VALUE ENGINEERING STUDY (Update)

Portsmouth Bypass
SCI-823-10.13
PID 79977

PREPARED FOR:

Ohio Department of Transportation
District 9
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April 2011

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INTRODUCTION

This study is based on the Stage 1 plans submitted by TranSystems. As a result of value engineering of Stage 1 plans submitted by TranSystems, it was decided by ODOT to re-evaluate certain design elements of these plans. ODOT developed three separate scenarios with independent guidelines to revise the profile of State Route 823. DLZ was to develop new profiles under the following guidelines:

Scenario #1 – An analysis of the profile using standard ODOT culverts and maximum fill heights allowable for those culverts while maintaining current bridge elevations.

Scenario #2 – An analysis of the profile using high fill culvert to replace the current design of the 78" culvert near STA 659; multiple culverts or alternate design at STA 815; and multiple culverts or alternate design at STA 855 for the 108" culvert. The culverts will be sized to one foot larger than the size required by the hydraulic analysis. Current bridge elevations will be maintained.

Scenario #3 – A profile the same as Scenario #2 with the addition of a taller and longer bridge over Morris Lake Blue Run Road to reduce the amount of profile drop, which results in a lot of excavation.

A benefit/cost ratio was generated for each of these alternatives utilizing the unit costs that were supplied by ODOT District 9, ODOT Estimator and Preliminary Bridge reports. Each benefit/cost analysis compares the original Stage 1 design to the scenario being studied. The following unit costs were used in preparing this report:

Excavation	$3.35 per cubic yard
Embankment	$0.74 per cubic yard
Waste Material	$1.10 per cubic yard
36" Culvert	$138.00 per linear foot
48" Culvert	$186.00 per linear foot
54" Culvert	$216.00 per linear foot
60" Culvert	$230.00 per linear foot
66" Culvert	$275.00 per linear foot
72" Culvert	$290.00 per linear foot
78" Culvert	$335.00 per linear foot
108" Culvert	$650.00 per linear foot
Stream Mitigation	$250.00 per linear foot
Bridge Impacts	Varies by bridge type

Each of these scenarios was evaluated independently of the others and with respect to the original Stage 1 plans. Cost saving Effects from two or more of the scenarios should not be combined without verifying that costs or savings are not duplicated.

DESCRIPTION

The purpose of this study was to investigate raising the profile of State route 823 in specified areas in order to reduce the amount of waste material on the project by increasing the embankment volume and decreasing the excavation on the project. In accordance with the ODOT L&D Manual Volume 2 – Drainage Design, the maximum cover over any culvert was set using Figure 1008-1, Table 1 for corrugated steel pipe. This table allows height of cover for pipes up to 266 feet, depending on the size of the pipe. However, all pipes with over 100 feet of cover would require the investigation of the allowable bearing capacity of the foundation. For the purposes of this study, any design in compliance with these guidelines would be considered.

ADVANTAGES / DISADVANTAGES

This Value Engineering Study has looked into the advantages and disadvantages of the current design and the effect profile changes will have to the project. The following is a list of the advantages and disadvantages associated with these profile changes:

Advantages:

- Reduces project cut and waste
- Maintains projects design speed
- Shortens the Flatwood Fallen Timbers Road bridge
- Reduces the overall cost of the project

Disadvantages:

- Longer more expensive culverts
- Increased environmental impacts
- Longer more expensive structure over Morris Lane Blue Run Road (Scenario #3)
- Additional design expense for culverts and bridge

STUDY APPROACH

The following parameters were established and used in developing alternative profiles for this study:

- Maintain the design speed of 70 mph for SR 823
- Maintain the current horizontal alignment
- Use a maximum grade of 5% on SR 823
- Project goal to minimize project waste
- Profile changes in certain areas, but no impacts to SR 823 bridges (Scenario's #1 & #2)
- Minimize impact to the project footprint

- Profile changes throughout the plan between Sta. 586+00 and Sta. 870+00, but the only SR 823 bridge that can be impacted is the Morris Lane Blue Run Road structure (Scenario #3)
- Use a maximum pier height of approximately 100 feet on the Morris Lane Blue Run Road bridge (Scenario #3)
- Maintain a minimum truck speed value of 50 mph
- Culverts shall be sized to one foot larger than the hydraulic design, to allow for future relining of the pipe
- Minimize the impacts on existing utility facilities, including: water, gas, telephone, electrical distribution and electrical transmission

Using these parameters, DLZ has developed three conceptual profiles as alternatives. Each of these profiles was developed using an iterative process, in which we made adjustments to each profile in order to minimize the amount of waste in each scenario. The first of these scenarios allowed us to make adjustments to the profile, while maintaining the current size culvert designs and making no changes to the bridges on SR 823. Similarly, the second scenario allows us to adjust the profile over the length of the project, while maintaining the current profiles across all the SR 823 bridges. At the larger culverts on this scenario, we will investigate using alternate hydraulic designs to allow for additional fill. The only significant change between our second and our third scenario's is being able to raise the proposed profile across the Morris Lane Blue Run Road Bridge. While there is a large shift in the earthwork quantities when this change is made, there is also a large increase in the length of the bridge, the cost per square foot of the bridge and the cost for the design of the bridge. As the profiles were developed, they were run through a truck speed program that was provided by ODOT. Profiles were run in both directions and adjustments were made so that the minimum truck speed value would not drop below 50 mph.

Because most of the cross sections along SR 823 were modified by hand due to the geotechnical design, DLZ has developed a simplified template using an equivalent straight line slope, which matches the original cross section quantities to within one percent. These straight line slopes were applied on a section by section basis to the original profile. The earthwork quantities at each section was checked against the original quantity and adjusted until the quantities fell within one percent of the original quantity. After establishing these templates, they were applied to the revised profiles to produce the new earthwork quantities and construction limits. In developing the fill sections for the project, the width of the graded shoulder was increased from 5 feet to 10 feet. Since the entire length of the project where we are changing the profile is protected by either guardrail or barrier, safety grading will not be used and barrier grading will be used. The construction limits of all 3 alternatives fall inside the environmental footprint of the project, but there will be additional impacts to the current right-of-way design. Embankment slopes will be modified to minimize these impacts, but additional right-of-way will be required at many of the culverts where the profile is being raised as well as at other locations.

Culvert and stream impacts were estimated using the culvert drawings from the original Stage 1 submission and raising the PI of the shoulder a distance equal to the difference in elevation between the original profile and the alternative profiles. The same side slope as was used in the original Stage 1 plans was applied to the grading to determine the length of the culverts. These will have to be refined in the next stage to take into account any necessary realignment due to the additional length. Construction costs for box culverts at the multiple conduit culverts were evaluated and dismissed due to excess costs. An evaluation of the box culvert costs is included in Appendix A.

Bridge impacts were calculated based on an additional square foot of deck basis for the Flatwood Fallen Timbers Road Bridge since no additional spans were required. However, on the Morris Lane Blue Run Road Bridge, an additional factor of 1.5 was applied to the cost of the bridge due to the height of the piers and the difficulty associated in its' construction. This structure also became substantially longer when the profile was raised. The estimated costs for all structure type changes are based on engineering judgment.

BENEFIT / COST ANALYSIS

All three profile scenarios have been carried into the benefit / cost analysis. All three profile scenarios impact the profile from approximately Sta. 586+00 to Sta. 870+00 with the profiles for scenarios #1 and #2 not affecting the area from Sta. 712+00 to Sta. 744+50. This is the area surrounding the Morris Lane Blue Run Road Bridge. The main difference between these two being the allowable depth of cover at the larger culverts. The profiles for scenarios #2 and #3 are identical for most of the project, except for from Sta. 670+62 to Sta. 769+10 where the scenario #3 profile raises the Morris Lane Blue Run Road Bridge approximately forty (40) feet.

Scenarios #2 and #3 both present a much larger overall savings to the project, compared to Scenario #1. Scenario #3 decreases the overall waste for this project from the original Stage 1 volume of almost 12.9 million cubic yards to just under 2.5 million cubic yards. However, the increase in the length of the Morris Lane Blue Run Road Bridge, and the increases in the difficulty in construction and design of the bridge, offset most of the earthwork savings. The additional costs associated with the alternative include: embankment, culvert lengths, bridge lengths and engineering costs. Tables 1-1 thru 3-2 show the estimated savings and costs associated with each scenario. Please note that the only side road quantity that is included as part of this study is the cost of the Flatwood Fallen Timbers Road Bridge and that the increase or decrease in the roadway pavement for either of the two bridges being changed is not accounted for in the estimates. See table 4-1 for a comparison of the earthwork for each of the alternatives.

VE Scenario #1

Table 1-1: New Profile Savings – Scenario #1

Item	Original Stage 1	Scenario #1	Difference	Unit Cost	Savings
Excavation (cu. yd.)	14,217,000	13,215,550	1,001,450	$3.35	$3,354,857
Waste (cu. yd.)	10,882,100	8,471,419	2,278,131	$1.10	$2,505,944
60" Culvert (ft.)	5325	3440	1885	$230.00	$433,550
66" Culvert (ft.)	1866	1126	740	$275.00	$203,500
Bridge Impacts					$175,700
			Total Savings		$6,673,551

Table 1-2: New Profile Costs – Scenario #1

Item	Original Stage 1	Scenario #1	Difference	Unit Cost	Cost
Embankment (cu. yd.)	5,600,000	6,726,464	1,126,464	$0.74	$833,583
36" Culvert (ft.)	0	260	260	$138.00	$35,880
48" Culvert (ft.)	0	1502	1502	$186.00	$279,372
54" Culvert (ft.)	0	1112	1112	$216.00	$240,192
72" Culvert (ft.)	688	766	78	$290.00	$22,620
108" Culvert (ft.)	448	534	36	$650.00	$23,400
Stream Mitigation	8389	9224	835	$250.00	$208,750
			Total Cost		$1,643,797

As shown in the tables above, the benefit / cost ratio for Scenario #1 is 4.06:1. The net savings realized by using design Scenario #1 is approximately $5.03 million.

VE Scenario #2

Table 2-1: New Profile Savings – Scenario #2

Item	Original Stage 1	Scenario #2	Difference	Unit Cost	Savings
Excavation (cu. yd.)	14,217,000	11,798,958	2,418,042	$3.35	$8,100,440
Waste (cu. yd.)	10,749,550	5,141,102	5,608,448	$1.10	$6,169,293
66" Culvert (ft.)	1866	1208	658	$275.00	$180,950
78" Culvert (ft.)	534	0	534	$335.00	$178,890
108" Culvert (ft.)	448	0	448	$650.00	$291,200
Bridge Impacts					$91,700
			Total Cost		$15,012,473

Table 2-2: New Profile Costs – Scenario #2

Item	Original Stage 1	Scenario #2	Difference	Unit Cost	Cost
Embankment (cu. yd.)	5,600,000	8,427,700	2,827,700	$0.74	$2,092,498
36" Culvert (ft.)	0	253	253	$138.00	$34,914
48" Culvert (ft.)	0	1547	1547	$186.00	$287,742
54" Culvert (ft.)	0	1431	1431	$216.00	$309,096
60" Culvert (ft.)	5325	6546	1221	$230.00	$280,830
72" Culvert (ft.)	688	1938	1250	$290.00	$362,500
Stream Mitigation	8389	10,113	1724	$250.00	$431,000
			Total Cost		$3,798,580

As shown in the tables above, the benefit / cost ratio for Scenario #2 is 3.95:1. The net savings realized by using design Scenario #2 is approximately $11.21 million.

VE Scenario #3

Table 3-1: New Profile Savings – Scenario #3

Item	Original Stage 1	Scenario #3	Difference	Unit Cost	Savings
Excavation (cu. yd.)	14,217,000	10,287,927	3,929,073	$3.35	$13,162,395
Waste (cu. yd.)	10,749,550	1,643,298	9,106,252	$1.10	$10,016,877
66" Culvert (ft.)	1866	1208	658	$275.00	$180,950
78" Culvert (ft.)	534	0	534	$335.00	$178,890
108" Culvert (ft.)	448	0	448	$650.00	$291,200
			Total Savings		$23,830,312

Table 3-2: New Profile Costs – Scenario #3

Item	Original Stage 1	Scenario #3	Difference	Unit Cost	Cost
Embankment (cu. yd.)	5,600,000	10,187,818	4,587,818	$0.74	$3,394,985
36" Culvert (ft.)	0	253	253	$138.00	$34,914
48" Culvert (ft.)	0	1553	1553	$186.00	$288,858
54" Culvert (ft.)	0	1697	1697	$216.00	$366,552
60" Culvert (ft.)	5325	6716	1391	$230.00	$319,930
72" Culvert (ft.)	688	1938	1250	$290.00	$362,500
Stream Mitigation	8389	10,555	2166	$250.00	$541,500
Bridge Impacts					$4,308,200
			Total Cost		$9,617,439

As shown in the tables above, the benefit / cost ratio for Scenario #3 is 2.48:1. The net savings realized by using design Scenario #3 is approximately $14.21 million.

