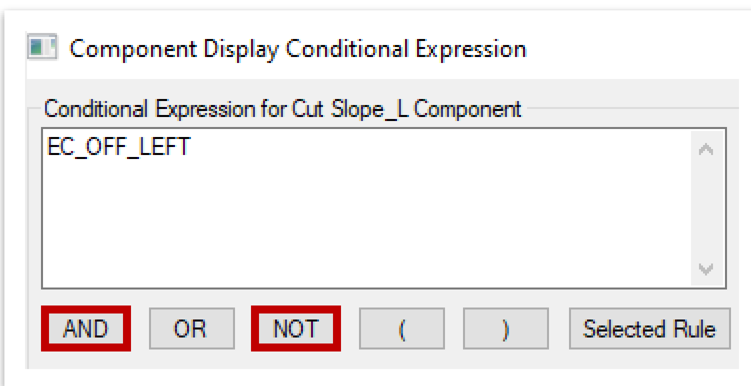
10. Next, click the **Add…** button at the bottom of the **Component Display Conditional Expression** window.



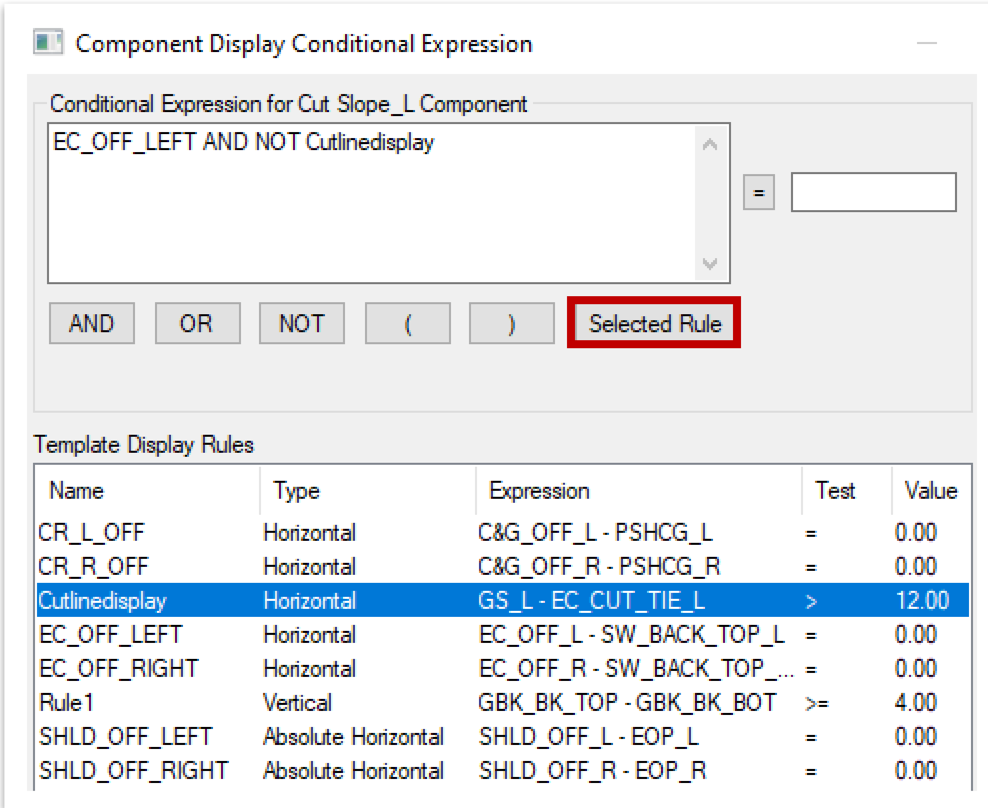
11. Within the **Display Rule** dialog box, select the following settings, and then click **OK**.
    a. **Name:** Cutlinedisplay
    b. **Type:** Horizontal (**Note:** This option must be selected to see the additional fields below.)
    c. **Between:** GS_L
    d. **And:** EC_CUT_TIE_L
    e. **Greater Than:** 12.00



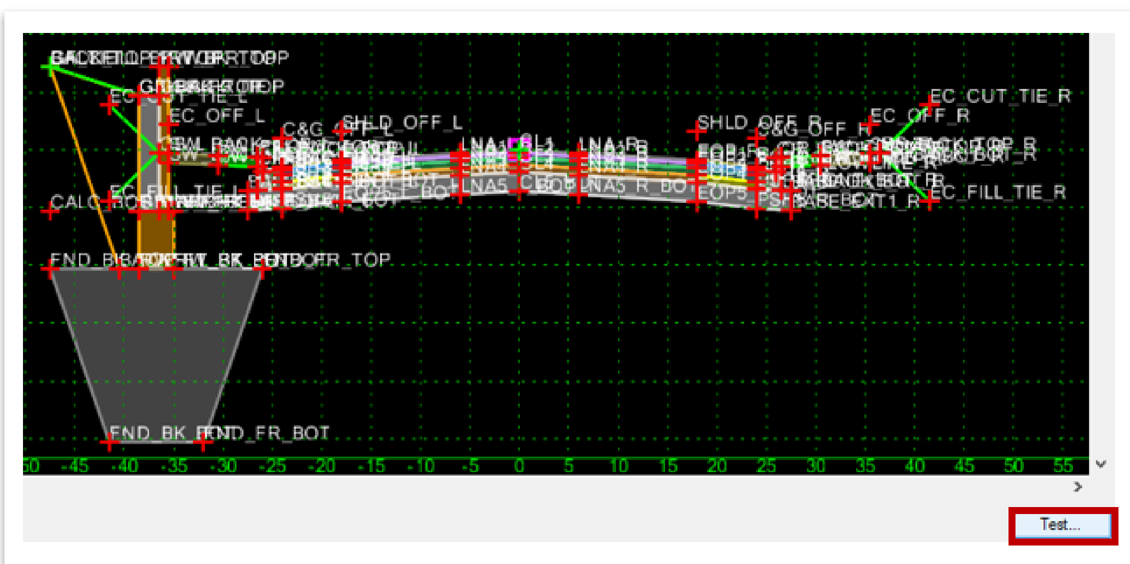
12. In the **Conditional Expression for Cut Slope_L Component** section, click the **AND** then **NOT** button to add onto the expression.



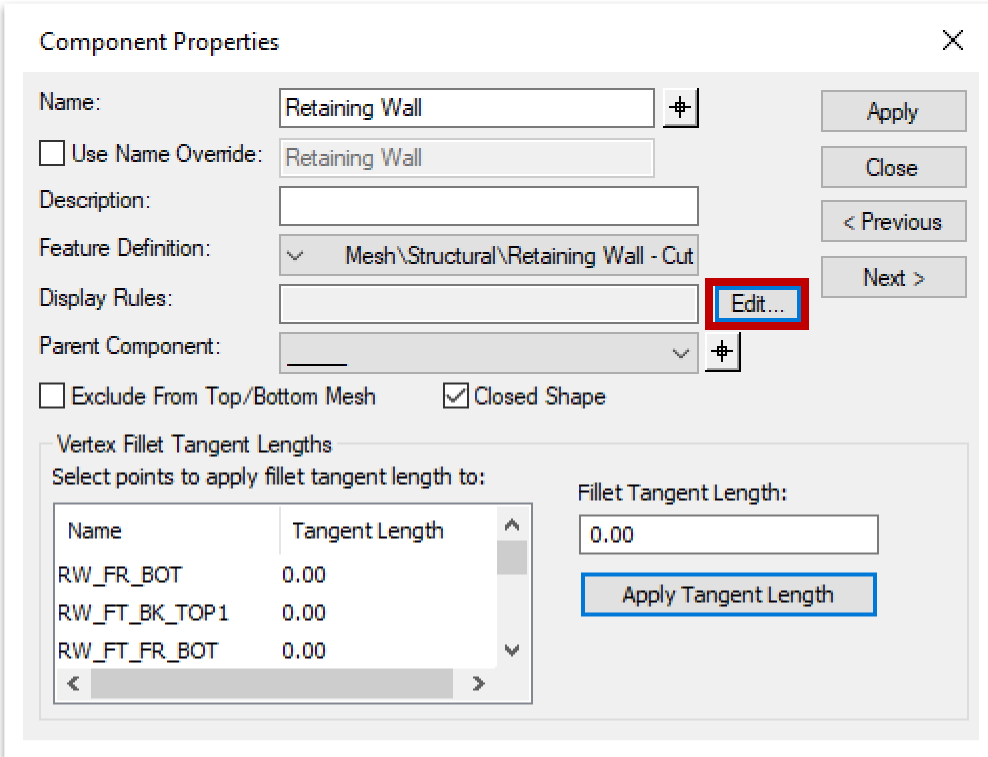
13. Then, select the **Cutlinedisplay** rule at the bottom and then click the **Selected Rule** button.



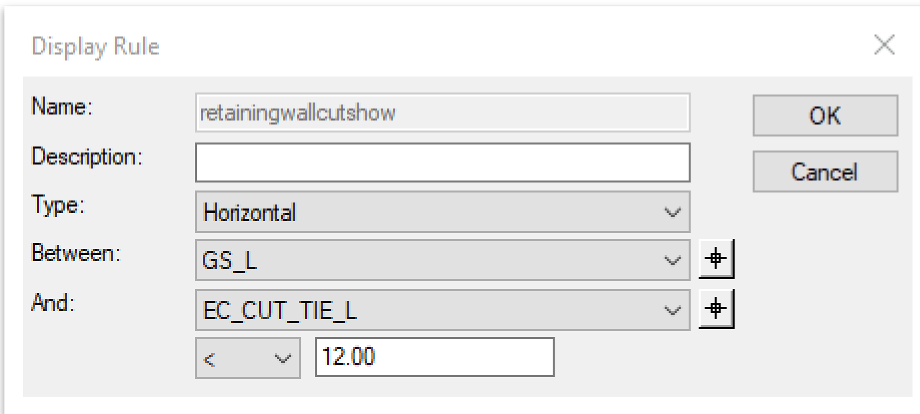
14. Click **OK** to close the **Component Display Conditional Expression** tool, and then click **Apply** and **Close** to close the **Component Properties** window.
15. Now, click the **Test…** button at the bottom right of the **Create Template** window.



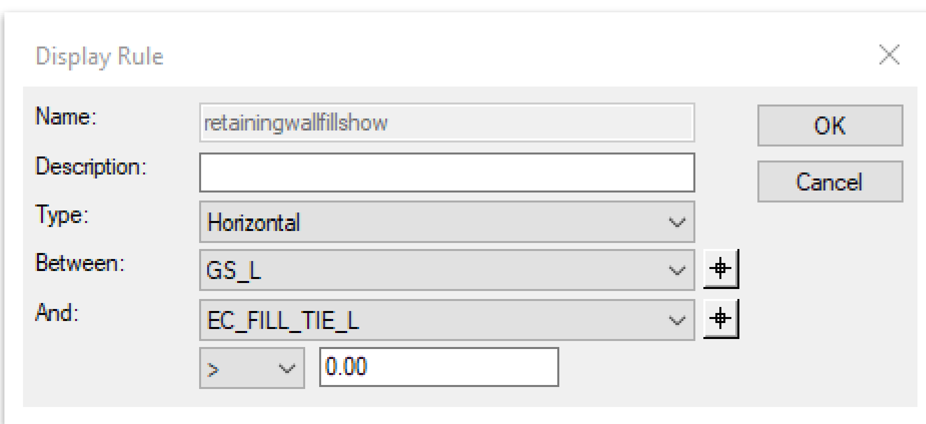
16. The **Test End Conditions** window should open. Click the **Draw** button on the right and then move the cursor up the template. The cut line will disappear after the **EC_CUT_TIE_L** is **12** feet away horizontally from the **GS**. Once tested, go ahead and click **Close** in the **Test** window.
17. Next, select the **Retaining Wall** component (orange object) to open the properties. Within the **Component Properties** window, click the **Edit…** button.



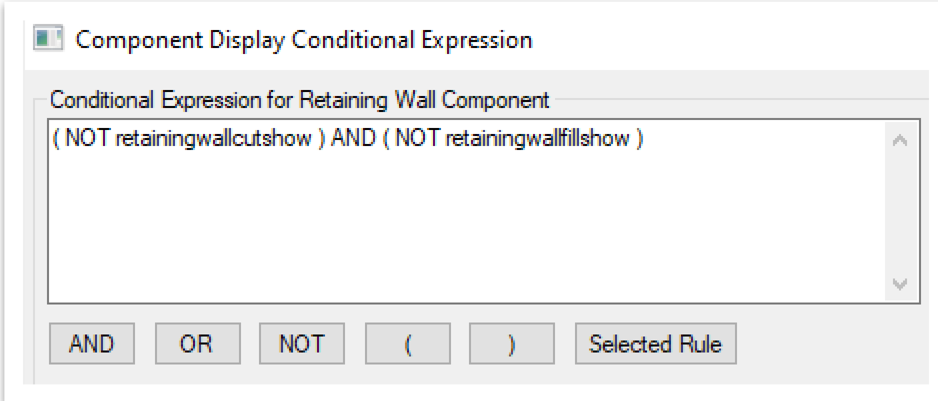
18. We will add the first **Display Rule** to not show the retaining wall when the cut is less than **12** feet horizontal. Within the **Component Display Conditional Expression** window, click **Add**. Within the **Display Rule** dialog box, select the following settings, and then click **OK**.
    a. **Name:** retainingwallcutshow
    b. **Type:** Horizontal
    c. **Between:** GS_L
    d. **And:** EC_CUT_TIE_L
    e. **Less Than:** 12.00



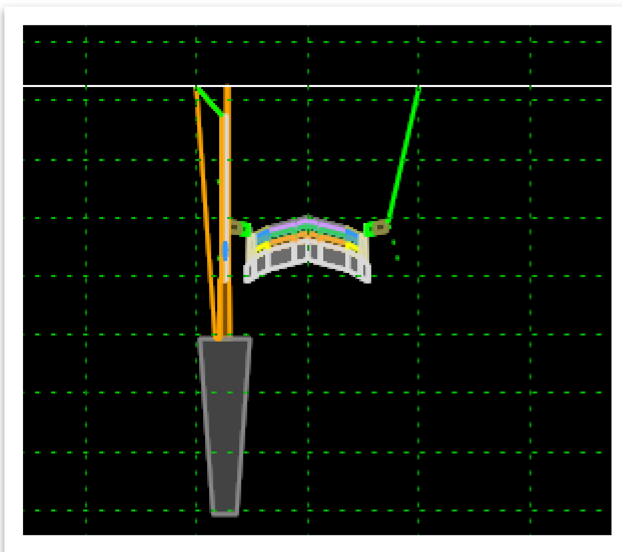
19. We will now add the second **Display Rule** to not show the retaining wall when the fill is more than **0** feet horizontal. Click **Add** once again, and within the **Display Rule** dialog box, select the following settings, and then click **OK**.
    a. **Name:** retainingwallfillshow
    b. **Type:** Horizontal
    c. **Between:** GS_L
    d. **And:** EC_FILL_TIE_L
    e. **Greater Than:** 0.00

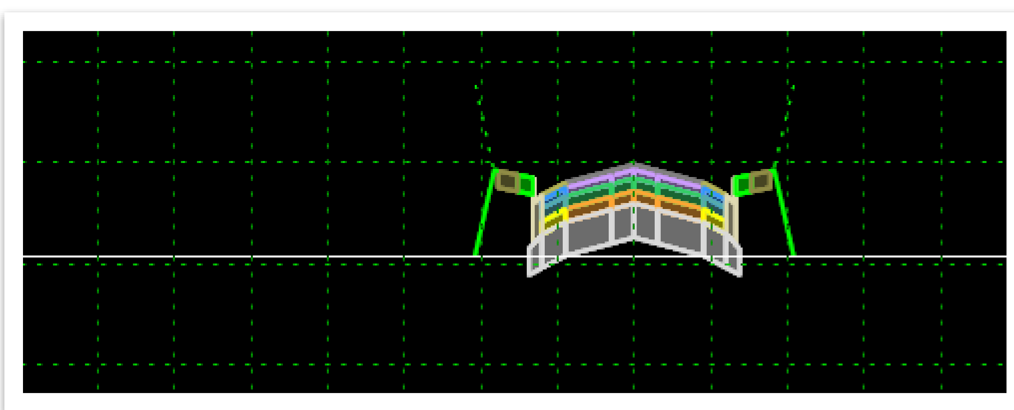


20. Next, create the **Conditional Expression** using the buttons, as show below: **(NOT retaining wallcutshow) AND (NOT retainingwallfillshow)**.

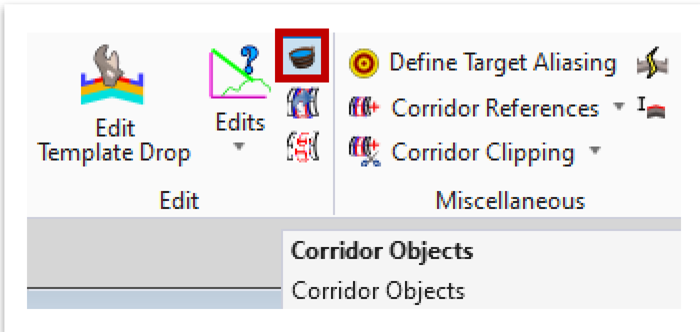


21. Click **OK** to close the **Component Display Conditional Expression** tool, and then click **Apply** and **Close** to close the **Component Properties** window. Test the file and the retaining wall should only show up when the cut line is more than **12** feet horizontal, and it should not show up when in fill.

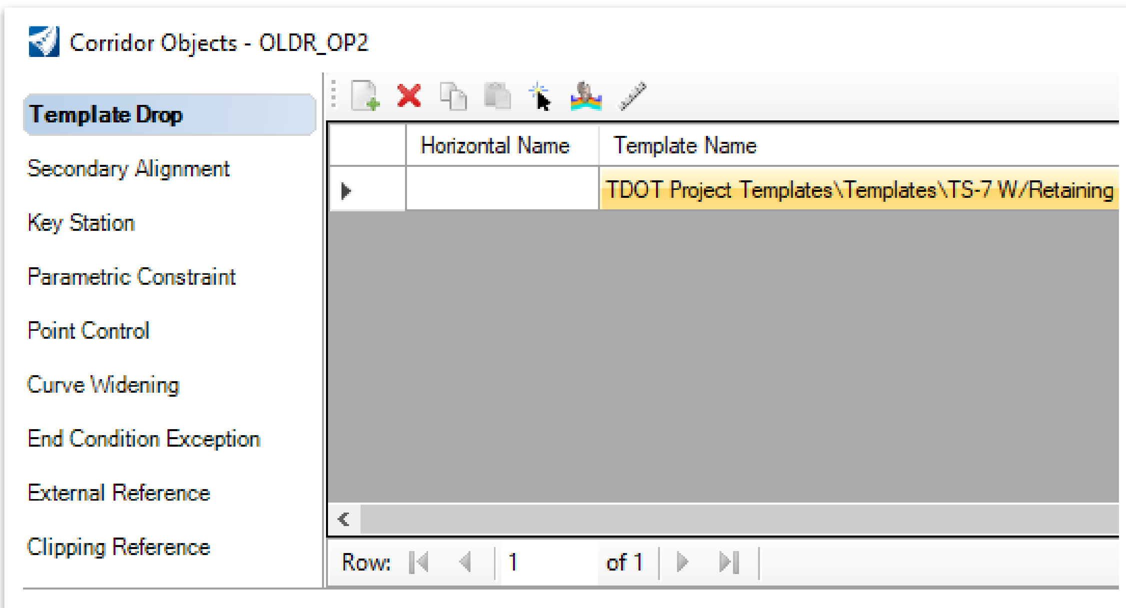




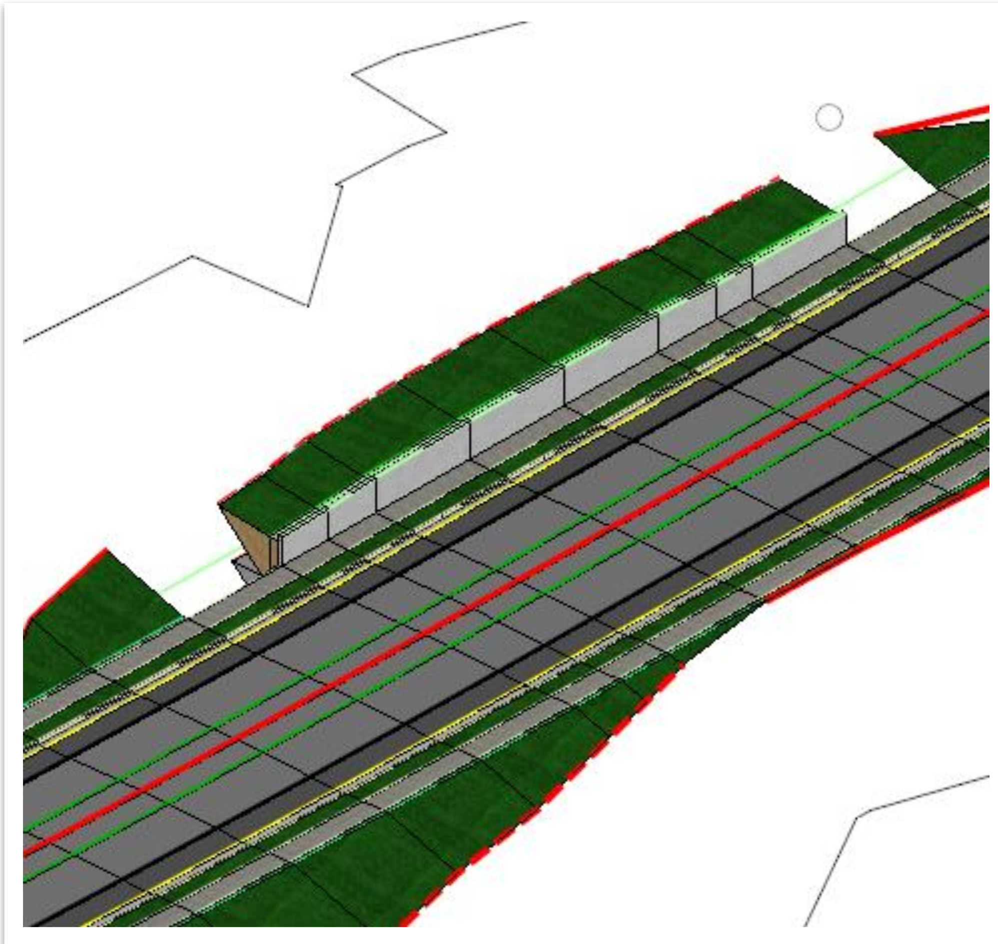
22. Go ahead and close the **Create Template** window. When asked to make changes to the ITL, click **Yes**. **Note:** This will save changes to the default TDOT ITL. It is recommended to delete these templates and any others saved during this training once completed with the manual. For an actual project, any ITL modifications should be saved within the applicable project workset.
23. Lastly, open the **Corridor Objects** tool (**OpenRoads Modeling >> Corridors >> Edit**).



24. Select the mainline corridor and within the **Template Drop** tab, change the template to the new template with the retaining wall.



25. Let the corridor process and then look for locations where retaining walls have now been automatically placed. If the retaining wall did not place correctly, delete the template, and replace with the new template created.



26. Notice that the corridor cannot transition between the cut of the end condition and the fill of the retaining wall before the next standard template drop. These conditions would have to be fixed using **Key Stations**. If this level of detail is not required in the 3D model, just update the plan view by drawing a line connecting the cut and fill lines using the **Prop End Condition - Fill Tie** feature definition (**Linear >> Roadway >> Grading and Ditches**).

Chapter 9. Bridges

Until TDOT Structures fully migrates to OpenBridge Modeler (OBM), there are bridge templates included in the TDOT ORD workspace (ITL) that will be utilized to fill the gap in the **ORD 3D** model, which will aide in the roadway and drainage design. Ultimately, structural bridge design will be done in OBM (which is compatible with ORD) and the **2D** detail sheets can be done in either OBM or ORD. This chapter will discuss how to use ORD 3D modeling tools to create an accurate bridge representation (roadway surface and bridge ends) to fill the gap.

9.1 Objectives

At the conclusion of this chapter, participants will be able to:

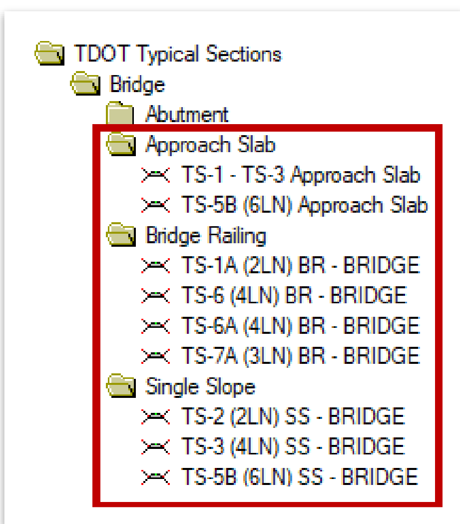
1. Create a bridge model control file.
2. Create a bridge model file.
3. Place and modify a bridge template drop.
4. Create an approach slab file.
5. Place and modify an approach slab template drop.
6. Place bridge ends.

9.2 Lecture: Bridge Modeling Overview

ORD does not contain the necessary tools to design the structural members of a bridge. Instead, **corridors** and **template drops** are used to approximately place the bridge deck and fill in the gap within the **3D** roadway model.

The TDOT workspace has **seven** pre-built **Bridge** templates within the template library (Figure 16). They are split into two folders based on the type of bridge barrier used:

FIGURE 16. BRIDGE TEMPLATES



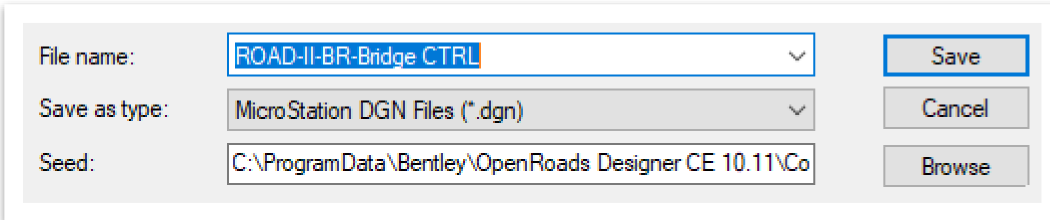
- **Bridge Railing:** Use the criteria set forth in TDOT standard drawing **STD-11-1** bridge rail and include sidewalks.
- **Single Slope:** Use the criteria set forth in TDOT standard drawing **STD-1-1SS** bridge rail and do not include sidewalks.

In addition to the Bridge templates, there are **two** pre-built **Approach Slab** templates within the template library (Figure 16). These will be used as a basis and should be modified to fit each model.

9.3 Exercise: Building Bridge Model Controls

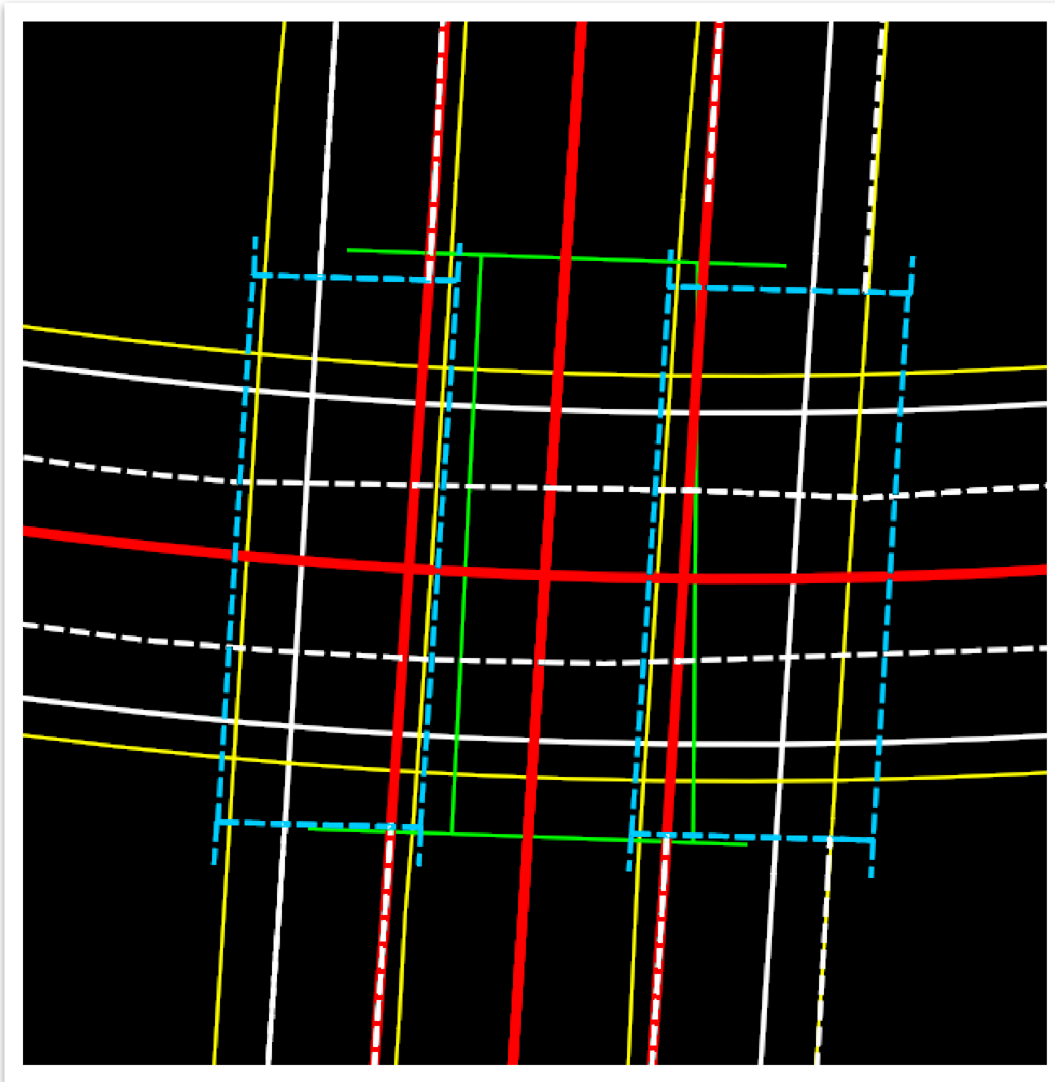
In this exercise, we will create the **controlling shapes** that will be necessary to clip both the bridge model and the approach slab model. This is most applicable when working with **skewed bridges**.

1. Create a new file and name it **ROAD-II-BR-Bridge CTRL**. Select the **TDOTSeed 2D.dgn** and click **Save**. **Note:** Save this file under the dgn Chapter 9 subfolder.

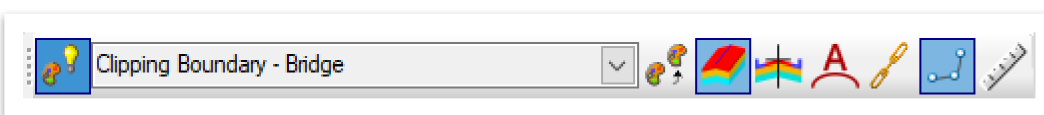


2. Make sure that the **Default** view is active in the lower left corner. Attach the following reference files using the **Coincident World** attachment method.
    - ROAD-II-BR-Alignments.dgn
    - ROAD-II-BR-Proposed.dgn
    - ROAD-II-BR-Survey.dgn
3. In the **ROAD-II-BR-Proposed.dgn** reference file, turn off all levels other than the following.
    - DESIGN - TRANSPORTATION - Edge of Traveled Way
    - DESIGN - TRANSPORTATION - Shoulder lines
4. In the **ROAD-II-BR-Survey.dgn** reference file, turn off all levels other than the following.
    - DESIGN - CENTERLINE - Proposed
    - SURVEY - DRAINAGE - Bridges
    - SURVEY - TRANSPORTATION – Roads
5. In the **ROAD-II-BR-Alignments.dgn** reference file, leave all levels on.

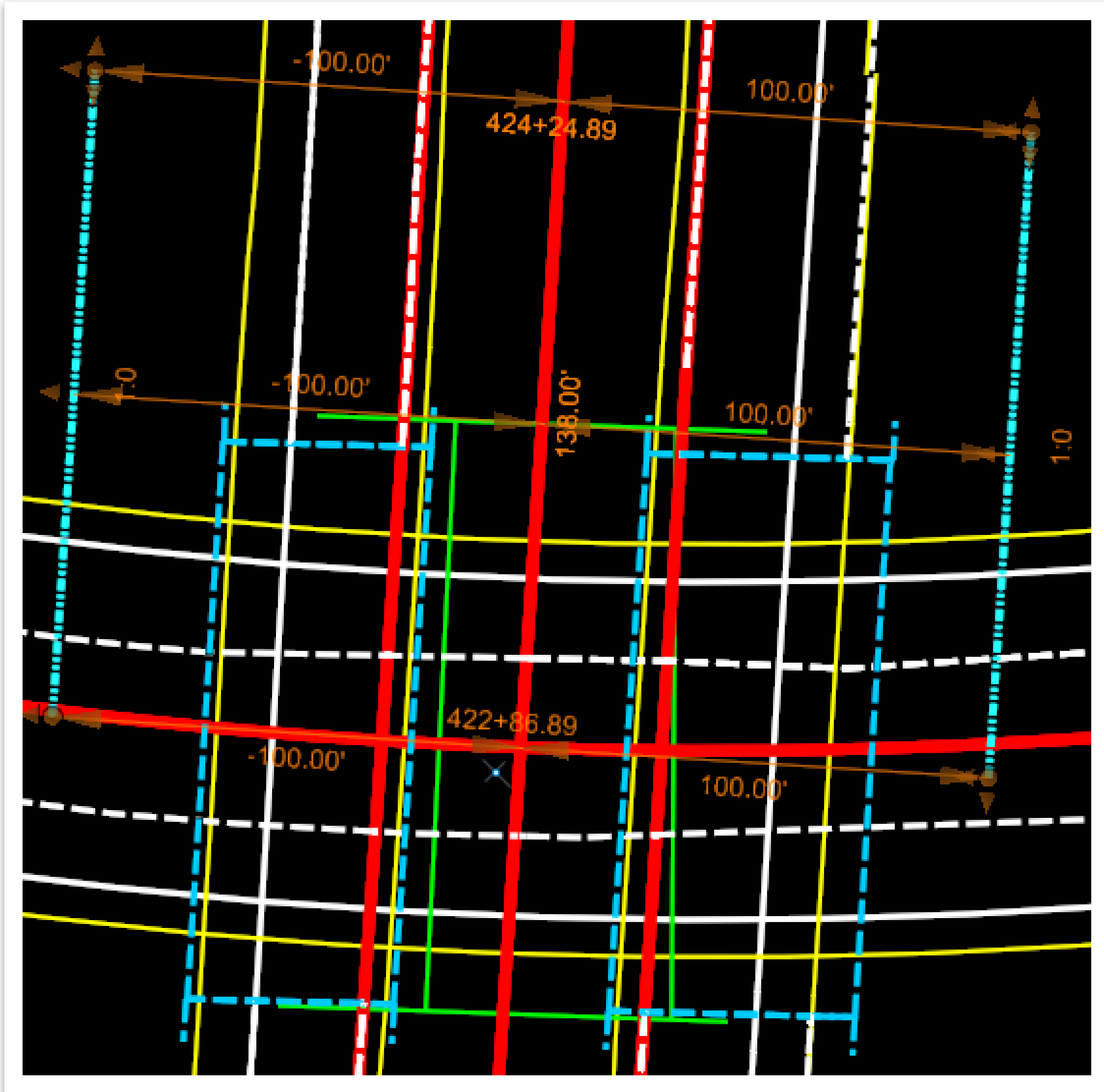
6. Locate the **bridge crossing** in the middle of the project. Notice that the existing bridge will be too small for the proposed **SR99**, resulting in the need for a new proposed bridge over the intersection. The existing bridge is **119** feet long, whereas the new bridge will be **274** feet long and will be slightly offset from the crossing feature centerline.



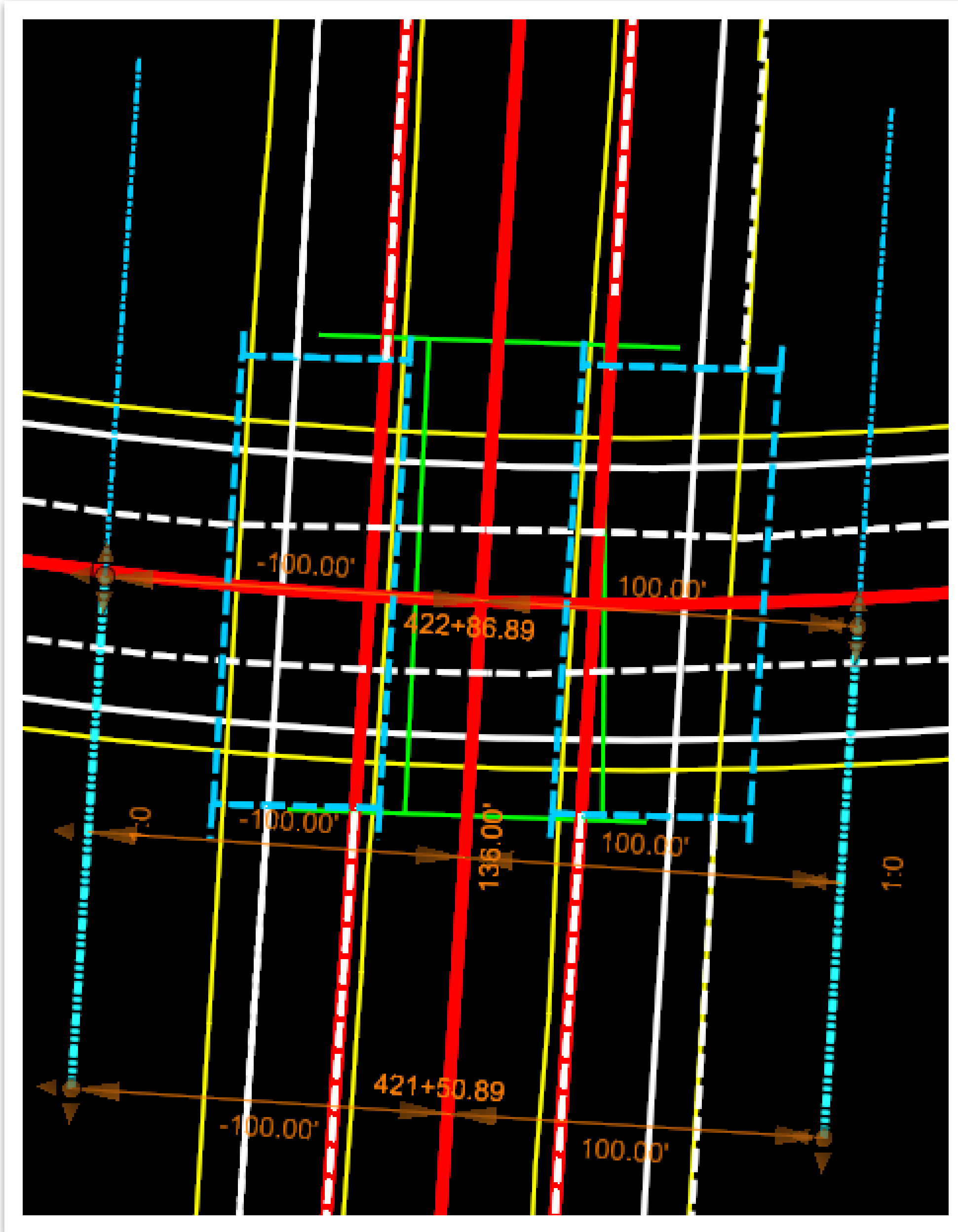
7. Select the **Clipping Boundary - Bridge** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Clipping**).



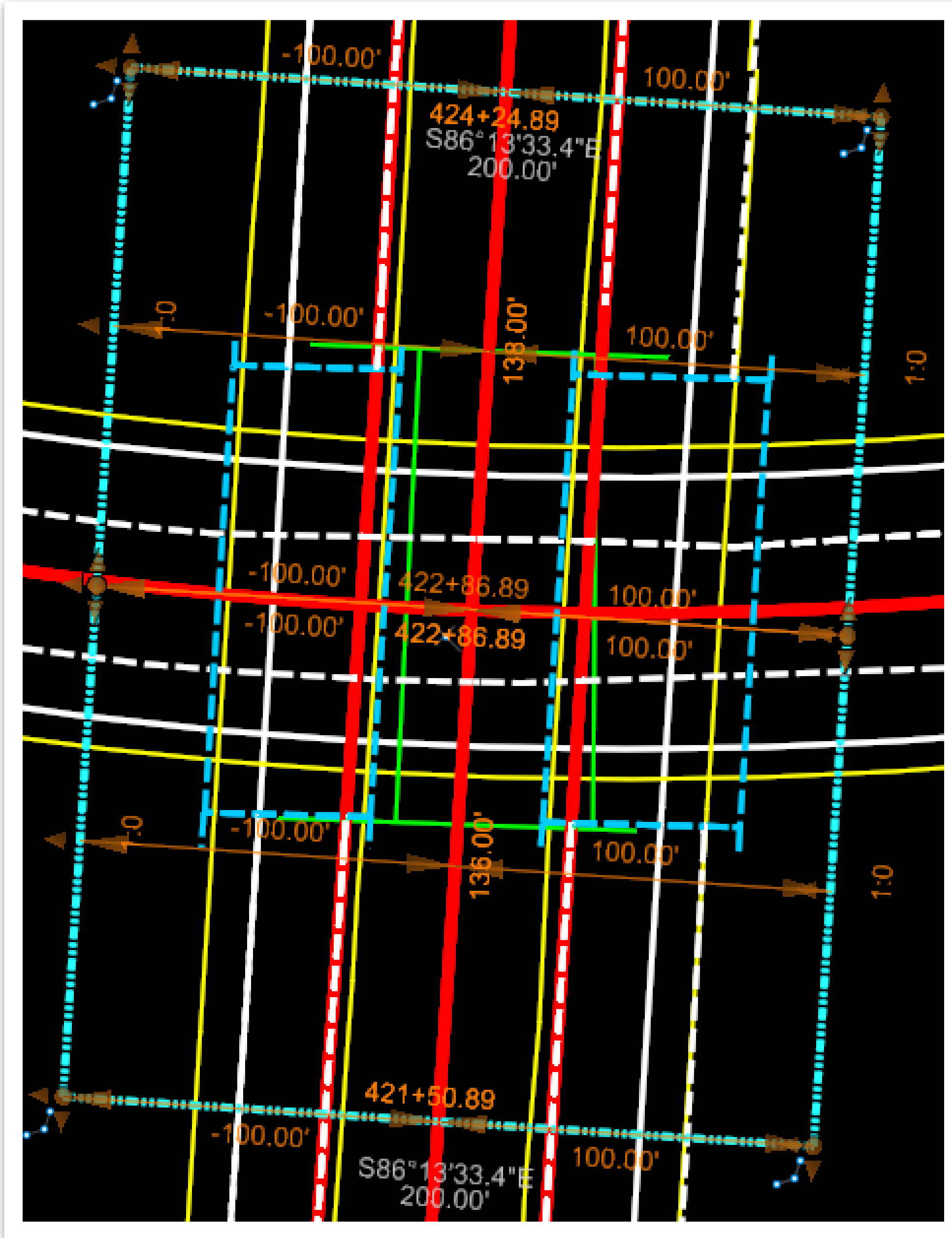
8. Next, open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the **I65** complex geometry alignment. Set the offset to **100** feet and the length to **138** feet. Mirror the offset and place the start at the intersection of the **I65** and **SR99** alignments and place **up station**. **Note:** Make sure the cursor is above the crossing centerline.



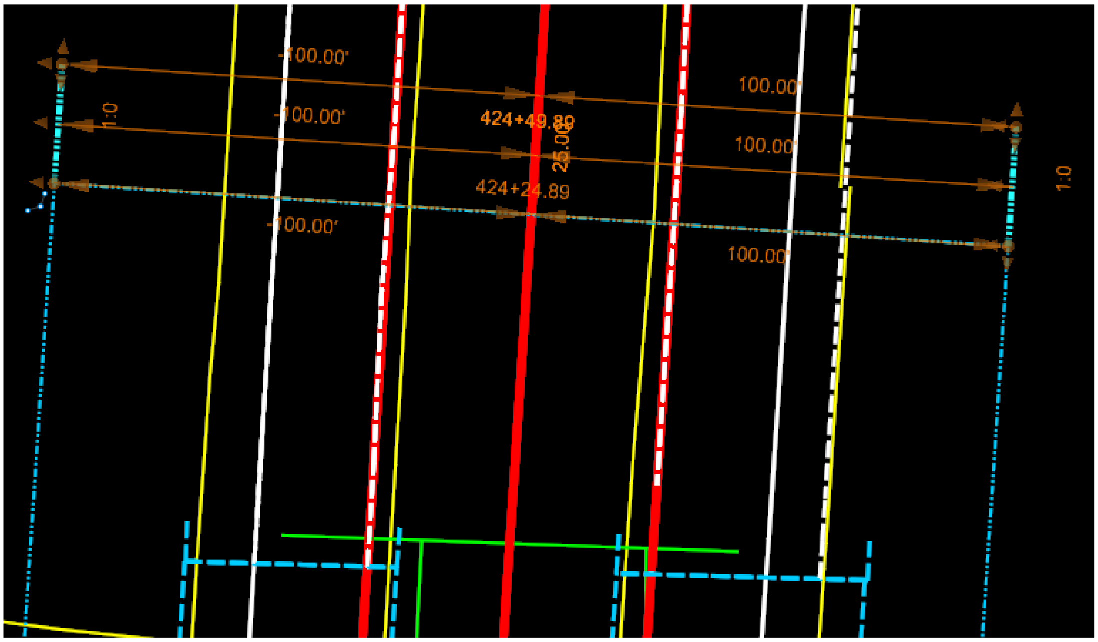
9. Repeat the previous step for the **down station** but make the length **136** feet. Place the start at the intersection of the **I65** and **SR99** alignments, and then make sure the cursor is below the crossing alignment to place the offset down station.



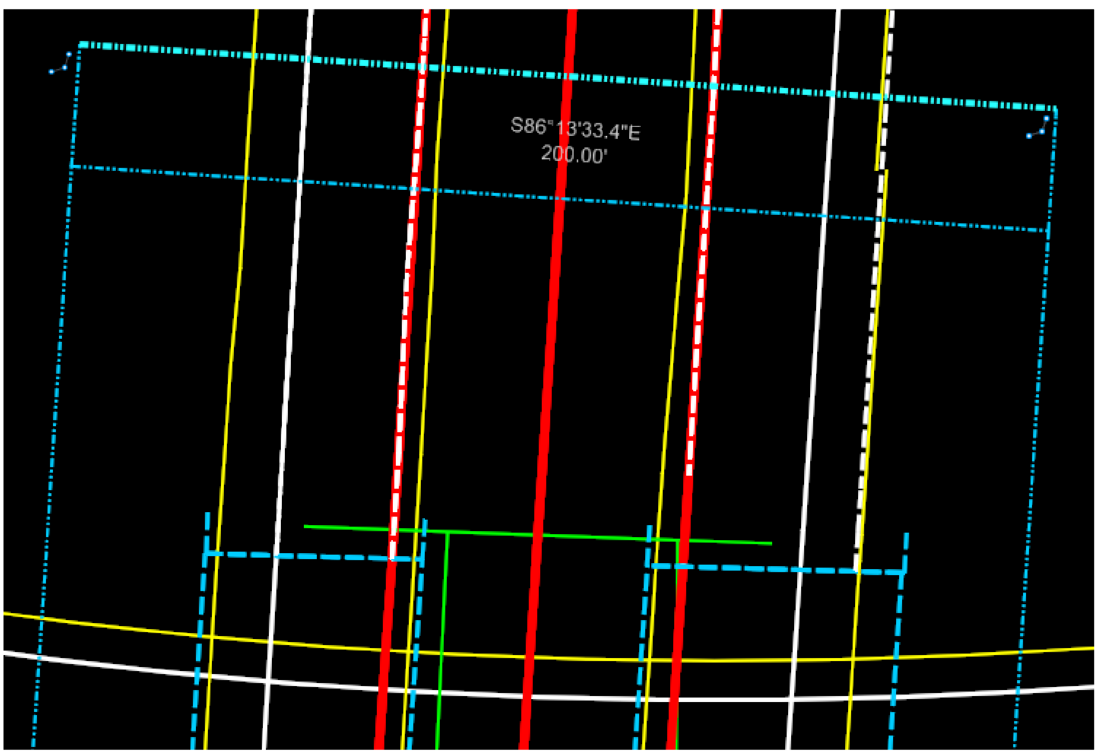
10. Now, open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and connect the offsets to close the bridge shape.



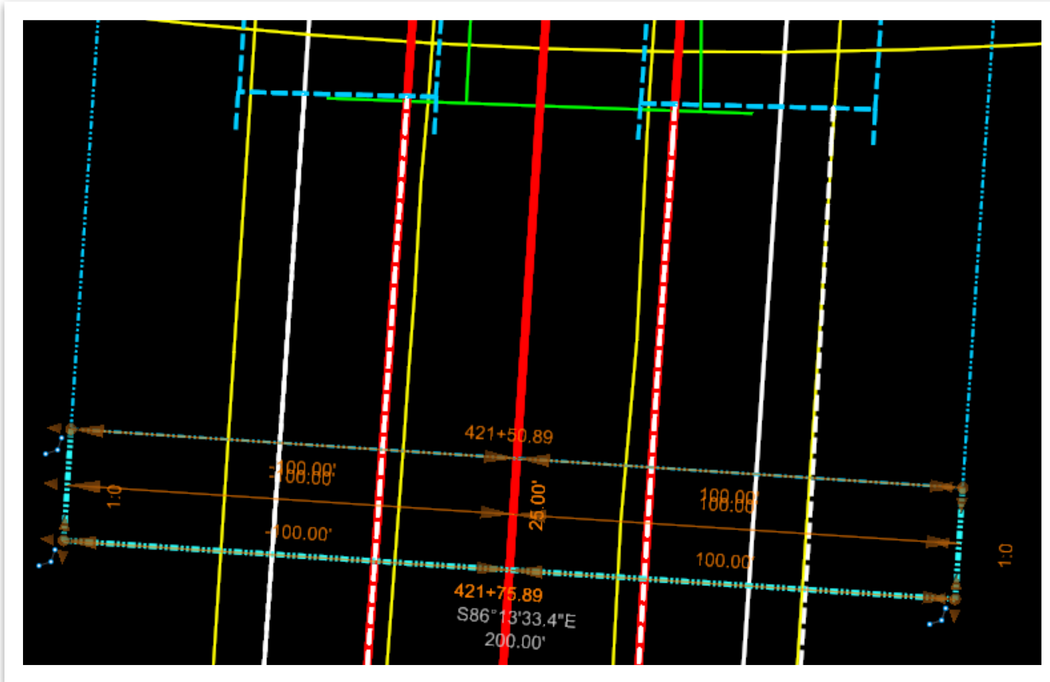
11. Next, we will create **four** more offsets. Select the **I65** centerline as the base and create a **25'** offset outward from the end of the last offsets.



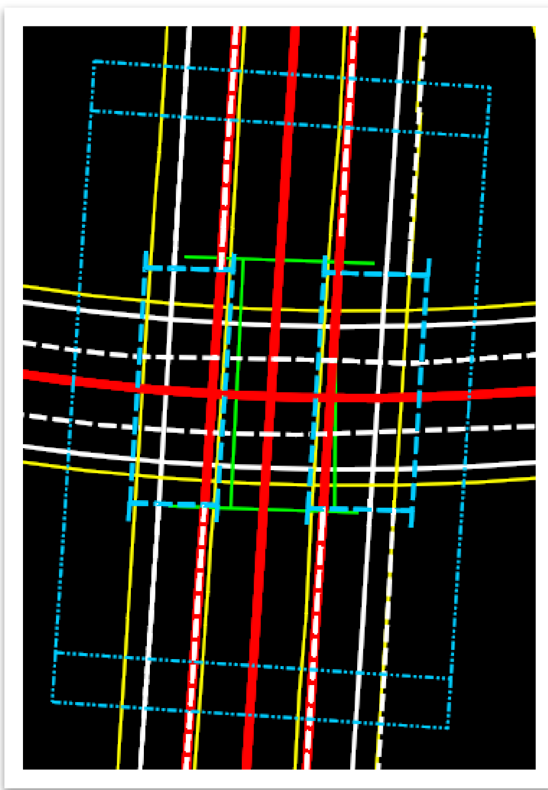
12. Then, open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and connect the two offsets.



13. Repeat this process for the other side of the bridge.



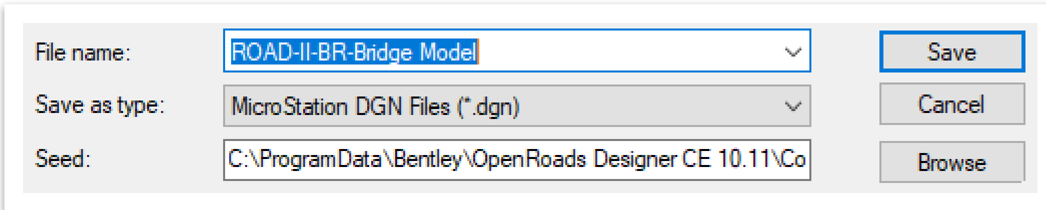
14. There should now be **three** shapes that are not complexed together: one bridge, one approach slab at the beginning of the bridge, and one approach slab at the end of the bridge. The additional **25** feet is for the approach slab template drop.



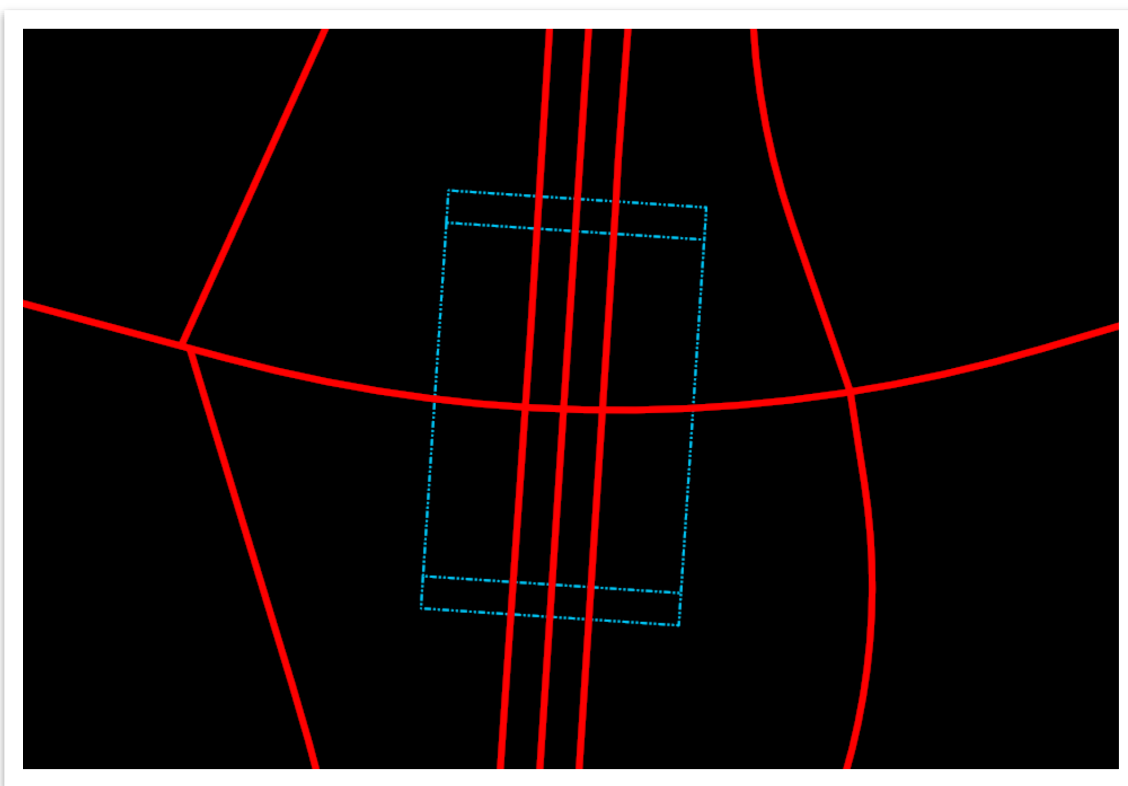
9.4 Exercise: Building a Bridge Model

In this exercise we will create a bridge model by editing an existing template in the ITL and placing it in a file.

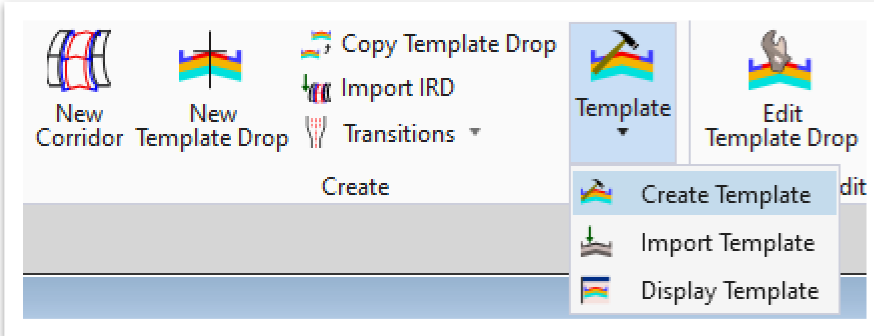
1. Create a new file and name it **ROAD-II-BR-Bridge Model**. Select the **TDOTSeed 2D.dgn** and click **Save**. **Note:** By default, it should save in your dgn Chapter 9 subfolder. <u>Also, a bridge model should always be built in a separate file</u>.



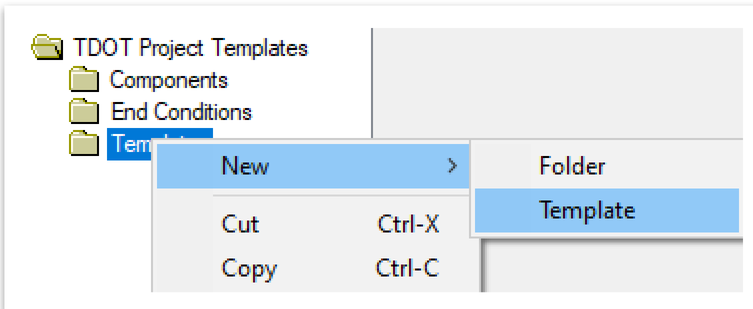
2. Make sure that the **Default** view is active in the lower left corner. Attach the following reference files using the **Coincident World** attachment method.
   - ROAD-II-BR-Alignments.dgn
   - ROAD-II-BR-Bridge CTRL.dgn (created in the previous exercise)
   - ROAD-II-BR-Terrain.dgn
3. Go ahead and turn off the **triangles** for both the **2D** and **3D** models, if not already off. Locate the bridge model **control shapes** within the model.



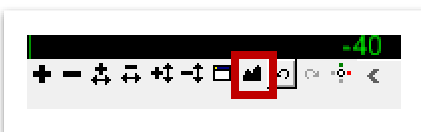
4. Next, open the **Create Template** tool (**OpenRoads Modeling >> Corridors >> Create >> Template**).



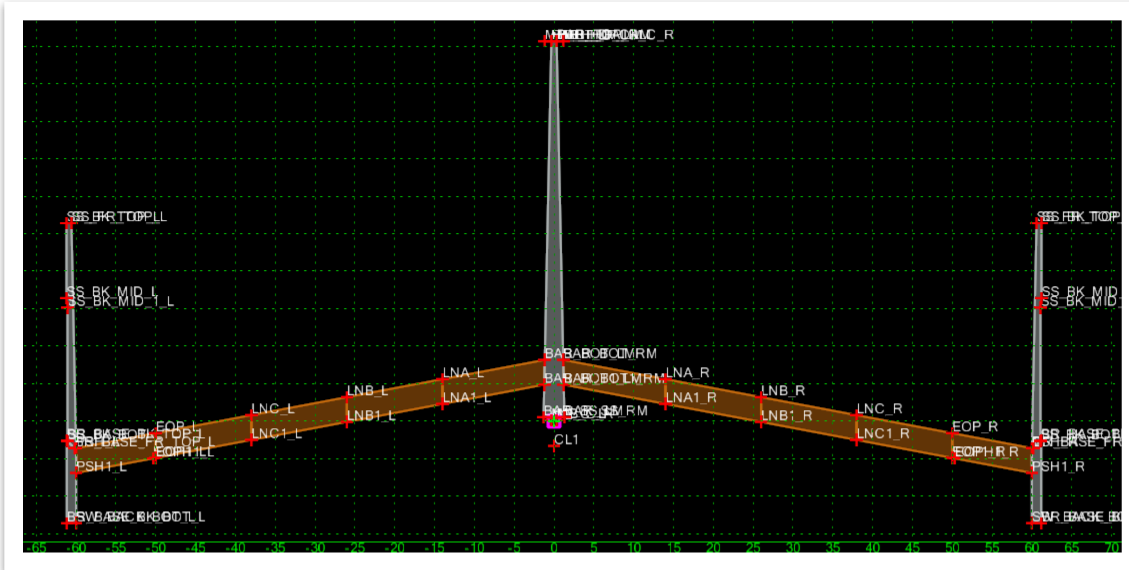
5. Under the **TDOT Project Templates** folder, **right** click on the **Templates** subfolder and select **New >> Template**. Name the new template **TS-5B (4LN) SS - BRIDGE**.



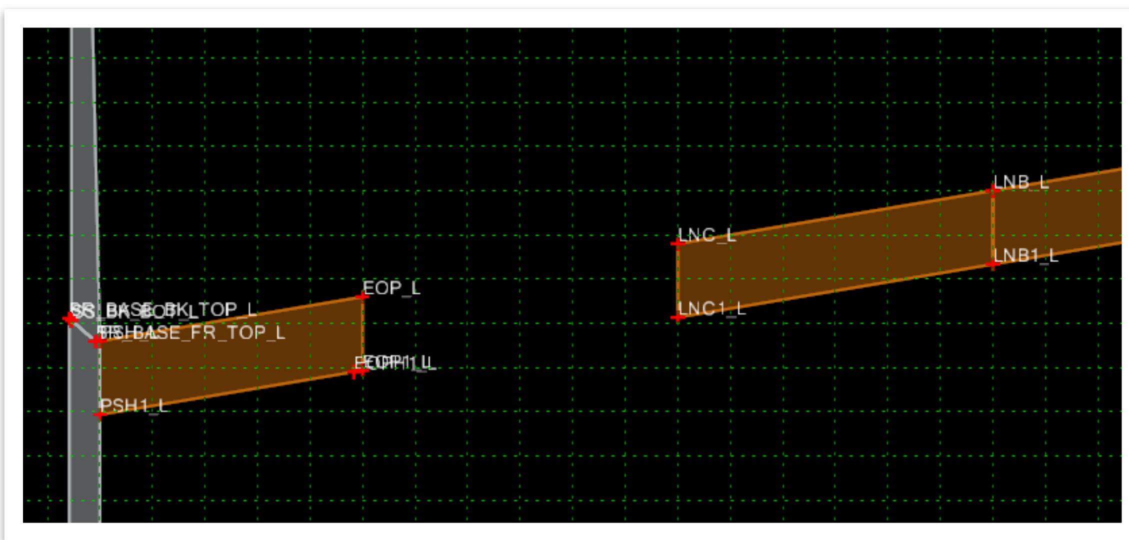
6. An empty template should now appear. Scroll up and select the **TS-5B (6LN) SS - Bridge** template (**Linear Templates >> TDOT Typical Sections >> Bridge >> Single Slope**). Click on the template once so that the preview shows up in the bottom left corner.
7. Now, **left** click and hold in the bottom preview window and drag the template over into the empty template area. Click **View Extent** to see the full template.



8. **Right** click on the **green CL** point within the **Create Template** window and select **Change Template Origin**.

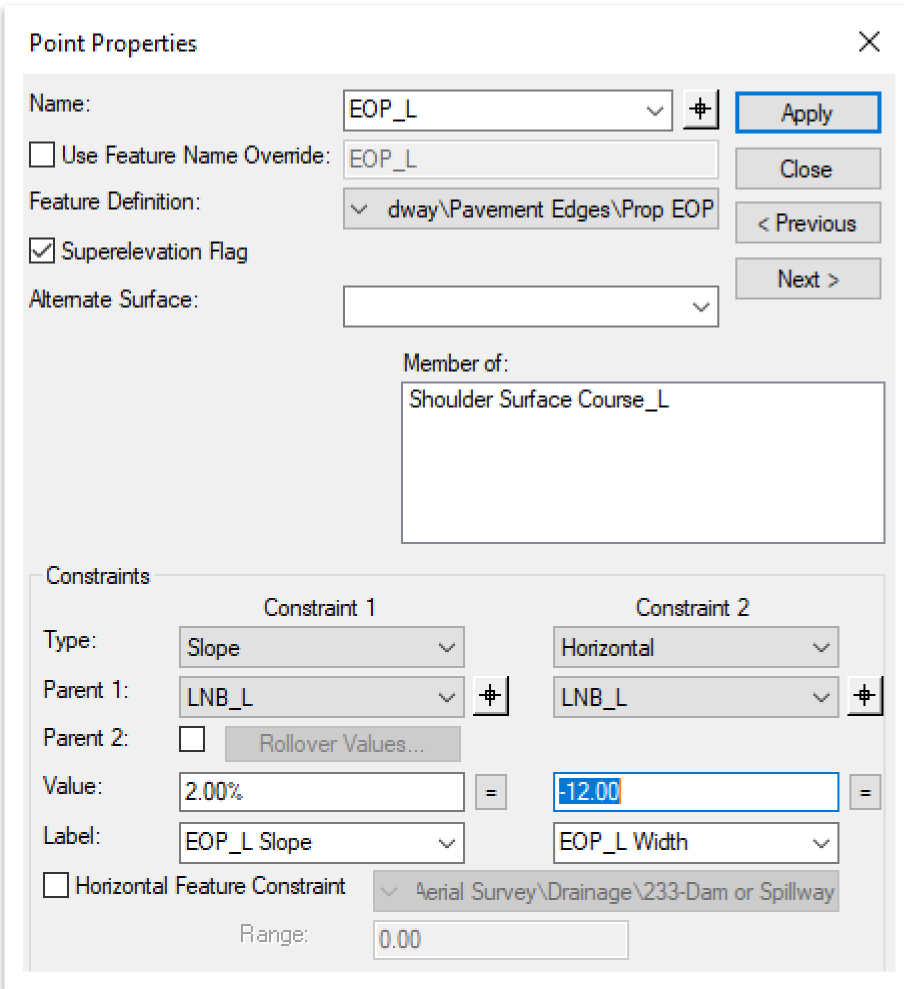


9. **Right** click in space and select **Delete Components**. Then, click and drag to draw through the components that need to be deleted. In this exercise, delete the components linking the **EOP** and **LNC** on <u>both</u> sides of the template.

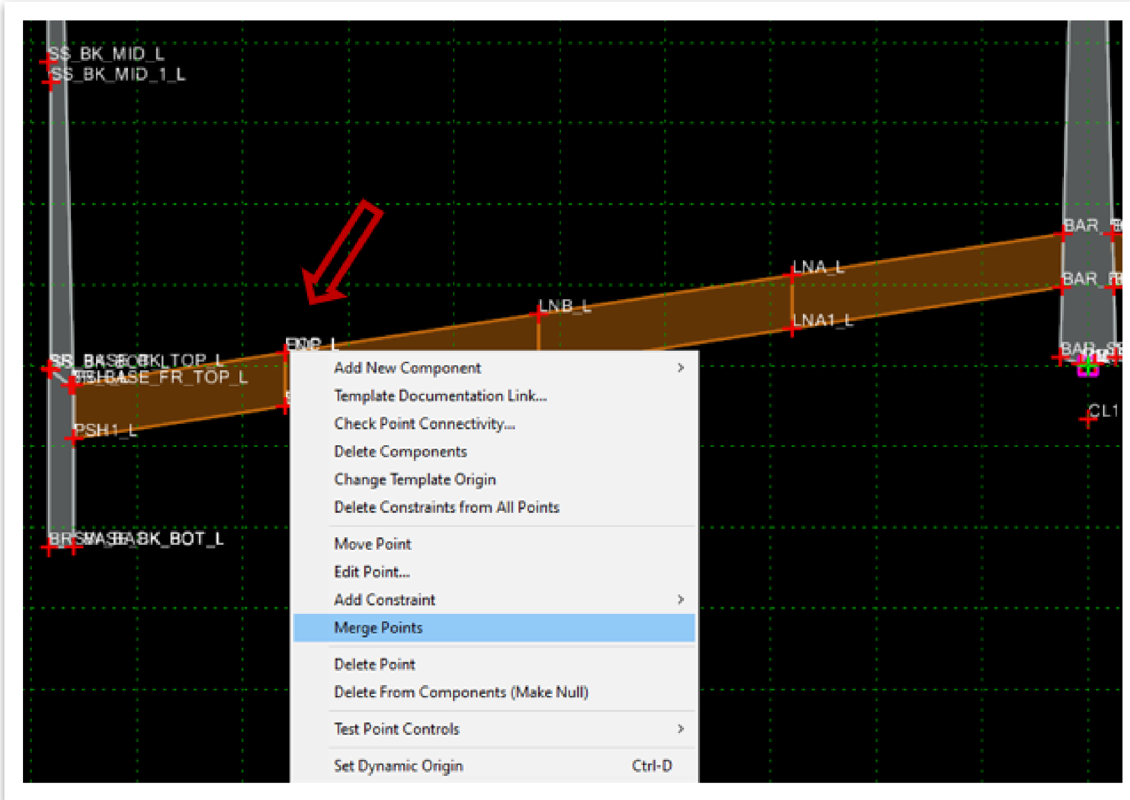


10. Go ahead and delete the **EOPH1_L** and **EOPH1_R** points from the template by right clicking on the point and selecting **Delete Point**.

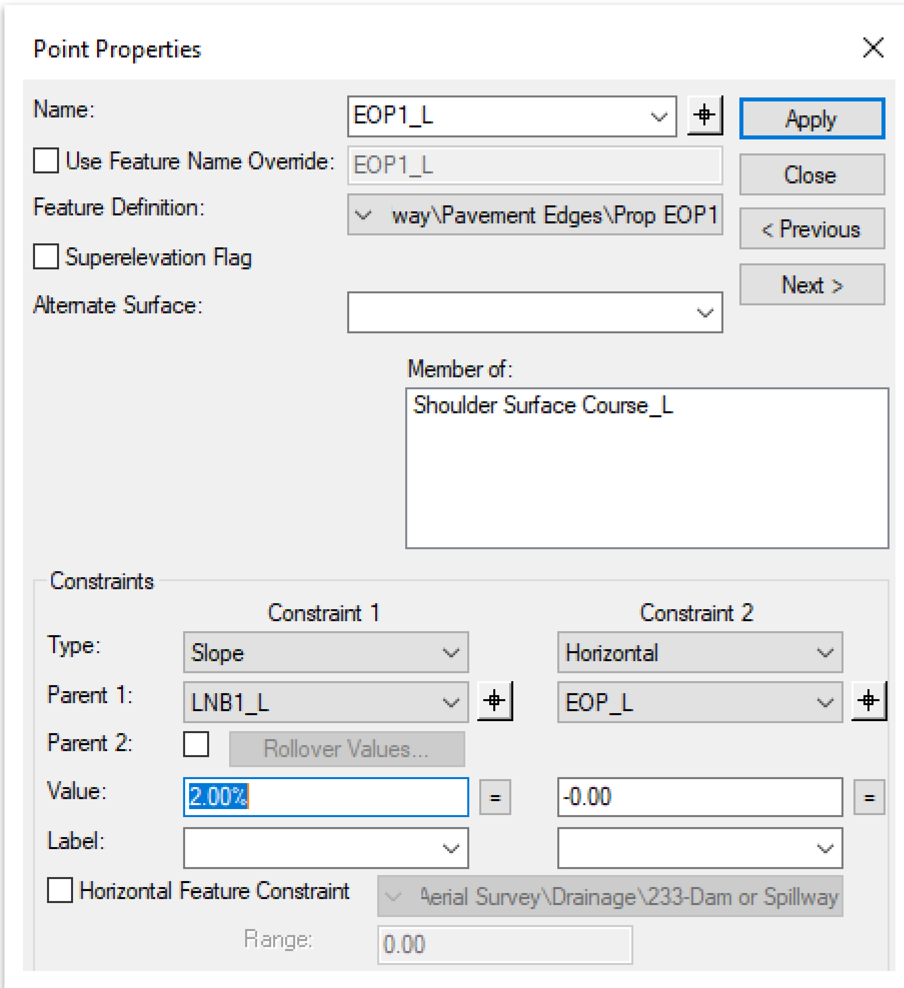
11. Next, open the **Point Properties** for **EOP_L** and update the following **Constraint** settings. Then click **Apply** and **Close**.
    a. **Constraint 1 (Parent 1):** LNB_L
    b. **Constraint 1 (Value):** 2.00%
    c. **Constraint 2 (Parent 1):** LNB_L
    d. **Constraint 2 (Value):** -12.00



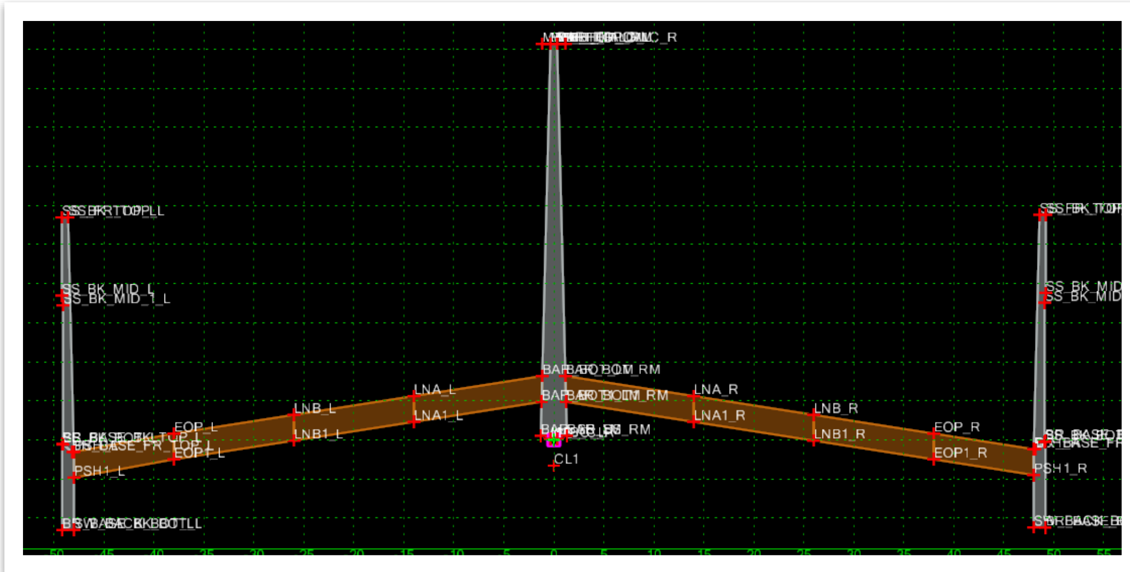
12. **Right** click on **EOP_L** and select **Merge Points**. Select **LNC_L** as the point to delete.



13. Now, open the **Point Properties** for **EOP1_L** and update the following **Constraint 1** settings. Then click **Apply** and **Close**.
    a. **Constraint 1 (Type):** Slope
    b. **Constraint 1 (Parent 1):** LNB1_L
    c. **Constraint 1 (Value):** 2.00%

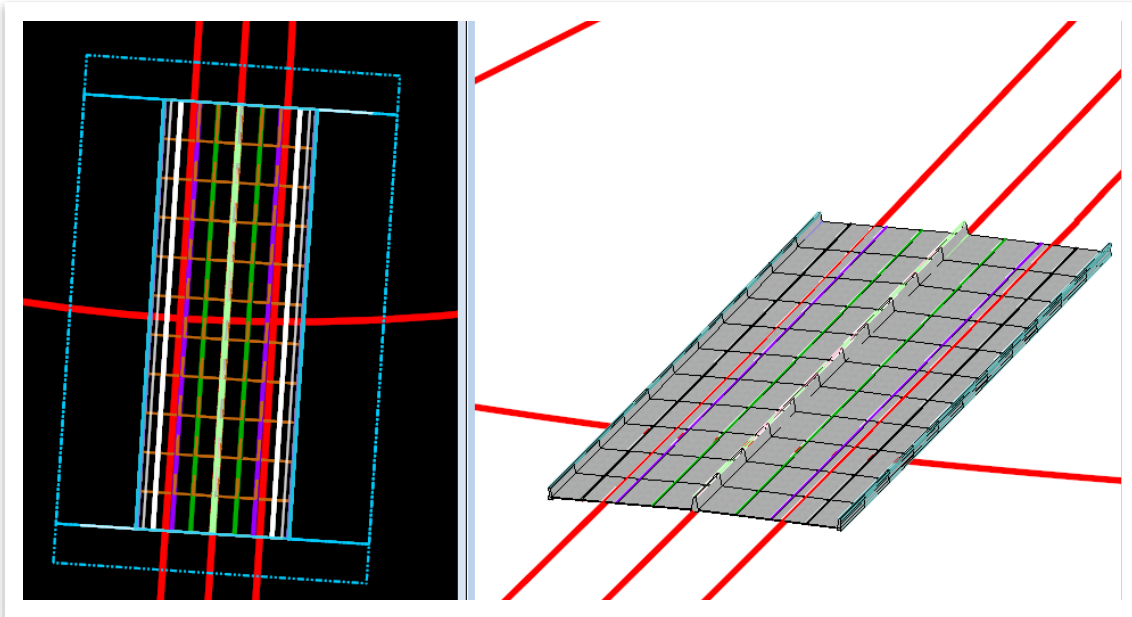


14. **Right** click on **EOP1_L** and select **Merge Points**. Select **LNC1_L** as the point to delete.
15. Repeat steps 11-14 for the right side of the template. Update the **EOP_R** point's **Horizontal Constraint** to positive **12.00** and the **Slope** to **-2.00%**. Once completed, the template is now ready to be placed.



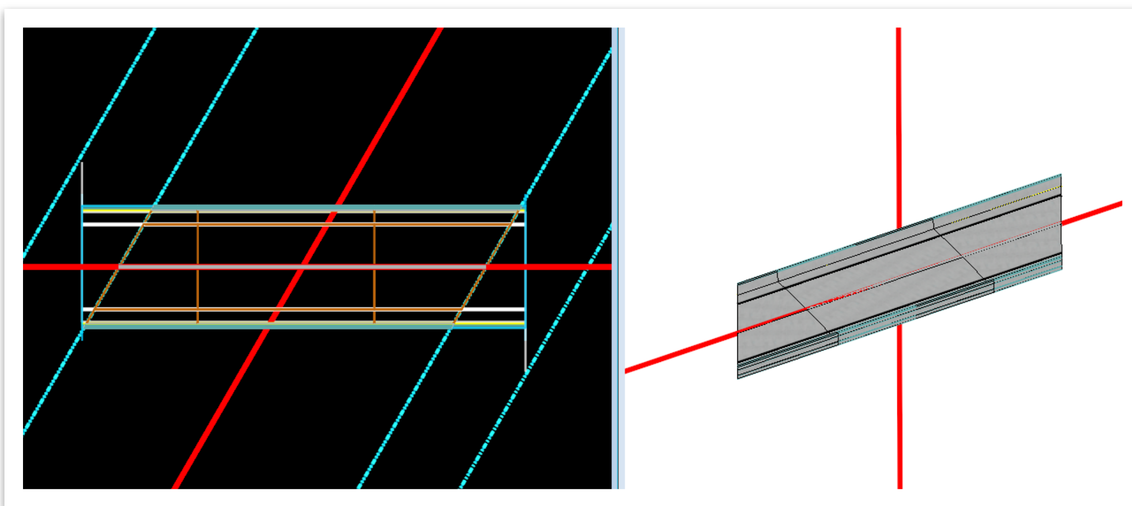
16. Click **File >> Save As** and name this ITL **Civil Templates-TDOT I65SR99 Bridge**. The file should automatically save to the workset folder structure by default (**C:\ProgramData\Bentley\OpenRoads Designer CE 10.11\Configuration\WorkSpaces\TDOT_Standards\WorkSets\123456.00_INITIALS\Standards\Template Library**). Then, close the **Create Template** window.

17. Lastly, open the **New Corridor** tool (**OpenRoads Modeling >> Corridors >> Create**) and select the middle centerline (**I65**). **Right** click for the active profile and **left** click for the name of the corridor. Select the **TS-5B (4LN) SS - BRIDGE** template that was just created (**TDOT Project Templates >> Templates**). Place the start and end of the template at the extents of the blue dashed bridge control shape (do not include bridge ends).



Take Note!

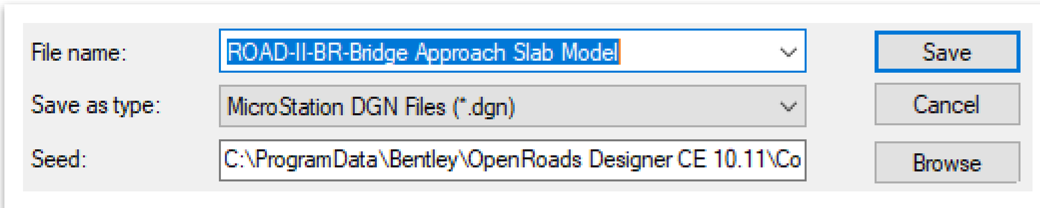
If the bridge is skewed, the template drops must extend beyond the long end of the skewed end of the bridge line, as shown below.



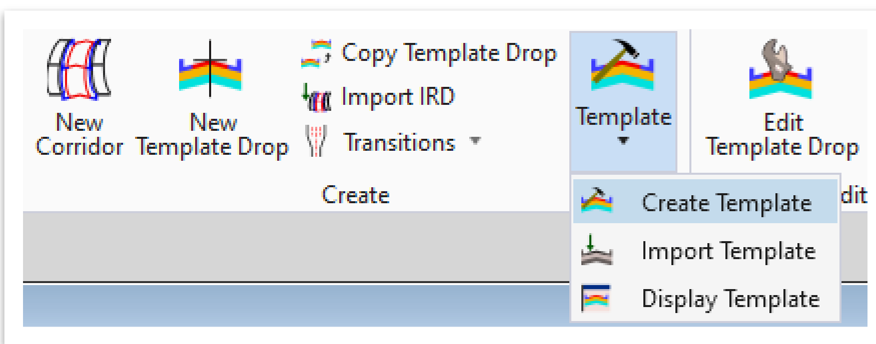
9.5 Exercise: Building an Approach Slab Model

In this exercise, we will create an approach slab model by editing a template within the ITL and placing it in a file.

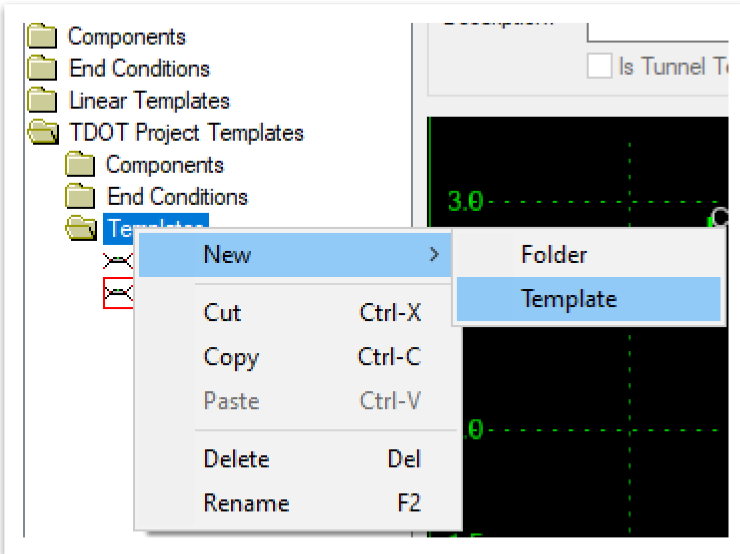
1. Create a new file and name it **ROAD-II-BR-Bridge Approach Slab Model**. Select the **TDOTSeed2D.dgn** and click **Save**. **Note:** By default, it should save in your dgn Chapter 9 subfolder.



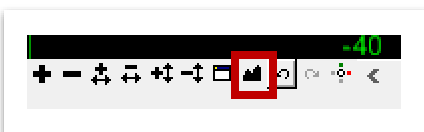
2. Make sure that the **Default** view is active in the lower left corner. Attach the following reference files using the **Coincident World** attachment method.
    a. ROAD-II-BR-Alignments
    b. ROAD-II-BR-Bridge CTRL
    c. ROAD-II-BR-Bridge Model (created in the previous exercise)
    d. ROAD-II-BR-Terrain
3. Go ahead and turn off the **triangles** for both the **2D** and **3D** models, if not already off. Open the **Create Template** tool (**OpenRoads Modeling >> Corridors >> Create >> Template**).



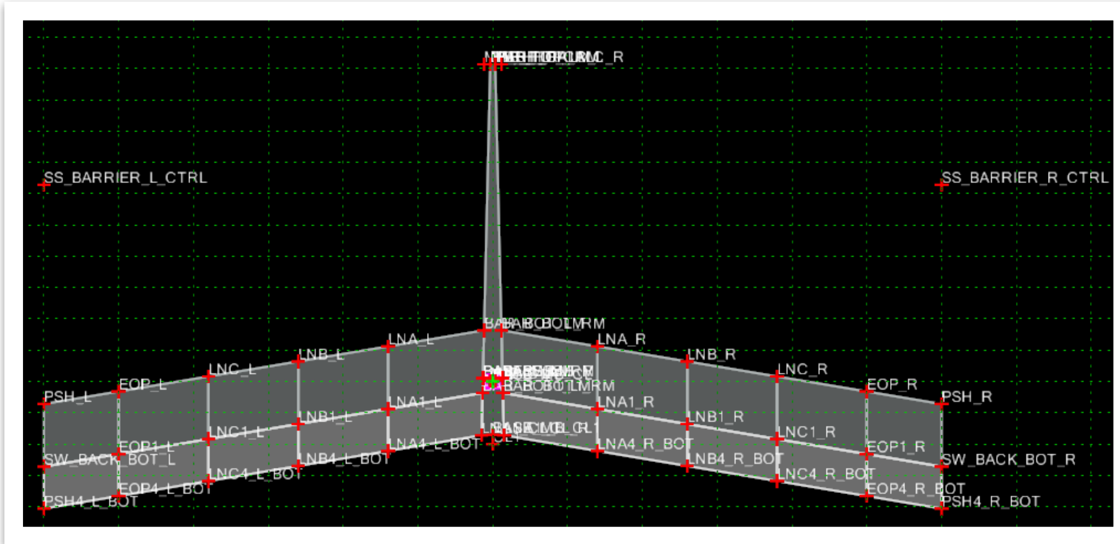
4. Click **File >> Open** and select the **Civil Templates-TDOT I65SR99 Bridge** ITL saved from the previous exercise (**C:\ProgramData\Bentley\OpenRoads Designer CE 10.11\Configuration\ WorkSpaces\TDOT_Standards\WorkSets\ 123456.00_INITIALS\Standards\ Template Library**).
5. We will now create a new template. Under the **TDOT Project Templates** folder, **right** click on the **Templates** subfolder and select **New >> Template**. Name the new template **TS-5 (4LN) Approach Slab**.



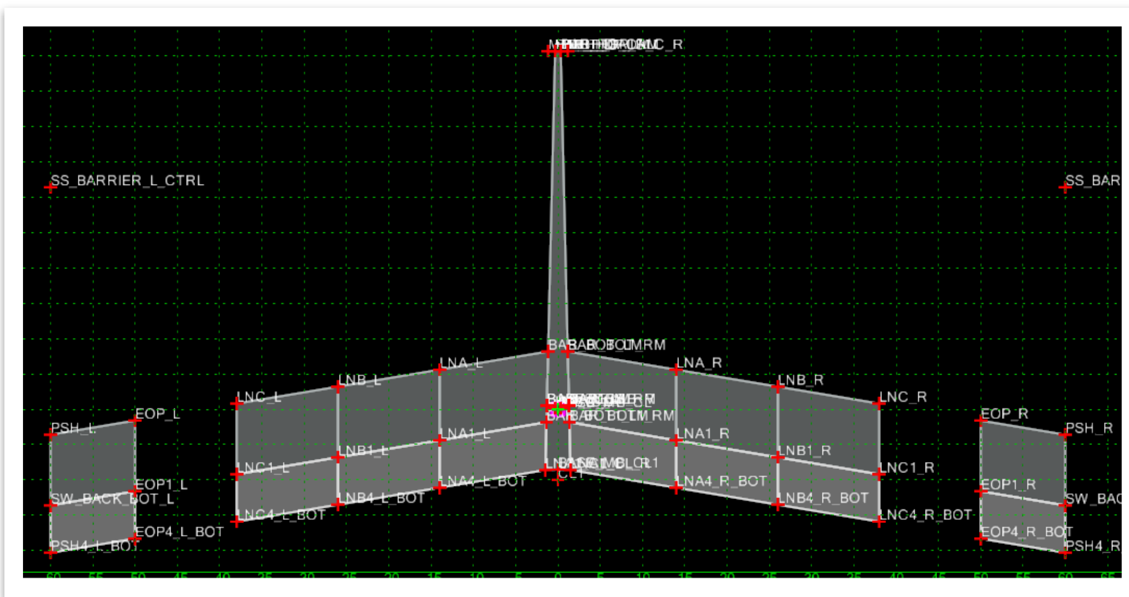
6. An empty template should now appear. Scroll up and select the **TS-5B (6LN) Approach Slab** template (**Linear Templates >> TDOT Typical Sections >> Bridge >> Approach Slab**). Click on the template once so that the preview shows up in the bottom left corner.
7. Next, **left** click and hold in the bottom preview window and drag the template over into the empty template. Click **View Extent** to see the full template.



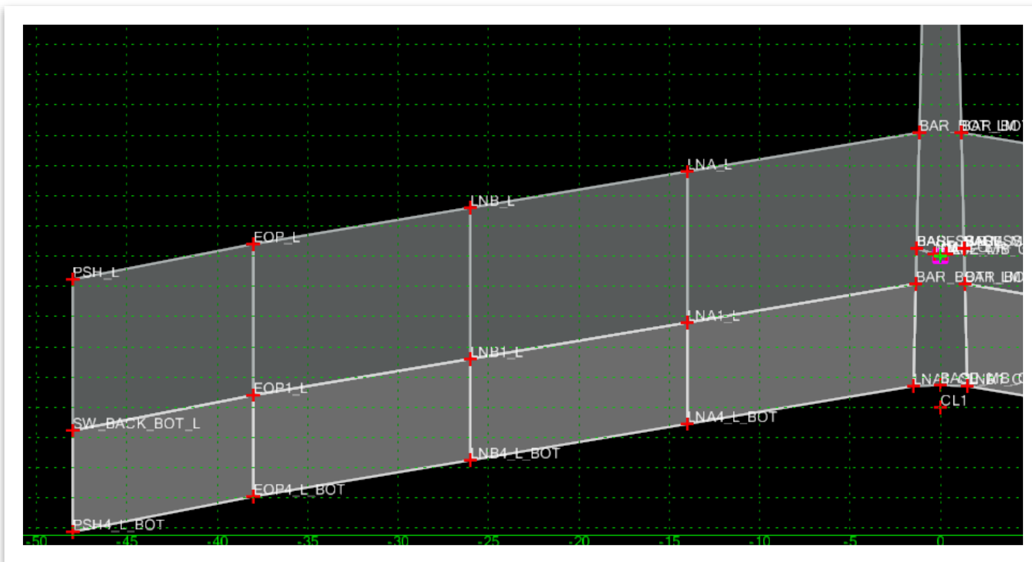
8. **Right** click within the **Create Template** window and select **Change Template Origin**. Then, select the green **BASE_MB_CL** point.



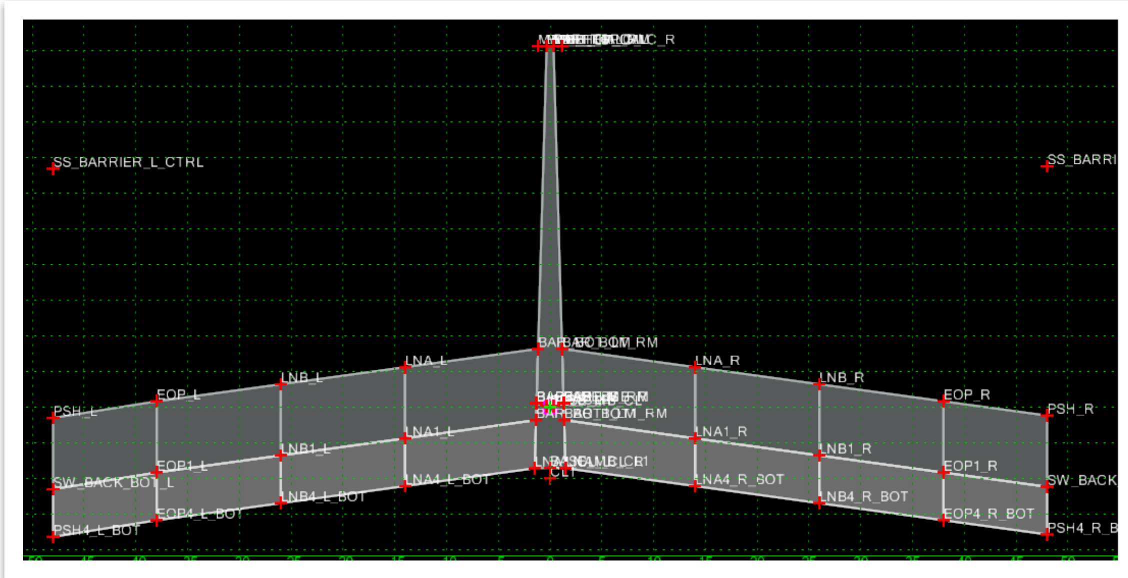
9. **Right** click in space and select **Delete Components**. Then, click and drag to draw through the components that need to be deleted. In this exercise, delete the components in between the **EOP** and **LNC** on <u>both</u> sides of the template.



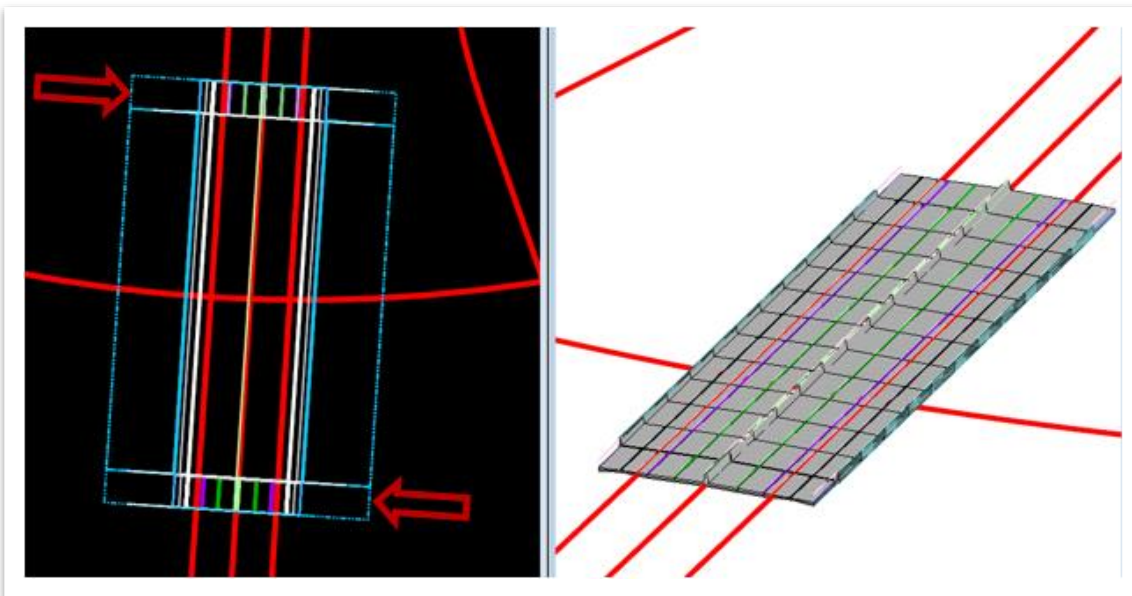
10. Next, open the **Point Properties** for **EOP_L** and update the following **Constraint** settings like we did for the Bridge Model. Then click **Apply** and **Close**.
    a. **Constraint 1 (Parent 1):** LNB_L
    b. **Constraint 1 (Value):** 2.00%
    c. **Constraint 2 (Parent 1):** LNB_L
    d. **Constraint 2 (Value):** -12.00
11. **Right** click on **EOP_L** and select **Merge Points**. Select **LNC_L** as the point to delete. Go ahead and update the following **Constraint** settings for **EOP1_L**, as listed below, and then repeat the same **Merge Points** procedure for the **EOP1_L** and **EOP4_L_BOT** points.
    a. **Constraint 1 (Type):** Slope
    b. **Constraint 1 (Parent 1):** LNB1_L
    c. **Constraint 1 (Value):** 2.00%



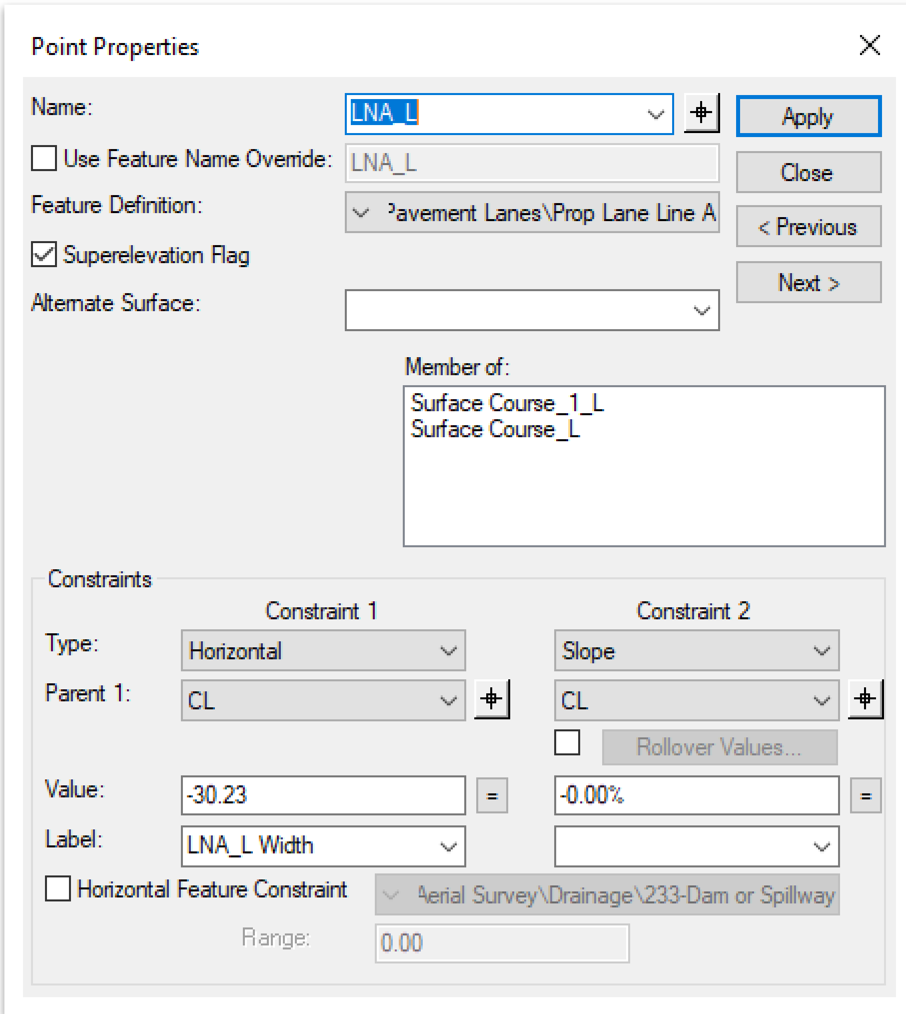
12. Repeat steps 10-11 for the right side of the template. Update the **EOP_R** point's **Horizontal Constraint** to positive **12.00** and the **Slope** to **-2.00%**, if needed. Once completed, the template is now ready to be placed.



13. Click **File >> Save** and then close the **Create Template** window. Next, open the **New Corridor** tool (**OpenRoads Modeling >> Corridors >> Create**) and select the middle centerline (**I65**). **Right** click for the active profile and then drop the template that was just created. The start and end locations at each end of the bridge are indicated below (approach slab control lines). You will have <u>two</u> template drops: Stations **421+25.89 – 421+50.89** and **424+24.89 – 424+49.89**.

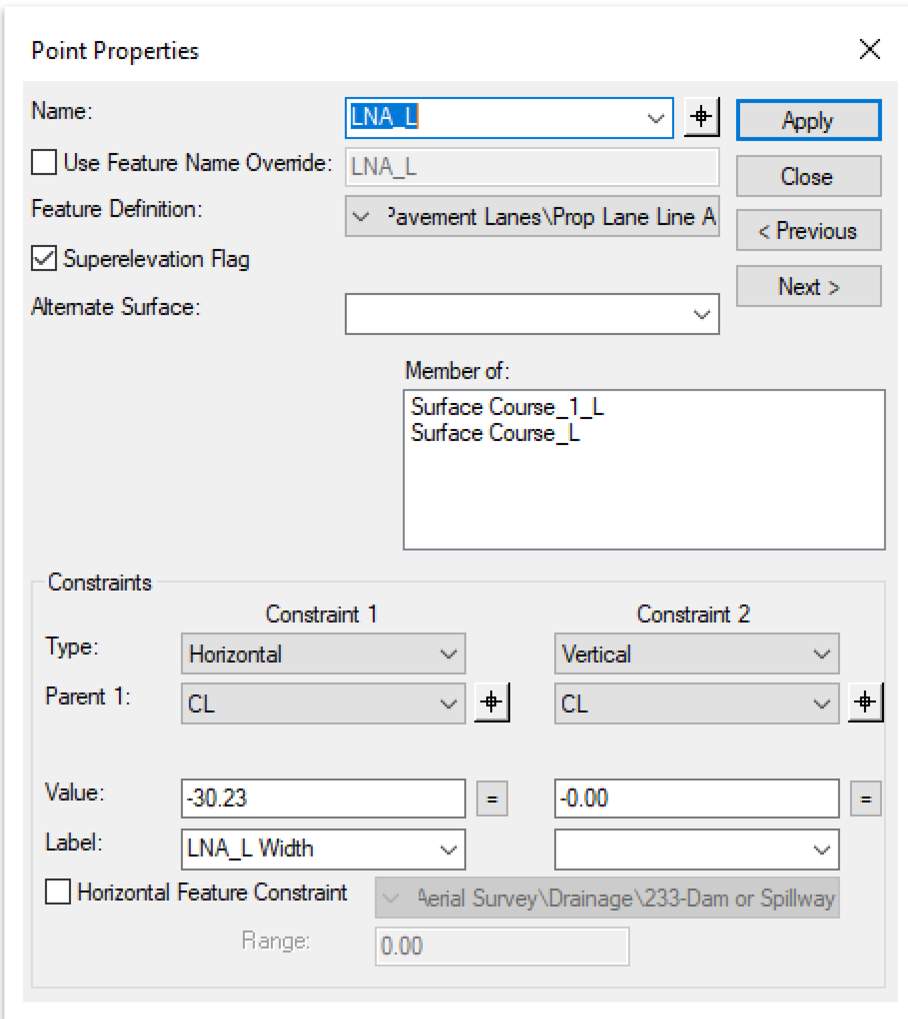


14. Now, attach the **ROAD-II-BR-I65 Corridor.dgn** reference file using the **Coincident World** attachment method. Notice how the bridge and approach slab do not line up with the roadway.
15. Open back up the **ROAD-II-BR-Bridge Model.dgn** file. Change to the **Multi-Model Views** view in the lower left corner so that the 2D and 3D models are visible. Open the **Create template** tool (**OpenRoads Modeling >> Corridors >> Create**) and open the bridge template. Open the **LNA_L** point properties and change the **Horizontal Constraint** to **-30.23** and the **Slope Constraint** to **0.00%**. Then click **Apply** and **Close**.



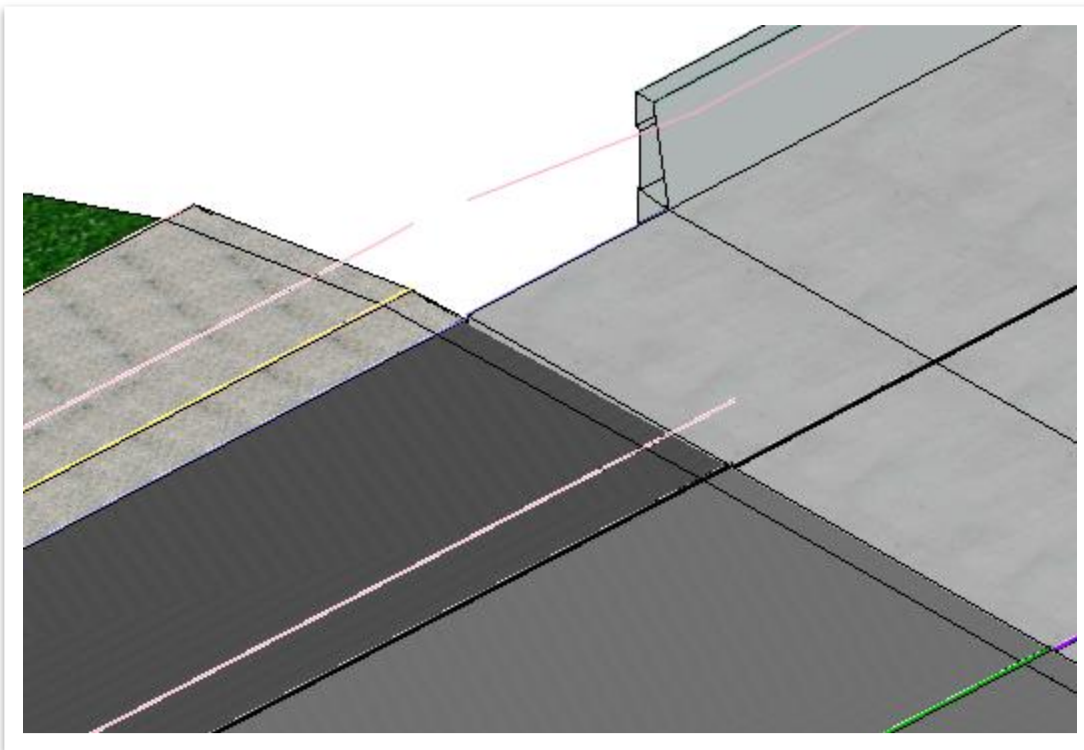
16. Repeat the previous step for **LNB_L** and change the **Horizontal Constraint** to **-42.23** and check that the **Slope Constraint** is set to **2.00%**. Then click **Apply** and **Close**.
17. Repeat the previous two steps for the **right** side of the bridge. The horizontal constraints will be (**+**) and the slope constraints will be (**-**). **Apply** and **Close** each change.

18. Once completed, **Close** and **Save** the template editor. Open the **Synchronize Template** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous**) and then select the bridge corridor. Then, open back up the **ROAD-II-BR-Bridge Approach Slab Model.dgn** file. The approach slab model must be edited to match the constraints of the bridge. Within the file, open the **Create Template** tool (**Open Roads Modeling >> Corridors >> Create >> Template**).
19. Next, open the **LNA_L** point properties and change the **Horizontal Constraint** to **-30.23** and the **Slope Constraint** to **0.00%**. Then click **Apply** and **Close**. **Note:** These point constraint changes will not look correct until after changing the constraints on point **LNB_L** in the next step.



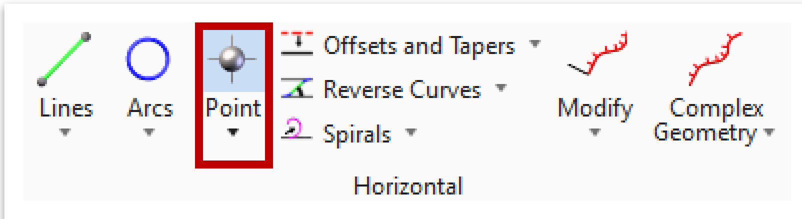
20. Repeat the previous step for **LNB_L** and change the **Horizontal Constraint** to **-42.23** and check the **Slope Constraint** is set to **2.00%**. Then click **Apply** and **Close**.
21. Repeat the previous step for the **right** side of the approach slab. The horizontal constraints will be (**+**) and the slope constraints will be (**-**). **Apply** and **Close** each change.

22. Go ahead and close and **save** the template editor. Open the **Synchronize Template** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous**) and then select the approach slab corridor. **Note:** The bridge alignments still do not line up exactly, as the inside lane will need to be point controlled to follow the **PGL** line like the mainline does. For this exercise, we will not set a point control.
23. We will now create a parametric constraint at the southwest corner of the bridge starting at the beginning of the bridge and ending **7** feet before the beginning of the bridge approach slab. The constraint will run for a total of **18** feet. Open the **Create Parametric Constraint** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and select the bridge approach model corridor. Set the **Start** and **Stop Stations** to **421+32.89** and **421+50.89**, and then select the **LEFT_BARRIER_ CTRL** constraint and make the start and stop value **1.00**. The bridge end will be placed within the remaining 7 feet between the start of the concrete barrier and the start of the bridge approach slab in the upcoming steps. **Note:** If this was a **Bridge Rail** bridge, the distance would be **6** feet.

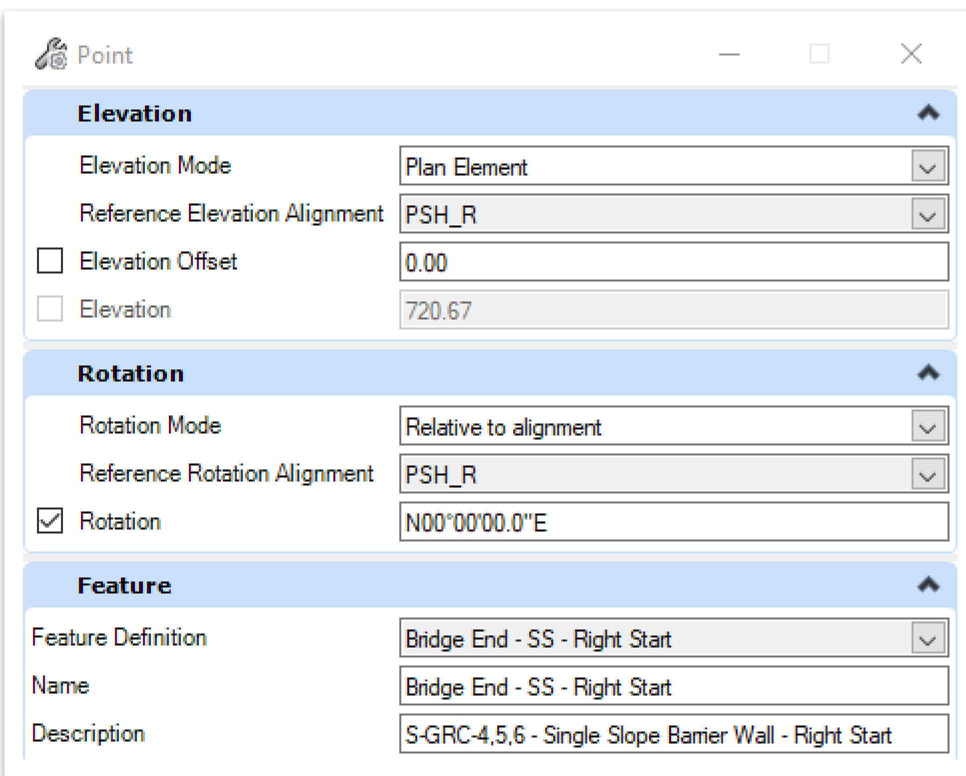


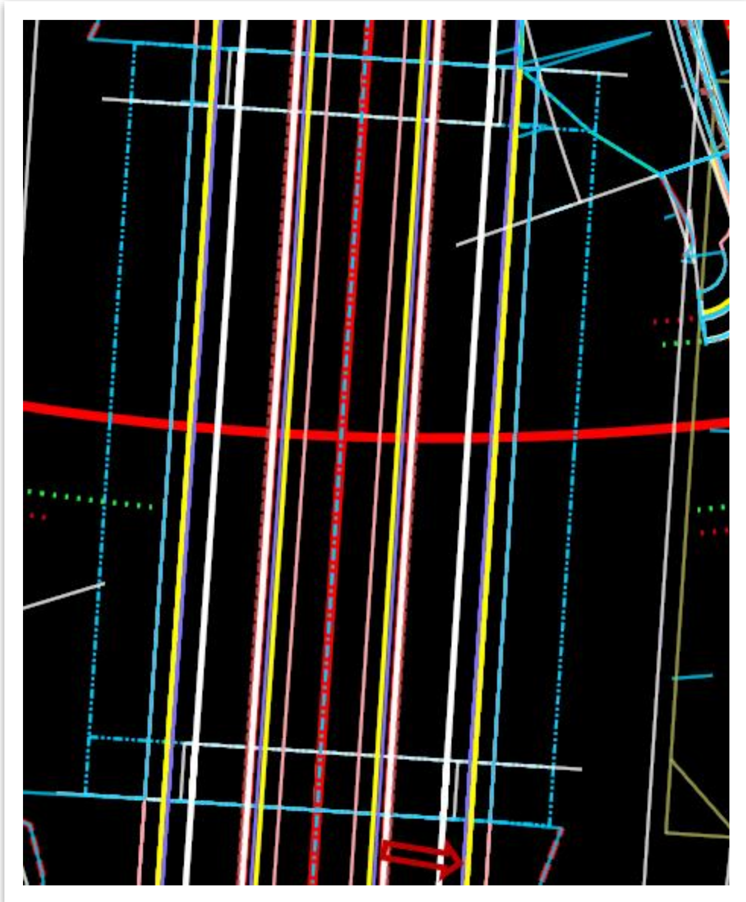
24. Repeat the process for the additional **three** corners of the bridge, using the **RIGHT_BARRIER_CTRL** constraint for the right side of the template. The **Start** and **Stop Stations** will change accordingly on the north side of the bridge to **424+24.89** and **424+42.89**.
25. Once completed, we need to place the bridge ends at the end of each concrete barrier. Temporarily turn off the **ROAD-II-BR-I65 Corridor.dgn** reference file.

26. We now need to place the **Right Start** bridge end first (SE corner). Open the **Point** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Point**).

