Regression Tools for Surveyed Centerline

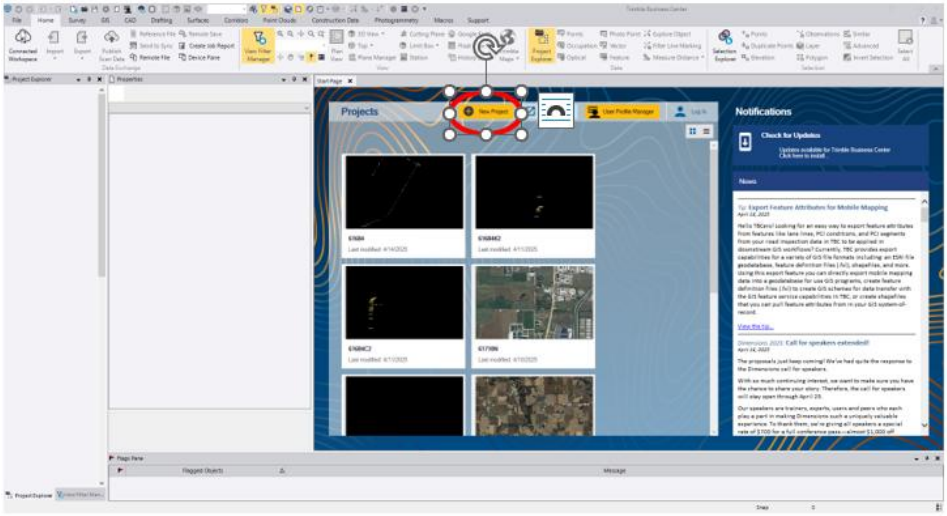
Description

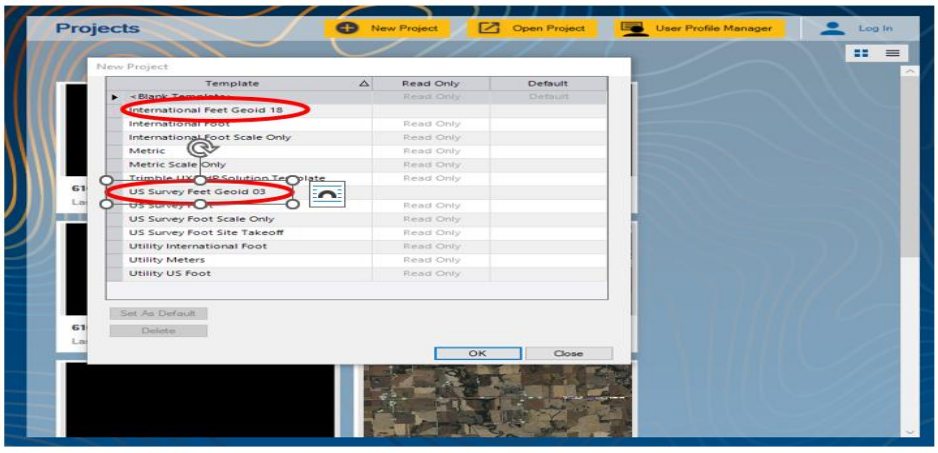
This document will walk users through the process of using the OpenRoads Designer (ORD) 2024 Regression Tools to create and refine horizontal alignments based on surveyed points. Use the below link to view a video demonstration of these Instructions.
https://www.youtube.com/watch?v=hAyZHclgJfc

Export Survey Points

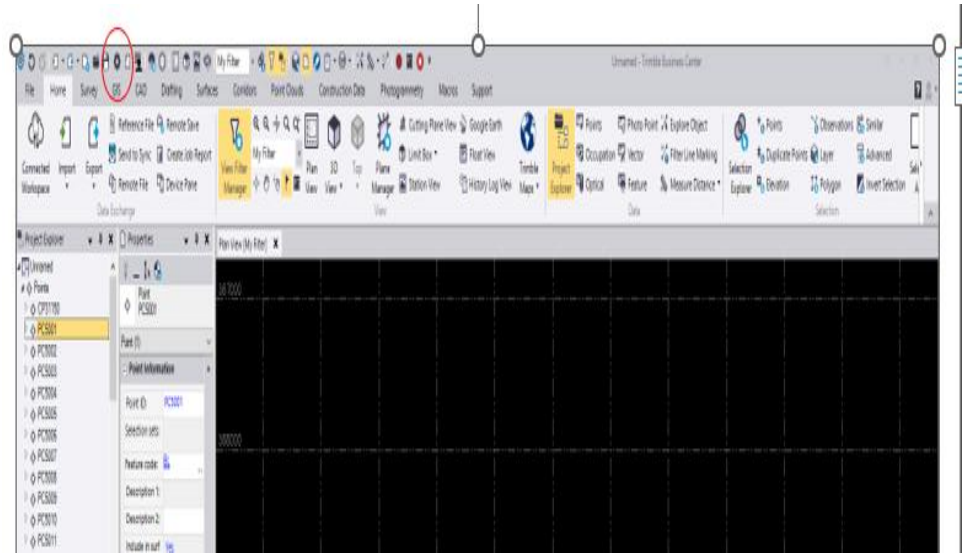
Note: This section walks you through importing ECCs points from collector into Trimble Business Center (TBC) and exporting to CSV file.

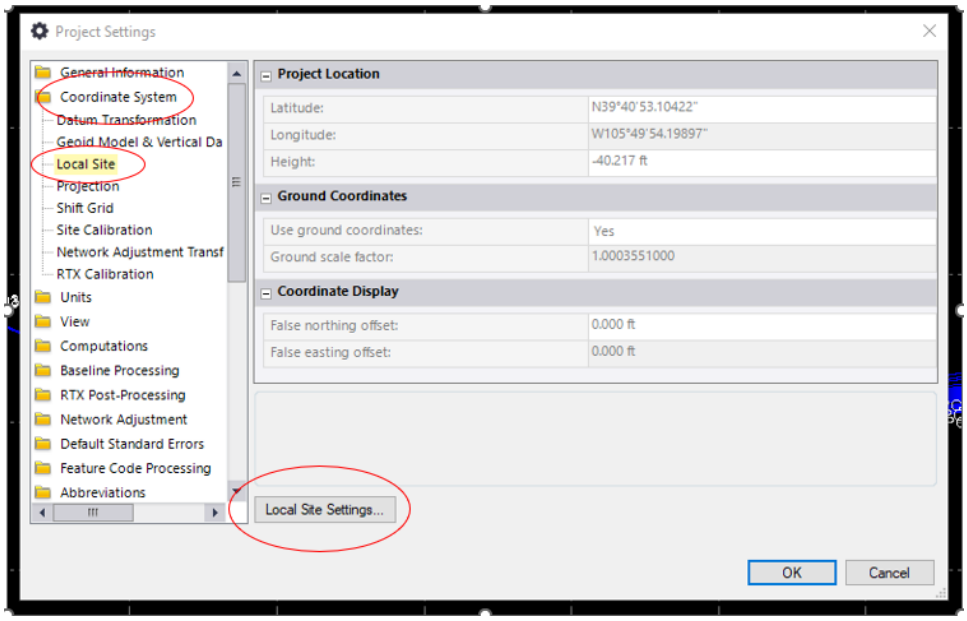
1. Open TBC > New Project > Select correct Template (International Feet Geoid 18 or US Survey Feet Geoid 03)



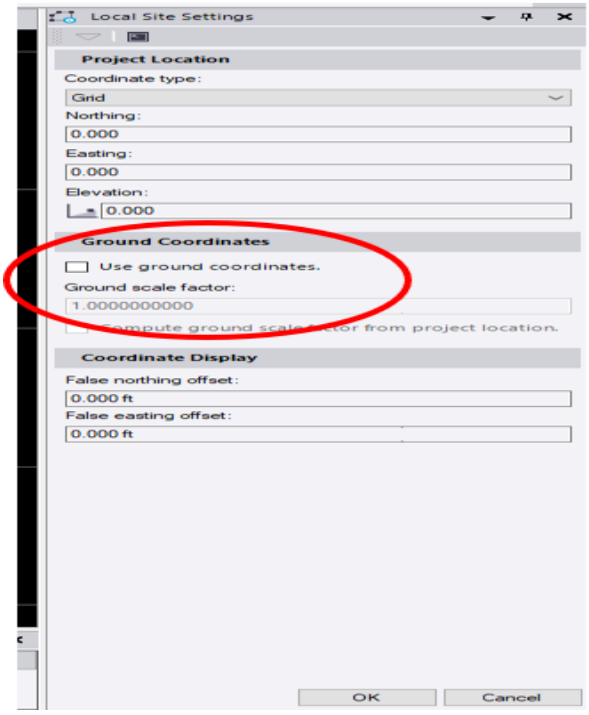


2. Project Settings > Coordinate System > Local Site > Local Site Settings

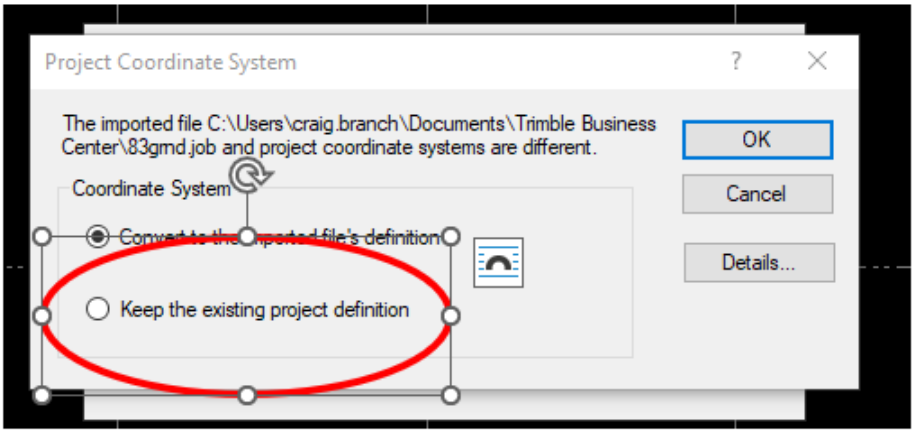




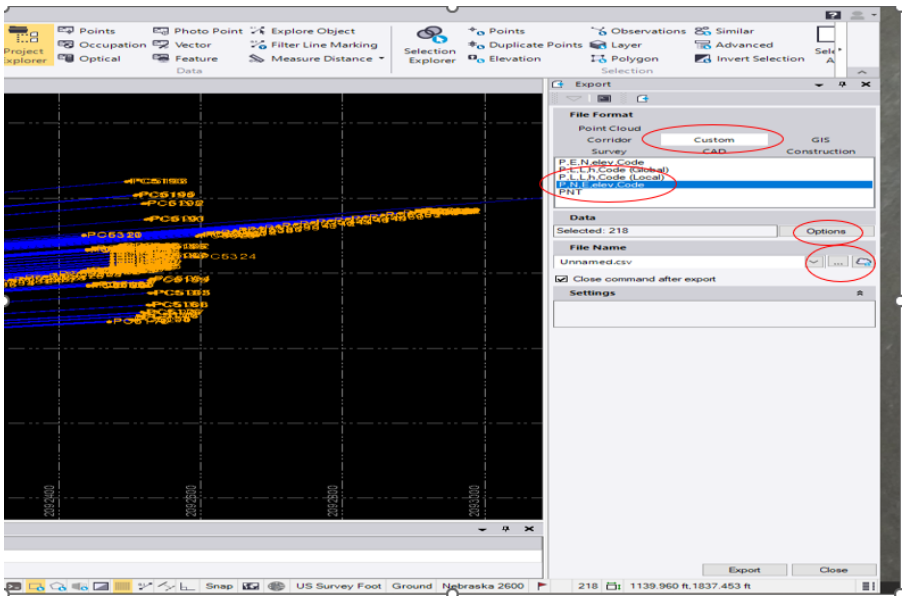
3. Local Site Settings > Ground Coordinates > Check box for Use ground coordinates > Ground scale factor > Input project specific DAF > Select OK at the bottom



4. Drag and drop ECCs JOB file into Plan View window > Keep the existing project definition.



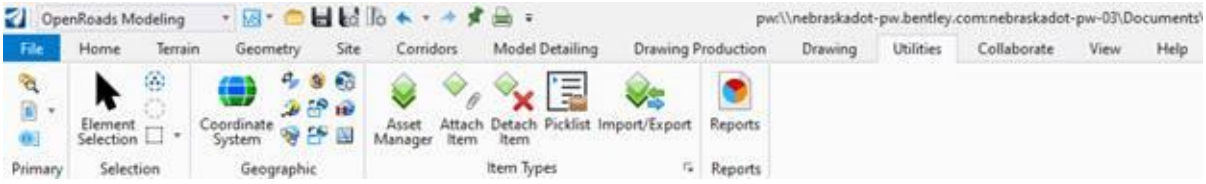
5. Select Export > Custom Tab > select P, N, E, elev, Code
6. Under Data > Options > Select All
7. File Name > Select ... > Name file and Map location
8. Select Export



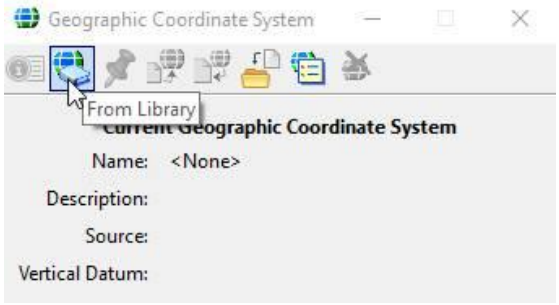
Import Survey Points

Note: This section walks you through importing points from CSV file to a 2D DGN file.

