Semester Design Project

CEE 4600 Transportation Planning and Design

Section D3, Group 4

Submitted to:
Dr. James Tsai & Lucas Yu

by:
Zhiwen Wei
Freyja A Brandel-Tanis
Ryan Foster

Due Date: April 16, 2020

ZRF Engineering

3000 Atlantic Drive
Atlanta, GA 30332
February 20, 2020

Dr. James Tsai
Georgia Institute of Technology
School of Civil and Environmental Engineering
790 Atlantic Dr.
Atlanta, GA 30332

Dear Dr. Tsai,

Accompanying this letter is the final design for the project that you requested on the Navy Ave Extension. The report provides an analysis of all three featured intersections and their signalization; the horizontal curvature and necessary superelevation of the road; the vertical curvature of the road; cross sections for typical sections, a horizontal curve, and the bridge; signage and markings at intersections, and how the mixed-use path along the Navy Ave extension connects to the mixed-use path that runs along the railway under the bridge.

Our design team used lecture slides, the MUTCD, AASHTO Green Book, AASHTO Guide to the Development of Bicycle Facilities, various GDOT manuals, and USDOT's Rails with Trails: Lessons Learned report to produce a compliant design that will serve the existing and future communities of the design area. The report includes an executive summary of the design, a procedural overview, checklist components, and concludes with a discussion on lessons learned throughout the design process. In addition, the report includes an appendix with reports, CAD drawings, supplementary tables, and further notes on the process.

If you have any comments or questions, please do not hesitate to contact us.

Sincerely,

Zhiwen Wei	Freyja A Brandel-Tanis	Ryan Foster
zwei79@gatech.edu	freyja.alice@gatech.edu	rfoster38@gatech.edu
/s Zhiwen Wei		/s Ryan Foster

Table of Contents

List of Figures

List of Tables

List of Equations

1 Executive Summary

This report describes the design of the Navy avenue extension from Gold street to White and Buzz streets. The objective of the extension is to relieve the lengthy detour from the current 3-way intersection of Gold Street and Navy Avenue. The extension is designed to provide enough capacity for the vehicle volume demand in a cost-effective way. Maintaining the safety and comfort of drivers is the primary goal of the design.

A full set of signal warrant analysis, left turn phase analysis, and turn bay analysis for all three intersection are included in this report.

There are two proposed horizontal curves with radius of 500ft, all of which used a more conservative radius of curvature than the minimum that is required to increase driver comfort. Superelevation designs are included in this report and essential stations are shown in the horizontal alignment plan.

The vertical alignment spans from an elevation of 930ft to 962.11ft over a total of 12 curves. Landscape curvature was obtained by interpolating the stations at elevations between contour lines. The decision was made to make all horizontal curves and intersections on level ground rather than coordinate the vertical and horizontal curves and to facilitate sight distance. The bridge is designed to slightly exceed the minimum clearance of 25ft, and a standard it clears for 50ft.

The typical cross section of road has a U-shaped median with a slope of 1:6. The shared-use path has a 12ft width with 2’ 6% cross-slope shoulders on each side. There are 5ft buffer zones on each side of the trail, creating necessary space between pedestrians and vehicles the slope of the terrain. The cross sections plans are included in this report and the conform to a 175ft right-of-way for the length of the project, with the exception of an expanded 220ft right-of-way for the bridge.

The proposed roadway ties into the multi-use path that runs along the railroad, at-grade. The proposed connection between the Navy avenue extension and the multi-use path is included in this report.

Signing and marking plans for all three intersections are included in this report. All signings and markings satisfy the MUTCD guidelines.

2 Introduction

The Gold street and Navy avenue intersection and the White street and Buzz street intersection are not directly connected although both are used heavily, especially during peak hours. Drivers attempting to travel between the two intersections currently must travel over 10,000 ft. To provide an efficient route, the extension of Navy avenue has been proposed.

The proposed roadway goes over a railroad track that transverses the land in N-S direction. The mixed-use path along the proposed roadway allows pedestrian and bicycle traffic to connect to and enjoy the convenience of an existing N-S trail and shorten their travel distance between the intersections.

Our team focused on designing the roadway alignment that is cost-effective and supports the current traffic demands. Furthermore, in consideration of the safety and comfort of the drivers on the roadway, conservative measures in determining sight distance, horizontal curve components such as the radius, degree, and the length of the curve, and vertical curve components such as curve length and tangent grades are taken.

This Page Intentionaly Left Blank

3 Procedure

3.1 Intersection Layout

In the design of the Navy avenue extension, there were certain requirements that needed to be met. The extension of Navy avenue needed to be designed as a 4-lane urban collector with 12ft lanes. The design speed for the road needed to be 35mph, with a 30mph posted speed limit. The peak hour factor was designated as 0.95, and the percentage of truck was 2%, the maximum rate of superelevation was 6%. The maximum vertical grade is 10%.

In the design of the two signalized intersections, there were additional requirements that needed to be met. For each intersection, the design team was provided hourly vehicle volumes during the AM and PM peak periods. The design of Navy avenue extension needed to accommodate these vehicles with minimum levels of service: E per movement, D per approach, and D per intersection. A 15 minutes analysis period was used for the LoS analysis. The maximum allowable volume to capacity ratio was 0.95, and right turns on red were not allowed. The cycle lengths were all adjusted to the nearest 5 seconds. Through movement phases were required to be long enough for pedestrians to cross safely. Both intersections used pre-timed signal control for all approaches. The design team has prepared a design that satisfies these requirements and ties back into the existing conditions.

For the intersection layout, the design team performed a warrant analysis for each of the three intersection. This analysis was performed using the 9 warrants provided in the chapter 4c of the MUTCD. The result determined whether each intersection would be signalized or unsignalized. The designers used the provided hourly traffic volumes during AM and PM peak periods to determine peak hour. The peak hour volumes were plugged into Synchro, along with other pertinent information. By using Synchro, the intersections layout and signal timing were adjusted to achieve the requirements. Once a satisfactory layout was achieved, a dual-ring diagram was drawn, and Synchro reports were created. The design team also used GDOT's left turn phasing policy and FDOT intersection design guide to perform a left turn phase analysis and turn bay analysis.

3.2 Horizontal Curve

To design the horizontal alignment for the Navy avenue extension, the designs first roughly sketched where the roadway would go. The alignment was chosen on several factors. It was important that the roadway did not encroach on the protected habitat area. And, the roadway connected to the driveway of the future development sites.

After having a rough idea of where the Navy avenue extension would go, the team performed calculations to determine the roadway's specific geometry. Based on the rough sketch, it was determined that the Navy avenue extension would have 2 curves. For safety purpose, the designers decided to have a radius of 500ft, which is larger than the minimum requirement. The team drew the horizontal alignment in AutoCAD, using the chosen horizontal curve radii along with stations. The chosen radii provided the necessary information to determine the actual superelevation for each curve. With AutoCAD, the team measured the curve data and used WolframAlpha to calculate the delta, tangent length, curve length, PI, PC, and PT for each curve.

3.3 Vertical Curve

For the vertical curve design, the existing ground was roughly sketched by identifying essential stations the crossed the contour lines, and the midpoints between contour lines. Linear interpolation filled in the unknown elevations, providing a satisfactory level of detail to understand the terrain enough for the project's sake. The stations and rough elevation for the railroad was marked on the existing ground sketches. There were a few requirements for the vertical alignment such as minimum bridge clearance of 25 ft, 50ft bridge span, and maximum vertical grade of 10%.

In designing the bridge, the design team elected to use a three-curve bridge to provide a crisp architectural profile to the valley. A designer created a layout of the railroad and pathway beneath the proposed bridge, relying on AASHTO guidelines and USDOT recommendations for trail placement relative to railroads. The layout determined the 50ft required clearance area, marking the stations where the bridge must exceed 25ft. Those

stations could not be the PVC and PVT and allow for the desired 6% grade on the bridge, so the PVC and PVT were found using the PVI station as the midpoint of the 50ft span.

3.4 Cross Section

The team designed a typical cross section and used it as a template for the other models. To create the cross sections for the horizontal alignment, the team first determined the elevations of the existing and proposed ground using the vertical alignment profile. These elevations were determined for every 100ft station and at important key stations in the superelevation transition. The difference between the proposed and existing elevations was used to determine if a station would be a cut or a fill condition. The process for creating the cross sections for the vertical curves was similar. Similarly, the design team used proposed and existing elevations to determine the layout for every 100ft station, the PVC and PVT stations, and the middle of the bridge.

3.5 Signing and Marking

To create the signing and marking plans, the design team used the MUTCD. Using the intersection layouts developed previously, the team determined which signs and pavement marking would be needed. Using the AutoCAD drawing of each intersection, the team determined and labeled the correct turn radii and sign stations.

This Page Intentionaly Left Blank

4 Signalization and Intersection Control

4.1 Summary

Cumulative warrant analyses result in pretimed signals at the Navy Ave/ Gold St and Navy Ave/Buzz St/White St intersections and two-way stop control at Navy Ave/Driveway, with Navy Ave freely flowing. All intersections, approaches, and movements meet or exceed the level of service requirements, as seen in Appendix 11.3. Intersection Schematics are available in Appendix Exhibit 11.5.29 through Exhibit 11.5.32

4.2 Intersection Analysis

4.2.1 Navy Ave and Gold St

4.2.1.1 Warrant analysis

For the Navy Ave and Gold Street intersection, Warrants 1 through 3 are met, because there is no pedestrian data so Warrants 4 and 5 could not be applied, Warrant 6 does not apply because there the intersection is not a part of a coordinated signal system, and no available accident or projection data is provided in order to apply for Warrants 7 and 8, and there is no at-grade railroad crossing so Warrant 9 is also not eligible. Therefore, the Navy Ave and Gold St intersection will be using a pre-timed traffic signal.

The more detailed warrant analysis can be found in Appendix Figure 11-1 through Figure 11-3.

4.2.1.2 Peak hour turning movement volumes

Table 4-1 Turning movement summary for Navy Ave and Gold St intersection

	Navy Ave at Gold St		**Northbound**			**Southbound**			**Eastbound**			**Westbound**		
	Start Time	End Time	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
AM Peak	7:00 AM	8:00 AM	255	305	275	255	275	250	55	1837	83	77	1392	105
PM Peak	3:00 PM	4:00 PM	75	275	70	95	305	50	275	1392	281	303	1837	281

Table 4-2 Turning movement totals for Navy Ave and Gold St

	Navy Ave at Gold St		**Intersection Total**
	Start Time	End Time	
AM Peak	7:00 AM	8:00 AM	5164
PM Peak	3:00 PM	4:00 PM	5239

4.2.1.3 Intersection Lane Configuration and Dual Ring Diagram

The diagram showing the designed intersection for Navy Ave and Gold St can be found in Exhibit 11.5.29 and the morning and afternoon dual-ring diagrams can be found in Figure 4-1 and Figure 4-2 respectively.

Figure 4-1 AM dual-ring diagram for Navy Ave and Gold St intersection

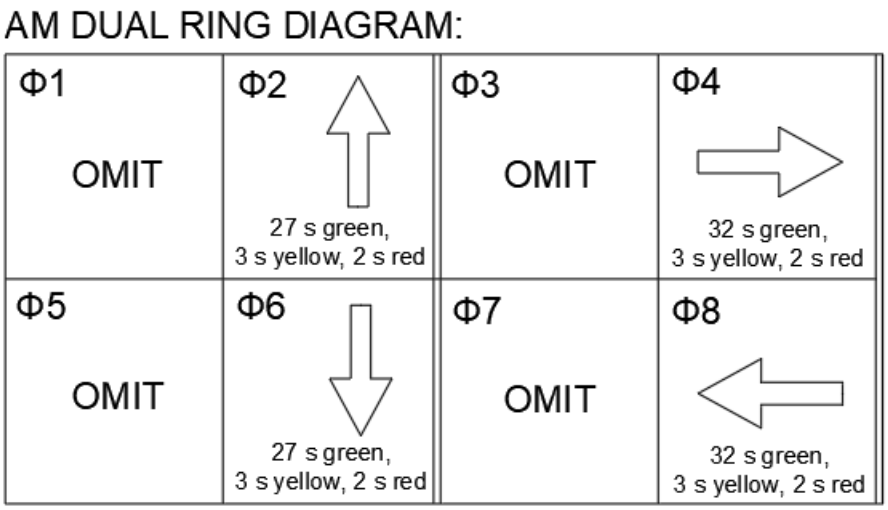


Figure 4-2 PM dual-ring diagram for Navy Ave and Gold St intersection

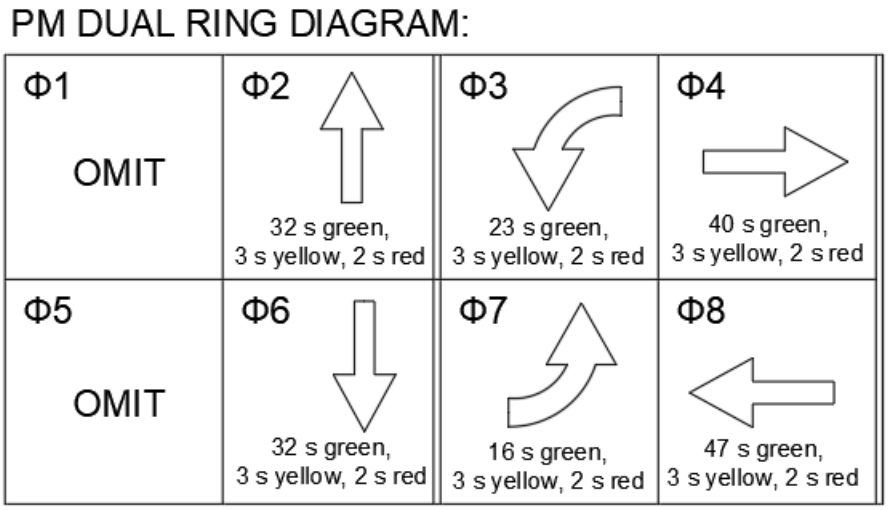


Table 4-3 Signal timing for Navy and Gold St intersection

Time of Day	**Phase 1**			**Phase 2**			**Phase 3**			**Phase 4**		
	G	Y	R	G	Y	R	G	Y	R	G	Y	R
AM	Omit			27	3	2	Omit			32	3	2
PM	Omit			32	3	2	23	3	2	40	3	2
	Phase 5			**Phase 6**			**Phase 7**			**Phase 8**		

	G	Y	R	G	Y	R	G	Y	R	G	Y	R
AM	Omit			27	3	2	Omit			32	3	2
PM	Omit			32	3	2	16	3	2	47	3	2

4.2.1.4 LOC and v/c summary

In the HCS summary reports (provided in appendix), the highest v/c ratio is 0.95 which occurs at the eastbound through movement in the morning and the westbound through movement during the afternoon peak hour. The lowest approach LOS was an E for the southbound right turn movement during the morning peak hour. The lowest approach LOS was a D which occurred in the eastbound left turn movement in the afternoon. Morning peak hour had a LOS of D for the intersection, and afternoon peak hour had a LOS of C for the intersection.

4.2.2 Navy Ave and Driveway

4.2.2.1 Warrant Analysis

For the Navy Ave and Driveway intersection, Warrants 1 through 3 fail, there is no pedestrian data so Warrants 4 and 5 do not apply, Warrant 6 does not apply because there the intersection is not part of a coordinated signal system, and there is no available accident or projection data to apply Warrants 7 and 8, and there is no at-grade railroad crossing so Warrant 9 is also not eligible. Therefore, the Navy Ave and Driveway intersection does not warrant a traffic signal by any of the measures.

4.2.2.2 Peak hour turning movement volumes

Table 4-4 Turning movement summary for Navy Ave and Driveway intersection

Navy Ave at Driveway			**Northbound**			**Eastbound**			**Westbound**		
	Start Time	End Time	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
AM Peak	7:00 AM	8:00 AM	70		25		402	61	33	842	
PM Peak	3:00 PM	4:00 PM	55		30		803	116	33	402	

Table 4-5 Turning movement totals for Navy Ave and Driveway intersection

Navy Ave at Driveway			**Intersection Total**
	Start Time	End Time	
AM Peak	7:00 AM	8:00 AM	1433
PM Peak	3:00 PM	4:00 PM	1439

4.2.2.3 LOS and v/c summary

The intersection does not warrant a signal under any warrants and thus is unsignalized, with Nave Ave moving freely and a stop sign at the driveway. Using a two-lane driveway provides C and D LoS for AM and PM movement from the driveway, and D and E respectively if using a left-turn bank. A drawing of the intersection can be found in Appendix Exhibit 11.5.30.

4.2.3 Navy Ave/Buzz St and White St

4.2.3.1 Warrant analysis

For the White St and Navy Ave/Buzz St intersection, warrants 1, 2, and 3 are all met regardless of the number of lanes chosen in the design. Since there is no pedestrian data, warrants 4 and 5 do not apply. Warrant 6 does not apply because there the intersection is not part of a coordinated signal system, and there is no available accident or projection data to apply to Warrants 7 and 8. Finally, the intersection is not close enough to an at-grade railroad crossing so Warrant 9 is also not eligible. Therefore, the White St and Navy Ave/Buzz St intersection will include a pre-timed traffic signal. Details of the warrant analysis are found in Appendix Figure 11-4,Figure 11-5,Figure 11-6.

4.2.3.2 Peak hour turning movement volumes

Table 4-6 Turning movement summary for Navy Ave/Buzz St and White St intersection

Navy Ave/Buzz St at White St			**Northbound**			**Southbound**			**Eastbound**			**Westbound**		
	Start Time	End Time	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
AM Peak	7:00 AM	8:00 AM	140	185	150	125	105	165	226	550	110	83	688	446
PM Peak	3:00 PM	4:00 PM	50	120	70	250	175	335	77	605	55	149	754	226

Table 4-7 Turning movement totals for Navy Ave/Buzz St and White St intersection

Navy Ave/Buzz St at White St			**Intersection Total**
	Start Time	End Time	
AM Peak	7:00 AM	8:00 AM	2,973
PM Peak	3:00 PM	4:00 PM	2,866

4.2.3.3 Intersection Lane Configuration and Dual Ring Diagram

The diagram showing the designed intersection for White St And Navy Ave/Buzz St can be found in Appendix Exhibit 11.5.32 and the morning and afternoon dual-ring diagrams can be found in Figure 4-3 and Figure 4-4, respectively.

Figure 4-3 AM dual-ring diagram for Navy Ave/Buzz St and White St intersection

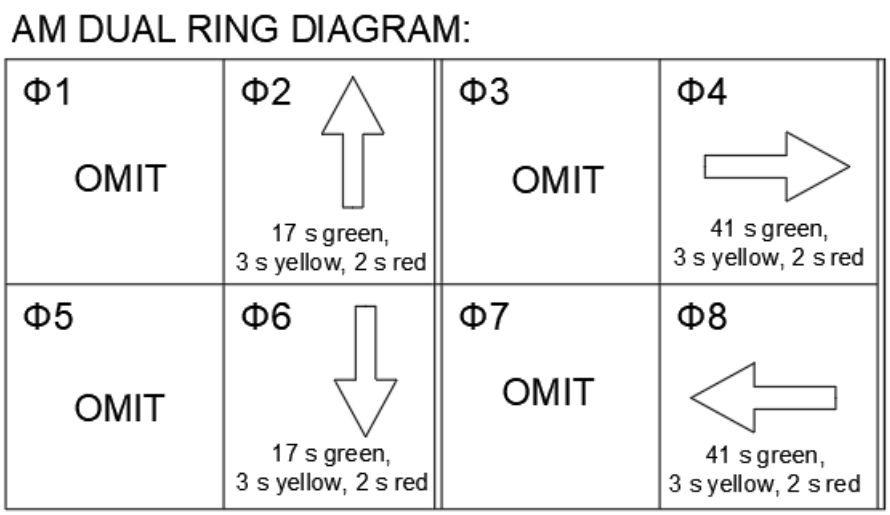


Figure 4-4 PM dual-ring diagram for Navy Ave/Buzz St and White St intersection

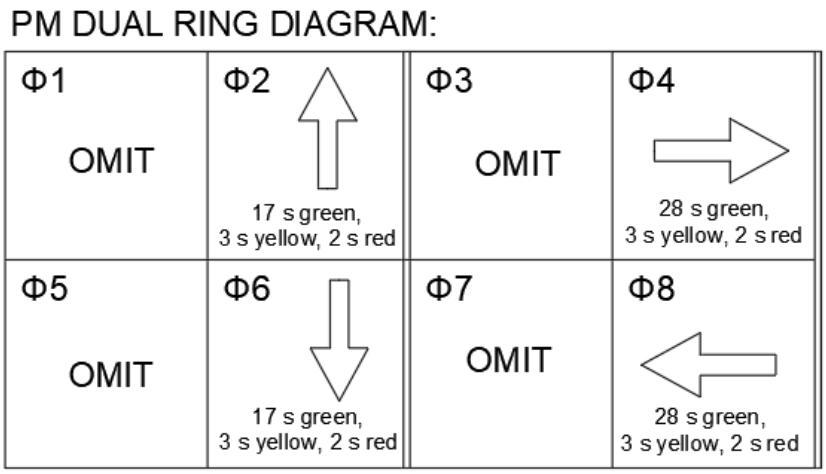


Table 4-8 Signal timing for Navy Ave/Buzz St and White St Intersection

Time of Day	**Phase 1**			**Phase 2**			**Phase 3**			**Phase 4**		
	G	Y	R	G	Y	R	G	Y	R	G	Y	R
AM	Omit			17	3	2	Omit			41	3	2
PM	Omit			17	3	2	Omit			28	3	2
	Phase 5			Phase 6			Phase 7			Phase 8		
	G	Y	R	G	Y	R	G	Y	R	G	Y	R
AM	Omit			17	3	2	Omit			41	3	2
PM	Omit			17	3	2	Omit			28	3	2

4.2.3.4 LOS and v/c Summary

As can be seen in the HCS summary reports, the highest v/c ratio is 0.95 which occurs at the eastbound left turn movement in the morning and the westbound through movement during the afternoon peak hour. The lowest lane group LOS was an E for the eastbound left turn movement and the southbound left turn movement during the morning peak hour. The lowest approach LOS was a D which occurred in the southbound direction in the afternoon and in the northbound and southbound directions in the morning. Both peak hours had a LOS of C for the entire intersection.

4.3 Turn Bay Analysis

4.3.1 Navy Ave and Gold St

There are total of eight turn bays in the intersection. Both Gold Street and Navy Ave have left turn bay and right turn bay for all four approaches. Since all four directions have a left turn volume greater than 125 vehicles per hour during one of the peak hours, turn bays and protected left turns are allowed based on the GDOT requirements. All approaches with turn bays have posted speed limits of 35 mph, in that case, lanes with design speeds of 45 mph are used to determine the length of the turn bays. The total deceleration length according to GDOT standards is 185 ft which will be combined with the expected length of the of each car which is 25ft multiply number of cars in the queue to determine the length of each turn bay. The Eastbound left turn bay will be 585 ft, The Eastbound right turn bay will be 610 ft, the westbound left turn bay will be 535 ft, the westbound right turn bay will be 1000 ft, the northbound left turn bay will be 385 ft, the northbound right turn bay will be 435 ft, the southbound left turn bay will be 460 ft, and the southbound right turn bay will be 410 ft.

4.3.2 Navy Ave and Driveway

For the AM and PM peaks, the Level of Service is adequate if all turns happen from a single lane, so the driveway does not require the addition of a turn bay. While Navy Ave does not require a turn bay, the presence of a median allows for easy integration of a turn bay for left-hand turns. Since there is not enough traffic to merit a turn bay, the turn bay is the minimum length of 25 ft.

4.3.3 Navy Ave/Buzz St and White St

There are four turn bays included in the intersection. Westbound on White St has both a right and left turn bay, Eastbound on White St has a left turn bay, and Northbound on Buzz St has a left turn bay. Since all four directions have a left turn volume greater than 125 vph during one of the peak hours, turn bays and protected left turns are allowed according to GDOT requirements. All three roads with turn bays have posted speed limits of 35 mph, so design speeds of 45 mph are used to determine the length of the turn bays. The total deceleration length according to GDOT standards is 185 ft which will be combined with the expected length of the of cars in the queue to determine the length of each turn bay. The Eastbound left turn bay will be 385 ft, the westbound left turn bay will be 260 ft, the westbound right turn bay will be 285 ft, and the northbound left turn bay will be 285 ft.

This Page Intentionaly Left Blank

5 Horizontal Alignment and Superelevation

5.1 Summary

The Navy Ave extension required two horizontal curves to appropriately connect Gold St and White St while avoiding the protected habitat and the grounds of future developments. The first step to creating adequate curves was to use table 3-7 in the Green Book with the given design speed (35 mph) and max superelevation (6.0%) to find the minimum radius of 340 ft. The project team decided to use a radius of 500 ft for both curves to create a smoother driving experience. Based on this radius, the calculated sight distance delta was 30° 5’ 32” and the minimum middle ordinate was 16’ 3.8” to ensure the curves did not have any sight distance issues. The actual values for Δ, T, L, e, and M were then calculated using the chosen radius, PC station bearing, and PT station bearing. This final design confirmed that both the minimum middle ordinate was reached and that the maximum super elevation was not exceeded. The results of this process are in Table 5-1.

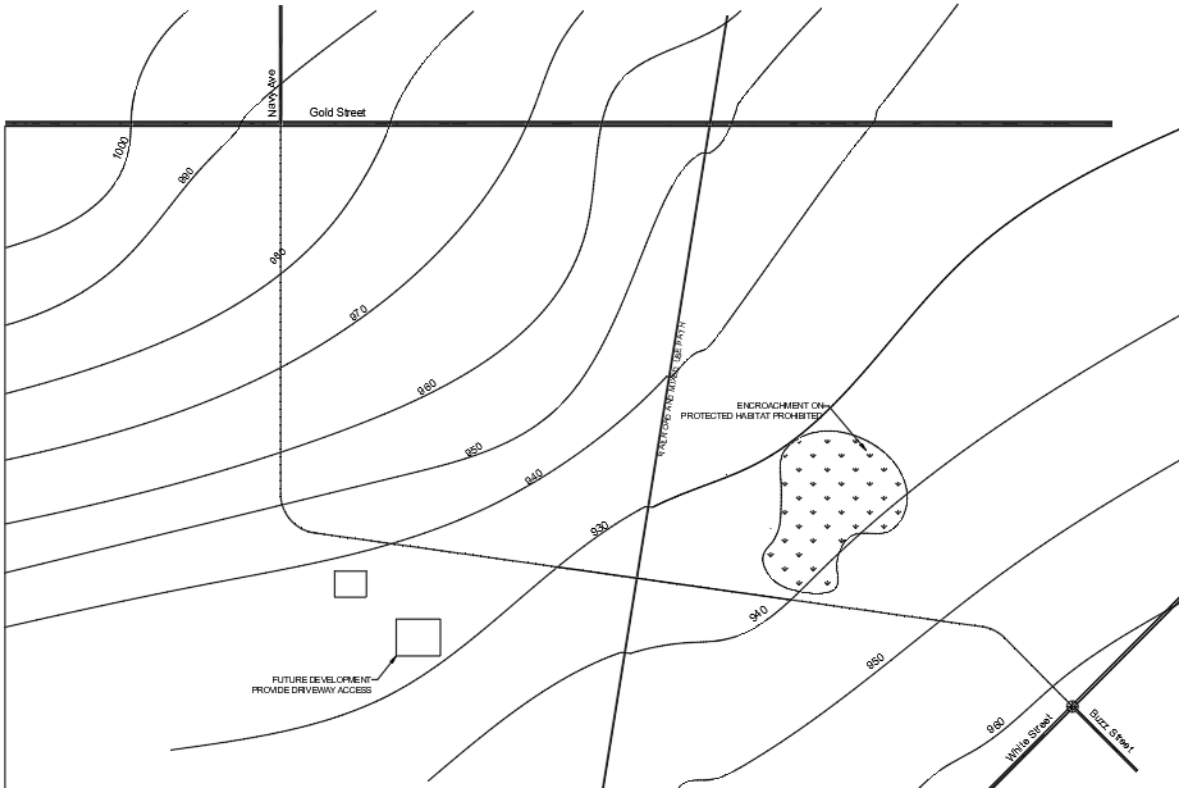
Table 5-1 Horizontal curve summary

Curve Number	**PC Station**	**PT Station**	**Δ**	**R**	**T**	**L**	**M**
1	56+64.07	65+33.51	82° 0' 34"	500	434.715	715.667	122.672
2	148+91.487	152+29.267	37° 19' 43"	500	168.894	325.754	26.2951

5.2 Centerline Schematic of Entire Route

The centerline schematic is available in Appendix Exhibit 11.5.1, as well as below in Figure 5-1.

