New Hampshire Department of Transportation

INTERIM INSPECTION REPORT FOR THE MEMORIAL BRIDGE OVER THE PISCATAQUA RIVER

247/084

August 2010

PREPARED BY:

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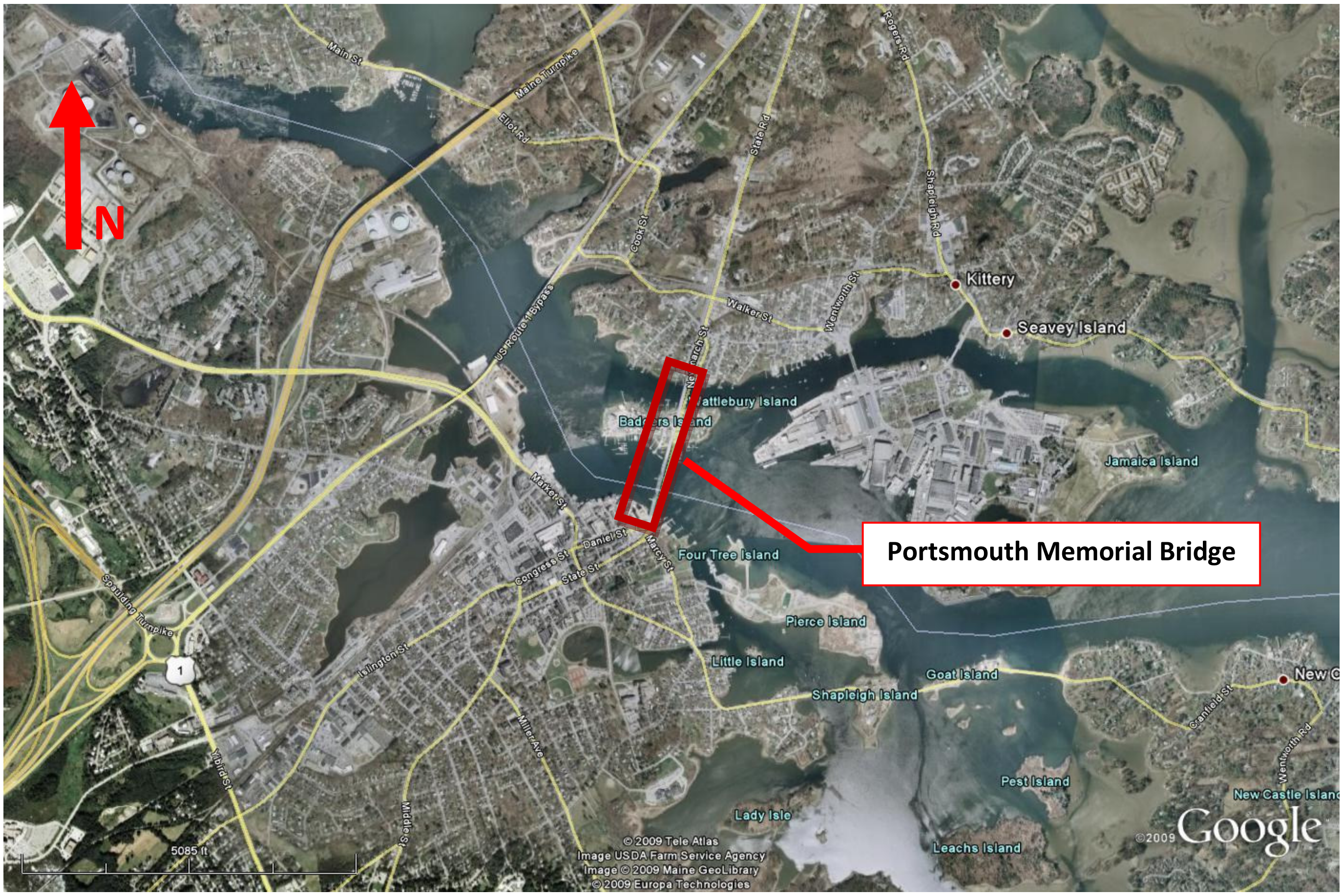
LOCATION MAP



DESCRIPTION OF BRIDGE

Date of Construction:	**1922**
Original Design Loading:	**Equivalent H15 Truck**
Bridge Type:	**Span-Drive Vertical Lift Bridge: Comprised of 3 through-trusses and 10 multi-stringer approach spans. The deck is open steel grating on the lift span and reinforced concrete in the approach spans.**
Skew:	**0°**
Spans:	**13 – Excluding Scott Avenue south approach spans**
Width of Bridge Deck:	**28'-0"**
Roadway Surface:	**Bituminous concrete on approach spans, open steel grating in lift span.**
Sidewalk/Walkway/Median:	**Timber planks supported by steel stringers.**
Bridge Railing:	**Steel pipe rail along sidewalk and steel guard rail along roadway.**
Approach Railing:	**Steel pipe rail**
Superstructure:	**Through-truss main vertical lift span with symmetrical through-truss approach spans. Multiple stringer approach spans on the north or Kittery end.**
Modifications to Original Superstructure:	**The deck had been replaced in the approach spans, numerous welded and bolted plates have been added to floorbeams and truss members. Some stringers have been replaced in the lift span; others have repair channels and plates bolted to the web.**
Utilities:	**Various electric conduits along the structure from both ends of the bridge (for bridge service only).**
Substructure:	**Reinforced concrete with stone masonry fascia in tidal zone.**
Modifications to Original Substructure:	**Most of the original Kittery Approach Span columns have been replaced by circular reinforced concrete columns with a timber protected base filled with concrete.**

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 Portsmouth Memorial Bridge for the New Hampshire Department of Transportation (NHDOT). The load rating based on this inspection found that several members rated below the statutory load of HS20. The bridge was closed for an emergency repair of one gusset plate; and then a 3-ton load restriction was posted for the bridge.

At the request of the New Hampshire Department of Transportation, 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 floorbeams and twenty gusset plates rated at or below HS10. Therefore, the May 2010 Interim Structural Inspection focused on these critical elements; Floorbeams FB4, FB5, FB6, FB7 and FB8 on Span 2, the Lift Span and the following gusset plates:

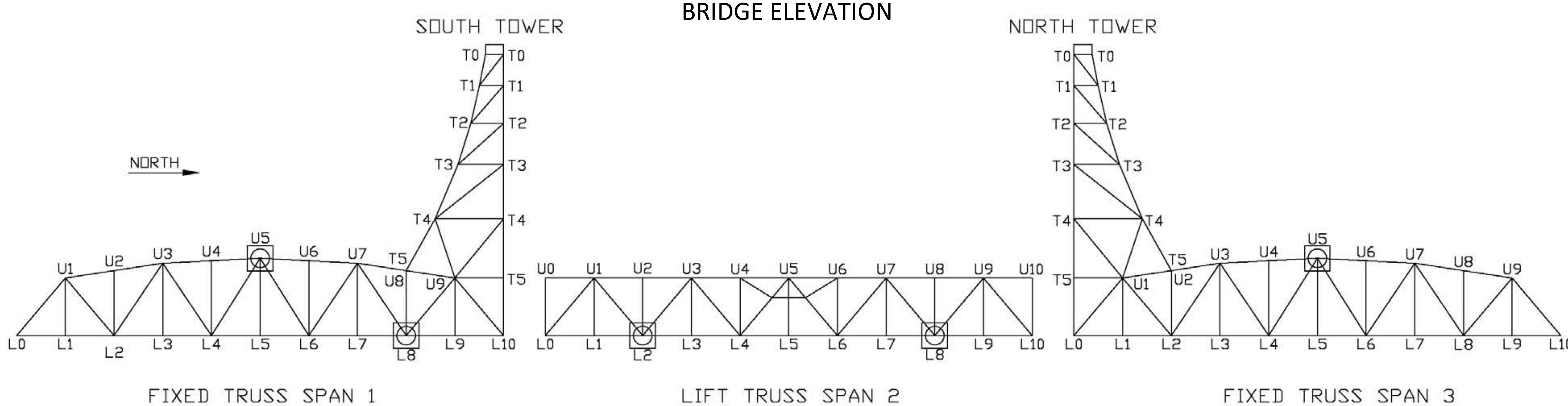
- Span 1, East Truss, Joint L2, Interior Gusset Plate
- Span 1, East Truss, Joint L8, Interior Gusset Plate
- Span 1, East Truss, Joint U5, Interior and Exterior Gusset Plates
- Span 1, West Truss, Joint L8, Interior and Exterior Gusset Plates
- Span 1, West Truss, Joint U5, Interior and Exterior Gusset Plates
- Span 2, East Truss, Joint L8, Interior and Exterior Gusset Plates
- Span 2, West Truss, Joint L2, Interior and Exterior Gusset Plates
- Span 2, West Truss, Joint L8, Interior and Exterior Gusset Plates
- Span 3, East Truss, Joint L2, Interior Gusset Plate
- Span 3, East Truss, Joint L8, Interior Gusset Plate
- Span 3, East Truss, Joint U5, Interior and Exterior Gusset Plates
- Span 3, West Truss, Joint U5, Interior and Exterior Gusset Plates

Refer to the Truss Span Elevation Plan on Page 4 and the Truss Span Framing Plan on Page 5 of this report for graphic details showing locations of inspected members.

Because the scope of this interim inspection is limited to the five floorbeams and twenty gusset plates listed above, this report only addresses NBIS items 59.3, Floorbeams and 59.7, Connections and Plates. For information regarding other components of this structure, see the In-Depth Inspection and Condition Report for the Portsmouth Memorial Bridge by HDR Engineering Inc. and Hoyle Tanner & Associates, Inc. dated October, 2009.

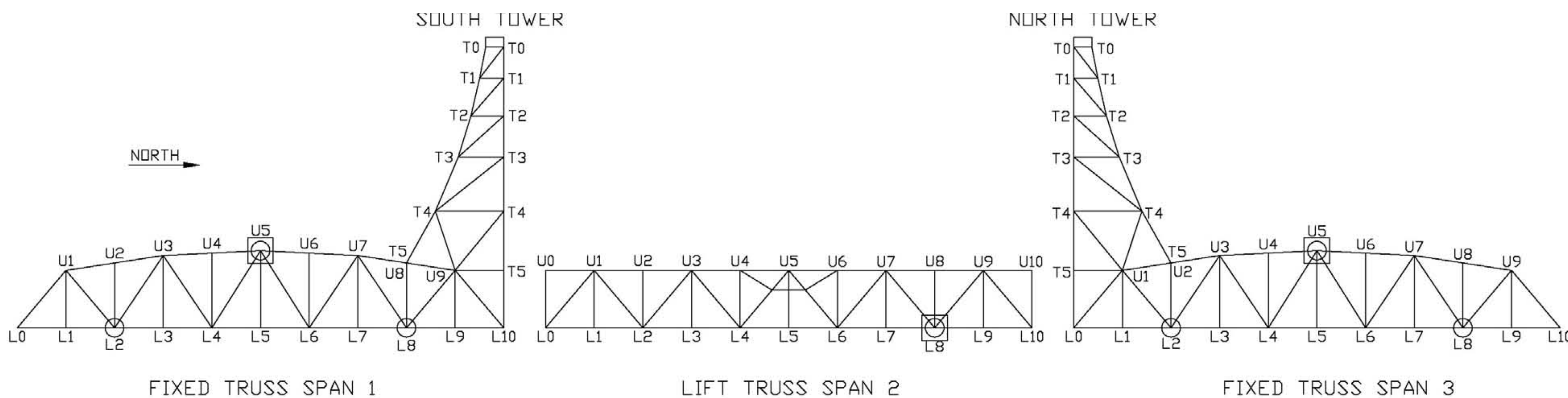
The May 2010 inspection results were compared to those found during the 2009 inspection to ascertain the extent that deterioration has progressed.

BRIDGE ELEVATION



MEMORIAL BRIDGE ELEVATION

WEST TRUSS



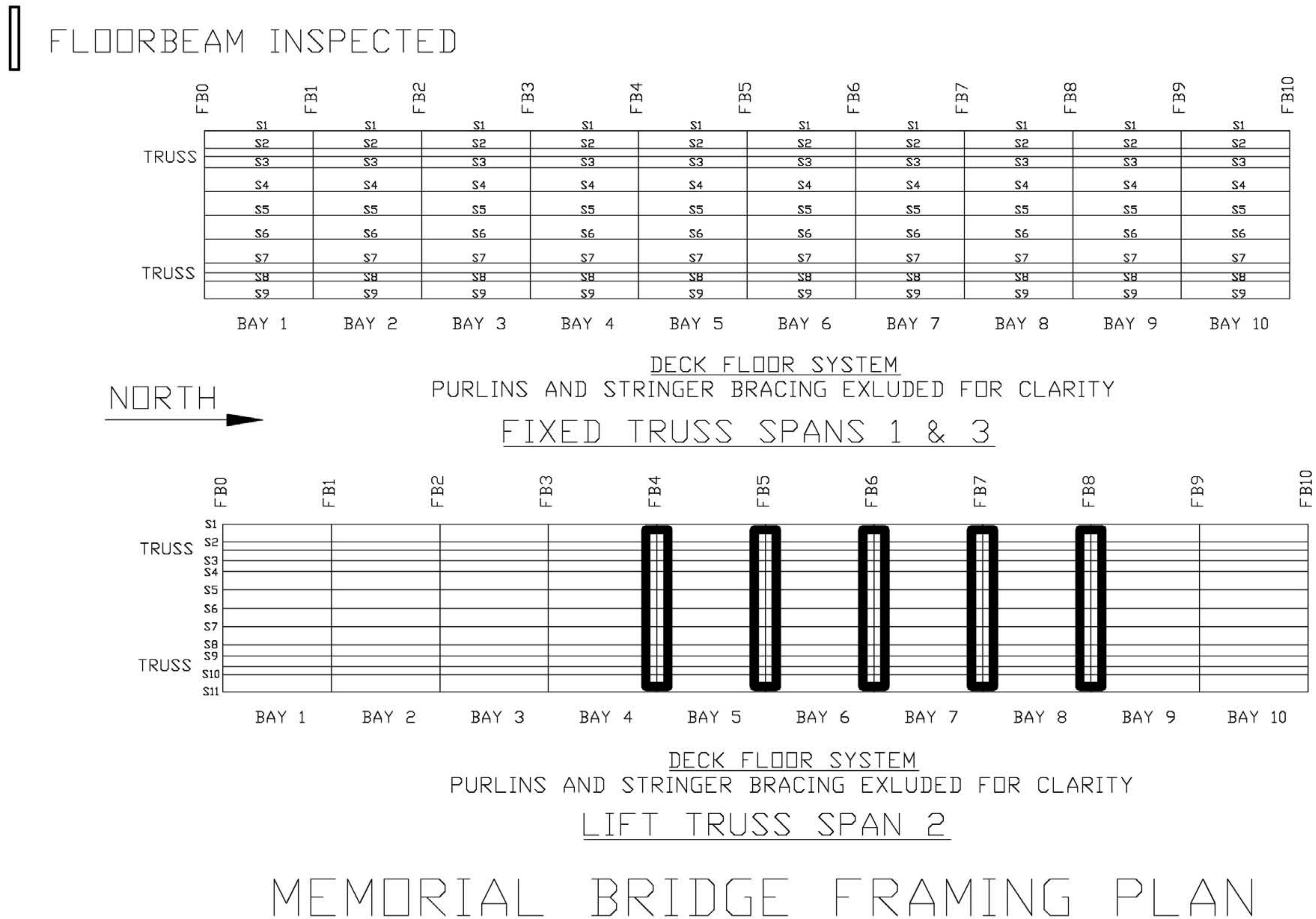
□ EXTERIOR GUSSET PLATE INSPECTED

○ INTERIOR GUSSET PLATE INSPECTED

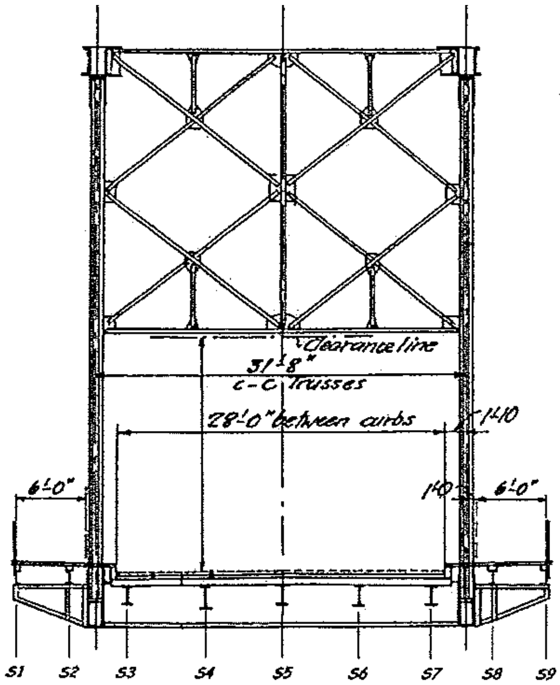
MEMORIAL BRIDGE ELEVATION

EAST TRUSS

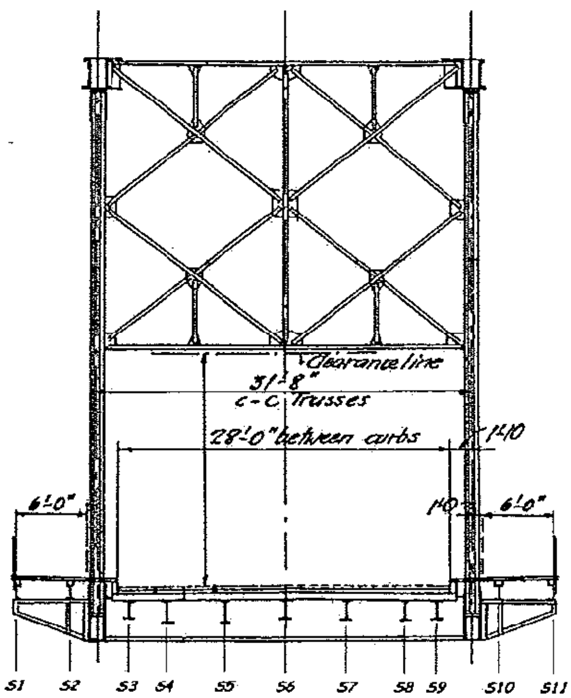
BRIDGE FRAMING PLAN



TYPICAL BRIDGE CROSS SECTION



CROSS SECTION - FIXED TRUSS SPANS
(LOOKING NORTH)
N.T.S.



CROSS SECTION - LIFT SPAN
(LOOKING NORTH)
N.T.S.

INSPECTION FINDINGS

BRIDGE DESCRIPTION

The Portsmouth Memorial Bridge carries Route 1 over the Piscataqua River from Portsmouth, New Hampshire to Kittery, Maine. The structure is located in a tidal area where water the 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, straightback, steel center lift through-truss. The approach spans, referred to as the Kittery Approach, are not included in this Interim Inspection Report. 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 are supported by reinforced concrete piers with granite facades.

The truss spans are numbered 1 to 3 from south to north. Truss panel points and floorbeams are numbered from south to north with the southernmost panel point or floorbeam of each span designated as 0.

INSPECTION METHODS

All members inspected during the Interim Structural Inspection were accessed utilizing industrial rope access.

BRIDGE CONDITION

During the Interim Structural Inspection, HDR found that deterioration on several members had increased, and new areas of deterioration were found.

The rope access methods utilized for the interim structural inspection allowed inspectors to access the top of the roadway stringers, gaining access not afforded by conventional methods. This increased level of access allowed inspectors to find three new corrosion holes on the floorbeam webs, above the roadway stringer connections.

Sketches detailing member conditions can be found in Appendix B.

Item 59 – Overall Superstructure – Serious Condition

59.3 Floorbeams:

Floorbeams FB4, FB5, FB6, FB7 and FB8 typically have corrosion with section loss on both flanges and webs. The majority of floorbeams have several corrosion holes throughout, with the largest being 13” wide. The largest web holes are generally located adjacent to stringer connections and at floorbeam ends. All floorbeams inspected except FB7 have repair plates spliced to the webs, with several of the splices welded to tension areas of the floorbeams.

Deterioration in the floorbeams has advanced in numerous locations. Most notably, several corrosion holes found in 2009 have increased in size. Additionally, new holes have formed in areas where severe corrosion was previously found.

Floorbeam FB4 has several holes that have increased in size. One new hole has formed adjacent to Stringer S9, where severe section loss was found in 2009. Due to the gained inspection access as described above, a new hole was found in the floorbeam web at the top of Stringer S6. Steel between two adjacent holes located near Stringer S5 has completely deteriorated, forming one larger hole.

Three holes in the web of Floorbeam FB5 have increased in size. The widest point of the largest hole has increased from 13”x3.5” to 13”x4”. The steel around a hole found between Stringers S8 and S9 has increased from 2” in diameter to 6” by 2”; however, it should be noted that the remaining steel around this hole was found to be severely corroded in 2009. So while the increase of section loss since 2009 is substantial, it is not a three-fold increase as the enlarged hole size would seem to indicate. An area with severe deterioration and multiple pin holes between Stringers S7 and S8 has further deteriorated to become a 4”x2” corrosion hole. There has also been increased deterioration on the bottom flange.

New holes were found in the web of Floorbeam FB6 at the top of Stringers S6 and S9. Two small corrosion holes have formed where severe corrosion was previously found. An L-shaped hole in the floorbeam web at Stringer S3 was found to have some increased section loss. Due to its odd shape and severe steel corrosion around the hole, it is considered to be a 5” by 5.5” hole.

Two holes in the web of Floorbeam FB7 have increased in size. The larger hole increased from 0.5”x 3” to 2”x3”. Similarly to the hole in Floorbeam FB5 web at Stringer S9, remaining steel around this hole was found to be severely corroded in 2009. So while the increase of section loss since 2009 is substantial, it is not a four-fold increase as the enlarged hole size would seem to indicate. A hole was found in the web at the top and bottom of Stringer S7. Additionally, more pronounced deterioration was found on the floorbeam web adjacent Stringer S3, and along the interface with the flange angle between Stringers S3 and S4.

Floorbeam FB8 has a new area of pitting at the west end of the web. In areas of severe corrosion on the floorbeam web, a new 2" diameter hole was found and an existing 2" hole increased to 4" by 2".

59.7 Connections and Plates:

The condition of several lower gusset plates have changed since the 2009 inspection. Most have increased deterioration in isolated areas. One plate has been retrofitted with additional plates. The following gusset plates have conditions different than that found in 2009:

- Span 1 gusset plate L2E Interior has increased corrosion in an area on the south end of the plate, above the bottom chord and below the diagonal interfaces. As little as 1/4"" thickness remains in this area.
- Span 1 gusset plate L8E Interior has increased corrosion in an area on the south end of the plate, below the diagonal interface to the bottom of the plate. Approximately 1/8" thickness remains in this area.
- Span 1 gusset plate L8W Interior has additional areas of laminar corrosion on the bottom of the plate. This area is approximately 3" high and runs the width of the plate.
- Span 3 gusset plate L2E Interior was repaired in October 2009. Repair plates and filler plates have been installed at this truss joint.
- Span 3 gusset plate L8E has an isolated, 4" diameter, area with severe deterioration. This area occurs on the north half of the plate, near the bottom of the plate.

Other gusset plates show no significant changes in condition. The following are descriptions of the condition of these gusset plates:

- Span 1 gusset plate L8W Exterior has laminar corrosion on approximately 50% of the plate's surface area.
- Span 2 gusset plates L2W Interior and Exterior have laminar corrosion throughout the plates.
- Span 2 gusset plates at truss joint L8 and both trusses have painted over pitting throughout the plates. Gusset plate L8W Interior has a ½"x1" corrosion hole.
- Span 3 gusset plate L8E Exterior has laminar corrosion throughout the plate and multiple repair plates welded to the gusset.
- Gusset plates at U5 joints typically have paint loss and surface rust on much of the surface. There is pitting at the interface with stiffener angles at Span 1 gusset plates U5E Interior and U5W Interior. There is up to ¾" prying due to pack rust on the corners of Span 1 gusset plates U5E Interior and Exterior, U5W Interior, as well as Span 3 gusset plates U5E Interior and U5W Interior.