Table 4-1: Earthwork Comparison

Alternative	Excavation	Excavation +15% Swell	Embankment	Waste
Original Stage 1 (cu. yd.)	14,217,000	16,349,550	5,600,000	10,749,550
Scenario #1 (cu yd.)	13,215,550	15,197,883	6,726,464	8,471,419
Scenario #2 (cu. yd.)	11,798,958	13,568,802	8,427,700	5,141,102
Scenario #3 (cu. yd.)	10,287,927	11,831,116	10,187,818	1,643,298

ADDITIONAL CONSIDERATIONS

There are additional elements to consider that have not been quantified in this benefit / cost analysis.

Construction Limits and Right-of-Way

One item which should be considered is the revised construction limits and how they fit in the existing environmental footprint. Construction limits will also have impacts on the current right-of-way design.

The construction limits of the original Stage 1 plans were compared to the construction limits that were developed for the three scenarios. Scenario #1 had an overall decrease in the construction limits area of 18 acres compared to the Stage 1 plans. Scenario #2 also produced a substantial decrease in the overall area of approximately 11.5 acres. Scenario #3, which had the most significant changes to the previous profile, had almost no impact on the overall area of the construction limits. The construction limits area for Scenario #3 was within one acre of that of the Stage 1 plans. It should be noted that the construction limits developed for the three scenarios were based on the simplified templates we discussed earlier. Because these templates did not account for the special benching required for this project, the final construction limits could vary.

Revised construction limits have been developed to go along with the revised profiles. All construction limits still fall within the limits of the environmental footprint of the project. Right-of-way for the project will have to be further refined when a final profile has been selected and cross sections are fully developed.

Waste Areas

Additional waste areas have been located throughout the project and have been shown as hatched areas in the plan view exhibits 2 thru 4. The construction limits for the additional waste areas were located by flattening out the foreslopes in fill areas to maximize fill volumes, while not drastically changing the existing drainage patterns. The culvert lengths would increase in these areas. The fill areas in the table below are depicted in the plan view exhibits. Additional areas may be determined as design progresses.

572+50 to 577+00, LT.	575+00 to 577+00, RT.
656+50 to 658+50, LT.	
670+50 to 674+50, LT.	
690+00 to 702+00, LT.	
714+50 to 716+50, LT.	714+50 to 716+50, RT.
720+00 to 726+00, LT.	
744+50 to 753+50, LT.	
766+00 to 773+50, LT.	795+50 to 798+50, RT.
818+50 to 825+00, LT.	810+50 to 812+00, RT.

Power Lines (AEP)

There are three locations on this project where American Electric Power (AEP) has overhead electric transmission lines which cross the alignment of the proposed roadway. Plan development has been coordinated with AEP plans in order to minimize the impact of the roadway on the existing transmission lines. The cost of changing the roadway design to avoid impacting the transmission lines will be weighed against the cost of raising or moving the transmission lines.

- The first crossing location is near Sta. 591+00, at which our new profile is in approximately twenty feet of cut below the existing ground and will not be impacted by the roadway.
- The second crossing location is near Sta. 610+00. At this location, we are raising the profile approximately 30 feet above the existing ground. This provides between 72 and 74 feet of clearance from the roadway to the transmission lines, which meets the requirements provided by AEP. For the given type of roadway and size of the transmission lines (765KV) the required clearance is 69.8 feet. To achieve this, we had to lower the original Stage 1 profile over 15 feet at this location.
- The third crossing location is near Sta. 857+25. At this location, the profile is raised approximately 60 feet in Scenario #1 and 80 feet in Scenario's #2 and #3. Under any of these scenarios, including under the original Stage 1 submittal, this transmission line would have to be raised and/or relocated. The elevation of the existing transmission lines is approximately 665, which would require the roadway profile to be below 645. The original Stage 1 design had a roadway elevation at this location of just under 677 and the new profile scenarios presented in this report raise the profile between 7 and 27 feet at the crossing. It would be possible to lower the profile to meet the required elevation, but it would have a significant negative impact on the earthwork quantities.

AEP also has overhead distribution lines at the following locations:

- Along the north side of CR 28 (Lucasville-Minford Road) the electric lines may need to go underground to avoid conflicts with the proposed bridge.
- Along CR 29 (Blue Run Road), where the pole under the bridge will need to be removed and the lines may need to go underground.
- Along the south side of CR 54 (Morris Lane Blue Run Road) there may not be a conflict with the proposed bridge, but there may be a conflict with the stream relocation.
- Along Flatwood Fallen Timber Road the electric lines will have to be realigned and the poles set to match the span of the proposed bridge.
- Along the east side of CR 55 (Fairgrounds Road) the electric lines will probably need to be relocated underground to avoid conflicts with the SR 823 and ramp bridges.
- Along the east side of the Norfolk Southern Railroad tracks the electric lines will probably need to be relocated underground to avoid conflicts with the SR 823 and ramp bridges.

Other Utilities

There are also existing water and gas lines which run along the east and west sides of Fairgrounds Road respectively. These lines appear to be outside the construction limits as they are shown, but should be located in the field as plans are developed further.

The proposed profiles established for the three scenarios are still conceptual and may need to be adjusted slightly in order to maximize savings and/or minimize the impacts to the area when the final cross sections are developed. All of these profiles have some culverts which have a height of cover over the culvert in excess of 100 feet. This will require additional cost for the design requirements of these culverts.

Implementation of any of these profile revisions will result in resubmission of Stage 1 plans and could result in delays to the overall schedule of this project and result in additional cost due to inflation. Expediting the design and review schedules would help to minimize or eliminate the impact of inflation.

RECOMMENDATIONS

After evaluating the three scenarios presented in this report, we recommend that Scenario #3 be the plan that is considered for further advancement. Scenario #3 allows the best truck performance amongst the scenario's considered and also provides the maximum savings in the construction cost.

APPENDIX - A

Cost Comparison Spreadsheets

Project Cost Comparison

PROJECT COST COMPARISON

		Original Stage 1			Scenario #1			Scenario #2			Scenario #3		
ITEM	DESCRIPTION	QUANTITY	UNIT PRICE	TOTAL COST	QUANTITY	UNIT PRICE	TOTAL COST	QUANTITY	UNIT PRICE	TOTAL COST	QUANTITY	UNIT PRICE	TOTAL COST
	TOTALS ==>			**$ 75,290,065.00**			**$ 70,260,310.76**			**$ 64,076,171.50**			**$ 61,077,192.57**
203	EXCAVATION	14217000	$ 3.35	$ 47,626,950.00	13215550	$ 3.35	$ 44,272,092.50	11798958	$ 3.35	$ 39,526,509.30	10287927	$ 3.35	$ 34,464,555.45
203	EMBANKMENT	5600000	$ 0.74	$ 4,144,000.00	6726464	$ 0.74	$ 4,977,583.36	8427700	$ 0.74	$ 6,236,498.00	10187818	$ 0.74	$ 7,538,985.32
203	ROADWAY, MISC.; WASTE	10749550	$ 1.10	$ 11,824,505.00	8471419	$ 1.10	$ 9,318,560.90	5141102	$ 1.10	$ 5,655,212.20	1643298	$ 1.10	$ 1,807,627.80
603	36" CONDUIT, TYPE A, 707.02	0	$ 138.00	$ -	260	$ 138.00	$ 35,880.00	253	$ 138.00	$ 34,914.00	253	$ 138.00	$ 34,914.00
603	48" CONDUIT, TYPE A, 707.02	0	$ 186.00	$ -	1502	$ 186.00	$ 279,372.00	1547	$ 186.00	$ 287,742.00	1553	$ 186.00	$ 288,858.00
603	54" CONDUIT, TYPE A, 707.02	0	$ 216.00	$ -	1112	$ 216.00	$ 240,192.00	1431	$ 216.00	$ 309,096.00	1697	$ 216.00	$ 366,552.00
603	60" CONDUIT, TYPE A, 707.02	5325	$ 230.00	$ 1,224,750.00	3440	$ 230.00	$ 791,200.00	6546	$ 230.00	$ 1,505,580.00	6716	$ 230.00	$ 1,544,680.00
603	66" CONDUIT, TYPE A, 707.02	1866	$ 275.00	$ 513,150.00	1126	$ 275.00	$ 309,650.00	1208	$ 275.00	$ 332,200.00	1208	$ 275.00	$ 332,200.00
603	72" CONDUIT, TYPE A, 707.02	688	$ 290.00	$ 199,520.00	766	$ 290.00	$ 222,140.00	1938	$ 290.00	$ 562,020.00	1938	$ 290.00	$ 562,020.00
603	78" CONDUIT, TYPE A, 707.02	534	$ 335.00	$ 178,890.00	534	$ 335.00	$ 178,890.00	0	$ 335.00	$ -	0	$ 335.00	$ -
603	108" CONDUIT, TYPE A, 707.02	448	$ 650.00	$ 291,200.00	484	$ 650.00	$ 314,600.00	0	$ 650.00	$ -	0	$ 650.00	$ -
	ADDITIONAL STREAM MITIGATION	0		$ -	835	$ 250.00	$ 208,750.00	1724	$ 250.00	$ 431,000.00	2166	$ 250.00	$ 541,500.00
	MORRIS LANE BLUE RUN RD.- BRIDGE	LUMP	$ 4,189,000.00	$ 4,189,000.00	LUMP	$ 4,189,000.00	$ 4,189,000.00	LUMP	$ 4,189,000.00	$ 4,189,000.00	LUMP	$ 10,582,500.00	$ 10,582,500.00
	FLATWOOD-FALLEN TIMBERS RD. - BRIDGE	LUMP	$ 5,098,100.00	$ 5,098,100.00	LUMP	$ 4,922,400.00	$ 4,922,400.00	LUMP	$ 5,006,400.00	$ 5,006,400.00	LUMP	$ 3,012,800.00	$ 3,012,800.00

Culvert Cost Comparison

SCENARIO #1 - Culverts

ALIGNMENT	STA	CDSS Calculated Diameter Pipe (in.)	APPROVED CULVERT SIZE (in.)	MAX COVER (ft.) SCENARIO #1 PROFILE	Corrugated steel pipe 707.02 (thickness)	Unit Cost / foot (707.02)	Length of Culvert	Total Cost (707.02)
SR 823	600+75.00	48	60"	75.0	0.109	$ 230.00	460	$ 105,800.00
SR 823	610+39.00	24	36"	31.0	0.064	$ 138.00	260	$ 35,880.00
SR 823	617+51.00	33	48"	74.8	0.109	$ 186.00	498	$ 92,628.00
SR 823	623+01.17	42	54"	76.0	0.109	$ 216.00	436	$ 94,176.00
SR 823	635+86.00	54	66"	104.6	0.168	$ 275.00	654	$ 179,850.00
SR 823	658+79.00	66	78"	99.4	0.168	$ 335.00	534	$ 178,890.00
SR 823	672+93.00	42	54"	72.6	0.109	$ 216.00	428	$ 92,448.00
SR 823	699+51.00	48	60"	103 NC	0.168	$ 230.00	656	$ 150,880.00
SR 823	723+50.00	42	54"	28 NC	0.079	$ 216.00	248	$ 53,568.00
SR 823	749+33.00	48	60"	87.0	0.138	$ 230.00	588	$ 135,240.00
SR 823	761+44.84	33	48"	62.5	0.079	$ 186.00	440	$ 81,840.00
SR 823	766+00.00	36	48"	105.2	0.138	$ 186.00	564	$ 104,904.00
SR 823	771+00.00	48	60"	114.0	0.168	$ 230.00	714	$ 164,220.00
SR 823	796+06.29	48	60"	108.2	0.168	$ 230.00	566	$ 130,180.00
SR 823	815+00.28	60	72"	93.0	0.138	$ 290.00	766	$ 222,140.00
SR 823	823+45.11	48	60"	81.4	0.138	$ 230.00	456	$ 104,880.00
SR 823	854+39.64	96	108"	65.4	0.168	$ 650.00	484	$ 314,600.00
SR 823	857+16.49	48	66"	61.0	0.109	$ 275.00	472	$ 129,800.00
								$ 2,371,924.00