Figure 5-1 Centerline Schematic of Navy Ave Extension



5.3 Horizontal Alignment Sample Calculations for Curve 1

Sample calculations for Curve 1's horizontal alignment are found in Equation 5-1 through Equation 5-10 and a drawing of Curve 1 is found in Appendix Exhibit 11.5.2 and Figure 5-2.

Equation 5-1 Delta (Curve 1)

$$\begin{aligned}\Delta &= \overline{\boldsymbol{PCPI}}_{\boldsymbol{bearing}} - \overline{\boldsymbol{PIPT}}_{\boldsymbol{bearing}} \\ &= \text{N0°0'0"E} - \text{S 82°0'33.68"E} \\ &= 82°0'33.68"\end{aligned}$$

Equation 5-2 Curve Length (Curve 1)

$$\begin{aligned}L &= \left(\frac{\pi}{180}\right) * \Delta * R \\ &= \left(\frac{\pi}{180}\right) * \ 82°0'33.68" \ * 500\ ft \\ &= \ 715.667\ ft\end{aligned}$$

Equation 5-3 Tangent Length (Curve 1)

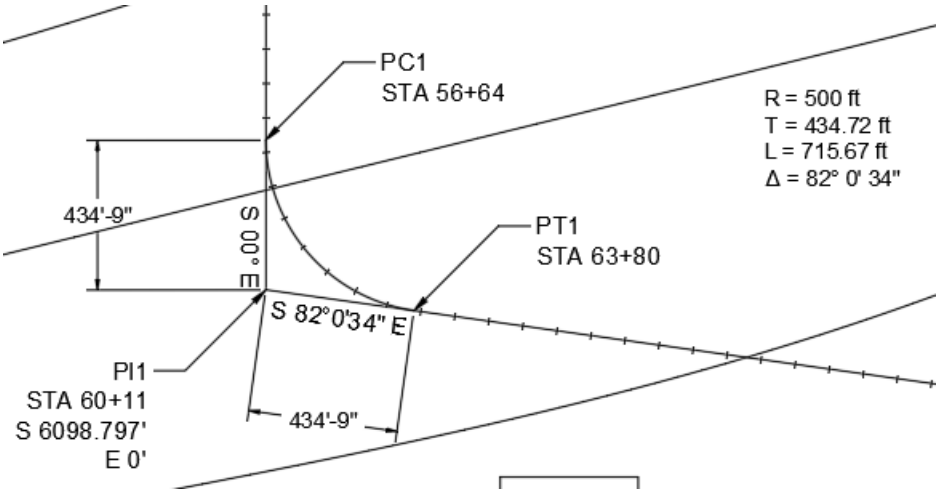
$$\begin{aligned}T &= R * \tan\left(\frac{\Delta}{2}\right) \\ &= \ 500\ ft * \tan\left(82°0'33.68"\frac{\Delta}{2}\right)\end{aligned}$$

$$= 434.715\ ft$$

Equation 5-4 Middle Ordinate (Curve 1)

$$M = R * \left(1 - \cos\left(\frac{\Delta}{2}\right)\right)$$
$$= 500\ ft * \left(1 - \cos\left(82°0'33.68" \frac{\Delta}{2}\right)\right)$$
$$= 122.672 ft$$

Figure 5-2 Curve 1 Detail



5.4 Superelevation Calculations

The road uses a common 2% crown, with lanes sloping at 2% away from the median. The maximum superelevation to be used for the Navy Ave extension is 6.0%. Using Table 3-9 in the Green Book, the design speed of 35mph, and the e_{max} of 6.0%, the chosen radius of 500ft falls between the radii for 5.4% and 5.6% superelevation. Since interpolation is not required to find the actual superelevation for curve, 5.6% is chosen since it is greater. Since both curves share a radius and design speed, 5.6% is an appropriate superelevation for them both. Both curves thus have equal superelevation runoff and tangent runout. Table 5-2 shows the superelevation values for each curve, with sample calculations for curve 1 shown below the table.

Table 5-2 Superelevation summary

Curve Number	PC Station	e_{actual} (%)	Runoff (ft)	Runout (ft)	BOLT	OLC0%	BILT	FULLE
1	56+64.07	5.6	163	58.2143	54+97.189	55+55.4033	56+13.618	57+18.403
2	148+91.487	5.6	163	58.2143	147+24.61	147+82.82	148+41.03	149+45.82

Equation 5-5 Length of Superelevatuib Runoff (Curve 1)

Based on Table 3-16a in the AASHTO Green Book, the runoff for a 35mph road with 5.6% superelevation and two lanes rotating is 163ft.

Equation 5-6 Length of Tangent Runout (Curve 1)

$$\Delta = \frac{L_R}{e}$$
$$= \frac{163\ ft}{5.6\%}$$
$$= 29.12\ ^{ft}/_{\%}$$
$$Runout = 29.12\frac{ft}{\%} * 2\%$$
$$= 58.21\ ft$$

Equation 5-7 Beginning of Outside Lane Transition Station (Curve 1)

$$BOLT = PC - \frac{2}{3}runoff - runout$$
$$= 56 + 64.07 - \left(\frac{2}{3}\right) * 163ft - 58.21\ ft$$
$$= 54 + 97.189$$

Equation 5-8 Outside Lane Crosses 0% Station (Curve 1)

$$OLC0\% = PC - \frac{2}{3}runoff$$
$$= 56 + 64.07 - \left(\frac{2}{3}\right) * 163\ ft$$
$$= 55 + 55.4033$$

Equation 5-9 Beginning of Inside Lane Transition Station (Curve 1)

$$BILT = PC - \frac{2}{3}runoff + runout$$
$$= 56 + 64.07 - \left(\frac{2}{3}\right) * 163\ ft + 38.65\ ft$$
$$= 56 + 13.618$$

Equation 5-10 Full Superelevation Station (Curve 1)

$$FULLE = PC + \frac{1}{3}runoff$$
$$= 56 + 64.07 - \frac{163\ ft}{3}$$
$$= 57 + 18.403$$

6 Vertical Alignment

6.1 Summary

The Navy Ave extension used twelve different horizontal curves to minimize the required amount of cut and fill on the site while also keeping a somewhat smooth route. This design was therefore both cost efficient and extremely safe. Approaches to the Gold St intersection and the White St intersection both utilized a small consistent grade of 0.5% slopping in the direction of the terrain to avoid sight distance issues but also encourage drainage from the intersection. Vertical curves began after an appropriate length of consistent slope was provided for the intersections. Data for each vertical curve including elevation, station, tangent grades, curve length, and curvature can be found in Table 6-1. As can be seen in the table, no tangent grades surpass the maximum allowable slope of 10%, with the only two tangent grades above 1.5% being the front and back slopes of the bridge.

A summary table of curve number, PVI station and elevation, tangent grades, curve length, PVC station and elevation, PVT station and elevation is included in Table 6-1.

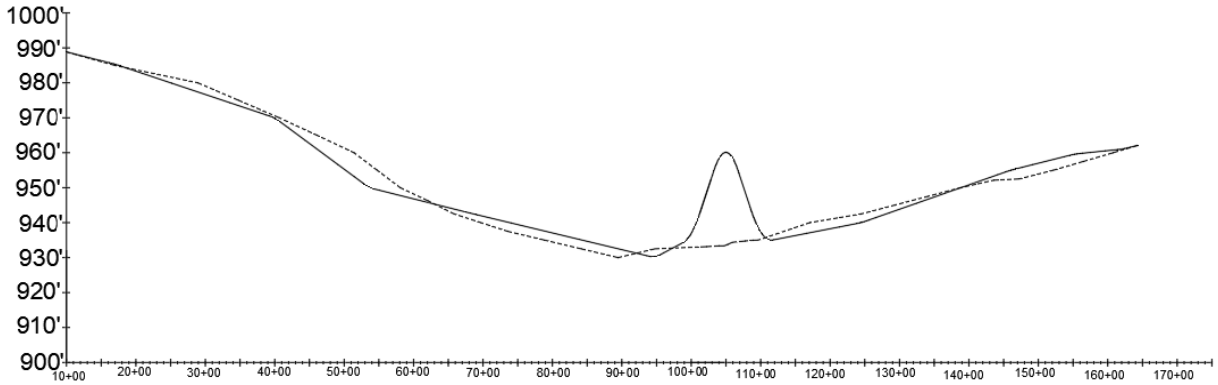
Table 6-1 Vertical curve summary

ID	PVI_{STA}	PVI_{Elev}	g1 (%)	g2 (%)	L	K	PVC_{STA}	PVC_{Elev}	PVT_{STA}	PVT_{Elev}
1	17+00	985.33	-0.5	-0.67	150	900.78	16+25	985.71	17+75	984.83
2	40+00	970	-0.67	-1.47	150	186.55	39+25	970.50	40+75	968.90
3	53+60	950	-1.47	-0.5	150	154.55	52+85	951.10	54+35	949.63
4	68+25	942.68	-0.5	-0.48	150	6913.04	67+50	943.05	69+00	942.32
5	94+75	930	-0.49	1.06	150	97.81	94+00	930.36	95+50	930.79
6	100+04.43	935.59	1.06	6	242.15	48.97	98+83.36	934.31	101+25.51	942.85
7	105+00	965.32	6	-6	347.54	28.96	103+26.23	954.89	106+73.77	954.89
8	110+15.03	934.42	-6	0.39	313.17	49.02	108+58.45	943.81	111+71.62	935.03
9	124+51	940	0.39	0.70	150	484.89	123+76	939.71	125+26	940.52
10	146+00	955	0.70	0.5	150	757.58	145+25	954.48	146+75	955.38
11	155+25	959.63	0.5	0.21	150	510.95	154+50	959.25	156+00	959.78
12	162+25	961.07	0.21	0.5	150	510.95	161+50	960.92	163+00	961.45

6.2 Schematic of Entire Route

A detailed route schematic is found in appendix Exhibit 11.5.4, but a simplified version is depicted in Figure 6-1.

Figure 6-1 Vertical Alignment of proposed and existing terrain



6.3 Vertical Sample Calculations

Sample calculations for Curve 5 are found in Equation 6-1 through Equation 6-7 and a drawing of Curve 5 can be found in Appendix Exhibit 11.5.5 and below in Figure 6-2. Curve 5, a sag curve at the lowest point of the existing terrain, begins the Navy Ave extension's path upwards to meet White St. PVI_5 is at station 94+75 and has an elevation of 930 ft.

As can be seen in Table 6-1, the grade of initial tangent (g_1) is -0.49% and the grade of final tangent (g_2) is 1.06%, so the algebraic difference between the grades is found in Equation 6-1.

Equation 6-1 Algebraic Difference Between Grades (Curve 5)

$$A = |1.06 - -0.49| = 1.53.$$

Using an SSD of 250mph for the design speed of 35, the curve length equations and results are given in Equation 6-2 and Equation 6-3.

Equation 6-2 Minimum Vertical Curve Length if S<L (Curve 5)

$$L_m = \frac{\mathrm{AS}^2}{400 + (3.5 * \mathrm{S})}$$
$$= \frac{1.53 * 250^2}{400 + (3.5 * 250)}$$
$$= 75.17$$

Equation 6-3 Minimum Vertical Curve Length if S>L (Curve 5)

$$L_m = 2 * S - \frac{400 + 3.5 * S}{A}$$

$$= 2 * 250 - \frac{400 + 3.5 * 250}{1.53}$$

$$= -331.40$$

Since both these values are less than 150 ft, the defined minimum vertical curve length for the project, the curve length for curve 5 is 150 ft.

Since PVI is at station 94+75 with an elevation of 930, we find the PVC and PVT stations and elevations using Equation 6- 4 through Equation 6-7

Equation 6- 4 PVC Station (Curve 5)

$$STA_{PVC} = STA_{PVI} - \frac{L}{2}$$

$$94 + 75 - 75\ ft$$

$$= 94 + 00$$

Equation 6-5PVC Elevation (Curve 5)

$$Elev_{PVC} = Elev_{PVI} - \frac{g_1}{100} * \frac{L}{2}$$

$$= 930\ ft - \left(75\ ft * \frac{-0.49}{100}\right)$$

$$= 930.36\ ft$$

Equation 6-6 PVT Station (Curve 5)

$$STA_{PVT} = STA_{PVI} + \frac{L}{2}$$

$$94 + 75 + 75\ ft$$

$$= 95 + 50$$

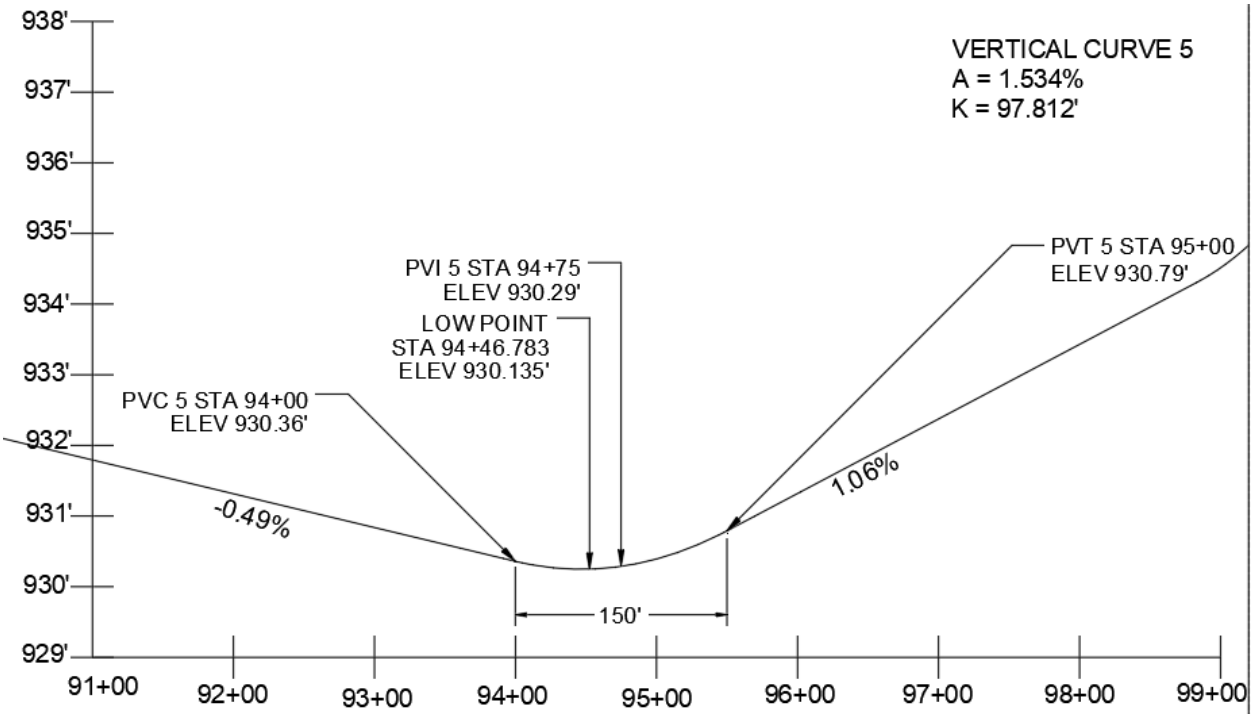
Equation 6-7 PVT Elevation (Curve 5)

$$Elev_{PVT} = Elev_{PVI} + \frac{g_2}{100} * \frac{L}{2}$$

$$= 930\ ft + \left(75\ ft * \frac{1.06}{100}\right)$$

$$= 930.79 ft$$

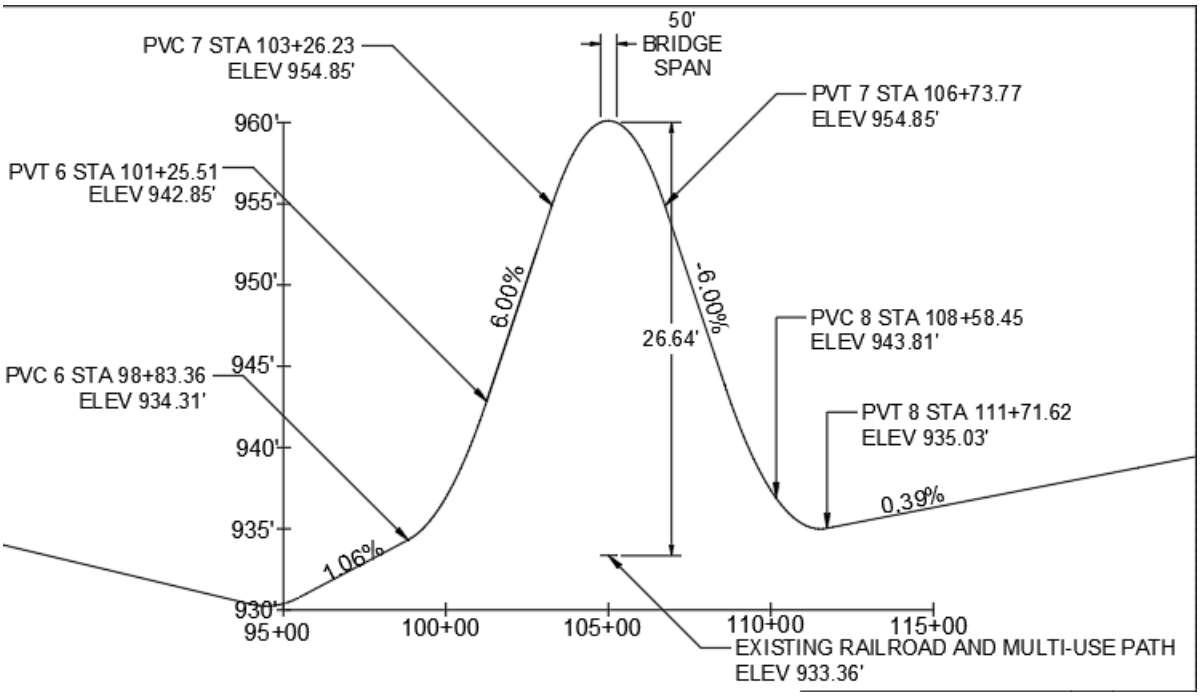
Figure 6-2 Vertical Curve 5 Detail



6.4 Bridge Schematic

The full bridge schematic is found in Figure 6-2. Note the difference in horizontal and vertical scale. The bridge schematic is also available in Appendix Exhibit 11.5.6.

Figure 6-3 Bridge Schematic



7 Cross Sections

7.1 Typical Cross Section Summary

A drawing of the typical cross section can be found in Figure 7-1 and a full schematic is found in Appendix Exhibit 11.5.7.

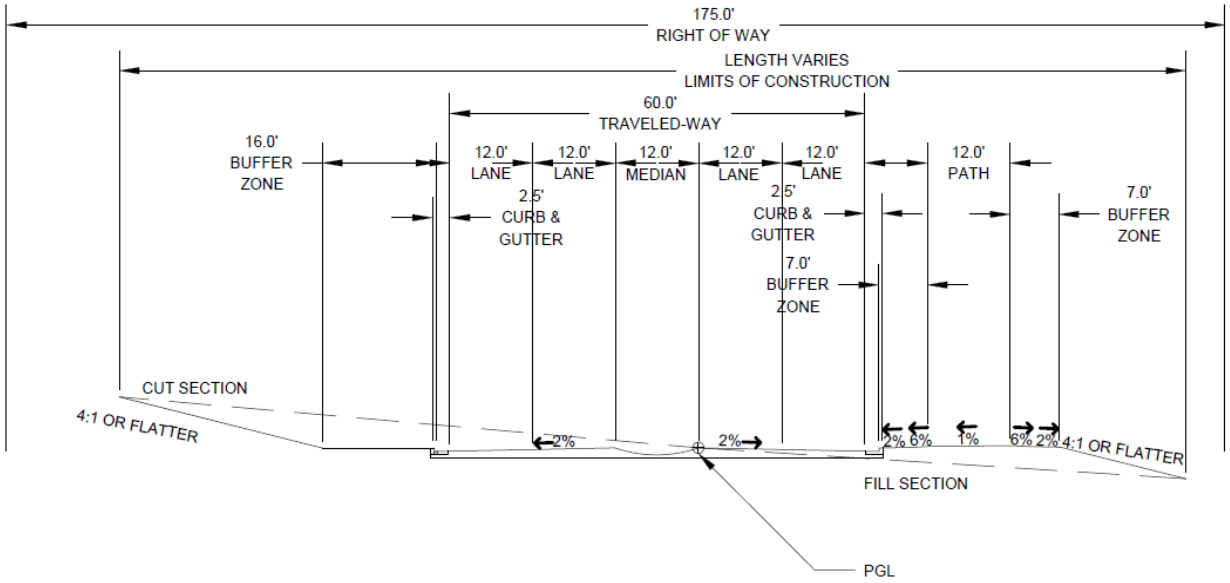
As per the project guidelines, a typical section of road features a depressed grassy median. The median has slope of 1:6 as per the AASHTO guidelines and is U shaped, rather than V shaped. The median will become a painted median over the bridge to reduce costs and weight.

The design features a shared-use path on the right side of the Navy Ave Extension. The path has a 12' width with 2' 6% cross-slopes on each side.[1] There is a 5' buffer zone from the edge of the curb to the path border and a 5' buffer zone on the opposite side of the path before the slope to meet existing terrain begins, to protect cyclists and pedestrians from vehicle traffic and the foreslope or backslope. The buffer zone and a 4:1 or flatter slope prevents the need for a fence.[2] To create a pedestrian-friendly environment for people of all mobilities, the cross-slope of the trail is 1%, angled towards the road to aid drainage.

The path follows the curve of the road with no issue for pedestrians and cyclists, since the minimum turning radius for bicycles is much smaller than that for cars, and the radius on both curves is generous as is. When road curves up for the bridge at vertical curve 6, the path will instead continue relatively along its regular grade to meet the path alongside the railroad that runs under the bridge, crossing the railroad at grade. Because there is no information given regarding the usage of either shared-use trail or the railroad, the at-grade crossing has been fit with an automatic gate.

[1] AASHTO Guide to Bicycle Facilities, Section 5.2.1
[2] AASHTO Guide to Bicycle Facilities, Section 5.2.1

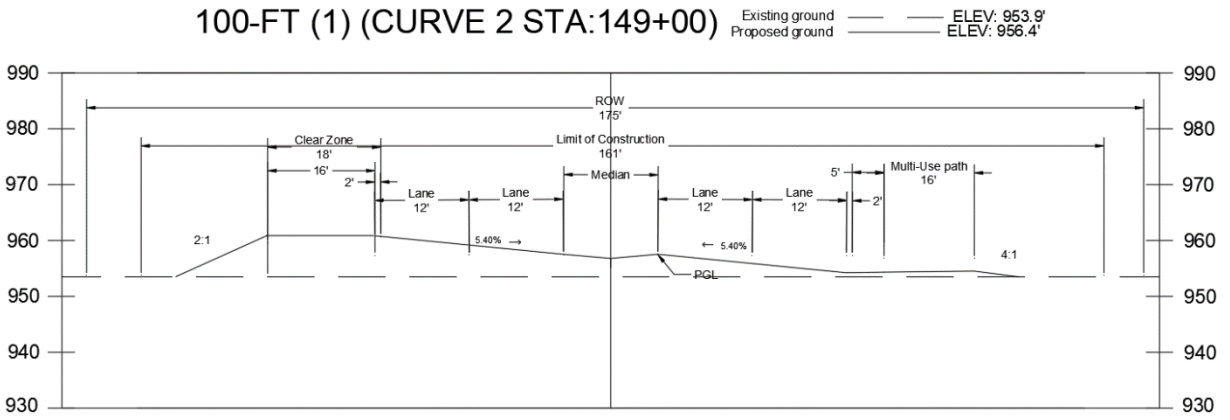
Figure 7-1 Typical Cross Section



7.2 Horizontal Curve Cross Section

The horizontal curve cross section drawings depict how the superelevation changes along curve 2. The drawings are available in Appendix Exhibit 11.5.8 through Exhibit 11.5.18, and an example is found in Figure 7-2 below.

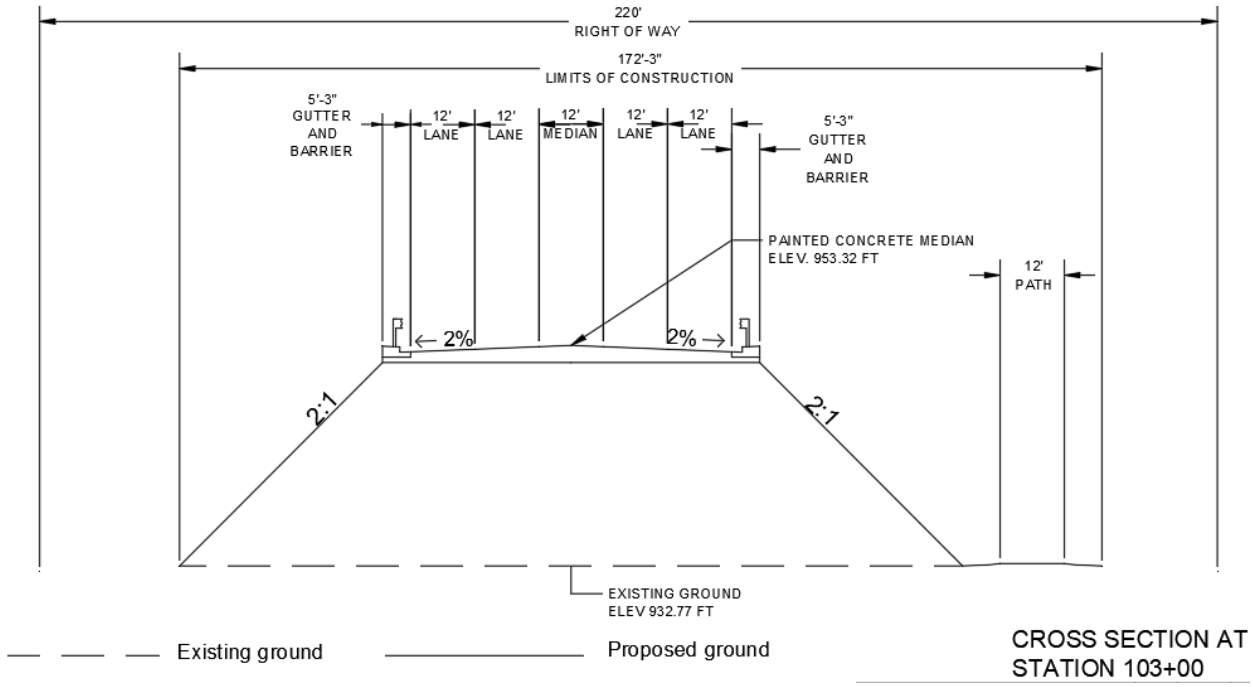
Figure 7-2 100-ft Horizontal Cross Section (Curve 2)



7.3 Bridge Cross Section

The bridge cross sections depict the relationship between the road moving over the bridge and the shared-use path continuing with the terrain. All bridge cross section drawings can be found in Appendix Exhibit 11.5.19 through Exhibit 11.5.28, and an example can be found in Figure 7-3 below.

