Introduction to Drainage Layout and Hydraulics

This course is suitable for the **2024 Release 2** *versions of:*

OpenSite Designer CONNECT Edition

OpenRoads Designer CONNECT Edition

OpenRail Designer CONNECT Edition

About this Practice Workbook...

- This workbook is designed for use in Live instructor-led training and for OnDemand self study. OnDemand videos for this course are available on the *LEARNserver*
- This PDF file includes bookmarks providing an overview of the document. Click on a bookmark to quickly jump to any section in the file.
- This course workbook uses the *Training and Examples* WorkSpace and the *Training-Imperial* WorkSet delivered with the software.
- The terms “Left-click”, “Click”, “Select” and “Data” are used interchangeably to represent pressing the left mouse button. The terms “Right-click” and “Reset” are also used interchangeably to represent pressing the right mouse button. If your mouse buttons are assigned differently, such as for left-handed use, you will need to adjust accordingly.

Have a Question? Need Help?

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

Bentley Institute

Edition **07-02**

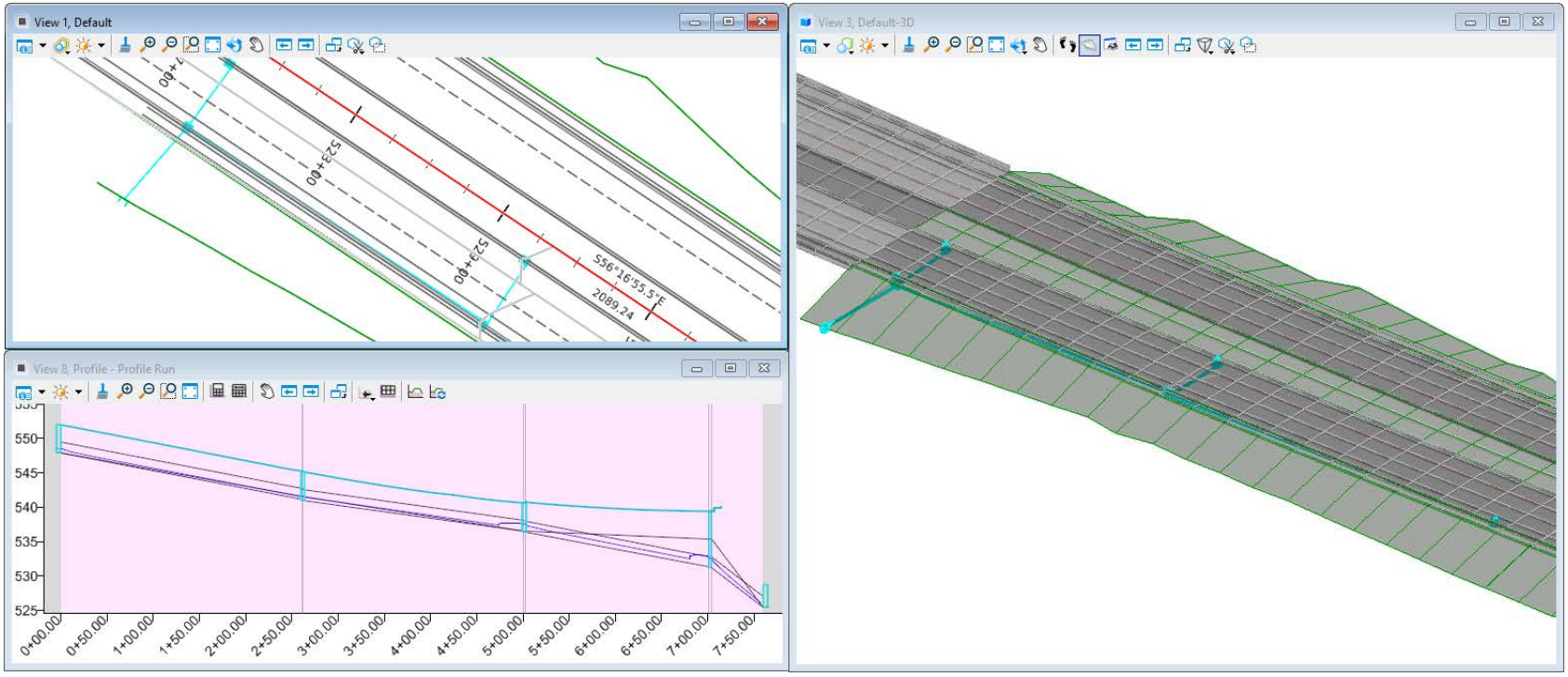
Course Level: **Fundamental**

Course Overview

In this course you will learn how to create and design a highway drainage system consisting of Inlets, Manholes, Outlets, Pipes, and Drainage Areas.

Topics covered in the course include placing drainage structures, placing drainage areas, placing drainage pipes and computing flows through the system. We will also cover creating profiles of the system.

It is assumed that you have a basic understanding of the OpenSite, OpenRoads or OpenRail Designer products including navigating the interface, using terrain models, horizontal and vertical geometry, and corridors.



Exercise 1: Create Proposed Drainage Design File and Attach Project Reference Files

Description

In this exercise, you will learn how to create a proposed drainage design file and attach the project reference files.

Skills Taught

- Create Project Design File
- Attach Project Reference Files
- Attach Reference Files
- Set an Active Terrain
- View 2D and 3D Models
- Display Styles

Create a Drainage Design File

In this section, you will start the software and create a new design file.

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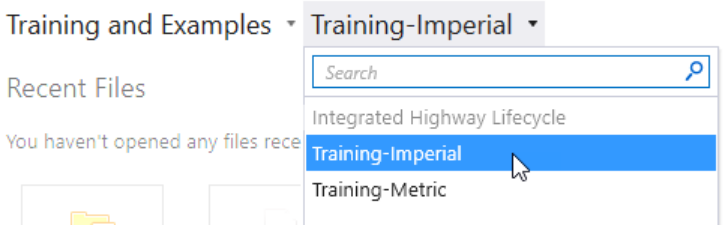
1. Start the software.
2. Set the WorkSpace and WorkSet.

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

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

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

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



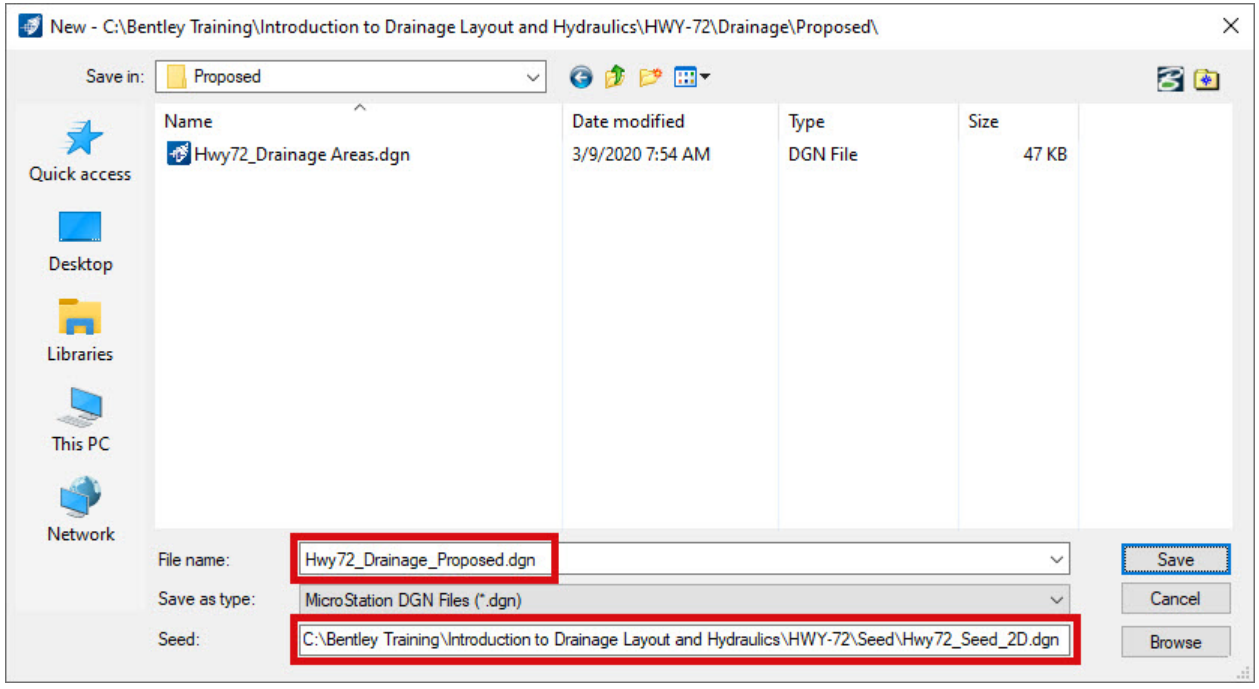
3. Create a new 2D Design file. This new file will be used for placing our drainage structures and pipe network for our project.

   a. Select **New File**.

   b. Browse to *C:\Bentley Training\Introduction to Drainage Layout and Hydraulics\HWY-72\Drainage\Proposed* or other folder where you unzipped the dataset files.

   c. In the *File name* field enter **Hwy72_Drainage_Proposed.dgn**.

   d. Set the *Seed* to *C:\Bentley Training\Introduction to Drainage Layout and Hydraulics\Seed***Hwy72_Seed_2D.dgn**.



   e. Click **Save**. The new file will be created and opened.

Attach Project Data

In this section you will attach the necessary project data to assist us with laying out our drainage network.

This will include but not limited to: Existing Survey, Existing Utilities, Proposed Roadway Design Planimetrics, Roadway Corridor and Proposed Terrain.

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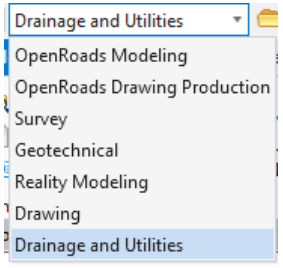
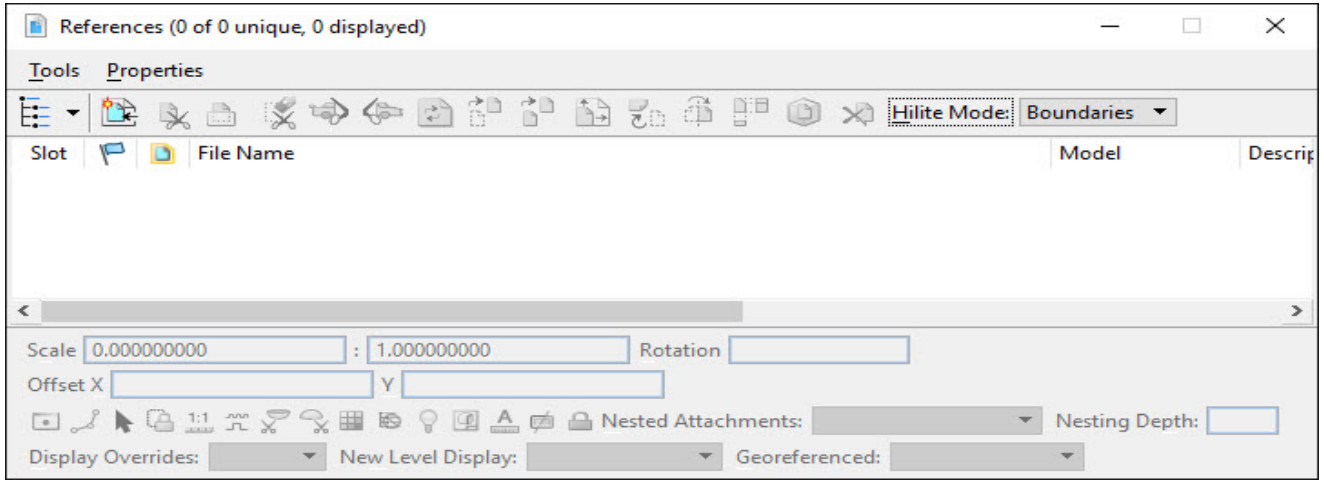
1. Select the **Drainage and Utilities** workflow from the drop down menu.

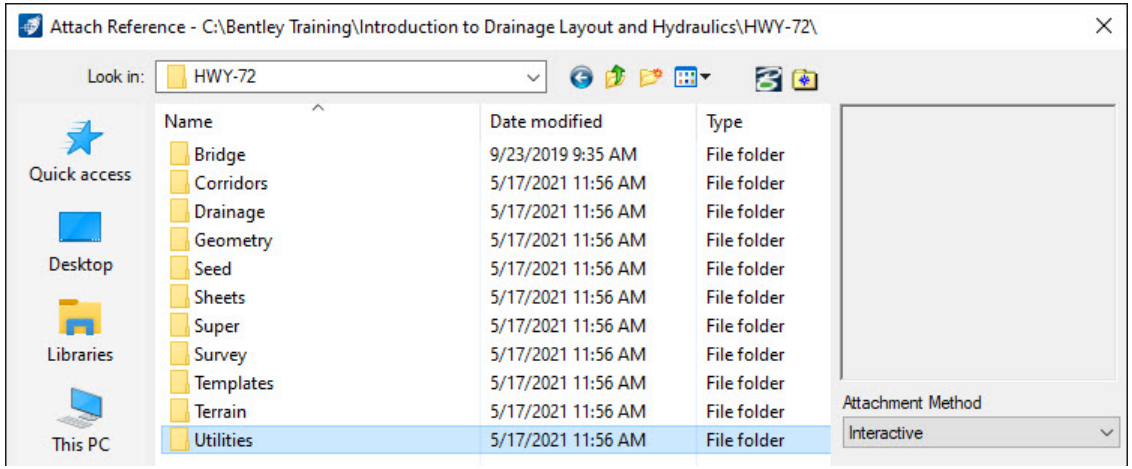


2. Click the **References** tool under *Home > Primary > Attach Tools >* **References.**



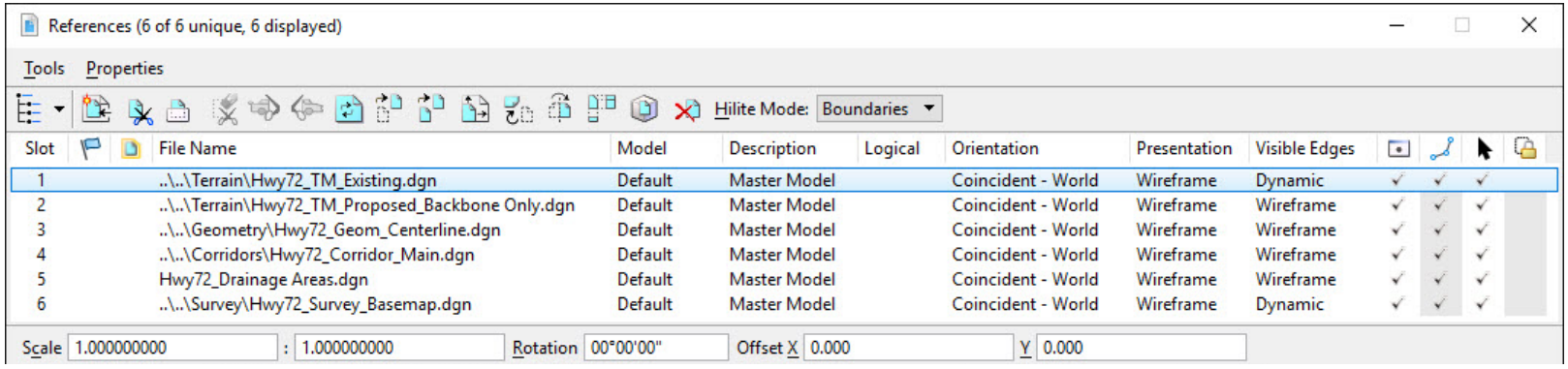
3. In the References dialog, from the *Tools* pull down menu, select **Attach...**.

   Our project data is federated into multiple files within multiple folders. The existing survey is in the **Survey** folder, the existing and proposed terrain is in the **Terrain** folder, the corridors are in the **Corridors** folder, Alignments are in the **Geometry** folder. We will need to go to each folder and select the appropriate project files that we want.

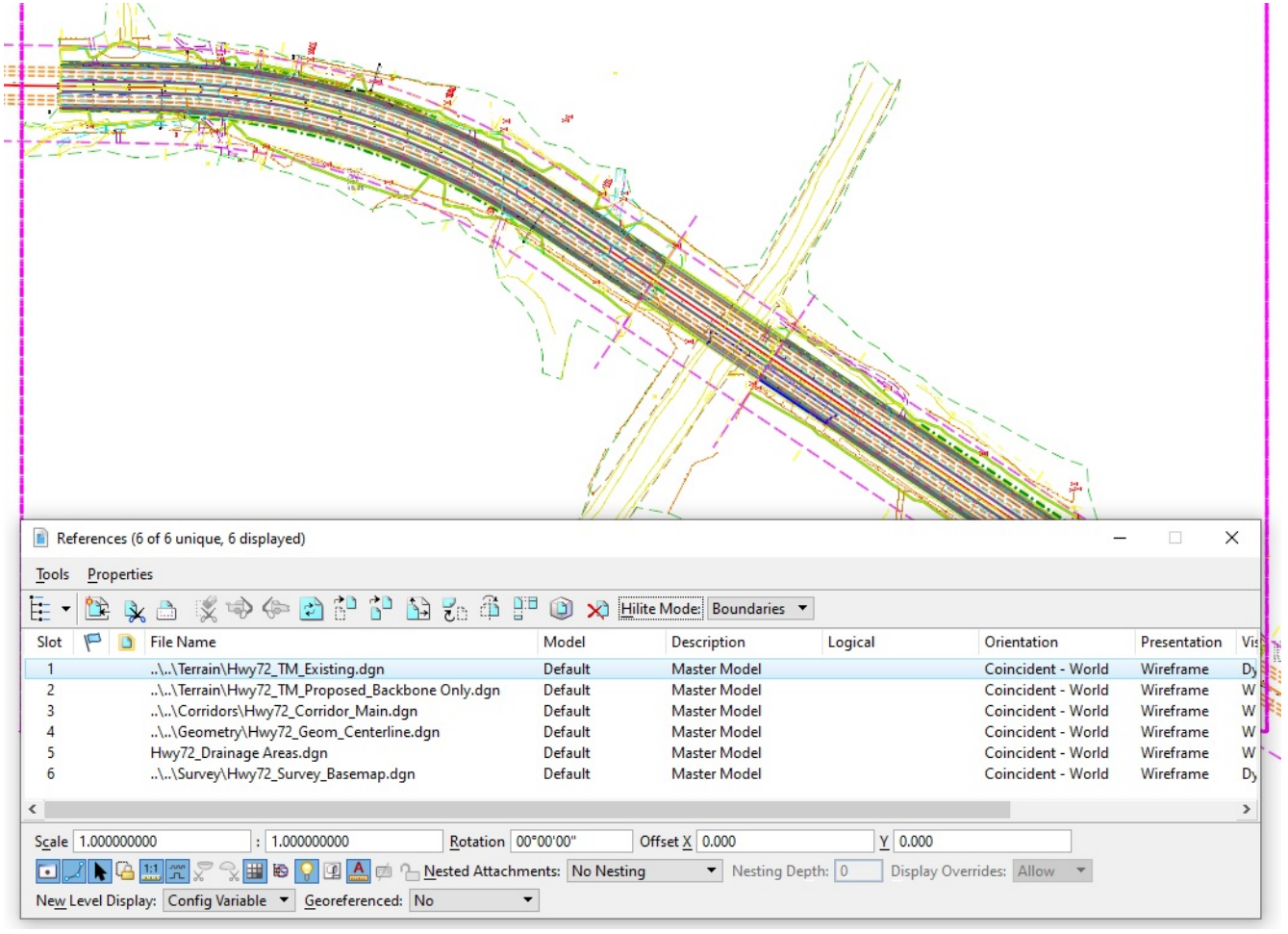


4. In the **Attach Reference** dialog, navigate to the following folders/files and attach them **one** at a time. Set the *Attachment Method* to **Coincident World**.

   - *\Bentley Training\Introduction to Drainage Layout and Hydraulics\HWY-72\Terrain***Hwy72_TM_Existing.dgn**
   - *...\HWY-72\Terrain***Hwy72_TM_Proposed_Backbone Only.dgn**
   - *...\HWY-72\Geometry***Hwy72_Geom_Centerline.dgn**
   - *...\HWY-72\Corridors***Hwy72_Corridor_Main.dgn**
   - *...\HWY-72\Drainage\Proposed***Hwy72_Drainage Areas.dgn**
   - *...\HWY-72\Survey***Hwy72_Survey_Basemap.dgn**

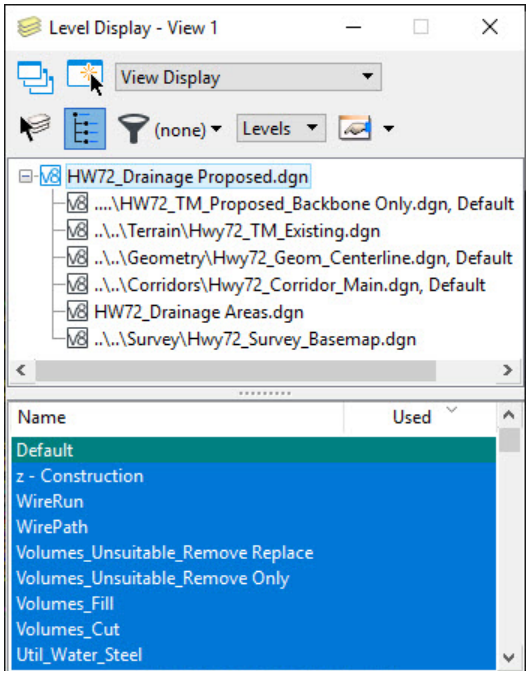


5. Click the **Fit View** Icon and then **Window Area** or **Zoom** into the main project area.



6. Close the **References** dialog.

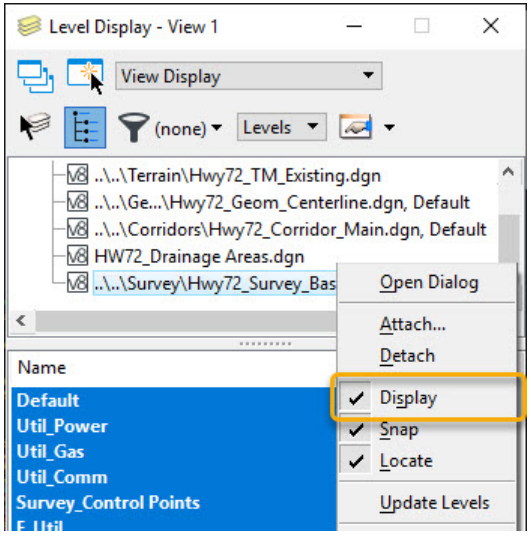
7. Click the **Levels Display** tool under the *Home* > *Primary* > **Level Display.**



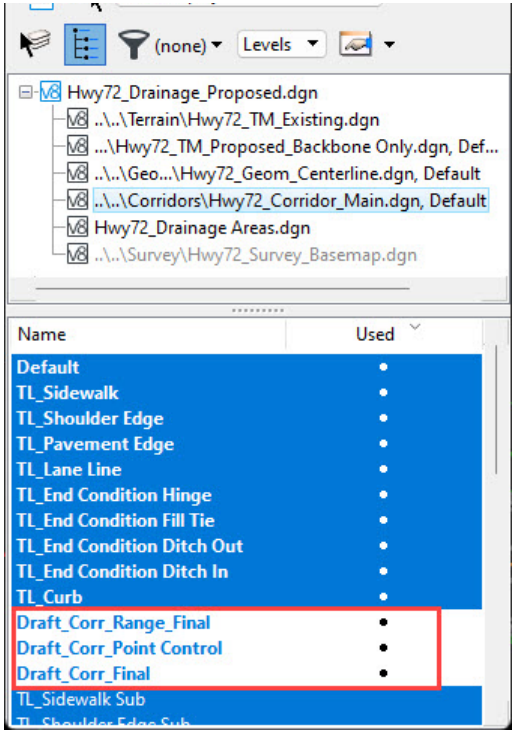
We will turn off the display of the Survey file and then we will turn off some levels in the Corridor file to make it easier to work.

8. **Highlight** the Survey file, **Hwy72_Survey_Basemap.dgn**.

9. *Right Click* on the file name and *Toggle* off **Display**.



10. Next **Highlight** the Corridor file, *Hwy72_Corridor_Main.dgn*.
11. **Sort** the list by the *Used* column.
12. Turn off the following **Levels:**
    - *Draft_Corr_Range_Final*
    - *Draft_Corr_Point Control*
    - *Draft_Corr_Final*
13. **Close** the *Level Display* dialog.



