NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

March 5, 2008

STRUCTURAL INVESTIGATION GROUP CHAIRMAN FACTUAL REPORT Report No. 08-015

A. ACCIDENT

Type of Accident:	Bridge Collapse
Date:	August 1, 2007
Location:	Interstate 35W Bridge across the Mississippi River, Minneapolis, Minnesota
NTSB No.:	HWY07MH024
Investigator in Charge:	Gary Van Etten

B. STRUCTUAL INVESTIGATION GROUP

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The Structures Investigation Group was greatly assisted by the following individuals: Dustin Thomas of the Minnesota Department of Transportation (MnDOT), Frank Zakar, Carl Schultheisz, and Derek Nash of the NTSB, Mike Koob, Jonathan McGormley, Mark Chauvin, Jennifer Dimig, Jon Lewis, Kristin Duchateau, Brady Shelburmun, Steve Michael, and Wade Clarke of Wiss Janney Elstner, Wesley Weir, Bill Clark, Scott Darling and Steve Shaup of Tran Systems, and Benjamin Graybeal, Bill Wright, and Justin Ocel of the Federal Highway Administration. MnDOT also provided extensive administrative and logistics support.

The contents of this report include the following major sections.

C. GENERAL DESCRIPTION OF THE BRIDGE AND NOMENCLATURE

The I-35W Bridge over the Mississippi River was a 14-span, 13-pier structure with a total length of 1,907 feet, as shown in figure 1. MnDOT designated this as Bridge 9340. The piers and spans were numbered from south to north. Spans 1 through 4 and a portion of span 5 are referred to as the south approach spans and were steel multi-beam spans having a length of 416 feet and a slight horizontal curvature. A portion of span 5, all of spans 6, 7, 8, and a portion of span 9 consisted of a variable depth steel deck truss having a total length of 1,064 feet. A portion of span 9 and spans 10 through 14 are referred to as the north approach spans and consisted of a 3-span continuous welded steel multi-beam module and a 3-span continuous voided concrete slab module having a length of 427 feet. The north end of the south approach spans and the south end of the north approach spans were cantilevered over their respective piers and were supported on the ends of the center deck truss portion of the bridge.

The deck truss structure extended from south of pier 5 to north of pier 8 and included a portion of span 5, the entirety of spans 6 through 8 and a portion of span 9. As shown in figure 1, the deck truss portion of the bridge consisted of 28 panels, each 38 feet long for a total length of 1,064 feet. The center span of the deck truss (span 7, which crossed the river) consisted of 12 panels at 38 feet each for a total length of 456 feet. The north and south portions of the deck truss each consisted of 8 panels at 38 feet each[1] for a total length of 304 feet each. Figure 2 shows a typical section through the deck truss.

The deck truss was supported at piers 5, 6, 7, and 8 and was 60 feet deep at piers 6 and 7, 30 feet deep at piers 5 and 8, and 36 feet deep at midspan. Both ends of the main trusses were cantilevered over the nearby pier and connected to transverse cross girders. The ends of the north and south approach spans were also supported by rocker bearings at the respective transverse cross girders at the ends of the main trusses.

The roadway of the bridge consisted of separate reinforced concrete deck slabs for the north and southbound traffic lanes. They were separated longitudinally by an approximate 6-inch gap. Each deck slab accommodated four 12-foot traffic lanes and two 2-foot shoulders. The northbound deck slab widens at the north end of the north approach to accommodate an off-ramp, and the southbound deck slab widens at the north end of the north approach to accommodate an on-ramp. Both deck slabs had a slight horizontal curve over the south approach spans to match the roadway alignment.

The south approach superstructure consisted of either rolled beams with cover plates or welded plate girders that ranged in depth from 33 inches to 48 inches. Spans 1 through 5 used 14 girders spaced at 8 feet-2 inches on center with a hinge in span 2. A typical section through the south approach spans is shown in figure 3. On the north approach, spans 9 through 11, the deck widened using 15 to 18 girders. All diaphragm and cross-frame connections in the steel approach spans were riveted.

[1] There was a slight variation from the 38-foot length for the first panel on the south end of the truss.

The far north approach superstructure (spans 12 through 14) was comprised of a 3 span continuous voided concrete slab. The slab was 2 feet deep. A typical section through the voided concrete slab is shown in figure 4.

The bridge was designed by Sverdrup & Parcel and Associates, Inc., St. Louis, Missouri, in 1965 and had been in continuous service since it was opened to traffic in 1967. The design was based on the 1961 AASHO *Design Specifications* and 1961, 1962 Interim Specifications, and Minnesota Highway Department *Standard Specifications for Highway Construction, 1964*, using welded built-up steel sections for girders and truss members with riveted and bolted connections. The deck truss members and approach girders were fabricated using M.H.D. 3306, M.H.D. 3309, M.H.D. 3310 and M.H.D. 3318 material that substantially conforms to ASTM A36, ASTM A242, ASTM A441 and ASTM A514 specifications, respectively.

Nomenclature

An identifying nomenclature for individual components of the variable-depth deck truss portion of the I-35W Bridge was established using designations provided on MnDOT design drawings and inspection reports. Although, in application, trivial variations did exist due to the number of personnel involved, essentially this nomenclature has been consistently used throughout the investigation. The components and nodes that are identified by this nomenclature are from the main trusses, the piers and bearings, the floor trusses, the sway frames, the lower lateral bracing, the upper lateral bracing, and the deck stringers. Each of these elements is described below.

Main Truss Elements

The deck truss contains two main trusses, designated *East* and *West* (*E* and *W*), that make up the primary load carrying members of this structure. From south to north, the node locations of these trusses are designated *0* through *14* (mid-span) and *13′* through *0′*. A U or L distinguishes the upper and lower nodes at each of these locations respectively. For example, L7 East would designate the 7th lower node from the south end of the east truss. There are four types of members in the trusses: the upper chord members that extend the entire length of the truss, the lower chord members that extend between Nodes 1 and 1′, vertical members that vertically connect like-numbered nodes on the upper and lower chords, and diagonals that connect adjacent nodes of the upper and lower chords. Members in each of the main trusses are identified by the connecting nodes. For example, a member of the east upper chord connecting node 7 to node 8 would be designated U7/U8 E, and the diagonal member in the east truss connecting lower node 7 to upper node 8 would be designated as member L7/U8 E.

See figures 5 and 6 for the main truss member nodes.

The members of the main trusses are composed of either box sections or H sections, connected using riveted joints at the nodes with gusset plates. The east and west sides of the box sections are referred to as the side plates, and the other two sides as the cover plates. In many of the box members, one or both of the cover plates have access holes that are oval shaped and provided access for fabrication and inspection. The H sections have flanges that are welded to the web plate. The flanges and side plates are riveted into the gusset plates at the truss nodes.

Piers and Bearings

The main truss spans are supported on bearing assemblies at piers 5, 6, 7, and 8. A fixed bearing is provided for each of the main trusses at pier 7, and expansion roller bearings are used at piers 5, 6, and 8. The two expansion roller bearings at pier 6 contain a lower bearing plate, four large diameter rollers, an upper bearing casting, a bronze domed casting, and a flange casting, which is bolted to the bottom of the node above. The bronze domed casting rests between the upper bearing casting and the flange casting, and these two members are held together with a hold-down stud. The expansion roller bearings at piers 5 and 8 are similar but contain three large diameter rollers. The spherical dome casting allows multi-directional rotation that provides concentric loading through the bearing. Overall height of the bearing assemblies (top of the concrete pier to the bottom of the truss) is 4 feet – 11 1/2 inches for pier 6 and 4 feet – 1 inch for piers 5 and 8. The fixed bearing assemblies at pier 7 do not allow any displacement of the truss relative to the top of the pier and has an overall height of 3 feet – 6 inches. The individual bearing locations are designated by the pier number and as either East or West.

Expansion rocker bearings are used at nodes U0 and U0′. These bearings support the connecting approach spans on the deck truss cantilevered ends. The rocker bearings consist of 1 foot – 6 inch tall rocker castings.

Floor Truss Elements

The floor trusses are designated *FT* and frame into the upper nodes of the east and west main trusses. The floor trusses are primarily made from rolled wide flange (WF) sections and cantilever approximately 16 feet past the east and west main truss upper chords. Floor trusses are designated by the main truss node connections. The upper chord of each floor truss is supported on and connected to the upper chords of the main trusses at the like-numbered nodes. The lower chord of each floor truss connects to the main truss vertical member approximately 12-feet below the floor truss upper chord. The lower chord of the floor trusses are longitudinally braced with diagonal members (kicker braces) at floor truss nodes L4 and L9. The braces extended upward from the floor truss lower chord to deck stringers on the south side of the floor trusses from nodes 1 through 14 and on the north side of the floor trusses from nodes 13′ to 1′.

The numbering of the floor truss nodes reflects the numbering provided in the MnDOT inspection reports. The upper nodes of the floor trusses, designated by a *U*, are numbered west to east *0* through *10* and then *12* through *14*. The lower nodes of the floor trusses, designated by an *L*, are numbered west to east *2*, *4*, *6*, *9* and *10*. The nodes of the upper and lower floor truss chords are connected by verticals or diagonals that are referenced by the connecting nodes.

For example, the floor truss that connects main truss nodes *U10 E* and *U10 W* is designated *FT10*. The eastern most upper node on this floor truss is designated *FT10U14*. The diagonal member that connects upper node *3* to lower node *2* of this floor truss is designated *FT10U3/L2*.

See figure 7 for a floor truss general elevation with node labels.

Stringers

Longitudinal 27WF94[2] stringers carry the concrete deck and are supported by the floor trusses spaced on 38 foot centers. The stringers are designated with an *S* and numbered east to west *1* through *14* (opposite the numbering direction for the nodes of the floor trusses). The stringers are spaced about 8 feet-1 inch on center.

The stringers are continuous between deck expansion joints located at main truss nodes U0, U4, U8, U14, U8′, U4′, and U0′. The section of stringers from Node 0 to Node 4 is bolted to all five of the floor trusses that it spans. The section of stringers from Node 4 to Node 8 is not bolted to FT 4 but is bolted to the remaining four floor trusses it spans. This stringer support pattern continues across the bridge. Stringers aligned directly above the main trusses (stringers 3 and 12) are not bolted to the floor trusses, but are restrained laterally with a clamping mechanism that allows longitudinal displacement.

Sway Frame Elements

The K-type[3] sway frames consist of box shaped members that are oriented transverse to the main truss in the plane of the same-numbered truss nodes. The deeper sections of the variable depth deck truss, nodes *6* through *10* and *10′* through *6′*, have a double layer of sway frames. The K configuration has a bottom strut connecting the lower nodes and, at locations of a double layer, an intermediate strut connecting vertical members of the main span at mid-depth (between the lower node and the lower floor truss connection). Diagonals (the legs of the K shape) then span from center of the struts to the vertical members on the main truss.

The nodes of the sway frame located at the mid-height of the main truss verticals are designated *M*. The nodes at the center of the lower struts are designated *CL* and the nodes at the center of the intermediate struts are designated *CM*. The sway frame members are designated by the connecting nodes. For example, the diagonal connecting lower node *2* of floor truss *8* to the center of the intermediate strut at this location is designated *FT8L2/CM8*, and the bottom strut that runs from the center to the main truss node at this same location is designated *CL8/L8 E*.

See figure 7 for a typical sway frame elevation at nodes 6 through 10.

Lower Lateral Elements

The lower lateral system is made up of diagonal members connecting lower chord nodes in the main truss and the center node of the bottom strut of the sway frame member at the next node immediately north for nodes *1* through *13*, and the lower chord nodes in the main truss and the center node of the bottom strut of the sway frame member at the next node immediately south for nodes *13′* through *1′*. The members are designated by the connecting nodes. For example, the diagonal member that connects the center node of the sway frame bottom strut at node *4′* to lower node *3′* of the west truss is designated *CL4′/L3′ W*.

See figure 8 for a plan view of the lower lateral system.

[2] A 27WF94 wide flange section has a depth of 27 inches and a weight of 94 pounds per foot.
[3] K type sway frames are so designated because of their resemblance to a capital letter K laid on its back.

Upper Lateral Elements

The upper lateral system is made up of diagonal members between upper chord nodes in the main truss and a connection at the center of the upper chord of the floor truss at the next node immediately north for nodes *0* through *13*, and between the upper chord nodes in the main truss and a connection at the center of the upper chord of the floor truss at the next nodes immediately south for nodes *13′* through *0′*. The connections at the center of the floor truss upper chords are designated *CU*. An extension of the upper lateral bracing system exists for the cantilevered portion of the floor trusses, with diagonal members that connect east main truss upper nodes *2*, *6*, *11*, *11′*, *6′* and *2′* to the immediate north and south floor truss upper chord node 0, and diagonal members that connect west main truss upper nodes *2*, *6*, *11*, *11′*, *6′* and *2′* to the immediate north and south floor truss upper chord node *14*.

For example, the diagonal member that connects the center of the upper chord of floor truss *5′* to upper node *4′* of the west main truss is designated *CU5′/U4′*, and the member that connects upper node *2* of the east main truss to upper chord node *14* of floor truss *3* is designated *U2/FT3U14*.

See figure 9 for a plan view of the upper lateral system.

D RECOVERY OF THE STRUCTURE

Initial removal of the truss structure of the bridge was directed by the Hennepin County Sheriff's office as part of their on-going recovery efforts for missing victims. During this phase of the removal, many of the vehicles were removed from the bridge and river, and the structure downriver from the lock (on the south side of the bridge) was removed from the channel leading to the lock. Many components in this area were further damaged as they were recovered.

During the initial phase of removal, it was agreed that the reinforced concrete deck and floor stringers could be cut or pulled with a shear equipped backhoe without regard to the amount of damage caused to the stringers and without attempts to precisely document the stringer number or the position of a stringer piece longitudinally. Shear studs were attached to the top flange of the stringer ends for approximately 30 feet adjacent to the expansion joints at nodes 0, 4, 8, 14, 8′, 4′ and 0′, so it was possible to at least longitudinally locate these stringer pieces. Some larger members of the main truss were torch cut during this phase but under the guidance of the NTSB. A pathway large enough to allow barge access in all areas in a channel below the lock was cleared during the initial phase of removal.

Following this initial removal phase and in situ inspections and documentation, the removal was directed by MnDOT, with concurrence from the NTSB Structures Investigation Group. During removal individual pieces were assigned a salvage number, recording the general location of the piece, the date of removal and member identification. The removal data were recorded in an electronic spreadsheet.

Many areas of the center portion of the deck truss portion of the bridge fell into the river and were not accessible for detailed inspections prior to removal. In particular, the lower chord sections north of nodes L9 and south of nodes L9′ were under the water. During the earliest stages of removal, some of these areas along the south bank of the river were cut with a shear,

pulled and twisted in attempts at removal. Later, less aggressive methods were employed, but some members were lifted out of the water while still connected, and additional deformation damage might have occurred. Detailed examinations of these members were conducted in the lay down area (Bohemian Flats) following removal.

The approach spans and some parts of the truss portion were examined by the Structural Investigation Group and released directly to MnDOT from the bridge site. Released areas of the bridge were transported to an MnDOT gravel pit at Afton. A chronology of release is presented in the table below. The NTSB retained control of other sections. The retained portions of the bridge were removed from the accident site and transported to Bohemian Flats Park, a location slightly downriver from the accident location. Upon arrival at this Park, the individual structural pieces were sorted, and appropriate floor trusses and portions of the main trusses were reconstructed.

Table ---Chronology of Release

Bridge Section	**Date of Release**
South approach spans	8/21/07
Concrete and rebar materials from the bridge deck in the truss portion of the bridge south of pier 6	8/22/07
Concrete and rebar material of the bridge deck in the truss portion of the bridge north of pier 7	9/1/07
North approach spans including the steel girder areas of span 9 and all of spans 10 through 14 including piers	9/1/07
Stringers from truss node 0 to truss node 4	9/4/07
Primary and secondary truss members from node 0 to node 4	9/13/07
Stringers 4 through 14 from truss node 6 to truss node 3	9/17/07
Stringers 1 through 4 from truss node 6′ to truss node 3′	9/19/07
Primary and secondary members from just north of truss node 8′ to truss node 0′	9/26/07
Primary and secondary members from truss node 4 to just south of truss node 8	9/28/07
Concrete portions of pier 5	10/1/07
Concrete portions of pier 8	10/2/07
Concrete portions of pier 6	10/9/07
Concrete portions of pier 7	10/10/07
Accident site is no longer needed for investigative purposes	10/15/07

Despite, in many cases, being heavily damaged during removal from the water, the stringers pieces were examined for local buckling of the stringer web at locations where they crossed floor trusses. No evidence of direct vertical buckling could be distinguished from other damage.

E TESTING AND MEASUREMENTS

Core Samples

Core samples from various areas of the decking and piers were provided to WJE and FHWA. WJE and FHWA will provide separate reports on core locations and results of testing.

Mechanical Testing

Pieces of the gusset plates at nodes U10 and U10′ East and West, full sections through 20 truss members, a side plate from one additional member, and six representative sections from floor truss 10 were cut out and provided to FHWA for mechanical testing. The truss members selected were: U8/U10W, U10/U12W, U10/L11W, L9/L11W, L9/U10W, L7/L8E (east side plate only), U8/U10E, U10/U12E, L9/L11E, L9/U10E, U10/L11E, U8′/U10′W, U10′/U12′W, U10′/L11′W, L9′/L11′W, L9′/U10′W, U8′/U10′, U10′/U12′E, L9′/L11′E, L9′/U10′E and U10′/L11′E. FHWA will provide a separate report on this mechanical testing.

Gusset Plate Verification

The nominal thickness, overall size and shape, and number and spacing of rivets were verified for the gusset plates from nodes 8 to 12 and 12′ to 8′ East and West. There were no noted discrepancies between the as-constructed condition and the design drawing specifications for these gusset plates. In some locations bolts were used instead of rivets, apparently to facilitate the assembly process.

Laboratory Examinations of Specific Fracture Areas

The following fracture areas were selected for more detailed examinations and characterization at the NTSB Materials Laboratory: (1) Node U10 West, east gusset plate between the diagonal L9/U10 West and the vertical L10/U10 West, (2) L10/L11W west side plate adjacent to node L11W. The NTSB will provide separate reports on these fracture areas.

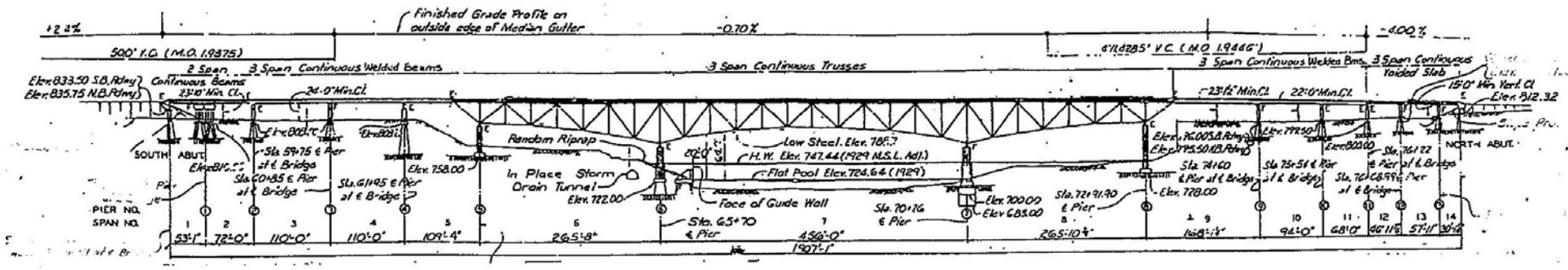

Figure 1. Elevation of I-35W Bridge (looking west)

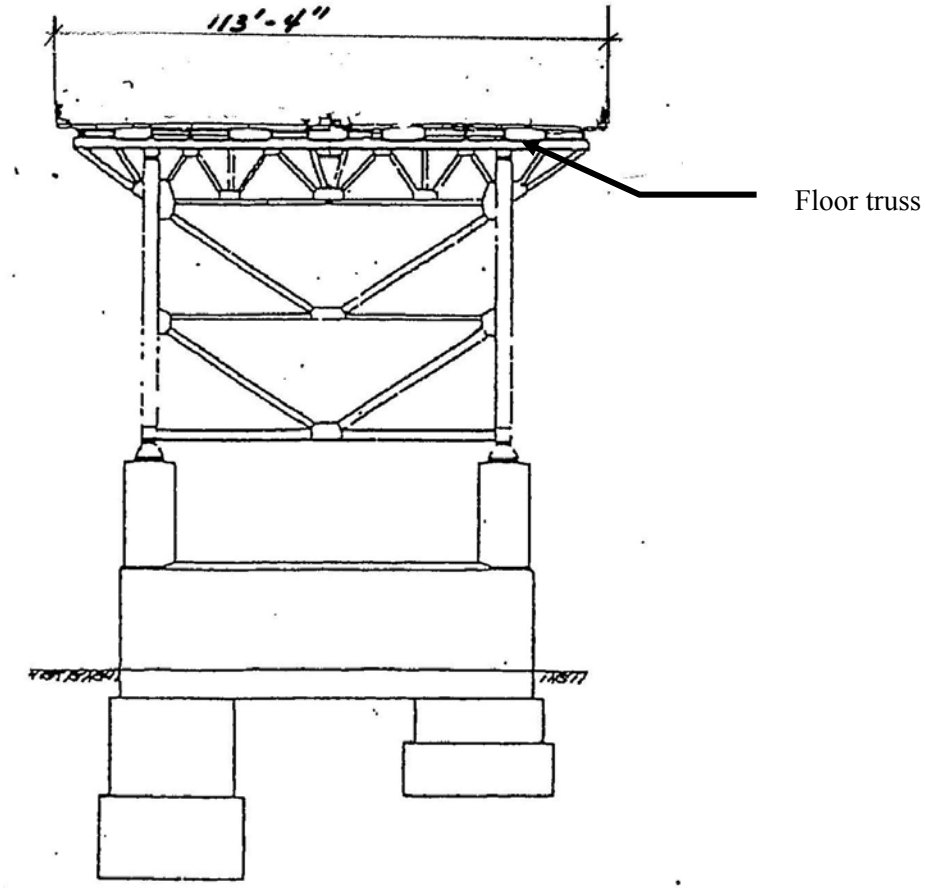

Figure 2. Typical deck truss section near Pier 6 or 7

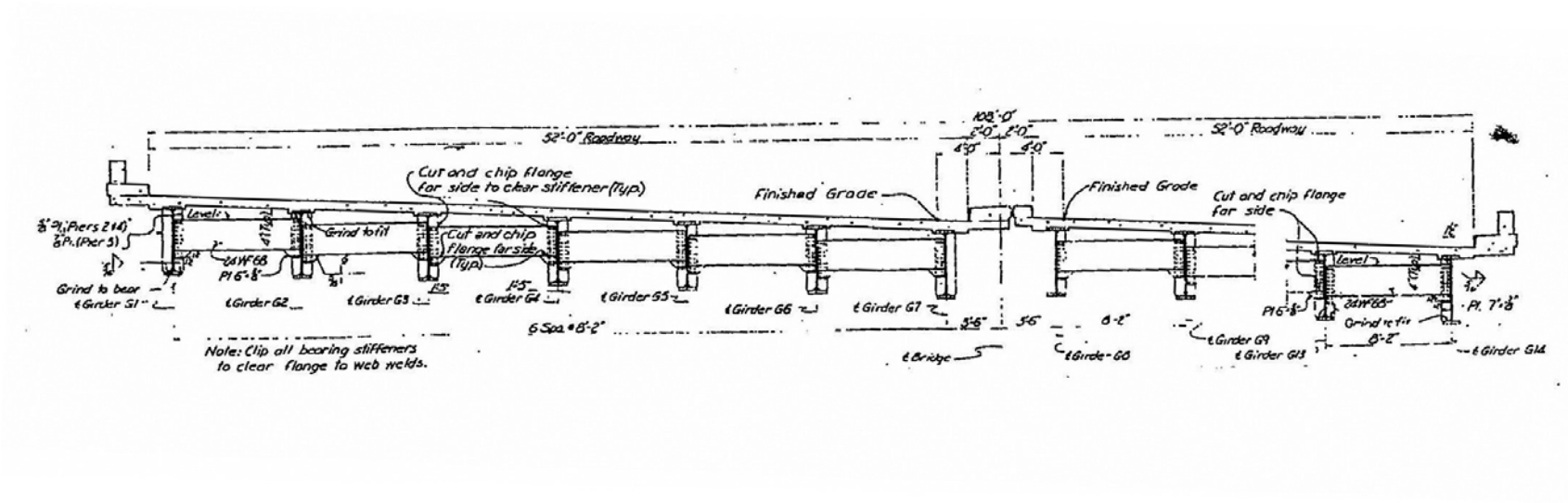

Figure 3. Typical section through steel multi-girder approach spans

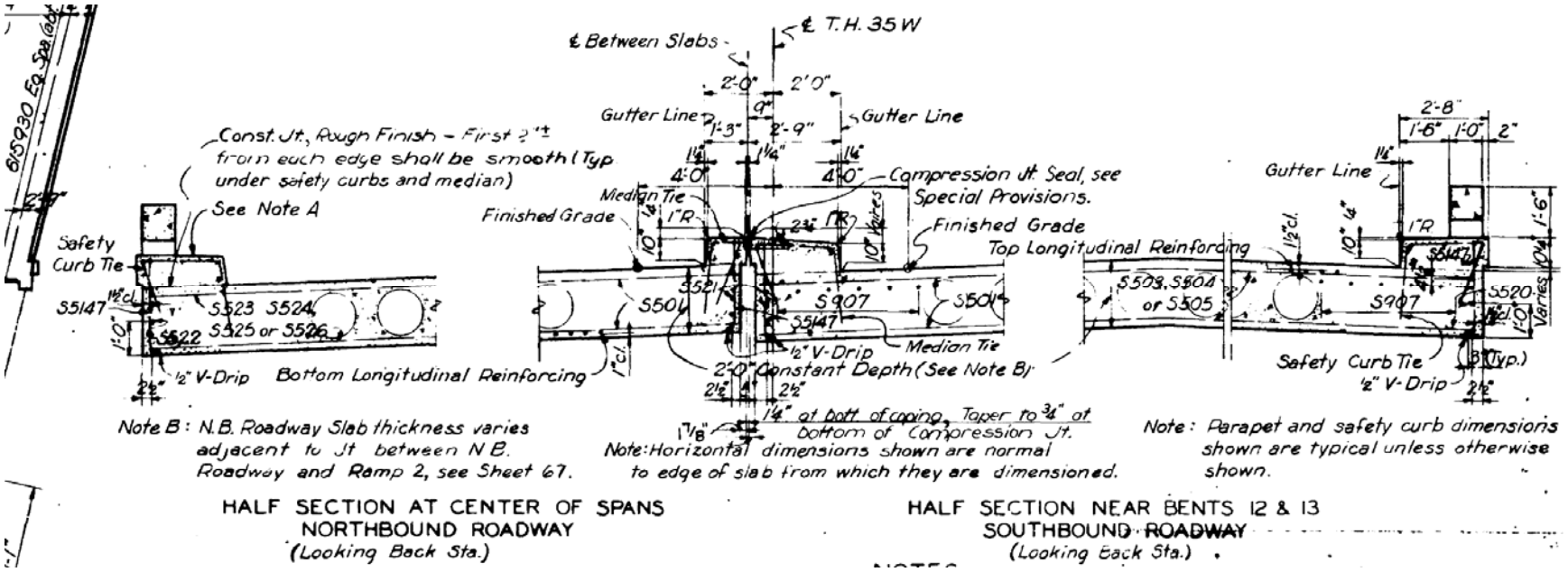

Figure 4. Typical section through voided concrete

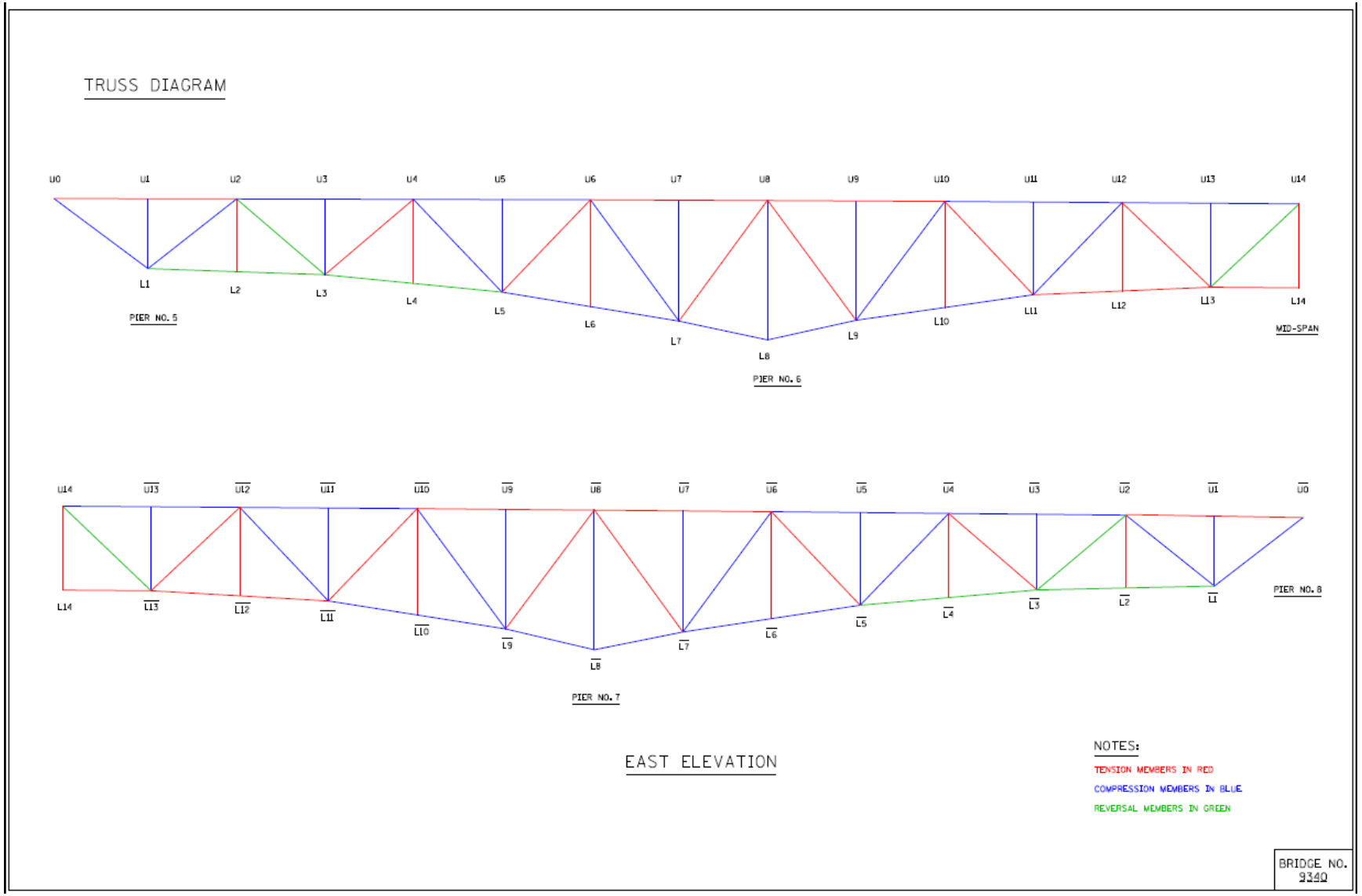

Figure 5. Elevation of East Main Truss.

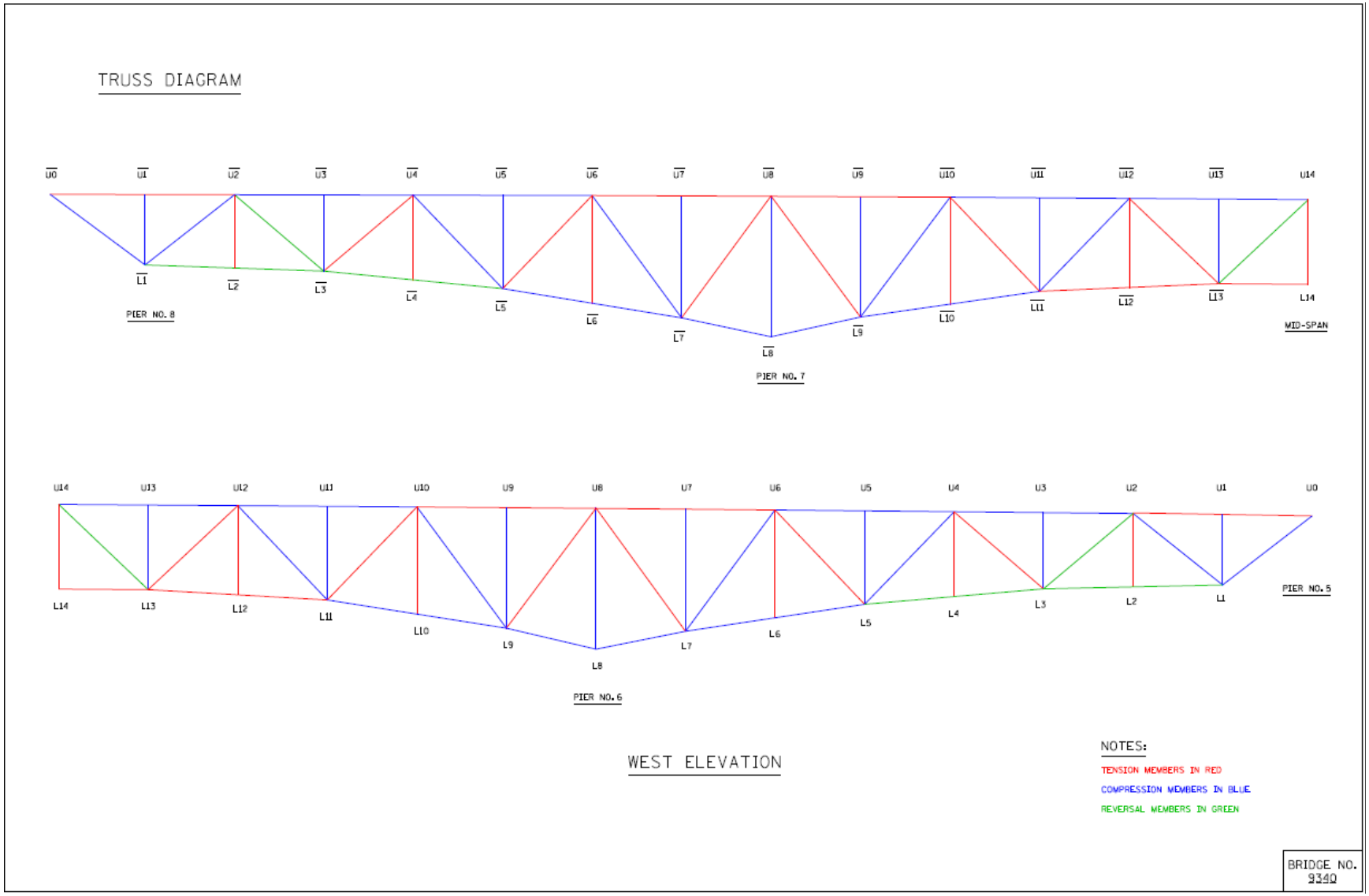

Figure 6. Elevation of West Main Truss.

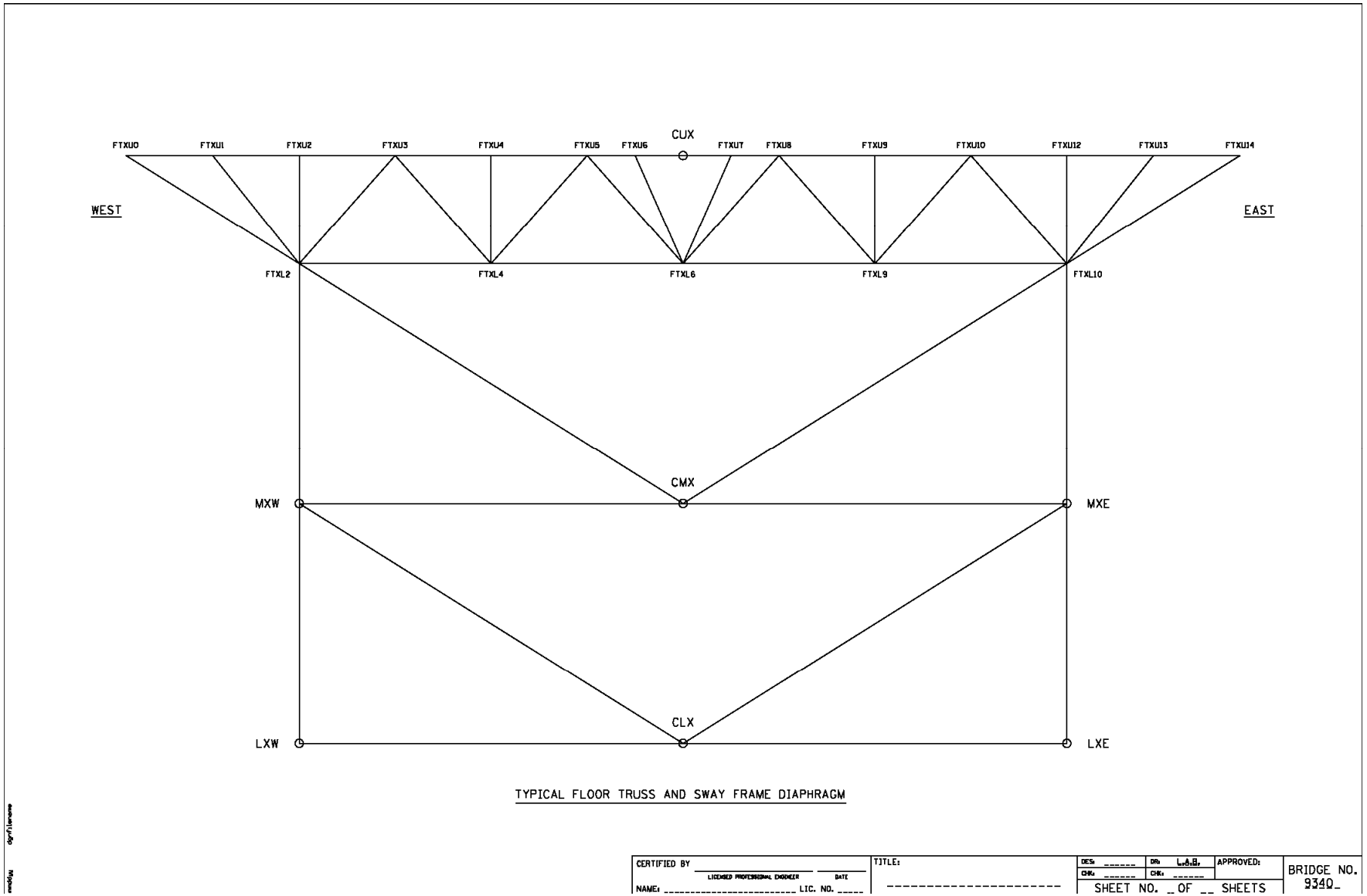

Figure 7. General Floor Truss and Sway Frame Elevation.