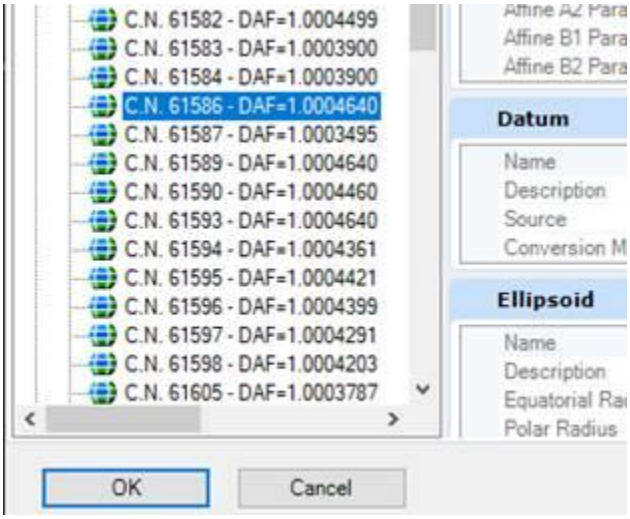
1. Copy and Paste the NDOT_2D_Seed_Int_Ft.dgn file onto your C drive. Rename the file "[CN] Surveyed Centerline.dgn" and open the file.
2. Open the "OpenRoads Modeling" Workflow. In the Utilities tab, select "Coordinate System".



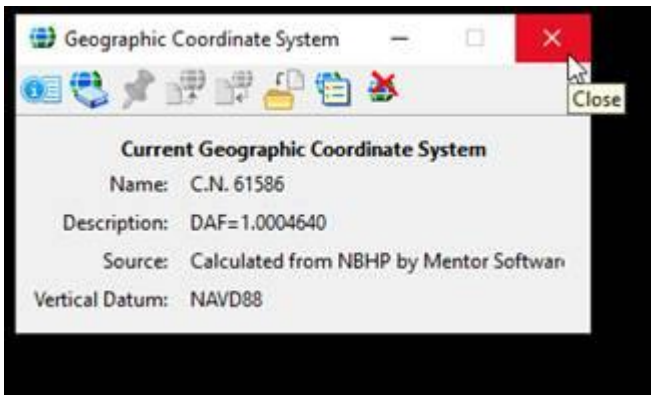
3. In the Coordinate System window, click "From Library". (second icon from the left)



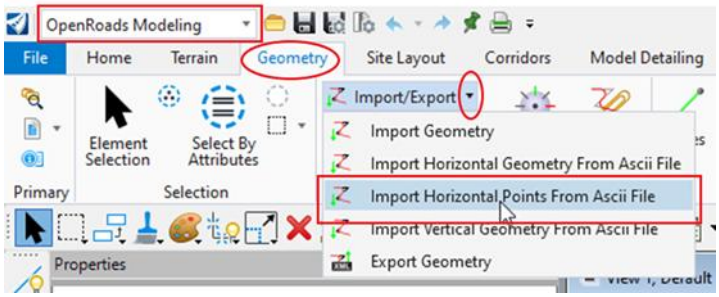
4. The DAF factors are in subfolders arranged by District. Browse to your projects DAF factor. Select it and click OK.



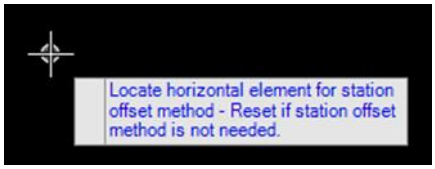
5. The coordinate system will be set. Close the Coordinate System window.



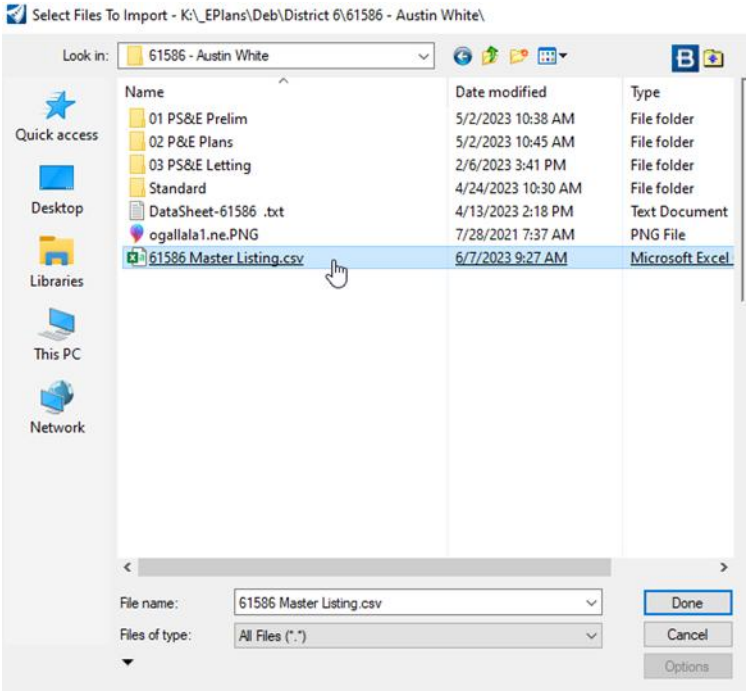
6. Next, in the Geometry tab, under the “Import/Export” drop-down, click "Import Horizontal Points from Ascii File".



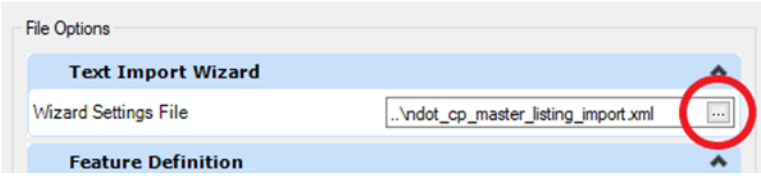
7. The cursor will prompt you to select an element for Station Offset method. We will not use this method, so Right-click to reset.



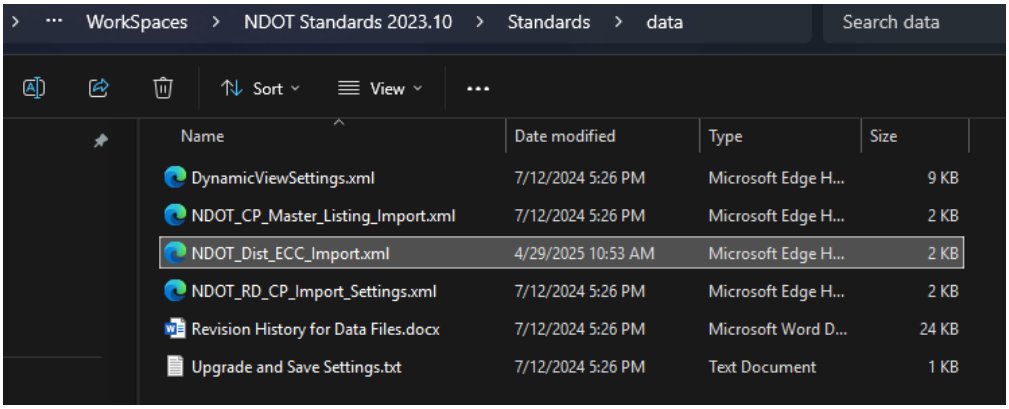
8. Change the “Files of type:” drop-down to All Files. Browse to the “[CN] Centerline Points” csv file that was exported from Trimble. Select the file and click “Done”.



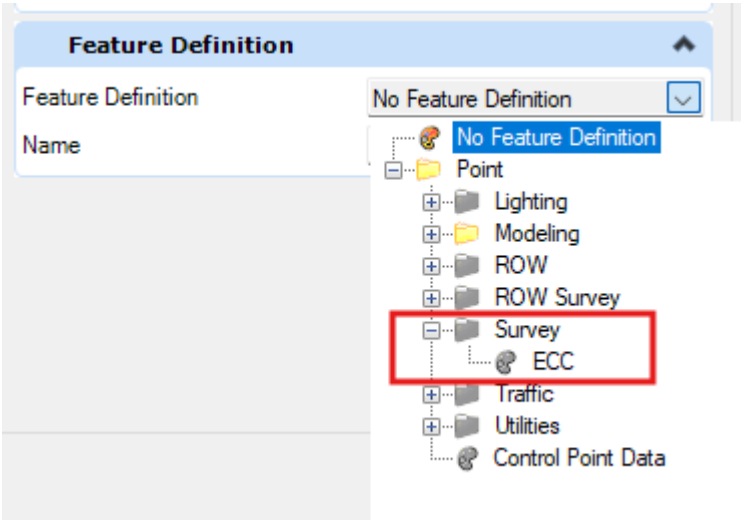
9. The Import Horizontal Points from ASCII File window will appear. To the right of “Wizard Settings File”, click the browse button (3 dots).



10. Browse to file “NDOT_Dist_ECC_Import.xml” located in the folder “C:\ProgramData\Bentley\OpenRoads Designer 2024.00\Configuration\WorkSpaces\NDOT Standards 2023.10\Standards\data”, click Add, and then click OK.

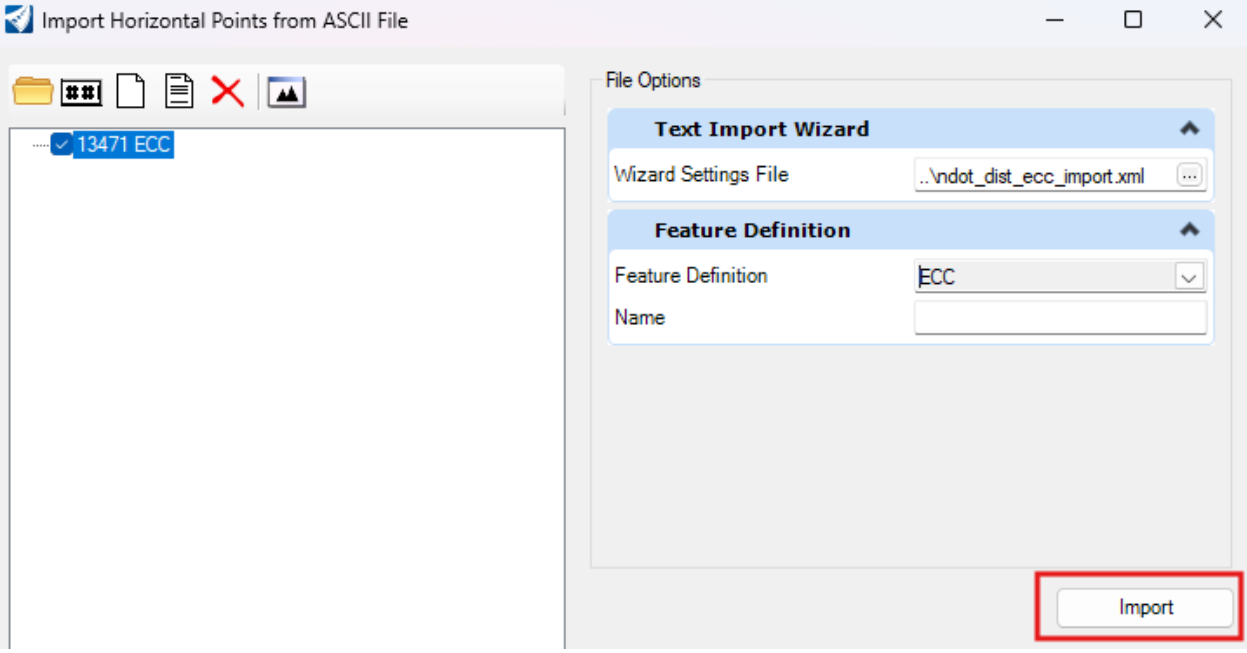


11. Next, under Feature Definition, use the drop-down to set the Feature Definition to "Construction Point".

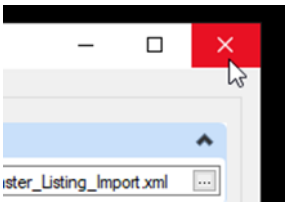


12. Leave the Name blank.

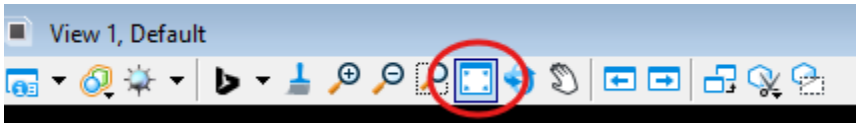
13. Click Import.



