Portsmouth Bypass
An Appalachian Development Highway

Value Engineering Studies
Phase 3 Profile Study

Portsmouth Bypass, Phase 3

SCI-823-0.00
PID 77366

December 15, 2009

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PHASE 3 PROFILE STUDY

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APPENDIX

1.0 Introduction

A second Value Engineering (VE) Study was held for the entire Portsmouth Bypass Project on December 3-6, 2007. This Study was based on the latest plans submitted by the preliminary engineering consultant for the project. At this meeting, thirty VE Alternatives were identified as either a potential cost savings item or a design suggestion. ODOT reviewed each of these alternatives and for Phase 3 of the project instructed HDR Engineering, Inc. (HDR) to study the vertical profile for potential cost savings. Phase 3 has a large quantity of borrow in addition to multiple high fill culverts (>100 feet). The purpose of this study is to evaluate the profile in order to reduce the volume of borrow material and reduce the height of fill over the proposed culverts.

2.0 Stage 1 Profile

Phase 3 of the Portsmouth Bypass (SR 823) begins at US 52, near Sciotodale and proceeds north a distance of approximately six miles to meet the southern end of Phase 1. The proposed bypass alignment leaves US 52, crosses mountainous terrain, then passes through the Highland Bend community before crossing the Little Scioto River, and then proceeds north across a series of mountains and valleys.

Scroll plots of the schematic plan and the profiles supplementing this report are bound separately for reference. The expressway begins at the point where a single lane exit ramp from US52 westbound (SR 823 northbound) meets a single lane entrance ramp to US 52 eastbound (SR 823 southbound). The ramp from US 52 westbound to SR 823 northbound is known as Ramp A and the ramp from SR 823 southbound to US 52 eastbound is known as Ramp B. The Ramp A profile starts at US 52 and begins to climb at a 5.01% grade to a high point that is located at the northern end of the bridge carrying SR 823 northbound over CR 503 (Gallia Street). The profile then starts on a slight (0.88%) downgrade to the beginning of the bypass. The Ramp B profile climbs up from US 52 to a high point at the north end of the CR 503 bridge at a more modest rate of 3.19%. It also starts on a slight (0.87%) downgrade to the beginning of the bypass.

The SR 823 (northbound and southbound) grade continues to remain modest (0.50% downgrade) until the bridge over SR 140 where the profile begins to climb at a rate of 5.00%. A partial interchange is located at the SR 140 crossing. The climb in mainline grade causes the single lane entrance ramp from SR 140 to SR 823 northbound to climb at a rate of 6.63% in order to meet the mainline at the ramp gore. This steep climb in mainline profile also requires the single lane exit ramp from SR 823 southbound to SR 140 to reach a grade of 5.50% to meet the mainline at the ramp gore.

The SR 823 profile continues to climb at a 5% upgrade as the roadway crosses the mountainous terrain. Near Station 96+00 the profile then begins to drop 100 feet to the Little Scioto River crossing (Station 136+00) at a 4.1% downgrade through the river valley at Highland Bend. Once the grade hits the river bridge, it begins to climb at a rate of 5.0%. This pattern of up and down grades continues through the mountains and valleys. The profile reaches its highest elevation of 872.14 near Station 253+00, which is nearly 275 feet above the river bridge elevation. From this point, the grade drops fairly steady to the north end of the project, which is nearly 225 feet below the high point. For more detailed information on the Stage 1 profile, see Figures 1 and 2 in the Appendix.

The AASHTO Truck Speed Performance Model program was used to analyze truck speeds within this section. Results indicate that a northbound 200lb/hp truck leaving US 52 at 55 mph will decline in speed to approximately 42 mph when the truck reaches the SR 140 entrance gore. A truck traveling up the SR 140 entrance ramp would be at a speed of approximately 23 mph at the same point. This is not a merge condition. Each truck will have a lane as the single lanes form to begin the 2-lane expressway. Since the trucks on SR 823 are traveling approximately 19 mph faster than those coming up the ramp, merging so that all trucks use the right lane may be difficult. The mainline trucks will reach the legal speed of 55 mph approximately 3,000 feet north of this gore point. Overall, the trucks reach the slowest speed of approximately 28 mph near the crest of the curve at PVI Station 166+00 north of the river bridge. From that point the trucks quickly climb back to the 55 mph limit and then quickly decrease speed to approximately 38 mph near the crest of the curve at PVI Station 252+00 before climbing back to 55 mph near the north end of the project.

A southbound truck will not suffer as much speed differential as the northbound vehicles. The southbound trucks will start a continual slowdown from 55 mph to approximately 41 mph as they enter the project and climb to the highest point on the on the profile near the crest of the curve at PVI Station 252+00. From this point they will gain speed as they start to descend to the river. They will reach 55 mph near Station 243+50 and continue at that speed until they hit the 4.00% uphill grade into the rising terrain just north of the river where they will slow to approximately 41 mph near the crest of the curve at PVI Station 166+00. The 5.00% downgrade will allow the trucks to quickly increase their speed back to 55 mph as they cross the river. The 4.10% upgrade just past the river crossing will cause the trucks to reach the slowest speed (approximately 33 mph) for a southbound truck traveling through this project. Once the truck reaches the peak of the profile near PVI Station 95+00 (south of Highland Bend) and begins the 5.00% downgrade toward US 52, the truck quickly reaches the speed of 55 mph. With the steady downgrades and flat upgrades to US 52, the truck will maintain the 55 mph speed to the end of the project. For more detailed information on the Stage 1 truck speeds, see Figures 3 and 4 in the Appendix.

The Stage 1 profile requires the use of high fill culverts (greater than 100 feet of cover) in six locations. Five of the structures are 8 ft. x 8 ft. cast-in-place concrete box culverts and one is a 60-inch Structural Steel Plate culvert. The 60-inch culvert has a maximum cover of 100 feet while the cover on the boxes range from 152 feet to 200 feet. A table of these culverts is shown below.

Table 2-1: High Fill Culverts

Station	Size & Type	Length	Maximum Cover
110+02	60" Structural Steel Plate	638'	100'
233+87	8'x8' Cast-In-Place Concrete Box	1116'	152'
239+18	8'x8' Cast-In-Place Concrete Box	867'	185'
297+33	8'x8' Cast-In-Place Concrete Box	1510'	200'
300+96	8'x8' Cast-In-Place Concrete Box	1038'	197'
311+81	8'x8' Cast-In-Place Concrete Box	767'	155'

Table 2-2 shows a sub-summary of the major earthwork sections associated with the Stage 1 profile.

Table 2-2: Earthwork Sub-Summary

Station Range	Excavation (CY)	Embankment (CY)
US 52 Ramp A	267,688	22,109
US 52 Ramp B	359,808	45,051
54+11.25 to Bridge over SR 140	412,733	7,865
Bridge over SR 140 to 75+00	36,522	102,016
75+00 to 105+50	1,876,601	4,082
105+50 to Bridge over CSX RR	12,514	814,318
Bridge over CSX RR to Bridge over Slocum	1,252	230,066
Bridge over Slocum to Bridge over Little Scioto	14,099	348,620
Bridge over Little Scioto to 173+00	3,235,258	58,308
173+00 to 197+50	215,812	935,377
197+50 to 207+00	496,530	42
207+00 to 213+00	19,517	246,721
213+00 to 227+50	506,857	15,986
227+50 to 257+00	13,666	4,549,803
257+00 to 289+00	727,912	164,451
289+00 to 323+50	72,421	5,721,474
323+50 to 343+50	909,062	32,869
343+50 to 348+00	4,125	235,309
348+00 to 352+00	88,027	82

The total earthwork quantities associated with the Stage 1 profile are presented below.

Table 2-3: Earthwork Volumes

Item	Quantity (CY)
Excavation	9,686,200
Embankment	13,581,000
Waste	N/A
Borrow	2,441,900

3.0 Identification of Alternatives

Since the project requires 2.4 million cubic yards of borrow, HDR reviewed the cross sections in the major embankment areas and found the Stage 1 side slopes to be 4:1 or flatter except at culvert locations. Steepening these slopes to 3:1 would save approximately 600,000 cubic yards of borrow. All of the alternatives presented in this report use the 3:1 slopes. The Stage 1 quantities shown in this study use the original flatter slopes.

When examining this project it becomes apparent that the Little Scioto River forms a natural divide for earthwork. The ideal condition would be to have balanced earthwork south of the river and balanced earthwork north of the river to avoid the cost associated with moving material across the river. Table 3-1 separates the Stage 1 earthwork volumes into the two sections – south of the river and north of the river (using the Stage 1 side slopes).

Table 3-1: Earthwork South and North of the Little Scioto River

Item	Total (CY)	South (CY)	North (CY)
Excavation	9,686,200	3,397,000	6,289,200
Embankment	13,581,000	1,620,600	11,960,400
Waste	N/A	2,285,900	N/A
Borrow	2,441,900	N/A	4,727,800

To balance the earthwork south of the river alone, the profile would have to be revised to reduce the amount of excavation by 2.0 million cubic yards (2.3 million cubic yards divided by the 15% swell factor). To balance the earthwork north of the river, the profile revision would have to reduce embankment and/or increase excavation to eliminate almost 5 million cubic yards of borrow.

The largest quantity of excavation south of the river is between Stations 75+00 and 105+50. As stated in Section 2 of this report, this is the area where the SR 140 entrance ramp joins up with the single lane section of SR 823 northbound. There is already a 5.00% profile grade in this area and the trucks are predicted to slow significantly. The only course of action to reduce the excavation required would be to steepen the grade above 5.00%, extend the 5.00% grade, or raise the whole profile uniformly. All of these measures would have an adverse impact to truck speeds and extending the uphill grade or raising the profile would have a negative impact to the embankment (expanded construction limits) and the series of bridges located in the Highland Bend community on the other side of this excavation.

For these reasons, HDR concluded that no changes in profile could be made south of the river to reduce the excavation without significant adverse impacts to truck speed, bridge costs, and additional residential impacts. Therefore, the focus for any potential change was north of the river. Since there is 2.3 million cubic yards of excess material south of the river, HDR divided the alternatives into two groups – the goal of Group 1 was to balance the earthwork north of the river by assuming that the 2.3 million cubic yards of excess material to the south would be brought north across the river and used for embankment purposes; the goal of Group 2 was to balance the earthwork north of the river by assuming that the 2.3 million cubic yards of excess material to the south would be wasted off-site, thus requiring the section north of the river to balance itself.

Alternative VE-1 fulfills the Group 1 goal and Alternatives VE-2A and VE-2B satisfy the Group 2 goal.

4.0 Alternative VE-1 (Group 1)

The goal of this alternative was to balance the earthwork north of the river by using the 2.3 million cubic yards from the south for embankment and adjusting the profile to eliminate the 2.4 million cubic yards of borrow, delivering a balanced total project.

Since the section north of the river required excessive borrow, the target for this Alternative was to reduce the amount of embankment required without significantly increasing the amount of excavation, so that the change in profile would be cost effective. The focus area to achieve this is the two very large embankment areas between Stations 227+50 and 257+00 and between Stations 289+00 and 323+50.

A PVI was introduced on the 3.10% upgrade at Station 223+50 and the ahead grade was flattened from 3.10% to 1.65%. This 1.65% upgrade was carried to Station 262+50, where it intersects with the 2.30% downgrade in the Stage 1 profile. The effect of this change lowered the profile a maximum of 34 feet through the first high fill area.

A PVI was introduced on the 2.30% downgrade at Station 287+00 and the ahead grade was steepened from 2.30% to 3.00%. This 3.00% downgrade was carried to Station 302+00, where it changes to a 1.50% downgrade. The 1.50% grade was carried to Station 333+00, where it intersects with the 4.70% downgrade in the Stage 1 profile. The effect of this change lowered the profile a maximum of 10 feet through the second high fill area.

The Truck Speed Performance Model was run with these modifications and the revised profile had no adverse impacts on the northbound truck or the southbound truck speeds. For more detailed information on the Alternative VE-1 profile and truck speeds, see Figures 1, 5, 6 and 7 in the Appendix. These changes result in the following earthwork quantities and culvert lengths for Alternative VE-1.

Table 4-1: Earthwork Quantities for VE-1

Item	Total Quantity (CY)	South Section	North Section
Excavation	9,939,100	3,397,000	6,542,100
Embankment	11,361,700	1,620,600	9,741,100
Waste	68,300	2,285,900	N/A
Borrow	N/A	N/A	2,217,600

Table 4-2: Culvert Lengths for VE-1

Station	Size & Type	Length	Maximum Cover
110+02	60" Structural Steel Plate	638'	100'
233+87	8'x8' Cast-In-Place Concrete Box	1055'	140'
239+18	8'x8' Cast-In-Place Concrete Box	776'	165'
297+33	8'x8' Cast-In-Place Concrete Box	1442'	195'
300+96	8'x8' Cast-In-Place Concrete Box	997'	185'
311+81	8'x8' Cast-In-Place Concrete Box	740'	145'

Pros:

- Balanced earthwork over entire project length
- No reduction in predicted truck speeds
- Lowered cover on culverts
- Minimal increase in excavation versus the Stage 1 profile
- Isolated changes to the Stage 1 profile

Cons:

- Must move 2.3 million cubic yards of material across the Little Scioto River
- Haul distance average is 3.25 miles (exceeds Stage 1 distance of 2.50 miles)

5.0 Alternative VE-2A (Group 2)

The goal of this alternative was to balance the earthwork north of the river without using the 2.3 million cubic yards from south of the river. This required the elimination of 4.7 (2.4+2.3) million cubic yards of borrow by a combination of decreased embankment and increased excavation.

The target for this alternative was to reduce the amount of embankment required while increasing the amount of excavation so that the net effect would result in balanced earthwork north of the river. Cost efficiency could still be achieved by increasing the amount of excavation due to eliminating the cost of borrow. The primary focus again was the two very large embankment areas. These areas are between Stations 227+50 and 257+00 and between Stations 289+00 and 323+50.

A PVI was introduced on the 3.10% upgrade at Station 218+50 and the ahead grade was flattened from 3.10% to 1.40%. This 1.40% upgrade was carried to a VPI at Station 264+50, where the ahead grade was a 2.80% downgrade. The 2.80% downgrade was carried to a VPI at Station 300+00, where it flattened to a 1.00% downgrade. The 1.00% downgrade was carried to the Stage 1 VPI at Station 333+00, where it intersects with the 4.70% downgrade in the Stage 1 profile. The effect of this change lowered the profile a maximum of 49 feet through the first high fill area and a maximum of 27 feet through the second high fill area. In cut, the profile was lowered a maximum of 36 feet.

The Truck Speed Performance Model was run with these modifications and the revised profile had no adverse impacts on the northbound truck or the southbound truck speeds. For more detailed information on the Alternative VE-2A profile and truck speeds, see Figures 1, 8, 9 and 10 in the Appendix. The changes result in the following earthwork quantities and culvert lengths for Alternative VE-2A.

Table 5-1: Earthwork Quantities for VE-2A

Item	Total Quantity (CY)	South Section	North Section
Excavation	10,682,300	3,397,000	7,285,300
Embankment	9,811,400	1,620,600	8,190,800
Waste	2,473,200	2,285,900	187,300
Borrow	N/A	N/A	N/A

Table 5-2: Culvert Lengths for VE-2A

Station	Size & Type	Length	Maximum Cover
110+02	60" Structural Steel Plate	638'	100'
233+87	8'x8' Cast-In-Place Concrete Box	1005'	130'
239+18	8'x8' Cast-In-Place Concrete Box	723'	150'
297+33	8'x8' Cast-In-Place Concrete Box	1327'	175'
300+96	8'x8' Cast-In-Place Concrete Box	921'	170'
311+81	8'x8' Cast-In-Place Concrete Box	695'	135'

Pros:

- Balanced earthwork north of the river
- No reduction in predicted truck speeds
- Smooth profile with revised grades under 3.00%
- Lowered cover on culverts
- Haul distance average is 2.0 miles (less than Stage 1 distance of 2.50 miles)
- With the project essentially divided into an independent south section and an independent north section, the project lends itself to having two independent earthwork contracts.

Cons:

- Must waste 2.3 million cubic yards of material south of the Little Scioto River
- Requires more on project excavation than the Stage 1 profile

6.0 Alternative VE-2B (Group 2)

The goal of this alternative was to balance the earthwork north of the river without using the 2.3 million cubic yards from south of the river. This required elimination of 4.7 (2.4+2.3) million cubic yards of borrow by a combination of decreased embankment and minimal increase in excavation.

Since Alternative VE-2A balanced the earthwork by both increasing excavation and decreasing embankment, the target for this alternative was to further reduce the amount of embankment required while decreasing the amount of excavation required by Alternative VE-2A so that the net effect would result in balanced earthwork north of the river. The focus again was the two very large embankment areas. These areas are between Stations 227+50 and 257+00 and between Stations 289+00 and 323+50.

