5.0: Bridge Inspection Summary

5.1. MEMORIAL BRIDGE

The following conditions overview of the Memorial Bridge was based on the in-depth and interim structural inspections and load rating performed by HDR. This section addressed only the three truss spans of the Memorial Bridge that span over the Piscataqua River; the Kittery Approach spans are not included. The purpose of this overview was to summarize reasons why the Memorial Bridge Rehabilitation was dismissed from further consideration based on the results of the 2009 Bridge Inspection Report and 2010 Bridge Condition Summary Report. Appendix 46 contains the full Memorial Bridge Condition Summary Memorandum. Appendix 48 contains a web link to the full Memorial Bridge Inspection Report.

INTRODUCTION

In May and June of 2009, HDR Engineering, Inc. (HDR) and Hoyle Tanner and Associates, Inc. (Hoyle, Tanner) performed an in-depth inspection of the Memorial Bridge for the NH DOT and MaineDOT. The inspection results were used to perform a load rating (November, 2009) for the existing structure in its as-built and as-inspected condition, and planning level cost estimates for rehabilitation of the Memorial Bridge as part of the Bridge Inspection and Cost Analysis (BICA) study. Subsequently, at the request of the NH DOT and MaineDOT, HDR performed an interim structural inspection, in May 2010, on all primary truss members that rated at or below HS10 according to the Bridge Rating Report submitted in November 2009. The HS designation is an approximation of a vehicle weight/configuration used to simulate the greatest stresses caused by actual trucks on the bridge.

BRIDGE DESCRIPTION

The Memorial Bridge carries U.S. Route 1 over the Piscataqua River between Portsmouth, New Hampshire and Kittery, Maine. The structure is located in a tidal area where the water elevation typically has an eight to twelve foot variation between high and low tide. The span-drive vertical lift bridge was built in 1922 and consists of three truss spans and ten approach spans. The truss spans are two Pratt-type, camelback, steel fixed through-trusses and a Pratt-type, straight back, steel center lift through-truss. The total length of the three truss spans is 900 feet. The approach spans, referred to as the Kittery Approach, are comprised of ten multi-stringer and floor beam approach spans on the north side of the structure; but are not included as part of this condition summary. The Scott Avenue Bridge spans in Portsmouth, NH are also not included as part of this condition summary.

The lift span has an open steel grating deck and all other spans have a reinforced concrete deck. The roadway decks are supported by steel purlins. The sidewalk decks are comprised of timber planks supported by steel stringers. The truss spans, including the vertical lift towers, are supported by reinforced concrete piers with granite facades.

IN-DEPTH INSPECTION (June 2009)

Inspection Methods

Several inspection access methods were utilized to perform the in-depth inspection of the Memorial Bridge.

The truss span bottom chords, bottom gusset plates and the floor system (comprised of the bottom side of the deck as well as the floorbeams, stringers, bottom lateral bracing, stringer bracing, purlins and all their connections) were inspected utilizing a bucket boat. The bucket boat is a custom designed and constructed craft consisting of a 30 foot by 15 foot boat with pontoons and a 60 foot hydraulic bucket. The truss span diagonals, verticals, top chords and towers were inspected by industrial rope access. Structure climbing and the use of the vertical lift truss were used to access the top of the towers. The truss span piers were inspected utilizing a bucket boat, as well as underwater diving.

Bridge Condition

Table 5-1 on the following page summarizes the Memorial Bridge conditions as part of the June 2009 Inspection.

Bridge Structure Summary

The in-depth inspection performed by HDR and Hoyle, Tanner in May and June of 2009 recommended that the bridge posting be lowered to 10 tons due to the further deterioration found in the structural members since the previous inspection and load rating performed in 2003. At the time of the inspection, the Memorial Bridge was posted for 15 tons. After the gusset plate load rating was finalized, the load rating analysis determined that emergency repair of one gusset plate was required. The bridge was closed for the emergency repair of the gusset plate in October-November 2009; and then a three-ton load restriction was posted for the entire bridge when it was reopened.