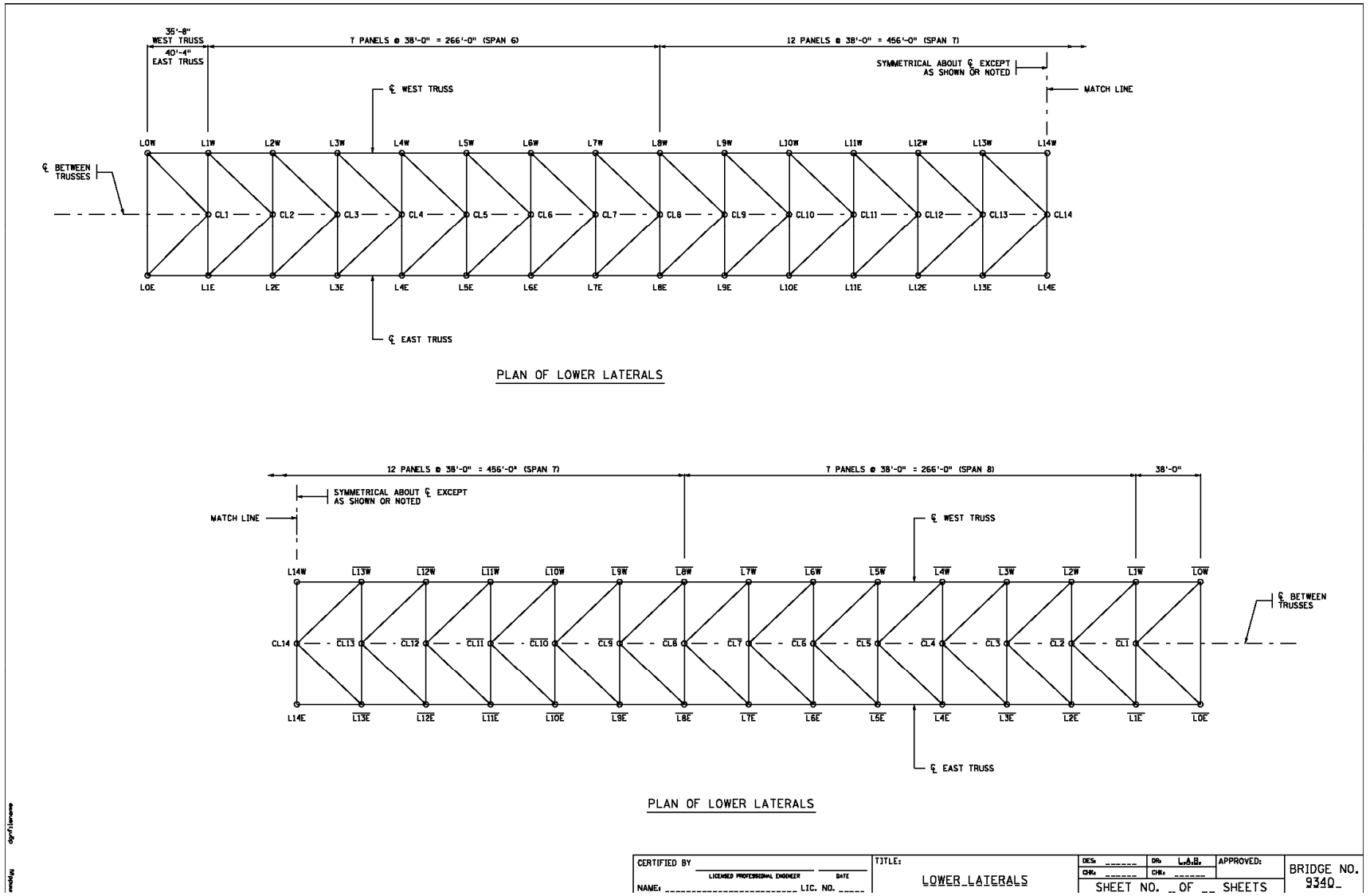

Figure 8. Plan View of Lower Lateral System.

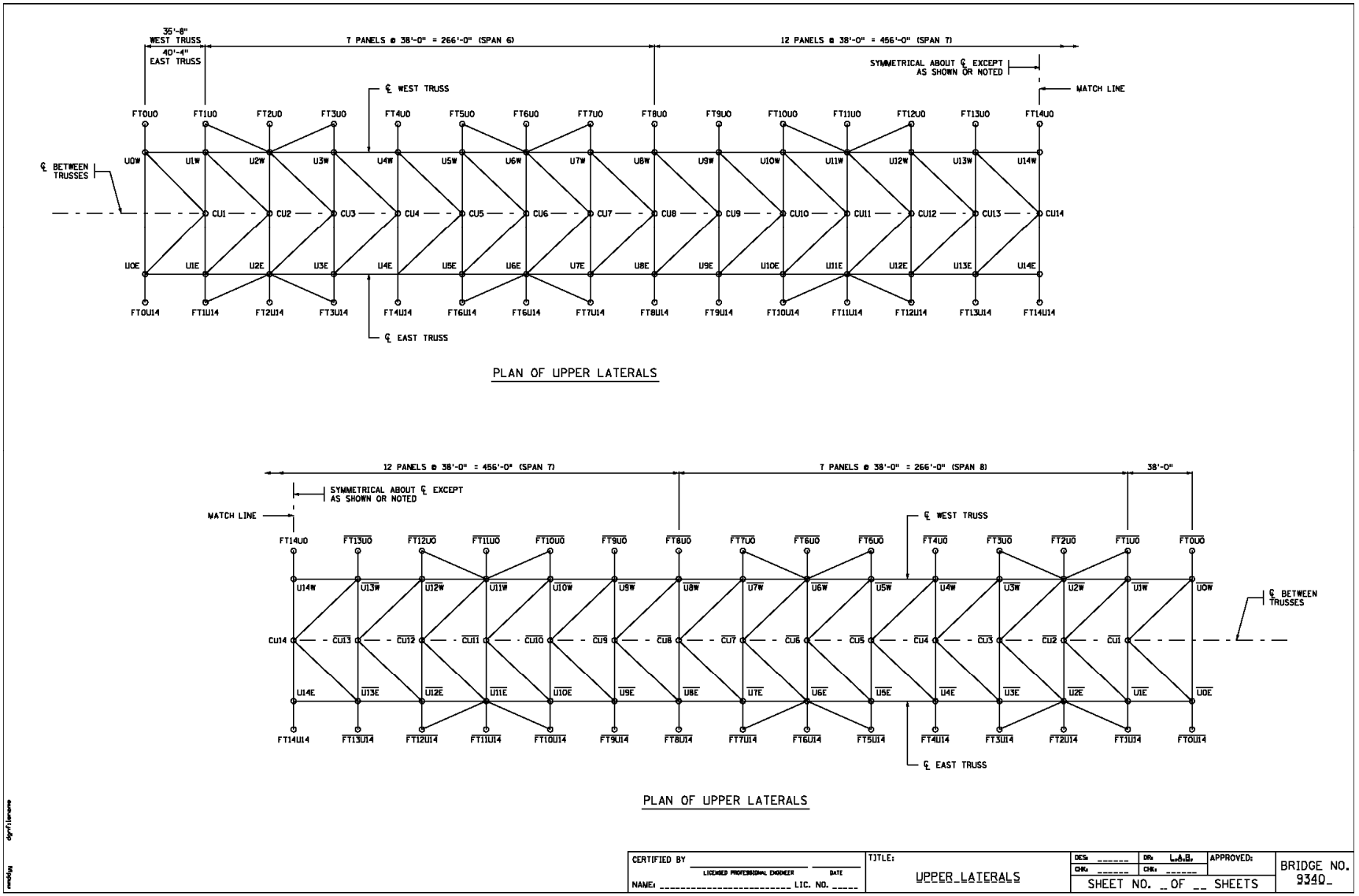

Figure 9. Plan View of Upper Lateral System.

Appendix 1 Detail Notes on Deck Truss

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Appendix 1 Detail Notes on Deck Truss

For ease of reference, the detailed notes on the deck truss are divided into sections, with four nodes per section. Each section is further divided into a section on the East main truss, the West main truss, and other structural elements (floor trusses, sway braces, and lateral braces). Additional notes on the piers and bearings from the deck truss are contained in appendix 2.

For portions of the main truss from nodes 8 to 8′, the descriptions of damage are as observed in the lay down area at the Bohemian Flats downstream of the original bridge location. Descriptions of other portions of the bridge generally refer to the undisturbed post-collapse positions unless specifically noted.

To clarify the meaning of various terms used in this report to describe the damage to the bridge members, the following discussion is provided.

“Fracture” indicates a region where a steel component has been severed by some means and a failure surface is exposed. It may refer to tensile, shear, ductile or brittle fractures, or combinations thereof. In some cases, more description is provided, for example, “tensile fracture”. Unless noted otherwise in the description, the reader should make no inference as to the failure mode when the term “fracture” is used. **"Partial fracture"** refers to a fracture that has not completely severed the component, and **“crack”** refers to a partial fracture in which the mating faces remained relatively close to each other.
“Gross section fracture” indicates a fracture that does not progress through a line of fastener holes.
“Net section fracture” indicates a fracture that progresses through a line of fastener holes.
“Buckling” and **“buckle”** are used to describe deformation due to compression loading unless noted otherwise.
“Fastener” is used where a combination of bolts and rivets are the primary components used to attached the plates and members at the connection being described. In connections comprised of entirely rivets or bolts, the terms **“rivet”** and **“bolt”** are used respectively to describe the connector.
“Positive bending” indicates loading of a horizontal or nearly horizontal member such that the resulting deformation deflects the member toward a “U shape.
“Negative bending” indicates loading of a horizontal or nearly horizontal member such that the resulting deformation deflects the member toward an inverted “U” shape.
“Hinged” indicates localized and severe bending deformation.

Node 0 to Node 4

General

The deck was offset to the south relative to the upper chord of the main truss by the following amounts, based on deformation of the standoff (east side) and/or upper chord of the floor truss.

- ~1 foot at U3 west node
- ~1 foot at U2 west node
- ~1 foot at U1 west node
- 1+ feet at U1 east node
- <1 foot at U2 east node
- 1+ feet at U3 east node

Pier 5 Bearings.

Nodes L1 East and West dropped off pier 5 to the north. On the west side one of the three rollers from the expansion bearing remains on top of the pier while the other two rollers fell off to the north. On the east side two rollers fell off to the north and one to the south.

End Floor Beam at U0 (South)

The floor beam was intact and connected at U0 East and West. The stiffeners above node U0 West were buckled. There was a bend in the beam's web such that bottom flange was displaced north relative to top flange for the center portion located east of stringer 11 and west of node U0 East with damage to slope paving. The bottom flange has rotated relative to web above the damaged area of the slope paving. The beam has displacement toward the river (north) with minimal sliding after impact with slope paving. There was downward bending east of node U0E due to impact of U0E with slope paving.

East Main Truss, Nodes 0 to 4

U0 East Node

- Intact, both U0/U1 east and U0/L1 east were buckled adjacent to U0 node.

U0/U1 East

- Fractured at U1 gusset along south rivet row due to positive bending. Gap between fracture mating surfaces measures approximately 1 foot horizontally and 1.5 feet vertically.
- Member resting on U0/L1 East and both members bent over Pier 5.
- Intact at U0 with large negative bending and buckling near U0.

U0/L1 East

- Resting on Pier 5. Damage from impact and scraping with Pier 5 starts 18 inches from bottom of gusset and extends up into U0/L1 approximately 12 feet. Box section was split open and buckled in damaged area.
- Large positive bending and buckling near U0.

U1 East Node

- Overall bending positive U0/U1 through U1/U2 east.

U1/L1 East

- U1 gusset plates were fractured at lowest rivet row (first rivet row at bottom of U1 chord) for U1/L1 on both sides of U1. Bending fracture as if lower end moves north relative to upper end.
- Portion of vertical below the floor truss lower chord has severe compression buckling and damage and box section was split open. Lower end was kicked out to the north. Buckling extends up to 12 feet from bottom of upper gusset plate (buckles below floor truss lower chord).

L1/L2 East

- South end fractured at north side of L1 node from positive bending. Gap between mating fracture surfaces measures approximately 17.5 feet. No evidence of sliding of fractured end, suggesting separation pre-existed contact of chord with roadway.

L1/U2 East

- L1/U2 East compression buckled, starting 11 feet from center of L1 up to 16.5 feet from L1. Loss of length was 3.5 feet (compressed).
- Scraping observed on east surface of L1/U2 at outer face of buckled box.
- L1/U2 resting on upper casting 8 feet-11 inches from node L1E with no impact deformation on side plates.
- South end split with scraping on top cover plate consistent with impact from diagonal.
- Some scraping on bottom cover plate of lower chord.

U2 East Node

- Gusset plate intact but partially fractured at L1/U2 connection with L1/U2 diagonal offset to west.

L2 East Node

- Gusset plate intact, distorted due to buckling of U2/L2
- Located 11 feet-6 inches north of U2 node
- Lower chord split open on both sides of node.
- Lateral L2/CL3 partially attached.
- Sway brace L2/CL2 detached.

U2/L2 East

- Lower end of U2/L2 forced through L2/L3. U2/L2 vertical severely damaged and completely fractured at L2 due to compression buckling.
- Upper end bent 90 degrees north at U2 gusset and layered between U2/L3 and L1/L2.

U2/U3 East

- Intact but bent near midspan due to ground impact with diagonal and lower chord. No deformation at gussets.

U2/L3 East

- Bent upward at U2 end.
- Flange deformed at L3 end due to sliding of vertical.
- Layered between upper chord U2/U3 and lower chord L2/L3 for most of length.
- Lower 15 feet slightly bent toward west and downward.

U3 East Node

- Upper chord and lateral bracing attached.
- U3/L3 detached.

L3 East Node

- Severe compression and damage from impact.
- U2/L3 East intact, bent at each node from ground impact.
- L2/L3 East buried under diagonal U2/L3. Appears intact, damaged due to impact of L2/U2 and bent at each node from ground impact.
- Soil below L3 East node displaced on top of L3/L4.

U3/L3 East

- U3/L3 vertical gusset plate fractured at 1st line of rivets on both sides at bottom of U3.
- U3/L3 bent to north, driven into L3/L4.
- U3/L3 buckled and split below floor truss lower chord with severe damage due to compression.
- U3/L3 East still minimally attached to L3 East gusset, but gusset not attached to L3 East node.

U3/U4 East

- Connected to nodes at U3 and U4.
- Moderate buckle in top cover plate near U4 due to positive bending.
- Member predominately straight.

L3/U4 East

- End of diagonal connected to U4.
- Member bent and split open approximately 4 feet from U4 and has pushed into lower chord L3/L4.
- West side plate peeled away toward west and north adjacent to L3 end.

L4 East Node

- Both gussets buckled and fractured at top of lower chord.
- Lower chord intact.

L3/L4 East

- Straight and intact at L4.
- L3 end buried.

U4 East Node

- All primary members attached.
- Gusset buckled upward at U4/L5 from bending.
- Partially fractured adjacent to vertical U4/L4 on west face and adjacent to diagonal U4/L5 on east face.

U4/L4 East

- Member bent northward below U4 gusset and lies west of L4/L5 with lower end resting 15 feet northwest of L4 node.
- Buckled approximately 4 feet above L4 connection.
- Gussets fractured at L4 connection.
- West flange fractured at gusset line at U4.

West Main Truss, Nodes 0 to 4

U0 West Node

- Node intact, members attached, gussets undeformed.
- U0/L1 buckled near U0 node in positive bending.
- No buckling in U0/U1 near node.

U0/L1 West

- Lower portion impacted on Pier 5 West at about 5 feet south of L1 node with scraping on bottom cover plate for an additional approximately 20 feet to where it was resting on Pier 5.
- West side plate fractured at south row of rivets in L1 gusset plate.
- Member and gusset fractured in bending from contact with Pier 5.
- Severe distortion in north 10 feet of member with north end of member sliding beyond node L1.

U0/U1 West

- Still attached and undeformed at U0 west node.
- Fracture in positive bending at U1 through member at south rivet line.
- Bent over Pier 5 along with U0/L1. Bottom cover plate punctured by U0/L1.

U1/L1 West

- Bent to north at U1 with partial fracture at gusset due to bending.
- Severe deformation and compression distortion in lower half.
- Upper half was straight. Lower portion was buckled and completely severed below floor truss lower chord. Upper part was approximately 7 feet north of L1 node.

U1/U2 West

- Still attached at nodes, straight.
- Some distortion of bottom cover plate at U2 West.

U2 West Node

- All members attached.
- Gussets deformed at diagonal L1/U2 connection.

L1/U2 West

- Attached at L1 and U2.
- Relatively straight/undamaged. Displaced west at U2 node approximately 1 foot.
- Compression buckling at L1.
- At U2, gusset plate bent up and west. Plate fractured along bottom surface of upper chord.

L1/L2 West

- Intact/relatively straight through L2, some fracturing and deformation of top cover plate at L2 West.
- Attachment to L1 buried. Member deformed adjacent to buried node with some twisting to the west.

L2 West Node

- U2/L2 severed at gussets, L1/L3 chord continuous through node but top cover plate punched down at and north of node due to L2/U2 impact.

U2/L2 West

- Bottom end compressed down into lower chord and displaced north of L2 node.
- Attached at U2, but partially ruptured gusset bent north and east and twisted approximately 90 degrees about axis.
- L2 end severed from L2 node through fractured gussets.
- Connection with lower chord floor truss displaced approximately 9 feet north of L2 node with west flange located west of lower chord west side plate and east flange through lower chord top cover plate.

L3 West Node

- Widely separated. L3/L4 portion and most of node approximately 21.5 feet north of L2/L3 segment.
- U3/L3 severed from node and located approximately 13 feet south of L3/L4 portion of L3 node, 90 degree bend below floor truss lower chord in north-south direction.
- U2/L3 north end was approximately 8 feet from L2/L3 segment.

U2/U3 West

- Intact, straight, and connected at nodes.
- West side plate of vertical U3/L3 partially punched through bottom cover plate at U3 node.

L2/L3 West

- South end straight but damaged from impact from U2/L2, split open adjacent to L2 node.
- North end bent over hill and driven into the ground below U2/L3 and U3/L3.

U2/L3 West

- Member bent up at U2.
- Lying on top of L2/L3. Runs underneath U3/L3 along ground (at bend in U3/L3).
- Bent and located past the south end of L3 node to north with severe bending and buckling adjacent to L3. Flange distorted from U3/L3 sliding along member.

U3/L3 West

- Bent south at U3 with partial fracture at gusset plate.
- Lower end driven down into ground.
- Buckled, bent below floor truss lower chord.

U3/U4 West

- Connected to U3 node with buckling on lower cover plate and lower portions of side plates at node U3.
- Straight over most of length but upward bending at U4 with buckling in top cover plate.
- Still connected at U4 node.

L3/U4 West

- Severed from L3 with L3 end buried in soil.
- Mostly straight and connected to U4 with large buckle in top located 1 foot from gusset plate connection.
- South end displaced west.

L3/L4 West

- Gusset plates fractured at L3 node.
- East side plate and upper cover plate fracture surfaces were visible, appear to be tension fractures.
- Gap between fracture mating surfaces measures approximately 21.5 feet.
- Bracing members CL3/L3W and CL4/L3W still attached to L3/L4.
- Member displaced west relative to upper chord U3/U4.
- Connected to L4.
- Relatively straight over its length, with some bending of west side plate at L4 node.
- Top cover plate damaged (punched) by L3/U4 near L3 node.

L4 West Node

- Lower chord intact.
- Vertical L4/U4 fractured due to compression buckling of gussets. Indented top cover plate of lower chord.
- L4/U4 displaced to the west.

- Node located 10 feet north of U4.

U4 West Node

- Gussets primarily intact except mild buckling and fractures along rivets at U4/L5 connection consistent with upward rotation of diagonal U4/L5 lower end.
- Lateral bracing detached from upper chord and displaced northeast.
- Gussets distorted to the east at diagonal U4/L3.

L4/U4 West

- Attached to U4 with slight bending north and north flange buckling at gusset.
- Bent 90 degrees to the north under last web stiffener for the floor truss.
- Severed from L4, both gussets fractured.

Other Structural Elements, Nodes 0 to 4

Upper Lateral Brace, Nodes 0 to 1

Both upper lateral bracing members U0/U1 were intact between FT1 U6/U7 and U0 East and West. Buckling of gussets plates at FT1 U6/U7 was noted. Both upper lateral bracing members were resting on Pier 5. Buckling noted in the lower flanges near U0 East and West.

Floor Truss 1

Floor truss 1 was intact. Partial fracture at the upper chord splice, east side between FT1 U10 and U12. Most of the lower chord was on the ground, but the east end was displaced north with the upper portion of vertical U1/L1 East. The cantilevered east end of the upper chord was buckled down at the east main truss, the cantilever diagonals were attached at each end, with deformation associated with the north movement of U1/L1 and the downward bending in the upper chord. At FT1-L6 the lower chord was severed. At FT1-L4 and L9, the gusset plates were buckled, apparently from ground impact. The cantilevered west end of the upper chord was bent down and the cantilever diagonals were buckled near mid-length. No apparent damage was noted to the FT1-L4 kicker bracing (6WF25). The FT1-L9 kicker bracing was bent upward at its lower end.

FT1 Sway Brace

The lower chord was intact from L1 East to L1 West with a twist to match the rotation of the L1 Node. The east diagonal (CL1 to FT1-L10) at the lower chord of FT1 L10 and the main portion were moved north with the upper portion of L1/U1 East and was under FT1. The member was separated from the CL1 gusset plate. The west diagonal (CL1 to FT1-L2) was attached at FT1-L2, and was bent over the lower lateral bracing with the gusset plate twisted 90 degrees upward at FT1-L2. The west diagonal was separated from the CL1 gusset plate and was lying under the lower chord of the sway bracing (L1W-CL1-L1E).

Upper Lateral Brace, Nodes 1 to 2

Intact and minimally deformed.

Lower Lateral Brace, Nodes 1 to 2

L1 East to CL2 was mainly straight, attached to gusset plates both ends. L1 East has bending in gusset plate from rotation of node L1E. No deformation at CL2 node at diagonals. L1 West to CL2 attached at L1 West, gusset plate was bent and crushed under FT1. L2 West to CL2 intact and straight. CL2 to L2 East was bent north at CL2, crushed under FT2 and fractured at the gusset plate at L2 East.

Floor Truss 2

The upper chord, FT web members and lower chord were intact, but web members at L9, L6, and L4 were fractured from the lower chord through the gusset plates, apparently from ground impact. Web members were displaced north relative to the lower chord at L9, L6, and L4. The lower ends of the web members were displaced north relative to the FT upper chord. East end of the lower chord was displaced north along with vertical L2/U2 East. The east cantilevered portion of the upper chord was bent down, and the cantilever diagonals were fractured through the gusset plates at the upper chord. Upper chord was crushed above U2 East with the upper flange displaced south relative to the lower flange. The FT kicker bracing members were intact but bent. The west cantilevered portion of the upper chord was intact but bent down. The west cantilever diagonals were attached at each end but heavily damaged. The upper chord at U2 West was rotated, with the upper flange displaced south relative to the lower flange. The lower chord at L2 West was partially fractured through the gusset plate and twisted to the north along with vertical L2/U2 West.

Floor Truss 2 Sway Brace

CL2 to FT2L10 was straight over most of its length, fractured at both ends. The east end of the member was displaced eastward and crushed between node U2 East gusset plate and L1/L2 East. CL2 to FT2L2 was straight over most of its length, fractured at both ends, and distorted at its west end from impact from the lower chord of FT2.

Upper Lateral Brace, Nodes 2 to 3

U2 East to FT3U6/U7 member was intact and straight at U2 East. It was bent at about the quarter point from FT3U6/U7, apparently from the lower member L2E-CL3 bending upward and pushing up into U2E to FT3U6/U7. U2E to FT3U6/U7 was intact and straight at CU3 and displaced upward. U2W to FT3U6/U7 was connected and straight at CU3, displaced down. The brace was straight and connected at U2W.

Lower Lateral Brace, Nodes 2 to 3

L2E to CL3 was attached at L2 East through the upper gusset plate, which has compression buckling. It was buckled upward at the mid point from CL3, and attached at CL3. L2W to CL3 was detached from CL3, mostly straight with some bending contoured to the ground. It was attached to L2W. CL3 to L3 West was attached at the L3/L4 side of L3 West and straight to where it passes under the lower chord of FT3. The member was also attached to CL3. The west end was displaced north with a portion of L3 West node. CL3 to L3 East was attached to CL3, but separated from L3 East and mostly straight and displaced west.

Floor Truss 3

The west FT kicker brace (at L4) was mostly straight. The east FT kicker brace (at L9) was bent closer to the L9 end. The upper chord, lower chord, and web members were intact. Web members at L4, L6, and L9 were displaced north relative to the lower chord with severe deformation and partial fracture of the gusset plates. The lower ends of the web members were displaced north relative to the upper chord. The west cantilevered portion of the upper chord was bent down and the cantilever diagonals were fractured at their lower ends. The shorter member was fractured at its upper end also. The shorter member was located east of the west truss. The east cantilevered portion of the upper chord was bent down and the cantilever diagonals were attached at both ends. The lower ends of the diagonals were displaced north with a portion of L3/U3 East. The upper chord above Node U3E has compression damage, mostly on the south side. The upper chord above the west truss was similar.

Floor Truss 3 Sway Brace

CL3 to FT3L10 was partially attached to CL3. It was mostly under the lower chord of FT3. CL3 to FT3L2 was separated from CL3 with the CL3 end displaced north. The center was mostly straight to where it was buried under the lower chord of FT3 near L3 West.

Lower Lateral Brace, Nodes 3 to 4

L3W to CL4 was intact at L3 West, with the gusset plates bent and partially fractured. It was mostly straight to where it crosses under FT4 lower chord. It was connected to CL4, with the gusset plates partially fractured. CL4 was displaced north relative to FT4. L3E to CL4 was straight and crushed under FT4. The ends of the member were not visible.

Upper Lateral Brace, Nodes 3 to 4

The two members of this brace were intact, straight and holding the upper chord of FT4 in position.

Floor Truss 4

The upper chord, web members, and the lower chord were intact. Node FT4 L10 was displaced north with vertical U4/L4. The lower chord was twisted between L9 and L6. At L6, the lower chord was displaced south relative to the web members. The east cantilevered portion of the upper chord was bent down and south. The east cantilever diagonals were attached at both ends. The lower ends of the diagonals were displaced north with vertical U4/L4 East. The upper chord was not crushed above the east main truss (U4 East). The decking north of FT4 has apparently pushed the lower chord of FT 4 south between L6 and L4. The median parapet for the southbound deck was under the lower chord at L6. FT4 in the center has been held in place by the upper laterals at FT4 U6/U7. The west cantilevered portion of the upper chord was bent down and south. The U1/L2 diagonal was intact at both ends, with gusset plate partial fracture at the upper end and bent gusset plate at the lower end. The U0/L2 diagonal was fractured through the gusset plate at the upper end, and intact at the lower end. There was some deformation of the vertical stiffeners in the upper chord above the east main truss. The FT4 kicker brace at L4 was bent and the kicker brace at L9 was straight.

Floor Truss 4 Sway Brace

CL4 to L4 West was straight at CL4 all the way to L4 West, which was displaced northward relative to U4W and FT4L2. CL4 to FT4L2 was straight at CL4, connected through gusset plates to CL4 to FT4L10, but both lower ends were separated from the remainder of CL4 and displaced west several feet from the remainder of CL4. CL4 to FT4L2 was crushed by the lower chord of FT4. It was fractured from FT4L2, displaced to the west of node U4 West. CL4 to FT4L10 was straight adjacent to the partial node CL4 then crushed under a stringer at the longitudinal joint, then straight. It was partially fractured from FT4L10 through sheared rivets on the north gusset and partial fracture of the member at the south gusset plate. CL4 to L4 East was intact and mainly straight. CL4 to L4 East was partially severed at CL4, and the gusset plates at L4 East were fractured. It was mostly straight except where it has been impacted by FT4.

Node 4 to Node 8

East Main Truss, Nodes 4 to 8

U4/U5 East

- Attached to U4 and buckled at north edge of gusset plate with fracture at rivet.
- Member bent down.
- Primarily straight and attached to U5. Located east of original alignment.

U4/L5 East

- Predominately straight, buckled near L5 connection.
- Partially attached at U4, east side plate partially fractured at lower south rivets in pattern.
- Partially attached to L5.
- Member translated to the west at L5.

L4/L5 East

- Partially connected to nodes at each end.
- End near L5 node buckled with member rotating downward and top cover plate was split from the side plates.
- Member longitudinal axis approximately in line with original alignment.

U5/L5 East

- U5 gusset plates fractured. Member bent to the south and buckled at FT5L10 connection.
- Remaining length connected at L5 node by small piece of gusset plate.
- Upper portion of L5 East gusset plate bent west.

U5/U6 East

- Positive bend and buckled at U5.
- Remainder of member was substantially straight.
- Still connected to U6 with buckle adjacent to gusset plate.

L5/U6 East

- Still connected to L5 but lower quarter of its length was bent 180° to the west. Largely fractured/separated at west gusset.
- Remaining length twisted slightly about longitudinal axis and still connected to U6.
- Side plate fractured along lower quarter length.

L5 East Node

- All members attached
- Both gussets folded west at upper edge of lower chord.
- West gusset contains multiple partial fractures. East gusset partial fracture at south edge.
- Multiple rivets fractured in east gusset plate.

U6 East Node

- Node intact, gussets minimally distorted.

U6/L6 East

- U6/L6 bent south and partially torn from node at lowest rivet line at U6.
- Partially attached with torn web at L6.
- Large radius bend and twist to south between U6 and L6.
- Local tears at twist.

L6 East Node

- Lower chord straight through node.
- East gusset partially torn at top row of rivets.
- West gusset bent east 90° above lower chord.

L5/L6 East

- Member attached at each node, predominately straight and in original alignment.

L6/L7 East

- Partially attached at L7 node, member rests on the ground for 15 feet from L7 then bent down and follows ground to L6.
- L6 East end translated east.
- Deformed and twisted at L7.
- Upper cover plate crushed down by L7/U6.
- East side plate vertical fracture.

U6/L7 East

- Attached at U6 node but buckled and displaced laterally west at U6.
- Largely straight below buckled section (at U6).

U7 East Node

- Intact lying on east face with cantilever deck inverted and underneath node.

U6/U7 East

- Member predominately on east side. Lying on an inverted portion of the east cantilevered deck section (i.e., deck rolled beneath upper chord member).
- Attached at both U6 and U7 nodes.
- Lower plate rippled most severely near U6.
- Slight lateral bend where sitting on deck edge.
- Impact marks on lower cover plate of upper chord.

U7/L7 East

- Buckles in gussets at attachment to U7 node, member shifted west relative to node.
- Relatively straight until buckled east approximately three quarters of length from U7 node.
- Partially attached at L7 with significant bending damage at node.
- Node L7 sits primarily vertical while U7/L7 was on its east side.

L7 East Node

- Both gussets heavily deformed. East gusset bent near 90°, west gusset some eastward bending. All bending at top of lower chord.
- Node-shaped impact mark in the ground approximately 12 feet behind (south of) pier 6.
- Node resting about 4 feet west of mark and 8 to 10 feet west of original alignment.
- L7/L8 unattached and all rivets connecting to that member in gusset were fractured.
- Other members attached.

L7/U8 East

- Bottom north edge row of rivets sheared, adjacent top row heads scraped.
- Both flanges of diagonal still attached to L7 node but web was stripped out over most of the length.
- Flanges deformed in very complex curves.
- Scraping on inside of flanges and on web indicates web was sheared by upward motion of L7/L8.

West Main Truss, Nodes 4 to 8

U4/L5 West

- Attached to U4 with member bent upward partially fracturing gusset plate at U4.
- Straight over most of its entire length and attached to L5 node.
- A buckle (negative bending) in the member just prior to the gusset at L5 node with partial fractures of the lower plate welds.

U4/U5 West

- Attached to nodes at both ends.
- Relatively straight but bent to the east and twisted (top cover plate rotated eastward) at U4 node, some lateral translation at U5 node.
- Some weld fractures of lower cover plate near U4 and U5.

L4/L5 West

- Bent over hill surface, connected at L4 (partially buried).
- Not visible for assessment at L5 node. Some splitting of chord was present south of node.

L5 West Node

- Mostly buried, all members attached with exception of L5/U5, which was not visible/obscured.
- Upper portions of east gusset folded west at top of lower chord, some tearing at north end of east plate at top of lower chord.

U5/L5 West

- Attached at U5 node, U5 end displaced west a few inches relative to upper chord.
- Buckled west below floor truss attachment. L5 end of member displaced west of L5 node and buried in soil.

U6/L5 West

- Attached at L5 with 90-degree bend (top to east) just prior to gusset.
- Connected at U6, bent 90 degrees, 10 feet from U6.

U6 West Node

- Intact, west surface facing up.
- Node and deck above displaced east 35 to 40 feet.

L6 West Node

- Suspended in air with all members attached.
- L6/U6 West bent to the south.
- Slight distortion of the west gusset.

L6/U6 West

- Intact at nodes, distortion and twisting along length. The south flanges near mid-height at sway brace M6W node were compressed toward each other, apparently due to impact with K bracing.
- Buckle between U6 gusset and FT6L2.

U5/U6 West

- Attached at both ends.
- Buckled and twisted at U6 West end top to the east.
- Lower and upper plates separated at welds and rivet holes.

L5/L6 West

- Attached at nodes, rippling full length of top cover plate visible adjacent to access hole covers.
- Relatively undamaged until node L6 West.
- Buckled to the west adjacent to L6 node with separation of the top plate.

L7 West Node

- Intact and suspended in air south of pier 6 West with its west face up.
- All members attached to the node.
- Node displaced east.

L6/L7 West

- Buckled and twisted at gusset of L7 West node.

U7 West Node

- Intact, gussets of vertical buckled outward to east and west approximately at bottom of upper chord.
- Impressions in lower surface of upper chord.

U7/U6 West

- Intact, straight, attached at both ends.

L7/U6 West

- Attached at nodes, west side facing up with slight curvature at mid-length due to weight of deck.
- Bowed in positive bending near node L7 West.

L7/U7 West

- Intact and attached at both nodes.
- Generally straight but with a mild curvature to north in the upper portion and bowed to the south in the lower third.
- Slight side bending at center from deck weight.

L7/L8 West

- Bowed up.
- Impacts and scrapes on lower cover plate.

L7/U8 West

- Intact and attached at both nodes, predominantly straight.

U7/U8 West

- Intact and predominantly straight, west side facing up.

Other Structural Elements, Nodes 4 to 8

Upper Lateral Brace, Nodes 4 to 5

Lateral U4W/CU5 was intact with a slight positive bend approximately 5 ft from U4W. U4W/CU5 was attached at CU5, with some deformation of the gussets. U4W/CU5 was detached at its U4W end, which was displaced approximately 11 ft east of node U4W. At the top gusset, the rivets were sheared and at the bottom gusset, the gusset was buckled and the attachment angle was fractured.

The general position of U4E/CU5 was just above L4E/CL5. (Node U4E was positioned over L4E and node CU5 was positioned over CL5.) Lateral U4E/CU5 has positive bends approximately 5 ft from CU5, 20 ft from U4E (at connection tab to stringer diaphragm) and 5 ft from U4E (due to impact of deck and stringers). U4E/CU5 was attached at CU5, with deformation of the top gusset and a partial fracture through the bottom flange of the spreader beam between FT5U6 and FT5U7. U4E/CU5 was partially attached at U4E. Both the top and bottom gussets were deformed. At the bottom gusset, the attachment angle was fractured. At the top gusset, the top flange of U4E/CU5 was partially fractured.

Lower Lateral Brace, Nodes 4 to 5

Lateral L4W/CL5 was intact and resting on the ground. The member bows upward slightly, following the grade. L4W/CL5 was attached to gussets at CL5. At L4W, the lateral was

attached at the top gusset. The bottom gusset was buried, but appears to be attached.

Lateral L4E/CL5 was intact and straight, and mostly resting on the ground. There was damage approximately 5 ft from CL5 due to impact from FT5 lower chord. L4E/CL5 was partially attached at CL5, the bottom gusset was slightly deformed and the rivets were sheared at the top gusset. At L4E, the lateral was attached at the top gusset. The bottom gusset was buried, but appears to be attached.

Floor Truss 5

The west cantilevered portion of the upper chord was bent downward 90 degrees. At U1, the top flange of the upper chord was fractured from the web member and bent upward. Diagonal U0/L2 has a 180 degree bend north at midlength, and was displaced east and slightly north of the west truss vertical due to the downward bend of the upper chord. Similarly, U1/L2 has a 150 degree bend north at midlength, and was displaced east and slightly north of the west main truss vertical. U0/L2 and U1/L2 were both fractured through the gusset at L2. U0/L2 was attached at U0, with deformation of the gusset. U1/L2 was partially fractured through the gusset at U1.

The east cantilevered portion of the upper chord was bent downward. The upper chord was detached from the east truss upper chord at U12, and there was a partial fracture through the top flange and web near U13. U14/L10 was buckled east just above L10 and buckled north just below U14. It was attached to the gussets at both ends. U13/L10 was buckled east near midlength and slightly twisted. It was attached to the gusset at L10. At U13, the gusset was mostly fractured. There was deformation of the gussets at U13, U14 and L10.

From the west truss to the east truss, FT5 was helical-shaped. The west half of the truss was curved to the south with the upper chord south of the lower chord. Near midspan, the floor truss was twisted. The east half of the truss was curved to the north with the upper chord north of the lower chord. The top and lower chords were intact. The upper chord was attached to the west main truss upper chord at U2 and was detached from the east truss upper chord at U12, but still positioned near U5E, and rotated slightly north. The upper chord exhibited two points of curvature near nodes U5 and U8. The lower chord was attached to the west truss vertical at L2, and partially attached to the east truss vertical at L10 with a partial fracture through the L10 gusset. The lower chord generally follows the upper chord from the west main truss to L6. From L6 to the east main truss, the lower chord was displaced south relative to the upper chord due to southward displacement of the east main truss vertical.

Web members U3/L2, U3/L4, U4/L4 and U5/L4 were intact and straight. Web member U5/L6 has a buckled flange near L6. At L6, the gusset plate was bent with partial fractures at U7/L6 and U8/L6 and complete fractures and separation at U5/L6 and U6/L6. U7/L6 and U6/L6 were bent south near the CU5 spreader beam. U8/L6 was bent and twisted. Web members U8/L9, U9/L9, U10/L9, and U10/L10 were intact and straight. The gussets at U8, L9, U10, and L10 were bent with partial fractures through the gussets at U8 (member U8/L9) and at U10 and L10 (member U10/L10). The L9 floor truss kicker brace was attached at L9 but bent. The L4 kicker brace was straight but detached at L4. At both locations, the kicker connection plates on the lower chord were bent.

Floor Truss 5 Sway Brace

L5W-CL5 and L5E-CL5 were intact and resting on ground. The members were slightly bent to the north at CL5. L5E-CL5 was bent south and upward slightly approximately 8 ft west of L5E with buckling of the bottom flange due to impact on diagonal L5/U6E. L5E-CL5 was still attached to the top and bottom gussets at L5E. There was some impact damage at L5E from the main truss diagonal. L5W-CL5 was detached at L5W with a fracture through the bottom face of the member and a fracture through the attachment angle connecting the top gusset to the main truss gusset. The top gusset was also bent.

Diagonal FT5L2/CL5 was straight and intact. FT5L2 was displaced south relative to CL5. At FT5L2, the member was partially fractured along the bolt line. Diagonal FT5L10/CL5 was buckled to south approximately 12 ft from FT5L10 and driven into the ground. Just north of this buckle, FT5L9 was resting on FT5L10/CL5. At FT5L10, the member was fractured. At the CL5 ends, FT5L2/CL5 and FT5L10/CL5 were still partially attached to each other with deformed gussets and member ends, but detached from CL5 and displaced 15 ft northeast relative to CL5. On the north face, the separation was a fracture through the attachment angle and, on the south face, the separation was due to fractures through the member along the bolt line.

Upper Lateral Brace, Nodes 5 to 6

Lateral U5W/CU6 was intact with negative bending near midlength at connection tab. U5W/CU6 was attached at U5W, with the south end of the bottom attachment angle displaced east from the west main truss node. U5W/CU6 was detached at CU6 with the rivets sheared at the top gusset and fracture through the attachment angle at the bottom gusset.

Lateral U5E/CU6 was buckled 90 degrees to the northeast at midlength near connection tab. U5E/CU6 was partially attached at U5E with partial fracture through the top gusset and distortion of the bottom gusset. U5E/CU6 was detached at CU6 with a fracture through the member at the top gusset and fracture through the gusset at the bottom.

Lower Lateral Brace, Nodes 5 to 6

Lateral L5W/CL6 was intact and straight. At L5W, the member was attached to the top gusset with the gusset bent upward. The bottom gusset was buried but appears attached. At CL6, the member was attached to the gussets, with the gussets bent downward and partial fractures at the west edge of both gussets.

Lateral L5E/CL6 has a slight buckle to the northeast at the third point from L5 East due to impact from FT6U7. The member was crushed about 2 ft from L5 East by the main truss diagonal. L5E/CL6 was attached at L5E with the top attachment angle pulled west away from the node. The member was attached at CU6.

Floor Truss 6

The west cantilevered portion of the upper chord was bent downward and north relative to U6W. The upper chord exhibited compression damage at U2. The bottom flange of the upper chord was still bolted to U6W with the web and upper flange at U2 fractured from the lower flange and displaced and rotated north. Diagonal U0/L2 was detached and fractured through

gusset at L2. At U0, the gusset was bent to the south with partial fracture in the gusset. Diagonal U1/L2 was completely separated, fractured through gussets at both ends, and was lying on the ground, bent and twisted.

The east cantilevered portion of the upper chord was bent downward and folded under U6E node. The upper chord was fractured at U12. Diagonal U14/L10 was buckled to the north 150 degrees and displaced west of U6E. At U14, the gusset was bent and mostly fractured. Diagonal U13/L10 was slightly deformed. At U13, the gusset was fractured. At L10, the gusset was bent north and almost completely fractured at U14/L10, with partial fractures through the gusset at the flange tips of U13/L10.

The upper and lower chords were intact, except at U12, but significantly curved and distorted. The upper chord was curved to the north from U2 to between U5 and U6, with a buckle south just west of U6. The lower chord was buckled south just east of L4, and was twisted and crushed between L6 and L9 due to impact from deck. Near the east main truss, the lower chord was rotated north and displaced south due to southward displacement of east truss vertical. The floor truss was folded at midheight with the upper chord rotated toward the south relative to the lower chord and lying just above the lower chord.

U3/L2 was intact with buckling of the west flange near U3 due to impact of lateral U6W/CU7. Web members U4/L4 and U10/L10 were intact and straight. U3/L4 and U5/L4 were slightly twisted. U5/L6 was buckled 90 degrees south at midlength. U6/L6 and U7/L6 were bent south at the location where the beam for the upper lateral braces attach to these members. At U6, the weld between the west flange of the web member and upper chord was partially fractured. U8/L6 has a slight bow to the south. U8/L9 has local buckling of the west flange due to impact. U9/L9 and U10/L9 were severely bent and twisted.

Gussets at L4, L6, L9, U3, and U5 were bent. At several locations, the gussets were torn at the tips of the web member flanges - L4 (all members), U5 (U5/L6), L6 (U6/L6, U5/L6, and U7/L7), U8 (U8/L9), and L9 (all members). At U8, the gusset was partially fractured. At U10, the gusset has fractured and both web members were detached. The L4 floor truss kicker brace was attached at L4 and straight. The L9 floor truss kicker brace was detached at L9 and bent.

Floor Truss 6 Sway Brace

Node CL6 was on the ground, and node CM6 was resting above and just east of CL6, on top of CL6/L6E. At CL6, the diagonals were still attached, with the gussets pulled south and partially fractured at CL6/M6E. There was some local buckling of the top flange of L6E/CL6/L6W at CL6. At CM6, the diagonal members were attached, with the gussets severely distorted. The north gusset was partially fractured, and the south gusset was mostly fractured. There was impact damage on the top flange of M6E/CM6/M6W at CM6. CM6/M6E was buckled north at CM6 with the M6E end rotated south due to southward displacement of the main truss vertical.

The west sway brace members CL6/L6W, CL6/M6W, CM6/M6W, and CM6/FT6L2 were straight and intact except at the member ends. CL6/L6W was partially attached at L6 West. The rivets were sheared at the bottom gusset and the attachment angle was partially fractured at

the top gusset, starting at the north end. At M6W, CL6/M6W was detached, with a fracture through the gusset on the south side and a fracture through the member on the north side. CM6/M6W was still attached to gussets at M6W with buckling and deformation of the gussets at this member. CM6/FT6L2 was detached at FT6L2 — fracture through attachment angle on south side and fracture through member on north side.

The east sway brace members CL6/L6E, CL6/M6E, CM6/M6E, and CM6/FT6L10 were lying on the ground and were impacted by the deck. The east ends of CM6/M6E and CM6/FT6L10 were resting on top of lower chord L6/L5, and were buckled near midlength as a result of the deck impact. CL6/L6E was attached at L6E. At M6E, CL6/M6E was detached with fractures through the gusset and member, but the member was lying near the M6E connection on the east truss vertical. CM6/M6E was still attached to the gussets with severe distortion of the gussets and member and partial fractures through member flanges. CM6/FT6L10 was detached at FT6L10 with fractures through the member and deformed gussets.

Upper Lateral Brace, Nodes 6 to 7

At CU7, both upper laterals were partially attached to the gussets with severe distortion of the gussets. The top and bottom flanges of the spreader beam were completely fractured from the web on the south side of the beam. U6W/CU7 was slightly bowed downward. It was also buckled to the northwest about 4 ft. from CU6. U6W/CU7 was partially attached at U6W — the rivets were sheared at the top gusset and the bottom gusset was buckled with a partial fracture through the attachment angle.

U6E/CU7 has a slight buckle east at midlength at the connection tab. It was also buckled east about 10 ft from U6E due to the impact from FT6. U6E/CU7 was crushed by the deck for about one third of the length from CU7. U6E/CU7 was detached at U6E — the top gusset was fractured and the bottom gusset was distorted with a fracture through the attachment angle.

Lower Lateral Brace, Nodes 6 to 7

L6W/CL7 was intact and buckled northwest and slightly upward due to impact on the retaining wall. At L6W, the rivets were sheared at the bottom gusset, and the top gusset and attachment angle were partially fractured. L6E/CL7 has two bends due to impact on the retaining wall - a positive bend about one third point from CL7 and a negative bend at two thirds point from CL7. The member was still attached at L6E. CL7 was resting on the ground. The bottom gusset was buried, but lateral members may still be attached to the bottom gusset. At the top gusset, L6W/CL7 was fractured through the member and the rivets were sheared at L6E/CL7.

Floor Truss 7

The west cantilevered portion of the upper chord was bent downward and north relative to node U7W. The upper chord was fractured just west of its attachment to node U7W. It was also buckled upward and partially fractured at U1. Both diagonals U1/L2 and U0/L2 were significantly deformed and buckled. U1/L2 was fractured at U1. U0/L2 was fractured at U0.

The east cantilevered portion of the upper chord was bent down and folded under the east main truss upper chord with the stringers and concrete deck attached. Diagonal U13/L10 was

fractured through the gusset at U13. Diagonal U14/L10 was fractured through gussets at both ends and likely buried under the east main truss upper chord.

The floor truss was twisted and distorted. The upper chord was folded over on top of the lower chord near the east main truss. The upper chord was partially fractured just east of the gusset at node U7W, and the upper chord has a 90-degree bend at the fracture from the upper chord being displaced north. The upper chord was also rotated south and partially fractured just west of the gusset at node U7E. The lower chord was intact, attached to the west main truss vertical at L2 and partially attached to the east main truss vertical at L10.

All web members except U10/L10 had some buckling and distortion. Web members U6/L6 and U7/L6 and spreader beam, and upper chord at this location, were bent south. U10/L10 was fractured through the gusset at U10. At several locations, the gussets were torn at the tips of the web member flanges — L2 (U3/L2), L4 (all members), U3 (U3/L2), U5 (U5/L6), and L9 (all members). The L4 kicker brace was detached at L4 and straight. The L9 kicker brace was detached at L9 and bent.

Floor Truss 7 Sway Brace

Node CL7 was resting on the ground. The diagonals were still attached to the gussets, with buckling, distortion and partial fractures of the gussets. L7E/CL7/L7W and CL7/M7W were straight and intact. L7E/CL7 was detached from node L7E, but still attached to lower lateral L7E/CL8. L7W/CL7 was detached at L7W, with a fracture through the attachment angle at the top gusset and sheared rivets at the bottom gussets. CL7/M7W was detached at M7W, with a fracture through the member on the north side and a fracture through the gusset on the south side. CL7/M7E was buckled upward and north about 5 ft from M7E, and was detached at M7E with fractures through the member.

At CM7, the diagonals were detached. The north gusset was fractured. At the south gusset, the west diagonal was fractured through the member and the gusset was fractured at the east diagonal. CM7/FT7L2 was generally straight and intact. M7E/CM7/M7W was bowed to the north with some top flange damage due to impact from sway diagonals. M7E/CM7/M7W was detached from M7E with a fracture through the attachment angle at the north gusset and a fracture through the member at the south gusset. The M7E end of the member was buckled and bent to the south. M7E/CM7/M7W was detached at M7W with fractured and distorted gussets. At FT7L2, CM7/FT7L2 was attached to the north gusset with some gusset distortion, and fractured through the member at the south gusset.

CM7/FT7L10 was buckled north at midlength, and was attached at FT7L10 with distortion and partial fractures in the gussets.

Upper Lateral Brace, Nodes 7 to 8

The CU8 ends of both diagonals were resting on top of pier 6 East. They appear to be at least partially attached to each other. They were detached from the floor truss at CU8. U7E/CU8 was buckled northeast near midpoint. The north half of the member, from midlength to CU8, was significantly bent and distorted. U7E/CU8 was detached at U7E — the top and bottom gussets were fractured and the attachment angle at the bottom was also fractured.

U7W/CU8 was severely buckled east and upward approximately 3 ft from U7W due to impact from the west main truss upper chord.

Lower Lateral Brace, Nodes 7 to 8

Both laterals were still attached at CL8 with severe distortion and buckling of the gussets. L7W/CL8 was intact and generally straight with a slight buckle northwest near midlength due to impact on pier base. The member was attached at L7W with distortion and buckling of the top gusset. L7E/CL8 was buckled east about 15 ft from L7E due to impact on pier. The member was still attached to sway brace member L7E/CL7/L7W, but they were both detached from node L7E.

Node 8 to Node 12

East Main Truss, Nodes 8 to 12

U8 East Node

Node U8E was similar construction to U8W but with bracing attachments on the west face. It was recovered in one piece (all main truss members attached) with the upper lateral brace partially attached and floor truss partially attached at the FT8/L10(W) gusset. In the post-collapse position, node U8E was lying west side up on the on top of other structure 35 feet east of pier 6 covered by sections of the bridge deck.

Upper chord member U7/U8E was a welded box section with 1 5/8 inch thick side plates and ½ inch cover plates. U7/U8E was torch cut 138 inches from the splice. Member U8/U9E was also a welded box section with 1 7/16 inch sides and ½ inch cover plates. It was cut about 185 inches from the splice. Both diagonal members, U8/L9E and L7/U8E, were H sections. U8/L9E had 1 ¾ inch side plates and a ½ inch central plate while L7/U8E had 1 3/8 inch side plates and a 7/16 inch central plate. The vertical member, U8/L8E, was a 34 inch by 20 inch box section with 2 3/8 inch side plates, ¾ inch cover plates and a transverse internal 3/4 inch plate at the vertical section centerline. The vertical was cut 13 inches from the edge of the gusset plates.

The node had three overlapping gusset plates on each side. The largest area gussets were against the members and measured 5/8 inch thick. The middle gussets were ¾ inch thick and were partially covered by another ¾ inch thick gusset plate. The node also had internal splice plates on the east and west sides with a filler plate on the U8/U9E member. External splice plates were also on the upper and lower surfaces of the chord. A transverse internal diaphragm (center stiffener) was located at the splice.

For removal, member U7/U8E was torch cut 107 inches from the node centerline, member U8/U9E was cut 154 inches from the centerline, U8/L7E and U8/L8E were cut 8 to 9 inches from the gusset edge and L9/U8E was cut at the gusset line.

Member U8/U9E was bent severely downward and to the west just north of the gusset, and the lower cover plate was compression buckled and fractured at the gusset edge. The west side plate upper and lower welds were fractured from the node to 81 inches from the edge of the gusset plate. The gussets were locally distorted adjacent to the bent member. Cracked and exposed paint lines also indicated that the member had yielded at the top of the gusset, with about ¼ to ½ inch of member pulled out of the gussets at the top.

Member U7/U8E was intact at the node with only slight warping of the top cover plate at the gusset and about 40 inches south of the gusset.

The lower gusset plate for the lateral brace (U8E/CU9) was partially fractured and bent north. The upper gusset plate rivets were sheared. The damage was consistent with the upper lateral rotating north. The upper surface of both upper lateral gusset plates showed light surface corrosion. A portion of the lower flange of the floor truss upper chord was attached to the node, with the east and west ends fractured and the web torn at the bottom flange. The end fractures

were consistent with bending with the adjacent portions of the floor truss moving north relative to the node.

The diagonal U8/L9E has a slight bow on both axes within about 9 feet of the gusset. Vertical U8/L8 was attached and straight. Diagonal U8/L7 was attached, no deformation.

L8 East Node

Lower node 8 East was a three-member joint supported by the bearing at Pier 6 East. The lower chord was discontinuous through the joint. The bracing attachments were on the west face of the node. The sole plate on the bottom of the node was a 1-inch thick plate spanning the lower end of the vertical member and bolted to the node's gusset plates with ¾ inch angle plates on the east and west sides. The upper bearing casting was bolted to the node through the sole plate. The sole plate also acted as the bottom gusset for attachment of the sway brace. The sole plate was bent down approximately 30 degrees at the west edge of the upper bearing casting, with all but one of the rivets attaching L8E/CL8 having been sheared. Description of the damage to the casting will be contained in the bearing section.

The node was recovered from the ground just north of pier 6 and south of the guide wall with parts of the lateral braces connected. The gussets were intact and appeared generally straight and undamaged. Member L8/L9E was torch cut 105 inches from the node centerline and member U8/L8E was cut 17 inches above the gusset edge.

Member L7/L8E was separated from the L8E node through the rivets for the west side plate and by a fracture through the east side plate of the member. Member L7/L8E was also separated from node L7E by fractures through the rivets. The member was recovered from the ground between the guide wall and pier 6. It was lying parallel to pier 6 with the L7 end to the east. The member was predominantly straight from the north end to approximately 83 inches south of L8 gusset with gradual negative curvature to an impact area near midspan.

The rivets for the L7/L8E west side plate were sheared at the gusset to member interface with a pattern indicating a relative upward rotation of the south end of L7/L8E within the gusset. The 2 ½-inch-thick east side plate was fractured within the gusseted area of node L8E. The fracture was brittle, initiating at rivet holes on the lower south end of the gusset and progressing upward and northward, intersecting multiple rivet holes near the top of the side plate and breaking through to the top edge of the side plate about midway through the riveted area. The fracture path appeared typical of a bending separation with the south end of the member bending upward relative to the node. A second brittle fracture initiated at the 2nd rivet holes from the south and intersected the first fracture, completely separating a smaller piece of the east side plate. This piece remained with the member, connected through the top cover plate weld to the side plate.

The lower edges of the gusset plates on the south side of the node and the adjacent bottom surface of L7/L8E contained two pairs of transversely oriented rounded dents in the lower edges of the gussets. The larger dent pair measured about 24 ½ inches wide and 2 inches in maximum depth. This larger dent pair was centered about 41 ½ inches from node centerline and also dented the adjacent area of the L7/L8E member. The bottom cover plate was pushed

upward, and the weld between the bottom cover plate and west side plate was fractured in this area. A second pair of smaller dents was centered 27 ½ inches further south (69 inches from node centerline). These dents measured 5 to 6 inches wide but less then 1/16 inch deep on the west gusset and 3/16 inch on the east gusset. The adjacent area of the member also had impact marks on both the east and west side plates. A third pair of dents was present in the lower surface of the L7/L8E member 18 inches south of the gusset plate edges (95 inches from lower chord splice). These dents were about 16 inches wide 5/8 inch deep.

- The lower surface of member L8/L7E had heavy contact marks adjacent to the east and west edges at the north end.
- Contact marks start 9 inches south of gusset edge on east and west faces at the 2nd dent pair, extending 24 inches (100 inches from node centerline) to south of gusset ending at the 3rd pair of dents.
- Gusset edge was 76 inches from the node centerline at the bottom edge.
- Contact marks restart 159 inches from node centerline on the east face, 169 inches from node centerline on the west face, and the marks extend to a transverse dent at 176 inches from gusset.
- Scrapes /scratches extend from 176 inch to 228 inches from node centerline.
- Transverse dent on bottom surface 262 inches from node centerline.
- Large impact centered at about 317 inches from node centerline on bottom surface with ductile fractures in top cover plate and partial brittle fracture in the upper portions of west side plate. Section distortion and skewing.
- Scrape marks continue with concrete dust to 368 inches from node centerline with marks turning laterally.
- Additional lateral scraping from 383 inches to 405 inches from node centerline on west edge of bottom cover plate near L7E gusset.
- South end of lower chord member L7/L8E separated from L7E by sheared rivets in the side plates and fractured side plates.

The U8/L8E vertical member was attached to the gusset and undamaged except for the south cover plate. The south cover plate was ripped and fractured between the access holes from the lower end of the member upward about 100 inches. The width of the gap between the tears was about 4 inches and appeared consistent with impact and tearing by the fractured end of the west side and cover plates of member L7/L8E. Vertical U8/L8E has some paint loss, minor surface corrosion and pitting.

Member L8/L9E remained attached to the node with all rivets present, but close inspection showed that the member had rotated (L9 end up) slightly in the node, with about ¼ inch pulled out of the node at the bottom and 3/8 inch pushed further between the gussets at the top. There was some minor pack rust between the gussets and the side plates of L8/L9E.

The upper surfaces of both lower lateral brace (L8E/CL9) gusset plates displayed moderate corrosion. The surrounding secondary members had some paint loss and minor section loss. No fractures were present in the corrosion area.

U9 East Node

The U9E node was a three-member node with a continuous upper chord. Braces attached on the west side of the node. The node was recovered in two pieces with the upper portion of the vertical remaining attached to floor truss 9 and the upper chord intact through the node. The upper chord was suspended between the guide wall and pier 6 East. During removal U8/U9E was torch cut 57 inches from the U9E node centerline.

The upper chord was intact with negative bending at the node. The lower cover plate had an impact mark from the west side plate of the vertical. The impact area was more severe on the south side, and the lower cover plate was penetrated in this area. The west gusset plate was fractured through the top rivet line on the vertical. The east gusset plate was fractured through and just below the bottom rivet line of the chord. The west gusset was buckled between the vertical and the lower chord.

The upper lateral brace (U9E/CU10) was attached and torch cut 4 feet from the attachment plates during recovery. The lower attachment angle for the upper lateral brace was partially fractured. The rivets between the upper lateral and upper gusset plate were sheared. Fractures, deformations, rivet shearing directions, and the location of the brace were consistent with the upper lateral brace rotating to the north.

A fractured segment of the bottom flange and web from the upper chord of floor truss 9 remained attached to the top of node U9E. The bottom flange fractures were consistent with movement of the floor truss north relative to the node.

L9 East Node

Node L9E was a 5-member node recovered in three pieces from the guide wall. Lower chord member L9/L10E and vertical U9/L9E were separated from the node. The node gusset plates were generally undamaged except for some slight distortion of the gussets adjacent to the separated vertical member.

During recovery, member L8/L9E was torch cut 29 inches from the gusset edge, U8/L9E was cut 38 inches from the gusset edge, and the L9/U10E diagonal was cut about 115 inches from the gusset edge.

Member L9/L10E was fractured at the connection to the node. The side plates were fractured through the northern most vertical line of rivets. The top cover plate was fractured through the 1st access hole past the gusset and the lower cover plate was fractured within the node, 27 inches south of side plate fractures. The side plate fractures displayed significant through-the-thickness yielding with transverse tension cracks in the paint layers adjacent to the upper portions of the fractures. The lower portion of the chord adjacent to the fracture was distorted and buckled. The overall fracture and deformation patterns were consistent with negative bending of the L9/L10E lower chord with the north end down relative to the node.

Vertical member U9/L9E was separated from both L9E and U9E nodes and fully attached to floor truss FT9 located between Pier 6 East and Pier 6 West. The side plates of the vertical member U9/L9E were fractured through the net section at rivet lines within the node.

The west side plate was fractured through the 3rd rivet line from the top of the gusset plate, and the east side plate was fractured at the 4th rivet line from the top of the gusset. Witness marks within the gusset plates indicated that the vertical rotated south within the node during and after the fracture process. The vertical was bowed to the north between node L9E and the lower chord attachment of FT9. The member was also bent 90° north at the first access hole below the floor truss.

L9/U10E was severely distorted and hinged consistent with negative bending of the diagonal at an area about 115 inches from the L9E gusset (at the location of the torch cut). The member was connected through the damaged area prior to torch cutting. At this location, the U10E end of this diagonal was bent down and to the west 135 degrees and twisted (top side to the west) 90 degrees relative to the L9E end of the member. The upper cover plate had tension fractures on each side of an access hole, and the lower cover plate had compression buckling adjacent to fractures at an access hole. The welded connections between the side plates and the upper cover plate were separated over a length of 3 feet on either side of the fractures in the upper cover plate, and the welded connections between the side plates and the lower cover plate were separated between 6 and 8 feet on either side of the fractures in the lower cover plate. Tension cracking of the paint was noted on the top edges of the side plates at the upper cover fractures. The portion of diagonal L9/U10E below and south of the distorted area was deformed, but the remainder of the member above and north of the distorted area was straight.

The lower lateral and sway brace upper attachment angles had gross section fractures, with the upper portion of the vertical leg of the angles pulled down and partially through the bolt heads. For the lower lateral brace, the fracture was a gross section fracture at the corner of the angle. For the sway brace the fracture was a gross section fracture at the north two rivets and through the rivet holes for the remaining four south rivets. The lower gusset plate also had a gross section fracture at and near the west edge of the node. Minor corrosion and some pitting was evident on the upper surfaces of the lower attachment gusset plate, the adjacent surfaces of the lower cover plate and on the lower edges of the internal structure of the node.

U10 East Node

The U10E node was a five-member node and had ½-inch thick gusset plates. Both the east and west gusset plates were fractured along multiple surfaces. A portion of the top cover plate was also fractured from upper chord member U10/U11E. These fractures separated the node into four major pieces:

(1) upper chord U9/U10E,
(2) diagonal L9/U10E,
(3) diagonal U10/L11E, upper chord U10/U11E, and portion of vertical L10/U10E, connected by portions of the east and west gusset plates, and
(4) 10-foot long portion of top cover plate of U10/U11E retaining some parts from the splice between U9/U10E and U10/U11E, a length of floor truss FT10, and lateral brace U10E/CU11 attachment structure.

The post accident position of the node pieces was as follows. The upper chord U10/U11E and diagonal U10/L11E portion of the node were folded together and partially

sticking up through the concrete deck in the water. The upper end of the vertical U10/L10E was also attached to this portion of the node. The diagonal L9/U10E portion of the node was connected at the L9E end of the member and was bent and folded down near node L9E. The diagonal was hanging over the guide wall with the U10E end extending over the river but not in the water. The upper chord U9/U10E portion of the node was primarily straight to node U9E, and the U10E end was above the guide wall. The 10-foot long portion of top cover plate of U10/U11E with other structure attached was recovered from the water.

The fracture locations in the east and west gusset plates of node U10E were similar. The plates were fractured on the north side of the upper end of diagonal L9/U10E (between the diagonal and vertical U10/L10E), between the upper end of diagonal and the lower side of the upper chord U9/U10E, and vertically through the upper chord area separating upper chord members U9/U10E and U10/U11E. The vertical fractures in the gusset plates were primarily in the first row of rivets south of the node centerline. These three fracture areas are described for each gusset plate below.

East Gusset Plate

The east side of the east gusset plate was painted blue in contrast to green paint on the other gussets of U10 East and West. The 10 rivets along the lower/north edge of the upper end of diagonal L9/U10E were numbered starting at the lower corner. The fracture in the east gusset plate on the north side of the upper end of this diagonal intersected rivet holes 4, 5, 6, 7, 8, and 10. Deformation patterns and fracture characteristics were indicative of fracture under in-plane tensile and shear stresses between rivets 7 and 8. Below hole 7 the plate was bent and not fractured through the rivet holes, indicative of bending or buckling loading. The fracture from hole 4 to 7 and from hole 8 to hole 10 had some out-of-plane deformation and intersected the two holes tangentially, indicative of shear loading. Above rivet hole 10, the gusset plate fracture largely followed the edge of vertical U10/L10E and extended on a smooth plane up into the area of the upper chord. The gusset plate on the north side of the fracture between the diagonal and the vertical remained with the major portion of node U10E and was significantly deformed and had post-fracture damage.

Multiple fracture planes were found in the fracture region between diagonal L9/U10E and upper chord U9/U10E, and the east gusset plate in this area had substantial bending and buckling deformation. At its south edge, the gusset plate was buckled to the west and fractured approximately at the center of the buckling damage on an approximately horizontal plane into rivets near the upper end of the diagonal. Directly above this fracture, the gusset plate was also partially fractured over 22 inches from the south end of the gusset adjacent to the lower edge of the upper chord. A portion of the gusset between the lower fracture and the upper partial fracture remained attached to U9/U10E and was bent up and west inside the upper chord. The remaining gusset area between these fractures including a length of the south edge was not recovered. The gusset plate fracturing also extended approximately on a horizontal plane in a north direction from the upper corner of the diagonal. This horizontal fracture intersected the vertical fracture extending upward on the north side of the diagonal, creating a V-shaped tip of the gusset plate above the upper end of the diagonal. This tip was folded nearly 180 degrees back onto the east face of the diagonal, consistent with westward translation of the upper end of the diagonal during the fracture process.

The fracture in the east gusset plate extended vertically upward through the upper chord portion of the node, separating the east sides of upper chord members U9/U10E and U10/U11E. In the lowest row of rivet holes in the upper chord, this fracture intersected the first and second rivet holes south of the node centerline. The remainder of the fracture through the area of the upper chord (above the lowest rivet row) intersected the seven other rivet holes just south of the node centerline. At each of these rivets holes, the gusset plate was elongated in a direction slightly offset from horizontal, with the angle gradually increasing from nearly horizontal at the lowest hole to more skewed (down and to the north) at the upper hole. This change in the angle of elongation and the deformation adjacent to the upper edge of the gusset plate were consistent with fracture under primarily horizontal tension in the lower portion of the fracture and more shear in the upper portion of the fracture, with the direction of shear indicating that the structure on the north side of the fracture was moving down relative to the structure on the south side of the fracture.

The east gusset plate also contained multiple areas of buckling and compression damage associated with the folding of the U10/L11E diagonal into the upper chord U10/U11E. The gusset plate was partially fractured along the top rivets of the U10/L11E diagonal.

West Gusset Plate

The fracture in the west gusset plate between the upper end of diagonal L9/U10E and vertical U10/L10E intersected the 4th, 6th, 7th, 8th, 9th and 10th rivet holes (as numbered from the bottom) adjacent to the north edge of the upper end of the diagonal. Deformation patterns and fracture characteristics were indicative of in-plane tensile and shear stresses from the 6th through 8th hole and between holes 9 and 10. From hole 4 to 6, the gusset plate was sheared along the edge of the diagonal, and below hole 4 the gusset plate was bent. Between hole 8 and hole 9, the fracture in the gusset plate was accompanied by bending deformation. Above rivet hole 10, the gusset plate fracture intersected the two upper rivet holes in the south column of rivets for the U10/L10E vertical. Around these two holes, the plate had large out of plane deformation and indentations associated with the heads of the rivets at these locations, indicating that the diagonal translated westward as this fracture occurred. The gusset plate also had bending-related fractures through the four lowest rivet holes in the south column of rivets for the U10/L9E vertical, and a portion of the gusset plate between the vertical and diagonal separated as a result of the intersection of these fractures.

The gusset plate between the upper end of the L9/U10E diagonal and the lower side of the U9/U10E upper chord member was buckled, and the deformation was accompanied by fractures in two locations. At its south edge midway between the upper chord and the diagonal, the gusset plate was buckled to the west and fractured at the center of the buckled damage on an approximately horizontal plane intersecting the south edge of diagonal L9/U10E at the seventh rivet from the bottom, then further through three more rivets to the upper end of the diagonal. The gusset was also fractured along the bottom edge of the upper chord U9/U10E, with the fracture intersecting the south four rivets in the bottom row on the upper chord. These two fractures intersected approximately below the eighth rivet from the south in the bottom row on the upper chord, and the portion of the gusset plate between these two fractures has not been found. The gusset plate fracturing also extended approximately on a horizontal plane in a north

direction from the upper corner of the diagonal, intersecting the tenth and eleventh rivets from the south in the bottom row on the upper chord. This fracture intersected the fracture extending upward along the north edge of the diagonal, creating a V-shaped tip of the plate above the upper end of the diagonal. This tip was folded about 135 degrees into the interior of the diagonal, consistent with westward translation of the upper end of the diagonal during the fracture process.

The fracture in the west gusset plate extended upward through the upper chord portion of the node separating upper chord members U9/U10E and U10/U11E, intersecting the 8 rivet holes for the column of rivets just south of the node centerline. At each of these rivets holes, the gusset plate was elongated in a direction slightly offset from horizontal, with angle gradually increasing from nearly horizontal at the lowest hole to more skewed (down and to the north) at the upper hole. This change in the angle of elongation and the deformation adjacent to the upper edge of the gusset plate were consistent with fracture under primarily horizontal tension in the lower portion of the fracture and more shear in the upper portion of the fracture, with the direction of shear indicating that the structure on the north side of the fracture was moving down relative to the structure on the south side of the fracture.

The west gusset plate was also severely buckled and completely fractured between the upper chord U10/U11E and the diagonal U10/L11E. A fracture extended horizontally from the north edge of the gusset near the midpoint between the upper chord and the diagonal to intersect the edge of the diagonal (adjacent to the eighth rivet from the bottom). The fracture extended up along the north edge and across the topmost edge of the diagonal. From the corner of the diagonal, the fracture extended to between the ninth and tenth rivets from the north in the bottom row of rivets on the upper chord; the fracture intersected the next four rivets to the south and intersected the other fractures described above. The west gusset plate was also partially fractured through the northernmost five rivets in the bottom row along the upper chord U10/U11E.

Other Damage to Node U10E

The 10-foot long portion of top cover plate of U10/U11E adjacent to the node was separated from the member by fractures at the welded connections to the side plates and by a transverse fracture through the top cover plate at the first internal diaphragm north of U10E. The pieces attached to this portion of the top cover plate included: a portion of the upper chord top splice plate, a piece of the lower flange and web of FT10 upper chord, the upper gusset plate for the lateral brace, the upper end plate and web of the vertical stiffener at the end of the lateral brace, and the upper plate and web of the U10E node central stiffener (diaphragm A). The side plates of the central stiffener remained in the U9/U10 portion of the node.

Node U10E and FT10 above the node contained the following impact marks and damage from the east side plate of diagonal L9/U10E transitioning through the interior of the node and the west side of the diagonal transitioning west of the node (between the main trusses).

- Impact mark on vertical L10/U10E on south side of web at center. Impact mark was approximately 2.5 inches wide and approximately 6 inches long at the top of the member. The web of the vertical in the area of the impact was bowed to the north but not separated from the flanges of the vertical.

- Bottom cover plate of upper chord U9/U10E fractured and folded upward (inward) at U10E with heavy scraping marks. A portion of the bottom cover plate along the west side between the first access hole and the centerline of the node was fractured and missing.
- The east gusset plate was fractured with a portion between the upper chord and diagonal L9/U10E folded up and through the access hole of the bottom cover plate of the upper chord, with abrasions.
- There was an impact mark approximately 2 inches square on the south end of the bottom cover plate of upper chord U10/U11E, between the second and third rivet hole from the east. The bottom cover plate was severely distorted adjacent in this area. The bottom cover plate was also bowed upward (inward) near the centerline of the node and separated from the upper chord east side plate for approximately 2 feet from the node centerline and from the west side plate approximately to the north edge of the gusset plate.
- The west side plate of upper chord U10/U11E has the bottom corner adjacent to the node centerline folded inward (eastward).
- The west gusset plate in the area of the upper chord was generally fractured along the first rivet column south along the centerline of the node. The mating surface of the fracture to the north has been heavily impacted and abraded such that it was flush with the end of the west side plate of U10/U11E with approximately 1.5 inches of material missing.
- There was a fractured notch approximately 7 inches in length extending from the first access hole on the bottom cover plate of the diagonal L9/U10E with a width consistent with the thickness of the west side plate and interior splice plate of the upper chord U10/U11E.
- Top cover plate of upper chord U9/U10E has an upward indentation at the 2nd bolt hole from the east.
- The top splice plate of the upper chord was fractured along the first bolt line south of the centerline of the node. Bolts were still intact north of the centerline of the node with a piece of floor truss attached to the top cover plate of U10/U11E.
- The top cover plate of the upper chord U10/U11E separated from the upper chord and was attached to a piece of the floor truss upper chord bottom flange and web as well as the upper lateral bracing gusset and vertical stiffener. The bolts in the southern bolt line of the floor truss connection sheared north-south as shown by the elongation of the bolt holes in the top cover plate of upper chord U9/U10E.
- The web of the upper chord center vertical stiffener (diaphragm A) was still attached to the top cover plate of upper chord U10/U11E with impact marks on south side located in the center of the web and extending from the bottom to the top of the web. The web was separated from the side and bottom end plates/flanges of the stiffener with a northward bow at the bottom, and the bottom was bent north relative to the top.
- There was an impact mark on the south side of the upper lateral brace vertical stiffener consistent with impact from the west side plate of the diagonal L9/U10E.
- The distance between the side plates of the diagonal L9/U10E was consistent with the distance between the impact mark on the web of the center vertical stiffener (diaphragm A) and the impact mark on the web of the upper lateral brace vertical stiffener.

- The attachment angle for upper lateral brace U12E/CU13 was bent up.

L10 East Node

Node L10E was a three member joint with continuous box section lower chord of members L9/L10E and L10/L11E and an H section vertical U10/L10E joined to the lower chord by gussets on the east and west faces.

The lower chord has 15/16 inch side plates and ½ inch cover plates on top and bottom. The vertical H section has ½ inch east and west flanges and a 3/8 inch web. The gusset plates are ½ inch plates on the east and west faces of the members. Sway and lower lateral braces attach to the west side of the node with angles at the top of the brace members and a gusset plate to the lower surface of the lower chord.

The L10E node was recovered from the river in 2 pieces: the vertical with the east gusset and the lower chord with the west gusset plate and a portion of the west flange and web of the vertical. The vertical had been mechanically sheared above the M10E sway brace node and the floor truss attachment during recovery.

The lower chord L9/L10E was intact through the node. The lower chord was hinged adjacent to the south edge of the gusset such that the structure north of the bend rotated upward and slightly westward relative to the structure south of the bend. The top cover plate at the hinge contains partial fractures adjacent to the sides of an access hole.

Vertical U10/L10E was separated from the L10E node by fractures through the east gusset and by a fracture through the west flange of the vertical from the upper southern most gusset rivet and through the lowest bolt hole for the ladder. The web of the vertical was fractured diagonally from its center just above the L10E node up to the west flange fracture. The vertical was partially fractured and severely bent to the north just below M10E, where it was mechanically sheared. The flanges were distorted on the north side indicating local flange buckling in an area of mechanical scraping. The north side of the east flange contained a partial fracture at the top of the gusset.

The west gusset of U10/L10E remained intact and attached to the lower chord, with the top slightly bent to the east. The east gusset plate was fractured in compression along the top of the lower chord on the south side and on the north side in tension through three rivets on the upper row of the lower chord. Compression buckling was noted on the south side of the vertical flanges above the east and west gusset plates, and along the fracture of the east gusset plate. Fracture features and deformation at the lower end of the vertical were consistent with clockwise rotation (facing east) of the member relative to the lower chord. A line of minor corrosion was noted on the west face of the west gusset plate, just above the single angle connection for the lower sway bracing. The gusset plate was only minimally deformed along the line of corrosion, but not fractured.

The upper attachment angles at L10E for the sway and lateral braces were fractured. The lower attachment gusset plate was intact and connected to the lower cover plate of the chord. The sway brace was separated from the bottom gusset through rivet failure. The rivets holding

the lateral brace, L10E/CL10, to the attachment gusset plate were sheared. Portions of the upper surface of the attachment gusset plate were moderately corroded with surface pitting in the area near the sway brace.

U11 East Node

Node U11E has a continuous box section upper chord of members U10/U11E and U11/U12E and a box section vertical U11/L11E, joined by gussets on the east and west faces and incorporated attachment for the lateral braces.

The upper chord has 1-inch thick side plates and ½-inch thick cover plates on top and bottom. The vertical was a box section with 3/4 inch thick side plates and ½ inch thick cover plates. The gusset plates are ½ inch plates on the east and west faces of the members. A lateral brace attaches to the west side gusset through an attachment angle at the lower edge of the upper chord and a 3/8 inch thick attachment gusset plate on the upper surface of the chord.

Node U11E was recovered from the river, with multiple layers of deck on top. The node was recovered in three pieces with the vertical separated from the upper chord through fracture of the gusset plates along the bottom of the upper chord and with a fracture in upper chord U10/U11E adjacent to the node. Upper chord member U11/U12E was torch cut 74 inches north of U11E centerline and near node U12E. Member U10/U11E was torch cut 83 inches south from node centerline and again closer to U10E.

U10/U11E had positive bending about Node U11E with fracturing of the upper chord and local buckling of the top cover plate for 10 feet south of the node. The upper chord was vertically fractured through the southern-most column of rivets in the west side plate of the node, through and south of the southern-most rivet column on the east side plate. The upper and lower cover plates were transversely fractured in line with the side plate fractures, and the cover welds were split about 6 feet adjacent to the deformation. The upper one third of both side plates were deformed from compression. The upper surface of U10/U11E was wavy from compression from the bent area up to approximately 10 feet from the node.

The lower surface of the chord at the node had an impact mark matching the shape of vertical U11/L11E on south side of the node. The gusset plates were fractured along the lowest rivet lines of the vertical and had compression buckling on their south edges and tension fractures on their north edges, consistent with counterclockwise rotation (looking east) of the member relative to the node.

Member U11/U12E was intact at the node area, but the member had an overall slight downward bow (positive bending) that extended into the node. The upper cover plate was wrinkled from compression for about 115 inches from the node consistent with the overall deformation of the member.

The brace gusset plate was attached to the upper chord and partially fractured at the upper lateral brace. The plate had some distortion with no predominant direction. The lower attachment angle was fractured through the elbow of the angle. The vertical stiffener at the end of the brace was attached at the top and bottom and intact. A piece of the lower flange and web

of the floor truss top chord were bolted to the main truss upper chord and the top of the brace gusset plate. The fracture on the west end of the flange piece was predominately tension, and the fracture on the east end of the flange piece was twisting.

L11 East Node

Node L11 East was a five member node splicing two lower chord members, L10/L11E and L11/L12E, together with two diagonals, L11/U10E and L11/U12E and a vertical member, L11/U11E, with gusset plates on the east and west faces. The node incorporated attachments for sway and lateral bracing on the west face.

Lower chord member L10/L11E was a welded box section with 15/16 inch east and west side plates and 1/2 inch top and bottom cover plates. The L10/L11E member was torch cut about 12 feet south of the node centerline. Member L10/L11E mated to lower chord member L11/L12E having 1 7/16 inch side plates and ½ inch top and bottom cover plates. The member was torch cut in the damage area approximately 10 feet from the node centerline. The lower chord splice had vertically oriented internal 1/2 inch filler plates on the L10/L11E side and 1/2 inch splice plates. No internal diaphragm was present at the splice. The lower surfaces of the lower chord members had a ½ inch splice plate and a portion of the 3/8 inch lower lateral attachment gusset plate. Additional brace attachments were angles on the west side of the gusset. The upper cover plates had a 3/8 inch splice plate.

The U10/L11E diagonal was an H section with 1 5/8 inch flanges and a 9/16 inch web. The vertical L11/U11E was a box section with 3/4 inch side plates and ½ inch cover plates. The L11/U12E box section diagonal had 1 7/16 inch side plates and 9/16 inch cover plates. The node gusset plates were ½ inch thick.

The node was recovered from the river bottom in three main sections and two small pieces before torch cutting: (1) the lower chord L10/L11E to L11/L12E (although damaged, the chord was connected through both side plates), (2) the U10/L11E diagonal connected to the node U10E, and (3) the L11/U12E diagonal connected at U12E with the lower end of vertical U11/L11 connected by means of the west side gusset plate. Recovered separately was (4) a 12-foot piece of the east side plate of U11/L11 vertical starting above the first internal diaphragm. Also recovered was (5) a 6-foot piece of the lower chord upper cover plate and splice plate.

The lower chord area of the node was severely fractured and distorted with scrapes, dents, and contact damage consistent with forceful contact with the riverbed and with other members. The lower chord side plates remained connected through the node. The top and bottom cover plates to the lower chord were fractured such that an 18 foot long section of the top cover plate remained attached to the east side plate and a 24 foot long section of the bottom cover plate remained attached to the west side plate. The remaining 6 foot section of the top cover plate was recovered separately. Where the upper cover plate was attached to the east side plate, it was folded down and to the inside face of the east side plate. Where the lower cover plate was attached to the west side plate, it was folded up and in against the inside face of the west side plate.

The gusset plates were deformed and fractured in multiple locations, but all portions appear to have been recovered and identified. The east and west gusset plates remained intact in the lower chord area. The west gusset plate was fractured near the top of the lower chord. The west gusset plate was also fractured through the northern/upper line of rivets of the L11E end of the U10/L11E diagonal. The west side of the L11/U12E diagonal remained attached to the lower end of the west side plate of vertical U11/L11E through the major portion of the west gusset plate. The east gusset plate was fractured near the top of the lower chord from its northern edge to 30 inches south of the node centerline, where it buckled and fractured adjacent to the south edge of the diagonal.

Deformation of the gusset plates adjacent to diagonal L11/U12E indicated that the side plates of diagonal L11/U12 went to the outside of the node (the east diagonal side plate translating east and the west diagonal side plate translating west) as the diagonal moved down and to the south outside the node.

The inside surfaces of both gusset plates exhibited lines of corrosion and section loss just above the upper edge of the lower chord. On the east face of the west gusset, the corrosion was apparent along the full length of the gusset. On the west face of the east gusset, the corrosion was in four more localized areas, two below the area of the vertical member L11/U11E and two below the area of the L11/U12E diagonal. The vertical width of the corrosion was approximately 1 inch. Documentation of the corrosion damage is contained in another appendix.

The lower end of the L11/U12E diagonal was severely distorted and fractured at the node. The west side plate with part of the gusset attached was bent to the west in a large arc of about 135°. The east side plate was curved to the east about 30°. Portions of both cover plates were fractured through access holes or along welds in the region of the deformation of the side plates for a distance of about 10 feet from end of the diagonal. Near midspan the diagonal was hinged. Above the hinge the diagonal was generally straight to node U12E.

Diagonal U10/L11E folded down, and translated east relative to node L11E, with the west flange of the diagonal impacting the upper cover plate of L10/L11E within about 14 feet of the node centerline. The bottom edge of the U10/L11E web sustained minimal damage, and the web did not appear to contact the lower chord. The diagonal was bowed to the south over most of its length.

The entire portion of vertical U11/L11E below FT11 had severe damage with substantial splitting of the cover plates from the side plates. Some of this damage was from the earliest phase of recovery.

West Main Truss, Nodes 8 to 12

U8 West Node

Node U8 West was a five member node splicing two upper chord members, U7/U8W and U8/U9W, two diagonals, U8/L7W and U8/L9W, and vertical member L8/U8W, with three overlapping gusset plates on each of the east and west faces. The node incorporated attachments for sway and lateral bracing on the east face.

In its post-collapse position, the node was intact and suspended above the ground resting on the northeast quadrant of pier 6 East with all five members attached. The node was recovered in one piece with a portion of lateral brace U8W/CU9 and a portion of the upper chord of FT8 attached.

Upper chord member U7/U8W was a welded box section with 1 ¾ inch thick side plates and ½ inch cover plates. U7/U8W was torch cut 138 inches from the splice. Member U8/U9W was also a welded box section with 1 ½ inch side and 5/8 inch cover plates. It was cut about 185 inches from the splice. Both diagonal members, U8/L9W and L7/U8W, were H sections. U8/L9W had 1 ¾ inch flange plates and a ½ inch web plate while L7/U8W had 1 3/8 inch flange plates and a 7/16 inch web plate. The vertical member, U8/L8W, was a 34 inch by 20 inch box section with 2 3/8 inch side plates, ¾ inch cover plates and a transverse internal 7/8 inch plate at the vertical section centerline. The vertical was torch cut 13 inches from the edge of the gusset plates.

The node had three overlapping gusset plates on each side. The largest area gussets were against the members and measured 5/8 inch thick. The middle gussets were ¾ inch thick and were partially covered by another ¾ thick gusset plate. The node also had internal splice plates on the east and west sides with a filler plate on the U8/U9W member. External splice plates were also on the upper and lower surfaces of the chord. A transverse internal diaphragm (center stiffener) was located at the splice.

The node was generally intact and the members were undamaged adjacent to the node. A small area of local bending was present in the southern edge of the largest west gusset just below the upper chord. The bend displaced a local area of the gusset plate to the east. At the lateral brace (U8W/CU9) upper gusset attachment, the rivets between the brace and the gusset were sheared and the gusset plate was bent down slightly. The lower attachment gusset plate was partially fractured and bent down. The rivet shear direction in the upper gusset plate and deformation associated with the fracturing of the lower attachment gusset plate were consistent with northward and slightly downward rotation of the lateral brace. The upper surface of both upper lateral gusset plates showed light surface corrosion.

Approximately a 4-foot segment of the upper chord of floor truss 8 remained intact across node U8W. The floor truss was fractured at the east and west ends with fracture and deformation patterns consistent with bending of the floor truss to the north relative to node U8W.

The vertical L8/U8W was straight and intact with no deformation.

Upper chord member U8/U9W was intact and straight.

L8 West Node

Node L8 West was a three-member node that was supported by the bearing assembly on top of pier 6 West. All three members were connected to the node in the post collapse position with the node suspended in the air about 28 feet north of pier 6 West. Member L8/L7E was resting on its east face on top of pier 6.

The L8W node joined discontinuous lower chord members L7/L8W and L8/L9W and vertical member L8/U8W with two overlapping gusset plates on each side. The larger area gusset plates, assembled against the members, were 1 inch thick, and the overlying smaller area gussets plates were ¾ inch thick. Lower chord members, L7/L8W and L8/L9W were similar box sections with 2 ½ inch east and west side plates, 5/8 inch top and bottom cover plates, and horizontal 7/8 inch plates along the section longitudinal centerlines. Members L7/L8W and L8/L9W were each torch cut 103 inches from the node centerline. Vertical L8/U8W was cut 69 inches above the top edge of the gusset plates. The vertical member, L8/U8W, was a 34 inch by 20 inch box section with 2 3/8 inch side plates, ¾ inch cover plates and a transverse internal 3/4 inch plate at the vertical section centerline. The vertical member extended to the bottom of the gussets with the discontinuous lower chord members separated by the vertical. Vertically oriented longitudinal and transverse internal diaphragms additionally braced the node.

The sole plate was a 1-inch thick plate spanning the lower end of the vertical member and bolted to the node's gusset plates with ¾ inch angle plates on the east and west sides. The upper bearing casting was bolted to the node through the sole plate, which was intact and undeformed. The sole plate also acted as the bottom gusset for attachment of the sway brace. Description of the damage to the casting is contained in the bearing section.

The node incorporated attachments for the lower lateral and sway braces on its east face. The end of the sway brace L8W/CL8 was attached at the node and the attachment hardware was generally intact; L8W/CL8 was torch cut at the edge of the sole plate. Lower lateral brace L8W/CL9 was not attached; rivets were missing in the lower attachment angle and the upper gusset had gross section and net section fractures.

The lower edges of the node gusset plates and the adjacent bottom surface of L7/L8W were damaged with many scrapes. Two generally parallel pairs of rounded dents deformed the lower edges of the gussets on the south side of the node as well as the attached L7/L8W member. The larger pair of dents was in the gusset overlap area measuring 16 ½ inches wide, 2 ¼ inches deep and centered approximately 38 inches south of the node centerline. The bottom of the adjacent lower chord bottom cover plate was also dented. The center of the second smaller pair of dents was 65 inches from node centerline measuring 8 to 10 ½ inches wide and ¼ and 5/16 inches at their deepest in the gussets. The second pair of dents was only in the larger area gussets and only slightly dented the adjacent lower chord.

Heavy contact marks at the east and west edges of the bottom cover plate of L7/L8W extended south from the 2nd pair of dents over a distance of 90 inches, ending in a 3rd pair of dents in the member edges located at about 150 inches from node centerline. These scrapes were not on the lower edges of the adjacent gusset plates in its recovered condition indicating that the member rotated within the gusset plates after the scrapes were formed. The 3rd pair of dents measured about 6 inches wide and about 3/16 inch deep. Heavy contact marks restarted at the edges of the bottom cover plate at about 195 inches from node centerline and ended at 230 inches from node centerline at a 4th pair of shallow dents in the bottom of the member.

Scrape marks with concrete dust were apparent on the east side plate of L7/L8W near the lower edge from 251 inches to 283 inches from node centerline. From photographs this appears to be the post collapse location of the member on the east edge of pier 6 West. Additional bottom cover plate contact marks were located between 309 inches and 347 inches from node centerline. The center of the bottom cover plate was deformed up in this area. The east edge of the bottom cover plate had a 16 inch wide tear / gouge with bottom cover material deformed toward the center of the member. Ten regularly spaced contact marks were located on the east side plate lower edge. These started within the concrete scraped area and continued to the start of the final bottom contact region. The width of the individual marks and the spacing were consistent with the size and spacing of the tops of the bearing roller rack teeth.

The L7/L8W member had an overall negative curvature from the gusset plate at L8W south with locally sharper curvatures centered at the locations of the dent pairs. The bottom cover plate was compression wrinkled from the L8W node south.

Many of the rivets were sheared and displaced between the L7/L8W member and the gusset plates on both sides. The member was still contained within the gusset plates but had rotated slightly as indicated by the paint lines at the gusset edges. The south end of L7/L8W rotated upward resulting in approximately 1 inch of the member pulling out of the gusset at the lower edge and 5/8 inches retracted into the gussets at the top.

Some corrosion was present on the upper surfaces of the sole plate and the surrounding fasteners and structure. The corrosion on the sole plate was minor, but the sole plate was not deformed, cracked or perforated at the corrosion. The lower lateral gusset from the lateral to the sway brace exhibited heavy corrosion, with localized areas corroded to a knife edge.

A 1/4–inch northward displacement of the paint line at the edge of the gusset near the bottom of L8/L9W indicated some upward rotation of the L9W end of L8/L9W with respect to node L8W.

U9 West Node

Node U9W was a three member node with a continuous box section upper chord of members U8/U9W and U9/U10W joined to a box section vertical U9/L9W with east and west gusset plates.

The upper chord has 1 7/16 inch thick side plates and ½ inch thick cover plates on top and bottom. The vertical has 7/8 inch east and west sides and 9/16 inch thick cover plates on the north and south sides. The gusset plates are ½ inch plates on the east and west faces of the members. The upper lateral brace was attached to the east side gusset with an attachment angle at the lower edge of the chord and an attachment gusset plate on the upper surface of the chord.

The node was recovered in one piece with torch cuts 67 inches to the south of the node centerline in U8/U9W, 101 inches to the north of the node centerline in U9/U10W and 19 feet below the upper chord centerline in vertical U9/L9W.

The U9/U10W chord was hinged (negative bending) adjacent to the gusset plates with compression buckling on the lower side due to bending of the member. The box section was severely distorted and the bottom cover plate was buckled and transversely fractured near the node. The upper and lower weld seams on the east side plate were also split open adjacent to the node.

The attachment angle for the upper lateral bracing was fractured. The bolts attaching the upper chord of the floor truss and the gusset for the upper lateral to the node were not present and no portions of FT9 or the gusset for the upper lateral U9W/CU10 were attached above the node. The associated bolt holes were elongated to the north and slightly east.

The gusset plates were buckled with the lower portions of the plates translating west relative to the upper portions. The west gusset was fractured at the deformation line at the top of the vertical. The east gusset was not fractured. The lower surface of the upper chord and the upper end of the vertical U9/L9W had matching impressions and dents from contact.

Vertical U9/L9W had a slight buckle to the south 3 feet below the FT9L2 floor truss attachment (17 feet below the upper chord). The lower floor truss FT9L2 gusset on the east side was vertically fractured, with fracture initiating at the toes of the weld for the floor truss diagonal and lower chord. The top of the floor truss attachment was pried away from the vertical. The portion of the gusset plate remaining on the vertical was bent to the north except at the toe of the weld for the diagonal, where it was deflected to the south. The sway brace FT9L2/CM9 was separated from U9/L9W, and the attachment angles for FT9L2/CM9 were fractured and deformed downward. The sway brace was also separated from U9/L9W at the M9W attachment; both attachment angles were fractured with residual deformation indicating prying to the south.

L9 West Node

Node L9 West was a five member node splicing two lower chord members, L8/L9W and L9/L10W, two diagonals, L9/U8W and L9/U10W, and vertical member L9/U9W, with gusset plates on the east and west faces. The node incorporated attachments for sway and lateral bracing on the east face.

Lower chord member L8/L9W was a welded box section with 2 ½ inch east and west sides and 5/8 inch top and bottom cover plates. L8/L9W had an internal, horizontal centerline web 7/8 inch thick. It was torch cut about 5 feet south from the node centerline and again 19 feet south from the centerline. Member L8/L9W mated to lower chord member L9/L10W having 15/16 inch sides and ½ inch top and bottom cover plates. The lower chord splice had vertically oriented internal 5/8 inch splice plates and ¾ and 13/16 inch filler plates on the L9/L10W side. The lower surface of the splice had a ½ inch splice plate and a portion of the 3/8 inch lower lateral attachment gusset plate. Additional brace attachments were attachment angles on the east side of the east gusset. The upper surface had a 3/8 splice plate. The U8/L9W diagonal was an H section with 1 ¾ inch flanges and a ½ web and was cut 4 feet from the gusset. The vertical L9/U9W was a box section with 7/8 inch side plates and 9/16 inch cover plates. The vertical had been torch cut approximately 3 feet from the gusset. The L9/U10W diagonal had 2-inch side plates and 11/16 inch cover plates. It was torch cut about 113 inches from the gusset.

Node L9W was suspended in the air above the guide wall with the west face up. It had members L8/L9W, U8/L9W, U9/L9W, and L9/U10W attached. The U10W end of L9/U10W was hanging down into the river. Members L8/L9W, U8/L9W and U9/L9 were intact and generally straight at the node. The gussets plates were intact and generally flat except for local eastward bending of the lower north corner of the east gusset plate.

L9/U10W was hinged over several feet adjacent to the gusset plates, with the U10W end displaced down approximately 90 degrees and twisted approximately 30 degrees (top to the west) relative to node L9 West. The east side plate of L9/U10W had severe bending and buckling deformation and was fractured 14 to 24 inches from the east gusset plate. The west side plate, although also severely bent and buckled, was not fractured. The upper cover plate had primarily tension fractures on each side of the first access hole adjacent to the node. The upper cover plate was separated from the side plates through the area of deformation associated with the bend in the member, over a length of about 100 inches. The lower cover plate was buckled and fractured through the first access hole adjacent to the node and also split from the side plates over a length of about 100 inches adjacent to the node. The first internal diaphragm in L9/U10W was fractured from the side and cover plates and was not identified in the recovered structure.

Lower lateral brace L9W/CL10 and sway brace L9W/CL9 were separated from the L9W node. The lower lateral and sway brace gusset plates and attachment angles were fractured and/or deformed downward.

A slight buckle was noted in the vertical at ¼ length from top with compression damage on the east and north faces of the member. The buckle was in the first access hole below the FT lower attachment gusset. FT9 was fractured from L9/U9 West at the lower attachment gusset.

Lower chord member L9/L10W was vertically fractured through the side plates along the most northern rivet line (6 rivets) near the edge of the gusset plates and transversely through adjacent areas in the top and bottom cover plates intersecting the nearest access holes. The fracture lines were about 53 inches from the node centerline. The lower edges of the side plates of L9/U10W had local compression buckling adjacent to the fracture, and the middle and upper portions of the side plate fractures were accompanied by large amounts of through the thickness yielding and longitudinal elongation. The paint adjacent to the fractures was cracked 1 to 2 inches from the fractures. Along the upper edges of the side plates, the paint was cracked indicative of plate yielding. The L9/L10W member had negative bending (L10 end down relative to the L9 node) for about 4 feet from the fracture. The welds along the lower east and west edges were fractured and split open for a length 6 to 8 inches south of the fracture and the lower east weld was also split open for a length of 10 inches north of the fracture.

U10 West Node

The U10W node was a five-member node and has ½ inch gusset plates. Both the east and west gusset plates were fractured in multiple places, separating the node into three major pieces:

(1) upper chord U9/U10W,
(2) diagonal L9/U10W, and

(3) diagonal U10/L11W, upper chord U10/U11W, and portion of vertical L10/U10W.

The post accident position of the node pieces was as follows. The upper chord U10/U11W and diagonal U10/L11W portion of the node were folded together through damage to the portion of the gusset plates between the two members and this structure was sticking up through the concrete deck in the water with the diagonal oriented nearly vertical. The flanges at the upper end of the vertical U10/L10W were also attached to this portion of the node. The diagonal L9/U10W portion of the node was still connected to node L9W and was bent and folded adjacent to L9W. The diagonal was hanging over the guide wall with the U10W end extending down into the river. The upper chord U9/U10W portion of the node was attached to node U9W and was also bent down adjacent to this node and hanging over the guide wall.

The fractures in the east and west gusset plates of node U10W were similar. The gusset plates were fractured between diagonal L9/U10W and vertical U10/L10W, between the upper end of diagonal L9/U10W and the lower side of the upper chord U9/U10W, and vertically through the upper chord area separating upper chord members U9/U10W and U10/U11W. The fracture through the upper chord area was primarily in the first row of rivets south of the node centerline. These three fracture areas are described for each gusset plate below. Both gusset plates had additional cracks or fractures, which will also be described.

East Gusset Plate

The fracture in the east gusset plate on the north side of the upper end of diagonal L9/U10W intersected each of the rivets adjacent to the north edge of the upper end of the diagonal. The 10 rivets along the lower/north edge of the upper end of the diagonal were numbered starting at the lower corner. The rivet heads remained on the diagonal in this row and were ground off to further examine the deformation patterns. A piece of the gusset plate containing the lowest eight rivet holes was cut from the plate for closer examination in the laboratory. Deformation patterns and fracture characteristics were indicative of in-plane tensile stresses primarily in the vertical direction between rivets 4 through 7, with horizontal cracks extending southward from rivet holes 5, 6, and 7 and shear cracks on a vertical plane extending between the tips of the horizontal tensile crack and the rivet hole below. Similar in-plane tensile and shear crack areas were found between rivet holes 3 and 4 and between rivet holes 7 and 8, but with the plane of tensile stress rotated from vertical. Below hole 3 and from hole 8 through 10, the gusset plate was raised above the surface of the diagonal, indicating out-of-plane bending or buckling loading. Above rivet hole 10, the gusset plate fracture largely followed the edge of vertical U10/L10W and extended on a smooth plane up into the area of the upper chord. The gusset plate on the north side of the fracture remained with the major portion of the node and was significantly deformed and had substantial post-fracture damage.

Multiple fracture planes were found in the fracture region above the upper end of diagonal L9/U10W, and the east gusset plate in this area had substantial bending and buckling deformation. A piece of the east gusset plate from this area was not recovered. At its south edge, the gusset plate was buckled to the west and fractured approximately at the center of the buckling damage on an approximately horizontal plane into the eighth rivet from the bottom on the south edge of the diagonal and extended to the ninth rivet and the tenth rivet at the upper corner of the diagonal. Directly above this fracture, the gusset plate was also fractured adjacent

to the lower edge of the upper chord U9/U10W; the missing portion of the east gusset plate was between these two fractures. The gusset plate fracturing also extended approximately on a horizontal plane several inches below the upper chord from the upper corner of the diagonal to the north. This horizontal fracture intersected the vertical fracture extending upward on the north side of the diagonal, creating at V-shaped tip of the gusset plate above the upper end of the diagonal. This tip was folded 180 degrees back onto the east face of the diagonal, consistent with westward translation of the upper end of the diagonal during the fracture process.

The fracture in the east gusset plate extended upward through the upper chord portion of the node separating upper chord members U9/U10W and U10/U11W. In the lowest row of rivets in the upper chord, this fracture intersected the second rivet south of the node centerline. The first rivet south of the node centerline (the southernmost rivet attaching the upper lateral brace attachment angle) was sheared and missing. The mating faces of the fracture near where it intersected the lowest row of rivets were both relatively undamaged. The fracture intersected this hole at an angle to vertical (approximately 30 degrees offset from vertical, with the fracture above the hole further north than the fracture below the hole) and the hole was significantly elongated in a direction perpendicular to the fracture. The fracture on the lower side of this hole intersected the continuation of the nearly vertical fracture extending upward from the north side of the diagonal about 1 inch below the hole, and there was a slight step where the two fracture planes met. The remainder of the fracture through the area of the gusset plate between upper chord members (above the lowest rivet row) intersected the seven rivet holes just south of the node centerline. At each of these rivets holes, the gusset plate was elongated in a direction slightly offset from horizontal, with the angle gradually increasing from nearly horizontal at the lowest hole to more skewed (down and to the north) at the upper hole. This change in the angle of elongation and the deformation adjacent to the upper edge of the gusset plate were consistent with fracture under primarily horizontal tension in the lower portion of the fracture and more shear in the upper portion of the fracture, with the direction of shear indicating the structure on the north side of the fracture was moving down relative to the structure on the south side of the fracture.

The east gusset plate also contained a fracture that completely separated the upper chord member U10/U11W from the diagonal U10/L11W on the east side. This fracture extended horizontally to the north from the plane of the fracture separating the upper chord members, intersecting the following rivet holes: the next to lowest rivet hole in the column just north of the node centerline, and the first through fourth rivet holes in the lowest row north of the node centerline. Fracture in this area was from in-plane vertical tension. Further north of this region, the east gusset plate was buckled and fractured as the U10/L11W diagonal rotated upward into upper chord U10/U11W, with the gusset plate fractured just below the bottom row of upper chord rivets with the gusset plate buckled eastward and prying on the rivets. Near the lower edge of diagonal U10/L11W, the gusset plate was bent up to the west nearly 180 degrees; this bend included the flange of the L10/U10W vertical still attached to the east gusset in this location.

West Gusset Plate

The fracture in the west gusset plate on the north side of the upper end of diagonal L9/U10W intersected the 4th, 6th, 7th, 8th, and 10th rivet holes adjacent to the north edge of the upper end of the diagonal. Deformation patterns and fracture characteristics were indicative of

in-plane tensile and shear stresses from the 6th through 8th hole. The fracture did not have the distinct step-like pattern found in the corresponding area in the east gusset plate. From hole 4 to 6, the gusset plate was sheared along the edge of the diagonal, and below hole 4 the gusset plate was raised above the surface of the diagonal, indicating out-of-plane bending or buckling loading. The fracture progressed directly from hole 8 to hole 10 and appeared to be primarily in-plane shear in this area. Above rivet hole 10, the gusset plate fracture intersected the two upper rivet holes in the south column of rivets for the U10/L10W vertical. Around these two holes, the plate had large deformation indentations associated with the heads of the rivets at these locations, indicating that the diagonal translated westward as this fracture occurred. The gusset plate on the north side of the fracture remained with the major portion of the node and was significantly deformed and had substantial post-fracture damage.

Multiple fracture planes were found in the fracture region above the upper end of diagonal L9/U10W, and the west gusset plate in this area had substantial bending and buckling deformation. A piece of the west gusset plate from this area was not recovered. At its south edge, the gusset plate was buckled to the west and fractured at the center of the buckling damage on an approximately horizontal plane into the 5th rivet from the upper end of the diagonal. Directly above this fracture, the gusset plate was also fractured mostly along the lowest rivet row for the upper chord member U9/U10W, with peeling deformation consistent with the diagonal translating west as the fracture occurred. The missing portion of the west gusset plate was between these two fractures. The gusset plate fracturing also extended approximately on a horizontal plane in a north direction from the upper corner of the diagonal. This horizontal fracture was intersected by the vertical fracture extending upward on the north side of the diagonal, creating a V-shaped tip of the gusset plate above the upper end of the diagonal. This tip was folded 180 degrees to the east into the interior of the diagonal, also consistent with westward translation of the upper end of the diagonal during the fracture process.

The fracture in the west gusset plate extended upward through the upper chord portion of the node separating the upper chord members U9/U10W and U10/U11W, intersecting the 8 rivet holes for the column of rivets just south of the node centerline. At each of these rivets holes, the gusset plate was elongated in a direction slightly offset from horizontal, with angle gradually increasing from horizontal at the lower portion of the fracture to the upper rivet row. This change in the angle of elongation and the deformation adjacent to the upper edge of the gusset plate were consistent with fracture under primarily horizontal tension in the lower portion of the fracture and more shear in the upper portion of the fracture, with the direction of shear indicating that the structure on the north side of the fracture was moving down relative to the structure on the south side of the fracture.

Between upper chord U10/U11W and diagonal U10/L11W, the west gusset plate was bent nearly 180 degrees, with a partial fracture through the top two rivets on the diagonal. Below the U10/L11W diagonal, the west gusset plate was buckled vertically; this area of buckling included the flange of the vertical L10/U10W still attached to the gusset.

Other Damage at Node U10W

The upper and lower cover plates of the upper end of the L9/U10W diagonal were fractured and split open 13.5 feet on the upper cover plate and 12.5 feet on the lower cover plate (measured

from the U10 end of the diagonal's side plates). Over most of the damaged area on the upper cover plate, pieces of the cover plate were folded inward (down). Over the lower several feet of the damaged area, the portion of the upper cover plate to the west was curled and buckled downward. Within 8 feet of the upper end of the diagonal L9/U10W, deformation and curling of the lower cover plate material was mostly down (away from the diagonal), but below that, the lower cover plate material was deformed upward into the interior of the diagonal.

The upper surface of the L9/U10W diagonal had scoring marks extending downward from the split-open area, but not directly from the furthest extent of the split area. One scoring mark started about 13 feet from the end of the diagonal (at the lower edge of a access hole), along the center of the upper cover plate with a width of about 2 inches and progressing to the next lower access hole gradually narrowing to about 1 inch wide. The mark continues on the cover plate between the next two holes with a nearly constant 1 + inch width. It continues out of the next hole then transitions to the east edge of the diagonal about 22 feet from the upper end of the diagonal. Other scoring marks were found along both edges of the cover plate in this area.

Node U10W and FT10 above the node contained the following impact marks and damage from the east side plate of diagonal L9/U10W transitioning through the interior of the node and the west side plate of the diagonal transitioning west (outside) of the node.

- The bottom cover plate of upper chord U9/U10W fractured and folded upward (inward) at U10W with heavy scraping marks.
- The bottom cover plate of upper chord U10/U11W was partially fractured along first rivet line north of the splice at U10W with fractured surface curled upward. The cover plate was also bowed upward (inward) and separated from the upper chord east side plate for approximately 6 feet from the node centerline, and from the west side plate approximately 2 feet from the node centerline.
- The bottom corner of the west side plate of upper chord U10/U11W adjacent to the node centerline was folded inward (eastward) and upward with heavy scraping marks.
- The west gusset plate in the area of the upper chord was generally fractured along the first rivet line south along the centerline of the node. The mating surface of the fracture to the north has been heavily impacted and abraded such that it was flush with the end of the west side plate of U10/U11W with approximately 1.5 inches of material missing.
- Impact mark on vertical U10/L10W on south side of web at center. Impact mark was approximately 2 inches wide and approximately 4 inches high extending to the top edge of the web. The web of the vertical in the area of the impact was bowed to the north, and the web was split from the flanges of the vertical down to the top stiffener for the floor truss lower chord at FT10L2.
- The east half of the web of the upper chord internal vertical stiffener (diaphragm A) was still attached to the east side plate of upper chord U10/U11W with impact marks on south side starting 5 inches from the bottom and continuing upward to top
- Top cover plates of upper chord members U9/U10W and U10/U11W (on underside) across the joint were impacted such that the impact mark was on the north and south side of the splice. The center of impact was located at the 3rd rivet hole from west side of the upper chord

- Top cover plate of upper chord U10/U11W was bowed upward (outward) at the 3rd rivet hole from the west. There was a fractured piece that was approximately 2 inches wide and was located between the 3rd and 4th rivet from the west and extends from the south end of the member to the 1st rivet line. This area contains multiple impact marks extending 13 inches north of the centerline of the node.
- The top cover plate of upper chord U10/U11W was separated from the side plates by fractures at the welds over a length of 10 feet north from node U10W (to the first internal stiffener north of U10W).
- Top splice plate of upper chord contains an impact mark on its underside at the 3rd bolt hole from west side of upper chord.
- Most of the top splice plate of upper chord was attached to U9/U10W and bent downward with fracture along the bolt line just north of the centerline of the node. There were marks on the top side of the upper chord splice plate and corresponding marks on the lower flange of FT10 consistent with FT10 sliding to the north and down over the splice plate after the top chord of the main truss separated at the node. The bolts in the southern bolt line of the FT connection sheared to the north as shown by the elongation of the bolt holes in the splice plate for the upper main truss.
- There was a local indentation of the doubler plate and the bottom flange of FT10 upper chord near the 3rd rivet from the east side of the main truss, with these members deformed upward.
- There was an impact mark on the bottom surface of the upper chord of FT10 west of the main truss and corresponding crushing of the FT web, upward deformation of the north side of the bottom flange, and translation of the top flange to the north relative to the bottom flange.
- The distance between the side plates of the diagonal L9/U10W was consistent with the distance between the impact marks on FT10 discussed above, one near the centerline of node U10W and one to the west of node U10W.
- The bottom flange and web of FT10 upper chord were fractured just west of the main truss at node U10W.
- There was a mark on the bottom of the gusset for the upper lateral brace U10W/CU11 corresponding to the position of the top edge of the east side plate of upper chord U9/U10W.

L10 West Node

Node L10W was a three-member joint with continuous box section lower chord of members L9/L10W and L10/L11W and an H section vertical U10/L10W joined to the lower chord by gussets on the east and west faces.