A PVI was introduced on the 3.10% upgrade at Station 223+50 and the ahead grade was flattened from 3.10% to a 0.50% downgrade. This 0.50% downgrade was carried to a VPI at Station 240+50, where the ahead grade was a 3.50% upgrade, creating a sag curve in the first large embankment area. The 3.50% upgrade was carried to a VPI at Station 262+50, where it became a 3.00% downgrade. The 3.00% downgrade was carried to a PVI at Station 284+40, where the ahead grade was steepened to a 3.50% downgrade. The 3.50% downgrade was carried to a VPI at Station 299+50, where the ahead grade was flattened to a 1.00% downgrade (matching the VE-2A profile). The 1.00% downgrade was carried to the Stage 1 VPI at Station 333+00, where it intersects with the 4.70% downgrade in the Stage 1 profile. The effect of this change lowered the profile a maximum of 60 feet through the first high fill area and 27 feet through the second high fill area. In cut, the profile was lowered a maximum of 26 feet.

The Truck Speed Performance Model was run with these modifications and the revised profile had no adverse impacts on the northbound truck speeds. The southbound truck speeds are predicted to slow from 43 mph to 39 mph near the crest of the curve at PVI Station 262+50 because of the 3.00/3.50% upgrades. There are no ramps in this area and this speed is still higher than the slowest southbound speed on the Stage 1 profile, which is 33 mph. For more detailed information on the Alternative VE-2B profile and truck speeds, see Figures 1, 11, 12 and 13 in the Appendix. The changes result in the following earthwork quantities and culvert lengths for Alternative VE-2B.

Table 6-1: Earthwork Quantities for VE-2B

Item	Quantity (CY)	South Section	North Section
Excavation	10,293,100	3,397,000	6,896,100
Embankment	9,426,700	1,620,600	7,806,100
Waste	2,410,300	2,285,900	124,400
Borrow	N/A	N/A	N/A

Table 6-2: Culvert Lengths for VE-2B

Station	Size & Type	Length	Maximum Cover
110+02	60" Structural Steel Plate	638'	100'
233+87	8'x8' Cast-In-Place Concrete Box	955'	120'
239+18	8'x8' Cast-In-Place Concrete Box	650'	130'
297+33	8'x8' Cast-In-Place Concrete Box	1327'	175'
300+96	8'x8' Cast-In-Place Concrete Box	921'	170'
311+81	8'x8' Cast-In-Place Concrete Box	695'	135'

Pros:

- Balanced earthwork north of the river
- No significant reduction in predicted truck speeds
- Less excavation required to balance the earthwork
- Lowered cover on culverts
- Haul distance average is 2.0 miles (less than Stage 1 distance of 2.50 miles)
- With the project essentially divided into an independent south section and an independent north section, the project lends itself to having two independent earthwork contracts.

Cons:

- Must waste 2.3 million cubic yards of material south of the Little Scioto River
- Maximum grade within the changed profile area is increased from 3.10% to 3.50%
- Creates an additional sag curve resulting in additional "rolling" of the profile (meets criteria)

7.0 Economic Analysis

The estimated unit costs for Item 203 Excavation and Item 203 Embankment as prepared for the Stage 1 plans were reevaluated due to the haul distance and large quantities of earthwork in Phase III. The unit costs for these items were adjusted based on review of past ODOT bid tabulations as well as conversations with several earthwork contractors. The average haul distance as determined for each construction profile was also used to help in the development of the unit cost for embankment.

The estimated quantities for both embankment and excavation on this project are greater than those available for recent ODOT projects of comparable size and length. The total quantities from the ODOT bid tabulations were plotted against their associated unit costs in order to determine a relationship between project quantity and cost. Using these relationships, preliminary unit costs for excavation and embankment were developed. This method applied to our quantities yielded a unit cost for excavation of $2.40/CY, and a unit cost for embankment of $0.60/CY. These unit prices were the same or lower than the unit price of $3.30 for excavation and $0.60 for embankment as presented in the cost estimate submitted with the Stage 1 plans. The swell factor used was 15% as opposed to the 30% swell factor as used in the cost estimate submitted with the Stage 1 plans.

The unit cost for embankment was further developed based on the average haul distances expected. As shown in Table 7-1, the average haul distance varied from 2 miles to 3¼ miles. Considering $0.60/CY a base cost for an average haul distance of ½ mile, a multiplier was developed using cost information and haul distances published in the 2009 edition of RSMeans "Heavy Construction Cost Data". As shown in Table 7-1, the anticipated unit cost for embankment varied from $0.75/CY to $0.90/CY for the various profile alternatives.

In 2008, conversations were held with four earthwork contractors having considerable experience in southern Ohio to substantiate previous unit costs developed. Based on our conversations with estimators from Kokosing Construction Co., Beaver Excavating Co., R.B. Jergens Contractors, Inc., and Independence Excavating, Inc., the estimated excavation costs provided ranged from $2.00/CY to $3.00/CY. For embankment, the unit costs varied from $0.60/CY to $1.00/CY. As the unit costs developed for both excavation and embankment fall within the range provided, the preliminary unit costs presented in Table 7-1 were used for this VE study.

Table 7-1: Study Earthwork Unit Prices and Haul Distances

Profile	Excavation (Cost/CY)	Embankment (Cost/CY)	Avg. Haul (Miles)
Stage 1	$2.40	$0.80	2.50
Alternative VE-1	$2.40	$0.90	3.25
Alternative VE-2A	$2.40	$0.75	2.00
Alternative VE-2B	$2.40	$0.75	2.00

The unit cost used in this study for waste ($1.10) was the same as established in the VE study for Phase 1 of the bypass. The unit cost used in this study for borrow ($2.40) is the same as the excavation costs. While the land for borrow material would have to be purchased from the property owner and the borrow material hauled to the project site, likely increasing the cost, to be conservative in estimating potential savings, the same unit cost was used.

For deep culverts, ODOT does not have standard unit costs since they require a special design. For this study, HDR assumed the box culvert walls to be 18" thick. A quantity of concrete was calculated for the 8'x8' box culverts using this wall thickness and a steel reinforcing area was calculated as a percentage of the concrete area. This analysis resulted in a cost per foot of $770. A 15% contingency was added and the unit cost became $885.50 per foot. For study purposes, this unit cost was rounded to $900 per foot.

The ODOT Historical Bid Item Data shows an average bid item cost for a 60" conduit to be approximately $200 per foot. Since our culvert is a deep culvert requiring Structural Steel Plate construction, the unit price was increased by 50% and a unit price of $300 per foot was used.

The Stage 1 profile and Alternative VE-1 profile require the excess material from south of the river to be taken across the river for use on the north side. Two methods were investigated for achieving this goal: 1) using a conveyor system; or 2) using on-road trucks and the local roadway system. A detailed breakdown of the costs associated with each of these methods is included in the appendix. The conveyor system is by far the most cost effective method with a total estimated cost of $1.3 million dollars. See Figure 17 in the Appendix to see how the river crossing costs were calculated.

Following are partial cost breakdowns of the Stage 1 profile, the VE-1 profile, the VE-2A profile, and the VE-2B profile. Only items necessary to evaluate the profiles have been included in these estimates. Therefore, these estimates are for comparative purposes only.

Table 7-2: Stage 1 (Base) Cost

Item	Quantity	Unit	Unit Cost	Cost
Excavation	9,686,200	CY	$2.40	$23,246,880
Embankment	13,581,000	CY	$0.80	$10,864,800
Borrow	2,441,900	CY	$2.40	$5,860,560
Conveyor System	1	LS	$1,300,000	$1,300,000
60" Culvert	312	LF	$300	$93,600
72" Culvert	567	LF	$230	$130,410
8' X 8' Box Culvert	5,296	LF	$900	$4,766,400
Stream Mitigation	6,355	LF	$250	$1,588,750
Additional Engineering	0	LS		
			Total Cost	**$47,851,400**

Table 7-3: Alternative VE-1 Cost

Item	Quantity	Unit	Unit Cost	Cost
Excavation	9,939,100	CY	$2.40	$23,853,840
Embankment	11,361,700	CY	$0.90	$10,225,530
Waste	68,300	CY	$1.10	$75,130
Conveyor System	1	LS	$1,300,000	$1,300,000
60" Culvert	308	LF	$300	$92,400
72" Culvert	550	LF	$230	$126,500
8' X 8' Box Culvert	5,010	LF	$900	$4,509,000
Stream Mitigation	5,320	LF	$250	$1,330,000
Additional Engineering	1	LS	$500,000	$500,000
			Total Cost	**$42,012,400**

Table 7-4: Alternative VE-2A Cost

Item	Quantity	Unit	Unit Cost	Cost
Excavation	10,682,300	CY	$2.40	$25,637,520
Embankment	9,811,400	CY	$0.75	$7,358,550
Waste	2,473,200	CY	$1.10	$2,720,520
60" Culvert	297	LF	$300	$89,100
72" Culvert	519	LF	$230	$119,370
8' X 8' Box Culvert	4,671	LF	$900	$4,203,900
Stream Mitigation	5,080	LF	$250	$1,270,000
Additional Engineering	1	LS	$500,000	$500,000
			Total Cost	**$41,898,960**

Table 7-5: Alternative VE-2B Cost

Item	Quantity	Unit	Unit Cost	Cost
Excavation	10,293,100	CY	$2.40	$24,703,440
Embankment	9,426,700	CY	$0.75	$7,070,025
Waste	2,410,300	CY	$1.10	$2,651,330
60" Culvert	297	LF	$300	$89,100
72" Culvert	519	LF	$230	$119,370
8' X 8' Box Culvert	4,548	LF	$900	$4,093,200
Stream Mitigation	4,965	LF	$250	$1,241,250
Additional Engineering	1	LS	$500,000	$500,000
			Total Cost	**$40,467,715**

Table 7-6: Total Cost Comparison

Profile	Cost (Millions)	Savings over Base Condition (Millions)
Stage 1 (Base)	$47.9	N/A
Alternative VE-1	$42.0	$5.9
Alternative VE-2A	$41.9	$6.0
Alternative VE-2B	$40.5	$7.4

The following table lists the maximum height of cover for each culvert in Stage 1 and the three alternatives.

Table 7-7: High Fill Culvert Comparrison

Station	Stage 1	VE-1	VE-2A	VE-2B
110+02	100'	100'	100'	100'
233+87	152'	140'	130'	120'
239+18	185'	165'	150'	130'
297+33	200'	195'	175'	175'
300+96	197'	185'	170'	170'
311+81	155'	145'	135'	135'

8.0 Dual Culvert Systems

There are two locations on the proposed alignment with dual 8'x8' box culverts in a deep fill situation. A dual culvert system occurs when two or more drainage areas converge within the footprint of the profile. The dual culverts share an outlet headwall but the inlets capture independent drainage areas. The outlet headwalls are located at Stations 238+70 and 303+35. An alternative for each system is to realign the channels to intersect before the inlet requiring only one culvert. See Figures 14 and 15 in the Appendix for an existing and proposed site layout of each system. Since these boxes are quite costly, ODOT asked HDR to investigate the feasibility and cost associated with combining the boxes into a single culvert crossing at each location as part of this study.

The two locations are very similar in nature, two drainage channels separated by a ridge between them. A channel must be cut through this ridge to connect the streams and bring them to a single culvert inlet. For this study, it was assumed that the stream going through the ridge would have a 10-15 ft. flat bottom ditch with 1.5:1 side slopes extending from the stream bottom to the top of excavation. A smaller sub channel could be constructed within the ditch bottom to allow for a more natural stream morphology and possible stream mitigation credit in the final design. See Figure 16 in the Appendix for a typical channel relocation cross section.

Table 8-1 summarizes the cost for the Stage 1 Dual Culverts. Tables 8-2, 8-3, 8-4 and 8-5 show the estimated costs associated with each culvert system under the Stage 1 profile and the alternative profiles discussed in Sections 3 through 6 of this study.

Table 8-1: Stage 1 – Dual Culverts (Base)

	Quantity	Unit	Unit Cost	Cost
233+87	1,122	LF	$900	$1,009,800
239+18	866	LF	$900	$779,400
			Sub Total	**$1,789,200**
297+33	1,510	LF	$900	$1,359,000
300+96	1,038	LF	$900	$934,200
			Sub Total	**$2,293,200**
			Total	**$4,082,400**

Table 8-2: Stage 1 Profile - Single Culvert Estimate

	Quantity	Unit	Unit Cost	Cost
Station 238+70				
Excavation*	529,870	CY	$0	$0
Waste on Site*	609,350	CY	$0	$0
Culvert	866	LF	$900	$779,400
			Sub Total	**$779,400**
Station 303+35				
Excavation*	316,372	CY	$0	$0
Waste on Site*	363,828	CY	$0	$0
Culvert	767	LF	$900	$690,300
			Sub Total	**$690,300**
Engineering				$100,000
			Total	**$1,569,700**

*Excavated material can be used to offset borrow on mainline, no added cost.

Table 8-3: Alternative VE-1 Profile - Single Culvert Estimate

	Quantity	Unit	Unit Cost	Cost
Station 238+70				
Excavation	408,511	CY	$2.40	$980,427
Waste on Site*	469,788	CY	$0.90	$422,809
Culvert	776	LF	$900	$698,400
			Sub Total	**$2,101,636**
Station 303+35				
Excavation	248,313	CY	$2.40	$595,951
Waste on Site*	285,560	CY	$0.90	$257,004
Culvert	740	LF	$900	$666,000
			Sub Total	**$1,518,955**
Engineering				$100,000
			Total	**$3,720,591**

* Waste will be used as additional embankment.

Table 8-4: Alternative VE-2A Profile - Single Culvert Estimate

	Quantity	Unit	Unit Cost	Cost
Station 238+70				
Excavation	351,915	CY	$2.40	$844,596
Waste on Site*	404,702	CY	$0.75	$303,527
Culvert	723	LF	$900	$650,700
			Sub Total	**$1,798,822**
Station 303+35				
Excavation	182,702	CY	$2.40	$438,484
Waste on Site*	210,107	CY	$0.75	$157,580
Culvert	695	LF	$900	$625,500
			Sub Total	**$1,221,565**
Engineering				$100,000
			Total	**$3,120,387**

* Waste will be used as additional embankment.

Table 8-5: Alternative VE-2B Profile - Single Culvert Estimate

	Quantity	Unit	Unit Cost	Cost
Station 238+70				
Excavation	307,478	CY	$2.40	$737,947
Waste on Site*	353,599	CY	$0.75	$265,200
Culvert	650	LF	$900	$585,000
			Sub Total	**$1,588,146**
Station 303+35				
Excavation	193,380	CY	$2.40	$464,111
Waste on Site*	222,387	CY	$0.75	$166,790
Culvert	695	LF	$900	$625,500
			Sub Total	**$1,256,401**
Engineering				$100,000
			Total	**$2,944,547**

* Waste will be used as additional embankment

Tables 8-2 through 8-5 above represent the minimum savings that will be achieved by combining the two sets of dual culverts into two independent crossings. If one of the three vertical profile alternatives is chosen, slight adjustments can likely be made in the mainline profile to reduce the amount of excavation on the mainline equal to the respective excavation shown in Tables 8-3 through 8-5. This would result in a savings equal to the excavation cost shown in these tables; therefore, total savings would range from $300,000 (Alternative VE-1 with no profile adjustments) to $2.3 million (Alternative VE-2B with profile adjustments to eliminate mainline excavation equal to stream excavation).

For illustrative purposes, if Alternative VE-2B was selected and the mainline profile was adjusted to eliminate approximately 500,858 (307,478+193,380) cubic yards of excavation, the savings for combining culverts would approach $2.3 million ($4,082,400 – ($2,944,547 - $737,947 - $464,111)). This range is based on the profile alternative selected and the amount that the profile can be adjusted to approach the relative cubic yards of excavation shown in the respective tables.

Removing the dual culvert systems and creating a single culvert crossing at Station 238+70 and Station 303+35 is cost effective for the Stage 1 profile and all three of the profile alternatives studied (VE-1, VE-2A, and VE-2B).

9.0 Conclusion

From this study, it can be concluded that there is significant savings associated with revising the Phase 3 profile. A key consideration in selection of the preferred profile alternative is judgment on the contractor's ability to waste 2.3 million cubic yards south of the river at a reasonable cost. All three of the alternatives presented herein meet current ODOT design criteria and all three provide acceptable profiles without adverse impacts to truck speeds. This study also shows that savings can be achieved by combining the two sets of dual box culverts into two single crossings regardless of the profile used.