Figure 7-3 Bridge Cross Section at Station 103+00



This Page Intentionaly Left Blank

8 Marking and Signage

8.1 Summary of Work

Signing and marking plans for the Navy Ave extension project included four interchanges: Navy Ave at Gold St, driveway at Navy Ave, multi-use path intersection by the railroad, and Navy Ave at White St. Each intersection required some of their own design features while also using some commonly seen markings or signs. Overall, all the intersections required 15 different types of road signs and all different kinds of markings. The exact location of each sign or marking can be found in the appropriate drawing in the appendix or referred to in Appendix Exhibit 11.5.34:Index of Signage. Prior to determining the correct signing and marking for the interchanges, the final geometry had to be established. This geometry includes using the minimum required turn radii and curb radius to account for single unit trucks, so that emergency vehicles can safely use the intersection as well as the regular expected vehicle. Road geometry was also affected by the intersection design between Navy Ave and Gold St, which required lane reduction after the intersection to return the road to the appropriate number of lanes. Exact geometry of all interchanges can also be seen in Appendix Exhibit 11.5.29 through Exhibit 11.5.33

8.2 Intersection and Roadway Design Plans

There is no note as to the design vehicle, but it seems that the Single-Unit Truck (three axle) design vehicle will allow the road to be used by typical urban emergency vehicles.[3] The curb radius is also chosen to account for emergency vehicles.[4]

Table 8-1 Turning Radius Requirements

	Single-Unit Truck 3-axle
Min Design TR	51.2’
Centerline TR	47.4’
Min Inside Radius	36.4’

Table 8-2 Curb Return Radius Specifications for Passenger Vehicles

	Curb Return Radius
Recommended	25’

[3] AASHTO Green Book, p2-59
[4] AASHTO Green book, p 9-66

8.2.1 Lane reductions

Both Gold St and the north side of Navy Ave increase the number of through lanes at the intersection, so both roads need to reduce their lane number as well after the intersection.

The following formulae provides the taper length (L) needed based on the offset (W) (in this case, the width of the lane being dropped), and the posted speed limit or 85th percentile speed (S), whichever is higher (speed limit is used due to availability).[5]

Equation 8-1 Navy Ave lane reduction taper length

$$L = \frac{WS^2}{60} = \frac{12 * 35^2}{60} = 245ft$$

On Navy Ave, the sign W4-2 is at station 8+30, 100' north of the speed limit sign. The taper begins 565' after this point, at station 2+65. The dashed lane line between the right and left lanes ends at station 6+88.75.

Equation 8-2 Gold St lane reduction taper length

$$L = WS = 12 * 45 = 540ft$$

Lane reductions on Gold St require arrows indicating the lane reduction, but these are not required on Navy Ave because Navy Ave's speed limit is less than 45 mph.[6]

8.2.2 Edge lines

Edge lines on the right side of the road are not necessary on the project's roads due to the presence of the curb.[7] Since no statement was made regarding curbs on Gold St, White St, and Buzz St, the assumption is made that curbs are also present and thus edge lines are not required.

8.2.3 Signage and markings notes

For each intersection, there are two tables of markings, one for Navy Ave, the Navy Ave Extension, and Buzz St, and the second for the cross streets of Gold St and White St. Tables of all signage and markings are available in Appendix 11.4: Signage and Markings Tables (Table 11-1 through Table 11-6).

[5] MUTCD Section 3B.09
[6] MUTCD Figure 3B-24
[7] MUTCD Section 3B.07

Stationing for Gold St and White St use STA 20+00 to be the center of the intersection, with increasing stations traveling East / Northeast. Driveway stationing uses 10+00 as the center of the intersection, increasing stations moving towards the settlement. The center of White St/Navy Ave intersection is STA 164+33 for Navy Ave.

8.3 Shared-Use Path Intersection

The design team elected to use an automatic gate for at-grade railroad crossing instead of passive protection, since there is no information pertaining to expected pedestrian and cyclist volume on the trails, nor are records of railway traffic included with the project. An active gate allows the city to be prepared for high trail volumes in the future.

The offset for the path that follows the railroad is 25ft, which is recommended by USDOT research to adequately separate those traveling on the path from the railroad.[8] A fence may be added depending on the amount of traffic on the trail, and if used a 5ft fence is adequate.

Signage and markings for the intersection between the two shared-use paths is included in Appendix Table 11-7, and the drawing of the intersection is available in Appendix Exhibit 11.5.31.

[8] USDOT, Trails-with-Rails, Section V

This Page Intentionaly Left Blank

9 Conclusion

Our team was tasked with the design of an extension for Navy avenue from Gold street to White street. Five checklists were used to guide through the whole design process. The design team created intersection layouts, signal timings, horizontal alignment, and vertical alignment that met all the design requirements and specifications.

There are some aspects of the design that could have been improved, such as better coordination of the design of horizontal and vertical curves. During the design process, the horizontal alignment was determined prior to any considerations for the vertical alignment. It would be beneficial to have both alignments designed at the same time, so that the team could determine and avoid any potential problems before completing either alignment. The vertical curve design lacked consideration for drainage, particularly in the sag curve featured after the bridge. The combination of being a sag curve while also being below the existing ground in a cut section means that water will naturally flood there. While this issue could be solved with significant hydrological features, it is poor practice to rely on those and a more experienced team would have the foresight to design a more appropriate curve.

Overall, the team is satisfied with the design of the Navy avenue extension. The proposed roadway provides accommodations for vehicles, bicycle, and pedestrian. The design prioritizes the safety and comfort of all roadway users.

This Page Intentionaly Left Blank

10 Bibliography

American Association of State Highway and Transportation Officials. “A Policy on Geometric Design of Highways and Streets.” American Association of State Highway and Transportation Officials, Washington, D.C.: 2018.

American Association of State Highway and Transportation Officials. “Guide to the Development of Bike Facilities.” American Association of State Highway and Transportation Officials, Washington, D.C.: 2012.

Birk et al. “Rails-with-Trails: Lessons Learned Literature Review, Current Practices, Conclusions.” US DOT, Cambridge, MA.: 2002

Handouts and slides from class

MUTCD, 2009 Edition, published by FHWA at https://mutcd.fhwa.dot.gov/pdfs/2009/pdf_index.htm

This Page Intentionaly Left Blank

11 Appendix

11.1 Checklists

Signed and marked checklists are included for:

Exhibit 11.1.1. Signalization and Intersection control

Exhibit 11.1.2. Horizontal Alignment/ Superelevation

Exhibit 11.1.3. Vertical Alignment

Exhibit 11.1.4. Cross sections

Exhibit 11.1.5. Marking and Signing

11.2 Warrant Analysis

Figure 11-1 Warrant 1 Analysis for Navy Ave and Gold St Intersection

warrant 1					meet? 100%A		meet? 100%B			meet? Combination of A and B			A	B
Main street	3015	minor street	220		x		x						x	x
	3229		305		x		x						x	x
	3141		260		x		x						x	x
	3015		275		x		x						x	x
	2910		200		x		x						x	x
	2575		155		x		x						x	x
	2498		110				x							x
	2608		145				x						x	x
	2949		220		x		x						x	x
	3229		305		x		x						x	x
	3103		275		x		x						x	x
	3169		295		x		x						x	x
	2855		205		x		x						x	x
	2492		120				x						x	x
	2300		100				x							x
					11 hours	Condition A met		Condition B met					combination of A &B met	

Note: The graphs for Warrants 2 and 3 for Navy Ave and Gold St Intersection are not included because the Major Street volumes are too large for any points to appear on the warrant graphs.

Figure 11-2 Warrant 2 Analysis for Navy Ave and Gold St Intersection

Warrant 2					Meet? (Based on Figure 4C	
Main street	3015	minor street	220		x	
	3229		305		x	
	3141		260		x	
	3015		275		x	
	2910		200		x	
	2575		155		x	
	2498		110			
	2608		145		x	
	2949		220		x	
	3229		305		x	
	3103		275		x	
	3169		295		x	
	2855		205		x	
	2492		120			
	2300		100			
					12 hours	warrant 2 me

Figure 11-3 Warrant 3 Analysis for Navy Ave and Gold St Intersection

Warrant 3					Meet? (Based on Figure 4C-3)													
Gold Street at Navy Ave		Northbound			Southbound			Eastbound			Westbound							
Start time	End time	left	Thru	Right	left	thru	right	left	thru	right	left	thru	right	major total volume	higher minor volume			
7:00 AM	8:00 AM	255	305	275	255	275	250	55	1837	83	77	1392	105	3229	305			
3:00 PM	4:00 PM	75	275	70	95	305	50	275	1392	281	303	1837	281	3229	305			
					This intersection warrants a singal													

Figure 4C-3. Warrant 3, Peak Hour

Figure 11-4 Warrant 1 analysis for White St and Navy Ave/Buzz St intersection

White St at Navy Ave		Northbound	Southbound	Eastbound	Westbound	Total	Warrant 1 - Condition A		Warrant 1 - Condition B		Warrant 1 - Combo	
Start Time	End Time	Sum	Sum	Sum	Sum	Total	Minor - 1 Ln	Minor - 2+	Minor - 1 Ln	Minor - 2 +	Minor - 1 Ln	Minor - 2 +
6:00 AM	7:00 AM	330	290	600	908	2128	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
7:00 AM	8:00 AM	475	395	886	1217	2973	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
8:00 AM	9:00 AM	415	375	793	1139	2722	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
9:00 AM	10:00 AM	415	375	810	1139	2739	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
10:00 AM	11:00 AM	310	265	507	847	1929	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
11:00 AM	12:00 PM	125	215	479	694	1513	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
12:00 PM	1:00 PM	95	160	402	595	1252	TRUE	FALSE	TRUE	TRUE	TRUE	FALSE
1:00 PM	2:00 PM	80	225	414	594	1313	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
2:00 PM	3:00 PM	155	530	578	810	2073	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
3:00 PM	4:00 PM	240	760	737	1129	2866	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
4:00 PM	5:00 PM	205	635	689	1068	2597	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
5:00 PM	6:00 PM	190	740	671	1013	2614	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
6:00 PM	7:00 PM	125	500	512	798	1935	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
7:00 PM	8:00 PM	65	305	364	612	1346	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
8:00 PM	9:00 PM	80	210	369	512	1171	TRUE	TRUE	FALSE	FALSE	TRUE	TRUE
					Number of Hours met		15	14	14	14	15	14

Figure 11-5 Warrant 2 analysis for White St and Navy Ave/Buzz St intersection

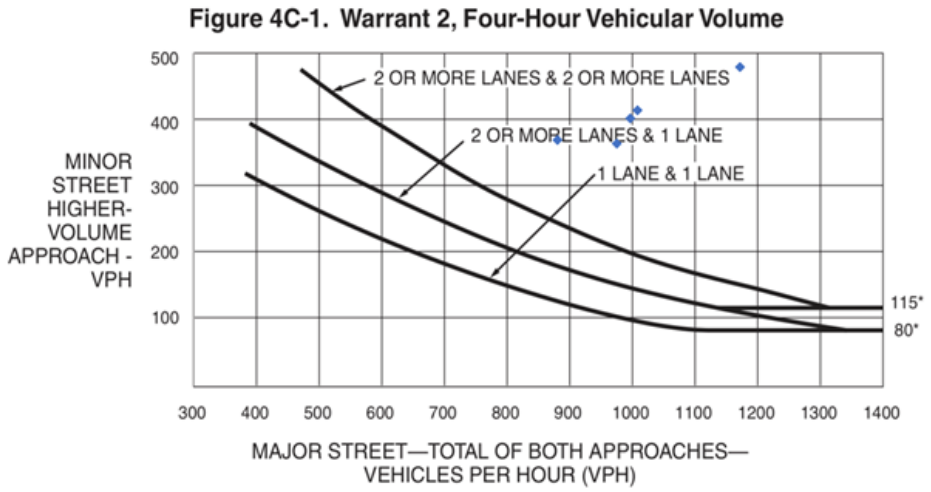
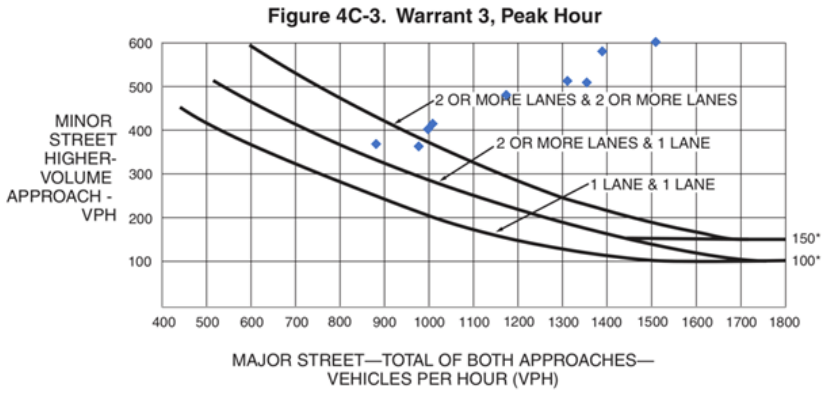


Figure 11-6 Warrant 3 analysis for White St and Navy Ave/Buzz St intersection



11.3 HCM Reports

Exhibit 11.3.1. AM Navy Ave/Gold St Report

Exhibit 11.3.2. PM Navy Ave/Gold St Report

Exhibit 11.3.3. AM Navy Ave/ Driveway Report

Exhibit 11.3.4. PM Navy Ave/ Driveway Report

Exhibit 11.3.5. AM White St/ Navy Ave/ Buzz St Report

Exhibit 11.3.6. PM White St/ Navy Ave/ Buzz St Report

11.4 Signage and Markings Tables

Table 11-1 Navy Ave Signage and Markings at Gold St Intersection

STA	Location	Sign/Marking	Designation	Dimension	Color	Reference
	Between lanes in same direction of travel	Broken line		1:3 line to gap ratio, 4-6 in wide	white	3B.05
	Between lanes in opposing directions of travel	Double solid line		4-6 in wide	yellow	3B.01, 3B.02
12+42	Right side of road	Speed limit 30	R2-1	30 x 36		2B.13
09+30	Right side of road	Speed limit 30	R2-1	30 x 36		2B.13
		Crosswalk lines		6-24in	white	3B.18
	Min 4’ behind crosswalk	Stop line		12 – 24 in	White	3B.16
	Down center of shared path	Dashed line		1:3 line to gap	yellow	

No guidance	Every approach needs to be able to read the street name. could be on a pole of its own or on the traffic light poles	Street name signs	D3-1	Varies x 12	Green, white text	2D.43
8+30	Northbound side of the road	Lane reduction sign	W4-2	36 x 36	yellow	2C.42
6+88.75	End the dashed white line					
2+65	Begin taper					
00+20	Taper ends					

Table 11-2 Gold St. Signage and Markings at Navy Ave Intersection

STA	Location	Sign/Marking	Designation	Dimension	Color	Reference
	Between lanes in same direction of travel	Broken line		1:3 line to gap ratio, 4-6 in wide	white	3B.05
	Between lanes in opposing directions of travel	Double solid line		4-6 in wide	yellow	3B.01, 3B. 02
21+42	Gold st, right side of road, 100 ft after intersection	Speed limit 45	R2-1	30 x 36	White	2B.13
18+58	Gold st, right side of road, 100 ft after intersection	Speed limit 45	R2-1	30 x 36	white	2B.13
17+58	side of the road	Lane reduction sign	W4-2	36 x 36	yellow	2C.42
15+64.25	End the dashed white line					

09+83	Begin taper					
04+43	Taper ends					
22+42	Northbound side of the road	Lane reduction sign	W4-2	36 x 36	yellow	2C.42
24+37.75	End the dashed white line					
30+17	Begin taper					
35+57	Taper ends					
		Crosswalk lines		6-24in	white	3B.18
	Min 4' behind crosswalk	Stop line		12 – 24 in	White	3B.16
No guidance	Every approach needs to be able to read the street name. could be on a pole of its own or on the traffic light poles	Street name signs	D3-1	Varies x 12	Green, white text	2D.43

Table 11-3 Navy Ave/ Buzz St Signage and Markings at White St Intersection

Station	Location	Sign / Marking	Designation	Dimension	Color	Reference
159+37	In the median	Left lane must turn left	R3-7	36 x 36	white	2B.20
	Min 4' behind crosswalk	Stop line		12 – 24 in	White	3B.16
	Across all roads	Crosswalk lines		6-24in	white	3B.18
	Between lanes in same direction of travel	Broken line		1:3 line to gap ratio, 4-6 in wide	white	3B.05
	Between lanes in opposing directions of	Double solid line		4-6 in wide each	yellow	3B.01, 3B.02

	travel					
	Down center of shared path	Dashed line		1:3 line to gap	yellow	
163+95	Towards end of shared use path, share pole		M1-8, M6-4	18 x 24		9B.21
164+71	On NW side of Buzz st, in line with stop line, share pole		M1-8, M6-4	12 x 9		9B.21
No guidance	Every approach needs to be able to read the street name. could be on a pole of its own or on the traffic light poles	Street name signs	D3-1	Varies x 12	Green, white text	2D.43
163+03	Left side of the road	Speed limit 30	R2-1	30 x 36	White	2B.13
163+73	Right side of road	Speed limit 35	R2-1	30 x 36	white	2B.13

Table 11-4 White St Signage and Markings at Navy Ave/Buzz St Intersection

Station	Location	Sign / Marking	Designation	Dimension	Color	Reference
		Crosswalk lines		6-24in	white	3B.18
	Min 4' behind crosswalk	Stop line		12 – 24 in	White	3B.16
	Bike lane			6'-6"	white	9C.04
	Right side of right lane (for bike lane)	Solid line		4-6in wide	white	3D.02
Min 4' behind crosswalk	Stop line		12 – 24 in	White	3B.16	
Across all roads	Crosswalk lines		6-24in	white	3B.18	
Between lanes in same direction of travel	Broken line		1:3 line to gap ratio, 4-6 in wide	white	3B.05	

Between lanes in opposing directions of travel	Double solid line		4-6 in wide each	yellow	3B.01, 3B. 02	
No guidance	Every approach needs to be able to read the street name. could be on a pole of its own or on the traffic light poles	Street name signs	D3-1	Varies x 12	Green, white text	2D.43

Table 11-5 Navy Ave Signage and Markings at Driveway Intersection

Station	Location	Sign / Marking	Designation	Dimension	Color	Reference
7886	Center of path	Yield	R1-2	18 x 18 x 18	White, red	9B.03
7914	Center of path	Yield	R1-2	18 x 18 x 18	White, red	9B.03
7913 (or where it fits)	Near multi-use path so driveway driver can see	Shared path xing here	Combo W11-15 W11-15P W16-7P	30 x 30 24 x 18 24 x 12	Yellow	9B.18
	Between lanes in same direction of travel	Broken line		1:3 line to gap ratio, 4-6 in wide	white	3B.05
	Between lanes in opposing directions of travel	Double solid line		4-6 in wide	yellow	3B.01, 3B. 02
77+00		Speed limit 30	R2-1			2B.13
79+00		Speed limit 30	R2-1			2B.13
	Down center of shared path	Dashed line		1:3 line to gap	yellow	

No guidance	Every approach needs to be able to read the street name. could be on a pole of its own or on the traffic light poles	Street name signs	D3-1	Varies x 12	Green, white text	2D.43
No guidance	Every approach needs to be able to read the street name. could be on a pole of its own or on the traffic light poles	Street name signs	D3-1	Varies x 12	Green, white text	2D.43

Table 11-6 Driveway Signage and Markings at Navy Ave Intersection

Station	Location	Sign/Marking	Designation	Dimension	Color	Reference
	Driveway Approach	Stop	R1-1	36 x 36	Red	2B.05
	Below the stop sign	Cross traffic DNS	W4-4P	24 x 12	yellow	2C.59
	Between lanes	Broken line		1:3 line to gap ratio, 4-6 in wide	yellow	3B.01
Across driveway approach	Min 4' behind crosswalk	Stop line		12 – 24 in	White	3B.16
Across driveway		Crosswalk lines		6-24in	white	3B.18
No guidance	Every approach needs to be able to read the street name. could be on a pole of its own or on the traffic light poles	Street name signs	D3-1	Varies x 12	Green, white text	2D.43

Table 11-7 Multi-Use Path Signage and Markings

Station	Location	Sign/Marking	Designation	Dimension	Color	Reference
104+74	On gate pole	crossbuck	R15-1	24 x 4.5		8B.03, 9B.14
104+74	1 gate per approach, arm extends over path. Gate base is 1' to the side of the shoulder	Gate				8C.04
103+74		RR warning	W10-1	24 Dia.		8B.06, 9B.19
104+24		RR crossing paint on path		See Figure 8B-7a and scale		8B.27
104+98	On gate pole	crossbuck	R15-1	24 x 4.5		8B.03, 9B.14
104+98	1 gate per approach, arm extends over path. Gate base is 1' to the side of the shoulder	Gate				8C.04, 8D.06,
105+98		RR warning	W10-1	24 Dia.		8B.06, 9B.19
105+48		RR crossing paint on path		See Figure 8B-7a and scale		8B.27
105+26	For those who just crossed tracks	Directions sign	D1-3b	Varies x 18	Green	9B.20
105+08	For those who are facing tracks	Directions sign	D1-3b	Varies x 18	Green	9B.20
	Down center of path	Dashed line		1:3 line to gap	yellow	

11.5 Drawings

Exhibit 11.1.1

Signalization and Intersection Control

Due:

Section D1: March 6th 2020
Section D2: March 6th 2020
Section D3: March 5th 2020

Formatting

- ☑ Organized, typed, and clearly written
- ☑ Summary of work
- ☑ Highlighted results or design elements

Analysis for Intersection (Driveway & Navy Ave)

- ☑ Warrant Analysis
- ☑ Peak hour turning movement volumes
- ☑ HCS reports for AM peak and PM peak
- ☑ Intersection lane configuration shown (final report submission must be as part of plan set)
- ☑ Dual Ring Diagram, green time, yellow change interval, and red-clearance time (if signal warranted)
- ☑ LOS and v/c summary tables and discussion

Analysis for Intersection (Navy Ave & Gold Street)

- ☑ Warrant Analysis
- ☐ Peak hour turning movement volumes
- ☑ HCS reports for AM peak and PM peak
- ☑ Intersection lane configuration shown (final report submission must be as part of plan set)
- ☑ Dual Ring Diagram, green time, yellow change interval, and red-clearance time (if signal warranted)
- ☐ LOS and v/c summary tables and discussion

Analysis for Intersection (Navy Ave/Buzz Street & White Street)

- ☑ Warrant Analysis
- ☑ Peak hour turning movement volumes
- ☑ HCS reports for AM peak and PM peak
- ☑ Intersection lane configuration shown (final report submission must be as part of plan set)
- ☑ Dual Ring Diagram, green time, yellow change interval, and red-clearance time (if signal warranted)
- ☑ LOS and v/c summary tables and discussion

Turn Bay Analysis

- ☑ Analysis for each intersection
- ☑ AM peak and PM peak hour traffic volumes shown for each turning movement
- ☑ Determine if GDOT left turn phasing criteria are satisfied
- ☑ Design speed and deceleration distance for each turn bay
- ☐ Calculations using the AM peak and PM peak traffic for each turn bay
- ☑ Length of each turn bay shown

_____TA Signature _____Group Representative _____ Date

Exhibit 11.1.2

Horizontal Alignment/Superelevation Checklist

Due: Section D1: March 13, 2020
Section D2: March 13, 2020
Section D3: March 12, 2020

Formatting

- ☑ Organized, typed, and clearly written
- ☑ Summary of work
- ☑ Highlighted results or design elements
- ☑ Title block for all CAD drawings

Horizontal Alignment Summary

- ☐ Highlighted results or design elements
- ☐ Methodology for designing horizontal alignment
- ☐ Provide summary table of all curves in horizontal alignment (Curve Number, PC Station, PT Station, Δ, R, T, L, M)

Horizontal Centerline Schematic of Entire Route

- ☑ Drawn neatly in CAD
- ☑ PIs labeled with #, Northing, and Easting
- ☑ Tangent distances shown
- ☑ Tangent bearings shown
- ☑ Curves labeled
- ☑ R, T, L and Δ shown for each curve
- ☑ Show beginning, end and PI stations
- ☑ North arrow
- ☑ Graphical scale (should match a typical engineering scale used)
- ☑ Title block in one corner (can be printed on several pages, if a large plot is not able to be printed – title block should be on each page)

Stationing

- ☑ Station beginning at Navy Ave and Gold St intersection (10+00)
- ☑ Mark every 100 foot station
- ☑ Stationing follows along curves

Horizontal Alignment Sample Calculations (Select 1 Curve)

- ☑ Demonstrated calculation for Δ
- ☑ Demonstrated calculation for L
- ☑ Demonstrated calculation for T from PI to PC, and from PI to PT
- ☑ Demonstrated calculation for M (middle ordinate)
- ☑ Drawing of selected curve
    - Bearings and tangents shown
    - Chosen radius shown
    - Curve data shown
    - North arrow and scale (or specify if not to scale)

Superelevation Calculations

- ☑ Normal Crown Rate used in Tangent Sections shown/stated
- ☑ Maximum allowable superelevation shown/stated
- ☐ Sample calculations shown for one selected curve
- ☐ Superelevation summary table completed with all curves:
    - Length of Superelevation Runoff shown for each curve
    - Length of Tangent Runout shown for each curve
    - Beginning of superelevation lane transition (BOLT), outside lane crosses 0% (OLC0%), begin inside lane transition (BILT), and full superelevation (FULLE) stations labeled for each curve
    - Superelevation sections do not overlap

TA Signature _____ Group Representative _____ Date

Exhibit 11.1.3

Vertical Alignment Checklist

Due: Section D1: April 3rd, 2020
Section D2: April 3rd, 2020
Section D3: April 2nd, 2020

Formatting

- ☑ Organized, typed, and clearly written
- ☑ Summary of work
- ☑ Highlighted results or design elements
- ☑ Title block for all CAD drawings

Vertical Curve Summary

- ☑ Summary table showing: curve #, tangent grades, lengths of curves, and PVC, PVI, & PVT stations and elevations

Vertical Alignment Schematic (entire Navy Ave. project length)

- ☑ Drawn neatly (in CAD)
- ☑ Existing (dashed) and proposed (solid) ground shown and labeled clearly
- ☑ PVC, PVI, PVT labeled for each vertical curve (station and elevation)
- ☑ Tangent grades shown to two decimal places
- ☑ Begin, end and intersection stations and elevations labeled
- ☐ Horizontal and vertical scales shown

