OpenRoads Designer User Manual

U.S. Department of Transportation
Federal Highway Administration

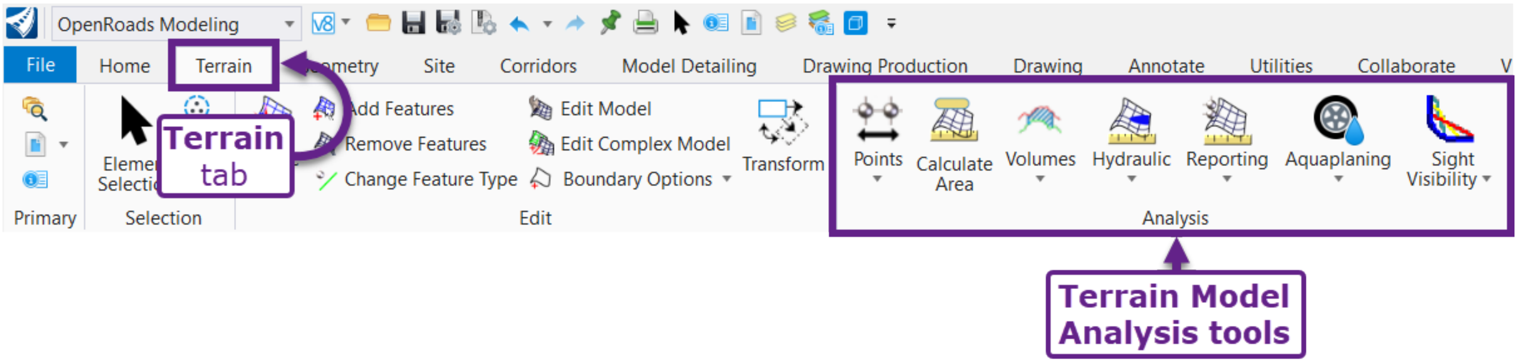
Chapter 21

TERRAIN MODEL ANALYSIS TOOLS

2021 R2 Update 10 – Version 10.10.21.04 – WorkSpace 10.10V
December 2022

Chapter 21 Terrain Model Analysis Tools

This chapter describes the tools used to analyze Terrain Models and also contains a workflow for Sight Visibility (SSD and PSD) analysis. All tools described in this chapter are found under the **Terrain** tab and in the **Analysis** group.



NOTE: Most Terrain Model Analysis tools are NOT compatible with Corridors and Linear Templates. However, a Corridor or Linear Template can be quickly converted into a Terrain Model using the *Create Terrain Model from Design Meshes* tool. See *22A.1 Create Terrain Model from Design Meshes tool*.

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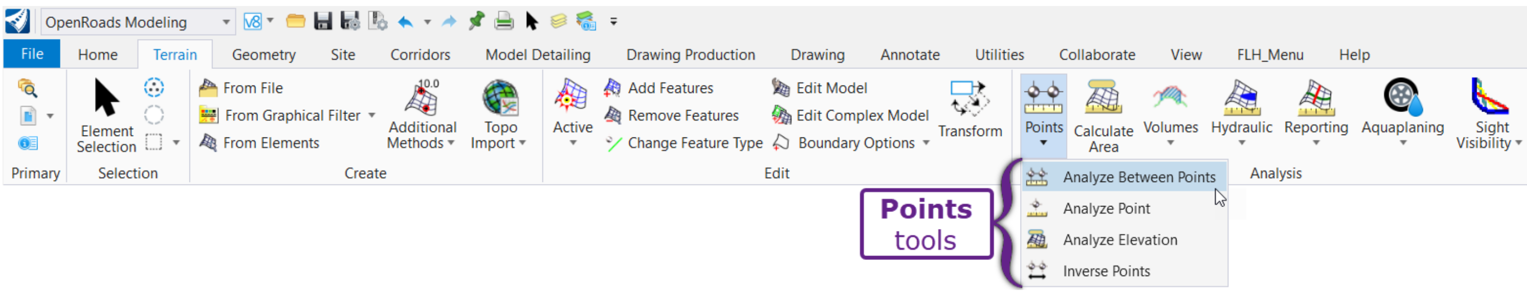
21A – POINTS TOOLS

Points tools are used to analyze point locations on a Terrain Model. These tools create a label element that measure the elevation, slope, and other parameters along a Terrain Model.

Points tools are found in the Ribbon in the following location:

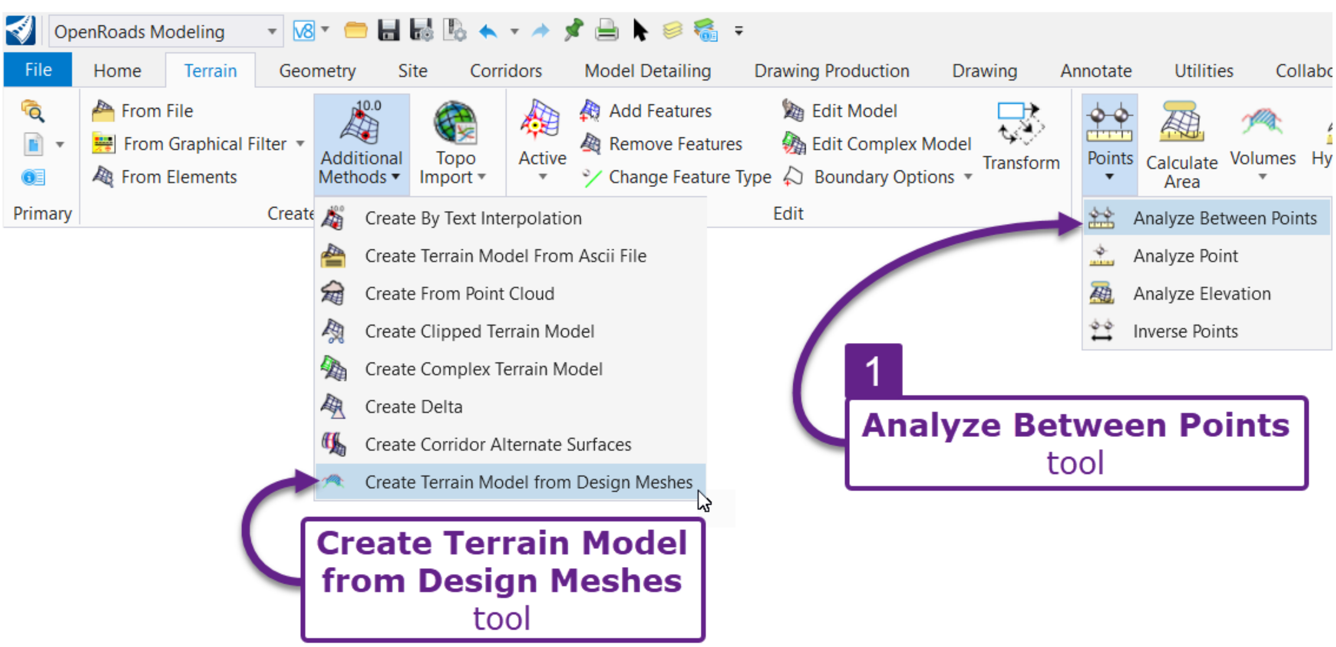
OpenRoads Modeling workflow → **Terrain** tab → **Analysis** group → **Points** drop-down



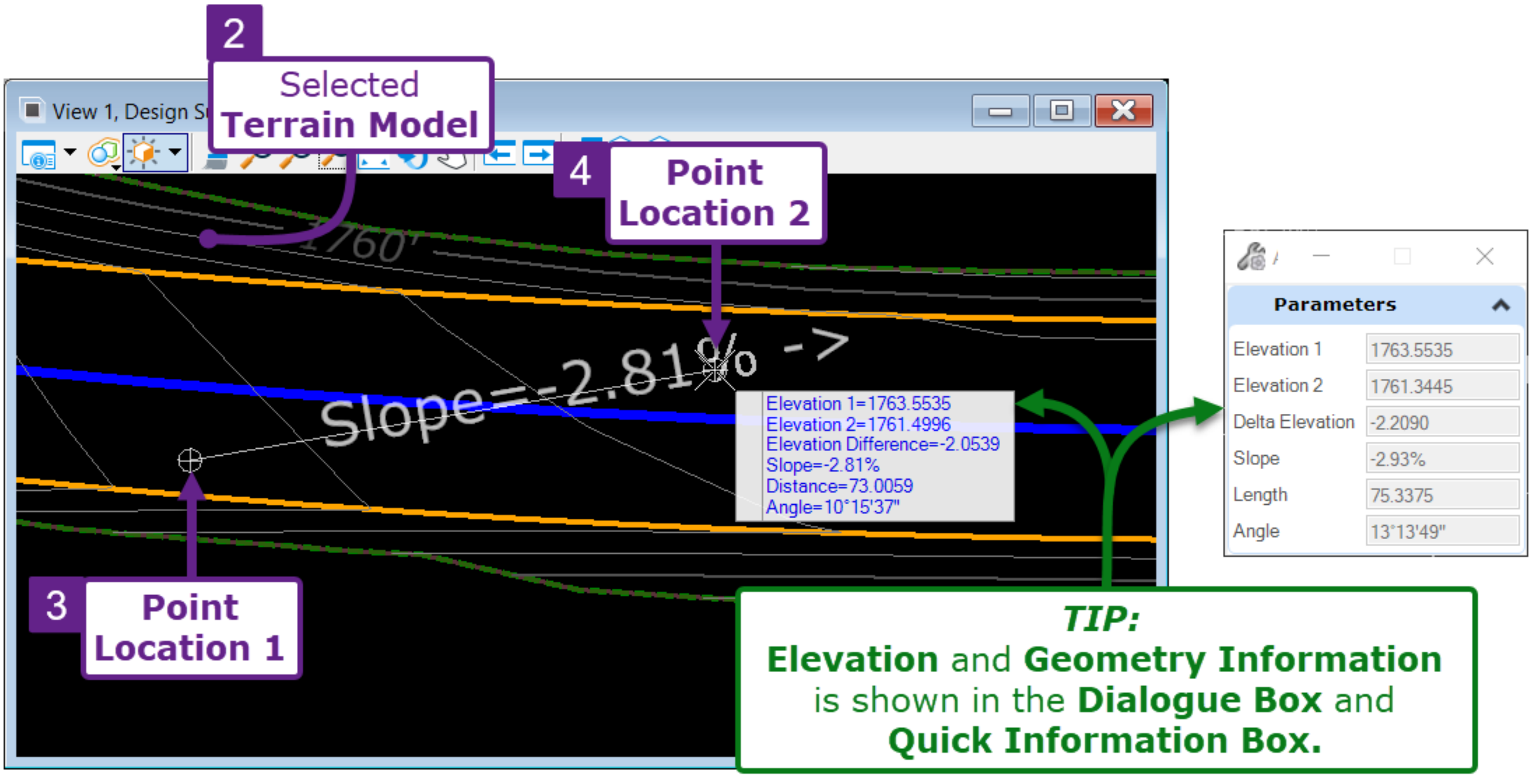
21A.1 Analyze Between Points tool

The *Analyze Between Points* tool creates a label that measures slope between two-point locations on a Terrain Model. This tool can be operated from either the *2D Design Model* or *3D Design Model* .

NOTE: This tool is NOT directly compatible with Corridors and Linear Templates. The Corridor or Linear Template must be converted into a Terrain Model for use with this tool. Use the *Create Terrain Model from Design Meshes* tool to convert Corridors and Linear Templates into a Terrain Model. See *22A.1 Create Terrain Model from Design Meshes*.



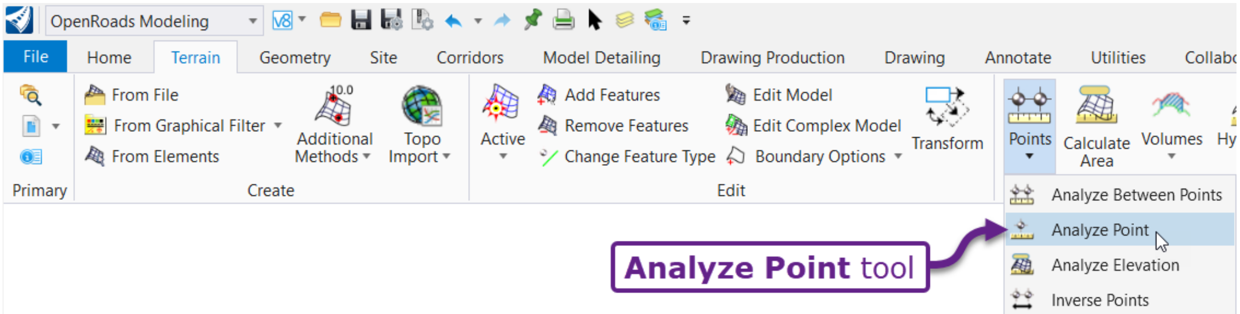
TIP: When placing the slope label, elevation and geometry information relating to the two-point locations is shown in the *Dialogue Box* and *Quick Information Box*.



1	From the Ribbon, select the *Analyze Between* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Analysis*** → ***Points***].
2	*Prompt: Select Terrain Model element* – Left-Click on the Terrain Model to analyze.
3	*Prompt: Select Start Point* – Left-Click at the first point location.
4	*Prompt: Select End Point* – Left-Click at the second point location.

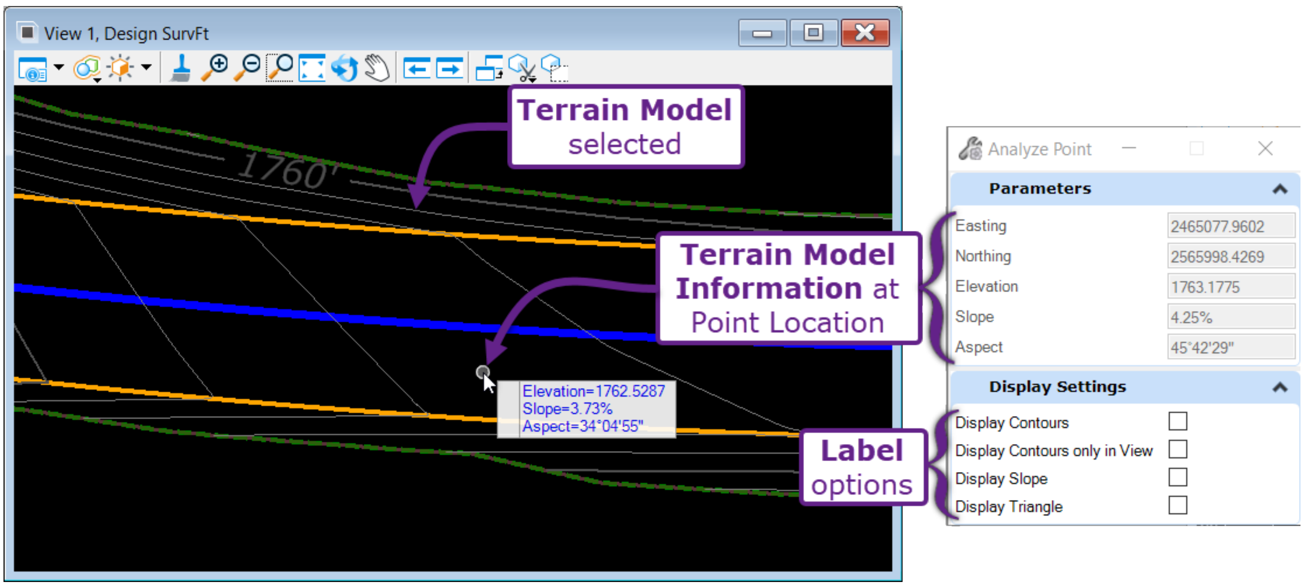
21A.2 Analyze Point tool

With this tool, a 3D element type is selected and a point location is analyzed for northing, easting, elevation and other parameters.

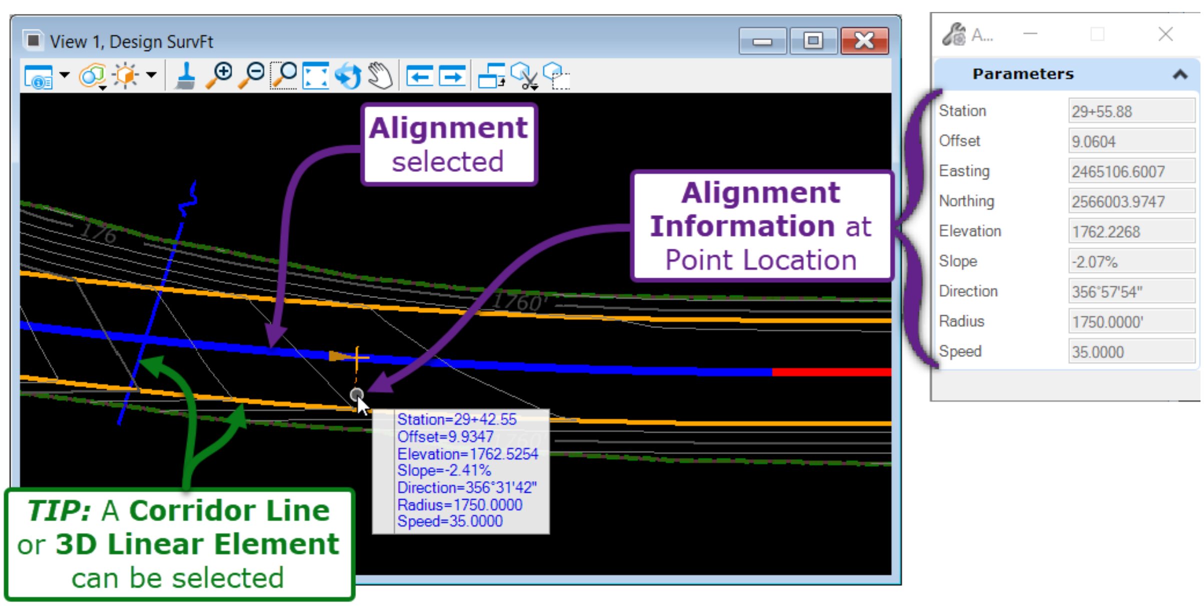


As shown below, many 3D element types that are compatible with this tool, including Corridors and Linear Templates. The analysis information shown in the *Dialogue Box* depends on the type of element selected.

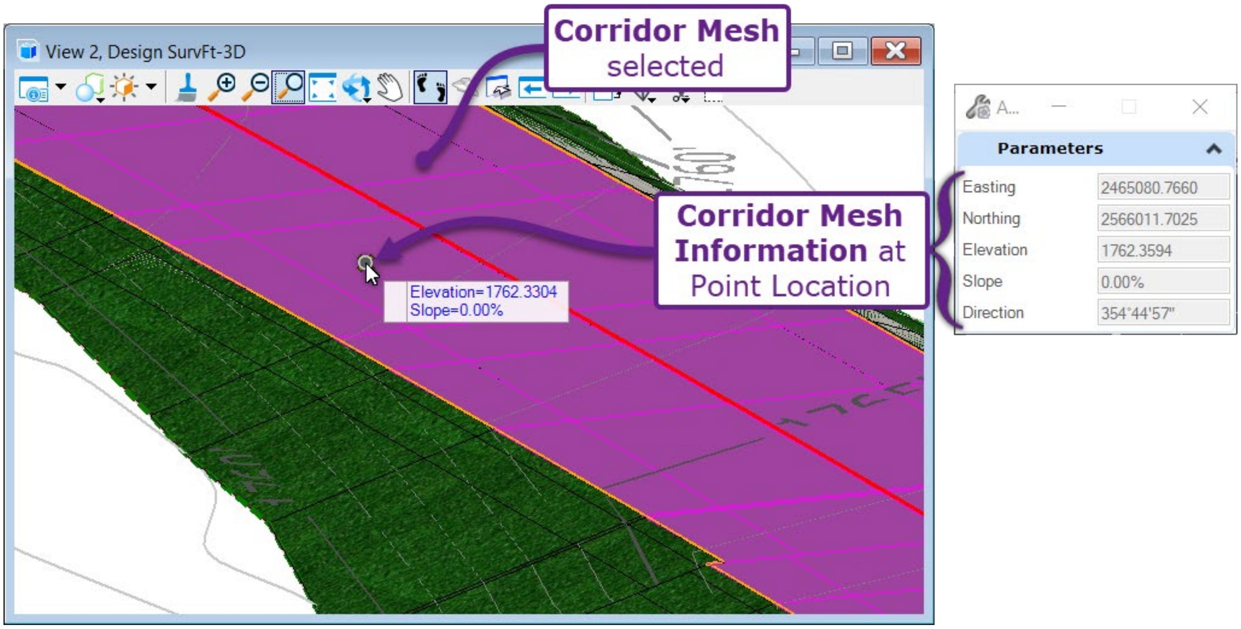
Selecting a Terrain Model:



Selecting an Alignment, 3D Linear Element, or Corridor Linework:



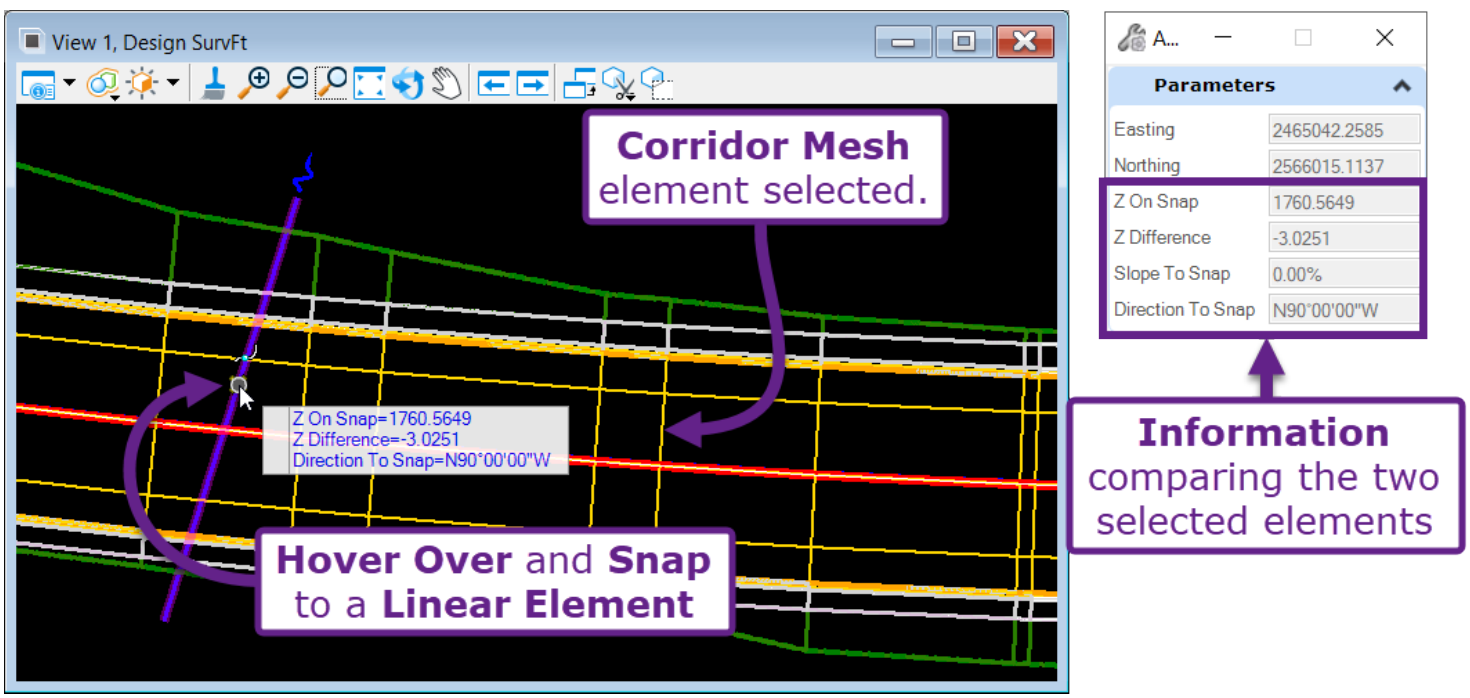
Selecting a Mesh element (Corridors, Linear Templates, and Surface Templates):



TIP: After selecting an element, hover the mouse cursor (ensure that Snaps are turned ON) over a different Linear Element. Information relating to the Linear Element will display in the *Dialogue Box*.

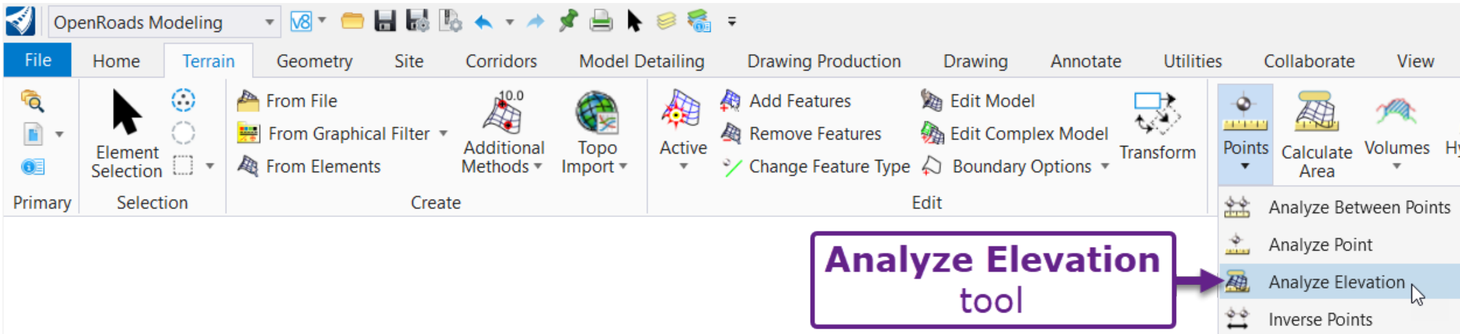
As shown below, a Corridor Mesh (Pavement Layer 1) element is selected. Next, the mouse cursor is hovered over a Linear Element (Culvert). The Culvert element contains an *Active Profile*.

The *Dialogue Box* shows comparison information between the Mesh and Linear Element. **Z On Snap** represents the **Linear Element (Culvert)** at the mouse cursor location. The **Z Difference** represents the height difference between the **Linear Element Profile** and **Corridor Mesh** elevations.

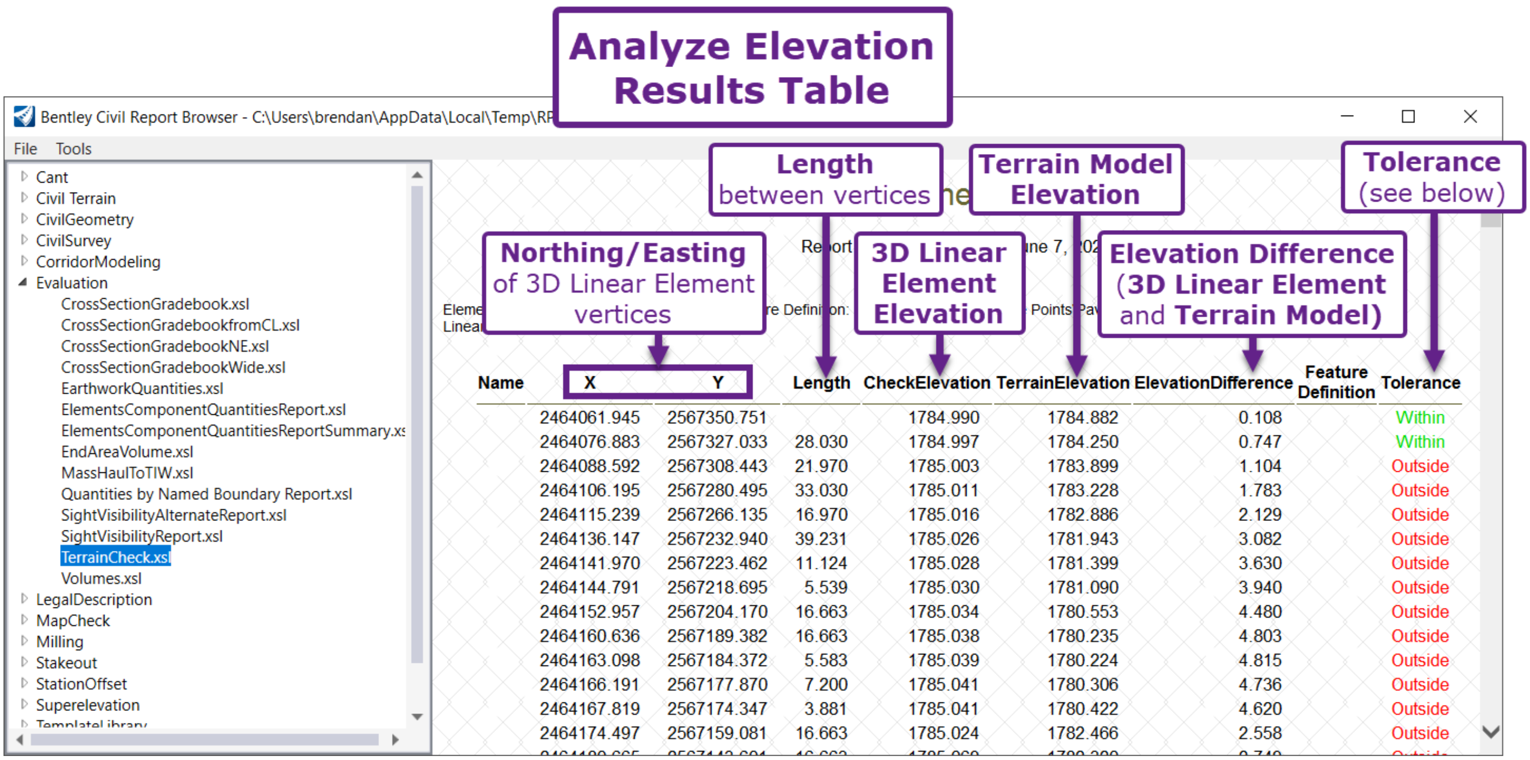


21A.3 Analyze Elevation tool

This tool creates a report that compares the elevation between a Terrain Model and 3D Linear Element (i.e., an Alignment).



The Terrain Model and 3D Linear Element elevations are compared at every vertex location along the 3D Linear Element.



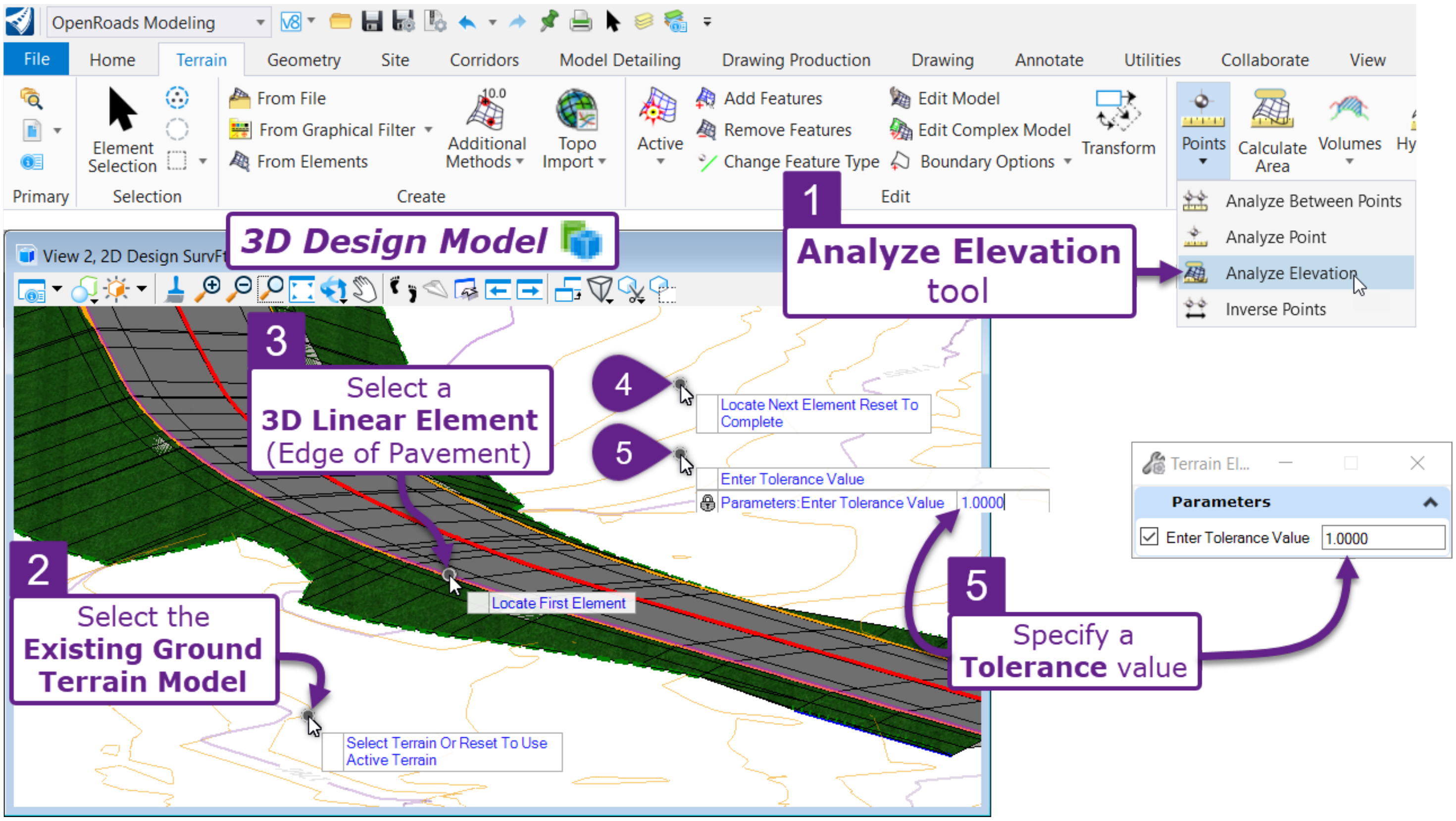
Name	X	Y	Length	CheckElevation	TerrainElevation	ElevationDifference	Feature Definition	Tolerance
	2464061.945	2567350.751		1784.990	1784.882	0.108		Within
	2464076.883	2567327.033	28.030	1784.997	1784.250	0.747		Within
	2464088.592	2567308.443	21.970	1785.003	1783.899	1.104		Outside
	2464106.195	2567280.495	33.030	1785.011	1783.228	1.783		Outside
	2464115.239	2567266.135	16.970	1785.016	1782.886	2.129		Outside
	2464136.147	2567232.940	39.231	1785.026	1781.943	3.082		Outside
	2464141.970	2567223.462	11.124	1785.028	1781.399	3.630		Outside
	2464144.791	2567218.695	5.539	1785.030	1781.090	3.940		Outside
	2464152.957	2567204.170	16.663	1785.034	1780.553	4.480		Outside
	2464160.636	2567189.382	16.663	1785.038	1780.235	4.803		Outside
	2464163.098	2567184.372	5.583	1785.039	1780.224	4.815		Outside
	2464166.191	2567177.870	7.200	1785.041	1780.306	4.736		Outside
	2464167.819	2567174.347	3.881	1785.041	1780.422	4.620		Outside
	2464174.497	2567159.081	16.663	1785.024	1782.466	2.558		Outside

This tool allows a **Tolerance** to be specified and analyzed. The Tolerance represents the elevation difference between the Terrain Model and 3D Linear Element. If the elevation difference is less than the Tolerance, then "Within" is shown in the results table. If the elevation difference exceeds the Tolerance, then "Outside" is shown.

NOTE: This tool requires the 3D Linear Element to be selected from the *3D Design Model*.

TIP: Multiple 3D Linear Elements can be selected for comparison.

