Geospatial Acquisition Technologies in Design and Construction

Construction Surveying Observations

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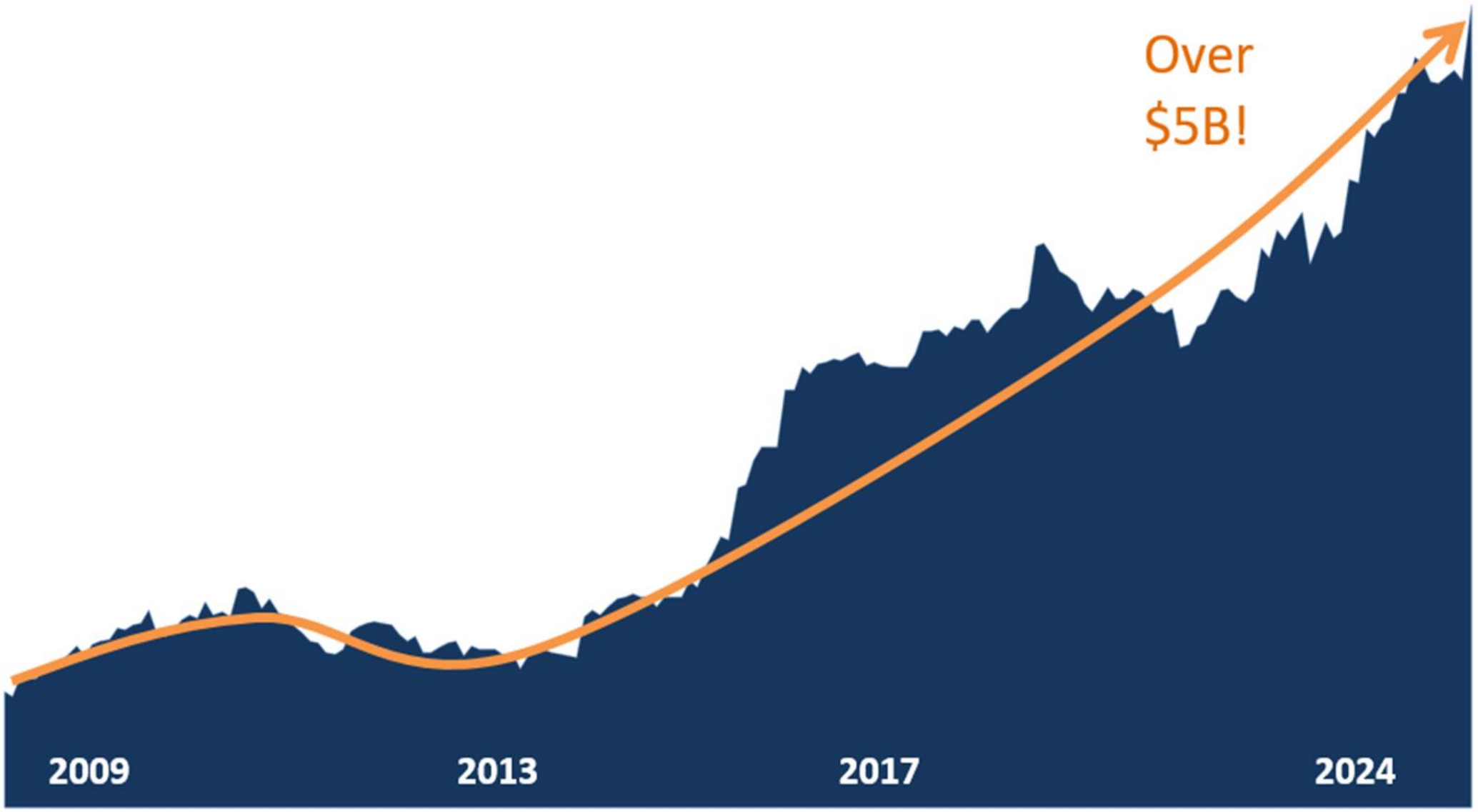
SCDOT has Dramatically Increased its Work Program



Evolving Data Acquisition Technologies

- Robotic Total Stations – Terrestrial Scanners
- GPS – Statewide Virtual Reference Systems (VRS) – Base and Rover
- MAS - Aerial LiDAR and Imagery
- UAS - Aerial LiDAR and Imagery
- Mobile Scanning
- Data Collectors and Tablets

Evolving Construction Surveying Technologies

- 3D Construction Models
- Automated Machine Guidance (AMG)
- Robotic Total Stations
- GPS: Virtual Reference Systems, Base and Rover, Millimeter
- UAS: Aerial LiDAR and Imagery – Borrow Pits
- Mobile Scanning
- Data Collectors and Tablets
- Paint Striping

Everything is Perfect… or is it?

For Discussion

- Widening Project - LiDAR
- Cross Slope Correction – Mobile Scanning
- As-Built Plans – Data Capture
- Updates and Revisions
- “Typos”

US 701 Widening Project
Loris, SC

- Letting Fall 2022 - Approx 1.5 Miles Long
- Widening Project - Mostly from 2 to 5 Lanes
- Tapers / Turning Lanes / Storage Areas
- Concrete Median in areas
- Curb and Gutter, Sidewalk, Pedestrian Ramps
- **Original Survey – Completed Fall 2018 – LiDAR**
- Survey met all State and ASPRS positional accuracy standards for Geospatial data (Ed.1,V.1 – Nov 2014)

BIM: Age of Control, Encroachment Permits, Overlay, etc.
The phone call – cuts of 3,3 ½ , 4”. Verify with contractor?

US 701 Widening Project

Preparing for the LiDAR Survey

Survey Control Methodology

The Survey Control Network developed for this project is based on South Carolina State Plane Grid coordinates with the horizontal values based on NAD 83/2011 and the vertical based on NAVD 88. Horizontal coordinates were established using the SC Virtual Reference Network (SCVRN) GPS system which allows for real-time corrected GPS locations. Each target and monument check point was observed for a minimum of three minutes. Vertical elevation values were established from the SCVRN as no NGS monuments were recovered in the vicinity of this project. Each target was elevated using differential leveling methods.

US 701 Widening Project

Preconstruction Survey Information

Level Loop Information:

- The maximum allowable error of closure for differential leveling surveys is 0.05’ X $\sqrt{M}$, where M = the number of miles in the level loop.
- Length of the Project: 1.8 Miles

Closure Calculation:

.05’ X $\sqrt{1.8M}$ = **0.07’**(Rounded)

.05’ X $\sqrt{(1.8M*2)}$ = **0.09’**(Rounded)

Closure for a 1000’ level loop = 0.02’

US 701 Widening Project

LiDAR Collection Information

- Craft: Bell 206L-3 Helicopter
- Altitude: 600’
- Overlap: 50%
- Scanner: RIEGL VQ-480i
- Pulse Rate: 300khz
- PPM: 30+
- Speed: 60kts

US 701 Widening Project

Project File	[redacted] LiDAR Control Report, US701 Widening – North Loris (1.8 miles), Horry County, SC
Project Unit	NAD83 - State Plane Coordinate System South Carolina - NAVD88 - International Feet
Requirement Type	RMSE(z)
RMSE(z) Objective	0.05-0.1 ft.
Control Points in Report	23
Elevation Calculation Method	Global Mapper Bare Earth Extraction
Control Points with LiDAR Coverage	13
Average Control Error Reported	0.016
Maximum (highest) Control Error Reported	0.099
Median Control Error Reported	0.052
Minimum (lowest) Control Error Reported	0.025
Standard deviation (sigma) of Error for sample	0.063
RMSE of Error for sample (RMSE(z))	0.062
NSSDA Achievable Contour Interval	0.2
ASPRS Class 1 Achievable Contour Interval	0.2
NMAS Achievable Contour Interval	0.2