TABLE 5-1
MEMORIAL BRIDGE - 2009 CONDITIONS SUMMARY TABLE

<table>
<tr><th colspan="6">(June 2009 Inspection)</th></tr>
<tr><th rowspan="2">Inspected Elements</th><th colspan="5">Condition Rating</th></tr>
<tr><th>Serious</th><th>Poor</th><th>Fair</th><th>Satisfactory</th><th>Good</th></tr>
<tr><td>Overall Deck (including concrete and open steel structural deck)</td><td></td><td>✔</td><td></td><td></td><td></td></tr>
<tr><td>Wearing Surface</td><td></td><td></td><td>✔</td><td></td><td></td></tr>
<tr><td>Deck Joints</td><td></td><td></td><td>✔</td><td></td><td></td></tr>
<tr><td>Sidewalks</td><td></td><td></td><td>✔</td><td></td><td></td></tr>
<tr><td>Bridge Rail</td><td></td><td>✔</td><td></td><td></td><td></td></tr>
<tr><td>Drainage</td><td></td><td></td><td>✔</td><td></td><td></td></tr>
<tr><td>Overall Superstructure</td><td>✔</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Purlins</td><td></td><td></td><td>✔</td><td></td><td></td></tr>
<tr><td>Stringers</td><td>✔</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Floorbeams</td><td>✔</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Truss Members</td><td></td><td>✔</td><td></td><td></td><td></td></tr>
<tr><td>Towers</td><td></td><td>✔</td><td></td><td></td><td></td></tr>
<tr><td>Tower Gusset Plates requiring attention</td><td colspan="2">✔</td><td></td><td></td><td></td></tr>
<tr><td>Bearings</td><td></td><td colspan="2">✔</td><td></td><td></td></tr>
<tr><td>Connections and Plates</td><td>✔</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Bracing</td><td>✔</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Overall Substructure</td><td></td><td></td><td>✔</td><td></td><td></td></tr>
</table>

INTERIM STRUCTURAL INSPECTION (May 2010)

Inspection Methods

At the request of the NH DOT and the MaineDOT, HDR performed an interim structural inspection, in May 2010, on all primary truss members that rated at or below HS10 according to the Bridge Rating Report submitted in November 2009.

It was found that five floor beams and twenty gusset plates rated at or below HS10. Therefore, the May 2010 Interim Structural Inspection focused on these critical elements:

- 5 floor beams in Span 2 (lift span)
- 8 gusset plates in Span 1 (Portsmouth side of lift span)
- 6 gusset plates in Span 2 (lift span)
- 6 gusset plates in Span 3 (Kittery side of lift span)

Therefore, the scope of the interim inspection was limited to the five floor beams and twenty gusset plates listed above. The May 2010 inspection results were compared to those found during the 2009 inspection to ascertain the extent that deterioration had progressed. During the interim structural inspection, HDR found that deterioration on several members had continued to progress, and new areas of deterioration were found. Rope access methods were utilized to gain access to the underside of the roadway deck, allowing inspectors better access to the top of the roadway stringers. This gained access, not afforded by the original bucket boat methods, allowed inspectors to discover three new corrosion holes on the floor beam webs, above the roadway stringer connections.

Bridge Condition

Table 5-2 summarizes the Memorial Bridge conditions as part of the May 2010 Inspection.

TABLE 5-2
MEMORIAL BRIDGE - 2010 CONDITIONS SUMMARY TABLE

(May 2010 Interim Inspection)					
Inspected Elements (limited to those members identified above that had rated previously below HS10)	**Condition Rating**				
	Serious	**Poor**	**Fair**	**Satisfactory**	**Good**
Overall Superstructure	✓				
Floorbeams and	✓				
Connections and Plates (Gusset Plates)		✓			

MEMORIAL BRIDGE INSPECTION RECOMMENDATIONS

In the one-year period since the baseline in-depth inspection (June 2009), deterioration has continued to measurably advance on multiple members, and would continue to do so. Since the progress of deterioration in the structural members varies from member to member, depending on member locations and their physical conditions; HDR recommends that the scope of each future interim inspection be expanded to cover more members. HDR recommends that the Memorial Bridge continues to be inspected in six month intervals; and, ***given the evidence of increased deterioration of floor beams, HDR recommends that all members that were found to have a load rating below HS15 be inspected in the next interim inspection.***

A check was performed on the load rating of the members, based on the condition documented from the interim inspection (May 2010). Despite the advancement in section loss on the members inspected, ***the structure's current posting of three tons is still sufficient***. While several gusset plates have seen advancement in section loss, the increased deterioration does not occur in areas of the plates which govern their current capacities.

MEMORIAL BRIDGE: GENERAL COMMENTS

Based on the inspection report and the load rating analysis, there are a number of areas of concern that cannot be adequately remedied with the rehabilitation of the bridge in its current "Serious" state. These items are as follows:

- The deterioration of the truss bottom chords, gusset plates and associated roadway deck structure are attributable to the original design details and location of the truss panel points with respect to the roadway and the pedestrian walkway. The truss chord panel points are located in areas that are subject to frequent application of deicing agents which have had a direct impact on the poor condition of the joints. In addition, the areas which are comprised of complex "built–up" sections are extremely difficult to access for routine maintenance, cleaning and painting. Even with rigorous and frequent maintenance, it is likely that these areas would still experience accelerated deterioration as compared to the rest of the structure.
- In addition to the detailing issues as described above, the rehabilitated structure with the built-up members maintains the "miles" of seams between plates and angles, and approximately 240,000 rivets that would provide avenues for similar deterioration patterns. Because of these details, it is difficult to clean the steel 100 percent due to access constraints; which then provides the potential "seed" for continued deterioration. By maintaining the same details, and not updating/improving the connections, the bridge would experience a similar pattern of deterioration.
- The overall "Serious" rating of the bridge introduces a higher level of uncertainty for the contractor when bidding on the project. Considering the current "Serious" condition of many of the structural members, and the documented continued advancement of deterioration, the true extent of deterioration is difficult to ascertain. The contractor would only know the true level of deterioration once the debris, paint and any temporary repairs are removed. This uncertainty could increase the contractors bid as well as

increasing the risk for potentially costly change orders during the course of the rehabilitation contract.

- The bottom chords represent a potential fatal flaw issue for rehabilitation. Given the deterioration noted at the bottom chord truss panel points, virtually all of the bottom chords are future candidates for replacement. In order to replace a bottom chord, the truss would need to be temporarily supported to bring the chord to a "no load" condition and removal of the stress from the chord being replaced. Providing temporary support to put even a single bottom chord into a "no load" condition involves installation of an extensive temporary structure. This process is time consuming and expensive. There are a total of 20 bottom chords per truss or 40 bottom chords (fixed truss spans) that would have to be considered for replacement. The schedule and related cost would likely be prohibitive.
- This approach is also problematic from a structural perspective. Even with putting the bottom chord into a "no load" condition for replacement of the chord, there would be a certain degree of unknown stress redistribution into the structure when the new, unloaded, member is loaded by removal of the temporary supports. This could result in redistributed stress patterns that are not fully known, once the bridge is again "loaded". This redistribution of stresses is compounded by the potential need to replace up to 20 bottom truss chord members per approach truss and is therefore not recommended.

Under any rehabilitation scenario, the Memorial Bridge would require substantially more maintenance and subsequent partial and full rehabilitations over the same life cycle period as a similar "new" replacement structure. A "new" replacement structure would have superior serviceability and operational reliability; and finally, a new replacement structure would be less expensive to construct and maintain over the design lifetime of the structure.

Bridges are routinely rehabilitated to increase their useful life; however, given the "Serious" condition rating that was based on the observed extent of deterioration of the structure and the structure details, inaccessible built up sections, and major structural elements and joints in areas subject to frequent application of deicing agents, the existing Memorial Bridge is not a viable candidate for rehabilitation.

At the request of the State DOT's, FHWA provided their perspective on the viability of the Memorial Bridge Rehabilitation option. FHWA indicated that based upon the results of the 2009 Bridge Inspection data and subsequent Consultant and State DOT bridge engineering expert recommendations, they concurred that the major rehabilitation of the Memorial Bridge did not appear to be a practical alternative which warranted further detailed consideration. The Study information indicates that the rehabilitation alternative would provide a much reduced service life at significantly higher operational and maintenance costs and therefore, not in the public interest to warrant further consideration. The FHWA further indicated that although the Memorial Bridge Rehabilitation option is not recommended for further detailed consideration, the rehabilitation must be considered as part of the NEPA and associated Section 106/Section 4(f) analysis process associated with the bridge. The Connections Study information will provide the necessary documentation and rationale as to why any such Section 106 or Section 4(f) avoidance and/or minimization alternatives considered were determined impractical to implement.

Based on the above data and bridge condition overview and associated documents, the Memorial Bridge Rehabilitation option was dismissed from further consideration.

5.2. SARAH MILDRED LONG BRIDGE

INTRODUCTION

In May and June of 2009, HDR and Hoyle, Tanner performed an in-depth inspection of the Sarah Mildred Long Bridge for the NH DOT and MaineDOT. The inspection results were used to perform a load rating (December, 2009) for the existing structure in its as-built and as-inspected condition, as part of the Bridge Inspection and Cost Analysis (BICA) study.

The approach spans consist of a fifteen-span girder structure on the New Hampshire approach (Spans 1-15), and the seven-span girder structure on the Maine approach (Spans 21 – 27). Based upon the results of the in-depth inspection and subsequent load rating analysis, it is understood that the approach spans control the overall load rating for the bridge, and it is therefore assumed that the abutments and approach spans would be replaced under all alternatives. The rehabilitation option for the Sarah Mildred Long Bridge consists of replacing the abutments and all approach piers and spans and rehabilitating the five existing truss spans.

BRIDGE DESCRIPTION

The Sarah Mildred Long Bridge carries the U.S. Route 1 Bypass over the Piscataqua River between Portsmouth, New Hampshire and Kittery, Maine. The Sarah Mildred Long Bridge also carries the Pan-Am Railways line over the Piscataqua River and connects to the Portsmouth Naval Shipyard. The structure is located in a tidal area where water elevation typically has an eight to twelve foot variation between high and low tide. The tower-driven vertical lift bridge was built in 1940. The five main truss spans carry both highway and rail traffic and consist of four fixed spans and one movable lift span; comprised of riveted steel, straight-back, warren-type truss spans. The roadway approach spans are comprised of built-up riveted deck girders and floor beams, as well as rolled I-shaped and C-shaped stringers. The railroad approach spans consist of three deck girder spans on the south approach, as well as two fixed deck girder spans and a retractable deck girder span on the north approach. The roadway and access walk decks are composed of reinforced concrete. The truss spans are supported by reinforced concrete piers with granite facades. The approach spans are supported by reinforced concrete piers and abutments, and steel pier bents.

IN-DEPTH INSPECTION (June 2009)

<u>Inspection Methods</u>

Several inspection access methods were utilized to perform the in-depth inspection of the Sarah Mildred Long Bridge. The fascia side of the trusses, the fascia side gusset plates, the overhang and floor beam support brackets and the bottom deck (railroad) floor system were inspected utilizing a bucket boat. The bucket boat is a custom designed and constructed craft consisting of a 30 foot by 15 foot boat with pontoons and a 60 foot bucket.

The interior face of the trusses and the underside of the roadway deck were inspected utilizing a UB-30 hi-rail vehicle operating from the railroad deck. The towers were inspected by industrial rope access. Structure climbing and the vertical lift truss span were used to access the top of the towers. The truss span piers were inspected utilizing a bucket boat, as well as underwater diving.

<u>Bridge Condition</u>

The inspection found the overall condition of the superstructure to be "Serious", the overall condition of the substructure to be "Serious" and the overall condition of the deck to be "Poor", as documented in the inspection report. Per National Bridge Inspection Standard (NBIS) guidelines, one overall condition rating is assigned to the entire structure, as was done in the Inspection Report. For purposes of this study, condition rating assessments are provided for the Truss Spans and Approach Spans separately, in order to provide a more accurate description of

TABLE 5-3
SARAH MILDRED LONG BRIDGE APPROACH SPANS
2009 CONDITION SUMMARY TABLE

(June 2009 Inspection)					
Approach Spans	**Condition Rating**				
Inspected Elements	**Serious**	**Poor**	**Fair**	**Satisfactory**	**Good**
Deck		✔			
Wearing Surface		✔			
Deck Joints			✔		
Sidewalks		✔			
Bridge Rail	✔				
Drainage		✔			
Superstructure	✔				
Highway Stringers	✔				
Highway Girders				✔	
Railroad Girders			✔		
Highway Floorbeams	✔				
Bearings			✔		
Connections and Plates			✔		
Substructure	✔				

the structure condition for the approach spans and for the truss spans. In addition, since the approach spans superstructure, abutments and piers are to be replaced under all options, subsequent discussion after the following summary tables focuses on addressing the truss spans.

Table 5-3 summarizes the Sarah Mildred Long Bridge Approach Spans Conditions and Table 5-4 summarizes the Sarah Mildred Long Truss Spans Conditions as found during the 2009 June inspection.

TABLE 5-4
SARAH MILDRED LONG BRIDGE TRUSS SPANS
2009 CONDITION SUMMARY TABLE

(June 2009 Inspection)					
Truss Spans	**Condition Rating**				
Inspected Elements	**Serious**	**Poor**	**Fair**	**Satisfactory**	**Good**
Deck		✔			
Wearing Surface		✔			
Deck Joints			✔		
Sidewalks		✔			
Bridge Rail	✔				
Drainage		✔			
Superstructure			✔		
Stringers			✔		
Floorbeams			✔		
Truss Members			✔		
Bearings			✔		
Connections and Plates			✔		
Substructure			✔		

GENERAL CONDITION COMMENTS

Superstructure

The concept plan for the rehabilitation of the Sarah Mildred Long Bridge consists of complete demolition and replacement of the abutments, approach spans, piers and foundations, superstructure and the rehabilitation of the fixed span trusses, towers, the lift span truss, and the associated foundations.

The overall superstructure condition rating of the structure was “Serious”, as indicated in the condition report, is governed by the approach spans (See Appendix 48). The general condition of the truss spans and towers is "Fair". The lift span electrical and mechanical systems were recently updated and are in good working order.

The In-Depth Inspection, Conditions Report, and its appendices (see Appendix 48 for the website to access the full Sarah Mildred Long Bridge Inspection Report) fully documents areas with deterioration and defects. Appendix B of Appendix 48, with photos, isolated areas on the trusses where deterioration is more severe, such as Photo II-32 (Truss Span 5, Vertical Member). These areas are not indicative of the overall superstructure condition, unless specifically noted as a typical condition. The tables in Appendix C of Appendix 48 thoroughly document the condition of each truss member.

More typically, deterioration of truss members consists of either surface rust or laminar corrosion limited to areas near the interface with batten or gusset plates, which has caused prying of the plates in many instances. The areas of laminar corrosion are generally localized to small portions of the member. As part of the rating analysis, HDR applied documented section losses from the inspection when rating the superstructure members.

The design of the Sarah Mildred Long Bridge has the roadway on top of the fixed and movable trusses and the corrosive deicing agents are confined within the roadway and removed and isolated from the structure below at the scupper drain locations. The design of the roadway joints on the trusses included the use of a drainage trough under the joint that routed contaminated materials that may have seeped through joints away from the structural support steel. This good detailing practice contributed to the observed "Fair" condition of the roadway beams and stringers.

The approach structures, on the other hand, employ a deck joint design that does not include the trough as part of the deck joint. As a result, contaminated runoff from the roadbed that seeped through the joint was a major factor in the observed severe deterioration of the support steel as well as the concrete piers below. This resulted in an overall rating of "Serious" for the approach structures on either side of the truss superstructure.

The rehabilitation option assumes the abutments and all approach spans, piers, foundations and superstructure are to be demolished and replaced. This removal and replacement work represents 60% of the structure by length. The approach structures would be replaced using construction materials and methods currently in use by both NH DOT and MaineDOT.

<u>Substructure</u>

The overall substructure condition rating was "Satisfactory". Concrete cores were taken from the tower piers below the low water line and evaluated using petrographic analysis. The petrographic analysis of the cores was used as a basis for estimating remaining life using numerical simulations and showed that without significant rehabilitation, concrete outside of the tidal zone would have an expected useful life over 50 years. Visual inspection of the cores found no corrosion of the steel reinforcement. The assessment also reported that, while elevated chloride levels were detected as much as 10 inches from the face of concrete, the lack of free oxygen within the concrete has prevented this condition from corroding the steel reinforcement for the concrete located below the splash line.

Concrete within the tidal zone is exposed to a more corrosive environment as well as freeze/thaw cycles and requires rehabilitation. Visual inspection indicated that the condition of the concrete and steel reinforcement in this area likely could be rehabilitated with standard construction practices to provide an expected life of at least 50 years.

A lump sum cost allocation has been made in the Life Cycle Cost Analysis to account for a major bridge rehabilitation at year 50 (See Appendix 30 for Life Cycle Cost Analysis information).

Based on the inspection of the piers performed in July 2009, Piers 15 through 20, those that support the Truss Spans, could potentially be rehabilitated. Deterioration found on the piers above the water line, such as cracking, erosion and spalls could also likely be repaired by traditional rehabilitation techniques. No critical problems, such as settlement, were found at these piers.

