Report to Congress **VOLUME II**

Potential Improvements to the Washington—Richmond Railroad Corridor

National Railroad Passenger Corporation

May 1999

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VOLUME II

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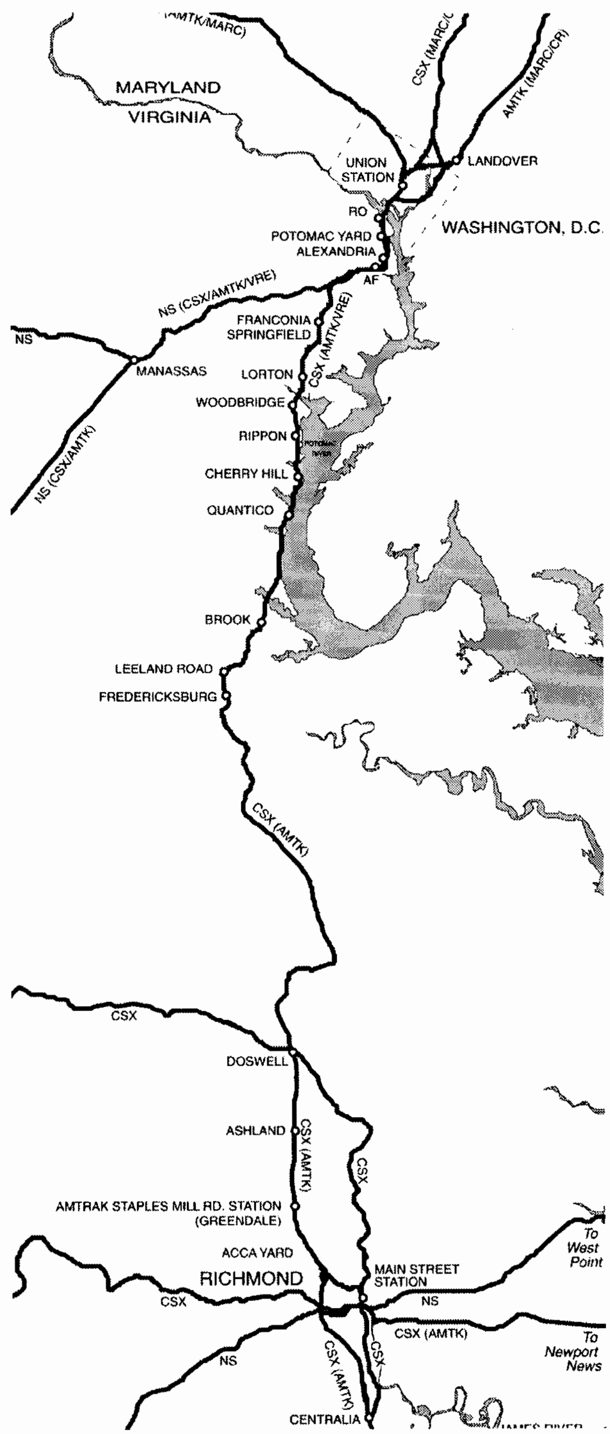
Report to Congress **APPENDIX A**

Potential Improvements to the Washington—Richmond Railroad Corridor



CURVE ANALYSIS WASHINGTON TO RICHMOND

Speed Analysis of Curves and Civil Impacts

May 1999

APPENDIX A
CURVE ANALYSIS WASHINGTON TO RICHMOND
SPEED ANALYSIS OF CURVES AND CIVIL IMPACTS

Recent simulations and analyses of future intercity, commuter, and freight operating requirements have concluded that significant track changes are required to achieve trip time goals, improve the reliability of intercity and commuter operations, increase capacity, and provide improved operating flexibility. These needs would be satisfied by reconfiguring major terminals and interlockings, removing existing crossovers and turnouts, and installing new (mostly higher speed) turnouts and crossovers to implement desired alignment and configuration changes. Revised interlocking layouts also will be required to optimize train operations entering and leaving the additional tracks, and passing sidings that also have been recommended. The number of interlockings that will be modified and the new interlockings that are recommended are significant. Details of recommended programs are contained in the body of the report. The proposed track configurations are illustrated in Appendix D. The interlocking changes that have been recommended are summarized in the body of the report.

Track curvature imposes the most severe constraint on trip time. Consequently, realigning or changing the physical characteristics of existing curves is a primary means of reducing trip times included in this program. Several types of fixed-plant improvements can minimize the constraints to speed associated with curves:

- increasing superelevation to the maximum allowable for a particular track alignment;
- changing horizontal and vertical alignment, either within the existing right-of-way, or by acquiring land outside the existing right-of-way;
- increasing the amount of unbalanced superelevation used to calculate speeds through curves to minimize track shifts; and
- modifying spirals (the length of track that provides a smooth transition from level, tangent track to curved, superelevated track) by eliminating superelevation runoff onto the adjacent tangent sections.

The rationale for the realignments recommended in this program is summarized in this appendix.

OBJECTIVE

The results of a speed analysis of curves, and the civil impacts associated with realigning them for the Richmond Line segment of the Northeast Corridor (between Washington and Richmond) was performed by De Leuw, Cather & Co. The results of those analyses are summarized in the following subsection.

The goal of the Plan is to reduce the trip time between Washington and Richmond to less than 2 hours. There are several changes to the methods of operation, to the facilities, and to the equipment that can contribute to the overall goal.

One of these changes is to increase the speed of the trains. Increasing the speed may require one or all of the following:

- more powerful or additional locomotives;
- coaches that can provide comfort at greater unbalanced speeds - tilt vehicles will be needed for operation at unbalanced superelevation greater than 5 inches;
- tracks and track beds that can withstand the energies transferred at higher speed (including greater imbalance); and
- alignments that can accommodate the greater speeds without exceeding acceptable limits for:
  - actual superelevation,
  - unbalanced superelevation,
  - lateral acceleration to the passenger
  - spiral lengths limited by:
    - rate of change of change of actual superelevation or twist,
    - rate of change of change of lateral acceleration to the passenger or jerk.

The objective of this analysis was to propose realignments to the existing curves so that proposed speeds can be reached and to identify civil impacts caused by the proposed realignments. The results of the analysis were used to develop a project estimate for realigning curves. The methodology employed to perform the analysis and the results of the analysis are presented in this subsection.

CRITERIA AND SCOPE

Criteria

The criteria utilized in the performance of this analyses were as follows.

Maximum actual superelevation should not exceed 6 inches. Actual superelevation was chosen in increments commensurate with the runoff rates specified by CSX and Conrail for the segments between RO Interlocking and Main St. Station and Virginia Avenue and RO Interlockings, respectively, and speed.

Maximum unbalanced superelevation should not exceed 5 inches, which assumes use of non-tilting equipment.

Maximum lateral acceleration parallel to the floorboards should not exceed 0.15 g.

For conventional coach equipment at 6 inches of unbalanced superelevation the roll angle should be 2.87 degrees and lateral acceleration parallel to floorboards should be 0.15 g.

All actual superelevation should be introduced and removed over the entire length of the spiral; actual superelevation should not be introduced and removed on the adjacent tangents.

Maximum jerk rate through the spiral should be 0.04 g per sec.

Maximum track twist rate (introduction and removal rate of actual superelevation) through existing spirals for speeds less than, and equal to 90 miles per hour, should be 1/2-inch in 50 feet.

Track twist rates for alignments at proposed speeds specified by CSX and Conrail:

CSX - RO to Main St. Station -

speeds from 0 to 50 miles per hour, 1/2-inch per 31 feet;
speeds from 51 to 70 miles per hour, 1/2-inch per 39 feet; and
speeds from 71 to 90 miles per hour, 1/2-inch per 50 feet.

Conrail - Virginia Avenue Interlocking to RO Interlocking -

speeds from 0 to 60 miles per hour, 1/2-inch per 31 feet;
speeds from 61 to 90 miles per hour, 3/8-inch per 31 feet; and
speeds from 91 to 100 miles per hour, 1/4-inch per 31 feet.

Scope

The curves to be considered in the analysis were those located between Washington Union Station and Main St. Station. Studies recently performed for VDRPT proposed maximum speeds for individual curves. These were speeds were used as initial speed goals, but were modified as necessary to reflect the iterative analysis process subsequently defined. Maximum speed varied by segment of the corridor:

- Washington Union Station to RO Interlocking - 35 mph;
- RO to Alexandria Station - 65 mph;
- Alexandria Station to Staples Mill Rd. Station - 90 mph; and
- Staples Mill Rd. Station to Main St. Station - 40 mph.

Presently maximum speed for passenger trains in the corridor is 70 mph. Maximum authorized speeds vary by location and are specified in the CSX and Conrail Employees Timetable. The analysis was based on data for Track 2 between Washington Union Station and RO interlocking and Track 3 between RO and Main St. Station[1].

One product of the analysis was the conclusion that, with a limited number of exceptions, each curve on the corridor had to be modified to some degree - usually both spiral length or superelevation changed. For each curve the highest speeds that can be reached without realignment or adjustment to the actual superelevation on each of the existing curves, while satisfying safety and comfort criteria, were calculated. An iterative process was then followed to identify the maximum speed attainable (in five mph increments) on each curve. Changes to superelevation and spiral length were determined.

The analysis indicates that the speed improvements can be attained in a limited number of instances by merely surfacing and aligning the track as part of a normal maintenance cycle.

The study did not identify specific curves that should have their degree of curvature decreased to enable speeds to be increased. Curves whose degree of curvature is two degrees or more would support speeds of 85 mph or less[2], and therefore would be candidates for further detailed analysis in subsequent studies. Curves to be modified should be selected on the basis of their cost effectiveness - the cost per minute saved as the result of the modification. The analysis will require that Train Performance Calculation (TPC) runs be made to determine the time savings as the result of each curve modification. The cost of each modification also will have to be estimated, and by dividing the cost by the time for all curve modifications a cost effective listing could be developed, which would assist the planner in evaluating which improvements should be funded.

A second product was the calculation of the highest speeds that can be reached with realignment to improve spiral lengths and with adjustment to the actual superelevation, while

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[1]Obtained from Amtrak Track Geometry Car Run of October 1996.

[2]Assuming maximum actual superelevation of six inches and maximum unbalanced superelevation of five inches.

satisfying safety and comfort criteria. The result of the analysis was a list of proposed realignments to reach the proposed speeds. In addition to safety and comfort criteria the proposed realignments will comply with standard CSX and CR field maintenance practices. Curves requiring shifts in excess of three-feet are shown in Table A-1. The seven curves requiring the largest shifts are located between Crystal City and Washington Union Station. They may require further study to verify their practicality and feasibility. Curves requiring shifts between 6 inches and 3 feet are shown in Table A-2. Curves requiring shifts of about 6 inches are shown in Table A-3.

The data on the curves located between Staples Mill Rd. and Main St. is not readily available. However, the superelevation and spiral length requirements to meet the 40 mph maximum speed were calculated and are shown in Table A-4.

The preliminary analysis performed indicated that no undergrade bridges would be impacted by the realignments. Initially, it would appear that some overhead bridges will have to be rebuilt to enable railroad clearance requirements to be satisfied. Actual bridge impacts will need to be confirmed on a bridge-by-bridge basis. Where there are no undergrade bridges and the shifts are less than 6 inches, the realignments can be performed with regular maintenance procedures, and will not result in significant additional civil costs. Curves that have turnouts to industrial spurs within their length have not been identified, but need to be; since turnouts will limit the actual superelevation and the speed in the curve. In these cases the realignment will be more significant resulting in increased costs.

The analysis technique (a spreadsheet) made it easier to answer "what-if?" questions, such as, how much will the proposed speed be reduced if the realignment shift was reduced so as not to impact bridge B? Or, how much additional shift would be required to increase the proposed speed on curve A?

The analysis technique resulted in an estimate that is considered accurate to plus and minus 0.1-foot for simple spiraled curves, provided that the radius (degree of curvature) was not changed or the spirals were not changed by a significantly unequal amount. For compound curves the analysis technique is not reliable. For these more challenging realignments dummy cogos should be run to determine the shifts. A dummy cogo is a cogo[3] that properly uses all of the geometric elements (degree of curvature, spiral length, and intersection angle) of the alignment but the coordinates are not associated to any specific location. A dummy cogo previously was performed on a two centered compound curve on the New Haven Line between

[3]Cogo, short for coordinate geometry, is a technique used to verify the mathematical feasibility of a concept.

Table A-1
Curves Requiring Shifts in Excess of 3 Feet

Cve No.	Trk No.	Curve degrees	Radius feet	South Spiral	North Spiral	Avg Ea Exist	90 mph V	Avg Ea Prop	Delta Ea	Optimal Ls	Expected Max Shift (ft)
108.6	3	5.1500	1,113	200	241	**3.75**	*65*	**6.00**	2.25	468	**6.70**
108.5	3	4.4667	1,283	177	194	1.25	*65*	**6.00**	4.75	468	**6.10**
109.1	3	4.7000	1,219	177	125	**1.75**	45	**6.00**	4.25	372	**4.20**
92.8	3	2.0000	2,865	329	194	**4.50**	**85**	**5.50**	1.00	550	**3.85**
69.5	3	1.5833	3,619	292	167	**5.00**	**90**	**6.00**	1.00	600	**3.82**
94.8	3	2.0000	2,865	218	362	**1.50**	**85**	**5.50**	4.00	550	**3.71**
102.7	3	2.0500	2,795	306	255	**1.75**	**85**	**5.50**	3.75	550	**3.54**
79.3	3	1.5000	3,820	200	280	1.50	**90**	**6.00**	4.50	600	**3.49**
57.8	3	2.1167	2,707	375	399	**4.50**	**85**	**6.00**	1.50	600	**3.38**
97.5	3	2.0500	2,795	279	334	1.00	**85**	**5.50**	4.50	550	**3.35**
64.5	3	2.0000	2,865	296	279	**4.25**	**85**	**5.50**	1.25	550	**3.27**
90.2	3	2.0500	2,795	334	292	1.50	**85**	**5.50**	4.00	550	**3.24**
99.8	3	2.0500	2,795	292	348	**3.25**	**85**	**5.50**	2.25	550	**3.24**
32.9	3	2.0000	2,865	296	344	**2.50**	**85**	**5.50**	3.00	550	**3.13**

Table A-2
Curves Requiring Shifts Between 6 Inches and 3-Feet

82.7	3	2.1167	2,707	417	408	1,015	1.75	85	6.00	4.25	600	2.98
66.8	3	2.0667	2,772	325	338	1,424	2.50	85	5.50	3.00	550	2.96
61.4	3	2.0000	2,865	338	320	1,335	4.75	85	5.50	0.75	550	2.91
62.5	3	2.0000	2,865	325	357	3,836	1.00	85	5.50	4.50	550	2.86
83.1	3	2.0000	2,865	357	338	2,717	5.00	85	5.50	0.50	550	2.74
27.2	3	2.0000	2,865	404	344	2,872	4.75	85	5.50	0.75	550	2.68
56.5	3	2.0667	2,772	385	367	1,647	4.50	85	5.50	1.00	550	2.52
109.2	3	2.8000	2,046	130	148	357	3.50	45	6.00	2.50	372	2.47
50.5	3	2.0000	2,865	367	371	2,241	4.75	85	5.50	0.75	550	2.44
54.9	3	2.0000	2,865	367	385	4,179	4.50	85	5.50	1.00	550	2.44
81.6	3	2.0000	2,865	375	404	3,033	1.25	85	5.50	4.25	550	2.35
50.1	3	2.1333	2,686	315	325	1,090	4.50	80	5.00	0.50	500	2.34
106.5	3	2.0667	2,772	292	190	1,299	1.75	70	5.50	3.75	429	2.22
68.0	3	2.5667	2,232	436	446	2,427	4.50	75	5.50	1.00	550	2.10
30.3	3	2.0000	2,865	408	399	1,720	4.50	85	5.50	1.00	550	2.08
108.9	3	2.0000	2,865	130	130	1,109	3.75	45	6.00	2.25	372	1.77
26.7	3	2.0000	2,865	427	450	1,127	4.00	85	5.50	1.50	550	1.75
49.5	3	2.0500	2,795	436	446	2,246	4.50	85	5.50	1.00	550	1.68
34.8	3	2.0667	2,772	450	469	1,174	5.00	85	5.50	0.50	550	1.50
53.6	3	1.9500	2,938	390	450	2,649	2.00	85	5.00	3.00	500	1.39
98.1	3	1.3333	4,297	265	380	4,364	4.25	90	4.50	0.25	450	1.28
104.8	3	2.0500	2,795	325	204	1,907	1.50	40	5.50	4.00	341	1.11
51.1	3	2.0500	2,795	404	362	1,925	4.50	80	4.50	-	450	1.07
48.9	3	2.4000	2,387	431	510	1,377	2.50	75	4.50	2.00	450	1.01
103.4	3	0.8000	7,162	194	232	1,368	4.50	90	4.50	-	450	0.96
91.3	3	0.5000	11,459	139	111	1,094	5.00	90	5.00	-	500	0.86
70.1	3	1.3333	4,297	204	292	2,672	4.25	90	3.50	(0.75)	350	0.78
93.8	3	1.0833	5,289	241	171	2,286	4.50	90	3.50	(1.00)	350	0.73
85.5	3	0.5000	11,459	121	315	1,178	4.50	90	4.50	-	450	0.68
23.3	3	1.0000	5,730	344	408	1,290	2.00	90	3.00	1.00	300	0.56
82.3	3	1.0000	5,730	130	136	502	4.75	90	3.00	(1.75)	300	0.53

Table A-3
Curves Requiring Throws of About 6 Inches

78.4	3	1.0000	5,730	158	265	1,328	1.00	**90**	**3.00**	2.00	300	**0.47**
95.8	3	0.3333	17,189	98	139	3,716	**4.50**	**90**	4.50	-	450	**0.47**
25.6	3	1.5000	3,820	344	413	4,495	2.00	**90**	**4.00**	2.00	400	**0.45**
84.1	3	1.0000	5,730	181	375	2,040	**4.50**	**90**	3.00	(1.50)	300	**0.42**
65.7	3	1.2500	4,584	357	283	1,159	**4.50**	**90**	**3.50**	(1.00)	350	**0.39**
38.9	3	1.0000	5,730	306	209	1,192	**1.75**	90	**3.00**	1.25	300	**0.34**
137.5	2	7.8500	730	155	135	615	2.00	35	**2.50**	0.50	155	**0.33**
80.5	3	0.8333	6,876	162	93	3,808	**1.50**	**90**	**2.50**	1.00	250	**0.33**
31.1	3	1.0000	5,730	218	292	3,047	**4.50**	**90**	**3.00**	(1.50)	300	**0.31**
138.1	2	5.8500	979	130	155	770	1.25	45	1.25	-	130	**0.30**
36.1	3	1.0000	5,730	362	273	1,493	**5.25**	90	**3.00**	(2.25)	300	**0.30**
40.7	3	1.0000	5,730	325	362	1,379	1.50	90	**3.00**	1.50	300	**0.30**
28.2	3	1.0000	5,730	315	232	1,062	**4.50**	**90**	3.00	(1.50)	300	**0.26**
58.2	3	1.1000	5,209	279	246	1,100	**5.00**	**90**	**3.00**	(2.00)	300	**0.24**
20.0	3	1.0000	5,730	241	315	2,319	1.00	**90**	**3.00**	2.00	300	**0.23**
101.8	3	0.6667	8,594	227	246	3,952	5.00	**90**	**1.00**	(4.00)	117	**0.23**
40.1	3	0.9333	6,139	269	302	1,123	**1.25**	90	**2.50**	1.25	250	**0.19**
6.3	3	1.0000	5,730	269	255	2,806	-	**90**	**3.00**	3.00	300	**0.18**
51.7	3	1.0000	5,730	255	279	4,342	**4.50**	**90**	**3.00**	(1.50)	300	**0.18**
138.5	2	0.9500	6,031	175	105	525	0.50	35	0.50	-	105	**0.14**
41.5	3	1.0000	5,730	279	329	1,869	**1.25**	90	**3.00**	1.75	300	**0.13**
17.2	3	0.5000	11,459	232	186	835	0.75	**90**	**1.50**	0.75	150	**0.11**
79.0	3	0.5000	11,459	170	130	515	**2.00**	**90**	2.00	-	200	**0.08**
15.5	3	0.3333	17,189	130	162	557	**-**	35	-	-	5	**0.06**
86.5	3	0.5000	11,459	194	194	1,585	**1.25**	**90**	**1.50**	0.25	150	**0.06**
79.8	3	0.5000	11,459	120	90	360	1.50	**90**	1.50	-	150	**0.05**
45.5	3	0.5000	11,459	190	162	1,734	**1.25**	90	**1.50**	0.25	150	**0.05**
10.3	3	0.5000	11,459	125	111	1,600	3.25	**90**	**1.50**	(1.75)	150	**0.04**
19.2	3	0.4167	13,751	107	111	404	-	**90**	**1.50**	1.50	150	**0.03**
61.9	3	0.5000	11,459	116	125	2,490	**4.50**	**90**	**1.50**	(3.00)	150	**0.03**

Table A-4
Curves Staples Mill road to Main Street

Cve No.	Trk No.	Curve degrees	Radius feet	South Spiral	North Spiral	Total Measured length	Avg Ea Exist	90 mph V	Avg Ea Prop	Delta Ea	Optimal Ls	Expected Max Shift
3.0	3	0.3333	17,189	0	0	0	-	40	0.50	0.50	31	**0.00**
3.6n	3	3.0000	1,910	0	0	0	-	40	1.50	1.50	93	**0.19**
3.3n	3	4.0000	1,432	0	0	0	-	40	2.00	2.00	124	**0.45**
2.9n	3	0.8333	6,876	0	0	0	-	40	0.50	0.50	31	**0.01**
2.6n	3	2.3333	2,456	0	0	0	-	40	1.00	1.00	62	**0.07**
2.4n	3	6.0000	955	0	0	0	-	40	2.50	2.50	155	**1.05**
2.2n	3	4.0000	1,432	0	0	0	-	40	2.00	2.00	124	**0.45**
1.9n	3	4.5000	1,273	0	0	0	-	40	2.00	2.00	124	**0.50**
1.7n	3	6.0000	955	0	0	0	-	40	2.50	2.50	155	**1.05**
1.5ncc	3	6.0000	955	0	0	0	-	40	2.50	2.50	155	**1.05**
1.2nr	3	8.0000	716	0	0	0	-	40	4.00	4.00	248	**3.58**
1.2nr	3	0.3000	19,099	0	0	0	-	40	0.50	0.50	31	**0.00**
0.7nr	3	2.9167	1,964	0	0	0	-	40	1.50	1.50	93	**0.18**
0.7nr	3	4.0000	1,432	0	0	0	-	40	2.00	2.00	124	**0.45**
0.4n	3	8.0000	716	0	0	0	-	40	4.00	4.00	248	**3.58**
0.2nr	3	6.0000	955	0	0	0	-	35	0.50	0.50	76	**0.25**
0.2nr	3	4.0000	1,432	0	0	0	-	35	0.00	-	56	**0.09**

Table A-5
Compound Curves

109.3cc	3	5.0667	1,131	160	0	355	3.50	45	6.00	2.50	372	5.10
77.5cc	3cc	1.9000	3,016	306	0	798	2.25	90	6.00	3.75	600	4.97
59.1cc	3cc	3.0833	1,858	362	0	1,155	3.50	70	6.00	2.50	468	4.91
59.7cc	3cc	2.5000	2,292	292	0	1,085	3.00	75	5.00	2.00	500	4.55
28.9cc	3cc	2.0000	2,865	390	0	2,125	2.00	85	5.50	3.50	550	4.40
59.3cc	3cc	3.9000	1,469	162	0	348	3.00	60	5.00	2.00	390	4.31
67.7cc	3cc	1.9667	2,913	115	290	705	4.50	85	5.00	0.50	500	3.39
108.1cc	3cc	2.0000	2,865	335	0	805	1.50	65	6.00	4.50	468	3.19
29.6cc	3cc	2.0833	2,750	435	454	1,283	4.50	85	6.00	1.50	600	2.59
73.1cc	3cc	2.0000	2,865	446	367	1,045	4.50	85	5.50	1.00	550	2.44
105.2cc	3cc	1.8000	3,183	111	0	329	1.75	70	5.50	3.75	429	2.41
67.4cc	3cc	1.6333	3,508	218	0	1,693	3.50	90	4.50	1.00	450	2.41
59.1	3cc	2.9000	1,976	213	279	696	2.75	70	5.00	2.25	390	2.25
137.1cc	3	6.2500	917	195	0	260	2.00	25	2.00	-	195	1.73
59.9cc	3cc	2.0000	2,865	325	296	2,634	1.25	80	4.50	3.25	450	1.67
108.2cc	3cc	1.4000	4,093	355	245	760	1.50	65	6.00	4.50	468	1.62
89.1cc	3cc	1.5000	3,820	385	181	951	-	65	-	-	135	1.42
72.9cc	3cc	1.2333	4,646	255	0	1,396	3.00	90	3.50	0.50	350	1.10
77.6cc	3cc	1.1000	5,209	209	0	974	1.00	90	3.00	2.00	300	0.72
77.7cc	3cc	0.4000	14,324	130	181	617	4.75	90	4.75	-	475	0.61
75.6cc	3cc	1.0667	5,372	140	230	920	1.75	90	3.00	1.25	300	0.55
48.6cc	3	1.3000	4,407	269	334	789	1.00	90	3.50	2.50	350	0.47
136.9cc	3	2.4000	2,387	80	180	1,020	1.00	25	1.00	-	180	0.45
136.7cc	3	4.4000	1,302	180	135	1,295	1.50	25	1.50	-	180	0.45
48.4cc	3	0.9000	6,366	255	0	774	1.00	90	2.50	1.50	250	0.41
75.5cc	3cc	0.9000	6,366	148	0	728	1.75	90	2.50	0.75	250	0.41
137.2cc	3	2.2000	2,604	150	0	265	1.25	35	1.25	-	150	0.36
74.7	3cc	0.7833	7,314	290	0	400	1.75	90	1.50	(0.25)	150	0.35
105.3cc	3cc	1.0000	5,730	139	232	2,833	1.75	55	3.00	1.25	234	0.26
137cc	3	1.1000	5,209	125	0	205	0.50	25	0.50	-	125	0.12
29.3cc	3cc	0.2500	22,919	315	0	2,110	2.00	90	2.00	-	200	0.11
88.1cc	3cc	0.5667	10,111	88	0	5,524	1.00	90	1.50	0.50	150	0.09
109.4cc	3	1.0000	5,730	175	148	1,472	1.75	45	3.00	1.25	186	0.09
74.7	3cc	0.5000	11,459	110	144	2,449	1.25	90	1.50	0.25	150	0.04

New Rochelle, NY and New Haven, CT, which was judged to be an extreme case[4]. From this cogo analysis it was judged that the maximum predicted shift will not be exceeded throughout the curve. However, the general characteristics of the shifting shown for compound curves should not be relied upon. The data on the compound curves is shown in Table A-5.

METHODOLOGY

Soft Realignments

There are two types of alignment changes: soft and hard. Soft alignment changes are changes in unbalanced superelevation, lateral acceleration to the passenger, and jerk that do not require physical changes. Therefore, there would be no cost associated with obtaining desired the speeds. These realignments would assume that the existing track twist (rate of introduction of superelevation) is acceptable. However, the present analysis did not identify any soft realignments between Washington and Richmond.

Hard Realignments

Hard alignment changes are changes to actual superelevation, degree of curvature, and/or spiral lengths. Hard changes result in a physical change to the track, and when certain thresholds are reached, hard changes will impact adjacent or supporting facilities, such as, overhead bridges, undergrade bridges, signal towers, catenary towers, station platforms, etc.

Actual Superelevation on Tangent, Maximum Twist, etc. To meet comfort standards it was not considered acceptable to extend actual superelevation or track twist on to the tangents. Introduction and removal of actual superelevation should be linear, and should occur over the length of the spiral. As curve improvements are implemented occurrences of superelevation on tangents should be eliminated.

Shifts and Impacts

Right of way is generally not considered a factor unless the shift is very large and in those cases right of way would have been considered separately. The shifts identified in this study were not considered sufficient to require right-of-way acquisition. In general, the impacts of track shifts on overhead and undergrade bridges are of greatest concern, as is a determination whether the change can be made as part of a routine track maintenance surfacing operation.

Although each bridge located on the body of a curve ultimately will have to be individually evaluated to determine the impact of the assumed track shift, for these analyses it was

[4]The Northeast Corridor Transportation Plan, New York City to Boston, Volume 2, Appendix I, July 1995.

generally assumed that if a specific shift exceeded the followings limits, the bridge would be impacted:

- open deck bridges with no additional improvement work proposed--any shift or change in superelevation;
- open deck bridges with through girders, or through deck girders scheduled for tie replacement--6 inches;
- open deck bridges with deck girders scheduled for tie replacement--1-foot;
- open deck bridges scheduled for conversion to ballasted deck--2 feet;
- ballasted bridges--2 feet; and
- overhead bridges--3 feet.

Bridges requiring replacement should be designed to accommodate the proposed alignment changes.

It also has been assumed that realignments that require shifts of 6 inches, and less, would be accomplished through regular maintenance practices and procedures. If the shift exceeds 6 inches, the track shifting cannot be done as part of maintenance and will require an independently scheduled effort.

Analysis Guidelines, Assumptions and Techniques

The analysis process utilized to analyze speeds and curves, and evaluate impacts on structures is subsequently described. The following are the guidelines, assumptions, and techniques for doing the analysis.

Degree of Curvature, Radius. The radius and degree of curvature were not changed.

Actual Superelevation. For curves whose superelevation is proposed to be changed, superelevation has been assumed to be implemented in increments in accordance with the way superelevation is introduced in the spiral by railroad maintenance personnel.

Unbalanced Superelevation. Unbalanced superelevation was computed from the following equation.

$$E_u = 0.0007 * D_c * V^2 - E_a$$

where E_u is unbalanced superelevation in inches
E_a is actual superelevation in inches
D_c is degree of curvature in decimal degrees
V is speed in miles per hour.

In accordance with previous agreed assumptions, unbalanced superelevation was limited to a maximum of 5 inches.

Lateral Acceleration Parallel to the Vehicle's Floor boards. When unbalanced superelevation occurs, passengers are subjected to a steady state lateral acceleration. This acceleration is the component of centripetal acceleration that is parallel to the floor boards of the vehicle. The calculation for this component takes into account the floor board rotation due to actual superelevation and the roll of the car body as it's suspension responds to the centripetal lateral acceleration. The lateral acceleration is computed from the following equation.

$$A_L = \{[(E_a + E_u) / G * COS(THETA - PHI * E_u / 6)] - SIN(THETA - PHI * E_u / 6)\} * g$$

where, A_L is lateral acceleration parallel to floor boards in g
THETA is the angle due to the actual superelevation = ARCSIN(E_a /G)
G = distance between rail head centers = 60 inches
PHI is the vehicle roll angle per 6 inches of unbalanced superelevation = 2.87 degrees per 6 inches of E_u.

The PHI value of 2.87 was derived from conventional coach data provided on page 21 of the report for the FRA entitled *Railroad Passenger Ride Safety*, revised April 1989. Conventional non-tilting equipment has to be considered since either tilting or non-tilting equipment ultimately may be used. The tests reported indicated that both the LRC Coach (tilt capability cut out) and the Amfleet Coach reached 0.15 g of steady state lateral acceleration at 6 inches of unbalanced superelevation. By substituting these values into the above equation a PHI value of 2.87 is found calculated all values of actual superelevation up to 6 inches.

For prior projects, review of previous research and consultation with the FRA lead to the recommendation that 0.15 g should be the lateral acceleration limit. This analyses performed assumed that 0.15 g to be the lateral acceleration limit. Vehicle test data indicates that 0.15 g will be reached at 6 inches of unbalanced superelevation, therefore as long as unbalanced superelevation is limited to 5 inches, the lateral acceleration limit of 0.15 g will not be exceeded.

The PHI value is based upon available data for conventional non-tilting equipment. It is unlikely that new, non-tilting equipment will have a larger PHI coefficient, however, it might have a smaller value. A smaller PHI value would result in smaller lateral accelerations (good for passenger comfort) and in shorter comfort spiral lengths that would be based on a maximum jerk rate (jerk rate and comfort spiral are discussed in the following subsection). Consequently, spirals established based on the PHI value of 2.87 will be longer than necessary if the new non-tilting equipment has a smaller PHI. Therefore, the construction impacts resulting from shifts determined by the PHI value established for this report will be conservative.

The Comfort Spiral, Jerk, and Jolt. The comfort spiral transitions the passenger through a change in lateral acceleration (unbalanced superelevation) at a comfortable rate. Assuming that a vehicle's speed is constant while traversing a spiral, unbalanced superelevation (lateral acceleration) changes linearly as the passenger travels along the spiral. This is because: degree of curvature changes linearly along a spiral; actual superelevation is introduced linearly along the spiral; and vehicle roll is linearly related to lateral acceleration. The change in lateral acceleration is referred to as jerk, with units of g per sec.

The jerk is computed by dividing the change in lateral acceleration (which is found by using the above equation and the change in unbalanced superelevation) by the time it takes for the passenger to travel over the spiral. The time is found by dividing the spiral length by the vehicle speed, with appropriate adjustments for units.

After a jerk rate has been established for a project, the minimum comfort spiral length can be computed by dividing the change in lateral acceleration by the jerk rate, and multiplying the quotient by the vehicle speed:

$$L_s = A_L / J * V = A_L / 0.04 * 88 / 60 * V = 36.67 * A_L * V$$

where, L_s is minimum comfort spiral length in feet
J is maximum jerk rate in g per sec
A_L is found from the earlier equation as a function of unbalanced superelevation.

AREA recommends 0.03 g per sec as a maximum jerk rate, when conditions permit. But where the cost of the realignment of existing tracks will be excessive the AREA recommends that the jerk rate should not exceed 0.04 g per sec. For this analysis a jerk rate of 0.04 g per sec for non-tilt train equipment was assumed.

The *Railroad Passenger Ride Safety* report, cited above, lists the lateral acceleration and jerk limits for several railroads. Jerk limits range from 0.03 to 0.1 g per sec. It is generally true that when a railroad accepts a higher jerk rate, it accepts a lower lateral acceleration. This is consistent with the observation reported in the same report that people are able to tolerate larger jolts when they are in a lower steady state lateral acceleration environment.

A jolt is also a rate of change of lateral acceleration per second, but it is considered as an occurrence that occurs in 1 second. A jolt is usually a response to a track irregularity. When jolts exceed 0.25 g per sec it is usually a sign that, for that speed, the track needs adjustment. The jerk through a spiral usually occurs over several seconds and, therefore, is not considered a jolt.

Usually back and forth car body rolling occurs when a track irregularity is encountered. The more violent the rolling the greater the jolt. When the jolt is measured as a lateral acceleration parallel to the floor boards, the position of the accelerometer affects the magnitude of the reading. In a double deck car, for the same track irregularity, a passenger on the lower level near the roll center of the car body will feel a smaller jolt than a passenger on the upper level.

The *Railroad Passenger Ride Safety* report also indicates that the researchers did not find any evidence that jerk is a comfort concern. This suggests that the comfort spiral could be shortened until the jerk is 0.25 g per sec. The problem with this approach is that the track has to be maintained in perfect condition. Any track irregularity would result in a total change in lateral acceleration that exceeds 0.25 g per sec.

The French National Railways (SNCF) was found to have the highest limits, 0.15 g and 0.10 g per sec. Since comfort is a subjective feeling of the passenger, the SNCF may be recognizing that the French have a higher threshold to discomfort, or that they may be willing to tolerate a higher percentage of the passengers to be uncomfortable. Or, and perhaps more likely, SNCF has made a commitment to high quality track with tight maintenance tolerances for their high speed lines. (The British and American comfort criteria were established at comfort limits where 50 percent of the passengers will be satisfied. The Japanese desire to have 90 percent of the passengers satisfied.)

Track Twist. If the track twist, the rate of introduction or removal of superelevation, is too large, safety is impaired. When computing the maximum allowable speed for the existing alignment, the analysis performed verified that the ratio of the existing spiral length to actual superelevation was equal to, or greater than, 62 for speeds below, and including, 90 miles per hour. For speeds above 90 miles per hour, the ratio would be equal to, or greater than, 83.

When the maximum allowable speed did not reach the proposed speed the spirals were lengthened and the actual superelevation adjusted, as necessary, to maximize the speed. A third alternative, decreasing the degree of curvature and adjusting spiral lengths and superelevation was not utilized in this study. Where these alignment changes were required the spiral lengths were changed to satisfy the appropriate actual superelevation runoff rate assumed for the Richmond Line. The new spirals also were checked for jerk. The actual superelevation was adjusted until the jerk criteria was satisfied. The following are the separate and distinct runoff rate criteria specified for CSX and CR. Only the CSX was used in the analysis.

CSX

Speed Range, miles per hour	Length of Runoff per 1/2"
0 to 50	31'
51 to 70	39'
71 to 90	50'

CR Speed Range, miles per hour	Runoff per 31'
0 to 60	1/2"
61 to 90	3/8"
91 to 100	1/4"

Track Shifts. For this analysis, shifts between the existing and the proposed alignments were computed at 2 points: near each of the curve spiral points. A third possible point, near the mid-point of the curve was not calculated. The shifts near the curve spiral points were estimated as the difference between the spiral offsets, the "p" distance, for the proposed and existing spirals. At the curve's mid-point the difference in the external distances for the proposed and existing alignment would have been estimated to be the amount of shift required.

The estimated shifts were checked for an earlier NEC study by running several dummy cogos using typical alignment curve data, and calculating offsets. A range of intersection angles, radii, spiral lengths, and differential spiral lengths, when the existing spirals are unequal, were tested. For simple, spiral curves it was found that the estimated shifts were within 0.1 feet and that they were usually on the conservative side, i.e., 0.1-foot larger than actual. If the proposed alignment has a different intersection angle or a significantly different radius, the estimated shifts become less accurate.

Compound Curves. Compound curves (a combination of two or more curves connected by transition spirals) added another level of complexity to the analysis. Except for the following modifications, the method used to estimate the amount of shift was basically the same as for simple curves. The following labeling was used:

Existing Compound Curve

- A-spiral length between tangent and longer radius curve
- B-longer radius curve
- C-combining spiral length
- D-shorter radius curve
- E-spiral length between tangent and shorter radius curve

Proposed Compound Curve

- PA-spiral length between tangent and longer radius curve
- PB-longer radius curve
- PC-combining spiral length
- PD-shorter radius curve
- PE-spiral length between tangent and shorter radius curve.

Each curve in the compound curve was analyzed separately. For the first curve the following curve elements were used:

Existing
- A-spiral length
- B-curve radius
- E-C-spiral length

Proposed
- PA-spiral length
- PB-curve radius
- PE-PC-spiral length.

For the second curve the following curve elements were used:

Existing
- A+C-spiral length
- D-curve radius
- E-spiral length

Proposed
- PA+PC-spiral length
- PD-curve radius
- PE-spiral length.

From initial checks it was found that the external distance is very dependent upon the intersection angle, but that the difference in external distances is not very sensitive to the intersection angle. Therefore, using data from track geometry car graphs provided by Amtrak, it was assumed to be sufficient to divide the total intersection angle in the same proportion as the curve lengths.

Dummy COGO checks indicated that the largest shift found using the estimating method is similar to the largest found with the dummy COGO but the location of the peak shift may not be correctly represented. To check for impacts at specific locations dummy COGO should be used.

Basis for Existing Curve Data

As with any analysis, the results of the curve analyses performed were only as good as the quality of the available existing data. The best source of data is good mapping or surveyed data points of the existing tracks. Description of an alignment by degree of curvature is incomplete, it is similar to describing a line by its slope. The description of a curve is not complete until the Y intercept is known. Stringline data and track geometry car data also are not ideal sources of data. The degree of curvature is never uniform, always varying. The result is that data elements assumed to describe the alignment may vary greatly from the actual configuration. The variation cannot be determined without mapping or surveyed data points.

The existing data sources used to develop information for the analyses performed were as follows:

- Amtrak track geometry car charts;
- earlier work performed by various consultants for VDRPT; and
- track charts.

The track charts were used for general orientation, but not to define spiral lengths, curvature, etc. The previous work efforts was used for background information only; data on proposed curve speeds and previous recommendations were obtained from the reports developed by those studies.

Data relative to the existing superelevation, spiral lengths, curve lengths, and degree of curvature were primarily developed from an analysis of the October 1996 Amtrak Track Geometry Car Charts, which were the result of a round-trip run of the corridor.

Although there were possible inconsistencies in the track geometry car data, it was necessary to use them in most instances. The data was valuable for providing the spiral lengths, which were measured directly from the charts of the individual simple and compound curves.

The track geometry car chart data was reduced as follows. The track geometry produces strip charts with fluttering lines. A visual average was made for the degree of curvature and actual superelevation. If the data was not uniform, the curve was subdivided into a compound curve. The distance between uniform curvature data points was assumed to be spiral lengths. The distance between uniform actual superelevation data was not assumed to have any relationship to spiral length because actual superelevation may have been run off onto the tangents and into circular curves.

It was assumed that third tracks and sidings also will be shifted, as necessary, when either would be the inside track on a curve, and thus need to be shifted to maintain adequate clearance to the shifted inner tracks. The costs for this effort were included in the project estimate, but it was assumed that the magnitude of shifts and, therefore, impacts on adjacent right-of-way structures would be driven by the changes required to the high speed tracks, tracks 2 and 3.

For each curve, the existing data from each source was tabulated. The source data was compared, curve by curve, and data type by data type. Finally, one set of existing data for each curve was selected and compiled. The compiled data is the most conservative.

Speeds

The existing speeds were taken from the existing CSX and CR Employees Timetables. The proposed speeds were initially taken from the speeds proposed in earlier VDRPT studies. Proposed speeds have been established in multiples of 5 miles per hour.

When determining the maximum allowable speed within the criteria the speed is shown to the nearest downward five miles per hour.

The Spreadsheet

To facilitate the analysis a spreadsheet was developed that allows for the existing speed, degree of curvature, spiral and curve lengths, and superelevation to be input. The input was utilized to perform a variety of calculations. The spreadsheet determined the maximum speed obtainable given the existing alignment and actual superelevation, by only making soft changes, i.e., only changes to speed, unbalanced superelevation, and jerk. For this initial analysis no change to curvature, spiral lengths, and actual superelevation were made. In general it was assumed that the proposed curvature will remain unchanged.

For those instances when superelevation and spiral length changes were analyzed, the spreadsheet was used to determine the shifts associated with changes in actual superelevation and spiral lengths that would satisfy railroad and comfort criteria, and attain the proposed speeds. For the proposed alignment only the proposed speed and actual superelevation had to be input. Unbalanced superelevation, optimal spiral lengths, and shifts were computed. "What if" questions about speeds were asked, and answered, by using different proposed speeds and superelevation for input. Limitations concerning the shift calculations were discussed earlier.

ANALYSIS PROCESS

The following questions for each curve were answered and the analysis proceeded as indicated.

1 What is the existing?:

- a. CR curve number
- b. CSX curve number
- c. speed
- d. degree of curvature or radius
- e. actual superelevation[5]

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[5]Whether superelevation ran onto either the tangent or circular curve was not determined.

f. spiral length(s)

The following were computed:

g. maximum speed with existing superelevation, not taking spiral length into consideration;
h. unbalanced superelevation;
i. steady state lateral acceleration to the passenger;
j. minimum spiral length based on unbalanced superelevation;
k. Minimum spiral length based on actual superelevation and railroad runoff rate criteria;
l. Optimal spiral length as the maximum of (i) and (j); and
m. spiral offset(s) and external.

2. Since it was assumed that the superelevation does not run onto the tangent and circular curve then the following were computed/developed:
   a. steady state jerk(s) based on optimal spiral length (k).
   b. track twist(s), rate of change of change in actual superelevation, i.e., ratio of existing spiral length to existing actual superelevation.
   c. list of bridges with no planned work.
   d. list of ballasted bridges.
   e. list of overhead bridges.
   f. list of bridges to be replaced.