SCENARIO #2 - Culverts

ALIGNMENT	STA	CDSS Calculated Diameter Pipe (in.)	APPROVED CULVERT SIZE (in.)	MAX COVER (ft.) SCENARIO #2 PROFILE	Corrugated steel pipe 707.02 (thickness)	Unit Cost / foot (707.02)	Length of Culvert	Total Cost (707.02)
SR 823	600+75.00	48	60"	75.0	0.109	$ 230.00	472	$ 108,560.00
SR 823	610+39.00	24	36"	30.0	0.064	$ 138.00	253	$ 34,914.00
SR 823	617+51.00	33	48"	74.0	0.109	$ 186.00	477	$ 88,722.00
SR 823	623+01.17	42	54"	75.0	0.109	$ 216.00	427	$ 92,232.00
SR 823	635+86.00	54	66"	106.0	0.168	$ 275.00	692	$ 190,300.00
SR 823	658+79.00	66	78"	NA	NA	NA	NA	NA
			TWIN 60"	115.5	0.168	$ 230.00	1220	$ 280,600.00
SR 823	672+93.00	42	54"	111.0	0.168	$ 216.00	756	$ 163,296.00
SR 823	699+51.00	48	60"	100.3	0.168	$ 230.00	656	$ 150,880.00
SR 823	723+50.00	42	54"	27 NC	0.079	$ 216.00	248	$ 53,568.00
SR 823	749+33.00	48	60"	86.0	0.138	$ 230.00	584	$ 134,320.00
SR 823	761+44.84	33	48"	71.0	0.109	$ 186.00	478	$ 88,908.00
SR 823	766+00.00	36	48"	111.6	0.138	$ 186.00	592	$ 110,112.00
SR 823	771+00.00	48	60"	118.4	0.168	$ 230.00	736	$ 169,280.00
SR 823	796+06.29	48	60"	119.0	0.168	$ 230.00	608	$ 139,840.00
SR 823	815+00.28	60	72"	NA	NA	NA	NA	NA
			TWIN 60"	116.0	0.168	$ 230.00	1816	$ 417,680.00
SR 823	823+45.11	48	60"	80.0	0.109	$ 230.00	454	$ 104,420.00
SR 823	854+39.64	96	108"	NA	NA	NA	NA	NA
			72" (3)	95.0	0.168	$ 290.00	1938	$ 562,020.00
SR 823	857+16.49	48	66"	82.4	0.138	$ 275.00	516	$ 141,900.00
								$ 3,031,552.00

SCENARIO #3 - Culverts

ALIGNMENT	STA	CDSS Calculated Diameter Pipe (in.)	APPROVED CULVERT SIZE (in.)	MAX COVER (ft.) SCENARIO #3 PROFILE	Corrugated steel pipe 707.02 (thickness)	Unit Cost / foot (707.02)	Length of Culvert	Total Cost (707.02)
SR 823	600+75.00	48	60"	75.0	0.109	$ 230.00	472	$ 108,560.00
SR 823	610+39.00	24	36"	30.0	0.064	$ 138.00	253	$ 34,914.00
SR 823	617+51.00	33	48"	74.0	0.109	$ 186.00	477	$ 88,722.00
SR 823	623+01.17	42	54"	75.0	0.109	$ 216.00	427	$ 92,232.00
SR 823	635+86.00	54	66"	106.0	0.168	$ 275.00	692	$ 190,300.00
SR 823	658+79.00	66	78"	NA	NA	NA	NA	NA
			TWIN 60"	115.5	0.168	$ 230.00	1220	$ 280,600.00
SR 823	672+93.00	42	54"	111.1	0.168	$ 216.00	756	$ 163,296.00
SR 823	699+51.00	48	60"	115.0	0.168	$ 230.00	704	$ 161,920.00
SR 823	723+50.00	42	54"	94.0	0.138	$ 216.00	514	$ 111,024.00
SR 823	749+33.00	48	60"	116.8	0.168	$ 230.00	706	$ 162,380.00
SR 823	761+44.84	33	48"	77.2	0.109	$ 186.00	504	$ 93,744.00
SR 823	766+00.00	36	48"	106.8	0.138	$ 186.00	572	$ 106,392.00
SR 823	771+00.00	48	60"	118.4	0.168	$ 230.00	736	$ 169,280.00
SR 823	796+06.29	48	60"	119.0	0.168	$ 230.00	608	$ 139,840.00
SR 823	815+00.28	60	72"	NA	NA	NA	NA	NA
			TWIN 60"	116.0	0.168	$ 230.00	1816	$ 417,680.00
SR 823	823+45.11	48	60"	80.0	0.138	$ 230.00	454	$ 104,420.00
SR 823	854+39.64	96	108"	NA	NA	NA	NA	NA
			72" (3)	94.1	0.168	$ 290.00	1938	$ 562,020.00
SR 823	857+16.49	48	66"	82.4	0.138	$ 275.00	516	$ 141,900.00
								$ 3,129,224.00

APPENDIX - B

Truck Speed Diagrams

Stage 1 Submittal

TRUCK SPEED PERFORMANCE MODEL

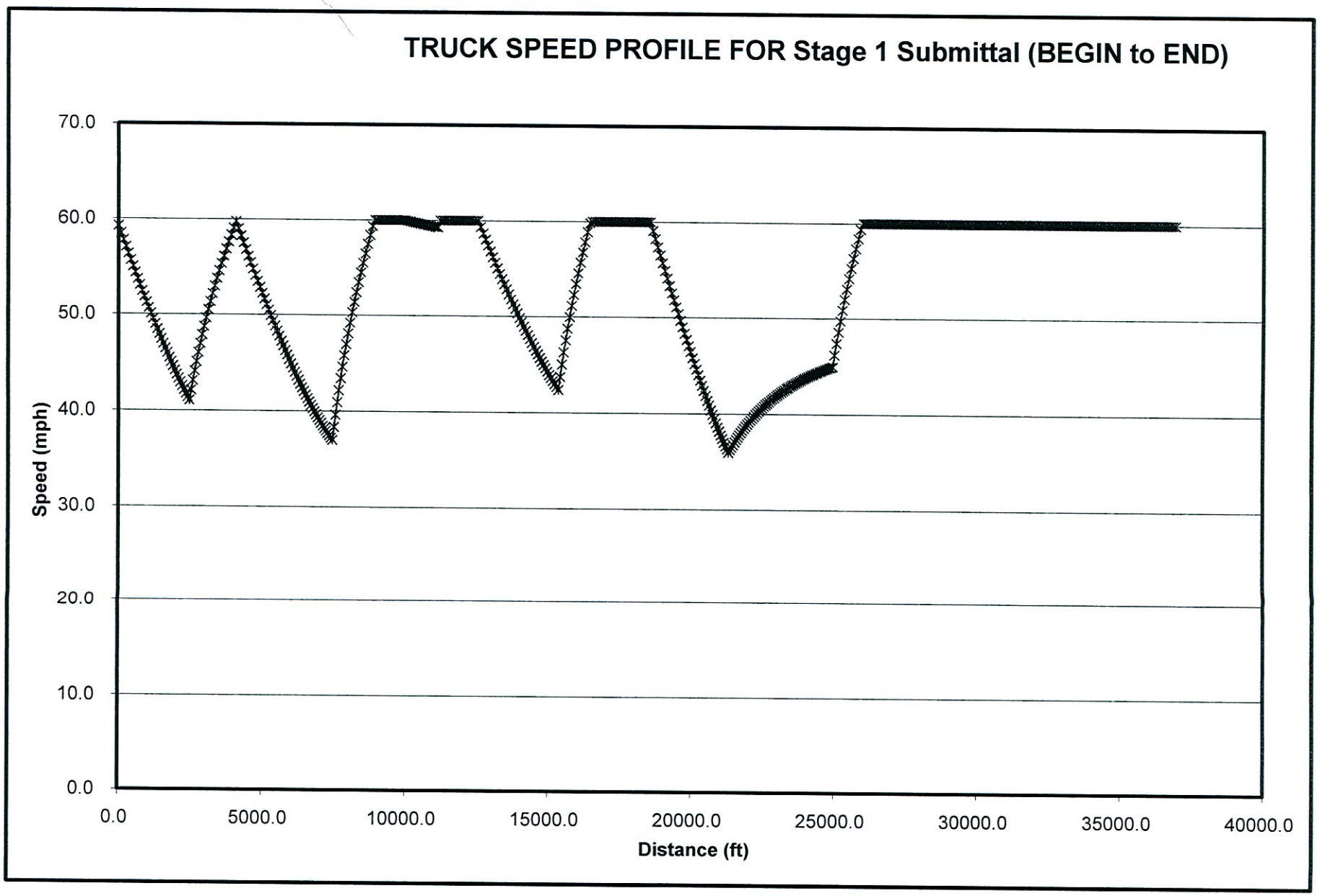
Desired speed (mph) = 60.0
Initial speed (mph) = 60.0
Weight/power ratio (lb/hp) = 200.0
Weight/frontal area ratio (lb/ft2) = 0.0 ← enter value or enter zero to use default estimate
Elevation (ft) = 1000.0
Location (legend) = Stage 1 Submittal (BEGIN to END)

Vertical Profile

(Beginning of first segment must equal 0)

Position (ft)		Percent Grade
Begin	End	
0	2500	4
2500	4100	-2.6
4100	7450	4
7450	10000	-3.7
10000	11200	0.95
11200	12600	-4
12600	15400	3.6
15400	18650	-4.2
18650	21350	4.6
21350	25000	1.76
25000	31700	-4
31700	33200	-0.64
33200	36910.82	-3

STATIONS	
53489.18	56000
56000	57600
57600	60950
60950	63500
63500	64700
64700	66100
66100	68900
68900	72150
72150	74850
74850	78500
78500	85200
85200	86700
86700	90400


TRUCK SPEED PROFILE FOR Stage 1 Submittal (BEGIN to END)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Speed (mph)
0.0
5000.0
10000.0
15000.0
20000.0
25000.0
30000.0
35000.0
40000.0
Distance (ft)

TRUCK SPEED PERFORMANCE MODEL

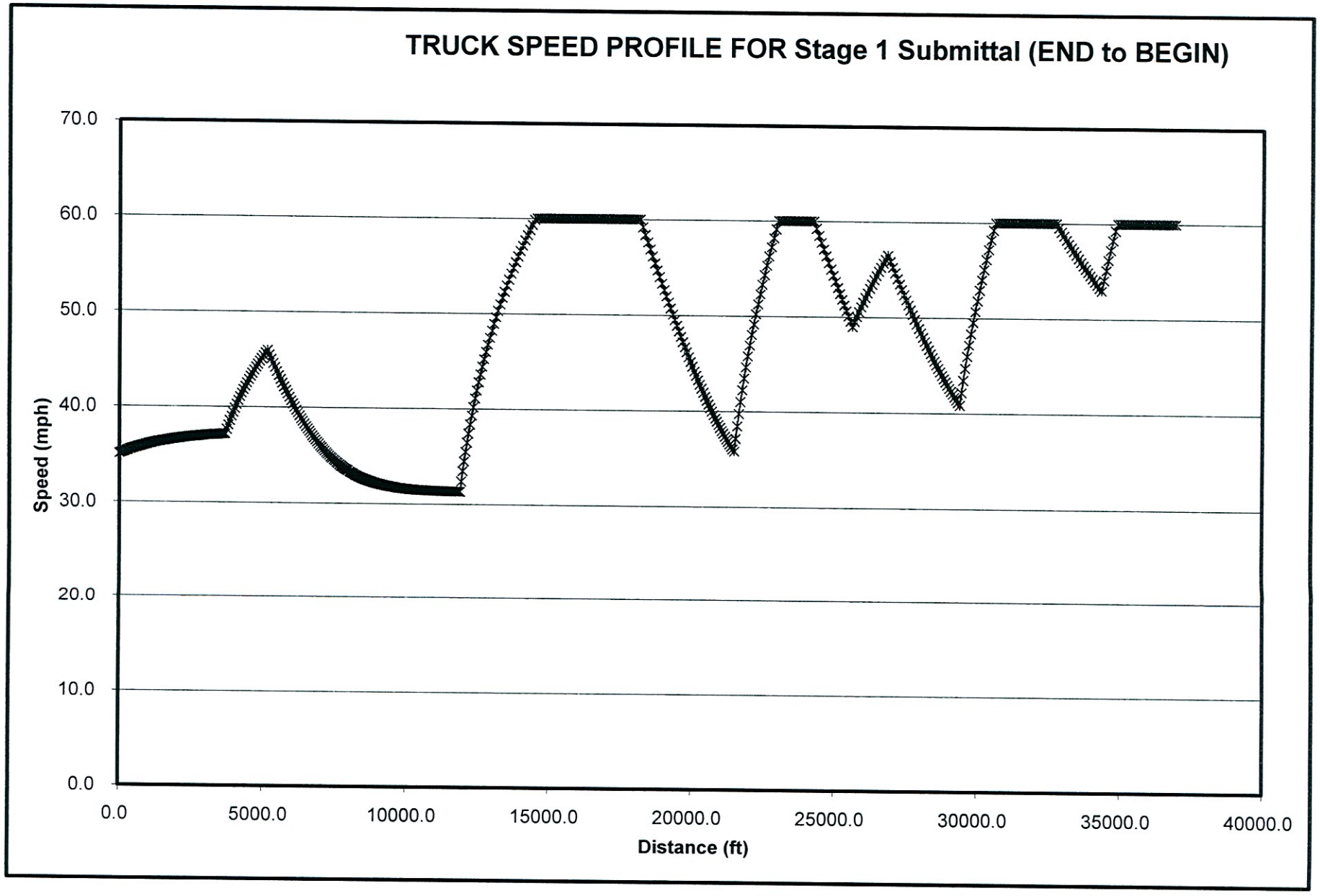
Desired speed (mph) =	**60.0**
Initial speed (mph) =	**35.0**
Weight/power ratio (lb/hp) =	**200.0**
Weight/frontal area ratio (lb/ft2) =	**0.0** ← enter value or enter zero to use default estimate
Elevation (ft) =	**1000.0**
Location (legend) =	**Stage 1 Submittal (END to BEGIN)**