Vertical Sample Calculations

- ☑ Explain methodology used for creating vertical alignment
- ☑ One curve selected for sample calculations
  - Algebraic difference (A) calculated and shown
  - K value selected, documented as adequate and shown
  - Length (L) of curve calculated correctly
  - PVI, PVC, PVT stations and elevations calculated
  - Proposed elevations of full stations (100') along curve calculated
  - Curve High/Low Point station and elevation calculated
- ☐ Drawing of Selected Curve
  - Grades of tangents shown (2 decimal places)
  - Algebraic difference shown
  - K value shown
  - Length of curve shown
  - Stations and Elevations of PVI, PVC, PVT, and High/Low Point shown

Bridge Schematic

- ☑ Show grades of tangent sections and bridge deck
- ☑ Bridge span labeled
- ☑ Show vertical curves (PVCs & PVTs labeled)
- ☑ Vertical and horizontal clearance labeled

Lucas Yu TA Signature _____ Group Representative 4-2-2020 Date

Exhibit 11.1.4

Cross Sections Checklist

Due: Section D1: April 3rd, 2020
Section D2: April 3rd, 2020
Section D3: April 2nd, 2020

Formatting

- ☑ Organized, typed, and clearly written
- ☑ Summary of work
- ☑ Highlighted results or design elements
- ☑ Title block for all CAD drawings

Typical Cross Section

- ☑ Discussion of median and bike/pedestrian facilities to be included
- ☑ Typical Section Drawing:
  - Show cut on left side and fill on right side
  - Existing (dashed) and proposed (solid) ground clearly labeled
  - Centerline clearly labeled
  - Roadway template shown for proposed ground side slopes, pavement cross-slopes, and dimensions are clearly labeled
  - Scale shown graphically (vertical scale exaggerated)
  - Limits of construction and minimum right of way limits clearly marked
  - Enlarged view of typical bike/pedestrian facilities and/or roadway curb

Horizontal Alignment Cross Sections

- ☑ For one selected horizontal curve:
  - Cross sections for every 100-foot station
  - Cross sections at PC and PT
  - Correct superelevations shown
- ☑ Cross-slopes clearly labeled
- ☑ Existing (dashed) and proposed (solid) ground clearly labeled
- ☑ Existing and proposed elevations shown at the centerline
- ☑ Scale shown graphically (vertical scale exaggerated)
- ☑ Cross section station labeled
- ☐ Limits of construction and minimum ROW limits clearly marked and dimensioned

Vertical Alignment Cross Sections

- ☐ Cross sections for every 100-foot station from beginning of bridge vertical curve transition to center of bridge
- ☐ Cross sections at all PVCs and PVTs
- ☑ Existing (dashed) and proposed (solid) ground clearly labeled
- ☐ Existing and proposed elevations shown at the centerline
- ☑ Scale shown graphically (vertical scale exaggerated)
- ☐ Cross section station labeled
- ☐ Limits of construction and minimum ROW limits clearly marked and dimensioned

Lucas Yu TA Signature _____ Group Representative 4-9-2020 Date

Exhibit 11.1.5

Marking and Signing Checklist

Due: Section D1: April 10th, 2020
Section D2: April 10th, 2020
Section D3: April 9th, 2020

Formatting

- ☑ Organized, typed, and clearly written
- ☑ Methodology for signing and marking plans (cite references used)
- ☑ Title block for all CAD drawings

Intersection and Roadway Design Plans

- ☑ Drawing for each intersection (Navy & Gold, Navy & Driveway, Navy & White)
- ☐ Stationing, north arrow, scale, and street names
- ☑ Stop bars, width and color
- ☑ Lane lines, width, color, length and spacing
- ☑ Edge of pavement lines, width and color
- ☑ Turning arrows (show how many), dimensions and color
- ☑ Bicycle accommodations (i.e. bike lane striping & marking), dimensions and color
- ☑ Pedestrian accommodations (i.e. crosswalks, etc.), dimensions and color
- ☑ Other pavement markings deemed necessary, dimensions and color
- ☑ Speed limit sign
- ☑ Street name sign
- ☑ Additional signs deemed necessary (i.e. stop signs, yield signs, etc.)
- ☐ For signalized & unsignalized intersections:
    - Labeled turn radii and clearances
    - Labeled curb return radii

Signalization Plans (extra credit)

- ☐ For each signalized intersection (Optional)
- ☐ Location of signal cabinet (Optional)
- ☐ Location of signal poles and support structures (Optional)
- ☐ Location and configuration of signal displays (Optional)
- ☐ Signal phasing sequence (Optional)

Pedestrian/Bicycle Connection to Multi-use Path

- ☑ Bicycle and/or pedestrian facilities tie into multi-use path near railroad, at-grade
- ☑ Any signs & pavement markings deemed necessary

Available Sources:

MUTCD (http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm) - primary reference
Urban Bikeway Design Guide (https://nacto.org/publication/urban-bikeway-design-guide/)

Lucas Yu TA Signature _____ Group Representative 4-9-2020 Date

Exhibit 11.3.1

Gold @ Navy AM
Final Project

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	55	1837	83	77	1392	105	255	305	275	255	275	250
Future Volume (veh/h)	55	1837	83	77	1392	105	255	305	275	255	275	250
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1826	1826	1826	1826	1826	1826	1826	1826	1826	1826	1826	1826
Adj Flow Rate, veh/h	60	1997	90	84	1513	114	277	332	299	277	299	272
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	5	5	5	5	5	5	5	5	5	5	5	5
Cap, veh/h	168	2268	102	122	2193	165	309	618	605	282	618	605
Arrive On Green	0.46	0.46	0.46	0.46	0.46	0.46	0.39	0.39	0.39	0.39	0.39	0.39
Sat Flow, veh/h	302	4890	220	193	4729	356	523	1578	1547	455	1578	1547
Grp Volume(v), veh/h	60	1355	732	84	1063	564	277	332	299	277	299	272
Grp Sat Flow(s),veh/h/ln	302	1662	1786	193	1662	1762	523	1578	1547	455	1578	1547
Q Serve(g_s), s	13.5	25.5	25.7	6.3	17.4	17.4	17.2	11.2	10.1	15.8	9.8	9.0
Cycle Q Clear(g_c), s	30.9	25.5	25.7	32.0	17.4	17.4	27.0	11.2	10.1	27.0	9.8	9.0
Prop In Lane	1.00		0.12	1.00		0.20	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	168	1541	828	122	1541	817	309	618	605	282	618	605
V/C Ratio(X)	0.36	0.88	0.88	0.69	0.69	0.69	0.90	0.54	0.49	0.98	0.48	0.45
Avail Cap(c_a), veh/h	168	1541	828	122	1541	817	309	618	605	282	618	605
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	26.8	16.8	16.8	33.8	14.6	14.6	28.2	16.2	15.8	29.4	15.8	15.5
Incr Delay (d2), s/veh	5.8	7.5	13.1	27.2	2.6	4.7	30.6	3.3	2.9	49.0	2.7	2.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(95%),veh/ln	2.0	13.6	16.2	3.9	9.3	10.4	11.2	7.1	6.2	12.8	6.2	5.5
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	32.6	24.2	29.9	61.1	17.1	19.3	58.7	19.5	18.7	78.4	18.5	17.9
LnGrp LOS	C	C	C	E	B	B	E	B	B	E	B	B
Approach Vol, veh/h		2147			1711			908			848	
Approach Delay, s/veh		26.4			20.0			31.2			37.9	
Approach LOS		C			C			C			D	

Timer - Assigned Phs		2		4		6		8				
Phs Duration (G+Y+Rc), s		32.0		37.0		32.0		37.0				
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0				
Max Green Setting (Gmax), s		27.0		32.0		27.0		32.0				
Max Q Clear Time (g_c+I1), s		29.0		32.9		29.0		34.0				
Green Ext Time (p_c), s		0.0		0.0		0.0		0.0				

Intersection Summary	
HCM 6th Ctrl Delay	27.0
HCM 6th LOS	C

Notes

User approved pedestrian interval to be less than phase max green.

Exhibit 11.3.2

Gold @ Navy PM

0408

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	275	1392	281	303	1837	250	75	275	70	95	305	50
Future Volume (veh/h)	275	1392	281	303	1837	250	75	275	70	95	305	50
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1826	1826	1826	1826	1826	1826	1826	1826	1826	1826	1826	1826
Adj Flow Rate, veh/h	299	1513	305	329	1997	272	82	299	76	103	332	54
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Percent Heavy Veh, %	5	5	5	5	5	5	5	5	5	5	5	5
Cap, veh/h	321	1627	327	455	2061	277	120	402	394	144	402	394
Arrive On Green	0.15	0.39	0.39	0.22	0.46	0.46	0.25	0.25	0.25	0.25	0.25	0.25
Sat Flow, veh/h	1739	4163	836	1739	4444	597	214	1578	1547	310	1578	1547
Grp Volume(v), veh/h	299	1207	611	329	1486	783	82	299	76	103	332	54
Grp Sat Flow(s),veh/h/ln	1739	1662	1675	1739	1662	1718	214	1578	1547	310	1578	1547
Q Serve(g_s), s	14.3	38.2	38.5	14.2	47.7	49.4	6.2	19.2	4.2	8.8	21.8	3.0
Cycle Q Clear(g_c), s	14.3	38.2	38.5	14.2	47.7	49.4	28.0	19.2	4.2	28.0	21.8	3.0
Prop In Lane	1.00		0.50	1.00		0.35	1.00		1.00	1.00		1.00
Lane Grp Cap(c), veh/h	321	1299	655	455	1541	797	120	402	394	144	402	394
V/C Ratio(X)	0.93	0.93	0.93	0.72	0.96	0.98	0.68	0.74	0.19	0.71	0.83	0.14
Avail Cap(c_a), veh/h	321	1299	655	455	1541	797	120	402	394	144	402	394
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	33.1	32.0	32.1	28.0	28.6	29.1	53.0	37.7	32.1	51.6	38.7	31.7
Incr Delay (d2), s/veh	35.6	12.9	22.2	9.6	15.9	27.9	27.2	11.8	1.1	25.8	17.4	0.7
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(95%),veh/ln	11.1	22.7	25.1	7.5	27.4	32.0	5.6	13.1	2.9	6.9	15.2	2.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	68.7	44.9	54.3	37.6	44.6	57.0	80.2	49.5	33.2	77.4	56.1	32.4
LnGrp LOS	E	D	D	D	D	E	F	D	C	E	E	C
Approach Vol, veh/h		2117			2598			457			489	
Approach Delay, s/veh		51.0			47.4			52.3			58.0	
Approach LOS		D			D			D			E	

Timer - Assigned Phs		2	3	4		6	7	8				
Phs Duration (G+Y+Rc), s		33.0	29.0	48.0		33.0	21.0	56.0				
Change Period (Y+Rc), s		5.0	5.0	5.0		5.0	5.0	5.0				
Max Green Setting (Gmax), s		28.0	24.0	43.0		28.0	16.0	51.0				
Max Q Clear Time (g_c+I1), s		30.0	16.2	40.5		30.0	16.3	51.4				
Green Ext Time (p_c), s		0.0	0.6	2.1		0.0	0.0	0.0				

Intersection Summary	
HCM 6th Ctrl Delay	50.1
HCM 6th LOS	D

Notes

User approved pedestrian interval to be less than phase max green.

Intersection	
Int Delay, s/veh	1.7

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	402	61	33	842	70	25
Future Vol, veh/h	402	61	33	842	70	25
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	25	-	0	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	95	95	95	95	95	95
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	423	64	35	886	74	26

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	487	0	968	244
Stage 1	-	-	-	-	455	-
Stage 2	-	-	-	-	513	-
Critical Hdwy	-	-	4.14	-	6.84	6.94
Critical Hdwy Stg 1	-	-	-	-	5.84	-
Critical Hdwy Stg 2	-	-	-	-	5.84	-
Follow-up Hdwy	-	-	2.22	-	3.52	3.32
Pot Cap-1 Maneuver	-	-	1072	-	251	757
Stage 1	-	-	-	-	606	-
Stage 2	-	-	-	-	566	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1072	-	243	757
Mov Cap-2 Maneuver	-	-	-	-	243	-
Stage 1	-	-	-	-	606	-
Stage 2	-	-	-	-	547	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.3	23.2
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	296	-	-	1072	-
HCM Lane V/C Ratio	0.338	-	-	0.032	-
HCM Control Delay (s)	23.2	-	-	8.5	-
HCM Lane LOS	C	-	-	A	-
HCM 95th %tile Q(veh)	1.4	-	-	0.1	-

Intersection	
Int Delay, s/veh	2.1

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Vol, veh/h	803	116	33	402	55	30
Future Vol, veh/h	803	116	33	402	55	30
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	25	-	-	-
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	95	95	95	95	95	95
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	845	122	35	423	58	32

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	967	0	1188	484
Stage 1	-	-	-	-	906	-
Stage 2	-	-	-	-	282	-
Critical Hdwy	-	-	4.14	-	6.84	6.94
Critical Hdwy Stg 1	-	-	-	-	5.84	-
Critical Hdwy Stg 2	-	-	-	-	5.84	-
Follow-up Hdwy	-	-	2.22	-	3.52	3.32
Pot Cap-1 Maneuver	-	-	708	-	181	529
Stage 1	-	-	-	-	355	-
Stage 2	-	-	-	-	741	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	708	-	172	529
Mov Cap-2 Maneuver	-	-	-	-	172	-
Stage 1	-	-	-	-	355	-
Stage 2	-	-	-	-	705	-

Approach	EB	WB	NB
HCM Control Delay, s	0	0.8	31
HCM LOS			D

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	226	-	-	708	-
HCM Lane V/C Ratio	0.396	-	-	0.049	-
HCM Control Delay (s)	31	-	-	10.3	-
HCM Lane LOS	D	-	-	B	-
HCM 95th %tile Q(veh)	1.8	-	-	0.2	-

Exhibit 11.3.5

HCM 6th Signalized Intersection Summary

3: 03/04/2020

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	226	550	110	83	688	446	140	185	150	125	105	165
Future Volume (veh/h)	226	550	110	83	688	446	140	185	150	125	105	165
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	246	598	120	90	748	485	152	201	163	132	111	174
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	259	912	183	358	1128	956	212	239	194	157	164	257
Arrive On Green	0.60	0.60	0.60	0.60	0.60	0.60	0.25	0.25	0.25	0.25	0.25	0.25
Sat Flow, veh/h	452	1512	303	734	1870	1585	1094	956	775	1018	656	1029
Grp Volume(v), veh/h	246	0	718	90	748	485	152	0	364	132	0	285
Grp Sat Flow(s),veh/h/ln	452	0	1816	734	1870	1585	1094	0	1731	1018	0	1685
Q Serve(g_s), s	23.0	0.0	17.7	6.2	18.0	11.9	6.6	0.0	13.6	3.4	0.0	10.4
Cycle Q Clear(g_c), s	41.0	0.0	17.7	23.9	18.0	11.9	17.0	0.0	13.6	17.0	0.0	10.4
Prop In Lane	1.00		0.17	1.00		1.00	1.00		0.45	1.00		0.61
Lane Grp Cap(c), veh/h	259	0	1095	358	1128	956	212	0	433	157	0	421
V/C Ratio(X)	0.95	0.00	0.66	0.25	0.66	0.51	0.72	0.00	0.84	0.84	0.00	0.68
Avail Cap(c_a), veh/h	259	0	1095	358	1128	956	212	0	433	157	0	421
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	26.9	0.0	8.9	16.7	8.9	7.7	31.7	0.0	24.2	33.3	0.0	23.0
Incr Delay (d2), s/veh	44.6	0.0	3.1	1.7	3.1	1.9	18.6	0.0	17.7	39.1	0.0	8.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	7.1	0.0	6.4	1.1	6.7	3.7	3.5	0.0	7.3	3.8	0.0	4.9
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	71.5	0.0	11.9	18.4	12.0	9.6	50.3	0.0	41.9	72.4	0.0	31.5
LnGrp LOS	E	A	B	B	B	A	D	A	D	E	A	C
Approach Vol, veh/h		964			1323			516			417	
Approach Delay, s/veh		27.1			11.6			44.4			44.4	
Approach LOS		C			B			D			D	

Timer - Assigned Phs		2		4		6		8				
Phs Duration (G+Y+Rc), s		22.0		46.0		22.0		46.0				
Change Period (Y+Rc), s		5.0		5.0		5.0		5.0				
Max Green Setting (Gmax), s		17.0		41.0		17.0		41.0				
Max Q Clear Time (g_c+I1), s		19.0		43.0		19.0		25.9				
Green Ext Time (p_c), s		0.0		0.0		0.0		7.1				

Intersection Summary	
HCM 6th Ctrl Delay	25.7
HCM 6th LOS	C

Notes

User approved pedestrian interval to be less than phase max green.

Exhibit 11.3.6

HCM 6th Signalized Intersection Summary

3: 03/04/2020

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	77	605	55	149	754	226	50	120	70	250	175	335
Future Volume (veh/h)	77	605	55	149	754	226	50	120	70	250	175	335
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870	1870
Adj Flow Rate, veh/h	84	658	60	162	820	246	54	130	76	263	184	353
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.95	0.95	0.95
Percent Heavy Veh, %	2	2	2	2	2	2	2	2	2	2	2	2
Cap, veh/h	164	777	71	229	860	729	168	376	220	441	195	374
Arrive On Green	0.46	0.46	0.46	0.46	0.46	0.46	0.34	0.34	0.34	0.34	0.34	0.34
Sat Flow, veh/h	529	1689	154	734	1870	1585	868	1107	647	1176	573	1099
Grp Volume(v), veh/h	84	0	718	162	820	246	54	0	206	263	0	537
Grp Sat Flow(s),veh/h/ln	529	0	1843	734	1870	1585	868	0	1754	1176	0	1672
Q Serve(g_s), s	1.9	0.0	17.2	5.8	21.1	5.0	1.4	0.0	4.4	10.8	0.0	15.6
Cycle Q Clear(g_c), s	23.0	0.0	17.2	23.0	21.1	5.0	17.0	0.0	4.4	15.2	0.0	15.6
Prop In Lane	1.00		0.08	1.00		1.00	1.00		0.37	1.00		0.66
Lane Grp Cap(c), veh/h	164	0	848	229	860	729	168	0	596	441	0	569
V/C Ratio(X)	0.51	0.00	0.85	0.71	0.95	0.34	0.32	0.00	0.35	0.60	0.00	0.94
Avail Cap(c_a), veh/h	164	0	848	229	860	729	168	0	596	441	0	569
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	24.8	0.0	11.9	23.5	13.0	8.6	24.7	0.0	12.3	18.0	0.0	16.0
Incr Delay (d2), s/veh	10.9	0.0	10.2	17.0	21.2	1.3	5.0	0.0	1.6	5.9	0.0	26.2
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	1.4	0.0	7.8	2.9	11.8	1.6	0.8	0.0	1.7	3.3	0.0	9.1
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	35.7	0.0	22.2	40.5	34.2	9.9	29.7	0.0	13.9	23.9	0.0	42.3
LnGrp LOS	D	A	C	D	C	A	C	A	B	C	A	D
Approach Vol, veh/h		802			1228			260			800	
Approach Delay, s/veh		23.6			30.1			17.2			36.2	
Approach LOS		C			C			B			D	

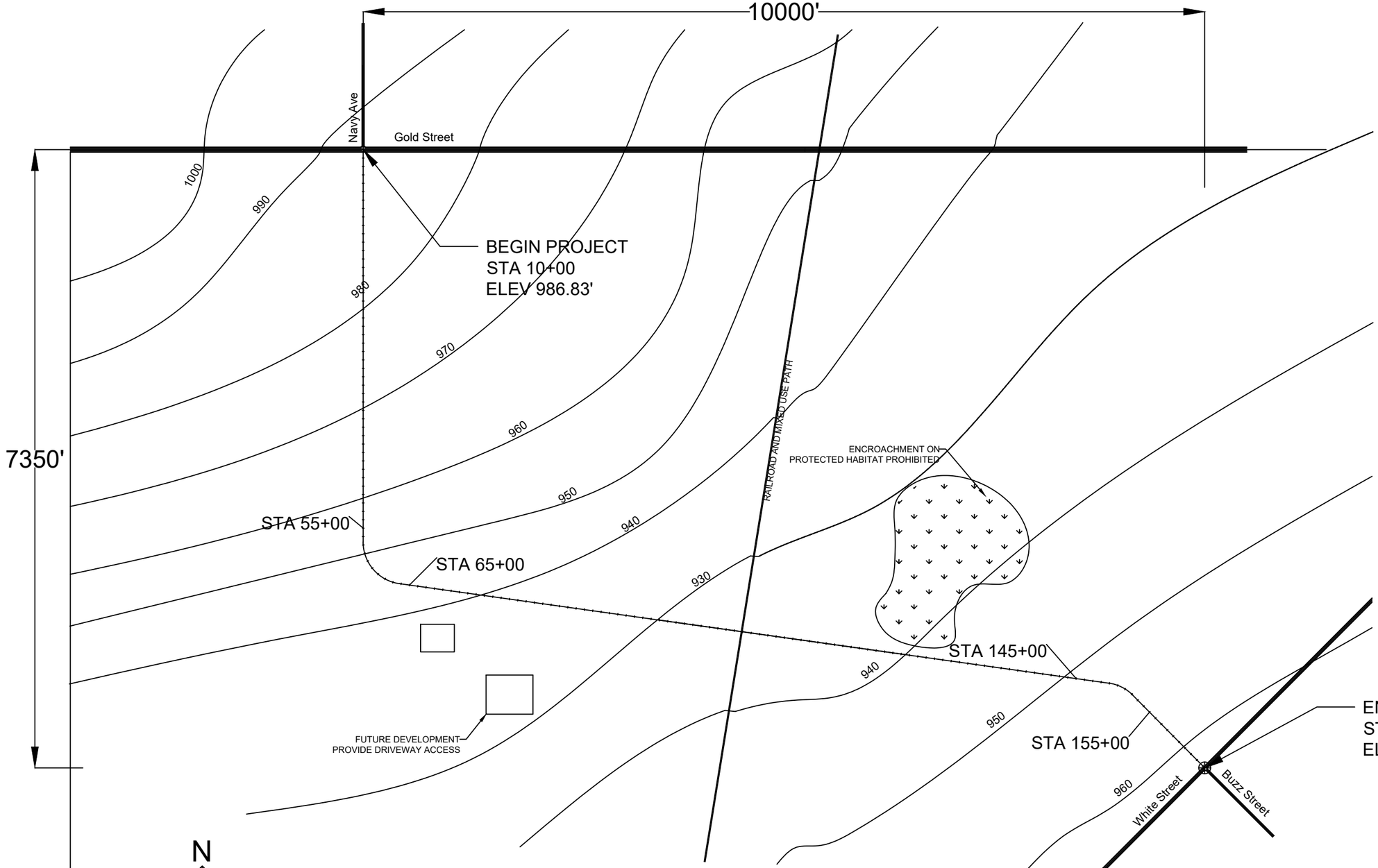
Timer - Assigned Phs	2	4	6	8
Phs Duration (G+Y+Rc), s	22.0	28.0	22.0	28.0
Change Period (Y+Rc), s	5.0	5.0	5.0	5.0
Max Green Setting (Gmax), s	17.0	23.0	17.0	23.0
Max Q Clear Time (g_c+I1), s	19.0	25.0	17.6	25.0
Green Ext Time (p_c), s	0.0	0.0	0.0	0.0

Intersection Summary	
HCM 6th Ctrl Delay	28.9
HCM 6th LOS	C

Notes

User approved pedestrian interval to be less than phase max green.

