NATIONAL TRANSPORTATION SAFETY BOARD

OFFICE OF RAILROAD, PIPELINE & HAZARDOUS MATERIAL INVESTIGATIONS

WASHINGTON, D.C.

Track & Structures

FACTUAL ACCIDENT REPORT

Accident No.:	DCA-13-MR-002
Location:	Paulsboro, New Jersey
Date:	November 30, 2012
Time:	06:59 a.m., Eastern Daylight Time
Railroad	Consolidated Rail Corporation
Property Damage:	$450,654.00
Injuries:	None
Type of Accident:	Train Derailment and Hazardous Materials Release

Prepared by: Cyril E. Gura, Safety Engineer
National Transportation Safety Board
31W775 North Avenue
West Chicago, Illinois 60185

Date: June 21, 2013

Party Participants

Cyril E. Gura,	Safety Engineer-Track & Structures Group Chairperson Office of Railroad, Pipeline and Hazardous Materials Investigations National Transportation Safety Board 31W775 North Avenue West Chicago, IL 60185
Timothy C. Tierney,	Vice President Chief Engineer Consolidated Rail Corporation 1000 Howard Boulevard 4th Floor Mt Laurel, NJ 08054-2355
Thomas E. Bilson,	Assistant Chief Engineer Maintenance of Way and Structures Consolidated Rail Corporation 1000 Howard Boulevard Room 470 Mt Laurel, NJ 08054-2355
David R. Killingbeck, P.E.,	Chief Engineer – Structures Office of Railroad Safety Federal Railroad Administration 3rd Floor - West / Mail Stop: 25 1200 New Jersey Avenue S.E. Washington, D.C. 20590
Mark J. Brink,	Bridge Safety Specialist Office of Railroad Safety Federal Railroad Administration 3rd Floor-West Mail Stop: 25 1200 New Jersey Avenue S.E. Washington, D.C. 20590
Ronald J. Marx,	Railroad Safety Inspector (Track) Federal Railroad Administration P.O. Box 400 Hopatcong, NJ 07843
Cameron P. Chasten, P.E.,	Chief, Engineering Management Branch US Army Corps of Engineers – Philadelphia District Wanamaker Building 100 Penn Square East Philadelphia, PA 19107

Synopsis

On Friday, November 30, 2012, about 6:59 a.m. EST, southbound Consolidated Rail Corporation (Conrail) freight train FC4230 consisting of two locomotives and 82 cars derailed seven cars, the 6th through the 12th, near milepost 13.7 on the Conrail Penns Grove Secondary track in Paulsboro, New Jersey. The derailment occurred as the train traveled over the Paulsboro Moveable Bridge.

Four tank cars that derailed on the bridge came to rest with portions of the cars in Mantua Creek. Three of the derailed tank cars that entered the creek contained vinyl chloride, and one contained ethanol. One of the tank cars was breached during the derailment and released approximately 20,000 gallons of vinyl chloride into the environment. Eyewitnesses reported seeing a vapor cloud rise from the scene immediately following the accident. The initial damage estimates are $450,654, which does not include response and remediation costs.

On the morning of the accident, 23 local residents were treated for possible vinyl chloride exposure at nearby hospitals and released. The conductor of the train and numerous emergency responders were also tested for vinyl chloride exposure.

Mantua Creek is a navigable waterway in Gloucester County, New Jersey, and is about 150 feet wide at the location of the derailment. It flows northwest for about 18.6 miles to the Delaware River at Paulsboro across from the Philadelphia International Airport. The FAA reported that airport operations were unaffected. The weather at the time of the incident was cloudy skies with 34 degree temperature and calm winds.

Parties to the investigation include the Federal Railroad Administration, Conrail, Trinity Tank Car, the Brotherhood of Locomotive Engineers and Trainmen, and the United Transportation Union.

Track and Structures Investigation

Postaccident investigative information, photography and site inspections, were provided by; the Consolidated Rail Corporation (CRSH), the US Army Corps of Engineers (USACE)[1] and the Federal Railroad Administration (FRA) who had investigated the accident from the accident site. Due to prolonged hazardous materials recovery operations, the NTSB track and structures group chairman was not able to access the site until January 8, 2013.

Track

Track Description

The CRSH Penns Grove Secondary is a single track main line which extends southward from Woodbury, NJ milepost (MP) 8.8; to Deep Water, NJ (MP 30.0). The track is designated and maintained to FRA Class 3 standards with a maximum operating speed of 30 mph with a 10 mph timetable speed restriction over the Paulsboro Moveable Bridge. About 8 trains traverse the bridge daily for an annual gross tonnage of about 3.6 million gross tons (mgt).

Approaching the accident site from the north, starting at the Paradise Road highway/rail grade crossing (MP 13.0), there are in succession: tangent track for 2,057 feet, a 3 degrees curve to the right with 1 inch of elevation in the east rail for 1,017 feet, and then a tangent track for 625 feet to the point of

---

[1] USACE was contracted by the NTSB to assist in the bridge investigation.

derailment at the north end of the swing span of the Paulsboro Moveable Bridge. There is a 0.77% descending grade from MP 13.0 to the Paulsboro Moveable Bridge.

The track is constructed with 112 pound continuous welded rail, wooden crossties and crushed stone ballast to the north end of the Paulsboro Moveable Bridge. The track was last tied and surfaced on September 5, 6, and 7, 2006. The track on the northern approach span of the Paulsboro Moveable Bridge is constructed with 132 pound rail and wooden bridge timbers.

The track is visually inspected weekly, and the track inspection is performed with the use of a hi-rail vehicle and/or on foot. The last track inspection prior to the derailment was performed on November 20, 2012, by hi-rail and on foot. The inspection found no exceptions to the Federal Track Safety Standards (FTSS) on the bridge or on the track in the vicinity of the bridge.

CRSH conducted two automated track inspections of the Penns Grove Secondary, one on June 1, 2012 and the other on October 16, 2012. Both automated track inspections found no exceptions to the track geometry on the Paulsboro Moveable Bridge or on the track in the vicinity of the bridge. The FRA also conducted an automated track inspection of the Penns Grove Secondary on June 13, 2012, and also found no exceptions to the track geometry either on the bridge or on the track in the vicinity of the bridge.

The last monthly on-foot inspection of the Paulsboro Moveable Bridge miter rails prior to the derailment was performed on November 20, 2012. The inspection found no exceptions to the FTSS at the miter rails.

Post-Accident Inspections

During the investigation, on December 1, 2012, the FRA conducted an inspection of CRSH's Track Inspection Records for the Penns Grove Secondary covering the period from December 1, 2011 to November 30, 2012. The records inspection disclosed that the track was inspected weekly. Any exceptions from the FTSS that were noted on the inspection records were repaired or the proper remedial action was taken. The FRA found that no exceptions were taken to the track on the Paulsboro Moveable Bridge or to the track in the vicinity of the bridge. Also, the frequency of the track inspections was found to be in compliance with the FTSS for Track Classes 1, 2, and 3 for main track and sidings.

§213.233 Track inspections.

(a) All track shall be inspected in accordance with the schedule prescribed in paragraph (c) of this section by a person designated under § 213.7.

(c) Each track inspection shall be made in accordance with the following schedule -

Class of Track	Type of Track	Required Frequency
Excepted track and Class 1, 2, and 3 track.	Main track and sidings	Weekly with at least 3 calendar days interval between inspections, or before use, if the track is used less than once a week, or twice weekly with at least 1 calendar day interval between inspections, if the track carries passenger trains or more than 10 million gross tons of traffic during the

		preceding calendar year.

The FRA also inspected the CRSH's miter rail inspection records for the Paulsboro moveable bridge. The inspection disclosed that the miter rail inspections were conducted monthly and there were no exceptions taken to the miter rails. The inspection also disclosed that the miter rail inspection frequency was in compliance with FTSS.

§213.235 Inspection of switches, track crossings, and lift rail assemblies or other transition devices on moveable bridges.

(a) Except as provided in paragraph (c) of this section, each switch, turnout, track crossing, and moveable bridge lift rail assembly or other transition device shall be inspected on foot at least monthly.

(c) In the case of track that is used less than once a month, each switch, turnout, track crossing, and moveable bridge lift rail assembly or other transition device shall be inspected on foot before it is used.

The FRA conducted an inspection of CRSH's rail inspection records of the Penns Grove Secondary for the year 2012. The inspection revealed that the track had been inspected on May 16, 2012, and two defects were discovered approximately 1,000 feet north of the bridge. The two defects were identified as transverse defects. The first defect was located at MP 13.47 and was affecting 20% of the rail head. The second defect was located at MP 13.53 and was affecting 30% of the rail head. Both rails were replaced on June 18, 2012. The FRA determined that the remedial action taken by CRSH was in compliance with the FTSS. The rail inspection records were found to be in compliance with the FTSS. The FRA took no exceptions to CRSH's rail inspection records.

§213.237 Inspection of rail.

(a) In addition to the track inspections required by § 213.233, a continuous search for internal defects shall be made of all rail in Classes 4 through 5 track, and Class 3 track over which passenger trains operate, at least once every 40 million gross tons (mgt) or once a year, whichever interval is shorter. On Class 3 track over which passenger trains do not operate such a search shall be made at least once every 30 mgt or once a year, whichever interval is longer. (This paragraph (a) is applicable January 1, 1999.)

§213.113 Defective rails.

(a) When an owner of track to which this part applies learns, through inspection or otherwise, that a rail in that track contains any of the defects listed in the following table, a person designated under § 213.7 shall determine whether or not the track may continue in use. If he determines that the track may continue in use, operation over the defective rail is not permitted until -

(1) The rail is replaced; or

(2) The remedial action prescribed in the table is initiated.

Defect	Length of defect (inch)		Percent of rail head cross- sectional are a weakened by defect		If defective rail is not replaced, take the remedial action prescribed
	More than	But not more than	Less than	But not less than	

					in note
Transverse fissure			70	5	B
			100	70	A2.
				100	A.

A. Assign person designated under § 213.7 to visually supervise each operation over defective rail.

A2. Assign person designated under § 213.7 to make visual inspection. After a visual inspection, that person may authorize operation to continue without continuous visual supervision at a maximum of 10 mph for up to 24 hours prior to another such visual inspection or replacement or repair of the rail.

B. Limit operating speed over defective rail to that as authorized by a person designated under § 213.7(a), who has at least one year of supervisory experience in railroad track maintenance. The operating speed cannot be over 30 mph or the maximum allowable speed under § 213.9 for the class of track concerned, whichever is lower.

On December 12, 2012, a CRSH track team measured the track geometry for 20 stations north of the derailment. The POD was recorded as station 0+00, and that was located at the north end of the bridge miter rail, MP 13.7. The geometry measurements did not exceed FTSS. See the track measurement notes attached to this document.

Bridge

Bridge Structure Description

The Paulsboro Moveable Bridge is a shear pole ("A" frame) swing bridge, configured with the pivot point (heal) located near the southern end of the span. The Paulsboro Movable Bridge is located at MP 13.70 and is a 5 span steel trestle bridge with a heel pivot swing span to accommodate navigation of small craft on Mantua Creek in Paulsboro, NJ. For the length of the bridge, an open tie deck is supported by 2 steel girders which are supported by steel pile bents. There are three approximately equal spans that make up the 88 ft – 4 in. south approach (two spans are 29 feet – 9 inches long and one span is 27 feet – 7 inches long.) The swing span is 56 feet – 4 inches long with 4 feet – 4 inches cantilever portion south of the swing center bearing. The north approach consists of one span that is 37 feet - 6 inches in length. The approach span girders are rolled structural steel, and the swing span girders are built up riveted steel members. The abutments are driven steel piles with steel caps encased in concrete with concrete back walls. The total overall length between abutment back walls is approximately 183 feet. The main track on the swing span of the bridge had guardrails[2] installed within the gage of the track.

The swing span is a heel pivot swing that is normally open to accommodate navigation on Mantua Creek and is closed (in-line) to allow train crossing. The south end of the swing span bears on the pivot pier constructed of steel cluster piles that are inter-connected with three cross caps (essentially three bents that are inter-connected). The span rotates on a center bearing with a flat ring plate and pony wheels. During movement of the span, the toe end of the bridge is supported by two tension rod bars (hog rods) that are anchored to an A-frame superstructure which rises on the east and west side of the bridge over the track.

---

[2] Guardrails are placed parallel to regular running rail along areas of restrictive clearance; such as a bridge, trestle, or tunnel. These have the effect of keeping the wheels of rolling stock in alignment in case of a derailment. It also helps to minimize damage to the structure and allow easier post-accident cleanup.

When the bridge is open it is oriented approximately 90 degrees to in-line and the toe end is supported by the A-frame hog rods. When closed, the toe end is then supported on a steel pile bent (the toe bent).

The swing span girders are presumably of original construction that occurred approximately 1917. The south approach spans and associated bents and the pivot pier bents were re-constructed in early 1980. The north approach girders were replaced in 1969 and the associated north approach bent and toe bent were re-constructed in 2009. The 2009 construction also included reinforcing with steel plates and encasing piles for the pivot bent and two of the south approach span bents. The design live load for the bridge is Cooper E-80[3] live load. The deck appeared to have been rehabilitated numerous times.

Identification for Structural Location

Typically, the normal convention for numbering of bents, piers, etc. is with numbers increasing in the same direction as increasing mile marker which is north to south for Bridge 13.70. For this report, however, the identification of bridge member will be consistent with the 2009 repair plan drawings for CRSH by Jacobs Civil Inc. The bridge is assumed to be oriented with rails running north-south to be consistent with rail line direction (the actual orientation is not north-south). Girders are identified as east or west. For approach spans and associated support piers, numbering is south to north. The swing span will be referred to as the swing span and its support bents will be referred to as the pivot bent (supports south end of swing span) and the toe bent. The pivot bent includes three separate bents that will be referred to by number from south to north.

Background for Structural Evaluation

It was initially reported that the bridge collapsed and a derailment occurred with a subsequent release of hazardous materials. A derailment can be caused by an inadequate bridge structure. If a structural deficiency was determined, then a loss of support to the train or excessive movement to the train would induce instability. Alternatively, if no structural deficiencies were found, then the bridge structure was not the cause of the derailment.

For this structural evaluation the NTSB and FRA bridge inspection team was not allowed to access the site. Therefore, a team lead by CRSH did access the site and recorded extensive video and still shot photography from the bridge deck, and a separate visual structural inspection was conducted on December 14, 2012 by a team of CRSH, Modjeski and Masters (structural engineering firm on contract with CRSH) and USACE personnel. The comments provided in this portion of the evaluation are based on the visual inspection and examination of various photographs. A load rating or mathematical analysis of structural members was not conducted since it was assumed that the members were sufficiently sized for design loads. Based on train load data, the train was not overloaded. It is known that various fully loaded cars weighed approximately 130 tons, which was within the design load of the bridge.

Basis of Evaluation

The USACE reported that the evaluation was based on visual observation of structural members above the water level. It was assumed that a sufficient design has been conducted (design live load has been reported as Cooper E-80) and that the derailed train was not overloaded. The bridge has been subjected to thousands of similar load events, so the design has proven to be sufficient. Data on train cars provides

---

[3] The Cooper live-load model gives a universal system with which all other load configurations can be compared. Engineering personnel of each railroad can calculate how the load effects of each piece of equipment compare to the Cooper loading. The 80 in E-80 refers to the 80 kip weight of the locomotive drive axles and the design impact values are based on an assumed train speed of 60 mph.

evidence that the train was not overloaded. Given a sufficient structural design, inspection and structural evaluation can be made by visual observation of structural features involving basic geometry of members and support conditions. The condition of structural members is evaluated by examining the existing cross section (evaluate section loss due to corrosion or other damage), member straightness, orientation (condition of plumb or level), and support conditions (adequacy of bearings and connections).

Visual Inspection

The USACE reported that the entire structure was examined visually on December 14, 2012. Only about half of the structure was inspected up-close due to obstructions and time constraints. The boat access time was limited due to rising tide, and the south approach was not accessible by boat due to obstruction of derailed rail cars lying in the south half of the Mantua Creek. Without boat access, only Span 1 of the south approach was accessible up close. The inspection consisted of the following access:

- close observation of South Approach Span 1 and South Bent 1 from the ground
- visual observation of South Approach Span 2 and South Bent 2 from South Bent 1 and the deck
- visual observation of South Approach Span 3, South Bent 3, and pivot bent from the deck
- close observation of the swing span from a boat and the deck
- close observation of the toe bent and Bent 4 from a boat and the deck
- close observation of the north approach span from the ground

Observations Based on Visual Inspection

The USACE inspection team reported that the overall condition of the bridge superstructure is good to very good. The steel members are in very good condition with little to no degradation due to corrosion. At various locations, paint failure with general surface corrosion was observed. However, there was no indication of section loss on any primary structural member (girders, bent caps and observed portions of piles). Therefore, there is no loss of strength to primary structural members due to corrosion degradation. Girders and pile caps were straight with no notable distortion. Pile caps also appeared to be level. Bearings consist of girders resting directly on steel bearing plates and the girder flanges are allowed to slide at expansion joints. Expansion is allowed by slotted holes in girder flanges (see Photo B4). All bearings appear to maintain good uniform contact and no significant deficiencies were found. Table 1 provides a summary of inspection comments for primary structural members.

Rail timber ties appeared to be in good condition in the approach spans. Ties damaged in the derailment had been replaced on approaches at the time of inspection. Many of the timber ties on the swing span were damaged during the derailment. The timbers appeared to be sound where not damaged.

Notable Deficiencies Based on Visual Inspection Reported by USACE

Various items that warrant discussion are identified below.

- The expansion bearing on Bent 1 is at the limit of movement (Photo B4). The girders are pushed south so the bearing bolt is bearing on the north side of the slotted hole. The bearing bolts are pushed out of plumb and girder movement to south is restricted. The USACE said that this condition would not contribute to a train derailment, but should be evaluated in the future.
- A dent exists in the bottom east flange of the east girder about mid-length of the swing span. The USACE said that this appears to have existed for some time and is of no concern.
- The northwest bearing stiffener of the east girder in Span 3 is distorted (Photo B6; bottom portion is pushed to the south). The USACE said that this condition is not considered to have contributed to the train derailment, but the condition should be evaluated in the future.

- Some of the stiffeners on the pivot bearing were cracked. The USACE said that the cracks could have occurred when the swing span was dropped during the derailment, but are not considered to have caused the derailment. The support of the pivot bearing will not be required in the future. During the weekend of December 15-16, 2012, a shim pack was installed and secured under each girder to provide a fixed bearing.
- The north diaphragm of the swing span girders was damaged severely during the accident. This was replaced during the weekend of December 15-16, 2012.

The USACE concluded in a statement that regarding structural integrity: there appeared to be no pre-existing structural conditions that would have attributed to train derailment.

Visual Inspection Discussion

As indicated in the Visual Inspection section, a portion of the bridge was not examined hands on or close-up; however it was possible to see all girders and pile cap members from the deck and embankment, and it appeared that orientation was proper and members were straight. From the evidence of the visual inspection, the bridge superstructure and pile bent caps were in overall very good condition. This was substantiated by a Modjeski and Masters report that the structure was sound for future operation with the span fixed in-line. The portion of the structure below water was not evaluated during the December 14, 2012 inspection; however based on the orientation of bent caps and visual portion of piles, there was no evidence that foundation problems exist. On December 16, 2012 a dive inspection by Enviro Sciences Inc. under the supervision of Modjeski & Masters confirmed the bridge foundation is structurally sound and no notable damage to substructure elements was evident.