Create a 3D Model

In this section we will set our existing terrain as the Active terrain which will create a managed 3D model in our design file. We will review the data in the 3D model and switch the Active terrain to our Proposed roadway surface.

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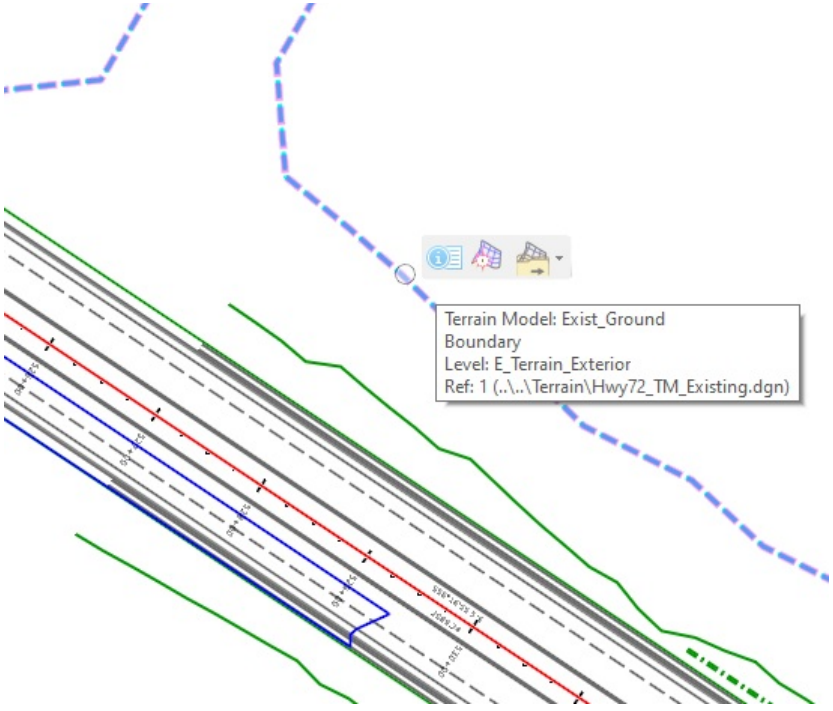
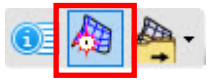
1. Locate the **Existing Ground** Terrain Boundary element and **Click** on it to select it.
2. Once selected, **Hover** over the element to access the *Context Menu*.

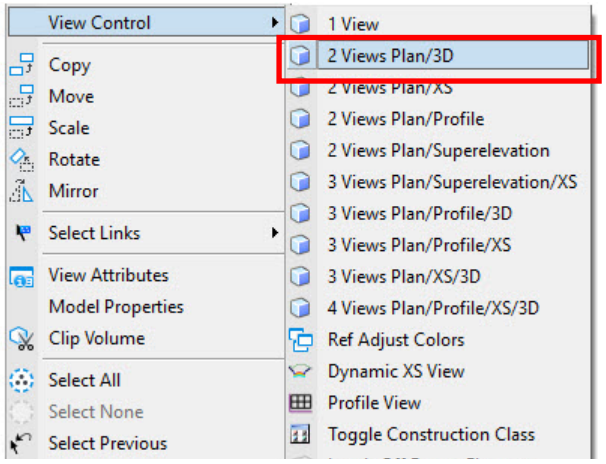


3. Select the **Set as Active Terrain Model** icon, second icon on the *Context Menu*.

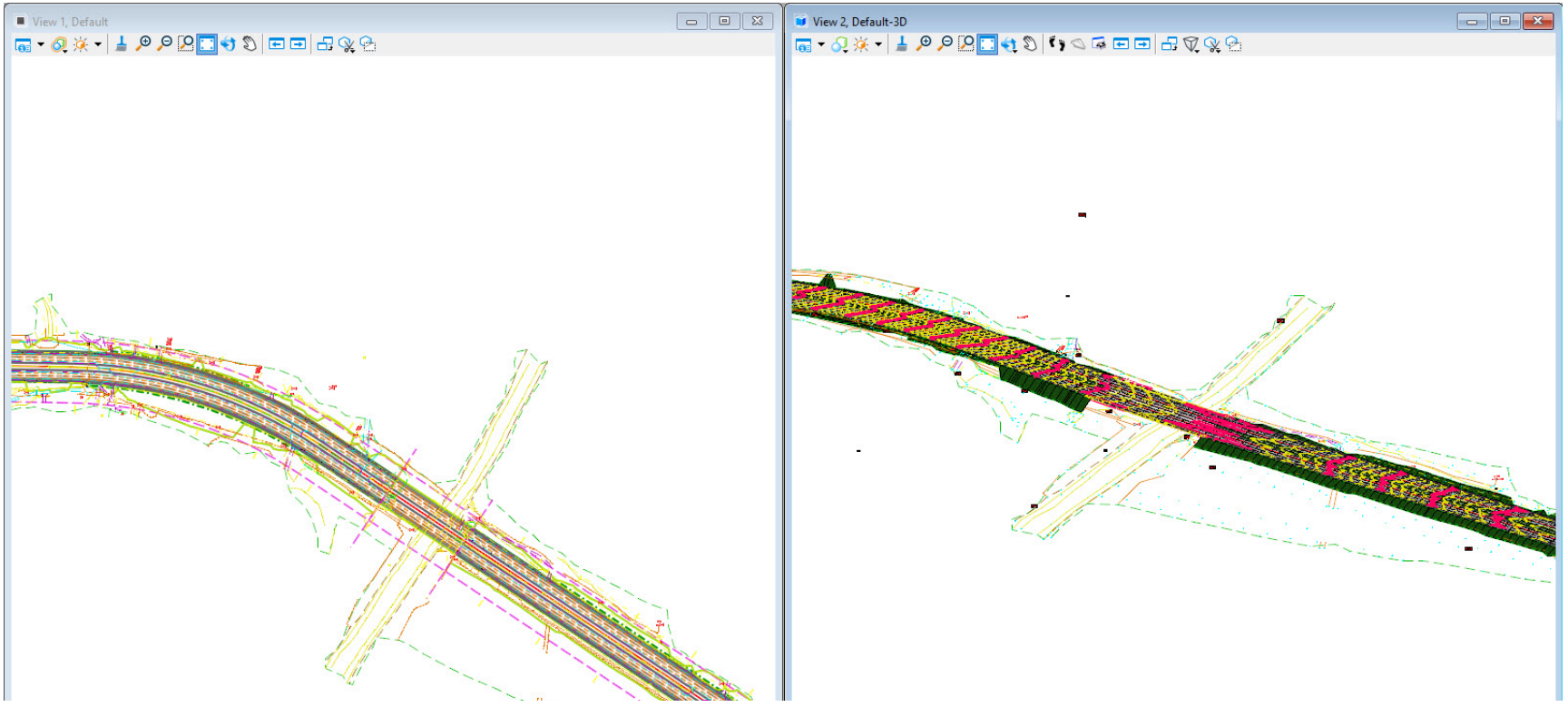


Once you activate the terrain in this 2D design file, the software will create a 3D model in the file. We can now open up another view and look at the 3D model.

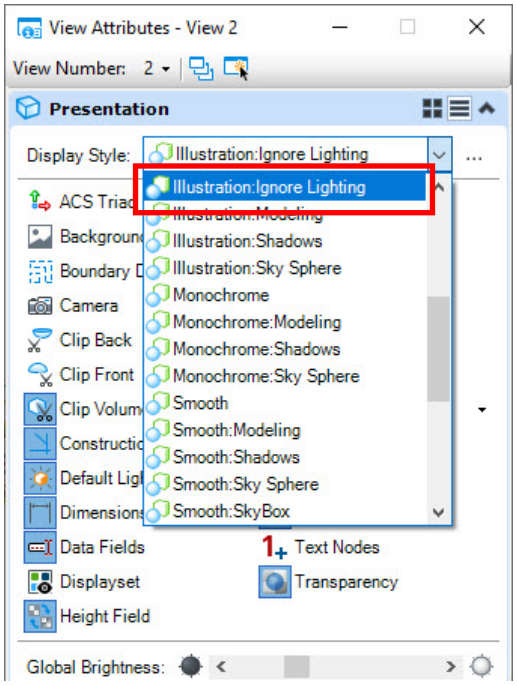
4. Place your cursor inside **View 1** and *press and hold* the **right** mouse button down until you get a pop up menu.



5. Select **View Control > 2 Views Plan/3D**. You may want to Tile the windows so they are side by side. **View Tab > Window Group > Tile**.



6. Click on the *View Attributes* icon in **View 2, Default-3D**.



7. Notice the **Display Style** is *Illustration:Ignore Lighting*. This was built into the macro we ran a few steps earlier. We can now change it to something else if we like. Select *Transparent* and notice how the 3D display changes. You can try others until you find one you like.

8. Select the **File** menu and then select **Save Settings.**

Set another Terrain Active

We plan on placing our proposed drainage system on the proposed roadway model. We have attached a design file with a terrain of our proposed roadway. We will set this terrain as our active terrain and turn on the display of it in View 1 to help us with placing our proposed structures.

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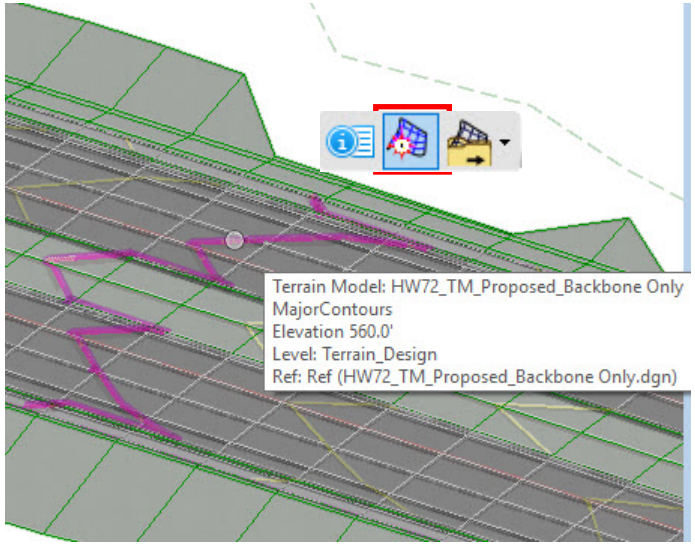
1. Select one of the contours in View 2 that represent the *Hwy72_TM_Proposed_Backbone Only* terrain and hover until you get the context menu and the select **Set as Active Terrain Model**.



   Note: You may want to turn off the display of the *Hwy72_Corridor_Main.dgn* reference file in **View 2** to make it easier to select.

2. Make **View 1** *Active* by left mouse clicking in it.

3. Open the **References** dialog.

   You will notice that the *Hwy72_TM_Proposed_Backbone Only.dgn* reference file was attached and that the *Default* model was originally attached.

4. Select the *Hwy72_TM_Proposed_Backbone Only.dgn* inside the **References** dialog.

   a. **Turn Off** the display of that reference.

   b. Close the **References** dialog.

5. Examine the Level Display to locate the *Hwy72_TM_Proposed_Backbone Only.dgn* 3D Model

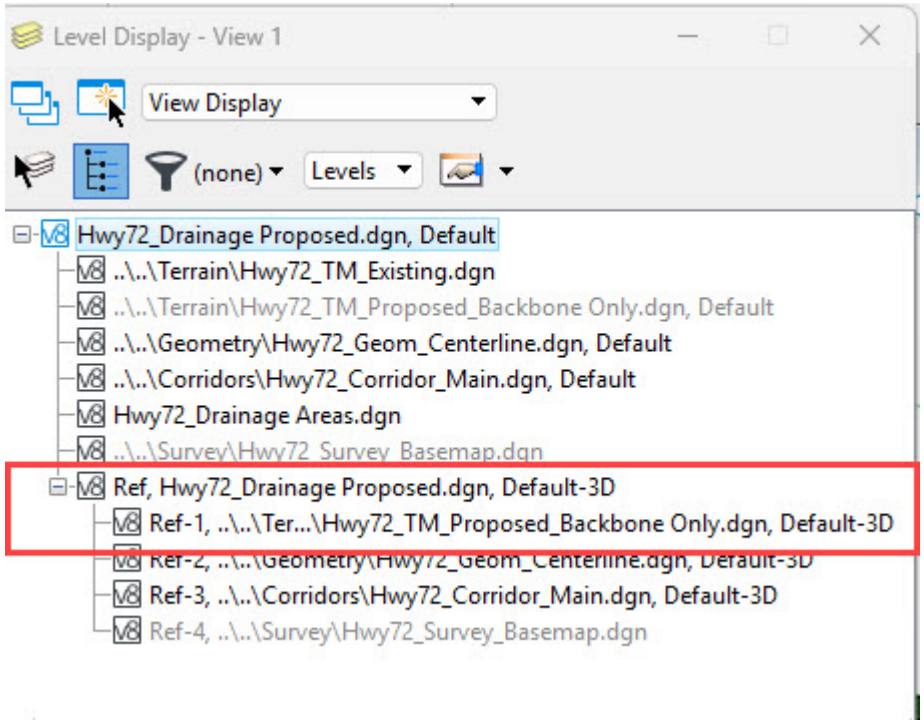
6. Select *Home* > *Primary* > **Level Display**

   Ensure that View 1 is active

   a. Expand the list of files under **Ref, Hwy72_Drainage Porposed.dgn, Default-3D**

   b. You will see **Ref-1..\..\Ter...\Hwy72_TM_Proposed_Backbone Only.dgn,Default-3D**

   What this means is that when the terrain model *Hwy72_TM_Proposed_Backbone Only* was Set Active in step 1 above this placed the 3D model of the Proposed backbone terrain into view 1.



Exercise 2: Place Drainage Node without Automatic Catchment

Description

In this exercise we will place a few drainage structures (Nodes) at low points on our roadway surface.

Skills Taught

- Create a Utility Model
- Place Node Command
- Compute for Flow and Spread

Create a Utility Model

In this section you will create a utility model in the design file. This is done by accessing any Drainage and Utilities tool. The software detects if the file has a utility model in it and if not will warn you that one is about to be created and the action of that can not be undone.

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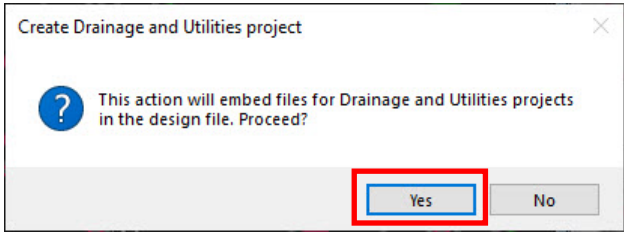
1. In the **Drainage and Utilities** Workflow, select the **Layout** Tab and from the **Layout** group select the **Place Node** tool.
2. The following question dialog will pop up.



3. Click **Yes**.

   There are a number of drainage settings and software settings that are automatically added to the design file when the Utility Model is created. Some examples of information added would be:

   - Rainfall Runoff Data (Storm Events).
   - Hydraulic information used in calculations (Runoff methods, Friction Loss Methods, Pipe Flow Calculation Methods, etc.)
   - Design constraints (Slope, Velocity, Cover).
   - Pipe, Inlet, Culvert, etc. catalogs available for placement and calculations.

   Note: OpenRoads is 3D, but the default location for geometry and structures is the 2D Model. Do **not** place structures in the 3D Model. Place all drainage structures in the 2D Model. OpenRoads will manage the 3D portion automatically.

   After the Utility Model is created, you may need to click the **Place Node** tool again.

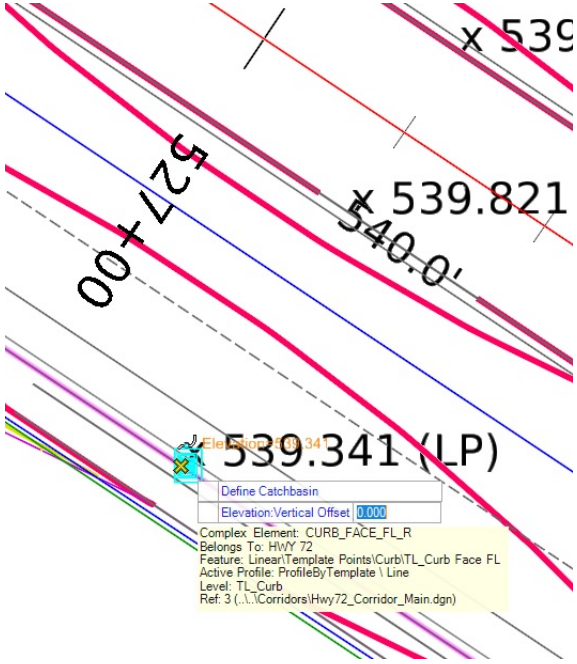
Place Inlet CB-1 at the Low Point on Hwy 72

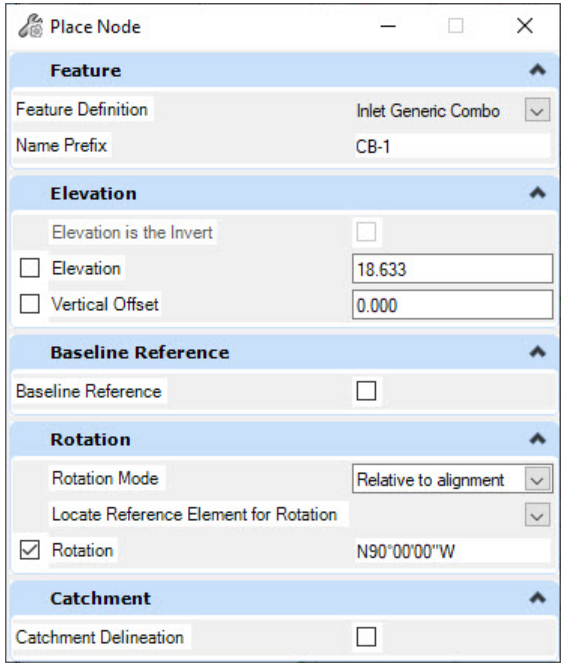
In this section we will place our first inlet and review the properties of it. When placing Inlets you should always work from the low point then upstream.

---

1. Zoom into View 1 to around *Station* **527+00** which is near the middle of the model.
2. Select the *Layout* > *Layout* > **Place Node** tool.

   We will place an inlet, Inlet Generic Combo, at the low point of our roadway on the south side of the roadway as shown in the picture below.





   a. Set the *Feature Definition* to *Node* > *StormWaterNode* > *Inlets* > **Inlet Generic Combo**

   b. Set the *Name Prefix* to **CB-1**

c. You are prompted to *Select Reference Element For Node Elevation.*

- You can select a contour line being displayed from the terrain surface, *Hwy72_TM_Proposed_Backbone Only*, or you can select the *low point text* that is also being displayed from the terrain.
- You can select the **Reference Element** in the **2D** view or the **3D** view.

d. Pick a contour line from the Terrain Model *HW72_TM_Proposed_Backbone_Only* reference.

- In the 2D view, *View 1*, the plan view cell for the inlet is attached to your cursor.

e. Set the *Snap Mode* to **Near Snap Point.**

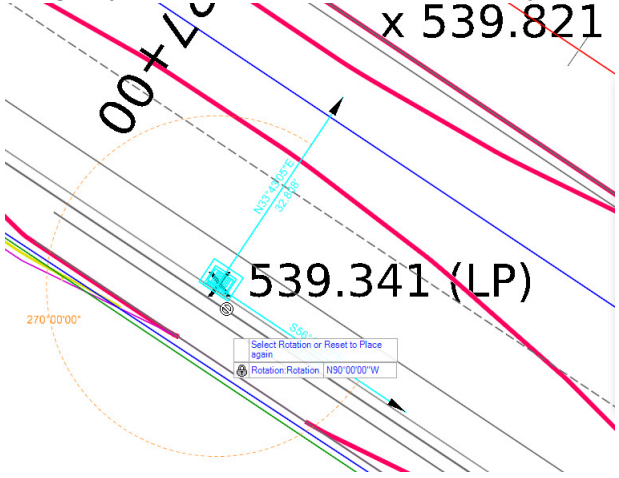
f. Locate the Feature **Curb_Face_FL_R** this represents the flow line in the corridor adjacent to where the low point text is located.

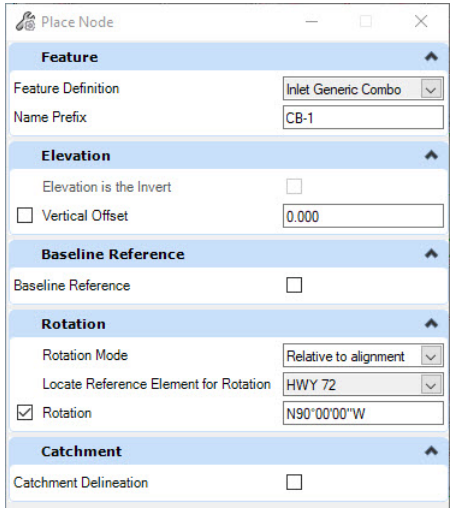
g. Set the **Vertical Offset**. Data point in *View 1* to accept the **Vertical Offset** of *0.00*.

h. Set the **Rotation Mode** to *Relative to Alignment,* data point in *View 1* to accept

i. Set the **Locate Reference Element for Rotation**. Click on the Centerline of the Roadway, *Complex Element: HWY 72*.

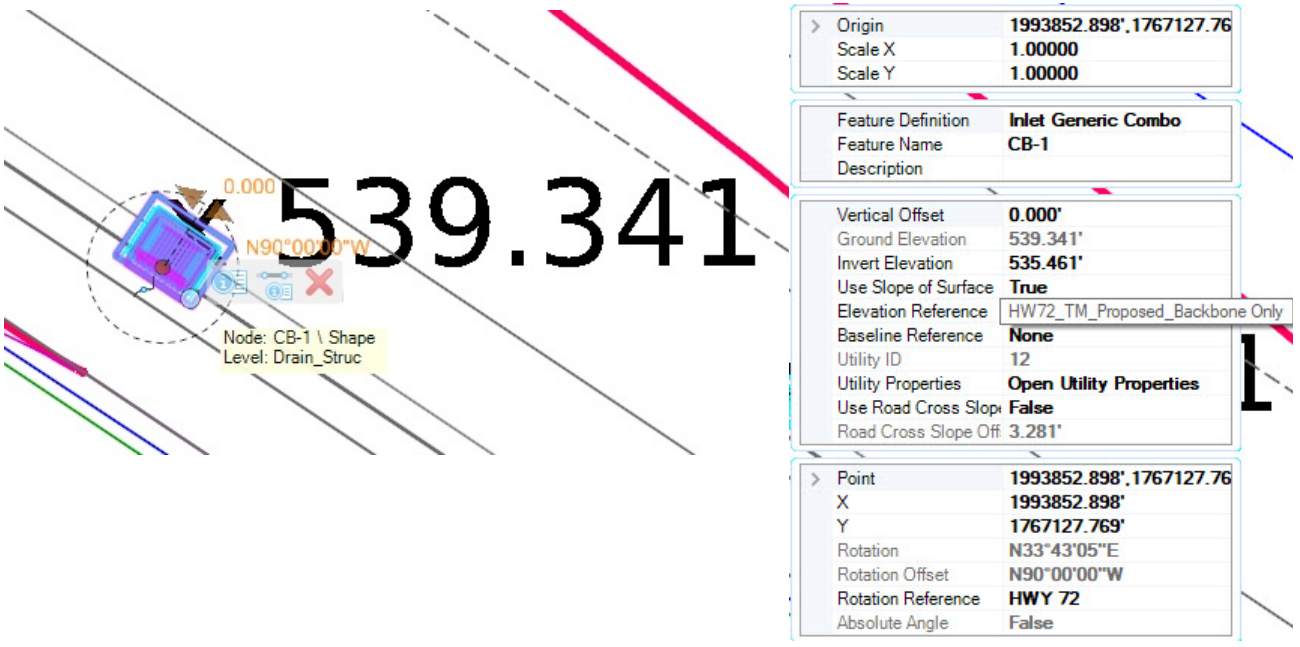
j. For the Rotation setting key-in **N 90 W** and click the **Tab** key or **Enter** key. to lock the rotation.