14. After the import has processed, close the Import window.



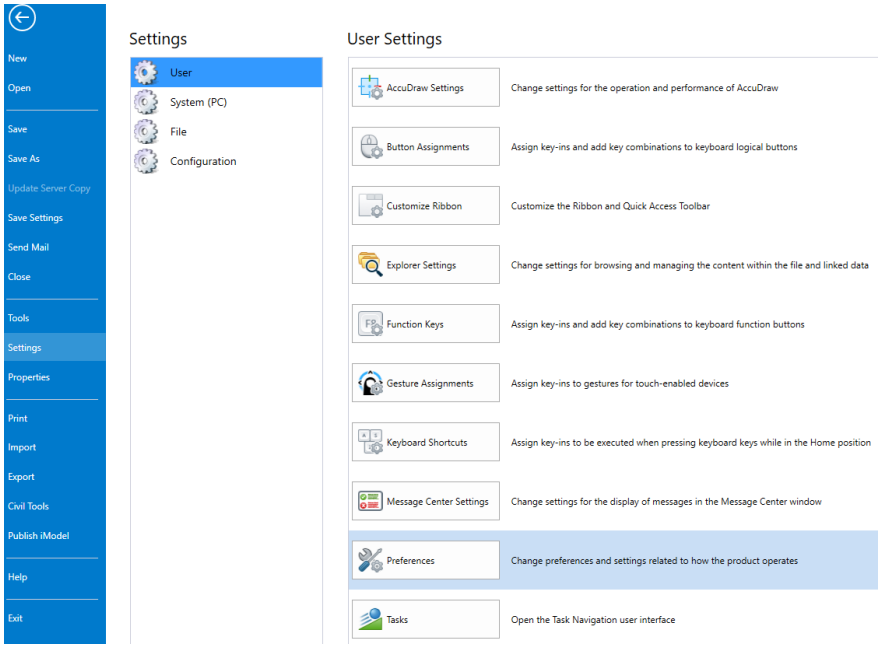
15. The points will be drawn in to the drawing window. Click “Fit View” to see them all.



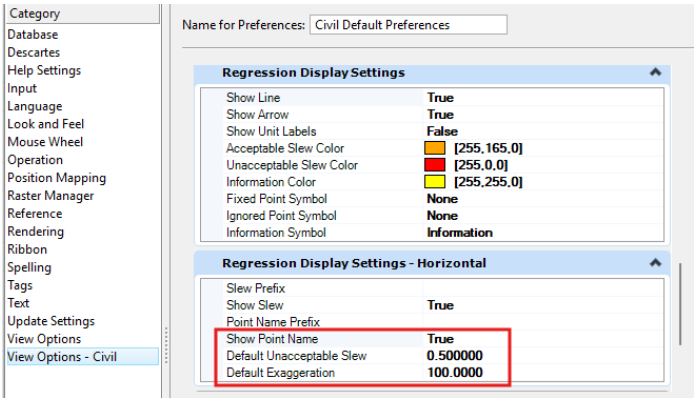
User Preference Settings

Note: These settings only need to be set once. They will only need to be reset if user preferences are cleared.

1. Go to File > Settings > User > Preferences.

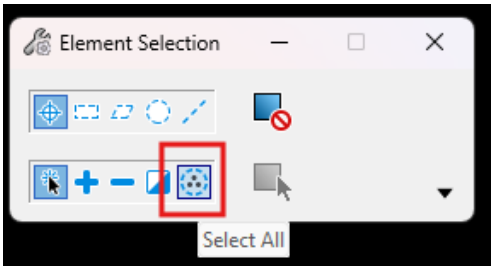


2. Navigate to View Options Civil > Regression Settings.
3. Set the **Unacceptable Slew Value** to 0.5 for horizontal regression. This value determines when the display color changes (e.g., orange below the value, red above).
4. Set the Exaggeration to 100. This will make the display of the regression line easier to understand.
5. Set “Show Point Name” to True. This will help identify what points you are looking at when running the regression analysis.

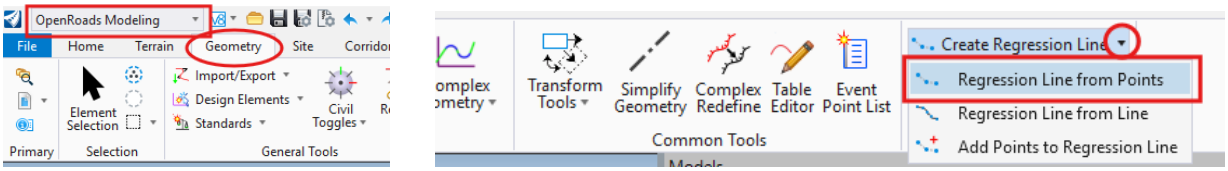


Create the Regression Line

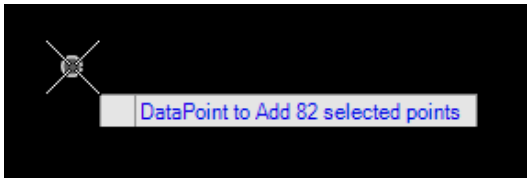
1. Select All ECC points using the Element Selection dialog.



2. In the OpenRoads Modeling workflow, under the **Geometry** tab, find the Regression tools section. Under the Create Regression Line dropdown, select **Regression Line from Points.**



3. Click in the Drawing to accept the selected points.

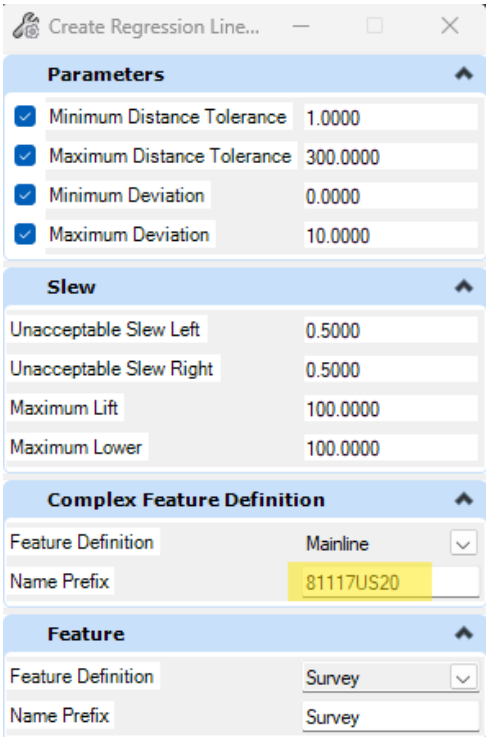


4. The next prompt asks to Locate the Starting Point for Regression. The first point will be at the beginning reference post for the project. This is usually the west-most or south-most point of the alignment.

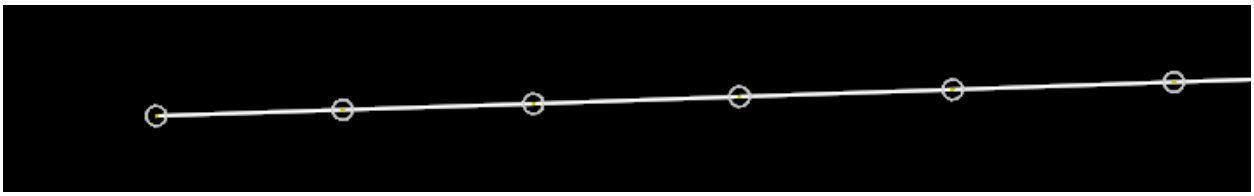
5. Next, it prompts you to select a second point that will define the Regression Direction. This is the same as the direction of the Stationing for the alignment.

6. In the Create Regression Line From Points dialog, match the setting to the image:

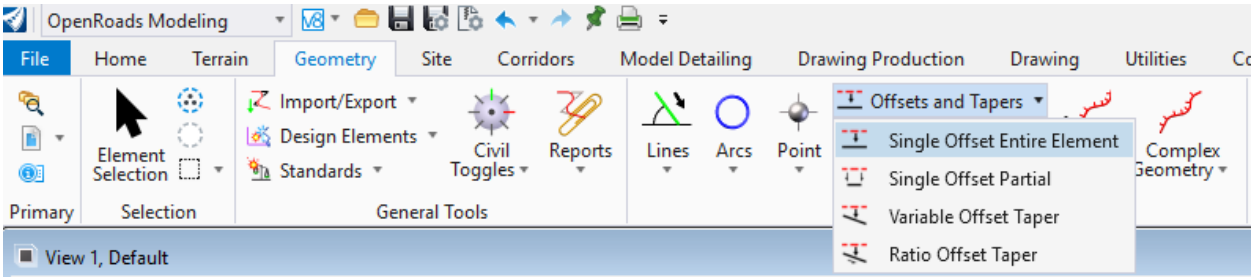
   - **Min/Max Distance Tolerance:** Controls the allowable distance *along* the alignment between the regression alignment and the original survey points (distance front/behind the current point being analyzed). Set the minimum to 1 and the maximum to 300.
   - **Min/Max Deviation:** Controls how much the generated regression line can deviate *laterally* (left/right) from the surveyed points. This helps smooth the alignment while staying close to the data. Set the miminum to 0 and the maximum to 10.
   - **Unacceptable Slew Left/Right**: This setting will help analyze when the regression line is beyond a certain distance. Set this to 0.5 for both.
   - **Maximum Lift/Lower**: This setting is used for vertical regression and is not being utilized for our purposes. Set both to 100.
   - **Complex Feature Definition:** This setting defines the feature definition of the Alignment that will be created with the regression tools and eventually used as the project centerline. Change the Feature Definition to Alignment/Mainline. Change the Name to the control number and highway number with formatting “[ControlNo.][HwyNo.]”.
   - **Feature**: This setting defines the feature definition of the regression line that visually displays the slews. Change the Feature Definition to Alignment/Survey. The name can be left as the default name.



7. In the Drawing window, click through all of the prompts (4 clicks). The regression line will be drawn between the points. Check through and confirm that the regression line is drawn all the way to the last surveyed point. If it is not, then press undo (Ctrl+Z) to undo its placement and try placing it again with higher values put in for the Maximum Distance Tolerance and Maximum Deviation.

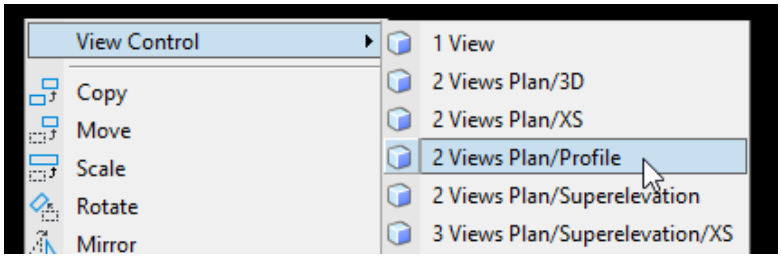


8. **OPTIONAL** In the Geometry tab, **select Single Offset Entire Element**. Define an offset of 50. Click on the Regression line and place an offset line on both sides of the alignment. This line will visually represent the maximum allowable slew distance.

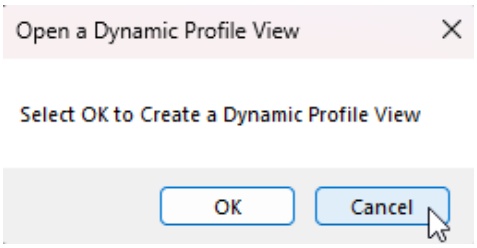


9. **Next, Generate the Curvature Diagram:**

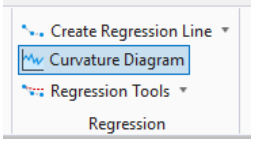
   a. Right-click and hold anywhere in the drawing. Click **View Control > 2 Views Plan/Profile**. This will create 2 drawing views.



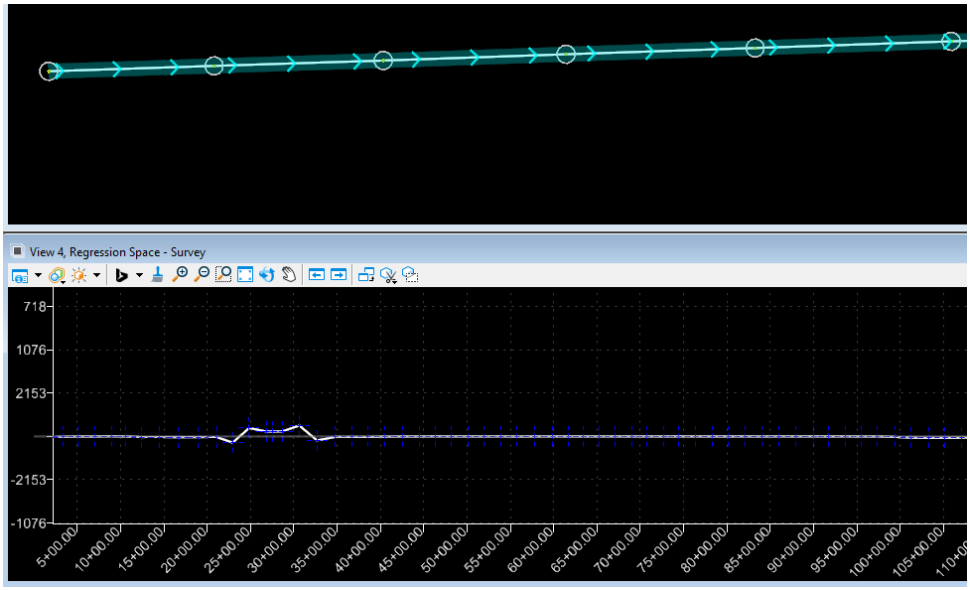
   b. A window will pop up to open a dynamic profile view. Click **Cancel**.



c. Next, in the Regression tools, click **Curvature Diagram**.



d. Select the Regression Line in the top view. Then click in the bottom view to place the diagram.



e. **Interpret Diagram:**

- The Horizontal Axis represents Stationing along your alignment.
- The Vertical Axis represents the deflection of each point relative to its neighboring points.
- Points **closer** to the horizontal axis have **low deflection**, indicating **Tangents**. Points **farther away** from the horizontal axis have **higher deflection**, indicating a **Curve**.
- Anything **below** the axis (negative deflection) indicates a **Left-hand curve**. Anything **above** the axis (positive deflection) indicates a **Right-hand curve**.
- A well-defined curve in the survey data should look relatively smooth in the diagram, somewhat resembling a curve shape.
- Jagged points or unexpected large jumps in deflection can indicate potential issues with the survey data or areas that will be difficult to fit with standard geometry (like the problematic curve in the transcript example). Look for points that seem out of place relative to the overall trend.
- Use Ctrl + Mouse Wheel to adjust vertical exaggeration, which can help visualize subtle changes or flatten noisy data.