Appendix

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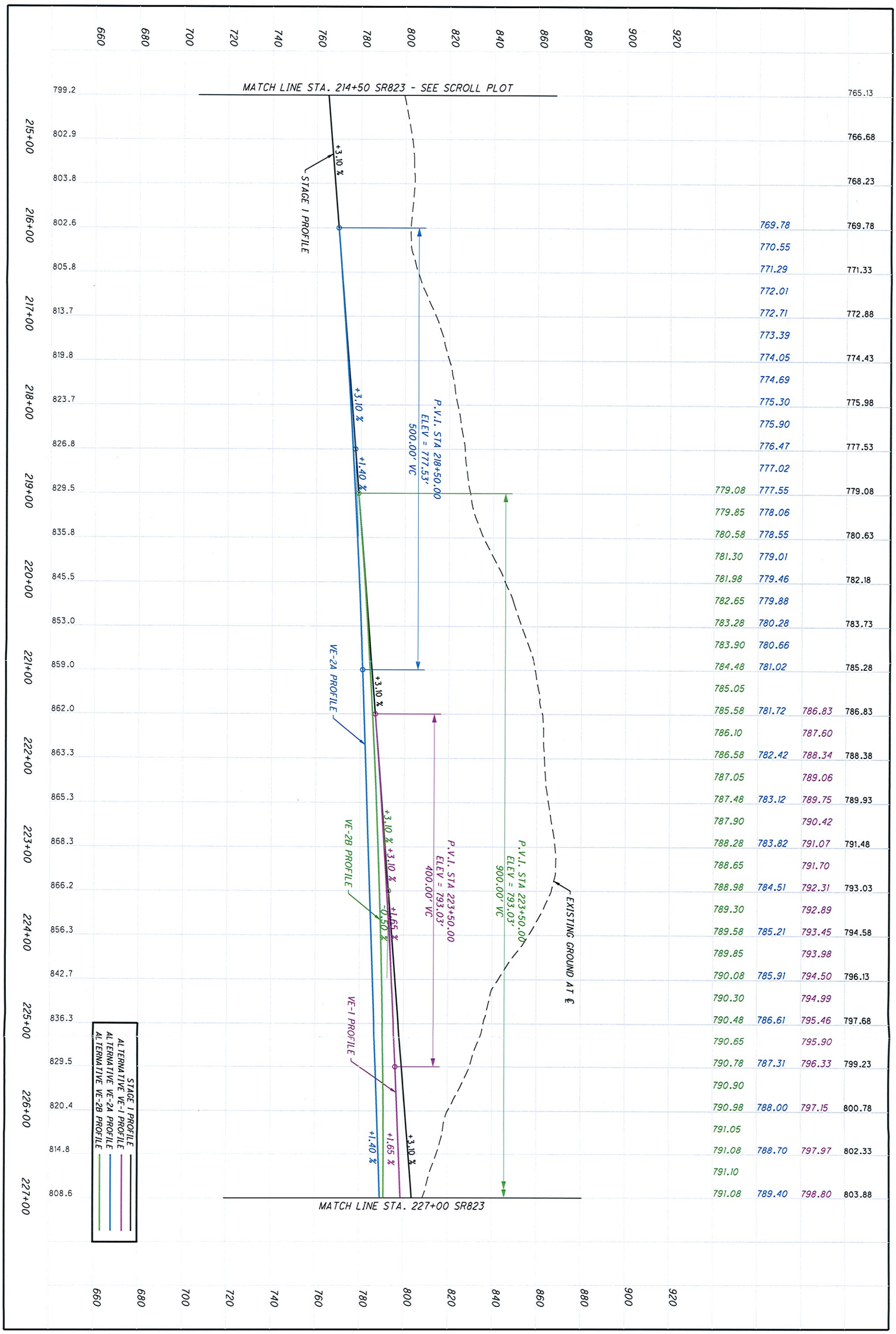

10 / 1	SCI-823-0.00	FIGURE 1 - VE STUDY PROFILES SR823 STA. 214+50 TO STA. 227+00	CALCULATED --- CHECKED ---

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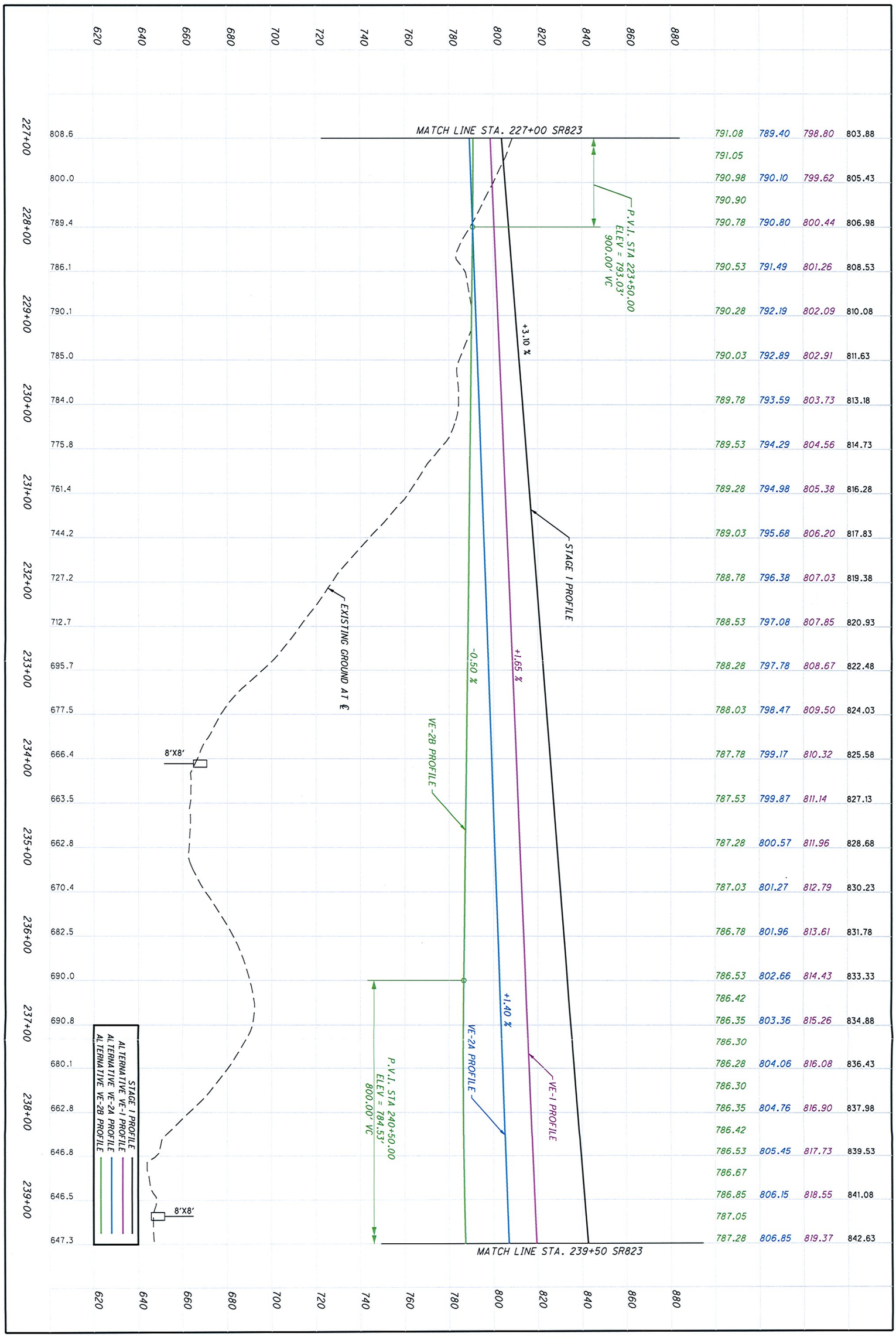

2/10	SCI-823-0.00	**FIGURE 1 - VE STUDY PROFILES SR823 STA. 227+00 TO STA. 239+50**	CALCULATED ___ CHECKED ___

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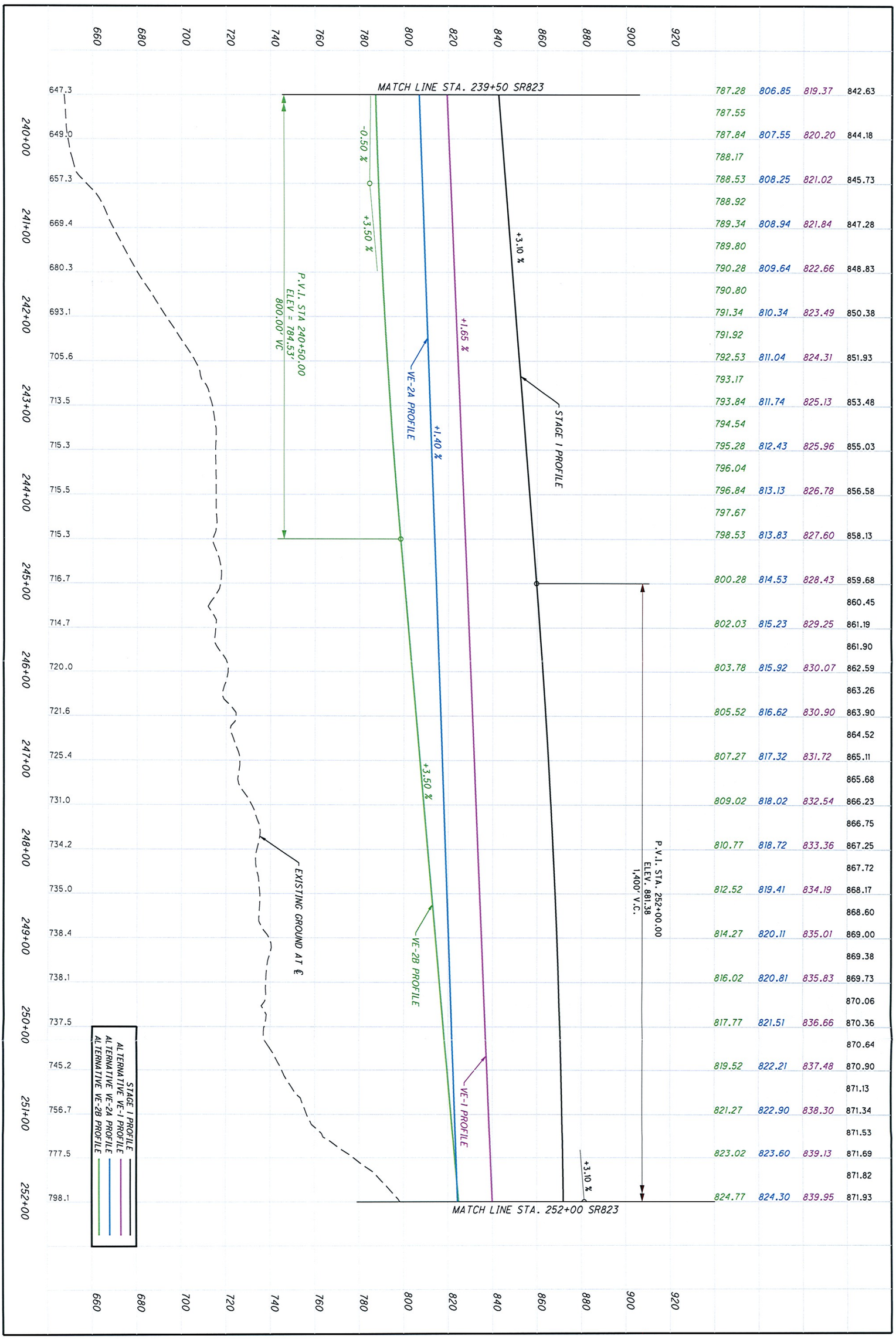

3/10	SCI-823-0.00	**FIGURE 1 - VE STUDY PROFILES SR823 STA. 239+50 TO STA. 252+00**	CALCULATED ___ CHECKED ___

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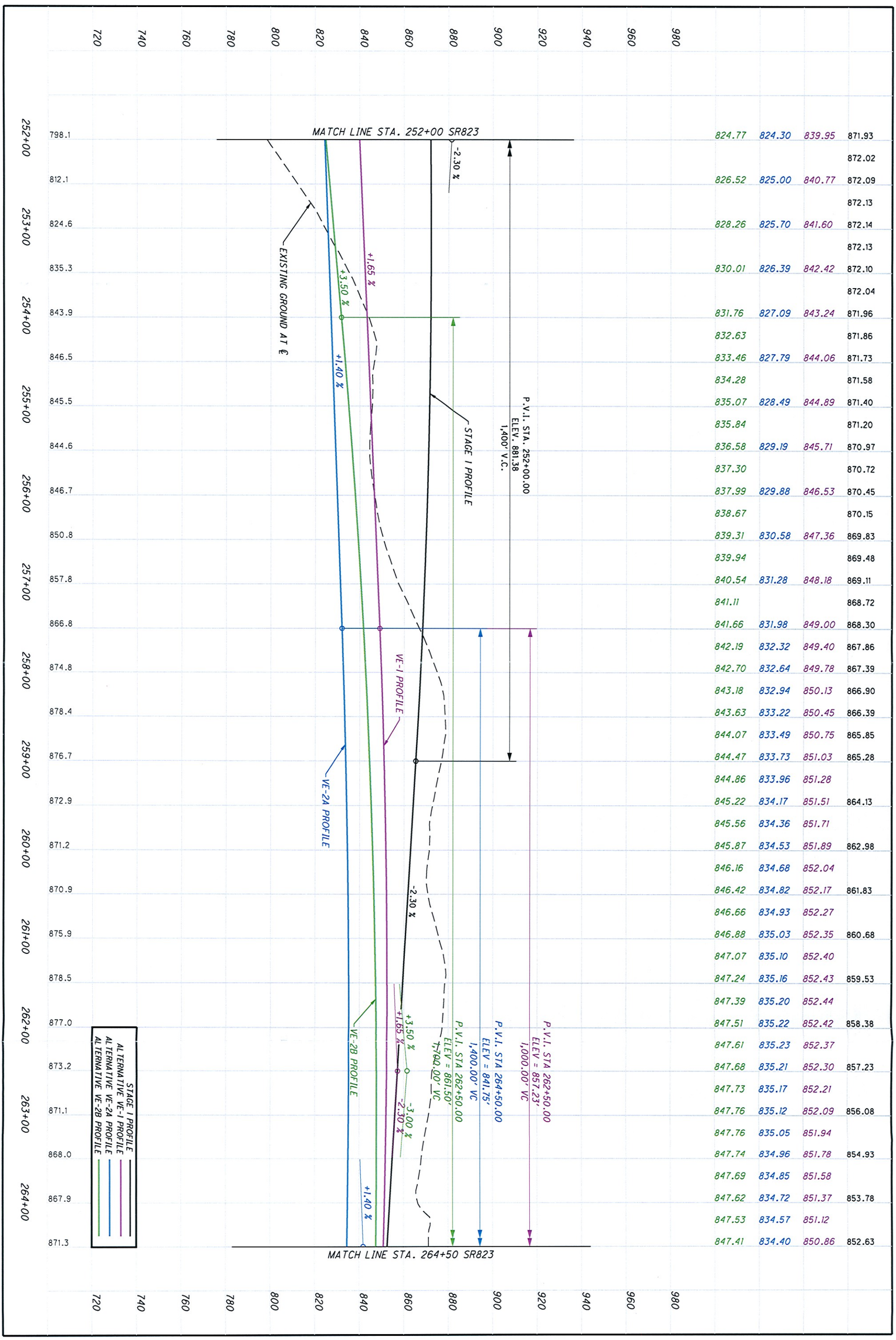

252+00	798.1				
	812.1				
253+00	824.6				
	835.3				
254+00	843.9	824.77	824.30	839.95	871.93
	846.5				872.02
255+00	845.5	826.52	825.00	840.77	872.09
	844.6				872.13
256+00	846.7	828.26	825.70	841.60	872.14
	850.8				872.13
257+00	857.8	830.01	826.39	842.42	872.10
	866.8				872.04
258+00	874.8	831.76	827.09	843.24	871.96
	878.4	832.63			871.86
259+00	876.7	833.46	827.79	844.06	871.73
	872.9	834.28			871.58
260+00	871.2	835.07	828.49	844.89	871.40
	870.9	835.84			871.20
261+00	875.9	836.58	829.19	845.71	870.97
	878.5	837.30			870.72
262+00	877.0	837.99	829.88	846.53	870.45
	873.2	838.67			870.15
263+00	871.1	839.31	830.58	847.36	869.83
	868.0	839.94			869.48
264+00	867.9	840.54	831.28	848.18	869.11
	871.3	841.11			868.72
		841.66	831.98	849.00	868.30
		842.19	832.32	849.40	867.86
		842.70	832.64	849.78	867.39
		843.18	832.94	850.13	866.90
		843.63	833.22	850.45	866.39
		844.07	833.49	850.75	865.85
		844.47	833.73	851.03	865.28
		844.86	833.96	851.28	
		845.22	834.17	851.51	864.13
		845.56	834.36	851.71	
		845.87	834.53	851.89	862.98
		846.16	834.68	852.04	
		846.42	834.82	852.17	861.83
		846.66	834.93	852.27	
		846.88	835.03	852.35	860.68
		847.07	835.10	852.40	
		847.24	835.16	852.43	859.53
		847.39	835.20	852.44	
		847.51	835.22	852.42	858.38
		847.61	835.23	852.37	
		847.68	835.21	852.30	857.23
		847.73	835.17	852.21	
		847.76	835.12	852.09	856.08
		847.76	835.05	851.94	
		847.74	834.96	851.78	854.93
		847.69	834.85	851.58	
		847.62	834.72	851.37	853.78
		847.53	834.57	851.12	
		847.41	834.40	850.86	852.63