3. Assuming that the superelevation does not run onto the tangent and circular curve, then the following were computed/developed:
   a. if 2.b. was greater than 83, the highest speed that does not exceed 5 inches of unbalanced superelevation, nor exceed 0.15 g lateral acceleration, nor exceed 0.04 g per sec jerk was determined. The existing radius, superelevation, and spiral length(s) were to remain unchanged. This speed was considered as the highest speed attainable with no impacts, no shift, and not requiring an alignment change. Note: when the existing spirals were of unequal length, the shorter spiral was used to compute jerk. The analysis proceeded to 4.

   b. if 2.b. was greater than 62, the highest speed less than or equal to 90 miles per hour that does not exceed 5 inches of unbalanced superelevation, nor exceed 0.15 g lateral acceleration, nor exceed 0.04 g per sec jerk was determined. The existing radius, superelevation, and spiral length(s) were assumed to remain unchanged. This speed was assumed to be the highest speed with no impacts, no shift, and that did not require an alignment change. Note: when the existing spirals were of unequal length, the shorter spiral was used to compute jerk. The analysis proceeded to 4.

c. if 2.b was less than 62 a spiral length change was required. The spreadsheet would report that an alignment change was required. The analysis would proceeded to 4.

4. Steps 1-3 were performed for all the curves, a curve list showing the highest speed determined in 3.a. and 3.b was developed. The proposed speed for each of these curves was listed. The curves whose highest speed met or exceeded their proposed speed were highlighted. The list was entitled *Highest Speeds for All Curves without Alignment Changes*. Proceed to 5.

5. For all curves that were not highlighted in 4 (i.e., those curves that will need alignment changes, and/or changes in superelevation, radius or spiral length-to achieve the proposed speed, without changing radius) increase actual superelevation in increments specified for the segment and speed, without exceeding 6 inches, until the proposed speed was reached without exceeding 5 inches of unbalanced superelevation or exceeding 0.40 g/sec jerk rate. If the proposed speed could not be achieved without exceeding the above limitations, the speed was decreased in 5 mph increments until the limitations were not exceeded. Proceed to 6.

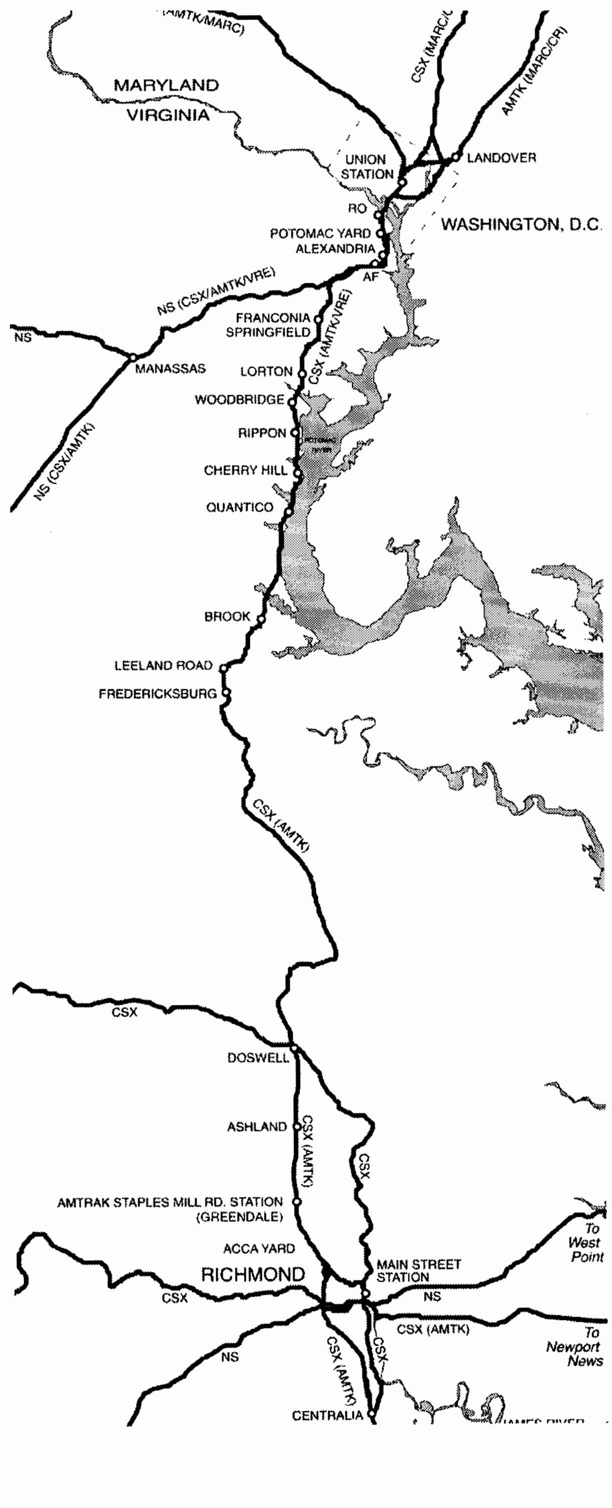
6. If 1.g (maximum speed with existing superelevation, not taking spiral length into consideration) exceeded the speed calculated in step 5 by five or more mph the following steps were followed -
   1. maximum speed was increased in five mph increments;
   2. actual superelevation was increased in increments specified for the segment and speed, without exceeding 6 inches, until neither 5 inches of unbalanced superelevation or exceeding 0.40 g/sec jerk rate were exceeded.
   3. 6.1 and 6.2 were repeated until a further five mph increase would require more than 6 inches of superelevation or the 0.40 g/sec jerk rate would be exceeded.
   4. Using the superelevation that was determined to be necessary to achieve the maximum feasible speed, the shortest spiral length that satisfied CSX curve criteria and did not exceed the 0.04 g per sec jerk, was calculated. Spiral lengths were established as an integer multiple of either 31, 39, or 50 feet, depending upon the speed. Shifts to achieve the proposed alignment were calculated.
   5. The impact of the proposed shifts on each bridge were evaluated. If the shifts exceeded the followings limits the bridge was considered to be impacted:
      - open deck bridges with no planned work-any shift or change in superelevation;
      - open deck bridges with through girders or through deck girders scheduled for tie replacement--6 inches;
      - open deck bridges with deck girders scheduled for tie replacement--1-foot;
      - open deck bridges scheduled for change to ballast--2 feet;
      - ballasted bridges--2 feet; and
      - overhead bridges--3 feet.

Bridges listed for replacement were assumed to not be impacted by alignment changes.

A list all of the curves that required alignment changes to achieve the proposed or optimal speed was developed. It included: proposed speeds, curves requiring 6 inches or less of shift, curves requiring between 6 inches and 3 feet of shift, and curves requiring more than 3 feet of shift.

Report to Congress **APPENDIX B**

Potential Improvements to the Washington—Richmond Railroad Corridor



TRAIN PERFORMANCE TO SUPPORT PROJECT GOALS

May 1999

Appendix B
TRAIN PERFORMANCE ANALYSIS TO SUPPORT PROJECT GOALS

INTRODUCTION

The results of the Train Performance Calculator simulations that were performed in support of this supplement to the Transportation Plan are discussed in detail in this Appendix. Results for intercity, commuter, and freight trains are presented. The ability of the recommended improvements to support reliable less than 2-hour intercity trip times also is evaluated. The results of the MONTE CARLO™ simulations are discussed in Appendix C.

ABILITY TO MEET PROJECT GOALS

A program of Train Performance Calculator (TPC) analyses was undertaken to assist in the development of a recommended track configuration and alignment that satisfies the recommended goal of regularly scheduled, safe, and dependable rail passenger service between Washington, DC and Richmond, VA in less than 2 hours. The Train Performance Calculator assesses the performance of a single train over the route to measure trip time differences between the existing track configuration and the proposed configuration for a variety of train consists, including conventional intercity and freight trains.

The results of the TPC simulations to date are summarized in this Appendix.

Conditions for Simulations of "Goal Trains"

Goal trains are those scheduled to meet the recommended less than 2-hour trip time between Washington and Richmond. TPC simulations of goal trains on the existing and the upgraded facility configurations were based upon the conditions described in the following subsections.

"Baseline" TPC Runs. Baseline TPC runs were performed with a train consist of six Amfleet cars powered by one P42 diesel locomotive upon the existing facility configurations, i.e., prior to any improvements being implemented under the present project. Trip times to Staples Mill Rd. Station and Main St. Station were simulated. The Baseline conditions included:

- Existing Maximum Authorized Speeds (MASs); passenger trains were limited to 70 miles per hour. Trains were limited to 35 mph through Ashland, and 40 mph between Staples Mill Rd. Station and Main St. Station;
- Speed restrictions as shown on CSX's and CR's employee timetables that were in effect in spring of 1997;

- Positive stops and Civil speed restrictions were not enforced by the signal system in these simulations; and
- Two intermediate station stops, of 2-minute duration, at Alexandria and Fredericksburg.

TPC Runs - MAS Increased to 90 mph. Another set of TPC runs to determine the amount of time savings to be experienced after increasing MAS to 90 mph, before other improvements were implemented, was performed. Trip times to Staples Mill Rd. Station and Main St. Station were simulated. The following conditions were used:

- MAS was increased to 90 mph between Alexandria and Staples Mill Rd. Station; speeds on individual curves were calculated using a spreadsheet previously described in Appendix A.
- As in the Baseline case, positive stops and curve speeds were not enforced.
- Improvements to spiral length and superelevation of selected curves to optimize speed for curves without changing curvature were assumed.
- Two intermediate station stops of, 2-minute duration, at Alexandria and Fredericksburg.
- Train consist was six Amfleet cars powered by one P42 diesel locomotive.
- Speeds were set assuming two levels of unbalanced superelevation - 3 inches and 5 inches.

TPC Runs - MAS Increased to 110 mph. A third set of TPC runs to determine the amount of time savings to be experienced after increasing MAS to 110 mph, before other improvements were implemented, was performed. Trip times to Staples Mill Rd. Station and Main St. Station were simulated. The following conditions were used:

- MAS was increased to 110 mph between Alexandria and Staples Mill Rd. Station; speeds on individual curves were calculated using a spreadsheet previously described in Appendix A. Trains were limited to 35 mph through Ashland, and 40 mph between Staples Mill Rd. Station and Main St. Station.
- As in the Baseline case, positive stops and curve speeds were not enforced.
- Concrete ties were assumed to be installed in stretches of 110 mph operation and on curves where unbalanced superelevation exceeds 5 inches (identified as E_u on the accompanying tables)[1].
- Improvements to spiral length and superelevation of selected curves to optimize speed for curves without changing curvature were assumed.
- Two intermediate station stops of 2-minute duration were used at Alexandria and Fredericksburg.
- Train consist was six Amfleet cars powered by one P42 diesel locomotive.

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[1]To offset the thrust of a train against the outer rail of a curve, the outer rail is raised in comparison to the inner rail. The amount that the outer rail (the "high rail") is raised above the inner rail (the "low rail") is called actual superelevation. If the train is operated around a curve at a speed requiring 9 inches of superelevation, and the curve has only 6 inches (the maximum allowed by Federal Track Standards) in track, the 3-inch differential is the amount of "unbalanced superelevation."

- Speeds were set assuming two levels of unbalanced superelevation - 3 inches and 9 inches.

TPC Simulations of Alternative Future Facility Improvements. TPC simulations of alternative motive power and future facility improvements (i.e., curve speed increases) were made using the following conditions:

- MASs of 90 and 110 miles per hour was used, where possible, between Alexandria and Staples Mill Rd. Station.
- Concrete ties were assumed to be installed in stretches of 110 mph operation and on curves where unbalanced superelevation exceeds 5 inches.
- Two intermediate station stops, of 2-minute duration, were used at Alexandria and Fredericksburg.
- Several train consists were tested:
  - one P42 locomotives and six Amfleet cars;
  - two P42 locomotives and six Amfleet cars; and
  - one AEM-7 electric locomotive and six tilt-body cars.
- The AEM-7 runs assumed that electrification was installed between Washington and Main St. Station. This eliminates engine changes at Washington Union Station, but requires an engine change for trains scheduled to proceed south of Richmond.
- Three sets of speed limits were used, speeds with 3 inches of unbalanced superelevation, with 5 inches of unbalanced superelevation, and with 9 inches of unbalanced superelevation; these all assume that selected curves are upgraded to 6 inches of actual superelevation.
- As in the Baseline case, positive stops and curve speeds were not enforced; signal system improvements compatible with the recommended speeds were assumed.

The runs with two P42 locomotives, and one AEM-7 locomotive with tilt train cars, were made for comparison purposes. The TPC runs illustrate the running times that could be expected given the relevant performance and physical characteristics of these types of rolling stock.

Conditions used in the TPC simulations, including MASs, speeds through curves, and unbalanced superelevation, are all a function of track structures, equipment structural capacity, and crashworthiness, and represent the collective best judgment of experienced rail operators. Before high-speed operations are introduced, however, many of these conditions will have to be analyzed in greater detail, and tested to ensure the safety of the total system.

TPC Running Times and Schedule Times

The TPC simulated running time is the best achievable time that may be expected of a given train operated over a railroad line with given physical characteristics. The TPC times reported in Tables B-1 through B-5 are therefore the most optimistic running times for each given train consist.

When train schedules are prepared using TPC simulated times as a basis for the train running times, it is necessary to add an allowance for minor operating irregularities en route, which may be expected to occur on a daily basis, while maintaining a high probability of on-time performance. Several terms are used for this allowance, the most common of which are "pad", "cushion time", or "slop". A discussion of the issue of the amount of pad that should be added to the TPC times is found in a later subsection. The addition of this allowance to the TPC running time will enable trains to perform reliably on a day-to-day basis. The pad also will enable trains to regain any lost time resulting from minor delays (i.e., temporary speed restrictions, diversions around maintenance work, time lost at a station when passenger boardings are slow or heavy, etc.). Pad also provides for two additional components: the probability that not all of the configuration and alignment improvements incorporated into the model will prove physically feasible; and the realization that the model assumes that the train engineer operates the train in a consistent and precise manner in response to speed changes.

Description of the Goal Train Output Tables

The results of the Goal Train TPC simulations are contained in Tables B-1 through B-5. The tables are organized to present the overall running times and time savings (compared with the Baseline TPC run) from Washington to Richmond for the different train consists and facility configuration assumptions. The running times and time savings to be achieved with varying levels of unbalanced superelevation, before any facility improvements, such as curve realignments, increases in superelevation, etc., are made, are illustrated in Table B-1. The Baseline scenario is identified in the tables as the scenario with "1-P42 + 6 Amfleet, 3" Eu, 70 mph".

Speed profile graphs showing the performance of various train consists, train speeds, and MAS assumptions also are provided (Figures B-1 through B-4).

The running times and time savings (also compared with the Baseline TPC run) resulting from improvements to curve geometry to permit operation at MASs of 90 and 110 mph and curve speeds computed for 3 inches of unbalanced superelevation, 5 inches of unbalanced superelevation, and 9 inches of unbalanced superelevation are shown in Tables B-2 and B-3. In all cases, selected curves are upgraded to 6 inches of actual superelevation.

The impact of adding a second P42 locomotive and an electrified alternative using one AEM-7 locomotive, respectively are shown in Tables B-4 and B-5. These runs were performed for the 3-, 5-, and 9-inch unbalanced superelevation cases.

TPC Results for the Goal Trains

The running times and time savings resulting from the facility configuration improvements are shown in Tables B-1 through B-5:

- Comparative Simulated Running Times With Various Train Consists and Facility Configurations Showing Effects of Increasing Curve Unbalance (Eu), Maximum Authorized Speed of 70 Mph, and Two Intermediate Stops are shown in Table B-1. No changes in track configuration. The impact of varying unbalanced superelevation can be gauged by comparing the Baseline 3-Inch diesel running time with the Baseline 5- and 9-inch times. The impact is less than one-minute.
- An estimate of the time savings that may be achieved by increasing MAS to 90 mph, selectively increasing actual curve superelevation to 6 inches, selectively increasing spiral length on curves to satisfy design and comfort criteria, as discussed in Appendix A, are provided in Table B-2. Also included are track capacity improvements to improve trip time reliability but that do not of themselves increase trip time. These improvements provide total time savings between Washington and Staples Mill Rd. Station ranging from about 8.9 minutes to 13.2 minutes compared, with the Baseline. Savings between Washington and Main St. Station compared with the Baseline scenario range from 9.3 minutes to 13.1 minutes.
- An estimate of the time savings that may be achieved by increasing MAS to 110 mph, selectively increasing actual curve superelevation to 6 inches, and selectively increasing spiral length on curves to satisfy design and comfort criteria as discussed in Appendix A are provided in Table B-3. Also included are track capacity improvements to improve trip time reliability but that do not of themselves increase trip time. These modifications provide total time savings between Washington and Staples Mill Rd. Station ranging from about 17.4 minutes to 21.4 minutes compared with the Baseline. Savings between Washington and Main St. Station compared with the Baseline scenario range from 18.1 minutes to 21.3 minutes.
- The incremental effect of adding a second P42 diesel locomotive to the consist is illustrated in Table B-4. Incremental time savings from the single locomotive option range from 3.0 minutes (for the 90 mph, 5-inch option) to 6.5 minutes (for the 110 mph, 9-inch option). The second locomotive produces total time savings between Washington and Staples Mill Rd. Station ranging from 13.2 minutes to 27.9 minutes.

Table B-1
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Increasing Curve Unbalance (Eu)
Maximum Authorized Speed of 70 mph
Two Intermediate Stops[2]

Train Consist Eu	Richmond Station Destination	Running Time	Difference From Baseline
1-P42+6 Amfleet 3" Eu 70 mph MAS **Baseline**	Staples Mill Rd.	1-49.6	N/A
	Main St.	2.03.7	N/A
1-P42+6 Amfleet 5" Eu	Staples Mill Rd.	1-48.7	0.9
	Main St.	2-02.8	0.9
1-P42+6 Tilt Coaches 9" Eu	Staples Mill Rd.	1-48.7	0.9
	Main St.	2-02.8	0.9

[2]Intermediate stops (1-minute dwell) at Alexandria and Fredericksburg.

Table B-2
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Increasing Maximum Authorized Speed to 90 mph
Two Intermediate Stops[3]

Train Consist Eu	Richmond Station Destination	Running Time	Difference From Baseline
1-P42+6 Amfleet 3" Eu 70 mph **Baseline**	Staples Mill Rd.	1-49.6	N/A
	Main St.	2.03.7	N/A
1-P42+6 Amfleet 3" Eu - 90 mph	Staples Mill Rd.	1-40.7	8.9
	Main St.	1-54.4	9.3
1-P42+6 Amfleet 5" Eu - 90 mph	Staples Mill Rd.	1-36.4	13.2
	Main St.	1-50.6	13.1
1-P42+6 Tilt Coaches 9" Eu - 90 mph	Staples Mill Rd.	N/A[4]	N/A
	Main St.	N/A	N/A

[3]Intermediate stops (2-minute dwell) at Alexandria and Fredericksburg.

[4]Run was not performed.

Table B-3
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Increasing Maximum Authorized Speed to 110 mph
Two Intermediate Stops[5]

Train Consist Eu	Richmond Station Destination	Running Time	Difference From Baseline
1-P42+6 Amfleet 3" Eu 70 mph MAS **Baseline**	Staples Mill Rd.	1-49.6	N/A
	Main St.	2.03.7	N/A
1-P42+6 Amfleet 3" Eu - 110 mph	Staples Mill Rd.	1-32.2	17.4
	Main St.	1-46.3[6]	17.4
1-P42+6 Amfleet 5" Eu - 110 mph	Staples Mill Rd.	N/A[7]	N/A
	Main St.	N/A	N/A
1-P42+6 Tilt Coaches 9" Eu - 110 mph	Staples Mill Rd.	1-28.2	21.4
	Main St.	1-42.3[5]	21.4

[5]Intermediate stops (2-minute dwell) at Alexandria and Fredericksburg.

[6]Data for Staples Mill Rd. to Main St. not available at this time, 14.1 minutes was added to calculate trip time.

[7]Run was not performed.

Table B-4
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of One Additional P-42
Various Maximum Authorized Speeds
Two Intermediate Stops[8]

Train Consist Eu	Richmond Station Destination	Running Time	Difference From Baseline
1-P42+6 Amfleet 3" Eu 70 mph **Baseline**	Staples Mill Rd.	1-49.6	N/A
	Main St.	2.03.7	N/A
1-P42+6 Amfleet 5" Eu - 90 mph	Staples Mill Rd.	1-36.4	13.2
	Main St.	1-50.6	13.1
2-P42+6 Amfleet 5" Eu - 90 mph	Staples Mill Rd.	1-33.5	16.1
	Main St.	1-47.6	16.1
1-P42+6 Tilt Coaches 9" Eu - 110 mph	Staples Mill Rd.	1-28.2	21.4
	Main St.	1-42.3[9]	21.4
2-P42+6 Tilt Coaches 9" Eu - 110 mph	Staples Mill Rd.	1-21.7	27.9
	Main St.	1-35.8[8]	27.9

[8]Intermediate stops (2-minute dwell) at Alexandria and Fredericksburg.

[9]Data for Staples Mill Rd. to Main St. not available at this time, 14.1 minutes was added to calculate trip time.

Table B-5
COMPARATIVE SIMULATED RUNNING TIMES
With Various Train Consists and Facility Configurations
Showing Effects of Electrifying Line
Various Maximum Authorized Speeds
Two Intermediate Stops[10]

Train Consist Eu	Richmond Station Destination	Running Time	Difference From Baseline
1-P42+6 Amfleet 3" Eu 70 mph **Baseline**	Staples Mill Rd.	1-49.6	N/A
	Main St.	2.03.7	N/A
1-P42+6 Amfleet 5" Eu - 90 mph	Staples Mill Rd.	1-36.4	13.2
	Main St.	1-50.6	13.1
2-P42+6 Amfleet 5" Eu - 90 mph	Staples Mill Rd.	1-33.5	16.1
	Main St.	1-47.6	16.1
1-AEM7+6 Amfleet 5" Eu - 90 mph	Staples Mill Rd.	1-33.1	16.5
	Main St.	1-47.3	16.4
1-P42+6 Tilt Coaches 9" Eu - 110 mph	Staples Mill Rd.	1-28.2	21.4
	Main St.	1-42.3	21.4
2-P42+6 Tilt Coaches 9" Eu - 110 mph	Staples Mill Rd.	1-21.7	27.9
	Main St.	1-35.8	27.9
1-AEM7+6 Tilt Coaches 9" Eu - 110 mph	Staples Mill Rd.	1-20.4	29.2
	Main St.	1-34.5	29.2

[10] Intermediate stops (2-minute dwell) at Alexandria and Fredericksburg.

Figure B.1: Washington - Richmond TPC Runs, Existing Speeds, 1 P-42 and 6 cars, 3 in. E_u

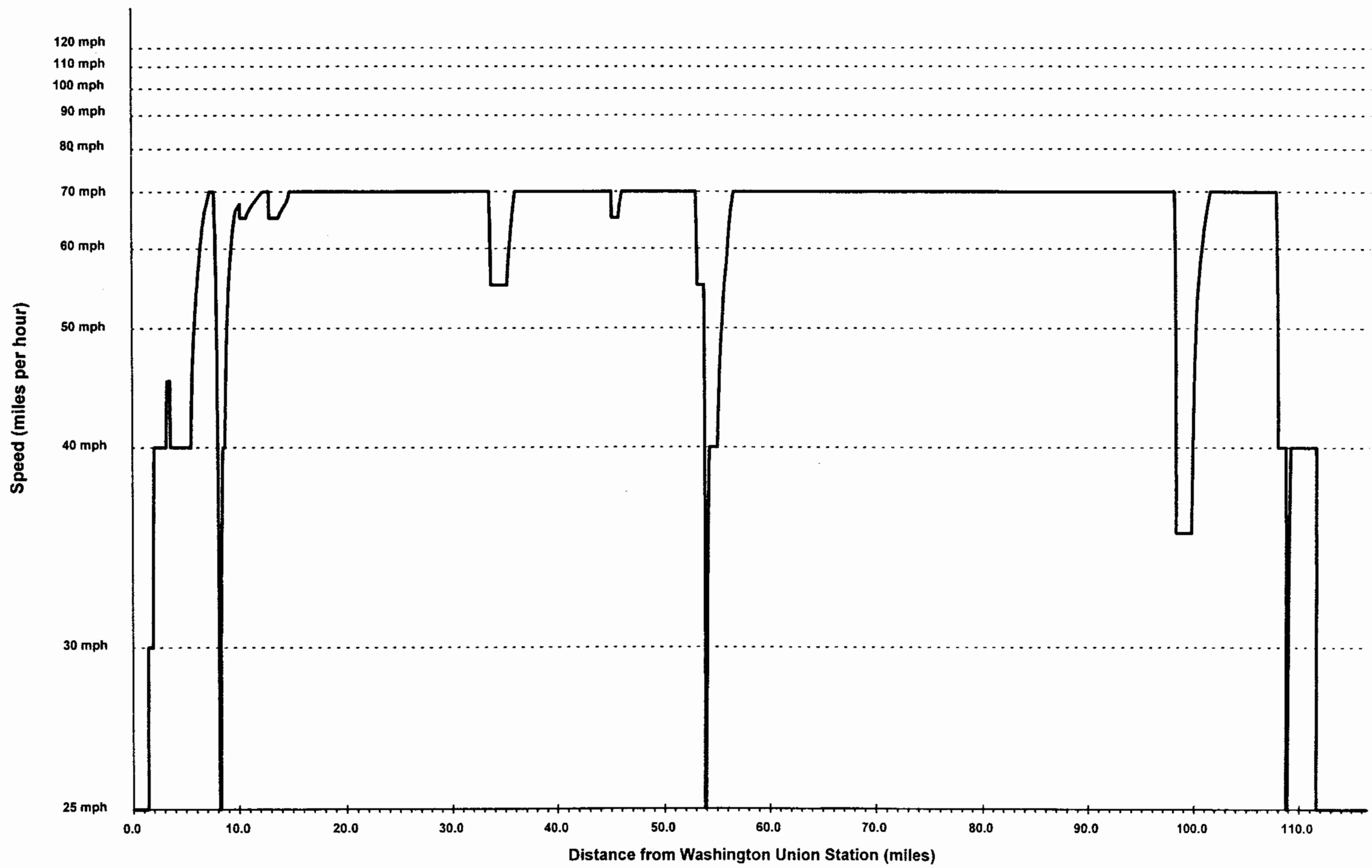


Figure B.2: Washington - Richmond TPC Run, 90 mph, 1 P-42 and 6 cars, 5 in. E_u

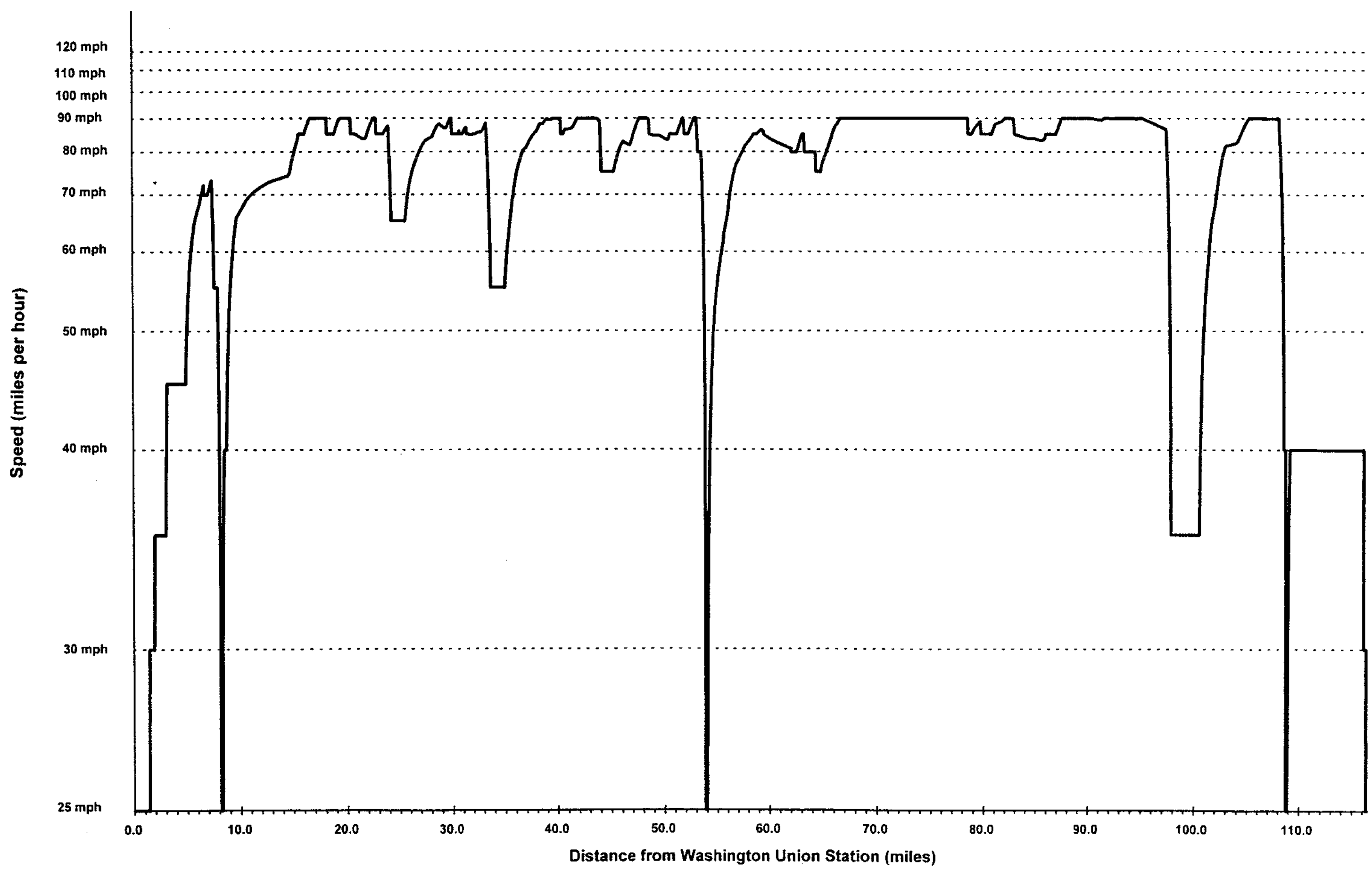


Figure B.3: Washington - Richmond TPC Run, 110 mph, 1 P-42 and 6 cars, 9 in. E_u

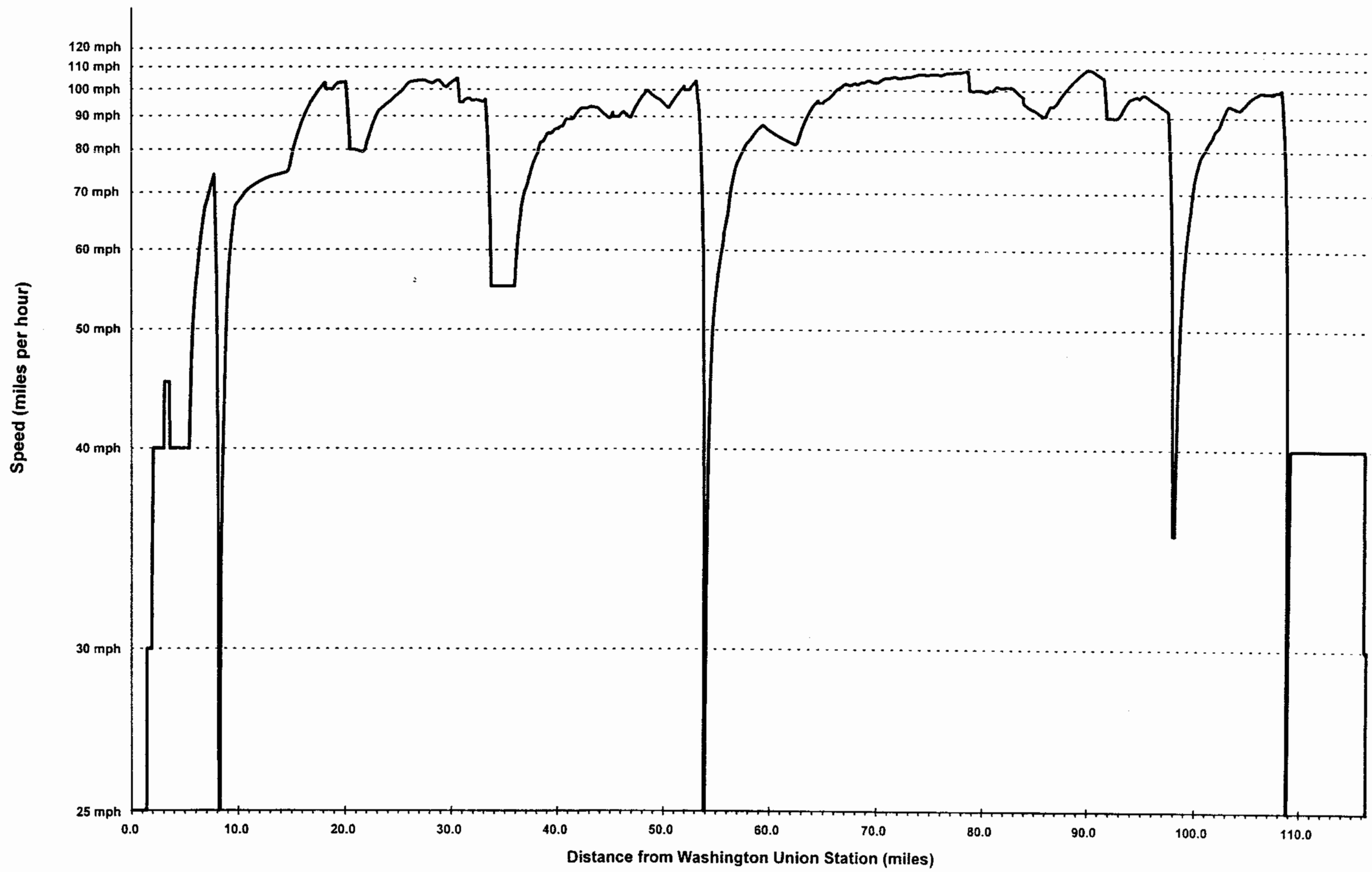
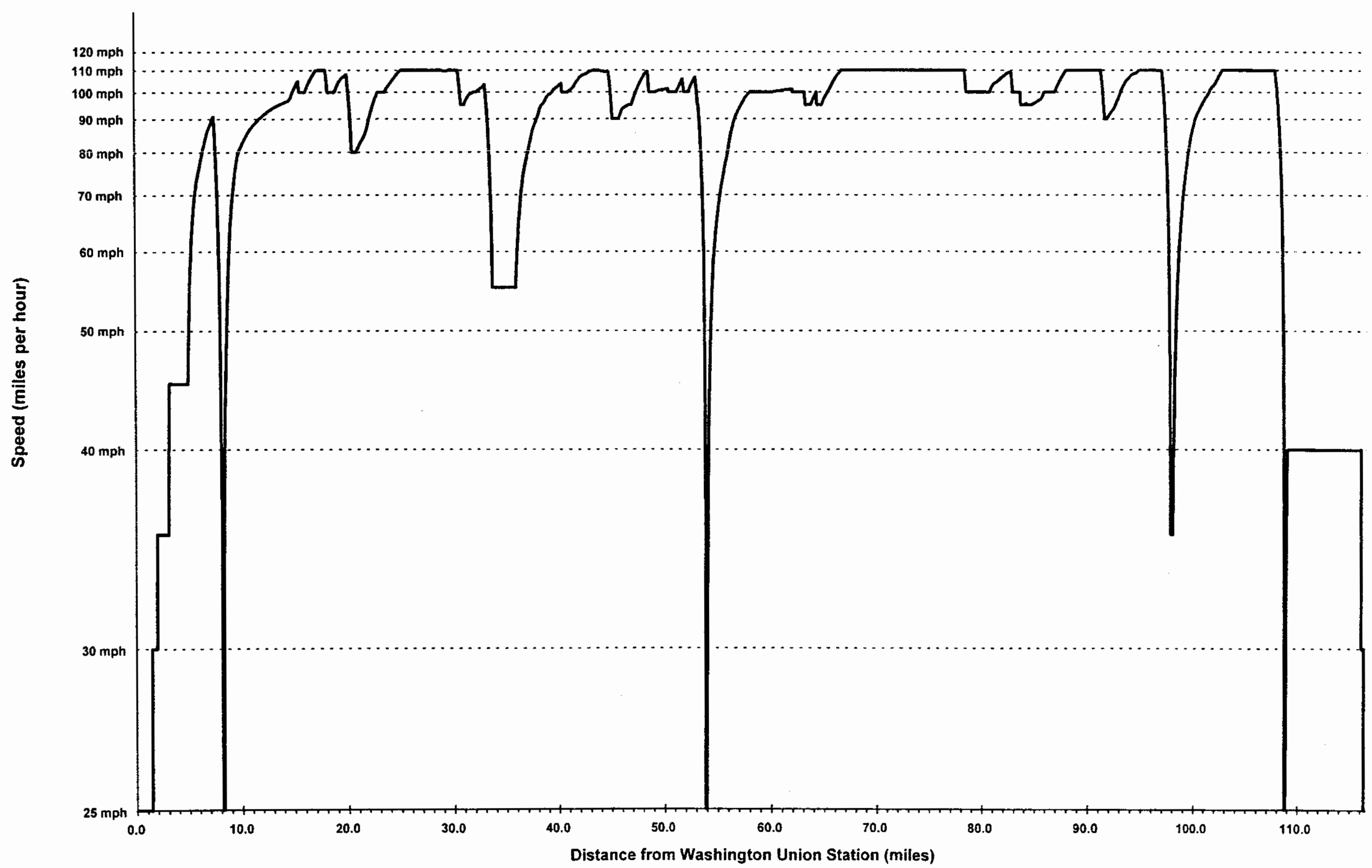


Figure B.4: Washington - Richmond TPC Run, 110 mph, 2 P-42 and 6 cars, 9 in. E_u



- The incremental effect of electrifying the Richmond Line and using an AEM-7 locomotive with Amfleet and Tilt-Train coaches is illustrated in Table B-5. The improvement produces total time savings between Washington and Staples Mill Rd. Station ranging from about 16.5 minutes to 29.2 minutes compared with the Baseline. Incremental time savings from the two P42 locomotive option range from 0.4 minutes (for the 90 mph, 5-inch option) to 1.3 minutes (for the 110 mph, 9-inch option).

Effect of Adding One Additional Diesel Locomotive

Vertical elevation has as significant an impact on trip times in the Richmond Corridor as horizontal alignment. Horizontal curvature previously is discussed in Appendix A. The impact of vertical gradient on trip times is illustrated in Figures B-3 and B-4. One P-42 locomotive with six tilt-capable coaches operating at an MAS of 110 mph, assuming nine inches of unbalanced superelevation in numerous locations, does not reach 110 mph, even though it appears that sufficient distance is available for the train to accelerate from the lower speed zone to 110 mph. One example is between Ashland and Staples Mill Rd. After clearing the 35 mph daytime restriction through Ashland, the train with one locomotive never reaches 100 mph in the 10 mile stretch before having to brake for Staples Mill Rd. Several long grades actually serve to reduce train speed in this stretch of railroad in which horizontal curvature would permit continuous 110 mph MAS. A similar effect is noted by automobile drivers on I-95 between Washington and Richmond. In numerous locations congestion and traffic backups are generated by the slowing down of trucks, cars with trailers, and other cars climbing the grades that exist on the route.

The effect of adding a second P-42 locomotive is shown in Figure B-4. Despite being somewhat restricted by grade, the revised consist operates at the 110 mph MAS for almost five miles between Ashland and Staples Mill Rd. A similar effect occurs south of Fredericksburg. In the 14-mile stretch between TPC run Mileposts 65 and 79, a train powered by one diesel never reaches 110 mph (Figure B-3), while a two-diesel consist operates at 110 mph for more than 10 miles (Figure B-4).

At 90 mph, with 5 inches of unbalanced superelevation, the second locomotive saves 3 minutes compared to use of a single locomotive. Increasing the MAS to 110 mph, with 9 inches of unbalanced superelevation, if practical and achievable, and adding a second locomotive is even more effective. The time savings is approximately 6.5 minutes.

Using the 90 mph time savings example, purchasing 15 additional locomotives at $2 million each, has a cost savings ratio of $10 million a minute.

Effect of Electrifying the Richmond Line

The effect of electrifying the Richmond Line between Washington Union Station and Main St. Station on trip time goals is shown in Table B-5. The improvement if implemented would result in the NEC being electrified between Boston, MA and Richmond, VA. Electrification also would eliminate the need to change engines from electric to diesel at Washington. However, the need to change engines merely will be relocated to Main Street Station in Richmond, where the proposed track configuration may not have the necessary flexibility to easily change engines.

Estimated to cost in excess of $300 million by an earlier VDRPT study, the cost effectiveness of the improvement compared to adding a second diesel locomotive to the consist is questionable.

Performance of Commuter Trains

VRE Fredericksburg Line Commuter trains presently make 10 intermediate stops - Leeland Road, Brooke, Quantico, Rippon, Woodbridge, Lorton, Franconia/Springfield, Alexandria, Crystal City, and L'Enfant - prior to arriving at Washington Union Station. This operation requires a scheduled 1-hour 28-minute trip for passengers boarding at Fredericksburg. This translates into an average speed of approximately 37 mph for a trip of approximately 54 miles. Passengers boarding at Rippon, the end of Zone 5, are scheduled to ride 56 minutes to cover less than 28 miles. These travel times are felt to be a deterrent to attracting more riders in this corridor that directly competes for riders whose options are I-95 and some form of van pool or bus service. This is especially true for long-distance riders from the outlying stations.

Commuter railroads such as the Long Island Rail Road and Metro-North use zone express trains to minimize the number of stops passengers further removed from New York City must make. Zone express service reduces travel time and makes the rail commute more attractive for most riders.

Contractual limitations and limited physical facilities have prevented VRE from initiating some form of zone express service to serve as an incentive to attract additional riders and hold current riders. For this study, various zone express options were considered and it was decided to simulate a service option that centered around Rippon Station. To determine the time savings to be achieved in the operation of commuter trains in the Fredericksburg segment of the Richmond Line after completion of the recommended improvements between Washington and Richmond, TPC simulations of four commuter train stopping patterns were performed. The four service patterns were as follows:

- VRE commuter trains making all stops between Fredericksburg and Washington[11];
- VRE commuter trains making all stops between Fredericksburg and Rippon, then running express to Alexandria.;
- VRE commuter trains making all stops between Washington and Rippon, then running express to Fredericksburg; and

[11] A proposed intermediate station located at Cherry Hill (MP 82.4), between Rippon and Quantico, was assumed in the 2015 TPC runs. A potential 12th Station, Widewater, which is presently being evaluated, was not simulated.

- VRE commuter trains running express southbound to Fredericksburg, from Alexandria.

Four train consist options were evaluated:

- One F-40 locomotive plus six single-level coaches, the present service.
- One F-40 locomotive plus six bi-level coaches, an option presently being considered.
- Two F-40 locomotive plus six bi-level coaches, and
- One AEM-7 locomotive plus six bi-level coaches.

The Bi-level coaches offer the advantage of hauling more passengers per train, but result in a heavier consist. The effect of the added weight on performance is shown by the results of the simulations.

Results of Commuter Train TPC Runs

The effect of the proposed zone express options upon the running time of VRE Commuter trains is shown in Table B-6. The baseline case indicates that the present VRE schedule has approximately a 12-percent pad (a calculated 1-hour 18.5-minute[12] running time compared to the scheduled 1-hour 28-minute running time) for the current 10-stop Fredericksburg to Washington commute. The specific time savings are as follows:

- About 9 minutes running express to Rippon and local to Fredericksburg;
- About 10 minutes running local to Rippon and express to Fredericksburg; and
- About 26 minutes running express to Fredericksburg

The effect of the use of Bi-level coaches in place of the existing Single-level coaches is illustrated in Table B-7. With only one F-40 locomotive the simulated running times for all stopping patterns increased. The specific results are as follows:

- About a 3.5-minute increase running the present local stopping pattern to Fredericksburg;
- About a 4-minute increase running express to Rippon and local to Fredericksburg;
- About a 2.5-minute increase running local to Rippon and express to Fredericksburg; and
- About a 1-minute increase running express to Fredericksburg.

The effect of adding a second F-40 locomotive to the Bi-level coach consists is illustrated in Table B-8. Budgetary constraints limited the number of runs simulated. By increasing the acceleration capability of the trains, the second F-40 made a significant impact on trip times. The specific results are as follows:

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[12]Calculated by removing 2 minutes 25 seconds, the time required for a commuter train to decelerate, stop, and accelerate to MAS at Cherry Hill, from the Baseline TPC run, Table B-6. The addition of a stop at Widewater would add approximately the same time, 2 minutes 25 seconds, to the Baseline TPC run.

