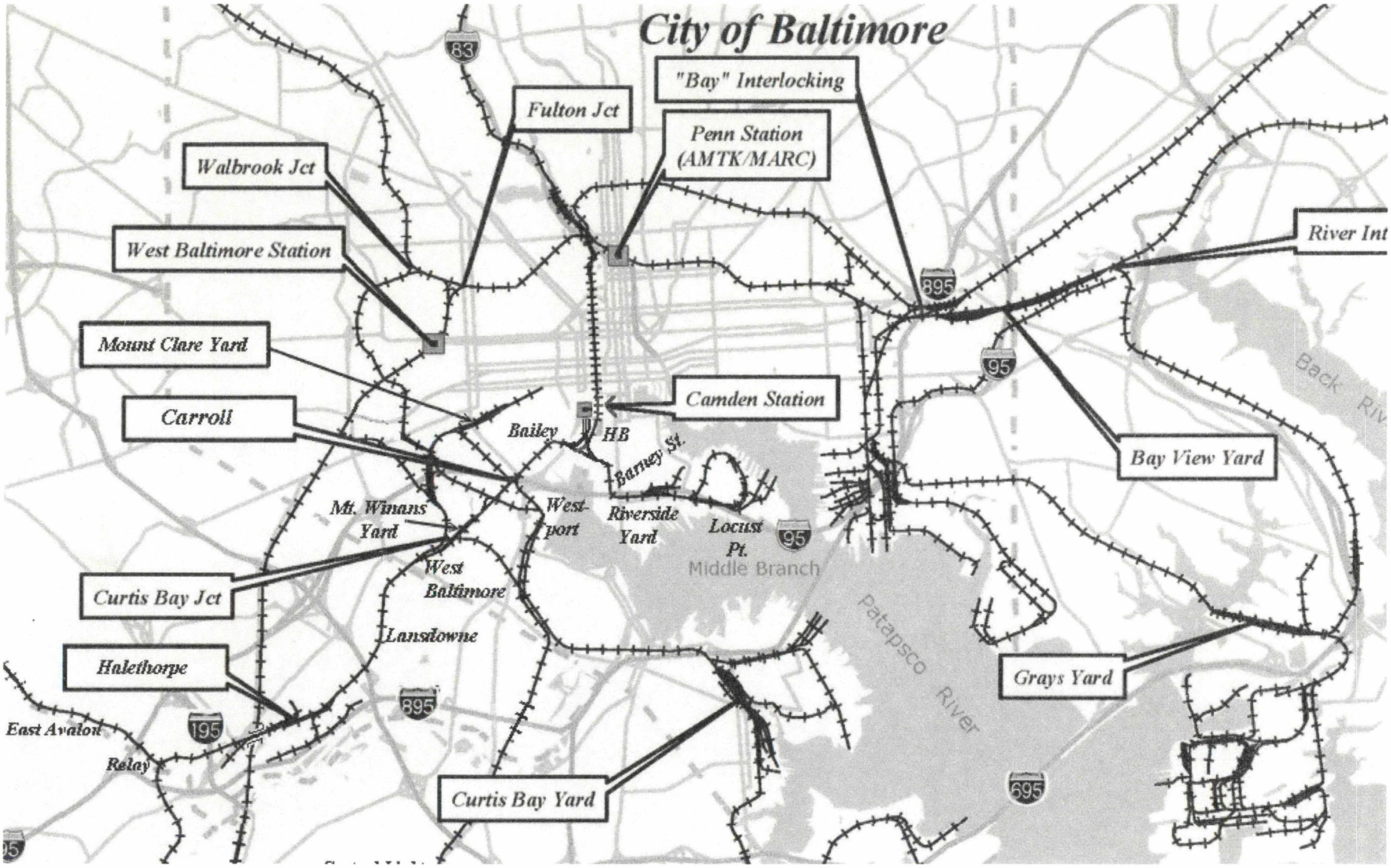
Report to Congress:

Baltimore's Railroad Network: Challenges and Alternatives



U. S. Department of Transportation
Federal Railroad Administration

November 2005

U.S. Department
of Transportation

Federal Railroad Administration

Administrator

**1120 Vermont Ave., NW.
Washington, DC 20590**

NOV 4 2005

The Honorable Thad Cochran
Chairman
Committee on Appropriations
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

House Report 107-308, the Conference Report to accompany H.R. 2299, making Appropriations for the Department of Transportation and Related Agencies for the Fiscal Year ending September 30, 2002, and for other purposes, dated November 30, 2001, requested the Federal Railroad Administration to provide to the House and Senate Committees on Appropriations a report on a comprehensive study of problems in the freight and passenger rail infrastructure in the vicinity of Baltimore, Maryland.

I am pleased to submit the report as requested.

Identical letters have been sent to the Ranking Member of the Senate Committee on Appropriations, and to the Chairman and Ranking Member of the House Committee on Appropriations.

Sincerely,

Joseph H. Boardman
Administrator

Enclosure

U.S. Department
of Transportation

**Federal Railroad
Administration**

Administrator

**1120 Vermont Ave., NW.
Washington, DC 20590**

NOV 4 2005

The Honorable Jerry Lewis
Chairman
Committee on Appropriations
United States House of Representatives
Washington, DC 20515

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Joseph H. Boardman
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EXECUTIVE SUMMARY

In November 2001, the Congress requested "a comprehensive study to assess problems in the freight and passenger rail infrastructure in the vicinity of Baltimore, Maryland." In particular, the study was to analyze the condition and capabilities of the railways' fixed facilities and "examine the benefits and costs of various alternatives for reducing congestion and improving safety and efficiency in the [rail] operations" in the Baltimore region.[1]

This report responds to that request.

The report comprises two parts. Tracing the development, current condition, and utilization levels of Baltimore's rail network, Part I ("Challenges") characterizes the dissonance between the network as it has evolved and the demands placed upon it. Part II ("Alternatives") examines the potential for restructuring actions that could raise passenger and freight railway capabilities in the Baltimore region to a new plateau.

PART I: CHALLENGES

INTRODUCTION [Chapter One]

Chapter One describes the study's funding history and scope.

Funding

The Congress envisioned a $3,000,000 study of America's oldest urban railway network, with costs to be shared equally by the Federal Government, the State of Maryland, and the two Class I freight railroads in Baltimore, CSX Transportation (CSXT) and Norfolk Southern (NS). Although the large freight railroads provided no financial support, they did contribute data and expertise, as did Amtrak. Only the Federal Railroad Administration (FRA) provided its full share of funding ($750,000); the State of Maryland was able to budget $250,000 for the effort, thus making a total of $1,000,000 available. Accordingly, the total resources available to this study amounted to one-third of the Congressional intention. Even so, by modifying the study plan and focusing the effort on highest-priority topics, the FRA was able substantially to fulfill the Congressional request.

Scope

The study focused on the principal elements of Baltimore's network of passenger and freight rail lines, extending from Perryville, northeast of Baltimore on the Susquehanna River—the junction of Amtrak's Northeast Corridor with the NS's principal route from Harrisburg and points west—to Halethorpe, southeast of the city, where the CSXT and Amtrak lines from Washington cross.

[1] U. S. House of Representatives, Report 107-308, Making Appropriations for the Department of Transportation and Related Agencies for the Fiscal Year Ending September 30, 2002, and for Other Purposes, November 30, 2001, p. 100.

CONTEXT AND EVOLUTION OF BALTIMORE'S RAILWAY NETWORK [Chapter Two]

In the Baltimore region, history and topography have combined to create a persistent challenge to efficient railway design and operating economy. At the core of Baltimore City, the Piedmont Plateau meets tidewater, thus constraining the optimal pathway for ground transportation to precisely that area—around the Inner Harbor, Pratt, and Lombard Streets—which achieved full development before the advent of the railroad. Denied the path of least resistance, the railroads were late in completing alignments through the City: the first through route across Baltimore came into being only in 1873, four years after the completion of the Transcontinental Railroad, which was evidently the easier of the two tasks. Intercorporate rivalries between the Pennsylvania and Baltimore & Ohio systems assisted in the dissipation of resources. In the end, each of the competing carriers built its own, inferior right-of-way, compromising even the then-prevailing standards for gradient, curvature, and operating efficiency. Despite subsequent improvements, today's network—still reliant on the Baltimore & Potomac (B&P), Union, and Howard Street Tunnels for connectivity[2]—is essentially the same as the geometrically compromised and operationally handicapped system cobbled together during the post-Civil War decades.

Although convoluted and antiquated, Baltimore's railroads have strategic importance far beyond the confines of their immediate region. Originating and terminating rail freight traffic in the Baltimore region remains significant, largely due to the Port—which ranks fourth among Atlantic Coast ports, and is the closest Atlantic port to major Midwestern markets—and the region's remaining industrial base. Through freight traffic is important on the CSXT's traffic lanes traversing Baltimore between the Northeast on the one hand, and the Midwest and South on the other, despite restrictions due to clearance limitations. Indeed, CSXT owns no alternate north-south route east of the Appalachian Mountains. With respect to intercity passenger service, one-fifth of Amtrak's passenger-trips, one-quarter of its passenger-miles, and one-third of its ticket revenues depend on travel over Baltimore's railways.[3] For all these reasons, the condition, capacity, efficiency, and effectiveness of the Baltimore region's rail network affect the performance of the national transportation grid—as became graphically evident in the massive traffic dislocations caused by the 2001 fire in the Howard Street Tunnel.

TODAY'S INFRASTRUCTURE [Chapter Three]

While Baltimore's railway network includes many important components (main lines, yards, branches, support facilities) and a variety of traffic flows (through, terminating,

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[2] The B&P and Union tunnels are part of Amtrak's Northeast Corridor right-of-way and carry mainly passenger traffic. The Howard Street Tunnel belongs to CSXT, which uses it for freight only. It was an extremely disruptive fire in the Howard Street Tunnel in 2001 that catalyzed public interest in the topics addressed in this report. (See Chapter 2.)

[3] Also worthy of note, but primarily of regional significance: rail commuter service in the Baltimore-Washington urban complex has shown marked growth since the 1970s under the sponsorship of the Maryland Department of Transportation.

originating, and within the region)—all of which would merit careful attention should any restructuring take place—the main traffic lane at issue is southwest–northeast across the region, and the principal facilities are two:

- Amtrak's Northeast Corridor (NEC) main line, built by the Pennsylvania Railroad (PRR) and subsidiaries, serving Pennsylvania Station (on the northern edge of the Central Business District (CBD) between Charles and St. Paul Streets), and passing through the Union Tunnels just east of the station and the Baltimore & Potomac (B&P) Tunnel to the station's west. The NEC carries a mixture of intercity passenger, commuter, and freight trains; the relative importance of each service type varies by segment.
- Completed by the Baltimore & Ohio Railroad (B&0) in the 1890s, CSXT's main line (also known as the "Belt Line") proceeds due north from the Camden Station area through the Howard Street Tunnel, then makes a relatively abrupt right turn near the geographic center of Baltimore City and continues due east to Bay View Yard, Wilmington, and Philadelphia. North of the Camden Station area, the line carries freight service only; between Camden Station and Washington, however, both commuter and freight movements take place.

The PRR and B&O designed and built their respective routes as multipurpose facilities, for both freight and passenger service. Since the 19th Century, however, the operating requirements and marketing characteristics of both services have evolved and diverged from each other, while the rail pathways through Baltimore have, in effect, remained constant. As a result, these two facilities increasingly fall short of what the traffic—not to mention the viability of the owning companies—would necessitate. Example of this mismatch between facilities and functions include:

- **Grades and curves.** Both the NEC and the CSXT main line suffer from too many curves that are too sharp, and too many grades that are too steep. The curvature constrains speeds for both passenger and freight trains; the grades—exacerbated by the curves—unduly hamper freight movements in particular.
- **Capacities.** Neither line provides adequate capacity for projected future freight and passenger operations. The CSXT Belt Line route has severe capacity constraints today, in view of its heavy freight traffic, the single-track operations through the Howard Street Tunnel, and the "helper" locomotives that must assist the heaviest trains up the daunting northbound grades and then return against opposing traffic. Although double- or triple-tracked and free of through freight service south of Bay View Yard, the NEC currently carries a voluminous and diverse traffic and even today lacks the capacity to recover from serious operational tie-ups.
- **Clearances.** Neither route can accommodate such modern, high-capacity freight car types as double-stack containers and triple-rack automobile carriers. To move such traffic, the NS must have recourse to its Shenandoah Valley line some 60 miles to the west, and the CSXT makes use of routes that it owns west

of the Appalachian Mountains. The NEC, suffering from particularly constrained clearances, cannot accept cars exceeding "Plate C" dimensions; thus unable to handle modern box cars or single level trailers, the NEC's utility for through freight movements is so limited that the NS was not making use of its NEC trackage rights between Alexandria, Virginia and Baltimore while this report was being prepared. In brief, Baltimore is a severe constraint to national freight traffic lanes up and down the East Coast.[4]

TRAFFIC LEVELS [Chapter Four]

Based on consultations with passenger and freight operators and a review of relevant economic forecasts, the study team analyzed existing, and projected future, traffic levels over the NEC and CSXT main lines in the study region. The results appear in Table ES - 1:

Table ES - 1: Existing and Projected Rail Traffic on Main Lines in the Baltimore Region

EXISTING SERVICE Daily Train Movements (Total Both Directions, Round Trip = 2 Movements)	Via CSXT Main Line		Via NEC Main Line		Total Both Routes	
	Aikin - Baltimore	Baltimore-Washington	Perryville - Baltimore	Baltimore-Washington	Northeast of Baltimore	Southwest of Baltimore
Passenger:						
Intercity	0	0	89	89	89	89
Commuter	0	22	16	45	16	67
Total Passenger	0	22	105	134	105	156
Freight	21	31	9	2	30	33
Grand Total Operations	**21**	**53**	**114**	**136**	**135**	**189**
PROJECTED SERVICE, 2050 Daily Train Movements (Total Both Directions, Round Trip = 2 Movements)	**Via CSXT Main Line**		**Via NEC Main Line**		**Total Both Routes**	
	Aikin - Baltimore	Baltimore-Washington	Perryville - Baltimore	Baltimore-Washington	Northeast of Baltimore	Southwest of Baltimore
Passenger:						
Intercity	0	0	110	110	110	110
Commuter	0	37	38	78	38	115
Total Passenger	0	37	148	188	148	225
Freight	37	56	27	13	64	69
Grand Total Operations	37	93	175	201	212	294
PROJECTED PERCENTAGE GROWTH 2003 – 2050	**Via CSXT Main Line**		**Via NEC Main Line**		**Total Both Routes**	
	Aikin - Baltimore	Baltimore-Washington	Perryville - Baltimore	Baltimore-Washington	Northeast of Baltimore	Southwest of Baltimore
Passenger:						
Intercity	no service	no service	24%	24%	24%	24%
Commuter	no service	68%	138%	73%	138%	72%
Total Passenger	no service	68%	41%	40%	41%	44%
Freight	76%	81%	200%	550%	113%	109%
Grand Total Operations	**76%**	**75%**	**54%**	**48%**	**57%**	**56%**

As Table ES - 1 indicates, the demand for train movements of all types is expected to increase by over 50 percent by 2050 from 2003 levels, with even greater proportional

[4] Washington's Virginia Avenue Tunnel constitutes a similar clearance constraint and would need to be addressed as part of a solution to the limitations on East Coast rail freight traffic.

increases on the already congested CSXT line. Thus by mid-century, a heightened pressure for transport would place a huge incremental load on an antiquated rail network that would, if left unchanged,[5] continue to detract from the speedy, efficient, and economic movement of passengers and goods along the East Coast.

The balance of the report develops and describes alternatives that would reverse these inherent difficulties by improving train routings, expanding freight clearances, and enhancing freight and passenger operations and capacities in the Baltimore region.

PART II: ALTERNATIVES

STUDY OBJECTIVES, STANDARDS, AND METHODS [Chapter Five]

After synthesizing the objectives of the analysis, the study team developed specific standards for developing and evaluating alternatives.

Study Objectives

The study objectives were as follows:

1. Make the service quality and capability of the system, both as a whole and in its important parts, no worse than it is today.

Beyond doing no harm:

2. Remove all through freight service from the Howard Street Tunnel.
3. Provide high-cube, double-stack clearance routes through Baltimore for both NS and CSXT freight trains.
4. Provide grades for freight trains that are less than those now encountered—preferably much less.
5. Provide a replacement for the B&P Tunnel.
6. Increase speeds for both passenger and freight trains wherever economically feasible.
7. Provide capacity to support traffic levels for freight, intercity passenger and commuter services based on reasonable projections for the year 2050, for each existing and projected route—while making every effort to reduce the future cost of providing still more capacity, should traffic grow beyond the design level.
8. Maintain access to all freight and passenger yards, port facilities, maintenance facilities, as well as CSXT Camden and Amtrak Pennsylvania Stations.
9. Provide for CSXT and NS intra-terminal moves in Baltimore.

[5] This statement assumes that the physical facilities can survive for another half-century—an assumption for which no conclusive engineering backup presently exists. As explained later in this report, the design life for new tunnels is 120 years.

10. Identify any relatively near-term improvements that could benefit users while long-term projects are progressed.

11. Avoid, minimize, and/or mitigate any significant adverse environmental impacts caused by Corridor improvements.

12. In making changes to accomplish all the above objectives, assure that railway operating expenses in the study area will not increase on a unit basis—and will, preferably, decrease.

Standards for Alternatives

Baltimore's topography and railway configuration, coupled with inherently different requirements for the movement of goods and people, inevitably lead to standards that differ for passenger and freight service. Indeed, it is one of the study's main conclusions that separate—rather than joint—freight and passenger facilities would be key to resolving the Baltimore challenge once and for all.

Chapter Five contains a very detailed exposition of the standards. Highlights follow:

- **Grades.** For freight, a one percent maximum (0.8 percent desirable maximum) would be established. As grades have a lesser impact on lighter and more highly-powered passenger trains, the ruling grade on the NEC (1.9 percent in the New York Tunnels, say two percent) would be acceptable as a maximum.

- **Curves.** Curvature needs to be reduced so that both services can achieve their maximum design speeds over as much trackage as possible. As curvature enters into the calculation of effective grades, easing the curvature could help to reduce the ruling grades for freight service.

- **Maximum Design Speeds.** The facilities should be designed to support maximum speeds of 60 and 55 mph for intermodal and merchandise freight trains, respectively. Maximum passenger speeds should be in the range of 125-150 mph. [6]

- **Clearances.** Plate H (allowing for double-stack containers and tri-level auto racks) would be established for freight service. To benefit most traffic flows, such a clearance upgrade would require improvement in Washington D.C.'s Virginia Avenue Tunnel, as well as investigation and correction of all undue clearance restrictions (e.g., overhead bridges) in the study area. For passenger service, only clearances equal to or better than those in the New York Tunnels would be required, unless interoperability of either passenger or freight trains over both the passenger and freight facility is mandated.[7]

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[6] The cost-effectiveness of expanding the NEC mileage subject to a 150 mph top speed limit has yet to be determined. Use of this theoretical 150 mph top speed in this report does not imply FRA endorsement of such an expansion, which would require Office of Safety approval.

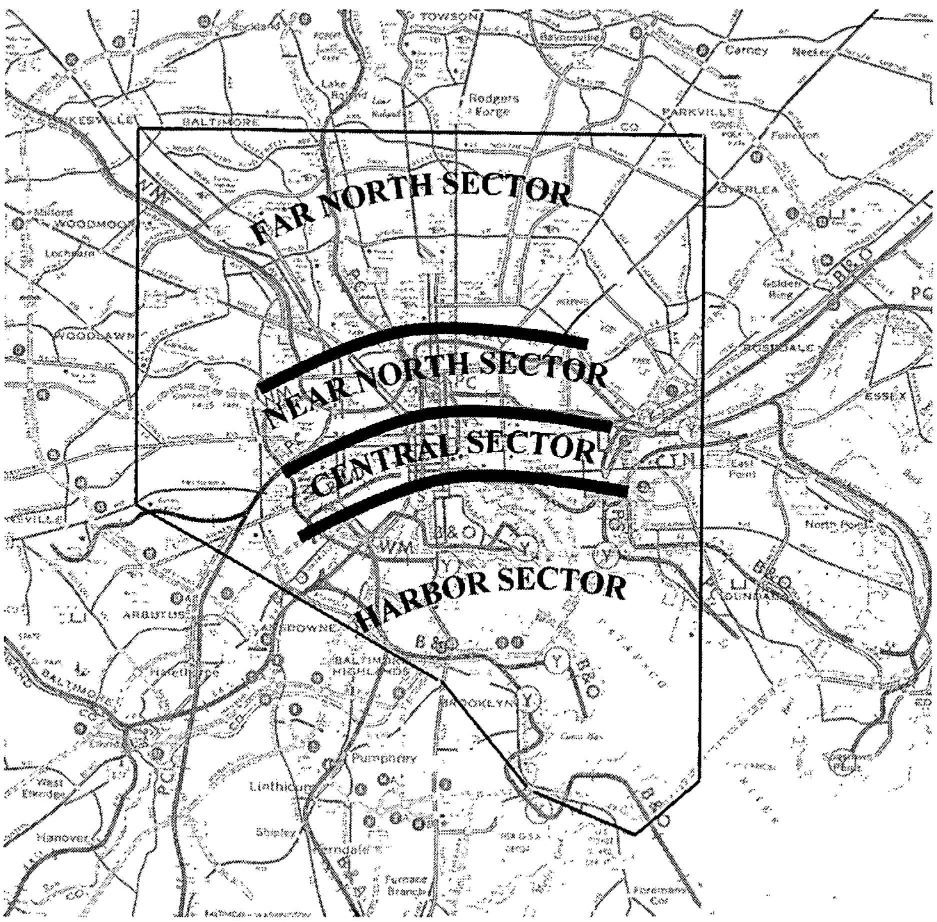
[7] The issue of interoperability is highly complex and would require additional study if Baltimore restructuring possibilities receive further attention.

- **Capacity.** For the first time ever, a double-track, dedicated freight main line route—meeting the clearance and all other standards—would be provided through the Baltimore region. Similarly, a double-track, dedicated passenger route would exist. For both services, additional tracks and support facilities would be in place where necessary to support the requirements of the traffic.

CONCEPTUAL FRAMEWORK FOR THE ALTERNATIVES [Chapter Six]

Since the primary flow of traffic across the Baltimore region is southwest to northeast and vice-versa, all alternative approaches would fall into one of four concentric sectors—Far North, Near North, Central, and Harbor—as depicted in Figure ES - 1:

Figure ES - 1: The Sectors



A preliminary screening of the four sectors for their suitability as sites for passenger and freight alternatives yielded the following results (Table ES - 2):

Table ES - 2: Initial Screening of Sectors for Passenger and Freight Service

Sector	Passenger	Freight
Far North	Does not serve Central Baltimore	Crosses built-up areas, grades likely to be heavy, lacks connectivity with existing network and yards
Near North	Possible	Possible
Central	Likely excessively expensive, but possible; more central station location for businesses	Too expensive, grade problems, and no need for freight to be in CBD
Harbor	Expensive and no closer to CBD than present station	Possible

Legend:	***May meet all initial standards***	***Has obvious difficulties***	***Ruled out at outset***

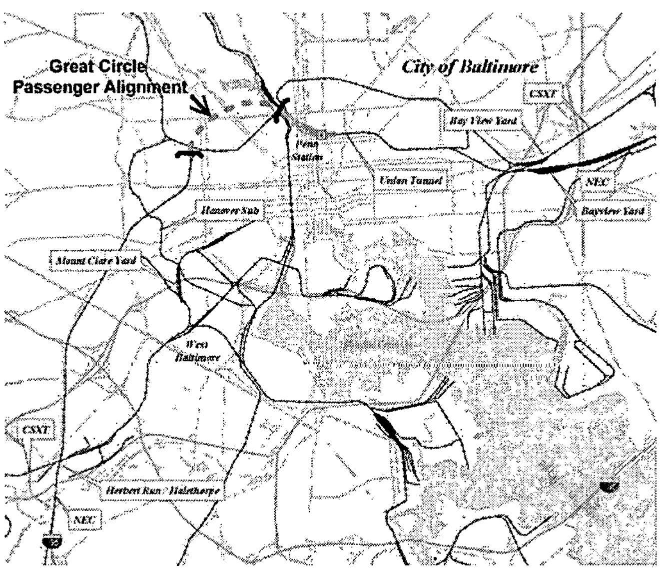
As Table ES - 2 reveals, the Near North Sector—the area selected by both major railroads for their main lines in the late 1800s—affords promising options for both freight and passenger restructuring. The Harbor Sector may offer an opportunity for freight. All other sectors are either ruled out entirely due to "fatal flaws," or only marginally attractive on the initial screening.

PASSENGER ALTERNATIVES [Chapter Seven]

Near North Sector—Great Circle Passenger Tunnel

Of the alternatives examined in the Near North Sector, a Great Circle Passenger Tunnel (GCPT) showed the most promise (Figure ES - 2). With portals not far removed from those of the B&P Tunnel, the GCPT would follow a large arc north of the existing alignment.

Figure ES - 2: Great Circle Passenger Alignment



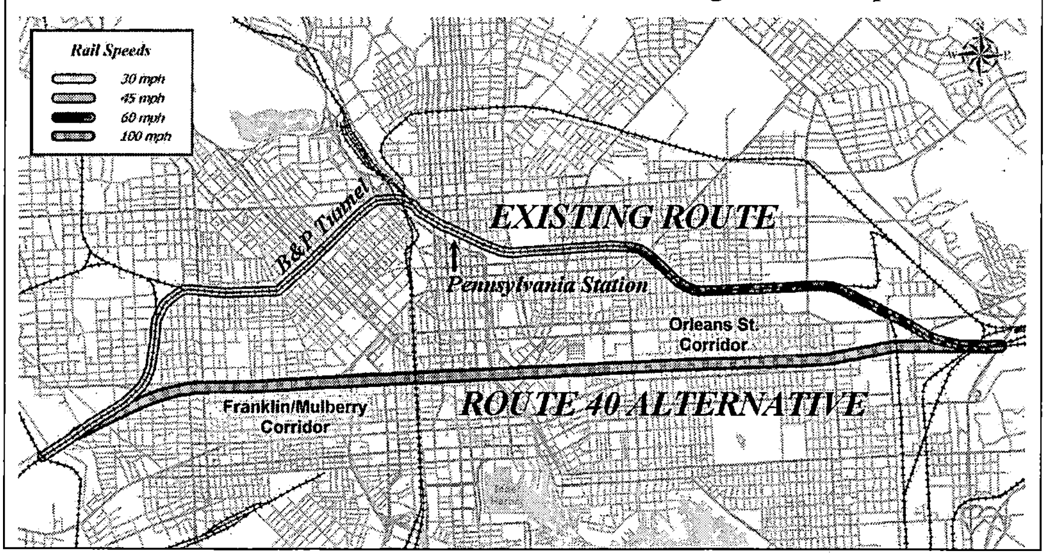
The Great Circle alignment would have a number of advantages. First, because of its gradual curvature, trains would be operated at much greater speeds than through the existing alignments. Initial train performance analyses have concluded that the Great Circle alternative, albeit longer than the extant route, would save about two minutes in comparison with the B&P Tunnel alignment.[8] Second, and much more importantly, as the Great Circle route follows the ridgeline, the tunnel can be deeper below the surface—in rock strata that would reduce construction costs by enabling a tunnel-boring machine (TBM) to be used.

Implementation of a GCPT would imply continued use of the existing Pennsylvania Station in Baltimore for both Amtrak intercity and MARC Penn Line commuter service.

Central Sector—Route 40 Alternative

Figure ES - 3 compares the location and speeds of the present B&P route with a hypothetical alignment for a Route 40 alternative along the Franklin/Mulberry–Orleans Street corridor. By replacing tortuous curves with a nearly straight line, such a Central Sector solution would markedly outperform the existing route. Although a Route 40 alignment would promise optimal performance and a more central station location, it would present three major difficulties: the huge costs and potential environmental consequences of a tunnel beneath Baltimore's core, and of a multi-track station that would likely be sited underground; the implications for Penn Line commuters from points north, who would have to penetrate much farther into the CBD than at present to reach their trains; and the potential community impacts on the Franklin-Mulberry corridor, the remaining residents of which are still living with the effects of highway construction battles of the 1960s and 70s. For all these reasons, the study team did not carry the Route 40 Alternative through to preliminary cost estimation.

Figure ES - 3:
Central Sector, Route 40 Alternative and Existing Route Compared

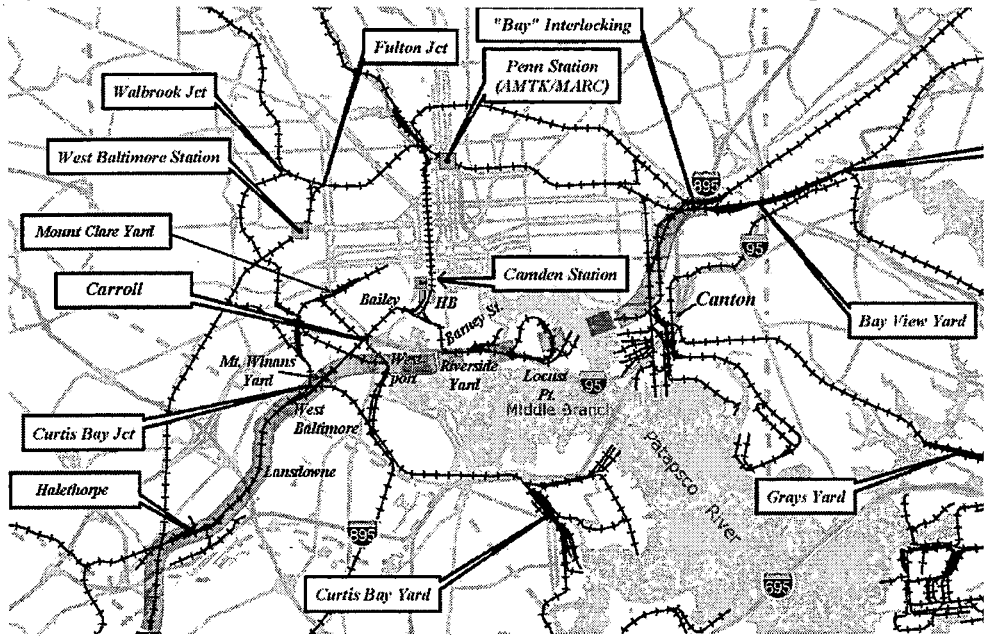


Harbor Sector—Locust Point Alternative

The study team also laid out a hypothetical passenger route between Locust Point and Canton (Figure ES - 4).

[8] It would thus reduce Amtrak's Washington–New York travel time by about one percent, and the Baltimore-Washington travel time by about six percent. (Times are for Acela Express.)

Figure ES - 4: Schematic of Harbor Sector—Locust Point Passenger Alternative



Like the Central Sector route, the Locust Point Alternative would present severe challenges. For example:

- It would entail reconstruction of the I-95 piers and abutments;
- It would involve a new, fixed bridge across the Middle Branch;
- The study team was unable to locate an obvious site for a new main passenger station that would be as accessible from downtown, for pedestrians and others, as the existing Pennsylvania Station;
- The traversal of Canton would be constrained by a host of existing railroad, highway, and industrial facilities;
- The impact on the Penn Line commuter service of a displacement to Locust Point would be even more severe than that of a move to the Central Sector. If the B&P Tunnel must be maintained for Penn Line services, the economics of any Harbor Sector alternative would suffer; and
- Cost estimates for underwater tunnels for freight service (see below) suggest that an underwater passenger tunnel would be far more costly than a land-based alternative.

Therefore, the study team did not carry the Locust Point Alternative through to preliminary cost estimation.

FREIGHT ALTERNATIVES [Chapter Eight]

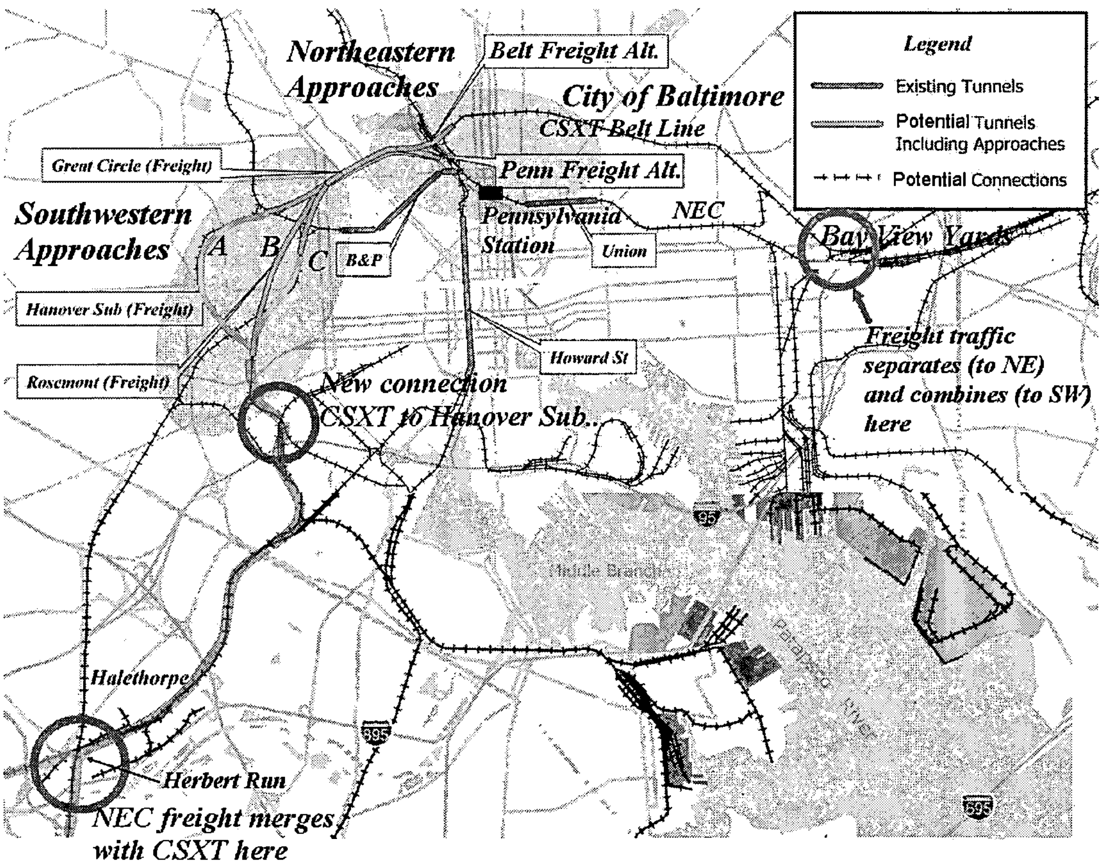
Near North Sector—Great Circle Freight Tunnel

In the vicinity of the existing main lines, the study team developed two land-based tunnel alternatives, both of which would employ a "Great Circle Freight Tunnel" (GCFT) similar in concept to the GCPT.

- In both alternatives, all northeast-bound freight traffic would make use of the CSXT main line and Mount Clare Branch between Halethorpe (Herbert Run) and a new connection to the CSXT Hanover Subdivision. The freight trains would proceed northward to a new tunnel portal in the general vicinity of the existing B&P tunnel entrance (three optional portal locations were examined). The new GCFT would curve gently to the northeast toward the Jones Falls Valley, where it would make one of the two possible connections described below.
- In the **Belt Freight Alternative,** the GCFT route would cross the Jones Falls Valley and would then effect a linkage with the CSXT "Belt Line" eastward to a junction at Bay View affording access to both the CSXT and NEC (Amtrak/NS) main lines.
- In the **Penn Freight Alternative,** the GCFT route would link up with the NEC just northwest of Pennsylvania Station, would employ upgraded freight-only trackage through the station area and a renewed Union Tunnel, and would have direct access at Bay View to both the CSXT and NEC (NS) freight trackage.

Figure ES - 5 depicts the GCFT and the two route alternatives described above.

Figure ES - 5: Great Circle Freight Tunnel, "Belt" and "Penn" Alternatives
[Letters "A," "B," "C" Refer to Optional Southwestern Approaches]



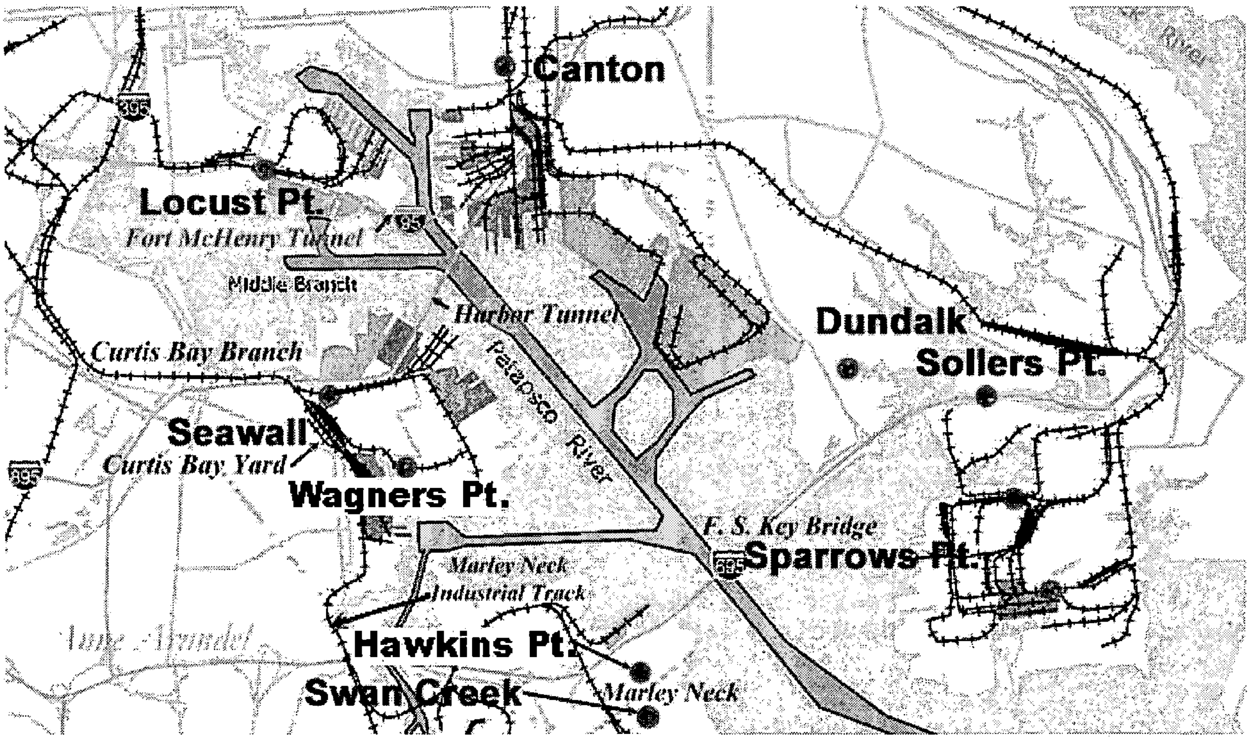
Freight Tunnels Under Baltimore Harbor

The study team considered five potential portal sites on each side of Baltimore Harbor, and all the possible tunnels between these two sets of portals. (See Figure ES - 6.) Of these many permutations, very few survived the limitations established by—

- The one percent grade maximum described in Chapter Five;
- The need to observe a channel depth of fifty feet in the harbor;
- The need to minimize the length of any tunnel;
- The assumed prohibition on tunneling beneath the existing Fort McHenry and Baltimore Harbor tunnels;
- The need to keep takings of residential and industrial real estate to a minimum; and
- The assumption that no harm would be tolerated to existing operations and facilities.

Figure ES - 6: Portals Examined in the Study

(Note: For design reasons, portal locations will sometimes differ from the locations of the features after which they are named.)



Based on the above stringent limiting factors, the study team found that a tunnel between a Marley Neck portal (at Hawkins Point or Swan Creek, at the bottom of Figure ES - 6) and Sparrows Point would appear to offer the most promise of any **underwater** alternative studied. However, in comparing this finding with those regarding the land-based alternatives, planners and decision makers will need to consider that—

- The cost of an underwater tunnel is projected to be approximately three times that of a land-based alternative;
- Considerable circuity is involved in any through routing via Sparrows Point, and detailed local routings are yet to be examined;
- The interface between a Marley Neck–Sparrows Point tunnel and the existing industry at that location—an important part of the region's industrial base—remains to be worked out; and
- No reasonably direct Sparrows Point routing would permit efficient service to the existing Bay View yards; all trains calling at Bay View would need to make time-consuming and costly reverse moves.

Thus, while all the alternatives developed in this study must be regarded as initial concepts, the harbor-based freight tunnel raises special concerns that merit especially attentive preliminary investigation in any further work on a Baltimore restructuring.

CONCLUSIONS AND PATHS FOR ANALYSIS [Chapter Nine]

Illustrative Alternatives

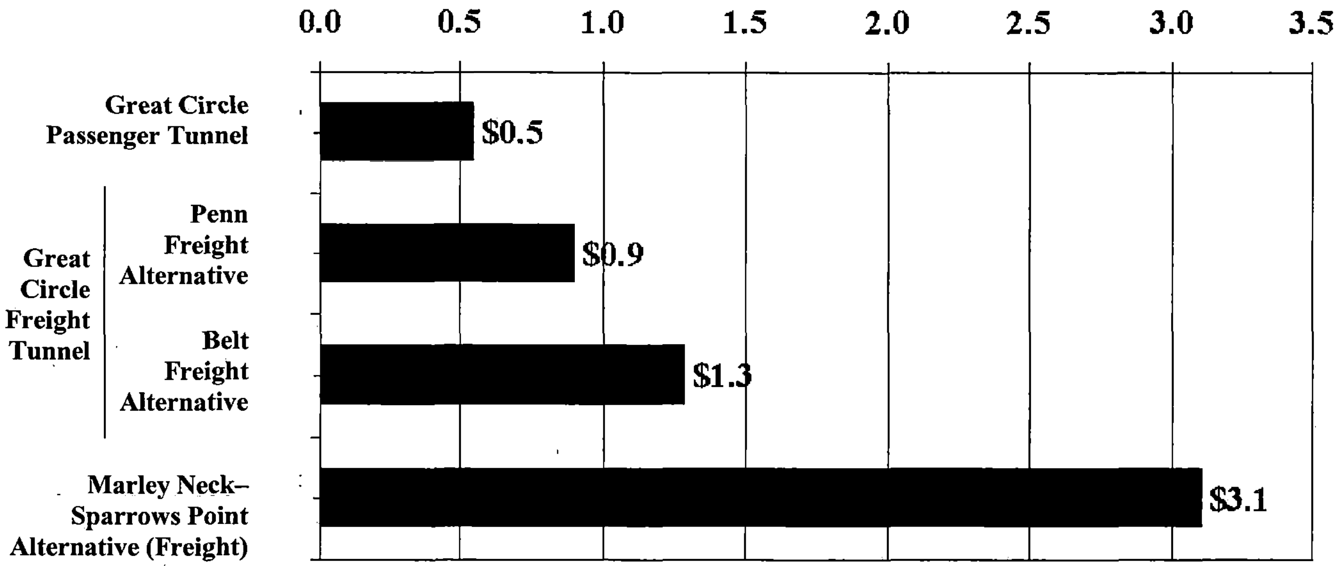
The following alternatives survived the process of elimination inherent in the study:

- **Passenger—Near North Sector: Great Circle Passenger Tunnel**
- **Freight:**
  - — **Near North Sector: Great Circle Freight Tunnel (Penn Freight alternative)**
  - — **Near North Sector: Great Circle Freight Tunnel (Belt Freight alternative)**
  - — **Harbor Sector: Marley Neck–Sparrows Point alternative**

Preliminary cost measures

Figure ES - 7, on the following page, summarizes the preliminary cost estimates for the illustrative alternatives:

Figure ES - 7: Preliminary Costs for Illustrative Alternatives
(Billions of 2003 Dollars)



These preliminary estimates include contingencies of between 30 and 40 percent (with the higher figure applied to tunneling costs), and add-on fees of 18 percent to cover design, construction management, and project management.

The significant difference in cost between the land- and water-based tunnels largely reflects, first, recent advances in the cost-effectiveness of deep boring techniques to which the geology of the Great Circle alternatives is projected to be conducive and, second, the need for elaborate new approaches to the Harbor Sector tunnel alternatives.

Study Conclusions

The principal conclusions of the study are as follows:

- Baltimore's railway network is so antiquated and underdeveloped, and so important to the Nation's transportation system, as to fully justify the Congressional request for this analysis. For example, the B&P Tunnel was completed eight years after the Civil War ended.
- In Baltimore, the needs of freight and passenger service differ so greatly as to justify separate freight and passenger facilities.
- Further incremental repairs to existing facilities, other than for purposes of safety and operational continuity, will not address any of the inherent geometric problems that plague the transit of Baltimore by rail.
- Baltimore City presents severe engineering challenges to the design of new tunnel crossings, whether for freight or passenger service.

- With respect to passenger alternatives: By a process of elimination, only a Near North alternative utilizing the existing Pennsylvania Station appears to provide a cost-effective long-term solution to the challenges posed by the existing B&P Tunnel.[9]
- With respect to freight alternatives:
  - — Both the Near North Sector and Harbor Sector appear to offer possibilities for alternative freight routes.
  - — Of the Harbor Sector freight alternatives, those farthest from the Inner Harbor have the best chance of meeting the objectives of this study.
  - — The cost of a land-based Great Circle Freight Tunnel appears to be one-third that of a Harbor Tunnel.
- If and when the concerned parties wish to progress a restructuring of the railway network in the Baltimore region, significant further analytical work will be unavoidable—and essential to verify this study's conclusions and assure that any possible future investment is wisely and optimally spent.

Possible Analytical Paths

If responsible authorities determine that a restructuring of Baltimore's railways merits further analysis, topics worthy of attention would include (but not be limited to) the following:

- **Refinement of alternatives analyzed in this report**. For example, the relative advantages and disadvantages of the Penn Freight and Belt Freight alternatives could benefit from additional scrutiny based on changes in such assumptions as the immovability of the Central Light Rail Line and its support facilities.
- **Investigation of other passenger alternatives** could include:
  - — Additional investigation of a Central Sector alternative with various station sites; and
  - — Additional investigation of a Harbor Sector alternative, particularly with respect to finding any suitable station site that is as close and as accessible to Charles Center as the present Pennsylvania Station.
- **Investigation of other freight alternatives:** For example, it may be worthwhile to devote additional attention to the Harbor Sector Locust Point–Canton alternative, with special attention to the effects on passenger infrastructure and operations.

---

[9] Regarding cost effectiveness: analyses by others imply that the cost of a Great Circle Passenger Tunnel could conceivably be less than that of rebuilding of the existing B&P Tunnel. See Chapter Seven, section entitled "Upgrade the B&P Tunnel." Any such inference would, of course, require detailed substantiation in the course of additional investigations.

- **Coordination of passenger and freight alternatives:** While the needs of passenger and freight fundamentally differ, there would be a need to optimize of the design of parallel alternatives, such as the Great Circle tunnels, to reduce points of conflict and lower the total cost of the two projects where possible. In addition, cross-operability of passenger and freight routes might undergo a benefit/cost analysis.

- **Analysis of Washington alternatives:** The full benefits of a Baltimore restructuring, at least for freight traffic up down the East Coast, can only materialize if the clearances in Washington's Virginia Avenue Tunnel are relieved simultaneously with those in Baltimore. In addition, clearances elsewhere in the region between Washington, Philadelphia, and New Jersey would need careful investigation.

- **Operations and facility analyses:** For each alternative under consideration, operational studies would be necessary to verify the degree of improvement they promise, with respect to both the present situation and each other. The techniques employed would include train performance calculator runs, and the modeling of all train movements for purposes of forecasting capacities. Special attention would be applied to signal layouts and support facilities for passenger and freight service. For example, station configurations and midday/overnight car storage facilities would need more careful analysis for passenger service; yard layouts and operations would require attention with respect to freight.

- **Further engineering analyses:** Further development of Baltimore tunnel alternatives would necessarily require ever-more-detailed engineering work, on such topics as:

  — Geology/underground utilities;

  — Confirmation of right-of-way/property lines;

  — Successive levels of design;

  — Construction staging; and

  — Refinement of construction cost estimates

- **Review regional alternatives for freight movement.** It would be most appropriate to examine:

  — Likely performance of the Baltimore network if no improvements are made and the traffic increases are retained in the rail mode;

  — Implications, on other modes' congestion and facility requirements, of handling future traffic increases by other modes, especially highway (and air to the extent of available capacity and likely demand); and

— Alternatives for upgrading or devising other rail freight routes[10] that would bypass the Baltimore region for through traffic in various national traffic lanes; their costs, benefits, and effects upon traffic to, from, and within the study region; their consequences for the various carriers that would be involved.

- **Comprehensive benefit/cost analyses for the alternatives.** Drawing on the operational and other investigations, total life-cycle benefits and costs (and their incidence) would appropriately be calculated for each of the rail restructuring alternatives. The results of these analyses would provide much fuller information to decision-makers and the public at large than estimates of construction costs alone, and would better prepare the way for the environmental documentation.
- **Institutional arrangements.** To effect any thoroughgoing Baltimore restructuring, and to derive all its promised benefits, would require well-designed institutional structures and relationships. Cost sharing would be an issue of profound importance, for example. The creation or adaptation of such institutions, and the resolution of cost and operational issues before any construction begins, would be an analytical task in itself of very high importance.
- **Environmental documentation.** Analyses like those exemplified above would help to support the important task of preparing all necessary environmental documentation for a restructuring, if any, of Baltimore's railway network.

[10] There are no such conceivable options for passenger traffic.

Letter from Robert L. Flanagan,
Secretary, Maryland Department of Transportation

May 6, 2005

Maryland Department of Transportation
The Secretary's Office

Robert L. Ehrlich, Jr.
Governor
Michael S. Steele
Lt. Governor
Robert L. Flanagan
Secretary
James F. Ports, Jr.
Deputy Secretary

May 6, 2005

Mr. Mark Yachmetz
Associate Administrator for Railroad Development
Federal Railroad Administration
Mail Stop 5
1120 Vermont Avenue, N.W.
Washington DC 20590

Dear Mr. Yachmetz:

The Maryland Department of Transportation (MDOT) wants to express its appreciation for the Federal Railroad Administration's (FRA) leadership and oversight of a one million dollar study of aging railroad tunnels in the Baltimore area.

The scope of the study included an evaluation of alternate tunnel routes for both freight and passenger service from, to and through the Baltimore metropolitan area. The study area was defined as Halethorpe to Bay View, Maryland. The final report, prepared by FRA, is entitled "Baltimore's Railroad Network – Challenges and Alternatives." The Maryland Department of Transportation has reviewed the draft copy dated 02-15-05 "Report to Congress." It was agreed MDOT would provide final comments in letter format which would be integrated and incorporated into the final report. We therefore offer the following:

The original appropriation to support this study was as a result of efforts by Maryland Senators Paul S. Sarbanes and Barbara A. Mikulski following the events of the Howard Street Tunnel fire in 2001. However, the deeper discussion of rail tunnel infrastructure limitations—both in capacity and clearances—have been ongoing for many years. The "chokepoints" of both the CSX-owned Howard Street Tunnel and the Amtrak-owned B&P Tunnels present significant rail infrastructure deficiencies for the entire Northeast rail system. The tunnel fire coupled with the 9-11-2001 tragedy and more recent acknowledgements of Amtrak's long-term tunnel issues in Baltimore, have served to heighten the awareness and place even more urgency on efforts to find solutions. The Baltimore Tunnel chokepoints are indeed issues of state, multi-state, even national significance.

My telephone number is 410-865-1000
Toll Free Number 1-888-713-1414 TTY User Call Via MD Relay
7201 Corporate Center Drive, Hanover, Maryland 21076

The report, although lengthy, does provide extensive background information, which is important to the reader's current understandings. As noted in the report, the budget for this project was unfortunately limited from original expectations. Therefore, several options and alignments were not able to be addressed. Also, the level of detailed work for those that were addressed was limited. In addition to the route studies that were provided in the initial scope, and after considerable work had been done on multiple alignments, the option to route both freight and passenger trains via a south harbor I-95 alignment was among those not considered for the purpose of this study. We now are aware of two additional possible tunnel alignments, for which no significant preliminary engineering work has been done. Maryland is continuing in its efforts to better define economic benefits of alternatives not necessarily described in this study.

As a result of these paralleling efforts, we feel this report and other studies are laying the groundwork for next steps. Remaining is a definition of the benefits of each route with an enhanced understanding of local, regional, and national benefits at large. The studies bring focus to the need for yet another corridor analysis to more fully determine which of the six or more tunnel routes would best serve any future investment strategy. When these initial analyses are complete, we could then recommend advancing studies to the 30%+ level of engineering thereby refining costs and impacts as well as benefits. This future detailed engineering analysis will more clearly identify the "most viable" route options for both passenger and freight rail from, to and through Maryland.

In closing, MDOT feels the state and federal partnership funding for this study has set the cornerstone of a good work in progress. We look forward to continuing in these efforts with our federal and private rail partners.

Sincerely,

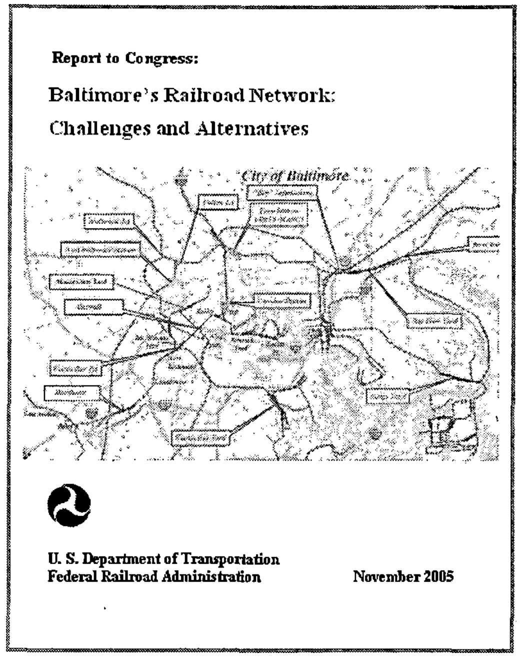
Robert L. Flanagan, Secretary
Maryland Department of Transportation

cc: Senator Paul S. Sarbanes
Senator Barbara A. Mikulski

Main Report

Part I:

Challenges



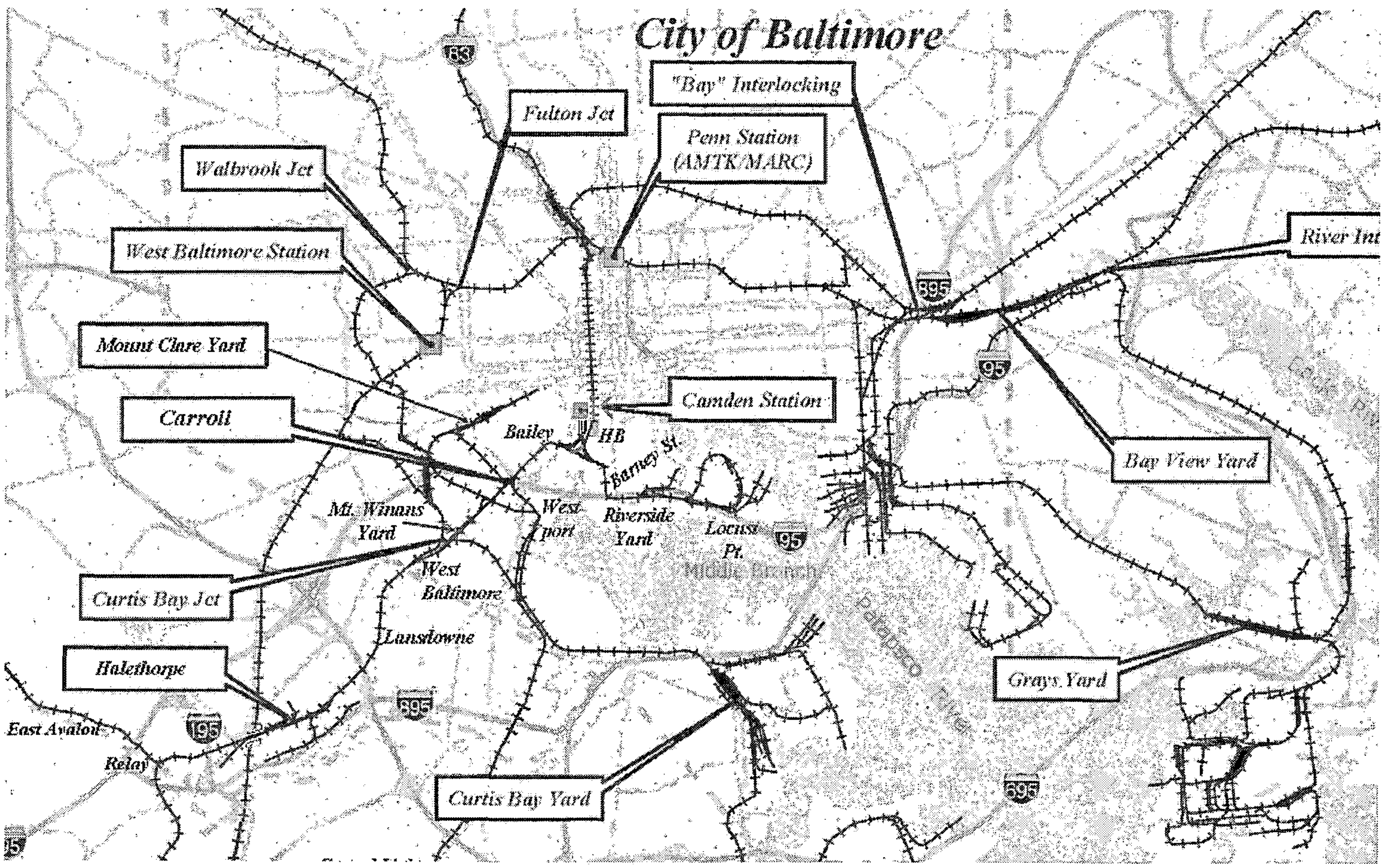
Report to Congress:

Baltimore's Railroad Network:

Challenges and Alternatives

U. S. Department of Transportation
Federal Railroad Administration

November 2005



Chapter One
INTRODUCTION

A. Committee report direction

In November 2001, after the railway infrastructure of Baltimore, Maryland had attracted public attention due a catastrophic fire in CSX Transportation's tunnel under Howard Street, the Congress made the following request:

> *Baltimore, Maryland freight and passenger infrastructure study.*—The conference agreement includes $750,000 to conduct a comprehensive study to assess problems in the freight and passenger rail infrastructure in the vicinity of Baltimore, Maryland. FRA shall carry out this study in cooperation with the state of Maryland, Amtrak, CSX Corporation and Norfolk Southern Corporation, as outlined in the Senate bill (Sec. 351). The Administrator of FRA shall submit a report, including recommendations, on the results of the study to the House and Senate Appropriations Committees not later than 24 months after the date of enactment of this Act.[1]
>
> *[Section 351 of the Senate bill reads as follows:]* SEC. 351. (a) Of the funds appropriated by title I for 16 the Federal Railroad Administration under the heading "Railroad Research and Development," up to $750,000 may be expended to pay 25 percent of the total cost of a comprehensive study to assess existing problems in the freight and passenger rail infrastructure in the vicinity of Baltimore, Maryland, that the Secretary of Transportation shall carry out through the Federal Railroad Administration in cooperation with, and with a total amount of equal funding contributed by, Norfolk Southern Corporation, CSX Corporation, and the State of Maryland.
>
> (b)(1) The study shall include an analysis of the condition, track, and clearance limitations and efficiency of the existing tunnels, bridges, and other railroad facilities owned or operated by CSX Corporation, Amtrak, and Norfolk Southern Corporation in the Baltimore area.
>
> (2) The study shall examine the benefits and costs of various alternatives for reducing congestion and improving safety and efficiency in the operations on the rail infrastructure in the vicinity of Baltimore, including such alternatives for improving operations as shared usage of track, and such alternatives for improving the rail infrastructure as possible improvements to existing tunnels, bridges, and other railroad facilities, or construction of new facilities.

(c) Not later than one year after the date of the enactment of this Act, the Secretary shall submit a report on the results of the study to Congress. The report shall include recommendations on the matters described in subsection (b) (2).

This report represents the response of the Federal Railroad Administration (FRA) to that request, subject to the funding limitations described below.

---

[1] U. S. House of Representatives, Report 107-308, Making Appropriations for the Department of Transportation and Related Agencies for the Fiscal Year Ending September 30, 2002, and for Other Purposes, November 30, 2001, p. 100.

B. Funding sources and limitations

The Congressional directive envisioned a $3,000,000 study of an urban railway network that is America's oldest[2] and arguably one of its most important and complex. That amount was appropriate to the task; thus, the FRA, with a $750,000 appropriation in hand, initiated the study on a scale commensurate with the Congressional directive. While the State of Maryland—despite the budgetary constraints afflicting all State governments in Fiscal Year 2002—provided a welcome $250,000 (one third of its Congressionally-foreseen share), the two major freight railroads, CSX Transportation (CSXT) and Norfolk Southern (NS), made no financial contribution.[3] Thus a study that was planned and begun on an assumed $3,000,000 budget ended up $2,000,000 short.[4]

In consultation with the State of Maryland, the FRA revised the study plan during the course of the project to recognize the unforeseen shortfall in funding. Although the reduction in scope precluded completion of the original study design, the study team was able to perform such analyses as would substantially fulfill the Congressional mandate, as evidenced by the present report. The final chapter of this document lays out additional tasks that would build on the work done to date, should interested public and private entities ever elect to pursue and fund comprehensive approaches to the challenges inherent in Baltimore's railways.

C. Contractor

The engineering work underlying this report was performed for FRA and the State of Maryland by the Parsons Transportation Group.

D. Railroad participation

The CSXT, NS, and Amtrak provided certain types of nonproprietary data and met with members of the study team on an as-needed basis. The smaller, local switching railroads (Canton and Patapsco & Back Rivers) were consulted regarding their operational needs. However, at this early stage, the large and small railroads were not asked to review the study concepts; their intensive involvement would, of course, be necessary in future stages of development, if any.

E. Geographic scope of the study

The study focused on the principal elements of Baltimore's network of passenger and freight rail lines, extending from Perryville, northeast of Baltimore on the Susquehanna River—the junction of Amtrak's Northeast Corridor with the NS's principal route from Harrisburg and points west—to Halethorpe, southeast of the city, where the CSXT and Amtrak

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[2] The Baltimore & Ohio Railroad, a predecessor of CSXT, laid its first stone in 1827.

[3] Owing to Amtrak's particularly precarious financial situation at the time of the 2002 appropriation process, the Congress elected not to seek Amtrak's funding participation even though it would be a major beneficiary of certain improvements covered by the study.

[4] I.e., with a total funding of $1,000,000—$750,000 from FRA and $250,000 from Maryland.

lines from Washington cross.[5] A more detailed definition of the study area appears in Chapter Three.

F. Plan of the report

Part I ("Challenges") traces the development, current condition, and utilization levels of Baltimore's rail network. Chapter Two shows how Baltimore's railways evolved over nearly two centuries on the basis of the City's geography and longstanding development patterns. The rail infrastructure, with its geometric failings and operational drawbacks, then undergoes close scrutiny (Chapter Three). Meanwhile, passenger and freight operations have expanded in recent years, and promise to show even more growth by mid-century (Chapter Four). Thus Part I underlines the dissonance between the network as it has developed and the demands placed upon it, a tension that constitutes the fundamental motivation for the study.

Part II ("Alternatives") demonstrates the potential for restructuring actions that would raise passenger and freight railway capabilities in the Baltimore region to a new plateau. Comparing the deficiencies in Baltimore with standard practices in the railroad industry, Chapter Five presents a set of objectives and standards that would appropriately guide the creation and evaluation of alternative Baltimore solutions, and summarizes the methodology adopted in this study. It becomes clear that the goals for passenger and freight service, respectively, cannot be met—given the design limitations established by geography, existing development, and railway operations—with a single mixed-use tunnel facility. Thus, Chapter Six presents the guiding concept for developing restructuring alternatives, while Chapters Seven and Eight explore the passenger and freight options respectively. Chapter Nine provides very preliminary cost estimates for illustrative alternatives, summarizes the study results, and identifies some avenues for further research that might provide decision-makers with deeper insights on the choices, costs, and benefits implicit in the restructuring of Baltimore's railway network

[5] The crossing is grade separated with no connection ever having existed between the two lines.

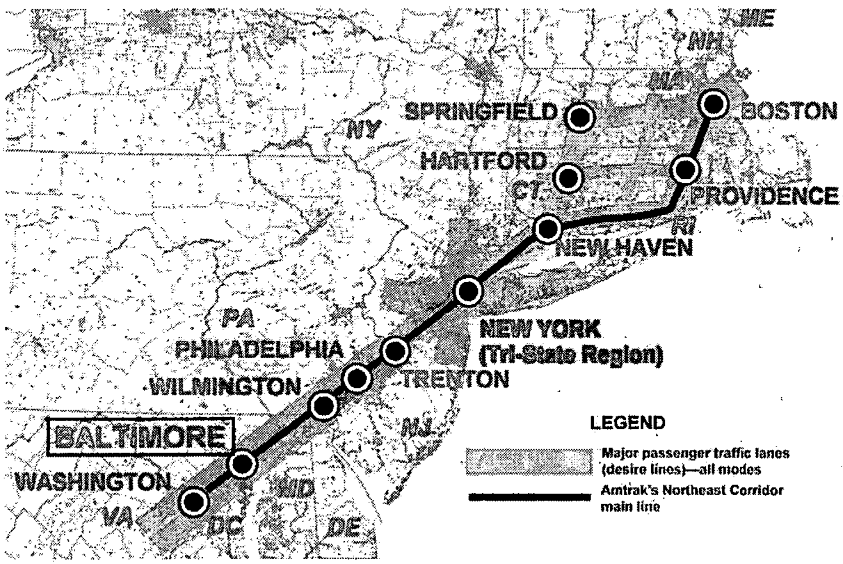
Chapter Two
CONTEXT AND EVOLUTION OF BALTIMORE'S RAILROAD NETWORK

Placing Baltimore's rail network in its national and regional context, this chapter explains the fundamental geographical and historical reasons for the facilities' many deficiencies.

A. Baltimore's importance in passenger and freight railroad transportation[1]

Baltimore City proper, with a population of 628,670,[3] ranks 18th among American cities; the Baltimore-Towson Metropolitan Statistical Area (MSA) ranks 19th among MSAs, with a population of 2.6 million.[4]

Figure 2 - 1: Baltimore's Prime Location in the NEC Region[2]



Transcending its substantial population levels, Baltimore's importance as a source of originating and terminating rail traffic, and as a link in key through routes, dates back to the early 19th Century and remains noteworthy to this day. Baltimore's location on Amtrak's most important route, its Northeast Corridor (NEC) main line between Washington, New York, and Boston (shown in Figure 2 - 1), assures an exceptional frequency and quality of intercity passenger train service. With Amtrak offering faster door-to-door travel times than are available by any other public mode from Baltimore to Washington, Philadelphia, New York, and other popular NEC destinations, Baltimore's Pennsylvania Station generated 424,245 boardings in 2003 and ranked eleventh among Amtrak stations in passenger volumes.[5]

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[1] Details on the facilities and services described in this section appear in subsequent chapters.

[2] Source: Adapted from the cover of U. S. Department of Transportation, *Recommendations for Northeast Corridor Transportation,* September 1971. The travel patterns shown in this figure do not include all those of interest from an intercity passenger rail perspective (e.g., Philadelphia–Harrisburg).

[3] U.S. Census Bureau data, Population Estimates for the 25 Largest U.S. Cities based on July 1, 2003 Population Estimates.

[4] U.S. Census Bureau, *Statistical Abstract of the United States: 2003,* Table No. 26: Large Metropolitan Statistical Areas–Population. 2002 data. In 2003, in a sweeping restructuring of the official list of metropolitan areas, the Office of Management and Budget reconstituted Baltimore as a separate MSA (it had previously been combined with the Washington area as the Washington-Baltimore Consolidated MSA). See Appendix II of the *Statistical Abstract.*

[5] Amtrak data, rankings of its top 20 stations, available at http://www.amtrak.com/about/amtrakfacts.html .

Baltimore has likewise assumed an important role in the growing Maryland Rail Commuter (MARC) service, which links Washington, D.C., with Baltimore's Camden and Pennsylvania stations (with a northeastern extension from the latter to Perryville). From a vestigial service operated (and internally subsidized) by the predecessor railroads in the 1960s, the MARC system has evolved, through State initiative, into a significant transit operation that generates over 175 million passenger-miles annually.

Baltimore has also retained an important role in both through and originating/ terminating freight service. CSXT continues to make use of its main line through Baltimore for important east-west and north-south traffic lanes to and from Philadelphia and other East Coast points. NS preserves, but uses minimally, its through trackage rights over the NEC between Washington, Baltimore, and other NEC points.[6] Originating and terminating rail freight traffic in Baltimore remains significant, largely due to the Port of Baltimore and the region's persistent industrial base. The Port—the closest Atlantic port to major Midwestern markets[7]—ranks 19th in the Nation in terms of tonnage handled (42.1 million short tons),[8] and ranks fourth among Atlantic Coast ports, behind the Port of New York and New Jersey (137.5 million short tons), the ports of Philadelphia and Marcus Hook (combined total of 65.5 million short tons), and the Hampton Roads ports of Newport News and Norfolk Harbor (combined total of 51.2 million short tons).

Thus, from every viewpoint, the Baltimore region represents a very important location on the Nation's railway map. As will become evident in later sections, the region would assume an even greater importance but for the underdeveloped nature of its rail infrastructure.

B. Geographic setting

Since railroads—particularly fledgling and underfunded ones—have historically sought out the path of least resistance to minimize initial expenditure and accelerate revenue production,[9] Baltimore's geography has determined the design of its rail network since 1827 and continues to limit the scope of realistic options for the future. The following sections summarize, and explore the long-term effects of, the city's main natural and man-made features.

1. The Fall Line

In the United States, the fall line—extending in an arc from the Carolinas through Virginia and Maryland to New Jersey—is the boundary between the Piedmont Plateau and the Atlantic Coastal Plain physiographic provinces. The Piedmont Plateau lies between the Coastal Plain and the Appalachian Mountains. Many towns and cities were founded along the fall line because it often marked the limit for navigation on rivers and because the waterfalls provided the

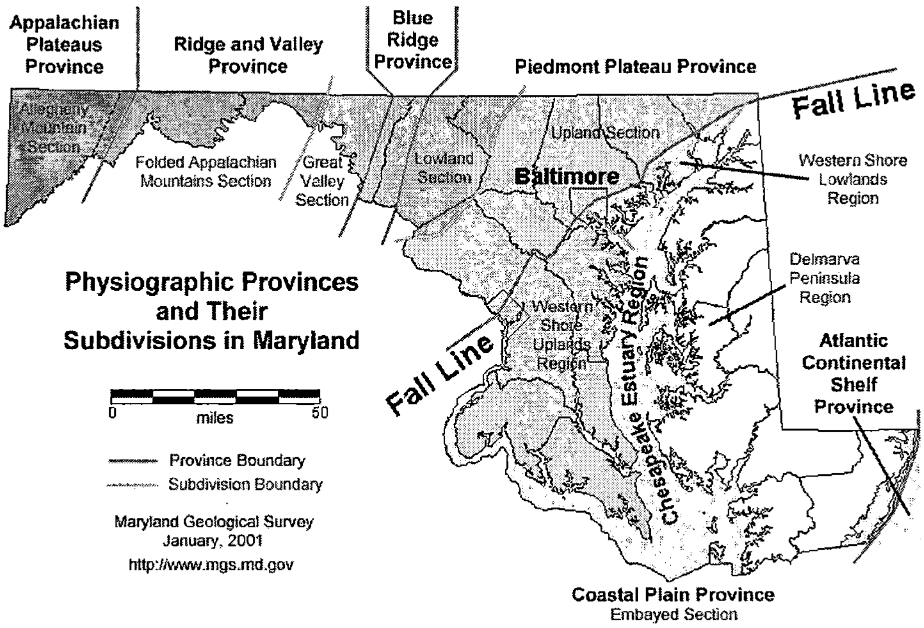
[6] The reasons for this sparing use are described later in this chapter. NS intensively uses its Perryville–Baltimore rights over the NEC; see later in this report.
[7] Maryland Port Administration, http://www.marylandports.com/info/index.htm
[8] Comparative port data are from U.S. Census Bureau, *op. cit.*, Table No. 1074, Selected U.S. Ports by Tons of Traffic, 2001. The tonnage statistics include many huge oil ports on the Gulf Coast—for example, the Port of South Louisiana (213 million short tons) and the Port of Houston (185 million short tons). All the East Coast ports grouped together above are reported individually by the Census Bureau.
[9] Cf. Arthur M. Wellington, *The Economic Theory of Railway Location,* 1877.

opportunity to create flume- and water-wheel-powered industries. Such cities include Baltimore, Philadelphia, and Washington.[10]

Figure 2 - 2: The Fall Line, Overview

The Fall Line, as depicted by the U.S. Geological Survey, appears in Figure 2 - 2. Figure 2 - 3, affording a more detailed view of the Fall Line in Maryland, clearly indicates how the Fall Line bisects Baltimore very close to the harbor itself.

Figure 2 - 3: The Fall Line in Maryland[11]



The geological map of Baltimore (Figure 2 - 4) highlights the complexity of Baltimore's geologic foundations: Piedmont rock formations extend almost to the water's edge.[12]

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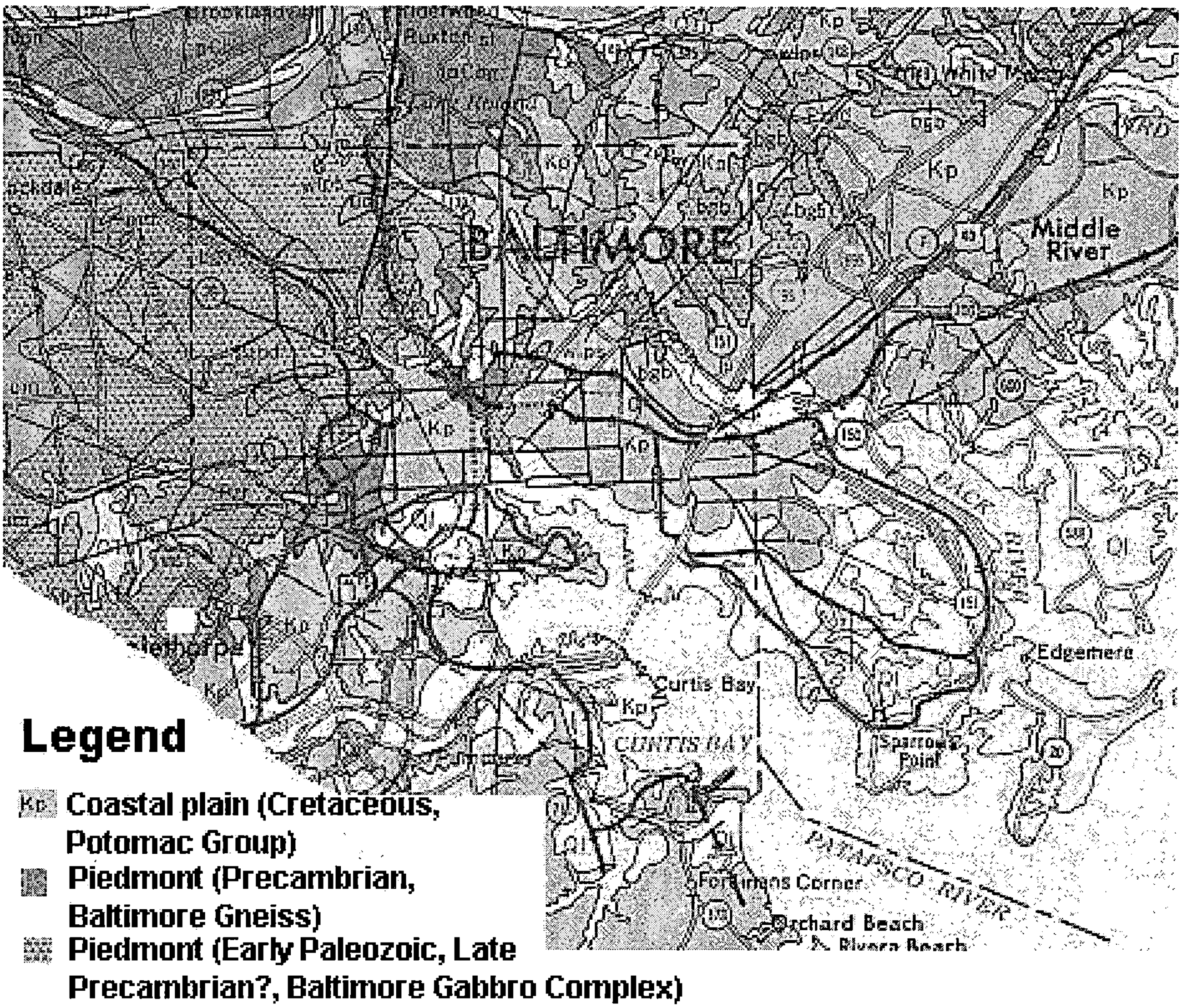
[10] The description and Fall Line overview are from the U.S. Geological Survey, http://tapestry.usgs.gov/features/14fallline.html

[11] From Maryland Geological Survey, http://www.mgs.md.gov/coastal/maps/g1.html

[12] Because tunneling is fundamental to this study, the geology of the region constitutes particularly important background. The Baltimore City area shares two major physiographic and geologic provinces, the Coastal Plain and the Piedmont (see Figure 2 - 4). Southwest of the Fall Line separating the two geologic provinces, the hard rocks of the Piedmont are buried beneath the unconsolidated Cretaceous and Pleistocene deposits of the Coastal Plain, which gradually dip and thicken to the southeast. The Cretaceous deposits are predominantly of the Potomac group, represented by the Patuxent, Arundel, and Patapsco Formations, and consist primarily of buff and light colored fluvial deltaic sands and clays. These sediments contain substantial amount of well to poorly graded silty and clayey sands and are frequently cross-bedded and intermixed with well to poorly graded gravels. Within the river streams, the Potomac group deposits were locally eroded during the sea level lowering and later replaced with estuarine deposits of softer organic clay and silt. The Piedmont province is about 40 miles wide and is characterized by moderate to high relief, rolling topography and by cristalline metavolcanic and metasedimentary rock of Pre-Cambrian and Paleozoic Ages. The Coastal Plain deposits and some adjacent areas of bedrock were capped after the last marine regression by a series of alluvial terrace deposits, represented mainly be inter-bedded gravel, sand, silt and clay of variable composition and sorting. Uppermost deposits may locally include recent marsh deposits. Surficial manmade fills are typical for most of the developed areas of the City.

Figure 2 - 4: Geological Map of Baltimore[13]



The effects of this topographical and geological complexity at Baltimore's heart become apparent in a 1912 view of Baltimore's core (Figure 2 - 5), which clearly shows the pronounced declivity from west to east, from Charles Street to the Jones Falls; the natural alignment of the easier topography (exploited by two early railways, the Western Maryland (WM) and Northern Central (NC)), along the Jones Falls from south to north; and the higher elevations to the northwest, which reach 425 feet in the far northwest corner of the city.

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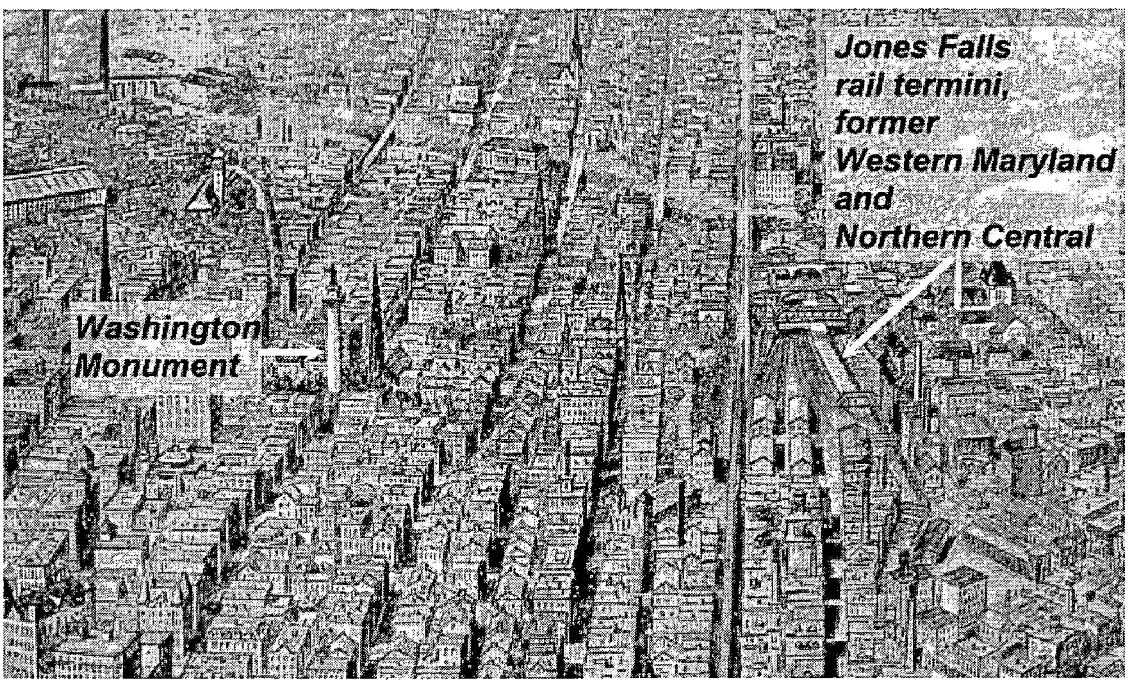
[13] Source: Maryland Geological Survey, http://www.mgs.md.gov/esic/geo/bal.html

Figure 2 - 5: Bird's Eye View of the Heart of Baltimore, Looking North[14]

These features are even more strikingly revealed in a close-up shot (Figure 2 - 6), taken from the same print. The line of the rooftops from the Washington Monument/ Peabody Conservatory area to the rail termini on the Jones Falls evidences the abruptness of the

Figure 2 - 6: Close-Up of Area between Monument Square and Pennsylvania Station



[14] Edward W. Spofford, "A birds-eye view of the heart of Baltimore," Baltimore, Norman T.A. Munder & Co., c1912, provided by Library of Congress at http://lcweb2.loc.gov.

downgrade. Pennsylvania Station is visible to the north, its original multipurpose nature (as a "Union" station of the NC, WM, and the Pennsylvania's NEC components) clearly apparent.

2. Rivers

The Patapsco River is one of the shorter rivers emptying into the western edge of the Chesapeake Bay, extending only 52 miles from its headwaters to its mouth. Along the way, it drains about 540 square miles of land. The river starts inauspiciously, seeping from a small pond on a farm at Parr's Spring. Not until it reaches Elkridge does the Patapsco widen and deepen, maturing into a full-fledged river.

The Tidewater area of the Patapsco includes the Northwest and Middle Branches. Like the Chesapeake, this section of the Patapsco River is considered an estuary—the zone where fresh water meets salt water. Several secondary tributaries flow into the Patapsco River Estuary: Jones Falls (much of which is channelized, as depicted at the lower right corner of Figure 2 - 5) joins the estuary on the north side of the Baltimore Inner Harbor, while Gwynns Falls discharges into the Middle Branch. To the south, smaller tributaries empty into the Patapsco.

Other major rivers in the study area from Halethorpe to Perryville include the Back, Middle, Gunpowder, and Bush Rivers, as well as the mighty Susquehanna—the source of the Chesapeake Bay. These rivers do not differentially impact the present study.

3. Drainage and Groundwater Levels

Baltimore City is located in the Chesapeake Bay drainage system, which reaches the Bay through the broad estuaries of the rivers named above. Groundwater levels coincide or are slightly above the water levels at streams or bays. Locally, the groundwater levels may be influenced by adjacent construction activities and by leakage from utility lines.

4. Tidal Levels

Using the NOAA database for the Fort McHenry Station and a tidal epoch of 1960 to 1978, the following are estimates of Patapsco River levels referred to the Baltimore City Datum:

- Highest observed water level (8/23/1933) .. 8.47
- Mean Higher High Water (MHHW) 2.23
- Mean High Water (MHW) 1.92
- Mean Low Water (MLW) 0.81
- Mean Lower Low Water (MLLW) 0.57

Baltimore City Datum is 0.57 feet below the 1929 National Geodetic Vertical Datum (NGVD).

5. Baltimore Harbor[15]

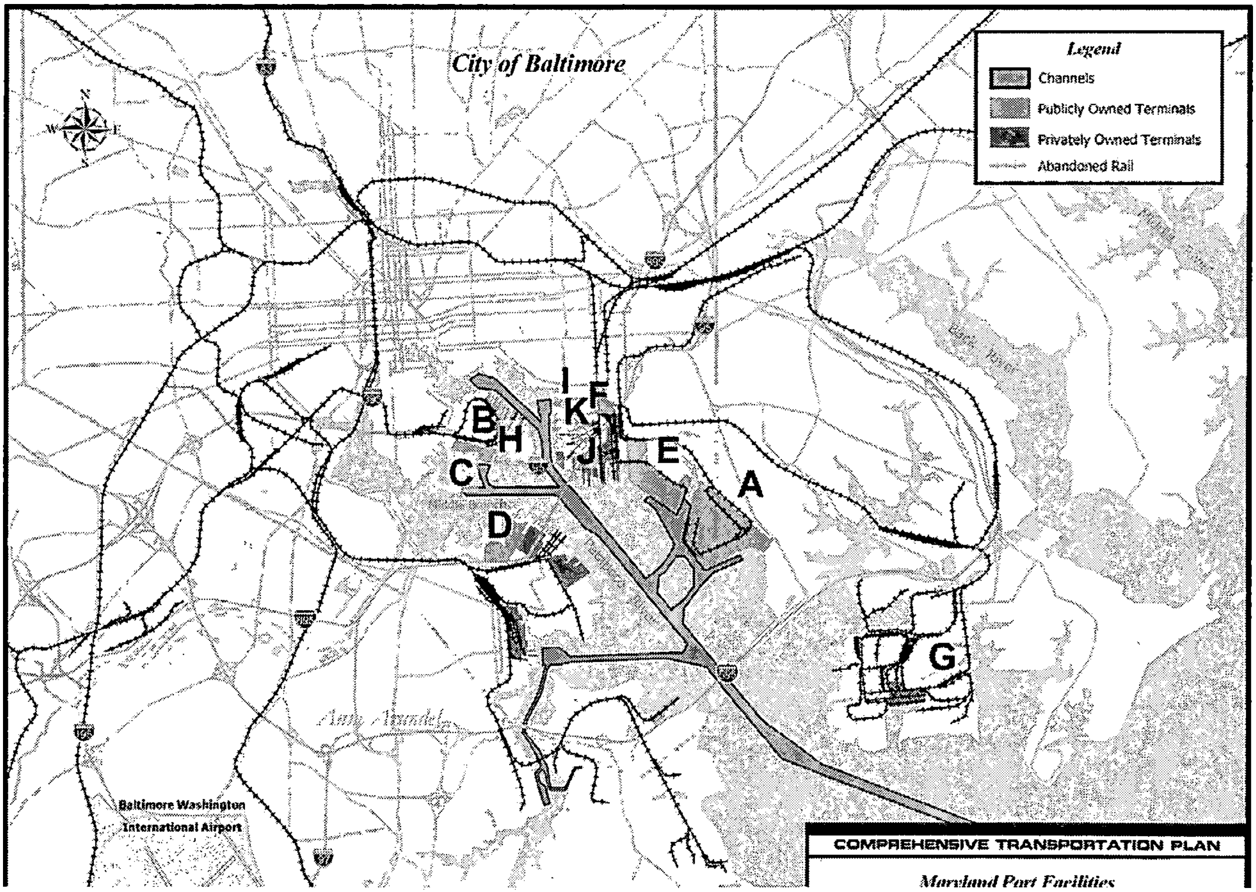
Established in 1706, the Port of Baltimore, located on the banks of the Patapsco River, initially transported farmers' crops along the Eastern Seaboard, as well as cargoes to and from

[15] Information for this section comes principally from the Maryland Port Administration, http://www.marylandports.com/info/index.htm

international destinations. As demand for Baltimore's port services grew, the naturally shallow depth of the harbor and river began to restrict the size of a ship that could navigate to the City. Dredging of the river began as early as 1798 and continues to this day[16]; the required channel depth has obvious practical implications for any tunneling under the harbor.

Traditionally one of the busiest maritime facilities on the East Coast (see at page 2-2), the Port of Baltimore generates $1.4 billion in revenues annually, employing nearly 126,700 Marylanders in maritime-related jobs. It has easy access to six interstate highways, which are linked by the Baltimore Beltway. Both CSXT and NS serve the port, providing on-dock or near-dock service. Thus the port has land connections to all points, although the highway facilities are more modern than the rail capabilities, with their circuity and often limited clearances.

Figure 2 - 7: Major Facilities of the Port of Baltimore
(Letters Indicate Approximate Locations of Selected Sites Mentioned in Table 2 - 1)



The port contains public terminals, owned and managed by the Maryland Port Administration, and private terminals. The various facilities are depicted in Figure 2 - 7 and listed in Table 2 - 1.

[16] Years of industrial and shipping activity in the area have caused toxic compounds to accumulate within the bottom sediments of the port, so the spoil is now dumped behind a 29,000-foot dike positioned just outside the mouth of the Patapsco.

Table 2 - 1: Selected Terminals of the Port of Baltimore[17]
("Location" refers to letters in Figure 2 - 7 showing approximate sites of the facilities.)

Name	Location	Public	Private	Description
Dundalk Marine Terminal	A	•		The facility is a multi-use general cargo facility that handles container, automobile, ro-ro (roll-on-roll-off), and general cargo traffic. NS presently has direct access to the terminal; CSXT has switching rights to access the facility.
North Locust Point	B	•		This port facility, located in South Baltimore, is a general cargo terminal, primarily handling steel and paper products. CSXT provides direct access to the facility.
South Locust Point	C	•		The terminal is a multi-use general cargo facility. CSXT provides direct rail access.
Fairfield Auto Terminals	D	•		A specialized auto terminal with easy access to the highway network. CSXT provides direct rail access.
Intermodal Container Transfer Facility	E	•		The terminal enables the efficient transfer of containers between the Seagirt Marine Terminal and intermodal trains. CSXT operates the Intermodal terminal, which is accessible to NS via the Canton Railroad.
Rukert Marine Terminal	F		•	The Rukert facility specializes in metals, ores, fertilizers, and alloys.
Sparrows Point Terminal	G		•	The terminal is a bulk and breakbulk loading and unloading facility.
Baltimore Metal and Commodities Terminal	H		•	The Terminal specializes in metals, soft commodities, and project cargo.
Highland Marine Terminal	I		•	The terminal was developed as an EPA Brownfields project; CSXT and NS serve the terminal's storage facilities.
Canton Marine Terminal	J		•	The terminal handles bulk, breakbulk, project, and Ro-Ro cargo.
Terminal Corporation	K[18]		•	The firm specializes in the handling of unitized, breakbulk, and project cargoes.

6. Tunnels

The following major tunnels in Baltimore are germane to this study. They appear in the maps on subsequent pages and in many detailed illustrations later in this report.

[17] For a fuller list and more information, readers are referred to the Maryland Port Authority's web site, http://www.mpa.state.md.us/facil/index.htm#PageTop

[18] Figure 2 - 7 shows one of multiple locations for the Terminal Corporation.

- **Railroad Tunnels:**
  - — **B&P (Baltimore & Potomac) Tunnel,** Amtrak, to the west of Pennsylvania Station;
  - — **Union Tunnels,** Amtrak, to the east of Pennsylvania Station;
  - — **Howard Street Tunnel,** CSXT, between Camden and (the disused) Mount Royal Stations;
- **Transit Tunnel:**
  - — **MTA Heavy Rail,** from Charles Center to the northwest, with an easterly extension to Johns Hopkins Hospital;
- **Highway Tunnels**
  - — The Fort McHenry Tunnel, Interstate 95;
  - — The original Baltimore Harbor Tunnel, Interstate 895.

All these tunnels, not just the railroad facilities, are important to this study because of clearance, construction staging, and similar considerations as they relate to the geometry of possible alternative rail routings.

7. Other urban features

Baltimore's other salient features (some of which include the tunnels) are listed below and summarized in a series of maps.

a. Subway and light rail systems

The light rail and subway lines constructed and proposed thus far appear in Figure 2 - 8.

b. Highway network

Baltimore's highly-developed system of interstate highways provides three major crossings of Baltimore Harbor, as shown on Figure 2 - 9:

- The two Harbor Tunnels mentioned above, and
- The Francis Scott Key Bridge, Interstate 695.

All are toll facilities, and all provide truckers and motorists with cross-Baltimore facilities that are far superior to those provided today by the rail network.

c. Baltimore City and typical neighborhoods

Figure 2 - 10 focuses on typical neighborhoods of Baltimore City and the rail lines that pass through them.

d. Baltimore Central Business District (CBD)

Showing streets, transit lines, and railroads, Figure 2 - 11 zooms in on Baltimore's CBD.

Figure 2 - 8: Principal Transit Lines

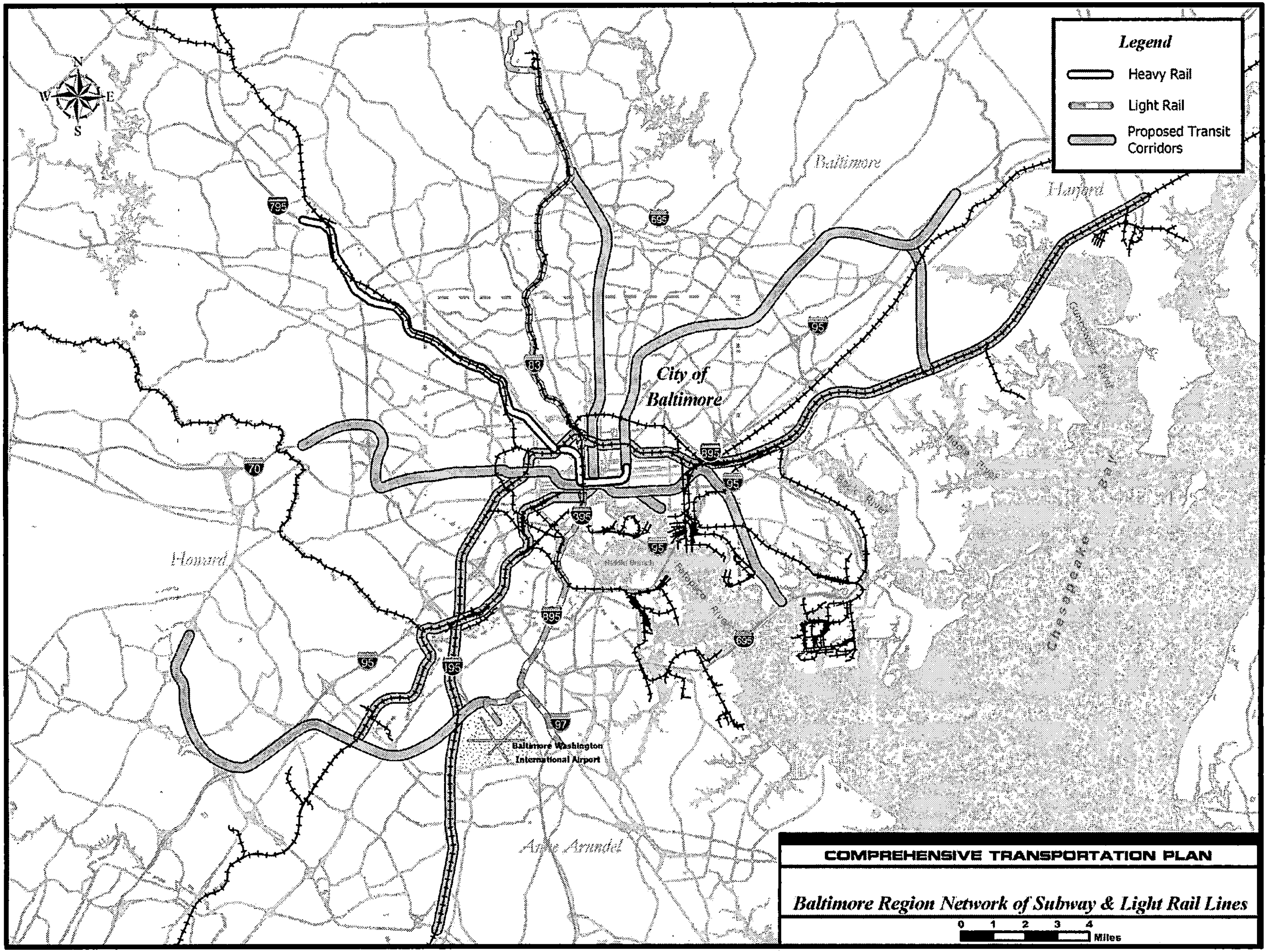


Figure 2 - 9: Principal Highways

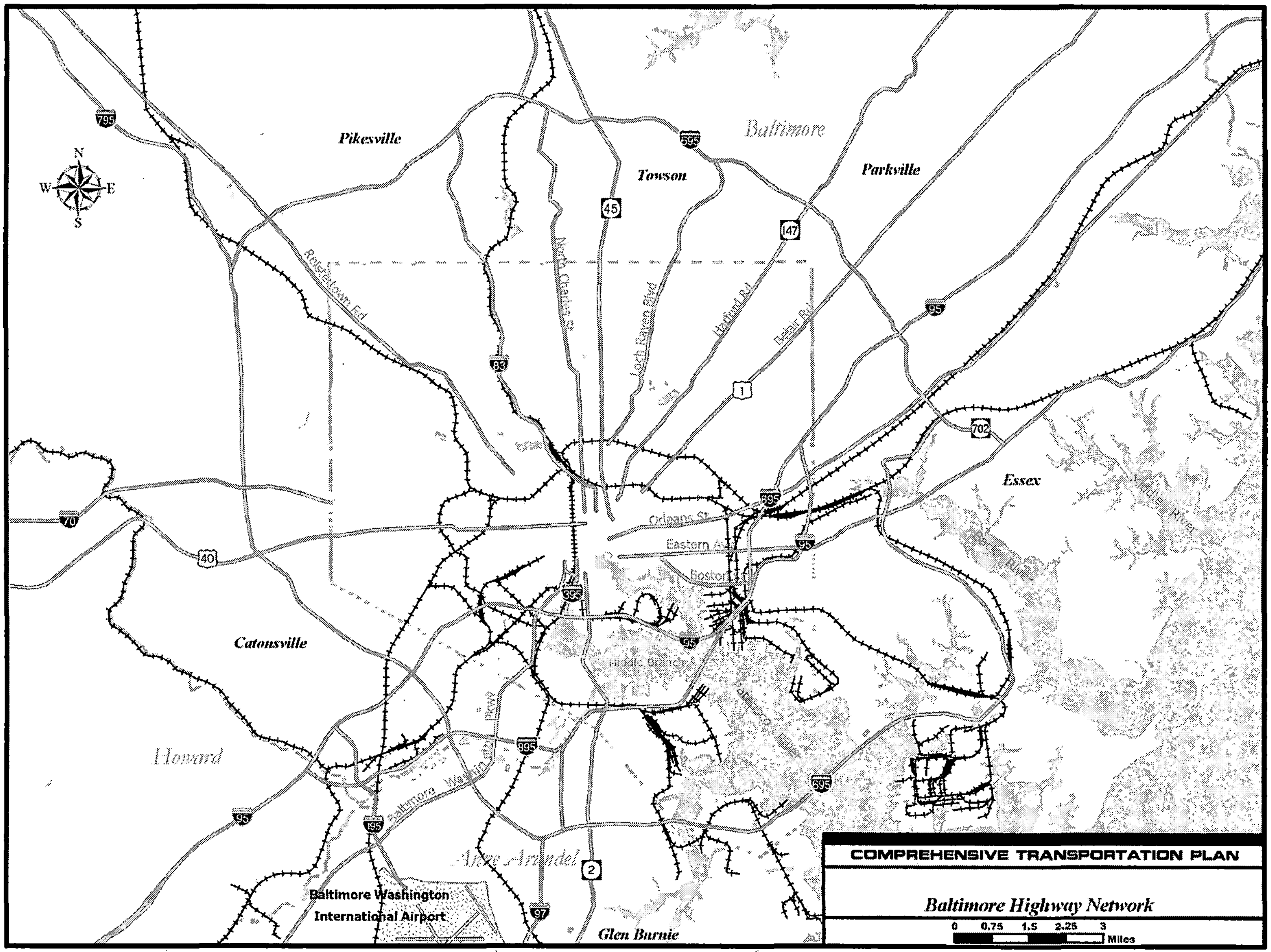


Figure 2 - 10: Typical Neighborhoods with Rail Lines (NOTE: Not all neighborhoods are labeled.)

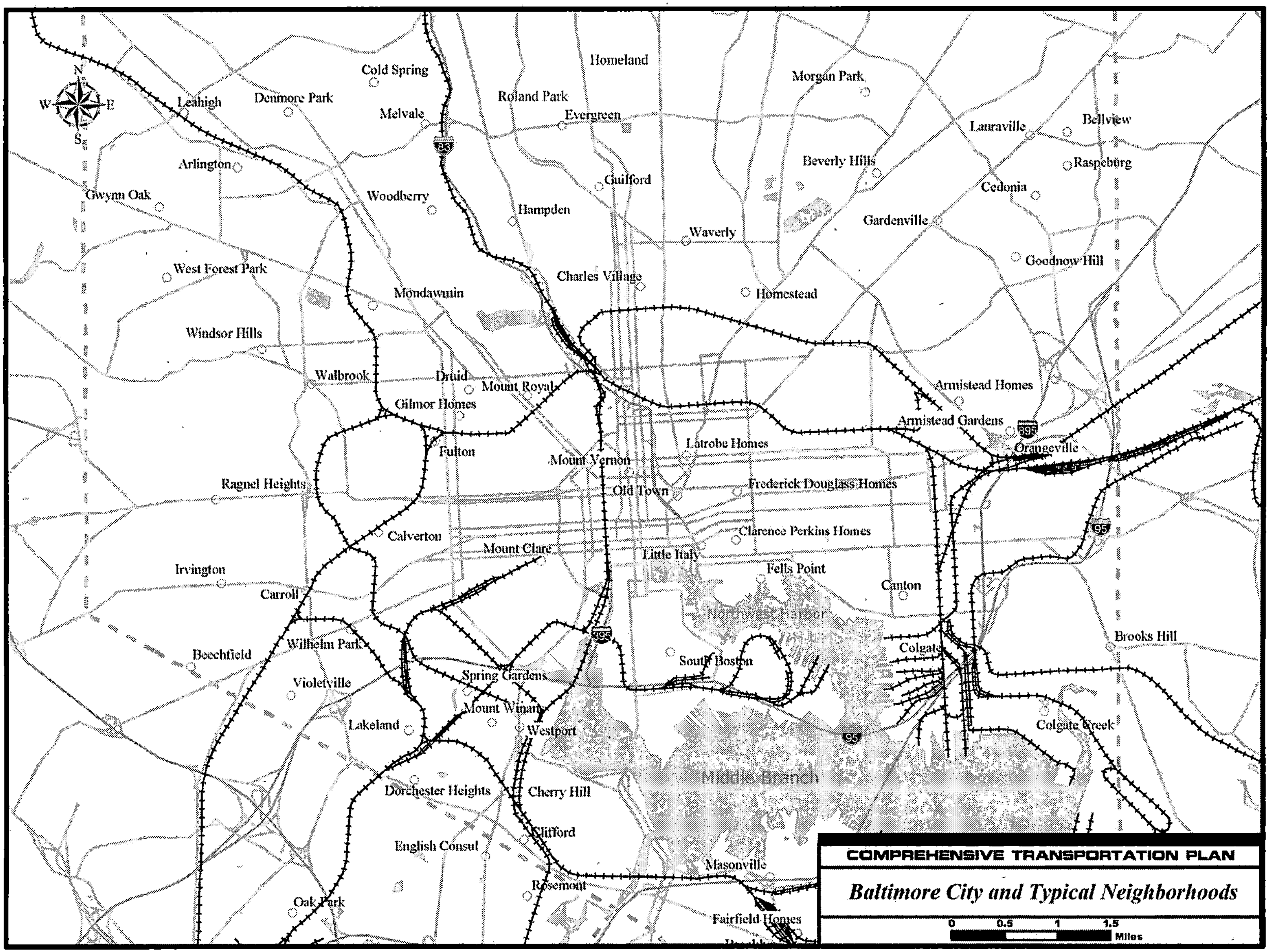
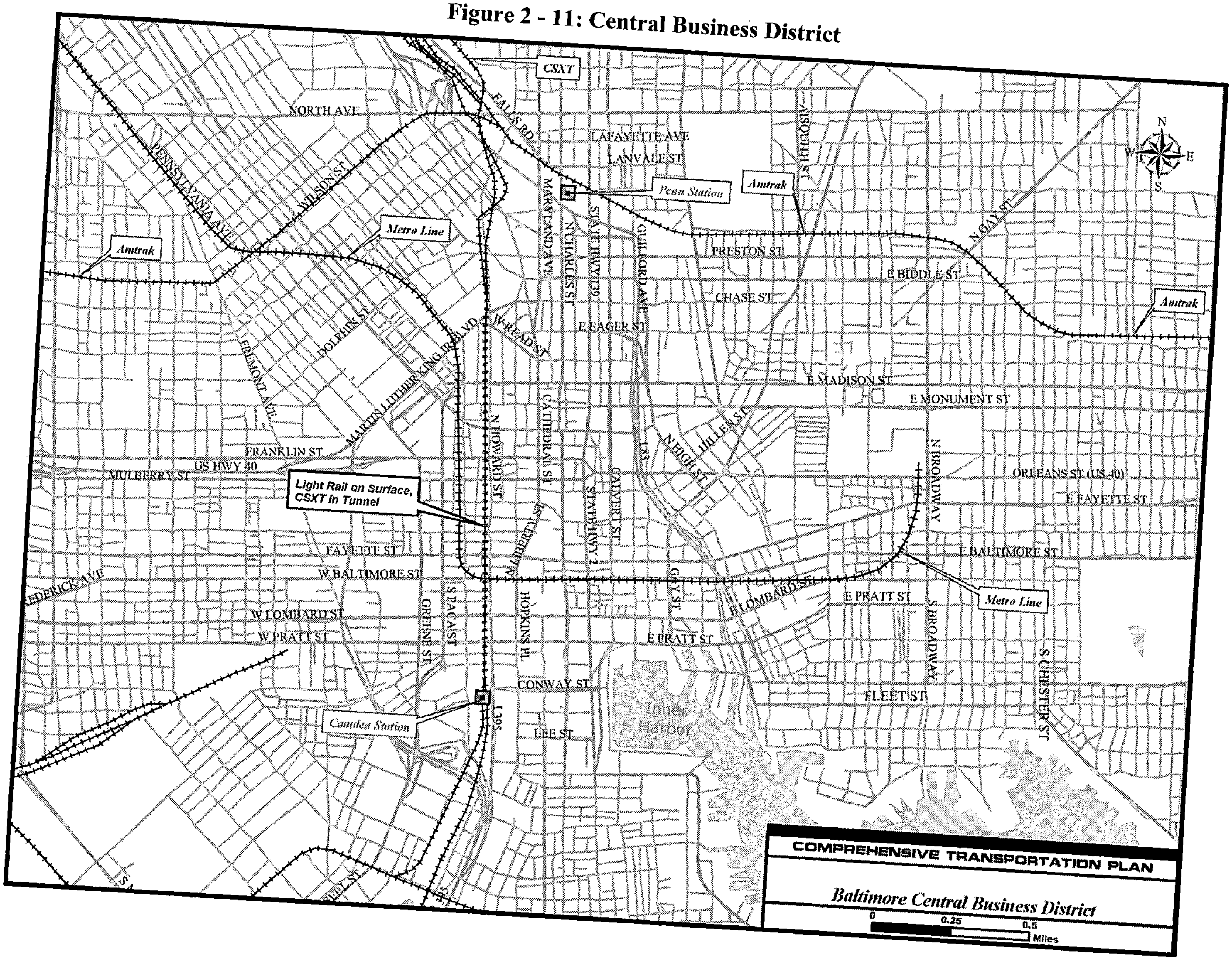


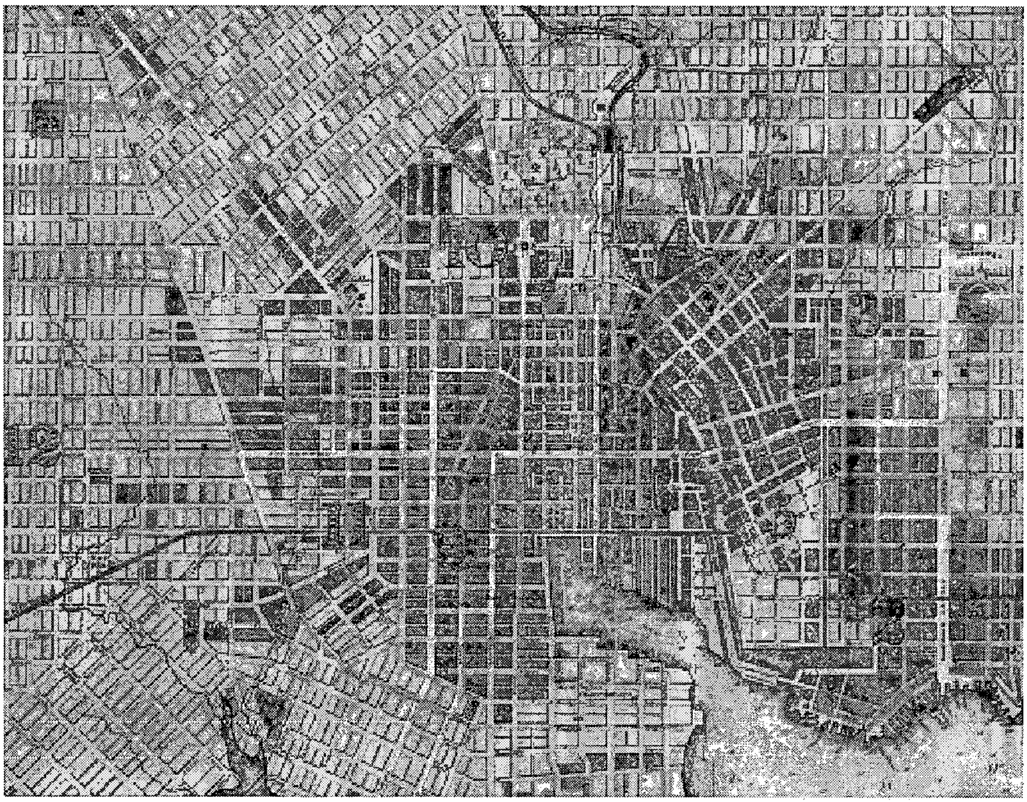
Figure 2 - 11: Central Business District



8. Implications of Baltimore's early importance

The age and early development of the CBD are noteworthy and germane to this report. In 1820, contemporary documents record a population of 62,738 for Baltimore; by 1836, it had grown by one-half to 91,000.[19] Thus by the dawn of the railway era, the area north of the Inner Harbor was already heavily built-up and populated, and growing more so, as a map dating to 1822-1836 (Figure 2 - 12) clearly demonstrates.

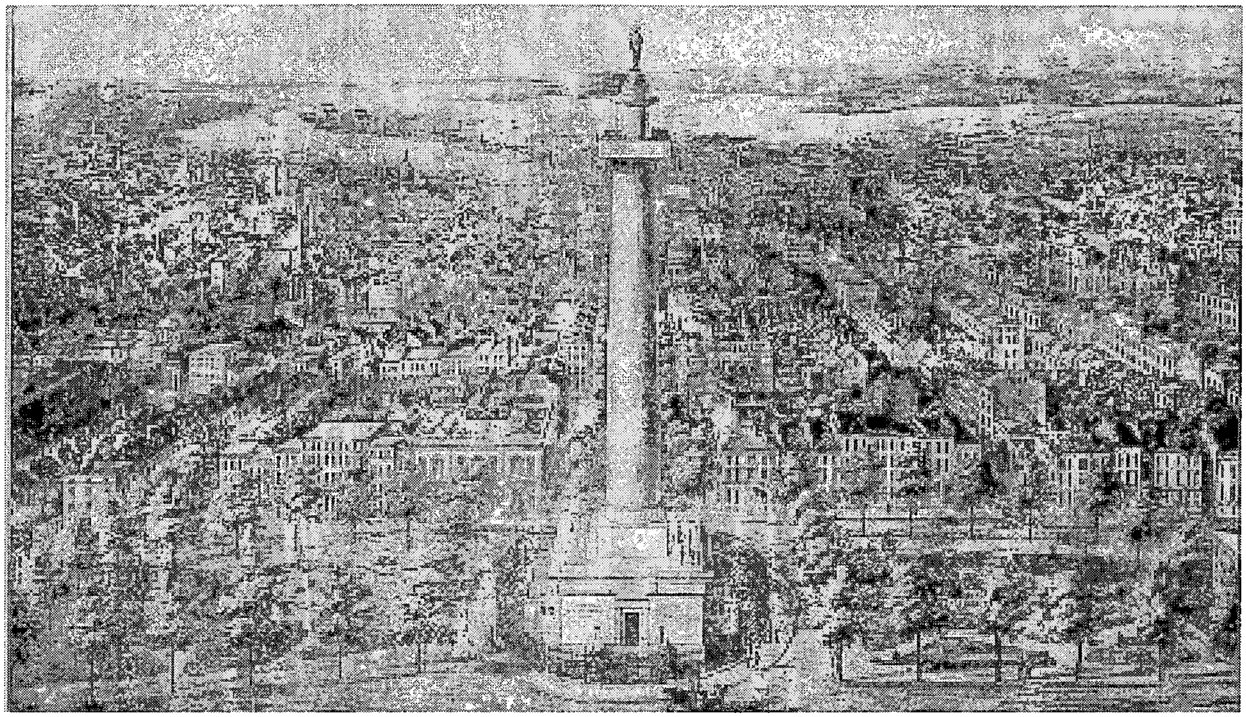
Figure 2 - 12: Early 19th-Century Development of Baltimore's CBD
(Map Surveyed 1822, Published 1836)



Therefore, even had the fledgling antebellum railroads found a satisfactory east-west through route across Baltimore, its cost would have been prohibitive. By the time the railroad companies matured in the later 19th Century, the development of the CBD had become even more intense, as a view looking south from the Washington Monument in 1880 indicates (Figure 2 - 13).

[19]The population figures and map are drawn from "Plan of the city of Baltimore compiled from actual survey by Fielding Lucas, Jr., 1822," call number G3844.B2 1836 .L8 TIL, Library of Congress Geography and Map Division Washington, D.C. 20540-4650, digital ID
(Copy one) g3844b wd000016 http://hdl.loc.gov/loc.gmd/g3844b.wd000016.

Figure 2 - 13:
View Looking South from the Washington Monument, 1880, Showing Heavy Development of CBD[20]



C. Development of the Baltimore Network

The complex historical development of the Baltimore rail network reflected geography, economics, and business relationships. The following summary presents the main stages of this development, with emphasis on the legacy facilities that still form the network's basis. For further details, readers are referred to excellent historical books covering the period and the roads involved.[21]

1. Stage 1: The early period and the line of least resistance (1827-1872)

During these formative years, neither the B&O nor the competing PRR possessed a "Northeast Corridor" through route across Baltimore. Passenger and freight movements across the City made use of various water-level expedients, such as horse-drawn cars along Pratt Street and car ferries across the harbor.

2. Stage 2: The Pennsylvania Railroad (PRR) consolidates through routes across Baltimore, in all directions (1873-1880)

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[20] Sachse (A.) & Company--The city of Baltimore City, Md. in 1880, reproduction number LC-USZ62-91157 DLC (b&w film copy neg.), repository: Library of Congress Prints and Photographs Division Washington, D.C. 20540, digital id (b&w film copy neg.) cph 3b37503 http://hdl.loc.gov/loc.pnp/cph.3b37503 ; (raster image) g3844b pm002541 http://hdl.loc.gov/loc.gmd/g3844b.pm002541

21 See especially *Royal Blue Line*, Herbert H. Harwood, Jr., Greenberg Publishing Company, Inc., 1990. The book is a source of abundant data relative to the expansion of the B&O to New York City and the subsequent variations of rail service between the two cities. The historical discussion in this section draws heavily on this source.

In this stage, the PRR carried out a master plan to establish direct through service between New York, Philadelphia, and Washington via Baltimore, as well as to create a through route from Washington and Baltimore to points west via Harrisburg, by:

- Building the present NEC route through the B&P and Union tunnels[22]; and
- At the route's junction with prestigious Charles Street, building a new Union Station[23] affording a connection with the Northern Central and Western Maryland railways to points north and west (and to downtown stations along the Jones Falls).

Although substandard geometrically even by the standards of the times (see Box 2 - 1), the PRR tunnels gave that carrier a through "Northeast Corridor" route.

Box 2 - 1: The PRR's Baltimore Tunnels Through the Years

The PRR's route through Baltimore was the result of the construction of a series of four under-street tunnels totaling 11,074 feet in length across north-Baltimore. The routing, alignment, and the grades were not ideal. The Union Tunnel north of the PRR passenger station has a 1.2 percent northward grade. However, the three tunnels south of the station, collectively referred to as the B&P Tunnel, are more restrictive. The tunnel consists of a single 7,669-foot bore separated by two short open cuts. A sharp curve at the south portal of the tunnel prevents southbound trains departing Baltimore Pennsylvania Station from accelerating beyond 30 mph. An uphill, mile-long, 1.34 percent grade further constrains train performance.

The PRR lowered the floor of the tunnel approximately 2-1/2 feet in 1916-17 to accommodate larger trains. The work included: underpinning of the side walls, installation of a concrete invert slab, and reconstruction of the track structure. The bases of the tunnel walls were chipped away to improve horizontal clearance.

Prior to the electrification of the New York – Washington main line in 1935, the poorly ventilated tunnels easily filled with smoke from the steam locomotives. The smoke also was a nuisance to the residential neighborhoods above the tunnels.

The tunnel was gunited to waterproof the arch and prevent icicles from shorting out the catenary wires prior to the initiation of electrified operation. However, financial considerations prevented the PRR from constructing a new passenger tunnel on the Presstman Street alignment, for which it previously had acquired rights. The PRR's plan envisioned using the new B&P and the original Union Tunnel for passenger operations, while the old B&P and a new, parallel Union Tunnel (completed in the 1930s) would have been used for freight operations.

In the late 1950s, the B&P tunnel, with its low and narrow clearances, became a hindrance to the growth of PRR's piggyback business. The curve at Pennsylvania Avenue was the biggest constraint. The PRR modified the tunnel walls and ceiling for a distance of 2,200 feet to improve clearance and enable high cars and piggyback trailers to traverse the tunnel without damaging their roofs. Second, a 928-foot long gantlet track was installed on southbound track 3 to route trains 17 inches closer to the middle of the tunnel. However, trains could not operate on track 2 while track 3 and the gantlet were being used. The use of the gantlet created a single-track tunnel; if a freight train broke down while using the gantlet, the tunnel was closed to all traffic until the train was moved.

Even with the gantlet, cars in excess of Plate C or in excess of 16 feet 3 inches in height were prevented from using the tunnel.

The tunnel underwent rehabilitation as part of the NECIP in the early 1980s. The repairs included replacing the existing invert, repairing the tunnel lining, upgrading the track structure, installing a new gantlet track,[24] and rehabilitating the tunnel drainage system. No fundamental change, however, was made in the tunnel's difficult geometry.

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[22] This was completed in 1873. Herbert Harwood, op. cit., p.24.

[23] Subsequently renamed "Pennsylvania Station."

[24] The gantlet track was subsequently removed due to changes in freight traffic patterns.

3. **Stage 3: The B&O struggles to attain its own direct route through Baltimore (1880-1900)**

Competitive pressures forced the B&O to provide its own northeast-southwest route through Baltimore. While readily constructing its own "Royal Blue" line from East Baltimore to Philadelphia, the B&O faced a much greater difficulty—due to the geographic and developmental factors stressed earlier in this chapter—in forging a link across its home town. "To build eastward toward Philadelphia [from Camden Station, the B&O] was *blocked on one side by the densely-developed city* and *on the other by the harbor, which was too wide to bridge or tunnel at any reasonable cost.*"[25] [Emphasis added.[26]]

The B&O's solution, with which its successor roads have lived to this day, was to build a tunnel north from Camden Station in the soft and watered soils under Howard Street. The "Belt Line" would emerge from the tunnel at Mount Royal Station (designed as an "uptown" stop very near the PRR's Pennsylvania Station), proceed north to cross over the PRR, and then make an almost 90-degree right turn to meet the Royal Blue Line at Bay View. The tunnel route, due to its length, adverse grades, and curves—all of which were evident from the beginning—would require electrification, which persisted until Dieselization in the 1950s.

With the exception of the PRR's second Union Tunnel in the 1930s, Baltimore's main line rail configuration was essentially fixed on completion of the B&O's Belt Line.

4. **Summation: Geography and history unite to create challenges in Baltimore.**

With the Piedmont Plateau virtually reaching the sea, with precocious urban development blocking water-level routes along the harbor shore, with no single railroad controlling an integral route through the city until well into the 19th Century, and with strong competition among carriers precluding concerted action, no easy, exploitable railway alignment through Baltimore has ever existed. Once the substandard B&P and Howard Street routes were in place, the two companies could never jointly develop a solution that would rectify the operating problems and undue expenses of the two problematic alignments. Meanwhile, the evolution of railway technology has made the two routes even less serviceable than before, and more needful of remediation.

The following chapter examines in more detail the physical plant as it stands today.

[25] Herbert Harwood, *op. cit.*, p. 31.
[26] Note the figures above that emphasize the early and complete development of Baltimore City north of the Inner Harbor

Box 2 - 2: The B&O's Howard Street Tunnel Through the Years

The B&O originally proposed to connect its Camden Station on the southwest side of downtown Baltimore to Philadelphia via an elevated line near the downtown shoreline. This was expensive and controversial; as an alternative, the B&O built the 7.3-mile Baltimore Belt Railroad north from Camden Station under Howard Street, across the Jones Falls Valley to Huntingdon Avenue, and then eastward across Baltimore's north side to the B&O's Philadelphia line at Bay View.[27]

The Belt Line included the 1.4-mile-long Howard Street Tunnel and eight short tunnels. The Howard Street Tunnel proved difficult to construct and then to operate. The tunnel had a grade of 0.8 percent to its north portal; from there to Huntingdon Avenue, the grade steepened until it reached a maximum of 1.55 percent. The 7,340-foot-long tunnel became the country's longest soft-earth tunnel. The Belt Line crossed over the top of the B&P tunnel near its east portal.

Train operations began in 1895 with electric traction, which was eliminated in the early 1950s with the B&O's Dieselization. Following the elimination of passenger service in 1958, the B&O and its successors single-tracked the tunnel and made other minor changes to obtain better clearances. Capacity was reduced, however, and the basic geometry of the tunnel remained unchanged from its 1896 state.

On Wednesday, July 18, 2001, a major fire occurred in the Howard Street Tunnel when part of a 60-car CSXT freight train derailed. A separation was found between the 45th and 46th cars, and Cars 45 through 54 were derailed, some of them carrying hazardous materials. The derailment occurred below the intersection of Howard and Lombard Streets. The major source of the fire was the 52nd car, a tank car loaded with tripropylene. The fire ignited adjacent cars loaded with paper, pulpwood, and plywood. A break in a 40-inch water main almost directly above the derailment hampered emergency response efforts. On July 21, emergency personnel removed three cars from the tunnel, with their contents still burning, and finally extinguished the fire. A subsequent inspection found no significant structural damage to the tunnel, allowing train traffic to resume. The first freight train passed through the tunnel at 8:48 a.m. on July 24.

The tunnel closing caused major disruption to CSXT freight traffic, Maryland Rail Commuter (MARC) commuter trains, and to Central Light Rail Line trains and bus lines that traversed Howard Street. To avoid the Howard Street Tunnel, CSXT had to send freight trains west to Cleveland, north to Albany, New York, and then south to Baltimore, incurring a three- to four-day delay. Some CSXT trains were rerouted via the busy NS line through Manassas, Virginia, Hagerstown, Maryland, and Harrisburg, Pennsylvania. At one point during the fire, eight CSXT trains that would have used the tunnel were detouring through Cumberland, Maryland, and Youngstown Ohio; five through Hagerstown and Harrisburg; five through Cleveland and Albany, New York; and 12 trains were stopping in various yards.

Beyond the adverse effects on railroad traffic, there was a massive effect on life and activities in downtown Baltimore. The incident forced the closing of streets and business over much of downtown for several days. Officials cancelled three Baltimore Orioles game, resulting in a $5 million loss to the team. They also closed Howard Street, along with 14 other cross streets, for five days. A two-block stretch of Howard Street remained closed for six more weeks. MTA rerouted 23 bus lines, and MARC service to Camden Station was suspended. The fire also disrupted or shut down many other activities for the duration. The fire and burst water main damaged power cables and left 1,200 Baltimore buildings without electricity. Severed fiber-optic lines backed up traffic regionally and nationally because the fiber-optic cable through the tunnel is a major line for the extremely busy Northeast corridor.

The aftermath of the fire affected some activities for longer periods. MTA shut down light rail service through the city for over seven weeks, with shuttle buses running between the North Avenue and Patapsco stations, and later between North Avenue and Camden. The City did not open the intersection of Howard and Lombard, one of the busiest in the city, until September 5. After a three-year investigation, the National Transportation Safety Board on December 16, 2004 issued an accident investigation report[28] *stating that it could not determine the cause of the accident. Therefore, this disaster can provide no lessons learned for the present study. However, it is reasonable to presume that a new facility, with easier grades and curves, modern construction, and state-of-the-art fire and life safety provisions, might preclude a great number of possible contributing factors to such disasters as that which occurred in the Howard Street Tunnel.*

[27] Herbert Harwood, op. cit., pp. 85 ff.

[28] National Transportation Board, http://www.ntsb.gov/publictn/2004/RAB0408.htm, December 16, 2004.

Chapter Three
TODAY'S INFRASTRUCTURE

The prior chapter explained how Baltimore's challenging railway plant came to be; the present chapter examines today's infrastructure in some detail. Although emphasis falls on the CSXT and NEC main lines, any further development of restructuring options would require intensive scrutiny of the storage and classification yards, branch lines, and trackage serving industries and the Port of Baltimore.

The geometrically substandard railroads of the Baltimore region can neither assure reliable operations, nor expeditiously move their critical burden of passenger and freight traffic, nor accommodate many state-of-the-art, high-capacity freight cars. These manifest failings provide the background for an analysis of potential improvements.

A. Limits of the study area

This report primarily treats the railroads in the region between the Gunpowder River,[1] to the northeast of Baltimore City, and Halethorpe (in the vicinity of Amtrak's BWI Airport Rail Station), where the CSXT tracks cross over Amtrak's Northeast Corridor. (Figure 3 - 1.)

The major railroads in the study area are Amtrak, CSXT, and NS.[2] Two short line railroads, the Canton Railroad and the Patapsco & Back Rivers Railroad (P&BR), serve selected portions of the industrial area on the eastern side of the region. Although the layout of trackage must be complex to reach the Port and industries, the main lines essentially consist of two parallel routes, those of Amtrak and CSXT, both serving the same Northeast Corridor (NEC) metropolitan areas. The principal yards, stations, and junctions in the study area are shown in Figure 3 - 2.

Baltimore—important as it is—cannot undergo scrutiny entirely in isolation. For instance, improvements in Baltimore to attain more generous freight car clearances along the NEC traffic lanes would be of limited value if the clearance limitations in Washington's Virginia Avenue Tunnel and at other locations are left unaddressed. For reasons such as this, the study team not only considered an extended region from the Susquehanna River through the District of Columbia (Figure 3 - 3), but was also mindful of the larger-scale traffic flows across the Nation that depend on a smoothly functioning network in Baltimore.[3]

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[1] CSXT and NS freight yards are located at Bay View, about 10 miles southwest of the Gunpowder River.

[2] Although NS owns no main lines in the immediate area, it accesses Baltimore on trackage rights and owns important yard and industrial facilities.

[3] See, for example, the preceding discussion of the nationwide impacts of the Howard Street Tunnel disruptions due to a fire in 2001 (Chapter Two, Box 2-2, "The B&O's Howard Street Tunnel Through the Years").

Figure 3 - 1: The Study Area

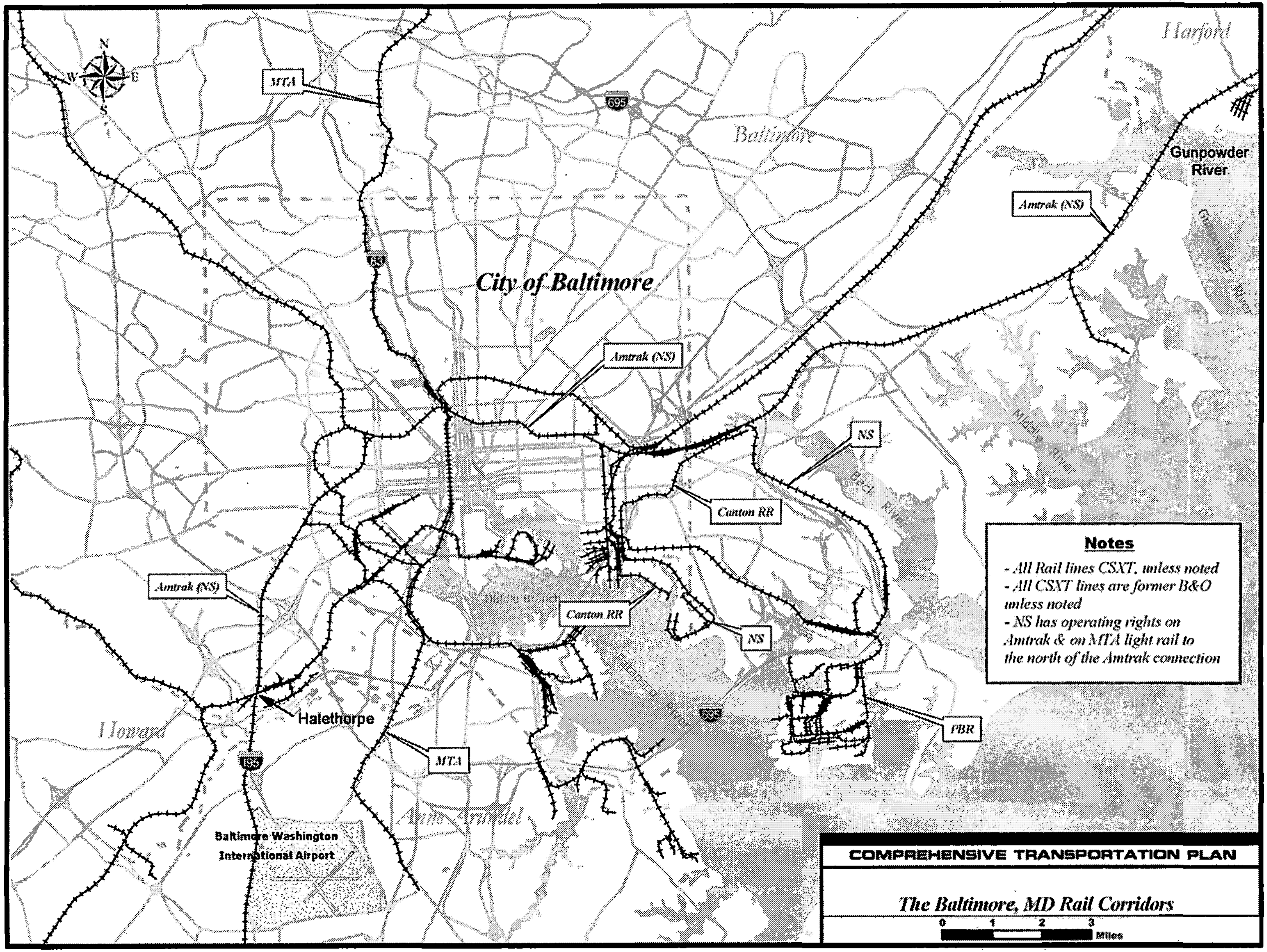


Figure 3 - 2: Principal Yards, Stations, and Junctions

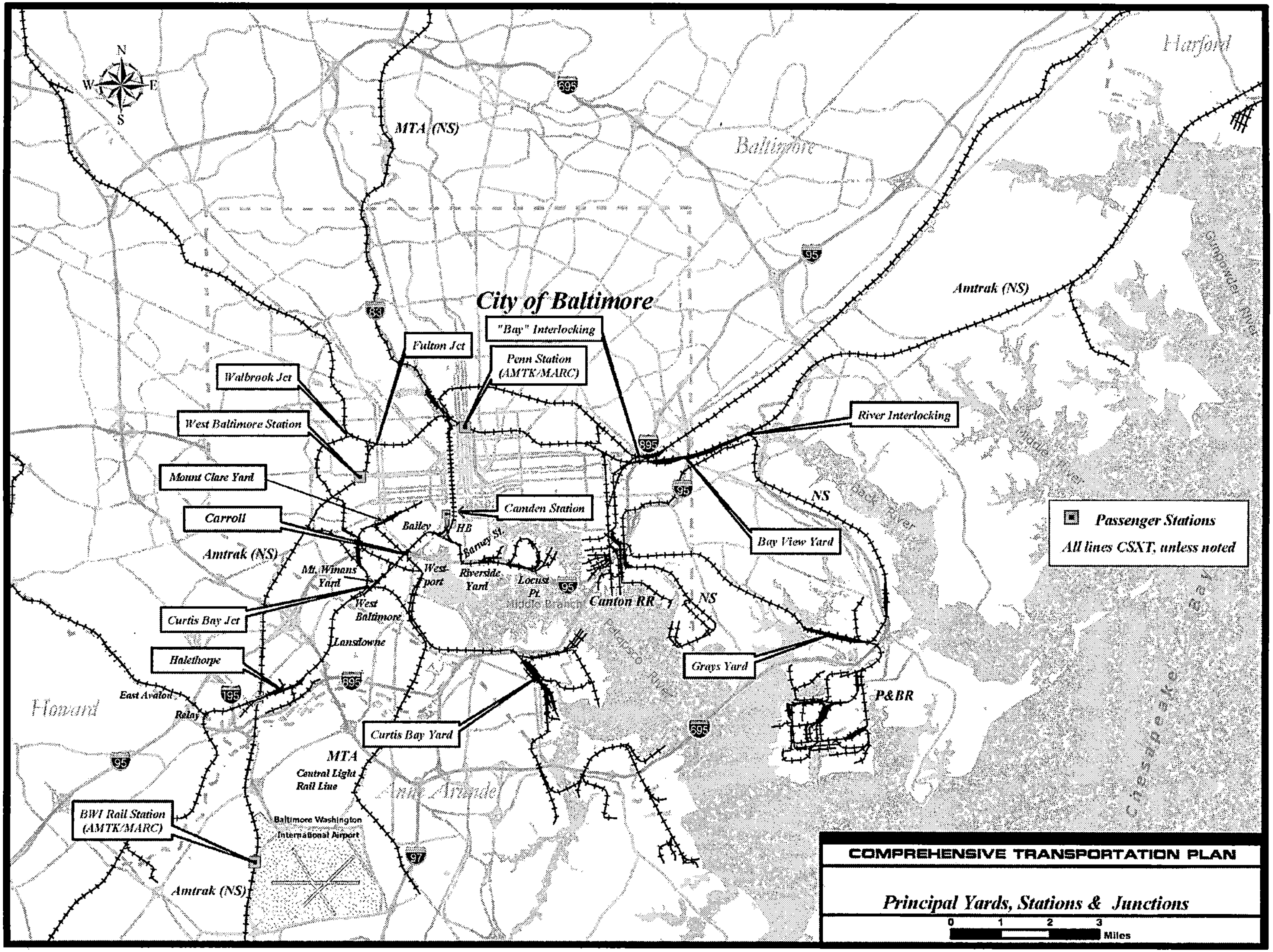
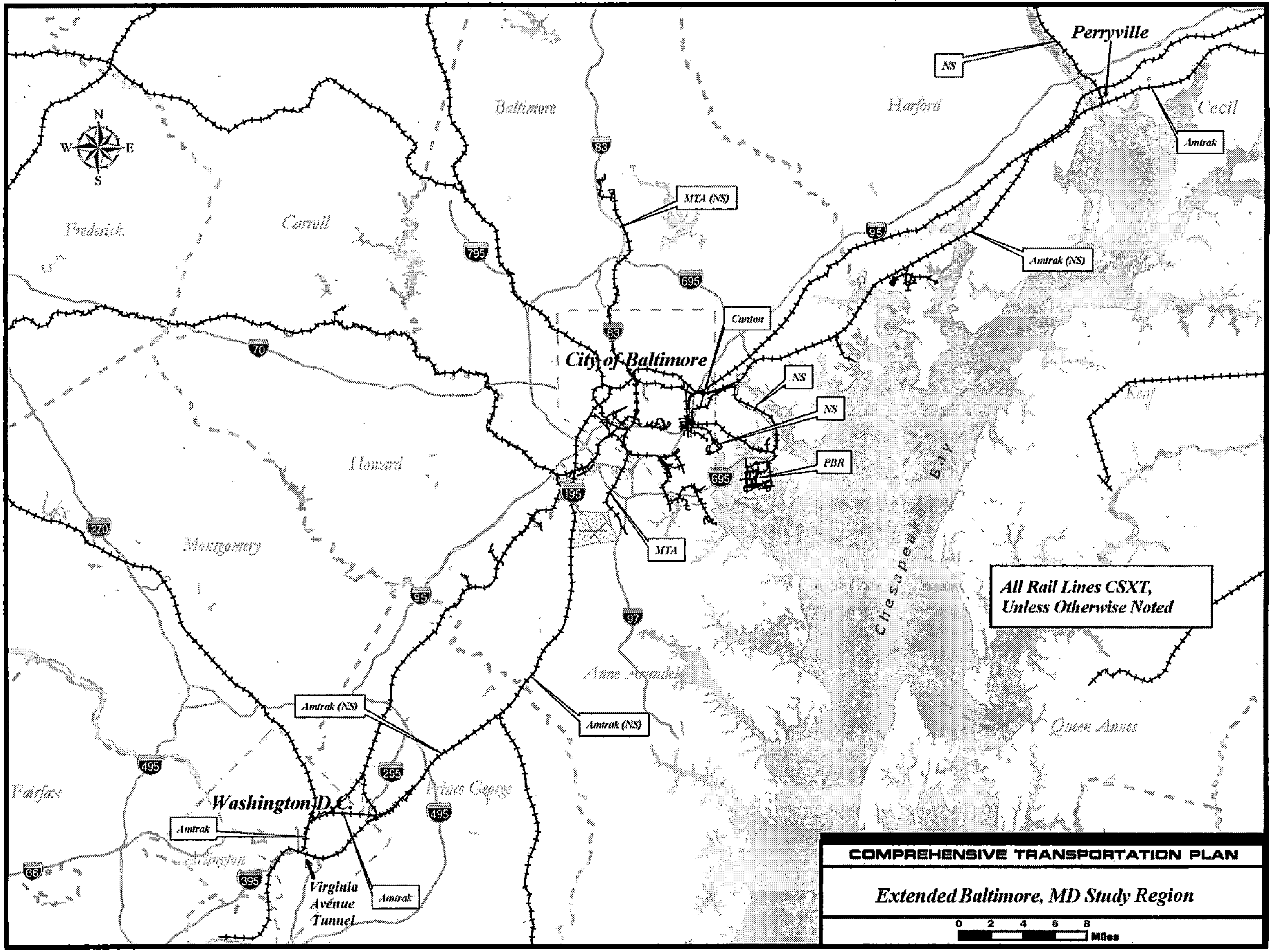


Figure 3 - 3: Extended Study Region



B. Ownership and control

As noted earlier, the owners of the railroad main lines in the study area are Amtrak and CSXT. NS owns only freight support facilities—yards, branch lines, industrial tracks, and appurtenances.

A summary of current track ownership and operating control appears in Table 3 - 1.

Table 3 - 1: Track Ownership and Operating Control of Main, Branch, and Short Lines in the Study Area

	Locations	Milepost[4]		Owner	Subdivision	Route-Miles	Dispatched From
		Between-	And-				
CSXT Main Lines	East Aikin (Perryville) – Bay View	BAK 54.5	BAK 89.6	CSXT	Philadelphia	35.1	Jacksonville, FL
CSXT Main Lines	Bay View – HB Tower	BAK 89.6	BAK 96.0	CSXT	Baltimore Terminal	3.4	Jacksonville, FL
CSXT Main Lines	HB Tower – Halethorpe	BAA 0.4	BAA 5.8	CSXT	Baltimore Terminal	5.4	Jacksonville, FL
CSXT Main Lines	Halethorpe – JD	BAA 5.8	BAA 33.6	CSXT	Capital	27.8	Jacksonville, FL
CSXT Main Lines	*Old Main Line:* Halethorpe–East Avalon	BAC 5.9	BAC 7.9	CSXT	Old Main Line	2	Jacksonville, FL
CSXT Branches	*Sparrows Point Branch:* Bay View Yard to Grays Yard	0	6	CSXT	Baltimore Terminal	6	Trainmaster Penn Mary
CSXT Branches	*Passenger Terminal Lead Track:* Camden Station – HB or Carroll	BAA 0.0	BAA 0.7	CSXT	Baltimore Terminal	0.7	Jacksonville, FL
CSXT Branches	*Locust Point Branch:* Barney St. – Bailey	BAM 0.0	BAA 0.7	CSXT	Baltimore Terminal	0.8	Jacksonville, FL
CSXT Branches	*Mt. Clare Branch:* Carroll – Curtis Bay Junction	BAN 0.0	BAN 2.2	CSXT	Baltimore Terminal	2.2	Jacksonville, FL
CSXT Branches	*Curtis Bay Branch:* Brooklyn – Curtis Bay Junction	BAO 0.0	BAO 3.3	CSXT	Baltimore Terminal	3.3	Jacksonville, FL
CSXT Branches	*Marley Neck Industrial Track:* South End Curtis Bay Yard to Curtis Creek	BBR 0.0	BBR 6.2	CSXT	Baltimore Terminal	6.2	n/a
CSXT Branches	*Former Western Maryland Main Line:* Westport – Walbrook Jct	BRN 0.5	BAS 3.8	CSXT	Baltimore Terminal and Hanover	4.3	Jacksonville, FL
Amtrak NEC Main Line	*The Northeast Corridor:* Perryville – BWI Airport Station	59.4	106.3	Amtrak	Main Line-Philadelphia to Washington (PW)	56.9	Philadelphia
NS Branches	*Sparrows Point Industrial Track:* Bay View Yard to North Point Boulevard			NS		5.6	Yardmaster Bay View
NS Branches	*Bear Creek Running Track:* Canton Jct. to Dundalk			NS		5.4	Yardmaster Bay View
Short Lines	*Canton Railroad:* East Baltimore, MD					6	(Short line in local service)
Short Lines	*Patapsco & Back Rivers Railroad:* Sparrows Point, MD						(Short line in local service)

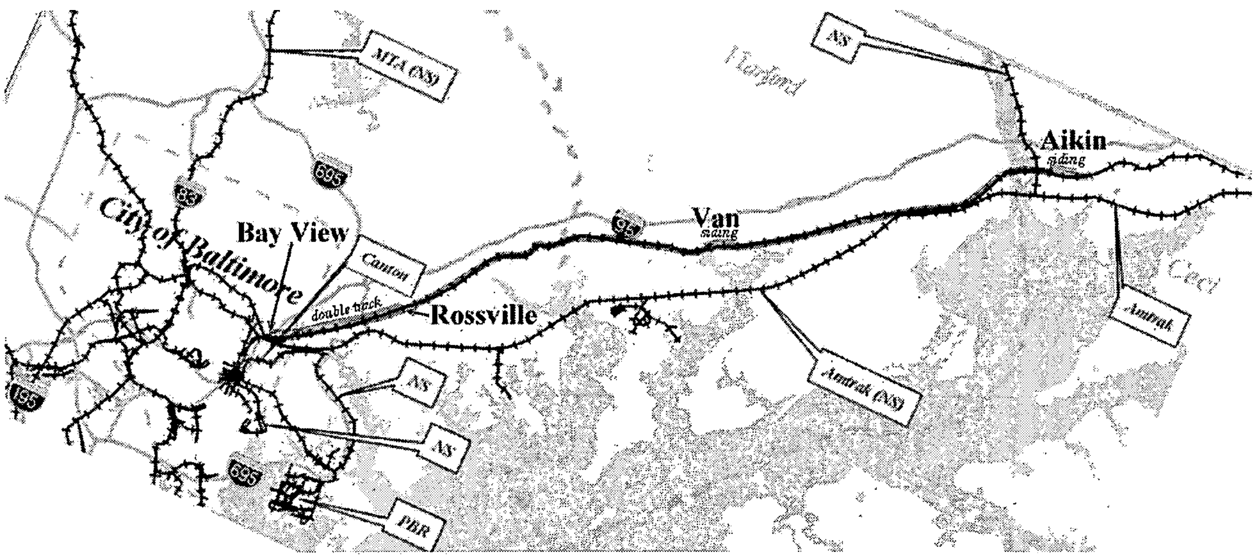
[4] Several numbering systems are in use in the study area; these reflect the subdivision organization of CSXT and the ownership of the rail segments in question by CSXT, Amtrak, and two short line railroads.

C. Trackage and track conditions by segment

This report assumes, on the basis of limited observations in the course of the study, that all segments of trackage have been maintained to a level of repair that meets or exceeds the FRA safety standards for the reported speed classifications.[5]

1. CSXT Main Line

Figure 3 - 4: East Aikin–Bay View (CSXT Main Line)



a. East Aikin–Bay View

This segment (Figure 3 - 4), a portion of the Philadelphia Subdivision of the CSXT mainline, is primarily single-tracked with sidings. The sidings include the 10,000-foot Aikin siding (east of the Susquehanna River Bridge) and the 10,450-foot Van siding. The Subdivision is double-tracked between Rossville (BAK 84.4) and Bay View (BAK 89.6).[6] The maximum freight train speed is 50 mph east of Bay View.

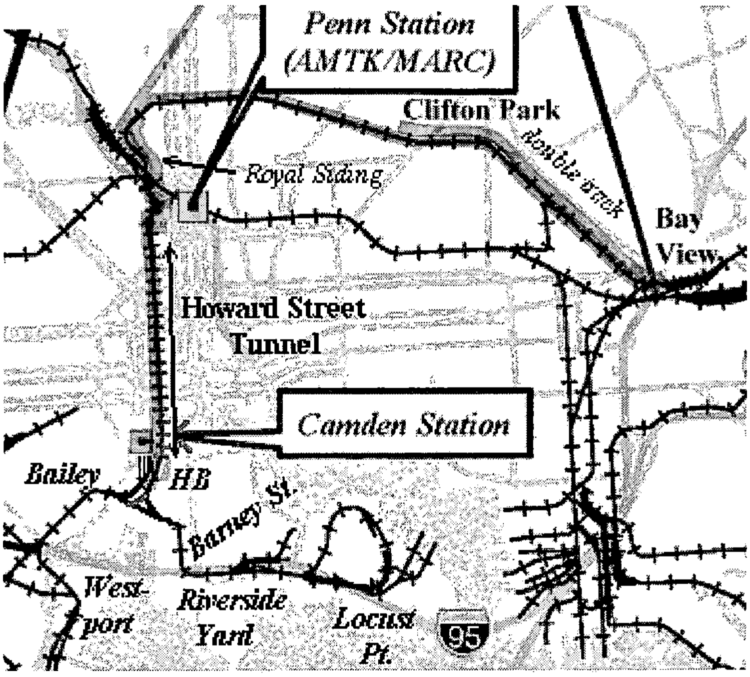
b. Bay View–HB Tower

This segment, a portion of the Baltimore Terminal Subdivision of the CSXT Main Line, is primarily single-tracked with one siding— the 4,600-foot Royal siding, which is located at the north end of the Howard Street Tunnel. The Subdivision is double-tracked between Bay View (BAK 89.6) and Clifton Park (BAK 91.5). The segment of the line between Clifton Park and HB Tower includes eight short tunnels and the Howard Street Tunnel. The rail line is single-tracked

[5] No conclusions regarding the safety of the infrastructure should be drawn from this assumption, which is for planning purposes only.

[6] The entire B&O line between Baltimore and Philadelphia was, however, double-tracked at its inception. Herbert Harwood, op. cit., p. 43.

Figure 3 - 5: CSXT, Bay View to HB



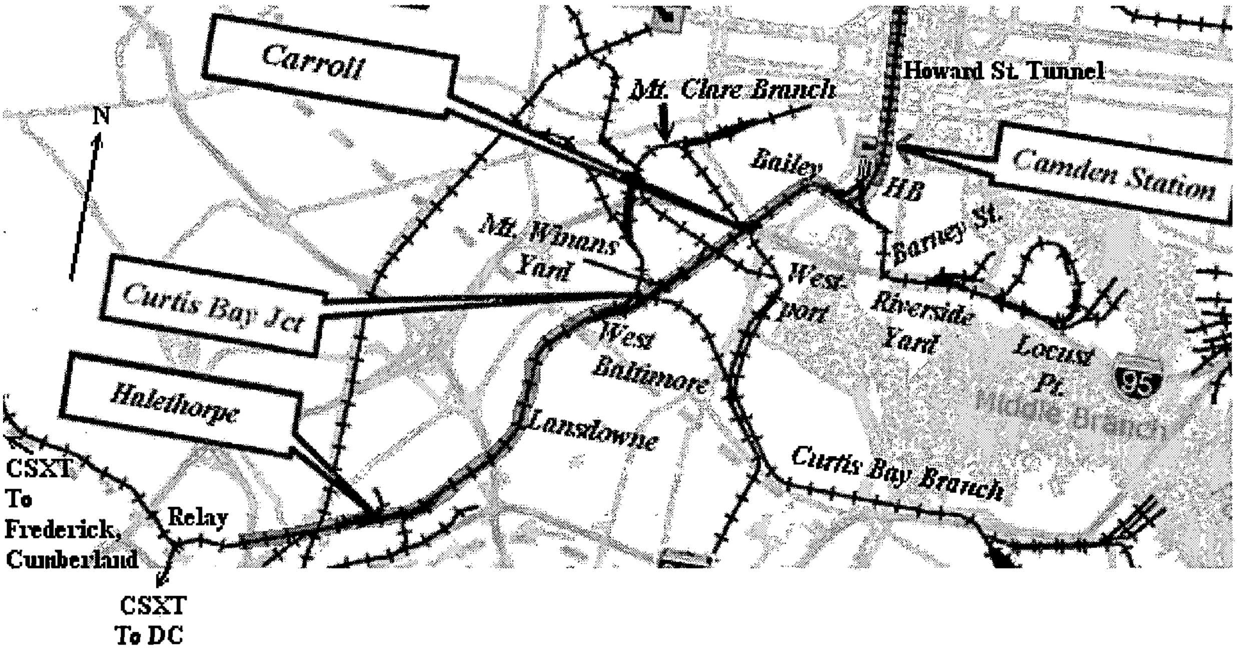
through the tunnels for clearance purposes. Passenger trains no longer operate over the line. The maximum freight train speed is 35 mph between Bay View and HB Tower.

c. HB Tower–Halethorpe

This line is a segment of the CSXT main line between Baltimore and Washington. MARC commuter trains originate on the passenger lead tracks at Camden Station and operate to Washington Union Station. The track configuration allows commuter train operations to merge with the main line either at HB (BAA 0.4) or Carroll (BAA 1.5). The Baltimore Terminal Subdivision is presently:

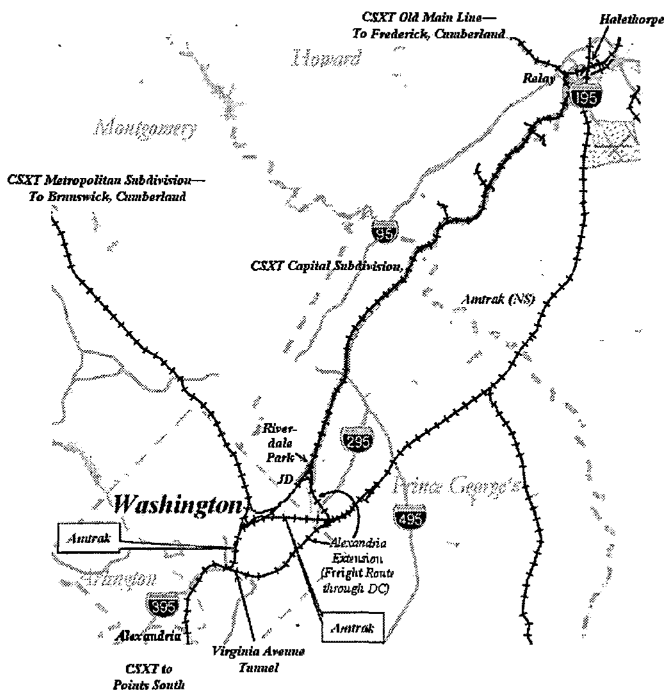
- Double-tracked for freight service between Bailey (BAA 0.7) and Carroll (BAA 1.5); a third track is configured exclusively for passenger train access to and from Camden Station;
- Double-tracked to West Baltimore (BAA 3.2), where the tracks to Curtis Bay Junction, the Curtis Bay Branch, and the Mt. Clare Branch become parallel to the main line tracks;
- Triple-tracked to Lansdowne (BAA 3.8); and
- Quadruple-tracked to Halethorpe (BAA 5.8).

Figure 3 - 6: HB to Halethorpe



West of Halethorpe (BAA 5.8), the CSXT mainline becomes the Capital Subdivision. The Old Main Line Subdivision to Cumberland and points west diverges from the Capital Subdivision at Relay (BAA 9.0).

Figure 3 - 7: Overview Halethorpe—JD



The maximum passenger train speed is 50 mph; the maximum freight train speed is 40 mph.

d. Halethorpe – JD

This segment of the Capital Subdivision is primarily double-tracked[7]. The maximum passenger train speed is 70 mph; the maximum freight train speed is 55 mph. There also are a few short yard leads and storage tracks to access yards, serve local industries, and store cars.

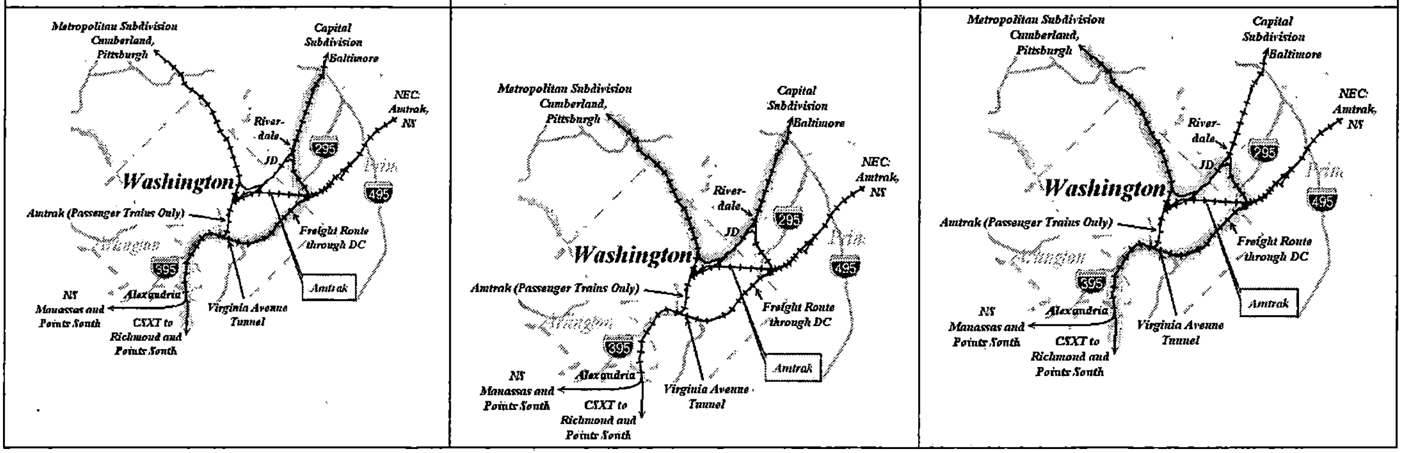
The wye connection to the Alexandria Extension is located in Hyattsville between Riverdale Park (BAA 32.7) and JD (BAA 33.6). This connection facilitates the following three movements, each in both directions (see Figure 3 - 8):

[7] Commuter trains use short sidings at Greenbelt.

1. Between Baltimore and points north, and Alexandria, Virginia and points south, via Anacostia and the Virginia Avenue Tunnel in D.C.;
2. Between Baltimore and points north, and Cumberland and points west,[8] via the CSXT wye just north of Union Station and the Metropolitan Subdivision; and
3. Between Cumberland and points west, and Alexandria and points south, also via the CSXT wye just north of Union Station and the Metropolitan Subdivision.

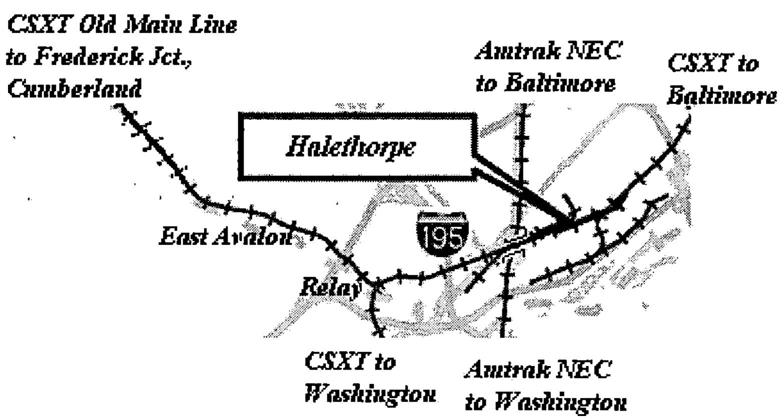
Figure 3 - 8: CSXT Movements Through Washington

(1) North—South Moves	(2) East—West Moves	(3) West—South Moves



Of the three CSXT traffic flows described above, one—the major East Coast north/south movement—is constrained by both the Virginia Avenue Tunnel in Washington and the Howard Street Tunnel in Baltimore, and their approaches. (Any analogous NS freight moves via the NEC are similarly constrained, by the Virginia Avenue, B&P, and Union Tunnels and approaches.) Thus, to be fully effective, any comprehensive approach to the Baltimore challenge would need to address clearance and other limitations in and near Washington as well; hence the importance of Washington's rail freight traffic flows, and the inclusion of the Nation's Capital as part of the extended study area.

Figure 3 - 9: Halethorpe – East Avalon



[8] Historically, CSXT and its predecessors have used two routes for freight trains between Baltimore and points west: one via the Old Main Line and Frederick Junction, the other via the Capital and Metropolitan Subdivisions.

e. **Halethorpe – East Avalon (Figure 3 - 9)**

At Halethorpe, the CSXT main line crosses over Amtrak's NEC. At Relay there is a junction between the Old Main Line (to and from Cumberland via Frederick Junction) and the Capital Subdivision (to and from Washington and points west and south). The Old Main Line Subdivision is generally single-tracked west of Relay. The MAS westward initially is 25 mph; it increases to 30 mph at MP BAC 7.4.

2. **Selected CSXT Branches**

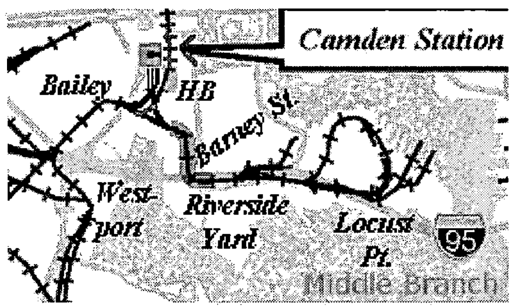
a. **Sparrows Point Industrial Track**

This CSXT branch extends for approximately six miles from a wye at the west end of Bay View Yard, southward through the Canton area of Baltimore, thence eastward to Grays Yard in Sparrows Point. The branch, providing for freight car interchange between CSXT and the Canton and P&BR railroads, is controlled by the yardmaster at Penn-Mary Yard in Canton.[9]

b. **Passenger Terminal Lead Track**

Allowing CSXT/MARC commuter trains to access the Camden Station terminal tracks, this 0.7 mile track operates in conjunction with the HB Tower–Halethorpe segment described above (page 7; note the configuration leading to Camden Station in Figure 3 - 10).

Figure 3 - 10: Locust Point Branch



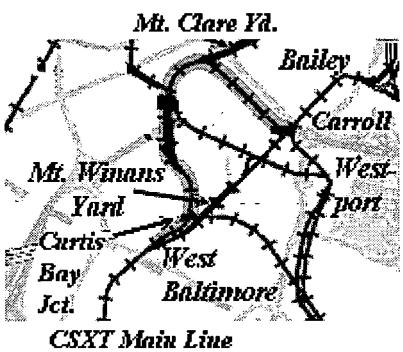
c. **Barney St. – Bailey (Locust Point Branch)**

The wye connection to the Locust Point Branch is located between HB (BAA 0.4) and Bailey (BAA 0.7). The west wye is the extension eastward of Baltimore Terminal Subdivision Track 2 to Locust Point Yard. The east wye provides a connection to and from the main line and the Howard Street Tunnel. The branch is double-tracked to Locust Point Yard.

d. **Carroll – Curtis Bay Junction (Mt. Clare Branch)**

Initially constructed in 1829 as the main line[10] of the B&O west and south of Baltimore, the Mt. Clare Branch provides access to Mt. Clare Yard and an alternate route between West Baltimore and the Baltimore Terminal Subdivision at Carroll. The branch is non-signaled, except for the approach to Carroll. The branch is single-tracked over the historic Carrollton Viaduct and to Carroll. Currently, the maximum authorized speed (MAS) for trains is 10 mph.

Figure 3 - 11: Mt. Clare Branch

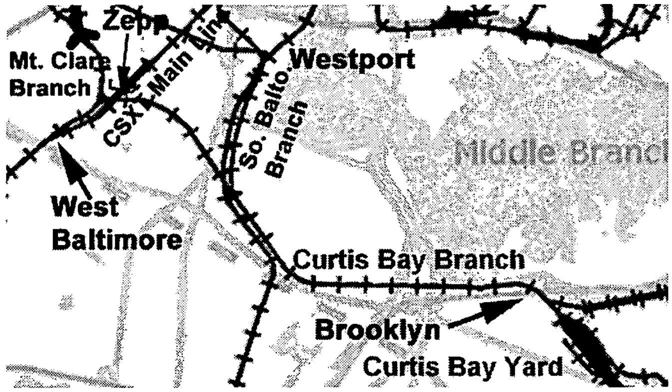


[9] CSX Transportation, Baltimore Division Timetable No. 4, April 2002, p. 6.
[10] Now known as the Old Main Line west of Relay.

e. **Curtis Bay Junction - Brooklyn (Curtis Bay Branch)**

Curtis Bay Junction (BAO 3.3) provides a wye connection to the Curtis Bay Branch from the Baltimore Terminal Subdivision and the Mt. Clare Branch. The branch is single-tracked on the bridge over the Baltimore Terminal Subdivision, and double-tracked from Zepp (BAO 3.1) to Brooklyn (BAO 0.0). Curtis Bay Yard extends eastward from Brooklyn. Currently, the maximum authorized speed (MAS) for freight trains is 15 mph.

Figure 3 - 12: Curtis Bay Branch



f. **Former Western Maryland Railway: Westport–Walbrook Junction**

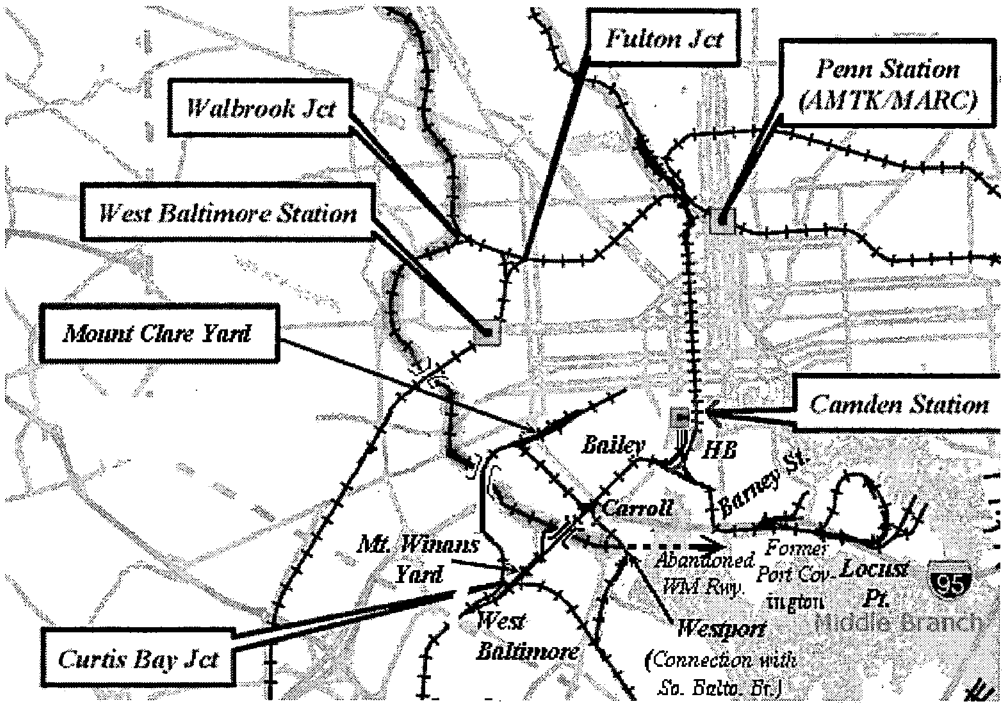
Historically, the Western Maryland Railway (WM) linked its freight terminus at Port Covington (south of the Locust Point facility) with southern Pennsylvania, western Maryland, and West Virginia.[11] The WM's traffic flows reached west of Pittsburgh via connecting lines. With the WM's absorption into CSXT and the decline of the coal industry in its service area, traffic patterns changed: Port Covington and its connecting bridge across the Middle Branch were abandoned, through freight service to and from Baltimore ceased, much trackage was transferred to short lines or placed out of service, and a portion of the former WM main line became a CSXT local freight service route between Baltimore and Hanover, Pennsylvania.

Today, CSXT's operations over the former WM begin at Westport (see Figure 3 - 13), where the Westport Branch connects with the South Baltimore Industrial Track to Curtis Bay. Proceeding west, the Westport Branch passes under CSXT's Main Line at Mount Winans Yard and becomes the Hanover Subdivision. A loop track[12] connects the Hanover Subdivision with Mount Winans Yard. Following the Gwynns Falls valley for part of its route, the Hanover Subdivision continues northwest, passing under the Mount Clare Branch and Amtrak's NEC main line. At Walbrook Junction, today's Hanover Subdivision joins the former WM main line from Hillen Street and Pennsylvania Station, and proceeds northwest to Baltimore County and Hanover, Pennsylvania.

[11] The WM also provided service to the east side of Baltimore, including passenger trains to and from Hillen Station near the Jones Falls in downtown Baltimore, via trackage rights on the PRR.

[12] At the time this study was completed, the loop track was not in service.

Figure 3 - 13: Hanover Subdivision and Westport Branch



The Hanover Subdivision—mainly single-tracked, with an MAS of 25 mph—will enter into some of the alternatives discussed later in this study.

3. **Perryville – BWI Airport Station (NEC Main Line)**

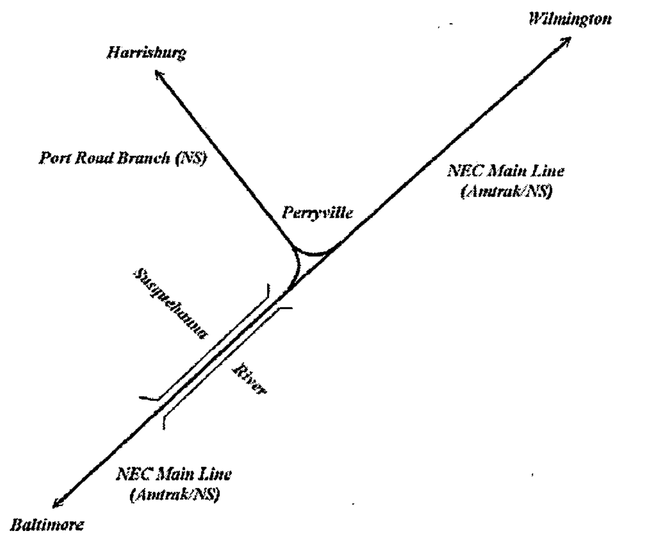
Consisting of three- and four-track segments punctuated by several double-track bottlenecks, Amtrak's NEC south of Perryville essentially parallels the CSXT main line, but is closer to the western shore of the Chesapeake Bay. Between the Jones Falls/Pennsylvania Station area and Halethorpe, however, the positions are reversed (see Figure 3 - 1): the Amtrak line is farther from, and the CSXT more proximate to, the Harbor and the Bay. Double-track segments on the NEC include the Susquehanna River Bridge immediately south of Perryville; the Bush River Bridge; the Gunpowder River Bridge; and the B&P Tunnel.

Many and varied rail operations make use of the NEC main line in the Baltimore region. MARC Penn Line commuter service links Perryville, Baltimore (Pennsylvania Station), and Washington.[13] Amtrak intercity trains connect Boston, New York, and intermediate points with Baltimore (Pennsylvania Station), Washington, and points south and west. NS freight trains to and from points north and west, and even points south,[14] serve Baltimore and Wilmington via the Port Road Branch along the Susquehanna River. At Perryville, there is a three way-junction

[13] All services mentioned have additional intermediate stops. Union Station is the main Washington, D.C. station for all passenger trains serving that city.

[14] Owing to restrictions on freight train access to the NEC, and to clearance limitations in Baltimore and Washington as discussed below, NS traffic between the South and Baltimore ordinarily flows via the Shenandoah Valley, Hagerstown (Maryland), Harrisburg, the Port Road, and Perryville, rather than via the more direct routing through Washington.

Figure 3 - 14: Schematic of Perryville for NS Freight



(Figure 3 - 14) between the Port Road Branch and the NEC in the directions of Wilmington and Baltimore.

Where geometric and other factors allow, the maximum intercity passenger train speed on the Perryville–Halethorpe segment of the NEC is 125 mph; 50 mph is the maximum freight train speed. However, freight trains are restricted to 30 mph between 6 a.m. and 10 p.m., when most intercity and commuter trains operate. This segment benefited from an important public investment under the NEC Improvement Program (NECIP) in the 1970s and 1980s,[15] and continues to receive ongoing maintenance and some betterments from Amtrak; for example, concrete ties have been installed in most tracks throughout the corridor. Previous studies have identified the Susquehanna River, Bush River, and Gunpowder River Bridges, as well as the B&P Tunnel, as needing replacement within the next two decades, although the funding and institutional arrangements for such massive capital projects have not crystallized.

4. NS Branch Lines

While accessing Baltimore by means of trackage rights, NS owns and operates some freight trackage in the region. Its principal yard facility is Bay View Yard,[16] located in East Baltimore on the south side of Amtrak's NEC Main Line.

a. Bay View Yard to North Point Blvd (Sparrows Point Industrial Track)

Diverging from the NEC Main Line east of Bay View [NS] Yard, this NS industrial track provides access to the Patapsco & Back Rivers Railroad that serves the Bethlehem Steel Sparrows Point complex. The track is within yard limits and is controlled by the NS yardmaster at Bay View.

b. Canton Jct. to Dundalk (Bear Creek Running Track)

Located in NS's Baltimore Terminal Area, the 10-mph running track winds through the port and industrial facilities of eastern Baltimore. The running track crosses the Canton Railroad at grade.

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[15] For details on the NECIP, see the 1986 FRA report, *Northeast Corridor: Achievement and Potential,* at www.fra.dot.gov/us/content/1596 .

[16] There are two separate yards at Bay View: that of CSXT to the north, and that of NS to the south. There is an interchange switching connection—but no connection for through service—between the two facilities, originally built by two railroads that were historically completely separate, highly competitive with one another, and reliant (between 1935 and approximately 1980) on divergent sources of line-haul motive power.

5. Short Line Railroad Companies

a. Canton Railroad

Connecting with the NS and CSXT, the Canton Railroad is a short line in the eastern part of Baltimore City and adjacent Baltimore County. It serves warehouse, distribution, port, and industrial facilities and is involved in numerous industrial development activities.[17]

b. Patapsco & Back Rivers Railroad (P&BR)

The Patapsco & Back Rivers Railroad Company is one of a number of subsidiary railroad companies owned by ISG/Bethlehem Steel. A common carrier short line operating in the Sparrows Point vicinity of Baltimore County, Maryland, where ISG has a steel mill,[18] the P&BR connects with CSXT and NS in Grays Yard.

D. Signaling

The CSXT main line, the Locust Point Branch, and the Curtis Bay Branch are signaled, and CSXT Traffic Control System Rules 265-272 govern train operations. The CSXT Sparrows Point Branch is not signaled; its train operations are under the direction of the yardmaster at Penn Mary Yard in Canton. The Hanover Subdivision is not signaled; CSXT Direct Traffic Control Block System Rules 120-132 govern train operations.

On the high-speed NEC between Perryville and BWI Airport Station, the NECIP replaced a more than 40-year-old signal system, so that the average age of the signaling between these two points is now less than 25 years. All main tracks have cab signaling installed. The Centralized Electrification & Traffic Control center (CETC) in Philadelphia controls train operations.

E. Highway-Railroad Grade Crossings

In the study area, the CSXT and NS trackage has a large number of public and private highway-rail grade crossings, while the Amtrak NEC main line is totally grade-separated. In total, there are 72 public and private crossings in the study area on the main lines and key branches of Class I railroads, as summarized in Table 3 - 2.

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[17] Further Canton Railroad information, including a list of shippers, is available on the Canton Railroad's web site at www.cantonrr.com.

[18] More information on Sparrows Point appears in Chapter Eight, "Freight Alternatives," under Harbor Sector crossings. Further information on the P&BR is also available through the parent company's web site, http://www.bethsteel.com/customers/fac_rail.shtml

Table 3 - 2: Grade Crossing Summary

Segment	Line	Route-Miles	Number of Public Crossings	Public Crossings per Mile	Number of Private Crossings	Private Crossings per Mile	Total Crossings	Total Crossings per Mile
CSXT Main Line and Selected Branches:								
Philadelphia Subdivision*	BAK	35.1	20	0.57	1	0.03	21	0.60
Baltimore Terminal Subdivision	BAK/ BAA	11.8	24	2.03	6	0.51	30	2.54
Capital Subdivision**	BAA	27.8	6	0.22	0	0.0	6	0.22
Locust Point Branch	BAM	0.5	2	4.00	0	0.0	2	4.00
Curtis Bay Branch	BAO	3.3	1	0.30	0	0.0	1	0.30
Hanover Subdivision	BAS	3.3	1	0.30	1	0.30	2	0.60
Total CSXT		81.8	54	0.66	8	0.10	62	0.76
Amtrak NEC:	NEC	49.7	0	0.0	0	0.0	0	0.0
NS Selected Branches:								
Sparrows Point Industrial Track	n/a	5.6	2	0.36	1	0.18	3	0.54
Bear Creek Running Track	n/a	5.4	6	1.11	1	0.19	7	1.30
Total NS		11.0	8	0.73	2	0.18	10	0.91

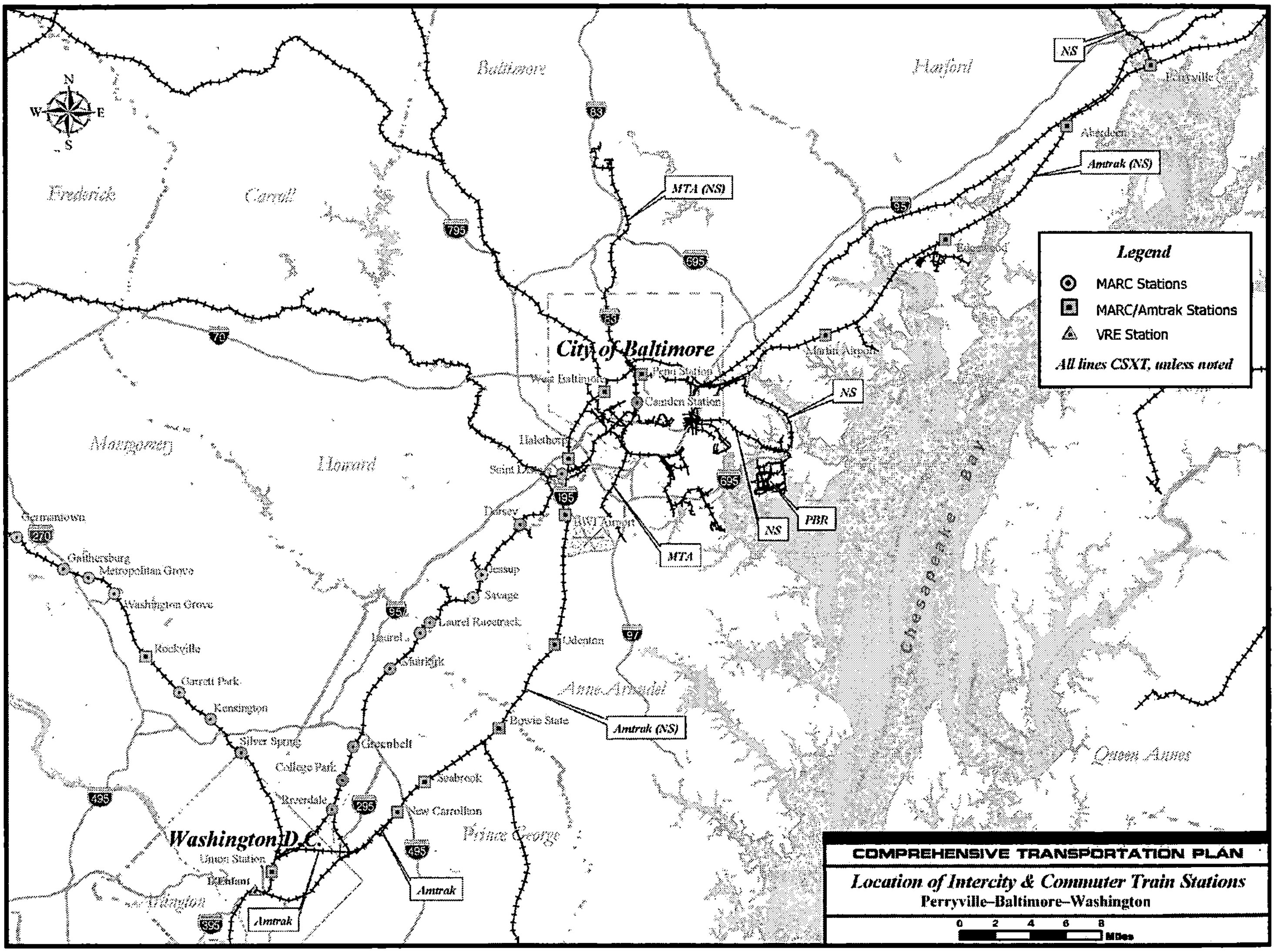
* E. Aikin, BAK 54.5, to Bay View, BAK 89.6.
** Halethorpe, BAA 5.8, to JD, BAA 33.6.

At a minimum, all the public crossings are protected by crossbucks. Various combinations of flashing lights, gates, and ringing bells are installed at most crossings.

F. Passenger Stations

Figure 3 - 15 shows the locations of intercity and commuter stations in the extended Perryville–Baltimore–Washington study area. An inventory of station ownership appears in Table 3 - 3. The location, ownership, and users of the stations are listed.

Figure 3 - 15: Passenger Stations in the Extended Study Area



Two issues concerning the rail passenger stations in the Baltimore region bear mention at this point: the location of the main NEC station (Pennsylvania Station) and the lack of an easterly "beltway"-type intercity station.

1. Pennsylvania Station

Amtrak's Pennsylvania Station has a location on the northern edge of Baltimore's central business district (CBD). As described above, its site was dictated by the PRR's search for a through route through Baltimore that would also service the Northern Central Railway, thus providing simultaneously for through operations between Washington, Philadelphia, and New York on the one hand, and (albeit more awkwardly) between Washington, Baltimore, Harrisburg, and the Midwest and upstate New York on the other.

Table 3 - 3: Inventory of Stations, Perryville–Relay

Note: Status as of February 2003.

SHA = State Highway Administration (Maryland), MTA = Mass Transit Administration (Maryland)

			Owner		
Milepost	Location	Users	Land	Station	Parking (Number of Spaces)
Amtrak NEC Main Line/MARC Penn Line					
NEC 59.4	Perryville	MARC	Amtrak	Amtrak	Amtrak (125)
NEC 65.5	Aberdeen	Amtrak-MARC	Amtrak	Amtrak	Amtrak (113)
NEC 75.1	Edgewood	MARC	Amtrak	MTA (Trailer)	Amtrak, MTA, US Govt., Edgewood (196)
NEC 84.0	Martin Airport	MARC	SHA	MTA (Trailer)	SHA (16519)
NEC 95.7	Baltimore	Amtrak-MARC	Amtrak	Amtrak	City (550)
NEC 98.5	West Baltimore	MARC	City	N/A[20]	City (256[21])
NEC 103.0	Halethorpe	MARC	MTA	N/A[22]	MTA (730 + 300 on street)
NEC 106.3	BWI	Amtrak-MARC	Amtrak	Amtrak	MTA[23] (3,114)
CSXT Baltimore and Capital Subdivisions/MARC Camden Line					
BAA 0.0	Camden	MARC	MSA[24]	MTA	n/a
BAA 6.8	St. Denis	MARC	CSXT	N/A	CSXT (41 + street)

Chapter Five analyzes Pennsylvania Station's location as it relates to future rail restructuring opportunities in the Baltimore region.

2. Beltway-Type Stations

The FRA planning guidelines state:

> One or more suburban stations need to be provided in the larger metropolitan areas with easy access to the local primary road system in order to accommodate potential riders living outside the city centers. Classic successful examples of suburban or beltway stations are Route 128 outside of Boston, MA and New Carrollton, MD outside of Washington, D.C. These "beltway"-type stations cater to automobile-oriented riders and thus need to have many hundreds,

19 To be expanded with the construction of MD 43.
20 Shelters (reclaimable by MTA) and platforms only
21 To be expanded to 300+.
22 MTA to add trailer.
23 Land owned by State Highway Administration
24 Maryland Stadium Authority

if not several thousand, parking spaces to fulfill their role in corridor transportation.[25]

Baltimore currently has a "beltway"-type station at BWI Airport that has so successfully attracted passenger traffic from the south and west sides of the region as to become Amtrak's sixteenth-busiest station nationwide. However, intercity travelers who originate east of the CBD for northeasterly destinations must currently either double back into the city to use Pennsylvania Station, or drive to Aberdeen—30 miles distant and infrequently served. Therefore, future studies of railway passenger traffic in Baltimore would usefully consider alternatives for a Beltway-type station east of the City, the existence of which may affect operating patterns and facility design in the study region as a whole. This topic, too, is outside the scope of this report, but worthy of attention nonetheless.

G. Tunnel clearances

1. The importance of clearances in modern rail freight transport

As the railroad industry matured in its almost two centuries of operation, it consistently sought to increase the ratio of payload to gross tonnage by carrying freight in higher, wider, and longer cars. Since 1929 alone, the average capacity of a freight car has doubled—from 46.3 to 93.1 tons.[26] Over the ten-year period 1994-2003, the average capacity of multi-level or trailer/container flat cars—of which some types require especially generous clearances —increased by over 28 percent. By 2001, some two-fifths of U.S. carloads were carried in multi-level or trailer/container flat cars.[27]

Thus, the utility of a railway facility increasingly depends on its ability to accommodate modern, high-capacity freight cars. To the extent such accommodation is lacking, the Nation's railroads must direct the affected traffic via circuitous routings, thereby incurring additional costs and consuming excess energy.

2. Clearance Plate Diagrams

The AAR's publication, *Railway Line Clearances*, specifies the allowable dimensions and weight of rail cars over various segments of individual railroads. Maximum load dimensions are defined in terms of "plates," diagrams that specify cross-sectional areas within which a certain series of railroad cars can be built. Five plates are presently defined as: "B," "C," "E," "F," and "H."

Based on two fundamental axes (Top of Rail Line and Track Centerline), the plate diagrams are oriented in an upright plane perpendicular to the centerline of a specified track. **The diagrams specify the extreme width of a car at a given height above the top of rail** (see Table 3 - 4); by this criterion, the limiting factor in tunnels is the height of the eaves at the two

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[25] Federal Railroad Administration, *Rail Corridor Transportation Plans: A Guidance Manual,* available at: http://www.fra.dot.gov/us/content/1415

[26] Association of American Railroads (AAR), *Yearbook of Railroad Facts,* 2002, p. 53.

[27] AAR Economics and Finance Department, *Railroad Equipment Report,* pp. 51, 53, and 65.

upper corners of the car, rather than the maximum height at the center of the tunnel's cross-sectional arch.

Table 3 - 4: Typical Clearance Plates—
Critical Dimensions and Examples of Associated Car Types

Plate	Maximum Height above top of rail	Width at Maximum Height above top of rail	Typical Car Types Satisfying Plate
C	15'6"	7'0"	Conventional box cars, flats (depending on load), gondolas, coal hopper cars
F	17'0"	8'10"	Modern box cars, single level trailers
H	20'2"	8'6-3/8"	Double stack containers, tri-level container stacks, tri-level auto carriers.

3. Other Clearance Considerations

For a variety of reasons, railway engineers do not design and build tunnels and other structures to the dimensions listed for a specific plate. Instead, whether for an upgraded or newly-constructed tunnel, the design requirements incorporate various adjustments to the plate dimensions. These adjustments define the "clearance envelope"—the available space for cars or lading to pass through, or the space that is to be checked for a potential obstruction[28] to the passage of a specific car. The adjustments—

- Allow for the movement dynamics of a car (sway and bounce) as it travels along the track;
- Accommodate the presence of overhead catenary;
- Provide for the effect of curvature on the centerline of the envelope; and
- Provide for the minor horizontal and vertical shifts in the location of the track, and catenary, if present, resulting from normal maintenance.

a. Curved Track

The minimum lateral clearance on each side of a track centerline is increased 1.5 inches per degree of curvature to account for the end of the car swinging outward from the centerline, and the center of the car swinging inward from the centerline. The allowance decreases to zero inches when the obstruction adjacent to the track is at least 80 feet beyond, or before, the curve and on tangent track.[29]

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[28] The envelope is defined within a plane, which is perpendicular or radial to the track centerline.

[29] Individual states, railroads, and Canada may require greater clearances than the minimums recommended by the American Railway Engineering and Maintenance-of-Way Association (AREMA).

b. Catenary

The electrification of the NEC, presently alternating current at a voltage of 12.5 kV, 25-cycles,[30] requires vertical and horizontal adjustments beyond those used in non-electrified railroads. The construction clearance must allow for a number of factors[31]:

- The electrical clearance between the structure and live parts of the overhead catenary system[32];
- The loading gage (i.e., the maximal static cross section of the vehicles to be operated);
- The electrical clearance between the contact wire and loading gage;
- The horizontal and vertical dynamic movement of the rolling stock, which creates a kinematic envelope that normally exceeds the loading gage by 1.5 to 2.5 inches);
- The uplift of the catenary system when the contact wire is swept by the pantograph (normally 1 to 2 inches, except 3 inches in tunnels);
- The construction and maintenance engineering tolerances; and
- The depth of the catenary, including wire and hardware.[33]

4. Clearances in the Baltimore tunnels

All the factors described above result in the following clearances through the Baltimore tunnels and nearby limiting facilities:

Table 3 - 5: Existing Tunnel Clearance Plates

Tunnel	Plate
NEC (Amtrak, NS)	
Union Tunnel Tracks 1 and 2	C+
Old Union Tunnel Track 3	C+
Pennsylvania Station, Baltimore: tracks beneath concourse	C
Pennsylvania Station, Baltimore: Track F (does not pass beneath concourse)	F
B&P Tunnel Tracks 2 and 3	C
CSX main line	
Howard Street Tunnel	F+
In Washington, D.C.—Affects traffic flows on both NEC and CSX	
Virginia Avenue Tunnel	F

These clearance limitations have the following effects on traffic flows in the study area:

[30] The conversion to a 25kV 60-cycle system has been evaluated.
[31] AREMA Manual, Chapter 33, Part 2.
[32] The catenary is the system of overhead wires that delivers the power to the train, by means of a power-collecting unit (pantograph) attached to the locomotive. The NEC and its Harrisburg extension are America's only long-distance, electrified passenger railroads; freight service on the NEC, formerly electrified as well, now uses Diesel power exclusively.
[33] Since the NEC elevation is lower than 3,000 feet above sea level, an altitude compensation factor is not used.

Table 3 - 6: Effects of Clearance Limitations on Rail Traffic Flows

Traffic Lane	Limiting Plate	Location(s) of Limitation	Alternate Route
NEC			
NS north-south flows, Virginia and Philadelphia/New Jersey/New York	C	B&P Tunnel	Via NS Shenandoah Valley route and former PRR main line
NS east-west moves, Midwest/ Pennsylvania and all NEC points south of Bay View Yard	C	B&P Tunnel	None nearby
NS east-west moves, Midwest/ Pennsylvania and Port of Baltimore points east of Union Tunnels	No limitation in the study area		
CSX main line (refer to Figure 3 - 8, page 9)			
CSX north-south flows, Virginia and Philadelphia/New Jersey/New York	F	Virginia Avenue Tunnel, D.C.	None nearby
CSX east-west flows via former B&O to Baltimore Harbor **south** of Howard Street Tunnel	No limitation in the study area		
CSX east-west flows via former B&O to all points north and east of Howard Street Tunnel	F+	Howard Street Tunnel	None
CSX west-south flows via former B&O and former RF&P, Midwest/Pennsylvania and Virginia/points south	F	Virginia Avenue Tunnel, D.C.	None nearby

Table 3 - 6 clearly shows that none of the north/south traffic lanes through Baltimore can accommodate the most modern, efficient freight cars (Plate H—double- and triple-stack container and auto carriers). NS must divert any such traffic to its hilly Shenandoah Valley route some 60 miles to the West[34]; CSXT owns no alternate route east of the Appalachian Mountains. Furthermore, for east-west traffic, NS cannot service any local shippers south of Baltimore with the most modern cars, nor can CSXT do so east or north of the Howard Street Tunnel. Moreover, NS faces such tight clearances in the B&P and Union Tunnels as to make the NEC unavailable to it for any cars exceeding Plate C. The only traffic lanes that benefit from comparatively unrestricted clearances are those of CSXT between points west and the southwestern part of the Port of Baltimore, and those of NS and the northeastern sectors of the Port.

In order to obtain even the limited available clearances, all CSXT tunnels in the study area have been single-tracked, thus severely constraining capacity (as will be discussed below).

[34] In the 1980s, Conrail had already diverted as much as possible of its former NEC traffic to its east-west main line via Harrisburg and Bethlehem, Pennsylvania, to Northern New Jersey and New York State. At that time, Conrail connected with the NS's Shenandoah Valley route at Hagerstown, Maryland, and with the CSX's east-west traffic at Lurgan, Pennsylvania.

Similar measures took place in the B&P Tunnel, as described in Chapter Two, Box 2-1. Today, the conditions in the B&P tunnel—as well as its criticality to the protection of a reliable passenger service—preclude its expanded use for most freight and constrain the flow of commerce to and through the Baltimore region.

H. Grades and curves

A railroad's efficiency as a transportation machine inherently depends on its vertical and horizontal profiles—its grades and curves. The same small zone of contact between steel wheel and steel rail,—which reduces rolling resistance and allows a single train with a minimal crew to move huge volumes of freight,[35]—also demands, for maximal utility, as straight and flat a roadbed as possible. This section examines the relationship of grades and curves to railroad operating performance in general and to the capabilities of Baltimore's rail lines in particular. As a general rule, freight service—with its heavier trains, relatively modest speeds, lower power-to-weight ratio, and need to be able to stop and restart at any point on the line without stalling or slipping—demands easy grades, and can tolerate most curves except as they exacerbate effective grades. Passenger service, on the other hand, can tolerate most grades—the ruling grade on the NEC for passenger service is two percent, in the Pennsylvania Station tunnels of New York City—but suffers from excessive curves due to the speed restrictions they impose for reasons of ride quality and safety. Thus the two services have different geometric tolerances and requirements.

1. How grades and curves influence railway operations[36]

Grade, particularly in combination with curvature, has a major impact on the tractive effort[37] and horsepower required to move a train of a given tonnage over a line. Collaterally, grades affect the speed, schedule, and on-time performance of a freight train, and to a lesser degree, a passenger train.

The total resistance a locomotive has to overcome is determined by adding grade resistance to the train and other resistances. The resistance is higher for a train starting up than for a moving train. Simply stated, on a tangent track, a given number of locomotives would haul fewer and fewer cars up increasingly steeper grades.

The presence of curvature increases resistance as the result of increased friction between wheels and the rail.[38] Curve resistance is measured in terms of the grade which would offer the

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[35] In 2001, the average freight train—including locals as well as through freights—had 68.5 cars (versus 47.6 cars in 1929) and carried 3,005 tons of freight (versus 804 in 1929). Also in 2001, the railroad industry generated 3,516 revenue ton-miles per employee-hour (versus 108 in 1929). (AAR, *Yearbook of Railroad Facts,* 2002 edition, pp.35, 37, and 41.) These efficiencies are largely inherent in the mode's configuration of steel wheel on steel rail.

[36] This discussion is based on William W. Hay, *Railroad Engineering*, 2nd Edition, John Wiley & Sons. 1982.

[37] "Tractive effort is the pulling force exerted, normally by a locomotive. When a bare figure for tractive effort is quoted without a speed qualification, this is normally for starting tractive effort, i.e. at a dead start with the wheels not turning." —Source: http://encyclopedia.thefreedictionary.com/Tractive%20effort

[38] The friction is the result of the inside and outside wheels traveling different distances and the rubbing of wheel flanges on the head of the outside rail on the curve.

same resistance as that imposed by the curve. Research in the 20th century concluded that the curve resistance of a one-degree curve equates to the resistance of a 0.04 percent grade.[39]

Thus, for example, a six-degree curve located on a 0.80 percent grade would result in an effective gradient of:

$$(0.80) + (6 \times 0.04), \text{ or } 1.04 \text{ percent}$$

Continuing the example, assume that a 12,000-ton train could operate up a 0.80 percent grade without stalling, but if a six-degree curve were superimposed on the grade, the train would stall.

To reduce the effective grade to 0.80 percent, the designer would seek ways to reduce the actual grade by—

$$(6 \times 0.04) \text{ or } 0.24 \text{ percent}$$

—to 0.56 percent to prevent the 12,000-ton train from stalling.[40]

Such a reduction may not be practical, particularly on an existing route that is crisscrossed by numerous highways, streams, valleys, and other features. The presence of overhead and undergrade bridges and adjacent development may prevent altering the grade. Consequently, the rail operator has limited options:

- Reduce the tonnage hauled by a train, thus requiring more trains to haul the potential traffic over the line;
- Add a locomotive(s) to the train to prevent stalling, which can be done in several ways:
  - — Have the locomotive(s) on the train from originating terminal to destination terminal, which means that the train is overpowered for the majority of its route, or
  - — Have the locomotive(s) added locally as a "helper" in railroad terminology, which delays the train and requires the helper locomotive(s) to return to the location where they were added, effectively reducing the capacity of that segment of the route, increasing the labor force necessary to conduct the operation, and potentially necessitating facility expansion.

All the above options would increase the railroad's operating ratio (expenses divided by revenues), thus harming the company's self-sustainability and status as a going concern.

Curves, in themselves, can severely limit train speeds because of the forces they create as trains pass over them, and the safety, ride quality, maintenance, and cost issues that these forces raise—issues that are worsened in mixed traffic conditions. For example, allowable superelevations (banking) on curves may differ for passenger and freight service. Where both

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[39] Amtrak's *MW 1000, Specifications for Inspection, Construction and Maintenance of Track*, states that the value for each degree of curvature should be 0.05 percent at locations where trains frequently stop.

[40] Depending on site-specific circumstances, reducing the actual gradient may have the additional negative effect of lengthening the grade, the distance needed to attain the desired elevation.

services regularly share the same trackage, compromises must be made that may allow neither service to operate optimally.

2. Curves and their effects in the study region

An inventory follows of the curves in the CSXT and NEC main lines through the study area.

a. CSXT alignments

Figure 3 - 16 shows the distribution of curvature in three segments of the CSXT main line.

(1) From the Susquehanna River to the south end of Bay View Yard (32.8 route-miles total)

Of this 32.8-mile segment, approximately 77 percent of the alignment is tangent. Twenty-five curves (most of them less than one degree) comprise the remaining 7.6 miles. Three of the curves exceed of three degrees, and are located in segments of the rail line restricted to 40 mph.

(2) From the south end of Bay View Yard to the south end of the Howard Street Tunnel at HB Tower (6.9 route-miles total)

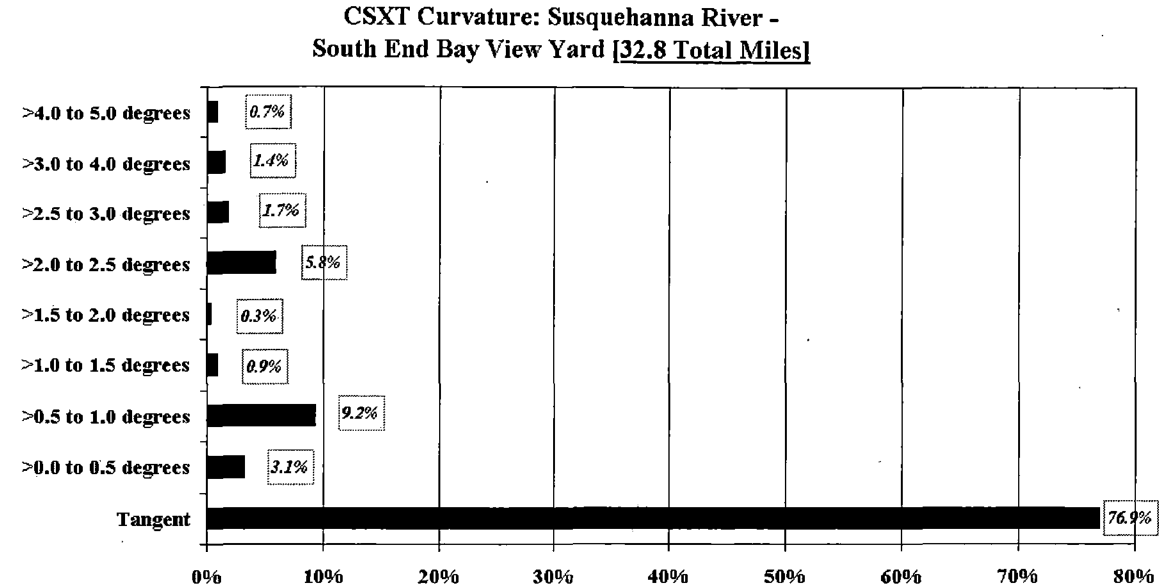
Approximately 58 percent (4.0 miles) of the alignment between the south end of Bay View Yard and the south end of the Howard Street Tunnel (HB Tower) is tangent. However, of the 2.9 miles of curves, 65 percent of the distance (1.9 miles) has curvature greater than three degrees. Thus, as Figure 3 - 16 shows, the curves between Bay View and HB are much sharper than those north of Bay View.

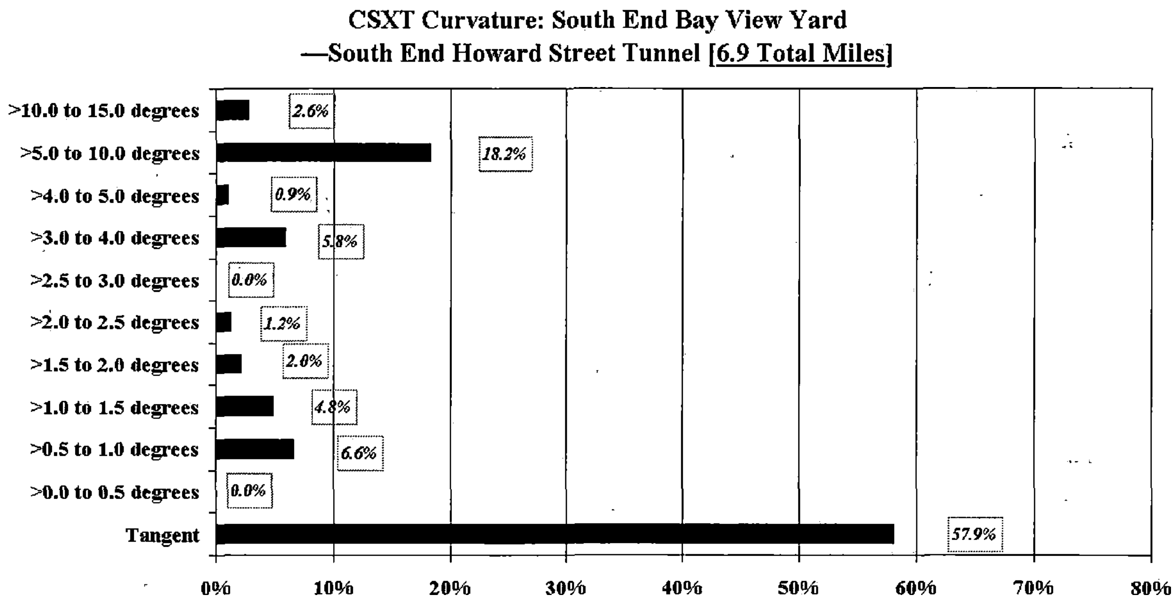
(3) From the south end of the Howard Street Tunnel to Riverdale Park/JD Tower, near D.C. (33.1 route-miles, total)

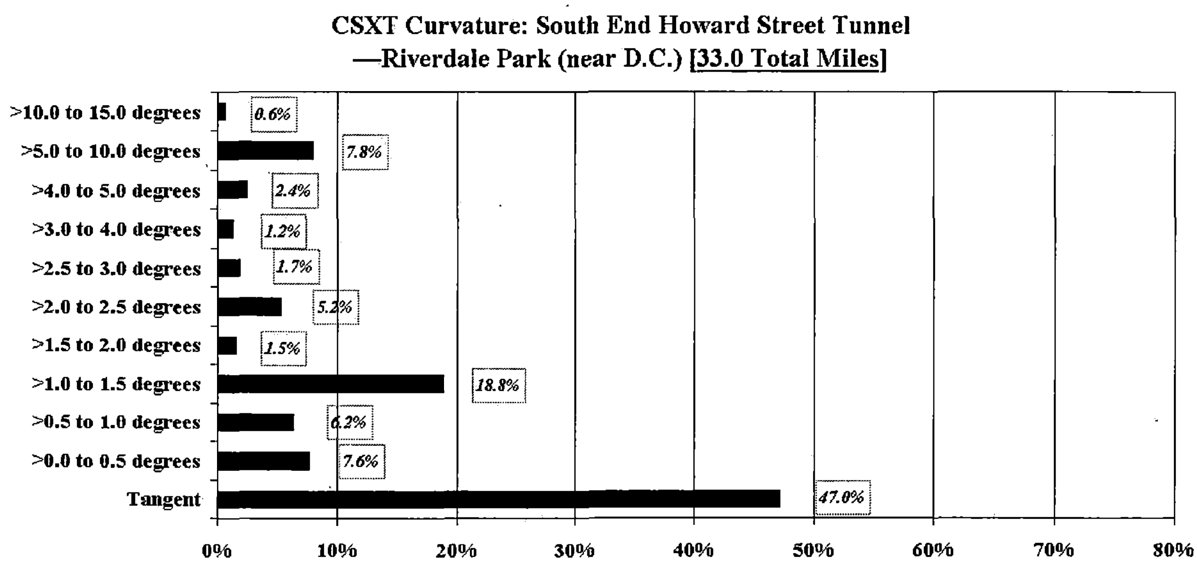
The Riverdale Park/JD Tower area of the CSXT main line houses the junction of CSXT's passenger line to Union Station, Washington, with the freight line to the South via Anacostia. Approximately 49 percent (16.1 miles) of the alignment between the south end of the Howard Street Tunnel and the Riverdale Park/JD area is tangent. Thirty-seven curves comprise the remaining 17 miles. Of these 17 miles, 6.2 miles (36 percent) of the curved alignment has a curvature between one degree and one degree thirty minutes. The curves immediately south of the Howard Street Tunnel are sharper than those south of MP BAA 10.1. Twelve of the curves are in excess of three degrees.

The freight speeds between the Howard Street Tunnel and MP 10.1 range between 25 and 45 mph. Freight train speeds are 55 mph between MP BAA 10.1 and JD.

Figure 3 - 16: CSXT—Percentage of Route Segments by Degree of Curvature







(4) Summary: CSXT curvature

Figure 3 - 16 clearly indicates that the CSXT's curvature problems most seriously affect the segments south of Bay View Yard. Relative age undoubtedly influences the comparative quality of these alignments: the territory north of Bay View Yard represents a relatively "recent" alignment (the Royal Blue Line completed in 1886), whereas CSXT's route from Baltimore to Washington (the "Washington Branch") dates back to 1835, eight years after the B&O's founding.[41] The Howard Street tunnel with its approaches, completed last of all in 1895, constitutes a special case due to Baltimore's exceptionally difficult railway topography as described earlier in this report.

b. NEC alignments

Figure 3 - 17 presents the curvature pattern for three segments of the NEC that are roughly analogous to the three CSXT main line segments just described. With the exception of the very difficult tunnel alignments on both roads, the NEC enjoys a more favorable alignment than the CSXT. Between Baltimore (north of the tunnels) and the Susquehanna River, for example, the NEC has only 0.8 miles of route curvature that exceeds two degrees; the CSXT has 3.2 miles. South of the Baltimore tunnels, the CSXT has a higher percentage of route-miles in sharper curves than does the NEC. These divergences stem both from geography (to the north, Amtrak's route hugging the Chesapeake Bay is gentler than the CSXT's inland, hillier route) and history (the NEC south of the tunnels is of more recent design and construction[42] than the CSXT's legacy alignment).

c. Speed effects of curvature

Railway engineers develop detailed formulas for calculating maximum authorized speeds (MASs) for various traffic types on specific sections of trackage. Among the many factors that enter into these calculations are:

- The degree of curvature;
- The adequacy of the spirals transitioning from tangent track to the maximum degree of curvature;
- The allowable superelevation (banking) to accommodate the needs of all traffic types making use of the segment;
- Other equipment- and site-specific conditions.

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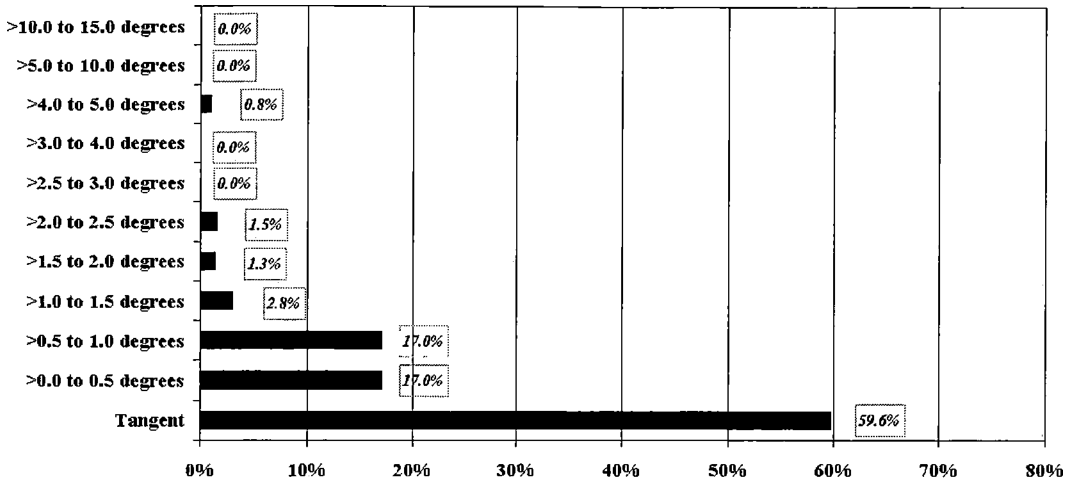
[41] Timothy Jacobs, ed., *History of the Baltimore & Ohio Railroad,* New York: Smithmark Publishers, Inc., 1995, pp. 64, 28, and 68.

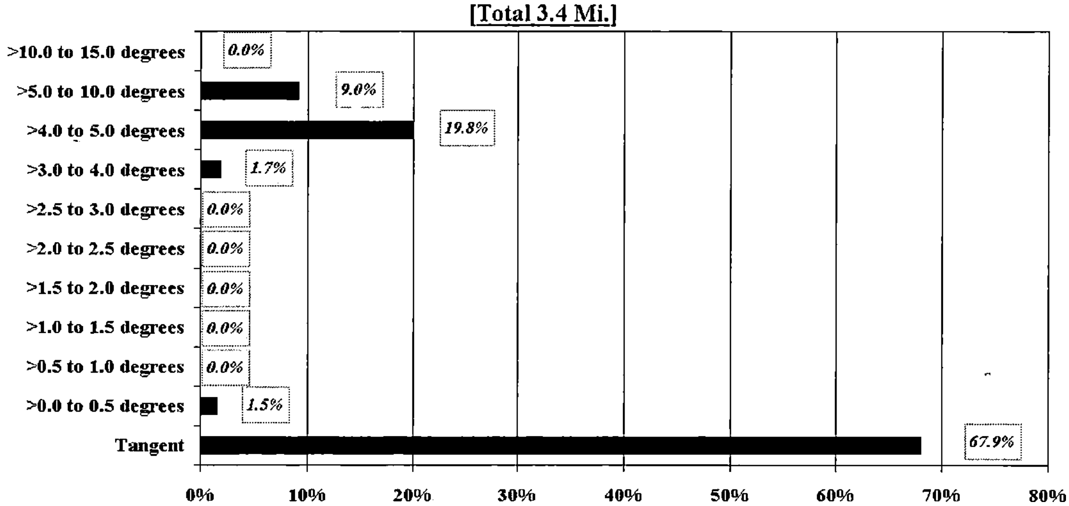
[42] 1873, versus the 1835 completion of the B&O's Washington Branch quoted above.

Figure 3 - 17: NEC—Percentage of Route Segments by Degree of Curvature

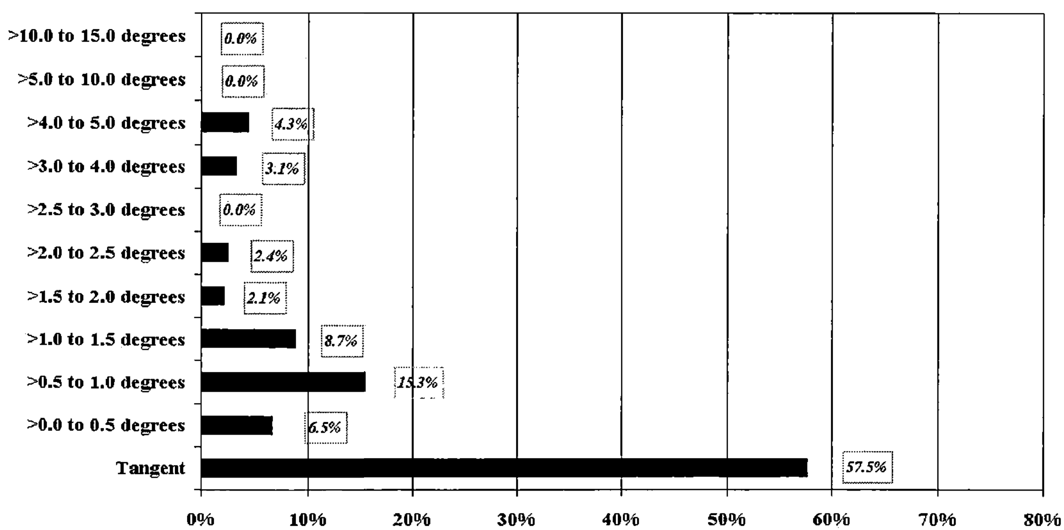
NEC Curvature: Susquehanna River
to North End of Union Tunnels [Total 34.9 Mi.]



NEC Curvature: Union and B&P Tunnels, Inclusive
[Total 3.4 Mi.]



NEC Curvature: South End of B&P Tunnel
to BWI Airport Station [Total 8.6 Mi.]



For the main lines at issue in this report, the results of these many calculations appear in Table 3 - 7.

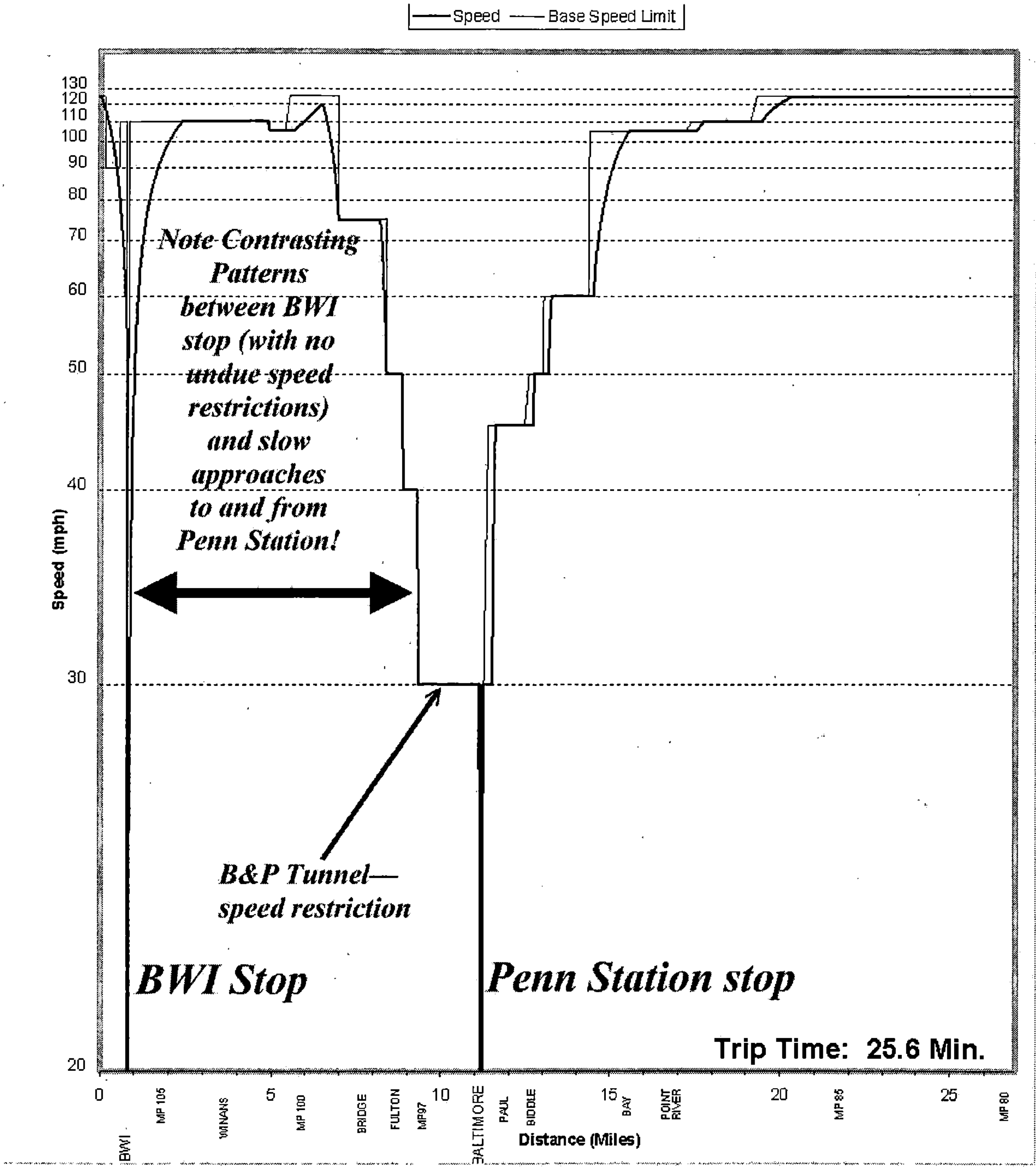
Table 3 - 7: Maximum Allowable Speeds[43] on CSXT and Amtrak Main Lines through Baltimore

Route Segment	Maximum Allowable Speeds	
	For Passenger Service	**For Freight Service**
CSXT Main Line		
North of Baltimore	no service	50 mph
—Except: On curves greater than 3° 15'	no service	*45 mph or less*
South of Bay View (MP BAK 90.6) to St. Paul/Calvert Street tunnel (MP BAK 03.4)	no service	35 mph
St. Paul/Calvert Street tunnel (MP BAK 93.4) through Howard Street Tunnel to Carroll (MP BAK BAA 1.5)(total of 4 miles approximately[44])	On passenger tracks: 15 to 45 mph	On freight thru tracks: 25 mph
South of Baltimore	70 mph	55 mph
—Except: On curves greater than 2° 15' but under 3° 0'	*65 mph or less*	55 mph
—Except: On curves greater than 3° 0'		*50 mph or less*
Amtrak NEC		
—Perryville (MP 59.4) and MP 85 (10.7 mi. north of Penna. Sta.)	125 mph	50 mph or less
—MP 85 to MP 91.9 (3.8 mi. north of Penna. Sta.)	110 mph	50 mph or less
—In Union Tunnels, north of Penna. Sta. *(Speeds gradually lessen on approach to station, where all trains stop)*	45 mph	30 mph
—In B&P Tunnel, south of Penna. Sta.	30 mph	20 mph
—From south of B&P Tunnel (MP 97.7) to BWI Airport Station (MP 106.3)	110 mph	50 mph or less

Figure 3 - 18 exemplifies the effects of Baltimore's difficult railway configuration on train performance. Especially noteworthy are the restrictions imposed by the B&P Tunnel (30 mph over some two miles, MP 95.9 to 97.7), and—especially—the contrast in linear shape between the stop at BWI, in which the train maintains and resumes top speeds very close to the station, and that at Pennsylvania Station, which takes many miles and minutes to accomplish.

[43] These are general guidelines, always subject to site- and time-specific considerations.
[44] Based on CSXT Baltimore Division Timetable No. 4, April 2002, and *Official Guide of the Railways*, June 1916, p. 526.

Figure 3 - 18: Optimal Speeds Achieved by an Acela Trainset Operating Unimpeded Between Perryville and BWI (Over Today's NEC Track Configuration)

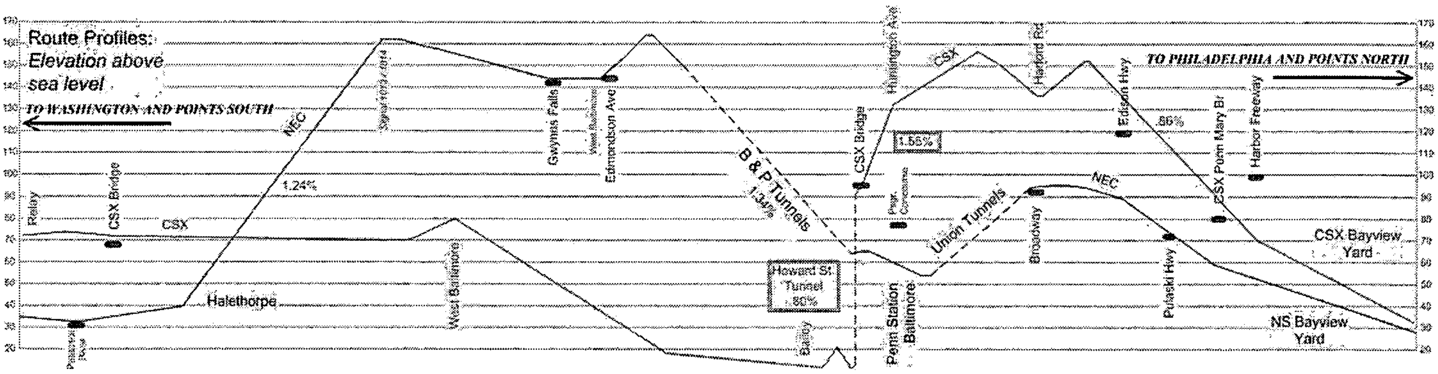


As the BWI stop demonstrates, it is not the equipment that consumes all the excess time in stopping at Pennsylvania Station—it is the alignment. Moreover, it is not just the high-speed intercity passenger service that loses time in central Baltimore City—it is the MARC commuter service as well, not to mention Amtrak's more conventional trains.

3. Grades and their effect on the study region

As described earlier in this chapter, the railroads in the 19th century made compromises to fulfill their conflicting goals of maintaining their separate multipurpose rights-of-way, providing passenger service as close to the central business district as possible, and avoiding construction that would wipe out critical areas of the city (i.e., the Inner Harbor), all within a challenging topographical environment. In no domain were these compromises more debilitating than in the maintenance of easy grades, a requisite for efficient freight service[45] and a help to all operations.

Figure 3 - 19: Grades through Baltimore on CSXT and NEC Routes[46]



These compromises show themselves starkly in Figure 3 - 19, which displays the grades of the CSXT and NEC main lines, each of which is described in the following sections.

a. Profile of the CSXT

(1) CSXT - Susquehanna River (BAK 56.58) to South End of Bay View Yard (BAK 89.5)

The CSXT rail line south of Philadelphia can be characterized as having a "saw tooth profile," in that the line consists of numerous adjacent crests and sags,[47] which can adversely affect train performance. (By contrast, the NEC has a flatter profile because it is closer to the Chesapeake Bay and constructed in less rolling terrain.[48]) The grades north of CSXT Bay View Yard generally are less steep than those in, and north of, the Howard Street tunnel. The steepest grade, 0.04-mile of downhill 1.17 percent (between MP BAK 87.68 and MP BAK 87.72), is near Bay View Yard. Charts showing the prevalence of various grades on the CSXT appear in Figure 3 - 20.

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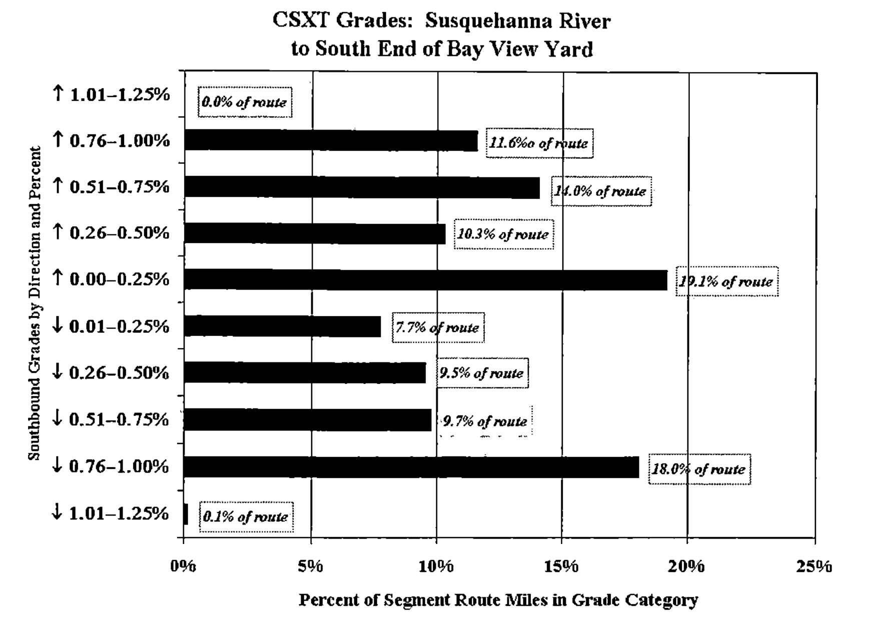
[45] For example, according to Robert S. McGonigal, "a given locomotive … can haul only half the tonnage up a 0.25-percent grade that it can on the level." (http://www.trains.com/Content/Dynamic/Articles/000/000/003/015kegsf.asp)

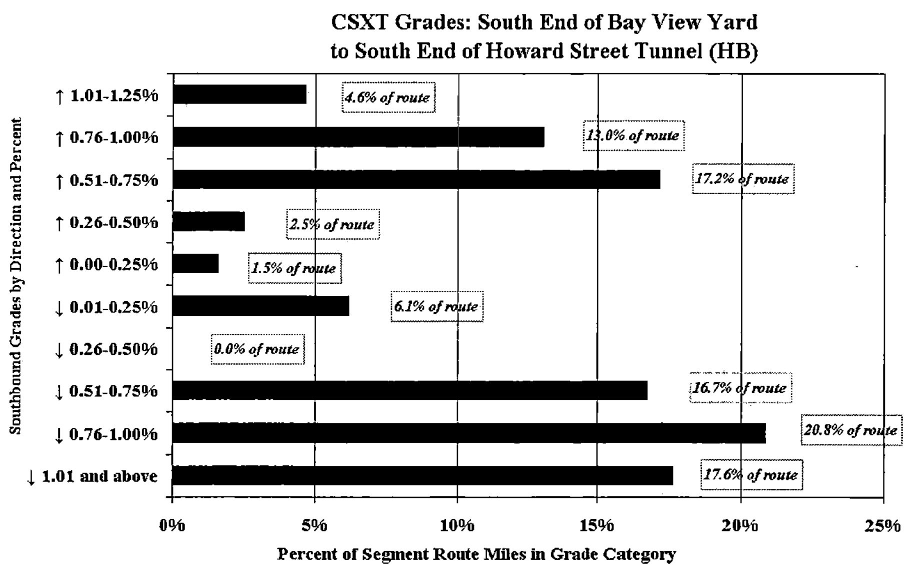
[46] Figure courtesy of Amtrak's Planning Department.

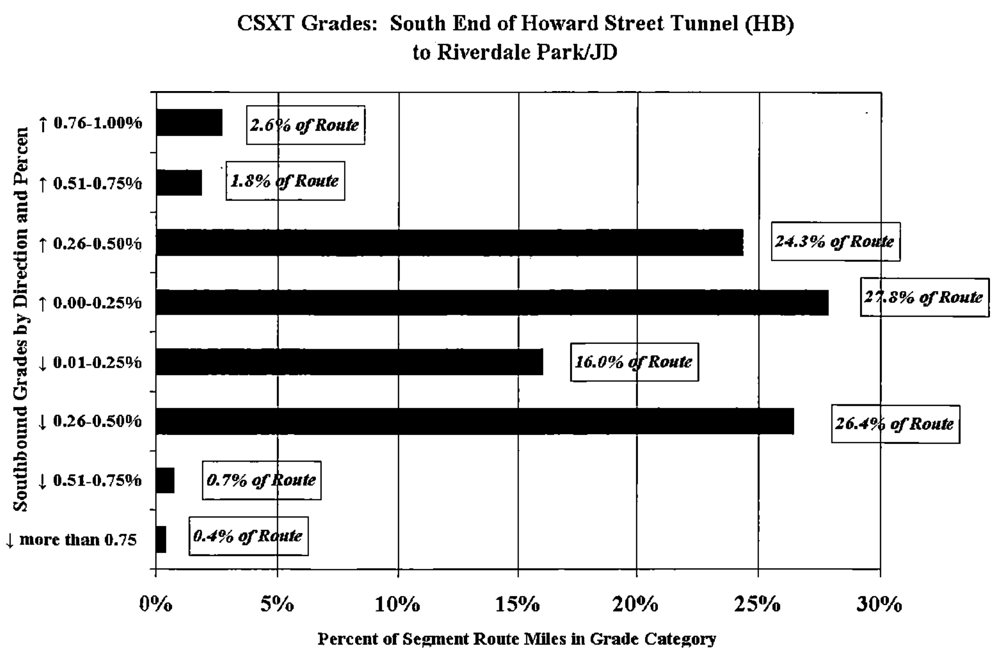
[47] The sags generally located where the rail line crosses the various rivers, streams, and creeks flowing into Chesapeake Bay.

[48] However, the NEC has the disadvantage of requiring major bridges on the Bush and Gunpowder estuaries.

Figure 3 - 20: Prevalence of Grades of Varying Severity on CSXT







(2) CSXT: South end of Bay View Yard to south portal of Howard Street Tunnel at HB Tower (between MP BAK 89.5 to MP BAA 0.5)

The grade from the vicinity of Camden Station to the north is uphill 0.8 percent through the 7,341-foot, single-track Howard Street Tunnel. The grade continues to climb[49] for approximately 4.5 miles. Between the Howard Street tunnel portal and Huntingdon Avenue, the northbound uphill grade reaches 1.55 percent—the type of freight railroad incline that is more appropriate to mountain passes than tidewater cities. The elevation at the south end of the tunnel is 11 feet above sea level; to the north, the highest elevation on the grade is 157.1 feet, near the Greenmount Avenue short tunnel.[50] The presence of three curves of between 3 degrees 15 minutes and 4 degrees 30 minutes in the Howard Street Tunnel, and of five curves of between 5 degrees 45 minutes and 10 degrees 10 minutes between the north end of the Howard Street Tunnel and Greenmount Avenue, further restricts the maximum authorized speeds. As described on page II-22, these curves effectively increase the grades in this segment by from 0.13 to 0.41 percent. The grades and the curvature thus combine to aggravate the constraints that make the Howard Street Tunnel a choke point in CSXT operations between Richmond and Philadelphia.

(3) CSXT: South portal of Howard Street Tunnel at HB Tower to Riverdale Park/JD (between MP BAA 0.5 and MP BAA 32.71)

The grades south of the Howard Street Tunnel generally are less steep than those in, and north of the tunnel. The steepest grade, 0.8 mile of southward uphill 0.83 percent (MP BAA 1.9 to MP 2.7), is located north of, and extends through, Mt. Winans Yard. The rail line south of Mt. Winans to Riverdale Park, in Hyattsville, the connection to Benning Yard, the District of Columbia, and Virginia, is largely gently rolling and presents a far easier gradient than the segments of CSXT main line north of HB Tower,

b. Profile of the NEC

(1) Susquehanna River to north portal of Union Tunnel

The grades north of Amtrak's Union Tunnel generally are moderate. The steepest grade, uphill 0.65 percent (MP 62.01 to MP 60.96), is located south of Grace as the NEC climbs out of the Susquehanna River valley. A comparison of Figure 3 - 21 with Figure 3 - 20 underlines the contrast in profiles between the NEC and the CSXT main lines northeast of Baltimore.

(2) North portal of Union Tunnel to south portal of B&P Tunnel

The Union Tunnels comprise:

- The original double-track tunnel—subsequently single-tracked in the 1930s—constructed in 1873 (at the same time as the B & P Tunnel); and
- A double-track tunnel, located south of the old tunnel, constructed in 1934.

Southbound, the grade through the Union Tunnels is downhill 1.17 percent.

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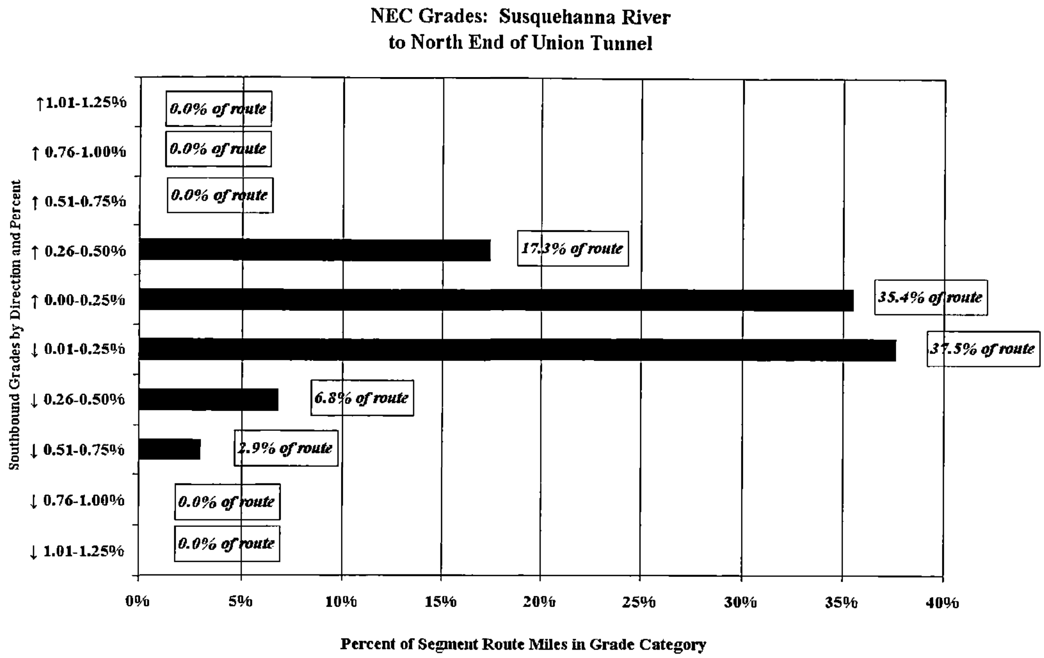
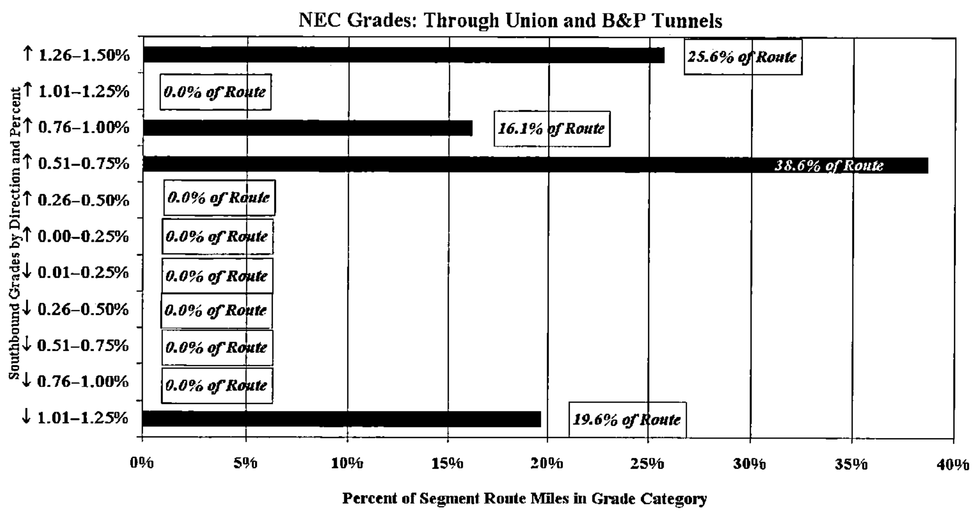
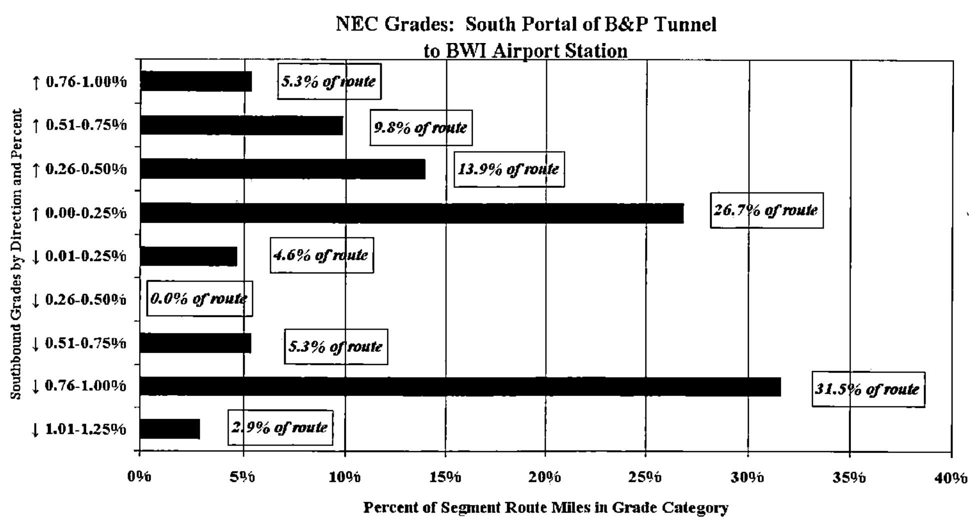
[49] A short downhill segment of less than ¾-mile is located approximately three miles into the segment.
[50] These elevations are derived from a 1949 B&O track chart.

Figure 3 - 21: Prevalence of Grades of Varying Severity on the NEC







The most restrictive grade between Philadelphia and Washington on the NEC is located in the B&P Tunnel, a series of three tunnels spanning 7,669 feet, separated by two short open cuts. Southbound trains entering the tunnels slow for a sharp curve, then ascend a mile-long 1.34 percent grade.

(3) NEC: South of B&P Tunnel (MP 97.7) to BWI (MP 106.3)

The grades south of the B&P Tunnel are steeper than the grades located north of the Union Tunnels.[51] The steepest grade, downhill 1.24 percent (MP 100 to 100.3), is located south of Wilkins Avenue.

I. Recap: Net effect of fixed plant on operations and their costs

As the main line for most freight and all passenger traffic by rail along the East Coast, the twin CSXT and NEC routes through Baltimore perform the same function as Interstate 95 does in the highway grid—with a critical difference: whereas I-95 has many nearby parallel routing options, there is no other rail option for through passenger service and, some sixty miles to the west, only a limited and circuitous parallel route for NS freight traffic. Indeed, CSXT has no other north-south option along the East Coast for its freight. Yet despite the criticality of the rail infrastructure through Baltimore, its design—last updated a century-and-a-quarter ago, with substandard engineering even for the 19th century—falls short of 21st century needs in the following ways:

- **Speed.** Freight trains must crawl through several miles of trackage at a maximum speed of 25 to 30 mph, where grades permit even that much; passenger trains lose valuable minutes in excruciatingly slow negotiation of the approaches to and from Pennsylvania Station. (By contrast, the Fort McHenry Tunnel of I-95 offers a 55 mph speed limit.)
- **Throughput capacity.** The main (CSXT) freight line through Baltimore is single-tracked, and the use of helper locomotives further reduces its capacity. The through (NEC) passenger route has only two tracks through the B&P Tunnel, to accommodate a growing mixture of commuter, high-speed, and conventional passenger trains that, with freight service, makes active use of three and four tracks elsewhere on the NEC. (By contrast, there are eight lanes in the Fort McHenry tunnel, four lanes in the Baltimore Harbor Tunnel, four lanes on the outer harbor crossing, and approximately six lanes on the Baltimore Beltway around the city to the north, for a total of 22 highway lanes through and around Baltimore.)
- **Loading flexibility.** Neither freight route accommodates the most modern, high-value freight cars (Plate H) with double-stacked containers or triple auto racks. In addition, the NEC cannot accommodate any cars exceeding Plate C, such as larger box cars or single-level trailers.

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[51] The rail line south of Baltimore is located in the Western Shore Uplands Region, while the line north of Baltimore is located in the Western Shore Lowlands Region and borders tidewater over much of its length.

- **Interoperability.** The CSXT and NEC routes through Baltimore City are essentially independent of each other. There is no expeditious way to operate CSXT freight traffic over the NEC, NEC freight traffic over CSXT, or any passenger traffic over the parallel route.[52] This situation reflects clearance differences, track layouts, and the status of operating rights. The lack of interoperability came to the fore in the Howard Street Tunnel fire, when CSXT had to route trains via Cleveland, Ohio (see Chapter Two, Box 2-2).
- **Interconnectivity within, and competitiveness of, Port of Baltimore.** Due to capacity, speed, and loading constraints, all-rail freight movements between the northeast and southwest parts of the Port of Baltimore are difficult and costly to accomplish. Furthermore, due to clearance inhibitions, the northeast part of the Port cannot route many types of shipments west via the CSXT, and the southwest part has similar limitations to use of the NS. This lack of connectivity and routing flexibility detracts from the Port's efficiency and attractiveness.
- **Externalities.** Inefficiency has its costs, and the antiquated rail link through Baltimore has implications for the general public as well as for the carriers and shippers involved. While measurement of these external costs was beyond the resources of this study, they merit at least a listing:

Costs to the general public:

— Highway congestion and its time, energy, and emissions costs due to the substitution of trucking for inefficient or impracticable rail freight moves across, to, and from Baltimore; as well as on highway corridors outside the study region, the truck traffic of which is influenced by the constraints inherent in the Baltimore rail system;

— Highway congestion and its costs due to rail's inability to further reduce its passenger trip times, enhance its reliability, and divert more automobile traffic;

— Reduced economic activity at the Port and in the Baltimore Region due to the constraints on its rail access;

— Constraints on access to BWI Airport due to limited rail capacity.

Costs to rail users:

— Added shipping and inventory costs for shippers due to the limitations and inefficiencies in rail freight transit across, and service to, Baltimore. Because this is the main East Coast rail link, these costs are also borne by shippers distant from Baltimore itself;

— Time-penalties for intercity rail passengers and commuters due to the slow running through Baltimore.

[52] Connections do exist for limited freight interchange, but these are not designed for through traffic purposes.

Costs to carriers:

- Added costs to freight railroads due to inefficiencies in their Baltimore operation;
- Opportunity costs of freight traffic lost due to capacity, speed, and loading constraints;
- Added costs to freight railroads due to circuitous routings around Baltimore;
- Added operating and maintenance costs to Amtrak and MARC due to the slow, difficult, and antiquated transit of Baltimore; and
- Opportunity costs of passenger traffic lost by Amtrak and MARC to other modes, due to extended rail travel times through Baltimore (see Figure 3 - 18).

Chapter Four
TRAFFIC LEVELS

Using the infrastructure, with its limitations, as portrayed in Chapter Three, the railroad companies manufacture their product—passenger and freight transportation—and thus generate their revenue by serving their customers. Of concern in this study are not only the present levels of rail traffic, but also those of the foreseeable future, since any contemplated restructuring must be assumed to remain in service for at least as long as the nineteenth-century B&P and Howard Street tunnels have thus far endured. Furthermore, insofar as engineering economy will allow, restructuring alternatives should provide for future expansion *beyond* foreseeable service levels, so as to reduce the investment that future generations may be forced to make the preserve the fluidity of their railway network.

After characterizing the region's rail traffic as a whole, the following sections examine each of the major traffic types in turn, both in their present and future aspects. The forecasts make use of various planning horizons ending with the "planning year," 2050. (In the context of this particular study, forty-five years into the future is not a very long time: it is only one-third the age of the present B&P Tunnel.) The chapter ends with a recapitulation of the levels of *total* traffic, passenger and freight, which the network bears currently and must be expected to handle in the future.

A. Overview of the existing operation

This section introduces the discussion of traffic levels by summarizing the types and quality of the transportation currently performed.

1. The traffic mix

Illustrating the diversity and complexity of the rail traffic mix to, from, within, and through the Baltimore region is the following partial list of today's train movements:

- Through and local freight train operations of CSXT between the Camden Station vicinity and Bay View Yard, via the Howard Street Tunnel;
- CSXT through-freight operations between Bay View Yard and West Aikin, an interlocking station east of the Susquehanna River;
- Amtrak passenger and NS through-freight operations between Perryville and the NS Bay View Yard in East Baltimore;
- CSXT freight operations and MARC commuter operations between the Camden Station area and Washington, D.C.;
- Intercity passenger and commuter rail operations through the B&P Tunnel and southward to Washington Union Station;

- CSXT and NS local freight yards and related movements in the Baltimore Terminal area; and
- Moves to and from the Canton and P&BR railroads and Maryland Port Administration and private port facilities, in places not readily accessible from the CSXT and NEC main lines.

2. **Service quality**

a. On the NEC

Even prior to marked traffic increases foreseen by 2050, the on-time performance of intercity passenger services on the NEC falls short of world-class standards. Of the corridor trains serving Baltimore, only one-third arrive at their final destination (usually Washington, New York, or Boston) punctually to schedule.[1] The two-thirds of trains that are late, are on average some 20 minutes late at their final terminals. Many and varied are the reasons for this performance: congestion elsewhere than in the Baltimore region, mechanical difficulties, failures in various system components such as downed electric traction wires, and heavy usage of portions of the NEC not controlled by Amtrak—all play their role. But the cramped, old, and convoluted facilities in Baltimore do not alleviate the present, and can do nothing to relieve the prospective, performance challenges faced by Amtrak in its most important corridor. On the other hand, NS freight operations between Perryville and Baltimore are regarded as relatively reliable.

b. On CSXT

MARC commuter passenger services between Baltimore and Washington on CSXT, as well as CSXT freight operations between Philadelphia and Washington, incur delays on a regular basis. The lack of capacity to operate existing levels of service is at issue. Over the years, analyses repeatedly have identified choke points, such as the Howard Street Tunnel and the lack of track capacity between Baltimore and Washington.

The freight-only CSXT mainline between Perryville and Baltimore exemplifies the day-to-day difficulties of many railway operations in the study area. Single-tracked except for several short segments of double-track, the route is equipped with automatic block signals. Freight trains use one or more of the main tracks at Bay View Yard (East Baltimore) and locations in West Baltimore to set off and pick up cars. These operations consume track capacity and result in conflicts with other trains. Southbound freights that are unable to access Track 2 adjacent to Bay View Yard to set off and pick up, are held on the signaled siding at Van Bibber, further consuming capacity. Under these circumstances, with so little margin of operating error over a fixed plant that presents challenges even when traffic is flowing smoothly, delays on the CSXT freight line north of Baltimore can snowball, thus affecting freight and passenger flows on CSXT's larger network.

Capacity and service issues like these reinforce the need for a careful scrutiny of the traffic patterns in the study region as a whole.

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[1] That is, exactly on time or before time. These figures include no allowance for lateness.

B. Passenger services

Passenger services in the study region include Amtrak's intercity trains (corridor and long-distance) as well as MARC's commuter operations. These are described below.

1. Intercity passenger trains

As the owner as well as the operator of the NEC, Amtrak currently operates all intercity passenger trains in the Perryville–Baltimore–Washington corridor. Heavy frequencies and high speeds (up to 125 mph) characterize Amtrak service south of New York City.

Amtrak provides two types of intercity passenger service in the NEC: corridor-type services linking Boston, New York City, Philadelphia, Washington, Richmond, and intermediate points, and longer-distance services to and from points south of Washington and Richmond. In general, the corridor trains have fewer, and the longer-distance trains have greater, passenger amenities, in keeping with the contrasting journey lengths of the respective clienteles. This basic operational pattern of intercity passenger service is assumed, for analytical purposes, to continue indefinitely into the future, irrespective of any institutional changes that may occur.

a. Existing traffic levels—Intercity Passenger

(1) Corridor Services

Amtrak presently operates three categories of corridor service on the NEC[2]:

- **High-Speed.** *Acela* is Amtrak's premium high-speed service, making a limited number of intermediate stops between Boston, New York City, and Washington. *Acela* offers reserved First Class and Business Class seating. Scheduled trip times between New York and Washington range between 2 hours 42 minutes and 2 hours 52 minutes.[3] *Metroliner* service is similar to *Acela*, but uses conventional Amfleet equipment. *Metroliners* have a limited number of intermediate stops between New York and Washington, D.C. Current scheduled trip times range between 2 hours 55 minutes and 3 hours 5 minutes.
- ***Regional*** – Amtrak's frequent *Regional* service provides numerous intermediate stops between Boston, New York City, and Washington, with selected trains continuing on to Richmond and Newport News, Virginia. *Regional* offers Business Class and coach seating. Current scheduled trip times between New York and Washington exceed three hours and vary according to the number of scheduled stops and the time of day. A single train[4] in both directions has traditionally operated overnight between Boston and Washington, with either connecting or through train arrangements for traffic to and from Richmond and Newport News. Amtrak groups all these conventional train services together under the category *"Regional."*

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[2] The following discussion refers to, and assumes, Amtrak's normative schedules, with *Acela* equipment in full, active service. As this report goes to press (mid-2005), an extraordinary and, it is assumed, temporary hiatus in *Acela* service prevails, due to equipment difficulties.
[3] All times are as of 2003, when the analyses for this report were completed.
[4] This train, formerly named *The Federal*, has no sleeping car as this report goes to press.

(2) Extended Corridor Services

"Extended corridor" services operate in daylight over distances of some 600-650 miles or more, with modest amenities and no first-class accommodations. At present Amtrak operates three extended corridor trains over the NEC:

- The ***Palmetto***, between New York and Savannah, Georgia;
- The ***Carolinian***, linking the NEC with destinations in Virginia and North Carolina; and
- The ***Vermonter***, between Washington and northern Vermont.

(3) Overnight services

Typically offering sleeping, dining, and lounge car facilities, Amtrak's overnight trains mainly accommodate long-distance travel, although some shorter-distance markets are served where schedules permit:

- ***Silver Service*** – Amtrak's Silver Service operates two overnight round-trip trains (*Silver Meteor, Silver Star*) linking the NEC with destinations in Florida, Georgia, South Carolina, North Carolina, and Virginia.
- ***Crescent*** – Amtrak's Crescent links the NEC with destinations in Virginia, North Carolina, South Carolina, Alabama, Mississippi, and Louisiana.

Amtrak's existing service offering in the Northeast Corridor via Baltimore is summarized in Table 4 - 1. That the importance of this service to Amtrak cannot be overemphasized becomes clear in Box 4 - 1.

Table 4 - 1: Existing Intercity Passenger Train Service Through Baltimore

Market Served	Train	Line of Business	Northern Terminus	Southern Terminus
Northeast Corridor/ Virginia	*Acela*	Corridor	Boston	Washington
	Metroliner	Corridor	New York	Washington
	Regional	Corridor	Boston	Washington/Richmond/ Newport News
Northeast Corridor–Georgia–Florida	*Palmetto*	Extended Corridor	New York	Savannah
	Silver Star	Overnight	New York	Florida
	Silver Meteor	Overnight	New York	Florida
Northeast Corridor–North Carolina	*Carolinian*	Extended Corridor	New York	Charlotte
Northeast Corridor–New Orleans	*Crescent*	Overnight	New York	Atlanta/New Orleans
Northeast Corridor–Vermont	*Vermonter*	Extended Corridor	St. Albans, VT	Washington

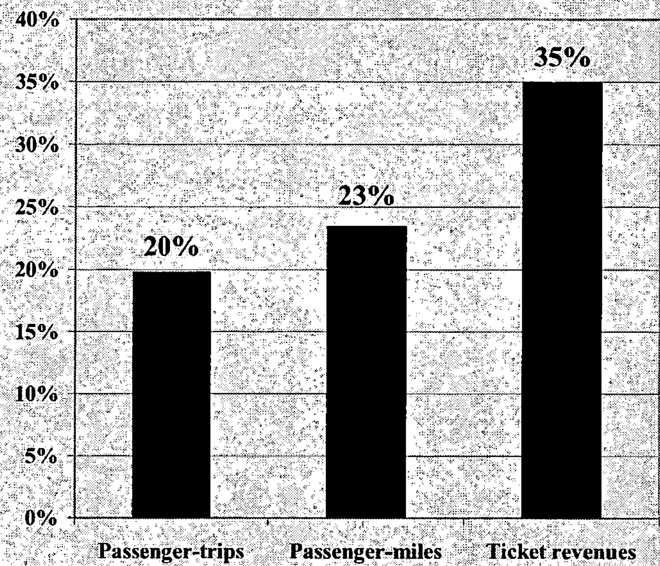
Box 4-1: Importance of the Baltimore Tunnels to Amtrak

Amtrak's route through Baltimore is crucial to the viability of all intercity rail passenger service in the United States. As demonstrated in the chart below, fully one-fifth of Amtrak's passenger-trips, one-quarter of its total passenger-miles, and *over one-third of its total ticket revenues* stem from trips making use of at least one of the NEC's Baltimore tunnels. Most of these trips depend on *both* the B&P and Union tunnels.

Figure 4 - 1:

Percentage of Amtrak's Total Traffic Dependent on One or Both of the NEC's Baltimore Tunnels

(Percentages are for 2004.)



b. Projections—Intercity Passenger

Amtrak has developed a 2015 planning timetable that contains corridor-type (high-speed[5] and *Regional*), extended corridor, and overnight services—the same types that exist today. Amtrak expects its train volumes (total movements in both directions) to increase from 2003 to 2015 at a 0.43 percent annual compound rate—from 96 daily trains to 101 daily trains by 2015. From 2015 to 2050, Amtrak train volumes are assumed to grow at a lower annual rate of 0.24 percent, which yields 110 trains per day by 2050—the assumed upper limit of the NEC's intercity passenger capacity. Significant investment, both in equipment and in bottleneck amelioration, would be required to support that growth rate. Operating longer intercity trains would accommodate some of the market's growth; for example, the *Acela* trainsets were designed to include up to 10 cars, thereby increasing available seating by approximately 85 percent over the present 6-car trainset. Throughput capacity in Pennsylvania Station, New York, constrains NEC operations during peak hours and would require attention and equitable resolution by all participating carriers, in order to assure reliable intercity service under the increased frequency assumptions of this report.

[5] I.e., Acela and Metroliner-type services

This report assumes that all intercity passenger trains in the study region will continue to operate (a) through Baltimore and (b) on the NEC. No intercity passenger trains would originate or terminate in Baltimore, nor would there be any restoration of intercity service on the CSXT in the area under examination.

Table 4 - 2 summarizes the intercity passenger train volumes projected for 2050 and considered in this study. No increase in the number of overnight trains is foreseen. However, this study assumes that—

- Corridor train movements would increase to 90 per day;
- Extended corridor services in the New York–Charlotte traffic lane would grow to eight movements per day;
- A new daylight round trip (two movements) would be instituted in the extended corridor between New York and Atlanta; and
- All other extended corridor services would retain their existing frequencies.

Table 4 - 2: Projected Intercity Passenger Train Service Through Baltimore, 2050

Market Served	Train	Line of Business	Northern Terminus	SouthernTerminus	Train Volume (Weekday) Round Trips	Train Volume (Weekday) Train Operations
Northeast Corridor/Virginia	*Acela-type*	Corridor	Boston	Washington	23	46
	Regional (includes Virginia service)	Corridor	Boston	Washington/ Richmond/ Newport News	22	44
Northeast Corridor-Georgia-Florida	*Palmetto*	Extended Corridor	New York	Savannah	1	2
	Silver Star	Overnight	New York	Florida	1	2
	Silver Meteor	Overnight	New York	Florida	1	2
Northeast Corridor-North Carolina	*Carolinian*	Extended Corridor	New York	Charlotte	4	8
Northeast Corridor-Atlanta-New Orleans	*Crescent*	Overnight	New York	Atlanta/New Orleans	1	2
	Daylight train	Extended Corridor	New York	Atlanta	1	2
Northeast Corridor-Vermont	*Vermonter*	Extended Corridor	St. Albans, VT	Washington	1	2
Total projected intercity passenger train volumes, 2050					**55**	**110**

2. Commuter service

As shown in Figure 4 - 2, the Maryland Department of Transportation, Mass Transit Administration, operates an extensive commuter rail network through the study region: two lines between Baltimore and Washington ("Camden Line" via CSXT, "Penn Line" via NEC), and an extension of the Penn Line between Perryville (on the Susquehanna River) and Baltimore (with service to and from Washington). Additional services, not directly affecting Baltimore, operate northwest from Washington over CSXT's Metropolitan Subdivision to Montgomery County, Brunswick, and Frederick (Maryland) and to Martinsburg (West Virginia). Table 4 - 3 presents some of MARC's vital statistics.

Figure 4 - 2: MARC System of Commuter Lines

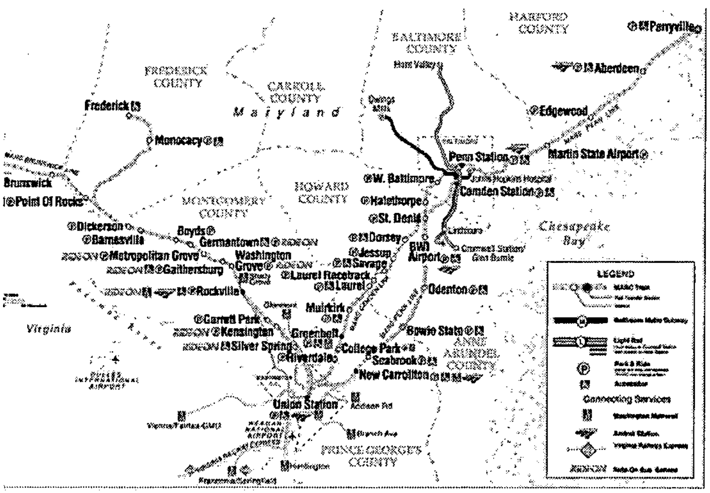


Table 4 - 3: Statistical Snapshot of MARC, 2001[6]

Operating Expense	$49,158,496
Capital Funding	$41,544,868
Annual Passenger Miles	175,191,930
Annual Vehicle Revenue Miles	4,438,031
Annual Unlinked Trips	5,816,975
Average Weekday Unlinked Trips	22,901
Annual Vehicle Revenue Hours	110,750
Fixed Guideway Directional Route-Miles	373
Vehicles Available for Maximum Service	140
Average Fleet Age in Years	12.2
Vehicles Operated in Maximum Service	110
Peak to Base Ratio	2.2
Percent Spares	27%
Incidents	61
Patron Fatalities	0

a. Existing traffic levels—Commuter

Most of today's commuter operations are not recent additions, as the former B&O and PRR offered local services in this region; however, today's rush hour frequencies are greater than those of the mid-1950s.[7] Thus, today's commuter services impose a relatively new pressure on the available capacity of the rail infrastructure, which has not changed in most respects in the intervening decades. The pressure is all the more intense because of the concentration of both intercity and commuter traffic in the rush hours, particularly in the afternoon.

[6] Source: Federal Transit Administration, National Transit Database, 2001, Maryland MTA section, "Commuter Rail."

[7] For example, in 1956, the PRR offered only two afternoon rush-hour (between 4 and 6 p.m.) local departures from Washington to Baltimore; today's Penn Line offers five such departures. The B&O offered two local departures in the same hours from Washington to Baltimore; MARC's Camden line today offers four such departures. Thus today's rush hour frequencies are at least double those of 1956. *Official Guide of the Railways,* July 1956, pp. 339 (PRR) and 428 (B&O); today's MARC schedules from the Maryland MTA web page, http://www.mtamaryland.com/services/marc.

b. Projections—Commuter

Over the entire planning period, commuter operations are expected to grow at an annual compounded growth rate of about one percent for the long-established Camden and Penn (Baltimore–Washington) lines, and at a rate just short of two percent for the newer Penn line extension between Perryville and Baltimore. However, the Baltimore–Washington commuter operations are expected to remain much more frequent than the service north of Baltimore. (See Table 4 - 4.) The expected frequency increases reflect MARC's 2020 planning timetable, extrapolated to 2050 at sharply reduced growth rates for the Camden and Perryville routes, and at a slightly increased rate for the Penn (Baltimore–Washington) segment. That these growth rates are relatively modest results from the assumed use of longer, higher-capacity trains to satisfy surging demand.

All told, the study team expects commuter train volumes on existing services to double, approximately, between 2003 and 2050. Thus, in any further elaboration of the present study, the Camden and Penn Line commuter projections will have to be compared in detail with likely CSXT, NS, and Amtrak traffic levels to determine the level of capacity improvements that would be necessary to protect the reliability and frequency of all services. Furthermore, since the Baltimore region has numerous rail lines, a widely distributed population, and severe motor vehicle congestion, new commuter services also are possible by 2050. The feasibility and cost of any such new services would relate closely to comprehensive planning for rail operations and facilities in the study area.

Table 4 - 4: Projected Growth in MARC Commuter Traffic

	Round trips per weekday			Train operations per weekday			Average annual compounded growth rates		
Route	**2003**	**2020**	**2050**	**2003**	**2020**	**2050**	**Period 2003-2020**	**Period 2020-2050**	**Average, 2003-2050**
MARC Camden Line (via CSXT)—Baltimore and Washington[8]	11	16.5	18.5	22	33	37	2.41%	0.40%	1.1%
MARC Penn Line (via NEC)—Perryville and Baltimore[9]	8	12.0	19	16	24	38	2.42%	1.54%	1.9%
MARC Penn Line (via NEC)—Baltimore and Washington	22.5	26.5	39	45	53	78	0.95%	1.31%	1.2%

[8] Does not include any deadhead moves (nonrevenue round trips) between Riverside Yard and Camden Station.
[9] Includes 6 deadhead trains (the equivalent of 3 nonrevenue round trips) between Baltimore and Perryville in the base year. The proportion of deadhead to total movements in future years will depend on MARC's operational planning and the availability of storage facilities at appropriate locations.

C. Freight services

The following discussion treats the existing and projected freight services in the Baltimore region.

1. Existing traffic levels

The predominant rail freight operations in and through the region are those of its two primary Class I carriers, CSXT and NS.[10] However, smaller railroads provide important localized services as well, the protection and furtherance of which will require close attention in any further planning.

a. CSXT

CSXT operates through and local freight services over the length of the study corridor. The route traverses the Baltimore Terminal, which consists of the Howard Street Tunnel, its approaches, and a series of yards and branches that serve local customers and the Port of Baltimore. (CSXT also provides rail service to the Morgantown and Chalk Point Power Plants located on the Popes Creek Branch, which intersects the NEC at Bowie; the unit coal trains operate through Benning Yard, Landover, and Bowie.)

b. NS via NEC

NS currently provides through and local freight service between Harrisburg and Baltimore on the NEC. From Harrisburg, through freight and unit coal trains operate via the "Port Road" along the Susquehanna River to Perryville, and thence via the NEC to the NS Bay View Yard. NS operates local freight trains from Bay View Yard to locations south of the B&P Tunnel. NS has overhead rights to operate between Baltimore and Alexandria, Virginia, thence to Manassas and the southeastern United States on its Piedmont Division. Presently, NS does not operate through freight trains between Bay View and Alexandria.[11]

Most of the comparatively slow freight service on the corridor operates at night to avoid conflicts with the much faster intercity and slightly faster commuter trains. In fact, Amtrak restricts all freight trains to a maximum speed of 30 mph between 6:00 AM and 10:00 PM. Amtrak permits solid intermodal trains and solid empty hopper trains to operate at various speeds up to 50 mph between 10:00 PM and 6:00 AM.

c. Local movements

The Patapsco & Back Rivers (P&BR) and Canton railroads provide important local movements to and from port and industrial sites on the east side of Baltimore Harbor. Access between these smaller carriers, the CSXT and NS, and local industrial and port facilities is provided by means of various interchange and switching arrangements worked out among the

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[10] In addition, the Delaware and Hudson Railway (D&H), part of the CP Rail System, has overhead trackage rights over the NEC from Perryville to Alexandria, Virginia, to permit it to interchange with railroads serving the southeastern United States. The D&H currently operates over the NEC south of Perryville on an irregular basis and is not presently a major factor in the Baltimore region.

[11] CSXT operates unit coal trains over its lines to Benning Yard in D.C., whence CSXT makes use of the NEC to access the Popes Creek Branch at Bowie, Maryland. This movement does not involve trackage in Baltimore.

carriers and industries. In addition, CSXT and NS need to interchange freight among themselves, and move cars between the two sides of the port. All these additional movements are over and above those shown in the summary table of daily train operations (Table 4 - 1), further below.

2. Projections—Freight

Forecasts of future freight traffic through Baltimore are uncommonly hazardous because—

- Provision of a modernized facility with improved clearances, grades, and curves will constitute a marked "paradigm shift" that will open the door to new traffic flows—originating, terminating, through, and local. Standard forecasting methods are of uncertain value in such a situation.
- Developments in the rail industry—for instance, mergers or improvements in other parts of the grid—could alter some freight traffic flows; and
- The future of heavy industry in Baltimore and its neighboring regions is unclear, as the closing of General Motors' Baltimore assembly plant in May 2005 exemplifies.

In making the following projections, the study team assumed no major structural change in America's freight railroad industry and no significant shift in the economic base of the Baltimore region or, indeed, of the Northeast Corridor megalopolis. Any such fundamental modifications would, of course, affect the projections and might alter the conclusions of any follow-on studies.

a. Underlying growth in freight volumes

Freight train-miles (FTMs) by service type constitute the appropriate unit of measure for this study because the number and performance of trains is the primary, but not the only, determinant of capacity. Such other measures as train weight and length also have a role in the design of betterments—for example, in the determination of siding length.

The four basic service types are:

- "Premium"—intermodal, i.e. trailers or containers;
- "Unit"—single-commodity, e.g. coal;
- "Merchandise"—all other through freight; and
- "Local"—operating within the study area.

Table 4 - 5 summarizes the annual compound growth rates that were applied to both CSXT and NS traffic levels, before some carrier- and site-specific adjustments came into play.

Table 4 - 5: Projected Annual Growth Rates in Freight Train-Miles

	Service Type							
	Premium		Unit		Merchandise		Local	
Time Period	Low	High	Low	High	Low	High	Low	High
2001 – 2007	1.23%		1.16%		1.19%		1.19%	
2007 – 2012	0.85%	1.36%	0.58%	0.93%	0.67%	1.07%	0.67%	1.07%
2012 – 2020	0.85%	1.36%	0.58%	0.93%	0.67%	1.07%	0.67%	1.07%
2020 – 2030	1.00%	1.61%	0.53%	0.86%	0.78%	1.25%	0.67%	1.07%
2030 – 2050	0.89%	1.43%	0.53%	0.86%	0.67%	1.07%	0.67%	1.07%

The projections in Table 4 - 5 reflect those provided by CSXT[12] by train type for the period 2001-2007. The post-2007 projections use, as their upper limit for the "high" case, the historical growth in tonnage for the Eastern Class I railroads (1.6 percent compounded annually between 1985 and 2001); this maximum growth rate is adjusted downward to acknowledge long-term increases in tonnage per train. The "low" case assumes growth rates on the order of two-thirds of the "high."

Train-miles in premium service are expected to grow relatively quickly after 2020 on the assumption that capacity and clearance improvements both within and adjoining the study region will allow a fuller range of auto rack and double-stack container cars to pass through Baltimore, thus allowing rail better to compete with truckers in the I-95 and I-81 corridors. By contrast, growth in unit-train volumes would lag behind that of other service types; while traffic may increase in such cargos as municipal solid waste, reductions in coal use for electric power generation are ultimately possible for environmental reasons.

b. Site- and carrier-specific projections

Beyond the general projections of freight traffic increases, the study team assumed that NS would, by 2020, divert from its Shenandoah Valley–Manassas–Hagerstown routing a pair of merchandise trains and a pair of premium intermodal trains between Alexandria, Virginia and Perryville, Maryland via the NEC through Baltimore.[13] Also assumed was the diversion of a

[12] NS provided no projections but, warning of the volatility of any such forecasts, took no exception to those adopted in this report. Letter from Steve Eisenach, NS's Director of Strategic Planning, to Richard U. Cogswell of FRA, August 25, 2003.

[13] These trains would make use of NS's trackage rights over the freight route through Washington, D.C., as well as NS's freight line between Anacostia and Landover. CSXT currently owns the entire railroad from Alexandria (where the junction with the NS lies south of the passenger station), across the Potomac River on the Long Bridge, through Southwest D.C., and via the Virginia Avenue Tunnel and the bridge over the Anacostia River to the junction with the NS freight route to Landover and the NEC. Historically, however, most of the route belonged to the PRR,

second pair of merchandise trains and a second pair of premium intermodal trains by 2030. This rerouting anticipates both the physical improvements mentioned above and a resolution—mutually beneficial to both the NEC's owner and NS—of the cost of, and appropriate time slots for, running freight on the high-speed passenger corridor north of Washington.

c. Distribution of freight train volume by segment and traffic lane

In the study area, CSXT originates and terminates numerous trains to and from the west and south, and fewer trains to and from the east and north. Numerous CSXT trains operate through Baltimore. It is projected that these patterns will continue.

NS presently originates local trains in Baltimore that operate between Baltimore and Washington and return. While NS has the rights to operate trains between Baltimore and Alexandria (Virginia) using CSXT tracks south of Landover, Maryland, it presently does not do so. Thus, all NS through-freight trains presently operate between Baltimore, Perryville, and Harrisburg (Pennsylvania). As mentioned above, it is anticipated that the implementation of capacity and clearance improvements through Washington and Baltimore would result in an increase in the number of NS trains routed to Baltimore, via Alexandria and Washington.

d. Detailed projections of freight volumes

Table 4 - 6 provides a breakdown of expected freight train volumes by segment, railroad, and type of freight service.

The study team regards these freight projections as balanced between optimism and pessimism—as taking into account both the historical trend lines in tonnage and train payloads, and recent evidence of transition from manufacturing to service in certain sectors of the economy of the Middle Atlantic States. However, in such a case as that of Baltimore, there is a danger in equating "balanced," even "low" traffic projections with "conservatism." To under-design a multi-billion dollar facility that will, if the past is any guide, likely serve the Nation for well over a hundred years, could lead to a recurrence of today's impasse and hobble commerce for many decades—until a future generation restudies the situation and invests in a "fix." Moreover, the incremental cost of added capacity in a project of this magnitude is far less than that of a future expansion, at least in current-dollar terms—particularly if the initial design makes cost-effective provision for possible future expansions. For these reasons, it will be important in any future studies to test a range of traffic assumptions and determine the related costs and benefits of various levels of capacity and utility.

Penn Central, and Conrail, and passed into CSXT's ownership (with the NS trackage rights) at the time of the Conrail breakup.

Table 4 - 6: Detailed Projections of Freight Traffic by Railroad, Segment, and Year

[**NOTE:** Low and high projections were only done for 2012 and later years. Totals may not add precisely due to rounding.]

CSXT: Aikin to Baltimore	2001	2007	2012		2020		2030		2050	
			Low	High	Low	High	Low	High	Low	High
Premium	7	8	8	8	9	9	10	11	12	15
Unit	4	5	5	5	5	5	5	6	6	7
Merchandise	9	9	9	10	10	10	11	12	12	15
Locals	0	0	0	0	0	0	0	0	0	1
Freight Total	21	22	22	23	24	25	26	29	31	37

NEC: Perryville to Baltimore (all NS trains)	2001	2007	2012		2020		2030		2050	
			Low	High	Low	High	Low	High	Low	High
Premium	3	4	4	4	4	4	7	7	11	13
Premium - *rerouted*					2	2	2	2		
Unit	2	2	2	2	2	2	2	3	3	3
Merchandise	2	2	2	2	2	2	5	5	8	9
Merchandise - *rerouted*					2	2	2	2		
Locals	1	1	2	2	2	2	2	2	2	2
Freight Total	9	9	10	10	14	15	20	21	23	27

CSXT: Washington to Baltimore	2001	2007	2012		2020		2030		2050	
			Low	High	Low	High	Low	High	Low	High
Premium	14	15	15	16	16	18	18	21	22	28
Unit	6	6	6	7	7	7	7	8	8	9
Merchandise	10	11	11	11	12	12	13	14	15	18
Locals	1	1	1	1	1	1	1	1	1	1
Freight Total	31	33	33	35	36	38	39	44	46	56

NEC: Washington to Baltimore (NS trains except as indicated)	2001	2007	2012		2020		2030		2050	
			Low	High	Low	High	Low	High	Low	High
Premium	0	0	0	0	0	0	2	2	5	5
Premium - *rerouted*					2	2	2	2		
Unit[14]	0	0	0	0	0	0	0	0	0	0
Merchandise	0	0	0	0	0	0	2	2	5	5
Merchandise - *rerouted*					2	2	2	2		
Locals	2	2	2	2	2	2	2	2	2	3
Freight Total	2	2	2	2	6	6	10	10	12	13

[14] CSXT unit coal trains that originate west of Brunswick, Maryland and use the NEC between Washington, Bowie (Maryland), and the Popes Creek Branch, are excluded from this table as they do not pass through the Baltimore region.

D. Total train movements, all traffic types

Both the CSXT and NEC main lines are largely multipurpose facilities and will most likely remain so.[15] Thus, the interaction among train types, and the total traffic burden to be borne by each facility, are important considerations in planning. The following sections, therefore, consolidate the traffic statistics and projections for the main facilities under analysis.

1. Existing traffic levels

Table 4 - 7 portrays the average weekday traffic, in terms of total train operations in both directions, over the main line railroads in the study area.

Passenger operations are almost always scheduled in advance and relatively easy to characterize accurately. Freight operations, however, are less predictable than passenger services, in terms of arrival and departure times, train size, and frequency in a given period. Freight trains' performance capabilities vary significantly; so does their compatibility with passenger trains. For example, unit trains (carrying coal and grain) generally have a lower horsepower-to-tonnage ratio than more time-sensitive trains; the former are usually restricted to lower speeds than the latter. Thus, a general merchandise or intermodal train ordinarily takes less time to clear a given route segment than a unit coal train. An intermodal train (with an average speed of approximately 45 mph) takes less time to clear a give route than a commuter train, which makes frequent stops. Readers should bear these factors in mind when reviewing Table 4 - 7 and similar traffic summaries. A railway route segment's capacity depends, not just on its physical layout and condition, —not just on the sheer number of trains it carries, —but on the complex interactions between a variety of train types of widely varying performance characteristics. This is especially true in the Baltimore region, with its diverse traffic mix.

2. Projections

Table 4 - 8 summarizes the mix of services as foreseen for the year 2050. The same projection appears in graphical form, with intermediate years' traffic levels, in Figure 4 - 3. Both displays make use of the "high" projections, which pertain to freight traffic only. An overview of the growth of total train movements for all rail services in the two major traffic lanes—north and south of Baltimore—appears in Figure 4 - 4.

The simple number of daily trains envisioned in Table 4 - 8 and Figure 4 - 3 for a typical 24-hour period does not adequately depict the potential congestion in the main lines of the study region. Intercity passenger trains are concentrated into an 18- rather than a 24-hour day, since operations between 11:00 p.m. and 5:00 a.m. are minimal. Furthermore, a business-oriented corridor such as the NEC, in which most trips are under 225 miles and take less than three hours, will tend toward a schedule with additional train departures at the start and end of the business day. Commuter trains have even more pronounced two- to three-hour morning

[15] However, as will be seen, specific restructuring alternatives may particular line segments to specialized roles.

Table 4 - 7: Existing Main Line Railroad Services in the Study Region[16]

(Number of Weekday Train Operations by Segment.[17] Total Both Directions—Round Trip Counts as Two Operations)

Type of Service	Via CSXT Main Line		Via NEC Main Line	
	Aikin – Baltimore	**Baltimore–Washington**	**Perryville – Baltimore**	**Baltimore -Washington**
Passenger				
Intercity				
Corridor-type services				
Acela Express			24	24
Metroliner			13	13
Regional (includes Virginia and "overnight" NEC services)			40	40
Total – Corridor Services			**77**	**77**
Extended corridor services				
NEC–North Carolina (*Carolinian*)			2	2
NEC–Georgia (*Palmetto*[18])			2	2
NEC–Vermont (*Vermonter*)			2	2
Total – Extended Corridor Services			**6**	**6**
Overnight services				
NEC–New Orleans (*Crescent*)			2	2
NEC–Florida (*Silver Service*)			4	4
Total – Overnight Services			**6**	**6**
Total Intercity Passenger			**89**	**89**
Commuter				
MARC Camden Line		22[19]		
MARC Penn Line (includes Perryville)			16[20]	45
Total commuter		**22**	**16**	**45**
Total Passenger Services		**22**	**105**	**134**
Freight [21]				
Operated by CSXT[22]	21	31	0	0
Operated by NS	0	0	9	2
Total Freight Services	**21**	**31**	**9**	**2**
Study Area Total	**21**	**53**	**114**	**136**

[16] Total trains on a typical weekday (round trips count as 2 trains). Because of the variability and directional imbalance of traffic flows, the numbers shown are estimates, and vary by day of week and season of year.

[17] Data for freight and passenger operations apply generally to the period 2001-2003, during which significant long-term changes in service did not intervene.

[18] Classification of the *Palmetto* as an "extended corridor" service actually began in 2004. In 2003, it was an overnight service that served Florida as well—but without sleeping car accommodations.

[19] Does not include 10 "deadhead" i.e., nonrevenue train movements from Riverside Yard, Baltimore, to Camden Station.

[20] Includes 6 deadhead trains between Baltimore and Perryville.

[21] Includes through freights, locals, and coal trains.

[22] CSXT unit coal trains that originate west of Brunswick, Maryland and use the NEC between Washington, Bowie (Maryland), and the Popes Creek Branch, are excluded from this table as they do not pass through the Baltimore region.

Table 4 - 8: Projected Main Line Railroad Services in the Study Region— 2050

(Number of Daily Train Operations by Segment, Total Both Directions. Round Trip = Two Operations. **NOTE:** "High" and "Low" Ranges Apply Only to Freight.)

Type of Service	Via CSXT Main Line		Via NEC Main Line	
	Aikin-Baltimore	**Baltimore-Washington**	**Perryville-Baltimore**	**Baltimore-Washington**
Passenger Services				
Intercity				
Corridor	0	0	90	90
Extended corridor	0	0	14	14
Overnight	0	0	6	6
Total intercity	0	0	110	110
Commuter Services	0	37	38	78
Total passenger services	**0**	**37**	**148**	**188**
Freight services—*High Volume*[23]				
Operated by NS[24]			27	13
Operated by CSXT[25]	37	56[26]		
Total freight service—High Volume	**37**	**56**	**27**	**13**
Grand total, projected train operations with freight service at high volume	**37**	**93**	**175**	**201**
Freight services—*Low Volume*				
Operated by NS			23	12
Operated by CSXT	31	46[26]		
Total freight service—Low Volume	**31**	**46**	**23**	**12**
Grand total, projected train operations with freight service at low volume	**31**	**83**	**171**	**200**

and evening peaks. Freight operations—typically unscheduled on American railroads—are not only random to a degree, but also subject to circumstances that may occur hundreds of miles away from the study area.[27] Thus, an assessment of the potential for congestion requires the analysis of the complex interactions of through freight, local freight, and passenger trains in congested portions of the study region over a typical week.[28] Such an in-depth analysis would

[23] With respect to freight traffic, which will show daily directional imbalances and volume fluctuations, the numbers shown must be regarded as projected daily averages over time.

[24] Includes through freights, locals, and coal trains.

[25] CSXT unit coal trains that originate west of Brunswick, Maryland and use the NEC between Washington, Bowie (Maryland), and the Popes Creek Branch, are excluded from this table as they do not pass through the Baltimore region.

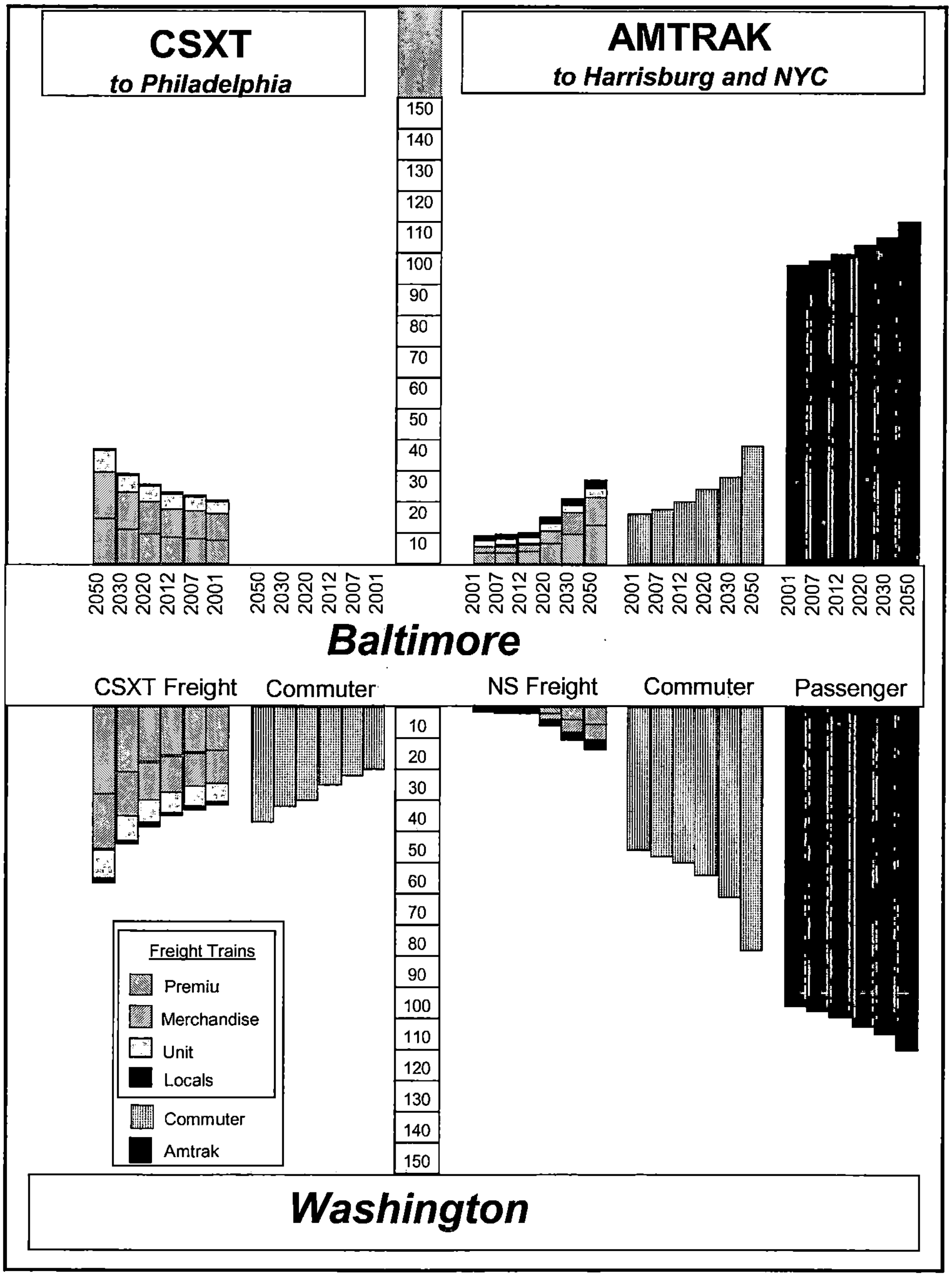
[26] Includes trains south to Alexandria/Richmond and west to Cumberland.

[27] The same unpredictability currently affects Amtrak's overnight and extended corridor operations over the freight railroads, which then impact on NEC reliability.

[28] Multi-day simulations are necessary because of the variability of freight traffic. In any event, detailed capacity analyses of freight and passenger operations and interactions, in a terminal zone of Baltimore's complexity, would make use of computerized train performance and simulation models and were beyond the scope of the present study.

inevitably be part of follow-on studies, if a decision is made to pursue comprehensive rail alternatives for the Baltimore region. Any analysis of this type would also need to examine carefully local freight operations in the Baltimore Terminal Area, including the setting off and picking up of cars.

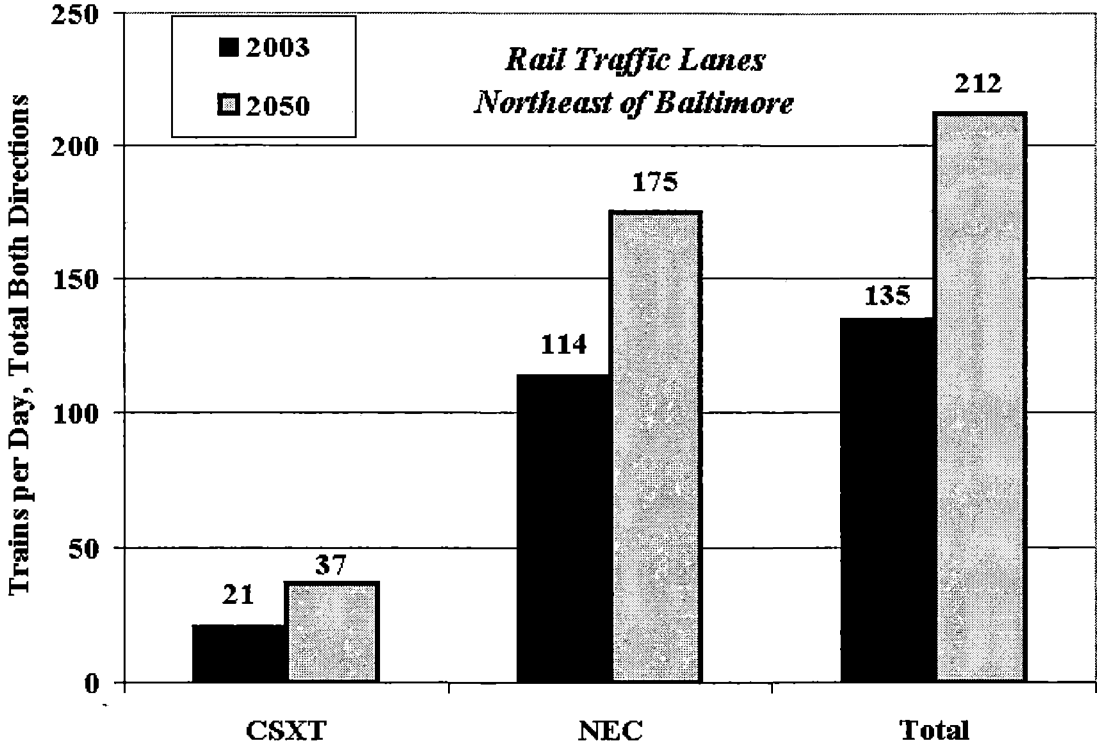
Figure 4 - 3: Expected Trends in Train Volumes in the Study Region by Year and Service Type, "High" Range[29]

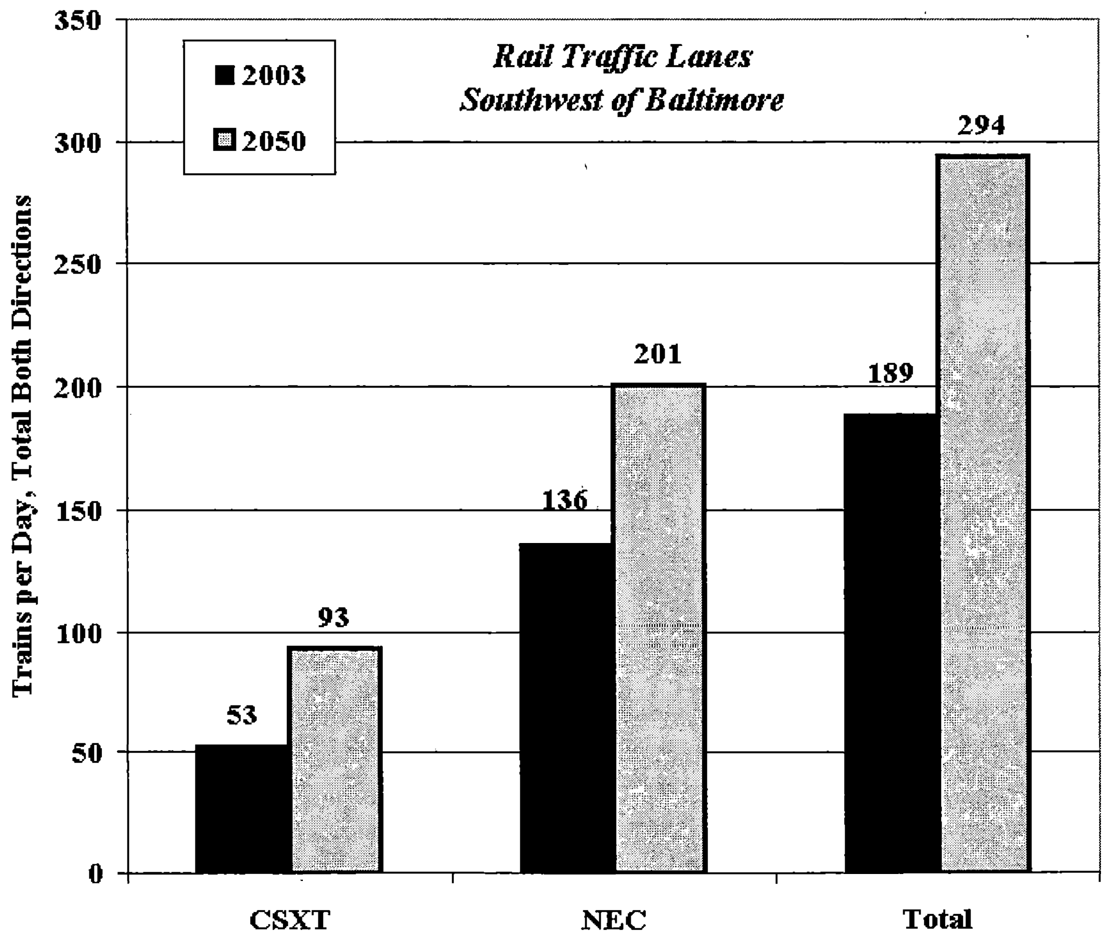


For recent examples of modeling techniques of this type, readers are referred to recent transportation planning reports by Amtrak and FRA on the Washington–Richmond, Philadelphia–Harrisburg, and Richmond–Charlotte corridors at http://www.fra.dot.gov/us/content/1240 .

[29] The "high" and "low" ranges pertain only to freight. See Table 4 - 8.

Figure 4 - 4: Overview of Expected Rail Volume Growth, All Service Types in the Baltimore–Northeast and Baltimore–Southwest Traffic Lanes
(With "High" Freight Traffic Levels)





E. Recapitulation: The challenges in brief

As Figure 4 - 4 demonstrates, the demand for total train movements of all types is expected to increase by over 50 percent by 2050 from its 2003 levels. In 2050, such a heightened pressure for transport would place a huge incremental load on a rail network that would, if left unchanged[30]—

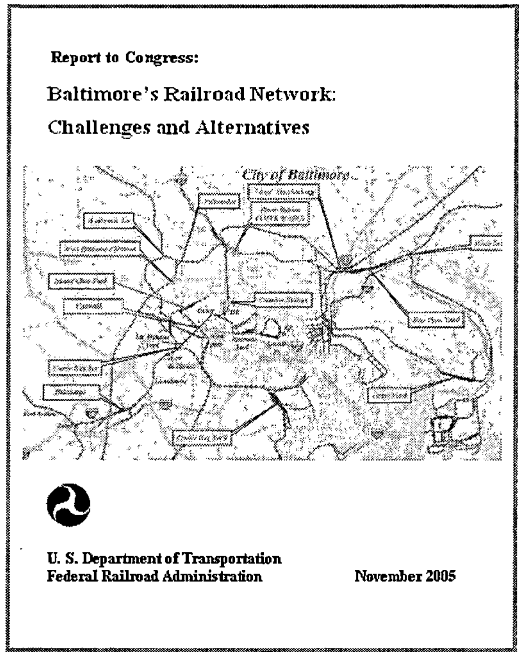
- Date back between 100 and 150 years, in some cases even further back;
- Hamper train movements with a geometry more fitting for mountainous terrain than for the tidewater East Coast of the United States;
- Present capacity constraints that already (in 2005) discourage rail transport and favor other modes that themselves are chronically congested;
- Consume crew time and fuel well beyond what an efficient railway would require, thus ballooning railway operating expenses for all carriers concerned;
- Add to freight transit times and unreliability, thus imposing costs on shippers up and down the East Coast—not just in the study area;
- Inflate intercity passengers' and commuters' travel time due to slow schedules and erratic performance through Baltimore, thus making auto travel relatively more attractive; and
- Impose social costs due to all the inefficiencies inherent in the system.

It is the purpose of the balance of this report to describe alternatives that would reverse these inherent difficulties by improving train routings, expanding freight clearances, and enhancing freight and passenger operations and capacities in the Baltimore region.

[30] This statement assumes that the physical facilities can survive for another half-century—an assumption for which no conclusive engineering backup presently exists. As explained later in this report, the design life for new tunnels is 120 years.

Part II:

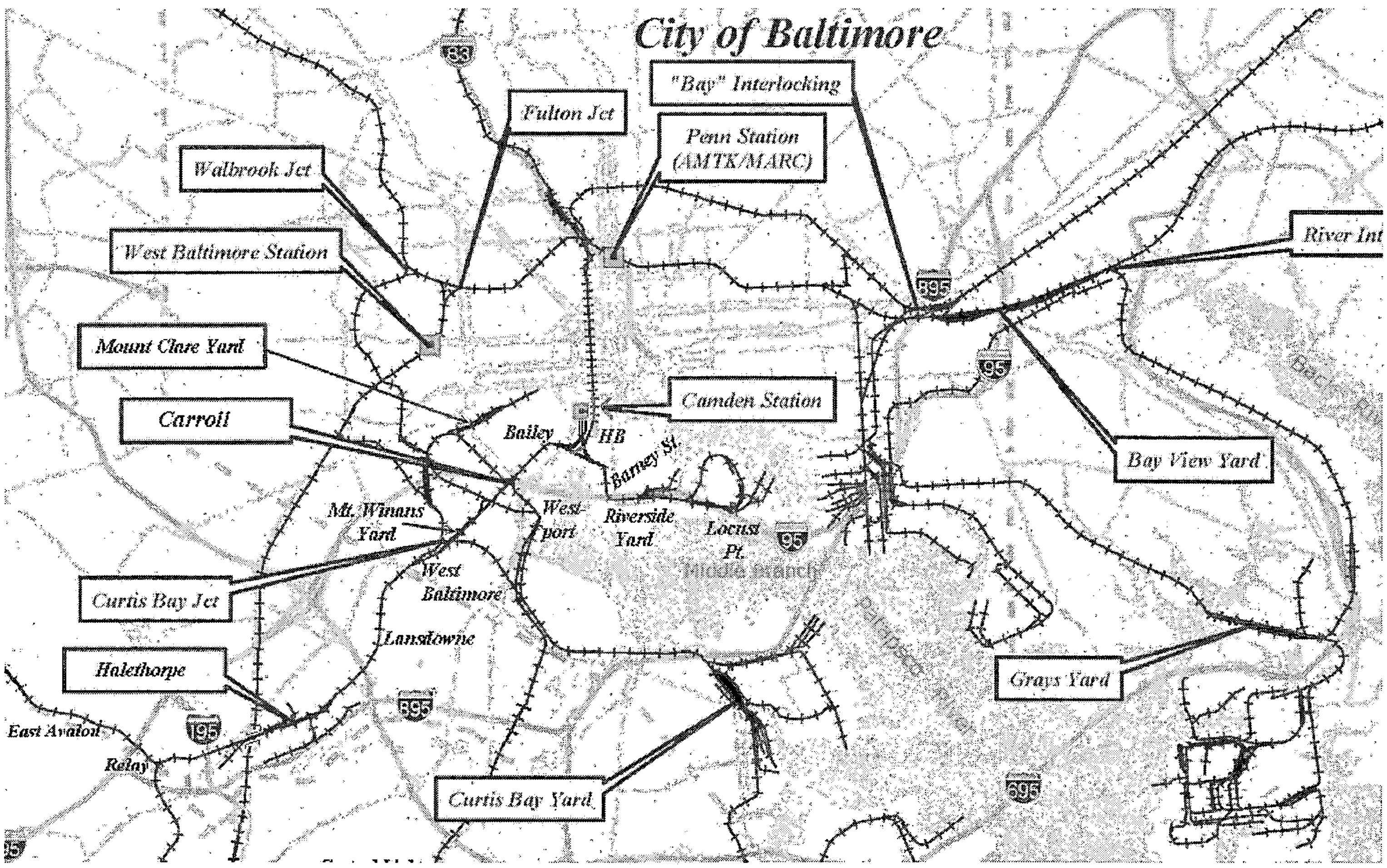
Alternatives


Report to Congress:

Baltimore's Railroad Network:

Challenges and Alternatives

U. S. Department of Transportation
Federal Railroad Administration **November 2005**



Chapter Five
STUDY OBJECTIVES, STANDARDS, AND METHODS

Part I of this report describes the challenges facing passenger and freight railroads as they serve their customers over an increasingly congested and antiquated collection of facilities in the Baltimore region. Part II elucidates the principles and techniques that guided, and the results that emerged from, the present effort to develop alternative solutions.

This chapter states the objectives of the planning effort, explains and presents the standards that the study team consistently applied during its investigations, and recounts the methods that the team employed. Subsequent chapters lay out in some detail the alternatives that survived what was essentially a winnowing process.

A. Study Objectives

To turn the built-in drawbacks of Baltimore's railways into inherent advantages, the study team adopted the following objectives:

1. **Make the service quality and capability of the system, both as a whole and in its important parts, no worse than it is today.**

   Beyond doing no harm:

2. **Remove all through freight service from the Howard Street Tunnel.**
3. **Provide high-cube, double-stack clearance routes through Baltimore for both NS and CSXT freight trains.**
4. **Provide grades for freight trains that are less than those now encountered—preferably much less.**
5. **Provide a replacement for the B&P Tunnel.**
6. **Increase speeds for both passenger and freight trains wherever economically feasible.**
7. **Provide capacity to support traffic levels for freight, intercity passenger and commuter services based on reasonable projections for the year 2050, for each existing and projected route—while making every effort to reduce the future cost of providing still more capacity, should traffic grow beyond the design level.**
8. **Maintain access to all freight and passenger yards, port facilities, maintenance facilities, as well as CSXT Camden and Amtrak Pennsylvania Stations.**
9. **Provide for CSXT and NS intra-terminal moves in Baltimore.**
10. **Identify any relatively near-term improvements that could benefit users while long-term projects are progressed.**

Such near-term improvements would, if implemented, foster capital and operating cost-effectiveness; minimize disruptions to the regional transportation system; and maximize use of the region's existing and committed transportation infrastructure.

11. **Avoid, minimize, and/or mitigate any significant adverse environmental impacts caused by Corridor improvements.**

    Any restructuring projects will necessarily—

    - Comply with all applicable local, State, and Federal standards and/or procedures such as those for air quality, noise, surface and ground water quality, storm water management, ecosystems, environmental justice, energy consumption, hazardous materials, and river navigation; and
    - Minimize community disruption, displacements, and relocations; as well as adverse impacts to public parks, historic resources, and visual resources and aesthetics resulting from mobility improvements in the Corridor.

12. **In making changes to accomplish all the above objectives, assure that railway operating expenses in the study area will not increase on a unit basis—and will, preferably, decrease.**[1]

B. Standards for the Development and Evaluation of Alternatives

To fulfill the objectives laid out above, each alternative would need to meet or exceed core design and performance standards. While subject to elaboration and revision, these standards allowed the study team to develop the initial set of alternatives for presentation and evaluation.

1. Different Needs for Freight and Passenger Service

Standards for Baltimore alternatives differ for passenger and freight service because the needs of the two types of transportation diverge. The divergence becomes apparent in Table 5 - 1, particularly with respect to gradient, clearances, and the desirability of passing through Pennsylvania Station. While one percent and two percent grade limits may appear very similar (as they are separated by a single percentage point), in railway engineering terms the difference is huge. Similarly, while reliability and uninterrupted train movements are aims common to both freight and passenger service, travel time in the NEC's city- pair markets—for example, through Baltimore itself—is the prime factor for passenger operations. For freight traffic, however, the elimination of circuity and the achievement of consistent, reduced transit times on a national scale (at least, for each carrier involved) constitute the prime ends. While faster freight train transit times within Baltimore would, of course, help the freight carriers, improved clearances and geometric layouts would have an even greater impact on the routing possibilities for modern freight cars and on operating economy. Thus the priorities of freight

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[1] This objective is listed here for the sake of completeness and as an expression of the study team's intention. Detailed analysis of operating expenses and the effects thereon of various alternatives, fell outside the scope of this study but would necessarily be part of future development, if any, of the alternatives. By way of example: this study does not address the terms or prices of trackage rights under the various alternatives, which will be subject to negotiation among the project partners.

and passenger service differ markedly—so much so that the creation of separate freight and passenger pathways may well provide the optimal solution to the Baltimore challenge. This is all the more true because the minimal capacity requirement—two freight and two passenger tracks—already implies the installation of between two and four tunnel tubes. If separate tubes are necessary, their designs can vary to follow their divergent functions and purposes.

Although this dichotomy of needs has always prevailed, only since the mid-20th Century—with the replacement of two parallel, competing, all-purpose railroads with an intercity passenger railroad (Amtrak's NEC), a commuter agency (MARC), and two Class I freight railroads (CSXT and NS), the latter of which enters the region over trackage rights—has the institutional structure so changed as to allow comprehensive solutions to emerge, in which separate, dedicated facilities for freight and passenger service may be contemplated.

2. Summary of initial standards

Table 5 - 1 summarizes the initial standards that the study team applied in developing and screening alternative scenarios for resolving the Baltimore challenge. Selected topics of special interest in the table are discussed in the following section.

Table 5 - 1: Initial Standards for Development and Evaluation of Alternatives

Criterion	Freight		Passenger	
	Comments	Initial Standard	Comments	Initial Standard
Main priority	The freight carriers wish to optimize flows on their networks. Efficient routings with unrestricted clearances through Baltimore are key.	Nationwide transit times, elimination of circuity, flexibility of operation. (Local flows within Baltimore region are definitely of concern as well.)	NEC's needs are paramount for Amtrak; efficiency and reliability of commuter operations are critical to MARC.	Transit times internal to the NEC, and to Baltimore in particular.
Grades	CSXT's maximum grade north and south of Baltimore is less than 1.0 percent.	1.0 percent maximum (0.8 percent desirable maximum)	The ruling grade on the NEC is 1.9 percent in the New York tunnels. (Grades are less injurious to relatively light, amply-powered passenger trains than to freights.)	2.0 percent
Curves	Curvature must be considered in conjunction with grades. CSXT's 10-degree curve north of Howard Street Tunnel and the NEC's sharp curves in the B&P Tunnel impact speeds and make train handling difficult.	Reduce curvature, below its present excessive levels, to allow maximum design speeds (below). NOTE: some of the alternatives impose speed restrictions due to curvature that require careful review given the long life of these improvements.	Curvature in B&P Tunnel adversely impacts through train speeds	Reduce curvature and improve geometry of high-speed paths, to allow maximum design speeds (below).

	Freight		Passenger	
Criterion	**Comments**	**Initial Standard**	**Comments**	**Initial Standard**
Maximum Design Speeds[2] (between Gunpowder River and Halethorpe)		60 mph (intermodal trains) 55 mph (merchandise freight trains) NOTE: some of the alternatives impose speed restrictions due to curvature that require careful review given the long life of these improvements.	Between Bay View Yard and B&P Tunnel area	125 mph
			North of Bay View and south of the B&P Tunnel area (per Amtrak proposal).[3]	150 mph
Clearances	Need to accommodate the largest freight cars, such as high-cube double stack container cars and tri-level auto racks, neither of which can now pass through the Baltimore tunnels.	Establish Plate H in double-track freight service through Baltimore. To benefit most traffic flows, this will require improvement in Washington D.C.'s Virginia Avenue Tunnel, as well as investigation and correction of all undue clearance restrictions (e.g., overhead bridges) in the study area.	Only passenger clearances (equal to or better than those in New York Tunnels) are required, unless interoperability of the freight and passenger services through each other's facility is desired and is feasible and cost-effective.[4]	

[2] The actual design speed contemplated for each location will depend upon the projected speeds resulting from braking or accelerating at stations or other constraining points. For example, a northbound Amtrak intercity train ideally could enter the south end of an alternative alignment to the B&P Tunnel at maximum authorized speed (MAS) but immediately begin to brake for the station stop; the curves in the tunnel would be designed to permit operation at the maximum braking or accelerating speed.

[3] The cost-effectiveness of expanding the NEC mileage subject to a 150 mph top speed limit has yet to be determined. Use of this theoretical 150 mph top speed in this report does not imply FRA endorsement of such an expansion.

[4] The issue of interoperability, its feasibility and its costs, including (among other issues) those of electrification, connectivity with Pennsylvania Station, the range of conditions in which sharing of facilities would occur, and what to do about freight trains negotiating steeper passenger grades, would need to be explored in any follow-up analyses.

Criterion	Freight		Passenger	
	Comments	Initial Standard	Comments	Initial Standard
Capacity	Capacity must be available to reliably accommodate current and future through, terminating, and originating services, in both north-south and east-west traffic lanes,[5] as well as all local services.	Provide a double-track main line freight route allowing for the most demanding clearances, with multiple tracks and other facilities where necessary to accommodate various types of freight service and yard operations.	Capacity must be available to reliably accommodate current and future services on existing routes. (Any potential new routes[6] were not part of this study.)	Provide at least a double-track main line passenger route with multiple tracks where necessary to accommodate various types of passenger service.
Tunnels: Design life of structures	120 years			
Design life of key internal fittings[7]	50 years			
Fire, life safety concerns	See discussion below.			
Bridges	Drawbridges are obstacles to water and rail commerce and centers of excessive cost.	No drawbridges are to be added to Baltimore's rail infrastructure.	There are already too many drawbridges in the NEC.	No drawbridges are to be added to Baltimore's rail infrastructure.
Commuter routings	Does not apply.		No basic restructuring is contemplated. (Any possible future use of the Howard Street Tunnel is beyond the scope of this report.)	CSXT Baltimore-Washington service will continue to serve Camden Station. NEC Perryville–Pennsylvania Station–Washington service will continue to use the through passenger route and station.

[5] The terms "north-south" and "east-west" refer to national traffic patterns, not to the localized movements by means of which the railroads satisfy those national patterns. For example, NS traffic from the West approaches Baltimore from the northeast (compass direction), and a portion of CSXT traffic from western points passes through Washington and approaches Baltimore from the southwest (compass direction).

[6] I.e., any possible future commuter services on certain portions of the Baltimore rail freight network that are currently freight-only. No new routes for intercity passenger service are presently envisioned for the Baltimore region.

[7] I.e., those fittings requiring tunnel closure for renewal.

Criterion	Freight		Passenger	
	Comments	Initial Standard	Comments	Initial Standard
Motive power:	Status quo assumed to be maintained.	All service: Non-electric. (See footnote 4.)	Status quo assumed to be maintained.	All intercity service, and commuter service via "Penn Line": Electrified. (See footnote 4.) Commuter service via Camden line: Non-electric.
Through passenger station[8]	If interoperability is deemed a major requirement, or if the optimal routing for freight makes use of the through passenger station location, then the track configuration at the through passenger station must provide for freight needs. (See discussion below.)		Explorations of realigning to other through passenger station locations revealed fatal flaws, e.g., capital costs many times higher than re-using Pennsylvania Station.	For through service: Serve Pennsylvania Station as a fixed point (see discussion below).
Freight yards–location, design, operating method	Some options may require modification of this standard. (See discussion below.)	Assume existing yards to be fixed in place. Track layouts should allow for through trains to set off or pick up cars without changing direction or backing up for a substantial distance ("progressive moves").	Does not apply	

3. Topics of particular interest

Certain topics in Table 5 - 1 merit expanded discussion, as follows.

a. Capacity

To be worthwhile, alternative scenarios must be capable of handling projected short- and long-term rail freight and passenger volumes from, to, and through the Baltimore region. These alternatives must overcome existing constraints while improving east-west and north-south train routes and simultaneously enhancing the ability of operators to serve local markets efficiently. The improved routes would upgrade clearances to handle oversize rail cars and furnish sufficient capacity to minimize the train delays that inconvenience freight customers, intercity travelers, and commuters.

[8] The use of Camden Station as a terminus for MARC's Baltimore-Washington commuter service via the Camden Line/CSXT is accepted as a given.

The routing solutions developed through the study effort would eliminate, or minimize the effect of bottlenecks on all types of freight and passenger service for all the carriers involved.

b. Facilities assumed immovable

Based largely on considerations of cost, safety, and the urgent need to maintain that continuity in all modes of transportation which is vital to the economic health of the Baltimore region, the study team assumed the following fixed points and constraints, and recognized a number of design challenges:

- Fixed points
  - — The port facilities in East and West Baltimore, either existing or proposed[9];
  - — The Baltimore Metro Subway Tunnel;
  - — The CSXT Capital and Old Main Line Subdivisions west of St. Denis;
  - — The CSXT Philadelphia Subdivision north of Bay View Yard;
  - — The NEC Main Line north of Bay View Yard; and
  - — The NEC Main Line south of West Baltimore Commuter Station.
  - — The location of the Central Light Rail Line main line and shops,[10] and the Jones Falls Expressway northwest of the existing Penn Station, adjacent to the former Northern Central Right-of-way.
- Constraints
  - — Maintain a maximum Fort McHenry channel depth of 50 feet (55 feet with an allowance for maintenance dredging).
  - — Cannot tunnel under the Fort McHenry (I-95) highway tunnel.
- Challenges
  - — The existing navigable streams and channels leading to the Patapsco River.
  - — Maintain an effective grade of one percent or less for tunnel approaches or relocated routes.
  - — Find environmentally acceptable routes through or around the city.

c. Pennsylvania Station

A prior chapter explained the PRR's decision to site its major passenger station north of the central business district (CBD) and adjacent to the Jones Falls and the Northern Central Railway. Although prior planning efforts[11] had viewed this location as immovable a priori,

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[9] This includes the existing railroad yards, branches, and industrial tracks serving the port facilities.
[10] Treating the Central Light Rail Line facilities as immovable adds greatly to the cost of the Belt Freight Alternative. Therefore, further studies may usefully examine the design and total cost implications of allowing changes these facilities.
[11] Specifically, planning for the NEC Improvement Project in the mid-to-late 1970s.

initial scenario development for this report disregarded any such restriction, for two reasons: (a) a station located in the heart of the CBD might theoretically be preferable; and (b) the current station location and orientation (at an approximate 90-degree angle to the desired flow of traffic), and the resultant difficult configuration of the tracks leading to it, result in a significant stretch of passenger train operations at speeds less than 110 mph (see Figure 3-18).[12]

Nevertheless, a review of station relocation options for intercity service concluded that a more central location would be prohibitively expensive. As Baltimore's ridges and valleys run north and south in the CBD area, any direct east-west route would necessarily run at cross purposes to the topography, thus occasioning monumental civil works—as already exemplified by the Orleans Street Viaduct. Such a project would inevitably involve very expensive tunneling under the CBD, its many historical landmarks, and its major commercial buildings. As a truly central station would require at least four tracks and probably more, an enormous and prohibitively expensive cavern would need to be dug out in the heart of Baltimore.[13] Other potential routings for passenger service (for instance, an underwater tunnel or a "beltway"-type route around the north) would entail exorbitant expense and would defeat the prime advantage of intercity rail service—its accessibility at the core of major cities. Finally, although fault can be found in Pennsylvania Station's location, it serves commercial and residential areas alike and affords easy access to major north-south arteries (Charles and St. Paul Streets and the Jones Falls Expressway); furthermore, it is at no greater a distance from its City's business center (about 15 blocks) than is 30th Street Station in Philadelphia or Union Station in Washington, D.C. For all these reasons, and in view of the relatively low cost of passenger alternatives that would preserve service via Pennsylvania Station, the study team by induction found that retention of the present location would make sense in any Baltimore restructuring. In effect, Pennsylvania Station became a fixed point as the study progressed, not beforehand.

For commuter service only, a vacated Howard Street Tunnel could imaginably afford options for some kind of through service with better downtown distribution than presently exists. Such options, their feasibility, and their concomitant requirements—a complex topic—fall outside the scope of this report, although their implementation might be integrated with that of any larger restructuring of Baltimore's railway facilities.

d. Freight train operations in Pennsylvania Station vicinity

The option of creating a freight route through Pennsylvania Station, which would require constructing a new freight tunnel and reconstructing the old Union Tunnel, was evaluated. The location of utilities under the tracks through the station and overhead bridge piers were physical constraints that were identified. Further studies, if any, would appropriately address the advisability of operating freight trains through Pennsylvania Station from all viewpoints—engineering, operational efficiency, and safety.

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[12] A series of Trip Time Performance Calculator (TPC) runs would necessarily be performed to document the trip time impact of the slow speed running, should alternatives development be pursued.

[13] An above-ground "central" station in the Jones Falls Valley, oriented in an east-west direction, was also considered.

e. Freight yard locations and train movements

Existing CSXT and NS yards initially were assumed to be fixed locations. However, an initial analysis of Harbor tunnel options, and at least one northern route, revealed that maintaining access to the existing facilities, particularly CSXT's and NS's neighboring Bay View yards, may result in inefficient routing of trains. Further, the analysis of harbor tunnel options indicated that an extension of the Curtis Bay Branch, which presently ends at Curtis Bay Yard, would be required. Such an extension would require reconfiguration of yard tracks and the possible relocation of the Car Repair Shop. To assess the feasibility of providing better train routings in this wide range of options, a certain level of conceptual design of altered yard facilities was necessary.

Maintaining efficient and economical access to, and between, all existing freight yards was one of the primary objectives that ultimately eliminated many potential alternatives. For example, maintaining access for CSXT through freight trains that currently set off or pick up at Bay View also required that, upon completion of any Baltimore restructuring, freight trains should be able to set off or pick up at Bay View in a progressive move as they do today, if possible. The same criterion initially was applied to NS freight trains and the NS Bay View Yard, should NS ever run through freight traffic on the NEC. Ultimately, the criterion was downplayed as other criteria eliminated consideration of numerous alignment alternatives and it became evident that certain alignment alternatives that did not facilitate progressive moves offered other advantages.

f. Fire, life safety concerns

The security systems within all tunnel options would provide full fire and life safety features for the users of the tunnels and emergency crews. Items to be included include:

- Fire detection and alarms;
- Supervisory control and data acquisition for pumps, ventilation fans, lighting and emergency services;
- Security systems, such as CCTV and intrusion alarms;
- Access control; and
- Telephones.

Other systems and design considerations would provide:

- Emergency lighting,
- Pumping,
- Signage throughout the length of the tunnel,
- Walkways throughout the length of the tunnels to allow evacuation in the event of an accident; and
- Cross-passages at regular intervals along the length of the tunnels to connect the adjacent bores.

The ventilation system would:

- Ensure acceptable temperatures throughout the tunnel system to support the normal operations;
- Maintain pollutants to an acceptable level for train crews; and
- Control smoke and temperatures in the event of a fire within the tunnels.

These state-of-the-art standards for security, safety, fire, and ventilation systems would not only benefit all users and operators of the new tunnels but also avoid the heavy expense of post-construction retrofitting.

C. Methodology

The study team began its complex task by gathering and assessing background information on the development, current status, and future prospects of Baltimore's railway infrastructure (Chapters Two, Three, and Four). Based on engineering analyses and contacts with users and government officials, the team derived a set of characteristics that a meaningfully restructured network should possess (Section B of the present Chapter). After identifying and screening the general sectors through which improved passenger and freight routes might pass (Chapter 6), the team developed and evaluated a sufficient number of alternatives to assess the viability of each sector for each type of rail transportation. By an iterative process of elimination reflecting the desired system characteristics and associated engineering requirements, the team arrived at a relatively small number of promising illustrative alternatives, for each of which it prepared initial cost estimates (Chapters Seven, Eight, and Nine). Finally, a review of the work upon which this report is founded suggested some avenues of further study (also Chapter Nine) that would assist planners and policymakers in resolving the Baltimore challenge in a cost-effective manner, should they choose to pursue such a resolution.

The following sections describe these methodological steps in further detail.

1. Gather Fundamental Data

Through personal communications with experts and examination of key documents, the study team reviewed the current status of all rail lines in the study area[14] and their ability to safely and efficiently handle the present and future levels of rail services imposed by passenger and freight railroads. The initial review addressed both facilities and operating patterns. Box 5 - 1 lists the principal elements of the fixed plant that received scrutiny, and the universe of evaluative factors that might apply[15] to each element.

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[14] Both existing and relevant abandoned facilities were considered. The degree of attention was roughly proportional to the facilities' proximity to and impact on the core of the study area in Baltimore City. Thus, the Virginia Avenue Tunnel in Washington, D.C., although important to obtaining the full benefit of any Baltimore-specific investment, was not reviewed and would need careful attention in any future investigations.

[15] The list does not claim to be exhaustive; a railway is a complex machine indeed. Also, the scope of the study did not permit all evaluative factors to be applied to all elements. Only the most important topics—those relevant to determining whether meaningful resolutions of the Baltimore challenge were potentially available, and in which general sectors—could qualify for attention in the present analysis.

Specialized documentation—base mapping and geological data—assisted the study team in developing concepts for passenger and freight alternatives in each sector under consideration.

a. Consultations and Documentation

Initial and follow-up consultations took place with appropriate staff members of the passenger and Class I freight railroads[16] and interested public transportation and planning agencies in the region. These contacts helped to identify the freight and passenger railroads' current and projected traffic levels and operations in the region, for traffic lanes through, from, to, and within Baltimore and its port.

The freight railroads provided essential track charts,[17] curve information, and some data on ongoing track maintenance and upgrading efforts. Amtrak, state and local agencies, and freight rail operators made available relevant maps and documents, including Valuation Maps and As-Built NECIP plans for review by the study team. The team also obtained and reviewed current information on use of the lines and pending plans for any betterments to the railroad system in the study region.

Limited on-site inspections occurred. The rail lines, particularly key locations, have been thoroughly documented with digital photographs.

Box 5 - 1: Main Components of Data Gathering

Fixed Plant Elements Considered	Evaluative Factors (Not All Apply to All Elements)
• Track	• Geometric design configuration
• Roadbed (ballast, subgrade)	◦ Location and accessibility
• Tunnels	◦ Grades
• Undergrade bridges	◦ Curvature
• Overhead bridges	◦ Clearances
• Other railroad structures	• Physical condition
• Signal and traffic control systems	• Speeds
• Electric traction systems	• Capacity
• Vehicle maintenance facilities (passenger and freight)[18]	• Routings
• Yards (passenger and freight) and their access	• Methods and measures of operation
• Passenger stations	• Life-cycle costs (operating, capital)
• Port facilities and their access	
• Grade crossings	
• Maintenance-of-way bases	
• Recently-completed improvements (since 1992)	
• Short-term improvement project proposals	

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[16] Any further development of options would require close and continuing coordination with the smaller railroads.

[17] A track chart is a scroll-like line diagram of a particular section of railroad, showing (among other items) each track, the degree of curvature and location of each curve, grades, stations, interlockings (see the Glossary at the end of this volume) and other details of the road's facilities and geometry.

[18] Identified but not inspected.

b. Base Mapping

Base mapping assisted in the delineation and evaluation of alternative routing concepts and the initial projection of their external impacts. The study team gathered geographic information system (GIS) data from sources including (but not limited to) the following:

- Baltimore City;
- U.S. Geological Survey (USGS);
- The FRA Maglev Deployment Program[19]; and
- The U.S. Army Corps of Engineers.

The data gathered have included:

- Maryland County Map information;
- Vector roadway data;
- Environmental resources (Wetlands; Floodplains; etc);
- Census data;
- Historic Resources data;
- USGS 7.5 minute Quadrangles and digital elevation models; and
- Aerial photography.

The base mapping for this study combined all these GIS data elements with the available railway-specific information. For example, railroad elevations, grades, and tunnels were entered into the system from track charts and related sources. The mapping and evaluation process enabled the study team to concentrate its efforts on alternatives that would respond to the project's goals and objectives while avoiding obvious "fatal flaws" in their design and external effects. The mapping effort also enabled team members to prepare detailed graphics of the alternatives.

c. Geological Data

Because any restructuring of the Baltimore rail network would inevitably involve major civil works including tunneling, geological information has assumed a special importance in this study. Accordingly, the following sources provided data for incorporation in the study's database:

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[19] The FRA Maglev Deployment Program, mandated under the TEA-21 transportation authorization, aims to demonstrate magnetic levitation technology in the United States in a relatively short (less that 50-mile) corridor. A number of corridor projects in several States have competed for available planning funds; a corridor between Baltimore (Camden Station vicinity), BWI Airport, and Washington—sponsored by the State of Maryland— has emerged as one of the leading contenders for implementation should Congress elect to provide additional funds. Current plans do not contemplate a direct intermodal connection at Pennsylvania Station, Baltimore, between the Baltimore/Washington Maglev project and the NEC through passenger service. There could, however, be design, construction, and other interactions in a number of locations in the Baltimore region if both the Maglev project and a Baltimore rail restructuring plan are implemented.

- Boring data collected in advance of Northeast Corridor Improvement Program (NECIP) investigations;
- Available borings from earlier NECIP investigations;
- Boring data from nearby Maryland State Highway Administration highway projects;
- Published geologic data for the project area; and
- Project data on file for earlier Baltimore projects.

2. Evaluate the Network's Current Status and Prospects

On the basis of the data thus gathered, the study team assessed the current status and prospects of Baltimore's railway network. The assessment necessarily considered not just historical conditions but also the very limited investments made by Amtrak, Maryland DOT, CSXT, and NS since 1992. Also taken into account were the current and projected service levels for intercity passenger, commuter, and freight operations. In conjunction with the track charts, the GIS data, and other resources, the traffic projections highlighted areas of concern with respect to operational capacity before, during, and after construction of the various alternatives.

With regard to the traffic projections:

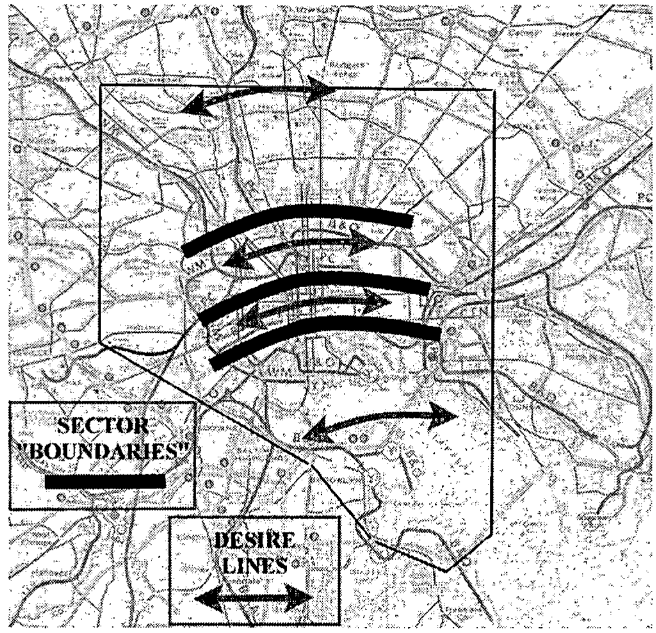
- Forecasts for both intercity and commuter train frequencies relied on schedules prepared in the late 1990s by the operating entities. Amtrak has a timetable for projected service in the year 2015, and MARC has done forecasts for 2020. Extrapolating from those carrier's horizon years, the study team developed train volumes for the year 2050.
- The scope of the study did not include detailed, computerized simulations of the projected operations on potential future infrastructures in the Baltimore region.[20] Accordingly, these forecasts served as inputs to the conceptual development of the alternatives, and for initial screening purposes.

The results of this evaluation appear in Chapters Two and Three above, and contribute to the findings that (a) improvement of the network is highly desirable and (b) meaningful improvements in operations would require separate, though highly coordinated, analysis and treatment of freight and passenger needs.

[20] Such detailed simulations will be essential to any detailed evaluation of alternatives; see Chapter 9.

3. Define "Sectors" for Initial Consideration

Figure 5 - 1: The Sector Concept



The prior chapters demonstrate how complex is the Baltimore challenge, with its many traffic types and service lanes. The freight operation, in particular, serves a host of shippers and commodity types on all sides of one of the East Coast's busiest ports; this intricate freight movement pattern involves short lines as well as the major national carriers. However, in its simplest terms, the main challenge devolves into a single question: how best to get the passenger and freight traffic from one side of Baltimore to the other? Addressing this underlying question, the study team noted that there were four broad, concentric arcs in which improvement alternatives might be sited to satisfy the inherent desire line of traffic (roughly southwest to northeast). These broad arcs are termed "sectors" in this report (Figure 5 - 1).

The study team then subjected the sectors to an initial screen based on common sense, in order to eliminate beforehand alternatives that would be frivolous. For example, the sector at the top of the map—many miles removed from the center of Baltimore—could not house passenger "service" worthy of the name and was eliminated accordingly. Most of the sectors, however, offered some advantage for either passenger or freight operations or both, and underwent further analysis.

4. Develop Potential Alternatives Within Each Sector

Once identified, the likely sectors were examined to develop a broad range of alternative solutions, all of which involved tunnels. This analysis considered all the GIS and geological data amassed earlier in the study, as well as the operational advantages and drawbacks of each alignment with respect to passenger and freight transportation. Also considered were concepts suggested in 20th Century studies of the same challenge.[21] The search for alternatives took into account all relevant prior reports and selective site visits—for example, inspections of alternative passenger station locations.

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[21] Baltimore's railway difficulties emerged almost as soon as the network was completed (before 1900), and studies—never implemented—began forthwith. The effect of subsequent growth in the Baltimore and Washington metropolitan regions militates against the early-20th Century design concepts created by the PRR and the B&O in their desperation to modernize, expedite, and economize on their Baltimore operations. The NECIP in the 1970s and 1980s also devoted planning resources to this issue, but budgetary limitations forbade any but short-term improvements.

5. Screen the Alternatives

The alternatives went through extensive screening both by the study team and by officials of participating organizations. Engineering judgment, railway operating experience, and familiarity with the study region influenced both the initial conceptualization and the ongoing, iterative review of the alternatives. In addition, a formalized screening and comparison of alternatives took place along the following lines:

- Functional/design screening: An evaluation of the railway design features, the operational benefits and liabilities, and potential construction staging problems of each alternative; and
- External impact screening: A preliminary effort to identify potential environmental and societal concerns of each route.

Alternatives passing the functional/design screening were then subjected to the external impact screening, as described below.

Not all criteria applied to all alternatives; the Harbor Sector options, for instance, faced some different tests than options in other Sectors.

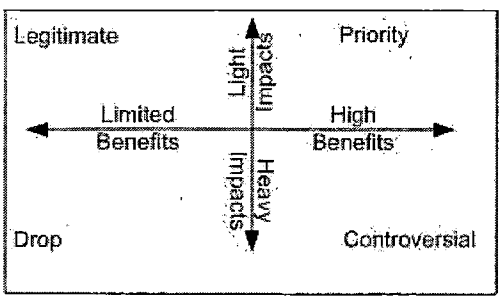
a. Functional/Design Screening Criteria

Functional/design screening was intended to identify and winnow out alternatives that would have very large negative impacts and that would do little to improve passenger and freight transportation through the Baltimore region. Functional design screening also allowed the detailed evaluation and discussion to focus on the most important and controversial remaining alternatives. The process enabled a preliminary analysis of alternatives by characterizing them according to the quadrants illustrated in Figure 5 - 2.

The primary determinants in winnowing the alternatives were:

- The availability of land to utilize for the tunnel approaches;
- The requirement to—
  - — Establish and maintain a maximum one percent gradient; and
  - — Safely and economically construct beneath either the Fort McHenry or Baltimore Harbor Tunnel (Harbor Sector tunnels only);
- The length and alignment of a tunnel[22]

Figure 5 - 2: Screening Concept



[22] The analysis assumed that any tunnel in the Harbor Sector would be constructed employing the immersed-tube technique. The construction of the tunnel would require dredging and deep excavations in soils ranging from very soft organic, clays, and estuarine silts to stiff over-consolidated cretaceous clays of the Potomac Group.
The analysis also assumed that the appropriate technique, whether it be the use of a TBM or mining, would be used to construct any land-based tunnel(s).

to connect the two potential portals,—particularly if the alignment would be constructed for a significant length beneath the Fort McHenry channel;

- The ease of integration of the train operations on the new alignment with:
  - — The existing rail network; and
  - — The existing freight and passenger yards and terminals.

For each alternative, the functional/design screening assumed that any significant adverse environmental impacts could be mitigated and that such implementation issues as legislative needs, jurisdictional questions, and public controversies could be addressed. These criteria properly belong to the next level of screening: for external impacts.

b. External Impact Screening Criteria

After functional/design screening had winnowed out the least productive alternatives, the remaining alternatives were evaluated for their external impacts. The following topics were addressed:

- Potential consistency with existing land uses[23];
- Potential extent of acquisitions, displacements, and relocations;
- Potential to impact resources listed on or eligible for listing on the National or State Register of Historic Places;
- Potential to impact parklands and 4(f)/6(f) resources;
- Construction impact severity and duration;
- Potential impacts to ecosystems and water resources; and
- Any identifiable implementation issues that are likely to inhere in each alternative, based on engineering judgment.[24]

6. Conduct Additional Analyses

Within each Sector and for each type of service, only a limited number of alternatives passed, without any fatal flaws, both the functional/design and external impact screens. The study team subjected an illustrative set of the surviving alternatives to some additional analyses:

- Conceptual engineering at a scale of 1'=400", including plan and profile drawings of the proposed route(s) and connections to existing lines and facilities;
- Initial analyses of critical system components and implementation methods, including—

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[23] Consistency with likely future land uses would need to be researched and estimated in any future studies that might build upon this report.

[24] Any of the Baltimore alternatives would be of such a size as to necessitate a formal public participation process, with intensive involvement of all involved governments. All implementation issues would thus be fully aired; but that is for the future, if any such project is progressed.

- Turnout sizes to be installed in interlockings and at the intersection of line segments;
- Signal system requirements;
- Temporary facilities required during construction (track, station platforms, signals, electric traction systems, etc.); and
- Construction techniques and any specialized equipment;

- Performance of a minimal number of train performance calculator (TPC) runs to compare the expected train operating characteristics of the restructuring alternatives with the existing routes;
- Identification of any betterments near the outer limits of the study area that would be required to support the contemplated Baltimore improvements and capitalize on the efficient through movement of people and goods; and
- A summary level operational analysis.

The study team then prepared initial cost estimates of a limited number of alternatives on the basis of unit cost methods and appropriate contingencies. Although these cost estimates must be regarded as very preliminary, they provide planners and policymakers with a contemporary overview of the potential cost of meeting the Baltimore challenge. They also provide an order-of-magnitude comparison of the relative costs by sector, and in so doing, suggest priority topics for possible future analysis.[25]

7. Identify Directions for Any Future Work

Finally, whether one year or 100 years from now, the study team believes that policymakers, planners, and transportation operators will wish to revisit the Baltimore challenge—if only because a late-19th Century infrastructure (particularly a substandard one) will not last indefinitely, nor can it possibly keep place forever with the growth of industrial commerce and travel in the busy NEC megalopolis. Whatever the timing or motivation for further analysis, certain predictable topics—left untouched or only partially explored in this study[26]—will require work. To assist future planners, the study team has developed a listing of the most critical areas for further exploration (see Chapter 9).

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[25] An example is the large cost differential between the Penn Freight and Belt Freight alternatives; the latter is over $0.4 billion, or 50 percent, higher than the former. The sizes of this differential suggests an eventual rethinking of the assumption that the Central Light Rail Line facilities cannot be moved—an assumption that contributes to the Belt Freight option's relatively high total cost.

[26] See Chapter I for a discussion of the scope and resources of the present study.

Chapter Six
CONCEPTUAL FRAMEWORK FOR THE ALTERNATIVES

This chapter presents a conceptual framework for the development of passenger and freight railway restructuring alternatives for the Baltimore region. Chapters Seven and Eight then go on to describe and evaluate the passenger and freight alternatives, respectively.

In theory, at least, rail passenger and freight traffic can cross the Baltimore region in one of four Sectors, as shown in Figure 6 - 1 and described below.

A. Description

The Sectors run roughly southwest to northeast, which is not only the general tendency of the traffic lanes but also a product of topography. Except within the Jones Falls Valley,[1] a radial climb from the Inner Harbor into the Piedmont produces nearly-impossible grades. (The basic problem with the CSXT's Belt Line is that it attempts such a radial climb across the grain of the Sectors—and pays a price, with its 1.87 percent compensated grade[2] between Mount Royal Station and Huntingdon Avenue.)

In brief, the Sectors are:

- **Far North Sector.** Serving as a kind of railroad "beltway," an alternative using this Sector would avoid the central areas of Baltimore City entirely.
- **Near North Sector.** This Sector lies just north of the CBD and currently houses Amtrak's NEC and the easterly portion of the CSXT's main line.
- **Central Sector.** This Sector would cross the CBD proper. As explained in Chapter Two, the natural route through Baltimore—abutting the Inner Harbor near Pratt and Lombard Streets—lies in this Sector but was never a possibility as development in that precise area antedated the invention of the railroad.
- **Harbor Sector.** Because the Harbor is extensive and complex, with multiple inlets and points on both sides, many alternatives are hypothetically possible in this Sector.

B. Evaluation of the Sectors

Based on all the considerations described in prior chapters, the study team considered the feasibility of using each of the four Sectors to improve the movement of passenger and freight trains, respectively, through Baltimore. Table 6 - 1 summarizes the findings of this initial analysis, which are described below.

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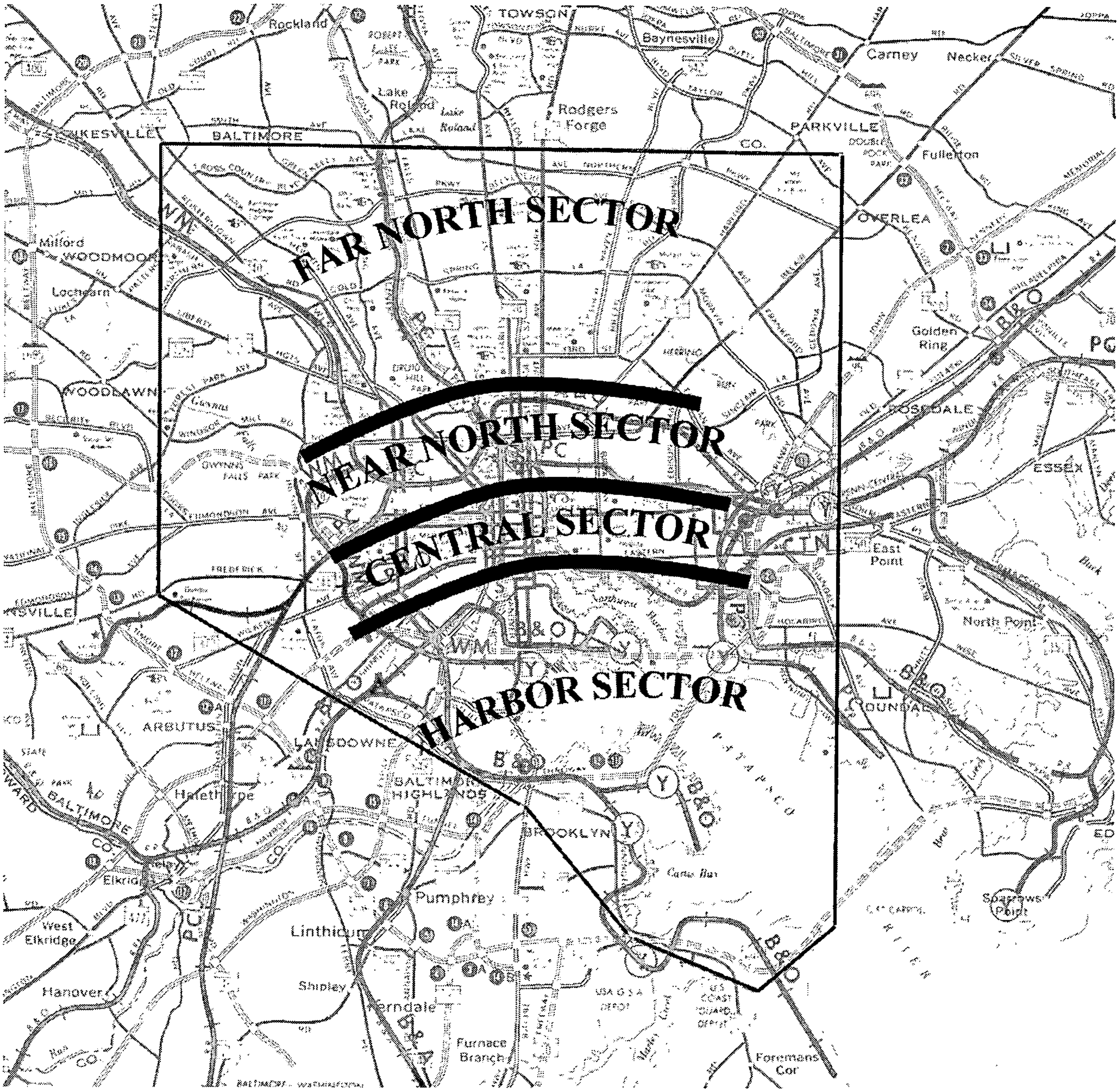
[1] The Valley is at a 90-degree angle to the direction of traffic—not much use for the purposes aimed at in this Report.

[2] 1.55 percent uncompensated grade on an 8 degree curve, 1.55 + (.04 x 8) = 1.87.

Figure 6 - 1: The Sectors[3]



[3] The Sector map is overlaid on the a map prepared in 1974 by the Cartographic Division of the Maryland State Highway Administration (SHA) entitled "State of Maryland Railway Network, 1974," © 1974 SHA. Used by permission.

Table 6 - 1: Initial Evaluation of Sectors for Passenger and Freight Service

Sector	Passenger	Freight
Far North	Does not serve Central Baltimore	Crosses built-up areas, grades likely to be heavy, lacks connectivity with existing network and yards
Near North	Possible	Possible
Central	Likely excessively expensive, but possible; more central station location for businesses	Too expensive, grade problems, and no need for freight to be in CBD
Harbor	Expensive and no closer to CBD than present station	Possible

Legend:	*May meet all initial standards*	*Has obvious difficulties*	*Ruled out at outset*

1. Far North

The Far North Sector would not provide a solution for passenger traffic. It would not only add to the NEC's distance but also eliminate center-city service, perhaps the foremost inherent advantage of high-speed rail. For freight service, initial studies suggest that a far northern route would cut a swath through built-up areas (Towson, for example), encounter challenging grades in crossing Piedmont hills and valleys, and be far removed from existing freight facilities and shippers. Although studied seriously by the former PRR and B&O in the early 20th Century, alternatives through the Far North Sector are unrealistic today and merit no further consideration.

2. Near North

The nexus of Baltimore's transportation system lies at the intersection of the CSXT, the NEC, the Northern Central Railway (right-of-way, Light Rail Line, and support facilities), the Jones Falls Expressway, North Avenue, and the north-south arterials (Howard Street, Maryland Avenue, Charles Street, and St. Paul Street).[4] Clearly, long experience has shown the Near North Sector to be an attractive site for transportation facilities and flows. Whether, with all these facilities already extant, crammed into close quarters, and occupying horizontal and vertical space, this Sector offers opportunities for meaningful improvement in the rail passenger and freight infrastructure, is examined further below.

[4] Also nearby, about one mile to the west, is Baltimore's Metro subway along Pennsylvania Avenue, which has a bearing on the design of Near North Sector alternatives.

3. Central

Involving tunneling under the very heart of Baltimore's business district, this Sector would inevitably prove to be very expensive and replete with engineering and environmental complexities. Although, as discussed above, passenger service might benefit from a more central location, the requirements for a CBD station—probably involving the digging of a cavern some 125-175 feet wide and 1200-1500 feet long beneath the built-up city core—would entail a very heavy expenditure. Despite the cost and in view of the marketing considerations, passenger alternatives utilizing this sector receive treatment later in this section.

Freight service has no need to be in the heart of the City and incur the associated expense. Therefore, no particular justification exists for considering the Central Sector for freight.

4. Harbor

For passenger service, an underwater tunnel would imply a relocated station south of the CBD. The precise location would depend on tunnel alignment possibilities; in the best case, the new station might lie at roughly the same distance from Charles Center (to the south) as that of Pennsylvania Station (to the north). While many other factors than distance must enter into any comparison of station locations, a Harbor Sector passenger route cannot be ruled out on the issue of station siting alone.

Freight service could potentially benefit from a Harbor Sector location. Indeed, the Study Team analyzed many alternatives to determine their operational implications and an order of magnitude of their costs.

C. Initial Findings

The initial review of passenger and freight improvements in the four identified sectors—

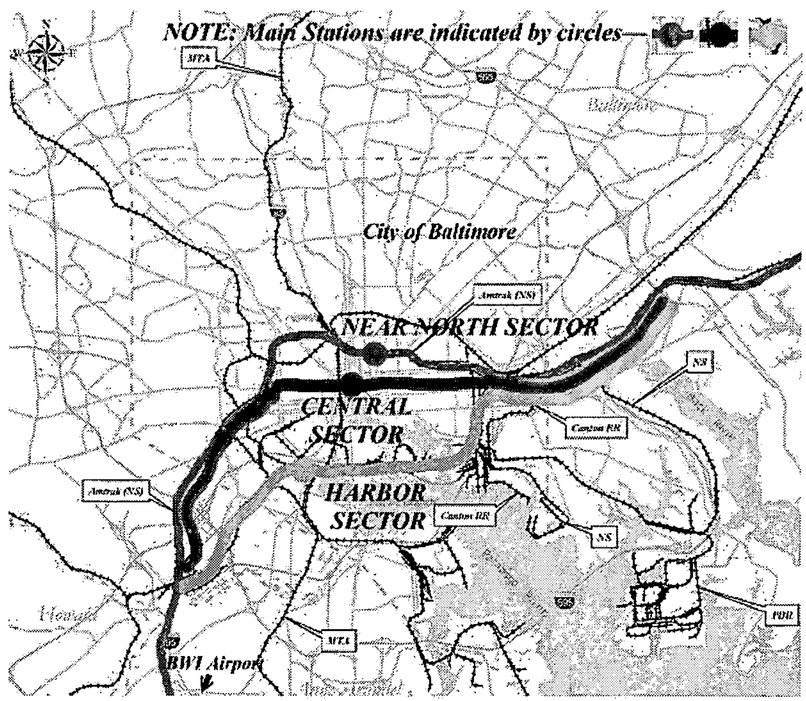
- Eliminated further consideration of passenger service in the Far North Sector and freight service in the Far North and Central Sectors;
- Indicated, pending further engineering work, the potential for meaningful passenger and freight betterments in the Near North Sector, and for meaningful freight betterments in the Harbor Sector; and
- Was inconclusive regarding the feasibility and utility of passenger improvements in the Central and Harbor Sectors, although the analysis did identify special challenges to passenger solutions in those Sectors.

The following Chapters describe the range of passenger and freight alternatives in the combinations of services and Sectors that remained after the initial findings summarized above.

Chapter Seven
PASSENGER ALTERNATIVES

Three of the Sectors could at least theoretically accommodate a restructured passenger route through Baltimore: the Near North, Central, and Harbor. Guiding the creation of alternatives (including the search for potential tunnel portals and approaches to them) was the requirement to access the existing Pennsylvania Station—or another main station location no farther than Pennsylvania Station from the CBD—while efficiently connecting to the NEC south and north of Baltimore. The design of passenger alternatives also took into account the need to minimize conflicts between intercity passenger, commuter, and freight trains, and to provide sufficient capacity for the expected types and volumes of traffic. In this regard, the lack of expansion-room adjacent to certain branch or main lines influenced the design of the alternatives.

Figure 7 - 1: Generalized Passenger Alignments and Main Stations



The study team found that use of the Near North sector would involve retention of Pennsylvania Station; that the Central Sector would imply a station in or near the Route 40 corridor; and that the Harbor Sector could include a station just southwest of the Inner Harbor. The generalized passenger alignments and station locations in each Sector appear in Figure 7 - 1.

The following sections describe and evaluate the detailed passenger alternatives examined in the course of the study. These are summarized in Table 7 - 1.

A. Near North Sector—Passenger Alternatives

All passenger alternatives in the Near North Sector would make use of the existing trackage from Bay Interlocking (at the NS Bay View Yard), through the Union Tunnels and Pennsylvania Station, to a new tunnel with a northeastern[1] portal in the Jones Falls Valley and a

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[1] Directions in this chapter follow the compass direction of the traffic lanes, which generally run southwest to northeast through the Baltimore region. Because the network is convoluted and circuitous, neither the railroad

Table 7 - 1: Passenger Alternatives by Sector							
		Station Location		Location of Tunnel and Approaches by Alternative			
Sector	**Alternatives Considered**	**Pennsylvania**	**Other**	**Southwestern Approach**	**Southwest Portal**	**Northeast Portal**	**Northeastern Approach**
Far North							
Near North	**Existing B&P Tunnel**	•		BWI to Bolton Hill/ Druid Hill Park area	Gilmor Street	Jones Falls	From NEC via Union Tunnels and Pennsylvania Station
	Presstman Street —PRR Alignment	•		BWI to Bolton Hill/ Druid Hill Park area	Presstman Street	Jones Falls just northwest of existing B&P portal	From NEC via Union Tunnels and Pennsylvania Station
	Presstman Street —Modified Alignment	•		BWI to Bolton Hill/ Druid Hill Park area	Presstman Street	Jones Falls just northwest of existing B&P portal	From NEC via Union Tunnels and Pennsylvania Station
	Great Circle Passenger Tunnel	•		BWI to Bolton Hill/ Druid Hill Park area	A location just north of existing B&P portal	Jones Falls just northwest of existing B&P portal	From NEC via Union Tunnels and Pennsylvania Station
Central	**Route 40 Alternative (Franklin/Mulberry/ Orleans Streets)**		•	BWI to West Baltimore	West end of the CBD, just west of IRS Building and Martin Luther King, Jr., Boulevard	Kresson Street south of Route 40, west of NEC Main Line near NS Bay View Yard	From NEC to Kresson Street
Harbor	**Locust Point Passenger Alternative (Locust Point–Canton)**		•	BWI to Herbert Run to Locust Point (generally following CSXT)	Locust Point	Canton	NEC to Canton via old PRR alignment

southwestern portal in the vicinity of Bolton Hill, south of Druid Hill Park. Most options (of course, excepting reuse of the double-track B&P Tunnel) would utilize two single-track passenger tunnels, an assumption that could change as and if design work progresses.

The Near North passenger alternatives are as follows:

- Employ the existing or parallel alignments:
  - — Enhance the existing B&P Tunnel; or
  - — Utilize the Presstman Street tunnel design and right-of-way inherited from the PRR (Presstman Street—PRR Alignment); or

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direction nor the compass direction at precise points adequately takes into account the underlying desire lines of the passenger traffic and freight shipments.

— Modify the Presstman Street alignment (Presstman Street—Modified Alignment); or

- Employ a "Great Circle" alignment north of Presstman Street ("Great Circle Passenger Tunnel")[2]

Each of these choices is discussed below in turn.

1. Existing and parallel alignments

In the late 1970s, the Northeast Corridor Improvement Project (NECIP) intended to make major B&P Tunnel improvements that would include decreasing tunnel leakage, rebuilding the drainage system, lowering the concrete invert of the tunnel to provide clearance for freight cars, and installing a new track system. Early in the NECIP planning effort it became evident that delays in service might be necessary during renovation and that an improved B&P Tunnel would not provide sufficient capacity for projected traffic. Therefore, the studies were expanded to include evaluation of a possible new Presstman Street tunnel to be used, in various configurations along with the existing tunnel, to provide capacity for reliable movement of future passenger and freight train volumes.[3] The new tunnel would have followed an alignment along the west side of Presstman Street about 1,200 feet northwest of and parallel to the existing Wilson Street tunnel. (The Presstman Street right-of-way was obtained by the Pennsylvania Railroad in 1931 for a new tunnel planned at that time.) The NECIP studies yielded a number of alternatives that proved useful in the present analysis and are described below.

a. Existing B&P Tunnel, Upgraded

All analyses of the B&P Tunnel, from the NECIP to the present, indicate that its betterment would not be an effective, much less cost-effective, approach to the Baltimore challenge.

(1) NECIP analyses

The NECIP team evaluated construction alternatives that would enable the existing tunnel invert to be lowered one track at a time, with the second track remaining in service during construction. Existing subsurface data, supplanted by additional borings and the installation of piezometers, were utilized.

The tunnel was inspected and evaluated between 1976 and 1978 by Amtrak and NECIP personnel. In summary, the tunnel arch was found to contain many areas of seepage, particularly between John Street and Pennsylvania Avenue. Water also was discharging from weep holes in the tunnel sides although many of the weep holes appeared to have become clogged. Seepage near the crown of the tunnel was often above the adjacent ground water level and appeared to be from other sources. Brick courses were found to have been removed at a few locations and anchor bolts added to permit clearance for freight cars.

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[2] All these alignments were treated in the NECIP. The "Great Circle" route was conceived under the NECIP but extensively elaborated for this study.

[3] At the time of the NECIP studies in the late 1970s, there still remained an important freight service on the NEC and the concept of tunnels segregated by function rather than by corporate ownership had not yet crystallized.

Drainage through the tunnel consisted of pipe drains below the center of each track. The pipes were clogged in some areas resulting in standing water or flow above the pipe to the next inlet. In other areas, the pipe was broken out leaving a trench. At that time, Amtrak's crews were in the process of performing temporary track repair to correct an uneven track condition that was very evident in some areas as trains passed through the tunnel.

The geotechnical investigations defined subsurface conditions generally surrounding the existing Wilson Street tunnel and determined the thickness and strength of the concrete invert and sidewalls of the tunnel at several locations. Some of the more pertinent conclusions reached by the NECIP team included the following:

1. The existing ground water table dropped 10 to 20 feet near this tunnel from its general surrounding levels, reflecting drainage through the tunnel walls. Sealing of the tunnel walls would raise water levels and increase tunnel loading. This was considered undesirable as the original tunnel was designed with a ballast invert and was not intended to be waterproof.
2. Leakage above the springline originated above the ground water table and very likely was coming from leaking utility lines.
3. Drainage along the invert was very poor. An improved drainage system design was needed.
4. The practical limit for lowering top of rail in the B&P as the method for obtaining additional clearance [would be] approximately 44". If a section requires greater interior dimensions, beyond that obtained by maximum rail lowering, the walls should be widened *by open cut methods.* [Emphasis added to underline environmental challenges].
5. Lowering of the tunnel invert by about three feet *would probably require blasting of rock for a length equivalent to four or five city blocks* in the northern portion of the tunnel. Alternative construction methods were evaluated and it was concluded that lowering of the invert three feet, while maintaining train traffic on one track, would be very expensive.[4] [Emphasis added to underline environmental challenges.]

Ultimately, the NECIP—short of funds but long on mandates for speedy service improvement—concentrated its resources on other system components and locations, and limited its work in the B&P Tunnel to minor repair of the tunnel lining, drainage improvements, and installation of a new improved track system after tunnel invert was replaced.[5] While benefiting

[4] A June 1977 NECIP report concluded that the "practical limit for lowering top of rail in the B&P as the method for obtaining additional clearance was approximately 44". If a section requires greater interior dimensions, beyond that obtained by maximum rail lowering, the walls should be widened by open cut methods".

[5] The contract to rehabilitate the tunnel invert and install a new track structure, one track at a time, was completed in 1982 and was deemed one of the NECIP's successes. See U.S. Department of Transportation, *Northeast Corridor: Achievement and Potential*, January 1986, pp. 2-19 and 2-20.

passenger safety, ride quality, and reliability in the short term, these improvements did nothing to effect a permanent improvement in passenger service capacity, travel times, or viability.[6]

(2) Recent B&P Evaluations

Since the NECIP B&P Tunnel Rehabilitation Project was completed, Amtrak has continued to have the responsibility for upkeep of the tunnel. Recent evaluations have concluded that the B&P tunnel should be replaced within 20 years as the existing tunnel is increasingly difficult and expensive to maintain.

For example, a recently completed Mid-Atlantic Rail Operations Study report[7] had the following summary; although emphasizing freight movement, it is relevant to this section:

"The Baltimore passenger station has the Union Tunnels to the north and the B&P Tunnel to the south. The Union Tunnels (actually two tunnels side by side) are approximately ¾-mile long, and consist of three tracks. Clearances through them are restricted to a maximum height of 17 feet 9 inches. The B&P Tunnel is nearly two miles long, was constructed in the 1870s. The B&P Tunnel consists of a two-track brick arch design built in three separate sections. In the [early 1980s], the invert (floor) was lowered and stabilized after structural problems nearly shut down the bore. Despite this work, the B&P Tunnel does not have clearance for cars greater than Plate E (15 feet 9 inches). The tunnel has [severe] curves, heavy grades and a constant water problem. The repairs [completed in 1982] were intended only as an interim design (30 to 50 years) and ultimately, this tunnel will need to be replaced. The present clearance through the entire route is restricted by the smaller B&P clearance, and the clearances through both tunnels preclude freight railroads from operating excess dimension car designs, including double-stack cars (maximum 20 feet 2 ins.) through the tunnels. This project consists of re-boring and rehabilitation of the tunnels to eliminate their continuing deterioration of the tunnels and increase their ability to handle modern railcar equipment. The order of magnitude of the cost of this project is estimated to be *$100 million in near term for design, with an additional $900 million in medium term for construction*. Benefit to be derived from this project is the elimination of deteriorating conditions and restrictions on the size of railcar traffic over the NEC through Baltimore."[8] [Emphasis added, regarding costs to rebuild the B&P Tunnel in place.]

(3) Observations Based on the Present Study

Upgrading the B&P Tunnel would contradict the fundamentals of engineering economy. As prior chapters amply demonstrate, the tunnel's basic geometry was substandard when it was

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[6] The tunnel invert, in addition, was not materially lowered and through freight services (then under Conrail's direction, and in the process of disappearing from the NEC) derived no clearance benefit.

[7] According to the Executive Summary of the *Interim Benefits Assessment* (I-95 Corridor Coalition, February 2004): "The Mid-Atlantic Rail Operations Study (MAROps) is a joint initiative of the I-95 Corridor Coalition, five member states (New Jersey, Pennsylvania, Delaware, Maryland and Virginia), and three railroads (Amtrak, CSX, and Norfolk Southern). The Federal Railroad Administration (FRA) and Federal Highway Administration (FHWA) participate as advisors. Over a two-year period, the MAROps participants crafted a 20-year, $6.2 billion program of rail improvements aimed at improving north-south rail transportation for both passengers and freight in the Mid-Atlantic region and helping reduce truck traffic on the region's overburdened highway system."

[8] I-95 Coalition, *MAROps Final Report,* 2002, Appendix I.

completed, and is irremediable by any reasonable amount of rehabilitation—whether for passenger or freight service. What's more, the B&P upgrading cost suggested by the MAROps study ($1 billion) would likely exceed that of a brand-new, much improved facility achieved by deep-bore tunneling. Neither expediting passenger nor enhancing freight service, the B&P Tunnel alternative deserves no further consideration in this study.

b. Presstman Street—PRR Alignment

The PRR in the early 1930s selected Presstman Street as a possible location for a new tunnel roughly parallel to the B&P (Figure 7 - 2). Twenty-seven borings were drilled then, of which the records included only generalized soil and rock types. Therefore, the NECIP study made six additional borings in 1977. The geotechnical investigations defined subsurface conditions for the completion of a preliminary study of the alignment.

Based on the geological sections thus developed, the study concluded that the original PRR proposal for the new tunnel along Presstman Street had the following advantages:

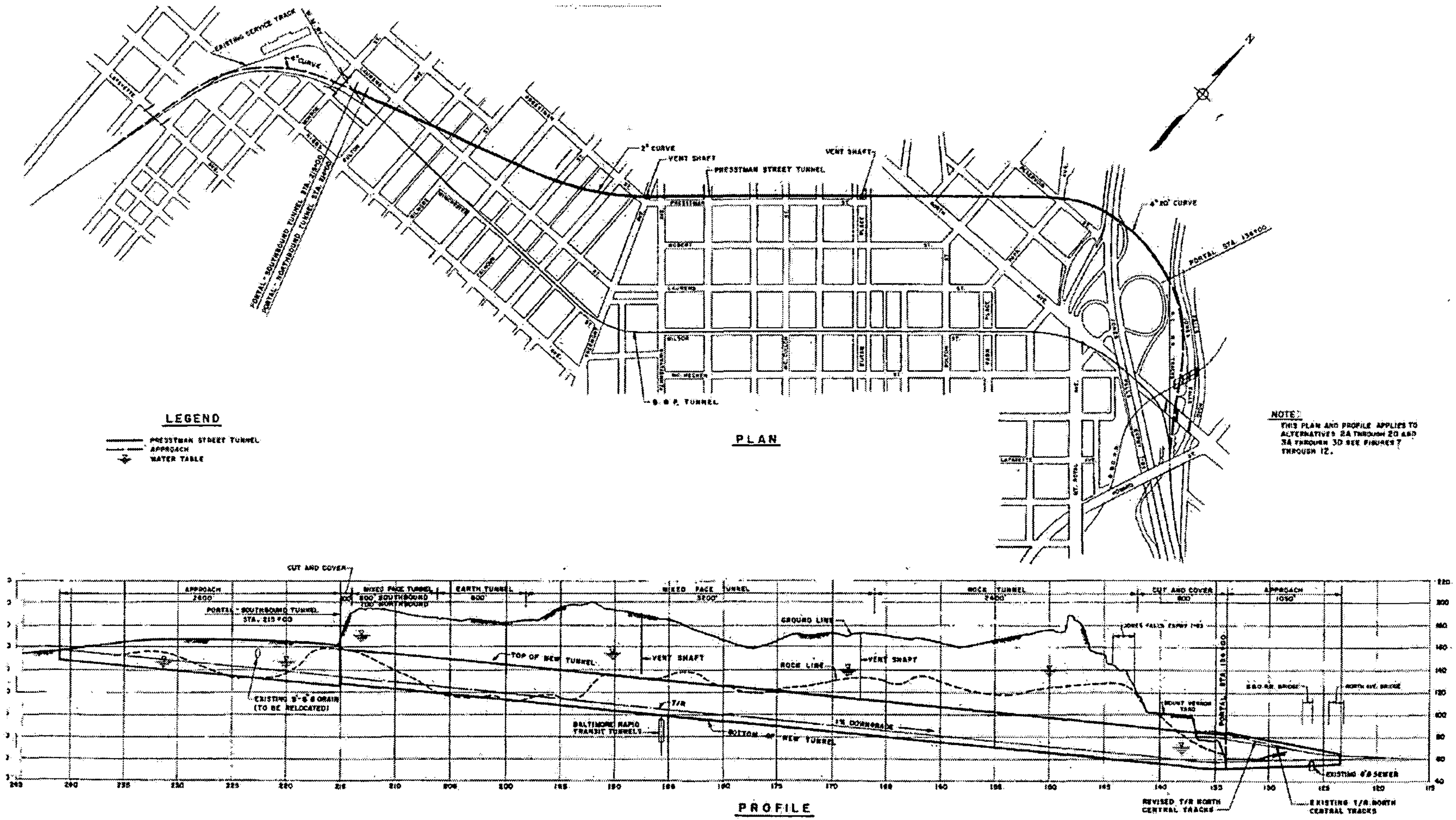
- The tunnel would have a uniform vertical compensated grade of 1 percent, which was a significant improvement over the existing B&P Tunnel (1.5 percent compensated[9]);
- The tunnel would be relatively short; and
- Most of the tunneling right-of-way along this alignment already had been acquired and had passed to Amtrak with its acquisition of the NEC.

The original PRR Presstman Street proposal was determined to have the following disadvantages:

- Construction of the Baltimore Rapid Transit Tunnels (since completed) immediately below this alignment could open joints in the rock above, increasing the tendency for costly overbreak when the railroad tunnels are excavated. Even though the transit tunnels were reportedly being designed to take into account this future tunnel loading, special precautions would be necessary during construction to—
  - — Limit blasting;
  - — Avoid concentrated temporary supports above the transit tunnels; and
  - — Maintain and possibly reinforce the rock on either side and between the underlying tunnels.
- Due to the position of the top of the rock along this alignment, a mixed face (soil and rock) tunneling procedure would be involved, and therefore result in a high cost of excavation.
- Dewatering would be difficult, and expensive, due to the location of the proposed tunnel mostly beneath existing buildings and the presence of porous soils close to and above the crown of the tunnel.
- Due to the shallow depth of the proposed tunnel, most of the buildings may have to be evacuated during construction, as a precautionary measure.

[9]Maximum grade of 1.34 percent uncompensated, with a four-degree curve; 1.34 + (4 x 0.04) = 1.5 percent.

Figure 7 - 2: Presstman Street —PRR Alignment



NORTHEAST CORRIDOR
TUNNELS STUDY-B&P SEGMENT
PRESSTMAN STREET TUNNEL
1930 PENN. R.R. ALIGNMENT

- Possible costly damage to some of the buildings along tunnel alignment.
- Extra cost of noise and vibration attenuation from trains at this shallow depth below buildings.

c. Presstman Street—Modified Alignment

In an effort to eliminate most of the disadvantages encountered by the PRR's Presstman Street Alternative, three additional alternatives—located below the Baltimore Rapid Transit Tunnels on Pennsylvania Avenue—underwent scrutiny. These alternatives consisted of varying tunnel slopes and tunnel lengths and included the flattening of horizontal curves as necessary.

Advantages of these alternatives included:

- A considerable increase in the length of rock tunnel with a resulting decrease in mixed face tunnel and a significant decrease in the tunneling cost.
- The possible use of a Tunnel Boring Machine (TBM), which would have reduced the construction time and construction costs.
- A substantial reduction of the environmental impact of the tunnel and tunnel construction.
- The work would have been accomplished in an area where, with some exceptions, the tunneling right-of-way was generally already acquired.

Disadvantages of these alternatives were:

- The first alternative required steep grades west of Pennsylvania Avenue.
- The second and third alternatives required longer tunnels and the lowering of the western approach to the tunnel on the NEC main line, which might have affected crossing roadways.
- A new tunnel may disturb the Baltimore Metro tunnels above.

From the geotechnical point of view, these alternatives appeared to be more desirable than the PRR Presstman Street Alternative. However, from a passenger service viewpoint, the four-degree curves in any of the Presstman Street alternatives—although much gentler than the 7-degree, 30-minute curve in today's B&P—would still hamper the speed of trains through Baltimore. At the high price entailed by any of these parallel B&P/Presstman Street tunnels,—all of which would require conventional instead of the cheaper deep-bore construction methods, and all of which would heavily impact the affected neighborhoods at least during the construction process,—a more satisfactory travel time payoff should be expected.

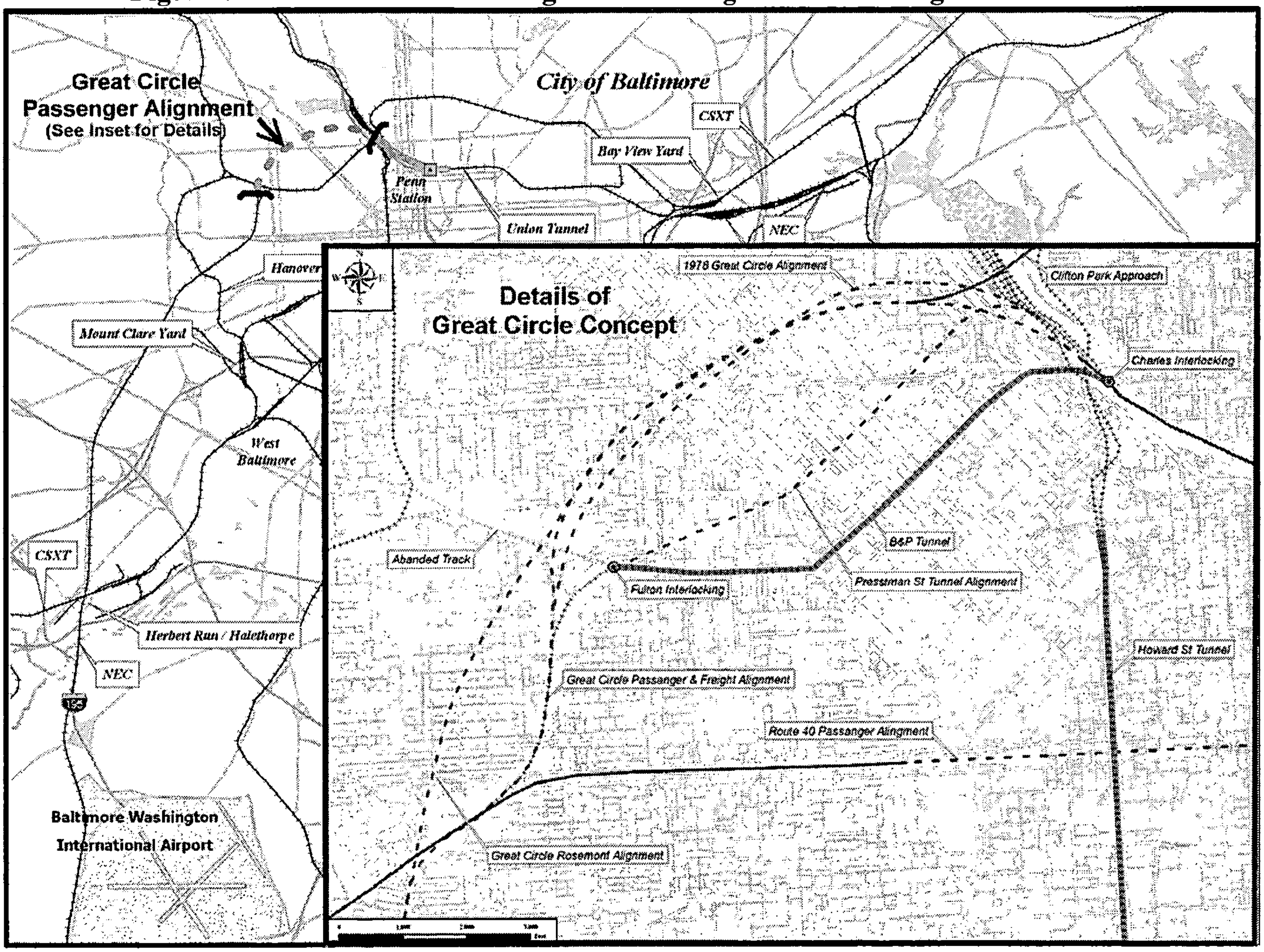
2. Great Circle Passenger Tunnel[10]

The Great Circle Passenger Tunnel (GCPT) alternative would replace the existing B&P Tunnel on an alignment ranging up to some 3,600 feet north of the present tunnel. This

[10] The Great Circle alignment was originally proposed by Mueser Rutledge Consulting Engineers (then known as Mueser, Rutledge, Johnston & DeSimone), working for the NEC Improvement Program, in March 1977.

alignment would have improved geometry for passenger service, would reduce trip times entering and leaving Baltimore Pennsylvania Station, and would retain the existing Union Tunnels and the alignment northward from the Union Tunnels to Bay Interlocking.

Figure 7 - 3: Great Circle Passenger Tunnel Alignment in Its Regional Context



a. General Description

With portals not far removed from those of the B&P Tunnel, the GCPT would follow a large arc north of the existing and Presstman alignments (Figure 7 - 3). By providing a gradual curvature permitting higher train speeds, the alignment would have a continually changing direction, which would minimize the possibility of encountering a weak shear zone.

The route retains the present NEC alignment south of Fulton (MP 97.7) through the West Baltimore MARC station. The route at the northeast end of the GCPT reconnects to the NEC at Charles (MP 95.9). The platforms at Pennsylvania Station would not be modified; however, the track alignment between Charles and Paul (MP 95.2) could optionally be reconfigured to enable train speeds to be increased on the approaches to the platforms.[11] Reconfiguration of the Pennsylvania Station tracks and platforms, especially if the Penn Freight alternative[12] is selected, would likely reduce the storage space available to MARC trains in the station, for which substitute facilities would be needed.[13]

The present NEC alignment between Paul and Bay (MP 91.9) would or would not be modified, depending upon the determination of the location of the freight alternative. The selection, side by side with the GCPT, of the Penn Freight alternative, would require a modification of the NEC between Broadway and Edison Highway to accommodate two freight tracks and two passenger tracks. The selection of any of the other freight alternatives would not modify the NEC between Paul and Bay.

b. Advantages of the GCPT

The Great Circle alignment would have a number of advantages. First, trains would be operated at much greater speeds than through the other two alignments. Initial train performance analyses have concluded that the Great Circle alternative, albeit longer than the extant route, would save about two minutes in comparison with the B&P alignment.[14] Second, and much more importantly, the Great Circle route follows the ridgeline so the tunnel can be deeper below the surface, in rock strata that would reduce construction costs by enabling a tunnel-boring machine (TBM) to be used.

c. Challenges Inherent in the GCPT

Unfortunately, a uniform grade cannot be obtained between the north and south GCPT portals because the profile must go under the Metro Subway near the intersection of Pennsylvania and North Avenues. The elevation of the bottom of the Metro subway at that important intersection is about 120 feet. Therefore, to pass under the subway, the elevation of the tracks of the Great Circle tunnel must be less than 85 feet. The highest elevation on Amtrak south of the B&P tunnel is about 168 feet near La Fayette Street, which is near the location of the current Bridge Interlocking (MP 98.2). The preliminary conceptual design indicates that the elevation could be lowered to elevation 162 feet at the La Fayette Street Bridge. The distance between La Fayette Street and the subway is about 5,250 feet and the conceptual design indicates that a descending grade of 1.75 percent would achieve a top of rail of about 78 feet beneath the tunnel.

The selection of the 1.75 percent, rather than the minimum 1.48-percent grade,[15] is the result of the initial design of the passenger tunnel to be constructible with the Great Circle Freight Tunnel (GCFT), discussed below. This design requires the passenger tunnel to pass over

[11] This option is not reflected in any trip time estimates reported in this section for the GCPT.
[12] Chapter 8 defines the "Penn Freight" and "Belt Freight" alternatives.
[13] The location of any alternate MARC storage was beyond the cope of present analysis. See Chapter 9, "Analytical Paths."
[14] It would thus reduce Amtrak's Washington–New York travel time by about one percent, and the Baltimore-Washington travel time by about six percent. (Times are for Acela Express.)
[15] The minimum grade is that which could be achieved by a passenger train tunnel alignment if there were no requirement to interface with a freight train tunnel.

the freight tunnel at a location approximately 1,350 feet north of the Metro Subway. The elevation of the roof of the tunnel at that location (essentially under McCulloh Street) is about elevation 56. The other option is to pass over the subway at a top of rail elevation of 155 to 160 feet, then descend to a top of rail elevation of about 55 feet beneath the access ramp to the North Avenue light rail station. The distance is about 5,950 feet. Going under the subway is preferable because it would be a deeper tunnel, constructed in better quality rock.

A schematic of the GCPT in conjunction with the GCFT appears in the section treating the latter.

3. Evaluation of Near North Passenger Alternatives

A major restoration of the existing B&P Tunnel, carried on under traffic, would entail a huge expense—about $1 billion according to the MAROps study—merely to preserve the existing capabilities of the NEC. No geometric characteristics of the tunnel would be altered—its seven degree, 30 minute and four degree curves would remain in place. As this option, studied in depth during the NECIP, would lead to no improvement beyond the safety benefit of restoring the tunnel, it constitutes a kind of "status quo" alternative that does not respond to the goals and objectives of the study. If, however, a more comprehensive restructuring is not initiated, then the B&P alternative will ultimately be necessary—at a potentially higher cost than the Great Circle route.

A Presstman Street tunnel, whether on the PRR or a modified alignment, would almost exactly parallel the existing B&P, would echo its debilities in attenuated form, and would do little to expedite passenger service. On the other hand, as a soft-earth tunnel close to the surface, a Presstman Street project would have heavy neighborhood impacts and excessive costs in comparison with deep-rock tunneling by means of a TBM. Thus, there is no apparent advantage to a Presstman Street routing in 2005, much as it may have appealed to the PRR's world-class engineers in 1931 with the technology, cost structure, and environmental laxness then prevailing.

Finally, a Great Circle Passenger Tunnel would significantly ease the curvature and raise the speed limits on the NEC's approach to Baltimore from the south.[16] Utilizing TBM technology in the deep rock, it could be constructed (as will be shown in Chapter 9) at relatively reasonable cost and, because of its depth, with much less risk of impact to the fully built-up neighborhoods above.

Therefore, from among the Near North Sector passenger alternatives, this study chose only the GCPT alignment for further analysis and screening, of which Table 7 - 2 summarizes the results.

[16] For reasons described elsewhere in this report, a GCPT alignment would involve a continued routing of passenger trains through the existing Pennsylvania Station

Table 7 - 2: Application of Screening Criteria to Illustrative Near North Passenger Alternative

Functional/Design Screening Criteria	Great Circle Passenger Tunnel
Availability of Land	Likely
Less than One Percent Grade Freight; Two Percent Passenger	Likely
Beneath Harbor Highway Tunnel	No
Tunnel Length > 4 miles	Unlikely
Ease of Integration with Network	Good
Ease of Integration with Yards	Good
Pass/Fail	*Pass*
Adverse Environmental Impact	
Implementation Issues	

External Impact Screening Criteria	Great Circle Passenger Tunnel
Consistent with Existing Land Use	Likely
Extent of Acquisitions, Displacements, and Relocations	Low
Impact Listed or Eligible National or State Historic Place	No
Impact Parklands, 4(f)/6(f) Resources	No
Construction Impact Severity	Pass
Impact Ecosystems, water resources	Low
Implementation Issues	
Pass/Fail	*Pass*
Issues to be Addressed Next Phase / Comment (in ())	

B. Central Sector—Passenger Alternatives

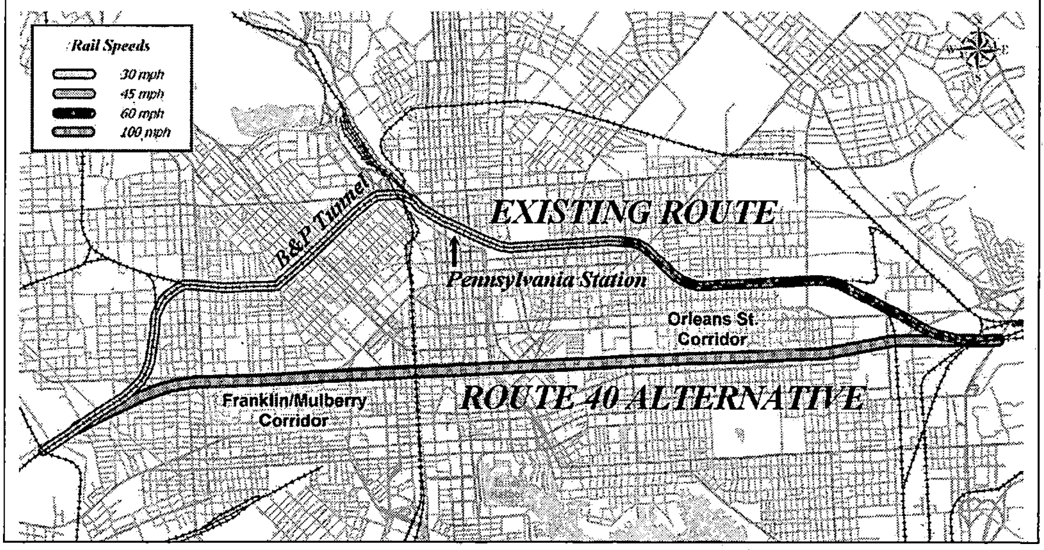
Hypothetically, the most obvious and direct route for a passenger alternative in the Central Sector would make use of a broad public right-of-way in the U.S. Route 40 corridor from the NEC at West Baltimore station, to the vicinity of Martin Luther King Boulevard, thence due east in a tunnel under the CBD to a connection with the NEC near Bay Interlocking. Termed in this report the "Route 40 Alternative," this route illustrates the challenges and costs of a Central Sector passenger solution. Other CBD-based passenger alternatives, posited further below, might ultimately merit closer examination should a Central Sector passenger solution be deemed advisable and affordable.

1. Overview and Performance Effects of a Route 40 Alternative

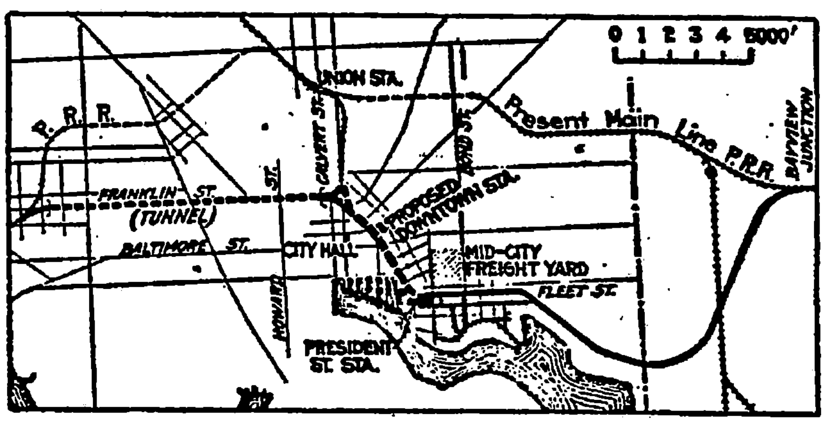
Figure 7 - 4 compares the location and speeds of the present B&P route with an illustrative alignment for a Route 40 alternative. By replacing tortuous curves with a nearly straight line, such a Central Sector solution would markedly outperform the existing route,

without a doubt.[17] The potential reduction in running time for express intercity passenger service remains to be calculated as it would depend on the station location, the alignment of its approaches, its track layout, and the resultant train braking and acceleration patterns; at a minimum, the alignment would allow the relatively high speeds northeast of Bay to be extended southwestwardly into the tunnel. If significant time savings are found, they might impact demand and revenue levels for Amtrak's high-speed services between Washington, Baltimore, Philadelphia, and New York, and perhaps affect the economics of the Route 40 alternative vis-à-vis those in the Near North and Harbor sectors. Whether those economic effects would appreciably counterbalance the higher cost of the Route 40 alternative is unknown.

Figure 7 - 4:
Central Sector, Route 40 Alternative and Existing Route Compared



[17] Interestingly, recent research indicates that PRR and city officials in 1917 were discussing a route (at that time proposed for freight service only) that would have used the west end of the present-day Route 40 corridor to City Hall and thence to President Street. "Pennsylvania Changes at Baltimore Under Discussion Again," *Engineering News Record,* Vol. 78, No. 5, May 3, 1917, pp. 252 ff. The route is shown below:



CITY OFFICIAL PROPOSES SEPARATE FREIGHT TUNNEL

2. Detailed Description of a Route 40 Alternative

This alternative would consist of three main segments (proceeding in a northeastwardly direction): the NEC to Martin Luther King, Jr. (MLK) Boulevard; MLK Boulevard to the Jones Falls Valley; and the Valley to the NEC near Bay Interlocking. These segments are addressed sequentially.

a. NEC to MLK Boulevard

Figure 7 - 5: U.S. 40 East of NEC in West Baltimore

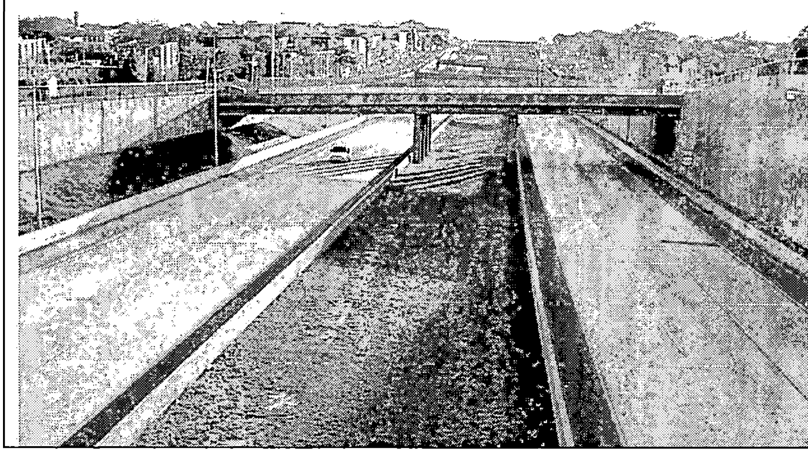
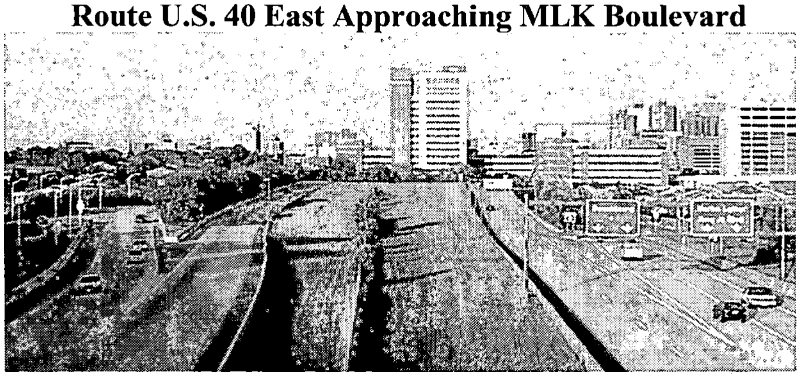


Figure 7 - 6:
Route U.S. 40 East Approaching MLK Boulevard



An initial analysis of the Central Sector indicated that there was an isolated segment of the former I-70 corridor, now Route U.S. 40 (Figure 22), between the current MARC West Baltimore Station and MLK Boulevard, approximately 7,000 feet long. (Figure 7 - 5.) The corridor is located between Mulberry Street, on the south, and Franklin Street, on the north. All of the property between Mulberry and Franklin Streets was taken for what had been intended to be a portion of I-70, but after considerable controversy and public participation, the Franklin-Mulberry segment was never connected to Exit 94 of I-70 on the west side of Leakin Park, at the city line.[18] The possibility of placing the rail alignment in this broad corridor was evaluated from an engineering viewpoint; the rail right-of-way potentially would

[18] According to one source, "I-70 was supposed to end at I-95 just east of Caton Ave. (Exit 50). I-70 through Baltimore City was killed due to community concern about its course through Leakin Park and along the Gwynns Falls… The section completed along the Franklin-Mulberry corridor…was redesignated US 40 in 1989. I-70 now ends at a park and ride at the city line."(http://www.mdroads.com/routes/ is070.html.) The project, and the community impacts that actually occurred before it was stopped (demolishments included a school, 971 houses and 62 businesses), raised such intense and lasting feelings in the community that as late as 1997, the Mayor of Baltimore was proposing to restore the neighborhood by eliminating the orphaned freeway section that was actually constructed. (*Baltimore Sun,* April 23, 1997.)

replace one of the two-lane roadways, since space was provided in the median for a future light rail line.

Near the West Baltimore Station, Franklin and Mulberry Streets descend westward to pass under the NEC. To the east, the "orphaned" freeway right-of-way ends at MLK Boulevard (Figure 7 - 6), an urban arterial ring road that connects I-395 and the Baltimore-Washington Parkway, on the south side, with I-83, the Jones Falls Expressway (JFX), on the north, channeling north/south traffic around the CBD.

b. MLK Boulevard to the Jones Falls Valley

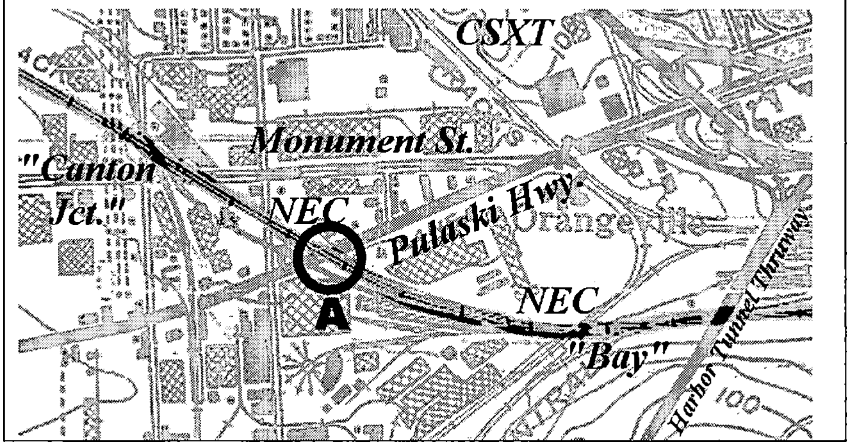
The CBD is at a higher elevation than the alignment of Route 40 to the eastward towards Orleans Street and westward towards the NEC. Approaching downtown from the west, the alignment would go into a tunnel that would have to pass under the central Enoch Pratt Free Library; the Basilica of the Assumption (the oldest Roman Catholic Cathedral in the United States); the Metro Tunnel; and the Howard Street Tunnel. The latter two are at a relatively high elevation, and initially it appears that the alignment would be well below them. Most of the tunnel alignment would be in mixed ground (soils and rock). Due to the sensitivity of the historic structures above, expensive low impact tunneling techniques would have to be implemented. Potentially, the alignment could be diverted to one side or the other, running under either Franklin or Mulberry Streets; this would lengthen the tunnel and might require an unacceptable gradient leaving/accessing the NEC.

The relatively deep Jones Falls Valley is located east of St. Paul Street, where Franklin and Mulberry Streets merge to become Orleans Street, which crosses the valley on a viaduct. The railroad alignment would emerge at, or above ground level in the valley. This would be a potential station site. Such a station would be located about four blocks north of City Hall and about six blocks north of the financial district. At this point there is good access to the JFX, which runs north to the Baltimore Beltway (I-695), allowing easy access to all points on the north side of the city. I-83 continues northward to York and Harrisburg, Pennsylvania, where it merges with I-81. I-83 also runs southward for a short distance, where it then connects with several major east-west arterials, some of which lead to I-395. The Jones Falls Valley in this location, which was a rail yard for both the Western Maryland (WM) and Northern Central (NC) railways, contains a significant amount of vacant land. A large portion of the land currently is used for surface parking. Some marginal industrial activity would need to be relocated; the effects on the street grid would need to be addressed in any further design work for this alternative.

c. From the Jones Falls Valley to a Junction with NEC near Bay

For illustrative purposes, the alignment was assumed to run northeastward under Orleans Street and Pulaski Highway to Point A in Figure 7 - 7, where Pulaski passes beneath the NEC, midway between Canton Junction and Bay. East of the viaduct over the JFX, Orleans Street is 10+ lanes wide as far as Broadway, where it narrows to 4 to 6. This would be the most difficult part to plan, design, and construct, in terms of community issues, due to the proximity of residences.

Figure 7 - 7:
Site of Potential Junction, Route 40 Alternative with NEC



A connection to the NEC between Bay and Canton Junction might prove suitable. The NEC descends on a 0.5-percent grade while turning its compass direction from southeast to east at MP 92.42, where Pulaski Highway passes under it while veering slightly toward the northeast as it heads away from downtown Baltimore. Conceptual engineering would be needed to determine whether the Route 40 Alternative would ramp directly up from under Pulaski into the NEC, or whether some other junction design would be optimal.

3. Other Central Sector Alternatives

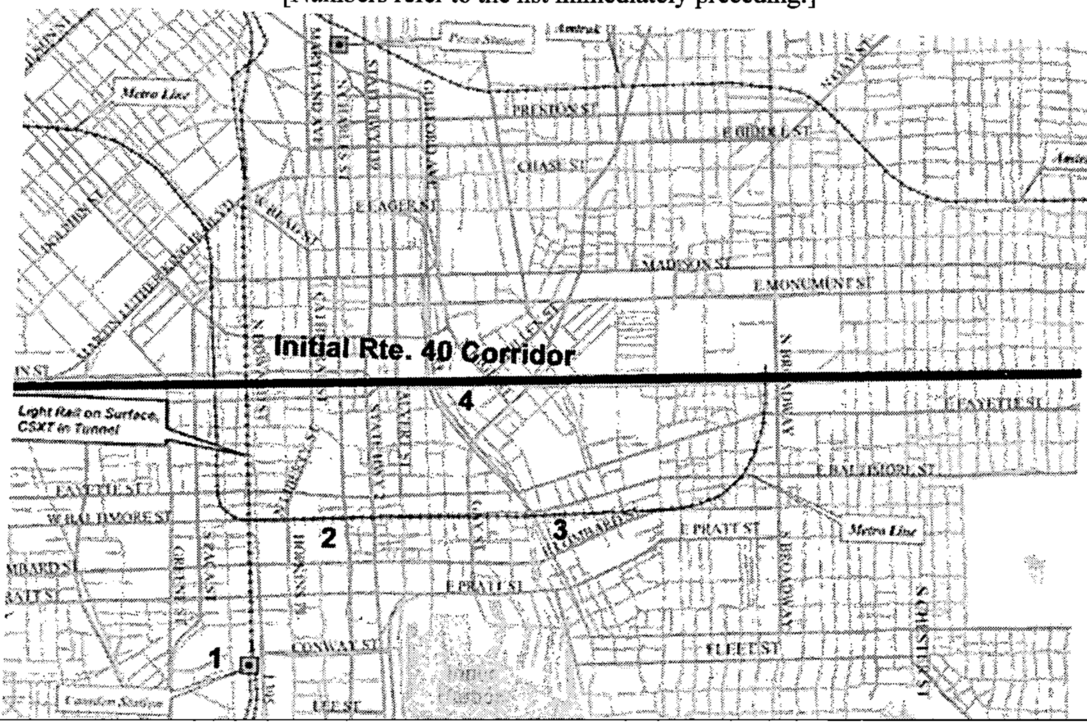
To relocate the NEC main line to the Central Sector would mean choosing a new main passenger station location. Any decision to abandon the present station and move rail passenger service closer to the CBD would require not just an engineering investigation of potential sites, but—even more to the point—a careful marketing and demand analysis of the workplaces, residences, and travel habits of actual and prospective station users, both commuter and intercity. The dynamics of and factors in their modal choice decisions must come under careful scrutiny. It is by no means certain, for example, that the origins and destinations of a majority of present and likely future users of Pennsylvania Station (in both intercity and commuter service) would be closer and more accessible to a downtown station than to the current one. On the other hand, a more central station might induce completely new travel demands and create perceptible shifts in modal shares that might outweigh any losses of current Pennsylvania Station users. Other important issues include the rail service goals and objectives of the various Metropolitan Planning Organizations, transportation agencies, and rail operators in the Baltimore and Washington metropolitan areas, as well as the economic and development impacts on the neighborhoods affected by such a change of venue.

All these complexities—while essential to the station location issue—fall outside the scope of this engineering report. In evaluating the Central Sector for passenger service, the study team satisfied itself with identifying a number of potential station sites, the existence of which would be the most critical element to be considered in the evaluation of potential alternative alignments. As shown in Figure 7 - 8 (in which the numbers are cross-referenced to the following list), the envisioned sites were:

1. Near the original CSXT Camden Station;

2. Adjacent to Charles Center Metro Station;
3. Adjacent to, or near, the Market Place Subway Station; and
4. The Jones Falls Valley station site, described earlier.

Figure 7 - 8: Alternate Station Sites, Central Sector
[Numbers refer to the list immediately preceding.]



Identification of possible alignments to serve the first three sites, and of concepts for the layout of all four stations, fell outside the scope of this report (see Chapter 9). Still, certain probabilities and issues came to light as the array of sites was scrutinized:

- The downtown station most likely would be underground, beneath the most densely developed part of Baltimore City, thus making it more expensive to construct. One preliminary reckoning is that such a station would need to be 125 to 175 feet wide and 1200 to 1500 feet long—a veritable cavern. Such a project would raise both environmental and cost concerns.
- The potential site mentioned in the discussion of the Jones Falls Valley Alternative (number 4 on the sketch), although above ground, would have no existing rail transit access and would be in a warehouse-type area north and slightly east of the financial district. While precise distances and accessibility issues cannot be known unless and until the station concept were to be better developed, a careful comparison of access, egress, and marketability would need to be made with the existing Pennsylvania Station.
- The new site would require commuters, living in the northern neighborhoods of Baltimore but working in Washington, to access a station deeper into the city than is presently the case. Transit availability, traffic conditions, and parking adequacy and prices would likely become important concerns to that group of system users. If Penn

Station and the B&P tunnel are retained for commuter service, then, effectively, two passenger tunnels would have to be constructed (or rehabilitated), maintained, and operated.

- The Charles Center and Market Place Station locations would imply a Baltimore Street alignment. The Metro Subway is located under Baltimore Street between Howard Street and Central Avenue. The potential for utilization of this street for a rail passenger tunnel would be limited.
- Inspection of aerial photos of the Central Sector indicates that access to the alternative station sites (number 1, 2, and 3 on the map) from West Baltimore and at Bay would necessarily use more southerly, and more difficult, alignments than that conceived for the Route 40 Alternative.

4. Initial Overview Assessment of the Illustrative Central Sector Alternative

An initial overview assessment based on detailed local knowledge of the area and a review of available mapping and photography (including aerial photos) indicated that many stretches of the illustrative Route 40 alternative would not pass under or through adjoining residential neighborhoods. For example, there is nothing residential between MLK and Asquith, and very little residential development between Asquith and Rutland Avenue (east of Broadway). East of Highland Avenue, too, the development is industrial.

On the other hand, the Franklin/Mulberry Corridor in West Baltimore is populated, as is Orleans Street between Rutland and Highland Avenues. While these neighborhoods have always experienced a high level of traffic on Route 40, public reaction to adding railway construction and operation to the ambient noise and activity levels is unknowable at this time. However, the intense (and ultimately effective) public response to the I-70 project decades ago testifies to the sensitivity of the affected communities to issues of transportation encroachment on their environment. Therefore, even beyond the customary and required environmental processes, early and well-heeded public participation would be of critical importance in any further consideration and development of the Central Sector.

Table 7 - 3 summarizes the performance of the Route 40 Alternative, illustrative of the use of the Central Sector for passenger service, on the screening criteria developed for this study. It passes "with comment" due to the environmental implications and likely public controversy. Also of great concern to the study team is the likely cost of any downtown station that directly serves the heart of the CBD, which would need to be underground, large, and in close proximity to the Baltimore Metro.

Table 7 - 3: Application of Screening Criteria to Illustrative Central Sector Passenger Alternative

Functional/Design Screening Criteria	Route 40 Alternative
Availability of Land	Probable
Less than One Percent Grade Freight; Two Percent Passenger	Likely
Beneath Harbor Highway Tunnel	No
Tunnel Length > 4 miles	Unlikely
Ease of Integration with Network	Good
Ease of Integration with Yards	Good
Pass/Fail	*Pass*
Adverse Environmental Impact	Potential for Parklands/4(f); Ecosystems; Construction impact
Implementation Issues	Public Controversy Likely

External Impact Screening Criteria	Route 40 Alternative
Consistent with Existing Land Use	Probable
Extent of Acquisitions, Displacements, and Relocations	Low
Impact Listed or Eligible National or State Historic Place	No
Impact Parklands, 4(f)/6(f) Resources	No
Construction Impact Severity	Pass
Impact Ecosystems, water resources	Low
Implementation Issues	Public Controversy Likely
Pass/Fail	**Pass with Comment**
Comment	Impact of construction: in Route 40, beneath center city, beneath Metro and Howard Street Tunnels

C. Harbor Sector—Passenger Alternatives

In order to test the feasibility of a Harbor Sector passenger route providing a main station reasonably close[19] to the CBD, the study team laid out a "Locust Point Passenger Alternative" crossing the Northwest Harbor to the north of the Fort McHenry Tunnel. The tunnel route from the southwest to the northeast connects Herbert Run (where the CSXT crosses the NEC) and Bay Interlocking in East Baltimore. Sited south of the CBD, this alternative would link Locust Point with Canton.

1. Description of the Locust Point Passenger Alternative

The basic concept for this alternative may be described as follows, proceeding from the southwest to the northeast (numbers refer to points on Figure 7 - 9):

1. At Halethorpe/Herbert Run, northeast-bound passenger trains would divert from the existing NEC to the CSXT main line via a connection that is yet to be configured. (Its configuration would depend on the operating patterns for other types of traffic through Baltimore.) For example, the junction might resemble Union Interlocking in Rahway, NJ, which connects the six-track NEC main line with the double track branch to Perth Amboy. The junction uses duckunders[20] constructed in the middle and side of the NEC to facilitate the movement of New Jersey Transit branch line trains to and from the NEC.

2. Between Halethorpe and Mt. Winans, the alternative could potentially have Amtrak, CSXT, NS, and MARC all operating in the already overburdened CSXT corridor. (Which carrier operates where for what type of traffic would depend on the resolution, if any, of the freight challenge in the region.) Development of a track configuration sufficiently capacious to accommodate up to the entire trans-Baltimore traffic, while minimizing conflicts, lay outside the scope of this study; six tracks might be necessary, with several complex interlockings and track connections and all the associated signaling and programming.

3. At a location east of Mt. Winans, the passenger alignment would diverge to the northeast from the CSXT right-of-way. It would continue to the northeast, crossing over local roads and streets, to Westport, where it would have an intermodal station stop as it bridges over Baltimore's light rail line (4). Trains would then cross the Middle Branch of the Harbor on an elevated structure located basically above the former WM moveable bridge (5).

6. Neither an advantageous station location in, nor a consequent route through, the Locust Point area could be identified within the scope of this study. (Hence the dotted lines in the Locust Point area in Figure 7 - 9.)

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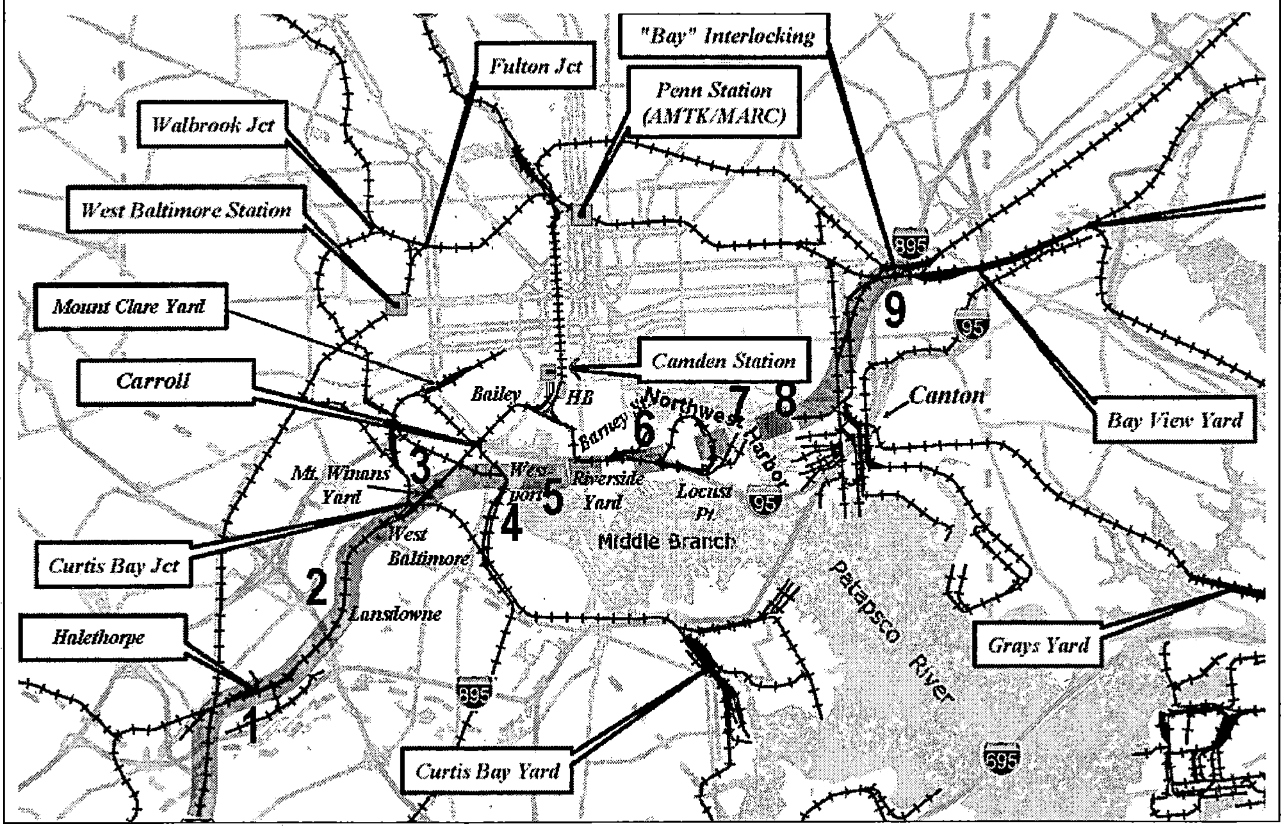
[19] "Reasonably close" in this context means "no farther from the CBD than the current Pennsylvania Station."

[20] A duckunder is a railway structure in which the branch line, separating from the main, gradually ramps down and, on attaining sufficient vertical distance from the main line grade, smoothly bears away from the principal right- of-way beneath a bridge carrying the main line tracks.

7. The option would utilize two single-track passenger tunnels that would pass under a portion of Locust Point before rising to ground level north of I-95 in Canton.

8. Northeast of the tunnel, the alignment—threading its way through freight trackage and other obstacles in the Canton port area (see evaluation below)—would necessarily be slow and circuitous and would not significantly contribute to reducing travel times through Baltimore.[21] Curves immediately east of Northwest Harbor and the curve connecting into the NEC at Bay (9)—both exceeding two degrees, 50 minutes—would restrict speed.

Figure 7 - 9: Schematic of Harbor Sector—Locust Point Passenger Alternative



2. Evaluation of the Harbor Sector—Locust Point Passenger Alternative

From both engineering and passenger traffic viewpoints, the Locust Point passenger alternative evinces obvious drawbacks:

[21] One of the Harbor Sector freight alternatives involves a Locust Point-Canton freight alignment that might be constructed above the Locust Point Passenger Alternative. However, due to grade problems that have not yet been resolved, this particular freight alternative did not survive the screening imposed on it (see further below).

- West of the Harbor, the passenger-only line would have to pass beneath I-95. Access beneath the interstate highway to create a relatively direct and fast route would require considerable reconstruction of the piers and abutments supporting the highway on its approach to the Fort McHenry Tunnel.
- The alignment would be made more difficult by the requirement to construct a grade-separated alignment, i.e., without a moveable bridge, over the Middle Branch, in the vicinity of the former Western Maryland swing bridge that once provided access to Port Covington.
- The Westport intermodal station would be farther from downtown Baltimore than the existing Pennsylvania Station, and would pose difficult barriers to pedestrian access. In Locust Point, a feasible location for a main station was not identified during the study. Within the alignment constraints already perceived by the study team, it would be almost impossible to site a Locust Point station within an equivalent walkable distance to downtown as that of the existing Pennsylvania Station.
- East of the Harbor, the access of Amtrak intercity trains between the NEC at Bay and the eastern portal at Canton would be constrained by:
  - At-grade railroad-highway crossings;
  - Overhead and undergrade bridges that presently separate the existing freight-only tracks from the city streets; and
  - The need to maintain local freight connections and operations between the CSXT and NS yards and local industries and facilities in Canton and Dundalk.
- Finally, if intercity rail passenger service is diverted to the south, a vicinity already served by MARC's Camden Line, then the Penn Line—providing access to the vast residential areas north of the CBD—may well remain in place. Retention of commuter service to Pennsylvania Station would necessitate —alongside the Harbor Sector passenger tunnel—either permanent maintenance and rehabilitation of the B&P tunnel for commuters, a new tunnel for commuter service alone, or an arrangement for commuter service to share trackage with a Great Circle Freight Tunnel. In the context of this comprehensive study, none of these outcomes accords with the economic theory of railway location.

The foregoing engineering and traffic considerations eliminated the Harbor Sector passenger alternative from further consideration. (See Table 7 - 4.) As there is no chance of designing any other Harbor Sector alternative that would both provide a main station 15 walkable blocks or less from the CBD and speed trains through Baltimore more quickly than via the present route, no need arose to develop additional passenger options in this Sector.

Table 7 - 4: Application of Screening Criteria to Illustrative Harbor Sector Passenger Alternative

Functional/Design Screening Criteria	Locust Point Passenger Alternative
Availability of Land	Probable
Less than One Percent Grade Freight; Two Percent Passenger	Likely
Beneath Harbor Highway Tunnel	No
Tunnel Length > 4 miles	Unlikely
Ease of Integration with Network	Poor; may increase congestion on upgraded CSXT Capital Subdivision
Ease of Integration with Yards	Good
Pass/Fail	*Fail*
Adverse Environmental Impact	Potential for Acquisitions, displacements, Relocations; Construction Impact
Implementation Issues	Would likely require reconstruction of I-95; would require approval of Coast Guard.

External Impact Screening Criteria	Locust Point Passenger Alternative
Consistent with Existing Land Use	Low
Extent of Acquisitions, Displacements, and Relocations	Medium
Impact Listed or Eligible National or State Historic Place	No
Impact Parklands, 4(f)/6(f) Resources	Yes, Parkland in Herbert Run
Construction Impact Severity	High (both on rail traffic and adjacent land)
Impact Ecosystems, water resources	Low
Implementation Issues	Would likely require reconstruction of I-95; would require approval of Coast Guard; Would increase congestion on upgraded CSXT Capital Subdivision.
Pass/Fail	**Fail**
Comment	

Chapter Eight
FREIGHT ALTERNATIVES

The study team identified two sectors in which viable freight alternatives might, at least theoretically, be found:

- **Near North**—roughly analogous to the existing PRR alignment and the eastern portion of the B&O Belt Line, but refined due to state-of-the-art engineering and construction techniques; and
- **Harbor**—an underwater solution that would be complex because of the number of potential portal sites, and the multiplicity of port, land transportation, and industrial facilities on either side of Baltimore Harbor.

As explained above, a Far North Sector freight alternative was ruled out because it would pose severe gradient challenges, bypass important freight yards, and disrupt much parkland and intense suburban development. Likewise, an inevitably costly freight solution in the Central Sector was not pursued as the associated expenditure would far outweigh any foreseeable benefit of such a location at the heart of Baltimore's CBD.

A. Freight Alternatives in the Near North Sector

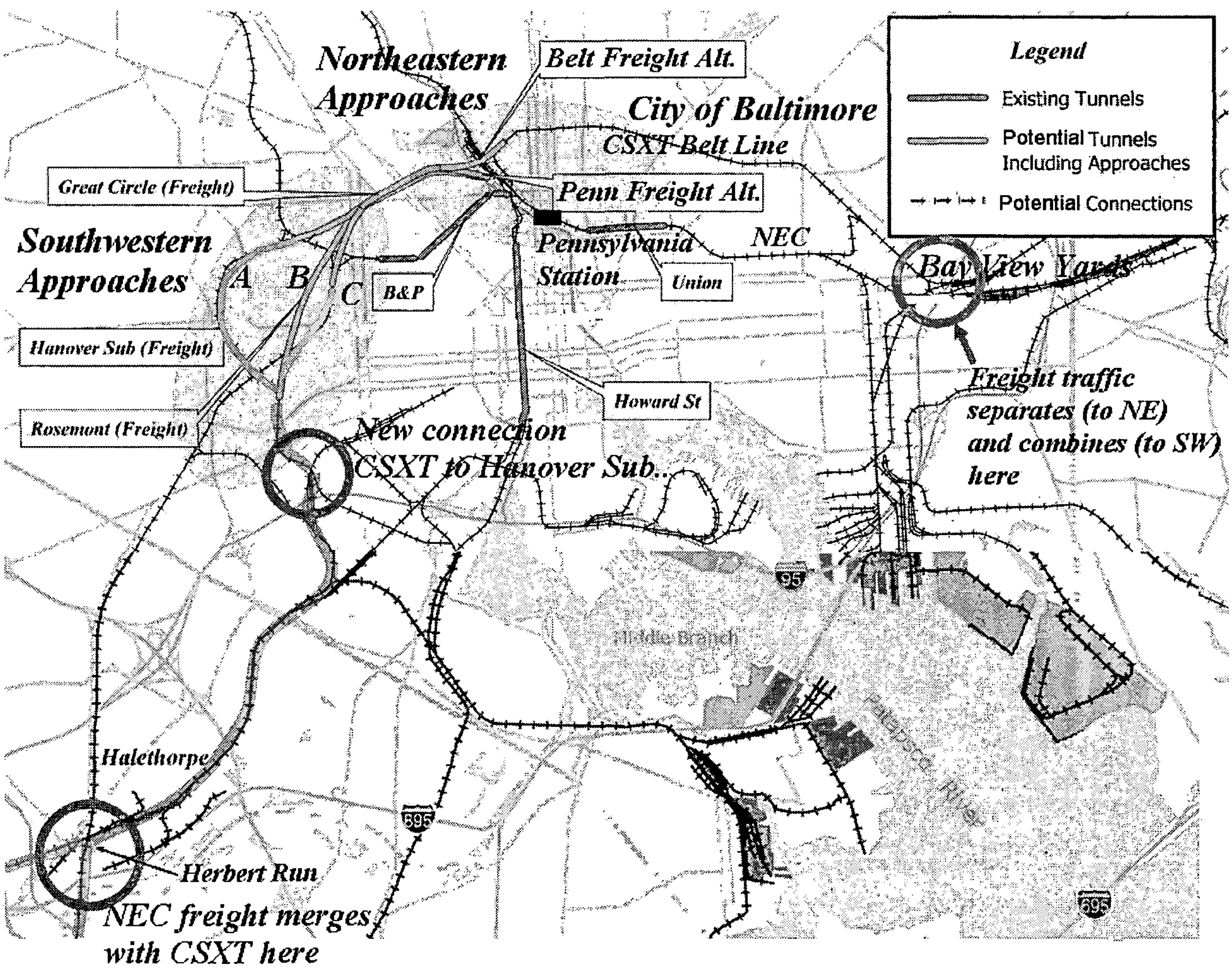
The two Near North freight alternatives would involve the construction of tunnels of varying lengths on different alignments. The freight alignments would replace both the existing CSXT route using the Howard Street Tunnel and the NEC route currently available to the NS via the B&P and Union tunnels. Concentrating all the cross-Baltimore freight traffic on a single, much-improved route, the Near North alternatives would relieve most of the constraints to commerce that the extant alignments interpose. Both of the Near North freight alternatives would involve a Great Circle Freight Tunnel (GCFT), similar in concept to the Great Circle Passenger Tunnel (GCPT) broached earlier. By following a gentle, long arc bored deeply underground, instead of a cut-and-cover excavation hewing to the vagaries of the City's street layout, a GCFT would help to attenuate the ill effects of Baltimore's challenging topography.

As depicted in Figure 8 - 1, all the Near North Freight alternatives would begin at Herbert Run (near Halethorpe), where northeast-bound NEC freight traffic would join through CSXT traffic on the CSXT main line.[1] Following the CSXT Mount Clare Branch to the Mount Winans Yard, the entire through freight traffic would divert briefly (using a new connection) toward compass northwest via the Hanover Branch (the former Western Maryland Railway). In West Baltimore, the route would bear compass northeast from the Hanover Branch to a tunnel portal leading to Presstman Street, where the GCFT's characteristic alignment begins. Emerging

[1] Only early conceptual engineering has taken place with regard to the connection at Herbert Run and the joint freight route from that point to the Hanover Subdivision to the contemplated tunnel portals. To handle the complex freight moves to, from, within, and through the Baltimore Terminal, connections would be required in addition to those described here.

through a portal west of the Jones Falls Valley, both alternatives would cross the Falls to rejoin existing but upgraded freight trackage. Near Bay View, the CSXT- and NS-based traffic would split, each company's trains going their separate ways. The shared operation, therefore, would occur between the Herbert Run (Halethorpe) and Bay View vicinities.

Figure 8 - 1: Near North Freight Alternatives: "Belt Freight" and "Penn Freight"[2]



Within this common Near North concept, there are two alternatives, differentiated by their routes and elevations across the Jones Falls Valley. In the **Belt Freight Alternative**, the through freight route would cross the Valley at a relatively high elevation toward compass northeast to a connection with the CSXT's Belt Line through Clifton Park to Bay View. By contrast, in the **Penn Freight Alternative,** the through freight route would bridge the valley at a lower elevation toward compass southeast and would make use of the NEC right-of-way through

[2] Note: Highlighted route in this schematic is for southwest-northeast through freight only. Additional connections would be needed to improve service to other flows, including those to and from Locust Point and internal moves within the region.

a refurbished "Old" Union Tunnel to Bay View. While the basic concept of the GCFT would remain constant, its design would vary significantly to meet the particular elevation requirements of the Belt Freight and Penn Freight Alternatives while also avoiding the Metro tunnel at Pennsylvania Avenue in West Baltimore.

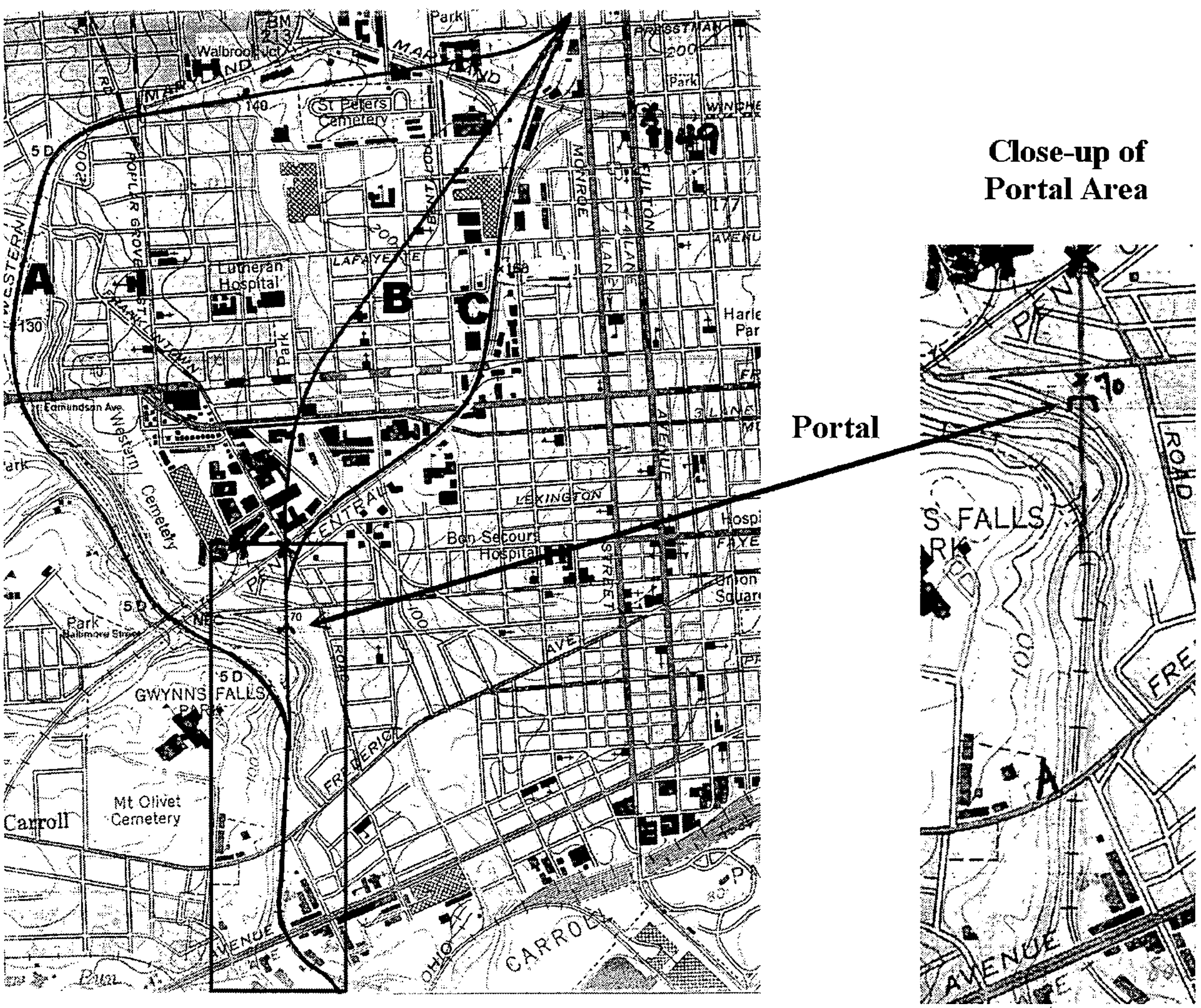
In the conceptualization of both Near North alternatives, the study team assumed that the GCPT must be provided for.

The following discussion first deals with the suboptions that may be available at the southwestern approaches to either alternative. Then follows a discussion and evaluation of the Belt Freight and Penn Freight Alternatives.

1. **Southwestern Approach Options (Potentially Available in Either Alternative)**

As noted above, the approach to the Great Circle Freight Tunnel from the southwest would make use of the CSXT Baltimore Terminal Subdivision between Halethorpe/Herbert Run

Figure 8 - 2:
Three Southwestern Approach Options to Great Circle Freight Tunnel



and Mt. Clare Yard to access the CSXT Hanover Subdivision (the former WM main line to/from Port Covington). Three alternative route approaches from the Hanover Division to the southwest tunnel portal were evaluated, are shown in Figure 8 - 2, and are discussed below. Of these options, two would utilize a common western portal located north of Gwynns Falls; the third would have its portal at Walbrook.

a. Gwynns Falls–NEC Option

Predicated on the assumption that minimal right-of-way acquisition would be required, the Gwynns Falls–NEC tunnel option ("C" on Figure 8 - 2) would be constructed underneath the NEC as far northeast as Fulton.[3]

From its portal just north of Gwynns Falls (see close-up in Figure 8 - 2), the tunnel alignment would curve to the northeast from the southwest portal to reach its position underneath the NEC right-of-way. The length and degree of curvature would vary depending on whether it was desirable to minimize the length of alignment rights that would have to be acquired. The longest, least sharp curve would be approximately two degrees 30 minutes and approximately 2,000 feet long; while a 1,215-foot long, three-degree 20-minute curve would result in a maximum speed of 50 mph.[4]

The NEC, just east of Franklintown Road (UG Bridge 98.95), is approximately 1,300 feet north of the contemplated south portal. The elevation of the NEC at Franklintown Road is approximately 134 feet. The roof of the freight tunnel would be approximately 35 to 40 feet beneath the NEC. Warwick Avenue[5] and Franklin Street pass under the NEC; however, the freight tunnel would have to be designed to pass beneath both streets. This requirement would apply for both the Belt Freight and the Penn Freight alternatives. Further investigations would be required to determine whether this vertical distance would be adequate to enable the tunnel to be constructed without disturbing the NEC roadbed and structures.

The alignment would proceed underneath the NEC to Lafayette Avenue, where the NEC is approximately at elevation 168 feet and the roof of the freight tunnel would be at approximately either elevation 135 or 75, depending upon the choice of either the Belt Freight or Penn Freight alternative. The Penn Freight Alternative would be located beneath the Great Circle Passenger Tunnel at Presstman Street, while the Belt Freight Alternative would be parallel to the Great Circle Passenger Tunnel.

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[3] The feasibility of tunneling underneath the NEC was not evaluated as part of this study, and would need careful and early analysis should work on this option be considered.

[4] While such speed restrictions would probably be "good enough" for most freight operations, they would hamper the railroads' operating (hence marketing) potential to expand their high-value freight business for all time and should be reviewed very carefully. The 50 mph mentioned here is **below the design speed** specified in the study's goals and objectives.

[5] It was assumed that the tunnel should be located at least 15 feet beneath the road surface of a street.

b. Rosemont Option

Alternatively, the shorter route between Gwynns Falls and Presstman Street (labeled "B" on Figure 8 - 2) would pass under the Rosemont section of Baltimore.

The alignment would extend northward from the Gwynns Portal until it passes under the NEC right-of-way. The alignment would curve to the northeast on a 2,831-foot long one-degree curve. The subsequent 3,980-foot long tangent would pass under the former WM Wye Tracks at Fulton on the NEC. The freight tunnel alignment becomes parallel to the Great Circle Passenger Tunnel, but approximately 90 feet lower, near Presstman Street.

c. Walbrook Option

The third option for accessing a Great Circle Freight Tunnel (labeled "A" in Figure 8 - 2) would continue following the CSXT Hanover Division to the vicinity of Bloomingdale Road, where it would bear to the right (going northeast) to converge with the other options under Presstman Street. Unfortunately, no portal and tunnel configuration using the Walbrook option could be found that would meet the grade or clearance requirements of this study. Accordingly, this option was dropped.

2. Belt Freight Alternative

Ascending to a top-of-rail elevation of at least 150 feet to enable the tunnel to pass over the Metro Subway at Pennsylvania Avenue, the Belt Freight Alternative would directly access the CSXT Belt Line (the Clifton Park Freight Alignment) east of Jones Falls, by means of a bridge spanning the valley. The Belt Freight Alternative option would parallel the Great Circle Passenger Tunnel between Baker Street and Newington Avenue. The option of constructing the Great Circle Freight tunnel beneath the Great Circle Passenger tunnel was evaluated; however, sufficient clearance between the tunnels could not be established to enable the alignment of the freight tunnel to cross over the top of the passenger tunnel between Presstman and Monroe Streets.

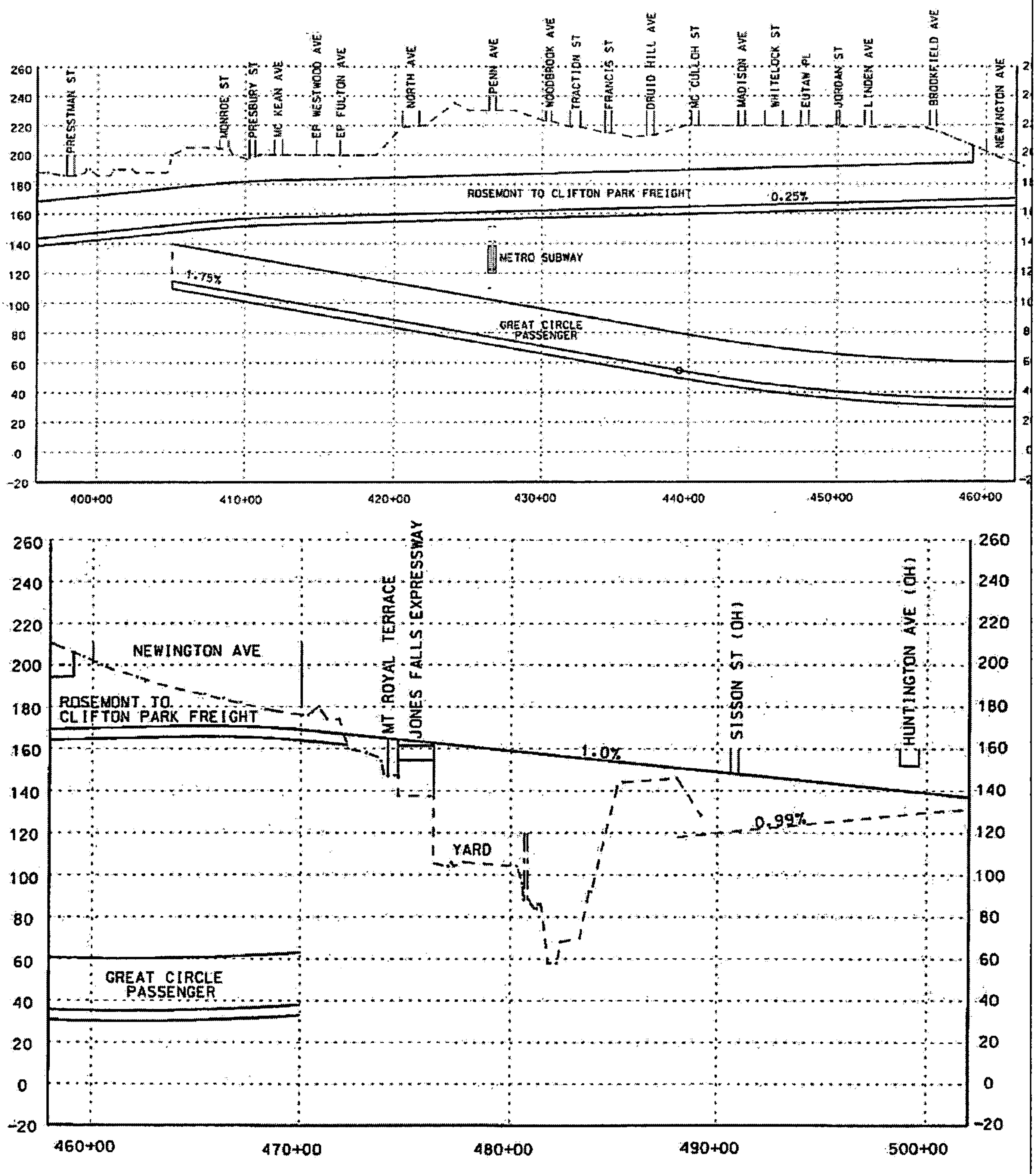
The profile of the Belt Freight Alternative from Presstman Street to Huntingdon Avenue on the CSXT Belt Line is shown in Figure 8 - 3. The alignment would ascend from less than 70 feet at the Gwynns Falls portal to pass over the subway at an elevation of 150 feet, on a one percent grade. The gradient would be controlled by the need to cross over the top of the Great Circle Passenger Tunnel near Baker Street. Some parts of the Belt Freight Alternative between the south portal and Pennsylvania Avenue would have less than 20 feet of ground cover. However, it does not appear upon first inspection that an open trough, rather than a tunnel, would be an option in these locations.

Selecting a Belt Freight alignment to cross the valley from the north portal of the Great Circle Freight Tunnel required careful analysis of the location of all important intervening structures. Vertical, as well as horizontal, alignment considerations were critical in the finalization of the analysis. The main elevations are shown in Figure 8 - 3.

The engineering analysis of the Belt Freight Alternative and its connection across the Jones Falls Valley to the northeastern portions of the CSXT Belt Line through Clifton Park led to the following conclusions, which take into account all the conflicting determinants:

- Exacting geometry restrictions are imposed by factors including but not limited to the following:
  - — The Metro tunnel at Pennsylvania Avenue;
  - — The proximity of a possible Great Circle Passenger Tunnel, which would need to be planned for (as long as it is a viable option);
  - — The need to pass over or under the JFX with ample clearances;
  - — The existence, on the direct path between any likely GCFT portal and the CSXT Belt Line, of the Central Light Rail Line yards, shops, and main trackage;
  - — The need to maintain grade separations at Sisson Street and Huntingdon Avenue on the east side of the valley; and
  - — The need to adhere to the one percent grade limitation (better if possible).
- The location of the Central Light Rail Line (CLRL) facilities, coupled with the assumption that they cannot be moved, prevents the Belt Freight Alternative from passing under the JFX and instead requires a high bridge across the freeway. This in turn—
  - — Raises the necessary elevation of the northeast tunnel portal, necessitates cut-and-cover construction through the local area, and forces the bridge over the valley to begin approximately 200 feet west of Mount Royal Terrace, thus markedly affecting the neighborhood between Druid Hill Park and North Avenue. In fact, preliminary estimates indicate that an 1800-foot strip of Mount Royal Terrace would have to be removed under the Belt Freight Alternative; and
  - — Results in a difficult aerial alignment through the CLRL, with freight train speed limits of 40 mph; this is inconsistent with the goals and objectives of the project.
- The establishment of a one percent grade east of the Great Circle Freight Tunnel eastern portal, connecting the new freight alignment with the CSXT Belt Line, would result in significantly raising the roadway surface of both Sisson Street and Huntingdon Avenue, or the closing of both streets. As a result of these neighborhood impacts, this option may not be viable. The only other choice (holding constant the horizontal alignment) would be to keep the elevation of the Belt Line constant and adjust the gradient of the connection from the northeastern tunnel portal to the east side of the Valley. The resultant gradient becomes 1.6 percent descending to the Belt Line—far beyond that allowable to meet the study objectives.
- Construction of the Belt Freight Alternative would encounter poor-grade rock and soil.

Figure 8 - 3: Profile of Belt Freight Alternative



- To meet study specifications, Belt Line improvements would require double-tracking and seven bridge replacements to provide double-stack clearances.
- Based on operational, neighborhood impact, and cost[6] considerations, the Belt Freight Alternative emerges from *this* study as inferior to the Penn Freight Alternative. However, changes in assumption and additional engineering investigations might improve the characteristics, feasibility, and relative position of the Belt Freight Alternative among potential approaches to railway restructuring in Baltimore.

3. **Penn Freight Alternative**

The Penn Freight Alternative would descend on a 0.60 percent grade from Franklintown Road (approximately 700 feet north of the Gwynns Falls portal) to pass under the Metro Subway at a top of rail elevation of approximately 15 feet. At this location the freight tunnel alignment would be north of the GCPT alignment. The freight tunnel would then descend for another 1,400 feet prior to ascending on a one-percent grade to the Jones Falls portal. The freight and passenger tunnels would have the same gradient and top of rail elevation for the nearly the last 2,100 feet of their respective tunnels. This is natural, as they would debouch onto the same NEC right-of-way.

The twin freight tunnels would remain parallel to each other until they were under the JFX. At this location the outside tunnel would diverge to the north to an alignment that would enable it to pass under the CSXT railroad bridge at North Avenue. The Penn Freight alignment would emerge from the GCFT at two portals[7] in the wall supporting the Light Rail line and would curve toward compass southeast towards Penn Station. (Figure 8 - 4.) The portal of the outside freight track would be located approximately 400 feet compass northwest of the portal of the inside freight track. At the CSXT railroad bridge:

- A bridge pier of the railroad bridge would separate the two freight tracks; and
- The inside freight track would be located adjacent to, and parallel with, the two passenger tracks.

The vertical curve connecting the tunnel alignments with the NEC would end east of the Howard Street Bridge.

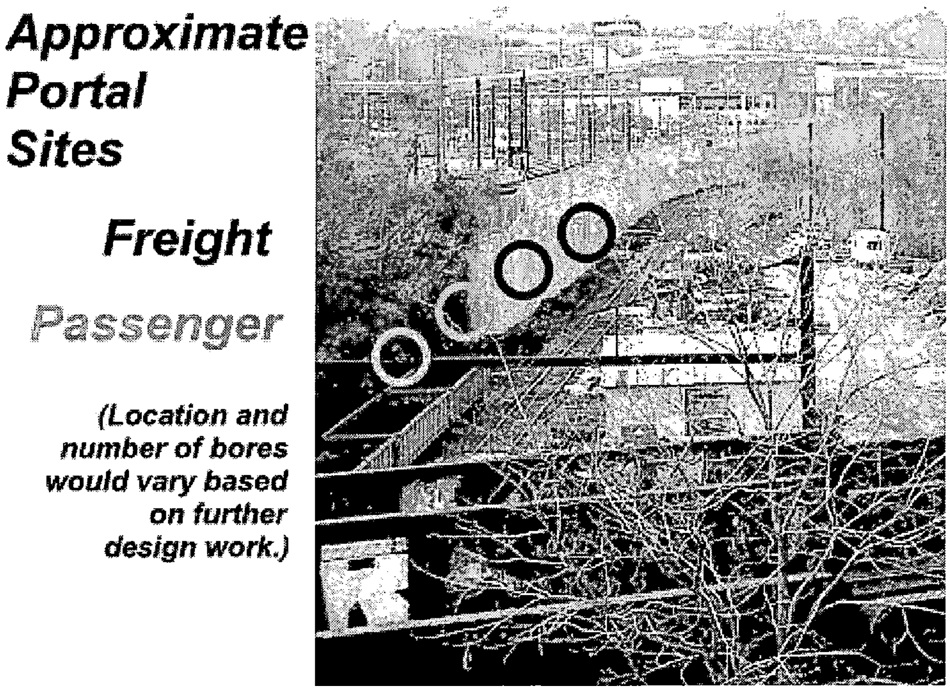
Connecting to the existing NEC near the north portal of the B&P Tunnel, the double-track Penn Freight alignment would be located compass northeast of the double-track passenger alignment. The combination passenger and freight alignment between the northeast portals of the Great Circle Tunnels and the station would require a reconfiguration of Charles Interlocking,

[6] Costs are reported in Chapter 9.

[7] The portal of the outside, northern, tunnel is located approximately 350 feet north of the inside tunnel. The locations of the piers for the CSXT Bridge and Howard Street require that the outside track cannot be located parallel, and 14 feet apart, from the inside track. The two tracks (or the tunnels they are located in) are not parallel for approximately the easternmost 3,000 feet of the Penn Station Freight Tunnel alignment. This assumes two bores for freight and two for passenger; the precise tunnel configurations and locations would be determined in further stages of design.

located compass northwest[8] of the station platforms. The track alignments would pass beneath the existing North Avenue Bridge and the CSXT Bridge.

Figure 8 - 4
View of Potential Portal Sites
for GCFT (Penn Freight) and GCPT
(View from CSXT Bridge over Northern Central Railway, Looking Northwest)



The freight alignment would pass to the north of the Penn Station platform tracks and utilize a rebuilt Old Union Tunnel to reach East Baltimore, where access to the CSXT main line and the NS Bay View Yard and the NEC would be provided.

As part of a Penn Freight Alternative, the Old (northernmost) Union Tunnel would have to be double tracked and clearances increased. The current grade through the Union Tunnel is 1.17 percent, eastward, which is greater than the specified maximum 1.0 percent grade. [9] The

[8] In discussing Pennsylvania Station, oriented at cross purposes to the direction of traffic, it is important to reiterate for the reader that—except where noted— all directions having to do with the railroad are expressed as southwest/northeast, which is the major traffic lane.

[9] Train Performance simulations show that three Dash 8 diesel units cannot start a 4,000-foot train consisting of loaded 315,000-pound capacity cars when the locomotive is stopped at the apex of the grade at Broadway (MP 94.50). Additionally, the same trains, if stopped at the south end of the Union Tunnel can barely make the grade. The train at the south end makes the grade because, when the locomotive is at the base of the grade, the entire train behind it is on a downgrade. This allows the locomotives to start the train and gain some momentum before the entire train is on the grade. If it were not for the momentum, the train would stall. Needing to depend upon momentum for normal operations is not preferred.

elevation at the south end of the Union Tunnel is 51 feet and the elevation of the apex at Broadway is 95 feet, a climb of 44 feet in 3,900 feet. The elevation cannot be lowered at Broadway. Therefore, the only way to make the grade through the Old Union Tunnel to meet the one percent requirement would be to raise the elevation at the south end of the tunnel by five feet. This would reduce the rise to 39 feet in 3,900 feet, or one percent. The overhead clearance under Guilford Avenue, the first overhead bridge south of the tunnel portal, would not be adversely impacted.

Although the Penn Freight Alternative has survived this preliminary analysis without the discovery of fatal flaws, questions remain to be answered about its feasibility, cost, and consequences. For example:

- The alignment requires clearance improvements through Pennsylvania Station, which would require careful investigation. For instance, initial indications are that five bridges do not meet minimum requirements;
- Connections to CSXT and NS yards in Orangeville are necessary; and
- The track configuration from the Union Tunnels to Bay View was not evaluated within the scope of this study.

4. Summary and Evaluation of Near North Freight Alternatives

Two alternative Near North Sector alignments to enhance CSXT and NS freight operations into and through Baltimore were evaluated. After careful investigation of the engineering possibilities, the study team carried both the Belt Freight and Penn Freight alternatives through to initial cost projections. The Penn Freight Alternative—deemed preferable under the study's assumptions—would require the construction of a Great Circle Freight Tunnel between Gwynns Falls and Pennsylvania Station's approaches and the rebuilding of the Old Union Tunnel. The Penn Freight alignment would replace the existing CSXT route using the Howard Street Tunnel and the NS freight route via the Union and B&P Tunnels. (The built-in limitations of these existing routes were explored in Chapter Two.)

Table 8 - 1 provides a formal comparison of the two major alternatives according to the screening criteria of this study.

Table 8 - 1:
Application of Screening Criteria to Near North Freight Alternatives

Functional/Design Screening Criteria	Belt Freight Alternative	Penn Freight Alternative
Availability of Land	Likely	Likely
Less than One Percent Grade Freight; Two Percent Passenger	Likely	Likely
Beneath Harbor Highway Tunnel	No	No
Tunnel Length > 4 miles	Unlikely	Unlikely
Ease of Integration with Network	Good	Good
Ease of Integration with Yards	Good	Good
Pass/Fail	*Pass*	*Pass*
Adverse Environmental Impact	Potential for: Acquisitions, Displacements, Relocations	Potential for: Conflict with land use; Acquisitions, Displacements, Relocations; Parklands/4(f); Impact National Historic Place
Implementation Issues	Public controversy likely	Public controversy likely

External Impact Screening Criteria	Belt Freight Alternative	Penn Freight Alternative
Consistent with Existing Land Use	Likely	Low
Extent of Acquisitions, Displacements, and Relocations	High	High
Impact Listed or Eligible National or State Historic Place	No	Yes, Greenmount Cemetery
Impact Parklands, 4(f)/6(f) Resources	Yes, Parkland in Herbert Run	Yes, Greenmount Cemetery, Parkland in Herbert Run
Construction Impact Severity	High	High
Impact Ecosystems, water resources	*Low*	Low
Implementation Issues	Public controversy likely	Public controversy likely
Pass/Fail	**Pass; but inferior to Penn alternative under prevailing assumptions.**	**Pass with comment. Superior to Belt alternative under prevailing assumptions.**[10]
Comment	As configured, 1800' of local neighborhood removed.[10]	Impact of rehab of Old Union Tunnel

[10] In the event that additional analyses are deemed appropriate, it is recommended that a Belt Freight Alternative option be evaluated under the assumption that the Light Rail Line and shops are relocated. This reconfiguration could conceivably alter the comparison between the Belt and Penn freight alternatives, when all relevant benefits and costs are weighed.

B. Freight Alternatives—Harbor Sector

Baltimore Harbor, with its lengthy coastline, is complex and—at least in theory—affords a host of opportunities for underwater railway crossings. Progressively eliminating the impractical while focusing on the feasible concepts, the study team identified the most likely portals, their plausible approaches and connections on each side of the harbor, and the tunnel alignments that would logically connect each pair of portals. While resources did not allow for full-scale investigations of all the theoretical approach-portal-tunnel-portal-approach combinations, sufficient data emerged to provide useful indications regarding the practicability, desirability, and cost of a harbor-based freight solution to the Baltimore challenge.

1. Assumptions and concerns common to all alternatives

The following factors guided the conceptual design and winnowing process:

a. Design concept

Based on standard engineering practice for situations analogous to that of Baltimore Harbor, the analysis assumed that a double-tube Harbor Tunnel (with a total of two tracks) would be constructed employing the immersed-tube technique. The construction of the tunnel would require dredging and deep excavations in soils ranging from very soft organic, clays, and estuarine silts to stiff over-consolidated cretaceous clays of the Potomac Group.

b. Importance of connections

Because a Harbor Sector tunnel would be located well to the south and east of the present CSXT and NEC alignments through Baltimore, the analysis focused heavily on the means of connecting the CSXT and NEC/NS freight facilities south and west of the harbor with the respective infrastructures of the CSXT, NEC/NS, Canton, and Patapsco & Back Rivers railroads north and east of the harbor. With so many freight movements to be handled reliably in this major logistical hub, the efficacy of connections among the various roads' facilities could make or break any Baltimore rail restructuring project—just as much as such a project's impacts on through moves, clearances, and capacity.

c. Availability of land

The availability of land for the two Harbor Sector tunnel approaches influenced the selection of alternative approach alignments and of potential locations for the tunnel portals. This is so because the expansion of railroad capacity through the construction of additional main line tracks and yard leads would generally require the acquisition of adjoining industrial real estate. In limited instances—for example, near necessary rail-highway grade separations— the need may also arise to obtain residential real estate.

A review of prior reports and an inspection of land uses bordering the existing railroad rights-of-way indicated that the level of residential and industrial development in the sections of Baltimore City and County adjacent to the Patapsco River would, in effect, require the use of existing railroad main lines, branch lines, and industrial tracks to access the proposed tunnel portals.

2. Southwestern Approaches

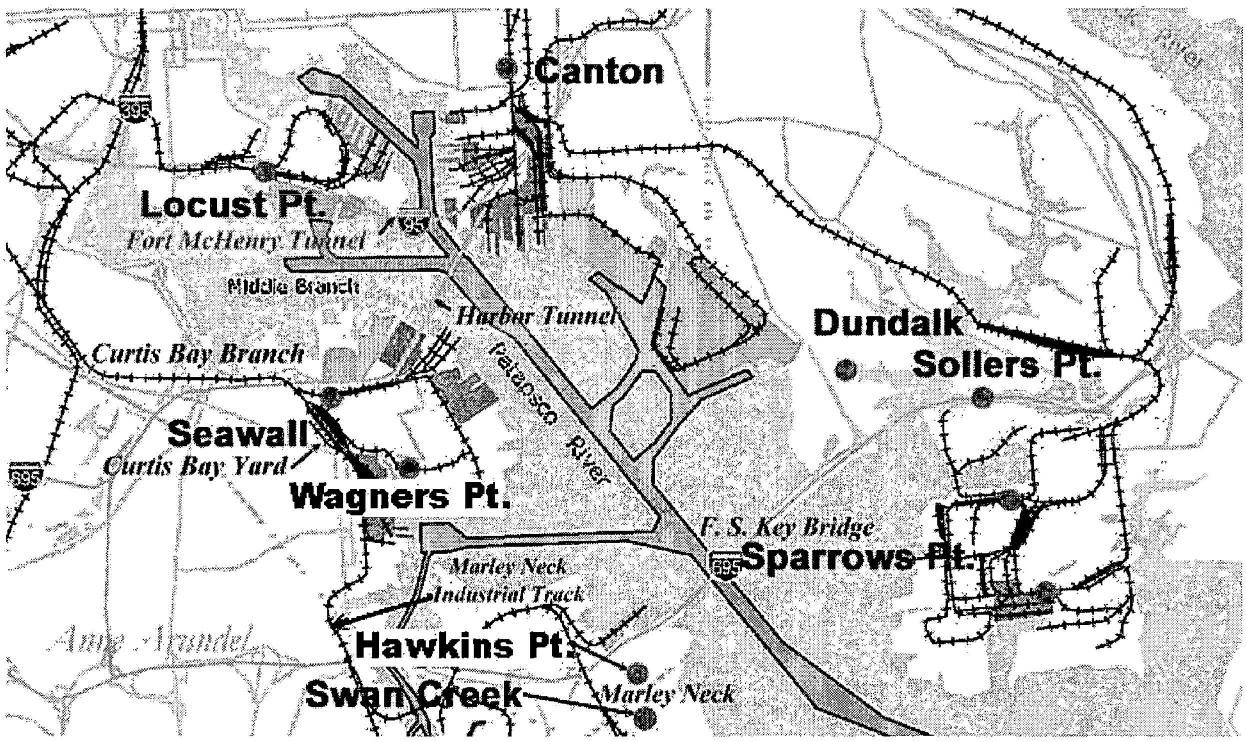
The harbor tunnel alternatives evaluated share a common southwestern approach between CSXT Halethorpe (BAA 5.8) and CSXT West Baltimore (BAA 3.2). Existing CSXT branch lines and secondary tracks were then used to access the southwestern tunnel portals. A brief overview of the approaches is provided below; a more detailed analysis appears in a subsequent section.

The secondary and branch lines used to access various possible southwestern tunnel portals were:

- The CSXT Locust Point Branch; and
- The CSXT Curtis Bay Branch in west Baltimore, including the Marley Neck Industrial Track that extends southeastward from Curtis Bay Yard. (See Figure 8 - 5.)

Figure 8 - 5: Potential Portals and Approaches—Harbor Sector Freight Tunnels

(Note: For design reasons, portal locations will sometimes differ from the locations of the features after which they are named.)



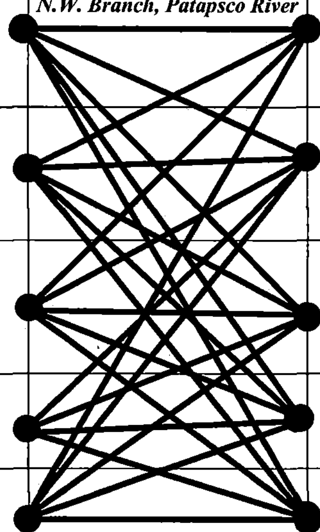
3. Portals—Summary Listing

As shown in Figure 8 - 5 and listed in Table 8 - 2, the portals were located either on or near an existing branch line and/or industrial track.

The analysis addressed, at least initially, potential tunnel alignments linking each of the southwestern with each of the northeastern portals shown in the table. As is evident from both Figure 8 - 5 and Table 8 - 2, linking portals closest with portals farthest from the Inner Harbor would require the longest tunnels. Also, as the portal locations become more and more distant from the Northwest Branch of the Patapsco River, both the length and circuity of the resultant through routes increase. The added length of the more distant[11] options, however, gives them more space to overcome—with a gradient under one percent—the significant differences in elevation between the low point in any tunnel (beneath the dredged Harbor channel) and the NEC and CSXT main lines to the southwest and northeast of the portals. On the other hand, the more distant Harbor crossings could add to the time and train-mileage required for through and local moves. For this reason, a painstaking examination of the operational and economic costs and benefits of the various alternatives would necessarily come at an early stage of any further work on rail restructuring in Baltimore.[12]

Table 8 - 2: Portal Options and Hypothetical Tunnel Connections

Portal Options— **Southwest Side of Baltimore Harbor**	**Tunnel Alignments Hypothetically Possible**	***Portal Options—*** **Northeast Side of Baltimore Harbor**
• East end of the <u>Locust Point</u> Branch	*N.W. Branch, Patapsco River*	• <u>Canton</u>, on the CSXT Sparrows Point Industrial Track, near MP 1
• East end of the <u>Seawall</u> Industrial Track, northeast of Curtis Bay Yard,		• <u>Dundalk</u>, on the PRR Bear Creek Track
• <u>Wagners Point</u>, southeast of Curtis Bay Yard		• <u>Sollers Point</u>, at the east end of I-695's Key Bridge over the harbor
• <u>Hawkins Point</u>, east of the Marley Neck Industrial Track		• <u>North Sparrows Point</u>, at the north end of the ISG steel plant
• <u>Swan Creek</u>, east of the Marley Neck Industrial Track	*Mouth of Patapsco River*	• <u>South Sparrows Point</u>, at the south end of the ISG steel plant



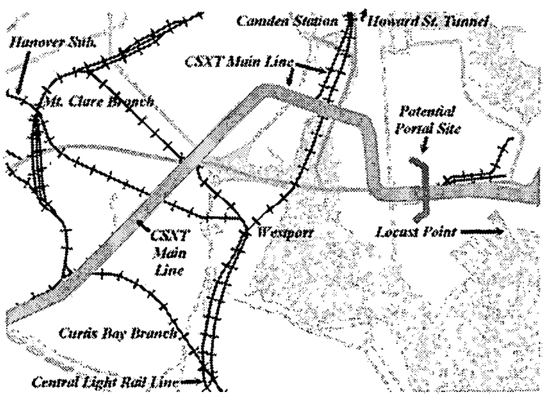
[11] I.e., more distant from downtown Baltimore, the Inner Harbor, the Northwest Branch, and Canton.
[12] See Chapter VII. In concept, such an examination would (a) identify and rank the most important local and through movements (e.g., CSXT moves from Curtis Bay to Bay View), (b) evaluate the operating, service quality, and cost effects on each movement of each tunnel alternative, and (c) develop a methodology for synthesizing the results into conclusions useful for planners and decision-makers.

4. Southwestern Portals and Associated Tunnel Connections

a. Locust Point – East End of CSXT Locust Point Branch

(1) The Portal

Figure 8 - 6: Possible Locust Point Portal Location



Note: See Figure 8 - 7 for possible tunnel alignments east of this potential portal site.

A potential Locust Point portal (Figure 8 - 6) would be located northwest of Fort McHenry and the Fort McHenry Tunnel, and would be west of Locust Point Yard. Motivating such a location would be the need to maintain a maximum one percent gradient on tunnel approaches and within the tunnels themselves. A maximum top-of-rail depth of minus 90 feet has been assumed for each alternative; this depth would provide clearance to a maintained depth of minus 50 feet in the harbor channel. Depending upon the location of the tunnel alternative alignment evaluated, the portal itself could shift a few hundred feet east or west of the location shown. The portal would be east of Bailey (BAA 0.7), and generally east of Russell Street and I-395, which pass over the Locust Point Branch. Each of the contemplated tunnels would pass beneath Locust Point Yard.

(2) Potential Tunnel Connections

Locust Point–Canton. Two alternative tunnel alignments between Locust Point and Canton were evaluated; they are shown in Figure 8 - 7. However, the northernmost alignment would lie almost directly beneath Tide Point, a $63 million conversion of the former Procter & Gamble soap factory into a 15-acre, 400,000 square foot corporate office complex. Since this premier waterfront property in Locust Point would sustain impacts from a northern tunnel and its approaches, the southernmost alignment was assumed to be more appropriate.

Conceptual engineering indicated that the gradient of the northeastern approach, on the right side of Figure 8 - 7, would have the most significant effects on the tunnel's vertical alignment. The connection between a Canton portal and the freight railroads on the northeastern side of the Harbor is discussed under "Northeastern Portals and Associated Approaches," on Page 8-21.

Locust Point to other eastern portal locations. Any freight tunnel to Dundalk, Sollers Point, or Sparrows Point from Locust Point would pass beneath the two existing highway tunnels shown in Figure 8 - 7. The proximity of the Fort McHenry Tunnel alignment to the west portal location in Locust Point would cause railway tunnel vertical alignments to exceed the specified limit of one percent. Moreover, due to concerns about the integrity of the existing structures and the consequent risk to the constant flow of vehicular traffic within them, State and Federal agencies most likely would not permit the construction of *any* new harbor tunnel beneath the

Fort McHenry and Baltimore Harbor Tunnels.[13] All options requiring construction of railway tunnels beneath highway tunnels were therefore dropped from further consideration. Thus, all hypothetical tunnel alternatives linking Canton with points south of Locust Point were also excluded.

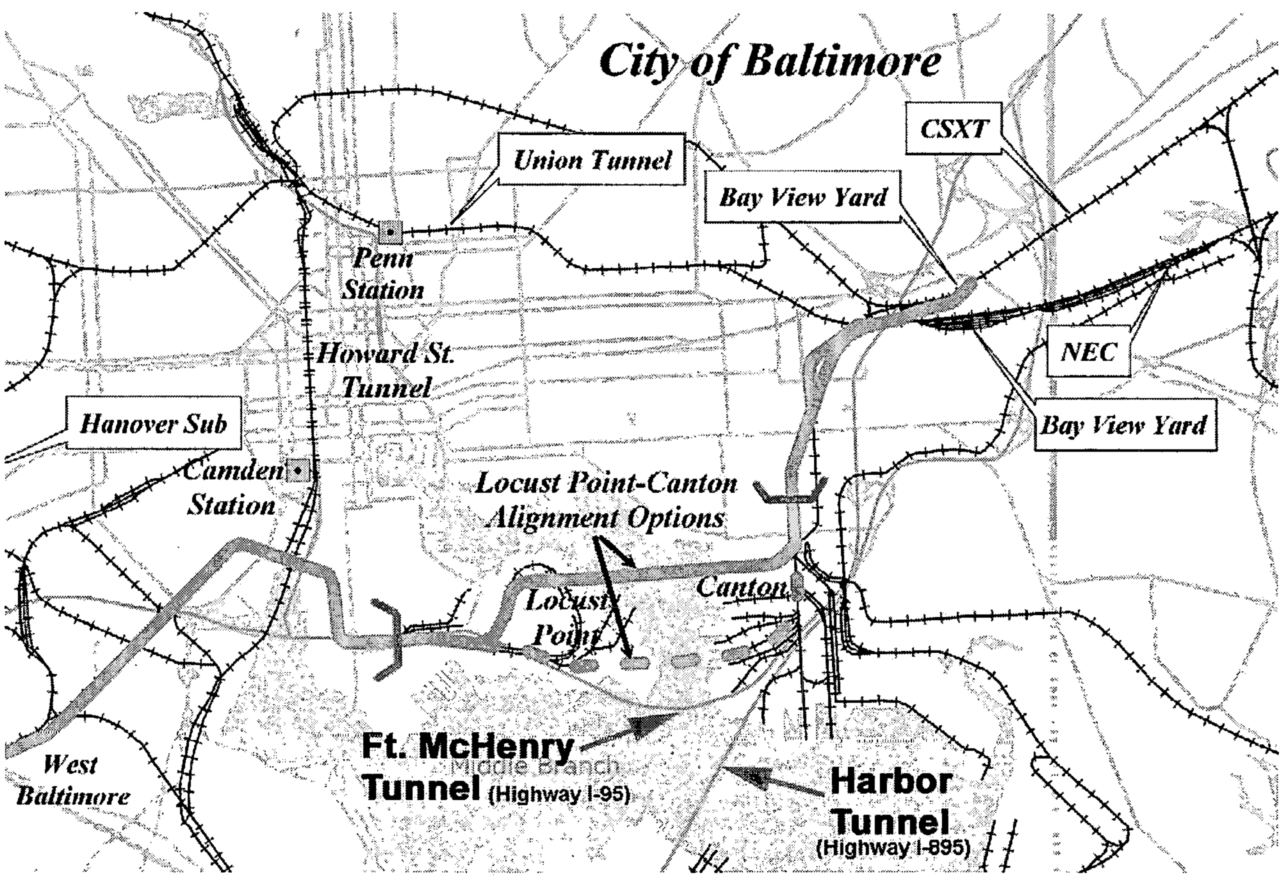
Even if crossing under the highways were feasible, any tunnel from Locust Point to Sollers or Sparrows Point would necessarily exceed five miles in length, much of which would underlie the dredged harbor channel. This length would make for a costly tunnel indeed, in comparison with shorter, more direct options. As a result of all these factors, the team did not develop alignments for tunnels from Locust Point to Dundalk, Sollers Point, and Sparrows Point.

b. The Seawall Portal – 7,000 Feet East of Curtis Bay Yard

(1) The Portal

The Seawall Portal would lie southeast of the Baltimore Harbor Tunnel (I-895). The

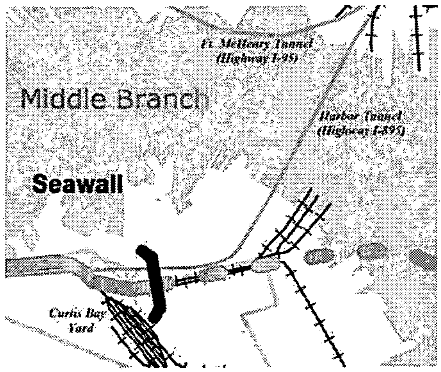
Figure 8 - 7: Locust Point–Canton Tunnel Options



[13] It is assumed that lengthy stoppages of cross-harbor vehicular traffic on account of railroad construction would not be permitted by State authorities.

location illustrated in Figure 8 - 8 is east of Curtis Bay Yard; any actual portal site, however, would vary with the location of the low-point of its associated tunnel concept.

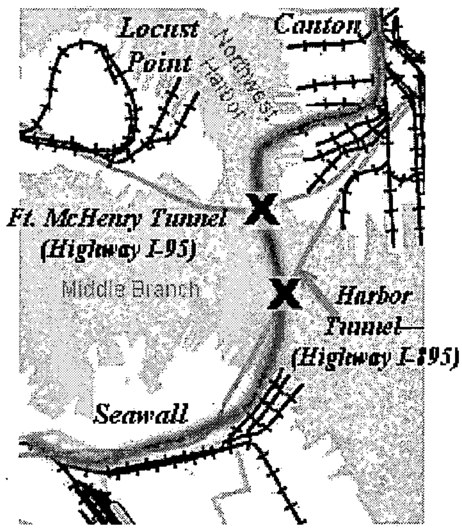
Figure 8 - 8: Seawall Portal
(showing potential tunnel alignment toward Dundalk)



(2) Potential Tunnel Connections

Seawall–Canton. Since a tunnel from a Seawall Portal to Canton would pass beneath the existing highway tunnels (see points marked "X" in Figure 8 - 9), it would not be allowable under the premises of this study.

Figure 8 - 9: Seawall–Canton: Excluded



Seawall–Dundalk. If feasible, a Seawall-Dundalk alignment concept would look something like that drawn in Figure 8 - 10. As the Seawall Branch is a primary, highly congested access route to numerous port facilities, however, providing capacity for through freight trains while facilitating local freight service would be impractical. The study team, in fact, was unable to develop a satisfactory southwestern approach to a Seawall portal. Since an acceptable northeastern approach to a Dundalk portal was not found either (see "Dundalk" under "Northeastern Portals and Associated Approaches" at Page 8-22), the Seawall–Dundalk alternative was dropped from further consideration.

Seawall to Sollers Point and North Sparrows Point. The same issues of tunnel length and pathway through the dredged harbor channel that would affect the alignments from Locust Point to Sollers Point or Sparrows Point also ruled out those starting at Seawall. Even though the latter options would be nearly 8,000 feet shorter than the former, the Seawall–Sollers or –Sparrows Point options would still rank among the longer, more expensive harbor tunnel possibilities.

As a result of the numerous, obvious difficulties attached to all the options using Seawall as the southwestern portal, the study team did not further refine these alignments.

c. The Wagners Point Portal

(1) The Portal

The Wagners Point portal would be located at the point indicated at the center of Figure 8 - 11), approximately 8,000 feet east of the east end of Curtis Bay Yard.[14]

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[14] As indicated in the discussion of other portals, more definitive locations would depend on specific tunnel designs—in particular, the low point.

Figure 8 - 10: Schematic of Seawall–Dundalk Concept (Excluded)

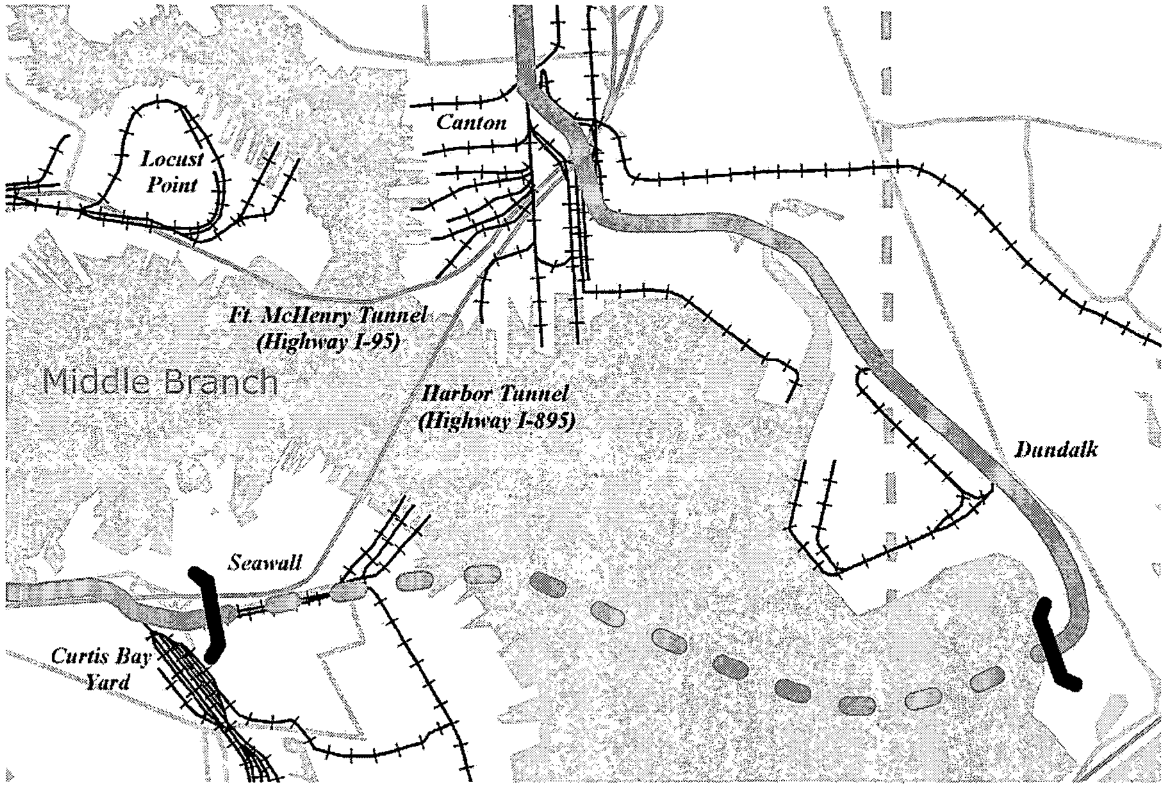
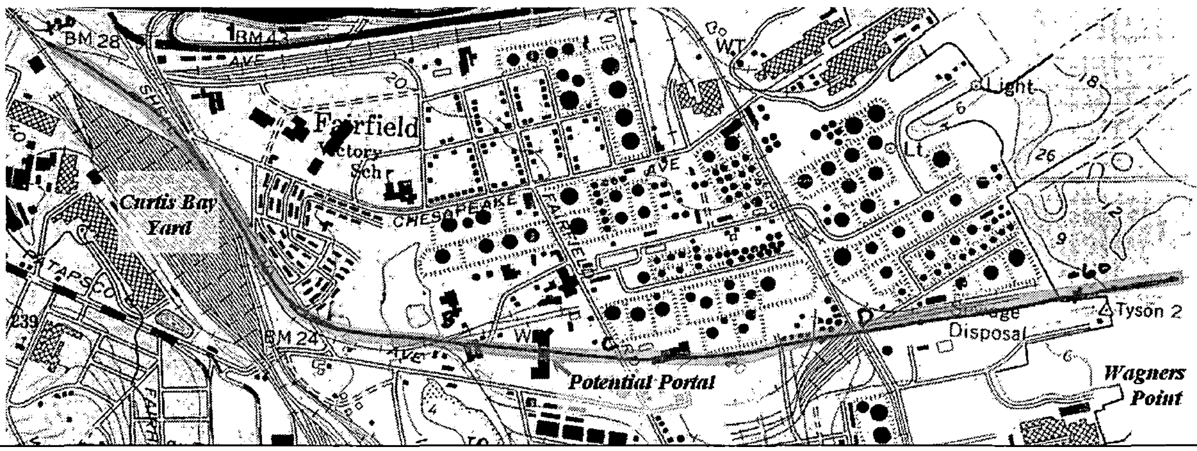


Figure 8 - 11: Wagners Point Portal and Approaches



The study team regards this portal site as less than optimal because of the potential for conflict with Curtis Bay Yard operations.

(2) Potential Tunnel Connections

A northeastern portal in Canton is ruled out because of the intervening highway tunnels; Dundalk fails the gradient test. Thus, a Wagners Point portal might be suitably paired only with

Soller's Point (which suffers from inherent disadvantages discussed below at Page 8-23) or the two Sparrows Point alternatives. While these last portal options appear to allow for proper approaches, they are much more distant from Wagners Point than from the Marley Neck portals described in the next section. For these reasons, there was no reason to pursue the Wagners Point options any further.

d. The Marley Neck Portals

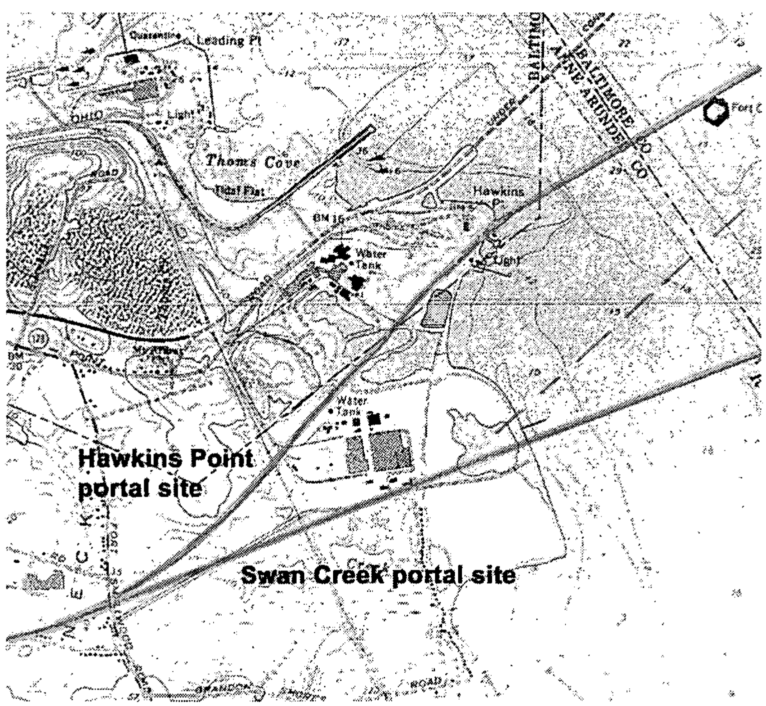
(1) The Portals

The study team evaluated two portal sites to which the CSXT Marley Neck Industrial Track would provide access:

- Hawkins Point, shown in the center of Figure 8 - 12; and
- Swan Creek, shown toward the bottom of Figure 8 - 12.

As is the case elsewhere in this report, the precise site of these portals within the indicated locales would depend on more detailed design.

Figure 8 - 12: Marley Neck Portal Options

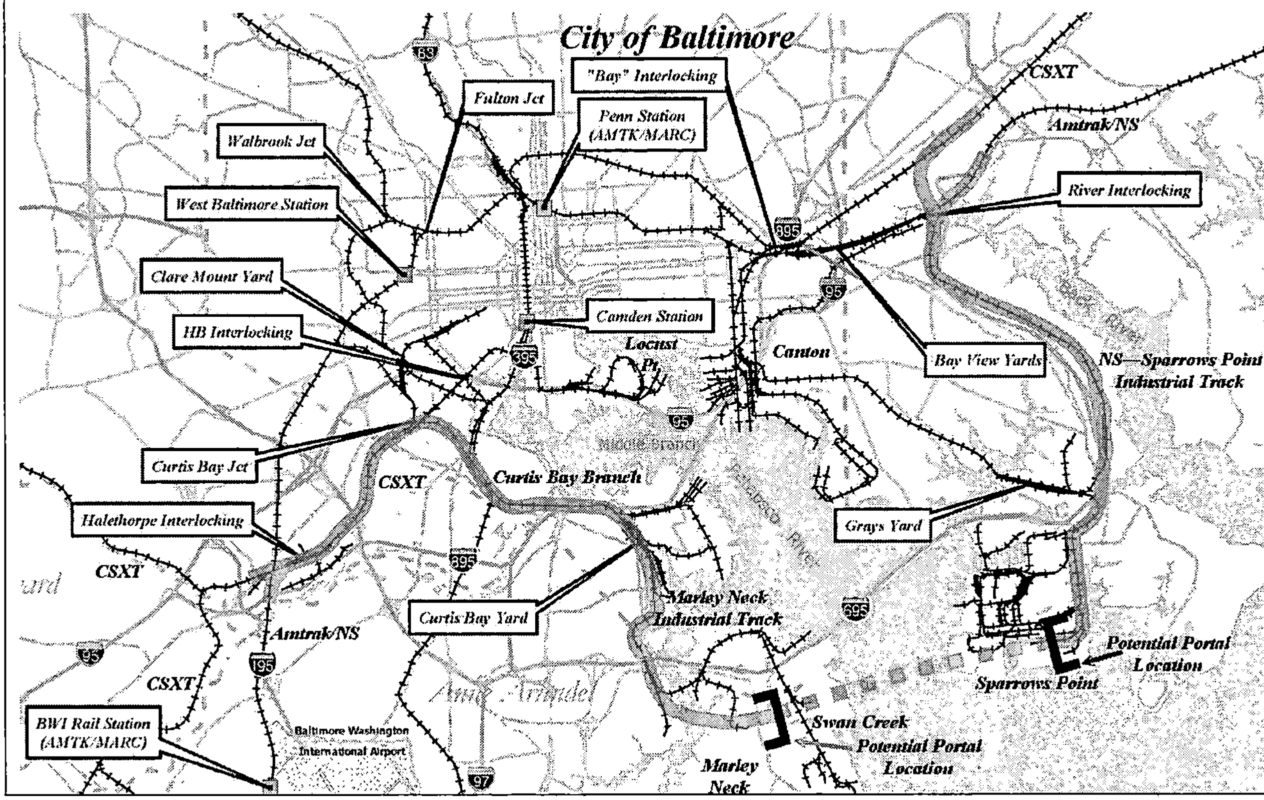


(2) Tunnel Connections

Since the northeastern portals at Canton, Dundalk, and Sollers Point are eliminated from consideration (as described below under "Northeastern Portals and Associated Approaches"), any Marley Neck tunnel alignments would cross the harbor south of the Francis Scott Key Bridge (I-695) to a northeastern portal in the vicinity of Sparrows Point (see Figure 8 - 17 on page 8-24). Several options exist for designing such a crossing; for purposes of this report, these options are designated collectively as the Marley Neck–Sparrows Point alternative.

Three options for crossing under the harbor and connecting into the Sparrows Point complex were evaluated: Hawkins Point to North Sparrows Point, Swan Creek to North Sparrows Point, and Swan Creek to Sparrows Point. The northerly route between Hawkins Point and North Sparrows Point would be the shortest route between Curtis Creek and the NS Sparrows Point Industrial Track; however, the southerly route, between Swan Creek and Sparrows Point, would have the shortest tunnel. (The Patapsco River is about 880 feet across between the point marked -60 in Figure 8 - 12 and the point marked -70[15] in Figure 8 - 17.) Employing the Swan Creek–Sparrows Point as an illustrative option, Figure 8 - 13 places the Marley Neck–Sparrows Point concept in context.

Figure 8 - 13: Marley Neck–Sparrows Point Tunnel: Initial Concept in its Regional Context
(Swan Creek–Sparrows Point Option for Example)



As further described in the next section, the eastern portals in Sparrows Point and North Sparrows Point would be located within the steel mill facility, about 3,000 feet inland from the northeastern shoreline.

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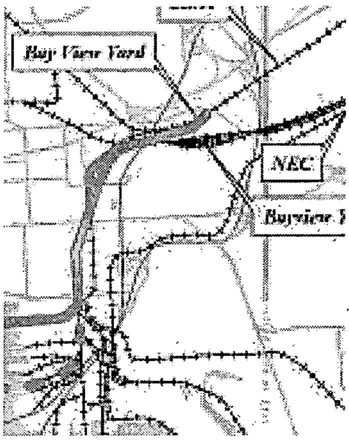
[15] As conceptually designed, the top of rail elevation rose to elevation -60.

Figure 8 - 14: Northeastern Approach, Canton—Bay View



5. Northeastern Portals and Associated Approaches

Treating the potential railway tunnel portals on the northeastern side of Baltimore Harbor, the following sections describe the connections and difficulties attendant on each.

a. Canton

Because of the assumption excluding a rail crossing beneath existing highway tunnels, the Canton portal would be available only to a tunnel extending from Locust Point (as described on Page 8- 15).

In theory, a Locust Point–Canton rail freight tunnel would present obvious advantages. It would be the least circuitous Harbor Sector option, and would preserve direct access to and through the Bay View freight yards from the southwest.

Thus, as shown in Figure 8 - 14, the study team evaluated an alignment that would access the respective Bay View Yards of CSXT and NS, as well as the CSXT and NEC main lines to the northeast, from a tunnel portal in Canton. To restrain costs and to maintain the existing NEC geometry, so vital to passenger service, this alternative assumed no major changes in the railway infrastructure in the Bay View area. For instance, the freight connector from Canton to Bay View would bridge the NEC at Bay (MP 91.9), as the CSXT Sparrows Point Industrial Track presently does.

Under this assumption, gradients would be a prohibitive problem for a Canton–Locust Point alignment. Indeed, the initial analysis concluded that after climbing upgrade from the tunnel mouth, the alignment would require an unacceptable gradient of 1.5 percent or greater. The reasons for this adverse geometry are as follows:

- The top of rail in a tunnel connecting Locust Point and Canton, at its maximum depth beneath the channel, would be approximately (-) 85 feet;
- The top of rail of the existing CSXT bridge over the NEC is +85 feet; and
- The distance between the two locations is approximately 13,000 feet.[16]

This geometry would result in an uncompensated grade[17] of 1.59 percent—worse than those in the Howard Street and B&P Tunnels, and far greater than the project's limit of one percent for freight grades. Even the connection between the critical low point in the rail tunnel,

[16] The distance between these same two points on the hypothetical alignment (the CSXT over the NEC and the critical low point under the dredged channel) would need to be an unattainable 17,000 feet or more to satisfy the project's one percent freight gradient standard.

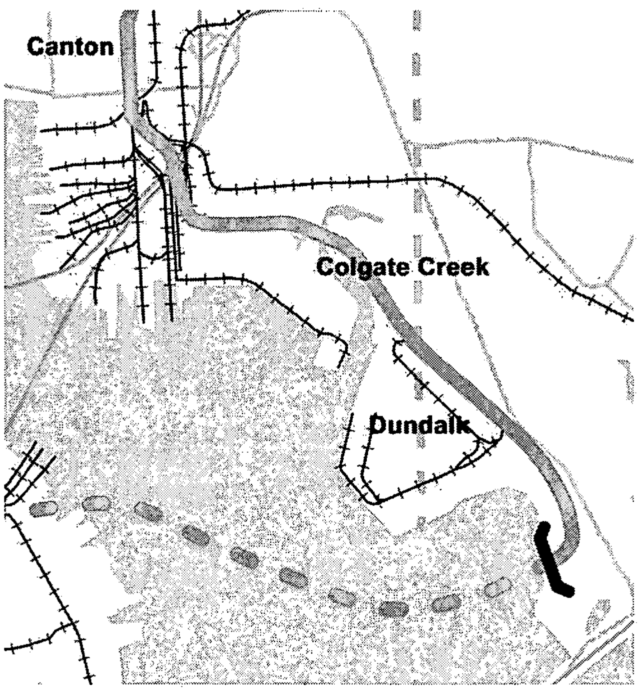
[17] For a discussion of the relationship of grades to curvature, see the extensive discussion of grades and curves in Chapter 2.

beneath the dredged channel, and the top of rail of the NEC *beneath* the CSXT bridge would not meet the one percent standard.[18]

As the unacceptable gradient northeastward to Bay View from Canton would be a fatal flaw, the Locust Point–Canton tunnel alignment was therefore dropped from further consideration in the present study.

It is worthy of emphasis that the decision to eliminate a Locust Point–Canton alignment rests on the assumption of no major redesign of the CSXT or NEC/NS facilities at Bay View. If a cost-effective, environmentally and operationally advantageous solution at Bay View can be devised that lowers the total cost of a Harbor Sector freight tunnel while fully meeting the standards for freight restructuring in Baltimore and having no adverse impact on passenger service quality, reliability, and capacity, then the viability of a Locust Point–Canton rail tunnel might eventually merit further scrutiny.

Figure 8 - 15: Northeastern Approach, Dundalk to Canton



Note: The highway tunnels, their approaches, and other highways are shown above in light gray.

b. Dundalk

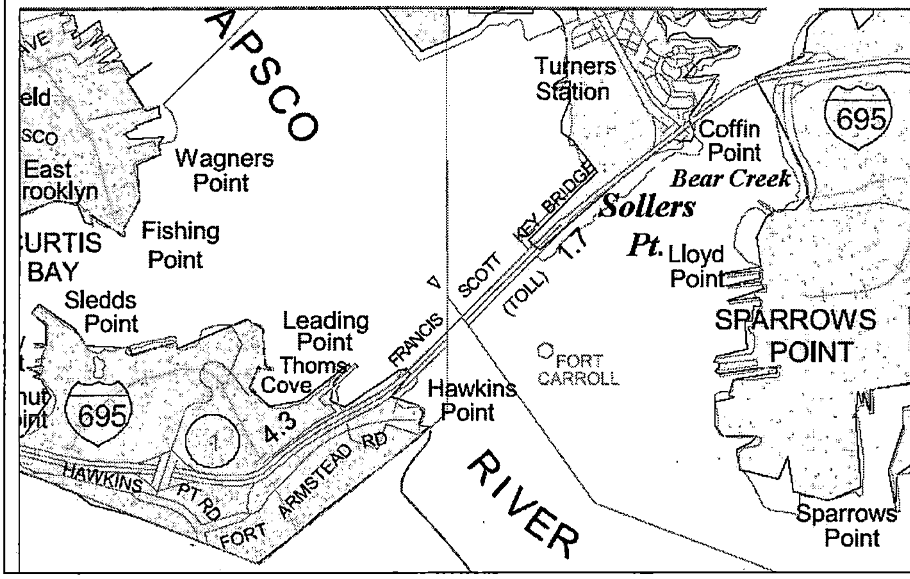
For many of the same reasons applicable to the Canton portal, a Dundalk portal would not satisfy the vertical gradient standards of this study. The rail alignment would have to pass beneath the complex skein of interstate and local highways (Figure 8 - 15) between Canton and Dundalk before beginning to ascend either to the +60 elevation of the NEC or to the +85 elevation of the CSXT bridge over the NEC. This cannot be done within the one percent freight gradient limit of this study.

Furthermore, an alignment northward from a portal in Dundalk would not only pass through the complex network of general cargo facilities of the 570-acre Dundalk Marine Terminal but also conflict with the NS rail network, also utilized by CSXT, that accesses the marine terminal and general cargo facilities.

[18] The top of rail of the NEC beneath the CSXT bridge is about (+) 60 feet; the distance between the NEC under the CSXT would need to be no less than 14,500 feet to provide an effective grade of one percent or less. This distance would be greater depending upon the degree of curvature that would be required to connect the alignment under the channel with the alignment between Canton and the NEC at Bay.

For all these reasons, a Dundalk portal, with its critical connection to the Bay View area, would be fatally flawed. The Dundalk alternatives were therefore dropped from further consideration.

Figure 8 - 16: Location of Sollers Point



c. Soller's Point

Located at the eastern end of the Francis Scott Key Bridge, where Bear Creek joins the Patapsco River, Sollers Point would not serve as an adequate tunnel portal site.

In view of the difficulties already noted in Dundalk and Canton, the most efficient, low-grade access from a Sollers Point portal to the NEC and CSXT main lines would be via Sparrows Point. In any tunnel leading to Sollers Point, a one percent grade from the critical low point beneath the dredged channel of the Patapsco River would not allow the alignment to rise enough in the available distance to enable the railroad to cross Bear Creek (a navigable waterway) on a fixed-span bridge.[19] Thus, any Harbor Sector crossing via Sollers Point would need to be extended in a continuous tunnel beneath an I-695 interchange as well as the Bear Creek channel. This necessity would lengthen a Sollers Point tunnel by minimum of 2,000 feet.

Accordingly, the study team dropped all Sollers Point options from further consideration.

d. Sparrows Point.

The study team investigated the concept of linking portals in the Sparrows Point area with the NEC and the CSXT Main Line east of their respective Bay View Yards. Such a concept would rely on the NS Sparrows Point Industrial Track, a 5.6-mile line that which presently links the northeast end of the NS Bay View Yard with the P&BR's Grays Yard serving the former Bethlehem Steel—now International Steel Group, Inc. (ISG)—mill at Sparrows Point. (See Figure 8 - 17 and Figure 8 - 18.) The NS Sparrows Point Industrial Track is advantageous in that its right-of-way permits expansion and it has a favorable geometry, with the exception of a five-degree curve at Eastern Avenue and a three-degree curve north of North Point Boulevard.

[19] A new drawbridge—representing a step backward and a permanent impediment to commerce—would be impermissible under the standards of the study. See Chapter 5.

Figure 8 - 17: Concepts for East Side of Marley Neck—Sparrows Point Tunnel

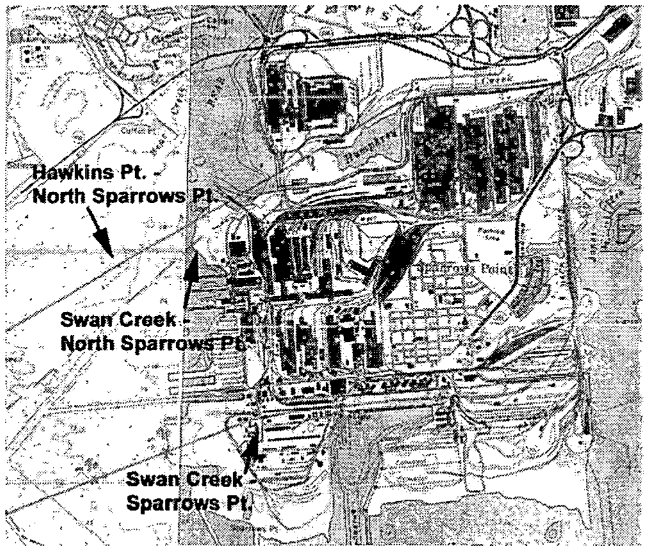
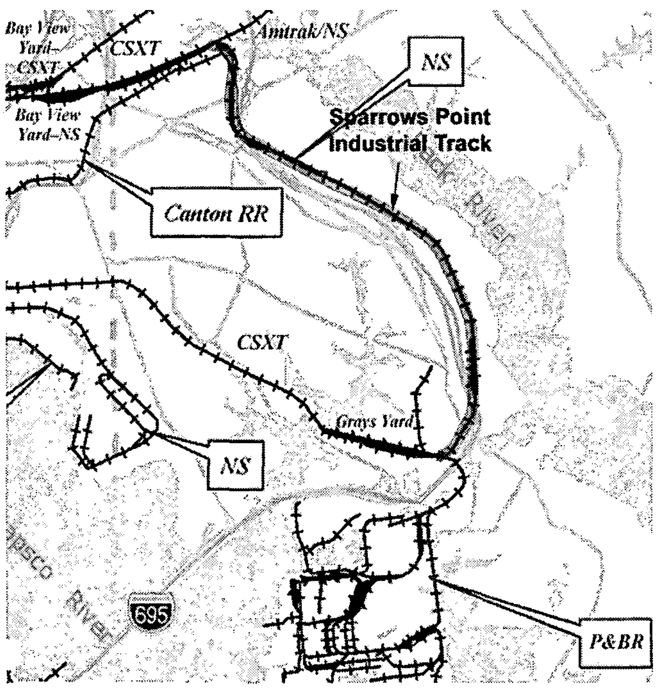


Figure 8 - 18: NS Sparrows Point Industrial Track



The resources available to this study permitted only a conceptual overview and initial exploration of these highly complex Sparrows Point alternatives, with respect to which selected issues are broached in this section.

(1) The Portals

As suggested in the concepts shown in Figure 8 - 17, both the North Sparrows Point and Sparrows Point portal sites would make use of property pertaining to ISG. According to ISG's corporate website: "...about 4,000 people produce four million tons of cast steel slabs for hot-rolled and cold-rolled sheets, tin mill products, galvanized products, galvanized sheet and Galvalume sheet" at the company's facility at Sparrows Point. Employment at the facility has decreased in recent years and the output of the facility has been reduced.

Potential tunnel alignments have not been discussed with ISG. Such discussions would be premature in view of the early stage of planning, the availability in the Near North Sector of a land-based—and perhaps preferable—alternative, and the uncertainties affecting the future of rail restructuring in the Baltimore region. However, for the sake of the region's economy, it will be important in any future planning effort to do nothing which might adversely affect the future of the plant, its owners, and its employees. Should a Sparrows Point alternative be selected at the end of a multi-year planning and environmental process, the closest public/private cooperation would be necessary, both before and after the selection is made, to assure that no economic harm is done.

(2) Connection to Railroad Main Lines

From a North Sparrows Point Portal. Initial perceptions by the study team suggested that a connector linking a North Sparrows Point portal with freight railroad main lines to the northeast might be somewhat shorter than the alignment from Sparrows Point described below. The need to set study priorities, however, precluded development of a conceptual alignment passing to the north of the steel plant but still located on ISG property. The determination that a Harbor tunnel between Marley Neck/Swan Creek and North Sparrows Point would be longer than a tunnel between Marley Neck/Swan Creek and Sparrows Point would offset the reduction in approach length imputed to a North Sparrows Point portal.

The concern that the eastern portion of the approach alignment would require a speed-restricted curve to connect to North Point Boulevard would need attention in any follow-on evaluations of a North Sparrows Point portal concept.

From a Sparrows Point portal. The study team developed a concept for a connection between a Sparrows Point portal and the NS Sparrows Point Industrial Track. Inevitably, such a connection would make use of the ISG property and would need to thread its way through many existing highway and other facilities.

At Sparrows Point, a theoretical alignment was found that would neither interfere unduly with existing traffic, nor violate the one percent gradient limit for freight, nor prevent trains from maintaining their intended speed maxima. Of all the Harbor Sector tunnel concepts described in this report, the Marley Neck–Sparrows Point alignment is the only one to survive, thus far, the many tests described in earlier chapters.

While hopeful, this finding must be regarded as extremely tentative, for the following reasons:

- It has not yet been proven that the freight route concept can be built through Sparrows Point without adversely affecting the operations and viability of the ISG steel mill, which is so vital to the economy of the Baltimore region.
- It would be very difficult, if not impossible, to adjust this concept to allow through trains to stop at Bay View to drop off or pick up cars as a through, single-direction move. Instead, through trains from the southwest would proceed directly through the tunnel, circle back toward Bay View, accomplish their business, and then reverse direction to head northeast from Bay View. This facet is not an improvement over the present operation, with all its many disadvantages.
- A Marley Neck–Sparrows Point route would be relatively distant from the central parts of the region. Detailed operational analysis would be necessary to assure that the added circuity implied by this distant location would be recompensed by higher overall speeds and the advantages of a virtually unrestricted-clearance route. In such analyses, the characteristics and requirements of both through and local movements, of both Class I and smaller railroads, and of both shippers and carriers would require careful and evenhanded attention.

- The specifics of the connections and approaches at both the northeastern and southwestern ends of this route would require significant development to confirm that a Marley Neck–Sparrows Point alignment would fulfill the promise of its concept in an environmentally, economically, and operationally advantageous way.
- Finally, the cost of this Harbor Sector tunnel concept (see Chapter 9) would require careful comparison with the benefits to be obtained to the carriers, to the Baltimore port and economy, to shippers, and—especially if public financing is involved—to the general public.

Chapter Nine
CONCLUSIONS AND PATHS FOR ANALYSIS

This study of the railway network in the Baltimore region has—

- Developed a conceptual framework and methodology for analyzing the complex and longstanding challenges presented by the subject matter;
- Winnowed through the available sectors through which practicable solutions might be designed;
- Screened and further eliminated a large number of alternatives;
- Performed initial conceptual design for a few illustrative alternatives; and
- For those alternatives, prepared preliminary estimates of investment costs.

This Chapter presents preliminary costs for the few alternatives that survived the triage process so well as to merit focused attention. It then goes on to recapitulate the study's analytical conclusions. Recognizing that this report could represent but the beginning of a planning process that—even if recommenced immediately on a priority basis—would require many years to yield tangible results, the study team concludes the report with a number of technical avenues that would inevitably need attention, whether next year or 100 years from now.

A. Illustrative alternatives

The following alternatives survived the screening described in the preceding chapters:

- **Passenger—Near North Sector: Great Circle Passenger Tunnel**
- **Freight:**
  - — **Near North Sector: Great Circle Freight Tunnel (Penn Freight alternative)**
  - — **Near North Sector: Great Circle Freight Tunnel (Belt Freight alternative)**
  - — **Harbor Sector: Marley Neck–Sparrows Point alternative**

B. Preliminary cost measures

Figure 9 - 1 summarizes the preliminary cost estimates for the illustrative alternatives. The underlying numbers appear in Table 9 - 1.

Figure 9 - 1: Preliminary Costs for Illustrative Alternatives
(Billions of 2003 Dollars)

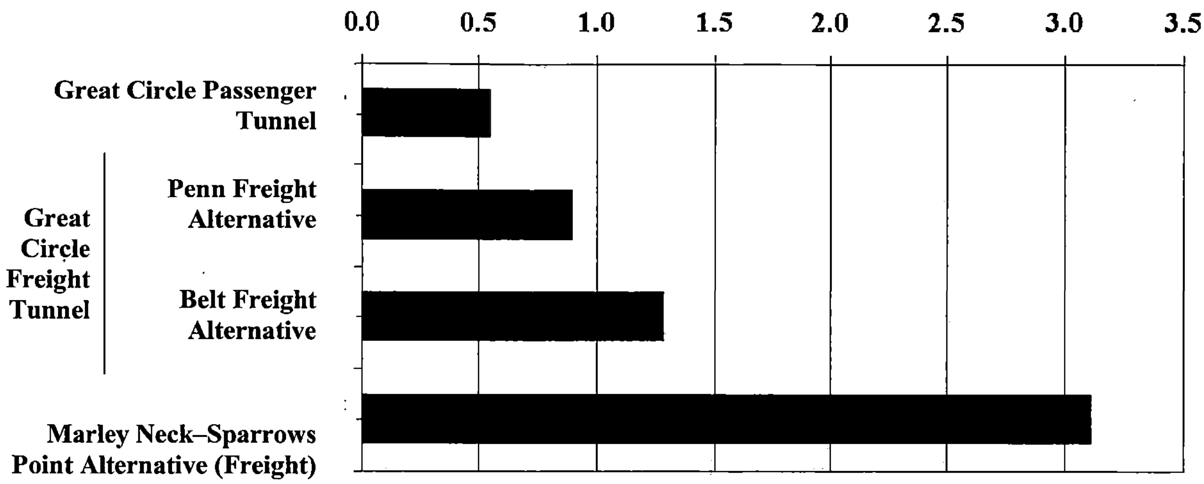


Table 9 - 1: Major Components of Preliminary Cost Estimates

Alternative		Western Approach	Tunnel	Eastern Approach	Total Estimated Cost
Great Circle Passenger Tunnel		$11,100,000	$529,200,000	$6,000,000	$546,300,000
Great Circle Freight Tunnel	Penn Freight Alternative	$103,400,000	$472,200,000	$289,400,000	$865,000,000
	Belt Freight Alternative	$103,400,000	$850,800,000	$304,900,000	$1,259,100,000
Marley Neck–Sparrows Point Alternative (Freight)		$300,200,000	$2,536,200,000	$271,200,000	$3,107,600,000

These preliminary estimates include contingencies of between 30 and 40 percent (with the higher figure applied to tunneling costs), and add-on fees of 18 percent to cover design, construction management, and project management.

The significant difference in cost between the land- and water-based tunnels largely reflects, first, recent advances in the cost-effectiveness of deep boring techniques to which the geology of the Great Circle alternatives is projected to be conducive and, second, the need for elaborate new approaches to the Harbor Sector tunnel alternatives.

C. Conclusions

The study team arrived at the following principal conclusions as a result of its investigations:

1. Baltimore's railway network is so antiquated and underdeveloped, and so important to the Nation's transportation system, as to fully justify the Congressional request for this analysis. For example, the B&P Tunnel was completed eight years after the Civil War ended.
2. In the environment of Baltimore's topography and development patterns, the needs of freight and passenger service differ so greatly as to mandate separate freight and passenger facilities.[1] To attempt to meet the challenge with a single facility would likely result in compromises that would undermine the justification for any restructuring plan so designed. Indeed, analogous compromises made in the nineteenth century by two separate railroads, each developing a multipurpose facility on limited funds, produced the two inadequate facilities inherited by the railways of today.
3. Further incremental repairs to existing facilities, other than for purposes of safety and operational continuity, will not address any of the inherent geometric problems that plague the transit of Baltimore by rail.
4. Baltimore City, with its heavy existing development, pre-existing facilities, and difficult topography, presents severe engineering challenges to the design of new tunnel crossings, whether for freight or passenger service.
5. Dividing the region into four sectors—Far North, Near North, Central, and Harbor—provides a useful conceptual framework for the derivation of passenger and freight alternatives, respectively.
6. With respect to passenger alternatives:
    a. The Far North Sector does not allow for a central station, and no reasonably close-in, accessible station site for a Harbor Sector tunnel was found.
    b. The Central Sector offers the prospect of a station in or near the heart of the CBD, but at such prohibitive cost in excavation and disruption to the downtown area as to raise questions about the practicability of this class of alternatives.
    c. By a process of elimination, only a Near North alternative utilizing the existing Pennsylvania Station appears to provide a cost-effective long-term solution to the challenges posed by the existing B&P Tunnel.[2]
7. With respect to freight alternatives:
    a. Neither the Far North Sector nor the Central Sector merits further study—the former because of its circuity, cost, and distance from freight facilities and shippers, and the latter because there is no purpose to be served in bringing freight, at enormous expense, closer to the downtown district.

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[1] While separate, such facilities would require a high level of coordination to avoid inefficiencies in design and construction.

[2] Regarding cost effectiveness: analyses by others imply that the cost of a Great Circle Passenger Tunnel could conceivably be less than that of rebuilding of the existing B&P Tunnel. See Chapter Seven, section entitled "Upgrade the B&P Tunnel." Any such inference would, of course, require detailed substantiation in the course of additional investigations.

b. Both the Near North Sector and Harbor Sector appear, on the basis of this study's analyses, to provide alternative freight routes. Confirmation of the utility and efficacy of these alternatives—particularly in view of the many complex and vital freight movements that must be handled—would be needed as part of any further development.

c. Of the Harbor Sector freight alternatives, it appears that those farthest from the Inner Harbor have the best chance of meeting the objectives of this study.

d. The cost of a land-based Great Circle Freight Tunnel appears to be one-third that of a Harbor Tunnel. However, the full range of life-cycle benefits and costs—especially, the place of both possible tunnels in the goods movement within, through, to, and from the Baltimore region—would need to be considered in any such choice.

8. If and when the concerned parties wish to progress a restructuring of the railway network in the Baltimore region, significant further analytical work will be unavoidable—and essential to assure that any possible future investment is wisely and optimally spent.

The following section outlines the areas of analysis that the study team deems important to test, confirm, and deepen the results of this study, should the interested polities and companies ever wish to do so.

D. Analytical paths

Topics worthy of further attention would include, but would not be limited to, the following:

1. Further refinement of alternatives

The present study does not claim to be the final word on the desirability of the alternatives it considered, or on the feasibility of other possible approaches. Additional conceptual design work might therefore be devoted to such options as the following:

- **Refinement of existing illustrative alternatives**, already discussed at length in this report. For example, the relative advantages and disadvantages of the Penn Freight and Belt Freight alternatives merit further analysis based on changes in such assumptions as the immovability of the Central Light Rail Line and its support facilities.

- **Other passenger alternatives:**

  — Additional investigation of Central Sector alternative with various station sites, including a station in the Jones Falls Valley, which might avoid the huge cost of a subterranean station under the heart of downtown, but which would not avoid the cost of a tunneled right-of-way in that area.

  — Additional investigation of a Harbor Sector alternative, particularly with respect to finding any suitable station site that is as close and as accessible to Charles Center as the present Pennsylvania Station.

- **Other freight alternatives:**
  - — Additional investigation of the Harbor Sector Locust Point–Canton alternative, particularly regarding alleviation of the grade differential between the low point in the tunnel and the junctions with the freight railroads near Bay View. The effects on passenger infrastructure and operations (and the attendant costs) would figure heavily in any such analysis.
- **Coordination of passenger and freight alternatives:** While the needs of passenger and freight fundamentally differ, it would be prudent to consider two areas of possible coordination:
  - — Optimization of the design of parallel alternatives, to reduce points of conflict and lower the total cost of the two projects where possible. This concept has already been applied in the case of the Great Circle tunnels (see Chapters Seven and Eight).
  - — Exploration of the requirements, costs, and benefits of cross-operability, wherein the passenger route could serve as a bypass route for freight, and/or vice versa, in the event of an emergency or some extended maintenance operation in or near one or other of the facilities. Such cross-operability would need to overcome the inherent differences in design standards and in motive power, and might entail changes in the track layout at critical junctions. It may well be found that the expected benefits of designing for cross-operability of some kind would be outweighed by the costs.

2. Analysis of Washington alternatives

The full benefits of a Baltimore restructuring, at least for freight traffic up down the East Coast, can only materialize if the clearances in Washington's Virginia Avenue Tunnel are relieved simultaneously with those in Baltimore. Accordingly, an analysis of the Virginia Avenue Tunnel—and of any other clearance constraints in the affected traffic lanes—would appropriately take place concurrently with further examinations of the challenges in Baltimore.

3. Operations analysis

For each alternative under consideration, operational studies would be necessary to verify the degree of improvement they promise, with respect to both the present situation and each other. The techniques employed would be as follows:

a. Train Performance Calculator runs

Train performance calculators (TPCs) model the acceleration, speed, running time, and fuel consumption of an individual train over a predefined segment of railroad. For each alternative, detailed TPC runs would need to be performed—not just for main line traffic over the contemplated alignment, but also for the important and typical local movements within the Baltimore region. An alternative that expedites through service but harms the quality of most local operations is not likely to meet the objectives for a Baltimore restructuring. This is particularly true of freight traffic, with its complex set of origins and destinations in the region.

b. Modeling of train movements for capacity review

In a complex situation like that of Baltimore, a TPC run—modeling a single train—serves only as a preliminary screening device. To verify the practicality of a particular alternative requires a simulation of *all* train movements and interactions within a given operating region over an extended period of time—for example, a week. Such a simulation, dealing with both scheduled and unscheduled trains, would offer the best available analytical proof of an alternative's capacity and its built-in bottlenecks. Knowledge of the latter can be fed back into the design process in an iterative manner.

The simulations, whether for passenger or freight alternatives, would have to cover not just the tunnels and approaches, but also the junctions between freight and passenger routes, and any other links and nodes of the network where capacity is at issue. To do less would be to ignore potentially serious operating conflicts, which must be avoided if a given alternative is to fulfill the first objective of any restructuring—to make the situation no worse than it is today (see Chapter Five).

c. Signal layout

The placement of signals, at yards and interlockings and on main line tracks, has a significant impact on operations and would be reflected in simulation results. Therefore, a signal layout would need to be designed to accompany any alternative, prior to the simulation of train interactions.

d. Support facilities

Both passenger and freight support facilities would require careful attention.

(1) Passenger

For passenger service, significant issues remain unresolved and would need study if any alternatives are to be progressed:

- Station configurations for all affected stations would require thoroughgoing attention, with respect to platform locations and lengths, track layouts, connections to the approach tracks, pedestrian flows within the station complex, and passenger access/egress. In some cases the choice of a freight alternative would affect the passenger station configurations.
- The station configurations could affect the ability to store commuter trains during the day and overnight. Thus, the location, size, cost, and operational characteristics of MARC storage and support facilities within each of the passenger and freight alternatives would require scrutiny.

(2) Freight

As discussed in Chapter 8, some of the alternatives could affect the design, or operation, or both, of certain freight yard facilities. All such affects would be identified and analyzed.

4. **Geology/underground utilities**

With tunneling so integral to any railroad restructuring in Baltimore, development of any alternatives would necessitate a comprehensive search for past boring information, new borings along potential routes, and the assembly and analysis of all utility maps of the affected areas. This intensive effort would supplement the initial searches undertaken within the scope of this work.

5. **Confirm right-of-way/property lines**

Studies of the affected rights-of-way would be needed to refine the cost of land takings and review options for not taking land, wherever possible.

6. **Construction staging**

For each alternative under continued scrutiny, a preliminary staging sequence would be developed and any required temporary facilities would be identified.

7. **Refine construction cost estimates**

On the basis of all the foregoing analytical work, it would be possible and necessary to develop updated estimates of the capital investment required for each alternative.

8. **Prepare comprehensive benefit/cost analyses for the alternatives**

Drawing on the operational and other investigations, total life-cycle benefits and costs would appropriately be calculated for each of the rail restructuring alternatives; furthermore, the incidence of those benefits and costs (i.e., the share to be borne by the general public, by the railways, and by other entities) could be estimated. The results of these analyses would provide much fuller information to decision-makers and the public at large than estimates of construction costs alone, and would better prepare the way for the environmental documentation.

9. **Review regional alternatives for freight movement**

Future analysis would appropriately place the Baltimore restructuring options in their larger context by examining other possibilities for handling the projected increases in passenger and freight traffic. Under this category, analyses of the following would appropriately occur:

- Likely performance of the Baltimore network if no improvements are made and the traffic increases are retained in the rail mode[3];
- Implications, on other modes' congestion and facility requirements, of handling future traffic increases by other modes, especially highway (and air to the extent of available capacity and likely demand);
- Alternatives for upgrading or devising other rail freight routes[4] that would bypass the Baltimore region for through traffic in various national traffic lanes; their costs,

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[3] Of course, certain of the increases projected in Chapter 4 cannot occur in the "no-improvement" case.
[4] There are no such conceivable options for passenger traffic.

benefits, and effects upon traffic to, from, and within the study region; their consequences for the various carriers that would be involved.

These "what-if" scenarios could provide a useful contribution to the environmental documentation, by broadening the range of alternatives covered in the background studies.

10. Institutional arrangements

As indicated in Chapter 2, the Achilles heel of Baltimore's railway network at the time of its construction was its fragmented ownership rife with intramodal rivalries. This condition precluded any concerted effort to overcome the challenges of topography and development; hence the network of today.

Much has changed since the 19th Century, within the railroad industry and in the industry's place in American transportation. It is therefore conceivable that someday, given a plan that draws on all the analytical processes envisioned in this chapter, the private and public sectors may be able to succeed where the magnates of the 19th century failed, in providing a railway infrastructure in Baltimore that meets contemporary standards for both engineering and service. To effect such an accomplishment, and to derive all its promised benefits in a cost-effective manner that responds to the public convenience and necessity, would require well-designed institutional structures and relationships. Cost sharing would be an issue of profound importance, for example. The creation or adaptation of such institutions, and the resolution of cost and operational issues before any construction begins, would be an analytical task in itself of very high importance.

11. Environmental documentation

The analyses described above would help to support the indispensable task of preparing the necessary environmental documentation for a restructuring of Baltimore's railway network.

GLOSSARY AND LIST OF ACRONYMS

Acronym/ Term	Meaning
ADA	Americans With Disabilities Act
AAR	Association of American Railroads (headquartered in Washington, D.C.; represents the Class I railroads)
AREMA	American Railway Engineering and Maintenance-of-Way Association
CFS	FRA's Commercial Feasibility Study of high-speed ground transportation, summarized in the 1997 report *High-Speed Ground Transportation for America,* available on-line at: http://www.fra.dot.gov/us/content/515
C&O	Chesapeake & Ohio Railway
CP	Control point—a term designating an interlocking, where trains can switch tracks. CP-Virginia is the current designation for the former "Virginia Interlocking."
CSXT or CSX	CSX Transportation, Inc., one of the Nation's largest freight railroads. CSXT comprises, among many other predecessor railroads, the former Baltimore & Ohio Railroad and Western Maryland Railway, and is thus a major owner and operator of Baltimore's railway infrastructure.
CTP	Corridor Transportation Plan
duckunder	A railway structure in which the branch line, separating from the main, gradually ramps down and, on attaining sufficient vertical distance from the main line grade, smoothly bears away from the principal right- of-way beneath a bridge carrying the main line tracks.
FRA	Federal Railroad Administration
GCFT	Great Circle Freight Tunnel—the main component (with variations possible) in a freight solution in the "Near North Sector" as defined in the report.
GCPT	Great Circle Passenger Tunnel—the main component in a passenger solution in the "Near North Sector" as defined in the report.
GIS	Geographical Information System
HP	High-level platform (at passenger stations)

Acronym/ Term	Meaning
interlocking	 Schematic of a universal, two-track interlocking (each track is represented by a single line). A location where carefully laid-out turnouts ("switches") allow trains to move from one track to another. The trackwork and accompanying signals are all controlled by a mechanical apparatus and/or electric circuitry that is "interlocked" to prevent conflicting paths from being established for simultaneously passing trains. A **universal interlocking** on a multiple-track railroad allows trains to move from any track to any other track.
JFX	Jones Falls Expressway, Baltimore City's north/south freeway.
LP	Low-level platform (at passenger stations)
MP	Milepost
MARC	The commuter rail operation of the State of Maryland, managed by the State's Mass Transit Administration.
MAS	Maximum Authorized Speed
NC	Northern Central Railway, ultimately a component of the Pennsylvania Railroad. A north/south route that followed the Jones Falls Valley to Harrisburg, thence up the Susquehanna Valley to central Pennsylvania and western New York State.
NEC	Northeast Corridor
NECIP	Northeast Corridor Improvement Project (sometimes: Program), a large Federal investment in the NEC main line, most of which occurred between 1976 and 1984.
NEC South	The portion of the NEC main line between New York, Philadelphia (30th Street), Baltimore, and Washington.
NS	Norfolk Southern Corporation
P&BR	Patapsco & Back Rivers Railroad
PRR	Pennsylvania Railroad

Acronym/ Term	Meaning
slip switch	 Where two tracks cross at grade at an acute angle, a special piece of trackwork that allows for trains to either go straight or diverge to the other track. A very simple schematic of a slip switch appears to the left. Because slip switches are complex and labor-intensive to maintain, modern railway engineering practice is to avoid them where possible.
STB	Surface Transportation Board, successor to the Interstate Commerce Commission
TEA-21	Transportation Equity Act for the 21st Century, enacted June 9, 1998 as Public Law 105-178
TPC	Train Performance Calculator
track chart	A scroll-like line diagram of a particular section of railroad, showing (among other items) each track, the degree of curvature and location of each curve, grades, stations, interlockings ("control points"—places where trains can switch from one track to another) and other details of the road's facilities and geometry.
Washington	All references to "Washington" are to "Washington, D.C."
WM	Western Maryland Railway, now a component of CSX.