4/10	SCI-823-0.00	**FIGURE 1 - VE STUDY PROFILES SR823 STA. 252+00 TO STA. 264+50**	CALCULATED ___ CHECKED ___

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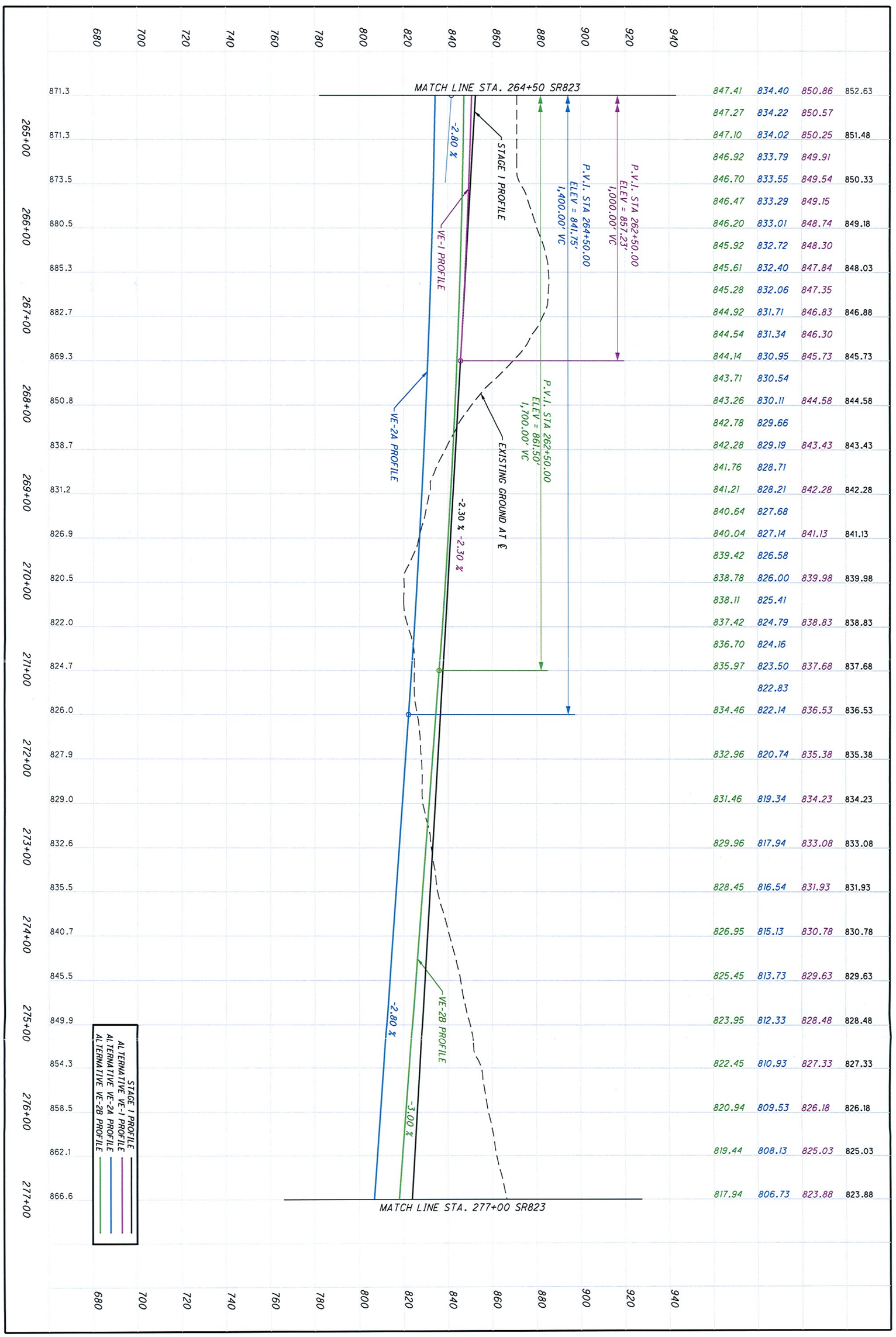

847.41	834.40	850.86	852.63
847.27	834.22	850.57	
847.10	834.02	850.25	851.48
846.92	833.79	849.91	
846.70	833.55	849.54	850.33
846.47	833.29	849.15	
846.20	833.01	848.74	849.18
845.92	832.72	848.30	
845.61	832.40	847.84	848.03
845.28	832.06	847.35	
844.92	831.71	846.83	846.88
844.54	831.34	846.30	
844.14	830.95	845.73	845.73
843.71	830.54		
843.26	830.11	844.58	844.58
842.78	829.66		
842.28	829.19	843.43	843.43
841.76	828.71		
841.21	828.21	842.28	842.28
840.64	827.68		
840.04	827.14	841.13	841.13
839.42	826.58		
838.78	826.00	839.98	839.98
838.11	825.41		
837.42	824.79	838.83	838.83
836.70	824.16		
835.97	823.50	837.68	837.68
	822.83		
834.46	822.14	836.53	836.53
832.96	820.74	835.38	835.38
831.46	819.34	834.23	834.23
829.96	817.94	833.08	833.08
828.45	816.54	831.93	831.93
826.95	815.13	830.78	830.78
825.45	813.73	829.63	829.63
823.95	812.33	828.48	828.48
822.45	810.93	827.33	827.33
820.94	809.53	826.18	826.18
819.44	808.13	825.03	825.03
817.94	806.73	823.88	823.88

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SCI-823-0.00

FIGURE 1 - VE STUDY PROFILES
SR823 STA. 264+50 TO STA. 277+00

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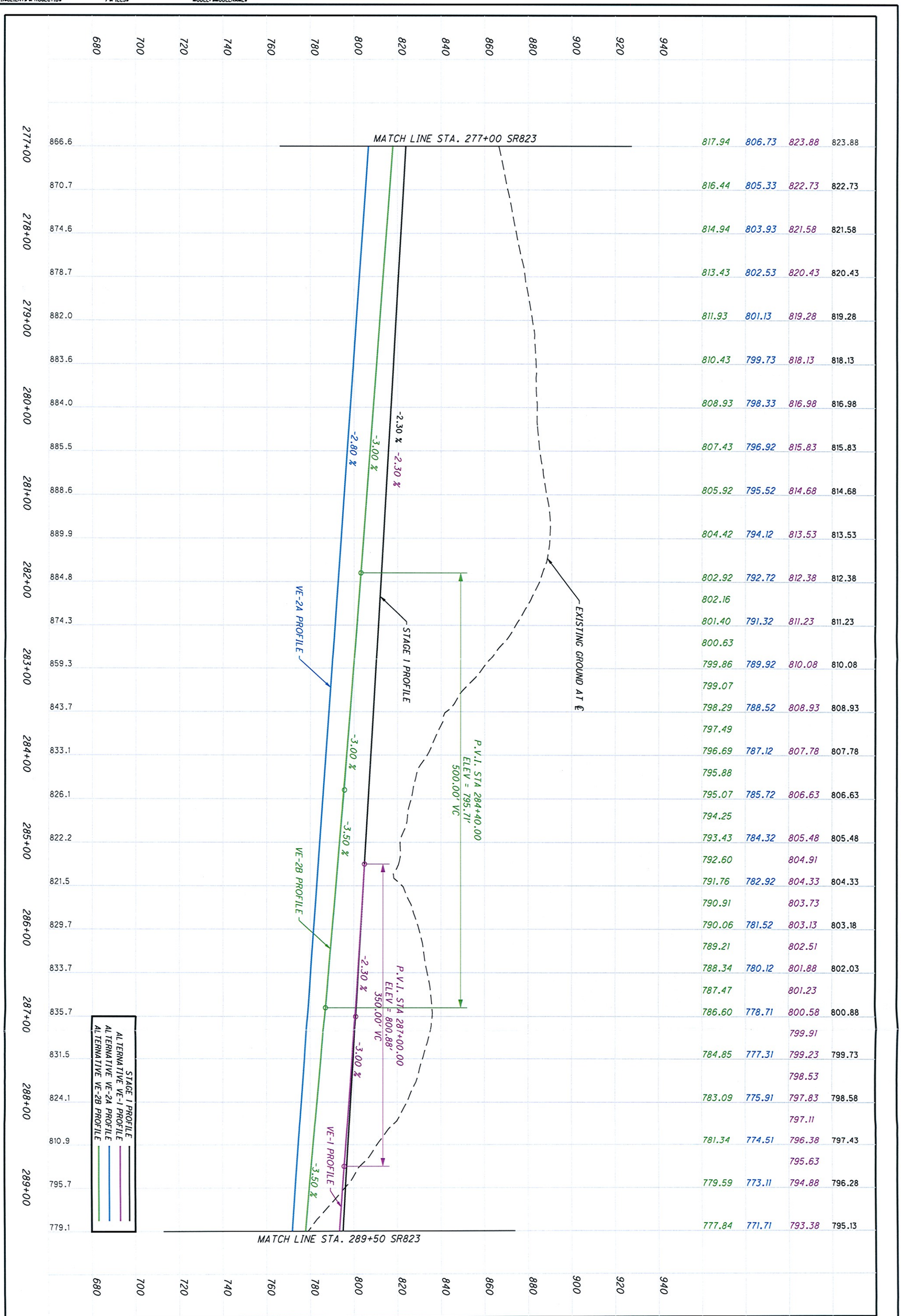

277+00	680	866.6			
	700	870.7			
278+00	720	874.6			
	740	878.7			
279+00	760	882.0			
	780	883.6			
280+00	800	884.0			
	820	885.5			
281+00	840	888.6			
	860	889.9			
282+00	880	884.8			
	900	874.3			
283+00	920	859.3			
	940	843.7			
284+00		833.1			
		826.1			
285+00		822.2			
		821.5			
286+00		829.7			
		833.7			
287+00		835.7			
		831.5			
288+00		824.1			
		810.9			
289+00		795.7			
		779.1			

817.94	806.73	823.88	823.88
816.44	805.33	822.73	822.73
814.94	803.93	821.58	821.58
813.43	802.53	820.43	820.43
811.93	801.13	819.28	819.28
810.43	799.73	818.13	818.13
808.93	798.33	816.98	816.98
807.43	796.92	815.83	815.83
805.92	795.52	814.68	814.68
804.42	794.12	813.53	813.53
802.92	792.72	812.38	812.38
802.16			
801.40	791.32	811.23	811.23
800.63			
799.86	789.92	810.08	810.08
799.07			
798.29	788.52	808.93	808.93
797.49			
796.69	787.12	807.78	807.78
795.88			
795.07	785.72	806.63	806.63
794.25			
793.43	784.32	805.48	805.48
792.60		804.91	
791.76	782.92	804.33	804.33
790.91		803.73	
790.06	781.52	803.13	803.18
789.21		802.51	
788.34	780.12	801.88	802.03
787.47		801.23	
786.60	778.71	800.58	800.88
		799.91	
784.85	777.31	799.23	799.73
		798.53	
783.09	775.91	797.83	798.58
		797.11	
781.34	774.51	796.38	797.43
		795.63	
779.59	773.11	794.88	796.28
777.84	771.71	793.38	795.13

6/10	SCI-823-0.00	**FIGURE 1 - VE STUDY PROFILES** **SR823 STA. 277+00 TO STA. 289+50**

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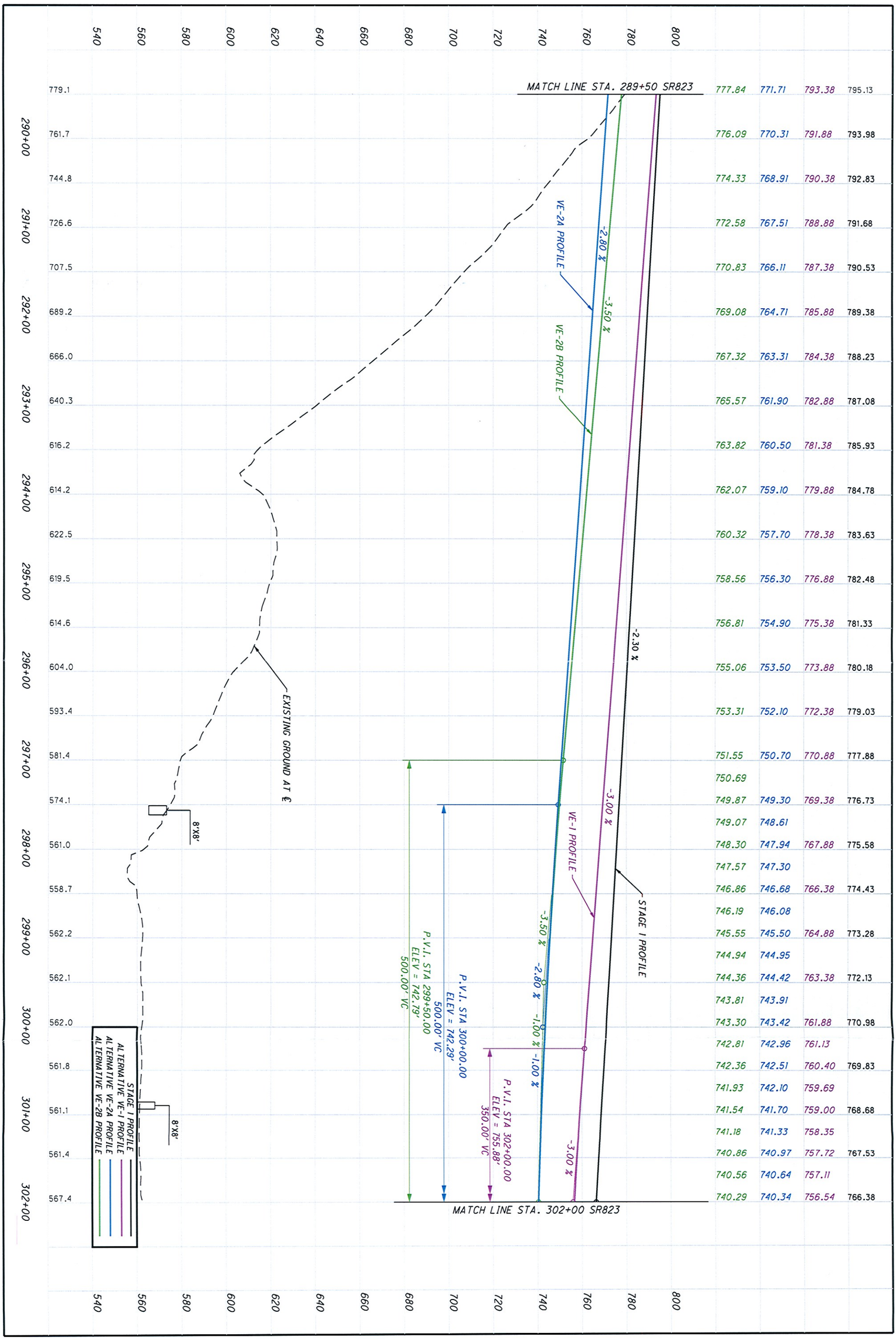