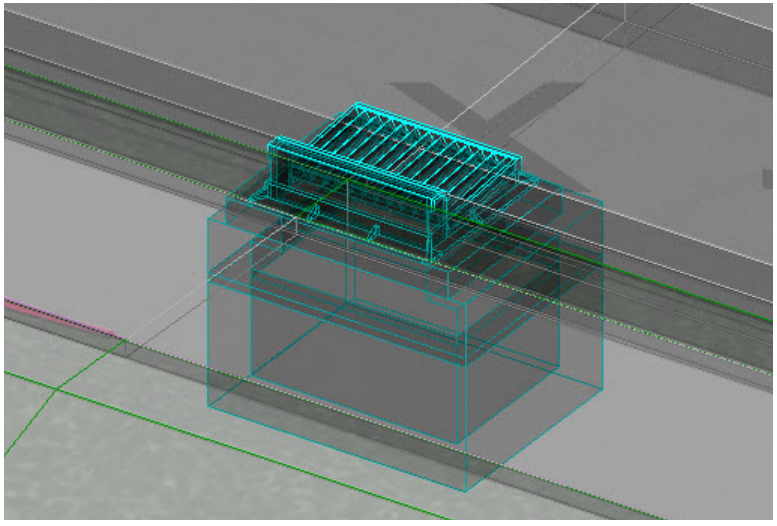




k. Make Sure the *Catchment > Catchment Delineation* is **unchecked** and then **Data Point** in **View 1**.

3. Select the **Element Selection** Tool. Select the **CB-1** inlet and then **Hover** over it and select the **Properties**.

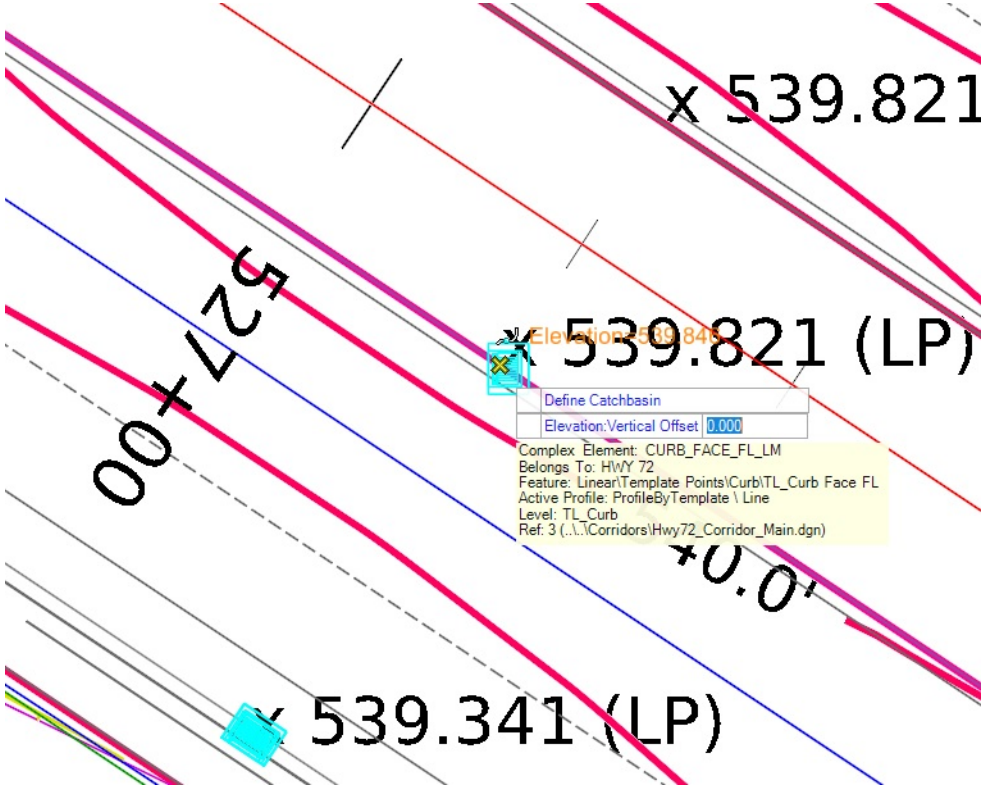


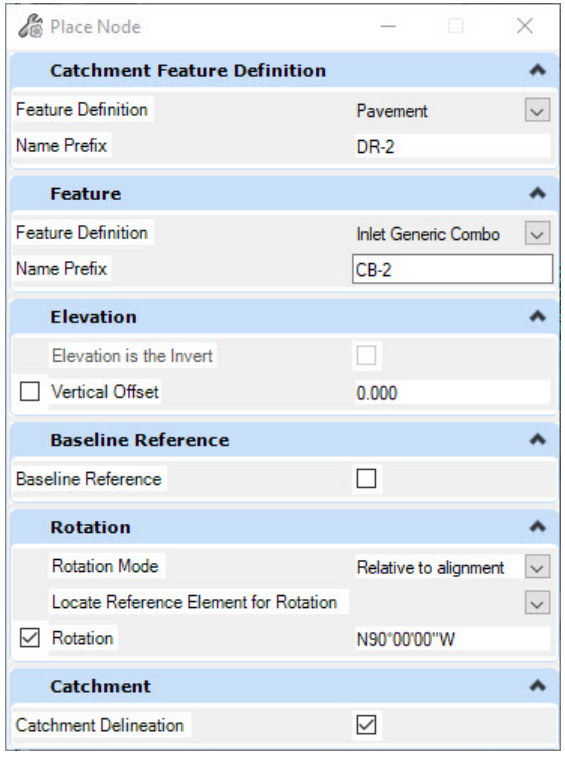


Place Node CB-2 with Automatic Catchment Delineation

We will place another node across the roadway with the Automatic Catchment Delineation option turned on.

1. Select *Layout > Layout >* **Place Node** tool.
2. Set the *Feature Definition* to *Node > StormWaterNode > Inlets >* **Inlet Generic Combo**
3. Set *Name Prefix* to **CB-2**.





l. Set the *Select Reference Element For Node Elevation*.

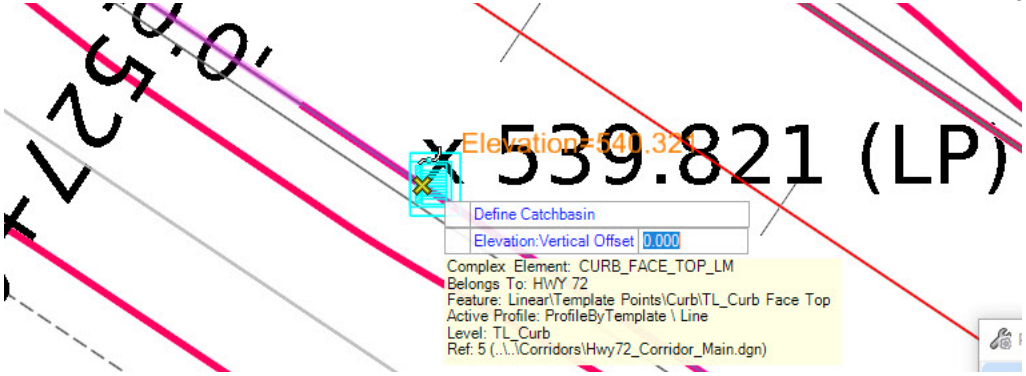
- You can select a contour line being displayed from the terrain surface, *Hwy72_TM_Proposed_Backbone Only*, or you can select the *low point text* that is also being displayed from the terrain.
- You can select the **Reference Element** in the **2D** view or the **3D** view.

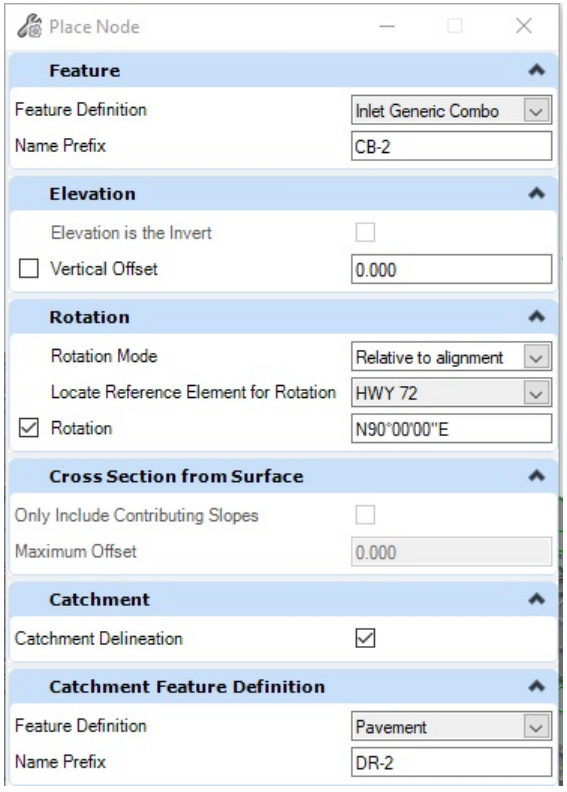
m. Pick a contour line from the Terrain Model *HW72_TM_Proposed_Backbone_Only* reference.

- In the 2D view, *View 1*, the plan view cell for the inlet is attached to your cursor.

n. Set the *Snap Mode* to **Near Snap Point.**

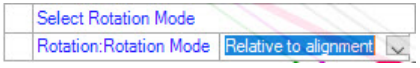
o. Locate the Feature **Curb_Face_FL_LM** this represents the flow line in the corridor adjacent to where the low point text is located.





p. Set the *Vertical Offset*. Data point in **View 1** to accept the *Vertical Offset* of **0.00.**

q. Set the *Rotation Mode* to **Relative to Alignment**.



r. Data point in *View 1* to accept that mode.

s. Set the **Locate Reference Element for Rotation**.

Click on the Centerline of the Roadway, *Complex Element: HWY 72*.

For the Rotation setting you will key-in **N 90 E** and click the *Tab* key or *Enter* key to lock the rotation.

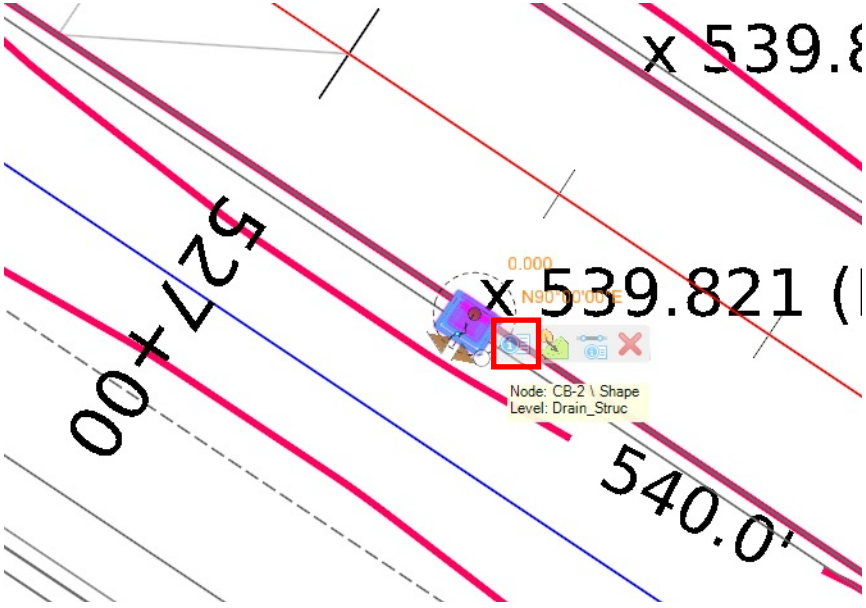
t. Make Sure the *Catchment > Catchment Delineation* is **checked**.

u. Set the *Feature Definition* > **Pavement**.

v. Set the *Name Prefix* > **DR-2.**

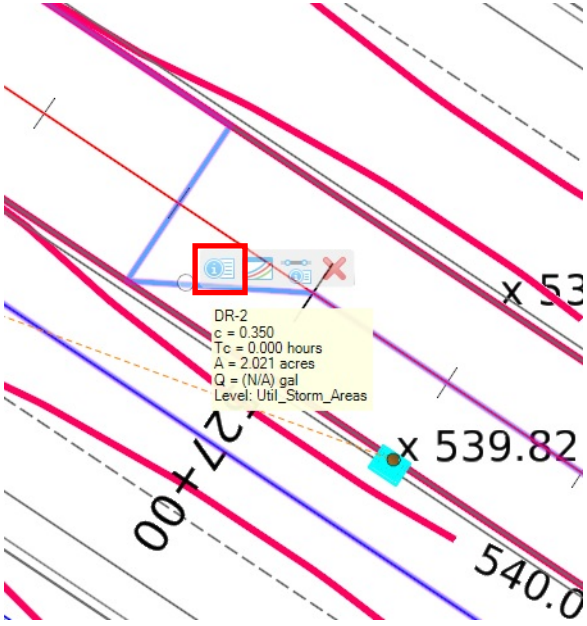
w. To finish - **Data Point** in *View 1*

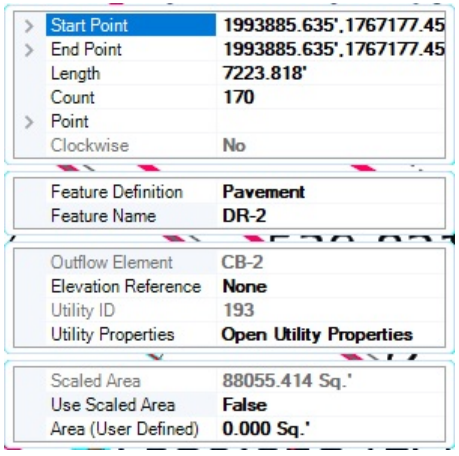
4. Select the **Element Selection** Tool. Select the **Node CB-2** and then **Hover** over it and select the **Properties** icon.



Origin	1993877.588',1767165.39
Scale X	1.00000
Scale Y	1.00000
Vertical Offset	0.000'
Ground Elevation	539.821
Invert Elevation	535.941
Use Slope of Surface	True
Elevation Reference	HW72_TM_Proposed_Bac
Station/Offset Referen	None
Utility ID	12
Utility Properties	Open Utility Properties
Use Road Cross Slop	False
Road Cross Slope Off	3.281
Feature Definition	Inlet Generic Combo
Feature Name	CB-2
Description	
PositionType	Nearest
Point	1993877.588',1767165.39
X	1993877.588'
Y	1767165.393'
Rotation	S33°43'05"W
Rotation Offset	N90°00'00"E
Rotation Reference	HWY 72
Absolute Angle	False

5. Select the **Drainage Catchment DR-2** and **Hover** over it and select the **Properties** icon.

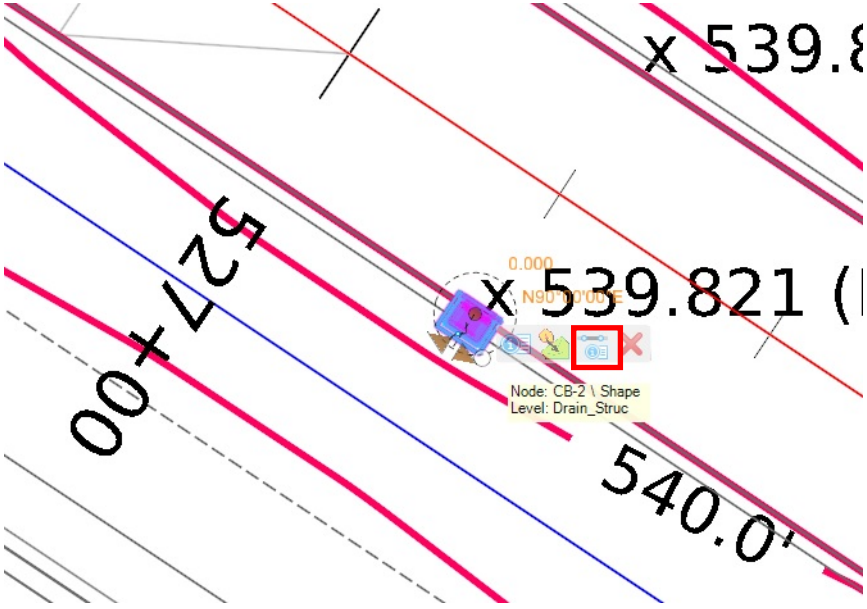


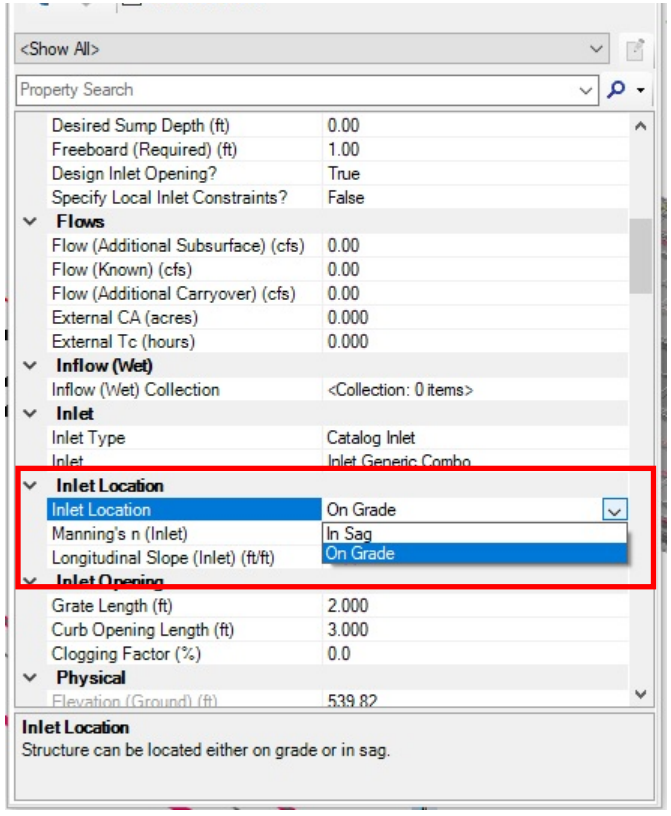


Modify Inlet Utility Property

The Inlets we have just placed are situated at the low points on the carriageway. By default the **Utility Property** of the inlets set their location to **'On Grade'**, for these two inlets we need to modify that property to **'In Sag'**. This is because they will take flow from both sides of the inlet.

1. Select the **Element Selection** tool. Select the **CB-2** inlet and then **Hover** over it and select the **Utility Properties** icon.





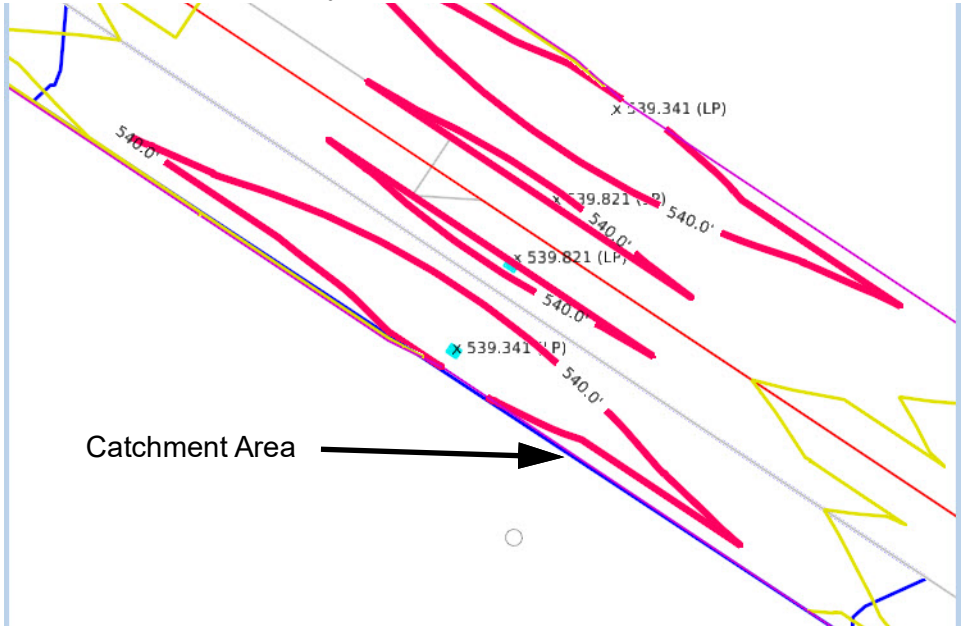
2. Locate the **Inlet Location** property and change it from *On Grade* to **In Sag.**
3. Repeat the process for Inlet **CB-1**.

Place Catchment for Inlet CB-1

We will create a drainage catchment for Inlet CB-1 and assign it to the Inlet.

---

1. Make sure the Reference File, **Hwy72_Drainage Areas.dgn**, is attached and the display is on.



2. In the **Drawing Tab**, select the **Copy** tool and copy the **Blue Shape** representing the Drainage Area.

   Note: Use the Key Point Snap to snap to a vertex on the shape and then copy it by snapping to the same point to define the distance and direction. Now the Shape is in our active file.

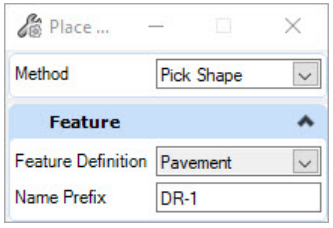
3. Turn the display of the reference file, **Hwy72_Drainage Areas**, *Off*.

4. Select the workflow **Drainage and Utilities,** go to the **Layout Tab** and select the **Place Catchment** tool.

   a. Select *Layout Method >* **Pick Shape.**

   b. Set the *Feature Definition >* **Pavement** and the *Name Prefix >* **DR-1.**

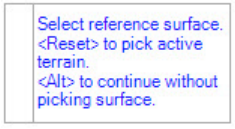
   c. Next, select the shape that represents the catchment area, select the catchment shape.



   d. Reset to Complete

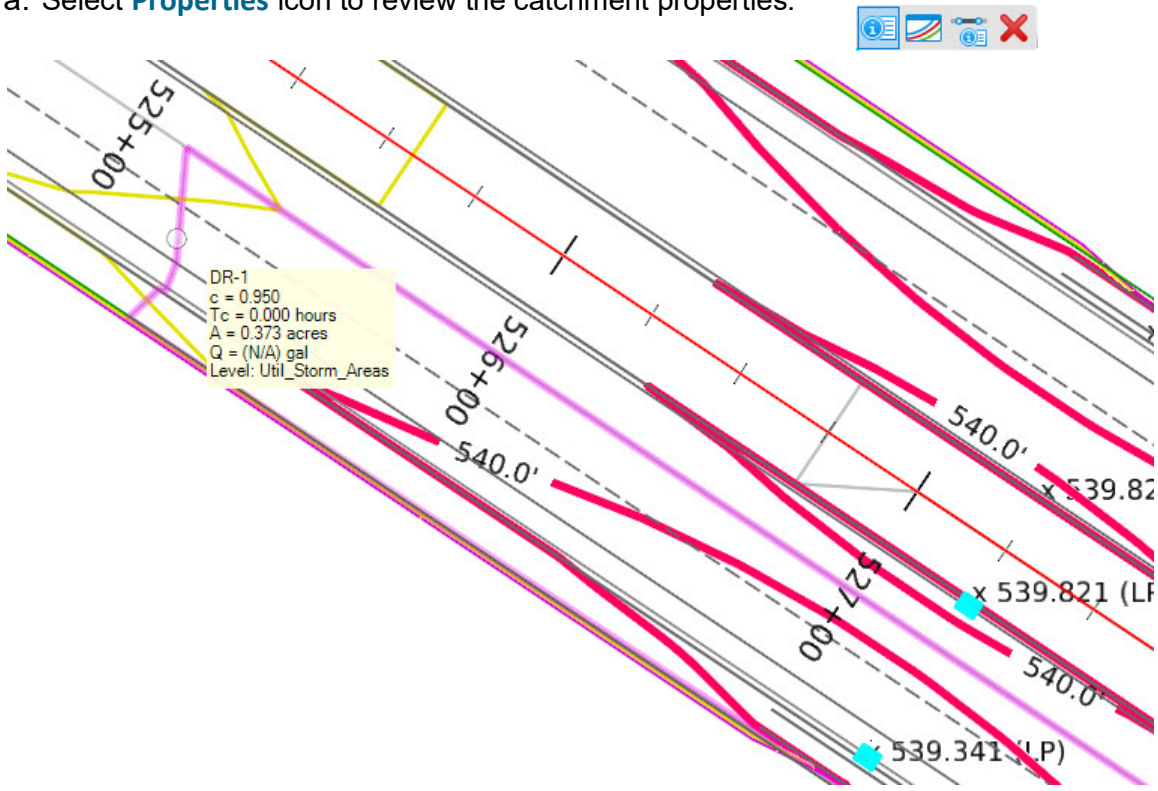
   e. Next, select **CB-1.**

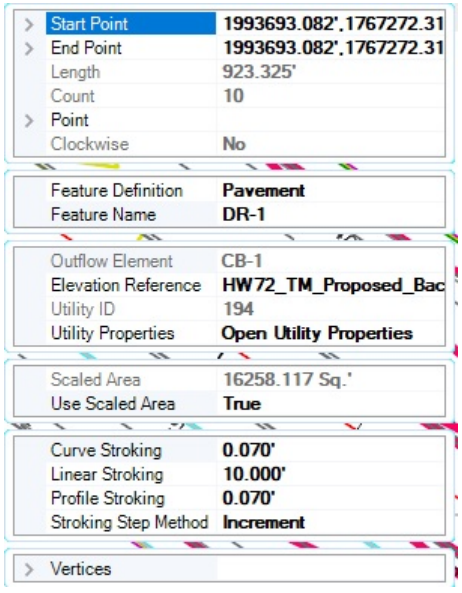
   The final prompt is there if you would like to have the catchment drawn on the terrain. You can select the terrain, *Hwy72_TM_Proposed_Backbone Only*. This will create the catchment up on the surface of the terrain.



   f. *Select > Reset >* to **select active terrain.**

5. Select the **Element Selection** Tool.
6. Select the catchment, **DR-1.**
   a. Select **Properties** icon to review the catchment properties.