- About a 6-minute decrease compared to the single F-40, with bi-level coaches, running the present local stopping pattern to Fredericksburg;
- About a 2.5-minute decrease compared to the baseline single F-40, with single-level coaches, running the present local stopping pattern to Fredericksburg;
- The option of running express to Rippon and local to Fredericksburg was not simulated, however, the improved acceleration capability would have reduced trip times similarly;
- The option of running local to Rippon and express to Fredericksburg was not simulated, however, the improved acceleration capability would have reduced trip times similarly; and
- About a 1-minute decrease running express to Fredericksburg. Compared to the baseline all-stop pattern the running time remained about 55 minutes.

The effect of electrifying the Richmond line is shown in Table B-9. The use of a single AEM-7 locomotive with six Bi-level coaches resulted in the following:

- About a 1-minute decrease compared to the baseline single F-40 Single-level coach operation running the present local stopping pattern to Fredericksburg; and
- About a 4-minute decrease compared to the baseline single F-40 Bi-level coach operation running the present local stopping pattern to Fredericksburg; and
- About a 2-minute increase compared to the baseline single F-40 Bi-level coach operation running the present local stopping pattern to Fredericksburg.

Table B-6
COMPARATIVE SIMULATED VRE COMMUTER TRAIN RUNNING TIMES
With Various Train Stopping Patterns[13]
Maximum Authorized Speed of 70 mph

Train Consist	Stopping Pattern	Running Time	Difference From Baseline
1-F40+6 Single-Level **Baseline**	All Stops Washington - Fredericksburg	1-20.9	N/A
1-F40+6 Single-Level	Express to Rippon Local to Fredericksburg	1-12.3	8.6
1-F40+6 Single-Level	Local to Rippon Express to Fredericksburg	1-11.2	9.7
1-F40+6 Single-Level	No Stops	0-55.2	25.7

[13]Two-minute dwell time at L'Enfant and one-minute dwell times at all other stations were assumed.

Table B-7
COMPARATIVE SIMULATED VRE COMMUTER TRAIN RUNNING TIMES
With Various Train Stopping Patterns[14]
Maximum Authorized Speed of 70 mph
VRE Uses Bi-Level Coaches

Train Consist	Stopping Pattern	Running Time	Difference From Baseline For Stopping Pattern
1-F40+6 Single-Level **Baseline**	All Stops Washington - Fredericksburg	1-20.9	N/A
1-F40+6 Bi-Level	All Stops Washington - Fredericksburg	1-24.4	(3.5)
1-F40+6 Bi-Level	Express to Rippon Local to Fredericksburg	1-16.3	4.6
1-F40+6 Bi-Level	Local to Rippon Express to Fredericksburg	1-13.6	7.0
1-F40+6 Bi-Level	No Stops	0-56.1	24.8

[14]Two-minute dwell time at L'Enfant and one-minute dwell times at all other stations were assumed.

Table B-8
COMPARATIVE SIMULATED VRE COMMUTER TRAIN RUNNING TIMES
With Various Train Stopping Patterns[15]
Maximum Authorized Speed of 70 mph
VRE Uses Bi-Level Coaches and Two F40 Locomotives

Train Consist	Stopping Pattern	Running Time	Difference From Baseline For Stopping Pattern	Difference From One F40 Locomotive
1-F40+6 Single-Level **Baseline**	All Stops Washington - Fredericksburg	1-20.9	N/A	N/A
2-F40+6 Bi-Level	All Stops Washington - Fredericksburg	1-18.3	2.6	6.1
2-F40+6 Bi-Level	Express to Rippon Local to Fredericksburg	N/A	N/A	N/A
2-F40+6 Bi-Level	Local to Rippon Express to Fredericksburg	N/A	N/A	N/A
2-F40+6 Bi-Level	No Stops	0-54.8	26.1	1.3

[15]Two-minute dwell time at L'Enfant and one-minute dwell times at all other stations were assumed.

Table B-9
COMPARATIVE SIMULATED VRE COMMUTER TRAIN RUNNING TIMES
With Various Train Stopping Patterns[16]
Maximum Authorized Speed of 70 mph
VRE Uses Bi-Level Coaches and One AEM-7 Locomotive

Train Consist	Stopping Pattern	Running Time	Difference From Baseline For Stopping Pattern
1-F40+6 Single-Level **Baseline**	All Stops Washington - Fredericksburg	1-20.9	N/A
1 AEM-7+6 Bi-Level	All Stops Washington - Fredericksburg	1-20.2	0.7

This indicates that the greater tractive effort of the two F-40 locomotives at low speeds provided better acceleration capability with the Bi-level coaches than the AEM-7, whose greater high-speed capabilities cannot be realized in commuter service at a 70 mph MAS.

The effect of electrifying the Richmond line, increasing MAS from 70 to 90 mph, and increasing the assumed unbalanced superelevation to 5 inches is shown in Table B-10. The use of a single AEM-7 locomotive with six Bi-level coaches resulted in the following:

- About a 5-minute decrease compared to the baseline single F-40 operation running the present local stopping pattern to Fredericksburg; and
- About a 4.5-minute decrease compared to the 70 mph AEM-7 operation running the present local stopping pattern to Fredericksburg.

This indicates that the AEM-7, which is designed for intercity, not commuter operation, is able to accelerate and either reach or come close to MAS for each track segment.

[16]Two-minute dwell time at L'Enfant and one-minute dwell times at all other stations were assumed.

Table B-10
COMPARATIVE SIMULATED VRE COMMUTER TRAIN RUNNING TIMES
With Various Train Stopping Patterns[17]
Maximum Authorized Speed of 90 mph and 5 Inches Unbalanced Superelevation
VRE Uses Bi-Level Coaches and One AEM-7 Locomotive

Train Consist	Stopping Pattern	Running Time	Difference From Baseline For Stopping Pattern
1-F40+6 Single-Level **Baseline**	All Stops Washington - Fredericksburg	1-20.9	N/A
1 AEM-7+6 Bi-Level	All Stops Washington - Fredericksburg	1-15.6	5.3

TRIP TIME FINDINGS

The repetitive TPC and dispatching (MONTE CARLO™) simulations, under varying train consists and track/right-of-way configurations, have identified a number of important factors that will affect Richmond Line operating strategy. The following section describes these operational and engineering factors, and the subsequent conclusions derived from the simulation activity.

Scheduling Pad

Background. In planning train schedules or analyzing the results of TPC runs, *pad* is defined as the difference between a published schedule time and the best achievable time between two terminals. When planning schedules the amount of pad allows trains to incur small increments of delay en route and still maintain a high probability of on-time performance. When analyzing the results of TPC runs, two additional components of pad must be taken into consideration:

- not all of the configuration and alignment improvements incorporated into the model will prove physically feasible; and
- the model assumes that every train engineer operates the train in a consistent and precise manner in response to required speed changes.

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[17] Two-minute dwell time at L'Enfant and one-minute dwell times at all other stations were assumed.

These assumptions usually are too optimistic.

Traditionally, the most common way of adding pad to the schedule is to concentrate much of it toward the end of the run. The reason for this technique is that pad, which is distributed throughout a schedule and is consumed by waiting for scheduled departure times at intermediate stations, is unavailable to cover any delays that may occur toward the end of a run. Since, traditionally, the on-time performance of a train is measured by the time at the final terminal, many schedule makers and transportation supervisors prefer to have the pad allocated toward the end of the run.

In scheduling high-performance trains on a route with heavy freight and commuter traffic, it is more appropriate to distribute pad at the location(s) where delay is most likely to occur.

Pad Considerations. The amount of pad to be provided depends upon the nature of the railroad being operated. Because of the significant differences in the amount of commuter rail service, the 63 miles of railroad between Richmond and Fredericksburg should require less pad than the 54 miles of railroad between Fredericksburg and Washington. Traditionally, a percentage of the schedule is allotted for pad.

Realistic estimates of pad cannot be made until a facility and schedules have been defined. Even then, determining the distribution of pad must be based on subjective evaluation and operating history.

A review of the MONTE CARLO™ simulations indicates that the volume of moves per day, particularly during the rush hours, is substantial. Thus the potential for conflicts that could delay intercity trains remains significant, suggesting that a pad in the range of 8 to 9 minutes, which represents 7- to 9-percent added to the TPC time for these trains, is justified.

Achievement of Planned Richmond Line Improvements and Impact upon Pad. The TPCs expected that the presently projected curve speed will be achieved. Experience has indicated that not all of these planned improvements will prove physically feasible and not all of the anticipated time savings will be achieved in the real world. This is another reason why a pad of at least 7 percent is necessary during the planning phase of a project.

Pad Recommendations. For planning purposes it is better to overestimate pad than to underestimate it, unless doing so grossly distorts construction costs. Based on the FRA's present analyses, a 8- to 9-minute pad is being used to determine whether a reliable, less than 2-hour trip time between Washington and Richmond for two-stop express trains is achievable.

Trip Time Goal Status

The TPC simulations have clearly indicated that the performance characteristics of the intercity rolling stock will be critical to achieving the trip time goal of less than 2 hours.

To determine whether a reliable intercity service of less than 2 hours can be operated, Table B-11 (B-16) is prepared to summarize the overall running times for various alignment and train consist options. The results are shown for speeds computed for the three different unbalanced superelevation conditions and the three MAS options between Washington and Richmond that have been simulated. The table also shows the amount of pad available for each run.

Using 1-hour 55 minutes as the goal speed (less than 2 hours) and the 8 to 9-minute pad recommendation mentioned in the previous section, it is clear that only the cases in which 110 mph MAS is assumed resulted in a run time that provides the recommended pad. The 3-inch unbalanced superelevation case just barely qualifies. Both 90 mph 5-inch cases provide more than 7 minutes of pad, however the electrification case (AEM-7) is not cost effective. Therefore, an operation with two-diesels hauling the consist is required, however its reliability would not be as great as the 110 mph options.

Table B-16
SIMULATED RUN TIMES
AND AVAILABLE PAD
Compared to Hypothetical 1-Hour 55-Minute (115 Minutes) Goal

Case	Simulated Run Time	Pad (minutes.)	Pad (% of TPC Time)
Existing, 1 P42+6 Amfleet	123.7	N/A	N/A
90 mph/5" Eu/1 P42	110.6	4.4	3.8%
90 mph/5" Eu/2 P42	107.6	7.4	6.4%
90 mph/5" Eu/AEM-7	107.3	7.7	6.7%
110 mph/3" Eu/1 P42	106.3	8.7	7.6%
110 mph/9" Eu/1 P42	102.3	12.7	11.0%
110 mph/9" Eu/2 P42	95.8	19.2	16.7%
110 mph/9" Eu/AEM7	94.5	20.5	17.8%

Considering the above-mentioned uncertainties, it appears that the two 90 mph cases with 5 inches of unbalanced superelevation (preferably with 2 P42 diesel locomotives) will achieve the trip time goal of less than 2 hours. A 9-inch unbalanced superelevation 90 mph option (assuming tilt equipment), although not simulated, would most likely meet the goal. All of the 110 mph options meet the goal. The two 9-inch unbalanced superelevation options enable the goal to be achieved. However, as previously discussed, electrifying the Richmond Line does not appear to be a cost effective improvement, unless trip times for points north of Washington are taken into consideration.

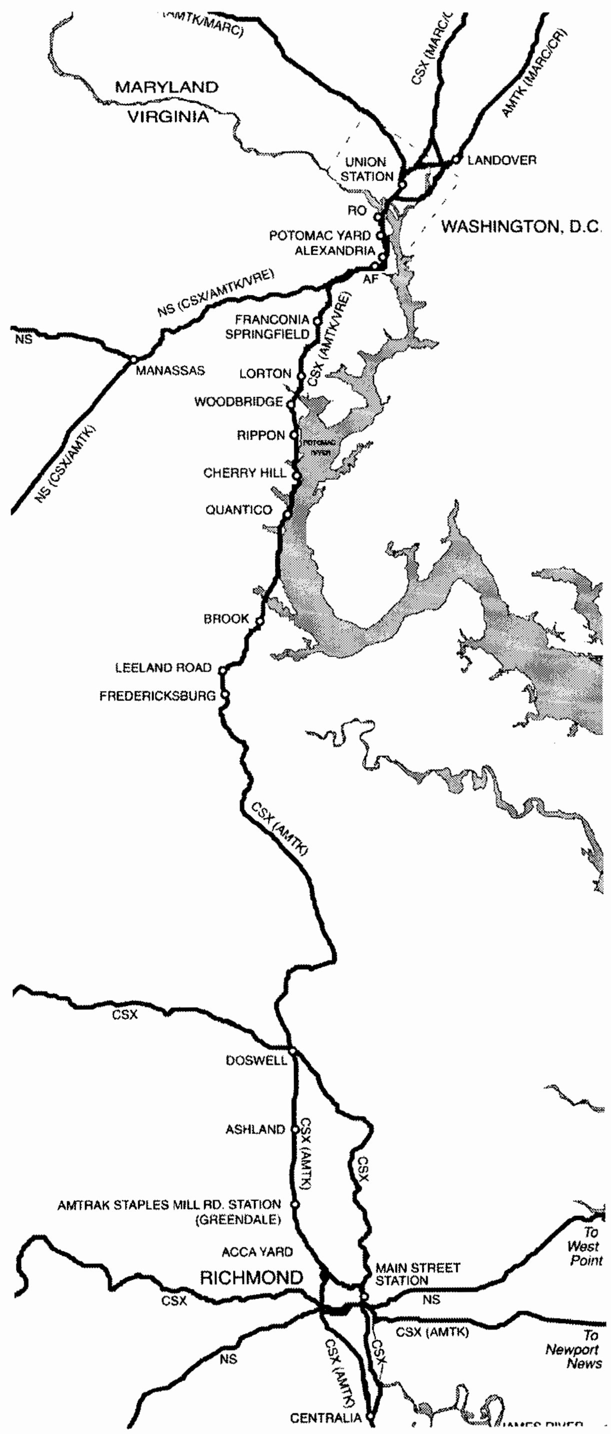
The service goal for acceptable on-time performance has yet to be established. It is believed that an on-time performance of at least 90 percent should be established as a goal for Richmond Line train services.

As previously discussed a number of potential changes in the conditions upon which the TPC results are based might occur, which further erodes the amount of available pad. For example:

- There may still be some question as to whether all of the curve modifications that are assumed in the TPC runs are feasible from an engineering standpoint;
- If a 90 mile-per-hour MAS cannot be achieved, there is some increase in TPC running time;
- If an unbalanced superelevation lower than 5 inches must be used, the trip time suffers; and
- Adding station stops at Ashland and Quantico to the schedules of goal trains results in an increase in running time of about 4 minutes; these trains possibly could be reliably operated on 120-minute schedules.

Report to Congress **APPENDIX C**

Potential Improvements to the Washington—Richmond Railroad Corridor



OPERATIONS ANALYSIS TO SUPPORT PROJECT GOALS

May 1999

Appendix C
OPERATIONS ANALYSIS TO SUPPORT PROJECT GOALS

INTRODUCTION

Simulations of passenger and freight operations between Washington, DC and Centralia, VA were performed to ascertain the facility improvements necessary to accommodate proposed 2015 levels of intercity and freight operations. Initially, a simulation to evaluate projected 2015 intercity passenger, commuter, and freight train operations between Washington, D.C. and Richmond, Virginia was performed. Desired frequencies and headways were utilized to develop preliminary schedules, which were later modified to integrate with intercity and commuter operations at Washington Union Station and eliminate obvious conflicts.

Terminal operations at Main Street Station in Richmond were not simulated as part of the Washington to Richmond Corridor study. Although it is was expected that the terminal could accommodate the traffic simulated, the capacity of the terminal could not be ignored, and it was decided to perform a detailed evaluation of train operations in the vicinity of Main Street Station. The interface of passenger and freight operations at the station and in the vicinity of the station are potential problems that were addressed by this analysis. However, this terminal capacity evaluation was performed to assist the City of Richmond resolve numerous issues necessary to complete the planning and design of the Richmond Multi-modal Transportation Center.

This Appendix:

- Describes the simulation process,
- Documents the rail facilities and train operating assumptions modeled between Washington and Richmond,
- Presents conclusions reached as the result of the simulations and analyses performed between Washington and Richmond,
- Documents the rail facilities and train operating assumptions modeled between Staples Mill Rd. Station and Centralia, VA, and
- Presents conclusions reached as the result of the simulations and analyses performed between Staples Mill Rd. Station and Centralia, VA.

2015 TRAFFIC LEVEL OPERATIONS

MONTE CARLO™ Simulations

When several services coexist on the same trackage, conflicts are likely. Time lost as a result of these conflicts can jeopardize the reliability of all services. Consequently, the LOGSIM and MONTE CARLO™ simulation packages, previously developed for the FRA and Amtrak, was utilized to measure the impact of these conflicts. Simulation of the entire system was the only valid methodology to evaluate the interrelated intercity, commuter, and freight services on the Richmond Corridor.

The purpose of the simulations was to provide information as to:

- where delays may occur;
- where schedule changes can eliminate conflicts and delays; and
- where facility changes can eliminate conflicts and delays.

Throughout this section the term "delay" is used to describe the additional time required to move a train between two points over and above the theoretically perfect TPC run for that type of train. The term does not refer to a "delay" from a schedule or published timetable that includes an acceptable "pad," which is described later in this section.

The MONTE CARLO™ simulator provides a large number of tabular reports to assist in analysis of the simulation. In addition, string lines of the simulation can be plotted for each simulation run using Amtrak's plotting program. The string lines visually depict the each trains's performance and delays.

LOGSIM™

LOGSIM™, a train simulation program embedded in MONTE CARLO™ developed to evaluate train operations scenarios in the densely traveled Northeast Corridor, was utilized to simulate projected 2015 intercity passenger, commuter, and freight train operations in the Richmond Corridor. Desired frequencies and headways[1] were utilized to develop preliminary schedules, which were later modified to integrate with intercity and commuter operations at Washington Union Station and eliminate obvious conflicts. The train simulation used MONTE CARLO™ to randomly vary hourly performance.

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[1] As provided by Virginia Railway Express (VRE), Virginia Department of Rail and Public Transportation (VDRPT), Amtrak, and CSX Transportation (CSX). Norfolk Southern (NS) schedules were assumed.

A number of individual train performance simulations and preliminary train operations models were created using several different track configurations to determine where the problem areas were likely to be located. Then, the train operations model was run through a series of iterations with various modifications to the track configuration (crossover configurations, passing track locations, platform locations, etc.) with the goal of improving the overall operating performance of freight, commuter and intercity passenger trains. When it appeared that the overall performance had stabilized with an economically feasible track configuration, a full 7 day MONTE CARLO™ simulation[2] was run to observe the impact of various trains deviating from their assigned schedule on a random basis (a reflection of real-world conditions).

WASHINGTON - RICHMOND SIMULATION

Simulation Methodology

The starting point for the Washington - Richmond simulation was to encode the planned 2015 route system into the MONTE CARLO™ format. Year 2015 schedules were obtained from each entity (VRE, VDRPT, CSX, NS, and Amtrak) and encoded into the model.

Intercity trains enter into the models at Washington and Richmond on their scheduled departure times. When each train enters the system, the model determines whether it will depart the terminal on time or late. If late, the model determines how late by sampling historical departure statistics. Before leaving the terminal, each train's road performance factor is determined, varying from the minimum running time to about 3 percent greater than the minimum. This technique accounts for minor differences in locomotive performances and train handling. Thus the operation of the same train on successive days probably varies, as they do in actual operations.

Long distance Amtrak passenger trains were allowed to enter the simulation according to a historical distribution supplied by Amtrak. Originating Amtrak and VRE commuter trains departed mostly on time but could depart as much as 10 minutes late. With this deviation, trains frequently left Washington or Richmond out of planned sequence. When Amtrak trains departed behind a local VRE train, the simulation utilized pre-coded logic to enable the intercity train to run around the commuter train by utilizing passing tracks, or other overtake points, if available.

Using the dispatching rules encoded in the model for that train, or a group of trains having the same stopping pattern, an actual dispatcher controlling the operation was simulated. The train

[2] Each scheduled train is entered into the model at the same time each day, but its entry into simulation is controlled by a random number generated within the simulator.

could be routed on regularly assigned tracks, or other tracks if necessary. If no track was available, or if an interlocking was blocked, the train would wait until a route was available. Trains were kept from following each other too closely just as they actually would be by the signaling system.

Every main track crossover and turnout was represented in the model. When a train used a crossover, either to reach an assigned track or because of contingencies, the additional time to use the crossover, if any, was accounted for by the model. Each interlocking route was blocked for a designated amount of time to preclude conflicting trains from using it simultaneously. The time consumed making station stops also was simulated.

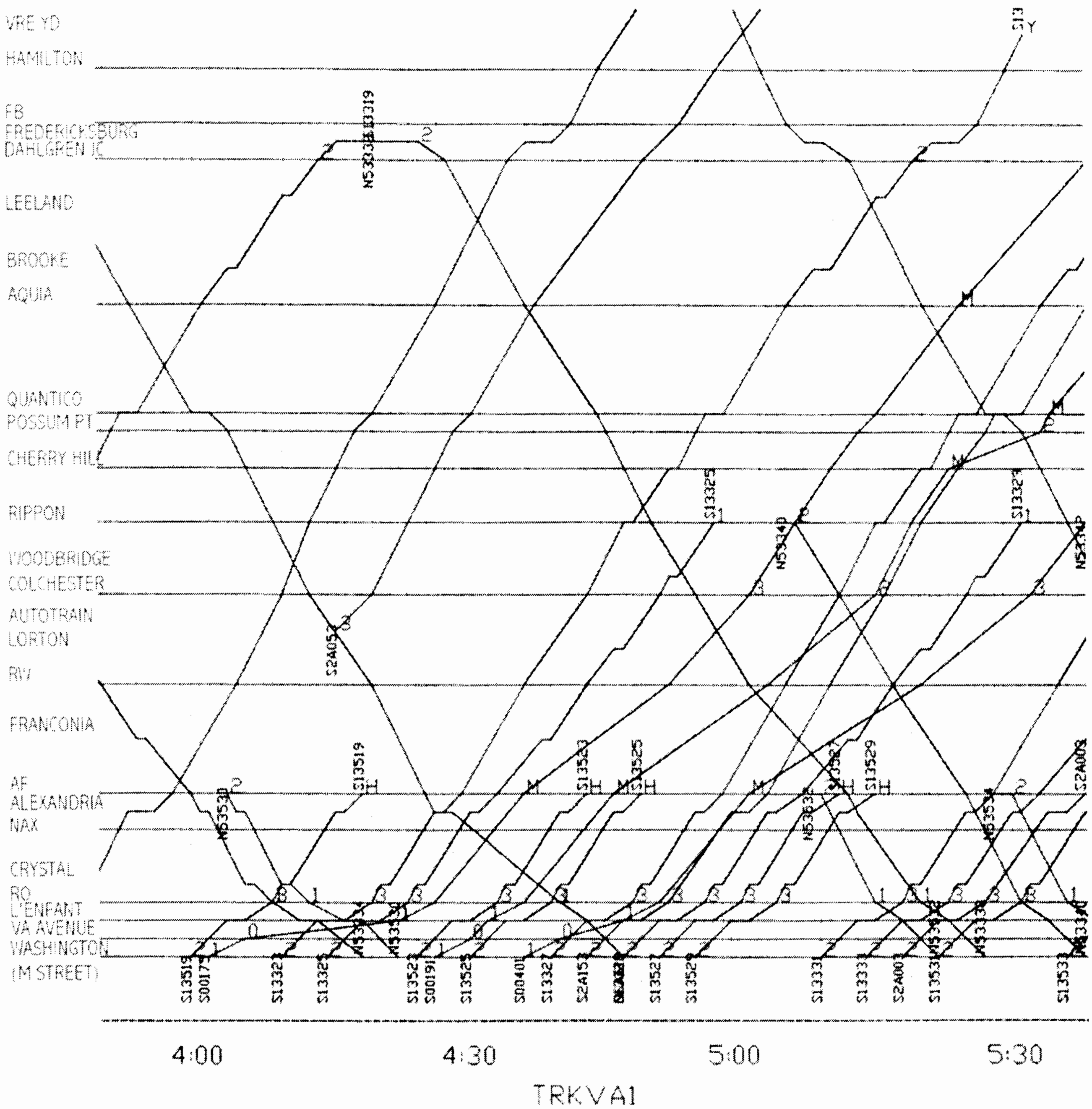
Commuter trains also entered the model on their scheduled times. VRE Fredericksburg Line trains entered at Fredericksburg and VRE Manassas Line trains entered at Alexandria. Both lines were entered into the model at Washington for their return trips. These trains were sampled for lateness and performance, and were routed in the same manner as intercity trains.

CSX freight trains randomly entered the simulation ranging from 30 minutes early to 1½ hours late. NS freight trains entered the simulation at 6 hour intervals, then were randomly released between that time and two hours later. This gave a wide range of entry times for both services. If an intermodal train selected a departure time placing it immediately behind a regular freight train, the intermodal train was given priority at its origin, like a train dispatcher would normally do. Northbound CSX trains entered at Richmond and northbound NS trains enter at Alexandria. Both railroads trains entered the model at CP Virginia for southbound trips. These trains were sampled for lateness and performance, and were routed in a manner similar to intercity trains.

Terminal operations in Washington were simulated as part of the New York to Washington Corridor Transportation Plan study. The simulation results will be documented in that report. Terminal operations at Main St. Station in Richmond were not initially simulated. It was expected that the terminal could accommodate the traffic simulated. The capacity of the terminal could not be ignored, and the interface of passenger and freight operations at the station and in the vicinity of the station were a potential problem that must be addressed. However, this study considered the terminal capacity a separate problem to be resolved by the City of Richmond during planning of the Richmond Multi-modal Transportation Center.

A typical plot of a simulation is shown in Figure C-1 The results shown are for the early afternoon peak - 4:00 p.m. to 5:30 p.m. - for the portion of the corridor between Washington and Fredericksburg. Trains departing Washington move from left to right up the page, while trains arriving Washington move from left to right down the page. The density of traffic southbound from Washington is clearly shown. The difference in speed of trains is shown by the variation in slope of the lines, in particular south of Alexandria where the impact of the Franconia Hill on train operations becomes evident.

Figure C-1 Plot of Simulation Model Results



Simulating Operations Between Washington and Crystal City

The results of the detailed computer simulations for the segment between Washington Union Station and Alexandria revealed that the most constrained operation between Richmond and Washington occurs in the 8-mile stretch between CP-Virginia Interlocking and AF Interlocking[3]. There are two primary reasons:

- the greatest number of passenger trains of any segment are operated, because it carries all of the trains operated on both the CSX and NS routes south and west of Alexandria, and
- an inability to economically add trackage, especially a third track over the Potomac River at Long Bridge.

Problems to be overcome and a number of potential solutions developed from analysis of the simulations are described below.

Preliminary Conclusions. Prior to performing detailed simulations, preliminary conclusions were arrived at. First, the single platform at the L'Enfant VRE Station, located 0.4 miles south of the CP-Virginia Interlocking, between 6th and 7th Streets, S.W. was inadequate. The single platform allows only the adjacent track to be used. With the proposed 2015 passenger train volume, the number of trains stopping at L'Enfant could not be handled on a single track, and a second platform located east of Track 1 was considered to be necessary. This configuration is shown in Figure C-2. Analysis of simulation results indicated that the number of freight trains held by passenger trains was unsatisfactory.

Another conclusion regarding passenger train operation was that improvements to the track arrangement for the movement of passenger trains were necessary. The existing crossover located on the curve leading to the 1st Street Tunnel should be relocated to allow a faster crossover movement. This can only be provided by installing a new crossover on tangent track, to the south on the viaduct. This opens up the track space and allows a long passenger train room to stand between the home signal at the tunnel portal and the home signal at CP-Virginia.

Allowing space for a train to stand at CP-Virginia frees up space at the critical "A" Interlocking, in the Station, at the other end of the tunnel. Trains can be held there temporarily after moving out of the station, or before moving into it. Numerous movements, back and forth through the interlocking, must be made to exchange electric and diesel locomotives on trains running through to locations south of Washington. The number of these trains are projected to increase significantly, and the ability to hold trains between "A" and the Conrail line, at CP-Virginia, will become increasingly beneficial.

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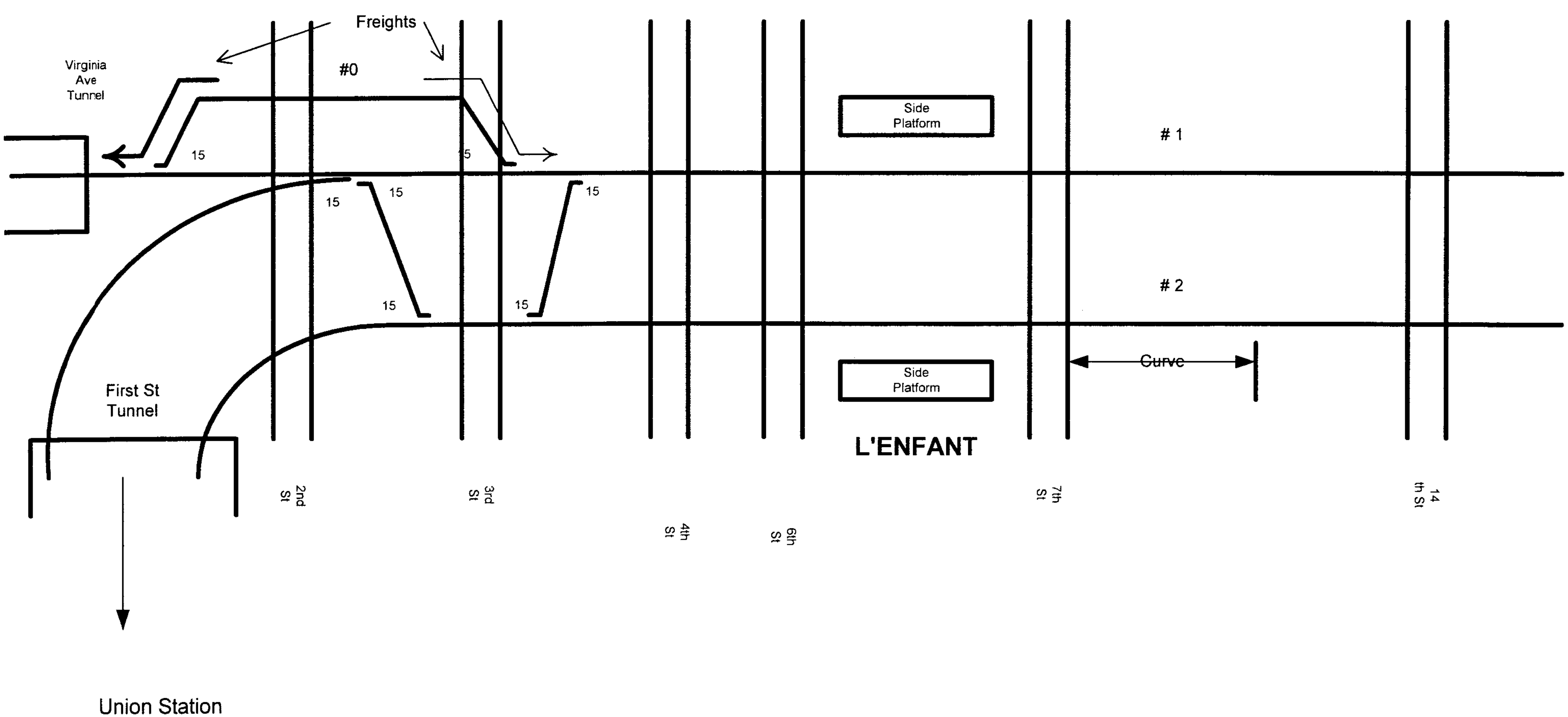
[3] AF Interlocking is located south of the Alexandria Station, near the Telegraph Road bridge.

Figure C-2 "CP Virginia" Interlocking



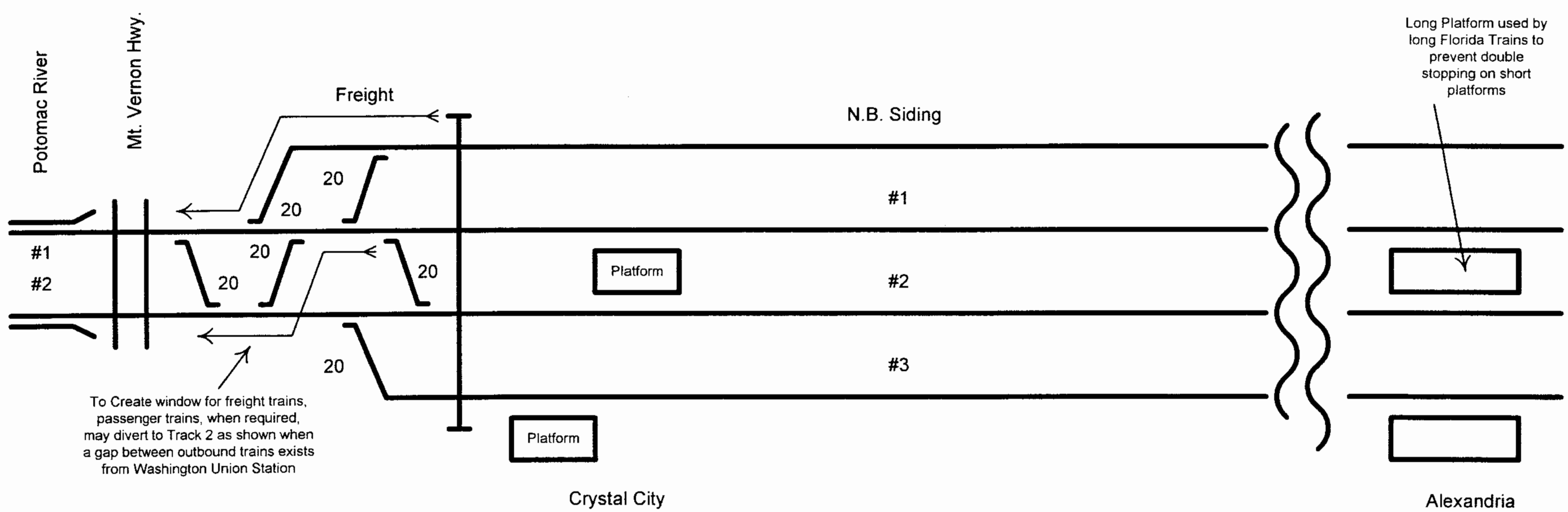
With the new crossover at CP-Virginia located on the straight track south of the curve, passenger trains would make crossover movements at 30 mph instead of 15, thereby reducing the time required for each movement. This contributes to expanded capacity by expanding the windows available for freight movements. In actuality, the new crossover would provide greater flexibility in the movement of multiple trains, because it would be used more often than the old one it would replace. Due to the constraints imposed by the signal system to protect the existing slow speed crossover, it was seldom used. Such a move generally takes longer than holding the train until the opposing train has passed, then allowing it to proceed on the same track. With these constraints eliminated, the new crossover would be used to its full advantage, unlike the present one.

Another initial conclusion was that there is a potential problem in the lack of capacity to operate the projected daily CSX and NS freight trains, between CP-Virginia and RO. South of 14th Street, one mile south of CP-Virginia, the right-of-way narrows to two tracks all the way to RO. The problem of lack of capacity actually extends to AF, south of Alexandria, but a significant part of the problem south of RO could be eliminated by constructing a fourth track on available right-of-way between RO and AF (see Figure C-3). The rationale for the fourth track is addressed in Appendix G. There is no similar solution however, and no simple or inexpensive way to add additional tracks to the two existing tracks between RO and 14th Street, or a second track through the Virginia Avenue Tunnel.

The problem of lack of capacity already exists with the existing level of freight traffic during the daytime hours. Most of the additional trains are projected to be operated at night, thereby, they would have minimal impact on passenger operations.

A third conclusion regards an adjacent segment to the north. The 2,000 foot single track connection between CSX (Shepherd Jct.) and Conrail (Anacostia) makes the de facto south end of double track for CSX at Shepherd Jct., not M Street, an interlocking located at the north end of the Virginia Avenue Tunnel. The existing double track segment between Anacostia and M Street cannot hold a long freight train, and the rear end of a southbound train held at M Street would extend onto the CSX single track between Shepherd Jct. and Anacostia, blocking the movement of a northbound freight train. A northbound train has even less room; even a short train most likely would not fit between M Street and the northbound home signal for Anacostia, because the signal is located south of the Anacostia Drawbridge. Without careful train dispatching, it is possible for an impasse to occur between two freight trains. Double tracking between Shepherd Jct. and Anacostia is critical to making the freight system work even at today's traffic levels. Consequently, the simulations assumed that this short segment was double tracked.

Figure C-3: "RO" Interlocking
(RF&P MP 110.1, CR MP 138.6



Even if the double track were extended, a segment of single track through Virginia Avenue tunnel would probably remain. Although it is possible that CSX will decide to make the additional investment, the second track could only be provided at significant additional expense. Even if this were done, the simulations discussed below determined that a second track, with adequate clearance, through the tunnel would allow double track operation for freight trains, ***only when no passenger trains were operating between CP-Virginia and RO***. Primarily, this is because to reach Track 2, the southbound freight trains would have to cross the path of all northbound passenger trains on Track 1 at CP-Virginia. They would have to be fitted into the schedule windows between the southbound passenger trains on Track 2, and the proposed 2015 passenger train operations would frequently take away the availability of Track 2 for southbound freight trains. The probability of having windows that occur simultaneously between the movements of both north- and southbound passenger trains, so that a southbound freight train could use Track 2 in a timely fashion without affecting passenger trains, was quite small during much of the day time. Therefore, for most of the day freight trains could only be operated on a single track between CP-Virginia and RO.

Conclusions from the Simulations. One of the first conclusions reached following the simulations is that it would be best to maintain a separation of freight trains and southbound passenger trains in Southwest Washington Corridor (the segment of the Richmond Corridor located between CP-Virginia and RO). Referring to Figure C-2, freight trains would be restricted to Track 1 between CP-Virginia and RO. Use of Track 2 by freight trains would be permitted only at times when passenger trains were not present. Effectively, this means that freight trains would be confined to a single track operation at most times when they would have to interface with passenger trains. Therefore, the object of the simulations, and the analyses of the train interactions, was to make the best of this situation, and achieve an acceptable combined freight and passenger operation.

Ideally, it would be desirable to construct an exclusively freight track next to Track 1, the full distance from CP-Virginia to RO (refer to Figures C-2 and C-3), with no passenger interface between CP-Virginia and AF. This would allow freight trains a single track, even during hours of relatively intense passenger train operations. Unfortunately, in spite of the critical need for this additional track, existing Federal parks and bridges between 14th Street and RO makes construction of this third track economically and environmentally unacceptable.

The second conclusion is that all train movements between Chesapeake Jct. (north of Anacostia on CSX) and on the Landover Line (on Conrail), on the north, and AF, on the south, should be controlled by the same train dispatcher. The operations were so time sensitive that the current hand-off at RO between two dispatchers via telephone should not continue.[4] The relaying of information takes time, and any delay in making that communication could easily cause an available window to close. In addition, if the dispatcher's territory were local, full attention could be given to the intense operations between AF and Chesapeake Jct. The rationale for this recommendation is demonstrated in the following paragraphs.

Operating Scenarios Resulting from Simulations. Based on the simulations performed and an analysis of the results, it is concluded that the most effective operation of freight trains is to use Track 1 for all movements, north and south.

Southbound freights would move on Track 1 from CP-Virginia (MP 136.7), near 2nd Street (Figure C-2) to RO, against the flow of northbound passenger trains. With today's track configuration this requires, at minimum, a 20-minute window between northbound passenger trains, to avoid delay. This window could be reduced to slightly more than 17 minutes by constructing Track 0 from CP-Virginia to 3rd Street (MP 136.7) and adding a parallel right hand crossover between Tracks 1 and 2 at CP-Virginia. The sequences that form this 17-minute window are shown in Table C-1. The difficulty with this scenario, however, is that the 17-minute window is virtually impossible to attain at certain times of the day. For example, between 0630 and 0800 hours the proposed 2015 schedule calls for 13 northbound passenger trains (average headway of 7 minutes). There is no gap of 17 minutes available between these trains.

Operating a southbound freight train between two northbound passenger trains having less than 17 minutes between them delays the second northbound passenger train, unless the second passenger train could operate on Track 2 between RO and 3rd Street, between southbound passenger trains. Waiting for a window between northbound passenger trains having less than 17-minute headways delays the southbound freight train, unless one or more of the northbound passenger trains could operate on Track 2 between southbound passenger trains to create a window for the freight train.

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[4] The CSX acquisition of a portion of Conrail should eliminate the Dispatcher handoff at RO. CSX will acquire the present Conrail right-of-way between RO and Landover, and will be responsible for train dispatching over this line. However, the need for CSX and Amtrak dispatchers to interface at CP-Virginia will remain.

Table C-1 Window required at RO between northbound passenger trains for movement of a southbound freight train between 3rd Street and RO (Figures C-2 and C-3)		
	Sequence	**Time (mins.)**
1	Northward passenger train passes RO	0
2	Northward passenger train passes 3rd Street (assumes stop[5] at L'Enfant)	5
3	From start of southward freight train to head end passing 3rd Street	9
4	Head end of southward freight passes RO	13
5	Rear of southward freight clears RO and next northward passenger train passes RO	17

Extending Track 0 south of 3rd Street (MP 136.7), to the north end of the Long Bridge, would further reduce the required window to about 13 minutes, but this is considered to be unacceptable, in terms of local and environmental issues. The largest portion of time (about 8 minutes, as shown in Table C-3) consists of the time required to start a standing freight train, after a passenger train had passed, and for a long freight train to clear the interlocking routes at RO.

Northbound freight trains require a smaller window than southbound freight trains because they move in the same direction as the northbound passenger trains. Furthermore, the unusable opposing single track time that must be made available to a southward freight at RO is eliminated. The windows required between northward passenger trains to allow a northward freight train to proceed were five minutes less that those required to allow a southward freight train to proceed. The 12-minute window between northbound passenger trains required to move a northbound freight train is shown in Table C-2.

Extending the south end of Track 0 from 3rd Street to 14th Street reduces the window to about 10 minutes. However, doing this places Track 0 in conflict with the need for a second side platform for northward trains at L'Enfant. There is room for one, or the other, but not both.

The workings of the signal system serves to increase the time required for a northbound freight train to follow a passenger train. When a standing northward freight is to follow a passenger train from RO, the engineer usually waits until the interlocking signal displays something more favorable than a Stop and Proceed, or a Restricting aspect. Otherwise, the

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[5] If train does not stop at L'Enfant deduct 2 minutes.

train must operate at Restricted Speed[6] until the next signal is observed, and must continue to maintain Restricted Speed until the entire train had passed the interlocking, before accelerating. This is because, with a Stop and Proceed or a Restricting indication, the engineer does not have the assurance that no broken rails are present in the track over which he is operating.

Any signal indication better than Restricting also confirms that the current that produces the signal has been able to pass through rails that are not broken or disconnected. Restricting, and Stop-and-Proceed indications can not convey this indication. Therefore, as a precaution, it is standard operating practice to require that a train operating under a Restricted Speed signal must continue at Restricted Speed when a better indication is observed, until the entire train clears the section where the Restricting signal governed. As long as the train remains in the section where no assurance regarding broken rails was given, it must be assumed that such a condition might be present. Therefore, for practical reasons, time is saved by waiting for a better signal at the interlocking and moving at a faster speed once underway.

How soon the signal displays an improved aspect depends upon the distance to the next signal and the speed of the preceding train. For example, a northbound freight train waits on the northbound siding at RO (refer to Figure C-3) to follow a passenger train on Track 1. If there were no intermediate signal between RO and CP-Virginia, the wait could be as long as five minutes (including station dwell time at L'Enfant) before the freight would receive a signal indication better than Restricted Speed (15 mph). Recently, the wait at RO has been reduced to two minutes by the installation of an intermediate signal at 14th Street.

Cab signals are not presently in effect between RO and CP-Virginia. When cab signals are in effect, the engineer would receive an immediate indication when a better signal is displayed, and may begin to accelerate immediately to the maximum permitted, unless Restricting was the engineer's previous indication. In this case the train must be run its length, as a precaution against the possibility of an undetected broken rail, before beginning to accelerate.

Operating some northbound passenger trains on southbound Track 2 from RO to CP-Virginia, then diverting them back to the normal northward Track 1 at CP-Virginia, enables freight trains on Tracks 0 and 1 to operate in parallel with passenger trains on Track 2. However, the northbound passenger trains also need windows between opposing southbound passenger trains to make the concept work, and this adds complexity. The 14-minute window that is required between southbound passenger trains if the crossover is located at 3rd Street is illustrated in Table C-2. Locating the crossover at 12th Street and extending Track 0 from 3rd Street would

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[6] A signal aspect requiring the engineer be prepared to stop his train within one-half of his range of vision, and short of any other train, any obstruction, a switch not properly lined, and looking out for broken rail or misaligned track, while not exceeding 15 mph. When operating a train weighing thousands of tons, this, of necessity, is extremely slow, on the order of a slow crawl.

require building an island platform at L'Enfant to enable Track 0 to be extended. Building this platform is not only geometrically difficult, due to curves and bridges, but providing passenger access to the platform from the street, and to the subway tracks underneath, may be prohibitively expensive. Any less expensive alternative may require a long, isolated walkway that could discourage its use. The feasibility of the center-island platform, in terms of track alignment and passenger access, requires additional detailed evaluation.

Table C-2
Window required between RO and 3rd Street (Figure C-2) between southbound passenger trains to run a northbound passenger train on Track 2 against primary traffic flow

	Sequence	Time (mins.)
1	Southward passenger train passes 3rd Street	0
2	Southward passenger train passes RO (assumes stop[7] at L'Enfant)	5
3	Reverse crossover, set signals, northward passenger train passes RO	7
4	Northward passenger train passes 3rd Street (assumes stop[7] at L'Enfant)	12
5	Reverse crossover, set signals, next southward passenger train passes 3rd Street	14

Operating a northbound passenger train on Track 2, when the window between southbound passenger trains is less than 14 minutes, delays the second southbound passenger train. There is insufficient room for this train to stand between the south portal of the 1st Street Tunnel and CP-Virginia, and delaying a train within the 1st Street Tunnel is not done because of diesel fumes.

Clearly, shortening the window is not the ultimate solution. Constructing a third track over the Potomac River would eliminate the need for the window entirely. However, that alternative is very expensive, and environmentally sensitive. Therefore, additional improvements to shorten the window were necessary.

Between 0700 and 0800 hours and also between 1630 and 1800 hours, the average headway between southbound passenger trains is 7 minutes. Therefore, attaining a 14-minute window is nearly impossible during these hours. If neither the northbound nor the southbound

[7]If train does not stop at L'Enfant deduct two minutes. Moving the crossover between Tracks 2 and 1 at CP-Virginia south so as to exclude the station from the single track reduces the needed window to 10 minutes, and moving the crossover farther south to 14th Street further reduces the needed window to 8 minutes.

passenger train stops at L'Enfant, the required window is reduced to 10 minutes (shown in Table C-2).

Running a northbound freight train between two northbound passenger trains having less than a 12 minutes between them (Table C-3) would delay the second northbound passenger train, unless it is able to operate on Track 2 between southbound passenger trains. Waiting for a 12-minute window between northbound passenger trains delays the northbound freight, unless a northbound passenger train could run on Track 2 between southbound passenger trains to create a window for the freight train.

Table C-3
Window required at RO between northbound passenger trains to move a following northbound freight train between RO and CP-Virginia (MP 137) (Figures C-2 and C-3)

	Sequence	Time (mins.)
1	Northward passenger train passes RO	0
2	From start northbound freight train, until head end occupies RO	4
3	Head end of freight passes MP 137	8
4	Rear of freight clears MP 137, signals realigned, next passenger train passes RO	12

In spite of these known drawbacks, described above, the configuration shown in Figure C-2 was simulated with reasonably satisfactory results, given the high cost of the alternative shown in Figure C-4 (over $40 million). In seven days of simulation, more than half of the freight trains passed through the corridor without being held at either RO or M Street, or at 3rd Street. Some of the freight trains that were held at M Street or RO were delayed on the de facto single track between those points by opposing freight trains. It is estimated that approximately one-sixth of the freight trains would find an opposing train there. When one considers the cost of the long-term solution, it is difficult to justify in the short-term.

Operation of northbound passenger trains on Track 2 appeared to go more smoothly than anticipated. A seven-day average of 6.2 northbound passenger trains operate on Track 2 between RO and 3rd Street to create windows so the freight trains could move on Track 1.

While a prima facie conclusion appears to be that the results were satisfactory, analysis of freight trains held by passenger trains shows that the results were actually not satisfactory. Some southbound freight trains, both in the morning and evening peak, were held as much 30 minutes (with a potential for holds of up to an hour) because northbound passenger trains could not divert to Track 2 at RO, because the required 14-minute window, referred to earlier, could not be obtained. This is to be expected because a combined total of eighteen northbound and southbound passenger trains operated between 0700 and 0800 hours, and fifteen trains operated between 1630 and 1730 hours.

The Proposed Solution - Three-Track 12th Street to CP Virginia, Four-Track north of CP-Virginia. As the above discussion indicates, the 14-minute window must be lessened. The three-track configuration between CP-Virginia and the curve north of 14th Street, shown in Figure C-4 has the ability to do that. The configuration includes a center island platform between 6th and 7th Streets to enable commuter trains to use either Tracks 2 or 4[8]. With the three-track configuration shown, a southbound commuter train could move south into L'Enfant station on Track 4, while a northbound train could move north on Track 1 from RO. The two could meet at the 12th Street overdeck. The northbound train could crosscontinue to Track 2 and L'Enfant station, while the southbound train could crossover to Track 2 from Track 4 after the northbound train had cleared the 12th Street Interlocking.

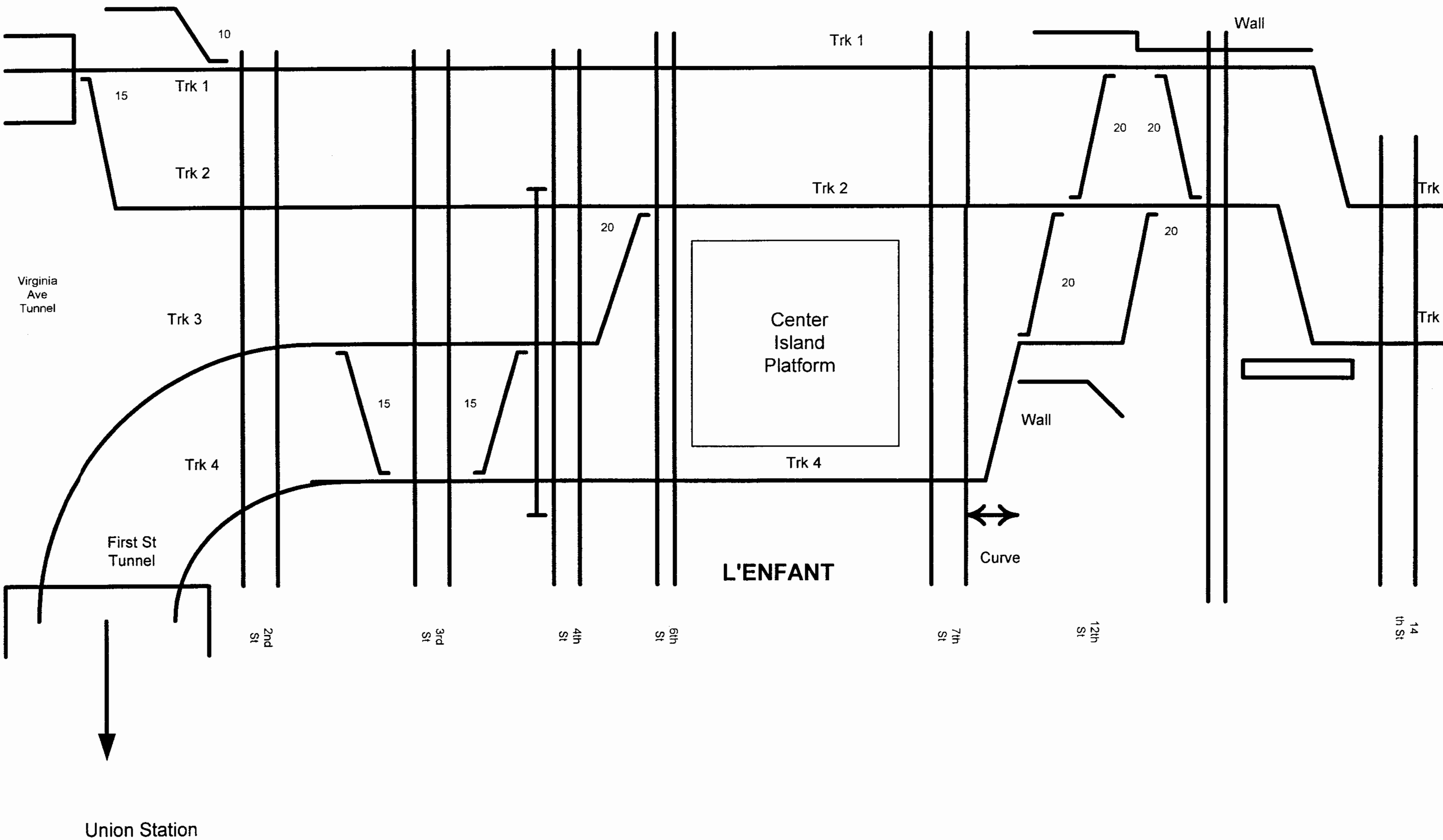
Without the third track, the northbound commuter train must operate on Track 1, and freight trains must be held at CP-Virginia and RO. The southbound freight route would be Track 0 from the Virginia Avenue Tunnel to 3rd Street and then Track 1 to RO.

The configuration shown in Figure C-4 provides significant flexibility. When a freight train is not programmed to run, a northbound commuter train or an intercity train could:

- Operate on Track 1 to 12th Street, then Track 2 to L'Enfant, and then Track 3 (CP-Virginia) to Union Station;
- Operate northbound on Track 2 to L'Enfant, then to Track 3 (CP-Virginia), to Union Station; or
- Track 2 to Track 4 at 12th Street and then to Union Station on either Tracks 3 or 4 north of CP-Virginia).

[8]The tracks have been renumbered based on the proposed configuration north of CP-Virginia: Tracks 1 (newly constructed between 8th Street and the Virginia Avenue Tunnel) and 2 lead to the Virginia Avenue Tunnel, while Tracks 3 and 4 North of CP-Virginia lead to Washington Union Station.

Figure C-4 "CP Virginia" Interlocking Long-Term Configuration



In summary, northbound passenger trains on Track 2 at 12th Street have three choices, each of which is independent of freight train operations on Track 1:

1. The first choice is the northbound train continues on Track 2 (the straight move at 12th Street), proceeds to L'Enfant, crosses over to Track 3 at CP-Virginia, and then continues on to Union Station;
2. Alternatively, the northbound train may use L'Enfant station on Track 4 by crossing over at 12th Street, if the move could be made without delaying a southbound train; or
3. The northbound train would hold until one of the 2 routes, whichever is first, becomes clear.

In conclusion, when freight and passenger trains are operating simultaneously in this area, some minor passenger train delay can be expected, since constructing a new bridge over the Potomac River appears unlikely. The best way to maintain schedule reliability is to allow sufficient schedule pad (discussed in Appendix B) for northbound trains between RO and Union Station. Also, by making the northbound stop at L'Enfant a D stop, to discharge passengers only, either track at L'Enfant could be used. This avoids the passenger handling problems arising from passengers waiting on one platform having to hurriedly move to the second platform to board a train. However, should joint service between MARC and VRE materialize, assigned station tracks would be necessary, and D stops could not be used for run-through trains.

The revised configuration would be of benefit to freight trains as well, as indicated by the simulated results, shown in Tables C-4 and C-5, for a day chosen at random, with and without the revised configuration. While there was no significant difference for northbound trains, delay to southbound trains was reduced from a total of 60 minutes to 12 minutes per day. In the simulation without the revised configuration, six northbound trains diverted at RO to Track 2 to make windows for freight trains. In the simulation of the same day with the revised configuration, four additional trains (a total of ten) were diverted to make windows for freight trains. Also, the portion of track 2 between 12th and 14th Streets was used four times in the simulated day. Stated in another way, the revised configuration allowed four additional trains to be diverted, reducing the holding times for freight trains.

Table C-4
Comparison of Freight Performance With And Without a Third Track at L'Enfant Station
(Holding Times in Minutes)
NORTHBOUND TRAINS

	Without Third Track			With Third Track			Causes for delay
Train	RO	MP 137	M St.	RO	MP 137	M St.	
410							
N52							
414	1			1			Southward train 415 clearing RO
174							
406	3			3			Restrictive signals following 3520
176							
NS4							
412							
K650							
192	3			3			Restrictive signals following 3530
NS6	1			1			Restrictive signals following 192
NS8							
406							
Totals	**8**	**0**	**0**	**8**	**0**	**0**	**Total minutes northbound freight trains were held**
	8						**Without Third Track**
				8			**With Third Track**

Table C-5
Comparison of Freight Performance With And Without a Third Track at L'Enfant Station
(Holding Times in Minutes)
SOUTHBOUND TRAINS

	Without Third Track			With Third Track			Causes for delay
Train	**RO**	**MP 137**	**M St.**	**RO**	**MP 137**	**M St.**	
405							
NS53		25			0		Without: Held for 3312, 3512, 3314; 3514 and 3316 diverted, without delay, to Track 2 at RO to make window for NS3; southbound A311 held 2 minutes at CP-Virginia for 3316 to clear Track 2. With: 3312 held at RO 3 minutes to let 3309 clear Track 2, then ran Track 2 to 9th Street to make window for NS3; A613 used siding to meet 3312; 3512 held 1-minute at RO for NS3 to clear.
413		5	7		1	7	Without/MP 137: Held for A602 and A020; 3522 diverted to Track 2 to make window for 413. M St.: Clearing single track at M Street With/MP 137: Held for A602; A020 and 3522 diverted to Track 2 to make window for 413. M St.: Clearing single track at M Street
173		7			0		Without: Held for 3526, A002 diverted to Track 2 at RO to make window for 173. With: Both 3526 and A002 diverted to Track 2 at RO to make window for 173.
409							
175							
NS5							
401							
191		15			3		Without: Held for 3338, 3340, and 3534; no window available on Track 2. With: Held for 3338, 3340 diverted to Track 2 at RO and met 3538 at siding; 3534 held 1-minute at RO for 3531 to clear; then 3534 diverted to Track 2 and met 3533 at siding.
NS7							
415		1			1		Held for A616.
Totals	**0**	**53**	**7**	**0**	**5**	**7**	**Total minutes northbound freights were held**
		60					**Without Third Track**
					12		**With Third Track**

Crystal City to Alexandria, (RO Interlocking to AF Interlocking)

Freight and passenger operations between RO and AF Interlockings should be separated as much as feasible (see Figure C-3). Separate tracks enable northbound passenger trains to overtake northbound freight trains, which may be held at RO due to the single track Virginia Avenue Tunnel. The N.B. Siding track, shown in both Figures C-3 and 5, serves that purpose.

Just as interaction between freight trains and southbound passenger trains was avoided between CP Virginia and RO those interactions also could be avoided at AF by having CSX freight trains use the middle Track south of AF[9] whenever possible. However, at some point the flow of northbound passenger trains to Union Station must be crossed by southbound freight trains from the Virginia Avenue Tunnel. When a southbound freight train uses Track 2 north of RO (see Figure C-3), a northbound passenger train would operate on Track 1 at RO. However, operating southbound freight trains on Track 2 north of RO prevents northbound passenger trains and freight trains from making parallel moves (freight to Track 1, passenger to Track 2) at RO. Therefore, southbound freight trains on Track 2 north of RO must move onto a track without conflicting with northbound passenger trains. This does not preclude southbound freight trains from using Track 2 in off-peak hours. A major reason for having the southbound freight trains cross the path of northbound passenger trains at AF was that there were fewer conflicts at this location. Southbound freight trains would not conflict with northbound Manassas Line commuter trains at AF.

A passing siding next to the horn track at AF has been assumed, to enable northbound and southbound Manassas Line trains to meet with nominal delay. Bringing the northbound Manassas trains in from the east side (Norfolk Southern freight yard route) to avoid conflicts with the southbound CSX trains also was considered, but this created conflicts with both northbound and southbound CSX freight trains somewhere between AF and CP-Virginia. The passing siding along the Horn Track appears to be the best solution, given the 3-4 miles of effective single track from AF Interlocking to Edsall Interlocking on the Manassas Line.

The connection to the Norfolk Southern on the east side should be used for freight trains, since all freights north of AF were on the east side (N.B. Siding and Track 1). AF Interlocking, as shown in Figure C-5 satisfactorily handles the proposed 2015 level of service.

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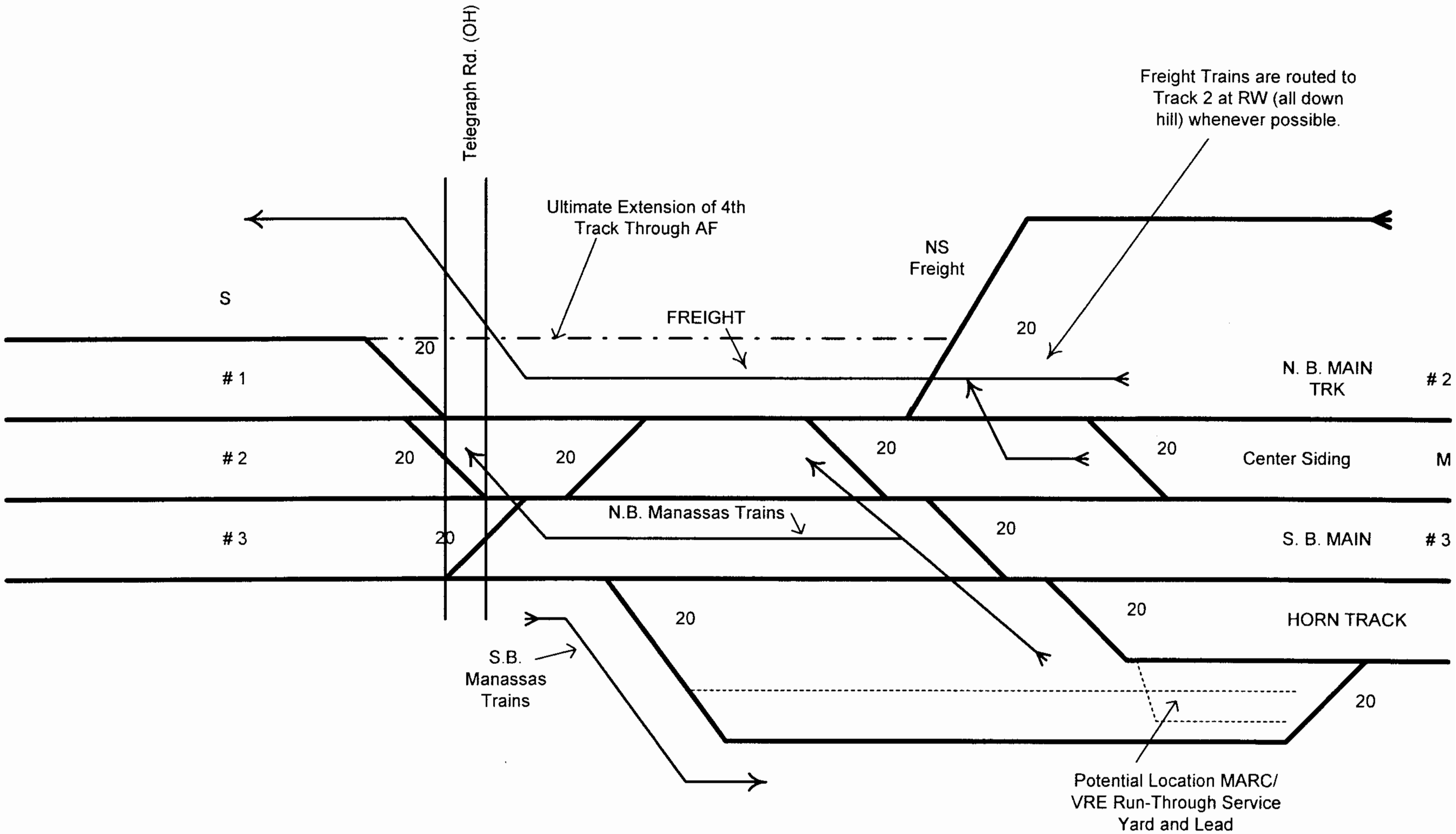
[9] Previously removed and must be reinstalled as subsequently discussed.

Figure C-5: "AF" Interlocking (MP 104.3)



Operations Between Alexandria and Fredericksburg

Alexandria to Ravensworth, (AF Interlocking to RW Interlocking). Southbound freight trains were slowed by the relatively steep (0.8 percent grade) 5 mile Franconia Hill between AF and MP 99. The slower operation reduces track capacity and makes a three track configuration essential in this area. A third track was added to the track configuration. Unless the segment of third track between RW and AF was occupied with northbound trains (see Appendix D, Exhibits 5A and 6A), all southbound freight trains were routed to the third track between AF and Colchester in the simulation. If northbound trains occupy the third track, the southbound freights may operate Track 3, if they would not delay passenger trains. This enables slower moving freight trains to climb the Franconia Hill without delaying other trains. No southbound freight trains used Track 3 in the seven-day simulation; meaning that all southward freight trains use the third track. Southbound intermodal trains climb Franconia Hill in the speed range of 20-25 mph and other freights at only to 15-20 mph. Many passenger trains use Track 3 to overtake freight trains on Franconia Hill.

At RW northbound freight trains on the third track were routed to Track 2, if Track 2 was clear of passenger trains, to avoid possible interference at AF. However, two or three northbound freight trains use the third track between RW and AF each day. Some of these were slowed slightly at AF to let the passenger trains running parallel to them on Track 2 go ahead. Appropriate radio communication between the dispatcher and the freight train would avoid stopping these trains.

Amtrak trains were not scheduled to overtake local commuter trains between AF and RW, but on most days an out-of-slot (later than scheduled) Amtrak train uses the third track from AF to overtake local commuter trains.

At RW, southbound freight trains continued on the third track unless the third track was occupied by a northbound train between Colchester and RW. Northbound freight trains normally did not use the third track unless Track 2 was occupied by northbound passenger trains. When a southbound freight train stops north of RW, on the third track waiting for a northbound freight train on the third track it was delayed until the northbound train crosses to Track 2 at RW or Track 3 becomes free, whichever occurs first. In the simulations, none of the southbound freights were caught in this trap and all continued on the third track to Colchester without delay. However, under some circumstances this condition could occur, especially if Amtrak trains were out of slot.

Colchester Interlocking. Northbound freights on Track 2 continued on Track 2 unless passenger trains were overtaking them from behind. In that case, they crossed to the third track to allow the overtake to occur. On most days, two or three northbound freight trains use the third track from Colchester.

Southbound freight trains operate on Track 2 between Colchester and Powells in parallel with passenger trains on Track 3, provided they could reach Powells and clear into the third track, and also provided that the third track between Aquia and Powells was clear of northbound trains. If Track 2 was not available, they cross over to Track 3 from Colchester, if they would not delay passenger trains. If neither route was available, they were held until a route was available. Some southbound freights were held at Colchester, but appropriate radio communication between the dispatcher and the train could avoid stopping the freight trains in most cases.

Powells Interlocking. Northward freight trains on the third track or Track 3 operated on Track 3 to Colchester, if opposing trains permit, and the third track was free of southbound trains between RW and Colchester. This situation rarely occurred because the third track was heavily used southward.

Aquia Interlocking to South Aquia Interlocking. Southbound freight trains on the third track went to Track 2 and back to the third track at South Aquia, if northbound trains on Track 2 permitted, and the third track between Dahlgren Jct. and South Aquia was free of northbound trains. If northbound trains on Track 2 would not permit this move, and if the third track was occupied by northbound trains, the southbound trains operated on Track 3 whenever they could.

Aquia Interlocking to Dahlgren Junction (DJ Interlocking). Nearly all southbound freight trains use the third track between Aquia and Dahlgren Jct. and two or three southbound Amtrak trains overtook VRE local commuter trains between South Aquia and Dahlgren Jct. by using the third track each day. Southbound freight trains sometimes were delayed to let passenger trains go into Fredericksburg Station first, and only a few of these would require stopping the freight train if the dispatcher instructs the freight train to slow down.

Fredericksburg (FB Interlocking). All northbound freight trains approached FB on Track 2. If no northbound passenger trains were closing from the rear and no northbound VRE local commuter trains were ahead on Track 2, northbound freight trains continued on Track 2. If they could not go on Track 2, they operated on Track 3 from FB to Dahlgren Jct., and then to the third track at that point, southbound traffic permitting. On most days three northbound freight trains and the Auto Train used Track 3. Northbound passenger trains approaching from the south diverted to Track 1 at Hamilton, when freight trains were delayed ahead on Track 2. This did not occur often, because freights were normally moved without delay, but it occasionally did occur.

VRE trains, which were scheduled to turn at Fredericksburg, turned on Track 2 in the station, provided northbound passenger trains from Richmond permitted. As mentioned above, freight trains used Track 3 to allow this to occur. If the turn could not be accomplished on Track 2, the passengers were unloaded on Track 3 and the train moved into the FB pocket track to make the turn. When ready, the turned train went into the station on Track 2 to load. On most days, three trains turned in the FB pocket track and four trains turned in the station on Track 2. The simulation assumed a minimum of 10 minutes to turn a train in preparation for its next scheduled departure.

VRE commuter trains originating at the VRE yard left the yard for Fredericksburg Station, loaded, and waited for departure time. Terminating VRE commuter trains were routed to Track 2 at Dahlgren Jct. when possible. Some VRE commuter trains that used Track 2 were delayed at Dahlgren Jct. to allow Amtrak trains on the third track to pass them. The VRE commuter trains unload and proceed to the VRE yard on Track 2, or if a northbound train was approaching they used Track 1 to Hamilton. This occurs once on most days. Trains that could not use Track 2 to unload used Track 3, and proceed to Hamilton via Track 4 to await a window to go to the yard. This occurs two to four times each day.

The daily usage and average usage of each of the new track segments discussed above is shown in Table C-6.

Operations Between Fredericksburg and Staples Mill (FB Interlocking to GN Interlocking)

The running time of a passenger train operating at up to 90 mph is about 30-35 minutes faster between GN and FB than a freight train operating at current authorized speeds. Therefore, if there were no intermediate sidings between GN and FB (see Track Chart Schematic), any freight train passing GN less than 40 minutes ahead of a passenger train had the passenger train catch up to it by FB. To avoid delaying passenger trains with the current configuration, freight trains would have to be held at GN if they were ready to depart GN less than 40 minutes ahead of a passenger train. Since there were 14 northbound passenger trains scheduled for year 2015, no northbound freight train could leave Richmond for 560 minutes of 1440 minutes each day, or 39 percent of the time. If freight trains arrive at GN at random times, which was mostly the case, 39 percent of the trains would be expected to be held at Richmond for passenger trains. Since there were 9 northbound freight trains, 3.5 trains per day could expect delays of up to 40 minutes. Likewise, since there were 8 southbound trains, 3.1 trains would be expected to be held at Fredericksburg. This was considered to be unacceptable.

By installing intermediate sidings, the total number of overtakes was not changed but the amount of delay was reduced. Two intermediate sidings were assumed. The first was between North Ashland and the South Anna River bridge, with a universal interlocking located just north of the bridge. The second was between Bowling Green, which had a universal interlocking, and approximately Rixey.

Therefore, since there were three holding locations instead of one, one third of the trains could be expected to be overtaken at Richmond and at each of the sidings. This projects to 1.2

northbound overtakes per day at each siding (one third of 3.5) and 1.0 southbound overtakes at each siding.

The actual simulated distribution of the northbound and southbound overtakes at each of the sidings for a seven day period is shown in Table C-6. At no time did a northbound train and a southbound train attempt to use a siding at the same time. At first that seems unusual, but when one considers that the usage per day was less than three trains, the odds of a simultaneous occupancy was quite small - only about 4 percent. Two trains attempting to use the same siding could happen, but it would be rare. Extra facilities to take care of a rare event were not economically justified.

The concept of using reverse running on the main tracks to accomplish overtakes, instead of installing passing tracks, was encoded into the model, but it was rarely used during the simulation and should not be assumed to be a viable alternate to the additional sidings. Only about one train per day was able to operate reverse on a track because of on-coming traffic. The conclusion is that trying to operate in this fashion was nearly equivalent of doing nothing, and was not acceptable.

At Doswell, the RF&P Subdivision (Washington to Richmond) and the Piedmont Subdivision (Richmond to Charlottesville) cross at grade. With increased traffic on each subdivision the crossing could become a source of substantial delay. The analysis indicates that this would not happen. Three to five 10-minute windows exist each hour to move Piedmont Subdivision trains across the RF&P Subdivision, even if RF&P Subdivision trains were given absolute priority. The simulation model predicts, as a worst case, 20 percent of the Piedmont Subdivision trains would be momentarily impacted by passenger trains on the RF&P Subdivision, and that 5-10 percent would be impacted by freight trains on the RF&P Subdivision. The number of 10-minute windows appears to be sufficient to handle the projected traffic.

Operations Between Staples Mill and Main Street (GN Interlocking to Main Street Station)

The initial simulations show that an average of 6 meets per day occur between passenger trains on the route between GN and Main St. Station. When an occasional freight train was added to this route, additional meets occur. Without a double track railroad between GN and Main St. Station, 42 percent of the daily passenger trains would be delayed as they wait for an opposing passenger train. A double track railroad between GN and Main St. Station was thus considered essential.

Table C-6: Daily Usage of Added Track Facilities - Washington To Richmond

Facility		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Average
Double Track Acca yard bypass	meets	7	5	4	8	7	6	6	6.0
South Anna Siding	north	1[10]	2	1	2	0	3	1	1.4
	south	3	1	0	1	0	2	3	1.4
Bowling Green Siding	north	2	1	1	1	3	1	0	1.3
	south	2	2	0	0	0	0	1	0.7
Track 4: Fredericksburg - Hamilton	north	0	0	0	0	0	0	0	0.0
	south	2	4	4	6	4	4	2	3.7
Track 1: Hamilton - Fredericksburg	north	0	0	1	0	0	0	0	0.2
	south	2	0	2	1	1	0	0	0.6
Turning Pocket - FB	turns	3	3	3	4	3	3	3	3.1
Center Track: Dahlgren Jct. - S. Aquia	north	3	4	3	3	3	5	1	3.2
	south	5	4	4	5	5	5	5	4.7
Center Track: Aquia - Powells	north	2	2	2	1	1	2	0	1.6
	south	5	3	5	5	5	5	4	4.6
Center Track: Colchester - RW	north	1	5	3	4	3	4	3	3.2
	south	8	8	11	10	10	10	10	9.6
Center Track: RW - AF	north	2	4	3	2	3	1	4	2.7
	south	9	9	11	10	10	10	8	9.6
NB Siding: AF - RO	north	13[11]	13	13	13	13	13	13	13.0
Passenger diversions at RO to create freight windows	north	6	9	5	5	6	8	4	6.2

[10] Two crossover moves Track 2 to Track 3 also occurred

[11] CSX and 4 NS trains

STAPLES MILL RD. STATION - CENTRALIA, VA SIMULATION

2015 Traffic Level Operations

A simulation of passenger and freight operations between Centralia, VA and Amtrak's Staples Mill Road Station (GN) was performed to ascertain the facility improvements necessary to accommodate proposed 2015 levels of intercity and freight operations. Train operations in the vicinity of Main Street Station were of primary interest. High-speed rail services proposed by the states of Virginia and North Carolina will utilize the station, which the City of Richmond is in the process of upgrading for the restoration of rail passenger service.

Terminal operations at Main Street Station in Richmond were not initially simulated as part of the Washington to Richmond Corridor study. Although it was expected that the terminal could accommodate the traffic simulated, the capacity of the terminal could not be ignored, and it was decided to perform a detailed evaluation of train operations in the vicinity of Main Street Station. The interface of passenger and freight operations at the station and in the vicinity of the station were potential problems that were addressed by this analysis. This terminal capacity evaluation was performed to assist the City of Richmond resolve numerous issues necessary to complete the planning and design of the Richmond Multi-modal Transportation Center.

Traffic Used for Simulations

The traffic levels simulated for year 2015 consist of the 1998 traffic level supplied by CSX with growth between 1998 and 2015 added. The growth factor is greater than has been achieved in recent years but reflects the potential for creation of new lines of business. Therefore, the 2015 service shows a very optimistic level of traffic. The 1998 traffic, the growth assumed, and the 2015 traffic level used in the simulations are shown Table C-7.

Table C-7
TRAFFIC LEVELS ASSUMED FOR 2015
(TRAINS PER DAY)

Location: From - To	1998	Growth	2015
Fulton-to-Acca			
Loaded Coal and Grain	8	6	14
Q302	1	0	1
H774	1	0	1
Y123	1	0	1
Total	11	6	17
Acca-to-Fulton			
Q303	1	0	1
H774	1	0	1

Table C-7
TRAFFIC LEVELS ASSUMED FOR 2015
(TRAINS PER DAY)

Location: From - To	1998	Growth	2015
Helpers	9	6	15
Total	11	6	17
Centralia-to-Piedmont Subdivision			
Empty coal and grain	8	6	14
Manifest	0	1	1
Solid waste	0	2	2
Extra	0	2	2
Total	8	11	19
Piedmont Subdivision-to-Centralia			
Manifest	0	1	1
Solid waste	0	2	2
Extra	0	2	2
Total	0	5	5
Fulton-to-Piedmont Subdivision			
Manifest	0	1	1
Solid waste	0	2	2
Empty coal and grain	0	4	4
Total	0	7	7
Piedmont Subdivision-to-Fulton			
Manifest	0	1	1
Solid waste	0	2	2
Total	0	3	3
Acca-Deepwater Turn	1	0	1
Collier-Fanshaw Turn	1	0	1
Hopewell-Collier Turn	1	0	1
Passenger Trains Thru Main Street			

Table C-7
TRAFFIC LEVELS ASSUMED FOR 2015
(TRAINS PER DAY)

Location: From - To	1998	Growth	2015
Washington - Florida	0	8	8
Washington - North Carolina	0	8	8
Washington - Newport News	4	2	6
Richmond - Bristol	0	4	4
Washington - Richmond	0	6	6
Total	4	28	32

Passenger trains were entered into the model at their assumed schedules and then held a period of time to reflect lateness. For example, 30 percent of the trains from Florida were allowed to enter the simulation at Centralia on schedule and the remainder were randomly entered up to 60 minutes. Non-Florida passenger trains have entered the simulation between 0 and 10 minutes late.

Freight trains were entered into the model uniformly spaced. For example, not having a schedule to work with, the 19 trains per day from Centralia were originated every 1.3 hours, and subsequently allowed to enter the simulation 0 to 60 minutes later. Thus the spacing between freight trains passing Centralia could range between 18 minutes and 138 minutes. Freight trains originating at other locations also were spaced based on the number of trains per day operated. They also were given a random delayed entry. Helpers[12] returning to Fulton were generated as the trains they have assisted pass AY Interlocking.

Because each simulated day was not the same, seven days of simulations were run to assure a representative picture.

Operational and Facility Assumptions Between Fulton and GN. Reopening Main Street station and operating additional trains between Staples Mill Road and Hermitage Interlocking (MP 3.5N) would greatly affect existing and future freight operations in an already congested location. Therefore, a double track Acca Yard passenger bypass has been assumed to have been built along the east side of the yard between GN, located north of Staples Mill Road Station (Figure C-6) and Hermitage (Figure C-7). A new center island platform would be constructed between the bypass tracks at the Staples Mill Road station, creating a double-tracked station. The existing platform and siding would be retained.

[12]Engines placed at the end of a train to assist in ascending a grade. The helper engines were removed from the train at a convenient location after the train had cleared the grade, and return to the base of the grade.

In addition the construction of a totally reconfigured Brown Street Interlocking (Amtrak Jct and Bone Dry Jct Interlockings combined) has been assumed (Figure C-8). This interlocking, and how it would be used to facilitate train movements, will be discussed in a separate section.

The simulations were performed to determine the facilities that would be needed to reopen Main Street station. The primary consideration was the development of an operating philosophy and a facilities plan that would enable 17 freight trains per day and 28 passenger trains per day in 2015 to be operated reliably between Fulton and the south wye at AY.

Each of the 14 loaded coal and grain trains (Table C-7) generate three moves through Rivanna Jct. (located south/east of Brown Street Interlocking at the intersection of the Piedmont Subdivision and the Rivanna Subdivision). These moves were: 1) the eastward move from the Rivanna Subdivision to Fulton, 2) the westward (northward) move from Fulton to Acca, and 3) the returning helper move from Acca to Fulton. These constitute a total of 42 moves per day for 14 trains.

The simulations did not assess the capacity impact these trains would have on the viaduct between Rivanna Jct. and R Cabin (west of Fulton Yard). The simulation also did not evaluate the manner in which Fulton yard would work in turning these trains, changing locomotives, and attaching helper engines. The simulation model, of necessity, ended at Rivanna Jct.

Optimally, implementing a direct connection between the Rivanna Subdivision and the S Line, between Acca and Centralia, would eliminate a great amount of congestion at both Fulton and Acca. The hypothetical connection would enable eastward trains from the Rivanna Subdivision headed for the A Line south of Centralia Line to be operated directly and progressively from the Rivanna Subdivision (which passes directly under the S Line) to the S Line without crossing the existing single-tracked James River Bridge or going through Acca. It would also substantially reduce operating costs by eliminating helper crews, locomotives, and fuel required to haul 12,000 ± ton freight trains about 150 feet (the elevation differential between Fulton and Acca) 14 times a day. However, lacking an agreed upon practical connection alternative, the study assumed that the present method of operating these trains would continue.

Figure C-6
Staples Mill Rd. Station
and GN Interlocking

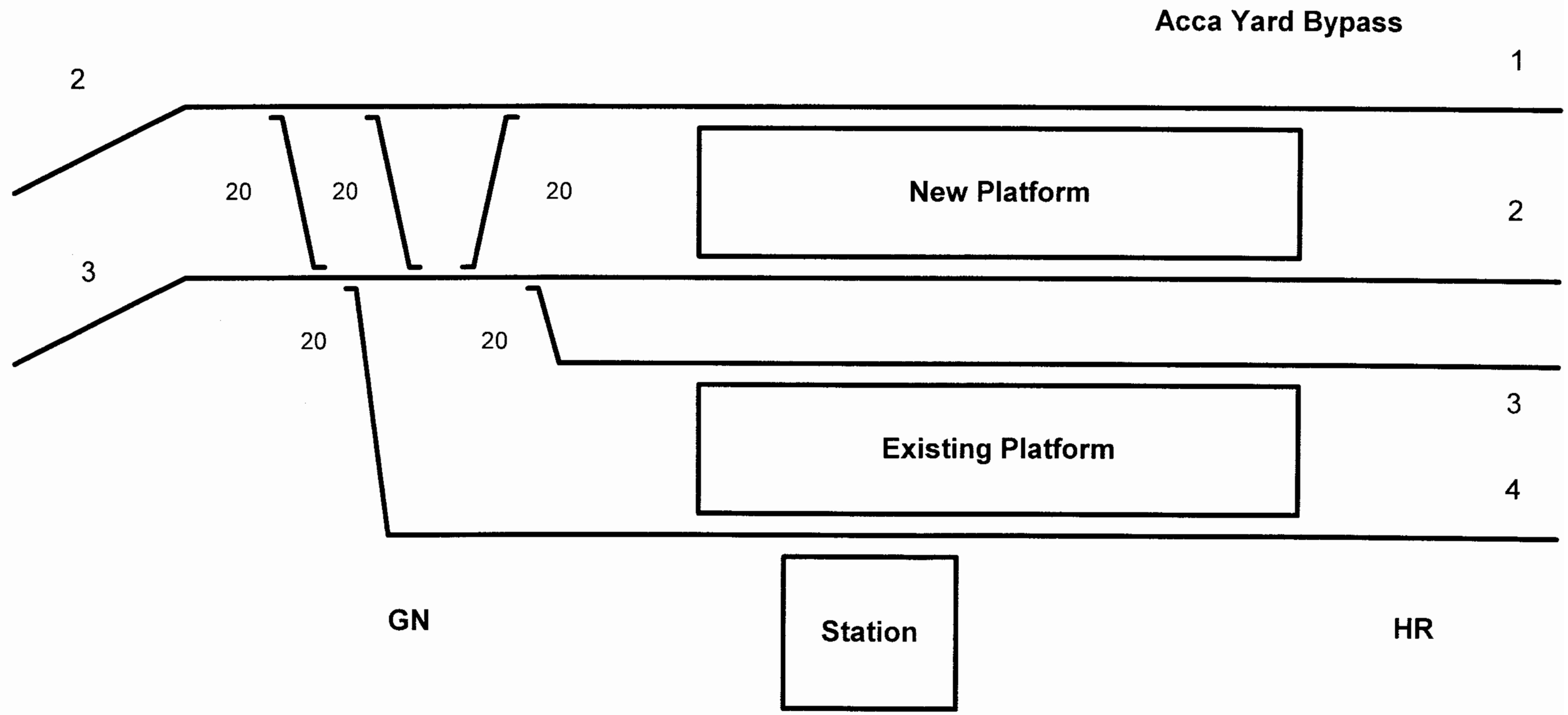


Figure C-7
Hermitage and SAY
Interlockings

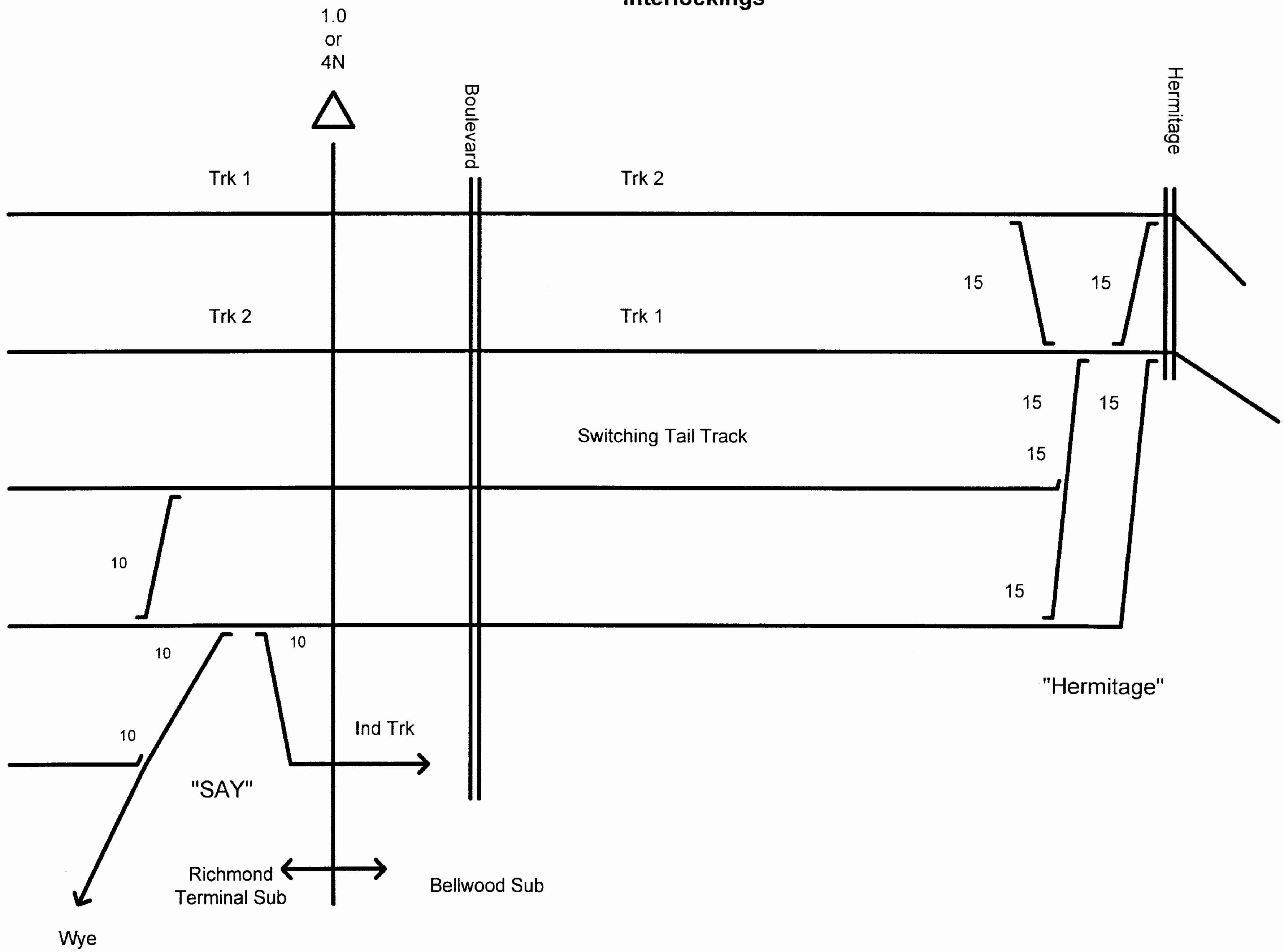
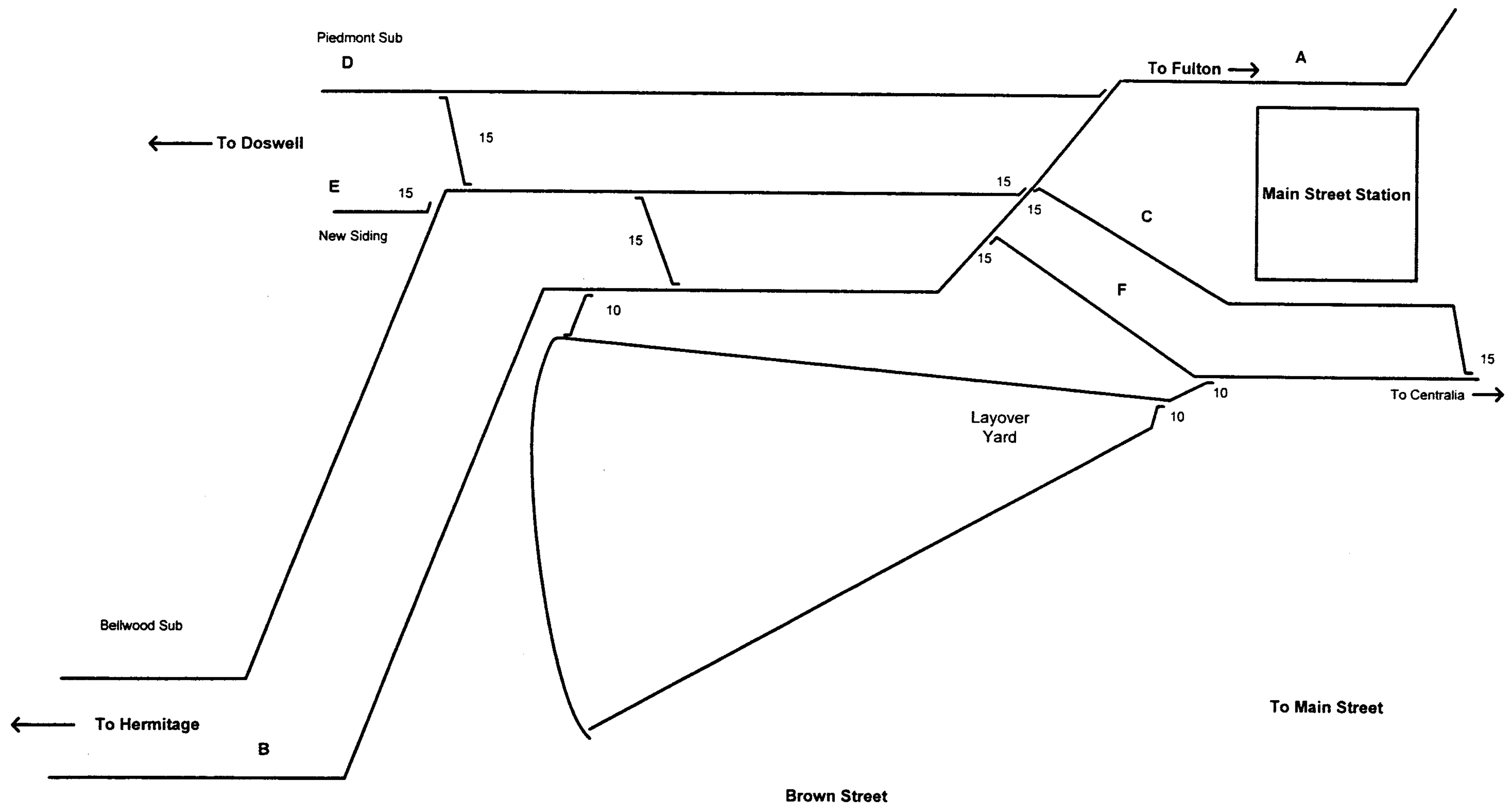


Figure C-8
Brown Street Interlocking and Main
Steet Station



The study assumed that:

- Freight trains moving between Acca and Fulton would be given absolute priority to operate on Track 1 between Brown Street and Hermitage Interlockings and that loaded trains **would not** be stopped on the ascending grade between these points; and
- An open track and capacity to accept these trains at Acca would be available before the train departed Fulton so the move at Hermitage could be made without stopping.

It also was assumed that a subsequent loaded train would not be released from Fulton until the previous loaded train had cleared Hermitage Interlocking. If for some reason a track was not available at AY, or the first train had stalled on the grade, the second train would not stop and block Rivanna Jct., the east side of Main Street Station (Newport News side), and Brown Street simultaneously. If such a situation would occur **ALL** operations north of the James River and south of Acca Yard, including the Piedmont Subdivision, would come to a standstill until the situation had been resolved.

It was further assumed that northward loaded trains would not operate on Track 2 between Brown Street and Hermitage Interlockings, except in an emergency. Track 2 was assumed to be reserved for passenger trains in both directions. In effect, passenger trains had a single track operation on Track 2 between Brown Street and Hermitage Interlockings, except when freight trains were not using, or were not lined up to use, Track 1. In that case passenger trains could use Track 1.

Additionally it was assumed that a crossover is provided at Hermitage to enable southward passenger trains to move from Track 1 to Track 2 at the same time that a northbound or southbound freight arrives/departs the yard and accesses Track 1 was provided. This parallel move capability would minimize conflicts between freight trains and passenger trains at Hermitage Interlocking (Figure C-7) However, if northward freight trains were allowed to use Track 2, passenger train operation would be interrupted for 10-12 minutes while a heavy train crawls from Track 2 to Track 1 and into the yard.

A fourth assumption regarding the movement of northward trains between Fulton and Acca involves helper locomotives returning to Fulton. Once a helper leaves Hermitage for Fulton it was assumed that another northward train would not be released from Fulton until the helper had cleared Rivanna Jct. This assumption prevents the helper and the loaded train from vying for the single track between Brown Street and Rivanna Jct. and thereby causing a conflict. Restoring a second track between Brown Street and Rivanna would avoid the conflict by allowing a helper and a northward train to pass each other at Main Street station.

Consideration was given, when coding the model, to restoring this short segment of double track. However, after further analysis it became clear that the almost sole beneficiary of this track would be the freight vs. freight operation, especially those trains moving from Fulton to the Piedmont Subdivision. It was therefore assumed that restoring this track should most appropriately considered to be a part of adding capacity to the Piedmont Subdivision rather than reopening Main Street station for passenger trains. Clearly, if there were no Fulton to-Doswell trains, as was the case today, the existing configuration is sufficient.

The final assumption concerning movement of northward trains from Fulton to Acca involves passenger trains to and from Newport News. It was assumed that a freight train would not be released from Fulton if that release would delay a northward passenger train (from Newport News). Likewise, a freight train would not be released from Fulton if southward passenger trains to Newport News would be delayed. Freight trains may leave Fulton yard independently of all other passenger trains.

Helper Assumptions. The first assumption concerning helpers was that 24 minutes after a loaded freight train had cleared Hermitage the helper assigned to that train would be ready to return to Fulton. Admittedly, the 24 minute interval was somewhat arbitrary, because when helpers would detach from the rear of the freight train was not known. What was known was that some interval of time must exist, so 24 minutes was assumed to be a reasonable duration.

The second assumption concerning helpers was that a helper returning to Fulton would be held at Hermitage until a succeeding loaded freight train that had been released from Fulton clears Hermitage. In a contingency, helpers could operate to Brown Street on Track 2 (the passenger track) after the loaded train had passed Brown Street on Track 1, however this contingency was not simulated.

A third assumption concerning helpers was that a helper would always be available at Fulton when the loaded freight train was ready. Initial analysis immediately concluded that one helper crew around the clock would cause excessive delay to loaded freight trains at Fulton. Based on the previous assumptions, the round trip cycle to Acca and return for helpers in the simulation was approximately about 1.5 hours. With 17 freight trains per day assumed to need help, more than one helper crew appears to be necessary. For the simulation, rather than trying to analyze specific helper assignments, it was assumed that helpers would always be available.

The effect of all of these assumptions for freight trains and helpers was that a de facto single track for freight operation exists between Fulton and Hermitage. These assumptions always preserve a passenger route through Richmond even though passenger trains themselves may be forced into a single track operation.

However, when in the single track mode, passenger trains could meet on two double track segments with only a few minutes delay: 1) between GN and Hermitage and 2) in Main Street Station. Therefore, it was essential that two tracks be provided on the west side of Main Street Station. If the second track isn't provided the effective single track operation would extend from Hermitage to Rocketts (located at the south end of the James River bridge). Because freight trains have priority usage of Track 1 between Hermitage and Brown Street, it would have to be assumed that passenger trains would be held. The single track operation between Hermitage and Rocketts would not be acceptable.

The major benefit of these assumptions was that freight train and passenger train operations would be separated to the greatest extent possible. Each could be operated independently of the other, except for the necessary and unavoidable conflicting moves at Brown Street. A description of train operations through this interlocking follows in a later section.

Operational and Facility Assumptions for Freight Trains Between the Piedmont Subdivision and Centralia or Fulton

Today the Piedmont Subdivision was a one-way westward railroad, primarily for empty unit coal trains. If reverse traffic was to be operated, CSX must add capacity to the line. The current number of sidings, and their length, is inadequate.

When operation of reverse trains from the Piedmont Subdivision to Centralia starts, the first issue to be answered is where should a crew change be made between a Piedmont Subdivision crew and a Northend Subdivision crew? The most logical location appears to be at Hospital Street. The second question that must be answered is: where would these Piedmont to-Centralia trains wait when a route was not clear for movement over the single-track James River Bridge? Again, the answer appears to be at Hospital Street.

Considering that the Piedmont Subdivision is single tracked at Hospital Street, it was obvious that these trains could not wait at Hospital Street, blocking the route of 26 northward trains per day (in 2015) moving from Centralia or Fulton on the Piedmont Subdivision. Clearly, a siding was required. The study assumed that this siding would extend to the Richmond-Henrico Turnpike crossing, where northward trains may wait or change crews.

It was further assumed that northward freight trains that have been released from Dale Avenue, and passenger trains having passed Centralia would have preference to use the James River Bridge. Also, southward passenger trains that have passed Staples Mill Road Station would have priority over Piedmont Subdivision-to-Centralia freight trains. The result of these assumptions was that, once released from Hospital Street, a freight train should have a clear, unrestricted run to Centralia.

Trains going to Fulton from the Piedmont Subdivision would operate independently of all passenger trains except for those to and from Newport News. These passenger trains would cross the route of northward freight trains from Centralia to the Piedmont Subdivision at Brown Street. The Newport News passenger trains also would compete for the single track between Brown Street and Rivanna Jct. with trains moving from Fulton to Acca, Acca to Fulton, and Fulton to the Piedmont Subdivision.

Operational and Facilities Assumptions for Brown Street Interlocking

Facilities to service and store passenger equipment turning at Richmond must be provided before the reopening of Main Street can occur. Eventually, space for four trains would be required for three trains from Washington and one train from Bristol. Crew facilities and equipment servicing, and the capability to turn trains (run the train around a loop to switch the locomotive so that it was heading north rather than south) facilities would be required.

The turning facility was assumed to be a loop track with a maximum curvature of 15 degrees 30 minutes. This loop track, and the four storage tracks, were assumed to be constructible between Brown Street Interlocking and the bluff west of the Main Line. At the conceptual design level it has not been determined whether the loop could be built within the space constraints, but for simulation purposes it was assumed to be feasible.

Brown Street Interlocking (Figure C-8) would be configured to function as a combined and reconfigured Amtrak Jct. and Bone Dry Jct. With the train volumes projected for year 2015, Brown Street would be a very busy interlocking with many intersecting and crossing train movements.

Referring to the lettering scheme shown in Figure C-8: 17 Fulton-to-Acca freight trains per day would move from A to B and 17 Acca-to-Fulton freight trains would move from B to A. As previously explained, the operational assumptions for these trains contained in the simulation were established to ensure that the freight trains would never conflict at Brown Street. However, these 34 freight trains between Acca and Fulton would intersect with and cross the route of 19 Centralia-to-Doswell freight trains C to D) and 5 Doswell-to-Centralia freight trains (E to F). In addition, the 34 freight trains would conflict with 22 daily passenger trains. The freight trains also would compete on the single track segment at A with 6 daily Newport News passenger trains.

In addition, 7 freight trains per day from Fulton-to-Doswell (A to D) would compete with the 17 Acca to Fulton moves (B to A) and the 6 daily Newport News passenger trains. The Fulton-to-Doswell freight trains would not conflict with passenger trains to/from the west side of Main Street Station because parallel moves would exist at Brown Street. As previously discussed, restoring the double track between Brown Street and Rivanna Jct. would eliminate potential conflicts between the 7 Fulton-to-Doswell freight trains and the 17 Acca-to-Fulton trains because a parallel route would be made available. However, since Rivanna Jct. was the terminal/entry point on the Rivanna Subdivision in the simulation model, potential operating problems between Rivanna Jct. and Fulton were not addressed.

Likewise, 3 daily Doswell-to Fulton freight trains (E to A) would conflict with the 17 northward freight trains from Fulton-to-Acca (A to B) and the 7 freight trains from Fulton-to-Doswell (A to D). The 3 daily Doswell-to Fulton freight trains also would conflict with the 6 daily Newport News passenger trains. Furthermore, restoring the double track between Brown Street and Rivanna Jct. would eliminate the conflict with the 7 freight trains going to the Piedmont Subdivision from Fulton, but not the freight trains going to Acca from Fulton. A crossover move, which might conflict with the other trains' crossover move, would still be required for these trains.

Freight trains going to the Piedmont Subdivision from Fulton would be the major beneficiary of the second track between Brown Street and Rivanna Jct. For this reason the second track was not recommended as being necessary for reopening Main Street station for passenger service.

In total there were nearly 100 conflicting moves per day at Brown Street. Since the speed for the freight trains was 10 mph on all routes, most freight trains would occupy a route from 8-10 minutes. The delays encountered during the simulation are documented in the following section.

Operational and Facility Assumptions Between Centralia and Brown Street

Currently, on days that Amtrak's Cardinal operates (Wednesday, Friday, and Sunday between Chicago and Washington, DC, via Charlottesville), a curfew applies between 0900 and 1200 for freight trains that would be routed from Fulton Yard or Centralia to the Piedmont

Subdivision (Doswell Line). The study assumed that by the year 2015 enough sidings and additional track would have constructed on the Piedmont Subdivision so that the curfew would no longer be necessary. However, for a period of time until traffic volume increases to justify the added facilities, the curfew would continue to exist. Even at today's traffic levels, at least one and possibly two trains per day would be held somewhere in the Richmond area for up to three hours.

In addition to trains being held at Richmond for the curfew, through freight train crews were changed at Richmond. Provided that fresh crews were available, the study assumed that the crew change could be accomplished with stops no longer than 10 minutes. The study did not simulate situations where crews were not immediately available, other than to recognize that the situation could occur and that track space was available to hold a train for that cause, if need be.

In 2015, holding trains for the curfew and crew changes at Main Street station would no longer be possible because the single-tracked James River Bridge must be kept open for passenger trains and southward freight trains. A total of 46 trains per day would be traversing the single-tracked span in 2015.

From a geographic standpoint, having northward trains pull clear of Hospital Street on the Piedmont Subdivision (MP 85.8) so that the head end stops at Dill Street (MP 87.6) would appear to be ideal for crew changes. However, operationally this location was less than ideal because stopped trains would have to restart on an ascending 1.15 percent grade.

A better crew change point would be the Richmond-Henrico Turnpike crossing (MP 90.2). This location would provide a 2.5 mile stretch without a highway-railroad crossing, according to Track Chart data. The grade was descending at this point and the Richmond-Henrico Turnpike crossing would provide access for crew changes. For the simulations, the study assumed that crew changes occurred at this location. Changing crews or holding for the curfew at the Henrico crossing completely separates these activities from passenger operations.

As a worst case the study also considered that holds and exchanges of crews may have to be done elsewhere between Centralia and Rocketts. Between Rocketts (MP S0.7) and Dale Avenue (MP S5.0) each mile has one or more highway crossings, making this area unacceptable for holding trains.

There are no crossings between Dale Avenue (MP S5.0) and the Texaco Crossing (MP S6.4) (approximately 7,300 feet), therefore trains shorter than 7,300 feet could be held at this location. Trains longer than 7,300 feet could be uncoupled to clear Dale Avenue, however, a better location to hold long trains would be between the Water Works crossing (MP S6.7) and the Kings Land Road crossing at MP S9.1, approximately 12,700 feet. A crossing cut would not be necessary at this location, but the distance to transport crews from Fulton was quite long. For these reasons the study assumed that a siding[13] located between Dill Street and the Henrico Turnpike crossing, with crew changes made at Henrico Turnpike, would be the optimal solution if crews could no longer be changed at Main Street Station.

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[13]The siding would not be needed until CSX initiates southbound freight service on the Piedmont Subdivision.

Track Configuration and Train Operating Assumptions Main Street Station to-Centralia. The study assumed that the double track south of Rocketts (Figure C-9) would be extended from MP S8.9 to Centralia (approximately S10.7) (Figure C-10) and the existing interlocking at Marlboro (S 4.5) would be replaced with a universal interlocking (with two No. 20 crossovers to enable 40 mph moves) at Dale (S 4.8).

Northward freight trains were assumed to have absolute priority on the extended Track 2 at Centralia, except when the following occurs:

- A northward freight train passes Centralia less than 10 minutes before a northward passenger train, while
- A southward train (either freight or passenger) was occupying Track 1 between Dale and Centralia.

Only if these two conditions exist simultaneously should northward freight trains be held at Centralia to let the passenger train proceed northward on Track 2, so the trains could meet (wait for the southward train to pass) at the first interlocking north of Centralia.

If a passenger train proceeds northward from Centralia on Track 2 it could become stopped behind a preceding northward freight train at Dale. This freight would be in a hold situation at Dale Avenue because it could not clear the James River bridge ahead of the passenger train. Therefore, the existing Falling Creek interlocking (MP S7.3) was assumed to removed and replaced with a universal interlocking (with two No. 20 crossovers) north of MP S-7. These crossovers would be located on the tangent between the north end of the two degree curve, at MP S-7.0, and the Falling Creek bridge. The new interlocking would enable the passenger train to divert from Track 2 to Track 1 after the southward train had passed the relocated Falling Creek Interlocking. Once diverted to Track 1, the northward passenger train could pass the preceding freight train being held for it on Track 2 at Dale Interlocking. Of course, the passenger train could continue northward to Rocketts on Track 2 without stopping or making a diversion, if a northward freight train was not ahead of the passenger train between Centralia and Dale.

Normally, when Track 2, between Centralia and Dale, was occupied by freight trains, northward passenger trains on Track 1 would proceed directly to Main Street Station. They would crossover to Track 2 at Dale only when necessary to pass or meet a train on Track 1 between Rocketts and Dale.

The most significant constraint between Brown Street and Centralia was the single-tracked James River bridge. It was assumed that passenger trains would have preference over freight trains for the use of the bridge. Therefore, northward freights would have to be sequenced at some point to enable them to follow a northward passenger train at Rocketts. Northward freight trains would be held at Dale Avenue, just south of Dale Interlocking, to avoid blocking highway crossings. Freight trains would not be released from Dale Avenue unless they could clear Main Street station before a Centralia-bound southward passenger train was scheduled to depart Main Street Station (Main St Interlocking at the south end of the Station was the north end of the single track over the bridge). When a northward freight was released from Dale Avenue, it must be assured non-stop access to the James River Bridge.

Figure C-9
Rocketts and Deepwater Jct

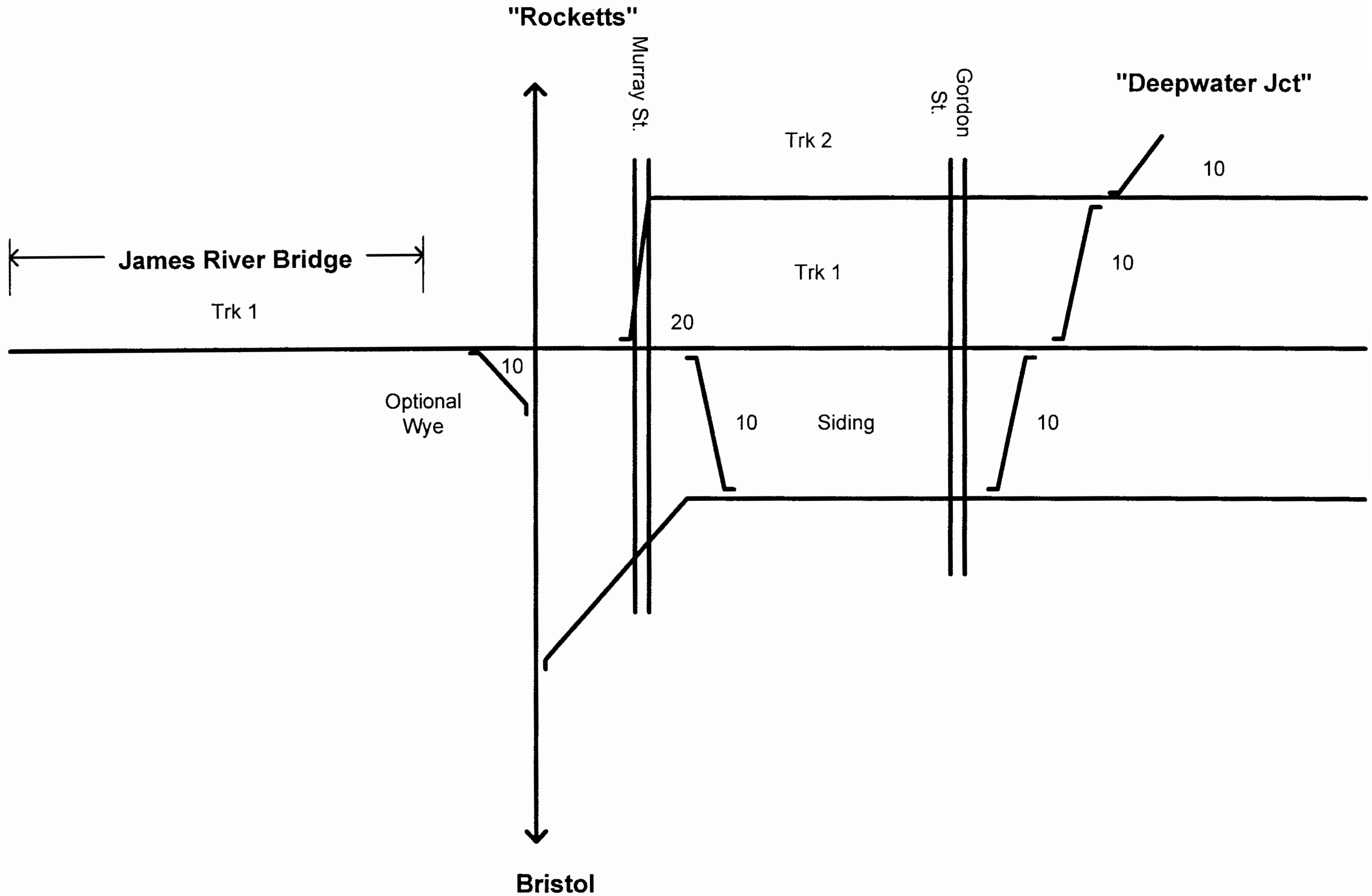
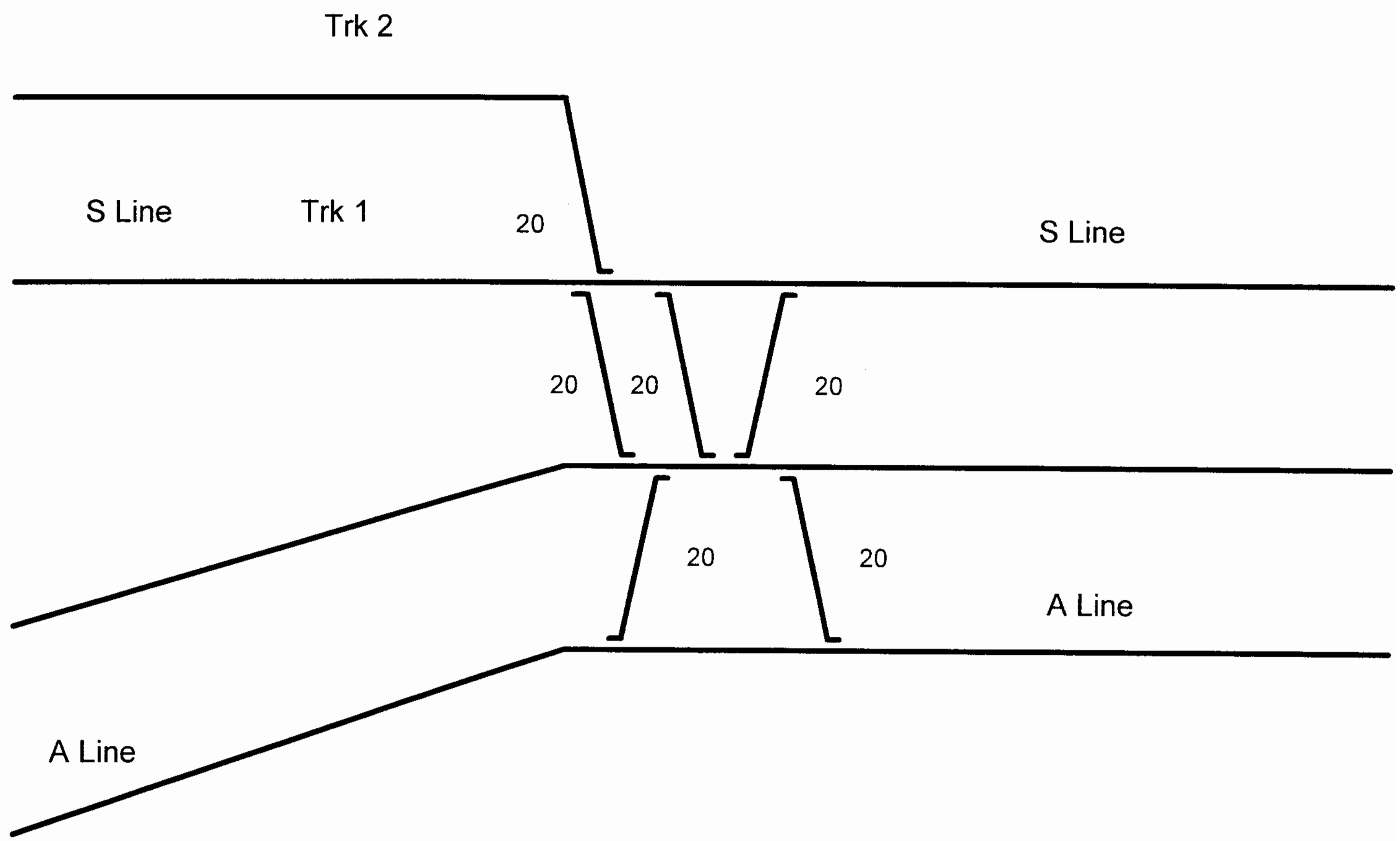


Figure C-10
Centralia Interlocking



Two tracks were assumed to be in place on the west side of Main Street station. This allows northward freight trains to pass through the station on Track 2 while southward passenger trains and/or northward originating trains were loading/unloading in the station on Track 1 (Figure C-8). This also allows northward and southward passenger trains to load/unload simultaneously.

Southward freight trains from the Piedmont Subdivision, which was discussed earlier, would not be released from Hospital Street (located north of Brown Street Interlocking) if a northward freight train had been released from Dale Avenue. The numerous highway crossings between Dale and Rocketts cause a de facto single track operation for freight trains between Brown Street and Dale even though two tracks actually exist between Rocketts and Dale[14].

To facilitate the movement of the Acca-Deepwater turn from South Yard (located west of the railroad) to Deepwater (located east of the railroad), it was assumed that the existing crossovers have been relocated to Deepwater Junction (MP S-1.8) and positioned so that a progressive move, from north to south, could be made from the siding (Sixth Street lead) to Deepwater. To make this move currently, a train must back onto the Main track (northward) and the James River bridge, if necessary because of its length, before heading to Deepwater (southward). The switch to Deepwater and the crossovers were assumed to be powered.

A train heading to Deepwater was assumed to back onto the siding towards Rocketts, towards the NS (Figure C-9) without entering Track 1, and then proceed across Tracks 1 and 2 to Deepwater. This greatly reduces occupancy time of the main tracks, thereby minimizing conflicts with through freight and passenger trains. Upon return from Deepwater, the train would make a progressive move across Tracks 2 and 1 to the siding. The train would then back onto cars destined for Acca Yard at South Yard before heading north onto the James River bridge at Rocketts and proceeding to Acca, via Main Street Station and Brown Street Interlocking.

Additional facilities were not needed to facilitate moves made by the Collier-Fanshaw turn and the Hopewell-Collier turn. The study assumed that the southward move of the Collier-Fanshaw turn would use the new crossover at Falling Creek, unless shifting at Bellwood was necessary.

Passenger train dwell times at Main Street Station could have significant capacity ramifications. As discussed above, northbound trains from Fulton to Acca would not be started across Brown Street Interlocking when a northbound passenger train was standing in the station. Likewise, if a southbound train was standing at Main Street, a northbound freight would not be released from Dale Interlocking until it was known that the southbound passenger train had moved onto the James River Bridge. Once the passenger train had cleared Rocketts, the freight train would be allowed to enter the single track between Rocketts and the station. Normally, the freight train should be able to make the movement from Dale, once it had started, without stopping.

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[14]Stopping a freight train between Dale and Rocketts would result in crossings being blocked, thereby, delaying cross-street traffic.

Dwell Times. Reflecting the complexity of train operations and the constraints of the facilities in the vicinity of the Main Street Station, the model conservatively assumed dwell times slightly greater than normally used. Through passenger trains were assumed to have 5 minute dwells at Main Street Station, and trains originating and terminating were assumed to have 10 minute dwells. Two minute dwells were assumed for trains stopping at Staples Mill Road Station. However, Amtrak plans to load and unload express at Staples Mill, this could lead to their decreasing the dwell times at Main Street. Since passenger trains standing at Staples Mill Road Station would occupy tracks designated solely for that purpose, and would not impede the movement of freight trains, as they do at Main Street, longer dwells at Staples Mill would have little impact on capacity at Main Street.

RESULTS AND ANALYSIS OF SIMULATIONS

Seven days of train operations were simulated. A summary of selected freight train delays is given in Table C-8.

The simulations confirmed that the facilities assumed to be required to support reliable passenger train operations are necessary. For example, each simulated day had at least two passenger meets per day in Main Street Station and also at least one or more occasions when freight trains moved through the station on Track 2 while one of the ten terminating or originating passenger trains was occupying Track 1. Undoubtedly, the second track in Main Street Station is an operational necessity.

On Day 1 of the simulation, seven such events involving Main Street Station occurred:

- Empty train from Centralia to Doswell passed through Track 2 while passenger train 3349 was terminating on Track 1 (12:56 a.m.).
- Empty train from Centralia to Doswell passed through Track 2 while passenger train 3318 was originating on Track 1 (6:08 a.m.).
- Passenger trains 604 and 613 met in the station (9:20 a.m.).
- Manifest train from Centralia to Doswell passed through Track 2 while passenger train 3351 was terminating on Track 1 (11:24 a.m.).
- Passenger trains 86 and 79 met in the station (12:15 p.m.).
- Passenger Trains 90 and 405 met in the station (4:55 p.m.).
- Solid waste train from Centralia to Doswell passed through the station on Track 2 while passenger train 83 arrived on Track 1 (9:19 p.m.).

On each of the seven days, two meets occurred between GN and Hermitage, confirming the need for a double track Acca yard bypass. In addition, four meets occurred each day just north of GN. In each case, if one of the trains had operated just 10 minutes earlier or later the meet would have occurred between GN and Hermitage. A single-track passenger route from GN to Brown Street (particularly since Track 1 between Brown Street and Hermitage is a designated freight track) would result in unacceptable passenger delays.

The need for a turning facility (a loop) and four storage tracks at Brown Street was a given. A simulation was not necessary to confirm this requirement.

The single-track James River bridge does not appear to be as significant an operational problem as first anticipated. The practice of staging northward freight trains at Dale Avenue did cause some modest delays to freight trains. On average about 4 of the 19 daily northward freight trains were delayed an average of 9 minutes to let northward passenger trains precede them over the James River bridge.

The longest freight train delay (26 minutes) occurred on Day 3. This delay occurred when:

- Passenger train 90 was operating on Track 1 from Centralia to run around a northward solid waste train on Track 2.
- Train 90 diverted from Track 1 to Track 2 at Dale to meet passenger train 405, which was on Track 1 passing by Rocketts.
- The solid waste train was held south of Dale to let Train 90 cross over ahead of it.
- Train 405 was also delayed 6 minutes to let Train 90 clear Track 1.

About one-third of the Acca-to Fulton trains (mostly helpers) were delayed in the simulations for an average of approximately 15 minutes at AY. The maximum delay, on Day 2, was 31 minutes. As explained in the section discussing train operations between GN and Fulton, a train from Acca would be not released if a loaded train to Acca had been dispatched from Fulton. Since there were 17 daily northward freight trains from Fulton and each train takes 30 minutes to move from Fulton to Acca, southward freight trains at Acca should find an opposing move 8.5 hours of the day or 35 percent of the time. Thus, it should be expected that about 35 percent of the trains would be delayed about 15 minutes.

About one-half of the northward freight trains from Fulton were delayed an average of 15 minutes per delay. In addition to having opposing trains, these trains compete with six passenger trains a day for the single track between Rivanna Jct. and Brown Street. While the passenger trains add to the delay, it was clear the most delay was caused by freight trains conflicting with freight trains.

This study has not attempted to develop facility and operating solutions to minimize freight train delays between Rivanna Jct. and Fulton, on the Piedmont Subdivision, and between Acca and Brown Street. However, average delays for the 7-day simulation period were deemed reasonable, and within the realm of what could be anticipated. Further evaluation of solutions to minimize freight train delays is CSX's responsibility.

Based on the 2015 volumes utilized in this study, 67 trains operated per day across the James River viaduct, not counting through freight moves in both directions between the Rivanna Subdivision and Newport News. It is possible that as many as 90 slow moving freight trains per day could operate on the viaduct.

Clearly, freight trains moving from Acca to Fulton could not be made to wait at Rivanna Jct. for Rivanna Subdivision through freight moves. Doing this would block Brown Street. The solution to the viaduct problem would determine the facilities needed between Rivanna Jct. and Acca. One solution alluded to earlier, the direct connection between the Rivanna Subdivision and the S Line would remove loaded trains, and their helpers, from the Fulton-to Acca route. If this solution eventually were adopted, any facilities added to take care of the current convoluted operation between the Rivanna Subdivision, Fulton, and Acca, would become redundant.

Table 8
Summary of Simulated Freight Train Delays

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	7 Day Average
Northward Freight Delays Leaving Fulton								
Number Delayed	13	9	10	10	17	9	11	11.3
Percent Delayed	54.2	37.5	41.7	44.7	70.1	37.5	45.8	47.4
Total Delay (mins)	195	155	192	124	240	112	220220	176.9
Range of Delay (mins)	2-54	3-58	1-44	3-25	1-41	4-22	2-44	-
Average Delay per Delay (mins)	15.0	17.2	19.2	12.4	14.1	12.4	20.0	15.8
Average Delay of All Trains	8.1	6.5	8.0	5.2	10.0	4.7	9.2	7.4
Cross Traffic Delays at Brown (Delays include traffic delays for trains coming Piedmont Sub, some of which are opposing and merging delays and some are crossing delays.)								
Number Delayed	15	19	17	16	13	20	19	17.0
Percent Delayed	22.1	27.9	25	23.5	19.1	29.4	27.92	25.0
Total Delay (mins)	121	80	168	133	75	108	173	122.6
Range of Delay (mins)	1-31	1-13	1-65	1-29	1-18	1-17	1-39	-
Average Delay per Delay (mins)	8.1	4.2	9.9	8.3	5.8	5.4	9.1	7.3
Average Delay of All Trains	1.8	1.2	2.5	2	1.1	1.6	2.5	1.8
Southward Freight Delays at Hermitage (AY)								
Number Delayed	5	4	6	7	7	6	5	5.7
Percent Delayed	29.4	23.5	35.3	41.2	41.2	35.3	29.4	33.6
Total Delay (mins)	56	72	98	114	90	105	91	89.4
Range of Delay (mins)	1-17	7-31	4-27	4-27	2-20	1-30	1-30	-
Average Delay per Delay (mins)	11.2	18	16.3	16.3	12.9	17.5	18.2	15.8
Average Delay of All Trains	3.1	4.2	5.8	6.7	5.3	5.5	5.4	5.1
Northward Freight Delays at Fanshaw (Marlboro I/L)								
Number Delayed	4	2	5	4	4	3	4	3.7
Percent Delayed	21	10.5	26.3	21	21	15.7	21	19.5
Total Delay (mins)	35	21	51	22	40	12	34	30.7
Range of Delay (mins)	3-13	8-13	1-26	1-9	3-23	1-7	4-18	-
Average Delay per Delay (mins)	8.8	10.5	10.2	5.5	10	4	8.5	8.2
Average Delay of All Trains	1.8	1.1	2.7	1.2	2.1	0.6	1.8	1.6

Brown Street interlocking was very busy. While simulated delays were modest, it is stressed that real life dispatching, and consequently train operations, may not be as trouble free. Rivanna Jct. must be considered integrally with Brown Street because they are so close and so interrelated. Each freight train that operates through either interlocking blocks both interlockings simultaneously.

Consequently, the reliability of passenger trains under the high freight train volumes is a cause for concern.

CONCLUSIONS

The principal conclusions concerning the re-institution of passenger train operations in Main Street Station, and the results of the recent simulation of proposed 2015 freight and passenger trains between Staples Mill Road Station, Centralia, and Fulton Yard, are listed below. The simulations performed for this study reinforced the initial conclusions reached through non-computer supported operations analyses: **the existing track configuration within the study area is inadequate to support the proposed level of 2015 train operations.**

1. Terminating and originating trains at Main Street Station is not possible without storage and turning facilities located in close proximity to the station.

2. A single track and platform on the west side of Main Street Station will be insufficient to reliably handle the volume of freight trains, through passenger trains, and terminating/originating passenger trains projected for 2015.

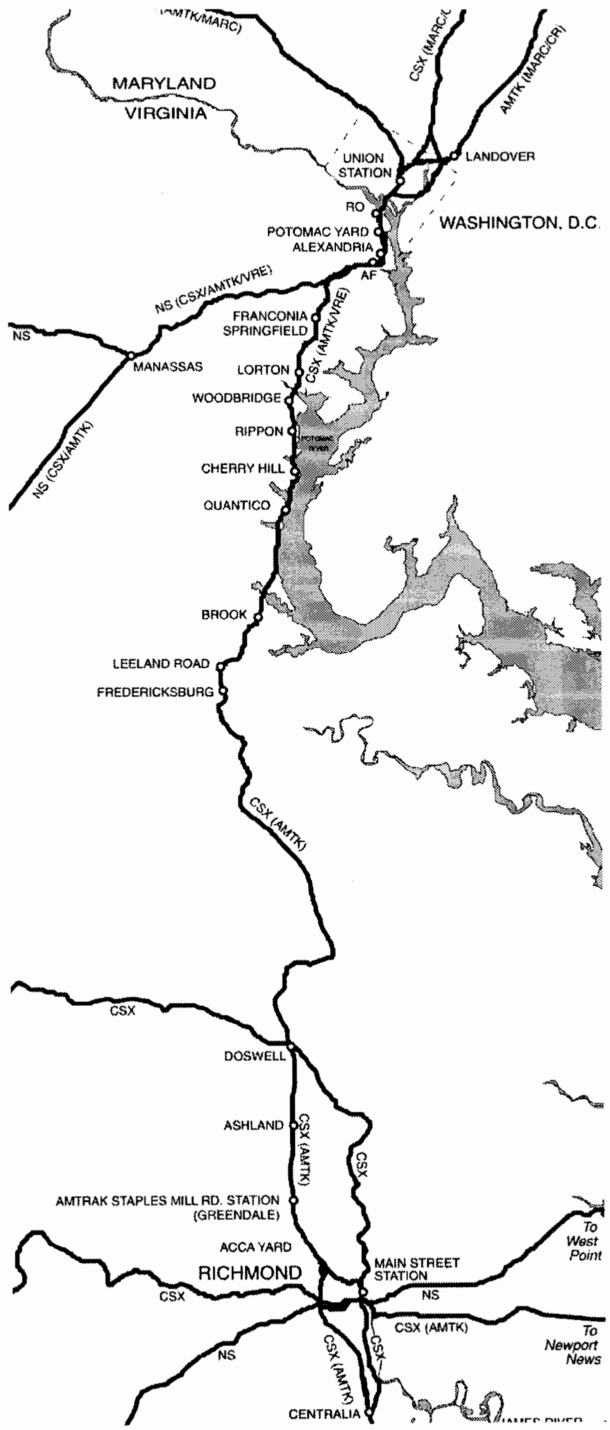
3. A bypass around Acca Yard extending from GN Interlocking to Hermitage Interlocking will be necessary to handle operate passenger trains between Staples Mill Road Station and Main Street Station. Recent simulations confirm that the bypass, located to the east of the yard, should be double tracked.

4) Simulations show that the density and complexity of train operations in the Brown Street - Rivanna Jct. - Rocketts area are such that reliable operations, with minimal delays, will be dependent upon efficient and timely decisions by the train dispatcher.

5) Full reverse signaling and universal interlockings at Dale and Falling Creek are essential to provide the operating flexibility and capacity to enable the train dispatcher to manipulate freight trains through the available windows between Rocketts and Main Street over the James River Bridge.