7/10	SCI-823-0.00	**FIGURE 1 - VE STUDY PROFILES SR823 STA. 289+50 TO STA. 302+00**	CALCULATED ___ CHECKED ___

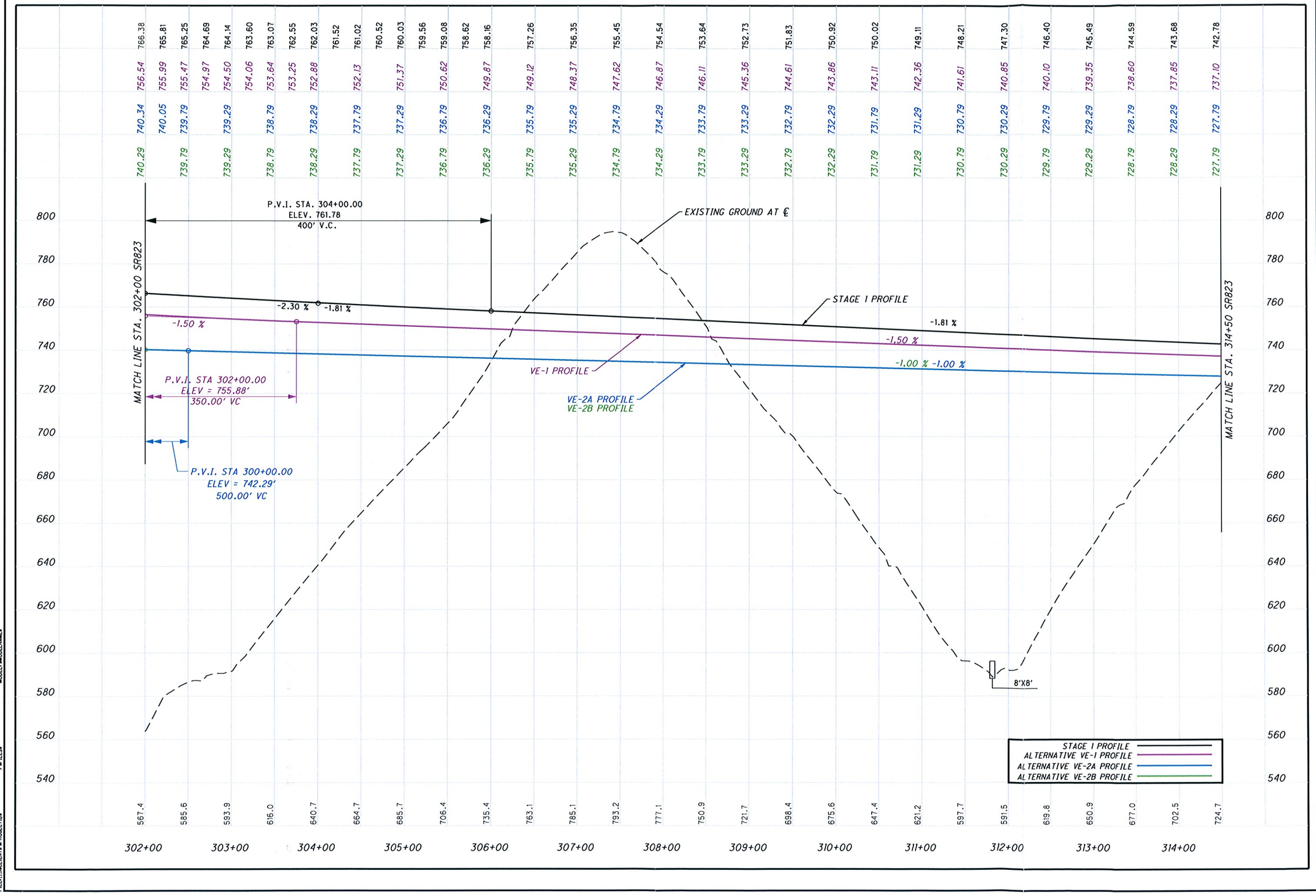

FIGURE 1 - VE STUDY PROFILES
SR823 STA. 302+00 TO STA. 314+50

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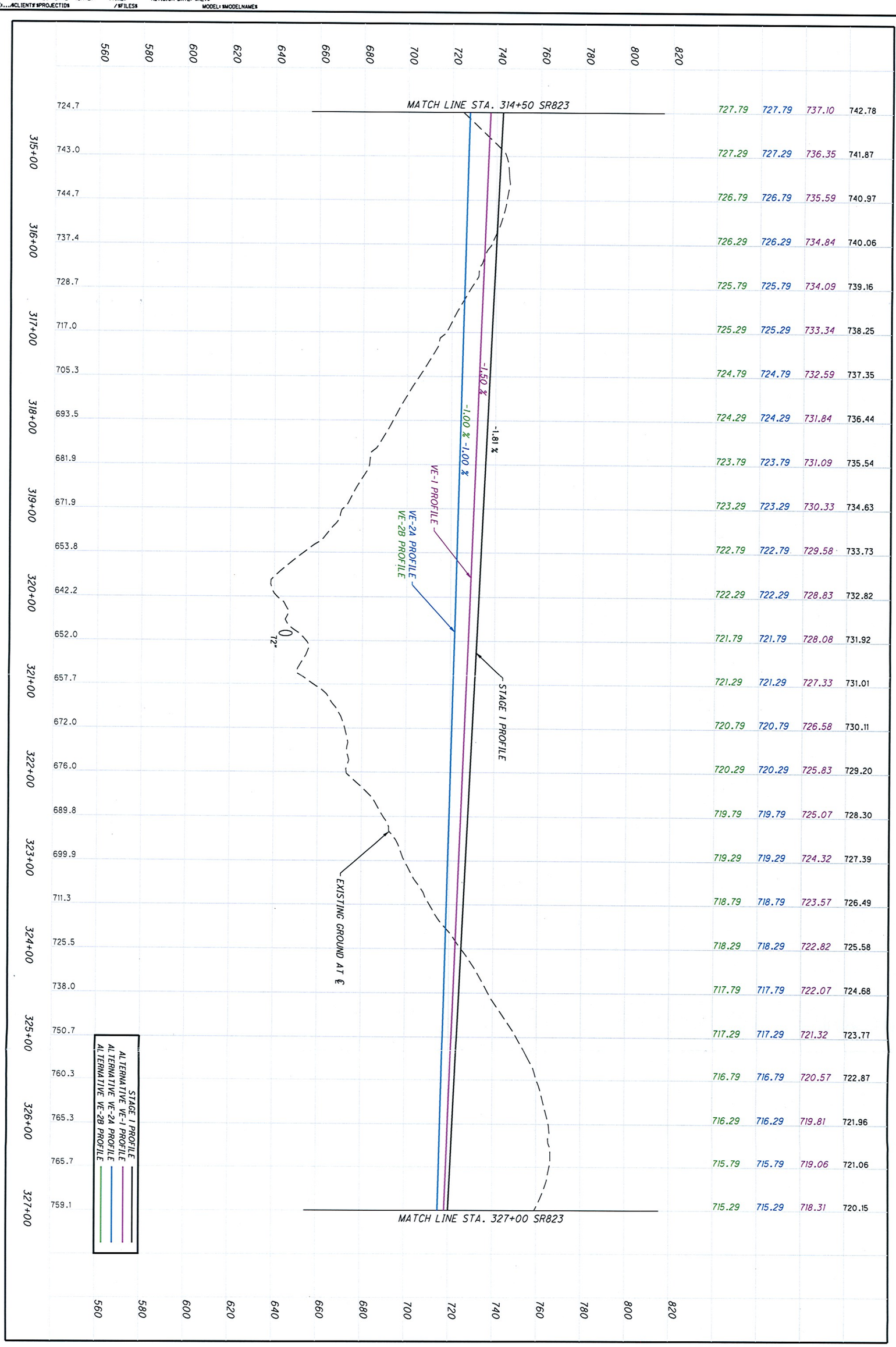

727.79	727.79	737.10	742.78
727.29	727.29	736.35	741.87
726.79	726.79	735.59	740.97
726.29	726.29	734.84	740.06
725.79	725.79	734.09	739.16
725.29	725.29	733.34	738.25
724.79	724.79	732.59	737.35
724.29	724.29	731.84	736.44
723.79	723.79	731.09	735.54
723.29	723.29	730.33	734.63
722.79	722.79	729.58	733.73
722.29	722.29	728.83	732.82
721.79	721.79	728.08	731.92
721.29	721.29	727.33	731.01
720.79	720.79	726.58	730.11
720.29	720.29	725.83	729.20
719.79	719.79	725.07	728.30
719.29	719.29	724.32	727.39
718.79	718.79	723.57	726.49
718.29	718.29	722.82	725.58
717.79	717.79	722.07	724.68
717.29	717.29	721.32	723.77
716.79	716.79	720.57	722.87
716.29	716.29	719.81	721.96
715.79	715.79	719.06	721.06
715.29	715.29	718.31	720.15

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SCI-823-0.00

FIGURE 1 - VE STUDY PROFILES
SR823 STA. 314+50 TO STA. 327+00

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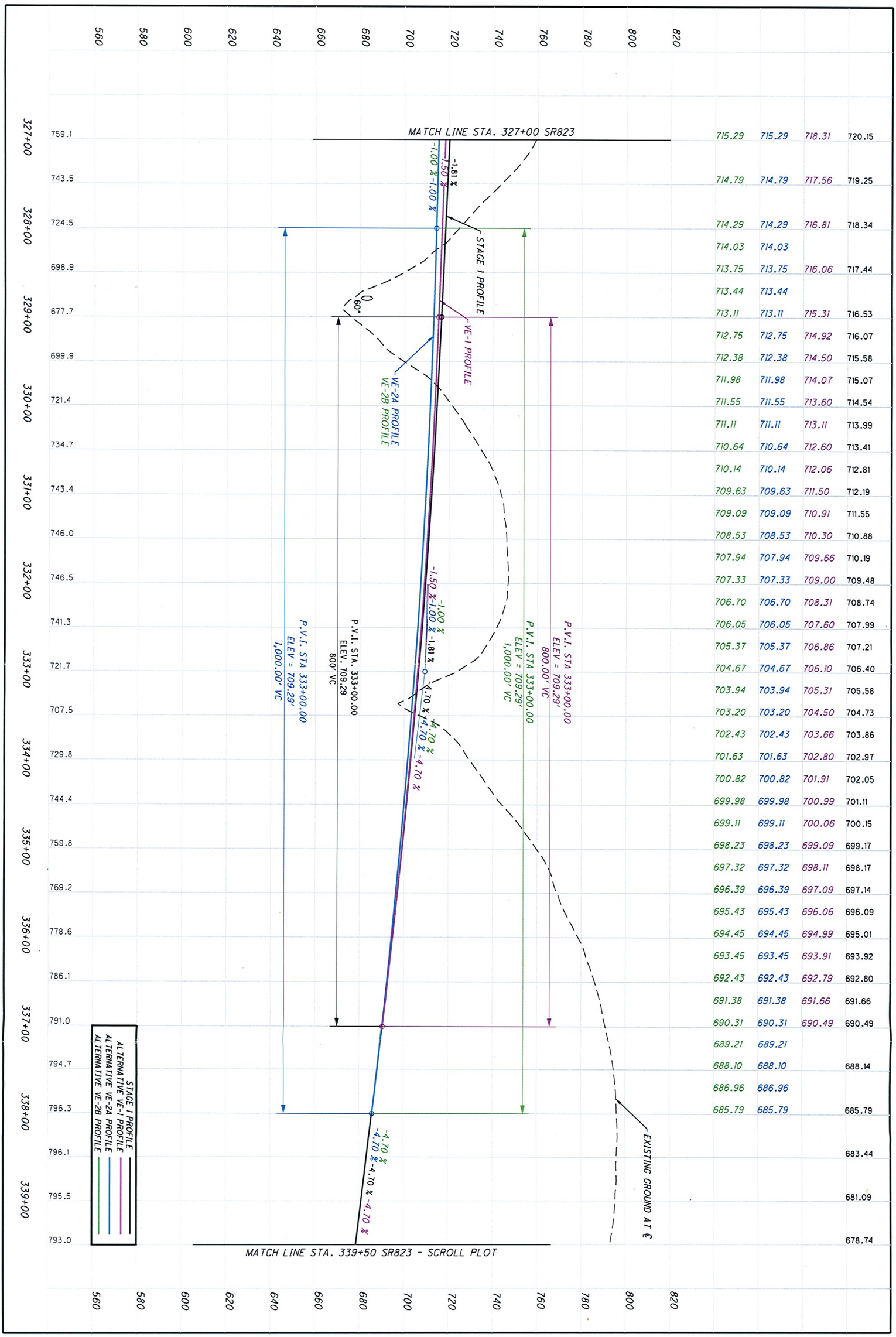


327+00	759.1	715.29	715.29	718.31	720.15
	743.5	714.79	714.79	717.56	719.25
328+00	724.5	714.29	714.29	716.81	718.34
	698.9	714.03	714.03		
		713.75	713.75	716.06	717.44
329+00	677.7	713.44	713.44		
		713.11	713.11	715.31	716.53
	699.9	712.75	712.75	714.92	716.07
		712.38	712.38	714.50	715.58
330+00	721.4	711.98	711.98	714.07	715.07
		711.55	711.55	713.60	714.54
	734.7	711.11	711.11	713.11	713.99
		710.64	710.64	712.60	713.41
331+00	743.4	710.14	710.14	712.06	712.81
		709.63	709.63	711.50	712.19
	746.0	709.09	709.09	710.91	711.55
		708.53	708.53	710.30	710.88
332+00	746.5	707.94	707.94	709.66	710.19
		707.33	707.33	709.00	709.48
	741.3	706.70	706.70	708.31	708.74
		706.05	706.05	707.60	707.99
333+00	721.7	705.37	705.37	706.86	707.21
		704.67	704.67	706.10	706.40
	707.5	703.94	703.94	705.31	705.58
		703.20	703.20	704.50	704.73
334+00	729.8	702.43	702.43	703.66	703.86
		701.63	701.63	702.80	702.97
	744.4	700.82	700.82	701.91	702.05
		699.98	699.98	700.99	701.11
335+00	759.8	699.11	699.11	700.06	700.15
		698.23	698.23	699.09	699.17
	769.2	697.32	697.32	698.11	698.17
		696.39	696.39	697.09	697.14
336+00	778.6	695.43	695.43	696.06	696.09
		694.45	694.45	694.99	695.01
	786.1	693.45	693.45	693.91	693.92
		692.43	692.43	692.79	692.80
337+00	791.0	691.38	691.38	691.66	691.66
		690.31	690.31	690.49	690.49
	794.7	689.21	689.21		
		688.10	688.10		688.14
338+00	796.3	686.96	686.96		
		685.79	685.79		685.79
	796.1				683.44
339+00	795.5				681.09
	793.0				678.74

SCI-823-0.00

FIGURE 1 - VE STUDY PROFILES
SR823 STA. 327+00 TO STA. 339+50

CALCULATED ---
CHECKED ---

Figure 2: Stage 1 Profile

Beginning profile description:

```
================================================================================
          STATION      ELEV     GRADE    TOTAL L    BACK L    AHEAD L

VPI     1    54+11.25    589.527

VPC          58+50.00    587.334    -0.500  K =  290.9
Low Point     59+95.45    586.970
VPI     2    66+50.00    583.334         1,600.000   800.000   800.000
VPT          74+50.00    623.334     5.000

VPC          83+50.00    668.334     5.000  K =  252.7  SSD = 738.5
VPI     3    95+00.00    725.834         2,300.000 1,150.000 1,150.000
High Point    96+13.74    699.927
VPT         106+50.00    678.684    -4.100

VPC         122+50.00    613.084    -4.100  K =  186.8
Low Point    130+15.93    597.382
VPI     4   131+00.00    578.234         1,700.000   850.000   850.000
VPT         139+50.00    620.734     5.000

VPC         154+50.00    695.734     5.000  K =  255.6  SSD = 742.6
VPI     5   166+00.00    753.234         2,300.000 1,150.000 1,150.000
High Point   167+27.78    727.678
VPT         177+50.00    707.234    -4.000

VPC         179+00.00    701.234    -4.000  K =  183.1
VPI     6   185+50.00    675.234         1,300.000   650.000   650.000
Low Point    186+32.39    686.586
VPT         192+00.00    695.384     3.100

VPC         245+00.00    859.684     3.100  K =  259.3  SSD = 748.0
VPI     7   252+00.00    881.384         1,400.000   700.000   700.000
High Point   253+03.70    872.141
VPT         259+00.00    865.284    -2.300

VPC         302+00.00    766.384    -2.300  K =  816.3
VPI     8   304+00.00    761.784           400.000   200.000   200.000
VPT         306+00.00    758.164    -1.810

VPC         329+00.00    716.534    -1.810  K =  276.8  SSD = 772.9
VPI     9   333+00.00    709.294           800.000   400.000   400.000
VPT         337+00.00    690.494    -4.700

VPC         341+50.00    669.344    -4.700  K =  193.5
VPI    10   347+50.00    641.144         1,200.000   600.000   600.000
Low Point    350+59.68    647.966
VPT         353+50.00    650.144     1.500
================================================================================
```