Vertical Profile

(Beginning of first segment must equal 0)

Position (ft)		Percent Grade
Begin	End	
0	3700	3
3700	5200	0.64
5200	11900	4
11900	15550	-1.76
15550	18250	-4.6
18250	21500	4.2
21500	24300	-3.6
24300	25700	4
25700	26900	-0.95
26900	29450	3.7
29450	32800	-4
32800	34400	2.6
34400	36910.82	-4

STATIONS	
90400	86700
86700	85200
85200	78500
78500	74850
74850	72150
72150	68900
68900	66100
66100	64700
64700	63500
63500	60950
60950	57600
57600	56000
56000	53489.18


TRUCK SPEED PROFILE FOR Stage 1 Submittal (END to BEGIN)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Speed (mph)
0.0
5000.0
10000.0
15000.0
20000.0
25000.0
30000.0
35000.0
40000.0
Distance (ft)

Scenario #1

TRUCK SPEED PERFORMANCE MODEL

Desired speed (mph) = 60.0
Initial speed (mph) = 60.0
Weight/power ratio (lb/hp) = 200.0
Weight/frontal area ratio (lb/ft2) = 0.0 ← enter value or enter zero to use default estimate
Elevation (ft) = 1000.0
Location (legend) = ROUTE 823 new (BEGIN to END) #1

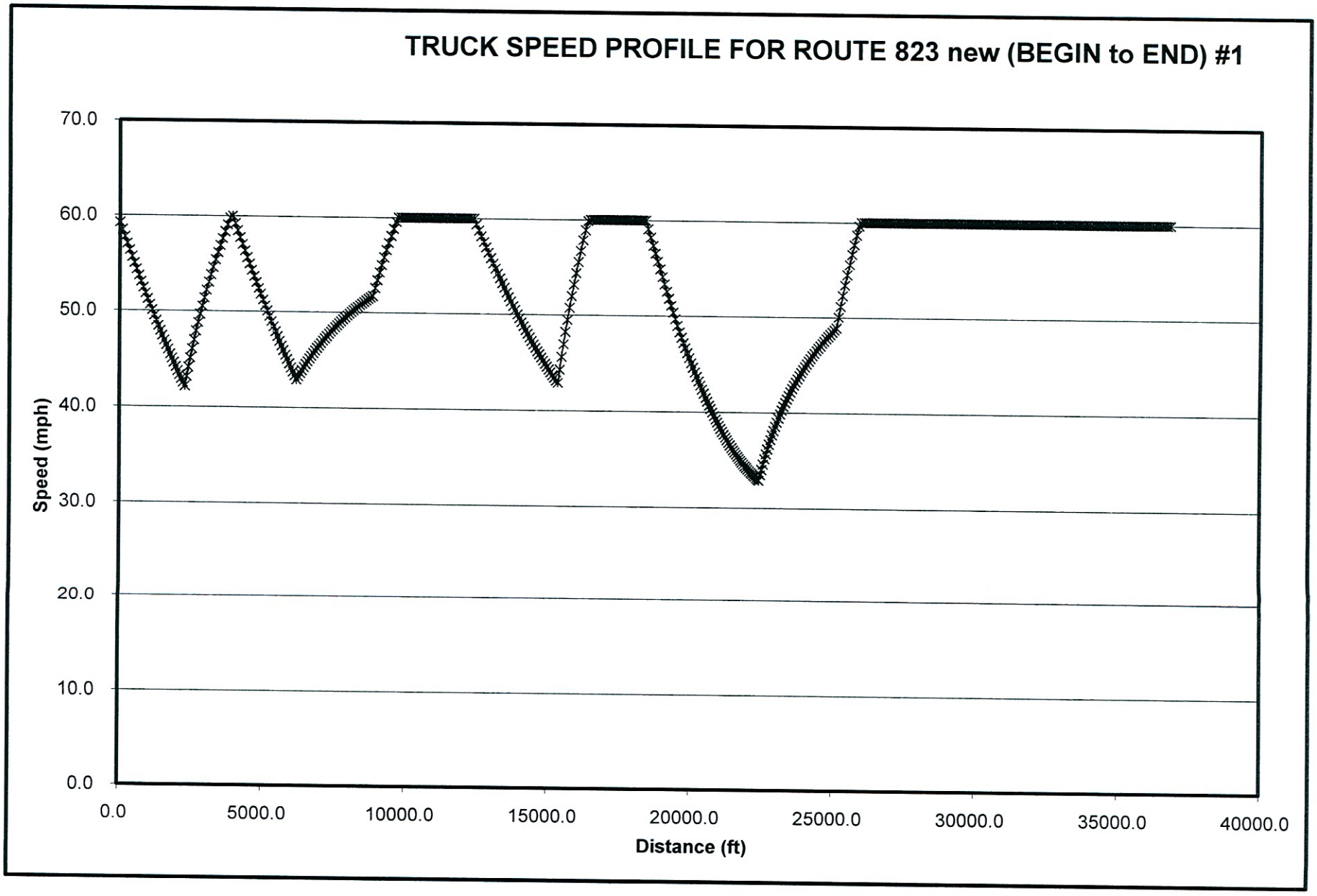
Vertical Profile

(Beginning of first segment must equal 0)

Position (ft)		Percent Grade
Begin	End	
0	2345	4
2345	3945	-2.6
3945	6245	4
6245	8870	0.6564
8870	11045	-2.675
11045	12445	-4
12445	15395	3.422
15395	17545	-4.5
17545	18495	-4.1996
18495	19645	4.5997
19645	22445	4.2
22445	25145	0.6319
25145	27945	-4
27945	28845	-2.84
28845	31545	-4.4
31545	33045	-1.3673
33045	36745	-3

STATIONS

53655	56000
56000	57600
57600	59900
59900	62525
62525	64700
64700	66100
66100	69050
69050	71200
71200	72150
72150	73300
73300	76100
76100	78800
78800	81600
81600	82500
82500	85200
85200	86700
86700	90400


TRUCK SPEED PROFILE FOR ROUTE 823 new (BEGIN to END) #1
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Speed (mph)
0.0
5000.0
10000.0
15000.0
20000.0
25000.0
30000.0
35000.0
40000.0
Distance (ft)

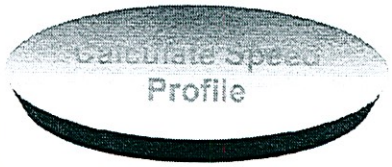
TRUCK SPEED PERFORMANCE MODEL

Desired speed (mph) = 60.0
Initial speed (mph) = 35.0
Weight/power ratio (lb/hp) = 200.0
Weight/frontal area ratio (lb/ft2) = 0.0 ← enter value or enter zero to use default estimate
Elevation (ft) = 1000.0
Location (legend) = ROUTE 823 new (END to BEGIN) #1

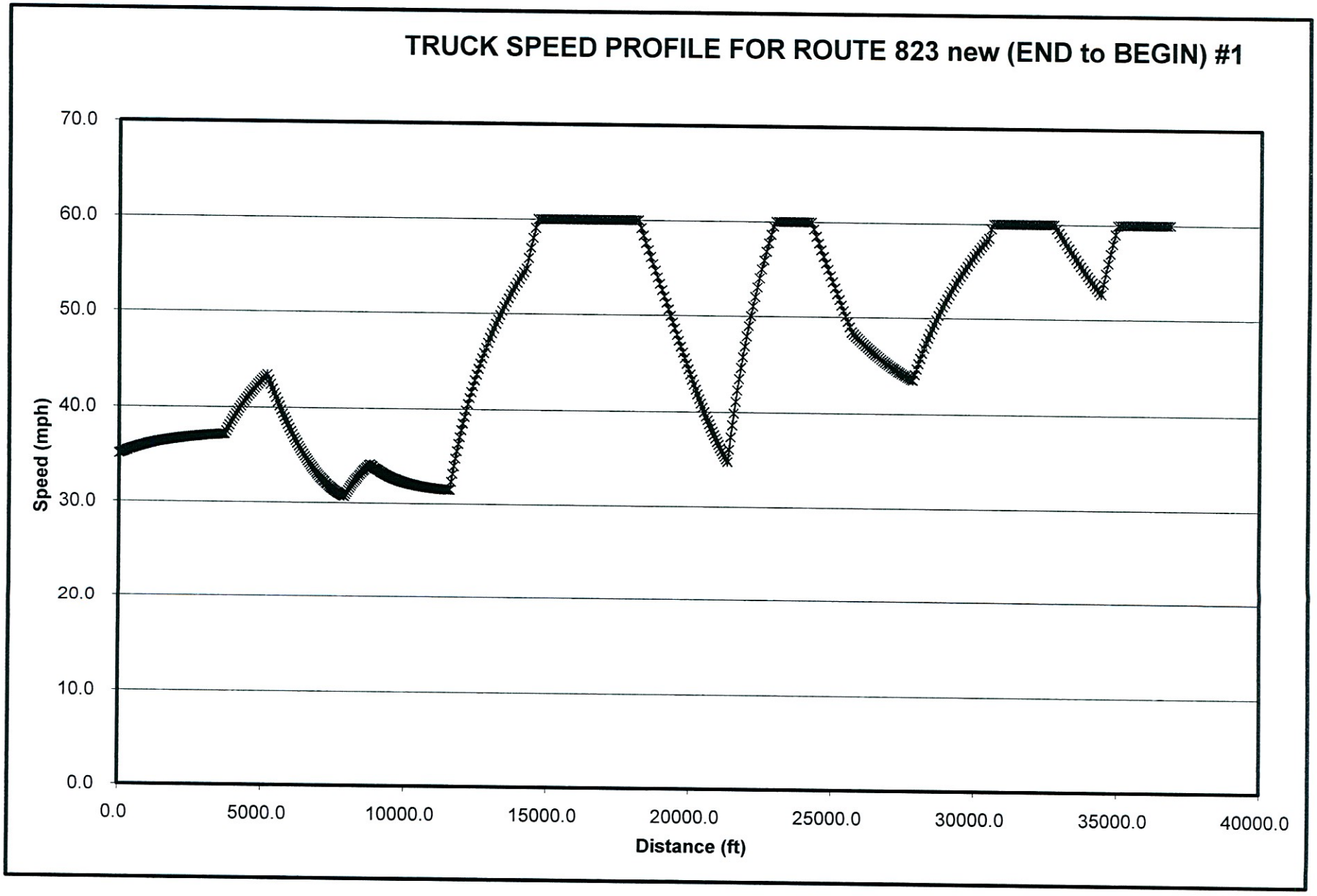
Vertical Profile

(Beginning of first segment must equal 0)

Position (ft)		Percent Grade
Begin	End	
0	3700	3
3700	5200	1.3673
5200	7900	4.4
7900	8800	2.84
8800	11600	4
11600	14300	-0.6319
14300	17100	-4.2
17100	18250	-4.5997
18250	19200	4.1996
19200	21350	4.5
21350	24300	-3.422
24300	25700	4
25700	27875	2.675
27875	30500	-0.6564
30500	32800	-4
32800	34400	2.6
34400	36745	-4



STATIONS	
90400	86700
86700	85200
85200	82500
82500	81600
81600	78800
78800	76100
76100	73300
73300	72150
72150	71200
71200	69050
69050	66100
66100	64700
64700	62525
62525	59900
59900	57600
57600	56000
56000	53655


TRUCK SPEED PROFILE FOR ROUTE 823 new (END to BEGIN) #1
Speed (mph)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.0
5000.0
10000.0
15000.0
20000.0
25000.0
30000.0
35000.0
40000.0
Distance (ft)