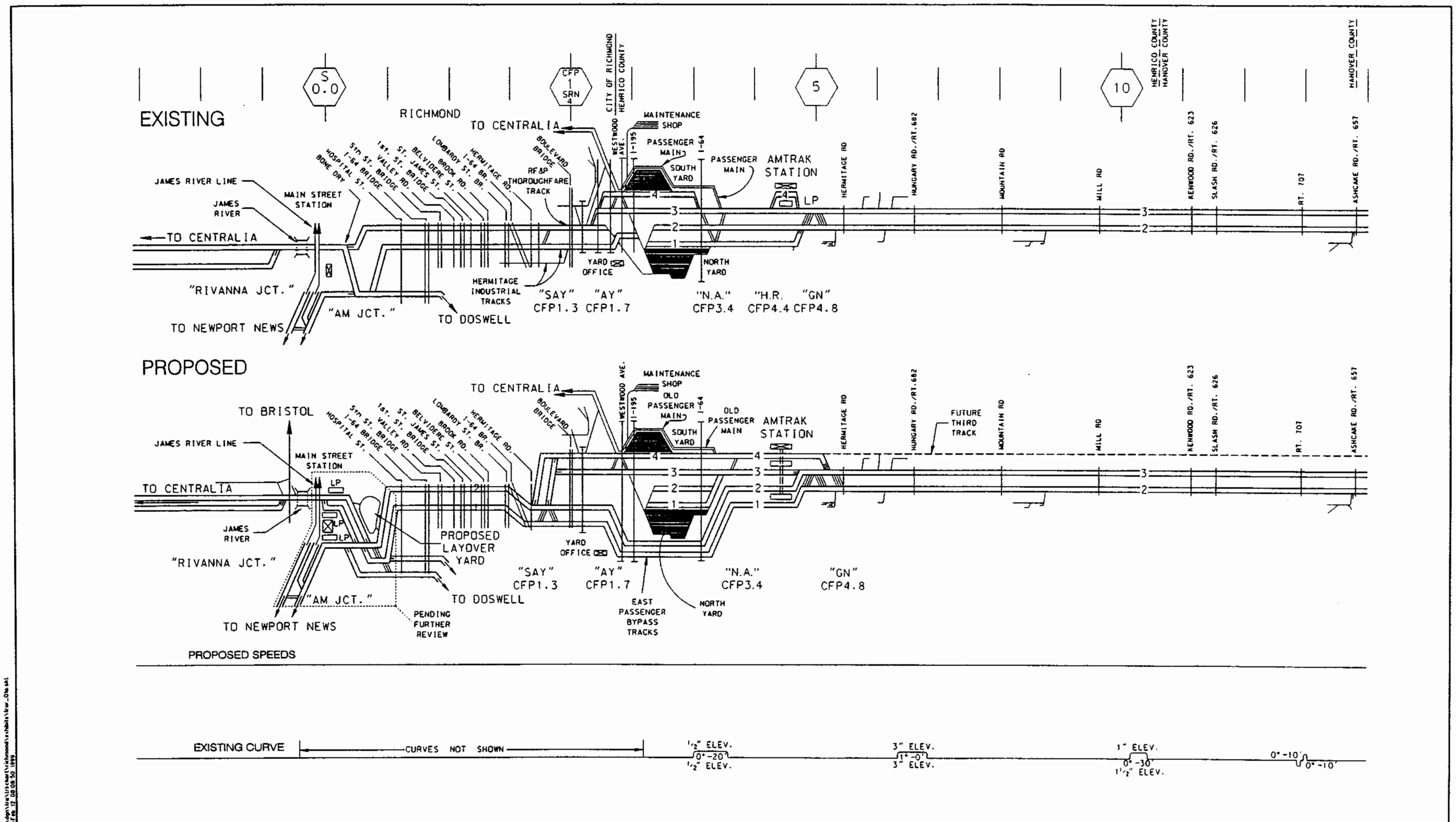
6) Should CSX decide to operate eastward trains from the Piedmont Subdivision to either Fulton or Centralia, simulations show that a siding west (north) of Brown Street will be necessary on the Piedmont Subdivision. A decision to construct the siding would be independent of the decision to restore passenger operations into Main Street Station.

Potential Improvements to the Washington—Richmond Railroad Corridor



EXISTING AND PROPOSED 2015 TRACK CONFIGURATION

May 1999



United States Department of Transportation * Federal Railroad Administration

A-E Support Services for Northeast Corridor Railroad Improvements

Task Order No. 103

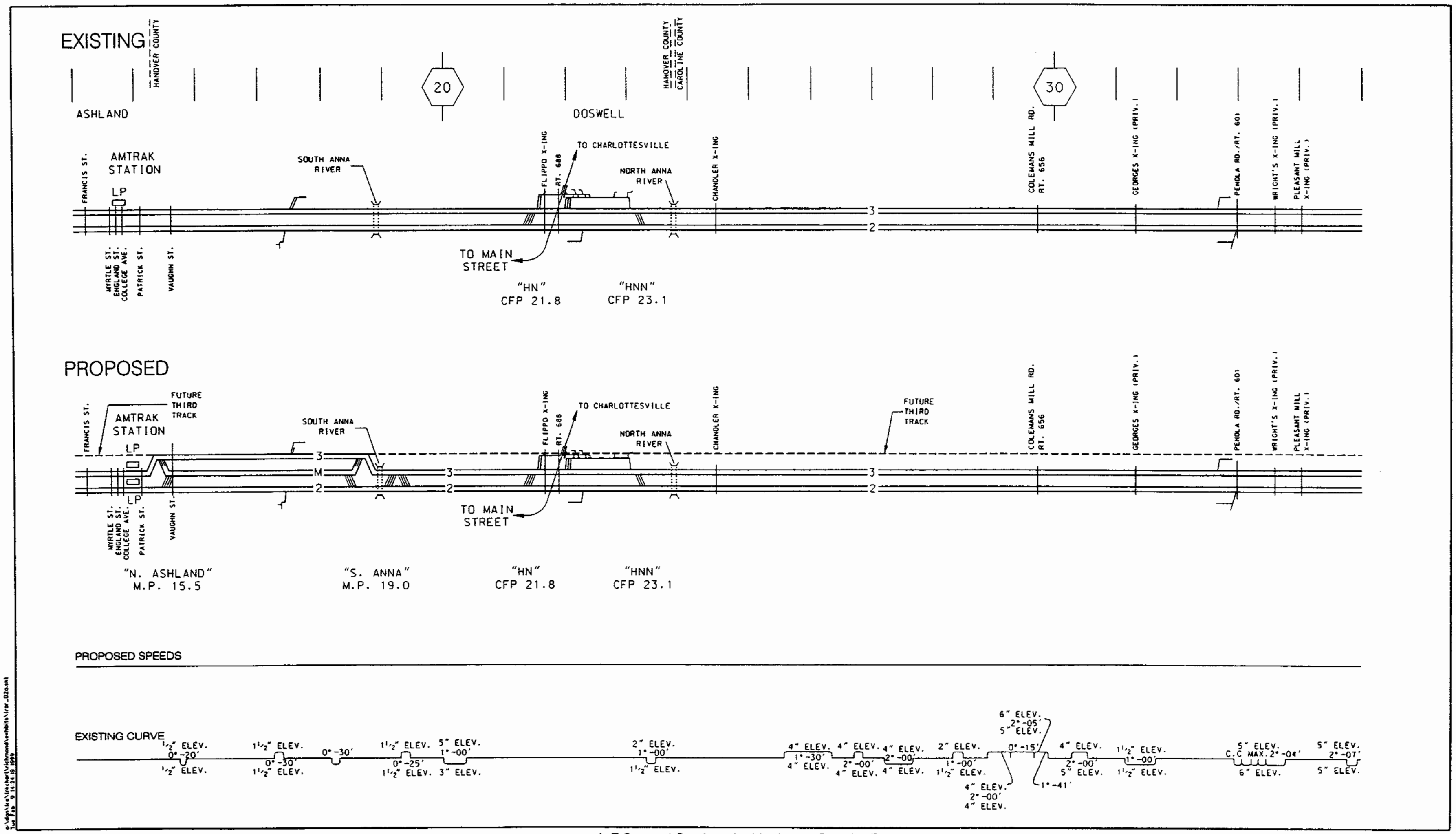
Task No. 4 - Washington, D.C. to Richmond, Va. Rail Study

SCALE IN MILES
0 1 2 3

De LEUW, CATHER

EXHIBIT 1A

Existing And Proposed 2015 Track Configurations



United States Department of Transportation * Federal Railroad Administration

A-E Support Services for Northeast Corridor Railroad Improvements

Task Order No. 103

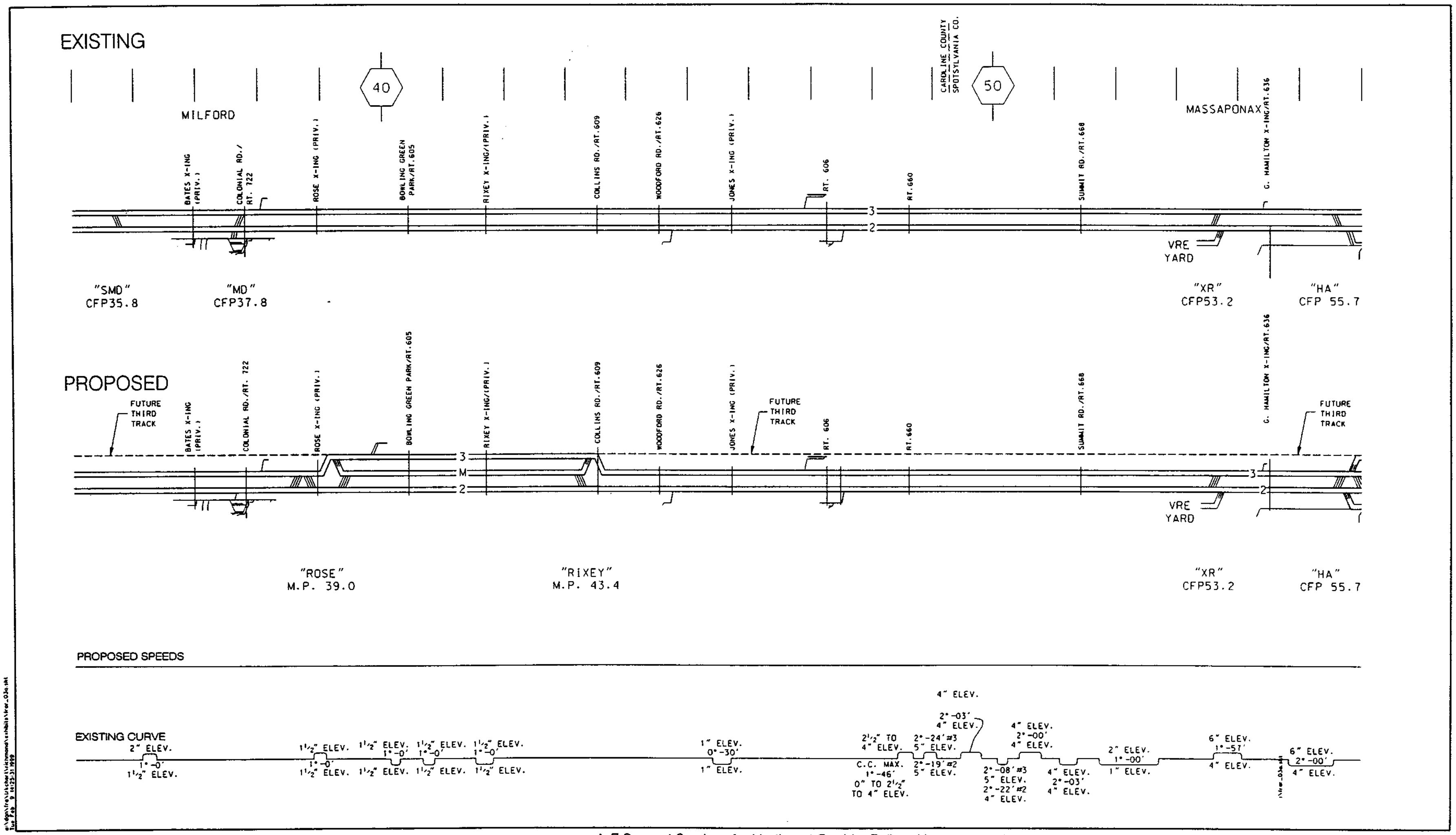
Task No. 4 - Washington, D.C. to Richmond, Va. Rail Study

SCALE IN MILES 0 1 2 3

De LEUW, CATHER

EXHIBIT 2A

Existing And Proposed 2015 Track Configurations

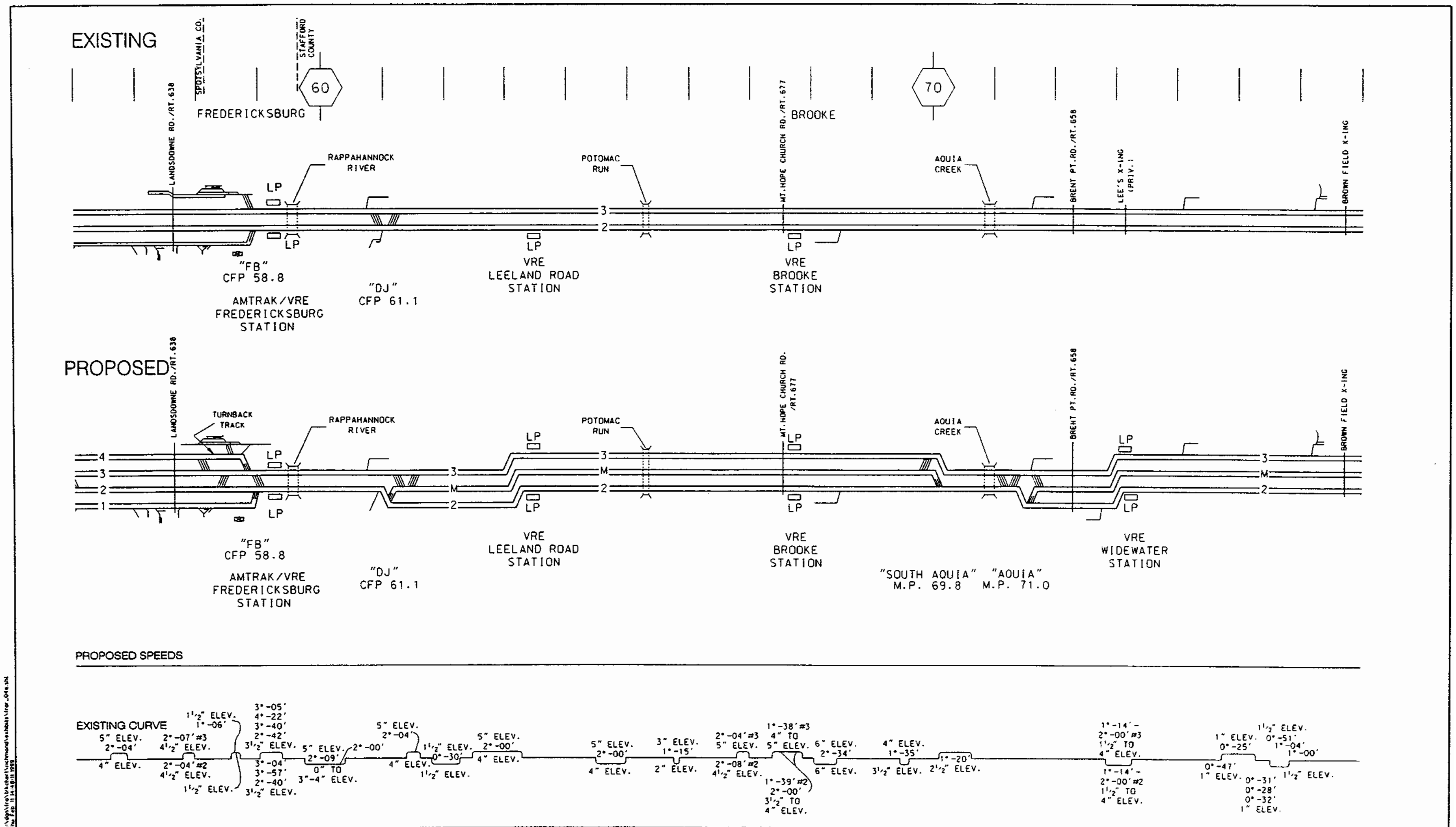


SCALE IN MILES 0 1 2 3

De LEUW, CATHER

EXHIBIT 3A

Existing And Proposed 2015 Track Configurations



United States Department of Transportation • Federal Railroad Administration

A-E Support Services for Northeast Corridor Railroad Improvements

Task Order No. 103

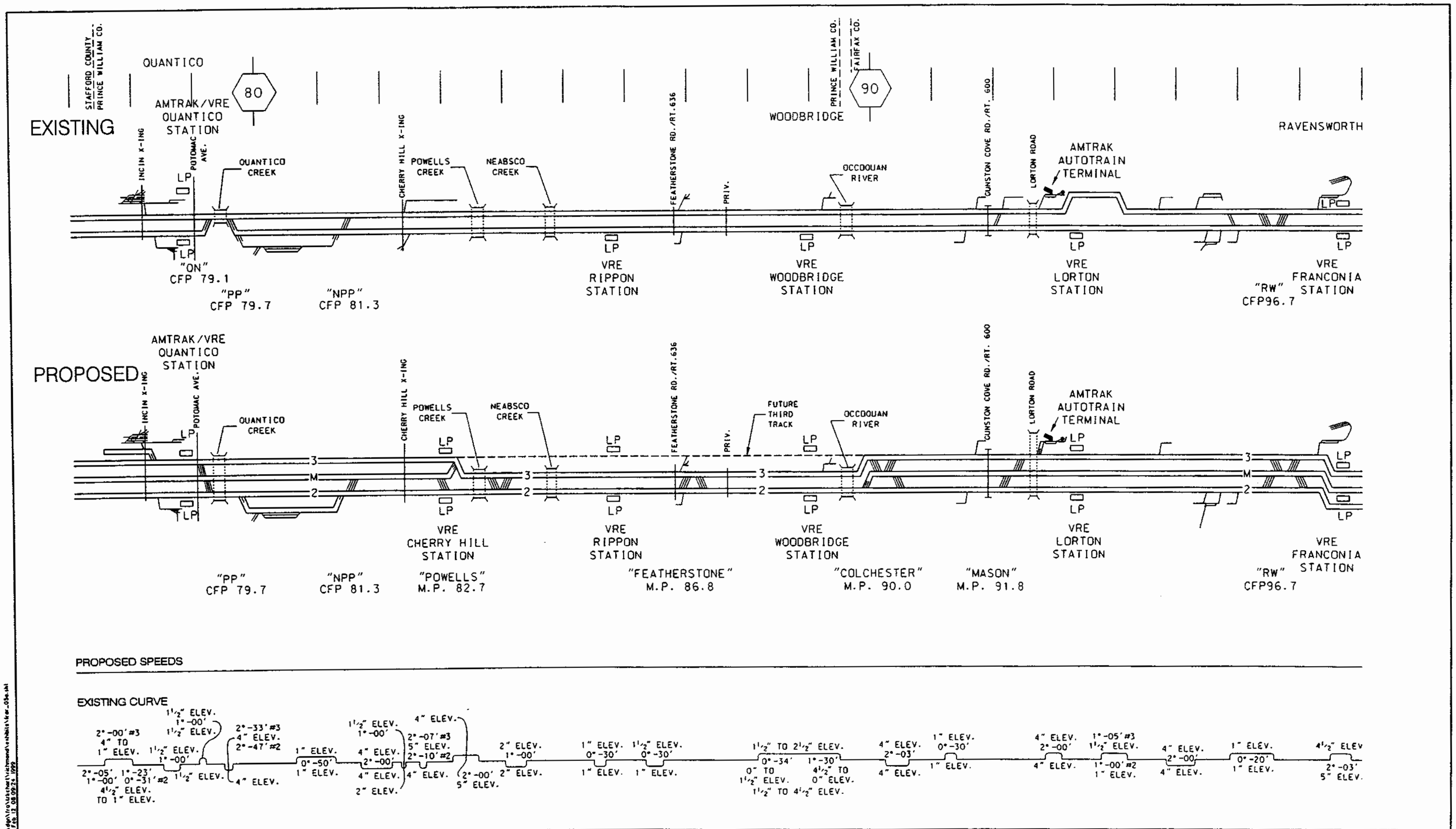
Task No. 4 - Washington, D.C. to Richmond, Va. Rail Study

SCALE IN MILES
0 1 2 3

De LEUW, CATHER

EXHIBIT 4A

Existing And Proposed 2015 Track Configurations



United States Department of Transportation • Federal Railroad Administration

A-E Support Services for Northeast Corridor Railroad Improvements

Task Order No. 103

Task No. 4 - Washington, D.C. to Richmond, Va. Rail Study

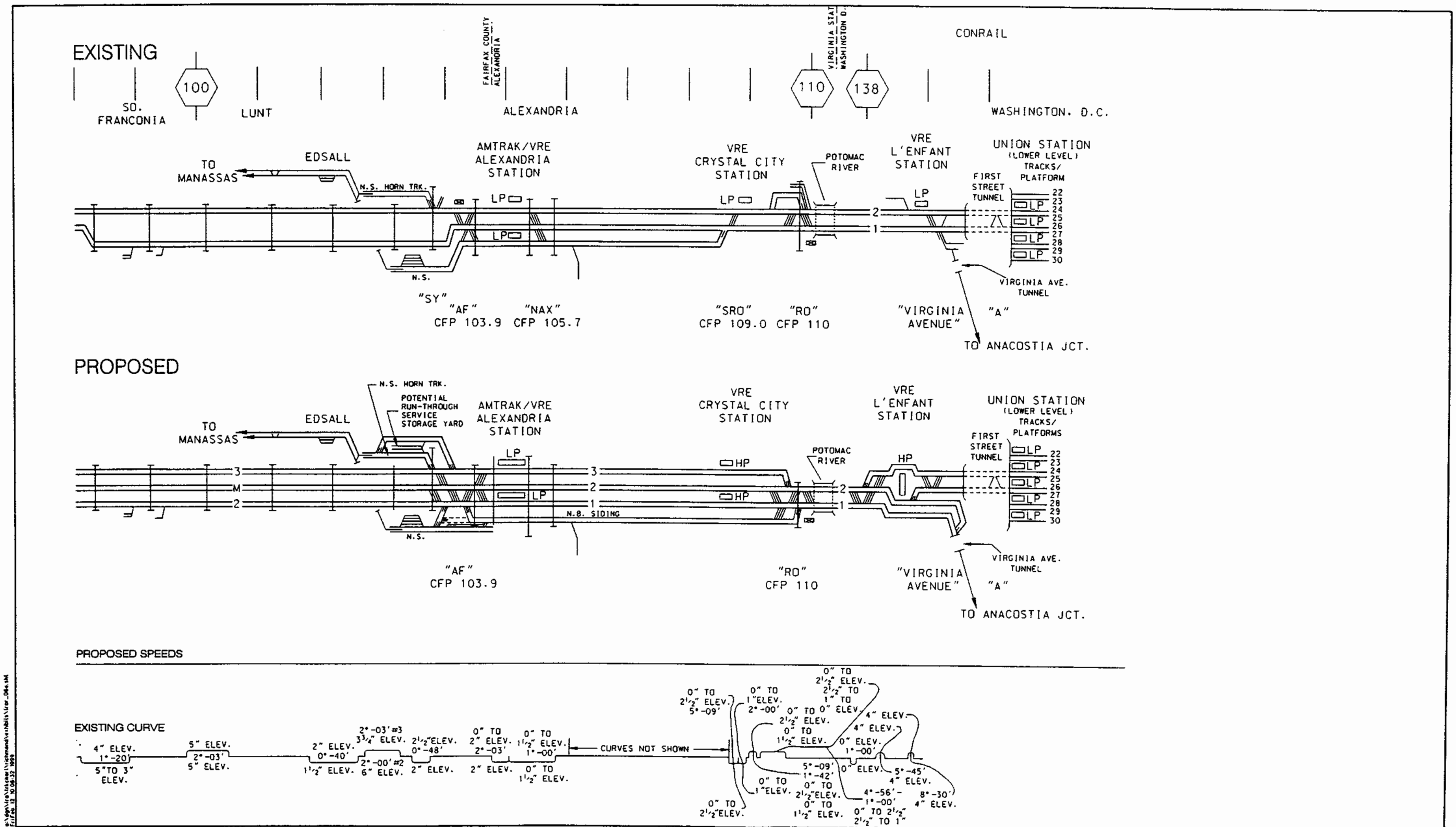
SCALE IN MILES

0 1 2 3

De LEUW, CATHER

EXHIBIT 5A

Existing And Proposed 2015 Track Configurations



United States Department of Transportation • Federal Railroad Administration

A-E Support Services for Northeast Corridor Railroad Improvements

Task Order No. 103

Task No. 4 - Washington, D.C. to Richmond, Va. Rail Study

SCALE IN MILES 0 1 2 3

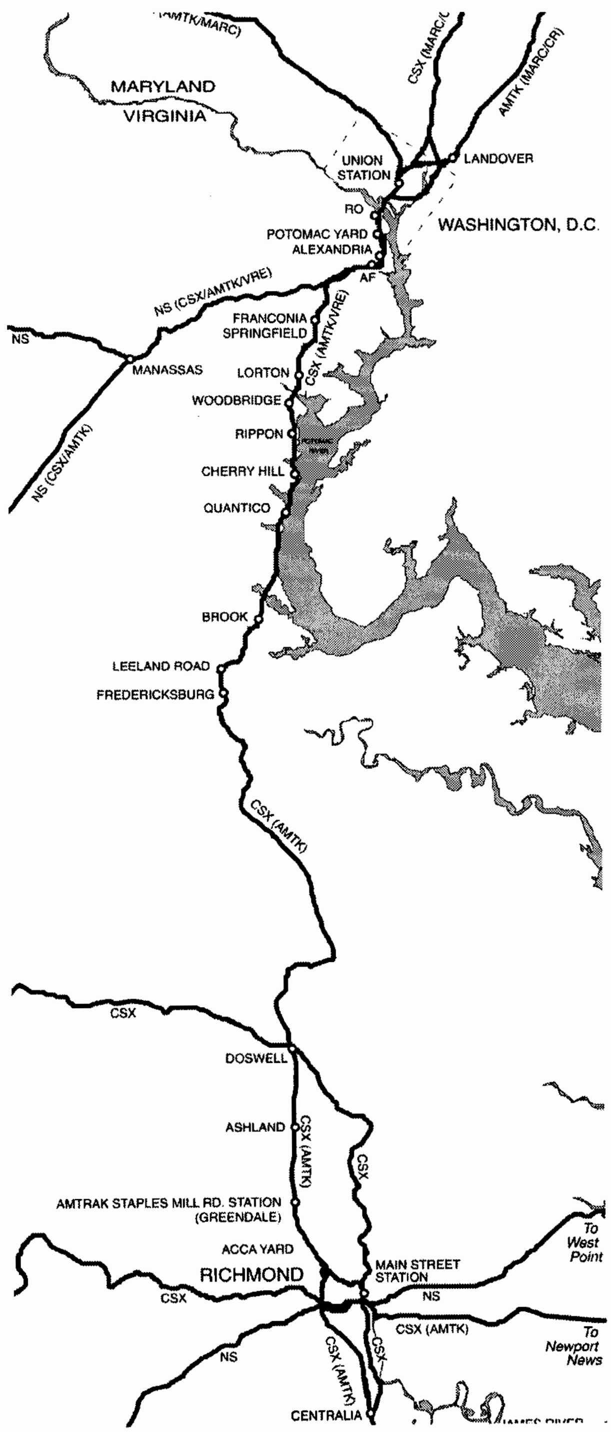
De LEUW, CATHER

EXHIBIT 6A

Existing And Proposed 2015 Track Configurations

Report to Congress APPENDIX E

Potential Improvements to the Washington—Richmond Railroad Corridor



OWNERSHIP AND OPERATING RIGHTS

May 1999

INTRODUCTION

The following summary is for information purposes only. It is not intended to establish the legal effects of the various agreements or the rights of the parties thereto. The summaries of the agreements do not necessarily include all of the points covered by the agreements.

SUMMARY OF OWNERSHIP AND OPERATING RIGHTS

Definition

The precise definition of the rail corridor considered in this report is the route extending from Richmond Virginia to Union Station, in Washington, D.C., via the tracks of CSXT, Conrail, and Amtrak. Primarily this is the RF&P Subdivision of the Baltimore Service Lane of CSXT, but it also includes a short segment owned by Amtrak, from Union Station to the junction with Conrail at CP-Virginia, and another segment owned by Conrail, from CP-Virginia to the junction with CSXT at the south bank of the Potomac River. The south end of the RF&P Subdivision is Greendale (MP 4.8), an interlocking adjacent to Amtrak's Staples Mill Road Station, located in the suburb of Greendale, approximately 8 miles northwest of downtown Richmond. In addition, it includes the CSXT route from the Staples Mill Road Station to Main Street Station, in downtown Richmond. It is possible that this definition may be extended to include a storage, cleaning, and maintenance facility, should it be located beyond Main Street. Several sites, north, south, and east of the station, were evaluated. Recently a site in Brown St. Yard, north of the station, has been identified. The site is constrained and until mapping of the property is completed and a conceptual design has been successfully developed a site selection decision can not be made.

It is important to note that for operating purposes, Amtrak's Northeast Corridor Strategic Business Unit defines the Corridor differently, extending it to Newport News. This report considers only the line between Richmond and Washington, D.C.

Ownership

The portion of the Northeast Corridor from Richmond, VA to Washington is primarily owned by CSXT. CSXT's ownership extends from RO Interlocking (inclusive), at the south bank of the Potomac River, through Richmond to the south, and east to Newport News, VA. The distance from RO to Richmond (Staples Mill Road Station) is 105.2 miles. The distance from

Staples Mill Road Station to Main Street Station is 7.9 miles. Newport News is an additional 74.5 miles from Richmond (Staples Mill Road Station).

Conrail owns a small, 2.2 mile segment from the south bank of the Potomac River to CP-Virginia, the junction with Amtrak at the south end of the Washington Terminal property. The remaining distance from CP-Virginia to Union Station is less than one mile, and is owned by Amtrak as part of the Washington Terminal Complex.

Operators

CSXT operates frequent freight service between CP-Virginia and Richmond. Conrail Performs local switching service in the vicinity of CP-Virginia. Norfolk Southern operates a transfer service between their yard in Alexandria and the Conrail yard at Benning.

Amtrak maintains operating agreements with Conrail and CSXT. Virginia Railway Express operates commuter rail service between Union Station and a storage yard south of Fredericksburg, and maintains operating agreements with Amtrak, Conrail, and CSXT. The major points of these agreements are highlighted below.

Amtrak's agreement with CSXT does not cover operation between Main Street Station and Centralia. Prior to initiation of service between Main Street Station and Raleigh, N.C. the agreement between Amtrak and CSXT will have to be modified.

AMTRAK

April 1, 1997 Agreement with CSXT

3.1 Rights of Services
"CSXT agrees to provide Amtrak with the use of facilities and services .... for .... Intercity Rail Passenger Service, including carrying of mail and express on Intercity Rail Passenger Trains to the extent authorized by the Act." Includes the right to modify or increase services, and the obligation to provide emergency services.

4.1 "CSXT shall .... not .... abandon its Rail Lines used in the operation of regular Amtrak Trains .... without Amtrak's prior written approval ...."

4.2 Rail lines used by Amtrak shall be maintained by CSXT at the level of utility existing on April 1, 1997, so that the same schedules can be operated regularly, with the same level of comfort.

4.3 Level of utility can be increased at Amtrak's expense. CSXT can be required to make the improvements necessary.

5.1A. Amtrak pays various avoidable unit costs specified in Appendix IV, including $ 1.046 per train mile for incremental track maintenance + performance payments (Appendix V).

7.2 Risk of Liability
"Amtrak agrees to indemnify and save harmless CSXT, irrespective of any negligence or fault of CSXT, its employees, [etc.] from any and all liability for injuries to or death of, or property damage to .... any person [or] property.

8.8 Term: Five years minimum; may be terminated, with 12 months notice.

April 14, 1996 "Off Corridor" Agreement with Conrail

3.1 Rights of Services
"Conrail agrees to provide Amtrak .... with the services requested .... for .... Intercity Rail Passenger Service, including carrying of mail and express on Intercity Rail Passenger Trains...." Includes the right to modify or increase services, and the obligation to provide emergency services.

3.3 "Conrail shall provide services in an economic and efficient manner ...."
"Conrail shall have sole control of the operation of Amtrak's ....[trains].... on Conrail ...."

4.1 "Conrail shall retain and not dispose of or abandon its Rail Lines used on April 14, 1996 in the operation Amtrak's Intercity Rail Passenger Service .... as long as such use continues or for the term of this agreement, whichever period is shorter ...."

4.2 ".... Rail Lines used in Amtrak's .... [service] .... shall be maintained by Conrail at no less than the class that will permit operation .... at the speeds set forth in Appendix II and in such a way as to allow the accomplishment of agreed upon schedules with a reasonable degree of reliability and passenger comfort.

4.3 Modifications to improve schedules can be made at Amtrak's expense. Conrail can be required to make the improvements necessary.

5.1(a) Amtrak pays various unit costs specified in Appendix IV, including $ 1.14 per train mile for incremental track maintenance + performance payments (Appendix V).

7.2(a) Rick of Liability
The *Liability Apportionment Agreement* between Amtrak and Conrail, dated June 19, 1979, remains in effect until December 31, 1998, at which time either party may request that the terms be renegotiated, unless "federal legislation pertaining to passenger train liability is enacted into law ...."

9.8 Term: Ten years minimum; may be terminated with 12 months notice.

VIRGINIA RAILWAY EXPRESS

Operating Access Agreement with Conrail

3.1,2 VRE service shall be operated through an approved agent, currently Amtrak, approved in advance by Conrail, with equipment which complies with federal requirements.

3.4 All railroads with previously existing operating agreement s, including Amtrak, have priority over VRE. Conrail has "the paramount right .... to use its own tracks [which] shall not be diminished by this agreement. Conrail ".... has heretofore granted rights to use the TRACKS to other railroad companies and NRPC". VRE agrees that they, or their operator, Amtrak, ".... will not assert .... that [VRE trains are] entitled to preference over the Railroad's freight operations, or the freight operations of [other railroads or Amtrak].

3.7(a) VRE pays the cost of improvements "required by the operation of the SERVICE".

3.7(d) "[R]etirements from the TRACKS .... may be deferred on condition that VRE increase[s] the BASE PAYMENT to the railroad by the amount necessary to compensate .... for such deferral, including maintenance, repair, renewal, taxes, and any lost opportunity cost ...."

4.1,2,3 Grants VRE the right to use the tracks and contract with an approved operator, currently Amtrak, to operate the trains.

5.1,2,3 Terms: Five years; VRE may terminate at any time on 60 days notice. Has been extended annually, and is currently in effect through November 30, 1998. The contract has been extended by mutual agreement. A further extension is under negotiation, with CSX's approval.

6.1(b,c) Payment

A base payment of $15 per train in 1989, subject to adjustment according to the AAR Eastern District Index of Material Prices and any increase on taxes resulting from VRE service.

7.1 Conrail shall ".... maintain the TRACKS in a condition that will permit the operation of the SERVICE [but] does not guarantee the condition of the TRACKS or that the SERVICE will not be delayed or interrupted."

12.1(a) Liability

"[VRE] shall protect, defend, indemnify, and save harmless the Railroad from any loss, cost, expense, or liability ...."

12.1(b) VRE must maintain policies of liability insurance ".... with annual aggregate limits of at least $200 million.

Operating Access Agreement with CSXT

2.3 VRE service shall be operated through an approved agent, currently Amtrak, approved in advance by CSXT, with equipment which complies with federal requirements.

2.6(a) VRE acknowledges that "the paramount right of [CSXT] to use its own tracks .... shall not be diminished by this agreement. Conrail ".... has heretofore granted rights to use the Tracks to other railroad companies and NRPC". VRE agrees that they, or their operator, Amtrak, ".... will not assert .... that [VRE trains are] entitled to preference over the Railroad's freight operations, or the freight operations of [other railroads or Amtrak].

2.6(b) "[CSXT] retains exclusive authority to approve or reject, in its sole discretion, any proposed modification of the Service .... and the right to require the construction of Improvements pursuant to .... modifications to the Service ...."

2.9(c) Expansion of Service beyond that defined in the agreement is not allowed "unless and until" a third parallel mainline is provided at no cost to CSXT. The third mainline track and "such other Improvements and conditions as (CSXT) determines ... necessary to ensure that commuter operations will not interfere with freight operations or intercity passenger service. It is contemplated that the new mainline will be primarily utilized for commuter operations...."

VRE "may request further expansion of the Service...by presenting to (CSXT) evidence of the Commissions' commitment to implement and to fund, at no expense to (CSXT), all or a significant portion of the...third mainline and such other Improvements as (CSXT) deems necessary...."

3.1 Grants VRE the right to use CSXT tracks for the Service.

4.1 Term: Until June 30, 1999; VRE may terminate at any time on 60 days notice.

5.1 VRE pays a Contract Fee plus costs incurred and revenues lost due to interference with CSXT's ability to provide freight operations.

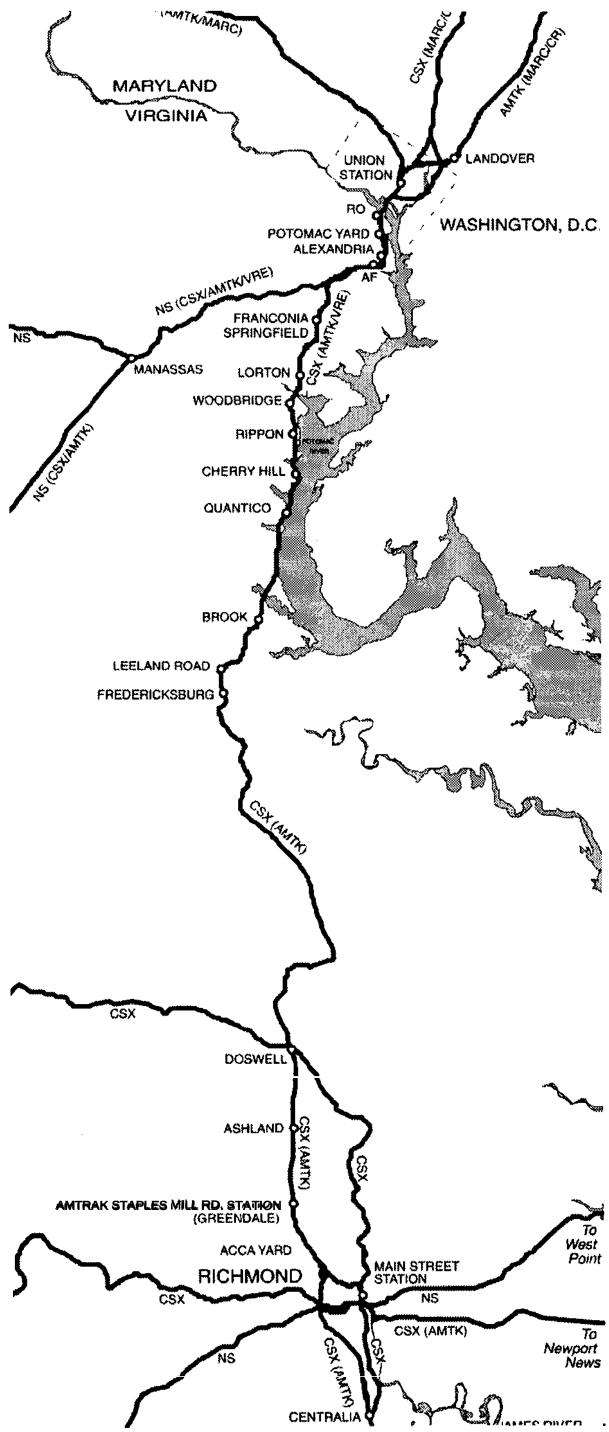
6.1 CSXT shall ".... maintain the Tracks in a condition that will permit the operation of the Service [but] does not guarantee the condition of the Tracks or that the Service will not be delayed or interrupted."

9.1(a) Liability
"[VRE] shall protect, defend, indemnify, and save harmless the Railroad from any loss, cost, expense, incurred by the Railroad .... and all liability ...."

9.1(b) VRE must maintain policies of liability insurance ".... with annual aggregate limits of at least $200 million.

Report to Congress **APPENDIX F**

Potential Improvements to the Washington—Richmond Railroad Corridor



PROPOSED 2015 SCHEDULES FOR INTERCITY AND COMMUTER TRAINS

May 1999

NOTES:

A. ADDITIONAL PROJECTED TRAINS DUE TO CONRAIL ACQUISITION BY CSX ARE NOT INCLUDED. CSX BELIEVES THESE ADDITIONAL FREIGHT TRAINS WILL NOT OPERATE IN PEAK WASHINGTON, DC COMMUTING HOURS AND WILL THUS NOT INFLUENCE PEAK HOUR CAPACITY ISSUES.

B. A UNIT COAL TRAIN CURRENTLY OPERATES AT NIGHT FROM ACCA YARD TO A PLANT NEAR QUANTICO, WHICH WAS NOT MODELED, AS IT DID NOT CREATE ANY CAPACITY ISSUES.