Ending profile description

Figure 3: Truck Speed Profile
Stage 1 Northbound SR823

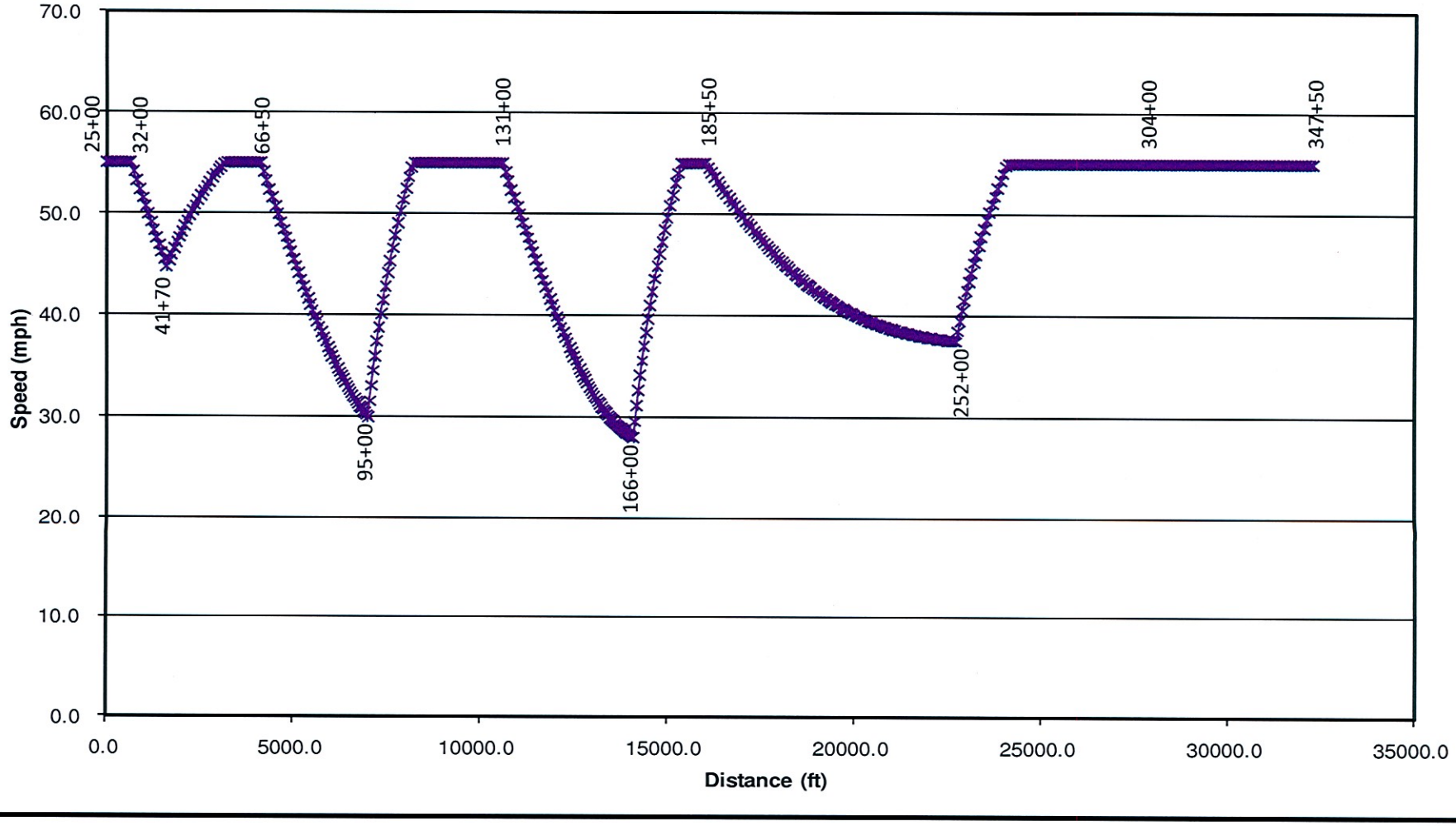


Figure 4: Truck Speed Profile
Stage 1 Southbound SR823

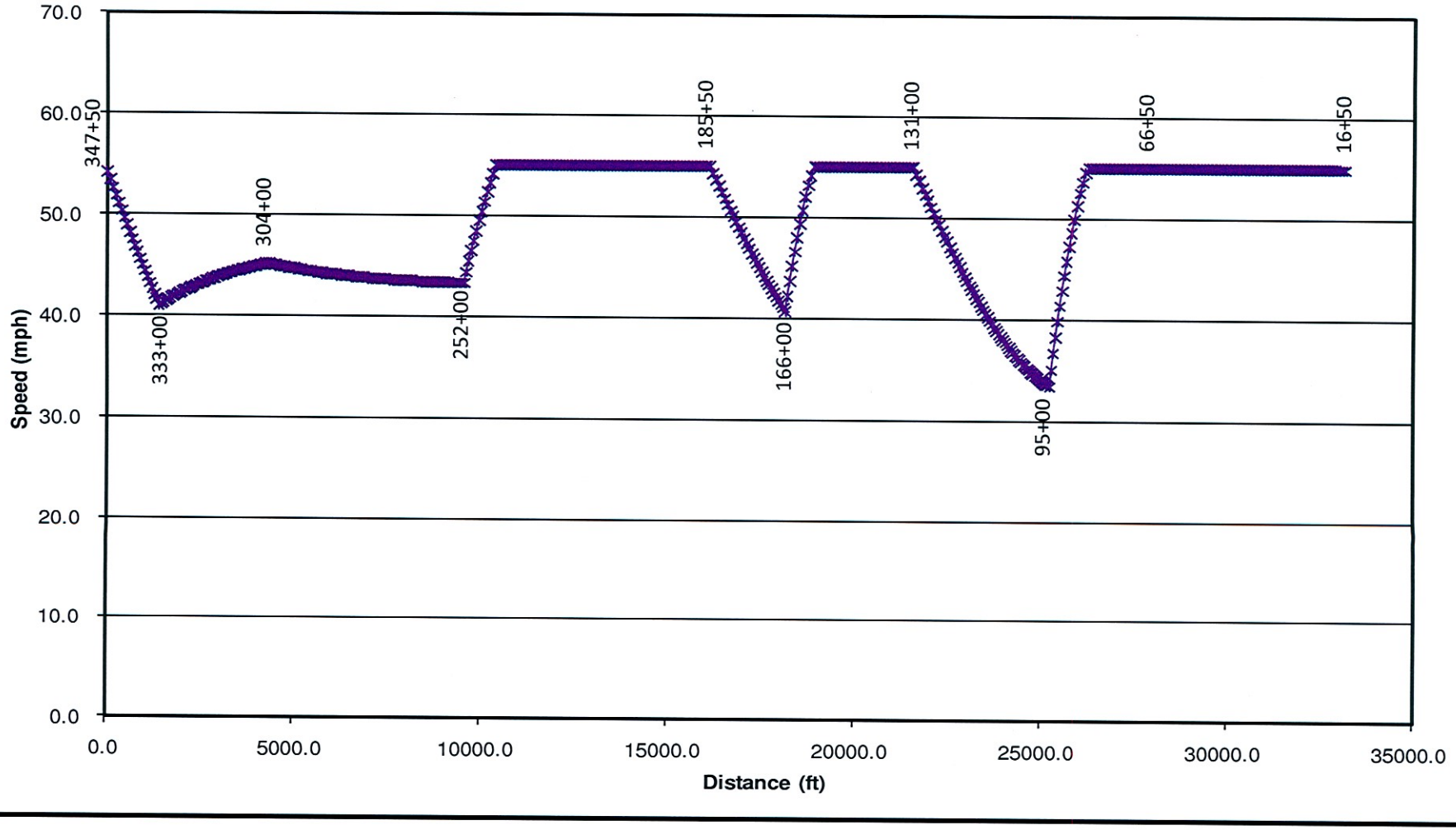


Figure 5: Alternative VE-1 Profile

Beginning profile description:

	STATION	ELEV	GRADE	TOTAL L	BACK L	AHEAD L
VPI 1	54+11.25	589.527				
VPC	58+50.00	587.334	-0.500 K = 290.9			
Low Point	59+95.45	586.970				
VPI 2	66+50.00	583.334		1,600.000	800.000	800.000
VPT	74+50.00	623.334	5.000			
VPC	83+50.00	668.334	5.000 K = 252.7 SSD = 579.6			
VPI 3	95+00.00	725.834		2,300.000	1,150.000	1,150.000
High Point	96+13.74	699.927				
VPT	106+50.00	678.684	-4.100			
VPC	122+50.00	613.084	-4.100 K = 186.8			
Low Point	130+15.93	597.382				
VPI 4	131+00.00	578.234		1,700.000	850.000	850.000
VPT	139+50.00	620.734	5.000			
VPC	154+50.00	695.734	5.000 K = 255.6 SSD = 582.8			
VPI 5	166+00.00	753.234		2,300.000	1,150.000	1,150.000
High Point	167+27.78	727.678				
VPT	177+50.00	707.234	-4.000			
VPC	179+00.00	701.234	-4.000 K = 183.1			
VPI 6	185+50.00	675.234		1,300.000	650.000	650.000
Low Point	186+32.39	686.586				
VPT	192+00.00	695.384	3.100			
VPC	221+50.00	786.834	3.100 K = 275.1 SSD = 657.1			
VPI 7	223+50.00	793.034		400.000	200.000	200.000
VPT	225+50.00	796.326	1.646			
VPC	257+50.00	849.003	1.646 K = 253.4 SSD = 580.3			
High Point	261+67.15	852.436				
VPI 8	262+50.00	857.234		1,000.000	500.000	500.000
VPT	267+50.00	845.734	-2.300			
VPC	285+25.00	804.909	-2.300 K = 500.0 SSD = 1124.3			
VPI 9	287+00.00	800.884		350.000	175.000	175.000
VPT	288+75.00	795.634	-3.000			
VPC	300+25.00	761.134	-3.000 K = 233.8			
VPI 10	302+00.00	755.884		350.000	175.000	175.000
VPT	303+75.00	753.254	-1.503			
VPC	329+00.00	715.305	-1.503 K = 250.2 SSD = 576.7			
VPI 11	333+00.00	709.294		800.000	400.000	400.000
VPT	337+00.00	690.494	-4.700			
VPC	341+50.00	669.344	-4.700 K = 193.5			
VPI 12	347+50.00	641.144		1,200.000	600.000	600.000
Low Point	350+59.68	647.966				
VPT	353+50.00	650.144	1.500			

Ending profile description

Figure 6: Truck Speed Profile
Alternative VE-1 Northbound SR823

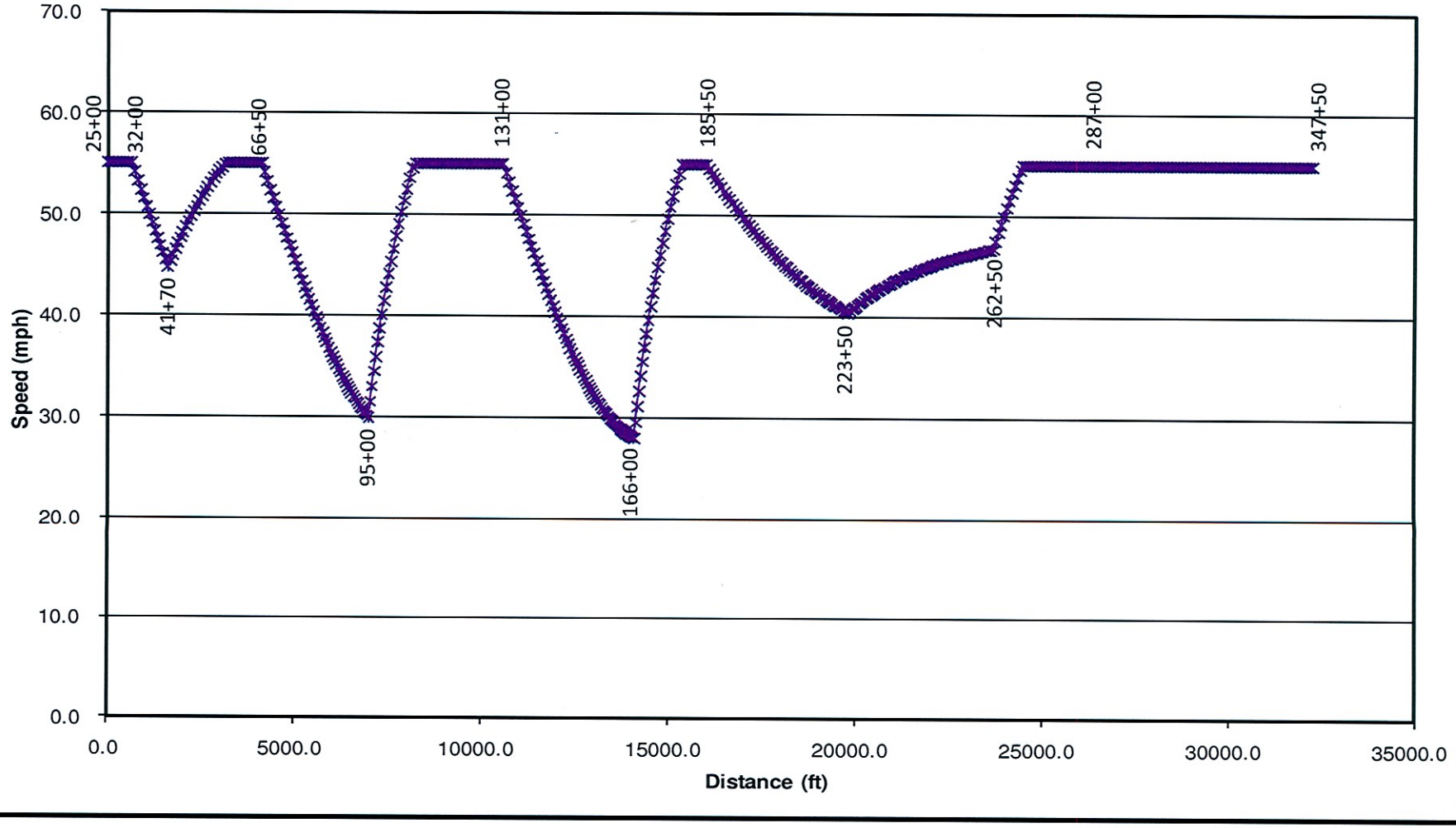


Figure 7: Truck Speed Profile
Alternative VE-1 Southbound SR823

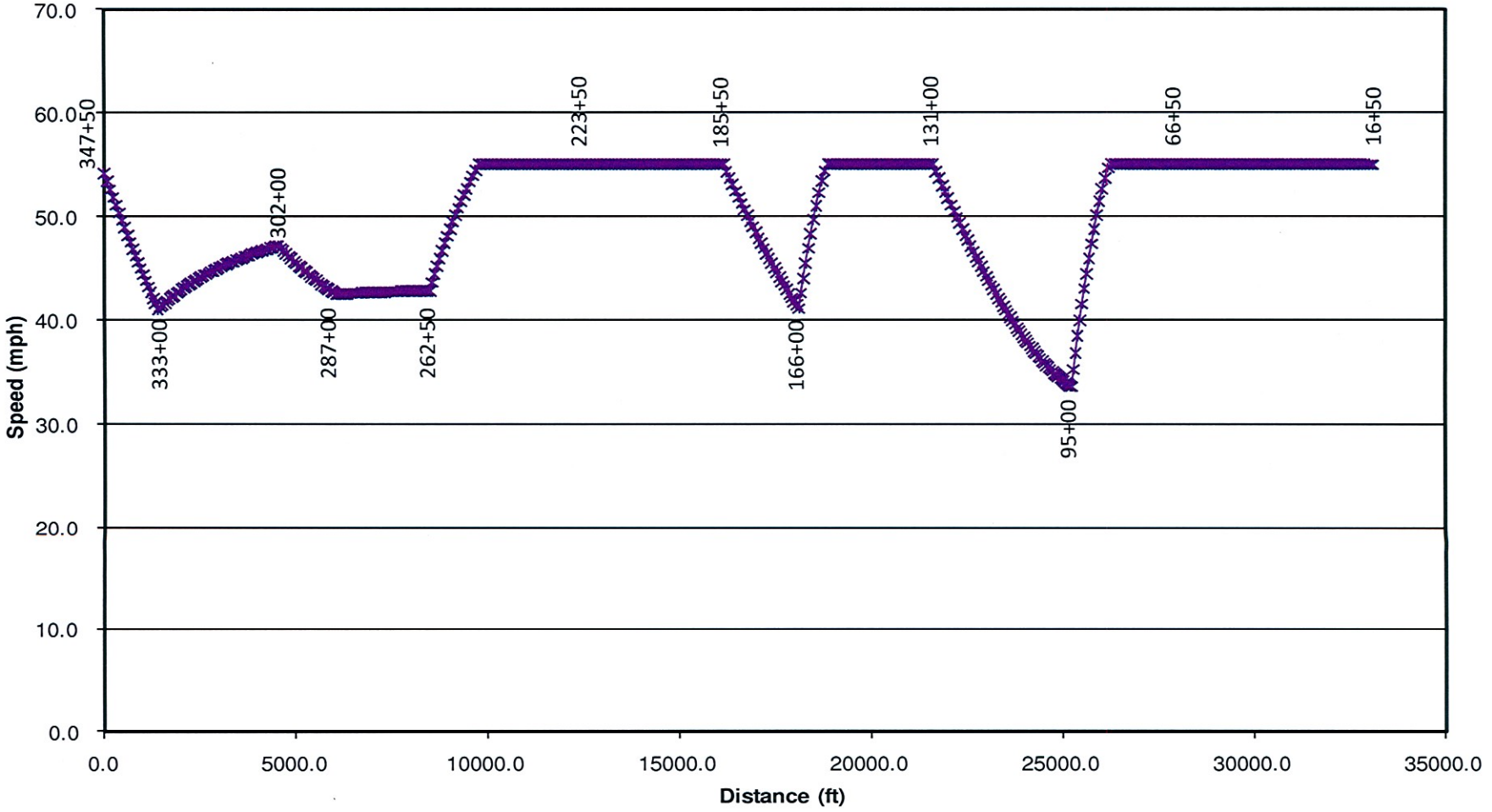


Figure 8: Alternative VE-2A Profile

Beginning profile description:

	STATION	ELEV	GRADE	TOTAL L	BACK L	AHEAD L
VPI 1	54+11.25	589.527				
VPC	58+50.00	587.334	-0.500 K = 290.9			
Low Point	59+95.45	586.970				
VPI 2	66+50.00	583.334		1,600.000	800.000	800.000
VPT	74+50.00	623.334	5.000			
VPC	83+50.00	668.334	5.000 K = 252.7 SSD = 579.6			
VPI 3	95+00.00	725.834		2,300.000	1,150.000	1,150.000
High Point	96+13.74	699.927				
VPT	106+50.00	678.684	-4.100			
VPC	122+50.00	613.084	-4.100 K = 186.8			
Low Point	130+15.93	597.382				
VPI 4	131+00.00	578.234		1,700.000	850.000	850.000
VPT	139+50.00	620.734	5.000			
VPC	154+50.00	695.734	5.000 K = 255.6 SSD = 582.8			
VPI 5	166+00.00	753.234		2,300.000	1,150.000	1,150.000
High Point	167+27.78	727.678				
VPT	177+50.00	707.234	-4.000			
VPC	179+00.00	701.234	-4.000 K = 183.1			
VPI 6	185+50.00	675.234		1,300.000	650.000	650.000
Low Point	186+32.39	686.586				
VPT	192+00.00	695.384	3.100			
VPC	216+00.00	769.784	3.100 K = 293.4 SSD = 640.0			
VPI 7	218+50.00	777.534		500.000	250.000	250.000
VPT	221+00.00	781.024	1.396			
VPC	257+50.00	831.978	1.396 K = 333.5 SSD = 665.8			
High Point	262+15.60	835.228				
VPI 8	264+50.00	841.750		1,400.000	700.000	700.000
VPT	271+50.00	822.139	-2.802			
VPC	297+50.00	749.298	-2.802 K = 277.5			
VPI 9	300+00.00	742.294		500.000	250.000	250.000
VPT	302+50.00	739.794	-1.000			
VPC	328+00.00	714.294	-1.000 K = 270.3 SSD = 599.3			
VPI 10	333+00.00	709.294		1,000.000	500.000	500.000
VPT	338+00.00	685.794	-4.700			
VPC	341+50.00	669.344	-4.700 K = 193.5			
VPI 11	347+50.00	641.144		1,200.000	600.000	600.000
Low Point	350+59.68	647.966				
VPT	353+50.00	650.144	1.500			

Ending profile description

Figure 9: Truck Speed Profile
Alternative VE-2A Northbound SR823

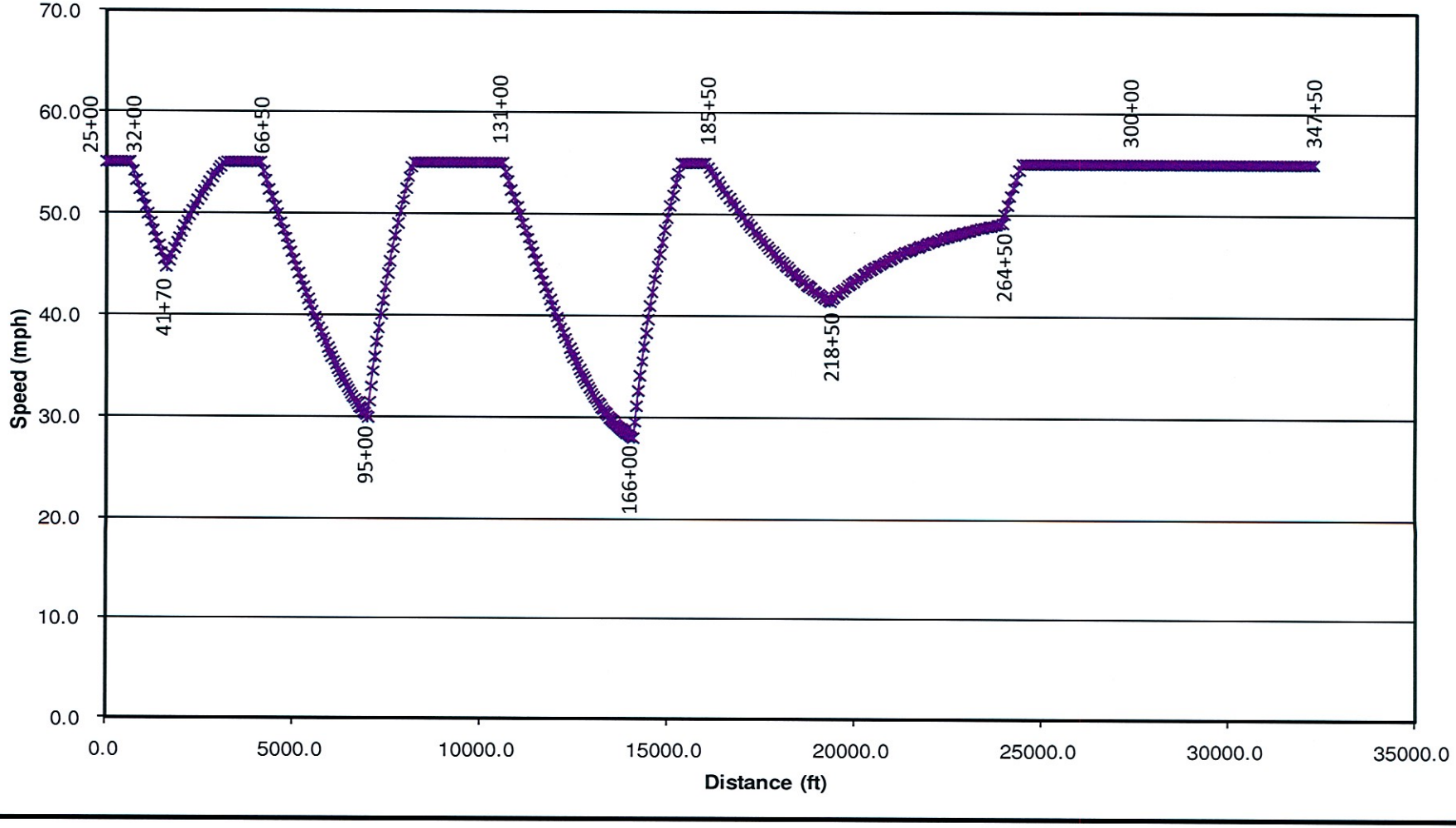


Figure 10: Truck Speed Profile
Alternative VE-2A Southbound SR823

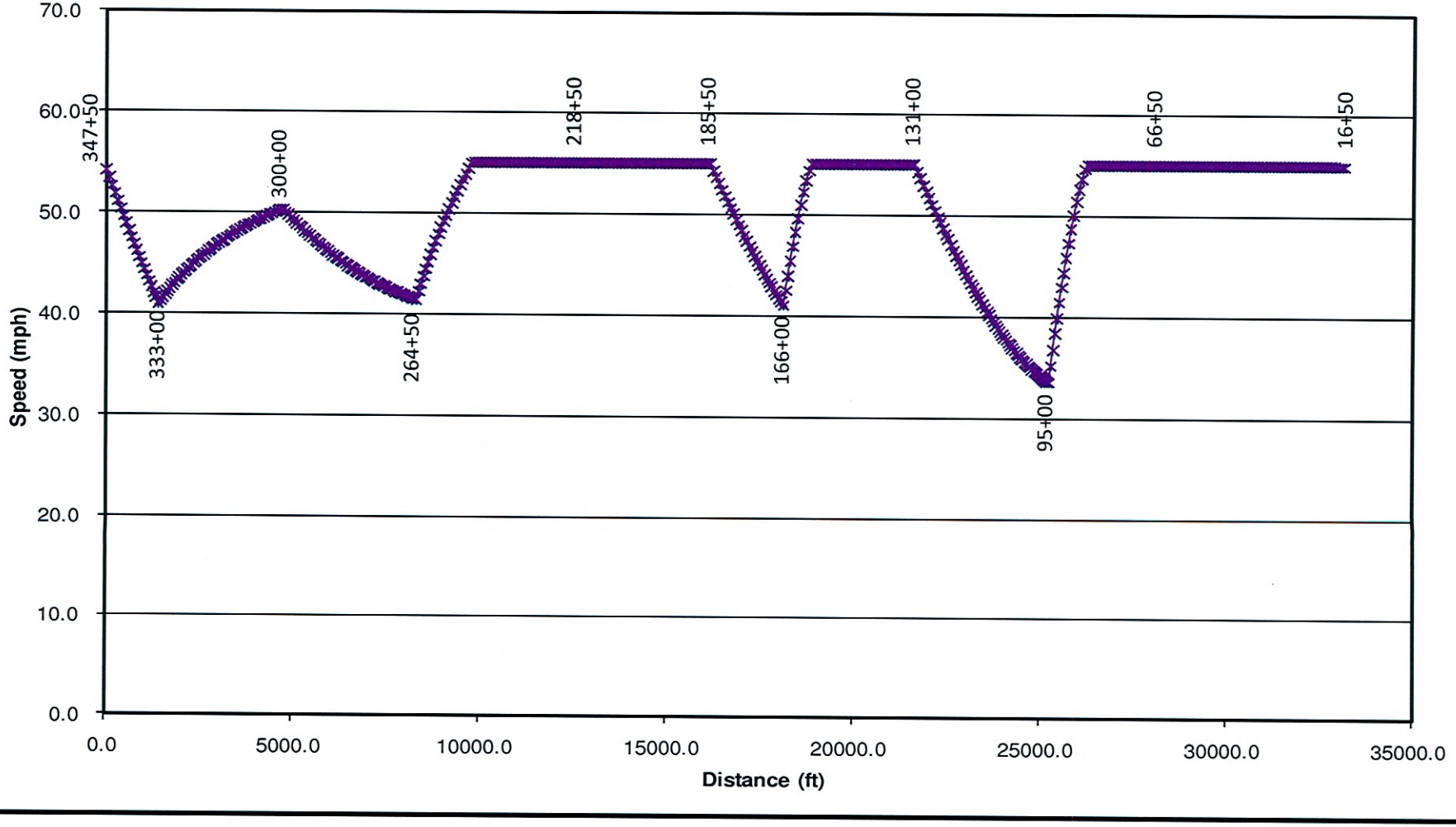


Figure 11: Alternative VE-2B Profile

Beginning profile description:

```
==========================================================================
          STATION     ELEV     GRADE   TOTAL L   BACK L    AHEAD L

VPI     1   54+11.25   589.527

VPC         58+50.00   587.334    -0.500  K =  290.9
Low Point   59+95.45   586.970
VPI     2   66+50.00   583.334         1,600.000  800.000  800.000
VPT         74+50.00   623.334     5.000

VPC         83+50.00   668.334     5.000  K =  252.7  SSD = 738.5
VPI     3   95+00.00   725.834         2,300.000 1,150.000 1,150.000
High Point  96+13.74   699.927
VPT        106+50.00   678.684    -4.100

VPC        122+50.00   613.084    -4.100  K =  186.8
Low Point  130+15.93   597.382
VPI     4  131+00.00   578.234         1,700.000  850.000  850.000
VPT        139+50.00   620.734     5.000

VPC        154+50.00   695.734     5.000  K =  255.6  SSD = 742.6
VPI     5  166+00.00   753.234         2,300.000 1,150.000 1,150.000
High Point 167+27.78   727.678
VPT        177+50.00   707.234    -4.000

VPC        179+00.00   701.234    -4.000  K =  183.1
VPI     6  185+50.00   675.234         1,300.000  650.000  650.000
Low Point  186+32.39   686.586
VPT        192+00.00   695.384     3.100

VPC        219+00.00   779.084     3.100  K =  250.0  SSD = 734.5
VPI     7  223+50.00   793.034           900.000  450.000  450.000
High Point 226+75.00   791.096
VPT        228+00.00   790.784    -0.500

VPC        236+50.00   786.534    -0.500  K =  200.1
Low Point  237+50.04   786.284
VPI     8  240+50.00   784.534           800.000  400.000  400.000
VPT        244+50.00   798.528     3.498

VPC        254+00.00   831.763     3.498  K =  261.4  SSD = 751.1
VPI     9  262+50.00   861.500         1,700.000  850.000  850.000
High Point 263+14.62   847.762
VPT        271+00.00   835.965    -3.004

VPC        281+90.00   803.220    -3.004  K =  999.4  SSD = 2406.8
VPI    10  284+40.00   795.710           500.000  250.000  250.000
VPT        286+90.00   786.949    -3.504

VPC        297+00.00   751.555    -3.504  K =  199.6
VPI    11  299+50.00   742.794           500.000  250.000  250.000
VPT        302+00.00   740.294    -1.000

VPC        328+00.00   714.294    -1.000  K =  270.3  SSD = 763.7
VPI    12  333+00.00   709.294         1,000.000  500.000  500.000
VPT        338+00.00   685.794    -4.700

VPC        341+50.00   669.344    -4.700  K =  193.5
VPI    13  347+50.00   641.144         1,200.000  600.000  600.000
Low Point  350+59.68   647.966
VPT        353+50.00   650.144     1.500
==========================================================================
```

