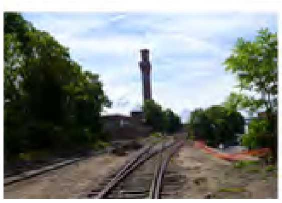
CENTRAL CONNECTICUT
RAIL STUDY

INFRASTRUCTURE ASSESSMENT REPORT



CONNECTICUT DEPARTMENT OF TRANSPORTATION

STATE PROJECT NUMBER: 171-366

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Chapter 1. Introduction

The purpose of this document is to review the existing infrastructure along the line and to identify infrastructure improvements necessary to upgrade the existing Pan Am freight line between Berlin and Waterbury. The document details these improvements under three conditions of gradual betterment of the line:

(1) Maintain Class II[1] Standards under State of Good Repair
(2) Improve the line to Class III Standards should service warrant
(3) Class III or higher Standards with passenger service considered.

The following chapters will revisit the historical background of the line, a review of the inspection findings, and development of a scope of work required to maintain a level of freight service commensurate with the level of demand, starting at a base level of FRA Class II.

Efforts to develop this report included review of existing track charts, right-of-way mapping, and several hi-rail trips of the 24-mile rail line. During the hi-rail inspections, we were able to acquire an understanding of the general condition of the rail line, as well as identify track bed conditions, drainage and clearance issues.

[1] Class I, II, III in terms of the Federal Railroad Administration (FRA) Track Safety Standards, Section 213.9

Chapter 2. Rail Service History

2.1 Historical Background

Passenger rail service existed for many years in the CCRS Study Corridor between Waterbury and Newington, dating back to the 1860s. An 1891 timetable shows that travel from Waterbury to Hartford, with stops in Bristol and New Britain, took approximately one hour. After the turn of the century, the New York, New Haven, and Hartford Railroad combined routes from two predecessor railroads, the Naugatuck and the NY and NE, to provide service on what was called the Highland Line. The image on the right shows a steam locomotive pulling commuter cars through Highland Junction as it heads east to Hartford in June 1947.[2]

The Highland Line (formerly the Highland Subdivision of the Hartford Division of the New York, New Haven, and Hartford Railroad) was once fully double-tracked between Hartford and Waterbury. For a long time, it was a commuter route for Waterbury, Bristol, Plainville, and New Britain residents. By the end of the 1950s, however, the Line was reduced to single track. The rail station in New Britain Station was demolished in 1956, though service continued until 1960.

The last passenger train in the Waterbury to Hartford service was roundtrip No. 460-461. The photo on the left, taken in September 1957, shows RDCs 22 and 130 heading for Hartford Station to pick up passenger for Train No. 461, the 5PM departure.[3]

2.2 Passenger Rail Service

Currently, there is no passenger service operating within the Study Corridor. The municipalities on the ends of the corridor, however, are each served by passenger rail. The Metro-North Railroad (MNR) Waterbury Branch terminates in Waterbury, and Amtrak's New Haven-Hartford-Springfield line includes a stop in Berlin.

2.3 Freight Rail Service

Freight rail service in this corridor is operated by Pan Am Southern Railways. Details of this service and its customers can be found in the *Freight Market Analysis Report*, which will be posted on the study website once finalized.[4]

[2] Photo from Kent Cochrane, Collection of Thomas J. McNamara, in *New Haven Railroad Passenger Trains* by Peter E. Lynch.
[3] Photo by J.W. Swanberg in *New Haven Railroad Passenger Trains* by Peter E. Lynch.
[4] http://www.centralctrailstudy.com

Chapter 3. Track Infrastructure

The Waterbury Branch Line (Waterbury Line or the Line) of the Pan Am Southern (PAS) Railroad runs 24 miles, east to west, from Berlin to Waterbury, Connecticut traversing the towns of New Britain, Plainville, Bristol, and Plymouth along the way. The Line is the Study Corridor of the CCRS. The eastern terminus of the Line is located at the northerly leg of the Berlin Wye on Amtrak's New Haven-Hartford-Springfield (NHHS) Line approximately 500' north of Berlin Station. The southern leg of the wye is currently not connected to the NHHS, though plans exist to bring the Line back into the NHHS alignment in coordination with the mainline improvements. The western terminus of the Line is located at Waterbury Yard, adjacent to Waterbury Station.

The Federal Railroad Administration (FRA) Track Safety Standards define the minimum requirements to which railroad track must be maintained for a given range of speeds (Table 1). The FRA Track Safety Standards set minimum requirements and allowable tolerances for the following: roadbed (drainage and vegetation), track geometry (gage, alignment, surface and superelevation) and track structure (ballast, crossties, rail, rail joints, tie plates, fasteners and turnouts).

Table 1: FRA Track Safety Standards – Classes of Track

Over track that meets all of the requirements prescribed in this part for	*The maximum allowable speed for freight trains is*	*The maximum allowable speed for passenger trains is*
Excepted	*10*	*N/A*
1	*10*	*15*
2	*25*	*30*
3	*40*	*60*
4	*60*	*80*
5	*80*	*90*

The Waterbury Line consists of a single track for its entire length, with four runaround tracks at New Britain (Mile Post (MP) 1.8), Cook's Quarry (MP 5.5), Forestville (MP 8.7), and Terryville (MP 15.3). According to the timetable, the Line is classified as Class II with maximum track speeds of 25 MPH (refer to Figure 1, Figure 2, and Figure 3). However, there are numerous sections where the track speed is limited to 10 MPH due to poor track condition, as well as each approach to adjacent lines at the east and west terminus locations in Waterbury and Berlin because of tight curvature. Similarly, the 10 MPH track speed through New Britain (MP2 to MP3) is likely speed limited due to the six closely spaced highway grade crossings within that section. We recognize that in order to operate at the timetable speed of 25 MPH, the line must be upgraded and maintained to FRA Class II track safety standards.