C. EXISTING NIGHTTIME LOCALS WERE NOT MODELED AS THEY DID NOT CREATE ANY CAPACITY ISSUES.

D. TRAIN K650 IS THE TROPICANA ORANGE JUICE TRAIN.

E. FOUR ROUND TRIP NS FREIGHT TRAINS WERE OPERATED BETWEEN ALEXANDRIA (AF) AND WASHINGTON (CP VIRGINIA)

F. THE DOSWELL LOCAL FROM ACCA YARD WAS NOT MODELED DUE TO ITS VARIABLE SCHEDULE AND LACK OF CAPACITY ISSUES.

				FLANYP		VREF	VREM	VREF	VREM	VREF	VREM
Train #		**CSX 410**	**NS2**	**A82**	**CSX 414**	**3300**	**3500**	**3302**	**3502**	**3304**	**3504**
Northbound											
Main St	D			3:25							
Richmond (ACCA)	D	22:45		3:45	2:30						
Ashland	D										
VRE Yard	D					4:45		5:15		5:30	
Fredericksburg	D	0:01			3:45	5:00		5:30		5:43	
Leeland	D					5:07		5:37			
Brooke	D					5:14		5:44			
Quantico	D					5:26		5:56			
Cherry Hill	D					5:32		6:02			
Rippon	D					5:38		6:07		6:11	
Woodbridge	D					5:44				6:17	
Lorton	D					5:51				6:24	
Franconia	D					5:59				6:32	
Alexandria (AF)	D	1:15	3:30		5:00	6:07	6:06	6:27	6:30	6:40	6:47
Crystal City (RO)	D	2:15	4:00		5:30	6:14	6:13	6:34	6:37	6:47	6:54
L'Enfant (VA)	D					6:20	6:19	6:40	6:43	6:53	7:00
Washington (VA)	A	3:15	4:15	5:35	6:00	6:25	6:26	6:45	6:50	6:58	7:07

				VREDH	VREM	VREDH		VREM	BOSNPN	VREDH	WASBRIS
Train #		**NS2**	**CSX 405**	**3301**	**3501**	**3303**	**NS4**	**3503**	**A613**	**3305**	**A001**
Southbound											
Washington (VA)	D	1:00	4:15	6:35	6:40	6:55	7:00	7:05	7:10	7:13	7:16
L'Enfant (VA)	D										
Crystal City (RO)	D	1:15	4:30				7:15				
Alexandria (AF)	D	1:45	5:30		6:59		7:45	7:24	7:25		7:35
Franconia	D										
Lorton	D										
Woodbridge	D										
Rippon	D					7:30				7:48	
Cherry Hill	D										
Quantico	D								7:50		
Brooke	D										
Leeland	D										
Fredericksburg	D		7:00	8:35					8:09		
VRE Yard	A										
Ashland	D								8:49		
Richmond (ACCA)	D		9:00						9:05		
Main St	A								9:25		

		VREF	VREM	FLANYP	VREF	VREM	VREF	VREM	VREF	VREM	VREF
Train #		**3306**	**3506**	**A84**	**3308**	**3508**	**3310**	**3510**	**3312**	**3512**	**3314**
Northbound											
Main St	D			5:15							
Richmond (ACCA)	D			5:35							
Ashland	D										
VRE Yard	D	5:45			6:00		6:20		6:30		6:45
Fredericksburg	D	6:00		6:25	6:13		6:30		6:43		7:00
Leeland	D	6:07					6:37				7:07
Brooke	D	6:14					6:44				7:14
Quantico	D	6:26		6:45			6:56				7:26
Cherry Hill	D	6:32					7:02				7:32
Rippon	D	6:37			6:41		7:07		7:11		7:37
Woodbridge	D				6:47				7:17		
Lorton	D				6:54				7:24		
Franconia	D				7:02				7:32		
Alexandria (AF)	D	6:57	7:00	7:10	7:10	7:17	7:27	7:30	7:40	7:47	7:57
Crystal City (RO)	D	7:04	7:07		7:17	7:24	7:34	7:37	7:47	7:54	8:04
L'Enfant (VA)	D	7:10	7:13		7:23	7:30	7:40	7:43	7:53	8:00	8:10
Washington (VA)	A	7:15	7:20	7:25	7:28	7:37	7:45	7:50	7:58	8:07	8:15

		VREM	VREFRE	VREM	VREDH	VREM	WASRVR		WASRVR	VREFRE	VREM
Train #		**3505**	**3307**	**3507**	**3309**	**3509**	**3311**	**CSX 413**	**3351**	**3313**	**3511**
Southbound											
Washington (VA)	D	7:20	7:25	7:35	7:38	7:50	8:10	9:00	9:10	9:15	9:25
L'Enfant (VA)	D	7:26	7:31							9:21	9:31
Crystal City (RO)	D	7:32	7:37					9:15		9:27	9:37
Alexandria (AF)	D	7:39	7:44	7:54		8:09	8:25	10:15	9:25	9:34	9:44
Franconia	D		7:52							9:42	
Lorton	D		8:00							9:50	
Woodbridge	D		8:07				8:43		9:43	9:57	
Rippon	D		8:13		8:13					10:03	
Cherry Hill	D		8:19							10:09	
Quantico	D		8:25				8:55		9:55	10:15	
Brooke	D		8:37							10:27	
Leeland	D		8:44							10:34	
Fredericksburg	D		8:50				9:15	11:30	10:15	10:40	
VRE Yard	A										
Ashland	D										
Richmond (ACCA)	D						10:05	13:00	11:05		
Main St	A						10:25		11:25		

		VREM	VRER	VREM	CLTNYP	VREM	VRER	AUTO		VREM	VREF
Train #		**3514**	**3316**	**3516**	**3318**	**3518**	**3320**	**A052**	**CSX 174**	**3520**	**3322**
Northbound											
Main St	D				6:15						
Richmond (ACCA)	D				6:35			6:55	5:00		
Ashland	D				6:50						
VRE Yard	D										
Fredericksburg	D				7:30				6:15		8:00
Leeland	D				7:37						8:07
Brooke	D				7:44						8:14
Quantico	D				7:56						8:26
Cherry Hill	D				8:02						8:32
Rippon	D		7:39		8:07		8:09				8:37
Woodbridge	D		7:45				8:15				
Lorton	D		7:52				8:22	8:45			
Franconia	D		8:00				8:30				
Alexandria (AF)	D	8:00	8:08	8:17	8:27	8:30	8:38		7:45	8:47	8:57
Crystal City (RO)	D	8:07	8:15	8:24	8:34	8:37	8:45		8:15	8:54	9:04
L'Enfant (VA)	D	8:13	8:21	8:30	8:40	8:43	8:51			9:00	9:10
Washington (VA)	A	8:20	8:26	8:37	8:45	8:50	8:56		9:00	9:07	9:15

		NYPCLT	NYPATL	NYPFLA	VREFRE	VREM				NYPFLA	VREFRE
Train #		**A79**	**A017**	**A89**	**3315**	**3513**	**CSX 173**	**CSX 409**	**NS6**	**A81**	**3317**
Southbound											
Washington (VA)	D	10:05	10:15	11:20	11:25	11:30	12:30	12:35	13:00	13:14	13:20
L'Enfant (VA)	D				11:31	11:36					13:26
Crystal City (RO)	D				11:37	11:42	12:40	12:50	13:15		13:32
Alexandria (AF)	D	10:20	10:30	11:35	11:44	11:49	12:50	13:00	13:45	13:29	13:39
Franconia	D				11:52						13:47
Lorton	D				12:00						13:55
Woodbridge	D				12:07						14:02
Rippon	D				12:13						14:08
Cherry Hill	D				12:19						14:14
Quantico	D	10:45		12:00	12:25						14:20
Brooke	D				12:37						14:32
Leeland	D				12:44						14:39
Fredericksburg	D	11:04		12:19	12:50		13:55	14:05		14:09	14:45
VRE Yard	A										
Ashland	D	11:44		12:59							
Richmond (ACCA)	D	12:00		13:15			15:00	15:15		14:59	
Main St	A	12:20		13:35						15:19	

		VRER	RVRNYP		NOLNYP	VREM	VREF	CLTNYP	VREM		
Train #		**3324**	**A602**	**NS4**	**A020**	**3522**	**3326**	**A128**	**3524**	**CSX 176**	**CSX 406**
Northbound											
Main St	D		7:30					8:15			
Richmond (ACCA)	D		7:50					8:35		8:15	7:30
Ashland	D										
VRE Yard	D										
Fredericksburg	D		8:40				9:00			9:20	8:50
Leeland	D						9:07				
Brooke	D						9:14				
Quantico	D		9:00				9:26				
Cherry Hill	D						9:32				
Rippon	D	8:39					9:38				
Woodbridge	D	8:45					9:44				
Lorton	D	8:52					9:51				
Franconia	D	9:00					9:59				
Alexandria (AF)	D	9:08	9:25	9:00	9:30	9:41	10:07	10:10	10:14	10:20	10:10
Crystal City (RO)	D	9:15		9:30		9:48	10:14		10:21	10:35	11:00
L'Enfant (VA)	D	9:21				9:54	10:20		10:27		
Washington (VA)	A	9:26	9:40	9:45	9:48	10:01	10:25	10:25	10:34	10:45	11:30

		VREM	NYPCVS	NYPCLT	VREFRE		VREM		NYPNPN	AUTO	VREM
Train #		**3515**	**A051**	**A405**	**3319**	**CSX 175**	**3517**	**CSX 401**	**A605**	**A053**	**3519**
Southbound											
Washington (VA)	D	13:25	13:55	14:30	15:00	15:00	15:05	15:30	15:39		16:00
L'Enfant (VA)	D	13:31			15:06		15:11				16:06
Crystal City (RO)	D	13:37			15:12	15:15	15:17	15:45			16:12
Alexandria (AF)	D	13:44	14:10	14:45	15:19	15:30	15:24	16:45	15:54		16:19
Franconia	D				15:27						
Lorton	D				15:35					16:15	
Woodbridge	D			15:03	15:42						
Rippon	D				15:48						
Cherry Hill	D				15:54						
Quantico	D			15:15	16:00						
Brooke	D				16:12						
Leeland	D				16:19						
Fredericksburg	D			15:35	16:25	16:35		18:00	16:34		
VRE Yard	A										
Ashland	D										
Richmond (ACCA)	D			16:25		17:45		19:30	17:24		
Main St	A			16:45					17:44	18:15	

		NPNNYP	VREF	VREM	BRISWAS	CLTNYP		VREF	FLANYP	VREM	CLTNYP
Train #		**A604**	**3328**	**3526**	**A002**	**A156**	**CSX K650**	**3330**	**A86**	**3528**	**3332**
Northbound											
Main St	D	9:25				11:00			12:15		13:00
Richmond (ACCA)	D	9:45				11:20	11:30		12:35		13:20
Ashland	D	10:00									
VRE Yard	D										
Fredericksburg	D	10:40	11:00				12:40	13:00			14:10
Leeland	D		11:07					13:07			
Brooke	D		11:14					13:14			
Quantico	D		11:26					13:26			14:30
Cherry Hill	D		11:32					13:32			
Rippon	D		11:38					13:38			
Woodbridge	D		11:44					13:44			14:42
Lorton	D		11:51					13:51			
Franconia	D		11:59					13:59			
Alexandria (AF)	D	11:19	12:07	12:11	12:25	12:55	13:00	14:07		14:16	15:00
Crystal City (RO)	D		12:14	12:18			13:30	14:14		14:23	
L'Enfant (VA)	D		12:20	12:24				14:20		14:29	
Washington (VA)	A	11:34	12:25	12:31	12:45	13:10	14:00	14:25	14:25	14:36	15:15

		VREM	VREFRE	VRERIP	VREM	VREM	NYPCLT	VREFRE	VRERIP	VREM	VREM
Train #		**3521**	**3323**	**3325**	**3523**	**3525**	**A153**	**3327**	**3329**	**3527**	**3529**
Southbound											
Washington (VA)	D	16:05	16:10	16:15	16:25	16:30	16:36	16:40	16:45	16:50	16:55
L'Enfant (VA)	D	16:11	16:16	16:21	16:31	16:36		16:46	16:51	16:56	17:01
Crystal City (RO)	D	16:17	16:22	16:27	16:37	16:42		16:52	16:57	17:02	17:07
Alexandria (AF)	D	16:24	16:29	16:34	16:44	16:49	16:51	16:59	17:04	17:09	17:14
Franconia	D			16:42					17:12		
Lorton	D			16:50					17:20		
Woodbridge	D			16:57					17:27		
Rippon	D		16:49	17:03				17:19	17:33		
Cherry Hill	D		16:55					17:25			
Quantico	D		17:01				17:16	17:31			
Brooke	D		17:13					17:43			
Leeland	D		17:20					17:50			
Fredericksburg	D		17:25				17:35	17:55			
VRE Yard	A										
Ashland	D						18:15				
Richmond (ACCA)	D						18:31				
Main St	A						18:51				

				VREF	VREM	NPNNYP	VREM	VREM	VREM	VREDH	VREF
Train #		**CSX 192**	**NS6**	**3334**	**3530**	**A612**	**3532**	**3534**	**3536**	**3340**	**3338**
Northbound											
Main St	D					14:30					
Richmond (ACCA)	D	12:00				14:50					
Ashland	D										
VRE Yard	D										
Fredericksburg	D	13:10		15:00		15:40					16:40
Leeland	D			15:07							16:47
Brooke	D			15:14							16:54
Quantico	D			15:26		16:00					17:06
Cherry Hill	D			15:32							17:12
Rippon	D			15:38						17:10	17:18
Woodbridge	D			15:44							17:24
Lorton	D			15:51							17:31
Franconia	D			15:59							17:39
Alexandria (AF)	D	14:20	15:00	16:07	16:06	16:25	*17:00*	*17:10*	*17:25*		17:47
Crystal City (RO)	D	14:50	15:30	16:14	16:13						17:54
L'Enfant (VA)	D			16:20	16:19						18:00
Washington (VA)	A	15:20	15:45	16:25	16:26	16:40	17:20	17:30	17:45	17:50	18:05

		VREFRE	VRERIP	WASBRIS	VREM	VREM	NYPNPN	VREFRE	VREFRE	VREM	NYPNOL
Train #		**3331**	**3333**	**A003**	**3531**	**3533**	**A609**	**3335**	**3337**	**3535**	**A019**
Southbound											
Washington (VA)	D	17:10	17:15	17:18	17:20	17:35	17:39	17:45	17:50	17:55	18:05
L'Enfant (VA)	D	17:16	17:21		17:26	17:41		17:51	17:56	18:01	
Crystal City (RO)	D	17:22	17:27		17:32	17:47		17:57	18:02	18:07	
Alexandria (AF)	D	17:29	17:34	17:37	17:39	17:54	17:54	18:04	18:09	18:14	18:20
Franconia	D		17:42						18:17		
Lorton	D		17:50						18:25		
Woodbridge	D		17:57						18:32		
Rippon	D	17:49	18:03					18:24	18:38		
Cherry Hill	D	17:55						18:30			
Quantico	D	18:01					18:19	18:36			
Brooke	D	18:13						18:48			
Leeland	D	18:20						18:55			
Fredericksburg	D	18:25	18:30				18:38	19:00	19:05		
VRE Yard	A	18:40						19:15	19:20		
Ashland	D										
Richmond (ACCA)	D						19:28				
Main St	A						19:48				

		CLTNYP	VREDH	VREM	CVSNYP	FLANYP	VREF	CLTNYP	ATLNYP	BRISWAS	VREM
Train #		**A080**	**3342**	**3538**	**A050**	**A090**	**3344**	**3348**	**A018**	**A004**	**3540**
Northbound											
Main St	D	16:00				17:00		18:00			
Richmond (ACCA)	D	16:20				17:20		18:20			
Ashland	D					17:35					
VRE Yard	D										
Fredericksburg	D	17:10				18:15	18:45	19:10			
Leeland	D						18:52				
Brooke	D						18:59				
Quantico	D	17:30					19:11	19:30			
Cherry Hill	D						19:17				
Rippon	D		17:40				19:23				
Woodbridge	D	17:42					19:29				
Lorton	D						19:36				
Franconia	D						19:44				
Alexandria (AF)	D	18:00		18:21	18:36	19:00	19:52	19:55	19:51	20:01	20:06
Crystal City (RO)	D			18:28			19:59				20:13
L'Enfant (VA)	D			18:34			20:05				20:19
Washington (VA)	A	18:15	18:20	18:41	18:55	19:15	20:10	20:10	20:10	20:20	20:26

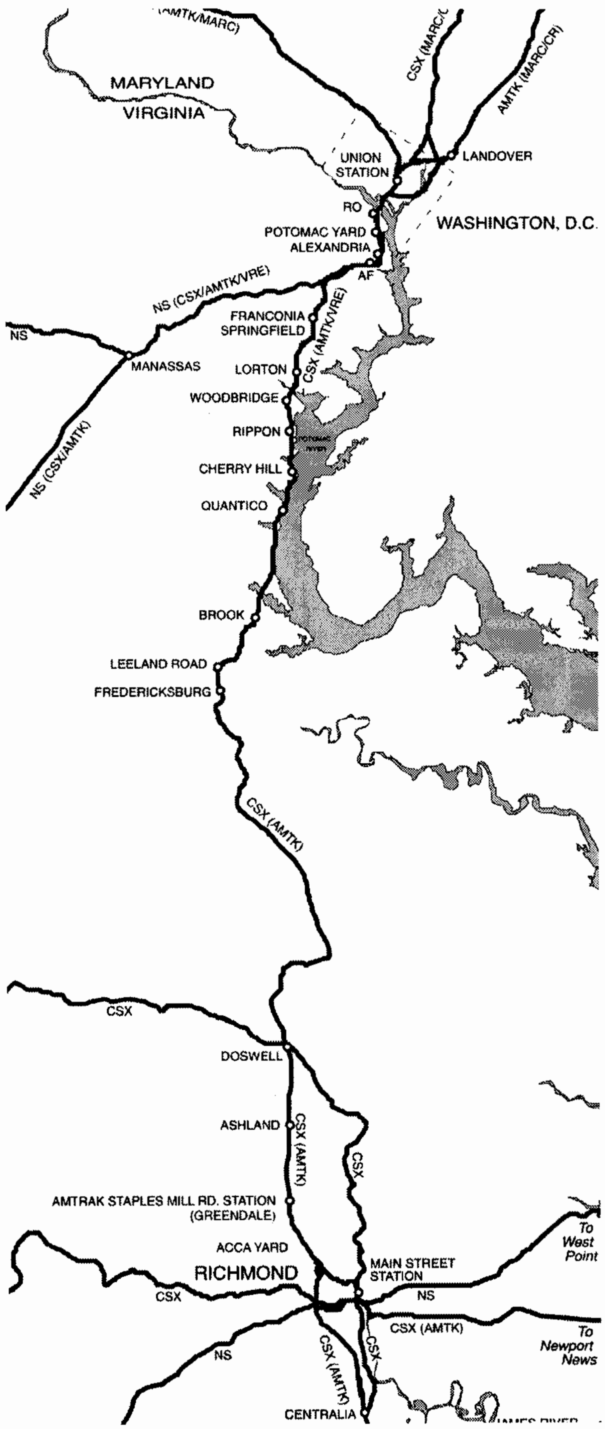
		VREM	VREFRE	VREFRE	NYPCLT	VREFRE	VREM		NYPFLA	VREFRE	
Train #		**3537**	**3339**	**3341**	**A611**	**3343**	**3539**	**NS8**	**83**	**3345**	**CSX 415**
Southbound											
Washington (VA)	D	18:10	18:15	18:20	18:39	18:45	18:55	19:00	19:09	19:45	20:30
L'Enfant (VA)	D	18:16	18:21	18:26		18:51	19:01			19:51	
Crystal City (RO)	D	18:22	18:27	18:32		18:57	19:07	19:15		19:57	20:45
Alexandria (AF)	D	18:29	18:34	18:39	18:54	19:04	19:14	19:45	19:24	20:04	21:45
Franconia	D			18:47		19:12				20:12	
Lorton	D			18:55		19:20				20:20	
Woodbridge	D			19:02		19:27				20:27	
Rippon	D		18:54	19:08		19:33				20:33	
Cherry Hill	D		19:00			19:39				20:39	
Quantico	D		19:06		19:19	19:45				20:45	
Brooke	D		19:18			19:57				20:57	
Leeland	D		19:25			20:04				21:04	
Fredericksburg	D		19:30	19:35	19:38	20:10			20:04	21:10	23:00
VRE Yard	A		19:45	19:50						21:25	
Ashland	D										
Richmond (ACCA)	D				20:28				20:54		0:30
Main St	A				20:48				21:14		

			VREF		NPNBOS	VREM	
Train #		**NS8**	**3346**	**CSX 400**	**A618**	**3542**	**CSX 410**
Northbound							
Main St	D			19:00	19:55		
Richmond (ACCA)	D				20:15		22:45
Ashland	D						
VRE Yard	D						
Fredericksburg	D		20:30	20:10	21:05		0:01
Leeland	D		20:37				
Brooke	D		20:44				
Quantico	D		20:56				
Cherry Hill	D		21:02				
Rippon	D		21:08				
Woodbridge	D		21:14				
Lorton	D		21:21				
Franconia	D		21:29				
Alexandria (AF)	D	21:00	21:37	21:20	21:50	22:06	1:15
Crystal City (RO)	D	21:30	21:44	21:40		22:13	2:15
L'Enfant (VA)	D		21:50			22:19	
Washington (VA)	A	21:45	21:55	22:00	22:05	22:26	3:15

		VREFRE	VREM	NYPFLA	WASRVR	VREM
Train #		**3347**	**3541**	**85**	**3349**	**3543**
Southbound						
Washington (VA)	D	20:45	20:50	22:15	22:20	22:50
L'Enfant (VA)	D	20:51	20:56		22:26	22:56
Crystal City (RO)	D	20:57	21:02		22:32	23:02
Alexandria (AF)	D	21:04	21:09	22:30	22:39	23:09
Franconia	D	21:12			22:47	
Lorton	D	21:20			22:55	
Woodbridge	D	21:27			23:02	
Rippon	D	21:33			23:08	
Cherry Hill	D	21:39			23:14	
Quantico	D	21:45			23:20	
Brooke	D	21:57			23:32	
Leeland	D	22:04			23:39	
Fredericksburg	D	22:10			23:45	
VRE Yard	A	22:25				
Ashland	D				0:25	
Richmond (ACCA)	D			0:10	0:41	
Main St	A			0:30	1:01	

Report to Congress APPENDIX G

Potential Improvements to the Washington—Richmond Railroad Corridor



DESCRIPTION OF INDIVIDUAL PROJECTS

May 1999

Appendix G
DESCRIPTION OF INDIVIDUAL PROJECTS

In response to the growth and expansion expected along the Richmond Corridor, many projects affecting the Corridor are being planned by governmental agencies and rail line operators. Analyses performed for the FRA and Amtrak identified additional improvements that would be required to support projected 2015 levels of intercity, freight, and commuter operations. These projects and improvements have been evaluated by FRA and Amtrak and integrated into the Washington - Richmond CTP.

This appendix presents descriptions of the various projects and Corridor program improvements that have been initially evaluated and found to be necessary and sufficient to support safe and dependable rail passenger service between Washington and Richmond in less than 2 hours. The projects would accommodate the projected level of intercity passenger, commuter and freight service in the year 2015. Proposed projects are listed according to the categories outlined in the body of the report.

Each proposed project is described under the following headings:

- needs assessment; and
- project description.

Information on project location and priorities is presented, however, information on design and construction schedules, and construction impact on operations has not been developed.

Required and Existing Project Funding are contained in Section V.

The geographic locations of the projects and their interrelationships are shown in Appendix D.

CONSIDERATIONS FOR ALL PROJECTS

The following considerations should be included, as appropriate, in the scope of each of these projects:

- Lengthen spans of overhead bridges as necessary.
- Provide independent structures at existing undergrade bridges where necessary to accommodate new tracks.

- Extend existing grade crossings to include improved approaches, maintenance of adequate site distances, and relocation of grade crossing signals.[1]
- Provide adequate drainage facilities, including the extension of existing culverts under the railroad.
- Relocate wayside signals, as necessary, to accommodate the new track.
- Optimize spacing of signals approaching new interlockings as part of upgrading the signal system.
- Maximize the use of 45 mph main line crossovers and turnouts.
- Maintain access to existing sidings and local industries.

TRIP TIME-RELATED PROJECTS

Curve Realignments

Needs Assessment. The Richmond Line was built when railroad technology was in it infancy. Although numerous line relocations have been made over the years, it remains a railroad with a significant number of curves. At many locations the surrounding community has developed to the point where relocation of the alignment is unrealistic. Environmental concerns make relocation difficult elsewhere. Nevertheless, several types of fixed-plant improvements to reduce the speed constraints associated with curves in the Washington to Richmond Corridor should be implemented:

- Increasing superelevation to the maximum allowable for a particular track alignment;
- Increasing the amount of unbalanced superelevation used to calculate speeds through curves to minimize track shifts; and
- Modifying spirals (the length of track that provides a smooth transition from tangent track to curved track) to provide a smoother ride.

The alternative of changing horizontal and vertical alignment, either within the existing right-of-way, or by acquiring land outside the existing right-of-way; was considered but deemed not necessary to meet the trip time goal of less than two hours between the two cities. The recommended alignment changes would allow higher speeds that can be sustained for meaningful periods of time.

The initial analysis represents a "best case". Though listed here as a single project, the improvements would actually consist of a large number of separate "sub-projects" at individual curves or groups of curves. It is likely that detailed study will reveal local constraints that would limit the feasibility or practicality of implementing some specific sub-projects.

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[1]As part of a separate initiative, the potential for eliminating individual grade crossings would be analyzed.

The curve realignment program will contribute significantly to the improvement in travel times in the corridor, thereby justifying the time and expense required to implement the program.

Project Description. Preliminary analysis of curves between Washington and Richmond used the latest Amtrak track geometry car data, and Conrail and CSX track chart data. The maximum lateral acceleration allowed in the body of the curve was kept below 0.15 g and maximum jerk rate was limited to 0.04 g per sec.[2] Spirals for increased speed were calculated in accordance with criteria previously used for the Northeast Corridor Improvement Project. Unbalanced superelevation was limited to 5 inches for commuter and conventional train operations, in conformance with criteria (based on ride comfort, maintenance, and spiral length concerns) assumed to be in compliance with upcoming revisions to FRA regulations.

For the purpose of the analysis, it was assumed that superelevation, for the 110 miles between Richmond and Long Bridge, would be increased (or similarly decreased) at linear rates specified by CSX, which presently allows:

- ½-inch in 31 feet up to 50 miles per hour;
- between 50 and 70 miles per hour a rate of ½-inch in 39 feet is allowed; and
- above 71 miles per hour a rate of ½-inch in 50 feet is allowed.

The analyses identified curves that should be realigned to adjust spiral length, and, if need be, superelevation to optimize goal speeds and enable trip times to be decreased. The curve realignments would not require the realignment of undergrade bridges. Additional curve documentation is provided in Appendix A.

As part of the project, the line needs to be surveyed to accurately record current conditions and enable final design to be completed. For the most part, the line has not been surveyed recently. Trip time sensitive realignments would be completed in conjunction with other improvements.

Safe braking distances at the increased speeds projected for the line would be established during the redesign of the signal system, which is described below.

The benefits of curve realignment come in small increments. Many small sub-projects would be undertaken to implement the program. Even though the curve realignments would be within the right-of-way, implementation implies expenditures that would disrupt train operations, with only small benefits being derived for each curve realigned. Improvements of

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[2]Except for tilt body train alternatives that assumed 9 inches of unbalanced superelevation, for which maximum jerk rate was limited to 0.064 g per sec. Operations at 9 inches of unbalanced superelevation would require the installation of concrete ties on curves where unbalance would exceed 5 inches.

this nature are only warranted in the context of an overall program directed toward significant trip time reduction.

Premium Ties and Fasteners. If tilt trains capable of operating at nine inches of unbalanced superelevation and a MAS of 110 mph are utilized in the corridor premium ties and fasteners would need to be installed on curves in which the trains would operate at greater than five inches of unbalanced superelevation. Preliminary analysis indicates that tilt trains would operate at greater than five inches of unbalanced superelevation on approximately 50 track miles of curves. Allowing ten percent for the approaches to curves or for short stretches connecting adjacent curves, 55 miles of premium ties and fasteners would be required to safely and efficiently operate tilt trains in the Richmond Corridor.

Signal System Upgrade - Washington to Richmond

Needs Assessment. The CSX and Conrail signal systems on the Corridor were installed in the late 1920s and are beyond their useful life. They should be replaced with state of the art equipment to accommodate higher speeds, increased train operations, and closer spacing of trains. The system should be made compatible with improvements in operating speeds, potentially up to 110 miles per hour. The system must be capable of allowing trains to be operated at MAS in either direction on either track under contingency conditions.

Project Description. The signal system would be upgraded to safely and efficiently handle increased train traffic on the corridor and permit improved intercity passenger service, while accommodating the projected levels of commuter and freight service on the same tracks. New block layouts and signal aspects would accommodate speeds up to 90 miles per hour. The signal system would use microprocessor-based track circuits and control/indication equipment. Block spacing would anticipate increased train speeds. Reverse signaling would be installed on all main tracks. Interlockings would be remotely controlled from Jacksonville, except for Washington Union Station.

In addition to supporting higher speed train operations, the new signal system would improve the reliability of train operations and reduce maintenance expenses.

Upgrade Doswell Crossing Diamonds

Needs Assessment. MAS over the Crossing Diamonds at Doswell is presently restricted to 50 mph. Recent improvements in crossing diamond construction techniques, in conjunction with modified maintenance practices, should enable MAS to be increased to a minimum of 80 mph for passenger trains. Freight speeds also should be increased, which will benefit all users.

Project Description. The condition of the existing at-grade rail crossing at Doswell, including alignment and subgrade, and new special trackwork, employing the latest technology, would be installed to permit higher train speeds.

Lengthen Northbound Alexandria Station Platform

Needs Assessment. The northbound platform at Alexandria frequently hinders the efficient movement of Amtrak long distance overnight trains, which typically are longer than this platform. When they stop, many of the cars do not have access to the platform. It is not safe to let passengers off except on a platform. At present, the best solution is to make two or more stops to give all cars an opportunity to be positioned at the platform. This can be very time consuming, particularly given the need to move very slowly and carefully, because of all of the passengers who will be standing and the unsecured luggage staged at the doors. The excessive amount of time taken for this process encroaches on the time allotted to other trains, and the resulting delays quickly cascade to them.

Project Description. The northbound station platform at Alexandria would be lengthened. This priority project would expedite the movement of Amtrak long distance overnight trains. The existing platform would be upgraded and extended towards Duke Street. The portion of the platform that was not replaced by VRE in the early 1990s would be removed and replaced with a low level concrete platform. At Duke Street, Track 3, on the east side of the platform, would be realigned to enable the south end of the platform to be widened.

High-Performance Intercity Trainsets

Needs Assessment. High-Speed Rail planning by Virginia Department of Rail and Public Transportation (VDRPT) and North Carolina DOT assumes an increased number of trains operating between New York City and points south of Washington. Their objective is to offer the public a reliable, high-quality, cost-effective, competitive high-speed intercity passenger rail service. Neither state has selected the trainsets (locomotive plus coaches) that will be used to provide this improved intercity rail service. Diesels and Amtrak Amfleet coaches are presently operated south of Washington.

A variety of trainset alternatives are being evaluated nationwide and will provide state planners with numerous options. Among the alternatives, the FRA's Next Generation High-Speed Rail Technology Program has initiated a program to develop and demonstrate a high-speed turbine-electric locomotive that would approach the speed and acceleration capability of electric trains without the cost of railroad electrification. Upon successful completion of a demonstration program, the non-electric locomotive would be a viable option to high-speed intercity passenger operators. Tilt-train equipment to enable trains to operate at increased speed safely and comfortably though curves is being operated in the Pacific Northwest and will be introduced in the Northeast Corridor in late 1999.

The trainset selected by the state planners will have to be compatible with NEC operating requirements and facilitate timely engine changes (between diesel and electric) in Washington.

Project Description. The train consists that would be operated in the Richmond Corridor to provide improved high-speed rail service have not been identified. Once a determination has been made, the cost of acquiring the trainsets would be evaluated

CAPACITY-RELATED PROJECTS

Reconfigure Tracks/Upgrade Speed - Riverdale (Alexandria Jct.) to Anacostia to CP-Virginia

Needs Assessment. The segment between Shepherd Jct. and CP-Virginia is a major choke point in the north-south movement of freight in the Eastern Seaboard corridor and a major bottleneck in passenger train operations south of Washington. CP-Virginia is the junction, located one mile from Washington Union Station, where freight and passenger operations merge: freight trains headed to and from the Landover Line, and passenger trains to and from Union Station. The Landover Line is single tracked from CP-Virginia to M Street Interlocking, including the 3,600-foot-long Virginia Avenue Tunnel. The tunnel was single tracked in 1936 to provide clearance to enable the line to be electrified. The single-track has been retained to provide clearance for increased-dimension freight cars. The limit of vertical clearance is 17' 3". Deteriorated track and structural conditions currently restrict speed through the tunnel to 10 mph. The tunnel is in need of extensive structural rehabilitation to restore it to a state of good repair.

The Landover Line is double-tracked from M Street, located at the north portal of the Virginia Avenue Tunnel, to Landover where it connects to the NEC. The double-track is only available to CSX trains for a distance of about one-mile, between M Street (CR MP 135.5) and Anacostia (CR MP 134.2, CSX MP 6.3). At Anacostia, located 2.5 miles north of CP-Virginia, CSX freight trains diverge from the Landover Line to the CSX Alexandria Extension. The Alexandria Extension is a single-track line to Riverdale (MP 0), except for a double-track segment between Shepherd Jct. (CSX MP 5.8) and Chesapeake Jct (MP 3.8). At Riverdale, a connection is made to the main line of the CSX Capital Subdivision by means of a wye, allowing trains to travel east to Baltimore and west to Brunswick.

With the Conrail Acquisition, NS would inherit Conrail's rights on the NEC and CSX lines, and CSX would have limited trackage rights on the NEC.

The single-track segments and the slow speed through the tunnel result in numerous freight train delays throughout the day. Trains at one end of the single track await trains from the other end traversing the segment at 10 mph. The freight trains that stop on the double-track line between CP-Virginia and Long Bridge (described below) seriously affect on-time performance of commuter and intercity trains.

Project Description. This project would upgrade train speeds to 30 mph from 10 mph through the Virginia Avenue Tunnel and implement improvements to increase the length of double-track for freight operations north of the Virginia Avenue Tunnel. The track reconfiguration would create double-track routes to the CSX Alexandria Subdivision and the Conrail Landover Line. The double-track CSX route would replace the existing Alexandria Extension (a combination double- and single-track route) between Benning road and Anacostia Jct. The CSX Alexandria Subdivision from Anacostia to Chesapeake Jct. would be double tracked as a result of the new junction created south of Benning Road. The track construction would create a double track from M Street Interlocking (CR MP 135.5) to Chesapeake Jct. (CSX BAR 3.8), a distance of more than 3.5 miles, enabling northbound and southbound CSX freight trains to meet at least 2 miles closer to the Virginia Avenue Tunnel than at present. Shepherd Jct (CSX BAR 5.8) would be reconfigured to provide a connection to the Shepherd Industrial Track.

The track structure through the Virginia Avenue Tunnel would be upgraded to eliminate the existing 10 mph slow order and thereby significantly improve the capacity of this single-track tunnel.

If deemed feasible, the tunnel would be modified to enable the alignment between M Street Interlocking and CP-Virginia to be double-tracked. As a minimum this would result in a double-track line extending from CP-Virginia to Chesapeake Jct.

Modifications at CP-Virginia Interlocking are described separately.

Increasing freight train speeds from 10 to 30 mph through the Virginia Avenue Tunnel would significantly reduce transit times through the segment. Lengthening the double track segment on the north side of the tunnel would assist in reducing delays. An improvement in freight train performance through this segment would have a positive effect on passenger train performance south of Washington.

Reconfigure Tracks - CP-Virginia to Long Bridge

Needs Assessment. The CP-Virginia junction has trackwork that permits train movements at medium speed (30 mph), with medium speed crossovers and turnouts and a sharp compound curve into the First Street Tunnel. As mentioned above, freight trains being held at the single-track Virginia Avenue Tunnel for opposing freight trains are common.

VRE's L'Enfant Station is located just south of the interlocking. Presently a single platform is located west (north) of Track 2; however, it is proposed, in a separate project, to install a low-level center-island platform (the existing platform would be removed after completion if the new platform) so that commuter trains can use two tracks, rather than being restricted to Track 2, as at present. Stairs, and ramps or elevators would be constructed to provide passenger flow to the street.

Intercity and commuter operations, as well as freight operations, are projected to increase on the double-track between CP-Virginia and RO Interlocking (south of the Long Bridge over the Potomac River). Therefore, it is imperative to minimize the number of times that freight trains are held and to optimize the speed of freight movements. Curvature in this section is a significant constraint to both commuter and intercity trains. The curves at 7th Street (CR MP 137.1) and 14th Street (CR MP 137.7) are presently restricted to 30 mph, and substantial increases in speed are not readily achievable.

The potential for operating MARC commuter trains through Washington Union Station to L'Enfant and Northern Virginia is being evaluated as part of a separate study. Train densities on the already busy double track in this area would increase with the addition of new run-through operations.

Project Description. This project would modify the alignment between the north (east) end of Long Bridge over the Potomac River and Cp-Virginia to optimize train operations, particularly during peak periods. Two levels of improvement have been identified - short- and long-term. The level of improvement implemented is dependent upon traffic growth and operating performance through this segment. The long-term improvements, described below, are intended to improve the separation of passenger and freight operations within the constraints of the present right-of-way.

North of 6th Street, CP-Virginia would be reconfigured to provide double-track approaches to the First Street Tunnel, and Washington Union Station, and the Landover Line leading to the Virginia Avenue Tunnel. A three-track configuration, replacing the existing two-track alignment, would be provided south of 6th Street. Reinstallation of previously removed Track 1 from 8th Street to the Virginia Avenue Tunnel provides the third track through L'Enfant and the second freight track. The All turnouts and crossovers would permit 30 mph diverging moves. The pair of Number 15 crossovers north of L'Enfant Station and south of 2nd Street would permit passenger trains to move between the tracks to/from the First Street Tunnel, as necessary. The reconfigured track alignment would allow passenger and freight trains to move simultaneously through L'Enfant Station - freights trains from the Landover Line to Track 1 while passenger trains could use Tracks 2 and 4.

The flexibility provided by the additional platform capacity would facilitate the increased level of passenger trains during peak periods by allowing use of either station track. The improved flexibility also would contribute to the timeliness of the proposed MARC/VRE run-through service to L'Enfant Station and Norther Virginia.

South of L'Enfant, between 8th and 12th Streets, a new interlocking connecting the new three-track alignment through L'Enfant with the existing two-track alignment would be constructed. Turnouts from existing Track 2 would provide access to/from Track 4.

Signal spacing in advance of the new/revised interlockings would be revised as part of the upgrading of the signal system (described in a separate project).

The recommended improvements would provide capacity to move freight trains more effectively through the segment. Improved freight train performance would serve to improve passenger train performance.

Reduced congestion, resulting from an increase in freight operating speeds through the CP-Virginia interlocking and double tracking of the Alexandria Extension, also would facilitate improved passenger train performance.

Reconfigure Tracks/Interlockings - RO Interlocking (Crystal City) to AF Interlocking (Alexandria)

Needs Assessment. Congestion will increase as Amtrak and VRE attempt to add service between Washington Union Station and Alexandria while facing an uncertain, but increasing, level of NS and CSX freight service. Projected intercity, commuter, and freight traffic between Crystal City and Alexandria will require more than the present three-track configuration that was completed between South RO (SRO) and Alexandria in early 1997.

In conjunction with ongoing development of the Potomac Yard site, the main line tracks between SRO Interlocking (south of the VRE Crystal City Station and one-mile south of RO) and Braddock Road were relocated east of the yard to facilitate unrestricted vehicle access from the Route 1 Corridor to the development site. A four-track alignment was provided, and three-tracks were constructed. Increased levels of intercity, commuter, and freight trains between Alexandria and Washington will result in the need for increased track capacity and interlocking flexibility.

Project Description. A series of staged improvements would be implemented to reconfigure the tracks between these two interlockings. The improvements include:

- Construction of a third track between SRO and RO Interlockings, including modification of RO;
- Removal of SRO Interlocking;
- Removal of NAX Interlocking, located north of Alexandria Station;
- Reconfiguration of AF Interlocking and approaches; and
- Construction of fourth track between RO and AF.

A second platform at Crystal City (separately described) would be constructed in conjunction with the SRO-RO Third Track.

Two freight and two passenger tracks would be required to minimize operational conflicts, particularly during peak periods when hourly intercity and frequent commuter trains in both directions are operating. RO, located at the south end of the double-track Long Bridge, would be reconfigured to provide additional operating flexibility that would enable this four-track-to-two-track interlocking to function effectively.

RO interlocking would be reconfigured, incorporating some of the present flexibility provided by SRO, which would be removed. As part of this effort, the track structure and drainage between the two present interlockings would have to be upgraded (reballasted and regraded) to handle the increased traffic loads while minimizing maintenance costs. Parallel move capability would be provided in each direction, i.e., northbound, a train would be able to move from Track 1 to Track 2 at the same time that a train moves from the new northbound siding to Track 1. Similarly, southbound a train would be able to move from Track 1 to Track 2 at the same time that a train moves from Track 2 to Track 3.

The existing two- and three-track alignment between RO and AF interlockings (about 5.5 miles) ultimately would be modified to a four-track alignment. Two tracks between RO and SRO (an interlocking just south of Crystal City Station) would be constructed, and a fourth track between SRO and AF Interlocking would be built. AF interlocking, south of the Alexandria passenger station, would be reconfigured to conform to the new alignment and provide operational flexibility to enable the tracks to be efficiently utilized. The line south of AF would be upgraded to a three-track railroad, as described below.

The industrial delivery siding, on the Crystal City side of the railroad, between RO and Crystal City would be removed, a new track constructed, and then realigned into Track 3, the proposed southbound main track, providing a third track to RO. At Track 3's north end a number 20 turnout would connect it into Track 2 at RO. A fourth track would be installed from RO southward and would be adjacent to the Metro tracks in the space that was allowed for it between SRO and AF. A bridge for the track over Four Mile Run was provided during the recent reconstruction through Potomac Yard. SRO would be removed after this work is completed and RO is reconfigured. NAX would be removed upon completion of the platform work, previously described, at Alexandria Station.

AF Interlocking, a junction of major CSX and NS lines, would be reconfigured to improve parallel move capability and increase allowable speed through the crossovers. A passing siding would be provided to the north (west) of the existing Horn Track (the primary route for VRE trains to and from the NS Manassas Line). The siding would enable inbound and outbound VRE Manassas Line trains to pass between AF and the NS main line. The revised AF, with the fourth track extended through the interlocking (Figure C-5), would enable CSX and NS freight trains to simultaneously enter the four-track configuration between AF and RO. Northbound trains from the NS could access Track 1, and then the northbound freight siding, while northbound CSX trains could move from Track 2 south of AF to Track 1 north of AF. These moves would not conflict with each other or the commuter rail operations. Similarly, southbound moves to the NS Horn Track[3] could be made simultaneously with southbound moves to Tracks M or 3 south of AF from either Tracks 2 or 1 north of AF.

In connection with the southward extension of Track 1, the existing platform between Tracks 1 and 2 at Alexandria would be upgraded and lengthened to enable long intercity passenger trains to make a single-stop on any of the three tracks in the station.

The parallel move flexibility at AF Interlocking, when combined with the additional station platform capacity added at L'Enfant, Crystal City, and Alexandria, would enable moving trains to bypass stopped trains rather than waiting for them or traveling slowly behind them as they stop for passengers. Track capacity north and south of RO would therefore increase. The six new No. 20 crossovers and four turnouts at AF would provide a level of operational flexibility and capacity far exceeding that presently available between Alexandria and Washington. Additionally, the revised No. 20 crossovers and turnouts would permit track speeds of 45 mph through the interlocking.

The capacity and operating flexibility improvements between AF and CP-Virginia would permit reliable operation of the projected 2015 levels of commuter, intercity, and freight traffic in the densest segment for train movements in the Richmond Corridor.

Reconfigure Tracks - Alexandria (AF Interlocking) to Occoquan.

Needs Assessment. Congestion also will increase between Alexandria and Fredericksburg as traffic grows. Existing capacity constraints, particularly in the peak periods, will be exacerbated by the increased level of intercity and commuter trains. Significant alterations to the track configuration will be needed to prevent additional operational conflicts.

Existing corridor congestion, particularly north of Franconia, will be aggravated by the speed differential between intercity, commuter, and freight trains and the increased number of potential train overtakes. The existing right-of-way is not sized to expeditiously handle these overtakes. The RF&P once had a third track (located in the middle of the right-of-way) between AF (MP104.3) and South Franconia (MP 98) until it was removed about 25 years ago. With the exception of a removed interior siding in the vicinity of the VRE Lorton Station the right-of-way was not configured to readily accommodate the construction of additional tracks.

The third track allowed freights to climb the steep southbound grade without interfering with other trains. The average gradient between MP 103.8 (at existing SY Interlocking) and MP 98.9 (south of Franconia) is approximately 0.8 percent ascending southbound. This location is known as Franconia Hill. The average gradient from MP 98.9 to approximately MP 93 is 0.6

[3]The Horn Track is scheduled to be extended from SY to AF by VRE.

percent descending. The 0.8 percent grade in particular is a major obstacle to freight train operations. Freight train speeds up the grade can average 15 to 17 mph, which can result in a transit time in excess of 20 minutes (including the time it takes the rear of a long freight to clear the crest). This reduces capacity to less than six freights an hour on the existing tracks. During the peak commuter periods it is anticipated that intercity trains will run hourly, and commuter trains will run every 20 minutes, making this grade a severe operational constraint. Reinstallation of the third track would free up valuable capacity for faster passenger trains and northbound freights on the other two tracks.

Project Description. The previously removed third track between AF and South Franconia Station would be reinstalled. At South Franconia, Track 2 would be extended to the east behind the existing platform, and the new third track would be cut and thrown to connect with the existing Track 2 through the station. The reconfiguration would create a three-track alignment through the station, and, in conjunction with an extension and upgrading of the short platform installed by VRE west of Track 3, would provide platform access for each track.

South of South Franconia Station, Track 2 would be realigned to connect with its present alignment, the new third track realigned to connect with Track 3, and Track 3 realigned and connected with a new Track 3 constructed approximately between MP 97 (where the previous three-track alignment ended) and MP 89.8, north of the Occoquan River. The third track would pass adjacent to the Auto Train facility. A project to upgrade access to the Auto Train facility is separately below.

No third track would be constructed over the Occoquan River, through Woodbridge and Rippon stations, over Neabsco Creek, or over Powells Creek. Construction over the waterways is deemed too expensive and potentially problematic environmentally. The stretches of third track between the waterways, and the interlockings the new track would require, would not be cost effective.

Ravensworth (RW) Interlocking would be reconfigured to provide a universal three-track interlocking. A new interlocking would be constructed at Colchester (MP 89.8), to provide operating flexibility at the two- to three-track junction north of Occoquan Creek.

The third track on Franconia Hill should facilitate the co-existence of slow moving freights and faster passenger trains. The three tracks, in addition to the new VRE platforms (separately described), would enable commuter trains, intercity trains, and faster freights to operate in both directions, while slower freights use the middle track.

Reconfigure Tracks - Powells (MP 83) - Aquia (MP 71)

Needs Assessment. The projected increase in intercity and proposed commuter rail service, at increased operating speeds, will require additional track capacity north of Fredericksburg for overtaking freight trains and other passenger trains. The two locations are operationally and environmentally viable endpoints for construction of a third track that will provide additional capacity and thereby avoid holding trains.

Project Description. A third track would be constructed west of the existing double-track railroad from approximately MP 83 to approximately MP 73, south of Lees private crossing. The new track would be east of the existing double-track railroad, between MP 73 and Aquia Creek (MP 70.8). Track 3 would be realigned and connected to the new track at Powells, and at Aquia. Interlockings would be installed at each end of the new track.

The long passing siding and the new VRE platform at Cherry Hill (separately described), would enable commuter trains to operate in both directions while intercity and freight train operations are maintained. The three-track configuration would facilitate commuter train operations as well as occasional extra (unscheduled) freight trains. Recent train simulations have shown that a siding located between these two locations would be necessary to avoid holding trains elsewhere.

This segment of additional main track would require construction of a new VRE platform at Quantico (described in separate project) to enable northbound and southbound commuter trains to have access to platforms from both outside main tracks. This improved access would substantially increase operating flexibility, prevent delays to commuter trains, and facilitate freight and intercity train operations.

Construct Double-Track Bridge - Quantico Creek.