Ending profile description

Figure 12: Truck Speed Profile
Alternative VE-2B Northbound SR823

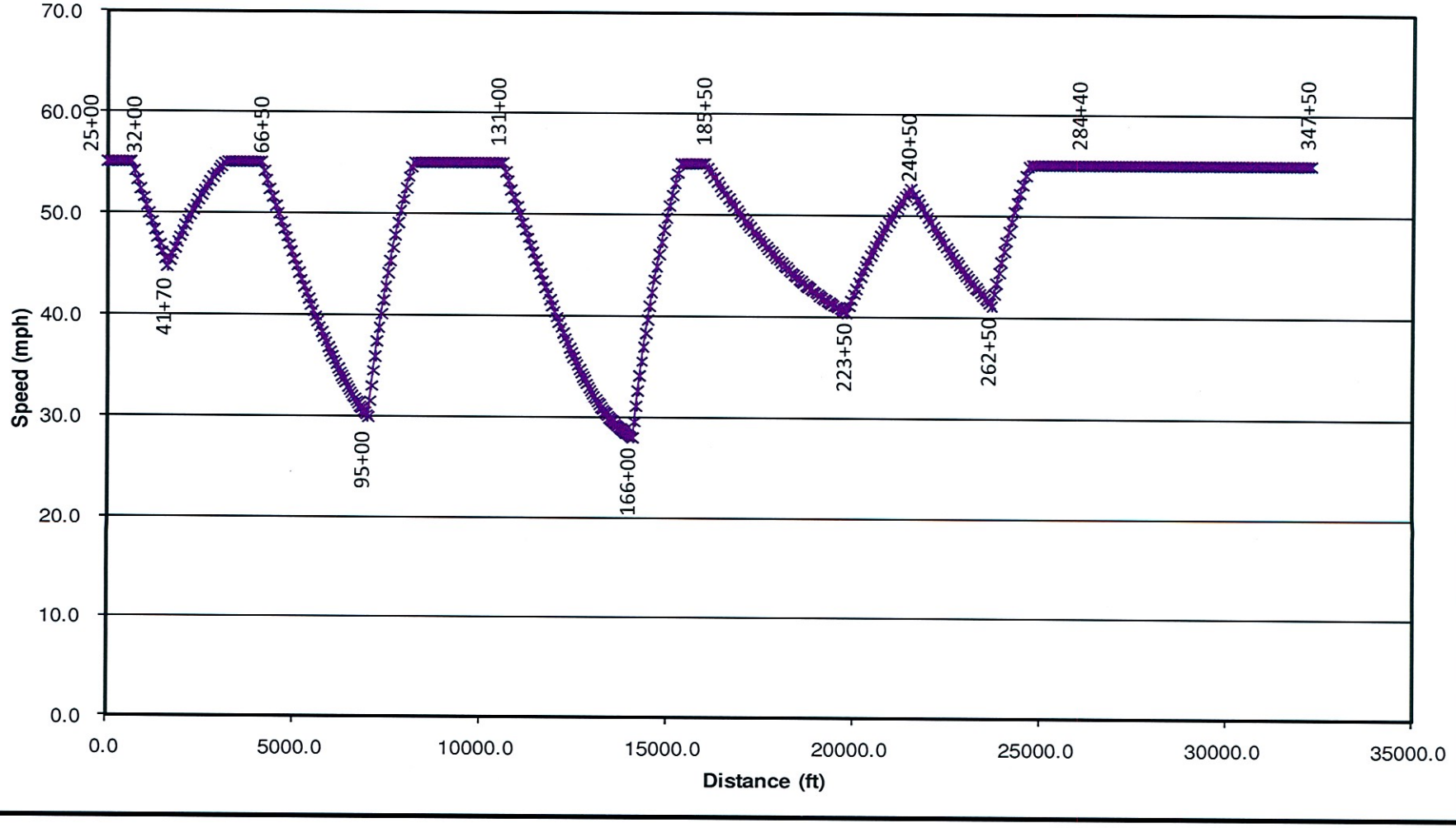
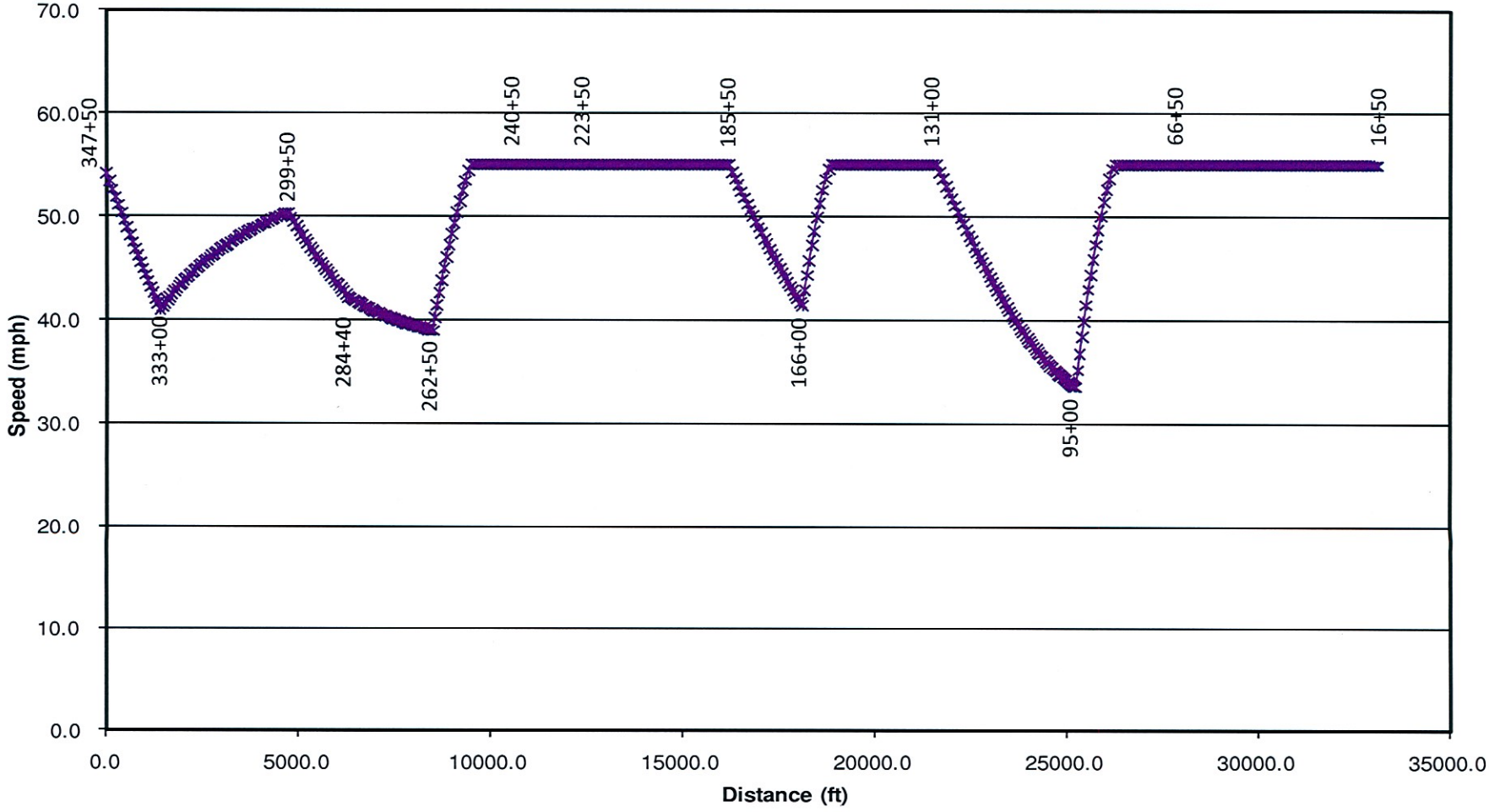
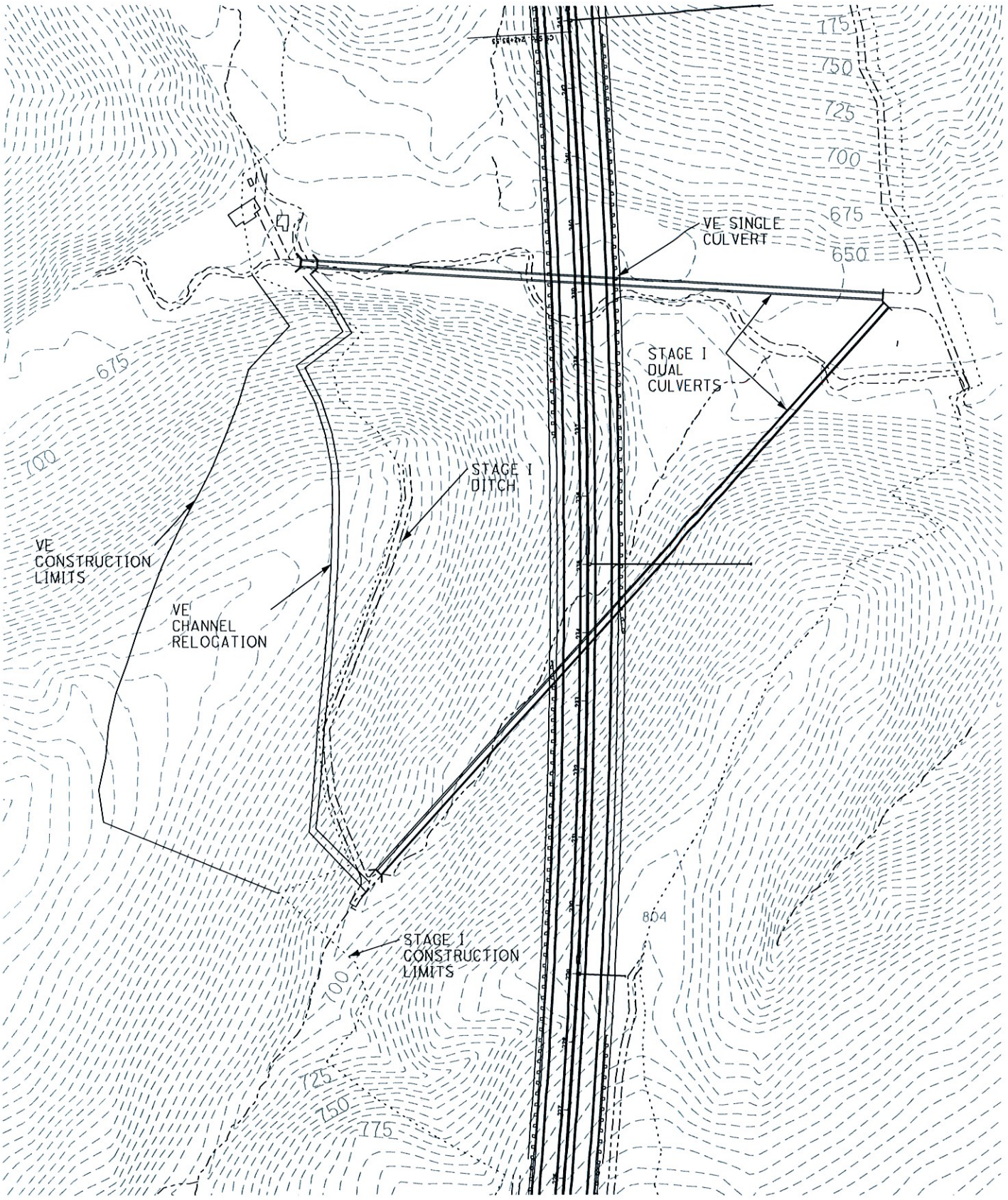


Figure 13: Truck Speed Profile
Alternative VE-2B Southbound SR823



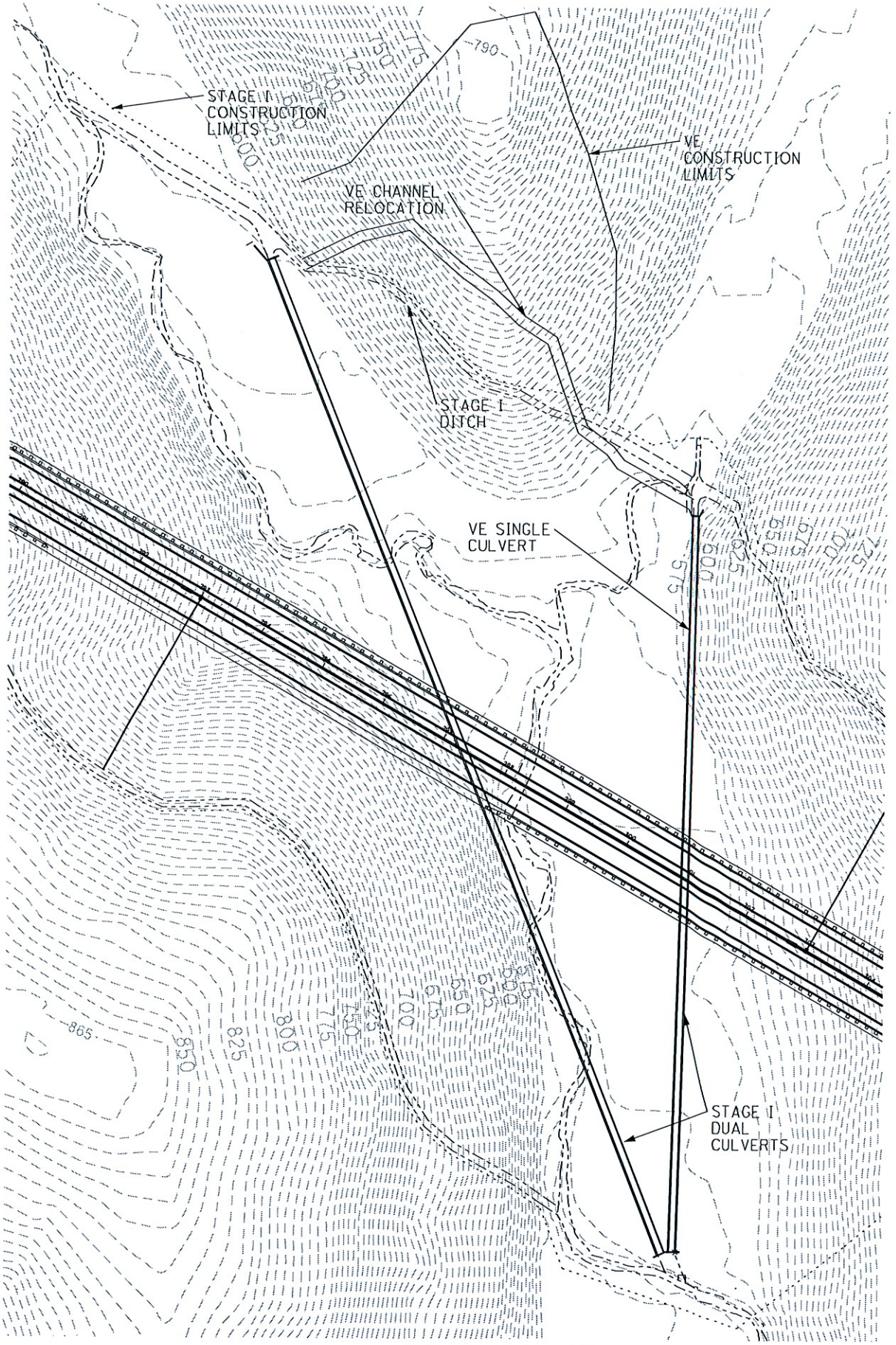


1"=200'

5' CONTOURS

FIGURE 14

CULVERT ANALYSIS STA 238+70



1"=200'

5' CONTOURS

FIGURE 15

CULVERT ANALYSIS STA 303+35

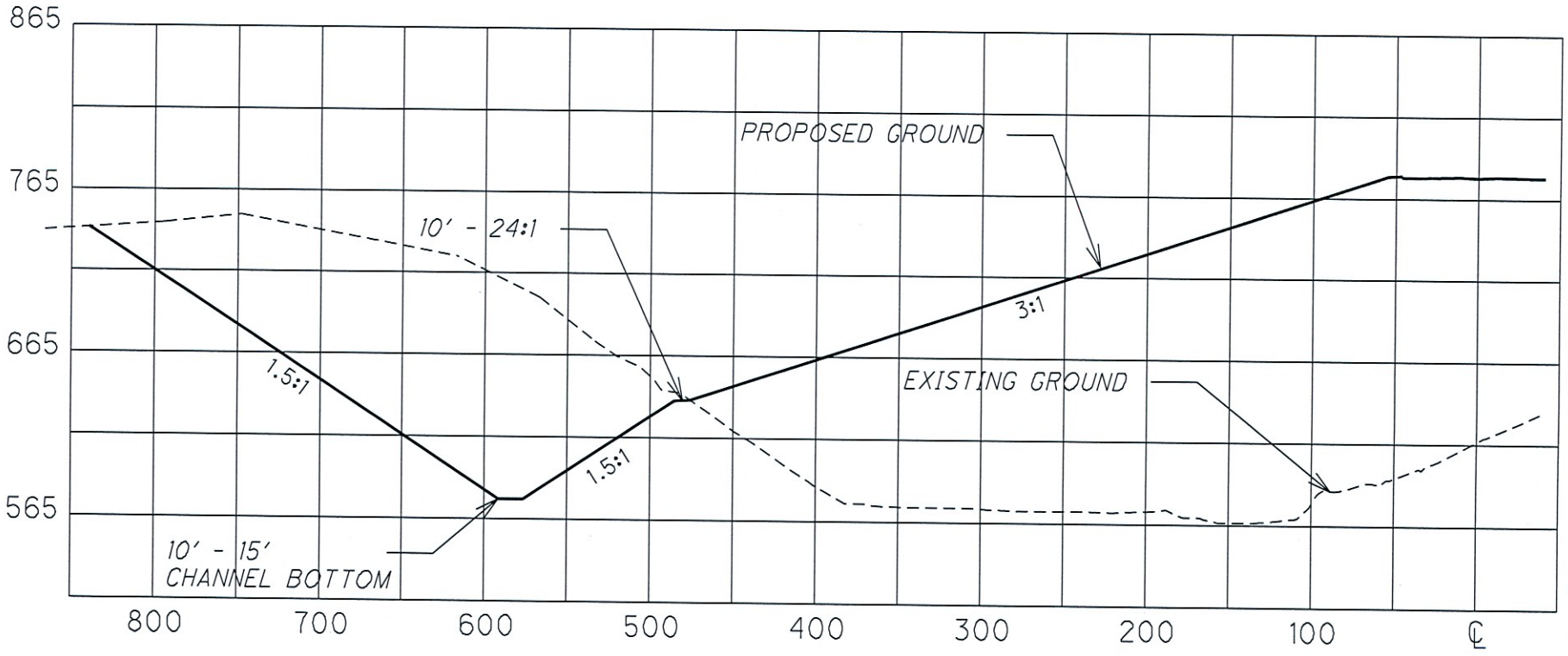


FIGURE 16
CHANNEL RELOCATION
CROSS SECTION

Figure 17: Costs To Get 2.3 Million Cubic Yards Across the Little Scioto River

Alternative 1 - Conveyor

Item	Unit	Unit Cost	Quantity	Total
Conveyor (60" belt, 460' long)	LS	$660,000	1	$660,000
Erection of conveyor	LS	$175,000	1	$175,000
Start-up of conveyor	LS	$30,000	1	$30,000
Hopper	EA	$10,000	2	$20,000
Excavators to load hoppers (2)	CY	$0.175	2,300,000	$402,500
Process to reduce maximum rock size to 20" *will be no added cost as the hoe ram will either be at the hopper or at the fill location*				$0
			Total	$1,287,500

Alternative 2 - On-Road Trucks

Item	Unit	Unit Cost	Quantity	Total
Trucking Costs	Load	$3.21	191700	$615,357
Excavators to load trucks (2)	Load	$2.12	191700	$406,404
Local road improvements	Mile	$457,600	1	$563,200
Little Scioto River bridge rehabilitation	SF	$120	4500	$540,000
			Total	$2,124,961

Road Improvements			Road	Length	SY	Cost
2-inch	$25.00	per SY	24	5280	14080	$352,000
4-6inch	$40.00	per SY	24	5280	14080	$563,200
					AVG	$457,600

There is a new bridge at Dixon Mills Road which should have a higher load rating if the structure on Slocumb Road/Swauger Valley is insufficent. Haul Distances would go from a two mile round trip to a 6.5 mile round trip assuming the empty trucks could cross the bridge on Slocumb on the return trip.

Unit Cost:	$5.30
Total trucking costs:	$1,016,010
Increase in trucking costs:	$400,653