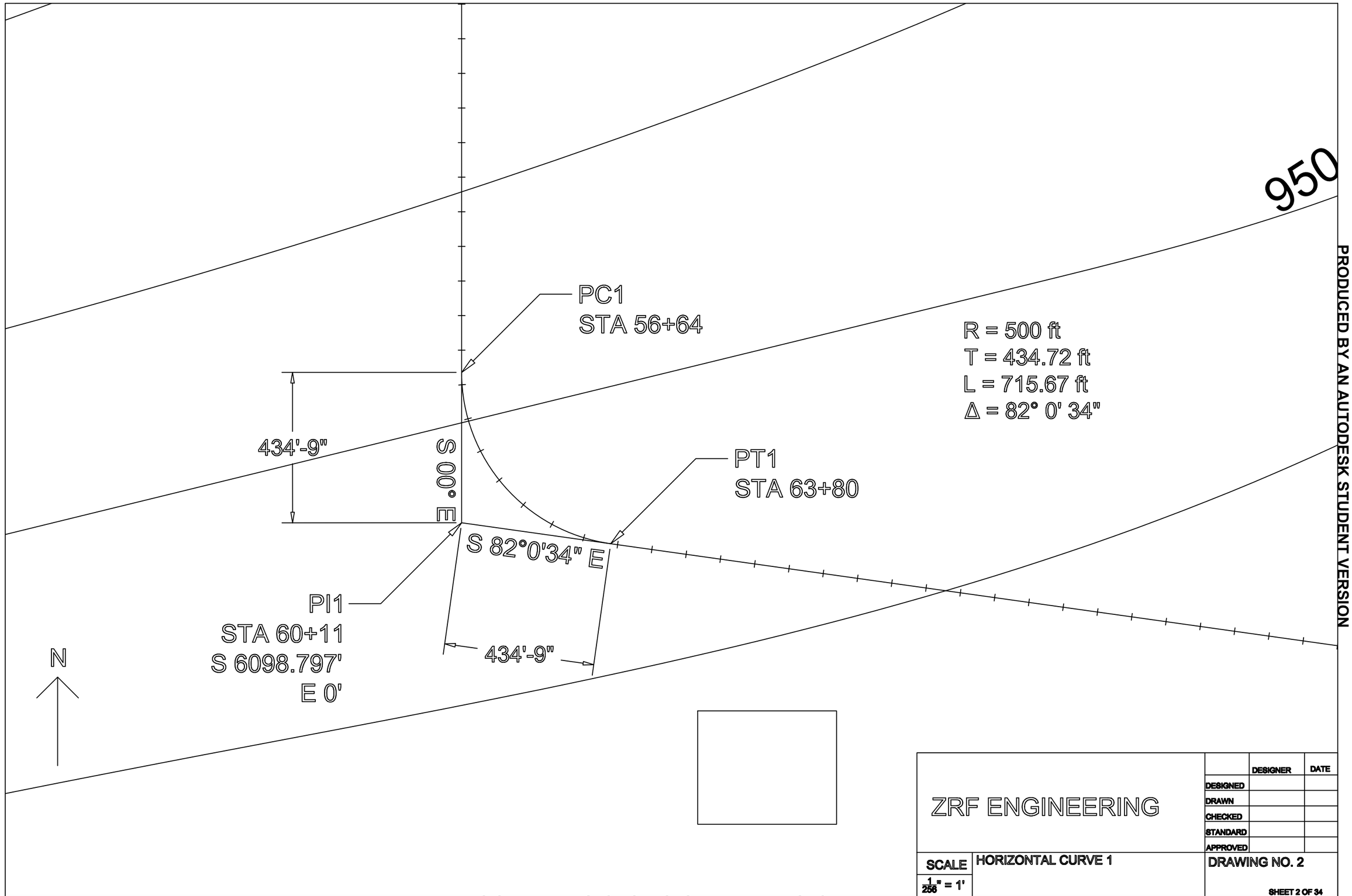
Exhbit 11.5.1



CEE 4600 - Design Project Area Sketch
Scale: 1" = 1500'
See CAD file "4600 Site Spring 2020.dwg"

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1:15000	HORIZONTAL CENTERLINE SCHEMATIC	DRAWING NO. 1	
		SHEET 1 OF 34	

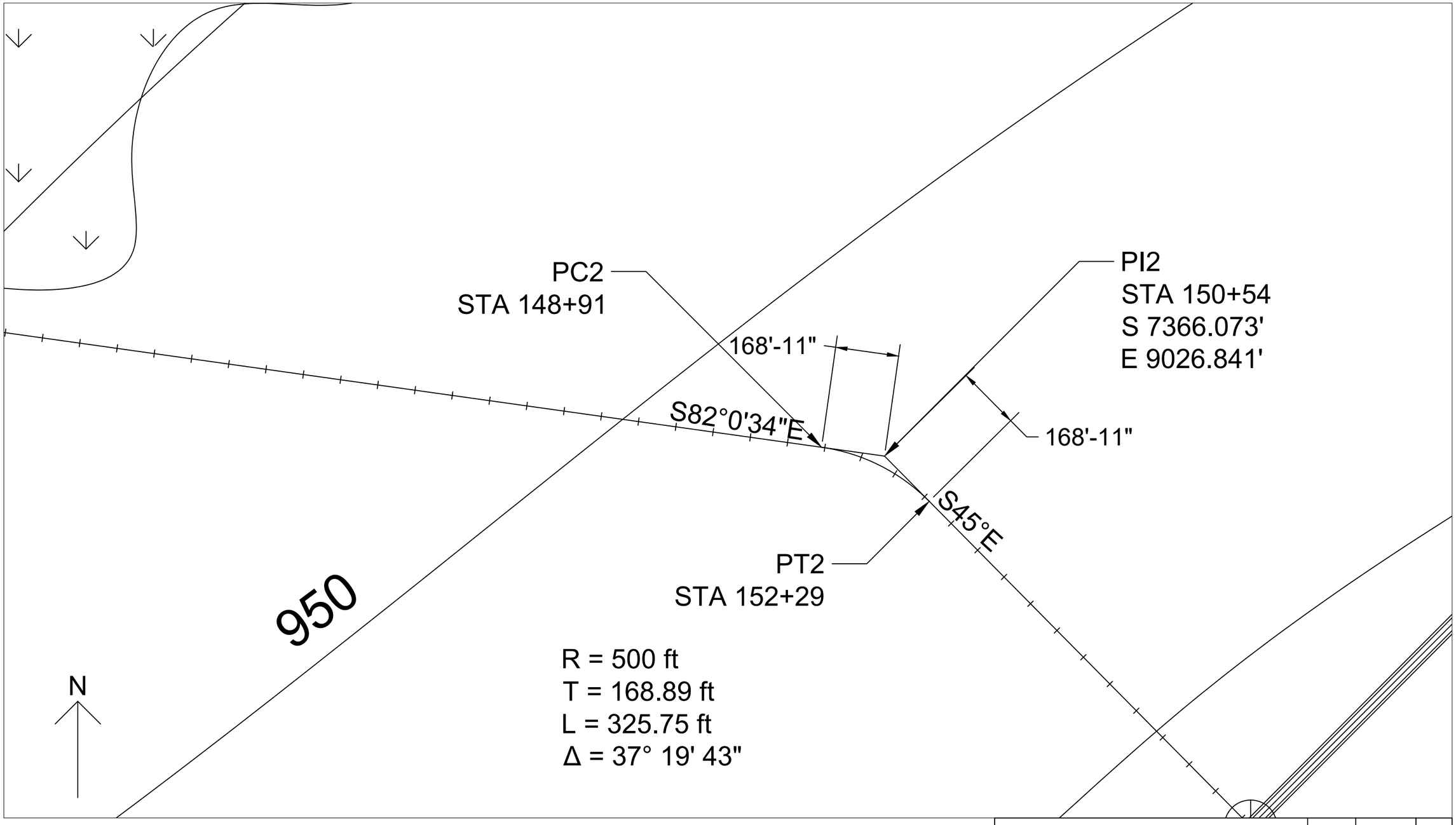
Exhbit 11.5.2



ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/256" = 1'	HORIZONTAL CURVE 1	DRAWING NO. 2	SHEET 2 OF 34

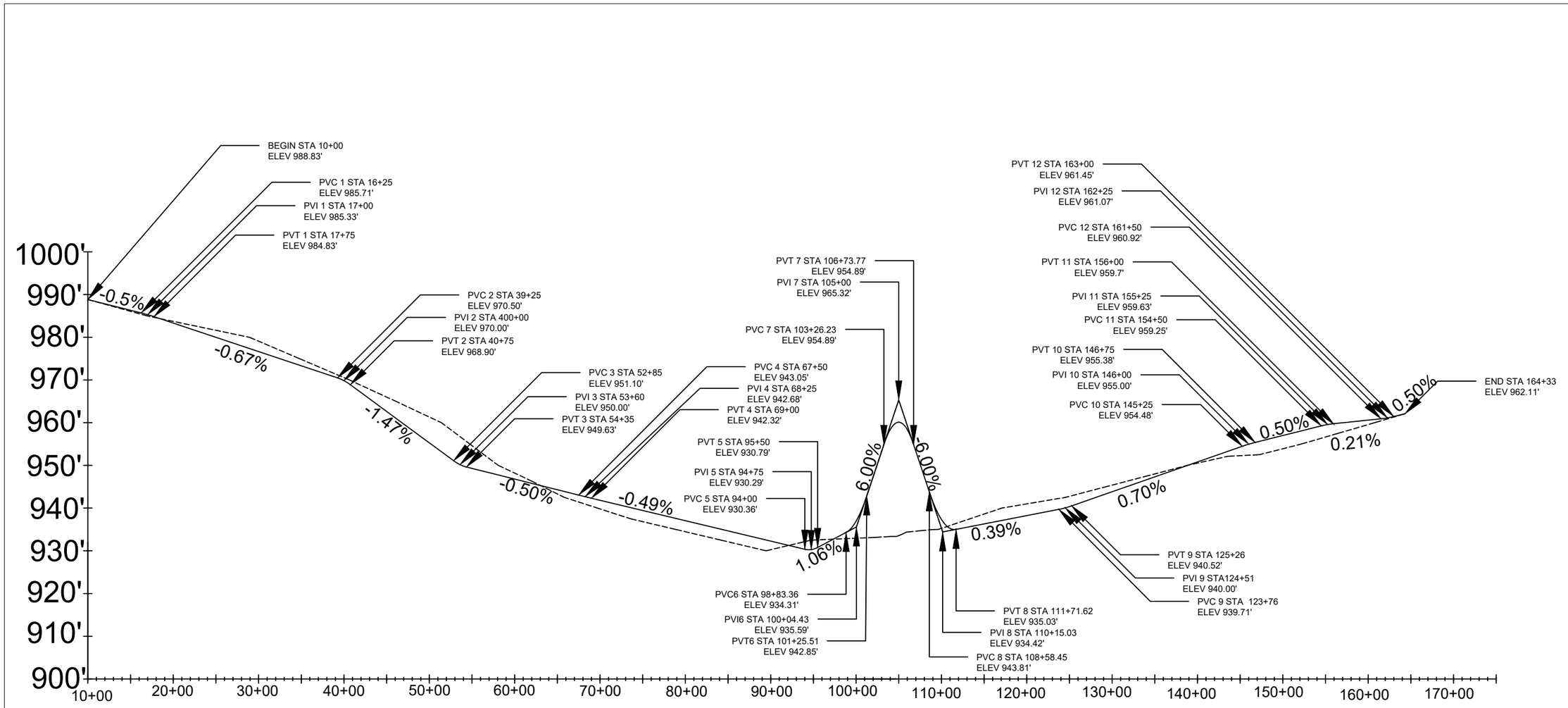
PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.3



ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{256}$" = 1'	HORIZONTAL CURVE 2	DRAWING NO. 3	SHEET 3 OF 34

Exhbit 11.5.4

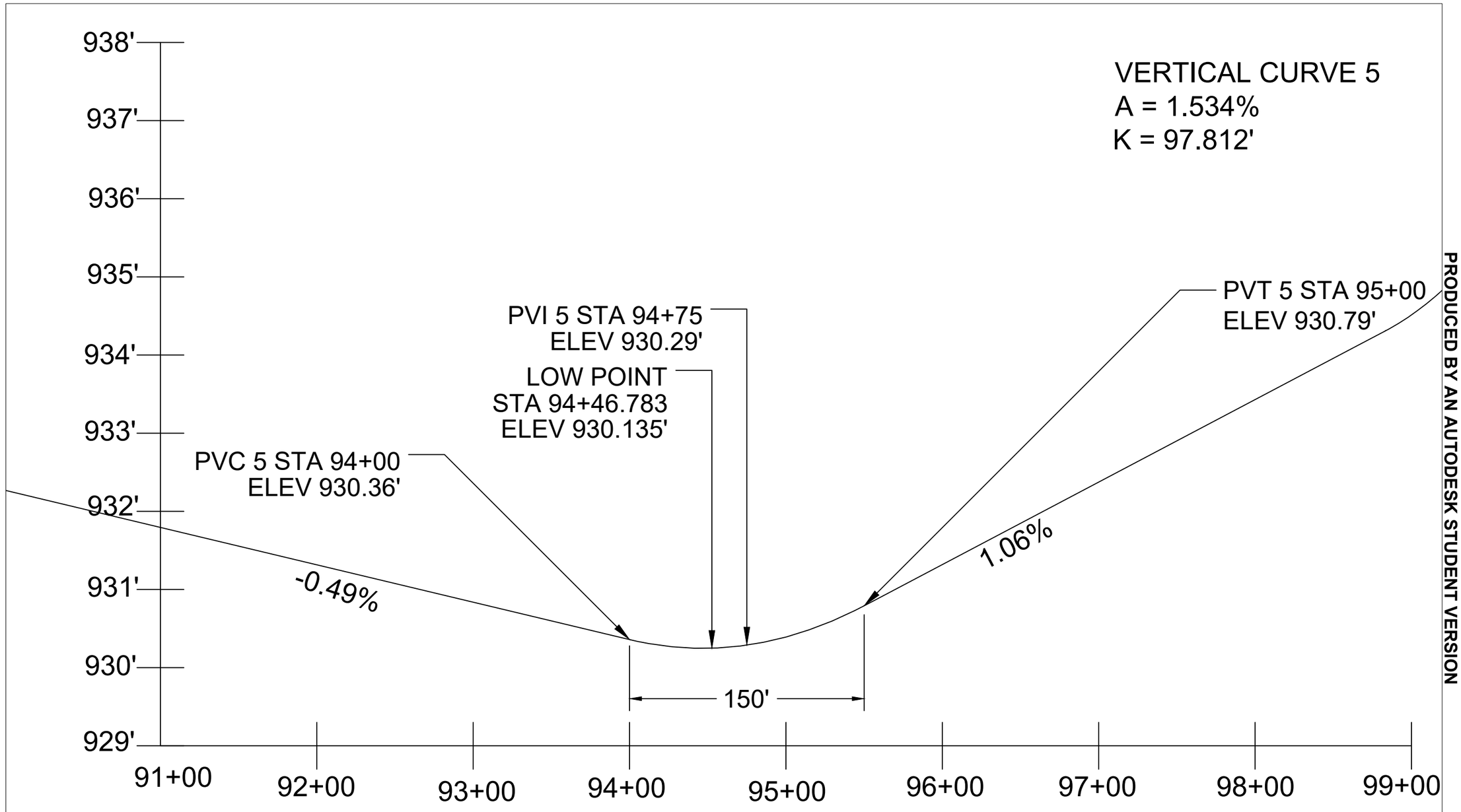


---------- Existing ground ———————— Proposed ground

NOTE: VERTICAL SCALE IS 50 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING			DESIGNER / DATE
		DESIGNED	
		DRAWN	
		CHECKED	
		STANDARD	
		APPROVED	
SCALE 1:15000	VERTICAL ALIGNMENT SCHEMATIC	DRAWING NO. 4	SHEET 4 OF 34

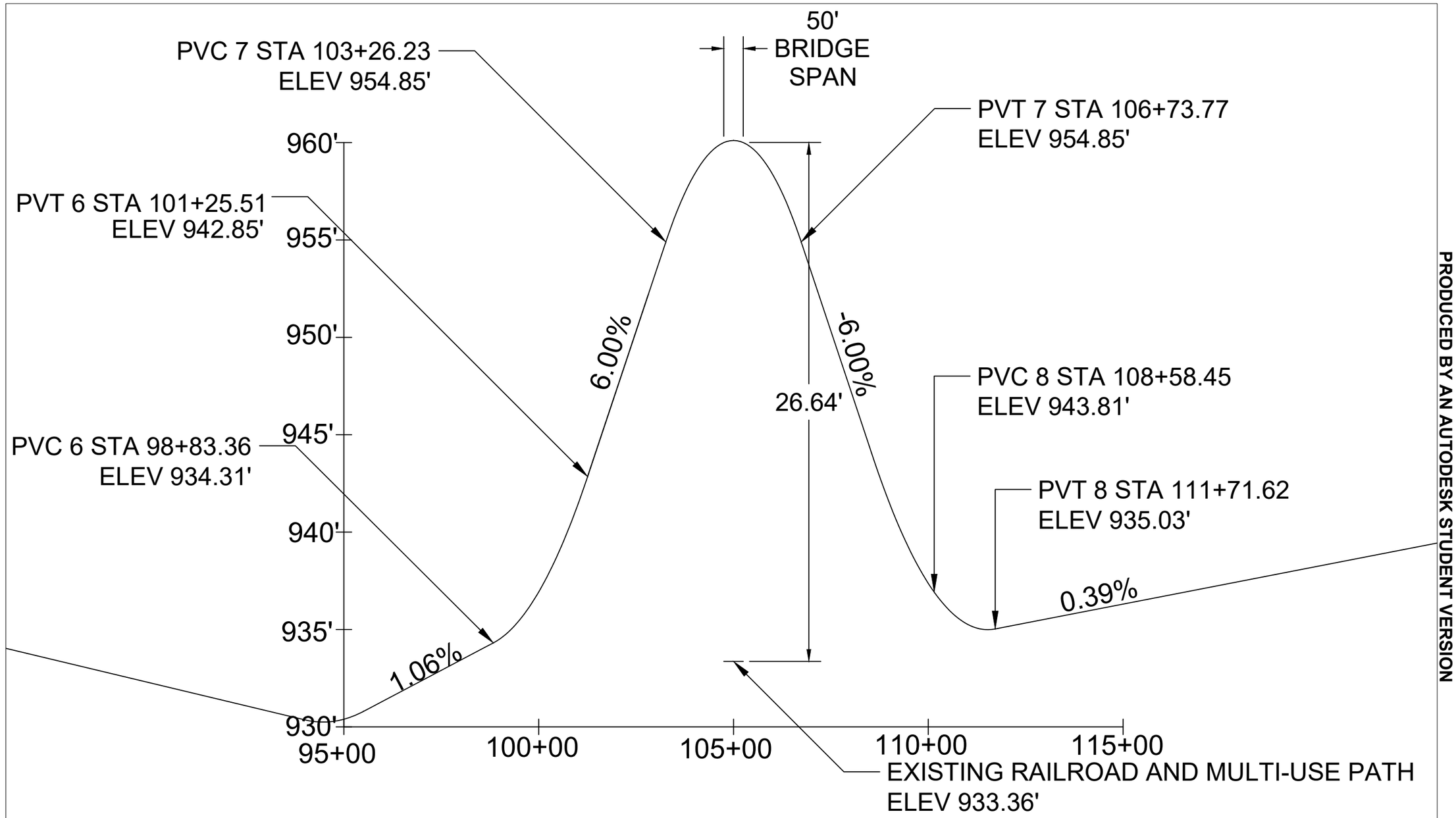
Exhbit 11.5.5



NOTE: VERTICAL SCALE IS 50 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{64}$" = 1'	TYPICAL VERTICAL CURVE	DRAWING NO. 5	SHEET 5 OF 34

Exhbit 11.5.6



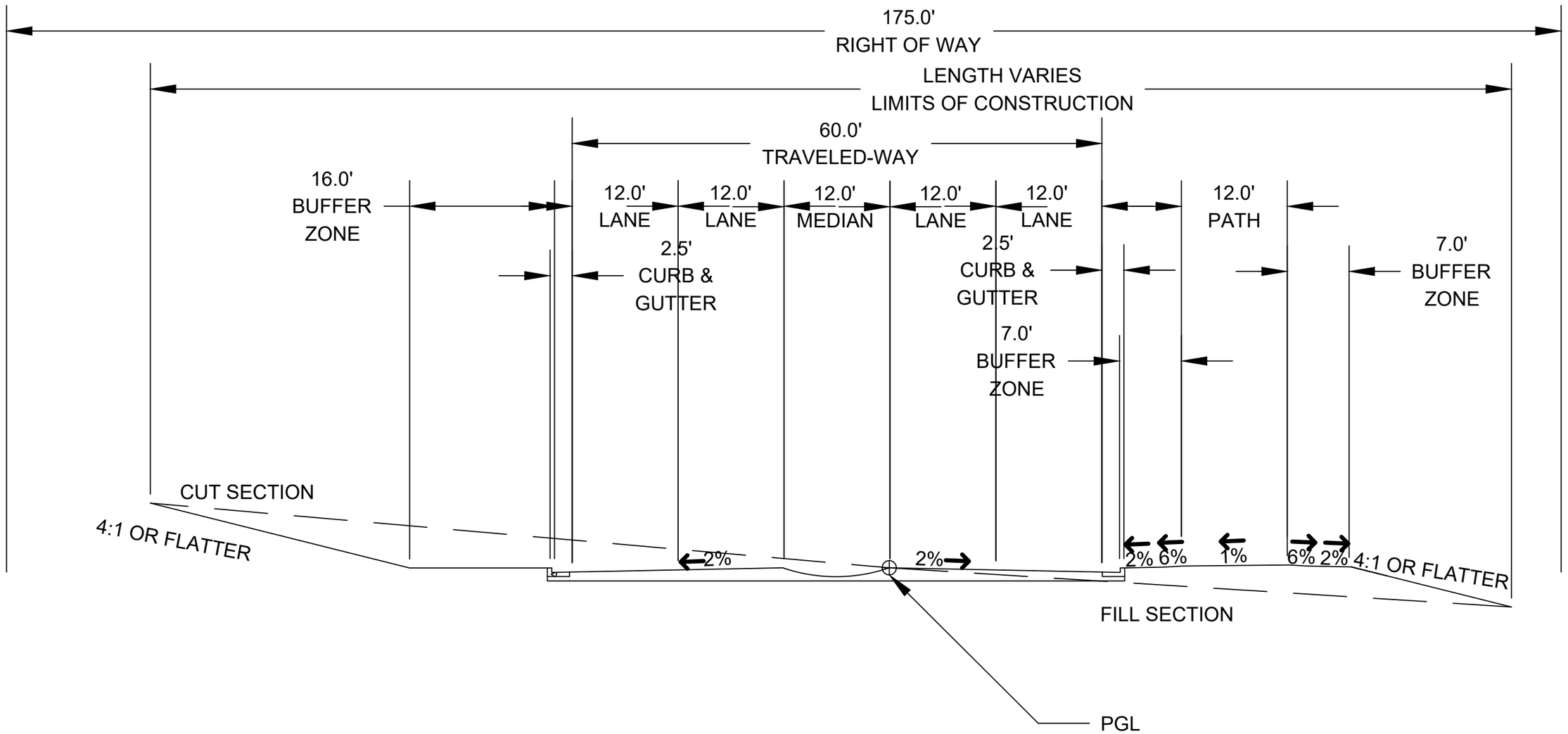
PRODUCED BY AN AUTODESK STUDENT VERSION

NOTE: VERTICAL SCALE IS 50 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{256}$" = 1'	BRIDGE SCHEMATIC	DRAWING NO. 6	SHEET 6 OF 34

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.7



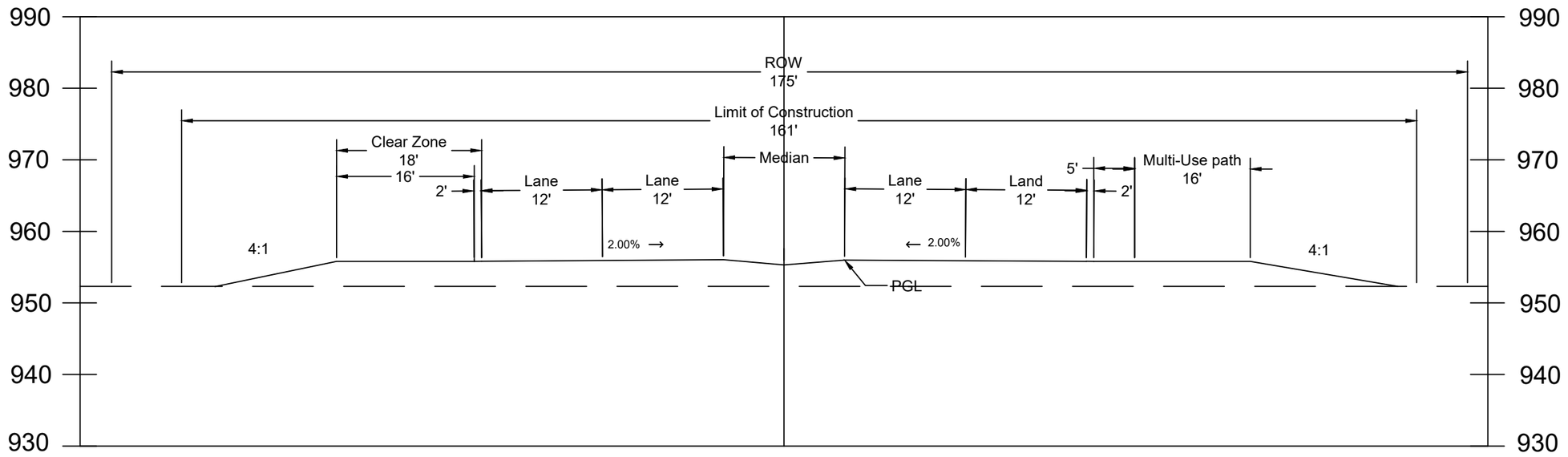
ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1" = 12'	TYPICAL CROSS SECTION	DRAWING NO. 7	
		SHEET 7 OF 34	

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.8

BOLT(PC 2 STA:147+24.61)

Existing ground ELEV: 952.13'
Proposed ground ELEV: 955.6'



ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	BOLT PC CROSS SECTION	DRAWING NO. 8	
		SHEET 8 OF 34	

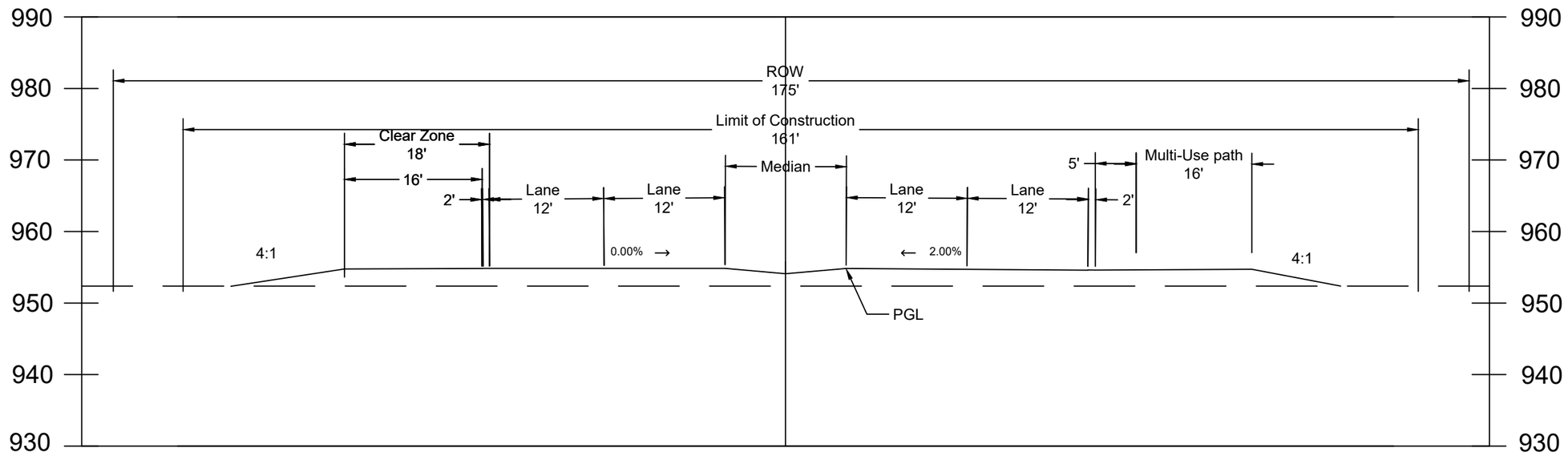
PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.9

OCL0%(PC 2 STA:147+82.82)

Existing ground —— —— ELEV: 952.47'
Proposed ground —— —— ELEV: 955.9'

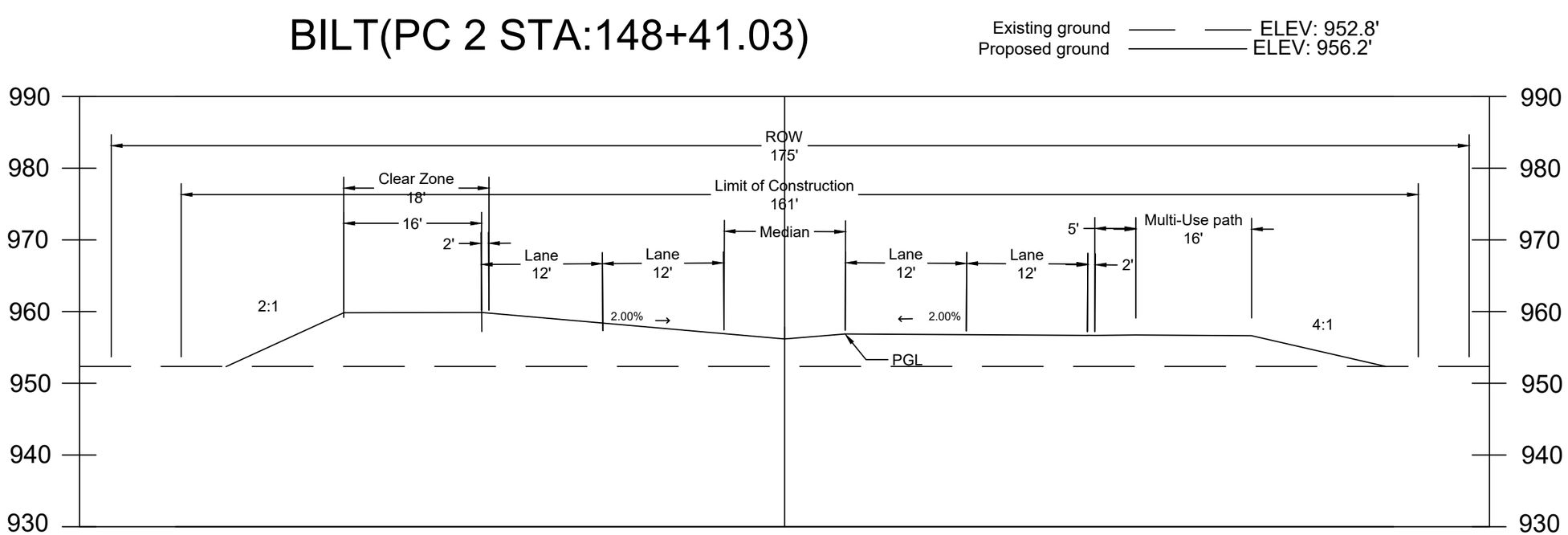


ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	OCL0% PC CROSS SECTION	DRAWING NO. 9	SHEET 9 OF 34