For more information regarding the condition of the piers, refer to the full *In-Depth Inspection and Condition Report for the Sarah Mildred Long Bridge*, Volumes 1 and 2 of 2. See Appendix 48 for website to access the full report.

LOAD RATING SUMMARY

It is assumed that the approach spans superstructure, as well as the approach spans piers, abutments and foundations of the Sarah Mildred Long Bridge would be replaced and the truss spans would be rehabilitated. Therefore, this load rating summary is specific to the truss spans only.

A load rating of a bridge structure pertains to the analysis of a structure in order to compute the maximum allowable loads that can be carried across a bridge safely over time.

The members of the truss spans were rated for both the American Association of State Highway and Transportation Officials (AASHTO) highway HS loading and the American Railway Engineering and Maintenance-of-Way Association (AREMA) Cooper E80 loading. The HS Loading is a scalable load, with HS20 used as the statutory limit for purposes of summarizing the load rating, as prescribed by AASHTO for the load rating of structures. Currently, the NH DOT and MaineDOT require that new structures be designed for HS25 loading. Information regarding members which do not meet requirements for HS25 loading is provided in the next section.

The HS20 loading designation refers to a hypothetical design vehicle for a truck loading, with a specific gross vehicle weight (pounds) and axle spacing, as outlined in AASHTO. An HS25 loading accounts for higher loading conditions, which represents a 25 percent increase in loading over the standard HS20 truck and a greater gross weight.

The Cooper E80 loading is recommended for design and analysis by AREMA. In addition, stringers supporting the railroad floor system at the towers were checked for capacity of the M130 military train loading at the request of the NH DOT and MaineDOT. The M130 railcar is a specialized transport railcar with a total maximum weight of 205 tons. One theoretical locomotive of the Cooper E80 loading weighs 284 tons. Since the Cooper E80 axle loads are higher, and the Cooper E80 axle spacing is closer than that of the M130 loading, the Cooper E80 loading will govern any analysis for train loads.

The Cooper E80 loading designation refers to a recommended train load (locomotive) in pounds per axle and uniform trailing load (remaining train cars), as outlined in AREMA. The Cooper E80 Loading also considers the design train to be traveling at 60 miles per hour (mph). This high speed accounts for high impact loading. If a structure does not rate for E80 at the recommended speed, the Cooper E80 rating may still be attained through the reduction of the recommended design speed by use of specific formulas from the AREMA Guidelines. Finally, an M130 train loading is a specific combination of axle spacings and loadings that pertain to the trains currently using the Sarah Mildred Long Bridge today.

The Sarah Mildred Long Bridge was designed for H20 highway loading and Cooper E72 Railway loading standards.

The following rating summary provides a response for specific requested rating categories/summaries for the truss spans:

Highway Load Rating:

- Members with load ratings below HS20
- Members with load ratings above HS20 but below HS25

Railroad Load Rating:

- Truss members with load ratings below E80
- Tower stringer and floor beam (governing location) load ratings for an M130 train.

<u>Highway Load Rating</u>

The highway load rating was performed with an assumption that the lower railroad deck is loaded simultaneously with an AREMA Cooper E80 train at full speed (60 mph), with full impact (standard recommended practice according to AREMA). The AASHTO Load Factored Method was used for the rating.

1) **Members with Load Ratings below HS20:**
    - All truss members and gusset plates have as-built (member structural properties in the new, as-built, condition) and as-inspected (member structural properties accounting for the deterioration outlined from the inspection) load ratings above HS20, except one (out of 90) vertical truss member, which has an as-inspected rating of HS15.0, on the west truss of Span 2. However, with the E-80 Cooper train speed reduced to 10 mph, the current speed at which trains travel on the bridge, the vertical truss member rated above HS20 for the as-inspected condition.

This member would require reinforcement to bring its capacity over HS20 with trains traveling at full speed.