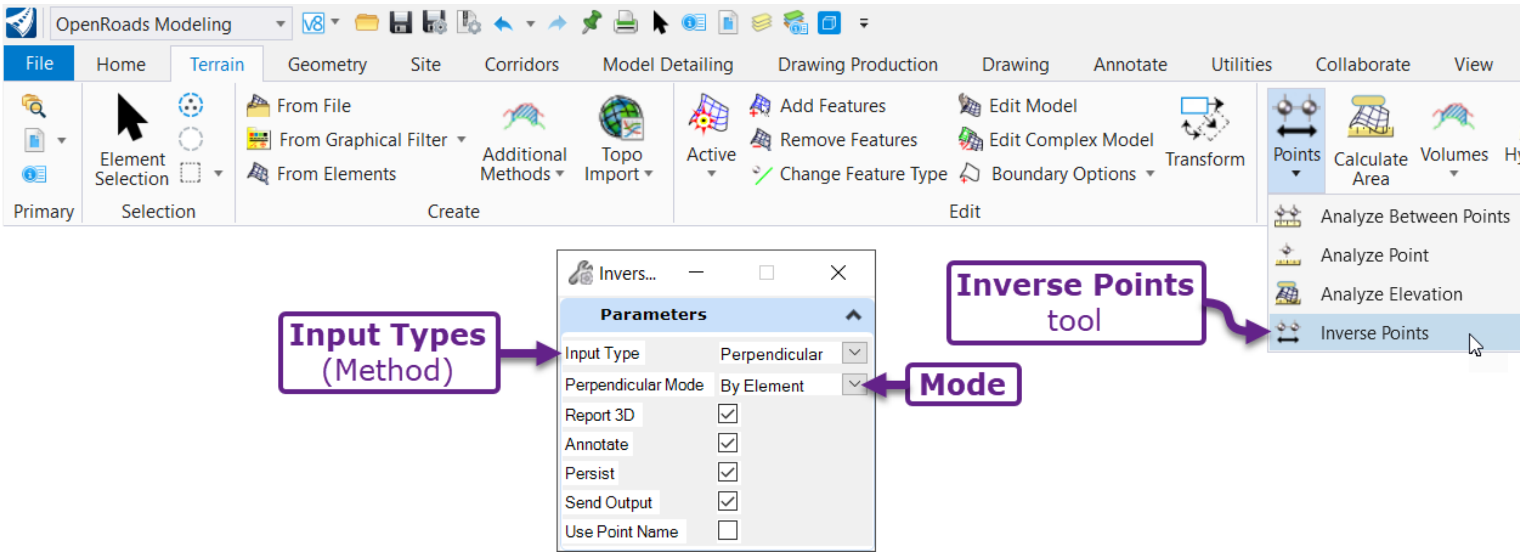
As a practical demonstration of this tool, the Edge of Pavement (3D Linear Element) and Existing Ground Terrain Model are selected for elevation comparison. The Edge of Pavement line is generated from the Corridor.



1	From the Ribbon, select the *Analyze Elevation* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Analysis*** → ***Points***].
2	*Prompt: Select Terrain or Reset to use Active Terrain* – Select the Existing Ground Terrain Model or right-click (reset) to select whatever Terrain Model is *active*.
3	*Prompt: Locate First Element* – Locate the 3D Linear Element to be compared with the Terrain Model. In this case, the Edge of Pavement line from the Corridor is selected.
4	*Prompt: Locate Next Element* – Either select another 3D Linear Element for comparison or right-click (reset) to advance to the next prompt.
5	*Prompt: Enter Tolerance Value* – Enter a Tolerance value for analysis in the resulting report. After this step, a report will be created.

21A.4 Inverse Points tool

The *Inverse Point* tool measures and annotates 2D/3D elements or between point locations. Measurements can be made either in the *2D Design Model* or *3D Design Model* .

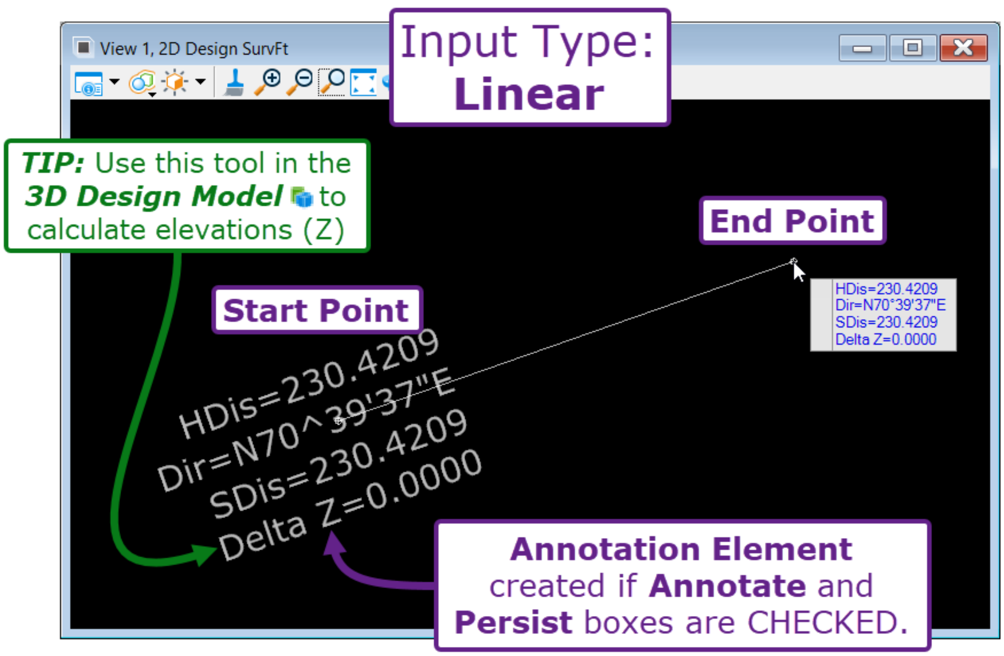


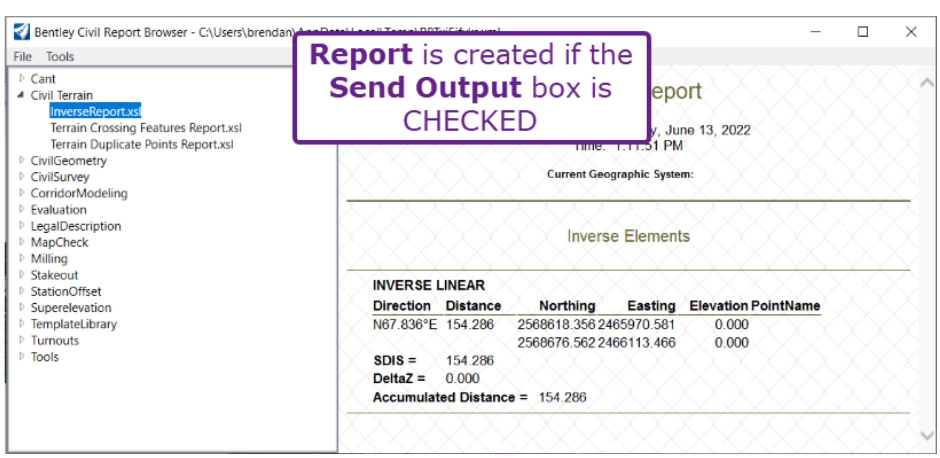
This tool contains many different methods (Input Types) for measuring. Graphical demonstrations of each Input Type is shown on the next page.

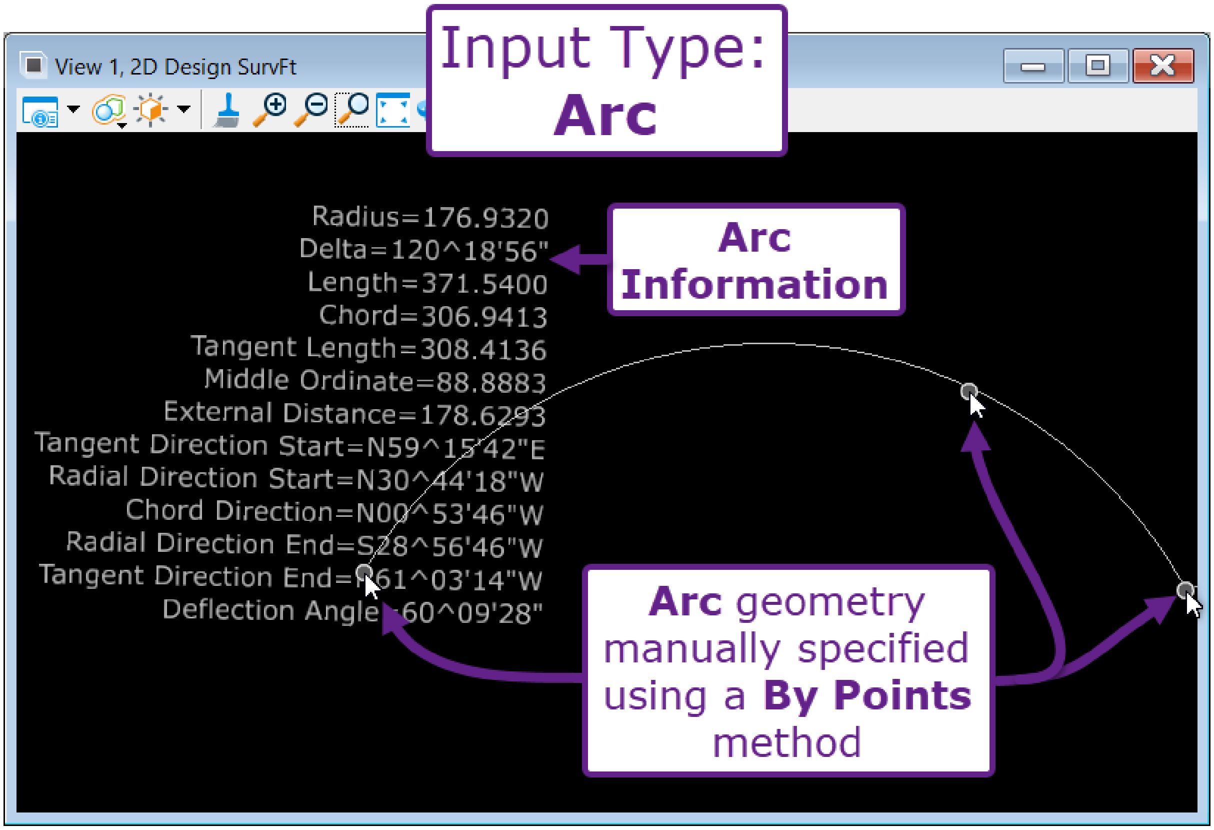
Inputs Types and Modes			
Input Type:	**Description:**	**Mode:**	
Linear	Measures the linear distance, direction, and elevations between two-point locations.		
Arc	The geometry of an arc is defined by clicking in several point locations. Geometry information for the arc is measured and reported. ***NOTE:*** Use the **By Element** type to measure a previously-created arc element.	**Radius Point**	First, a start point on the perimeter of the arc is specified. Next, the center point of the arc is specified. Last, the end point on the perimeter of the arc is specified.
		Point on Curve	First, a start point on the perimeter of the arc is specified. Next, the end point of the arc is specified. Last, a point along the length of the arc is specified.
Radial	Used to make multiple **Linear** measurements. Each measurement begins from a common start point. All Linear measurements are radial to the start point.		
Perpendicular	Used to make a Linear measurement that begins perpendicularly from an element.	**By Element**	First, an element is selected. Next, a point location is specified. The linear distance measured is perpendicular from the point to the element.
		Between Points	Measures the perpendicular linear distance between two points.
By Element	An element is selected and measured. The following element types are compatible: Lines, Arcs, Complex Chains, and Complex Elements (Alignments and Profiles).		

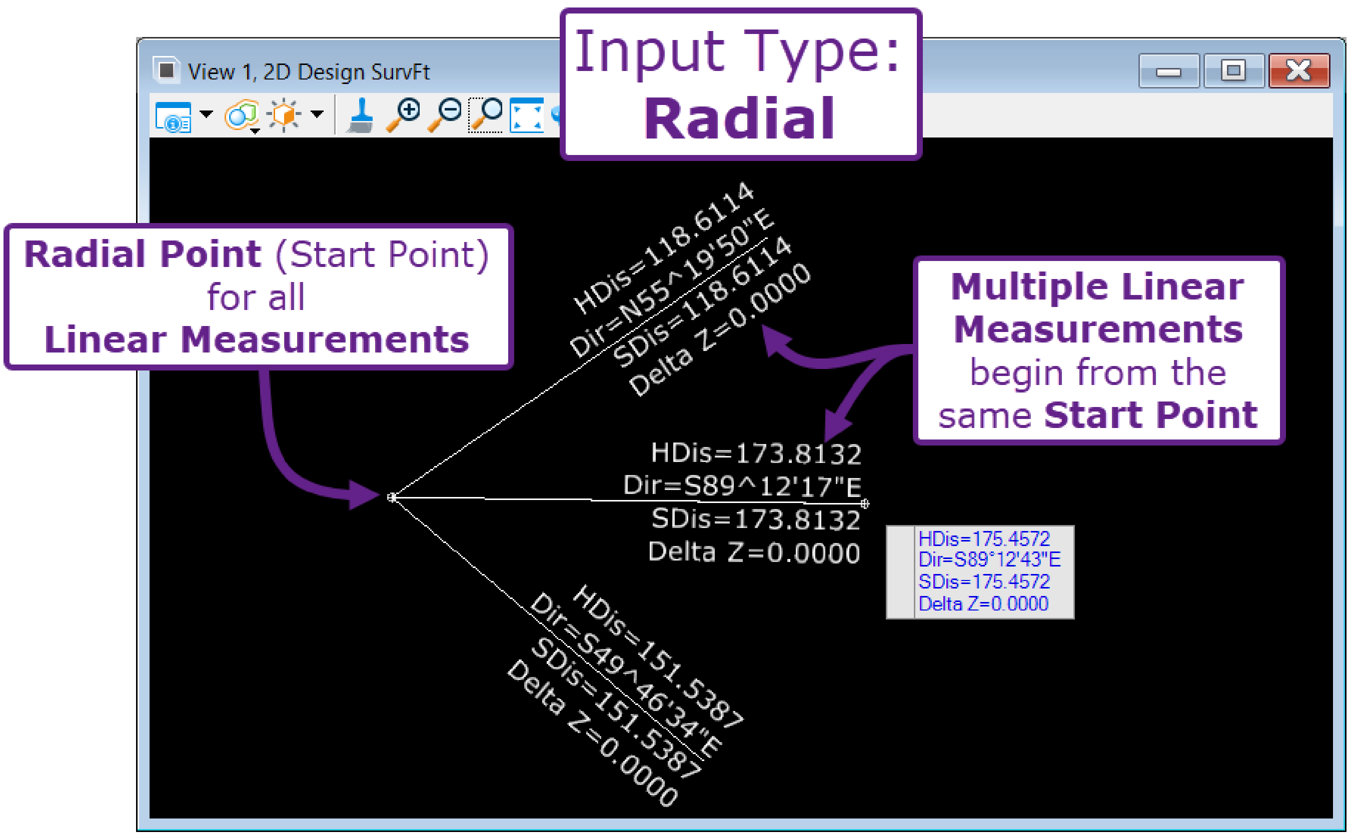
The remaining CHECK BOXES for the *Inverse Points* tool are explained below:

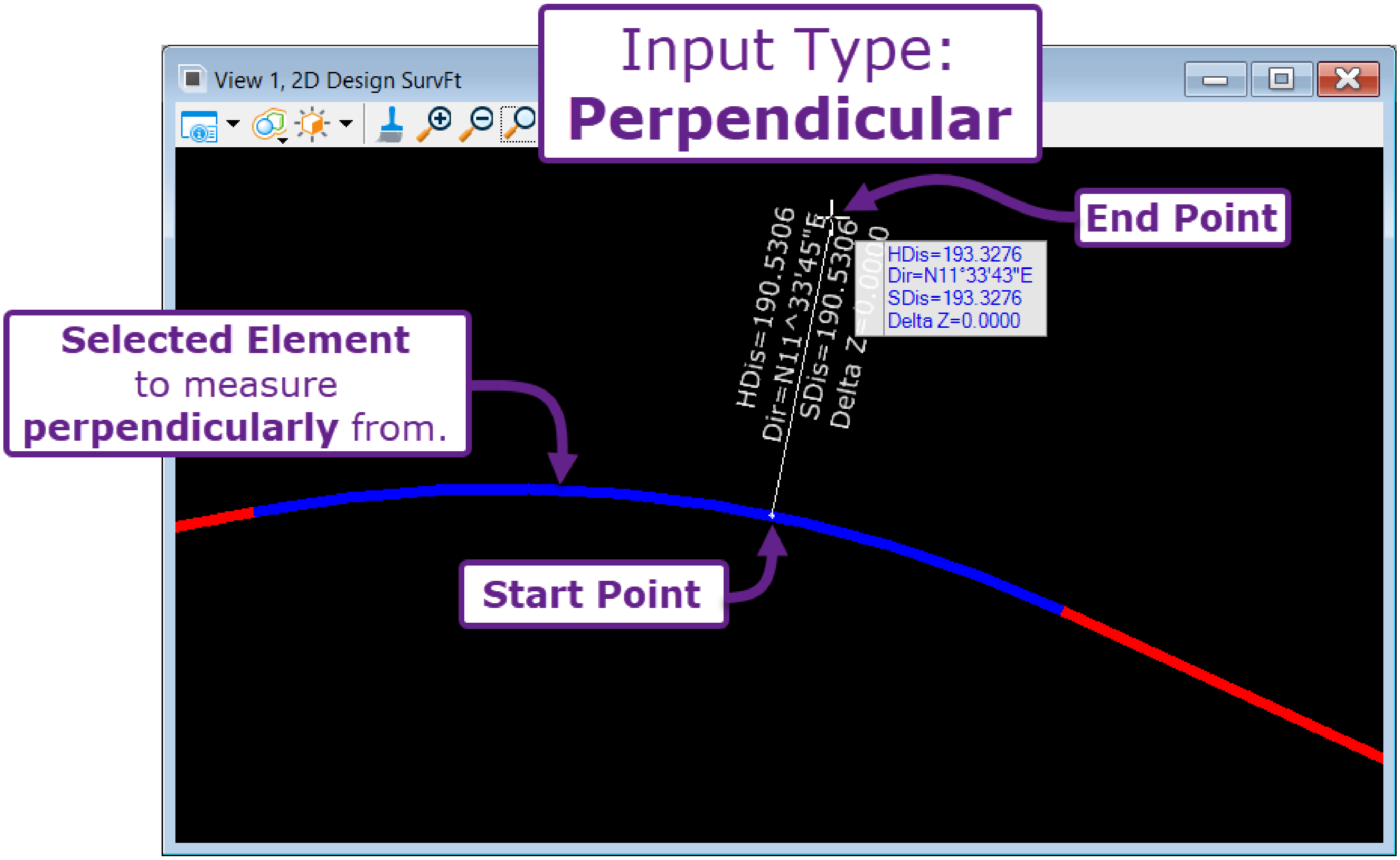
Inverse Points Dialogue Box Settings	
Setting:	**Description:**
Report 3D	If CHECKED, then elevation of the selected element or point location is analyzed. ***NOTE:*** This option is ONLY relevant when measuring in the *3D Design Model*. When using this tool in the *2D Design Model*, the Profile elevation of the selected element is NOT reported.
Annotate	If CHECKED, then an annotation with all the measurement information is shown. ***NOTE:*** If the **Persist** box is UNCHECKED, then the annotation will disappear after operation of this tool.
Persist	This box is only relevant if the **Annotate** box is CHECKED. If CHECKED, then an Annotation element is created and will persist after the operation of this tool.
Send Output	If CHECKED, then a report with all measurement information is created.
Use Point Name	Optionally, a previously-created Survey Point or ORD Point can be used in the measurement. If the name of the Point is known, then the name can be typed here for use in the measurement.

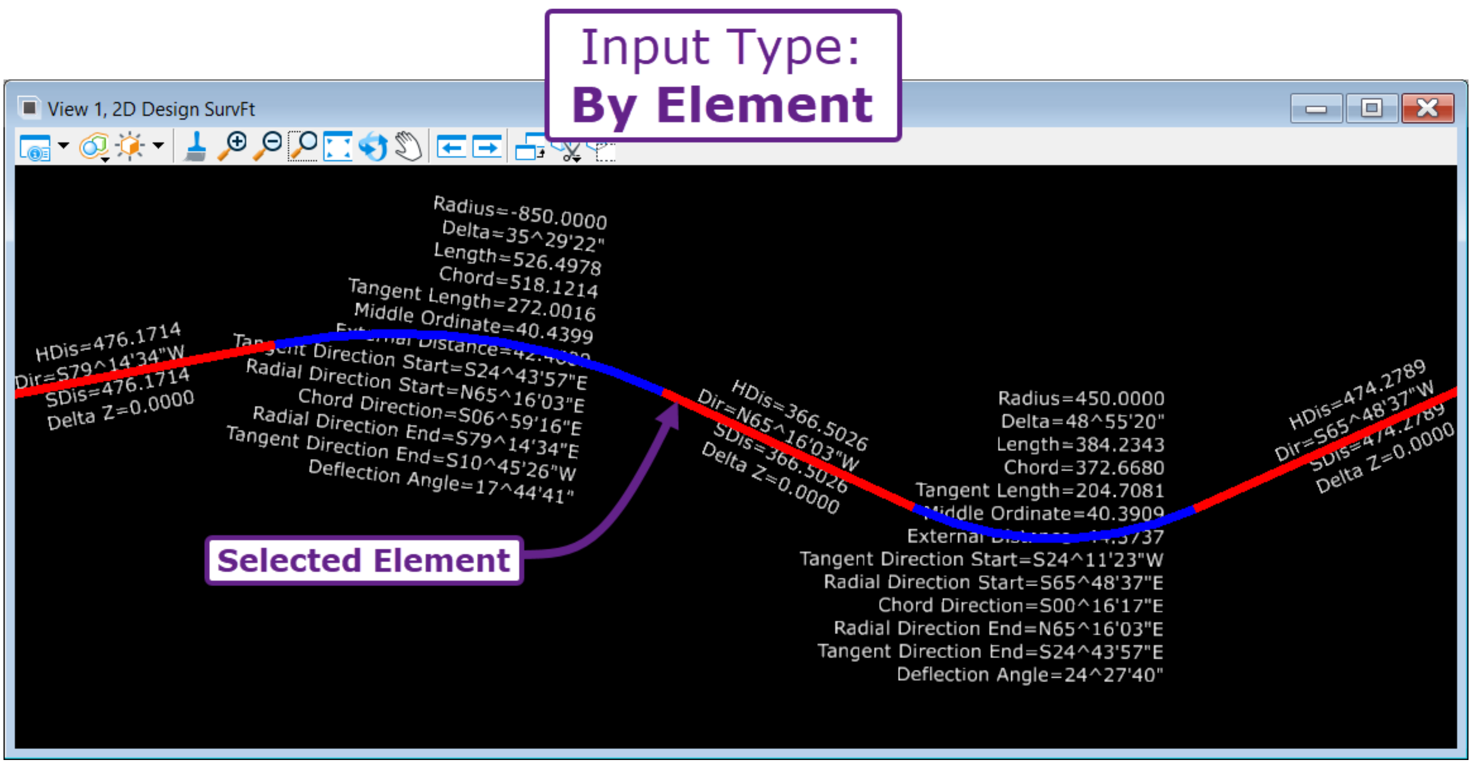





Input Type:
Arc
View 1, 2D Design SurvFt
Radius=176.9320
Delta=120^18'56"
Length=371.5400
Chord=306.9413
Tangent Length=308.4136
Middle Ordinate=88.8883
External Distance=178.6293
Tangent Direction Start=N59^15'42"E
Radial Direction Start=N30^44'18"W
Chord Direction=N00^53'46"W
Radial Direction End=S28^56'46"W
Tangent Direction End=N61^03'14"W
Deflection Angle=60^09'28"
Arc Information
Arc geometry manually specified using a By Points method


Input Type:
Radial
View 1, 2D Design SurvFt
Radial Point (Start Point) for all Linear Measurements
HDis=118.6114
Dir=N55^19'50"E
SDis=118.6114
Delta Z=0.0000
Multiple Linear Measurements begin from the same Start Point
HDis=173.8132
Dir=S89^12'17"E
SDis=173.8132
Delta Z=0.0000
HDis=175.4572
Dir=S89°12'43"E
SDis=175.4572
Delta Z=0.0000
HDis=151.5387
Dir=S49^46'34"E
SDis=151.5387
Delta Z=0.0000


Input Type:
Perpendicular
View 1, 2D Design SurvFt
End Point
HDis=193.3276
Dir=N11°33'43"E
SDis=193.3276
Delta Z=0.0000
Selected Element to measure perpendicularly from.
Start Point

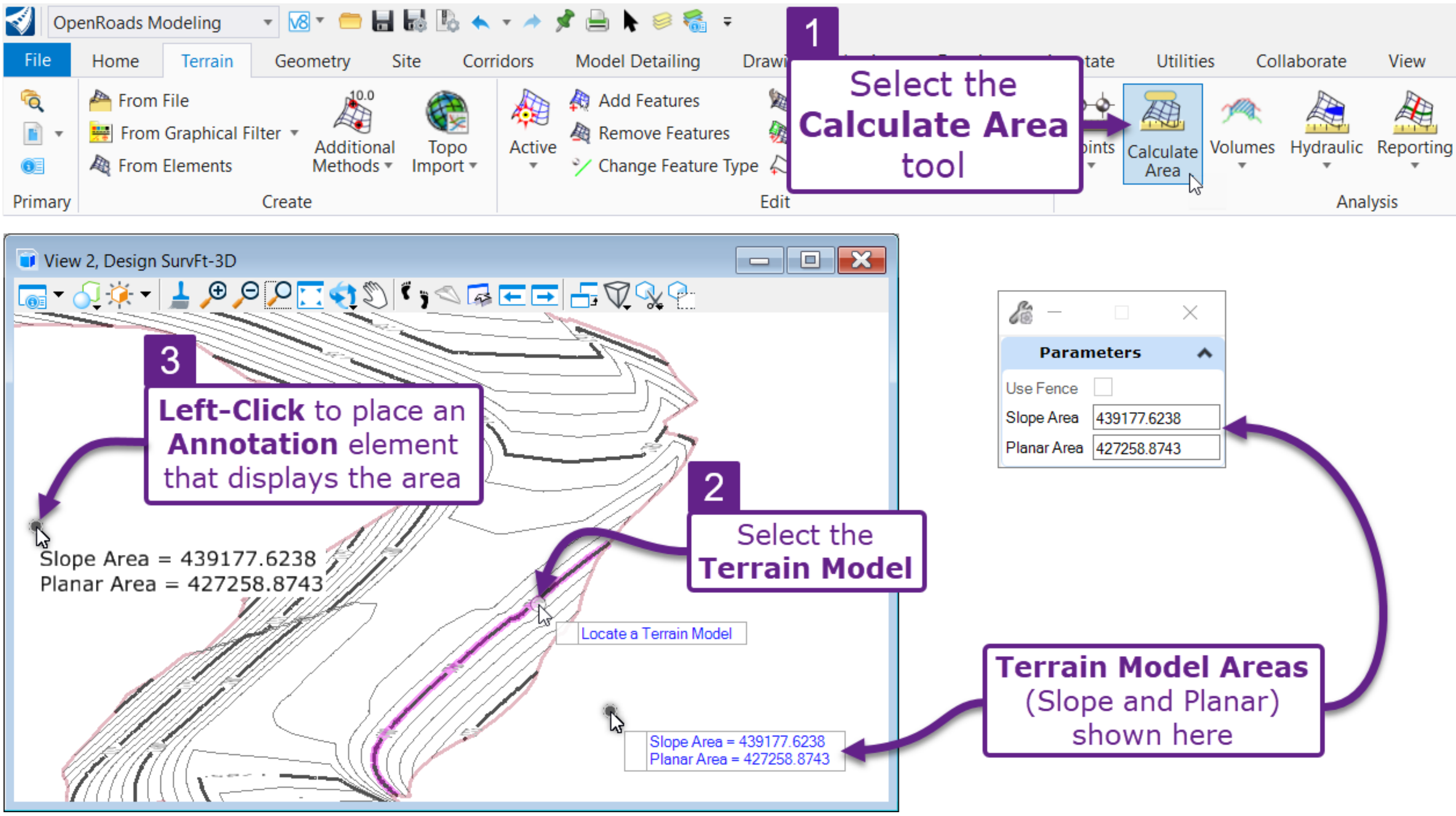

Input Type:
By Element
View 1, 2D Design SurvFt
Radius=-850.0000
Delta=35^29'22"
Length=526.4978
Chord=518.1214
Tangent Length=272.0016
Middle Ordinate=40.4399
Radial Direction Start=N65^16'03"E
Chord Direction=S06^59'16"E
Radial Direction End=S79^14'34"E
Tangent Direction End=S10^45'26"W
Deflection Angle=17^44'41"
HDis=476.1714
Dir=S79^14'34"W
SDis=476.1714
Delta Z=0.0000
HDis=366.5026
Dir=N65^16'03"W
SDis=366.5026
Delta Z=0.0000
Radius=450.0000
Delta=48^55'20"
Length=384.2343
Chord=372.6680
Tangent Length=204.7081
Tangent Direction Start=S24^11'23"W
Radial Direction Start=S65^48'37"E
Chord Direction=S00^16'17"E
Radial Direction End=N65^16'03"E
Tangent Direction End=S24^43'57"E
Deflection Angle=24^27'40"
HDis=474.2789
Dir=S65^48'37"W
Delta Z=0.0000
Selected Element

21B – CALCULATE AREA TOOL

This tool calculates the **Planar Area** and **Slope Area** of a Terrain Model.

Planar Area: Represents the plan or footprint area of the Terrain Model. The Planar Area is the 2-dimensional area of the Terrain Model.

Slope Area: Represents the 3-dimensional area of the Terrain Model. The Slope Area accounts for tilted and sloped areas in the Terrain Model.



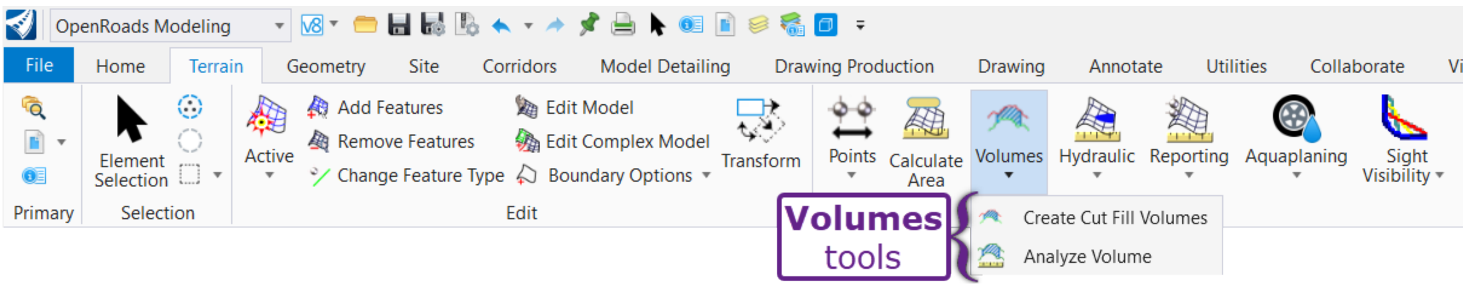
TIP: Optionally, a Fence can be placed before operation of this tool. If the **Use Fence** box is CHECKED, then ONLY the Terrain Model area within the Fence limits is calculated.

21C – VOLUMES TOOLS

These tools are used to analyze the volume of a Terrain Model relative to a different Terrain Model or to a plane elevation.

Volume tools are found in the Ribbon in the following location:

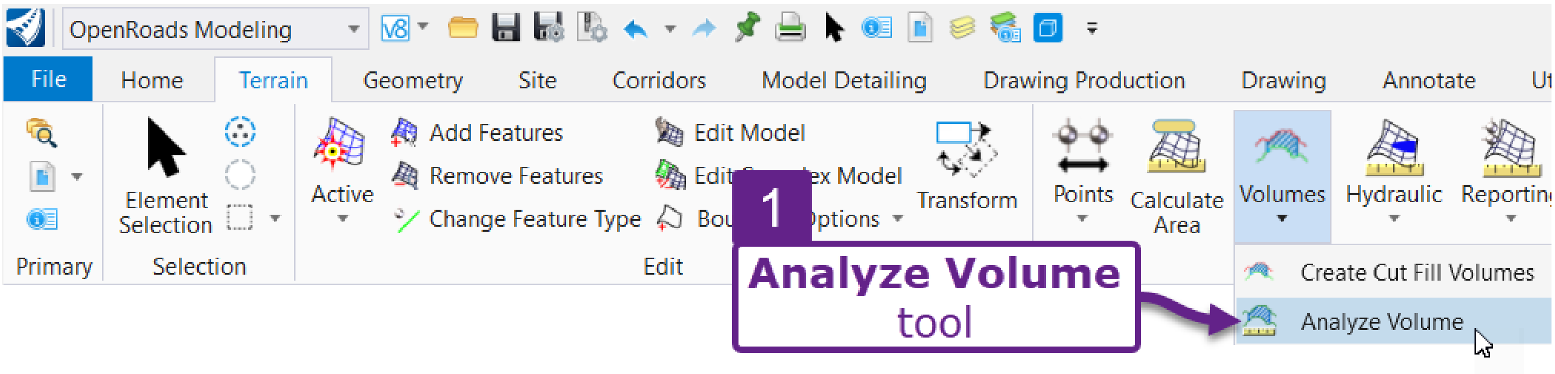
OpenRoads Modeling workflow → **Terrain** tab → **Analysis** group → **Volumes** drop-down



NOTE: Detailed workflows for calculating Cut and Fill volumes from Corridors, Linear Templates, and Surface Templates are shown in *Chapter 20 – Quantities*. Additionally, the *Create Cut Fill Volumes* tool is described in *20B.2 Create Cut Fill Volumes tool – Workflow*.

21C.1 Analyze Volume tool

This tool calculates the cut/fill volumes between two Terrain Models OR between a Terrain Model and a flat plane set at a specified elevation.