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.10

BILT(PC 2 STA:148+41.03)



ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	BILT PC CROSS SECTION	DRAWING NO. 10	SHEET 10 OF 34

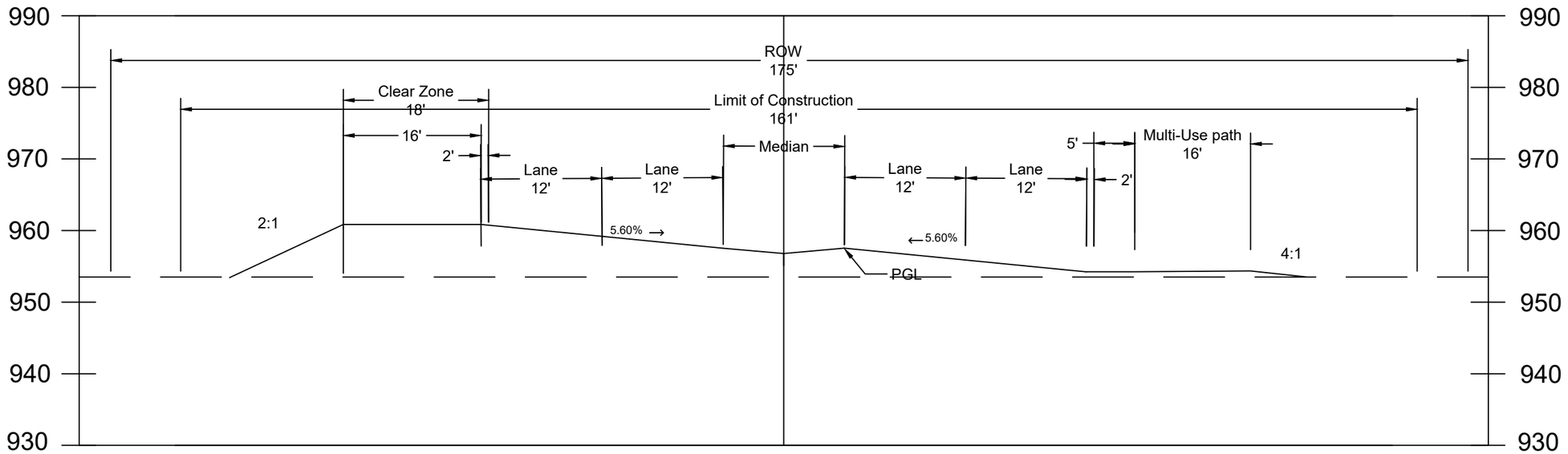
PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.11

FULLE (PC 2 STA:148+91.48)

Existing ground ——— ELEV: 953.4'
Proposed ground ——— ELEV: 956.7'



ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	FULLE PC CROSS SECTION	DRAWING NO. 11	
		SHEET 11 OF 34	

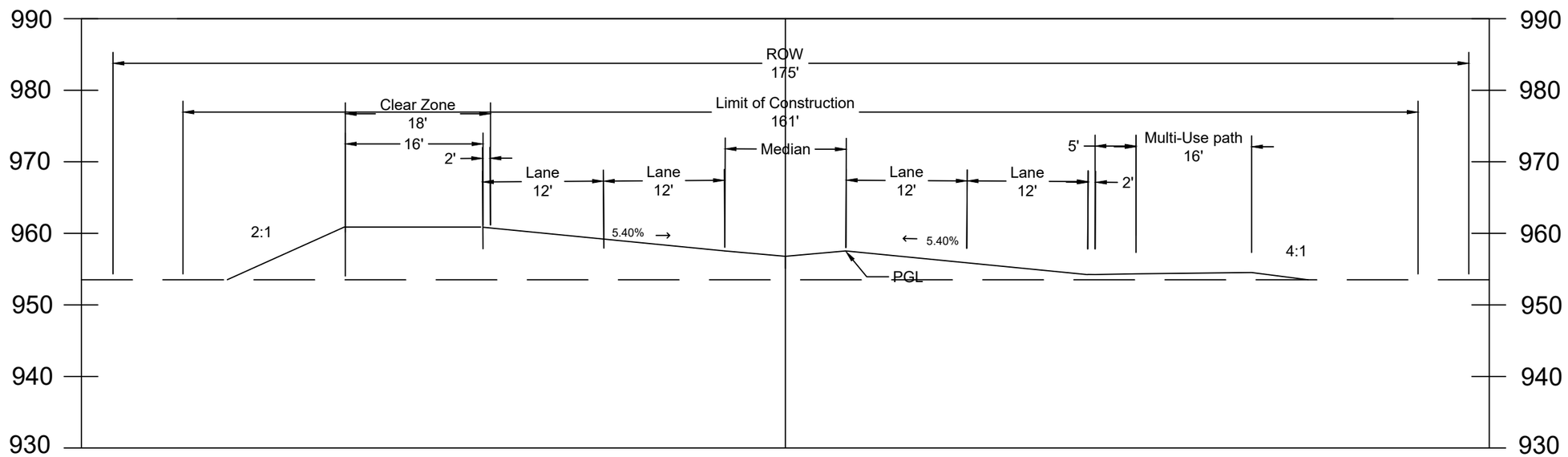
PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.12

100-FT (1) (CURVE 2 STA:149+00)

Existing ground —— —— ELEV: 953.9'
Proposed ground —————— ELEV: 956.4'



ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	HORIZONTAL CROSS SECTION 1	DRAWING NO. 12	
		SHEET 12 OF 34	

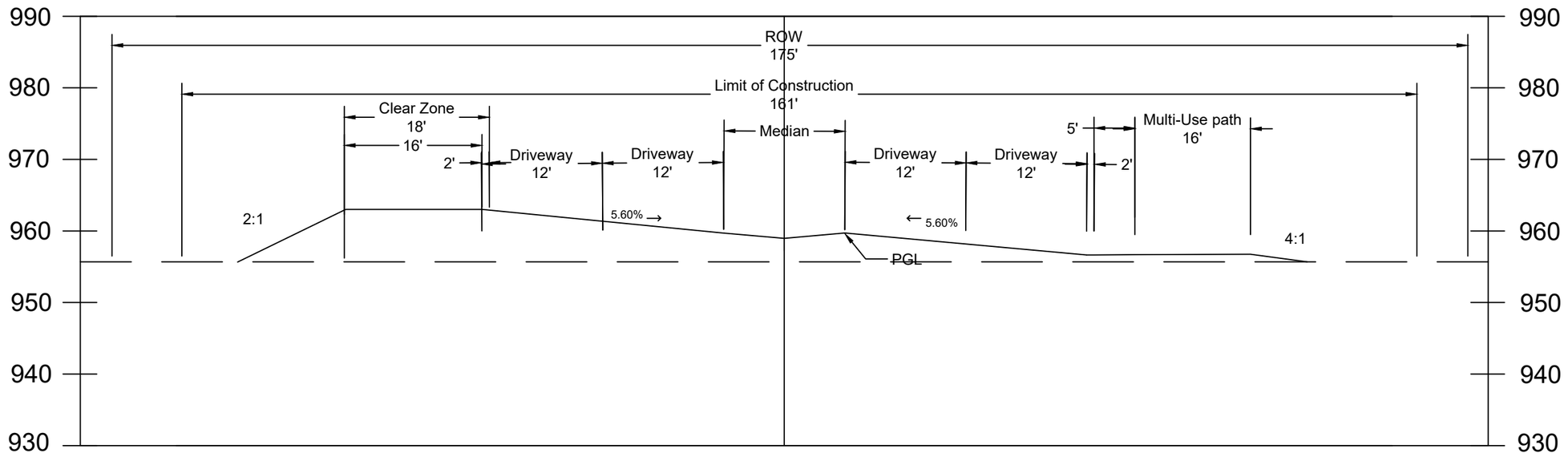
PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.13

100-FT (2) (CURVE 2 STA:150+00)

Existing ground —— —— ELEV: 954.7'
Proposed ground —— —— ELEV: 956.9'

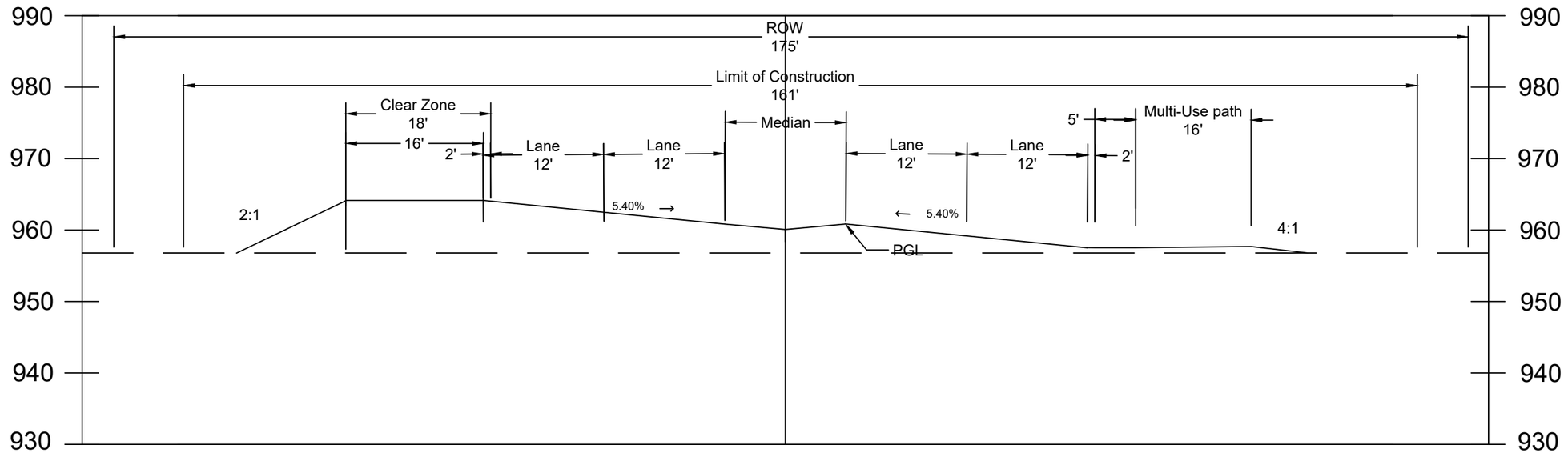


ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	HORIZONTAL CROSS SECTION 2	DRAWING NO. 13	SHEET 13 OF 34

Exhbit 11.5.14

100-FT (3) (CURVE 2 STA:151+00)

Existing ground ——— ELEV: 955.1'
Proposed ground ——— ELEV: 957.6'



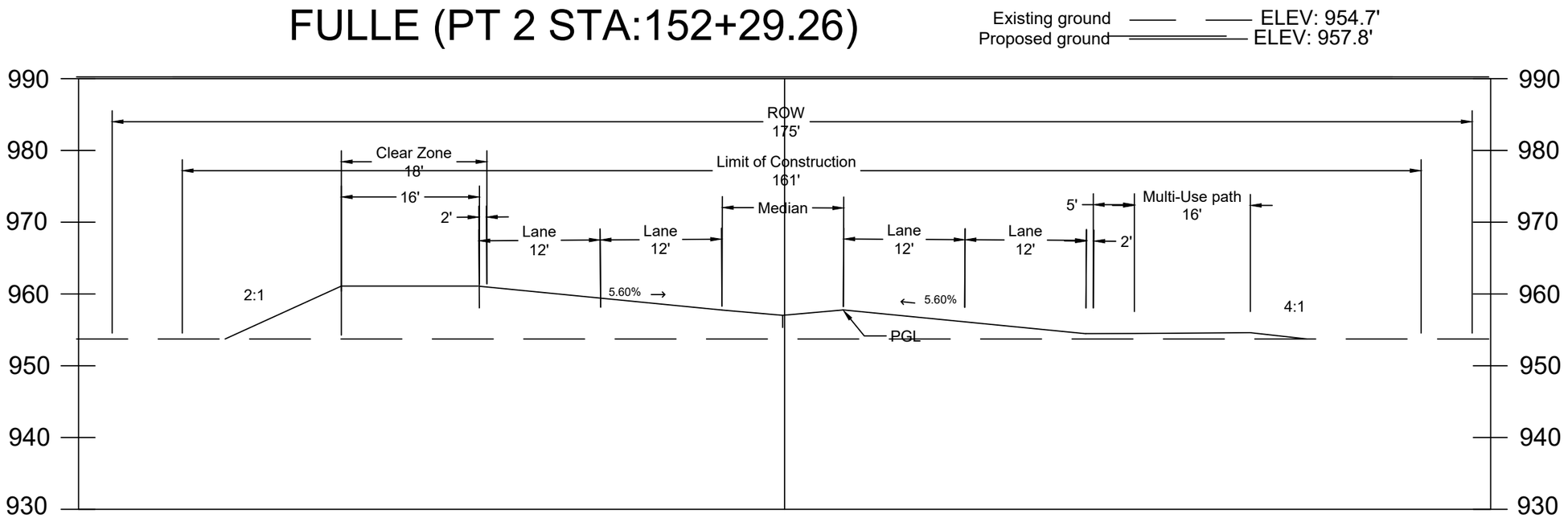
		DESIGNER	DATE
ZRF ENGINEERING	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	HORIZONTAL CROSS SECTION 3	DRAWING NO. 14	
		SHEET 14 OF 34	

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.15

FULLE (PT 2 STA:152+29.26)

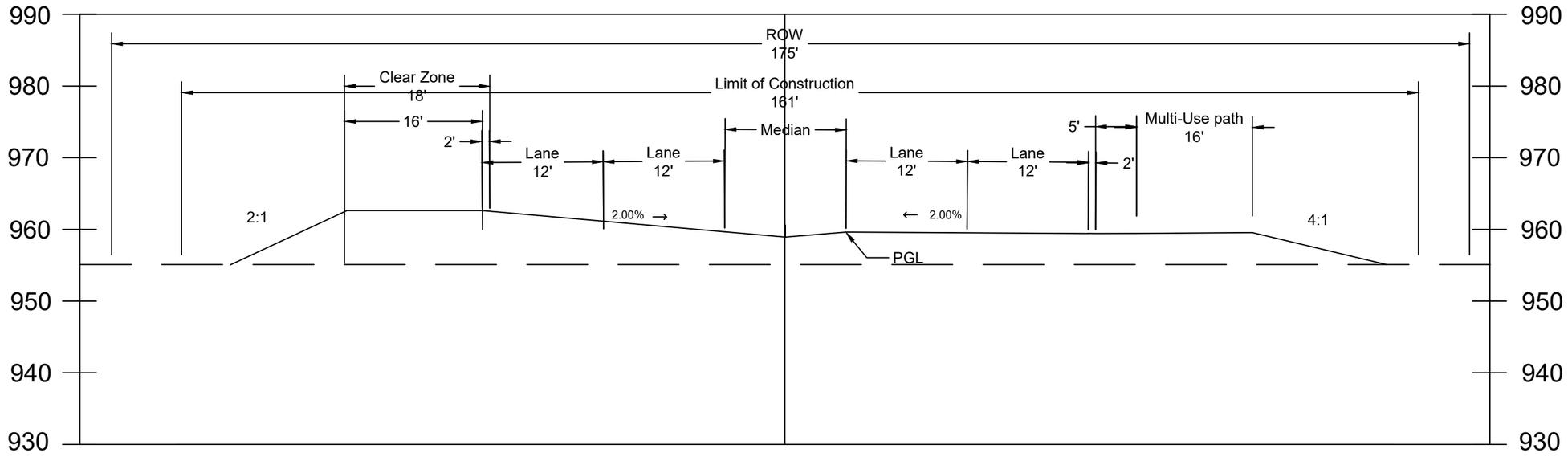


ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	FULLE PT CROSS SECTION	DRAWING NO. 15	
		SHEET 15 OF 34	

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.16

BILT(PT 2 STA:152+79.72)



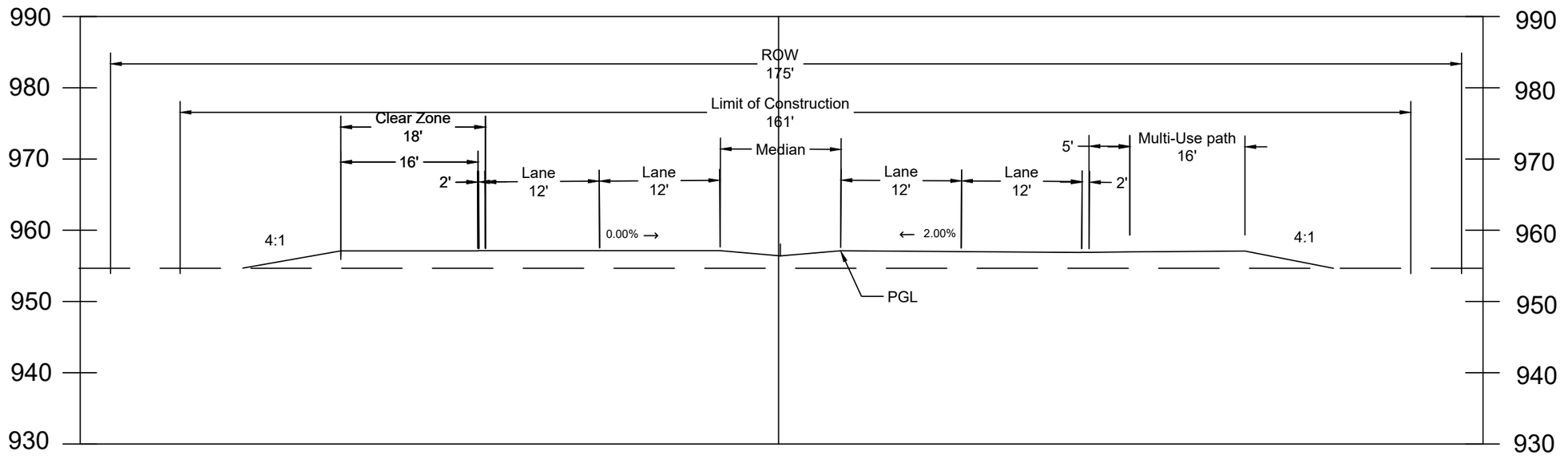
ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	BILT PT CROSS SECTION	DRAWING NO. 16	SHEET16 OF 34

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.17

OCL0%(PT 2 STA:153+37.93)

Existing ground ——— ELEV: 955.7'
Proposed ground ——— ELEV: 958.6'

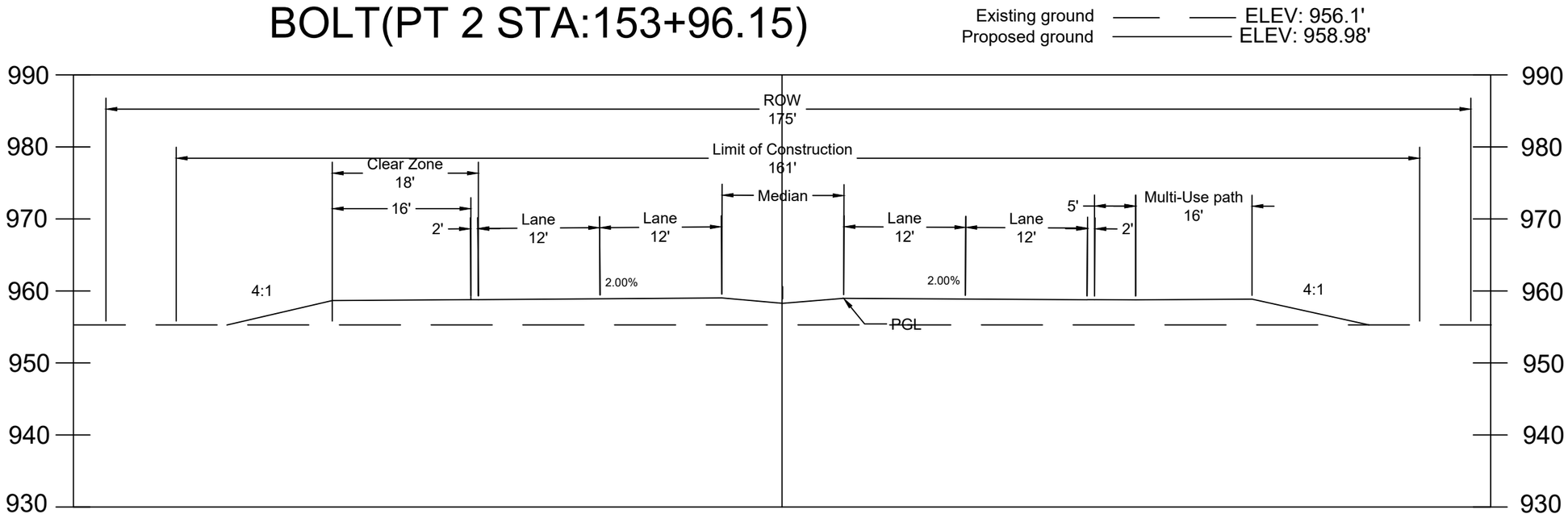


ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	OCL0% PT CROSS SECTION	DRAWING NO. 17	
		SHEET 17 OF 34	

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.18

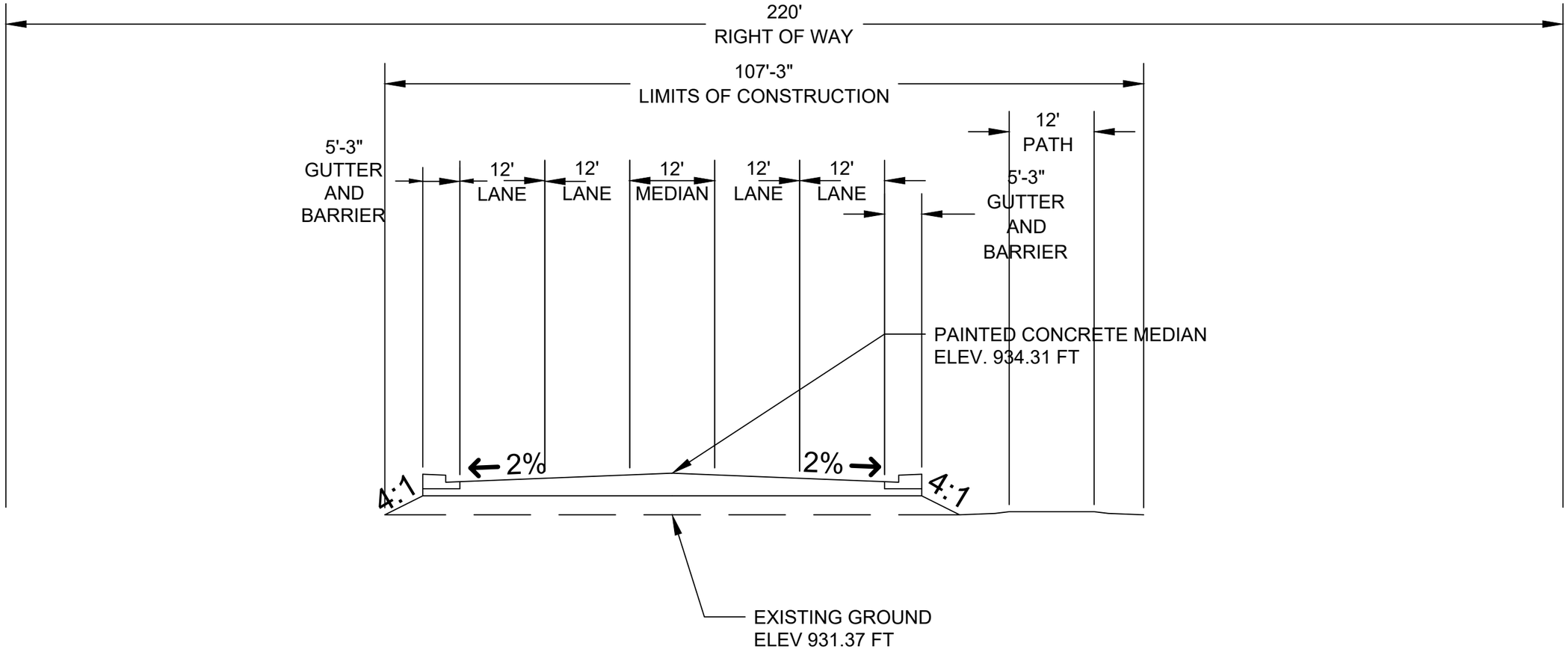
BOLT(PT 2 STA:153+96.15)



ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/2" = 1'	BOLT PC CROSS SECTION	DRAWING NO. 18	SHEET 18 OF 34

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.19



CROSS SECTION AT
PVC 6 STATION 98+83.36

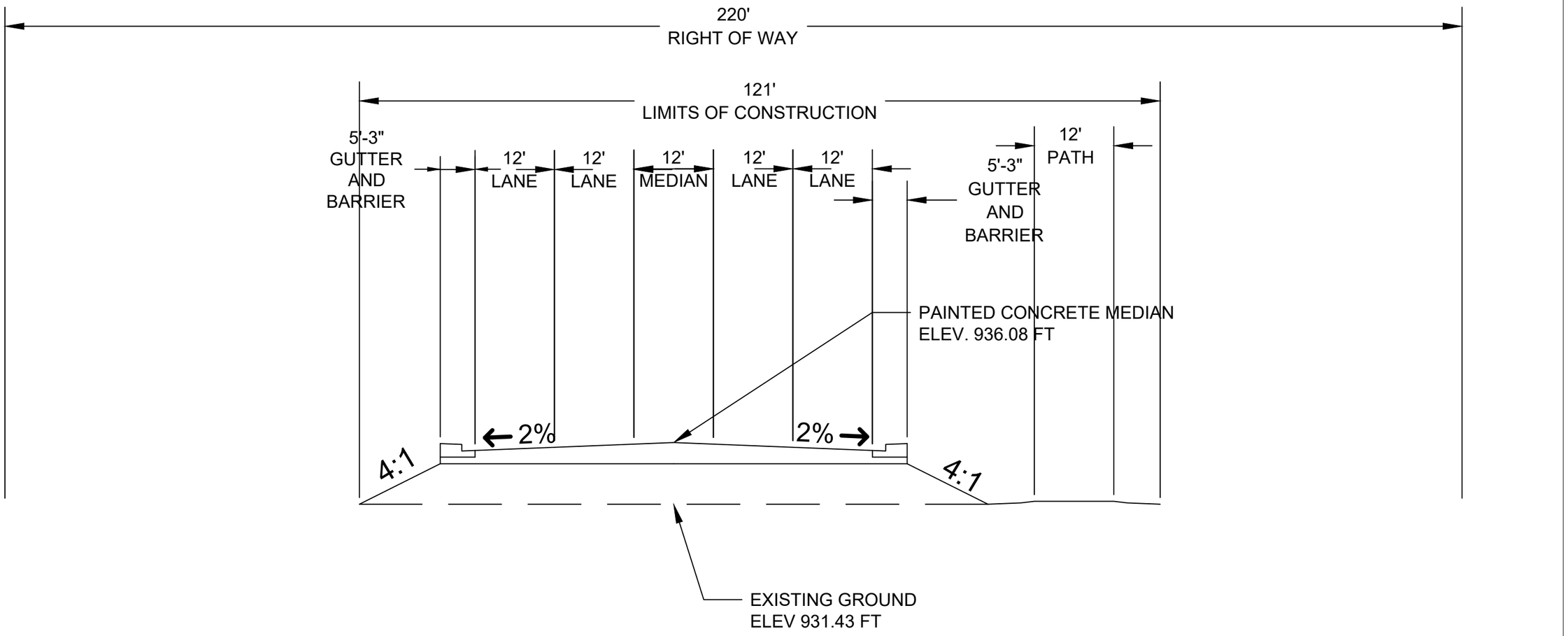
Existing ground

Proposed ground

NOTE: VERTICAL SCALE IS 2 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BRIDGE CROSS SECTION 1	DRAWING NO. 19	
		SHEET 19 OF 34	