Scenario #2

TRUCK SPEED PERFORMANCE MODEL

Desired speed (mph) = 60.0
Initial speed (mph) = 60.0
Weight/power ratio (lb/hp) = 200.0
Weight/frontal area ratio (lb/ft2) = 0.0 ← enter value or enter zero to use default estimate
Elevation (ft) = 1000.0
Location (legend) = ROUTE 823 new (BEGIN to END) #2

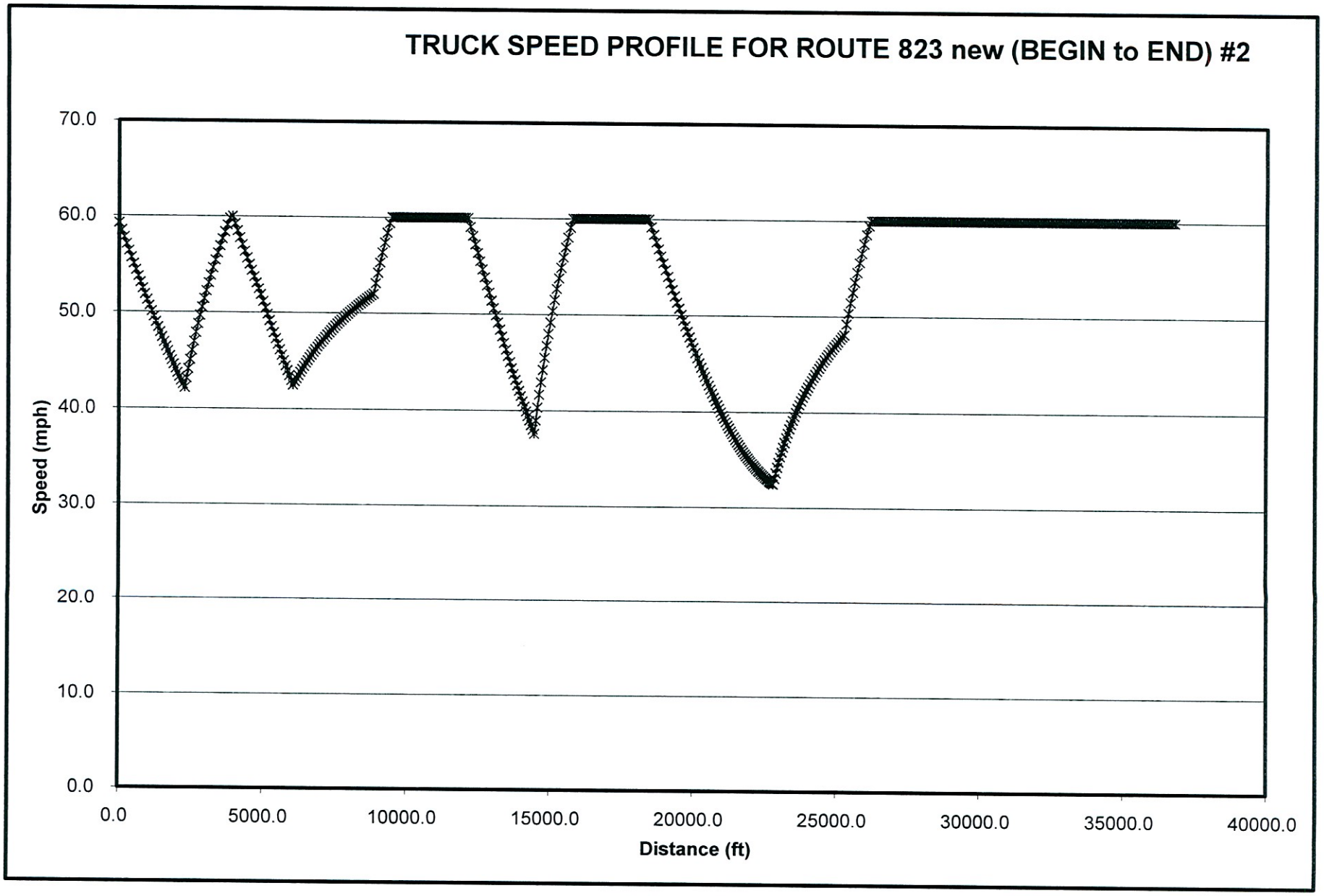
Vertical Profile

(Beginning of first segment must equal 0)

Position (ft)		Percent Grade
Begin	End	
0	2345	4
2345	3945	-2.6
3945	4945	3.9996
4945	6095	4.4
6095	8870	0.6357
8870	9745	-4
9745	11045	-1.7066
11045	12195	-3.4699
12195	14507	4.8
14507	18495	-4.0816
18495	22805	4.1982
22805	25345	0.62
25345	32695	-3.7486
32695	36755.82	-2.9996

STATIONS

53655	56000
56000	57600
57600	58600
58600	59750
59750	62525
62525	63400
63400	64700
64700	65850
65850	68162
68162	72150
72150	76460
76460	79000
79000	86350
86350	90410.82


TRUCK SPEED PROFILE FOR ROUTE 823 new (BEGIN to END) #2
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Speed (mph)
0.0
5000.0
10000.0
15000.0
20000.0
25000.0
30000.0
35000.0
40000.0
Distance (ft)

TRUCK SPEED PERFORMANCE MODEL

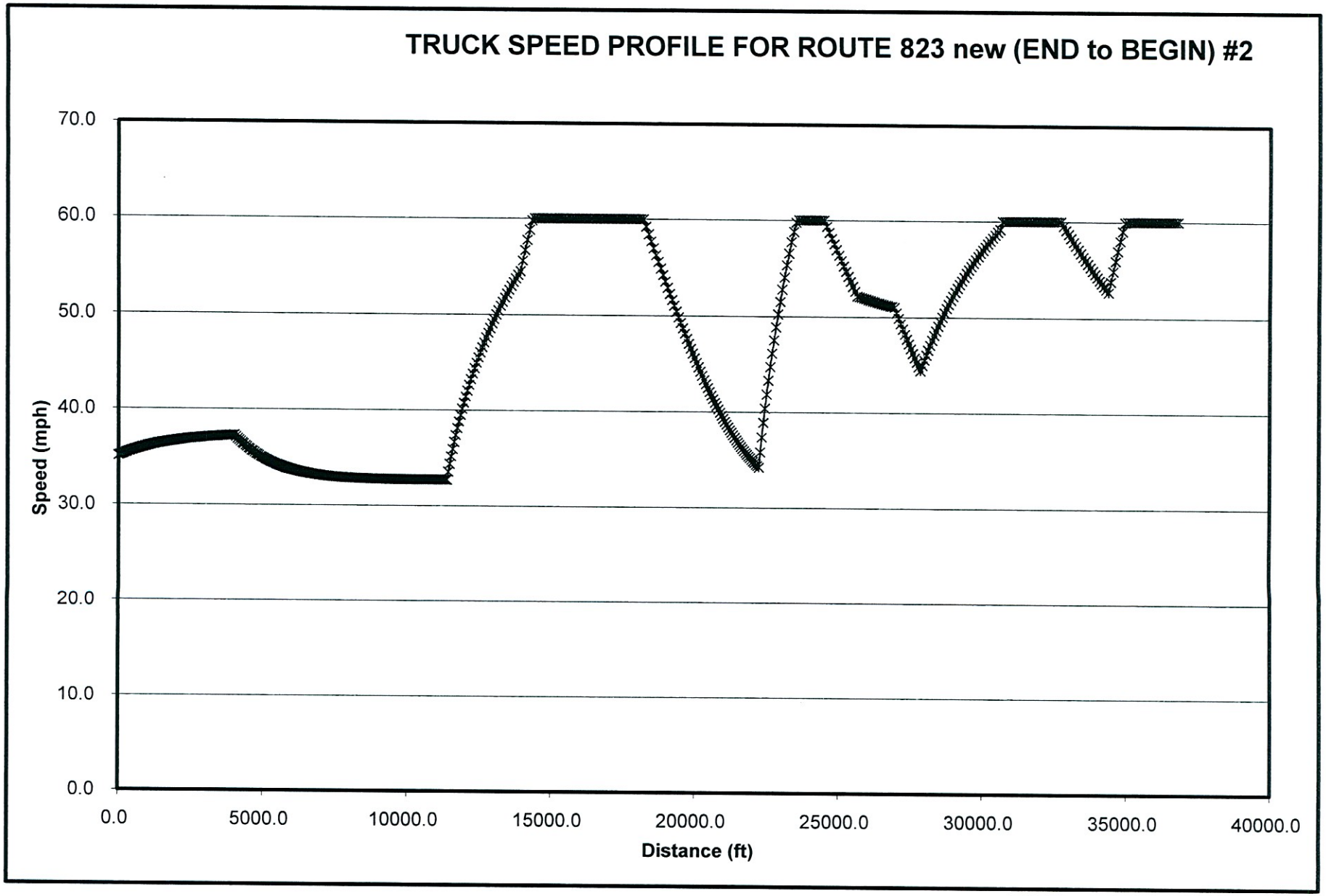
Desired speed (mph) = 60.0
Initial speed (mph) = 35.0
Weight/power ratio (lb/hp) = 200.0
Weight/frontal area ratio (lb/ft2) = 0.0 ← enter value or enter zero to use default estimate
Elevation (ft) = 1000.0
Location (legend) = ROUTE 823 new (END to BEGIN) #2

Vertical Profile

(Beginning of first segment must equal 0)

Position (ft)		Percent Grade
Begin	End	
0	4060.82	2.9996
4060.82	11410.82	3.7486
11410.82	13950.82	-0.62
13950.82	18260.82	-4.1982
18260.82	22248.82	4.0816
22248.82	24560.82	-4.8
24560.82	25710.82	3.4699
25710.82	27010.82	1.7066
27010.82	27885.82	4
27885.82	30660.82	-0.6357
30660.82	31810.82	-4.4
31810.82	32810.82	-3.9996
32810.82	34410.82	2.6
34410.82	36755.82	-4

STATIONS	
90410.82	86350
86350	79000
79000	76460
76460	72150
72150	68162
68162	65850
65850	64700
64700	63400
63400	62525
62525	59750
59750	58600
58600	57600
57600	56000
56000	53655


TRUCK SPEED PROFILE FOR ROUTE 823 new (END to BEGIN) #2
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Speed (mph)
0.0
5000.0
10000.0
15000.0
20000.0
25000.0
30000.0
35000.0
40000.0
Distance (ft)

Scenario #3

TRUCK SPEED PERFORMANCE MODEL

Desired speed (mph) = 60.0
Initial speed (mph) = 60.0
Weight/power ratio (lb/hp) = 200.0
Weight/frontal area ratio (lb/ft2) = 0.0 ← enter value or enter zero to use default estimate
Elevation (ft) = 1000.0
Location (legend) = ROUTE 823 new (BEGIN to END) #3

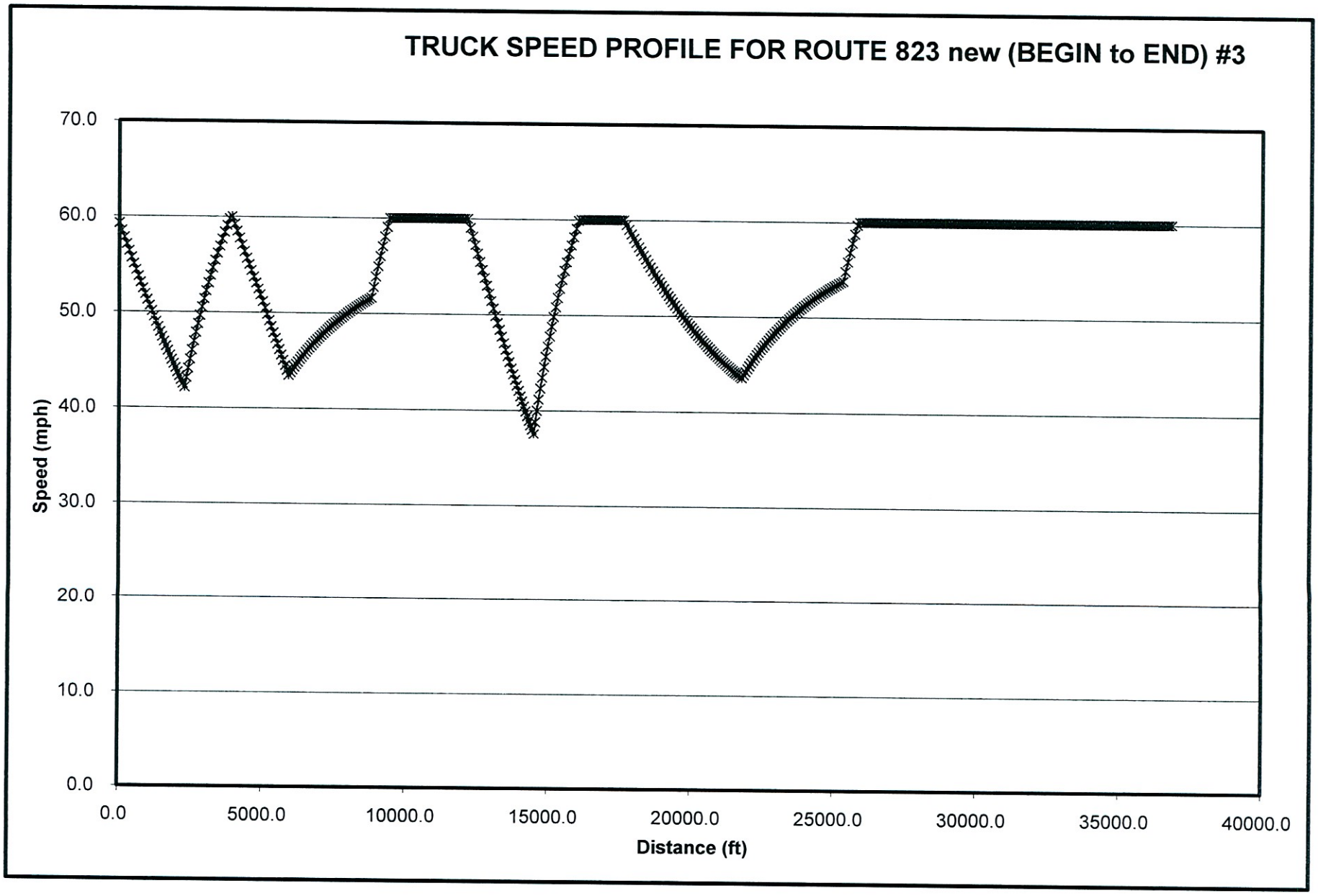
Vertical Profile

(Beginning of first segment must equal 0)