The lower chord has 15/16 inch sides and ½ inch top and bottom cover plates. The vertical H section has ½ inch flange plates and a 3/8 inch thick web plate. The gusset plates are ½ inch plates on the east and west faces of the members. Sway and lateral braces attach to the east side of the node with angles on the top of the brace members and to the lower cover plate of the lower chord through a gusset plate.

The node was recovered in two pieces: the vertical above the gusset plates and the lower chord. The lower chord had been torch cut during removal about 9 feet south and 23 feet north

of the node centerline. The vertical had been cut above the M10W sway brace node or about 24 feet from the lower end.

The lower chord was intact through the node but had numerous scrapes on the side and top and a perforation on the upper cover plate 35 inches south of the node centerline. The perforation appears related to the recovery of the member.

The flanges of the vertical were transversely fractured through the upper fastener holes attaching the vertical to the gusset plates and vertically through the web to the lower edge of the member. The south portions of the flanges had buckling deformation while the north sides were straight tension fractures. The gusset plates were intact but bent west. Damage was consistent with bending of the member to the south and west. Pieces from the lower end of the vertical remained riveted within the gusset plates. A line of minor corrosion was noted on the east side of the east gusset plate, in the area just above the attachment angle for the sway brace. The vertical above the fracture was distorted and crushed with much of the damage attributed to removal operations. The vertical member was bowed north.

The upper attachment angles for the sway and lateral braces were fractured. The lower attachment gusset plate was intact and connected to the lower cover plate of the chord. A portion of the fractured sway brace bottom flange was riveted to the mounting plate and gusset plate. The rivets holding the lateral brace, L10W/CL10, to the attachment gusset plate were sheared generally along the axis of the brace. Portions of the upper surface of the attachment gusset plate were moderately corroded with surface pitting.

U11 West Node

Node U11W has a continuous box section upper chord of members U10/U11W and U11/U12W and a box section vertical U11/L11W, joined by gussets on the east and west faces and incorporated attachment for the lateral braces.

The upper chord has 1-inch thick side plates and ½-inch thick cover plates on top and bottom. The vertical was a box section with 3/4 inch thick east and west side plates and ½ inch thick cover plates on the north and south sides. The gusset plates are ½ inch plates on the east and west faces of the members. A lateral brace attaches to the east side gusset through an attachment angle at the lower edge of the upper chord and a 3/8 inch thick attachment gusset plate on the upper surface of the chord.

Node U11W was under water in the post-collapse position and had multiple layers of deck on top. The node was recovered in two pieces with the vertical separated from the upper chord. Upper chord member U11/U12W was torch cut near node U12W. Member U10/U11W was torch cut 114 inches from the node centerline and again an additional 103 inches further south.

U10/U11W was hinged (U10 end up) and twisted slightly (CCW looking north) just south of the node. The upper surface was wavy from compression from the bent area to the second cut. In the area of the bend, the weld between the lower cover plate and the east side plate was fractured, and small lengths of the upper east and west welds were cracked.

The lower surface of the chord at the node had a triangular shaped upward indention and perforation. Member U11/U12W was intact at the node area, but the member had an overall slight downward bow that extended into the node. The gusset plates had compression buckling on their south edges and tension fractures on their north edges, consistent with bending of the vertical to the south, with the southern edge of the west flange penetrating the lower cover plate in the node area.

The upper attachment gusset plate for the brace was intact and attached to the upper chord. The plate had some distortion with no predominant direction. The upper lateral brace was separated through the rivets. The vertical stiffener next to the brace was attached at the top and torch cut through the middle. The lower flange of the fractured floor truss top chord was bolted to the chord and the top of the brace attachment. The east and west ends of the floor truss flange were fractured along with the web. The east end fracture was predominantly from tension and the west end fracture was from twisting.

The lower attachment angle was fractured by tearing through the angle, gusset plate and the brace member.

L11 West Node

Node L11 West was a five member node splicing two lower chord members, L10/L11W and L11/L12W, together with two diagonals, L11/U10W and L11/U12W, and a vertical member, L11/U11W, with gusset plates on the east and west faces. The node incorporated attachments for sway and lateral bracing on the east face.

Lower chord member L10/L11W was a welded box section with 15/16 inch east and west side plates and 1/2 inch top and bottom cover plates. The east side plate of L10/L11W was torch cut about 78 inches south of the node centerline and again through the entire box section 9 feet south of the first cut. Member L10/L11W mated to lower chord member L11/L12W having 1 7/16 inch side plates and ½ inch top and bottom cover plates. The east face of the member was torch cut 115 inches from the node centerline and again through the entire box section near the L12W node. The lower chord splice had vertically oriented internal 1/2 inch filler plates on the L10/L11W side and 1/2 inch splice plates. No internal diaphragm was present at the splice. The lower surface of the lower chord members had a ½ inch splice plate and a portion of the 3/8 inch lower lateral attachment gusset plate (thickness per design drawing). Additional brace attachments were angles on the east side of the gusset. The upper cover plate had a 3/8 inch splice plate.

The U10/L11W diagonal was an H section with 1 5/8 inch flanges and a 9/16 web. The vertical L11/U11W was a box section with 3/4 inch side plates and ½ inch cover plates. The L11/U12W box section diagonal had 1 7/16 inch side plates and 9/16 inch cover plates. The node gusset plates were ½ inch thick.

The node was recovered from the river bottom in 4 main sections before torch cutting: (1) the lower chord L10/L11W to L11/L12W (although severely damaged, the chord was continuous through the east side plate), (2) the U10/L11W diagonal connected to node U10W, (3) the

L11/U12 diagonal connected to node U12W, and (4) the U11/L11W vertical connected to part of floor truss 11.

The lower chord area of the node was severely fractured and distorted with scrapes, dents, and contact damage consistent with forceful contact with the riverbed, with other members, and from recovery.

The west side plate of member L10/L11W was vertically fractured near the south edge of the gusset plate. Although the plate was deformed adjacent to the fracture, the majority of the fracture displayed brittle features with chevron markings indicating propagation from the lower region of the plate upward. A 1 ½ inch long portion of the fracture had non characteristic brittle features at the brittle fracture initiation area approximately 9 inches above the lower edge of the member. The plate fracture region immediately below this area was ductile fracture, and the side plate was heavily deformed, peeled from the gusset plate, and twisted at the fracture and surrounding area. The north face of the side plate fracture had less damage than the south face of the fracture. The feature and surrounding area of the north side of the fracture was cut from the remainder of the west plate of L10/L11W for more detailed laboratory examination at the NTSB Materials Laboratory. Opposite the fractured west side plate, the east side plate was severely bent and twisted, but was not fractured (torch cut location). At its lower edge, the east side plate had partially peeled from the gusset plate in a manner similar to the peeling found in the west side plate at the fracture location.

The lower cover plate of lower chord L10/L11W was transversely fractured 58 inches south of the node centerline. The lower cover plate edge welds were split from the side plates 84 inches south of the node centerline on the east edge and 60 inches south of the node centerline on the west edge. The upper cover plate welds were also fractured, with the east edge weld split open 115 inches south of the node centerline, and the west edge weld broken over a 59 inches in a location that was roughly centered at the west plate fracture. The upper cover plate was transversely fractured near the west side plate fracture location.

The east side plate was bent horizontally away from the node, starting about 10 feet north of the node centerline, but remained intact. The bottom cover plate west edge weld was split open for 102 inches from the node centerline with a transverse tensile fracture into an access hole at the north end. The east edge of the bottom cover plate was also fractured between 111 inches and 154 inches north of the node centerline. The fracture followed the lower edge of the side plate, consistent with the horizontal bend in the plate.

The splice plates and rivets on the lower chord side plates were damaged but the joints remained connected. The top cover on member L11/L12W was fractured along the eastern weld for 142 inches from the node centerline. The cover was folded down 90° along the western side plate near the node.

The gusset plates were deformed and fractured in multiple locations, but most portions appeared to have been recovered and identified. The east and west gusset plates remained intact in the lower chord area. The gussets were fractured along the top edge of the lower chord except for a portion of the east gusset plate near the northern edge. The diagonals L11/U12W and

L11/U10W translated west relative to the lower chord as was evident by the folding of the west gusset plate over the tip of the west side plates of the diagonal and peeling away of the east gusset plate at the tip of the east side plates of the diagonals, which went through the node folding the top cover plate over.

The lower end of the L11/U12W diagonal was severely distorted and fractured at the node suggesting further damage consistent with impact with the riverbed. The west side plate with part of the gusset attached was bent to the west in a large arc of about 225°. The east side plate was curved to the east and transversely fractured within the curved area about 75 inches from the lower end. The transverse fracture was brittle with no clear direction of propagation. Both cover plates or the welds of this diagonal were fractured in the region of the deformation of the side plates, about 132 inches from the lower end of the diagonal. This diagonal and the lower chord also display mutual contact damage consistent with the diagonal moving down and southward through the lower chord.

Diagonal U10/L11W only partially penetrated into the lower chord of the node; the diagonal rotated CCW (looking east) relative to the node, contacting the upper surface of the lower chord and translating west relative to the node. At the lower end, the east flange was also displaced north relative to the west flange. Both flanges spread apart fracturing the web. The west flange was separated from the web for approximately 58 inches from the lower end of the member, and the east flange was separated 48 inches. At the lower end of the member, the web was displaced to the south with abrasions on the north side, consistent with the shape of the vertical L11/U11W.

Vertical U11/L11W sustained severe compression damage at the lower end of the member within several feet of node L11W.

The west gusset plate had a line of corrosion and section loss about 1 inch wide (vertically) just above the top of the lower chord. No fractures were observed along the reduced plate section. Approximately 18 inches of the inside surface of the gusset plate was not visible for inspection. The east gusset plate had a similar line of corrosion at the upper edge of the lower chord that was visible adjacent to the south edge of the plate. Documentation of the corrosion damage is contained in another appendix.

Other Structural Members, Nodes 8 to 12

Floor Truss 8 (FT8)

The west cantilevered portion of the floor truss upper chord was bent south relative to main truss node U8W, and the upper chord was partially fractured just west of FT8U2. Both diagonals were attached and the gussets were distorted. FT8U0/L2 was intact. FT8U1/L2 was bent to the north at L2. The floor truss upper chord was fractured between the connection to the main truss outboard of Node U8W and the upper chord riveted splice.

The east cantilevered portion of the floor truss upper chord was bent north. The upper chord was fractured completely just west of FT8U12. The bottom flange of the upper chord was still attached at main truss Node U8E. The east cantilever diagonals were straight and intact with

some deformation at both the FT8U13 and FT8U14 gussets, with small tears in the gusset at FT8U13. The gusset at FT8L10 was bent to the north.

Web members FT8U3/L2 and FT8U3/L4 were straight and intact. At several locations, the gussets were torn at the tips of the web member flanges – FT8L2 at FT8U3/L2, and FT8U3 at FT8U3/L2. The kicker braces near FT8L2 and FT8L9 were detached and the connection plates were splayed/bent or fractured.

Lower Lateral Brace, Node 8 to 9

The lower lateral braces were detached at L8W and L8E, with the L8W end lying on the ground north of pier 6 West under the suspended node L8W and the L8E end lying on the ground northwest of pier 6 East near node L8E. The L8E end was still attached to sway brace horizontal L8E/CL8. Both the lower laterals were still attached at CL9, which was positioned near the top of the guidewall.

The west lower lateral had a negative bend near midlength, where it was resting on the wall between the columns of Pier 6. The east lower lateral was buckled to the northeast near midspan.

Upper Lateral Brace, Nodes 8 to 9

Both the upper lateral braces remained partially attached to U8W and U8E nodes and still attached to each other at CU9, but were detached and significantly displaced from FT9. The upper laterals fell to the east with the main trusses, and FT9 fell over the guidewall and was partially in the river. The CU ends of the laterals were positioned north and slightly east of pier 6 East.

The west upper lateral has a positive bend about 5 ft from U8W and was buckled to the southeast about 10 ft from its CU9 end due to impact from the west truss top chord U9/U8W.

Floor Truss 9 (FT9)

The portion of FT9 between the main trusses was found lying on its north side with the west end in the water and the east end over the guide wall. It was oriented longitudinally as opposed to its original transverse orientation in the bridge. The floor truss lower chord remained attached to main truss vertical L9/U9 East. The diagonals for the east cantilever also remained attached to the main truss vertical L9/U9 East but were both unattached to the floor truss top chord as a result of fractures in the FT9U13 gusset plate. FT9 was largely intact between the main trusses but was separated from L9/U9 West by a fracture in the FT9L2 gusset plate. The floor truss upper chord was heavily damaged and fractured just inboard of U9 East.

The FT9 upper chord was fractured below the stringer attachment location above U9 West. There were compression/bending fractures in the upper gusset plates for the west cantilever diagonals, as if the cantilevered portion of the upper chord rolled to the north and down. The west cantilever diagonals remained attached to vertical L9/U9 West and were minimally damaged. There was some bending in the inboard diagonal (FT9U1/FT9L2) about an impact mark on the north side of this member near mid-length. Under stringer 12 (at the west truss) the stiffeners on the north side of the floor truss upper chord were buckled as if the upper

flange rotated north relative to the lower flange of the upper chord. The fracture in the floor truss upper chord bottom flange (just outboard of the stringer) has a large amount of downward bending. The fracture in the top flange of the upper chord (located just inboard of the stringer) connection was deformed by twisting and bending. The floor truss upper chord web was fractured adjacent to the lower flange at the stringer location and vertically below the east set of stringer bolt holes. Overall, the fracture was consistent with the outboard part of the cantilevered portion of the upper chord moving down and rotating north, creating a large amount of bending and twisting prior to fracture.

At the lower connection of the west cantilever diagonal, the gusset plate has compression damage, bending to the south adjacent to L9/U9 West and then bending opposite closer to the diagonals. The gusset plate was almost entirely fractured.

The vertical stiffener bracket of the lateral bracing connection was still attached to the FT9 upper chord bottom flange.

At FT9U3 (just east of U9 West) the gusset plate was bent to the north around web member L2/U3 with partial fracture of the plate around the L2/U3 flanges. The two floor truss chords were rotated away from each other in this area. There was also bending to the north at the lower end of L2/U3 and in the gusset plate at L4. There was no deformation in web member L2/U3. The upper portion of the fracture in the gusset plate at L2 appears to initiate at the toe of the weld at the west (top) flange of U3/L2. The lower portion of the fracture intersects the toes of the welds for the flanges of FT9 lower chord.

There was some twisting along the length of the FT9L4/FT9U3 web member.

On the east side, the lower chord was twisted between node FT9L9 and FT9L10 as if the lower chord at FT9L9 rotated north, with about 30 degrees of rotation relative to L10. The lower chord was also twisted consistently but to less an extent between L9 and L6 (roughly 10 degrees). The floor truss brace (kicker) at L9 was not present in the laydown area, but the kicker was present in post-collapse photographs. This kicker was relatively straight but had a slight bend approximately where it might have contacted the upper chord. The upper chord of the floor truss has impact marks above the kicker attachment location. On the lower chord of FT9, the kicker's pin attachment flanges were slightly spread apart, and there were impact marks from the kicker flanges on both the top and bottom flanges of the floor truss lower chord.

Neither the kicker nor the pin at FT9L4 was present in the laydown area. The attachment plates were bent to the west and the hole in the western most attachment plate was elongated.

The gusset plate at L9 was bent at the lower ends of the web members, as if the upper ends of the web members were displaced southward. Vertical web member FT9L9/FT9U9 was bowed to the south. The gusset plate at U10 has significant bending above web member FT9U10/FT9L10 (a diagonal). The direction of bending was as if the upper chord of the floor truss rotated north relative to the diagonal. Floor truss web diagonal FT9L9/FT9U10 was twisted consistent with the bending indicated in the gusset plate at FT9U10.

Both the outboard (cantilevered) and inboard portions of the upper chord of FT9 were bent in-plane northward about the U9 East node. In the floor truss upper chord above node U9 East, there were tension fractures in the south side upper chord flanges and compression buckling on the north side of the top flange of the floor truss upper chord. A portion of the web and bottom flange remained attached to node U9 East.

The east cantilevered portion of the upper chord was bent southward just outboard of the stringer 2 attachment location. The stringer to FT connection for stringer 2 (at FT9U13) has out-of-plane tension yielding deformation around the south bolt holes. There were partial tension fractures through the north bolt holes, and a portion of the upper flange between the north bolt holes has fractured out. The stringer to FT connection at stringer 1 (at FT9U14) has out-of-plane tension yielding deformation at all four bolt holes. The fill plate for stringer 1 created an impression in the top flange of the upper chord at the southeast corner of the contact area. The gusset plate for L10/U14 at U14 was bent to the south.

The upper chord of FT9 has reverse curvature bending centered at the truss centerline and changing direction at FT9U9 and FT9U4, which were bent to the north. The lower chord of FT9 has a larger bend to the south just west of its center (between L6 and L9) with local buckling damage approximately where the lower chord would have contacted the top of the guide wall in the recovery position.

There was a series of impact marks across the south face of FT9, apparently made by L9/U10 West, based on post-collapse photos. The marks start east of FT9 web member L6/U7, and continue on web members L6/U6 at about its mid-length, on L6/U5 at about one third from its lower end, and on the floor truss lower chord upper flange between nodes L6 and L4. There was only local deformation associated with these marks. The south face of the web members attached to FT9L4 had an additional series of more severe impact marks. The direction of damage from these impact marks was approximately from east to west.

The upper lateral brace attachment area between U6/U7 has the same type of south loading damage as was found on FT10.

Floor Truss 9 Sway Braces

Nodes CM9 and CL9 were recovered near each other on top of the guide wall, slightly west of their original position. All the sway members were still attached to each other but detached from the east and west truss verticals and Nodes L9E and L9W, with the exception of the west diagonal CM9-FT9L2 which was completely detached at both ends and was lying on the ground between Pier 6 West and the guide wall. This west diagonal also had a positive bend near mid-length. The lower west diagonal CL9-M9W had a positive bend about its one third point from CL9. CL9-L9W had a positive bend near mid-length.

Lower Lateral Brace Nodes 9 to 10

The lower lateral braces were detached from L9W and L9E, and remained attached at CL10. The L9E end of the east lower lateral was recovered near collapsed node L9E. The L9W end of the west lower lateral was located directly north of pier 6 West, while node L9W was recovered approximately 35 ft east of pier 6 West.

L9E-CL10 had a negative bend about 5 ft from CL10 where it impacted and rested on the guide wall. It also had impact damage at 12 ft and 18 ft from the L9E end due to impact from east and west truss members. L9W-CL10 was found generally straight and intact.

Upper Lateral Brace Nodes 9 to 10

Both the upper lateral braces were still attached to each other at CU10, but were detached from FT10. U9E-CL10 was detached from node U9E, but was recovered near that node. U9W-CL10 was detached from node U9W and the U9W end was found significantly west of the collapsed node U9W, suggesting the separation occurred prior to the west truss falling to the east. The U9W end of U9W-CL10 was submerged in the river near the west end of FT9. Both upper laterals were generally straight and intact.

Floor Truss 10 (FT10)

Most all of FT10 was found in the water north of pier 6. An approximate 6.5 foot long piece of the floor truss upper chord from above node U10E remained attached to the upper cover plate of main truss upper chord member U10/U11 East. Each end of the central portion of FT10 (between the main trusses) was at least partially attached to verticals L10/U10 East and West. These vertical members and the majority of FT10 were found nearly upside down, with the upper end of the verticals in the water and the lower ends near the guidewall. These members were located approximately directly below and slightly south of their position in the bridge. The major portion of FT9 and multiple other structural members were on top of FT10 and main truss verticals U10/L10 East and West.

There was only one fracture in the portion of FT10 between the main trusses, located in the upper chord approximately 5.5 feet inside the centerline of the U10 East node. At this location the fracture initiated in the bottom flange of the upper chord, where the gusset plate at FT10U10 is welded to the bottom flange. Deformation adjacent to the fracture indicates primarily upward bending. The upper chord was also fractured just above the U10 East node, with severe downward deformation and tensile fracture of the upper flange of the floor truss upper chord, consistent with the east end of the upper chord moving downward, resulting in bending at the fracture location. See notes on the U10E node for more information on the damage patterns associated with these fractures.

Both of the east cantilever diagonals were relatively undamaged, but were fractured from the upper chord of FT10 at least partially at the interface between the weld and the surface of the gusset plate, indicating lack of fusion.

The floor truss upper chord inside of U10 East was bent to the south relative to vertical U10/L10E. The lower chord was still attached to the U10/L10E main truss vertical.

Vertical U10/L10 West has severe downward buckling / crushing in the portion of the member above the gusset for the attachment of the FT10 lower chord.

All stringers were separated from FT10 through fracture of the attachment bolts. (Stringers above the main trusses are clamped to the FT, not actually bolted to the upper surface of the floor truss upper chord.)

The floor truss upper chord has nearly symmetric (about the centerline) reverse curvature in the horizontal plane. In the center, it was bowed to the south with inflection points between the attachment locations for Stringer 6 and at Stringer 10. On the west side, the upper chord was buckled just west of the upper chord splice nearest U10 West. The floor truss upper chord near the connection to U10 East was heavily damaged during the recovery operation. At the location where the upper lateral braces attach to the south side of the upper chord of FT10, the lower framing member was fractured with severe deformation in the south direction, and the rivets to the lower flange of the upper chord were fractured.

On the west side, the FT10 structure was relatively undamaged inboard of the west main truss and was still attached to main truss vertical U10/L10 West at the FT10L2 gusset plate. However, this gusset plate was bent relative to U10/L10 West as if the main truss moved toward the river relative to the floor truss. The gusset plate has a partial fracture around the end of the FT10L2/U3 web member. This partial fracture was nearly identical to the fracture at this same location on FT9.

The portion of vertical U10/L10 West above the FT10 lower chord was heavily buckled and crushed downward. However, while the upper chord of FT10 was partially fractured just inboard of the west main truss, the vertical geometry of the triangle formed by the upper chord between FT10U3 and FT10U0, the FT10U0/L2 web member, the lower chord at vertical U10/L10 West, and the FT10L2/U3 web member remained largely unchanged.

While a portion of the weld between the FT10U1/L2 cantilever diagonal and the floor truss upper chord shows poor weld adhesion, the remainder of the separation between these components was the result of a fracture through the gusset plate. For the FT10U0/L2 cantilever diagonal, the gusset plates at the lower and upper ends were partially fractured. The partial fractures were on the inboard side of the member at the upper end and on the lower (outboard) side at the lower end.

The sway brace members joined at the bottom of FT10 were intact and relatively undamaged, including where they attach to U10/L10 East and West.

Floor Truss 10 Sway Braces

Nodes CL10 and CM10 were recovered near each other on the north face of the guidewall, approximately at the longitudinal centerline of the bridge. At CM10, all the members were still attached and generally intact and straight, with some distortion of the CM10 gussets. The horizontal M10W-CM10-M10E was attached to the east and west main truss verticals. The sway brace diagonals CM10-FT10L2 and CM10-FT10L10 were separated from floor truss 10 at the FT10L2 and FT10L10 nodes. At CL10, horizontal member L10W-CL10-L10E was bent approximately 90 degrees on either side of the gusset and the L10W and L10E ends were oriented north and submerged underwater in the area where the L10W and L10E nodes, respectively, were found. Both sway diagonals were generally straight and intact and detached

from the floor truss at their connection at CL10 by fractures through both the north and south angles (recovery photographs indicate that the sway brace diagonals might have been at least partially attached to CL10 in the post-collapse position). Diagonal CL10-M10W was still attached at the west truss vertical. Diagonal CL10-M10E was detached from the east main truss vertical.

Floor Truss 11 (FT11)

All portions of this floor truss were recovered from the river, approximately below the original position of the floor truss in the intact, pre-collapsed bridge. Some marking and damage on the floor truss lower chord, web members and gusset plates were caused by the shear equipped excavator during recovery and lifting.

FT11 has many impact marks and substantial deformation and damage, consistent with it having been mangled, crushed and buried by the stringers, deck, and barrier elements as the bridge collapsed into the river. Almost all of the web member connections between the floor truss upper chord and lower chord were severed by fractures in those members or in the connecting gusset plates. Bending deformation was generally consistent with the upper chord rotating southward about the lower chord. The center portion of the floor truss upper chord (at the attachment location for the U10E-CU11 and U10W-CU11 upper lateral braces on the south side of the upper chord), had twisted relative to the lateral braces, resulting in impact of those braces on the upper flange of the floor truss upper chord. There was an approximate 2.5 foot fracture at the top of the web of the floor truss upper chord in the area where the lateral bracing was attached.

The west cantilevered portion of the upper chord was fractured near the connection to the west main truss. Approximately 18 inches of the bottom flange of the west cantilevered portion of the upper chord remained attached to the main truss. Overall, the fracture was consistent with the outboard part of the cantilevered portion of the upper chord moving down. There were compression/bending fractures in the upper cantilever diagonal gusset plates consistent with the cantilevered portion of the upper chord rolling to the south and down. The gusset connections to the diagonals at FT11U0 and FT11U1 were both fractured, but the west cantilever diagonals remained attached to main truss vertical L11/U11 West. The upper end of outboard diagonal (FT11U0/L2) was bent 90 degrees to the south.

The east cantilevered portion of the floor truss upper chord was fractured at the connection location to the east main truss, and this fracture was accompanied by substantial deformation. Inboard of the fracture, approximately 3 feet of the bottom flange was missing between the upper chord riveted splice and the fracture at the main truss. Over that same 3 feet, the web was separated from both flanges; the top flange was bent in an S shape in this location with the outboard end pushed down and inboard. Outboard of the fracture, the cantilevered portion of the upper chord was bent near its midpoint in a horizontal plane by 180 degrees and twisted 90 degrees; at the bend, the bottom flange was fractured and the top flange was separated from the web over approximately 21 inches. There were compression/bending fractures in the upper cantilever diagonal gusset plates consistent with the upper chord rolling to the south and down. The upper end of outboard diagonal (FT11U14/L10) was bent 90 degrees to the south.

The east cantilever diagonals remained attached to main truss vertical L11/U11 East, but the gusset plate at this location was fractured through an estimated 75 percent of its cross section.

Diagonal web member FT11L2/U3 remained attached to the main truss vertical L11/U11 West, but was separated from the upper chord by a fracture through the gusset at FT11U3. Diagonal FT11U3/L4 was fractured near its midpoint. The gusset at FT11L4 was fractured, severing the connection to all of the web members, as was the gusset at FT11L6. At FT11L9, the gusset was fractured through an estimated 75 percent of its cross section although some of this fracture was caused by the removal process. The gusset connections were fractured at both ends of the FT11L10/U10 diagonal. All of these fractures were generally accompanied by deformation consistent with the upper chord rolling down and to the south with respect to the lower chord.

The lower chord was separated from both the east and west main truss verticals (L11/U11 West and East) by fractures through the gusset plates. Just to the east of FT11L4, a fracture in the lower chord separated the top flange, the web, and half of the bottom flange; the lower chord was bent at this location about its strong axis by 90 degrees. Between FT11L4 and FT11L6, the lower chord was twisted and the flanges pinched on the south side between FT11L6 and L9. From FT11L6 to the point where the floor truss lower chord attached to the east main truss vertical, the lower chord twisted approximately 90 degrees, with the bottom flange rotated to the south and up; the twist was accompanied by bending of the lower chord (east end up) of approximately 45 degrees.

The floor truss brace (kicker) was not present at either the FT11L4 or FT11L9 locations. At FT11L4, the kicker plates were splayed open symmetrically, each by an angle of approximately 45 degrees; the pin remained in the east plate. At FT11L9, the east plate was bent approximately 45 degrees to the east and the west plate was bent approximately 15 degrees to the west; the pin was not present.

The web member diagonals were separated from the floor truss upper chord at both FT11U6 and FT11U7, largely through fractures at welds with inadequate fusion. However, there was a note on these components indicating that the FT11U7 fracture occurred during recovery. On FT9 and FT10, the upper plate where the lateral brace attached to the lower flange of the upper chord was missing. A portion of that plate was still attached to the lower flange of the floor truss upper chord, but was fractured at the edge of the lower flange by upward bending. The upper lateral connection member between U6 and U7 was deformed to the south, and the upper flange of the lateral connection has fractured where it was bent upward.

The FT11 upper chord bows to the south, but the maximum curvature appears in approximately the U5 area.

Floor Truss 11 Sway Brace

The pieces of the FT11 sway brace were removed from the river from a location approximately below the floor truss.

Lower Lateral Brace, Nodes 11 to 12

The pieces of the lower lateral brace were removed from the river from a position approximately between nodes 11 and 12.

Upper Lateral Brace, Nodes 11 to 12

The pieces of the upper lateral brace were removed from the river from a position approximately between nodes 11 and 12.

Node 12 to Node 12′

Main Trusses, Nodes 12 to 12′

After the collapse, the east and west main truss upper chords from nodes 12 to 12′ (inclusive) were intact, generally parallel and situated approximately below their original positions. Post removal examinations found the main truss lower chords were separated at one location and partially separated at two others.

Member L14/L13′E separated from node L13′E through rivet shear along the lower chord side plates and fractures along a net section in the splice plates; deformation at the net section fractures exhibited tension at the bottom of the lower chord member transitioning to shear at the top, indicating upward bending of the L14′E end of L14/L13′E relative to node L13′E.

Except for a connection through the top cover plate, member L12/L13E was almost completely separated from node L13E by fractures at the net section and rivet shear. Deformation at the fractures indicated tension at the bottom of the lower chord member transitioning to shear at the top, consistent with upward bending of the L12E end of L12/L13E relative to node L13E.

Node L13′W was substantially damaged, and a majority of the gusset rivets were sheared at the connection of member L12′/L13′W; the L12′/L13′E member in this area was also bent in the horizontal plane.

All of the diagonals and verticals between node 12 and node 12′ exhibited significant bending or buckling damage consistent with compression loading, with most of the verticals buckled below the level of the floor truss lower chord attachments.

Other Structural Members, Nodes 12 to 12′

The floor trusses between the main truss upper chords generally remained intact and upright. The upper lateral braces between node 12 and node 12′ also remained in or near their original positions. The east and west cantilevered sections of the deck and supporting floor trusses fractured downward along the lines of stringers 3 and 12, located at the tops of the main truss upper chords. On the north side, the deck also fractured along the line of stringer 4. Along the centerline of the bridge, the concrete deck separated to leave a V-shaped gap (with the point of the V at node 12′ and an approximate 10-foot gap at node 12); the stringers were also deformed or shifted away from the bridge centerline in this area. The deck was also slightly separated along the expansion joint that had been situated above node 14. The deck translated to the south with respect to the underlying steel structure; the final position of the expansion joint was approximately 5 feet south of the final position of node 14 on both the east and west sides of the bridge.

Node 12′ to Node 8′

East Main Truss, Nodes 12′ to 8′

U11′ East Node

- The upper chord U11′E/U12′E was not deformed adjacent to the node.
- Vertical U11′E/L11′E has severe compression buckling and was partially fractured at the upper end, but was mostly straight between FT11′L10 and L11E′.
- Upper chord U11′E/U10′E has a large hinge approximately 4 feet from the edge of the U11′E gusset, with compression buckling across the top cover plate and most of the side plates. Beyond the hinge, the member was straight to node U10′.
- There was a piece of the upper chord of FT11′ attached to the top of the node at FT11′U12. The upper chord of the floor truss was fractured at the east edge of the upper chord of the main truss. To the west, the floor truss was bent down and to the south, and the web was buckled to the south.
- The upper lateral U11′E/CU12′ was attached to the node and also bent downward.

L11′ East Node

- Gusset plates were intact in the area of the side plates of the lower chord.
- Lower chord L11′/L10′E was severely distorted with bending and compression buckling approximately 7 to 15 feet from the centerline of node L11′E, with side plates split from cover plates. The north end of lower chord L11′/L10′E was displaced south, west and up relative to node L11′E.
- Lower cover plates for the two lower chord members were attached to each other in the node, but separated from the side plates over a distance south of the node centerline about 68 inches and over a distance north of the node centerline of 33 inches (west side) to about 15 feet (east side – through the area of severe distortion in the lower chord L11′/L10′E).
- The gusset plate on the west side was fractured where it was folded to the east over the top edge of the lower chord.
- The gusset plate on the east was fractured mostly at the top rivet row on the lower chord where the plate was folded east.
- The L11′E/U10′E diagonal was attached through the west gusset plate to a piece of the west side plate of the L11′E/U12′E diagonal (which fractured in a brittle manner from the remainder of the diagonal at the first internal stiffener).
- The lower end of the L11′E/U10′E diagonal was split open and the flanges were splayed apart with the web fractured over a length of approximately 6 feet.
- Lower end of vertical has significant compression damage.
- Contact marks indicate that the diagonals and vertical at L11′E all penetrated the node after translating east relative to the lower chord.
- The sway brace L11′E/CL11′ and the lower lateral brace L11′E/CL12′ were fractured from the node, with residual deformation of the gussets and/or angles indicating downward motion of the braces relative to node L11′E.

- There was minor surface corrosion and pitting on the top surface of the lower gusset for the sway brace L11′E/CL11′ and the lower lateral brace L11′E/CL12′.

U10′ East Node

- Contact marks indicate that U10′E/L9′E diagonal penetrated the node, with the upper cover plate of the diagonal damaged 6 feet from the U10′E end and the lower cover plate damaged 2 feet from the U10′E end. The direction of damage was mainly downward and toward node L9′E.
- Gusset plates were fractured between U10′/L9′E diagonal and U10′/L10′E vertical, buckled and fractured between diagonal U10′/L9′E and the U10′/U9′E upper chord, and fractured vertically through the first row of rivets north of the centerline of the node between upper chord members U10′/U9′E and U10′/U11′E.
- The fractures between rivets in the gusset plates between upper chord members U10′/U9′E and U10′/U11′E appear to be primarily tension in the lower portions of the upper chord, transitioning to tension plus shearing towards the upper edge of the upper chord.
- On both the east and west sides, the fracture in the gusset plates between the diagonal U10′/L9′E and the vertical U10′/L10′E was in plane from the 5th to the 8th rivet (counting from the lowest rivet), with out of plane bending deformation evident between the 1st and 5th rivets and above 8th rivet.
- The triangular piece of the west gusset plate attached at the upper end of the L9′/U10′E diagonal was folded to the east over the tip of the diagonal, indicating that the diagonal displaced to the west as it penetrated the node. The similar piece from the east gusset plate remained with the U10′/U9′E upper chord and was peeled back over the rivets at the tip of the diagonal, also indicating that the diagonal displaced to the west as it penetrated the node.
- The north face of the web of vertical U10′E/L10′E has an impact mark from the upper end of the U10′E/L9′E diagonal approximately in the center of the web, within about 2 inches of the upper end of the member.
- The lower splice plate (4 rivets wide) and the bottom cover plate of the upper chord were fractured and pushed / bent up and into the member consistent with contact from the U10′/L9′E diagonal.
- The lower surface of the upper cover plate for upper chord member U10′/U9′E has an impact mark from the east side plate of the diagonal about 1 foot from the south end of the cover plate, and the cover plate has been penetrated a length of 9 inches from the south end, consistent with contact from the U10′/L9′E diagonal moving upward through the node.
- On the south side of the joint, the upper cover plate for U10′E/U11′E has been peeled back approximately 6 feet, beyond the south edge of gusset plate, fracturing the welds to the side plates.
- The 4-rivet wide top splice plate remains attached to the peeled part of the upper cover plate and has an impact mark on the lower side where it normally contacts the U10′ /U9′E upper chord. Splice plate rivet holes in the U10′/U9′E upper chord top cover plate were grossly elongated north–south.

- A portion of the lower flange of the upper chord of FT10′ (18 inches) was attached to the peeled-back portion of the top cover plate of U10′/U11′E. Also attached at the same location were the gusset plate for the upper lateral and a fill plate between the upper cover plate and the top chord of FT10′. Also attached was a small piece of the upper cover plate of lateral brace U10′E/CU11′.
- The east gusset plate at the U10′E end of U10′/L9′E fractured in bending at the upper line of rivets (row of rivets closest to the tip of the diagonal) as the plate folded at the rivet line.
- There was a partial fracture at the upper chord rivets in both gusset plates between the upper chord U10′/U11′E and diagonal U10′/L11′E. Otherwise, the gusset plates in the rest of the node (connecting U10′/U11′E, U10′/L11′E and U10′/L10′E) were intact, but heavily deformed.
- The U10′/L11′E diagonal was rotated toward the upper chord U10′/U11′E and offset east relative to the upper chord.
- The U10′E/L10′E vertical has substantial compression damage and buckling in the area above FT10′L10. There was an area approximately 3 inches long of web mid-plane separation from compression loading just above lower chord of FT10′ (on the section of vertical attached to U10E′).
- Stringer 3 was partially wedged through the main portion of the node (the south portion), with the top flange through the node, the web cut by the west side plate of U10′/U11′E, and the bottom flange located west of the node.

L10′ East Node

- Compression buckle in lower chord L11′/L10′E immediately south of node L10′E, with a partial fracture of the west side plate and in the west halves of the top and bottom cover plates. The partial fractures were centered at the buckle.
- The gusset plates for the vertical were fractured along the top of the lower chord.
- The lower end of the vertical has substantial compression damage. The vertical member U10′/L10′E has a hinge and twist below M10′E. There were several compression folds in the north edges of the east flange between M10′E and the lower chord of FT10′ (FT10′L10). There was significant vertical compression buckling and fracture in the upper part of the vertical.
- The sway brace L10′E/CL10′ and the lower lateral brace L10′E/CL11′ were fractured from the node, with residual deformation of the gussets and/or angles indicating downward motion of the braces relative to node L10′E. (Possibly removal damage.)
- There was minor surface corrosion and pitting on the top surface of the lower gusset for the sway brace L10′E/CL10′ and the lower lateral brace L10′E/CL11′.