RECOMMENDATIONS

Deterioration has continued to advance on several members. HDR recommends that the Memorial Bridge continues to be inspected in six month intervals. Given the increased deterioration of floorbeams, 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. Despite the advancement in section loss on the members inspected, the structure's current posting of 3-tons is 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.

During the Interim Structural Inspection, inspectors observed several trucks crossing the bridge that may be over the 3-ton posting. HDR recommends that the NHDOT investigate the need for implementing enforcement of the 3-ton posting.

APPENDICES

Appendix A: Photos

Appendix B: Condition Summary Sketches

Part I – Floorbeam Condition

Part II – Gusset Plate Condition

Appendix A

Photos

Photo 1: Span 1, Gusset Plate L2E, Interior. Gusset plate was repaired in 2009.

Photo 2: Span 1, Gusset Plate L2E, Interior. Paint placed in 2009 on existing steel starting to fail at edges. Rust showing through.

Photo 3: Span 2, Gusset Plate L8W, Interior. Painted over pitting.

Photo 4: Span 1, Gusset Plate U5E, Exterior. Surface rust throughout plate. Pitting on plate along interface with steel angle.

Photo 5: Span 1, Gusset Plate L8E, Interior. Heavy laminar corrosion throughout plate.

Photo 6: Span 2, Floorbeam FB4. South Face. Web between Stringers S4 and S5. Several web holes and heavy section loss in web. Holes occur in 17” by 16” area.

Photo 7: Span 1, Floorbeam FB4, North Face. Web at Stringer S5. Holes in web below stringer.

Photo 8: Span 1, Floorbeam FB4, South Face. Web at east end. Multiple holes in web.

Photo 9: Span 2, Floorbeam FB8, South Face. Laminar corrosion on bottom flange near Stringer S6.

Photo 10: Span 2, Floorbeam FB8, South Face. Laminar corrosion on web at midspan.

Photo 11: Span 2, Floorbeam FB5, North face. 13”x4” corrosion hole in web.

Appendix B

Condition Summary Sketches

Section I – Floorbeam Condition

Legend:

Red Text – Inspection comments from 2009 Inspection

Blue Text – New inspection comments from May 2010 Inspection

PIT – Pitting

SL – Section Loss

FLG – Flange

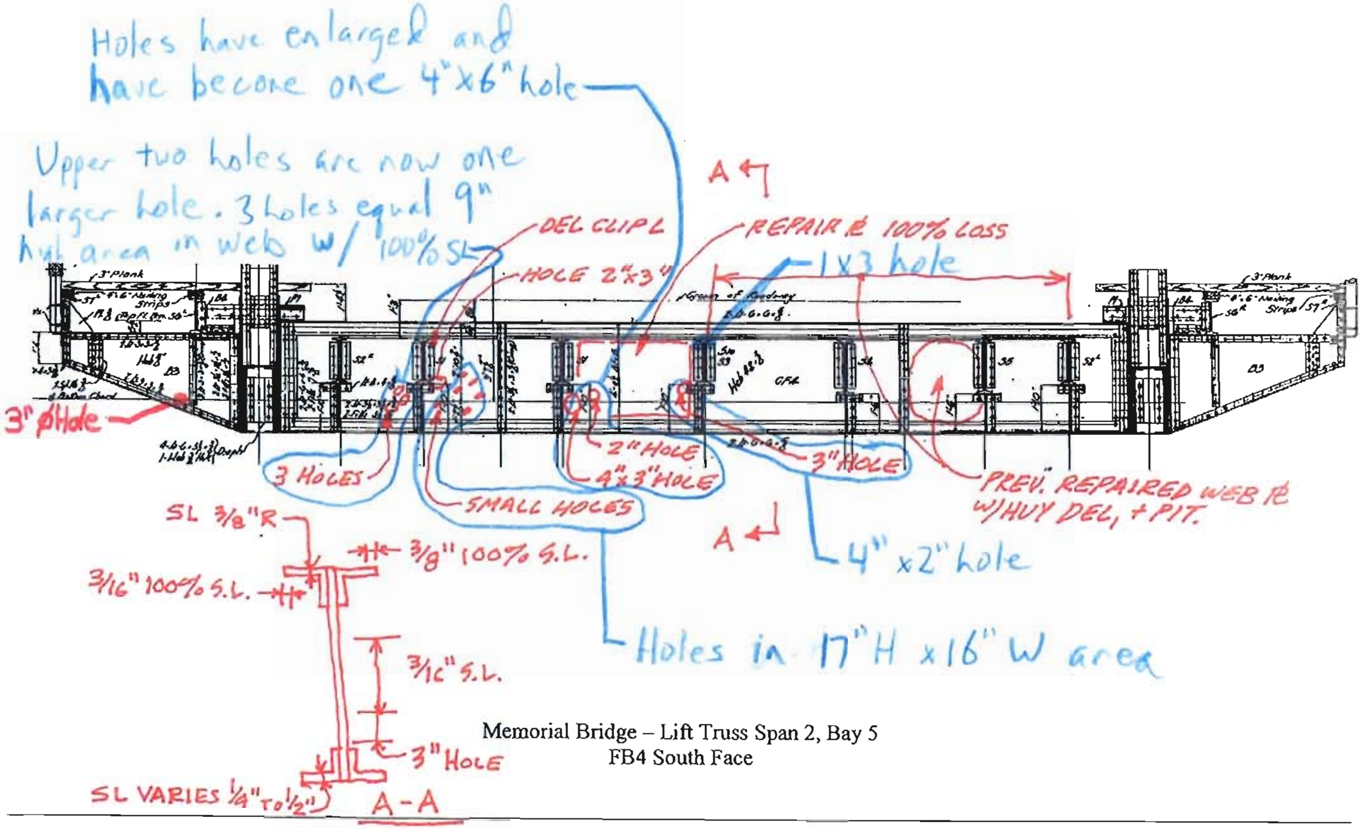
BF – Bottom Flange

TF – Top Flange

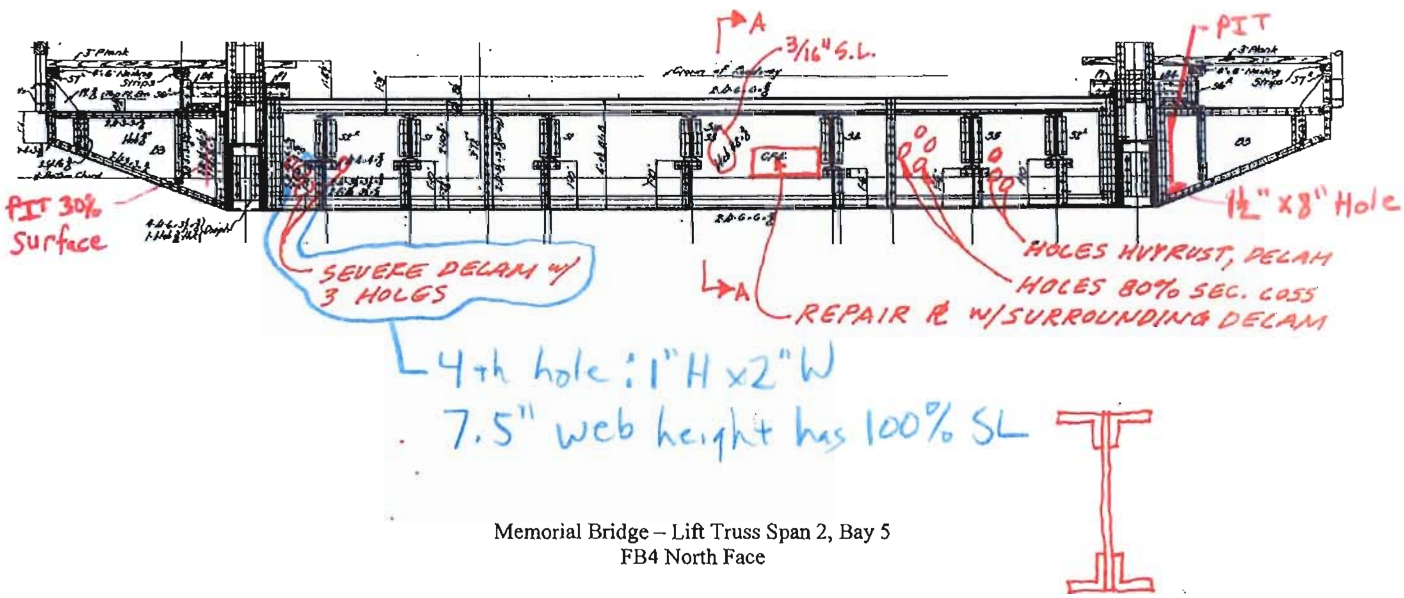
Hvy – Heavy

REP - Repair

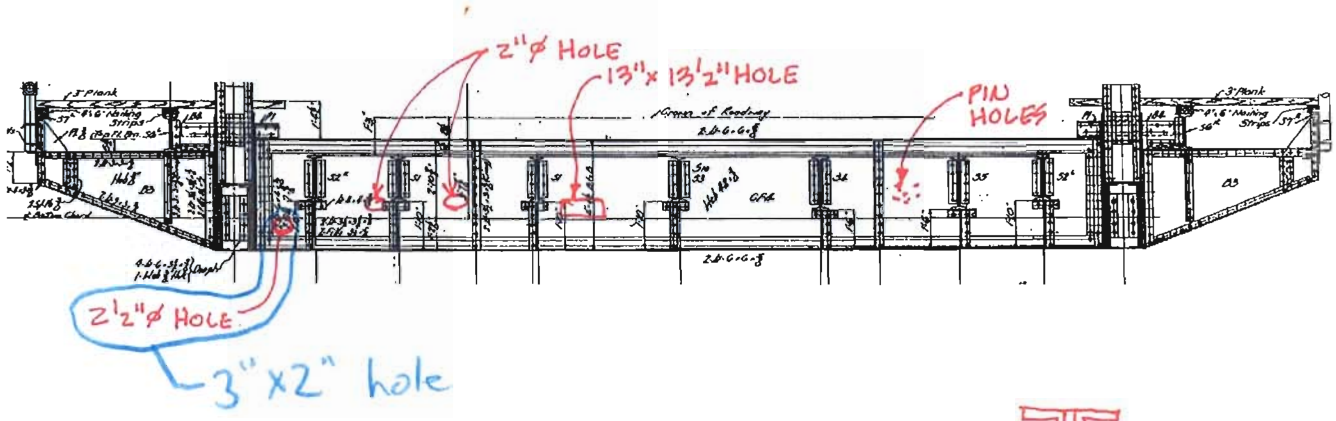
DEL, DELAM, DELAMINTED – Laminar Corrosion

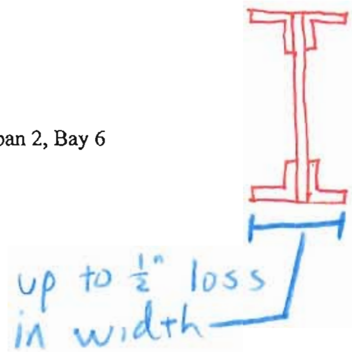


Memorial Bridge – Lift Truss Span 2, Bay 5
FB4 South Face

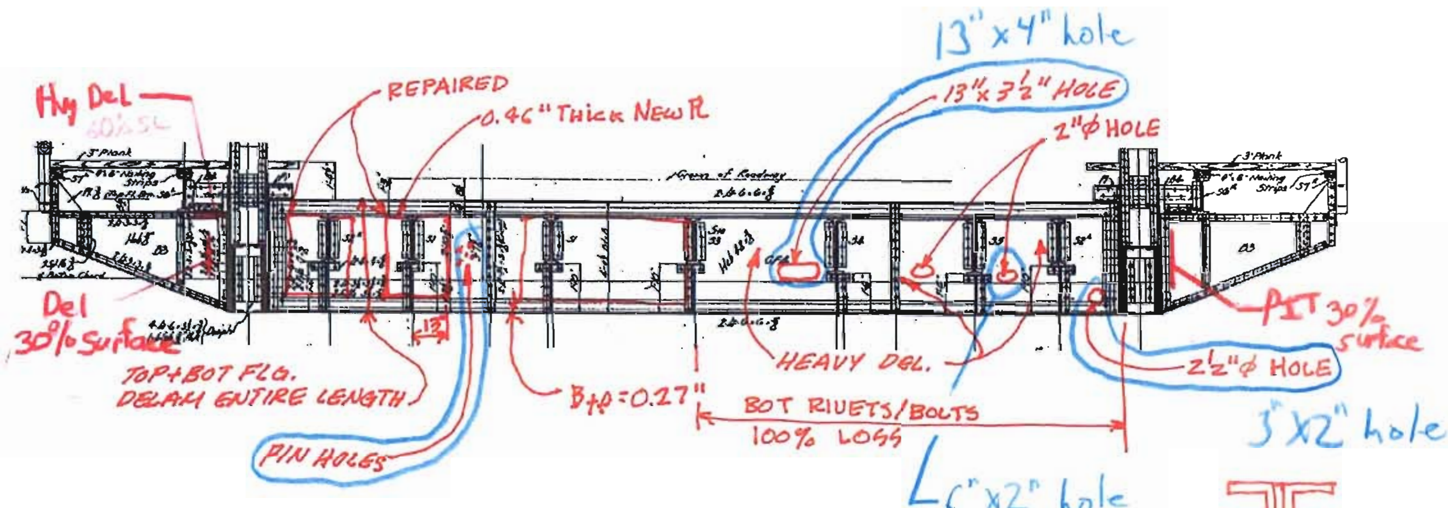


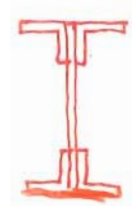
Memorial Bridge – Lift Truss Span 2, Bay 5
FB4 North Face



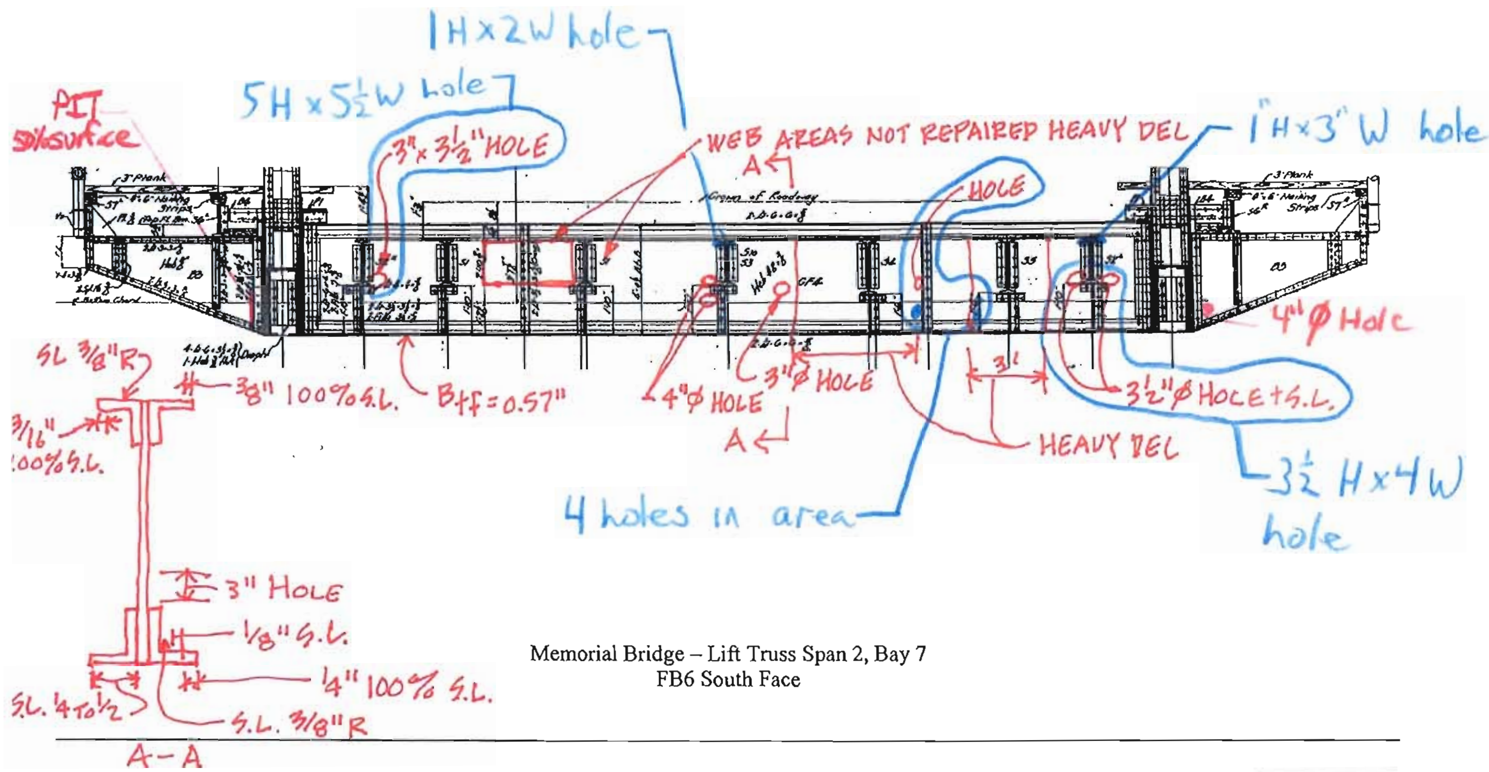


Memorial Bridge – Lift Truss Span 2, Bay 6
FB5 South Face

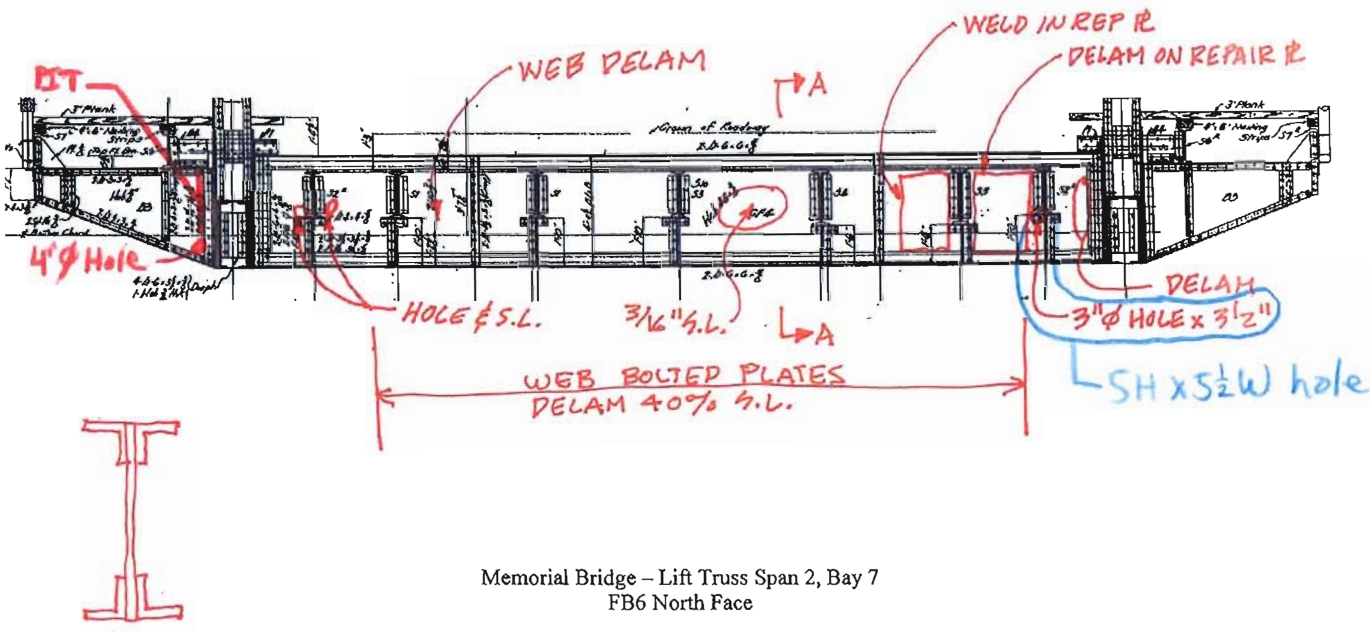




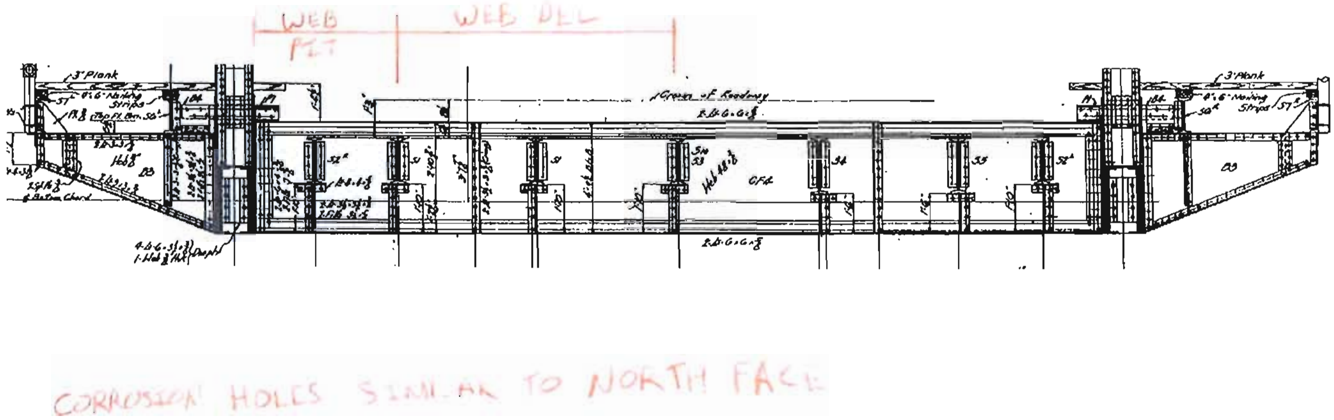
Memorial Bridge – Lift Truss Span 2, Bay 6
FB5 North Face



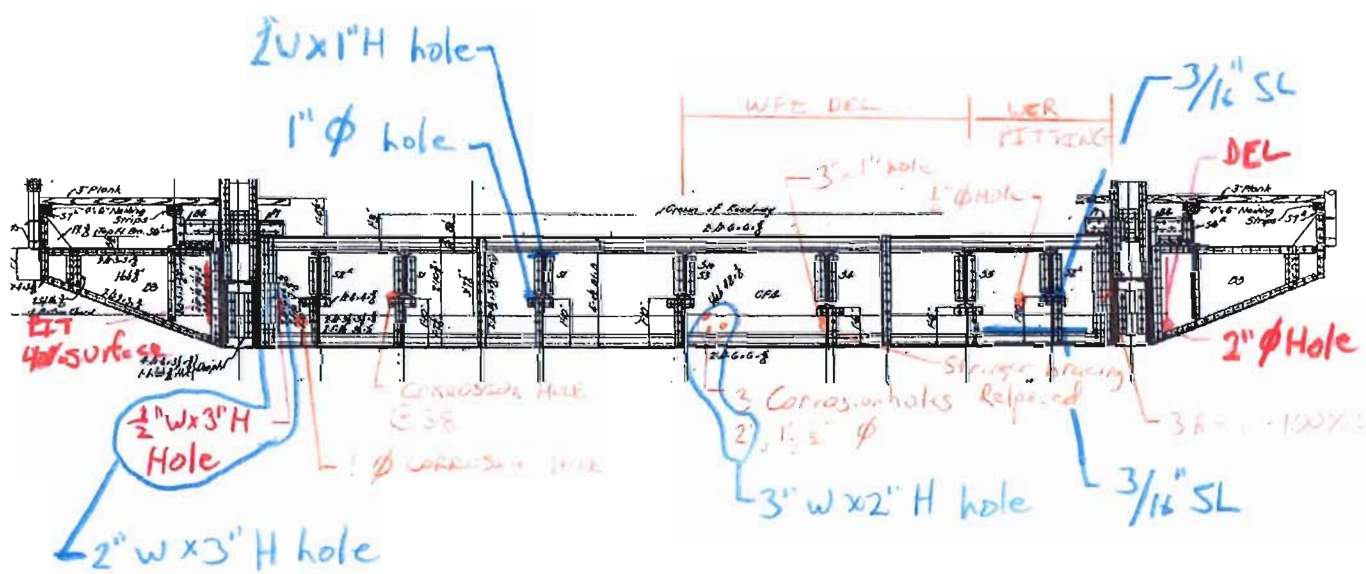
Memorial Bridge – Lift Truss Span 2, Bay 7
FB6 South Face