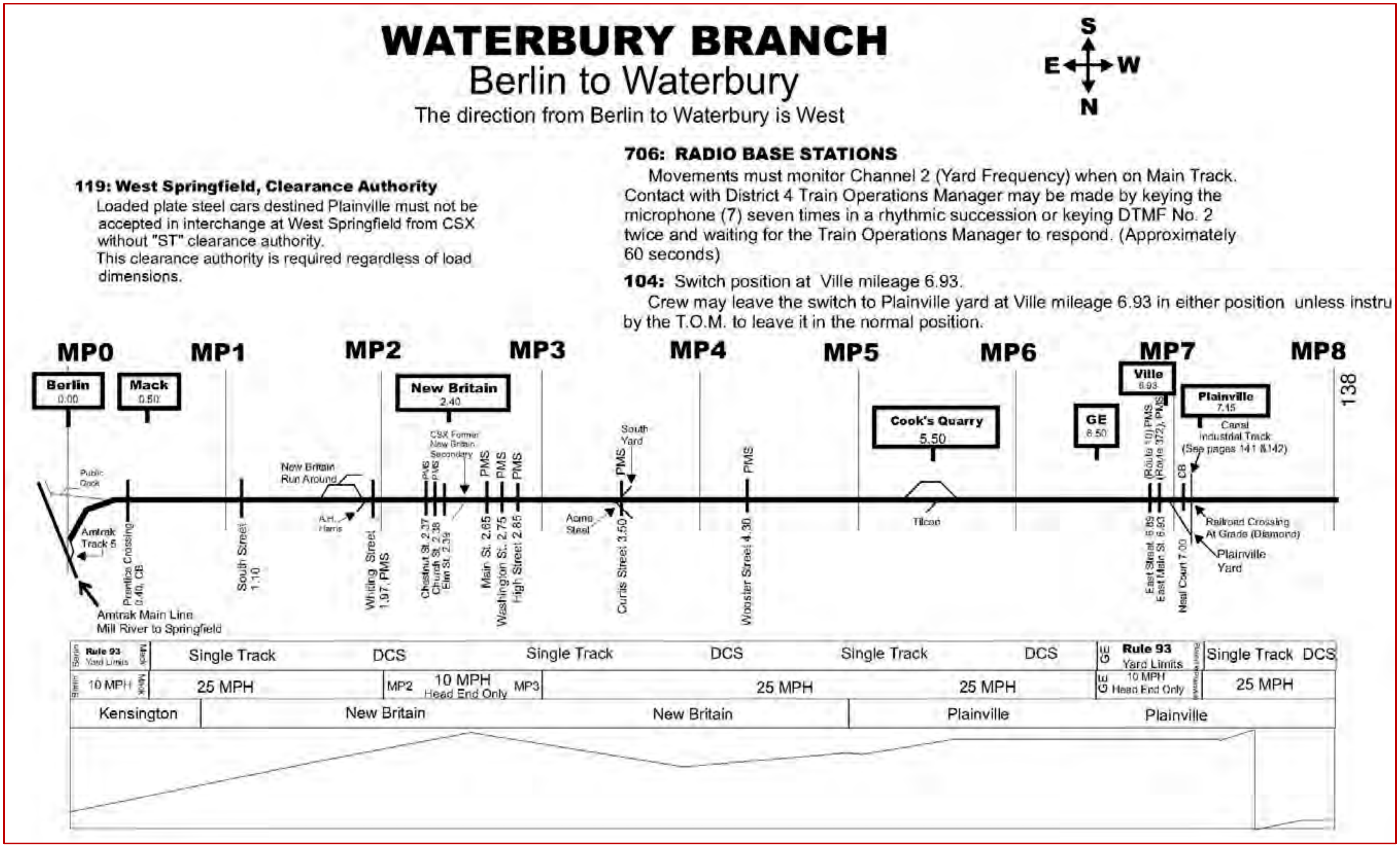

Figure 1: Pan Am Southern Track Speeds: Waterbury Line, MP 0-8

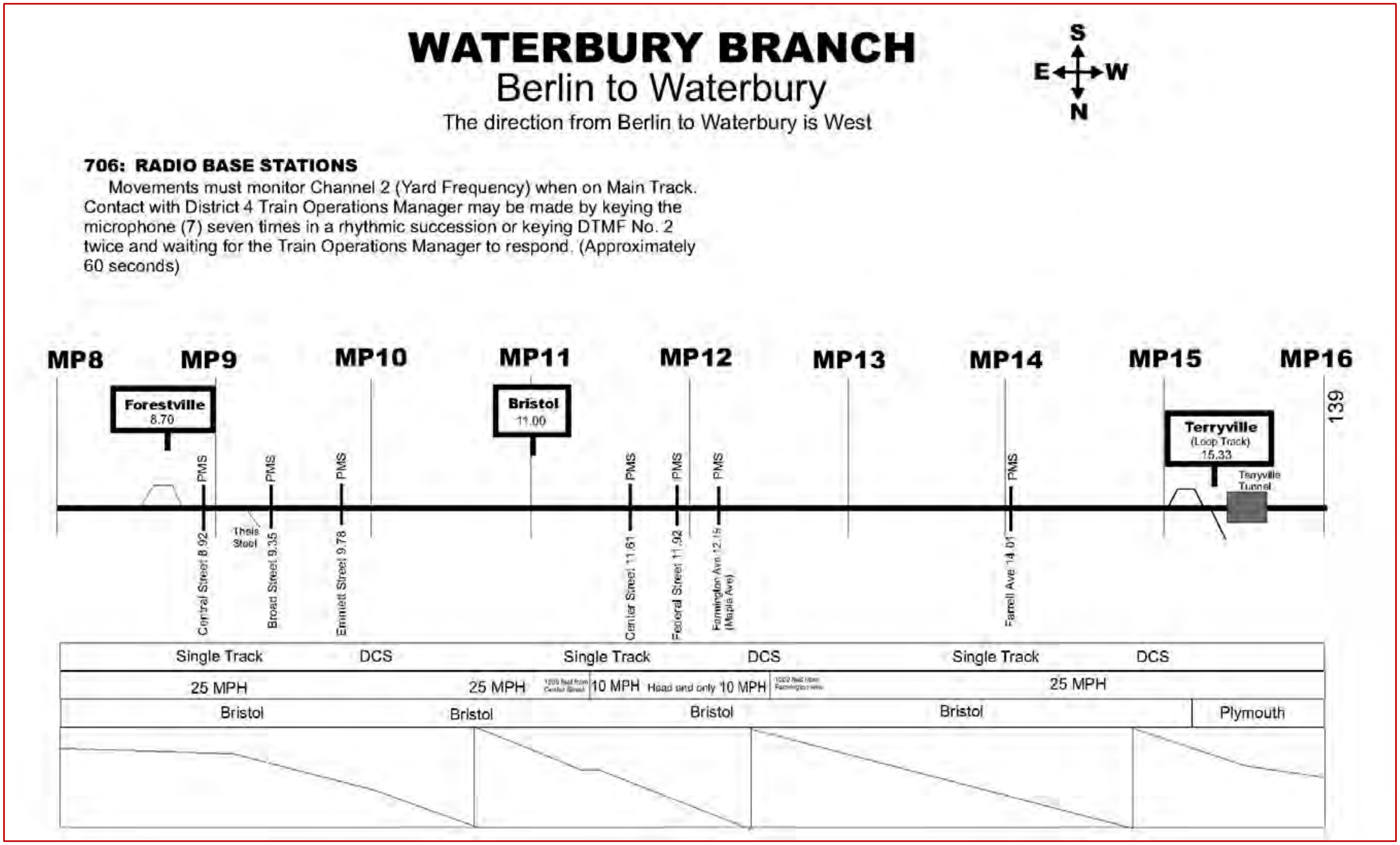

Figure 2: Pan Am Southern Track Speeds: Waterbury Line, MP 8-16

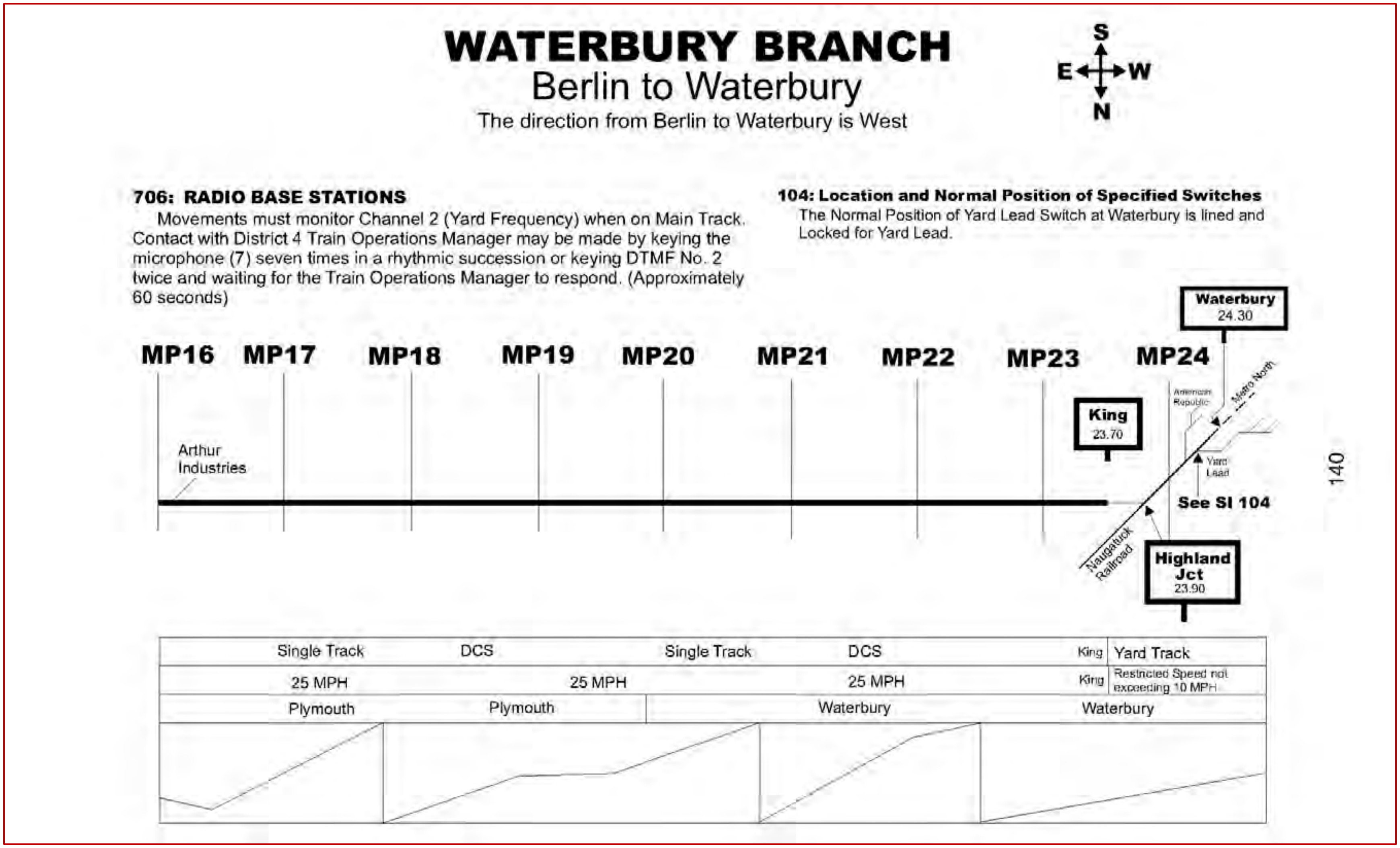

Figure 3: Pan Am Southern Track Speeds: Waterbury Line, MP 16-24

3.1 Profile and Grade

Referring to Track Charts dated May 24, 1996 (Figure 4, Figure 5, and Figure 6), the existing profile of the Waterbury Line consists of five major sections:

Entrance to the 3,850-foot long Terryville Tunnel, once considered the longest bored rail tunnel in the United States

- The Line descends at an estimated average grade of 1.0% between Berlin (MP 0.0) and Stanley Street overhead bridge (MP 2.5).[5] The longest sustained grade is 1.09% between Prentice Crossing (MP 0.4) and the Route 372 Connector under-grade bridge (MP 0.9). This leads into the maximum grade for this section of 1.21%, between the Route 372 Connector (MP 0.9) and the Route 72 Tunnel (MP 1.2).
- The Line then ascends at 0.81% between Stanley Street (MP 2.5) and Washington Street (MP 2.75) and then at 0.72% to approximately MP 3.8.
- The Line descends approximately 0.4% between MP 3.8 and Crooked Road Overhead Bridge (MP 5.7). The longest sustained grade is 0.45% between MP 4.0 and MP 5.0, with a maximum grade of 0.64% between Cook's Quarry runaround and Crooked Road (MP 5.7). This is immediately followed by a 1.4 mile segment of level track to the railroad crossing (diamond at MP 7.1).
- The Line then ascends 9.3 miles, from the Railroad Crossing to MP 16.4, at an average grade of 0.72%. The grade ascension ranges from 0.08% to a maximum of 1.16% through this segment with the maximum grade located between MP 10.6 and MP 11.3. The longest sustained grade of 1.10% runs 4.0 miles from MP 11.5 to MP 15.5, at the approximate mid-point of the Terryville Tunnel.
- The last segment of the Line descends towards its terminus at Highland Junction at an average grade of 0.77% with a 0.7 mile level section between MP 18.7 and MP 19.4. There are two sections of track, both with the maximum grade of 1.0%, running from MP 16.4 to MP 18.7 and from MP 19.5 and MP 21.9.

Profiles and grades along this freight line meet or exceed the standards set forth by the American Railway Engineering and Maintenance-of-Way Association (AREMA). They are also relatively

[5] The available information only shows mileposts for at-grade crossings. Mileposts are approximate for overhead and under-grade bridges, as well as culverts.

consistent with the conditions found on other short freight lines in the area, and they do not appear to pose any operational concerns for PAS.

3.2 Curvature, Superelevation, and Underbalance

In an ideal environment, a railroad should be constructed on tangent track and level grade. At the time of the original line construction, however, the availability of right-of-way combined with existing geologic and topographic conditions often results in the use of curves and grades to get the rail line from point A to point B in the most economical and environmentally sensitive manner. As can be ascertained from the track charts for the Waterbury Line (Figure 4, Figure 5, and Figure 6), the horizontal alignment of the Line consists of 39 curves. Since this line is currently classified as Class II Track[6], it does not appear that the curvature of the track limits operating speed.

In order to bring the line back to a State of Good Repair (SGR) of Class II track, no upgrades to the track curvature need to be made. However, due to the track settling over time, it is recommended that a track surfacing operation be completed to bring the curve superelevation back to the designed cross level.

In order to upgrade the track from Class II to Class III, it would be recommended that all curve superelevations be increased for the higher speeds of Class III track. This would require raising the outer rail on curves and lengthening the entrance and exit spirals in order to support the higher speeds.

To further improve train speeds on the Line and bring the track up to Class III standards, it may be worthwhile to investigate whether the tighter curves can be flattened out (degree of curvature lowered) in areas where there is sufficient ROW to allow for it. This would not only have a positive impact on train velocity, but may lower the actual superelevation needed. In general, maximum track speed decreases as degree of curvature increases. Curves that are 3 degrees and sharper would limit train speeds to less than 40 MPH, depending on the curvature. This is the case for roughly half the curves on the line.

Further investigation would be required to ascertain the ROW's capacity to accommodate significant curve modifications. From historical information, ROW mapping and field investigations, it appears that much of the ROW had double tracking at one time and could currently accommodate double tracking with 12'+/- track centers, however a majority of the double tracking has long been removed. Currently, the Railroad appears to have taken advantage of the additional ROW available in the curved areas and has flattened curves to take over the space originally occupied by both tracks. This needs to be kept in mind for locating future passing sidings (and impacts during the potential construction efforts).

[6] Much of the track charts indicate track speeds of 25 MPG, which suggests that the track is maintained at FRA Class II.