Alignment Creation Process Outline

The following instructions will use a combination of the Regression tools and Horizontal Geometry tools to create the alignment as a single complex element. These instructions will show how to use the tools, but the alignment creation will not always be straight forward, depending on the complexity. Here is a quick rundown of the process of creating the alignment:

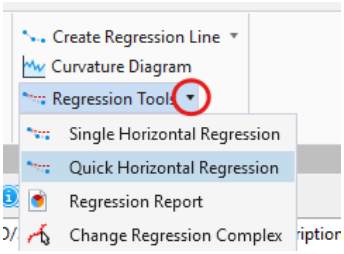
1. Run the **Quick Horizontal Regression** tool (page 15) on the whole alignment with Tolerance set to 0.5.
2. Check the tangents and curves for slew values above 0.5 or gaps.
    a. **Scenario 1**: If all slew values are within 0.5 and there are no gaps, the alignment was created successfully and you may move on to the "Finalize Alignment" section in these instructions (page 27).
    b. **Scenario 2**: If there are slew values above 0.5 within tangent sections only, use the **Insert Vertex** tool (page 16) to create an additional PI until the slew is within 0.5. The alignment is then finished and you may move on to the "Finalize Alignment" section in these instructions (page 27).
    c. **Scenario** 3: If there are slew values above 0.5 within curves or gaps in the alignment, mark the areas where it is off using a circle or line and delete the alignment. Move on to step 3.
3. Run the **Quick Horizontal Regression** tool (page 15) on each tangent section of the alignment, starting and stopping 2 ECC points short of PC or PT, with the tolerance set to 0.5.
    a. Use the "Insert Vertex" tool (page 16) to create additional PI's if there are slews above 0.5 within the tangent sections.
4. Run the **Quick Horizontal Regression** tool (page 15) on each curve, starting and stopping 1 point within the PC/PT of the curve, with the tolerance set to 1.0.
    a. If the slews along the curve are larger than 0.5, press undo and try again with a higher tolerance (1.5, 2, etc.).
        i. If this yields a line with slews less than 0.5, skip to step 7.
        ii. If a line with slews less than 0.5 cannot be drawn, press undo (Ctrl+Z) to remove the line and move to step 5.
5. Run the **Single Horizontal Regression** tool (page 18) on the first curve.
    a. Start by running a single line across the whole curve, from PC to PT. If this creates a regression line with slew values all less than 0.5, you may move on to step 6. If not, press undo (Ctrl+Z) to remove the placement of that line.
    b. Create two or more curves within the single curve. Space them out at least 3 ECC points apart. Use the Curvature Diagram to help determine what points to include or exclude.
6. Use the **Geometry Connector** tool (page 19) to connect 2 curve elements within the same Alignment curve.
    a. If the Geometry Connect cannot solve, close the Geometry Connector window and press undo (Ctrl+Z) to remove the lines drawn in step 5, and repeat step 5 with curves placed in different locations or with more curves.
7. Use the **Line To Element** tool (page 24) to draw a line tangent from curve element to the line element (this line will NOT get added to the complex element).
8. Manually move the end of the curve to the line drawn in step 7 to remove the gap or overlap.
    a. Remember to uncheck the "Sweep Angle" box.

9. Delete the line drawn in step 7.
10. Use the **Single Horizontal Regression** tool (page 18) to draw a line between the tangent and the curve (this line will get added to the complex element).
11. Manually move the line drawn in step 10 to connect to the tangent element on one end and the curve element on the other end.
12. Repeat steps 4 through 11 until a single alignment has been created without any gaps and all slews are within 0.5. Move on to the "Finalize Alignment" section in these instructions (page 27).

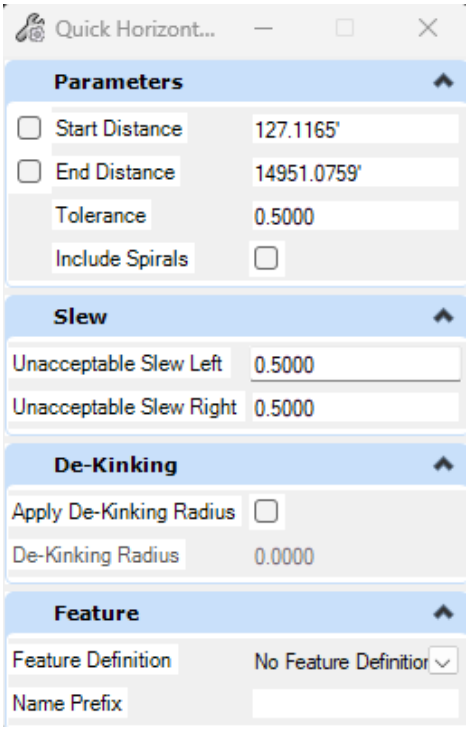
Regression and Geometry Tools

1. **Quick Horizontal Regression** tool:

    a. In the Geometry tab in the Regression Tools drop-down, select the **Quick Horizontal Regression** tool.



    b. Set the **Tolerance** to 0.5. This defines an offset the software tries to achieve for its best-fit alignment through the surveyed points. It is *not* a guarantee of maximum slew. It's a target value less than or equal to which the tool attempts to fit the geometry. Experiment with this value; smaller values aim for higher precision but might fail or produce gaps if data varies too much. Sometimes a slightly higher tolerance gives smoother, more usable results even if individual slews are larger.



    c. Leave the "Include Spirals" and "Apply De-Kinking Radius" boxes unchecked.

    d. Set both Unacceptable Slew values to 0.5.

    e. The Feature definition does not need to be set. The tool will use the feature definition settings defined when creating the regression line.

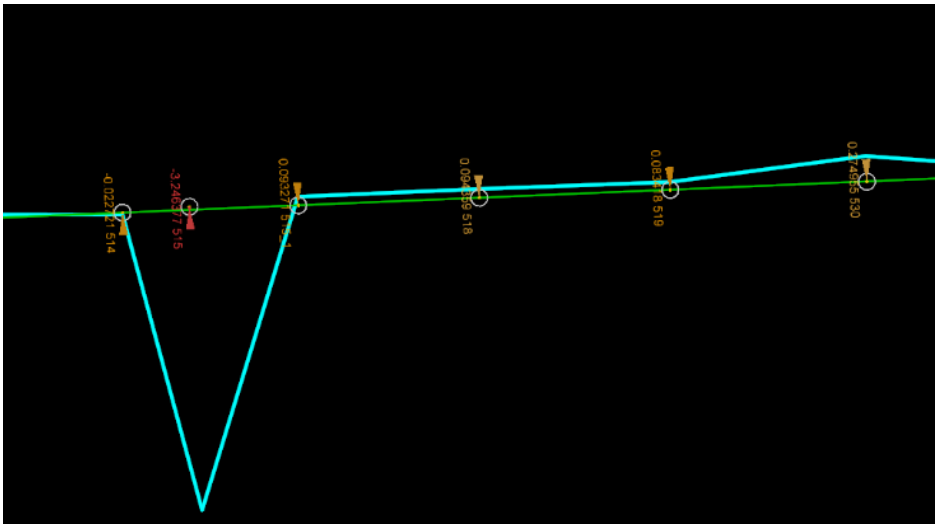
f. Then, in the plan view window (top window), select the Regression Line.

g. Define the start and end points along the regression line. Press Alt to snap to the beginning of the regression line, click, and then press Alt again to snap to the end of the regression line and click again.

h. Click to accept the 0.5 tolerance.

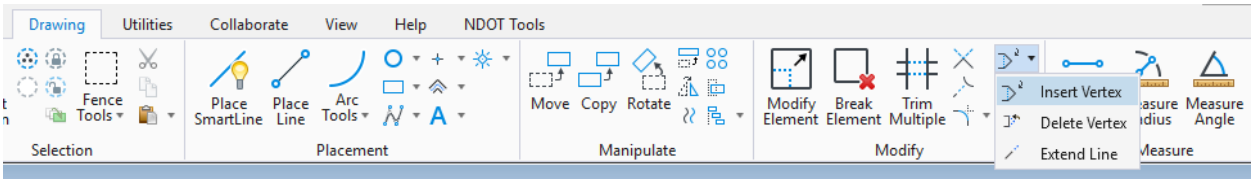
i. The software will create an alignment (green line) that includes tangents and curves. The regression line (white line) will move away from the surveyed points at a distance equal to the space between the surveyed point and the green line multiplied by 100. It will try to stay within the tolerance, but may not be able to in some areas.

j. Select the Regression line and zoom in. You'll be able to visually see what the slew values are. Any slew value that is greater than 0.5 will appear red.



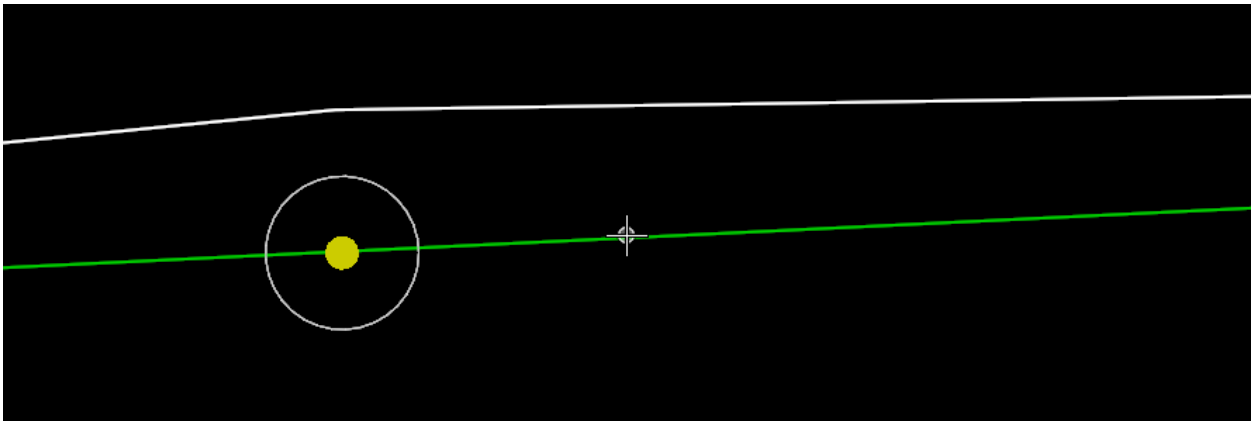
2. **Insert Vertex** tool:

a. In the Drawing window, under the top-right drop-down in the Modify section, select **Insert Vertex**.

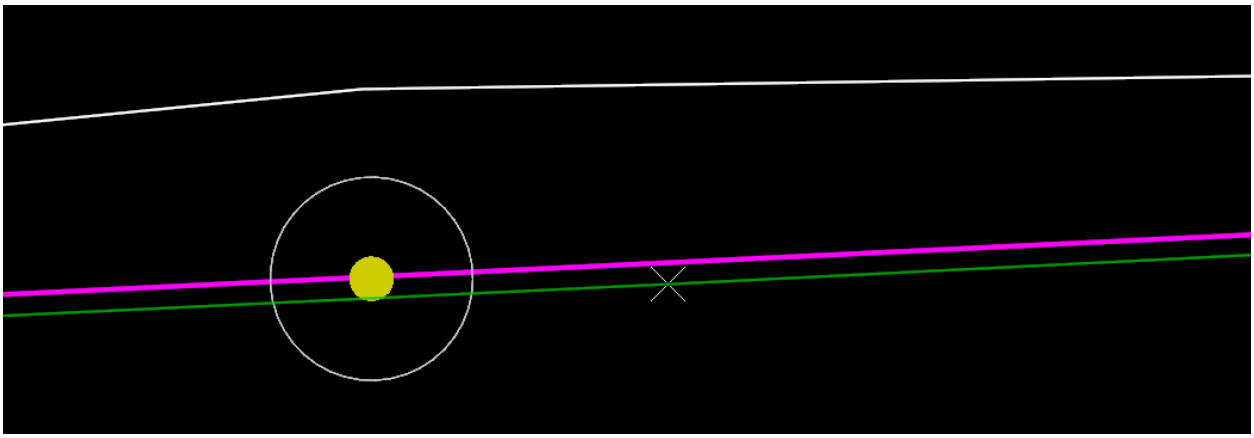


b. Click on the line segment in the approximate location where you want to place the PI.