U9′ East Node

- The upper chord was intact through the node.
- Upper chord U10′/U8′E has negative bending centered at node U9′E, with compression buckling in the lower cover plate just north of U9′E.

- Vertical U9′/L9′E separated from U9′E node through fractures in the gusset plates at the bottom line of rivets in the upper chord. The northeast corner of the vertical impacted and partially penetrated the lower cover plate of the upper chord.
- A 3-foot piece of the bottom flange of the upper chord of floor truss FT9′ remained attached above the node.
- The upper lateral brace U9′E/CU10′ was separated from the node.

L9′ East Node

- This node remained connected to the large intact portion of the bridge that tilted to the north and rested on pier 7.
- Gusset plates were intact and not deformed except for slight bending deformation at the south edge where the lower chord L9′/L10′E fractured.
- L9′/L10′E lower chord has localized negative bending adjacent to the node, and the east and west side plates were fractured at the south line of rivets at the gusset plate.
- L9′/L10′E had buckling deformation in the lower halves of the side plates and bottom cover plate adjacent to the node. The upper half was yielded with a slight negative curvature adjacent to the node.
- The top and bottom cover plates of member L9′/L10′E were fractured at the first access hole south of the side plate fractures. The top cover plate exhibited signs of tensile fracture, and the bottom cover plate was fractured in the bend of a buckle.
- Rivet hole deformation and paint cracks indicate longitudinal tension at the top of the lower chord transitioning to tension plus shear at the bottom of the lower chord consistent with negative bending of the lower chord.
- L9′/U10′E diagonal connected at node but severely distorted in an area between 2 feet and 7 feet from the edge of the gusset. The U10′E end was bent and/or buckled down and to the west approximately 135 degrees. The west side plate and the top and bottom cover plates were fractured in the bend, and the east side plate was partially fractured through half of its section.
- Vertical L9′/U9′E was also bent down to the west approximately 135 degrees at about 3 feet from the edge of the gusset plate.
- Vertical L9′/U9′E was bowed to the south at the middle strut connection for the sway bracing.
- Vertical L9′/U9′E was also fractured with compression buckling below floor truss FT9′ lower chord attachment at FT9′L10.
- The sway brace L9′E/CL9′ and the lower lateral brace L9′E/CL10′ were fractured from the node, with residual deformation of the gussets and/or angles indicating downward motion of the braces relative to node L9′E.
- There was minor surface corrosion and pitting on the top surface of the lower gusset for the sway brace L9′E/CL9′ and the lower lateral brace L9′E/CL10′.
- There was some minor pack rust between the inside of the gusset plates, the top cover plates of the lower chord members, and on the adjacent gusset face. A small area of corrosion and section loss was on the west face of member U9′/U10′E near the gusset line.

U8′ East Node

- This node remained connected to the intact portion of the bridge that tilted to the north and rested on pier 7.
- Gussets were intact with no deformations except a slight bending deformation at the south edge of the gussets at the upper chord U8′/U9′E.
- Upper chord U8′/U9′E was bent out of plane (to west) and down approximately 80 degrees adjacent to the node with separation of west side plate from cover plates and fracture of the bottom cover plate at an access hole.
- Lateral U8′E/CU9′ hinged approximately 4 feet from the node.
- There was upward impact damage on the bottom surface of the lower gusset for lateral U8′E/CU9′.
- There was some paint loss on the top surface of the node and lateral brace gusset.

L8′ East Node

- This node remained connected to the intact portion of the bridge that tilted to the north. The south end of the node was resting against the north side of pier 7 near the top of the pier.
- Node and gussets intact, with no deformations.
- Bearing separated through pintle shear (node displaced to the north of pier) with lower bearing casting still on pier 7 East.
- The top and bottom surfaces of the sole plate exhibited some corrosion.
- The lateral brace L8E/CL9′ was fractured from the node.
- The lower gusset for the lateral brace L8′E/CL9′ had localized corrosion adjacent to its connection to the sway brace L8′E/CL8′.
- The lower cover plate of sway brace L8′E/CL8′ had some corrosion with an estimated 50 to 70 percent section loss.
- The gusset plates had some minor surface corrosion and paint loss.
- There was some minor pack rust between the inside of the gusset plates and the top cover plates of the lower chord members.

West Main Truss, Nodes 12′ to 8′

U11′ West Node

- The upper chord was minimally distorted through the node.
- Vertical U11′/L11′W was still attached at node U11′W.
- The gusset plates were buckled, with the top end of vertical U11′/L11′W translating east and impacting the lower cover plate of the upper chord, and with the upper portion of U11′/L11′W rotating counterclockwise looking west relative to the node (i.e., lower end moving north).
- Top cover plate was bowed down on the south side of the node.
- Part of floor truss FT11′ was attached above the node. This piece of the floor truss was compressed and deformed to the south, and the east end was bent down.
- Upper lateral brace U11′W/CU12′ was attached at the lower gusset, but separated through the rivets at the upper gusset.

L11′ West Node

- Both the east and west gusset plates were buckled and fractured near the top edge of the lower chord members.
- The lower parts of the gusset plates were continuous across the node and still connect the side plates of lower chord members L10′/L11′W and L11′/L12′W.
- The upper parts of the gusset plates were continuous above the node and still partially connect the side plates of diagonals U10′/L11′W and L11′/U12′W and the vertical U11′/L11′W.
- The lower ends of the diagonals U10′/L11′W and L11′/U12′W and the vertical U11′/L11′W were pushed downward through the node, with the diagonals and the vertical translating west relative to the lower chord.
- There was substantial damage on all members with plate separation and extensive deformation extending approximately 10 feet from the node.
- There was a large compression buckle in the L11′/L10′W lower chord adjacent to node. This area was subjected to lifting and bending loads during the removal process.
- The sway brace L11′W/CL11′ and the lower lateral brace L11′W/CL12′ were fractured from the node.
- The west flange of L11′/U10′W was fractured in two locations about 6 feet apart, both in areas of bending deformation. The lower fracture was about 1 foot above the gusset plate. The piece between the two fractures has not been identified in the recovered structure.

U10′ West Node

- Upper chord U11′/U10′W intact and has slight positive curvature.
- No portion of FT10′ was attached to the node.
- The gusset plate was buckled and fractured on the north side of the node centerline, with L9′/U10′W diagonal translating to the east and penetrating the node.
- The west side plate of the L9′/U10′W diagonal impacted the lower cover plate of upper chord U9′/U10′W, which was torn and bent upward over a length of 3 feet north of the node. The side plate of the L9′/U10′W diagonal did not contact the web of the vertical, but it did impact the center vertical stiffener (diaphragm A in the drawings) of the node several inches above the lower cover plate. This side plate of the diagonal penetrated through to the top of the node, peeling out a 2-inch by 15-inch rectangular portion of the stiffener web. The upper cover plate south of the node was separated from the side plates of the upper chord back 56 inches to the edge of the gusset plate. The side plate of the diagonal also impacted the lower surface of the upper cover plate north of the node centerline and peeled out a small 2-inch wide by 10-inch long portion of the center of the plate.
- The upper and lower cover plates of the L9′/U10′W diagonal were torn, 90 inches on the lower side into an access hole, and 110 inches on the upper side as measured from the end of the side plate. Most of the deformation in the torn area of the lower cover plate was down, and the upper cover plate was bent down over the entire damage area.
- The fracture in the east gusset plate between diagonal L9′/U10′W and vertical U10′/L10′W was in-plane tension and shear from rivets 6-7, and 7-8 (with rivets counted

from the bottom rivet on L9′/U10′W). From rivets 8-10 the fracture was primarily in-plane shear. Gusset was torn/buckled below rivet 6. The fracture pattern in this area was nearly identical to the fracture pattern in the corresponding area of the west gusset plate of node U10E (on the south side).

- The fracture in the west gusset plate between diagonal L9′/U10′West and vertical U10′/L10′W was in-plane tension and shear from rivets 5-6, 6-7, 7-8, and 8-10. Gusset was torn/bent below rivet 5.
- All portions of the gusset plates were present. There was a small piece of the east gusset plate between the L9′/U10′W diagonal and the U10′/L10′W vertical that was fractured out but the piece was recovered and identified. The "tips" of the gusset plate above the upper end of the L9′/U10′W diagonal (as found on the U10 nodes) remained with the U10′/U9′W upper chord.
- Fractures of the gusset plates through the upper chord intersect the first row of rivets north of the node centerline. Fracture was primarily tensile through the lower portion of the upper chord and tension/shear at the top, with the direction of the shear as if the south side of the fracture moved down relative to the north side.
- The east and west gusset plates were minimally distorted around the remainder of the node (diagonal L11′/U10′W, upper chord U11′/U10′W, vertical U10′/L10′W), except for buckling between the L11′/U10′W diagonal and upper chord.
- The vertical U10′/L10′W has a large buckle with substantial deformation and damage below the U10′W node and above the floor truss FT10′ attachment at FT10′L2.
- Upper lateral brace U10′W/CU11′ was fractured from the node, with residual deformation of attachment angle bent upward consistent with impact on the lower gusset from the east side plate of the L9′/U10′W diagonal.

<u>L10′ West Node</u>

- Lower chord has a distinct positive bend through the node but was intact with only minor buckling of upper cover plate near the node.
- Some localized corrosion and pitting were noted over an area of about 25 square inches in upper cover plate at the node.
- Gusset plates for the vertical U10′/L10′W had compression buckling, and the north end of east flange tip of the vertical translated down and to the west and impacted the upper surface of the lower chord.
- The east gusset plate was fractured near the top edge of the lower chord, and the west gusset plate was partially fractured about 3 inches above the top edge of the lower chord (and the unfractured portion of this gusset was subsequently torch cut).
- Vertical U10′/L10′W has a compression buckle 3 feet above the L10′W gusset plates, a hinge below M10′W (mid strut), and a small compression buckle below the lower chord attachment area for the lower chord of FT10′ (FT10′L2).
- There was a compression buckle in lower chord L11′/L10′W 13 feet south of L10′W. Location was midway between two internal stiffeners of the lower chord. Cover plates were separated from the east side plate, and the lower cover plate and east side plate were partially fractured.

- L10′/L9′W lower chord had a compression buckle 15 feet north of L10′W. There were separations at the welds between the cover plates and the west side plate and partial fractures of the west half of the cover plates and bottom portions of the west side plate.
- The sway brace L10′W/CL10′ and the lower lateral brace L10′W/CL11′ were fractured from the node, with residual deformation of the sway brace attachment angle indicating downward motion of the sway brace relative to node L10′W.

U9′ West Node

- The upper chord was intact through the node.
- U9′/U8′W upper chord has a negative bend adjacent to the node U9′.
- U10′/U9′W upper chord has a slight negative bend adjacent to the node resulting in slight buckling of the lower cover plate.
- The gusset plates were buckled and fractured along the bottom edge of the upper chord.
- Vertical U9′/L9′W has fractured from the node through the gusset plates, and the northwest corner of the vertical has partially penetrated the lower cover plate of the upper chord and partially fractured the lower cover plate.
- The upper cover plate south of the node was bowed downward from localized impact.
- A piece of the bottom flange of the upper chord of floor truss FT9′ remains attached above the node. The east part of the floor truss was bent south and down, possibly from removal damage.
- The lateral U9′W/CU10′ has separated from the node through shearing of the gusset plate rivets on the upper side of the lateral and fracture of the attachment angle on the lower side of the lateral. (Photographs indicate that the upper lateral was still attached to the node through the lower gusset immediately following the collapse.) The upper gusset was generally deformed to the south and down, possibly from removal damage.

L9′ West Node

- This node remained connected to the intact portion of the bridge that tilted to the north and rested on pier 7.
- Gusset plates were intact and minimally deformed at L9′/L10′W.
- Lower chord L9′/L10′W has negative bending and fracture in the first row of rivets of the gusset plates due to bending at node L9′W with compression buckling along the lower portions of the side plates.
- The upper and lower cover plates were fractured adjacent to the side plate fractures. The lower cover plate side welds were fractured and the plate was bent down.
- The diagonal U10′/L9′W was buckled and fractured within about 2 feet of the edges of the gusset plates. Some parts of the fractures were brittle. A triangular piece (~1 foot wide by ~1 foot high) was missing from the east side plate at the fracture. An adjacent piece of the south cover plate at an access hole was also missing.
- The diagonal has negative bending out to about 15 feet from the edges of the gusset plates and then reverses curvature slightly near U10′W node. Below the fracture, the top cover plate of the U10′/L9′W diagonal was torn and deformed down and into the member over a 2-foot length from impact.
- U8′W/L9′W diagonal and L9′/L8′W lower chord members were intact and not bent. Lower portion of the vertical was bowed south consistent with the fracture at node L9′.

- Vertical U9′/L9′W has a hinge below the floor truss FT9′ lower chord attachment at FT9′L2 and was fractured from node L9′W through the side plates at the 3rd rivet line from the top. A local buckle was present in the north side plate near the L9′ end. The cover plates on vertical U9′/L9′W had scraping damage adjacent to the fracture.
- The sway brace L9′W/CL9′ and the lateral brace L9′W/CL10′ were fractured from the node, with residual deformation of the gussets and/or angles indicating downward motion of the braces relative to node L9′W.
- There was moderate corrosion and pitting on the top surface of the lower gusset for the sway brace L9′W/CL9′ and the lateral brace L9′W/CL10′.
- There was some minor pack rust between the inside of the gusset plates and the top cover plates of the lower chord members.
- There was some paint loss inside the node.

U8′ West Node

- This node remained connected to the intact portion of the bridge that tilted to the north and rested on pier 7
- All members attached.
- U8′/U9′W upper chord was bent down approximately 75 degrees and slightly east adjacent to the node. Photographs show this upper chord member just east of intact main truss structure immediately after the collapse.
- Gusset plates were intact with no deformation except slight bending deformations at isolated section at upper chord U8′/U9′W.
- All floor truss and bracing members still attached to main trusses.
- Lateral brace U8′/CU9′ hinged approximately 4 feet from the node.

L8′ West Node

- This node remained connected to the intact portion of the bridge that tilted to the north. The south end of the node was resting against the north side of pier 7 near the top of the pier.
- Node and gussets intact, with no deformations.
- Bearing separated through pintle failure (pintle missing from bottom of node) with lower bearing casting still on pier.
- The top surface of U8′/U9′W has some paint loss.
- The top surface of the sole plate has some corrosion.
- The lateral brace L8W/CL9′ was fractured from the node.
- The lower gusset for the lateral brace L8′W/CL9′ had heavy localized corrosion with an estimated 50 percent section loss adjacent to its connection to the sway brace L8′W/CL8′.
- The lower cover plate of sway brace L8′W/CL8′ had some corrosion with an estimated 30 percent section loss. The interior stiffener of sway brace L8′W/CL8′ had corrosion with an estimated 50 percent section loss.
- The gusset plates had some minor surface corrosion and paint loss.
- There was some minor pack rust between the inside of the gusset plates and the top cover plates of the lower chord members.

Other Structural Members, Nodes 12′ to 8′

Floor Truss 11′

FT11′ was recovered from the river, approximately in line with nodes 11′ East and West. The floor truss was generally in its original position with respect to the main trusses. The general vertical section shape of the interior of the floor truss was consistent with vertical compression loads resulting in bending south of the web members at their connection to the lower chord and the restraint or reverse bending of these same members at or near their connection to the upper chord.

Except for some additional deformation of the floor truss lower chord east end and a fracture at the lower chord west end, which were labeled as recovery damage, the deformation and damage of the floor truss was very symmetric about its centerline. The floor truss upper chord was intact between its riveted splices but both splices had failed, and it was bowed primarily to the south. The floor truss lower chord remained attached to the main truss verticals, and was bowed to the north. At the three nodes on the floor truss lower chord between the main truss verticals where web member were attached (FT11′L4, FT11′L6, and FT11′L9) the lower chord was rotated to the south relative to the web members, with severe deformation of the gusset plates at all three locations and complete gusset plate fracture at FT11′L4 and FT11′L9 and localized cracking at FT11′L6.

On the west cantilever, the floor truss upper chord cross-section was collapsed just west of the connection location to the west main truss and fractured at the main truss node (U11′ West) from downward bending. The stringer attachment location above main truss node U11′ West had been pressed downward into the upper chord of FT11′. Fractures and deformation at the gusset connections FT11′U0 and FT11′U1 both indicate bending due to the upper chord moving south with respect to FT11′U0/L2 and FT11′U1/L2. Residual deformations at the FT11′L2 gusset on the west side of U11′ West indicate that this gusset also fractured from bending down and to the north.

On the east cantilever, the floor truss upper chord cross-section was collapsed just east of the connection location to the east main truss and fractured at the main truss node (U11′ East) from downward bending. Fractures and deformation at the gusset connections FT11′U13 and FT11′U14 both show fracture under compression with the upper chord moving south with respect to FT11′L10/U13 and FT11′L10/U14. The lower tip of FT11′L10/U14 penetrated downward into the northeast corner of the U11′/L11′ East main truss vertical.

At the top of both of the U11′ main truss nodes (West and East), the floor truss upper chord was compressed with the top flange translated to the south. Also, the top chord was separated at both the west and the east riveted splices between the primarily outboard 12WF53 sections and the central 12WF106 section. In both cases, the structural members on each side of the splice were generally intact, but rivets were sheared, which permitted separation at the splice.

Similar fractures occurred on both the east and west sides of the floor truss where the upper ends of web diagonals FT11′L2/U3 and FT11′L10/U10 fractured from the upper chord. In both cases, the gussets at FT11′U3 and FT11′U10 fractured at the top ends of the diagonals due to bending with the upper chord moving down and to the south with respect to the web members.

The west half of the gusset plates for the upper laterals was still attached at this location, but lateral member CU11′/U10′ West was torch cut approximately 18 inches from the edge of the gusset connection during recovery. The east lateral was not present, but residual deformation of its connection gusset plates suggests that it separated by fracture from a combination of bending/twisting and tension.

Neither kicker was attached to the floor truss. At the FT11′L4 kicker connection, the west attachment plate was relatively undamaged and the east plate was bent east 90 degrees inboard; the pin was not present. At the FT11′L9 kicker, the east plate was undamaged and the west plate was bent west 45 degrees inboard; the pin remained in the west plate.

Floor Truss 10′

FT10′ was recovered from the river with the north face generally down and a large section of deck resting on the south face. All parts of the floor truss were generally found aligned with nodes 10′ East and West.

West cantilever diagonals FT10′U0/L2 and FT10′U1/L2 were separated from the west face of main truss vertical L10′/U10′ West by a vertical fracture through the gusset plate at FT10′L2. Members FT10′U0/L2 and FT10′U0/L1 were also separated from the upper chord by horizontal fractures through the gusset connections at FT10′U0 and FT10′U1. At FT10′U0, the gusset plate fractured. Member FT10′U0/L2 was bent north near mid-span with impact damage in the bend. Member FT10′U1/L2 showed impact damage with the member slightly rotated to the north at FT10′L2. The floor truss upper chord in the west cantilever was bent upward approximately 90 degrees at FT10′U1 and substantially damaged between FT10′U1 and the splice area. The web and upper flange of the floor truss upper chord were fractured above main truss node U10′ West, and the web was separated from the bottom flange of the floor truss upper chord in this area. The upper chord was flattened above node U10′W, with the top flange twisted to the south relative to the bottom flange. The lower flange was also split and partially fractured between FT10′U1 and FT10′U2. The remaining connected portion of the lower flange was torch cut approximately 2 feet outboard of node U10′ West.

The floor truss upper chord was separated from the top of main truss node U10′ West by fractures in connection components and fasteners. A portion of the upper cover plate of main truss upper chord U9′/U10′ West remained attached to the floor truss upper chord, and this portion of the cover plate retained a rectangular tab approximately 4 inches long and 2 inches wide pointing north. The lower surface of the attached cover plate and fasteners showed several wide metal-to-metal impact marks in line with the rectangular tab. Similarly shaped markings were also found on the floor truss upper chord web above this location. Additional marks were located about 20 inches to the east on the lower surface of the upper lateral brace bracket. The lower flange of the floor truss upper chord was bent 90 degrees downward at the east and west

edges of the main truss U10′ West node. The web of the floor truss upper chord was deformed and collapsed in the region above the main truss node.

All structural members were present at the riveted splice between the outboard upper chord section and the central chord section of the floor truss. However, several rivets were fractured and/or missing. The upper chord was torch cut inboard of the splice adjacent to FT10′U3.

The floor truss lower chord and web member FT10′L2/U3 were separated from the west side of main truss vertical L10′/U10′ West by a vertical fracture through the gusset plate at FT10′L2, with only a small portion of the gusset plate remaining on vertical U10′/L10′ West. Residual deformation indicated that the fracture occurred through bending from northward displacement of the floor truss lower chord and FT10′L2/U3 relative to main truss vertical L10′/U10′ West.

The floor truss web diagonals and verticals between the east and west main truss positions were largely intact, but all of these members (except possibly FT10′L6/U8) had impact damage and local flange buckling of varying severity along their lengths, especially on their south sides.

Members FT10′L6/U6 and FT10′L6/U7 framed in the connections for the upper lateral braces at CU10′. Both of these members were deformed to the north. Member FT10′L6/U6 had a large area impact mark near mid-span that bent the south edges of its flanges. Member FT10′L6/U7 also was impacted on the south side in two locations that bent the south edges of its flanges.

The CU10′ connection plate fasteners at the floor truss upper chord were fractured and/or missing and the upper plate of the connection was not attached to the floor truss. The upper flange of the framing member attached to the lower brace connection was torn out around the fasteners, and the bottom flange of the cross member was twisted.

Floor truss member FT10′L10/U10 was separated from the floor truss lower chord and the main truss vertical L10′/U10′ West by vertical and horizontal fractures in the gusset plate. Residual deformation indicates fracture as a result of compression buckling and bending of the floor truss lower chord.

The east end of the floor truss upper chord was fractured in two locations. One location was 17 inches outboard of the east splice. Residual deformation indicated twisting of the top flange to the south. All structural members of the splice were present, but some rivets were fractured and/or missing.

The second location of a floor truss upper chord fracture was east of the east main truss. At this fracture the lower flange of the floor truss upper chord was fractured through the first or second eastern bolt holes for the bolts between the floor truss and node U10′ East, and the upper

flange and web were fractured several feet further east. The portion of the upper chord of the floor truss between the two fractures was not recovered.

East cantilever diagonals FT10′L10/U13 and FT10′L10/U14 were separated from the east side of main truss vertical L10′/U10′ West by a fracture through the gusset plate at FT10′L10. Residual deformation indicated that the fracture occurred after twisting and compression buckling. Member FT10′L10/U13 separated from the upper chord along the weld at the gusset connection at FT10′U13. Areas of inadequate fusion were visible in the failed weld. Member FT10′L10/U14 was separated from the floor truss upper chord by a fracture through the FT10′U14 gusset. Residual deformation indicated that the floor truss upper chord rotated with the upper flange moving to the south. Between FT10′U12 and FT10′U13, the floor truss upper chord was substantially damaged from vertical compression and was twisted 90 degrees with the top flange south. At FT10′U13, the floor truss upper chord was bent 45 degrees with the outboard end to the south.

The kicker at FT10′L4 was still in place, but torch cut at approximately 18 inches from the pin connection. The kicker and the floor truss lower chord showed impact damage consistent with the kicker rotating into the top flange of the floor truss lower chord.

The kicker at FT10′L9 was missing, but the pin remained in the west plate. The west plate was bent to the west approximately 45 degrees, and the east plate was bent to the east approximately 10 degrees.

The east half of the portion of the floor truss upper chord between the east and west main trusses was slightly bowed southward until a reverse bend at a damage area near FT10′U9. The west side was deformed and substantially bowed to the north. A long metal to metal scrape mark was visible on the upper south edge of the upper flange extending from FT10′U3 to the midpoint between FT10′U5 and FT10′U6 with an impact at the east end of the mark that deformed the upper flange upward. Additional deformations of the upper flange were noted on the east and west side of FT10′U3 and the east side of FT10′U4. These deformations locally bent the south edge of the upper flange downward and were consistent with contact with the floor stringers.

Between the east and west main trusses, the lower chord of FT10′ was bent to the north just east of FT10′L4 with the deflected lower chord approximately 8 feet farther north than the main truss attachments. A second larger diameter bend to the north was noted in the lower chord centered at FT10′L6. The remainder of the lower chord was generally straight. There was minimal vertical deformation of the floor truss lower chord between the main trusses. The floor truss lower chord was torch cut approximately 3 feet west of the connection to the east main truss vertical L10′/U10′ East. Between the torch cut and node FT10′L9, the lower chord was twisted 90 degrees, upper flange to the south. Outboard of the torch cut, the lower chord was still attached to the main truss vertical and shows twisting of 45 degrees, upper flange to the north. This twisting damage was consistent with rotation of the top of the main truss vertical to the north at the floor truss lower chord attachment.

Floor Truss 10′ Sway Braces

The sway brace members at FT10′ were buried under the concrete deck and it was not possible to determine whether or not they remained attached to the main truss verticals after the collapse. Based on post-removal survey of the main truss verticals, at U10′/L10′E the mid horizontal strut was pulled from the vertical primarily in tension with gross section fractures through the corners of the attachment angles on both sides. At U10′/L10′W the mid horizontal strut was pulled from the vertical with bending to the south and upward - gross section fracture through the attachment angle on the south side with prying that increases toward the bottom of the connection, and gross section fracture through the connection plate on the north side with slight compression buckling at the top of the connection and a partial fracture through the attachment angle at the bottom of the connection.

Lower Lateral Brace Nodes 9′ to 10′

The lower lateral braces were both detached at nodes L9′E and L9′W. At L9′W, the top connection plate to the lateral had a partial fracture extending from the north end suggesting the lateral was pulled to the south. The top connection plate was also bent downward, consistent with the post-collapse position of the lateral.

Upper Lateral Brace Nodes 9′ to 10′

The east upper lateral brace was detached at U9′E. The west upper lateral brace was only attached at U9′W through the attachment gusset plate. At both U9′E and U9′W, the top connection plates had been pulled south resulting in compression buckling along the south edge of the plates. The upper lateral braces were still attached to each other at CU10′, but were detached from FT10′.

Floor Truss 9′

The central portion of FT9′ and the east cantilever of this floor truss were located at or south of pier 7, connected to the upper segment of main truss vertical L9′/U9′ East. The west cantilever at this floor truss location was separated from main truss vertical L9′/U9′ West but was found lying near the west end of FT9′ on top of the deck in the water. The center portion of the lower chord of FT9′ was attached to the vertical at FT9′L10. Vertical L9′/U9′ East was also nearly completely fractured just below the lower connection to FT9′.

The west end of the lower chord of FT9′ was attached to main truss vertical L9′/U9′ West. The gusset plate at this location was bent almost 90 degrees to the south at this vertical member (the gusset at this bend was subsequently torch cut). Vertical L9′/U9′ West was buckled and bent slightly below FT9′.

Both the east and west cantilever floor truss upper chords fractured at the connections at the top of the main truss (nodes U9′ East and West) by bending. However, the two riveted splices in the top chord remained intact. The gusset connections between the cantilever diagonals and the main truss verticals fractured under compressive buckling and bending to the south.

The deformation to the central portion of FT9′ was approximately symmetrical. The floor truss upper chord was bowed to the south approximately 10 feet. The top flange of the floor truss upper chord has been locally rotated and deformed northward at FT9′U3 through FT9′U10, buckling the vertical stiffeners on the north web face. The attachments for the central connection of the upper lateral brace on the north side of the upper chord of FT9′ showed sheared rivets and fractured pieces indicating initial tension to the north in the lateral braces. The separated upper lateral brace members between main truss nodes U8′ and CU9′ were still attached to each other at the CU9′ ends and hinged down near the U8′ nodes.

Both kicker braces were attached to the floor truss but separated from their stringers. The kicker braces were smoothly curved and twisted downward along their length. Both kicker braces came to rest against the upper chord of FT9′, with some impact damage at each location.

Floor Truss 9′ Sway Braces

Nodes CM9′ and CL9′ fell into the river just south of pier 7, and were positioned between the end of the collapsed deck slab at node 8 and pier 7. Node CL9′ was positioned slightly east of the longitudinal centerline of the bridge. Node CM9′ was positioned just south and approximately 15 feet east of CL9′. All the sway members were completely detached from the east and west truss verticals and nodes L9′E and L9′W, but most were at least partially attached to each other. At CL9′ the lower sway diagonals were detached from CL9′, but still attached to each other, with the CL9′ ends positioned north and approximately 20 feet east of CL9′. Both lower sway diagonals were still at least partially attached to the mid sway horizontal strut at the M9′E and M9′W ends. At CM9′, the west mid sway diagonal was still attached and the east mid sway diagonal was detached.

At U9′/L9′E, the mid horizontal strut pulled from the vertical primarily in tension, perhaps bending to the south, with net section fracture along the rivets on the vertical on the north side and prying initiating partial net section fractures along the rivets on the vertical on the south side. The vertical was bent slightly to west near M9′E consistent with tension loading of the strut. At vertical U9′/L9′W, the mid horizontal strut pulled from the vertical primarily in tension, perhaps bending to the south, with gross section fracture through the corners of the attachment angles and prying of the angles on both sides, and partial net section fracture through the top rivets on the vertical on the north side.

Lower Lateral Brace, Nodes 8′ to 9′

The east lower lateral brace remained attached at L8′E. The west lower brace was detached from L8′W. Both lower laterals were still attached to the lower sway horizontal strut at CL9′, which fell to the river just south of pier 7.

Upper Lateral Brace Nodes 8′ to 9′

Both the upper lateral braces remained attached at U8′W and U8′E nodes and still attached to each other at CU9′, but were detached from FT9′. The upper laterals hinged just south of the haunches at the U8′W and U8′E ends, with the CU9′ ends displacing downward as a result of the detachment at FT9′.

Floor Truss 8′

The floor truss was intact and generally straight and undistorted between the east and west main trusses. The upper chord portions of the west and east cantilevers were also intact and did not have bending deformation but were twisted with slight rotation to the north.

Floor Truss 8′ Sway Brace

The lower and middle sway braces were intact and undamaged.

U9′/L9′E Mid Strut:

- Pulled from U9′/L9′E vertical primarily in tension, perhaps bending to the south.
- Vertical U9′/L9′E was bowed slightly to the west consistent with tension loading by the strut.

U10′/L10′E Mid Strut:

- Pulled from vertical primarily in tension, similar fracture on both sides with fracture in the corner of the attachment angles.

U10′/L10′W Mid Strut:

- Some compression buckling in north side with the attachment plate buckled and fractured adjacent to the attachment angle, and primarily tension fracture of attachment angle on south side.

U9′/L9′W Mid Strut:

- Pulled from vertical U9′/L9′W primarily in tension, perhaps some bending to the south, with some fracture adjacent to angle rivets on vertical on north side.

Node 8′ to Node 4′

East Main Truss, Nodes 8′ to 4′

L7′/L8′ East
- Attached to nodes with no deformation.

L7′/U8′ East
- Attached to nodes with no deformation.

U7′/U8′ East
- Attached to nodes with no deformation.

U7′/L7′ East
- Attached to nodes with no deformation.

U7′ East Node
- Gussets intact with no deformation.

L7′ East Node
- Gussets intact, with no deformation.

L6′/L7′ East
- L7′ end was slightly displaced east with 30 degree bend/buckle adjacent to gussets.
- Separation between top flange and side plates adjacent to L7′.
- Top flange fractured at access hole adjacent to L7′.

U6′/L7′ East
- Attached to node with no deformation.

U6′/U7′ East
- Attached to node with no deformation.

U6′/L6′ East
- Flanges were wavy at the south edges due to bending from U6E′ (compression buckling of flanges due to buckling of member north). This extends from U6E′ to approximately 10 feet along member.
- 180 degree buckle/bend to south approximately 10 feet above L6E′.
- 30 degree buckle/bend to north approximately 8 feet below FT6′L10.
- L6′ end was fractured through gussets and buckled with gross section failure on west gusset between vertical and lower chord and net and gross section failure on east gusset at top line in lower chord.
- M6W′-CM6′ and M6W′-CL6′ was partially attached.
- FT6′L2 was still attached.

U6′ East Node

- Floor truss and bracing were still attached.
- All members attached with no deformation of gussets.
- Displaced approximately 25 feet north of L6′ and resting approximately 10 feet above ground.

L6′ East Node

- Sway and lateral bracing still attached, with deformations.
- Impact damage on top of lower chord from vertical member.
- West gusset has gross section failure between the vertical and the lower chord.
- East gusset has gross and net section failure at the top row of bolts in the lower chord.
- Lower chord intact through node.

L5′/L6′ East

- At L5′ end, side plates buckled to the east consistent with rotation of L5′ node.
- At L5′ end, separation between top and side plates near node with fracture in top flange at access hole.
- L6′ end was slightly displaced west relative to L6′ node, just north of gusset.
- L5′ end was crushed from U6′/L5′ East, U5′/L5′ East, and U5′/U6′ East above and block retaining wall below.
- All but north end of member was straight and resting on ground.

L5′/U6′ East

- Severely distorted.
- At U6′ end, the member was attached to the gussets.
- Just below the U6′ gusset, a nearly 180 degree bend to the east and up, then 180 degree bend to the west and down.
- Approximately 12 feet below the westward and downward bend, the member punctures the roadway/ground and then bends 160 degrees to the north and bent over L5′/L6′ lower chord near L5′.
- Web fractured for up to an approximate 6 foot length from U6′ due to distortion.
- L5′ end attached to gussets.
- Underground electrical line shorted from diagonal L5′/U6′ impact.

U5′/U6′ East

- Attached at U6′ end with compression buckling just north of gusset and approximately 30 degree upward rotation relative to U6′.
- Resting on U5′/L5′ East.
- Buckle 10 feet south of U5′ with 20 degree rotation.

U5′/L5′ East

- Detached from U5′ through net section failure of gussets.
- L5′ end detached from node through rivet failure.

- L5′ end located 8 feet south of L5′ node with U5′/U6′ resting on it.
- Severe compression buckle below FT5′L10.

U5′ East Node
- Vertical L5′/U5′ detached from node through net section failure of gussets.

L5′ East Node
- L5′/U4′ diagonal gusset separated from node with gross and net section fracture.
- Rivets sheared at L5′/U5′ vertical.
- Node deformed around large retaining wall block.
- Gusset at top of lower chord bent 90° to west.
- L5′/L6′, L5′/U6′, and L5′/L4′ gusset intact and deformed. Partially obscured by retaining wall block, truss members, and concrete.

L4′/L5′E
- Member mostly lying on ground and partially obscured by concrete.
- Up to 3 feet from L5′ East, top cover plate fractured at west side plate and top of side plates rotated east relative to L5′E.

U4′/L5′E
- Net section fracture through gussets at U4′ East.
- Member generally straight and on ground. Lying on east side.
- Gross and net section fracture of gusset at L5′ East

U4′/U5′E
- Negative buckling/plastic hinge and separation of side and cover plates 1 foot from U4′ East with 45 degrees of rotation.
- Positive buckling and separation of cover plate near midspan with 10 degrees of rotation.
- Compression buckling and separation of side and cover plates near U5′ East node.

U4′/L4′
- Bent 120 degrees, just below FT4′L10 so in vertical position. About 7 feet from U4′ East node bent about 80° down, with impact from concrete at bend.

L4′ East Node
- Gusset fractured along top plate of lower chord partially obscured by concrete and adjacent U4′/L5′ East diagonal.
- Vertical impacted lower chord causing compression distortion.

Remaining portion of east main truss was intact and contained in the large intact portion of the truss that rotated to the north.

West Main Truss, Nodes 8′ to 4′

The following members and nodes north of Node 8′ were intact and were contained in the large intact portion of the truss that rotated to the north: L7′/L8′ West, L7′/U8′ West, U7′/U8′ West, U7′/L7′ West, L7′ West Node (West gusset and east gusset were bent west at lower chord member L6′-L7′ from impact with ground), U7′ West Node, U6′/L7′ West, and U6′/U7′ West.

L6′/L7′ West

- Attached to L7′ node gussets.
- Buckled adjacent to L7′ with 30 degree upward rotation and lateral translation to west relative to L7′ node.
- Welds between top cover plate and side plates separated adjacent to L7′.
- Impact damage to top plate at L6′ end due to L6′/U6′ vertical.

U6′ West Node

- Located approximately 25 feet north of L6′ West and 10 feet above ground.
- Rotated approximately 45 degrees to north.
- West gusset was fractured (gross section) approximately 1 foot in length at the north edge and along the bottom of the upper chord. The west gusset was deformed/bent east with L5′/U6′ and 3 rivets were popped out of L5′/U6′ connection.
- East gusset was not fractured, but was deformed to the east with L5′/U6′ and 2 rivets were popped out of U5′/U6′.
- Floor truss upper chord and bracing members were attached.

U6′/L6′ West

- Member was bent 135 degrees to north just below FT6′L2, and then bent 135 degrees south approximately 6 feet below FT6′L2 (i.e., “S” kinked).
- Slight buckle/bend south approximately 8 feet above L6′ (impacted lower chord).
- Member was fractured at U6′ end (net section through lowest line of bolts in the vertical member) and web also fractured.
- The L6′ end was fractured through gussets (gross section between vertical and lower chord members), and also fractured down the web due to impact/compression on L6′/L7′.
- M6W′/CM6′ was still partially attached, but M6W′/CL6′ was detached.

L6′ West Node

- Floor truss 6′ was still attached, with partial fracture of gussets.
- Sway bracing and lateral bracing were partially attached. The sway bracing was failed through net section at the top attachment angle. The bottom plate was not failed. The lateral bracing was partially failed through gross section at the top attachment angle. The bottom plate was not failed.
- L6′/U6′ vertical detached through gross and net section failure of gussets.