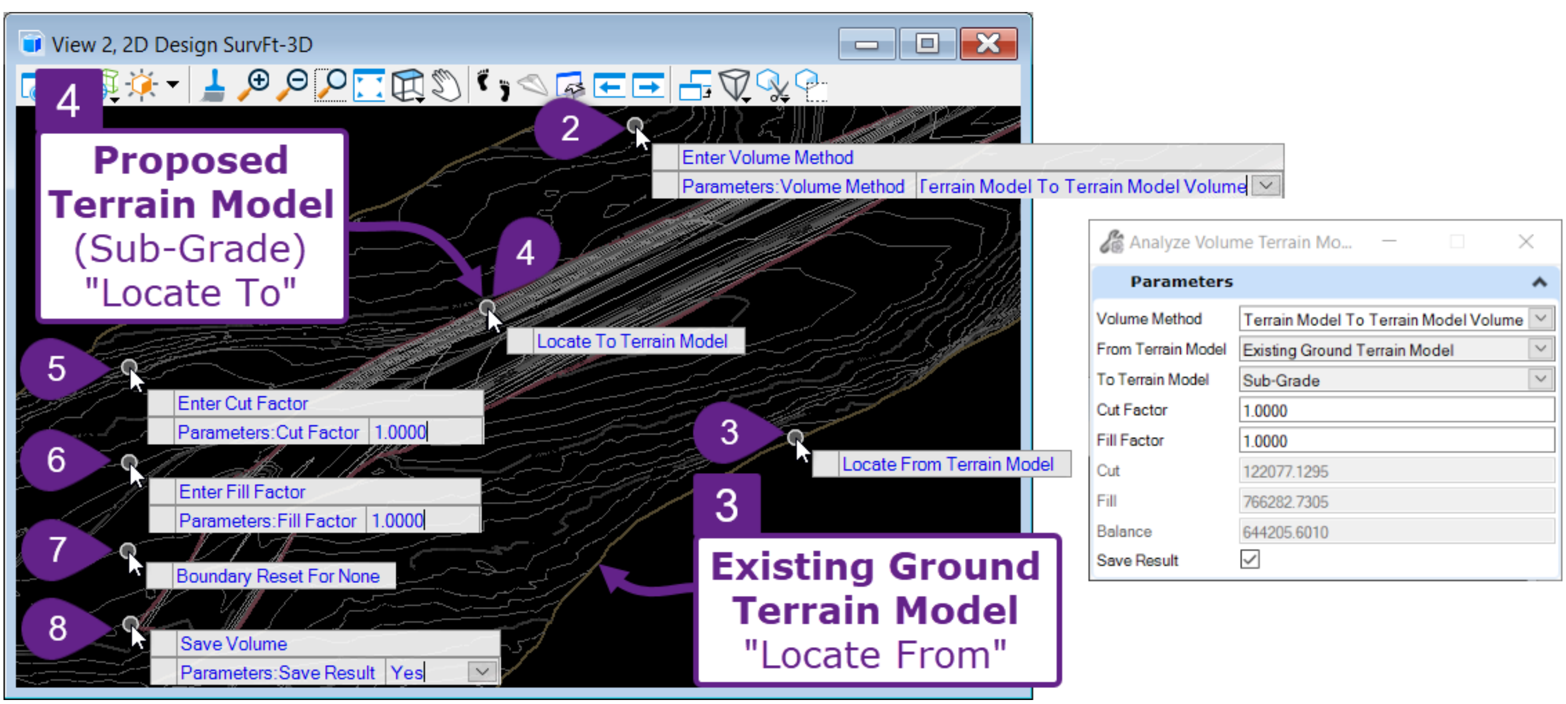


NOTE: If analyzing between an Existing and Proposed Terrain Model:

- Select the **Existing Terrain Model** as the "**From Terrain Model**" (as shown in step 3).
- Select the **Proposed Terrain Model** as the "**To Terrain Model**" (as shown in step 4).

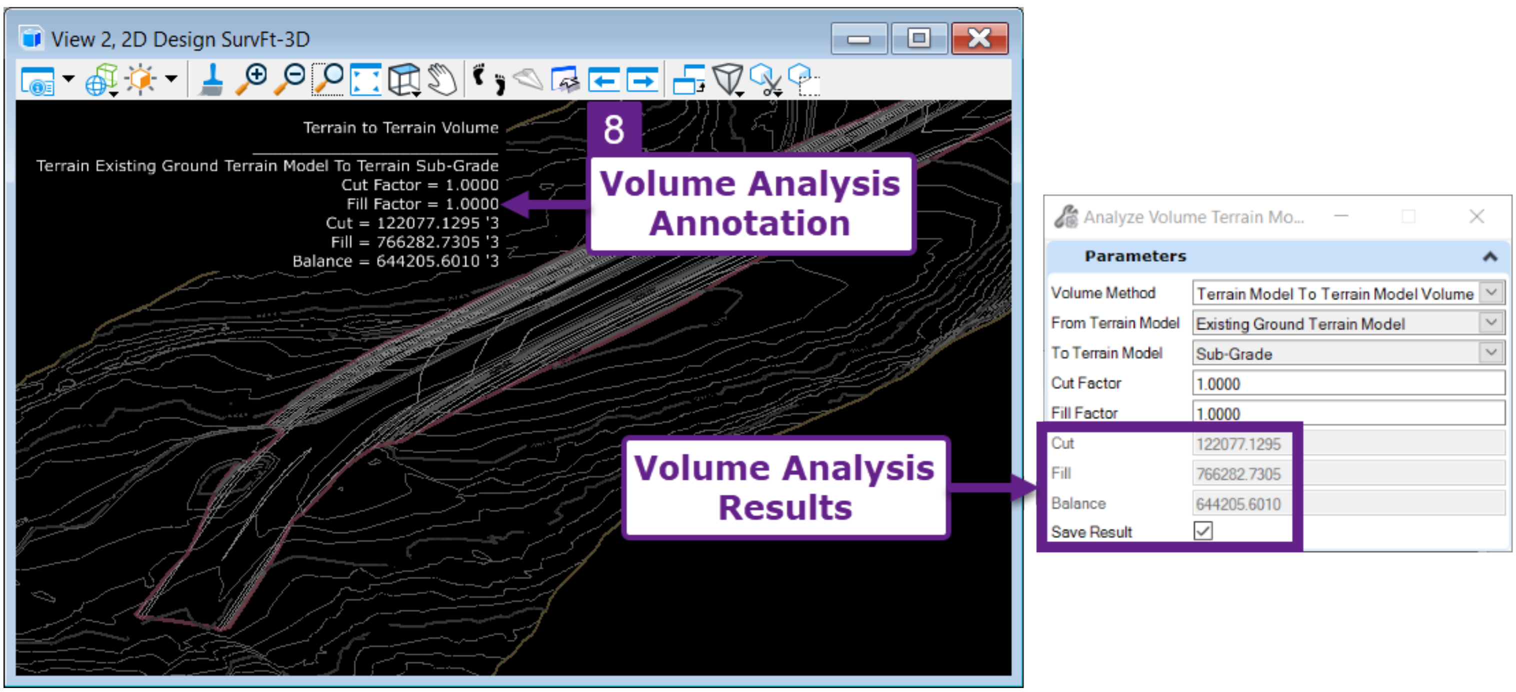
TIP: Create a Proposed Terrain Model from Corridors, Linear Templates, and Surface Templates using the *Create Terrain Model From Design Meshes* tool. To create a Sub-Grade Terrain Model, select **Bottom** for the **Select Side of Closed Mesh** option. See *22A.1 Create Terrain Model from Design Meshes tool*.

TIP: Optionally, a boundary element can be drawn and selected for the volume analysis (as shown in step 7). If selected, then the resulting cut/fill volumes are ONLY calculated within the limits of the boundary. The boundary element can be drawn in the *2D Design Model* using MicroStation Tools (i.e., *Place SmartLine* tool).



1	From the Ribbon, select the *Analyze Volumes* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Analysis*** → ***Volumes***].

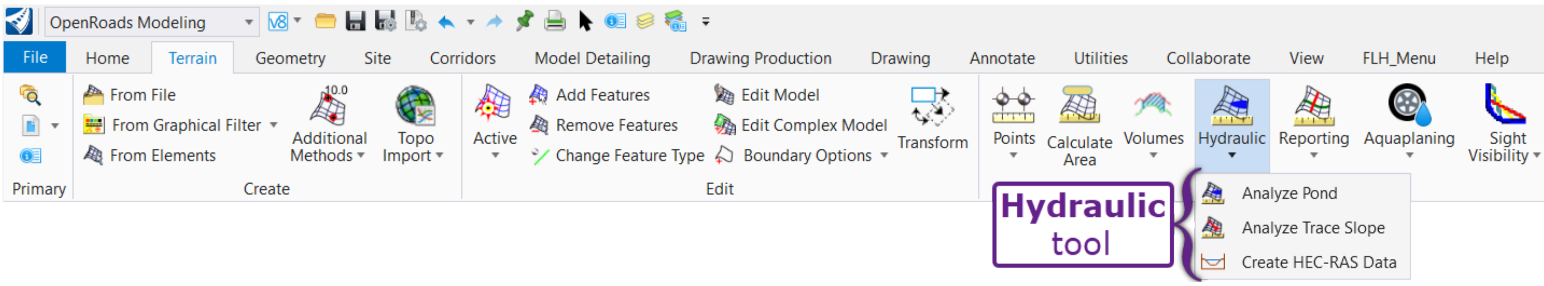
2	*Prompt: Enter Volume Method* – Select either "Terrain Model to Terrain Model Volume" or "Terrain Model to Plane". If "Terrain Model to Plane" is selected, then a Plane elevation is specified in the next step.
3	*Prompt: Locate From Terrain Model* – Select the **Existing Ground Terrain Model**.
4	*Prompt Locate To Terrain Model* – Select the **Proposed Terrain Model**.
5	*Prompt: Enter Cut Factor* – If desired, enter a multiplier value for the resulting Cut volume. The Cut Factor typically corresponds with the "shrink factor".
6	*Prompt: Enter Fill Factor* - If desired, enter a multiplier value for the resulting Fill volume. The Fill Factor typically corresponds with the "swell factor"
7	*Prompt: Boundary Reset For None* – Right-Click (reset) to NOT use a boundary element. The boundary of the "To Terrain Model" (step 4) is used for the analysis. If desired, manually draw and select a Boundary element. The analysis will ONLY calculate the Terrain Model volume within the limits of the Boundary element.
8	*Prompt: Save Volume* – If YES is selected, then an annotation element that shows the volume analysis is created. If NO is selected, then the volume analysis values can be found in the *Dialogue Box*.



21D – HYDRAULIC TOOLS

The tools describe in this section are used to analyze the surface hydraulics of a Terrain Model. Hydraulic Tools are found in the Ribbon in the following location:

OpenRoads Modeling workflow → **Terrain** tab → **Analysis** group → **Hydraulics** drop-down



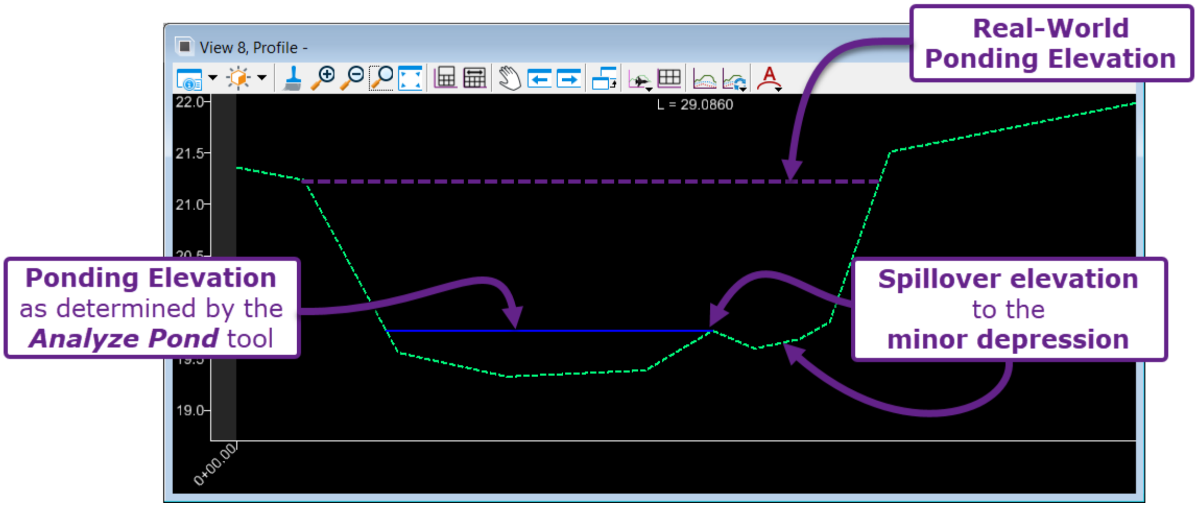
NOTE: Hydraulic Tools are for simple Terrain Model analysis. **Drainage and Utilities** tools are used to perform complex hydraulic analysis and layout/modeling for drainage systems. See *Chapter 25 – Drainage Analysis (Drainage and Utilities tools)*.

21D.1 Analyze Pond tool

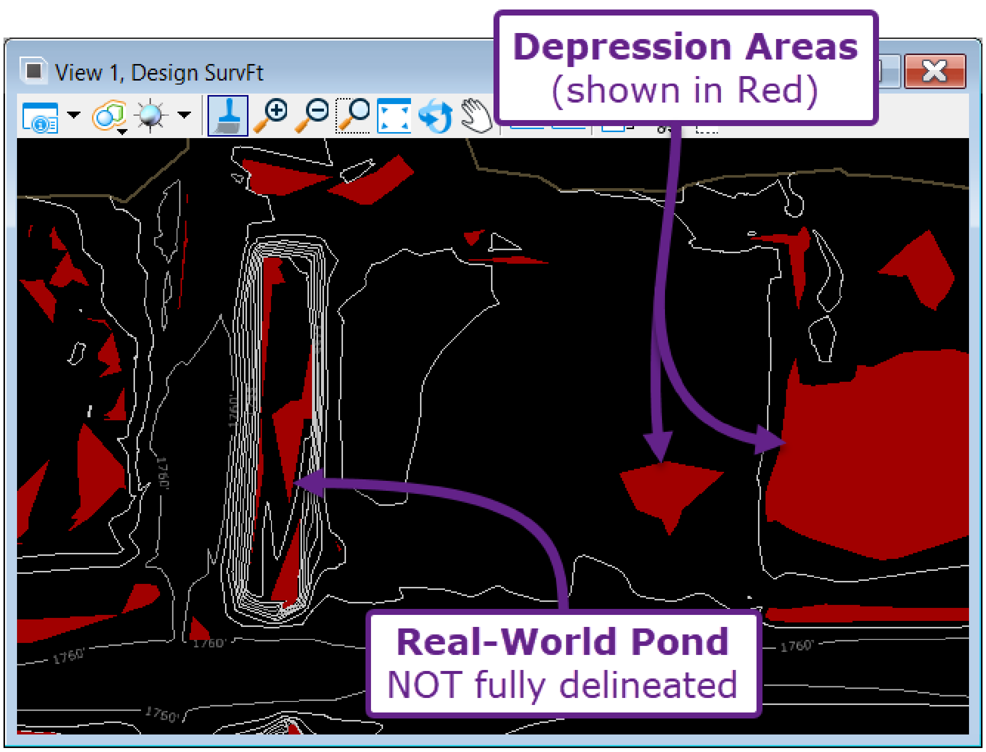
The *Analyze Pond* tool analyzes a Terrain Model for depressions and low areas (ponding). Depressions in the Terrain Model are automatically delineated and can be selected to reveal more information relating to the Volume, Depth, Ponding Elevation, and Ponding Area.

> ***NOTE:*** This tool has difficulty delineating ponds in the Existing Ground Terrain Model because existing ponds typically have many minor depressions on the bottom surface. With this tool, a depression is ONLY analyzed up to the FIRST spillover elevation. This causes each minor depression to be analyzed, instead of the real-world pond volume.

Shown below is a cross section view of an existing pond. This tool ONLY analyzes the depression shown on the left, because it spills over to the minor depression shown on the right.

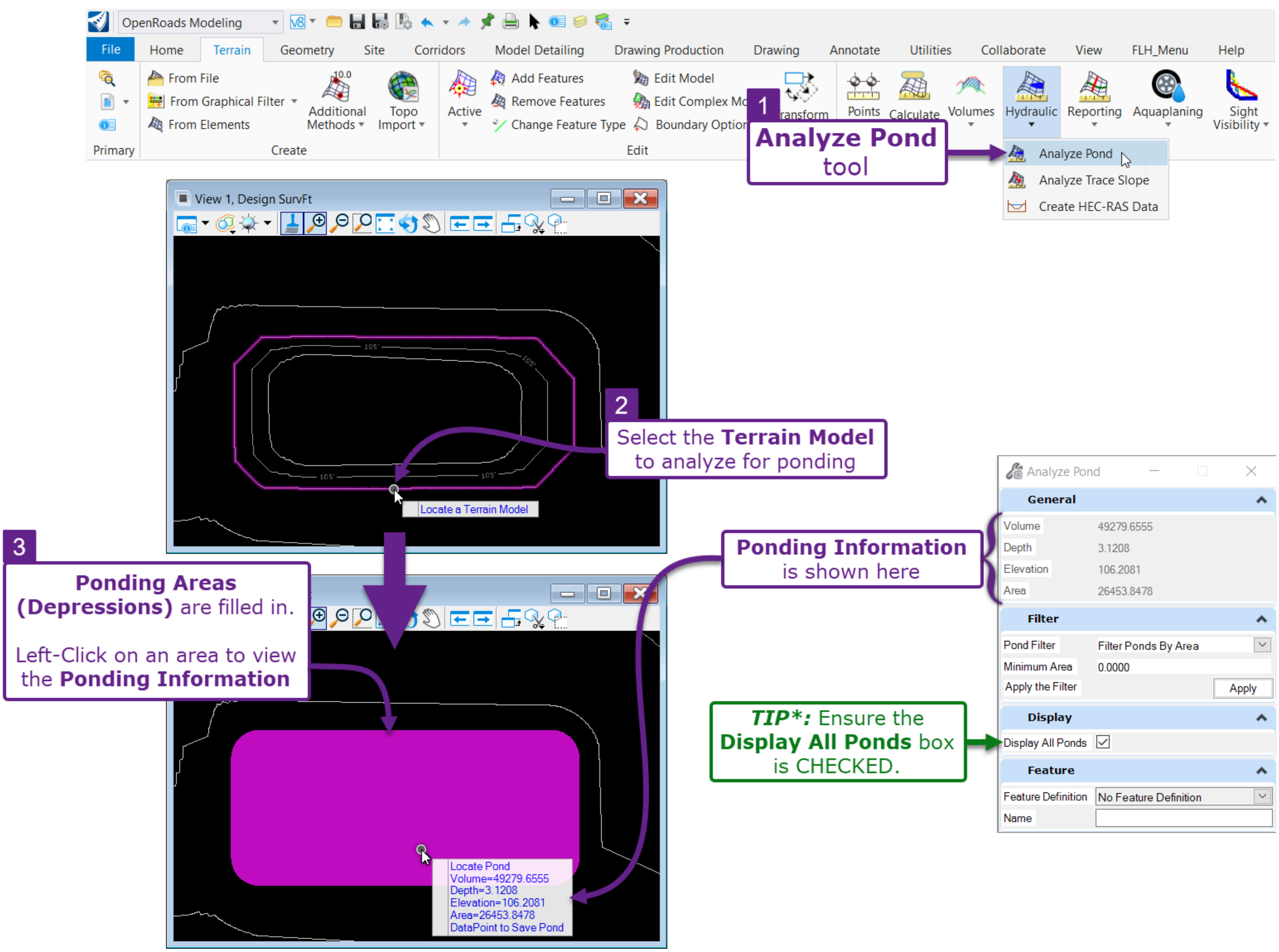


Shown below are the results of *Analyze Pond* tool when ran on an Existing Ground Terrain Model. The delineated Ponding Area are shown in red. Each minor depression in the Terrain Model is delineated. On the left-side of this graphic is a real-world pond that is NOT fully delineated because it contains minor depressions on the bottom.



***Analyze Ponds* tool workflow:** As shown in the following workflow, this tool is most useful for analyzing ponds that have a smooth, uniform bottom; such as a proposed detention basin.

1	From the Ribbon, select the *Analyze Pond* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Analysis*** → ***Hydraulic***].
2	*Prompt: Locate Terrain Model* – Locate the Terrain Model to be analyzed for ponding. After the Terrain Model is selected, all ponding areas will be filled with a color (depending on the *active* Level). ***TIP*:*** If the **Display All Ponds** box is UNCHECKED, then ponding areas are NOT shown. This box must be CHECKED to display ponding areas.
3	*Prompt: Locate Pond* – Left-Click on a ponding area to display the **Ponding Information** in the *Dialogue Box* and *Quick Information Box.*



General Settings: The values shown in the General drop-down apply to the last pond area selected.

Analyze Ponds – General Settings	
Setting:	**Description:**
Volume	Displays the volume of the selected pond in cubic feet.
Depth	Displays the maximum depth of the selected pond in feet.
Elevation	Displays the ponding elevation (water surface) of the selected pond.
Area	Displays the top water surface area of the selected pond.
Selection	This method allows for manual selection of Template Points for inclusion the report. This method is demonstrated in the following workflow.

Filter Settings: Optionally, a filter can be applied to display ONLY ponds that exceed a specified Area or Depth. After a filter has been set, push the **Apply** button to reprocess the ponding results and apply the filter.

Analyze Ponds - Filter Settings	
Setting:	**Description:**
No Pond Filtering	All ponding areas are shown. No ponding areas are filtered out.
Filter Ponds By Area	Only ponding areas that exceed the **Minimum Area** value are shown.
Filter Ponds By Depth	Only ponding areas that exceed the **Minimum Depth** value are shown.
Minimum Area/Depth	This value works in conjunction with the **Filter Bonds By Area/Depth** settings. ***NOTE:*** **Minimum Area** is in square feet units. **Minimum Depth** is in feet units.
Apply	Push this button to apply the filter.

Feature Settings: If a Feature Definition and Name is set, then a 3D Linear Element is created around the perimeter of a pond area.

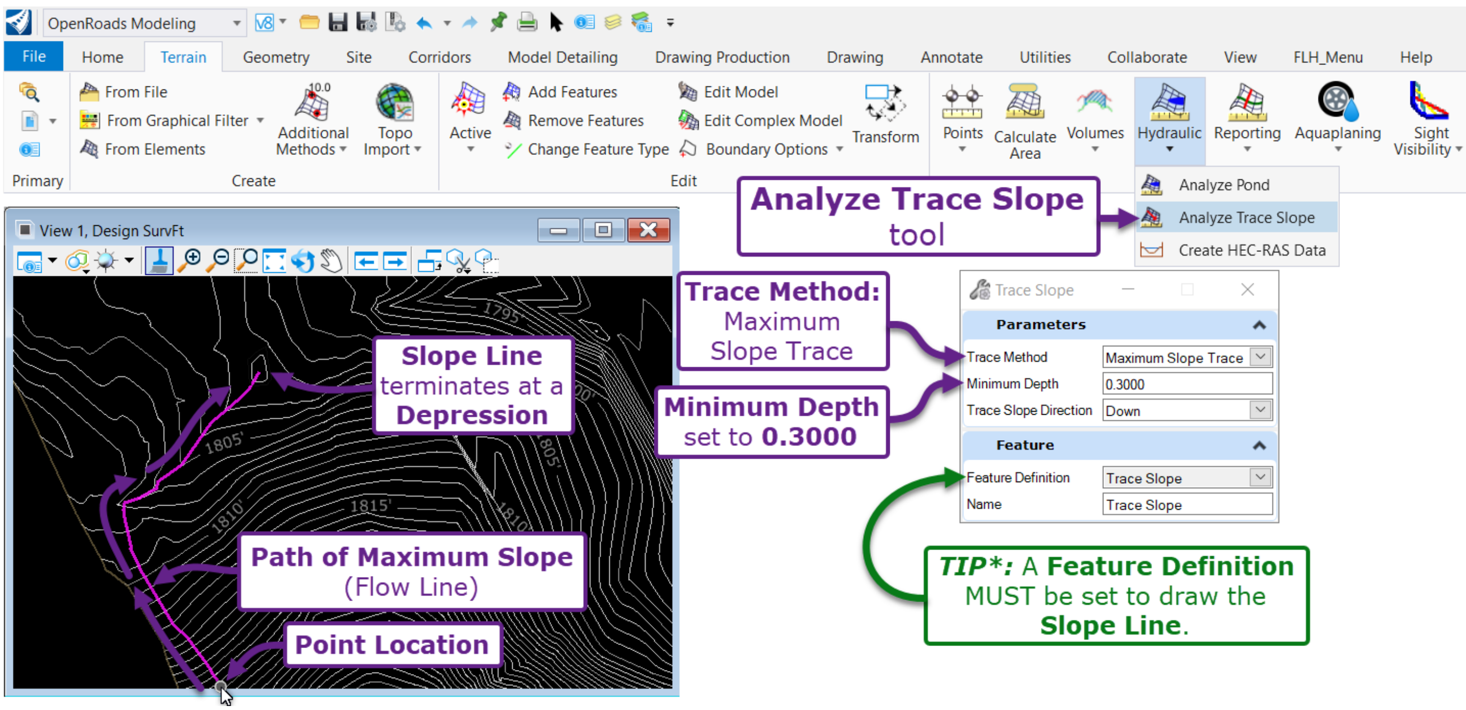
Analyze Ponds - Feature Settings	
Setting:	**Description:**
Feature Definition	Sets the Feature Definition for the resulting 3D Linear Element.
Name	Sets the Name for the resulting 3D Linear Element.

21D.2 Analyze Trace Slope tool

This tool analyzes flow lines or lines of constant slope on a Terrain Model. ***TIP*:*** A **Feature Definition** must be set in the *Dialogue Box* for this tool to draw the slope lines.

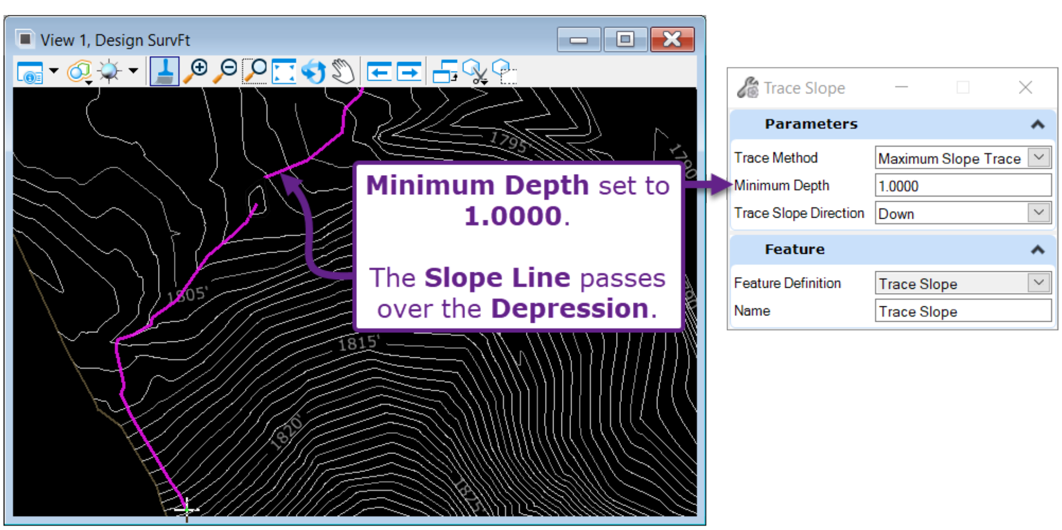
There are two **Trace Methods** for operating this tool: **Maximum Trace Slope** and **Constance Slope Trace.**

Maximum Trace Slope: With this method, a point-location is specified on a Terrain Model and a line is drawn along the path of maximum slope. The resulting line can be interpreted as the flow path of a water when dropped on the point-location.

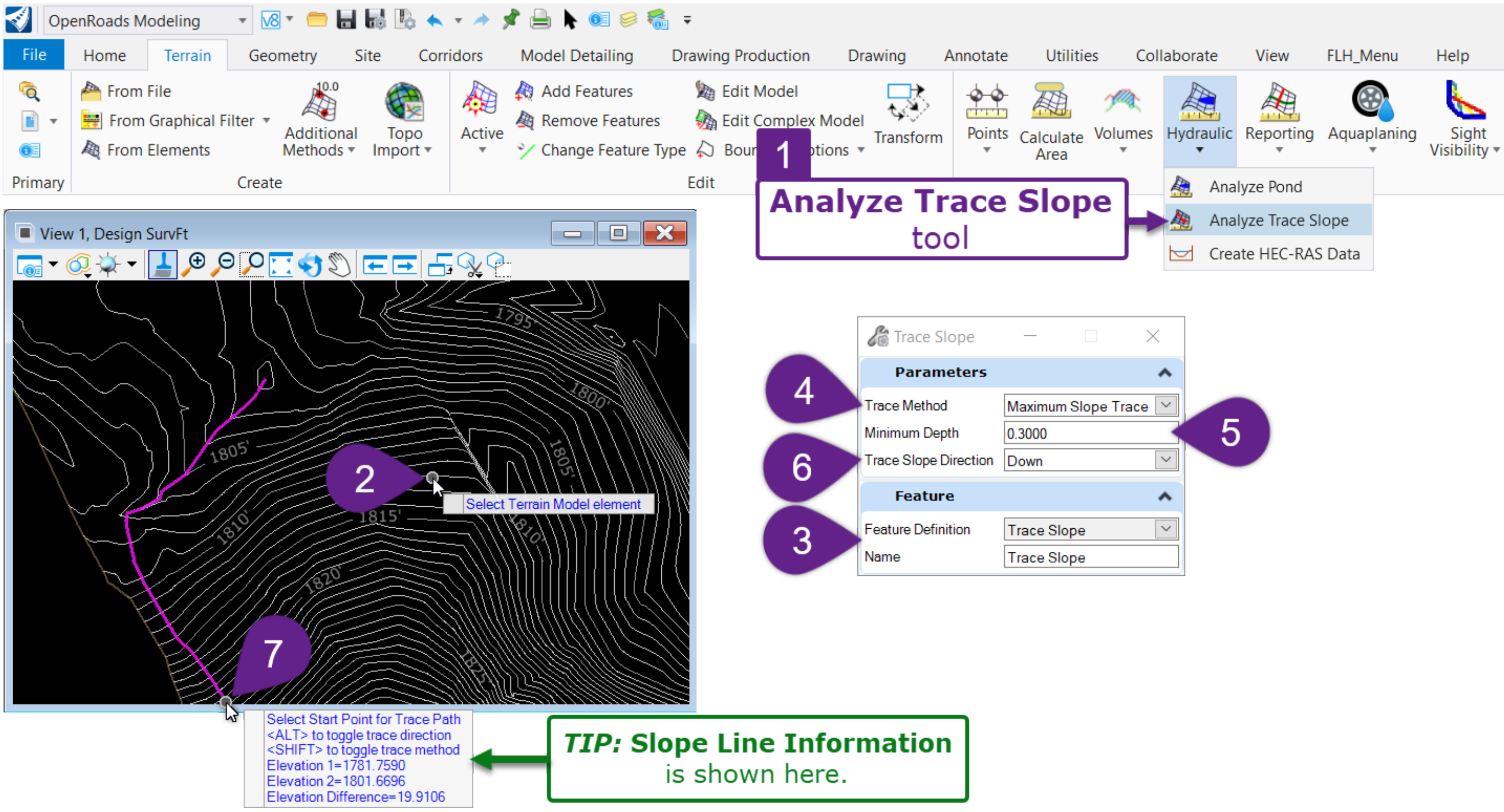


The Slope Line terminates when it reaches a depression point in the Terrain Model. In a depression point, there is no direction where a downward slope can be achieved.

The **Minimum Depth** setting is used to pass over depressions that are shallower than the specified depth. For example, in the graphic above, the **Minimum Depth** is set to 0.3000 and cause the Slope Line to terminate at the depression in the Terrain Model. In the graphic below, the **Minimum Depth** is set to 1.0000 and the Slope Line passes over the depression point.



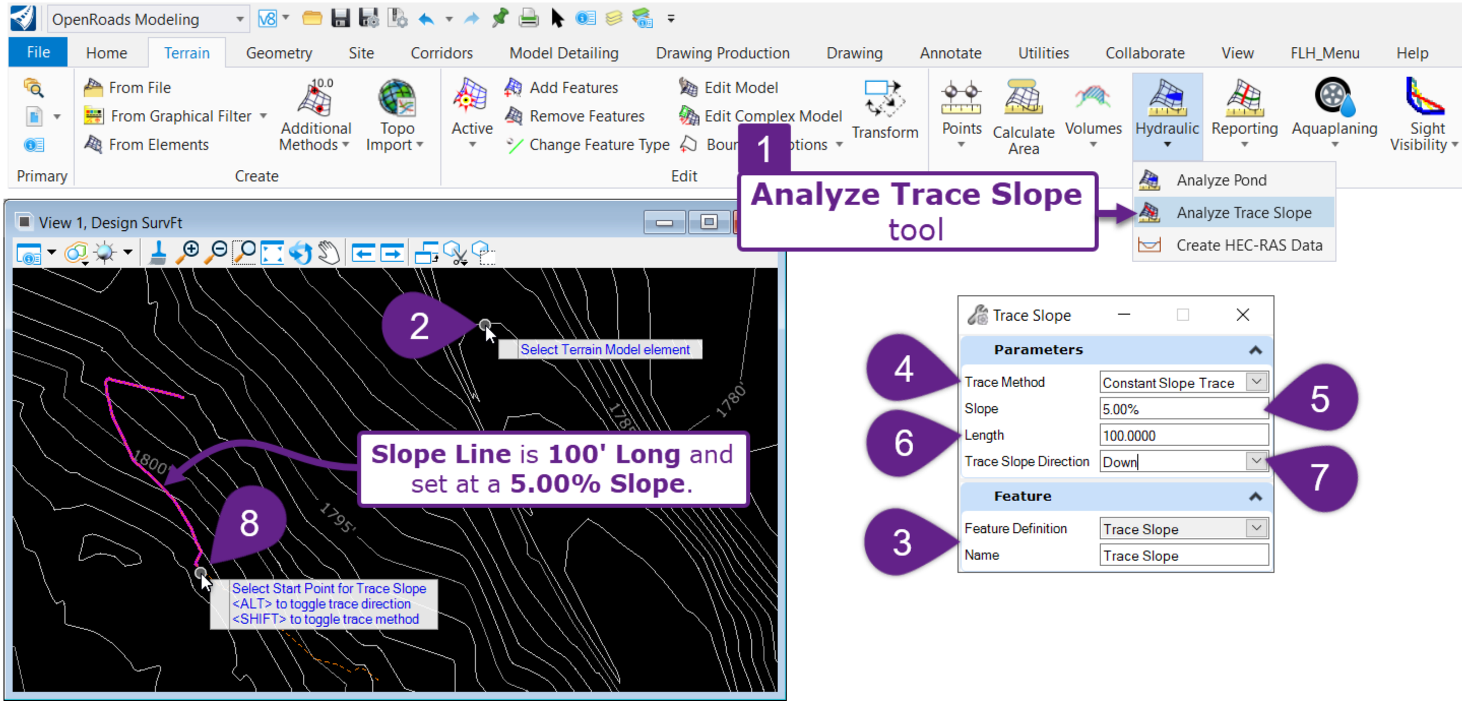
Maximum Slope Trace – Workflow:



1	From the Ribbon, select the *Analyze Trace Slope* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Analysis*** → ***Hydraulic***].
2	*Prompt: Select Terrain Model element* – Left-Click (select) the Terrain Model to draw a Slope Line on.
3	In the *Dialogue Box*, set **Feature Definition** and **Name** for the Slope Line element to be drawn.
4	In the *Dialogue Box*, set the **Trace Method** to **Maximum Slope Trace**.
5	In the *Dialogue Box*, specify a **Minimum Depth.**
6	In the *Dialogue Box,* specify a **Trace Slope Direction**. If **Up** is selected, then the Slope Line is drawn upwards from the current point location. The Slope Line terminates when a high-point is reached. If **Down** is selected, then the Slope Line is drawn downwards from the current point location.
7	Left-Click at the desired point location to draw the Slope Line from. ***TIP:*** In the *Quick Information Box*, information relating to the Slope Line is shown. Elevation 1 corresponds with the elevation of the selected point location. Elevation 2 corresponds with the termination point elevation.

NOTE: The resulting Slope Line is a 3D Linear Element and is placed in the *3D Design Model*. To delete the Slope Line, locate it in the *3D Design Model*.