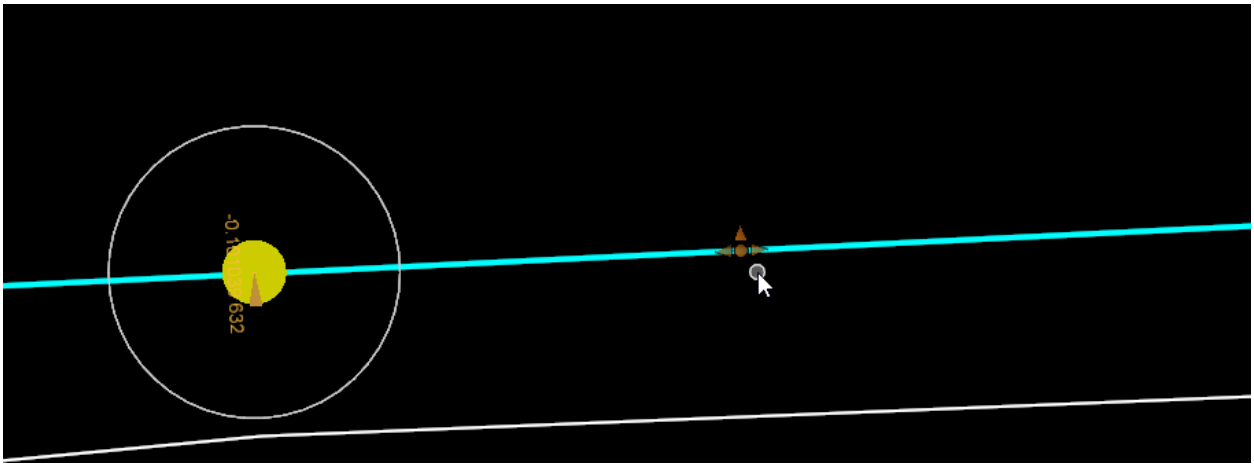
NOTE This tool only works to place a PI on a line element. This tool will not work on a curve element.



c. The original line will turn purple and the green line will follow your cursor.

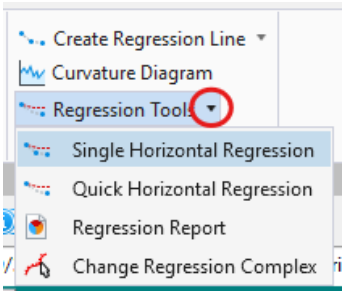


d. The Line will be placed and the White regression line will adjust to the new offsets. Check that the slew values for both line segments before an after the new PI are less than 0.5. If adjustments still need to be made, click on the alignment and find the handles. The dot in the center represents end/beginning of the two line segments. Click on this dot and move your cursor to the desired location. This will move the PI.

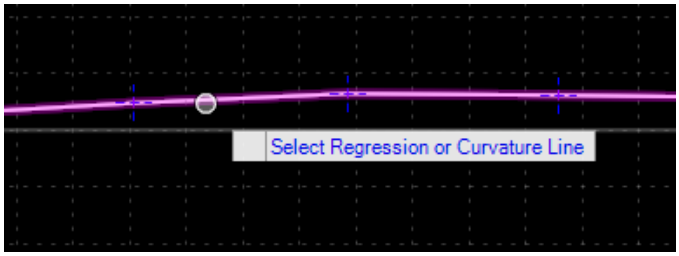


3. **Single Horizontal Regression**:

   a. Select the **Single Horizontal Regression** tool.



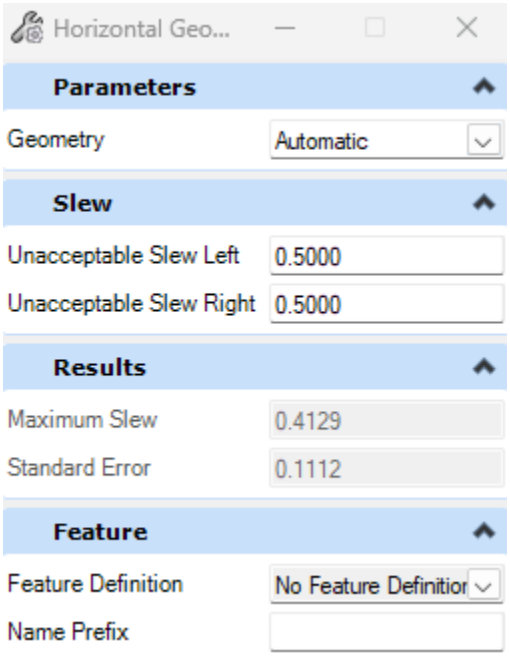
   b. Select the Regression Line in the Curvature Diagram (bottom window).



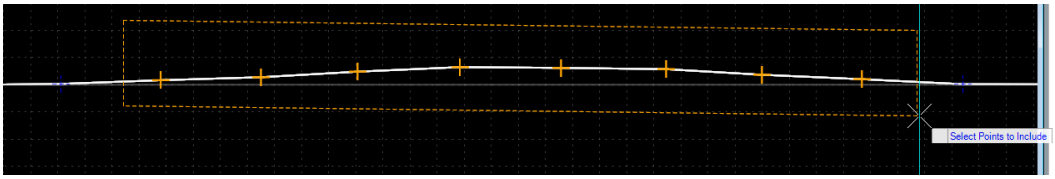
   c. In the Horizontal Geometry window, set the Geometry drop-down to **Automatic.** This can be set as Line or Arc if desired.

   d. Set the Unacceptable Slew values to 0.5

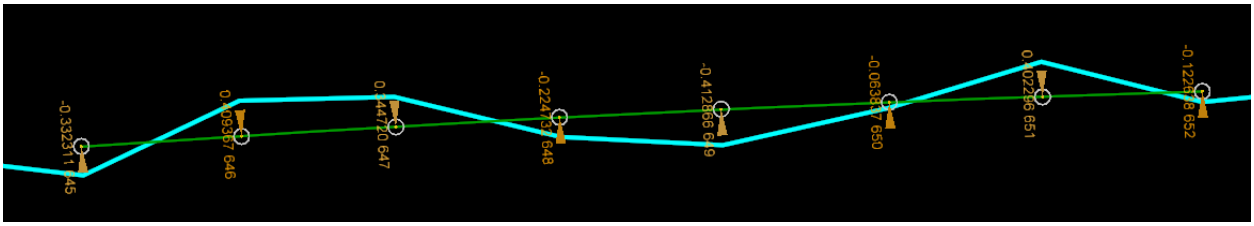
   e. The Feature definition does not need to be set. The tool will use the feature definition settings defined when creating the regression line.



f. Then, in the Curvature Diagram, select a place on the window that is before the first survey point used. Then select a second point that is after the last survey point used. Then move your cursor up or down to create a rectangle big enough that includes all survey points between the first and last survey points. The survey points will turn orange. You will also see a preview of the slews in the plan view (top window).



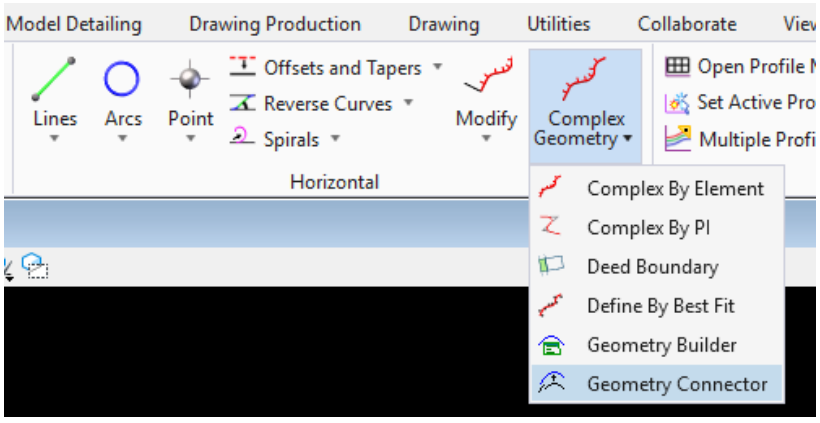
g. Click again to accept the placement of the geometry line.



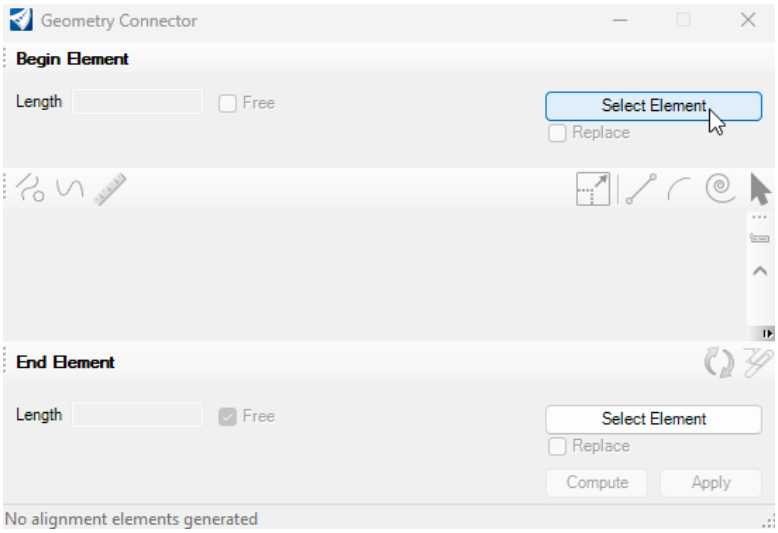
h. Review the slew values. If there are values greater than 0.5, then click Undo and try creating the same line with one less point at the end or beginning. You may need to create several curve elements within a single alignment curve and then connect the segments through the next method.

4. **Geometry Connector** Tool:

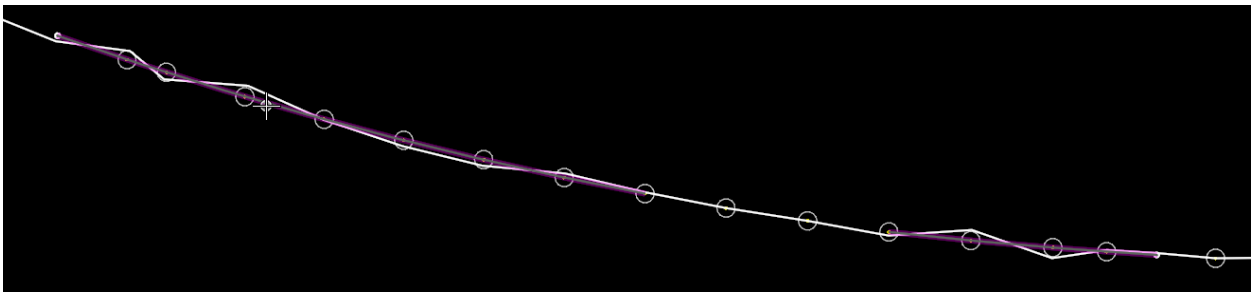
a. In the Geometry tab, in the Complex Geometry drop-down, click Geometry Connector.



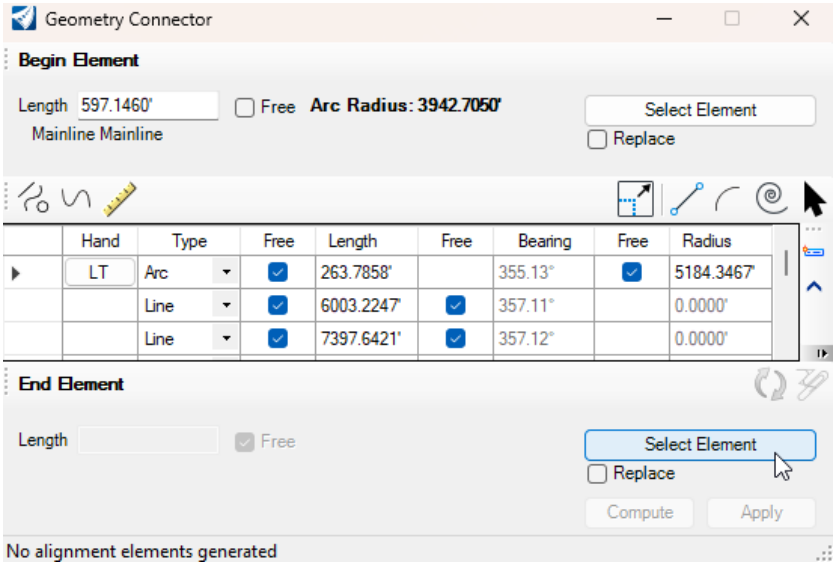
b. The Geometry Connector window will appear. First, we need to define the Begin and End element. At the top right of the window, click Select Element.



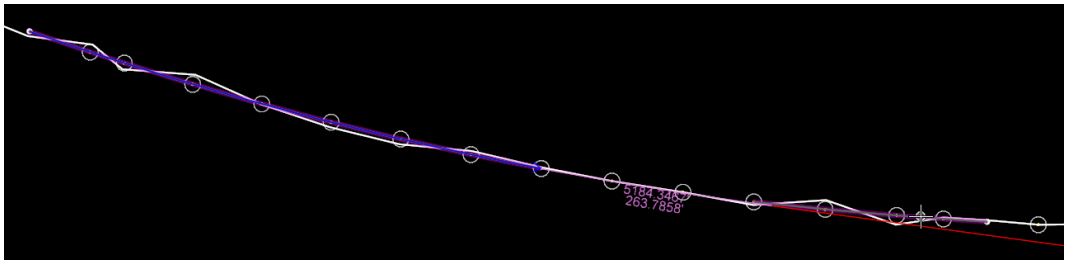
c. Select the first segment from the alignment. Click on the segment a second time to accept the selection.



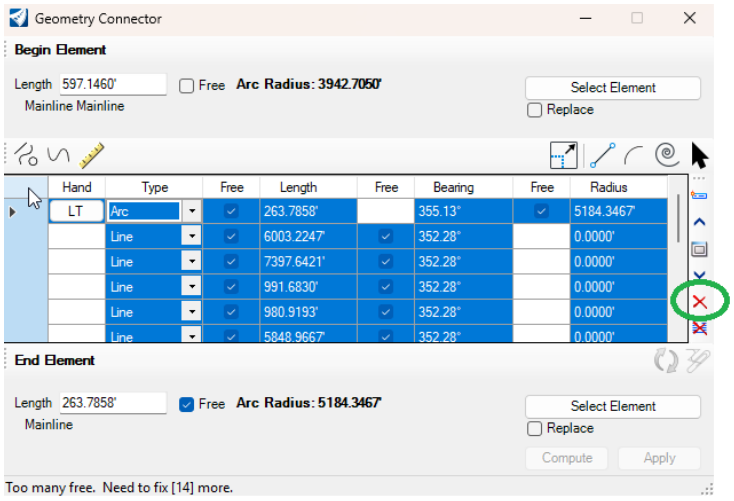
d. The Geometry Connector window will populate with that element's attributes. Next, in the bottom right of the window, click Select Element.



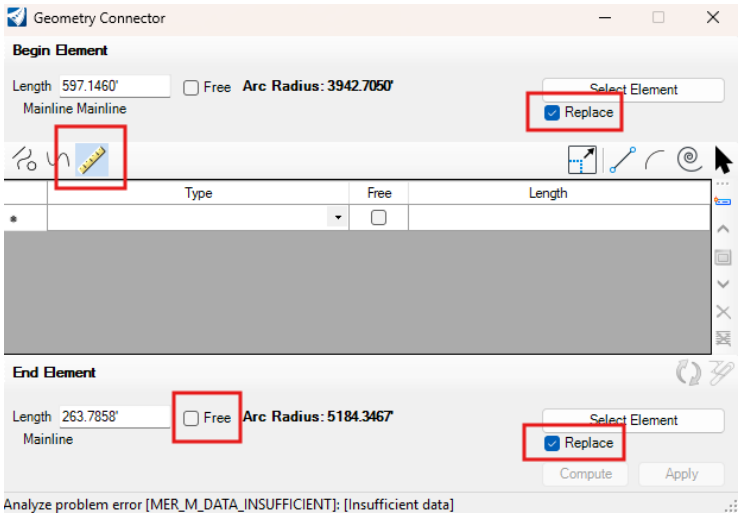
e. Click on the second segment from the alignment. Click on the segment a second time to accept the selection.



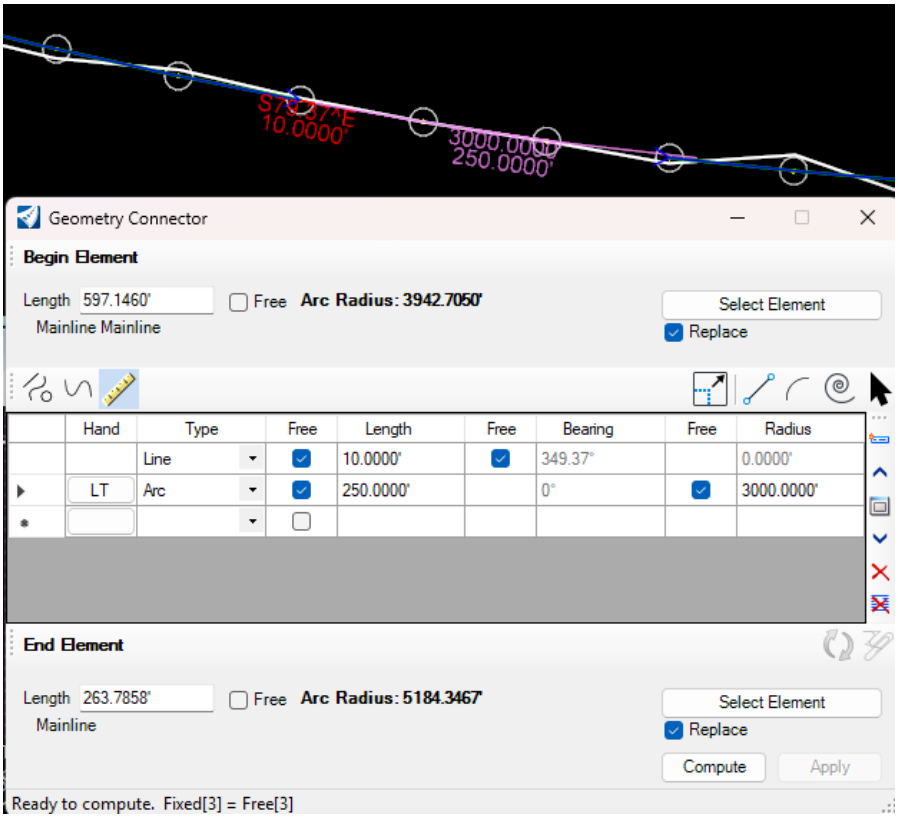
f. The End Element will populate with the element information. Select the heading of the first column to select all elements between the begin and end element and press delete (5th icon from the top on the right side).



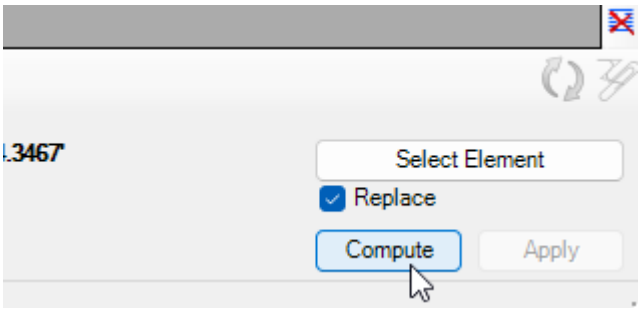
g. Uncheck the "Free" box for the End Element. Check the "Replace" box for both the Begin and End elements. Toggle on the "Rules" toggle (third icon from the right, top left side of the window).



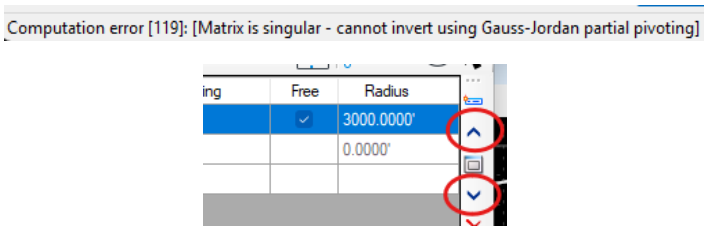
h. Next, we will add elements between the begin and end elements. Use the Drop-down in the Type column to select either a line or a curve (we do not allow spiral curves). Define an approximate length for the line. If placing an Arc, define and approximate length and radius, and click the toggle in the Hand column to switch the direction of the arc. In the plan view, it will display a preview of the elements placed. Try to define lengths and radii that makes the preview appear close to the solution.



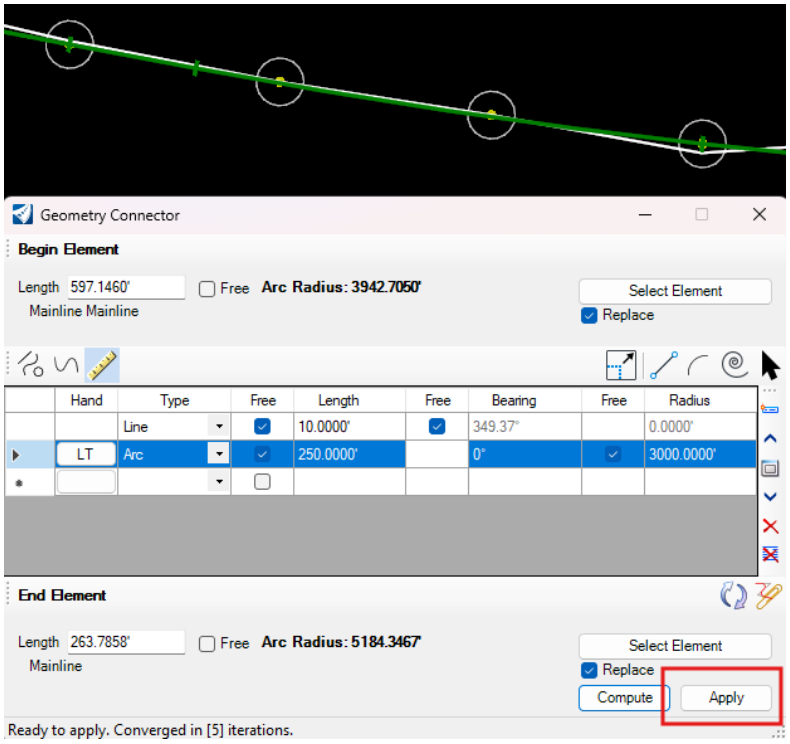
i. The bottom left needs show “Ready to Compute”. If it does not, then uncheck/check “Free” boxes within the window until the proper number of free and fixed elements are defined. Once it’s showing “Ready to Compute”, click Compute.



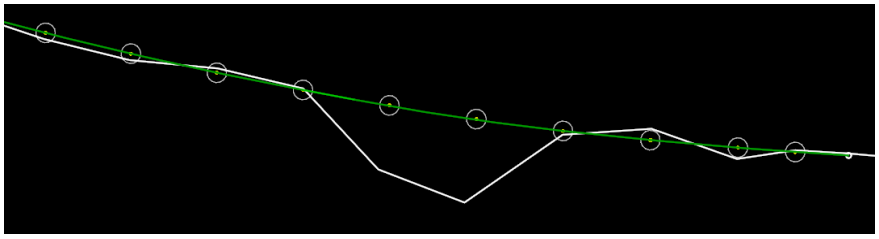
j. You may see a computation error similar to the one below. If this occurs, try using the Up or Down arrows on the right side of the window to change the order of the elements.



k. If the computation is successful, then the line in the lines connecting the begin and end element will appear in the drawing window. Click Apply.

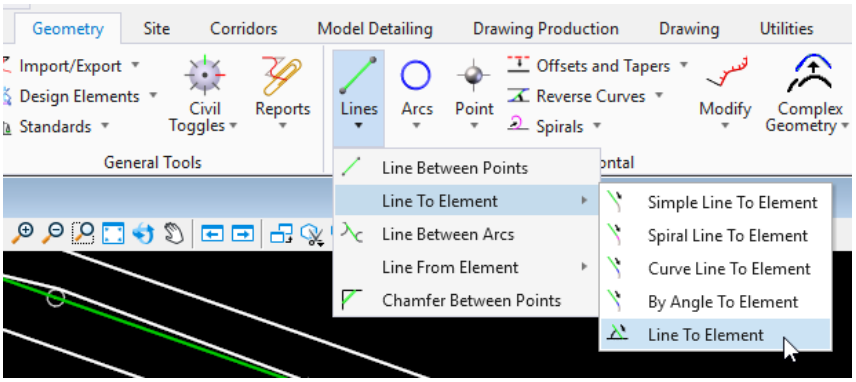


l. Close the Geometry Connector window. The alignment with the connected elements will be drawn and the Regression Line will update. Check the slews for the new elements drawn. If the slews are larger than 0.5, press undo (Ctrl+Z) to remove the connected elements. Manipulate the begin/end elements and then try the geometry connector again.



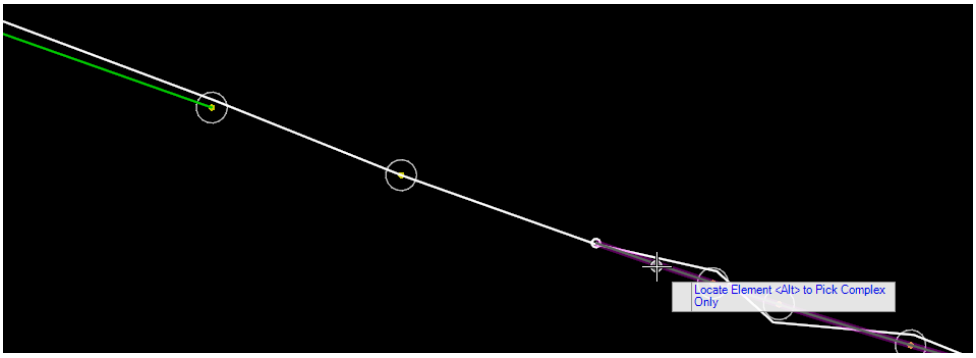
5. **Line To Element** Tool:

   a. In the Geometry Tab, under the Lines drop-down, navigate to Line To Element > **Line To Element**.