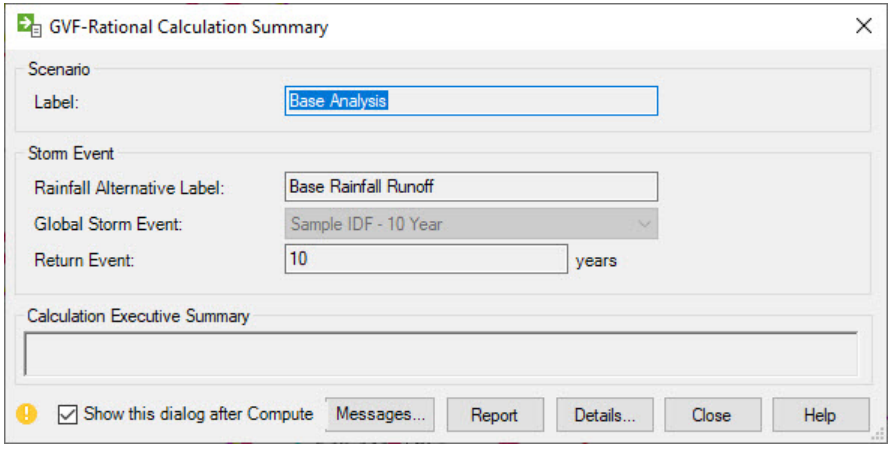
Calculate Catchment Flow and Check Inlet Spread

In this section we will have the program calculate the Catchment Flow for our two catchments and we will check the utility properties of the Inlets and review the spread and flow.

---

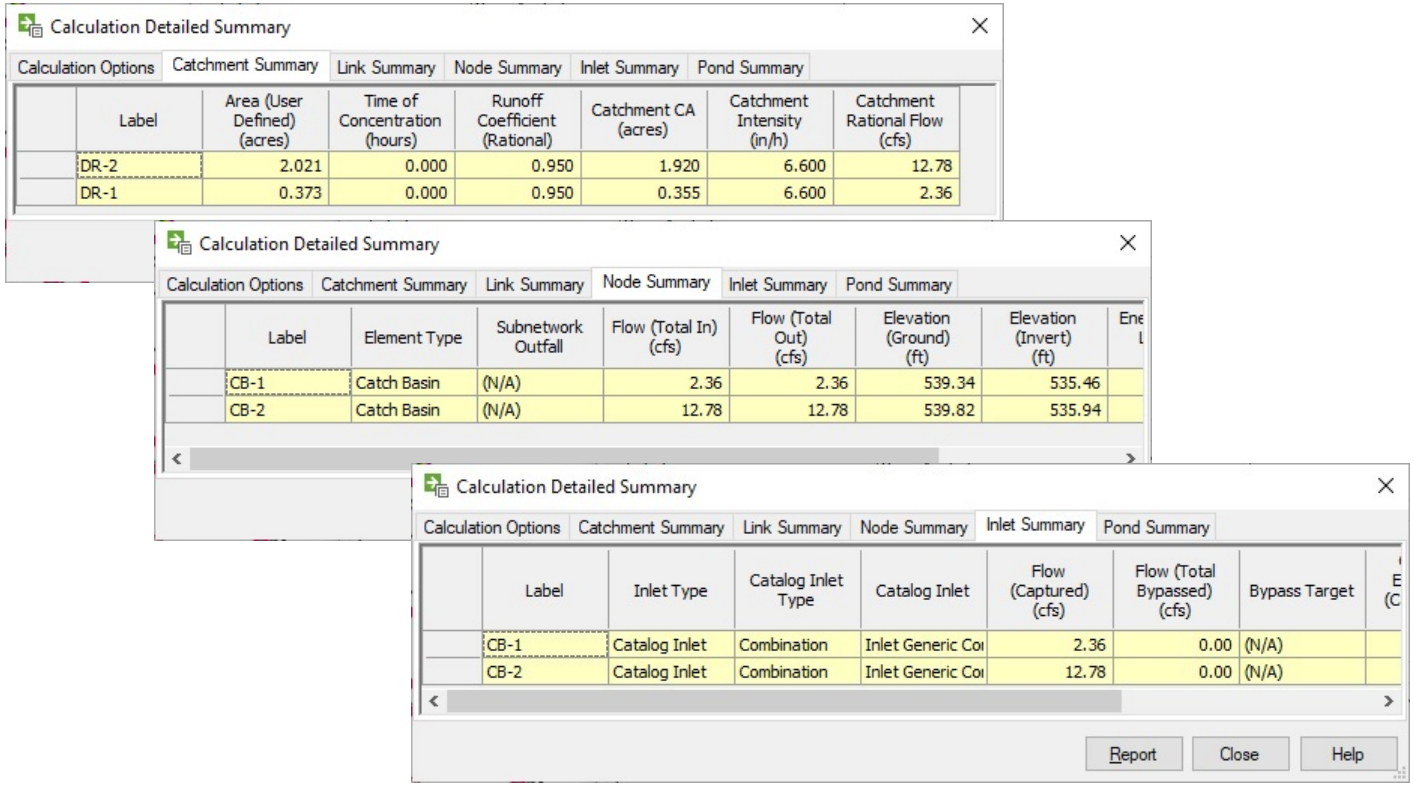
1. Select workflow **Drainage and Utilities**, switch to the **Analysis Tab**.
2. Click the *Compute* > **Compute Scenario** icon located on the *Calculation Group.*

   a. The *GVF-Rational Calculation Summary* dialog will come up once the calculations have run successfully.



When our Utility Model was created in the design file it came with some preset preferences as mentioned earlier. In our case the Utility Model had a default storm event set called, *Sample IDF- 10 year*. There are many other settings that came across that we will touch on as we continue through the course.

b. Click the **Details** button located on the above dialog. Review the *Catchment Summary* Tab, *Node Summary* Tab, and the *Inlet Summary* Tab.



We can also go to each individual node or catchment and review the **Utility Properties** of each.

c. **Close** the *Calculation Detailed Summary* dialog and *GVF-Rational Calculation Summary* dialog.

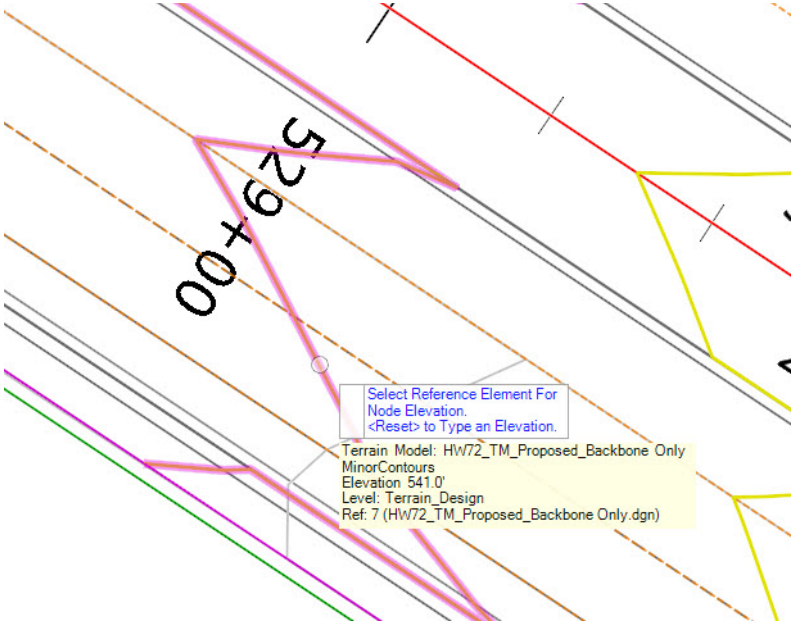
If the Civil Message Center opens, click the 'x' in the upper right to close it.

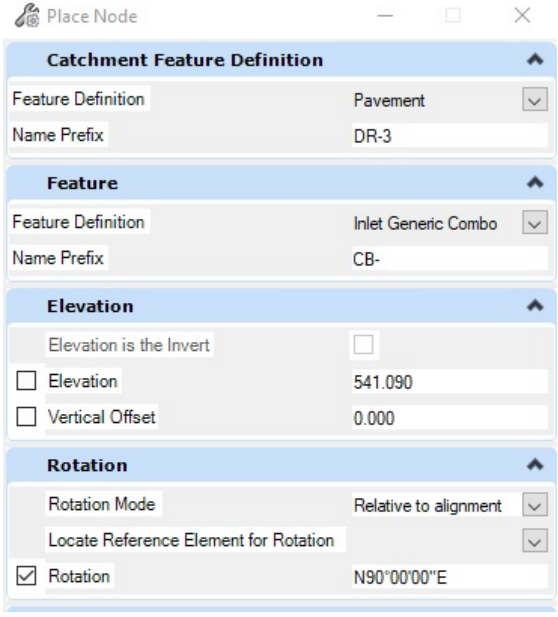
3. We will continue to place more nodes and catchments in the next section.

Place Node Upstream

In this section we will place another node upstream of our two low points. We will snap to a curb flow line again in the placement of this node.

1. In **View 1**, Pan or Zoom to around **Station 529+25**.
2. Select *Layout* > *Layout* > **Place Node** tool.
   a. Set the *Feature Definition* > **Inlet Generic Combo.**
   b. Set the *Name Prefix* > **CB-3.**





   c. You are prompted to *Select Reference Element For Node Elevation*.
      - You can select a contour line being displayed from the terrain surface, *Hwy72_TM_Proposed_Backbone Only*.
      - You can select the **Reference Element** in the **2D** view or the **3D** view.
   d. Pick a contour line from the Terrain Model *Hwy72_TM_Proposed_Backbone Only* reference.

e. Select the **Near Snap Point** icon along the bottom of the application window.

f. We will snap to the Curb Flow Line. (**North Side of Eastbound Roadway**) The element that represents the curb flow line is called, **CURB_FACE_FL_LM**.

g. Set the *Vertical Offset.* Place the node around station **529+25** along the curb flow line on the **North Side** of the roadway and to accept the *Vertical Offset* of **0.00**.

h. Set the *Rotation Mode* - We preset it to **Relative to Alignment**. So we need to data point in *View 1* to accept that mode.

i. Set the **Locate Reference Element for Rotation** - Click on the Centerline of the Roadway, *Complex Element: HWY 72*.

j. For the Rotation setting you will key-in **N 90 E** and click the **Tab** key or **Enter** key to lock the rotation. Then data point in **View 1**.

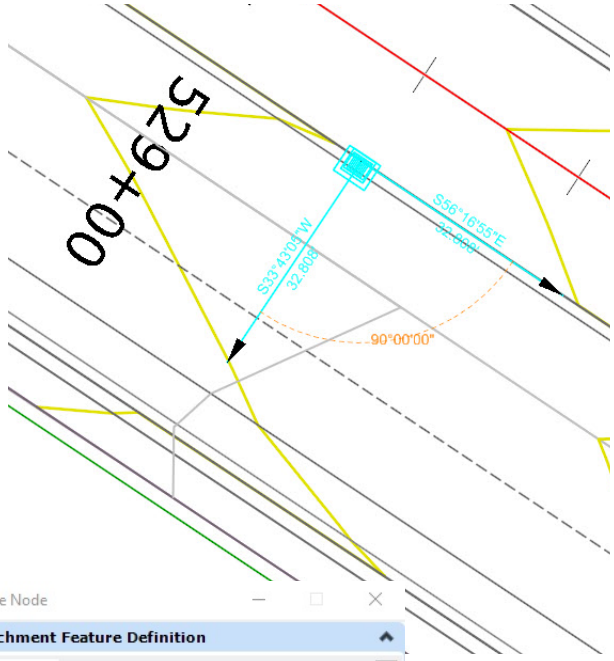
k. Make Sure the *Catchment* > **Catchment Delineation** is **checked**.

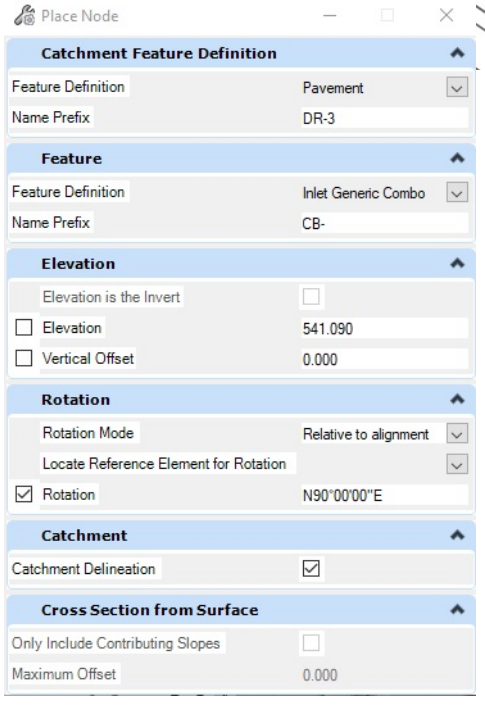
l. Set the *Feature Definition* > **Pavement**.

m. Set the *Name Prefix* > **DR-3.**

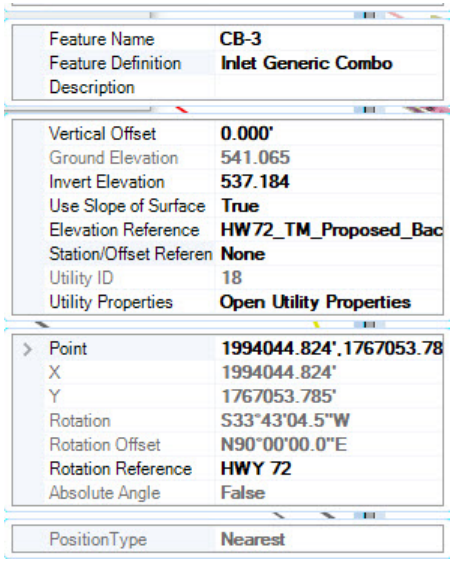
n. To finish - **Data Point** in **View 1**

3. Click on the **Element Selection** tool.

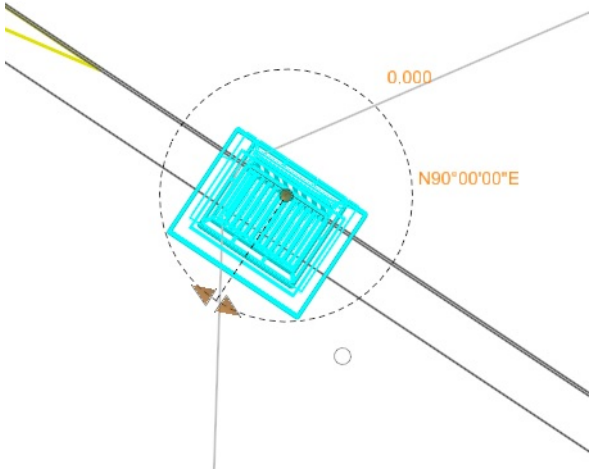


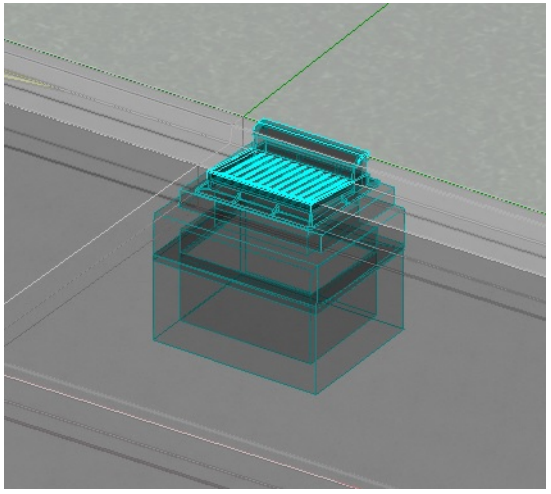


4. **Click** and **Hover** on the node you just placed. Select the *Properties* icon.



Notice the *PositionType* property is set to *Nearest*. The software will remember all aspects of placement including snap mode.





Update the Downstream Catchment

We will update the catchment downstream so that it stops adjacent to our new catchment.

---

1. In **View 1**, pan to Node **CB-2** located on the north side of the eastbound roadway at Station **527+25**.

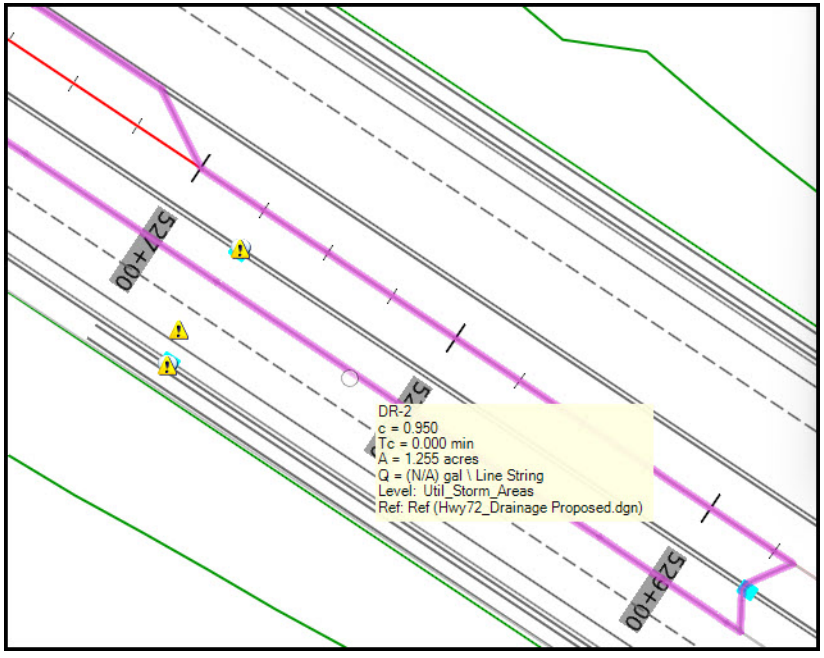
   a. Use the **Element Selection** tool to select the Node **CB-2**

   Hover over the node to get the context menu.

   b. Select the 2nd Icon, **Update Catchment for Inlets,** to recompute the catchment area, **DR-2**, for Node **CB-2**.

   c. Zoom out so that you can see the right side of the catchment **DR-2** then select it with the Element Selection tool.

   Notice that the graphic is redrawn and stops at the edge of Catchment **DR-3**.



Place Node (Station/Offset)

In this section we will place a node at a specific station and offset using the Civil AccuDraw command in conjunction with the Place Node command.

---

1. Place an inlet at station **529+25.00** and offset **59.5.**

a. Go to *Layout > Toggles >* and select the *Civil AccuDraw* icon. The *Civil AccuDraw* menu bar will pop up.

b. Click the *Toggle Civil AccuDraw* icon on the menu bar. It will show like the image below when toggled on.

Note: When you have View 1, your 2D view, with focus the dialog should look like the one above. You can switch to different views, 2D, 3D, Profile, Cross Section, and the menu bar will change accordingly.

c. Select the **Station-Offset** Mode icon on the *Civil AccuDraw* menu bar.

d. Select the **Place Node** tool.

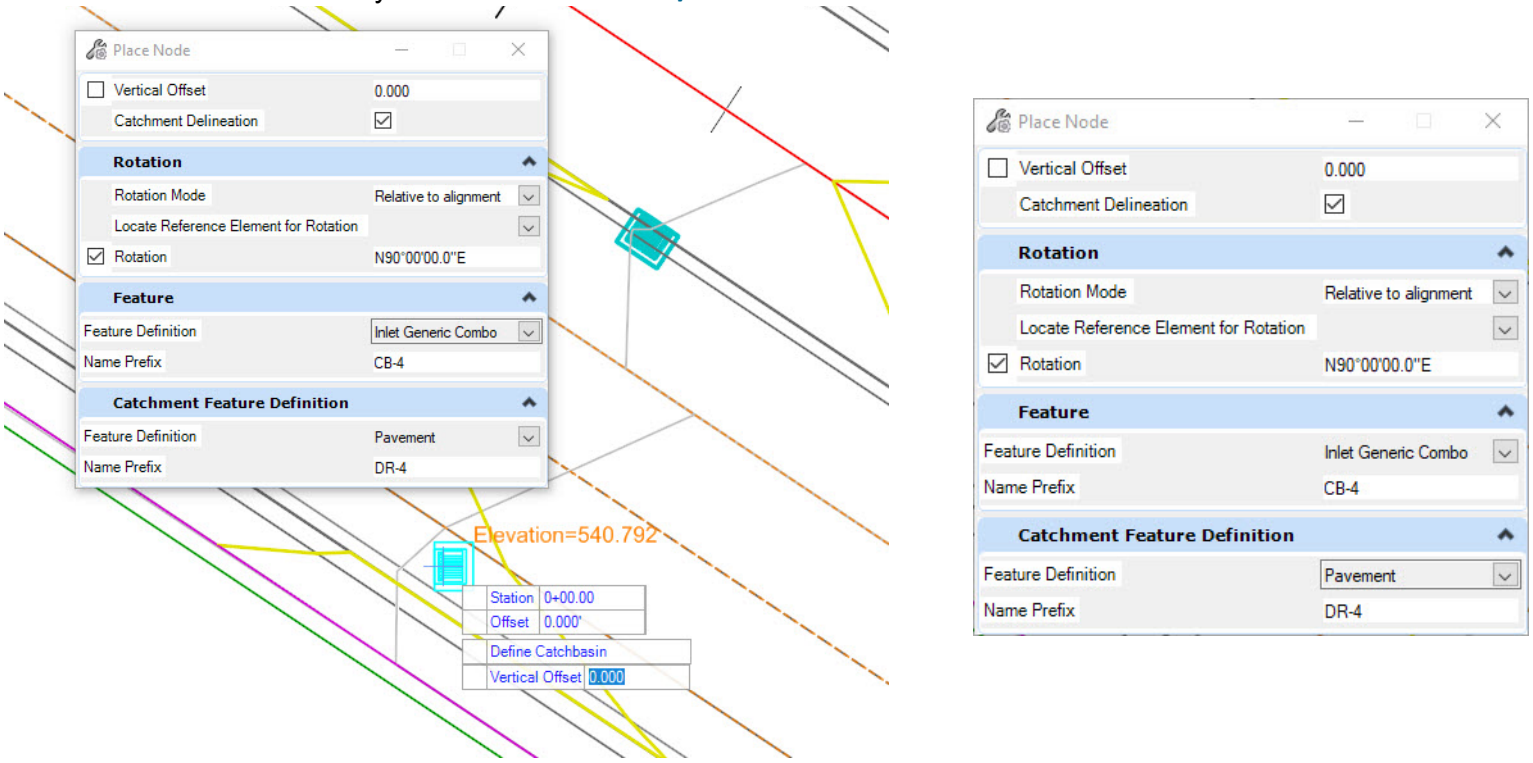
e. Set the *Feature Definition >* **Inlet Generic Combo.**

f. Set the *Name Prefix >* **CB-4**

g. You are prompted to *Select Reference Element For Node Elevation.*

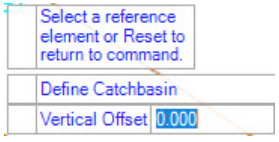
- You can select a contour line being displayed from the terrain surface, *Hwy72_TM_Proposed_Backbone Only*

2. Once the surface is selected you will see the **Station/Offset** information available on the cursor.



a. Use your **Tab** Key to move the focus of your tool prompt up to the **Station** field as shown.

b. Type the letter **'O'** in the Station field to set the origin to calculate *Station/Offset* values from.

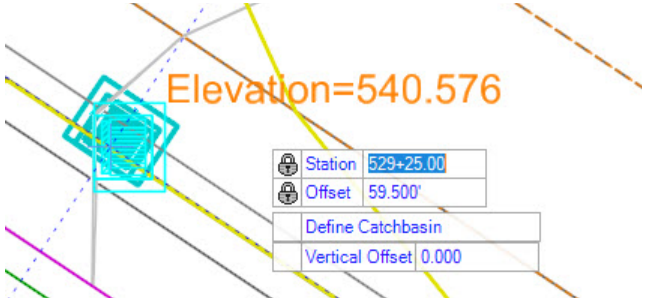


c. Select a **reference element**, select the centerline of the roadway, *Complex Element: HWY 72*.