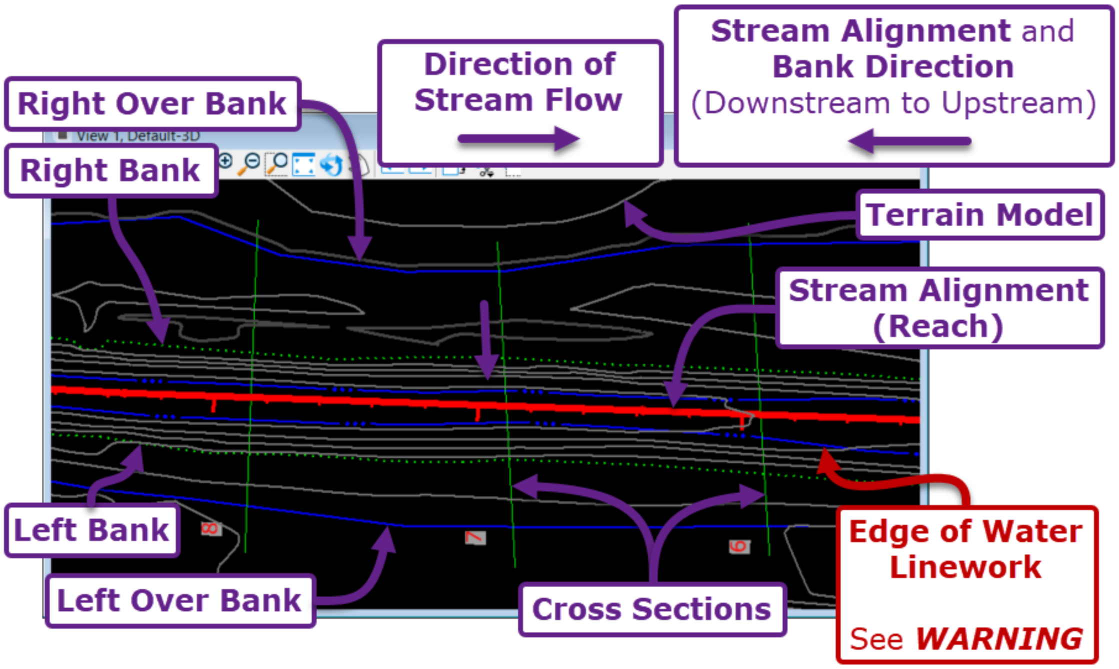
Constant Trace Method: This method creates a Slope Line that follows a constant slope path along the Terrain Model. In the *Dialogue Box*, the **Slope** setting controls the constant slope value.



1	From the Ribbon, select the *Analyze Trace Slope* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Analysis*** → ***Hydraulic***].
2	*Prompt: Select Terrain Model element* – Left-Click (select) the Terrain Model to draw a Slope Line on.
3	In the *Dialogue Box*, set **Feature Definition** and **Name** for the Slope Line element to be drawn.
4	In the *Dialogue Box*, set the **Trace Method** to **Constant Slope Trace**.
5	In the *Dialogue Box*, specify the **Slope**.
6	In the *Dialogue Box,* specify the **Length**. The **Length** sets the termination point for the Slope Line. The Slope Line will terminate at the specified length or if the Terrain Model becomes too flat to sustain the specified slope.
7	In the *Dialogue Box,* specify a **Trace Slope Direction**.
8	Left-Click at the desired point location to draw the Slope Line from.

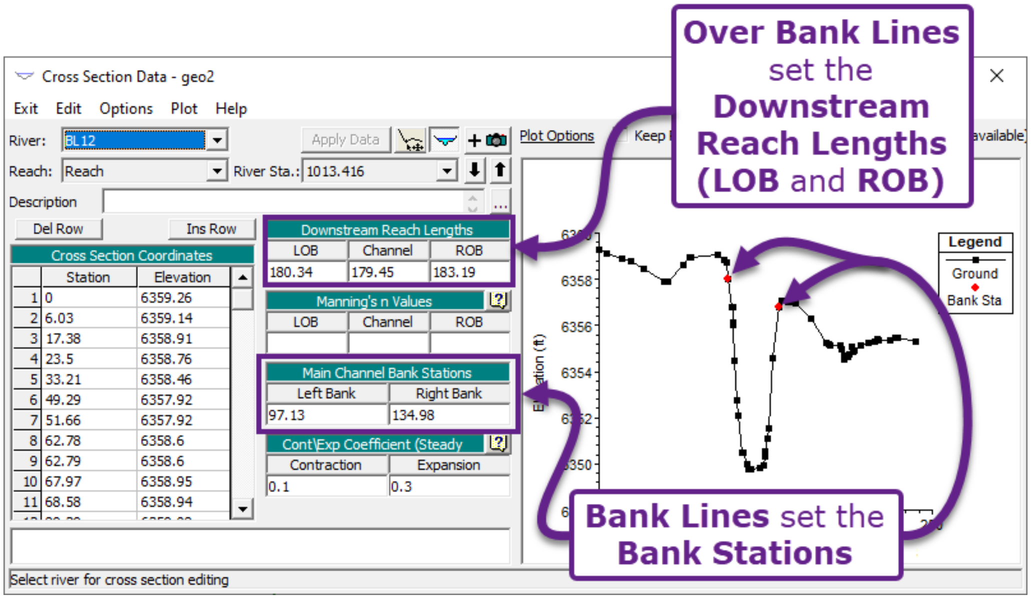
21D.3 Create HEC-RAS Data tool

This tool analyzes a Terrain Model to create a HEC-RAS geometry file (.geo). This tool requires the following elements to create the HEC-RAS data:



- **Terrain Model:** The Terrain Model is analyzed to determine elevations for the Cross Section Lines.
- **Cross Sections Lines:** Must be oriented/drawn from right bank to left bank when looking upstream. All Cross Section Lines must be within the boundary of the Existing Ground Terrain Model. Commonly, Stream Cross Sections are surveyed and placed on the "E_HYD_Stream_X-Section" Level. However, Stream Cross Sections may be manually drawn or traced using a MicroStation Element (i.e., a Smart Line).
- **Stream Alignment or Reach:** Must be oriented/drawn from downstream to upstream. Commonly, the Stream Alignment is surveyed and placed on the "E_HYD_Stream_Profile" Level. However, the Stream Alignment should be an ORD Element (i.e., an Alignment). Using an ORD Element is advantageous because the ORD Element can be stationed and assigned a (Reach) Name. Stationing and Name will carry over to the HEC-RAS data. ***BEST PRACTICE:*** Manually draw or trace the Stream Alignment using ORD Elements. The Stream Alignment should be a continuous ORD Element.
- **Left/Right Bank Line:** Must be oriented/drawn from downstream to upstream. Commonly, Bank Lines are surveyed and placed on the "E_GEO_Top_of_Bank" Level. A Bank Line element must be continuous along the entire reach. Bank Lines can be manually drawn or traced using a MicroStation Element. ***WARNING:*** Typically, the Edge of Water Linework should NOT be chosen as the Bank Lines. The Edge of Water represents the water level at the time of the survey, which may be lower than the bank.
- **Left/Right Over Bank Line:** Must be oriented/drawn from downstream to upstream. In HEC-RAS, the Over Bank Lines determine the **Downstream Reach Lengths** for the **LOB** and **ROB**. The Over Bank Lines correspond with Reach Lengths for over bank flow. Typically, the Over Bank Lines are NOT surveyed and must be drawn manually using MicroStation Elements. ***TIP:*** The Bank Line can be selected as the Over Bank Line. In other words, a single element can serve as both the Bank Line and Over Bank Line.

IMPORTANT: The direction of the elements must be oriented in the appropriate direction for correct importation into HEC-RAS. The Stream Cross Sections Lines must be drawn from right bank to left bank, if looking upstream. All other elements (i.e., Banks, Over Banks, and the Stream Alignment) must be drawn from downstream to upstream.

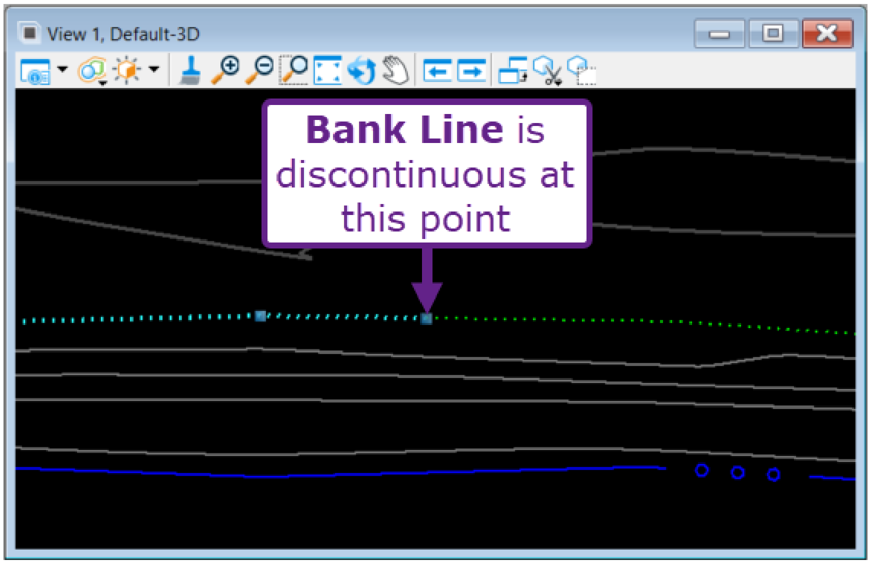


Create HEC-RAS Data – Workflow:

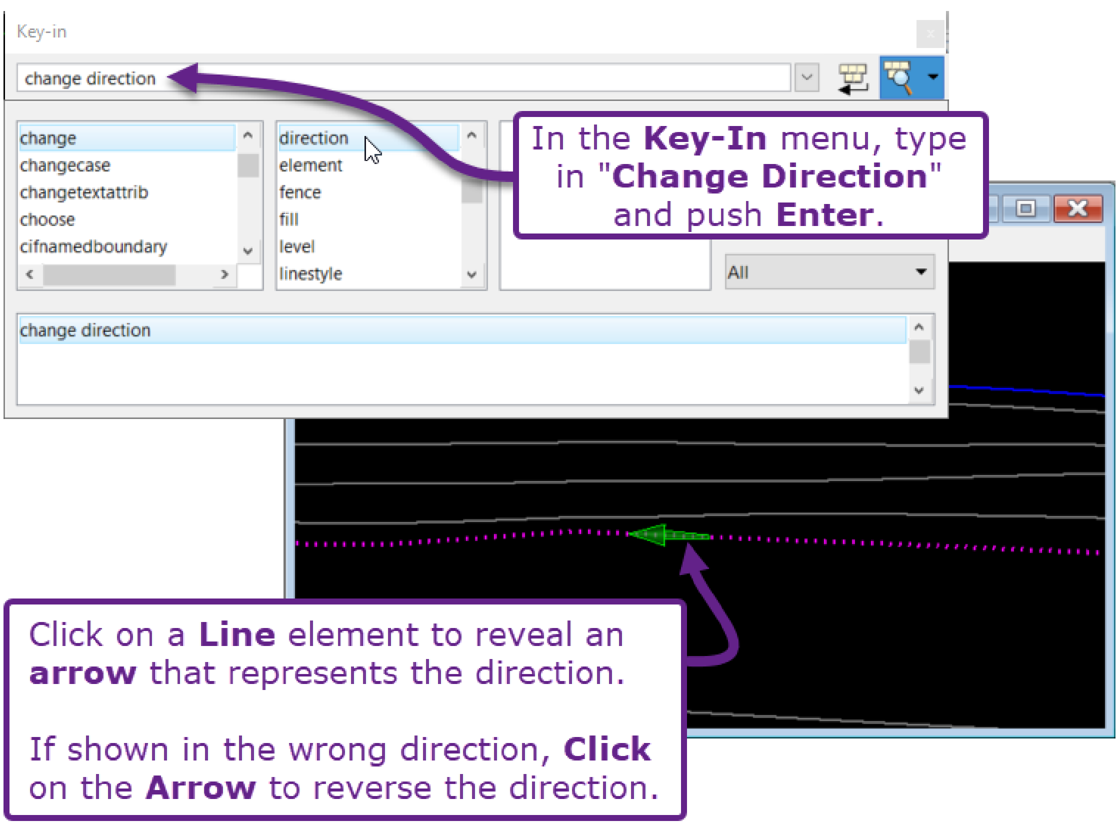
1	Create a new ORD File using a 2D Seed File. See *3B – Create a New ORD File*.
2	In the new ORD File, reference in the Survey ORD File.
3	*Activate* the Existing Ground Terrain Model.
4	Draw or trace the **Stream Alignment (Reach)** using ORD Element Tools. Draw the Alignment from downstream to upstream. Use the Line Between Points tool to draw a series of connected, line segments. See *7D.1.a.i Lines Between Points*. Combine the line segments into a single, continuous Alignment using the Complex By Element tool. When using the Complex By Element, ensure the resulting Alignment direction is oriented from downstream to upstream (as indicated by the purple arrow). See *7D.2.a Complex By Elements tool*. ***TIP:*** Assign the Stream Alignment to the "Baseline" Feature Definition. In the Properties box, assign the Alignment a Name. ***TIP:*** Use the Start Station tool to set the start station value for the Stream Alignment. See *7E.4.a Start Station*. ***TIP:*** Use the Annotate Element tool to create alignment/station annotations for the Stream Alignment. See *15D.2 Alignment Annotations – Workflow.* **ALTERNATE WORKFLOW:** If a Stream Alignment was surveyed (i.e., a survey element placed on the "E_HYD_Stream_Profile" Level), then use the Copy tool to bring the survey element in to the current ORD File. The referenced survey element is converted to a Line String (MicroStation Element) when copied in to the current ORD File. Use the Complex By Element tool to convert the MicroStation Element into an ORD Element. The ORD Element can be named and stationed.

In steps 5-7, the **Bank**, **Over Bank**, and **Cross Section Lines** are drawn or setup using MicroStation Elements. If these lines have been surveyed, then use the *Copy* tool to bring the referenced survey elements into the current ORD File as a MicroStation Element. There are two checks that must be performed before the copied MicroStation Elements can be used with the *Create HEC-RAS Data* tool:

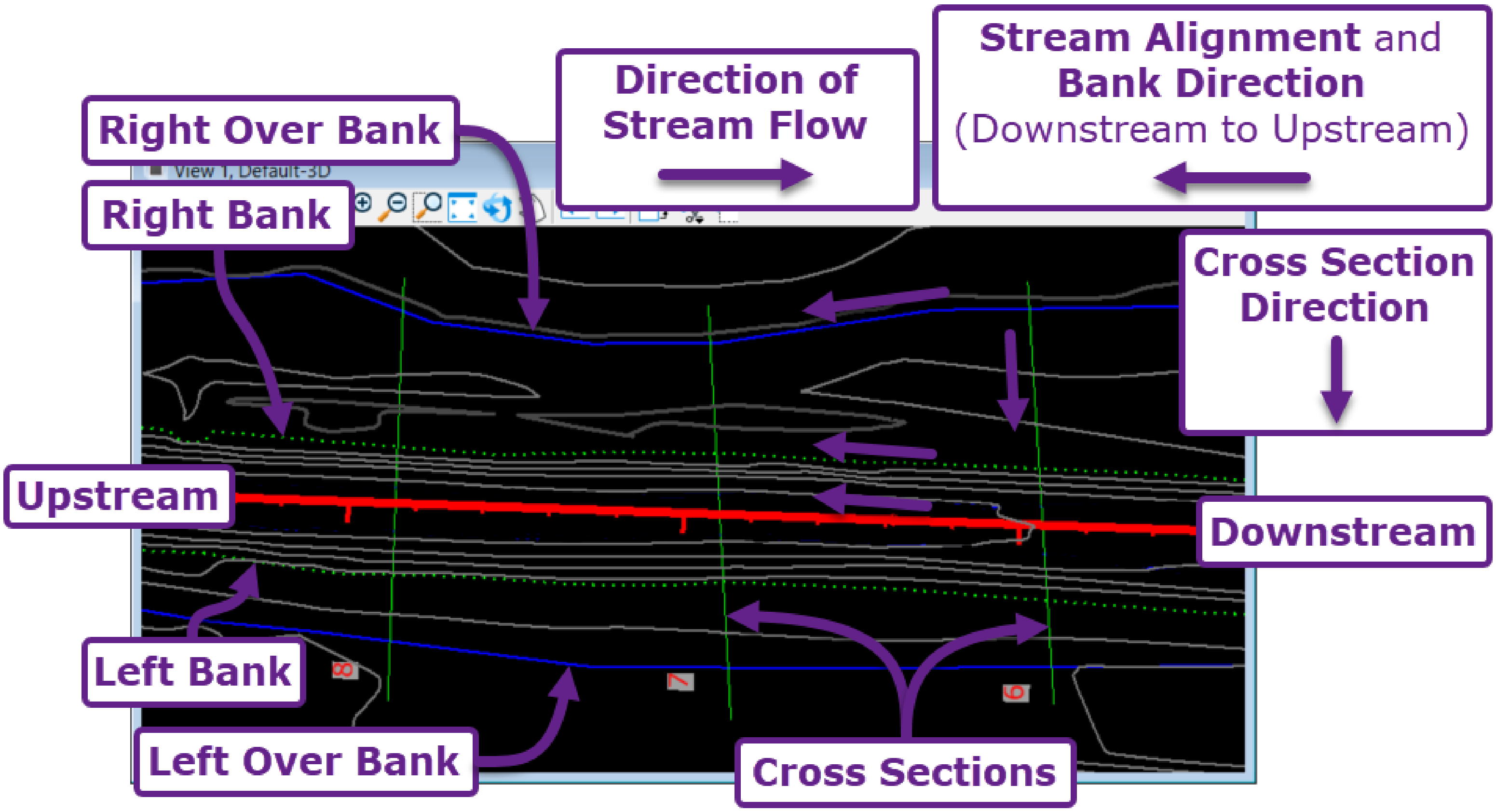
- Ensure the lines are continuous. For example, a Bank Line must be a single, continuous element. If there is a gap in a line, then use *Place Smart Line* tool to draw a line between the gap. Use the *Create Complex Chain* tool to combine multiple lines into a single MicroStation Element. See *6H.2 Create Complex Chain tool*.



- Ensure the Lines are oriented in the appropriate direction. Use the "*Change Direction*" Key-In to check the direction of a Line and reverse it if necessary. The "*Change Direction*" Key-In is demonstrated in *6I.5 Flip the Direction of a Line Style*.

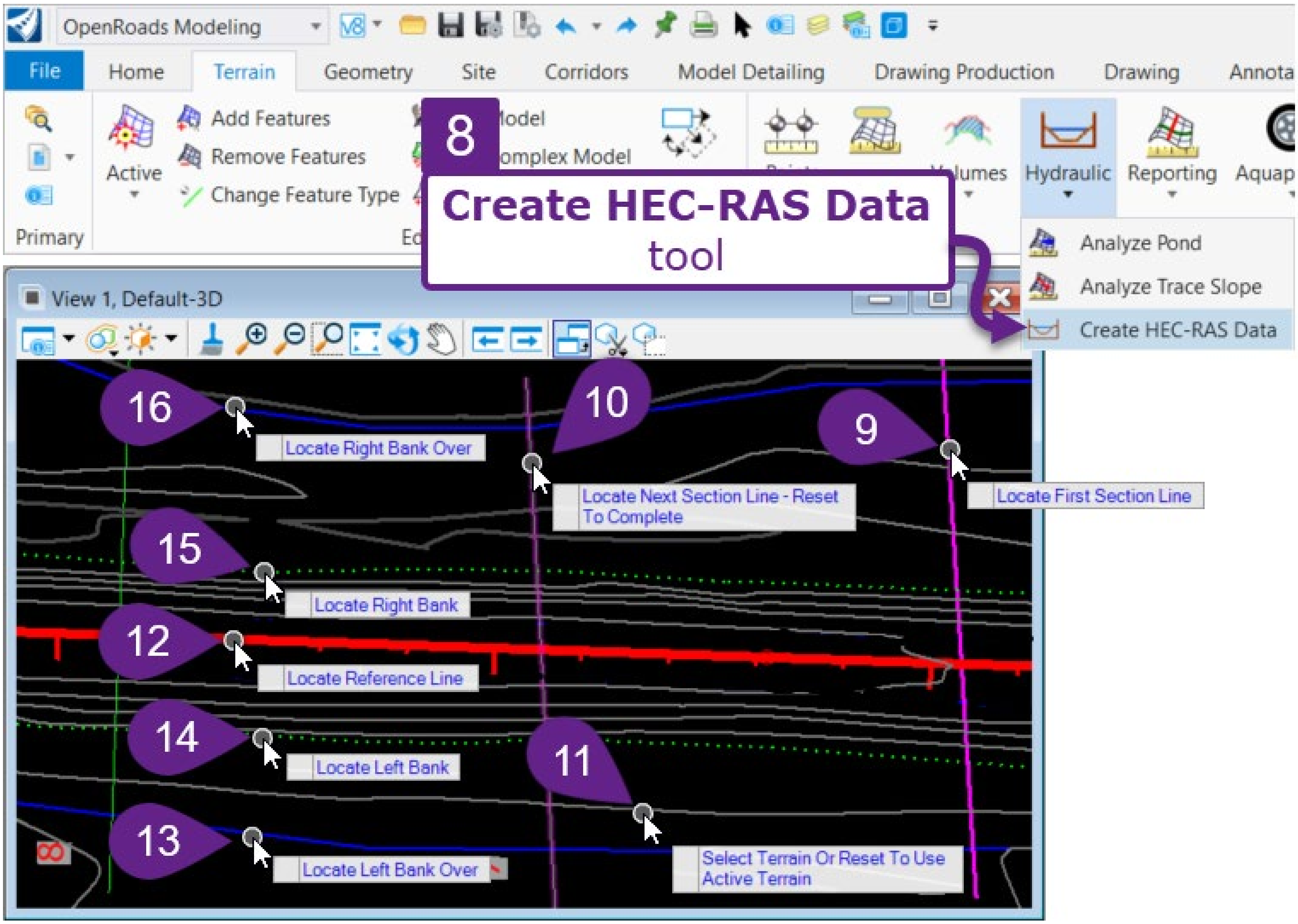


5	Draw, trace, or copy in the **Left** and **Right Bank Lines**. The direction of the Bank Lines must be from downstream to upstream. If drawing the Bank Lines, use the *Place SmartLine* tool to create a single, continuous, element for each Bank Line.
6	Draw, trace, or copy in the **Left/Right Over Bank Lines**. The direction of the Over Bank Lines must be from downstream to upstream. ***TIP:*** When using the *Create HEC-RAS Data* tool, the **Bank Lines** can also be selected as the **Over Bank Lines**.
7	Draw, trace, or copy in the **Cross Section Lines**. The direction of the Cross Section Lines must be from the right bank to the left bank when looking upstream.

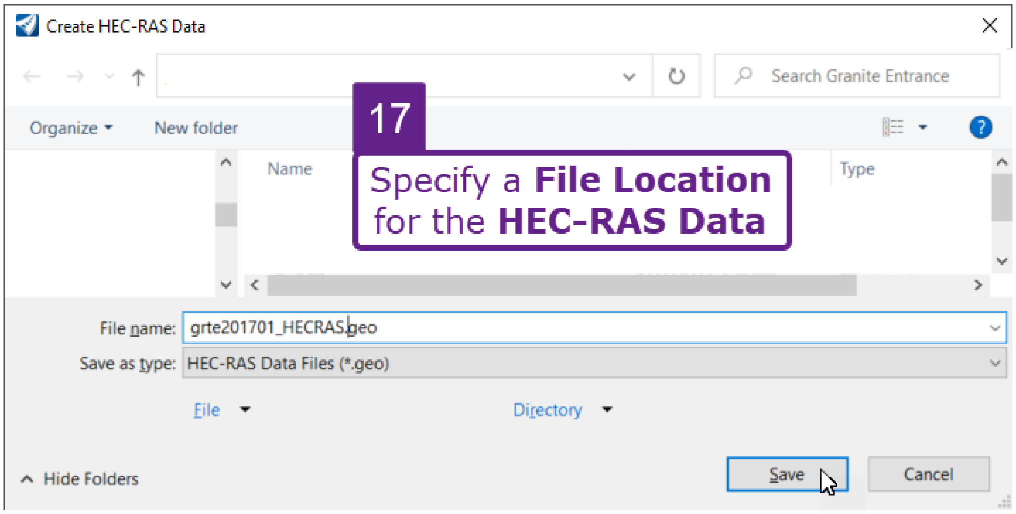


8	From the Ribbon, select the *Create HEC-RAS Data* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Analysis*** → ***Hydraulic***].
9	*Prompt: Locate First Section Line* – Select a **Cross Section Line**. ***NOTE:*** Cross Section Lines can be selected in any order. They do NOT have to be selected from downstream to upstream.
10	*Prompt: Locate Next Section Line – Reset to Complete* – Select the remaining **Cross Section Lines**. After selecting the last Cross Section Line, right-click (reset) to advance to the next *Prompt*.
11	*Prompt: Select Terrain or Reset to Use Active Terrain* – Select the Existing Ground Terrain Model. Alternatively, if the Existing Ground Terrain Model is *active*, then right-click (reset) to select it.

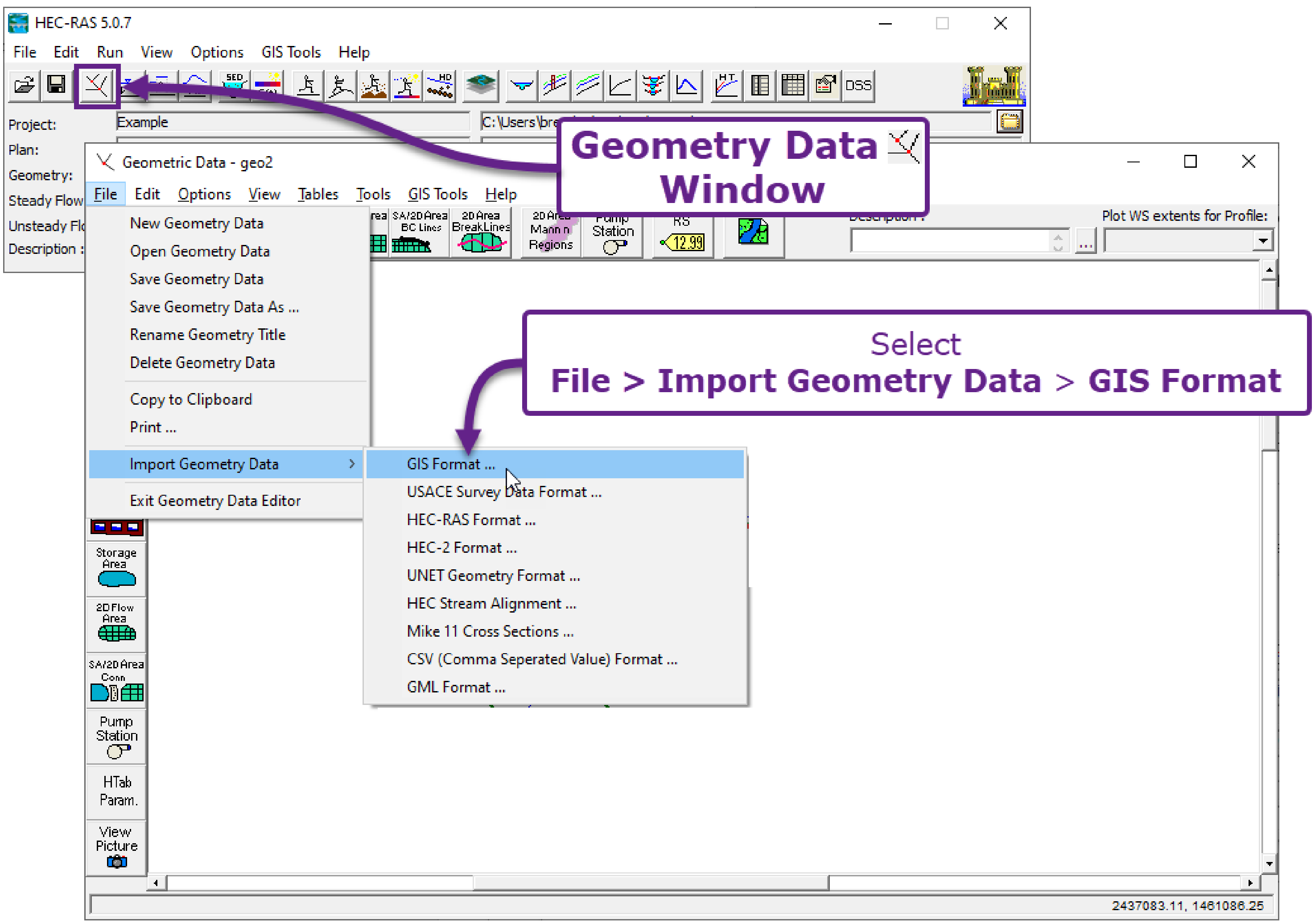
12	*Prompt: Locate Reference Line* – Select the **Stream Alignment (Reach)**.
13	*Prompt: Locate Left Bank Over* – Select the **Left Over Bank Line**. The Left Over Bank Line is positioned to the left of the Stream Alignment when looking upstream. ***TIP:*** The **Left Bank Line** may also be selected in this step as the **Left Bank Over Line**.
14	*Prompt: Locate Left Bank* – Select the **Left Bank Line**.
15	*Prompt: Locate Right Bank* – Select the **Right Bank Line**.
16	*Prompt: Locate Right Bank Over* – Select the **Right Over Bank Line**.



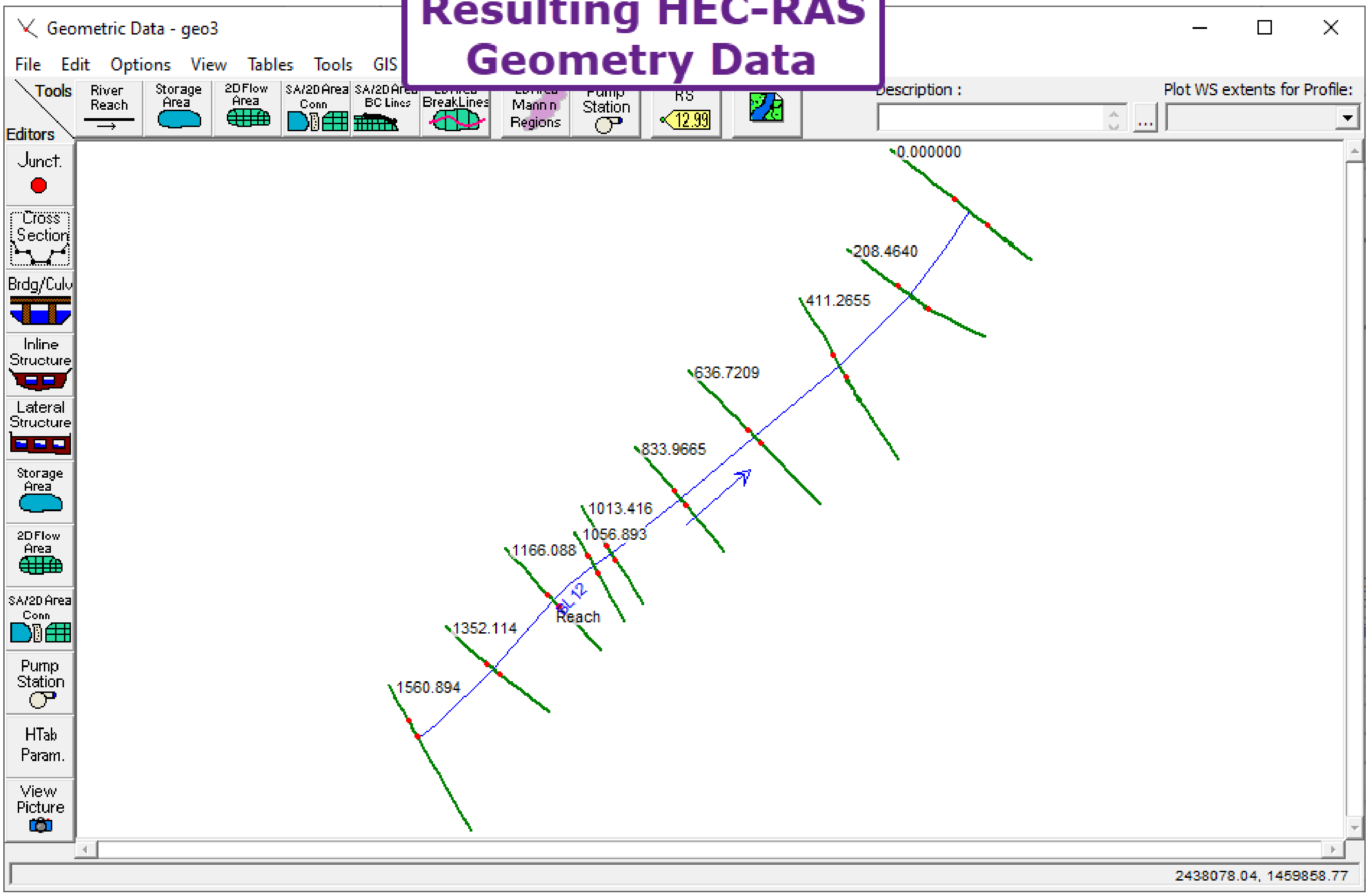
17	After step 16, all information is analyzed and packaged into a HEC-RAS Geometry File (.geo). Specify a location for the HEC-RAS Geometry File.



Import the Data into HEC-RAS: With the Geometric Data window opened, the **Import Geometry Data** tool is used to import the data gathered from the ORD Software. ***IMPORTANT:*** Use the **GIS Format** option to import the data. ***WARNING:*** Do NOT use the HEC-RAS Format.



Resulting HEC-RAS Geometry Data

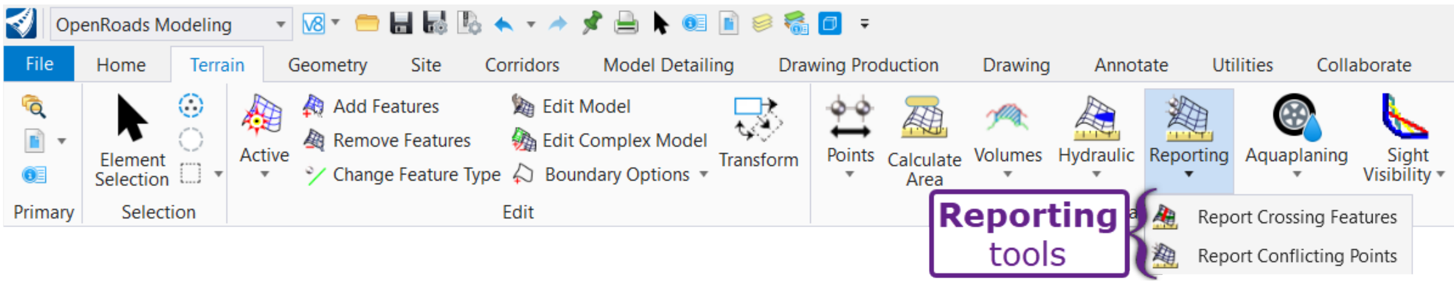


21E – REPORTING TOOLS

Reporting tools are used to locate conflicting break lines or points within a Terrain Model.