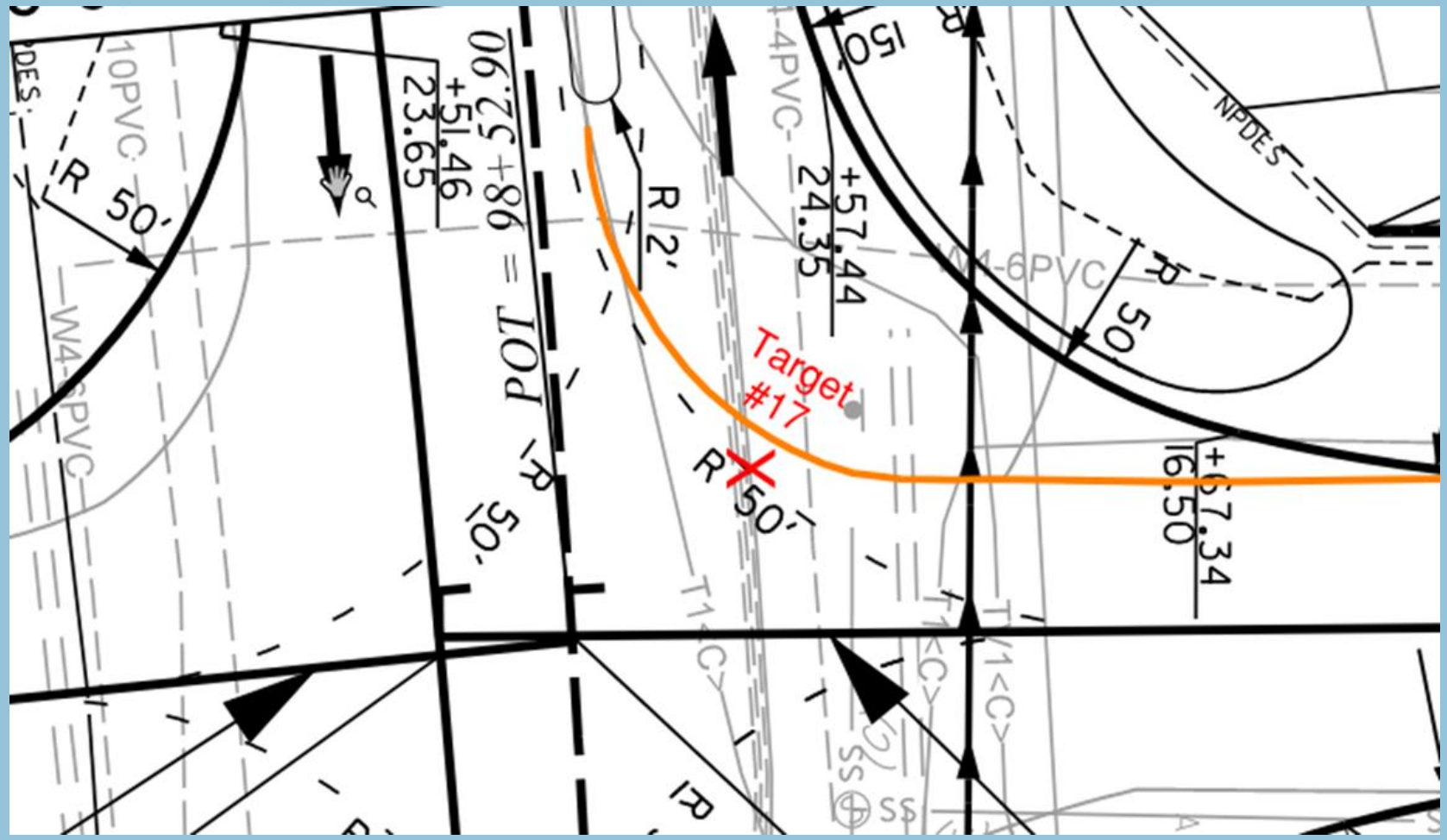
Table 2 LiDAR Control Summary

US 701 Widening Project

Preconstruction Survey Information

PID	Y control	X control	Control Point Z	Z from LiDAR	Z Error
TGT_20	2232763.676	564159.600	99.298	99.397	0.099
TGT_17 *	2235509.136	563159.945	102.298 *	102.206 *	0.092
TGT_06	2238486.689	562128.593	109.038	109.120	0.082
TGT_11	2241270.774	559987.589	108.368	108.300	0.068
TGT_13	2243590.257	558367.308	106.508	106.442	0.066
TGT_14	2246642.826	557752.701	105.328	105.393	0.065
TGT_03	2249794.242	556701.769	95.892	95.944	0.052
TGT_18	2252099.794	555693.002	102.758	102.708	0.050
TGT_04	2254549.000	554126.978	95.413	95.463	0.050
TGT_10	2256962.853	552777.325	109.908	109.953	0.045
TGT_08	2260876.184	551709.550	108.718	108.753	0.035
TGT_12 *	2261375.626	550527.144	108.348 *	108.373 *	0.025
TGT_05 *	2260234.374	548380.085	108.608 *	108.633 *	0.025