Exhbit 11.5.20



CROSS SECTION AT
STATION 99+00.00

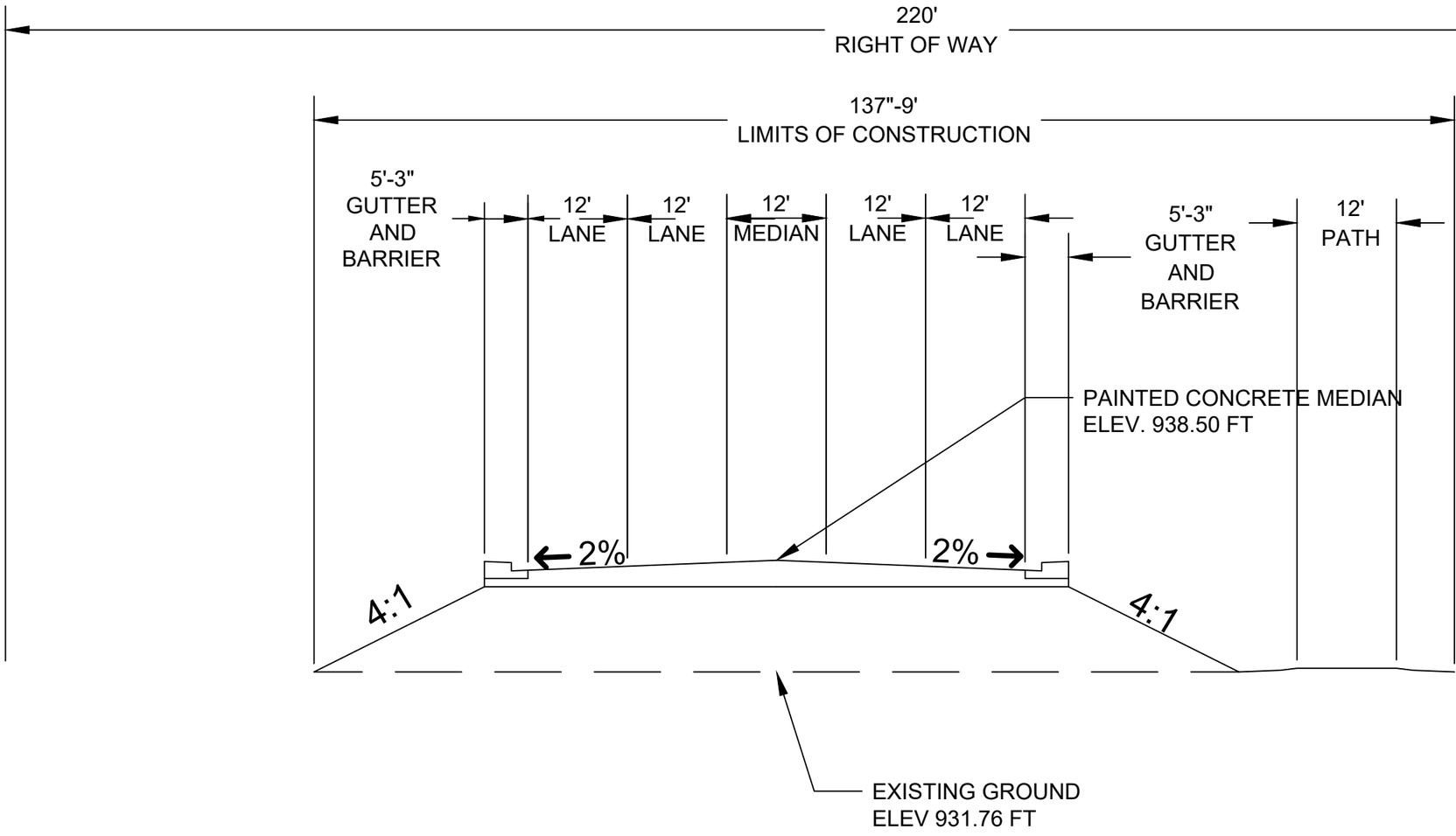
Existing ground

Proposed ground

NOTE: VERTICAL SCALE IS 2 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BRIDGE CROSS SECTION 2	DRAWING NO. 20	SHEET 20 OF 34

Exhbit 11.5.21



CROSS SECTION AT
STATION 100+00.00

Existing ground

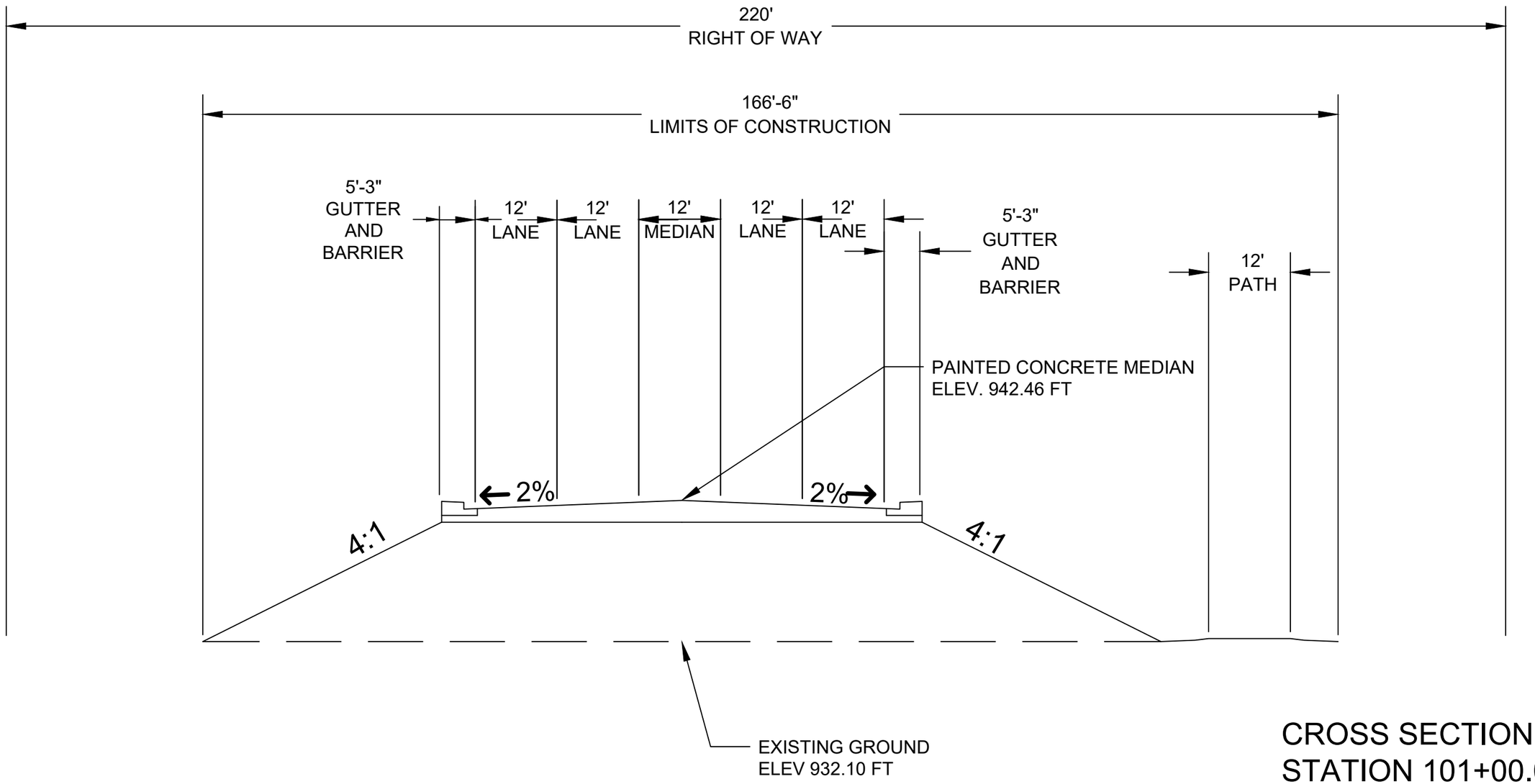
Proposed ground

NOTE: VERTICAL SCALE IS 2 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BRIDGE CROSS SECTION 3	DRAWING NO. 21	
		SHEET 21 OF 34	

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.22



Existing ground

Proposed ground

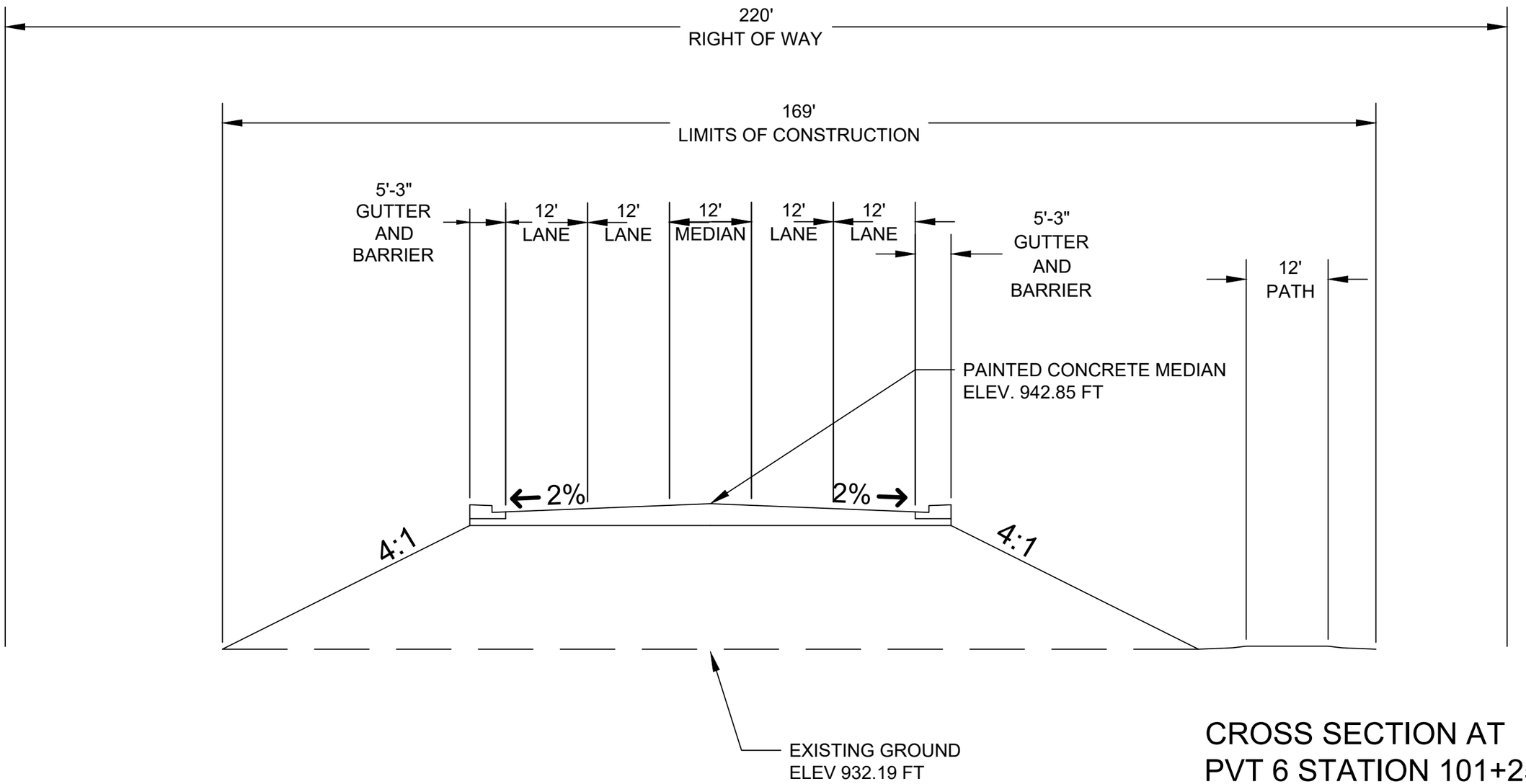
CROSS SECTION AT
STATION 101+00.00

NOTE: VERTICAL SCALE IS 2 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BRIDGE CROSS SECTION 4	DRAWING NO. 22	
		SHEET 22 OF 34	

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.23



PRODUCED BY AN AUTODESK STUDENT VERSION

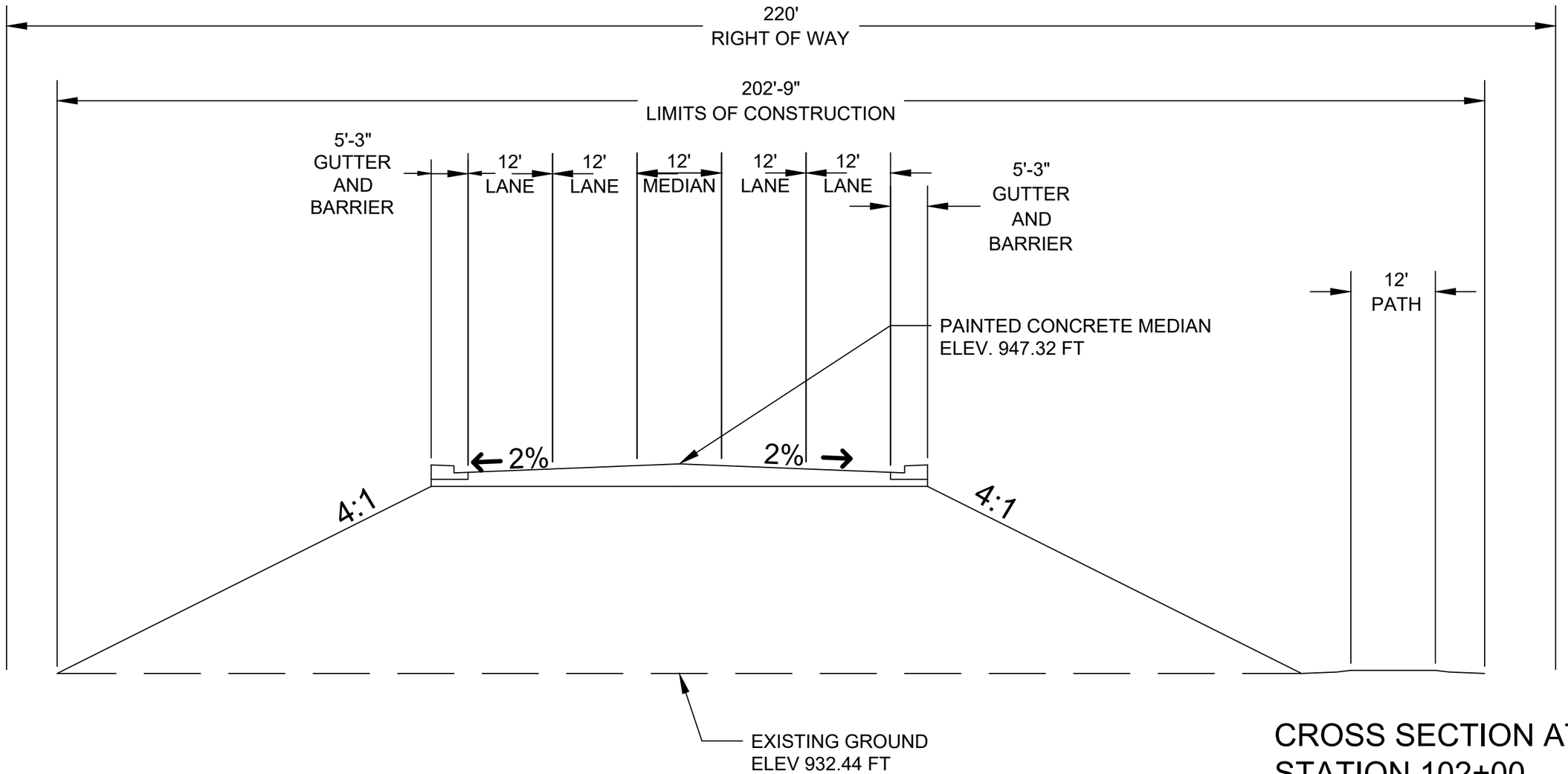
CROSS SECTION AT
PVT 6 STATION 101+25.51

NOTE: VERTICAL SCALE IS 2 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BRIDGE CROSS SECTION 5	DRAWING NO. 23	
		SHEET 23 OF 34	

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.24



Existing ground

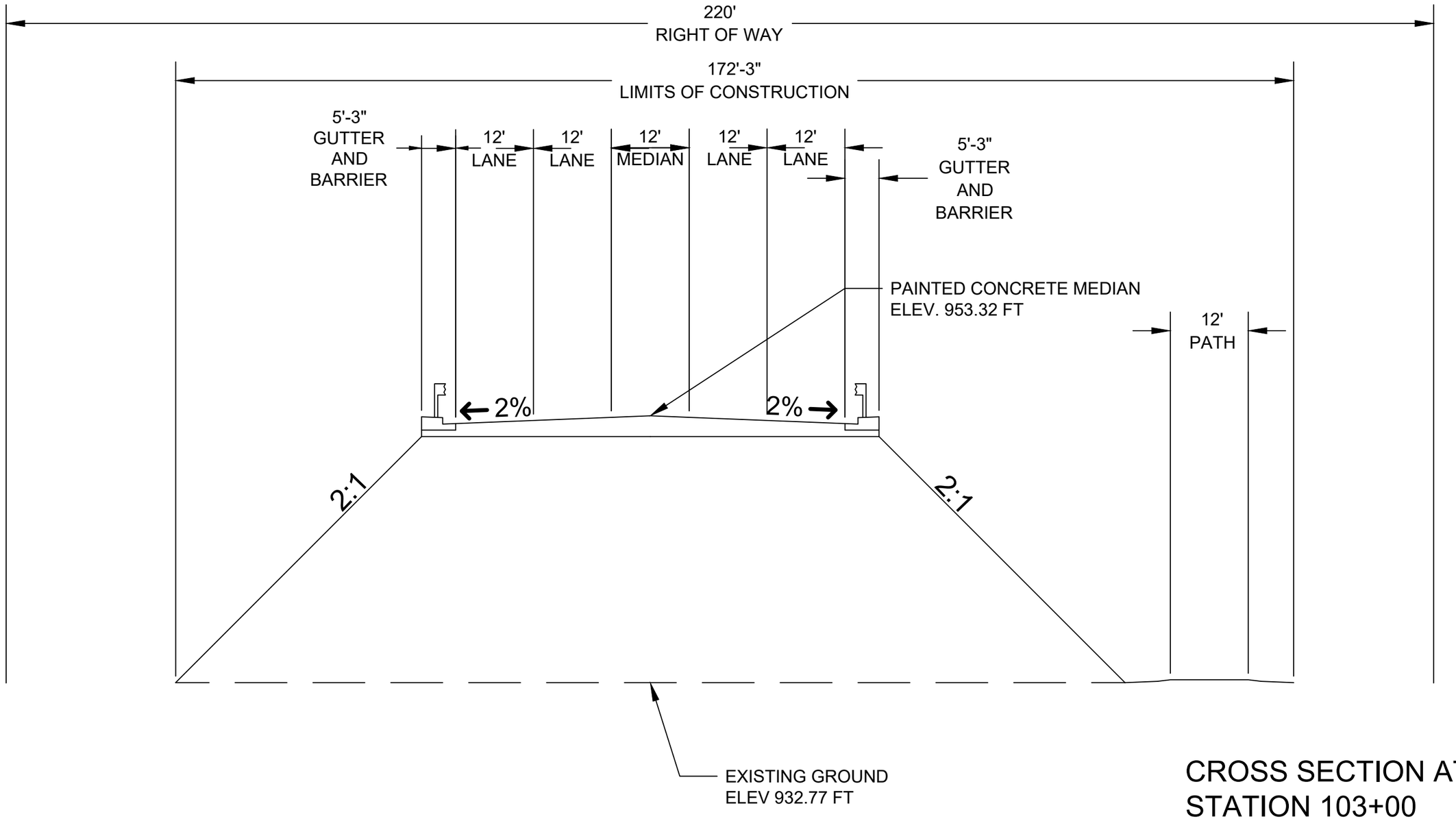
Proposed ground

CROSS SECTION AT STATION 102+00

NOTE: VERTICAL SCALE IS 2 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BRIDGE CROSS SECTION 6	DRAWING NO. 24	
		SHEET 24 OF 34	

Exhbit 11.5.25



Existing ground

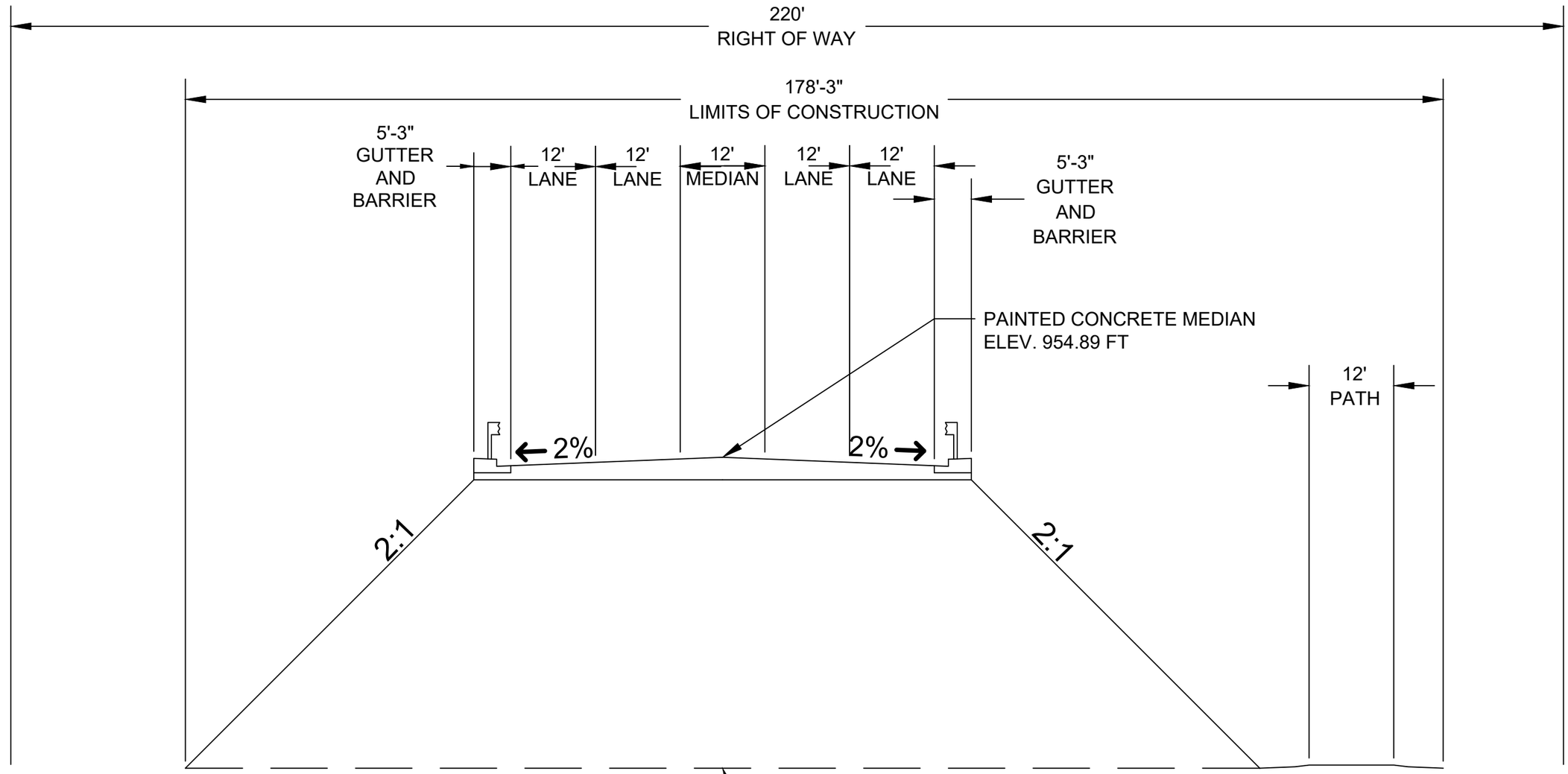
Proposed ground

NOTE: VERTICAL SCALE IS 2 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

CROSS SECTION AT STATION 103+00

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BRIDGE CROSS SECTION 7	DRAWING NO. 25	SHEET 25 OF 34

Exhbit 11.5.26



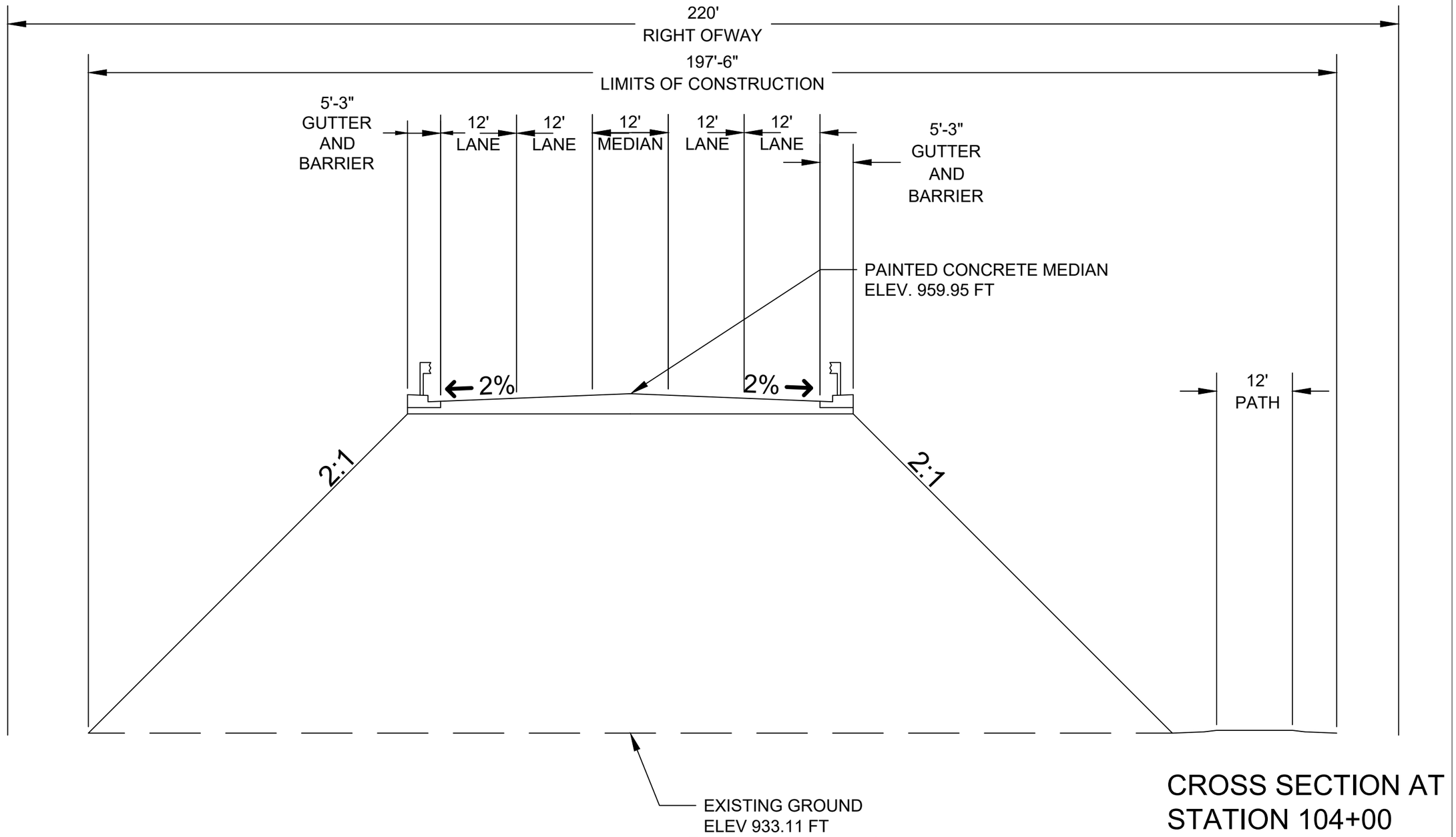
CROSS SECTION AT
PVC 7 STATION 103+26.23