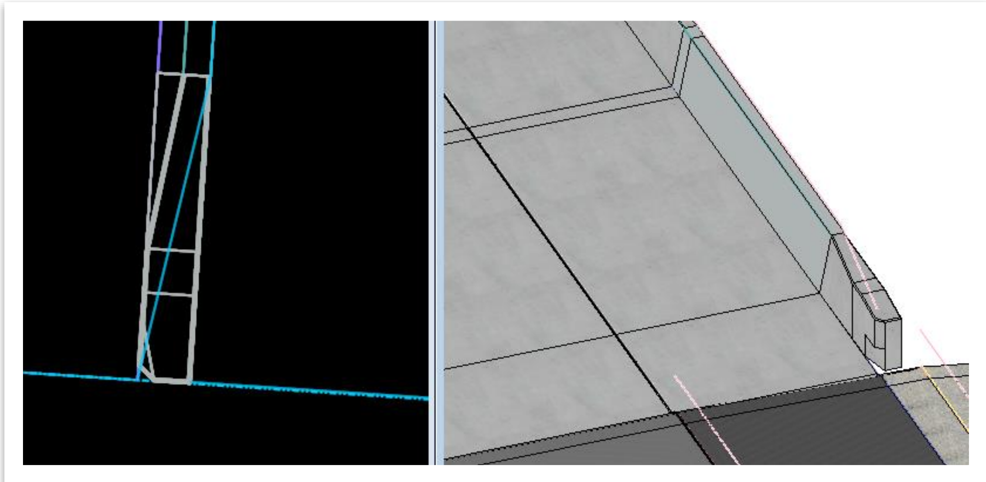


27. Within the **Point** dialog box, select the following settings.
    a. **Elevation Mode:** Plan Element
    b. **Reference Elevation Alignment:** PSH_R (select the I65 corridor PSH_R in plan view when prompted to Locate Elevation Plan Element (purple line highlighted in the screenshot on the next page))
    c. **Elevation Offset:** 0.00
    d. **Rotation Mode:** Relative to alignment
    e. **Reference Rotation Alignment:** PSH_R (select the I65 corridor PSH_R in plan view when prompted to Locate Reference Element for Rotation)
    f. **Rotation:** N00˚00’00” E
    g. **Feature Definition:** Bridge End - SS - Right Start (**Point >> Roadside Barriers >> Bridge Ends**)



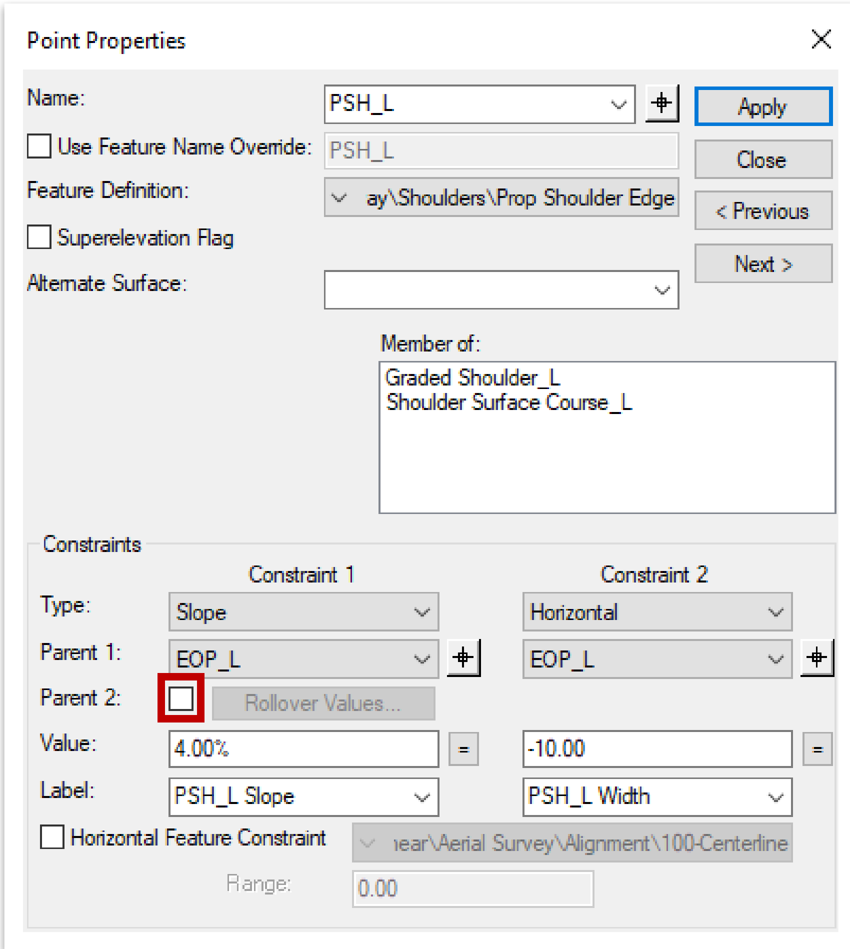


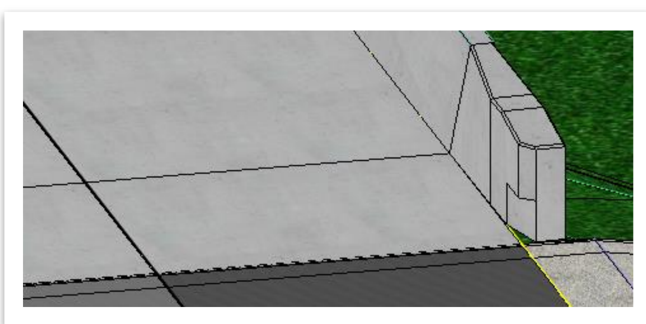
28. Click through the prompts, and then data point with the intersection snap to place the point at the intersection of the **PSH_R** and the end of the concrete barrier.



29. Repeat Steps 26-28 to place the bridge end in the remaining three corners, making sure to use the corresponding feature definition for each orientation. **Note: Start** and **end** are flipped for the **Left** side as the start/end is based on travel direction (i.e., the SW corner will use the **Left End** feature definition).

Note: The only remaining step would be to change the bridge slopes from **4.00%** to **2.00%**. This would be done by creating a parametric constraint of the **PSH** lines in the main **I65** corridor model. This **parametric constraint** would be **90** feet from the start of the bridge to match the superelevation runout of the roadway. **Note:** For a parametric constraint to work on the **PSH** values, the PSH slope constraint **Rollover** values will need to be turned off (shown below), meaning a separate template drop will be needed. Alternatively, a point control could be placed to control the shoulder vertically.





Chapter 10. Underpass Slope Protection

The TDOT standards for both **Underpass Slope Protection** and **Bridge End Drainage** have been incorporated into the TDOT ORD workspace so that they can be properly modeled in ORD via civil cells. This chapter will discuss how to place and manipulate the applicable civil cells to accurately model this complex interaction between template drops. **Note:** The civil cells are not a replacement for structural drawings. The **Underpass Slope Protection** civil cells are meant to assist in the grading of slopes around underpasses.

10.1 Objectives

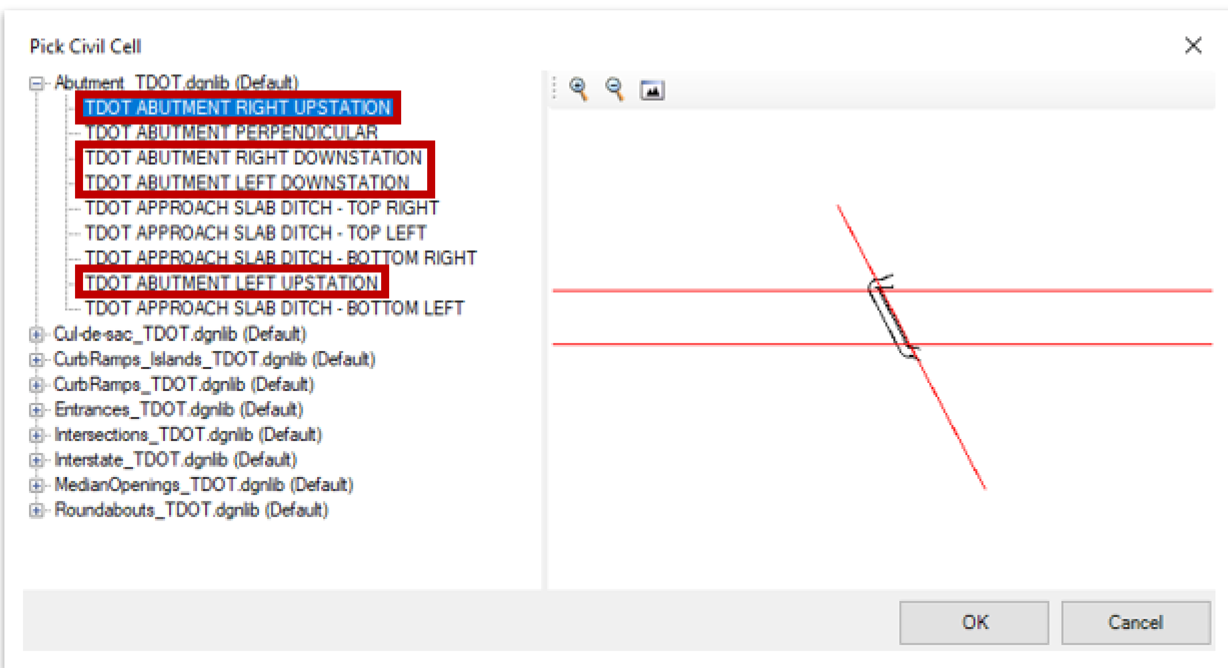
At the conclusion of this chapter, participants will be able to:

1. Place an Underpass Slope Protection civil cell.
2. Edit the civil cell template drops to properly align with the slopes.
3. Place Approach Slab ditches on a corridor.

10.2 Lecture: Underpass Slope Protection

Underpass Slope Protection is developed and modeled in ORD using **civil cells** and additional **surface templates**. There are **five** TDOT abutment civil cells, which are aligned with TDOT standard drawings RD01-SA-1 and STD-10-3 (Figure 17). If the bridge is perpendicular to the roadway, only one civil cell is necessary (**TDOT ABUTMENT PERPENDICULAR**). For any skewed scenario, there are two civil cells that handle left skews and two civil cells that handle right skews (red boxes below).

FIGURE 17. ABUTMENT CIVIL CELLS



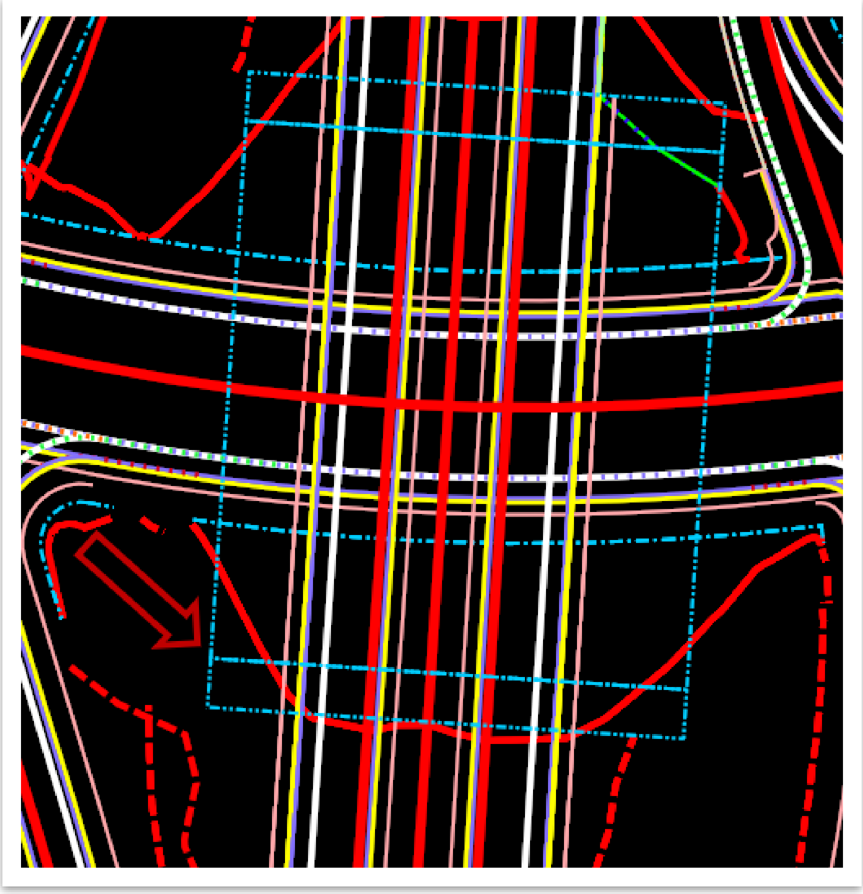
To place an abutment civil cell, the user must first draw an **abutment control line**, which represents the back of the abutment. This is for representation purposes only and the abutment is assumed to have a thickness of **1'**. The control line should be profiled so it is at least **1'** below the proposed shoulder lines (**PSH**) of the bridge. At a minimum, the control line should extend well beyond the **PSH** points of the roadway to avoid any issues during placement. <u>When placing the abutment civil cells, the left and right skew orientation assumes that **UPSTATION** is to the **right**</u>.

Once the applicable civil cells have been placed, **ditches** will need to be placed at the end of the approach slabs. There are **four** TDOT approach slab ditch civil cells for the placement of these ditches, which are aligned with TDOT standard drawing **STD-10-3**.

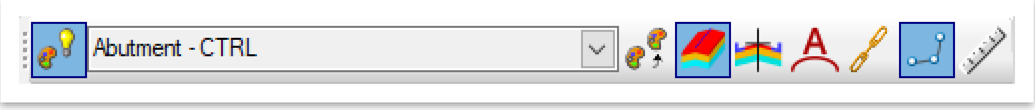
10.3 Exercise: Placing Underpass Slope Protection

In this exercise, we will place underpass slope protection using a civil cell. **Note:** This exercise shows how to place and manipulate the civil cell. The grading outside of the civil cell will not be covered and will not follow standards specified in STD-10-3.

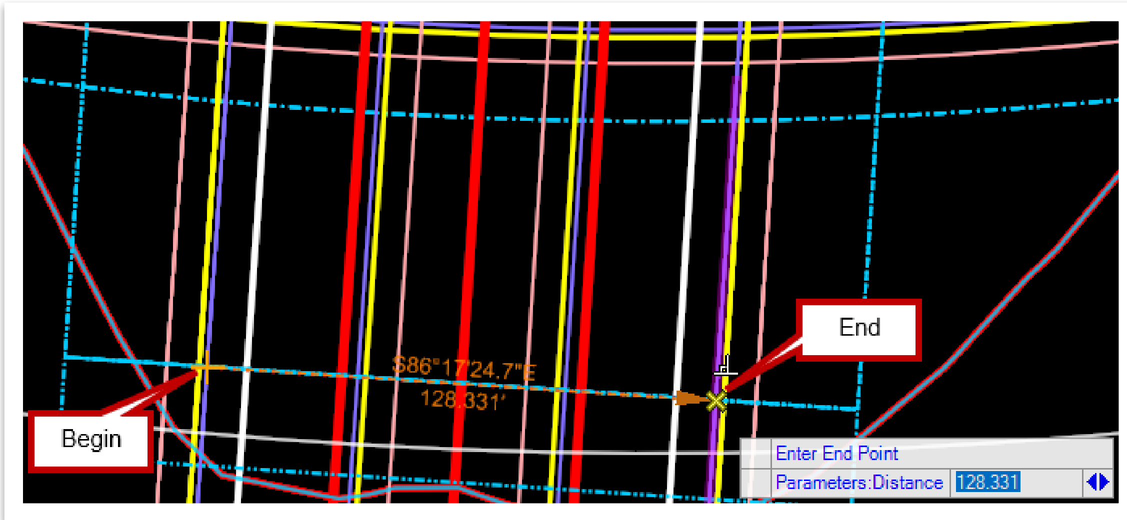
1. Open the **ROAD-II-USP-SR99 Corridor.dgn** file within the dgn Chapter 10 subfolder. Make sure that the **Default** view is active in the lower left corner. Locate the **south** end of the bridge in the middle of the project, where the bridge meets the abutment.

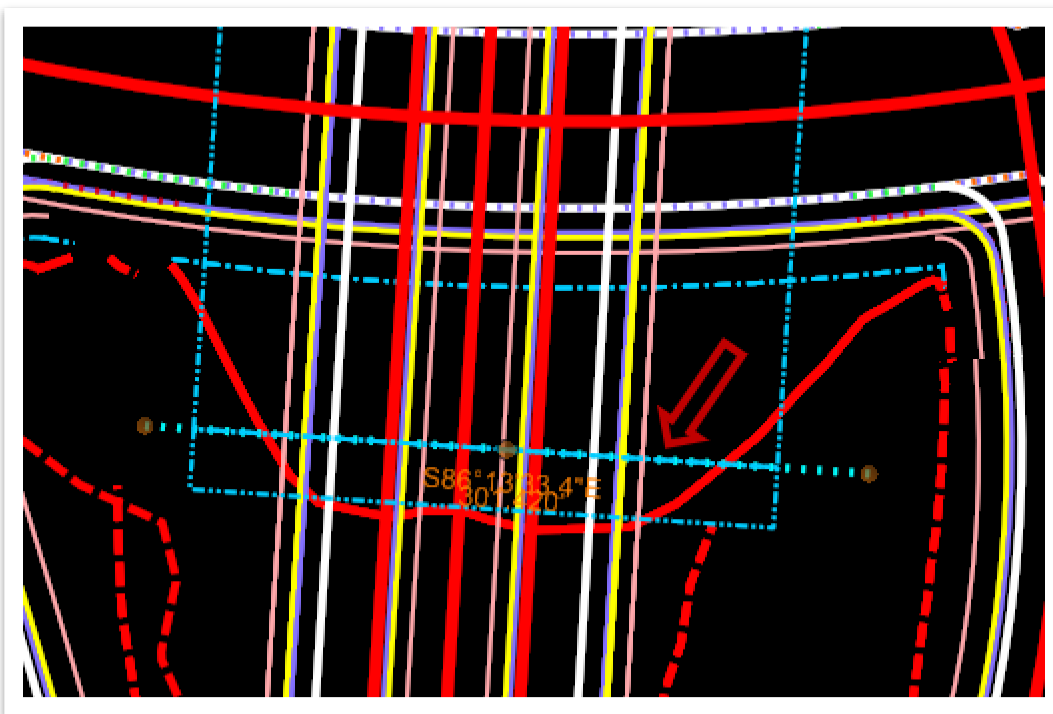


2. Select the **Abutment - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Bridge**) and toggle on **Create 3D Automatically**.

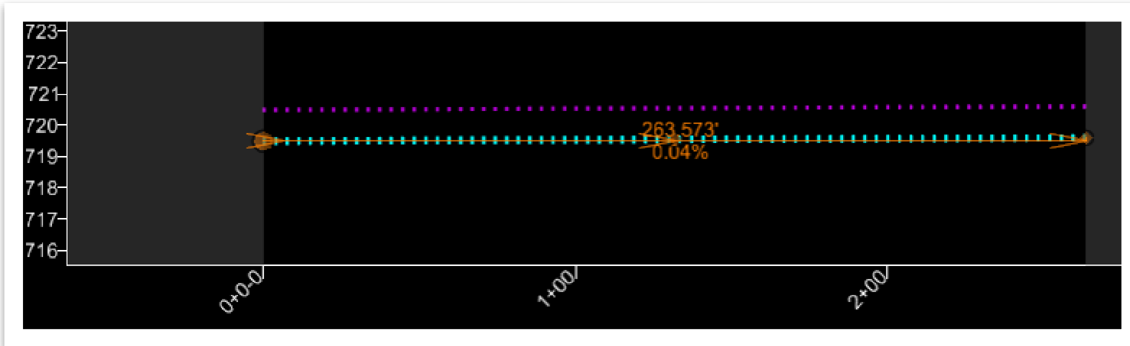


3. Using the **Near Snap Point** snap, open the **Line Between Points** tool (**Open Roads Modeling >> Geometry >> Horizontal >> Lines**) and draw a line from the **PSH_L** line (near snap the **PSH_L** line) at the **SW** corner of the bridge across to the **PSH_R** line. Use the **Perpendicular Snap** to snap to the **PSH_R** line. Then, using the orange handles on the line, drag the ends of the line outside the **PSH** lines at least **10** feet on each side.

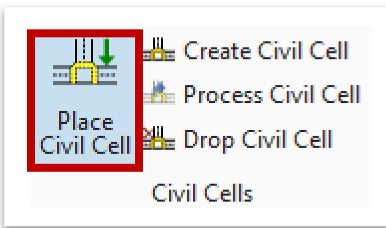




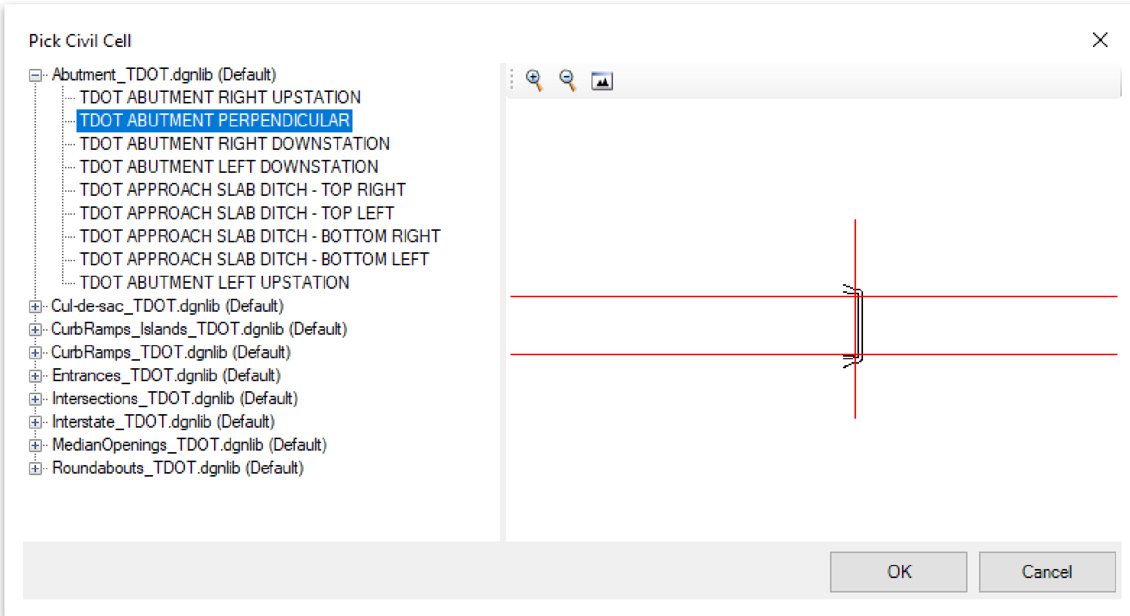
4. Next, open the **profile** view of the abutment control line just drawn. If drawn correctly, the line should have a profile elevation around **720.50’**. The abutment civil cell is created so that the abutment control line is **1’** below the **PSH** elevations. With the same feature definition still active, create a new profile line **1’** below the current profile line using the **Profile Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Lines**) and set the new profile to **active**. **Note:** This elevation controls the top of the abutment and will need to be modeled for the bridge being designed.



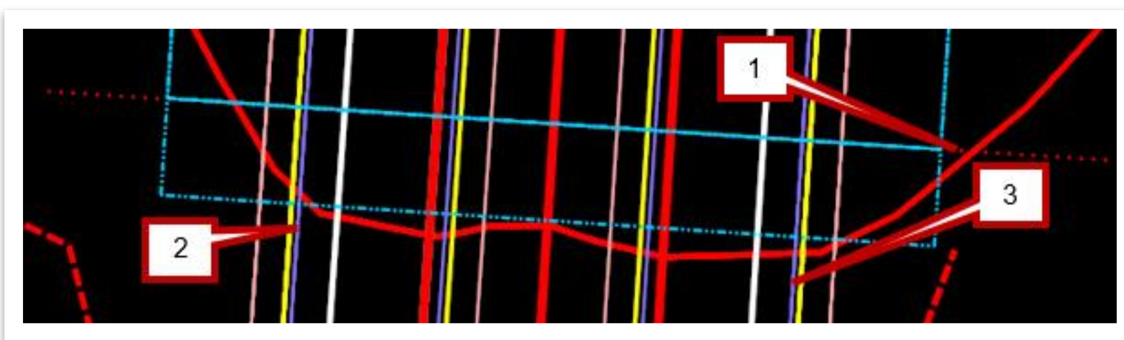
5. Return to the **Default** view and then open the **Place Civil Cell** tool (**OpenRoads Modeling >> Model Detailing >> Civil Cells**).



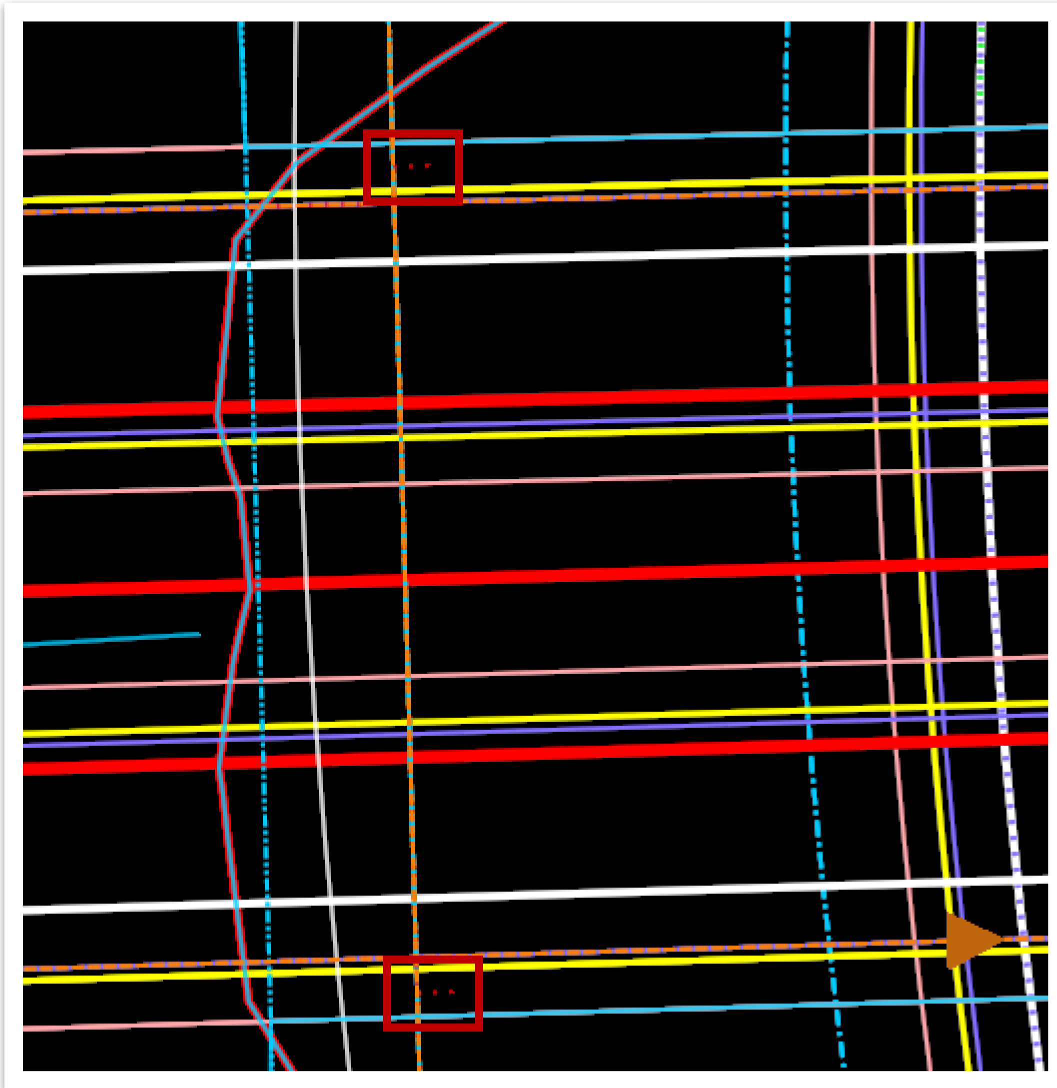
6. Within the **Place Civil Cell** dialog box, click the **3 dots** to open the **Civil Cell** folder. Since the abutment control line will be perpendicular to the bridge, select the **TDOT ABUTMENT PERPENDICULAR** civil cell under the **Abutment_TDOT.dgnlib** and click **OK**.



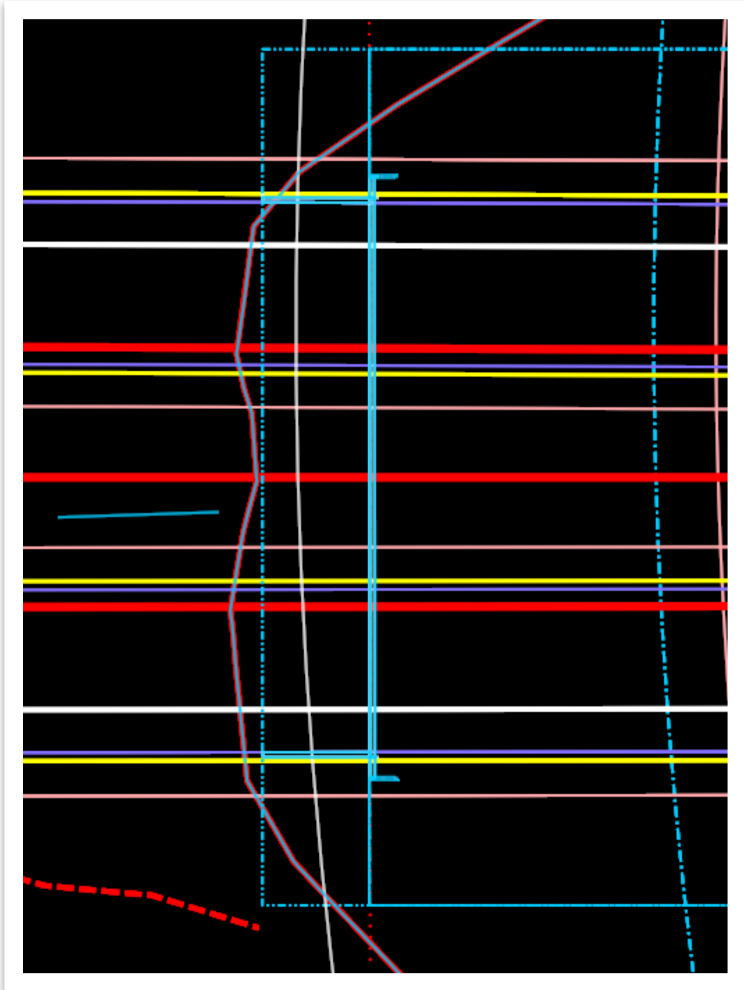
7. In the **2D** view, follow the prompts and select the **Abutment CTRL** (**1**), **PSH_L** (**2**) and the **PSH_R** (**3**). **Note:** This cell works in both left and right directions. The selection order for the other side abutment placement would be the **PSH_R** line and then the **PSH_L** line.



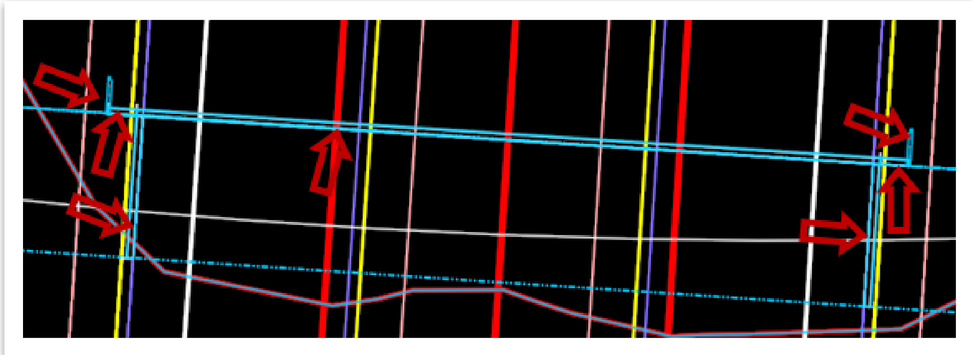
8. Now, adjust the direction of the reference lines, if needed. In the civil cell preview, the small red **CTRL** lines need to be outside the **PSH** lines and towards the bridge. **Note:** You should not need to reverse the reference line directions for this civil cell. Also, the screenshot has been rotated counterclockwise so that the **PSH_L** line is at the top of the screen.



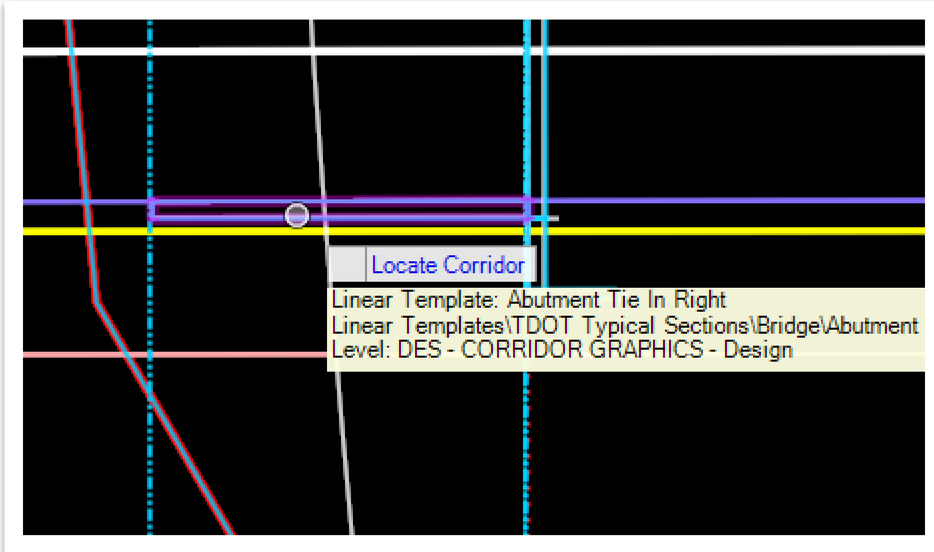
9. **Right** click to reset and then **left** click to place the civil cell.



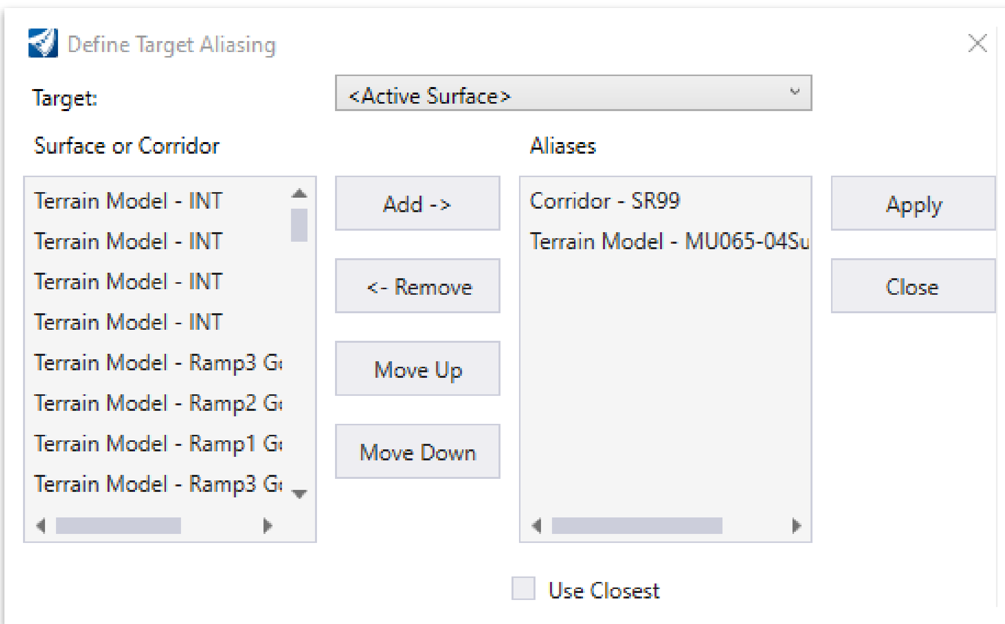
10. This civil cell contains **seven** different template drops that will be placed within the civil cell. Each template drop will need a **target alias** added to continue with the modeling. Make sure the **DES - CORRIDOR GRAPHICS** levels are turned on. **Note:** The screenshot has been rotated back to due north.



11. Next, open the **Define Target Aliasing** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous**) and select the template drop that is parallel to the **I65** corridor at the bottom of the screen (**Abutment Tie In Right**).

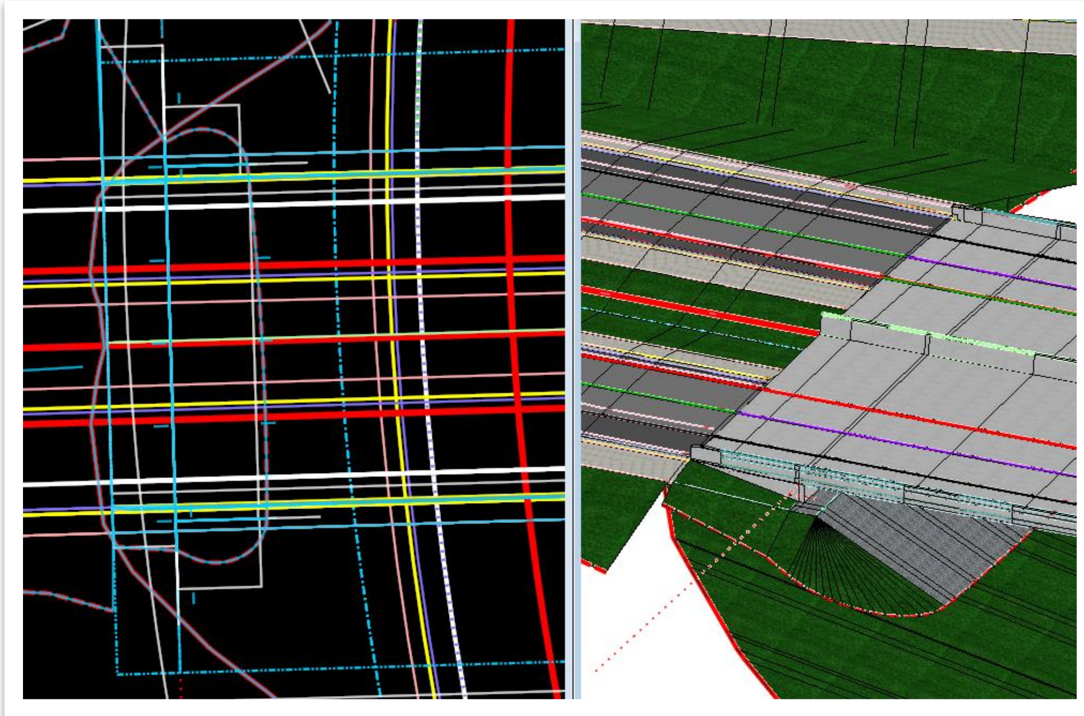


12. Add **Corridor - SR99** and **Terrain Model - MU065-04 Survey DTM** as target aliases for the templates that parallel the **I65** corridor (**Abutment Tie In Right** and **Abutment Tie In Left**).

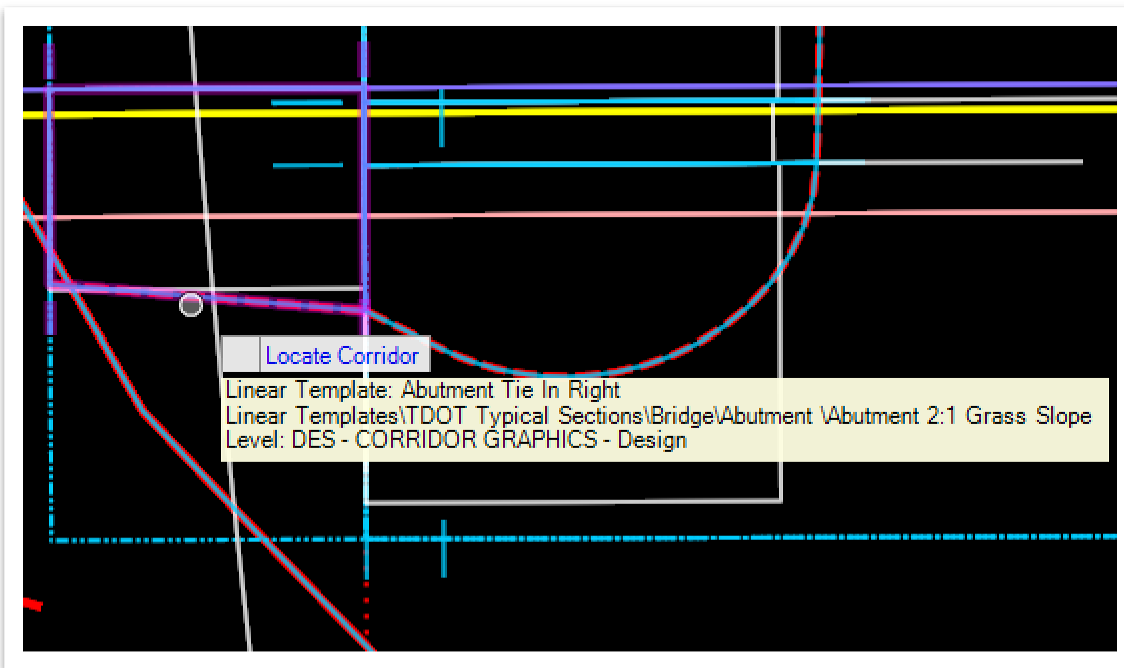


13. Using the same **Define Target Aliasing** tool, select the following template drops in order from <u>bottom to top</u> and add **Corridor - SR99** to each one: **Abutment Nose Right**, **Abutment Gravel Right**, **Abutment Main**, **Abutment Gravel Left**, and **Abutment Nose Left**. **Note:** If necessary, you can turn off the reference files to select the template drops more easily.

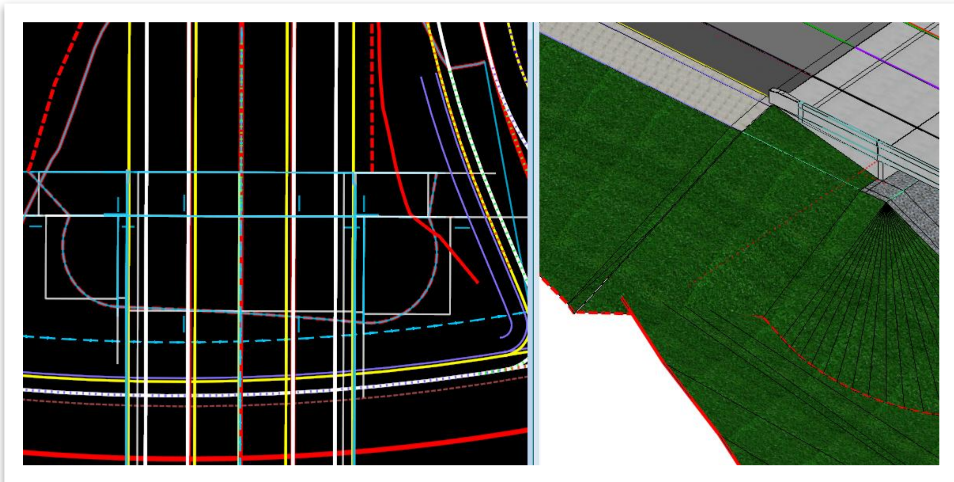
14. Once all **seven** template drops are aliased, the abutment is almost complete.



15. Now, a **parametric constraint** needs to be added on the **PSH_R** side of the abutment to tie the I65 slope to the abutment slope. Open the **Create Parametric Constraint** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**). Select the **Abutment Tie In Right** corridor.

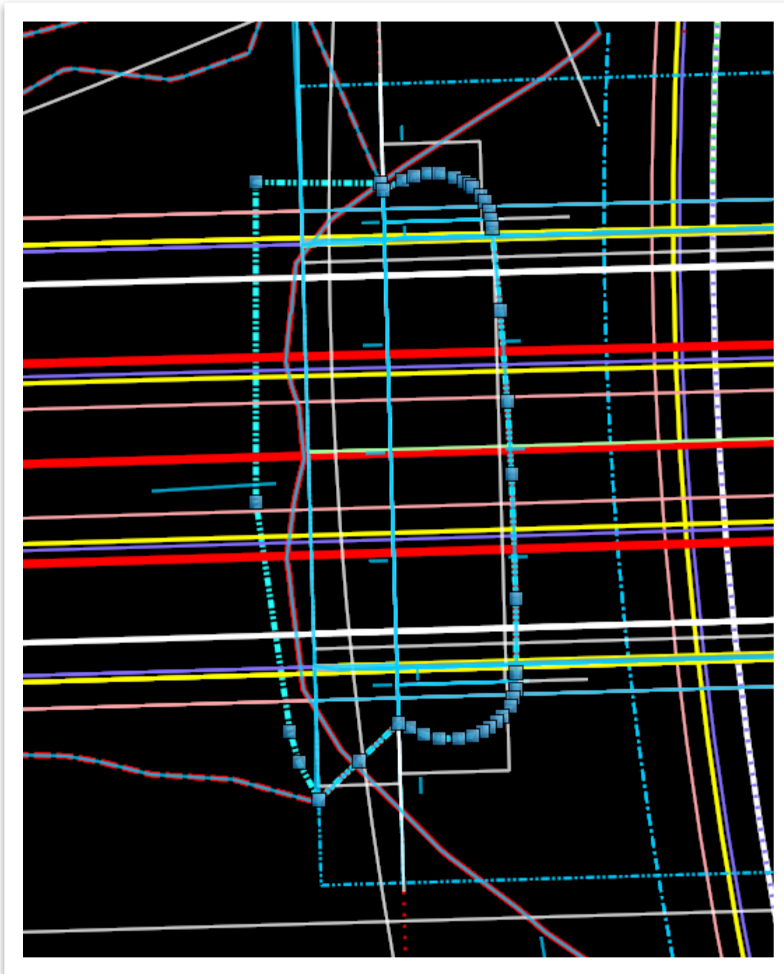


16. Within the **Create Parametric Constraint** dialog box, select the following settings to change the slope of the end conditions and then **left** click to accept the prompts. This will cause the end condition to disappear. **Note:** The screenshot has been rotated to show the entire abutment.
    a. **Lock to Start and End:** Toggle On
    b. **Constraint Label:** EC_FILL_TIE_SLOPE
    c. **Start Value:** 50%
    d. **Stop Value:** 25.00%



17. Repeat the previous step and create a **parametric constraint** on the **PSH_L** side of the abutment. Set the **Start Value** to **50.00%** and the **Stop Value** to **33.33%**.
18. For this exercise, we will not place the abutment civil cell again on the **right** side of the bridge. For future reference, remember that the selection of the **PSH** reference lines will be reverse for that side.

19. Lastly, we need to draw a **clip shape** around the south abutment that will clip the **SR99** corridor so that the end condition does not continue under the abutment. Open the **Place Shape** tool (**OpenRoads Modeling >> Drawing >> Placement >> Polygon Tools**) and draw the shape that is selected in the screenshot below, which clips the **SR99** corridor where it is under the abutment or the road.



20. Then, open the **Add Clipping Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor Clipping**) and select the **SR99** corridor. Select the clipping shape that was just drawn to clip the **SR99** corridor and that will complete the **left** side underpass slope protection. **Note:** This would also have to be done on the **right** side of the bridge as well if the user placed the other civil cell. Also, this will not change the **2D** model end condition boundaries, only the **3D** model. TDOT CADD Support website under [ORD Resources]

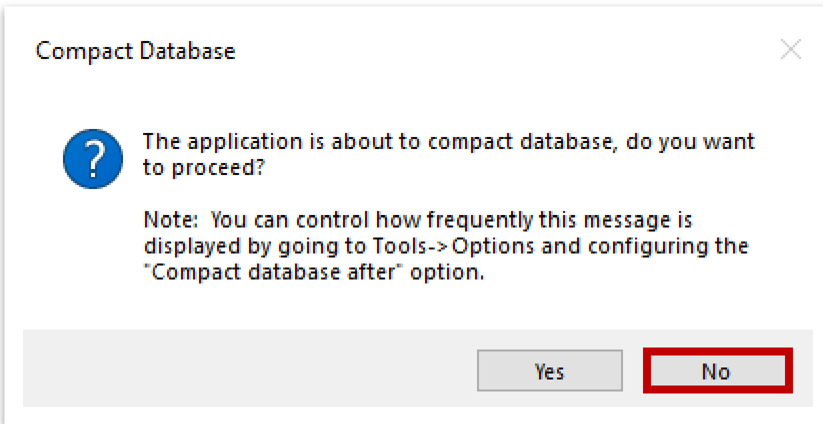
Take Note!

For details on how to place other TDOT Civil Cells, please refer to the individually recorded videos provided on the TDOT CADD Support website under ORD Training Material >> [ORD Civil Cell Tips and Videos].

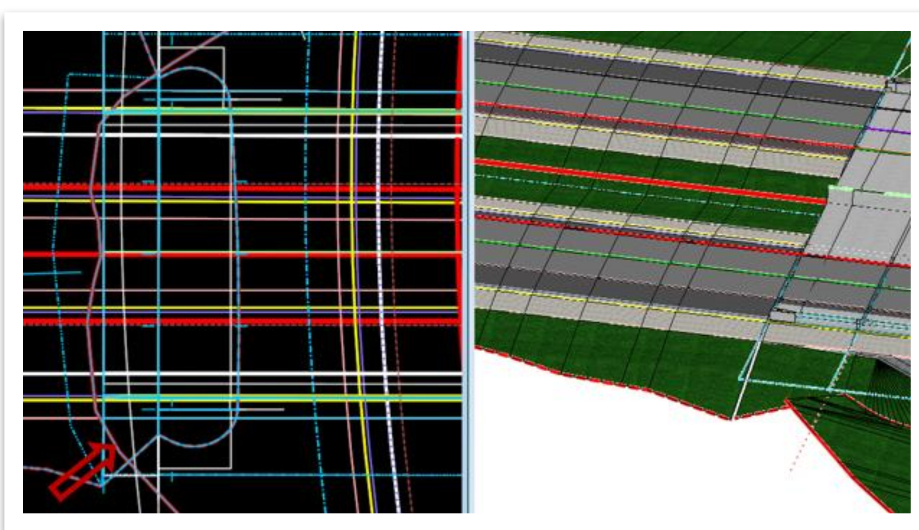
10.4 Exercise: Adding Approach Slab Ditches

In this exercise, we will place an approach slab ditch at each of the four bridge corners using civil cells. **Note:** This exercise shows how to place and manipulate the civil cell. The grading outside of the civil cell will not be covered and will not follow standards specified in [STD-10-3](STD-10-3).

1. Open the **ROAD-II-USP-I65 Corridor.dgn** file within the dgn Chapter 10 subfolder. You should get a **Compact Database** alert twice asking if you want to proceed. Click **No** both times. By default, the **triangles** should be turned off in both the **2D** and **3D** models. **Note:** The alert will appear when opening any ORD file that contains drainage and utilities data. If you receive this alert in other exercises, go ahead and click **No**.

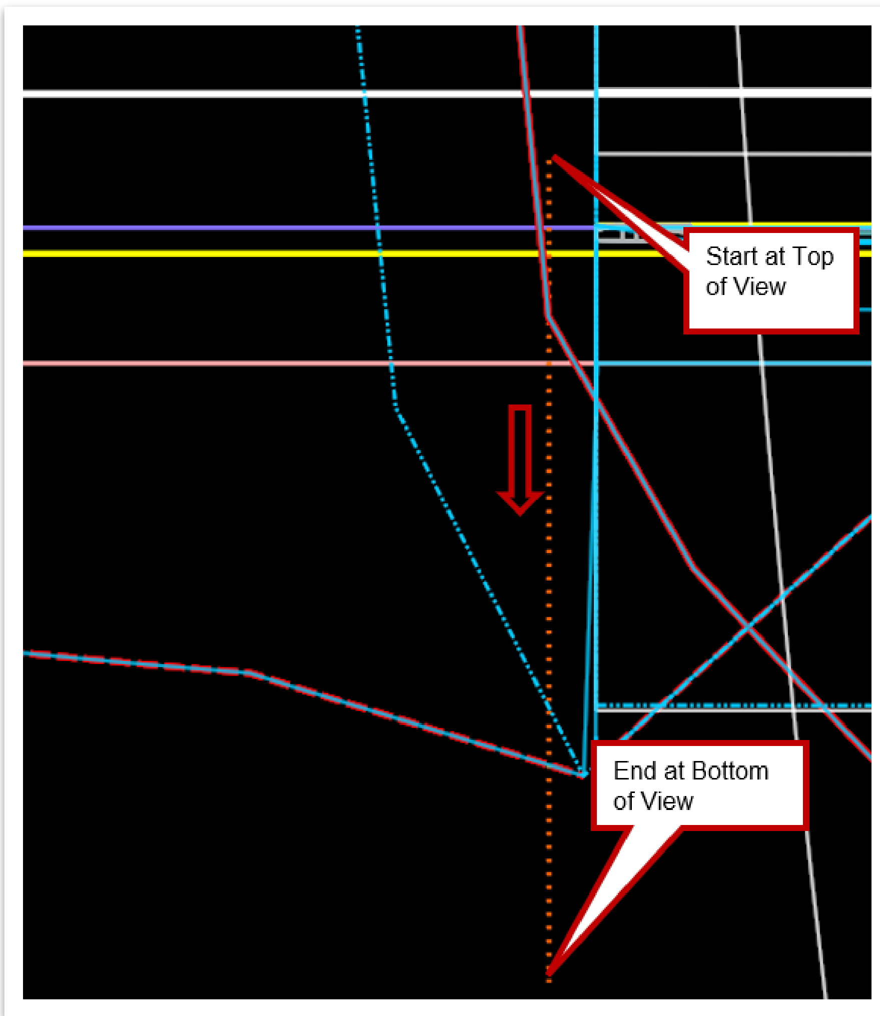


2. Within the **Default** view, rotate the view so that the **I65** mainline stationing runs left to right, with the **EOP_L** being at the top. We will need to locate the bottom left corner of the bridge. The **ditch** civil cells are set up to work when upstation is left to right in plan view. **Note:** The bottom left corner of the bridge approach slab is located on the **right** side of the corridor alignment.

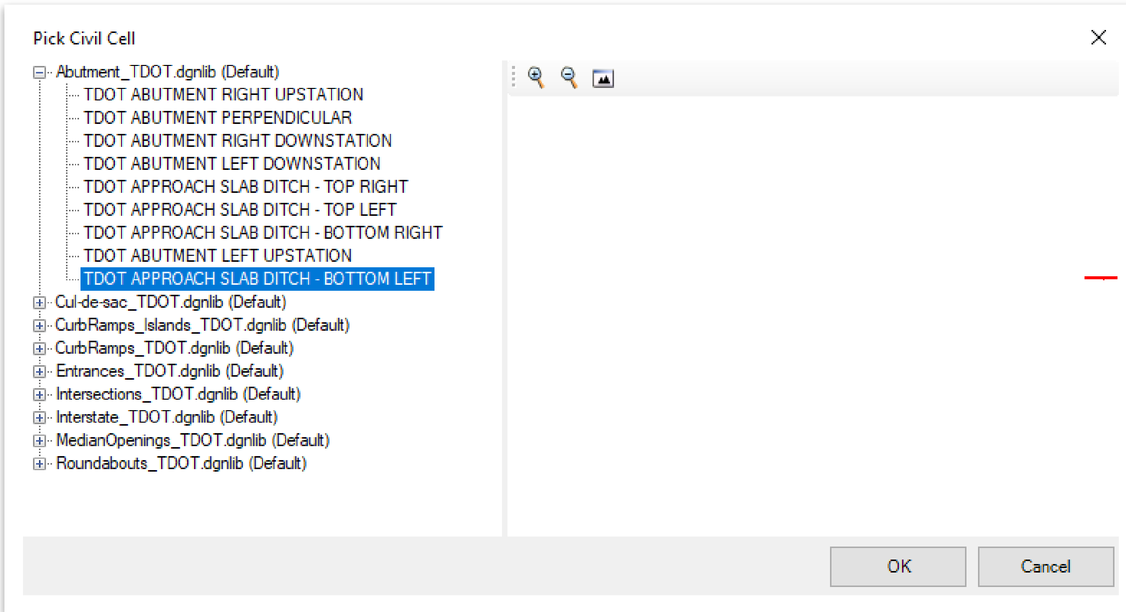


3. Select the **Matchline - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Matchline**) and toggle on **Create 3D Automatically**. **Note:** A **controlling** line must be placed to define the location of the civil cell. The naming convention of the civil cells relate to the location of the ditch relative to the bridge and the current view.

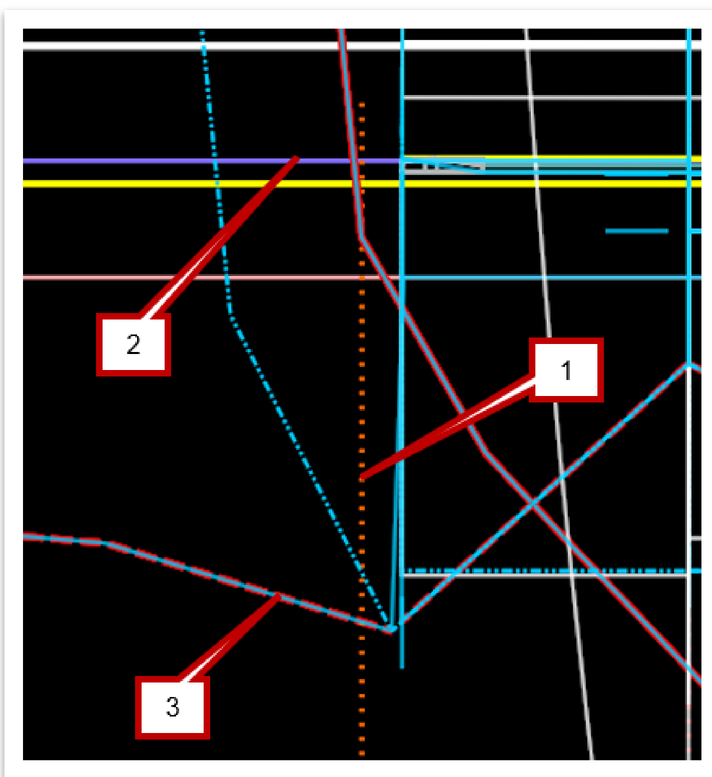
4. Open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and draw a line just left of the end of the **I65** template drop from the top of the view to the bottom of the view. Make sure this line crosses the corridor **PSH** line and **Tie Slope** line. Also, make sure the line does not cross template drops. With **Create 3D Automatically on**, a profile will be associated with the control line. This profile does not need to be modified and is not used by the civil cell.



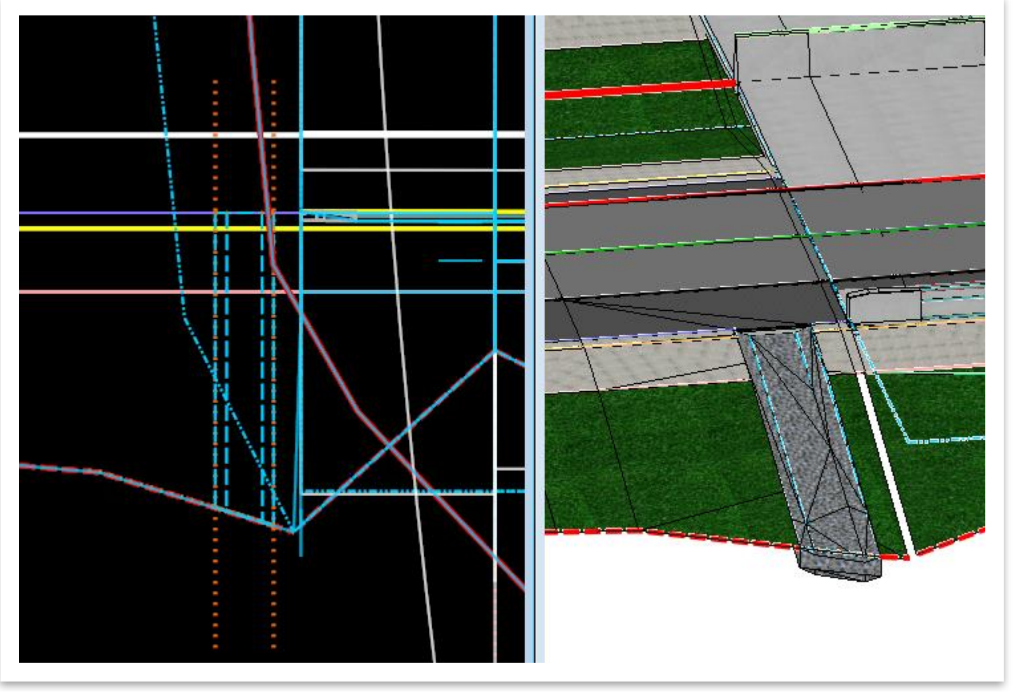
5. Next, open the **Place Civil Cell** tool (**OpenRoads Modeling >> Model Detailing >> Civil Cells**). Within the **Place Civil Cell** dialog box, click the 3 dots to open the **Civil Cell** folder. Select the **TDOT APPROACH SLAB DITCH - BOTTOM LEFT** civil cell located under the **Abutment_TDOT.dgnlib** and click **OK**.



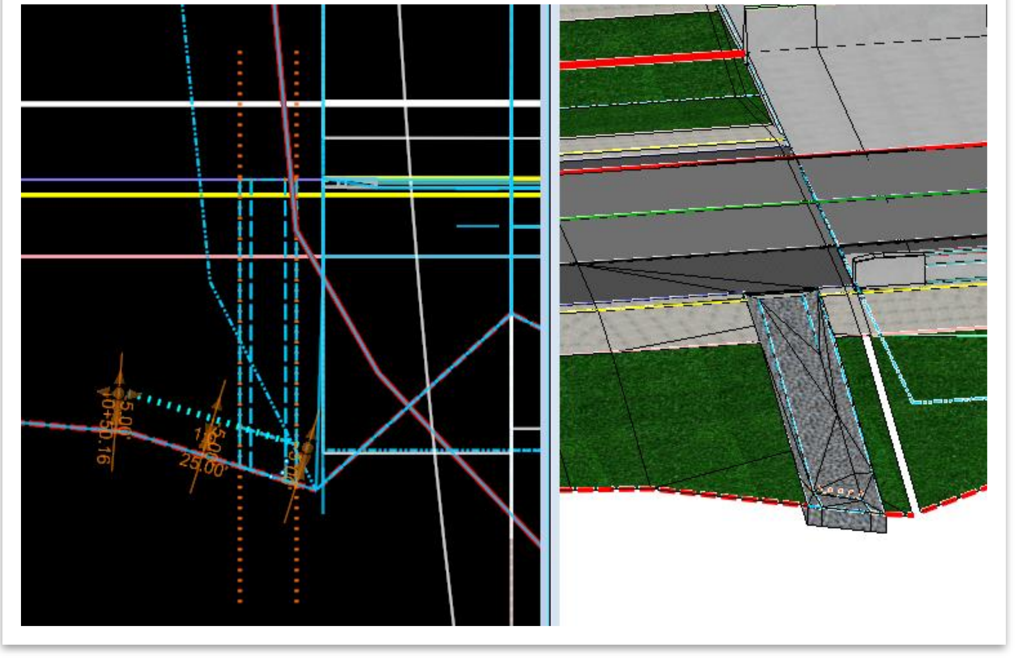
6. In the **2D** view, follow the prompts and select **Ditch CTRL** (**1**), **PSH_R** (**2**) and the **EC_FILL_TIE_R** (**3**).



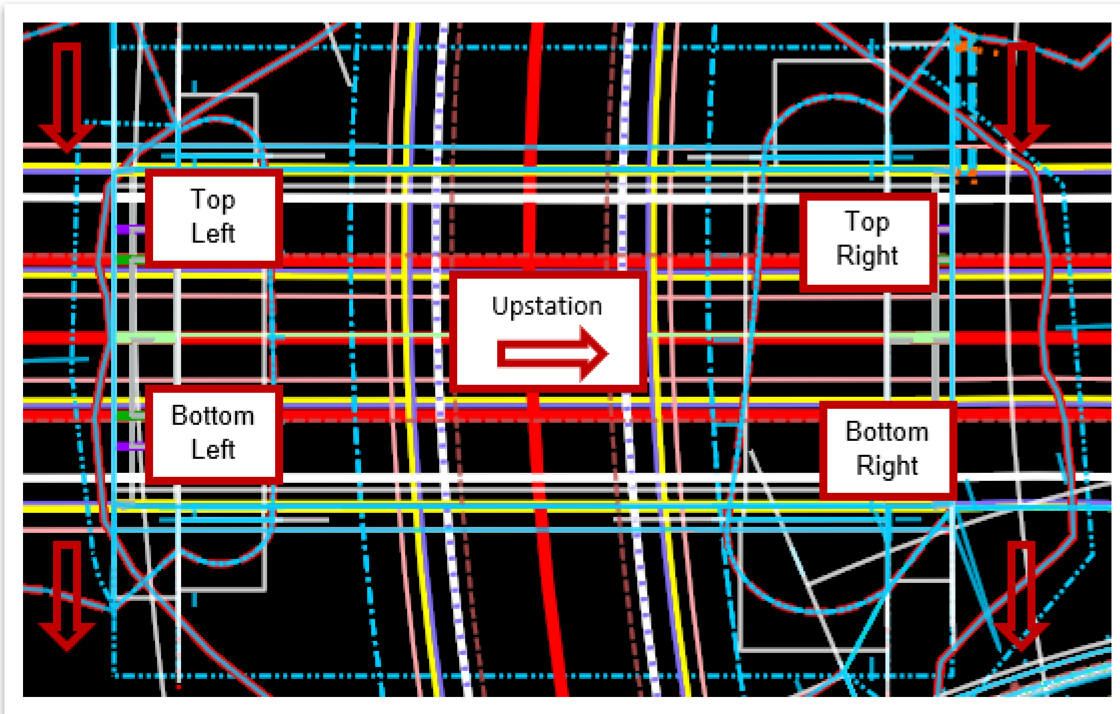
7. **Right** click to skip direction of reference lines and then select the **I65** corridor to clip. The **ditch** should now be placed, as shown below.



8. Zoom in to the bottom of the civil cell and locate the **orange** matchline handle slightly offset from the tie slope line. Changing the location of this handle changes the breakline of the civil cell and allows it to match the standard drawing, where it can move up to **5'** from the end of the ditch. **Note:** You can select the outside lines on the civil cell and profile them to match the slopes of the fill, if desired.



9. You would repeat Steps 4-8 to place the approach slab ditches on the other **three** corners of the bridge, using the appropriate civil cell for each corner of the bridge. **Note:** The arrows below show the direction to draw the matchline control line to work correctly with the applicable civil cell, from the top of the view to the bottom of the view.



Chapter 11. Ramps and Gores

Ramp and **Gore** modeling requires complex interaction between multiple template drops or corridors. Due to the complexity and constraints, these scenarios will not be placed via civil cells. Instead, this chapter will discuss the necessary tools to accurately model the ramp and gore interaction with the mainline alignment.

11.1 Objectives

At the conclusion of this chapter, participants will be able to:

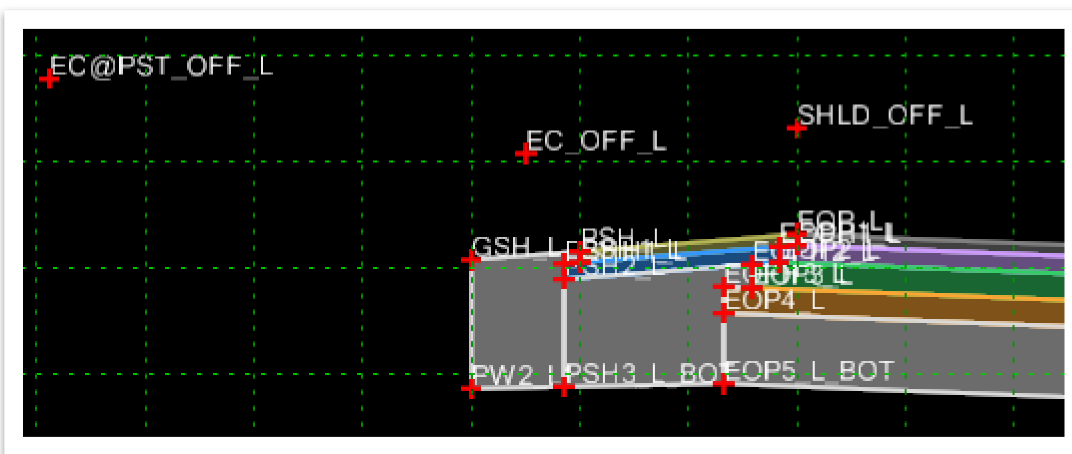
1. Model a ramp gore with geometry tools.
2. Override two corridor end conditions to follow a single ditch control line.

11.2 Lecture: Ramps and Gores Overview

Ramps and gores will be modeled using a combination of **template drops** and **surface templates**. Within the default TDOT template library, **display rules** are present, which allow certain template components to be turned off, thus enabling two templates to converge onto one-another. Three different display rules have been created for ease of modeling gores and other scenarios:

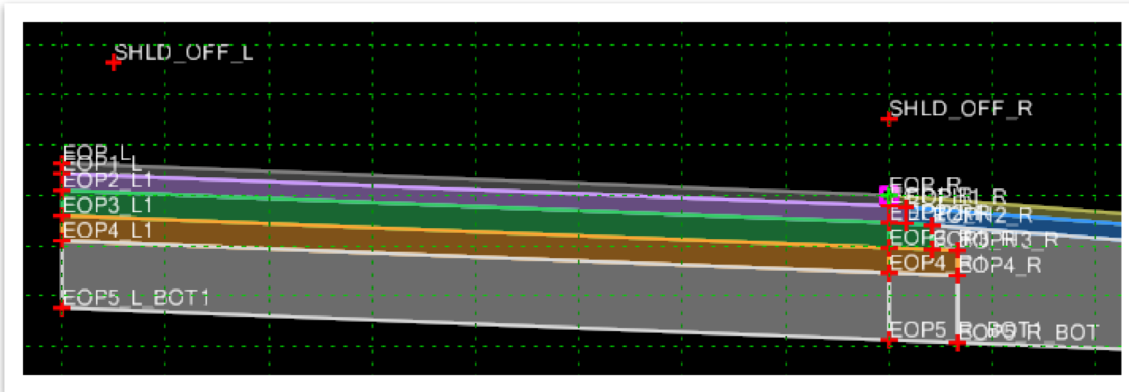
- **EC@PST_OFF:** Turns off the end condition at the **Graded Tie In** point. This is a simple on/off and does not have different hidden elements.
- **EC_OFF:** Turns off the end condition and modifies the graded shoulder, so it is a straight cut down from the edge of the 2' graded shoulder (Figure 18). This display rule does have hidden elements that are turned on.

FIGURE 18. END CONDITION DISPLAY RULE



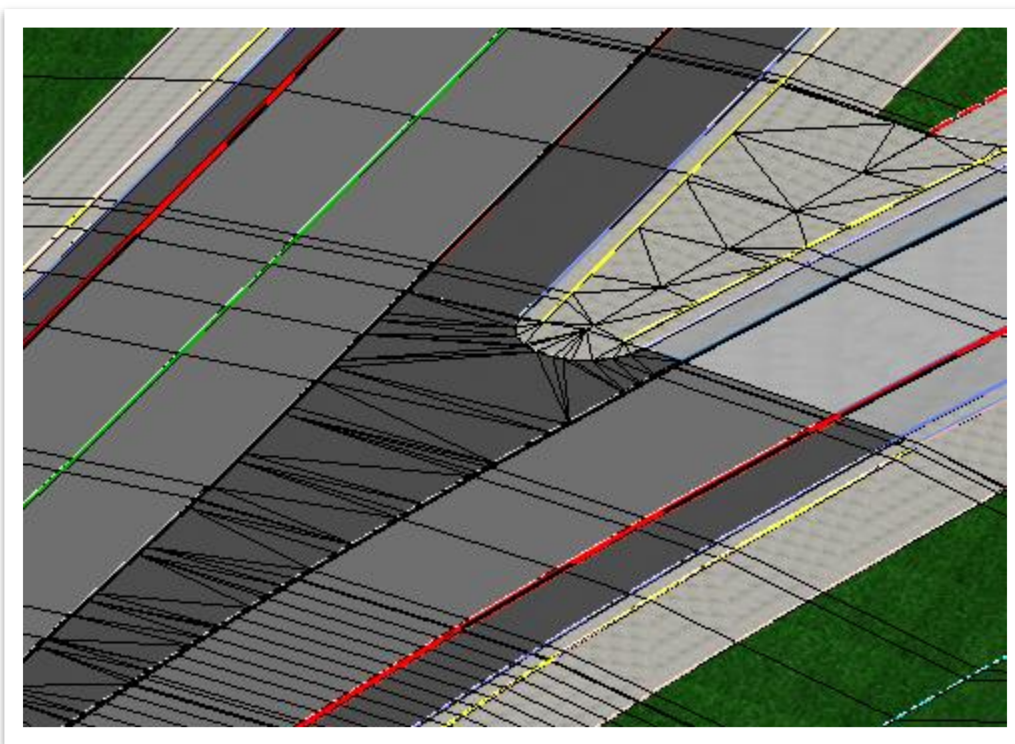
- **SHLD_OFF:** Turns off the end condition and the shoulder at the **Edge of Pavement** (Figure 19). For templates that have stepped asphalt layers, those components will be turned off and new components without the stepped layers will be turned on.

FIGURE 19. SHOULDER DISPLAY RULE



The actual gore area will be created using a **surface template** (Figure 20). The graded area behind the paved gore, but prior to the mainline and ramp end condition connection point, will be filled in using another surface template. Then, the ditch line will be carried from the graded area behind the gore to the end of the ramp and targeted by both the mainline and ramp corridors.

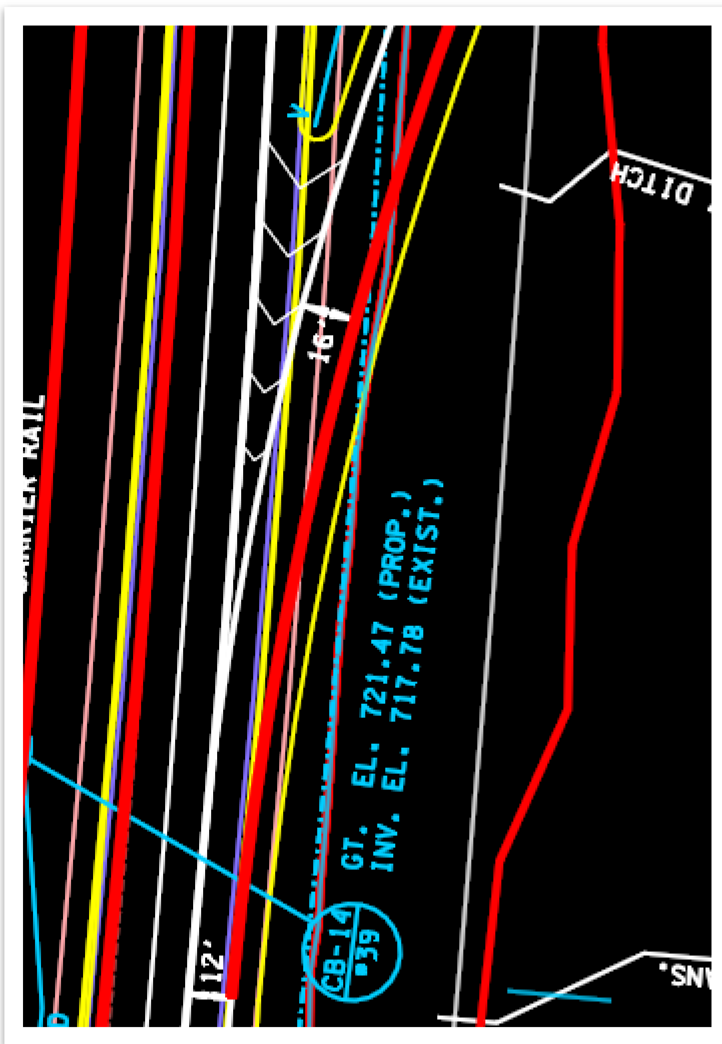
FIGURE 20. GORE MODEL EXAMPLE



11.3 Exercise: Creating a Ramp Gore

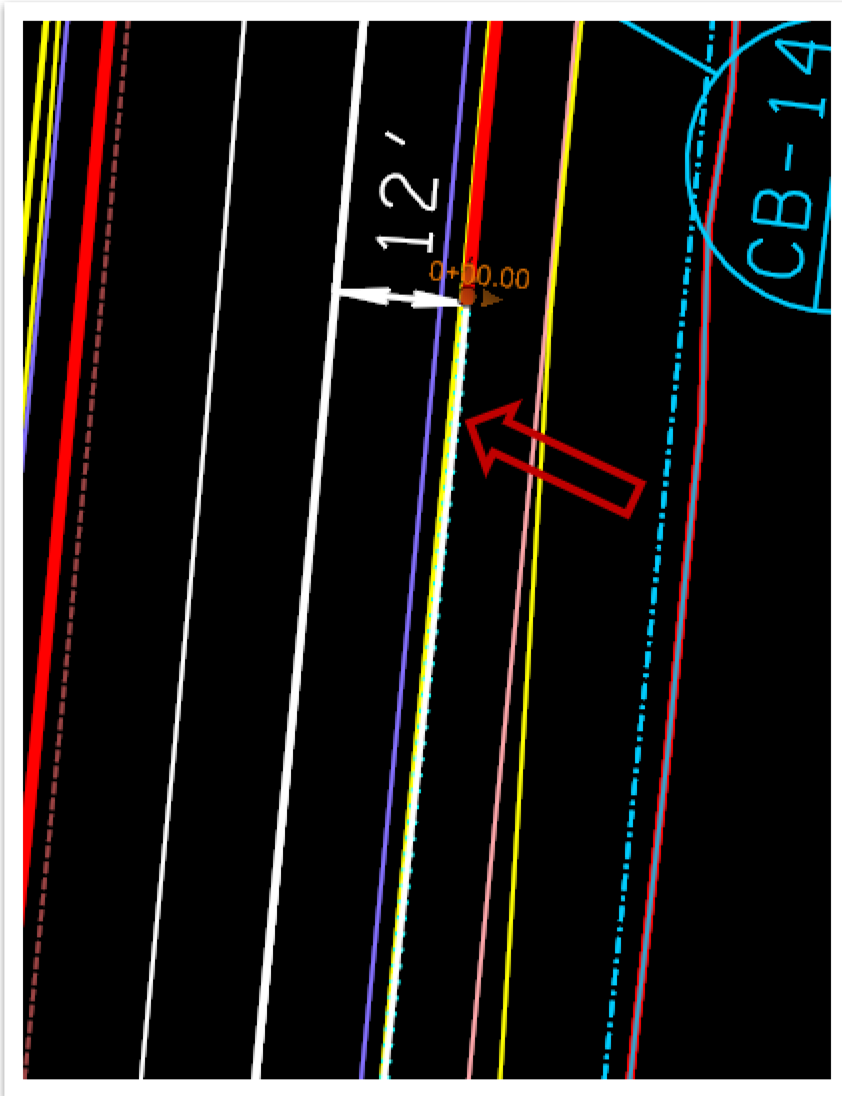
In this exercise, we will use a variety of modeling tools to create a ramp gore on an exit ramp.

1. Open the **ROAD-II-RG-I65 Corridor.dgn** file within the dgn Chapter 11 subfolder. Make sure that the **Default** view is active in the lower left corner. The following files should already be referenced in the 2D view.
   - ROAD-II-RG-Alignments.dgn
   - ROAD-II-RG-Proposed.dgn
   - ROAD-II-RG-Ramp Corridor.dgn
   - ROAD-II-RG-Terrain.dgn
2. Locate the ramp in the **lower right corner** of the interchange. **Note:** The **ROAD-II-RG-Proposed.dgn** file is a 2D SS2 file that will serve as a reference for what we will be recreating in ORD.

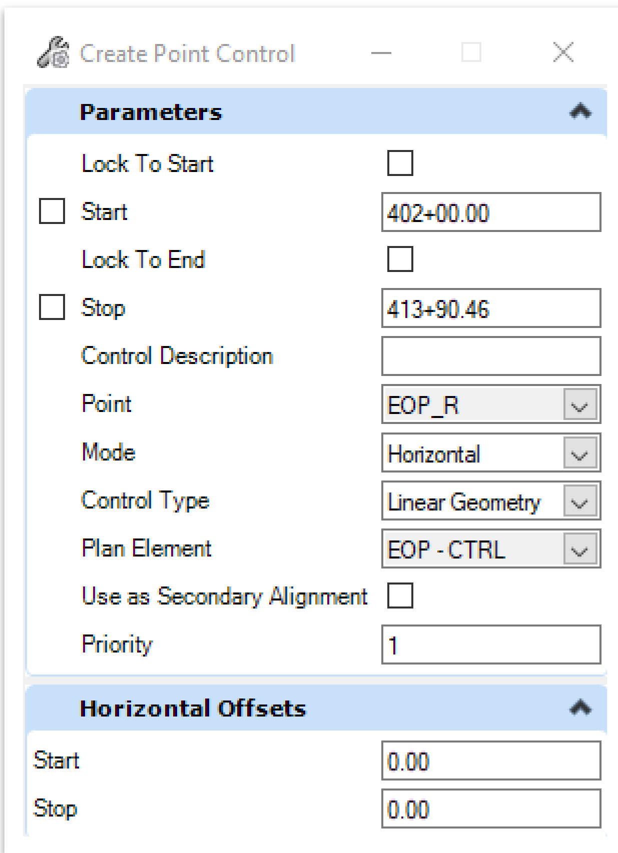


3. First, we need to create an auxiliary lane for the entrance into the ramp using a **Point Control**. Select the **Prop EOP - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> EOP**). **Note:** For these next steps, Create 3D Automatically does not need to be on.

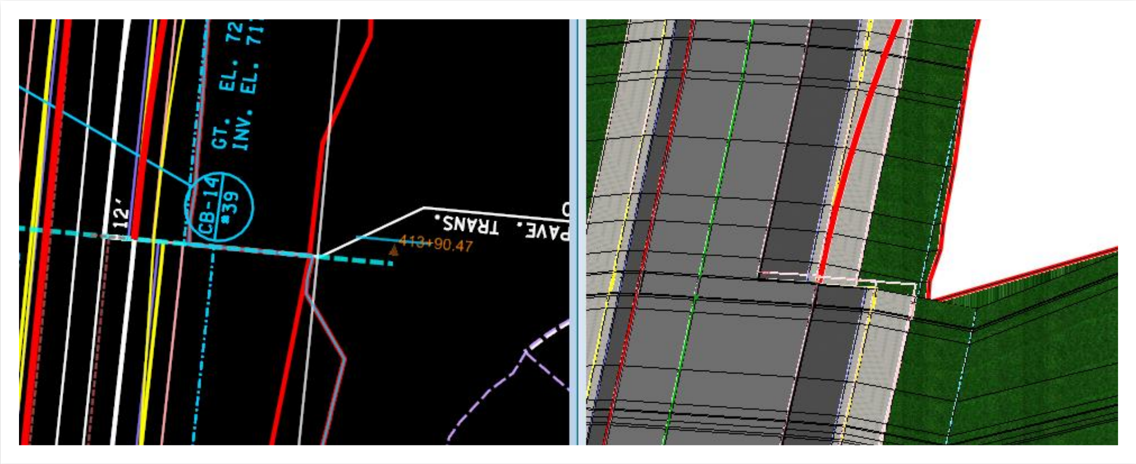
4. Next, open the **Single Offset Entire Element** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the edge of pavement in the **2D SS2** model. Set the **Offset** to **0'** and **left** click to accept.



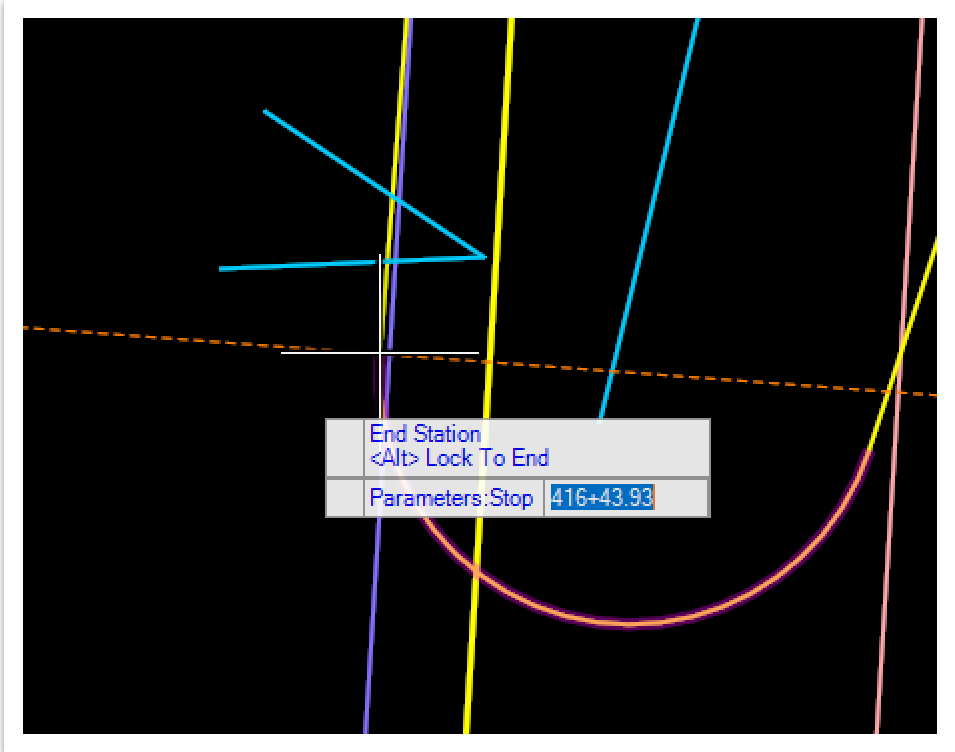
5. Now, open the **Create Point Control** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**). Select the **I65** corridor and then select the following settings.
    a. **Start:** 402+00.00 (start of corridor)
    b. **Stop:** 413+90.46 (start of ramp geometry)
    c. **Control Description:** Blank
    d. **Point:** EOP_R
    e. **Mode:** Horizontal
    f. **Control Type:** Linear Geometry
    g. **Plan Element:** EOP - CTRL (**Note:** This is the point control line created in the previous step. The 2D references may need to be turned off to see this point control line.)



6. Click through the prompts to accept the point control. Then, open the **Create Key Station** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and add a key station at **413+90.47** near the transition to create a smooth break. The auxiliary lane on the mainline (**I65**) corridor has now been created.

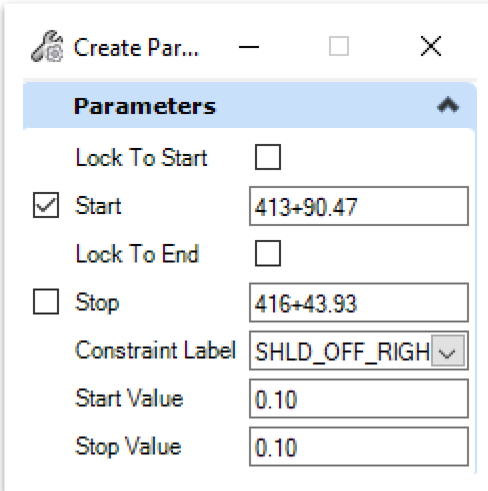


7. Next, we need to turn the mainline corridor **shoulder** off. Open the **Create Parametric Constraint** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and select the **I65** corridor. Then, select the following settings.
    a. **Start:** 413+90.47 (end of the ramp alignment)
    b. **Stop:** 416+43.93 (end of the rounded end of the gore)

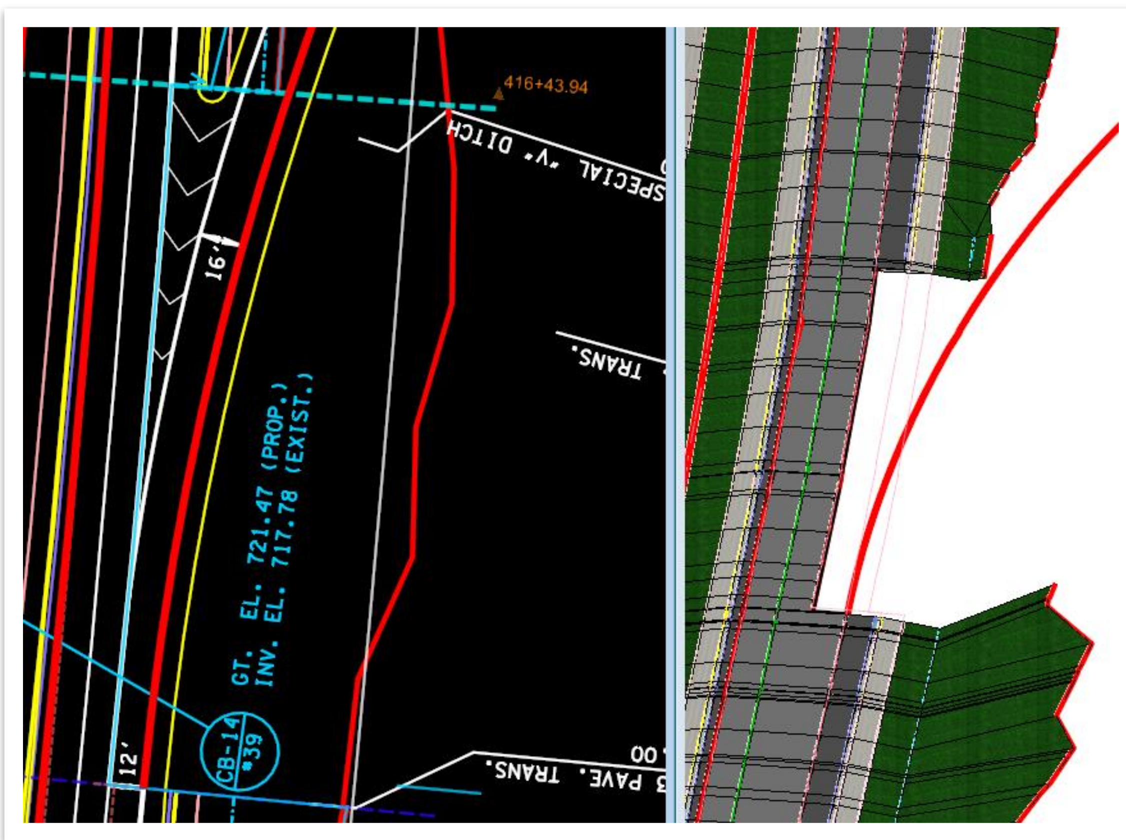


c. **Constraint Label:** SHLD_OFF_RIGHT

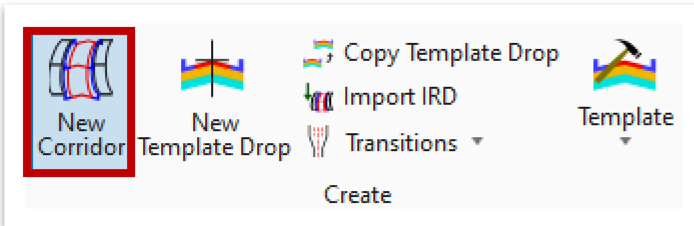
d. **Start** / **Stop Values:** 0.10 (**Note:** The value can be anything other than 0 to turn off the shoulder.)



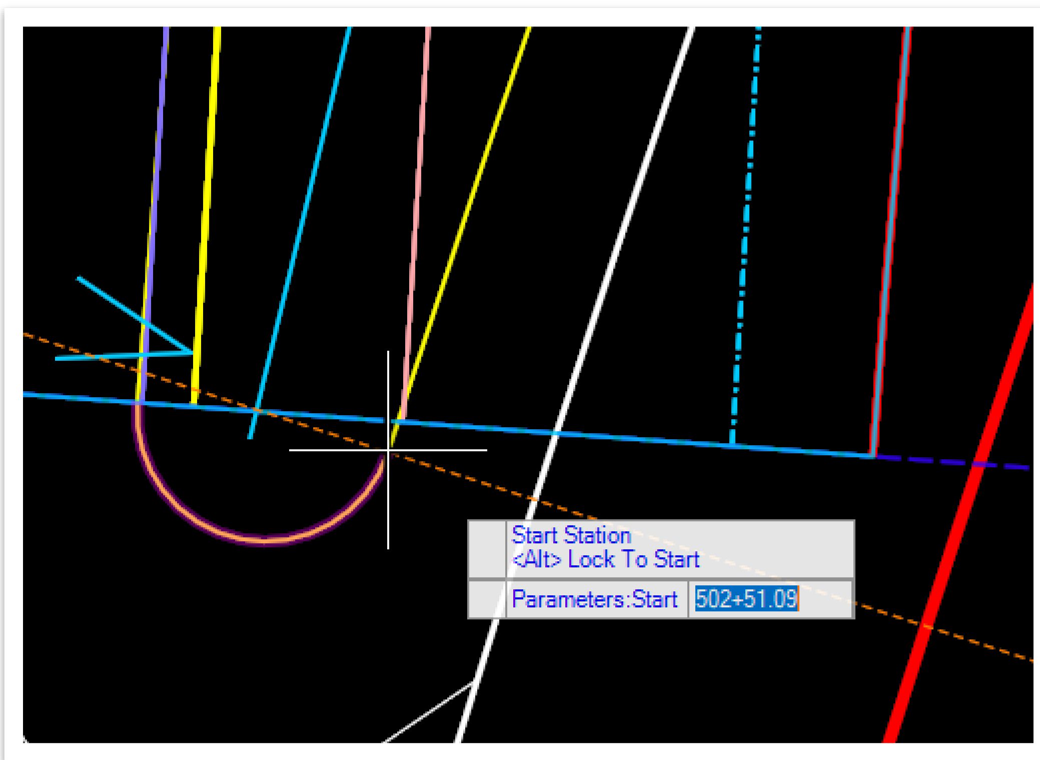
8. Go ahead and open the **Create Key Station** tool once again (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and add a key station at **416+43.94** to create a clean break where the shoulder turns off.



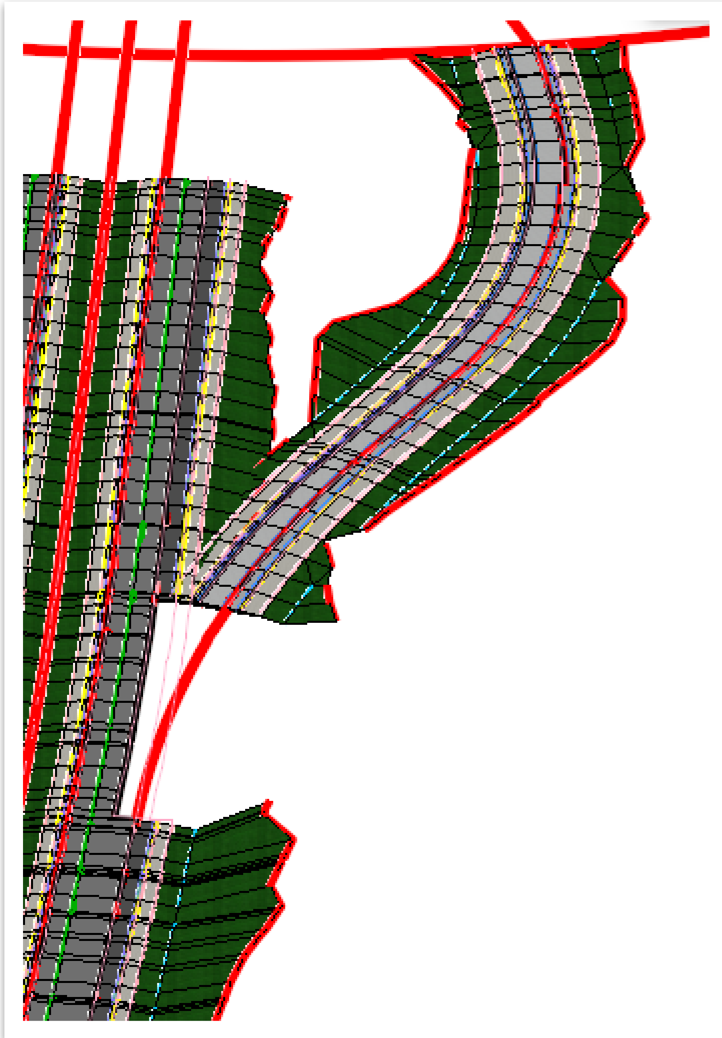
9. Now, open the **ROAD-II-RG-Ramp Corridor.dgn** file within the dgn Chapter 11 subfolder. This file is blank other than the attached reference files. We will be placing **two** templates on the ramp: the concrete ramp itself and the asphalt tie from the mainline corridor through the gore.
10. First, we will place the concrete portion of the ramp. Open the **New Corridor** tool (**OpenRoads Modeling >> Corridors >> Create**). Within the **Create Corridor** dialog box, select the **Final Design** feature definition and name the corridor **Ramp3**. Select the ramp geometry, **right** click to accept the active profile, and then **left** click to accept.



11. Within the **Create Template Drop** dialog box, select the **TS-4 RIGHT (1LN) - CONC.** template (**Linear Templates >> TDOT Typical Sections >> Undivided**). Set the **Drop Interval** to **25.00'**. Place the start of the template at the start of the nose of the gore (Station **502+51.09**) and then lock to the end of the alignment.



12. Notice that the concrete ramp has now been placed based on the extents selected in the previous step.

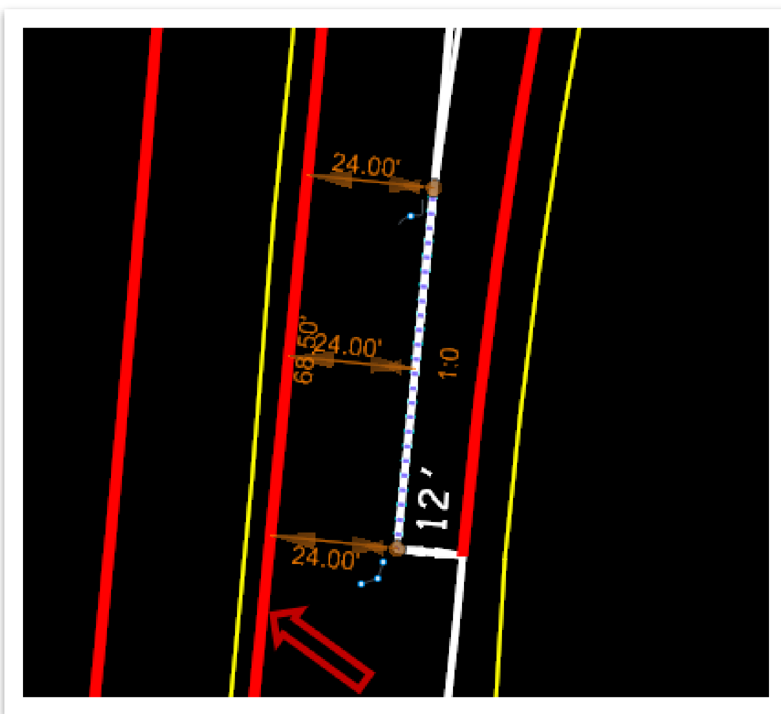


13. Before placing the asphalt template drop, we need to set a **point control** on the mainline corridor. Select the **Prop EOP - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> EOP**), if not still selected.

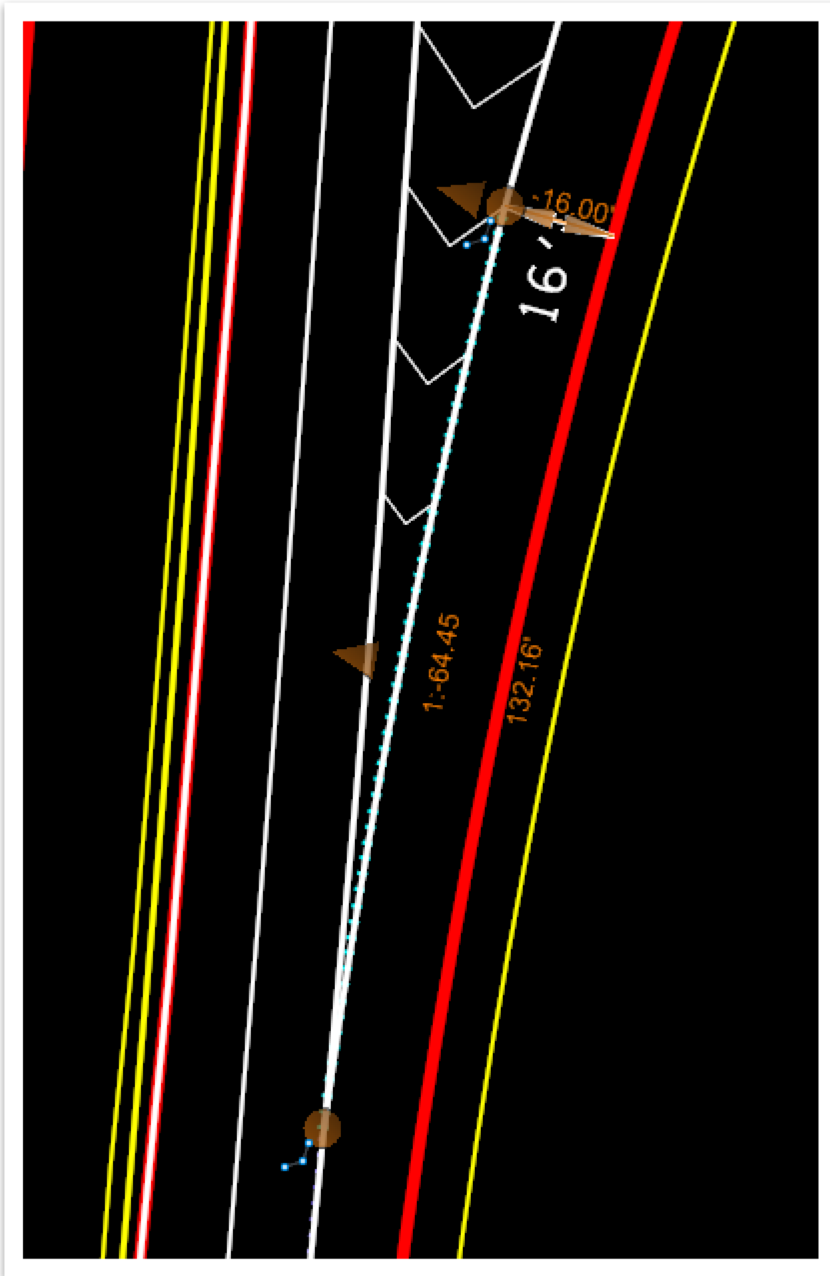
14. To assist in locating snaps, go ahead and turn all levels off other than the following.

Reference File(s)	Level(s)
ROAD-II-RG-Alignments.dgn	DES - CL - Proposed
ROAD-II-RG-I65 Corridor.dgn	DES - MODEL - Lines Pavement Edge
ROAD-II-RG-Proposed.dgn	DESIGN - TRANSPORTATION - Edge of Traveled Way DESIGN - TRANSPORTATION - Shoulder Lines DESIGN - TRANSPORTATION - Text
ROAD-II-RG-Ramp Corridor.dgn	DES - MODEL - Lines Pavement Edge DES - TRAN - Edge of Traveled Way

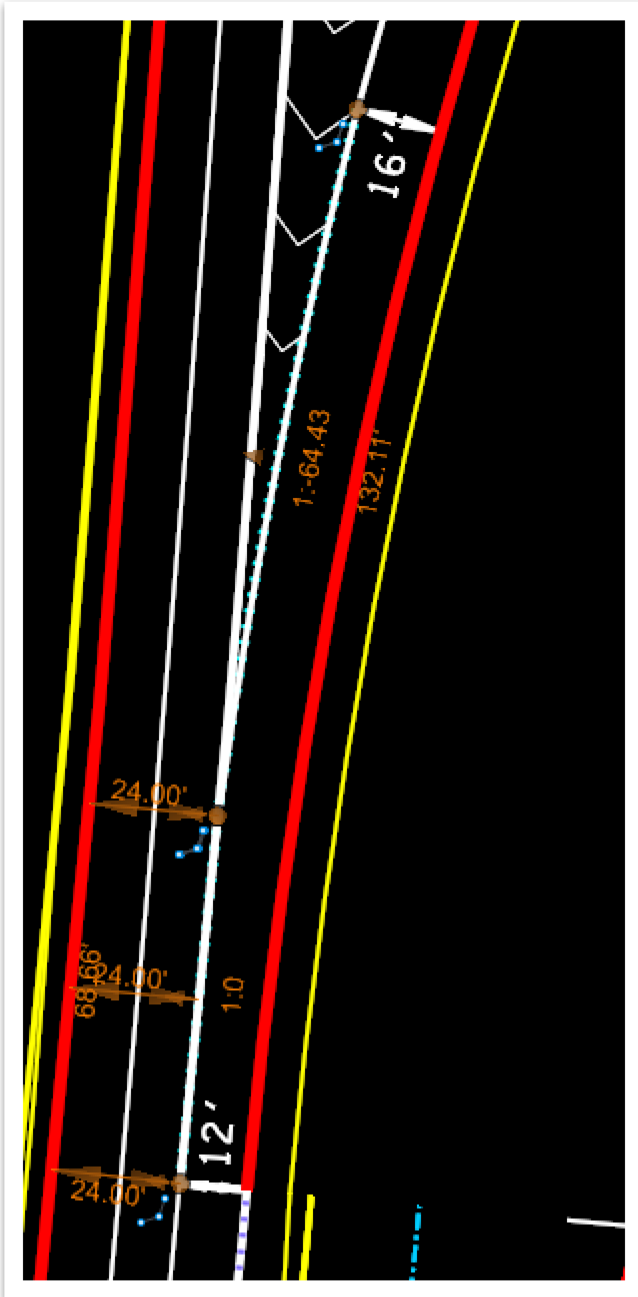
15. Next, open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and then select the **EOP_RM** for the **mainline** corridor. Key-in an **Offset** of **24'** from the start of the ramp alignment until the ramp starts to split off. You can snap to the start of the EOP curve in the **ROAD-II-RG-Proposed.dgn** reference file. In this scenario, the distance is approximately **68.5'**. **Note:** The **EOP_RM** line should be on top of the Northbound alignment. You can turn off the **DES - CL - Proposed** level in the **ROAD-II-RG-Alignments.dgn** reference file, if necessary, so that it is easier to select the line.



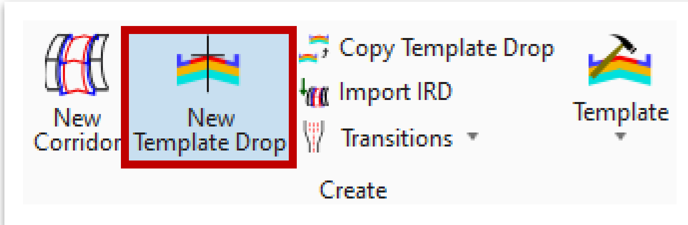
16. With the same **Prop EOP - CTRL** feature definition still set, open the **Variable Offset Taper** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**). Select the ramp alignment and snap to the line just created. Then, snap to the **16'** dimension in the **ROAD-II-RG-Proposed.dgn** reference file.



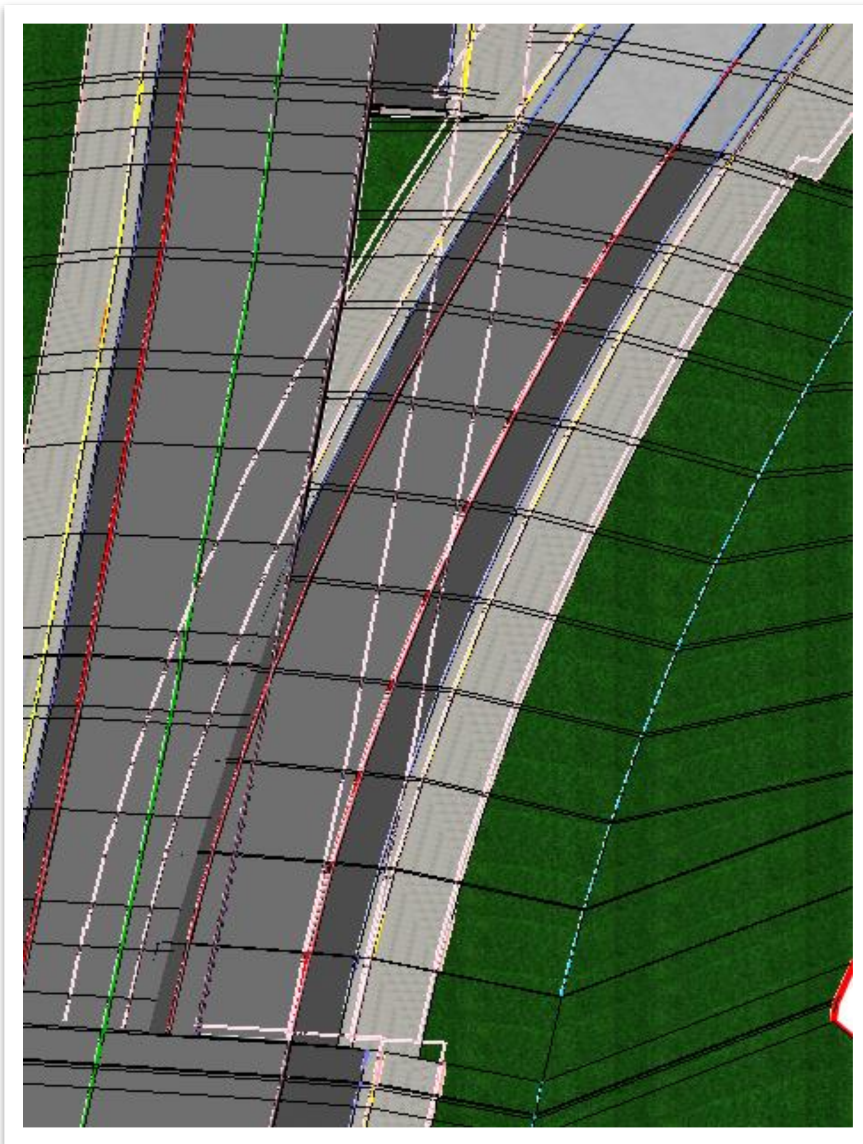
17. Once completed, complex the two lines that were just created and then turn on all levels in the active file.



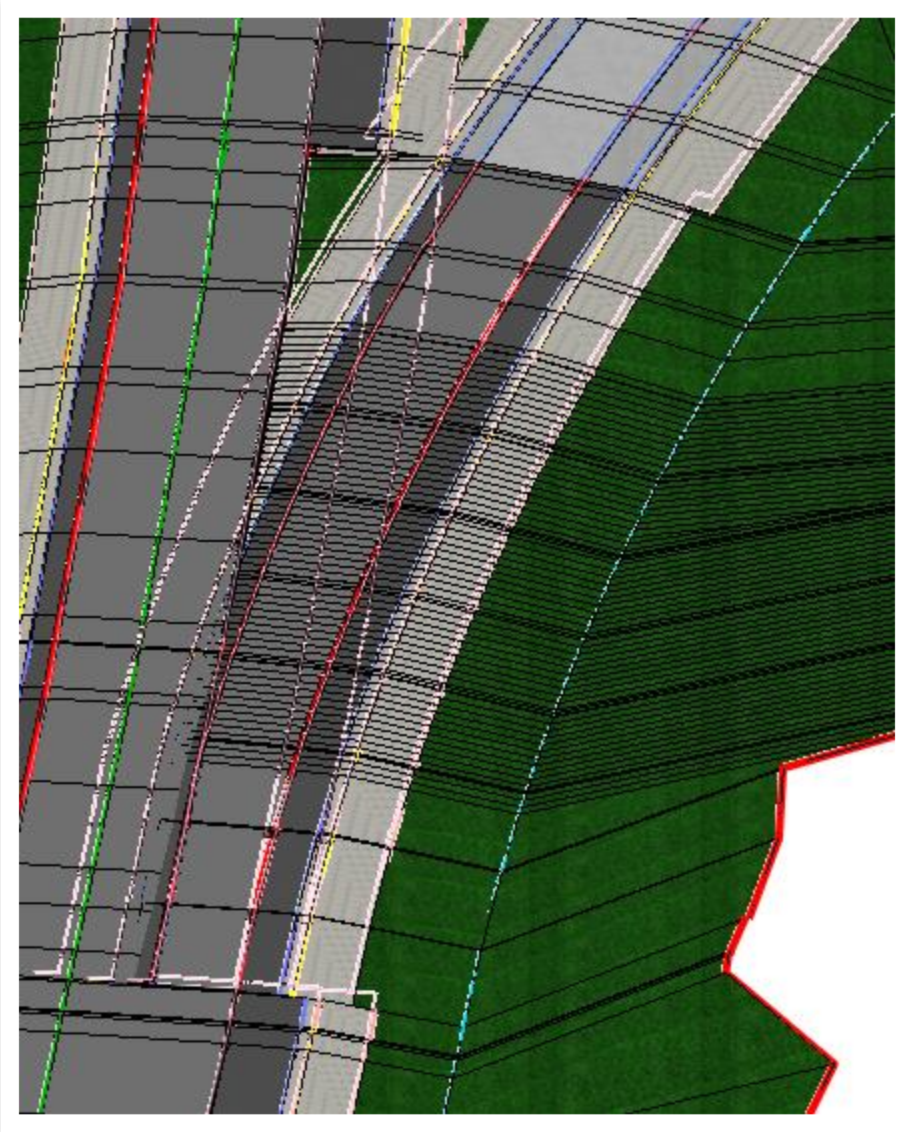
18. Now, open the **New Template Drop** tool (**OpenRoads Modeling >> Corridors >> Create**).



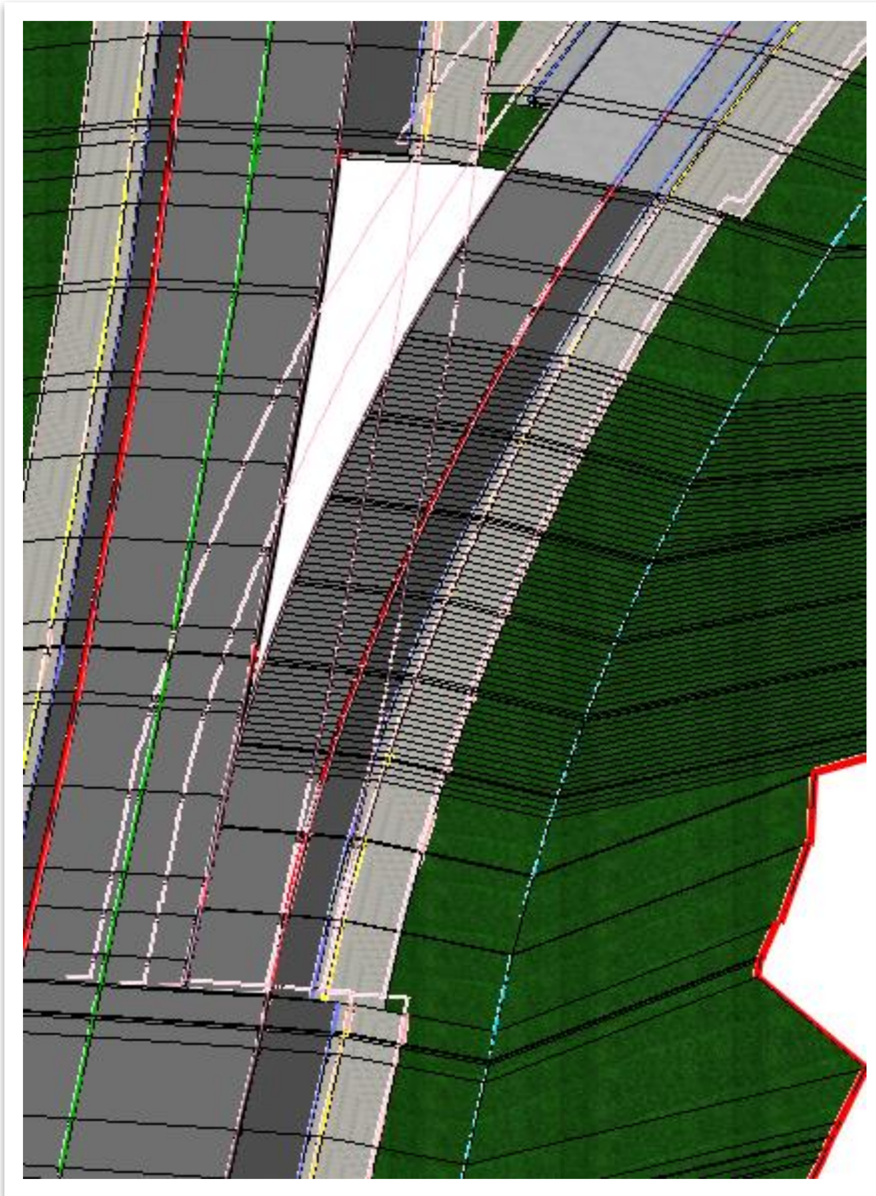
19. Select the **TS-4 RIGHT (1LN) - 4 LAYER** template (**Linear Templates >> TDOT Typical Sections >> Undivided**). Then, select the **ramp** corridor and place the template from the start of the ramp alignment (Station **500+00**) to where the concrete ramp begins (Station **502+51.09**).