US 701 Widening Project

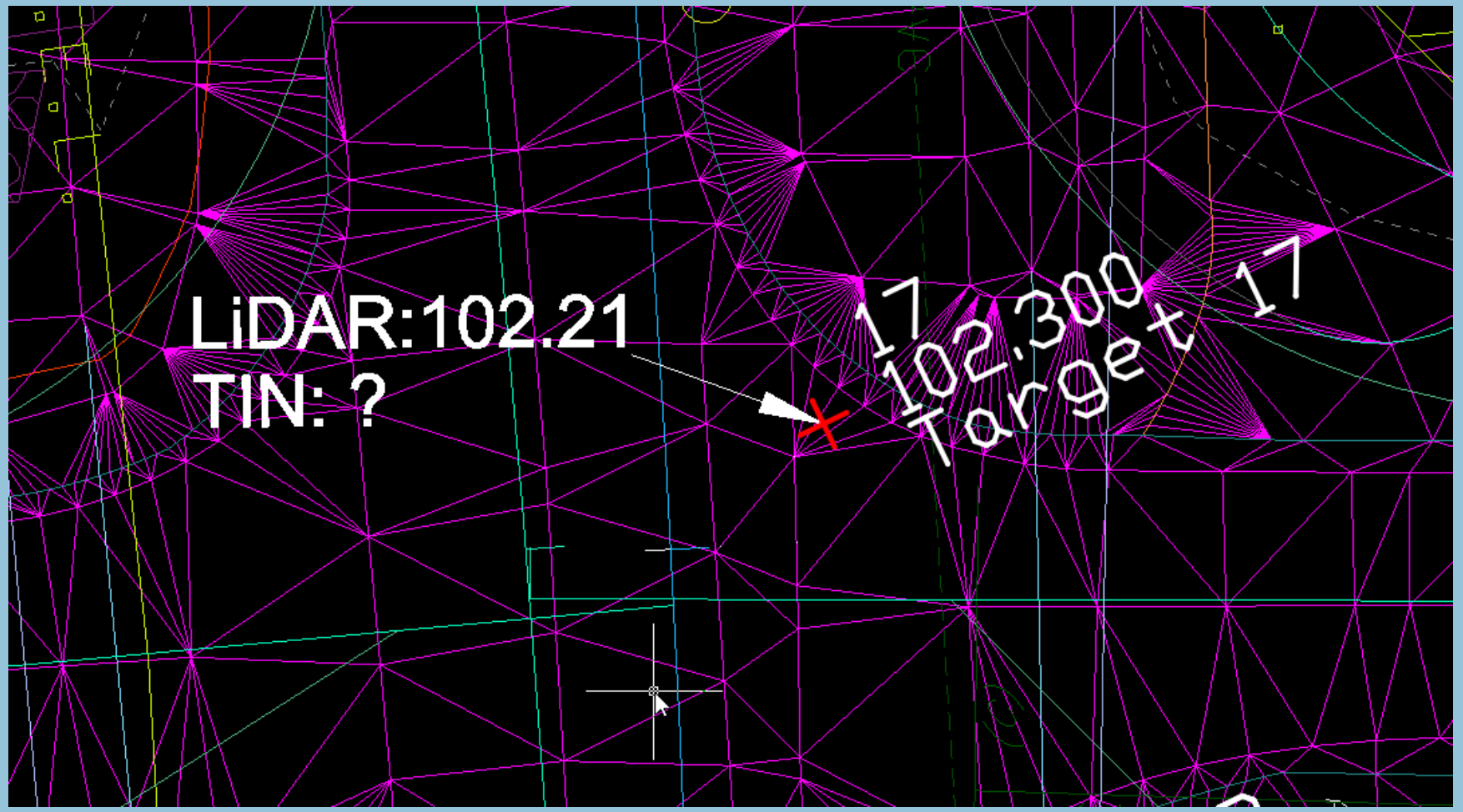


US 701 Widening Project

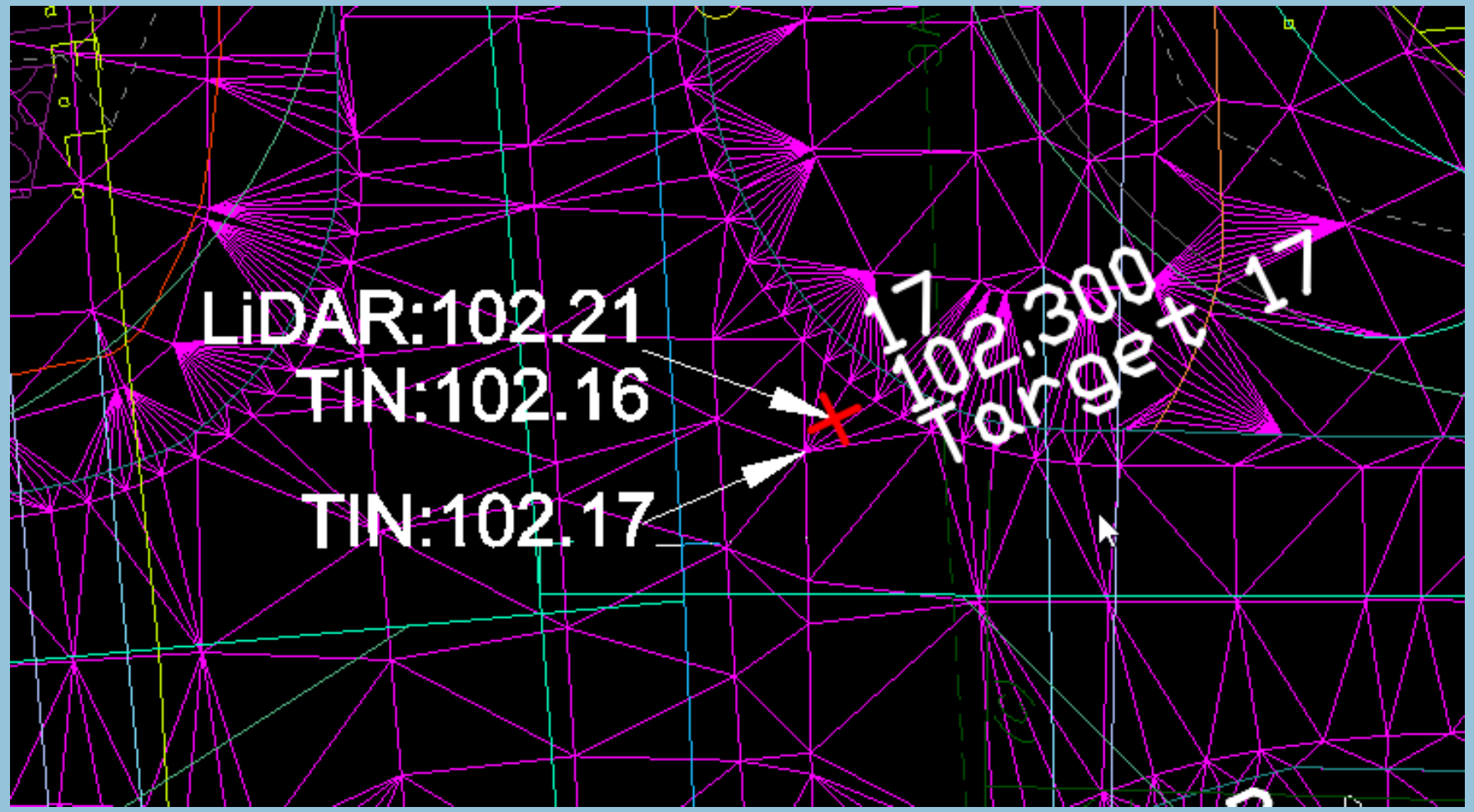
Example Control/Panel Point

US 701 Widening Project

Any guesses what the TIN elevation is?



US 701 Widening Project



US 701 Widening Project

The Surface is not Adjusted to match the Control

PID	Y control	X control	Control Point Z	Z from LiDAR TIN	Z Error
TGT_20	2232763.676	564159.600	99.298	99.397	0.099
TGT_17 *	2235509.136	563159.945	102.298 *	102.206 102.16	0.092
TGT_06	2238486.689	562128.593	109.038	109.120	0.082
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TGT_08	2260876.184	551709.550	108.718	108.753	0.035
TGT_12 *	2261375.626	550527.144	108.348 *	108.373 108.24	0.025
TGT_05 *	2260234.374	548380.085	108.608 *	108.633 108.51	0.025

The Differences Have To Be Made Up Somewhere.

Affects Construction Staking, Quantities, and subsequently, Pay Items.

- Milling – Example: 5000sy (2”) 2000sy (Var.)
- Asphalt
- Borrow

The Differences Have To Be Made Up Somewhere.

Milling Example

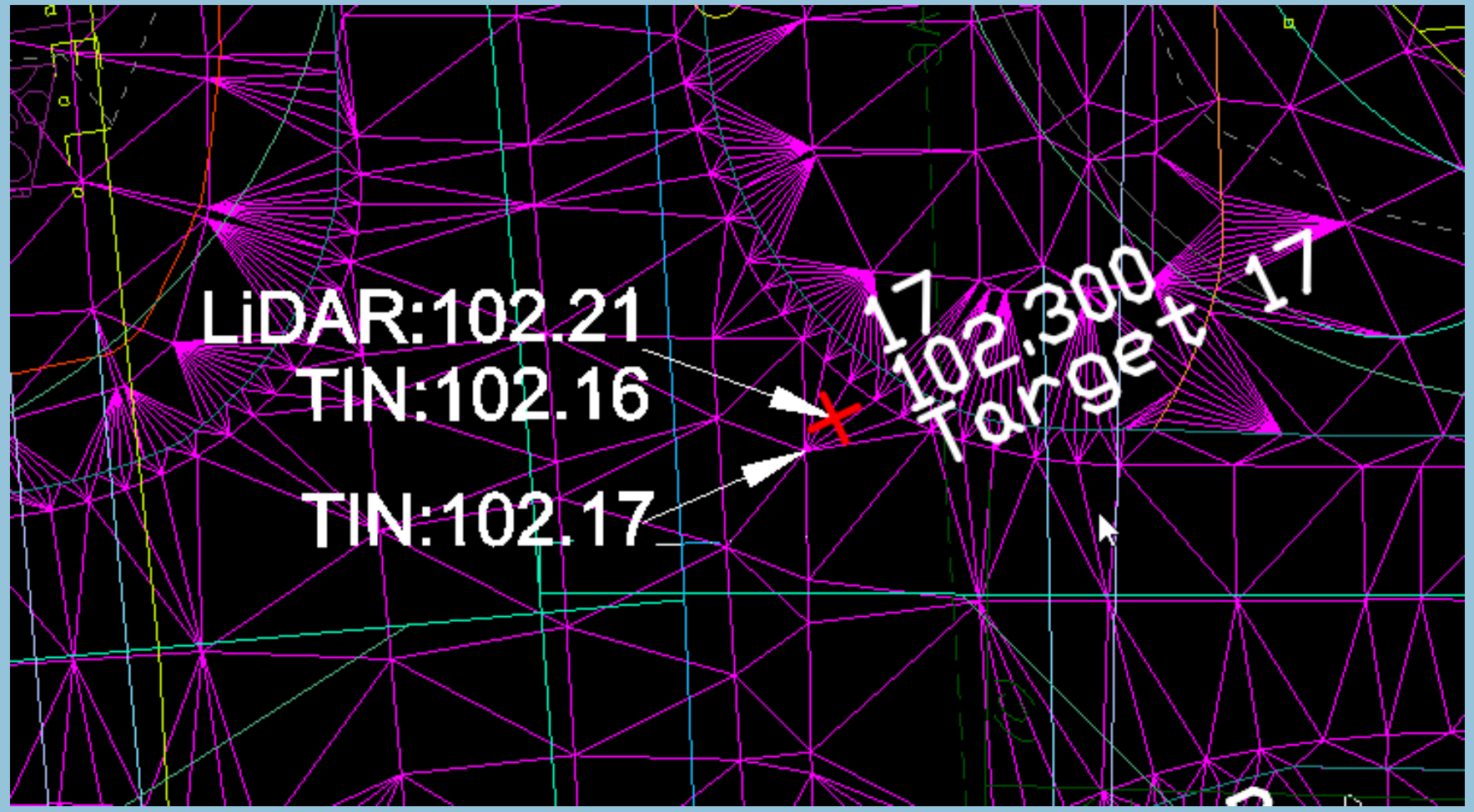
- Estimated Qty's: 5000sy (2") 2000sy (Var.)
- Bid Pricing: 2"=$3/sy, Var.=$10/sy
- Bid Total = $35,000
- If all milling considered Var: $70,000

US 701 Widening Project

Observations - Conclusions

- Contractors and Construction Surveyors are going to use the published coordinates and elevations for the control points, panel points, and benchmarks found in the plans.
- The Surface and Panel points have a relationship, but is it accurate enough for hard (paved) surfaces? Processing the TIN.
- Opinion: The surface should be adjusted to match the control point elevations used to create the surface.

Adjust the TIN to match the Elevations of the Targets.

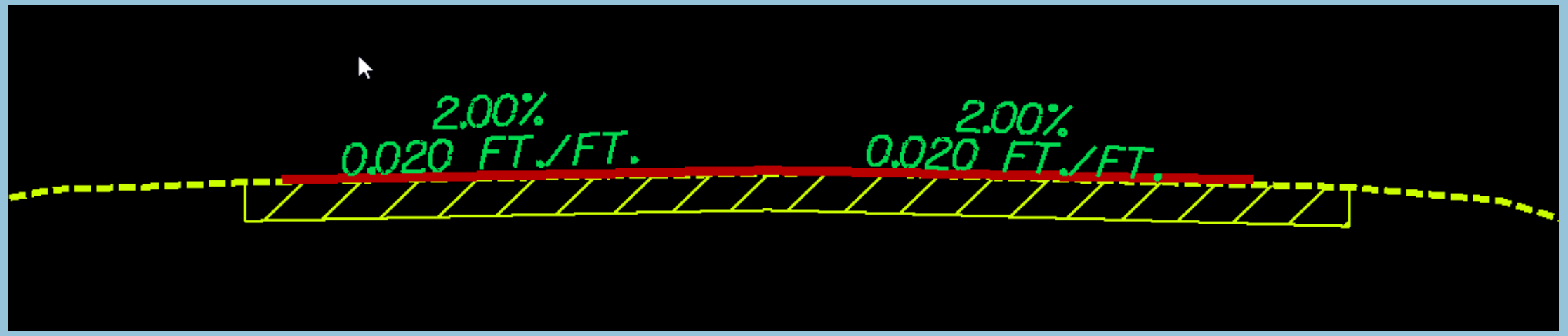


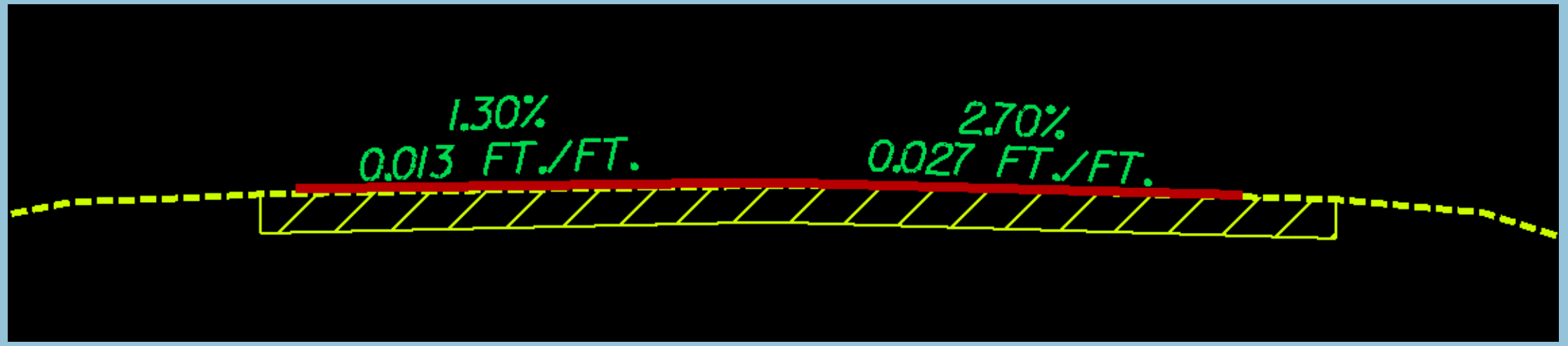
Cross Slope Correction Mobile Scanning Interstate Routes

Cross Slope Correction – Mobile Scanning
Interstate Routes

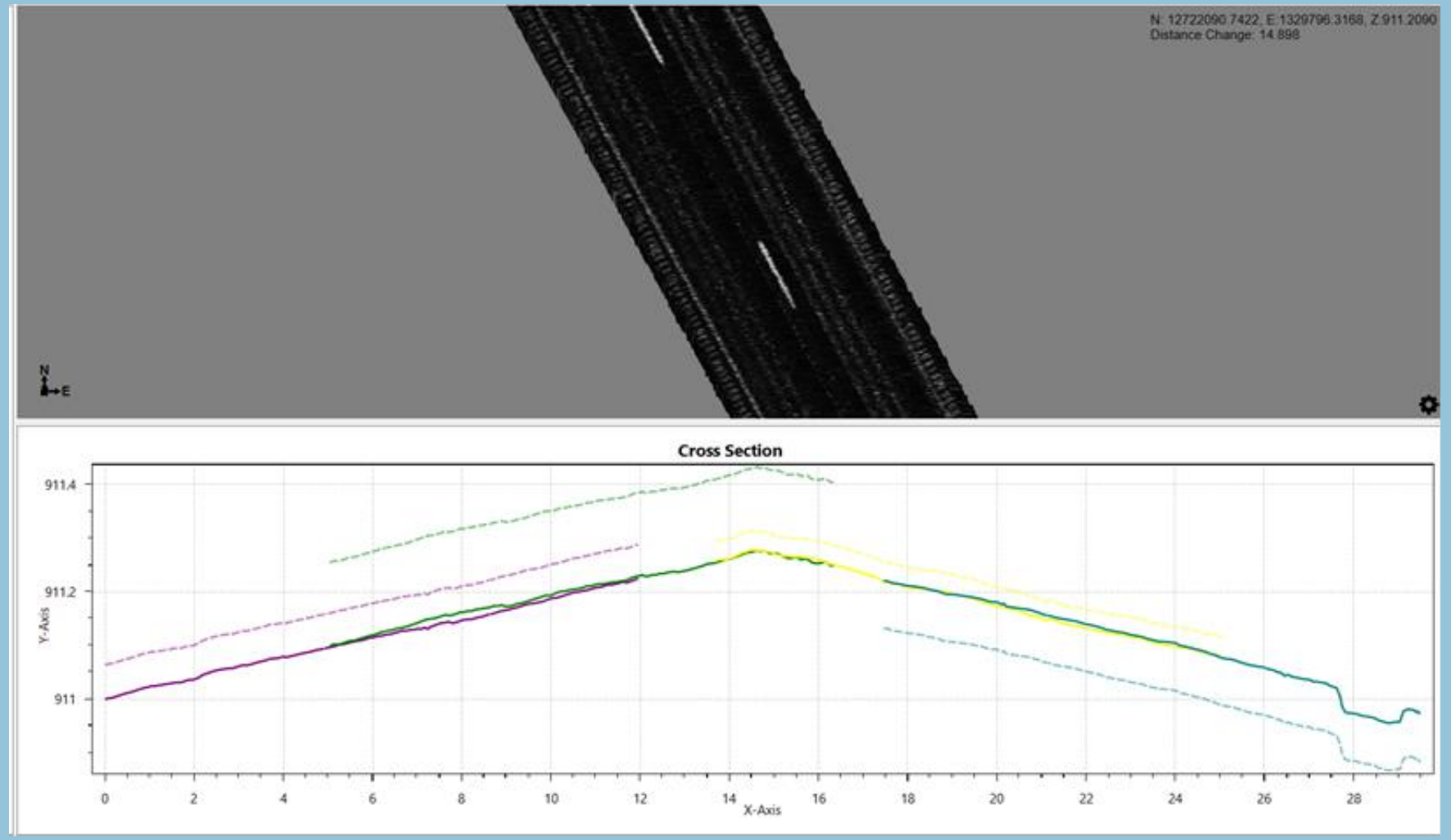
Cross Slope Correction – Mobile Scanning

The difference 1” (Vert.) makes in cross slope for a 12’Lane.