NOTE: VERTICAL SCALE IS 2 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BRIDGE CROSS SECTION 8	DRAWING NO. 26	
		SHEET 26 OF 34	

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.27

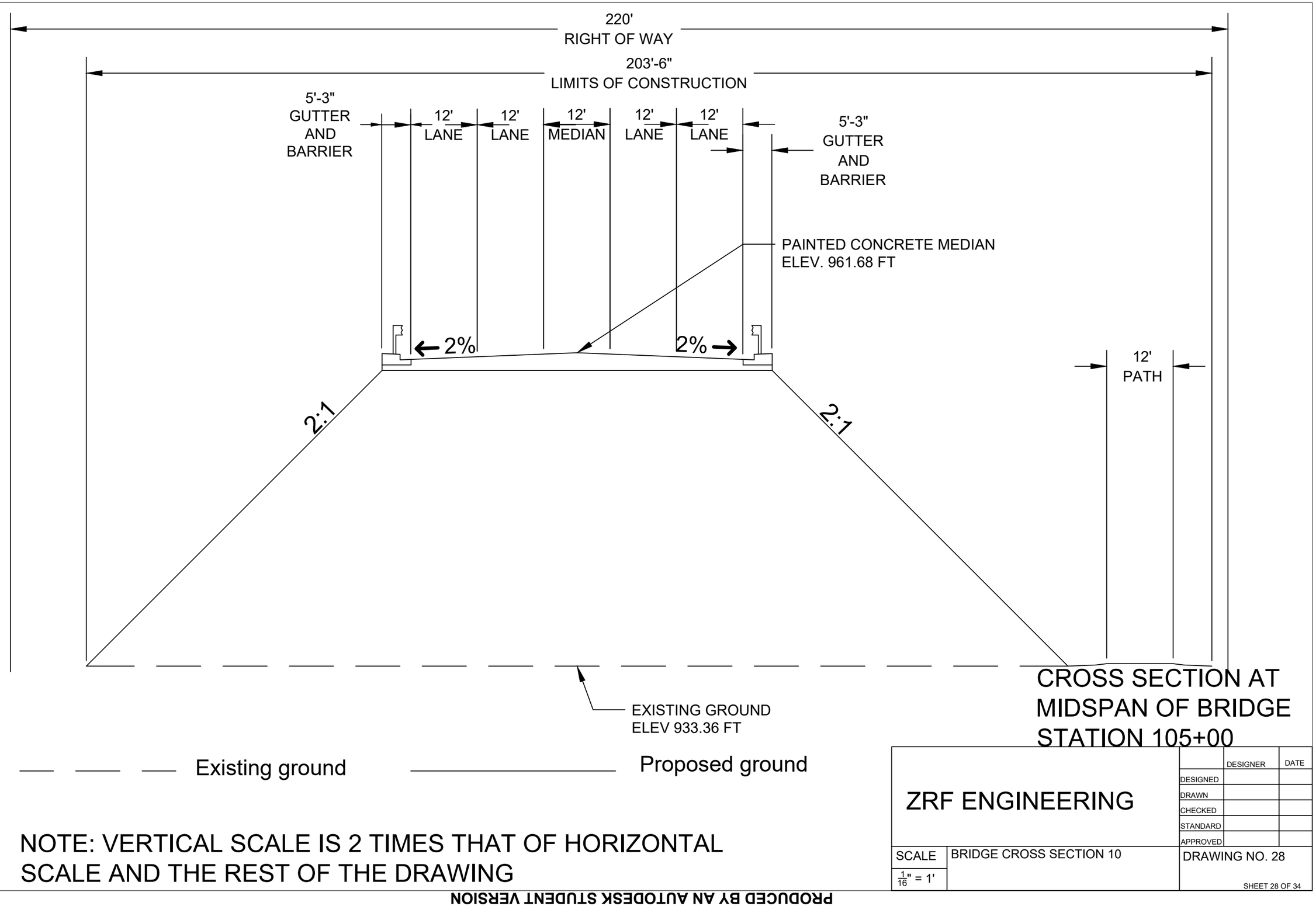


CROSS SECTION AT
STATION 104+00

NOTE: VERTICAL SCALE IS 2 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BRIDGE CROSS SECTION 9	DRAWING NO. 27	
		SHEET 27 OF 34	

Exhbit 11.5.28



CROSS SECTION AT MIDSPAN OF BRIDGE STATION 105+00

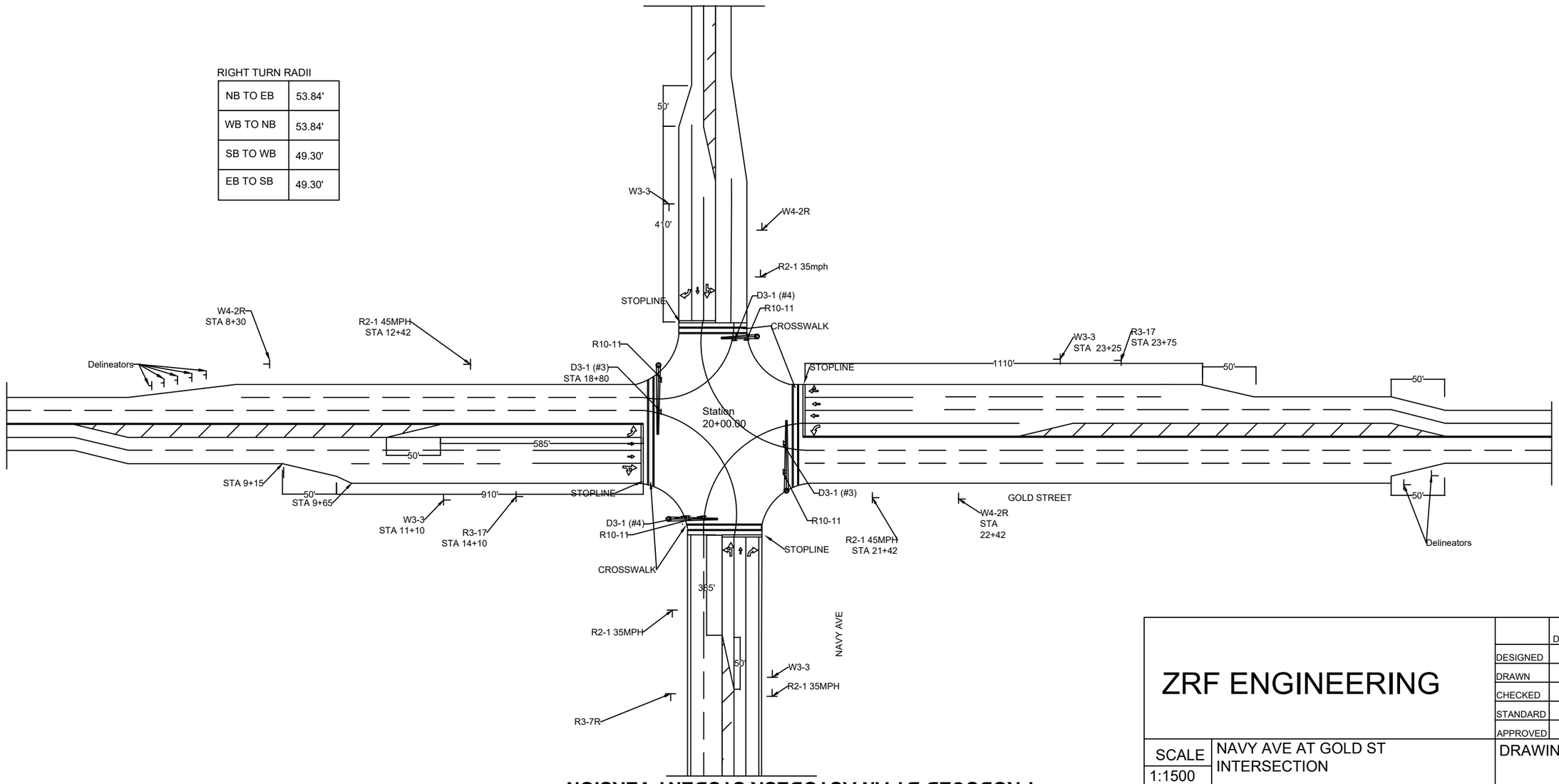
NOTE: VERTICAL SCALE IS 2 TIMES THAT OF HORIZONTAL SCALE AND THE REST OF THE DRAWING

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BRIDGE CROSS SECTION 10	DRAWING NO. 28	
		SHEET 28 OF 34	

Exhbit 11.5.29

RIGHT TURN RADII

NB TO EB	53.84'
WB TO NB	53.84'
SB TO WB	49.30'
EB TO SB	49.30'



PRODUCED BY AN AUTODESK STUDENT VERSION

ZRF ENGINEERING

	DESIGNER	DATE
DESIGNED		
DRAWN		
CHECKED		
STANDARD		
APPROVED		

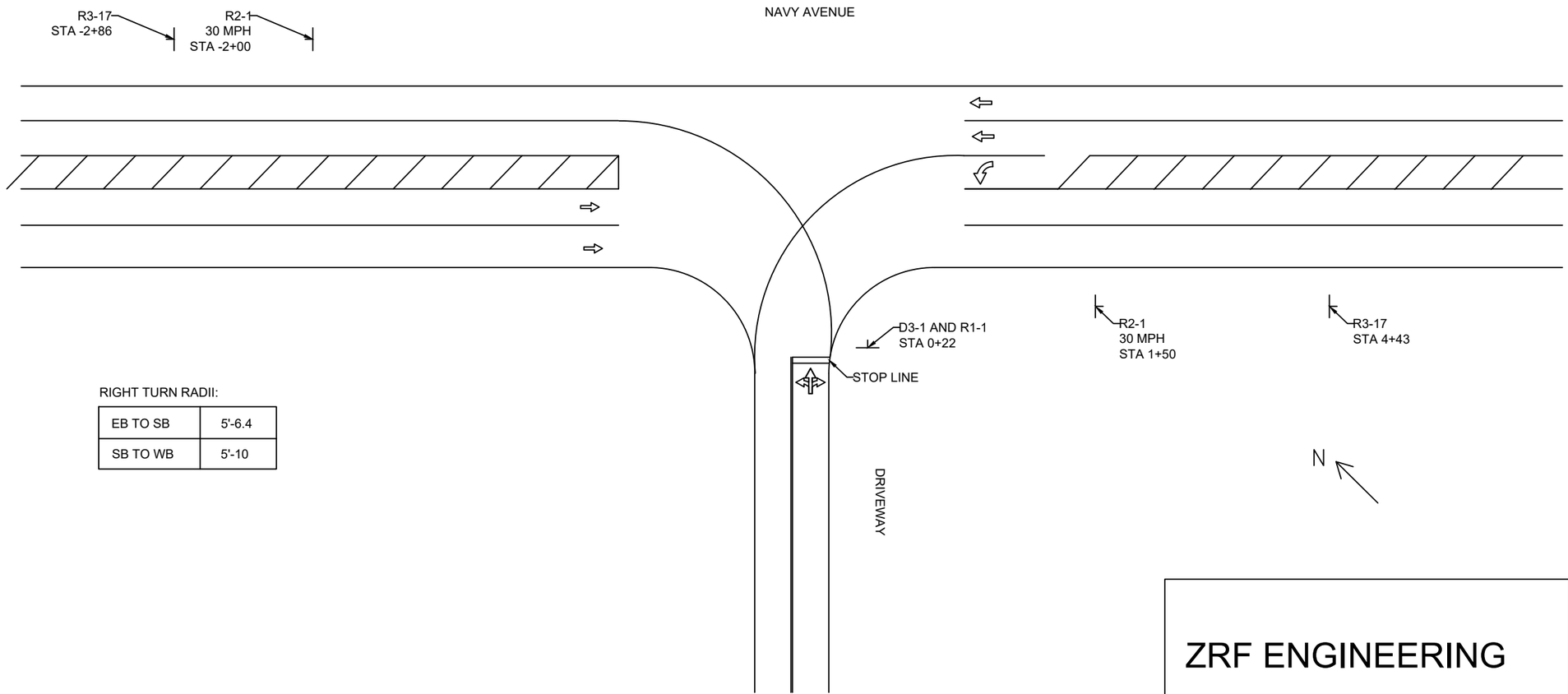
SCALE 1:1500

NAVY AVE AT GOLD ST INTERSECTION

DRAWING NO. 29

Exhbit 11.5.30

NAVY AVENUE AT DRIVEWAY



RIGHT TURN RADII:

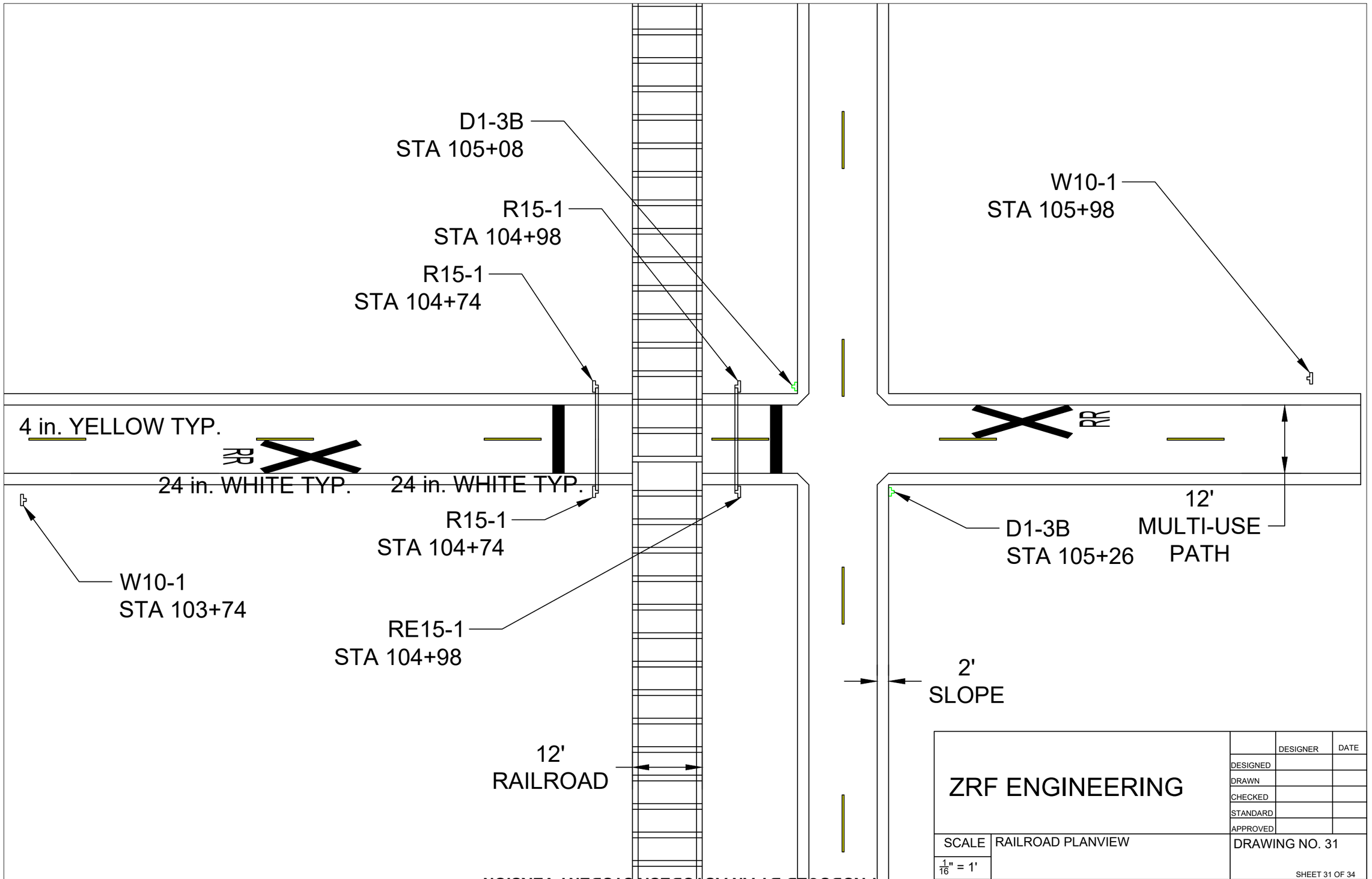
EB TO SB	5'-6.4
SB TO WB	5'-10

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1/16" = 1'	NAVY AVENUE AT DRIVEWAY INTERSECTION	DRAWING NO. 30	
		SHEET 30 OF 34	

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

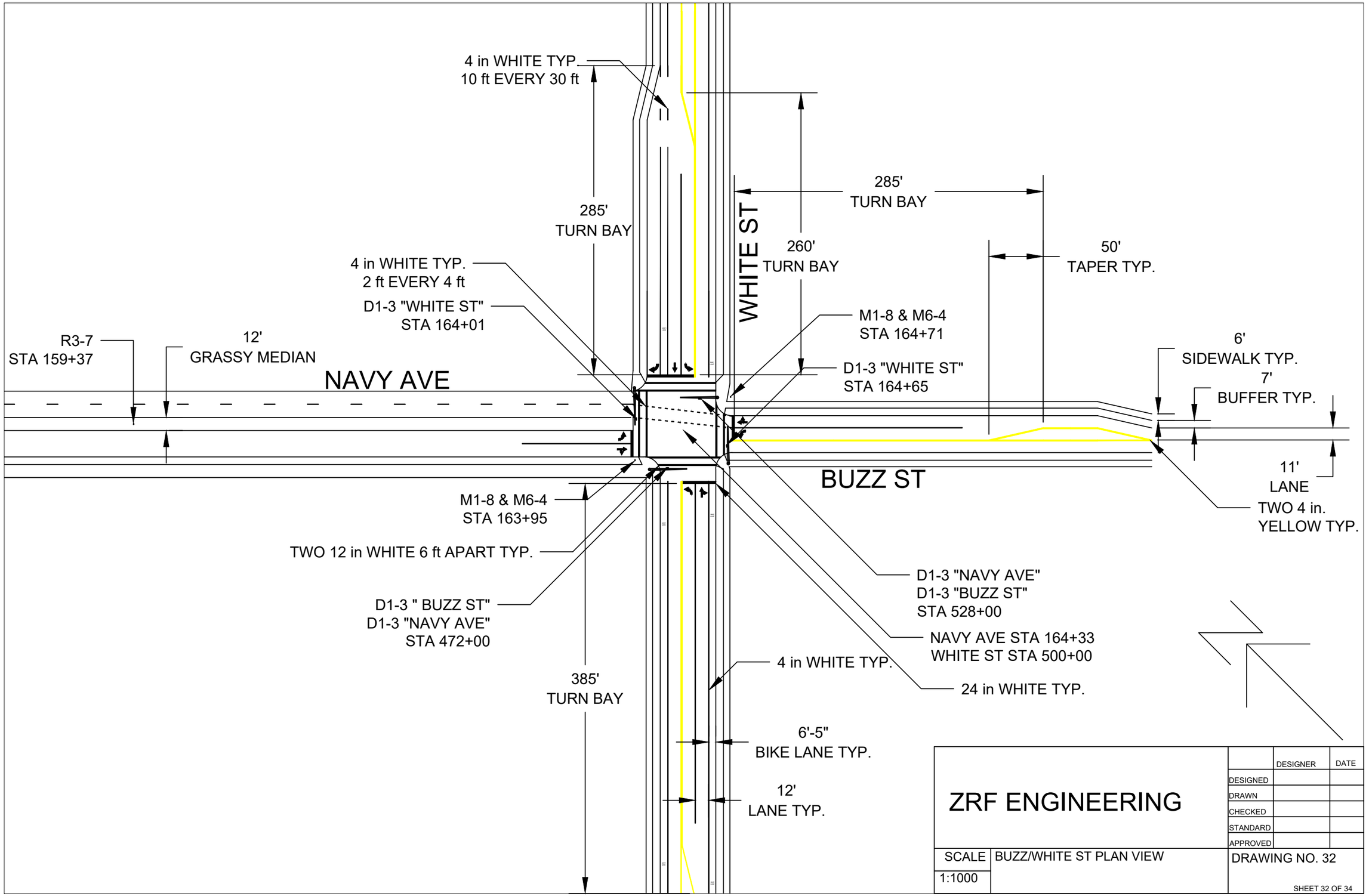
Exhbit 11.5.31



ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	RAILROAD PLANVIEW	DRAWING NO. 31	SHEET 31 OF 34

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.32

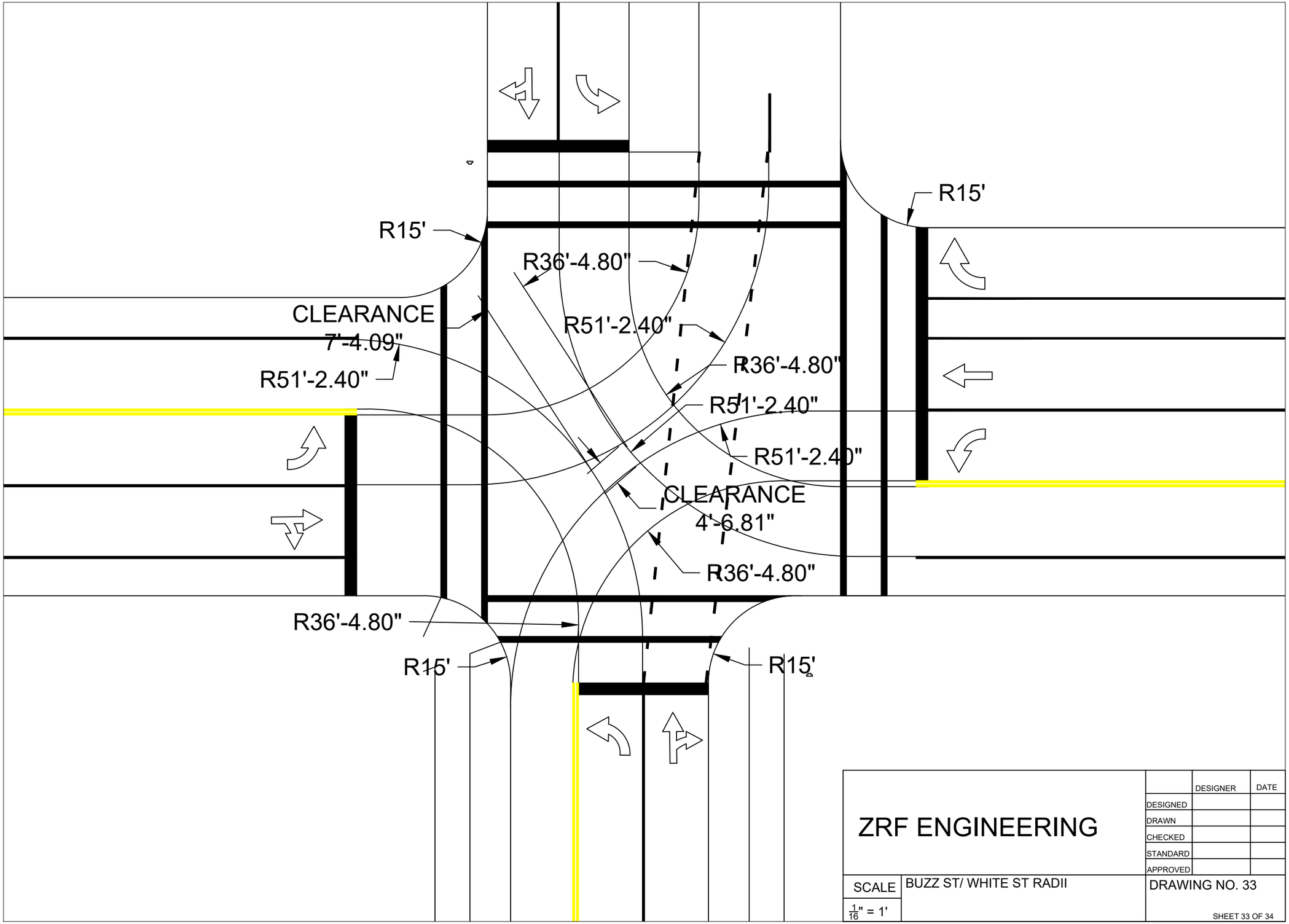


ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1:1000	BUZZ/WHITE ST PLAN VIEW	DRAWING NO. 32	SHEET 32 OF 34

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

Exhbit 11.5.33



ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE $\frac{1}{16}$" = 1'	BUZZ ST/ WHITE ST RADII	DRAWING NO. 33	SHEET 33 OF 34

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

R1-1, 36" x 36"
SOURCE: 2B-05

R1-2, 18" x 18" x 18"
SOURCE: 2B-05

R2-1, 30" x 36"
SOURCE: 2B-13

R3-7, 36" x 36"
SOURCE: 2B-20

D1-3b, VARIES x 18"
SOURCE: 9B-20

D3-1, VARIES x 12"
SOURCE: 8B-03

M1-8, 18" x 24"
SOURCE: 8B-21

M6-4, 12" X 9"
SOURCE: 8B-21

W11-15, 30" x 30"
SOURCE: 9B-18

W11-15P, 24" x 18"
SOURCE: 9B-18

W16-7P, 24" x 12"
SOURCE: 9B-18

W 4-2, 36" x 36"
SOURCE: 2C-42

W 4-4P, 24" x 12"
SOURCE: 2C-59

W 10-1, DIAMETER 24"
SOURCE: 8B-06

R15-1, 24" x 4.5"
SOURCE: 8B-03

ZRF ENGINEERING		DESIGNER	DATE
	DESIGNED		
	DRAWN		
	CHECKED		
	STANDARD		
	APPROVED		
SCALE 1:20	SIGNING INDEX	DRAWING NO. 34	SHEET 34 OF 34

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION