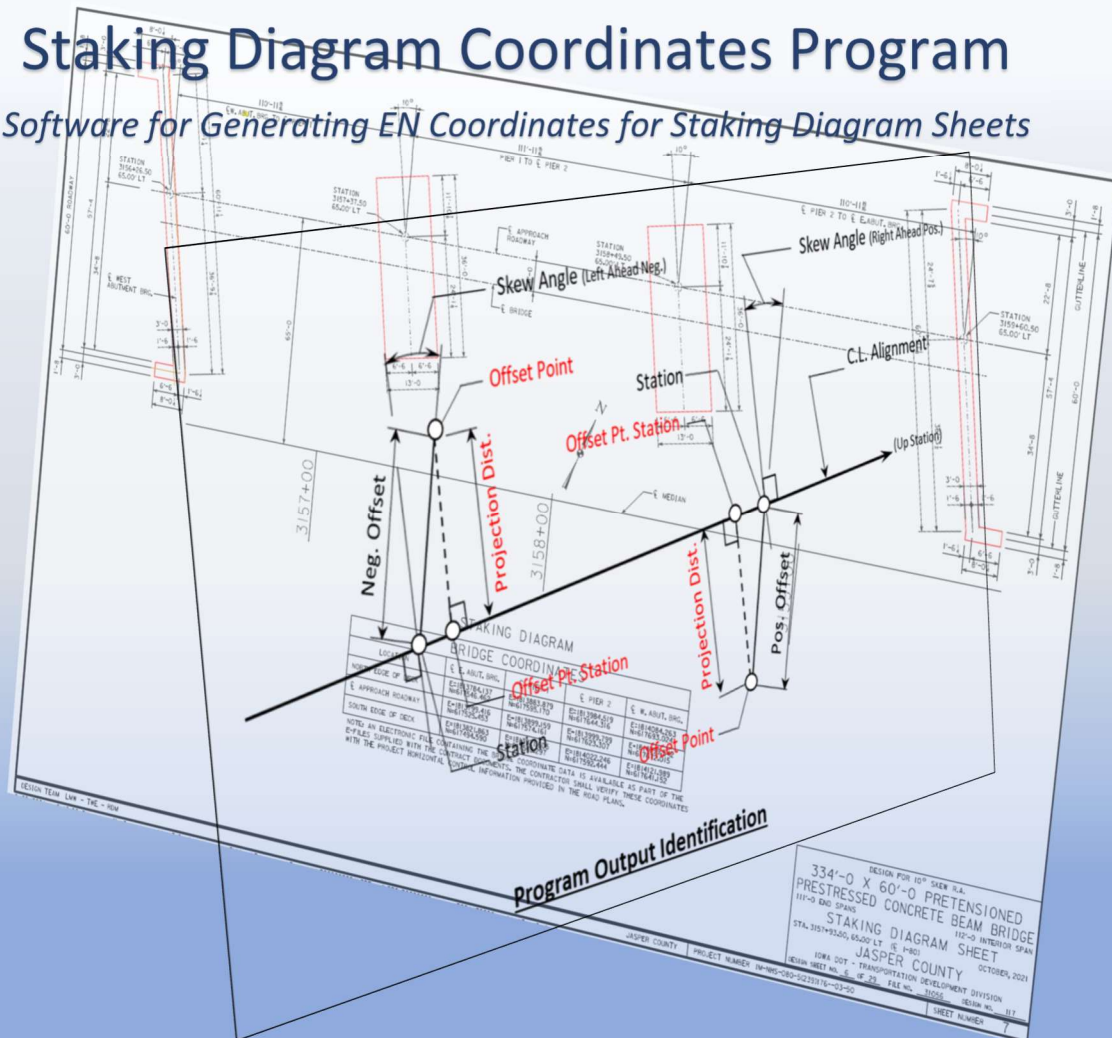




# Staking Diagram Coordinates Program

## Software for Generating EN Coordinates for Staking Diagram Sheets



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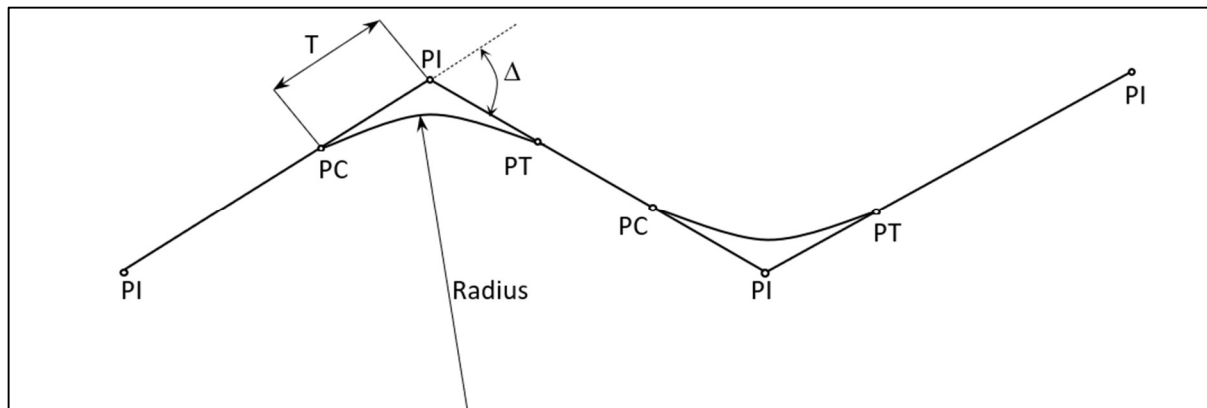
## **Overview**

The Staking Diagram Coordinates program will generate the Easting and Northing (EN) coordinates of a State Plane Coordinate System, for desired points on or off a bridge located on a horizontal alignment.

The EN coordinates are often provided in the DOT bridge plan sets, specifically the Staking Diagram sheet. EN coordinates at intersections of a CL Support and Edge of Slab are usually given in a Bridge Coordinates table to aid the contractor in their surveying efforts to accurately lay out the foundation elements of the bridge in the field during construction.

A basic understanding of horizontal alignments is needed to define the vertices or Points of Intersection (PIs) of a roadway alignment. The following background information concerning traditional Civil Engineering horizontal alignments is provided on a tab in the workbook and is repeated here.

A horizontal alignment consists of a series of tangent lines connected at Points of Intersection (PIs). Traditional civil engineering circular curves are most often located (but not required) at the interior PIs of the alignment. Each horizontal alignment entered in the program consists of a series PI points, each defined by EN (X and Y) coordinates. Associated with a circular curve located at a PI is the corresponding Radius of the curve.



**Figure 1 – Horizontal Alignment**

The program computes the PC, PT,  $\Delta$  and T (Point of Curvature, Point of Tangency, Central Angle and Tangent Length, respectively) for each curve when determining the location of an Offset Point.

## **G Sheets**

The PIs needed to define the alignment that the bridge is located on can be found in sheets that are included in a document prepared by road design. These sheets are commonly referred to as the 'G Sheets'. The document that contains the G Sheets can be found in the project directory on Project Wise. The file is often located in the project's Design/ Design Events sub folder. The Design Events folder has folders named D1, D2, D3, ...etc. The naming convention and location of the file may vary for each project.

Because the G Sheets are routinely used by road design engineers, bridge designers may not be familiar with identifying and retrieving the PIs necessary to define an alignment. Although a brief example of the use of the G Sheets is included in the case study outlined in this document, for those users who have little or no experience with them, it is recommended the user consult with an engineer who has experience in using them to gain knowledge and confidence in their use.

## Program Function

Associated with each alignment are Station & Offset series. A Station & Offset series is typically defined as a collection of any number of offset points measured along an Offset Line. The Offset Line intersects the alignment at the requested station. The Offset Line is oriented at a skew angle that is measured from a line normal to the alignment at the requested station to the Offset Line.

The user may enter multiple alignments and each alignment can have any number of Station & Offset series in an alignment.

### *o Program Input*

For each user supplied Station located on the C.L. Alignment, the program calculates the EN coordinates for the given Offset Points located along the Offset Line. The required input includes an Offset Distance measured from the Station on the C.L. Alignment to the desired Offset Point on the Offset Line. The Offset Distance is positive for points located to the right of the C.L. Alignment and is negative for points to the left of the alignment. The Skew angle of the Offset Line is positive for right ahead (Counterclockwise) angles and negative for left ahead (Clockwise) angles.

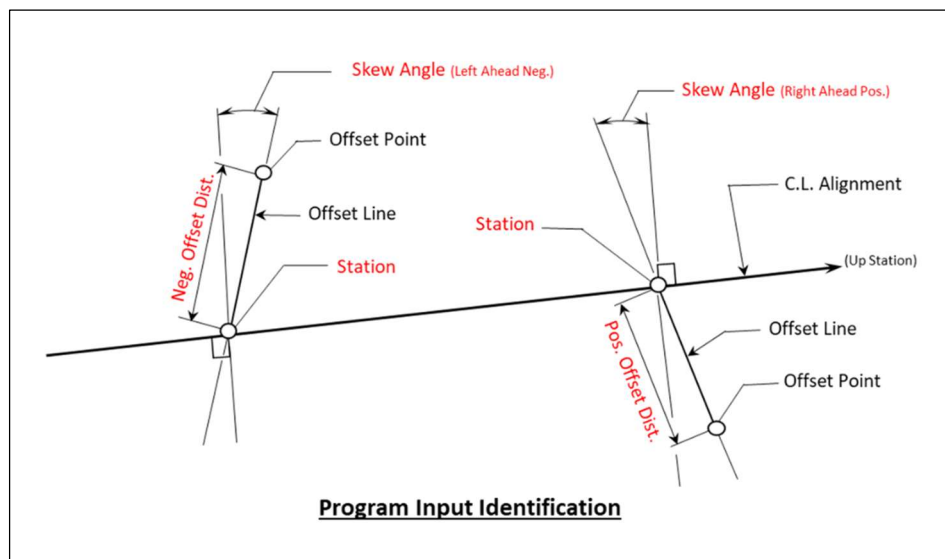
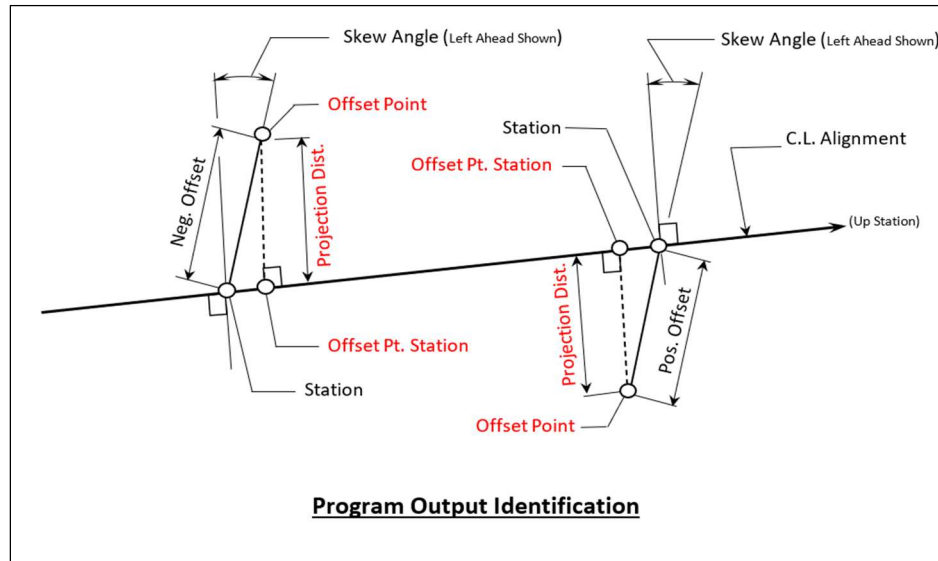


Figure 2

### *o Program Output*

For each Offset Point located on the Offset Line, the program reports the EN coordinates at the desired point. In addition to reporting the coordinates of each Offset Point, the program determines the Offset Point Station of the Offset Point. This Station is the location of the Offset Point when 'projected' to a point located on and normal to the C.L. Alignment. The Projection Distance is the distance measured from the Offset Point to the Offset. The Offset Point Station is defined as the location on the C.L. Alignment where a line from the Offset Point that is normal to the C.L. Alignment intersects the C.L. Alignment (i.e., the 'projected' location of the Offset Point).



**Figure 3**

### Program Interface

The user interface consists of a ribbon tab named Iowa DOT (Item 1). The ribbon contains a group titled 'Staking Diagram Coordinates' with a button titled 'View Task Pane' (Item 2). Click this button to show the 'Staking Coordinates' task pane (Item 3) when it's not visible. The task pane contains the controls that provide the interface for the user to enter and edit program input.

1. The user interface consists of a ribbon tab named Iowa DOT.
2. The ribbon contains a group titled 'Staking Diagram Coordinates' with a button titled 'View Task Pane'.
3. The task pane contains the controls for entering and editing user input.
4. The PI coordinates for a Horizontal Alignment are entered here.
5. The Station and Offset Distances for points on a Offset Line are entered here.
6. The program output for the computed EN coordinates at each Offset Point is reported here.

**Alignments**

No.	E (X)	N (Y)	Radius (ft)
1	1806925.06	614096.13	
2	1814719.26	617902.31	

**Station & Offsets**

No.	Station	Offset (ft)
1	3079+44.52	-65.0000
2	3166+18.42	-65.0000

**Output**

Offset Point				Offset Point on Alignment			
No.	Station	Offset (ft)	E (X)	N (Y)	Station	E (X)	N (Y)
1	3079+44.52	-65.0000	1806896.537	614154.538	3079+44.52	1806925.060	614096.130
2	3166+18.42	-65.0000	1814690.736	617960.717	3166+18.42	1814719.259	617902.310

Prjctn. Dist. (ft): 65.000

**Figure 4 - Program Interface**

## Case Study

The bridge selected for this example is Jasper 117. It is a 334' PPCB beam bridge on a 10° skew (right ahead) replacement for the existing I-80 west bound bridge. The situation plan and the staking diagram sheet from the plan set are shown below.

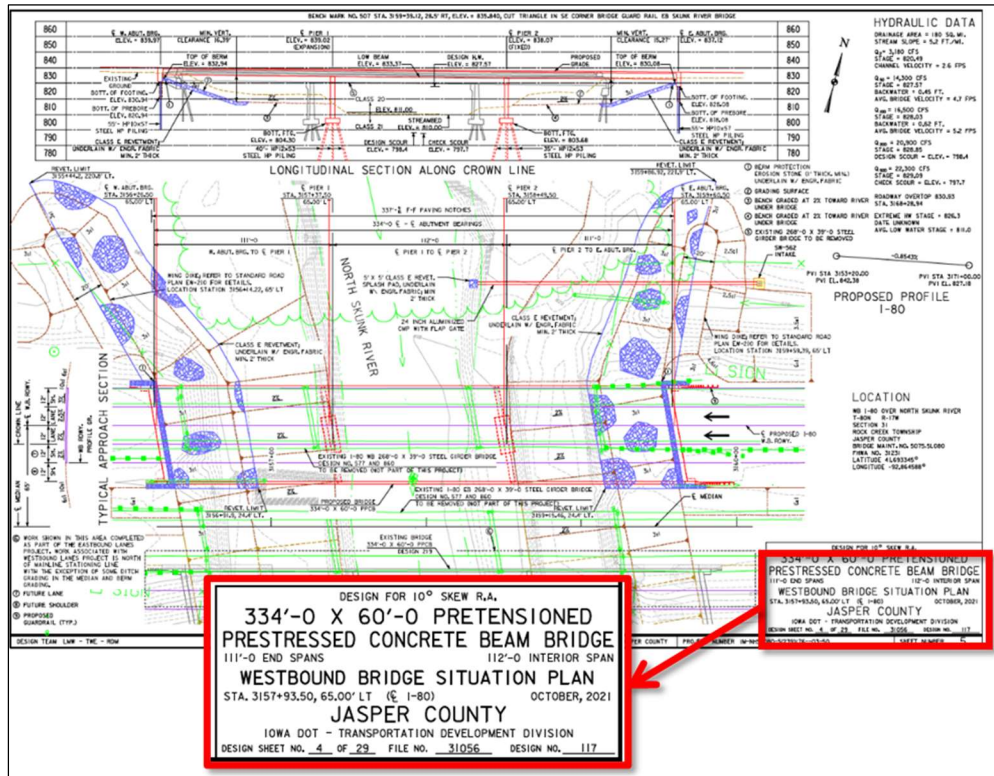


Figure 5 – Jasper 117 Situation Plan

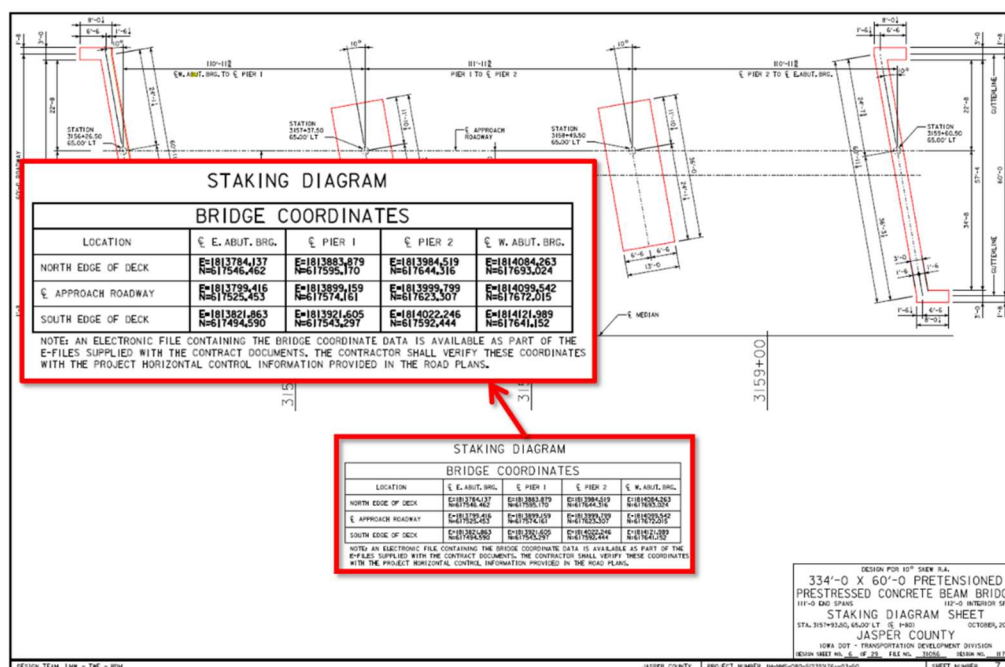


Figure 6 – Jasper 117 Staking Diagram Sheet



The coordinates reported for the points given in the Staking Diagram Sheet are located at the intersection of the center line of supports with the North Edge of Deck, CL WB Approach Rdwy, and the South Edge of Deck. The center line of supports are the CL W Abut Brg, CL Pier 1, CL Pier2 and CL E Abut Brg.

This example will illustrate the steps necessary to find the 3 offset points on CL Pier 1.

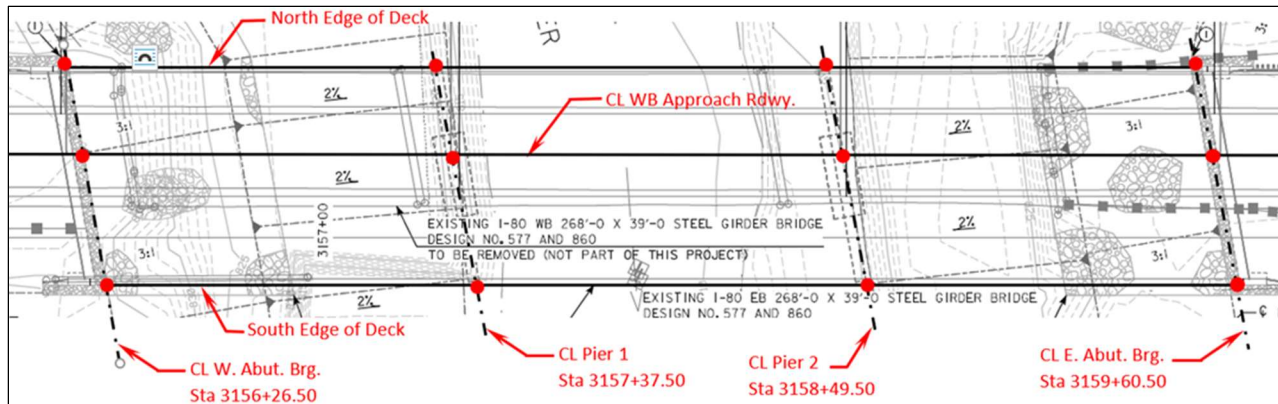


Figure 7 -Staking Diagram Coordinates Locations

First, we must establish the CL WB Approach Rdwy alignment. The given horizontal alignment in the plan set is reported for the CL I-80 median. This means the horizontal alignment for the CL WB App Rdwy needs to be defined. The CL WB App Rdwy is 65' to the left of the CL I-80 Median alignment.

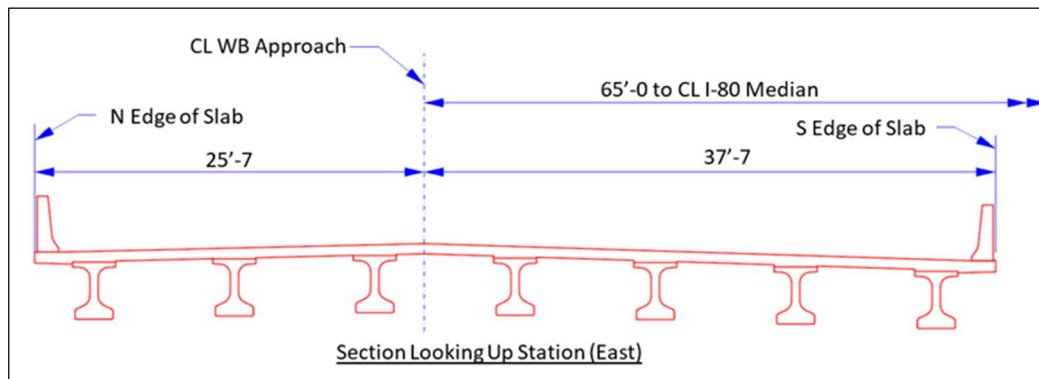


Figure 8 - WB Bridge Superstructure Cross-Section

Establishing the CL WB App Rdwy can be done in two ways. It can be hand calculated or can be determined by using the program itself. Both approaches are demonstrated here.

The first step in either approach is to define the alignment for the CL I-80 Median. This is done with the use of 'G Sheets'. Referring to the Alignment Coordinates sheet (Figure 9) in the G Sheets section of the document, in this case G.4, the location of the bridge on the alignment is established. The Jasper 117 bridge Station is 3157+93.50 and this means the bridge is located between the end of a curve, Sta 3079+44.52 and the beginning of a curve, Sta 3166+18.42. Stated differently, the bridge is located on a tangent line between the PT (end) Sta of the preceding curve and the PC (begin) Sta of the subsequent curve (Figure 1). The end point coordinates of the tangent line define the segment of the CL I-80 alignment used in this example.

[illegible]

Figure 9 – G.4 Alignment Coordinates Sheet

Once the coordinates for the CL I-80 alignment have been determined, the points that define the CL WB App Rdwy can be found. Here we will illustrate how this can be done by hand calculation.

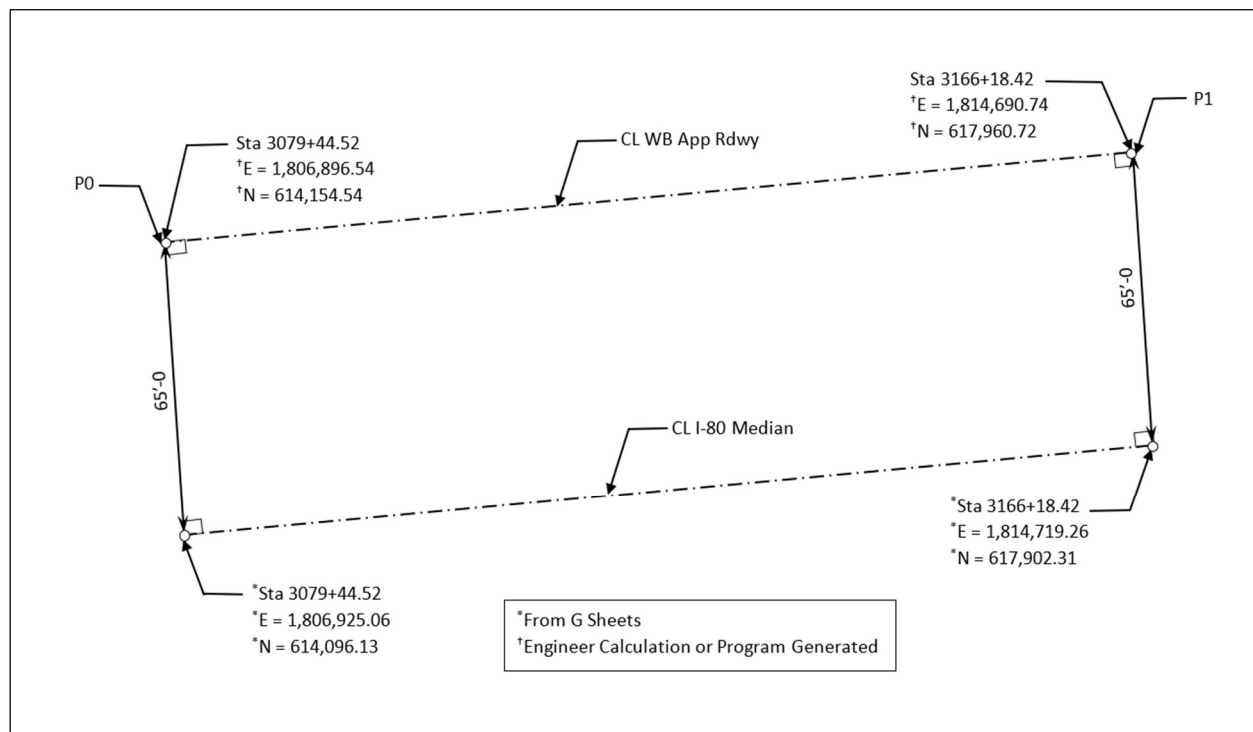


Figure 10 - Establish CL WB App Rdwy Alignment

o *CL WB Approach Rdwy Alignment - Hand Calculation*

- Tangent Length CL Median I-80

$$dx = 1,814,719.26 - 1,806,925.06 = 7794.20$$

$$dy = 617,902.31 - 614,096.13 = 3806.18$$

$$Tangent\ Length = \sqrt{7794.20^2 + 3806.18^2} = 8673.90$$

- Unit Vector for CL Median I-80

$$Ux = 7794.20 \div 8673.90 = 0.8986$$

$$Uy = 3806.18 \div 8673.90 = 0.4388$$

- Vector Normal to CL Median I-80

$$Nx = -Uy = -0.4388$$

$$Ny = Ux = 0.8986$$

- Initial Point P0 - CL W.B. App. Rdwy.

$$P0x = 1,806,925.06 + 65(-0.4388) = 1,806,896.54$$

$$P0y = 614,096.13 + 65(0.8986) = 614,154.54$$

- End Point P1 - CL W.B. App. Rdwy.

$$P1x = 1,814,719.26 + 65(-0.4388) = 1,814,690.74$$

$$P1y = 617,902.31 + 65(0.8986) = 617,960.72$$

CL W.B. Approach Alignment		
Station	E(X)	N(Y)
3079+44.52	1,806,896.54	614,154.58
3166+18.42	1,814,690.74	617,960.72

o *CL WB Approach Rdwy Alignment – Program Generated*

- Add a Horizontal Alignment named CL I-80 Median with its Initial Station, in this case 3079+44.52 in the task pane (Figure 4 – Item 3). Then enter the end point coordinates for the CL I-80 tangent line of the alignment determined above and highlighted in the Horizontal Alignment Input range (Figure 4 – Item 4).



**Staking Coordinates**

**Alignments**

Horizontal Alignments: CL I-80 Median

Initial Station: 3079+44.52

Number of PI Points: 2

Add Delete Rename

No.	E (X)	N (Y)	Radius (ft)
1	1806925.06	614096.13	
2	1814719.26	617902.31	

**Station & Offsets**

No.	Station	Offset (ft)

Figure 11 – Add CL I-80 Median Alignment

- Add a Station & Offset series named CL WB App Rdwy and a Skew angle of 0.0 in the task pane (Figure 4 – Item 3). Enter the tangent line end stations, 3079+44.52 and 3166+18.42 respectively, for the CL I-80 Median tangent line in the Station & Offsets range of the sheet (Figure 4 – Item 5) highlighted below. Also include the offset distance to the CL WB App Rdwy of -65 feet (left negative).

**Staking Coordinates**

**Station & Offsets**

Station & Offsets: CL WB App Alignment PIs

Number of Stations: 2

Skew Angle (deg.): 0.00

Add Delete Rename Copy

No.	E (X)	N (Y)	Radius (ft)
1	1806925.06	614096.13	
2	1814719.26	617902.31	

No.	Station	Offset (ft)
1	3079+44.52	-65.0000
2	3166+18.42	-65.0000

Figure 12 – Add CL WB App Rdwy Station & Offset Series

- The results for the EN coordinates of the two Offset Points that define the CL WB App Rdwy are highlighted here. The alignment points generated using the program agree closely with those computed by hand.

CL W.B. Approach Alignment			Output				
Station	E(X)	N(Y)					
3079+44.52	1,806,896.54	614,154.58					
3166+18.42	1,814,690.74	617,960.72					

Offset Point		Offset Point on Alignment			
No.	Station	Offset (ft)	E (X)	N (Y)	Prjctn. Dist. (ft)
1	3079+44.52	-65.0000	1806896.537	614154.538	65.000
2	3166+18.42	-65.0000	1814690.736	617960.717	65.000

Figure 13 – CL WB App Rdwy Alignment Output

### o Offset Points – CL Pier 1

- The first step to find the coordinates of the Offset Points on CL Pier 1 is to define the Offset Distances to the points. All Offset Distances are measured from the Station on the alignment to the desired Offset Point on the Offset Line. In this case these Offset Points are the N Edge of Deck and S Edge of Deck.

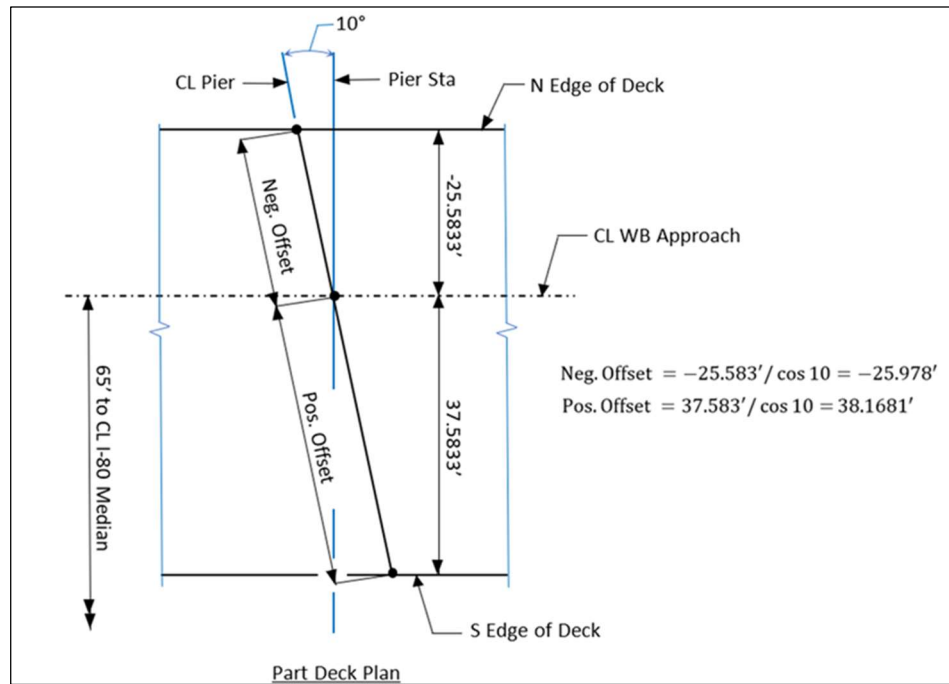


Figure 14 - Definition Program's Offset Distance

- In this example the N Edge of Deck is located 25.5833' perpendicular to left of the CL WB App Rdwy and the S Edge of Deck is located 37.5833' perpendicular to the right of the alignment. Refer to Figure 8 and 14. The program requires Offset Distances that are measured along the Offset Line to locate the desired point. In this case the CL Pier is on a 10° skew and the perpendicular offset distances must be resolved to distances measured along the CL pier. This is accomplished with basic trigonometry as shown above.

Staking Coordinates

Alignments

Station & Offsets

Horizontal Alignments

CL W.B. Rdwy.

Initial Station

3079+44.52

Number of PI Points

2

Add

Delete

Rename

Alignments

Name	Initial Station	Number Of PI Points
CL W.B. Rdwy.	3079+44.52	2

No.	E (X)	N (Y)	Radius (ft)
1	1806896.54	614154.54	
2	1814690.74	617960.72	

Station & Offsets

Name	Initial Station	Number of Stations	Skew Angle (deg.)
CL E Abut Brg		3	10.00

No.	Station	Offset (ft)
1		
2		
3		

Figure 15 – CL WB App Rdwy Horizontal Alignment

- Next, add a Station & Offset series named CL Pier 1 with three Stations and a Skew angle of 10.0° using the task pane controls (Figure 4 – Item 3). Enter the Station for CL Pier 1, 3157+37.50, for each of the Station values in the input range of the sheet (Figure 4 – Item 5). Enter the Offset Distances defined above, for the three Offset Points located on the Offset Line (CL Pier 1). The values of -25.9780, 0.0, and 38.1631 represent the Offset Distances for the N Edge of Deck, CL WB App Rdwy and S Edge of Deck, respectively.

The screenshot shows the 'Staking Coordinates' window with the 'Station & Offsets' task pane active. The task pane contains a dropdown menu set to 'CL Pier 1', a 'Number of Stations' input set to 3, and a 'Skew Angle (deg.)' input set to 10.00. Below these are buttons for 'Add', 'Delete', 'Rename', and 'Copy'. The main window displays two tables: 'Alignments' and 'Station & Offsets'.

Alignments			
Name	CL W.B. Rdwy.		
Initial Station	3079+44.52		
Number Of PI Points	2		

Station & Offsets		
Name	CL Pier 1	
Number of Stations	3	
Skew Angle (deg.)	10.00	

No.	E (X)	N (Y)	Radius (ft)
1	1806896.54	614154.54	
2	1814690.74	617960.72	

No.	Station	Offset (ft)
1	3157+37.50	-25.9780
2	3157+37.50	0.0000
3	3157+37.50	38.1631

Figure 16 – CL Pier 1 Station & Offset Series

- The results for the coordinates and station for the Offset Points on CL Pier 1 are shown here. Refer to Figure 3, Program Output Identification for output definitions.

Output								
		Alignment Name		CL W.B. Rdwy.				
		Station & Offsets Name		CL Pier 1				
		Skew Angle (deg)		10.00				
No.	Station	Offset (ft)	Offset Point			Offset Point on Alignment		
			E (X)	N (Y)	Station	E (X)	N (Y)	Prjctn. Dist. (ft)
1	3157+37.50	-25.9780	1813883.879	617595.171	3157+32.99	1813895.105	617572.183	25.583
2	3157+37.50	0.0000	1813899.159	617574.162	3157+37.50	1813899.159	617574.162	0.000
3	3157+37.50	38.1631	1813921.605	617543.299	3157+44.13	1813905.114	617577.070	37.583

Figure 17 – CL Pier 1 Offset Points Output