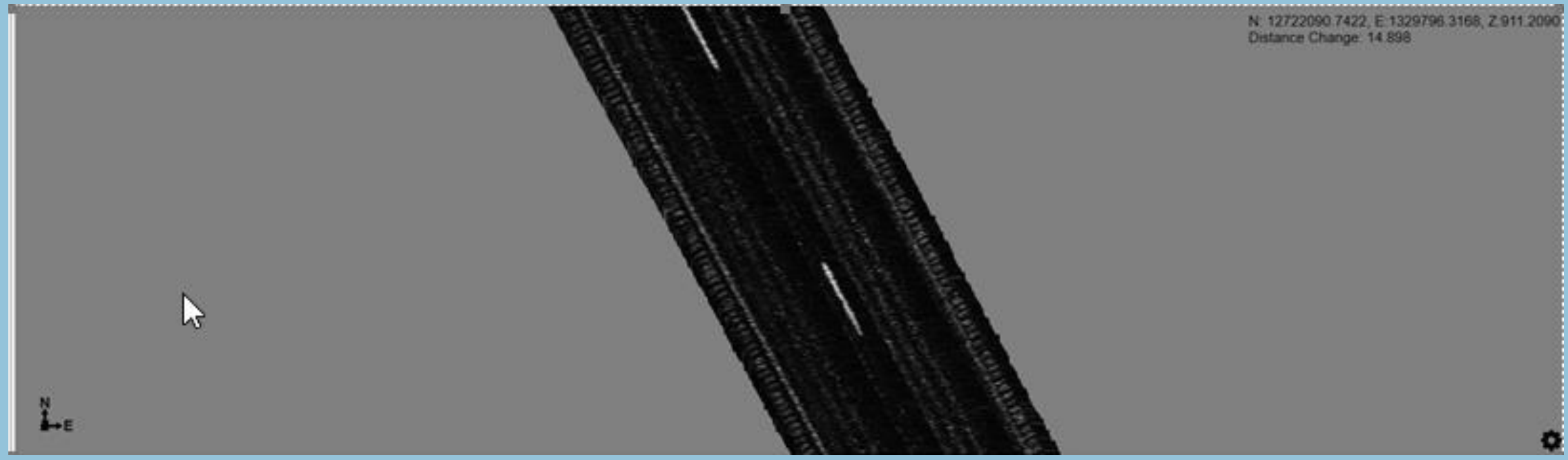




Cross Slope Correction – Mobile Scanning Interstate Routes



Cross Slope Correction – Mobile Scanning
Interstate Routes



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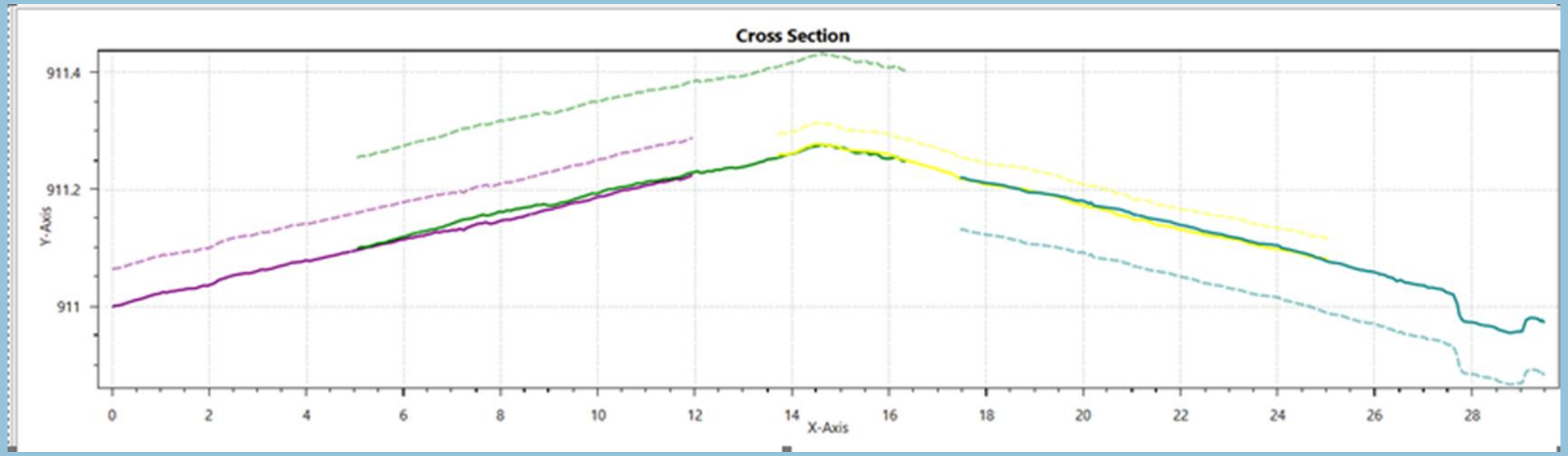

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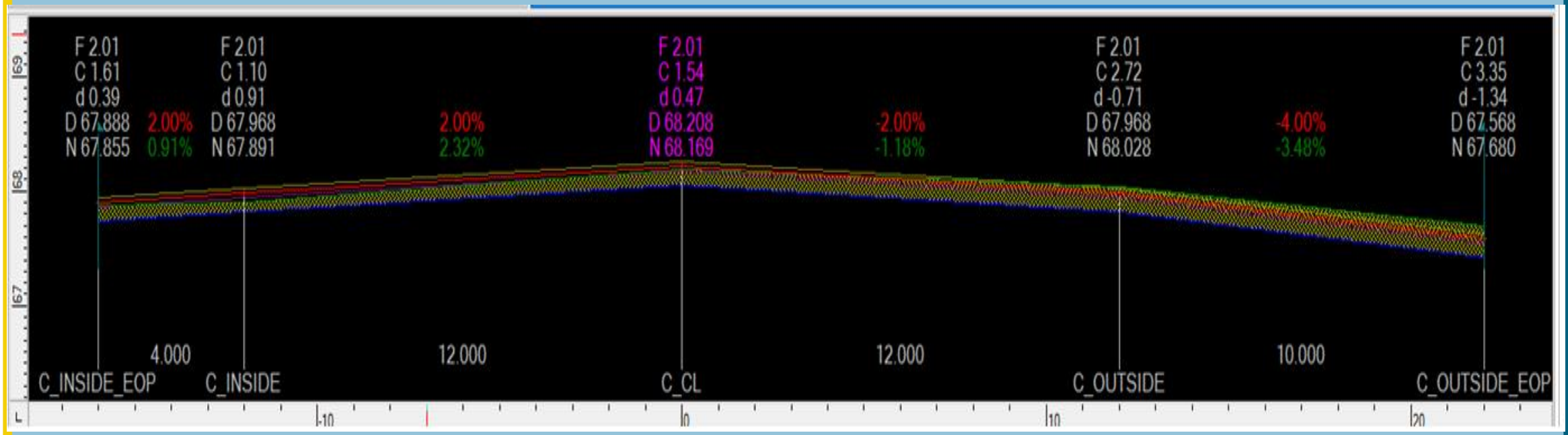
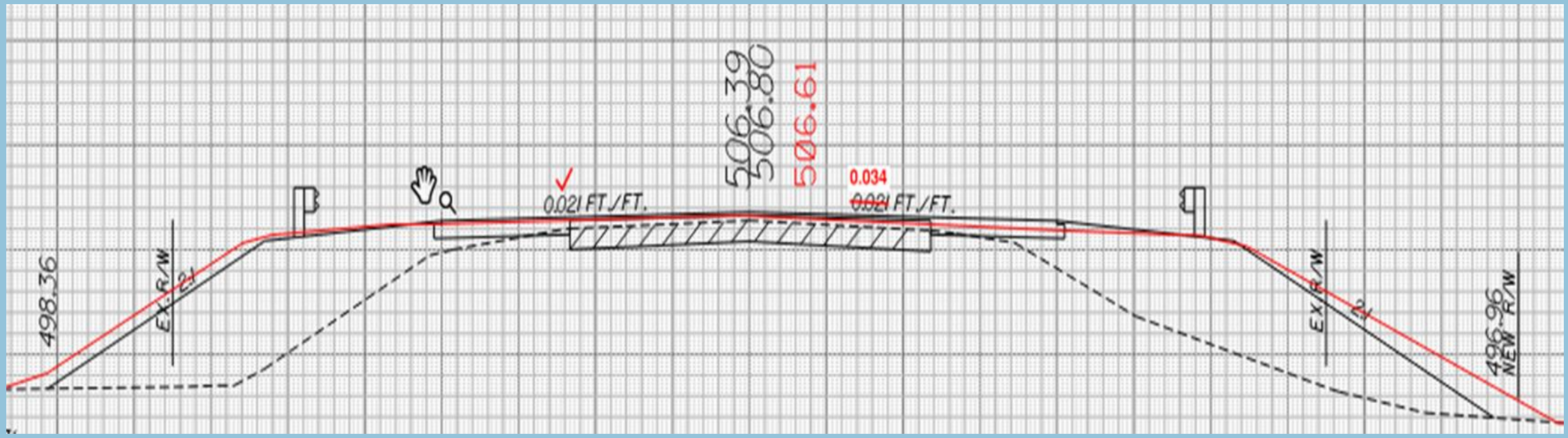
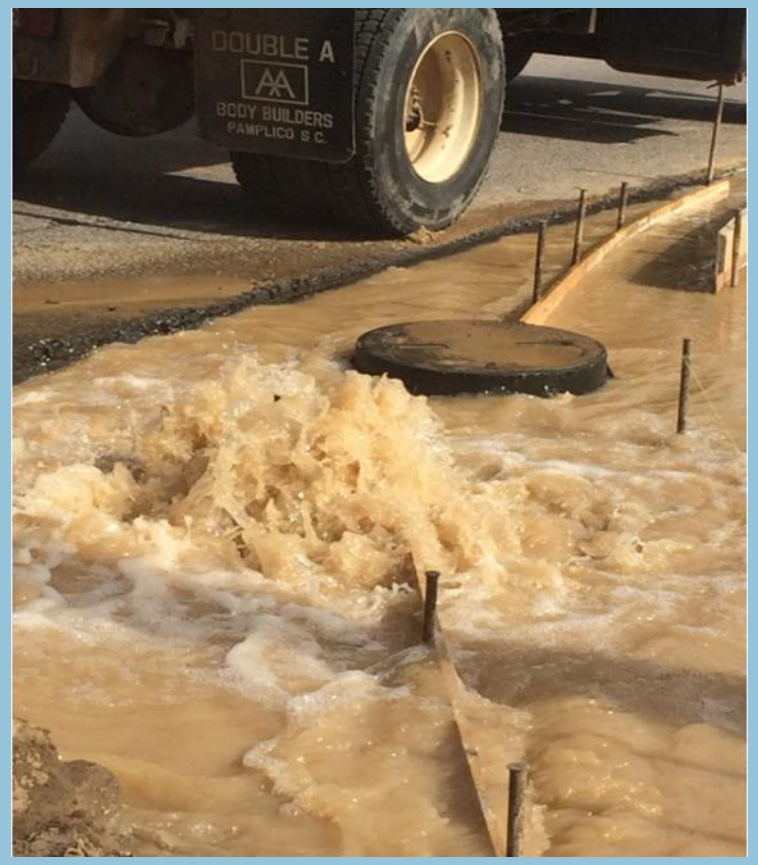