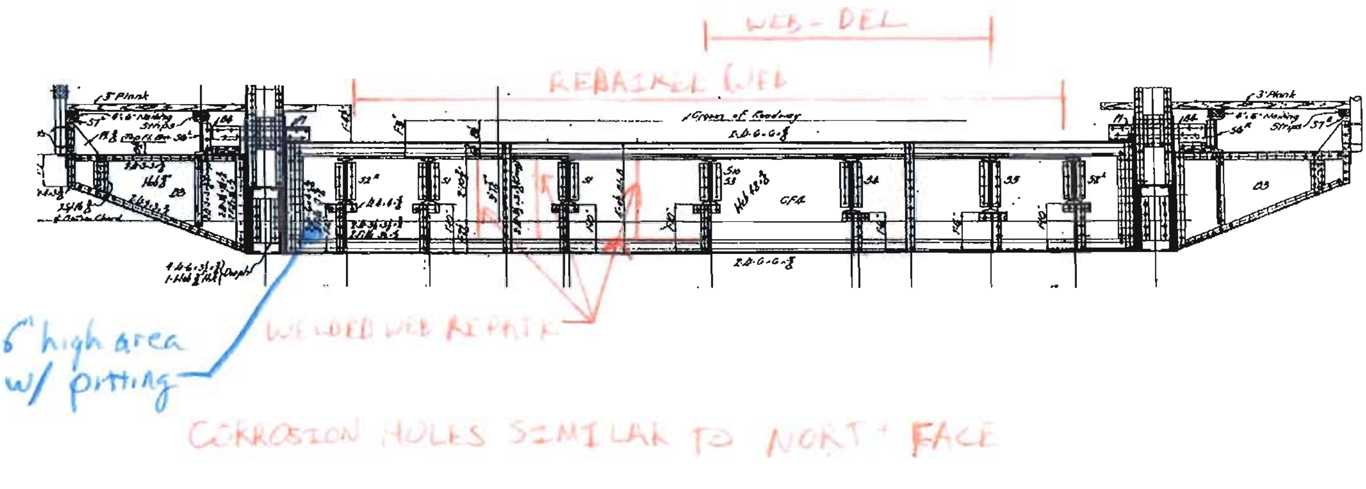
Memorial Bridge – Lift Truss Span 2, Bay 7
FB6 North Face



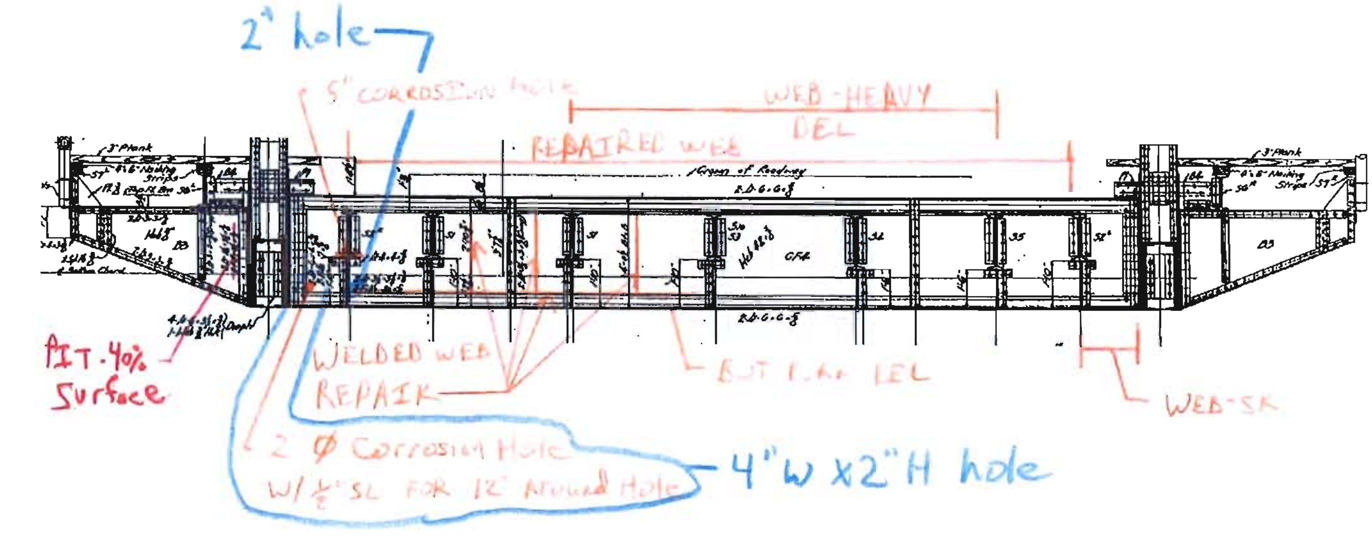
Memorial Bridge – Lift Truss Span 2, Bay 8
FB7 South Face



Memorial Bridge – Lift Truss Span 2, Bay 8
FB7 North Face



Memorial Bridge – Lift Truss Span 2, Bay 9
FB8 South Face



Memorial Bridge – Lift Truss Span 2, Bay 9
FB8 North Face

Section II – Gusset Plate Condition

Legend:

Red Text – Inspection comments from 2009 Inspection

Blue Text – New inspection comments from May 2010 Inspection

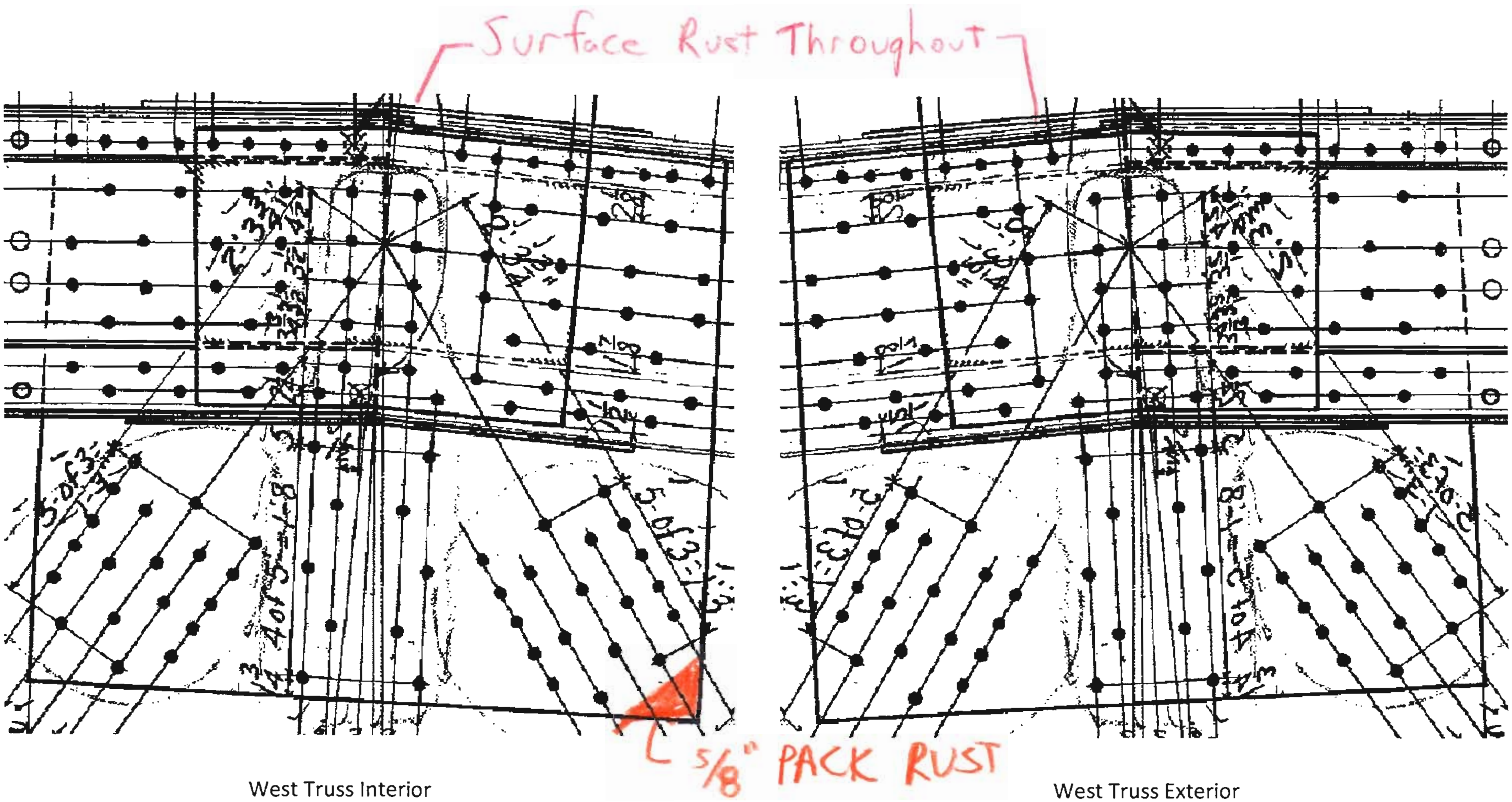
PIT – Pitting

SL – Section Loss

Hvy – Heavy

REP - Repair

Lam – Laminar Corrosion

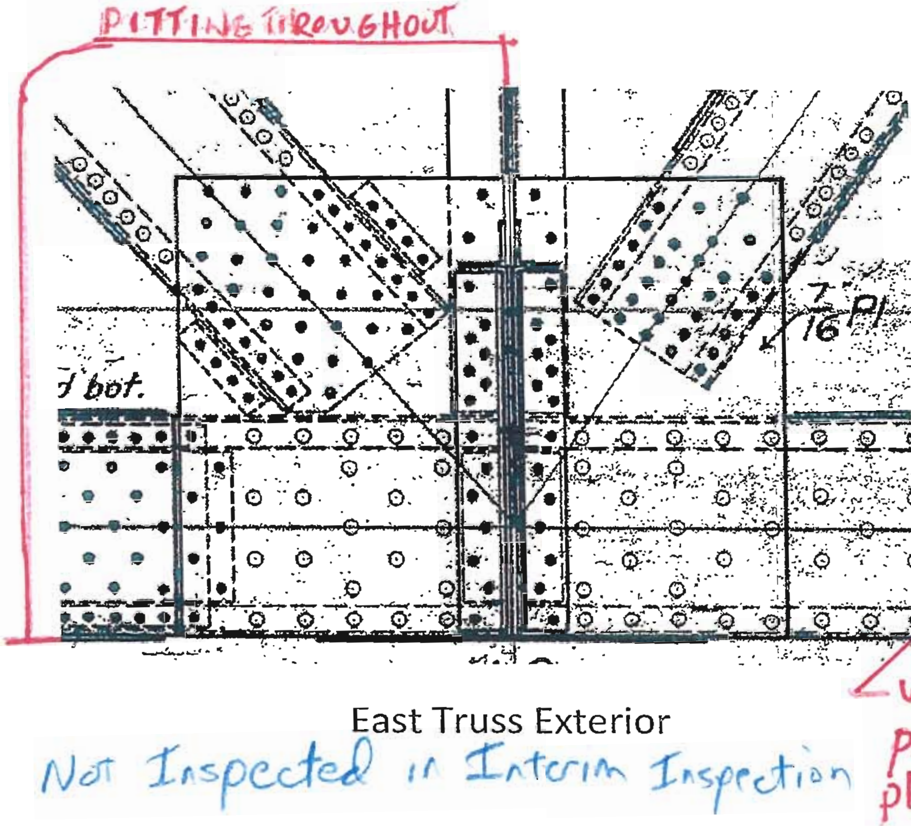


West Truss Interior

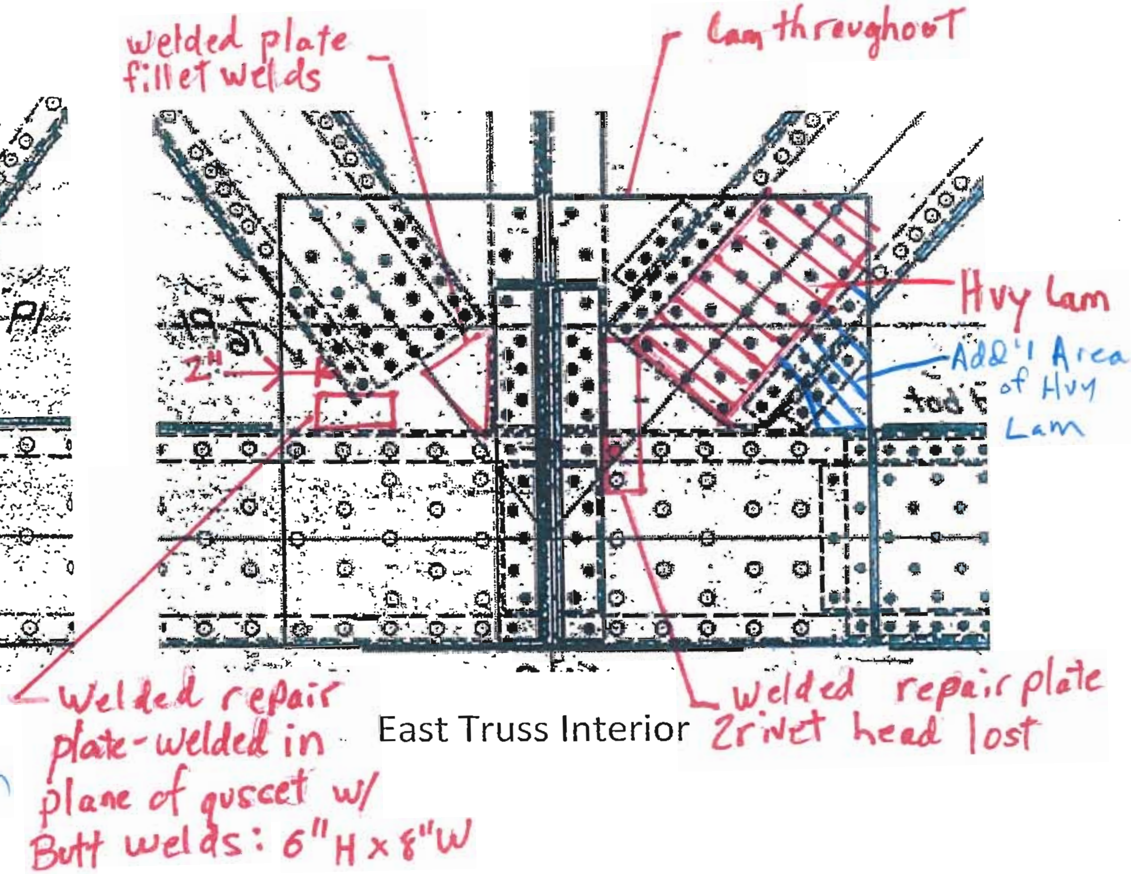
West Truss Exterior

Memorial Bridge Gusset Plate

Span 3 – U5



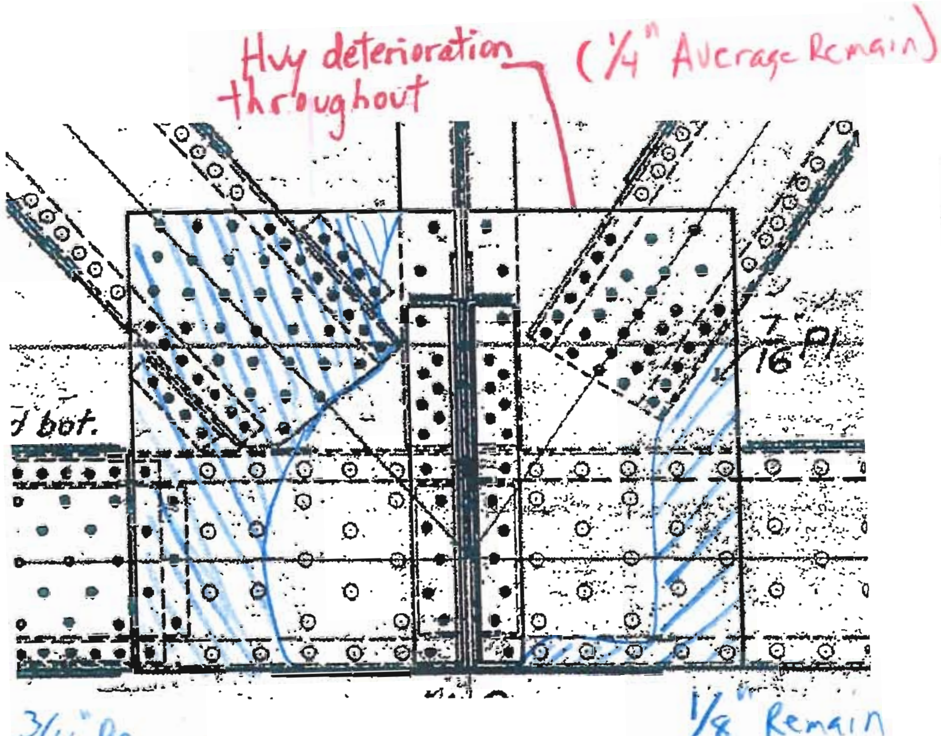
East Truss Exterior



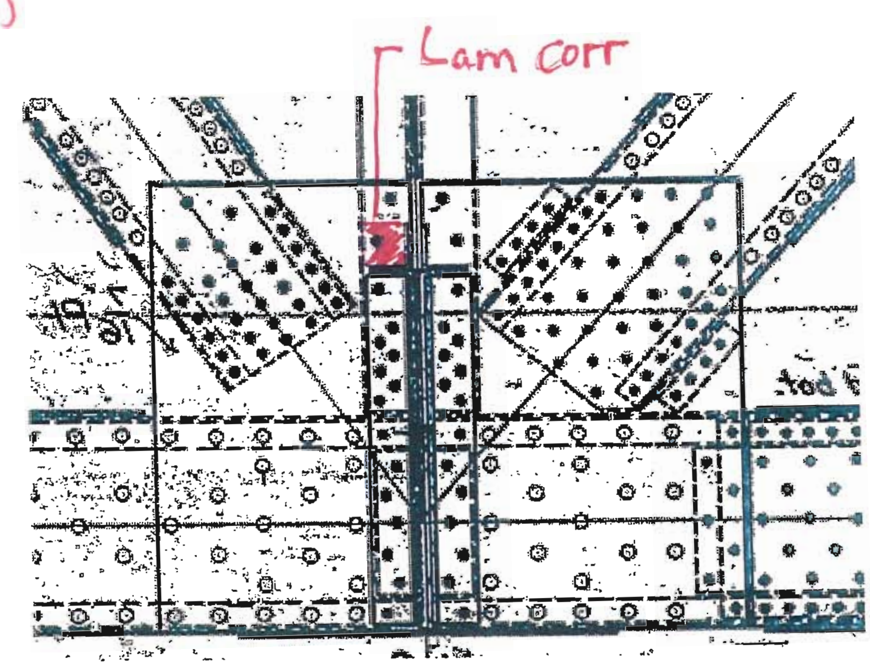
East Truss Interior

Memorial Bridge Gusset Plate

Span 1 - L2



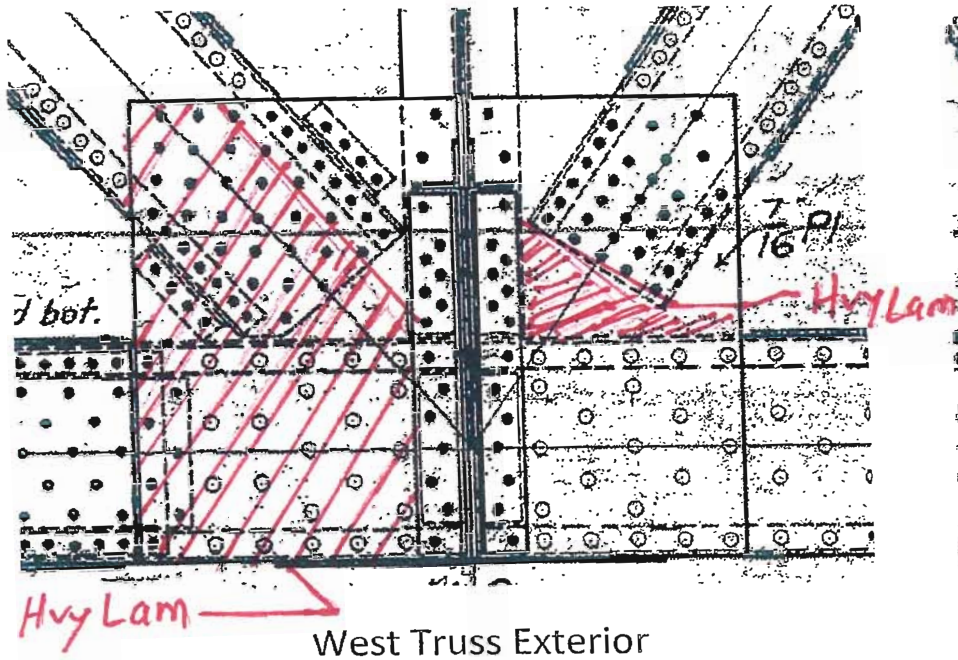
East Truss Interior



East Truss Exterior

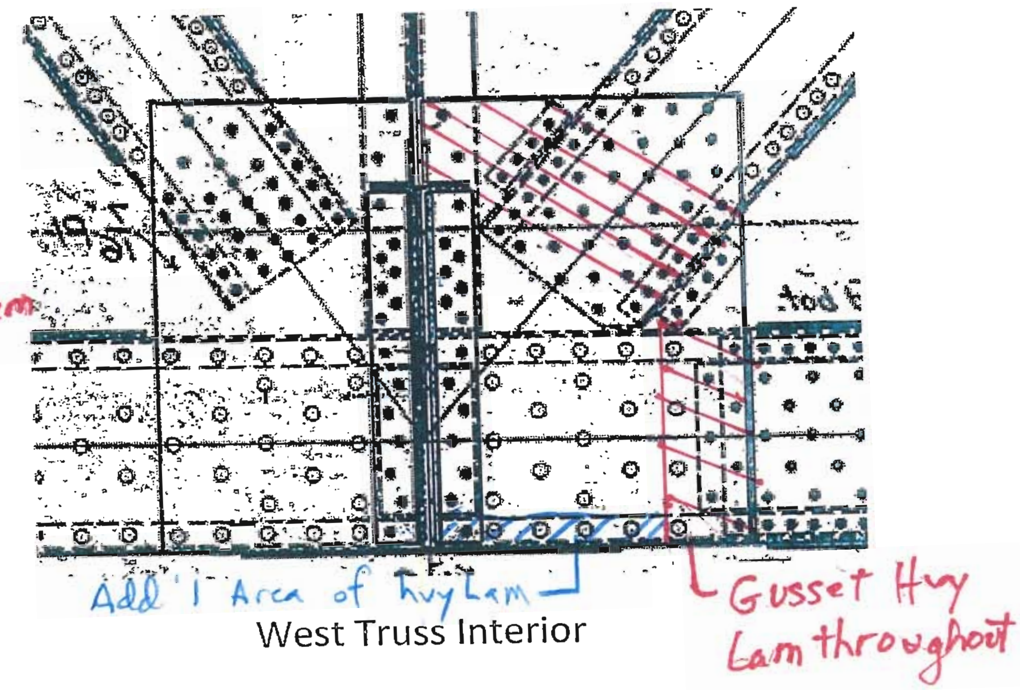
Not Inspected in Interim Inspection

Memorial Bridge Gusset Plate
Span 1 - L8



West Truss Exterior

No significant changes in condition

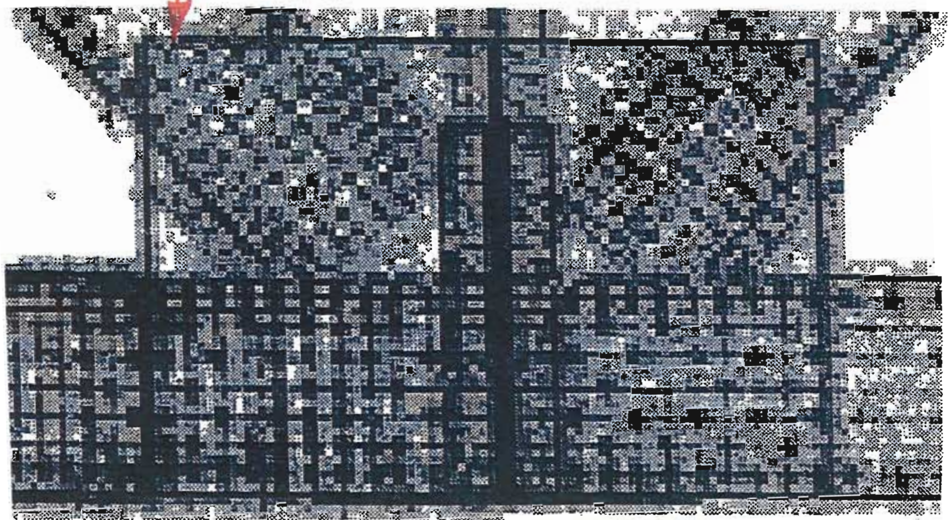


West Truss Interior

Memorial Bridge Gusset Plate

Span 1 - L8

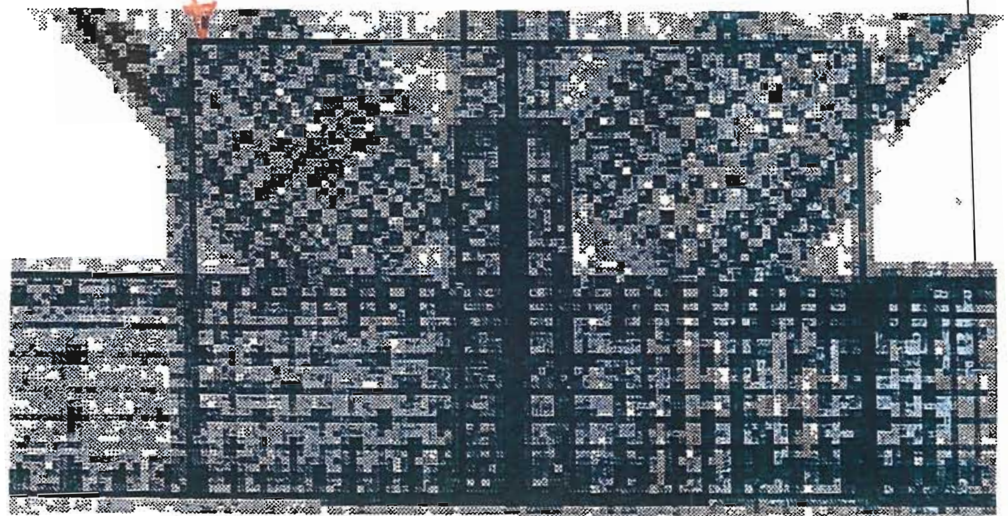
LAM ON GUSSET, W/ S.L. ALL OVER



TRUSS GUSSET L2
WEST INTERIOR

No significant change in condition

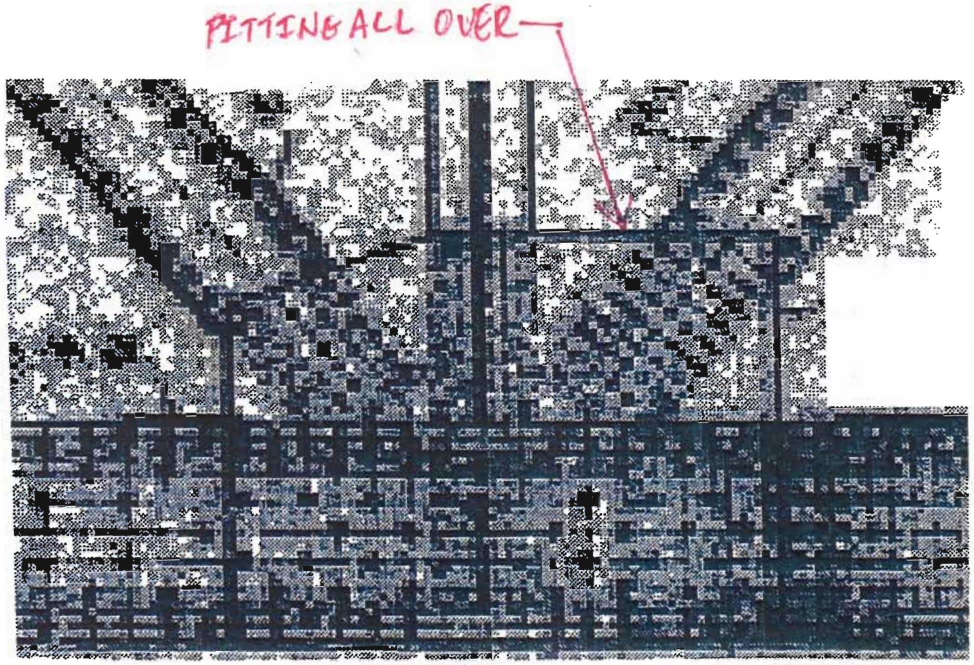
MINOR LAM, SOME S.L. ALL OVER



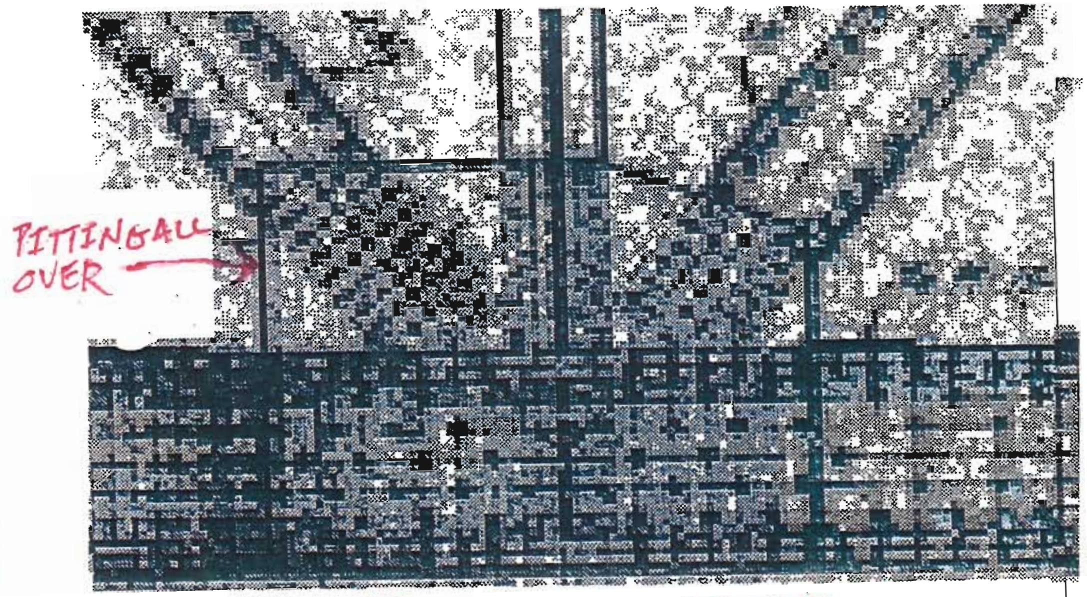
TRUSS GUSSET L2
WEST EXTERIOR

No significant change in condition

MEMORIAL - SPAN 2, BAY 3



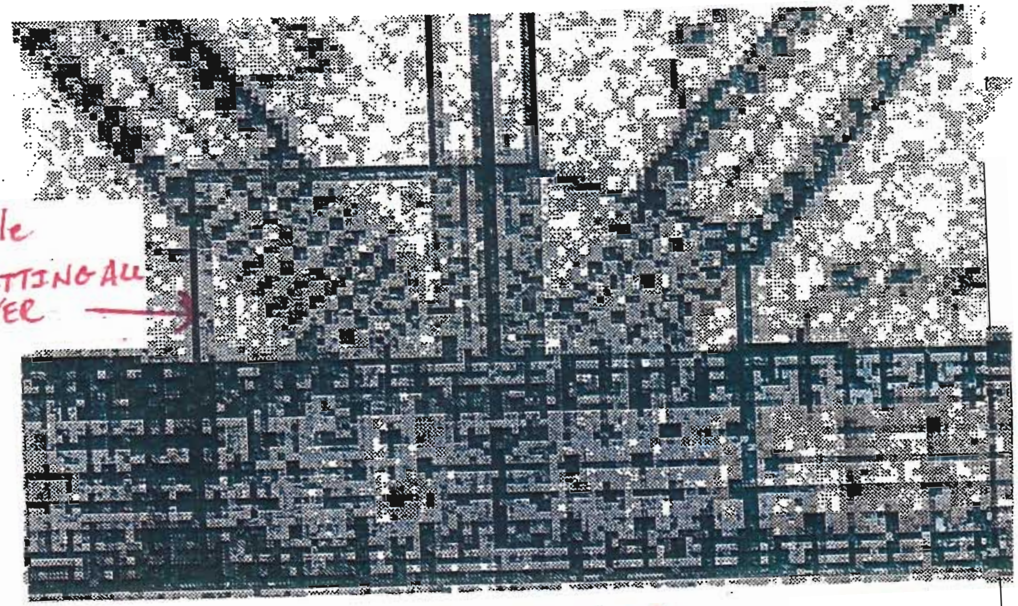
TRUSS GUSSET L8
EAST INTERIOR
No significant change in condition



TRUSS GUSSET L8
EAST EXTERIOR
No significant change in condition

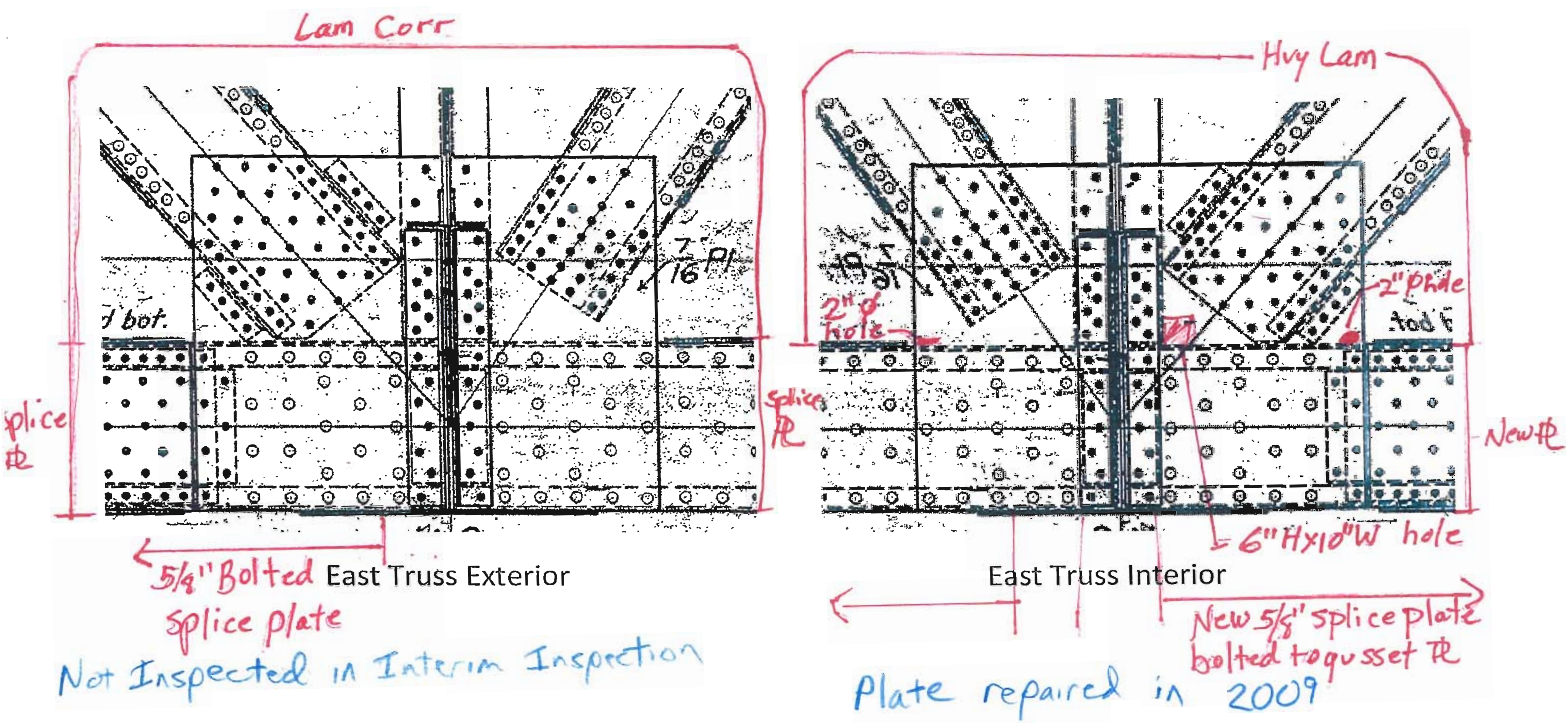
MEMORIAL SPAN 2, BAY 8

TRUSS GUSSET L8
WEST INTERIOR
No change in Condition



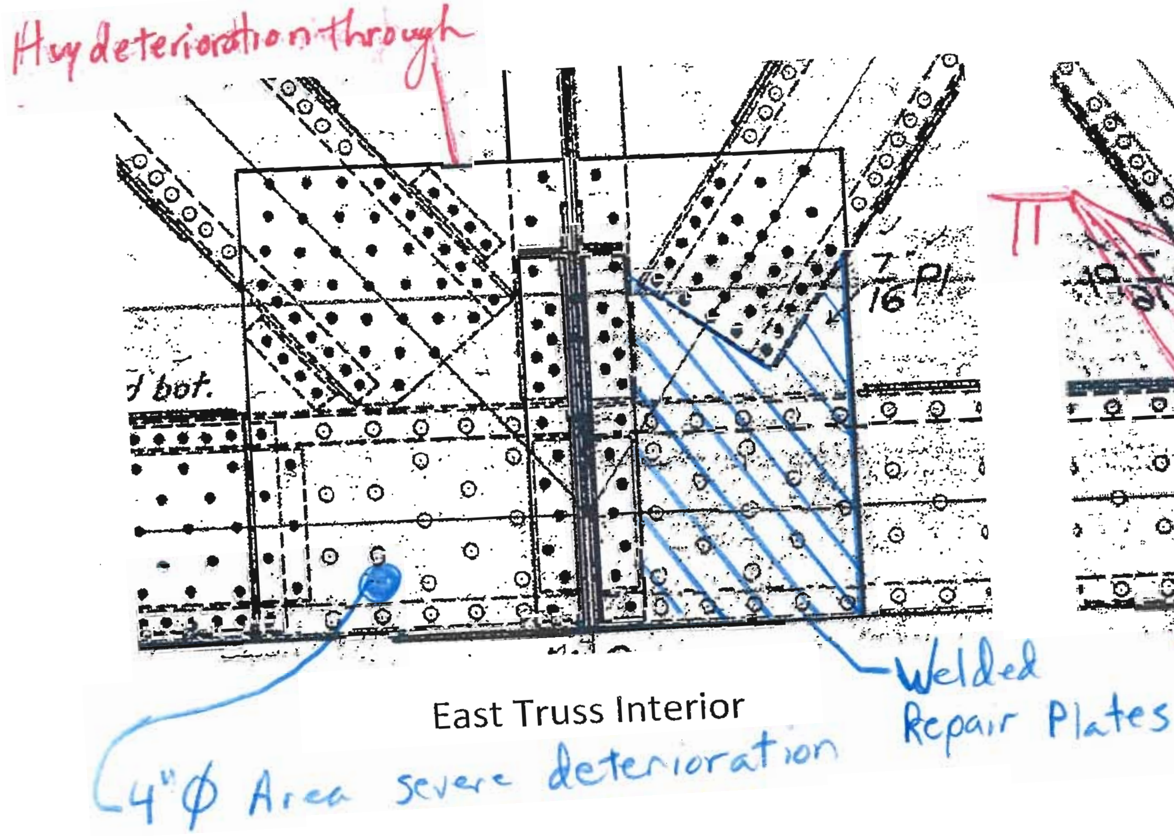
TRUSS GUSSET L8
WEST EXTERIOR
No change in Condition

MEMORIAL - SPAN 2, BAY 8

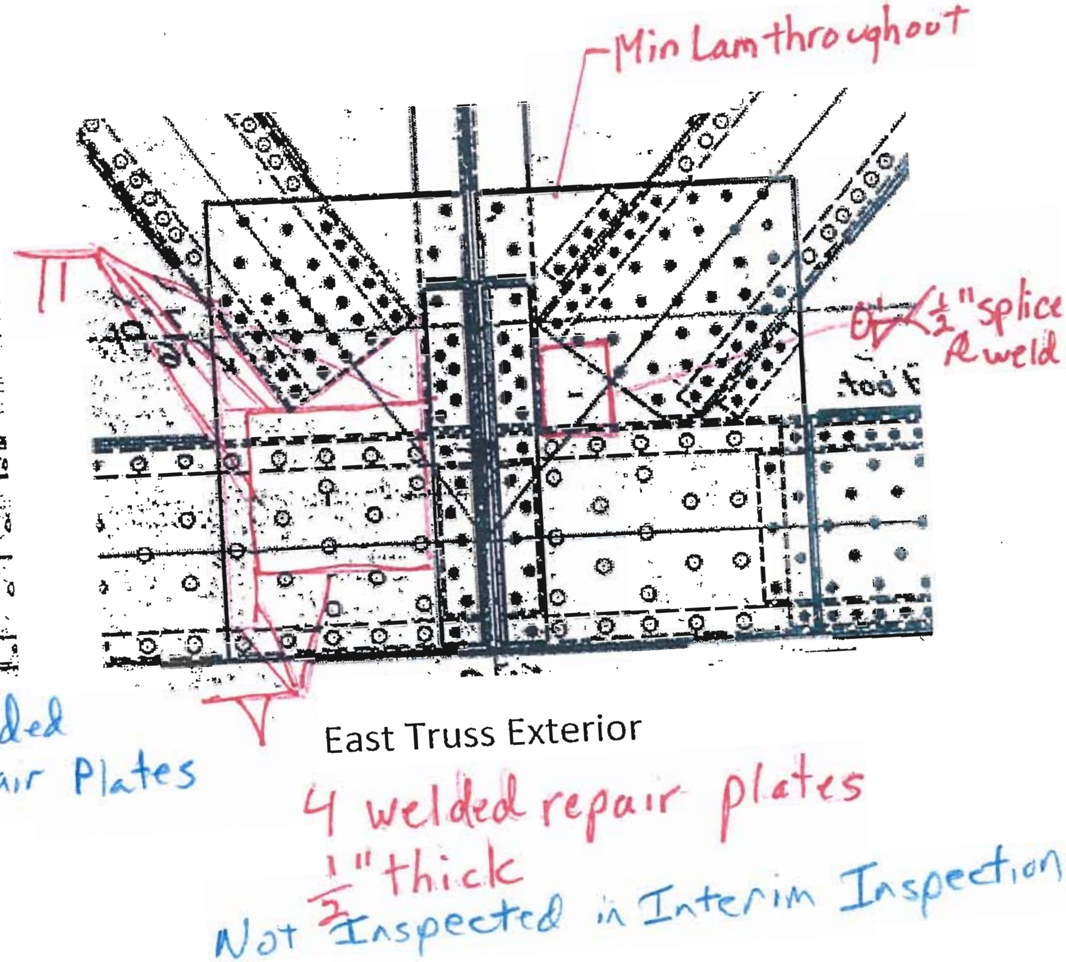


Memorial Bridge Gusset Plate

Span 3 - L2



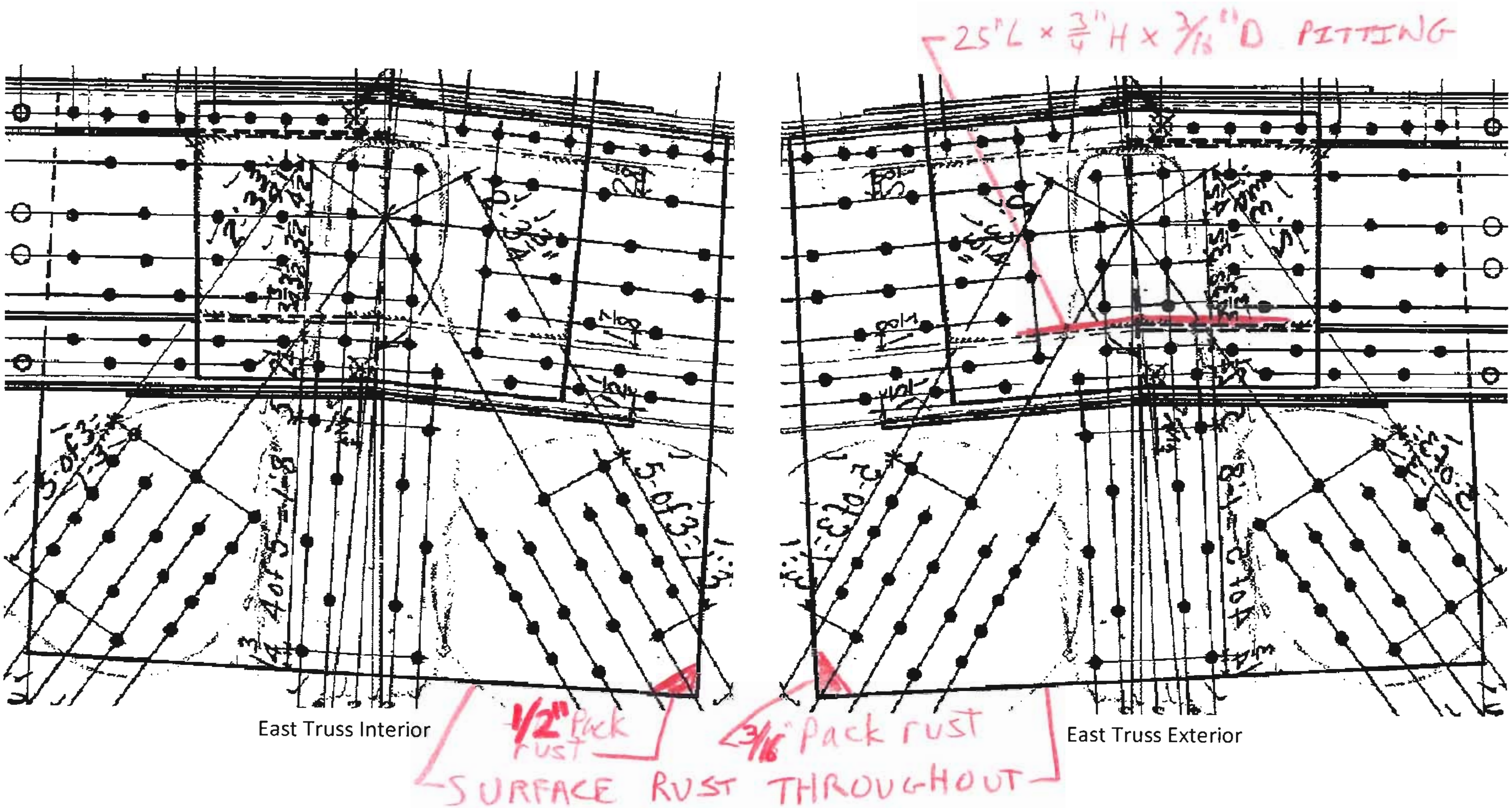
East Truss Interior



East Truss Exterior

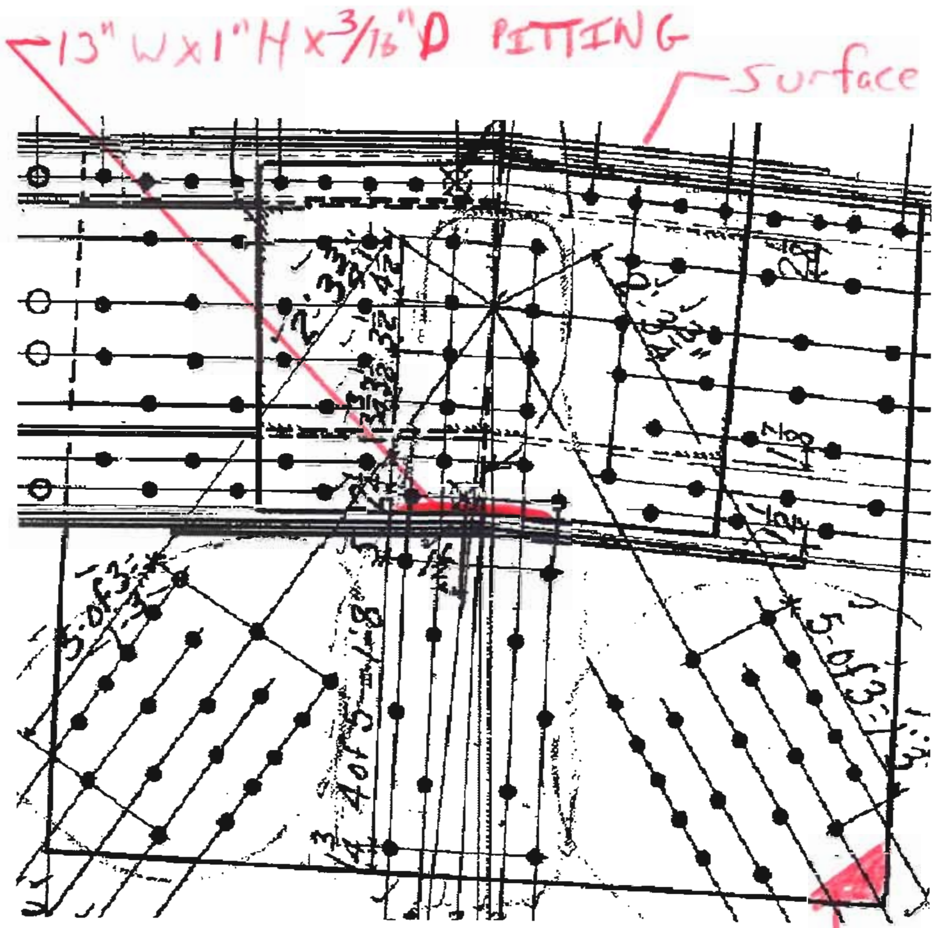
Memorial Bridge Gusset Plate

Span 3 - L8

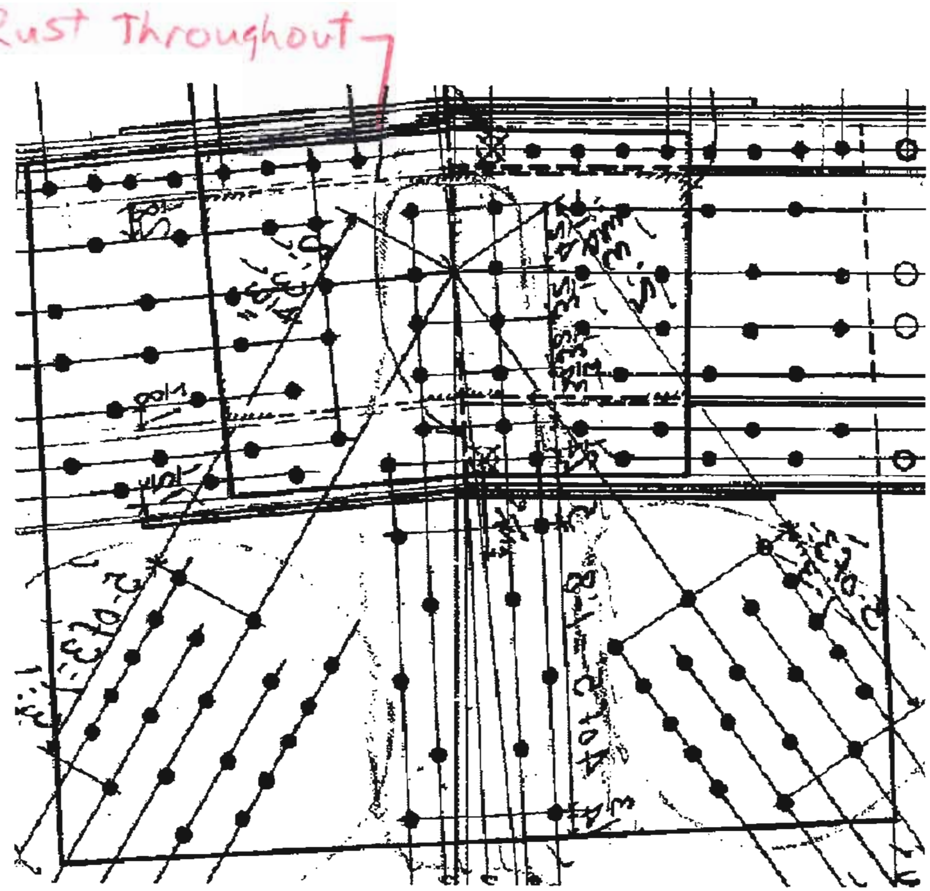


Memorial Bridge Gusset Plate

Span 1 – U5



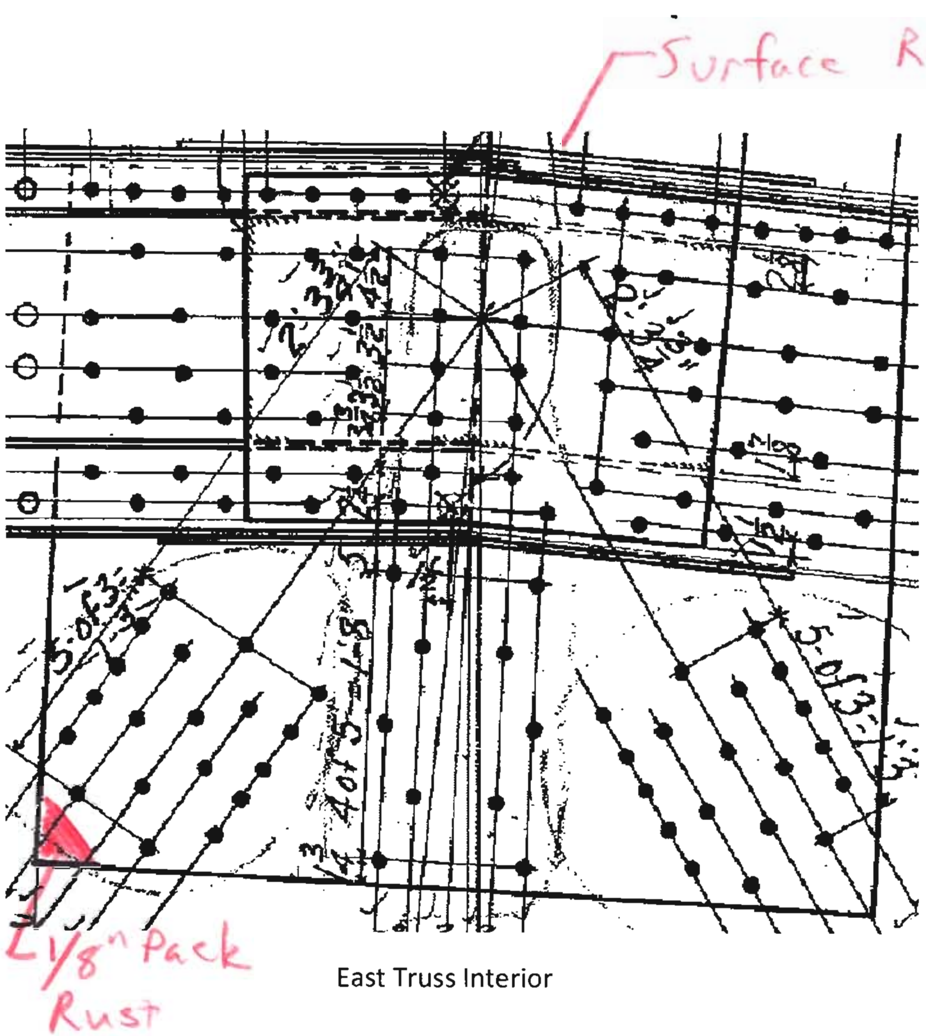
West Truss Interior



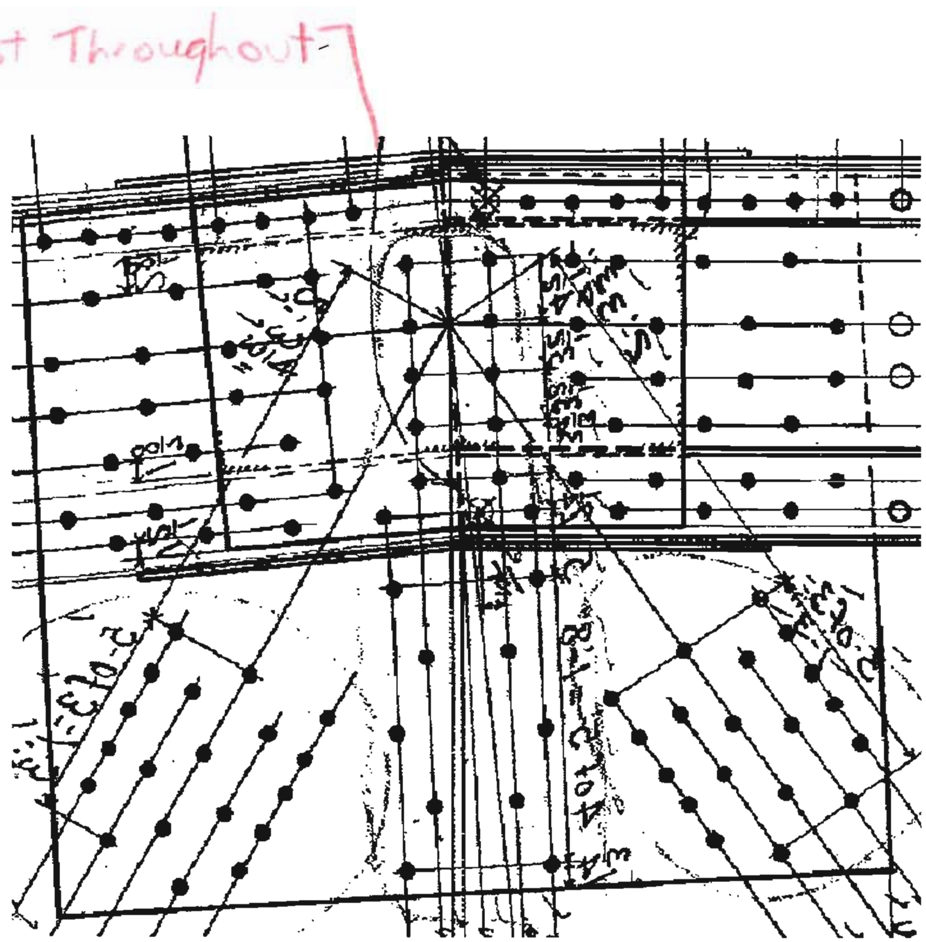
West Truss Exterior

Memorial Bridge Gusset Plate

Span 1 – U5



East Truss Interior



East Truss Exterior

Memorial Bridge Gusset Plate

Span 3 – U5

Part II: Interim Mechanical Inspection Report

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Part II: Interim Mechanical Inspection Report

SECTION

APPENDICES

Field Inspection Report
Memorial Bridge Interim Inspection Spring 2010
Nondestructive Testing Firm – Waves in Solids LLC

1. Executive Summary

An inspection of the counterweight ropes, trunnions, and equalizers for the Memorial Bridge was performed on May 18-21 of 2010 by HDR Engineering. A visual inspection was performed on all counterweight ropes. A visual inspection and an ultrasonic inspection were performed on select counterweight equalizer plates and pins. A visual inspection, ultrasonic inspection, and wet magnetic particle inspection were also performed on all trunnion shafts. The inspection found no indications of fatigue cracks in the trunnions, or equalizers. However, it was determined that the level of wear in the ropes and equalizer pin connections are above allowable levels. Steps should be taken to improve the condition of the equalizer, and safety of the system, as provided in Section 4 Recommendations.

2. Inspection Approach And Methodology

The purpose of this work was to perform an in depth inspection of the counterweight ropes, trunnions, and equalizers. All ropes were cleaned and inspected at the point of tangency with the span side of the sheave when the span is in the seated position. This location is the point of greatest wear. The trunnion bearing caps were removed cleaned and visually inspected. The trunnion journals and fillets were cleaned, visually inspected, and underwent both magnetic particle testing, and ultrasonic testing. The equalizer pins and links (See Figure 2-1 Equalizer Assembly) were cleaned, visually inspected, and inspected using ultrasound. Ultrasonic testing was limited to pins A, through G, and the primary and tertiary plates in all corners. Additionally, the crack on the outboard side of the NE counterweight sheave was visually checked for growth.

3. Inspection Findings

3.1. Counterweight Ropes

In general the wire ropes in the area inspected were found to have reduced diameters, and heavy crown wear (See Photo 2-6) ranging up to 11/16" in length (See Table 2 through Table 5 for full list of measurements). The ropes replaced in 2008 also had crown wear up to 3/8" in length. During the scoping study performed by HDR in the spring of 2009 it was found that all counterweight grooves were worn beyond the acceptable limits of the "minimum for worn groove" gauge. The Wire Rope User Manual recommends that ropes be replaced once their diameter has reached 95% of its nominal diameter (1.544" for a 1-5/8" rope). The measurements taken indicate that ropes 1, 2, and 3 on the SW corner and rope 1 on the SE corner should be replaced based on their diameter. Note that Rope 3 in the SW corner was replaced in 2008, and the diameter should be confirmed in upcoming inspections. Lubrication of the ropes was fair to poor. Lubrication was typically dry and caked (See Photo 2-7), with areas of bare wire rope, and surface rust. HDR found only one break on Rope 10 in the SE quadrant (See Photo 2-8). Due to the amount of caked grease on the ropes it is difficult to identify broken wires. It should be noted that during previous interim inspections (by others) the crown wear given in the reports indicate more crown wear than measured in this report.

This variation may be due to the location where the measurements were taken. Based on crown, wear the worst of the ropes has about 84% of their area intact (See Figure 2-2: Rope wear). Given that high tensions and high wear are likely to coincide, it is possible to have several ropes with factors of safety as low as 4.7 (See Additional Analysis section 1). AASHTO recommends a factor of safety of 8.

3.2. Balance assemblies

The balance assemblies show no significant changes since the previous reports, although the condition continues to deteriorate. It was noted that the balance assemblies continue to creak during operation. The assemblies have peeling paint and surface rust over much of the plates (Photo 2-9). Fretting corrosion is typical between the plates (Photo 2-10) and at the pin connections (Photo 2-9), since there are no means for greasing the joints of the connections and there are no spacers between the plates. The fretting between the plates has led to areas of minor section loss of the plates. It was noted that the on the SW corner balance pins F and G (see Figure 2-1 Equalizer Assembly) are frozen. It was also noted that pin D in the NW and SW corners have such large clearances that the plate has worn into, and may be bending the cotter pins as it bears against them (Photo 2-11). No indications were found in the pins or plates see NDT testing report Appendix: D Appendix D. Upon cleaning of the NW corner it was noted that all the plates were welded across the tension zones of the plate. The area of most concern is a weld next to pin D (See Photo 2-12). This weld is near the area of greatest tension in the connection. See Table 6: Balance Assembly Pin Clearances.

3.3. Trunnion Shafts and Bearings

The trunnion shafts were found to have light to severe scoring, pitting, and galling (See Photo 2-13 SW Inboard Trunnion, and Photo 2-14 NE inboard Trunnion). These defects tended to be concentrated at the fillet, and thrust faces. There were no indications found with wet magnetic particle testing, or with ultrasonic testing. Bearing caps show mild to moderate scoring on the thrust faces. Table 1: Journal Conditions provides detailed conditions of the trunnions based on visual inspection. See Appendix: D NDT Testing report for details on ultrasonic and magnetic particle testing results.

4. <u>Recommendations</u>

The following section provides the recommended maintenance to the machinery needed prior to a major rehabilitation or replacement of the bridge. See Appendix: A Additional Analysis Section 2 Repair Alternatives for additional information.

- No action should be taken to replace the trunnion shafts, counterweight sheaves, or counterweight ropes. The ropes should be visually inspected annually, the trunnions should be ultrasonic, and wet magnetic particle tested every five years, and the counterweight sheaves should be visually inspected annually.
- Replace all tertiary plates, and pins D-G on all corners, field bore and sleeve secondary plates at location of pins D-G as required. Yearly inspections should continue to monitor the balance assembly. See Appendix: A Section 2.3.2 Repair Equalizer for further details.

Appendix: A Additional Analysis

1. Counterweight Rope Factors of Safety

Assuming best the case scenario of equal tension of the ropes and an estimated span weight of 2100 kips, each rope should have approximately 32.8 kips of direct tension. The original ropes had a tensile strength of 209 kips giving a direct tension factor of safety (FOS) of 6.37. The rope with the most diameter reduction due to crown wear has about 84% (See Figure 2-2: Rope wear) of its area intact giving a tensile strength of 178 kip and a FOS of 5.4. The actual condition of the ropes may be worse. During the fall of 2009 HDR measured random tensions, See "Mechanical and Electrical Scoping Study for the Portsmouth Memorial Bridge Over the Piscataqua River" in Volume II of the "In Depth Inspection and Condition Report for the Memorial Bridge," submitted in November of 2009. The tension measurements taken show an average tension of 33.48 kips and tensions up to 37.97 kips. Given that high tensions and high wear are likely to coincide in a rope, it is possible to have some ropes with factors of safety as low as 4.7. AASHTO recommends a factor of safety of 8 for direct tension on a rope.

2. Repair Alternatives

The following sections give additional repair alternatives that may be feasible instead of the recommended option. These options vary in cost, expected service life, and safety. The options consider work alternatives for the counterweight ropes, counterweight sheaves, and balance assembly.

2.1. Trunnions and Counterweight Sheaves

2.1.1. Monitor Condition

Continue ultrasonic and wet magnetic particle testing of the trunnion shafts every five years, as well as monitor groove, and bearing wear during bi-annual inspections. This option should be considered for the short term only. The ropes that were replaced two years ago already show significant crown wear (3/8" long). One contributor to the wear of the new ropes is that all grooves that engage new ropes were shown to be worn by a "minimum for worn groove" gauge. The condition of the worn grooves will cause accelerated wear of both new and used ropes.

2.1.2. Re-Machine Counterweight Sheave Grooves

Continue ultrasonic and wet magnetic particle testing of the trunnion shafts every five years, and bearing wear measurements during bi-annual inspections. Remachine the grooves to the proper dimensions (1-5/8" +5%) at a slightly smaller pitch diameter. This work would require an analysis of the current counterweight sheaves to determine if this option is viable. The analysis is out of the scope of this inspection. Remachining the existing counterweight sheave grooves would be much less costly than replacing the counterweight sheaves, however, it would require the counterweight to be jacked and temporarily supported during a sixty day marine outage. This repair will extend the life of the sheave, and counterweight ropes. However, no prediction can be made without further analysis on how long this will extend the life of the system. Previous inspections have indicated that the trunnions are at the end of their fatigue life.

2.1.3. Replace Sheaves, Trunnions, and Bearings

Replacing the counterweight sheaves, trunnions, and bearings would provide the maximum service life. The work would require the bridge to be closed to marine traffic for several weeks while the counterweight is jacked. During the marine outage the sheave and bearing would be replaced. The ropes would also have to be removed during the marine outage, and presumably would be replaced along with the equalizer assembly.

2.2. Ropes

2.2.1. Monitor Condition

Continue to monitor ropes for further crown wear, breaks, and rope tensions on an annual basis. The ropes have a low factor of safety compared to AASHTO standards, however, it is unlikely that any rope will catastrophically fail. The lower factor of safety is a contributor to a high wear rate, and will cause a reduced service life.

2.2.2. Replace Select Ropes

Replacing select ropes will improve the service life of the machinery. This option may be performed with a few short outages, and would not require the counterweight to be jacked. The cost would be less than replacing all the ropes, however, this option will no provide as much service life as a replacement of all the ropes.

2.2.3. Replace All Ropes

Replacing all of the ropes will provide the maximum service life, especially if completed with a replacement or remachining of the counterweight sheaves, and the replacement of worn equalizer plates. The replacement of the ropes may be performed during short outages, and would not require the counterweight to be jacked. This work would require more outages than replacing select ropes, and carries a greater cost.

2.3. Equalizer

The rope equalizer is in poor condition and in need of replacement. For comparison, pins D, E, F, and G should have less than .01” of wear to be considered in good condition. Current wear measurements show the greatest pin clearance to be as large as .875”. In general, the wear on all the pins is accelerating (see Figure 2-3: Balance Assembly Pin Clearances).

The balancing pin and the two connections it equalizes must be along, or at least close to the same axis to provide equalization. In the current configuration each equalizing plate creates an imbalance between the ropes it equalizes. Assuming an accuracy of plus or minus .25” per 100’ of rope (standard tolerance from WireCo) the tolerance of the counterweight ropes should be approximately plus or minus .43 inches over 172 feet. Say there is a difference between two ropes connected to the same quaternary plate (see Figure 2-1 Equalizer Assembly) of .4” in length. This difference would result in a rotation of the plate of only 3.3 degrees, however because of the geometry of the plates one rope would have a tension of 37.2 kips and the other would have a tension of 28.4 kips a difference of approximately plus or minus 13% from the mean tension of 32.8 kips (Figure 5-4: Quaternary Plate Sample Loading); well above industry standard of plus or minus 2.5%. The intention of the equalizer is probably only to compensate for minor adjustments, not be the primary device to keep the rope tensions equal. This effect can be compounded by each plate below it. In the current configuration NE pin D has worn .8" further than pin E, which effectively causes different lengths between the two groups of ropes connected to the two pins, and a similar effect to the previous example. A difference in tension between the two groups of ropes of plus or minus 6% from the mean tension results (See Figure 2-5: Secondary Plate Sample Loading). The equalizer assembly should be used for only minor differences between the ropes, and the take ups below the lifting girder should be used primarily to ensure equal tensions.

2.3.1. Monitor Condition

Continue monitor rope equalizer on a bi-annual basis for wear, and by ultrasonic testing every five years. This approach should not be considered for long term due to the condition of the rope equalizer. The current condition may lead to a plate slipping off a pin, or a plate failure and should be corrected.

2.3.2. Repair Equalizer

Repairing worn equalizer plates and pins would improve the service life of the machinery, especially if completed with a replacement of the counterweight sheaves. This option may be performed during short marine outages, and would not require the counterweight to be jacked and supported. The work would include replacing all tertiary plates, and pins D-G on all corners, as well as field boring and sleeving the secondary plates at the location of pins D-G as required. The new counterweight pins can be fabricated with provisions for lubrication to prevent wear. This option is unlikely to maintain equal tension in all of the ropes due to the geometry of the plates, however, it will improve their current condition. Over time as the plates continue to wear rope tensions will continue to change.

2.3.3. Replace Equalizer

Replacing the equalizer would improve the service life of the machinery, especially if completed with a replacement of the counterweight sheaves. The work requires the counterweight to be jacked and supported during a six week marine outage. This option is unlikely to maintain equal tension in all of the ropes due to the geometry of the plates, however, it will improve their current condition. All connections can be designed to incorporate provisions for lubrication. This option is be the most costly alternative, and will not provide the greatest service life.

2.3.4. Remove Equalizer

Removing the equalizer would require the counterweight to be jacked and supported while the work is performed. This work requires a marine outage for several weeks and will provide the greatest benefit if performed while the counterweight sheaves are replaced. The work requires an anchor to be fabricated to terminate the counterweight ropes on the counterweight. The current equalizer design introduces significant imbalance between the ropes, and can be corrected by a properly designed anchor with no equalizer. Rope tensions will be adjusted at the take ups below the lifting girder to provide tensions within plus or minus 2.5%. This method is also likely to be less costly than replacing the entire equalizer, will provide the maximum service life, and will require minimum maintenance in the future.

Appendix: B Tables and Figures

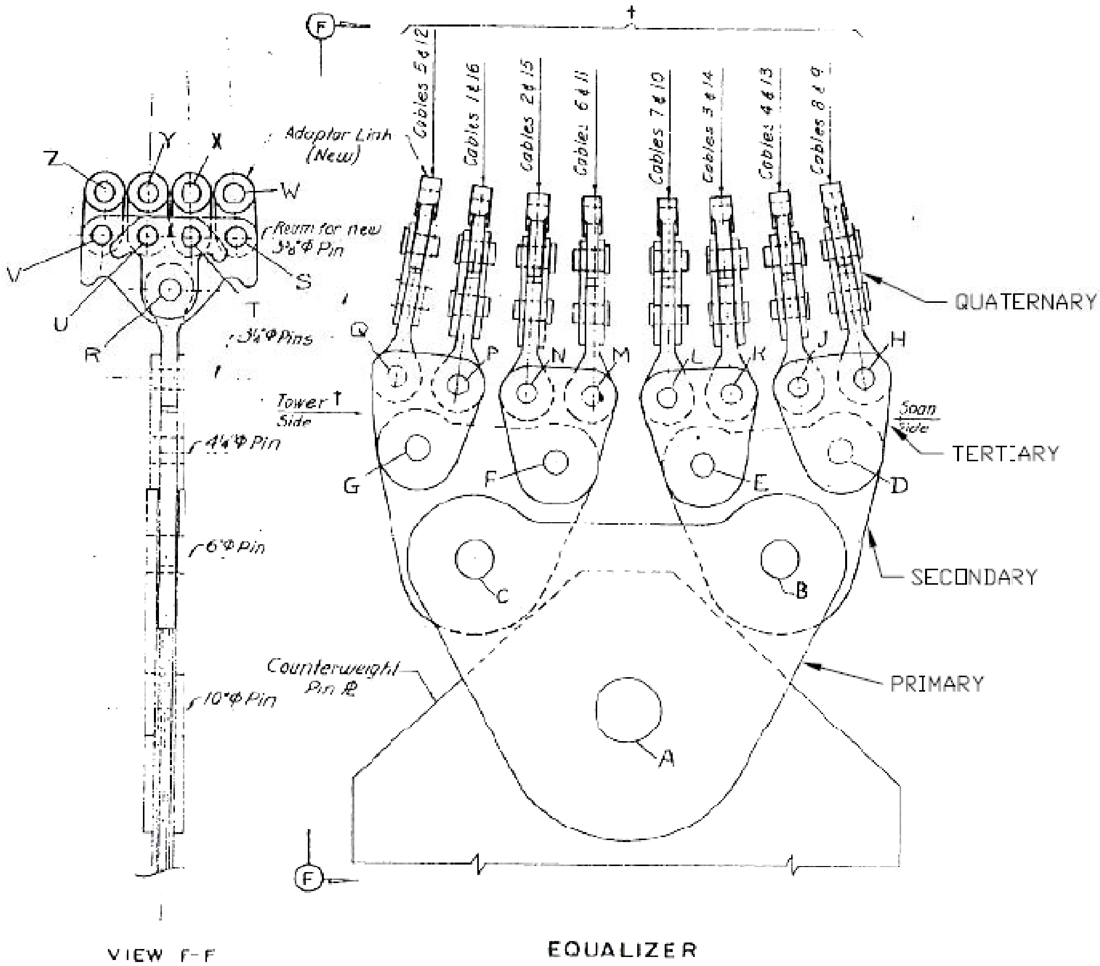

Figure 2-1 Equalizer Assembly

Tower	Trunnion	Location	Suface Condition
South	East	Inboard	Light scoring on journal and around the fillet, and heavy scoring on the thrust face.
South	East	Outboard	Light scoring on the fillet and journal, light scoring and galling on the thrust face
South	West	Inboard	Light scoring on fillet and journal, Heavy scoring on thrust face, moderate to heavy pitting on journal near fillet, and on fillet.
South	West	Outboard	Light scoring on fillet journal and thrust face.
North	East	Inboard	Light scoring and pitting on trunnion shaft and fillet. Moderate galling and scoring near the end of the journal. Heavy galling and scoring on thrust face
North	East	Outboard	Light scoring on journal, fillet, and thrust face, moderate pitting on fillet, and thrust face.
North	West	Inboard	Light scoring on journal, light pitting on journal near fillet and on fillet. Moderate to heavy scoring on fillet. Tool mark on fillet
North	West	Outboard	Light scoring and galling on fillet and thrust face, light to moderate scoring, pitting, and galling on fillet.

Table 1: Journal Conditions

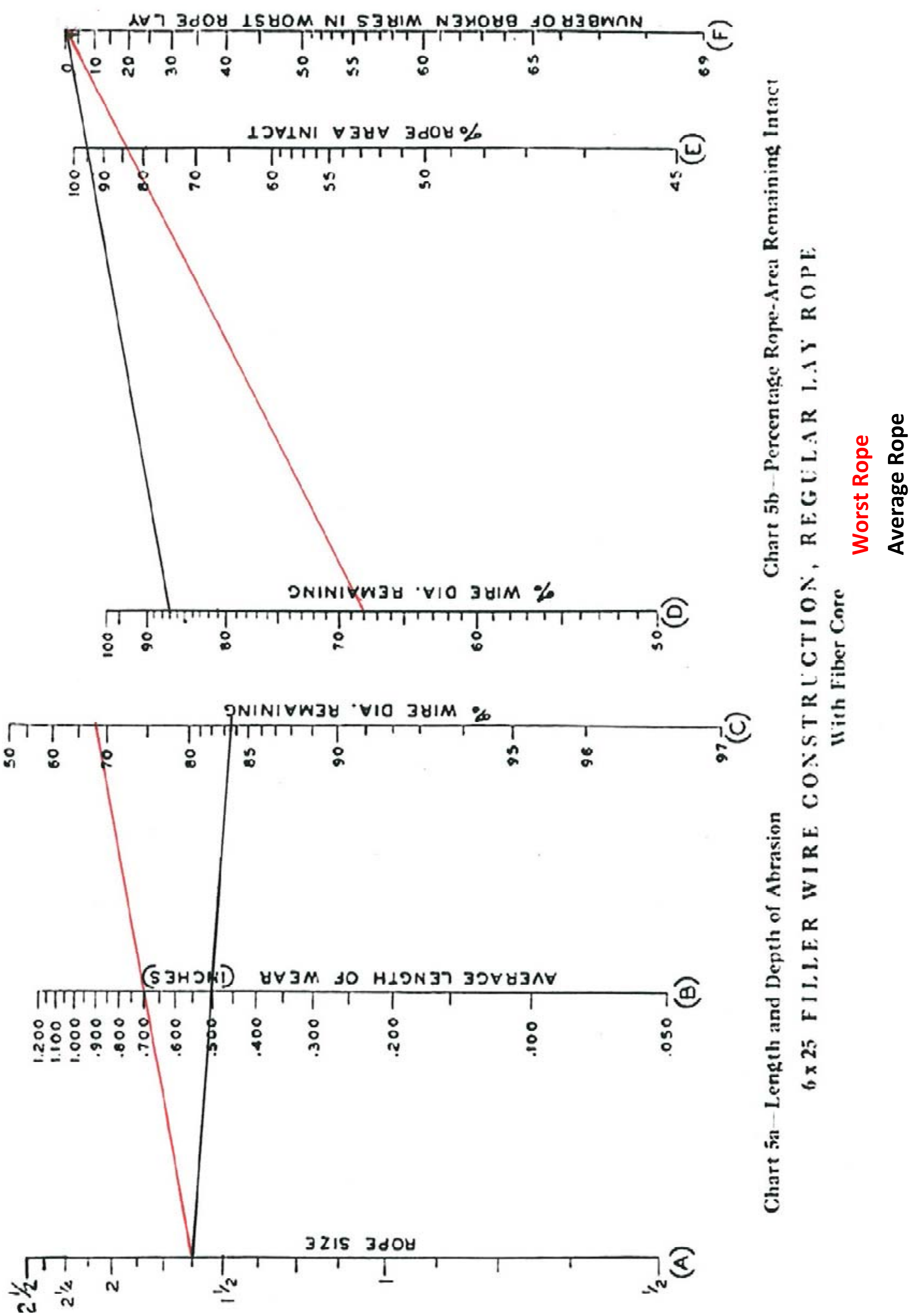

Figure 2-2: Rope wear

NW Corner	Crown Wear length (in)	Rope Diameter 1* (in)	Rope Diameter 2* (in)	Average Diameter (in)
1	0.47	1.606	1.575	1.591
2	0.53	1.594	1.591	1.593
3**	0.22	1.603		1.603
4	0.53	1.603		1.603
5	0.44	1.581	1.586	1.584
6	0.44	1.594		1.594
7	0.34	1.598		1.598
8	Not Measured	1.592		1.592
9	Not Measured	1.598		1.598
10	Not Measured	1.585		1.585
11	Not Measured	1.583		1.583
12	0.56	1.575	1.578	1.577
13	0.00	1.581		1.581
14	0.34	1.591		1.591
15	0.53	1.569		1.569
16**	0.38	1.646	1.639	1.643
Average	0.40			1.593
Max	0.56			

All measurments taken at the tanget point to counterweight sheave on the span side when bridge is seated.

*A second rope diameter was measured where accessability permitted

** Indicates a rope that was replaced in April 2008

Table 2: NW Corner CWT Rope Measurements

NE Corner	Crown Wear length (in)	Rope Diameter 1* (in)	Rope Diameter 2* (in)	Average Diameter (in)
1	0.38	1.598	1.584	1.591
2	0.41	1.572		1.572
3	0.31	1.607		1.607
4	0.28	1.587		1.587
5	Not Measured	1.58	1.582	1.581
6	Not Measured	1.575		1.575
7	Not Measured	1.581		1.581
8	Not Measured	1.578		1.578
9	0.47	1.609		1.609
10	Not Measured	Not Measured		Not Measured
11	0.38	1.608		1.608
12	0.47	1.598		1.598
13	0.56	1.601		1.601
14	0.59	1.6		1.600
15	0.53	1.594		1.594
16	0.47	1.582	1.585	1.584
Average	0.44			1.591
Max	0.59			
All measurments taken at the tanget point to counterweight sheave on the span side when bridge is seated.				
*A second rope diameter was measured where accessability permitted				
** Indicates a rope that was replaced in April 2008				

Table 3: NE Corner CWT Rope Measurements

SW Corner	Crown Wear length (in)	Rope Diameter 1* (in)	Rope Diameter 2* (in)	Average Diameter (in)
1	0.56	1.529	1.528	1.529
2	0.69	1.529		1.529
3**	0.16	1.537		1.537
4	0.56	1.555		1.555
5	0.63	1.544	1.555	1.550
6	0.56	1.551		1.551
7	0.50	1.565		1.565
8	0.50	Not Measured		Not Measured
9	0.63	Not Measured		Not Measured
10	Not Measured	1.556		1.556
11	0.53	1.561		1.561
12	0.63	1.542	1.555	1.549
13	0.56	1.579		1.579
14	0.56	1.579		1.579
15	0.66	1.579		1.579
16	0.50	1.552	1.559	1.556
Average	0.55			1.555
Max	0.69			

All measurments taken at the tanget point to counterweight sheave on the span side when bridge is seated.

*A second rope diameter was measured where accessability permitted

** Indicates a rope that was replaced in April 2008

Table 4: SW Corner CWT Rope Measurements

SE Corner	Crown Wear length (in)	Rope Diameter 1* (in)	Rope Diameter 2* (in)	Average Diameter (in)
1	0.63	1.534	1.534	1.534
2	0.63	1.581		1.581
3	0.56	1.567		1.567
4	0.66	1.565		1.565
5	0.63	1.559	1.561	1.560
6	0.63	Not Measured		Not Measured
7	Not Measured	Not Measured		Not Measured
8	0.69	1.573		1.573
9	Not Measured	1.561		1.561
10	Not Measured	1.573		1.573
11	Not Measured	1.562		1.562
12	Not Measured	1.562	1.574	1.568
13	Not Measured	1.562		1.562
14	Not Measured	1.573		1.573
15	Not Measured	1.539	1.554	1.547
16	0.56	1.528	1.532	1.530
Average	0.62			1.561
Max	0.69			
All measurments taken at the tanget point to counterweight sheave on the span side when bridge is seated.				
*A second rope diameter was measured where accessability permitted				
** Indicates a rope that was replaced in April 2008				

Table 5: SE Corner CWT Rope Measurements

NW Corner	Fall 2005	Spring 2006	Spring 2007	Spring 2008	January 2009	Spring 2009	Spring 2010
D	0.165	0.169	0.169	0.18	0.159	0.188*	0.297
E	0	0	0	0	0	0	0.017
F	0.081	0.084	0.086	0.082	0.082	0.085	0.095
G	0.504	0.504	0.513	0.508	0.516	0.500*	0.563
NE Corner	Fall 2005	Spring 2006	Spring 2007	Spring 2008	January 2009	Spring 2009	Spring 2010
D	0.75	0.75	0.772	0.805	0.843	0.750*	0.875
E	0	0	0.069	0.078	0.082	0.069	0.072
F	0	0	0	0	0	0	0
G	0.458	0.465	0.465	0.479	0.479	0.563*	0.531
SW Corner	Fall 2005	Spring 2006	Spring 2007	Spring 2008	January 2009	Spring 2009	Spring 2010
D	0.329	0.336	0.333	0.352	0.365	0.375*	0.359
E	0	0	0	0	0	0	0
F	0	0	0	0	0	0	0
G	0	0	0	0	0	0	0
SE Corner	Fall 2005	Spring 2006	Spring 2007	Spring 2008	January 2009	Spring 2009	Spring 2010
D	0.376	0.386	0.375	0.373	0.373	0.375*	0.492
E	0	0	0	0	0	0	0
F	0	0	0	0	0	0	0
G	0.141	0.168	0.158	0.164	0.100	0.135	0.180

* Note: measurement was taken with a ruler, and is not as accurate as the other measurements.

Table 6: Balance Assembly Pin Clearances

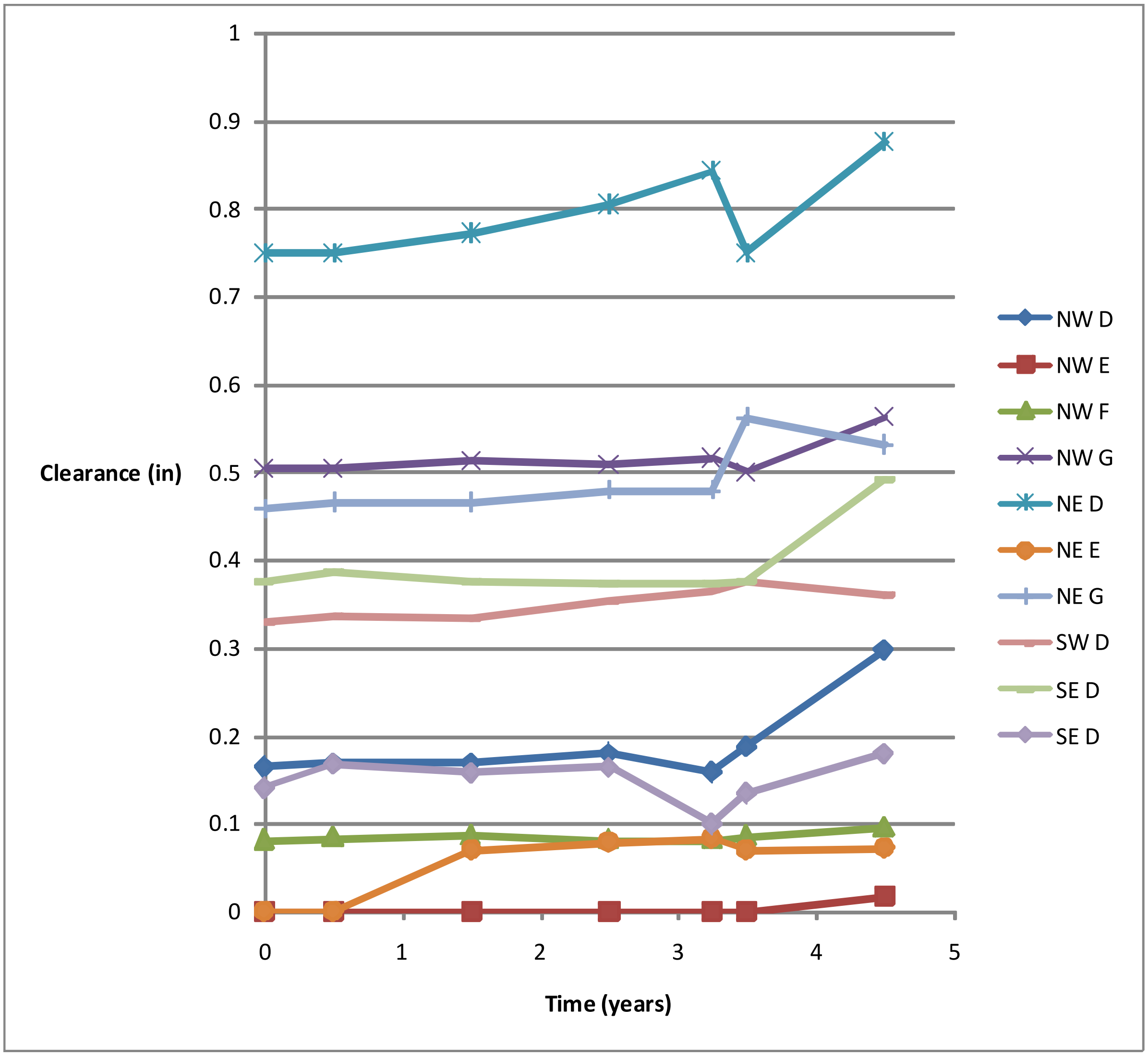

Figure 2-3: Balance Assembly Pin Clearances

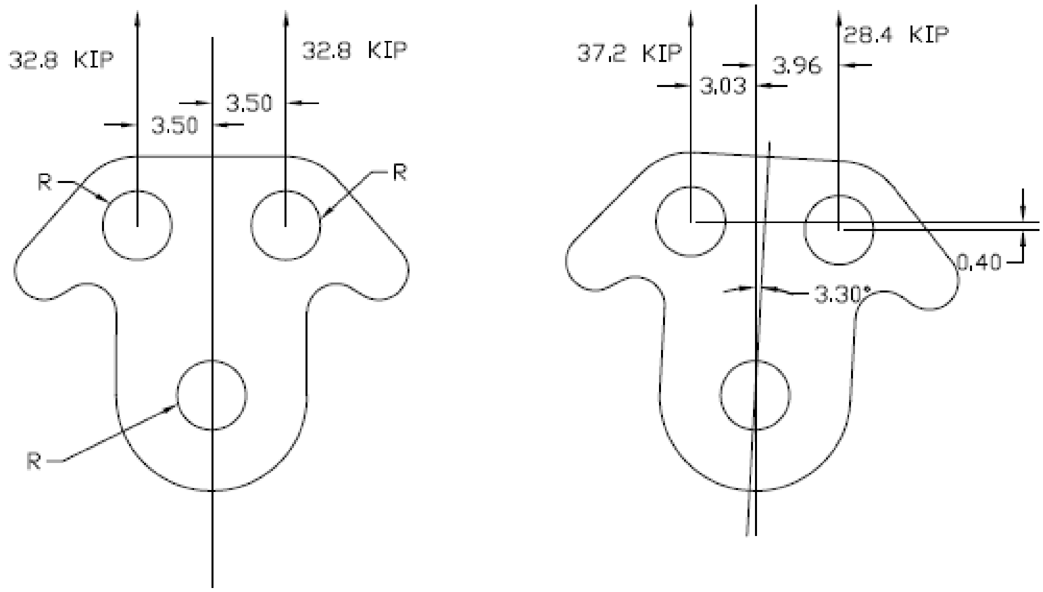

Figure 2-4: Quaternary Plate Sample Loading

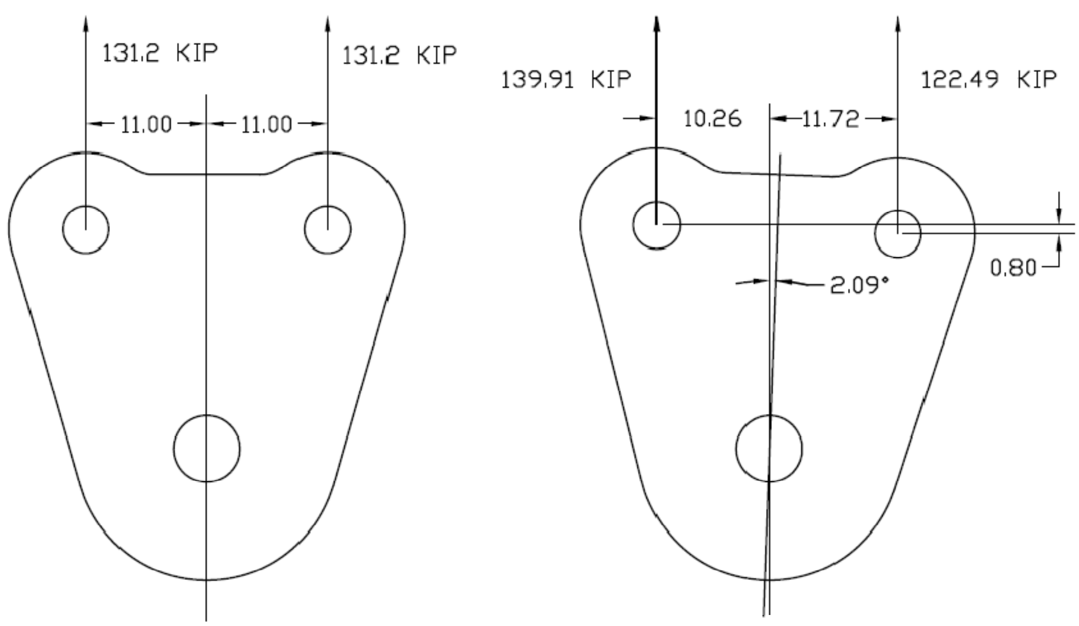

Figure 2-5: Secondary Plate Sample Loading

Appendix: C Photos

Photo 2-6: SE corner rope 1 with 5/8” crown wear.

Photo 2-7: Dry, and caked lubrication of ropes; this is typical of all ropes.

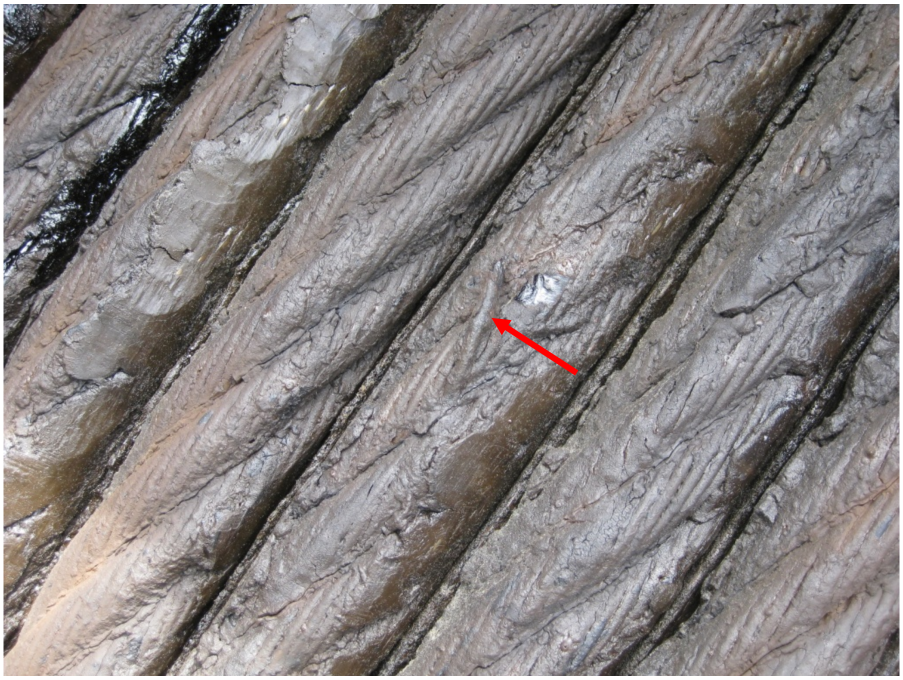

Photo 2-8: Wire break on rope 10 in the SE corner

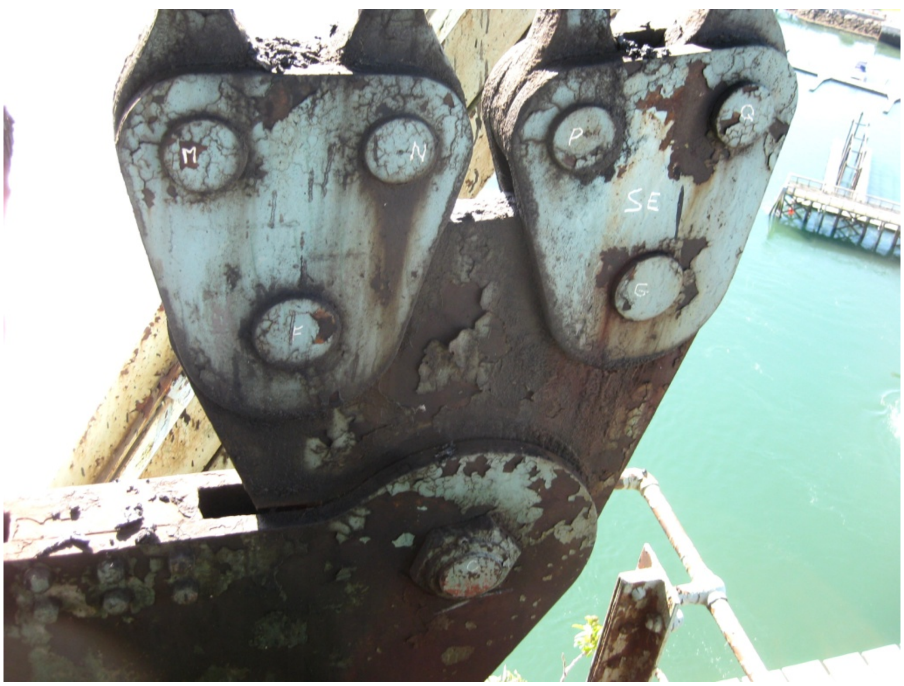

Photo 2-9: Typical general condition of equalizer plates, peeling paint, surface rust, and fretting corrosion between plates, and pins.