Position (ft)		Percent Grade
Begin	End	
0	2345	4
2345	3945	-2.6
3945	4945	3.9996
4945	5970	4.4
5970	8870	0.798
8870	9745	-4
9745	11045	-1.7066
11045	12195	-3.4699
12195	14507	4.8
14507	17725	-3.2532
17725	21845	2.8376
21845	25345	0.62
25345	32695	-3.7486
32695	36755.82	-3

STATIONS

53655	56000
56000	57600
57600	58600
58600	59625
59625	62525
62525	63400
63400	64700
64700	65850
65850	68162
68162	71380
71380	75500
75500	79000
79000	86350
86350	90410.82


TRUCK SPEED PROFILE FOR ROUTE 823 new (BEGIN to END) #3
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Speed (mph)
0.0
5000.0
10000.0
15000.0
20000.0
25000.0
30000.0
35000.0
40000.0
Distance (ft)

TRUCK SPEED PERFORMANCE MODEL

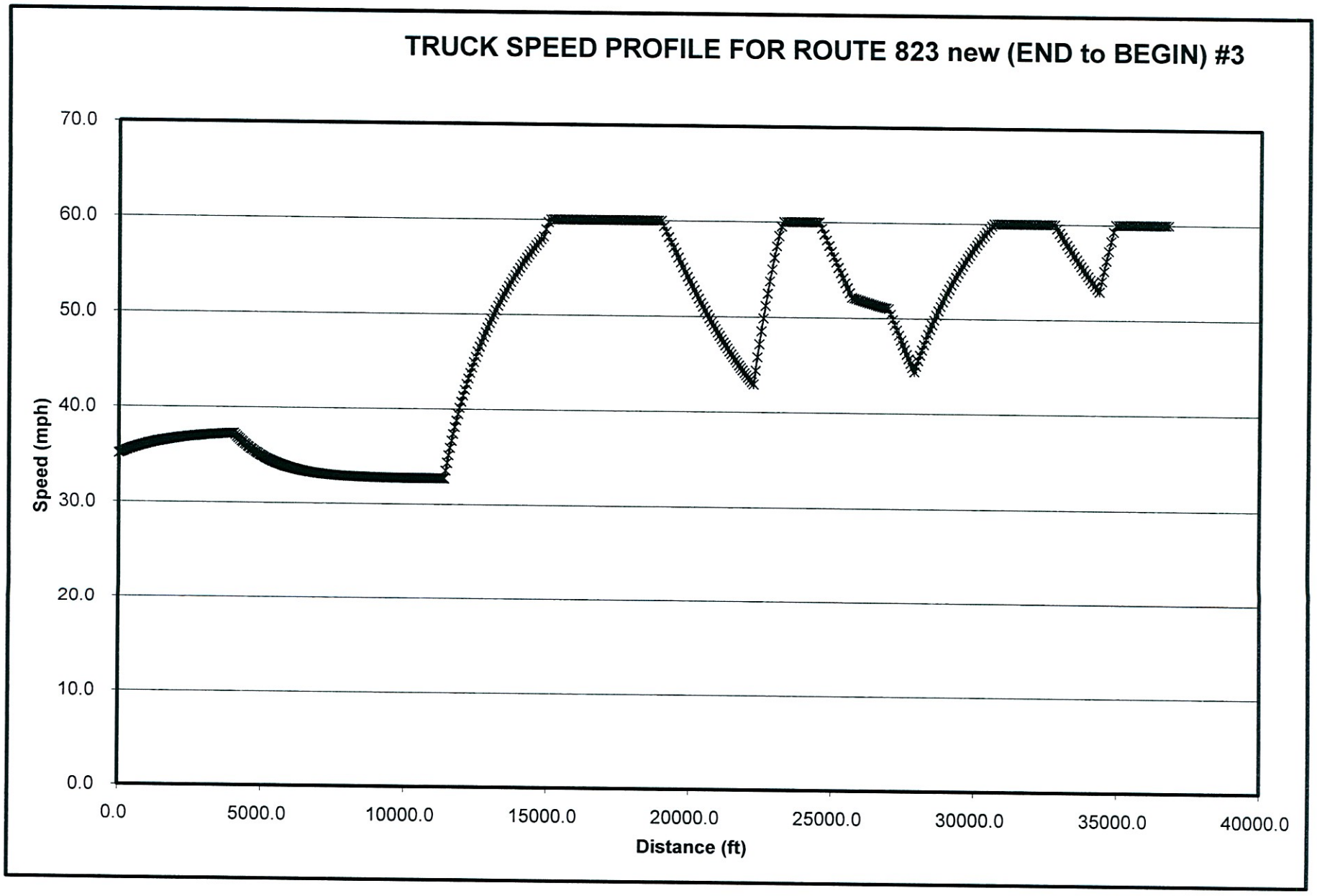
Desired speed (mph) = 60.0
Initial speed (mph) = 35.0
Weight/power ratio (lb/hp) = 200.0
Weight/frontal area ratio (lb/ft2) = 0.0 ← enter value or enter zero to use default estimate
Elevation (ft) = 1000.0
Location (legend) = ROUTE 823 new (END to BEGIN) #3

Vertical Profile

(Beginning of first segment must equal 0)

Position (ft)		Percent Grade
Begin	End	
0	4060.82	3
4060.82	11410.82	3.7486
11410.82	14910.82	-0.62
14910.82	19030.82	-2.8376
19030.82	22248.82	3.2532
22248.82	24560.82	-4.8
24560.82	25710.82	3.4699
25710.82	27010.82	1.7066
27010.82	27885.82	4
27885.82	30785.82	-0.798
30785.82	31810.82	-4.4
31810.82	32810.82	-4
32810.82	34410.82	2.6
34410.82	36755.82	-4

STATIONS	
90410.82	86350
86350	79000
79000	75500
75500	71380
71380	68162
68162	65850
65850	64700
64700	63400
63400	62525
62525	59625
59625	58600
58600	57600
57600	56000
56000	53655


TRUCK SPEED PROFILE FOR ROUTE 823 new (END to BEGIN) #3
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Speed (mph)
0.0
5000.0
10000.0
15000.0
20000.0
25000.0
30000.0
35000.0
40000.0
Distance (ft)

APPENDIX - C

Profile Printout – Vertical Curve Data

Stage 1 Submittal

<* 1 PRINT PROFILE PSR823

Beginning profile PSR823 description:

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		STATION	ELEV	GRADE	TOTAL L	BACK L	AHEAD L
VPI	1	50+23.01	591.4686				
VPC		58+50.00	587.3336	-0.5000	K = 290.9		
Low Point		59+95.45	586.9700				
VPI	2	66+50.00	583.3336		1,600.0000	800.0000	800.0000
VPT		74+50.00	623.3336	5.0000			
VPC		83+50.00	668.3336	5.0000	K = 252.7	SSD = 738.5	
VPI	3	95+00.00	725.8336		2,300.0000	1,150.0000	1,150.0000
High Point		96+13.74	699.9270				
VPT		106+50.00	678.6836	-4.1000			
VPC		122+50.00	613.0836	-4.1000	K = 186.8		
Low Point		130+15.93	597.3820				
VPI	4	131+00.00	578.2336		1,700.0000	850.0000	850.0000
VPT		139+50.00	620.7336	5.0000			
VPC		154+50.00	695.7336	5.0000	K = 255.6	SSD = 742.6	
VPI	5	166+00.00	753.2336		2,300.0000	1,150.0000	1,150.0000
High Point		167+27.78	727.6781				
VPT		177+50.00	707.2336	-4.0000			
VPC		179+00.00	701.2336	-4.0000	K = 183.1		

VPI	6	185+50.00	675.2336		1,300.0000	650.0000	650.0000
Low Point		186+32.39	686.5857				
VPT		192+00.00	695.3836	3.1000			
VPC		245+00.00	859.6836	3.1000	K = 259.3	SSD = 748,0	
VPI	7	252+00.00	881.3836		1,400.0000	700.0000	700.0000
High Point		253+03.70	872.1410				
VPT		259+00.00	865.2836	-2.3000			
VPC		302+00.00	766.3836	-2.3000	K = 816.3		
VPI	8	304+00.00	761.7836		400.0000	200.0000	200.0000
VPT		306+00.00	758.1636	-1.8100			
VPC		329+00.00	716.5336	-1.8100	K = 276.8	SSD = 772.9	
VPI	9	333+00.00	709.2936		800.0000	400.0000	400.0000
VPT		337+00.00	690.4936	-4.7000			
VPC		341+50.00	669.3436	-4.7000	K = 193.5		
VPI	10	347+50.00	641.1436		1,200.0000	600.0000	600.0000
Low Point		350+59.68	647.9662				
VPT		353+50.00	650.1436	1.5000			
VPC		421+50.00	752.1436	1.5000	K = 250.0	SSD = 734.5	
High Point		425+25.00	754.9561				
VPI	11	429+00.00	763.3936		1,500.0000	750.0000	750.0000
VPT		436+50.00	729.6436	-4.5000			
VPC		439+50.00	716.1436	-4.5000	K = 183.1		
VPI	12	446+00.00	686.8936		1,300.0000	650.0000	650.0000
Low Point		447+73.94	697.6049				
VPT		452+50.00	703.7936	2.6000			

VPC	461+00.00	725.8936	2.6000	K =	254.5	SSD =	741.2
High Point	467+61.82	734.4973					
VPI 13	468+00.00	744.0936		1,400.0000	700.0000		700.0000
VPT	475+00.00	723.7936	-2.9000				
VPC	484+00.00	697.6936	-2.9000	K =	202.7		
Low Point	489+87.84	689.1700					
VPI 14	491+50.00	675.9436		1,500.0000	750.0000		750.0000
VPT	499+00.00	709.6936	4.5000				
VPC	508+00.00	750.1936	4.5000	K =	256.8	SSD =	744.4
VPI 15	517+50.00	792.9436		1,900.0000	950.0000		950.0000
High Point	519+55.41	776.1903					
VPT	527+00.00	765.3936	-2.9000				
VPC	528+50.00	761.0436	-2.9000	K =	188.4		
Low Point	533+96.38	753.1212					
VPI 16	535+00.00	742.1936		1,300.0000	650.0000		650.0000
VPT	541+50.00	768.1936	4.0000				
VPC	551+50.00	808.1936	4.0000	K =	257.6	SSD =	745.6
VPI 17	560+00.00	842.1936		1,700.0000	850.0000		850.0000
High Point	561+80.30	828.7997					
VPT	568+50.00	820.0936	-2.6000				
VPC	570+00.00	816.1936	-2.6000	K =	181.8		
Low Point	574+72.73	810.0482					
VPI 18	576+00.00	800.5936		1,200.0000	600.0000		600.0000
VPT	582+00.00	824.5936	4.0000				
VPC	599+50.00	894.5936	4.0000	K =	259.7	SSD =	748.7