Cross Slope Correction – Mobile Scanning Interstate Routes

As-Built Plans – Data Capture

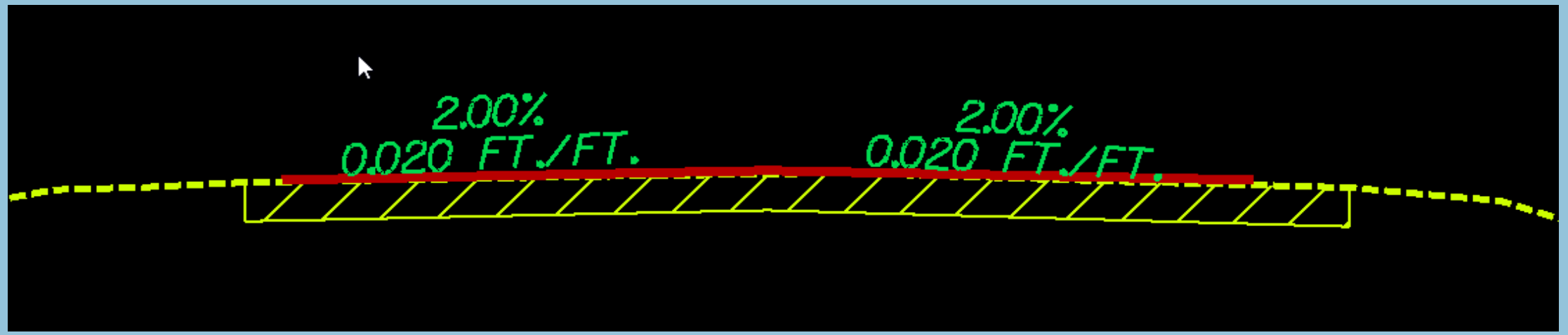


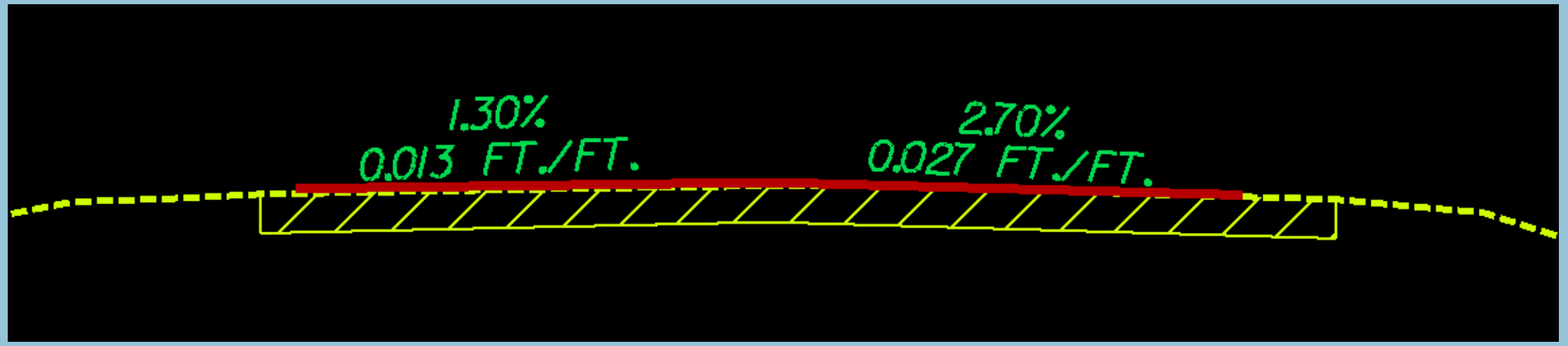
The Importance of Accurate As-Built Information



I have been the victim of poor as-builts.

As-Built Plans – Data Capture
The difference 1” makes in cross slope – 12’Lane.





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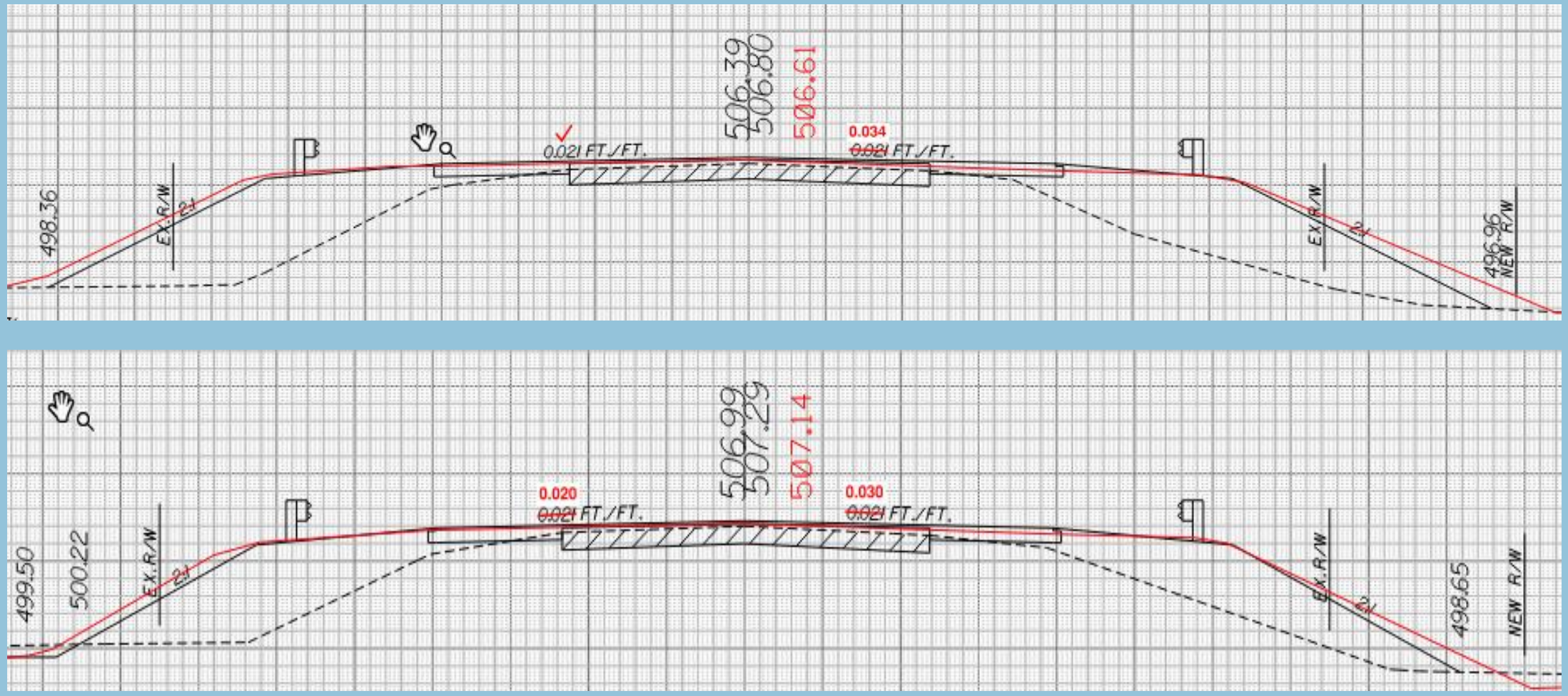