- Now the **Station and Offset** fields will update based on where the cursor is relative to the *Centerline*.

d. Use your **Tab** key and move the focus back up to the **Station** field

- Key-in **529+25.00**
- Click the **Tab** key to lock the value and move to the **Offset** field.
- Key-in **59.500**
- Click the **Tab** key to lock the value.

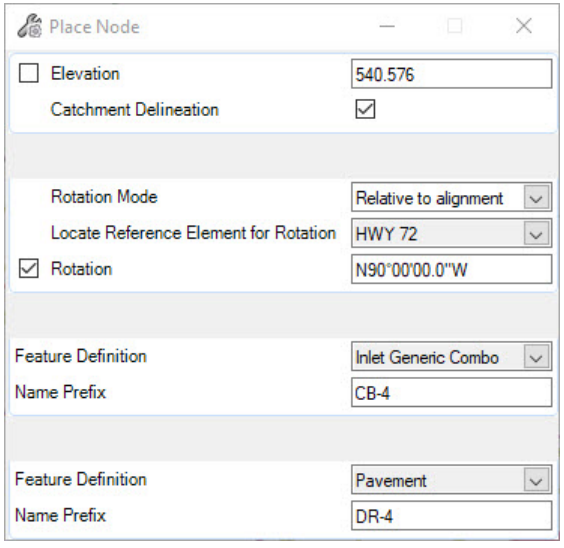


3. Set the *Vertical Offset* data point in **View 1** to accept the *Vertical Offset* of **0.00**.

a. Set the *Rotation Mode* > **Relative to Alignment** data point in **View 1** to accept that mode.

b. **Set the Locate Reference Element for Rotation**. Click on the Centerline of the Roadway, *Complex Element: HWY 72.*

c. For the Rotation setting you will key-in **N 90 W** and click the **Tab** key or **Enter** key to lock the rotation. Then data point in **View 1.**



d. Toggle on **Catchment Delineation**, set the *Catchment Feature Definition* > **Pavement**

e. Set the *Name Prefix* > **DR-4.**

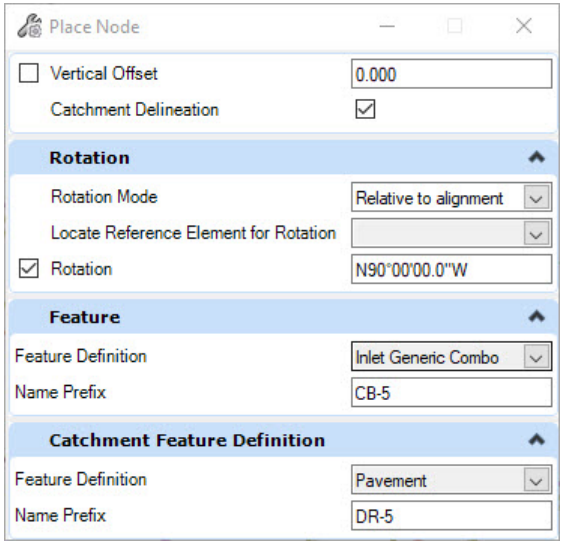
f. **Do not exit the tool**, your tool prompt should be set to **Define Catch basin.**

Place Another Node (Station/Offset)

Place another node, **CB-5**, at Station **534+25** and Offset **59.50**. Since we did not exit the tool or choose another tool we can quickly place another node and catchment.

---

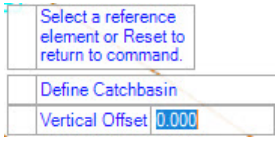
1. Preset the following in the **Place Node** dialog.



   a. Set the *Feature Definition* > **Inlet Generic Combo.**

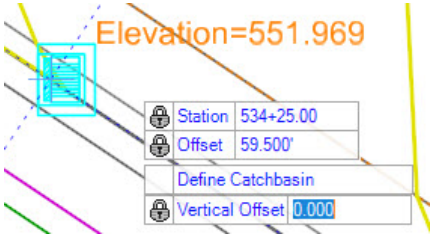
   b. Set the *Name Prefix* > **CB-5.**

   c. Use the **Tab** key and move the focus into the **Offset** Field on your cursor and click the **'O'** key.



   d. You are prompted to select a **reference element**, select the centerline of the roadway, *Complex Element: HWY 72*.

e. Lock the *Station* value at **534+25** and the *Offset* at **59.50** as we did previously.

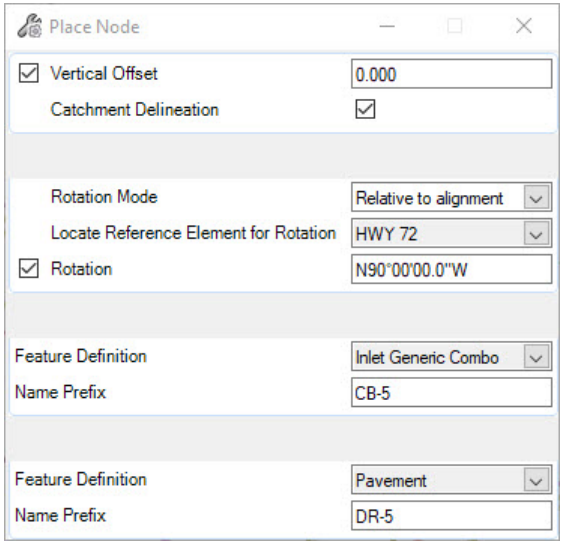


f. Set the *Vertical Offset*. Data point in **View 1** to place the node and to accept the *Vertical Offset.*

g. Set the *Rotation Mode* > **Relative to Alignment.** Data point in **View 1** to accept that mode.

h. **Locate Reference Element for Rotation**. Click on the Centerline of the Roadway, *Complex Element: HWY 72.*

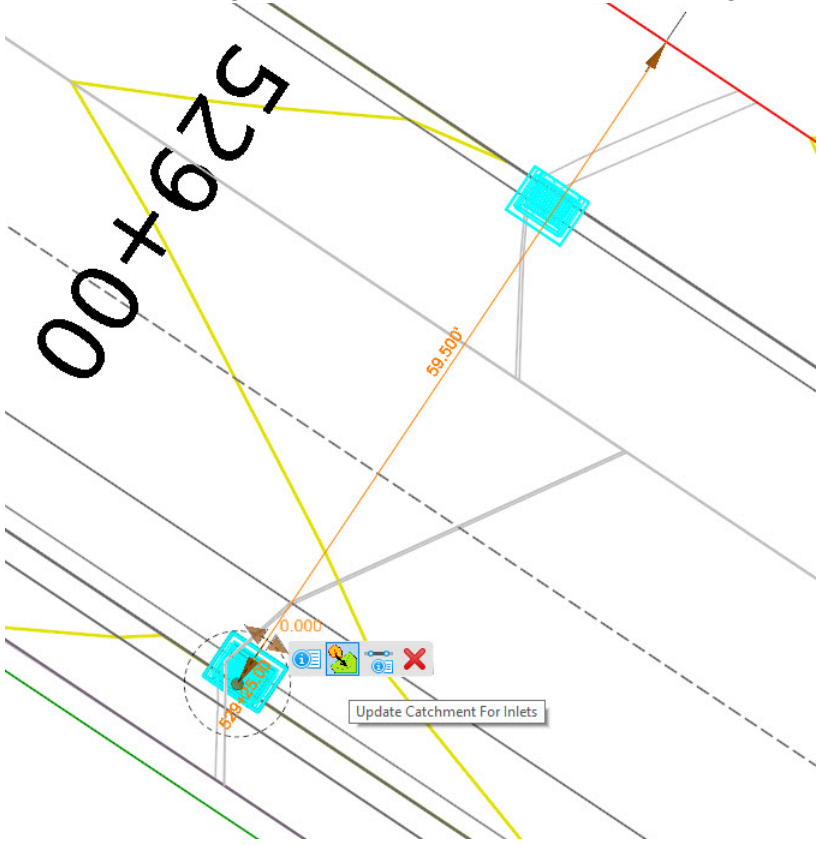
i. For the Rotation setting you will key-in **N 90 W** and click the **Tab** key or **Enter** key to lock the rotation. Then data point in **View 1.**

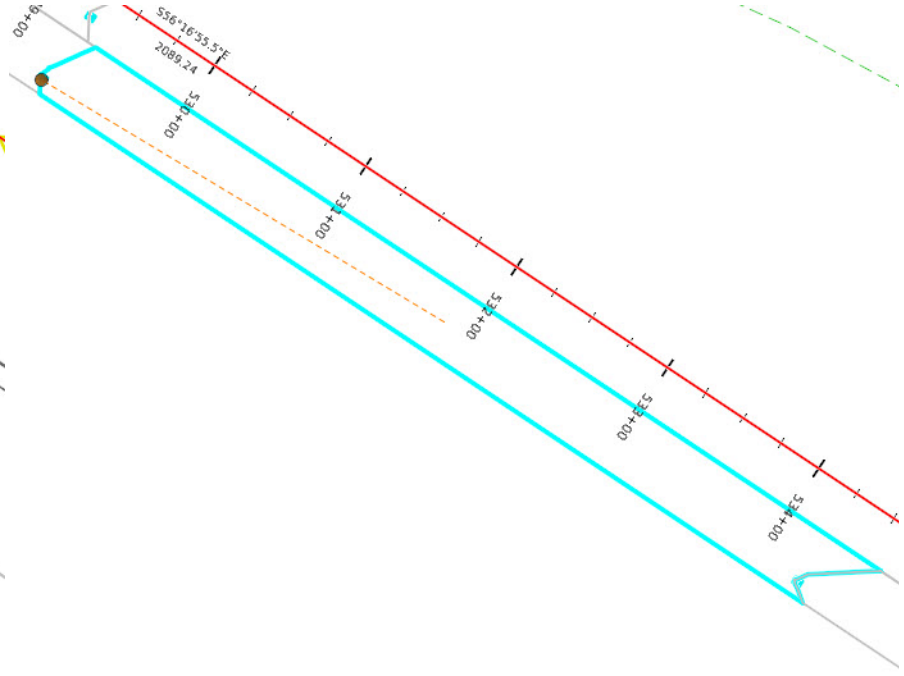


Now that the inlet is placed we can run the computations again and check our numbers.

Before running computations we will update the catchment area, **DR-4**, for Node **CB-4**.

2. Repeating the steps we did earlier, zoom to Node **CB-4**.
3. Use the **Element Selection** tool to select the Node **CB-4**.
   a. **Hover** over the node to get the context menu.
   b. Select the 2nd Icon, **Update Catchment for Inlets**, to recompute the catchment area, **DR-4**, for Node **CB-4**.
   c. Zoom out so that you can see the right side of the catchment **DR-4** then select it with the *Element Selection* tool.
      - Notice that the graphic is redrawn and stops at the edge of Catchment **DR-5**.



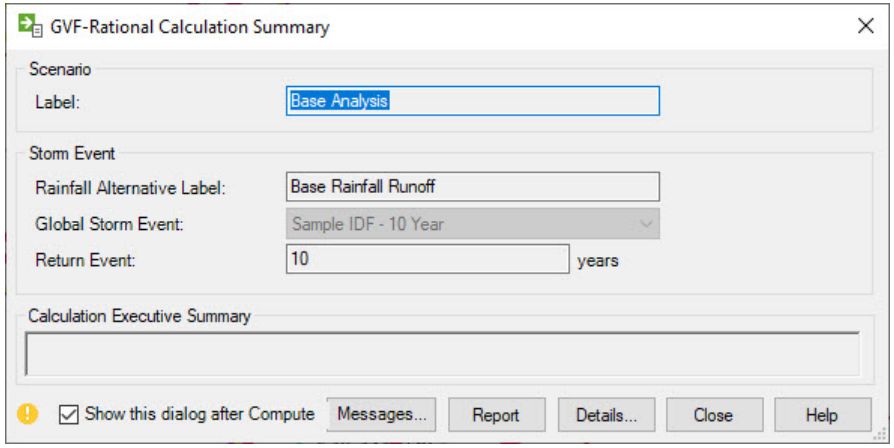


Compute for Flow and Spread

We will run the computations again and check our numbers.

---

1. In the **Drainage and Utilities Workflow**, switch to the **Analysis Tab**.
2. Click the *Compute* icon located on the **Calculation Group**.
3. The following *GVF-Rational Calculation Summary* dialog will come up once the calculations have run successfully.



When our Utility Model was created in the design file it came with some preset preferences as mentioned earlier. In our case the Utility Model had a default storm event set called, *Sample IDF- 10 year*. There are many other settings that came across that we will touch on as we go.

4. Select the **Details** button to review the results.
5. Close the **Summary** dialog when finished.

Exercise 3: Place Drainage Outfall, Conduits and Manhole

Description

In this exercise, you will learn how to place the drainage outfall for the network and the conduits that will connect the nodes placed in the previous exercise. Additionally, you will learn how to insert a manhole into an existing conduit.

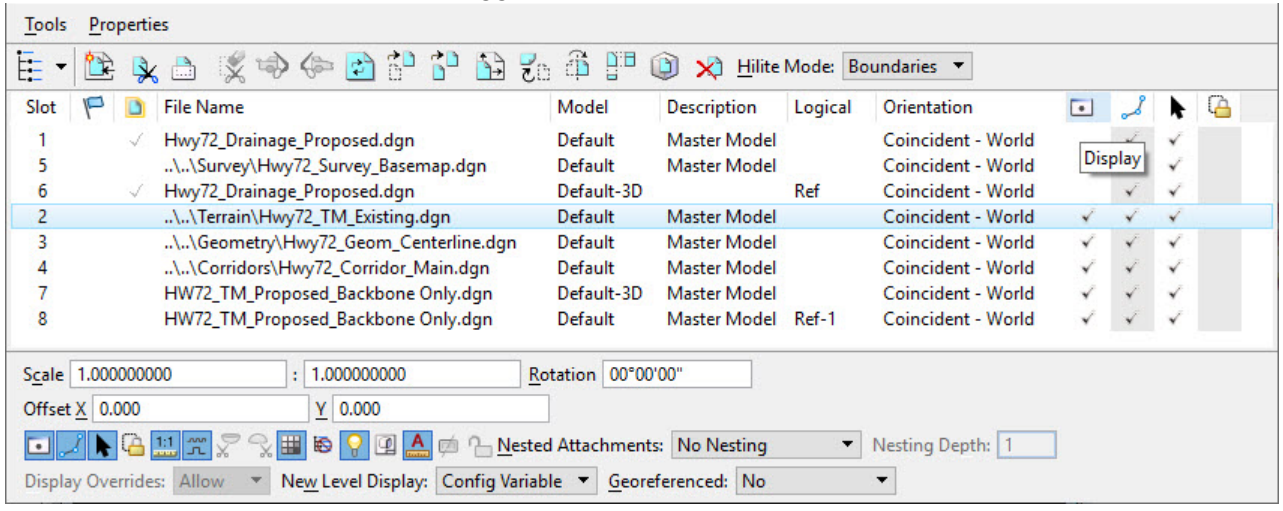
Skills Taught

- Place an Outfall
- Place Conduits
- Place a Manhole
- Move a Manhole

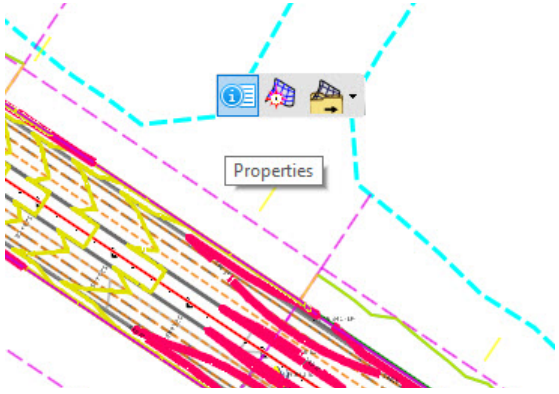
Place an Outfall

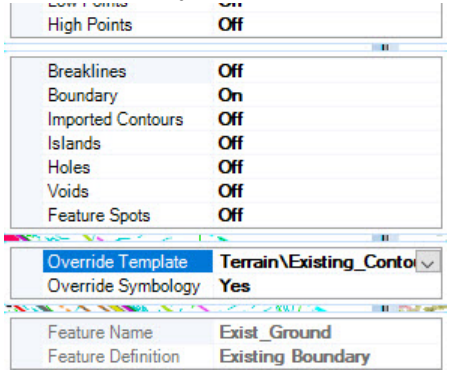
In this section we will place an outfall for our system. Our outfall will be located back toward the bridge, around Station **527+25**, the roadway low point.

1. First we will turn on the Existing Terrain Contours if not already on. Select the **Reference File** Tool.
2. Highlight the *Hwy72_TM_Existing.dgn* and toggle on the **Display**.



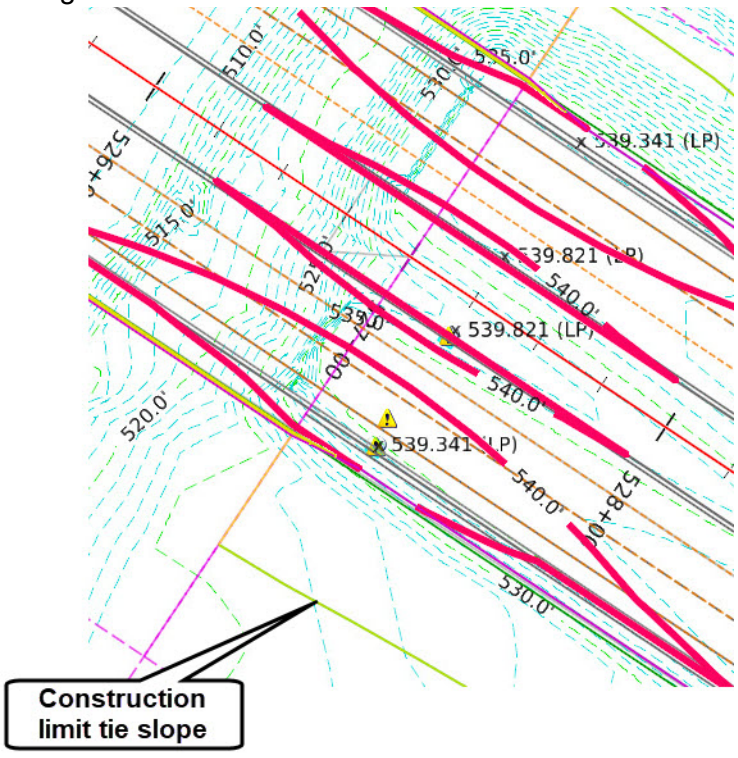
a. Using the **Element Selection** tool select the *Existing Ground* terrain boundary and then **Hover** to access the Element **Properties**.





b. Change the *Override Symbology* from *No* > **Yes** and set the *Override Template* > **Terrain\Existing_Contours**.

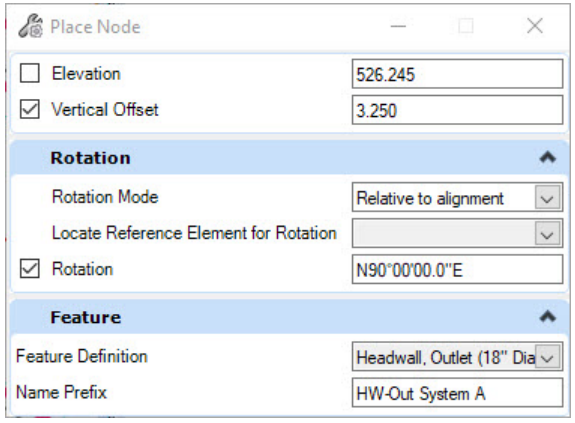
Zoom to the location shown in the image.



We will place the outlet on the south side of the roadway at the construction limit tie slope shown by the green line.

3. Select the **Place Node** tool.

   a. Set the *Feature Definition* > **Headwall, Outlet (18” Dia)**



   You can find it under the *Node* > *StormWaterNodes* > **Outfalls** category.

   b. Set the *Name Prefix* > **HW-Out System A**.

   Select Reference Element For Node Elevation.

   c. Select a contour line being displayed from the terrain surface, **Existing Ground**.

   d. Toggle On the *Vertical Offset* option and set it to **3.250**. (The Elevation is being read at the top of the headwall in the cell).

   e. *Define Outfall* location with a **Data Point.** Place along the green element that represents the *Tie Slope*.

      - Note: You could use *Civil AccuDraw* to place it at station 527+25 and 112’ offset.

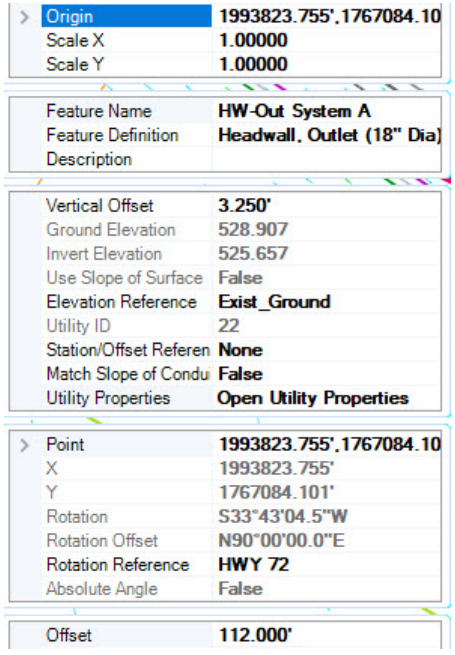
   f. Set the *Rotation Mode* > **Relative to alignment**.

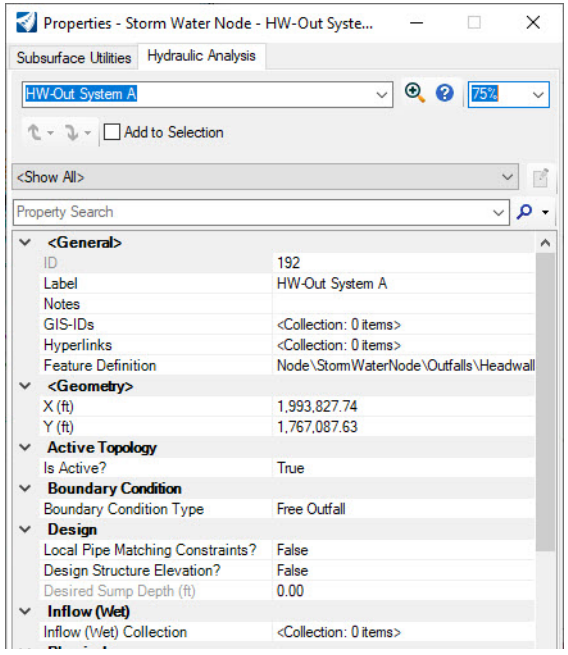
   g. Click on the Centerline of the Roadway, **Complex Element: HWY 72.**

   h. For the *Rotation* setting you will key-in **N 90 E** and click the **Tab** key or **Enter** key to lock the rotation. Then data point in **View 1**.

   i. **Data point** to place the outlet. (The exact location is not critical).

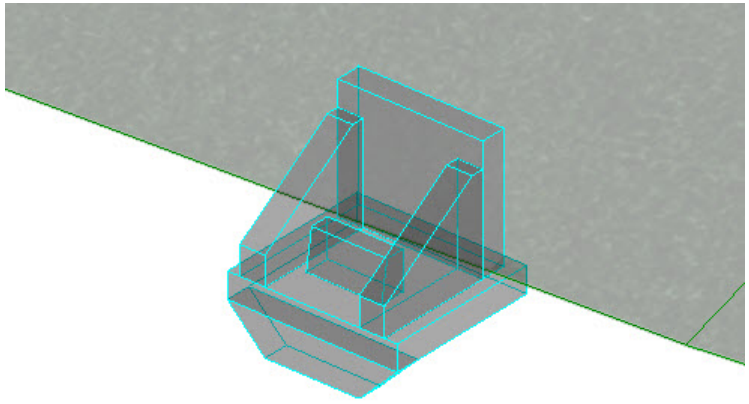
4. Review the **Properties** and the **Utility Properties** of the Outfall, **HW-Out System A**.





a. Close the two **Properties** Dialogs.

5. Click in **View 2** to make it active. Select *Primary > References* and turn on the display for **Hwy72_Corridor_Main.dgn**. Zoom in to the outfall. Your view may vary depending on your Display Style setting.