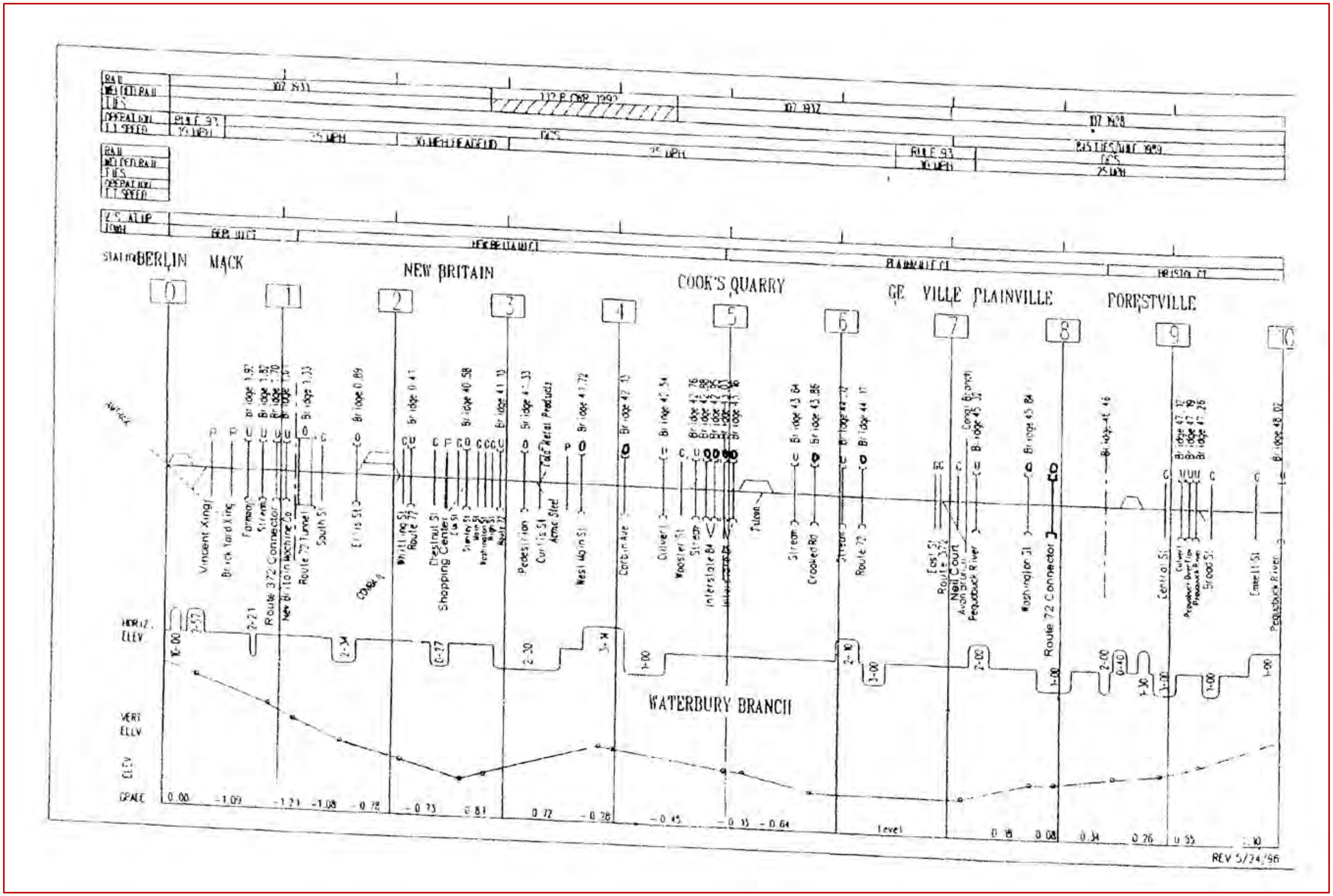

Figure 4: Pan Am Southern Track Charts: Waterbury Line, MP 0-10

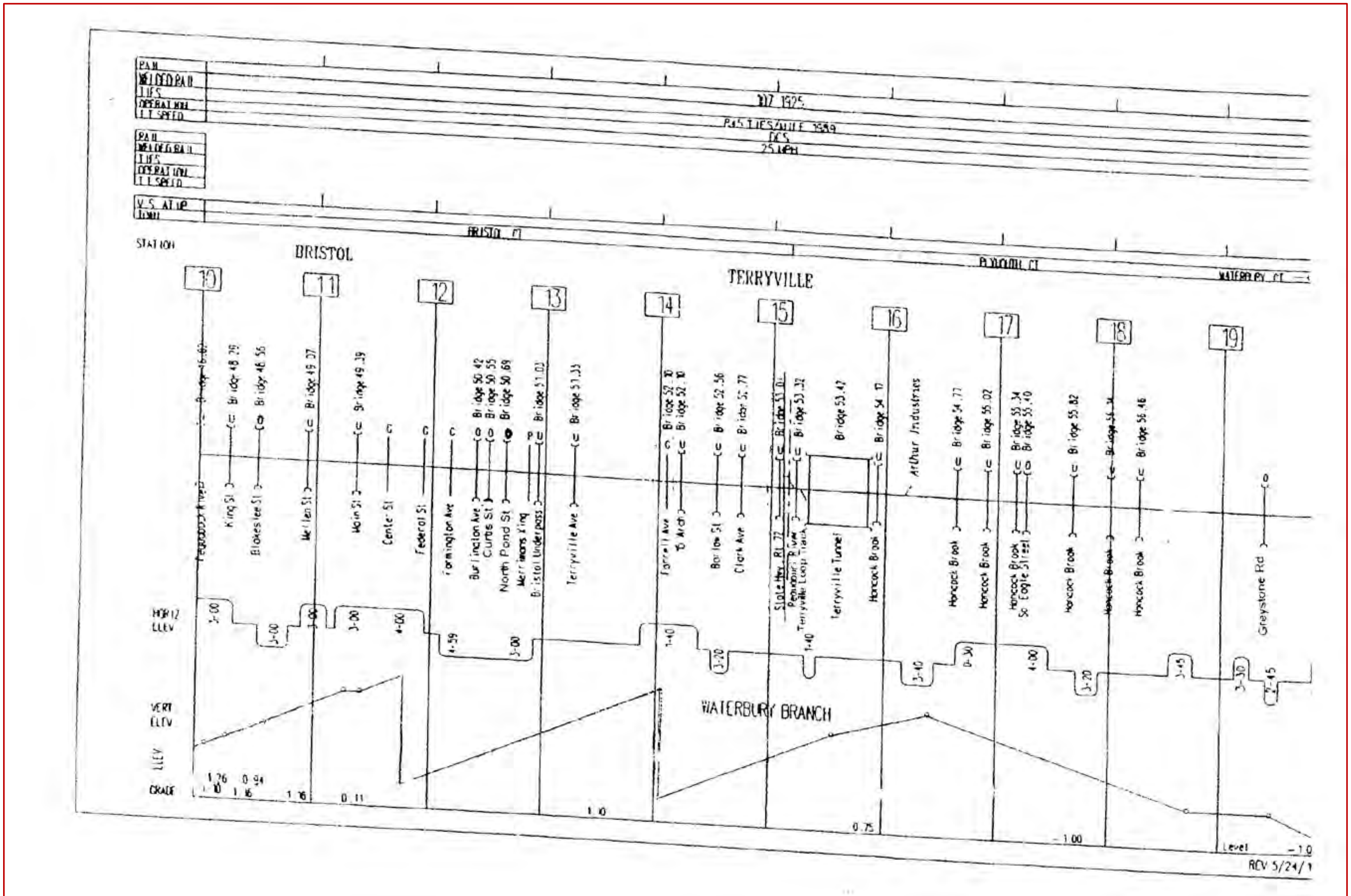

Figure 5: Pan Am Southern Track Charts: Waterbury Line, MP 10-20

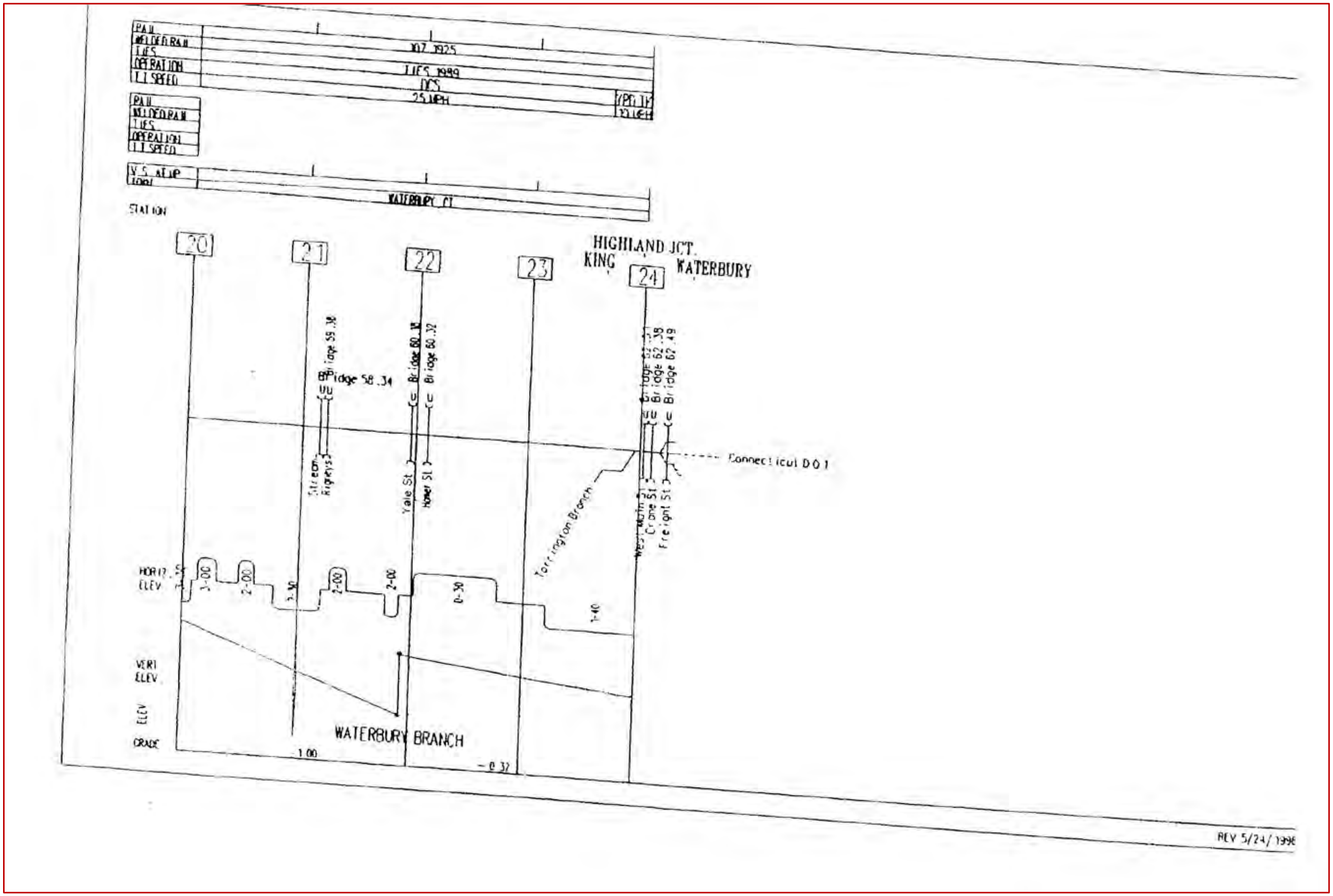

Figure 6: Pan Am Southern Track Charts: Waterbury Line, MP 20-24

3.3 Horizontal and Vertical Clearances

The State of Connecticut has legal vertical clearance requirements that railroads must maintain based on level, tangent track, which are covered under Connecticut General Statute 13b-251. In general, the following minimum horizontal and vertical clearances shall be maintained:

- Vertical Clearances: 22'6" of vertical clearance between the top of rail and the bottom of a structure (such as a highway bridge or tunnel ceiling). Exceptions may be granted to permit a reduction in clearance requirements. CGS 13b-251 contains several exceptions to this clearance requirement.
- Horizontal Clearances: 8'6" from centerline of track to face of obstruction, such as fences, bridges and retaining walls.
- Horizontal Clearances: 5'7" from centerline of track to face of high-level passenger platforms.
- Track Centers: 12'0" between main tracks. Note that any track within 25'0" is considered an adjacent track.

The dimensions noted above would need to be increased on curves to account for superelevation and rail car overhang. It may be desirable, or even necessary, to increase track centers where the degree of curvature increases significantly.

No significant improvements to horizontal and vertical clearances are planned at this time, other than a recommended vegetation clearing program to maintain clear distance between vegetation and the sides of the vehicles.

3.4 At-Grade Crossings

The Line has 21 at-grade crossings, 17 of which have predictor/motion sensing automatic warning devices including gates, lights, and pedestrian bells (Table 2). Two of the at-grade crossings currently are protected only by flashing lights and bells. The remaining two crossings are private, and are passively protected with signs to provide advanced warning to the travelling public. In addition, the Line consists of one at-grade railroad crossing (diamond), located at MP 7.15. For future analysis, it should be noted that there are no at-grade crossings west of MP 14.01.

No changes to the grade crossing equipment are needed in order to bring the line into a state of good repair for Class II track. However, due to the track upgrades that will need to be made, it is recommended that the crossing surfaces be replaced and/or upgraded during this time.

For an upgrade to Class III track, it may not be necessary to upgrade the crossing equipment. However, because of the current timetable speed of 25 MPH, the approach circuits would need to be lengthened to accommodate the increased train speeds such that the warning systems are fully activated for the appropriate amount of time prior to the train arriving at the crossing.

Left: The approach to the South Street at-grade crossing, with only lights for advance warning.
Right: The approach to a private at-grade crossing, with only signs for advanced warning.

Table 2: List of Grade Crossings

Milepost	*Crossing*
0.40	Vincent X-ing
1.10	South Street
1.97	Whitting St
2.37	Chestnut St
2.38	Shopping Center
2.39	Private Crossing
2.65	Main St
2.75	Washington St
2.85	High St
3.50	Curtis Street
4.30	Wooster St
6.89	East Street (Rte 10)
6.93	East Main St (Rte 372)
7.00	Neil Court
8.92	Central Street
9.35	Broad Street
9.78	Emmett Street
11.61	Center Street
11.92	Federal Street
12.19	Maple St/Farmington Ave
14.01	Farrell Ave

3.5 Right-of-Way General Conditions

The existing conditions of the track structure, drainage, and vegetation observed along the right-of-way of the line appear typical for FRA Class II track conditions.

3.5.1 Drainage

There are 50 culverts passing under the railroad right-of-way, and as expected, there are many rock cut areas with drainage swales running alongside the track. Several of these areas are obstructed by debris, silting and/or vegetation. This condition, if left uncontrolled, will contribute to the breakdown of the track structure.

Typical conditions in a rock cut area, including overgrown vegetation, obstructed drainage swales, and fouled ballast.

Several additional areas were observed with drainage pipes leading from adjacent properties onto the right-of-way. Additionally, it appeared that where several city streets dead-ended at the edge of the ROW, significant water runoff could be observed. This was especially prevalent through the rock cut areas in New Britain and Bristol. These areas should be further reviewed with property owners. Without mitigation, this uncontrolled stormwater will continue to impact the track structure.

It is recommended that ditches and culverts be cleaned out and repaired as required as a part of the programmed upgrades to bring the Line up to Class II standards.

MP 13.5 - Area of Significant Fouled Ballast

In addition, of special note, was an area located at about Mile Post 13.5, between Route 6 and Farrell Avenue, in Bristol, was observed (see photo to the right). As can be seen in the photo, the track bed has significant infiltration of sand, which we were informed is due to trespassing off-road vehicles adjacent to the track. Due to the grade difference here, we suggest that some form of permanent barrier be installed to keep the material away from the track bed.

3.5.2 Vegetation

Overgrown vegetation is prevalent throughout the 24 miles of the Line. This vegetation often restricts sight lines at approaches to grade crossings, and it brushed against the sides of passing rolling stock in many locations. It is recommended that a semi-annual vegetation maintenance weed spray program be implemented to maintain a vegetation free zone along the railroad right-of-way.

3.5.3 Track Structure

A large percentage of the wood ties on the line are considered to be in poor condition.

The rail throughout most of the Line is 107NH# (weight is 107 pounds per yard) bolted rail, with one section of 112RE (112 pounds per yard) continuous welded rail between MP 2.8 and MP 4.4. The south leg of the Berlin Wye appears to be recently constructed utilizing 115RE# (115 pounds per yard) rail for the future connection back to the Amtrak NHHS Line. A large percentage of the wood ties on the line have deteriorated to the point that they are considered to be in poor condition and many require replacement. For the most part, the ballast is in decent condition, but there are areas where it has been fouled with mud, dirt, and/or debris, or is insufficient for good track drainage. In some places, the ballast is so fouled it is not visible at all. Visual inspection of the rail showed no visibly significant issues, and may not need replacement as a part of the SGR or Class III upgrades. However, an inspection vehicle with ultrasonic rail testing capability would be required to ensure there are no internal defects within the existing rail.

For a state of good repair, it is recommended that approximately 33% of the ties be replaced. During this improvement, the ballast should be cleaned and/or replaced, via undercutting or shoulder ballast replacement. There should then be a complete track surfacing and lining operation to restore the track to its design profile.

To upgrade the track to Class III, in addition to the SGR work above, it is recommended that an additional 33% of ties be replaced and another surfacing and tamping operation be performed. Having 67% of the ties replaced will help stabilize the track structure for higher train speeds.

For passenger service, it is recommended that in addition to the above improvements for SGR and Class III, all existing rail should be replaced with 136RE continuously welded rail (CWR), similar to the new 136RE CWR installed on the Knowledge Corridor "Restore Vermonter" ARRA project in Massachusetts. While 115RE# is recommended as a minimum, the heavier rail section 136RE is recommended for longer life and lower life cycle maintenance costs. All existing turnouts (track switches) should also be rehabilitated to meet Class III standards and replaced where Class III standards cannot be met. The rail section for turnouts and diamonds should match the rail weight and section of the new CWR.

Another requirement for the proposed passenger service would be passing sidings. The schedule created for this service indicates that there will be trains traveling in opposite directions and will "meet" in certain areas of the 24 mile line. Since this Line is single track territory, passing sidings would be needed in order for these trains to pass each other as well as any potential freight traffic on the Line during service hours. It is recommended that each siding be large enough to accommodate the longest train that will traverse the Line. In this case, it is assumed that the longest freight train could be up to a mile long.

3.5.4 Signalization

Currently there is no existing signal and train control system on the Waterbury Line. Signals would not be required for SGR or Class III (freight only) upgrades or if proposed passenger operations were going to have train speeds below 60 MPH, and would have a uni-directional service plan (all passenger trains inbound in the morning, outbound in the evening). This also assumes that no freight trains would be operating on the Line during passenger service hours.

However, since the proposed passenger operation plan requires the use of passing sidings, a dispatcher controlled signal and train control system is highly recommended to keep operations moving smoothly and safely. A new cab signal-based Centralized Traffic Control or CTC system would include track circuits to detect the presence of trains, wayside signals as required, Interlocking signals, and powered turnouts at each end of the passing sidings. The system also requires that all hand throw turnouts on the main line be equipped with electric locks that are controlled by the dispatcher. This deters anyone from accidentally throwing a switch when a train may be approaching.

3.6 Track Improvement Recommendations and Associated Cost Estimates

The preparation of the cost estimate is based upon the following assumptions:

Class II (Table 3, state of good repair):

- Three miles of track would be undercut to remove fouled ballast. New ballast would be unloaded following undercutting to restore the track to its original top of rail elevation. The balance of the line will have shoulder ballast replaced.
- Every third crosstie (33%) will be replaced with a new crosstie. Two new crossties will be provided at each rail joint.
- The track will be lined, surfaced and regulated
- All bolted joints use four bolt-assemblies per rail joint. Assume 10% of assemblies/bolts are missing/damaged and will be replaced
- All in-place and joint bars will be tested for internal defects. It is assumed that no consistent defect patterns would be noted that would indicate the need for a full-scale replacement of rail and joint bars
- A contingency will be in place to account for other possible repair and replacements (damaged tie plants, worn switch plates, rail welding for end battered rails, etc.)
- Grade crossing surfaces
- Improved drainage and mitigation of off-site drainage

Table 3: Conceptual Cost Estimate, Track Improvements, Class II

FTA SCC	ITEM DESCRIPTION	UNIT	QTY	UNIT COST	COSTS	CONTIN-GENCY	COSTS w/ CONTINGENCY
10	Guideway and Track Structures						
10.11	Track: Ballasted						
	Main Line Trackwork						
	Ballast Shoulder Replacement	Mile	20.9	$ 150,000	$ 3,135,000	40%	$ 4,389,000
	Undercutting	Mile	3.0	$ 270,000	$ 810,000	40%	$ 1,134,000
	Surface Track w/33% Timber Tie Replacement	Mile	23.9	$ 291,000	$ 6,955,000	40%	$ 9,737,000
	RR Flagman/Protection	2%	of CCS Item		$ 218,000	40%	$ 305,000
	Mobilization, MPT, Grubbing	11%	of CCS Item		$ 1,199,000	40%	$ 1,679,000
					$ 12,317,000		$ 17,244,000
10	**Cost Category Total**				**$ 12,317,000**		**$ 17,244,000**

Class III (Table 4, in addition to above):

- Every third crosstie (33%) will be replaced with a new crosstie. Two new crossties will be provided at each rail joint.
- The track will be lined, surfaced and regulated
- Grade crossing warning device circuits upgraded for higher train speeds.

Table 4: Conceptual Cost Estimate, Track Improvements, Class III Freight

FTA SCC	ITEM DESCRIPTION	UNIT	QTY	UNIT COST	COSTS	CONTIN-GENCY	COSTS w/ CONTINGENCY
10	Guideway and Track Structures						
10.11	Track: Ballasted						
	Main Line Trackwork						
	Surface Track w/33% Timber Tie	Mile	23.9	$ 291,000	$ 6,955,000	40%	$ 9,737,000
	Line and Surface with 2" Ballast Lift	TF	126,192	$ 11	$ 1,388,000	40%	$ 1,943,000
	RR Flagman/Protection	2%	of CCS Item		$ 167,000	40%	$ 234,000
	Mobilzation, MPT, Grubbing	11%	of CCS Item		$ 918,000	40%	$ 1,285,000
					$ 9,428,000		$ 13,199,000
10	**Cost Category Total**				**$ 9,428,000**		**$ 13,199,000**

Class III (Table 5, passenger service, in addition to both above):

- All rail will be replaced with 136RECWR.
- Assumed industry turnouts are all #9's or #10's and need to be replaced to match new 136RE rail. Main line turnouts to be #15 or #20 AREMA standard pattern turnouts.
- Two 5,000' sidings needed for passing meets.
- New signal and train control system to be installed for remote dispatcher control of all train movements on the Line, passing sidings, Interlocking signals, and other Control Points as needed to increase operational efficiency and safety on the line.
- All industrial turnouts to have electric locks installed that will be under dispatch control.
- It is assumed the existing railroad radio communications system is adequate for additional service along the Line.

Table 5: Conceptual Cost Estimate, Track Improvements, Class III Passenger

FTA SCC	ITEM DESCRIPTION	UNIT	QTY	UNIT COST	COSTS	CONTIN-GENCY	COSTS w/ CONTINGENCY
10	**Guideway and Track Structures**						
10.11	Track: Ballasted						
	Main Line Trackwork						
	Rail Replacement CWR	LF	249,914	$ 62	$ 15,495,000	40%	$ 21,693,000
	Field Weld	EA	361	$ 775	$ 280,000	40%	$ 392,000
	Passing Siding						
	New 136# CWR Track, Complete w/ Wood Ties	EA	10,000	$ 210	$ 2,100,000	40%	$ 2,940,000
	RR Flagman/Protection	2%	of CCS Item		$ 358,000	40%	$ 501,000
	Mobilzation, MPT, Grubbing	11%	of CCS Item		$ 1,966,000	40%	$ 2,752,000
					$ 20,199,000		$ 28,278,000
10.12	Track Special						
	Main Line Trackwork						
	Turnout Removal #9	EA	17	$ 3,950	$ 67,000	40%	$ 94,000
	Turnout Installation #9, Timber	EA	17	$ 68,200	$ 1,159,000	40%	$ 1,623,000
	Diamond Crossing Removal	EA	1	$ 4,270	$ 4,000	40%	$ 6,000
	Diamond Crossing	TF	1	$ 77,500	$ 78,000	40%	$ 109,000
	Passing Siding						
	Turnout Insallation - #15, Timber	EA	4	$ 170,000	$ 680,000	40%	$ 952,000
	RR Flagman/Protection	2%	of CCS Item		$ 40,000	40%	$ 56,000
	Mobilzation, MPT, Grubbing	11%	of CCS Item		$ 219,000	40%	$ 307,000
					$ 2,247,000		$ 3,147,000
10	**Cost Category Total**				**$ 22,446,000**		**$ 31,425,000**

Chapter 4. Bridges and Culverts

The bridges and culverts through the corridor were evaluated to determine the current condition and to provide an evaluation of the level of rehabilitation which may be required for upgrades of service and operations. The evaluation included a review of existing mapping and inspection reports provided by Pan Am Railroad, a site visit and a compilation of estimated effort and costs for rehabilitation

4.1 Data Collection

The Pan Am Railroad provided a listing of undergrade and overhead structures for Conrail's northeastern region, dated January 1, 1981. In addition, track charts were provided with a latest revision date of May 24, 1996. The listing assigned a mile point location to each structure and gave basic geometric information for various structures along the track. The track chart graphically represents the locations of the various structures and road crossings by listing them along a line corresponding to the mile points along the route. An updated listing of structures over/under the track and the road crossings was developed, checked against aerial photos, and reviewed with the operator of the line, Pan Am Railroad. A copy of the updated list is given in Table A of the Appendix. Table B in the Appendix is a listing of just the railroad structures.

The following is a summary of structure types that exist along the line and the quantity of each type of structure:

- 20 Overhead Structures
- 40 Culverts (< 5 ft span)
- 49 Structures (> 5 ft span)
    - 3 Tunnels
    - 1 Concrete Pipe
    - 3 Stone Arches
    - 10 Concrete Arch with Closed Deck
    - 1 Concrete Slab
    - 1 Prestressed Concrete Closed Deck
    - 6 Steel Beam with Closed Deck
    - 21 Steel Beam with Open Deck
    - 2 Rail Top with Closed Deck
    - 1 Timber Trestle

Pan Am Railroad provided copies of their latest inspection reports for review.

4.2 Site Visit

A site visit (via hi-rail vehicle) was made to review typical structure conditions along the line. The scope of this study included only a general view of typical structures and not an in-depth evaluation of their condition. In-depth inspections will be required to more accurately establish the existing condition of each structure and to determine the extent of rehabilitation required for each structure.

4.3 Typical Structure Conditions

Inspection reports for the railroad structures were obtained from the Railroad subsequent to conducting the site visit. The reports were reviewed to generally confirm the observed condition assessments of the bridges along the line.

Pan Am rates the components of the bridge as poor, fair or good. Most of the bridges along the line are in fair condition; however some are in good condition, and a few have components in poor condition. Pan Am did not report any of the bridges as being currently scheduled for rehabilitation. None of the bridges has a weight restriction below the 263 kip load limit for the line for the current time table speeds. Speed restrictions below the 25 mph for the line are due to track condition and not the structural condition of the bridges, however a complete bridge assessment including bridge ratings will be required during preliminary engineering.

Below are the assumptions made on the typical condition of the structures based on a limited site review of typical conditions and a review of Pan Am Railroad's bridge inspection records. The discussion is grouped by structure type:

A. **Overhead Structures –** There are 20 overhead structures along the line which are owned and maintained by others. No evaluation of these structures was made.
B. **Tunnels –** There are three tunnels along the line. Two of these are concrete arches constructed in the 1970's to support Route 9/72. These tunnels are in good condition and rehabilitation is not required at this time. The third tunnel is the 3,580 foot long Terryville Tunnel constructed in 1910. The condition of this structure and the required repairs is discussed separately in Section 5 of this report.

Typical Overhead Bridge

CCR #1.0 Tunnel under Route 9

C. **Culverts and Concrete Pipes –** There are 40 culverts and 1 concrete pipe along the line. Most of the culverts are less than 5-feet in span/diameter. The concrete pipe is six-foot in diameter. These structures are located at the base of the railroad embankment and typically have a sufficient depth of cover over the structure to provide good distribution of live load. There is very little information available regarding the condition of these structures. A few representative structures were evaluated as part of this study and they were found to be in fair condition. Hence, in general, it is assumed that the culverts are in fair condition with possible localized deterioration. Typically, culverts may have debris buildup at the inlet or along their length which should be cleaned out as part of routine maintenance.

D. **Stone Arches** – There are three stone arch bridges along the line. These structures typically have areas of missing mortar, deteriorated wingwalls, and debris at the inlet or outlet.

E. **Concrete Arches** – There are ten concrete arches along the line. Most were constructed prior to 1910 and have areas of deterioration (cracks, scale, spalls and hollow areas) both on the underside and on the headwalls. A few have eroded/scaled areas along the waterline. Two examples are: 1) CCRS #14.4 over Barlow Street where the structure is in fairly condition, and 2) CCRS #15.3 over the Pequabuck River just east of the Terryville Tunnel where widespread cracking and a scour hole were noted.

CCRS #14.4 over Barlow Street

CCRS #15.3 over the Pequabuck River just east of the Terryville Tunnel

F. Concrete Slab – There is one concrete slab structure on the line. No information is available.

G. Prestressed Concrete with Closed Deck – There is one prestressed concrete structure constructed in 1972 to carry the railroad over Route 72. This structure is in good condition and can support more than one track.

H. Steel Beam with Closed Deck – There are six steel beam bridges with closed decks along the line. Five of the structures consist of beams supporting a deck with ballast supporting the rails and ties. These five are newer structures built for one track and are in generally good condition. CCRS #10.2 over King Street is typical of this type of structure The sixth structure, CCRS #24.05over Main Street in Waterbury, was built in 1906 and is a multi-track structure with through girders, an orthotropic steel deck and one active track. This structure is in poor condition with areas of significant deterioration noted on the deck, superstructure, and steel columns.

I. **Steel Beam with Open Deck –** There are 21 steel beam bridges with open decks along the line supporting one track. These structures were installed in the 1910's and consist of longitudinal steel girders with the railroad ties fastened directly to the steel superstructure members. The structures typically have no remaining protective coatings and there are areas of corrosion with loss where debris accumulates and traps moisture. Most structures are in fair condition; however, some have components in poor condition due to corrosion and section loss. In many instances the abutments were constructed to support a superstructure for two parallel tracks, however, the superstructure for the second track may or may not be still in place. CCRS #11.3 over Main Street in Bristol is typical of this type of structure.

CCRS #10.2 over King Street
Typical steel structure with closed deck

CCRS #11.3 over Main Street
Typical steel structure with open deck

J. **Rail Top with Closed Deck –** There are 2 rail top structures along the line. These structures were constructed in the 1910's and consist of railroad track laid side by side typically covered with unreinforced concrete. The rails act as reinforcing for a one way slab. A relatively thin layer of ballast is placed on top. The inspection reports indicate that the structures are in fair to good condition. Heavy rust is on the rails, pointing and miscellaneous repairs are required to the substructure, and debris are in the channel. CCRC #8.85 has a collapsed wingwall which should be addressed in the short term. The inspection report also mentioned a deviation in the rail top near the tracks of CCRC. These structures most likely constructed for more than one track.

K. **Timber Trestle –** There is one such structure on the line which is in fair condition.

4.4 Cost Estimate – Restore Structures for 25 MPH Freight

This section estimates the work and associated costs to increase the current 10 mph Class I track to 25 mph Class II track for freight service only, and to bring the structure up to a state of good repair. The evaluation and cost estimate in this study are only sufficient for preliminary planning purposes, and further refinement is required if this plan is to be advanced. As discussed in the section on data gathering, limited information was available on the specific structures along the line; and, therefore a number of assumptions were made.

To further refine the required work, detailed in-depth inspections will need to be conducted and the structural condition documented for each structure. Load ratings will be required if they are not available or if the condition noted in the in-depth inspection warrants re-analysis. Pan Am also noted that load rating will be required if the track speed is to be increased above the current 25 mph limit. Once this data is gathered, each structure should be evaluated for required interim repairs and rehabilitation/replacement.

A. **Overhead Structures –** These structures do not affect the track speed. These structures are owned and maintained by entities other than the railroad.

B. **Tunnels –** There are three tunnels along the route. Any speed reduction would be due to the condition of the tracks within the tunnel, which is discussed under the track section of this report. The two tunnels under Rte. 9/72 are in in a state of good repair. The third tunnel, the Terryville Tunnel, has deterioration and will require rehabilitation to return it to a state of good repair. The work and cost estimate for the Terryville Tunnel is discussed in Section 5 of the report.

C. **Culverts and Concrete Pipes –** These structures typically have a significant amount of fill between them and the tracks above, spreading any load and dampening any impact loads. Therefore, assuming the structures are in at least fair condition, the track speed is governed by the condition of the tracks and not the structure. Costs to upgrade the track are included in the overall track costs for the line. It is assumed that only minimal work will be required for the majority of these structures in to return them to a state of good repair. For culverts a budget number of $10,000 was assumed for 36 of the culverts for minor repairs and cleaning debris. It is assumed that 4 of the culverts, at $200,000 each, will require replacement or significant repairs. The two six-foot diameter concrete pipes are in a state of good repair and will not require rehabilitation.

D. **Stone Arches –** These structures typically have a significant amount of fill between them and the tracks above, spreading any load and dampening any impact loads. Therefore, assuming the structures remain in at least fair condition, the track speed is governed by the condition of the tracks and not the structure. For budget purposes $20,000 in repairs per structure is assumed to address short term repairs. Costs to upgrade the track are included in the overall costs for the line. Rehabilitation including, repointing, masonry repairs to the wingwalls and cleaning of debris from the inlet or outlet, will be required to return these structures to a state of good repair.

E. **Concrete Arches** - These structures typically have a significant amount of fill between them and the tracks, spreading any load and dampening any impact loads. Therefore, assuming the structures remain in at least fair condition, the track speed is governed by the condition of the tracks and not the structure. Rehabilitation in order to restore 25 mph track speed are assumed not to be required; however, there are areas of deterioration which should be stabilized to prevent further deterioration, and a large scour hole was noted at one concrete arch For budget purposes $20,000 in repairs per structure is assumed to address short term repairs. Costs to upgrade the track are included in the overall track costs for the line. To bring these structures up to a state of good repair will require concrete patching and possibly streambed scour countermeasures. For purposes of this study it is assumed that rehabilitation will be required to bring these structures up to a state of good repair.

F. **Concrete Slab –** No information is available. It's assumed that any interim repairs will be minor and covered by contingency costs in this study. It's assumed that rehabilitation will be required to return the structure to a state of good repair.

G. **Prestressed Concrete with Closed Deck –** This structure carries the railroad over Route 72 and is in a state of good repair.

H. **Steel Beam with Closed Deck –** The ties for five of the structures sit upon a relatively thin layer of ballast on the structure, and any repairs the track would be similar to that required on the approaches of the structure and are included in the overall track costs for the line. These five structures are in good condition and are either in a state of good repair or would require a minor amount of work to place them in that state. CCRS # 24.05 over Main Street in Waterbury requires rehabilitation and possibly replacement. It's assumed that some repairs to this structure will be required until such time that the structure can be rehabilitated. For budget purposes, $75,000 was assumed for short term repairs.

I. **Steel Beam with Open Deck –** The ties for these structures are bolted directly to the superstructure and assumed it assumed that the ties replacement and the resetting the rails may be required to increase track speeds. Interim repairs, such as plating, will be required for localized areas. For budget purposes a value of $40,000 per structure is assumed for interim repairs. For purposes of this study, it is assumed that to bring these structures up to a state of good repair that some form of rehabilitation will be required, but that they can remain unpainted. It should be noted that these structures have been in service for about a hundred years, and therefore, it's possible that replacement may be a better alternative if any work is significant. Several of these structures currently have underclearances for the roadway below which are below the current standards. For purposes of this report, barring any signs of significant impact damage, the lack of underclearance alone will not be a reason to rehabilitate or replace the bridge.

J. **Rail Top with Closed Deck –** Since the ties sit upon a relatively thin layer of ballast they would be repaired using the same basic methods as used on the approaches. Therefore, the cost of any track work is included in the overall track work for the line. It is assumed that some initial repairs will be required for short term needs. For budget purposes a repair amount of $40,000 per structure is assumed for interim repairs. Given the type of structure and the fact that they have been in-service for more than 100 years is assumed that at least rehabilitation will be required and possibly replacement. For purposes of this study it's assumed that they can be rehabilitated.

K. **Timber Trestle** – There is one such structure on the line. It is assumed that minor repairs will be required in the short term. For budget purposes this is assumed to be $75,000. Rehabilitation will be required to bring the structure up to a state of good repair.

4.4.1 Restore Line to 25 MPH Freight Service

Based on conversation with Pan Am and observations, it is assumed that the current track speed is controlled by the general condition of the track, ties, and rail along the line and not the structures. Therefore, pending detailed inspection and bridge ratings, interim repairs to the structures are expected to be sufficient to address short term repairs to restore a 25 mph track speed. The opinion of cost for this work is shown in Table 6. The anticipated work includes minor repairs to address existing deterioration and needed short term maintenance items. Discussion of the various structures is included in the repair/rehabilitation comments in Section 4.4.2 below.

Table 6: Structure Cost Estimate - 25 mph for Freight Service

Structure Type	Quantity	Cost per Structure	Opinion of Cost	Comments
Rte 9/72 Tunnels	2	-----	$0	
Terryville Tunnel	1	-----	----	See write-up on tunnel
Culverts	40	-----	$0	
Concrete Pipe	1	-----	$0	
Stone Arches	3	$20,000	$60,000	
Concrete Arches	10	$20,000	$200,000	
Concrete Slab	1	$0	$0	
Prestress with Closed Deck	1	-----	$0	
Steel with Closed Deck	5	$0	$0	Newer structures
Steel with Closed Deck	1	$75,000	$75,000	Original structure
Steel Beam with Open Deck	21	$40,000	$840,000	Localized repairs
Rail Top with Closed Deck	2	$40,000	$80,000	Localized repairs
Timber Trestle	1	$75,000	$75,000	Misc. repairs
		Subtotal	$1,330,000	(excludes Terryville Tunnel)
		Minor Items (25%)	$332,500	
		Subtotal	$1,662,500	
		Rounded Total	**$1,663,000**	Estimate does not include contingency

4.4.2 Restore Structures to a State of Good Repair and 25 MPH Freight Service

Structures are considered in a state of good repair if the structure has a useful life in excess of 20 years with only routine maintenance required, can be expected to maintain 25 mph speeds without load restrictions for this period, and that there are no safety and operational issues.

In order to bring the line up to a state of good repair, bridge rehabilitation and in some cases bridge replacement may be required. The bridge rehabilitations may be constructed in a phased sequence based upon prioritized needs.

Table 7 summarizes the costs by structure type. Table C in the Appendix provides a breakdown by bridge with culverts not listed individually

Table 7: Structure Cost Estimate - Restore Structures to State of Good Repair

Structure Type	Qty.	Rehab	Replace	Opinion of Cost	Notes
Rte 9/72 Tunnels	2	0	0	$0	
Terryville Tunnel	1	------	------	----	See Chapter 5
Culverts & Concrete Pipes	40	36	4	$1,116,000	Inc. $10k ea. for repairs
Concrete Pipe	1	0	0	$0	
Stone Arches	3	3	0	$540,000	
Concrete Arches	10	10	0	$4,882,500	
Concrete Slab	1	1	0	337,500	
Prestressed with Closed Deck	1	0	0	$0	
Steel with Closed Deck	6	1	0	$960,000	
Steel Beam with Open Deck	21	21	0	$10,377,600	
Rail Top with Closed Deck	2	2	0	$360,000	
Timber Trestle	1	1	0	$474,000	
			Subtotal	$19,047,600	
			Minor Items (25%)	$4,761,900	
			Subtotal	$23,809,500	
			Rounded Total	**$23,810,000**	Estimate does not include contingency

4.5 Cost Estimate - Restore Structures for Class III Freight Service

The additional speeds for Class III Freight Service will increase the impact loading on the structures and additional load evaluation. For budget purposes it is assumed that three of the steel beam bridges with open deck will require superstructure replacement.

4.6 Cost Estimate - Restore Structures for Class III Passenger Service

No additional structure work is anticipated to upgrade the line from Class III Freight to Class III Freight and Passenger.

Chapter 5. Terryville Tunnel

The scope of work completed for this phase of the project includes inspection of the Terryville Tunnel and an assessment of the work required to repair the existing tunnel concrete lining. An estimate has also been completed of the appropriate budget allowance that should be included in this planning level study for the completion of this work.

This study included several high rail trips and a walk through of the tunnel along with research of the available background information. If the project proceeds a more detailed study will be required to fully develop an appropriate scope of work and budget for this repair work. The recommended components for these further investigations are outlined at the end of this report.

This planning level study has assumed the following:

- At this stage only the work required to repair the existing tunnel for continued freight train use has been considered. Any regulatory issues associated with the continued use of the tunnel for freight or the conversion of the tunnel from freight to passenger use are not part of this report, but will be considered under the alternatives review for passenger rail service.

- The change in use from freight to passenger rail will be governed by a range of regulations. A number of additional issues will need to be considered including the requirements for:
  - Lighting
  - Ventilation
  - Emergency passenger egress
  - Fire suppression systems
  - Water control measures

5.1 Approach

This is a planning level study and the level of effort reflects the conceptual stage of this project. A complete walk through of the tunnel was accomplished on October 8th 2014 by Nick Eldred and Stephen Gazillo of URS. The tunnel was visually inspected and photographed during the walk through. A measuring wheel was used to approximately establish locations in the tunnel and the length and proportion of the tunnel categories described in this report. Detailed plans of the tunnel were not available.

5.2 Background

The section of rail line between Hartford and Waterbury, CT was opened in July 1855. At that time the route included a winding section of track that that crossed the hills between the towns of Terryville/ Bristol to the east and Waterbury to the west. The Terryville Tunnel was constructed between 1906 and 1911 to replace this section of winding, steep track and the tunnel was opened in January 1911. Initially double tracked the line was single tracked in 1939[7] and used for

[7] Gigure, Judith (July 2011). "The Piquabuck Tunnel". Plymouth Town History

passenger service until 1962. The line is currently used for freight services by Pan Am Southern.

The tunnel is 3,580 feet long, horseshoe shaped with a reported height of 24' and width of 36'[8] (Figure 7). At this time it has not been possible to locate the original design or construction records for the project. The information currently available includes: a series of historical photographs; contemporary newspaper articles; and the geological map for the area.

Figure 7: Western Entrance to the Terryville Tunnel

The cover above the tunnel was estimated at up to 250' in some areas. The overlying land is a mixture of farmland and woods with a number of streams and one significant pond towards the western end of the tunnel.

The geological map and historical photographs indicate the tunnel was excavated through rock by drill and blast techniques. The geological map shows the tunnel passing through metamorphic rocks, predominately schist and granofels of the Goshen Formation and Southington Mountain Member. The tunnel appears to have been excavated in at least two headings (see Figure 8, Figure 9, and Figure 10), an initial top heading to form the crown of the tunnel and a second heading for the lower section of the tunnel. No information is available regarding primary support requirements for the rock mass during excavation. Photographs indicate a reasonably competent rock mass that in some areas may have had a stand up time without support of days or weeks while other photographs show the use of temporary wooden supports (Figure 11). The photographs also indicate an excavated tunnel with "slabby" over break consistent with drill and blast excavation in a metamorphic foliated rock mass. Based on

[8] Verbal report by Pan Am engineer and estimated on site by URS.

the geological map and the available photographs foliation appears to strike at approximately 45 degrees to the tunnel alignment, dipping to the south.

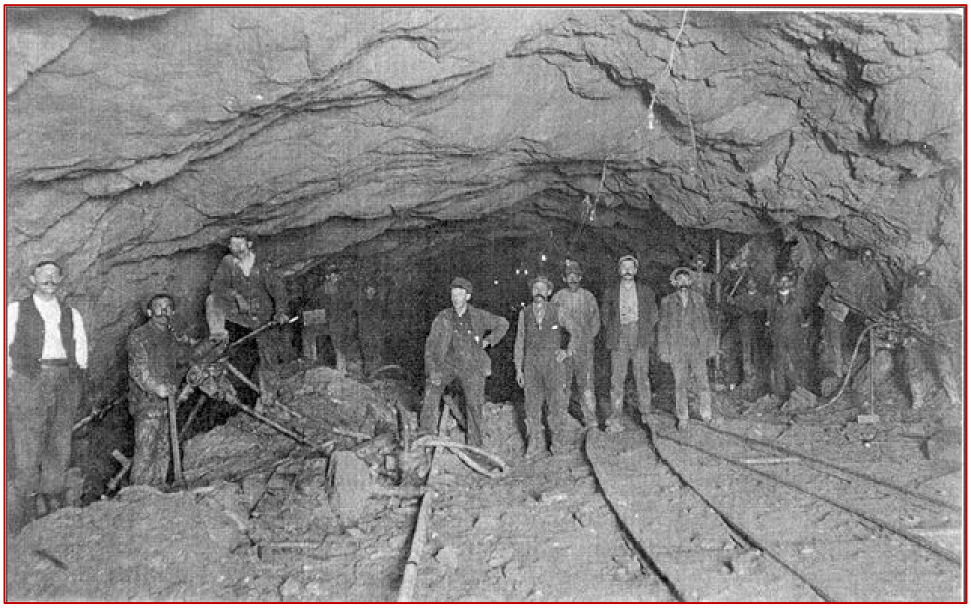

Figure 8: Terryville Tunnel during Construction

Figure 9: Top Heading during Construction

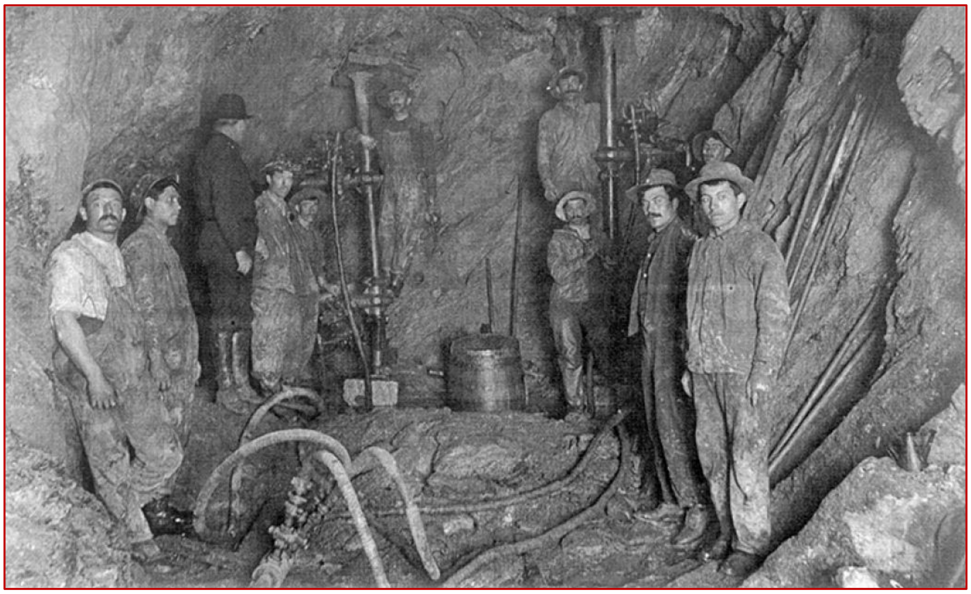

Figure 10: Tunnel Face during Construction

Figure 11: Wooden Support Used during Tunnel Excavation

Cast-in-place concrete was installed as a support system/tunnel lining. It is unclear how long after excavation of each heading the concrete was placed. Observations described below indicate the concrete lining is up to 36" thick and has at least some steel reinforcement (Figure 9 shows concrete lining in place in the top heading at the tunnel portal during construction).

Contemporary newspaper articles report a "cave in" of the tunnel during construction in 1908.[9] Based on the report this appears to be associated with slope failure at one of the open cut

[9] http://www.centralctrailstudy.com/docs/HistoricTerryvilleTunnelPhotos.pdf

excavation for the tunnel portals rather than an underground rock mass failure. The event is reported to have followed a period of heavy rain which is a common trigger of slope failures.

5.3 Field Observations

The following observations were made during the field visit:

- The tunnel can be broadly divided into three categories with respect to the observed condition of the existing concrete lining. These categories are described below. In general, groundwater seepage has had a significant impact on the tunnel conditions. Where seepage has occurred the condition of the tunnel lining has degraded significantly compared to areas where no seepage is evident. Near the tunnel entrances the deleterious effects of groundwater seepage appear to have been further exacerbated by freeze/thaw action.
- As described above, the tunnel is a horseshoe shape with a height to crown above track level of approximately 24’ and a tunnel width of approximately 36’. Based on the available historical photographs the concrete lining was poured in three sections, the crown and two side walls. At approximately 500’ spacing’s along both side walls safe retreat alcoves were formed in the concrete walls. These are approximately 36” deep, 7’ high and 4’ wide. At two locations larger alcoves have been formed (50”deep, 7’ high and 15” wide). These may have been used as magazine alcoves for the storage of blasting supplies during tunnel excavation.
- Regularly spaced 4” drainage holes were included through the concrete lining to allow groundwater to drain from the rock mass. The current status and performance of these drain holes is highly variable, as described below.
- In a number of locations failure of the concrete lining has exposed steel reinforcing within the concrete. It was not possible to determine the spacing or type of reinforcement with any certainty.
- As discussed above, a single track was relocated to the center of the tunnel in 1939. The area to either side of the track is filled with ballast and the invert of the tunnel was not observed during this inspection. Standing water in the ballast was observed on the northern and southern sides of the tunnel from approximately 50’ inside the tunnel to the eastern tunnel portal. Otherwise the ballast was superficially dry. In areas of degraded tunnel lining, material that has fallen off the walls has been allowed to accumulate on the tunnel invert. This appears to have been allowed to accumulate for many years (See Figure 12).
- At some point in the past a significant amount of remedial work appears to have been undertaken in the more degraded sections of tunnel lining. Steel mesh and concrete has been used to patch degraded areas of the original lining. No record is available of when this work was completed but based on observations it is likely to be a long period in the past. In a number of areas these remedial patches have subsequently failed, largely due to groundwater issues, as described below (see Figure 13).

Figure 12: Current Single Track and Water around Invert
(also note accumulation of debris at toe of sidewalls)

Figure 13: Past Repair Work to Tunnel Crown
(date of work unknown)

5.4 Tunnel Lining Category

The following three categories have been used to describe the current condition of the tunnel lining system and to make preliminary recommendations regarding potential repairs. The tunnel inspection used the USDDT Highway and Rail Transit Tunnel Inspection Manual (2005) terminology to describe the condition of the tunnel concrete lining. All tunnel stations in this report are in feet starting from Station 0+00 at the western tunnel portal. It should be recognized that all observations and recommendations in this report are preliminary. An outline of recommended tasks required to further investigate the tunnel are provided at the end of this report. It should also be noted that the tunnel invert could not be observed and the condition is unknown along with any drainage system that may be located under the railroad ballast.

5.4.1 Category 1

In these sections of the tunnel the original tunnel lining system is largely intact. The concrete lining is characterized by areas of minor scaling (less than 5% of tunnel surface), occasional minor to moderate cracks (spacing in excess of 20') and occasional spalling or pop outs (typically less than 1' in diameter and less than 1% of tunnel surface). Staining of the concrete surface is extensive (approximately 80% of lining) with localized areas of efflorescence (less than 10%). When struck with a hammer, the concrete had a ringing sound with no evidence of delamination.

These sections of the tunnel were largely dry which appears to have been a significant determining factor in the performance of the concrete lining. Drain holes were typically dry or occasionally damp.

No past remedial works were observed in these sections of the tunnel.

This category of tunnel was observed between Station 10+00 to 24+00 and 26+00 to 29+00 along with other small sections. For preliminary estimation purposes this category is estimated to represent 50% of the tunnel length.

5.4.2 Category 2

In these sections of the tunnel some degradation of the original tunnel lining system has occurred. The concrete lining is characterized by more significant areas of minor to severe scaling (up to 20% of tunnel surface). Cracking is more frequent (spacing less than 20 feet and minor to severe. Spalling and pop outs are also more frequent (5% of tunnel surface) and minor to severe with some up to 24" in size with exposed reinforcement. Staining is extensive (in excess of 80% of tunnel surface) and efflorescence is more frequent (10 to 20% of tunnel surface), typically associated with areas of seepage from drainholes although no flowing water was observed in these sections of tunnel.

Past remedial works were either minor or absent from these sections of tunnel.

This category of tunnel was observed between Station 24+00 and 26+00 and 29+00 to 33+00. Other small sections were observed. For preliminary estimation purposes this category is estimated to represent 20% of the tunnel length. Figure 14 shows an example of the tunnel crown in one of these sections.

Figure 14: Tunnel Crown

5.4.3 Category 3

In these sections of tunnel the original lining, and often the later remedial lining works, are typically extensively degraded. The concrete lining is characterized by extensive areas of minor to severe scaling (up to 80% of tunnel surface – Figure 15). Furthermore, in localized areas (approximately 5% of tunnel area) the concrete lining has failed completely exposing the underlying rock mass or rock mass with a veneer of residual concrete (individual areas up to 30 square feet) – Figure 16. These failures occur most frequently towards the base of the sidewalls or in the back wall of the safe retreat alcoves where the concrete thickness is significantly less (approximately 3”) – Figure 17. However, they can also occur in the crown. In addition, in some of these failed areas the concrete has lost integrity, being reduced to a dense sand/gravel mix that can be excavated by a geological hammer – Figure 18. In all these areas reinforcing is frequently exposed and is either severally rusted or lost completely – Figure 19.

Cracking is extensive (spacing less than 10’) and minor to severe. Staining is also extensive (greater than 90% of tunnel surface) and efflorescence is common (50 to 70% of tunnel surface). As discussed above, old remedial works were focused in these areas and have now also frequently degraded or failed (Figure 20).

Figure 15: Extensive Scaling from Walls at Eastern Portal

Figure 16: Local Failure of Concrete Lining and Exposure of Rock

Figure 17: Failure of Alcove Lining Exposing Rock Mass (note flowing groundwater)

Figure 18: Concrete Reduced to a Dense Sand/Gravel Mix

Figure 19: Exposed and Rusted Reinforcing

Figure 20: Failed Remedial Works – Steel Mesh/Concrete

Water is a common theme throughout Category 3 sections and seepage or inflows are typically associated with areas of significant lining failure. Some flows of up to 10 to 15 gallons per hour were observed from drain holes or areas of failed lining. In some locations water could be observed flowing out of the interface between the lining and underlying rock mass where lining failures had occurred. In many areas drain holes have become blocked by efflorescence build up.

This category of tunnel was observed from the eastern portal to around Station 33+40 and from the western portal to around Station 10+00. Groundwater inflows to the tunnel in the portal areas are likely to be associated with a lower depth of cover above the tunnel and consequently a more weathered and permeable rock mass. In addition, a number of water features including a large pond are located above the tunnel from around Station 3+00 to 10+00 which may be the source of groundwater inflows in this area. Freeze/thaw actions appears to have exacerbated the damage to the lining within approximately 300' of each portal.

For preliminary estimation purposes this category is estimated to represent 30% of the tunnel length.

5.5 Preliminary Recommendations – Structural Repair of the Tunnel Lining

5.5.1 Category 3

For planning purposes it has been assumed that all of the concrete lining on the side walls and crown will need to be replaced for category 3 tunnel sections. The status of the invert could not be determined and for planning purposes it has been assumed to be adequate for current rail use. A number of options are available for lining replacement. For planning purposes the following option has been assumed:

- The tunnel lining will be replaced in discrete sections to ensure tunnel stability is maintained and operations can be withdrawn from the tunnel to allow continued freight use (assumed to be once per week). Sections will be cut and concrete lining removed by road header or similar.
- Rock bolts installed as necessary to stabilize the rock masses behind the lining.
- Groundwater drainage system installed including regularly spaced drainage holes and/or drainage layer where required to channel significant flows to the tunnel invert.
- Mesh and/or fiber reinforced shotcrete, or cast-in-place reinforced concrete replacement lining.

5.5.2 Category 2

These sections of tunnel are assumed to require localized repair of the tunnel lining system. These localized areas may be repaired using a similar approach to that described for Category 3. For planning purposes it has been assumed 20% of this category lining will require repair or complete replacement. As this category represents approximately 20% of the whole tunnel length the actual additional length requiring repair is estimated to be 4% of tunnel length.

5.5.3 Category 1

These sections of the tunnel are assumed to require minimal work beyond cleaning of drainholes and minor concrete patch works. A 40% contingency has been included in the budget below to allow for this work and other uncertainties at this budget planning stage.

5.6 Budget Allowance

URS has completed a number of tunnel repair projects in the US. Based on these projects and other available unit rate information[10] a linear foot rate of $10,000 has been assumed for the repairs described above. All Category 3 and 20% of category 2 will require replacement which equates to 54% of the total tunnel length or 1,933 feet. Therefore, the estimate for budgetary purposes to complete this work is $19.33M.

As discussed above, at this stage a 40% contingency for budgetary purposes is appropriate giving a total budget for the tunnel of $27.06M.

5.7 Further Investigations

Further investigations are recommended to include the following components:

- Locating and review of any available construction, inspection and maintenance records for the tunnel.
- Review of relevant geological and geotechnical experience at other locations in these ground conditions.
- A more detailed inspection and logging of the existing tunnel conditions.
- Drilling of investigation cores through the tunnel lining and into the underlying rock mass at selected locations. This will assist in characterizing the existing lining (particularly where it is currently assumed to be competent and not require replacement). Drill holes should be extended into the underlying rock mass to allow characterization of the geological conditions.
- In-situ and laboratory testing of the concrete lining and underlying rock mass to assist in characterization.
- Test pits in the railroad ballasted area to expose and characterize the tunnel invert and any associated drainage system.

[10] RS Means, Heavy Construction Cost data, 28th Annual Edition, 2014

Chapter 6. Conceptual Cost Estimates

This chapter contains three tables which summarize the estimated program costs for varying levels of improvement to the line.

Table 8 summarizes the costs for line improvements to go from the current condition to FRA Class II Track in a State of Good Repair for 25 MPH freight use.

Table 9 summarizes the additional costs for line improvements to go from FRA Class 2 Track in a State of Good Repair for 25 MPH freight use to FRA Class III Track for freight use. Note that from current conditions the costs would be the combined total of Table 8 Table 9 (summarized in Table 11).

Table 10 summarizes the additional costs for line improvements to go from FRA Class III Track for freight use to FRA Class III Track for passenger use. Note that from current conditions the costs would be the combined total of Table 8, Table 9, and Table 10 (summarized in Table 11). An estimated cost for the tunnel to accommodate passenger trains is still to be determined.

Table 8: Current Condition to Class II Freight in SGR, Conceptual Cost Estimate

FTA SCC	ITEM DESCRIPTION	UNIT	QTY	UNIT COST	COSTS	CONTIN-GENCY	COSTS w/ CONTINGENCY
10	**Guideway and Track Structures**						
10.11	Track: Ballasted						
	Main Line Trackwork						
	Ballast Shoulder Replacement	Mile	20.9	$ 150,000	$ 3,135,000	40%	$ 4,389,000
	Undercutting	Mile	3.0	$ 270,000	$ 810,000	40%	$ 1,134,000
	Surface Track w/33% Timber Tie Replacement	Mile	23.9	$ 291,000	$ 6,955,000	40%	$ 9,737,000
	RR Flagman/Protection	2%	of CCS Item		$ 218,000	40%	$ 305,000
	Mobilization, MPT, Grubbing	11%	of CCS Item		$ 1,199,000	40%	$ 1,679,000
					$ 12,317,000		$ 17,244,000
10	**Cost Category Total**				**$ 12,317,000**		**$ 17,244,000**
40	**Sitework & Special Conditions**						
40.02	Site Utilities, Utility Relocation						
	Main Line Trackwork						
	Ditch Cleaning	Mile	23.9	$ 138,000	$ 3,298,000	40%	$ 4,617,000
	RR Flagman/Protection	2%	of CCS Item		$ 66,000	40%	$ 92,000
	Mobilization, MPT, Grubbing	11%	of CCS Item		$ 363,000	40%	$ 508,000
					$ 3,727,000		$ 5,217,000
40.05	Site Structures						
	Bridge and Tunnels						
	Initial Repairs	LS	1		$ 1,663,000	40%	$ 2,328,000
	Rehabilitaion/Replacement	LS	1		$ 23,810,000	40%	$ 33,334,000
	Terryville Tunnel Rehab	LS	1		$ 19,330,000	40%	$ 27,062,000
	RR Flagman/Protection	2%	of CCS Item		$ 896,000	40%	$ 1,254,000
	Mobilization, MPT, Grubbing	11%	of CCS Item		$ 4,928,000	40%	$ 6,899,000
					$ 50,627,000		$ 70,877,000
40.07	Vehicular Access and Parking Lots						
	Grade Crossing Improvements						
	Pre-cast Crossing Panels without Roadway Improvements	EA	19	$ 125,000	$ 2,375,000	40%	$ 3,325,000
	Private Grade Crossing Renewal	EA	2	$ 31,000	$ 62,000	40%	$ 87,000
	RR Flagman/Protection	2%	of CCS Item		$ 49,000	40%	$ 69,000
	Mobilization, MPT, Grubbing	11%	of CCS Item		$ 268,000	40%	$ 375,000
					$ 2,754,000		$ 3,856,000
40	**Cost Category Total**				**$ 57,108,000**		**$ 79,950,000**
	CONSTRUCTION TOTAL (SCC 10-50)				**$ 69,425,000**		**$ 97,194,000**
80	**Professional Services**						
80.01	Preliminary Engineering	4%	of Construcion Cost		$ 2,777,000	40%	$ 3,888,000
80.02	Final Design	8%	of Construcion Cost		$ 5,554,000	40%	$ 7,776,000
80.03	Project Mng for Design & Construction						$ -
	CTDOT Project Mangement	3%	of Construcion Cost		$ 2,083,000	40%	$ 2,916,000
	Amtrak & Pan Am Force Accounts	1%	of Construcion Cost		$ 694,000	40%	$ 972,000
80.04	Construction Admin & Mng	10%	of Construcion Cost		$ 6,943,000	40%	$ 9,720,000
80	**Cost Category Total**				**$ 18,051,000**		**$ 25,272,000**
90	**Unallocated Contingency**						
90.00	Unallocated Contingency	15%	of Construcion Cost		$ 10,414,000	40%	$ 14,580,000
90	**Cost Category Total**				**$ 10,414,000**		**$ 14,580,000**
	NON-BID TOTAL (SCC 60-100)				**$ 28,465,000**		**$ 39,852,000**
	TOTAL PROGRAM ESTIMATE				**$ 97,890,000**		**$ 137,046,000**
					2014 Costs		2014 Costs

Table 9: Class II SGR to Class III Freight, Conceptual Cost Estimate

FTA SCC	ITEM DESCRIPTION	UNIT	QTY	UNIT COST	COSTS	CONTIN-GENCY	COSTS w/ CONTINGENCY
10	**Guideway and Track Structures**						
10.11	Track: Ballasted						
	Main Line Trackwork						
	Surface Track w/33% Timber Tie	Mile	23.9	$ 291,000	$ 6,955,000	40%	$ 9,737,000
	Line and Surface with 2" Ballast Lift	TF	126,192	$ 11	$ 1,388,000	40%	$ 1,943,000
	RR Flagman/Protection	2%	of CCS Item		$ 167,000	40%	$ 234,000
	Mobilzation, MPT, Grubbing	11%	of CCS Item		$ 918,000	40%	$ 1,285,000
					$ 9,428,000		$ 13,199,000
10	**Cost Category Total**				**$ 9,428,000**		**$ 13,199,000**
40	**Sitework & Special Conditions**						
40.05	Site Structures						
	Bridge and Tunnels						
	Assumed Replacement	LS	3	$ 1,500,000	$ 4,500,000	40%	$ 6,300,000
	RR Flagman/Protection	2%	of CCS Item		$ 90,000	40%	$ 126,000
	Mobilzation, MPT, Grubbing	11%	of CCS Item		$ 495,000	40%	$ 693,000
					$ 5,085,000		$ 7,119,000
40	**Cost Category Total**				**$ 5,085,000**		**$ 7,119,000**
50	**Systems**						
50.02	Crossing Protection						
	Upgrade Crossing Circuits for Increased Speed	EA	19	$ 34,000	$ 646,000	40%	$ 904,000
	RR Flagman/Protection	2%	of CCS Item		$ 13,000	40%	$ 18,000
	Mobilzation, MPT, Grubbing	11%	of CCS Item		$ 71,000	40%	$ 99,000
					$ 730,000		$ 1,021,000
50	**Cost Category Total**				**$ 730,000**		**$ 1,021,000**
	CONSTRUCTION TOTAL (SCC 10-50)				**$ 15,243,000**		**$ 21,339,000**
80	**Professional Services**						
80.01	Preliminary Engineering	4%	of Construcion Cost		$ 610,000	40%	$ 854,000
80.02	Final Design	8%	of Construcion Cost		$ 1,219,000	40%	$ 1,707,000
80.03	Project Mng for Design & Construction						
	CTDOT Project Mangement	3%	of Construcion Cost		$ 457,000	40%	$ 640,000
	Amtrak & Pan Am Force Accounts	1%	of Construcion Cost		$ 152,000	40%	$ 213,000
80.04	Construction Admin & Mng	15%	of Construcion Cost		$ 2,286,000	40%	$ 3,200,000
80	**Cost Category Total**				**$ 4,724,000**		**$ 6,614,000**
90	**Unallocated Contingency**						
90.00	Unallocated Contingency	15%	of Construcion Cost		$ 2,286,000	40%	$ 3,200,000
90	**Cost Category Total**				**$ 2,286,000**		**$ 3,200,000**
	NON-BID TOTAL (SCC 60-100)				**$ 7,010,000**		**$ 9,814,000**
	TOTAL PROGRAM ESTIMATE				**$ 22,253,000**		**$ 31,153,000**
					2014 Costs		2014 Costs