Bridge Operation Sequence

The Paulsboro moveable bridge is normally positioned open to river traffic[4], and not lined for rail traffic like it was on the day of the accident. On approach to the bridge, a train must be prepared to stop at the wayside signal, check that the waterway is clear of traffic, and use a radio signal to remotely close the bridge aligning it for rail traffic. Four slide locks are used to secure the moveable bridge when it is lined and locked for rail traffic. The slide locks are located outside of each running rail on each end of the movable span. Mechanical switches and inductive proximity detectors are used to detect the position of the slide locks used to secure the bridge for rail traffic. When the slide locks are not within the range of the proximity sensors (about ½ inch) the bridge is considered unlocked, and the controlling wayside signal will show "red" aspect and the train has to stop. Alternatively, when the slide locks are within sensing range of the proximity sensors the wayside signal shows a "green" aspect and the train can proceed.

A request to close the bridge, aligning the span for rail traffic, is designed to produce the following bridge response:

1. A warning message will be broadcast over the loudspeakers on bridge (including two warning signal blasts) announcing the closing of the bridge.
2. The bridge swing span will be driven using an electric hydraulic pump driving a hydraulic actuator to the closed position. This will accomplish a horizontal alignment of the rails.
3. The bridge swing span will be lowered about 3/8 inches into the seated position from the raised position by the "A" frame and hog rods via a worm gear. This will accomplish a vertical alignment of the rails.
4. Slide locks, one for each rail on both the north and south ends, will slide approximately 7" to secure

---

[4] The bridge is typically closed to river traffic from December 1st through March 1st.

the track at the heel and toe of the movable span. This will assure that the tracks remain aligned during train movement.

A request to open the bridge, aligning the span for marine traffic, is designed to produce the following bridge response:

1. A warning message will be broadcast over both radio and loudspeakers on bridge (including five warning signal blasts) announcing the opening of the bridge.
2. Slide locks, one for each rail on both the north and south ends, will slide approximately 7” to unsecure the track at the heel and toe of the movable span.
3. The bridge swing span will be raised by the “A” frame and hog rods via a worm gear to permit clearing the fixed portion of the bridge.
4. The bridge swing span will be driven using an electric hydraulic pump driving a hydraulic actuator to move to the open position.

A request to close the bridge is normally made by the train operator using a code entered via keypad on a locomotive or handheld radio. The train must be shunting the adjacent track circuit for the automated bridge control system to process this request. Once the train has crossed the bridge and cleared the adjacent track circuit on the far side, the bridge control system is designed to automatically open the span.

The bridge can also be opened and closed using controls located in pole-mounted control boxes located on the wayside at the north and south approaches to the bridge. These control boxes are configured in pairs – one for maintenance and one for train operators – and are locked for security. The train operator remote control box contains two buttons; a reset button, and a close button. The close button will initiate closure of the bridge provided that the bridge controls are switched to REMOTE MODE. The maintenance box also contains an open button.

If the bridge control system encounters certain errors, the system is designed to stop bridge operation and set an internal error flag. The bridge control system must then be reset before normal bridge operation can resume. Once a reset has been successfully accomplished, and assuming the cause of the malfunction has been rectified, the close button can be used to cause bridge closure. Resetting the bridge control system erases any and all error codes previously flagged.

Description of Bridge Control System

The control system for the Paulsboro Movable Bridge was installed on or about July 2003 by Heidenriech Associates, Inc., Control Systems Engineers; Greenwich, Connecticut. At that time, a manually operated mechanical system was replaced by an electronically automated, hydraulic powered system. A hydraulic piston is used to swing the bridge open and closed. Motor driven worm gears are used to seat and unseat the bridge for motion, and to lock the rails in position for rail traffic when closed. The system is controlled by a Modicon 984-130, PLC housed in a structure near the south end of the bridge, just to the west of the railroad tracks.