VPI 19	609+50.00	934.5936		2,000.0000	1,000.0000	1,000.0000
High Point	609+88.96	915.3729				
VPT	619+50.00	897.5936	-3.7000			
VPC	630+50.00	856.8936	-3.7000	K = 193.5		
VPI 20	635+00.00	840.2436		900.0000	450.0000	450.0000
Low Point	637+66.13	843.6452				
VPT	639+50.00	844.5186	0.9500			
VPC	640+50.00	845.4686	0.9500	K = 262.6	SSD = 752.8	
High Point	642+99.49	846.6537				
VPI 21	647+00.00	851.6436		1,300.0000	650.0000	650.0000
VPT	653+50.00	825.6436	-4.0000			
VPC	654+00.00	823.6436	-4.0000	K = 184.2		
VPI 22	661+00.00	795.6436		1,400.0000	700.0000	700.0000
Low Point	661+36.84	808.9068				
VPT	668+00.00	820.8436	3.6000			
VPC	679+00.00	860.4436	3.6000	K = 256.4	SSD = 743.9	
High Point	688+23.08	877.0590				
VPI 23	689+00.00	896.4436		2,000.0000	1,000.0000	1,000.0000
VPT	699+00.00	854.4436	-4.2000			
VPC	713+50.00	793.5436	-4.2000	K = 181.8		
Low Point	721+13.64	777.5073				
VPI 24	721+50.00	759.9436		1,600.0000	800.0000	800.0000
VPT	729+50.00	796.7436	4.6000			
VPC	744+50.00	865.7436	4.6000	K = 281.4	SSD = 779.3	
VPI 25	748+50.00	884.1436		800.0000	400.0000	400.0000

VPT		752+50.00	891.1727	1.7573			
VPC		777+50.00	935.1041	1.7573	K = 260.5	SSD = 749.8	
High Point		782+07.84	939.1268				
VPI	26	785+00.00	948.2835		1,500.0000	750.0000	750.0000
VPT		792+50.00	918.2835	-4.0000			
VPC		848+00.00	696.2835	-4.0000	K = 238.3		
VPI	27	852+00.00	680.2835		800.0000	400.0000	400.0000
VPT		856+00.00	677.7093	-0.6436			
VPC		864+00.00	672.5607	-0.6436	K = 254.6	SSD = 757.9	
VPI	28	867+00.00	670.6300		600.0000	300.0000	300.0000
VPT		870+00.00	661.6300	-3.0000			
VPI	29	904+00.00	559.6300	-3.0000			

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Ending profile PSR823 description

Scenario #1

<* 1 PRINT PROFILE PSR823_TEST1

Beginning profile PSR823_TEST1 description:

		STATION	ELEV	GRADE	TOTAL L	BACK L	AHEAD L
VPI	1	50+23.01	591.4686				
VPC		58+50.00	587.3336	-0.5000	K = 290.9		
Low Point		59+95.45	586.9700				
VPI	2	66+50.00	583.3336		1,600.0000	800.0000	800.0000
VPT		74+50.00	623.3336	5.0000			
VPC		83+50.00	668.3336	5.0000	K = 252.7	SSD = 738.5	
VPI	3	95+00.00	725.8336		2,300.0000	1,150.0000	1,150.0000
High Point		96+13.74	699.9270				
VPT		106+50.00	678.6836	-4.1000			
VPC		122+50.00	613.0836	-4.1000	K = 186.8		
Low Point		130+15.93	597.3820				
VPI	4	131+00.00	578.2336		1,700.0000	850.0000	850.0000
VPT		139+50.00	620.7336	5.0000			
VPC		154+50.00	695.7336	5.0000	K = 255.6	SSD = 742.6	
VPI	5	166+00.00	753.2336		2,300.0000	1,150.0000	1,150.0000
High Point		167+27.78	727.6781				
VPT		177+50.00	707.2336	-4.0000			
VPC		179+00.00	701.2336	-4.0000	K = 183.1		

VPI	6	185+50.00	675.2336		1,300.0000	650.0000	650.0000
Low Point		186+32.39	686.5857				
VPT		192+00.00	695.3836	3.1000			
VPC		245+00.00	859.6836	3.1000	K = 259.3	SSD = 748.0	
VPI	7	252+00.00	881.3836		1,400.0000	700.0000	700.0000
High Point		253+03.70	872.1410				
VPT		259+00.00	865.2836	-2.3000			
VPC		302+00.00	766.3836	-2.3000	K = 816.3		
VPI	8	304+00.00	761.7836		400.0000	200.0000	200.0000
VPT		306+00.00	758.1636	-1.8100			
VPC		329+00.00	716.5336	-1.8100	K = 276.8	SSD = 772.9	
VPI	9	333+00.00	709.2936		800.0000	400.0000	400.0000
VPT		337+00.00	690.4936	-4.7000			
VPC		341+50.00	669.3436	-4.7000	K = 193.5		
VPI	10	347+50.00	641.1436		1,199.9999	599.9999	599.9999
Low Point		350+59.68	647.9662				
VPT		353+50.00	650.1436	1.5000			
VPC		387+00.00	700.3936	1.5000	K = 714.3		
VPI	11	392+00.00	707.8936		1,000.0000	500.0000	500.0000
VPT		397+00.00	722.3930	2.8999			
VPC		412+00.00	765.8912	2.8999	K = 270.3	SSD = 763.7	
High Point		419+83.76	777.2553				
VPI	12	422+00.00	794.8900		2,000.0000	1,000.0000	1,000.0000
VPT		432+00.00	749.8900	-4.5000			

VPC	435+00.00	736.3900	-4.5000	K = 233.3		
VPI 13	442+00.00	704.8900		1,400.0000	700.0000	700.0000
Low Point	445+50.00	712.7650				
VPT	449+00.00	715.3900	1.5000			
VPC	460+70.00	732.9400	1.5000	K = 361.9	SSD = 883.7	
High Point	466+12.86	737.0114				
VPI 14	470+20.00	747.1900		1,900.0000	950.0000	950.0000
VPT	479+70.00	711.5650	-3.7500			
VPC	481+90.00	703.3150	-3.7500	K = 181.8		
Low Point	488+71.82	690.5309				
VPI 15	489+40.00	675.1900		1,500.0000	750.0000	750.0000
VPT	496+90.00	708.9400	4.5000			
VPC	508+00.00	758.8900	4.5000	K = 267.0	SSD = 759.0	
VPI 16	518+00.00	803.8900		2,000.0000	1,000.0000	1,000.0000
High Point	520+01.33	785.9198				
VPT	528+00.00	773.9728	-2.9917			
VPC	529+55.00	769.3356	-2.9917	K = 200.2		
Low Point	535+54.05	760.3747				
VPI 17	536+55.00	748.3936		1,400.0000	700.0000	700.0000
VPT	543+55.00	776.3936	4.0000			
VPC	551+50.00	808.1936	4.0000	K = 257.6	SSD = 745.6	
VPI 18	560+00.00	842.1936		1,700.0004	850.0002	850.0002
High Point	561+80.30	828.7997				
VPT	568+50.00	820.0936	-2.6000			
VPC	570+00.00	816.1936	-2.6000	K = 181.8		
Low Point	574+72.73	810.0482				

VPI	19	576+00.00	800.5936		1,200.0000	600.0000	600.0000
VPT		582+00.00	824.5936	4.0000			
VPC		594+75.00	875.5936	4.0000	K = 254.2	SSD = 740.7	
VPI	20	599+00.00	892.5936		850.0000	425.0000	425.0000
VPT		603+25.00	895.3833	0.6564			
VPC		618+50.00	905.3931	0.6564	K = 289.7	SSD = 790.7	
High Point		620+40.17	906.0172				
VPI	21	625+25.00	909.8237		1,350.0000	675.0000	675.0000
VPT		632+00.00	882.8025	-4.0031			
VPC		633+00.00	878.7994	-4.0031	K = 228.5		
VPI	22	636+00.00	866.7900		600.0000	300.0000	300.0000
VPT		639+00.00	862.6582	-1.3773			
VPC		643+50.00	856.4605	-1.3773	K = 266.9	SSD = 761.4	
VPI	23	647+00.00	851.6400		700.0000	350.0000	350.0000
VPT		650+50.00	837.6400	-4.0000			
VPC		654+25.00	822.6400	-4.0000	K = 181.9		
VPI	24	661+00.00	795.6400		1,350.0000	675.0000	675.0000
Low Point		661+52.56	808.0887				
VPT		667+75.00	818.7387	3.4220			
VPC		680+50.00	862.3697	3.4220	K = 252.5	SSD = 738.1	
High Point		689+13.93	877.1516				
VPI	25	690+50.00	896.5900		2,000.0000	1,000.0000	1,000.0000
VPT		700+50.00	851.5900	-4.5000			
VPI	26	712+00.00	799.8400	-4.5000			

VPC		713+50.00	793.5406	-4.1996	K = 181.8			
Low Point		721+13.63	777.5059					
VPI	27	721+50.00	759.9436		1,600.0000	800.0000	800.0000	
VPT		729+50.00	796.7411	4.5997				
VPI	28	733+00.00	812.8400	4.5997				
VPC		755+00.00	905.2400	4.2000	K = 336.3	SSD = 851.9		
VPI	29	761+00.00	930.4400		1,200.0000	600.0000	600.0000	
VPT		767+00.00	934.2311	0.6319				
VPC		782+00.00	943.7089	0.6319	K = 259.1	SSD = 747.7		
High Point		783+63.70	944.2261					
VPI	30	788+00.00	947.5000		1,200.0000	600.0000	600.0000	
VPT		794+00.00	923.5000	-4.0000				
VPC		814+75.00	840.5000	-4.0000	K = 215.5			
VPI	31	816+00.00	835.5000		250.0000	125.0000	125.0000	
VPT		817+25.00	831.9500	-2.8400				
VPC		823+00.00	815.6200	-2.8400	K = 256.4	SSD = 891.7		
VPI	32	825+00.00	809.9400		400.0000	200.0000	200.0000	
VPT		827+00.00	801.1400	-4.4000				
VPC		849+00.00	704.3400	-4.4000	K = 197.8			
VPI	33	852+00.00	691.1400		600.0000	300.0000	300.0000	
VPT		855+00.00	687.0380	-1.3673				
VPC		864+50.00	674.0483	-1.3673	K = 306.2	SSD = 910.9		
VPI	34	867+00.00	670.6300		500.0000	250.0000	250.0000	
VPT		869+50.00	663.1300	-3.0000				

VPI	35	904+00.00	559.6300	-3.0000

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Ending profile PSR823_TEST1 description

Scenario #2

<* 1 PRINT PROFILE PSR823_TEST2

Beginning profile PSR823_TEST2 description:

		STATION	ELEV	GRADE	TOTAL L	BACK L	AHEAD L
VPI	1	50+23.01	591.4686				
VPC		58+50.00	587.3336	-0.5000	K = 290.9		
Low Point		59+95.45	586.9700				
VPI	2	66+50.00	583.3336		1,600.0000	800.0000	800.0000
VPT		74+50.00	623.3336	5.0000			
VPC		83+50.00	668.3336	5.0000	K = 252.7	SSD = 738.5	
VPI	3	95+00.00	725.8336		2,300.0000	1,150.0000	1,150.0000
High Point		96+13.74	699.9270				
VPT		106+50.00	678.6836	-4.1000			
VPC		122+50.00	613.0836	-4.1000	K = 186.8		
Low Point		130+15.93	597.3820				
VPI	4	131+00.00	578.2336		1,700.0000	850.0000	850.0000
VPT		139+50.00	620.7336	5.0000			
VPC		154+50.00	695.7336	5.0000	K = 255.6	SSD = 742.6	
VPI	5	166+00.00	753.2336		2,300.0000	1,150.0000	1,150.0000
High Point		167+27.78	727.6781				
VPT		177+50.00	707.2336	-4.0000			
VPC		179+00.00	701.2336	-4.0000	K = 183.1		

VPI	6	185+50.00	675.2336		1,300.0000	650.0000	650.0000
Low Point		186+32.39	686.5857				
VPT		192+00.00	695.3836	3.1000			
VPC		245+00.00	859.6836	3.1000	K = 259.3	SSD = 748.0	
VPI	7	252+00.00	881.3836		1,400.0000	700.0000	700.0000
High Point		253+03.70	872.1410				
VPT		259+00.00	865.2836	-2.3000			
VPC		302+00.00	766.3836	-2.3000	K = 816.3		
VPI	8	304+00.00	761.7836		400.0000	200.0000	200.0000
VPT		306+00.00	758.1636	-1.8100			
VPC		329+00.00	716.5336	-1.8100	K = 276.8	SSD = 772.9	
VPI	9	333+00.00	709.2936		800.0000	400.0000	400.0000
VPT		337+00.00	690.4936	-4.7000			
VPC		341+50.00	669.3436	-4.7000	K = 193.5		
VPI	10	347+50.00	641.1436		1,200.0000	600.0000	600.0000
Low Point		350+59.68	647.9662				
VPT		353+50.00	650.1436	1.5000			
VPC		387+00.00	700.3936	1.5000	K = 714.3		
VPI	11	392+00.00	707.8936		1,000.0000	500.0000	500.0000
VPT		397+00.00	722.3930	2.8999			
VPC		412+00.00	765.8912	2.8999	K = 270.3	SSD = 763.7	
High Point		419+83.76	777.2553				
VPI	12	422+00.00	794.8900		2,000.0000	1,000.0000	1,000.0000
VPT		432+00.00	749.8900	-4.5000			