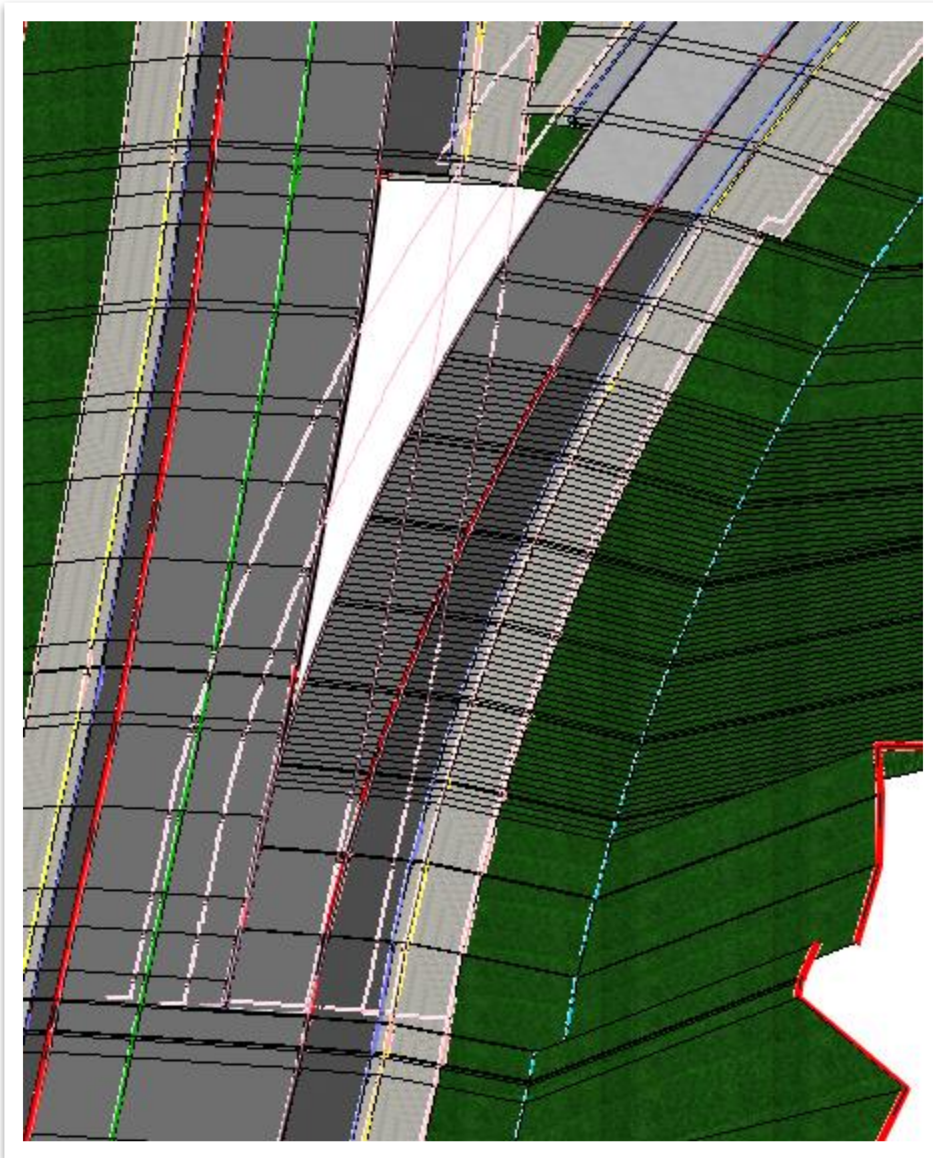
20. Next, open the **Create Point Control** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**). Select the **ramp** corridor and then select the following settings.
    a. **Start:** 500+00.00 (start of asphalt template)
    b. **Stop:** 502+51.09 (end of asphalt template)
    c. **Control Description:** Blank
    d. **Point:** EOP_L (ramp)
    e. **Mode:** Horizontal
    f. **Control Type:** Linear Geometry
    g. **Plan Element:** EOP - CTRL (geometry created for the plan element)
21. Click through the remaining prompts and notice that the **EOP_L** now follows the control line.



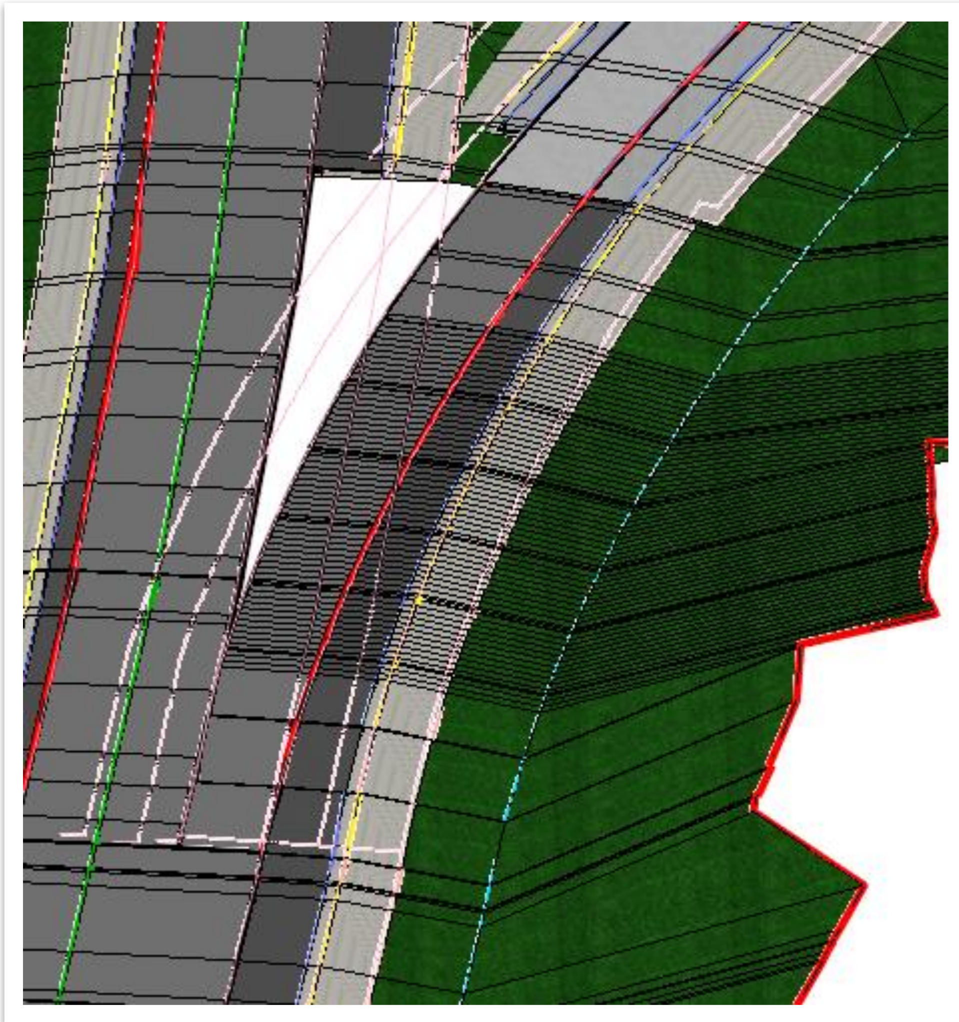
22. Now, open the **Create Parametric Constraint** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**). Select the asphalt ramp template and then select the following settings.
    a. **Start:** 500+00.00 (start of asphalt template)
    b. **Stop:** 502+51.09 (end of asphalt template)
    c. **Constraint Label:** SHLD_OFF_LEFT
    d. **Start** / **Stop Values:** 0.10



23. We need to match the outside shoulder width of the mainline corridor. Go ahead and open the **Create Parametric Constraint** tool once again (**OpenRoads Modeling >> Corridors >> Edit >>Edits**) and create another **parametric constraint** along the entire asphalt template (Station **500+00.00** to Station **502+51.09**). This time, however, set the **Constraint Label** to **GSH_R_Width** and set the **Start** / **Stop Values** to **12.00** and **8.00**, respectively.

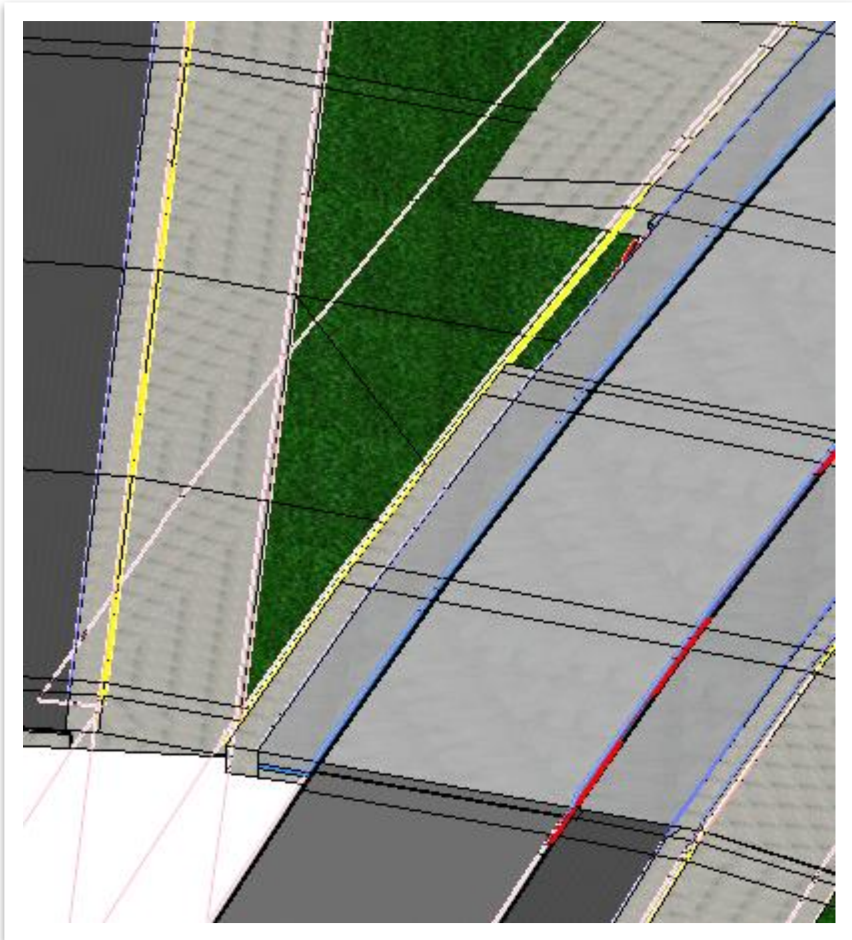


24. In addition to the shoulder transition, we need to transition the standard ditch depth. The ditch depth for the I65 mainline is **3.5'** but the ditch depth for the ramp is **4.17'**. Create another **parametric constraint** using the **DITCH_Depth_R** constraint label to transition the ditch depth across the asphalt ramp with the **Start** / **Stop Values** set to **-3.50** and **-4.17**, respectively.

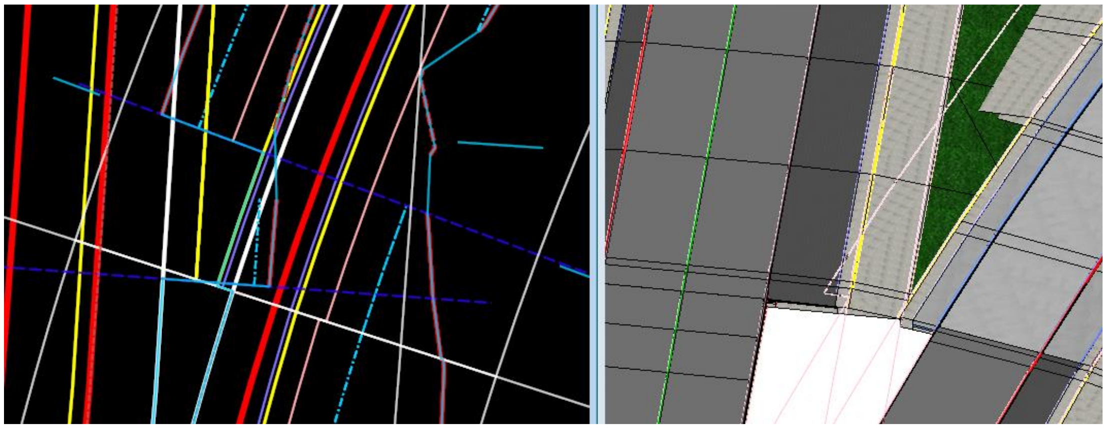


25. Next, we will model the gore between the templates. Go ahead and turn off the **ROAD-II-RG-Proposed.dgn** reference file.

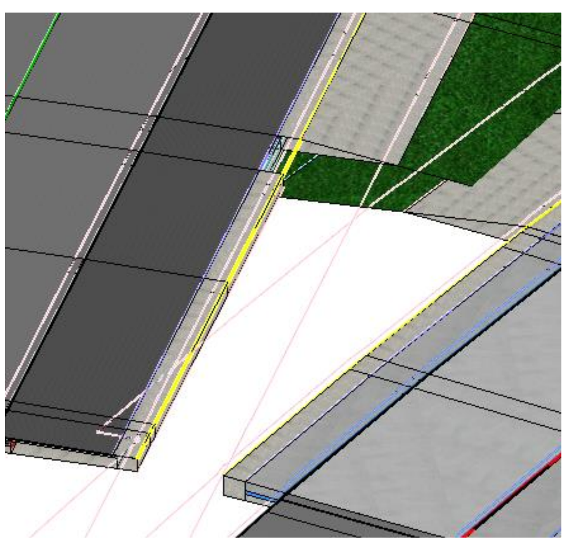
26. Open the **Create Parametric Constraint** tool once again (**OpenRoads Modeling >> Corridors >> Edit >>Edits**). Select the **ramp** corridor, and then select the following settings to adjust the **left** end condition within the **concrete** template.
    a. **Start:** 502+51.09 (start of the concrete template)
    b. **Stop:** 503+01.09 (**Note:** The length of the gravel shoulder at a minimum must be long enough so that the mainline graded shoulder, which extends down to meet at the subgrade, is above the same point on the ramp template drop. In this scenario, 50 feet was added to the start station.)
    c. **Constraint Label:** EC_OFF_LEFT
    d. **Start** / **Stop Values:** 0.10



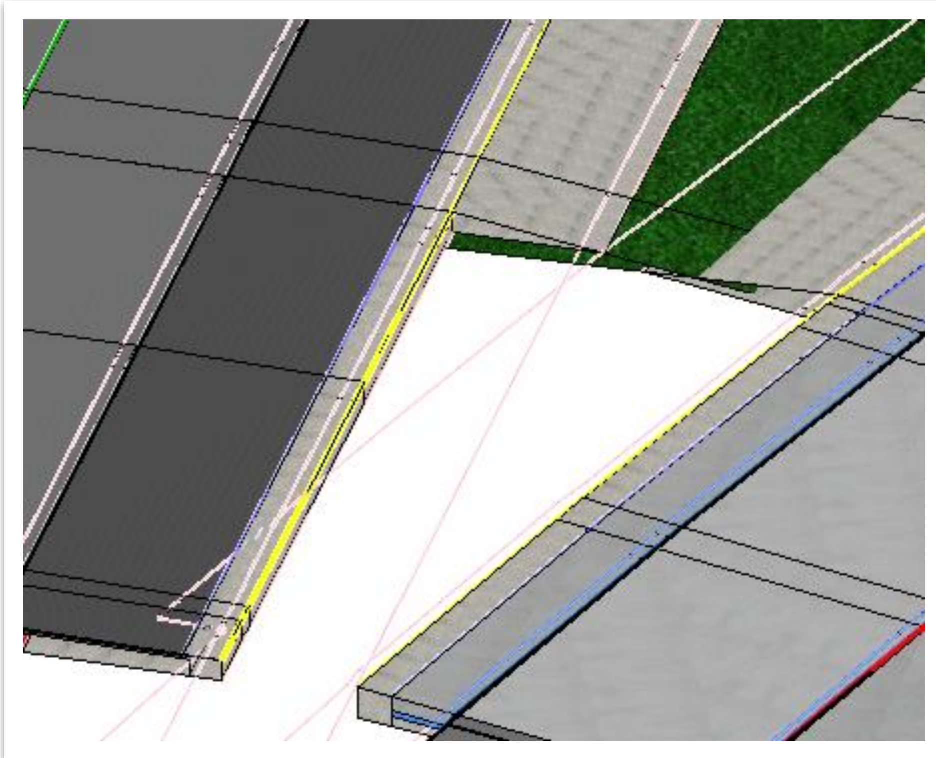
27. Now open the **Create Key Station** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and add a key station at **503+01.10** (right after the end of the parametric constraint) to close the missing part of the template.



28. Once completed, open back up the **ROAD-II-RG-I65 Corridor.dgn** file. Confirm that the **ROAD-II-RG-Proposed.dgn** reference file is turned off. It will not be needed for the remainder of the modeling.
29. Next, we will repeat the parametric constraint steps for the mainline corridor. Open the **Create Parametric Constraint** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and select the mainline corridor. Then, select the following settings.
    a. **Start:** 416+43.93 (start of the shoulder)
    b. **End:** 416+93.93 (add 50' to the start)
    c. **Constraint Label:** EC_OFF_RIGHT
    d. **Start** / **Stop Values:** 0.10

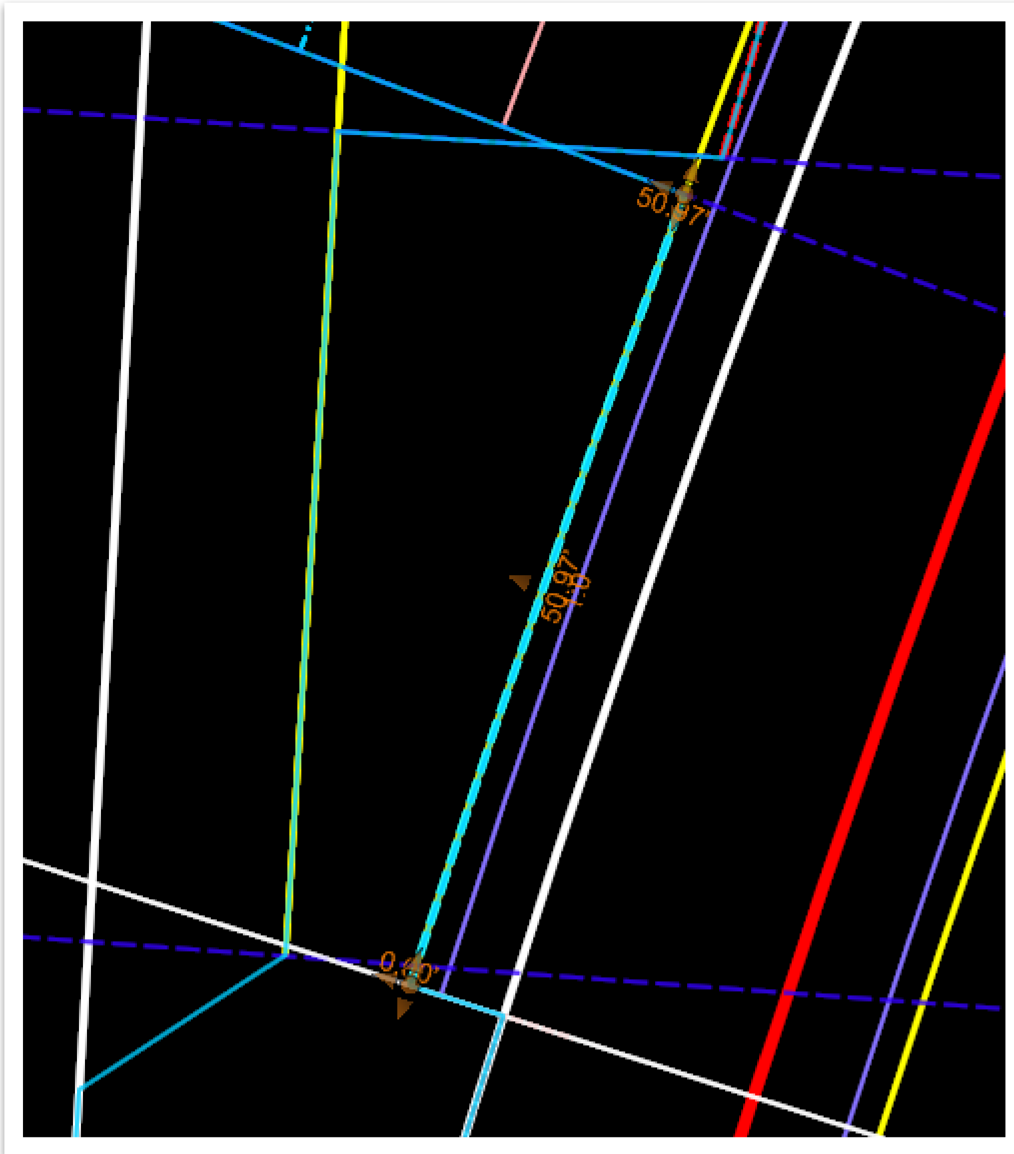


30. Now, open the **Create Key Station** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and add a key station at **416+93.94** (right after the end of the parametric constraint) to close the missing part of the template.

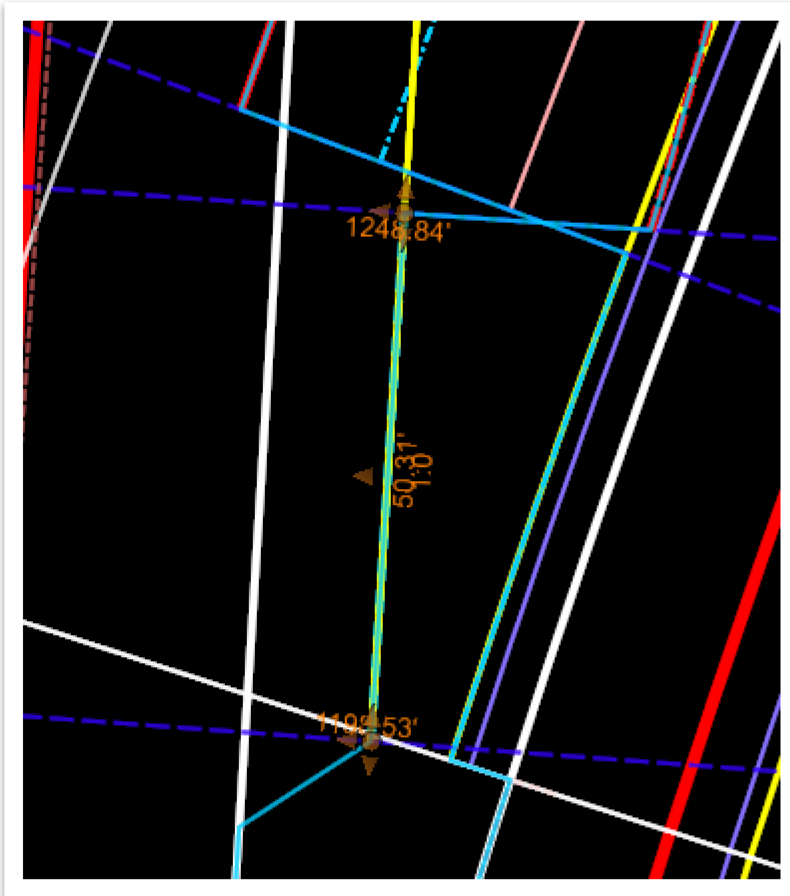


31. We will now draw the controlling lines for the two surface templates we are going to create. Open the **ROAD-II-RG-Ramp Corridor.dgn** file once again. Select the **Special Ditch - EDGE - IN - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Special Ditch**).

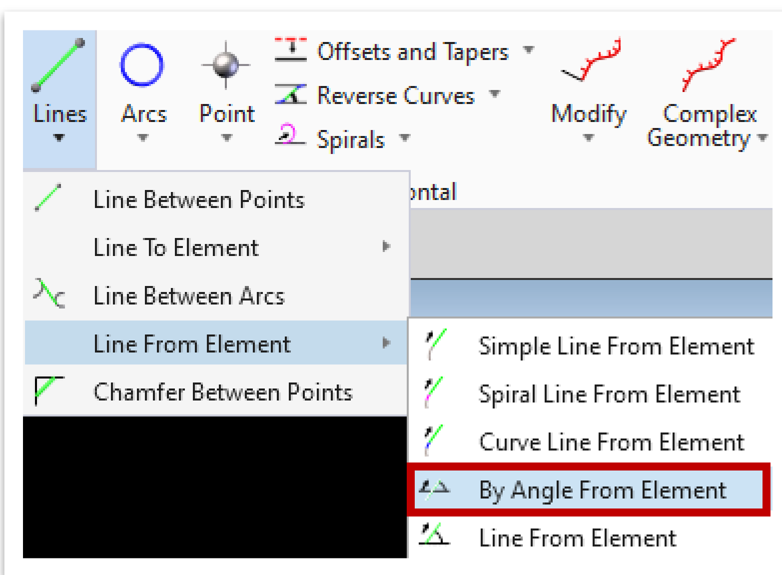
32. Next, open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and then select the **GSH_L** for the **ramp** from the start of the **concrete** template. Key-in and **Offset** of **0'** and make the end of the line at the end of the parametric constraint.



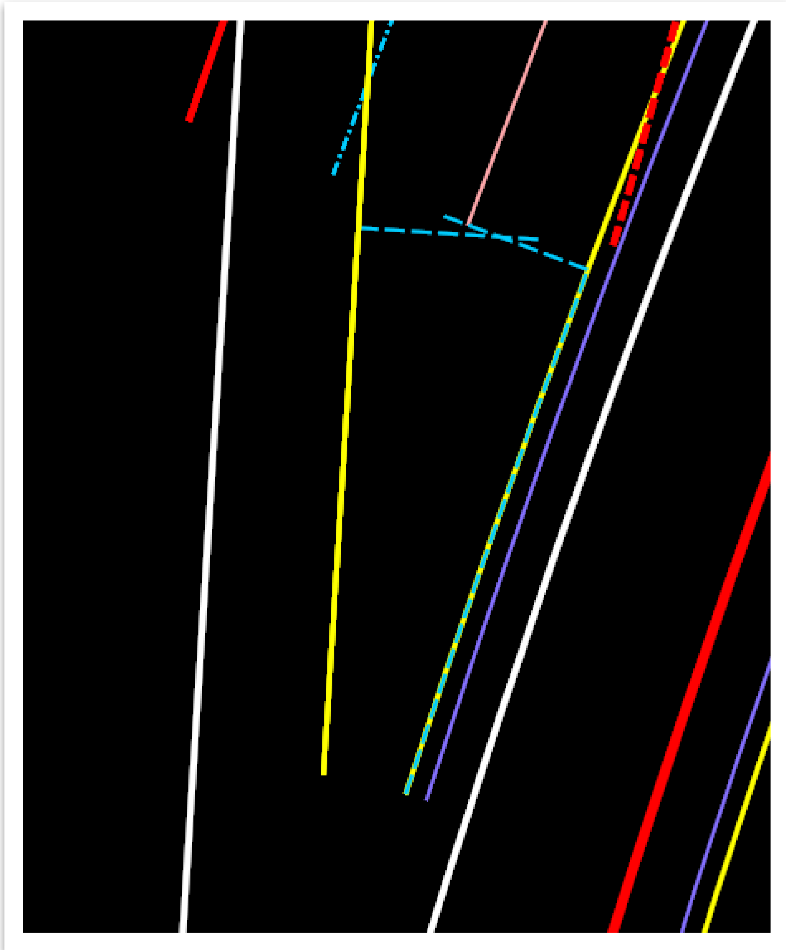
33. Repeat the previous step for the **PSH_R** line on the **mainline** corridor.



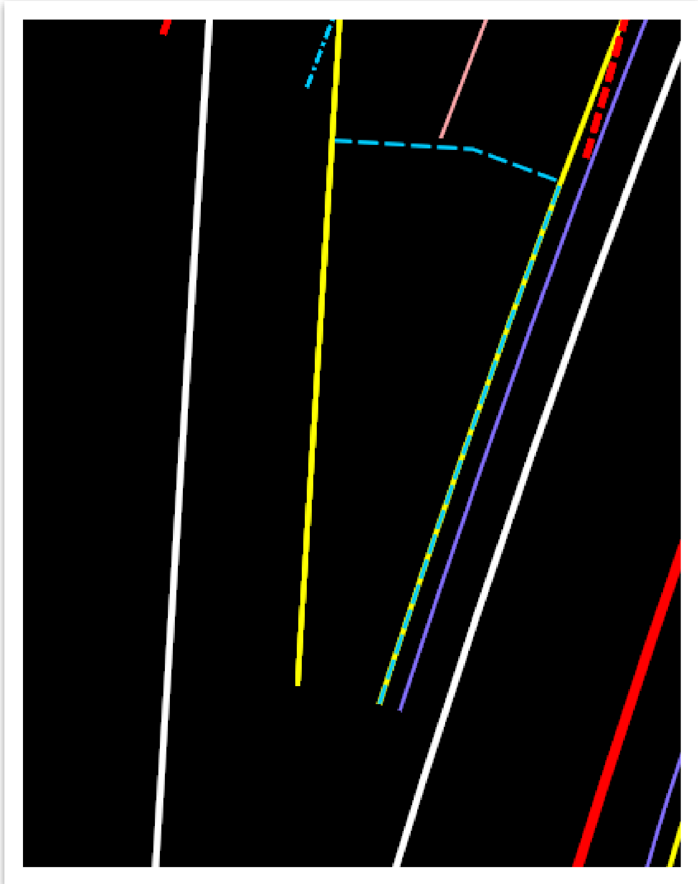
34. Within the feature definition toolbar, make sure **Create 3D Automatically** is still toggled on. Open the **By Angle From Element** line tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines >> Line From Element**).



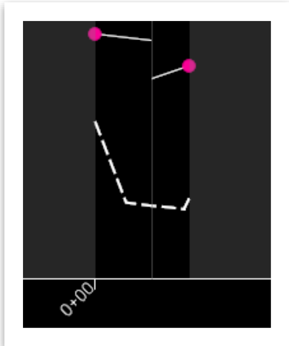
35. Select the offset line drawn in Step 32 and snap to the end of the offset for the start point. Key-in a **90˚** skew and click the end of the offset again. Then, select towards the other corridor to draw the line. Repeat the step for the offset line drawn in Step 33 to create the two lines shown below. **Note:** Since the yellow **GSH** lines lie on top of the offset lines, you can turn off the **DES - MODEL - Lines - Shoulder Edge** level in the **ROAD-II-RG-I65 Corridor.dgn** reference file, if necessary, so that it is easier to snap to the offset lines.



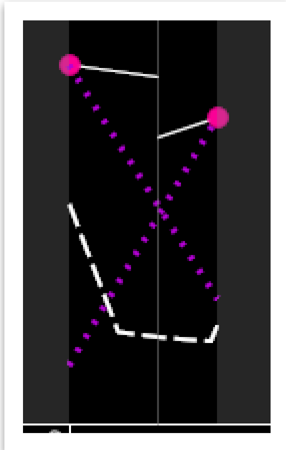
36. Now, use the geometry handles and the intersection point snap to drag the handles of the two lines and snap to each other. Then, complex the two perpendicular elements that were just drawn from left to right.



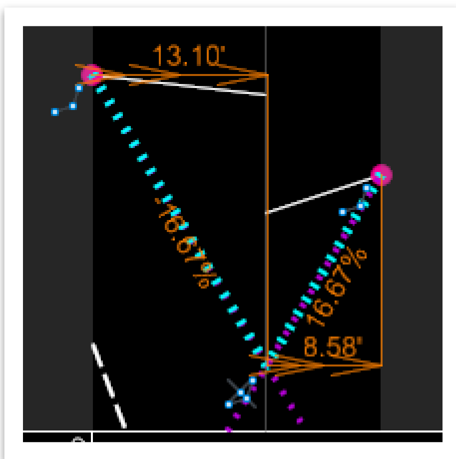
37. Next, open the **profile** of the complex element just drawn and then open the **Profile Intersection Point** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Profile Creation**). In plan view, select the ditch line that was just drawn (complexed) in Step 36 and then select the two offset ditch lines that were created in Steps 32 and 33. **Two** pink dots should show up in the profile of the ditch line. **Note:** The automatically generated profile lines shown below do not matter. We will create new profiles in the upcoming steps.



38. Since the slopes of the gravel shoulders are **6:1**, go ahead and draw a profile line from each pink intersection point that slopes downwards at a **6:1** (16.67%) slope.

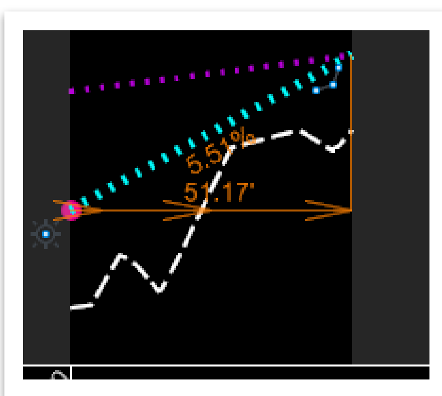


39. Now, draw two new lines that follow the first two lines drawn in the previous step, to create a **V ditch** and then complex the two lines and set the line to **active**. **Note:** The automatically drawn **3D** lines might still be in the 3D model. You can delete those lines now, if necessary.



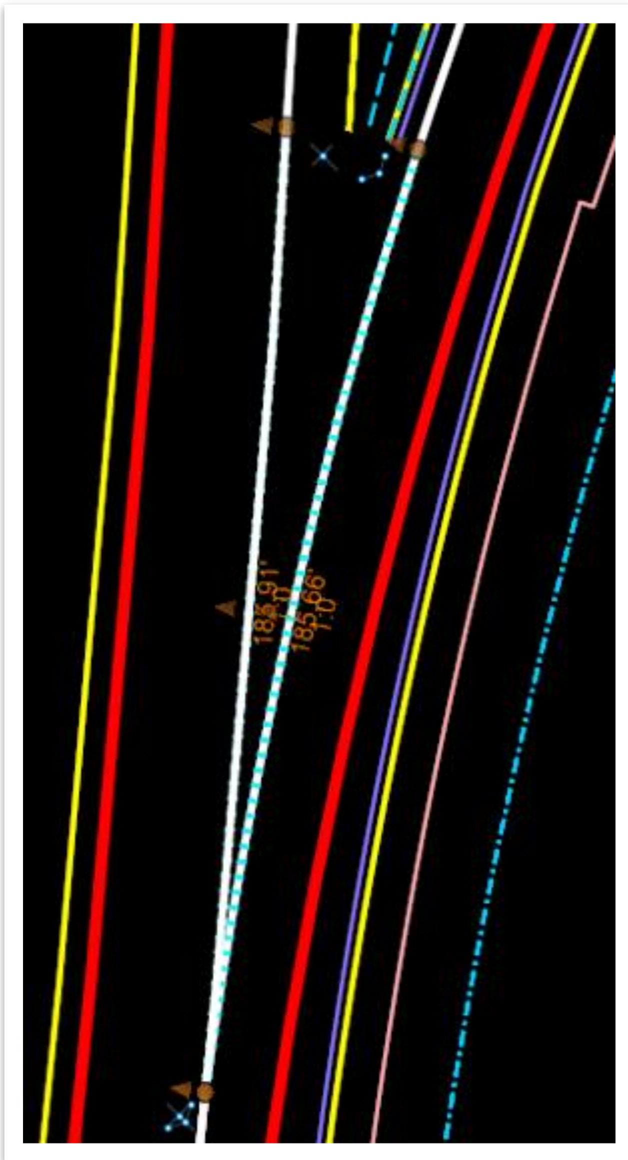
40. Next, we need to draw the break line for the center of the graded area. Open the **Variable Offset Taper** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**). Select the mainline **GSH_R** line and then select the intersection of the horizontal complex geometry that was created in Step 36 as the start of the new control line. Then, place the end of the new control line anywhere near the middle at the end of the two ditch edges towards the gore area.

41. Once drawn, open the profile of the **taper element** and then open the **Profile Intersection Point** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Profile Creation**). Select the taper and then select the horizontal complex geometry to show the pink profile intersection point. Open the **Profile Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Lines**) and draw a line from the pink dot to the other end of the profile that was drawn automatically. Then, set the profile geometry line to the **active** profile.

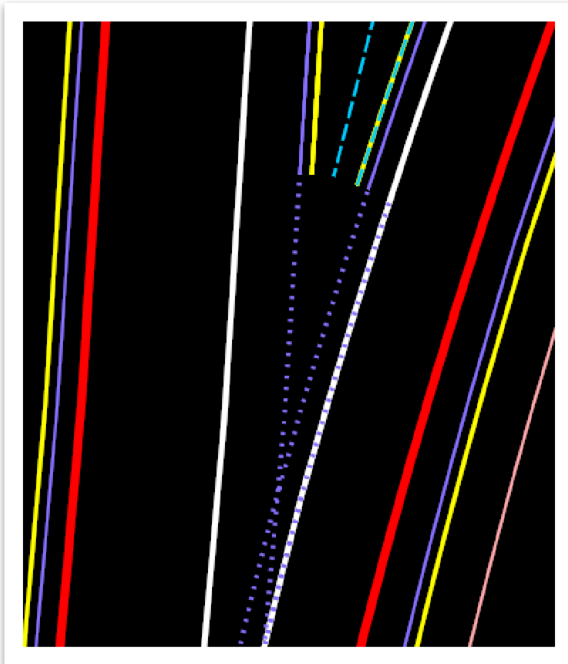


42. Now, we need to model the **asphalt gore** before placing any templates. Select the **Prop EOP - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> EOP**). **Note:** Make sure **Create 3D Automatically** is still toggled on, which will save some profiling steps for the upcoming lines.

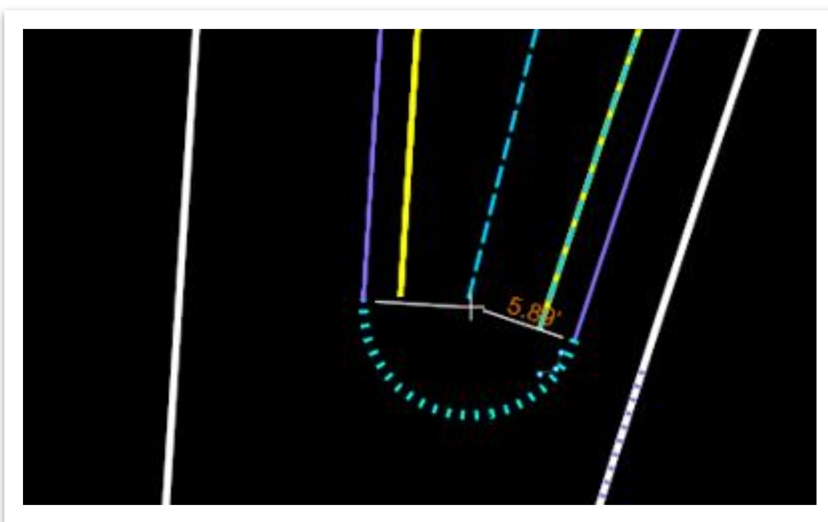
43. Open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and then select the **EOP** for the **mainline** corridor and start at the intersection of the mainline and ramp **EOP** lines. Key-in an **Offset** of **0'** and end the offset at the start of the shoulder line. Then, repeat for the ramp corridor.



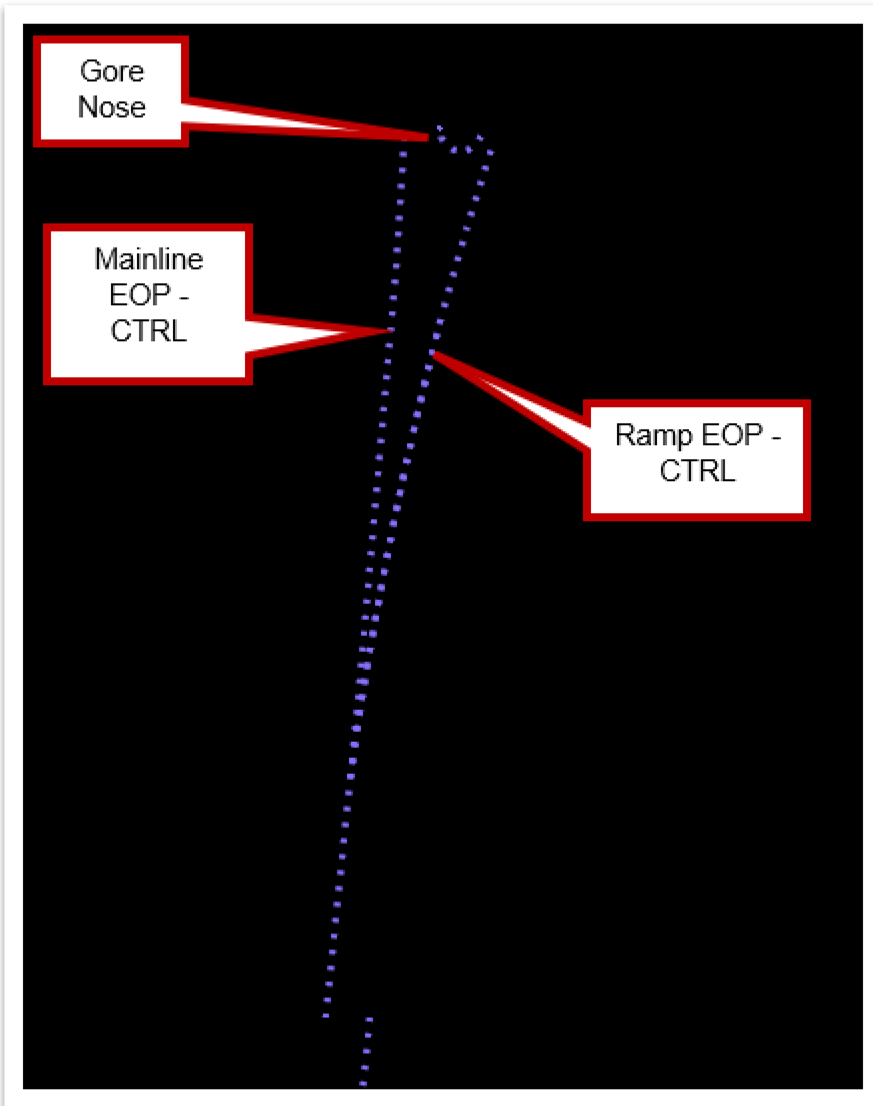
44. Next, open the **Single Offset Entire Element** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and offset the two **EOP - CTRL** lines. First, offset the mainline **EOP CTRL** line **10'**. After placement, open its **properties** and set the **Slope** to **-4.00%**. Then, offset the ramp **EOP CTRL** line **4'** and set the **Slope** to **2.00%**.



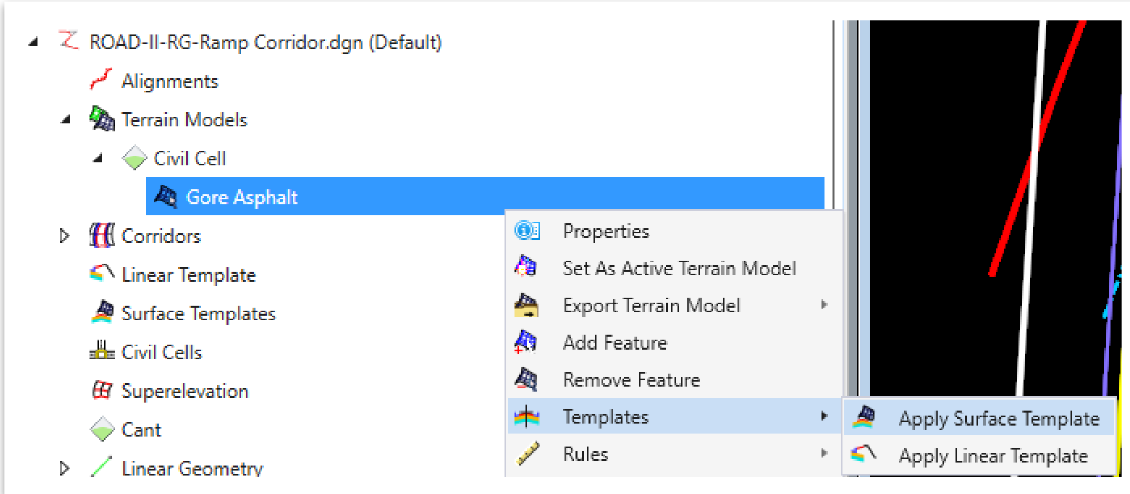
45. Now, we need to create the **curved nose** of the paved gore. Open the **Simple Arc** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Arcs >> Arc Between Elements**). Select the two **EOP - CTRL** lines that were offset in the previous step and then place the arc near the end of the shoulder lines. Set the Trim to **Both**.



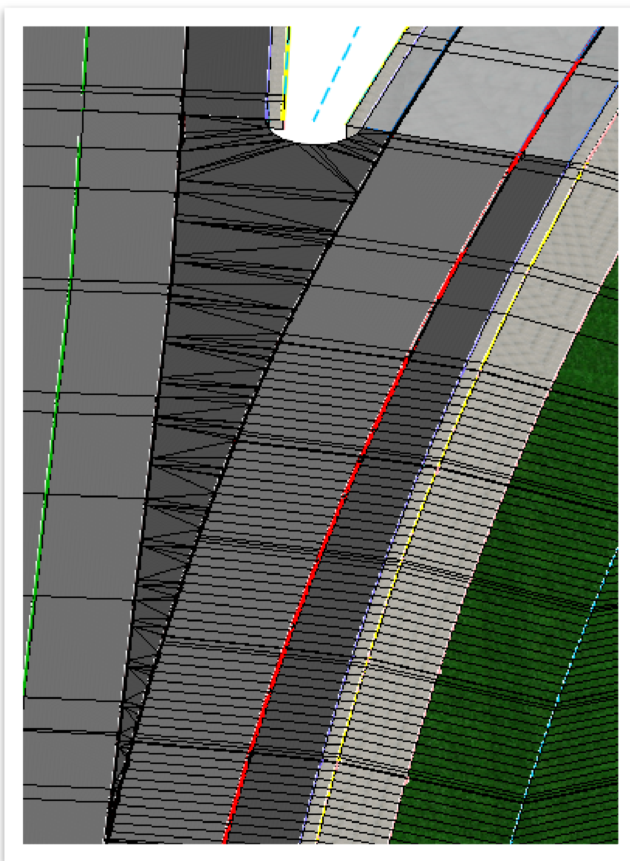
46. Next, open the create terrain **From Elements** tool (**OpenRoads Modeling >> Terrain >> Create**) and select the following settings.
    a. **Feature Type:** Boundary
    b. **Edge Method:** None
    c. **Feature Definition:** Civil Cell
    d. **Name:** Gore Asphalt
47. Then, in the **2D View**, in a clockwise direction, select the **gore nose**, the **Ramp EOP - CTRL** line, and the **Mainline EOP - CTRL** line. **Right** click to accept and then click through the remaining prompts to create the terrain. **Note:** Turn off all levels except the **DES - TRAN - Edge of Traveled Way** level to make it easier to select the three lines.



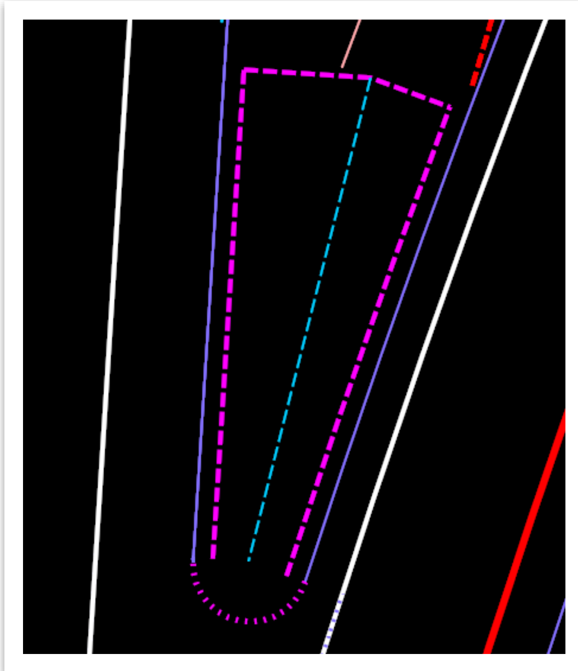
48. Go ahead and open the **Explorer** and locate the **Gore Asphalt** terrain under **OpenRoads Model >> ROAD-II-RG-Ramp Corridor.dgn (Default) >> Terrain Models >> Civil Cell**. **Right** click on the terrain and select **Templates >> Apply Surface Template**.



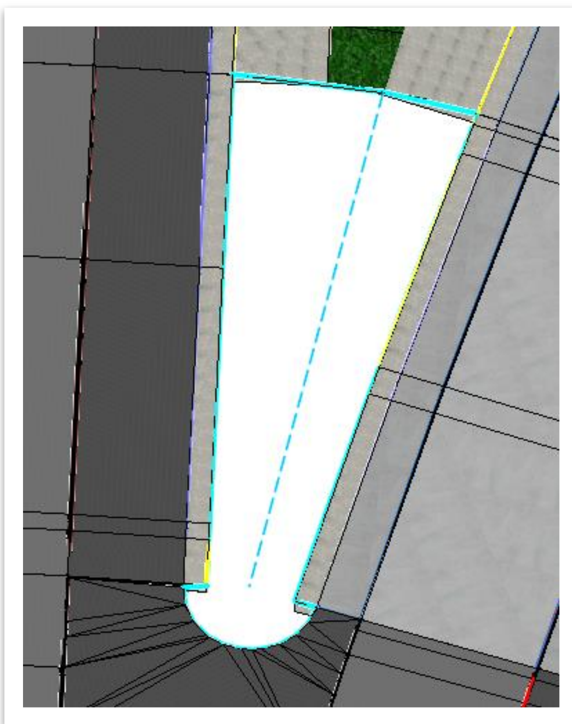
49. Select the **SURFACE - SHOULDER** template (**Linear Templates >> Civil Cells >> Surface**). Toggle off **Apply External Clip Boundary** and then click through the remaining prompts to apply the surface template.



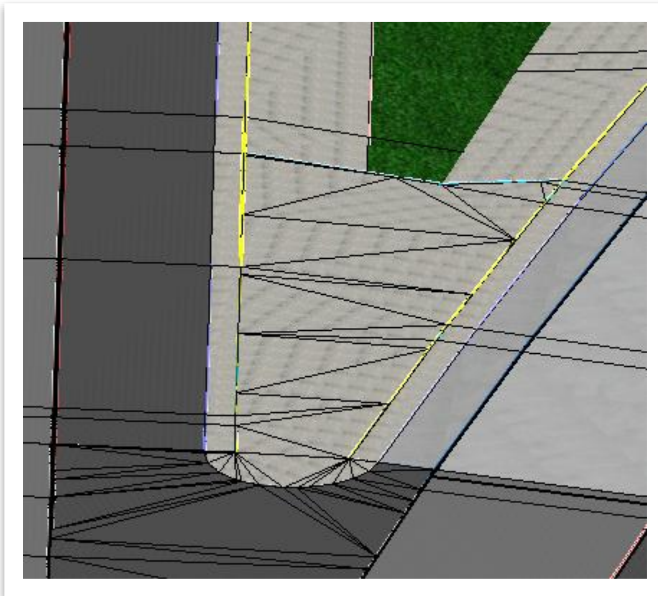
50. Now, open the create terrain **From Elements** tool once again (**OpenRoads Modeling >> Terrain >> Create**). Select the exterior ditch lines and the nose elements in a clockwise direction, but **do not** select the **center ditch line**.



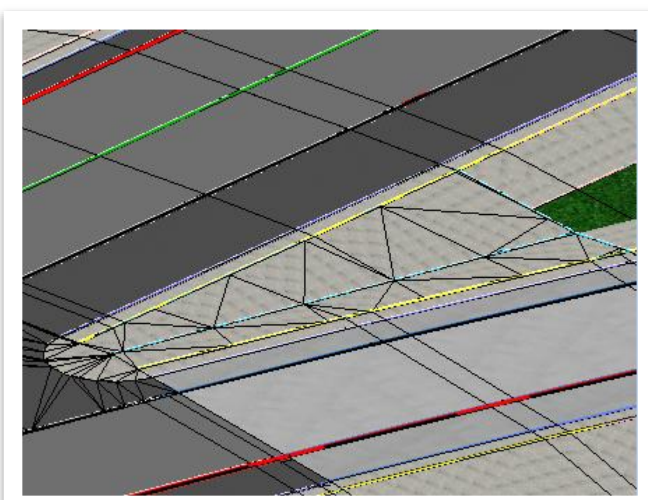
51. Set the **Feature Type** to **Boundary**, the **Edge Method** to **None**. Set the **Feature Definition** to **Civil Cell** and the terrain **Name** as **Gore Aggregate**.



52. Open the **Explorer** once again and locate the **Gore Aggregate** terrain under **OpenRoads Model >> ROAD-II-RG-Ramp Corridor.dgn (Default) >> Terrain Models >> Civil Cell**. **Right** click on the terrain and select **Templates >> Apply Surface Template**.
53. Select the **SURFACE - AGGREGATE** template (**Linear Templates >> Civil Cells >> Surface**). Toggle off **Apply External Clip Boundary** and then click through the remaining prompts to apply the surface template.



54. Lastly, we need to add the break line down the middle of the surface. **Right** click on the **Gore Aggregate** terrain once again in the **Explorer** and select **Add Feature**. Select the center **ditch line** drawn and then **right** click to accept. Set the **Feature Type** to **Break Line** and then click through the remaining prompts to accept. Notice that the ditch has been added to the surface and the modeling of the ramp gore is complete.

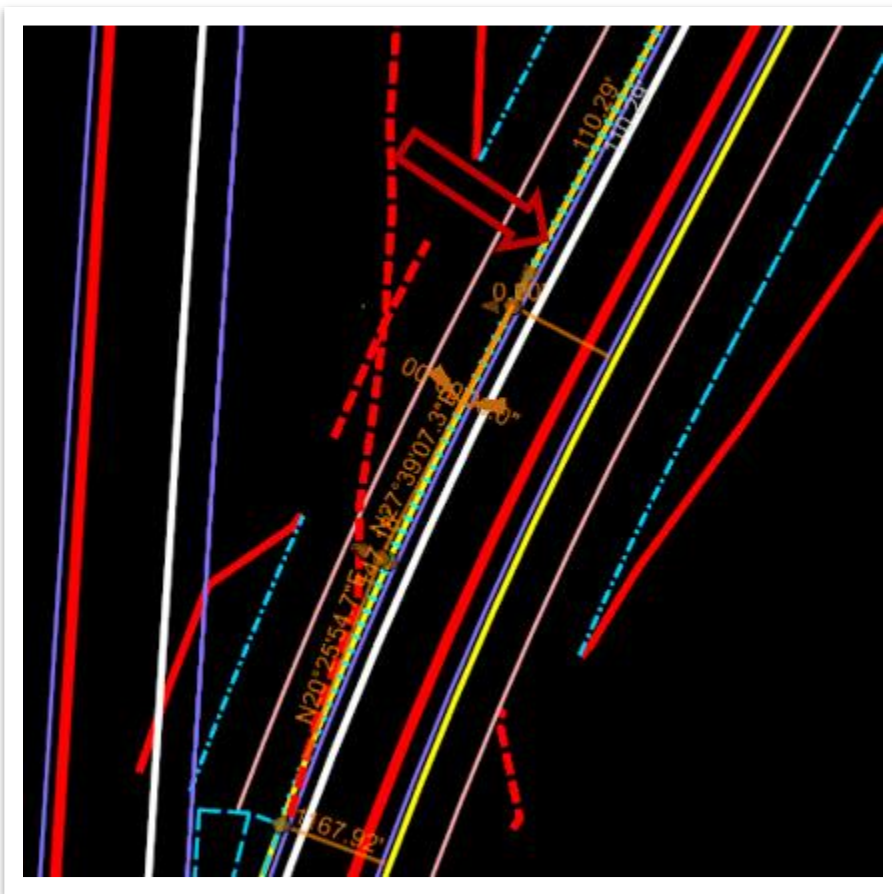


11.4 Exercise: Modeling a Ditch Between Two Corridors

In this exercise, we will target a ditch and merge the end conditions of two corridors. We will continue to utilize the same **ROAD-II-RG-Ramp Corridor.dgn** file.

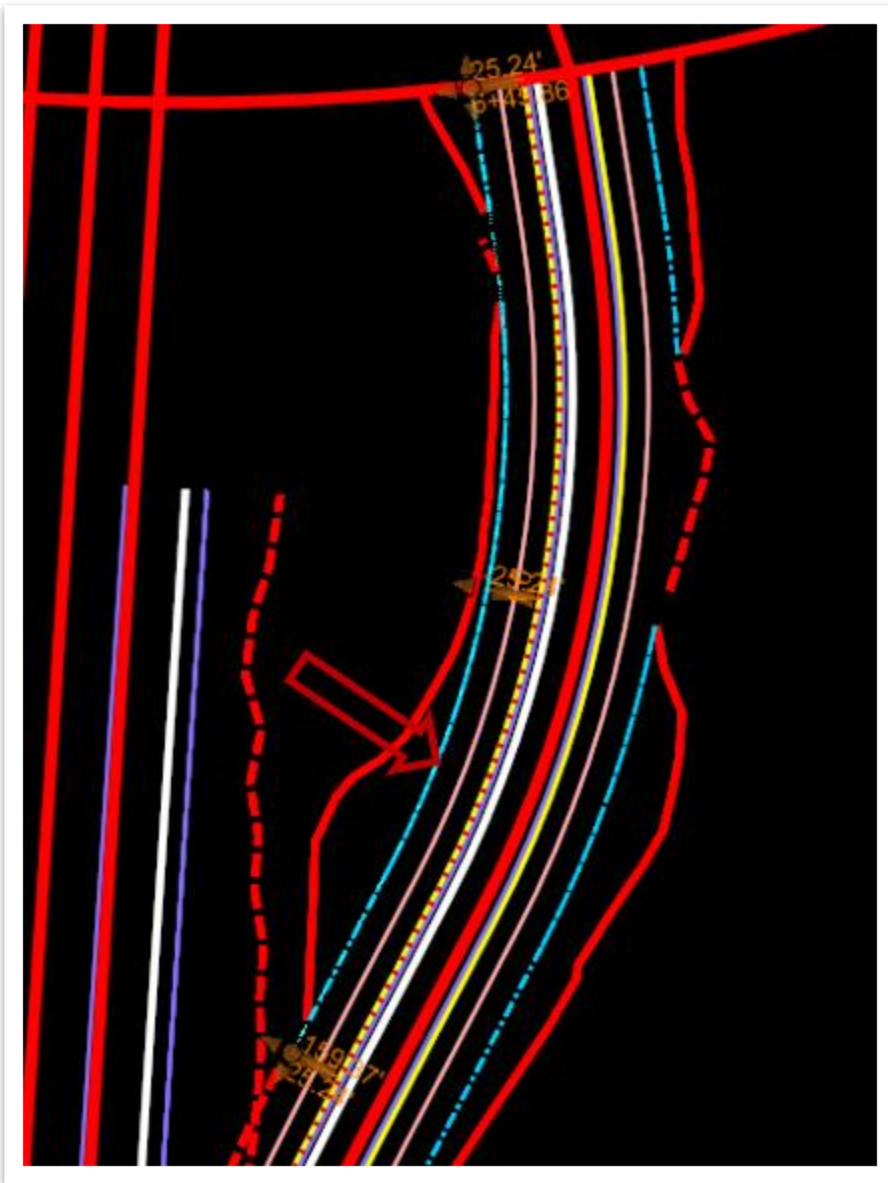
1. In the **2D** view, select the **Shoulder - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Shoulder**) and make sure **Create 3D Automatically** is toggled on.

2. Next, open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the **GSH_L** for the ramp. Key-in an **Offset** of **0'** and toggle on **Remove Offset Rule**. Select the start of the line right after the end of the gore aggregate surface and the end of the line at the end of the template. **Do not snap to any lines on the gore aggregate** or this will make a recursive constraint later. **Note:** If preferred, the user could offset from the alignment and change the slope instead of removing offset rules, which would not cause a recursive constraint.



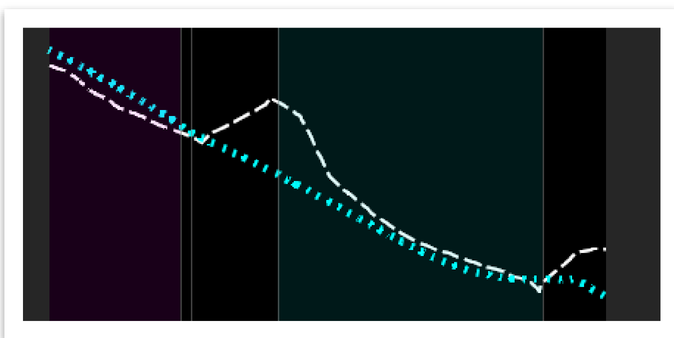
3. Now, select the **Special Ditch - CL - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Special Ditch**).

4. Go ahead and open the **Single Offset Partial** tool once again (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the **Shoulder - CTRL** line. Key-in an **Offset** of **-25.24'** and toggle off **Remove Offset Rule**. Place the start of the line near the large cut section in the north portion of the ramp corridor but remember **do not snap to anything within the corridor**. Place the end of the line at the end of the ramp corridor.

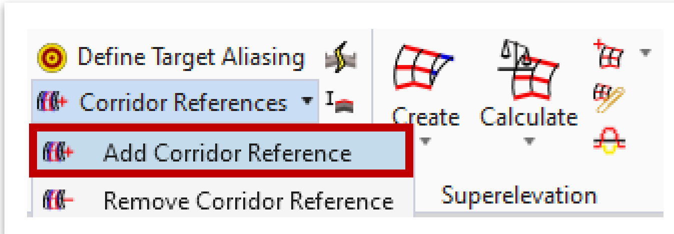


5. Next, open the **Variable Offset Taper** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the **Shoulder Control** line. Set the start of the line near the ditch line of the gore aggregate. **Do not snap to the ditch line** created in the previous exercise but you can snap to the ditch line just drawn.

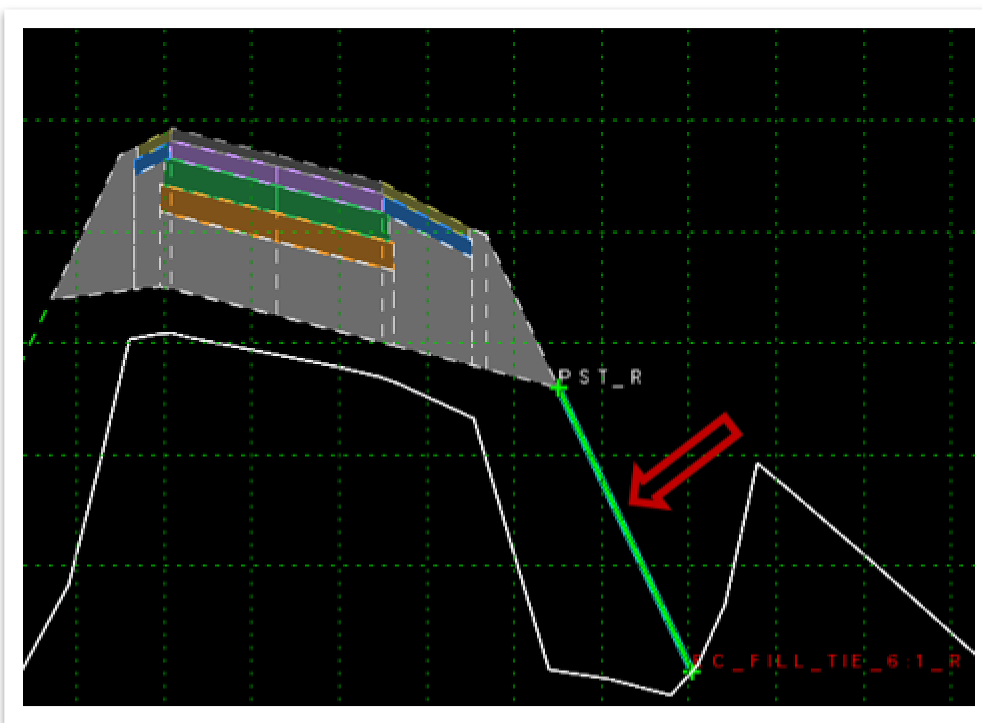
6. For both ditch lines placed, change the offset **Slope** to **-16.67%** in the **properties** of the horizontal line and then complex the ditch lines together. Once completed, open the **profile** of the complex line. Go ahead and complex the two profile lines and set the complex profile to **active**.



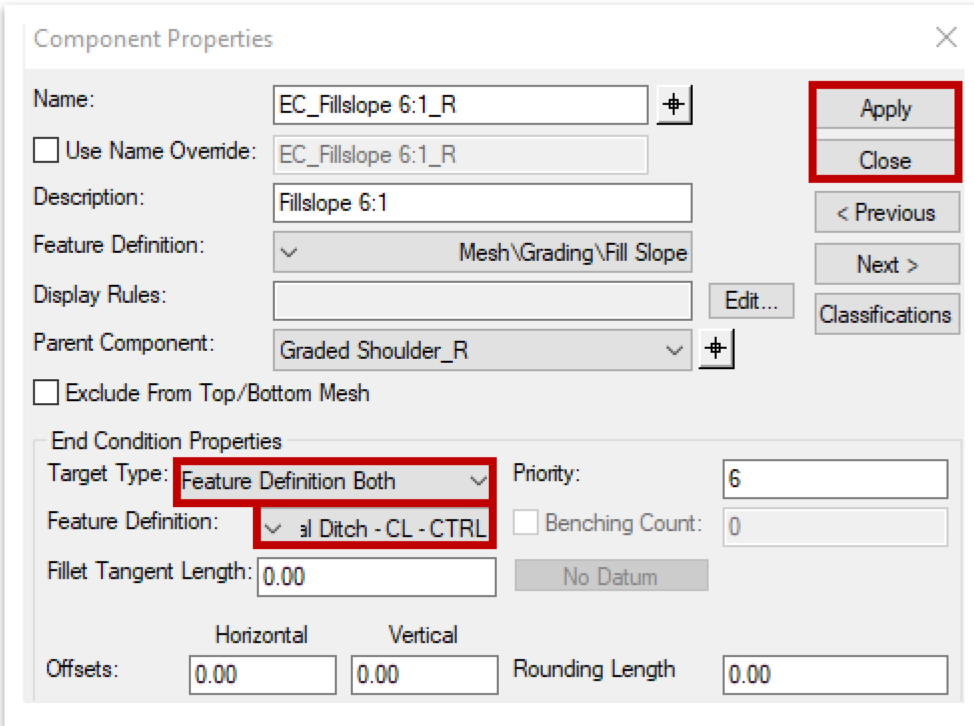
7. Open back up the **ROAD-II-RG-I65 Corridor.dgn** file and then open the **Add Corridor Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor References**). Select the **mainline** corridor and then select the complex ditch control geometry to add the corridor. **Right** click to accept.



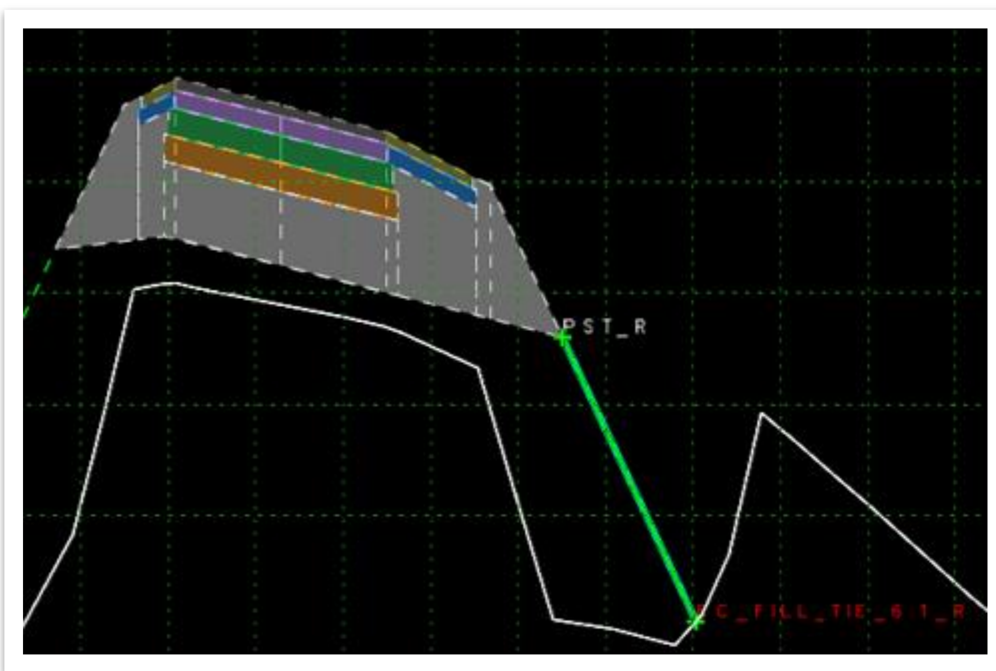
8. Now, open the **Create End Condition Exception** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**). Select the **mainline** corridor and then select the following settings.
    a. **Name:** Mainline End Condition
    b. **Apply ECE To:** Right Override
    c. **Start:** 416+93.94
    d. **End:** 421+13.11
9. A **Right Override** window should open. Double click on the **EC_Fillslope 6:1_R** end condition component.



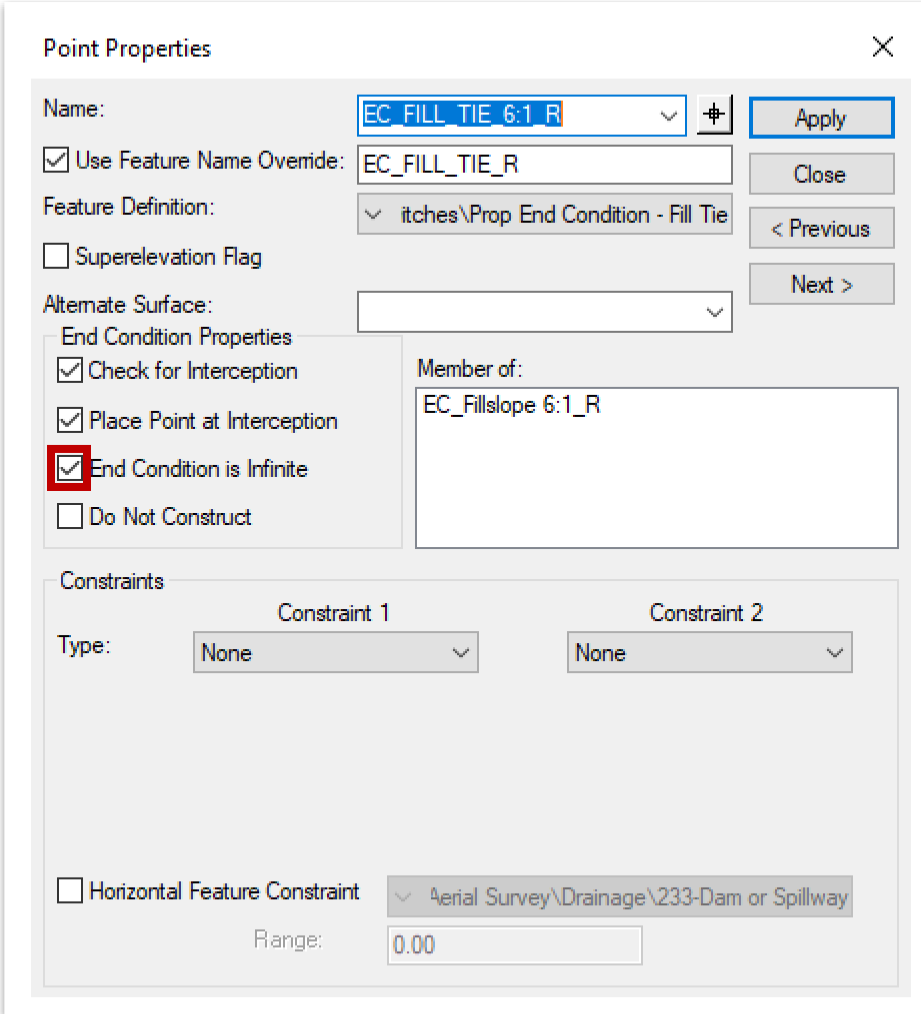
10. Change the **End Condition Properties Target Type** to **Feature Definition Both**. Change the **Feature Definition** to **Special Ditch - CL - CTRL** (**Linear >> Roadway >> Model Control - 2D Plan >> Special Ditch**). Then click **Apply** and **Close**.



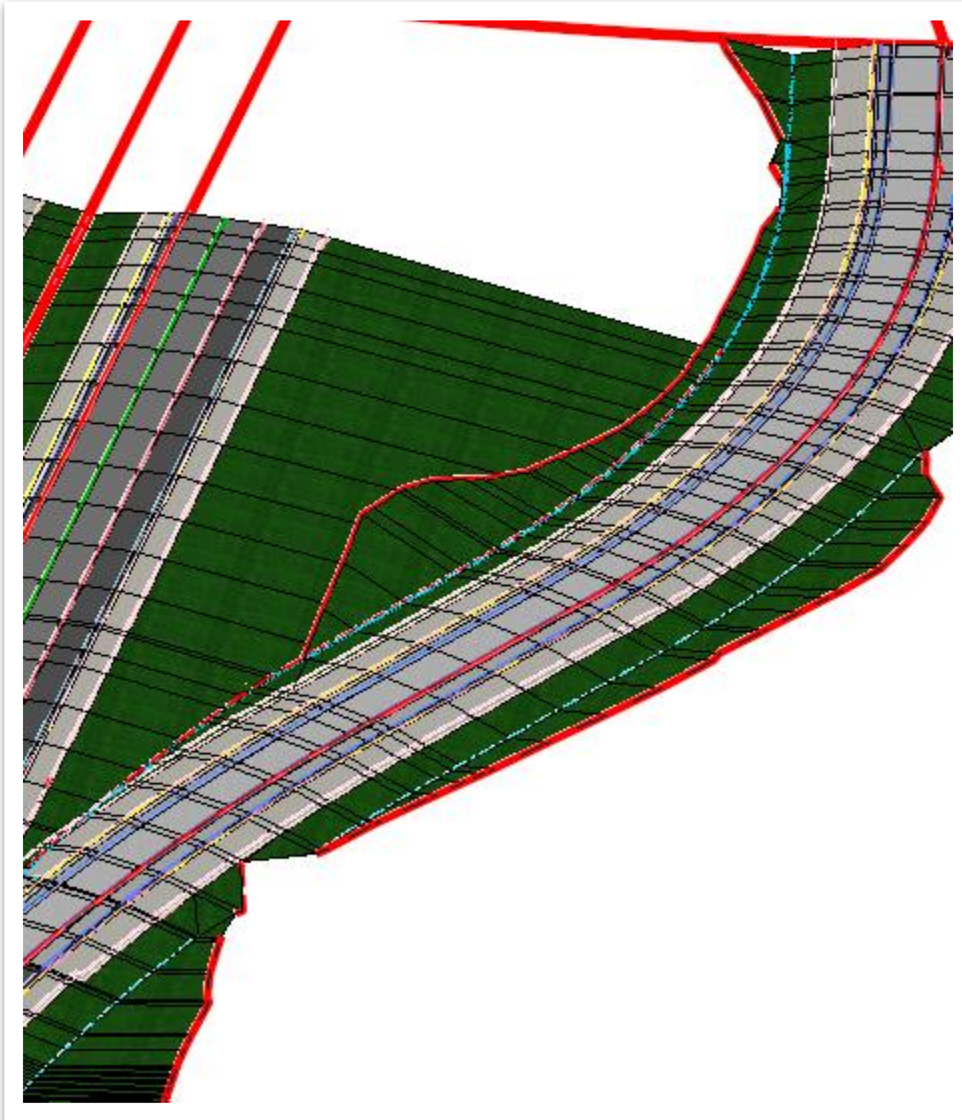
11. Next, double click on the **EC_FILL_TIE_6:1_R** point.



12. Toggle on **End Condition is Infinite**. Then click **Apply** and **Close**.

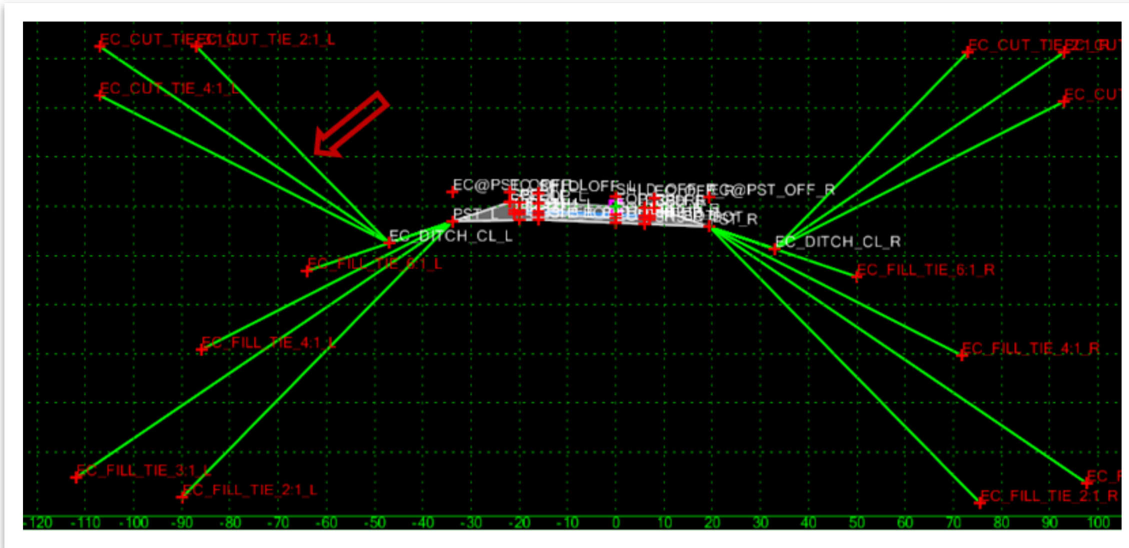


13. Click **OK** in the **Right Override** window and the end condition should now follow the ditch line.

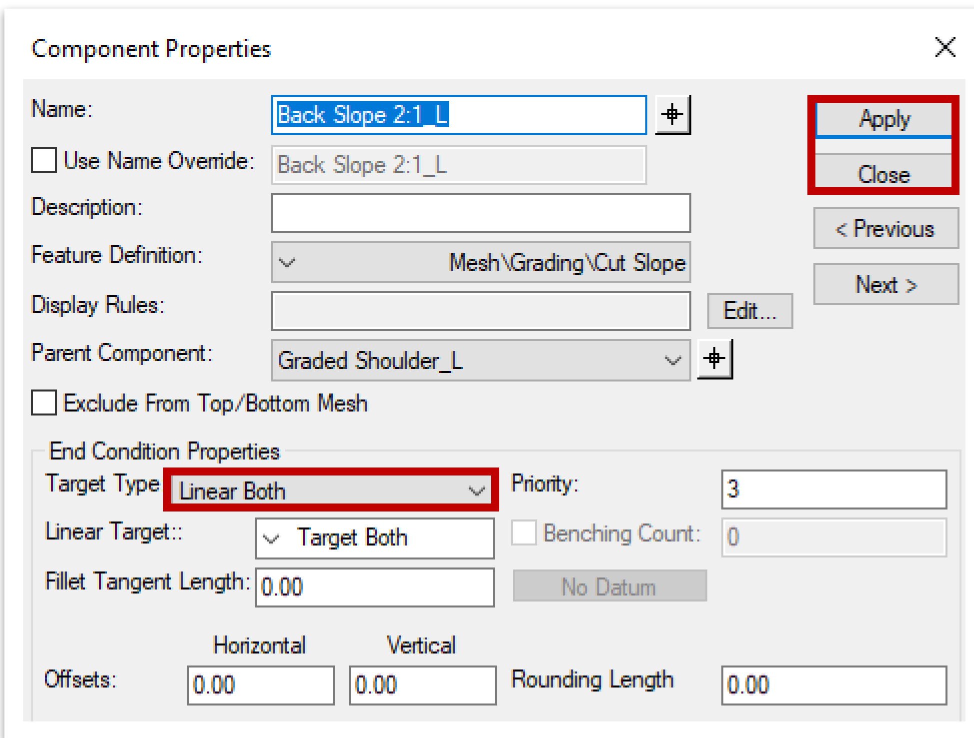


14. Open back up the **ROAD-II-RG-Ramp Corridor.dgn** file and then open the **Add Corridor Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor References**). Add the **ditch** line as a corridor reference to the ramp corridor by selecting the ramp corridor and then the ditch line created.

15. Now, open the **Edit Template Drop** tool (**OpenRoads Modeling >> Corridors >> Edit**) and select the **concrete** template drop. Then, select the **Back Slope 2:1_L** component.

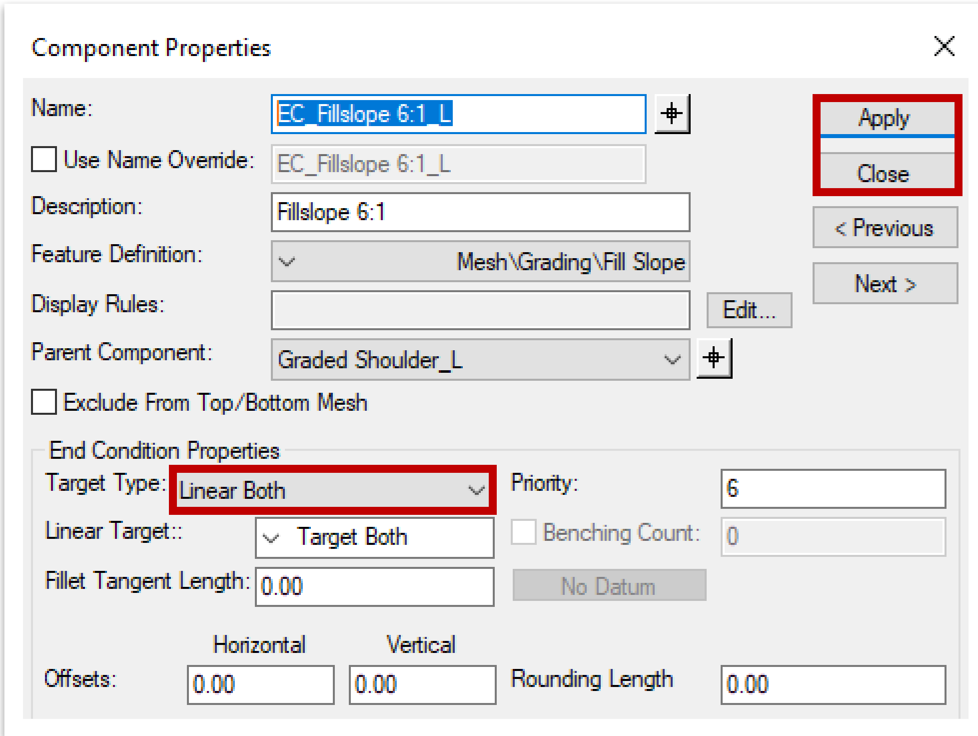


16. Change the **End Condition Properties Target Type** to **Linear Both**. Then click **Apply** and **Close**.



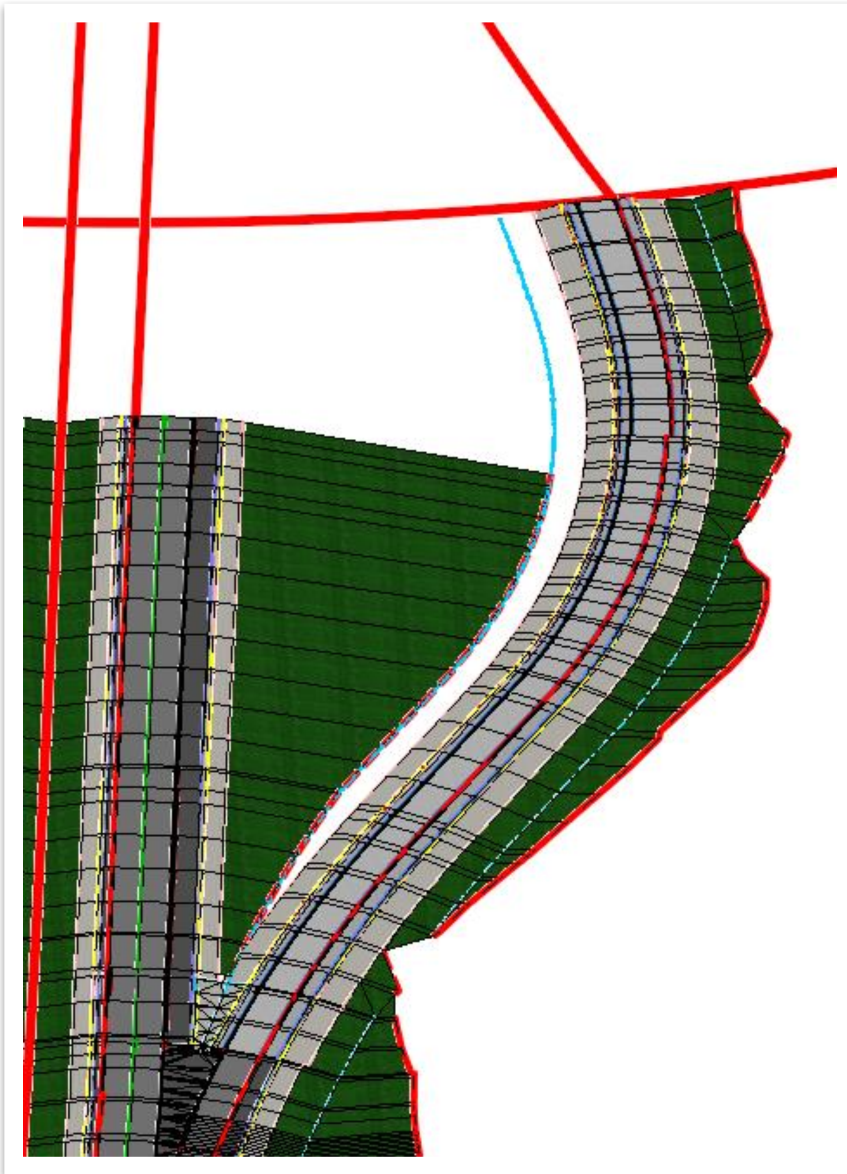
17. Repeat the previous step to change the **Target Type** to **Linear Both** for the remaining **cut** components on the **left** side of the template.

18. Next, select the **EC_Fillslope 6:1_L** component. Change the **End Condition Properties Target Type** to **Linear Both**. Then click **Apply** and **Close**.

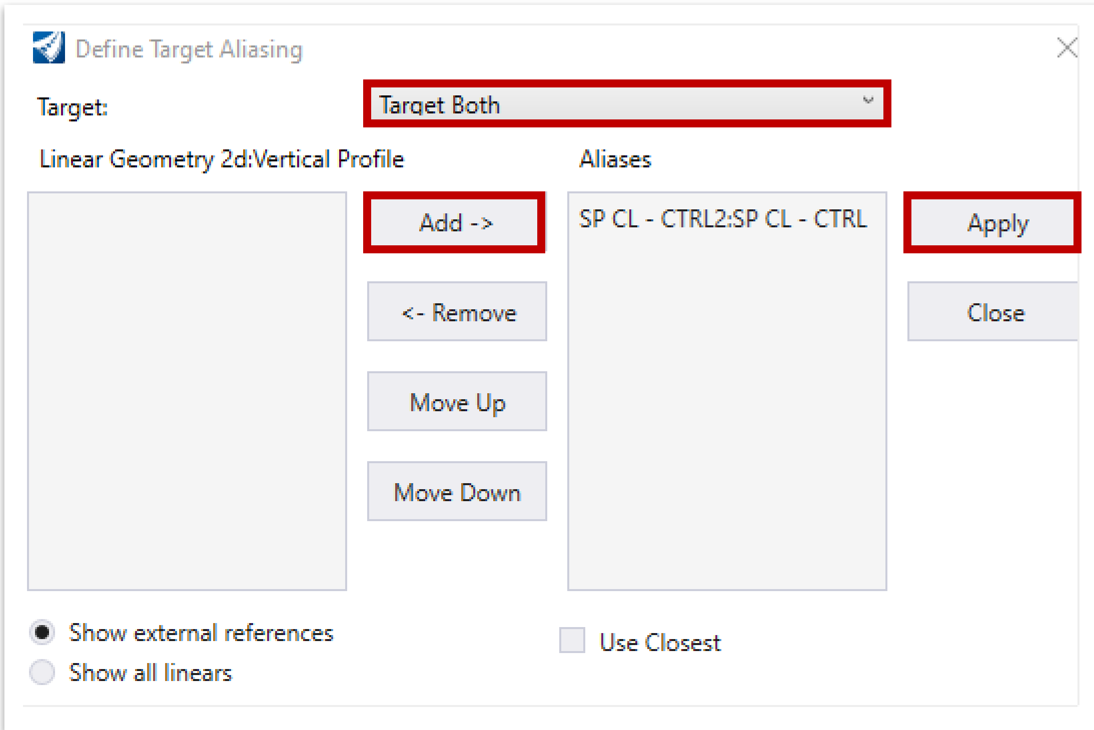


19. Repeat the previous step to change the **Target Type** to **Linear Both** for the remaining **fill** components on the **left** side of the template.

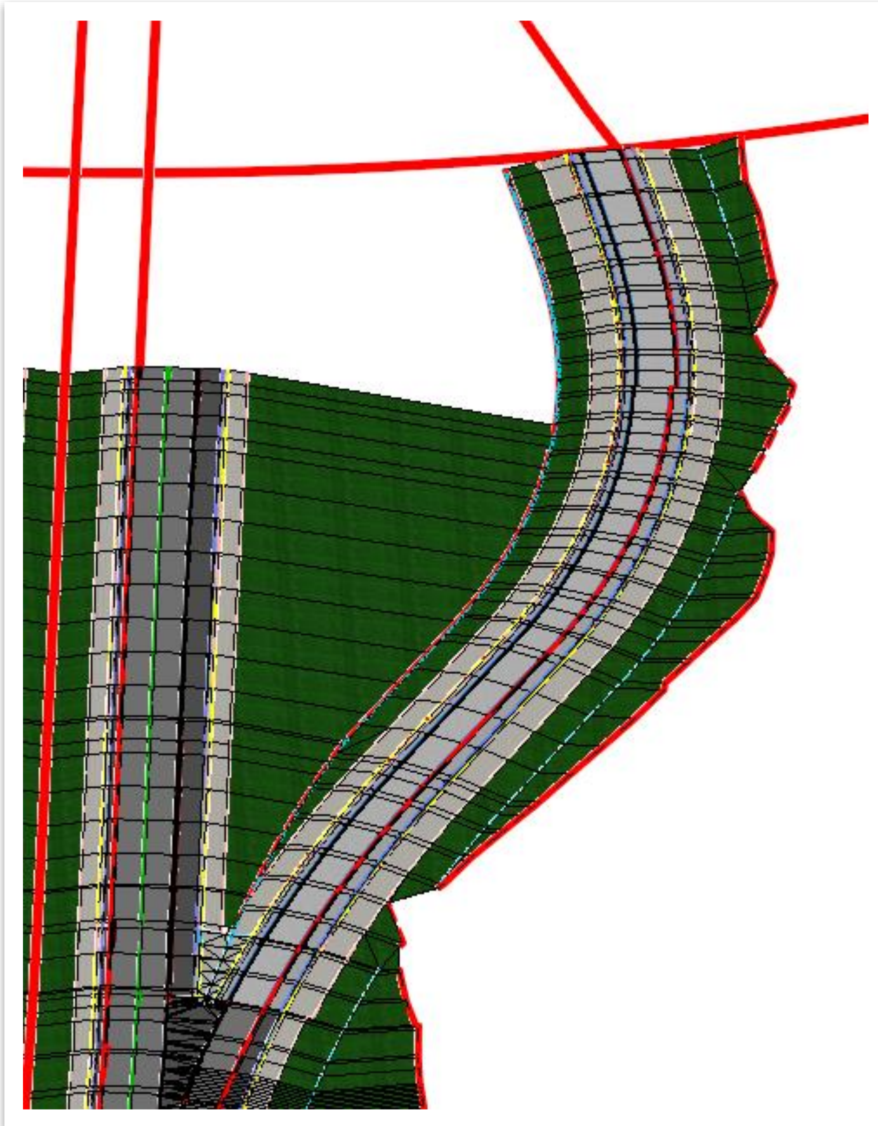
20. Click **OK** in the **Edit Template** window and the end condition of the ramp corridor should disappear.



21. Now, open the **Define Target Aliasing** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous**) and select the **ramp** corridor. Change the **Target** drop-down option to **Target Both**. Select the **SP CL - CTRL2** line and click **Add** and then **Apply**. **Note:** If nothing shows up, toggle on **Show all linears** in the bottom left corner of the window and find the ditch line in the list.



22. Notice that the ramp corridor end condition now follows the ditch line drawn.



Chapter 12. Box Culverts

Box culverts can be hydraulically analyzed within ORD. This chapter will discuss how to hydraulically analyze and model **box culverts** and **wingwalls** in 3D.

12.1 Objectives

At the conclusion of this chapter, participants will be able to:

1. Run hydraulic modeling for a box culvert.
2. Build an accurate 3D model of a box culvert.
3. Use parametric constraints to accurately model wingwalls for the box culvert.
4. Add the box culvert model to the roadway file.

12.2 Lecture: Box Culverts

The **hydraulic capacity** determination of a box culvert follows the culvert design procedure per Chapter 6 of the TDOT Drainage Manual. This manual provides the various types of box culverts utilized on TDOT projects. Box culvert design calculations may be performed using other approved software programs such as **HY-8** and **HEC-RAS**, depending on the complexity of the model. However, ORD is more beneficial for **sizing** box culverts. If the structure is part of an overall storm drain network or if the upstream and downstream channel flows need to be modeled together, other software is better at modeling these complex calculations. Currently any culvert with a design **Q** greater than **500 cfs** should not be modeled in ORD and should be recommended to TDOT Hydraulics or appropriately modeled in other software. **Note:** This chapter does not cover floodplain cross section evaluation.

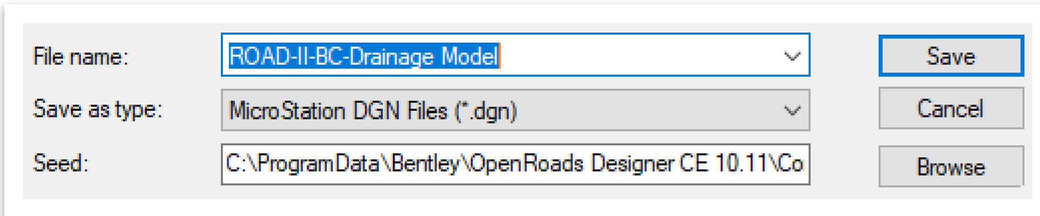
Within ORD, there is a 2-step process for box culvert design and inclusion on the plans:

1. Perform the hydraulic calculations and design a box culvert size that would safely convey the stream flows and meet the hydraulic design criteria.
2. Model the proposed box culvert for inclusion in both the **2D** plans and the **3D** model.

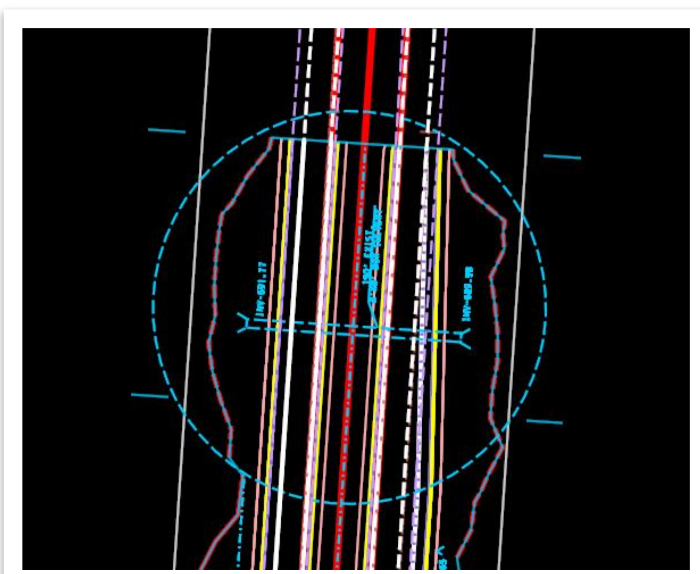
12.3 Exercise: Proposed Box Culvert Alignment

In this exercise, we will utilize roadway design files and an existing drainage model file that crosses the roadway geometry to create the proposed box culvert alignment.

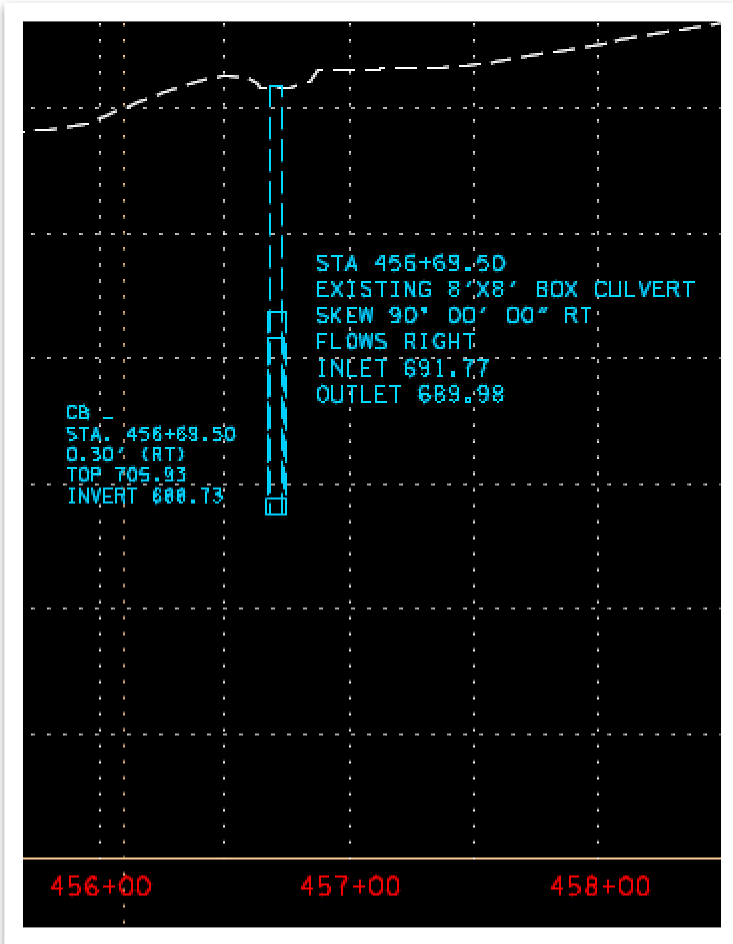
1. Create a new file and name it **ROAD-II-BC-Drainage Model**. Select the **TDOTSeed 2D.dgn** and click **Save**. **Note:** Save this file under the dgn Chapter 12 subfolder.



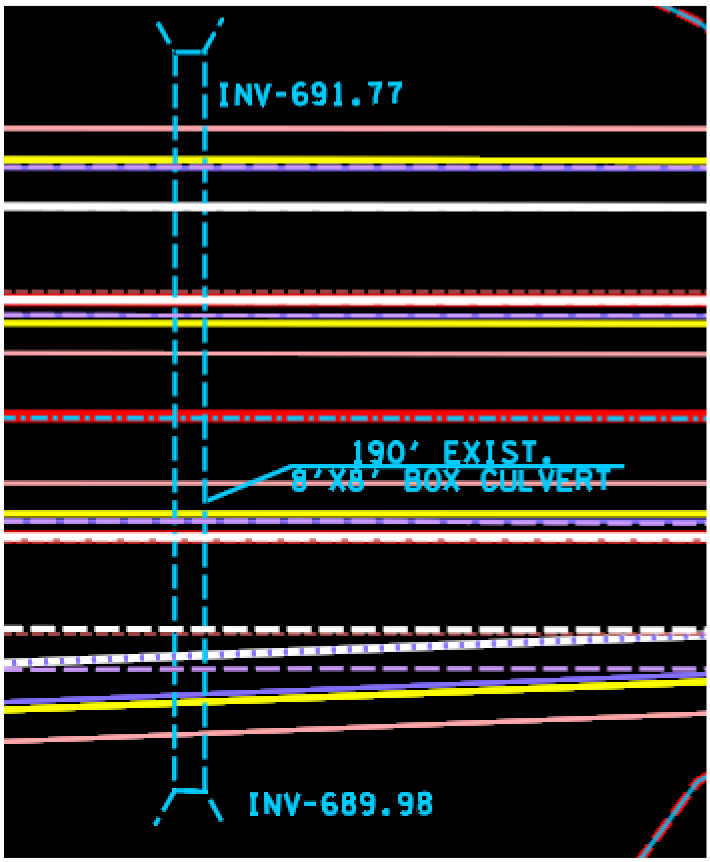
2. Make sure that the **Default** view is active in the lower left corner. Attach the following reference files using the **Coincident World** attachment method and then click **Fit View**.
    - ROAD-II-BC-Geometry.dgn
    - ROAD-II-BC-I65 Corridor.dgn
    - ROAD-II-BC-Survey.dgn
    - ROAD-II-BC-Terrain.dgn (set the **terrain** to active)
3. First, zoom in to the <u>northern</u> part of the project and notice there is an existing **190'** long **8' x 8' box culvert** within the dashed blue circle crossing **I-65**. In this exercise, we will be placing the proposed box culvert alignment at this location.

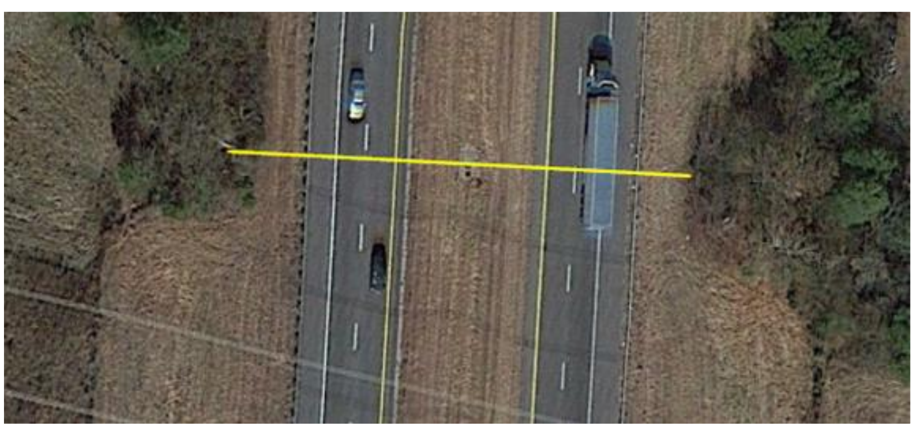


4. Next, click **Fit View** and zoom in to the <u>northern</u> end of the **I-65** profile, referenced in the **ROAD-II-BC-Survey.dgn** file (approximate Station **456+69.50**). Notice the existing box culvert and the applicable drainage data which is important for proposed box culvert design. The key elevation we will utilize is **705.93 ft**, which is the existing roadway elevation at the top of the existing culvert, or the top of the catch basin that drains into the box culvert. It is also important to notice the existing clearance above the box culvert relative to the roadway.

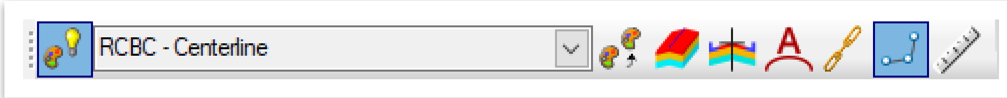


5. It is also important to factor in the proposed corridor updates at the box culvert. For this exercise, the I-65 corridor at the box culvert has a slope correction on the western side and a lane taper (additional width) on the eastern side. We need to evaluate whether the existing box culvert is too short to accommodate the new roadway slopes and if the structure is sized correctly to handle the existing flows. Also, the existing ground cover around the box culvert should also be understood. In this case, a **Perennial** stream is crossing the interstate.

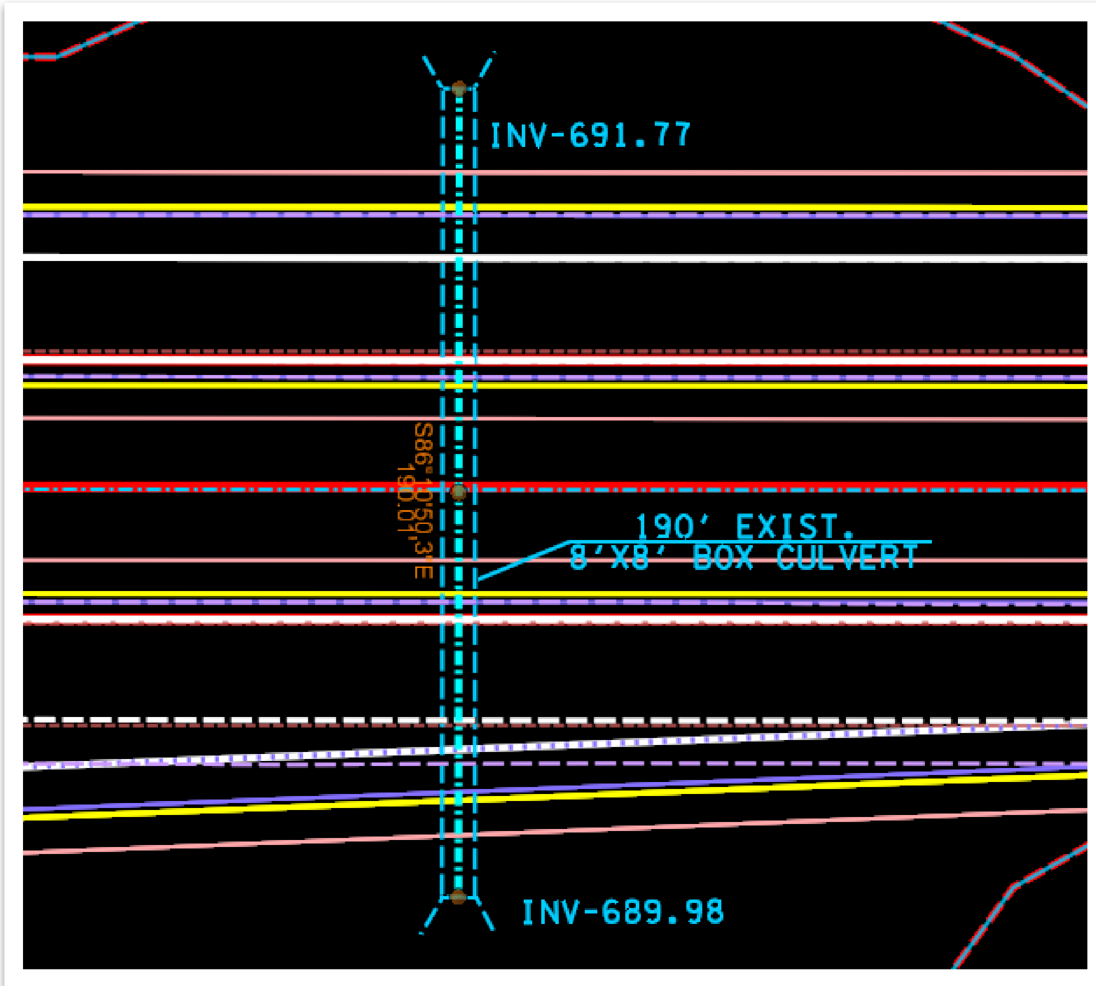




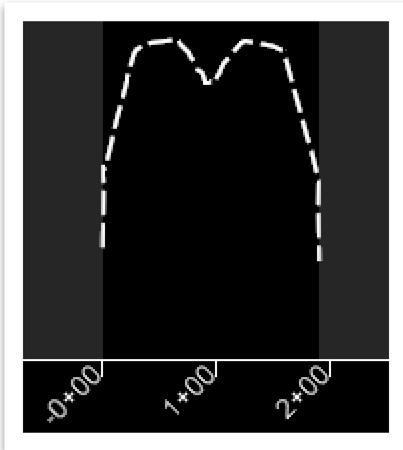
6. Based on the review, the stream alignment shouldn't need to change, even if the box culvert needs to be upsized or extended. Go ahead and select the **RCBC - Centerline** feature definition (**Linear >> Roadway >> Drainage >> RCBC**).



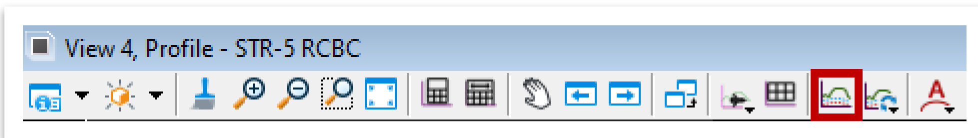
7. Now we will draw a preliminary centerline for the stream using the existing **start** and **end** points. Open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and draw the centerline from the top invert at **691.77** to the bottom invert at **689.98**. Name the element **STR-5 RCBC**.



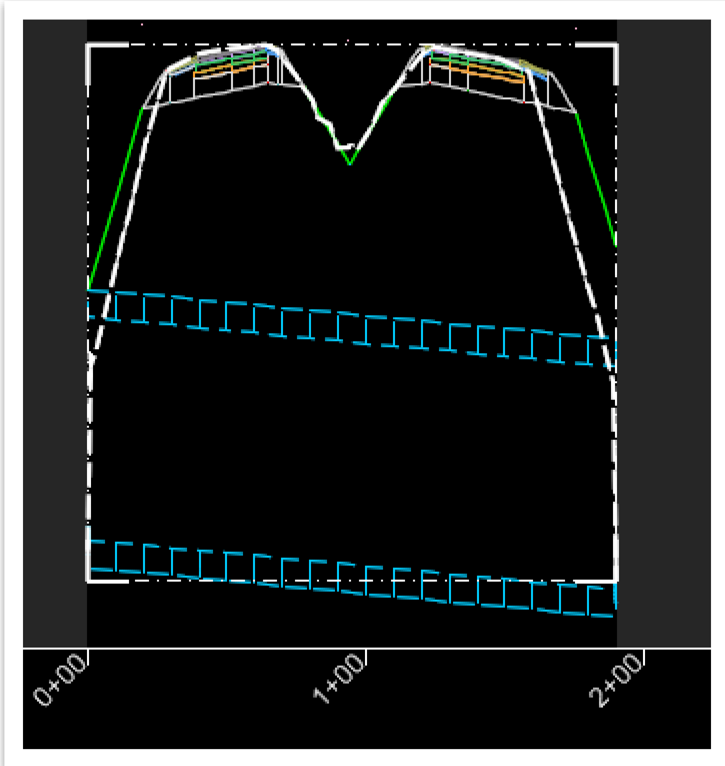
8. Make sure that the terrain is set to active, and then open the **STR-5 RCBC** profile in **View 4** and notice that the profile represents the **roadway** over the **stream CL**. This profile confirms the direction of flow along the stream since the left side of the roadway is higher than the right side. The proposed box culvert will be placed from **upstream** to **downstream** at the lowest elevations and at the two ends of the roadway cross section.



9. Within **View 1** (Default view), attach the **ROAD-II-BC-Existing Drainage.dgn** reference file, and then go back to **View 4** (stream profile). Open the **Create 3D Cut** tool. Set the **Placement Method** to **Full Profile** and **left** click to accept. **Note:** Typically, TDOT Survey will provide the existing **Utility.dgn** file, which will contain the existing box culvert model.



10. Notice the existing box culvert model is now displayed along with the proposed roadway. It seems that the box culvert might not be long enough on the right side unless the roadway is re-graded.

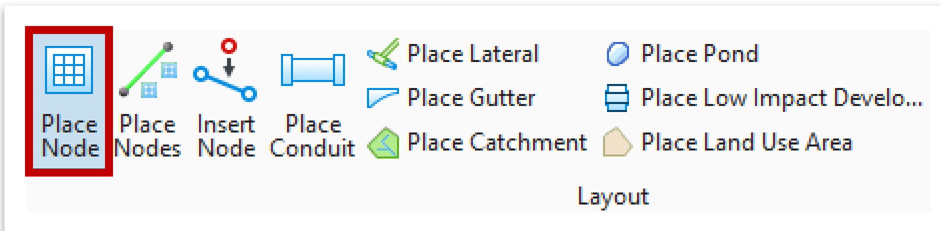


11. We need to determine the maximum height available for a new box culvert should the current size be deemed insufficient. This scenario has a maximum of **16.7’** available. Assuming a **6”** curb lip and **10”** ST value, the max standard height of this structure could be **14’**. We will confirm the size of the box culvert in the next exercise.

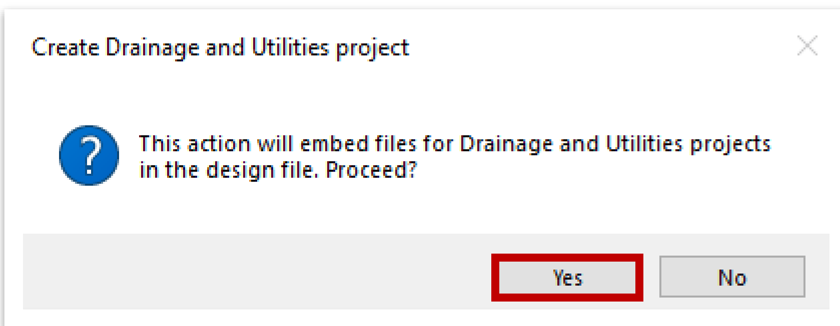
12.4 Exercise: Box Culvert Utility Model and Analysis

In this exercise, we will lay out a box culvert, and then analyze the hydraulics so we can correctly size it for the proposed flows. We will continue to utilize the same **ROAD-II-BC-Drainage Model.dgn** file.

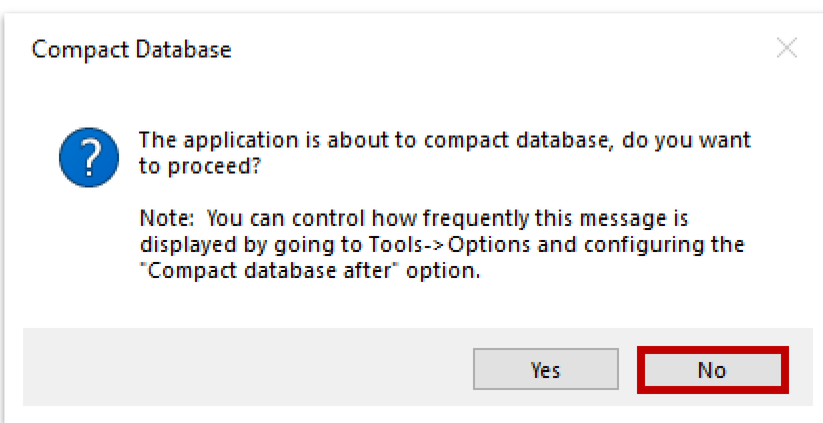
1. Turn off the **ROAD-II-BC-Existing Drainage.dgn** reference file. Select the **Default** view in the lower left corner and then switch to the **Drainage and Utilities** workflow in the upper left corner.
2. Open the **Place Node** tool (**Drainage and Utilities >> Layout >> Layout**).



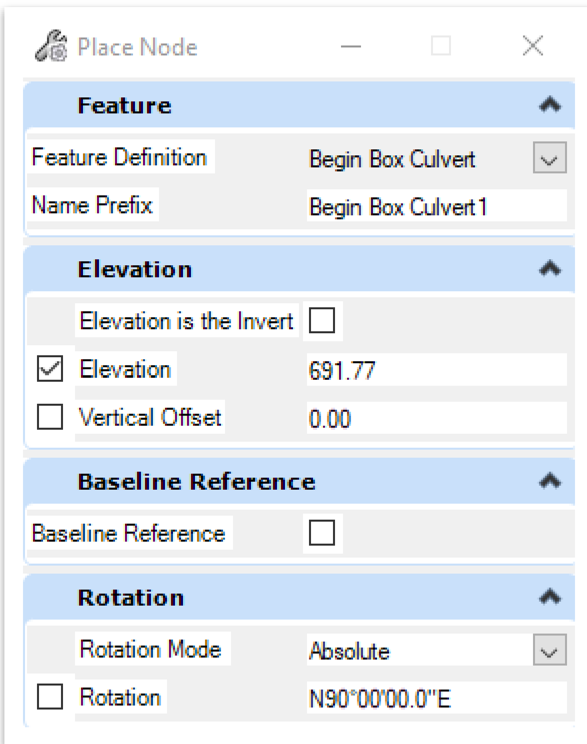
3. A warning will display asking if you want to proceed with embedding files for Drainage and Utilities projects in the design file. Click **Yes** and give the software few seconds to load the drainage standards from the library.



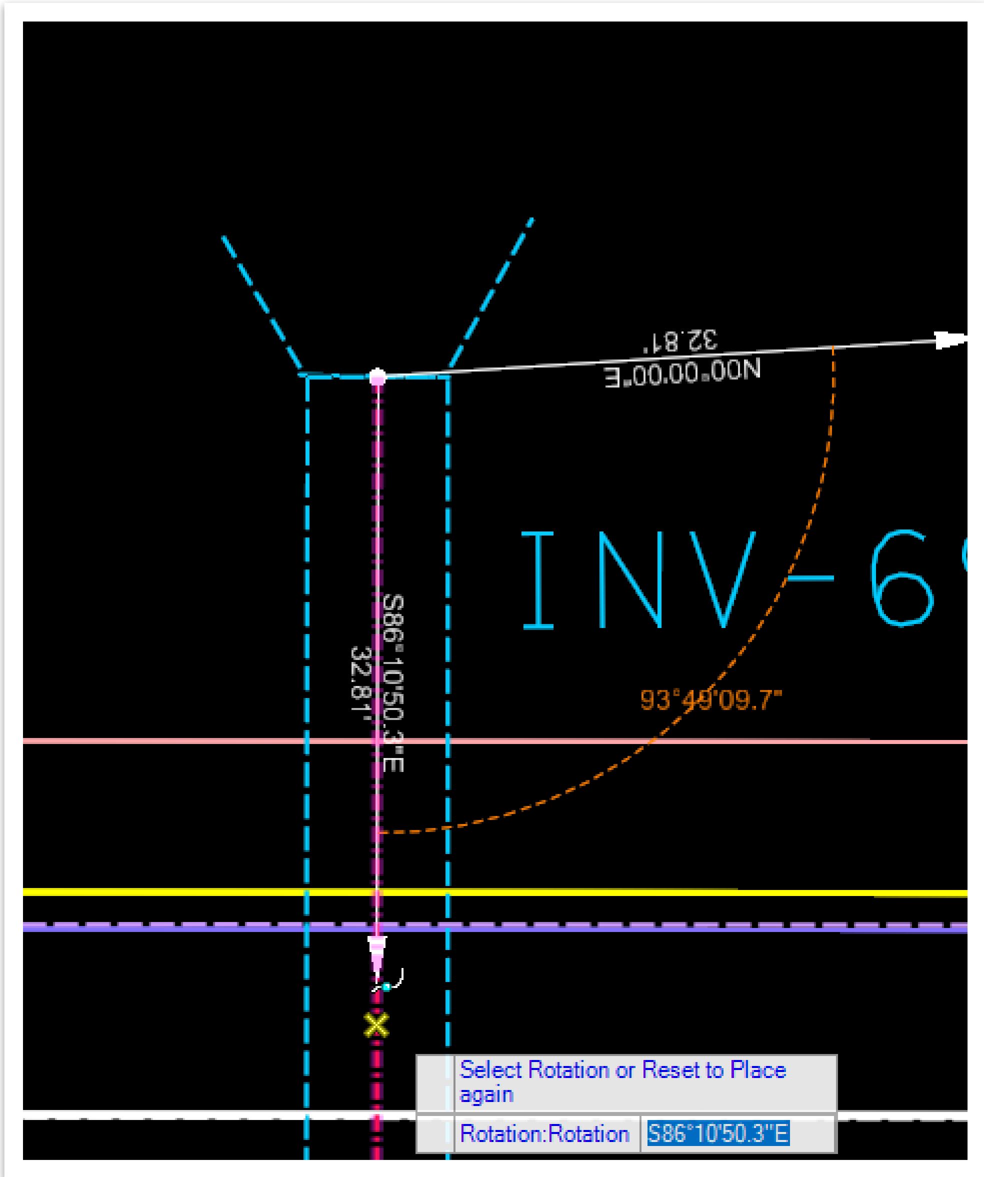
4. You should get a **Compact Database** alert asking if you want to proceed. Click **No**. **Note:** It is recommended to always click **No** unless the database (i.e., the drainage dgnlib) has been updated and needs to be compacted.



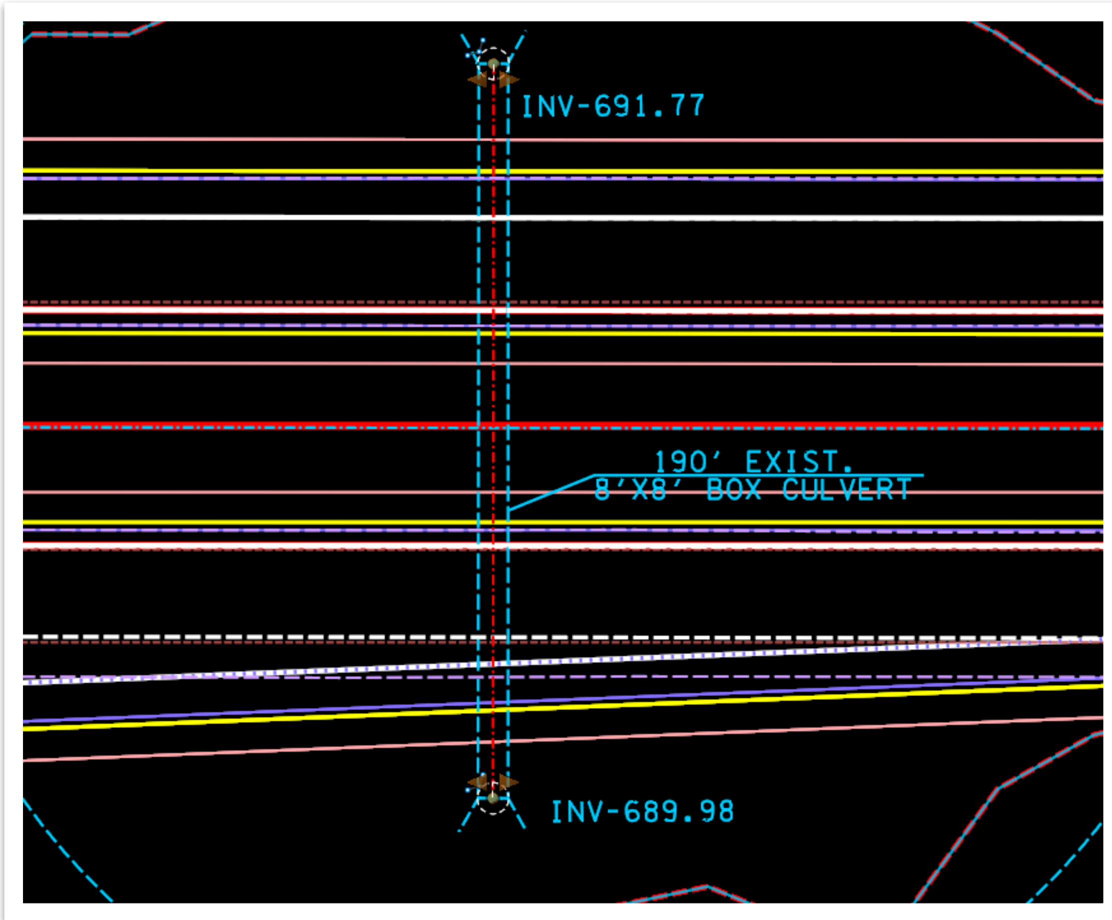
5. As a reminder, the previous two steps are only seen when creating a drainage model in a **new** file. All drainage modeling tools will now open the first time in this file. Go ahead and open the **Place Node** tool again and select the following settings. **Note:** The nodes in this part of the model are just used to facilitate the hydraulic analysis. The box culvert model with wingwalls that is accurate to TDOT standards will be created in Exercise 12.5.
    a. **Feature Definition:** Begin Box Culvert (**Node >> StormWaterNode >> Endwalls >> Cross Drains >> Box Culverts**)
    b. **Name Prefix:** Begin Box Culvert1
    c. **Elevation is the Invert:** Toggle on
    d. **Elevation:** 691.77 (should match the same elevation as the begin invert in the survey)
    e. **Rotation Mode:** Absolute (you can ignore the rotation angle)



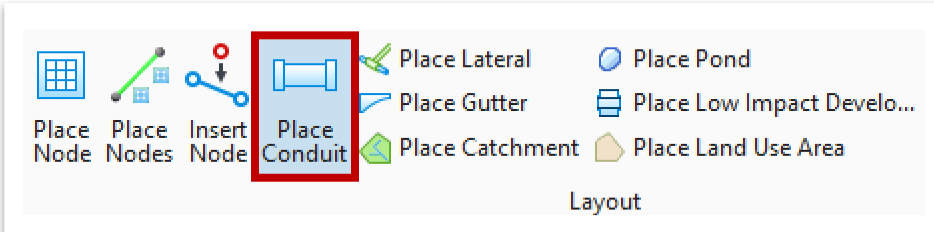
6. **Right** click to **Type an Elevation** and then snap to the start of the box culvert alignment drawn in the previous exercise to **define the headwall**. **Left** click to accept the node location on the upstream side. Then, **left** click again to accept the **rotation mode** and then **left** click to accept the rotation. **Note:** For this node, the rotation angle is insignificant since it is circular.



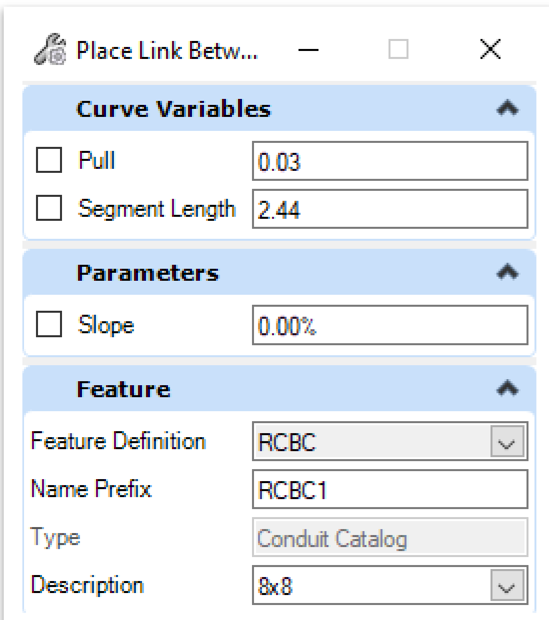
7. Repeat the previous two steps to place another node on the downstream side of the box culvert. Select the **End Box Culvert** feature definition and set the **Elevation** to **689.98**. Once the second endwall has been placed, hit **ESC** to clear the tool.



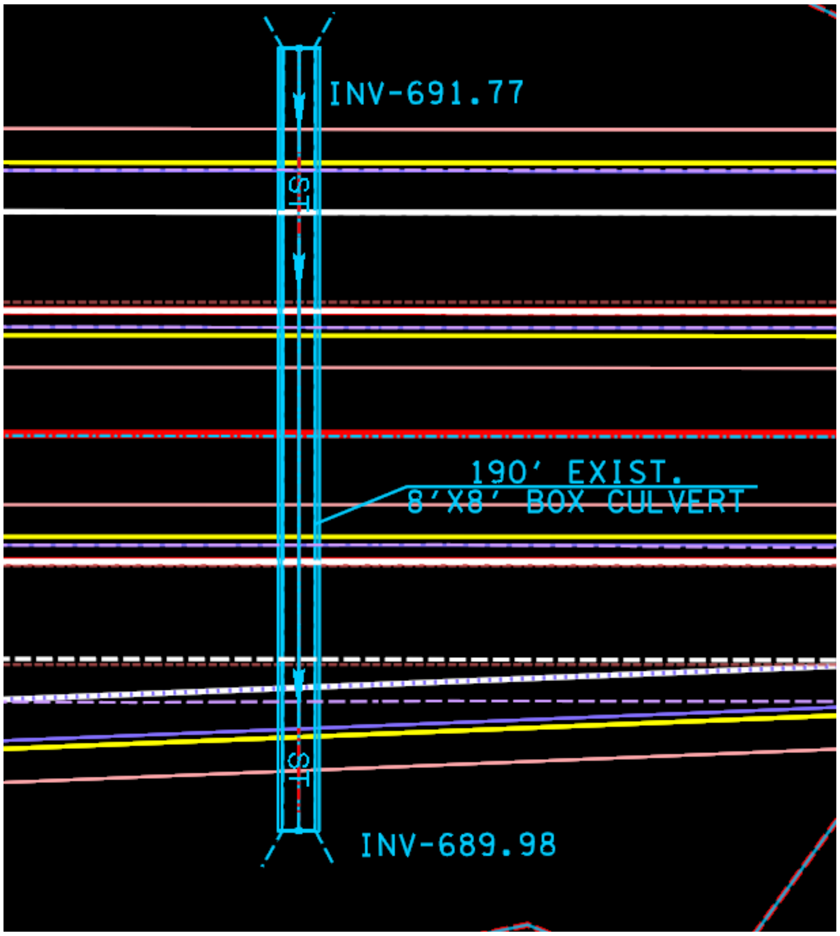
8. Next, let's place a **box culvert** between the two endwalls. Open the **Place Conduit** tool (**Drainage and Utilities >> Layout >> Layout**). We will be analyzing the existing **8' x 8'** culvert to see if it is sufficiently sized to convey the proposed flows.



9. Select the **RCBC** feature definition (**Conduit >> StormWater >> Culvert Pipes >> Proposed**) and set the **Description** to **8x8**. **Note:** If the **8x8** option is not available under the **Description** drop-down, close the file and clear your user preferences.



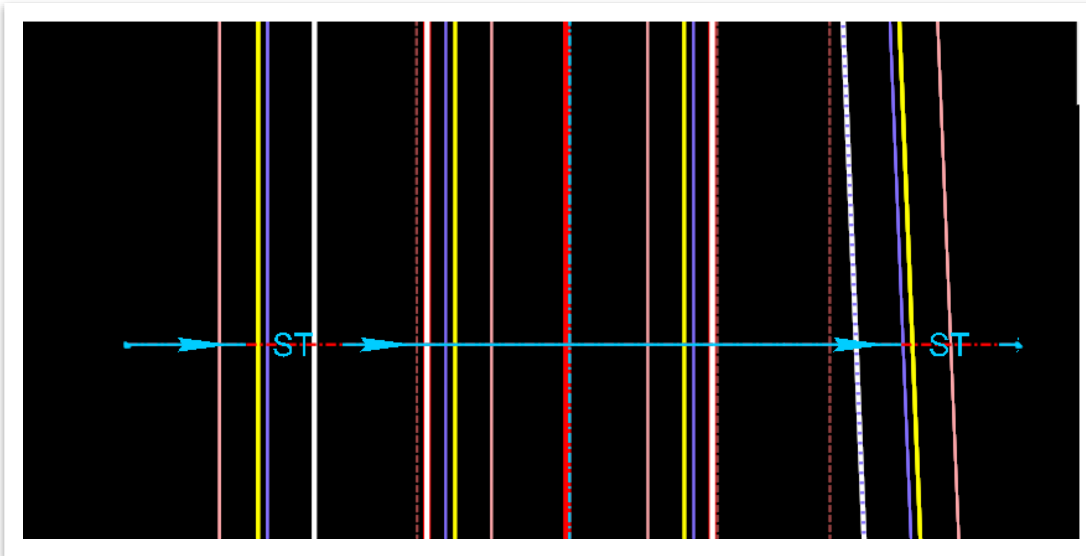
10. Select the **upstream** and **downstream** nodes as the **Start** and **End** nodes respectively to place the conduit. Notice that the **width** of the box culvert is represented by the double lines (wall) and is seen because the active file's **3D** reference file is turned on.



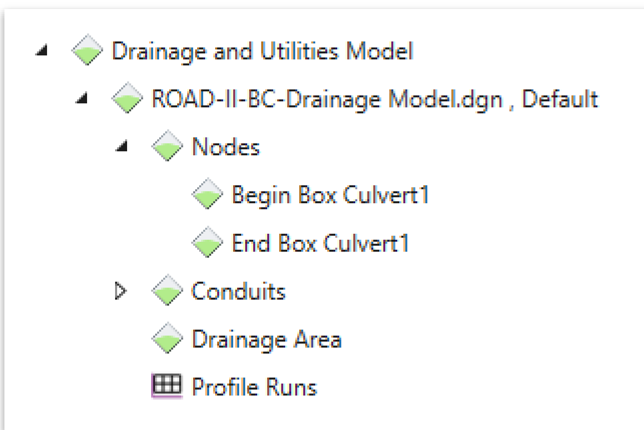
Take Note!

*If the box culvert is a 3-sided box or a box culvert with a natural channel, the user will need to use this feature definition but change the **manning's n** for the scenario in the box culvert **utility** properties.*

11. Go ahead turn off the **ROAD-II-BC-Drainage Model.dgn** (**Default-3D**) and the **ROAD-II-BC-Survey.dgn** reference files, and you should only see the centerline of the proposed box culvert.

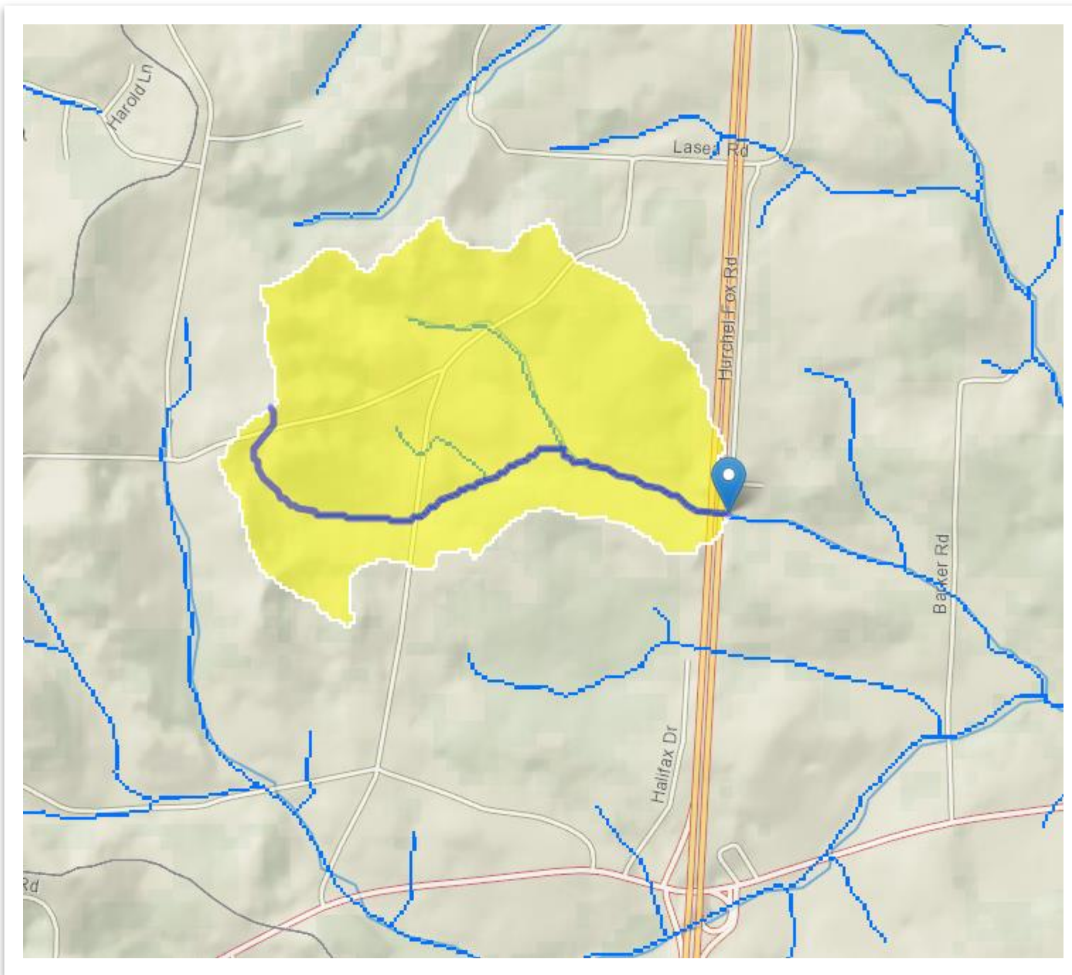


12. Within the **Explorer** under the **Drainage and Utilities Model** tab, notice that the drainage features are now populated. **Note:** Refresh the **Explorer** if they do not appear.



13. The following steps discuss how to input **flows** to this culvert. For hydraulic analysis, this exercise obtains the **design flows** from **USGS StreamStats**. As an alternative, you can calculate the runoff draining to this culvert using regression equations mentioned in the [TDOT Hydraulics Manual] (Tennessee Hydraulic Memorandum – 02). A TDOT **survey file** would also provide the **drainage area** for each culvert. You would need to calculate the **Time of Concentration**, if relying on ORD to calculate the runoff. **Note:** Refer to Exercise 5.11.1.5 in the [SUDA (ORD) Manual] on how to input **Time of Concentration** or calculate composite **Tc** values. Once flows are determined, it is recommended to check the **Q50 < 500 cfs** constraint.

14. The **Design Storm** (Q10, Q25, Q50 or Q100) for which the box culvert will be sized depends on several factors, such as whether the roadway is owned by TDOT or local jurisdiction, or if the crossing is in a FEMA Zone. You will need to follow the TDOT Hydraulics Manual and Chapter 4 of the TDOT Drainage Manual to determine the **Design Storm Event**. For this exercise, the box culvert will be designed for a **100 Year** storm.
15. The design storm flows and the contributing drainage area for the current crossing have been obtained from **USGS StreamStats.** For reference, the contributing drainage area and the **Q100 (cfs)** are provided below. **Note:** It is assumed that the designer is familiar with obtaining flow stats from the StreamStats website or by other methods. If not, refer to Exercise 3.5.1 in the SUDA (ORD) Manual.



Peak-Flow Statistics

Peak-Flow Statistics Parameters [MultiVariable Area 3 CDA LT 30.2]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
CONTDA	Contributing Drainage Area	0.38	square miles	0.173	30.2
CSL10_85	Stream Slope 10 and 85 Method	108.22	feet per mi	2.12	132

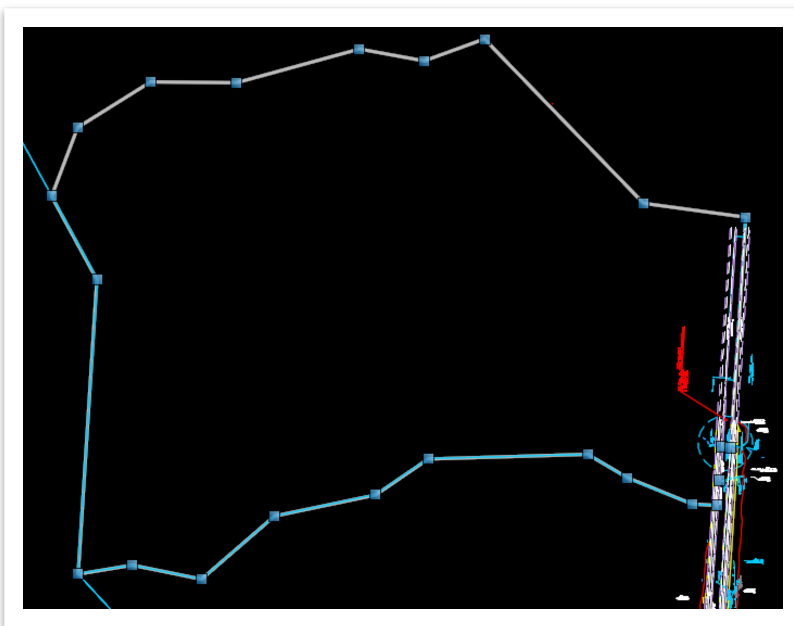
Peak-Flow Statistics Flow Report [MultiVariable Area 3 CDA LT 30.2]

PII: Prediction Interval-Lower, PIu: Prediction Interval-Upper, ASEp: Average Standard Error of Prediction, SE: Standard Error (other -- see report)

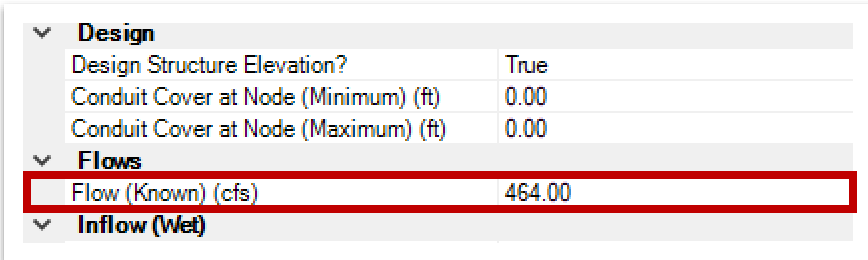
Statistic	Value	Unit	PII	PIu	ASEp	Equiv. Yrs.
50-percent AEP flood	129	ft^3/s	70.8	235	35.2	2.2
20-percent AEP flood	212	ft^3/s	117	385	34.9	2.7
10-percent AEP flood	271	ft^3/s	148	497	35.4	3.5
4-percent AEP flood	347	ft^3/s	186	648	36.4	4.5
2-percent AEP flood	406	ft^3/s	213	772	37.4	5.2
1-percent AEP flood	464	ft^3/s	239	901	38.6	5.8
0.2-percent AEP flood	598	ft^3/s	291	1230	40.5	7

Peak-Flow Statistics Citations

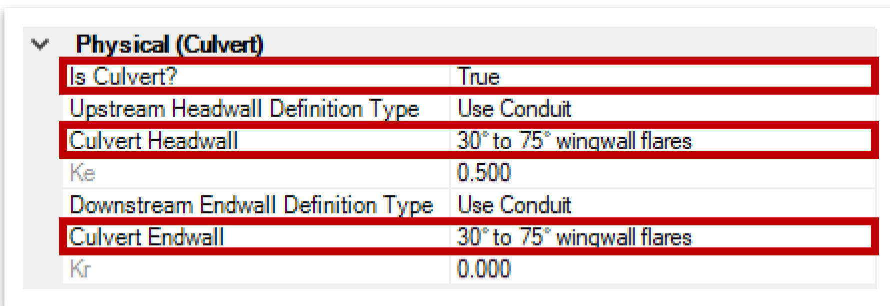
16. From this data, we can determine that the box culvert will need to accommodate **464 CFS** without overtopping the roadway to meet a **100 Year** flood. Also, we meet the 500 CFS constraint, so would not need to send this culvert to TDOT Hydraulics.
17. It is recommended to compare the area obtained from **USGS** to the area provided by **TDOT Survey** to ensure that they are not vastly different. The highlighted area below represents the area contributing to this culvert location. Notice that the drainage area boundary closely matches the boundary obtained from **USGS StreamStats** shown in Step 15.



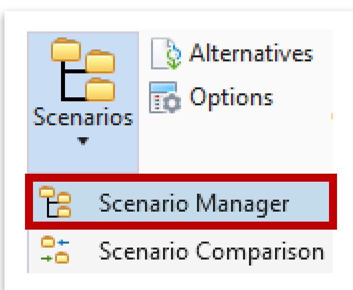
18. Within the **Explorer** under the **Drainage and Utilities Model** tab, **right** click on the **Begin Box Culvert1** node and select **Utility Properties**. Under the **Drainage** tab, scroll down under **Flows** and key-in the **100 Year** flow of **464.00** CFS. **Note:** If the Utility Properties do not populate, close the Explorer and then re-open to refresh.



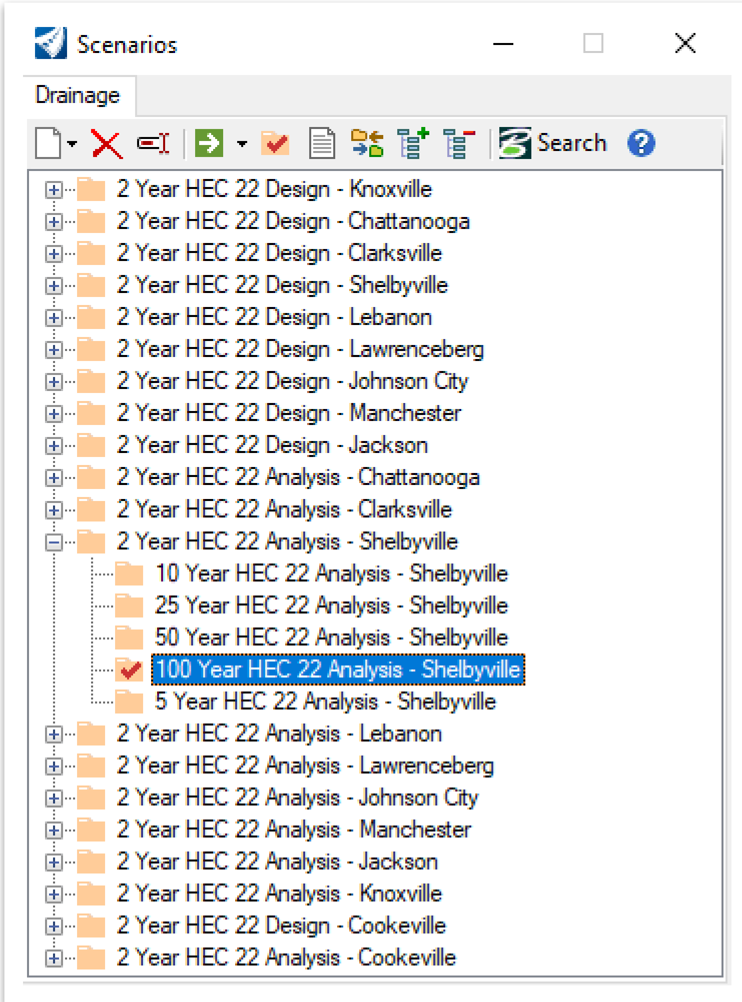
19. Next, within the **Explorer** under the **Drainage and Utilities Model** tab, **right** click on the **RCBC1** conduit and select **Utility Properties**. Under the **Drainage** tab, scroll down under **Physical (Culvert)** and set the **Is Culvert?** field to **True**. The remaining fields will then appear. Since the box culvert will have wingwalls, we need to set the **Culvert Headwall** and **Culvert Endwall** fields to **30˚ to 75˚ wingwall flares**. **Note:** If the utility properties do not open using the method in this step, select the conduit in plan view and then open the **Utility Properties** from the ribbon (**Drainage and Utilities >> Utilities View >> Element Views**).



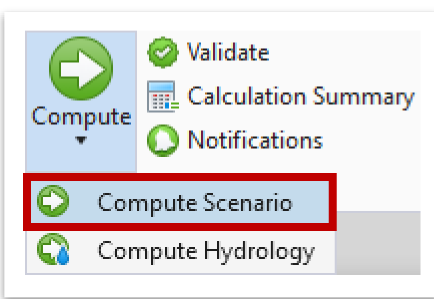
20. Now, we need to analyze the box culvert hydraulic capacity using the most applicable option. Open the **Scenario Manager** tool (**Drainage and Utilities >> Analysis >> Calculation >> Scenarios**).



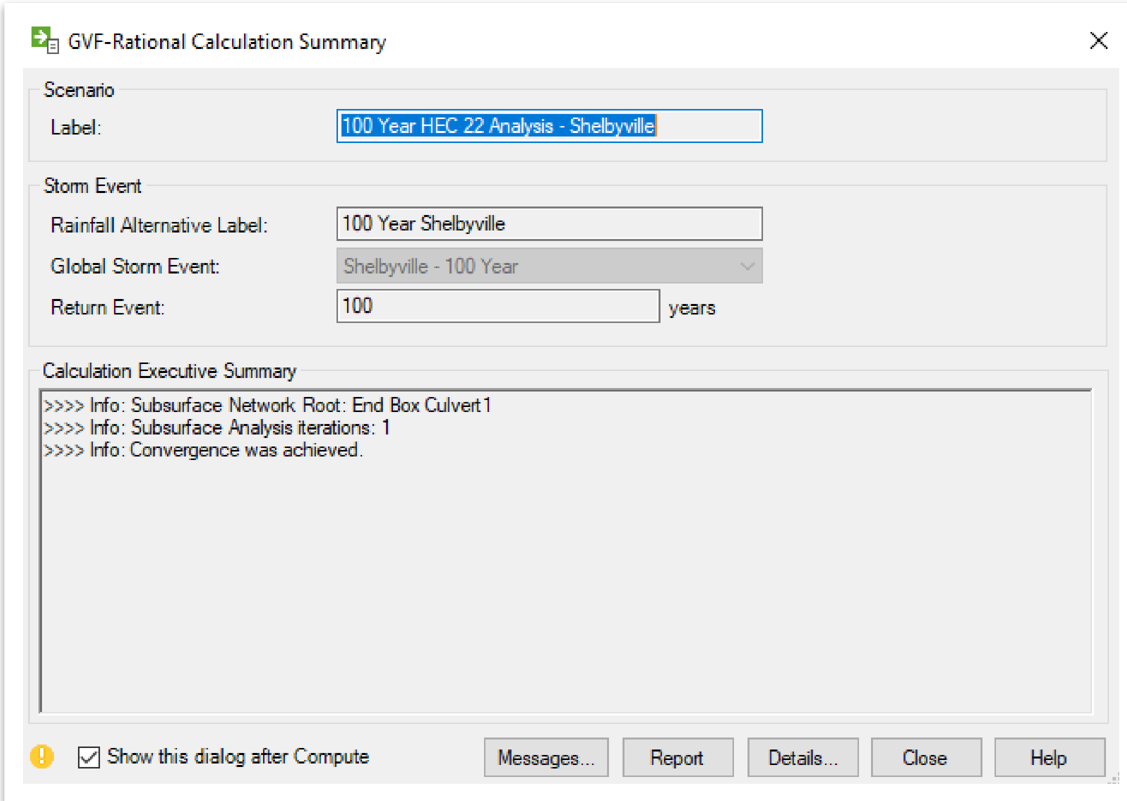
21. Expand the **2 Year HEC 22 Analysis - Shelbyville** folder and **right** click on **100 Year HEC 22 Analysis - Shelbyville** and select **Make Current**, which will add a red check mark next to the scenario. Close the **Scenario Manager** once you are done.



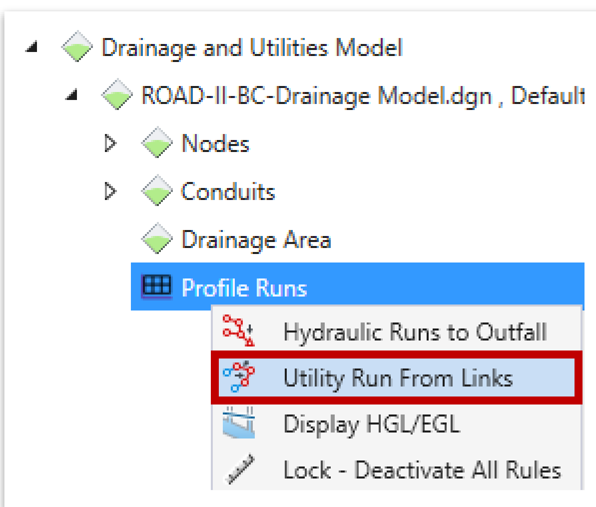
22. Next, open the **Compute Scenario** tool (**Drainage and Utilities >> Analysis >> Calculation >> Compute**) and let the software compute the selected scenario.



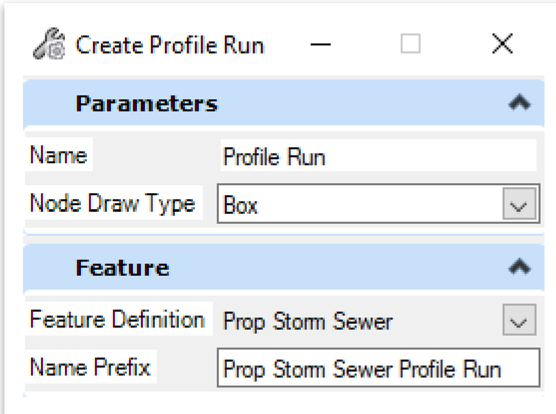
23. A **GVF-Rational Calculation Summary** has now been generated. Go ahead and close the window. You likely will see a **Civil Message Center** open on either the side or bottom of the screen. Go ahead and close that as well for now.



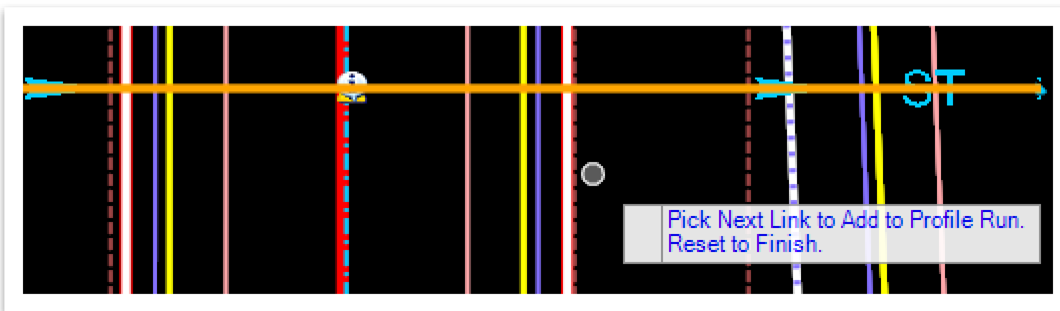
24. Now, let's create a profile along the box culvert so we can view the hydraulic grade line (**HGL**). First, deselect **Use Active Feature Definition** within the **Feature Definition Toolbar**, which will allow us to select the correct feature definition for the Profile Run. Within the **Explorer** under the **Drainage and Utilities** tab, **right** click on **Profile Runs** and select **Utility Run From Links**.



25. Within the **Create Profile** dialog box, select the **Prop Storm Sewer** feature definition (**Linear >> Profiles >> Profile Runs >> Design**) and set the **Node Draw Type** to **Box**.

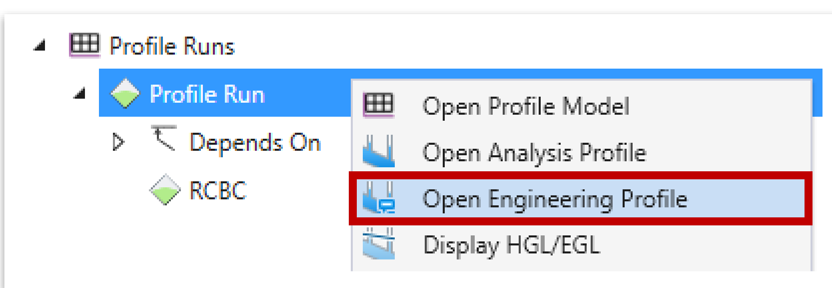


26. Select the **box culvert conduit** as the **first link** and then **right** click to reset. The traced profile should be highlighted in orange.

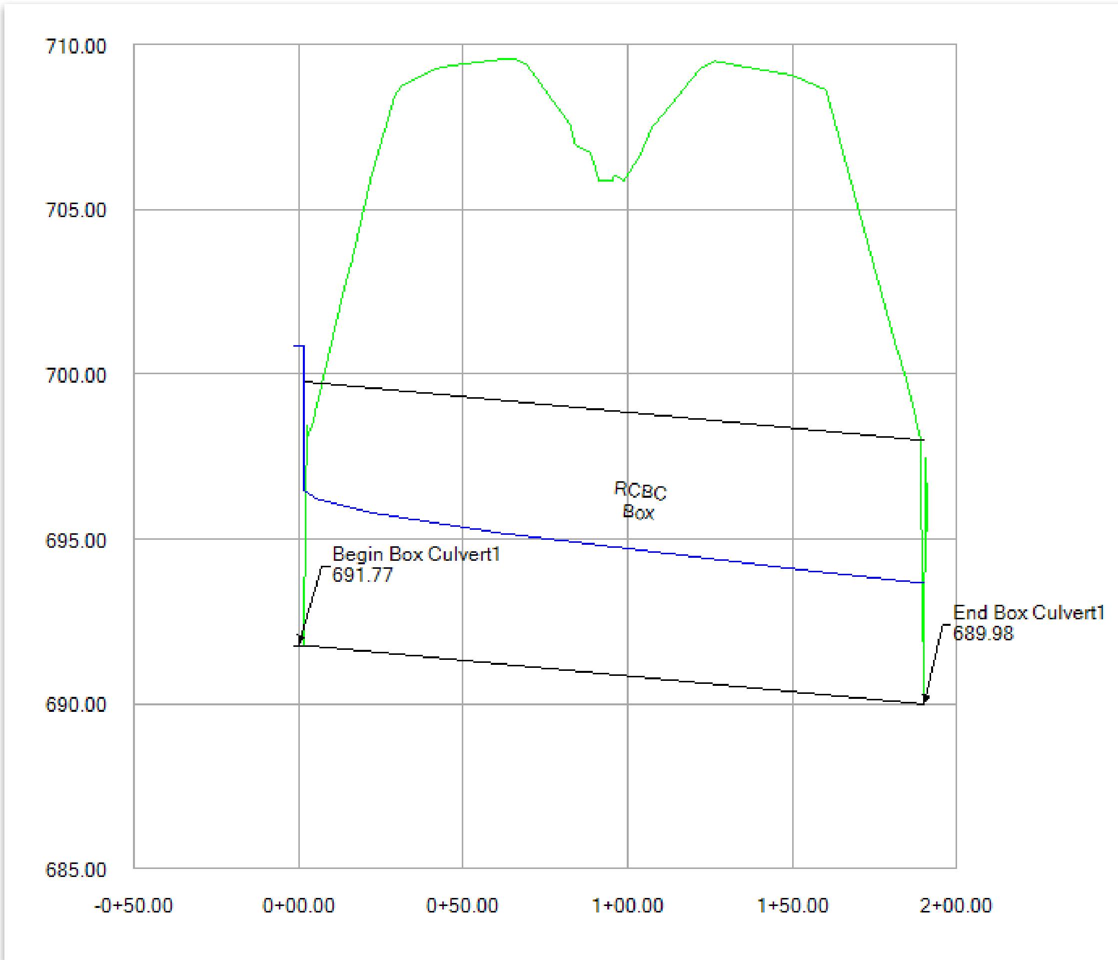


27. Notice that a profile run has now been created within the **Explorer**. Before we open the engineering profile, go to **File >> Save As** and create a copy of the current dgn file. We will then work in the **copied** file for the next few steps. **Note:** The need to copy the file is due to a defect in 2022 Release 1, where after opening the engineering profile, the file becomes unusable beyond that point (i.e., cannot be re-opened). If you are using **2022 Release 1.1**, Bentley has resolved this issue so there is no need to copy the file.

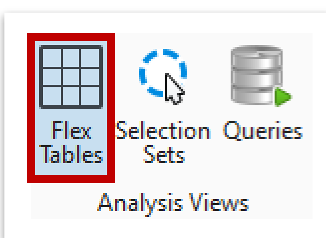
28. In the copied file, **right** click on **Profile Run** and select **Open Engineering Profile**. This profile is shown along the **pipe length** and not along the project's alignment.



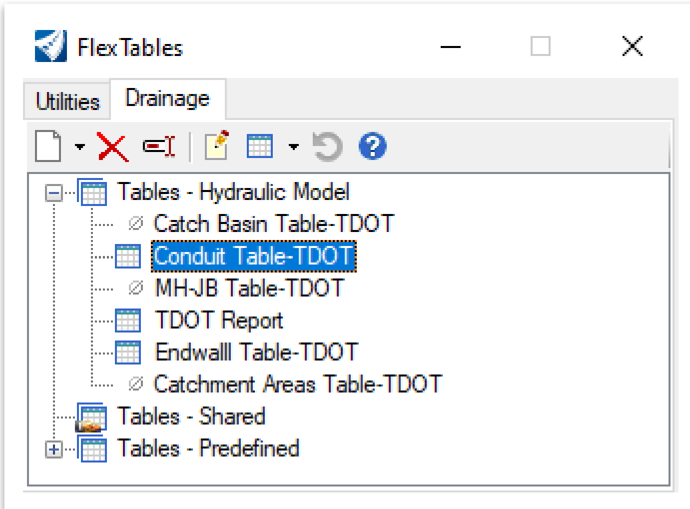
29. In the **Engineering Profile** window, review the **Nodes**, **Conduit**, **Ground Elevations**, **Inverts**, **etc**. to verify if the inlets and pipe are connected correctly in the direction of flow, along the box culvert. The **blue** line represents the hydraulic grade line (**HGL**). This profile shows that the box culvert is currently not over topping the roadway and is able to handle the flows. This also shows that the existing culvert is **correctly sized** for the **100 Year** flow reaching the box culvert. **Note:** If the culvert was sized incorrectly, you would need to change the size of the box culvert until it successfully conveyed the flows.



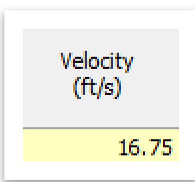
30. Furthermore, you can open the **Flex Tables** tool (**Drainage and Utilities >> Analysis >> Analysis Views**) and review the **results**.



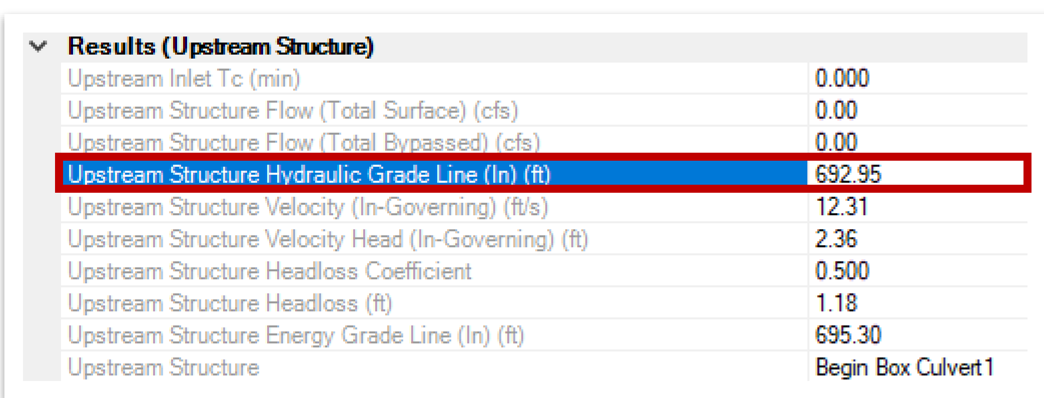
31. Within the **Flex Tables** window, double click on the **Conduit Table-TDOT** flex table under the **Drainage** tab.



32. Scroll over to **Velocity (ft/s)** and notice that the outlet velocity is **16.75**. This is below the TDOT max velocity of **20 ft/s** and would require significant treatment at the outlet to mitigate downstream erosion. Refer to Chapter 6 of the TDOT Drainage Manual for further details regarding velocity limits. Since this flow is above **12 fps**, an energy dissipater would be needed. Refer to Chapter 9 of the TDOT Drainage Manual for further details on energy dissipaters. **Note:** For this exercise, will ignore the need for energy dissipaters.



33. In addition, within the **RCBC1 Utility Properties**, the **HGL** elevation is shown under **Results (Upstream Structure)**. From here we can confirm that the hydraulic grade (**692.95**) is lower than the roadway elevation and the **100 Year** flow will not overtop the roadway.



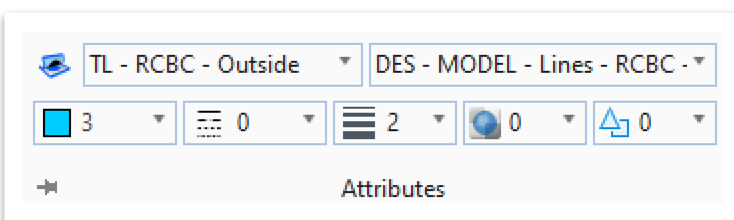
34. Now that we have looked at all the hydraulic data, open back up the main **ROAD-II-BC-Drainage Model.dgn** file. **Note:** You can delete the copied file since it cannot be re-opened now.
35. Lastly, we need to **size** and **layout** the **wingwalls** for the proposed box culvert, according to the TDOT standard drawings. Designers will need to locate the applicable standard drawing for their proposed box size (**STD-17-51** – **STD-17-168**). For this exercise, go ahead and open [STD-17-53,](#) which is the applicable standard drawing. From this drawing, we need to pull the following information by selecting a maximum **fill** height. In this scenario, the box culvert will have around **10’** of **fill**, so we will use the following dimensions:
    - **ST (Top of Slab Width):** 9”
    - **SB (Bottom of Slab Width):** 9”
    - **WT (Exterior Wall Width):** 8”
    - **BW (Out-to-Out Width):** 9.33’
36. Then, we need to locate the applicable **wingwall** standard drawings for the proposed box culvert based on the structure **skew** and the **slopes** of the proposed roadway at all four corners of the box. The wingwall standard drawings are **STD-17-11** – **STD-17-14**. For this exercise, the box culvert is at a **90-degree skew** to the proposed roadway, so **STD-17-11** is the applicable standard drawing. The proposed roadway has **4:1** slopes and the box height is **8’**. However, that is the cell height and not the box height. Our box is under about **17’** of fill, so we need to include the height of **edge beam** as well. From **STD-17-7** we can determine that the height of the edge beam is **1’**. We need the height of the edge beam and the **ST** dimension to calculate the height of the wingwalls, which equates to **9.75’** (**8’ + 9” + 1’**). To be conservative, we will round up and use a **10’** value for the length of the wingwalls.

37. From **STD-17-11**, we need the following highlighted dimensions. **Note:** For scenarios requiring a **1’** embedment per Chapter 6 of the TDOT Drainage Manual, ensure that the proposed box culvert and wingwall heights account for this embedment. Likewise, the proposed inverts need to be adjusted **1’** down from the hydraulic inverts to place the box correctly.

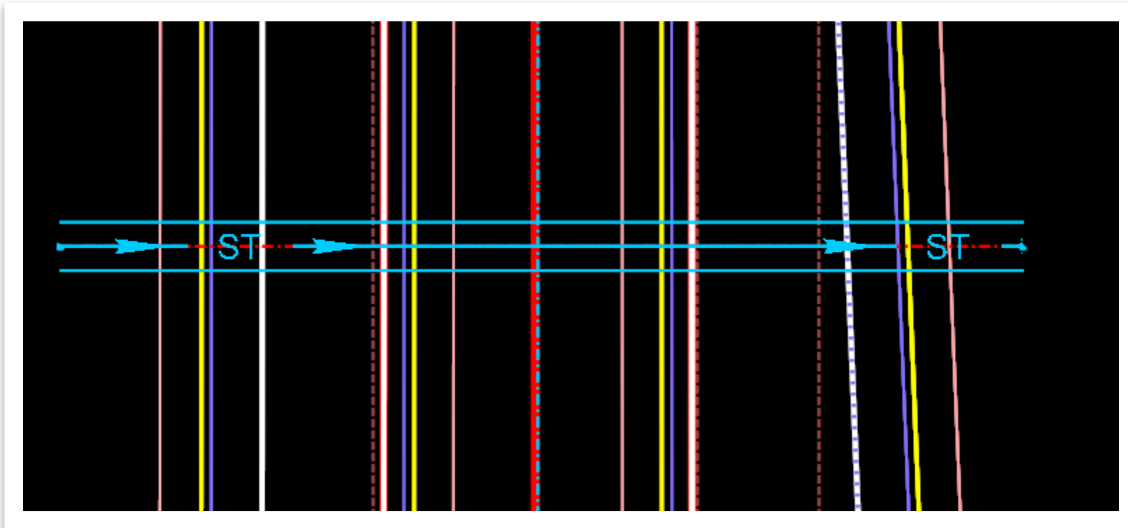
4:1 SLOPE				
H	W	h	CONCRETE (C.Y.)	REINF. STEEL (LBS.)
4	7.25	2.50	5.1	716
4.5	8.25	3.00	6.4	786
5	9.00	3.25	7.9	896
5.5	10.00	3.50	9.4	1,067
6	11.00	4.00	11.1	1,176
6.5	12.00	4.25	12.8	1,265
7	12.75	4.50	14.9	1,611
7.5	13.75	5.00	17.9	1,779
8	14.75	5.25	20.1	1,915
8.5	15.75	5.50	22.4	2,119
9	16.50	6.00	25.7	3,136
9.5	17.50	6.25	28.4	3,257
10	18.50	6.50	31.3	3,584
10.5	19.50	7.00	35.5	3,869
11	20.50	7.25	39.8	4,321

- **H (Fill Height):** 10’
- **W (Wall Length):** 18.50’
- **h (Wall Height):** 6.50’

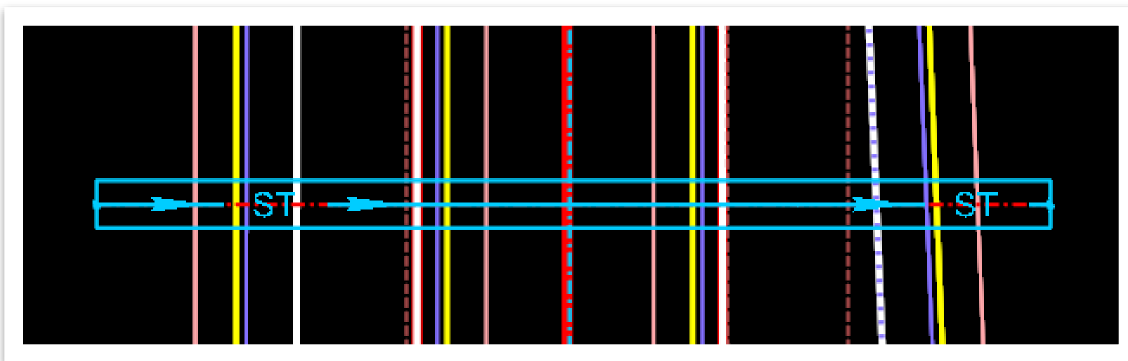
38. Now, select the **TL - RCBC - Outside** element template (**Design >> Roadway - 3D Template Points >> Drainage >> Box Culverts**).



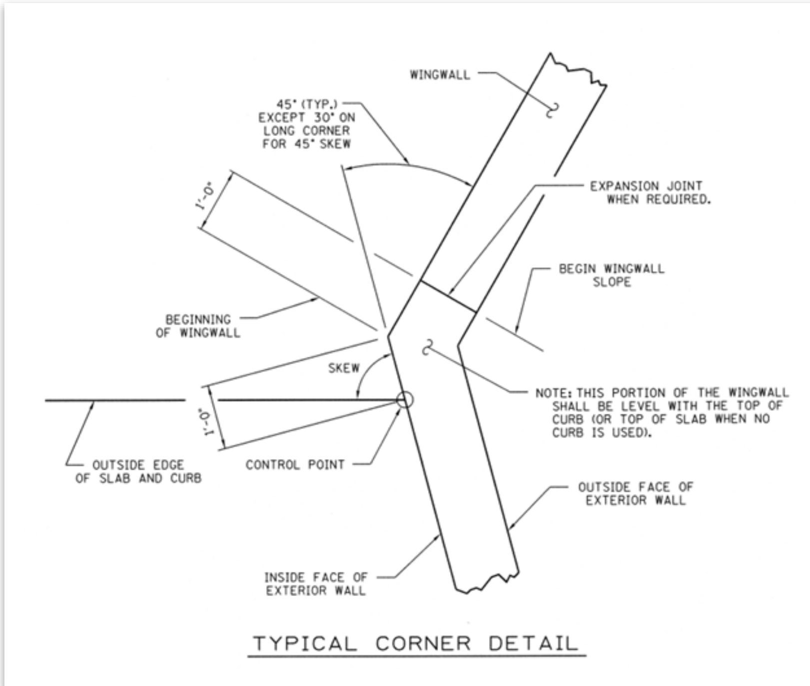
39. Open the **Place SmartLine** or **Place Line** tool (**Drainage and Utilities >> Drawing >> Placement**) and draw a **190'** line down the centerline of the box. Then, offset this line **4.00'** on both sides of the centerline, which represents the inside width of the box (**8.00'**). Once completed, go ahead and delete the centerline that was just drawn. **Note:** The inside dimensions will be used since that is what controls the wingwall templates in the following exercise.



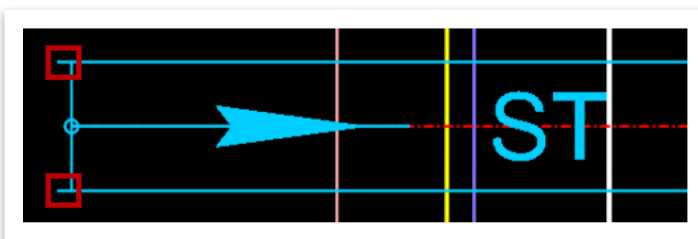
40. Using the same line tool from the previous step, connect the ends of the box culvert to create a closed shape. **Note:** The shape does not have to be complexed. It is only used as a guide for the modeling.



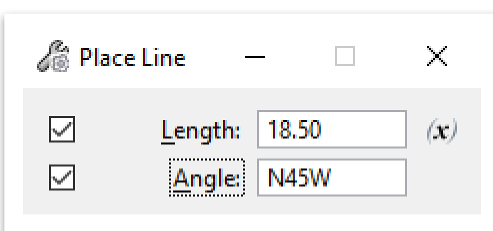
41. Next, we need to draw the **wingwalls**. According to [**STD-17-10**] (**Typical Corner Detail**), the wingwalls have a **1'** lip that extends out from the box, as shown below. **Note:** This **1'** extension is not included in the wall length we located in Step 36.



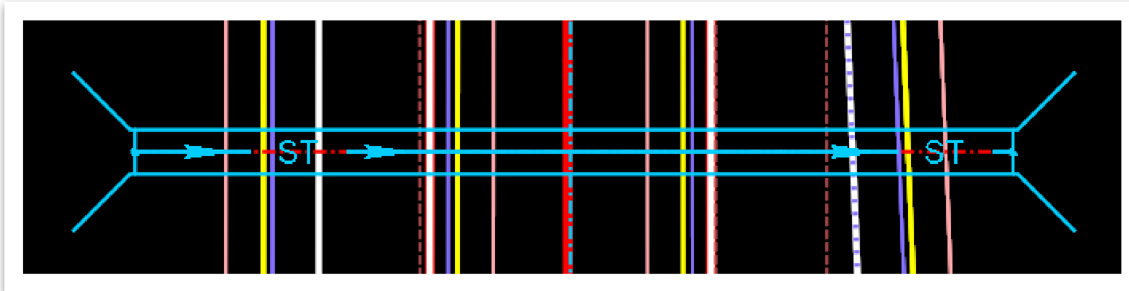
42. Now, draw **1'** extensions outward from the ends of the box on all **four** corners. **Note:** Only the **two** on the left are shown in the screenshot below.



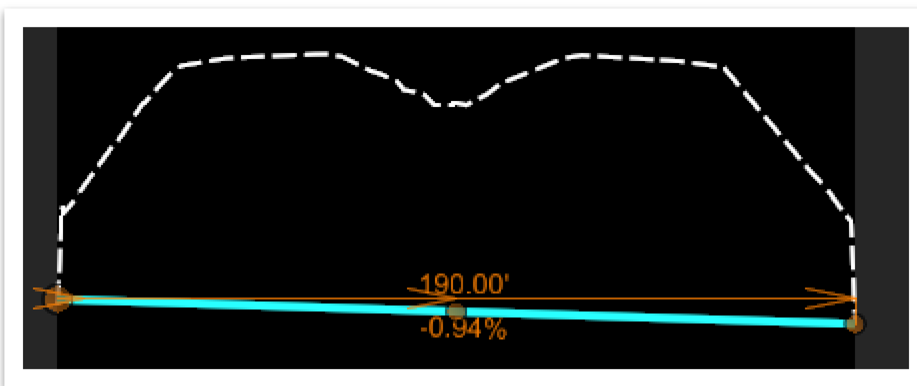
43. The skew angle is with respect to the roadway centerline. We need to draw the wingwalls at **45°** angles from the box culvert skew. To do this, rotate the view along the length of the box culvert, if not already rotated. The wall length should be **18.50'** from the 1' extension. Open the **Place Line** tool (**Drainage and Utilities >> Drawing >> Placement**). For the upper left wingwall, draw a **18.50'** line at a **N45W** angle.



44. Repeat the previous step for the remaining **three** wingwalls, keying in the applicable angle.



45. Since we know that the existing box inverts work, we will need to create a profile for the box culvert. Open the **STR-5 RCBC** profile and delete the **3D cut** if it is still present, by hovering over the 3D cut border and selecting the red X in the heads-up display. The profile should just have the active terrain in it. Select the **RCBC - Centerline** feature definition (**Linear >> Roadway >> Drainage >> RCBC**).
46. Go ahead and switch back to the **OpenRoads Modeling** workflow. Turn on **Civil AccuDraw** for the profile and then open the **Profile Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Lines**). Key-in the **Start** and **Stop** values for the box culvert inverts.
    a. **Start:** 0+00, 691.77’
    b. **End:** 1+90, 689.98’

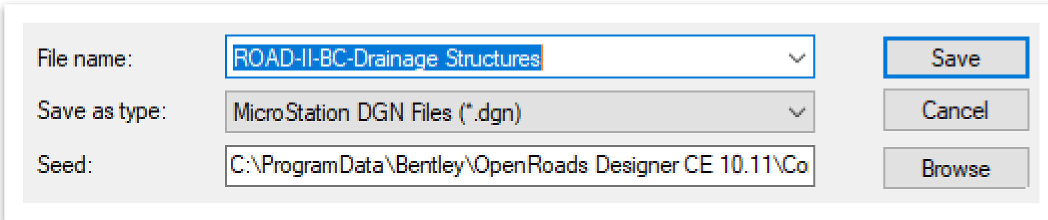


47. Set the profile to **Active** and then the drainage portion of modeling a box culvert is complete. We have now set up the plan view layout to model the box culvert in **3D**.

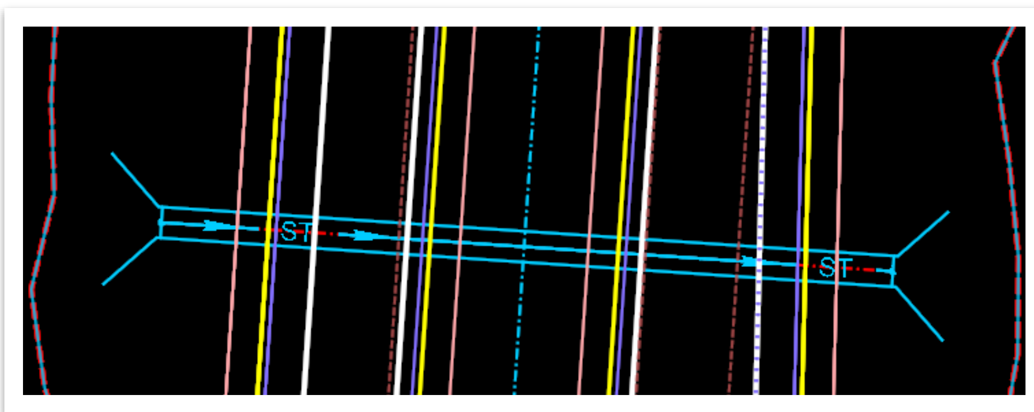
12.5 Exercise: Creating a Box Culvert

In this exercise, we will create a box culvert per TDOT standards and make the necessary updates to incorporate it into the 3D roadway model.

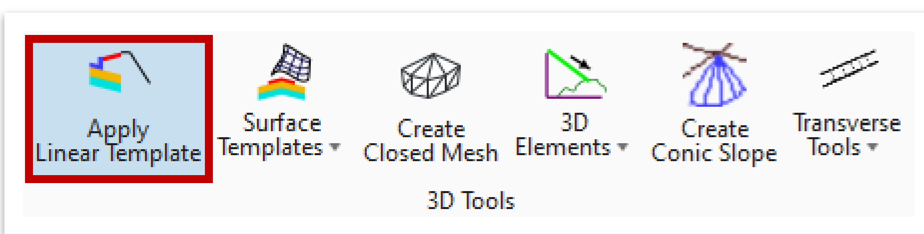
1. Create a new file and name it **ROAD-II-BC-Drainage Structures**. Select the **TDOTSeed 2D.dgn** and click **Save**. **Note:** Save this file under the dgn Chapter 12 subfolder.



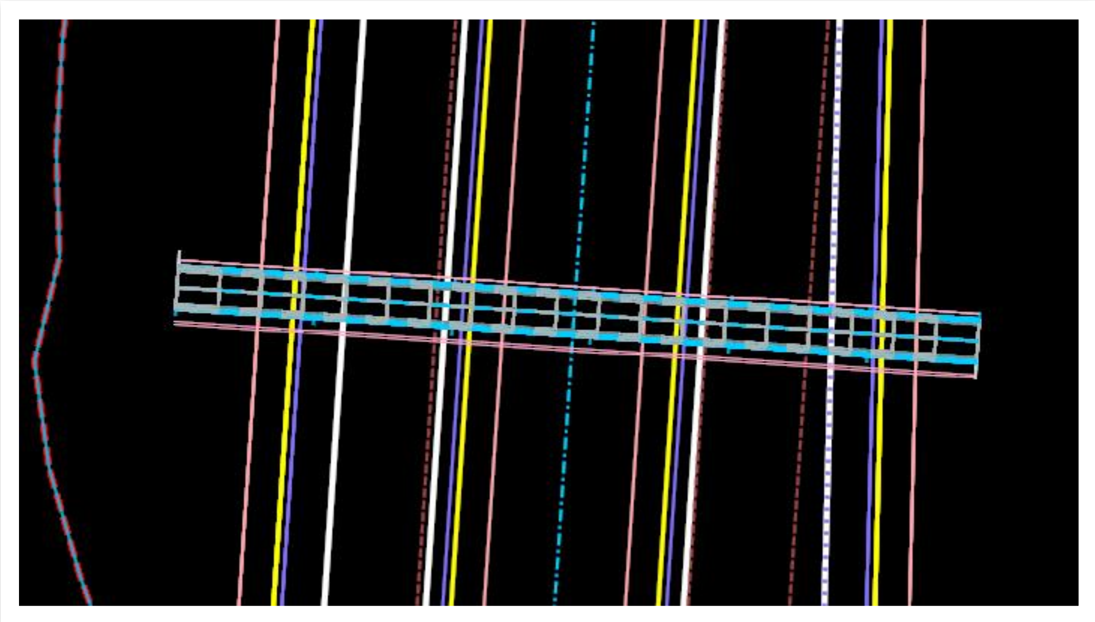
2. Make sure that the **Default** view is active in the lower left corner. Attach the following reference files using the **Coincident World** attachment method and then click **Fit View**. Zoom in to the location of the box culvert created in the last exercise.
   - ROAD-II-BC-Drainage Model.dgn (created in previous exercise)
   - ROAD-II-BC-I65 Corridor.dgn
   - ROAD-II-BC-Terrain.dgn (set **terrain** to active)



3. Within the **ROAD-II-BC-Drainage Model.dgn** reference file, turn off all levels other than the **DES - MODEL - Lines - RCBC - Centerline** level. Locate the box culvert centerline and then open the **Apply Linear Template** tool (**OpenRoads Modeling >> Model Detailing >> 3D Tools**).

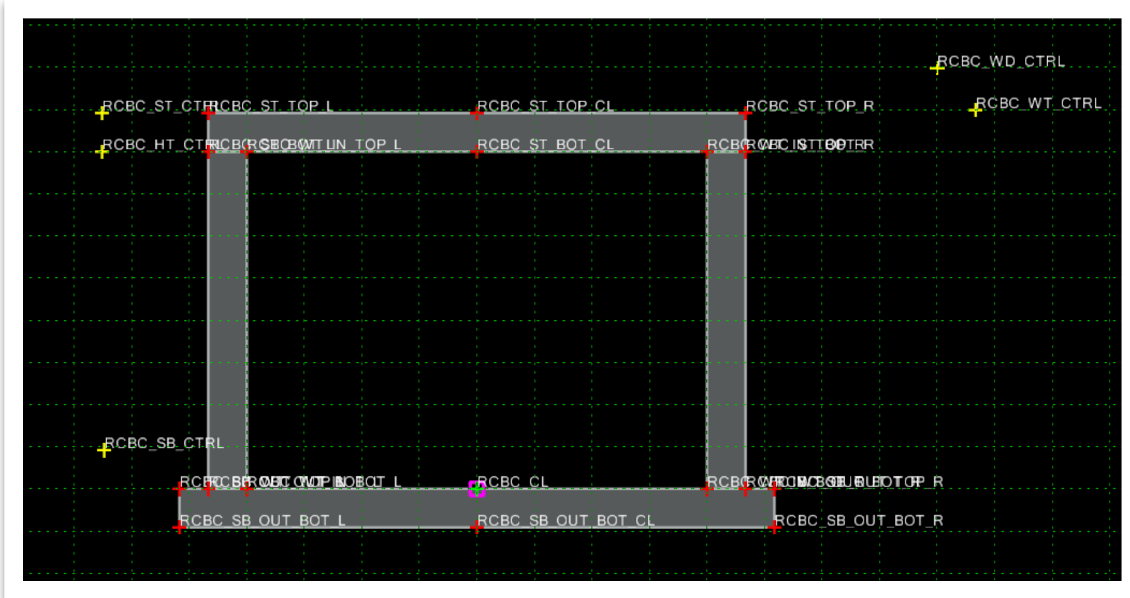


4. Next, select the centerline of the box culvert and then select the **RCBC - Single** template (**Linear Templates >> Box Culverts & Slab Bridges**). Toggle on **Lock To Start** and **Lock To End**. Make sure that the reflection shape is placed on the <u>bottom</u> of the screen so that the point names will be on the correct side. **Left** click through the prompts to accept placement. **Note:** For a scenario involving a **3-sided** slab bridge, there are three **RCSB** templates in the same ITL folder that operate in the same way as the box culvert templates.



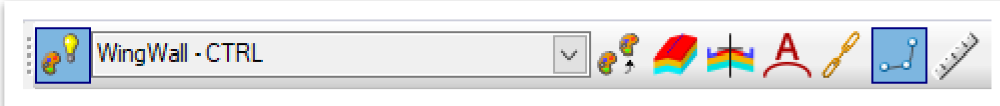
5. The linear template that was just placed needs to be modified to fit the dimensions of the proposed **8' x 8'** box. We will edit the template to match what was created in the last exercise. For this scenario, reference **STD-17-53**. **Note:** If the **3D** modeling is being done by someone other than the hydraulic engineer, the information from the applicable standard drawing should be given to the 3D modeler.
    - **Cell Width (Interior Cell Height):** 8'
    - **Cell Height (Interior Cell Width):** 8'
    - **ST (Top of Slab Width):** 9"
    - **SB (Bottom of Slab Width):** 9"
    - **WT (Exterior Wall Width):** 8"
    - **BW (Out-to-Out Width):** 9.33'

6. Now, open the **Edit Template Drop** tool (**OpenRoads Modeling >> Corridors >> Edit**) and select the **box culvert**.

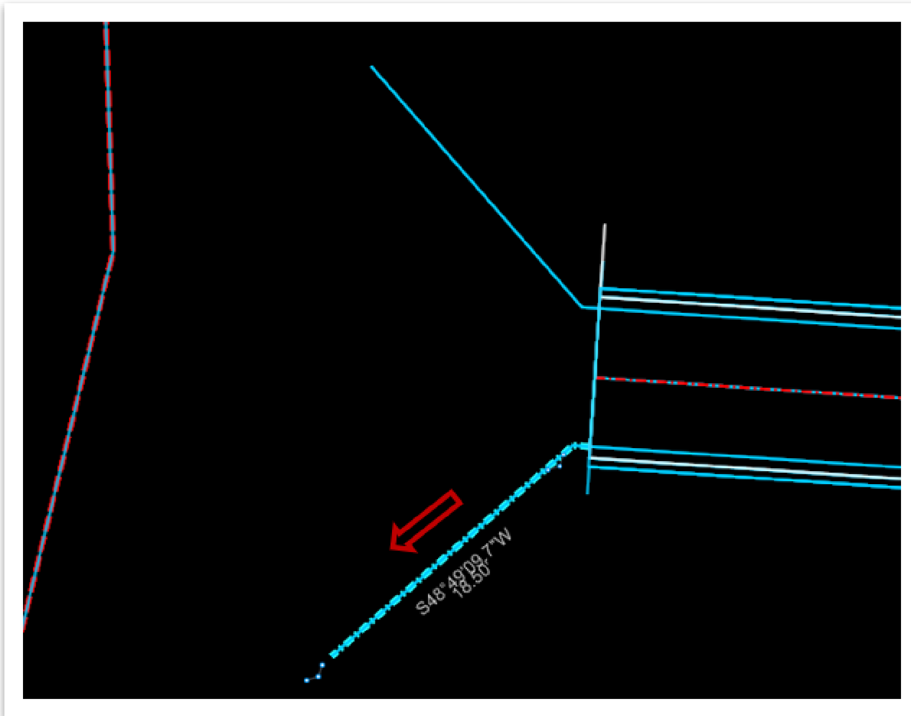


7. Notice the **five** <u>yellow</u> points. These points are only constrained in one direction and control the point described. Update the **vertical constraint** to **0.75** for the following **two** points by double clicking on each one individually. Once the update is made for each point, click **Apply** and then **Close**.
   - RCBC_SB_CTRL
   - RCBC_ST_CTRL
8. This template happens to be set up as an **8' x 8'** box so the other three yellow point constraints are already correct. The height would be controlled by **RCBC_HT_CTRL**, the width would be controlled by **RCBC_WD_CTRL** and the structure width would be controlled by **RCBC_WT_CTRL**. Click **OK** within the **Editing Roadway Designer Template Drop** window and it will automatically close. The model will re-process and you should see the updates. **Note:** All these points can also be controlled by **parametric constraints**.
9. Turn off the **ROAD-II-BC-Drainage Structures.dgn** (**Default-3D**) reference file. Within the **ROAD-II-BC-Drainage Model.dgn** reference file, turn on the **DES - MODEL - Lines - RCBC - Outside Edge** level. This will show the **2D** outline of the box that was drawn during the hydraulic analysis. We will use this to help model the wingwalls properly. **Note:** In this exercise, the box culvert is at a 90° skew. If it was at any other skew, you would need to create a **clip shape** to clip the **3D** model.

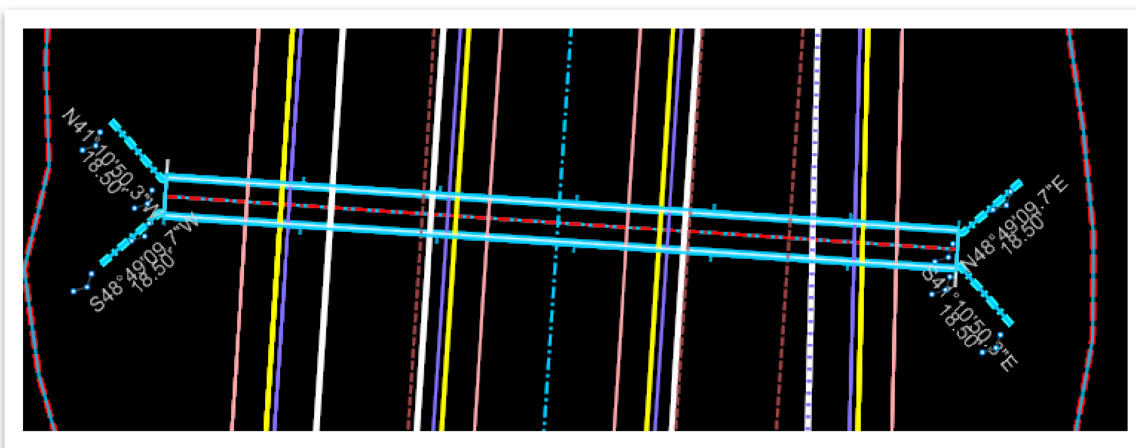
10. Next, we need to draw the **control lines** for the wingwalls. Select the **WingWall - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Drainage**).



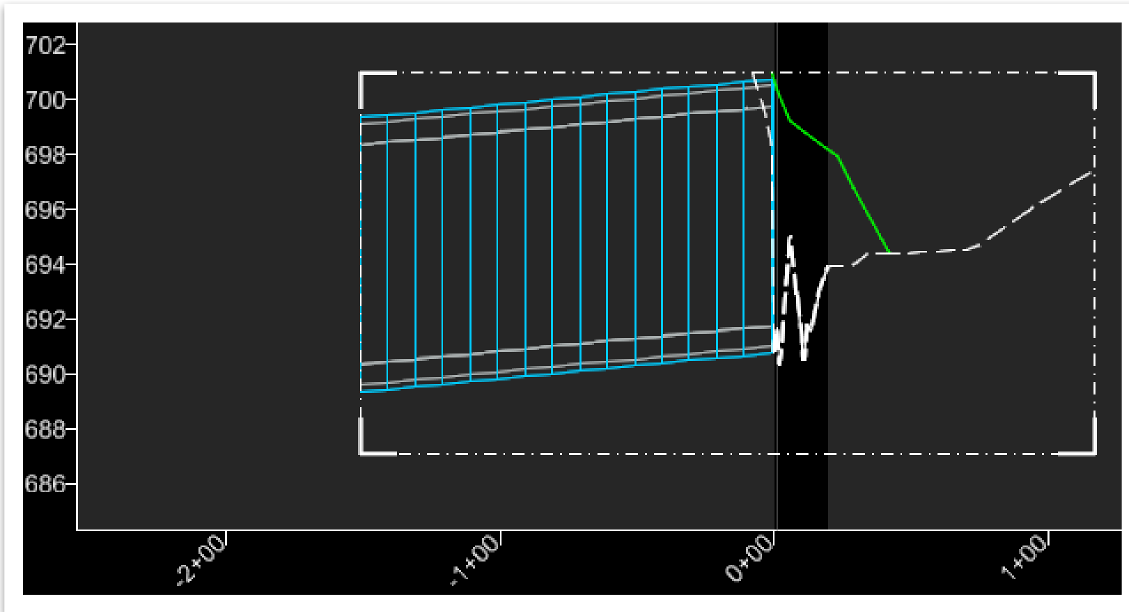
11. Open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and trace over the lower left **2D** wingwall that we drew in the previous exercise. Then, **complex** the two elements drawn going **away** from the box culvert.



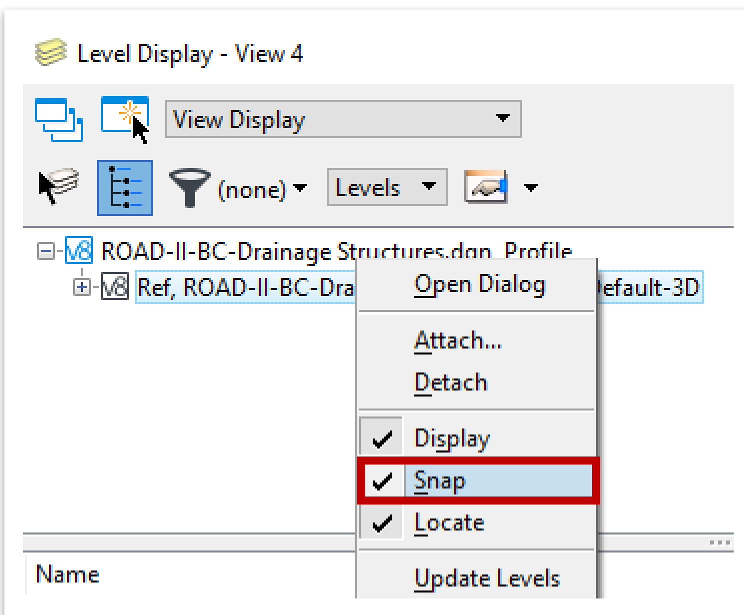
12. Repeat the previous step for the other **three** wingwalls.



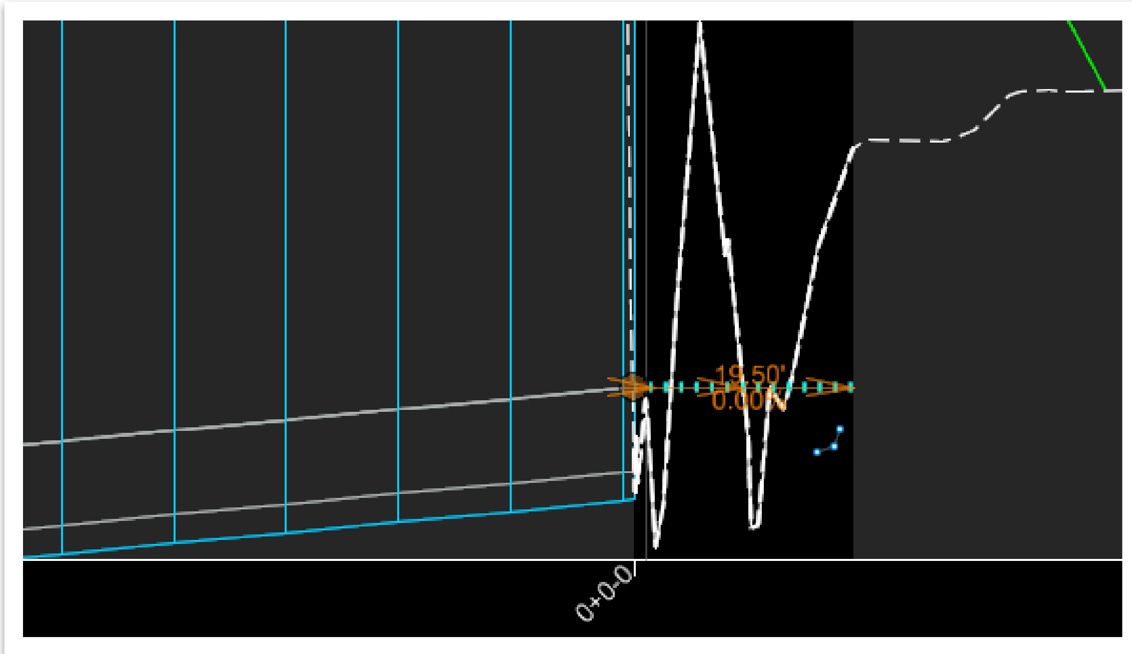
13. Now, open the **profile** of any complex element just created. The profile of this line will control the bottom of the wall, above the footing. To find the bottom of the box culvert, create a **3D cut**. Select the **Corners** placement method and then draw an area so that the proposed box culvert shows up sufficiently on the left side of the profile.

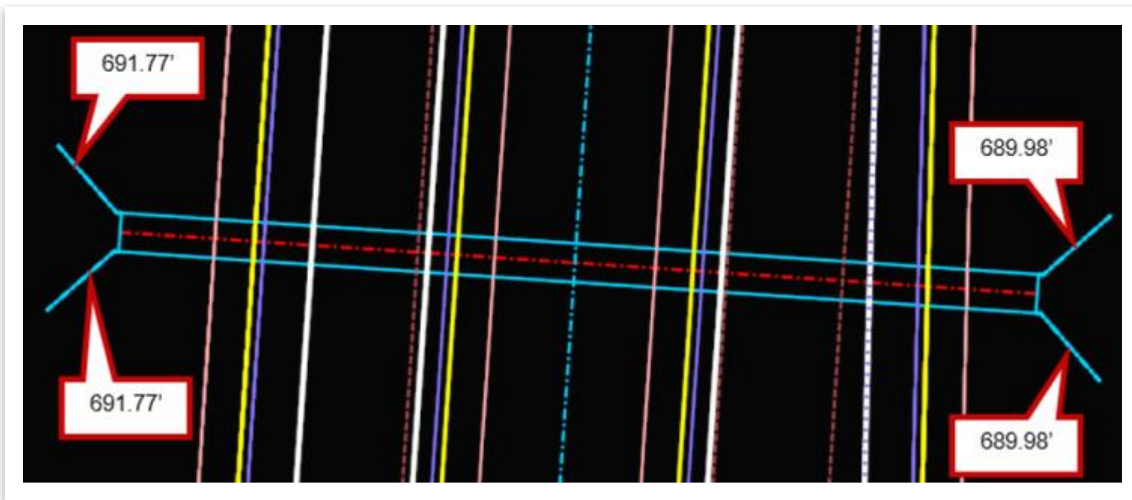


14. In order to snap to a 3D cut, open the **Level Display**. **Right** click on the **ROAD-II-BC-Drainage Structures.dgn, Default-3D** reference file and toggle on **Snap**.

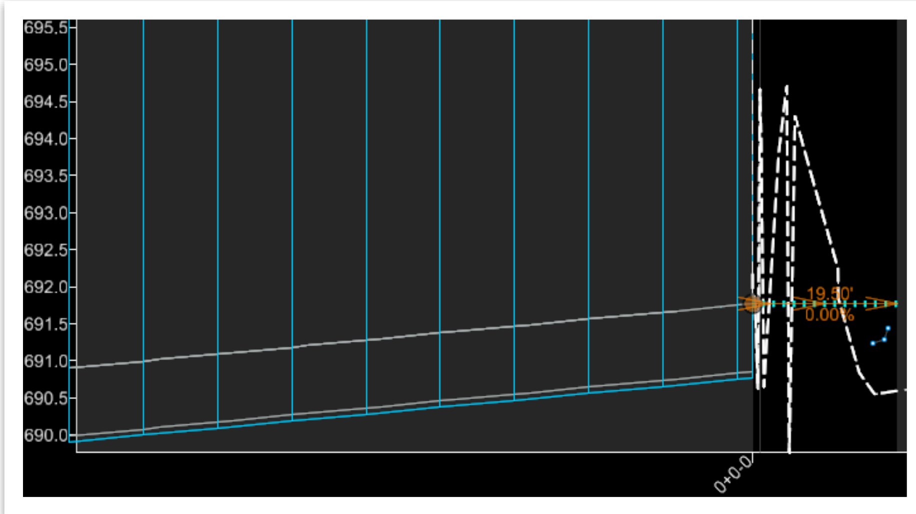


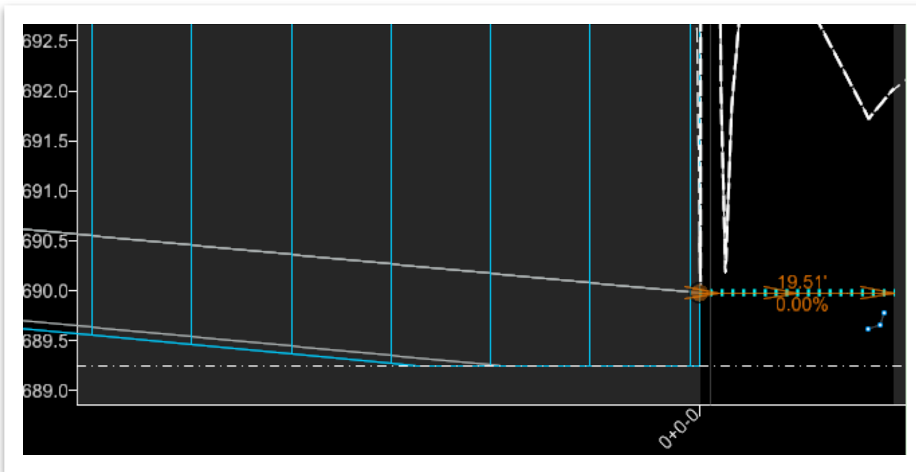
15. Next, we need to create a level profile line for each wingwall footing that the template will follow. Open the **Profile Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Lines**) and snap to the beginning of the box culvert bottom (second bottom grey line). Set the **Slope** to **0%** and then snap to the end of the profile. Set the profile to **active**. **Note:** The **upstream right** wingwall profile is shown below. The profile elevations are labeled which match the inverts of the box culvert.

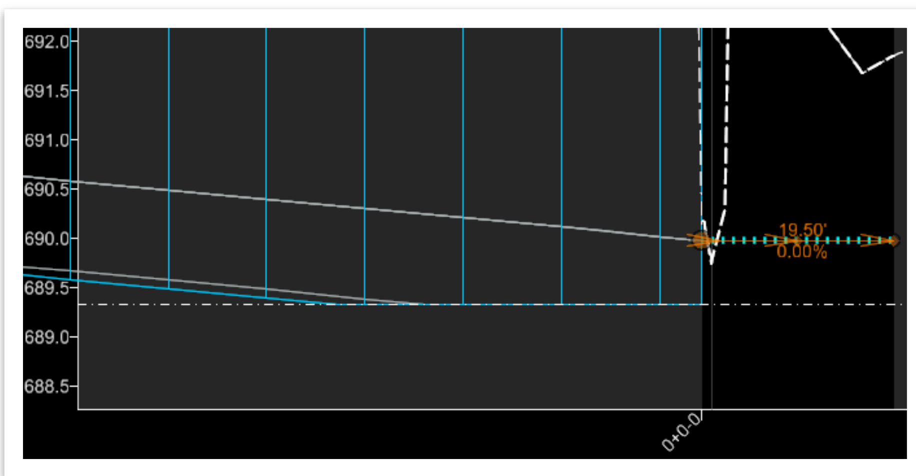




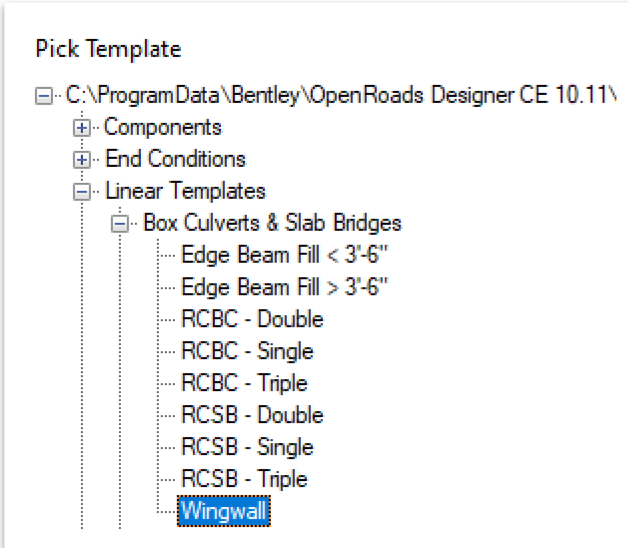
16. Repeat Steps 13-15 for the other **three** wingwalls. The profiles for each wingwall are shown below in the following order: **Upstream Left**, **Downstream Left**, and **Downstream Right**.



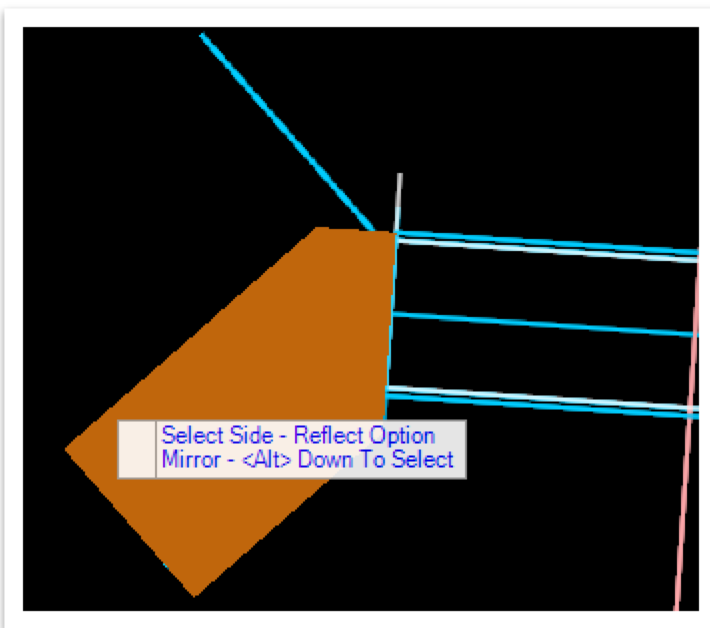




17. Once completed, we now need to place the linear **template drops** for each wingwall. Open the **Apply Linear Template** tool (**OpenRoads Modeling >> Model Detailing >> 3D Tools**) and select the **Wingwall** template (**Linear Templates >> Box Culverts & Slab Bridges**) template.



18. Select the **upstream right** wingwall geometry to apply the template. Toggle on **Lock To Start** and **Lock To End** and then click through the prompts to accept. When prompted which side to place the template, select towards the center of the box culvert.

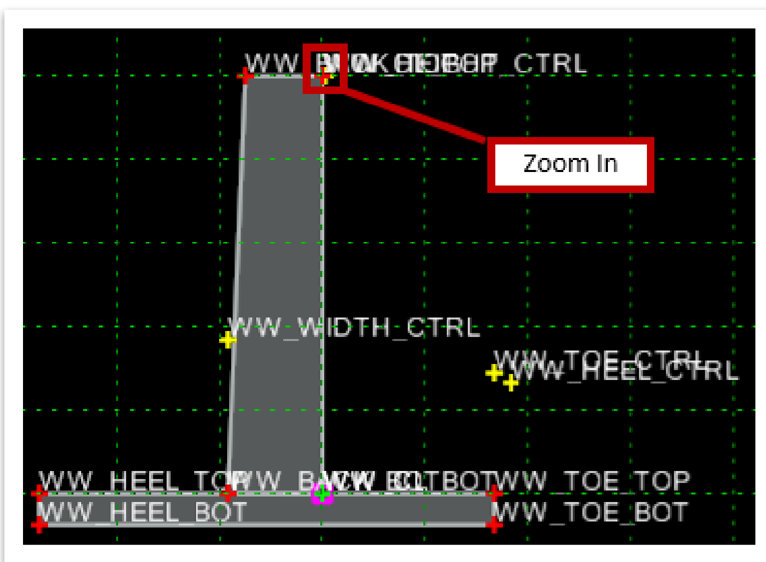


19. Repeat the previous step for the other **three** wingwalls.

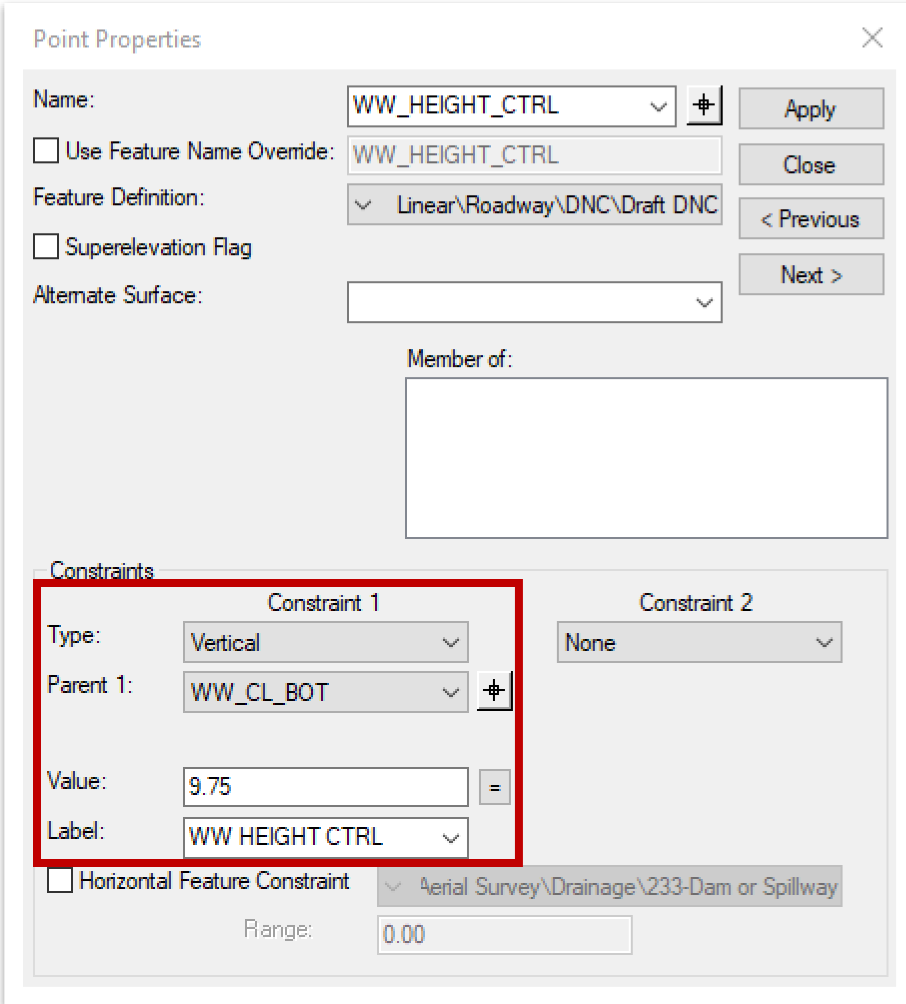
20. We need to reference both **STD-17-11** and **STD-17-15** to determine the applicable dimensions for the wingwalls. These will be input as **parametric constraints** in the following steps.
    - **From STD-17-11 (4:1 Slope):**
        - **H (Fill Height)**: 10’
        - **W (Wall Length):** 18.50’
        - **h (Wall Height):** 6.50’
        - **ST:** 9”
    - **From STD-17-15:**

DESIGN SECTION	WALL DIMENSIONS					
	DESIGN HEIGHT	BASE	TOE	W	HEEL	D
1	4′-0"	2′-9"	1′-3"	11"	7"	9"
2	6′-0"	3′-9"	1′-6"	1′-0"	1′-3"	9"
3	8′-0"	4′-7"	1′-8"	1′-1"	1′-10"	9"
4	10′-0"	5′-7"	1′-11"	1′-2"	2′-6"	9"
5	12′-0"	6′-7"	2′-2"	1′-3"	3′-2"	11"

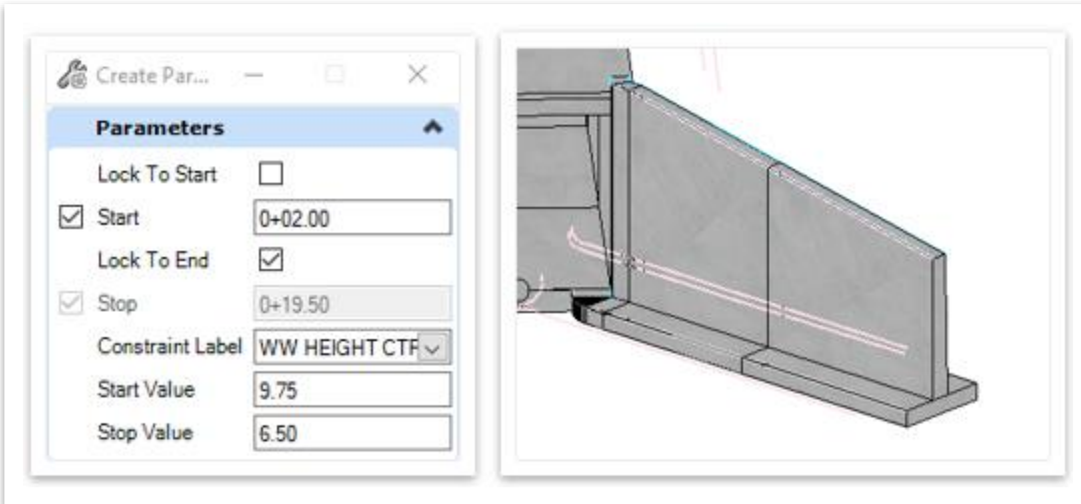
21. Now we need to edit the wingwall template that was placed and set the **base height** for the wingwall. Open the **Edit Template Drop** tool (**OpenRoads Modeling >> Corridors >> Edit**) and select one of the **wingwalls**. Then, double click on the yellow **WW_HEIGHT_CTRL** point.



22. Update the **vertical constraint** to **9.75** (8' box height, 9" top structure height, 1' curb lip from STD-17-8). Once the update is made, click **Apply** and then **Close**. Repeat for the other **three** wingwalls.



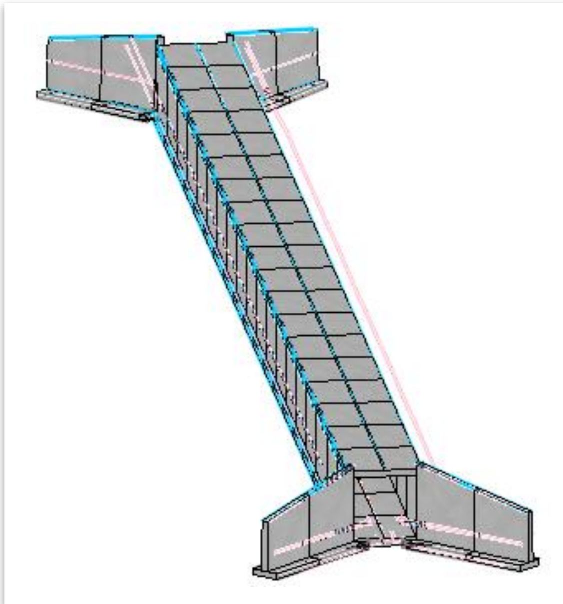
23. For each wingwall, there will be **four parametric constraints** to control the wingwall and match the TDOT standard drawing specifications. Open the **Create Parametric Constraint** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and select one of the wingwall templates to create the first parametric constraint. To create the height control, use the **WW HEIGHT CTRL** constraint label. The **Start** station should be **2'** from the end of the box culvert and the **Stop** station is the end of the wall. Set the **Start** and **Stop Values** to **9.75** and **6.50** respectively.



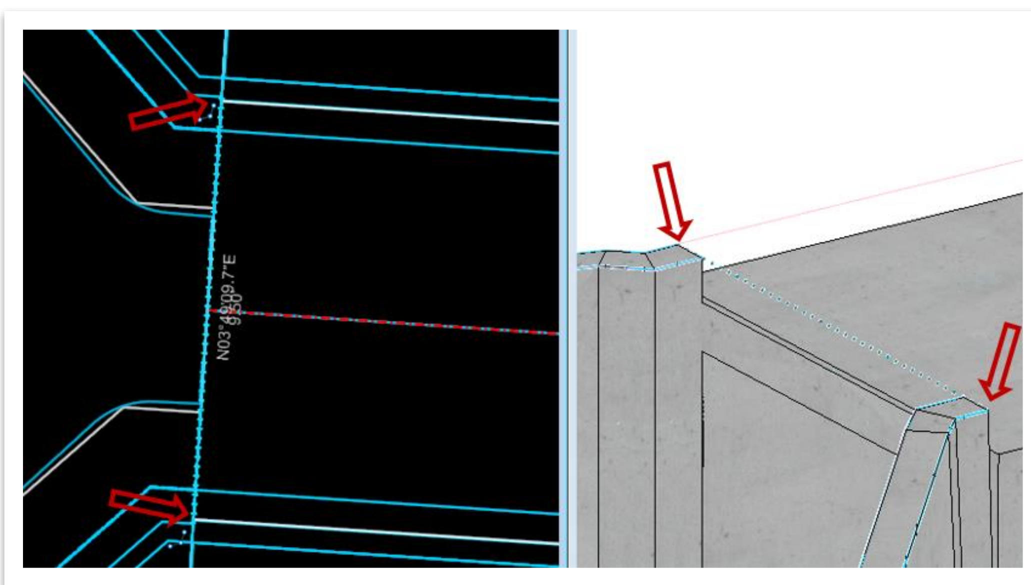
24. Then, repeat the previous step for the other **three** wingwalls.
25. Next, create the remaining **three** parametric constraints for <u>each</u> wingwall based on the table below. For each constraint, toggle on **Lock To Start** and **Lock To End**.

Constraint Label	Start Value	Stop Value
WW TOE CTRL	1.92	1.50
WW WIDTH CTRL	-1.17	-1.00
WW HEEL CTRL	2.50	1.25

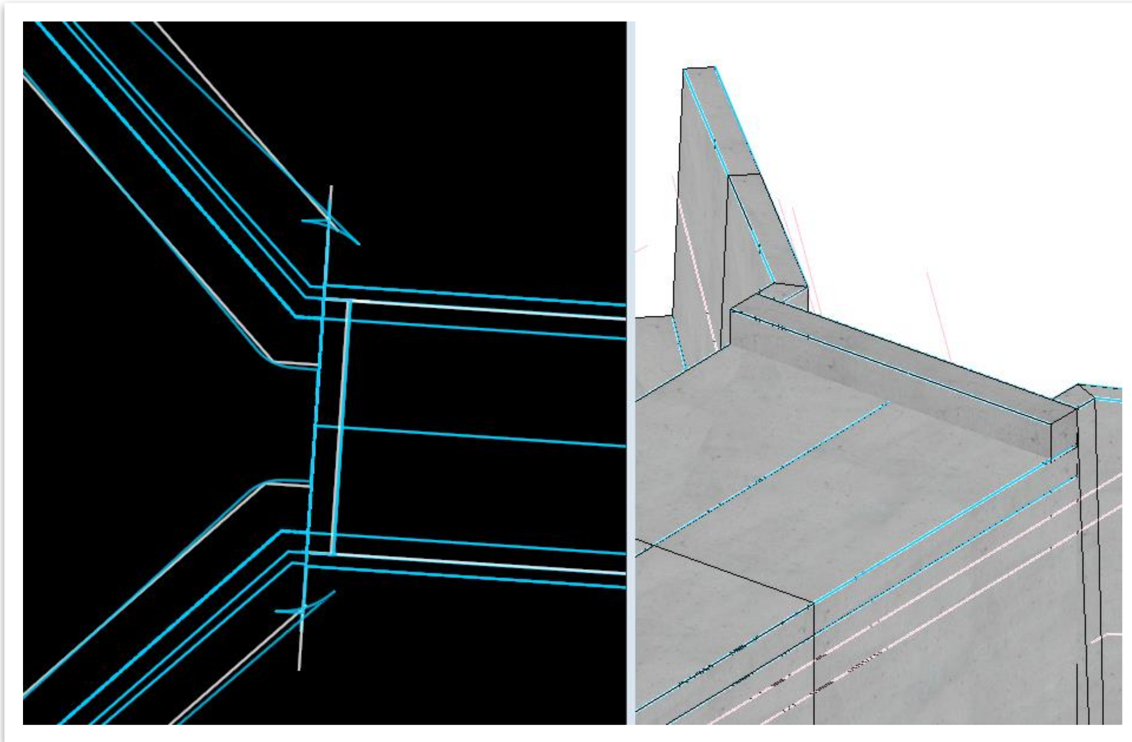
26. Once completed, your box culvert model should look like the screenshot below. **Note:** The 3D view has been rotated and the I65 corridor reference has been turned off.



27. Now, we need to add the **edge beam** along the top of the box culvert. To do this, select the **Curb - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Curb and Gutter**). Make sure **Create 3D Automatically** is toggled on. Open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and draw a line along the top of the box culvert snapping to the **WW_BACK_TOP** lines from each wingwall. Repeat for the other side of the box culvert. **Note:** Make sure that **Create 3D Automatically** is toggled on so that the upcoming steps will work properly.

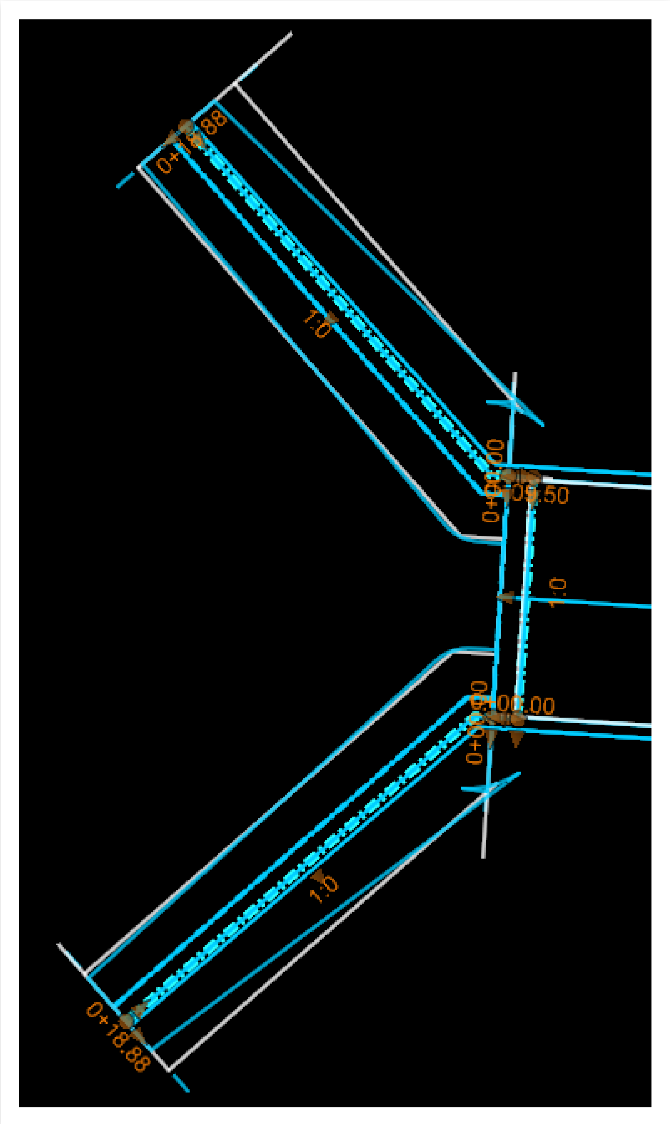


28. Next, open the **Apply Linear Template** tool (**OpenRoads Modeling >> Model Detailing >> 3D Tools**) and select the **Edge Beam Fill > 3'-6"** template (**Linear Templates >> Box Culverts & Slab Bridges**). Select the control line just drawn and toggle on **Lock To Start** and **Lock To End**. Select to place <u>inside</u> the box and then repeat for the other side of the box culvert.

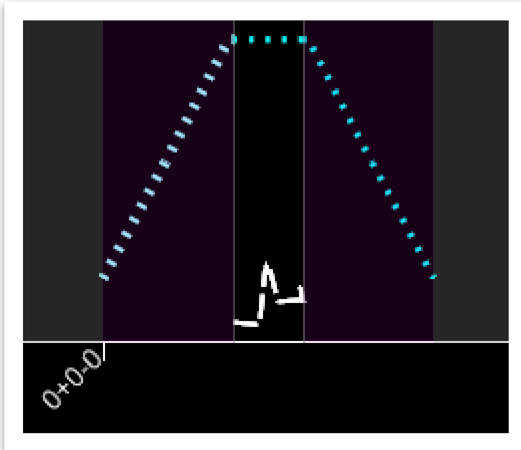


29. The box culvert model is now complete. The last item we need to do is target the **slope lines** to the new box culvert model. Go ahead and open the roadway corridor file (**ROAD-II-BC-I65 Corridor.dgn**) and attach the **ROAD-II-BC-Drainage Structures.dgn** file that was just created. Within the drainage structures file, turn off the **DES - CORRIDOR GRAPHICS - Design** level.
30. Select the **WingWall - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Drainage**). Make sure **Create 3D Automatically** is still toggled on.

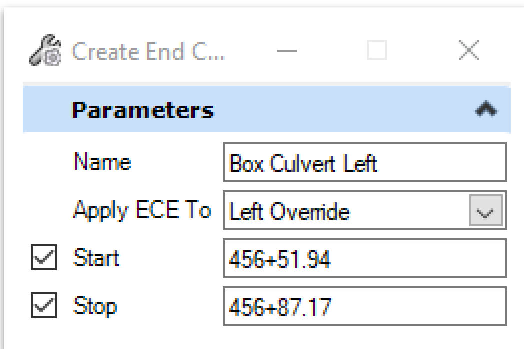
31. We will create a **complex** geometry for the **I65** corridor to target. First, open the **Single Offset Entire Element** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**). Set the **Offset** to **0** and then offset the **WW_ BACK_TOP** line on both wingwalls, and the **CURB_BACK** line on the edge template. **Note:** In this exercise, we will only show the upstream side, but the process would be the same for the downstream side.
32. Open the **Complex By Element** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Complex Geometry**) and set the **Method** to **Manual**. Complex the three elements that were previously drawn, from the bottom of the screen to the top, with the purple arrow pointing upwards for all elements. **Note:** In general, complex elements do not have to connect. In this scenario, it's not an issue that the complex element is still 3 separate elements. This step is done so that the corridor has a single element to target in the following steps.



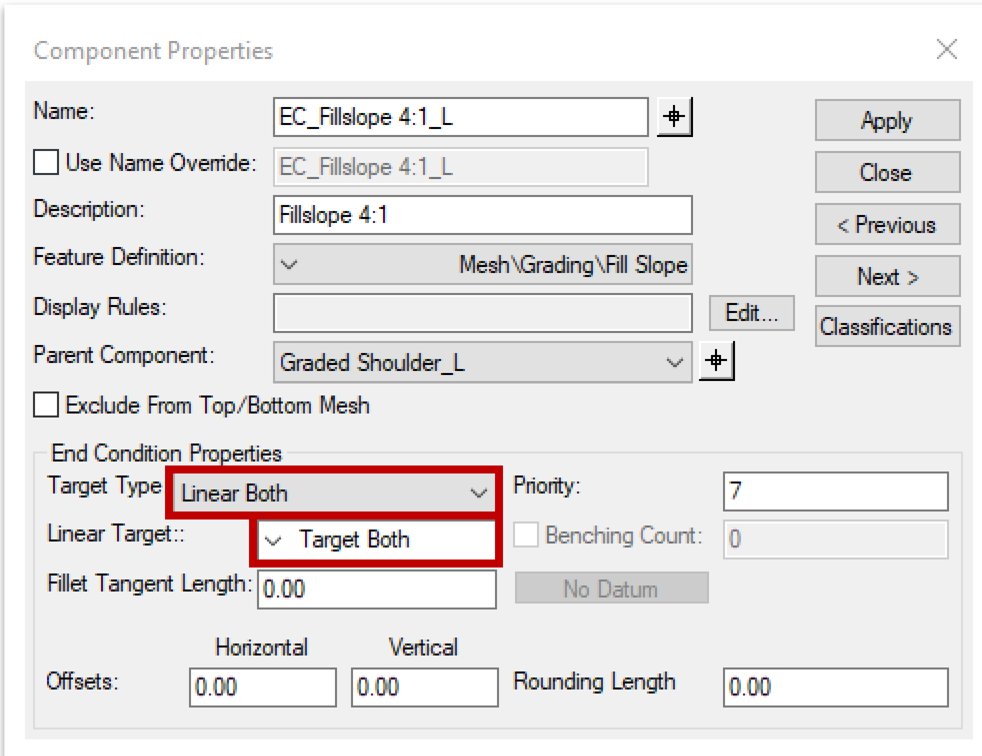
33. Open the **profile** of the complexed element, and vertically complex the elements that were automatically drawn.



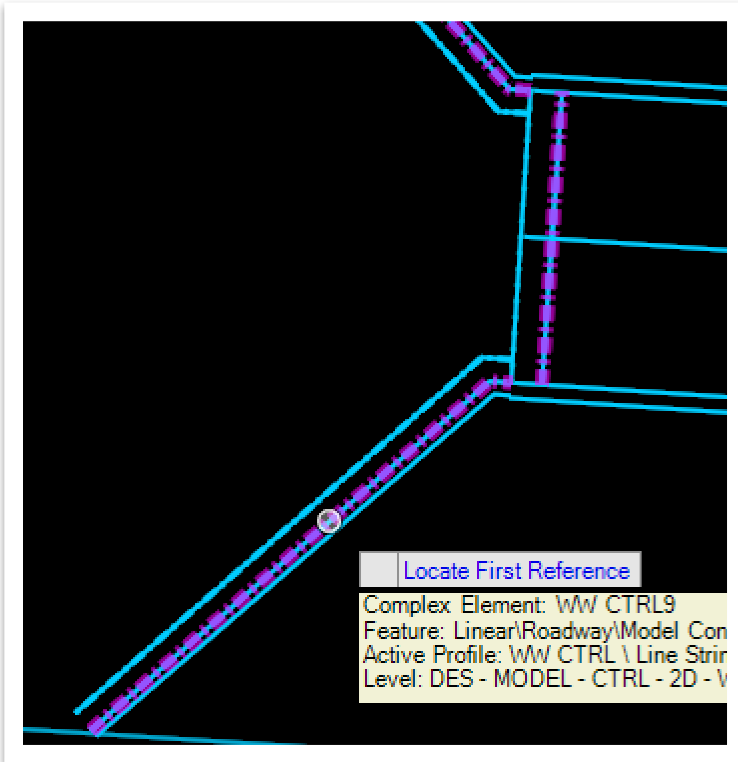
34. Now, open the **Create End Condition Exception** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and select the **I65** corridor. Name it **Box Culvert Left** and set the **Apply ECE To** option to **Left Override**. **Note:** When setting the **Start** and **Stop** stations, do so right at the start and end of the wingwalls but **do not snap** to the wingwalls. Your stations may vary depending on where you clicked.



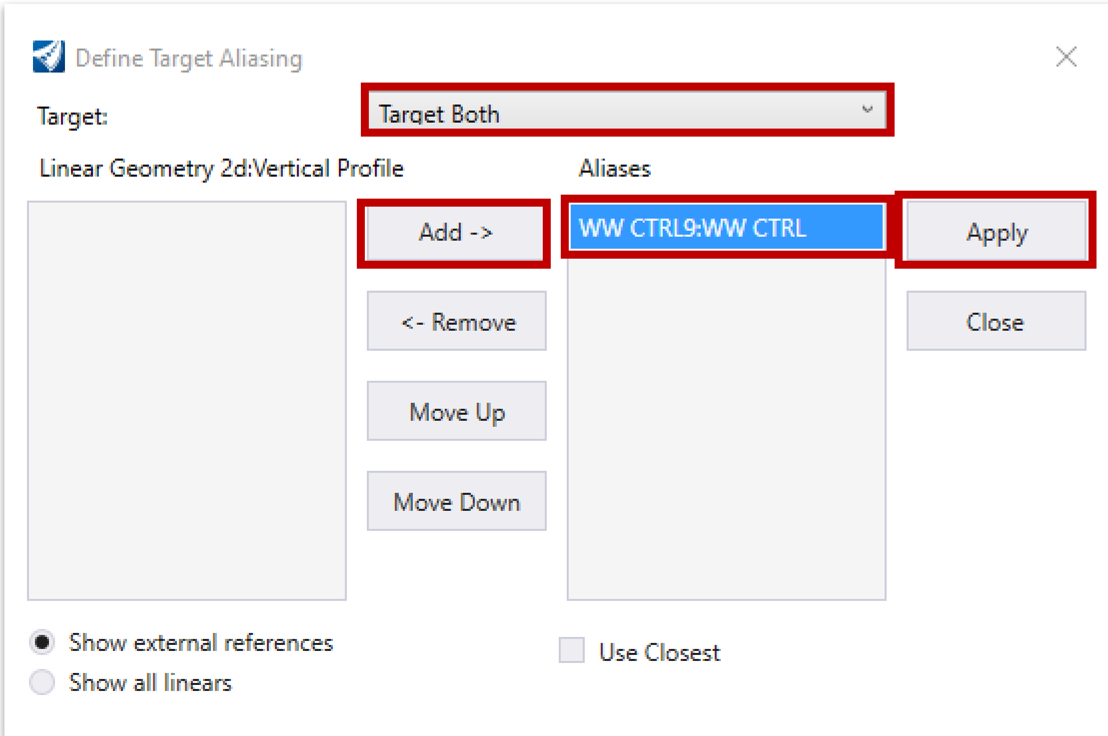
35. A **Left Override End Condition Exception** window should appear. Double click on the end condition component and change the **Target Type** to **Linear Both** and the **Linear Target** to **Target Both**. Then click **Apply** and **Close**. Click **OK** to close the **Edit Template** window.



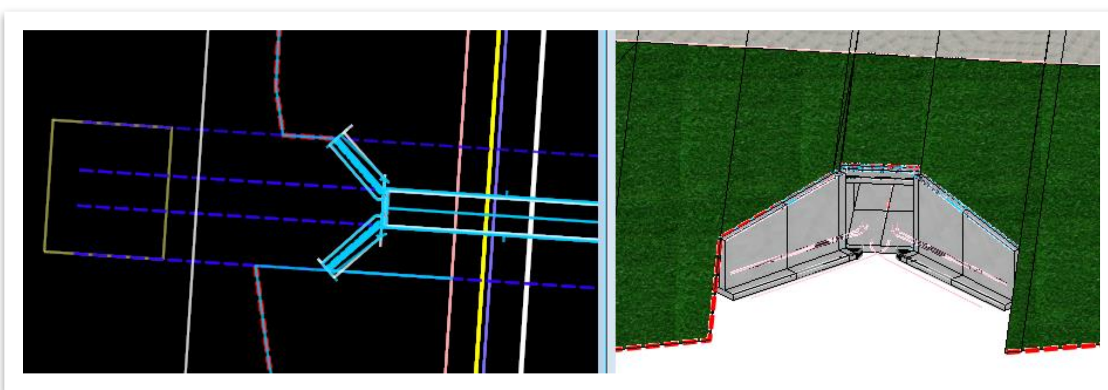
36. Once the **Edit Template** window closes, you may notice that the end condition disappears completely or perhaps nothing changes. There are a few more steps in order for the corridor to target the complex element. Open the **Add Corridor Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor References**) and select the **I65** corridor and then target the **WingWall - CTRL** complex geometry that was drawn.



37. Next, open the **Define Target Aliasing** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous**) and select either the **End Condition Exception** or the **I65 Corridor** graphics. Change the **Target** drop-down option to **Target Both**. Select the **WW CTRL9** line that was just added as a reference and click **Add** and then **Apply**.



38. The corridor still may not look correct. This is because the end condition is only targeting the element at every **25'** template drop. You would need to open the **Create Key Station** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and select the **I65** corridor. Then, place a key station at <u>each</u> location where the wingwall changes direction. **Note:** Additional key stations may be needed compared to what's shown.



Chapter 13. Special Ditches

Special ditches and **ditch lining materials** are prevalent in roadway design. This chapter will discuss how to hydraulically analyze and modify ditch configurations and then how to implement the designed configuration into the roadway model.

13.1 Objectives

At the conclusion of this chapter, participants will be able to:

1. Verify the hydraulic capacity of standard and special ditches.
2. Modify ditch components and roadway templates.

13.2 Lecture: Standard Ditch and Special Ditch Modeling

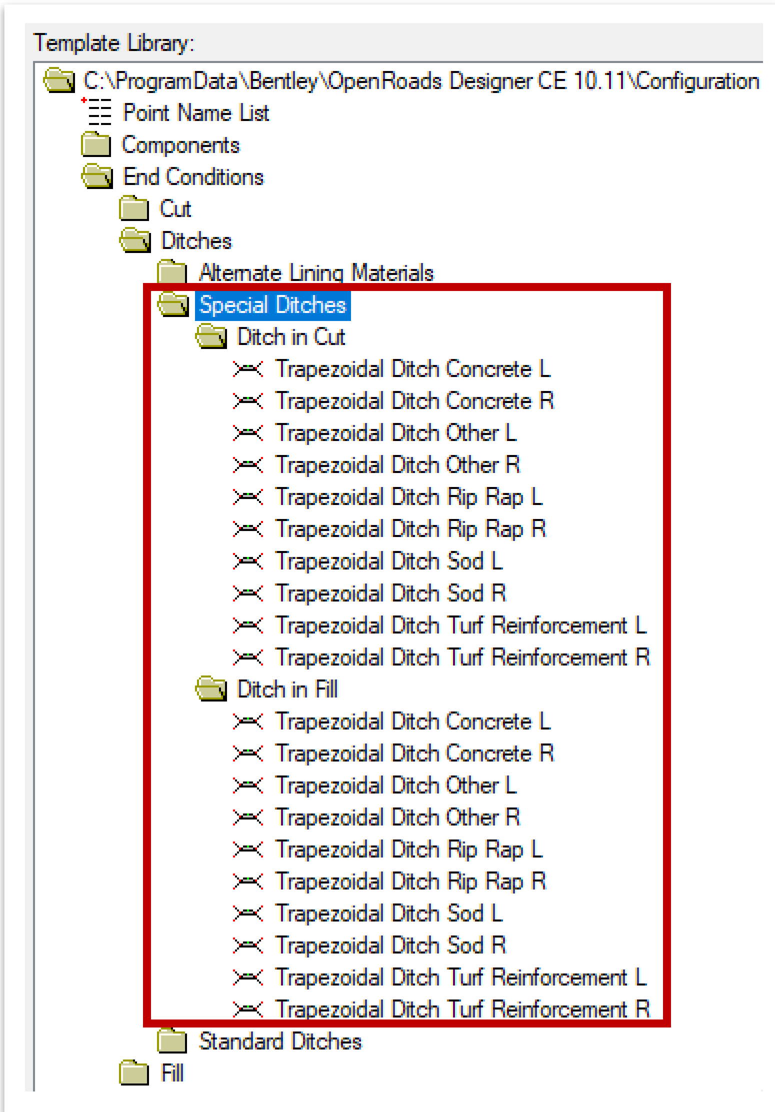
Roadside ditches are typically designed to carry the runoff from the proposed roadway width, which drains to both sides from the crown of the roadway. A ditch that is placed at a fixed offset from the roadway alignment and that runs through most of the project length is considered a **Template Ditch** or a **Standard Ditch**. These ditches should already be present in any **3D** roadway model. The pre-configured ditch is set by the TDOT standard drawing that is being referenced. If the designer determines instead that a **non-standard** ditch needs to be used as a project standard, the modifications need to be made in the standard template drop for that project.

If using the standard sod/grass treatment, the designer would need to change the constraints on the **EC_DITCH_CL** point to reconfigure the standard ditch in the template drop. If the ditch lining treatment needs to change, you would follow the steps in Exercise 13.4.

If the designer still determines that a different ditch configuration or treatment is needed within the corridor, a **Special Ditch** will be needed.

Within the default TDOT template library (ITL), there are both **Ditch in Cut** and **Ditch in Fill** special ditch components (**End Conditions >> Ditches >> Special Ditches**) (Figure 21). These components can easily be added to any project template as necessary. Simple modifications can be made to the horizontal, vertical or slope point constraints to create any ditch configuration required.

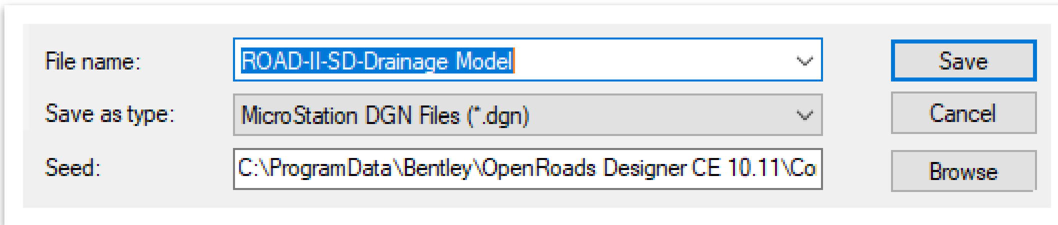
FIGURE 21. SPECIAL DITCH COMPONENTS



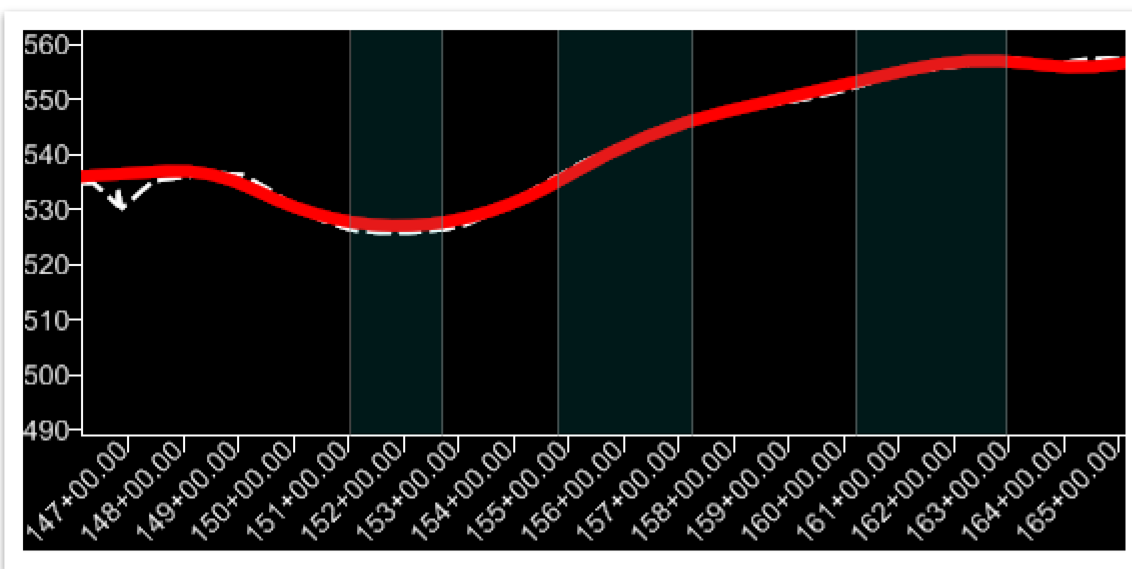
13.3 Exercise: Standard Ditch Hydraulic Analysis

In this exercise, we will analyze input flows in a ditch from the approximate high point to the approximate low point. **Note:** For this exercise, it is assumed that the user has prior knowledge of basic hydrology / hydraulics principles and has reviewed the [SUDA (ORD) Manual](#).

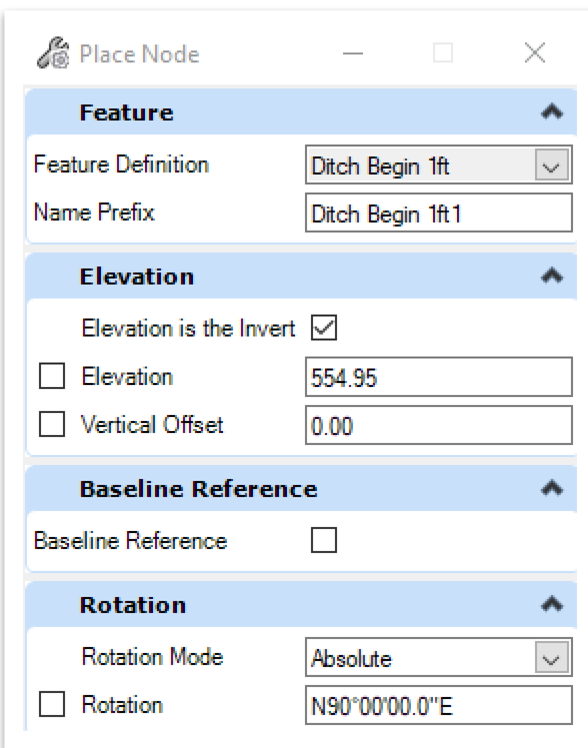
1. Create a new file and name it **ROAD-II-SD-Drainage Model**. Select the **TDOT Seed2D.dgn** and click **Save**. **Note:** Save this file under the dgn Chapter 13 subfolder.



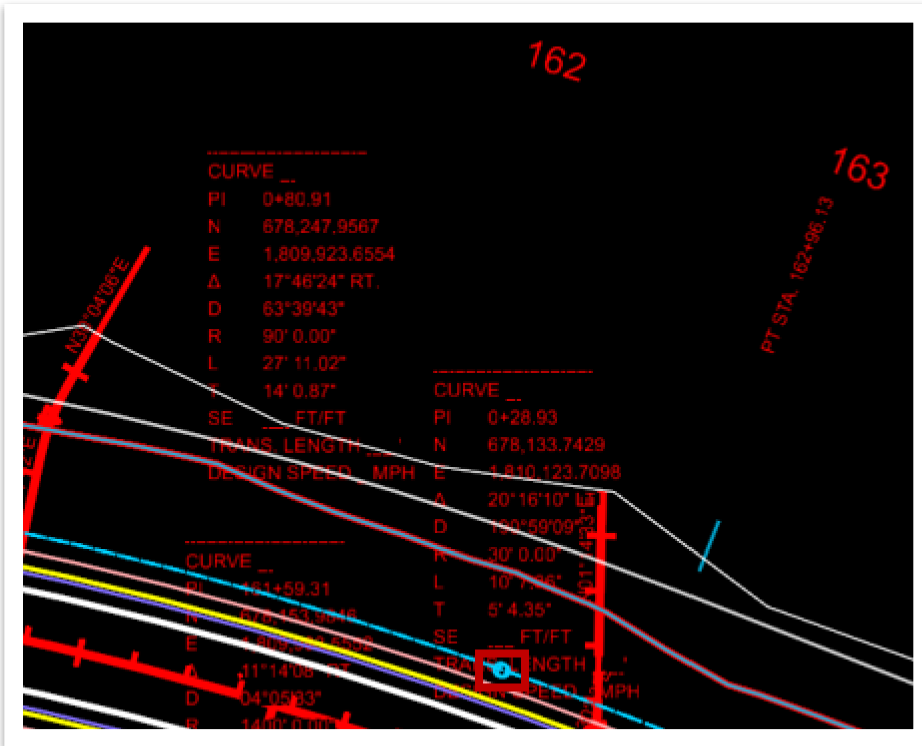
2. Make sure that the **Default** view is active in the lower left corner. Attach the following reference files using the **Coincident World** attachment method and then click **Fit View**.
    - ROAD-II-SD-Alignments.dgn
    - ROAD-II-SD-Corridor.dgn
    - ROAD-II-SD-Terrain.dgn (set **terrain** to active)
3. Before we create a utility model, let's look at the proposed profile. Switch back to the **Drainage and Utilities** workflow. Open the **Open Profile Model** tool (**Drainage and Utilities >> Utilities View >> Drawing Views**) and select the mainline centerline. Scroll to the approximate area between Stations **147+00.00** and **165+00.00**.



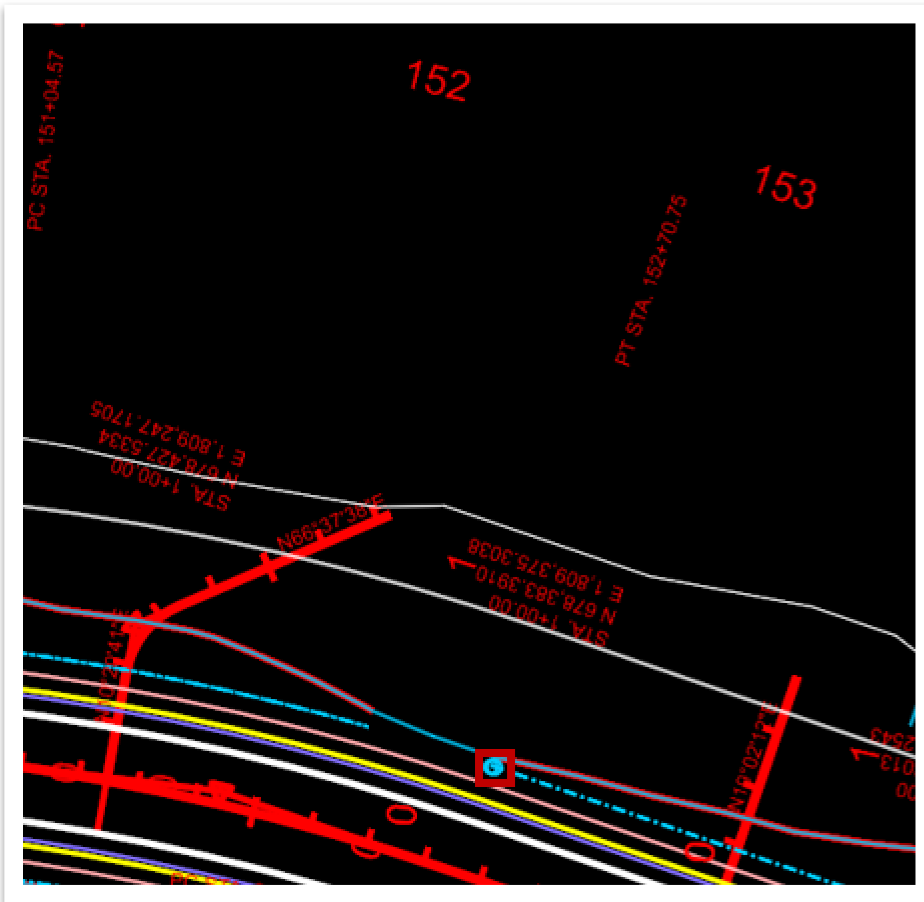
4. Notice the low point of the profile is around Station **152+00.00**. There is another low point around Station **164+00.00** and a high point around Station **162+50.00** Essentially, all the flow from Station **162+50.00** will collect at the low point at Station **152+50.00** since there will be a proposed outfall at this location. Go ahead and minimize the profile view for now.
5. Next, we will analyze this area to see if the standard template ditch can handle this flow. Open the **Place Node** tool (**Drainage and Utilities >> Layout >> Layout**). A warning will display asking if you want to proceed with embedding files for Drainage and Utilities projects in the design file. Click **Yes** and give the software a few seconds to load the drainage standards from the library. You should get a **Compact Database** alert asking if you want to proceed. Click **No**.
6. Go ahead and open the **Place Node** tool again and select the following settings.
    a. **Feature Definition:** Ditch Begin 1ft (**Node >> StormWaterNode >> Ditch Nodes**)
    b. **Name Prefix:** Ditch Begin 1ft1
    c. **Elevation is the Invert:** Toggled on
    d. **Elevation:** Unchecked (value will be determined in the next step)
    e. **Rotation Mode:** Absolute (any rotation)
    f. **Rotation Mode:** Absolute (you can ignore the rotation angle)



7. Select the **proposed** corridor as the **elevation reference** and then place the node on the north side along the roadway **ditch CL** (blue dashed line), at approximate Station **162+50.00**. **Do not snap to the Ditch CL**, because if the ditch location changes in the template, the nodes will lose the location, and attempt to snap to a different ditch in a different area of the corridor. **Left** click to accept the **rotation mode** and then **left** click to accept the rotation. **Note:** For this node, the rotation angle is insignificant since it is circular. Also, for this exercise, the approximate location is sufficient.

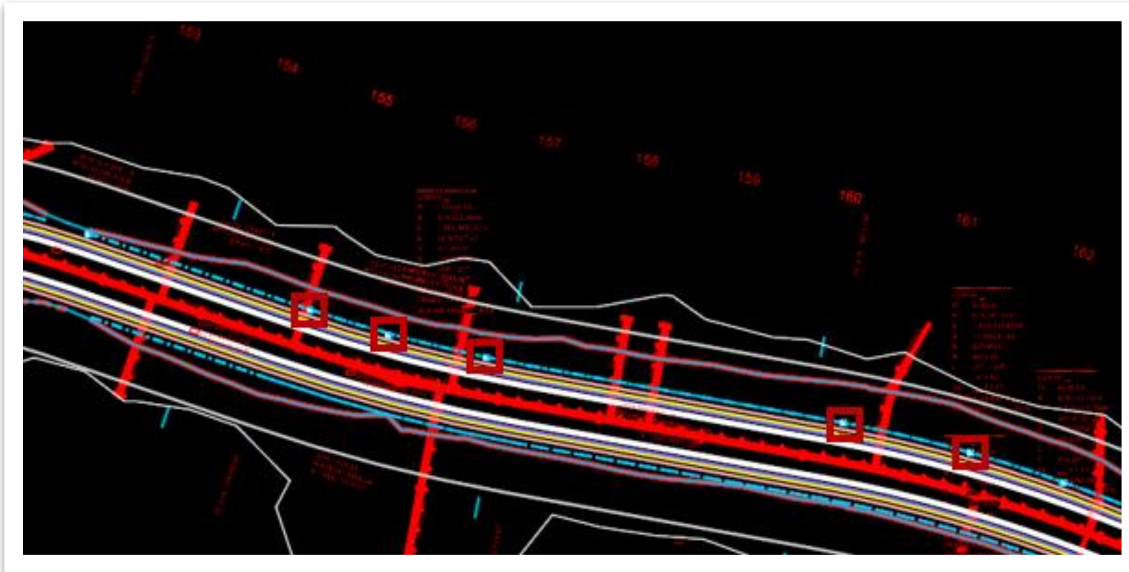


8. Repeat the previous step to place the **ditch end** node. Select the **Ditch End 1ft** feature definition (**Node >> StormWaterNode >> Ditch Nodes**) and place the node on the <u>north</u> side along the roadway **ditch CL**, at approximate Station **152+70.00**. Once placed, hit **ESC** to clear the tool. **Note:** The low point is around Station **152+00.00** as previously mentioned, but in this case, placing the **ditch end** node right at the end of the proposed ditch around Station **152+70.00** will allow the node to utilize the terrain more accurately.

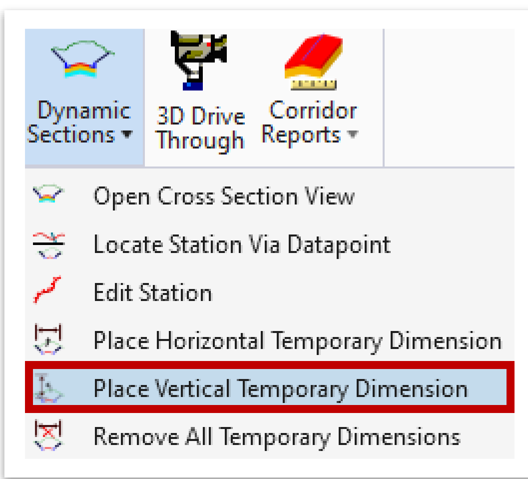


9. Now that the begin and end ditch nodes are placed, we need to draw the ditch **conduit** that the software will use to analyze. Since the alignment is curved, a simple connection line between the begin and end nodes will not work. We need to first place **change nodes** at the vertices of the ditch centerline to approximate its curve. To determine the **vertices**, we will use the drawing tools to approximate the ditch centerline from the corridor model. **Note:** This is an interpolation. The more data points or vertices you use, the better the curve approximation will be. For this exercise, **5** vertices should be enough.

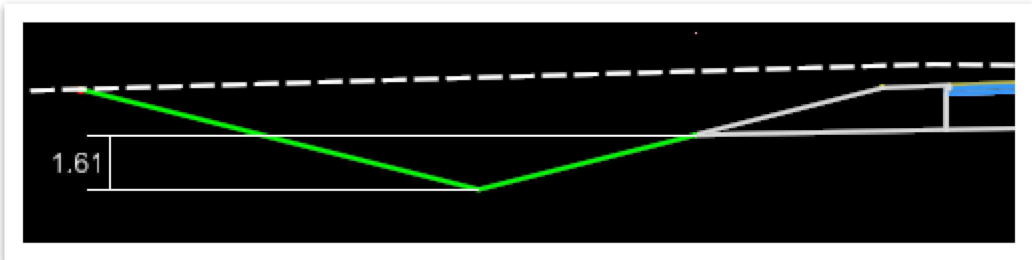
10. Open the **Place Node** tool again (**Drainage and Utilities >> Layout >> Layout**). Select the **Ditch Change 1ft** feature definition (**Node >> StormWaterNode >> Ditch Nodes**) and then select the **proposed** corridor. Place a change node **five** times along the proposed ditch CL at the locations shown below (approximate Stations **155+00.00**, **155+80.00**, **156+60.00**, **160+30.00**, and **161+50.00**). Remember, **do not snap to the Ditch CL**.



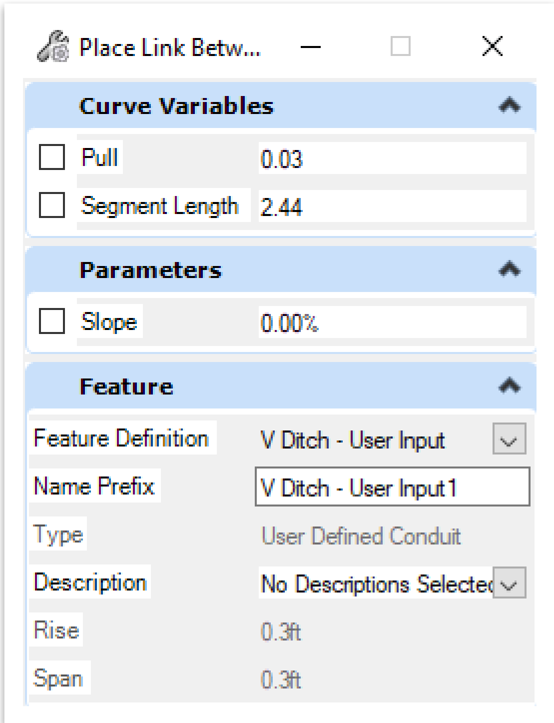
11. Before placing conduit between the nodes, we need to confirm the standard ditch configuration from the **proposed** corridor cross sections. Switch back to the **OpenRoads Modeling** workflow. Open the **Open Cross Section View** tool (**OpenRoads Modeling >> Corridors >> Review >> Dynamic Sections**). Select the **proposed** corridor and open in any view. **Note:** If you select the alignment instead, the temporary dimension labels in the upcoming steps will not work.
12. Next, open the **Place Vertical Temporary Dimension** tool (**OpenRoads Modeling >> Corridors >> Review >> Dynamic Sections**).



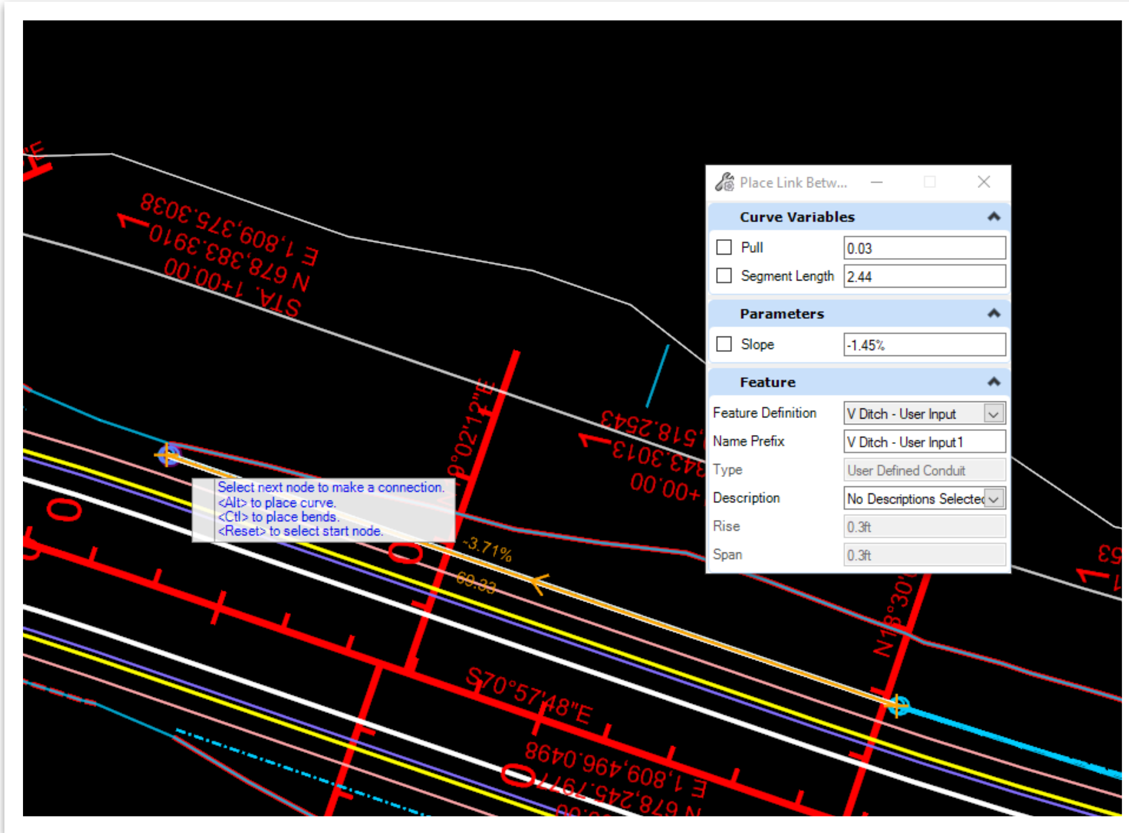
13. Select the dynamic cross section view and then select the **start point**, **end point** and **dimension location**. For this exercise, we want to dimension the vertical height from the **subgrade tie-in** point to the **bottom** of the **V-Ditch**, which should equate to **1.61'**. In general, ditch flow should always be below the subgrade elevation. We have a max **depth** of **1.6'** in the standard template ditch. The **top width** is **12.8'** with **4:1** side slopes. Go ahead and close the dynamic cross section view. **Note:** The dimension will not work on end conditions if the terrain is not set to active. The dynamic cross section for Station **100+00.00** is shown below for reference.



14. Now, switch back to the **Drainage and Utilities** workflow. Open the **Place Conduit** tool (**Drainage and Utilities >> Layout >> Layout**). Select the **V Ditch - User Input** feature definition (**Conduit >> StormWater >> Ditches >> Standard V Ditches**) and leave the **Description** as **No Description Selected**.



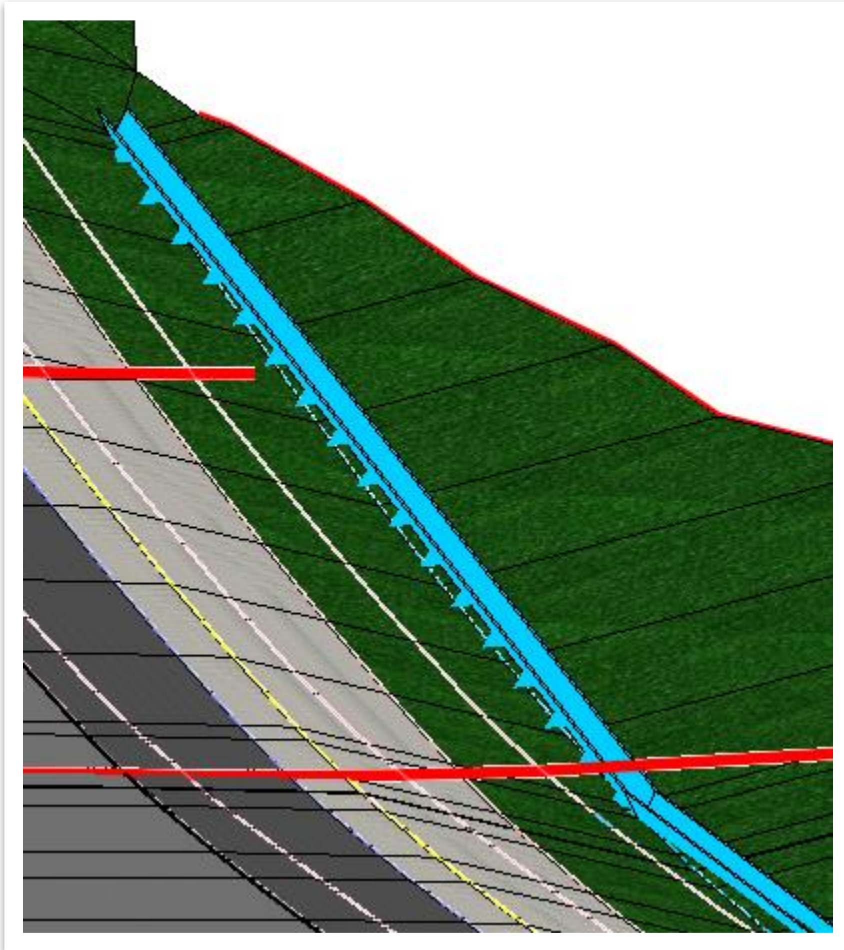
15. Go ahead and place conduits between each node in the direction of flow starting at Station **162+50.00** and going towards Station **152+70.00**.



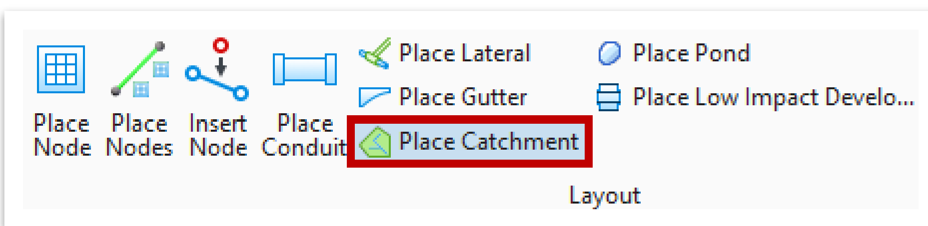
16. Next, open the **Utility Properties** for the **first** ditch conduit. Under the **Drainage** tab, scroll down to **Physical** and notice that the **Rise (ft)** and **Span (ft)** are **1.00** and **1.00** respectively. We need to update the values to match the standard ditch for the template. Update the **Rise (ft)** to **1.61**' and the **Span (ft)** to **12.80'**. Notice that a Manning's **n value** of **0.030** corresponds to the **Grass** surface of the ditch. **Note:** If a **Concrete** material is chosen, the Manning's n value will be **0.013**.

Physical	
Conduit Type	User Defined Conduit
Size (Display)	(N/A)
Section Type	Triangular Channel
Material	Bare soil
Rise (ft)	1.61
Span (ft)	12.80
Number of Barrels	1
Roughness Type	Single Roughness
Manning's n	0.030
Use Local Conduit Description?	False
Conduit Description	Triangular Channel - 12.80 x 1.61 ft

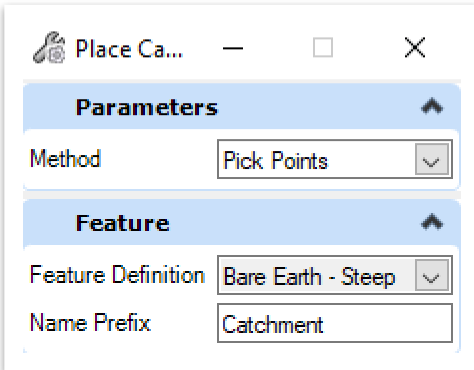
17. Repeat the previous step for the remainder of the ditch conduits placed. **Note:** The user input conduit may not update the size in the **3D** model.



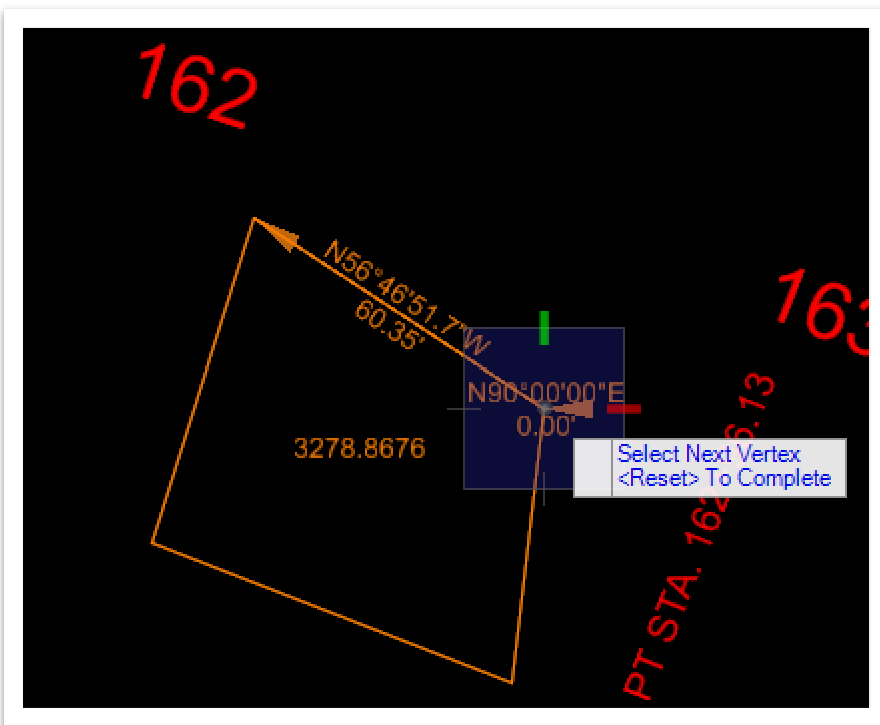
18. Lastly, we need to define a **catchment area** and input a defined **acreage** and **time of concentration**, so we can run the analysis. Open the **Place Catchment** tool (**Drainage and Utilities >> Layout >> Layout**). Turn off the **ROAD-II-SD-Corridor.dgn** reference file.



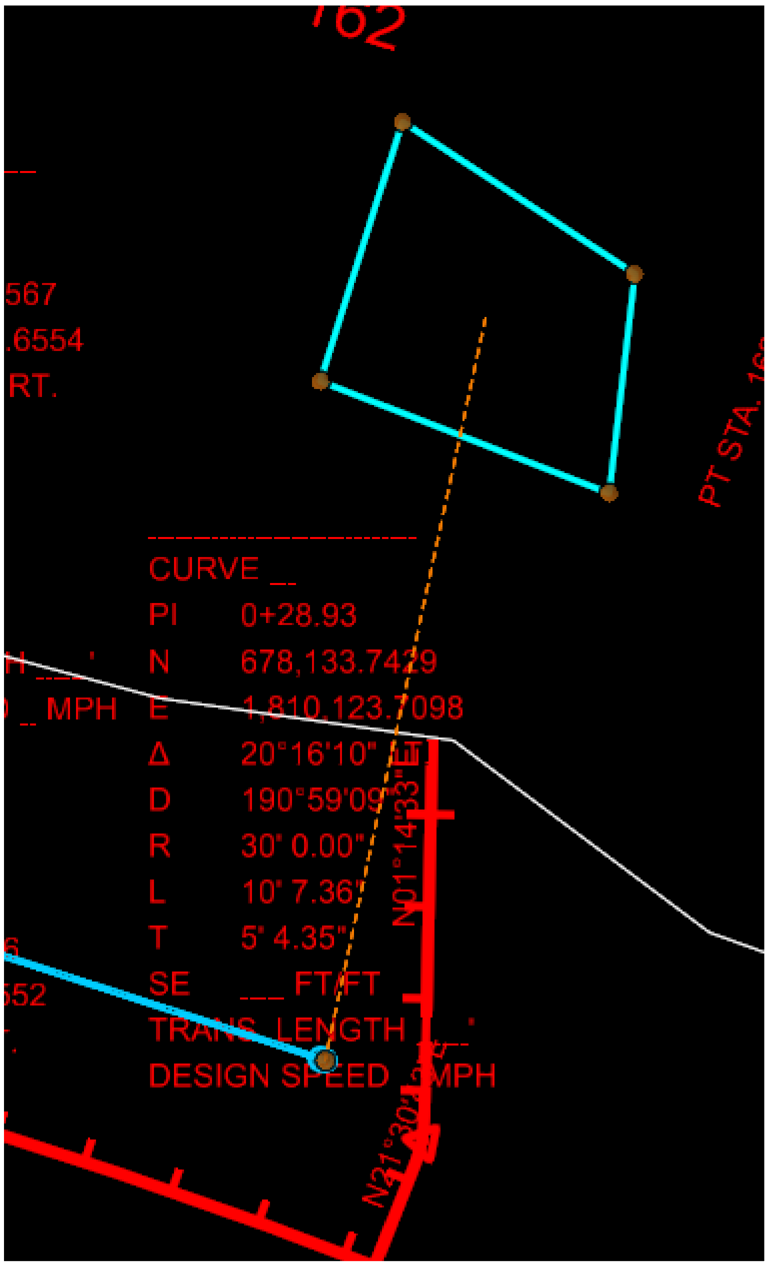
19. Within the **Place Catchment** dialog box, select the following settings.
    a. **Method:** Pick Points
    b. **Feature Definition:** Bare Earth - Steep (**Drainage Area >> Catchment >> Rural**)
    c. **Name Prefix:** Catchment



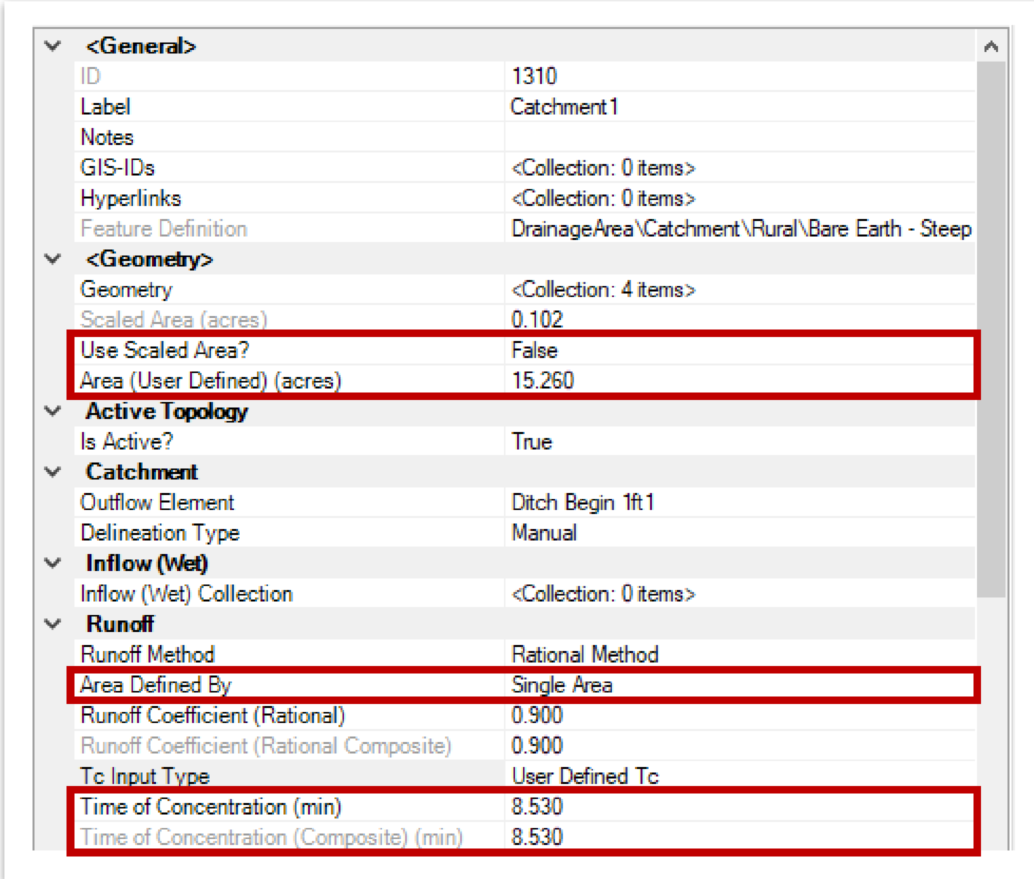
20. **Left** click to accept the **Method** and then draw a **complete shape** anywhere near the ditch **begin** node around Station **162+50.00**. **Right** click once the shape is complete**. Note:** Your shape does not need to match exactly. It can be any closed shape with any area. The drawn area will be ignored, and we will input a pre-determined drainage area value.



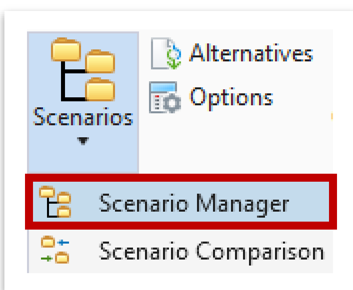
21. Select the **Ditch Begin 1ft1** node as the **Outflow** and the **existing** terrain boundary as the **Reference Surface**.
22. Once the catchment area is placed, use the **Element Selection** tool to select the drainage area, and notice that it shows a **link** to the outflow node (**Ditch Begin 1ft1**).



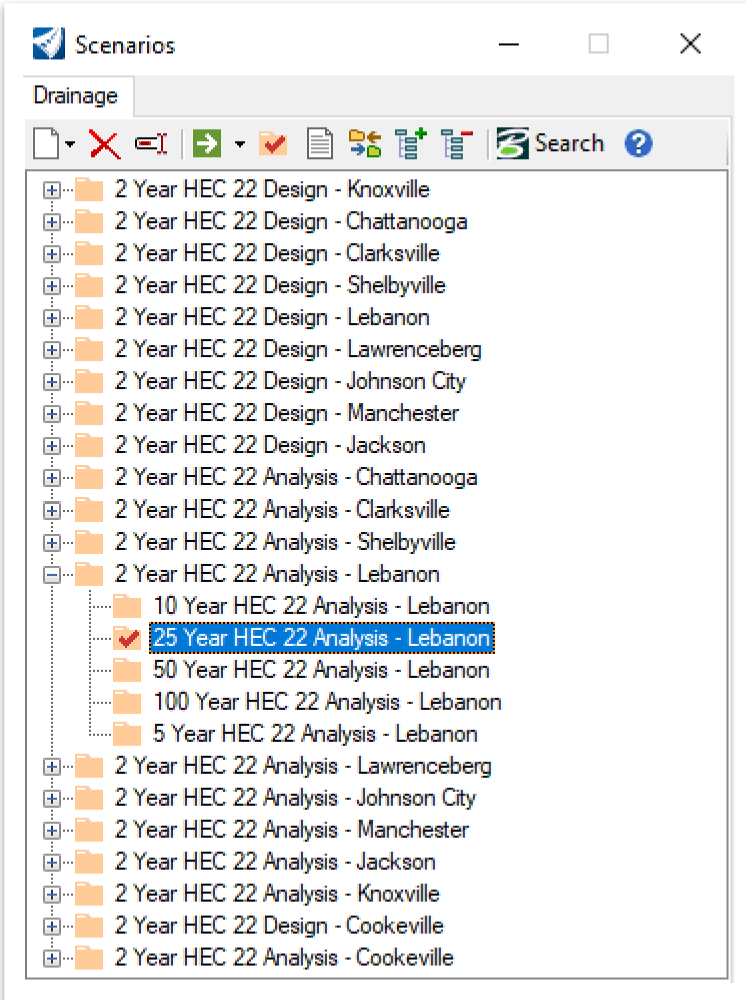
23. Open the **Utility Properties** for the **Catchment** and select the following settings.
    a. **Use Scaled Area?:** False
    b. **Area (User Defined) (acres):** 15.260
    c. **Area Defined By:** Single Area
    d. **Time of Concentration (min):** 8.530



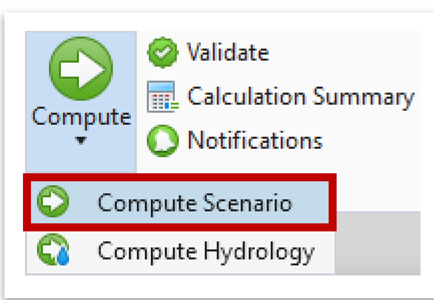
24. Now that the flow is entered, let's run the model and analyze the results to make sure the ditch has enough hydraulic capacity. Open the **Scenario Manager** tool (**Drainage and Utilities >> Analysis >> Calculation >> Scenarios**).



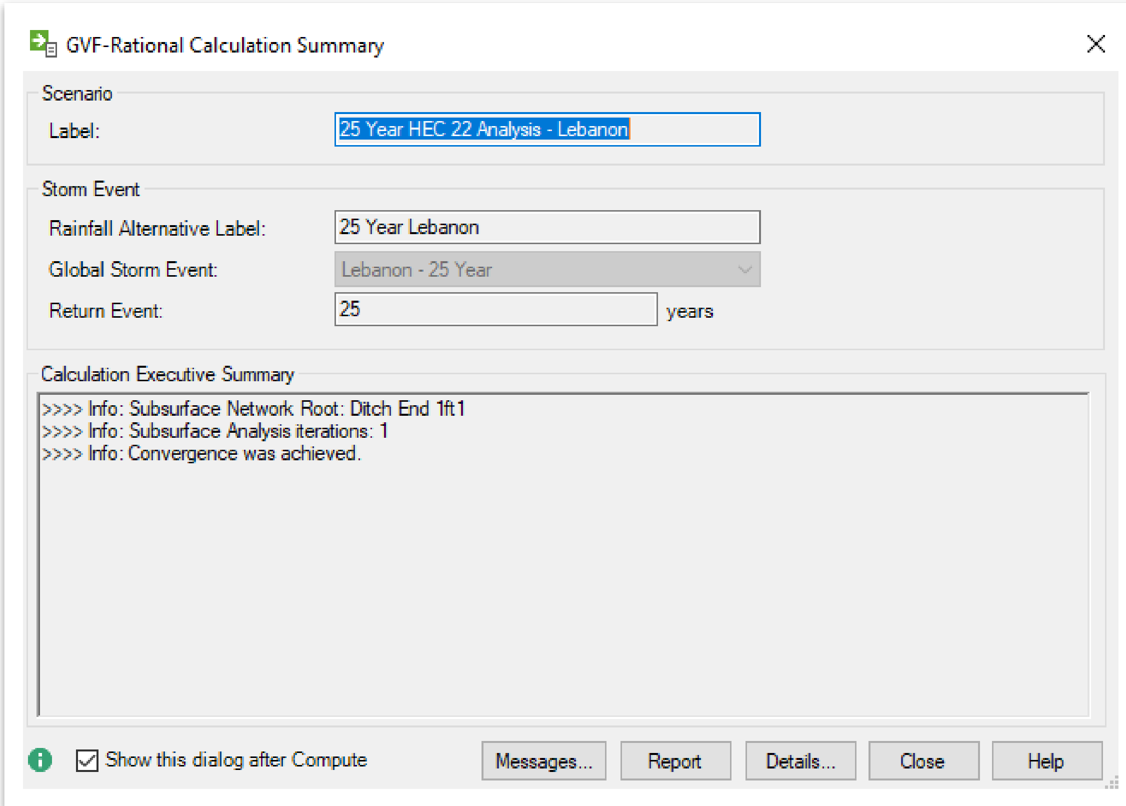
25. Expand the **2 Year HEC 22 Analysis - Lebanon** folder and **right** click on **25 Year HEC 22 Analysis - Lebanon** and select **Make Current**, which will add a red check mark next to the scenario. Close the **Scenario Manager** once you are done.



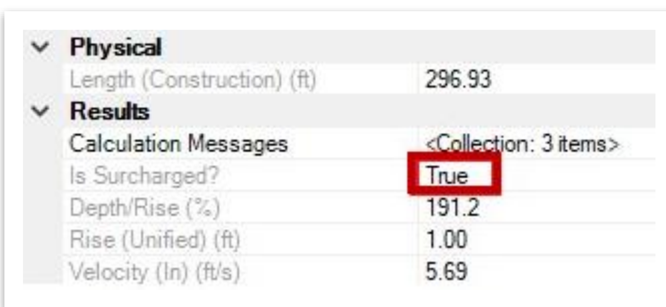
26. Then, open the **Compute Scenario** tool (**Drainage and Utilities >> Analysis >> Calculation >> Compute**) and let the software compute the selected scenario.



27. A **GVF-Rational Calculation Summary** has now been generated. **Go ahead and close** the window. You likely will see a **Civil Message Center** open on either the side or bottom of the screen. Go ahead and close that as well for now.



28. As a review, open the **Utility Properties** for one of the ditches. Under the **Drainage** tab, scroll down to **Results** and notice that the **Is Surcharged?** field is **True**. This confirms that the ditch is not sufficiently sized to handle the required capacity. If you review the other ditch segments, you will see the same result.



Take Note!

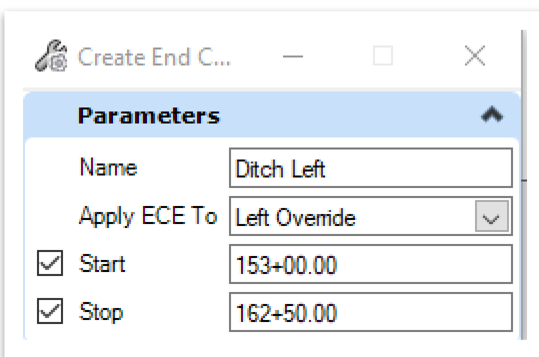
*In this chapter, we will not review the **Engineering Profile**. As discussed in Exercise 12.4, opening the Engineering Profile will cause the file to become corrupt and un-usable beyond that point (i.e., cannot be re-opened). If the user needs to look at the Engineering Profile, save a copy of the file and then create the Profile Run in the copied file.*

29. After reviewing all ditch segments, we know that a **1.61’** depth, **12.8’** top width, **4:1 V-ditch** does not adequately convey the flow between Stations **152+70.00** and **160+50.00**. This confirms that the standard ditch for the template will not suffice. We will create a **special ditch** in the following exercises.

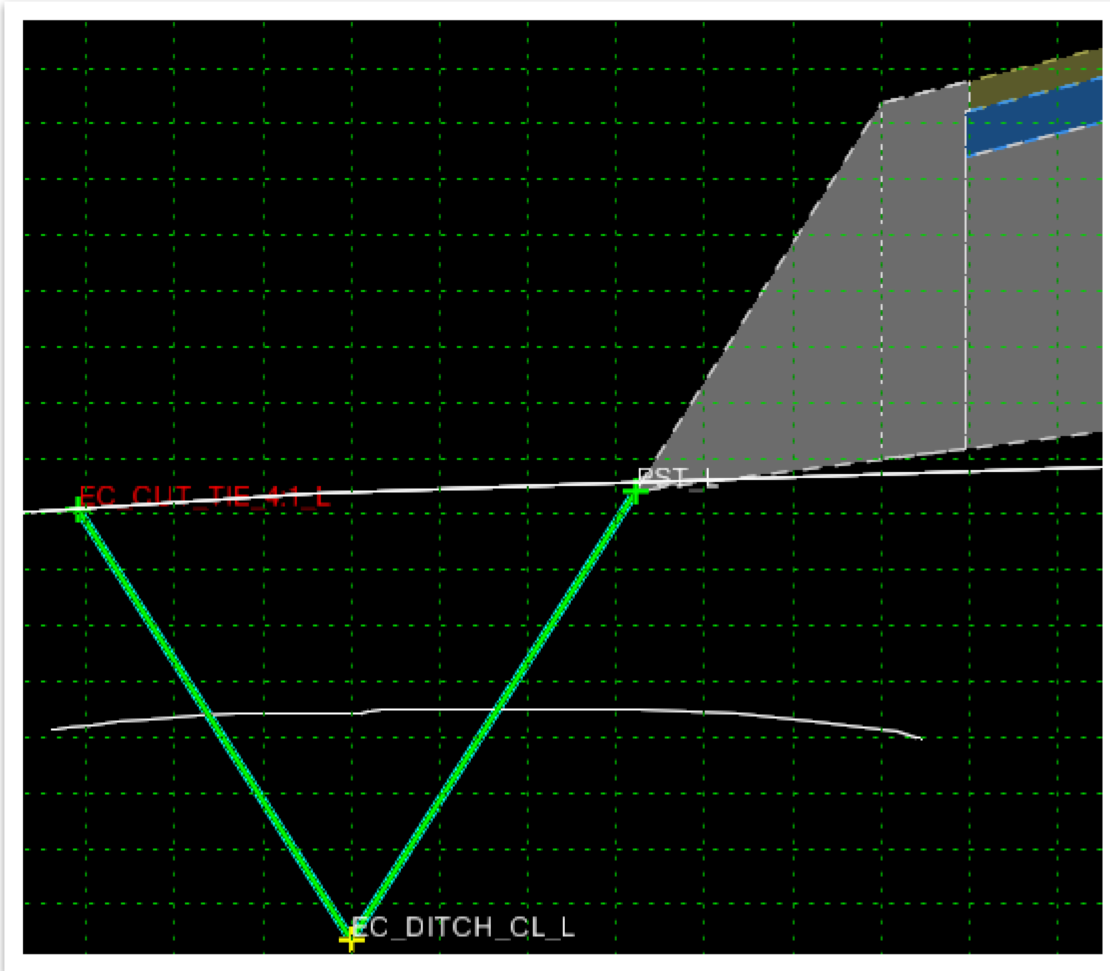
13.4 Exercise: Modifying a Standard Ditch in the Roadway Model

In this exercise, we will assume that the hydraulic analysis has been completed for a standard ditch and that the result is that we need to change the lining material but keep the same size.

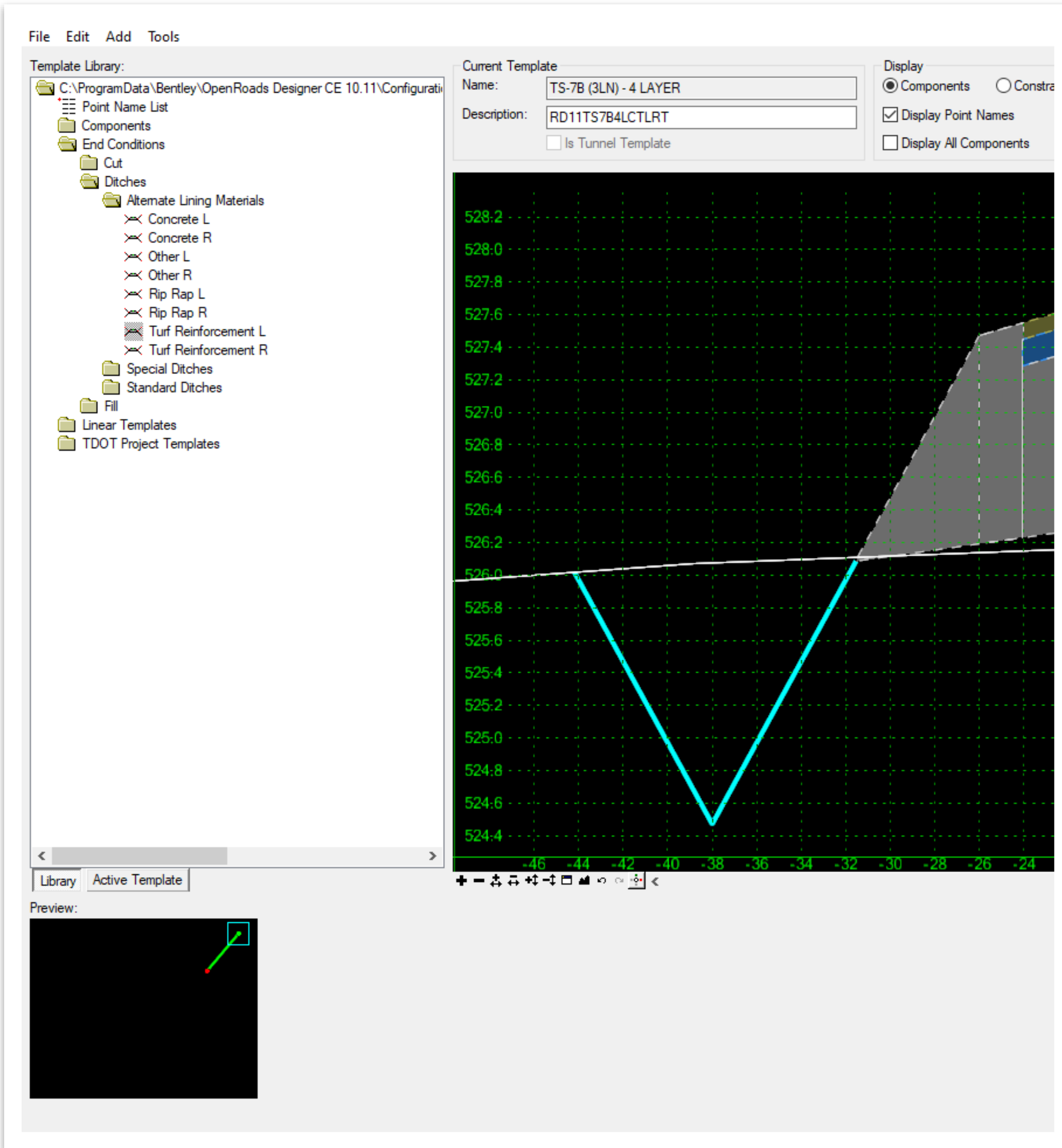
1. Open the **ROAD-II-SD-Corridor.dgn** file within the dgn Chapter 13 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner and then switch back to the **OpenRoads Modeling** workflow.
2. Open the **Create End Condition Exception** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**). Select the **proposed** corridor and then select the following settings. **Note:** For this exercise, we will use Station **153+00.00**, even though eventually we will want the ditch to start at Station **152+50.00**. Remember, we only used Station **152+70.00** for the drainage model to have the templates to assist us with placing the end node. We need to place the ditch in an area where the template is currently in **cut** and not transitioning or in fill. Therefore, we will start at Station **153+00.00**. Later in the exercise, we will alter the end condition to allow the ditch to start at the true end point (Station **152+50.00**).
    a. **Name:** Ditch Left
    b. **Apply ECE To:** Left Override
    c. **Start:** 153+00.00
    d. **Stop:** 162+50.00



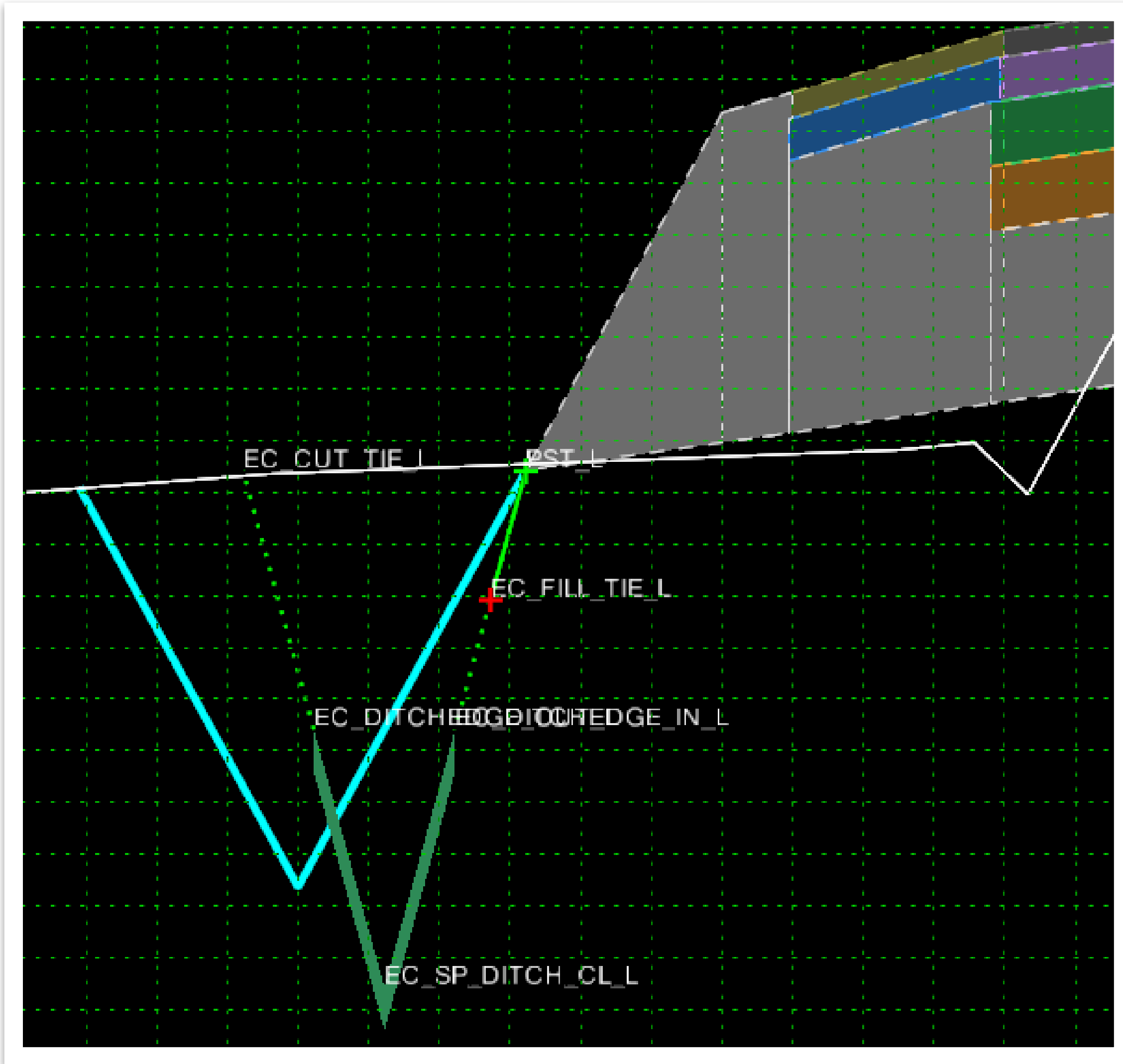
3. Within the **Left Override** window, delete the existing **end condition** components.



4. After deletion, there should be a **blue** ghost line highlighting the end condition shown. Now, expand the template folder and select the **Turf Reinforcement L** template (**End Conditions >> Ditches >> Alternate Lining Materials**). The template should appear in the preview window in the lower left corner.

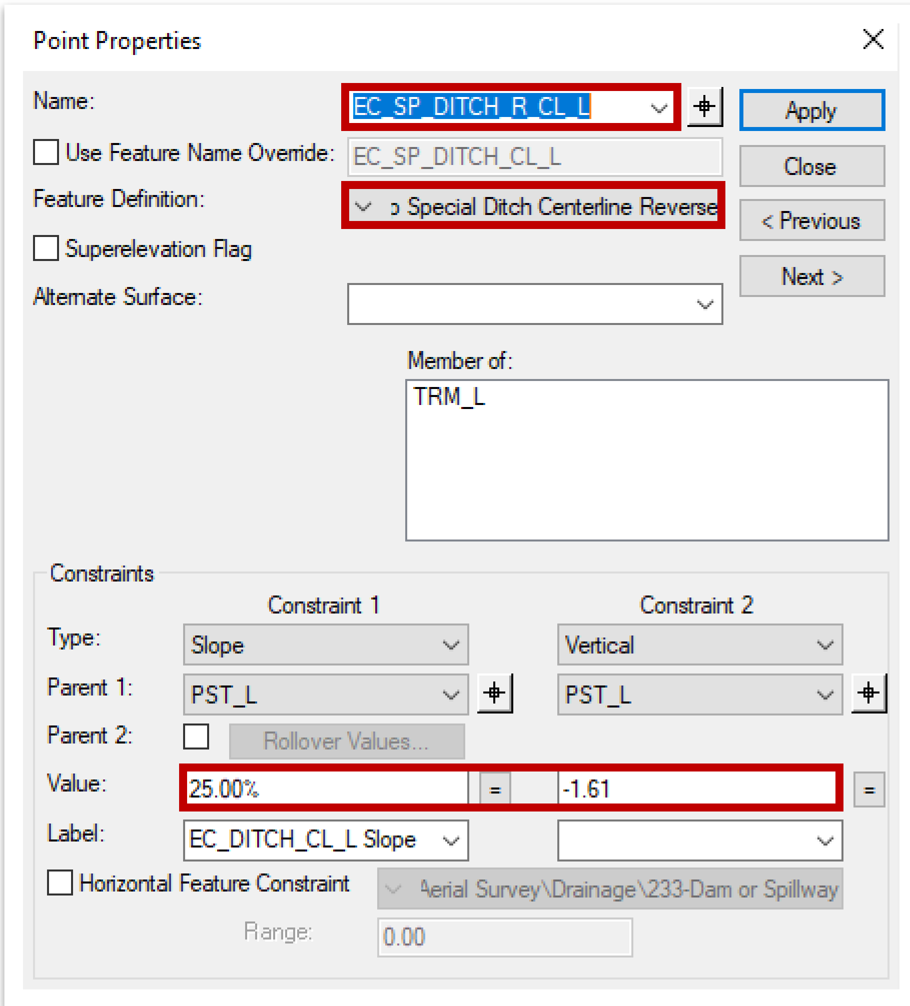


5. Drag and drop the template component onto the main template, snapping to the subgrade tie point (**PST_L**). **Note:** These template components have display rules hiding certain components. After placement, turn on **Display All Components** to see what is hidden.

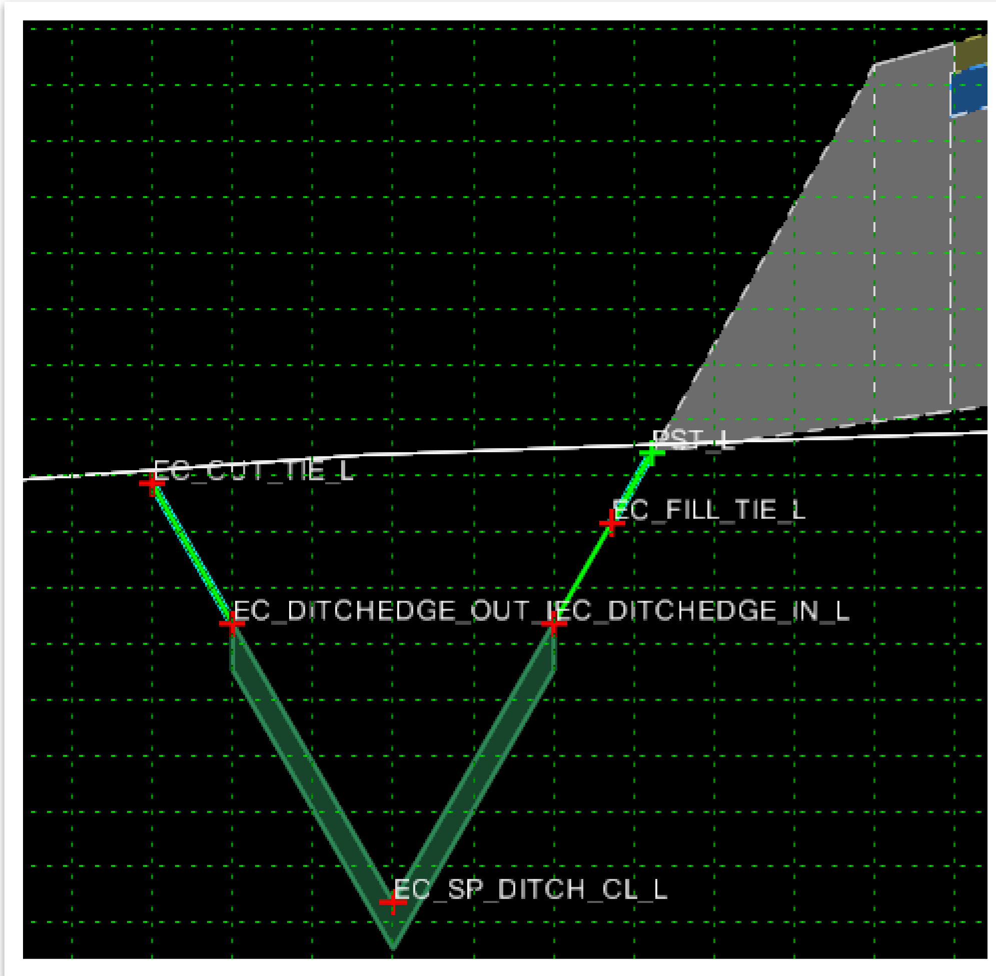


6. These ditch components are all drawn with a **2:1** slope by default. These will require editing to match the standard template ditch with **4:1** slopes and a **1.61'** depth from subgrade tie point. Switch to the **Active Template** tab so that we can select the points.

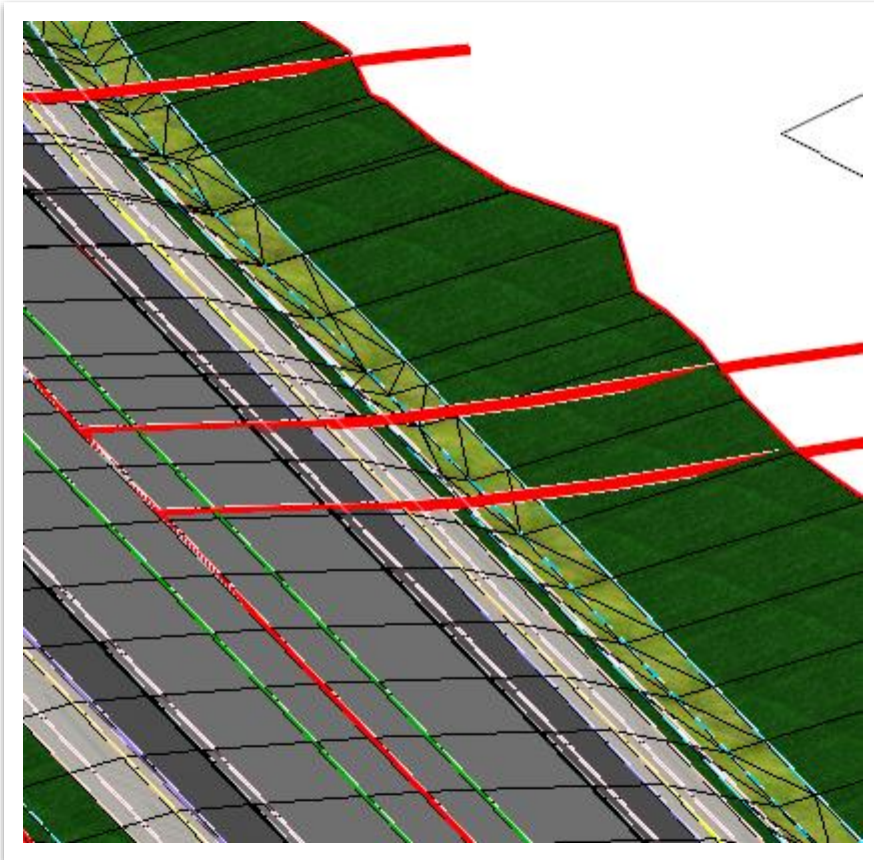
7. Open the **EC_DITCHEDGE_OUT_L** point properties and change the **Slope Constraint** to **-25.00%** (**4:1**). Then click **Apply** and **Close**.
8. Next, open the **EC_SP_DITCH_CL_L** point properties and change the **Slope Constraint** to **25.00%** (**4:1**). Also, change the **Vertical Constraint** to **-1.61**, referenced to the **PST_L** point. In the **Name** drop-down, select **EC_SP_DITCH_R_CL_L**. Notice how the feature definition changed to **Prop Special Ditch Centerline Reverse**. This feature definition will create the ditch directional arrow in plan view to be in the opposite direction of the roadway stationing, therefore pointing in the correct flow direction. Click **Apply** and **Close**.



9. Lastly, open the **EC_FILL_TIE_L** point properties and change the **Slope Constraint** to **25.00%** (**4:1**). Then click **Apply** and **Close**.



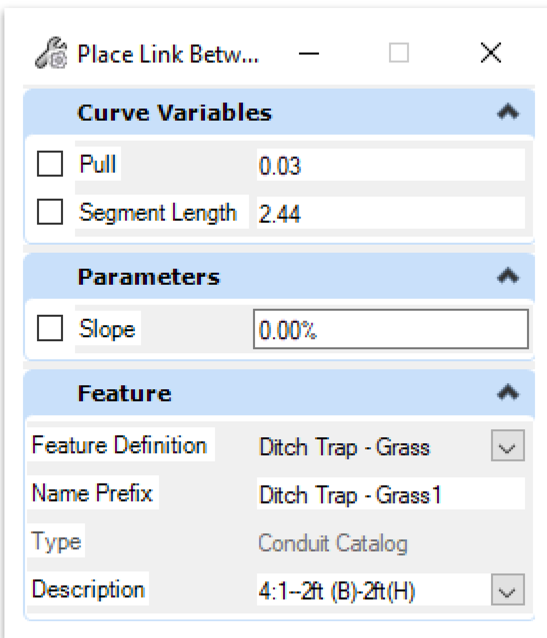
10. Click **OK** to close the **End Condition Exception Editor** and process the changes. This completes the necessary updates to match this new template component to the standard ditch configuration. The **corridor model** should look like the screenshot below.



13.5 Exercise: Special Ditch Hydraulic Design

In this exercise, we will apply a grass feature definition to the trapezoidal ditch and re-compute the scenario for assessment relative to the roadway.

1. Open back up the **ROAD-II-SD-Drainage Model.dgn** file within the dgn Chapter 13 subfolder that was created in Exercise 13.3. Make sure that the **Default** view is active in the lower left corner and then switch back to the **Drainage and Utilities** workflow. Select each ditch segment and delete them. We will replace them with a **special ditch**. **Note:** Ditch sizing would be an iterative process. For this exercise, however, the size has already been determined.
2. Open the **Place Conduit** tool (**Drainage and Utilities >> Layout >> Layout**). Select the **Ditch Trap - Grass** feature definition (**Conduit >> StormWater >> Ditches >> Special Ditches**). Set the **Description** to **4:1--2ft (B)-2ft(H)** and then replace the conduit runs between each ditch node. **Note: (B)** equates to width of the base and **(H)** equates to depth.



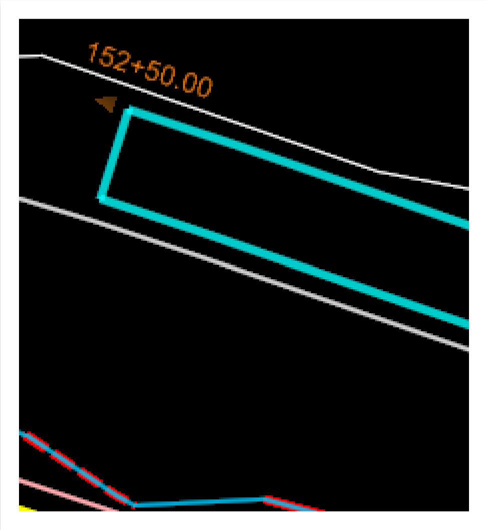
3. Next, the scenario needs to be re-computed. Open the **Compute Scenario** tool (**Drainage and Utilities >> Analysis >> Calculation >> Compute**) and let the software re-compute the selected scenario. A review of the conduit **Utility Properties** should show **False** for the **Is Surcharged?** field for <u>all</u> conduits now. This means that the **2ft (B)** and **2ft (H)** ditch with a **4:1** slope is adequately sized for the flows.

4. Lastly, you would then need to review the **velocity** and **shear stress** to determine the appropriate lining material for the special ditch. Refer to Chapter 5 of the [TDOT Drainage Manual] for this determination. For this scenario, the computed shear stress would be over **2lb/sf**, so a permanent **turf reinforcement** would be needed to protect against erosion, which we will incorporate in the next exercise.
5. In conclusion, the special ditch drainage model from Station **162+50.00** to **152+50.00** will be a **trapezoidal 2’ flat bottom** ditch with a **4:1** foreslope <u>and</u> backslope with a **2’** depth below subgrade.

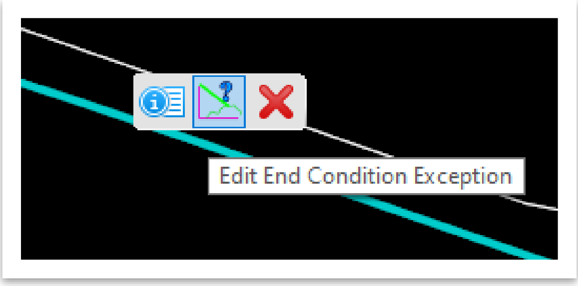
13.6 Exercise: Modeling a Designed Special Ditch in the Roadway Model

In this exercise, we will place a special ditch template within the roadway model and then place the ditch centerline that will be used on the plan sheets.

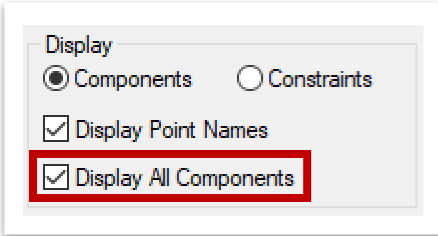
1. Open back up the **ROAD-II-SD-Corridor.dgn** file within the dgn Chapter 13 subfolder. Make sure that the **Default** view is active and then turn off the **ROAD-II-SD-Corridor.dgn** (**Default-3D**) reference file.
2. We will first place an **end condition exception** on the **left** side of the corridor from Station **152+50.00** to Station **162+50.00**. Remember, we already placed an end **condition exception** in this area in Exercise 13.4 and because we are using the same file, we do not need to do re-do it. However, we do need to change the **start** station of the end condition exception to Station **152+50.00**. In the **2D** view, select the brownish yellow rectangle above the template drop that represents the limits of the end condition exception. Change the start station to **152+50.00**.

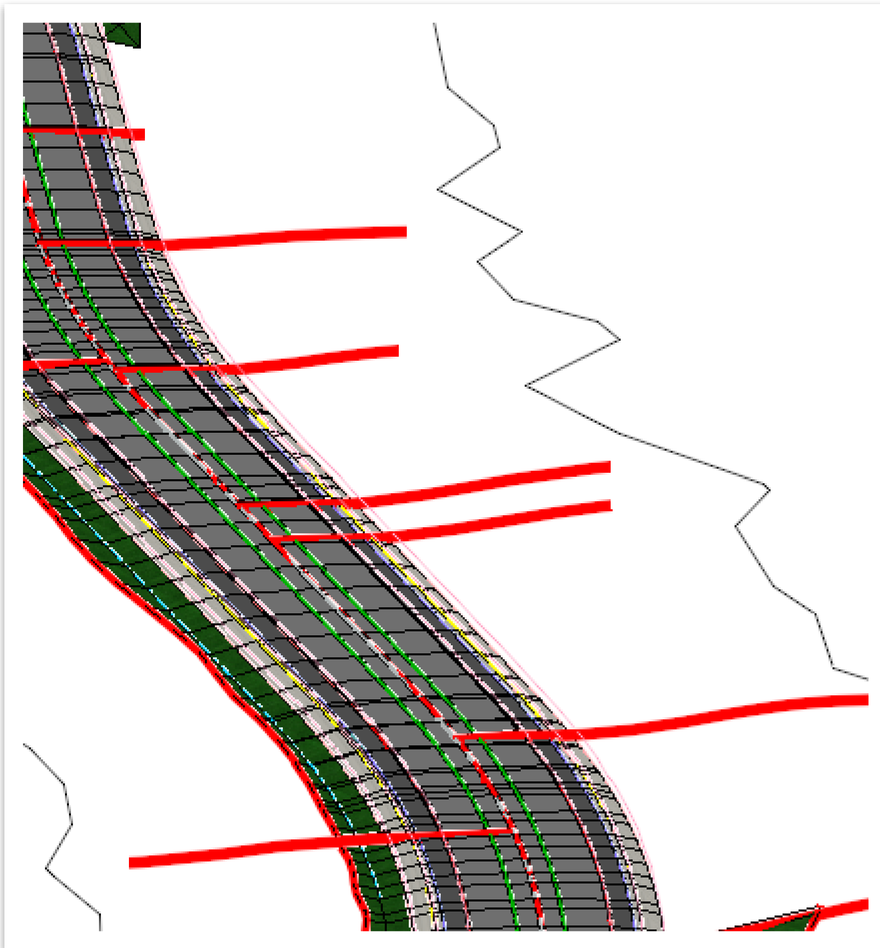


3. Next, open the **Edit End Condition Exception** view. This can be done in various ways: by hovering over the end condition exception in **2D** view, by **right** clicking on the end condition exception in the **Properties** view, or by navigating to the end condition exception section in the **Corridor Objects** tool.



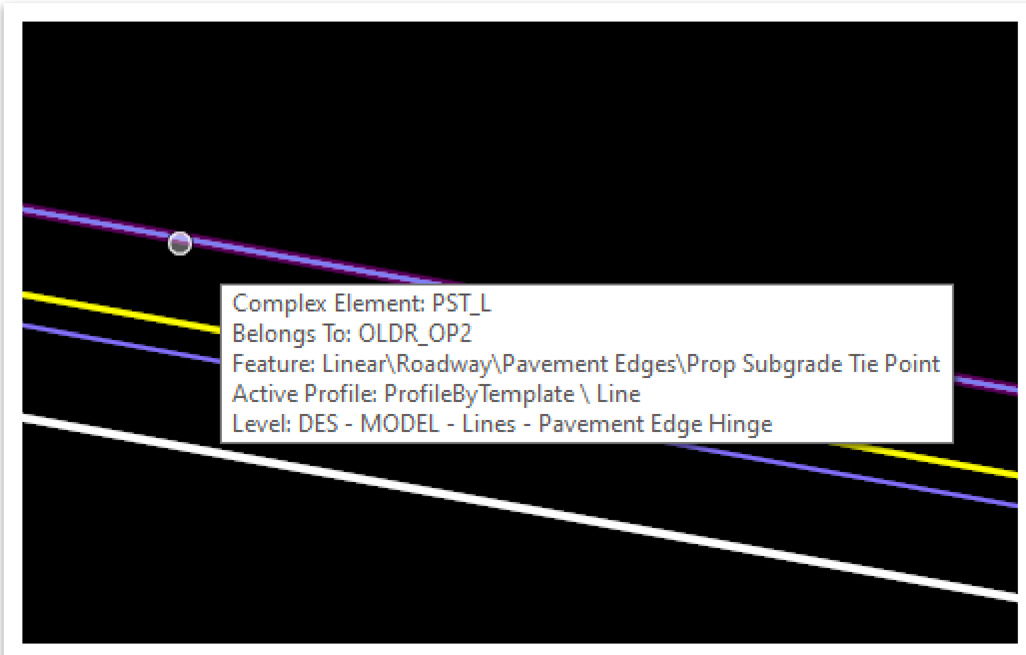
4. Toggle on **Display All Components** in the top right corner. Delete **all** the end condition components. Then click **OK** and the software will process the changes. Notice there are now no end conditions present within the station range. We will not place the new template within the **End Condition Exception** tool.



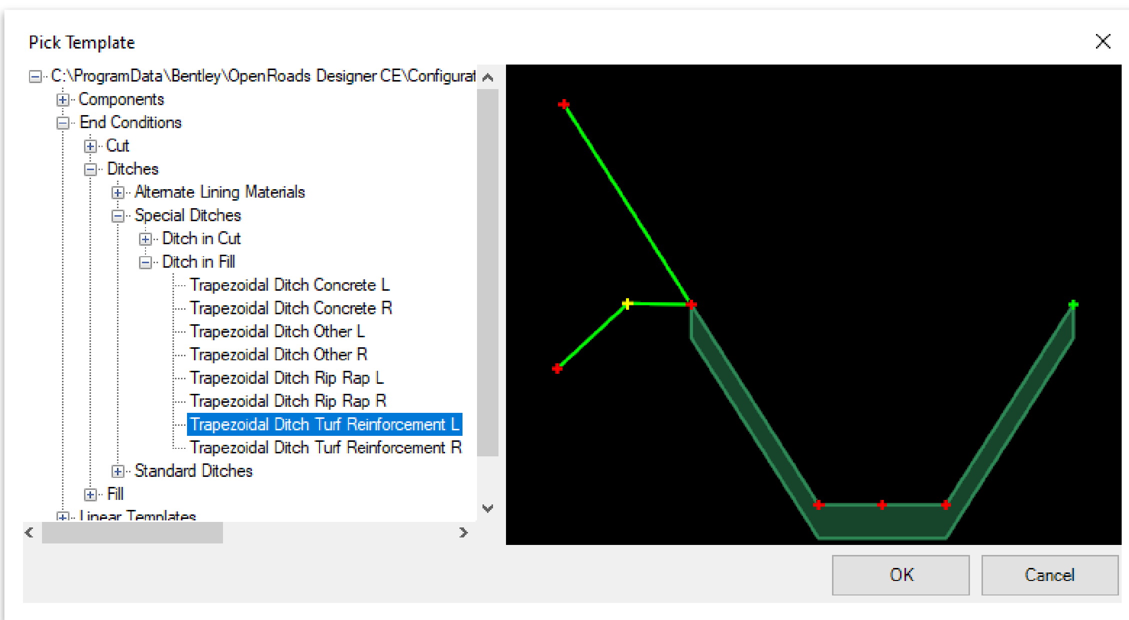


5. Now, switch back to the **OpenRoads Modeling** workflow. Open the **Single Offset Partial** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and select the **mainline** centerline. Key-in any **Offset** other than **0**. The **Start** and **End Distance** should be **152+50.00** and **162+50.00** respectively. **Note:** It is recommended to use an offset distance between **30** and **50**. This is just a dummy element used to provide snap points for the next step, so setting the feature definition or anything else is not critical, since we will delete this element later.

6. Next, open the **Apply Linear Template** tool (**OpenRoads Modeling >> Model Detailing >> 3D Tools**) and select the left subgrade **tie point** line (**PST_L**) in the **2D** view. It is the outermost purple line, as shown below.

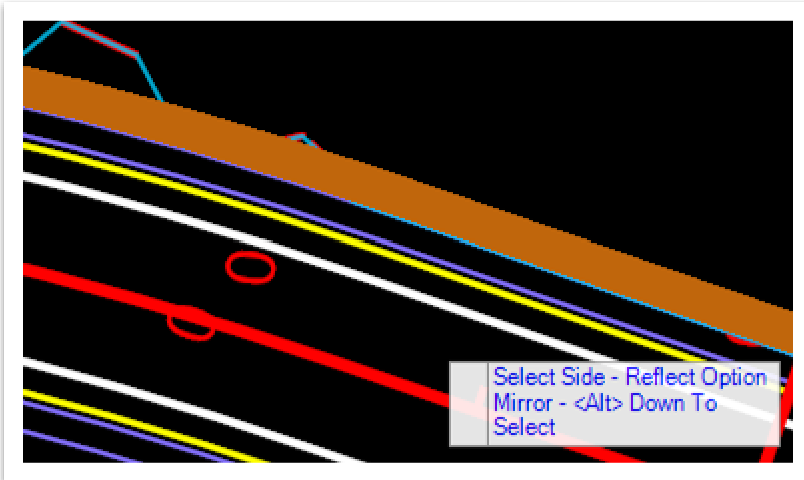


7. Select the **Trapezoidal Ditch Turf Reinforcement L** template (**End Conditions >> Ditches >> Special Ditches >> Ditch in Fill**).

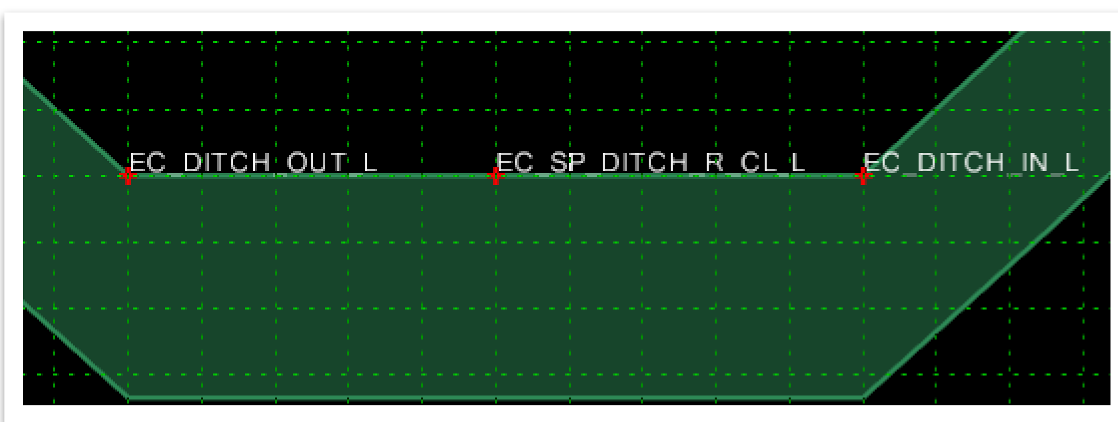


8. For the **Start** and **End Station**, snap to the ends of the dummy element created in Step 5.

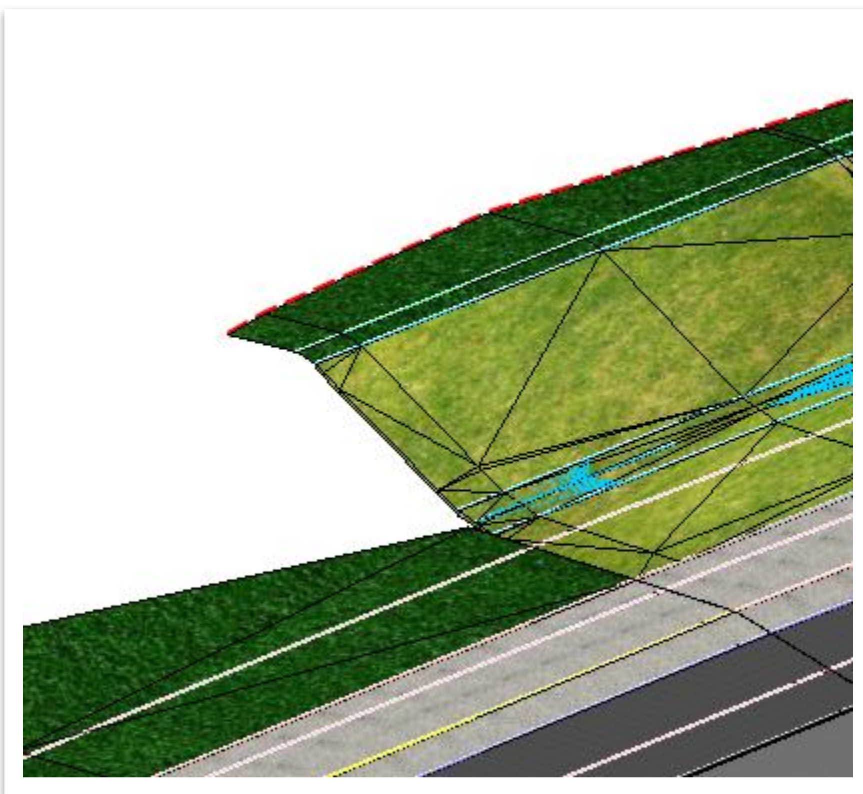
9. Place the orange object on the outside of the template and **left** click through the prompts to accept.



10. The template has now been placed in the model. Go ahead and delete the dummy element created in Step 5. Now, we need to edit the template to match the proposed special ditch configuration. Open the **Edit Template Drop** tool (**OpenRoads Modeling >> Corridors >> Edit**) and select the **special ditch** template drop.
11. Remember, the proposed special ditch configuration is a **trapezoidal 2' flat bottom** ditch with a **4:1** foreslope <u>and</u> backslope with a **2'** depth below subgrade. Open the **EC_DITCH_IN_L** point properties and change the **Vertical Constraint** to **-2.00**. Change the **Slope Constraint** to **25.00%** (**4:1**). Then click **Apply** and **Close**.
12. Now, open the **EC_SP_DITCH_CL_L** point properties and notice the **Horizontal Constraint** is set to **-1.00**. The ditch configuration has a **2'** bottom ditch, so the centerline should be halfway between **EC_DITCH_IN_L** and **EC_DITCH_OUT_L**, or **1.00**. Using the **Name** <u>drop-down</u>, change the name of the point to **EC_SP_DITCH_R_CL_L** to get the ditch flow arrow to be in the opposite direction of stationing.



13. Next, open the **EC_DITCHEDGE_OUT_L** point properties. Change the **Slope Constraint** to **-25.00%**. Then click **Apply** and **Close**.
14. Once updated, your ditch should match the designed special ditch. Click **Test** in the lower right corner to see how this end condition operates. Then, click **Draw** and move your cursor up and down to simulate change in the existing terrain. **Close** the window once you have reviewed.
15. Click **OK** to process the changes. **Note:** You should see a gap near the ends of the special ditch. Adding key stations on the mainline can reduce this gap. Finding the right key station placement to fill the gaps is an **iterative** process. Currently, key stations cannot be placed on linear templates.
16. Now, open the **Create Key Station** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and add key stations at **152+49.99** and **162+50.01**. The gap should then fill in. **Note:** Gaps less than **0.1'** are common and required in modeling scenarios where template drops, template components and constraints are changing. Designers should use discretion and engineering judgment to determine when a model has gaps that are negligible. Knowing exactly where templates change can be helpful and placing key stations **.01'** from a change can fully eliminate gaps in models.

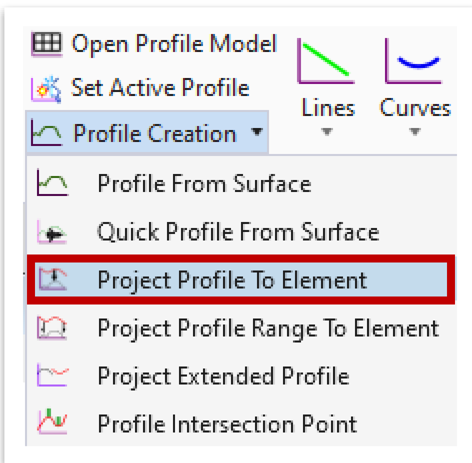


13.7 Exercise: Display a Special Ditch in Profile View

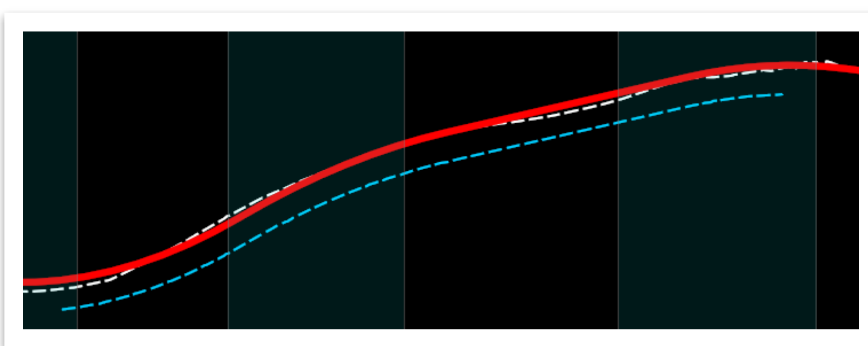
In this exercise, we will project the special ditch onto the roadway profile and then view it in profile view.

1. Open the **ROAD-II-SD-Alignments.dgn** file within the dgn Chapter 13 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner. Attach the **ROAD-II-SD-Corridor.dgn** reference file using the **Coincident World** attachment method.
2. Select the **Prop VA Special Ditch - Left** feature definition (**Linear >> Profiles >> Drainage >> Proposed**).

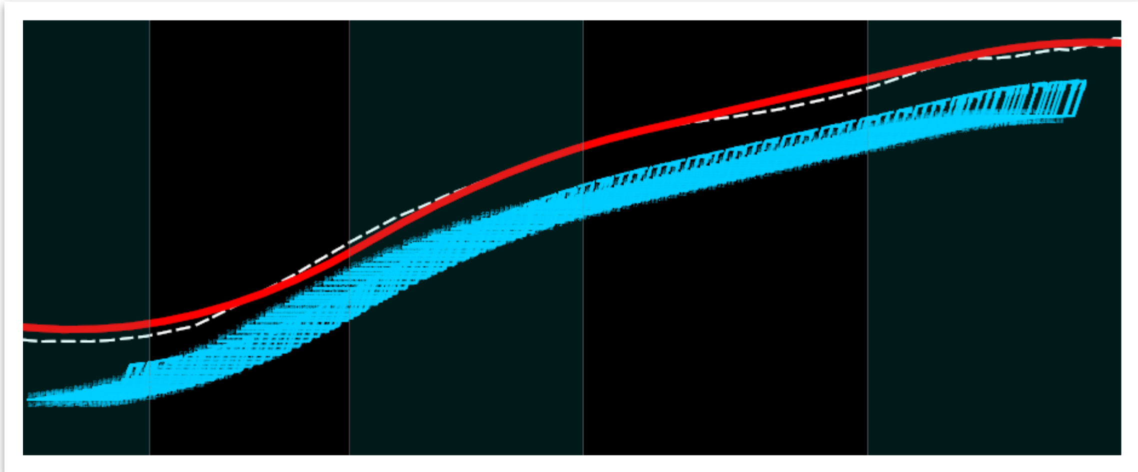
3. Open the **profile** model of the mainline centerline. Then, open the **Project Profile to Element** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Profile Creation**).



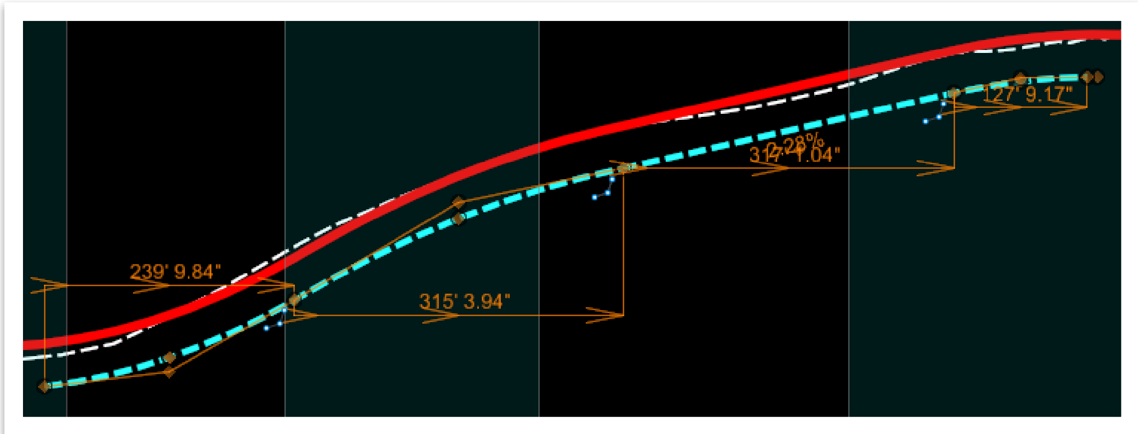
4. Select the **special ditch** centerline in **plan** view (Station **152+50.00** to Station **162+50.00**) and then select the **mainline** centerline. Open the roadway **profile** view, if not already open, and you should now see the **special ditch** profile projected onto the roadway profile.



5. The next logical step would be to annotate the special ditch profile using the **Annotate Element** tool. However, the annotation group selects all vertical breaks and places many labels since the profile is a graphical line. **Note:** You do not need to place annotation yet. The screenshot is only shown as an example.

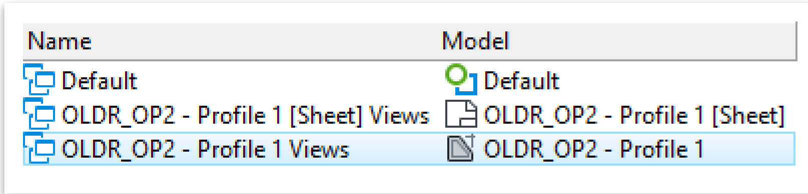


6. To fix the annotation issue, we need to first draw in the special ditch profile <u>manually</u> by using the **vertical** geometry tools. Go ahead and trace over the projection with **lines** and **parabolas** and then **complex** it. Once drawn, delete the projection. **Note:** Since the alignment that we drew had no VPI points, the VPI labels will not appear on this alignment. The screenshot below is a best guess for the geometry based on the roadway profile.

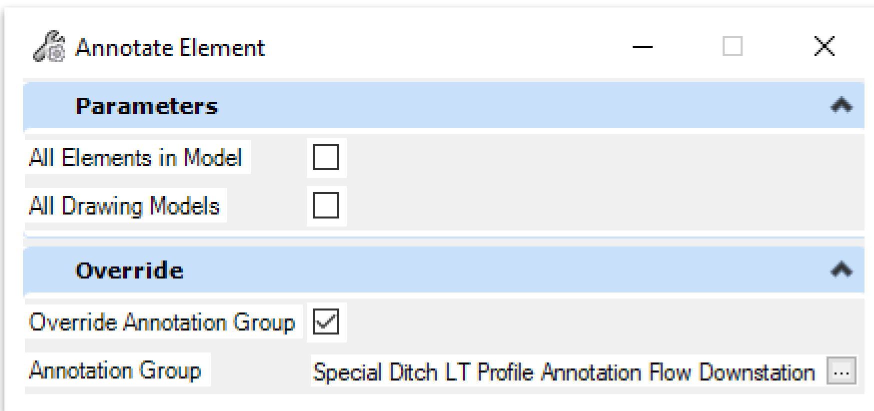


7. You could annotate the alignment here using the **Element Annotation** tool, but the annotation would look incorrect unless the **exaggeration** is set to **1**. It is recommended that the labeling for the special ditch profile be done in the **mainline profile drawing model**.

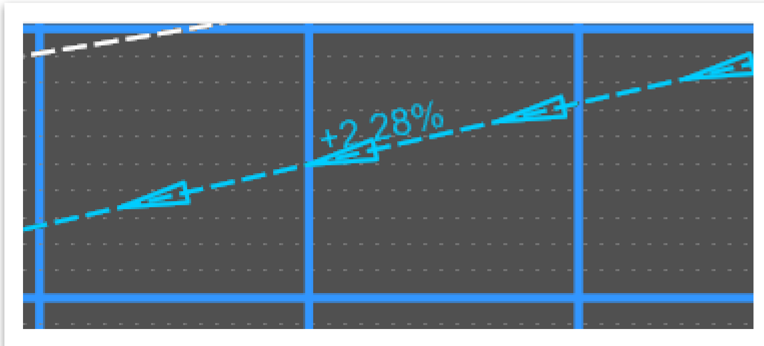
8. Now, open the **ROAD-II-SD-Mainline Profile.dgn** file within the dgn Chapter 13 subfolder. By default, the **OLDR_OP2 - Profile 1 Views** drawing model should be active.



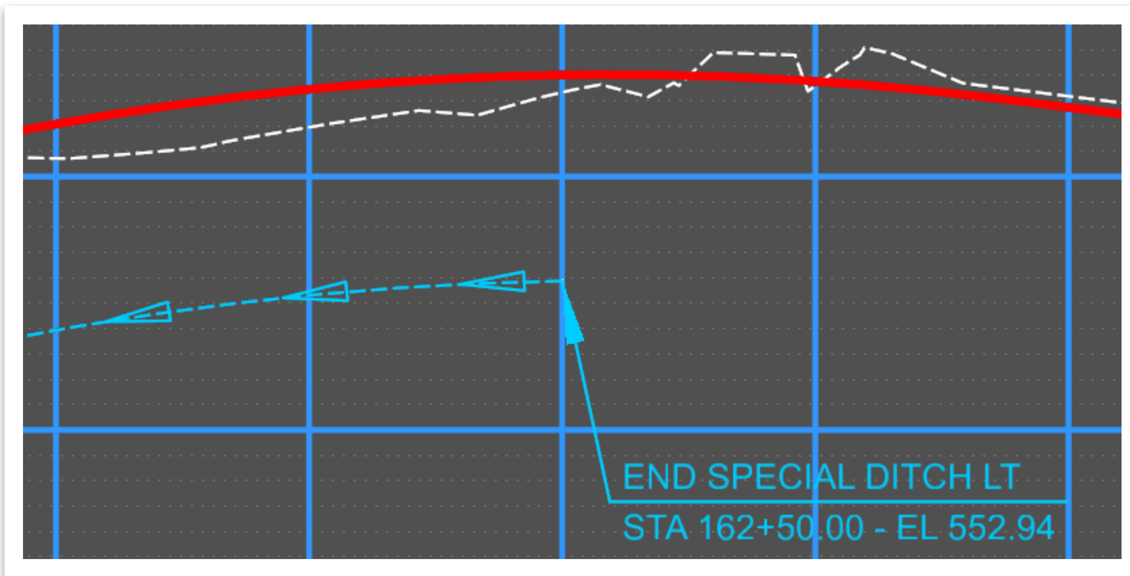
9. Open the **Annotate Element** tool (**OpenRoads Modeling >> Drawing Production >> Annotations >> Element Annotation**). Toggle on **Override Annotation Group** and then select the **Special Ditch LT Profile Annotation Flow Downstation** annotation group (**Profile >> Linear**). Neither **Parameters** option should be toggled on. **Note:** Notice there are three other annotation groups for special ditches. The reason we selected this annotation group is because the ditch is on the **left** side of the alignment, and the ditch is flowing **downstation**, relative to the mainline alignment.



10. Click through the prompts and then select the special ditch **profile**. Once selected, **right** click to complete the annotation. Notice the directional arrow and the slope label that were placed on the special ditch. Also notice that there are no VPI labels due to how the profile was drawn. **Note:** The annotation group only labels grade breaks, not transitions between a line and a parabola.



11. To add the **Begin/End** labels, open the **Civil Labeler** tool (**OpenRoads Modeling >> Drawing Production >> Labels**). Under the **TDOT - Design - Profile** folder, select the **Special Ditch Begin LT** and **Special Ditch End LT** labels. **Note:** Only the **End Ditch** label is shown below for reference. The special ditch is labeled in the direction of stationing, hence the End Special Ditch notation.



Take Note!

Refer to the Roadway Design I (ORD) Manual and Requirements for Model-Centric Design for profile annotation.

Chapter 14. Channel Relocations

Channel Relocation design follows the natural stream design procedure per Chapter 11 of the TDOT Drainage Manual. This chapter will discuss the modeling procedure for a proposed channel relocation, using a pre-created alignment and profile.

14.1 Objectives

At the conclusion of this chapter, participants will be able to:

1. Model a relocated channel.
2. Incorporate side drains into the relocated channel.

14.2 Lecture: Channel Relocation Overview

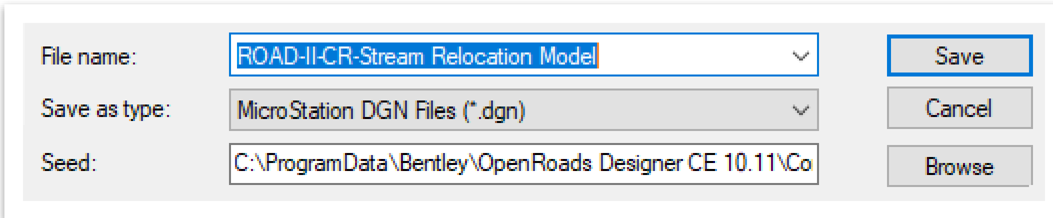
Channel relocations will be modeled using **template drops**, which will need to be modified by the designer to match the proposed channel cross section. This chapter will not discuss the process to hydraulically size and align the proposed channel relocation. **Chapter 13** (Special Ditches) may be referenced within this manual or Chapter 11 of the TDOT Drainage Manual for that information. This chapter only covers how to model a proposed channel configuration after it has been hydraulically designed**.**

The process for creating and storing a channel alignment and profile follows the same procedures as creating and storing a roadway alignment and profile.

14.3 Exercise: Modeling a Channel Relocation

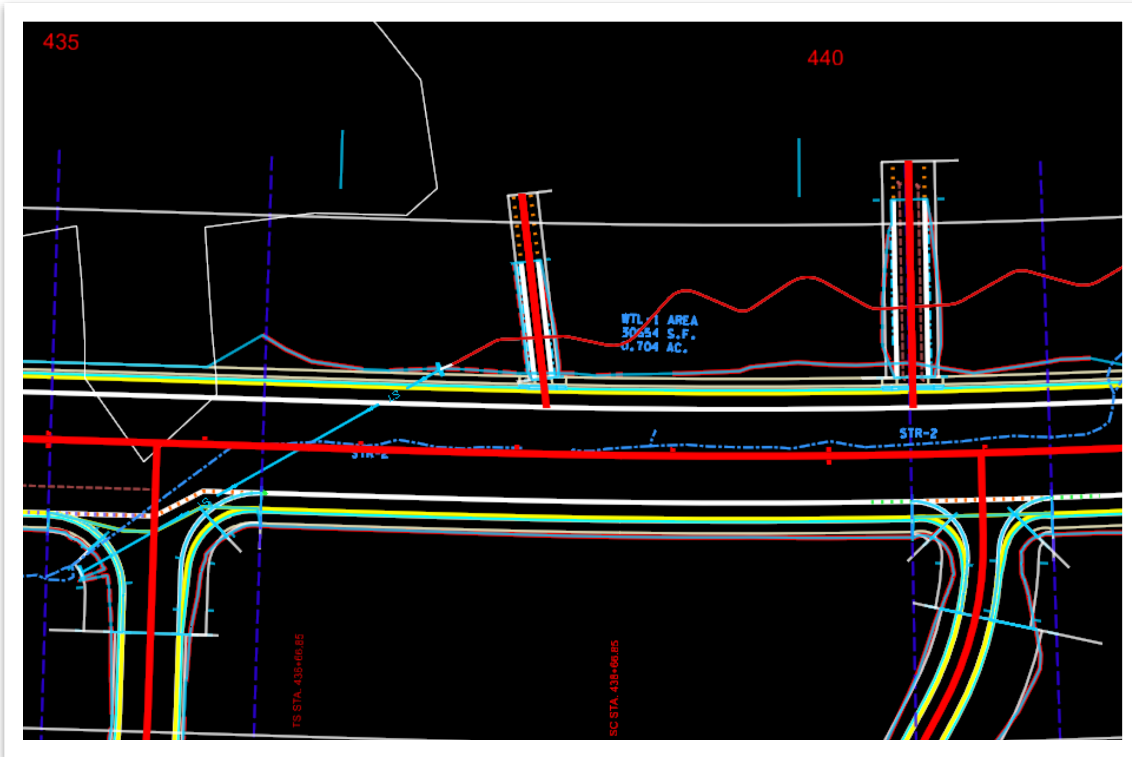
In this exercise, we will use pre-created channel relocation geometry and create a template along the channel alignment to model a channel relocation.

1. Create a new file and name it **ROAD-II-CR-Stream Relocation Model**. Select the **TDOTSeed 2D.dgn** and click **Save**. **Note:** Save this file under the dgn Chapter 14 subfolder.

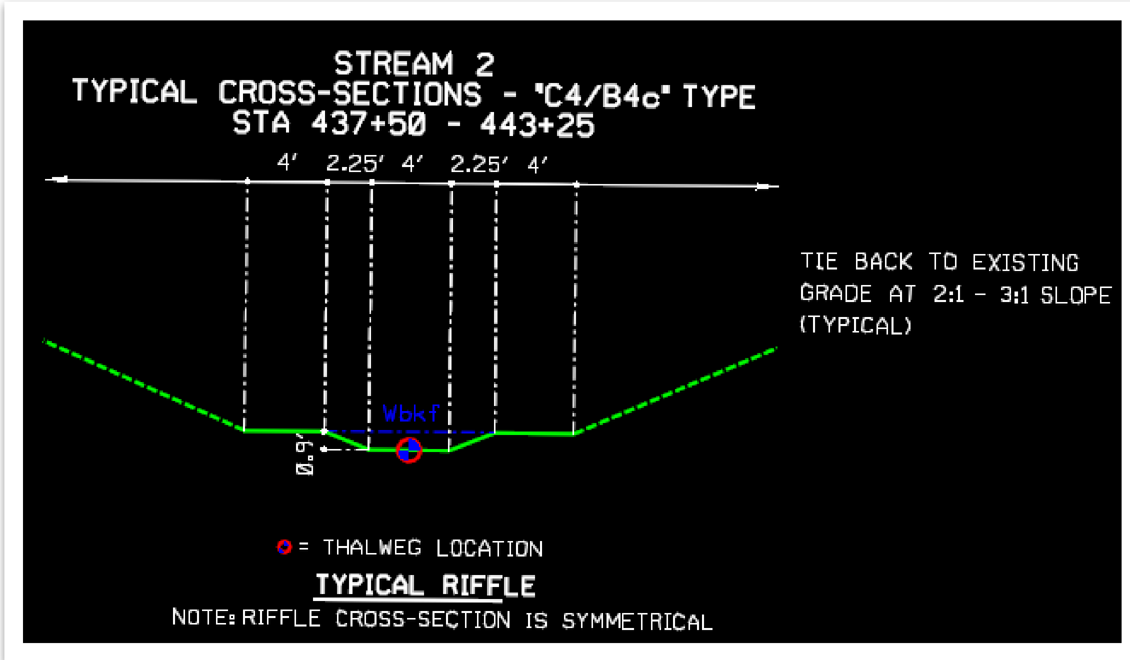


2. Make sure that the **Default** view is active in the lower left corner. Attach the following reference files using the **Coincident World** attachment method.
   - ROAD-II-CR-Corridor.dgn
   - ROAD-II-CR-Drainage Model.dgn
   - ROAD-II-CR-Existing Drainage Features.dgn
   - ROAD-II-CR-Geometry.dgn
   - ROAD-II-CR-Stream Relocation Geometry.dgn
   - ROAD-II-CR-Terrain.dgn

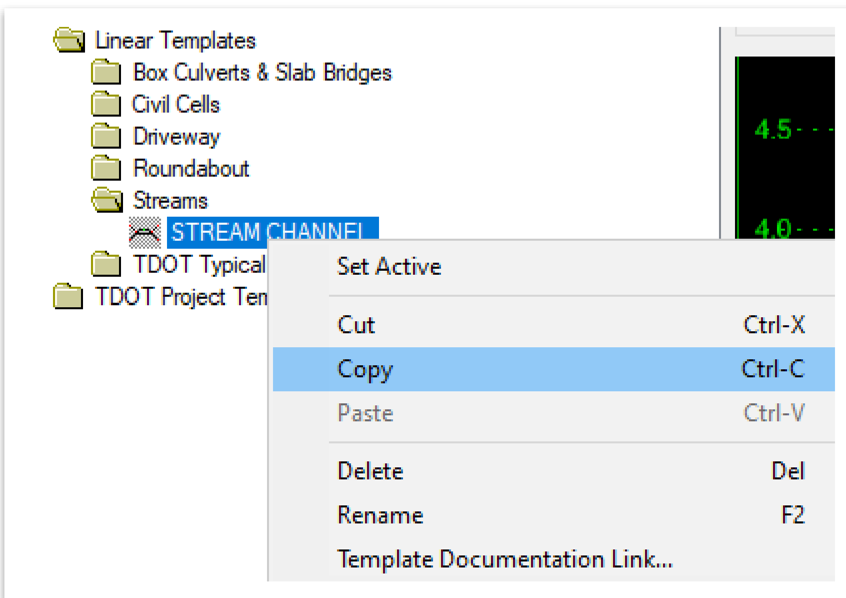
3. **Activate** the terrain and locate Station **440+00.00**. Notice that an existing stream (**STR-2**) runs in the middle of the corridor between Stations **435+00.00** and **442+00.00**. Within the **ROAD-II-CR-Drainage Model.dgn** and **ROAD-II-CR-Stream Relocation Geometry.dgn** reference files, notice that the proposed relocated stream alignment has already been drawn and that there is a proposed storm drain crossing under the new alignment. **Note:** The proposed relocated stream alignment is determined based on **ROW** requirements, the **topography** of the terrain and the desire to keep the natural flow patterns.



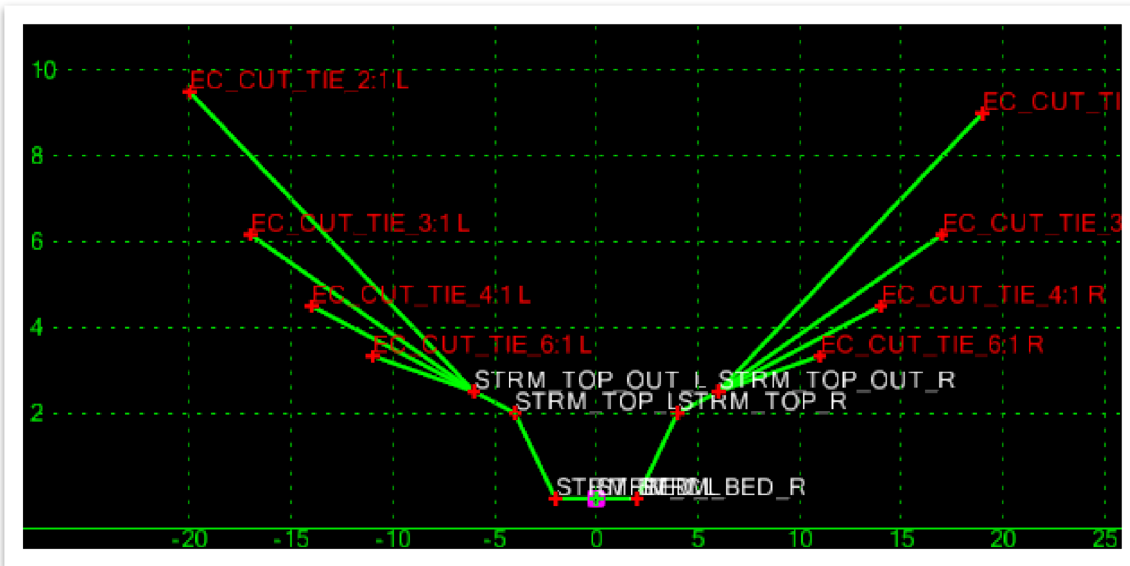
4. Before we model the stream, let's review the proposed stream **typical section**, which is shown below for reference.



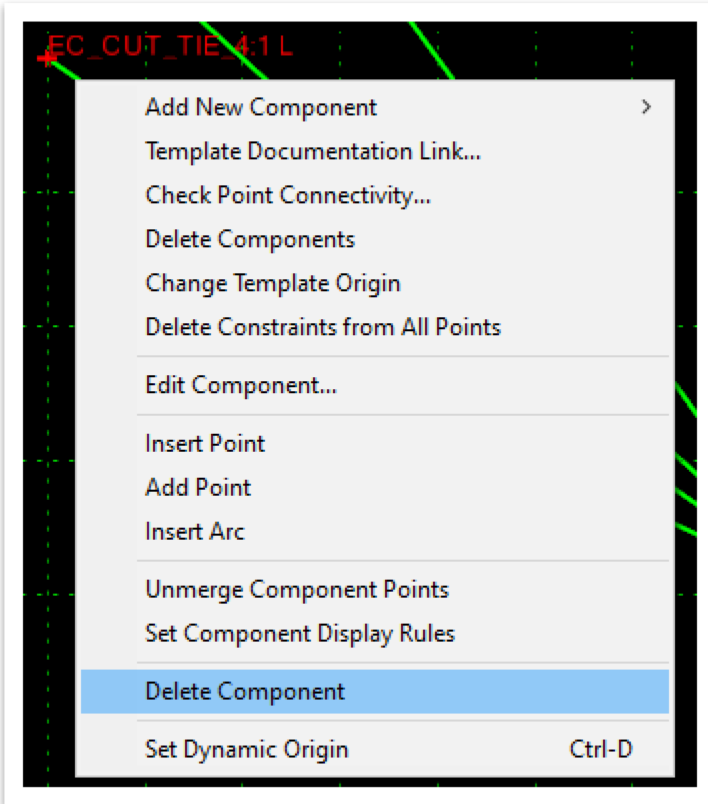
5. Open the **Create Template** tool (**OpenRoads Modeling >> Corridors >> Create >> Template**). Select the **STREAM CHANNEL** template (**Linear Templates >> Streams**) and then **right** click and select **Copy**.



6. Scroll down to the **TDOT Project Templates** folder. **Right** click on the folder and select **Paste**. The **STREAM CHANNEL** template should now be shown. **Note:** It is recommended that all templates used in a project should be saved in the project specific template library (**ITL**). Also, every template should be copied from the TDOT standard templates down to the **TDOT Project Templates** folder, so the original templates are not unintentionally modified.
7. Double click on the **STREAM CHANNEL** template under **TDOT Project Templates**. This default template has a **slope table** on either side that goes from **6:1** to **2:1**. As a reminder, the typical section referenced in Step 4 indicates that the slopes should be either **3:1** or **2:1** but does not provide additional guidance for that switch. Therefore, we will need to use engineering judgment to set a switch for those slopes. We also need to remove the **4:1** and **6:1** slope components from the template.

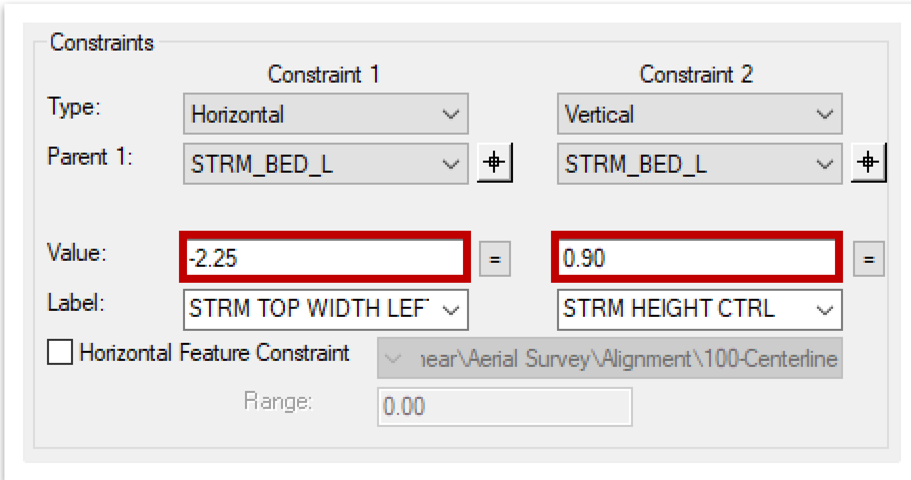


8. Go ahead and delete the **4:1** and **6:1** slope components on both the left and right sides by **right** clicking on the component, selecting **Delete Component**, and then drawing a line through the components.

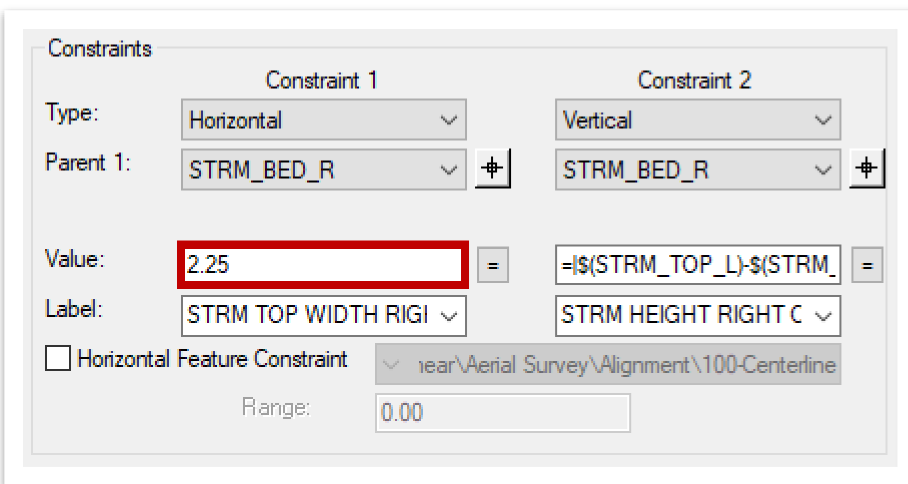


9. Next, open the **EC_CUT_TIE_3:1 L** point properties. The **Horizontal Constraint** should be **-11.00** by default. When a horizontal or vertical constraint is present with an end condition table, it means that specific end conditions will be used up to that point. Because we deleted the 6:1 and 4:1 end conditions, the **3:1** end condition is now the first end condition. Therefore, a **3:1** slope will be used for the first **11** feet and then a **2:1** slope will be used for anything beyond 11 feet. Designers can manipulate these constraints to get an end condition that satisfies the requirements for a given project. However, for this exercise, keep the default distance. Go ahead and close the **Point Properties** window.

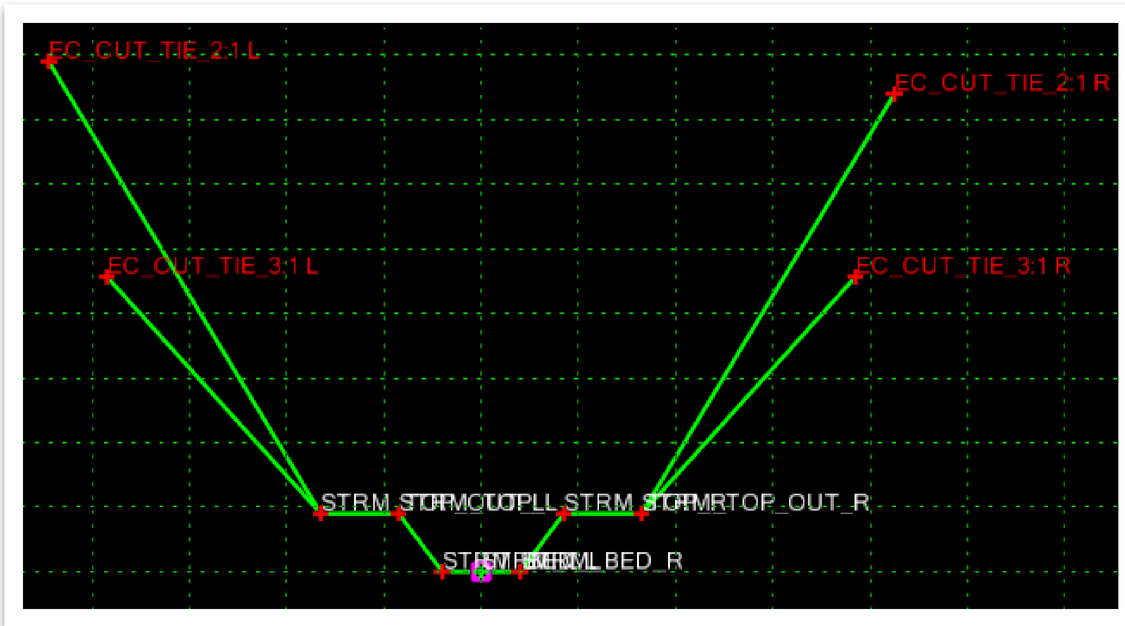
10. Now, we need to set the **channel** constraints to match the typical section. By default, the **stream bed** is **4'** wide, so we do not need to change the **STRM_BED_L** or **STRM_BED_R** points. Open the **STRM_TOP_L** point properties and set the **Horizontal** and **Vertical** constraints to **-2.25** and **0.90**, respectively. Then click **Apply** and then **Close**.



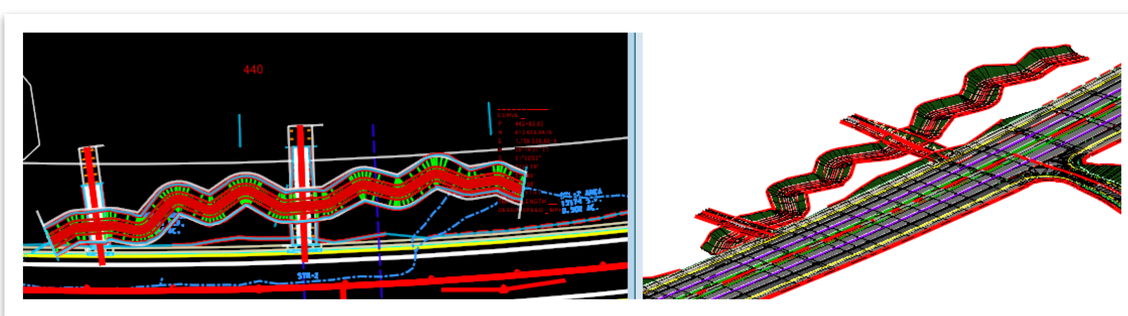
11. Next, open the **STRM_TOP_R** point properties. The **Vertical** constraint is set to match the left vertical constraint by default. If required, you could override that value here. For this exercise, the channel has the same height on either side of the centerline. We still need to change the **Horizontal** constraint to **2.25** to match the left side. Once updated, click **Apply** and then **Close**.



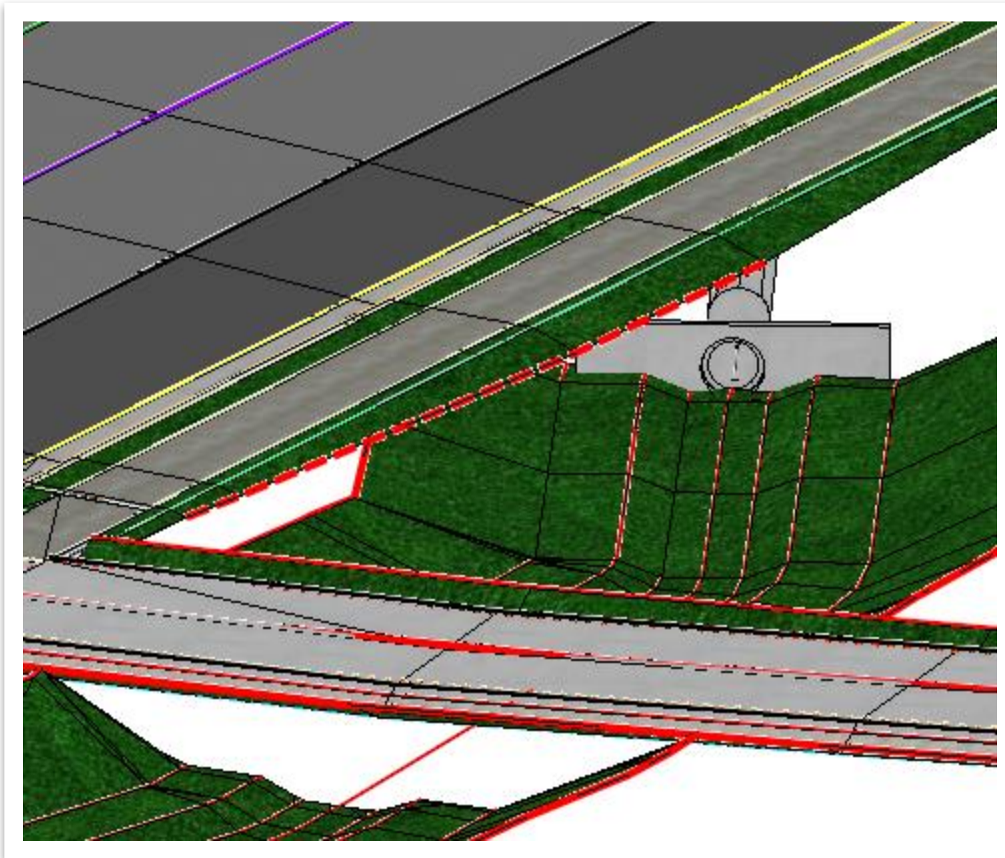
12. To complete the template updates, we need to update the **top of stream** points. Open the **STRM_TOP_OUT_L** point properties and set the **Horizontal** and **Vertical** constraints to **-4.00** and **0.00**, respectively. Then click **Apply** and **Close**. Repeat this step for the **STRM_TOP_OUT_R** point, setting the same constraints to **+4.00** and **0.00**, respectively. The template should now match the proposed typical section. **Save** and **Close** the template library once you have finished.



13. Now, we will create a **New Corridor** using the stream centerline. Open the **New Corridor** tool (**OpenRoads Modeling >> Corridors >> Create**). Within the **Create Corridor** dialog box, select the **Preliminary Design** feature definition and name the corridor **STRM 2**. Select the proposed stream centerline, **right** click to accept the active profile, and then **left** click to accept.
14. Within the **Create Template Drop** dialog box, toggle on **Lock To Start** and **Lock To End**. Set the template **Drop Interval** to **15.00**. Select the template we previously created (**STREAM CHANNEL**) and click **OK**. **Left** click through the prompts to accept. Notice that the stream model crosses **two** driveways, which means that **side drains** are needed under each driveway. We will add the side drains in the next exercise.



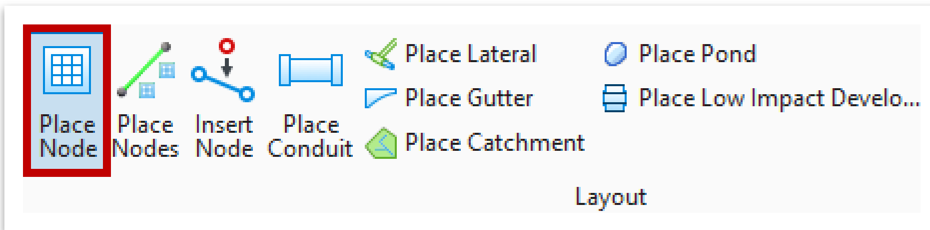
15. Go ahead and clip the stream corridor by the two driveway corridors using the **Add Clipping Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor Clipping**). Once clipped, the **3D** model should look like the screenshot below. **Note:** Only one of the driveways is shown.



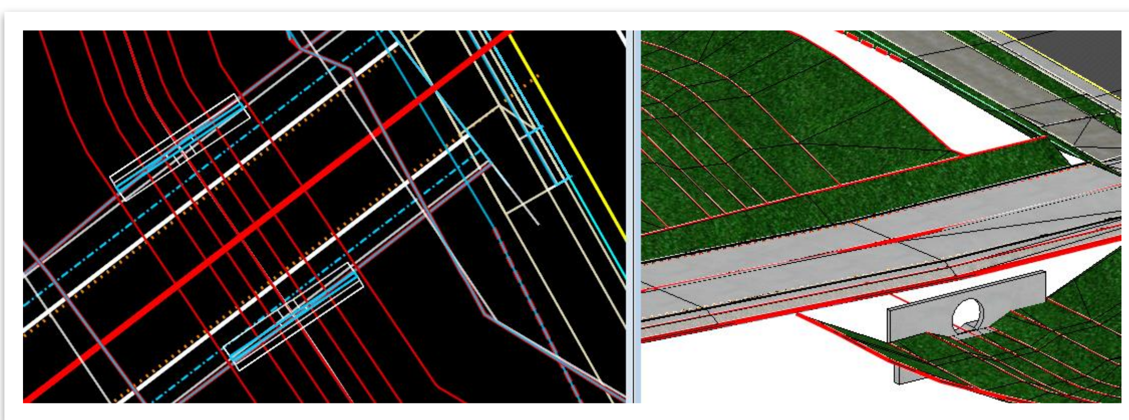
14.4 Exercise: Modeling Side Drains Within a Stream Relocation

In this exercise, we will model the drainage structures needed to connect a stream under driveways or other roadway appurtenances. We will assume that the correct pipe size has already been calculated for this exercise and will not perform any hydraulic calculations.

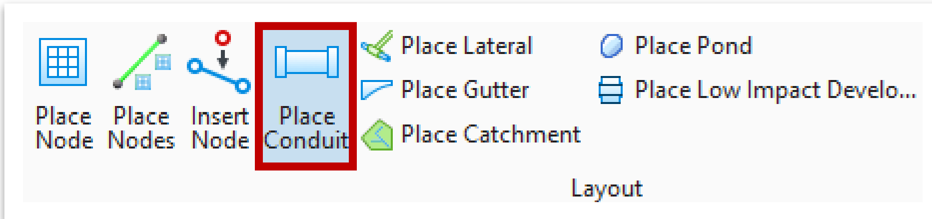
1. Open the **ROAD-II-CR-Drainage Model.dgn** file within the dgn Chapter 14 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner. Attach the **ROAD-II-CR-Stream Relocation Model.dgn** reference file and then switch to the **Drainage and Utilities** workflow.
2. We first need to place the **endwalls** on each side of the first driveway. Open the **Place Node** tool (**Drainage and Utilities >> Layout >> Layout**) and select the **EW-Straight Round 30-90** feature definition (**StormWaterNode >> Endwalls >> Cross Drains >>Straight >> Round >> 18”-30”; Skew 90**).



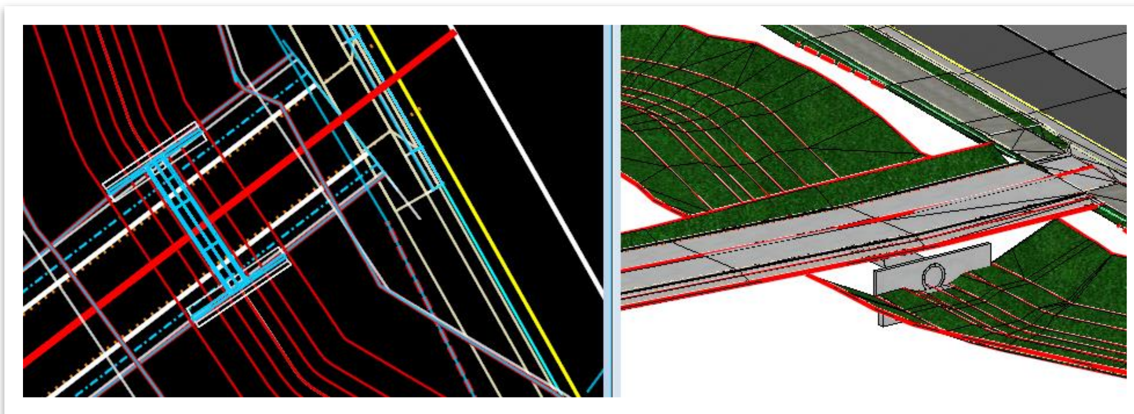
3. Go to the first driveway at approximate Station **438+20.00** and place an endwall on the **left** side of the driveway near the side slope tie-ins. Select the **stream centerline** as the elevation reference. Toggle on **Elevation is the Invert** to place the endwall at the elevation of the stream alignment (**STREAMREALIGN1**). Set the **Rotation Mode** to **Relative to Alignment** and then select the driveway alignment as the reference element for rotation. Set the rotation angle to be **90˚** from the driveway alignment. Repeat this process and place an endwall on the **right** side of the driveway.



4. Then, place the endwalls for the second driveway using the same process in Steps 2-3.
5. Next, open the **Place Conduit** tool (**Drainage and Utilities >> Layout >> Layout**).



6. Select the **Side Drain RCP** feature definition (**Conduit >> StormWater >> Culvert Pipes >> Proposed**). Place a **30" RCP** connecting the endwalls under <u>both</u> driveways to complete the relocated stream model. **Note:** You should place conduit in the **direction of flow**, which is opposite the mainline stationing.



Chapter 15. Earthwork

Earthwork is a critical component of any roadway design. The earthwork tools available within ORD continue to evolve with every software release. This chapter will discuss the current procedure to calculate earthwork for a TDOT design project.

15.1 Objectives

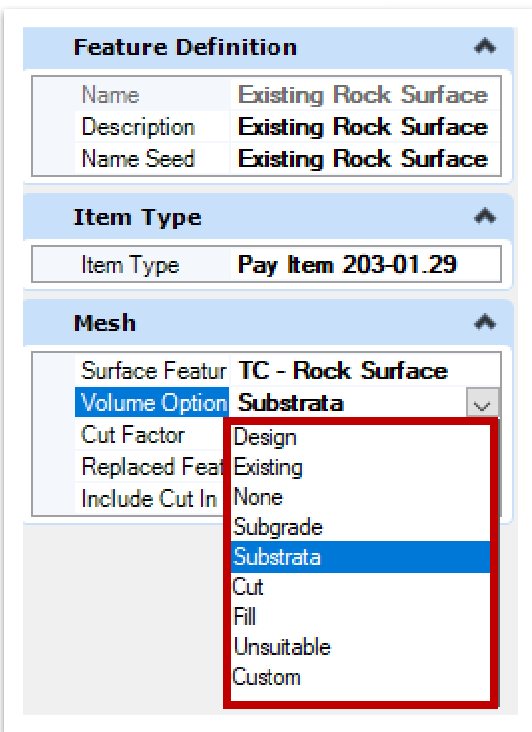
At the conclusion of this chapter, participants will be able to:

1. Run earthwork with two layers: topsoil and existing pavement.

15.2 Lecture: Earthwork Overview

The **earthwork** functionality in ORD allows the user to calculate the amount of **cut** and **fill** required in a model. ORD determines whether to include a mesh in the earthwork calculation based on the **Volume Options** tied to each **Mesh** and **Terrain** feature definition (Figure 22). Some of the volume options are further explained below.

FIGURE 22. VOLUME OPTIONS



Design: Most meshes fall in this category. Included as a final feature of the model.

Substrata: Use when creating subsurfaces other than the normal cut or fill (e.g., rock surface).

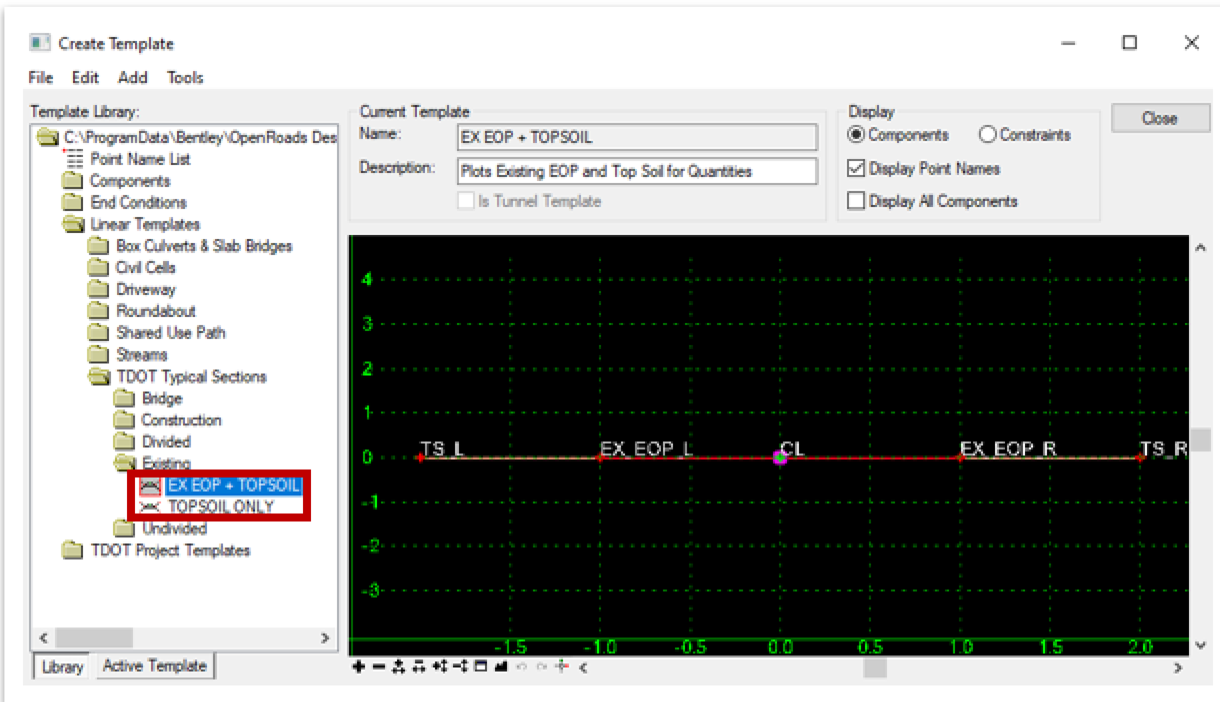
Unsuitable: When earthwork is run, the volume will not be included in the earthwork cut/fill volume. Assumed to be removed during construction.

Within the default TDOT template library (ITL), there is an **EX EOP + TOPSOIL** template and a **TOPSOIL ONLY** template (Figure 23). The first option allows for the exclusion of the existing pavement and topsoil from the cut values whereas the second option allows for the exclusion of the topsoil only. These templates need to be placed along the existing alignment. Then, the **Existing EOP** lines should be referenced, so the templates will automatically follow them. Utilization of **point controls** would then be needed to set the topsoil edges to the edge of the cut and fill lines (horizontally and vertically).

Take Note!

*Both the existing pavement and topsoil will follow the surface of the **active terrain** rather than the design corridor.*

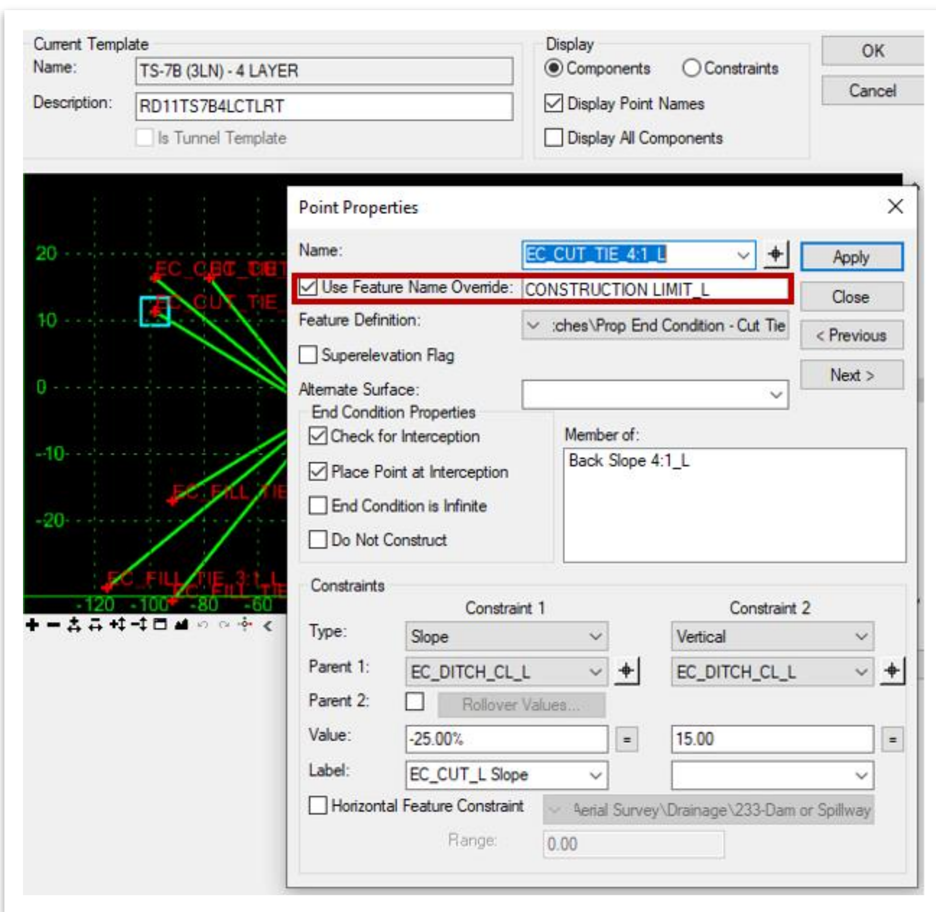
FIGURE 23. EX EOP + TOPSOIL TEMPLATE



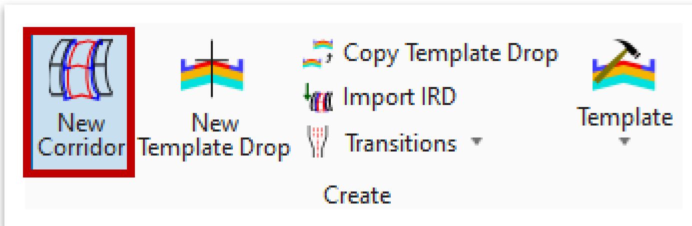
15.3 Exercise: Calculate Earthwork

In this exercise, we will run earthwork for a proposed model with a surface terrain and a sub-surface terrain.

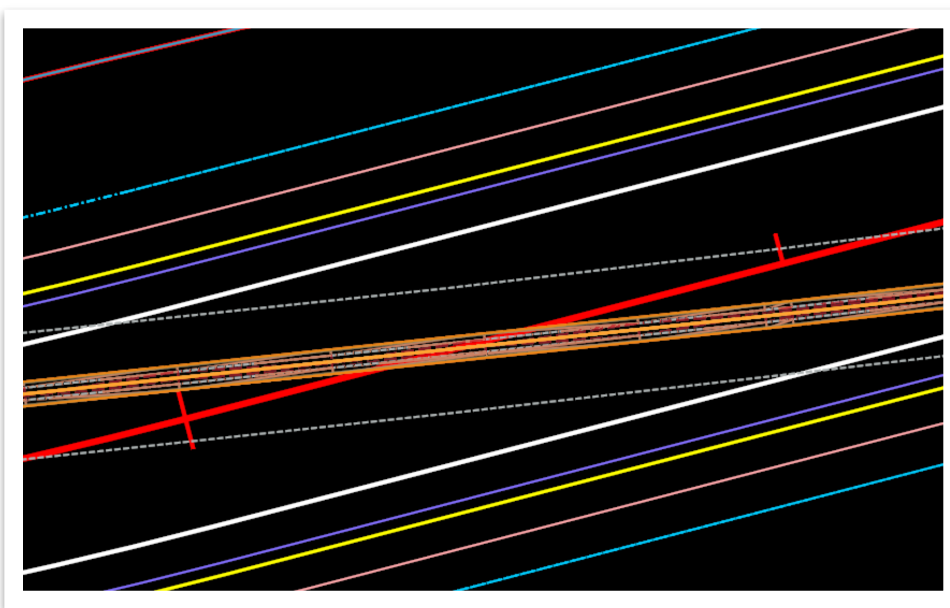
1. Open the **ROAD-II-EW Corridor.dgn** file within the dgn Chapter 15 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner and then switch back to the **OpenRoads Modeling** workflow. The following files should already be referenced in the 2D view.
    - ROAD-II-EW-Alignments.dgn
    - ROAD-II-EW-Survey.dgn
    - ROAD-II-EW-Terrain.dgn (set terrain to active if not already active)
2. Open the **Edit Template Drop** tool (**OpenRoads Modeling >> Corridors >> Edit**) and select the mainline template drop. Make sure that all the <u>left</u> and <u>right</u> **cut** and **fill** tie points have the **Use Feature Name Override** option toggled on. Also, make sure the left and right feature override name is set to **CONSTRUCTION LIMIT_L** and **CONSTRUCTION LIMIT_R**, respectively. This allows the template drop to connect the cut and fill tie lines into one line. **Note:** The **EC_CUT_TIE_4:1_L** point properties are shown below as an example.



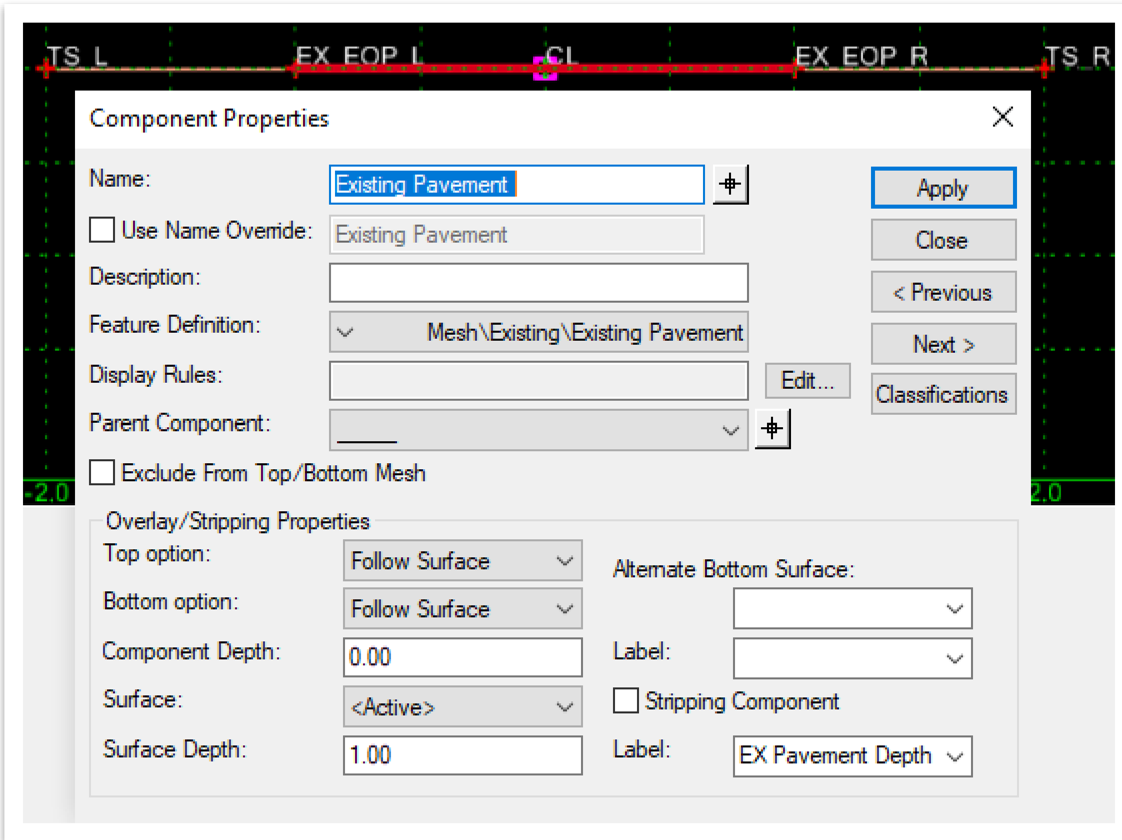
3. Now, open the **ROAD-II-EW-Existing Corridor.dgn** file within the dgn Chapter 15 subfolder. The following files should already be referenced in the 2D view. **Note:** This file contains a complex element for the existing centerline (**EX CL**), and lines that define the existing EOP using the **EX EOP** feature definition. All lines were copied from an SS2 survey and converted to featurized lines.
    - ROAD-II-EW-Alignments.dgn
    - ROAD-II-EW-Corridor.dgn
    - ROAD-II-EW-Terrain.dgn (set terrain to active if not already active)
4. First, we need to create a new corridor along the existing centerline (**EX CL).** Open the **New Corridor** tool (**OpenRoads Designer >> Corridors >> Create**). Within the **Create Corridor** dialog box, select the **Earthwork** feature definition.



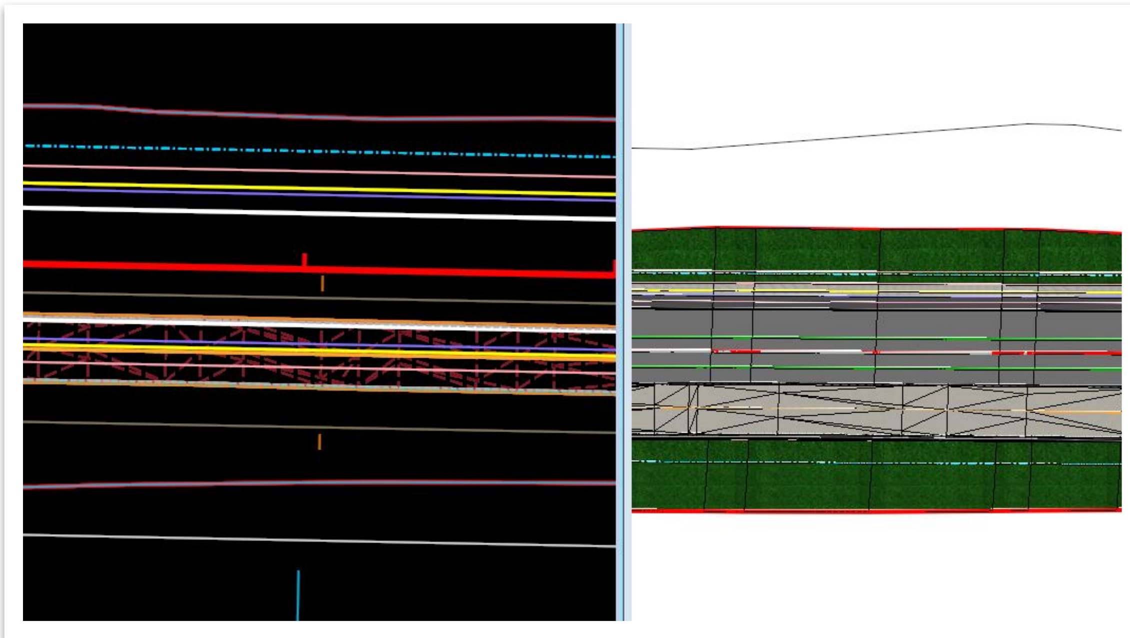
5. Select the **EX CL** alignment as the **Corridor Baseline**. **Right** click to select the active profile of the **EX CL**, which is the existing terrain. Then, change the **Name** of the corridor to **Unsuitable Material**.
6. Within the **Create Template Drop** dialog box, toggle on **Lock To Start** and **Lock To End**. Set the template **Drop Interval** to **25.00**. Select the **EX EOP + TOPSOIL** template (**Linear Templates >> TDOT Typical Sections >> Existing**) and click **OK**. **Left** click through the prompts to accept. **Note:** The template placed along the **EX CL** will be narrow.



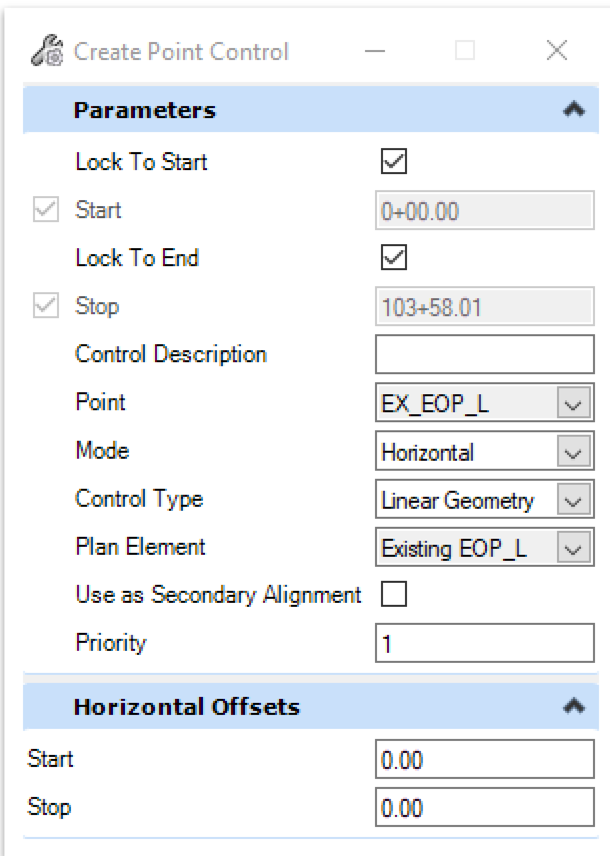
7. Let's examine the template drop that was just placed. Open the **Edit Template Drop** tool (**OpenRoads Modeling >> Corridors >> Edit**) and select the earthwork corridor that was just created. Notice there are **three** lines that follow the surface of the terrain. The red line represents **existing pavement** and has a **1'** depth. The brown lines represent **topsoil** and currently have a **3"** depth. These can be changed within the **Component Properties**. For this exercise, leave the default values as-is and then close the **Edit Template Drop** tool. **Note:** The **Existing Pavement** component properties are shown below.



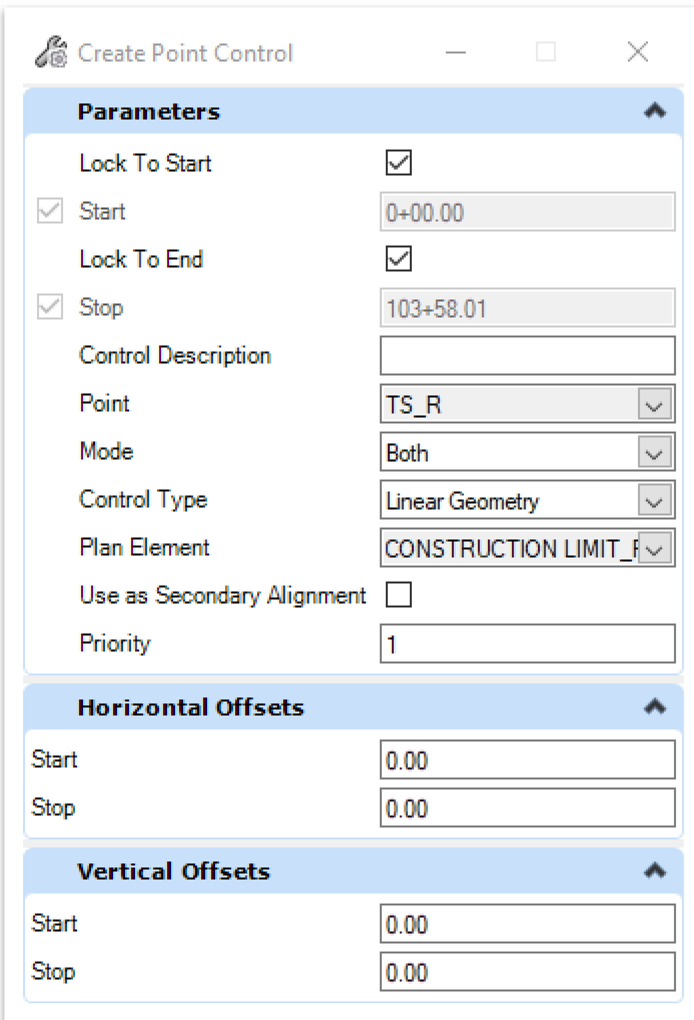
8. The **EX_EOP** points in the template are searching for lines with the same feature definition. Open the **Add Corridor Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor References**). Select the **Unsuitable Material** corridor and then select the **Existing EOP** lines. **Right** click to close the tool. The template drop should now match the existing **EOP** lines. **Note:** If your file crashes during this step, see Step 9 for an alternate point control method to control the corridor.



9. You can skip this step if the previous step worked. Open the **Create Point Control** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) Select the **Unsuitable Material** corridor and then select the following settings. Click through the remaining prompts to accept. Then, repeat the point control for the right point (**EX_EOP_R**).
    a. **Lock To Start:** Toggle on
    b. **Lock To End:** Toggle on
    c. **Control Description:** Blank
    d. **Point:** EX_EOP_L
    e. **Mode:** Horizontal
    f. **Control Type:** Linear Geometry
    g. **Plan Element:** Existing EOP_L (**Note:** Must be selected in plan view.)

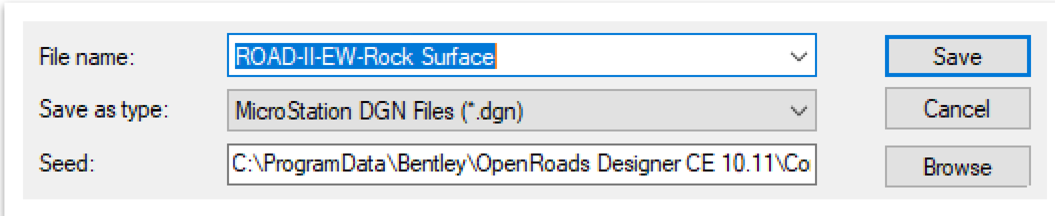


10. Next, we will point control the edge of topsoil to be removed. Open the **Create Point Control** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**). Select the **Unsuitable Material** corridor and then select the following settings. Click through the remaining prompts to accept.
    a. **Lock To Start:** Toggle on
    b. **Lock To End:** Toggle on
    c. **Control Description:** Blank
    d. **Point:** TS_R
    e. **Mode:** Both
    f. **Control Type:** Linear Geometry
    g. **Plan Element:** CONSTRUCTION LIMIT_R (**Note:** Must be selected in plan view.)

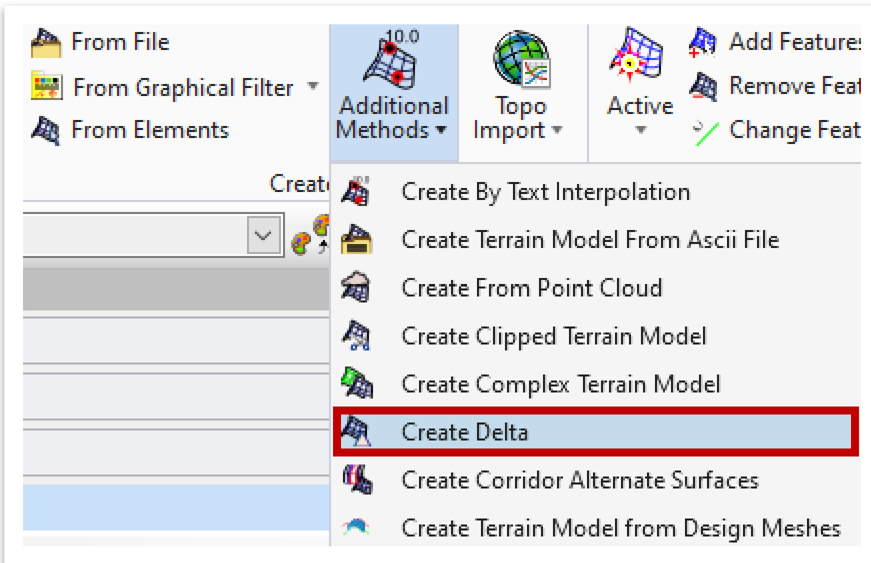


11. Repeat the previous step to create a point control on the **left** side. Select the **TS_L** point and click on the **CONSTRUCTION LIMIT_L** line. The topsoil should now follow the surface to the edge of the cut and fill lines.

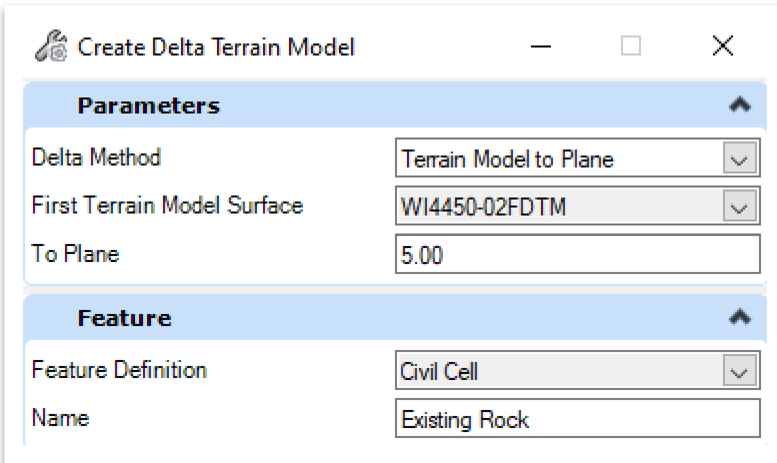
12. Now, we will create an **existing rock** terrain with the assumption that the rock surface is **5'** below grade. Create a new file and name it **ROAD-II-EW-Rock Surface**. Select the **TDOTSeed3D.dgn** and click **Save**. **Note:** Save this file under the dgn Chapter 15 subfolder.



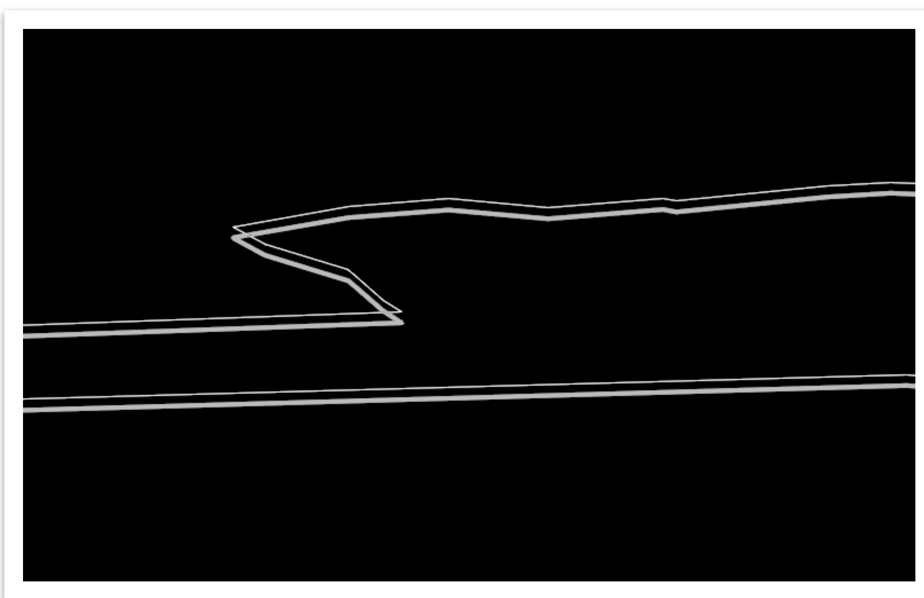
13. Delete the embedded cells in the file and then attach the **ROAD-II-EW-Terrain .dgn** reference file. Then, click **Fit View**. We are going to apply a simple offset of the original existing terrain to create the top of the **rock surface**. Open the **Create Delta** tool (**OpenRoads Modeling >> Terrain >> Create >> Additional Methods**).



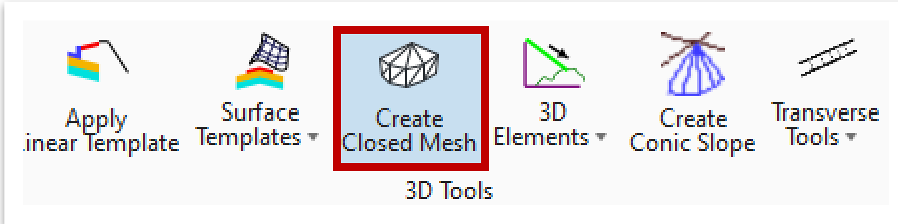
14. Within the **Create Delta Terrain Model** dialog box, select the following settings.
    a. **Delta Method:** Terrain Model to Plane
    b. **First Terrain Model Surface:** WI4450-02FDTM (select terrain boundary in plan view)
    c. **To Plane:** 5.00
    d. **Feature Definition:** Civil Cell (under the **Terrain** folder)
    e. **Name:** Existing Rock



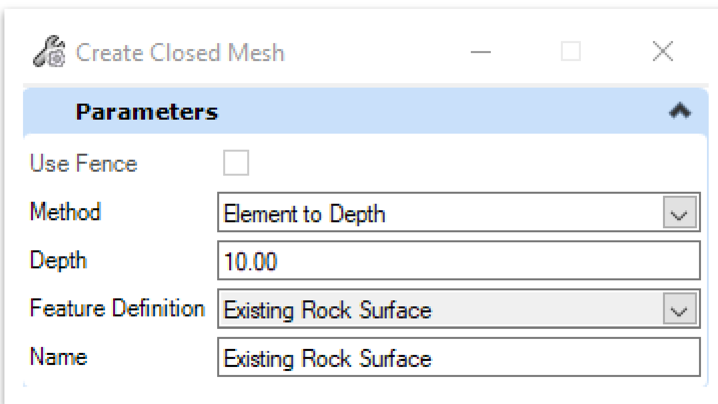
15. **Left** click to accept and notice a new **existing rock** terrain surface has now been created **5'** below the original existing terrain. Within the new terrain, go ahead and turn off the **triangles**, if not already off.



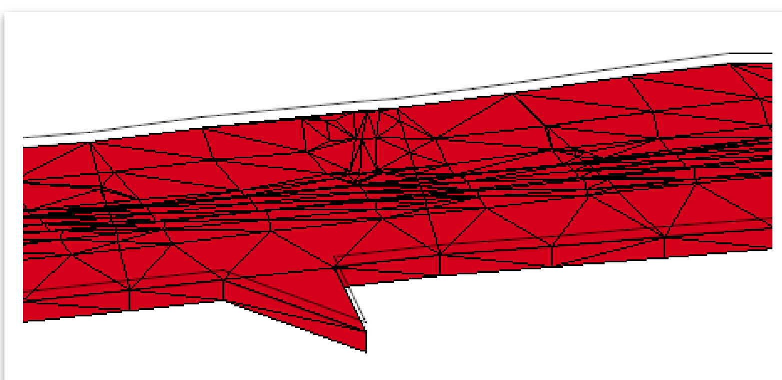
16. Next, we need to create a **mesh**. Open the **Create Closed Mesh** tool (**Open Roads Modeling >> Model Detailing >> 3D Tools**).



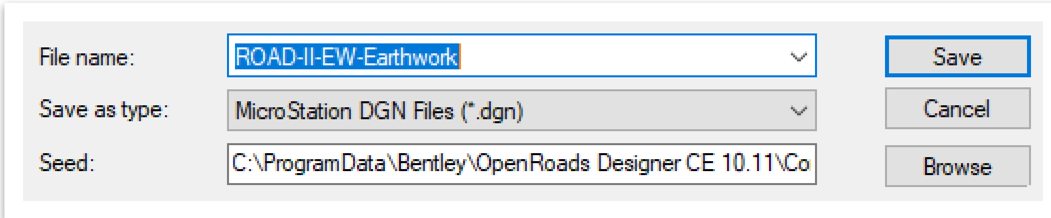
17. Within the **Create Closed Mesh** dialog box, select the following settings. **Note:** The depth should be project specific so ensure that the depth is deep enough encompass all cut needed for a project. Since we do not have a lot of major cut areas in this example, it does not have a large depth.
    a. **Method:** Element to Depth
    b. **Depth:** 10.00
    c. **Feature Definition:** Existing Rock Surface (**Mesh >> Existing**)
    d. **Name:** Existing Rock Surface



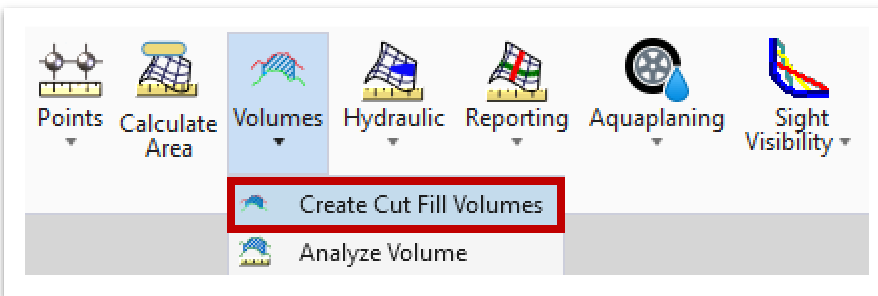
18. **Left** click to accept the **Method**. When prompted for the **Top Surface Element**, select the **Existing Rock Surface** terrain created earlier in the exercise. When prompted to select the **Boundary Surface Element**, select the **offset terrain**. **Left** click through the remaining prompts to accept.



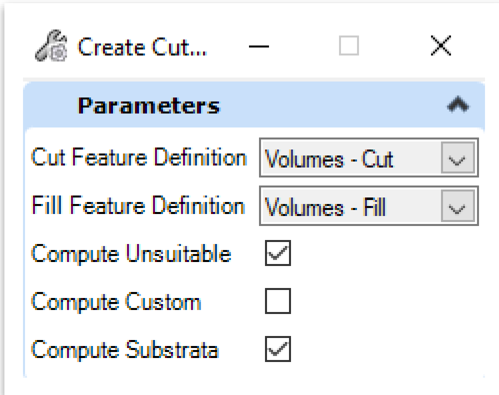
19. Create a new file and name it **ROAD-II-EW-Earthwork**. Select the **TDOTSeed 2D.dgn** and click **Save**. **Note:** Save this file under the dgn Chapter 15 subfolder. This file will be used for the earthwork shapes, which are generally quite large. Due to the size, it is recommended to create the shapes in a separate file so they can be referenced separately from other models.



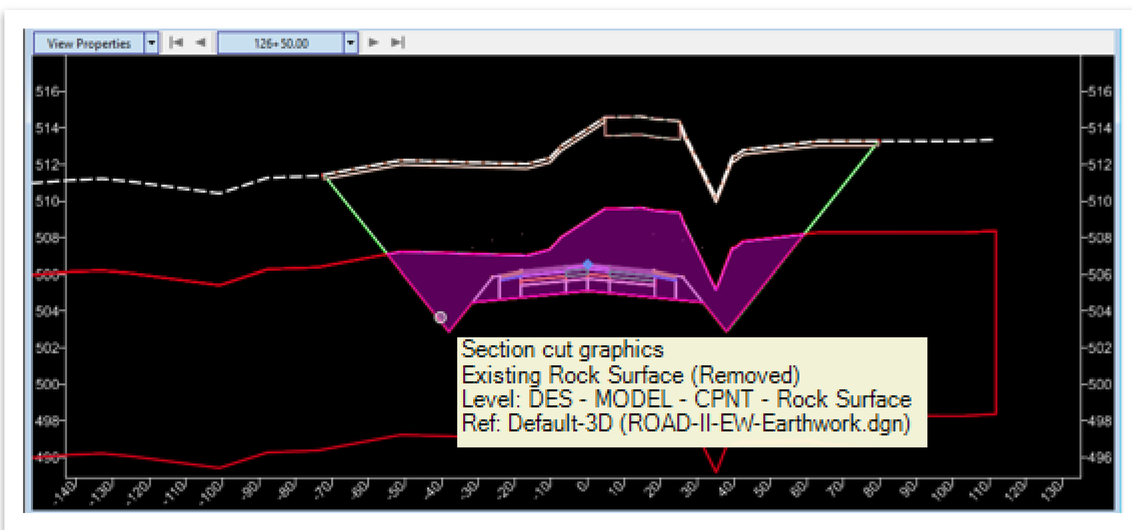
20. Attach the following reference files using the **Coincident World** attachment method.
    - ROAD-II-EW-Alignments.dgn
    - ROAD-II-EW-Corridor.dgn
    - ROAD-II-EW-Existing Corridor.dgn
    - ROAD-II-EW-Rock Surface.dgn
    - ROAD-II-EW-Terrain.dgn (Set this terrain to active, which will also create a 3D model)
21. Now, the **cut** and **fill** volumes can be run. Open the **Create Cut Fill Volumes** tool (**OpenRoads Modeling >> Terrain >> Analysis >> Volumes**).



22. The **Cut** and **Fill** feature definitions should already be set. Toggle on the **Compute Unsuitable** and **Compute Substrata** options. This will calculate the existing pavement and excludes the topsoil from the cut and fill calculations. It also includes the existing rock layer as a separate cut volume. Since the **Existing Rock Surface** feature definition is set to have the **substrata volume** option, the software will know that the mesh is the substrata.



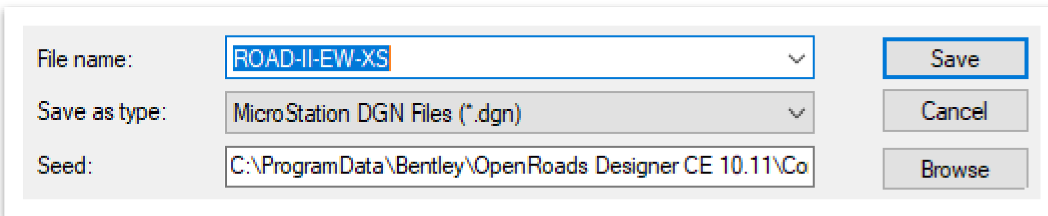
23. The earthwork will take some time to process, so be patient. Once completed, open the **Open Cross Section View** tool (**OpenRoads Modeling >> Corridors >> Review >> Dynamic Sections**). Select the **mainline** corridor and then scroll through using the directional arrows at the top of the window, which is the easiest way to view the results in a particular area. <u>The cut volumes do not include topsoil, whereas the fill volumes do</u>. The earthwork volumes also calculated the cut into the rock section separately from the normal cut section. In addition, the existing pavement volume was calculated separately to determine what volume will and will not need to be replaced with fill.



Take Note!

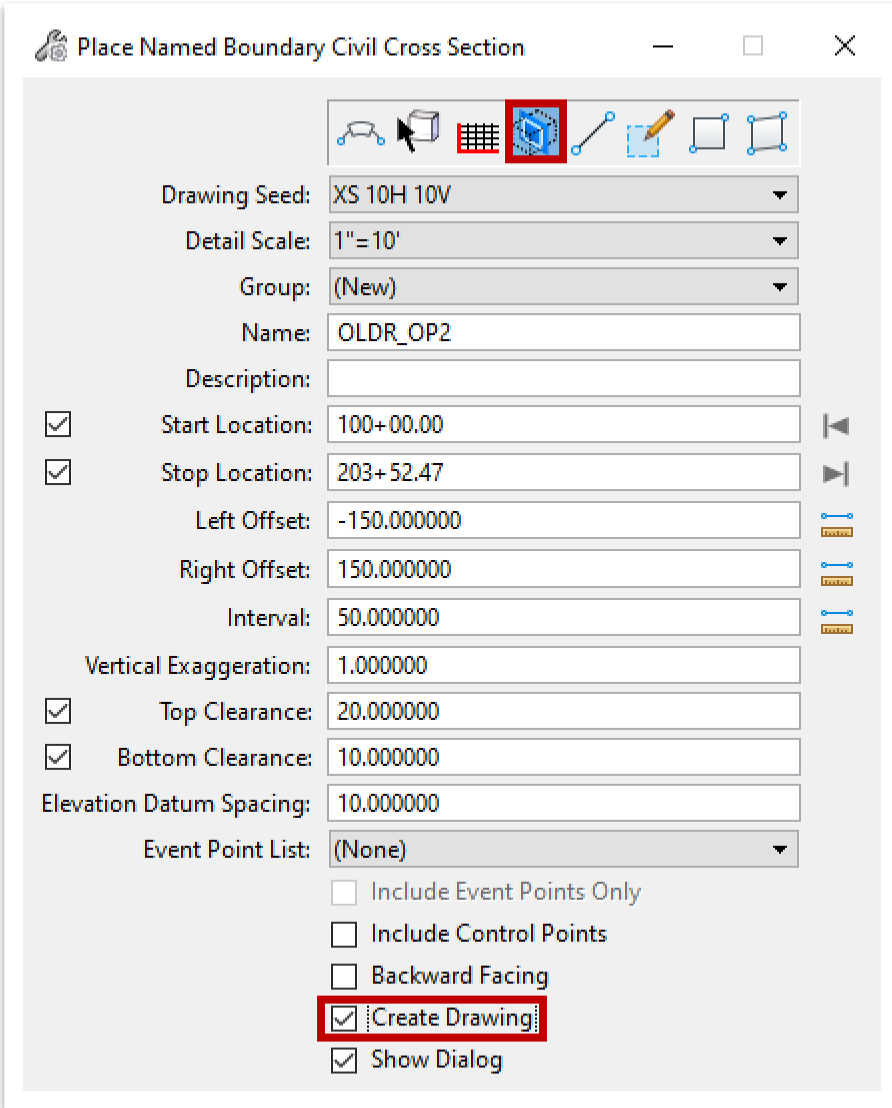
*ORD runs significantly slower once earthwork shapes have been placed in a file. It is recommended to hold off running earthwork until the end and not model anything significant with these shapes in the file. If necessary, you can delete the earthwork shapes while making changes to the model and then re-run the earthwork. To delete the shapes, you must select the shapes in the **3D** view or the **cross section**. If you run the earthwork again, a prompt will appear asking if you want to delete the previous results. This means that deleting shapes is not necessary to re-run the earthwork.*

24. The earthwork can now be placed into the cross sections and an **End Area Volume Report** can be created, which will be used for TDOT earthwork quantities. Go ahead and create a new file named **ROAD-II-EW-XS.dgn**. Select the seed file **TDOT2DSeed Master File.dgn**.

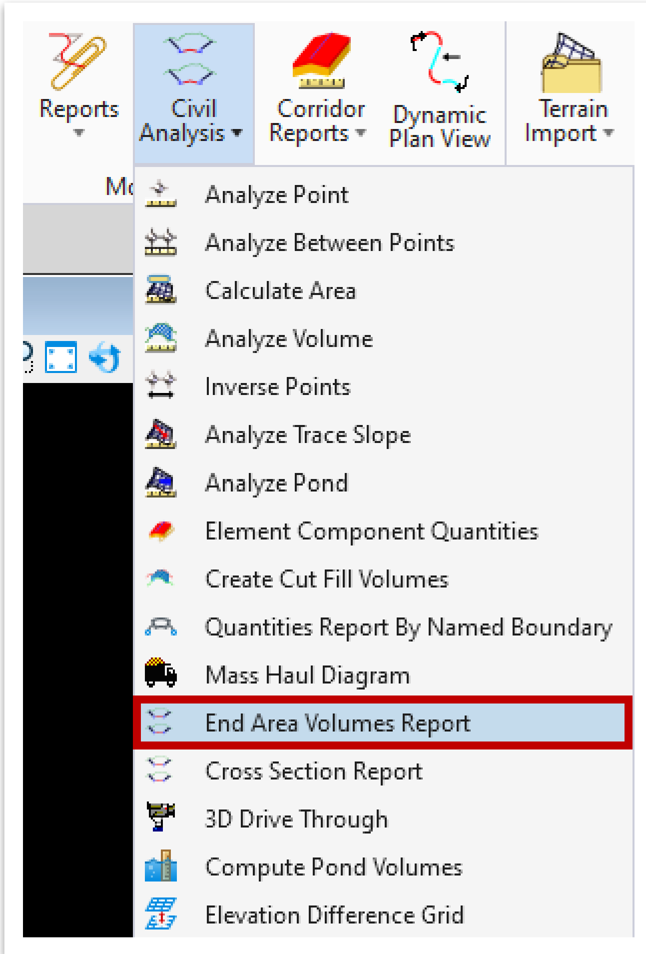


25. Make sure the **Default-3D** view is open and then attach the following reference files using the **Coincident World** attachment method to the **2D Default** view.
    - ROAD-II-EW-Alignments.dgn
    - ROAD-II-EW-Corridor.dgn
    - ROAD-II-EW-Earthwork.dgn
    - ROAD-II-EW-Existing Corridor.dgn
    - ROAD-II-EW-Rock Surface.dgn
    - ROAD-II-EW-Terrain.dgn (Set terrain to active)

26. Open the **Place Named Boundary** tool (**OpenRoads Modeling >> Drawing Production >> Named Boundaries >> Named Boundary**). Select the **Civil Cross Section** option and the **XS 10H 10V** drawing seed. Then, select the proposed mainline alignment and toggle on **Start** and **Stop Location**. Make sure that the **Create Drawing** option is toggled on at the bottom and then click through the prompts. **Note: OLDR_OP2** is the **Name** of the proposed mainline alignment.



27. Within the **Create Drawing**, click **OK** to accept all default settings. By default, the software should open to the last **sheet** model. Switch back to the **Default** model and open the **End Area Volumes Report** tool (**OpenRoads Modeling >> Home >> Model Analysis and Reporting >> Civil Analysis**).



28. Within the **End Area Volumes Report** dialog box, select the **OLDR_OP2** named boundary group that was just created. **Left** click to accept. Since there are no exceptions, **right** click to complete. The software will then process the **Named Boundaries**. The **End Area Volume Report** should automatically open (within the **Bentley Civil Report Browser**). **Note:** By default, the cut/fill volume columns are in **cubic feet**. You can click **Tools >> Format Options** and toggle on **Convert to Cubic Yard**, as well as other format updates, as necessary.

End Area Volume Report

Report Created: Thursday, March 30, 2023
Time: 4:05:47 PM

Cross Section Set Name: OLDR_OP2

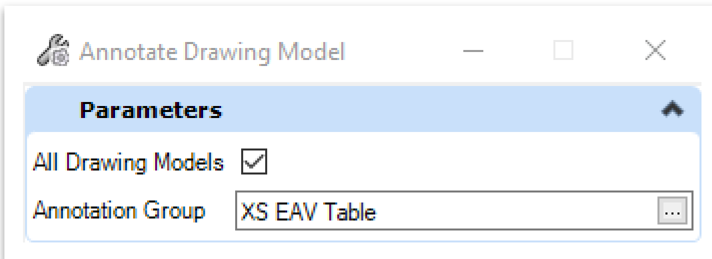
Alignment Name: OLDR_OP2

Input Grid Factor:

Note: All units in this report are in feet, square feet and cubic yards unless specified otherwise.

	Station Quantities								
	Cut				Fill				
Baseline Station	Factor	Area	Volume	Adjusted	Factor	Area	Volume	Adjusted	Mass Ordinate
100+00.00 R1	1.000	160.403	0.00	0.00	1.000	0.000	0.00	0.00	0.00
100+50.00 R1	1.000	176.730	312.16	312.16	1.000	0.236	0.22	0.22	311.94
101+00.00 R1	1.000	64.332	223.21	223.21	1.000	0.086	0.30	0.30	534.85
101+50.00 R1	1.000	138.637	187.93	187.93	1.000	1.059	1.06	1.06	721.72
102+00.00 R1	1.000	148.067	265.47	265.47	1.000	1.223	2.11	2.11	985.08
102+50.00 R1	1.000	148.310	274.42	274.42	1.000	2.171	3.14	3.14	1256.36
103+00.00 R1	1.000	170.262	294.97	294.97	1.000	1.792	3.67	3.67	1547.66
103+50.00 R1	1.000	172.845	317.69	317.69	1.000	0.213	1.86	1.86	1863.50
104+00.00 R1	1.000	153.624	302.29	302.29	1.000	0.390	0.56	0.56	2165.23
104+50.00 R1	1.000	165.378	295.37	295.37	1.000	0.235	0.58	0.58	2460.02
105+00.00 R1	1.000	147.757	289.94	289.94	1.000	0.229	0.43	0.43	2749.53
105+50.00 R1	1.000	97.034	226.66	226.66	1.000	0.597	0.76	0.76	2975.42
106+00.00 R1	1.000	66.394	151.32	151.32	1.000	1.506	1.95	1.95	3124.80
106+50.00 R1	1.000	32.183	91.27	91.27	1.000	25.673	25.17	25.17	3190.91

29. Next, we will annotate the cross sections with the **EAV** table. Switch to any of the XS **Drawing Models**. Open the **Annotate Drawing Model** tool (**OpenRoads Modeling >> Drawing Production >> Annotations >> Drawing Model Annotation**). Within the **Annotate Drawing Model** dialog box, toggle on **All Drawing Models**, which will place the table at every cross section. Click the ellipses next to **Annotation Group** and select **XS EAV Table** (**Cross Section >> Drawing**).



30. **Left** click twice to accept the settings and notice that the cut/fill annotation has now been added to the lower right corner of the cross sections. **Note:** At this time, the EAV table only shows the standard cut volume and will not include the **Rock Surface** cut volume. Reference Station **126+50.00** for an example. For more accurate quantities, the user can open the **Quantities Report By Named Boundary** tool (**OpenRoads Modeling >> Home >> Model Analysis and Reporting >> Civil Analysis**). Regardless, <u>TDOT requires the use of the **EAV** report for overall earthwork quantities</u>.

Chapter 16. Item Types

Item types allow for the assignment of TDOT **pay items** and **other fields** to design elements within the 3D model, thus aiding in estimated quantities. This chapter will discuss the current item types that have been setup in ORD and how to use them.

16.1 Objectives

At the conclusion of this chapter, participants will be able to:

1. Understand how item types work and the current applications of pay items.

16.2 Lecture: Item Types

Item types are used to link fields into easily exportable fields, whether automatically calculated or not. They will not replace the current TDOT estimated quantities process, nor will they create the TDOT Estimated Quantities excel spreadsheet. They serve as the first step in making this process more efficient for designers and add the ability to export pay items to excel.

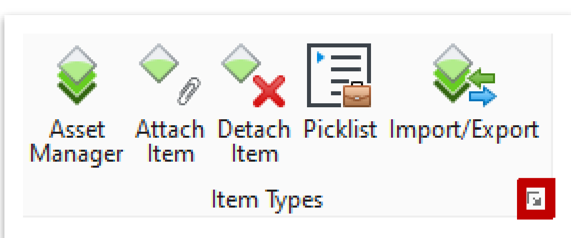
Currently, there are three reasons for item types being used in the TDOT workspace: **TDOT pay items**, **exporting to shapefile**, and **parcel annotation**. Many feature definitions have been setup with attached item types, which will be applied automatically once utilized. However, all other TDOT pay items in the library can be linked to any element in a model. This gives the user flexibility when modeling different elements relative to the TDOT pay items.

Take Note!

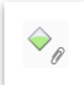
In the future, the model and the attached item types will hold all quantities necessary for bidding, which can then be reviewed and updated accordingly within ORD and the applicable Bentley platform.

The **Item Types** tools can be accessed here: **OpenRoads Modeling >> Utilities >> Item Types** (Figure 24). **Note:** The arrow in the lower right corner opens the Item Type Library.

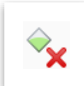
FIGURE 24. ITEM TYPES TOOLS



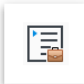
<u>Asset Manager</u>: Uses customizable excel files to apply item types to meet a user's needs. There is a single excel sheet (**Shape Export.xlsm**) set up in the TDOT workspace for exporting into shapefiles: **Organization-Civil\TDOT_Standards\Asset Manager**. Exercise E.1 will utilize this tool.



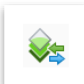
Attach Item: Allows a user to attach item types to any element in a file. This will be used when users need to attach one or multiple item types to a single file or to a selection set.



Detach Item: Allows a user to remove item types from any element in a file. The user can remove based on item type or by selection set.



Picklist: Used within item types and are stored in the **TDOT_Pay Items Lookup.xlsx** file. **Note:** Currently, the picklist tool is empty since the pick lists are stored in the excel file.

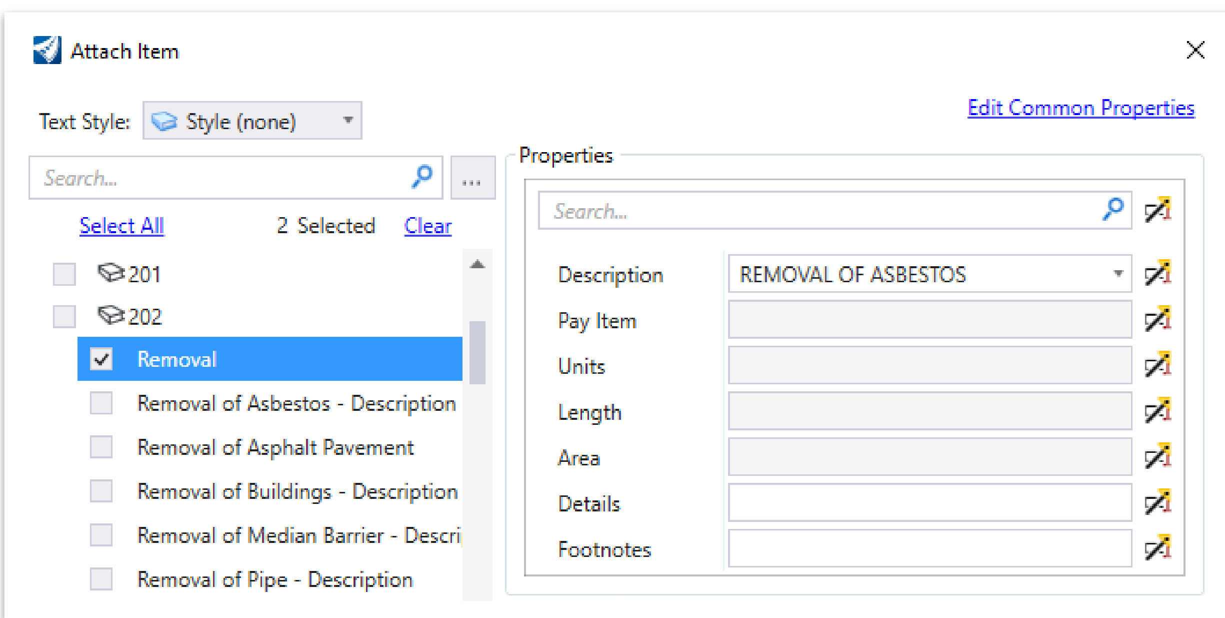


Import/Export: Allows a user to import item types from excel files or export item types from the dgn into excel spreadsheets.

All TDOT item types are broken down by the first **3** numbers of a given pay item. Each 3 number group has its own folder (library). Item types within those folders are broken down into different individual item types based on software limitations. Some folders have many different item types, whereas some only have one that encompasses the entire folder. Most item types require a **drop down** to select the individual pay item contained in that item type. This drop down is set up within the item type and is stored in an excel file (**TDOT_Pay Items Lookup.xlsx**) located in the TDOT workspace: **Organization-Civil\TDOT_Standards\Dgnlib\Item Types**. The excel file does not contain every TDOT pay item but does contain those that would be used for design.

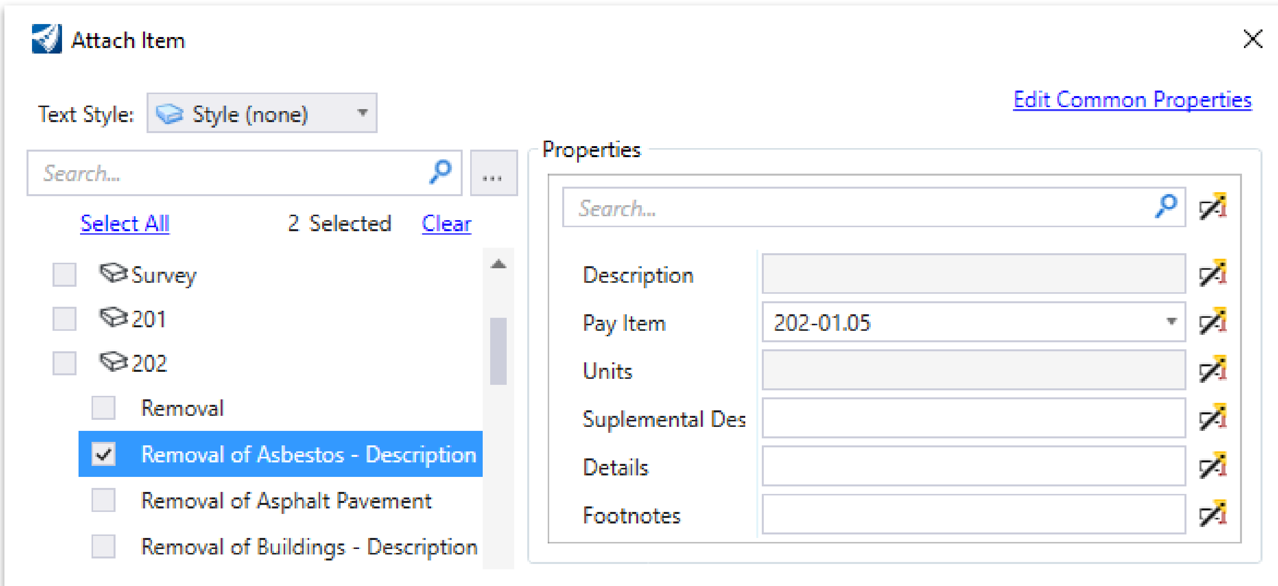
For some item types, the **Description** field is a drop down (Figure 25), meaning there is only a single pay item tied to the item type. The fields shaded in grey will populate once an item type is attached to an element.

FIGURE 25. ATTACH ITEM WINDOW – DESCRIPTION FIELD



For other item types, the **Pay Item** field is a drop-down (Figure 26). These are more concise item types that often only have one description or have different units. The designer will need to know which pay item to select so that the other fields populate correctly. Any item type that needs to have a supplemental description will have a **– Description** on the end of the item type name and will have an additional field called **Supplemental Description** to allow the designer to place the additional description of the pay item.

FIGURE 26. ATTACH ITEM WINDOW - PAY ITEM



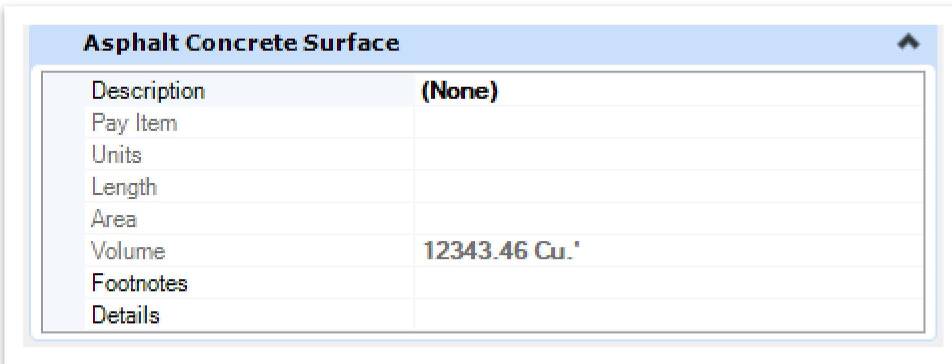
Take Note!

*If a <u>line</u> is selected, the **Length** field will populate. If a <u>shape</u> is selected, the **Area** field will populate. If a <u>mesh</u> is selected, the **Volume** field will populate. Not all item types will have these three fields linked to them. It is dependent on the units that are contained in the item type. The **Footnotes** and **Details** fields, however, are at the bottom of <u>every</u> item type and allow the user to add supplemental information that is linked to the element (e.g., converting volume units in the **Details** field).*

16.3 Exercise: Utilization and Exporting of Item Types

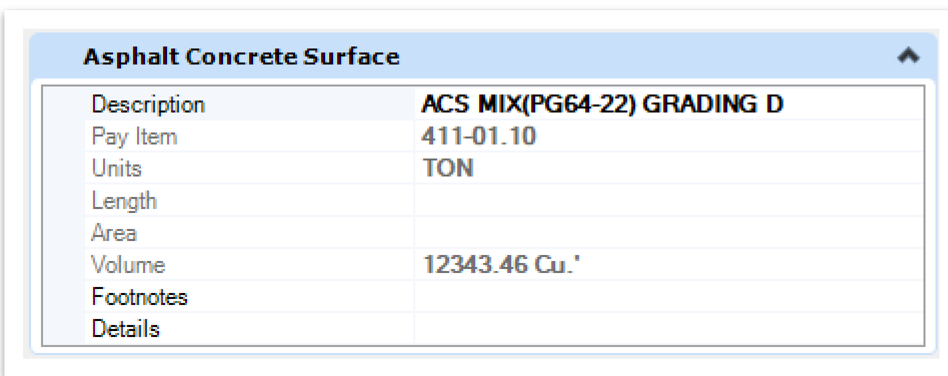
In this exercise, we will explore the item type fields within the element properties and then attach an item type and export the active item types within the model.

1. Open the **ROAD-II-IT-Corridor.dgn** file within the dgn Chapter 16 subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner. The following files should already be referenced in the 2D view.
    - ROAD-II-IT-Geometry.dgn
    - ROAD-II-IT-Terrain.dgn
2. In the **3D** view, select <u>any</u> **asphalt mesh** on the roadway and notice in the **Properties** that an item type is already attached (**Asphalt Concrete Surface**). The **Description** field is currently set to **(None)** but needs to be updated so that the **Pay Item** and **Units** fields populate. **Note:** This exercise utilizes the <u>westbound</u> travel lane for screenshots and calculations.



Asphalt Concrete Surface	
Description	(None)
Pay Item	
Units	
Length	
Area	
Volume	12343.46 Cu.'
Footnotes	
Details	

3. Next, click the **Description** field drop-down arrow and select **ACS MIX (PG64-22) GRADING D**. **Note:** Once this option is selected, the Pay Item and Units fields automatically update.



Asphalt Concrete Surface	
Description	ACS MIX(PG64-22) GRADING D
Pay Item	411-01.10
Units	TON
Length	
Area	
Volume	12343.46 Cu.'
Footnotes	
Details	

4. Go ahead and select the mesh below the asphalt surface and notice that a different item type is attached. Click on the **Description** field drop-down arrow and notice there are different options compared to those for the asphalt surface. For this exercise, we will only calculate the top asphalt mesh.
5. Let's add the calculated value for the asphalt concrete surface. Reference Chapter 7 of the TDOT RDG (7-411.01) to see the calculation.

7-411.00 ASPHALTIC CONCRETE SURFACE (HOT MIX)

7-411.01 COMPUTATIONS FOR ASPHALTIC CONCRETE SURFACE (HOT MIX)

The computed quantity for asphalt surface mixtures is as follows:

$$\frac{\text{Compacted volume (C.Y.)} \times \text{Density (Lb./C.Y.)}}{\text{2,000 Lb./ Ton}} = \text{Tons}$$

OR

$$\frac{\text{Area (S.Y.)} \times \text{Density (Lb/SY-in) x Compacted Thickness (in.)}}{\text{2,000 Lb./ Ton}} = \text{Tons}$$

6. By default, the item type volume is in cubic feet. We need to convert to cubic yards and then use the first conversion above to get **Tons**. The density for **PG64-22 Grading D** is found on **Table 7-2** in Chapter 7 of the TDOT RDG (**3816 lb/CY**).

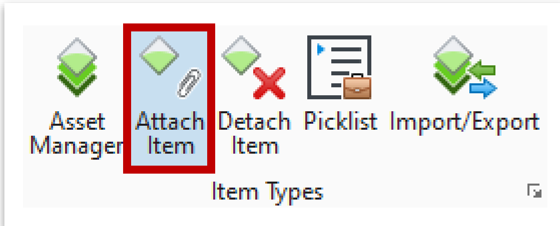
$$\frac{\left(\frac{12343.46\ CF}{27\ \frac{CF}{CY}}\right) * 3816\frac{lb}{CY}}{2000\frac{lb}{ton}} = 872.27\ tons \approx 873\ tons$$

7. Then, update the **Details** field of the item type by keying in **873 Tons**. **Note:** Your value will vary depending on which asphalt mesh you selected.

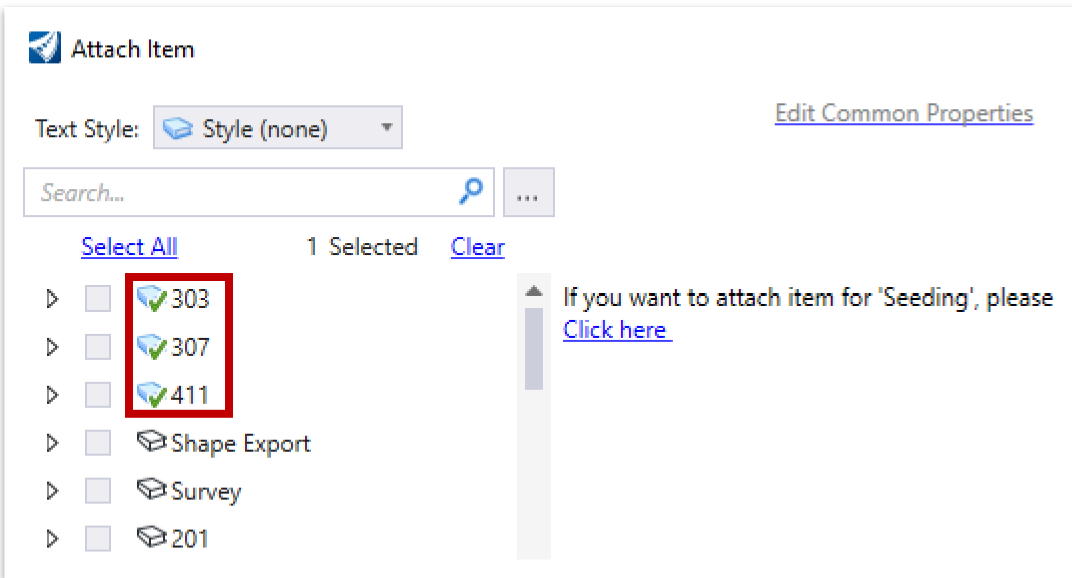
Asphalt Concrete Surface

Description	ACS MIX(PG64-22) GRADING D
Pay Item	411-01.10
Units	TON
Length	
Area	
Volume	12343.46 Cu.'
Footnotes	
Details	873 Tons

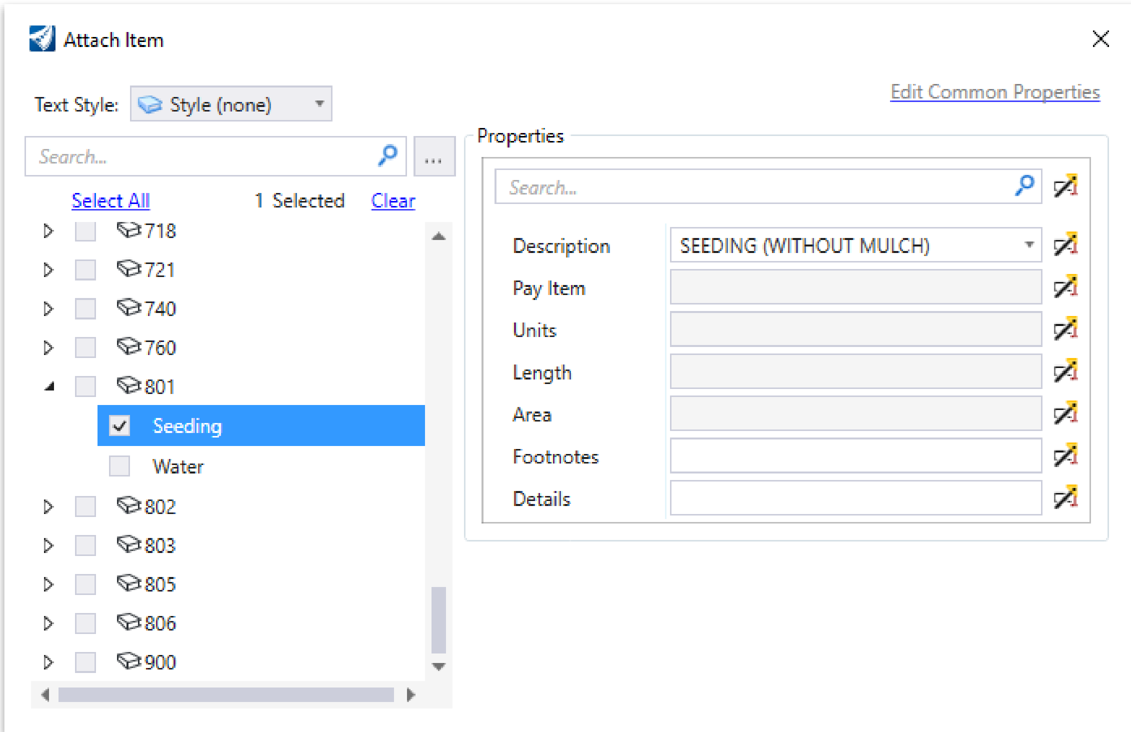
8. Now let's manually attach an item type to a single element, which can be done in the **2D** or **3D** model view. Open the **Attach Item** tool (**OpenRoads Modeling >> Utilities >> Item Types**).



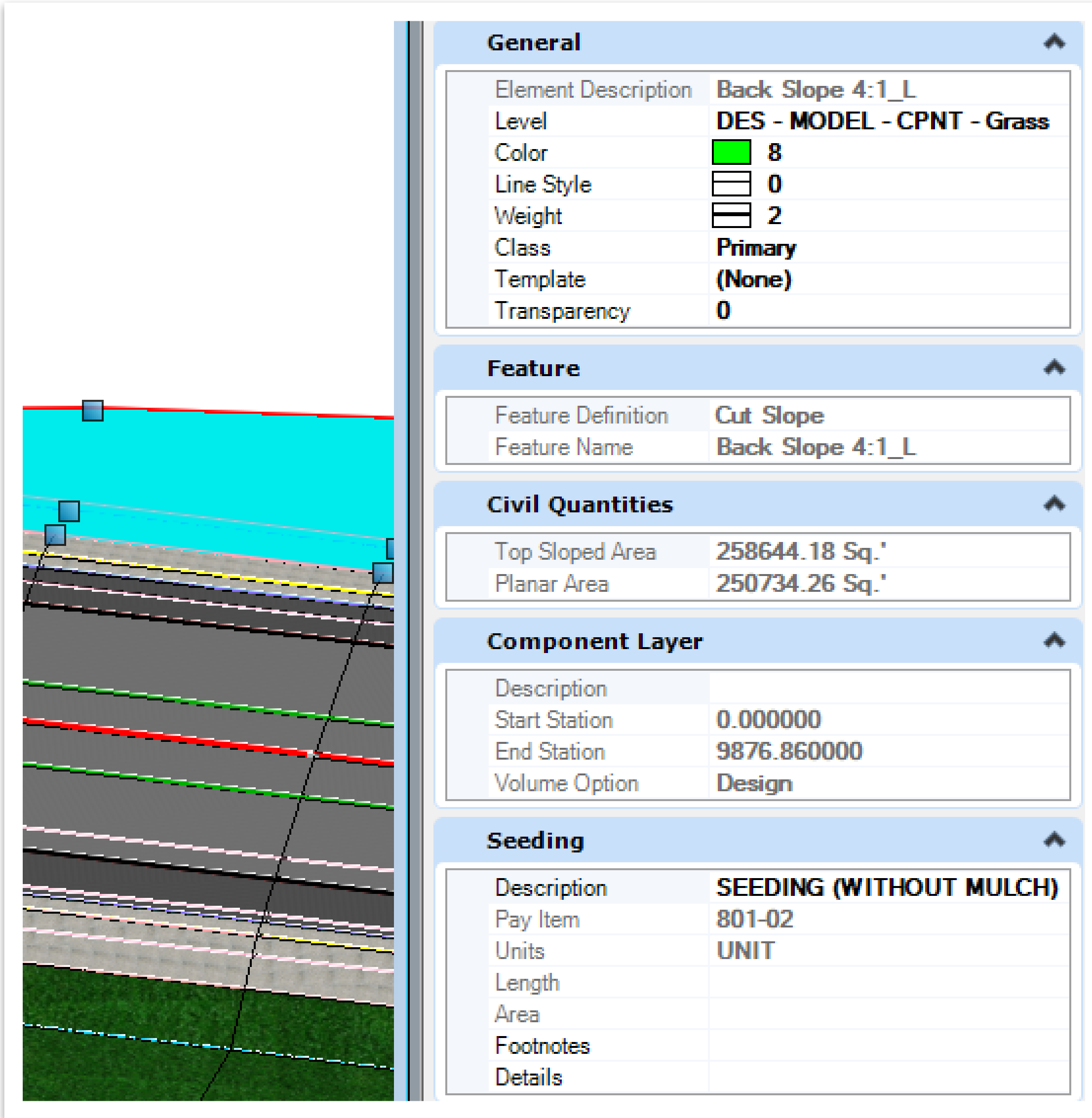
9. Within the **Attach Item** window, notice the different item type libraries on the left side. The ones that are already used in the file (303, 307 and 411) will show as active and appear at the **top** of the list.



10. Scroll down to the **801** item type library and select the **Seeding** item type. Click the **Description** field drop-down arrow and select **SEEDING (WITHOUT MULCH)**. We will leave all other fields as-is but you could add footnotes or details if desired. **Note:** You can select as many item types as desired to attach to an element. However, the same item type cannot be attached to the same element multiple times.



11. Next, we need to select the element in the model to attach the item type to. Select the **cut slope** on the north side of the road in the **3D** model and then notice that the **Seeding** item type is added to the properties. Close the **Attach Item** window once completed.



12. Let's add the calculated value for seeding. Reference Chapter 7 of the TDOT RDG (7-801.03) to see the calculation.

$$\frac{\text{Total area of seeding (Sq. ft.)} \times \text{number of effective phases of the sequence of construction}}{\text{1,000 (Sq. ft.)/unit}} = \text{Total seeding (UNITS)}$$

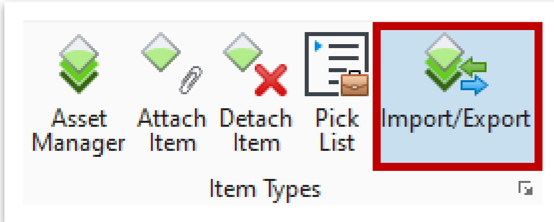
13. By default, this item type is attached to a mesh without a volume. Within the selected mesh properties, look under **Civil Quantities** and take note of the **Top Sloped Area**, which equates to **258644.18 Sq.'** for the selected element. You'll notice that two areas are shown: **Top Sloped Area** and **Planar Area**. The Top Sloped Area looks at the **3D** top surface (considering slopes), while the Planar Area only looks at the **2D** top view. This means that the values will be slightly different depending on how varying the slopes are within the mesh. If the entire element had a slope of 0%, the two areas would be the same. **Note:** The **Top Sloped Area** cannot handle vertical faces. In general, the software has issues with vertical faces, so it is recommended to avoid them, and instead use a near-vertical slope.

Civil Quantities	
Top Sloped Area	258644.18 Sq.'
Planar Area	250734.26 Sq.'

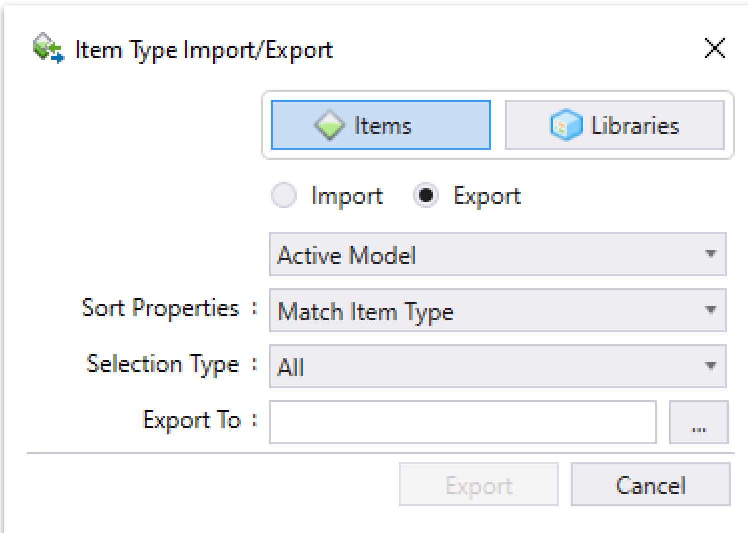
14. To convert the area to **Units**, simply divide the area by 1,000 per the equation in Step 12 and then multiply that value by how many phases of construction the seeding will be needed for. Assuming one phase for this exercise, the value would be 258.64. Update the **Details** field of the item type by keying in **259 Units** (rounded).

Seeding	
Description	SEEDING (WITHOUT MULCH)
Pay Item	801-02
Units	UNIT
Length	
Area	
Footnotes	
Details	259 Units

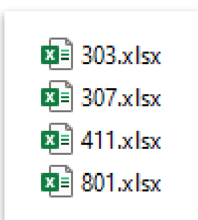
15. Now let's look at the export process. Open the **Import/Export** tool (**OpenRoads Modeling >> Utilities >> Item Types**).



16. Select the **Items** icon and the **Export** option. We will only export the **Active Model** but, if necessary, you could export all models. Leave the other settings as-is. Click the ellipses next to **Export To** and browse to any location on your computer where you wish to save the separate exported excel files for each 3-digit item type library. Once selected, click **Export**. **Note:** It is recommended to create a folder for the export so that all files are contained in an easily accessible location.



17. Once the export is complete, notice there are multiple excel files named after each active item type library. Go ahead and open one of the excel files and you should see a **Header** tab and then the applicable **Item Type** tab(s). Within the Item Type tab(s), you should see the pay item, unit and all other fields attached to the item type.



Revision History

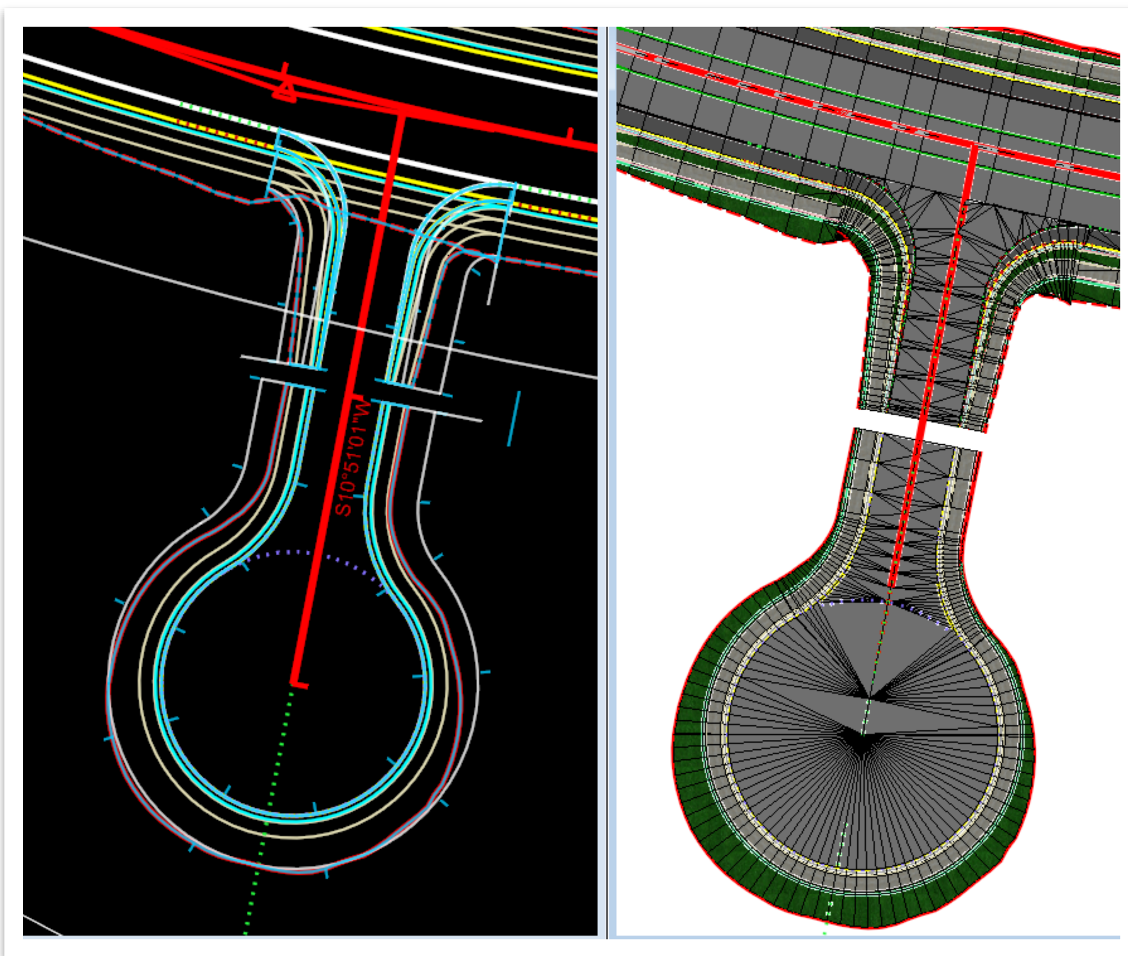
DATE (MONTH/YEAR)	AUTHOR/EDITOR	IB #	SECTIONS MODIFIED

Appendix A. Civil Cells

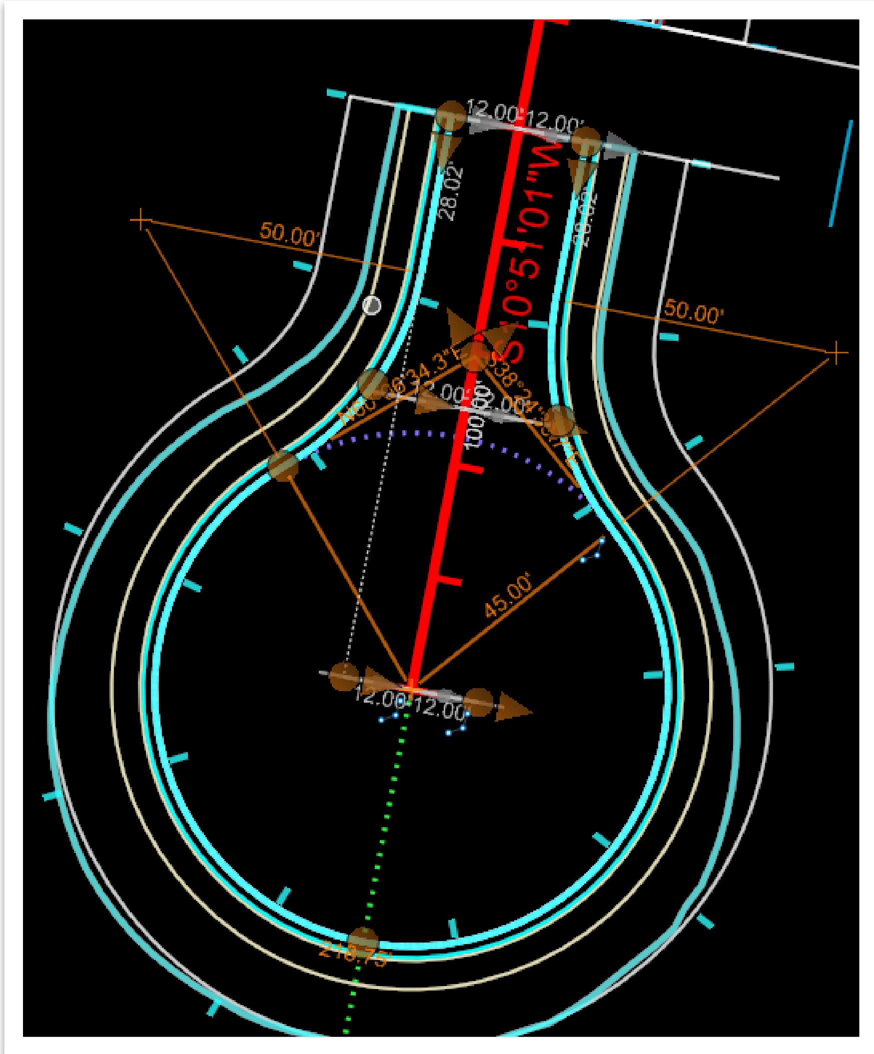
A.1 Exercise: Creating a Cul-De-Sac

In this exercise, we will place a cul-de-sac civil cell at the end of an alignment.

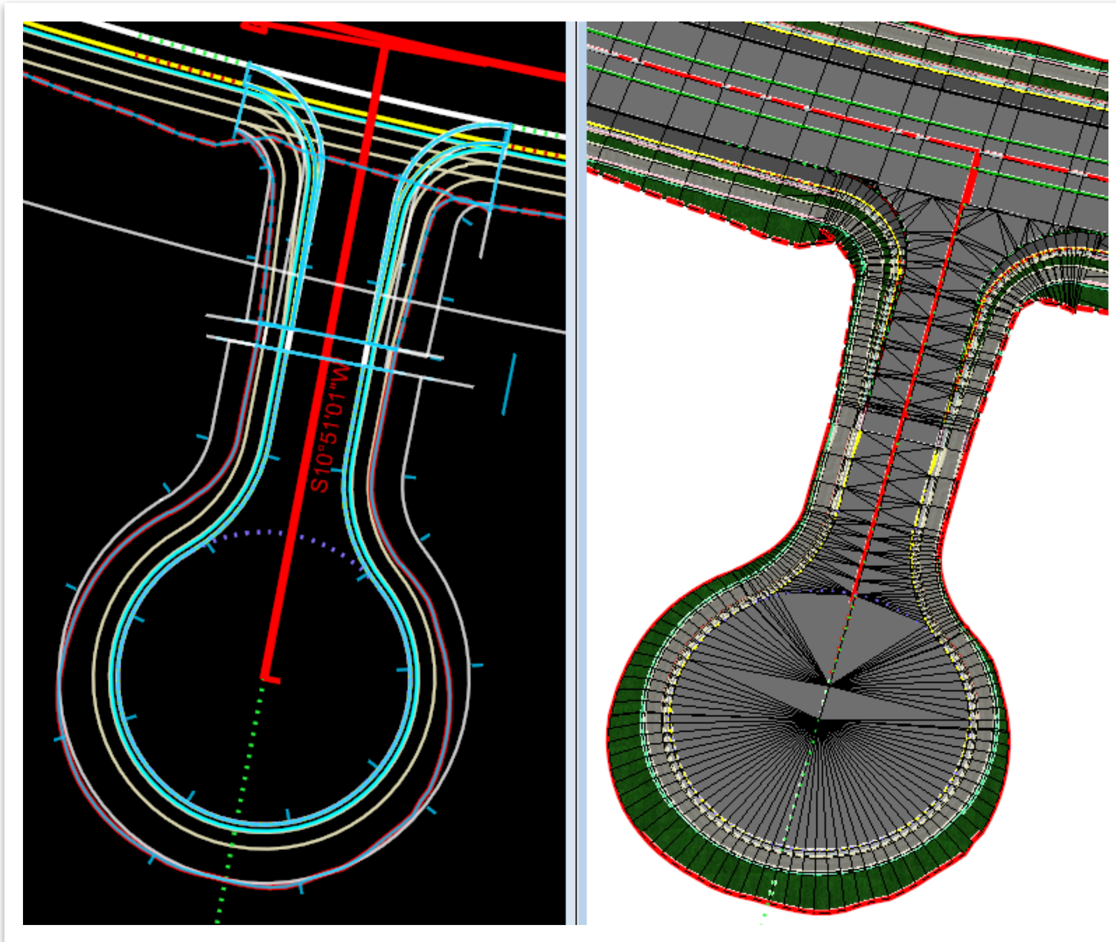
1. Open the **ROAD-II-CC-Corridor.dgn** file within the dgn Appendix\Appendix A subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner and locate the **KELSEYGLEN** side road (approx. mainline Station **156+50**). A civil cell should be placed on the alignment at the intersection.
2. Open the **Place Civil Cell** tool (**OpenRoads Modeling >> Model Detailing >> Civil Cells**) and select the **TDOT CUL-DE-SAC** civil cell under the **Cul-de-sac_ TDOT.dgnlib**. For the cul-de-sac **center point**, we need to select the end of the side road centerline. <u>Do not select the actual centerline</u> but rather the end tick mark using the intersection snap. Click through the remaining prompts and notice the civil cell placement.



3. Select the cul-de-sac civil cell and notice there are several civil cell **handles** available: circle radius and approach width.



4. To connect the two civil cells, place a corridor along the side road and attach the **TS-2 (2LN) C&G, SW - 4 LAYER** template from the default TDOT template library (ITL) (**Linear Templates >> TDOT Typical Sections >> Undivided**). Then, place the template in between the **cul-de-sac** civil cell and the **T-intersection** civil cell, as shown below, to complete the process.

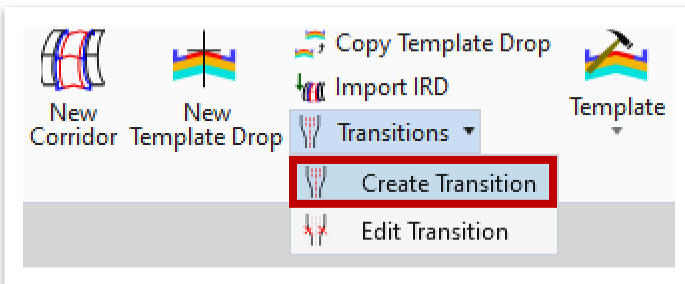


Appendix B. Template Drop Transitions

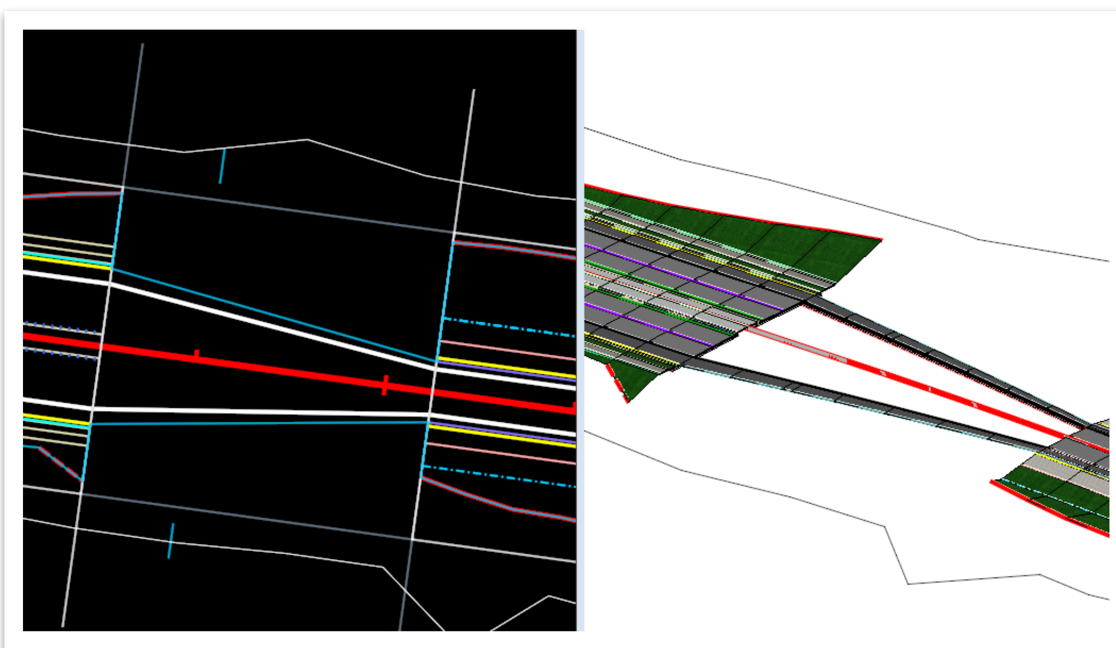
B.1 Exercise: 4-Lane with Median to 3-Lane Transition

In this exercise, we will create a transition from a 4LN to a 2LN typical section using the transition tool. Then, we will use surface templates to model what the transition tool does not create.

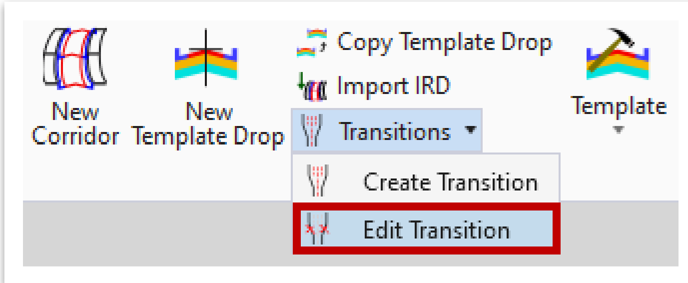
1. Open the **ROAD-II-TDT-Corridor.dgn** file within the dgn Appendix\Appendix B subfolder. Make sure that the **Multi-Model Views** view is active in the lower left corner.
2. Locate the second transition between Station **183+50.00** and **185+25.00** and then open the **Create Transition** tool (**OpenRoads Modeling >> Corridors >> Create >> Transitions**).



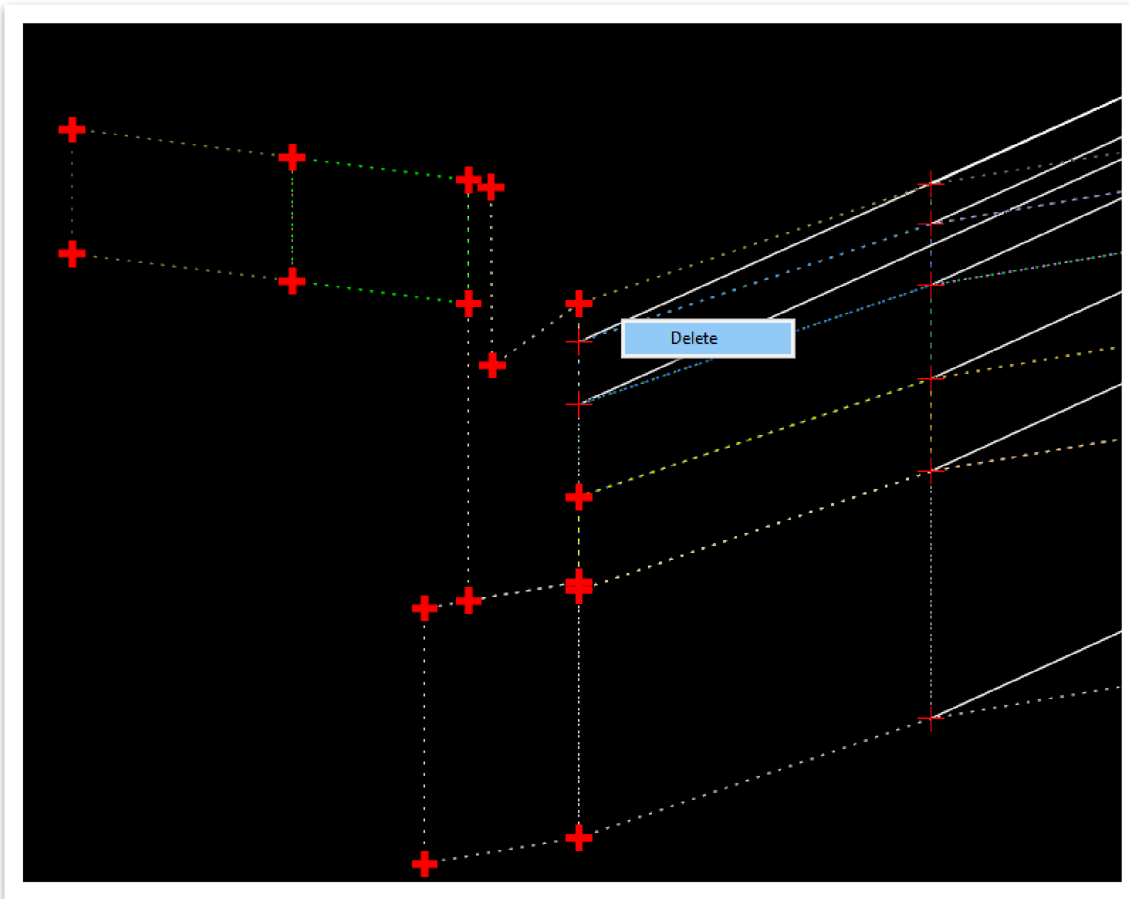
3. Select the two template drops in the **2D** plan view. The **2D** and **3D** model will both render a **transition**, but only for the **EOP** and the **paved shoulder**.



4. To edit the transition, open the **Edit Transition** tool (**OpenRoads Modeling >> Corridors >> Create >> Transitions**) and then select the transition handle.



5. For this exercise, the transition will have linear templates applied to the shoulders that include paved shoulders. Therefore, delete the **PSH1_L** and **PSH2_L** lines.



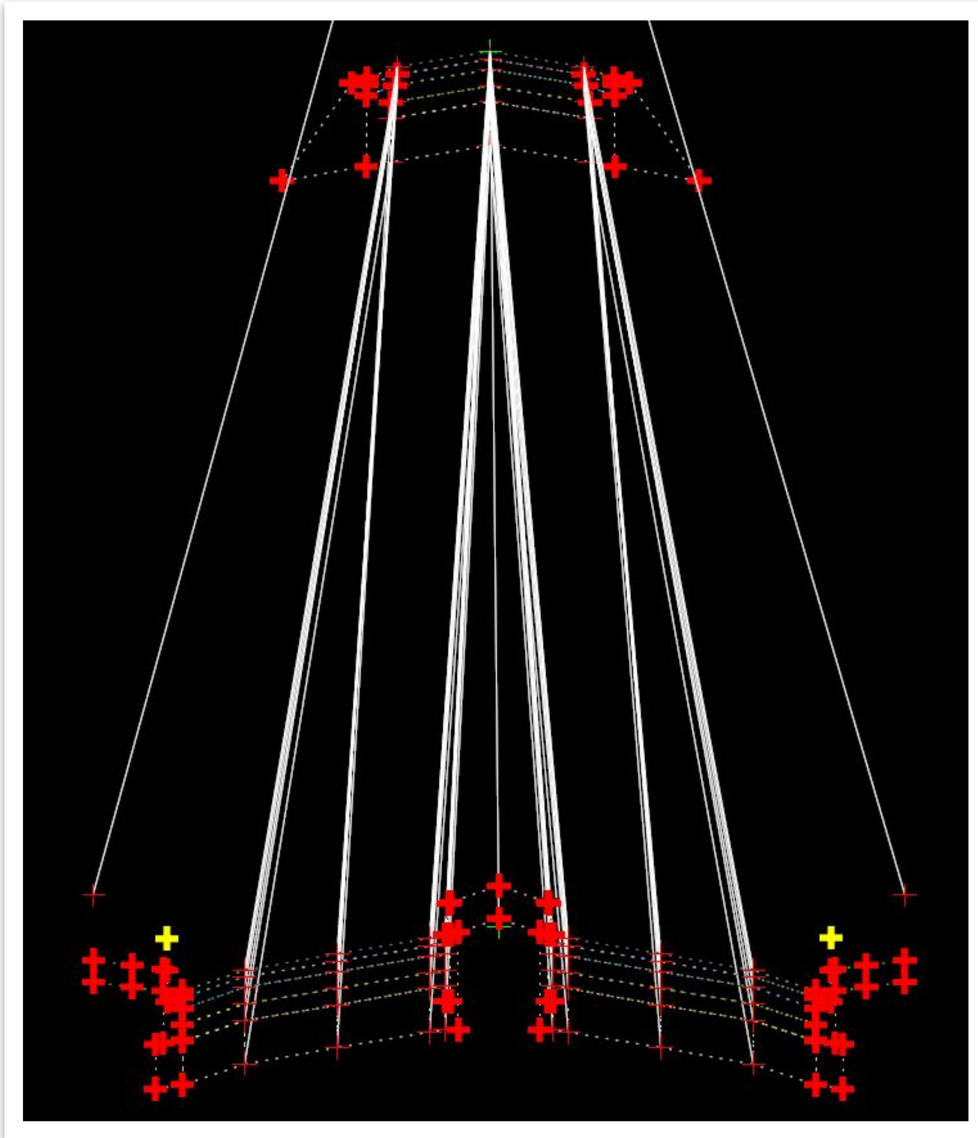
6. Repeat the previous step for the right side and delete the **PSH1_R** and **PSH2_R** lines.

7. Now, working from left to right, bottom to top, connect the respective **LNB** of the **4-lane** template to the **EOP** of the **2-lane** template. Then, connect both the **LNA** and **CR_FLOWLINE** of the **4-lane** template to their respective **CL** of the **2-lane** template. Complete this for both the left and the right points. The table below (and on the next page) lists the points that need to be connected, from left to right, bottom to top.

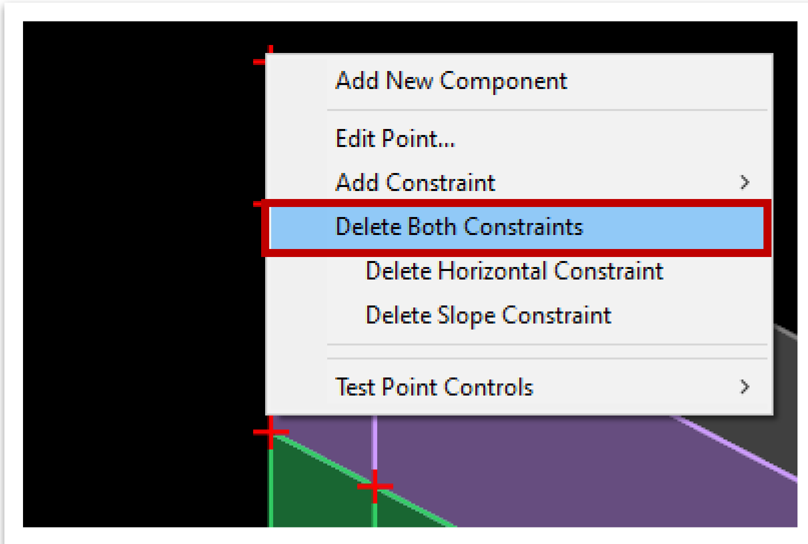
4 Lane Template Point	3 Lane Template Point
LNB5_L_BOT	EOP5_L_BOT
LNB4_L	EOP4_L
LNB3_L	EOP3_L
LNB2_L	EOP2_L
LNB1_L	EOP1_L
LNB_L	EOP_L
LNA5_L_BOT	CL5_BOT
LNA4_L	CL4
LNA3_L	CL3
LNA2_L	CL2
LNA1_L	CL1
LNA_L	CL
CR_FLOWLINE5_LM	CL5_BOT
CR_FLOWLINE4_LM	CL4
CR_FLOWLINE3_LM	CL3
CR_FLOWLINE2_LM	CL2
CR_FLOWLINE1_LM	CL1
CR_FLOWLINE_LM	CL
CR_FLOWLINE5_RM	CL5_BOT

4 Lane Template Point	3 Lane Template Point
CR_FLOWLINE4_RM	CL4
CR_FLOWLINE3_RM	CL3
CR_FLOWLINE2_RM	CL2
CR_FLOWLINE1_RM	CL1
CR_FLOWLINE_RM	CL
LNA5_R_BOT	CL5_BOT
LNA4_R	CL4
LNA3_R	CL3
LNA2_R	CL2
LNA1_R	CL1
LNA_R	CL
LNB5_R_BOT	EOP5_R_BOT
LNB4_R	EOP4_R
LNB3_R	EOP3_R
LNB2_R	EOP2_R
LNB1_R	EOP1_R
LNB_R	EOP_R

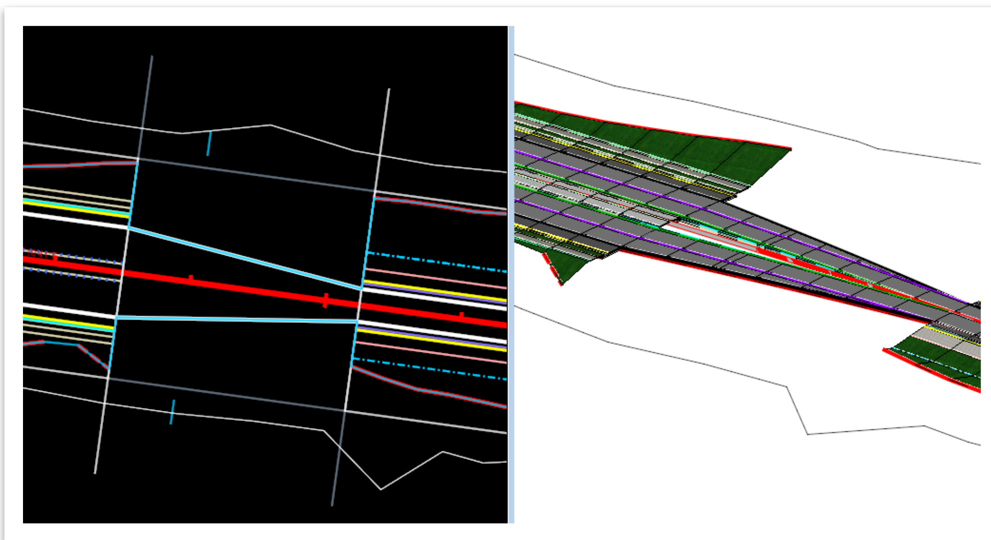
8. Once the left and right points have been connected, the transition should look like what is shown below.



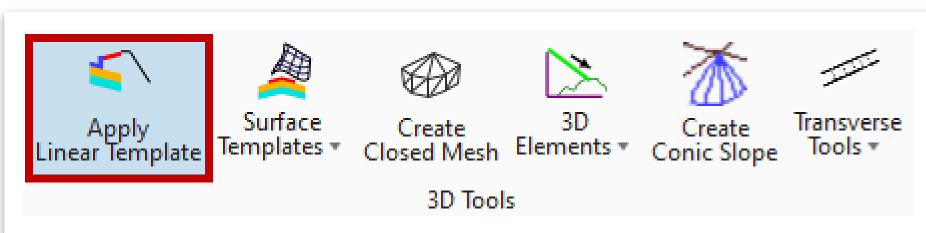
9. Click **OK** to move to the next window and then click **OK** again if a reminder appears. **Right** click on the top points and delete both constraints. The model will now convert the four-lane with a median down to a two-lane as you slide the transition slider from **Start** to **End**.



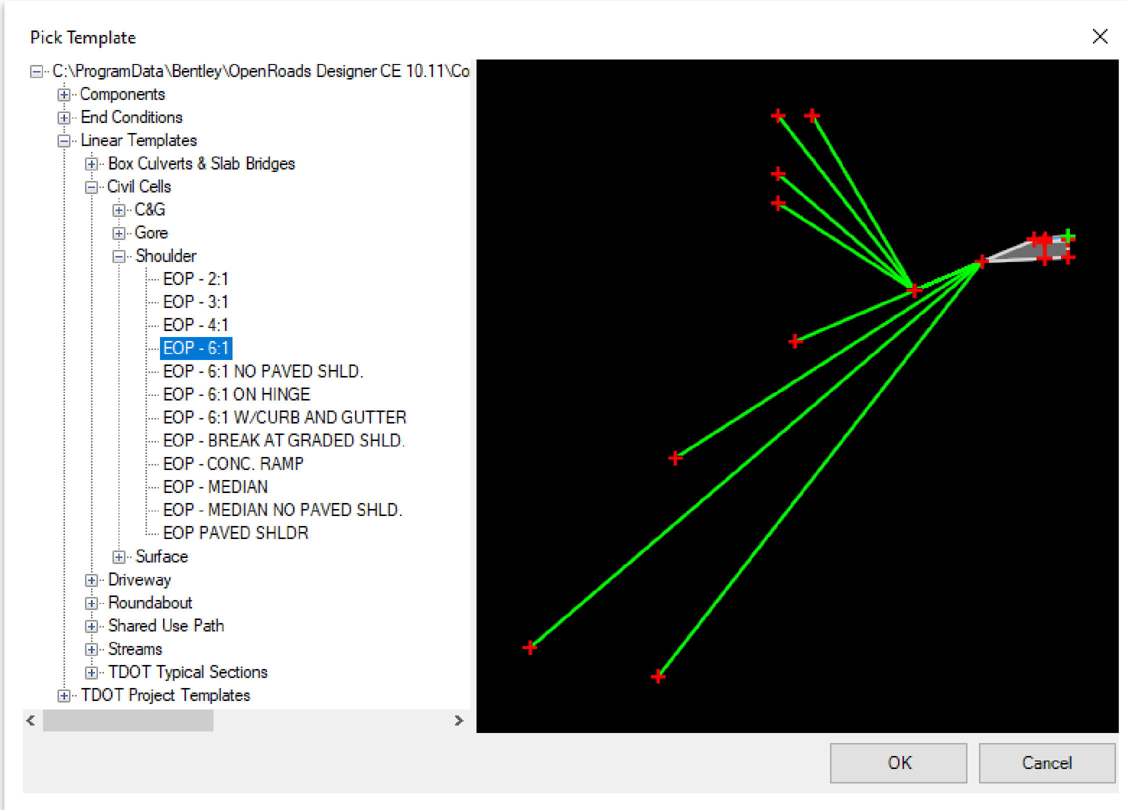
10. Click **OK** and the template should now transition from four lanes down to two lanes.



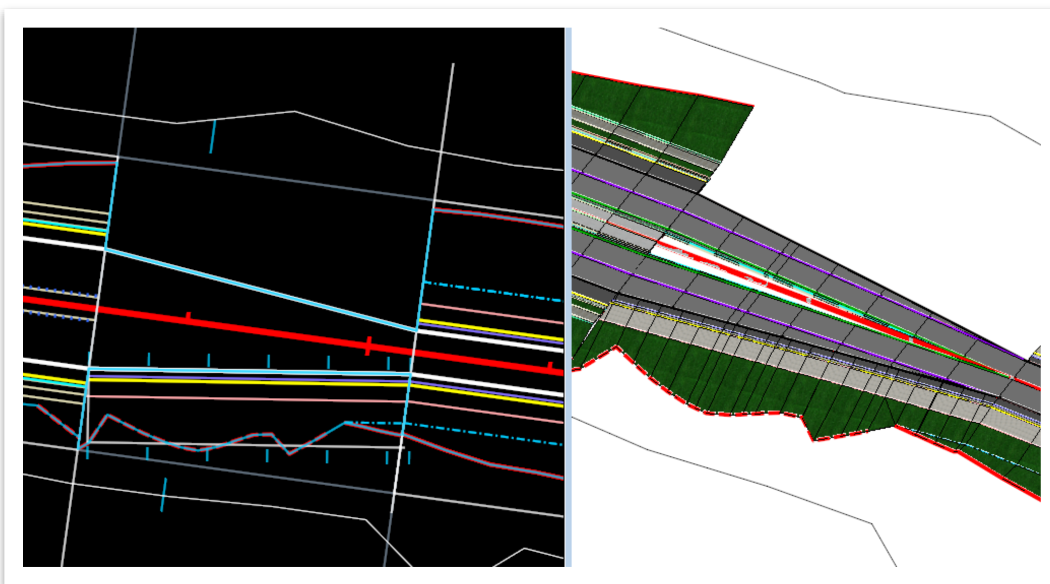
11. Next, open the **Apply Linear Template tool** (**OpenRoads Modeling >> Model Detailing >> 3D Tools**) and select the **EOP_R** line.



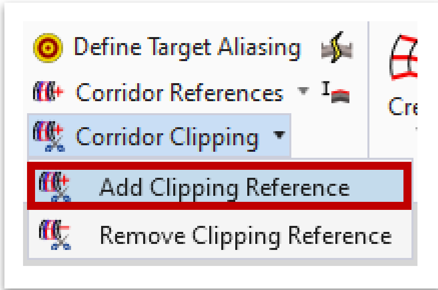
12. Select the **EOP - 6:1** template (**Linear Templates >> Civil Cells >> Shoulder**).



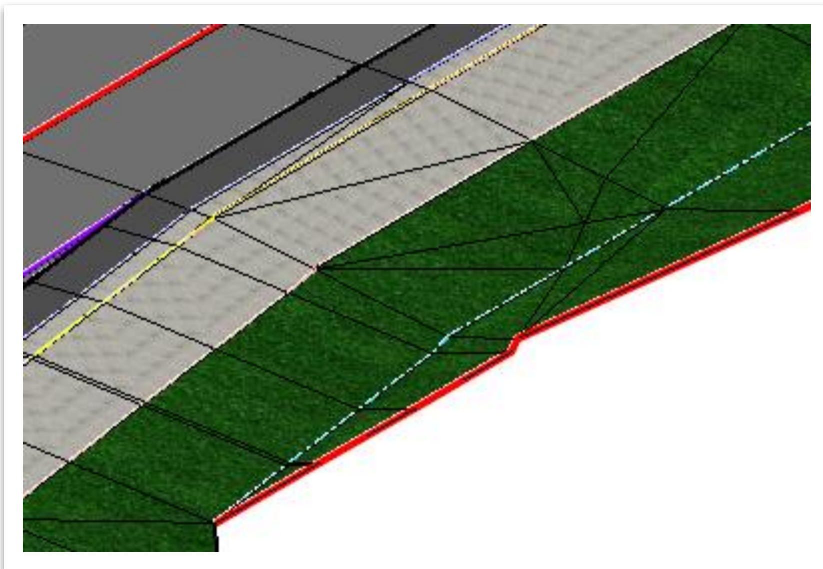
13. Then, select the **EOP_R** line that runs the length of the corridor. Select the **start** location (Station **83+49.39**) and the **stop** location (Station **85+25.65**). Place the orange object on the outside of the **EOP_R** and **left** click through the prompts to accept. The transition should now have the same shoulder style as the two-lane template.



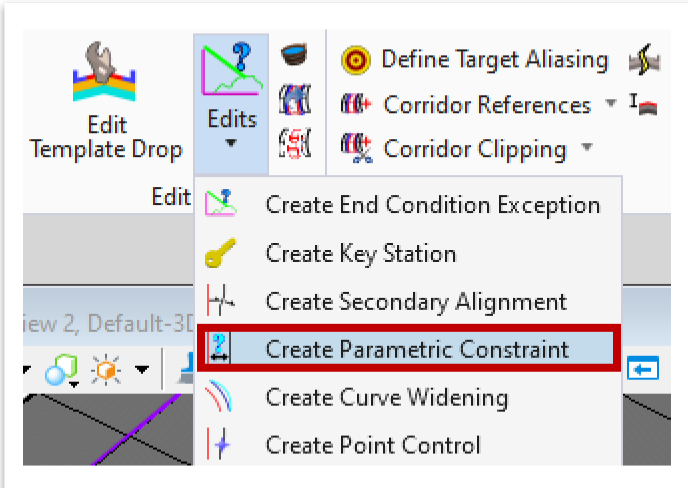
14. Now, open the **Add Clipping Reference** tool (**OpenRoads Modeling >> Corridors >> Miscellaneous >> Corridor Clipping**) and clip the mainline corridor with the linear template as the clipping reference to smooth out the transition of the fill and shoulder.



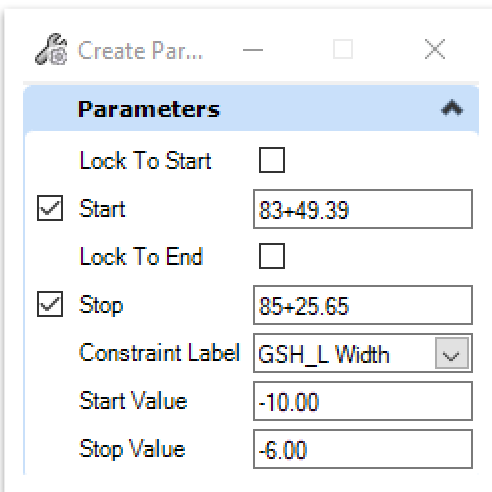
15. Review the changes in the **3D** view and notice that the slopes of the two templates should now be closely aligned.



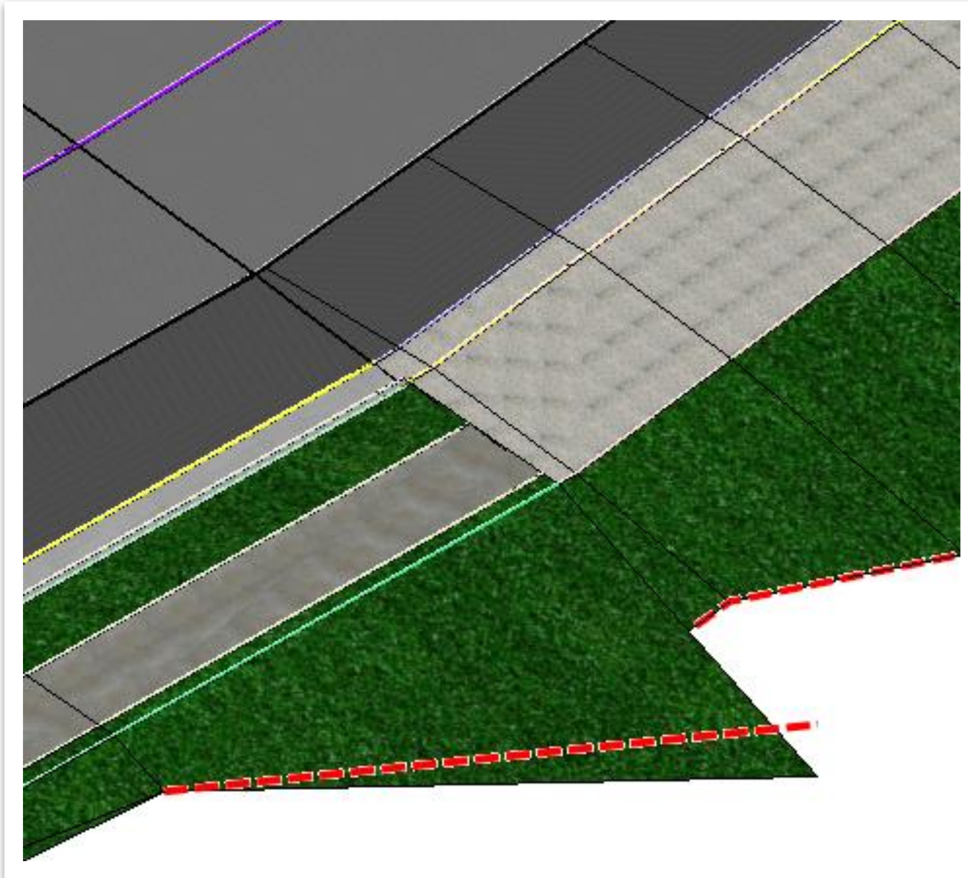
16. Lastly, we need to create a parametric constraint. Open the **Create Parametric Constraint** tool (**OpenRoads Modeling >> Corridors >> Edit >> Edits**) and select the linear template.



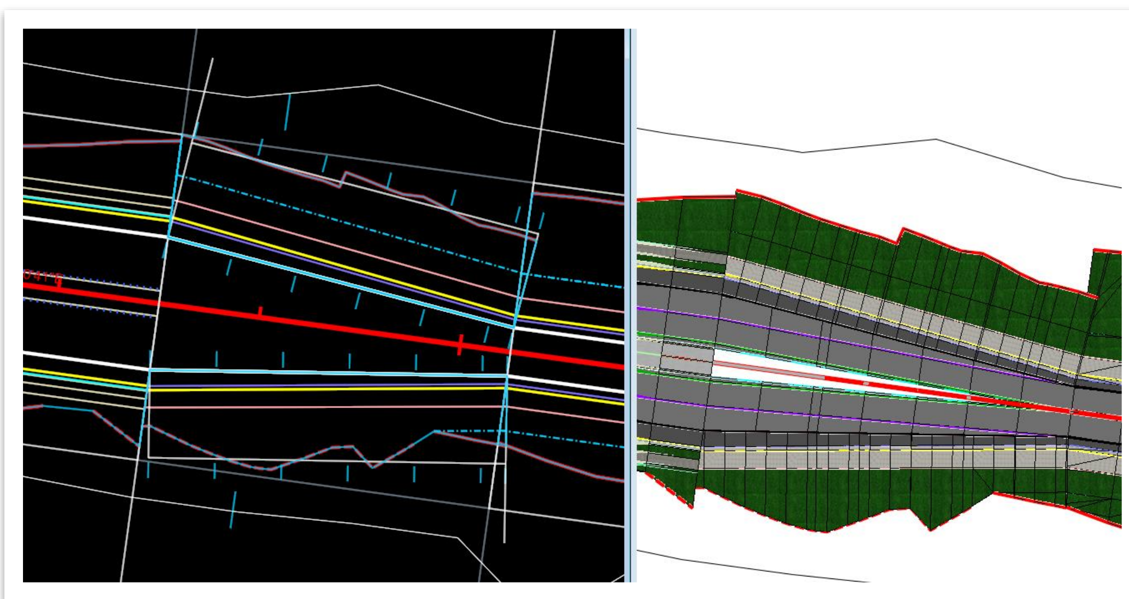
17. Select the **start** location (Station **83+49.39**) and the **stop** location (Station **85+25.65**). Within the **Create Parametric Constraint** dialog box, change the **Constraint Label** to **GSH_L Width** and the **Start Value** to **-10.0**. **Left** click through the prompts to accept.



18. The shoulder should now line up with the four-lane template.

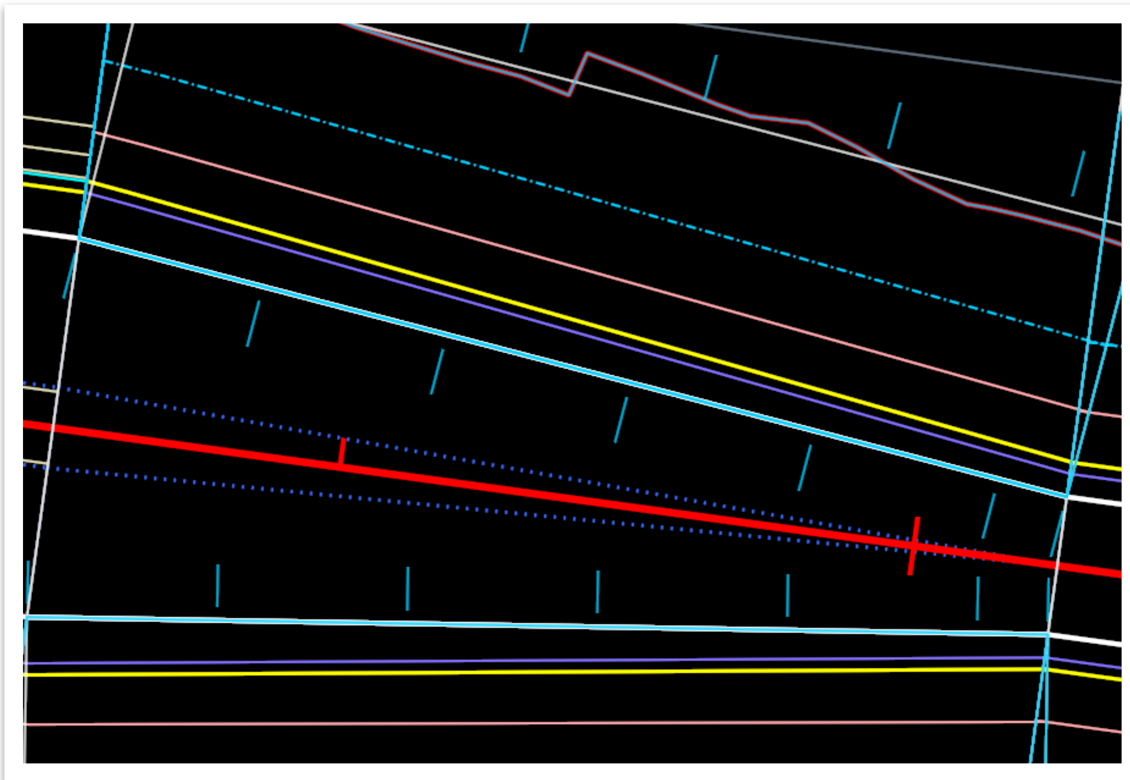


19. Repeat Steps 11-18 to place the same linear template for the left side of the roadway. The **start** and **stop** locations for this template drop will be Stations **83+53.23** and **85+29.49** respectively.

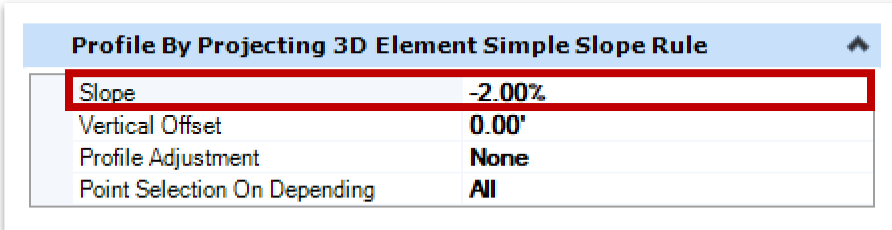


20. Next, select the **C&G Flowline - CTRL** feature definition (**Linear >> Roadway >> Model Control - 2D Plan >> Curb and Gutter**) set it active. Make sure **Create 3D Automatically** is toggled on.

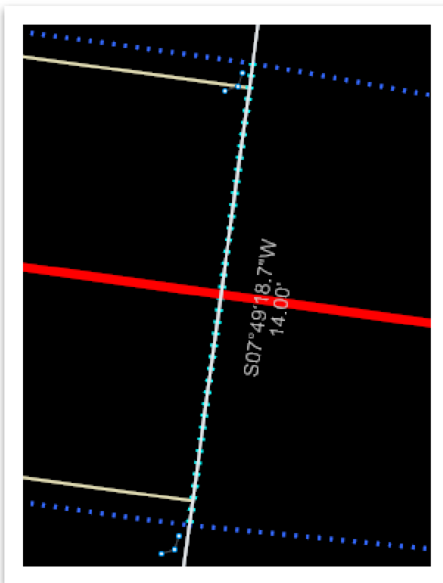
21. Open the **Variable Offset Taper** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Offsets and Tapers**) and snap from the bottom **flowline control** on the left side of the template to the **centerline** at the right end of the transition with a length of **175'**. Repeat the variable offset for the top flowline control.



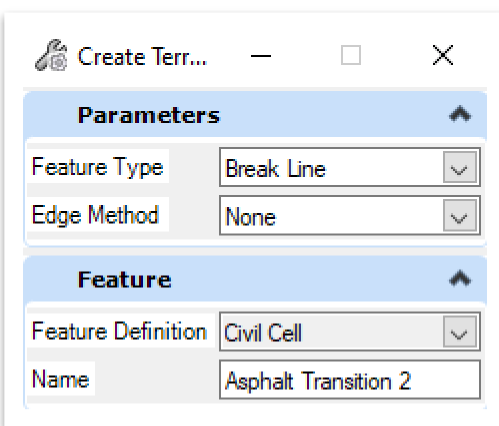
22. Select the **CTRL** lines that were just placed and open the **Properties**. Within the properties under the **Profile By Projecting 3D Element Simple Slope Rule** header, change the **Slope** to **-2.00%**.



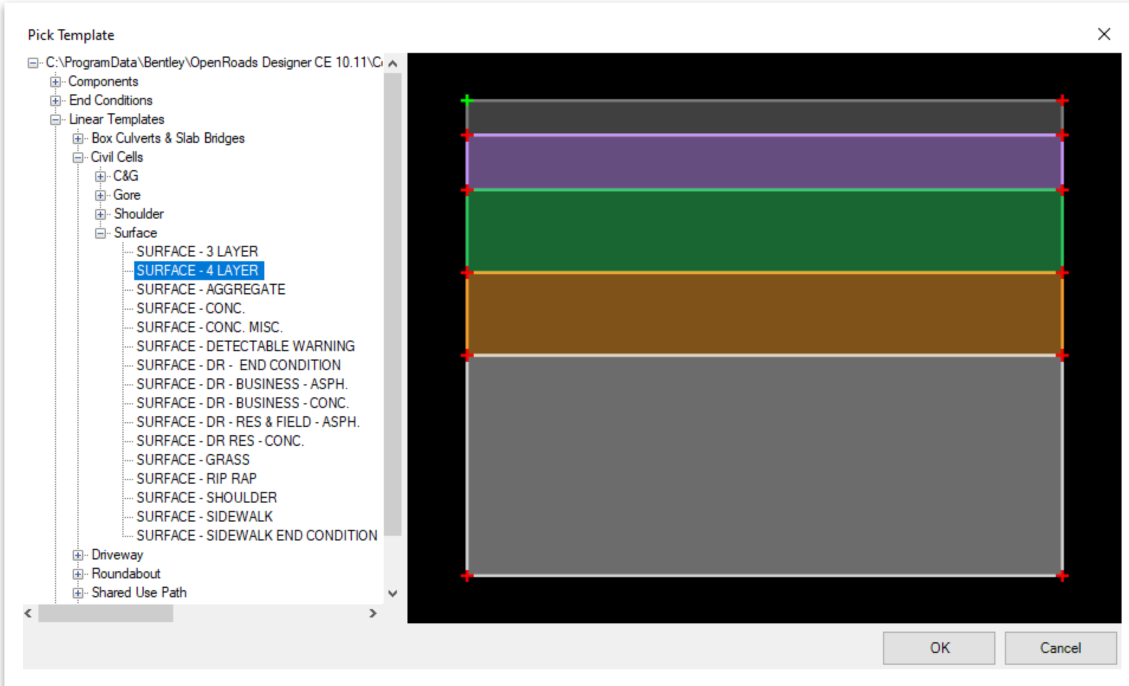
23. Then, open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and connect the two tapers at the median. The median transition should now be a closed shape.



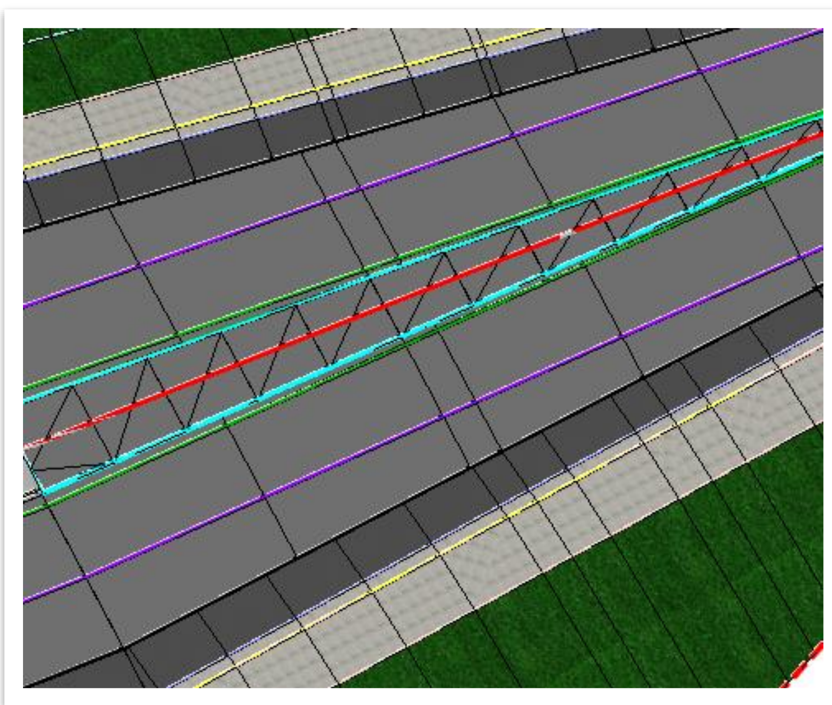
24. Now, open the **Create Terrain Model From Elements** tool (**OpenRoads Modeling >> Terrain >> Create**) and select the three lines. **Right** click and click through the prompts and name the terrain model **Asphalt Transition 2**.



25. Next, open the **Apply Surface Template** tool (**OpenRoads Modeling >> Model Detailing >> 3D Tools >> Surface Templates**). In the **3D** model, select the terrain boundary that we just created and then select the **SURFACE - 4 LAYER** template (**Linear Templates >> Civil Cells >> Surface**).

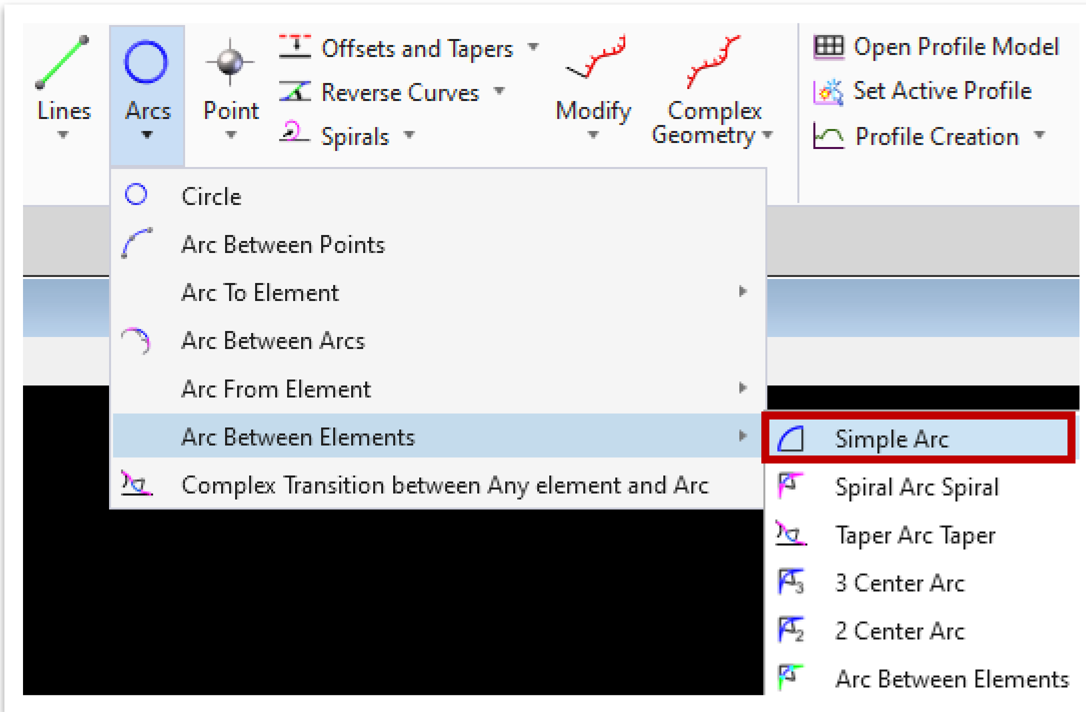


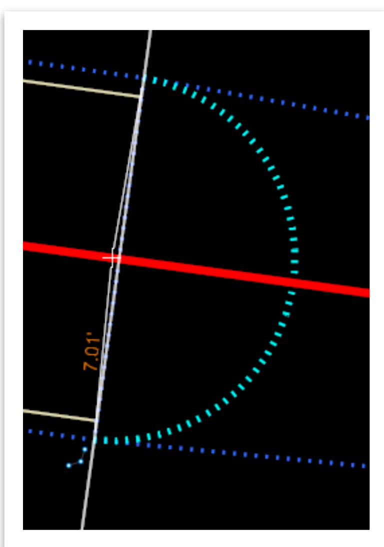
26. Click through the prompts to place the surface and notice that the median transition should now have a surface.



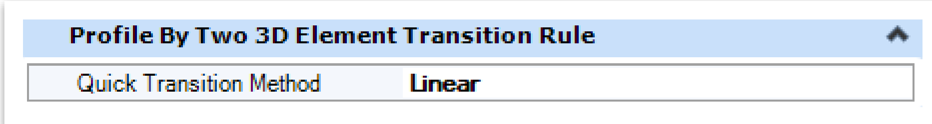
27. Now, select the **Curb - CTRL** feature definition (**Roadway >> Model Control - 2D Plan >> Curb and Gutter**).

28. Open the **Simple Arc** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Arcs >> Arc Between Elements**). Select the bottom taper and then the top taper, and then snap to the end of the bottom taper to place the arc. Set the **Trim/Extend** option to **None**.

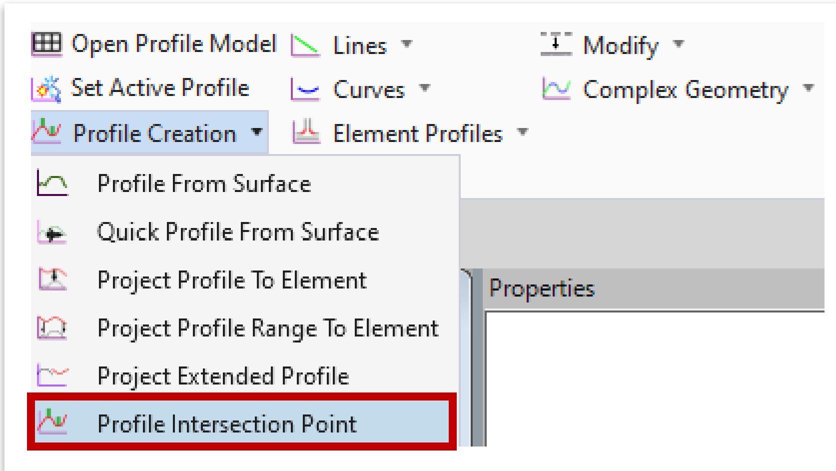




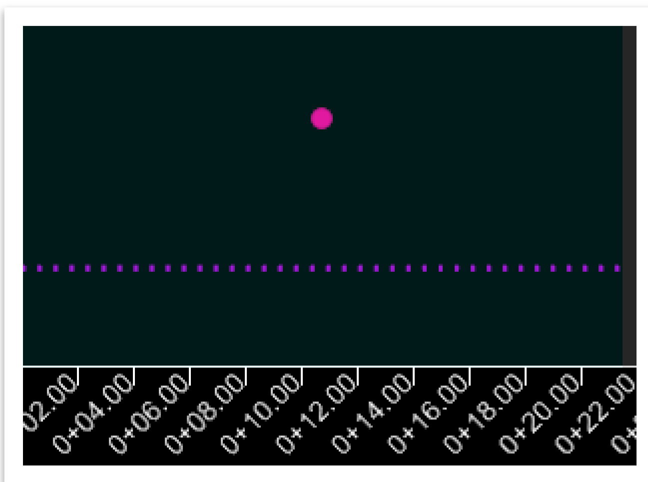
29. Next, select the arc that was just placed and open the **Properties**. Change the **Quick Transition Method** to **Linear** under the **Profile By Two 3D Element Transition Rule** header.



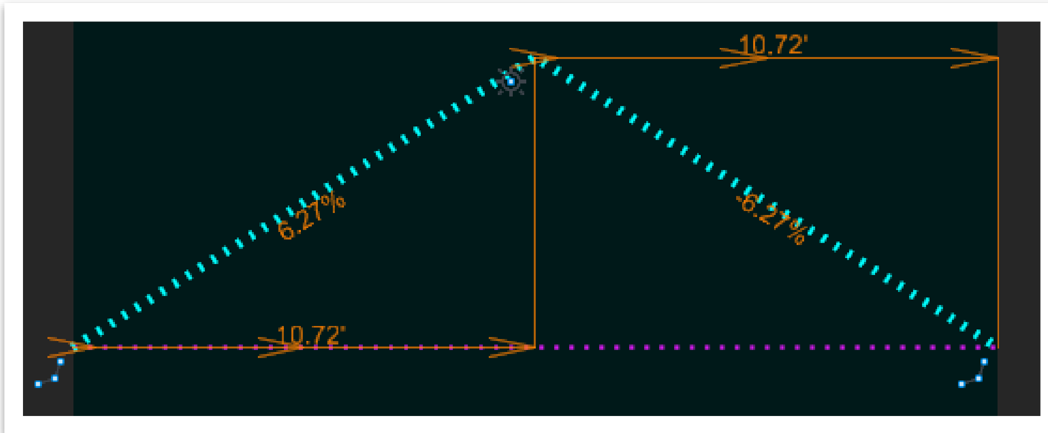
30. Open the profile of the arc that was just placed and locate the profile elevation at approximately **604.7’**. Open the **Profile Intersection Point** tool (**OpenRoads Modeling >> Geometry >> Vertical >> Profile Creation**).



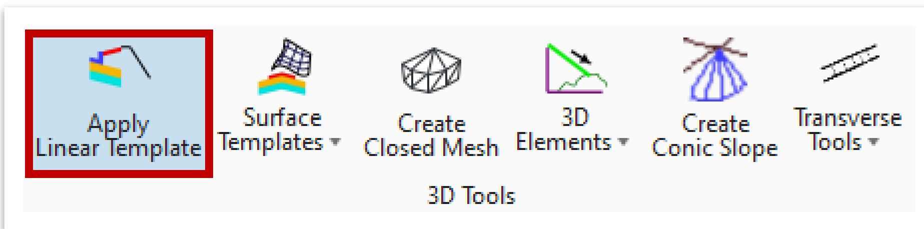
31. Select the arc and then select the centerline and reset. In the profile window, a pink dot should appear, as shown below.



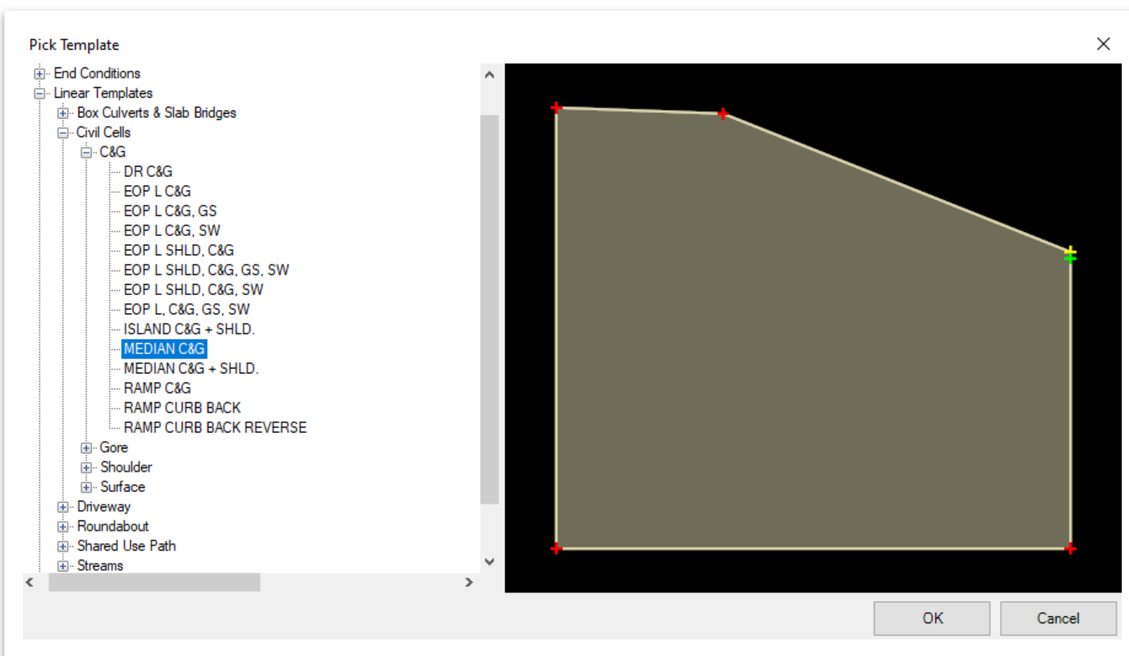
32. Go ahead and draw vertical geometry from the start of the arc to the dot, and then back down to the end of the arc. Complex that geometry and set it as the active profile.



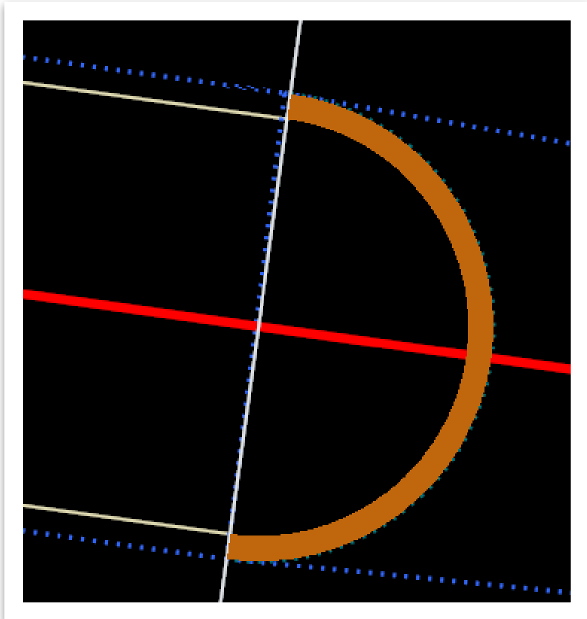
33. Now, open the **Apply Linear Template** tool (**OpenRoads Modeling >> Model Detailing >> 3D Tools**) and select the arc.



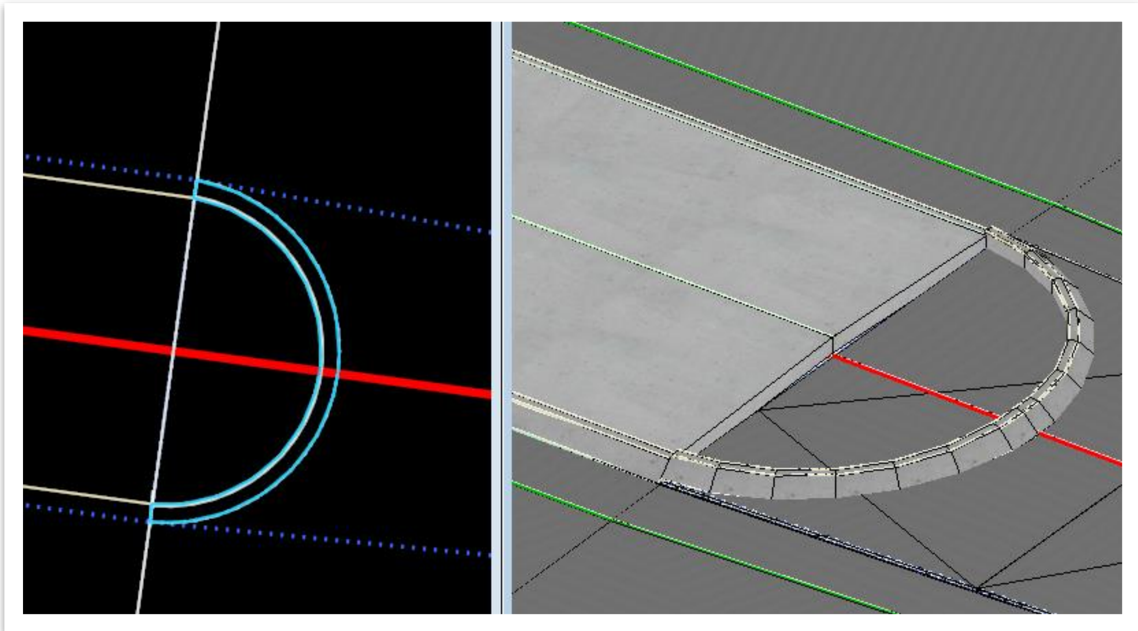
34. Select the **Median C&G** template (**Linear Templates >> Civil Cells >> C&G**) and click **OK**.



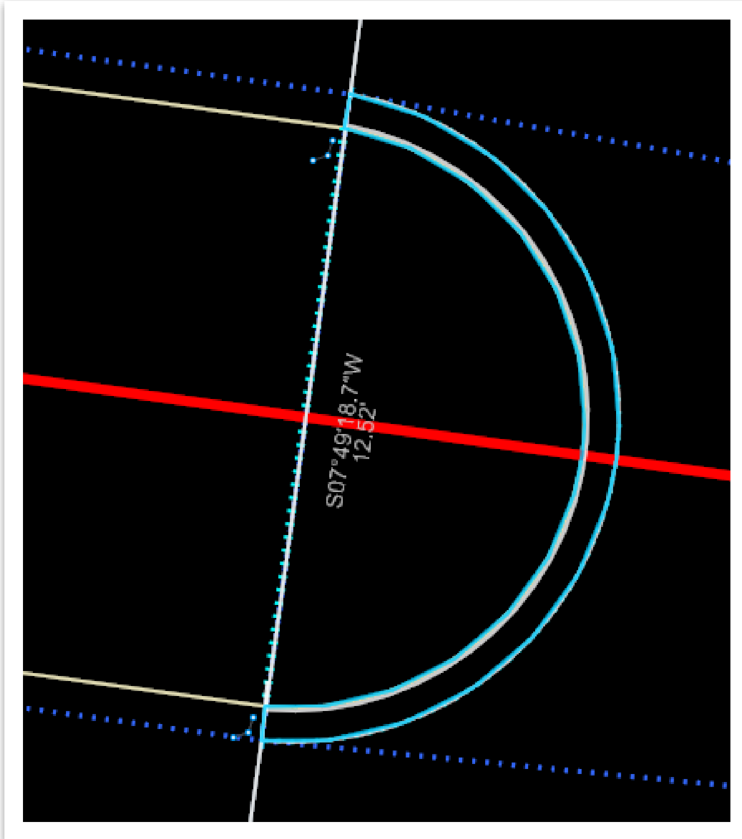
35. **Lock to Start** and **End** and place the **orange** preview on the **inside** of the arc by moving the cursor to the left, outside the arc.



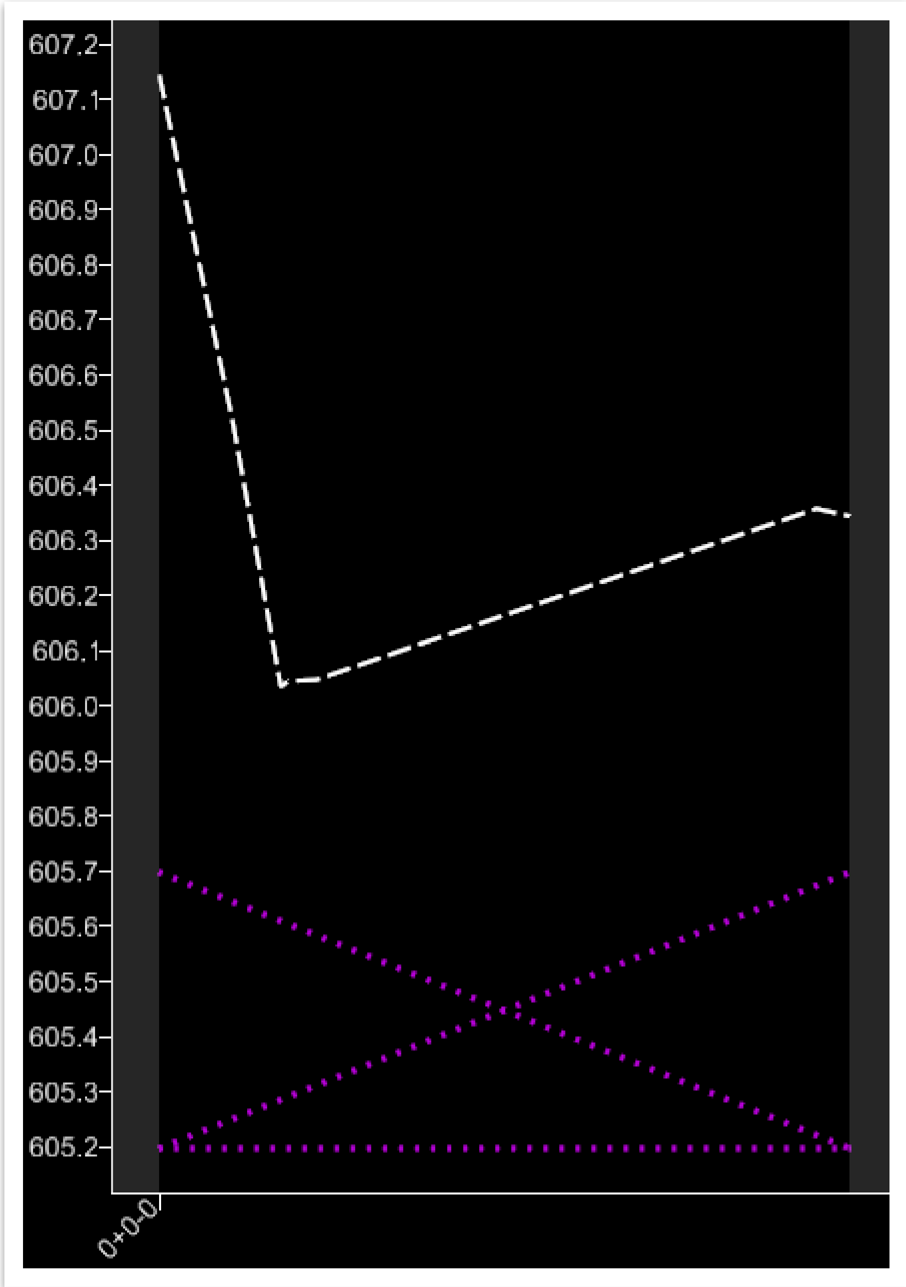
36. Click through the prompts to accept placement and notice that the linear template shows up in both **2D** and **3D**.



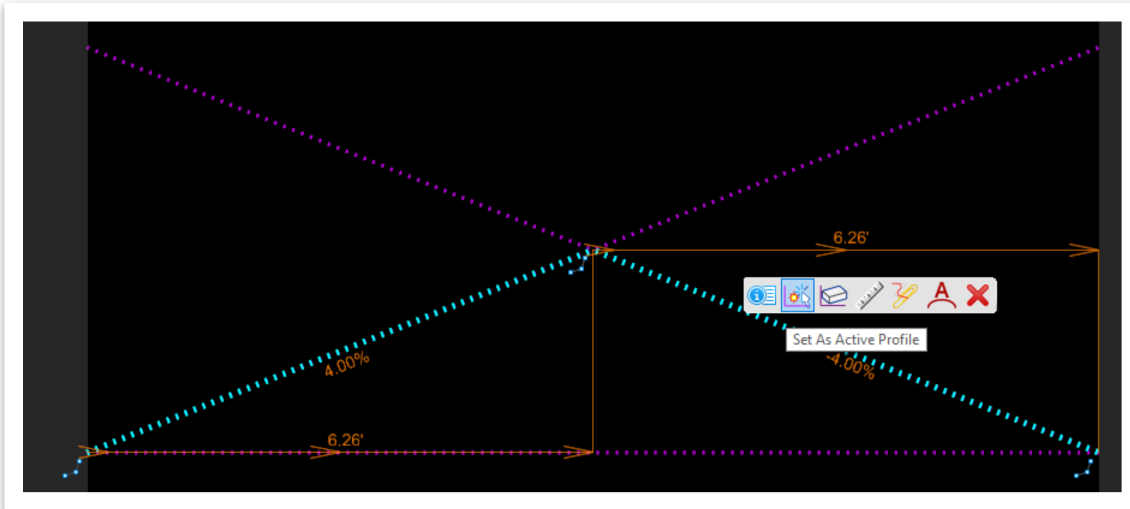
37. Open the **Line Between Points** tool (**OpenRoads Modeling >> Geometry >> Horizontal >> Lines**) and draw a line from the inside edge of the linear template to the other, snapping to the arc (**CR_BACK_TOP_RM**).



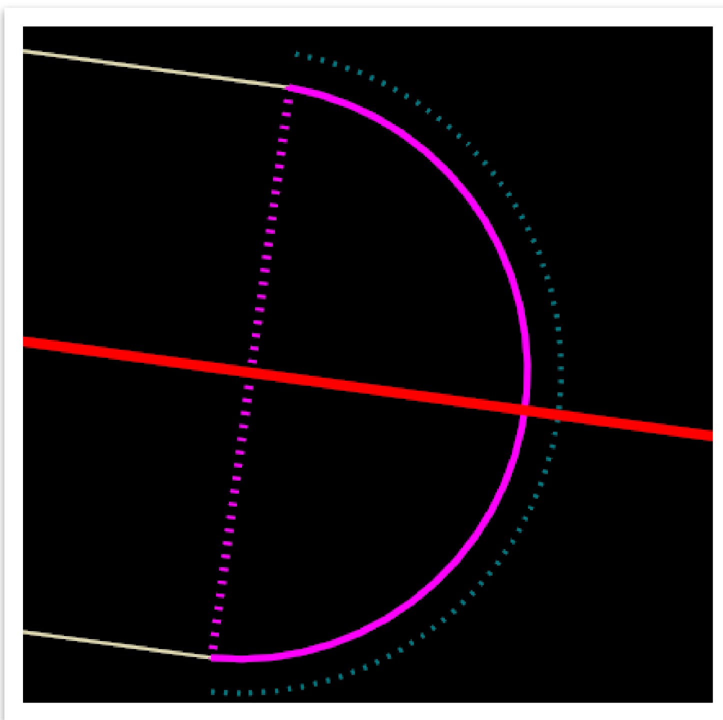
38. Go ahead and open the **profile** view of the line that was just placed. Using the **Key Point** snap, draw two lines (one at **4%** and one at **-4%**) snapping to the respective end of the horizontal purple dotted line and then across to the end of the black area in profile view.



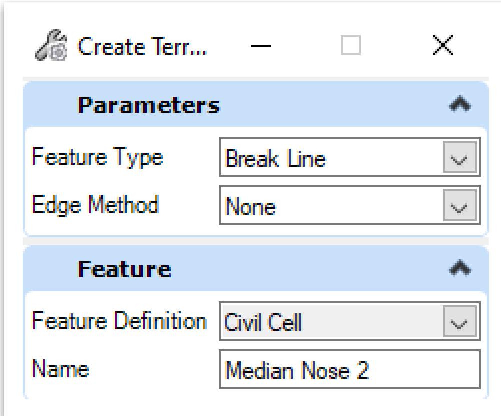
39. Next, trace the **positive 4%** line starting from the left end and terminating at the intersection of the two 4% slope lines. Then, trace the **negative 4%** line starting with a key snap to follow the element just created that terminates at the intersection of the two 4% lines and key snap to the right at the end of the -4% line. Lastly, complex those two elements together and set it to **active**.



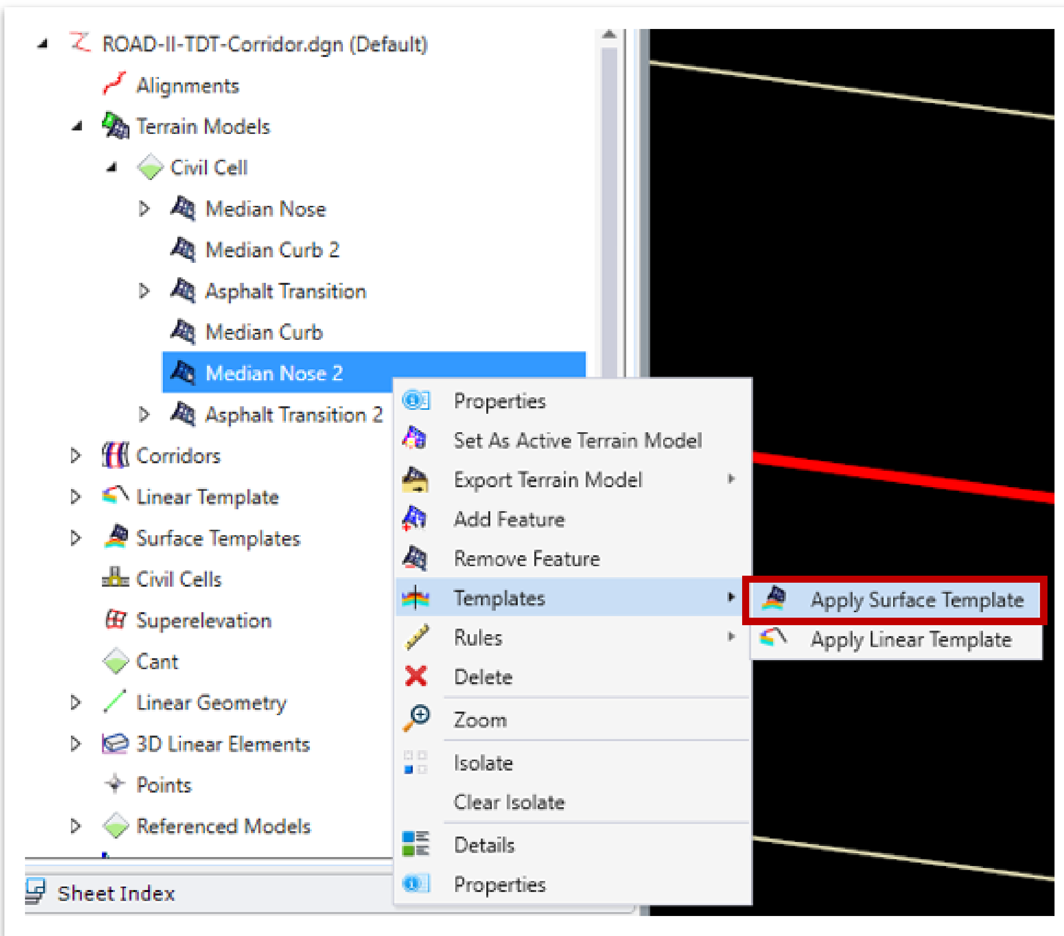
40. Now, we will create another terrain. Open the **Create Terrain Model From Elements** tool (**OpenRoads Modeling >> Terrain >> Create**). Turn off the **DES - CORRIDOR GRAPHICS - Design** and **DES - MODEL - Lines - Curb Flowline** levels to make it easier to select the two lines. Select the **Curb** line with the new profile and then select the **CR_BACK_TOP_RM** line.



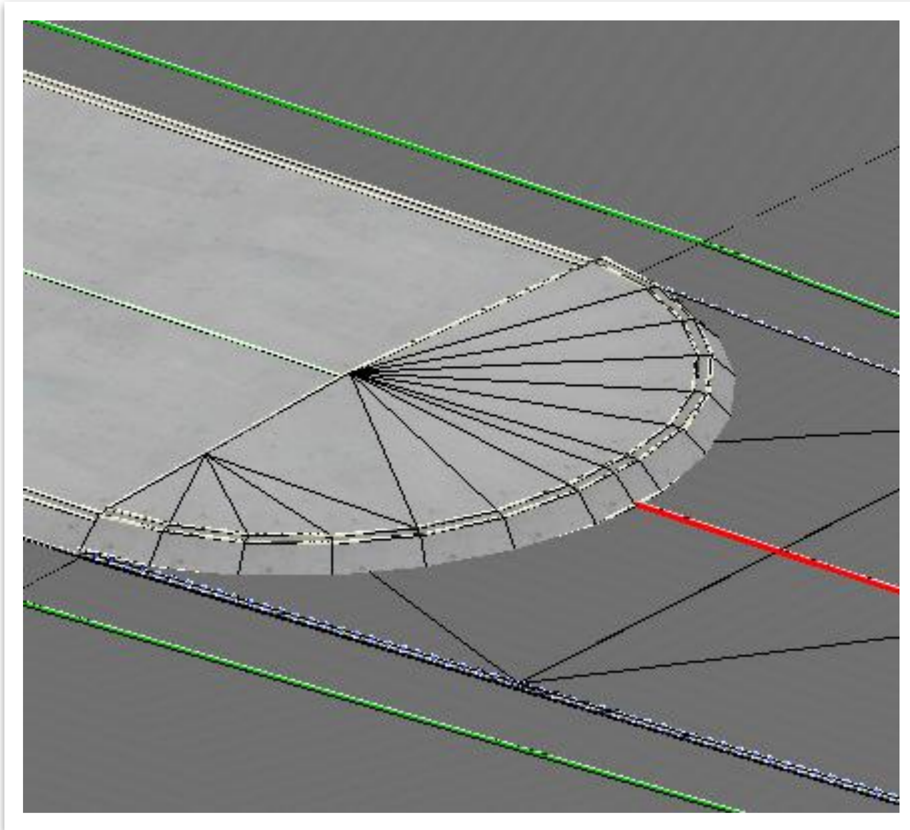
41. **Right** click to accept those two lines, and then make sure the **Feature Type** is set to **Break Line**, the **Edge Method** is set to **None** and that the **Feature Definition** is a **Civil Cell**. Name the terrain **Median Nose 2**. **Left** click through the prompts to accept.



42. Within the **Explorer**, **right** click on the **Median Nose 2** terrain just created (**OpenRoads Model >> Terrain Models >> Civil Cell**) and select **Apply Surface Template**.



43. Select the **SURFACE - CONC. MISC.** template (**Linear Templates >> Civil Cells >> Surface**) and **left** click through the prompts to apply the surface template.



Appendix C. Extended TIN Surface Creation

When considering the drainage design for a project, quite often an **extended TIN surface** is needed relative to what is provided in the survey. This will allow for additional context and input during design. This chapter will discuss how to source data and how to manipulate it into a workable format for the designer.

C.1 Lecture: Extended TIN Surfaces

Because drainage areas often extend outside the surveyed terrain, an **extended TIN surface** is needed to provide the additional terrain data within the drainage areas.

Within ORD, contour lines can be displayed from a surface but not drawn into a file. This means that whenever a user changes the view, the contours will re-process and then re-display. While this is not a concern when working with smaller terrains, it does present an issue when working with larger extended terrains. At a minimum, the extended terrain will cause the software to lag during re-processing and likely crash. Therefore, it is recommended to **turn off the contour display within a terrain until the terrain has been trimmed to its final size**. In addition, never select a feature definition that will automatically display contours when loading or complexing terrains.

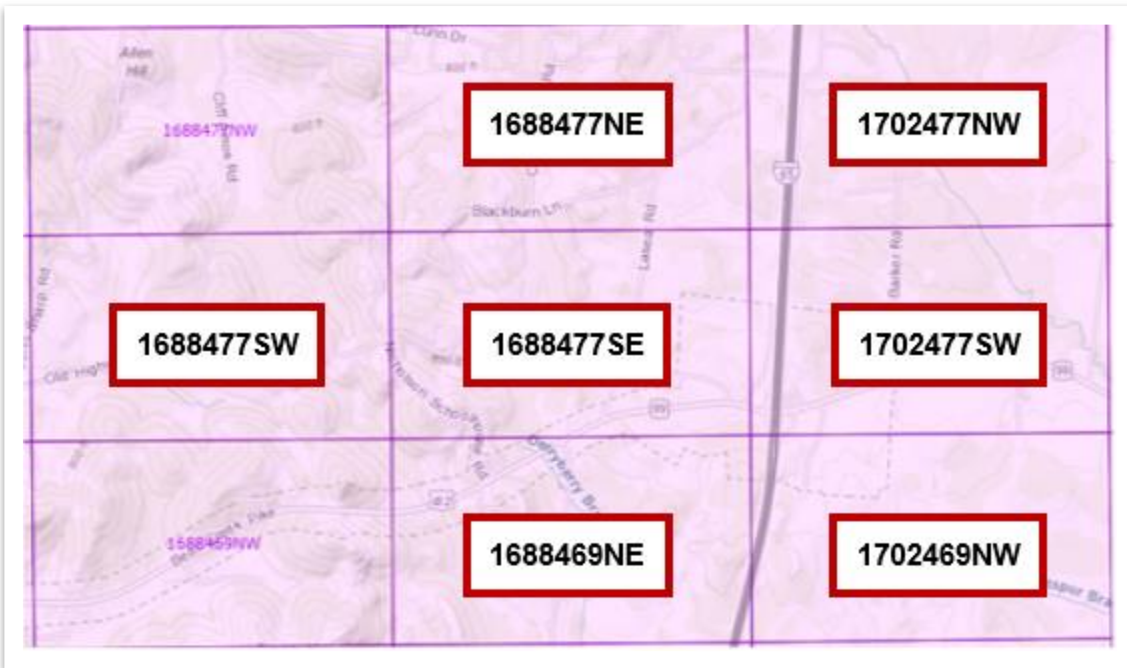
Take Note!

*If you still experience software crashes while loading contour features, it is recommended to export the terrain as a **.TIN** or **.DTM** file. Then, draw the contours into a file using the DTM tools in a secondary software (e.g., GEOPAK SS2/SS10).*

C.2 Exercise: Download and Convert LiDAR Data to Import

In this exercise, we will download LiDAR data from the **State of Tennessee LiDAR Coverage** website to create an extended surface for the sample I-65/SR-99 (Bear Creek Pike) Interchange project, located in Columbia, TN.

1. There are multiple ways to access LiDAR data. Please select the option below based on whether you are a TDOT employee or a consultant.
    a. **TDOT:** Steps 2-3 only.
    b. **Consultants:** Go to Step 4.
2. Browse to the following location on the TDOT network: **\\tdot05nas001\GIS\LiDAR**. Copy the highlighted tiles shown below: **1688477SW**, **1688477NE**, **1688477SE**, **1688469NE**, **1702477NW**, **1702477SW**, and **1702469NW**. Save the copied tiles in the following location: **C:\ProgramData\Bentley\OpenRoads Designer CE 10.11\Configuration\WorkSpaces\TDOT_Standards\WorkSets\123456.00_INITIALS\dgn\Appendix\Appendix C (Extended TIN)**.

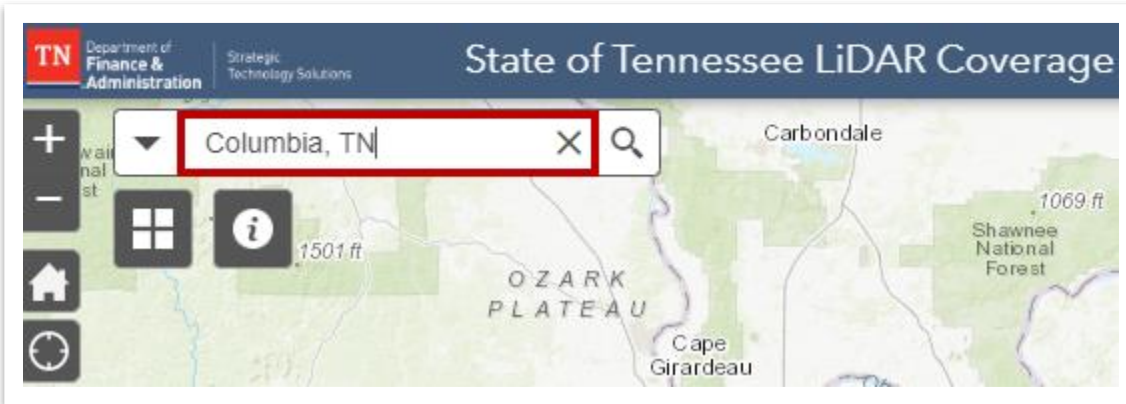


3. Since the files are in **.las** format, they are ready to import into ORD. File type conversions are not needed. Continue to Exercise C.3 to import and create the clipped terrain models.

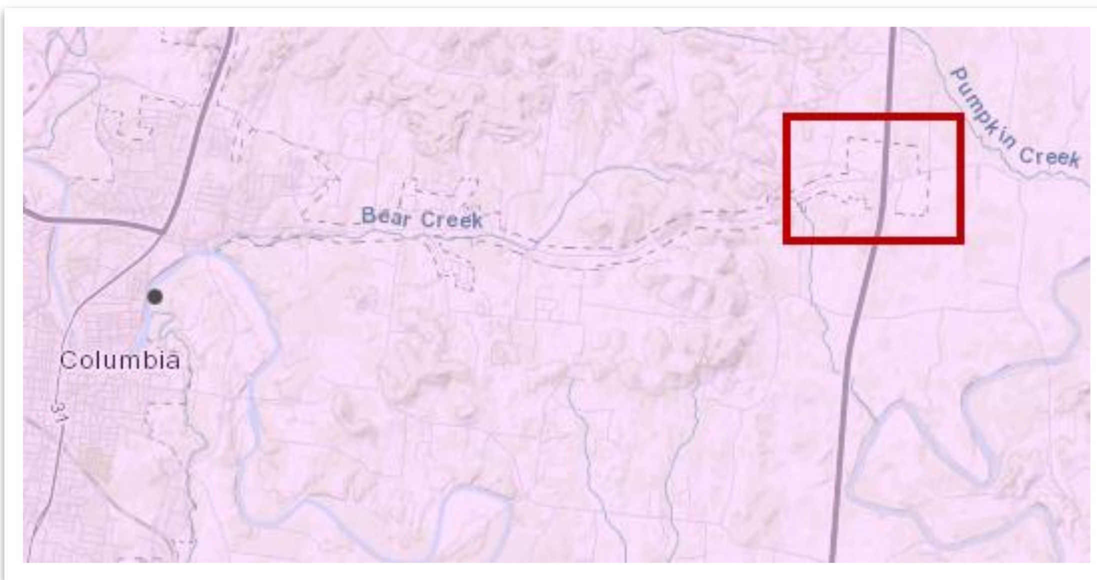
4. Click the following link to open the **State of Tennessee LiDAR Coverage** website to retrieve the map tile data. **Note:** Do not use Internet Explorer. **Google Chrome** was used for the exercise images, but other current browsers may be used.

   https://tnmap.maps.arcgis.com/apps/webappviewer/index.html?id=1bf015da6e10402487a6bae1c0f71385

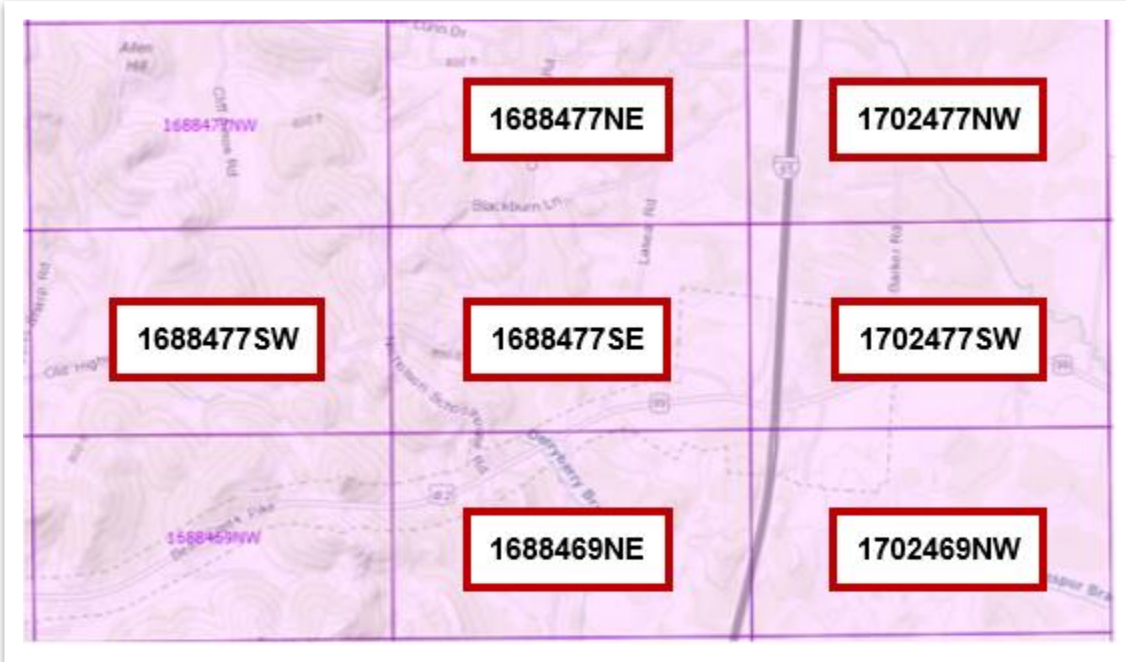
5. In the upper left corner, key-in **Columbia, TN** in the search bar and then hit **Enter**. This will narrow the search location to the applicable area.



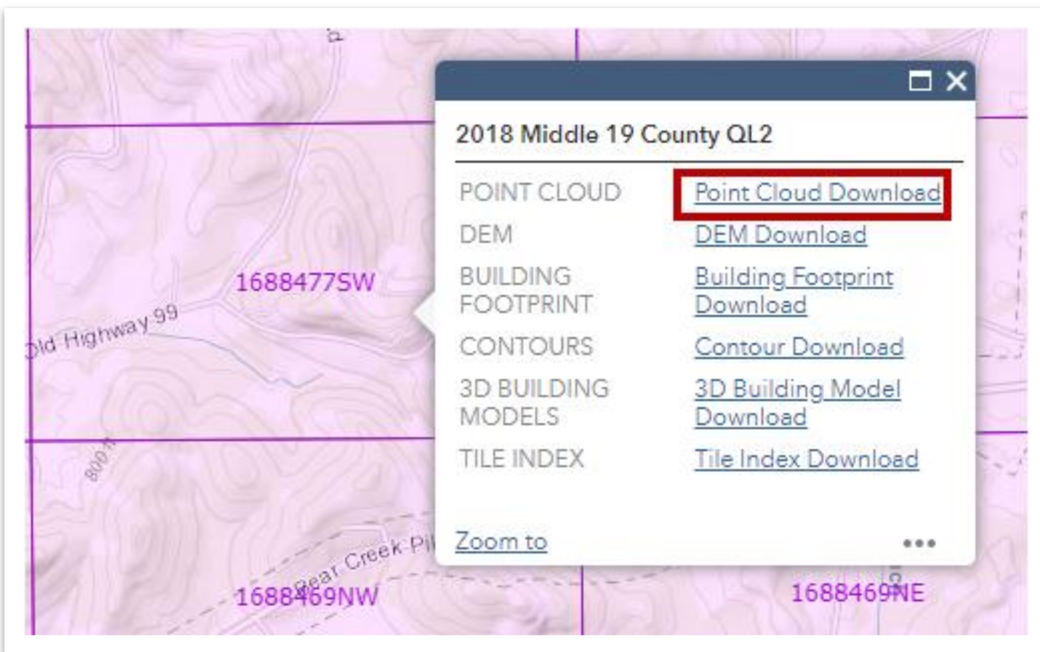
6. Zoom in to the project area, I-65/SR-99 (Bear Creek Pike) Interchange, either by clicking on the **+** sign in the upper left corner or by using your mouse wheel.



7. Notice the tiles within the project area. For this exercise, we will download the highlighted tiles shown below: **1688477SW**, **1688477NE**, **1688477SE**, **1688469NE**, **1702477NW**, **1702477SW**, and **1702469NW**.



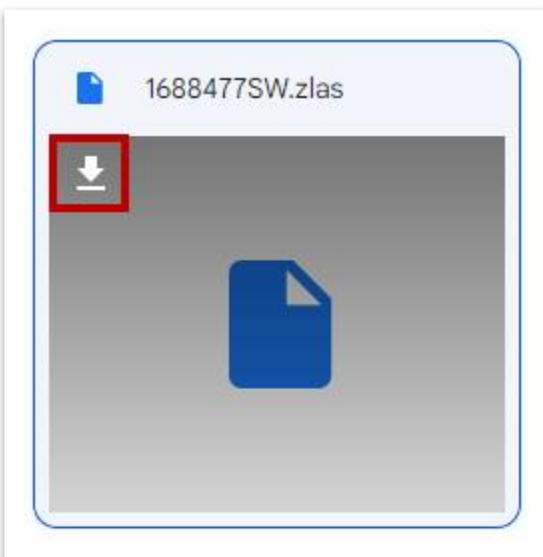
8. **Left** click anywhere within the **1688477SW** tile and select **Point Cloud Download**.



9. You'll notice that various county <u>folders</u> appear within **Google Drive**. Double click on **Maury County** for this exercise.

10. Within the **Maury County** folder, notice all of the tiles are listed in **.zlas** format. Scroll down to **1688477SW.zlas** and move your cursor to within the tile so that the download icon appears. Go ahead and **download** the tile and accept any prompts that may appear. Save the file in the following location:

    C:\ProgramData\Bentley\OpenRoads Designer CE 10.11\Configuration\WorkSpaces\TDOT_Standards\WorkSets\123456.00_INITIALS\dgn\Appendix\Appendix C (Extended TIN)

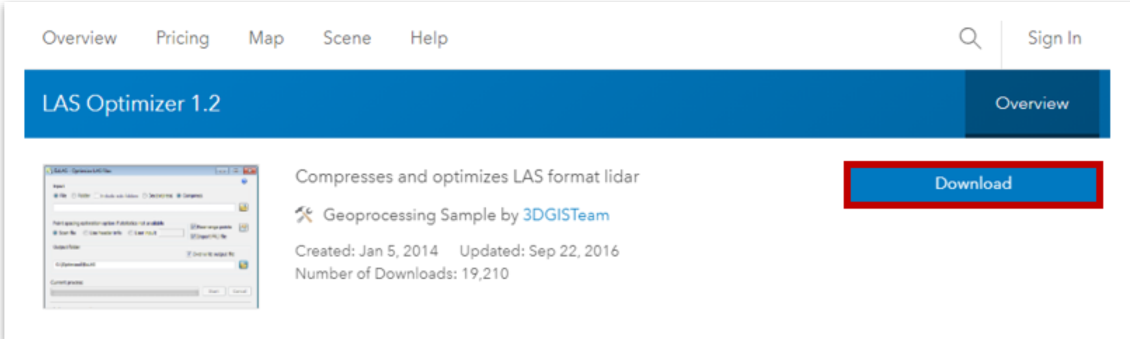


11. Repeat Steps 8-10 and download the other **six** tiles as listed in Step 7.

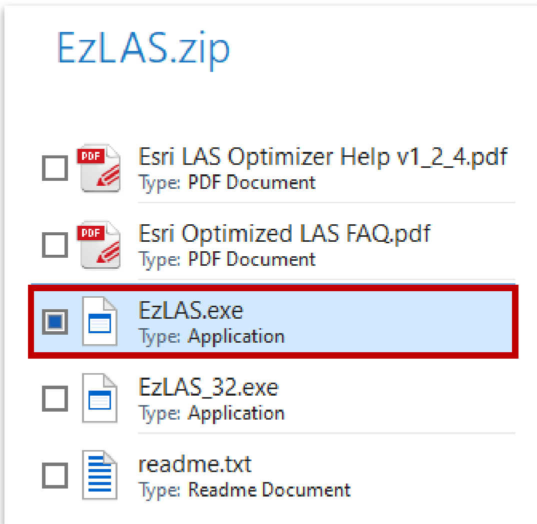
12. Since the files are in **.zlas** format, they need to be converted to **.las** format to import into ORD. Click the following link to access the **LAS Optimizer 1.2** converter website. **Note:** If you already have the converter installed, open it, and skip to Step 15.

    https://www.arcgis.com/home/item.html?id=787794cdbd384261bc9bf99a860a374f

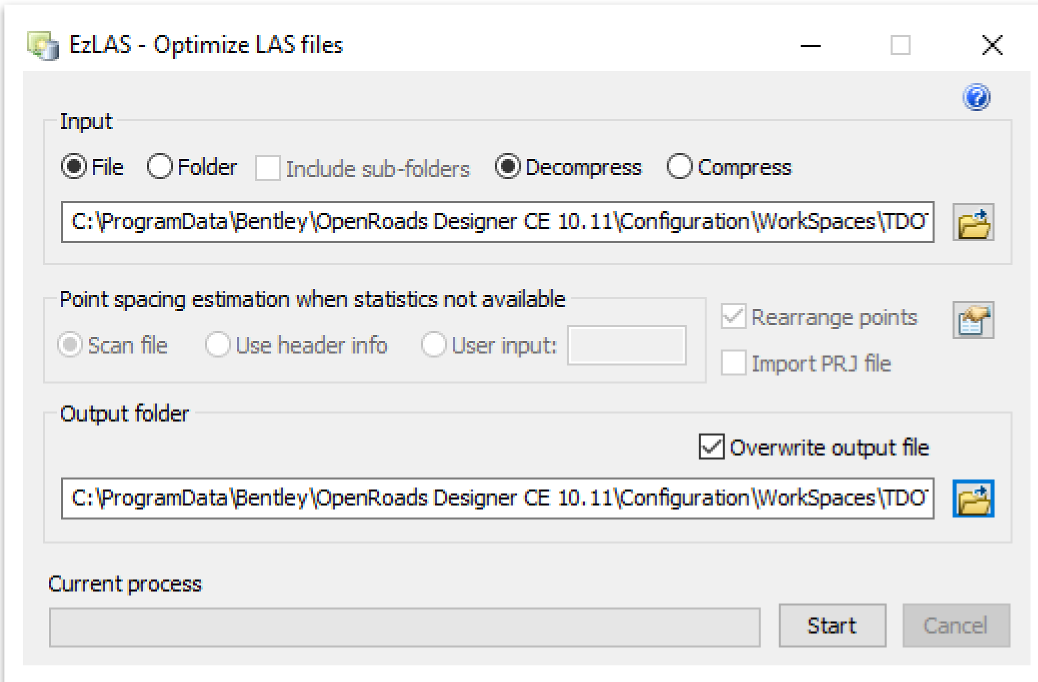
13. Select **Download** in the upper right corner to download the **EzLAS.zip** file.



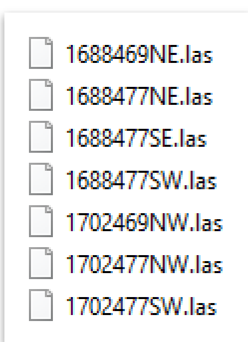
14. Open the zip file and then double click on the **ExLAS.exe** file. If prompted, click on **Yes, open this file**. **Note: WinZip Pro** was used in the image, but you may have a different program.



15. An **EzLAS - Optimize LAS files** window should open. Under **Input**, select **File** and **Decompress** and then browse to the **1688477SW.zlas** file. Under **Output folder**, select the folder where the **.las** file will be saved, which should be the same dgn Appendix\Appendix C subfolder within your **123456.00_ INITIALS** workset.



16. Click **Start** to begin the conversion process from **.zlas** to **.las** format. Go ahead and repeat the previous step for the other **six** .zlas files separately.
17. Once completed, all **seven .las** files should be in your dgn Appendix\Appendix C subfolder. They are now ready to import into ORD, which we will do in the next exercise.



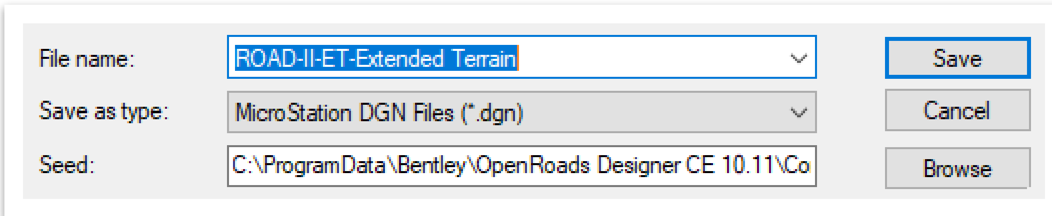
Take Note!

*If LiDAR data is needed from the **USGS 3DEP LiDAR Explorer** website, reference Appendix D.1 and Appendix D.2 which show the conversion process from **.laz** to **.las** and **.laz** to **.pod** respectively.*

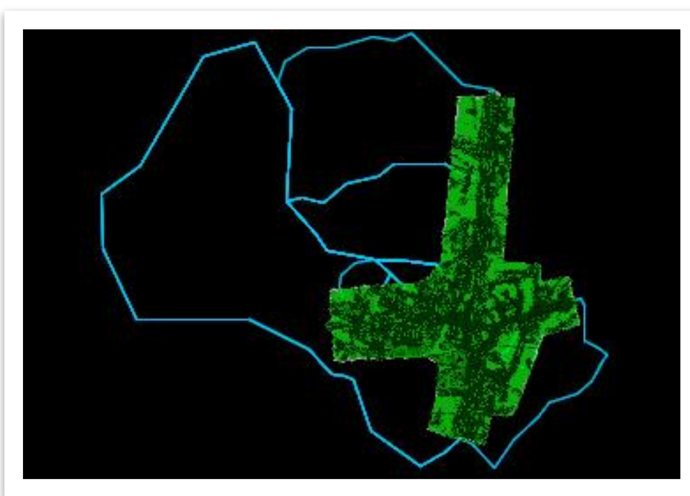
C.3 Exercise: Import LAS Data and Create Clipped Terrain Models

In this exercise, we will import the **.las** terrain data from the previous exercise and create clipped terrain models.

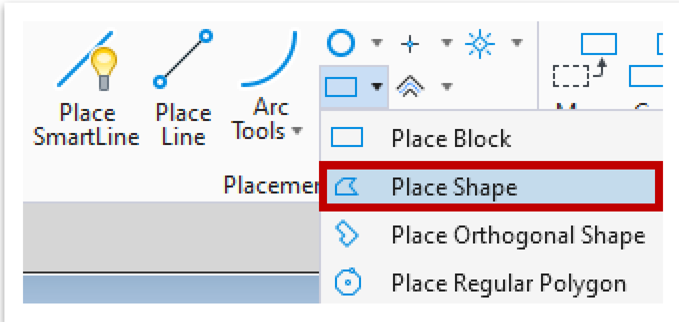
1. Create a new file and name it **ROAD-II-ET-Extended Terrain**. Select the **TDOT Seed3D.dgn** and click **Save**. **Note:** Save this file under the dgn Appendix\ Appendix C subfolder.



2. In the active file, make sure that the **Default** view is active in the lower left corner and then open the **Level Display** and turn off the following levels.
    - SUR - CTRL - Text
    - SUR - Project Information and Notes
    - SUR - UTL - Owners
3. Attach the following reference files using the **Coincident World** attachment method and then click **Fit View**.
    - ROAD-II-ET-Survey.dgn
    - ROAD-II-ET-Terrain.dgn
4. Within the **ROAD-II-ET-Survey.dgn** reference file, turn off all levels other than the **SURVEY - DRAINAGE - Area Shapes** level, which provides the drainage area extents (blue lines) for the example project, and then save settings. Notice that the extent of the terrain does not cover the drainage areas completely.

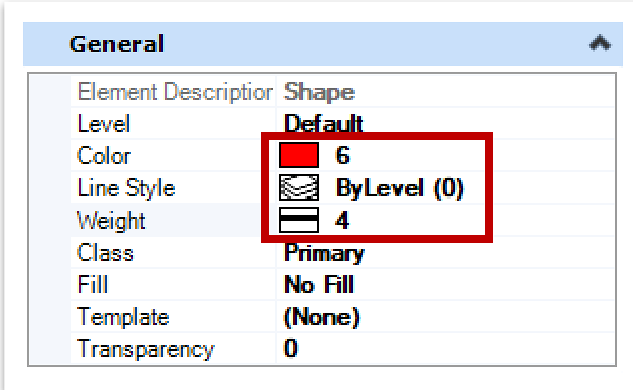


5. To decrease the file size and improve design efficiency, we will now create a **clip boundary** just beyond the drainage area extents to use when clipping the LiDAR tiles. Open the **Place Shape** tool (**OpenRoads Modeling >> Drawing >> Placement >> Polygon Tools**).



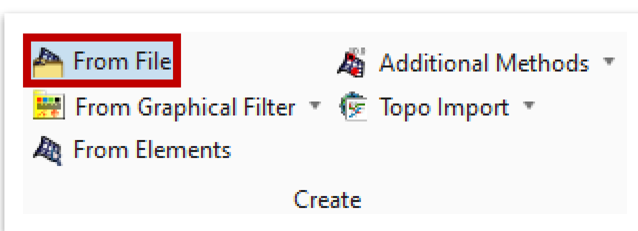
6. Draw a line around the **outer extent** of the drainage area boundary so that it is completely enclosed, as shown below. **Note:** Your shape does not need to match exactly. Make sure not to click on any of the triangles.

7. Next, select the boundary and update its **Properties**, if necessary, to match the settings below.

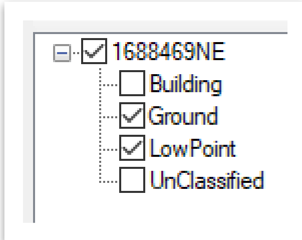


8. Click **Fit View** and then save settings.

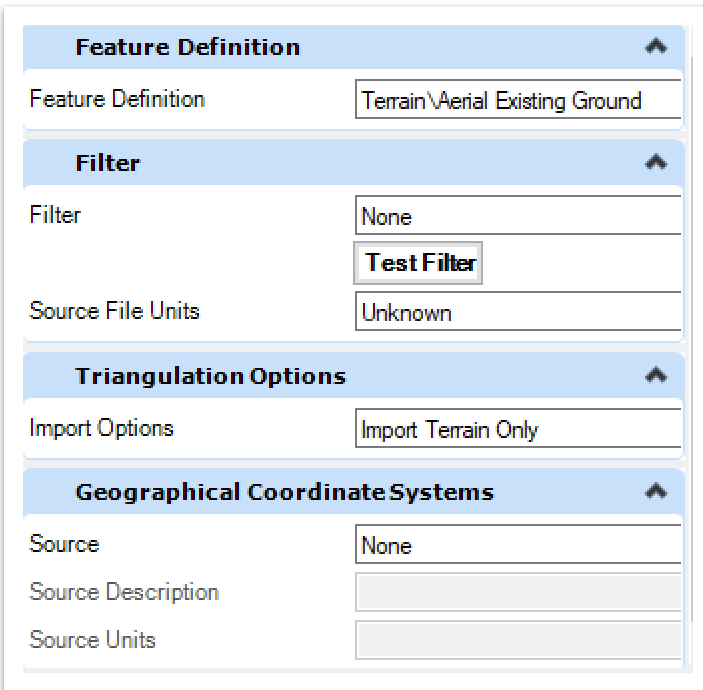
9. We will now create the terrain from the **.las** files. Open the create terrain **From File** tool (**OpenRoads Modeling >> Terrain >> Create**) to import the <u>first</u> **.las** file. Change the **File Type** drop-down to **All Files**. Select the **1688469NE.las** file in the dgn Appendix\Appendix C subfolder and then click **Done**. **Note:** Give the software a minute to process.



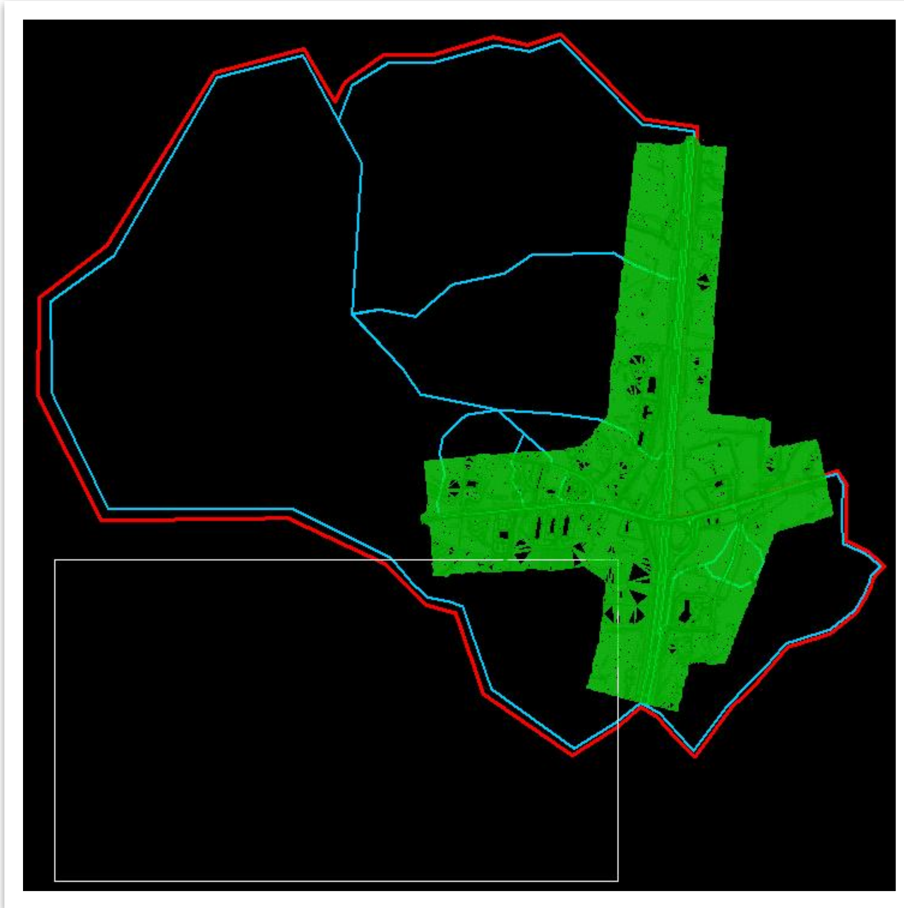
10. Within the **Import Terrain Model(s)** dialog box, uncheck the **Building** and **Unclassified** filters.



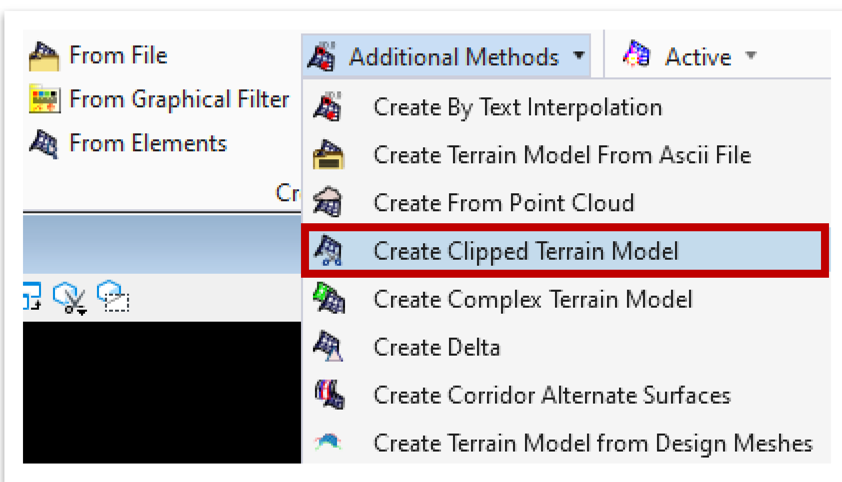
11. Under **File Options**, within the **Import Terrain Model(s)** dialog box, select the following settings. **Note:** The **Global Options** are already set.
    a. **Feature Definition:** Aerial Existing Ground (under the **Terrain** folder)
    b. **Filter:** None
    c. **Triangulation Options:** Import Terrain Only
    d. **Geographical Coordinate Systems:** None



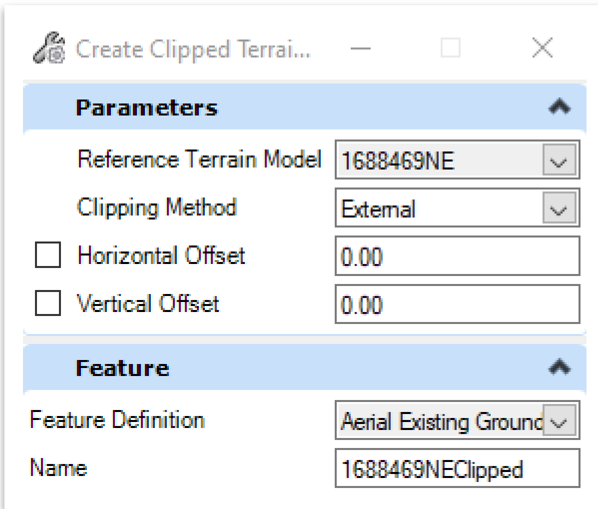
12. Once all the settings are selected, click **Import** and give the software a minute to process. Then **Close** the **Import Terrain Model(s)** dialog box. It is recommended to turn off the triangles within the imported terrain tile to help with file efficiency.



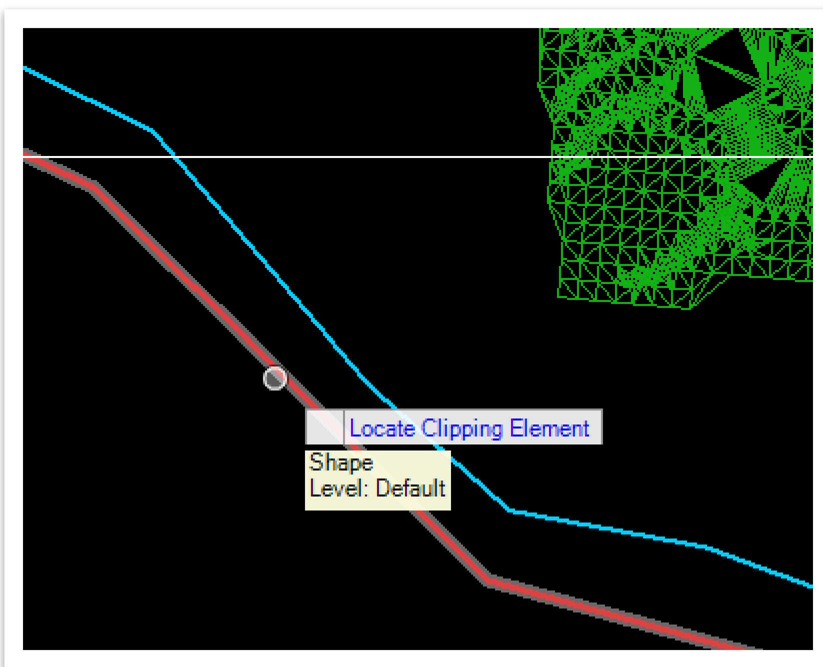
13. Now, we will go through the steps to create a clipped terrain model from the **1688469NE** tile. Open the **Create Clipped Terrain Model** tool (**OpenRoads Modeling >> Terrain >> Create >> Additional Methods**).



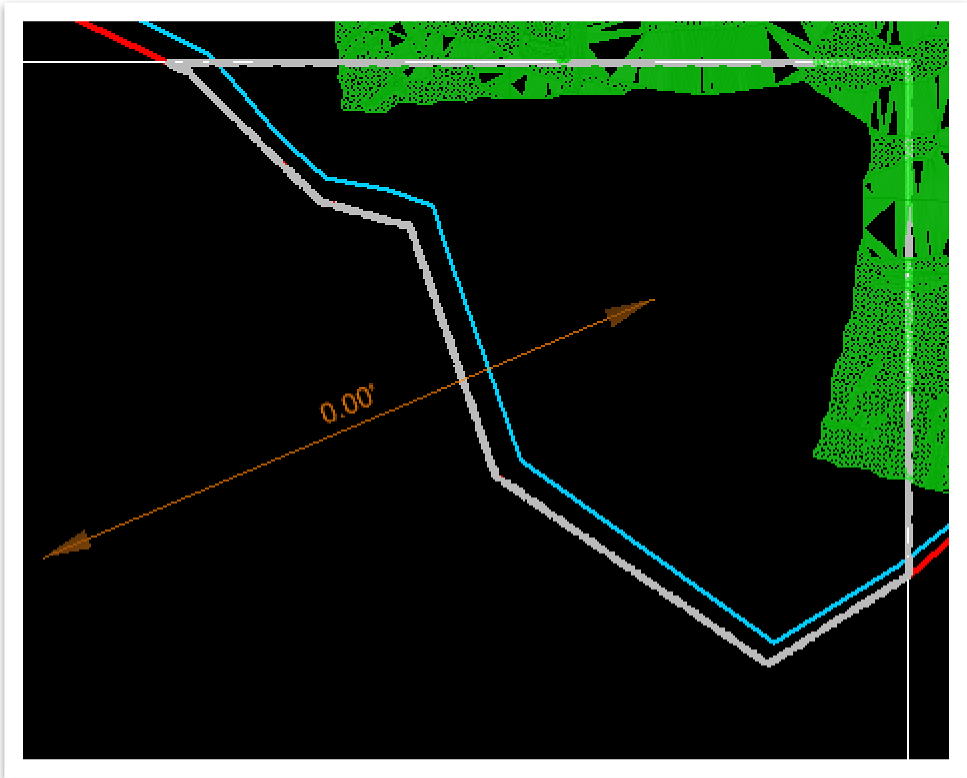
14. Within the **Create Clipped Terrain Model** dialog box, select the following settings.
    a. **Reference Terrain Model:** 1688469NE
    b. **Clipping Method:** External
    c. **Horizontal/Vertical Offsets:** 0.00
    d. **Feature Definition:** Aerial Existing Ground (under the **Terrain** folder)
    e. **Name:** 1688469NEClipped



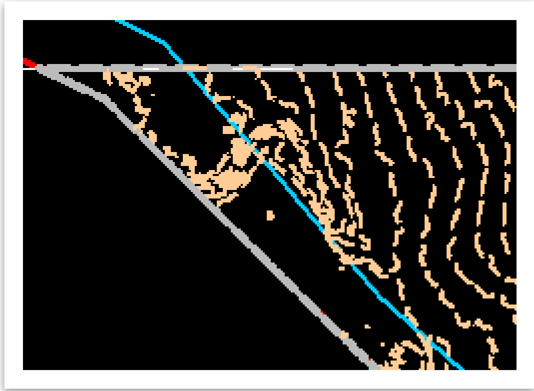
15. Select the **red** clipping element that was created earlier in the exercise and then **right** click to reset.



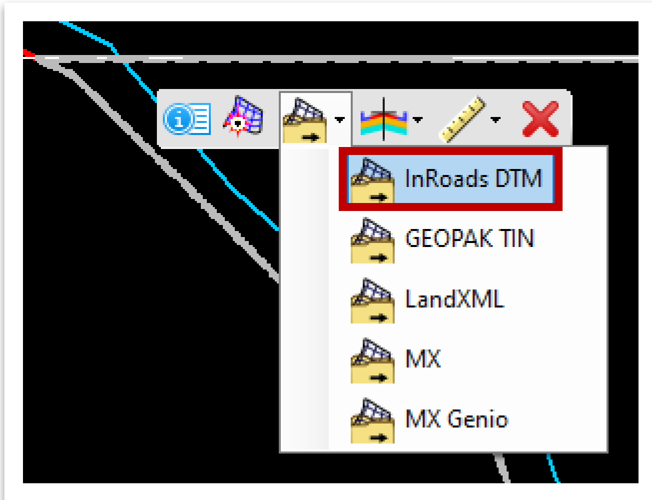
16. **Left** click to accept the remaining prompts. Then **right** click to clear the tool. You should now see the clipped terrain boundary following the red boundary. Turn off the triangles in the clipped terrain, if necessary. **Note:** You will also notice an axis line.