2) **Members with Load Ratings above HS20 but below HS25:**
   - As-Built Condition: The truss members and gusset plates that have as-built load ratings above HS20 but below HS25 are:
     - Four (out of 80) Top Chord Truss Members
     - Twelve (out of 180) Truss Gusset Plates
     - All Roadway Stringers
     - All Roadway Floorbeams
   - As-Inspected Condition: The truss members and gusset plates that have as-inspected load ratings above HS20 but below HS25 are:
     - Four (out of 80) Top Chord Truss Members
     - Twelve (out of 180) Truss Gusset Plates
     - All Roadway Stringers
     - All Roadway Floorbeams

The remaining truss members and gusset plates have as-built and as-inspected load ratings ***above HS25.***

Railroad Load Rating

The railroad load rating was performed to truss members with an assumption that the AREMA Cooper E80 loading was at full speed (60 mph) on the lower deck and the upper roadway deck is loaded simultaneously with HS20 loading, the statutory loading required by AASHTO for load rating of bridges. The AREMA Allowable Stress Method was used for the rating.

1) **Truss Members with Ratings below E80:**
   - As-Built Condition: The truss members that have as-built load ratings below E80 are:
     - Four (out of 80) Top Chord Truss Members
   - As-Inspected Condition: The truss members that have as-inspected load ratings below E80 are:
     - Four (out of 80) Top Chord Truss Members
     - Three (out of 80) Diagonal Truss Members

Under current practices the train speed is 10 mph. At this speed reduction, all members except two Top Chord members in Span 2 (one on East Truss, one on West Truss) and two Top Chord members in Span 4 (one on East Truss, one on West Truss) have ratings above E80.

The Top Chord member on Span 2, East and West Trusses, and Top Chord member on Span 4, East and West Trusses, do not rate because of the way in which they were originally modeled in LARSA (the structural computer software used during the analysis). During the first round of the analysis, the towers were not included as part of the structural model and the end joint of these top chords were modeled as pinned connections, because of their connection to the tower. However, there are no signs of overstress on these members. Further analysis modeling the actual stiffness of the towers may yield that the as-inspected ratings for these members, with the reduced speed of 10 mph, would be above E80. If this is not found to be the case, these members would require reinforcement.

The four Top Chord truss members and three Diagonal truss members that do not meet statutory loading requirements will require rehabilitation to accommodate faster than 10 mph train speeds, if required in the future.

2) **Tower Stringer and Floorbeam Load Ratings for Cooper E80 and M130 trains:**
The railroad stringers and floorbeams at the two towers were rated for both the AREMA Cooper E80 and an M130 train for as-inspected conditions. The load ratings, controlled by a stringer in the South Tower, are as follows:
   - Cooper E80 Loading – E56.8
   - M130 Loading – Rating Factor = 0.62 (225.2 kip out of a 410 kip vehicle)
   - A speed reduction to 15mph is required for the stringer to rate for E80.
   - A speed reduction to 25mph is required for the stringer to rate for M130.

   If faster train speeds are required in the future, then the railroad stringers and floorbeams at the two towers would require reinforcement.

It should be noted that there are also speed constraints caused by the geometry of the track on the north and south sides of the bridge structure; as well as the Class designation of the track, according to the U.S. Department of Transportation (USDOT), Federal Railroad Administration (FRA) – Office of Safety, Code of Federal Regulations. To the north, there is a 7.5-degree horizontal curve, and to the south there is a 6.0-degree horizontal curve; and this rail line is designated as a Class 2 track. According to the Code of Federal Regulations, Track Safety Standards Part 213; the maximum allowable operating speed for freight trains, Class 2 track, is 25 mph. Class 2 passenger trains can travel at 30 mph. However, with the governing approach horizontal curve of 7.5-degree, the maximum allowable curving speed is 24 mph (Elevation of outer rail = 0 inches).

Load Rating Analysis Assumptions

The above ratings are based on combined highway and railroad loadings on the bridge structure, which is standard load rating procedure. The current practice is to close the bridge to highway traffic when there is a train movement over the bridge due to the restrictions surrounding the type of cargo that the train transports. Therefore, it is reasonable to project that the above load ratings would increase if only one loading condition (either highway or railroad loadings) was applied at a time.

The current load rating analysis includes the State of New Hampshire and State of Maine Maximum Certified Vehicle Weights for single unit vehicles and combination vehicles. The maximum weight for the combination vehicles category is 99,000 pounds (lbs). NH DOT has developed a Legal Load Equivalents table for Ordinary Legal Loads and Certified Vehicles

(Single Unit and Combination Units); all equivalents are in HS tons. The HS tons are converted based on the longitudinal effective span lengths of each member and the load rating is included in the Bridge Capacity Summary, Form 4, of the Load Rating Report prepared by HDR.