U5′/L5′ West

- Lying horizontal between U5′/U6′ and L4′/L5′ above FT5′L2. Below FT5′L2 severe plate separation and distortion for about 4 feet.
- L5′ end detached from node and partially attached to gusset.

- Detached from U5´ through fracture of gussets.

L5′/L6′ West

- The L6′ end was slightly bent to the east just north of L6′ node and partially fractured in the east side plate.
- The L5′ end was crushed between the block retaining wall, L5′/U6′, and U5′/U6′.
- A separation exists between the cover plates and side plates for 10 feet south of L5′.

L5′/U6′ West

- L5′ end was detached and displaced to the west of L5′ node with 180 degree bend located 15 feet from L5′ end.
- Center portion of member was crushed between U5′/U6′ West and L5′/L6′ West.
- Flanges at U6′ end were attached at U6′ node, except for a few rivets.
- The web was torn from the flanges for a distance of approximately 4 feet from U6′ node. The member was bent to the northwest approximately 3 feet below U6′ node.
- Member was bent to east with gusset plates.

U5′/U6′ West

- U5′ end intact and generally straight.
- Member was bent upward at north side of U6′ West node with 45 degree rotation. The plates were separated with side plates buckled outward just north of U6′.

U5′ West Node

- Net section fracture through gusset for U5′/L5′ through first lower rivets of upper chord.
- Node located approximately 25 feet to north of L5′ West.

L5′ West Node

- Node crushed retaining wall.
- East face of L5′/U4′ attached to node.
- Side plates of lower chord intact across node.
- West gusset fractured at top of lower chord.
- East gusset fractured at top of lower chord from south and continued above L5′/U4′ to north.

L4′/L5′

- Attached to gussets at L5′ with top and side plate separation.
- Lying on ground underneath U5′/L5′ and U5′/U6′.

U4′/U5′

- Negative buckle near U4′ West node, generally straight.

U4′/L5′ Diagonal

- Net section gusset fracture at U4′.
- Member generally straight along length.

- East gusset at L5′ intact. West gusset at L5′ net section fracture.

Other Structural Members, Nodes 8′ to 4′

Lower Laterals, Nodes 7′ to 8′

Both lower laterals were intact and straight. Some gusset distortion was present at node CL8′ with some rivets sheared.

Upper Laterals, Nodes 7′ to 8′

Both upper laterals were intact and straight.

Floor Truss 7′, Sway Brace

The lower and middle sway braces were generally intact and straight. Slight distortion was present at the gussets of node M7W′. In addition, slight negative curvature was present along the length of lower lateral sway brace L7W′-CL7′-L7E′ with slight buckling of the bottom plate of the lateral at node CL7′.

Floor Truss 7′

The floor truss was intact and generally straight between the east and west main trusses. The upper chord has slight curvature to the north. The west and east cantilevers were also intact and straight with more noticeable rotation and slight twisting to the north.

Lower Laterals, Nodes 6′ to 7′

Both lower laterals were intact and straight. Some gusset deformation was present at L7W′.

Upper Laterals, Nodes 6′ to 7′

Both upper laterals were intact and straight with slight gusset deformation at node CU7′.

Floor Truss 6′, Sway Brace

Lateral sway brace L6W′-CL6′-L6E′ was intact and lying on the ground. The gussets were distorted at CL6′. Sway brace CL6′-M6W′ was straight but was detached at M6W′ due to fracturing of the member and gusset connection plate. Lateral sway brace M6W′-CM6′-M6E′ was lying on its north face on top of the lower laterals with slight positive curvature due to the M6W′ and M6E′ ends being displaced further north than node CM6′. Node CM6′ was also slightly north of node CL6′. Diagonal sway braces FT6′L2/CM6′ and FT6′L10/CM6′ were attached, intact and straight although they were oriented north face down. The connection gussets at nodes FT6′L10 and FT6′L2 were slightly distorted and these ends of the members were also slightly distorted. This curvature resulted in the side plate separating from the top plate at the east end of brace M6W′/CM6′ near node CM6′. The gussets of node CM6′ were also distorted.

Floor Truss 6′

The floor truss was intact between the main trusses. The lower chord exhibited slight positive or downward curvature between nodes L2 and L10. Slight distortion was also visible

along the length of the upper chord with mild double curvature (west and east sections of floor truss rotated to the north, center section of floor truss at node CU6′ rotated to the south). All floor truss gussets were intact.

Lower Laterals, Nodes 5′ to 6′

Lateral L5E′-CL6′ was straight and intact with slight distortion of the top plate near mid-length. This member was still attached at CL6′ and was still attached to the connection plate adjacent to lower lateral sway brace L5E′-CL5′; however, that connection plate and the lower lateral sway brace were detached from main truss node L5E′. Lateral L5W′/CL6′ was similar to L5E′/CL6′ although the L5W′ end was obstructed from view on the retaining wall. Node CL6′ was lying on the ground and the gussets were distorted.

Upper Laterals, Nodes 5′ to 6′

Laterals U5W′/CU6′ and U5E′/CU6′ were still attached to the east and west main trusses at U5W′ and U5E′ although the gusset connection plates exhibited distortion. The laterals wrap up and over top of the concrete retaining wall, and exhibited associated distortion, but both upper laterals were still connected at CU6′. The CU6′ gusset was distorted.

Floor Truss 5′, Sway Brace

The lower lateral sway brace L5W′/CL5′/L5E′ was located along the top of the concrete retaining wall and was distorted along its length. L5E′/CL5′ has detached from node L5E′. The CL5′ node was obstructed by concrete debris. The diagonal sway braces FT5′L10/CL5′/FT5′L2 appear to be at least partially attached to the floor truss lower chord at both FT5′ nodes. The CL5′ ends of these diagonal sway braces were wrapped up and over the concrete retaining wall, with associated distortion, and were detached from the CL5′ node as a result of the gussets fracturing. The CL5′ ends were crushed into each other and the gussets were significantly distorted and buckled.

Floor Truss 5′

Floor truss 5′ was generally lying on the ground, or on debris, on its north face. The upper chord has curvature along its length. The upper chord was still attached to the east main truss at FT5′U12 and this section of the floor truss was generally plumb with slight rotation to the north. The upper chord portion of the east cantilever was rotated to the north and has a partial fracture in the web and a complete fracture of the lower flange at FT5′U12. The upper chord was distorted at FT5′U2 with the web fracturing from the bottom flange over main truss node U5′ West. The upper chord portion of the west cantilever was rotated to the north and distorted over the west main truss. The lower chord was wrapped up over top of the concrete retaining wall, or lying on the ground on its north face, and was significantly distorted. Gusset fractures were visible at FT5′ nodes L6 and L4 due to the lower chord wrapping over the concrete wall. The lower chord still appears attached to the east main truss vertical (L5E′/U5E′) at FT5′L10 and the west main truss vertical (L5W′/U5W′) at FT5′L2 although the verticals were buckled and were lying on the ground almost horizontally on their north faces.

Lower Laterals, Nodes 4′ to 5′

Laterals L4W′/CL5′ and L4E′/CL5′ were generally straight and intact with denting of the top plate at several locations along their length due to debris and collapse-related impacts. Both members were wrapped up over top of the concrete retaining wall and exhibited associated buckling and distortion. These members were still attached at both ends with rivet failures on one of the gusset connection plates at node CL5′ for each member (either top or bottom plate).

Upper Laterals, Nodes 4′ to 5′

Laterals U4E′/CU5′ and U4W′/CU5′ were intact and generally straight. Lateral U4E′/CU5′ was partially attached at U4E′ in the bottom connection plate with fractures in the top plate. Heavy corrosion was present at the top connection plate with several small perforations of the plate visible. U4E′/CU5′ exhibited positive curvature and buckling approximately 5 feet away from the U4E′ node with the majority of the member lying on the ground/debris. Additional negative curvature and buckling was present near mid-length where the member was wrapped up and over L4E′/CL4′ which was lying on the ground. Lateral U4W′/CU5′ exhibited buckling and negative curvature at the tapered end adjacent to U4W′ with additional buckling and positive curvature approximately 4 feet away. Both laterals may still be attached at CL5′ although this connection was obstructed by debris.

Floor Truss 4′, Sway Brace

Sway brace CL4′/FT4′L10 was detached from the floor truss lower chord, fracturing in the gusset connection plate. Impact damage was present on the member approximately 6 feet west of this node where the lower chord of FT4′ landed on top of the member. The member was lying on the ground with the FT4′L10 end located approximately 18 feet north of the CL4′ end.

At node CL4′, a partial net section fracture was present in the gusset at the connection of FT4′L10/CL4′ with an additional fracture below this connection at the east end of the south gusset due to northward translation of FT4′L10/CL4′. The west half of the gussets were also distorted due to the diagonal sway brace FT4′L2/CL4′ falling to the ground north of node CL4′. Sway brace FT4′L2/CL4′ was generally straight and still attached at CL4′ although it was lying on the ground to the north of the CL4′ node. The connection of sway brace FT4′L2/CL4′ was obstructed from view at the lower chord of FT4′.

Floor Truss 4′

The upper chord of FT4′ was leaning to the south, relative to the lower chord, in the section east of node U5, and was bent and distorted to the north between nodes U2 and U5. The upper chord was completely fractured at node U12. The lower chord was significantly distorted between nodes L8 and L10 but was still connected to the east main truss vertical L4E′/U4E′. The lower chord exhibited northward rotation below the west half of the truss with significant associated twisting and distortion of the truss members at and west of node L4 (i.e., L4-U5, L4-U4, and L4-U3). The lower chord was still connected to the west main truss vertical L4W′/U4W′ The gusset at node U3 was partially fractured with a truss diagonal unattached. Light corrosion of the floor truss upper chord was present between nodes U9 and U12 with more moderate corrosion of the upper cord portion of the east cantilever. The upper portion of the east cantilever

was rotated to the north and down, and the diagonals L10-U13 and L10-U14 were fractured from the east truss vertical L4′/U4′E through the gusset. The upper portion of the west cantilever was crushed and rotated to the north at node U2 such that the web was lying on the main truss upper chord and the web and bottom flange were fractured. The west diagonals L2/U0 and L2/U1 were still attached to the main truss vertical L4W′/U4W′ with a partial fracture in the gusset. These floor truss members were rotated to the north and sandwiched underneath main truss member U4W′/U5W′ as a result of buckling of the vertical. Diagonal U0/L2 was still attached to the upper chord portion of the west cantilever U2/U0.

Node 4′ to Node 0′

East Main Truss, Nodes 4′ to 0′

U4′ East Node

- Located approximately 18 feet north of L4′ East node.
- Gussets had surface corrosion and some pack rust around upper chord rivets just south of centerline of node.
- East and west gusset plate has block shear/net section failure through gusset at U4′/L5′.
- U4′/L4′ was still intact at node, but buckled/partially fractured within the U4′ connection.
- U4′/L3′ was still attached at U4′ East and was buckled just below U4′.
- U3′/U4′ and U4′/U5′ intact through node.

L3′/L4′ East

- Generally intact and straight.
- Slight buckle of top cover plate near L4′ adjacent to compression damage from vertical at node.

L3′/U4′ East

- L3′ end detached from node and displaced approximately 18 feet north and 6 feet east of node.
- L3′ end severely deformed with side and cover plates separated up to 5 feet from node.
- Attached and buckled below U4′.
- The cover plates were separated from the side plates for about 3 feet from compression.

U3′/U4′ East

- Intact at both ends.
- Impact buckle of top plate at U4′ end.
- Upward bend of south half of member.

U3′/L3′ East

- Net section failure of gusset at U3′ end; U3′ end was approximately 2 feet south from U3′ node and under U3′/U4′.
- Detached at U3′ node with L3′ obscured by concrete.
- L3′ end west of L3′ node.

L3′ East Node

- Obscured by concrete debris.
- East gusset deformed.
- West gusset severely distorted and partially fractured.
- Diagonals and vertical not attached.

U3′ East Node

- Gross and net section failure of both gussets at bottom row of rivets in upper chord and bottom of upper chord. The vertical member was not attached.
- Bottom flange of upper chord distorted at the access holes due to impact of U3′-L3′.
- U3′ was located approximately 20 feet to north of L3′.
- CM4′/U3′ lateral was fractured at top plate through rivets. Connection angle from lower plate lateral detached from U3 East. Deformation of gusset and member at the attachment to main truss.
- FT3′ was fractured on the east side above the main truss between the floor truss upper chord web and the bottom flange (bottom flange of floor truss remained attached to main truss upper chord).

L2′/L3′ East

- Generally intact and straight.
- Buckling adjacent to north side of L3′ node with separation of top cover plate to side plates.

U2′/L3′ East

- Still attached at the U2′ node, but buckled just below U2′.
- Fractured through member at L3′ east flange and through gusset at L3′ west flange.
- Member intact and straight with south end approximately 6 feet north and 3 feet west of L3′.

U2′/U3′ East

- The U2′ end was partially attached and intact.
- Member intact at U3′.
- North end of top cover plate detached from side plates up to south end of gusset at U2′.

U2′/L2′ East

- Still attached to U2′ west gusset, and partially attached to U2′ east gusset.
- Severely distorted between U2′ and FT2′.
- L2′ end was buckled above node with web separated from flanges. Flanges were still attached to gussets.
- Both sides of FT2′ were still attached at FT2′L10.
- All but the east flange was fractured just below FT2′L10.

L2′ East Node

- L2′/U2′ flanges attached to gussets but web separated from flange within gusset.
- East and west gussets distorted along top edge of lower chord.

U2′ East Node

- Located approximately 15 feet north of L2′ east node.
- Net section failure through gussets at upper chord splice.

- U2′/L1′, west plate partially attached, with the two bottom rows of rivets exhibiting tension failure.
- East and west gussets were both severely distorted.
- U2′/U3′, U2′/L3′ intact with distortion of gusset between members.
- U2′/L2′ flanges attached to gusset.
- U2′/L1′ east plate connection failed at net section in gusset.

L1′/L2′ East

- Compressive and upward bending/buckle with translation to west and 30 degree upward bend.
- Buckle with eastward translation of member relative to L2′ just north of L2′.
- Impact on bottom plate approximately 4 feet south of L1′ from landing on the bearing upper casting.
- L1′/L2′ mostly resting on ground.

L1′/U2′ East

- At U2′ end, the west side plate was still attached to node at gusset; the west side plate was unzipped from the cover plates for approximately 15 feet.
- U2′ end minus west side plate was displaced approximately 25 feet south of U2′ node.
- L1′ end was attached and intact.
- The east gusset remains attached to east side plate and was fractured from node.
- Partial member fracture of west side plate just beyond gusset connection.

U1′/U2′ East

- Net section failure through gusset at U2′.
- North end of member bent over pier with the U2′ end pointing southwest and downward. The east side plate was separated from the cover plates at welds in the area of the U2′ gusset.
- Impact damage on bottom plate near U2′ East end for approximately 4 feet.
- U1′ end was attached to node north of pier 8 east column near top.

L1′/U1′ East

- At L1′ end, both side plates were still attached.
- The member was fractured and deformed just above L1′.
- A 5 foot long piece of north or south cover plate separated from side plates and was located west of pier.
- Severely deformed and separated from U1′ through gusset fracture.
- Fractured 5 feet below FT1′L10 with partial separation of member plates at FT1′L10.

L1′ East Node

- Located just south of pier 8 east column and top rotated approximately 30 degrees toward the south.
- Net section failure through gussets at L1′/U0′.
- Both gussets were buckled between L1′/U2′ and L1′/L2′.

- Top of east gusset bent to east at vertical L1′/U1′.
- Upper casting detached through pintle failure.

U1′ East Node
- North of pier 8 east column near top.
- Upper chord intact through node.
- Vertical detached at bottom of upper chord through net section failure of gusset.

U0′/U1′ East
- Intact and straight.
- Hanging vertically from north side of pier 8 east column.

U0′/L1′ East
- Hanging on north side of pier 8 east column with U0′ end oriented downward.
- Approximately 1 foot from U0′ gusset, west, top, and bottom plates fractured with east plate bent.
- U0′ member end displaced west of node U0′.
- Buckled approximately 5 feet from L1′.
- Detached from L1′ through gusset fracture.

U0′ East Node
- Gusset plates intact.
- Hanging from U0′/U1′.

West Main Truss, Nodes 4′ to 0′

U4′/L4′ Vertical
- Web detached from flange for 4 feet from L4′. 90° buckle to east near L4′.
- Flange distortion along length.
- Web fracture in U4′ node and net section fracture of flanges at U4′ node.
- Member lying horizontal east of west truss.
- Severe distortion of member at and below lower attachment to floor truss.

L4′ West Node
- Vertical L4′/U4′ attached, both gussets bent 90° to east with compression damage on top plate of lower chord from vertical U4′/L4′ impact.

U4′ West Node
- Rotated 45° to north.
- Net section fracture of gussets for U4′/L5′ diagonal.
- Partial net section fracture of gusset between U4′/L3′ diagonal and upper chord.
- U4′ approximately 25 feet north of L4′. Partially visible from concrete debris.
- Vertical U4′/L4′ flanges attached to gusset.

L3′/L4′ West

- One half of member located below U4′/L3′.
- Member lying on ground, generally straight with some impact damage on the top.

L3′/U4′ West

- L3′ end was severely distorted.
- L3′ end west side plate was buckled with gross section failure through gusset. East side plate was obscured.
- At U4′ West, the east gusset was attached, while the west gusset had net section fracture. Severe distortion and plate separation of U4′ West end.
- Downward buckle of east side plate near L3′ node.
- L3′ node obstructed by concrete.

U3′/U4′ West

- Negative buckle just south U3′.
- Resting on ground at U4′ and still attached to the gusset but the top cover plate was separated for 5 feet from the east side plate.
- Positive buckle adjacent to U4′.

L3′/U3′ West

- At the L3′ end, the side plates separated from the flanges.
- U3′ end was intact and detached from node, with some local buckling.
- Member was buckled north, just below FT3′L2.
- Severely distorted just above L3′ with plate separation.
- FT3′L2 was attached on the east side.

L3′ West Node

- Resting on the ground approximately 15 feet south of U3′.
- West gusset still attached to the lower chord and L3′/U2′.
- Diagonal U4′/L3′ west side plate detached with net and gross section fractures. East side plate obscured.
- Vertical L3′/U3′ partially attached with net and gross section fractures.
- East gusset was partially inaccessible from concrete and sway bracing, but still attached to lower chord and L3′/U2′.

U3′ West Node

- Net section fractures through both gusset plates at bottom row of rivets in upper chord.

L2′/L3′ West

- Located under U2′/L3′ and partially under L3′/U3′.
- Attached at both ends.
- Lying on ground generally straight.
- Top plate distortion for about 12 feet near L3′ from impact of U2′/L3′.

U2′/L3′ West

- U2′ end was fractured through net section in member at U2′ with north end of member located 6 feet south of node.
- Distorted flanges and impact related distress approximately 8 feet south of end of member from landing on U2′/L2′ vertical.
- Still attached to both gussets at L3′ node.
- At the L3′ end, the west flange fractured from the web for about 15 feet. The east flange was underneath L3′/U3′.

U2′/U3′ West

- Attached at both ends.
- Buckle at U3′ end, just north of gusset with 30 degree rotation and lateral translation to east relative to node.
- Top cover plate separated from side plates above U2′ gusset.

U2′/L2′ West

- U2′ end was attached to the west gusset and partially attached to the east gusset.
- U2′ web was separated from east flange.
- Buckled and bent 90 degrees to south from node U2′ and severely distorted near U2′.
- Buckled approximately 8 feet above L2′ with 90° bend to north.
- FT2′L10 was still attached, partially obscured by concrete.
- Buckled at L2′ and lying to east.

L2′ West Node

- Gussets intact with failure of a few rivets, but severely distorted to east above lower chord.
- Compression buckle of lower chord top cover plate due to impact from vertical.

U2′ West Node

- Located approximately 15 feet north of L2′.
- East and west gussets had net section fractures at upper chord splice.
- Both gussets were distorted below the upper chord.
- East gusset has net and gross section fractures at U2′/L1′ and the fractured end was folded back to the south 180 degrees.
- West gusset still attached to U2′/L1′, distorted and folded to east.
- Gussets attached to flanges of U2′/L2′.
- Gussets attached to U2′/L3′ with fracture in member.

L1′/L2′ West

- L1′ end was attached, compression buckled with westward translation and upward rotation.
- Lying on ground and buried under concrete debris for most of length.
- Buckling and partial fractures at first access hole north of L2′.

L1′/U2′ West

- Attached and intact at L1′.
- At U2′, the west side plate was attached to west gusset of node U2′. The west side plate separated for about 10 feet at U2′ end.
- At U2′, the east side plate has net and gross section fractures.
- U2′ end was buckled and unzipped between the east side plate and cover plates.
- Intact approximately two thirds of its length from L1′, then west side plate was unzipped and bent 180 degrees north back to U2′.
- U2′ end, minus the west side plate, was displaced 20 feet south of U2′ node.
- At U2′ end, east side plate was bent 135 degrees to the west at the first access hole.

U1′/U2′ West

- U1′ end was attached to node on north side of pier 8 west column near top.
- Net section fracture through gussets at U2′.
- East side plate separated from bottom plate along U2′ gusset.
- North end of member bent over pier 8 west column.

U1′/L1′ West

- Still attached and intact at L1′.
- Fractured with some plate separation approximately 8 feet above L1′.
- U1′ end hanging from top of pier 8 west column and was fractured with severe plate separation and deformation just below FT1′L2.
- Member separated from U1′ node through fractures in gussets.

L1′ West Node

- Located south and adjacent to pier 8 west column.
- Rotated south approximately 30 degrees.
- Intact except for west and east gussets had block shear failure at L1′/U0′.
- Upper casting broken, detached through pintle failure.

U1′ West Node

- Located on top of pier 8 west column near north side with U1′/U2′ upper chord bent over top of pier.
- U1′/L1′ vertical net section fracture through first line of rivets.
- Upper chord intact through node.

U0′/U1′ West

- Intact and straight. Hanging vertically from north side of pier 8 west column.

U0′/L1′ West

- U0′ end was still attached to the node.
- Hanging from top of pier 8 west column with U0′ end downward.
- Buckled and partially fractured at the first access hole just below U0′ with 45 degree rotation and lateral translation to east relative to U0′.

- L1′ end was at top of pier 8 west column and its end was not visible but resting on pier transverse strut.
- Buckled near end with downward rotation and westward translation relative to end of member.

U0′ West Node

- Gussets intact.
- Hanging from U0′/L1′ and U0′/U1′ on north side of pier 8 west column.

End Floor Beam at U0′ (north)

- Stiffeners connecting trusses were fractured.

Other Structural Members, Nodes 4′ to 0′

Lower Laterals, Nodes 3′ to 4′

Laterals L3′E/CL4′ and L3′W/CL4′ were generally straight and attached at node CL4′ with slight denting or distortion of the top plate at several locations along their length due to impact damage from debris and the lower chord of floor truss 4′. The L3′E and L3′W ends of these laterals were obstructed by debris but appear attached and intact.

Upper Laterals, Nodes 3′ to 4′

Laterals U3′W/CU4′ and U3′E/CU4′ were still connected at U3′W and U3′E but both gussets were distorted and rivets were sheared at U3′E. The members were buckled near their tapered ends with additional distortion of the top plates at several locations along the member length. Significant member distortion and buckling was present near the CU4′ ends of the laterals with both members still attached to each other through the CU4′ gusset connection plate, but the plate has detached from floor truss 4′ and the ends of the members were pointing straight up into the air.

Floor Truss 3′, Sway Brace

Sway brace CL3′/FT3′L2 was detached from the floor truss at node L2 following the fracture of the north gusset connection plate and the rivets failing at the south connection plate. The member was generally straight but has some impact related distortion along its length. Node CL3′ was obstructed by concrete debris but the members framing into the node all appear straight even though the gussets were clearly distorted and fractured with all members were lying on the ground with translation to the north. Node CL3′ was located approximately 15 feet south of floor truss 3′. Braces CL3′/FT3′L2 and CL3′/FT3′L10 were lying on the ground north of the lower lateral sway brace (L3′W/L3′E) with the top plate of each member still oriented up and with buckling or crushing of the member ends near the CL3′ node.

Floor Truss 3′

Floor truss 3′ was rotated or leaning to the north (upper chord relative to lower chord) with the east half buried under concrete debris and lying on the ground. The west half of the upper chord was translated further to the north than the east half with curvature along the entire

length of the upper chord. Upper chord gussets were intact where visible. The upper chord was bowed to the north approximately 4 to 5 feet in the region between floor truss nodes U3 and U5. The upper chord was distorted over top of node U3′W of the west main truss with fractures in the web and bottom flange and with the top flange displaced approximately 5 feet north of the bottom flange, lying on upper chord U2′W/U3′W. The upper chord was crushed overtop of U3′E at node U12. The lower chord was still attached to vertical L3′W/U3′W at node L2 but the chord exhibited significant distortion and twisting in other areas where visible. Significant distortion (180 degree rotation) was present at node L4. The east diagonals L10/U13 and L10/U14 were still attached to vertical L3′E/U3′E but were rotated to the north and lying on the ground due to buckling of the vertical. The west diagonals L2/U1 and L2/U0 were minimally attached to the west vertical L3′W/U3′W with fractures in the L2 gusset. These members were also rotated to the north due to buckling at the bottom of the main truss vertical U3′W/L3′W, and rotation of that member to the north, to which they were attached.

Lower Laterals, Nodes 2′ to 3′

Laterals L2′W/CL3′ and L2′E/CL3′ were intact and generally straight where visible. Lateral L2′W/CL3′ was still connected at L2′W however the member was distorted near mid-length due to impact of node L4 of floor truss 3′ which crushed the top plate and buckled out the side plates. Lateral L2′E/CL3′ was completely obstructed by debris.

Upper Laterals, Nodes 2′ to 3′

Both U2′E/CU3′ and U2′W/CU3′ were generally straight with top plate buckles near mid-length due to the south end of the members contacting ground and/or the floor truss 2′ sway bracing which was lying on ground. Laterals U2′E/CU3′ and U2′W/CU3′ were still attached to their connection plates, but the plates were detached from main truss nodes U2′W and U2′E due to rivets shearing. At the U2′W end of U2′W/CU3′, the bottom plate of the lateral has peeled out and remains attached to the connection plate although the plate has fractured from the floor truss upper chord. In addition, the east side plate of the lateral has rivet denting and abrasion, with compression of the tapered section, which appears related to impact of the L1′W/U2′W gusset. The connection plate at the U2′E end of lateral U2′E/CU3′ was still attached to the floor truss 2′ upper chord. Both of these members appear connected at CU3′, however this node was buried under concrete debris and the connections were not entirely visible.

Floor Truss 2′, Sway Brace

At Node CL2′, all members framing in appear generally straight and intact but the node gusset plates were distorted due to the upper ends of members CL2′/FT2′L10 and CL2′/FT2′L2 rotating to the north. FT2′L2/CL2′ and FT2′L10/CL2′ were not connected to the floor truss lower chord. FT2′L10/CL2′ detached due to a fracture in the north gusset connection plate and shearing of rivets at the south plate. Both of these members were lying on the ground north of the lower lateral sway brace. The connections at nodes L2′W and L2′E were obstructed by concrete debris but appear intact.

Floor Truss 2′

Floor Truss 2′ was oriented with its upper chord up and it was resting on the lower laterals (nodes 1′ to 2′) on ground. The upper chord of the floor truss exhibited rotation to the north near Nodes U2′W and U2′E but was generally plumb near the center of the bridge. The upper chord was detached from, and suspended above, main truss node U2′E. The bottom flange of the floor truss upper chord was still connected to the top plate of the U2′W node although this top plate was peeled up for approximately 6 feet south of the node along the top of U2′W/U3′W. Significant curvature was present along the length of the lower chord such that floor truss node L6 was lying approximately 15 feet north of nodes L2 and L10. The lower chord was still attached to both of the main truss verticals (L2′W/U2′W and L2′E/U2′E) but the verticals were buckled significantly and were displaced toward the interior of the bridge (i.e., west vertical displaced east and vice versa). The floor truss diagonals L10/U14 and L10/U13 were still attached to L2′E/U2′E but were partially fractured from the upper chord portion of the east cantilever and sandwiched between L1′E/L2′E and U2′E/L3′E with distortion and rotation to the north. The upper chord portion of the west cantilever was fractured just west of U2′W in the web and bottom flange with rotation to the north. Diagonals L2/U0 and L2/U1 were obstructed by debris but may still be connected to the main truss vertical L2′W/U2′W.

Upper Laterals, Nodes 1′ to 2′

Laterals U1′E/CU2′ and U1′W/CU2′ were intact and generally straight but were oriented straight down toward the ground from the U1 to CU2 ends. Distortion and abrasion was present on the top plates of both members near their connections to the main trusses consistent with stringer impact. These members were still attached at CU2′ but were detached from U1′E and U1′W due to fractures in the connection plates. At CU2′, the bottom connection plate was still connected to the floor truss upper chord but the top plate was detached due to rivet shearing.

Lower Laterals, Nodes 1′ to 2′

Laterals L1′W/CL2′ and L1′E/CL2′ were still attached at the main trusses (i.e., L1′E and L1′W) although the gusset connection plates were distorted. These members were generally straight and are lying on the ground. The top plate of each member was distorted near mid-length due to the lower chord of floor truss 2′ landing on them.

Floor Truss 1′, Sway Brace

L1′E/CL1′ and L1′W/CL1′ were still attached at both nodes and were predominantly straight with slight rotation to the south (due to node L1′ rotation) and slight twisting due to downward bending at the CL1′ node. The gusset plates of Node CL1′ exhibited distortion with partial fractures along the top edge of the CL1′/L1′W sway brace. The gussets were distorted but intact between the upper sway braces (i.e., U1′E/CL1′ and U1′W/CL1′) although the south rivets were sheared at the U1′E/CL1′ connection. Sway braces FT1′L10/CL1′ and FT1′L2/CL1′ were intact and generally straight but were detached from the lower chord of floor truss 1′ with the failure occurring in the member at L10 and in the gusset at L2.

Floor Truss 1′

The upper portion of FT1′ was wrapped over top of pier 8 with the upper chord hanging over the north edge of, or on top of, the pier cap. The lower chord was hanging adjacent to the south face of the pier cap. Significant distortion was visible at several diagonals and verticals where these members were wrapped up and over onto the pier cap. Distortion of the upper and lower chords was also apparent with several gusset fractures visible including at the end of diagonals at the FT1′L6 and FT1′L4 nodes. The east cantilever truss diagonals (U13/L10, U14/L10) were fractured from U1′E/L1′E with the gusset punched through the east side plate of U1′E/L1′E which has rotated 180 degrees. The upper chord portion of the east cantilever (U12/U14) was fractured at the splice plate just west of node U1′E and was crushed overtop of node U1′E. The west cantilever diagonals U0/L2 and U1/L2 remain attached to vertical U1′W/L1′W but were fractured from the upper chord portion of the west cantilever U0/U2, which was severely distorted, but intact, over the U1′W node and hanging at the north side of pier 8.

Upper Lateral Braces, Nodes 0′ to 1′

Laterals U0′W/CU1′ and U0′E/CU1′ were intact and still attached at both U0′W and U0′E. A slight buckle was present in the bottom of each member adjacent to the tapered end at the main trusses. The gusset connection plate at U0′E exhibited slight distortion. The members were generally straight with slight curvature in the plan of the bridge deck and were oriented such that they were pointing straight up into the air on the north face of pier 8. No other obvious or significant distortion was visible. Node CU1′ was located at the top of pier 8 and was detached from floor truss 1′. U0′W/CU1′ was still connected to the top connection plate at CU1′ but the rivets were sheared and the plate detached from the upper chord. U0′E/CU1′ was obstructed by debris.

Appendix 2

Survey Results and Description of Piers and Bearing, Deck Truss

Pier 5

Pier 5 was found intact and relatively undamaged after the collapse other than the spalled and chipped concrete at the top of the columns that resulted from impact from the bearing rollers, upper flange castings and main truss members U0/L1. A post-collapse excavation of the footing revealed no damage or rotation at the column-to-footing connections. The lower bearing plates remained attached to the piers although the northern anchor bolts had impact/crushing damage from the bearing rollers. The northern anchor bolt flanges of the lower bearing plate had impact marks from a roller guide flange and scraping/damage from the collapsed superstructure. The wear patterns on the lower bearing plates indicated a range of movement by the rollers of approximately 5 inches.

The pre-collapse positions of the rollers in the bearing were determined based on the damage patterns.

The southern most roller of the pier 5 East bearing was found south of its column, while the northern roller, the middle roller, and the upper bearing casting were found on the ground directly to the north of the pier column. The bracket plates (racks) were still attached to the lower bearing plate and the upper bearing casting. The northern most roller had impact marks from the northeast and northwest anchor bolts (that hold the lower bearing plate to the pier) on its surface. The hold-down stud was sheared at the top of the bronze surface of the domed casting, with the upper bearing casting moving north relative to the flange casting. The post-collapsed surveyed elevation measurement of the top of concrete was 802.62 ft or 3/8 in. lower than the design elevation of 802.65 ft.

The southern most roller of the pier 5 West bearing remained on its lower bearing plate atop the west pier column, while the northern roller, the middle roller, and the upper bearing casting were found directly north of the pier column on the ground. The upper bearing casting was found upside-down. The bracket plates (racks) were still attached to the lower bearing plate and the upper bearing casting. The northern most roller was found buried in the ground by the main truss lower chord and had impact marks and scrapes at several locations but none that could be easily distinguished as being made by impact with the anchor bolts. The scraping was from the excavator bucket which was used to recover the roller from the ground. The center roller had a distinct impact from the northwest anchor bolt on its surface. The hold-down stud was bent to the south and sheared at the top of the bronze surface, with the upper bearing casting moving north relative to the flange casting. The post-collapsed surveyed elevation measurement of the top of concrete was 802.63 ft or 1/4 in. lower than the design elevation of 802.65 ft.

In addition, the surveyed measured horizontal distance between pier 5 and pier 6 was 265.57 ft or 1 1/4 in. less than the plan dimension of 265.67 ft.

Pier 6

Pier 6 was found intact and relatively undamaged after the collapse other than the spalled and chipped concrete at the top of the columns that resulted from impact from the bearing rollers and components of the main truss. There was some additional scraping along the sides of the east pier column from impact with superstructure components as they collapsed around the pier. A post-collapse excavation of the footing revealed no damage or rotation in the columns or at the column to footing connections. The lower bearing plates remained attached to the piers with the northern anchor bolts crushed/flattened by impact from the rollers. The level of corrosion on the top surfaces of the lower bearing plates made it difficult to estimate the range of movement of the rollers. The best indication was given by wear marks from the middle-south roller of the east bearing which seemed to indicate a range of movement of approximately 2½ inches.

The upper bearing casting, with bracket plates attached, and all four rollers of the pier 6 East bearing were found on the ground almost directly north of the east column of pier 6. The east bracket plate from the lower bearing plate was found to the east of pier 6 while the west bracket plate remained attached to the lower bearing plate. The hold-down stud was sheared, with the upper bearing casting moving north relative to the flange casting. The south edge of the bronze domed casting and nearby areas of the top of the upper bearing casting had impact damage from striking the northern rim of the upper flange casting, which was similarly damaged. The north, middle-north and middle-south rollers had impact marks from striking the northern anchor bolts of the lower bearing plate. The middle-north roller had its guide flanges crushed where they struck the north anchor bolt flange of the lower bearing plate. The middle-north, middle-south and south rollers all had impact marks and scrapes from the lower cover plate of the main truss lower chord member L7/L8 East. The post-collapse surveyed elevation measurements of the top of concrete were 771.30 ft or 3/8 inch lower than the design elevation of 771.33 feet.

The upper bearing casting, with bracket plates attached, and all four rollers of the pier 6 West bearing were found on the ground north of the west pier column. The hold-down stud in the upper bearing casting was sheared off, with the upper bearing casting moving north relative to the flange casting. Damage to the southern edge of the bronze domed casting indicated that the casting struck the northern rim of the upper flange casting, which was similarly damaged. The middle-north roller had impact marks from the anchor bolts. The middle-north, middle-south and south rollers had their guide flanges crushed where the roller came off of the bearing surface of the lower bearing plate onto the anchor bolt flange and had impact and scraping marks from the bottom cover-plate of main truss lower chord member L7/L8 West. The post-collapse surveyed elevation measurements of the top of concrete were 771.31 ft or 1/4 in. lower than the design elevation of 771.33 ft.

Note that the surveyed measured horizontal distance between pier 5 and pier 6 was 265.57 ft or 1 1/4 in. less than the plan dimension of 265.67 ft.

Pier 7

A post-collapse excavation inspection of pier 7 determined that the pier columns had hinged about the top of their footings resulting in a 9° 22’ 10” tilt of the pier towards the river.

Otherwise, the pier 7 was intact and undamaged with the lower bearing castings of the fixed bearings still attached to the top of the columns.

The pier 7 West bearing bronze domed casting had damage along its northern edge. The hold-down stud of this bearing was sheared off at the top of the bronze surface with the domed casting moving south relative to the flange casting. The post-collapse surveyed elevation measurements of top of concrete were 769.79 feet or 2 7/8 inch higher than the design elevation of 769.56 feet. Note that pier 7 tilted about 9.4 degrees to the south as a result of the collapse.

The pier 7 East bearing bronze domed casting also had damage along its northern edge. The hold-down stud was fractured through the threads at the bottom of the domed casting. The post-collapse surveyed elevation measurements of the top of concrete were 769.79 feet or 2 7/8 inch higher than the design elevation of 769.56 feet. Note that Pier 7 tilted about 9.4 degrees to the south as a result of the collapse.