Photo 2-10: Typical fretting rust between equalizer plates. This photo is of the interface between the primary and the North secondary plates on the NE corner.

Photo 2-11: Pin D on the NW corner. Plate appears to be bearing against the cotter pin causing section loss and the pin to bend.

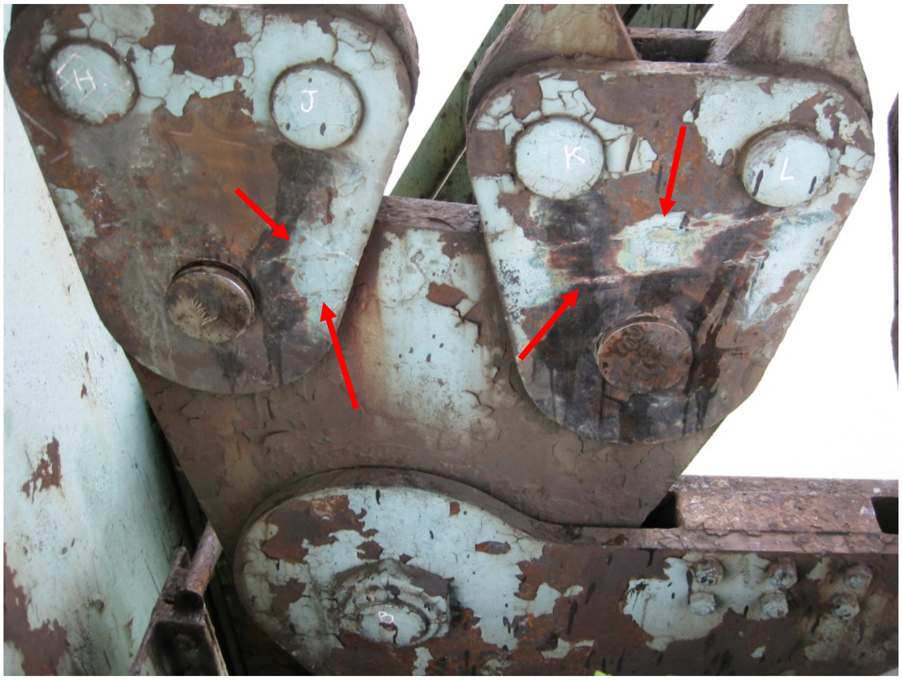

Photo 2-12: Welding on the tertiary plates on the NW corner equalizer near pin D and above pin E.

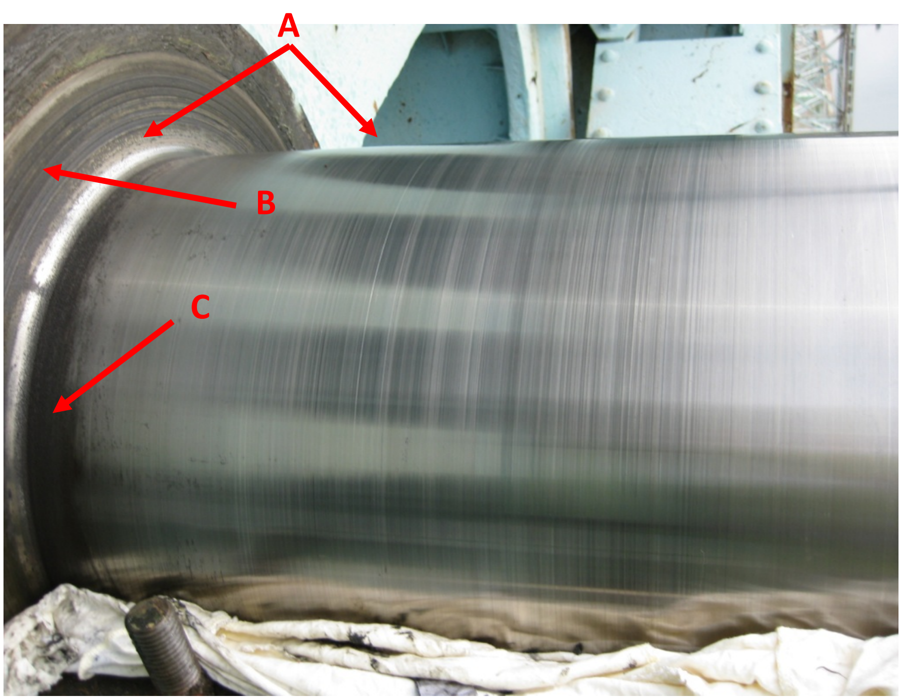

Photo 2-13: SW inboard trunnion has (A) light scoring on the fillet and journal, (B) heavy scoring on the thrust face, and (C) moderate to heavy pitting on the adjacent and on the fillet.

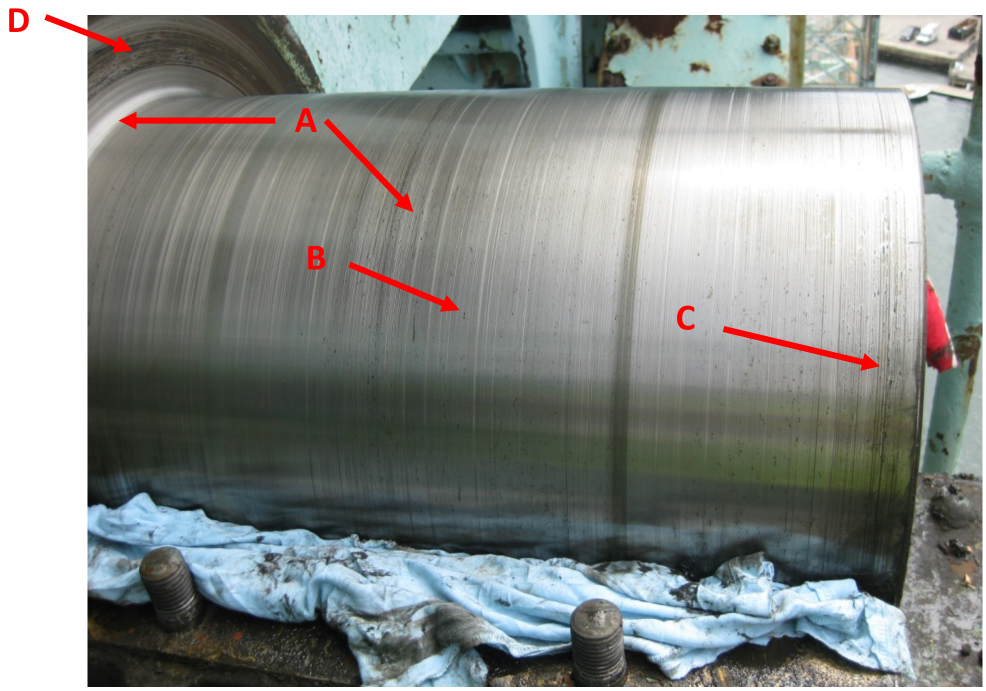

Photo 2-14: NE inboard trunnion has (A) light scoring and (B) pitting on trunnion shaft and fillet, (C) moderate galling and scoring near the end of the journal, and (D) heavy galling and scoring on thrust face.

Appendix: D NDT Testing report

Memorial Bridge Trunnion & Equalizer Plate Inspection Technical Report

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7/21/2010

Executive Summary

Nondestructive inspection was performed on the eight rotating counterweight trunnion shafts and eight counterweight equalizer plates of the Memorial Bridge in Portsmouth, NH on May 17-21, 2010. The methods used were shear wave ultrasound, phased array ultrasound and visual inspection aided by the wet magnetic particle method. No major surface or subsurface defects were found in any of the inspected parts. It is recommended to retest the trunnion shafts and equalizer plates on a semi-annual schedule.

Table of Contents

Table of Figures

1 Introduction

The Memorial Bridge is the US route 1 bridge that crosses the Piscataqua River between Portsmouth, NH and Kittery, ME. Fracture critical areas on the bridge include the 8 rotating counterweight trunnion shaft journals and the 8 counterweight equalizer plates. The general locations are shown in Figure 1.

Figure 1: Memorial bridge inspection locations

1.1 Bridge Nomenclature

The Memorial Bridge trunnion shafts are large plain bearings. Each trunnion consists of 2 load-bearing journals and a center barrel, which supports a rotating wire rope sheave. There are 2 trunnion shafts in each tower and each trunnion shaft has 2 journals, inboard and outboard. The trunnions in the North (Maine) tower were labeled as NE and NW with both inboard and outboard components while the trunnions in the South (New Hampshire) tower were labeled as SE and SW with both inboard and outboard components. An example trunnion ID is **TRN-SW-Out**

The counterweights on the Memorial Bridge are connected to the lift cables via a series of equalizer plates. At each side of each counterweight, there are 7 inboard and 7 outboard plates connected with pins. The inspected plates were the 4 top plates labeled as D, E, F, G (inboard and outboard) and the bottom plate A (inboard and outboard). The plate labels are shown in Figure 2. These plates were located on the NE, NW, SE and SW sides of the lift-span. An example plate ID is **EQU-NE-In-D**.

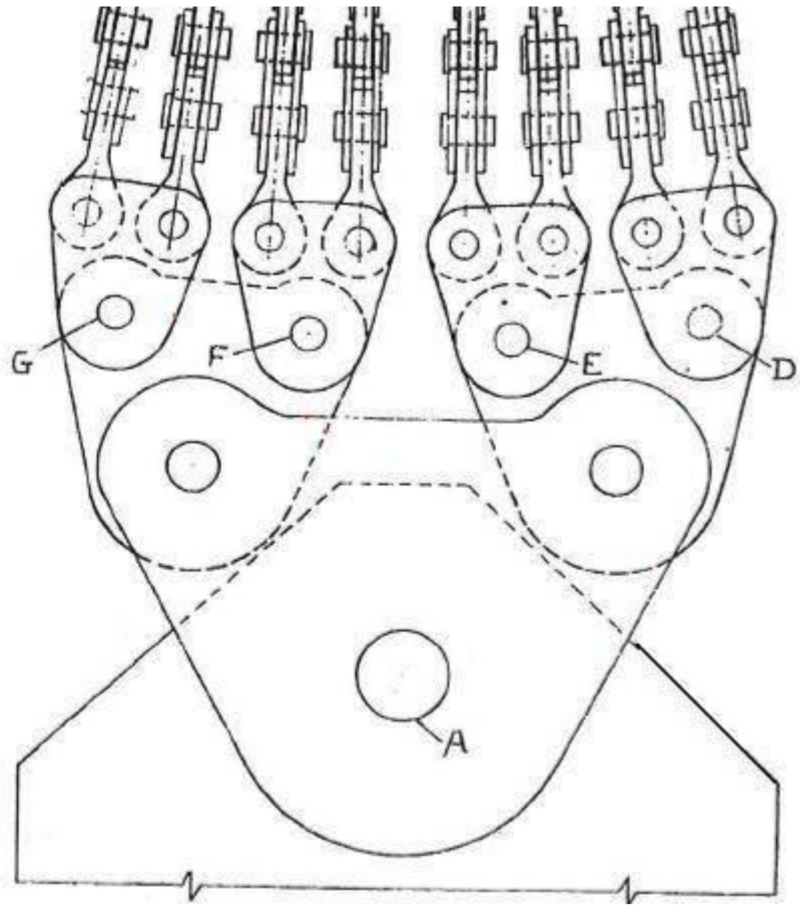


Figure 2: Counterweight equalizer plate naming scheme

1.2 Ultrasound Equipment

A Harfang X-32 ultrasonic phased array instrument was used for inspection of the trunnion shafts. A phased array system is advantageous to conventional ultrasound since it provides full volumetric coverage from limited sensor positions. The ability to sweep ultrasonic angles minimizes the requirement for transducer wedges thus reducing the time required to inspect each pin. A 2.25 MHz transducer was selected for the required sensitivity and depth of penetration.

A Sonatest D-20 ultrasonic flaw detector was used for shear wave inspection of the trunnion shafts and equalizer plates. The flaw detector was outfitted with a 2.25 MHz transducer. The transducer was coupled to a 70° wedge. The 70° wedge generates a shear wave that has an angle of refraction of 70° in the steel.

1.3 Magnetic Particle Equipment

An alternating current electromagnetic yolk was used to generate a magnetic field in the specimen. Wet magnetic particles suspended in an aerosol were then applied to the surface while the electromagnet was pulsed for one-second intervals. The particles were black on a contrasting white background, which made it easy to observe flaws.

2 Procedure

Following is a description of the inspection procedure carried out by the inspector.

2.1 Calibration

The trunnion calibration specimen was fabricated for detailed end face UT of the fillet areas using phased array ultrasound. An artificial defect was introduced in calibration specimens outside diameter in the journal-toe of the fillet. A schematic of the calibration specimen used is shown in Figure 3.

Calibration for the equalizer plates was done with a Miniature Angle Beam (MAB) calibration block. The small 0.06” diameter hole was used to generate a reference reflection comparable to the expected size of possible flaws.

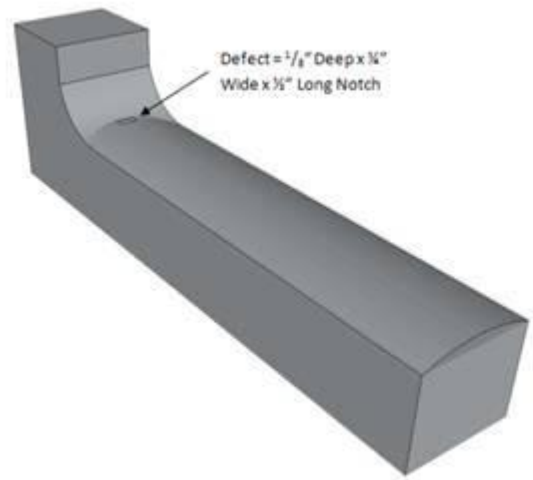


Figure 3: Schematic of the UT calibration block

2.2 Phased Array Data Presentation

The phased array display includes a couple of important features. The first feature is the sectoral scan (S-scan). This display represents the angular coverage of the volume of the pin from a specific probe position. Reflectors from defects or geometric features seen in this view are color mapped according to their intensity. The color mapped intensity profile of a typical trunnion reflection is shown in Figure 4.

The next feature of importance on the phased array display is the amplitude scan (A-scan). The A-scan is a waveform representing the amplitude of the ultrasound signal as a function of distance. Reflectors in this view are seen as distinct increases in amplitude, as seen on the right side of Figure 4.

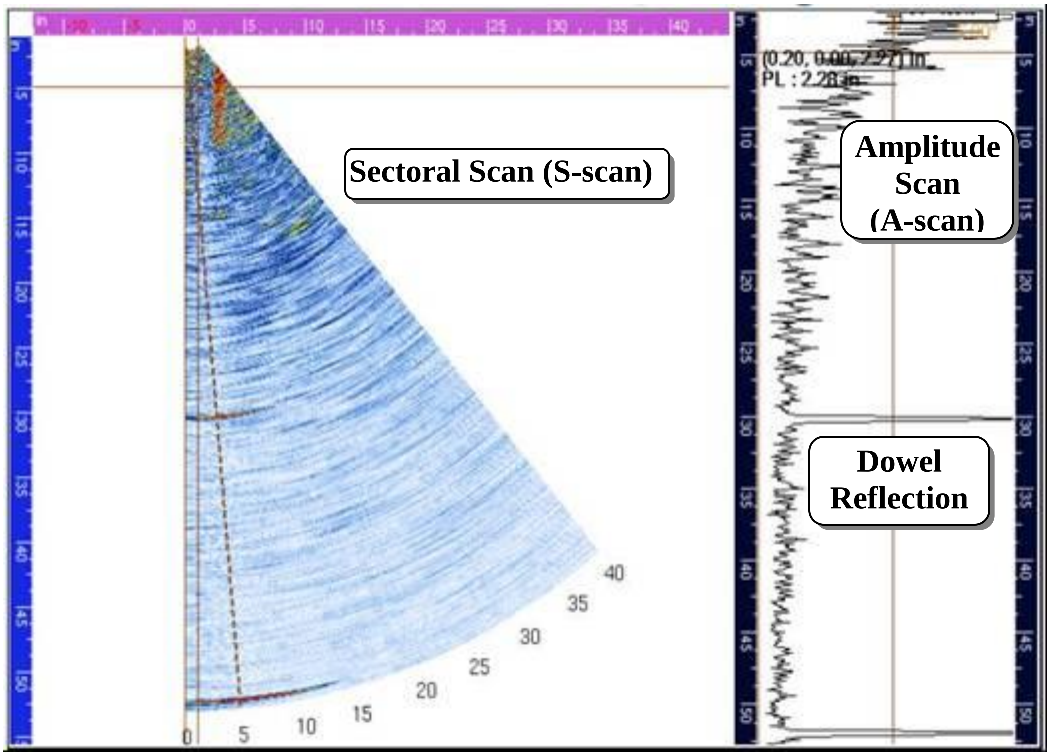


Figure 4: Phased array view with important features identified

2.3 Surface Preparation

Each trunnion shaft was prepared for inspection to ensure that ultrasound could be coupled efficiently from the transducer into the steel pin. Prior to inspection, the bearing covers were removed and the degreased. Due to the presence of the protective bearing covers, it was not required to wire brush or grind the trunnion shafts. A prepared trunnion shaft is shown in Figure 5. After the trunnion shaft was prepared, ultrasonic couplant was applied evenly over the surface.

The equalizer plates had loosely adhering layers of paint and rust as Figure 6 shows. These layers were removed using a wire wheel attached to an electric grinder. Once the surface was free of paint and rust, ultrasonic couplant was applied to the face of the plates and inspection was carried out.

Figure 5: Trunnion shaft prepped for inspection

Figure 6: Equalizer plate condition

2.4 Scanning Sensitivity

The transducer gain during the inspection was set to 12 dB higher than the transducer gain established during the calibration procedure (reference gain). The reason for scanning at a higher gain than the reference gain is to make interpretation easier as shown in Figure 7. Once a reflector was found, the gain was lowered to the reference gain and the reflection was compared to the calibration DAC.

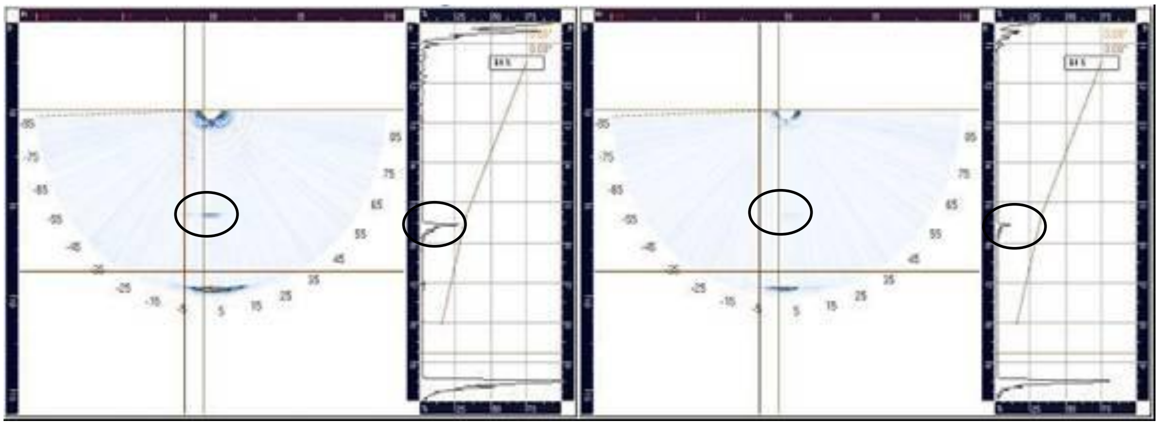


Figure 7: Comparison of reflection at transducer gain of 15 dB (left) and 9 dB (right)

2.5 Probe Movement/Scanning Procedure

For trunnion shafts, the top of each pin (0 degrees) was chosen as the angular reference point for scanning. The probe was positioned at the center of the pin so that the phased array volumetric scan was parallel to the transducer scan path. The back wall echo was maximized. The transducer was then scanned in the radial direction towards the edge of pin. The procedure was repeated at 45° increments from the angular reference point until the scanning pattern shown in Figure 8 was completed.

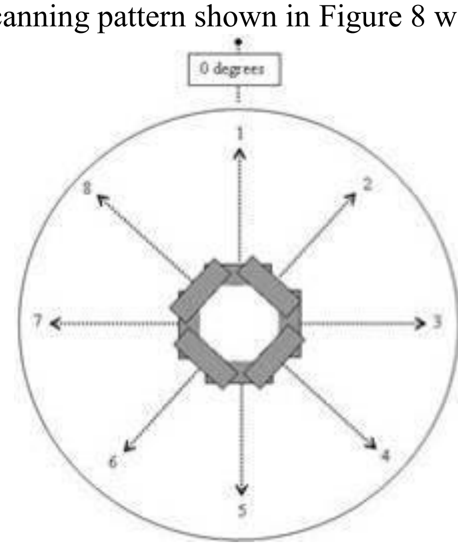


Figure 8: Probe scanning procedure

Additionally, the trunnion shafts were inspected from both barrel ends rather than the contact surface. The sensor was oriented perpendicular to the barrel as close to the top as possible and scanned in a circumferential path. The sensor was then turned 180° and the same scanning procedure was followed, the scanning procedure is illustrated in Figure 9. Both scans were performed at +12 dB to monitor the near fillet area for subsurface cracking.

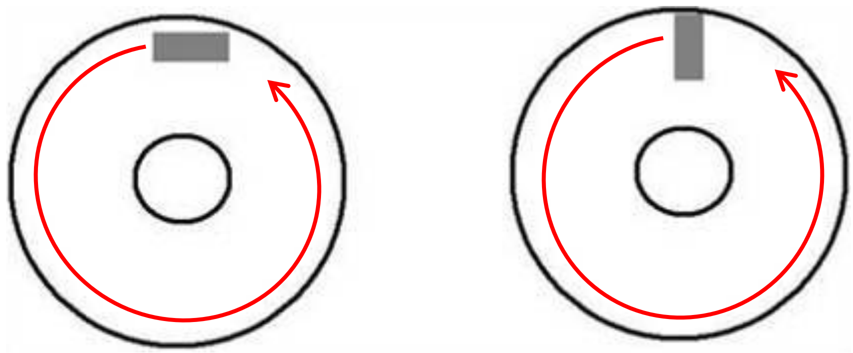


Figure 9: Scanning procedure for the trunnion shaft face

The equalizer plates were inspected perpendicularly to an imaginary line between the bottom pin and each of the top pins. The tension zone in the plates (zone bellow the bottom pin) was scanned in both the vertical and horizontal direction. Representative scan paths used for equalizer plate inspection are shown in Figure 10. Pins A, D, E, F and G were scanned using a longitudinal (0°) transducer.