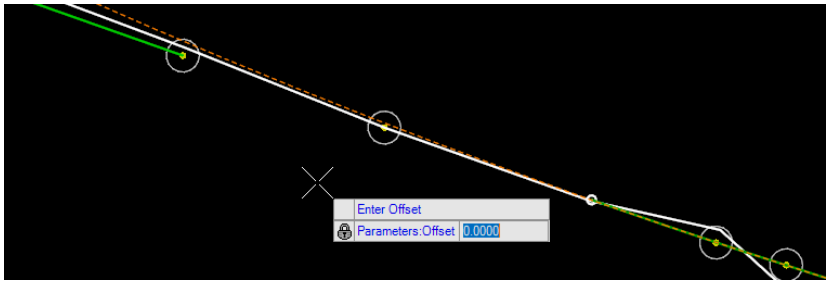


   b. Look at the message next to your cursor. It should read as shown below. If it does not, press “Alt” on your keyboard.

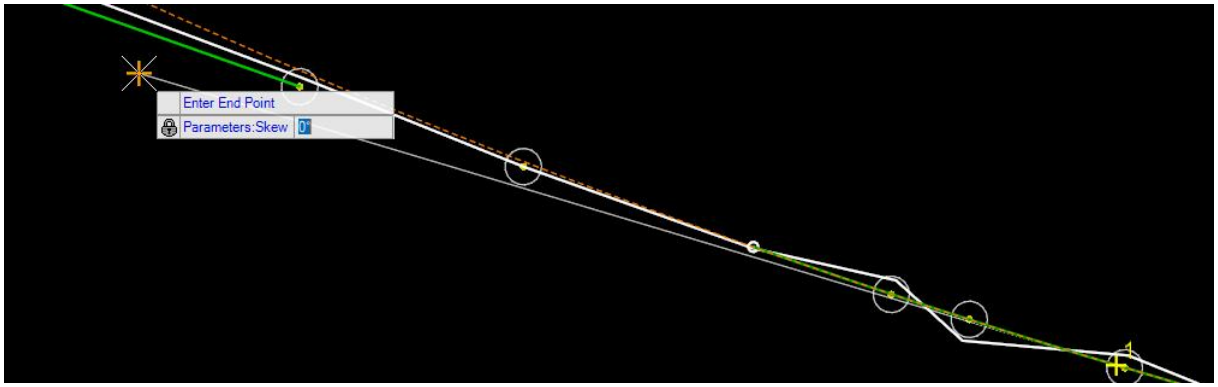
   c. Click the beginning/end of the curve element.



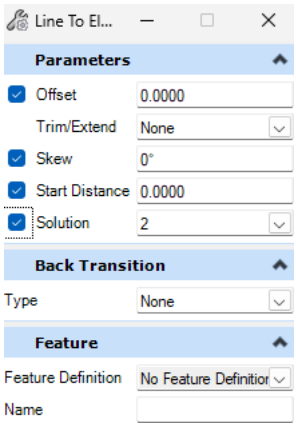
   d. Next, set the Offset to 0 and click to accept.



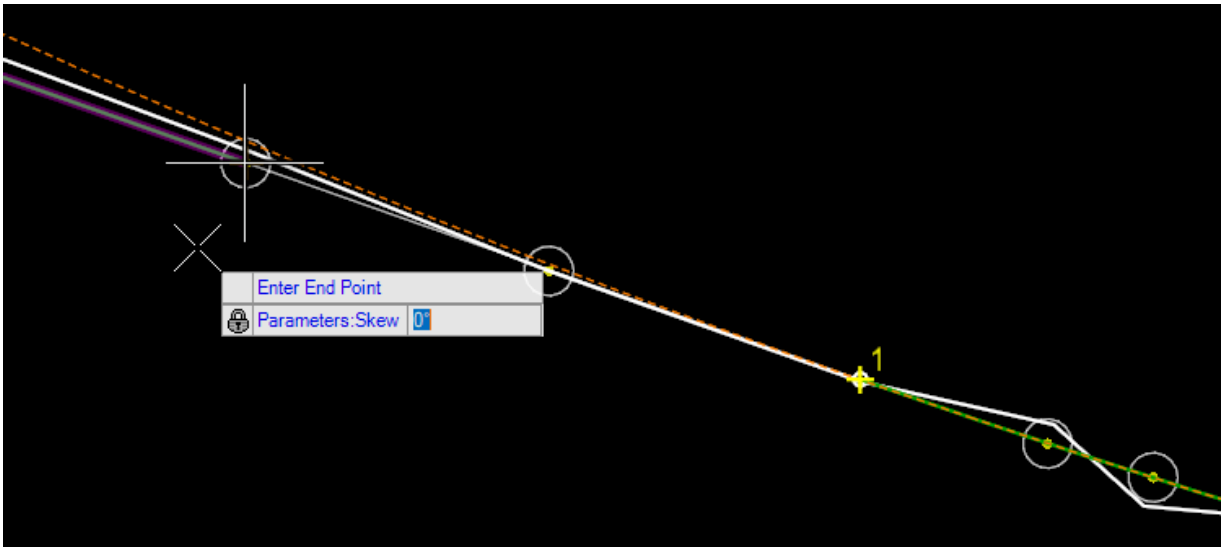
e. Then, set the skew to 0. Move your cursor and a line will appear between your cursor and the curve.



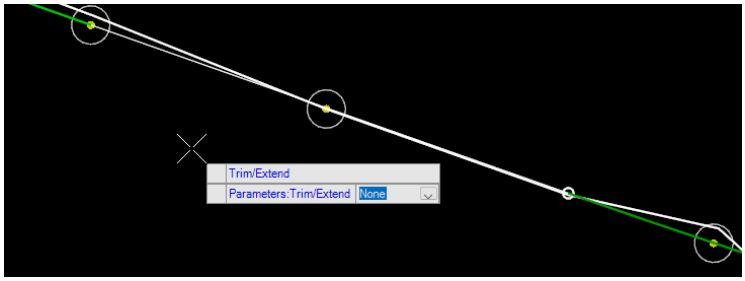
NOTE If the line appears in the wrong direction, then in the Line To Element window, check the Solution checkbox and change the solution drop-down to 2. Then move your cursor to the drawing window and the line will appear the correct direction.



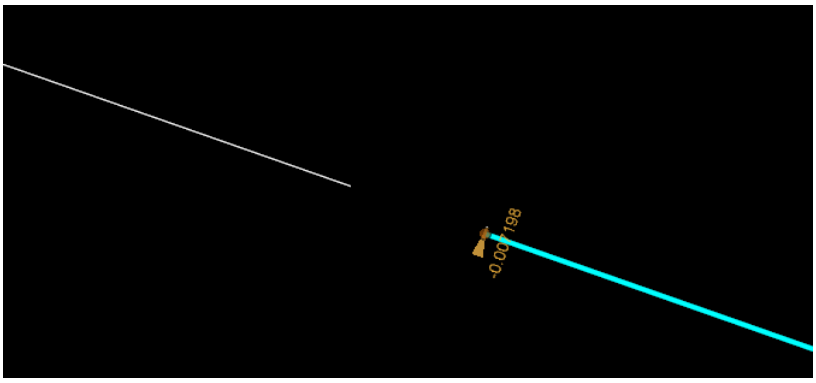
f. Snap to the endpoint of the tangent line and click to place the line.



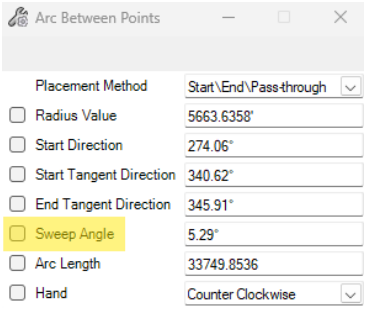
g. We will not use the Trim/Extend setting. Click again to accept the placement of the line.



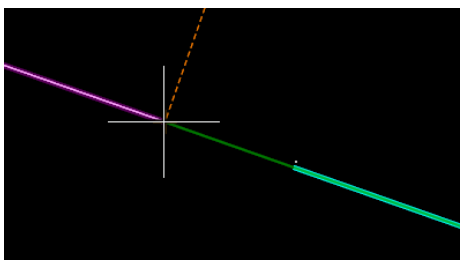
h. Zoom in to the location where the line runs tangent into the curve. There will either be a gap or an overlap between the line and the curve. Click on the curve and locate the handle for its endpoint.

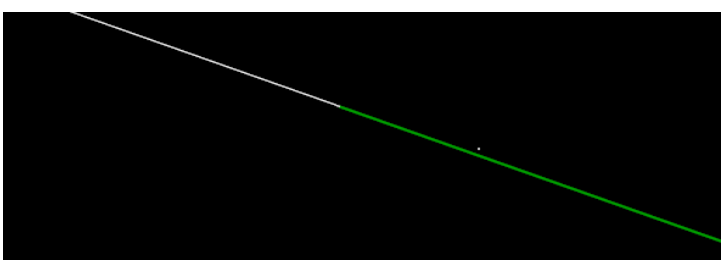


i. Click on the Dot. Then, the Arc Between Points window will appear. Uncheck the "Sweep Angle" check box and ensure that no other checkboxes are checked.



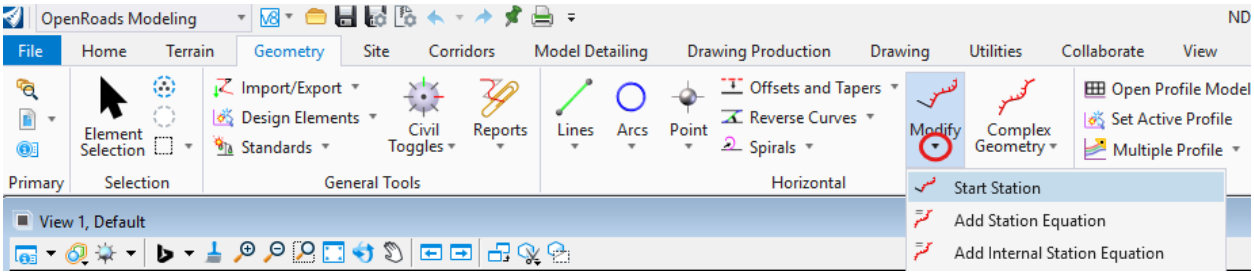
j. Snap to the Line and click to place. The curve will now connect to the line with now gap or overlap.



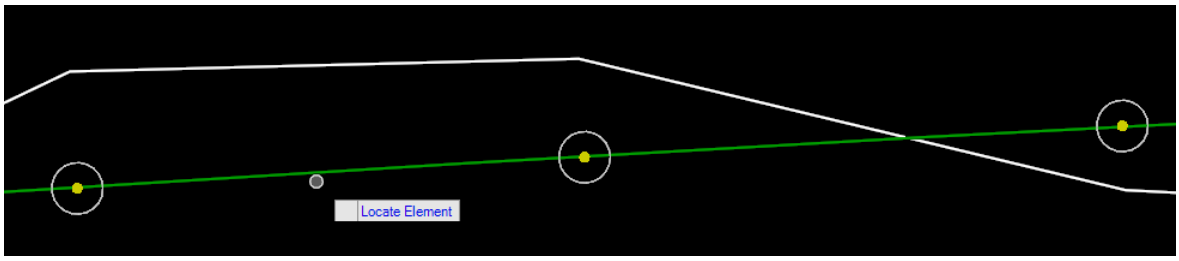


Finalize Alignment

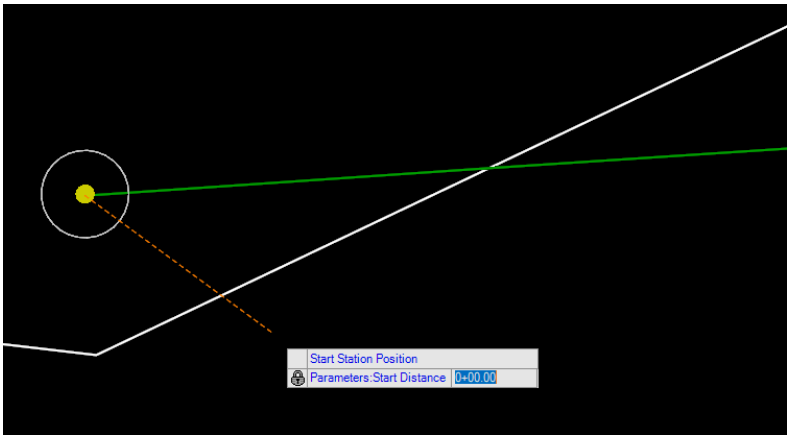
1. **Define Stationing:**
    - In the Geometry tab, under the Modify drop-down, select **Start Station**.



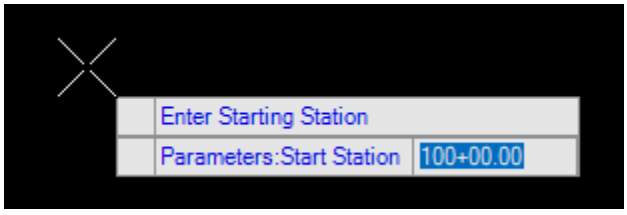
    - Click the Alignment.