Pier 8

A post-collapse excavation inspection of pier 8 determined that the pier columns had hinged about a section approximately 3½ feet above the top of the footings near the location where the dowel bars had been cut off. (The dowel bars extended down into the footing and had been cut off about 3 ½ feet above the footing prior to casting of the pier.) This hinging left a significant residual southern tilt in the pier. The top of the pier columns were damaged, with chipped and spalled concrete, from impact with the collapsed superstructure.

The rollers and upper bearing castings of both pier 8 bearings were found primarily south of the pier on the ground except the northern most roller of the pier 8 West bearing which was found to the north of the pier. The bracket plates (racks) remained attached to the lower bearing plates and upper bearing castings. The lower bearing plates remained attached to the top of the pier columns and indicated a range of movement by the rollers of approximately 2½ inches.

The pier 8 East hold-down stud was sheared off, with the upper bearing casting moving east relative to the flange casting. Scraping and impact marks were also visible on the east side of the bronze domed casting and adjacent portion of the upper bearing casting. The southeastern anchor bolt had impact damage from the rollers, and the other southern anchor bolts were sheared off or missing. Impacts from the southeast and southwest anchor bolts were clearly visible on the southern roller. The middle and northern rollers had impact marks only from the southeastern anchor bolt. The post-collapse surveyed elevation measurement of the top of concrete was 796.18 ft or 3/8 in. lower than the design elevation of 796.21 ft. Note that pier 8 exhibited permanent displacement due to the collapse.

The pier 8 West bearing hold-down stud was sheared off, with the upper bearing casting moving south relative to the flange casting. The southwest anchor bolt had impact damage from the rollers, but the other southern anchor bolts had been sheared off. The middle roller had impact damage from the southwest anchor bolt. The northern roller had significant scraping and loss of coating on its surface. The post-collapse surveyed elevation measurement of the top of

concrete was 796.29 ft or 1 in. higher than the design elevation of 796.21 ft. Note that pier 8 exhibited permanent displacement due to the collapse.

Appendix 3

Corrosion Measurements, Nodes L11E and L11W

In an attempt to quantify section loss due to corrosion in the gusset plates at nodes L11E and L11W, plate thickness was measured, where possible, using an electronic point micrometer. These measurements were made at approximately 1-inch intervals along the line of corrosion, which was on the inside face of the gusset plate at approximately the level of the top surface of the lower chord upper cover plate. However, due to the extent of bending, impact and fracture damage near this line of corrosion, these measurements may include the effects of necking associated with ductile yielding on plate thickness. Where access of the micrometer to both sides of the plate in the line of corrosion was impossible, section loss due to corrosion was estimated by using the micrometer probe to assess the depth of pitting. That depth was then subtracted from the nominal plate thickness to calculate the remaining plate thickness. The table below contains the measured thicknesses.

Although there were a few areas of more localized pitting corrosion, in general the corrosion produced a distinct trough between ½ inch and 1-½ inches wide in the gusset plate. Measurements taken with the point micrometer were possible where the fracture of the gusset plate ran near to, or along, the corrosion line. At points where there was plastic necking at the fracture line, or impact damage, measurements were taken at the point slightly away from the fracture or damage in order to minimize the effect of plastic necking or impact damage on the result; that is to say, at these locations measurements were not taken of the absolute thinnest point in the gusset plate if that point was obviously damaged or necked. At locations where the micrometer could not be directly used, section loss was determined using the micrometer probe to estimate the depth of the corrosion from the edge of the trough to the bottom of the trough.

In the table below, the location is the distance from the south edge of the gusset plate to the point of measurement. In some locations on the west gusset plate of node L11W, the plate thickness was measured on each side of a fracture, and both sets of measurements are given. Where an "X" is listed, the corrosion area was either inaccessible or missing. Where a "-" is listed, no corrosion was present. The thicknesses estimated using the micrometer probe are marked with an asterisk (*).

Node L11E: East Gusset Plate		Node L11E: West Gusset Plate		Node L11W: East Gusset Plate		Node L11W: West Gusset Plate	
Location [in]	Plate Thickness [in]	Location [in]	Plate Thickness [in]	Location [in]	Plate Thickness [in]	Location [in]	Plate Thickness [in]
0	0.50*	0	0.47	0	0.42	0	-
1	0.47*	1	0.38	1	0.38	1	-
2	0.45*	2	0.39	2	0.41	2	-
3	0.45*	3	0.42	3	0.41	3	-

4	0.43*	4	0.35	4	0.37	4	-	
5	0.43*	5	0.39	5	0.37	5	-	
6	0.44*	6	0.38	6	0.35	6	-	
7	0.48*	7	0.45	7	0.38	7	-	
8	0.49*	8	0.29	8	0.42	8	-	
9	0.49*	9	0.34	9	0.43	9	-	
10	0.49*	10	0.33	10	X	10	-	
11	X	11	0.29	11	X	11	-	
12	X	12	0.27	12	X	12	-	
13	X	13	0.34	13	X	13	-	
14	X	14	0.43	14	X	14	-	
15	X	15	0.43	15	X	15	-	
16	X	16	0.32	16	X	16	-	
17	X	17	0.36	17	X	17	-	
18	X	18	0.37	18	X	18	-	
19	X	19	0.39	19	X	19	-	
20	X	20	0.44	20	X	20	-	
21	X	21	0.49	21	X	21	-	
22	X	22	0.44	22	X	22	-	
23	X	23	0.44	23	X	23	-	
24	X	24	0.45	24	0.40	24	-	
25	X	25	0.39	25	0.38	25	X	
26	X	26	0.38	26	0.37	26	X	
27	X	27	0.43	27	0.40	27	X	
28	X	28	0.47	28	0.41	28	X	
29	X	29	0.45	29	0.36	29	X	
30	X	30	0.43	30	X	30	X	
31	X	31	0.44	31	X	31	X	
32	X	32	0.43	32	X	32	0.46	0.50
33	X	33	0.37	33	X	33	0.50	0.43
34	0.49	34	0.35	34	X	34	-	0.42
35	0.45	35	0.37	35	X	35	-	0.39
36	0.42	36	0.38	36	X	36	-	0.40
37	0.40	37	0.37	37	X	37	-	0.41
38	X	38	0.41	38	X	38	-	0.45
39	X	39	0.39	39	X	39	-	0.45
40	0.39	40	0.39	40	X	40	-	0.42
41	0.38	41	0.41	41	X	41	-	0.37
42	0.39	42	0.40	42	X	42	-	0.37

43	0.38	43	0.39	43	X	43	-	0.39
44	0.36	44	0.37	44	X	44	-	0.41
45	0.38	45	0.41	45	X	45	0.35	0.36
46	-	46	0.39	46	X	46	0.39	0.34
47	-	47	0.40	47	X	47	0.36	0.39
48	-	48	0.31	48	X	48	0.30	0.36
49	-	49	0.37	49	X	49	0.35	0.40
50	-	50	0.43	50	X	50	0.39	0.38
51	-	51	0.42	51	X	51	0.39	0.34
52	-	52	0.42	52	X	52	0.34	0.36
53	-	53	0.45	53	X	53	0.34	0.40
54	-	54	X	54	X	54	0.38	0.42
55	0.47	55	X	55	X	55	0.37	0.36
56	0.44	56	0.41	56	X	56	0.36	0.39
57	0.45	57	0.40	57	X	57	0.34	0.43
58	0.43	58	0.42	58	0.46	58	0.35	0.49
59	0.41	59	X	59	0.45	59	0.40	
60	0.42	60	X	60	0.39	60	0.45	
61	0.44	61	X	61	0.38	61	0.38	
62	0.49	62	X	62	0.40	62	0.42	
63	0.50	63	X	63	X	63	0.37	
64	0.50	64	X	64	X	64	0.46	
65	X	65	X	65	X	65	X	
66	X	66	X	66	X	66	X	
67	X	67	X	67	X	67	X	
68	X	68	X	68	X	68	X	
69	X	69	X	69	X	69	X	
70	X	70	X	70	X	70	X	
71	X	71	X	71	X	71	X	
72	X	72	X	72	X	72	X	
73	X	73	0.44	73	X	73	X	
74	X	74	0.44	74	X	74	X	
75	X	75	0.47	75	X	75	X	
76	X	76	0.43	76	X	76	X	
77	X	77	0.40	77	X	77	X	
78	X	78	0.41	78	X	78	X	
79	X	79	0.43	79	X	79	X	
80	X	80	0.42	80	X	80	X	
81	X	81	0.45	81	X	81	X	

82	X	82	0.42	82	X	82	-
83	X	83	X	83	X	83	-
84	X	84	0.47	84	X	84	-
85	X	85	X	85	X	85	-
86	X	86	0.46	86	X	86	-
87	X	87	0.42	87	X	87	-
88	X	88	0.42	88	X	88	-
89	X	89	0.43	89	X	89	-
90	X	90	0.41	90	X	90	-
91	X	91	0.40	91	X	91	-
92	X	92	0.45	92	X	92	-
93	X	93	0.45	93	X	93	-
94	X	94	0.42	94	X	94	-
95	X	95	0.49	95	X	95	-
96	X	96	0.50	96	X	96	-
97	X	97	0.50	97	X	97	-
98	X	98	0.48	98	X	98	-

Appendix 4

Summary of Notes on South Approach Spans

On 20 August 2007, observations of the post-collapse condition of the south approach spans for the I-35W Bridge over the Mississippi River were made. The purpose of these observations was to document the overall condition of this portion of the structure prior to demolition.

General Description of Structural System

The five approach spans at the south end of the bridge consist of welded plate girders that support and act compositely with the reinforced concrete deck. Span lengths vary from approximately 51 feet at span 1 adjacent to the south abutment to 110 feet at interior spans 3 and 4. The northbound and southbound lanes are effectively independent structures, as they are separated by a longitudinal joint. However, the girders all frame into the same cross girder at the north end of the approach portion of span 5. There are seven steel girders on each side of this longitudinal joint, and they are laterally stabilized by steel diaphragms spaced approximately 22 feet on center. There are four pairs of interior concrete piers (piers 1 through 4) that support the steel girders and their bearings. The piers are founded on steel piles. At the south end, the superstructure terminates at the south abutment. At the north end of the approach spans, the steel girders were supported by the cantilevered portion of the main truss extending southward past pier 5. Longitudinal expansion is accommodated by expansion joints located at the south abutment, south of pier 2 and at the north end of the approach portion of span 5.

Post Collapse Condition

The collapse of the main truss spans eliminated support for the north end of the approach portion of span 5 and ultimately led to the collapse of this span. The structural elements of spans 1 through 4, however, remained stable. A brief description of these elements as observed during the investigation follows below.

Concrete Bridge Deck and Parapets

The top surface of the concrete bridge deck and parapets exhibited many large transverse cracks over pier 4 consistent with the collapse of the approach portion of span 5. Water was ponded over a large area of spans 3 and 4 adjacent to the west parapet. Many areas of partial depth concrete repair were underway at the time of the collapse. A new concrete overlay had recently been placed in the western half of the southbound lanes. No other areas of significant structural distress (cracking, distortion, displacement, etc.) were evident in the bridge deck or overlays. The original concrete and aluminum bridge rail was supplemented with a concrete barrier wall on the east and west edges of the roadway. A Jersey barrier wall is present along the median separating the northbound and southbound roadways.

Steel Girders and Diaphragms

The steel superstructure south of pier 3 was intact and has not been significantly affected by the collapse. South of pier 3, girders generally appear plumb, connections appear undamaged, and all diaphragms were in place. Fatigue retrofits have been performed throughout the south approach spans, and are typically located at the first diaphragms on both sides of piers 3 and 4. A total of

five fatigue retrofit locations were marked for preservation prior to demolition. These locations include:

- Portions of girders G7 and G12 at the first diaphragm location south of pier 3
- A portion of girder G3 at the first diaphragm location north of pier 3
- Portions of girders G7 and G12 at the first diaphragm location north of pier 4.

The cross girder and approximately the 10 northernmost feet of the longitudinal girders at the north end of the approach portion of span 5 were also marked for preservation, as were the bearing assembly for girder 5 at the expansion joint just south of pier 2.

Plastic hinging was evident in the steel girders in the vicinity of pier 4. The bottom flange of the girders was buckled laterally north and south of pier 4. The diaphragms at pier 4 stabilized the girders directly over the pier, forcing the deformation to occur between the pier and the first line of diaphragms immediately north and south of pier 4. Beyond these north and south diaphragms, the bottom flanges of the girders remained relatively straight. The girders in span 4 just south of pier 4 were lifted slightly by the collapsed portion of approach span 5 and now slope slightly towards the south. No significant lateral movement of the steel superstructure was evident at any of the piers. Some localized distress in the diaphragm connections was visible in the vicinity of pier 4.

Bearings

Bearings at the south abutment and piers 1 through 3 were intact, with generally light to moderate surface corrosion. Bearings at the south abutment, pier 2, and pier 4 are expansion bearings while the bearings at piers 1 and 3 are fixed. The upper steel plates of the pier 4 bearings were dislodged and translated slightly southward due to the collapse of span 5. The steel girders came to rest on the north side of pier 4.

Piers and Abutments

In general, the concrete piers and abutments were in good condition, with little visible distress. Isolated areas of shrinkage cracking and delaminated concrete (typically 5 square feet or less) were apparent on some of the piers, but these areas did not appear to be structurally significant. Some localized spalling was apparent at the north face of pier 4 where the steel girders came to rest directly atop the pier. Previous MnDOT reports indicated that pier 1 had tilted slightly northward, but this was not readily evident.

Detailed Notes on Bearings

On 16 August 2007, observations of the girder bearings at the south approach spans were made.

South Abutment

- The bearings at G4, G5, G6, G7, G11, G12, and G14 exhibited moderate corrosion. The G14 bearing was the most severely corroded.
- Bearings and anchor rods exhibited no distress. Bearings were not displaced.

Pier 1

- Bearings exhibited no corrosion.
- Bearings and anchor rods exhibited no distress. Bearings were not displaced.

Pier 2

- Bearings exhibited minor corrosion.
- Bearings and anchor rods exhibited no distress. Bearings were not displaced.

Pier 3

- Bearings exhibited no corrosion.
- Bearings and anchor rods exhibited no distress. Bearings were not displaced.

Pier 4

- Bearings exhibited no corrosion.
- Anchor rods exhibited no distress. Masonry plates were not displaced.
- Rocker plates and the upper bearing assembly were displaced to the southeast and were rotated counterclockwise as a result of the lateral-torsional buckling of the supported girders. Displacement of the west side of the rocker plates was approximately 12 in. to 13 in. to the south. Displacement of the east side of the rocker plates was approximately 6 in. to the south. Rocker plates were displaced approximately 1 inch to 2 inches east.
- Pintles were partially engaged in the upper bearing assembly. The connection of the upper bearing assembly to the girder bottom flange was intact, and the upper bearing assembly was inclined at an angle matching that of the girder flange.

Expansion Joint

- The finger joint south of pier 2 exhibited no excessive movement. Joint opening width was consistent across the width of the southbound roadway, measuring 10 3/4 in. clear. Joint opening width was also consistent across the width of the northbound roadway, measuring 10 1/2 in. clear.
- The steel framing adjacent to the expansion joint exhibited slight corrosion.
- The contact and bearing conditions noted in the June 2006 Fracture Critical Bridge Inspection In-Depth Report were not observed.

Detailed Notes on Previously Identified Fatigue Crack Locations

On 13 August 2007, an examination of the fatigue cracks and repairs at the south approach spans of the I-35W Bridge over the Mississippi River was performed. Existing conditions were compared with the conditions reported in MnDOT's June 2006 Fracture Critical Bridge Inspection In-Depth Report for the I-35W Bridge.

Cracks and repairs were evident at the first diaphragm line south of pier 3, the first diaphragm line north of pier 3, and the first diaphragm line north of pier 4. Diaphragms have been lowered at these locations, as well as at the first diaphragm line north of pier 2, and the first diaphragm line south of pier 4. At these locations the lowered diaphragms were typically connected with 4 bolts in each of the two bottom corners. No cracks or repairs were evident elsewhere in the south approach spans.

First Diaphragm Line South of Pier 3

- G1: 1/4 in. crack at top of interior stiffener
- G2: 2 in. diameter hole each side of stiffener, crack contained
- G3: ~ 1/4 in. diameter intersecting holes at top of stiffener
- G4, G5, G6: 2 in. diameter hole each side of stiffener, crack contained
- G7: Crack ground out on south side, 2 in. diameter hole on north side, slight crack extension beyond hole (no apparent change from 2006)
- G8, G9, G10, G11: No cracks or repairs
- G12: 2 in. diameter hole each side of stiffener, 2 in. diameter hole in stiffener, crack extension ground out (no apparent change from 2006)
- G13: No cracks or repairs
- G14: 2 in. diameter hole on south side, crack on north side stiffener weld does not extend past weld toe (no apparent change from 2006)
- No apparent changes from June 2006 MnDOT fracture critical inspection

First Diaphragm Line North of Pier 3

- G1, G2: No cracks or repairs, strain gages at G2
- G3: 1/2 in. flange/web weld and small stiffener weld crack reported, no apparent change
- G4: Small crack at top of stiffener weld, no repair (no apparent change)
- G5: Small crack at top of stiffener weld, east side (no apparent change)
- G6: Small crack at top of stiffener weld, strain gages east side (no apparent change)
- G7: Small crack at top of east stiffener weld (no apparent change)
- G8, G9, G10: No cracks or repairs
- G11, G12: 2 in. diameter hole each side of stiffener, crack contained
- G13: No cracks or repairs
- G14: 2 in. diameter hole each side of stiffener, crack contained
- No apparent changes from June 2006 MnDOT fracture critical inspection

First Diaphragm Line North of Pier 4

- G1, G2: No cracks or repairs
- G3, G4: 2 in. diameter hole each side of stiffener, crack contained

- G5, G6: No cracks or repairs
- G7: 2 in. diameter hole each side of stiffener, small crack at top of stiffener weld on both sides reported, no apparent change
- G8, G9: No cracks or repairs
- G10: 2 in. diameter hole each side of stiffener, crack contained
- G11: Small crack top of stiffener weld (no apparent change)
- G12: 2 in. diameter hole each side of stiffener, ~ 1/4 in. hole in stiffener weld, crack contained (no apparent change)
- G13, G14: Small crack top of stiffener weld (no apparent change)
- No apparent changes from June 2006 MnDOT fracture critical inspection

Appendix 5

Summary of Notes on North Approach Spans

From 21-24 August 2007, observations of the post-collapse condition of the north approach spans for the I-35W Bridge over the Mississippi River were made. The purpose of these observations was to document the overall condition of this portion of the structure prior to demolition.

General Description of Structural System

There are six approach spans (spans 9 through 14) at the north end of the bridge. Spans 9, 10 and 11 consist of three-span continuous welded steel plate girders that support and act compositely with the reinforced concrete deck. Spans 12, 13, and 14 are three-span continuous voided concrete slabs.

Spans 9, 10 and 11 have lengths of approximately 130 ft., 94 ft. and 67 ft. respectively. The northbound and southbound roadways are independent structures, as they are separated by a longitudinal joint. However, the girders all frame into the same cross girder at the south end of the approach portion of span 9. In spans 9, 10, and 11, seven steel girders support the southbound lanes, and either ten or eleven girders support the variable width northbound lanes and off-ramp. The girders lateral system consists mainly of steel channel and wide-flange diaphragms spaced approximately 24 feet on center.

The voided concrete slabs in spans 12, 13, and 14 are typically 2 ft. deep and have spans of approximately 51 ft., 60 ft. and 31 ft., respectively. The slabs are integral with the concrete piers at piers 12 and 13, and sit upon expansion bearings at pier 11 and the north abutment.

There are five pairs of interior concrete piers (piers 9 through 13) that support the steel girders and their bearings, or the voided concrete slabs. The piers are founded on steel piles. At the north end, the approach spans terminate at the north abutment. At the south end of the approach spans, the steel girders were supported at node U0′ on the cantilevered portion of the main truss which extended northward past pier 8. Longitudinal expansion of the superstructure was accommodated by expansion joints located above the support at the main truss (node U0′), pier 11, and the north abutment.

Post Collapse Condition

Both the northbound and southbound roadways of the north approach spans collapsed between the deck truss and pier 9 (span 9). The superstructure was still supported on pier 9, but the lack of support from the missing main deck truss at the south end of span 9 caused this portion of the structure to drop to the ground and partially overhang the stone retaining wall north of pier 8. Spans 10 through 14 remain erect with the exception of span 11 of the southbound roadway, which collapsed to the ground after the superstructure was pulled south off pier 11 bearings.

Concrete Bridge Deck and Parapets

The top surface of the concrete bridge deck in spans 9 and 10 exhibited transverse cracking up to 7/8 inch wide and negative curvature that was consistent with the pattern of the collapse. The parapets also exhibited cracking and rotation. The deck and parapet have been lifted in span 10 due to the collapse of span 9. The deck joint at pier 11 has widened as a result of the collapse of span 9 and associated upward displacement in span 10. No significant visible distress was evident in the voided slabs and parapets of spans 12, 13, and 14. A new concrete overlay has recently been placed in the western half of the southbound lanes. In addition, deck joint repair work was underway at pier 11 and the north abutment at the time of the collapse consisting of the removal of the strip seal and joint armor in portions of the southbound and northbound lanes. The original concrete and steel bridge rail has been supplemented with a concrete barrier wall on the east and west sides of the roadway. A concrete barrier wall has been installed along the median separating the northbound and southbound roadways.

Steel Girders and Diaphragms

Span 9. Both the northbound and southbound roadways collapsed at the south end of span 9. The steel girders remain relatively straight in span 9, but slope downward to the south from the top of pier 9 towards the crossbeam at the approach span/main deck truss junction. The steel girders landed atop two railcars near the middle of span 9 and overhang the stone wall north of pier 8. The diaphragms for span 9 were generally intact, but some short length cracks in and around their connections to the girders were observed in all five diaphragm lines. These short cracks resulted from localized deformations caused by the collapse and were located at ends of stiffener welds used for diaphragm connections to girder webs. Several cracks previously noted at the first diaphragm line south of pier 9 in the 2006 MnDOT Fracture Critical Bridge Inspection Report were unchanged from the conditions noted in that report.

Span 10. The steel superstructure for both the northbound and southbound roadways remained erect in span 10 but has experienced significant plastic hinging and widespread local deformation. The steel girders underwent lateral-torsional buckling consistent with excessive negative moment developing about 25 ft. north of pier 9 following the collapse of the main truss. The girder bottom flanges buckled laterally between the diaphragm lines north of pier 9 on both the northbound and southbound roadways and also at the second diaphragm line north of pier 9 on the southbound roadway, with plastic hinges present at approximately 15 and 30 feet north of pier 9, respectively. The extent and magnitude of the plastic hinging were greater in the southbound lanes where both spans 9 and 11 collapsed to the ground. None of the girders for either roadway exhibited significant plastic deformation in the northern half of span 10. Both roadways lifted upward significantly in span 10 due to deformation of the underlying girders and the collapse of span 9 (as well as span 11 for the southbound roadway). Girders G2 through G7 (numbered from east to west) supporting the northbound lanes lifted off of the bearings at pier 10 and were suspended above the top of the pier cap.

Many diaphragm connections distorted or failed their bolted connections due to the collapse and the buckling of the girders. Several cracks were documented at the first diaphragm line north of pier 9 in the 2006 MnDOT report and these conditions were unchanged from conditions noted in that 2006 report. One exception is at Girder G6 where a pre-existing crack was observed near

the top flange, and this crack exhibited possible signs of extension due to the collapse. Several additional short length cracks caused by collapse-induced deformation were noted at the first and second diaphragm lines north of pier 9.

Span 11. The steel superstructure for the northbound lanes remained erect in span 11, but the southbound lanes collapsed at pier 11. The steel girders in both structures translated at least 5 to 7 inches southward as a result of the plastic hinging of girder bottom flanges and significant upward displacement that occurred north of pier 9. The girders supporting the southbound lanes were pulled off pier 11. The girders supporting the northbound lanes moved south 5 to 7 inches but are generally straight and do not show obvious signs of deformation or distortion and were still bearing on the south edge of pier 11. The bottom flanges for the southbound lane girders, girders G8 through G14 (numbered east to west), exhibited plastic hinging just north of the pier 10 bearings, with the hinges now resting directly over top of the pier 10 bearings and on the north edge of the pier cap. These girders were relatively straight north of pier 10, and sloped downward towards pier 11 where the bearings rested on the ground. No instances of fatigue cracking were documented for span 11 in the 2006 MnDOT report, and no new cracks were identified during the current examination. Diaphragms and their connections to the girders generally were intact with isolated distortion at some locations due to the collapse.

Bearings

Bearings at pier 9 were designed as fixed bearings for longitudinal movement, while the bearings at piers 10, 11, and the north abutment were designed as expansion bearings. The voided slabs are integral with the concrete piers at piers 12 and 13. Bearings at the north abutment were intact and nested and no distress or evidence of movement was present at the slab/pier interfaces at piers 12 and 13. The curved plates of some voided slab bearings at pier 11 were offset several inches either north or south of center. The fixed bearings of the southbound lane girders at pier 9 were dislodged and translated west due to the collapse. Southward movement of the superstructure also dislodged the expansion (sliding) bearings at piers 10 and 11. The girders supporting both the southbound and northbound roadways were lifted and shifted off of the expansion bearings at pier 10 following plastic hinging in the girder bottom flanges north of piers 10 and/or 9. The upper bearing plates of the pier 10 bearings remained connected to the girder sole plates but these components translated approximately one to two feet south and up to one foot west of the lower bearing plates and were either suspended above, or minimally supported on, the south edge of the pier. The northbound lane girders remained suspended above the pier following the collapse such that they effectively spanned between piers 9 and 11. The southward movement of the southbound roadway was significant enough to pull the upper bearing assemblies off of pier 11, leading to the partial collapse of this span. Southward movement of the northbound roadway has occurred, but the pier 11 bearings still partially rest on the pier.

Piers and Abutments

The concrete piers and abutments were in good condition, with little visible distress. Isolated areas of shrinkage cracking and delaminated concrete (typically 5 square feet or less) were observed on some of the piers, but these areas were not structurally significant. Some localized spalling was exhibited where the steel girders or bearing assemblies impacted or came to rest directly on top of piers 10 and 11 at the southbound roadway due to the collapse of spans 9 and

11. No spalling was present in the vicinity of the bearing locations of the northbound roadway and off-ramp.

Samples for Preservation
Several representative areas of the steel superstructure were selected for preservation prior to the demolition of the north approach spans. These areas include:

- Fatigue cracks and retrofits at girders G4, G6, and G11 in the first diaphragm line north of pier 9, and at girder G2 in the first diaphragm line south of pier 9.
- Bearings supporting girder G6 at pier 9, girder G11 at pier 10, and girders G5, G8, and G14 at pier 11.
- Cross girder and bearing assemblies at the south end of span 9 girders. Note that the cross girder and approximately 8 feet of the longitudinal girders at the south end of span 9 were retained.

All areas for preservation were field marked with spray paint.

Detailed Notes on Previously Identified Fatigue Crack Locations

On 23 and 24 August 2007, an examination of welded diaphragm connections on the north approach spans of the I-35W Bridge over the Mississippi River was performed. Existing conditions were compared with the conditions reported in the MnDOT June 2006 Fracture Critical Bridge Inspection In-Depth Report for the I-35W Bridge.

According to the June 2006 report, existing cracks and repairs were noted by MnDOT at the first diaphragms north and south of pier 9. Diaphragms had been lowered at these locations, since the original construction, as part of a retrofit effort, as well as at the first diaphragm lines on either side of pier 10. At these locations the lowered diaphragms are typically connected with 4 bolts in each of the two bottom corners. New cracks are now evident at other diaphragm locations in the north approach spans as a result of localized girder and stiffener deformation which occurred due to the collapse. No additional repairs beyond those noted in the 2006 MnDOT report were observed elsewhere in the north approach spans. A summary of the conditions noted during the field investigation follows below:

Diaphragm Line at Pier 11
No cracks evident.

1st Diaphragm Line South of Pier 11
No cracks evident.

2nd Diaphragm Line South of Pier 11
No cracks evident. Diaphragms have been lowered as part of the MnDOT retrofit to reduce web gap distortion.

Diaphragm Line at Pier 10
No cracks evident.

1st Diaphragm Line South of Pier 10
No cracks evident. Diaphragms lowered (MnDOT retrofit).

2nd Diaphragm Line South of Pier 10
Several conditions noted:

- Girder G1: Slight tear at stiffener connection to web near bottom flange, due to the collapse.
- Girders G8, G9, G10, and G11: Horizontal crack at top of weld between web and bottom flange, approximately centered at diaphragm stiffener. All conditions due to the collapse.

3rd Diaphragm Line South of Pier 10 / 1st Diaphragm Line North of Pier 9
Diaphragms lowered. Several conditions noted:

- Girder G1C: Small crack at toe of stiffener weld near top flange due to the collapse. Also, small tear in first stiffener north of this diaphragm, near bottom flange, due to the collapse.
- Girder G2: 1/2 inch crack at toe of stiffener weld near top flange, due to the collapse.
- Girder G3: 1/2 inch crack at toe of stiffener weld near top flange, due to the collapse.
- Girder G4: Two-inch diameter holes drilled through the web on both sides of the stiffener near the top flange, original crack noted in the MnDOT report was contained between these holes by the retrofit. Short crack at toe of stiffener on west side. This area was marked for preservation during demolition.
- Girder G5: Two-inch diameter holes drilled through the web on both sides of the stiffener near the top flange, original crack noted in the MnDOT report was contained between these holes by the retrofit. Short crack at toe of stiffener on east side.
- Girder G6: Short crack at toe of stiffener weld near top flange, due to collapse. Also, horizontal crack in web just below web/flange weld. The middle portion of this web crack exhibited some corrosion. This crack was not noted in the 2006 MnDOT report. This area was marked for preservation during demolition.
- Girder G9: Crack in top flange/web weld & top of west stiffener weld noted in 2006 MnDOT report. No change.
- Girder G10: Crack in top flange/web weld (east side) noted in 2006 MnDOT report. Crack was about 4 inches long, no change from 2006 report. Additional crack at stiffener weld toe, approximately 2 inches long, also unchanged since 2006 report. Short crack (approximately 1/2 inch long) indication in flange to web weld.
- Girder G11: Two-inch diameter holes drilled through the web on both sides of the stiffener near the top flange, original crack contained between these holes. No change since 2006 MnDOT report. Retrofit contained crack. This area has been marked for preservation during demolition.
- Girder G12: Two-inch diameter holes drilled in web on either side of the stiffener near the top flange, original crack contained between these holes. No change since 2006 MnDOT report. Retrofit contained crack.

Diaphragm Line at Pier 9
No cracks evident.

1st Diaphragm Line South of Pier 9

Diaphragms lowered. Several conditions noted:

- Girder G1: Per MnDOT 2006 report, east face of this girder had a 1/2 inch indication near the top flange. No change was evident.
- Girder G2: Per 2006 MnDOT report, bolted splice plate repair added to this girder to contain a 4-foot long "U-shaped" crack. Crack was contained by retrofit. This area was marked for preservation during demolition.
- Girder G4: 1/2 inch crack in girder web near top flange, west side, just above toe of stiffener weld. Noted in 2006 MnDOT report. No change. Additional 3/8 inch crack in stiffener weld near the top flange, east side, due to collapse.
- Girder G5: 1/2 inch crack in stiffener weld on both sides of stiffener near top flange, east side, due to stiffener deformation resulting from the collapse.
- Girder G6: 1/2 inch crack in stiffener weld on both sides of stiffener near top flange, east side, due to stiffener deformation resulting from the collapse.
- Girder G9: Crack in top of stiffener weld noted in 2006 MnDOT report. No change.
- Girder G11: 1/2 inch crack at toe of stiffener weld near top flange, east side, noted in 2006 MnDOT report. No change.
- Girder G12: 1/2 inch crack at toe of stiffener weld near top flange, east side, noted in 2006 MnDOT report. No change.

2nd Diaphragm Line South of Pier 9

One condition noted:

- Girder G1C: 1/2 inch crack at toe of stiffener weld near bottom flange, east side, due to collapse. Additional crack at web/bottom flange weld on west side due to collapse.

3rd Diaphragm Line South of Pier 9

Several conditions noted:

- Girder G1C: Crack in web at toe of stiffener weld near bottom flange. Additional crack in web just above web/bottom flange weld.
- Girder G2: Crack in web at toe of stiffener weld near bottom flange. Additional crack in web just above web/bottom flange weld.
- Girder G5: Crack in web at toe of stiffener weld near bottom flange. Additional crack in web just above web/bottom flange weld.
- Girder G6: Crack at toe of stiffener weld near bottom flange on west side. Crack in web at weld to bottom flange.
- Girder G9: Crack in stiffener weld near bottom toe, extends into web.
- Girders G12 and G14: Peeling paint and distortion evident near stiffener/bottom flange junction. Possible cracks at these locations, but close up inspection could not be performed due to railcars.

All cracks noted on this diaphragm line resulted from localized deformation caused by the collapse.

4th Diaphragm Line South of Pier 9

Two conditions noted:

- Girder G6: Crack in girder web at toe of stiffener weld near bottom flange due to collapse.
- Girder G7: Possible crack in girder web at web/bottom flange weld due to collapse.

5th Diaphragm Line South of Pier 9

Two conditions noted:

- Girder G8: Separation between stiffener and weld to top flange. Caused by localized distortion of girder due to collapse.
- Girder G9: Crack in web at weld to bottom flange due to collapse.
- Diaphragm connections at many girders were not accessible due to proximity of stone retaining wall.

Detailed Notes on Bearings

On 21 and 22 August 2007, observations of the voided slab and steel girder bearings at the north approach spans were made. Bearings at pier 9 were designed as fixed bearings for longitudinal movement, while the bearings at piers 10, 11, and the north abutment were designed as expansion bearings. The voided slabs were integral with the concrete piers at piers 12 and 13. All bearings are numbered from east to west. The following generally summarizes the conditions observed at each pier:

North Abutment

- The bearings exhibited light to moderate corrosion on the lower plates with the more significant corrosion present below the northbound lanes and off-ramps.
- No evidence of unusual or significant/excessive movement was present at the bearing locations. The curved plates were all nested and fully bearing on the lower plates with no significant south or north translation.

Pier 11 - Span 12 (Voided Slab)

- Upper and lower bearing plates exhibited moderate corrosion. No significant corrosion was observed on the curved plates.
- No distress was observed in the upper and lower bearing plates or the anchor bolts with the exception of bearing VS7 (west edge of northbound lane) where some prying was present along the south edge of the lower plate and the east anchor bolt exhibited slight tilting. The curved plate was also offset 4 inches north and resting on the north edge of the pier cap.
- The curved plates of several northbound lane bearings (VS6 to VS4, VS2) were offset 2 in. north of center. The curved plate of VS5 was dislodged from the bearing and lying on the ground north of the pier. However, bearings VS1 and VS3 were offset similarly south of center.
- The curved plates of the three western southbound lane bearings (VS 15 to VS13) were offset 2 to 4 inches south of center. No evidence of movement was present at the remaining southbound lane bearings where the curved plates were centered and nested.

Pier 11 - Span 11 (Steel Girders)

- Only lower bearing plates were available for inspection in the southbound lanes due to the collapse of Span 11. Light to moderate corrosion was present. No distress was present to the anchor bolts. Abrasion marks with a NW-SE orientation were present on the surface of the sliding plates for the bearings of G14 through G11 (west half of southbound lanes) and the east keepers had been sheared off at the bearings for G13 and G12.
- Moderate to heavy corrosion was present on some upper and lower bearing plates and girder bottom flanges at the northbound lane and off-ramp bearings. The curved plates remained connected to the upper bearing assemblies however these components had translated south approximately 6 inches and were minimally supported by the south edge of the lower bearing plate and/or pier cap.

Pier 10

- Bearings exhibited no significant corrosion.
- Lower bearing plates and anchor bolts exhibited no distress or evidence of movement.
- In both the northbound and southbound lanes (G14 to G2), the upper bearing plates remained connected to the girder sole plates but these components had translated approximately one to two feet south and up to one foot west of the lower bearing plates and were either suspended above, or minimally supported on, the south edge of the pier. The curved plates typically remained centered and nested in the lower bearing plates and the pintles were intact at all locations.

Pier 9

- Bearings exhibited no significant corrosion.
- The southbound lane bearings exhibited westward displacement of approximately 11-17 inches. This movement occurred at the bearings for G13 and G12 as a result shearing of the bolts at the upper bearing plate to girder sole plate connection, which resulted in sliding of the upper bearing assembly. The movement occurred at the bearings for G11 to G9 as a result of shearing of the anchor bolts and sliding of the entire bearing assembly on the pier cap.
- Similar westward displacement was also present at southbound lane slider bearings for G14 and G8 located at the east and west ends of the pier. The curved plate of the bearing for Girder G8 was completely dislodged from the bearing and located on the ground 17 feet north of pier 9.
- Less significant bearing movement and distress was present at the northbound lane and off-ramp bearings as described below:
    - Slider bearings for girders G7 and G1 displayed some southward rotation or skew but no distress to the upper and lower bearing plates or anchor bolts was observed.
    - The lower bearing plate was intact and no anchor bolt distress was present at bearings for girders G6 to G2 and G1C. However, most or all of the bolts at each of these upper bearing plate to girder sole plate connections had been sheared and the sole plates subsequently rotated to the south, with some slight translation, relative to the orientation of the upper plates. No obvious distress was present at the sole plate to girder bottom flange welds.

- Bearings for the off-ramp girders G1D and G1B had translated south approximately 11 inches in line with the original bearing orientation after the anchor bolts sheared off. All components of the bearing assembly remained connected.