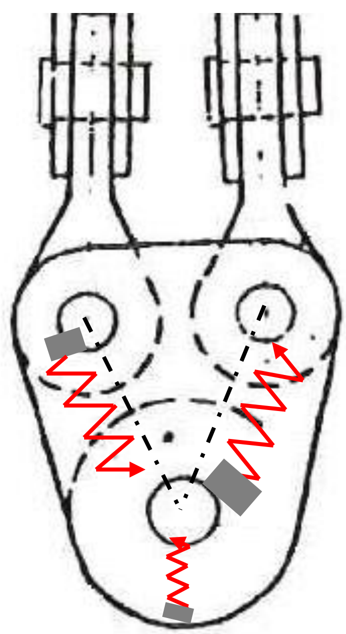


Figure 10: Equalizer plate scanning procedure

3 Results – Rotating Counterweight Trunnion Shafts

Figure 11: Rotating counterweight trunnion shaft with bearing cover installed

3.1 Geometry

All 8 shafts were geometrically similar. A trunnion shaft is presented schematically in Figure 12. The trunnion journals are 20 ½" long (on each side) with a diameter of 15 ½". The middle barrel of the trunnion is 31" long with a diameter of 17 ¼". There was a 3 ½" diameter borehole in all of the shafts. The journals and the fillet into the barrel were the focus of inspection. Inspection was performed using phased array and wet magnetic particle methods.

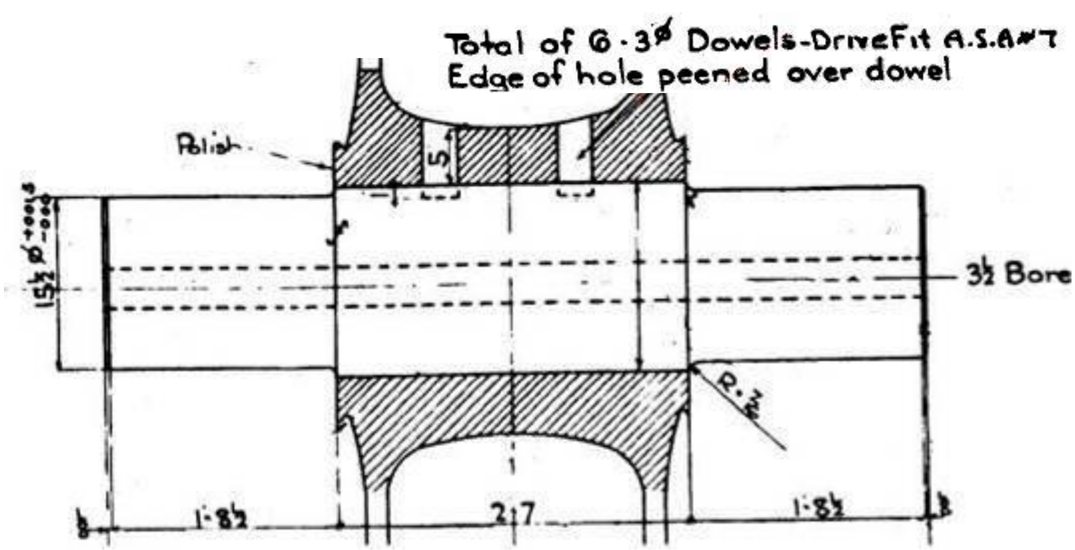


Figure 12: Schematic of a counterweight trunnion shaft

3.2 Reflector Free Trunnion Shafts

All of the 8 trunnion shafts on the Memorial Bridge had no unexplained ultrasonic reflectors. An example of a reflector free trunnion is shown in Figure 13. All trunnions not mentioned in this section are cleared as *reflector free trunnion shafts* and do not require additional follow-up.

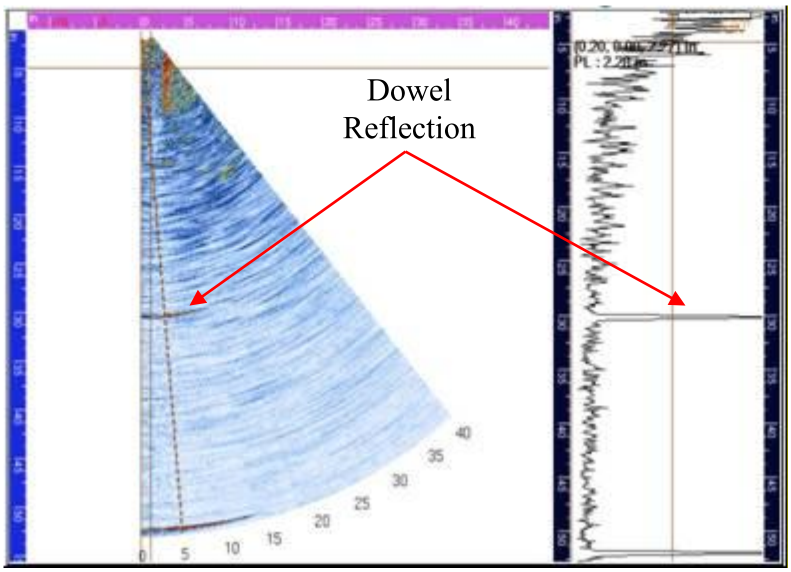


Figure 13: S-scan (left) and A-scan (right) from a reflector free trunnion shaft

3.3 Indication Free Trunnion Shafts

All of the 8 trunnion shafts on the Memorial Bridge were free of abnormal surface or subsurface indications identified by magnetic particle inspection.

3.4 Pin Findings, Summary and Recommendations

A summary of the pins inspected and findings for each pin is shown in Table 1. In the follow up inspections the phased array unit will be focused on the journal radius and the dowels, 20 ½” and 30” from the inspection face respectively.

Table 1: Trunnion inspection summary

Trunnion ID	UT Findings	Recommendation
TRN-NE-In	Reflector Free	Re-inspect on semi-annual interval. Use phased array focusing at 20 ½” and 30” and wet magnetic particle.
TRN-NE-Out	Reflector Free	Re-inspect on semi-annual interval. Use phased array focusing at 20 ½” and 30” and wet magnetic particle.
TRN-NW-In	Reflector Free	Re-inspect on semi-annual interval. Use phased array focusing at 20 ½” and 30” and wet magnetic particle.
TRN-NW-Out	Reflector Free	Re-inspect on semi-annual interval. Use phased array focusing at 20 ½” and 30” and wet magnetic particle.
TRN-SE-In	Reflector Free	Re-inspect on semi-annual interval. Use phased array focusing at 20 ½” and 30” and wet magnetic particle.
TRN-SE-Out	Reflector Free	Re-inspect on semi-annual interval. Use phased array focusing at 20 ½” and 30” and wet magnetic particle.
TRN-SE-In	Reflector Free	Re-inspect on semi-annual interval. Use phased array focusing at 20 ½” and 30” and wet magnetic particle.
TRN-SE-Out	Reflector Free	Re-inspect on semi-annual interval. Use phased array focusing at 20 ½” and 30” and wet magnetic particle.

4 Results –Counterweight Equalizer Plates

Figure 14: Counterweight equalizer plate

4.1 Geometry

All 8 equalizer plates inspected had the same geometry. A dimensioned schematic of the equalizer plates is shown in Figure 15. The area above the single pin in the top four lobes was the area of interest.

4.2 Reflector Free Plates

There were no ultrasonic indications observed from plate defects in any of the 8 equalizer plates on the Memorial Bridge.

4.3 Reflector Free Pins

There were no ultrasonic indications observed from pin defects in any of the 40 equalizer plate pins on the Memorial Bridge.

4.4 Plate Findings, Summary and Recommendations

A summary of the equalizer plates inspected and findings for each pin is shown in Table 2.

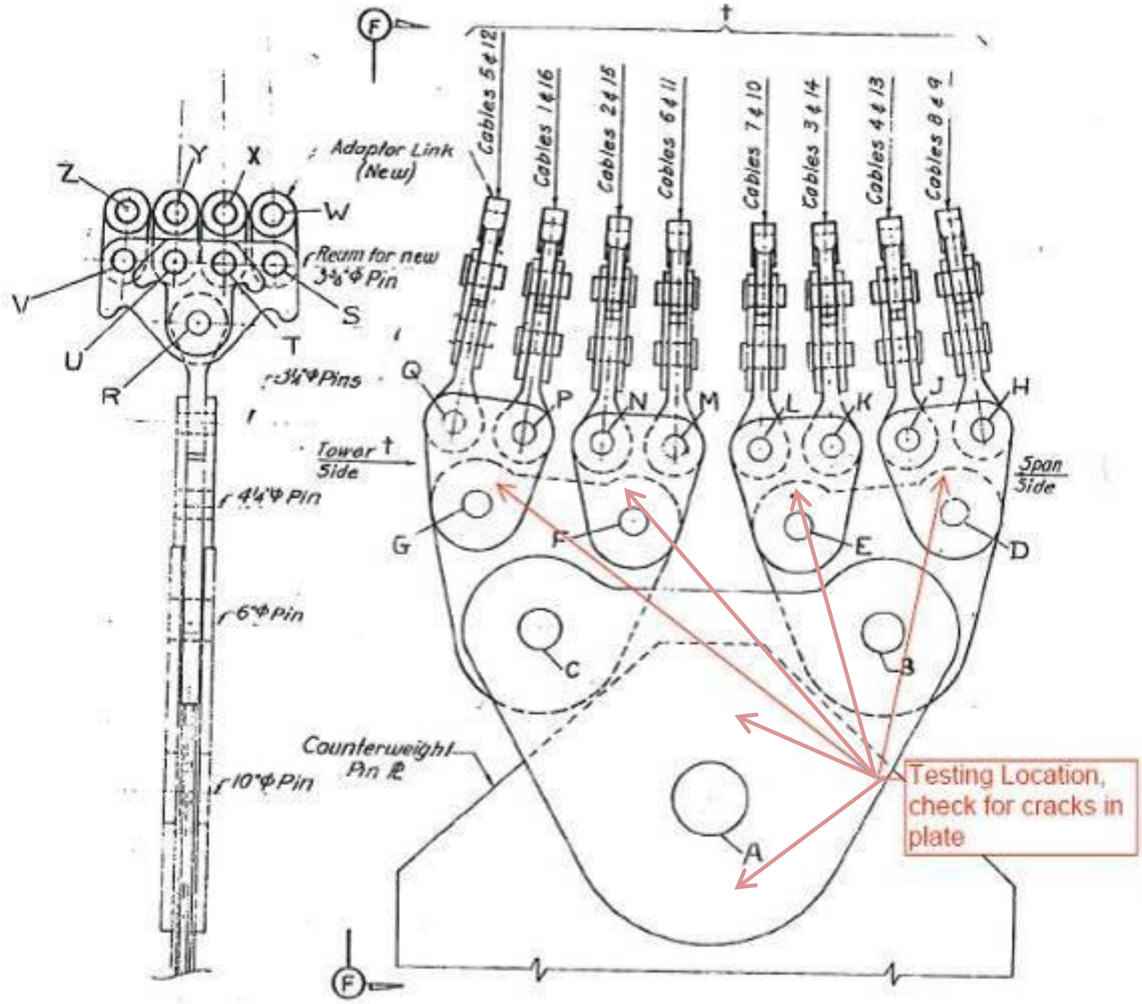


Figure 15: Schematic of the equalizer plates

Table 2: Equalizer plate inspection summary

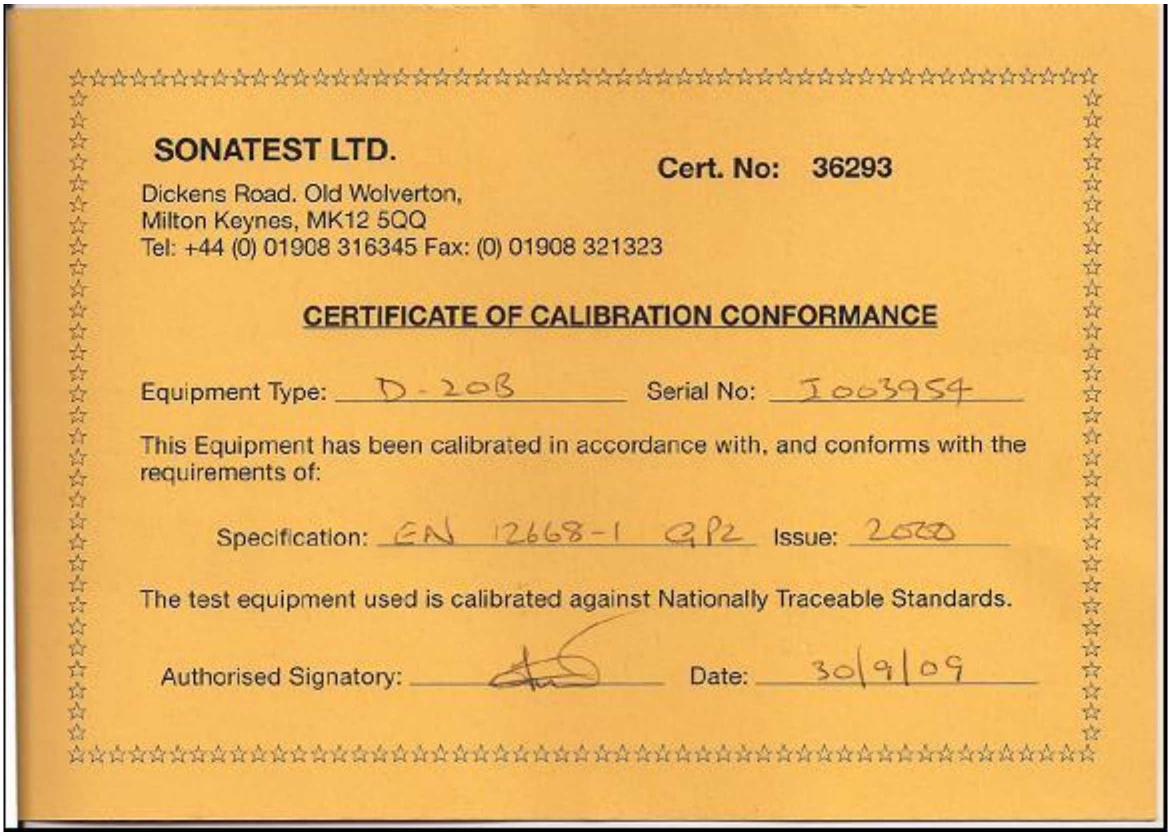
Location ID	Plate ID	Plate Findings	Pin Findings	Recommendation
EQU-NE-In	A	Reflector Free	Reflector Free	Re-inspect on semi-annual interval.
	D	Reflector Free	Reflector Free	
	E	Reflector Free	Reflector Free	
	F	Reflector Free	Reflector Free	
	G	Reflector Free	Reflector Free	
EQU-NE-Out	A	Reflector Free	Reflector Free	Re-inspect on semi-annual interval.
	D	Reflector Free	Reflector Free	
	E	Reflector Free	Reflector Free	
	F	Reflector Free	Reflector Free	
	G	Reflector Free	Reflector Free	
EQU-NW-In	A	Reflector Free	Reflector Free	Re-inspect on semi-annual interval.
	D	Reflector Free	Reflector Free	
	E	Reflector Free	Reflector Free	
	F	Reflector Free	Reflector Free	
	G	Reflector Free	Reflector Free	
EQU-NW-Out	A	Reflector Free	Reflector Free	Re-inspect on semi-annual interval.
	D	Reflector Free	Reflector Free	
	E	Reflector Free	Reflector Free	
	F	Reflector Free	Reflector Free	
	G	Reflector Free	Reflector Free	
EQU-SE-In	A	Reflector Free	Reflector Free	Re-inspect on semi-annual interval.
	D	Reflector Free	Reflector Free	
	E	Reflector Free	Reflector Free	
	F	Reflector Free	Reflector Free	
	G	Reflector Free	Reflector Free	
EQU-SE-Out	A	Reflector Free	Reflector Free	Re-inspect on semi-annual interval.
	D	Reflector Free	Reflector Free	
	E	Reflector Free	Reflector Free	
	F	Reflector Free	Reflector Free	
	G	Reflector Free	Reflector Free	
EQU-SW-In	A	Reflector Free	Reflector Free	Re-inspect on semi-annual interval.
	D	Reflector Free	Reflector Free	
	E	Reflector Free	Reflector Free	
	F	Reflector Free	Reflector Free	
	G	Reflector Free	Reflector Free	
EQU-SW-Out	A	Reflector Free	Reflector Free	Re-inspect on semi-annual interval.
	D	Reflector Free	Reflector Free	
	E	Reflector Free	Reflector Free	
	F	Reflector Free	Reflector Free	
	G	Reflector Free	Reflector Free	

5 Summary

Nondestructive inspection was performed on the eight rotating counterweight trunnion shafts and eight counterweight equalizer plates of the Memorial Bridge in Portsmouth, NH on May 17-21, 2010. The methods used were shear wave ultrasound, phased array ultrasound and visual inspection aided by the wet magnetic particle method. No major surface or subsurface defects were found in any of the inspected parts. It is recommended to retest the trunnion shafts and equalizer plates on a semi-annual schedule.

Appendix 1: Equipment Calibration Information

Sonatest D-20



SONATEST LTD.

Cert. No: 36293

Dickens Road. Old Wolverton,
Milton Keynes, MK12 5QQ
Tel: +44 (0) 01908 316345 Fax: (0) 01908 321323

CERTIFICATE OF CALIBRATION CONFORMANCE

Equipment Type: D-20B Serial No: I003954

This Equipment has been calibrated in accordance with, and conforms with the requirements of:

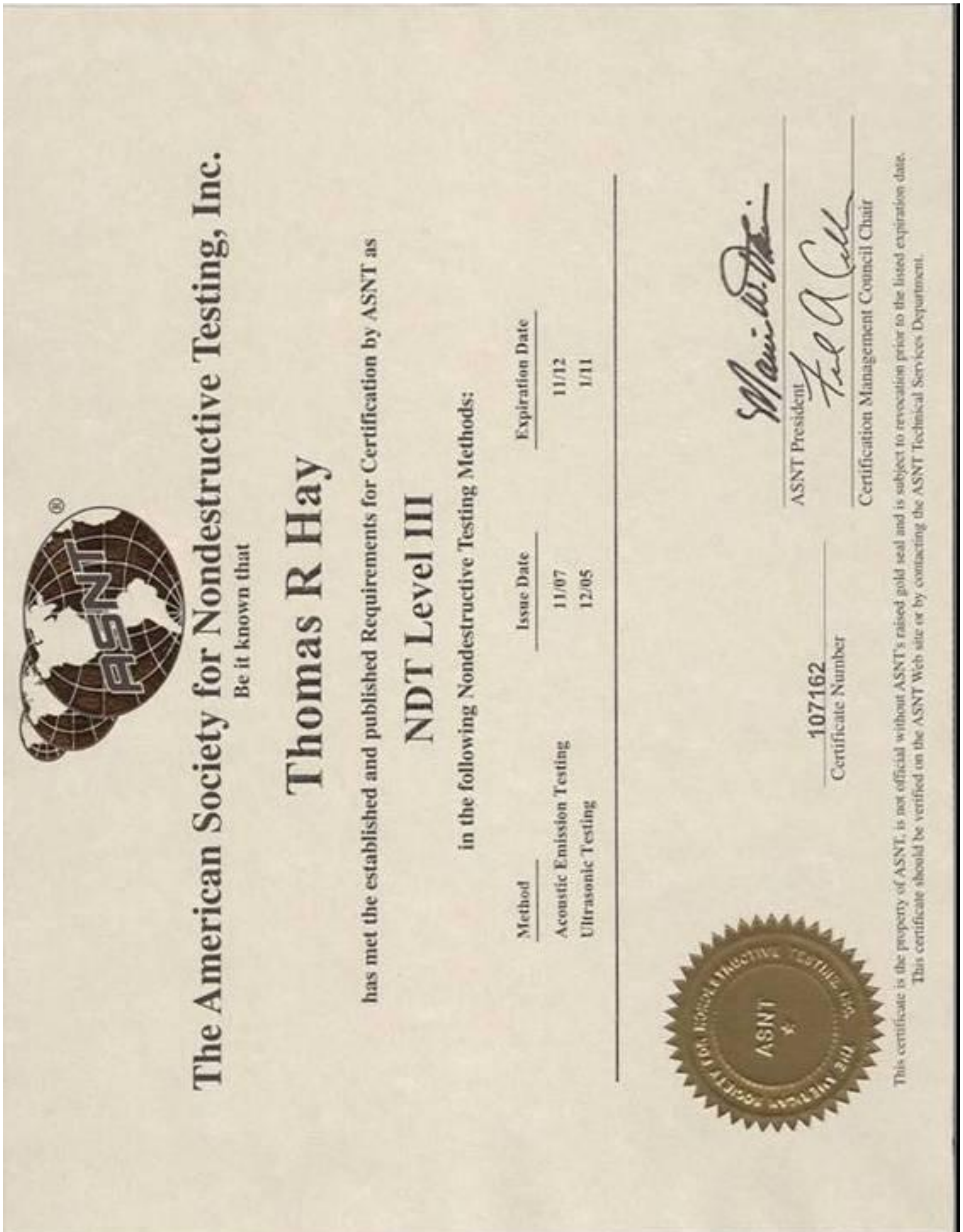
Specification: EN 12668-1 GP2 Issue: 2000

The test equipment used is calibrated against Nationally Traceable Standards.

Authorised Signatory: Date: 30/9/09

Appendix 2: Personnel Certifications

Thomas R. Hay



The American Society for Nondestructive Testing, Inc.

Be it known that

Thomas R Hay

has met the established and published Requirements for Certification by ASNT as

NDT Level III

in the following Nondestructive Testing Methods:

Method	Issue Date	Expiration Date
Acoustic Emission Testing	11/07	11/12
Ultrasonic Testing	12/05	1/11

107162
Certificate Number

ASNT President

Certification Management Council Chair

This certificate is the property of ASNT, is not official without ASNT's raised gold seal and is subject to revocation prior to the listed expiration date. This certificate should be verified on the ASNT Web site or by contacting the ASNT Technical Services Department.

Joel Hay

Certificate of Qualification and Certification Summary

Name:	Joel R. Hay	Method:	UT Level II, MT& PT Level III
TISEC Certification Date:	September 10, 1999	Expiration Date:	June 02, 2011
Written Practice:	TCP 001		

This is the true and factual background of the individual named above. A review of the individual's education, training and experience has been performed. Based on this review, it has been determined that this individual meets the qualification requirements for certification as described in the referenced written practice.

Formal Education Summary

Degree	Institution	Date
High School	Laurentian Regional High School	1984/06
NDT Specialist	U.S. Navy Great Lakes Training Center	1997/06
Harfang X32	Harfang Microtechniques	2007/05

Training in Nondestructive Testing

Organization	Location	Type of Class	Date	Hours	Classroom
US NAVY, NDT	Great Lakes, IL	Theory/Lab/Practical	1997-09	408	Theory/Lab/Practical
US NAVY, NDT	Ingleside, TX	Refresher	97-10/99-08	22	Theory/Practical
TISEC Inc.	Montreal	Recertification	1999-09-10	48	Theory/Lab/Practical
TISEC Inc.	Montreal	Recertification	2002-08-27	24	Lab/Field
TISEC Inc.	Montreal	Recertification	2005-08-19	24	Lab/Field
TISEC Inc.	Montreal	Recertification	2008-08-21	24	Lab/Field

Examination Results

Exam	By	Date	Status	Score
Basic	TISEC	1999-09-07	Pass	90%
Method	TISEC	1999-09-08	Pass	95%
Specific	TISEC	1999-09-09	Pass	90%

Physical Results

The individual has satisfactorily completed the required visual acuity qualification examination. Current results are maintained on file.

CERTIFICATION

This is to certify that this individual is qualified in accordance with SNT-TC-1A as in the written practice listed above.

Thomas R. Hay	Tho Hay	ASNT Level III	August 29, 2008
Certifying Authority	Signature	Title	Date

Uncontrolled distribution copy – Original Signed