Reporting tools are found in the Ribbon in the following location:

OpenRoads Modeling workflow → **Terrain** tab → **Analysis** group → **Reporting** drop-down



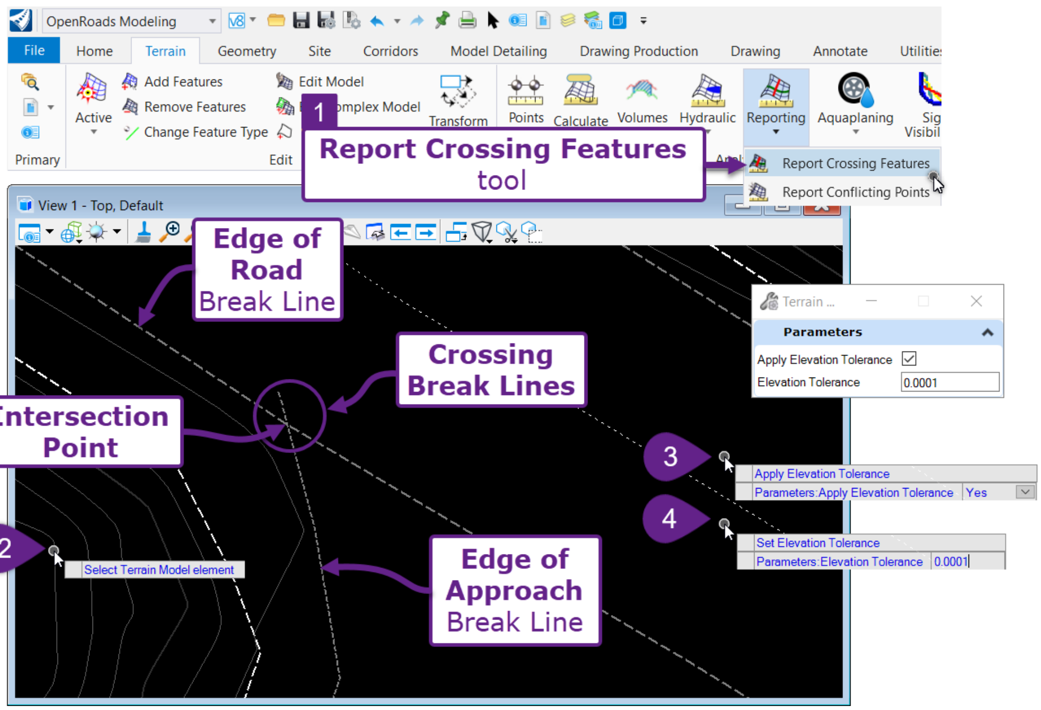
NOTE: Reporting tools have very limited usages for design and drafting purposes. These tools are generally used by surveyors when creating and analyzing the Existing Ground Terrain Models for errors.

21E.1 Report Crossing Features tool

This tool analyzes a Terrain Model for intersecting break lines and voids. For example, a Terrain Model may contain two break lines which cross. It is possible for each break line to be set a different elevation at the intersection point. This tool locates the crossing features and provides options for reconciling the difference between conflicting elevations to automatically fix the Terrain Model.

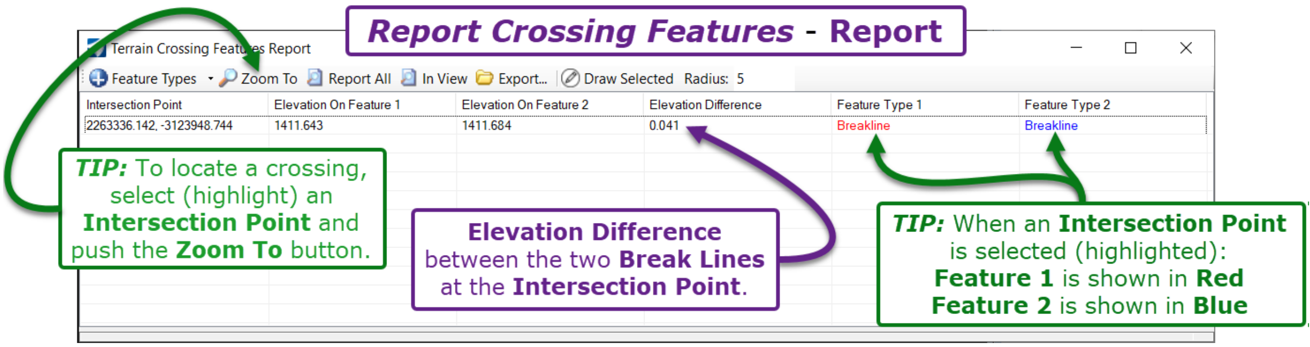
NOTE: This tool has limited applicability for design work. Instead, this tool is most useful for surveyors when creating and analyzing the Existing Ground Terrain Model for break line discrepancies.

In the example shown below, the **Edge of Road** and **Edge of Approach** break lines are both used in the Existing Ground Terrain Model. The *Report Crossing Features* tool creates a report that shows the elevation of both break lines at the intersection point.

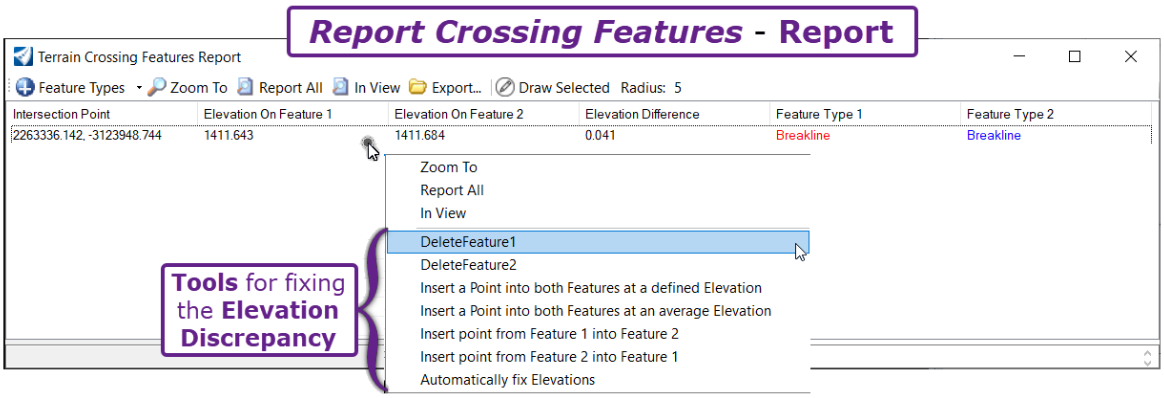


1	From the Ribbon, select the *Report Crossing Features* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Analysis*** → ***Reporting***].
2	*Prompt: Select Terrain Model element* – Select (left-click) on the Terrain Model to analyze.
3	*Prompt: Apply Elevation Tolerance* – If NO is selected, then the resulting report will list EVERY crossing/intersecting Break Line or Void in the Terrain Model. Even if two break lines cross at the same elevation (Elevation Difference = 0.0000), the intersection point will be listed in the report. If YES is selected, then an **Elevation Tolerance** must be specified in step 4. The Elevation Tolerance is used to filter out break line intersection points with an Elevation Difference smaller the specified tolerance. ***TIP:*** To locate ONLY crossing Break Lines with differing elevations at the intersection point, set the Elevation Tolerance to a very small value (i.e., 0.0001). With this configuration, Break Lines that cross at the same elevation will NOT be listed.
4	*Prompt: Set Elevation Tolerance* – Key-in the desired Elevation Tolerance for the analysis. The recommended value is 0.0001.

After step 4, the *Report Crossing Features* report is created and all Break Line Intersection Points are listed. As shown in the report below, there is an Elevation Difference of 0.041 feet at the intersection point of the **Edge of Road** and **Edge of Approach** break lines.



By Right-Clicking on an Intersection Point, the elevation discrepancy can be automatically fixed and the Terrain Model will be adjusted.



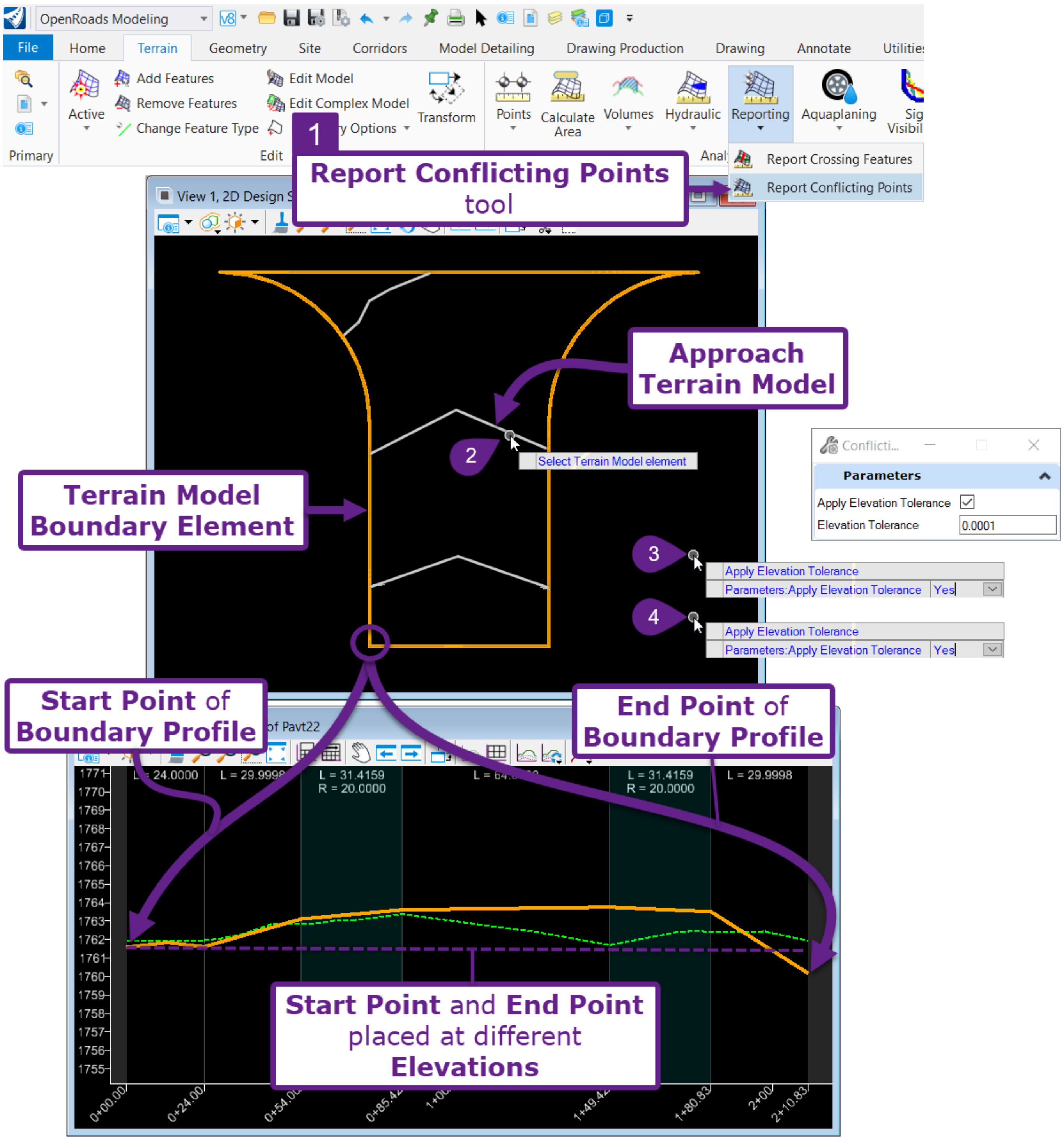
Elevation Discrepancy Tools	
Tool:	**Description:**
Delete Feature 1	Feature 1 is removed from the Terrain Model. ***NOTE:*** The element that corresponds with Feature 1 is NOT deleted. Only removed from the Terrain.
Delete Feature 2	Feature 2 is removed from the Terrain Model.
Insert a Point into both Features at a defined Elevation	An elevation point is inserted into both Features. The elevation of the point is specified by the User.
Insert a Point into both Features at an average Elevation	An elevation point is inserted into both Features. The elevation of the point is the average of "Elevation on Feature 1 and 2".
Insert point from Feature 1 into Feature 2	A point is inserted into Feature 2. The elevation of the point matches the "Elevation on Feature 1".
Insert point from Feature 2 into Feature 1	A point is inserted into Feature 1. The elevation of the point matches the "Elevation on Feature 2".
Automatically fix Elevations	The User is prompted to enter a "Maximum Elevation Difference". Then the average elevation at the Intersection Point is calculated. The average elevation is used if the resulting point does NOT exceed the "Maximum Elevation Difference" value in respect to "Elevation of Feature 1 and 2". If the "Maximum Elevation Difference" is exceeded, then the inserted point is adjusted to an elevation that is NOT exceeded.

21E.2 Report Conflicting Points tool

This tool analyzes a Terrain Model for two or more Points placed at in the same horizontal position, but at different elevations.

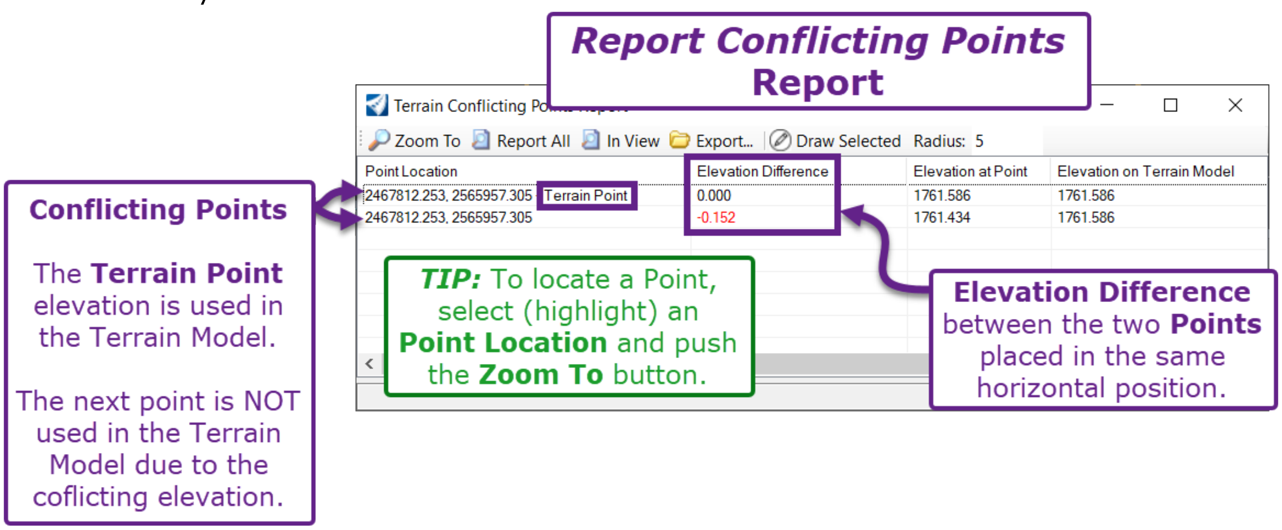
For example, a Terrain Model used to create the surface of an Approach requires a closed Boundary element to be created. When creating the Profile of the Boundary element, the start point of the Profile should be placed at the same elevation as the end point.

However, if the start and end point are errantly placed at differing elevations, the conflicting elevations will be located and listed by the *Report Conflicting Points* tool. Also, the differing elevation points can be automatically reconciled by this tool.

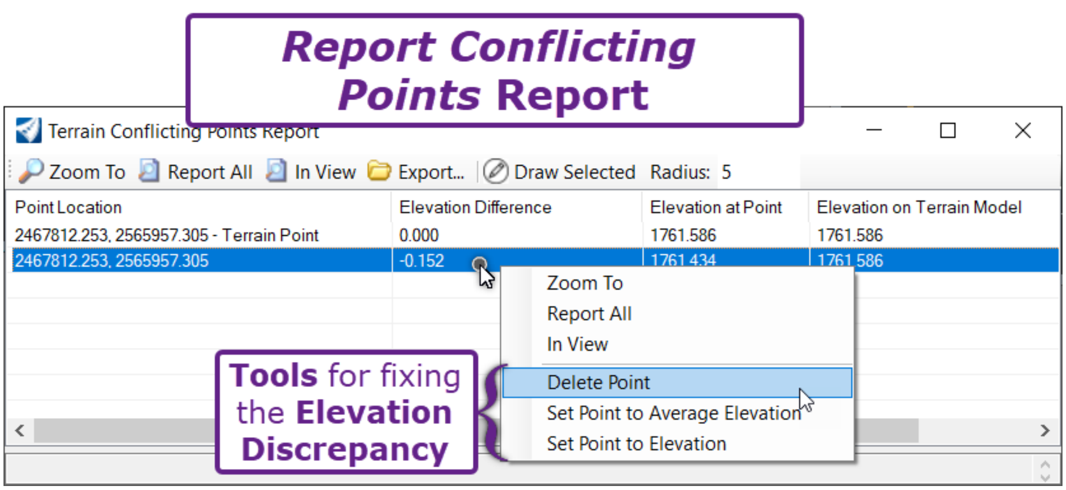


1	From the Ribbon, select the *Report Conflicting Points* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Analysis*** → ***Reporting***].
2	*Prompt: Select Terrain Model element* – Select (left-click) on the Terrain Model to analyze.
3	*Prompt: Apply Elevation Tolerance* – If NO is selected, then the resulting report will list All points that are placed in the same horizontal position. Even points are placed at same elevation (Elevation Difference = 0.0000) are listed in the report. If YES is selected, then an **Elevation Tolerance** must be specified in step 4. The Elevation Tolerance is used to filter out same position points with an elevation difference smaller the specified tolerance. ***TIP:*** To analyze for same position points with conflicting elevation values, set the Elevation Tolerance to a very small value (i.e., 0.0001). Same position points placed at equal elevations will NOT be listed.
4	*Prompt: Set Elevation Tolerance* – Key-in the desired Elevation Tolerance for the analysis.

After step 4, the *Report Conflicting Points* report is created and all conflicting points in the Terrain Model are listed. As shown in the report below, there is an Elevation Difference of 0.152 feet at the Start/End Point of the Boundary element.



By Right-Clicking on a Point, the elevation discrepancy can be automatically fixed.

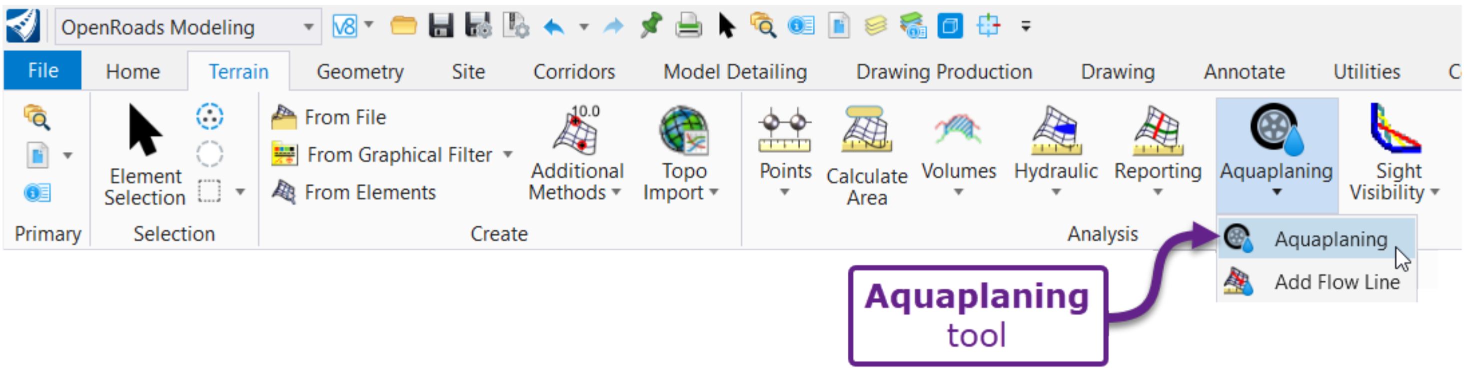


Elevation Discrepancy Tools	
Tool:	**Description:**
Delete Point	The selected Point is deleted. If the "Terrain Model" Point is deleted, then the elevation of the other point is used at the conflicting point location.
Set Point to Average Elevation	The elevations of the two conflicting points are averaged and the Terrain Model is automatically adjusted at the point location.
Set Point to Elevation	The selected Point is set to an elevation specified by the User.

21F – AQUAPLANING TOOL

The *Aquaplaning* tool analyzes the Finished Ground Terrain Model to create a report that measures film depth along the length of the road for a specified rainfall intensity.

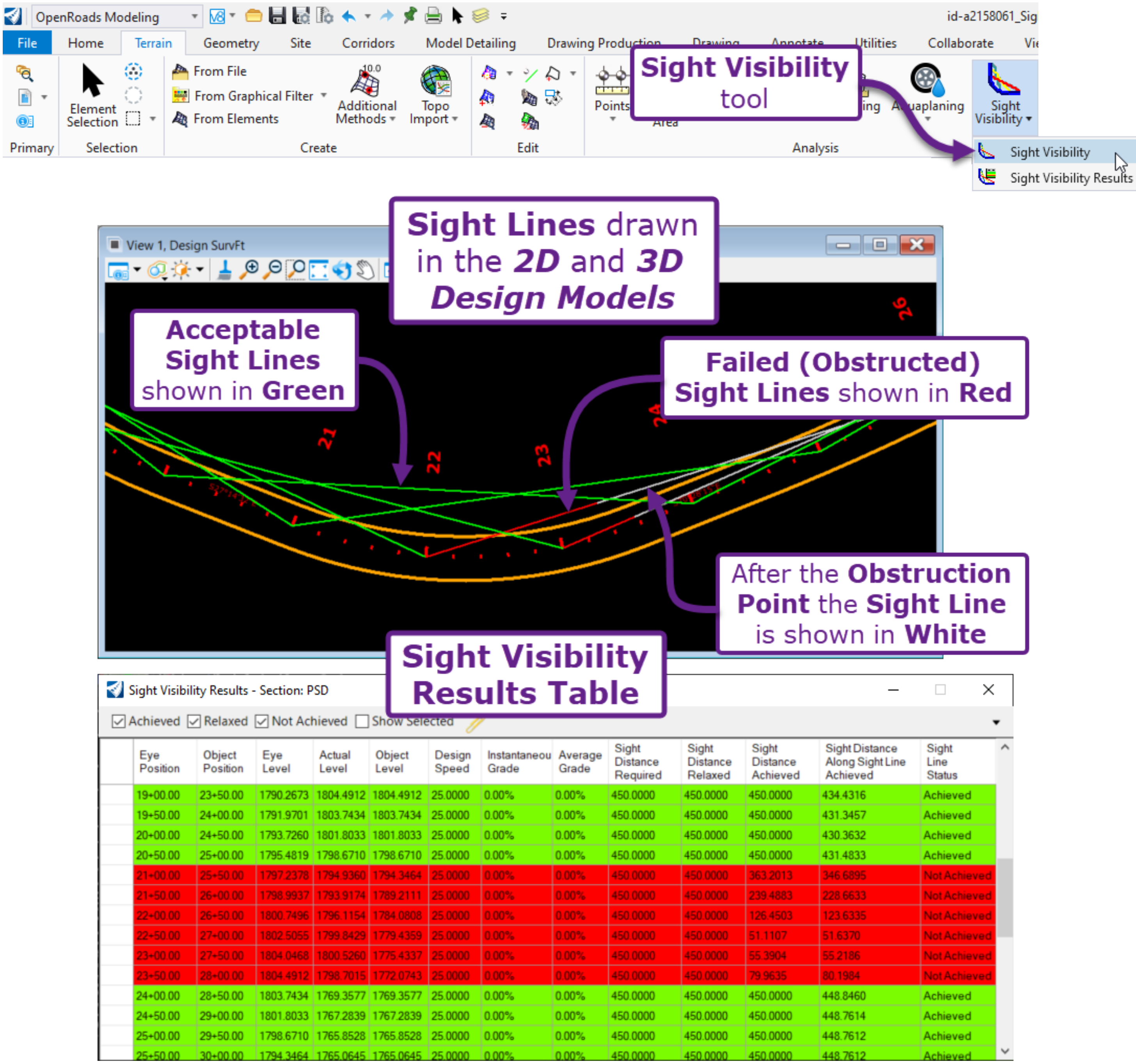
NOTE: The FLH WorkSpace does NOT support Feature Definitions for use of this tool. This tool is NOT used in FLH projects.



TIP: Analyzing the Corridor or Finished Ground Terrain Model with Thematic Displays can be used to identify flat areas that may result in ponding or aquaplanning. For more information on Thematic Displays, see *21H – Use Thematic Display Styles to Analyze Slopes*.

21G – SIGHT VISIBILITY TOOL

The *Sight Visibility* tool generates sight lines and a report that analyzes the Stopping Sight Distance (SSD) or Passing Sight Distance (PSD) at station intervals along the mainline alignment.



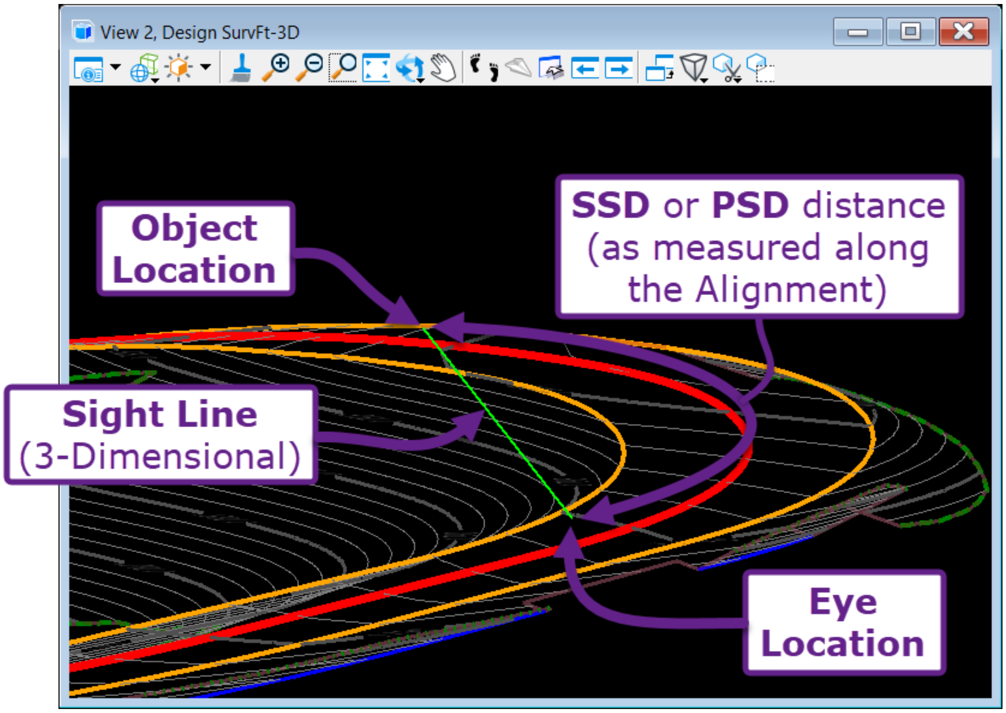
Eye Position	Object Position	Eye Level	Actual Level	Object Level	Design Speed	Instantaneou Grade	Average Grade	Sight Distance Required	Sight Distance Relaxed	Sight Distance Achieved	Sight Distance Along Sight Line Achieved	Sight Line Status
19+00.00	23+50.00	1790.2673	1804.4912	1804.4912	25.0000	0.00%	0.00%	450.0000	450.0000	450.0000	434.4316	Achieved
19+50.00	24+00.00	1791.9701	1803.7434	1803.7434	25.0000	0.00%	0.00%	450.0000	450.0000	450.0000	431.3457	Achieved
20+00.00	24+50.00	1793.7260	1801.8033	1801.8033	25.0000	0.00%	0.00%	450.0000	450.0000	450.0000	430.3632	Achieved
20+50.00	25+00.00	1795.4819	1798.6710	1798.6710	25.0000	0.00%	0.00%	450.0000	450.0000	450.0000	431.4833	Achieved
21+00.00	25+50.00	1797.2378	1794.9360	1794.3464	25.0000	0.00%	0.00%	450.0000	450.0000	363.2013	346.6895	Not Achieved
21+50.00	26+00.00	1798.9937	1793.9174	1789.2111	25.0000	0.00%	0.00%	450.0000	450.0000	239.4883	228.6633	Not Achieved
22+00.00	26+50.00	1800.7496	1796.1154	1784.0808	25.0000	0.00%	0.00%	450.0000	450.0000	126.4503	123.6335	Not Achieved
22+50.00	27+00.00	1802.5055	1799.8429	1779.4359	25.0000	0.00%	0.00%	450.0000	450.0000	51.1107	51.6370	Not Achieved
23+00.00	27+50.00	1804.0468	1800.5260	1775.4337	25.0000	0.00%	0.00%	450.0000	450.0000	55.3904	55.2186	Not Achieved
23+50.00	28+00.00	1804.4912	1798.7015	1772.0743	25.0000	0.00%	0.00%	450.0000	450.0000	79.9635	80.1984	Not Achieved
24+00.00	28+50.00	1803.7434	1769.3577	1769.3577	25.0000	0.00%	0.00%	450.0000	450.0000	450.0000	448.8460	Achieved
24+50.00	29+00.00	1801.8033	1767.2839	1767.2839	25.0000	0.00%	0.00%	450.0000	450.0000	450.0000	448.7614	Achieved
25+00.00	29+50.00	1798.6710	1765.8528	1765.8528	25.0000	0.00%	0.00%	450.0000	450.0000	450.0000	448.7612	Achieved
25+50.00	30+00.00	1794.3464	1765.0645	1765.0645	25.0000	0.00%	0.00%	450.0000	450.0000	450.0000	448.7612	Achieved

In practice, this tool has two main usages:

- Determine areas with inadequate Stopping Sight Distance (SSD). For example, if an object was placed on the roadway, this tool analyzes if a vehicle has adequate Stopping Sight Distance to come to a stop before reaching the object.
- Analyze Passing Sight Distance (PSD) to determine passing zones. Once passing zones are determined, appropriate pavement markings can be drawn in for the permeant traffic control plan. For example, for two lane highways, this tool can be used to determine placement of broken yellow centerline markings that designate passing zones.

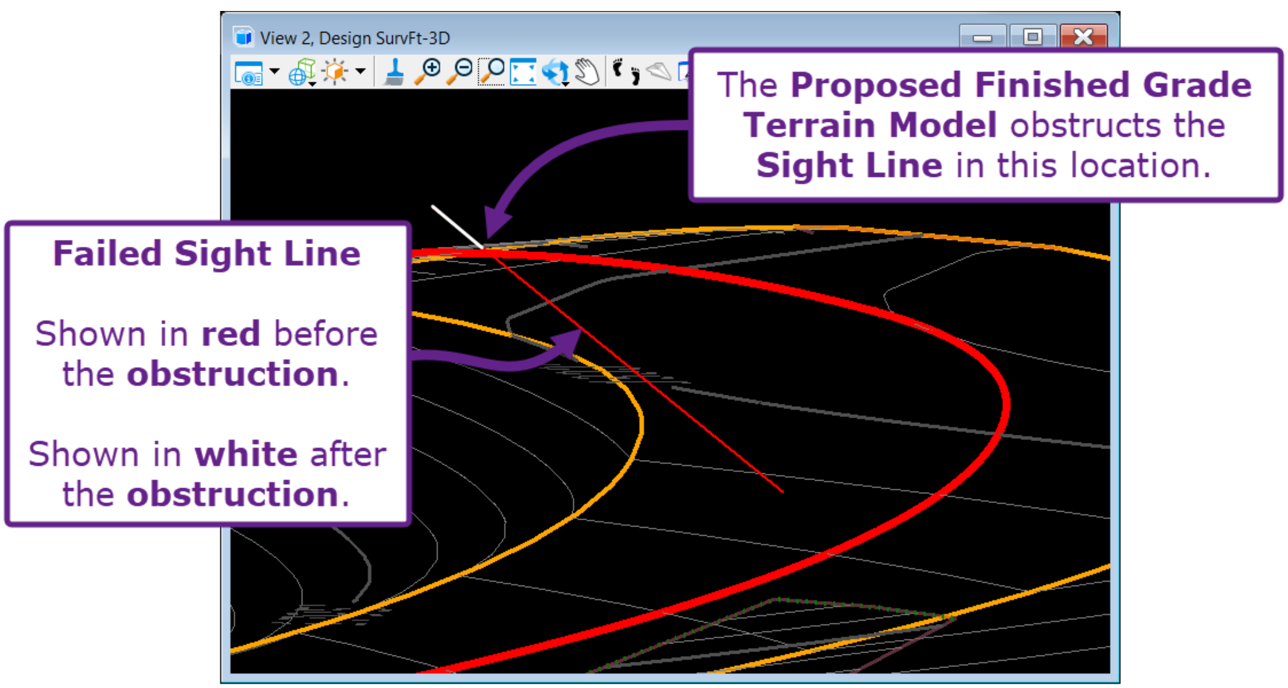
21G.1 Capabilities and Limitations of the *Sight Visibility* tool

At every station interval, this tool draws a 3-dimensional sight line from the eye location of the motorist to the object location, which is placed further down the mainline alignment. The distance from the eye location to the object is set by the SSD or PSD distance required for the motorist operating speed. The SSD or PSD distance is measured along the Alignment and represents the path of the vehicle.



In operation of this tool, the Proposed Finished Grade Terrain Model or a Corridor is selected. Sight Line failure is determined if the Finished Grade Terrain Model or Corridor obstructs the sight line from the eye location to the object. Acceptable sight lines are shown in green. Failed sight lines are shown in red.

As shown below, the sight line is shown in red (failure) because the proposed crest vertical curve interrupts the sightline between the eye and object.

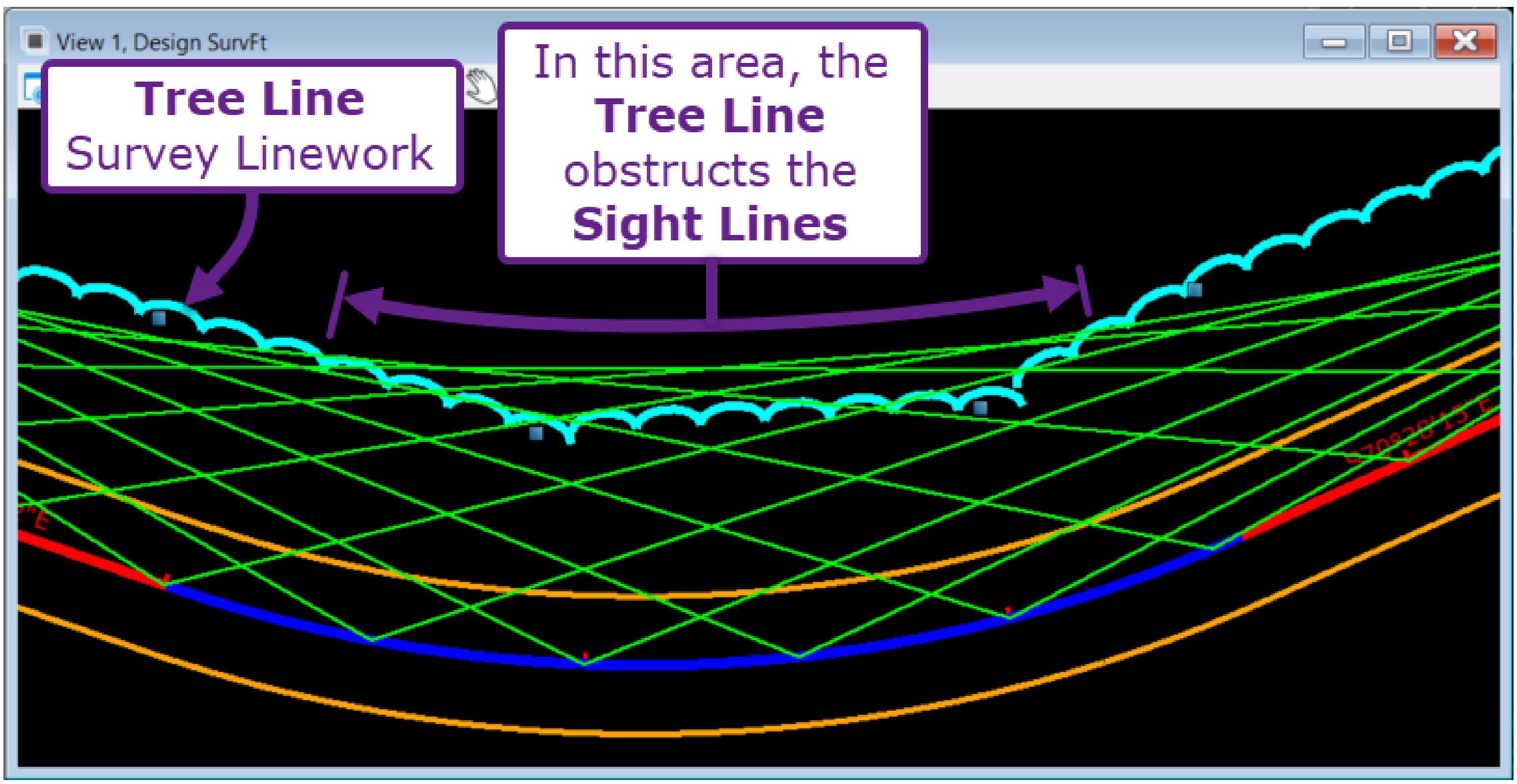


Sight Lines that extend past the Finished Grade Terrain Model or Corridor: Optionally, this tool allows the Existing Ground Terrain Model to be selected to further analyze sight lines that extend past the selected Finished Grade Terrain Model/Corridor. In areas where the Existing Ground Terrain Model and Finished Grade Terrain Model/Corridor overlap, the Existing Ground Terrain Model is ignored.