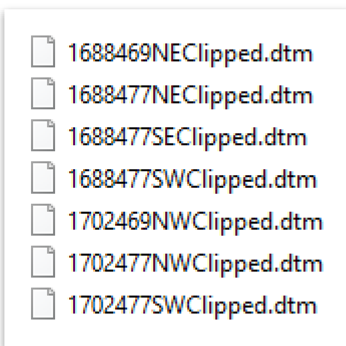
17. If you have the surveyed triangles turned on, go ahead and turn off the **SUR - DTM - Triangles** level within the **ROAD-II-ET-Terrain.dgn** reference file. Now, select the clipped terrain and turn on the **Major Contours**. Once reviewed, turn them back off so that the file processing is more efficient.



18. Next, we will export the clipped terrain. Select the clipped boundary once again and open the **Properties** within the heads-up display. Select **InRoads DTM** under **Export Terrain Model** and click **Save**. By default, it should open to the dgn Appendix\Appendix C subfolder within your **123456.00_INITIALS** workset. **Note:** There are multiple export options available. InRoads DTM will be used in this exercise.



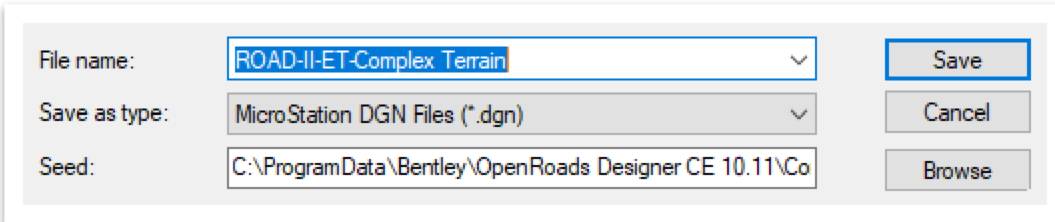
19. Repeat Steps 9-18 to import and clip the other **six** .las files. To prevent the software from crashing, make sure to import one .las file at a time. Once completed, all **seven** clipped .dtm files should be in your dgn Appendix\Appendix C subfolder **Note:** In general, if you experience file slowness or crashing when storing multiple clipped terrains in one dgn file, it is recommended to import each .las file into its own dgn file to make the file sizes smaller.



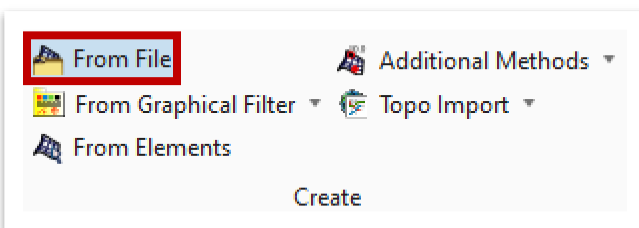
C.4 Exercise: Create Complex Terrain Model

In this exercise, we will create a complex terrain model by appending the clipped terrains and then create a final extended terrain model.

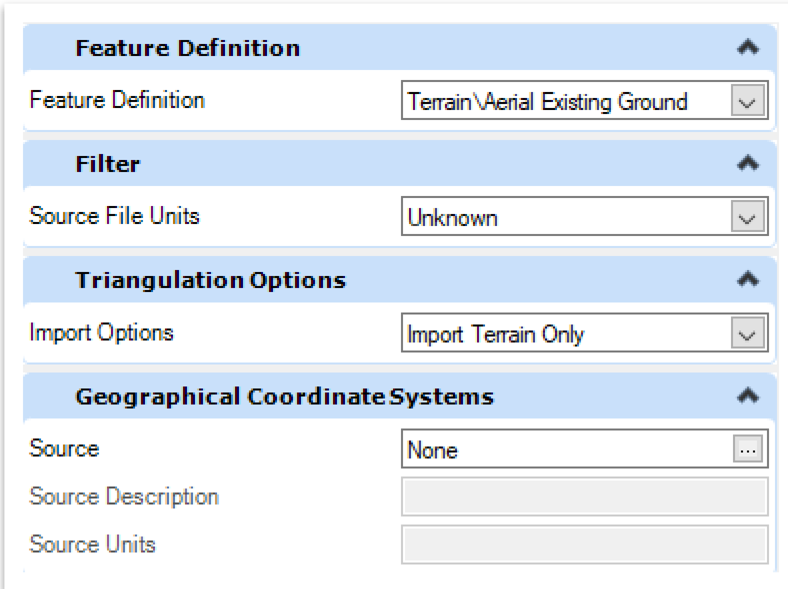
1. Create a new file and name it **ROAD-II-ET-Complex Terrain**. Select the **TDOT Seed3D.dgn** and click **Save**. **Note:** Save this file under the dgn Appendix\Appendix C subfolder.



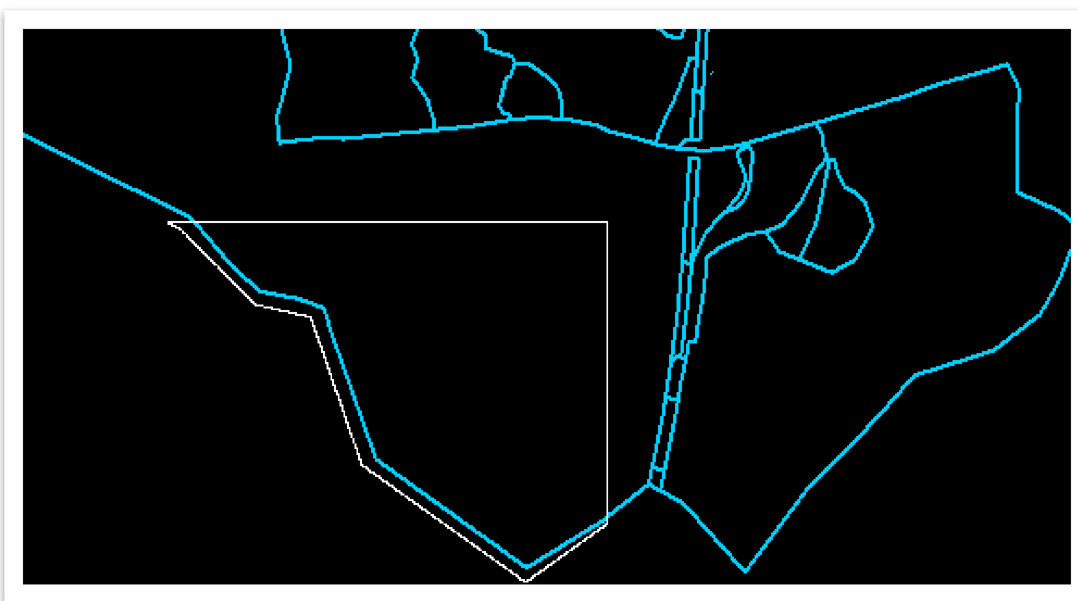
2. In the active file, make sure that the **Default** view is active in the lower left corner and then open the **Level Display** and turn off the following levels.
   - SUR - CTRL - Text
   - SUR - Project Information and Notes
   - SUR - UTL - Owners
3. Attach the **ROAD-II-ET-Survey.dgn** reference file using the **Coincident World** attachment method and then click **Fit View**. Within the reference file, turn off all levels other than the **SURVEY - DRAINAGE - Area Shapes** level and save settings.
4. Next, open the create terrain **From File** tool (**OpenRoads Modeling >> Terrain >> Create**) to import the clipped **.dtm** files from the previous exercise. Select the **1688469NEClipped.dtm** in your dgn Appendix\Appendix C subfolder and then click **Done**. **Note:** To prevent the software from crashing, we will import each clipped .dtm file separately.



5. Under **File Options**, within the **Import Terrain Model(s)** dialog box select the following settings. **Note:** The **Global Options** are already set.
    a. **Feature Definition:** Aerial Existing Ground (under the **Terrain** folder)
    b. **Source File Units:** Unknown
    c. **Triangulation Options:** Import Terrain Only
    d. **Geographical Coordinate Systems:** None

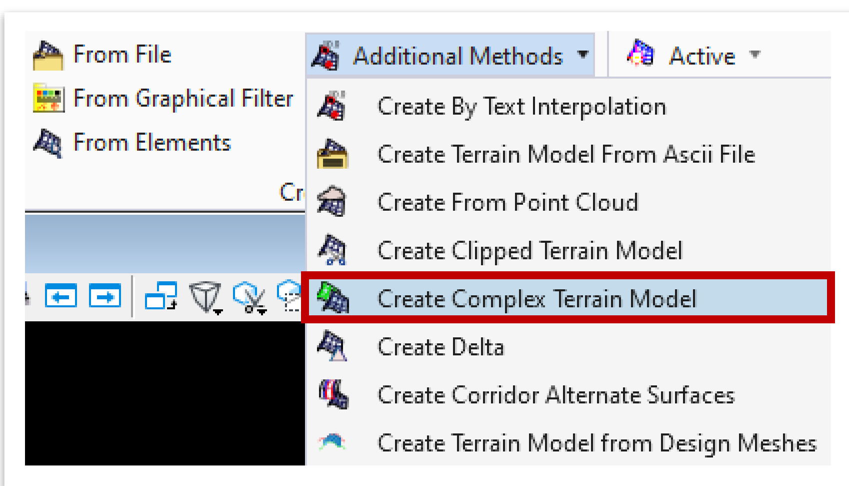


6. Once all the settings are selected, click **Import** and give the software a minute to process. Then **Close** the **Import Terrain Model(s)** dialog box. Once again, it is recommended to turn off the triangles within the imported dtm to help with file efficiency.

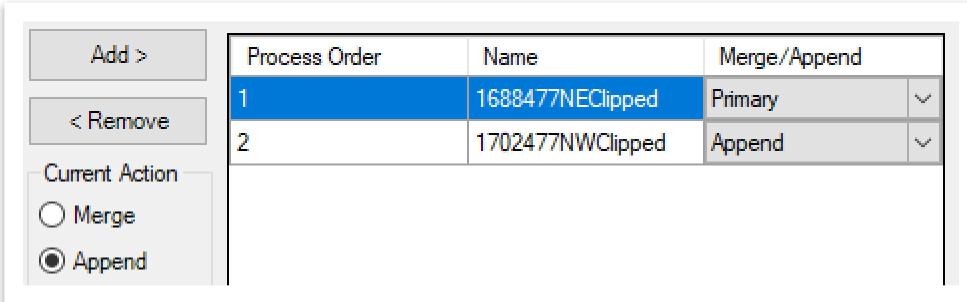


7. Repeat Steps 4-6 for the other **six** clipped .dtm files.

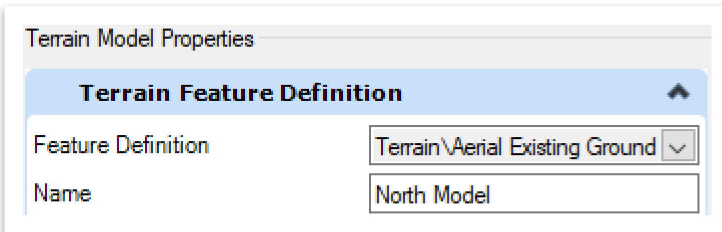
8. Now, we will **append** each of the clipped terrain models to create one **complex** model. To prevent the software from crashing, we will append the models in segments. Open the **Create Complex Terrain Model** tool (**OpenRoads Modeling >> Terrain >> Create >> Additional Methods**).



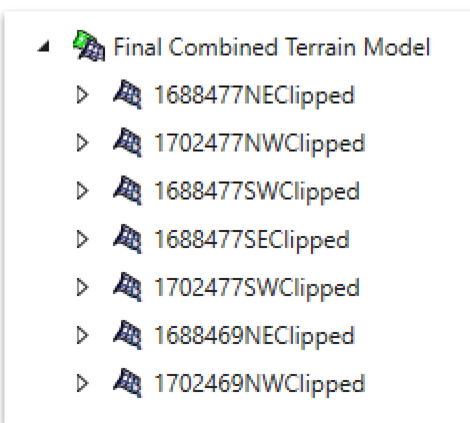
9. Within the **Create Complex Terrain Model** dialog box, first select the two northern clipped models on the left side (**1688477NEClipped** and **1702477NWClipped**) and click **Add**. Once added, you will see them on the right side, as shown below. Make sure the **Current Action** is set to **Append**.



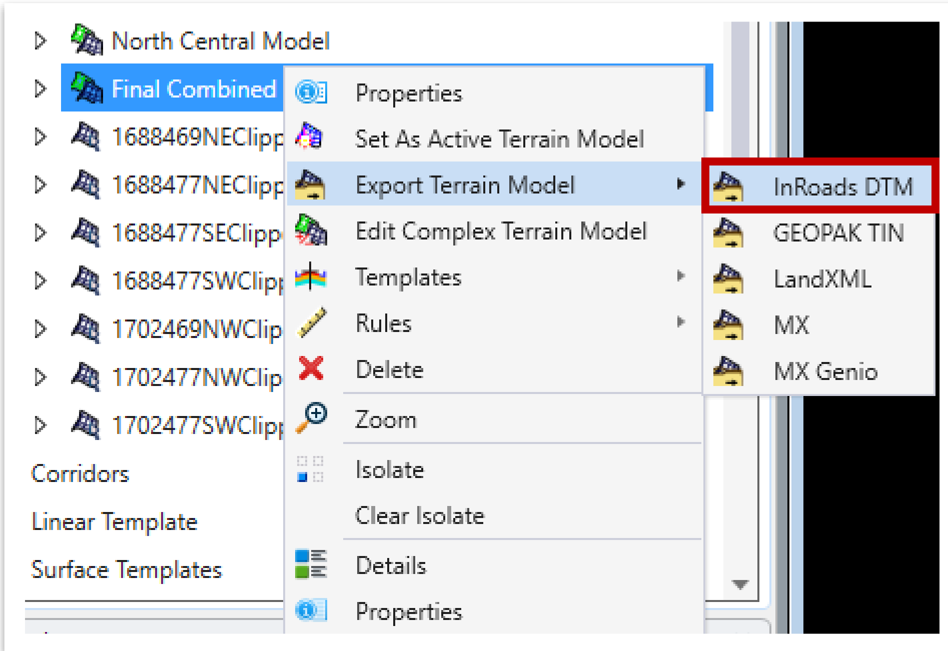
10. Next, set the **Feature Definition** to **Aerial Existing Ground**. Name this complex terrain model **North Model**, then click **Finish**.



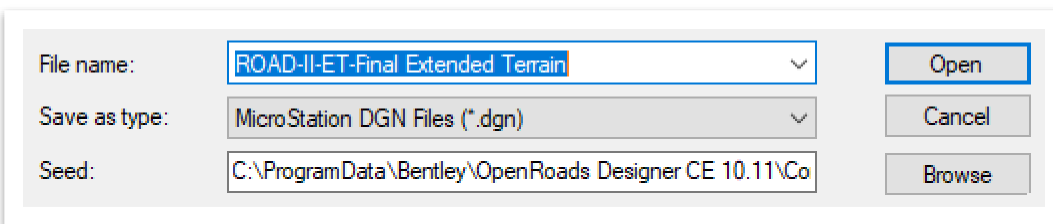
11. Repeat Steps 8-10 two more times to create the following complex terrain models:
    a. Central Model (**1688477SWClipped**, **1688477SEClipped** and **1702477SW Clipped**)
    b. South Model (**1688469NEClipped** and **1702469NWClipped**)
12. Now, repeat Steps 8-10 two more times to create the final combined terrain model. First, append the **North** and **Central** models and name the terrain **North Central Model**. Then, append the **South** model to the **North Central** model and name the terrain **Final Combined Terrain Model**. This final model should contain all **seven** clipped models, as shown in the **Explorer** under the **OpenRoads Model** tab.



13. Next, we need to export the final combined terrain model. **Right** click on the **Final Combined Terrain Model** within the **Explorer**. Select **InRoads DTM** under **Export Terrain Model** and name the dtm **Final Combined Terrain Model**. Then, click **Save**. By default, it should open to the dgn Appendix\Appendix C subfolder within your **123456.00_INITIALS** workset. **Note:** There are multiple export options available. InRoads DTM will be used in this exercise.



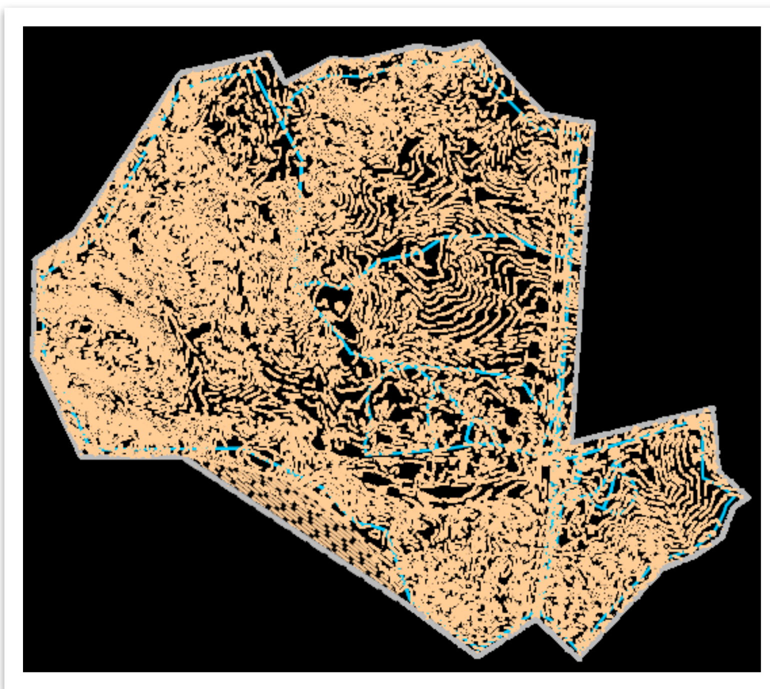
14. Lastly, we will create a clean dgn file that contains the final extended terrain that can be referenced into other design files. Create a new file and name it **ROAD-II-ET-Final Extended Terrain**. Select the **TDOTSeed 3D.dgn** and click **Save**. **Note:** Save this file under the dgn Appendix\Appendix C subfolder.



15. In the active file, open the **Level Display** and turn off the **three SUR** levels.
    - SUR - CTRL – Text
    - SUR - Project Information and Notes
    - SUR - UTL – Owners
16. Attach the **ROAD-II-ET-Survey.dgn** reference file using the **Coincident World** attachment method and then click **Fit View**. Within the reference file, turn off all levels other than the **SURVEY - DRAINAGE - Area Shapes** level and save settings.

17. We will now import the **Final Combined Terrain Model.dtm**. Open the create terrain **From File** tool (**OpenRoads Modeling >> Terrain >> Create**) and use the same settings from Step 5.
18. Once all the settings are selected, click **Import** and give the software a minute to process. Then **Close** the **Import Terrain Model(s)** dialog box.

19. Select the **Final Terrain Model** boundary and turn on the **Major Contours** within the **Properties**.



Appendix D. Additional LiDAR Options

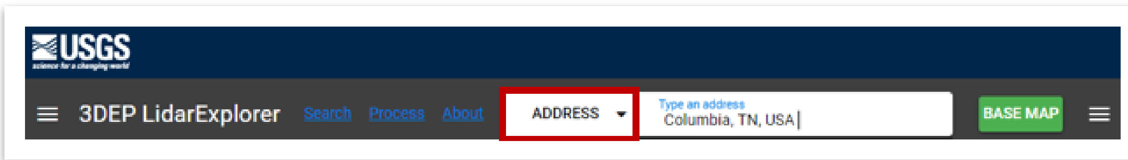
D.1 Exercise: USGS 3DEP LiDAR – LAZ to LAS

In this exercise, we will show how to download LiDAR data from the **USGS 3DEP LiDAR Explorer** website (**.laz**) and then convert to **.las** files. We will use the same project location from Appendix C (Columbia, TN). This conversion process is offered as an alternative to the workflow described in Exercise C.2. **Note:** This process is also detailed in Appendix F.2 in the SUDA (ORD) Manual. As an alternative option, you can use **ArcGIS Pro** to convert .laz or .las files to a usable ORD raster.

1. Click the following link to open the **USGS 3DEP LiDAR Explorer** website to retrieve the map tile data. **Note:** Do not use Internet Explorer. **Google Chrome** was used for this exercise, but other browsers may be used.

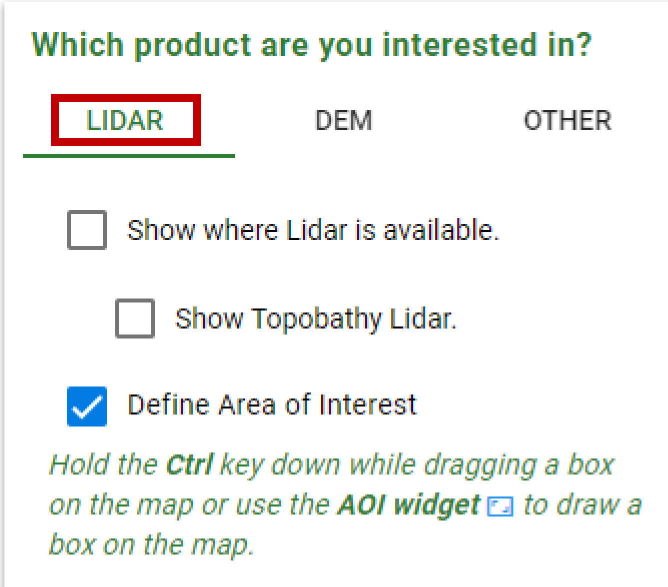
   https://apps.nationalmap.gov/lidar-explorer/#/

2. In the upper right corner, set the search category to **Address** and then key-in **Columbia, TN, USA** and select it from the drop-down menu. This will narrow the search location to the applicable area.

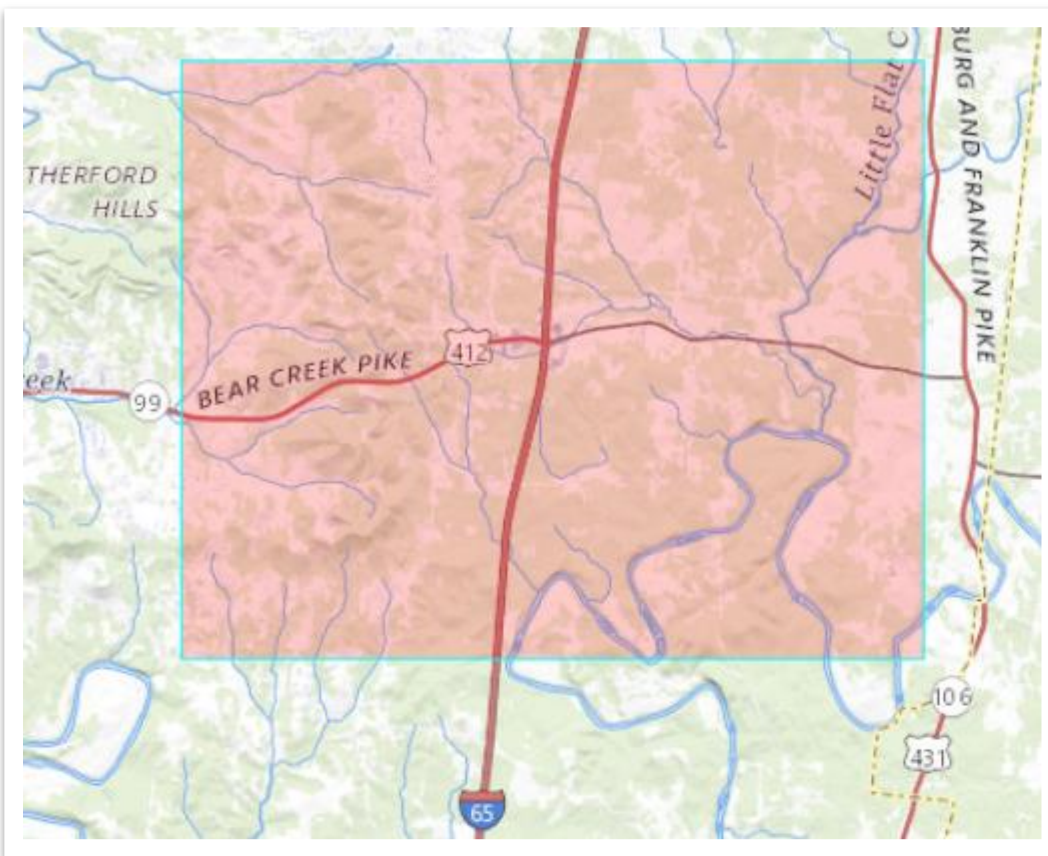


3. Zoom in to the project area, I-65/SR-99 (Bear Creek Pike) Interchange, by using your mouse wheel.

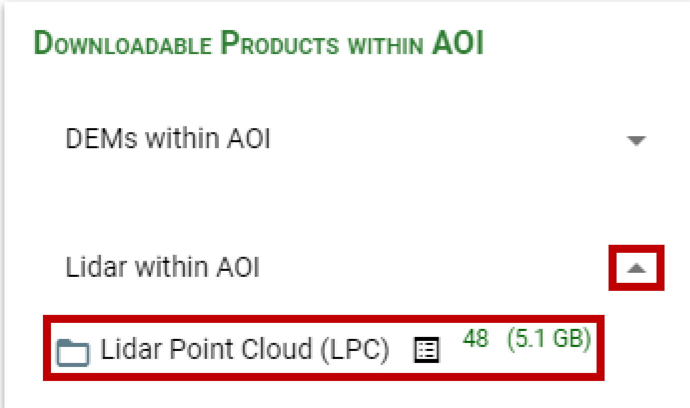
4. On the left side of the screen, choose the **LIDAR** product and select **Define Area of Interest**.



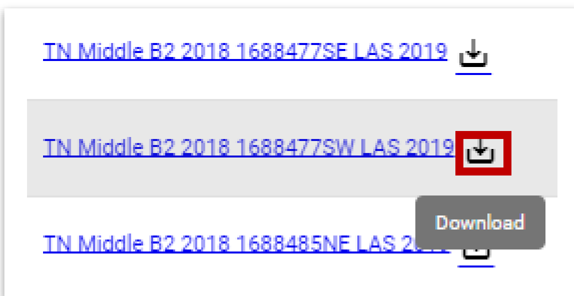
5. Follow the USGS instruction to define the area of interest. **Note:** Your area does not need to match the image exactly.



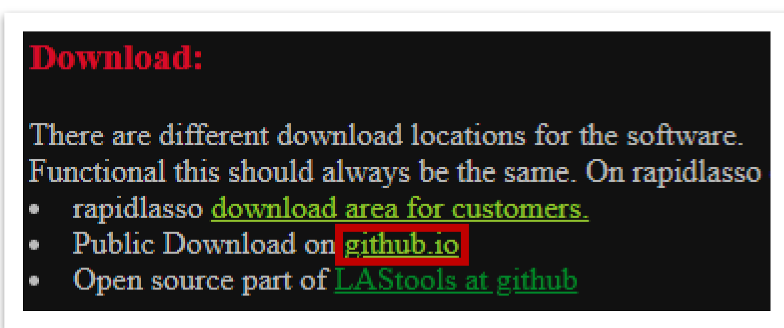
6. For the defined area of interest, expand the **Lidar within AOI** folder on the right side of the screen and click on **Lidar Point Cloud (LPC)**.



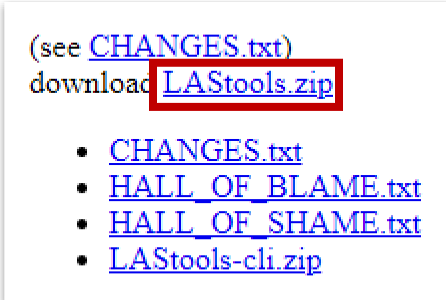
7. For this exercise, we will only download the **1688477SW** tile. Within the **Filter results**, scroll down and click on the download icon next to **TN_Middle_B2_2018_ 1688477SW_LAS_2019**. Accept any prompts that might appear. Save the file in the following location: **C:\ProgramData\Bentley\OpenRoads Designer CE 10.11 \Configuration\WorkSpaces\TDOT_Standards\WorkSets\123456.00_ INITIALS\dgn\ Appendix\Appendix D (Additional LiDAR Options)**.



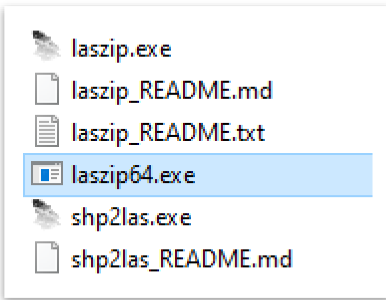
8. Notice the tile is saved in a **.laz** format. It needs to be converted to a **.las** format to import into ORD. Click on the following link to access the **LAStools** website. [https://lastools.github.io/.](https://lastools.github.io/)
9. Scroll down to the bottom under **Download** and click the **github.io** link next to **Public Download**.



10. Next, click on **LAStools.zip** at the top of the screen.



11. Unzip the **LAStools** folder to the dgn Appendix\Appendix D subfolder within your **123456.00_INITIALS** workset folder. Within the folder, browse to the **bin** subfolder and click on the **laszip64.exe** file, which will open a command prompt window.

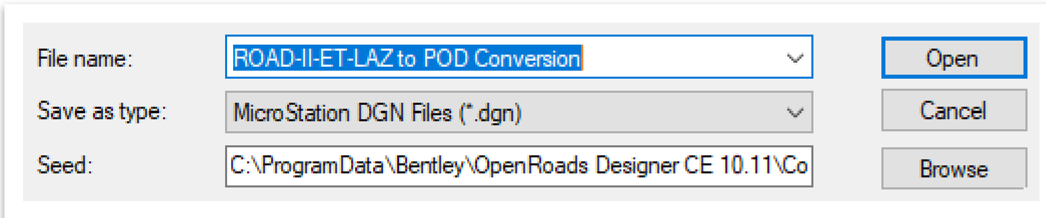


12. Next, to **enter input file**, key-in the file path of the **.laz** file and then hit **Enter**: **C:\ProgramData\Bentley\OpenRoads Designer CE 10.11\Configuration\WorkSpaces\TDOT_Standards\WorkSets\123456.00_INITIALS\dgn\Appendix\Appendix D (Additional LiDAR Options)\USGS_LPC_TN_Middle_B2_2028_ 1688477_LAS_2019.laz**.
13. Lastly, next to **enter output file**, key-in the same file path but change the extension to **.las** and then hit **Enter**. Give the software a minute to process and then close the command prompt window. You should then notice that the .las file has been created in your Appendix\Appendix D dgn subfolder and can now use it in ORD.

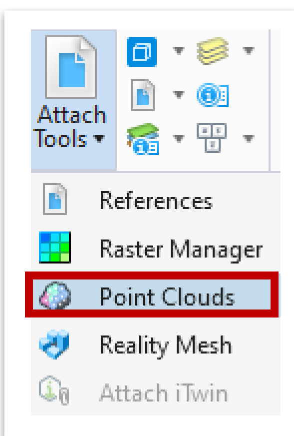
D.2 Exercise: USGS 3DEP LiDAR – LAZ to POD

In this exercise, we will show how to take the downloaded **.laz** file from the previous exercise and convert to a **.pod** file within ORD. This conversion process is also offered as an alternative to the workflow described in Exercise C.2.

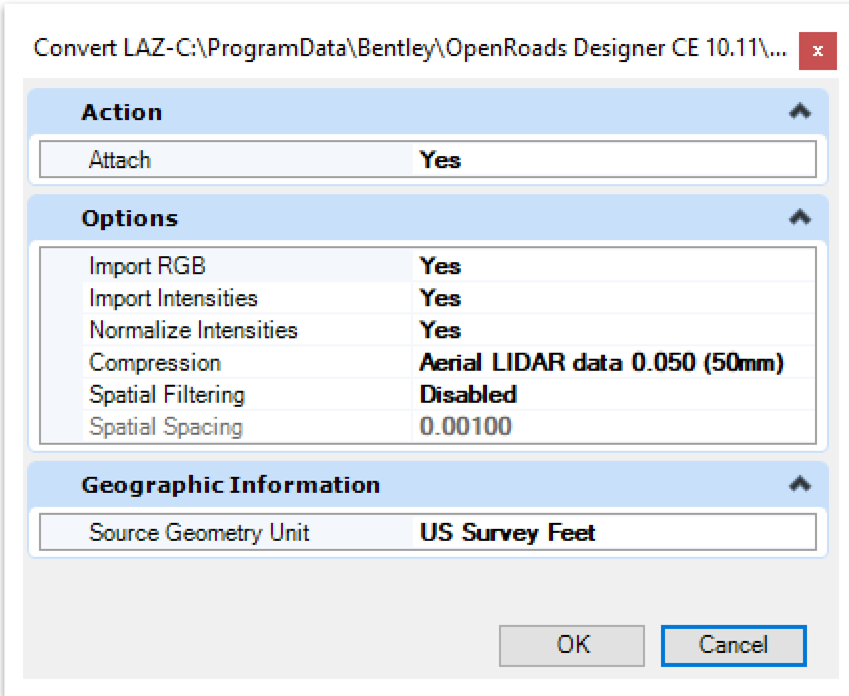
1. Within ORD create a new file and name it **ROAD-II-ET-LAZ to POD Conversion**. Select the **TDOTSeed 3D.dgn** and click **Save**. **Note:** Save this file under the dgn Appendix\Appendix D subfolder.



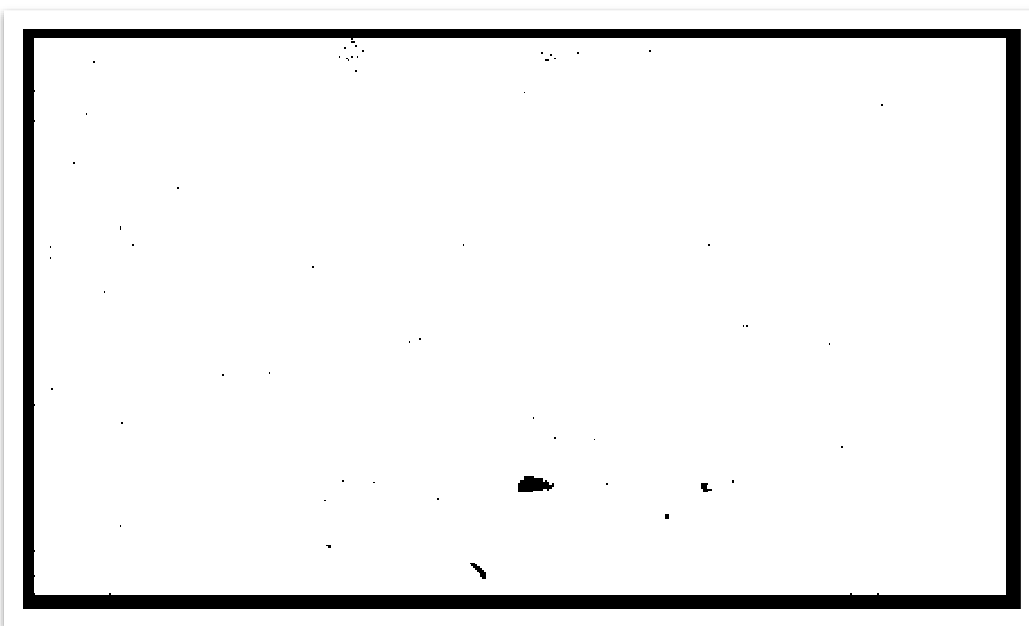
2. In the active file, make sure that the **Default** view is active in the lower left corner and then open the **Level Display** and turn off the following levels and save settings.
   - SUR - CTRL – Text
   - SUR - Project Information and Notes
   - SUR - UTL - Owners
3. Open the attach **Point Clouds** tool (**OpenRoads Modeling >> Home >> Primary >> Attach Tools**) and attach the **USGS_LPC_TN_Middle_B2_2018_1688477SW_LAS_2019.laz** file. **Note:** If you do not see the .laz file, change the **File Type** drop-down to **All Files**. Also, if you have multiple **.laz** files to convert, it is recommended to attach <u>one at a time</u> to prevent the software from crashing.



4. The **Convert LAZ** dialog box should automatically open. Select the following settings and then click **OK**.



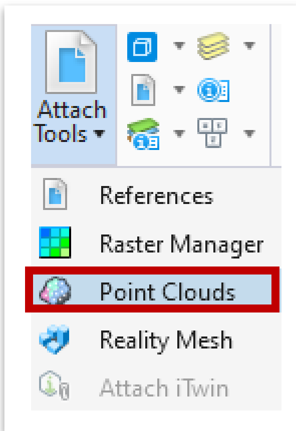
5. Save the converted **USGS_LPC_TN_Middle_B2_2018_1688477SW_LAS_2019.pod** file in the dgn Appendix\Appendix D subfolder. **Note:** Give the software a minute to process.
6. Once completed, click **Fit View** and notice the **.pod** point cloud. This file could then be utilized as necessary in ORD.



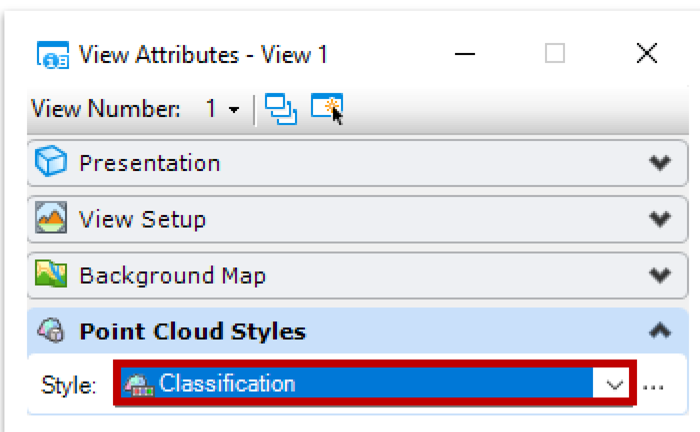
D.3 Exercise: Import POD Data

At times, a user may need to import **.pod** terrain data to create a clipped and then extended terrain model. In this exercise, we will import the **.pod** file from the previous exercise to show the process. We will use the **ROAD-II-ET-Extended Terrain.dgn** file that was created in Appendix C.

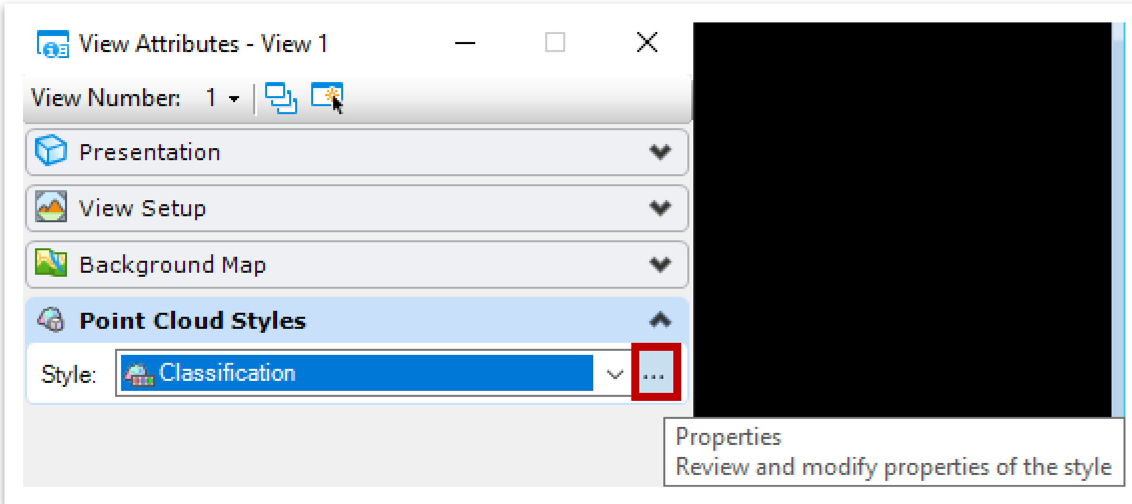
1. First, we need to attach the **.pod** file. Make sure that the **Default** view is active in the lower left corner. Open the attach **Point Clouds** tool (**OpenRoads Modeling >> Home >> Primary >> Attach Tools**) and attach the **USGS_LPC_TN_Middle_B2_2018_1688477SW_LAS_2019.pod** file.



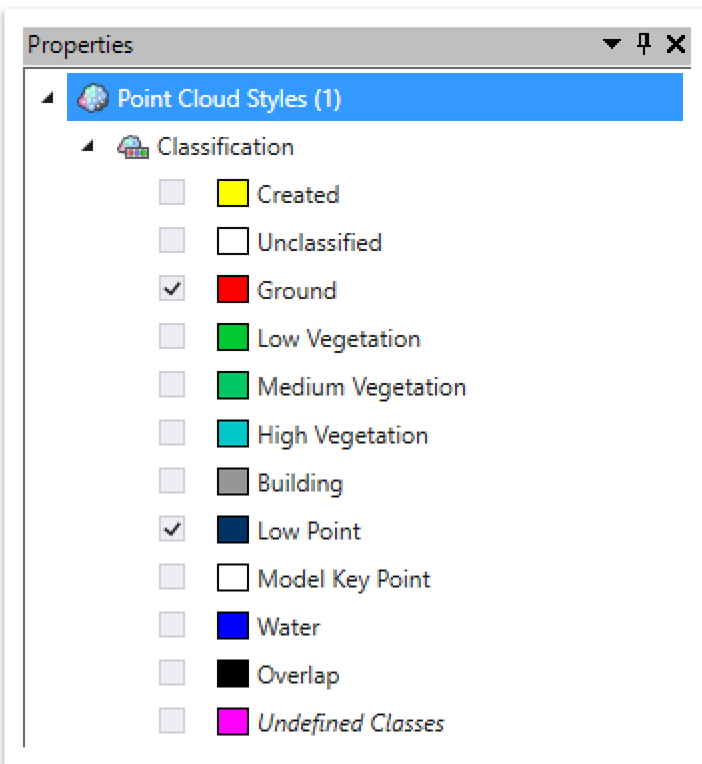
2. Open the **View Attributes** tool (**OpenRoads Modeling >> View >> Presentation**) or **CTRL + B** and set the **Point Cloud Style** to **Classification**.



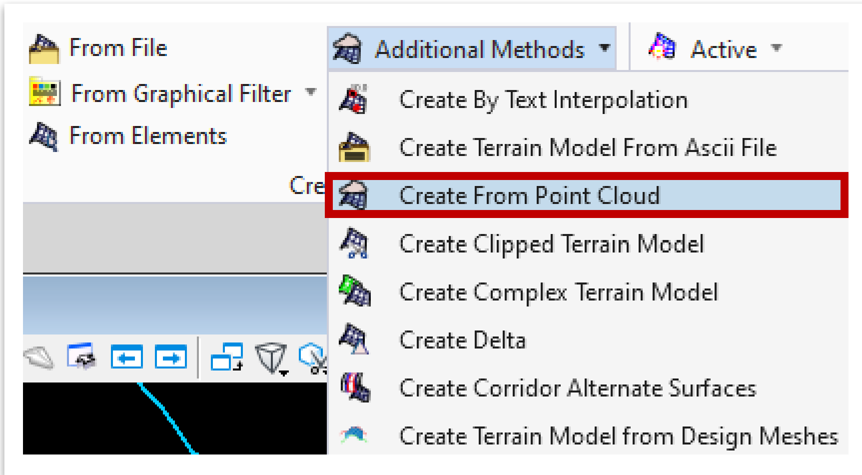
3. Now, select the **Point Cloud Styles** properties (the three dots, right of the **Classification** style).



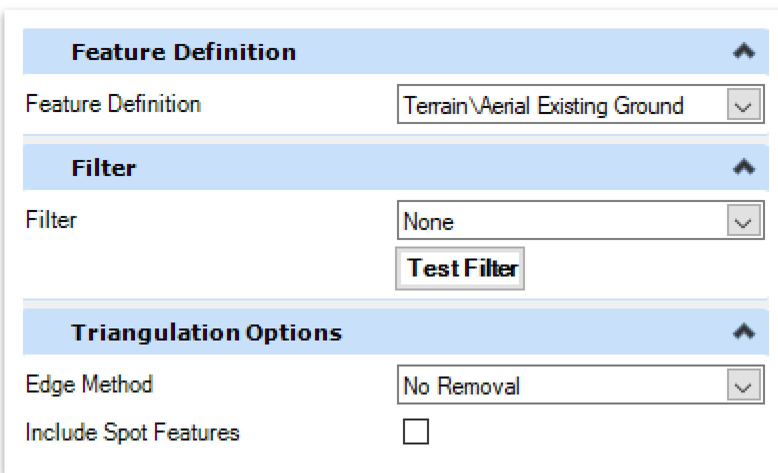
4. Within the **Properties** dialog box, uncheck all the classifications except for **Ground** and **Low Point** classifications.



5. Next, open the **Create From Point Cloud** tool (**OpenRoads Modeling >> Terrain >> Create >> Additional Methods**).



6. Under **File Options**, within the **Create Terrain From Point Cloud** dialog box, select the following settings. **Note:** The Global Options are already set.
   a. **Feature Definition:** Aerial Existing Ground (under the **Terrain** Folder)
   b. **Filter:** None
   c. **Triangulation Options:** No Removal



7. Once all the settings are selected, click **Import** and give the software a minute to process. Then **Close** the **Create Terrain From Point Cloud** dialog box. **Note:** If you need to turn off a **.pod** file at any time, you can highlight the **.pod** file in the **Point Clouds** window and turn off **View 1**.

Take Note!

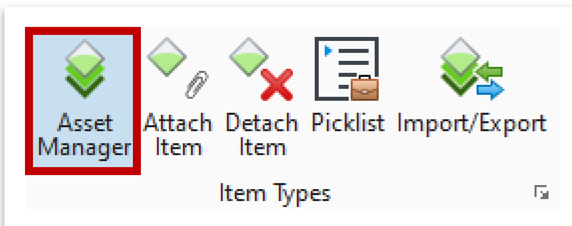
*The **.pod** workflow for the **Clipped Terrain Model** creation and the **Complex Terrain Model** creation is the same as the **.las** workflow beyond Step 7. Reference [Exercise C.3] (starting at Step 13) and [Exercise C.4], respectively.*

Appendix E. Exporting Shape Files

E.1 Exercise: Exporting a Shapefile Using Asset Manager

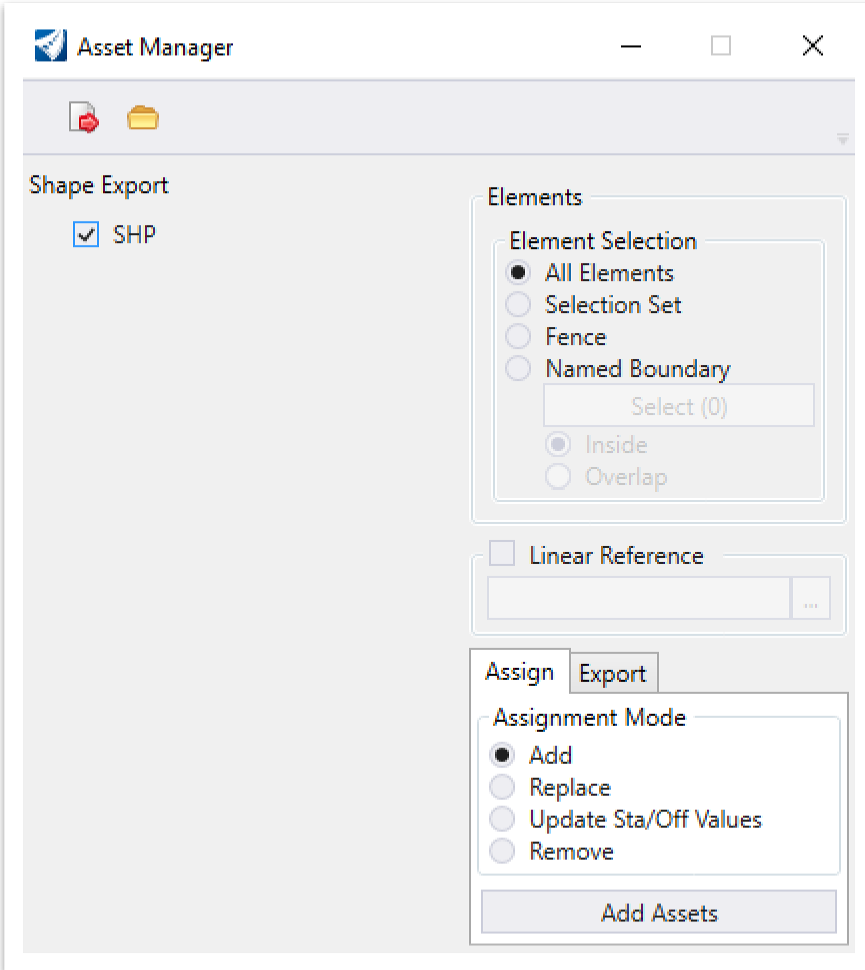
In this exercise, we will export the corridor edge of pavement's (EOP's) into a shapefile.

1. Open the **ROAD-II-SF-Corridor.dgn** file within the dgn Appendix\Appendix E subfolder. Make sure that the **Default** view is active in the lower left corner. The following files should already be referenced in the 2D view.
    - ROAD-II-SF-Geometry.dgn
    - ROAD-II-SF-Terrain.dgn
2. Open the **Asset Manager** tool (**OpenRoads Modeling >> Utilities >> Item Types**).

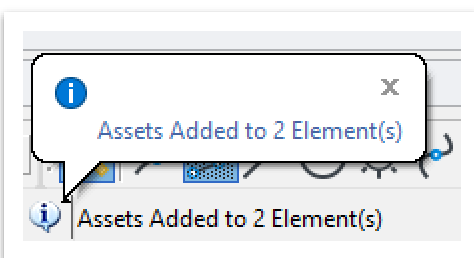


3. Within the **Asset Manager** window, browse to the **C:\ProgramData\Bentley\OpenRoads Designer CE 10.11\Configuration\Organization-Civil\TDOT_Standards\Asset Manager** folder and select **Shape Export.xlsm** and then click **Open**.

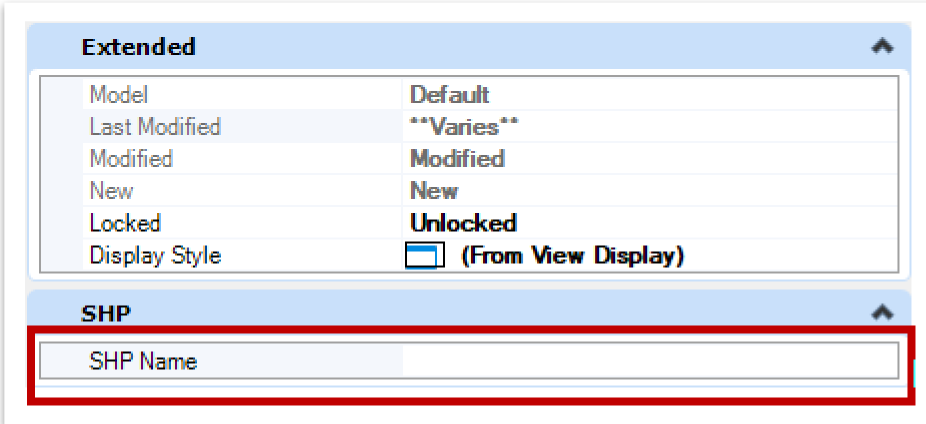
4. One item type (**SHP**) option should now appear under **Shape Export**. Toggle on the **SHP** check box, which will set it as an active item type to be attached to elements.



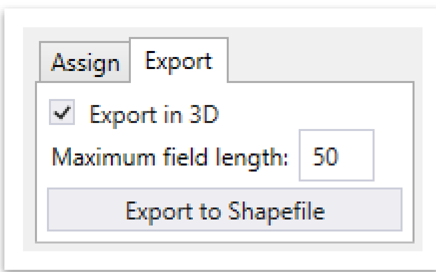
5. Before we can export, we need to assign the **SHP** item type to the elements that need to be exported. Go ahead and update the **Element Selection** method to **Selection Set** and leave the **Assign** option as **Add**. Hold **CTRL** and select the two **EOP** lines in plan view and then click **Add Assets**. Notice an alert at the bottom of the screen indicating that assets have been added to **2 Element(s)**.



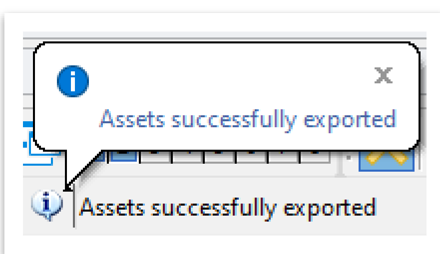
6. Next, let's confirm that the **SHP** item type was added to the EOP's. With both EOP's still selected, look at the **Properties**. The **SHP** item type should be attached with a **SHP Name** property, which is where you can name the element prior to the shape export.



7. Select each **EOP** individually and name the **SHP** name **EOP L** and **EOP R** respectively. This is helpful when importing into Google Earth because the field can be linked to the element name in the shapefile.
8. Within the **Asset Manager** window, make sure the **Elements** settings are still set to **Selection Set** and that <u>both</u> EOP's are selected. Update the workflow from Assign to **Export** and toggle on **Export in 3D**. Leave the default **Maximum field length** as-is and then click **Export to Shapefile**.



9. A **Browse For Folder** window should appear. Select a location on your computer to save the shapefile and click **OK**. Notice an alert at the bottom of the screen indicating that assets have successfully exported. By default, the shapefile will be named **SHP_PolylineZ.shp** and it can be opened in Google Earth, if necessary. **Note:** The EOP lines might be offset since no projection correction was applied.



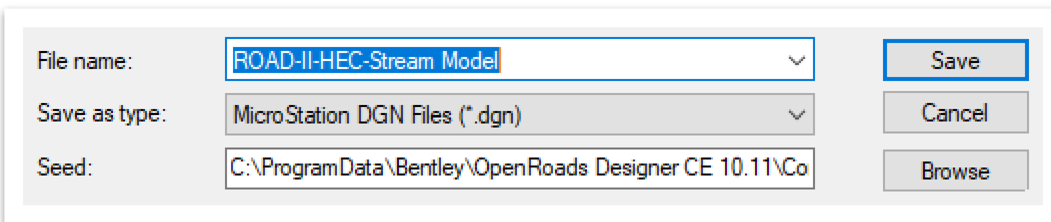
Appendix F. Preparing ORD Data for HEC-RAS

HEC-RAS is an analysis tool to perform one-dimensional and two-dimensional hydraulic calculations of natural and constructed channels, overbank/floodplain areas, levee protected areas, etc. HEC-RAS uses a built-in geospatial tool to provide a visual representation of the analysis. The results can be exported from HEC-RAS to ORD to capture channel and overbank/floodplain area impacts along a stream reach within project areas.

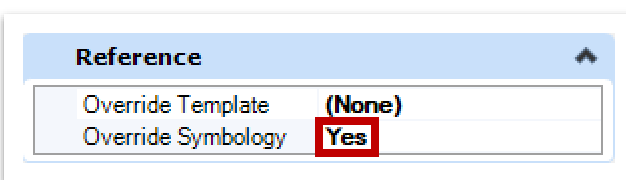
F.1 Exercise: Exporting Stream Geometry from ORD into a HEC-RAS Model

In this exercise, we will add the applicable stream survey geometry and cross sections into ORD and then export the data that can be used in a HEC-RAS model.

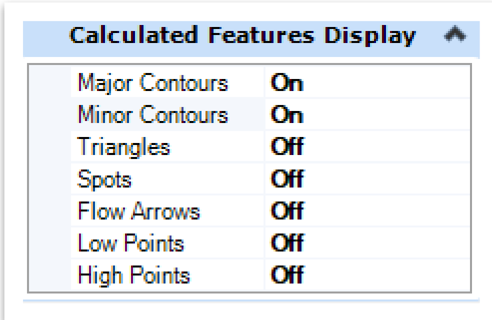
1. Create a new file and name it **ROAD-II-HEC-Stream Model**. Select the **TDOT Seed2D.dgn** and click **Save**. **Note:** Save this file under the dgn Appendix\ Appendix F subfolder.



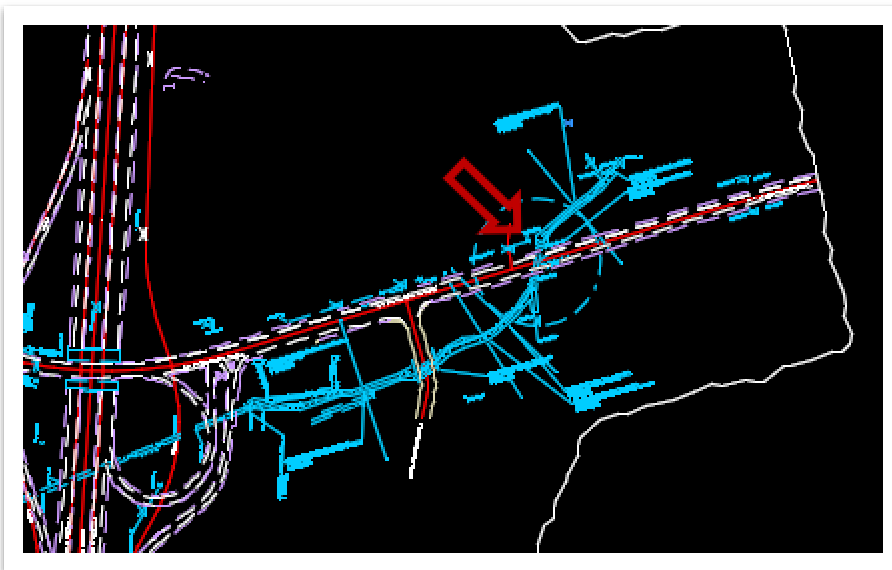
2. Make sure that the **Default** view is active in the lower left corner. Attach the following reference files using the **Coincident World** attachment method.
   - ROAD-II-HEC-Alignments.dgn
   - ROAD-II-HEC-Survey.dgn
   - ROAD-II-HEC-Terrain.dgn (Set terrain to active)
3. Next, select the terrain boundary and open the **Properties**. Under the **Reference** header, change the **Override Symbology** to **Yes**. **Note:** This allows the user to control which terrain elements are displayed.



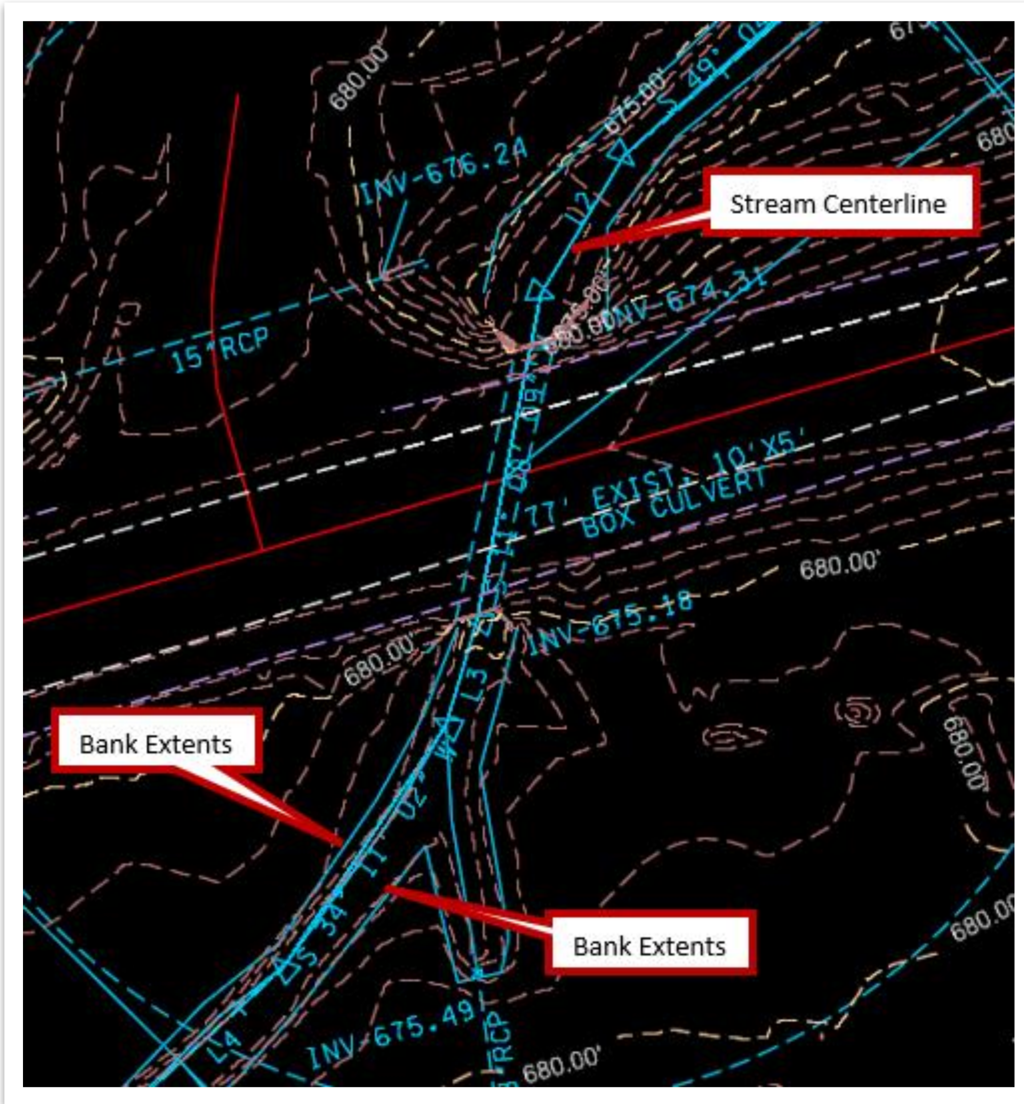
4. Under **Calculated Features Display** header, change the **Major** and **Minor Contours** to **On**, and confirm that the **Triangles** are **Off**.



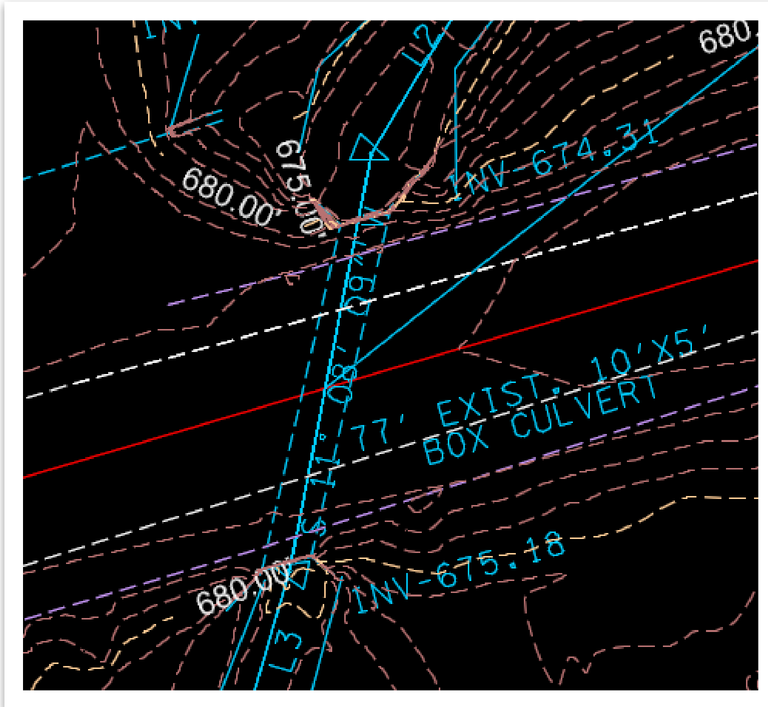
5. Zoom to the dashed blue circle at the existing box culvert on the eastern side of the project.



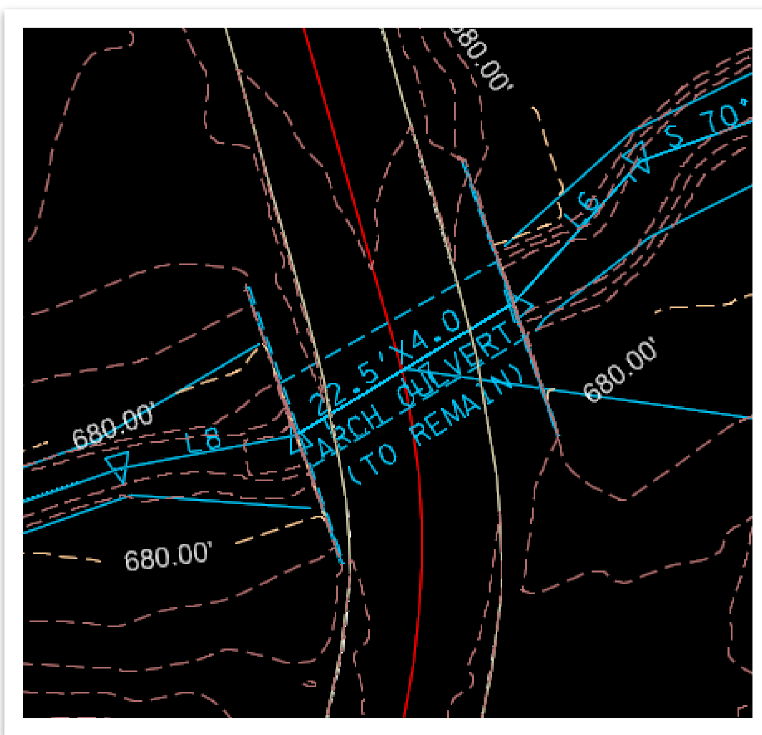
6. The survey reference file provides mapped survey elements for the project area including the stream centerline for **Pumpkin Creek Branch**, bank extents, endwalls, and pipe/culvert invert elevations. **Note:** The next three steps will be a review of the survey data along the stream.



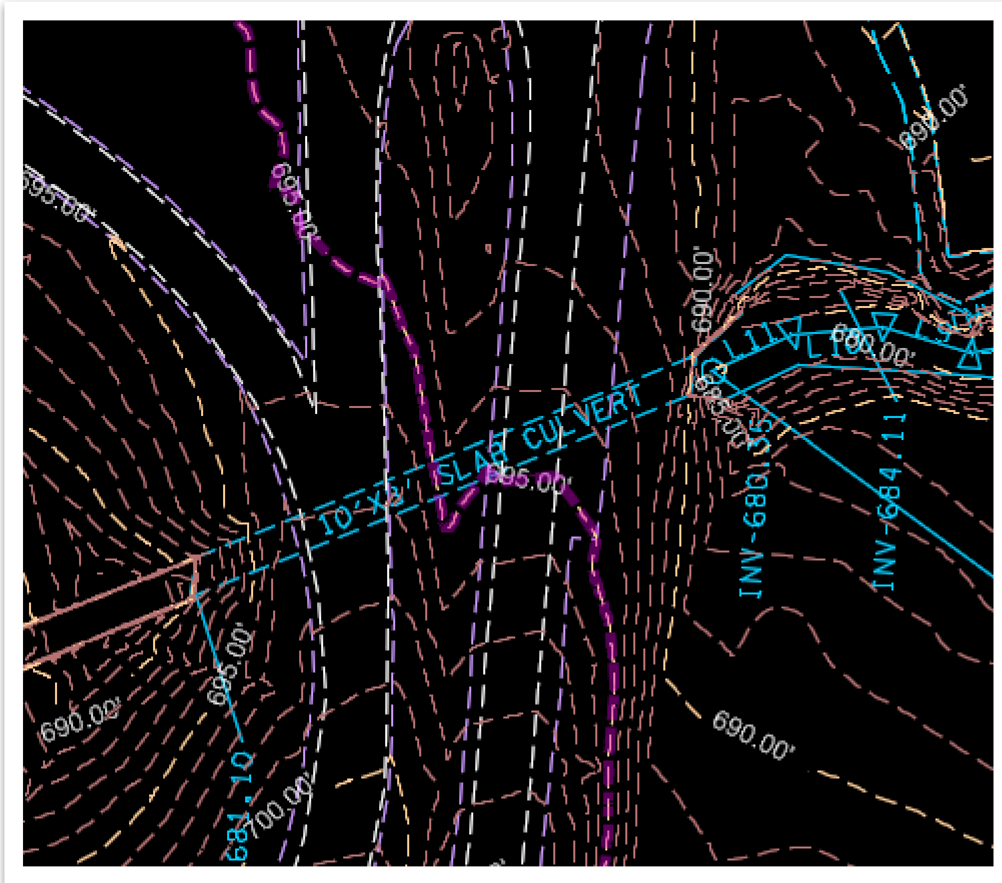
7. Now let's review the survey data along the stream and locate the existing **77'** long **10' x 5' box culvert** within the dashed blue circle.



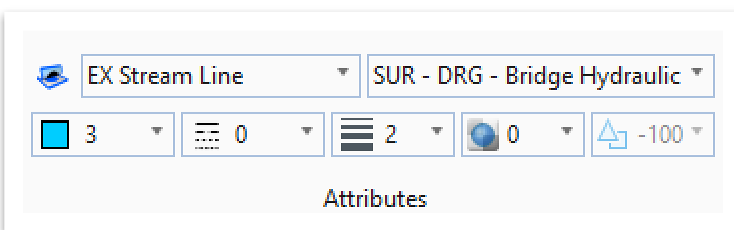
8. Follow the stream **CL** upstream (in the southwest direction) and locate the existing **64'** long **22.5' x 4.0' arch culvert**.



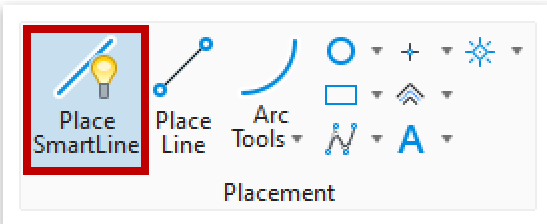
9. Continue to follow the stream **CL** upstream to the end of the survey data and locate the existing **483’** long **10’ x 8’ slab culvert** that crosses through the interchange.

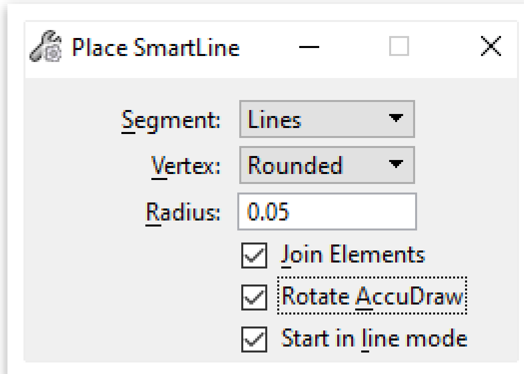


10. Next, we need to trace the stream **CL** for **Pumpkin Creek**. Select the **EX Stream Line** element template (**Survey >> Drainage >> Natural >> Existing**). **Note:** The stream CL is drawn from downstream to upstream.

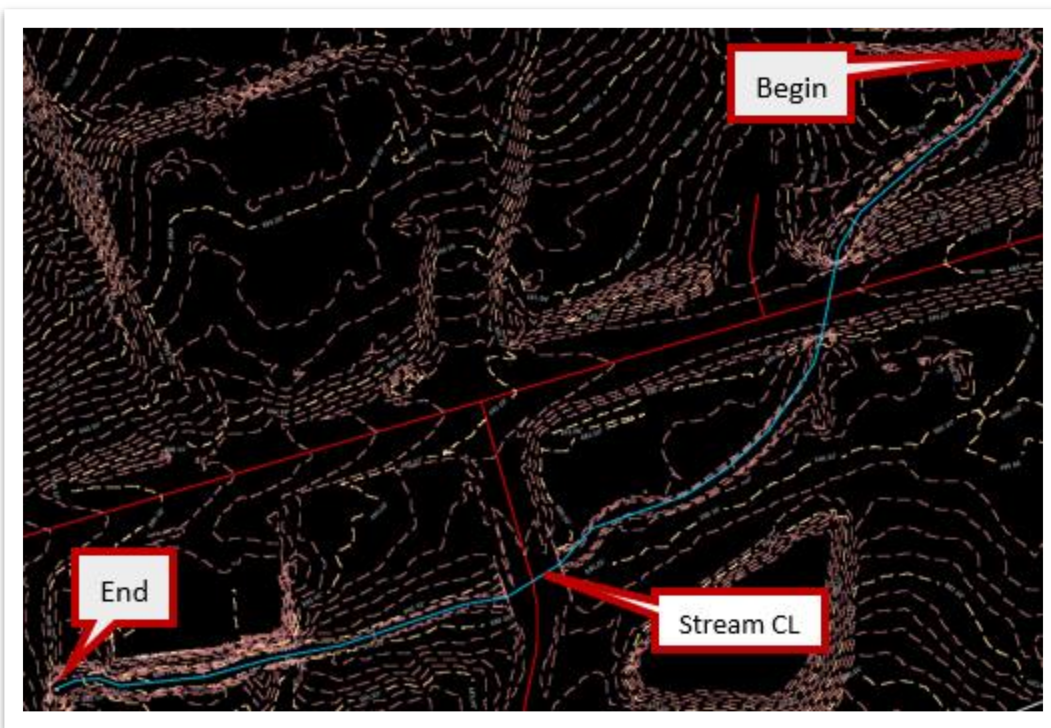


11. Open the **Place SmartLine** tool (**OpenRoads Modeling >> Drawing >> Placement**) and select the settings shown below.

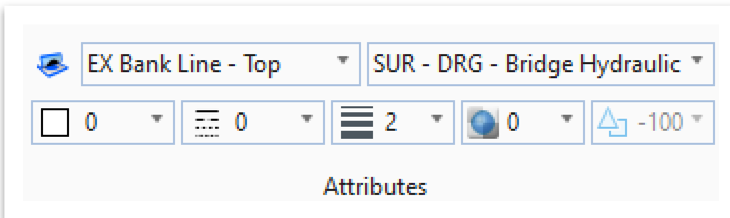




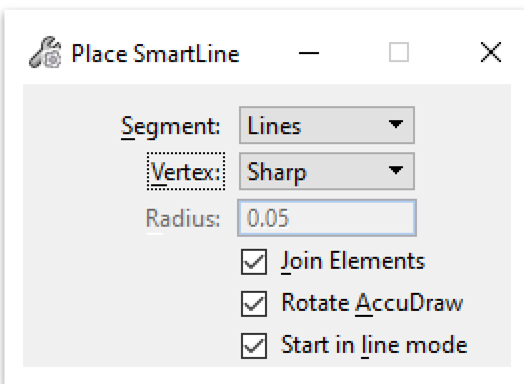
12. Starting on the north side of the roadway at the **downstream** end of **Pumpkin Creek** (Station **700+00.00**), trace a SmartLine along the stream **CL** to the **upstream** end at the interchange ramp (Station **712+85.73**). Then, set the chain start station to **700+00.00**. Once complete, turn off the **ROAD-II-HEC-Survey.dgn** reference file to view the stream CL. **Note:** There are two overlapping centerlines: one that is broken into segments and one that covers the entire length. Make sure to trace the latter.



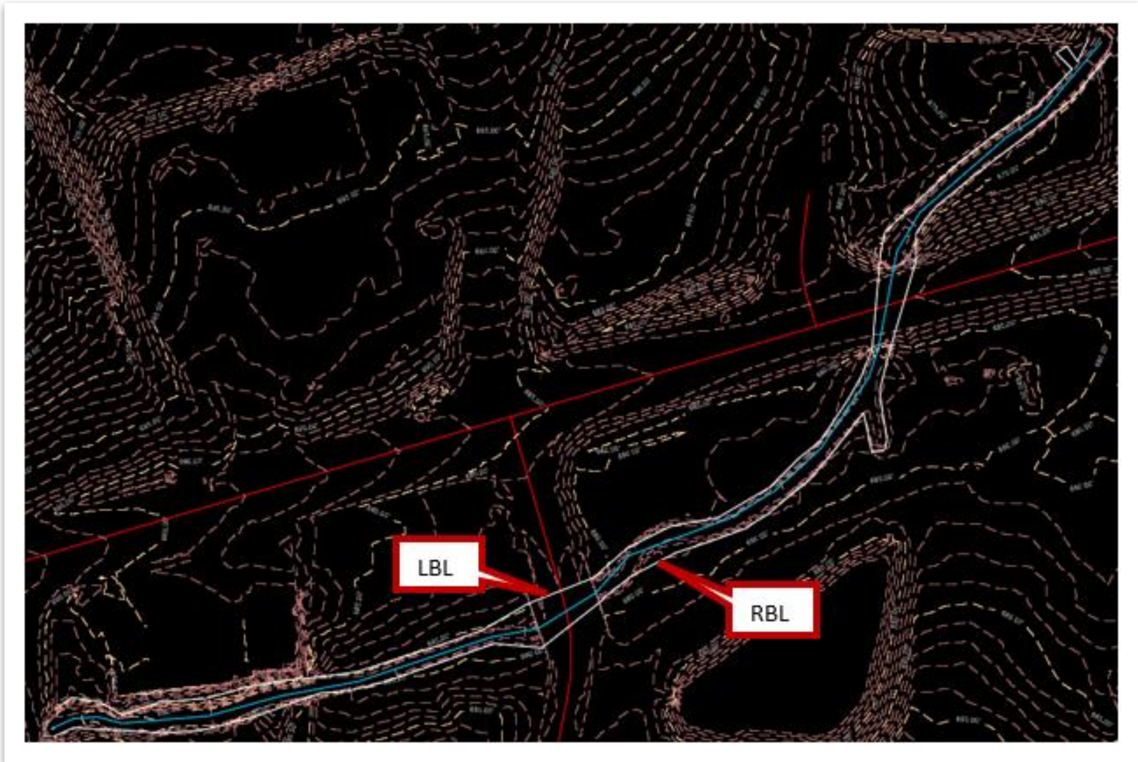
13. Now we need to draw in the **left** and **right** banks of the stream. Turn the **ROAD-II-HEC-Survey.dgn** reference file back on. Select the **EX Bank Line - Top** element template (**Survey >> Drainage >> Natural >> Existing**). **Note:** The provided survey for this project has already defined the stream banks. Bank lines will not always be defined in the survey file and may require the designer to draw in the bank lines either by using a direct offset from the stream CL or by using individual survey points.



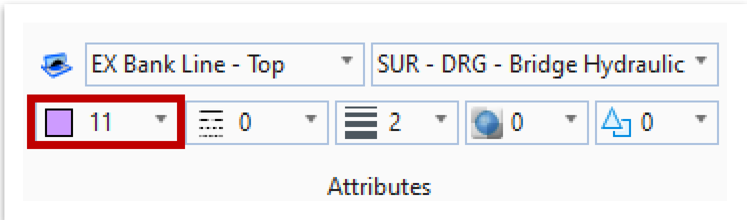
14. The left bank line (**LBL**) and right bank line (**RBL**) are established from the stream CL facing downstream. For this exercise, the LBL will be on the left (northwest), and the RBL will be on the right (southeast). Open the **Place SmartLine** tool once again (**OpenRoads Modeling >> Drawing >> Placement**) and select the settings shown below.



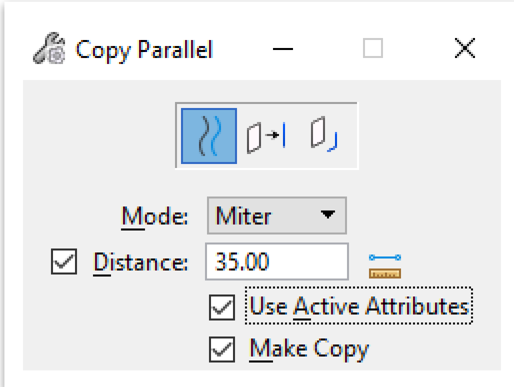
15. Trace the **LBL** from the survey starting at the **downstream** end of **Pumpkin Creek** going towards the **upstream** end. Whenever there is a break in the survey bank line, connect the bank line to where it reappears to maintain a continuous line. Then, trace the **RBL**. Once complete, turn off the **ROAD-II-HEC-Survey.dgn** reference file once again to view the stream bank lines.



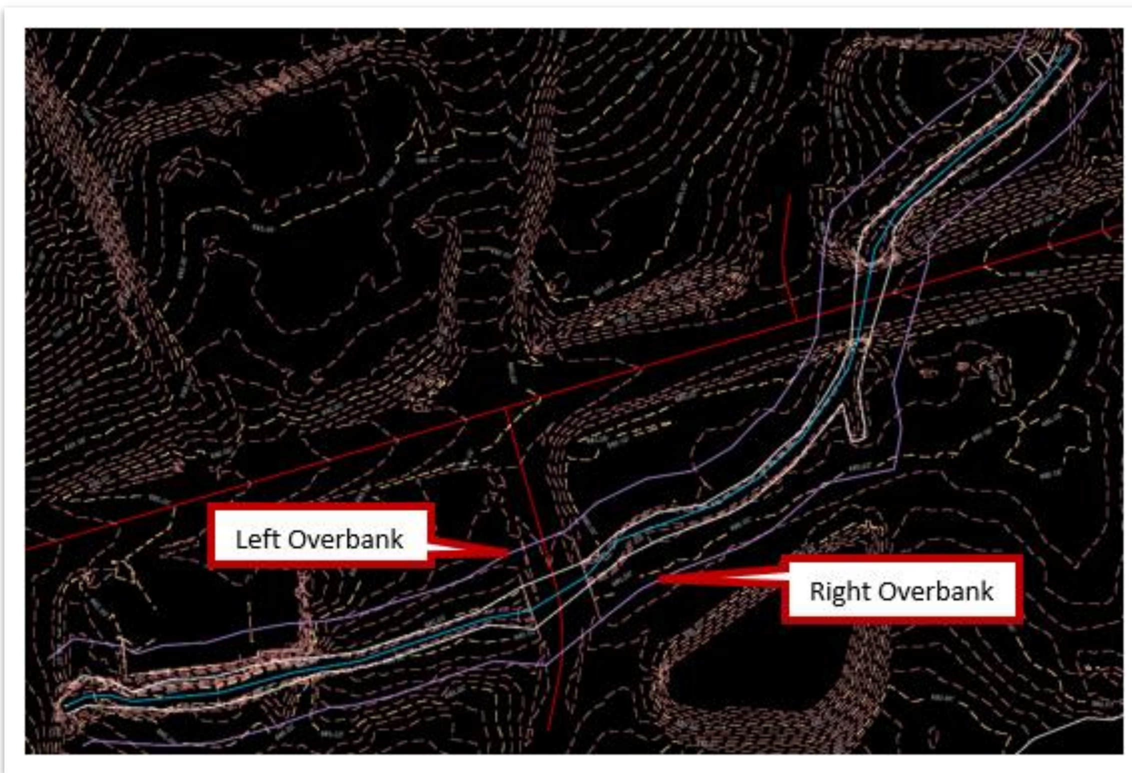
16. Next, we need to draw in the left overbank line (**LOB**) and right overbank line (**ROB**) using a **35'** offset from the LBL and RBL. Turn the **ROAD-II-HEC-Survey.dgn** reference file back on. Using the same **EX Bank Line - Top** element template, change the line color to **11** (purple). **Note:** The user can select any line style attributes. For this exercise, however, a specific color was chosen to provide a visual difference between the features drawn.



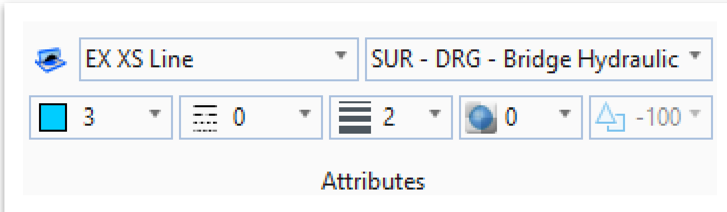
17. Open the **Move Parallel** tool (**OpenRoads Modeling >> Drawing >> Manipulate**) and select the settings shown below.



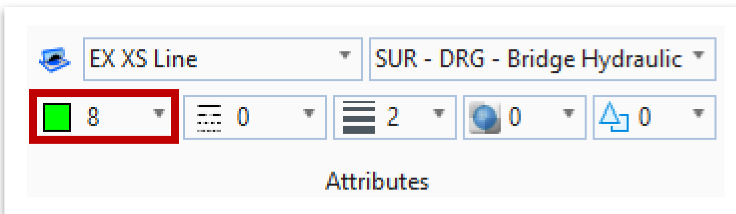
18. Select the **LBL** and **left** click to the outside of the stream to offset the LBL by 35'. Then, select the **RBL** and **left** click to the outside of the stream to offset the RBL by 35'. Once complete, turn off the **ROAD-II-HEC-Survey.dgn** reference file once again to view the stream bank lines. **Note:** If necessary, you can check and remove any extra vertices or kinks in the overbank lines to smooth them out. For this exercise, the overbank lines were not altered.



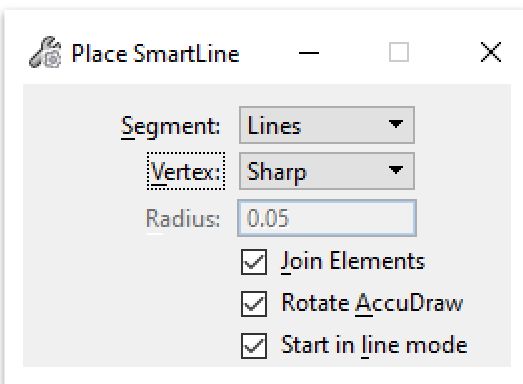
19. Now we need to draw the cross section lines along the stream. Turn the **ROAD-II-HEC-Survey.dgn** reference file back on. Select the **EX XS Line** element template (**Survey >> Drainage >> Natural >> Existing**).



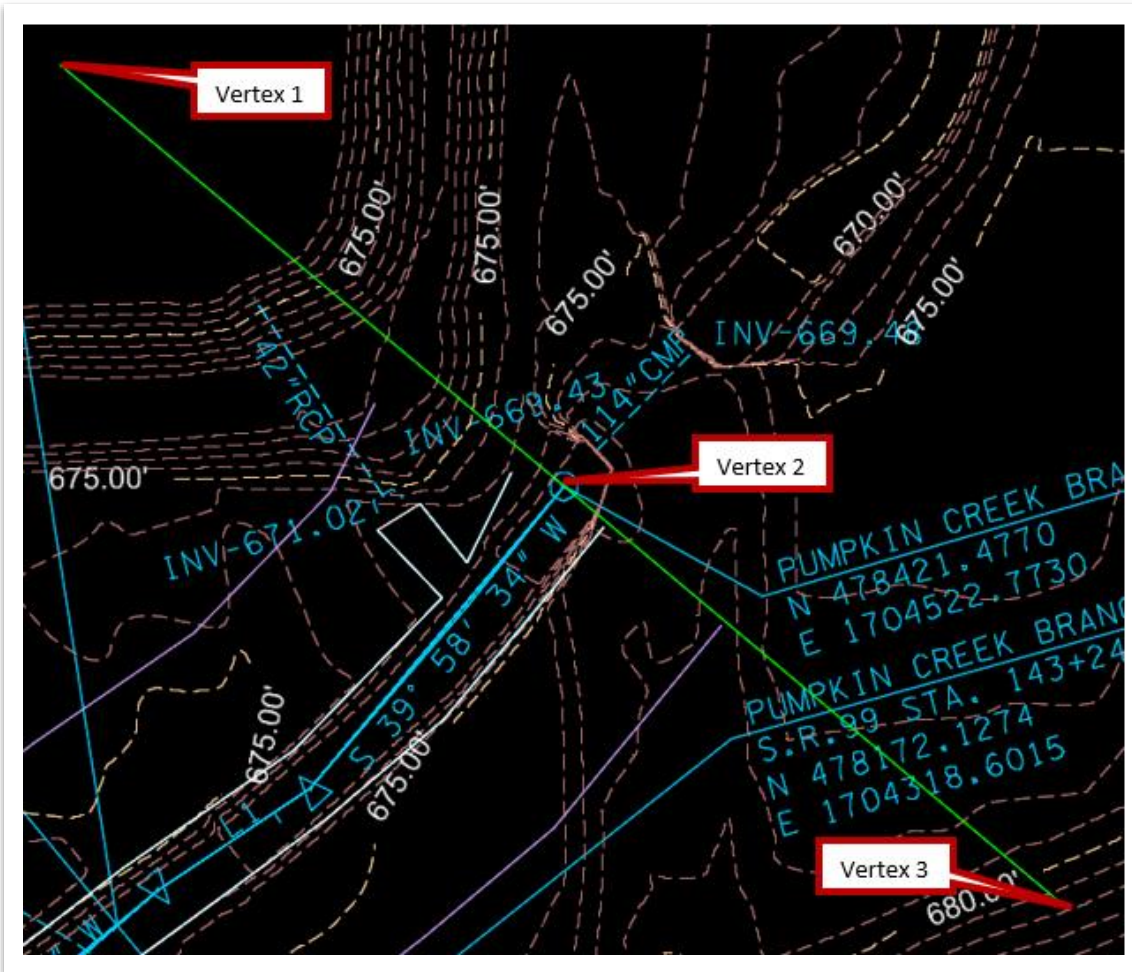
20. Change the line color to **8** (green). **Note:** Once again, the user can select any line style attributes. For this exercise, however, a specific color was chosen to provide a visual difference between the features drawn.



21. Open the **Place SmartLine** tool once again (**OpenRoads Modeling >> Drawing >> Placement**) and select the settings shown below.



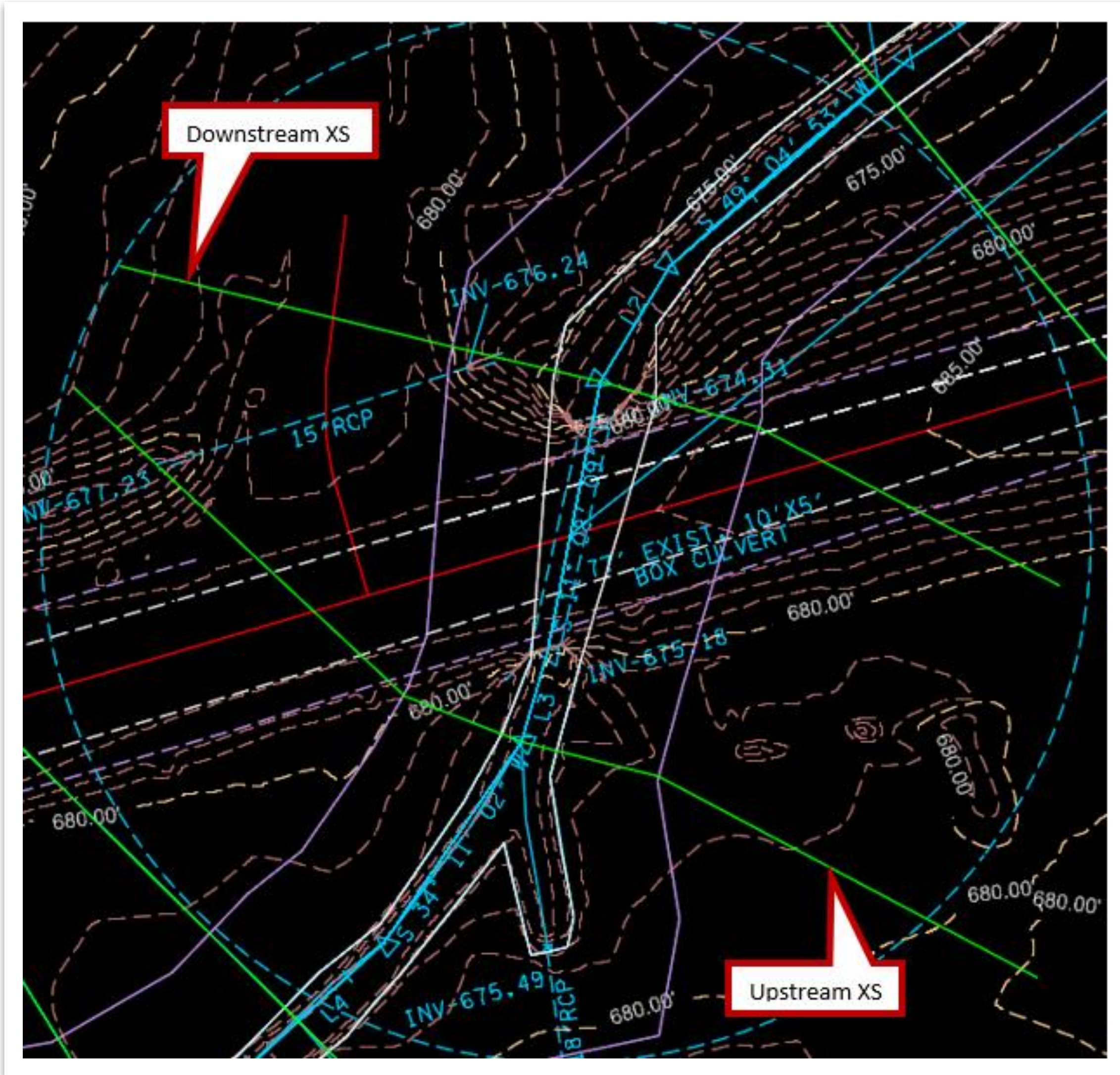
22. Let's first draw the cross section line at the **downstream** end of **Pumpkin Branch** (Station **700+00.00**). Place the first vertex on the northwest side of the stream CL, the second vertex directly on the stream CL, and the third vertex on the southeast side of the stream CL, as shown below. **Note:** Cross sections are drawn from left to right looking downstream along the stream CL. Also, the number of XS vertices can vary at each XS line. Vertices should be added as necessary to ensure the XS line is perpendicular to the contours outside the bank lines and perpendicular to the stream CL within the bank lines.



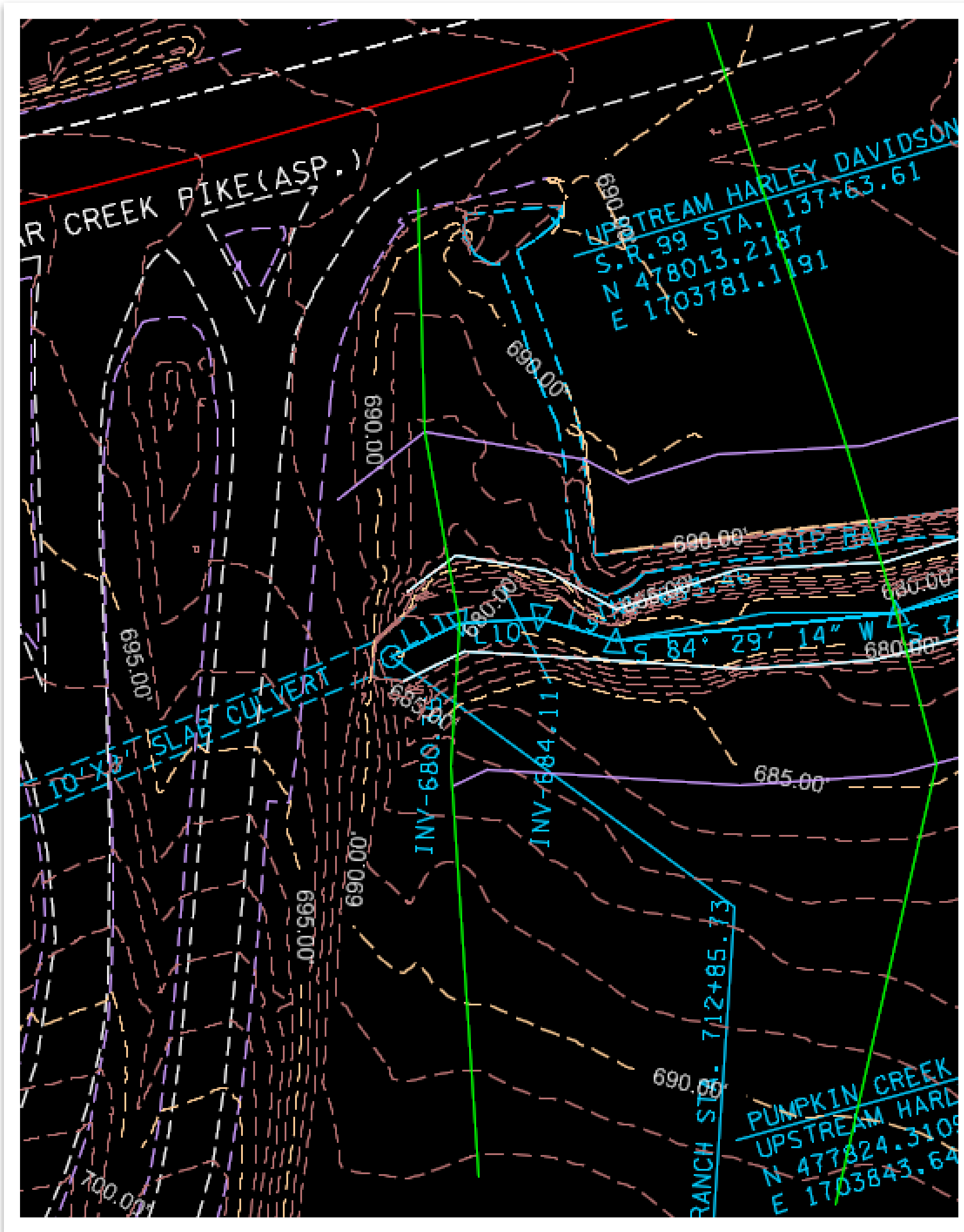
Take Note!

Do not place bounding cross sections near the survey limits or culvert openings. The terrain in these areas may vary in accuracy due to the terrain triangle connections in these challenging areas.

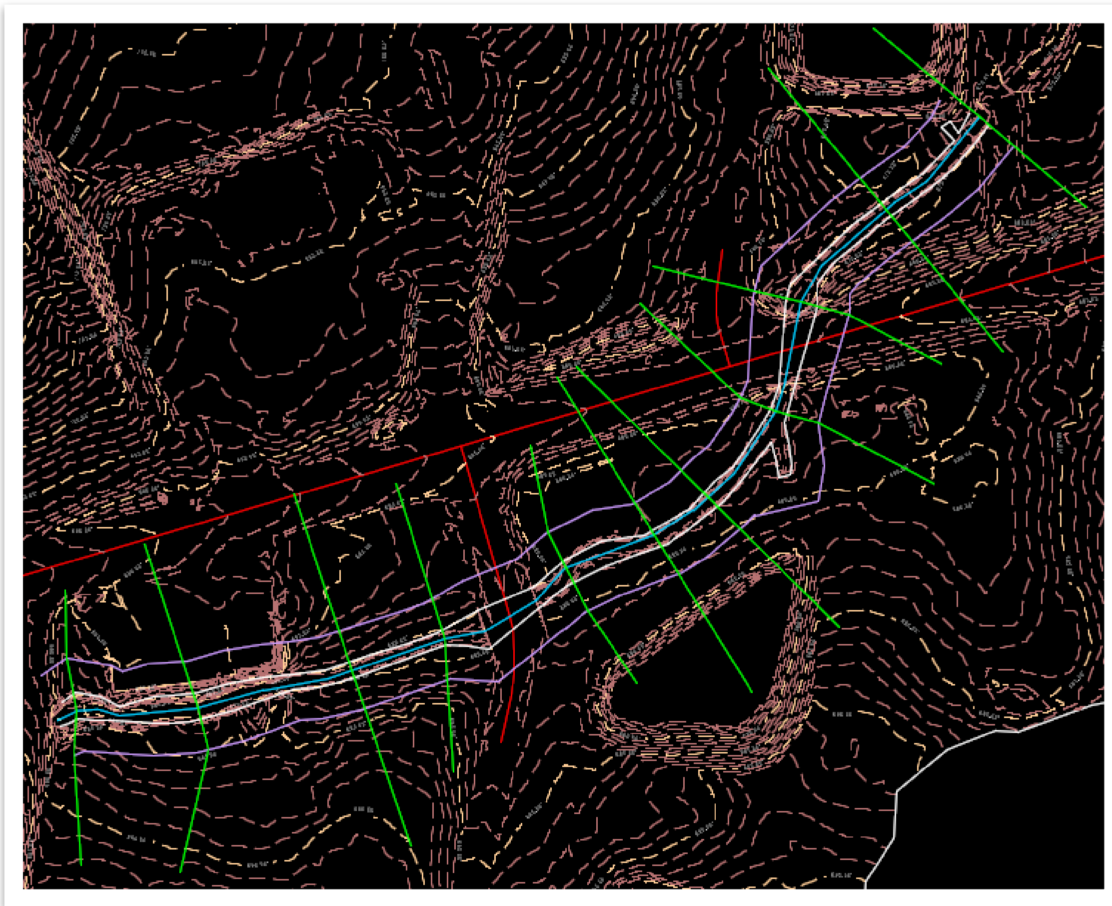
23. For the remaining cross section lines, go ahead and first trace the **four** provided in the survey reference file. Like the downstream cross section line, trace in the northwest to southeast direction. It is recommended to draw at least **two** cross section lines on <u>both</u> the downstream and upstream sides of a culvert. Since some of the cross section lines have already been traced in from the survey, we need to add **one** additional cross section line on each side of the **box culvert** <u>and</u> **arch culvert**. Add vertices as necessary when drawing in the cross section lines. **Note:** The upstream and downstream XS lines for the **box culvert** are shown below.



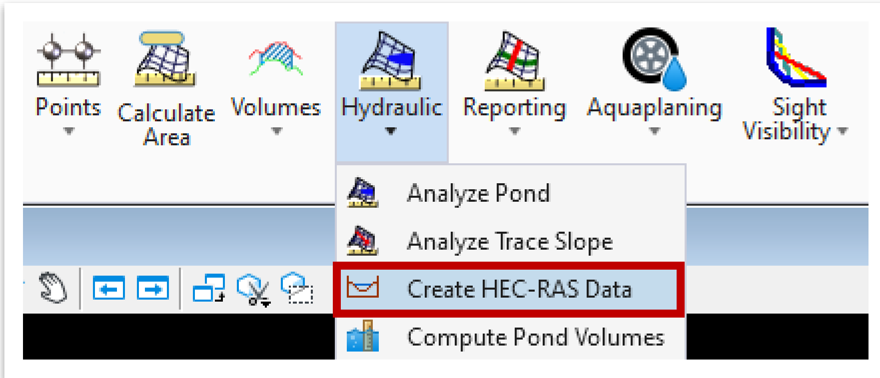
24. Next, we need to draw a cross section line just **downstream** of the **slab culvert** at the upstream end of **Pumpkin Creek** (approximate Station **712+62.95**). Finally, draw in the last cross section line about equal distance between the cross section line just drawn and the next survey cross section line downstream. Again, add vertices as necessary. **Note:** Your cross section station does not need to match exactly. The stationing will vary depending on how the SmartLine was drawn.



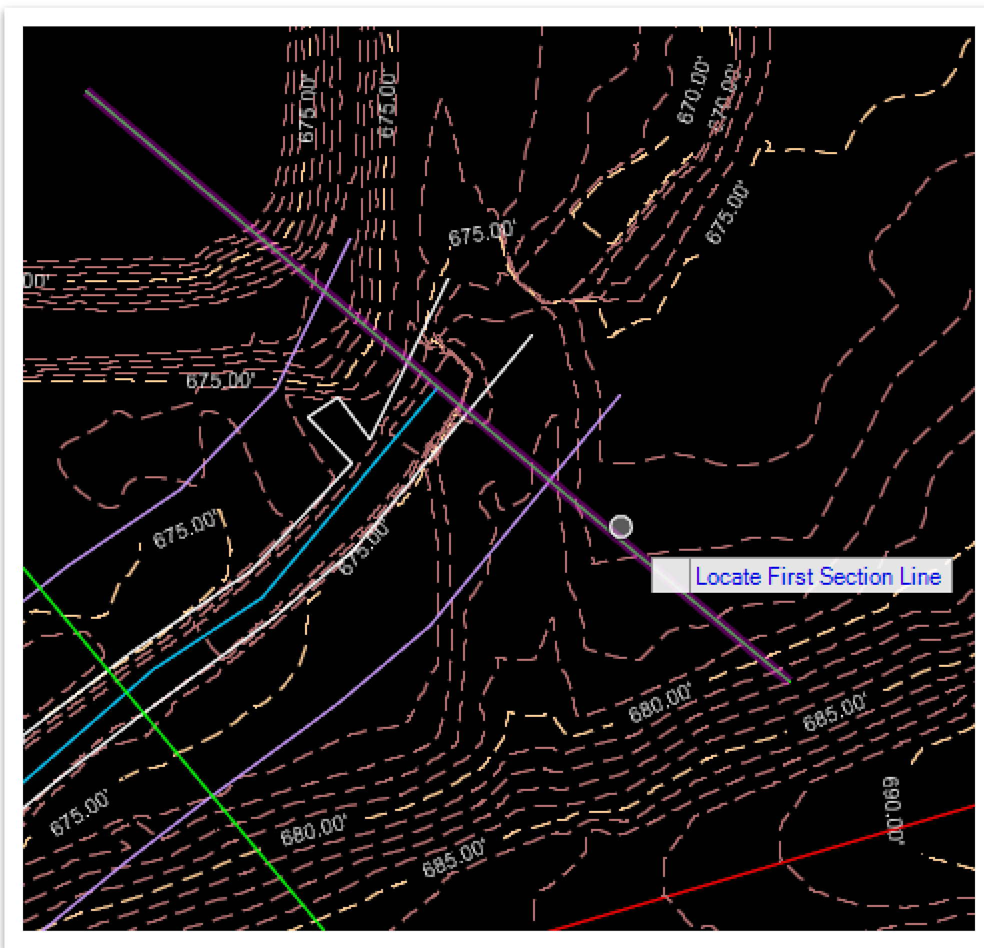
25. Go ahead and turn off the **ROAD-II-HEC-Survey.dgn** reference file to confirm that all **eleven** cross section lines are visible. For reference, the cross section lines below are drawn at the following stations: **700+00.00**, **701+43.99**, **702+80.36**, **704+02.55**, **705+21.74**, **705+92.77**, **706+95.26**, **708+53.03**, **709+57.76**, **711+30.40**, and **712+62.95**. **Note:** Your cross section stations do not need to match exactly. The stationing will vary depending on how the SmartLines were drawn. Also, if the bank/overbank lines do not extend beyond the cross section lines at the beginning/end of the stream, HEC-RAS will not be able to recognize those cross section lines once exported. Open the **Extend Line** tool if necessary (**OpenRoads Modeling >> Drawing >> Modify**) and extend the bank and overbank lines beyond the cross section lines.



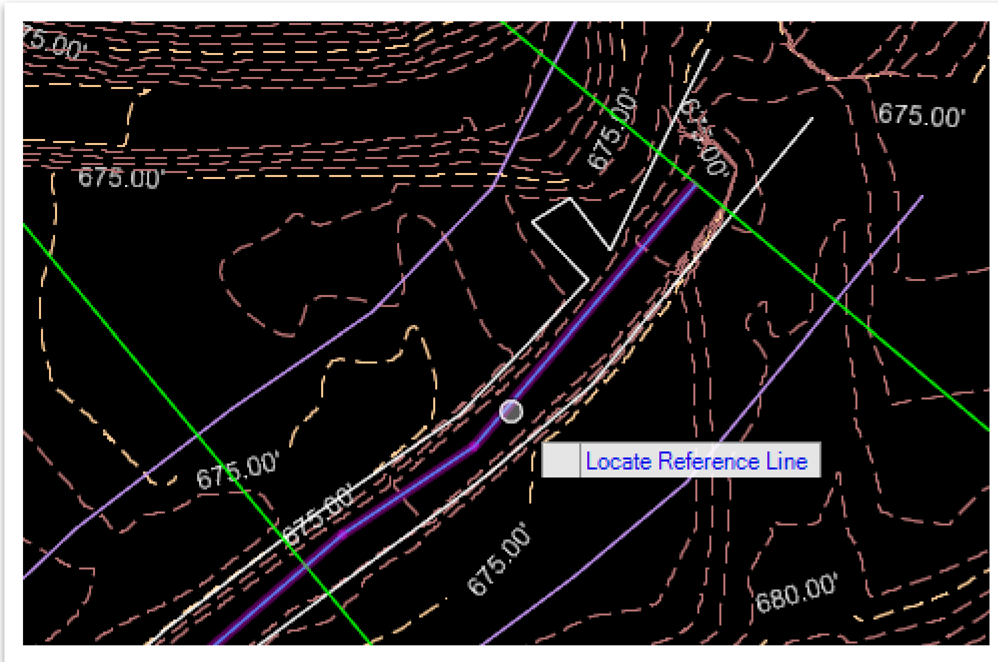
26. We will now export the stream model into a format that can be opened in the HEC-RAS software. Open the **Create HEC-RAS Data** tool (OpenRoads **Modeling >> Terrain >> Analysis**).



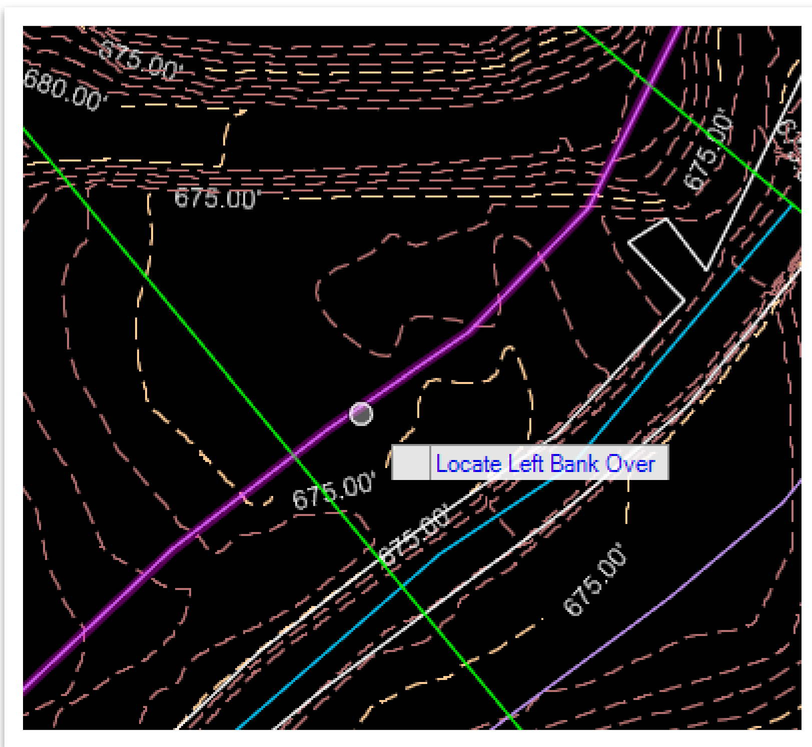
27. Notice the first prompt: **Locate First Section Line**. Select the **first** cross section line on the **downstream** end of Pumpkin Creek (north side of the roadway). Then, select the remainder of the cross section lines in the **upstream** direction and **right** click to end the selection.



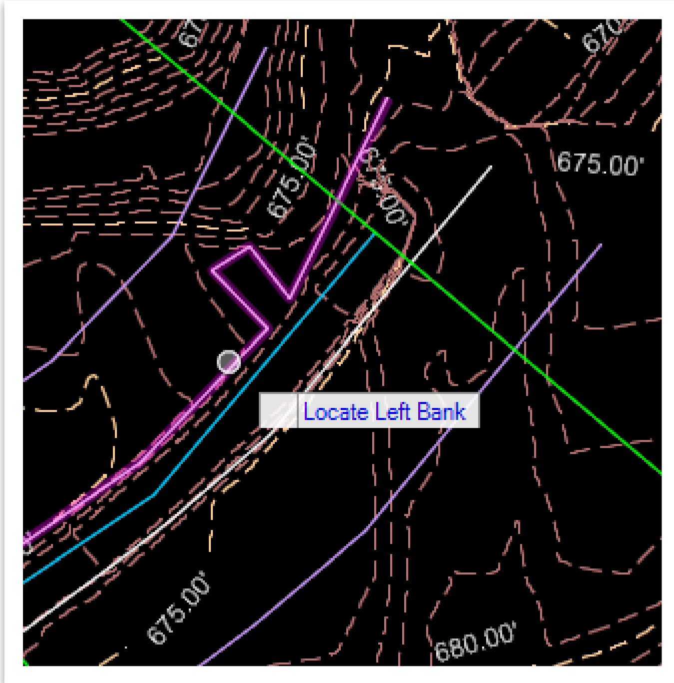
28. Notice the next prompt: **Select Terrain**. The terrain should have previously been set to active so **right** click to use the active terrain. If not, go ahead and select the terrain boundary.
29. Notice the next prompt: **Locate Reference Line**. Select the stream **CL**.



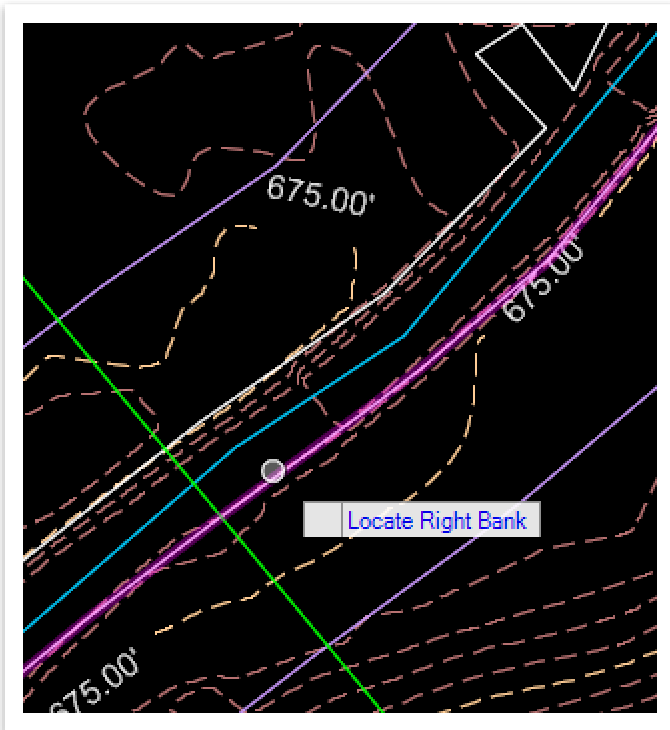
30. Notice the next prompt: **Locate Left Bank Over**. Select the **left** overbank line.



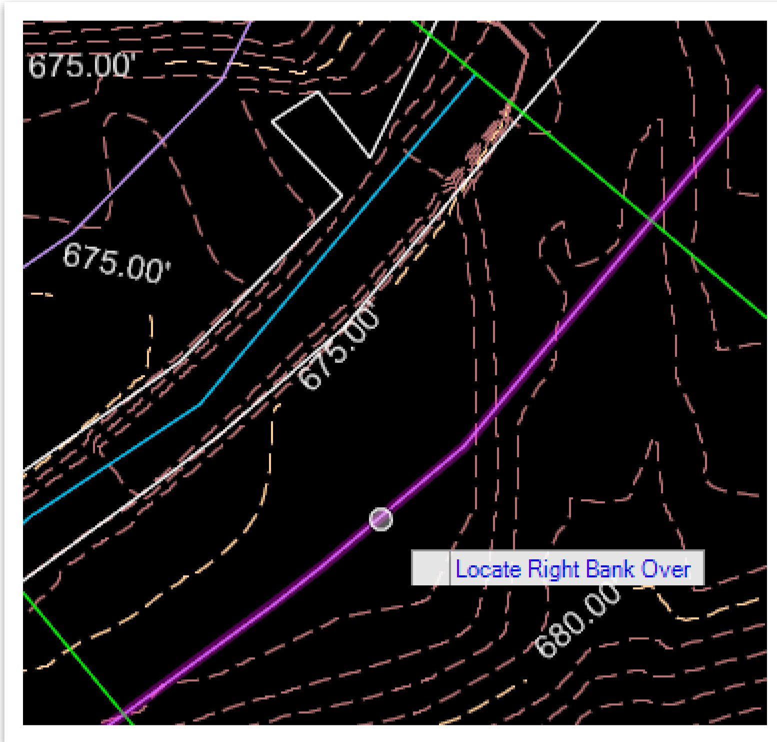
31. Notice the next prompt: **Locate Left Bank**. Select the **LBL**.



32. Notice the next prompt: **Locate Right Bank**. Select the **RBL**.



33. Notice the last prompt: **Locate Right Bank Over**. Select the **right** overbank line.



34. A **Create HEC-RAS Data** window should appear. For this exercise, browse to your **Documents** folder and create a new subfolder called **HEC-RAS**. Save the **ROAD-II-HEC-Stream Model.geo** file in this location. This export would then be used in HEC-RAS. Since this manual does not cover HEC-RAS modeling, go ahead and close ORD.