For truss members with longitudinal effective span lengths of 224-feet, the required capacity for supporting the 99,000 lb combination vehicle is HS20.5. As outlined in this section, only one truss member would rate below HS20.5; but rates under current practices of reducing the train speed to 10 mph. Given the current prohibition to simultaneous movements of both vehicles and trains, the bridge can accommodate the 99,000 lb vehicle.

As a result of the in-depth inspection and the subsequent load rating analysis, the truss spans of the Sarah Mildred Long Bridge can carry an HS20 loading and the State of New Hampshire and State of Maine Maximum Certified Vehicle 99,000 lbs combination vehicle loading under current train speeds. This analysis was based on combined highway and railroad loadings on the bridge structure, which is standard load rating procedure. Some members, as previously listed, will require rehabilitation to support HS20 and HS25 truck loading if trains are to travel at full speed in the future.

Impacts to Railroad and Marine Operations during Rehabilitation of the Sarah Mildred Long Bridge

A significant portion of the Sarah Mildred Long Bridge rehabilitation work is related to the demolition and reconstruction of the approach spans which are highway focused and largely independent of railroad and marine operations. The rail operations are generally confined to the truss spans of the structure. Thus, the demolition and reconstruction of the approach spans is not dictating that the rail portion of the structure be closed for the full two to three year construction period. Marine traffic can be accommodated by keeping the lift span in a raised position, until critical electrical and mechanical activities need to get underway. Highway access would not be possible during the rehabilitation.

The rehabilitation of the Sarah Mildred Long Bridge would require multiple independent construction activities including demolition, excavation, concrete foundation, pier and deck construction, steel repair and replacement, approach roadway construction, electrical mechanical upgrades and painting. Depending on contractor methods and schedules, some of these activities might possibly be isolated to specific areas of the structure and would not all occur at one time or at the same location, the work would have to be well-coordinated between PNSY, Pan Am Railways, the contractor, NH DOT and MaineDOT and sequenced accordingly. The need to sequence these activities provides opportunities to maintain full time marine access and intermittent rail traffic to and from the PNSY.

Since the trains run infrequently over the truss structure, many phases of the rehabilitation of the truss spans, deck replacement, repair and replacement of structural steel, electrical and mechanical upgrades, cleaning and painting of the trusses, etc, could be sequenced in a manner that supports periodic train traffic. There would be periods of time where the bridge would not be available to rail traffic, but careful staging of construction and communication with PNSY can minimize interruption. Please note that the majority of railroad movable bridge rehabilitation projects routinely completed around the country are performed under live traffic or with very short duration closure windows available to the contractors for critical construction activities. It is therefore a common practice to sequence rehabilitation of movable structures to maintain some minimum level of desired functionality.

CONCLUSION

Based on the bridge inspections and load ratings performed during 2009 and 2010, the overall condition rating of the superstructure is "Serious" and the overall condition rating of the substructure is also "Serious". The overall condition rating includes both the approach spans and truss spans. Under rehabilitation the approach spans would be replaced and only the truss spans would remain, which have a superstructure and substructure condition rating of "Fair". Refer to the Life Cycle Cost Analysis (Appendix 30) for costs associated with rehabilitation of the structure.

The load rating analysis accounted for the current deteriorated condition of the bridge structure. Future section loss and related deterioration can be mitigated with application and maintenance of paint and sealer. Proper and frequent maintenance of the coating system is vital to minimize further deterioration of the structure. The Life Cycle Cost Analysis identifies a cost to be incurred every 5 years which accounts for this maintenance (See Appendix 30 for the Life Cycle Cost Analysis).

Members listed in this section that do not rate for HS25 design criteria, would require reinforcement under rehabilitation. Since the deck would be replaced under the rehabilitation option, access to these members would be straight forward for purposes of rehabilitation or reconstruction. Portions of the substructure located within the tidal zone would also require partial depth rehabilitation of the concrete.

Finally, because the overall (approach spans and truss spans) condition rating of the Sarah Mildred Long Bridge is "Serious", as documented in the Bridge Inspection Report in accordance with National Bridge Inspection Standards guidelines for condition rating structures, MaineDOT and the NH DOT have also requested that the FHWA consider whether rehabilitation is a reasonable and viable alternative.