Limitation – Accounting for Other Vertical Obstructions (i.e., trees and buildings): As mentioned above, this tool analyzes Terrain Models and/or Corridors for sight line obstructions due to grade changes. Trees, buildings, and other vertical obstructions are NOT analyzed because they are NOT a part of the Existing Ground Terrain Model.

Accounting for vertical obstructions can be done manually by examining the resulting sight lines from the *2D Design Model* (plan view). ***BEST PRACTICE:*** After using this tool, scroll down the alignment and search for sight lines that extend past vertical obstructions (i.e., trees, buildings, clearing limits) or the right-of-way.

TIP: Turn on the *Background Map* aerial to assist in identifying vertical obstructions. See *3D – Setup a New ORD File*.

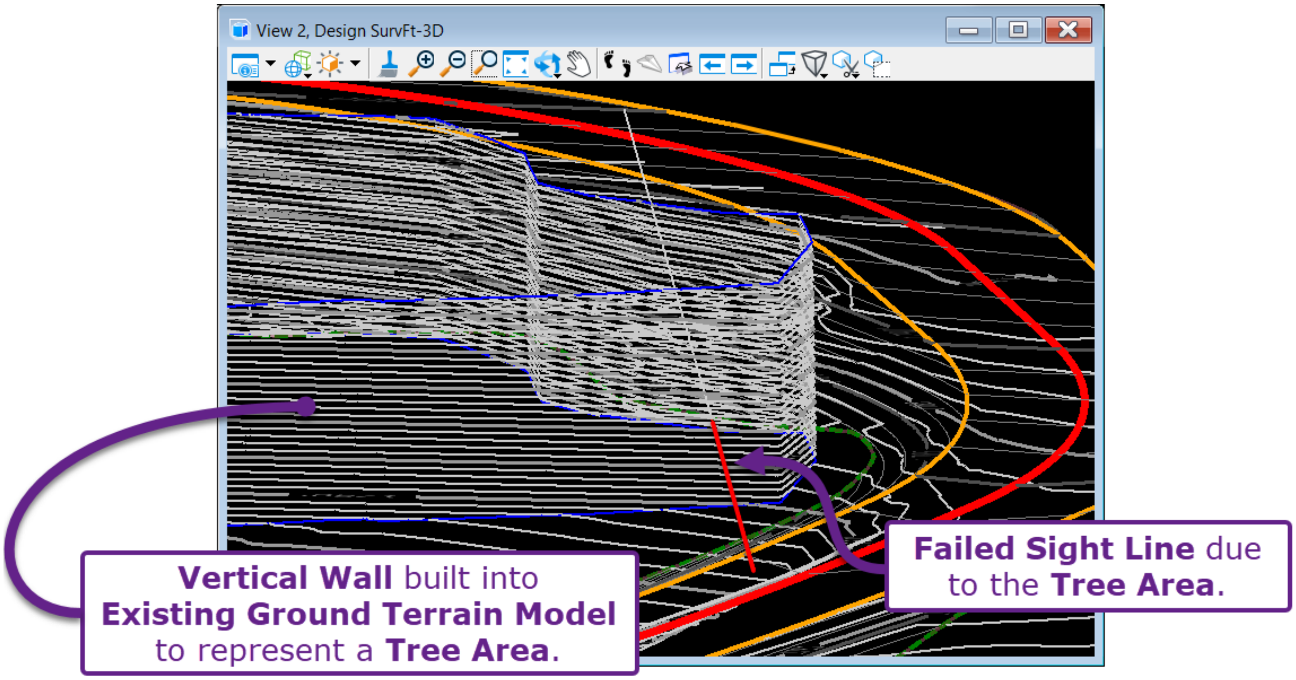


For example, in the graphic above, all sight-lines are deemed acceptable by the *Sight Visibility* tool because the Terrain Models/Corridor grade changes do NOT obstruct the sight-line. However, there is an area that would be obstructed by the surveyed Tree Line.

TIP: When scrolling down the alignment, isolate Levels that correspond with vertical obstructions, such as the tree line (E_VEG_Tree_Line), buildings (E_PLM_BLDG_Building), and clearing limits (P_RDW_Clearing_Limts). Also, it is commonly undesirable to have sight lines extend past the existing or proposed right-of-way and property lines (E_RW_Right_of_Way_Lines, P_RW_Right_of_Way).

TIP: In step 29 of the *21G.2 Sight Visibility – Workflow*, the start station for analysis is specified. Before accepting the start station, a sight line is dynamically drawn. Move the dynamic sight line down the length of the alignment to quickly identify locations that are obstructed by surveyed or proposed linework.

Vertical obstructions can be automatically analyzed by creating a 3D model of the obstruction and adding it to the Existing Ground Terrain Model. However, modeling each obstruction area can be very time consuming and will slightly alter the triangulation of the Existing Ground Terrain Model when added.

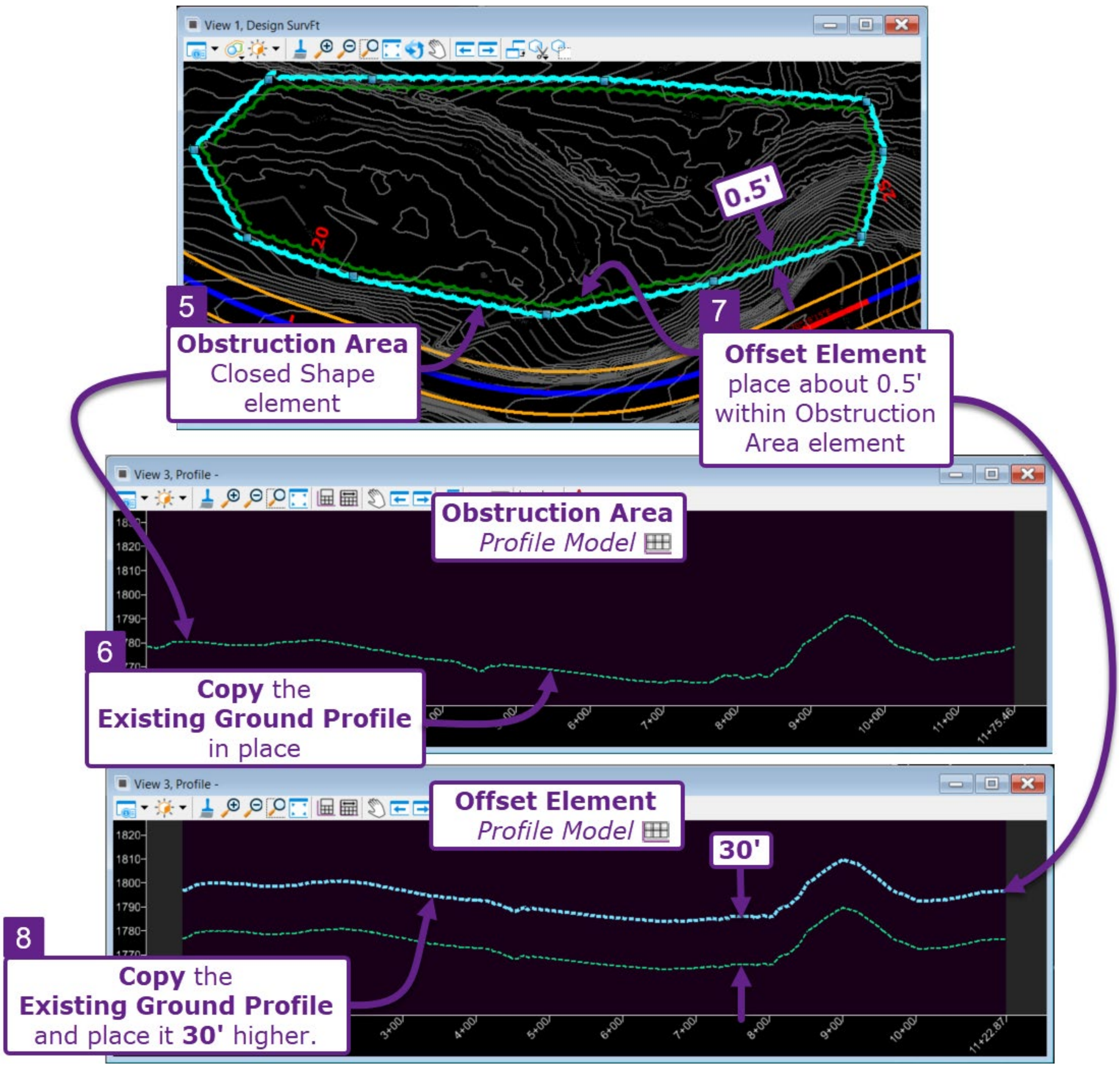


In summation, the process for modeling an obstruction area is as follows:

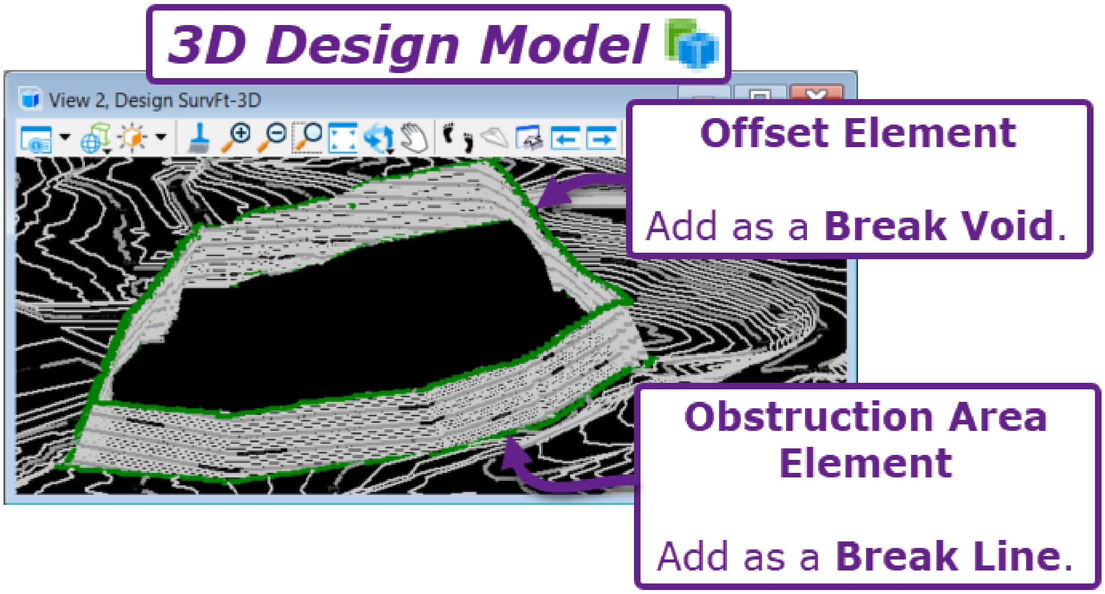
NOTE: For this process, a new ORD File should be created. The Survey ORD File must be *merged* (imported) into the new ORD File to make modifications to the Existing Ground Terrain Model. Specifically, the Survey ORD File must be *merged* into the *3D Design Model* to import the Existing Ground Terrain Model.

1	Create a new ORD File using a 2D Seed File.
2	Reference in the Survey ORD File and *activate* the Existing Ground Terrain Model.
3	Enter the *3D Design Model* of the new ORD File. Open the References manager. Select (highlight) the Survey ORD File and use the *Merge Into Master* tool. See *1E7.a Merge into Master tool (Import Reference into Current ORD File)*. ***WARNING:*** If the *Merge Into Master* tool is used when the *2D Design Model* is *active*, then the Terrain Model is converted to a Cell element.
4	Return to the *2D Design Model* of the new ORD File and *activate* the merged (imported) Existing Ground Terrain Model.
5	Create Closed Shape elements (MicroStation Elements) that represent the Obstruction Area. ***TIP:*** Combine Linework that represents obstruction areas using the *Create Complex Shape* tool. ***TIP:*** Turn on the *Background Map* aerial to trace obstruction areas. ***TIP:*** Use the *Copy* tool with referenced Linework to import the desired lines into the new ORD File.

6	Open the *Profile Model* for an Obstruction Area element. Using the *Copy* tool, copy the profile for the Existing Ground Profile and place it in the same location. *Activate* the copied Profile. ***WARNING:*** Do NOT directly *activate* the Existing Ground Profile. *Activate* the copy. If the Existing Ground Profile is directly *activated*, then the Obstruction Area element will be rejected when adding it to the Existing Ground Terrain Model.
7	Return to the *2D Design Model*. Using the *Move Parallel* tool, create an offset copy of the Obstruction Area element. Place the Offset element 0.5 feet within the Obstruction Area element.
8	Open the *Profile Model* for the offset copy. Using the *Copy* tool, copy the Existing Ground Profile and place it directly above the original location using AccuDraw. Place the copy 15-20 feet above original location. *Activate* the copied Profile.



9	Enter the *3D Design Model*. ***NOTE:*** After *activating* the Profiles for both the Obstruction Area element and Offset element, corresponding *3D Linear Elements* are shown in the *3D Design Model*.
10	Add the *3D Linear Elements* to the Existing Ground Terrain Model using the *Add Features* tool. ***IMPORTANT:*** Add the Obstruction Area element as a Break Line. ***IMPORTANT:*** Add the Offset element as a Break Void. ***NOTE:*** When using the *Add Features* tool, the elements to be added must be selected from the *3D Design Model*.



Limitation – Accounting for Grade in SSD Calculations: A variable in the Stopping Sight Distance (SSD) formula is the current grade (G) that the vehicle is traveling on.

Greenbook Equation (3-3):

$$d_B = \frac{V^2}{30[\frac{a}{32.2} \pm \text{G}]}$$

Where:

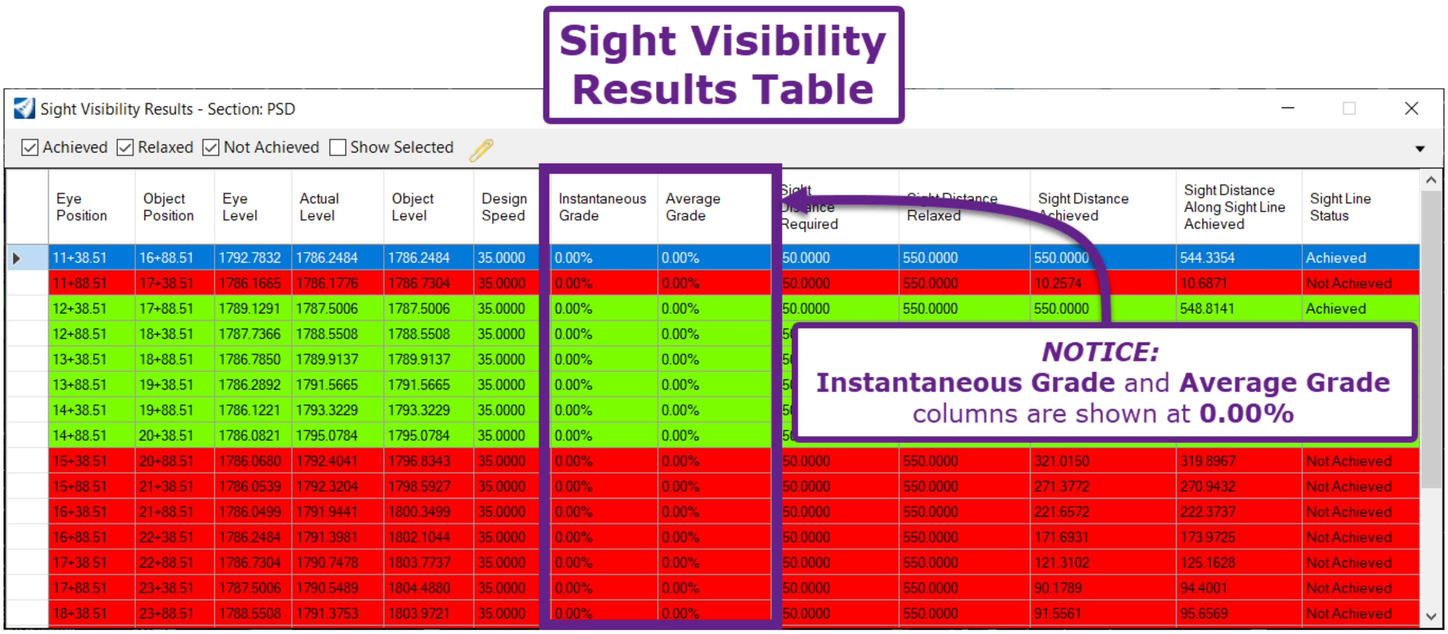
d_B = Breaking Distance on grade (ft)

V = Design speed (mph)

a = deceleration (ft/s^2)

G = Current Grade (%)

Unfortunately, the ORD software suffers from a known bug, that prevents the Instantaneous Grade and Average Grade information to be collected, which means the calculated Stopping Sight Distance does NOT account for Average Grade.



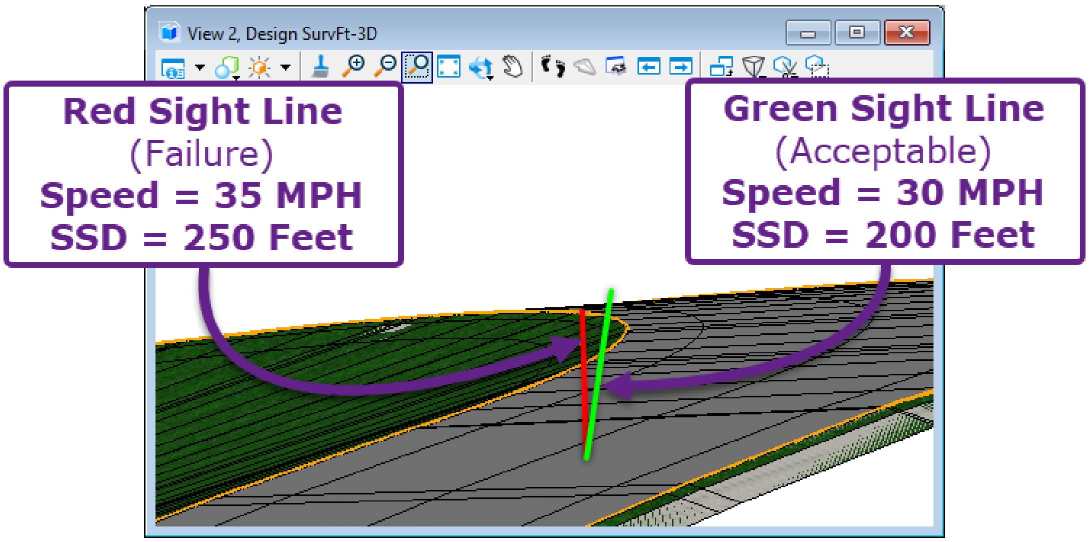
Eye Position	Object Position	Eye Level	Actual Level	Object Level	Design Speed	Instantaneous Grade	Average Grade	Sight Distance Required	Sight Distance Relaxed	Sight Distance Achieved	Sight Distance Along Sight Line Achieved	Sight Line Status
11+38.51	16+88.51	1792.7832	1786.2484	1786.2484	35.0000	0.00%	0.00%	50.0000	550.0000	550.0000	544.3354	Achieved
11+88.51	17+38.51	1786.1665	1786.1776	1786.7304	35.0000	0.00%	0.00%	50.0000	550.0000	10.2574	10.6871	Not Achieved
12+38.51	17+88.51	1789.1291	1787.5006	1787.5006	35.0000	0.00%	0.00%	50.0000	550.0000	550.0000	548.8141	Achieved
12+88.51	18+38.51	1787.7366	1788.5508	1788.5508	35.0000	0.00%	0.00%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13+38.51	18+88.51	1786.7850	1789.9137	1789.9137	35.0000	0.00%	0.00%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13+88.51	19+38.51	1786.2892	1791.5665	1791.5665	35.0000	0.00%	0.00%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14+38.51	19+88.51	1786.1221	1793.3229	1793.3229	35.0000	0.00%	0.00%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14+88.51	20+38.51	1786.0821	1795.0784	1795.0784	35.0000	0.00%	0.00%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15+38.51	20+88.51	1786.0680	1792.4041	1796.8343	35.0000	0.00%	0.00%	50.0000	550.0000	321.0150	319.8967	Not Achieved
15+88.51	21+38.51	1786.0539	1792.3204	1798.5927	35.0000	0.00%	0.00%	50.0000	550.0000	271.3772	270.9432	Not Achieved
16+38.51	21+88.51	1786.0499	1791.9441	1800.3499	35.0000	0.00%	0.00%	50.0000	550.0000	221.6572	222.3737	Not Achieved
16+88.51	22+38.51	1786.2484	1791.3981	1802.1044	35.0000	0.00%	0.00%	50.0000	550.0000	171.6931	173.9725	Not Achieved
17+38.51	22+88.51	1786.7304	1790.7478	1803.7737	35.0000	0.00%	0.00%	50.0000	550.0000	121.3102	125.1628	Not Achieved
17+88.51	23+38.51	1787.5006	1790.5489	1804.4880	35.0000	0.00%	0.00%	50.0000	550.0000	90.1789	94.4001	Not Achieved
18+38.51	23+88.51	1788.5508	1791.3753	1803.9721	35.0000	0.00%	0.00%	50.0000	550.0000	91.5561	95.6569	Not Achieved

As a workaround, FLH has a Microsoft Excel spread sheet template that calculate Average Grade based on the **Eye Level** and **Object Level** elevations. The values generated in the **Sight Visibility Results Table** are copied into FLH spread sheets to automatically calculate SSD values that account for grade. Exporting the Sight Visibility Results table into the FLH spread sheet template is discussed in *21G.3 Import Results into Microsoft Excel Template*.

TIP: Another workaround for addressing the average grade bug is to locate steepest grade on the project from the Alignment Profile. Use Table 3-2 from the AASHTO Greenbook to determine the SSD distance for the steepest grade. In step 10 of the *21G.2 Sight Visibility - Workflow*, a custom Distance (SSD) value can be specified. Enter the SSD distance for the steepest grade during this step. The resulting analysis will be more conservative because the worst-case situation is analyzed.

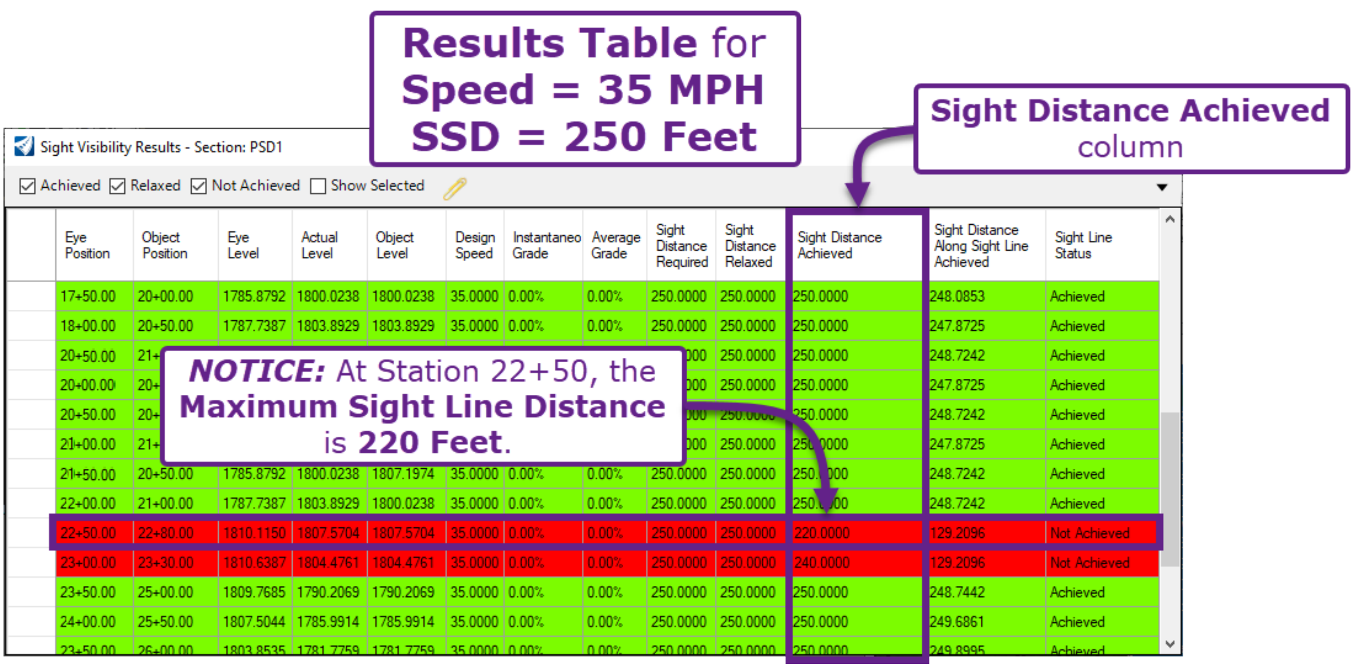
Limitation – Maximum Sight Distance is NOT Calculated: Knowing the Maximum Sight Distance that a motorist can see is beneficial in areas of marginal SSD or PSD. This tool does NOT provide additional analysis or extend a sight line after SSD or PSD is achieved.

For example, if the SSD is 200 feet (speed = 30 mph), analysis is ceased when determined that 200 feet of Sight Distance is achievable. In this case, the motorist has a Maximum Sight Distance of 220 feet (As shown in the results table below), which is marginal compared to the SSD of 200 feet. This marginal area may be of interest to the designer.



As a workaround, the operating speed or SSD (Distance) variable can be increased when using the *Sight Visibility* tool. In the example shown above, failure is invoked by increasing the speed from 30 mph to 35 mph, which changes the target SSD value from 200 feet to 250 feet.

In the Sight Visibility Results Table, failed sight lines (shown with red rows) can be analyzed in the **Sight Distance Achieved** column. The value shown in this column is the Maximum Sight Distance at the station.



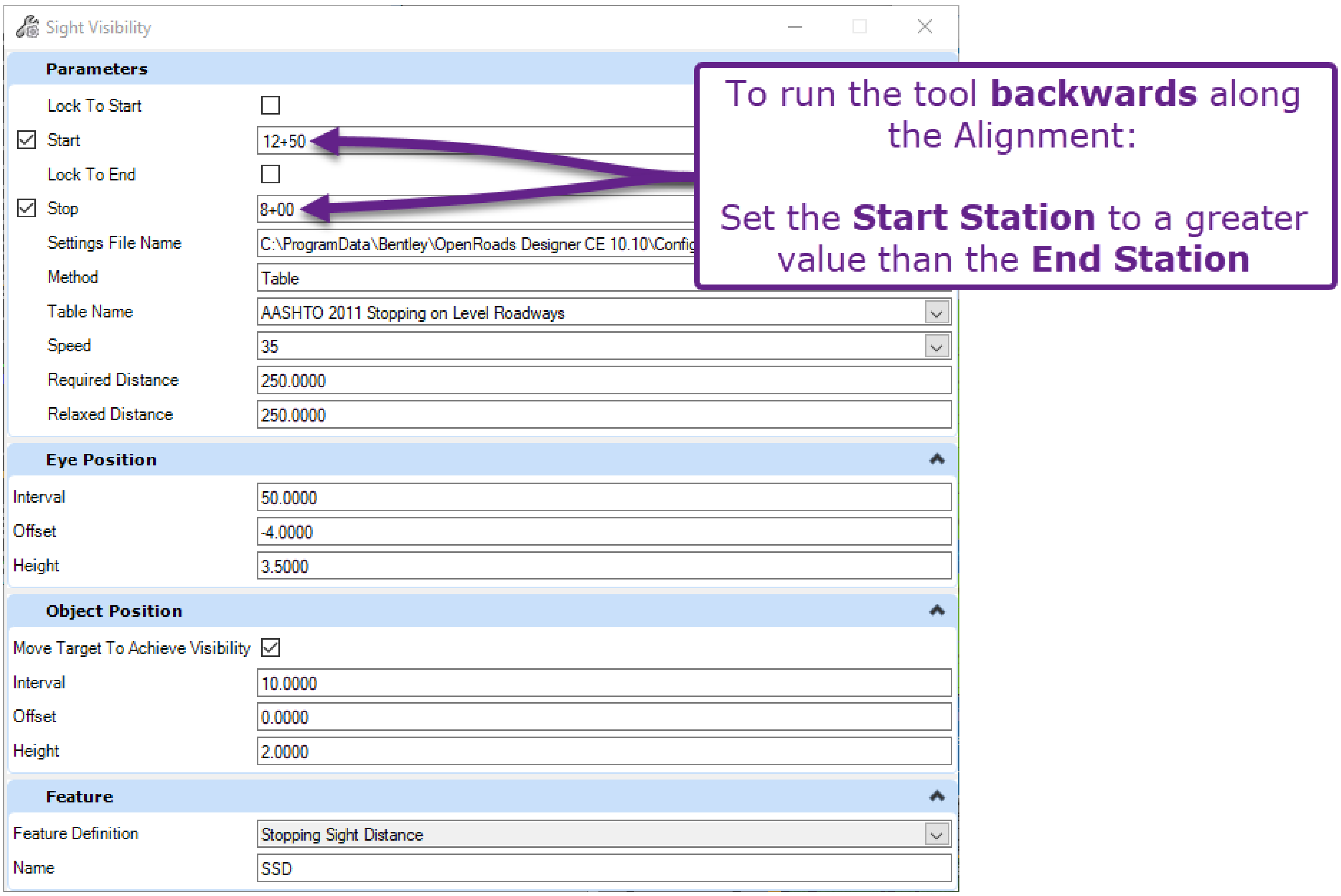
Eye Position	Object Position	Eye Level	Actual Level	Object Level	Design Speed	Instantaneo Grade	Average Grade	Sight Distance Required	Sight Distance Relaxed	Sight Distance Achieved	Sight Distance Along Sight Line Achieved	Sight Line Status
17+50.00	20+00.00	1785.8792	1800.0238	1800.0238	35.0000	0.00%	0.00%	250.0000	250.0000	250.0000	248.0853	Achieved
18+00.00	20+50.00	1787.7387	1803.8929	1803.8929	35.0000	0.00%	0.00%	250.0000	250.0000	250.0000	247.8725	Achieved
20+50.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	250.0000	250.0000	248.7242	Achieved
20+00.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	250.0000	250.0000	247.8725	Achieved
20+50.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	248.7242	Achieved
21+00.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	250.0000	[illegible]	247.8725	Achieved
21+50.00	20+50.00	1785.8792	1800.0238	1807.1974	35.0000	0.00%	0.00%	250.0000	250.0000	[illegible]	248.7242	Achieved
22+00.00	21+00.00	1787.7387	1803.8929	1800.0238	35.0000	0.00%	0.00%	250.0000	250.0000	[illegible]	248.7242	Achieved
22+50.00	22+80.00	1810.1150	1807.5704	1807.5704	35.0000	0.00%	0.00%	250.0000	250.0000	220.0000	129.2096	Not Achieved
23+00.00	23+30.00	1810.6387	1804.4761	1804.4761	35.0000	0.00%	0.00%	250.0000	250.0000	240.0000	129.2096	Not Achieved
23+50.00	25+00.00	1809.7685	1790.2069	1790.2069	35.0000	0.00%	0.00%	250.0000	250.0000	250.0000	248.7442	Achieved
24+00.00	25+50.00	1807.5044	1785.9914	1785.9914	35.0000	0.00%	0.00%	250.0000	250.0000	250.0000	249.6861	Achieved
23+50.00	26+00.00	1803.8535	1781.7759	1781.7759	35.0000	0.00%	0.00%	250.0000	250.0000	250.0000	249.8995	Achieved

BEST PRACTICE: When using the *Sight Visibility* tool, set the Speed to 5-10 mph greater than the actual operating speed of the road. For failed sight-lines, compare the **Sight Distance Achieved** with the actual SSD of the road. This practice allows areas of marginal SSD to be identified.

Limitation – Only 1 Direction of Traffic is Analyzed per Use of the Tool: This tool can analyze sight lines either forwards or backwards along the alignment. However, it CANNOT analyze both directions at the same time.

To analyze sight lines **forwards** along the alignment, the start station must be less than the end station.

To analyze sight lines **backwards** along the alignment, set the start station to a value grater than the end station.



TIP: When analyzing **backwards** along the alignment, set the start station to a round station (i.e., 12+50). In the resulting report, the station intervals will be set to round values (i.e., 12+50, 12+00, 11+50, etc…).

WARNING: If the start station is set to an irregular station (i.e., 12+56.23), then then resulting report will list station intervals relative to the start station (i.e., 12+56.26, 12+06.56, 11+56.26, etc…).

21G.2 Sight Visibility – Workflow

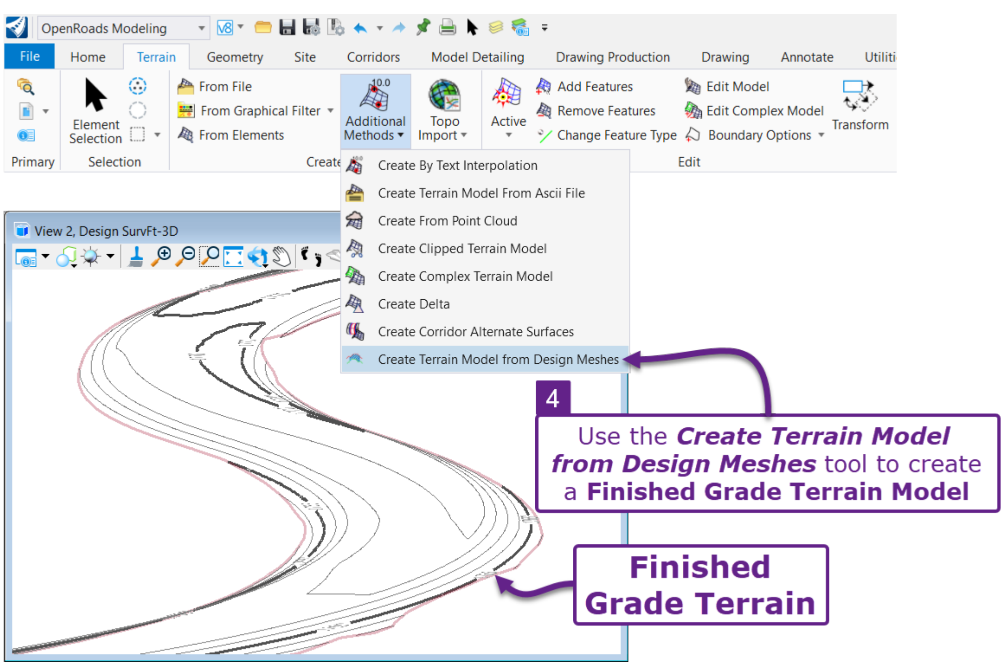
In this workflow, the *Sight Visibility* tool is used to generate sight lines and a results report.