Table 10. Class III Freight to Class III Passenger, Conceptual Cost Estimate

FTA SCC	ITEM DESCRIPTION	UNIT	QTY	UNIT COST	COSTS	CONTIN-GENCY	COSTS w/ CONTINGENCY
10	**Guideway and Track Structures**						
10.11	Track: Ballasted						
	Main Line Trackwork						
	Rail Replacement CWR	LF	249,914	$ 62	$ 15,495,000	40%	$ 21,693,000
	Field Weld	EA	361	$ 775	$ 280,000	40%	$ 392,000
	Passing Siding						
	New 136# CWR Track, Complete w/ Wood Ties	EA	10,000	$ 210	$ 2,100,000	40%	$ 2,940,000
	RR Flagman/Protection	2%	of CCS Item		$ 358,000	40%	$ 501,000
	Mobilzation, MPT, Grubbing	11%	of CCS Item		$ 1,966,000	40%	$ 2,752,000
					$ 20,199,000		$ 28,278,000
10.12	Track Special						
	Main Line Trackwork						
	Turnout Removal #9	EA	17	$ 3,950	$ 67,000	40%	$ 94,000
	Turnout Installation #9, Timber	EA	17	$ 68,200	$ 1,159,000	40%	$ 1,623,000
	Diamond Crossing Removal	EA	1	$ 4,270	$ 4,000	40%	$ 6,000
	Diamond Crossing	TF	1	$ 77,500	$ 78,000	40%	$ 109,000
	Passing Siding						
	Turnout Insallation - #15, Timber	EA	4	$ 170,000	$ 680,000	40%	$ 952,000
	RR Flagman/Protection	2%	of CCS Item		$ 40,000	40%	$ 56,000
	Mobilzation, MPT, Grubbing	11%	of CCS Item		$ 219,000	40%	$ 307,000
					$ 2,247,000		$ 3,147,000
10	**Cost Category Total**				**$ 22,446,000**		**$ 31,425,000**
20	**Stations, Stops, Terminals**						
20.01	At-grade station, stop, shelter, platform				TBD		TBD
40	**Sitework & Special Conditions**						
40.05	Site Structures				TBD		TBD
	Terryville Tunnel Passenger Upgrades						
50	**Systems**						
50.01	Train Control						
	Train Signalling						
	Install CTC System (Single Track)	Mile	25.9	$ 1,000,000	$ 25,900,000	40%	$ 36,260,000
	Install PC System Overlay	RM	23.9	$ 200,000	$ 4,780,000	40%	$ 6,692,000
	Electric Lock and Derail for Industry Turnout	EA	17	$ 124,000	$ 2,108,000	40%	$ 2,951,000
	RR Flagman/Protection	2%	of CCS Item		$ 656,000	40%	$ 918,000
	Mobilzation, MPT, Grubbing	11%	of CCS Item		$ 3,607,000	40%	$ 5,050,000
					$ 37,051,000		$ 51,871,000
50	**Cost Category Total**				**$ 37,051,000**		**$ 51,871,000**
	CONSTRUCTION TOTAL (SCC 10-50)				**$ 59,497,000**		**$ 83,296,000**
70	**Vehicles**						
70.01	Light Rail				TBD		TBD
	Refurbished Passenger Rolling Stock						
80	**Professional Services**						
80.01	Preliminary Engineering	4%	of Construcion Cost		$ 2,380,000	40%	$ 3,332,000
80.02	Final Design	8%	of Construcion Cost		$ 4,760,000	40%	$ 6,664,000
80.03	Project Mng for Design & Construction						
	CTDOT Project Mangement	3%	of Construcion Cost		$ 1,785,000	40%	$ 2,499,000
	Amtrak & Pan Am Force Accounts	1%	of Construcion Cost		$ 595,000	40%	$ 833,000
80.04	Construction Admin & Mng	15%	of Construcion Cost		$ 8,925,000	40%	$ 12,495,000
80	**Cost Category Total**				**$ 18,445,000**		**$ 25,823,000**
90	**Unallocated Contingency**						
90.00	Unallocated Contingency	15%	of Construcion Cost		$ 8,925,000	40%	$ 12,495,000
90	**Cost Category Total**				**$ 8,925,000**		**$ 12,495,000**
	NON-BID TOTAL (SCC 60-100)				**$ 27,370,000**		**$ 38,318,000**
	TOTAL PROGRAM ESTIMATE				**$ 86,867,000**		**$ 121,614,000**
					2014 Costs		2014 Costs

1) Does not include: Modifications to Terryville Tunnel, Stations, Rolling Stock

Table 11: Total Conceptual Cost Estimate for Each Track Class

FRA Track Class	Cost	Cost w/ Contingency
Class II State of Good Repair (TOTAL)	***$97,890,000***	***$137,046,000***
Class III *(Incremental Cost)*	$22,253,000	$31,153,000
Class III (TOTAL)	***$120,143,000***	***$168,199,000***
Class III w/ Passenger Upgrades *(Incremental Cost)**	$86,867,000	$121,614,000
Class III w/ Passenger Upgrades (TOTAL)*	***$207,010,000***	***$289,813,000***

**Cost for passenger service does not include: stations, equipment, or improvements to Terryville Tunnel*

Appendix

Table A: Pan Am Southern Bridges, Crossing and Culverts: Berlin to Waterbury

Table B: Pan Am – Waterbury Line Bridges

Table C: Conceptual Cost Estimate – Restore Structures to State of Good Repair Service – Structure Summary

Table A: Pan Am Southern Bridges, Crossing and Culverts: Berlin to Waterbury									
CCRS No.	**Type**	**Feature Crossed**	**Structure Type**	**Deck Type**	**No. of Spans**	**Max Span**	**Total Length**	**Built**	**Comment**
		NEW BRITIAN							
0.4	X-ing	Vincent X-ing	X-ing						
0.5	X-ing	Brick Yard X-ing	X-ing						
0.52	< 5ft	Culvert	Culvert						
0.6	RR Bridge	Farmway Crossing	I-Beam	Open	1	28	28	1912	
0.7	RR Bridge	Stream	Timber Trestle	Open	3	79	79	---	
0.8	RR Bridge	Rte 372 Connector	Thru Girder	Concrete Slab	2	68	138	---	State Br. 1100. 1 track structure
0.9	RR Bridge	New Britain Machine Co	Deck Girder	Open	1	28	28	1918	
1.0	Tunnel	Rte 9 (Tunnel Under)	Concrete Arch		1	20	670	1966	State Br 3508
1.1	< 5ft	Culvert	Culvert						
1.1	X-ing	South Street	X-ing						
1.6	Overhead	Ellis Street		Concrete Slab	1	81	81		
1.97	X-ing	Whitting St	X-ing						
2.0	< 5ft	Culvert	Culvert						
2.1	RR Bridge	Rte 9	Deck Girder	Iron Plates, Ballast	3	125	377	1977	1 track structure
2.37	X-ing	Chestnut St	X-ing						
2.38	X-ing	Shopping Center	X-ing						
2.39	X-ing	Private Crossing							
2.4	Overhead	Stanley Street (Rte 71)							
2.65	X-ing	Main St	X-ing						Start Busway
2.7	< 5ft	Box Culvert	Culvert						
2.75	X-ing	Washington St	X-ing						
2.85	X-ing	High St	X-ing						
2.9	RR Bridge	Rte 72	Prestress Conc	Concrete Slab	2	83	168	1978	State Br 4247
3.2	Overhead	Footbridge	Thru Truss	Concrete Slab	1	84	84	1917	
PLAINVILLE									

Table A: Pan Am Southern Bridges, Crossing and Culverts: Berlin to Waterbury

CCRS No.	Type	Feature Crossed	Structure Type	Deck Type	No. of Spans	Max Span	Total Length	Built	Comment
3.50	X-ing	Curtis Street	X-ing						
3.6	X-ing	Private Crossing							
3.7	Overhead	West Main Street	I-Beam	Concrete Slab	1	46	46	1930	
4.1	Overhead	Corbin Ave	I-Beam	Concrete Slab	3	107	107	1937	
4.15	< 5ft	Culvert	Culvert						
4.2	< 5ft	Culvert	Culvert						
4.25	< 5ft	Culvert	Culvert						
4.30	X-ing	Wooster St	X-ing						
4.6	RR Bridge	Stream	Deck Girder	Open	1	23	23	1937	State Br 3320
4.7	Overhead	Rte I-84 On Ramp	I-Beam	Concrete Slab	1	90	90		
4.8	Overhead	Rte I-84 Off Ramp	I-Beam	Concrete Slab	1	90	90		
4.85	Overhead	Adv Sign	Steel Trestle	Metal Grate	1	33	33	1971	
4.9	Overhead	Rte I-84 EB	I-Beam	Concrete Slab	1	0			
5.1	Overhead	Rte I-84 WB	I-Beam	Concrete Slab	2	90	90		
4.8	< 5ft	Culvert	Culvert		2				
4.85	< 5ft	Culvert	Culvert		2				
5.5	RR Bridge	Stream	Deck Girder	Open	1	23	23	1903	
5.8	Overhead	Crooked Street	I-Beam	Concrete Slab	3	0	188		
5.9	RR Bridge	Stream	Deck Girder	Open	1	23	23	1911	
6.2	Tunnel	Rte 72 (Tunnel Under)	Concrete Arch		1	40	455	1970	State Br 02911
6.4	RR Bridge	Ditch	Concrete Arch		2		20		20 ft span assumed
6.7	Removed	Pedestrian Bridge			2				Overhead removed since 2012
6.89	X-ing	East Street (Rte 10)	X-ing						
6.93	X-ing	East Main St (Rte 372)	X-ing						
7.00	X-ing	Neil Court	X-ing						
7.15	RR X-ing	Railroad X-ing (Diamond)	RR X-ing						
7.2	RR Bridge	Pequabuck River	Deck Girder	Open	1	92	92	1895	

Table A: Pan Am Southern Bridges, Crossing and Culverts: Berlin to Waterbury

CCRS No.	Type	Feature Crossed	Structure Type	Deck Type	No. of Spans	Max Span	Total Length	Built	Comment
7.7	Overhead	North Washington St.	Plate Girder	Concrete Slab	3	30	30	1961	
FORESTVILLE Town Line									
7.8	< 5ft	Culvert	Culvert						
7.85	Overhead	Rte. 72							
7.9	< 5ft	Culvert	Culvert						
8.85	RR Bridge	Culvert	Rail Top	Concrete Slab	1	6	6		
8.92	X-ing	Central Street	X-ing						
9.1	RR Bridge	Stream	Stone Arch		1	8	8		
9.15	RR Bridge	Culvert	Rail Top	Concrete Slab	1	10	10	1912	
9.2	RR Bridge	Pequabuck River	I-Beam	Open	2	19	38	1911	
BRISTOL									
9.3	RR Bridge	Pequabuck River	Thru Girder	Open	2	49	98	1898	
9.35	X-ing	Broad Street	X-ing						
9.78	X-ing	Emmett Street	X-ing						
10.0	RR Bridge	Pequabuck River	Deck Girder	Open	1	62	62	1895	
10.2	RR Bridge	King St.	Thru Girder	Iron Plates / Ballast	1	95	95		State Br 3503. 1 track structure
10.25	< 5ft	Culvert	Culvert						
10.3	< 5ft	Culvert	Culvert						
10.4	Overhead	Blakelee St.		Open	1				Replaced with 1 span bridge
10.45	< 5ft	Culvert	Culvert						
10.9	RR Bridge	Mellen St.	Thru Girder	Open	1	56	56	1910	
11.2	< 5ft	Culvert	Culvert						
11.3	RR Bridge	Main St.	Thru Girder	Open	3	41	65	1900	
11.61	X-ing	Center Street	X-ing						
11.7	< 5ft	Culvert	Culvert						
11.92	X-ing	Federal Street	X-ing						
11.95	< 5ft	Culvert	Culvert						

Table A: Pan Am Southern Bridges, Crossing and Culverts: Berlin to Waterbury									
CCRS No.	**Type**	**Feature Crossed**	**Structure Type**	**Deck Type**	**No. of Spans**	**Max Span**	**Total Length**	**Built**	**Comment**
12.19	X-ing	Maple Street	X-ing						Combined with Farmington
12.20	X-ing	Farmington Ave	X-ing						Combined with Maple
12.4	Overhead	Burlington Ave.	Thru Girder	Plank & Ameisite	1	100	100	1992	Est. span from photo
12.5	Overhead	Curtiss (Conlon St.)	I-Beam	Concrete Slab	3	33	100	1910	
12.6	Overhead	N. Pond St.	I-Beam	Concrete Slab	3	33	103	1924	
12.65	RR Bridge	Culvert	Stone Arch		1	8	8		
12.7	RR Bridge	Stream	Stone Arch		1	8	8		
12.8	RR Bridge	Underpass	Concrete Slab		1	15	15		
12.9	RR Bridge	Culvert	Concrete Arch		1	8	8		
TERRYVILLE									
13.3	RR Bridge	Terryville Ave	Thru Girder	Open	3	56	102	1910	State No 00472
13.5	< 5ft	Culvert	Culvert						
13.6	Utility	Water Main							
14.01	X-ing	Farrell Ave	X-ing						
14.1	RR Bridge	Brook	Concrete Arch		1	15	15		
14.4	RR Bridge	Barlow St.	Concrete Arch		1	20	20	1906	
14.5	RR Bridge	Culvert	Concrete Arch		1	8	8	1906	
14.6	RR Bridge	Clark Avenue	Deck Girder	Concrete Slab	1	60	60		State Br 3633
15.1	RR Bridge	Terryville Ave (Rte 72)	Thru Girder	Open	1	76	76	1907	State Br 1107
15.3	RR Bridge	Pequabuck River	Concrete Arch		1	41	41	1906	
15.4	Tunnel	Tunnel	Concrete Arch		1	?	3580	1910	
15.9	RR Bridge	Hancock Brook	I-Beam	Open	2	15	30	1910	
16.4	< 5ft	Culvert	Culvert						
16.5	RR Bridge	Hancock Brook	Deck Girder	Open	1	35	35	1907	
16.9	RR Bridge	Hancock Brook	Deck Girder	Open	1	35	35	1907	
17.2	RR Bridge	Hancock Brook	Deck Girder	Open	2	24	48	1906	State Br 5534
17.3	Overhead	S. Eagle St.	Thru Girder	Plank &	1	38	38	"Not	