Needs Assessment. The existing single-track bridge over Quantico Creek constrains train operations today and will be inadequate to support the 2015 levels of traffic. Based on recent evaluations of this bridge, a program has been developed jointly by the Northern Virginia Transportation Commission (NVTC), and the VDRPT to design (not construct) a new bridge adjacent to the existing structure. Various alternatives are being evaluated, including construction of a substructure that would be adequate to support two additional tracks. Options within that alternative include: constructing a single-track superstructure and trackbed or constructing a double-track superstructure but installing only a single-track. Recent train simulations have concluded that the 2015 plan should assume that the second-track and superstructure are constructed, resulting in three tracks over Quantico Creek, and available to relieve anticipated long-term operational constraints.

Project Description. This project involves constructing two additional tracks on the proposed new superstructure planned for Quantico Creek. The three-track alignment would eliminate the need for interlockings adjacent to the bridge to provide junctions between three-track and two-track segments.

The three-track bridge at Quantico Creek would minimize delays to commuter and intercity trains while freight train operations are maintained.

Reconfigure Tracks - South Aquia (MP 70) - Dahlgren Jct. (MP 61)

Needs Assessment. The projected increase in intercity and proposed commuter rail service, at increased operating speeds, will require additional track capacity north of Fredericksburg for overtaking freight trains and other passenger trains. The two locations are operationally and environmentally viable endpoints for construction of a third track that will provide additional capacity and thereby avoid holding trains. The third track, in addition to the new second VRE platforms at Brooke and Leeland Road (separately described), would enable commuter trains to operate in both directions while intercity and freight train operations are maintained.

Project Description. A third track would be constructed west of the existing double-track railroad. Track 3 would be realigned and connected to the new track south of Aquia Creek (MP 70.8) and north of the curve at MP 70. Interlockings would be installed at each end of the new track. The existing DJ (Dahlgren Jct.) Interlocking at MP 61.1 would be removed, but access to the Dahlgren Industrial Track would be maintained. The Dahlgren Industrial Track would be shortened to locate the new DJ as close to the north end of the curve as practicable. The new track could be constructed east of the railroad between DJ and Leeland.

Reconfigure Tracks - FB to Crossroads

Needs Assessment. The projected increase in intercity rail service, and increased operating speeds, will require additional track capacity south of Fredericksburg for the overtaking of freight trains and other passenger trains. The proposed four-track configuration, consisting of two main tracks and two long passing sidings, also would facilitate commuter train operations as well as occasional extra (unscheduled) freight trains. Train operations will increase into and out of the VRE's Crossroads Yards. When combined with the increased levels of intercity and the projected level of freight train service, this increased level of commuter rail operation are expected to affect train operations.

Project Description. The tracks south of the Rappahannock River would be upgraded to a four-track configuration between FB (MP 58.8) and HA (MP 55.7) Interlockings. The existing FB and HA Interlockings would be reconfigured and upgraded to improve access to the tracks. Unnecessary turnouts and crossovers would be removed. A pocket track for VRE trains would be provided west of Track 4, just south of FB Interlocking. The track would facilitate turning trains not scheduled to go to the yard, thereby freeing up track capacity. A No. 20 crossover would be installed in place of the existing No. 15 crossover at XR (Crossroads) Interlocking. The new crossover would improve the parallel move capability at this interlocking that provides access to the VRE Yard.

The additional operating flexibility would minimize delays south of Fredericksburg resulting from VRE trains entering and leaving Crossroads Yard. Intercity and freight trains would be able to use Tracks 2 and 3 to run around trains to and from the yard. VRE trains would be able to use Track 1 to and from the Crossroads yard and FB, which would minimize the need for commuter trains to use Track 2 for almost 6 miles, on their way to and from Fredericksburg.

Reconfigure Tracks - Rixey to North Milford

Needs Assessment. The projected increase in intercity rail service, at increased operating speeds, will require additional track capacity south of Fredericksburg for overtaking freight trains. The third track, which would serve as a long passing siding, also would facilitate local freight train operations as well as occasional extra (unscheduled) freight trains.

Project Description. This project involves constructing a third track west of the existing double-track railroad. Track 3 would be realigned and connected to the new track south of Collins Road grade crossing and north of Rose private grade crossing, at MP 39. Universal interlockings would be installed at the south end of the new track, and connections made to Tracks 2 and 3 at the north end. Existing interlockings, MD (Milford, MP 37.8) and SMD (S. Milford, MP 35.8) would be removed, but access to the Milford Team Track would be maintained.

The Ross and Rixey grade crossings would be modified to accommodate the additional track.

The recommended improvements would provide additional passing and overtake capacity and flexibility to operate trains between Richmond and Fredericksburg.

Reconfigure Tracks - South Anna to North Ashland

Needs Assessment. The projected increase in intercity rail service, at increased operating speeds, will require additional track capacity south of Fredericksburg for overtaking freight trains. The third track, which would serve as a long passing siding, also would facilitate local freight train operations as well as occasional extra (unscheduled) freight trains.

Project Description. A third track would be constructed west of the existing double-track railroad. Construction of a major bridge over the South Anna River would be avoided by realigning Track 3 and connecting it to the third track south of the existing bridge. Interlockings would be provided at each end of the new track. A two-track universal interlocking would be located immediately north of the South Anna River (MP 18.8). The third track would be extended beyond the Vaughn Street crossing north of Ashland, which would maximize the length of three-track territory.

The recommended improvements would provide additional passing and overtake capacity and flexibility to operate trains between Richmond and Fredericksburg.

Reconfigure Tracks - Staples Mill Rd. Station/Greendale (GN) - Main St. Station.

Needs Assessment. Congestion in the segment between Staples Mill Rd. Station and Main St. Station will increase when intercity passenger service is extended to downtown Richmond. Operations will be restricted by low track speeds and freight/passenger train conflicts. Presently, only two daily trains to Newport News pass the east side of Main St. Station, and these do not stop. No passenger trains pass the west side of the station.

The City of Richmond is developing a program to reactivate the station and develop it as an intermodal passenger terminal. The existing station and the track configuration between Main St. and the existing Amtrak station at Staples Mill Rd. are inadequate to handle the increased levels of Amtrak service and freight service. There are no train storage facilities in the vicinity of the station.

Rerouting intercity passenger service between Greendale and Main St. Station to the east side of Acca Yard would minimize conflicts with existing freight operations (both through and yard movements) in the Richmond area. Access for trains using the former Atlantic Coast Line route to the south was, and is, by way of the Richmond Terminal Subdivision, South AY Interlocking, and the Northend Subdivision ("A Line") to Florence, SC. In recent years, a "Passenger Main" was built along the west side of Acca Yard. Access for trains using the former Seaboard Air Line route to the south, via Main St. Station, was via the present Bellwood Subdivision ("S Line") to Columbia, SC.

Currently, the four Amtrak trains to Newport News must cross over through all freight traffic at AY, after using the "Passenger Main" around Acca Yard, to reach the Bellwood Subdivision. They then travel to AM Junction (MP CA 85.6), the Piedmont Subdivision to Rivanna Junction (MP CA 84.5), and finally, the Peninsula Subdivision to Newport News.

The introduction of through service to Charlotte, NC and the origination/termination of three trains at Main St. Station, will significantly increase conflicts between intercity and freight trains.

Conflict points between Staples Mill Rd. Station and Main St. Station include the following locations.

<u>**AY Interlocking, Southend of Acca Yard**</u>. The present intercity passenger route uses the "Passenger Main", west of the South Yard at Acca. At AY this track connects to the north leg of the Wye, to and from the A line tracks to the south. Located west of downtown Richmond, the Wye is heavily used by slow moving (5 to 10 mph) yard traffic. With increased intercity train traffic, AY would become a major conflict point. Significant delays to both passenger and freight trains routed to Main St. Station will occur when attempting to share AY interlocking.

<u>AM Jct</u>. Amtrak trains to Newport News pass through this interlocking, which recently was reconfigured. Significant conflicting movements, and resulting delays, are anticipated at the junction because of the projected increase in both passenger and freight trains.

Project Description. A series of staged improvements would be implemented to reconfigure the tracks between these two stations. The improvements are discussed in the following subsections.

<u>Reconfigure Tracks - GN (Greendale) to AY</u>. Current train operations would be improved by establishing a passenger route that bypasses the entire yard at Acca. A double-track route would be constructed east of the yard, thereby avoiding conflicts with freight trains at the wye, located at the south throat to Acca Yard. At Staples Mill Rd. Station a new passenger train facility would be provided on the east side of the railroad, including a platform between Tracks 1 and 2. An overhead structure would be constructed to provide passenger access from the existing station building and parking facility.

The east side bypass route would be isolated from the yard and the existing yard office at the south end of the yard. Adequate track centers would be provided between Track 2 and the yard leads, tracks, and facilities. Provision of a fence between the yard tracks and the bypass route would ensure worker safety and protection. An overhead bridge or tunnel would be provided, if necessary, to enable employee access to the yard.

Track 4 would be upgraded and extended from the south end of the curve between MP 6 and 7. GN Interlocking would be relocated to serve as a universal interlocking at approximately MP 7. The left-hand crossover at existing GN would be maintained to provide access from Track 3 to the new platform Track 1. HR Interlocking (MP 4.4) would be removed.

Rerouting intercity passenger service between Greendale (Staples Mill Rd. Station) to Main St. Station would establish a route that would minimize conflicts with existing freight operations in the Richmond area, while restoring passenger service to downtown Richmond.

The new track facilities at Staples Mill Rd. Station would provide operational flexibility through the station, and minimize conflicts between passenger train and freight operations.

<u>Reconfigure Tracks - AY to AM Jct</u>. The double-track passenger main would be extended e from AY to Hermitage, where a direct connection fo the Bellwood Subdivision would be provided. A tail track for yard operations would be provided parallel to the double-track passenger main. The track would end north of the curve located at Hermitage Road. South of Hermitage Road an upgraded double track main would be provided to AM Jct.

Conflicts between passenger and freight operations between Acca Yard and AM Jct. should be minimized, based on anticipated long-term freight service plans on this segment.

Reconfigure Tracks - AM Jct to Main St. Station. AM Jct. ultimately would be reconfigured from a single- to a double-track junction by constructing a second track through the junction and upgrading the existing interlocking to adequately support proposed freight and passenger operations. No. 15 crossovers would be installed because of the restricted speeds in the area. A route from both tracks to the west side of the station would be provided.

This major facility improvement between AM Jct. and Main St. Station would minimize the potential for conflict with freight movements, while providing access to both sides of the renovated Main St. Station. This work would restore the 10-minute running time achieved by Seaboard Air Line passenger trains between South Acca Yard and Main St. Station in the 1950s, making possible a reliable 15-minute running time between Main St. Station and Staples Mill Rd. Station. Other benefits include provision of capacity to facilitate empty hopper train movements to the Piedmont Subdivision, as well as fewer passenger and freight train conflicts and fewer delays in the vicinity of Main St. Station.

Track Upgrade - Main St. Station to Centralia

Needs Assessment. The line between Richmond Main Street Station and Centralia needs to be upgraded to both improve line capacity to accommodate increased levels of freight and intercity trains and allow higher train speeds necessary to accomplish North Carolina (NCDOT) intercity travel goals.

Project Description. Upgrade the Bellwood Subdivision to accommodate the proposed levels of intercity passenger and freight traffic. New rail and ties would be installed and diamond crossings would be replaced as necessary to upgrade tracks to a 79 mph MAS. Adequate length spirals and sufficient superelevation to support 79 mph MAS would be provided. Turnouts and crossovers would be renewed as necessary. Grade crossing protection circuits and signals would be upgraded to ensure safety and optimized train operations.

STATION AND MAINTENANCE FACILITIES

Reconfigure Quantico Station.

Needs Assessment. It is envisioned that many commuter trains in the a.m. and p.m. peak periods could turn at Quantico, rather than at Fredericksburg, and make a return trip to Washington. This would enable trains from Fredericksburg to operate as zone expresses[4], which would significantly reduce travel times for VRE riders originating south of Quantico.

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[4]Fredericksburg trains would make all stops to Quantico and then run express to Alexandria, then stop at all stations (Crystal City, L'Enfant, and Washington). Passengers for stations between Quantico and Alexandria would transfer at Quantico.

This improvement would shorten the round trip for Quantico Trains by 52 miles, and allow several more sets of equipment to make a second rush hour trip, thereby improving VRE's financial and operating productivity.

While Quantico has been used in this study as the end of the first zone a more detailed analysis of ridership requirements could relocate the turnback point, further north, possibly to Cherry Hill or Rippon. Initially, Rippon had been assumed to be the turnback station, and was included in the simulations described in Appendix C. However, based on a determination by VRE, Quantico has been included as the turn back station. The additional trip time for deadhead equipment moves to Quantico, rather than Rippon, could result in an additional trainset being required to support the desired service level, over the number assumed in the simulations.

Project Description. A turnback tail track would be constructed south of the proposed southbound platform. The new tail track would be located west of Track 3. A No. 15 turnout would provide access to the tail track from Track 3 that, together with appropriate signal improvements, would allow an expeditious approach speed to the tail track. Two No. 20 crossovers, which would replace most of existing Possum Point Interlocking presently located north of the Quantico Creek Bridge. The crossovers would be installed north of the station and Potomac Avenue crossing, and would enable northbound trains on Track 3 to cross over to Track 2. A new platform would be constructed west of Track 3, as part of the station improvement program, to enable commuter trains to use both tracks, rather than being restricted to Track 2.

VRE commuter operations during peak periods would be improved by reducing trip times for trains making an additional round trip during the peak period. Trains initiating their runs at Quantico would load passengers on the Track 3 and could proceed northward either on Track 3 or crossover to Track 2. The initiation of zone express service south of Quantico would reduce transit times for patrons boarding south of Quantico.

Install Additional Commuter Platforms

Needs Assessment. Improved passenger handling is another immediate priority. Currently, all commuter stops, except Alexandria, have a platform on only one side of the tracks. While platforms have been located on the side on the track that is most likely to be used under normal conditions, they are a restriction to operating flexibility under abnormal conditions. By providing second platforms, or center-island platforms, at locations where only one currently exists, either track can used by commuter trains, thus providing significant additional operating flexibility in this high-density area.

Project Description. Low-level commuter platforms would be added at the following stations:

- Franconia,
- Lorton,
- Woodbridge,
- Rippon,
- Quantico (described in another project),
- Brooke,
- Leeland Road, and
- Fredericksburg.

High-level platforms would be installed at L'Enfant and Crystal City.

Pedestrian access across the tracks would be provided via an underpass or an overpass; other amenities would include station canopies, lighting, and ticketing facilities.

VRE trains and certain scheduled intercity trains would have access to platforms from all outside main tracks, substantially increasing in operating flexibility, preventing delays to commuter trains, and facilitating freight and intercity train operations. VRE also would be able to increase train frequencies.

Richmond Service Facility

Needs Assessment. An efficient storage yard and maintenance facility in the vicinity of Main Street Station will be necessary to ensure that passengers are provided safe, reliable, and clean trains. Presently a location in Brown Street Yard is under evaluation.
Sufficient yard storage capacity to handle overnight layovers for trains scheduled to depart Richmond the next day, and to store equipment awaiting maintenance must be provided.

Project Description. This project involves constructing a storage yard and a maintenance facility to store trains both during the day and overnight, enable various equipment cleaning functions to be performed, and accomplish assigned maintenance functions. Further evaluation of train operations through the area and potential locations would be required to finalize the location. The location, when set, may alter the configuration between AM Jct and Main St. Station. Interlocked access to the yard from the main line would be available.[5]

Switches in the yard would be hand- or power-operated depending upon their location and intended function. Yard lighting, water and power hookups, a fueling facility, crew quarter

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[5]Control would be from the CSX control center in Jacksonville, Florida.

facilities, employee locker room, and supervisory office space would be included. Commissary facilities to service train sets would be furnished.

Upgrade Amtrak Auto Train Facility - Lorton, Va

Needs Assessment. The Auto Train[SM] facility is located at MP 92. The arrival/departure of a train from the facility ties up valuable main line track capacity. Access to the Lorton Auto Train[SM] facility is provided by a turnout from Track 3, at the south end of the facility. The turnout is located north of the Lorton Road single lane undergrade bridge, resulting in the lack of space to make up the train and shift cars in the yard. Consequently, the process of making up (or yarding) the train occupies Track 3 for about an hour. This process results in a single track operation on Track 2 between RW Interlocking (MP 96.7) and Featherstone Interlocking (MP 86.8), a distance of 10 miles, while Track 3 is occupied by the Auto Train[SM]. With the projected increased level of passenger and freight service the present train operations at this facility would limit operating capacity and result in conflicts and trains being held between Franconia/Springfield and Occoquan. Replacement of the Lorton Road bridge is presently underway. The third track would provide additional train handling capacity in the vicinity of the Auto Train[SM] facility.

Project Description. This project would provide an extended lead track for the Auto Train[SM] facility. This would be accomplished by installing a tail track north of the facility that would enable train handling functions to be accomplished without tying up mainline capacity. The track would be long enough to enable the train to be made up or taken apart without occupying the main line. The present hand-operated crossover at MP 92 would be upgraded to an interlocked crossover (two No. 15 crossovers and one turnout) to facilitate train access to and from any of the main tracks. The tracks in the facility would be reconfigured, if necessary, to accommodate the third track.

Improved facilities for train switching at the Auto Train[SM] Terminal would minimize interference with mainline trains during the Auto Train[SM]'s arrival and departure.

Main St. Station Improvements.

Needs Assessment. The City of Richmond is developing a program to reactivate the station and develop it as an intermodal passenger terminal that will enable intercity passenger operations to be re-instituted from the Staples Mill Rd. Station to Main St. Station, in downtown Richmond. The existing station and the track configuration between Main St. and the existing Amtrak station at Staples Mill Rd. are inadequate to handle the increased levels of Amtrak service and freight service. A train storage and service facility was previously described.

Project Description. Passenger handling facilities at this station would be upgraded in accordance with plans being developed by the City of Richmond. A platform for handling passengers on the west side of the station would be included, and an additional southbound platform provided on both the east and west sides to improve operating flexibility and minimize conflicts between passenger and freight trains. Main St. Station would be converted into an intermodal passenger terminal and retail and commercial complex. This project would provide direct access to the central business district, thereby improving the desirability of the rail passenger service.

Modernizing and upgrading this facility would allow it to accommodate 2015 passenger volumes for intercity and high speed service.

IMPROVEMENTS EVALUATED BY OTHERS

The following projects were evaluated by others and are incorporated in this report to ensure that projects impacting train operations or facility considerations are included.

MARC And VRE Run-through Train Operations

Needs Assessment. A study of the potential for improved commuter rail operations in the Washington-Baltimore metropolitan area was recently completed. The goal of this study, jointly funded by MARC and VRE, is to enable some commuters to achieve a more convenient rail trip between stations in Maryland and Virginia by eliminating one or more transfers en route. The study evaluated options for the run-through operation of VRE and MARC trains onto each other's lines and recommended a two-phase service initiation program. Problems evaluated included incompatibility of equipment and lack of track capacity.

Project Description. The first phase would include a limited number of MARC trains operating through to Alexandria, where a small yard would be constructed to store trains between the morning and evening peak periods. The second phase, based on 2015 schedules would include extensive operation of MARC and VRE trains to terminals on each others lines.

New Stations - Cherry Hill And Widewater

Needs Assessment. Continued development in the Northern Virginia area is expected to result in an increased demand for train service, which would best be served by additional station stops conveniently located adjacent to access routes and populated areas. VRE anticipates that additional stations south of Rippon will be required to serve the expanding suburban commuter market in the vicinity of Cherry Hill and Widewater.

Project Description. Two new stations are proposed to serve VRE riders. Station platforms would be constructed on both sides of the right-of-way. Adequate roadway access and sufficient parking would also be provided. Access across the tracks would be via an underpass or an overpass; other amenities would include station canopies, lighting, ticketing facilities, and other required facilities.

New station locations would provide convenient access to frequently scheduled train service.

IMPROVEMENTS NOT EVALUATED

Intercity And Commuter Parking

Needs Assessment. As commuter service levels are increased, and as intercity train schedule times are reduced, more business will be attracted, and there will be need for expanded parking facilities at various stations along the Washington - Richmond Corridor. A detailed evaluation of the parking requirements at individual stations was not undertaken as part of this study. It is recommended that subsequent studies define the scope and cost of the necessary parking improvements.

Project Description. Expanded parking to accommodate increased ridership levels would be required for the existing stations listed below. The number of spaces should be developed during follow-on planning and design projects. Provision of adequate parking at new commuter stations is described in separate projects.

Joint Amtrak/Commuter Facilities:

- Alexandria
- Fredericksburg
- Woodbridge
- Quantico

Commuter-Only Facilities:

- Franconia
- Lorton
- Rippon
- Cherry Hill
- Widewater
- Brooke
- Leeland Road

Amtrak-only facilities:

- Ashland
- Staples Mill Rd.
- Main St. Station.

Expanded parking facilities would provide the capacity needed to handle projected increases in intercity and commuter passenger market, as well as contributing to greater convenience for travelers.

Key Station ADA Access.

Needs Assessment. The Americans with Disabilities Act (ADA) prohibits discrimination against the disabled. USDOT has issued rules implementing the transportation provisions of ADA. Among other things, these rules require commuter rail transportation providers to identify key commuter-only stations and to make them fully accessible to the disabled. All existing Amtrak stations are to be compliant by 2010. All new stations must comply with the standards. A detailed evaluation of the ADA requirements at individual stations was not undertaken as part of this study. It is recommended that subsequent studies define the scope and cost of the necessary ADA improvements.

Project Description. Various improvements would be made at designated Amtrak stations and Key VRE stations to provide access to the disabled, in accordance with ADA provisions. All new stations meet ADA requirements. Signage would include Braille in conformance with ADA standards; access to both east- and westbound platforms would be provided by tunnel or elevator; new pavement and striping, sidewalks and handicapped parking stalls would be provided; accessible routes would be provided; station interiors would receive new doors; ticket counters would be modified; public address and telephone systems updated; and restrooms, where present, modified.

This project would result in Amtrak stations and Key VRE stations being made fully accessible, in accordance with ADA requirements.

Construct Amtrak Station Improvements

Needs Assessment. Intercity ridership at certain stations is expected to increase substantially with the attractive trip times and increased levels of service that will be offered once track, signaling, and other improvements are completed. In many cases, intercity stations are near capacity with existing ridership. The rehabilitation of stations has been severely curtailed due to a shortage of funds. The need for such rehabilitation has increased over time. A detailed evaluation of the rehabilitation requirements at individual Amtrak stations was not undertaken as part of this study. It is recommended that subsequent studies define the scope and cost of the necessary Amtrak Station rehabilitation improvements.

Project Description. Expansion and renovation of other Amtrak stations between Washington and Richmond is proposed to efficiently handle the increased passenger volumes anticipated as a result of the improvements made to the Washington - Richmond Corridor. Projects initially evaluated include: improved/additional ticketing facilities, expansion of station facilities and construction of additional seating, renovation of existing facilities, improved signage/graphics, and improvements to commissary facilities.

PROJECT ESTIMATES

The estimated cost for the Washington to Staples Mill Rd. Station projects are summarized in Table G-1. The estimated cost for the Staples Mill Rd. Station to Centralia projects are summarized in Table G-2. Table G-2 includes costs that were developed for an initial breakdown of the projects into Phase I and Phase II efforts. The final breakdown of projects has not yet been established. All estimates are in 1997 dollars.

Table G-1: Cost Summary
Washington - Richmond Improvements (1997$)

Location	Track	Sum Signals/ Interlocking	Block Signals	ROW/ Structural	TOTAL
Shephard Jct. to CP Virginia	$ 1,155,954	$ 1,006,106	$ -	$ -	$ 2,162,060
CP Virginia to Long Bridge	$ 4,091,485	$ 2,149,894	$ -	$ 19,970,014	$ 26,211,393
L'Enfant Metro Access	$ -	$ -	$ -	$ 17,358,865	$ 17,358,865
RO to SRO 3rd Track	$ 2,247,617	$ 1,214,100	$ 577,458	$ 889,235	$ 4,928,410
Remove SRO	$ 135,759	$ 31,261	$ -	$ -	$ 167,020
Remove NAX	$ 181,012	$ 162,235	$ -	$ -	$ 343,247
RO to AF 4th Track	$ 5,766,306	$ 1,361,781	$ 1,475,727	$ 2,272,488	$ 10,876,302
AF	$ 3,448,125	$ 2,749,370	$ -	$ -	$ 6,197,496
Horn Track	$ 1,929,158	$ -	$ -	$ -	$ 1,929,158
AF-RW	$ 6,486,366	$ 1,361,781	$ 1,340,595	$ 357,489	$ 9,546,231
Lorton Amtrak AutoTrain Terminal	$ 1,613,461	$ 998,960	$ -	$ 1,143,284	$ 3,755,706
Featherstone	$ 709,935	$ 668,680	$ -	$ -	$ 1,378,615
Quantico	$ 352,667	$ 238,930	$ -	$ 4,027,968	$ 4,619,565
RW-Colchester	$ 9,226,703	$ 1,514,293	$ 1,685,178	$ 19,197,332	$ 31,623,506
Aquia/Brooke I/L	$ 709,935	$ 685,780	$ -	$ -	$ 1,395,715
Powells to Aquia	$14,088,870	$ 2,695,516	$ 2,527,767	$ 19,986,895	$ 39,299,048
South Aquia to DJ	$10,143,115	$ 1,490,554	$ 2,018,499	$ 23,658,449	$ 37,310,616
FB to HA Trk 4 - Sbd	$ 4,035,647	$ 1,790,045	$ 2,006,338	$ 2,043,782	$ 9,875,812
FB to HA Trk 1 - Nbd	$ 4,869,223	$ 1,123,218	$ -	$ 1,617,221	$ 7,609,663
XR	$ 491,187	$ 298,055	$ -	$ -	$ 789,242
Rose I	$ 709,935	$ 685,780	$ -	$ -	$ 1,395,715
Rose ii- Rose to Rixey	$ 6,057,459	$ 1,520,148	$ 3,781,199	$ 3,485,189	$ 14,843,995
Doswell	$ 728,957	$ -	$ -	$ -	$ 728,957
S. Anna I	$ 709,935	$ 685,780	$ -	$ -	$ 1,395,715
S. Anna to Ashland	$ 4,690,052	$ 1,540,288	$ 2,627,347	$ 10,350,291	$ 19,207,978

Table G-2: Cost Summary
Staples Mill Rd. Station to Centralia

Location	Track	Sum Signals/ Interlocking	Block Signals	ROW/ Structural	TOTAL
GN	$ 379,757	$ 160,600	$ -	$ 4,417,920	$ 4,958,277
GN II	$ 2,793,966	$ 1,467,466	$ 218,873	$ 1,202,739	$ 5,683,045
GN Summary	$ 3,173,723	$ 1,628,066	$ 218,873	$ 5,620,659	$10,641,322
HR	$ 834,251	$ 34,772	$ -	$ 480,137	$ 1,349,160
HR II	$ -	$ -	$ -	$ -	$ -
HR Summary	$ 834,251	$ 34,772	$ -	$ 480,137	$ 1,349,160
NA	$ 1,108,530	$ 7,786	$ 89,949	$ 614,453	$ 1,820,718
NA II	$ 669,131	$ 1,485,719	$ 89,949	$ -	$ 2,244,799
NA Summary	$ 1,777,661	$ 1,493,505	$ 179,898	$ 614,453	$ 4,065,517
AY	$ 2,196,258	$ 72,569	$ 179,898	$ 1,566,855	$ 4,015,581
AY II	$ 2,159,258	$ 95,720	$ 179,898	$ -	$ 2,434,877
AY Summary	$ 4,355,517	$ 168,289	$ 359,797	$ 1,566,855	$ 6,450,458
SAY	$ 577,827	$ 7,786	$ 89,949	$ 337,949	$ 1,013,511
SAY II	$ 1,600,484	$ 766,012	$ 89,949	$ -	$ 2,456,445
SAY Summary	$ 2,178,311	$ 773,798	$ 179,898	$ 337,949	$ 3,469,957
Hermitage	$ 2,142,296	$ 751,491	$ 179,898	$ 491,562	$ 3,565,248
Hermitage II	$ 1,480,924	$ 564,537	$ 274,885	$ 184,336	$ 2,504,682
Hermitage Summary	$ 3,623,220	$ 1,316,029	$ 454,784	$ 675,898	$ 6,069,931
Brown	$ 1,248,799	$ 943,693	$ 179,898	$ 219,491	$ 2,591,882
Brown II	$ 1,254,873	$ 894,396	$ 179,898	$ -	$ 2,329,168
Brown Summary	$ 2,503,672	$ 1,838,089	$ 359,797	$ 219,491	$ 4,921,049
Hermitage - Brown Track	$ 2,586,882	$ -	$ -	$ -	$ 2,586,882
Hermitage - Brown Track II	$ -	$ -	$ -	$ -	$ -
Hermitage-Brown	$ 2,586,882	$ -	$ -	$ -	$ 2,586,882

Table G-2: Cost Summary
Staples Mill Rd. Station to Centralia

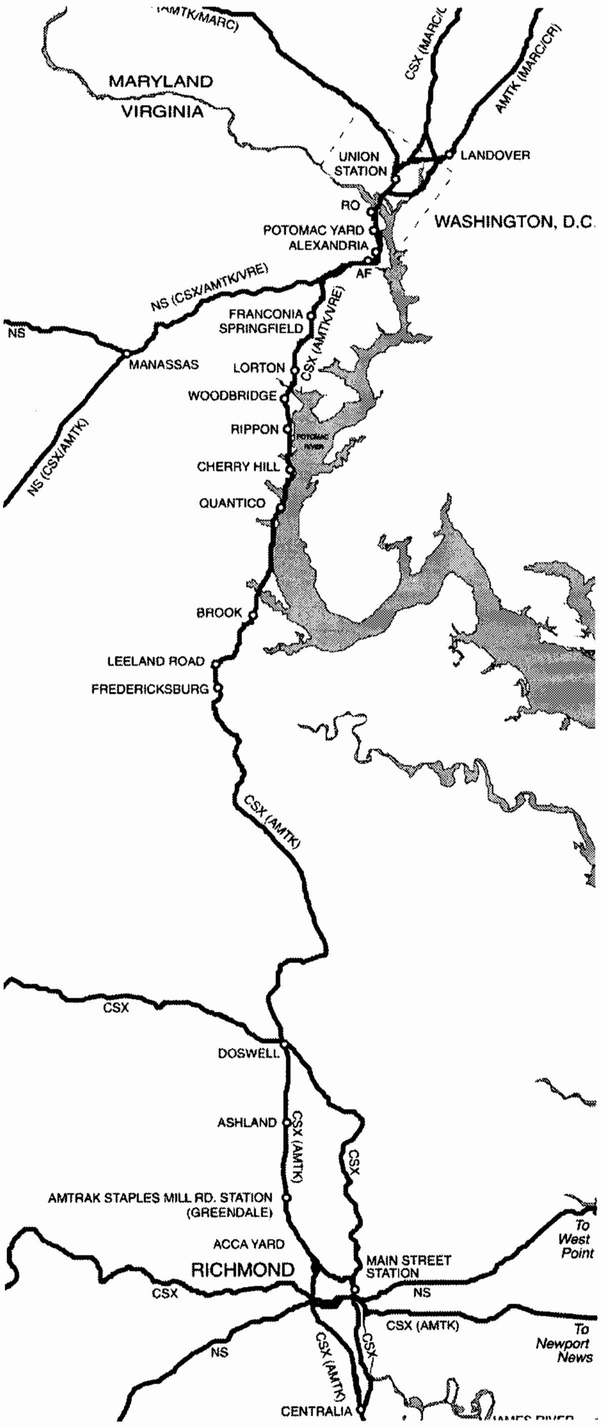
Location	Track	Sum Signals/ Interlocking	Block Signals	ROW/ Structural	TOTAL
Summary					
Brown St Yard	$ -	$ -	$ -	$ -	$ -
Brown St Yard II	$ -	$ -	$ -	$ -	$ -
Brown St Yard Summary	$ -	$ -	$ -	$ -	$ -
C&O Siding	$ -	$ -	$ -	$ -	$ -
C&O Siding II	$ 2,884,073	$ 338,031	$ -	$ 1,689,627	$ 4,911,732
C&O Siding Summary	$ 2,884,073	$ 338,031	$ -	$ 1,689,627	$ 4,911,732
Bone Dry I	$ 75,381	$ 219,857	$ -	$ -	$ 295,238
Bone Dry II	$ 102,471	$ 59,269	$ -	$ -	$ 161,740
Bone Dry Summary	$ 177,852	$ 279,126	$ -	$ -	$ 456,978
Main Street	$ -	$ 9	$ 184,936	$ -	$ 184,946
Main Street II	$ 883,172	$ 256,915	$ 184,936	$ 1,064,345	$ 2,389,368
Main Street Summary	$ 883,172	$ 256,924	$ 369,873	$ 1,064,345	$ 2,574,313
SUMMARY - Staples to Main Street I	$ 11,149,981	$ 2,198,564	$ 904,530	$ 8,128,369	$22,381,443
SUMMARY - Staples to Main Street II	$ 13,828,353	$ 5,928,066	$1,218,390	$ 4,141,046	$25,115,855
SUMMARY - Staples to Main Street	$ 24,978,333	$ 8,126,630	$2,122,920	$12,269,415	$47,497,298
Rocketts	$ 743,070	$ 1,360,732	$ -	$ 306,800	$ 2,410,602
DWT	$ 316,771	$ 842,169	$ 184,936	$ -	$ 1,343,876
Dale	$ 633,235	$ 852,138	$ 184,936	$ -	$ 1,670,309
Falling Creek	$ 633,235	$ 706,105	$ 184,936	$ -	$ 1,524,276
Centralia Future	$ 1,406,985	$ 1,551,009	$ 184,936	$ 605,888	$ 3,748,817
SUMMARY - Main St to Centralia	$ 3,733,296	$ 5,312,152	$ 739,745	$ 912,688	$10,697,881

Table G-2: Cost Summary
Staples Mill Rd. Station to Centralia

Location	Track	Sum Signals/ Interlocking	Block Signals	ROW/ Structural	TOTAL
SUMMARY - Staples to Centralia					
Phase I	$ 11,149,981	$ 2,198,564	$ 904,530	$ 8,128,369	$22,381,443
Phase II	$ 17,561,649	$11,240,218	$1,958,135	$ 5,053,734	$35,813,736
Total	$ 28,711,629	$13,438,782	$2,862,665	$13,182,103	$58,195,179
Main St to Centralia Track	$ 9,423,232	$ -	$ -	$ -	$ 9,423,232

Report to Congress **APPENDIX H**

Potential Improvements to the Washington—Richmond Railroad Corridor



GRADE CROSSINGS

May 1999

APPENDIX H
GRADE CROSSINGS

Increasing speeds and the frequency of trains raises concern for safety at the numerous at-grade highway crossings on the Richmond Line. There are a total of 65 crossings on the Richmond Line between Washington, D.C. and Main St. Station, 52 of these are for public use, and 13 allow access to private property. The crossings are listed in Table H-1. All of the public crossing are protected, at a minimum, by crossbucks, flashing lights, gates, and ringing bells, with one exception. Brown St., in Richmond, is not equipped with gates.

Featherstone Rd./Rt. 636, located at MP 86.85, is the northern-most public crossing. This means that in the first 25 miles from Washington, D.C. there are no public grade crossings. North of Featherstone Rd., there is only one private grade crossing, an unnamed road at MP 87.7. Within the territory of VRE Fredericksburg Line operation, there are seven public, and two private grade crossings, including the two already mentioned. This is a relatively limited number for such an intensive train operation. VRE trains do operate over two additional crossings between Fredericksburg and the yard at Olive, but do not carry passengers.

The situation south of Fredericksburg is significantly different. There are 12 public, and 10 private crossings in the span of 36 miles from Fredericksburg to Doswell, an average of one every 1.8 miles. Many of these are very lightly traveled, but are difficult to justify closing, because, in most cases, there is no alternative access to the homes and families they serve. Many crossings where alternate routes are available, have already been closed.

The frequency of crossings south of Doswell is even greater, with 27 public, and 2 private grade crossings between there and the Staples Mill Rd. Station, a distance of 14 miles. This is an average of one every 0.4 miles. Nineteen of these are concentrated in the city of Ashland, including 12 for pedestrians. The seven road crossings in Ashland are protected by crossbucks, gates, lights and bells. The pedestrian crossings have no protection, but the track is on tangent (straight), with excellent visibility. There are no private crossings in Ashland.

There are six crossings on the proposed reinstitution of service to Main St. Station, all of which are located on the Bellwood Subdivision, and are south of Acca Yard. Three of these, Hermitage Rd., Brook Rd. and Hospital St., are heavily used. The other three, St. James St., Valley Rd., and Brown St., are not. Brown St. no longer serves any purpose except access to the railroad for maintenance.

Protection and Elimination

The VDRPT has an on-going program to identify crossings that can either be:

- Eliminated, through closing them:
- Separated, through construction of a bridge on underpass; or
- Improved, through the installation of more extensive and move highly visible protection devices.

Currently, there is partial funding for the construction of a pedestrian bridge near the private crossing at MP 87.7, where an athletic field is located. There is also funding for ROW acquisition and Preliminary engineering for a separation at Colonial Rd./Rt. 722, at MP 37.80 in Caroline County.

Safety is a primary concern when raising speeds on the part of the Richmond Line between Washington, D.C. and the Staples Mill Rd. Station. Higher speeds will require, at minimum, that the actuating circuits be lengthened to initiate warnings sufficiently in advance of the arrival of the train. Faster trains take less time to traverse the length of the circuit, and reach the crossing sooner than slower trains. At crossings with fixed circuits, warning time must be set for the fastest possible train. This creates a potential problem, in that when a slow train approaches the crossing, the gates are held down for an inordinate amount of time, Some motorists loose patience with the situation, and drive around the gate at the risk of a collision.

Constant Warning Time circuits can offset this problem by automatically adjusting the length of the warning to a time appropriate to the speed of each individual oncoming train. The system has the ability to determine the speed of an approaching train, and initiate the crossing warning cycle so that a predetermined period of warning will have transpired when the train reaches the crossing. Constant Warning Time devices are currently installed at numerous crossings on the Richmond Line.

A new innovation, which could be applied at selected crossings, is a system of four-quadrant gates, wherein four gates, instead of two, are lowered across the traffic lanes, blocking both directions on both sides, and barriers are placed down the center of the roadway. This system prevents a motor vehicle from driving around the gates after they are lowered. The possibility of closing additional crossings must also constantly be re-examined.

Effect on Speed on the Staples Mill Rd. Station - Main St. Station Segment

Speed is a significant concern when considering the crossings on the segment between Staples Mill Rd. Station and Main St. Station over which passenger service will be significantly increased. Operations on this segment will not reach the speeds that are planned north of Staples Mill Rd. Station, but the fact that the most heavily used crossings, Hermitage Rd., Brook Rd. and Hospital St., are located on curves presents a problem. To attain the moderate increase in speed planned over these crossings, an increase in superelevation would be necessary.

With superelevation, the outside rail on each track on the curve is raised as much as several inches above the level of the inside rail to reduce lateral "G" forces felt by the passengers. With a multiple-track crossing, as each of these are and will be after the improvements, this means that there is a series of inclines to be crossed, one between the rails of each track, and a dip from the slope of one track to the next. There is also likely to be a slope upward to the tracks on each side, the one on the outside of the curve being significantly greater than the one on the inside of the curve. This is not practical on a heavily traveled road, and may require that these crossings be closed, or grade-separated. Analysis will be required to develop a recommendation for each crossing.

Conclusions

With the introduction of more trains, many of which would be traveling at higher speeds, it is imperative that the effort be continued to eliminate as many crossings as possible, and increase protection on those that remain. Efforts to eliminate lightly used crossings, by finding alternatives, or other means, should continue. Separation of traffic at as many high-density crossings as possible must be achieved. Improved crossing protection should be installed at crossings for which separation cannot be justified.

Table H-1
GRADE CROSSINGS
Washington to Richmond (Main St.)

Milepost	Name	Public/ Private	Protection *	FRA #
87.7		Private	None	860626C
86.85	Featherstone Rd./Rt. 636	Public	CB, L, G	860600A
82.38	Cherry Hill Rd.	Public	CB, L, G	860601G
78.83	Potomac Ave.	Public	CB, L, G	860605J
78.11	Henderson Rd.	Public	CB, L, G	860609L
76.70	Brown Field Rd.	Public	CB, L, G	
73.10	Lee's	Private	None	860582E
72.34	Brent Point Rd.	Public	CB, L, G	860581X
67.4	Mt. Hope Church Rd./Rt.677	Public	CB, L, G	860578P
57.6	Landsdowne Rd./Rt. 638	Public	CB, L, G	860558D
54.9	Hamilton Rd./Rt. 636	Public	CB, L, G	860557W
51.41	Summit Rd./Rt. 668	Public	CB, L, G	860548X
48.63	Claiborne Rd./Rt. 660	Public	CB, L, G	860547R
47.24	Rt. 606	Public	CB, L, G	860545C
45.77	Jones	Private	None	860543N
44.50	Woodford Rd./Rt. 626	Public	CB, L, G	860542G
43.50	Collins Rd./Rt. 609	Public	CB, L, G	860541A
41.70	Rixey	Private	None	860540T
40.43	Bowling Green Park Rd./Rt. 605	Public	CB, L, G	860539Y
38.99	Rose	Private	None	860538S
37.80	Colonial Rd./Rt. 722	Public	CB, L, G	860534P
36.95	Bates	Private	None	860531U

*Crossbucks (CB), Lights (L), Gates (G), Cantilevers (CL)

Table H-1 GRADE CROSSINGS Washington to Richmond (Main St.)				
Milepost	**Name**	**Public/ Private**	**Protection ***	**FRA #**
36.66	Airport Rd.	Private	CB	860530M
34.01	Pleasant Mill	Private	None	860329T
33.50	Wrights	Private	None	860528L
33.00	Penola Rd./Rt. 601	Public	CB, L, G	860527E
31.30	Georges	Private	None	860526X
29.72	Colemans Mill Rd./ Rt. 656	Public	CB, L, G	860525R
24.40	Chandler	Private	None	860521N
21.81	Rt. 688	Public	CB, L, G	860520G
21.66	Excelsior Mill (Flippo Const.)	Private	None	860519M
15.62	Vaughn St.	Public	CB, L, G	860513W
15.16	Patrick St.	Public	CB, L, G	860512P
15.1	Pedestrian	Public	None	860511H
14.9	Pedestrian	Public	None	860510B
14.83	College St.	Public	CB, L, G	860462N
14.8	Pedestrian	Public	None	860461G
14.7	Pedestrian	Public	None	860460A
14.64	England St.	Public	CB, L, G	860459F
14.6	Pedestrian	Public	None	
	Pedestrian	Public	None	860457S
14.6	Pedestrian	Public	None	
14.57	Myrtle St.	Public	None	860455D
14.5	Pedestrian	Public	None	
14.5	Pedestrian	Public	None	860453P

*Crossbucks (CB), Lights (L), Gates (G), Cantilevers (CL)

Table H-1 GRADE CROSSINGS Washington to Richmond (Main St.)				
Milepost	**Name**	**Public/ Private**	**Protection ***	**FRA #**
14.5	Pedestrian	Public	None	860452H
14.4	Pedestrian	Public	None	860451B
14.20	Francis St.	Public	CB, L, G	860450U
G1 14.1	Pedestrian	Public	None	860449A
13.85	Ashcake Rd./Rt. 657	Public	CB, L, G	860448T
12.95	Rt. 707	Public	CB, L, G	860447L
12.66	Smiths	Private	None	860446E
11.55	Slash Rd./Rt. 626	Public	CB, L, G	860445X
11.15	Kenwood Rd./Rt. 623	Public	CB, L, G	860443J
9.65	Mill Rd.	Public	CB, L, G	860441V
8.10	Mountain Rd.	Public	CB, L, G	860438M
6.60	Hungary Rd./Rt. 662	Public	CB,L,G,C L	860437F
5.45	Hermitage Rd.	Public	CB, L, G	860435S
N3.45	Hermitage Rd.	Public	CB,L,G,C L	623518E
N3.10	Dinneen St.	Public	CB, L	623519L
N2.30	Brook Rd.	Public	CB,L,G,C L	623522U
N1.75	St. James St.	Public	CB,L,G	623525P
N1.60	Valley Rd.	Public	CB,L,G	623527D
N1.35	Hospital St.	Public	CB,L,G	623530L
85.12	Brown St.	Public(?)	CB,L	224963R

*Crossbucks (CB), Lights (L), Gates (G), Cantilevers (CL)