VPC	435+00.00	736.3900	-4.5000	K = 233.3		
VPI 13	442+00.00	704.8900		1,400.0000	700.0000	700.0000
Low Point	445+50.00	712.7650				
VPT	449+00.00	715.3900	1.5000			
VPC	460+70.00	732.9400	1.5000	K = 361.9	SSD = 883.7	
High Point	466+12.86	737.0114				
VPI 14	470+20.00	747.1900		1,900.0000	950.0000	950.0000
VPT	479+70.00	711.5650	-3.7500			
VPC	481+90.00	703.3150	-3.7500	K = 181.8		
Low Point	488+71.82	690.5309				
VPI 15	489+40.00	675.1900		1,500.0000	750.0000	750.0000
VPT	496+90.00	708.9400	4.5000			
VPC	508+00.00	758.8900	4.5000	K = 267.0	SSD = 759.0	
VPI 16	518+00.00	803.8900		2,000.0000	1,000.0000	1,000.0000
High Point	520+01.33	785.9198				
VPT	528+00.00	773.9728	-2.9917			
VPC	529+55.00	769.3357	-2.9917	K = 200.2		
Low Point	535+54.05	760.3747				
VPI 17	536+55.00	748.3936		1,400.0000	700.0000	700.0000
VPT	543+55.00	776.3936	4.0000			
VPC	551+50.00	808.1936	4.0000	K = 257.6	SSD = 745.6	
VPI 18	560+00.00	842.1936		1,700.0000	850.0000	850.0000
High Point	561+80.30	828.7997				
VPT	568+50.00	820.0936	-2.6000			
VPC	570+00.00	816.1936	-2.6000	K = 181.8		
Low Point	574+72.75	810.0478				

VPI	19	576+00.00	800.5936		1,200.0009	600.0004	600.0004
VPT		582+00.00	824.5915	3.9996			
VPC		584+75.00	835.5905	3.9996	K = 624.4		
VPI	20	586+00.00	840.5900		250.0000	125.0000	125.0000
VPT		587+25.00	846.0900	4.4000			
VPC		592+50.00	869.1900	4.4000	K = 265.7	SSD = 757.2	
VPI	21	597+50.00	891.1900		1,000.0000	500.0000	500.0000
VPT		602+50.00	894.3684	0.6357			
VPC		619+25.00	905.0159	0.6357	K = 258.9	SSD = 747.4	
High Point		620+89.55	905.5390				
VPI	22	625+25.00	908.8300		1,200.0000	600.0000	600.0000
VPT		631+25.00	884.8300	-4.0000			
VPC		631+75.00	882.8300	-4.0000	K = 196.2		
VPI	23	634+00.00	873.8299		450.0001	225.0001	225.0001
VPT		636+25.00	869.9900	-1.7066			
VPC		644+75.00	855.4836	-1.7066	K = 255.2	SSD = 836.9	
VPI	24	647+00.00	851.6436		450.0000	225.0000	225.0000
VPT		649+25.00	843.8364	-3.4699			
VPC		651+00.00	837.7641	-3.4699	K = 181.4		
Low Point		657+29.37	826.8449				
VPI	25	658+50.00	811.7400		1,500.0000	750.0000	750.0000
VPT		666+00.00	847.7400	4.8000			
VPC		670+62.00	869.9160	4.8000	K = 247.7	SSD = 731.1	
VPI	26	681+62.00	922.7160		2,200.0000	1,100.0000	1,100.0000

High Point		682+50.98	898.4515				
VPT		692+62.00	877.8189	-4.0816			
VPC		713+50.00	792.5961	-4.0816	K = 193.2		
Low Point		721+38.73	776.4999				
VPI	27	721+50.00	759.9436		1,600.0000	800.0000	800.0000
VPT		729+50.00	793.5294	4.1982			
VPC		760+10.00	921.9950	4.1982	K = 251.5	SSD = 736.7	
VPI	28	764+60.00	940.8870		900.0000	450.0000	450.0000
VPT		769+10.00	943.6770	0.6200			
VPC		784+50.00	953.2250	0.6200	K = 251.8	SSD = 737.2	
High Point		786+06.12	953.7090				
VPI	29	790+00.00	956.6350		1,100.0000	550.0000	550.0000
VPT		795+50.00	936.0190	-3.7484			
VPC		862+25.00	685.8155	-3.7484	K = 334.1		
VPI	30	863+50.00	681.1300		250.0000	125.0000	125.0000
VPT		864+75.00	677.3800	-3.0000			
VPI	31	904+00.00	559.6300	-3.0000			

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Ending profile PSR823_TEST2 description

Scenario #3

<* 1 PRINT PROFILE PSR823_TEST3

Beginning profile PSR823_TEST3 description:

		STATION	ELEV	GRADE	TOTAL L	BACK L	AHEAD L
VPI	1	50+23.01	591.4686				
VPC		58+50.00	587.3336	-0.5000	K = 290.9		
Low Point		59+95.45	586.9700				
VPI	2	66+50.00	583.3336		1,600.0000	800.0000	800.0000
VPT		74+50.00	623.3336	5.0000			
VPC		83+50.00	668.3336	5.0000	K = 252.7	SSD = 738.5	
VPI	3	95+00.00	725.8336		2,300.0000	1,150.0000	1,150.0000
High Point		96+13.74	699.9270				
VPT		106+50.00	678.6836	-4.1000			
VPC		122+50.00	613.0836	-4.1000	K = 186.8		
Low Point		130+15.93	597.3820				
VPI	4	131+00.00	578.2336		1,700.0000	850.0000	850.0000
VPT		139+50.00	620.7336	5.0000			
VPC		154+50.00	695.7336	5.0000	K = 255.6	SSD = 742.6	
VPI	5	166+00.00	753.2336		2,300.0000	1,150.0000	1,150.0000
High Point		167+27.78	727.6781				
VPT		177+50.00	707.2336	-4.0000			
VPC		179+00.00	701.2336	-4.0000	K = 183.1		

```
VPI       6    185+50.00   675.2336          1,300.0000  650.0000  650.0000
Low Point      186+32.39   686.5857
VPT            192+00.00   695.3836    3.1000

VPC            245+00.00   859.6836    3.1000  K =  259.3  SSD = 748.0
VPI       7    252+00.00   881.3836         1,400.0000  700.0000  700.0000
High Point     253+03.70   872.1410
VPT            259+00.00   865.2836   -2.3000

VPC            302+00.00   766.3836   -2.3000  K =  816.3
VPI       8    304+00.00   761.7836          400.0000  200.0000  200.0000
VPT            306+00.00   758.1636   -1.8100

VPC            329+00.00   716.5336   -1.8100  K =  276.8  SSD = 772.9
VPI       9    333+00.00   709.2936          800.0000  400.0000  400.0000
VPT            337+00.00   690.4936   -4.7000

VPC            341+50.00   669.3436   -4.7000  K =  193.5
VPI      10    347+50.00   641.1436        1,200.0000  600.0000  600.0000
Low Point      350+59.68   647.9662
VPT            353+50.00   650.1436    1.5000

VPC            387+00.00   700.3936    1.5000  K =  714.3
VPI      11    392+00.00   707.8936        1,000.0000  500.0000  500.0000
VPT            397+00.00   722.3930    2.8999

VPC            412+00.00   765.8912    2.8999  K =  270.3  SSD = 763.7
High Point     419+83.76   777.2553
VPI      12    422+00.00   794.8900        2,000.0000 1,000.0000 1,000.0000
VPT            432+00.00   749.8900   -4.5000
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VPC             435+00.00   736.3900    -4.5000  K =  233.3
VPI      13     442+00.00   704.8900          1,400.0000  700.0000  700.0000
Low Point       445+50.00   712.7650
VPT             449+00.00   715.3900     1.5000

VPC             460+70.00   732.9400     1.5000  K =  361.9  SSD = 883.7
High Point      466+12.86   737.0114
VPI      14     470+20.00   747.1900          1,900.0000  950.0000  950.0000
VPT             479+70.00   711.5650    -3.7500

VPC             481+90.00   703.3150    -3.7500  K =  181.8
Low Point       488+71.82   690.5309
VPI      15     489+40.00   675.1900          1,500.0000  750.0000  750.0000
VPT             496+90.00   708.9400     4.5000

VPC             508+00.00   758.8900     4.5000  K =  267.0  SSD = 759.0
VPI      16     518+00.00   803.8900         2,000.0000 1,000.0000 1,000.0000
High Point      520+01.33   785.9198
VPT             528+00.00   773.9728    -2.9917

VPC             529+55.00   769.3357    -2.9917  K =  200.2
Low Point       535+54.05   760.3747
VPI      17     536+55.00   748.3936          1,400.0000  700.0000  700.0000
VPT             543+55.00   776.3936     4.0000

VPC             551+50.00   808.1936     4.0000  K =  257.6  SSD = 745.6
VPI      18     560+00.00   842.1936         1,700.0000  850.0000  850.0000
High Point      561+80.30   828.7997
VPT             568+50.00   820.0936    -2.6000

VPC             570+00.00   816.1936    -2.6000  K =  181.8
Low Point       574+72.75   810.0478
```

VPI	19	576+00.00	800.5936		1,200.0009	600.0004	600.0004
VPT		582+00.00	824.5915	3.9996			
VPC		584+75.00	835.5905	3.9996	K = 624.4		
VPI	20	586+00.00	840.5900		250.0000	125.0000	125.0000
VPT		587+25.00	846.0900	4.4000			
VPC		591+25.00	863.6900	4.4000	K = 277.6	SSD = 774.0	
VPI	21	596+25.00	885.6900		1,000.0000	500.0000	500.0000
VPT		601+25.00	889.6797	0.7979			
VPC		619+25.00	904.0424	0.7979	K = 250.1	SSD = 734.7	
High Point		621+24.57	904.8386				
VPI	22	625+25.00	908.8300		1,200.0000	600.0000	600.0000
VPT		631+25.00	884.8300	-4.0000			
VPC		631+75.00	882.8299	-4.0000	K = 196.2		
VPI	23	634+00.00	873.8299		450.0000	225.0000	225.0000
VPT		636+25.00	869.9900	-1.7066			
VPC		644+75.00	855.4836	-1.7066	K = 255.2	SSD = 836.9	
VPI	24	647+00.00	851.6436		450.0000	225.0000	225.0000
VPT		649+25.00	843.8364	-3.4699			
VPC		651+00.00	837.7641	-3.4699	K = 181.4		
Low Point		657+29.37	826.8449				
VPI	25	658+50.00	811.7400		1,500.0000	750.0000	750.0000
VPT		666+00.00	847.7400	4.8000			
VPC		671+62.00	874.7160	4.8000	K = 248.3	SSD = 732.1	
VPI	26	681+62.00	922.7160		2,000.0000	1,000.0000	1,000.0000

High Point		683+54.07	903.3257				
VPT		691+62.00	890.1839	-3.2532			
VPC		707+80.00	837.5469	-3.2532	K = 197.0		
VPI	27	713+80.00	818.0276		1,200.0000	600.0000	600.0000
Low Point		714+20.95	827.1212				
VPT		719+80.00	835.0530	2.8376			
VPC		752+00.00	926.4223	2.8376	K = 270.6	SSD = 786.6	
VPI	28	755+00.00	934.9350		600.0000	300.0000	300.0000
VPT		758+00.00	936.7950	0.6200			
VPC		784+50.00	953.2250	0.6200	K = 251.8	SSD = 737.2	
High Point		786+06.12	953.7090				
VPI	29	790+00.00	956.6350		1,100.0000	550.0000	550.0000
VPT		795+50.00	936.0190	-3.7484			
VPC		862+25.00	685.8154	-3.7484	K = 334.1		
VPI	30	863+50.00	681.1300		250.0000	125.0000	125.0000
VPT		864+75.00	677.3800	-3.0000			
VPI	31	904+00.00	559.6300	-3.0000			

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Ending profile PSR823_TEST3 description

APPENDIX - D

Plan Sheets (1"=100'H)

Profile Sheets (1"=100'H, 1"=25'V)