When using this tool either the Alignment or Corridor can be selected (which is shown in step 26). If the Alignment is selected, then a **Design Surface** (i.e., the Proposed Finished Grade Terrain Model) must also be selected. The Design Surface is used to calculate the Eye Level and Object Level and analyze for obstructions due to grade change. Creating a Finished Grade Terrain Model from a Corridor is shown in *22A.1 Create Terrain Model from Design Meshes tool*.

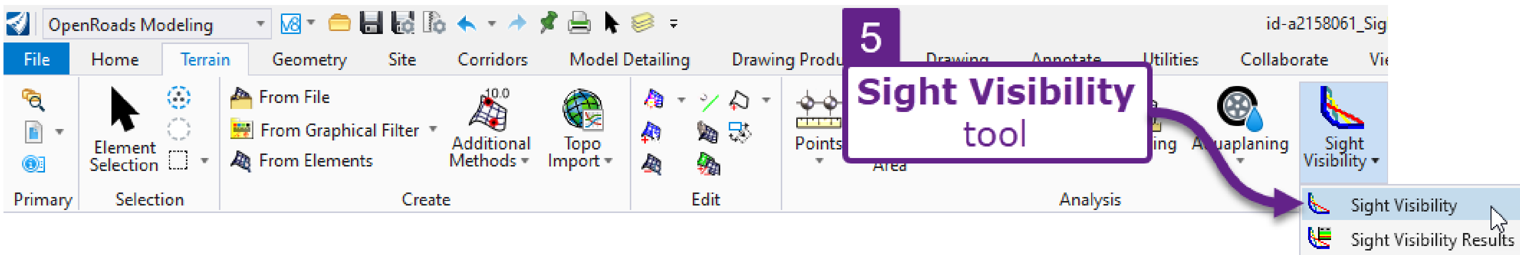
Selecting the Corridor vs Alignment/Design Surface: If the Corridor is selected, then only the top surface of the Corridor is analyzed for sight line obstructions. If an Alignment/Design Surface is selected, then a Design Surface can be created using a combination of Corridors, Linear Templates, and Surface Templates. All Corridors, Linear Templates, and Surface Templates included in the Design Surface are analyzed for sight line obstructions.

NOTE: As stated above, either the Corridor or the Alignment/Design Surface can be selected. Regardless of the selection, the Existing Ground Terrain Model can also be selected. In areas beyond the Corridor or Alignment/Design Surface, the Existing Ground Terrain Model is analyzed for sight line obstructions.

1	Create a new ORD File using a 2D Seed File. See *3B – Create a New ORD File*. ***TIP:*** Set the Coordinate System for the new ORD File. The Coordinate System must be set to use the *Background Map* tool.
2	In the new ORD File, reference in the Survey ORD File, Alignment ORD File, and Corridor ORD File, and any other pertinent Design ORD Files.
3	*Activate* the Existing Ground Terrain Model.
4	OPTIONAL: If an Alignment/Design Surface is to be selected in step 26, then create a Finished Grade Terrain Model use the *Create Terrain Model From Design Meshes* tool. Selecting the Alignment/Design Surface is useful when a Design Surface has been created that is comprised of multiple Corridors, Linear Templates, and/or Surface Templates. All features used to create the Design Surface is analyzed.

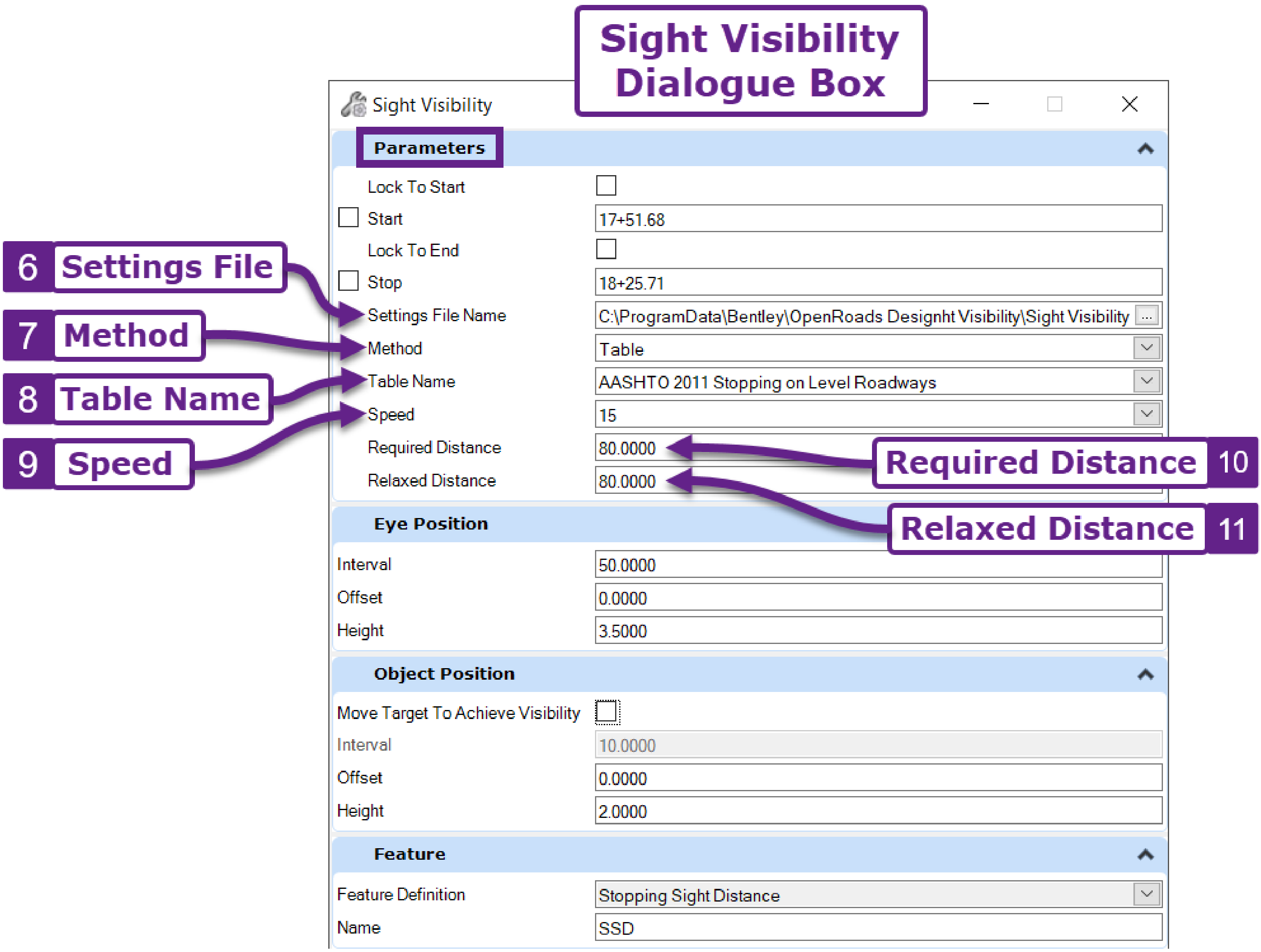


5	From the Ribbon, select the *Sight Visibility* tool: [***OpenRoads Modeling*** → ***Terrain*** → ***Analysis***].



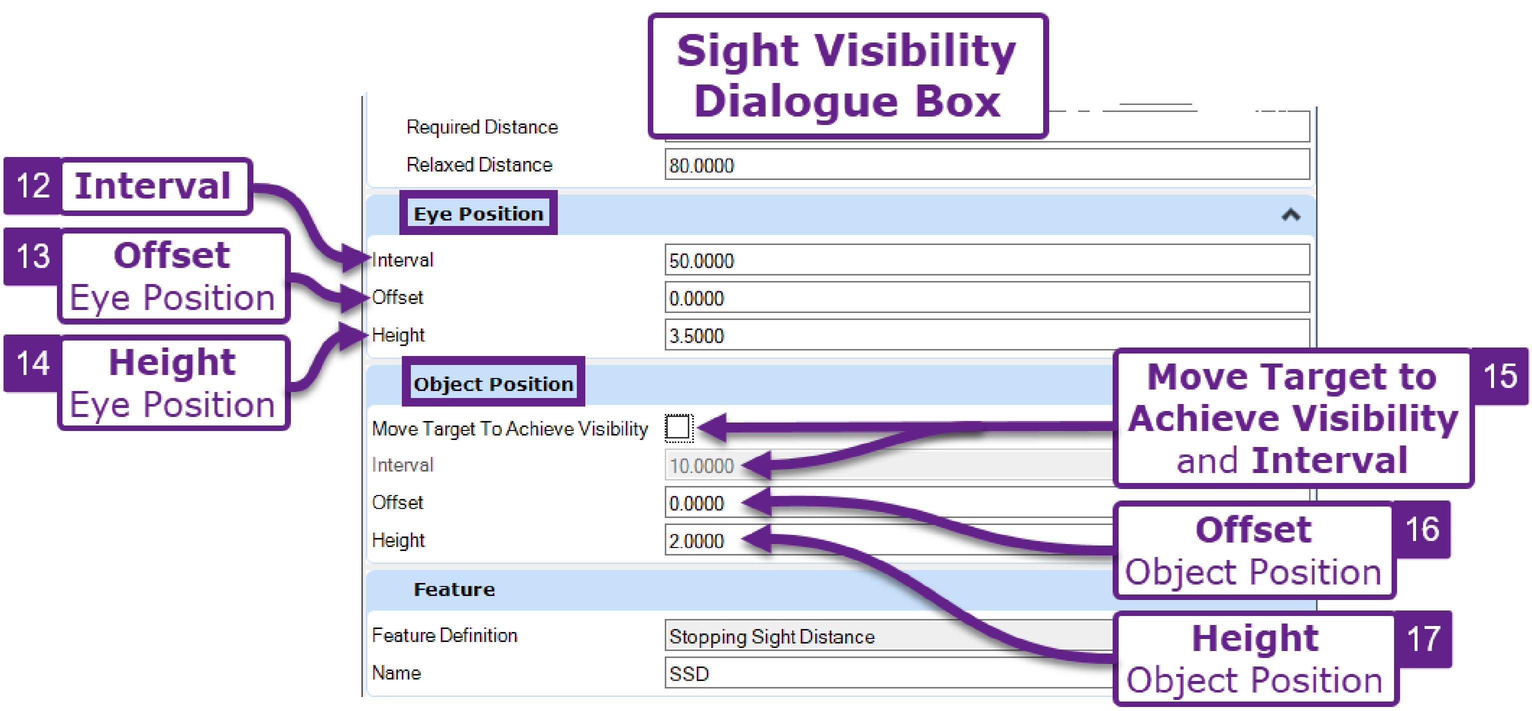
This tool requires the User to follow *Prompts* (shown around the mouse cursor) and configure the *Dialogue Box* for correct operation.

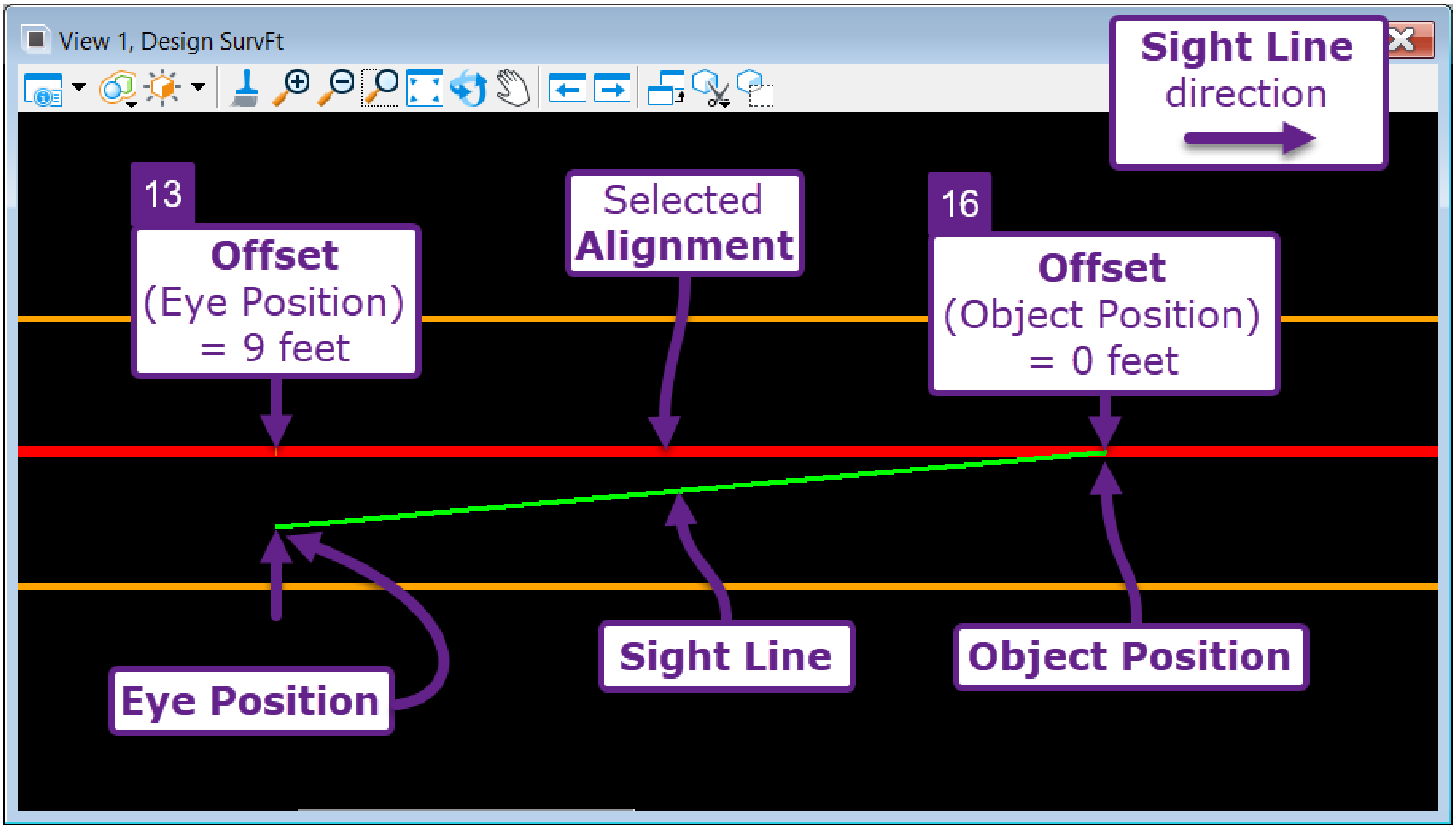
Dialogue Box Configuration: Steps 6-11 explain how to configure the **Parameters** options in the *Dialogue Box*.



6	**Settings File Name:** The Settings File is a configuration file that contains AASHTO SSD and PSD tables. Press the … button to select the Settings File. This file is located in the FLH WorkSpace in following location: …\OpenRoads Designer CE 10.10\Configuration\Organization-Civil\FLH_Stds-WS10.10.21.00V\Sight Visibility
7	**Method:** To use the *Settings File* (selected in step 6), then select the **Table** method. ***NOTE:*** All other Method options require a *Speed Table* to be set for the Alignment.
8	**Table Name**: The Table Name determines whether **Stopping Sight Distance (SSD)** or **Passing Sight Distance (PSD)** is analyzed. **AASHTO 2018 Stopping on Level Roadways –** Uses Greenbook Table 3-1 to determine Stopping Sight Distance (SSD) **AASHTO 2018 Passing –** Uses Greenbook Table 3-5 to determine Passing Sight Distance (PSD).
9	**Speed:** Select the design speed (in MPH). ***BEST PRACTICE:*** Set the speed 5-10 MPH above the project design speed, which allows for analyzation of SSD/PSD in marginal areas. For more information, see **Limitation – Maximum Sight Distance is NOT Calculated** in *21G.1 Capabilities and limitation of the Sight Visibility tool*.
10	**Required Distance:** The Required Distance sets the SSD or PSD for sight line analysis. By default, this value is automatically set by the **Table Name** (step 8) and **Speed** (step 9). Changing this value results in an overridden SSD or PSD.
11	**Relaxed Distance:** The Relaxed Distance parameter is NOT used in AASHTO SSD and PSD analysis. However, ensure this value matches the Required Distance (Step 10).

Steps 12-17 explain how to configure the **Eye Position** and **Object Position** options in the *Dialogue Box:*

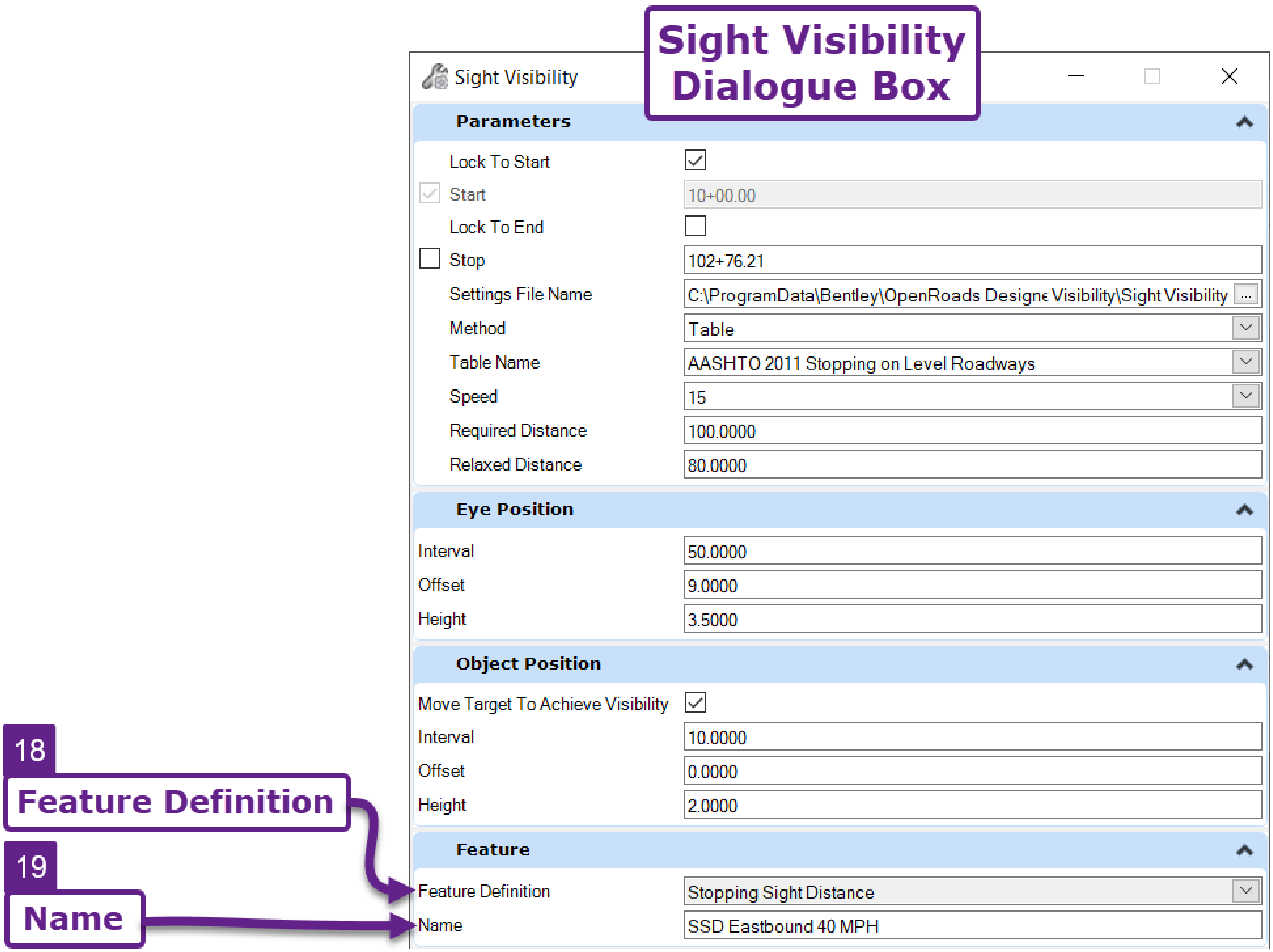




12	**Interval:** Determines the station interval between each sight line to be created. If set to 50', a sight line is created and analyzed every 50'.
13	**Offset (Eye Position):** Represents the horizontal offset distance between the Eye Position and the Alignment. If the Offset is 0.0000, then the Eye Position is placed directly on the Alignment. If set to +9.0000, then the offset is placed 9 feet to the right of the alignment.
14	**Height (Eye Position):** This value represents the height distance from road surface to the Eye Position. ***IMPORTANT:*** By default, this value is automatically set by the **Table Name** (step 8).
15	**Move Target to Achieve Visibility:** This option only applies to failed (obstructed) sight lines. If this box is CHECKED, then the failed sight line is further analyzed. The failed sight line is drawn to show the Maximum Sight Distance at the Eye Position station. The Maximum Sight Distance is shown in the **Sight Distance Achieved** column of the Sight Visibility Results Table. If this box is UNCHECKED, then the failed sight line is drawn from the Eye Position to where the Object Position would be located if SSD was achieved. At the point location where the sight line is obstructed, the red-colored (failed) sight line changes to white. **Interval:** This option is ONLY relevant when the Move Target to Achieve Visibility box is CHECKED. When a Sight Line is obstructed, the Object Position is incrementally moved backwards from the theoretical SSD location until a maximum Sight Distance is achieved. The Interval value determines the incremental distance the Object is moved back until a sight line is achieved.
16	**Offset (Object Position):** Represents the horizontal offset distance between the Object Position and the Alignment.
17	**Height (Object Position):** This value represents the height distance from road surface to the Object Position. ***IMPORTANT:*** This value is automatically set by the **Table Name** (step 8).

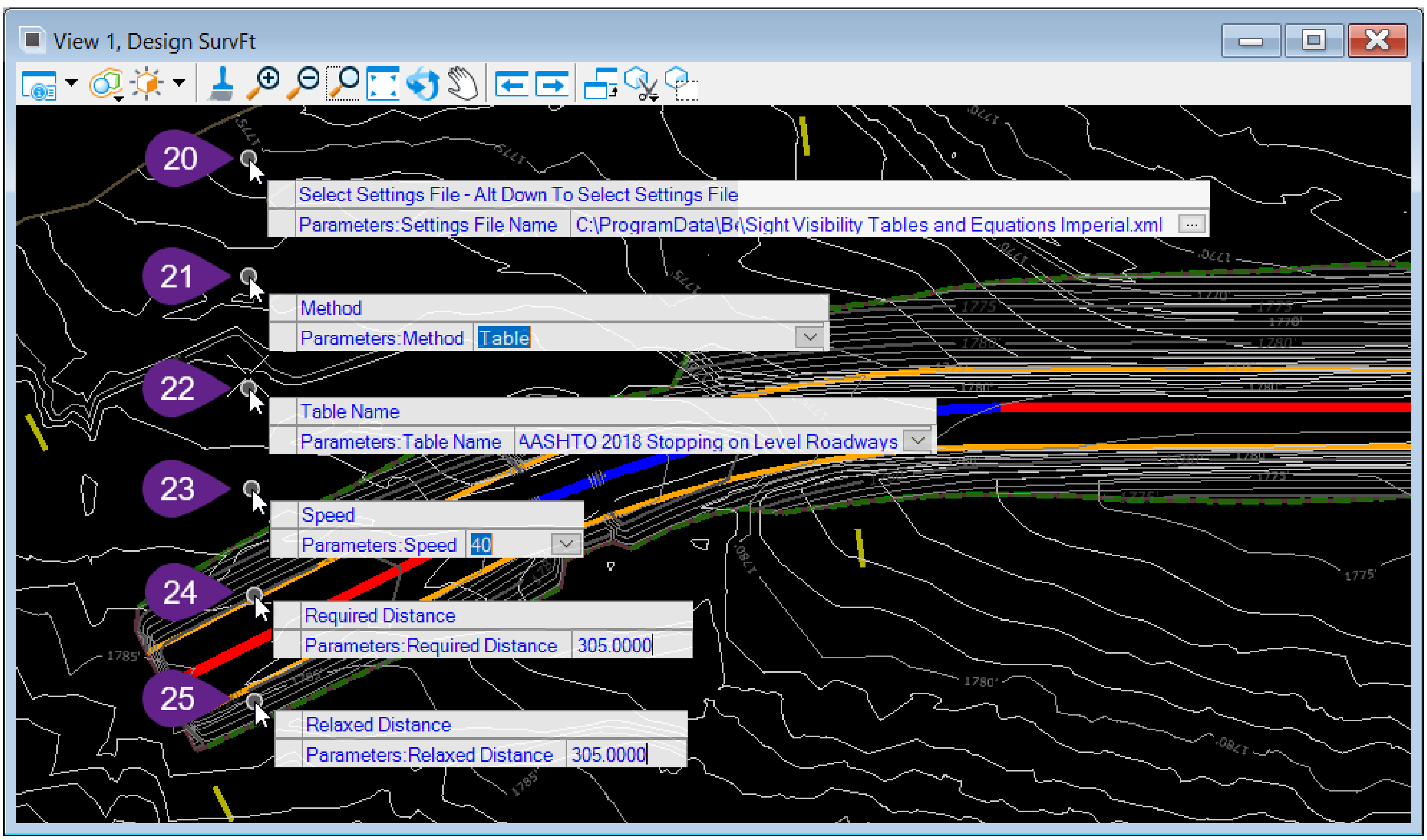
In step 18 - 19, the Feature Definition and Name for the *Sight Visibility* analysis run is assigned in the *Dialogue Box*.

18	Select a **Feature Definition** based on the type of analysis. The available options are **Stopping Sight Distance**, **Passing Sight Distance**, and **Overtaking Sight Distance**. ***NOTE:*** The Feature Definition does NOT affect the analysis or calculations made by the software. The Feature Definition is simply used to organize different runs of the *Sight Visibility* tool in the Explorer.
19	Assign the *Sight Visibility* run a descriptive **Name**. For example: "SSD Eastbound 40 MPH".

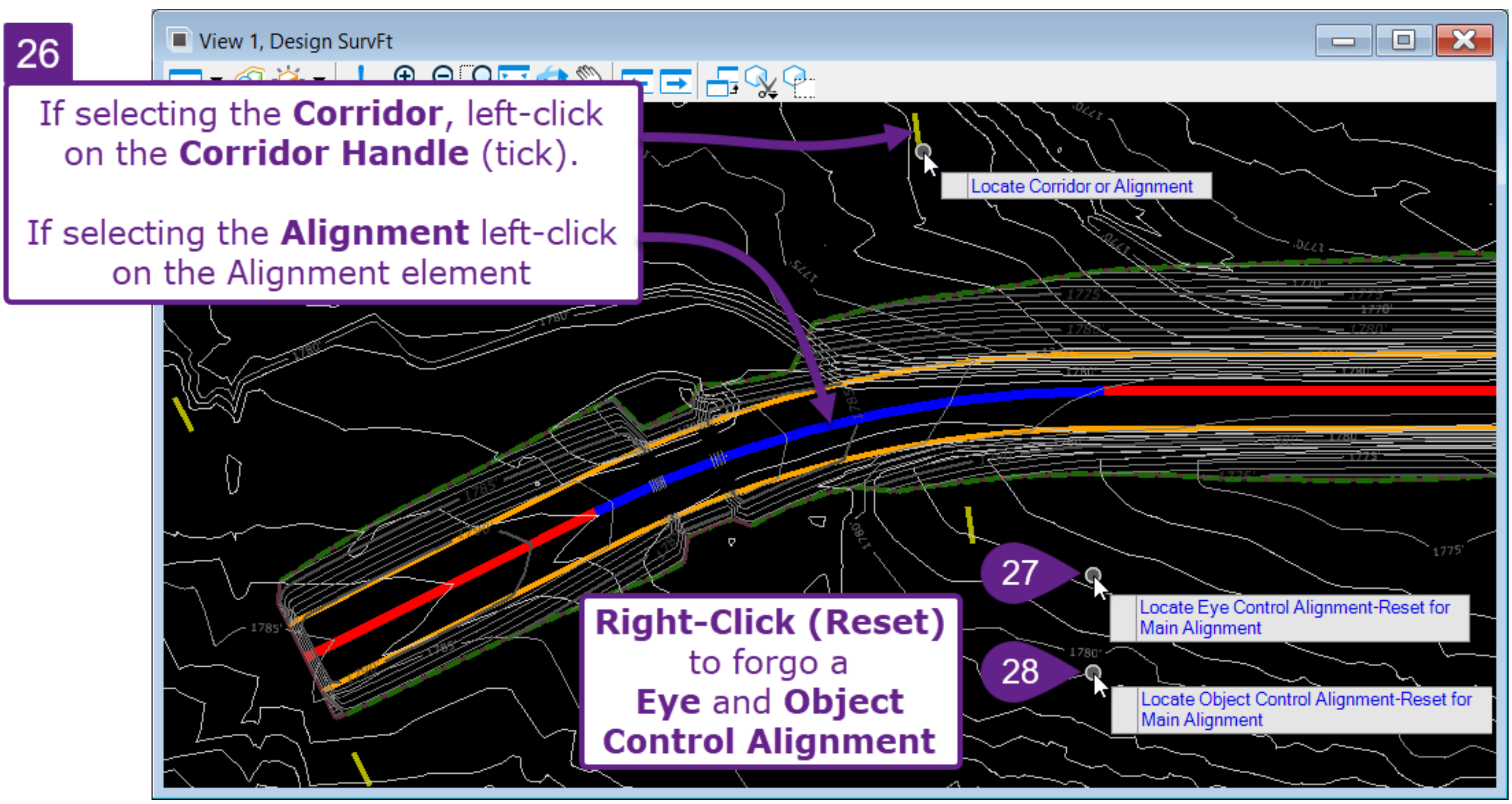


The remainder of the steps in this procedure follow the *Floating Prompts*. ***NOTE:*** Steps 20-25 correspond with steps 6-11, which where set in the *Dialogue Box*. The parameters and values set in the *Dialogue Box* will display in the *Floating Prompt* box.

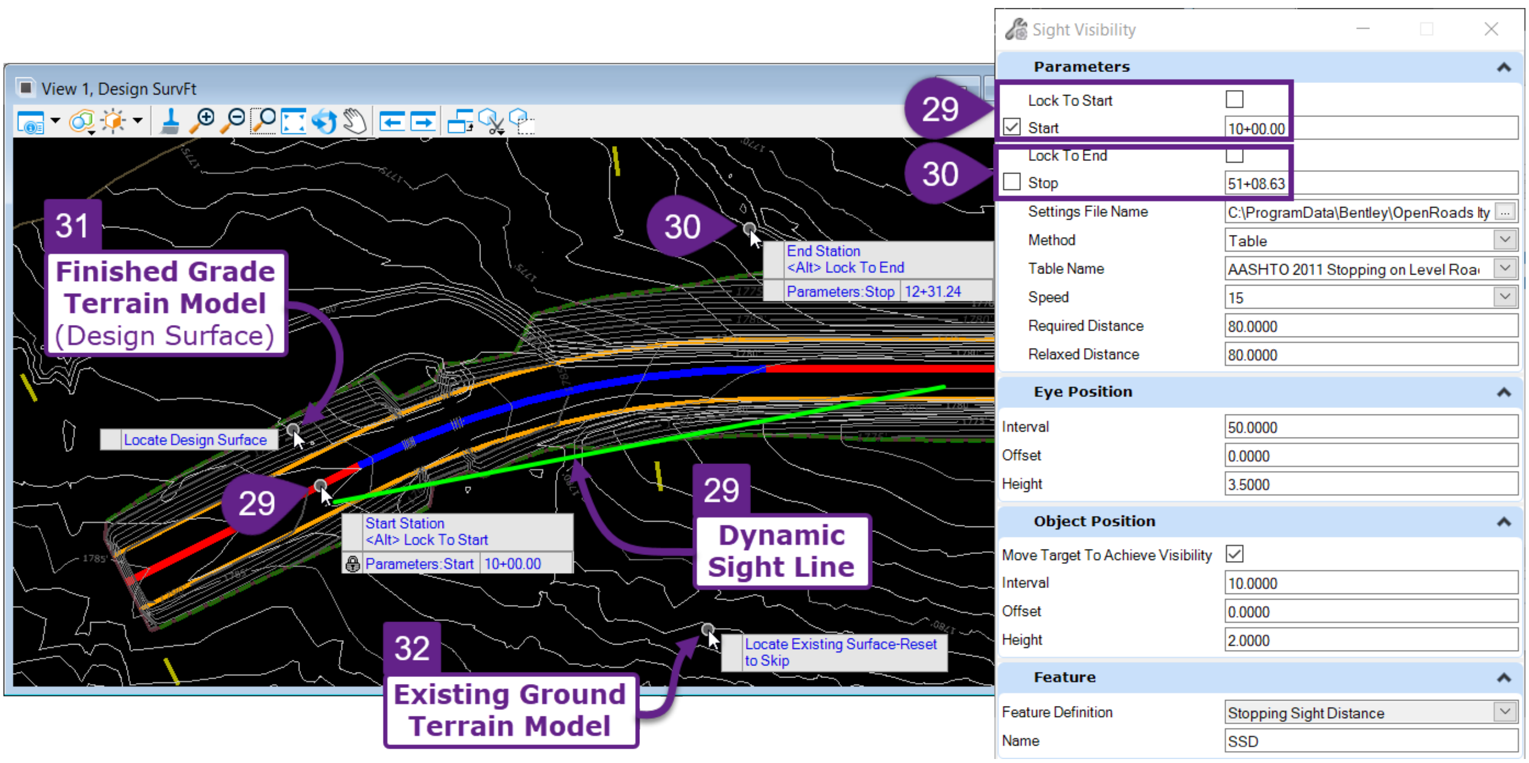
20	*Prompt: Select Settings File* – The **Setting File** was set in step 6 through the *Dialogue Box*. Confirm the correct settings file is shown and left-click anywhere in the *View* window to advance to the next step.
21	*Prompt: Method* – The **Method** was set in step 7 through the *Dialogue Box*. Left-Click anywhere in the *View* window to advance to the next step.
22	*Prompt: Table Name* – The **Table Name** was set in step 8 through the *Dialogue Box*. Left-Click anywhere in the *View* window to advance to the next step.
23	*Prompt: Speed* – The **Speed** was set in step 9 through the *Dialogue Box*. Left-Click anywhere in the *View* window to advance to the next step.
24	*Prompt: Required Distance* – The **Required Distance** (SSD or PSD) was set in step 10 through the *Dialogue Box*. Left-Click anywhere in the *View* window to advance to the next step.
25	*Prompt: Relaxed Distance* – The **Relaxed Distance** was set in step 11 through the *Dialogue Box*. Left-Click anywhere in the *View* window to advance to the next step.



26	*Prompt: Locate Corridor or Alignment* – Left-Click on either the Corridor Handle (tick) or the Alignment. If the **Alignment** is selected, then a **Design Surface** must be selected in step 31. The Design Surface is analyzed for sight line obstructions. If the **Corridor** is selected, then the original Corridor Alignment is used for stationing and the top surface of the Corridor is analyzed for sight line obstructions. Step 31 is NOT shown when the Corridor is selected.
27	*Prompt: Locate Eye Control Alignment – Reset for Main Alignment* – Optionally, a custom Alignment can be used to control the horizontal position of the Eye. If an Eye Control Alignment is used, then main Alignment is ONLY used for stationing purposes. ***TIP:*** An Eye Control Alignment is NOT necessary if an **Eye Position Offset** is specified in Step 13. Right-Click (reset) to forgo an Eye Control Alignment and use the main Alignment to control the Eye Position.
28	*Prompt: Locate Object Control Alignment – Reset for Main Alignment* – Optionally, a custom Alignment can be used to control the horizontal position of the Object. However, the Object Control Alignment is NOT necessary if an **Object Position Offset** is specified in Step 16. Right-Click (reset) to forgo an Object Control Alignment and use the main Alignment to control the Object Position.



29	*Prompt: Start Station <ALT> Lock to Start* – Select a Start Station with the mouse-cursor or enter a value into the *Dialogue Box*. ***TIP:*** If the start station is set to an irregular station (i.e., 12+56.23), then then resulting report will list station intervals relative to the start station (i.e., 12+56.26, 12+06.56, 11+56.26, etc…). ***TIP:*** Hover the mouse cursor along the length of the Alignment to show a dynamic sight line. Look for area where the dynamic sight line crosses vertical obstructions linework (i.e., tree line, buildings, right-of-way lines).
30	*Prompt: End Station <ALT> Lock to End* – Select an End Station with the mouse-cursor or enter a value into the *Dialogue Box*.
31	*Prompt: Locate Design Surface* – Select the Finished Grade Terrain Model. ***NOTE:*** This step is ONLY shown if the Alignment was selected in step 26.
32	*Prompt: Locate Existing Surface – Reset to Skip* – Select the Existing Ground Terrain Model. The Existing Ground Terrain Model is analyzed for sight line obstructions in areas that extend past the Finished Grade Terrain Model/Corridor.

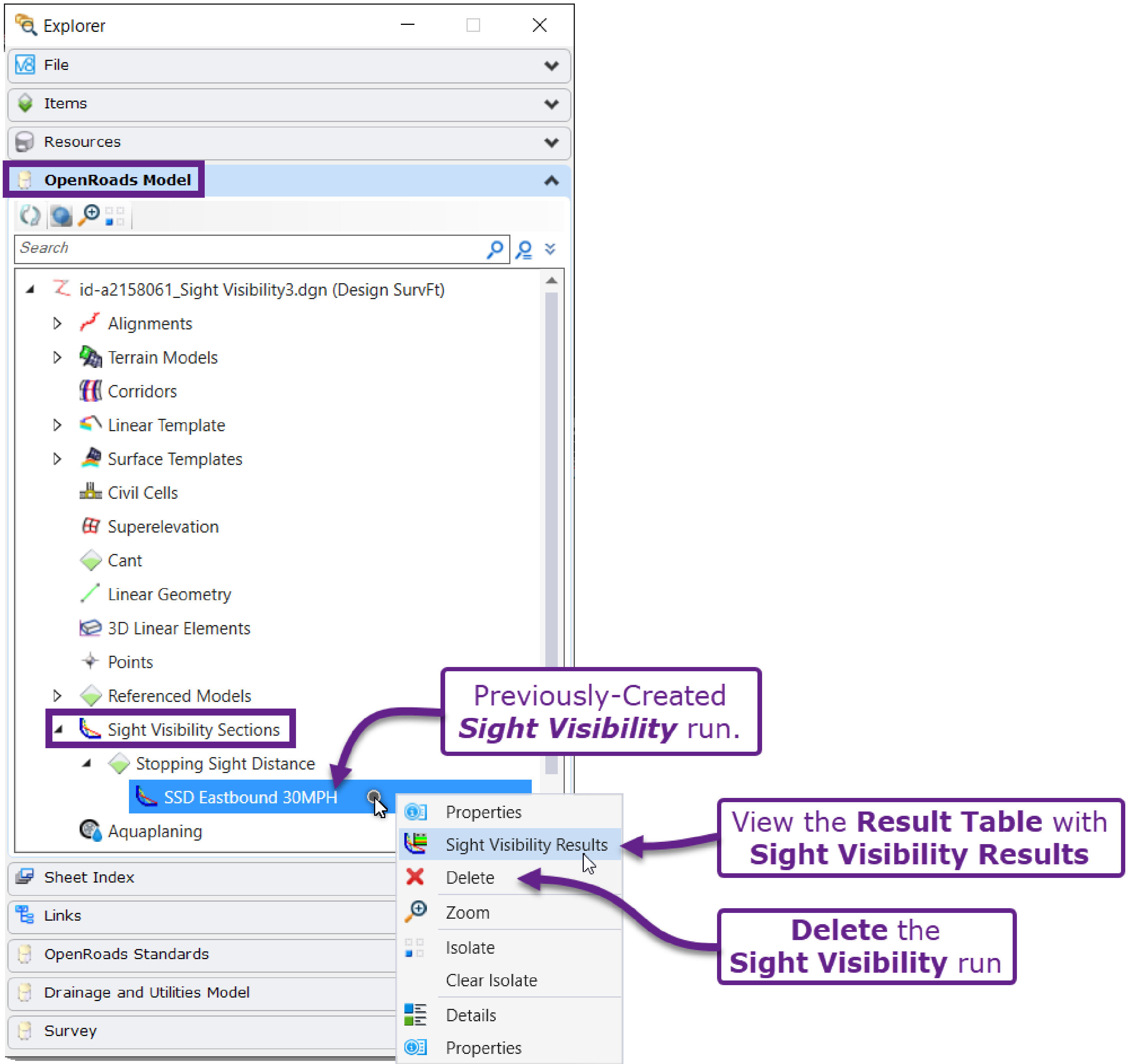


33	*Prompt: Data Point to Accept Design* – Left-Click in the *View* window to place the sight line graphics and view the results table.

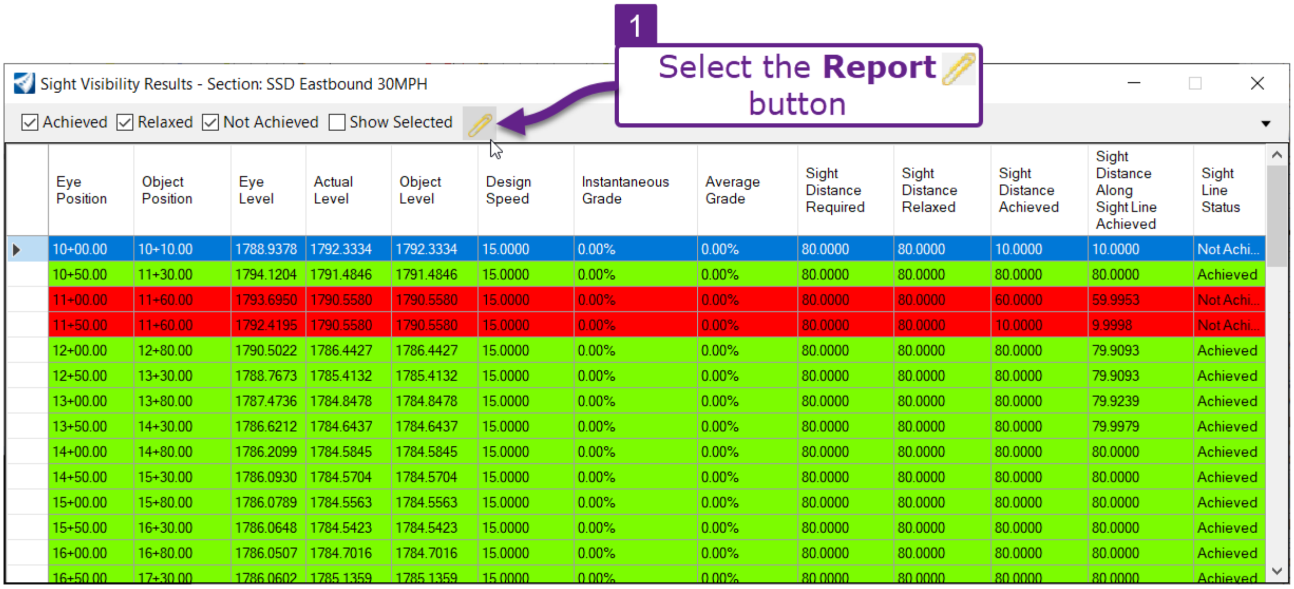
TIP: There are two methods for deleting a previously-created run of the *Sight Visibility* tool:

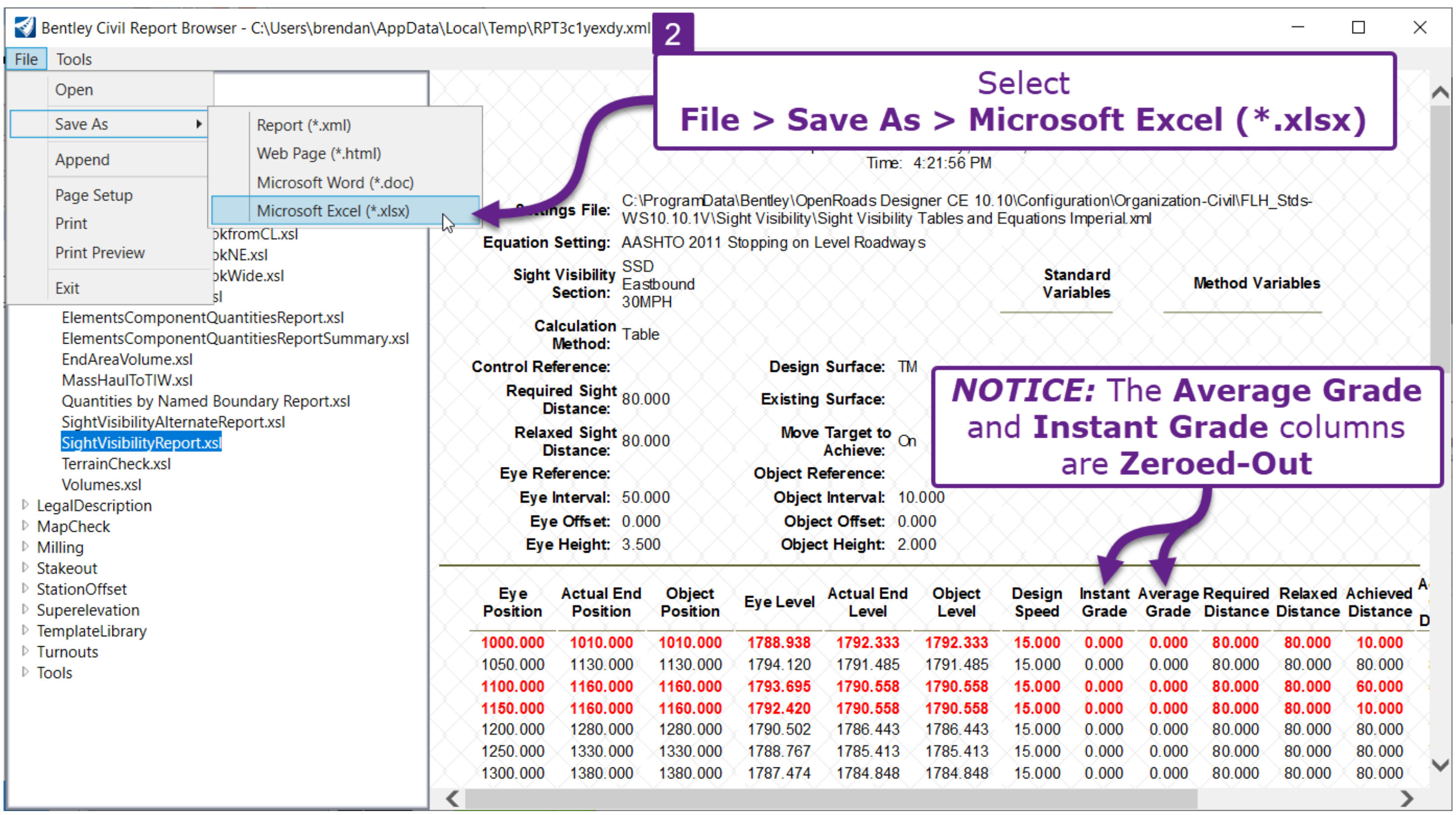
- Select the sight line elements from the ***3D Design Model*** and delete it. ***NOTE:*** Sight-lines CANNOT be deleted by selecting the sight lines in the *2D Design Model*.
- Locate the *Sight Visibility* run in the Explorer. Previously-created *Sight Visibility* runs are located under the **OpenRoads Model** drop-down and in the **Sight Visibility Sections** drop-down.

TIP: Retrieve a Sight Visibility Results Table for a previously-created run from the Explorer: Right-Click on the run and select the *Sight Visibility Results* option.



TIP: Export the Sight Visibility Results Table to Microsoft Excel:





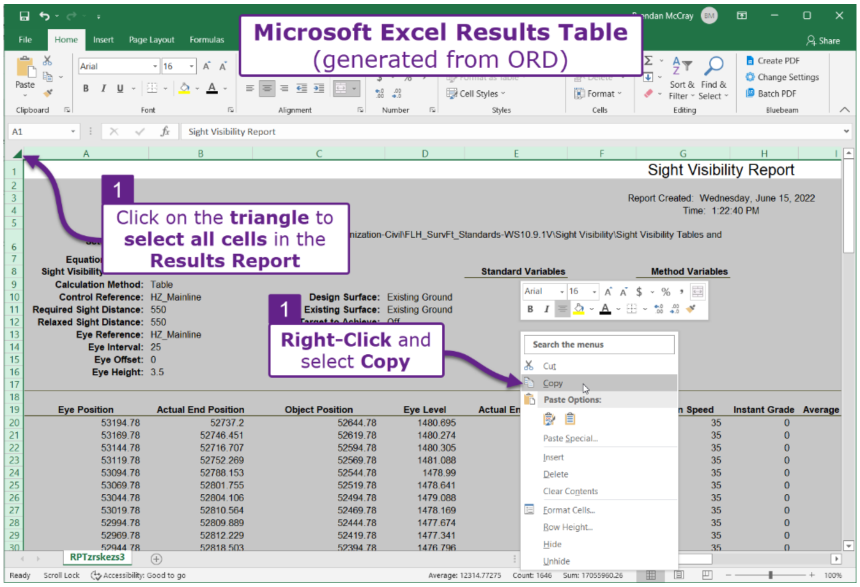
As shown in the graphic report above, the Average Grade and Instant Grade columns are zeroed out. To account for grade in the SSD/PSD calculations, the results table must be imported into the FLH spread sheet template, which is shown the next section.

21G.3 Import Results into the Microsoft Excel Template

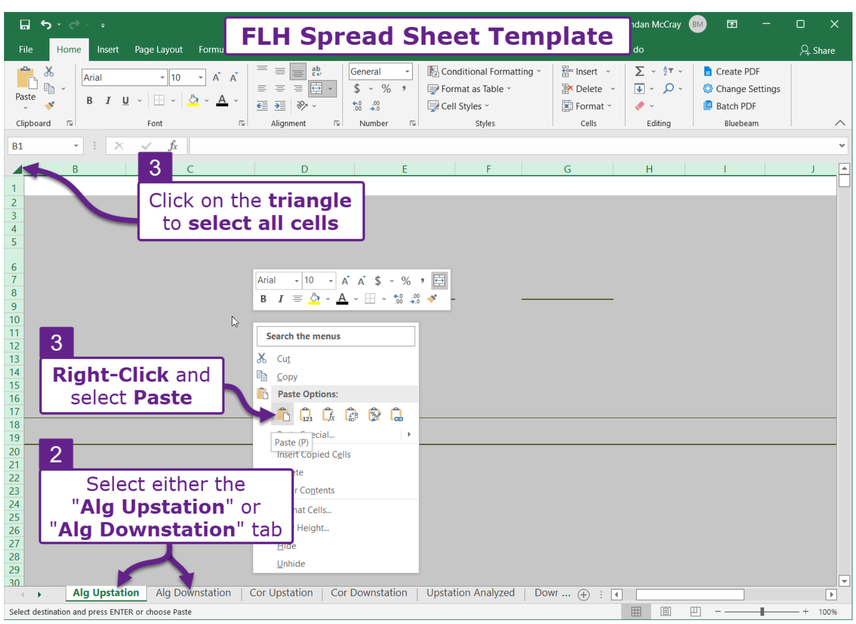
The resulting tables from the SSD or PSD analysis must be copied into FLH spreadsheet template to account for grade in the calculations and create a report. The FLH SSD and PSD spread sheet templates are located at:

https://highways.dot.gov/federal-lands/design/forms/sight-distance

NOTE: Generation of the Microsoft Excel results table from ORD is shown on the previous page. Both the ORD results and FLH template spread sheets must be opened for this procedure.

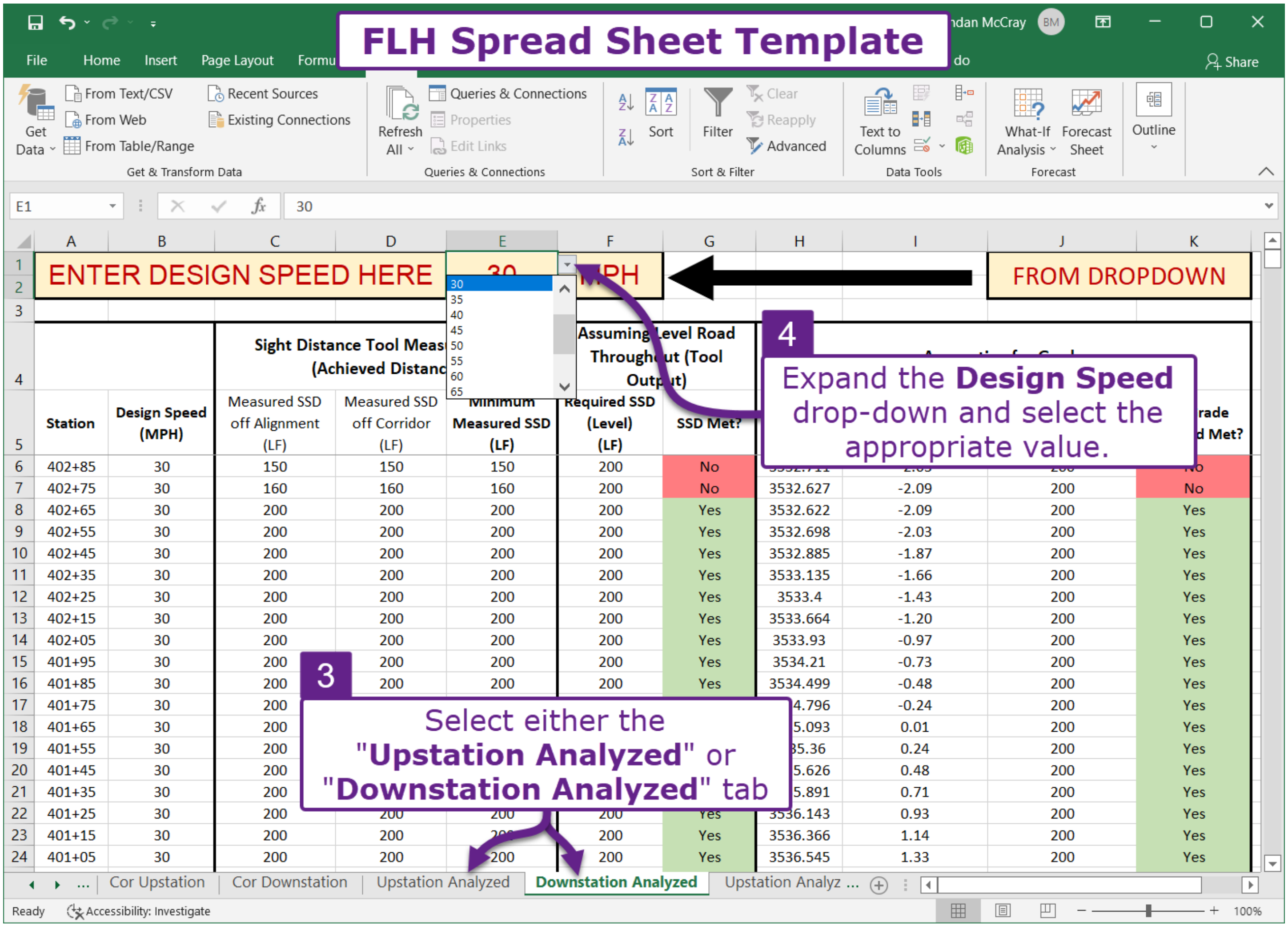


1	In the Microsoft Excel results table, select all cells by pushing the Triangle button located in the upper-left corner. Right-Click and select **Copy**.
2	In the FLH spread sheet template, select either the "Alg Upstation" or "Alg Downstation" tab. The selected tab depends on which direction along the alignment the Microsoft Excel Results table was generated from.
3	Select the Triangle button located in the upper-left corner. Right-Click and select **Paste**.

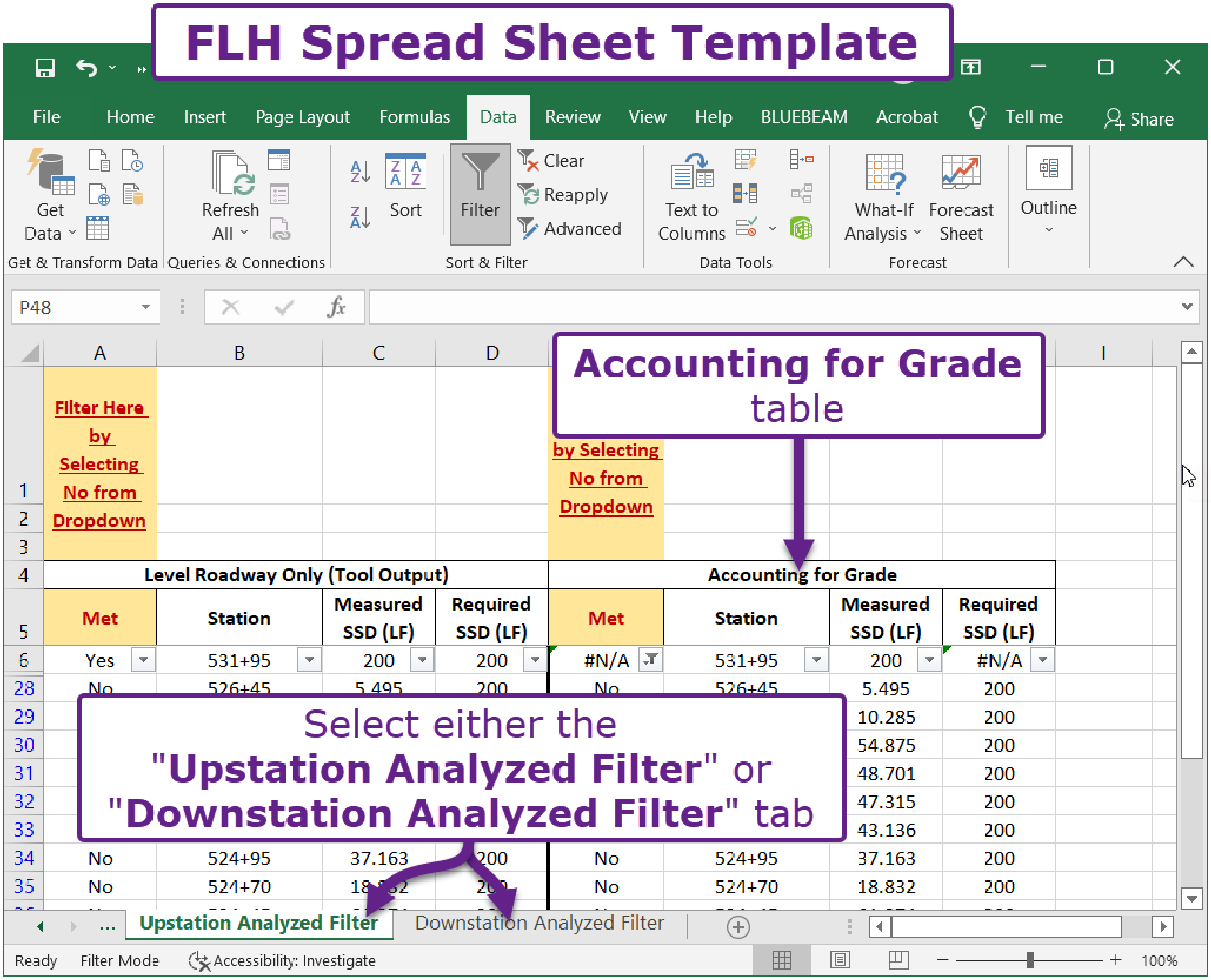


Repeat Steps 1-3 for the opposing direction along the alignment. Ensure that results generated from ORD are copied into both the "Alg Upstation" and "Alg Downstation" tabs.

4	In the FLH spread sheet template, select either the "Upstation Analyzed" or "Downstation Analyzed" tab
5	Expand the **Design Speed** drop-down located in cell E1. Select the appropriate design speed. Repeat steps 4-5 for the opposing direction along the alignment. Ensure the Design Speed has been selected in both the "Upstation Analyzed" and Downstation Analyzed" tabs.



After the design speed has been selected, select the "**Upstation Analyzed Filter**" and "**Downstation Analyzed Filter**" tabs to review the results. Results shown in the "Level Roadway Only (Tool Output)" table are generated directly from ORD. Results shown in the "Accounting for Grade" calculate the SSD with the effect of grade accounted for. These results use the ORD generated eye level and object level elevations to calculate an approximate average grade.

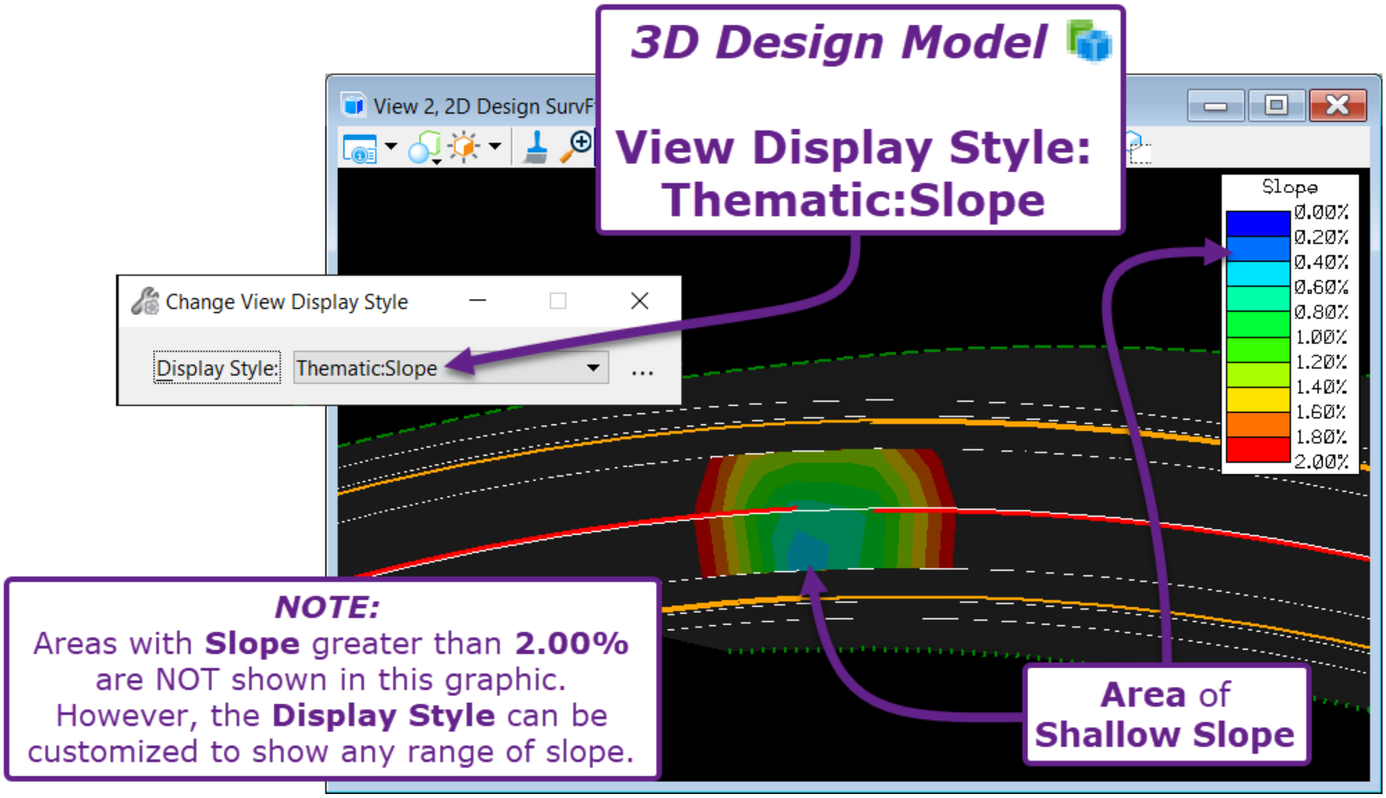


21H – USE THEMATIC DISPLAY STYLES TO ANALYZE SLOPES

Using the "Thematic:Slope" Display Style, slopes along a Corridor, Linear Template, Terrain Model can be analyzed. The "Thematic:Slope" Display Style can be used to locate flat pavement areas where a drainage/ponding issue may form or to review slopes along a model to ensure ADA/ABA compliance.

The "Thematic:Slope" Display Style color-grades the surface of the Corridor, Linear Template, or Terrain Model. A legend is shown in the upper-right corner of the *View* window that identifies the approximate slope of each colored area.

NOTE: Thematic Display Styles are ONLY available in the *3D Design Model*. This analysis must be performed from the *3D Design Model*.



The "Thematic: Slope" Display Style must be edited in the Display Style Editor for effective use. By default, this Display Style uses degree units in the legend and color grading. The Display Style should be edited to show percent units, instead of the default degree units.

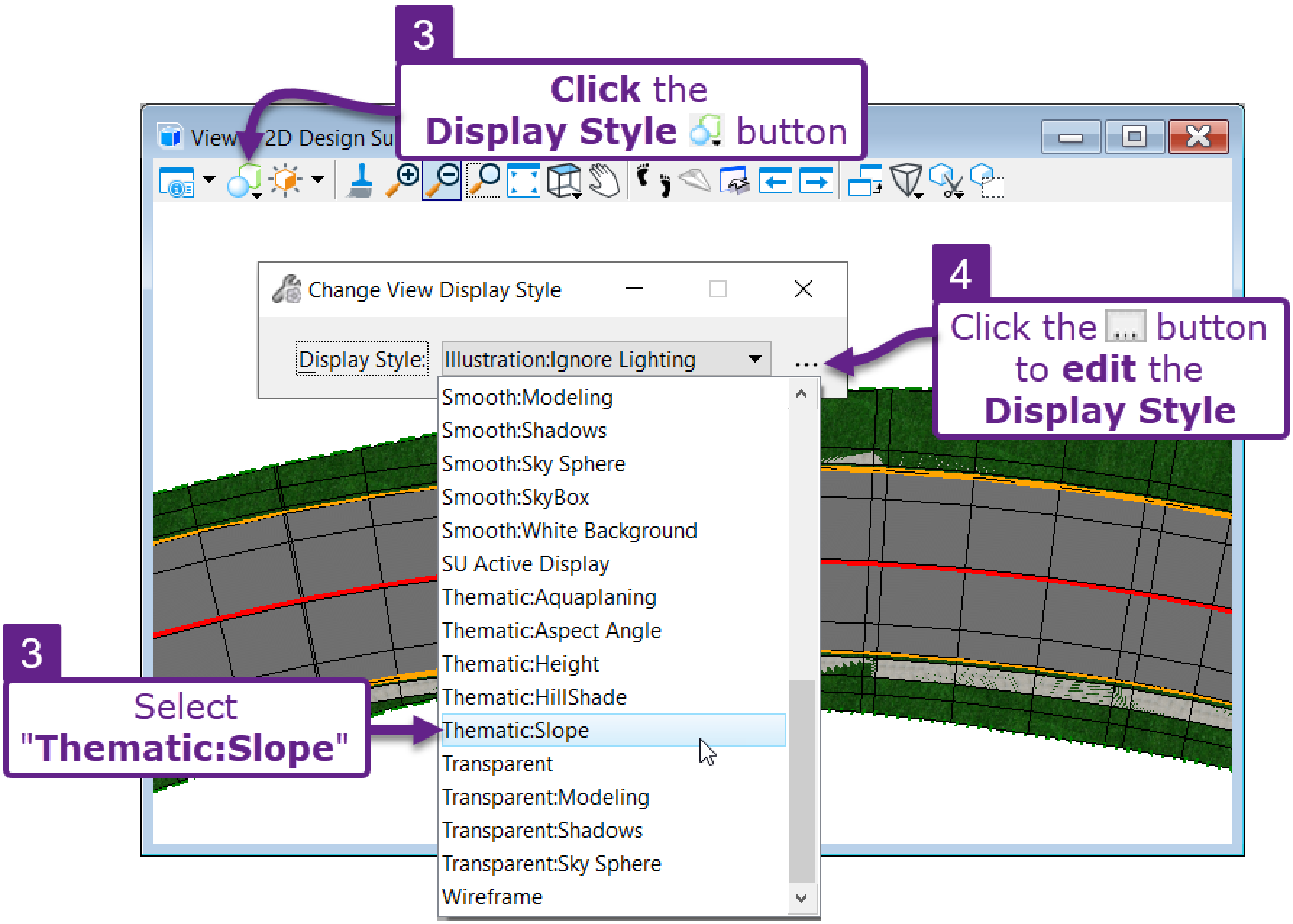
When editing the Display Style, a slope range should be specified. The default slope range (which is 0% to 100%) is too broad, which causes areas of shallow slope are displayed as completely flat. In the graphic above, the slope range is edited to ONLY show slopes from 0.00%-2.00%, which means slopes greater than 2.00% are NOT shown and color-graded.

Setting the range from 0.00%-2.00% is useful for locating areas where ponding or drainage may be an issue. The narrow slope range is necessary to depict small changes of slope in relatively flat areas. If the slope range was set from 0.00%-10.00%, then areas of slope between 0% and 1.9% are shown as completely flat (0.00%).

BEST PRACTICE: Set and adjust the slope range to isolate areas of interest. Engineering judgement may be required in setting the slope range for the particular analysis. A recommended slope range for identifying drainage and ponding issues is 0% - 2%. A recommended slope range for assessing ADA/ABA compliance is 2% - 10%.

Workflow for Setting and Editing the "Thematic:Slope" Display Style:

1	Open the Corridor ORD File. ***NOTE:*** A Corridor must have been previously-created for this analysis.
2	Open the *3D Design Model* .
3	Change the **View Display Style** to "Thematic:Slope". At the top of the *View* window, click the button open *Change View Display Style* box. Select the "Thematic:Slope" option in the drop-down.
4	As discussed on the previous page, the "Thematic:Slope" Display Style needs to be customized to show the slope in percent units in the legend and narrow down the slope range. In the *Change View Display Style* box, push the button to open the Display Style Editor box.



5	In the Display Style Editor box, select (highlight) the "Thematic:Slope" style.
6	Push the **Thematic Display**  drop-down button.
7	Set the **Display Mode** to **Percent**.
8	Set the **Stepped Display** to **Accurate**. ***NOTE:*** If the default option "Off (Smooth)" is used, then fine details in the grading are smoothed over and not depicted.
9	Set the **Slope Range** as appropriate for the analysis. Setting the Slope Range too broad is problematic because small changes in slope may NOT be depicted in the color grading. Slopes outside of the set range will NOT be shown as color-graded. ***BEST PRACTICE:*** For analyzing flat areas for ponding or drainage issues, it is recommended that the Slope Range is set from 0.00% to 2.00%. To analyze areas for ADA/ABA compliance, it is recommended that the slope range is set from 2% to 10%. In all cases, engineering judgment is necessary for setting a slope range that isolates the areas of interest.