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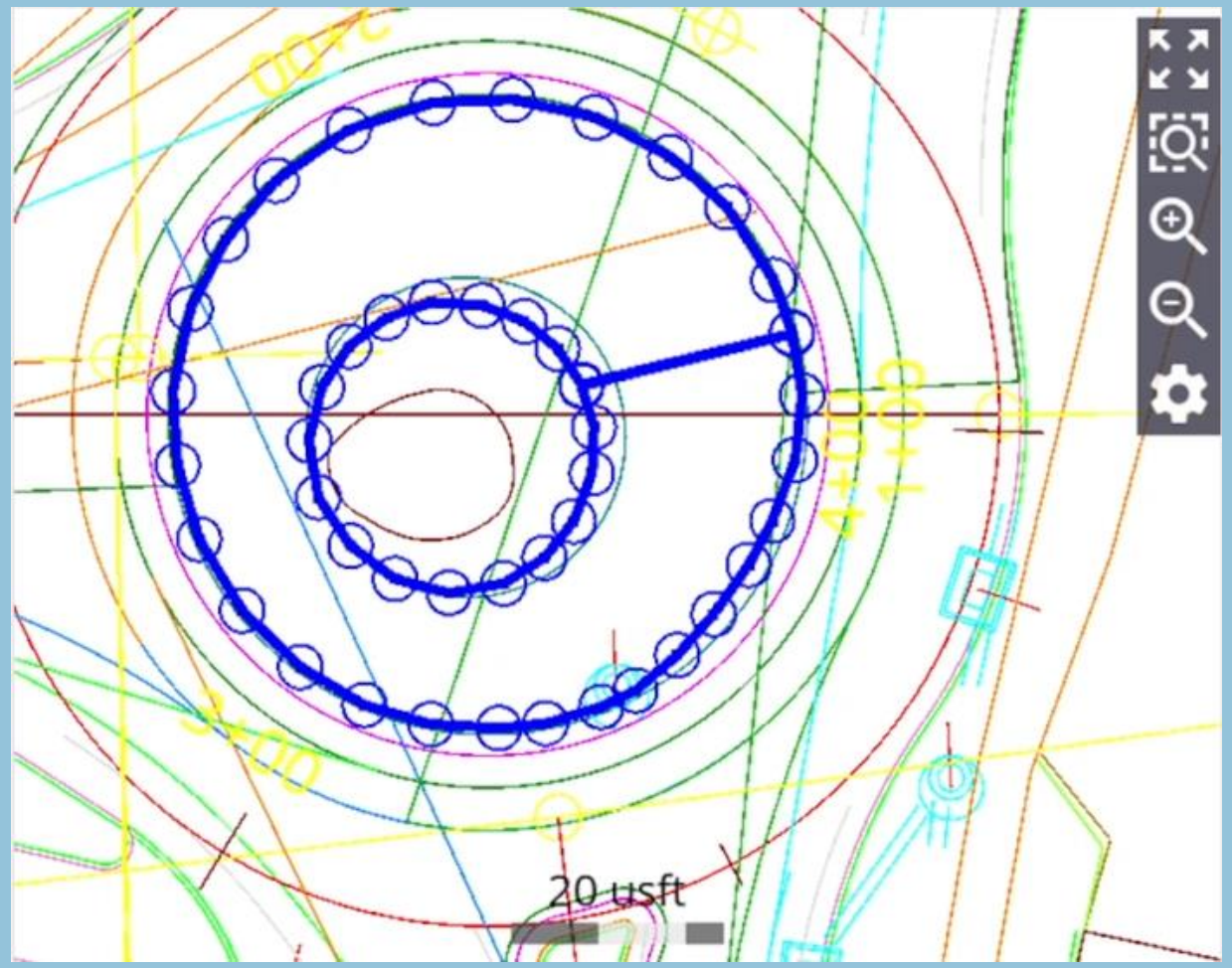
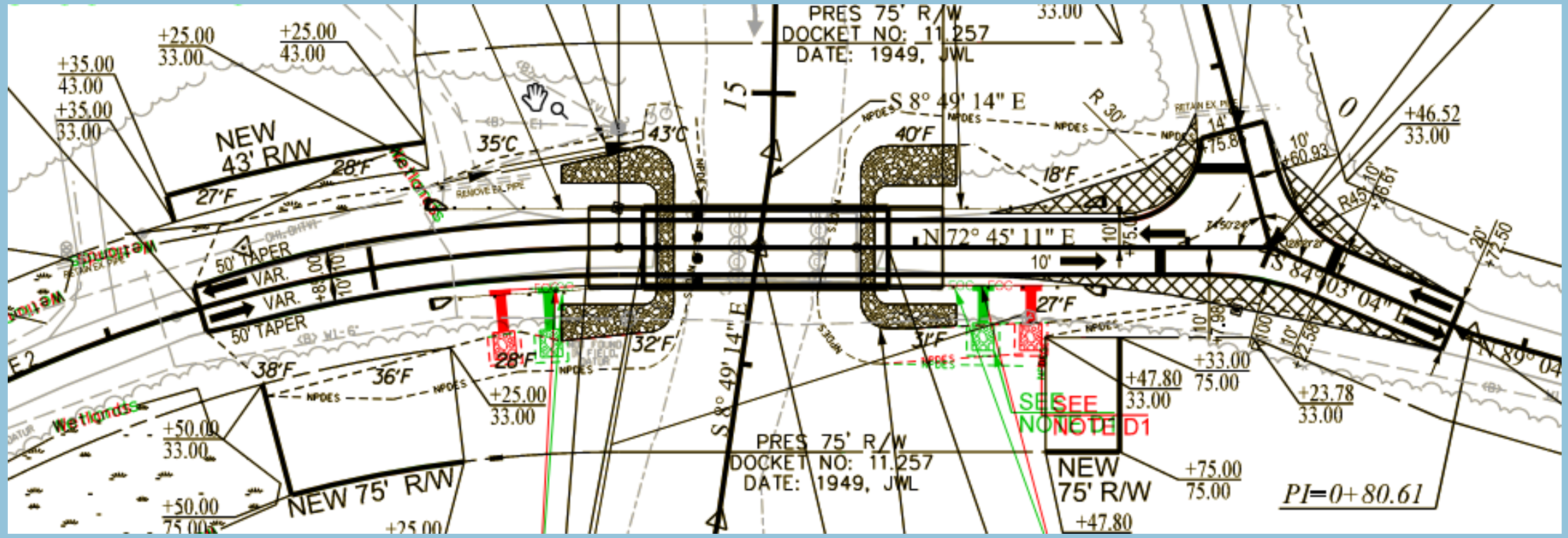
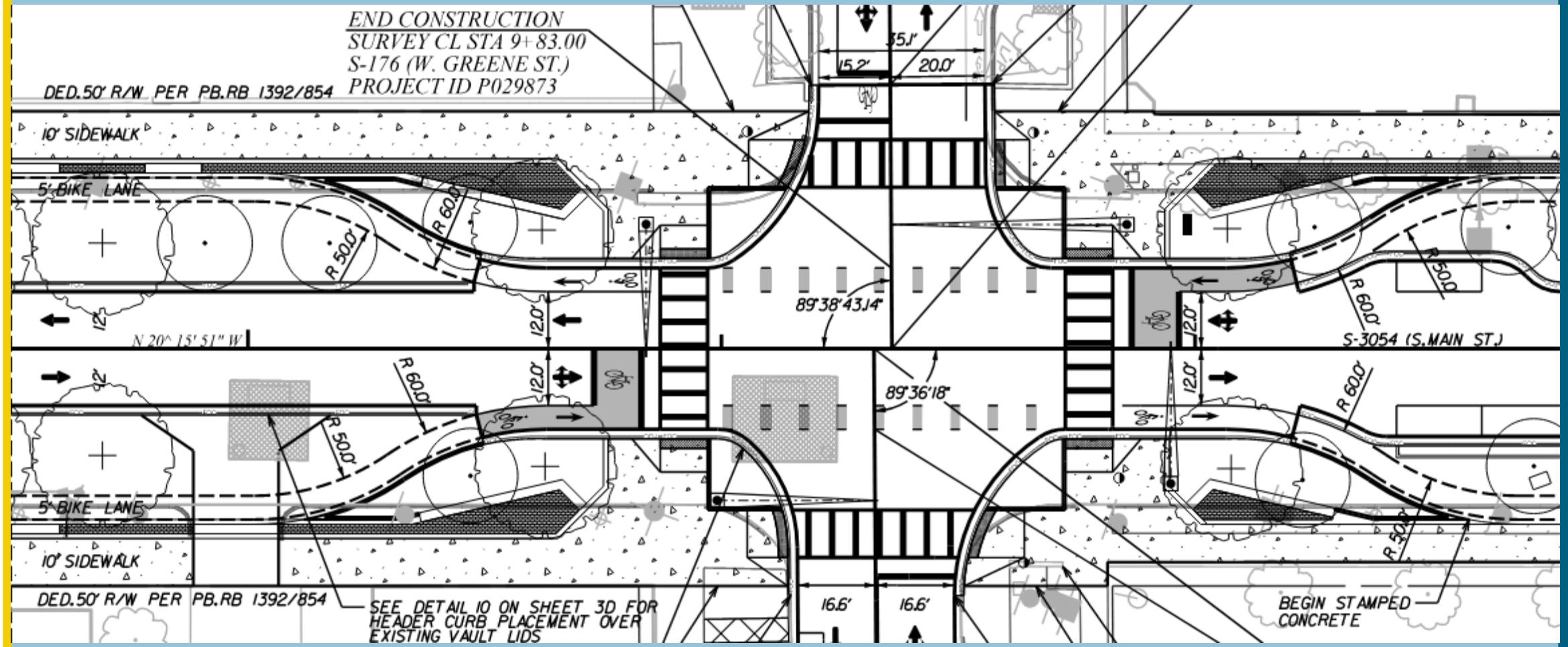


Updates and Revisions
Plan Sheets / CAD Files / Model



Updates and Revisions
Old Plan Sheet



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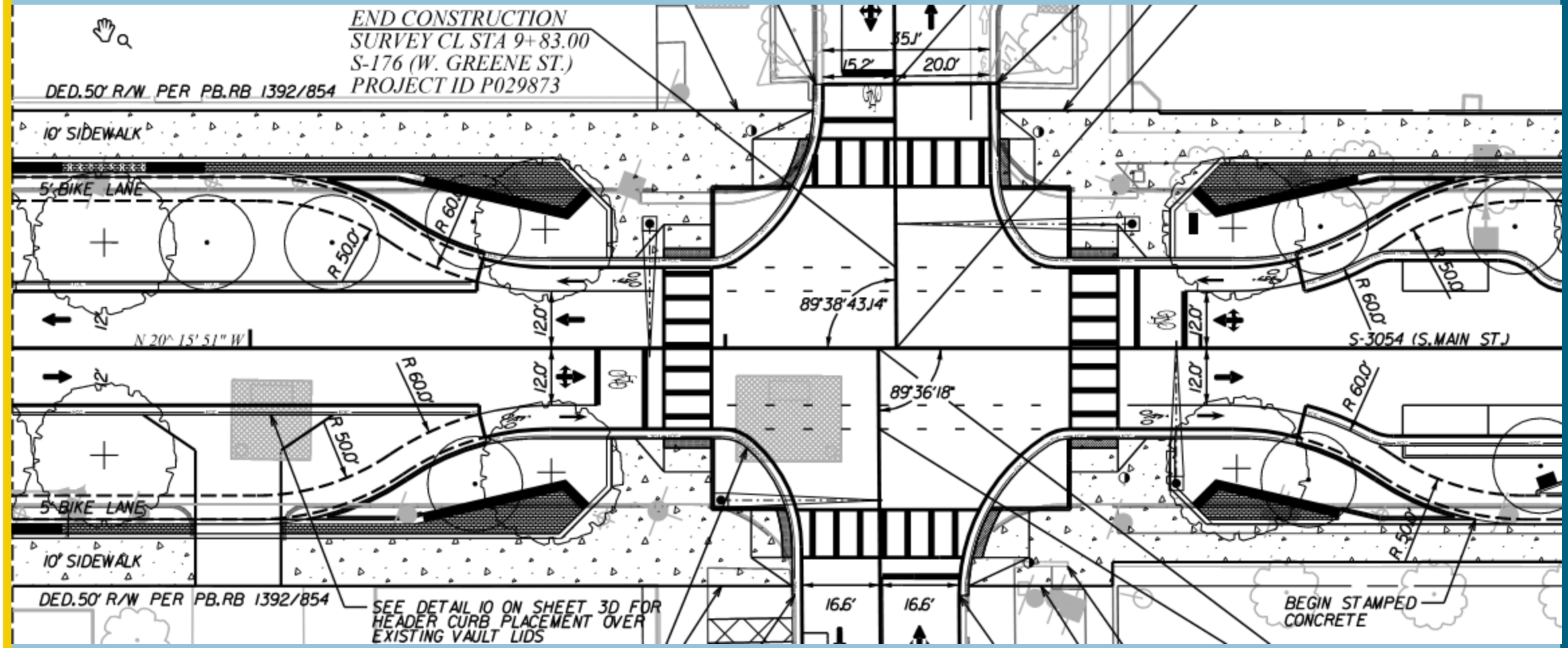
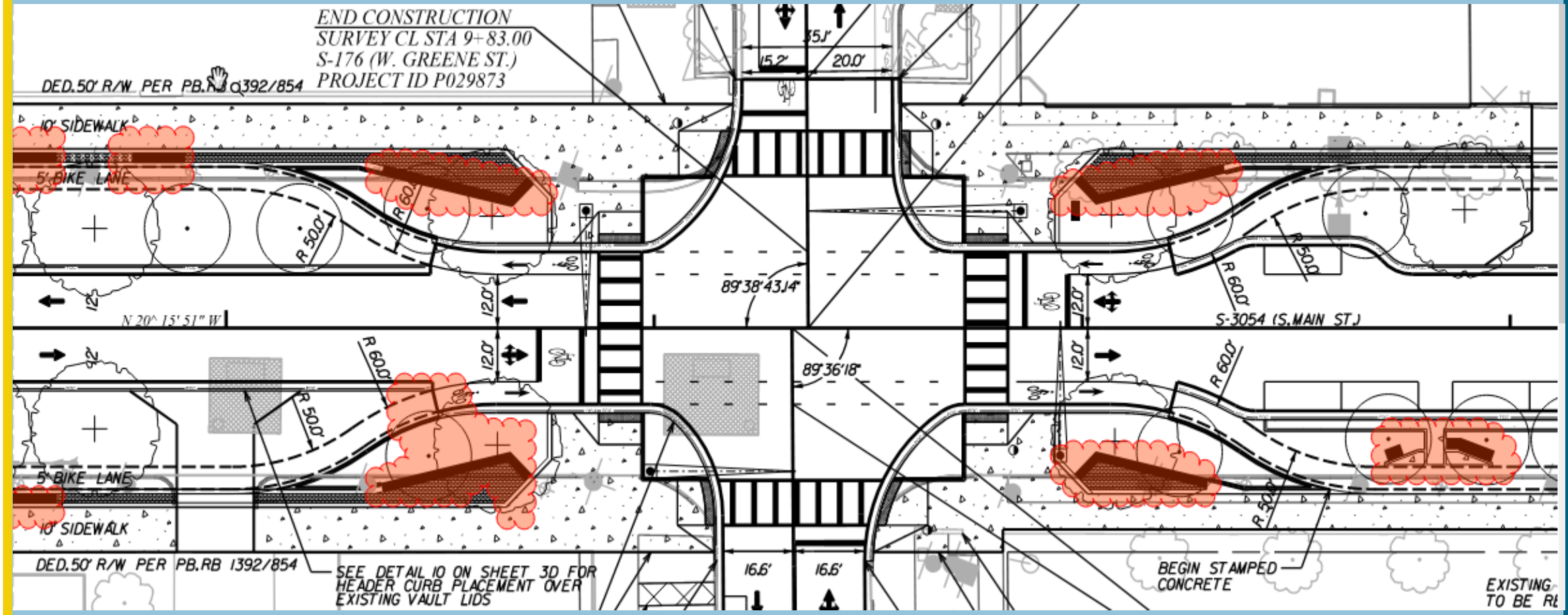
New Plan Sheet



Revisions Clouded in Bluebeam

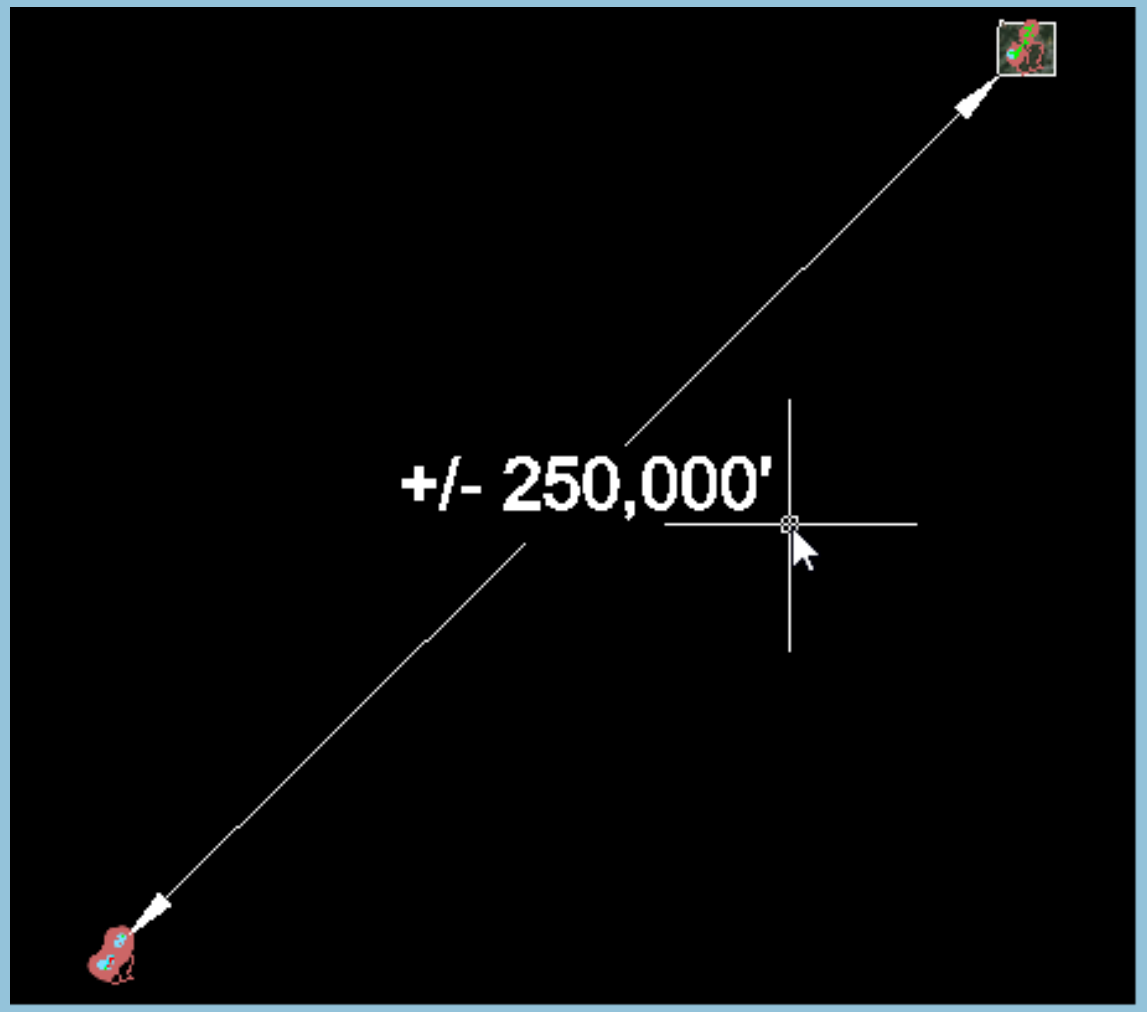


“Typos” in Construction

CONTROL POINTS - S-II-49 EXIST.		
	NORTHING (Y)	EASTING (X)
POT = 66+06.22	1,185,973.605	1,820,068.552
PC = 68+21.13	1,186,109.347	1,820,235.162
PI = 71+63.23	1,186,325.432	1,820,500.387
PT = 75+04.59	1,186,570.409	1,820,739.182
PC = 78+20.98	1,186,796.966	1,820,960.023
PI = 79+58.86	1,186,895.704	1,821,056.270
PT = 80+91.05	1,186,936.587	1,821,187.956
POT = 83+30.56	1,187,007.599	1,821,416.697
PC = 86+70.92	1,186,109.347	1,821,234.283
PI = 87+38.53	1,187,352.034	1,821,198.053
PT = 87+89.62	1,187,406.657	1,821,237.884

1,187,294.9593

“Typos” in Construction



Construction Surveying Challenges

Be Aware (Beware)…

- of the Equipment’s Capabilities
- of the Data you are collecting or using.
- of how this information gets utilized or portrayed in the plans / model / as-built plans.

Geospatial Acquisition Technologies in Design and Construction

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