    - Set the Start Distance to the beginning of the alignment (It will display 0+00, you can hit 0 on your keyboard and press enter to snap to it).



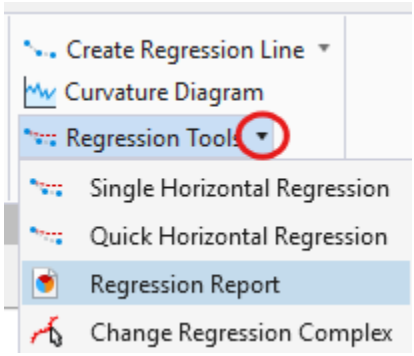
    - Type in the beginning station of the alignment. The stationing should at minimum start at 100+00.



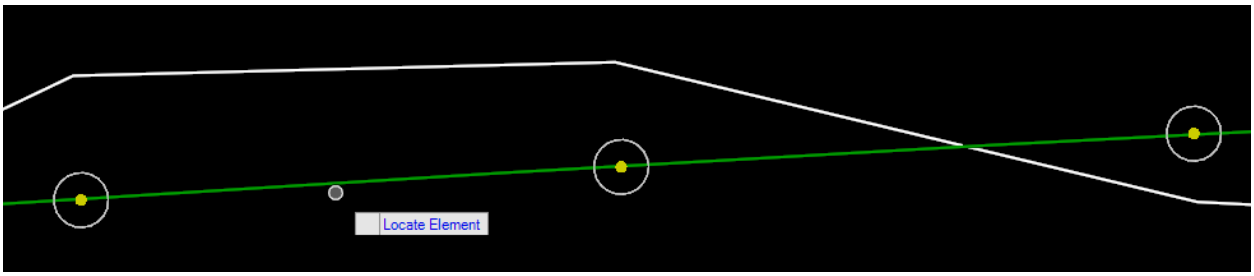
    - Click again to accept.

2. **Reporting:**

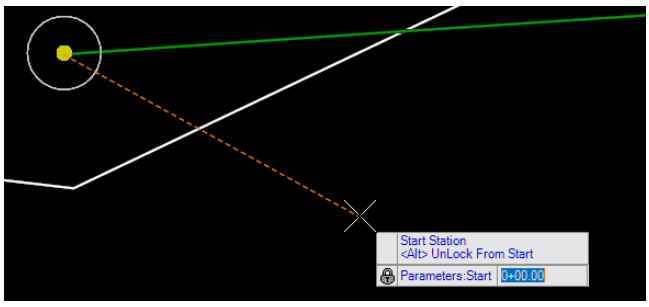
   - In the Regression Tools drop-down, click **Regression Report.**



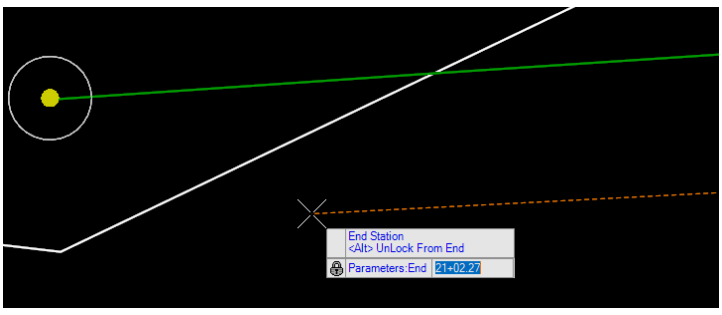
   - Click the Alignment.



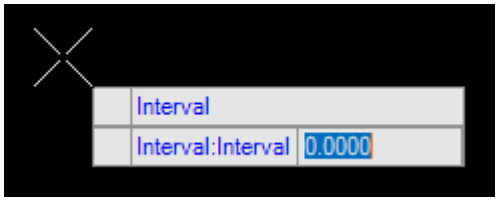
   - Locate the start station. Click Alt on your keyboard to snap to the beginning of the alignment, then click once.



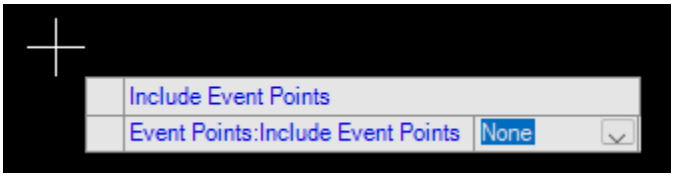
   - Locate the end station. Click Alt on your keyboard to snap to the end of the alignment, then click once.



- Set the Interval to 0. Click once.



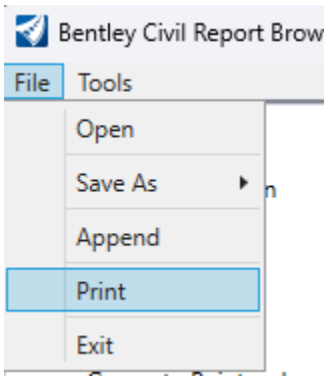
- Set the “Include Event Points” to None. Click once.



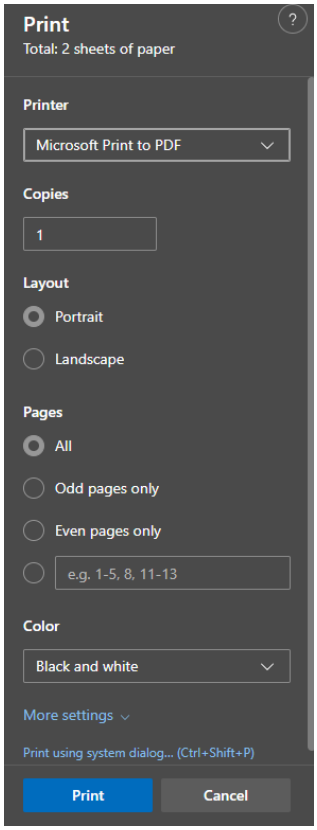
- The Bentley Civil Report Browser will appear. On the left, click on the report “NDOT Regression/NDOT Regression Review”.
- The report will display 2 different reports.

    1. The first section is the Regression Review. On the right, the column “Slew” shows the distance between the surveyed points to the Alignment. Any Slew value that is greater than 0.5 will highlight red.
    2. The second section checks the integrity of the Alignment. The column “Angular Difference (End to Next)” shows the deflections of the PI’s, PC’s, PT’s, and other points along the alignment. This value will highlight red if the line approaching a PC or beyond a PT has a deflection other than zero. It will also highlight red if it shows a deflection between two tangent sections that is greater than 0°30’.

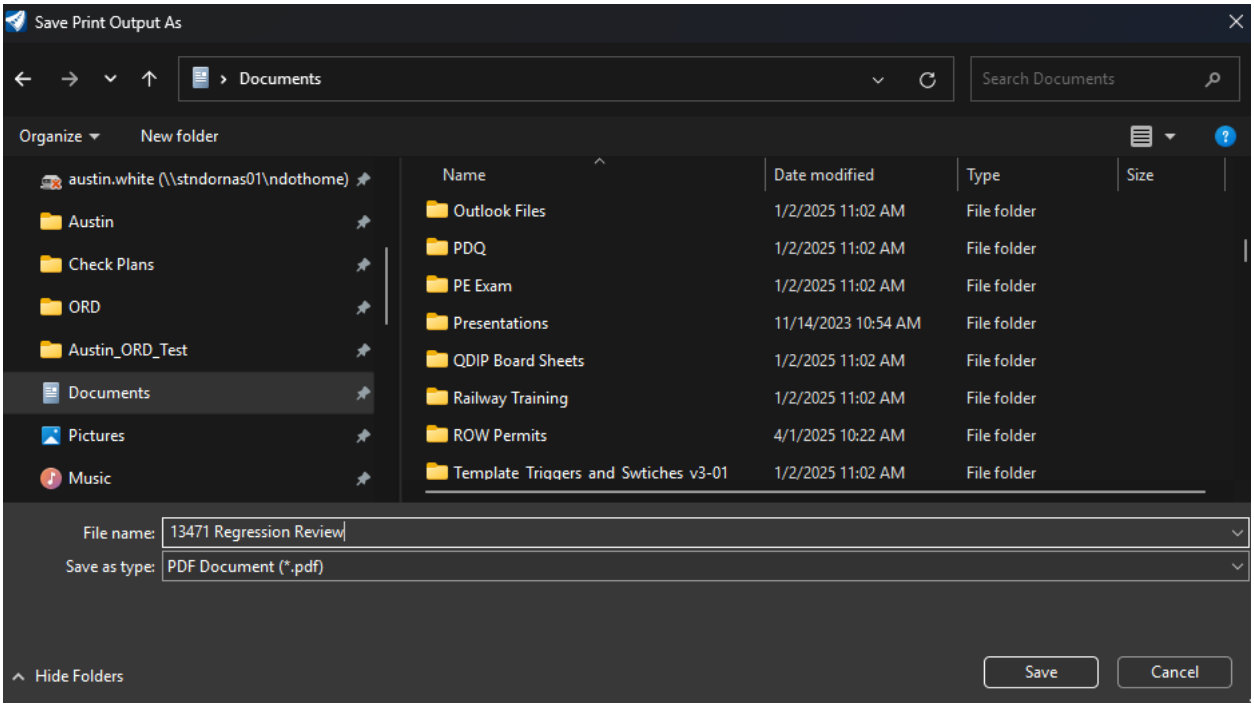
- Once the report is reviewed and accepted, click File > Print.



- Change the Printer to Microsoft Print to PDF. Click Print.

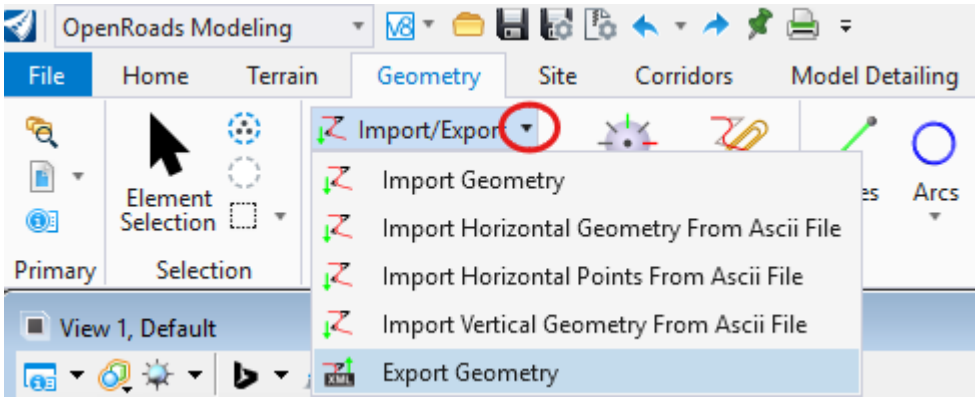


- Browse to the desired location on your C drive. Change the File Name to "[CN] Regression Review". Click Save.

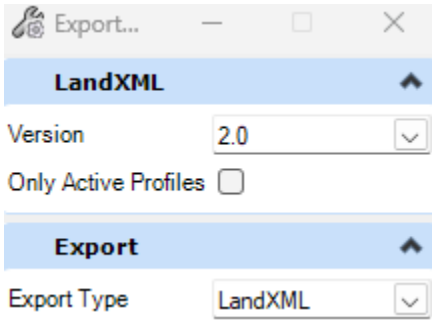


3. **Exporting**:

   - In the Geometry tab, under the Import/Export drop-down, click **Export Geometry**.

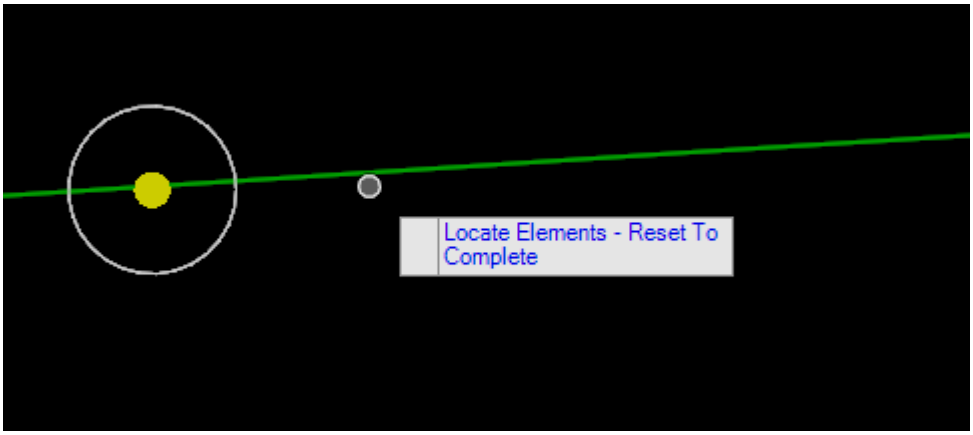


   - Change the version to 2.0. Uncheck the Only Active Profiles box. Set the Export Type to LandXML.



   - Click once to accept the export type.

   - Next, select the alignment. Then, right-click to accept.



   - Click through the prompts (two clicks) to accept the settings.

- The document name will match the name of the alignment by default. Browse to the desired location on your C drive and click Save.