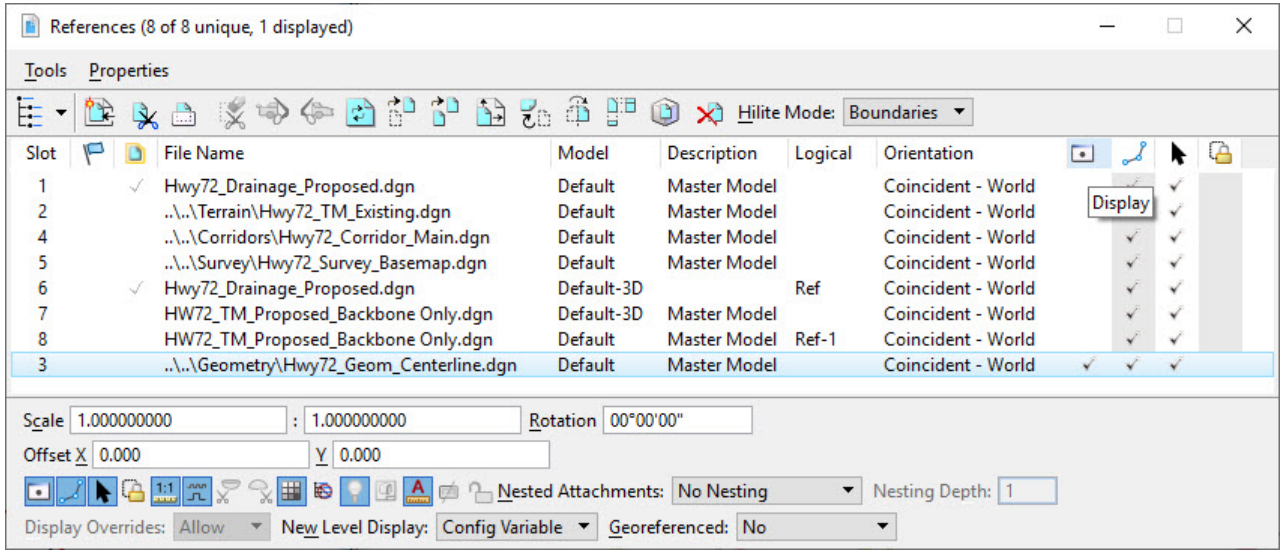
Place Conduits

In this section we will cover creating drainage pipes to connect up our previously placed nodes. We will begin at the *downstream end* of our **network system**. When placing the pipes, we will always ensure to place the **pipe** beginning at the *upstream node* and ending at the *downstream node*.

---

1. First we will turn off the display of several reference files to simplify our view. Select the **Reference File** Tool.

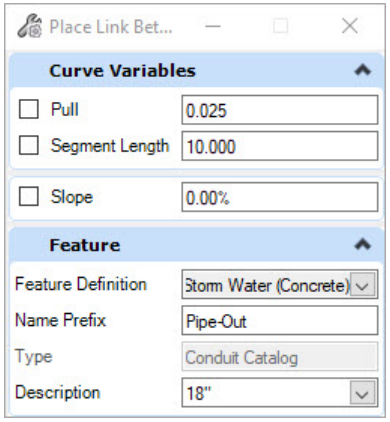
   a. Toggle off the **Display** of every Reference file in **View 1** except the **Hwy72_Geom_Centerline.dgn**.



   b. **Close** the *Reference File* dialog.

2. Select **Drainage and Utilities** workflow then *Layout* > *Layout* > **Place Conduit**.

3. The **Place Link Between Nodes** dialog will appear. We will set the Feature Definition.



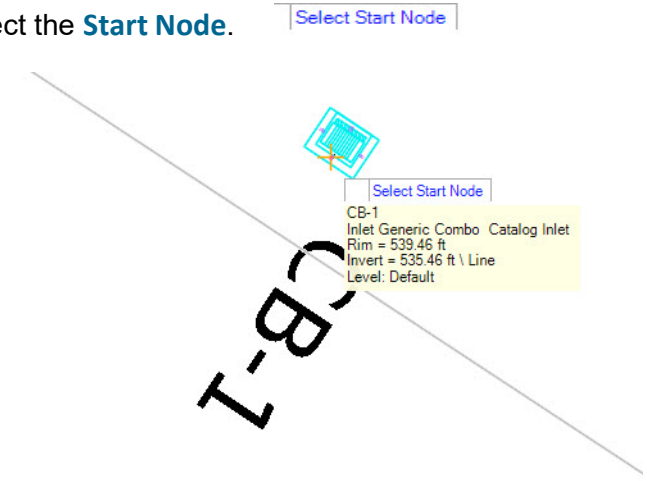
   a. Set the *Feature Definition* > **Storm Water (Concrete)** located in the *Conduit* > *Storm Water* > *Circular* category.

   b. Set the *Name Prefix* > **Pipe-Out**

   c. Select **18”** for the *Description.*

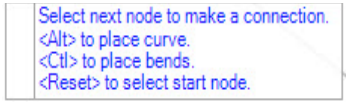
   Toggle Off *Civil AccuDraw* if it is still on.

4. The first prompt is to select the **Start Node**.



   a. Select the *Node* **CB-1** as shown.

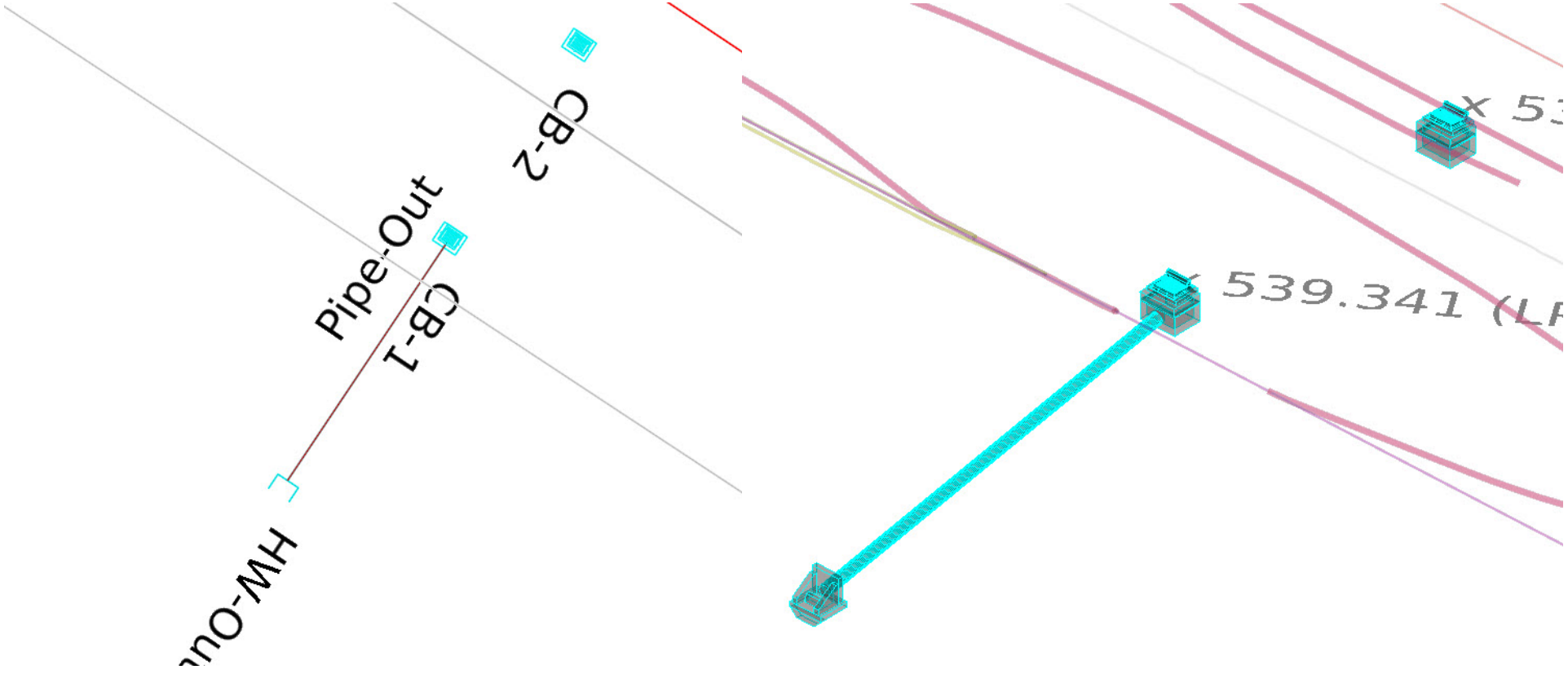
   Next you are prompted to select the next node to make a connection



   a. Select the *Outlet* > **HW-Out System A**

   Note: Always place conduits from the upstream node to the downstream node.

The pipe is placed in the plan view and modeled in the 3D View.



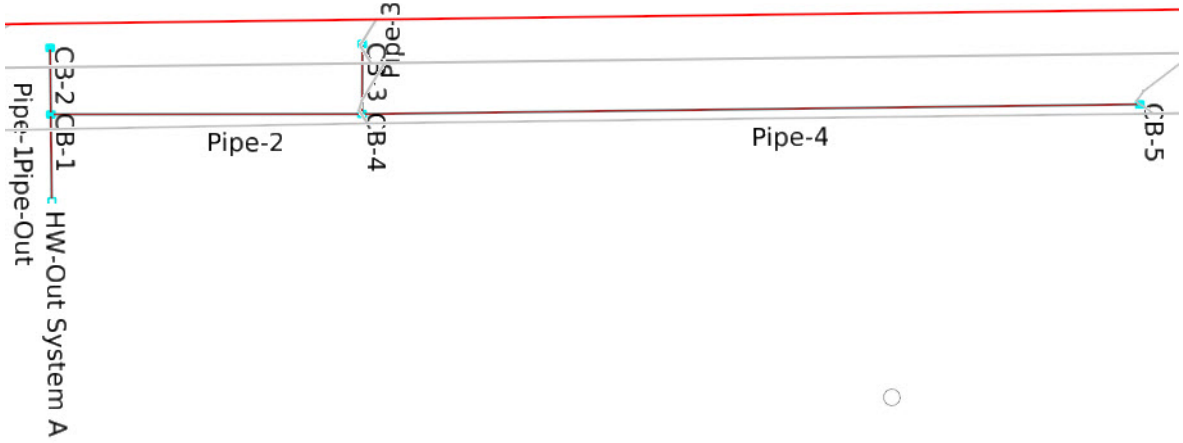
Place Conduit (continued)

We will continue in the Place Conduit tool and connect up the rest of our system.

---

1. Select the **Place Conduit** tool from the *Drainage and Utilities Workflow > Layout >* **Layout.**

   We are going to layout the drainage pipes as shown in the sketch below.

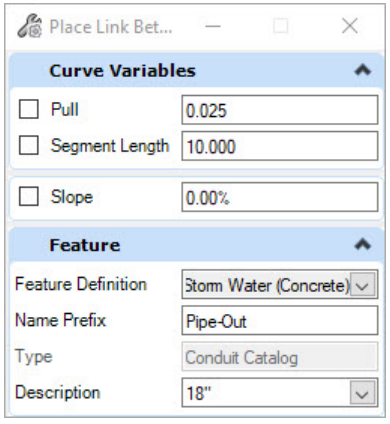


2. Change the tool settings as needed to name the Pipes as shown.

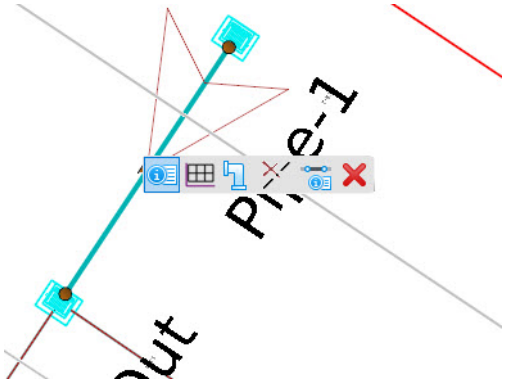
   The Pipe Diameter can be 18” or you can change it if desired.

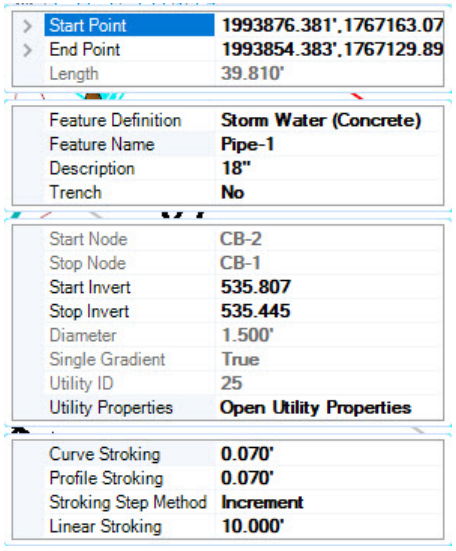
   - **Pipe-1 CB-2 to CB-1**
   - **Pipe-2 CB-4 to CB-1**
   - **Pipe-3 CB-3 to CB-4**
   - **Pipe-4 CB-5 to CB-4**

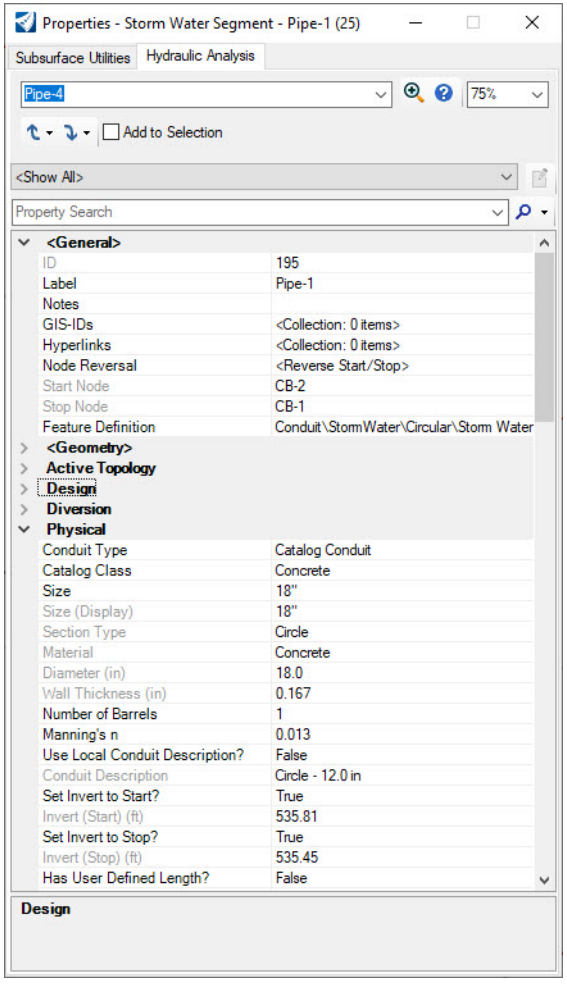
   Note: <u>Remember to place each pipe from upstream to downstream.</u>



3. Use the **Element Selection** tool, select one of the pipes you just placed and **Hover** over it to access the **Properties** Dialog and the **Utility Properties** dialog from the *Context Menu*.







4. **Close** the *Properties* and *Utility Properties* dialogs.

Place a Manhole

In this section we will insert a manhole node into our Pipe that runs from CB-5 to CB-4.

---

1. In **View 1**, Zoom so that you can see **Pipe-4** that runs from **Node CB-5** to **CB-4**. We will place a manhole in the middle of this pipe.
2. Click in **View 2** to make it active.
3. Pan or zoom so that you can see **Pipe-4** in that view as well.
4. Make **View 1** active again by selecting the *view title bar.*
5. Select the **Insert Node** tool from the *Drainage and Utilities Workflow > Layout Tab >* **Layout**.

   We will preset the tool settings for the *Insert Node* tool.

   a. Toggle **Off** *Vertical Offset.*

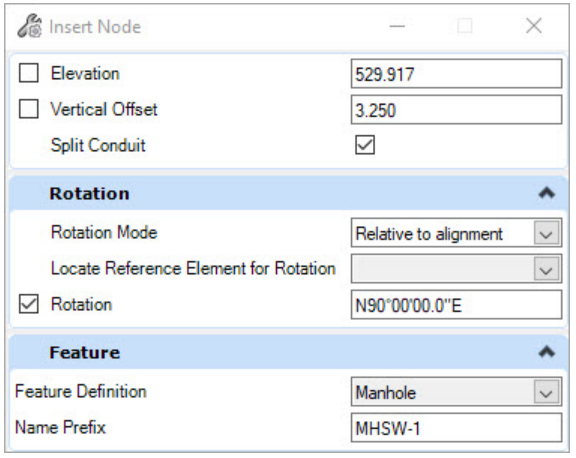
   b. Toggle **On** *Split Conduit.*

   c. Set the *Feature Definition > Node > StormWaterNode > Manholes >* **Manhole**.

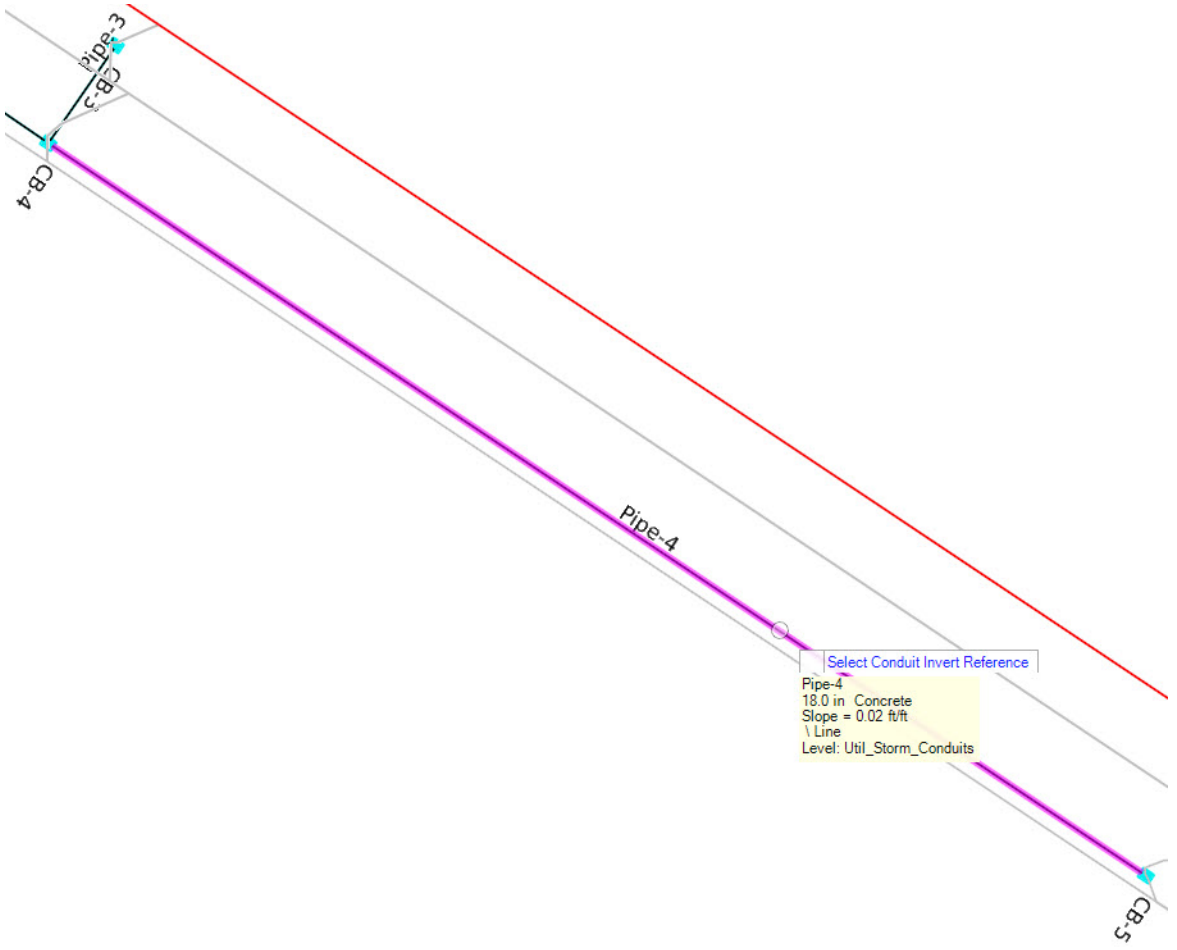
   d. Set the *Name Prefix >* **MHSW-1**.

   The tool prompts you to **Select Reference Element for Node Elevation**

   e. In **View 2**, the 3D view, select the proposed concrete shoulder **component** from the corridor, **TC_Concrete Pavt Shld1**, located adjacent to **Pipe-4**.



f. **Select Conduit Invert Reference** element, select **Pipe-4** in the **2D view** that runs from Node **CB-5** to Node **CB-4**.



g. Toggle Split Conduit to **Yes** by Toggling the option on in the tool settings. So all we need to do is *Data Point* to accept *Yes*.

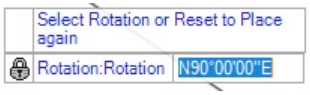
h. Now you will need to select the location where to insert the manhole. Pick a location and *Data Point*. Location is not critical.

i. Set the *Rotation Mode* > **Relative To Alignment** and **Data Point.**

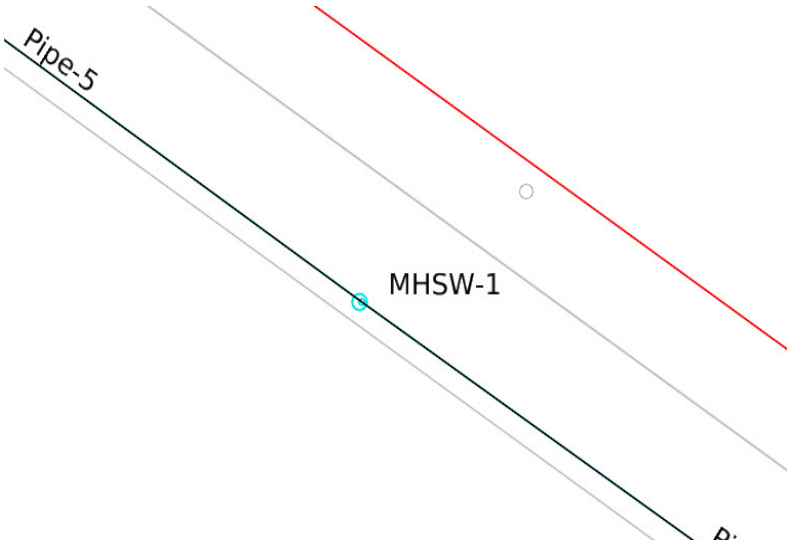
Locate Reference Element for Rotation.

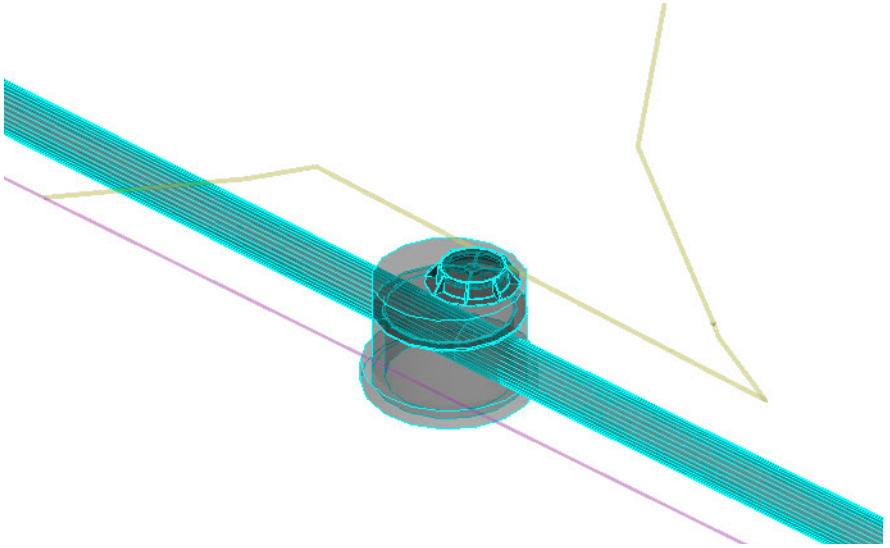
j. Click on the Centerline of the Roadway, *Complex Element: HWY 72.*

k. For the Rotation setting you will key-in **N 90 E** and click the **Tab** key or **Enter** key. to lock the rotation. Then data point in **View 1**.



l. Zoom to the Manhole in **View 1.**





You can see from the view above that there will be some clean-up. You can move the two pipe ends to connect where you would like around the manhole and you can rename the pipes if needed.