Table A: Pan Am Southern Bridges, Crossing and Culverts: Berlin to Waterbury

CCRS No.	Type	Feature Crossed	Structure Type	Deck Type	No. of Spans	Max Span	Total Length	Built	Comment
				Ameisite					
Orig"									
17.45	< 5ft	Culvert	Culvert						
17.6	RR Bridge	Hancock Brook	Concrete Arch		1	30	30	1906	
17.8	RR Bridge	Hancock Brook	Concrete Arch		1	30	30	1907	
17.85	< 5ft	Culvert	Culvert						
19.95	< 5ft	Culvert	Culvert						
18	RR Bridge	Hancock Brook	Concrete Arch		1	30	30		
18.4	RR Bridge	Hancock Brook	Concrete Pipe		1	6	6	1964	
19.4	Overhead	Graystone Road	I-Beam	Concrete Slab	2	56	112	1964	
20	< 5ft	Culvert	Culvert						
20.1	< 5ft	Culvert	Culvert						
WATERBURY									
20.5	< 5ft	Culvert	Culvert						
20.7	< 5ft	Culvert	Culvert						
20.8	< 5ft	Culvert	Culvert						
20.9	< 5ft	Culvert	Culvert						
21	< 5ft	Culvert	Culvert						
21.1	RR Bridge	Stream	Concrete Arch		1	15	15		
21.15	RR Bridge	Rigneys	I-Beam	Open	1	19	19	1908	
21.2	< 5ft	Culvert	Culvert						
21.4	< 5ft	Culvert	Culvert						
21.6	< 5ft	Culvert	Culvert						
21.8	< 5ft	Culvert	Culvert						
21.9	RR Bridge	Boyden St.	Deck Girder	Open	1	57	57	1907	
22.1	RR Bridge	Homer St.	Deck Girder	Closed	1	57	57	1996	
22.4	< 5ft	Culvert	Culvert						

Table A: Pan Am Southern Bridges, Crossing and Culverts: Berlin to Waterbury

CCRS No.	Type	Feature Crossed	Structure Type	Deck Type	No. of Spans	Max Span	Total Length	Built	Comment
22.5	< 5ft	Culvert	Culvert						
22.6	< 5ft	Culvert	Culvert						
22.7	< 5ft	Culvert	Culvert						
23.0	< 5ft	Culvert	Culvert						
23.1	< 5ft	Culvert	Culvert						
23.3	< 5ft	Culvert	Culvert						
24.05	RR Bridge	W. Main St.	Thru Girder	Orthotropic	3	67	100	1906	State Br 600R
24.1	RR Bridge	Crane St.	Thru Girder	Open	1	55	55	1906	State Br 9100R
24.2	RR Bridge	Freight St.	Deck Girder	Open	4	35	88	1907	State Br 4234R

1) Mileposts are estimated, except at grade crossings
2) Information from obtained from CONRAIL Undergrade and Overhead Structures Document dated January 1, 1981.

Table B: Pan Am – Waterbury Line Bridges

CCRS No.	Type	Feature Crossed	Structure Type	Deck Type	No. of Spans	Max Span	Total Length	Built	Comment
NEW BRITIAN									
0.6	RR Bridge	Farmway Crossing	I-Beam	Open	1	28	28	1912	
0.7	RR Bridge	Stream	Timber Trestle	Open	3	79	79	---	
0.8	RR Bridge	Rte 372 Connector	Thru Girder	Concrete Slab	2	68	138	---	State Br. 1100. 1 track structure
0.9	RR Bridge	New Britain Machine Co	Deck Girder	Open	1	28	28	1918	
1.0	Tunnel	Rte 9 (Tunnel Under)	Concrete Arch		1	20	670	1966	State Br 3508
2.1	RR Bridge	Rte 9	Deck Girder	Iron Plates, Ballast	3	125	377	1977	1 track structure
2.9	RR Bridge	Rte 72	Prestress Conc	Concrete Slab	2	83	186	1978	State Br 4247
PLAINVILLE									
4.6	RR Bridge	Stream	Deck Girder	Open	1	23	23	1937	State Br 3320
5.5	RR Bridge	Stream	Deck Girder	Open	1	23	23	1903	
5.9	RR Bridge	Stream	Deck Girder	Open	1	23	23	1911	
6.2	Tunnel	Rte 72 (Tunnel Under)	Concrete Arch		1	40	455	1970	State Br 02911
6.4	RR Bridge	Ditch	Concrete Arch		2		20		20 ft span assumed
7.2	RR Bridge	Pequabuck River	Deck Girder	Open	1	92	92	1895	
FORESTVILLE									
8.85	RR Bridge	Culvert	Rail Top	Concrete Slab	1	6	6		
9.1	RR Bridge	Stream	Stone Arch		1	8	8		
9.15	RR Bridge	Culvert	Rail Top	Concrete Slab	1	10	10	1912	
9.2	RR Bridge	Pequabuck River	I-Beam	Open	2	19	38	1911	
BRISTOL									
9.3	RR Bridge	Pequabuck River	Thru Girder	Open	2	49	98	1898	
10.0	RR Bridge	Pequabuck River	Deck Girder	Open	1	62	62	1895	
10.2	RR Bridge	King St.	Thru Girder	Iron Plates / Ballast	1	95	95		State Br 3503. 1 track structure
10.9	RR Bridge	Mellen St.	Thru Girder	Open	1	56	56	1910	

Table B: Pan Am – Waterbury Line Bridges									
CCRS No.	**Type**	**Feature Crossed**	**Structure Type**	**Deck Type**	**No. of Spans**	**Max Span**	**Total Length**	**Built**	**Comment**
11.3	RR Bridge	Main St.	Thru Girder	Open	3	41	65	1900	
12.65	RR Bridge	Culvert	Stone Arch		1	8	8		
12.7	RR Bridge	Stream	Stone Arch		1	8	8		
12.8	RR Bridge	Underpass	Concrete Slab		1	15	15		
12.9	RR Bridge	Culvert	Concrete Arch		1	8	8		
13.3	RR Bridge	Terryville Ave	Thru Girder	Open	3	56	102	1910	State No 00472
14.1	RR Bridge	Brook	Concrete Arch		1	15	15		
14.4	RR Bridge	Barlow St.	Concrete Arch		1	20	20	1906	
14.5	RR Bridge	Culvert	Concrete Arch		1	8	8	1906	
14.6	RR Bridge	Clark Avenue	Deck Girder	Concrete Slab	1	60	60		State Br 3633
15.1	RR Bridge	Terryville Ave (Rte 72)	Thru Girder	Open	1	76	76	1907	State Br 1107
15.3	RR Bridge	Pequabuck River	Concrete Arch		1	41	41	1906	
15.4	Tunnel	Tunnel	Concrete Arch		1	?	3580	1910	
15.9	RR Bridge	Hancock Brook	I-Beam	Open	2	15	30	1910	
16.5	RR Bridge	Hancock Brook	Deck Girder	Open	1	35	35	1907	
16.9	RR Bridge	Hancock Brook	Deck Girder	Open	1	35	35	1907	
17.2	RR Bridge	Hancock Brook	Deck Girder	Open	2	24	48	1906	State Br 5534
17.6	RR Bridge	Hancock Brook	Concrete Arch		1	30	30	1906	
17.8	RR Bridge	Hancock Brook	Concrete Arch		1	30	30	1907	
18	RR Bridge	Hancock Brook	Concrete Arch		1	30	30		
18.4	RR Bridge	Hancock Brook	Concrete Pipe		1	6	6	1964	
WATERBURY									
21.1	RR Bridge	Stream	Concrete Arch		1	15	15		
21.15	RR Bridge	Rigneys	I-Beam	Open	1	19	19	1908	
21.9	RR Bridge	Boyden St.	Deck Girder	Open	1	57	57	1907	
22.1	RR Bridge	Homer St.	Deck Girder	Closed	1	57	57	1996	
24.05	RR Bridge	W. Main St.	Thru Girder	Orthotropic	3	67	100	1906	State Br 600R

Table B: Pan Am – Waterbury Line Bridges

CCRS No.	Type	Feature Crossed	Structure Type	Deck Type	No. of Spans	Max Span	Total Length	Built	Comment
24.1	RR Bridge	Crane St.	Thru Girder	Open	1	55	55	1906	State Br 9100R
24.2	RR Bridge	Freight St.	Deck Girder	Open	4	35	88	1907	State Br 4234R

Table C: Conceptual Cost Estimate - Restore Structures to State of Good Repair - Structure Summary

CCRS No.	Feature Crossed	Structure Type	Total Length	Assumed Width	Bridge SF	Rehabilitation / Replacement	Unit Cost ($/SF)	Total Cost
NEW BRITIAN								
0.6	Farmway Crossing	I-Beam	28	12	336	Rehabilitation	$800	$268,800
0.7	Stream	Timber Trestle	79	12	948	Rehabilitation	$500	$474,000
0.8	Rte 372 Connector	Thru Girder	138	12	1,656	Not Req		
0.9	New Britain Machine Co	Deck Girder	28	12	336	Rehabilitation	$800	$268,800
1.0	Rte 9 (Tunnel Under)	Concrete Arch	670			Not Req		
2.1	Rte 9	Deck Girder	377			Not Req		
2.9	Rte 72 WB	Prestress Conc	377			Not Req		
PLAINVILLE								
4.6	Stream	Deck Girder	23	12	276	Rehabilitation	$800	$220,800
5.5	Stream	Deck Girder	23	12	276	Rehabilitation	$800	$220,800
5.9	Stream	Deck Girder	23	12	276	Rehabilitation	$800	$220,800
6.2	Rte 72 (Tunnel Under)	Concrete Arch	455			Not Req		
6.4	Ditch	Concrete Arch	20	50	1,000	Rehabilitation	$450	$450,000
7.2	Pequabuck River	Deck Girder	92	12	1,104	Rehabilitation	$800	$883,200
FORESTVILLE								
8.9	Culvert	Rail Top	6	50	300	Rehabilitation	$450	$135,000
9.1	Stream	Stone Arch	8	50	400	Rehabilitation	$450	$180,000
9.2	Culvert	Rail Top	10	50	500	Rehabilitation	$450	$225,000
9.2	Pequabuck River	I-Beam	38	12	456	Rehabilitation	$800	$364,800
BRISTOL								
9.3	Pequabuck River	Thru Girder	98	12	1,176	Rehabilitation	$800	$940,800
10.0	Pequabuck River	Deck Girder	62	12	744	Rehabilitation	$800	$595,200
10.2	King St.	Thru Girder	95	12	1,140	Not Req		
10.9	Mellen St.	Thru Girder	56	12	672	Rehabilitation	$800	$537,600
11.3	Main St.	Thru Girder	65	12	780	Rehabilitation	$800	$624,000

Table C: Conceptual Cost Estimate - Restore Structures to State of Good Repair - Structure Summary								
CCRS No.	**Feature Crossed**	**Structure Type**	**Total Length**	**Assumed Width**	**Bridge SF**	**Rehabilitation / Replacement**	**Unit Cost ($/SF)**	**Total Cost**
12.7	Culvert	Stone Arch	8	50	400	Rehabilitation	$450	$180,000
12.7	Stream	Stone Arch	8	50	400	Rehabilitation	$450	$180,000
12.8	Underpass	Concrete Slab	15	50	750	Rehabilitation	$450	$337,500
12.9	Culvert	Concrete Arch	8	50	400	Rehabilitation	$450	$180,000
TERRYVILLE								
13.3	Terryville Ave	Thru Girder	102	12	1,224	Rehabilitation	$800	$979,200
14.1	Brook	Concrete Arch	15	50	750	Rehabilitation	$450	$337,500
14.4	Barlow St.	Concrete Arch	20	50	1,000	Rehabilitation	$450	$450,000
14.5	Culvert	Concrete Arch	8	50	400	Rehabilitation	$450	$180,000
14.6	Clark Avenue	Deck Girder	60	12	720	Not Req		
15.1	Terryville Ave (Rte 72)	Thru Girder	76	12	912	Rehabilitation	$800	$729,600
15.3	Pequabuck River	Concrete Arch	41	50	2,050	Rehabilitation	$450	$922,500
15.4	Tunnel	Concrete Arch	3,580			See Other Table		
15.9	Hancock Brook	I-Beam	30	12	360	Rehabilitation	$800	$288,000
16.5	Hancock Brook	Deck Girder	35	12	420	Rehabilitation	$800	$336,000
16.9	Hancock Brook	Deck Girder	35	12	420	Rehabilitation	$800	$336,000
17.2	Hancock Brook	Deck Girder	48	12	576	Rehabilitation	$800	$460,800
17.6	Hancock Brook	Concrete Arch	30	50	1,500	Rehabilitation	$450	$675,000
17.8	Hancock Brook	Concrete Arch	30	50	1,500	Rehabilitation	$450	$675,000
18.0	Hancock Brook	Concrete Arch	30	50	1,500	Rehabilitation	$450	$675,000
18.4	Hancock Brook	Concrete Pipe	6	50	300	Not Req		
WATERBURY								
21.1	Stream	Concrete Arch	15	50	750	Rehabilitation	$450	$337,500
21.2	Rigneys	I-Beam	19	12	228	Rehabilitation	$800	$182,400
21.9	Boyden St.	Deck Girder	57	12	684	Rehabilitation	$800	$547,200
22.1	Homer St.	Deck Girder	57	12	684	Not Req.		

Table C: Conceptual Cost Estimate - Restore Structures to State of Good Repair - Structure Summary

CCRS No.	Feature Crossed	Structure Type	Total Length	Assumed Width	Bridge SF	Rehabilitation / Replacement	Unit Cost ($/SF)	Total Cost
24.1	W. Main St.	Thru Girder	100	12	1,200	Rehabilitation	$800	$960,000
24.1	Crane St.	Thru Girder	55	12	660	Rehabilitation	$800	$528,000
24.2	Freight St.	Deck Girder	88	12	1,056	Rehabilitation	$800	$844,800

Cost Summary:

Subtotal:	$17,931,600
Culverts:	$ 1,116,000
Subtotal:	$19,047,600
Minor Items (25%):	$ 4,761,900
Subtotal:	$23,809,500
Rounded Total:	**$23,810,000**

Estimate does not include contingency

Costs for one operational track

Rehabilitation of concrete arches, concrete slab =	$	450	/ SF
Rehabilitation of stone arches =	$	450	/ SF
Rehabilitation of steel beam with closed deck =	$	800	/ SF
Rehabilitation of steel beam with open deck =	$	800	/ SF
Rehabilitation of timber trestle =	$	500	/ SF
Replacement of rail top =	$	450	/ SF

Unit costs base on 2014 CTDOT Cost Estimating Guidelines,
Adjusted for work on the railroad.