Note: To move the pipe you would select it and then click on the Reconnect Link graphic handle and move it to the desired connection point.

6. Before continuing, left click in **View 1**. Using the *References* tool, check that the **Hwy72_Corridor_Main.dgn** reference file is turned **On**.

Move Manhole to middle of Shoulder

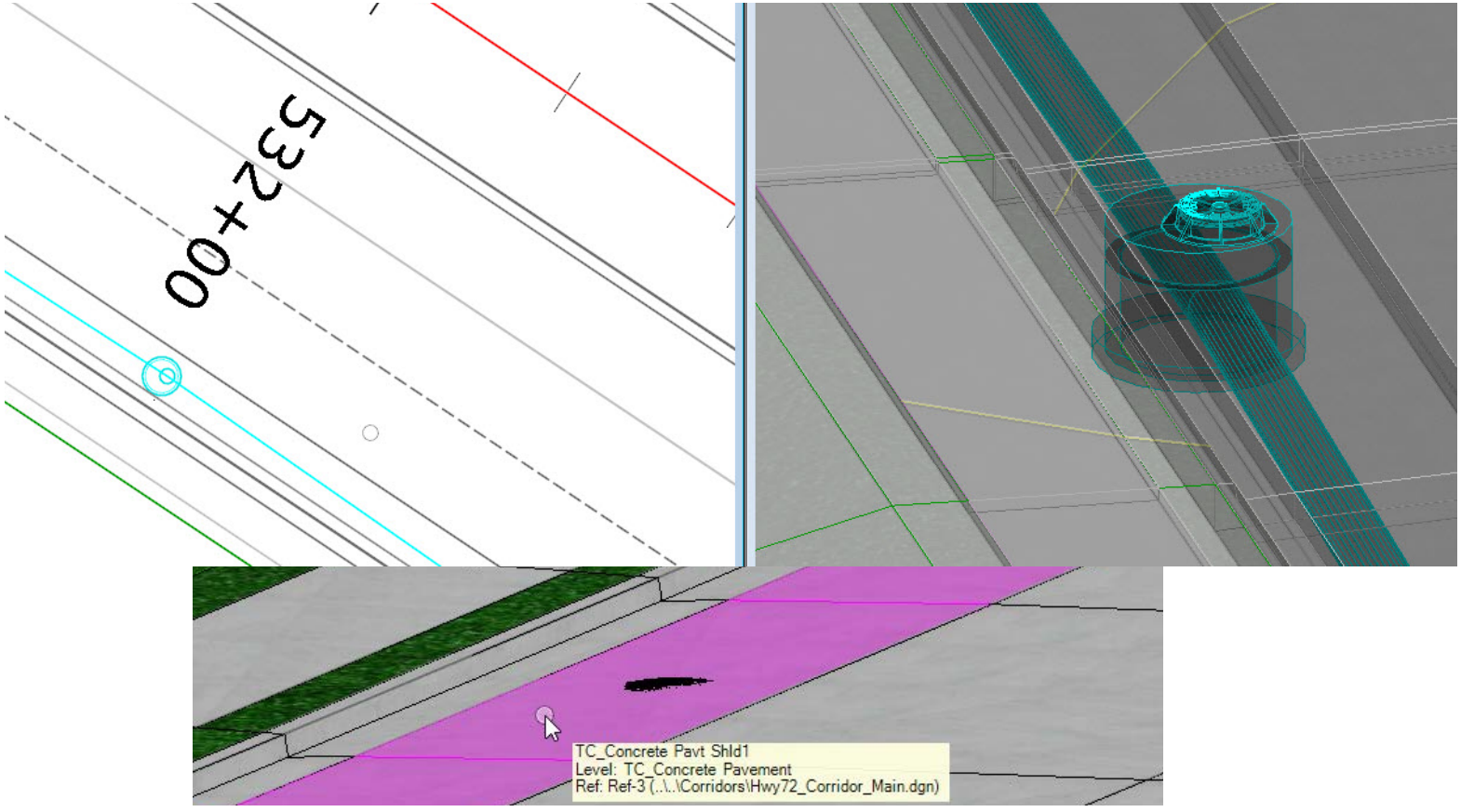
We set our Elevation Reference to the Corridor Shoulder component so we will move our Manhole into the middle of the Shoulder.

1. Use the **Element Selection** Tool and in **View 1**, select the Manhole, **MHSW-1**.

   a. Hover over the Manipulator handle in the center of the manhole until you see the tool tip Move Node.

   There are several manipulators on a node, this one allows us to Move the node or change the Elevation Reference.

   b. *Click* or *Data Point* on the **Move Node** manipulator and move the node into the *Shoulder* area.



Exercise 4: Create Profile, Compute and Design System

Description

In this exercise, you will learn how to create a profile of the network system and compute the system. Then you will learn how to design the system where the software will change conduit sizes to maximize the system design.

Skills Taught

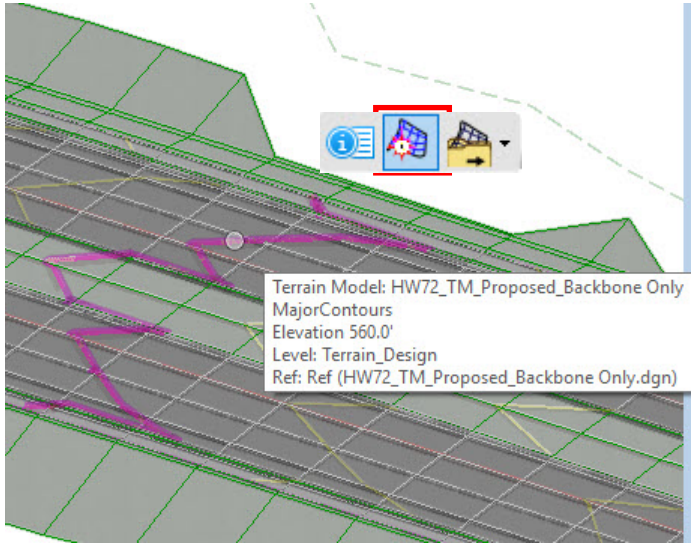
- Create Profile Run
- Compute the System
- Design the System
- Limit Available Pipe Sizes for Design

Create Profile

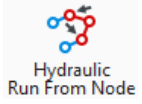
In this section we will create a Profile Run.

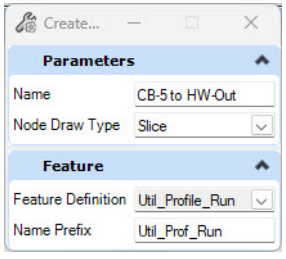
---

1. Select one of the contours in **View 2** that represent the *Hwy72_TM_Proposed_Backbone Only* terrain and hover until you get the context menu and the select **Set as Active Terrain Model**



2. Select the **Hydraulic Run From Node** tool located in the workflow *Drainage and Utilities* > *Layout* > **Profile Runs**.





   a. Set the *Name* > **CB-5 to HW-Out**.

   b. *Node Draw Type* > **Slice**

   c. Set the *Feature Definition* > *Linear* > *Miscellaneous* > **Util_Profile_Run**.

d. Set the *Name Prefix* > **Util_Prof_Run**

e. You are prompted to *Select Start Node*. Select Start Node

f. Select *Node* > **CB-5**

The program finds the shortest route from the Node you select to the Outlet and selects them, you are then prompted to select the stop node or accept the selection. Select Stop Node or Reset to Accept

g. *Right Mouse Click to Accept*.

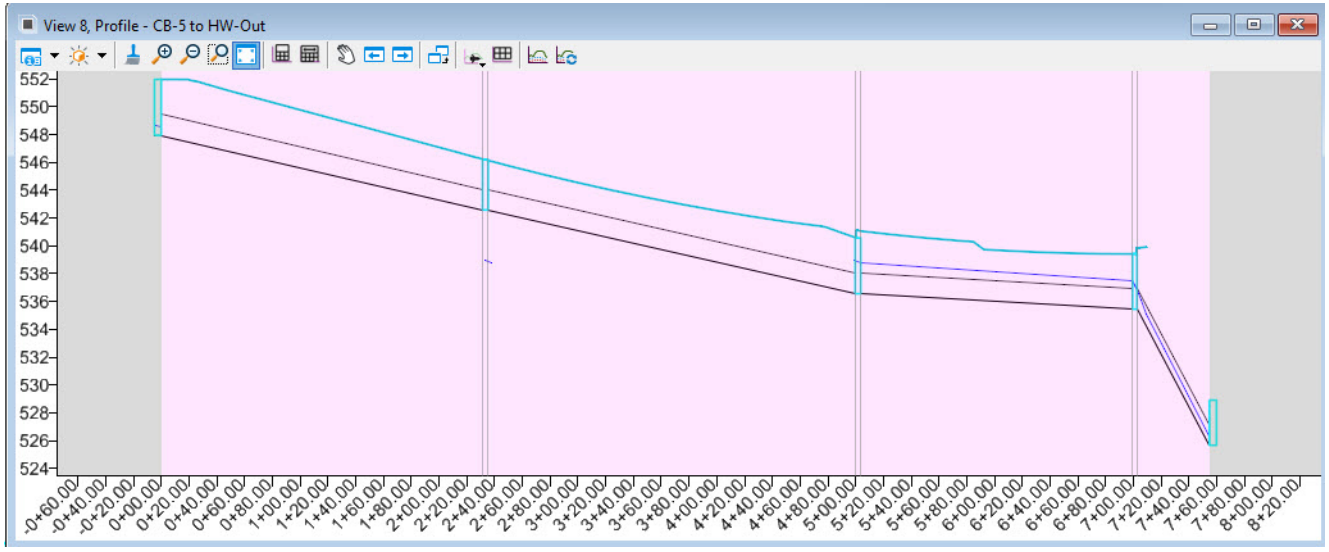
h. Next **Data Point** to create the profile. Click to Accept Profile Run

A Profile Run is stored in the Drainage and Utilities Model and a Linear Feature and Profile is stored in the OpenRoads Model. You can access those from the Explorer.

3. Open **View 8.**

4. In **View 1**, *Click and Hover* on the **Util_Profile_Run** linear geometry element.

a. Select the **Open Profile Model** Icon and *Data Point* in *View 8* to place the profile.

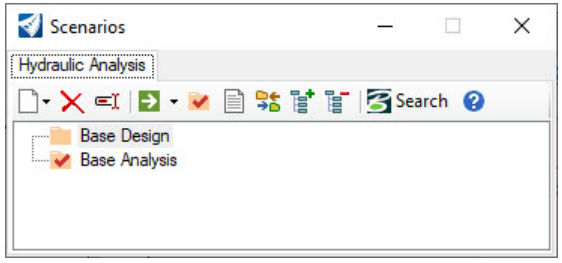


Compute the System

In this section we will compute the system. No adjustments will be made, the software will simply compute the flows and provide you with a summary of the results for your review.

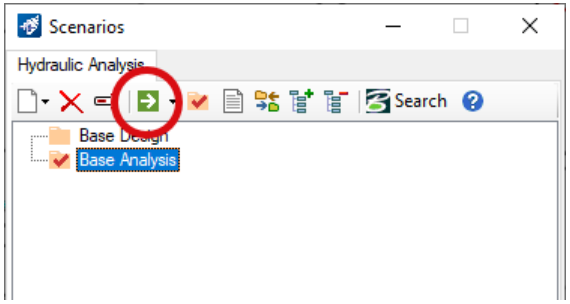
---

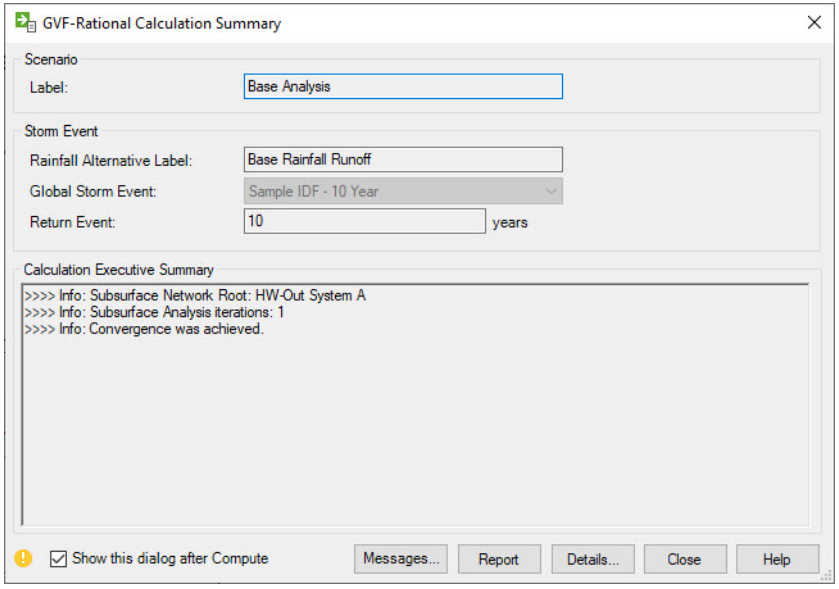
1. Leave the *Profile View* open.
2. Select the workflow *Drainage and Utilities* select the **Analysis Tab**.
3. From the *Calculation Group > Scenarios >* **Scenario Manager**



   a. Select the **Base Analysis** option.

4. On the **Scenarios** dialog, click the green *Compute Scenario* icon. Do not select Compute icon on the ribbon menu.

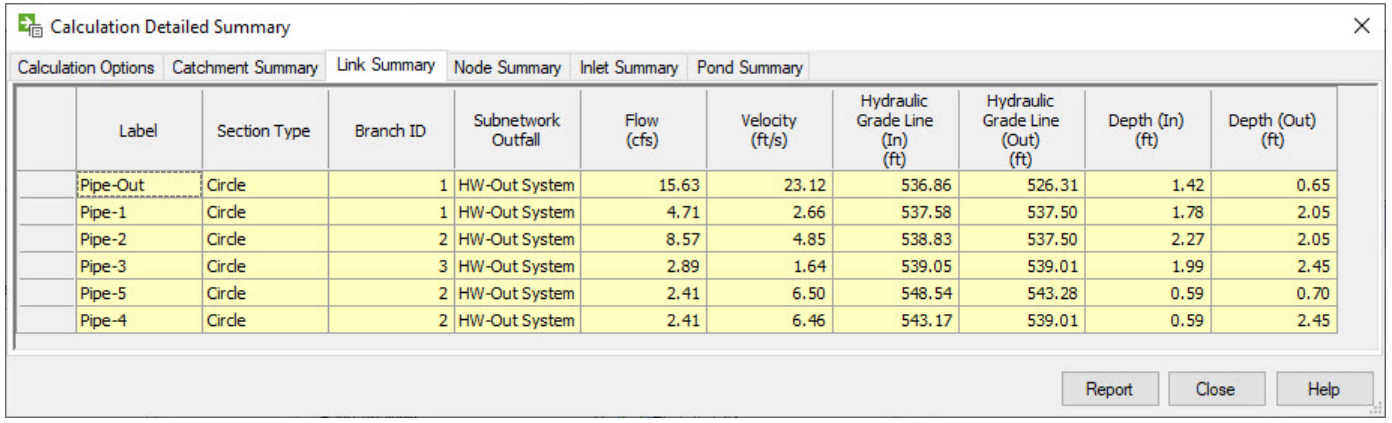




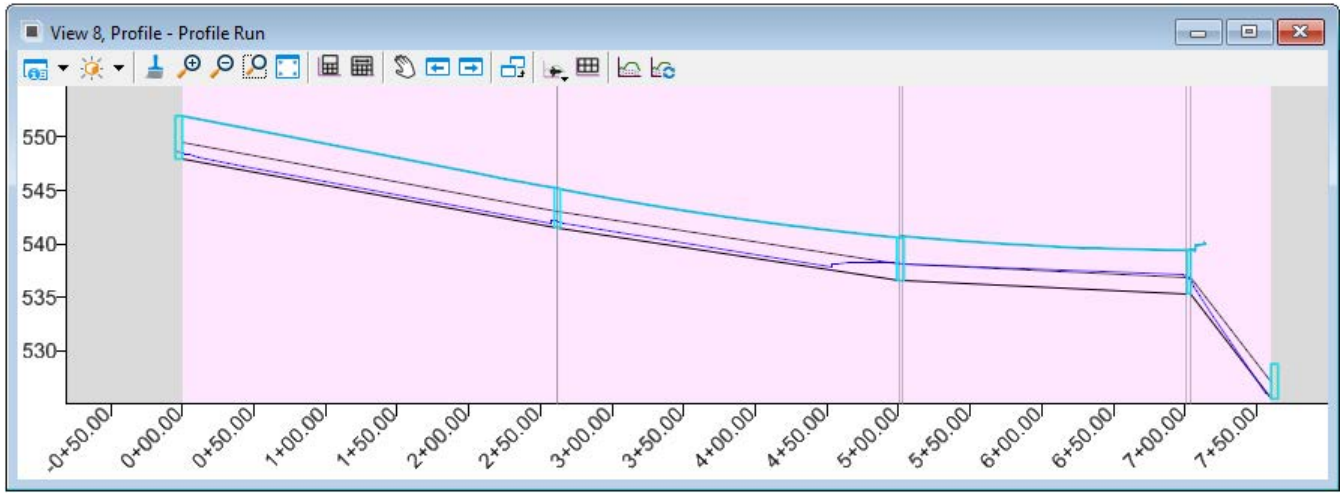
The hydrology and hydraulics calculations are carried out and after a few moments, the Calculation Summary dialog above will open.

Note: *Convergence was achieved* is good news! Also, note that the dialog shows the Storm Event Properties

a. You can click the *Details* button to review the calculations and you will also notice that the profile is updated with the *Hydraulic Grade Line* being shown.



	Label	Section Type	Branch ID	Subnetwork Outfall	Flow (cfs)	Velocity (ft/s)	Hydraulic Grade Line (In) (ft)	Hydraulic Grade Line (Out) (ft)	Depth (In) (ft)	Depth (Out) (ft)
	Pipe-Out	Circle	1	HW-Out System	15.63	23.12	536.86	526.31	1.42	0.65
	Pipe-1	Circle	1	HW-Out System	4.71	2.66	537.58	537.50	1.78	2.05
	Pipe-2	Circle	2	HW-Out System	8.57	4.85	538.83	537.50	2.27	2.05
	Pipe-3	Circle	3	HW-Out System	2.89	1.64	539.05	539.01	1.99	2.45
	Pipe-5	Circle	2	HW-Out System	2.41	6.50	548.54	543.28	0.59	0.70
	Pipe-4	Circle	2	HW-Out System	2.41	6.46	543.17	539.01	0.59	2.45



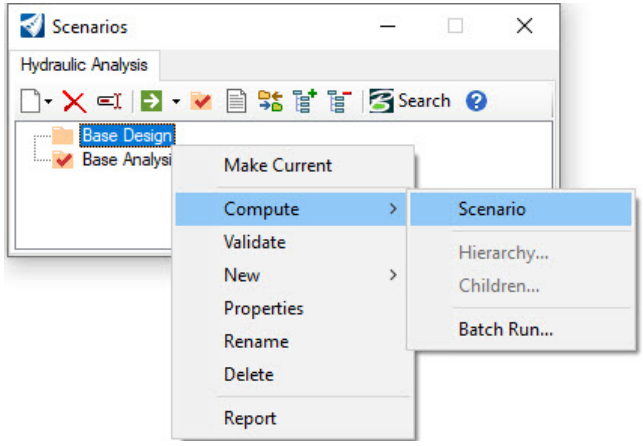
b. **Close** the *Calculation Summary* dialog when finished.

Let the Software Design the System

In this section we will adjust a few settings and allow the software to design the system for us. We will allow the software to adjust Pipe Sizes and set Pipe Inverts for optimal system performance.

---

1. In the **Scenarios** dialog, Select *Base Design*, right click on it and select *Compute* > **Scenario**.



The software will begin to compute the scenario. The software recognizes that in a Design Calculation, Pipe Sizes, Invert Elevations, and other Physical properties will change from your original layout.

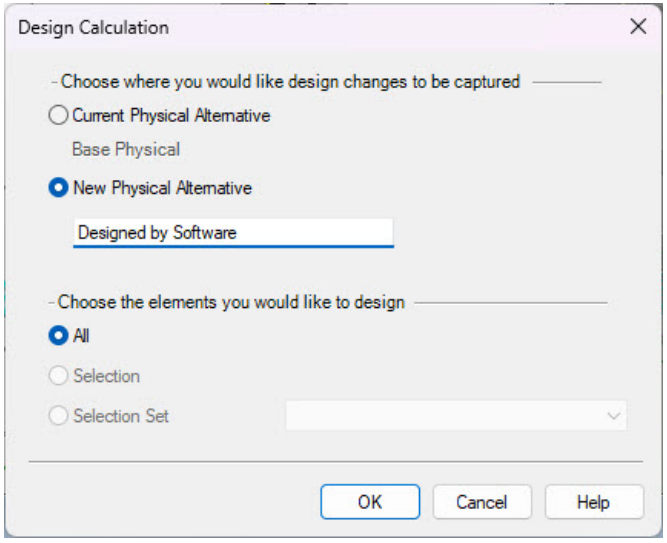
So it stops the process and wants to allow you to save these new sizes and elevations off under a separate name of your choosing. So that if you want to get back to your original data it will be very easy.

a. *Select* > **New Physical Alternative**

Type in a name for the Physical properties alternative.

b. For example key in **Designed By Software.**

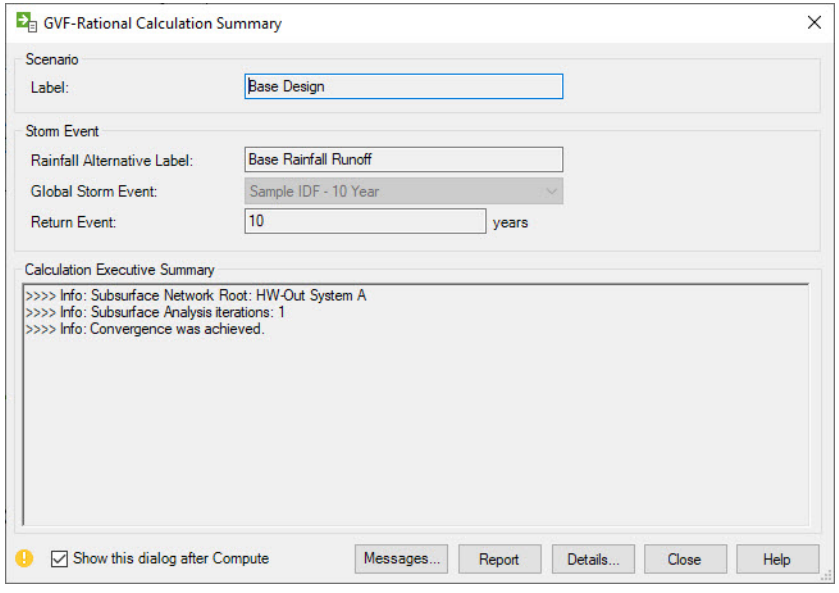
c. *Click* **OK**



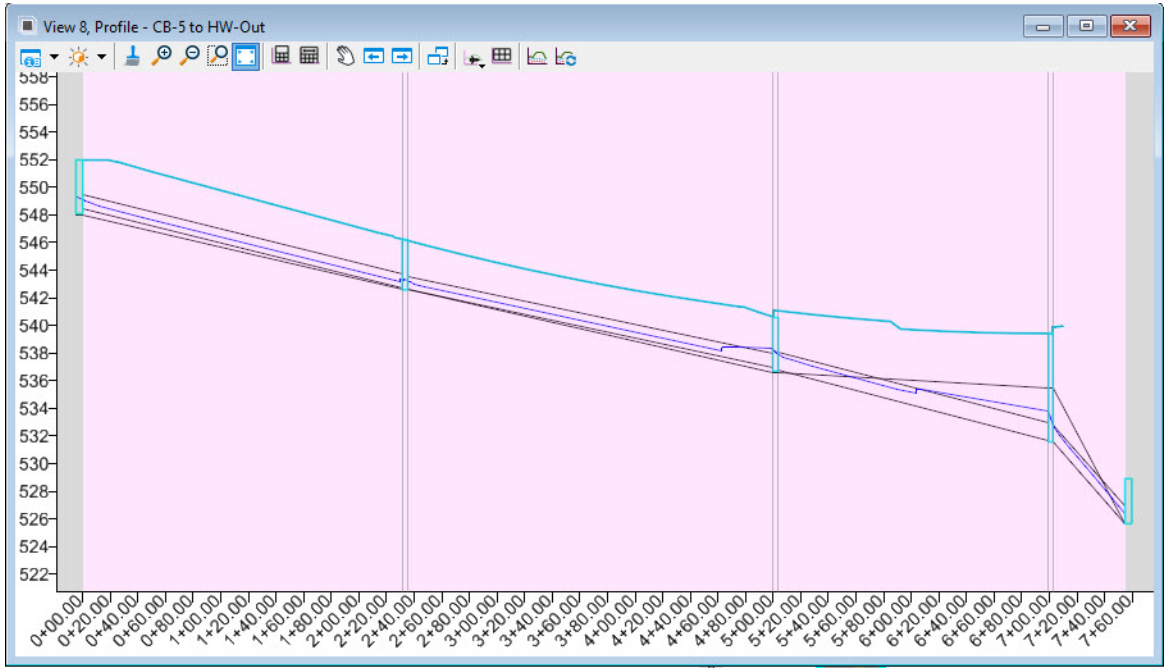
The software continues to compute and optimize the design and eventually the *Calculation Summary* dialog will appear.

d. Click the **Details** button to review the *Link Summary*.

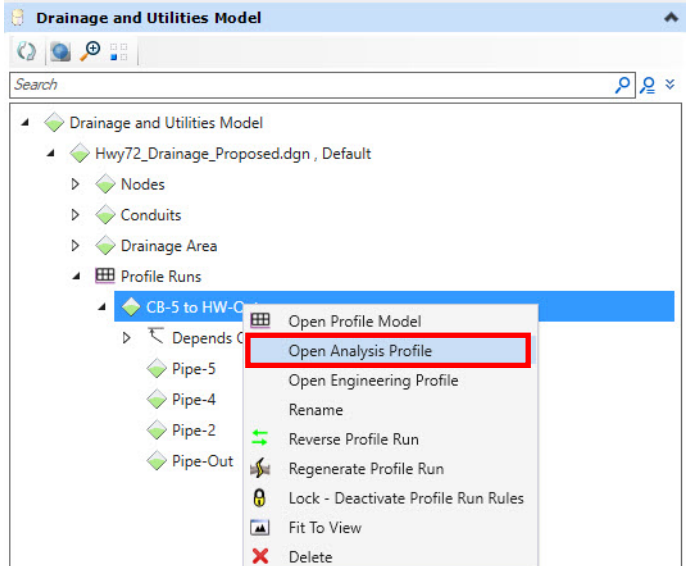
e. **Close** the dialogs when finished.



The Profile View should still be open and has been updated to the current design scenario.

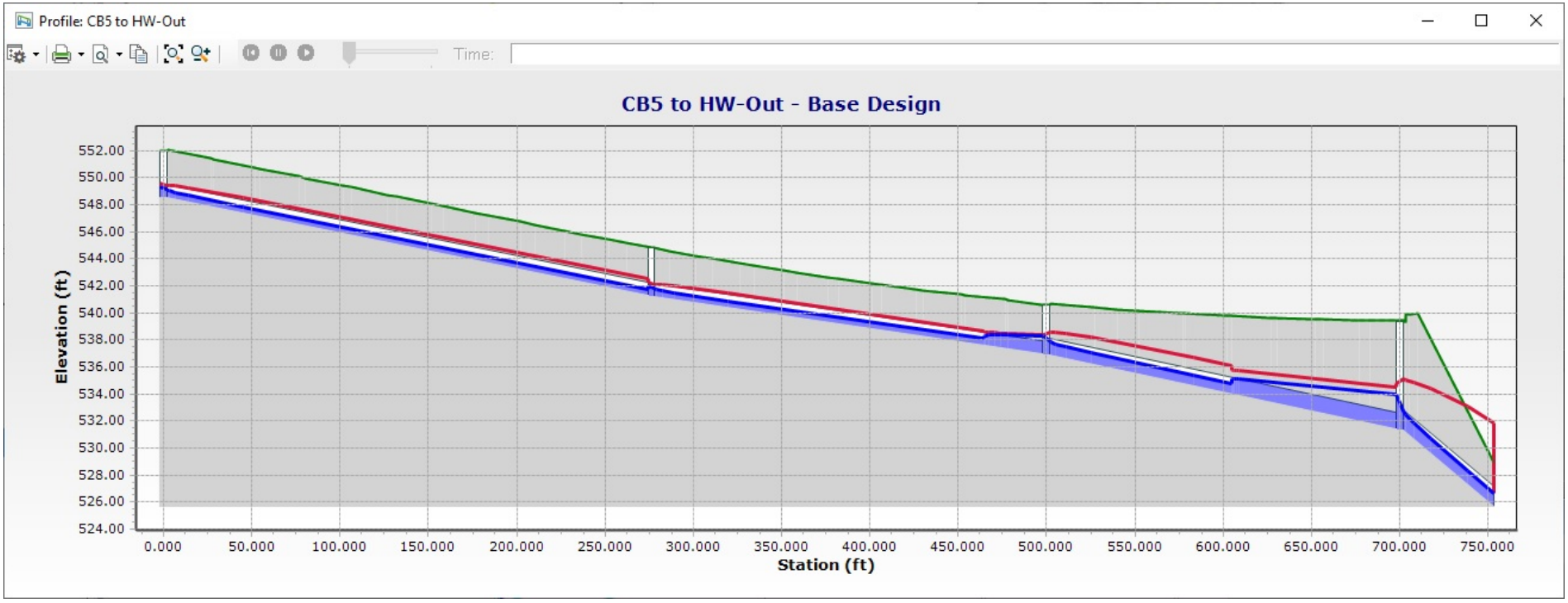


2. Open the **Explorer** window and expand the **Drainage and Utilities Model** Tab.



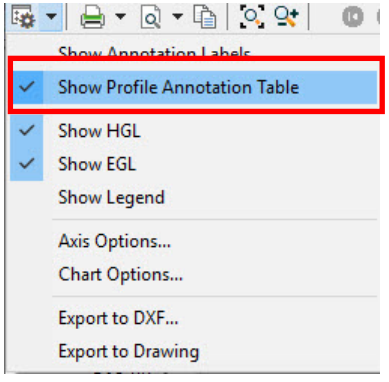
a. Expand the **Profile Runs** and *Right click* on the **CB-5 to HW-Out** profile and select **Open Analysis Profile**.

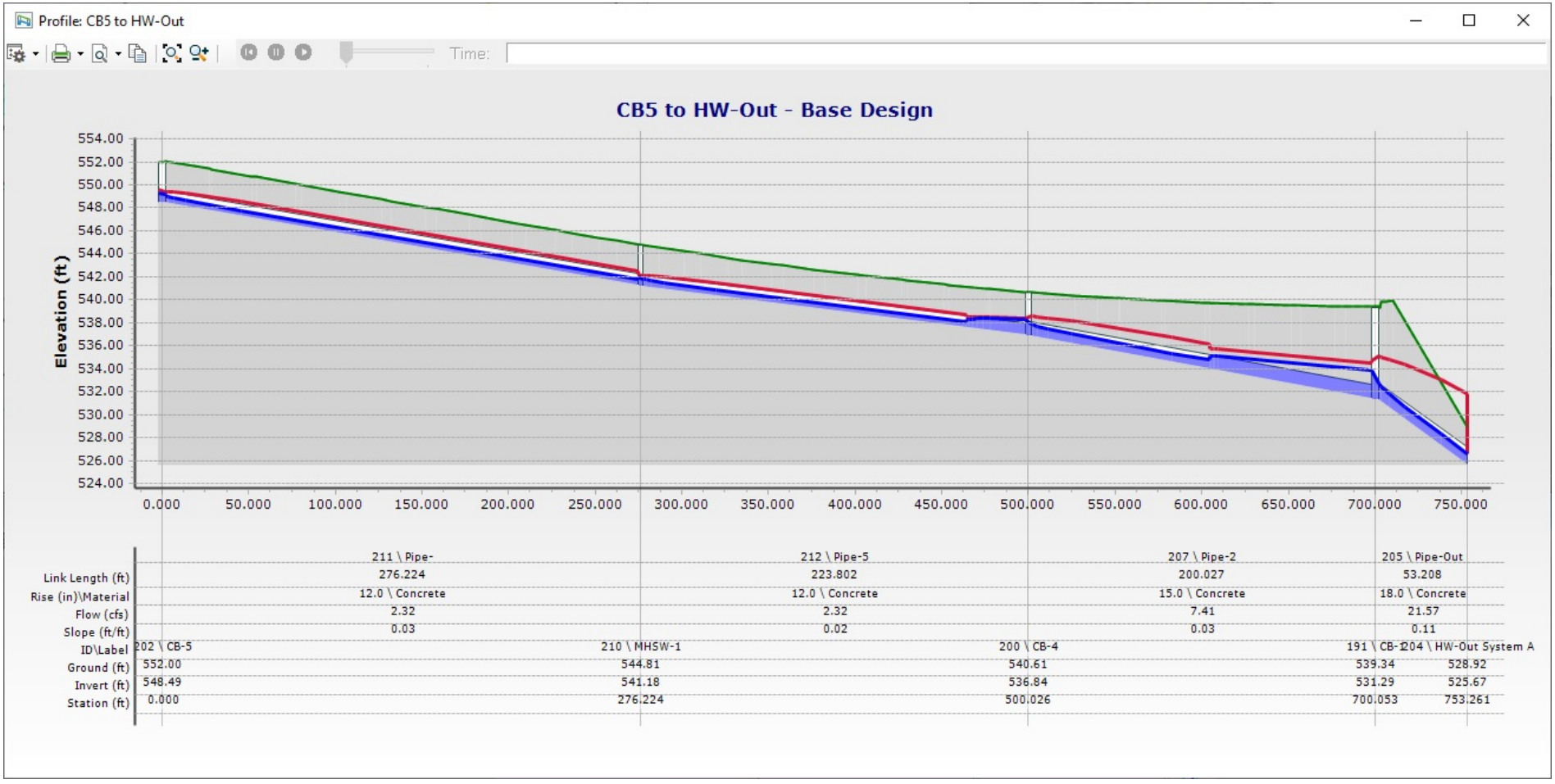
This profile will display in its own window.



b. Click the *Down Arrow* next to the **Chart setting** icon in the upper left corner of the Profile window.

c. Select **Show Profile Annotation Table** to show the Pipe information along the bottom of the Profile view window.





d. **Close** the Profile analysis window when finished.

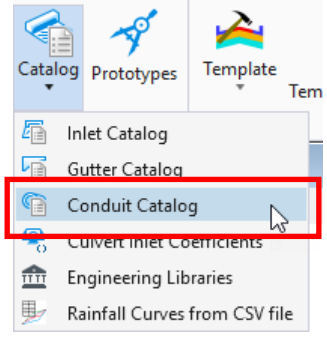
Limit the Pipe Sizes available for Design

In this section we will not allow the software to use pipe sizes smaller than 18” in diameter.

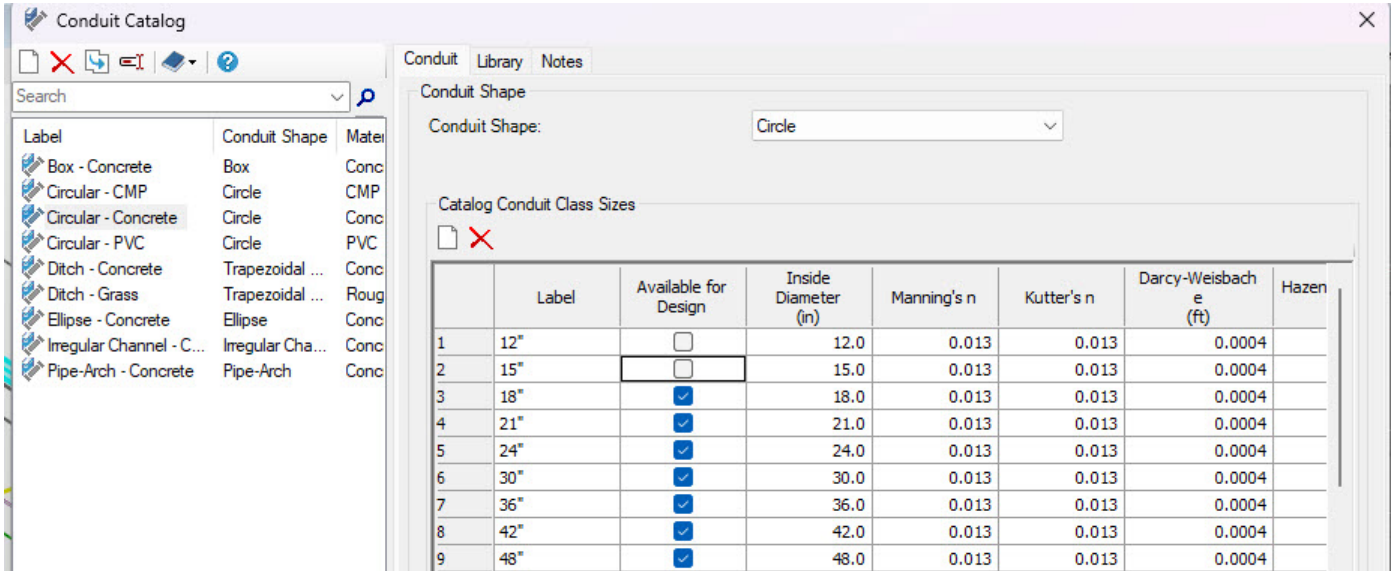
---

1. In the Workflow *Drainage and Utilities* switch to the **Components** Tab.

   a. In the *Catalog* Group click the down arrow under the *Catalog* icon and select **Conduit Catalog**.



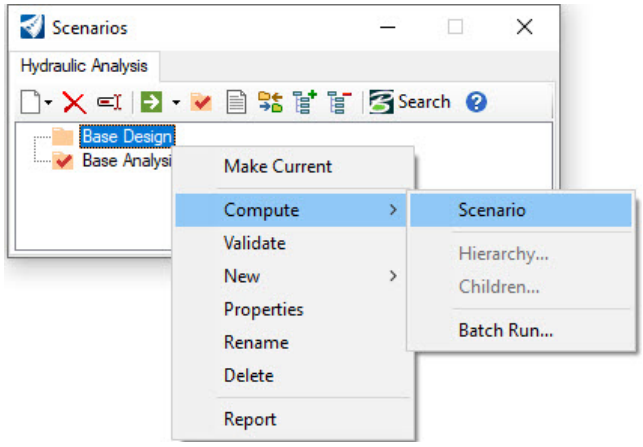
   b. The *Conduit Catalog* will open and we will select **Circular-Concrete** under the *Label* column.



   c. In the *Available for Design* column, *toggle* **off** the option for the **12” and 15”** sizes.

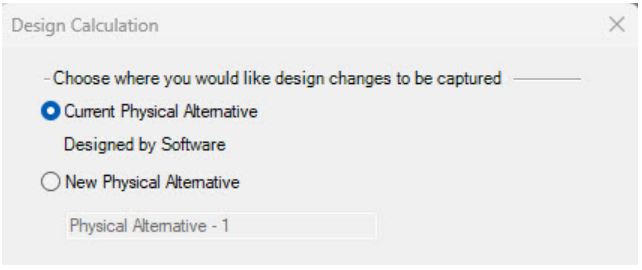
   d. **Close** the *Conduit Catalog*.

2. In the **Scenarios** dialog, highlight *Base Design*, right click on it and select *Compute* > **Scenario.**



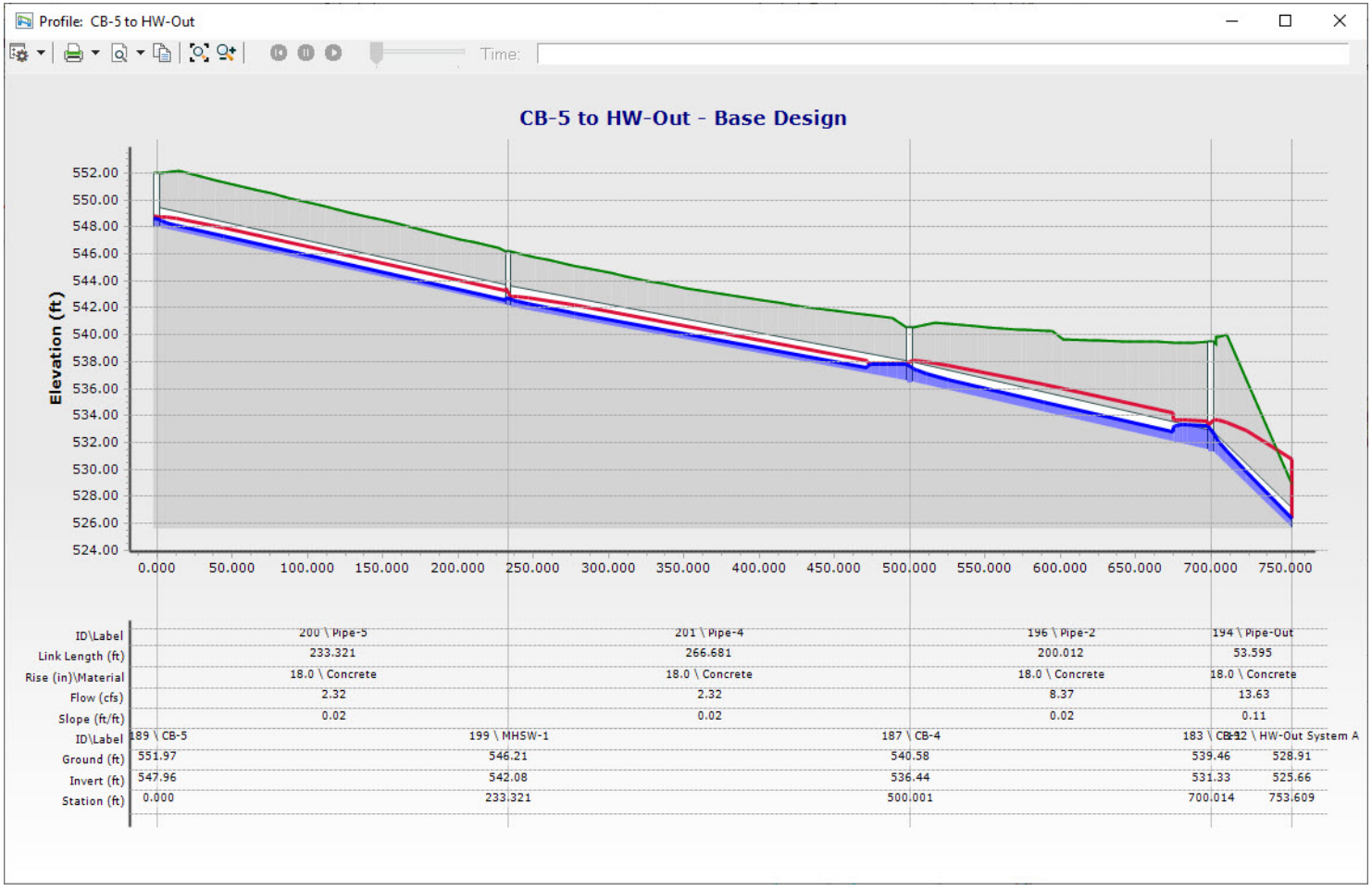
The software will begin to compute the scenario. The software recognizes that in a Design Calculation, Pipe Sizes, Invert Elevations, and other Physical properties will change.

So it stops the process and wants to allow you to save these new sizes and elevations off under a separate name of your choosing. This time we will just use the same one we just did called *Designed By Software.*



a. *Click* the **OK** button.

b. **Close** the Summary dialog when it comes up and go and open an **Analysis Profile** from the Explorer window.



3. **Close** the *Profile Analysis* window when finished.

Skills Assessment

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

---

1. A user should manually create a 3D model in their 2D project file.
   a. True
   b. False
2. The utility model is stored in the design file.
   a. True
   b. False
3. You should always place your drainage structures in 3D.
   a. True
   b. False
4. Which tool would be used to change the inlet location from On Grade to In Sag?
   a. Explorer
   b. Properties
   c. Utility Properties
   d. References
5. Which tool can be used to place an inlet at a specific station and offset relative to the centerline?
   a. AccuDraw
   b. Civil AccuDraw
   c. Utility Properties
   d. AccuSnap

6. Always place conduits from the upstream node to the downstream node.
   a. True
   b. False

Skills Assessment - Answers

The answers to the skills assessment questions are highlighted below.

---

1. A user should manually create a 3D model in their 2D project file.
   a. True
   b. **False - use the *Set As Active Terrain Model* command and let the software automatically create the 3D model.**
2. The utility model is stored in the design file.
   a. **True**
   b. False
3. You should always place your drainage structures in 3D.
   a. True
   b. **False - place all drainage structures in the 2D model. The software will automatically manage the 3D model.**
4. Which tool would be used to change the inlet location from On Grade to In Sag?
   a. Explorer
   b. Properties
   c. **Utility Properties**
   d. References
5. Which tool can be used to place an inlet at a specific station and offset relative to the centerline?
   a. AccuDraw
   b. **Civil AccuDraw**
   c. Utility Properties
   d. AccuSnap

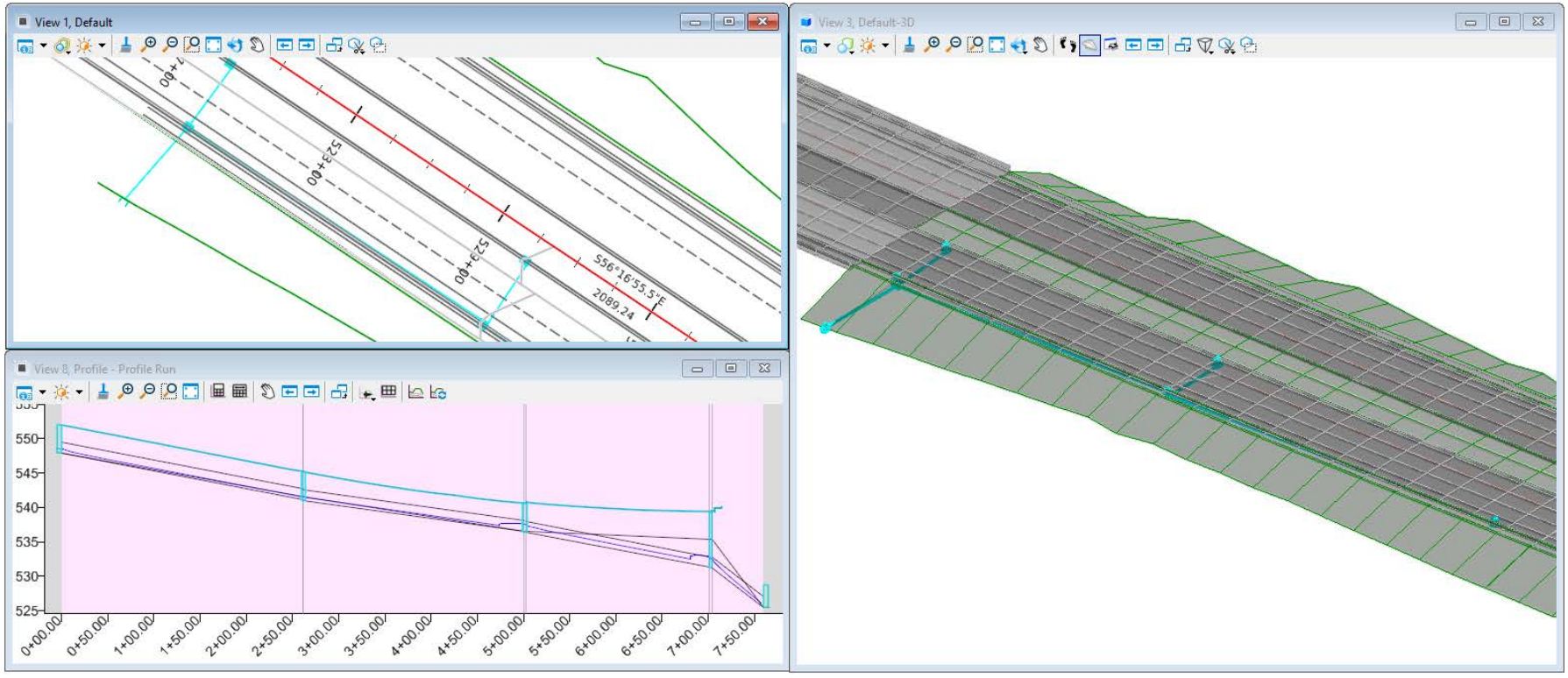
6. Always place conduits from the upstream node to the downstream node.

   a. **True**

   b. False

Summary

In this course you have learned how to layout and compute a drainage network.



For additional information and help with the software please visit the Drainage and Utilities Wiki page:

https://communities.bentley.com/products/road___site_design/w/road_and_site_design__wiki/38322/subsurface-utilities

Or the OpenRoads/OpenSite Forum:

https://communities.bentley.com/products/road___site_design/f/