The bridge control system monitors sensors and controls servos installed at various points on the bridge, and from the CRSH bridge control system. The inputs from these sensors are processed by program logic running in the Modicon PLC. The output from this program logic is sent to servos controlling movement of the bridge, and to the CRSH signal system. The sensors monitored by the bridge control system include:

- Signals from the wayside signal system including the OPEN PERMIT signal and signals indicating adjacent track circuit occupancy.

- Positions / modes of the various manual control switches in the bridge control room and each remote control box.
- Mechanical limit switches indicating that the bridge is either fully open or fully closed.
- Mechanical limit switches indicating that the rail is in the fully seated position.
- Inductive proximity sensors indicating that the bridge is in the fully closed position.
- Fluid level in the hydraulic reservoir for the bridge swing movement system.
- Additional inputs monitoring power and battery status at various points in the bridge control system.

Inductive proximity sensors are also installed on the bridge adjacent to each slide lock assembly to provide indication to the railroad signal system that the slide locks are fully extended. These sensors are not interfaced to the bridge control system. Selected inputs to the bridge control system are also passively monitored (track occupancy) and recorded by the CRSH signal system to aid in troubleshooting bridge problems. Outputs from the bridge control system include:

- Signals to the wayside signal system indicating bridge position (open or closed) and status of the bridge control system (normal or ‘failure to operate’).
- Signals to make audible announcements of bridge operation locally and over a radio channel.

The bridge control system also accepts input from a ‘watchdog timer’ which will suspend bridge control operation and flag an error if certain operations take too long to perform. The purpose of this logic is to prevent component damage due to mechanical problems preventing normal servo operation. The bridge control system employs redundancy in several areas to enhance reliability and permit limited bridge operation in case of component failure. This includes:

- Two independent PLCs running simultaneously in real time. Each PLC looks at the same set of sensor inputs, and runs identical program code. Only one PLC provides output to external servos and the CRSH signal system. The PLC exerting control can be switched manually from within the bridge control room.
- Two independent sets of position and limit switches monitoring rail position and bridge swing span position. In the event of a malfunction in one switch or sensor, limited bridge operation may still be possible. An error code will be flagged.

The Modicon PLC’s act as the central processor for the bridge control system. The PLC’s are programmed in ‘Ladder Logic’, which is a graphical programming language that resembles the circuit diagrams of relay logic familiar to many industrial control operations. The program is typically written on a PC running specialized software, and downloaded into the PLC via a serial port connection, or via an EEPROM4 card containing the finished program that is inserted into the PLC before power up.

Once configured, the PLC will continuously update all of the inputs, perform the logic specified in its programming, and adjust all of the outputs accordingly. The inputs to the PLC come from sensors, switches, and signals indicating the status of various components of the bridge control system, the wayside signal system, and instructions for bridge operation such as opening/closing. The outputs from the PLC drive servos used to control bridge operation and inform the wayside signal system.

The PLC is programmed to assert (make ‘true’) certain discrete output lines to flag certain anomalies. These output lines are programmed to remain asserted until the bridge control system is reset. A Red Lion operator interface located in the bridge control room is configured to display on an LCD screen the code for the first error flagged by the PLC. A blue ‘acknowledge’ button to the right of the operator interface screen causes the unit to poll each consecutive output line in turn, and display the associated error code for each line that is found to be asserted ‘true’ on the same LCD screen. The LCD screen can only display one error code at a time. Subsequent codes are displayed two seconds apart until all of the output lines have been polled. Then the process repeats.

Immediate Postaccident Bridge Inspections

On Friday, November 30, 2012 at approximately 8:00 AM, the FRA Bridge Safety Specialist was notified of the train derailment on the CRSH Paulsboro Moveable Bridge and was instructed to report to the derailment site to commence the FRA accident investigation.

The FRA bridge specialist arrived on derailment site at approximately 11:45 AM. After consulting with CRSH personnel on site as to environmental conditions, he was informed that toxic fume levels had dropped below hazardous levels to a point that he could safely access the bridge and surrounding areas for accident investigation.

The FRA bridge specialist’s site investigation began from the south end of the bridge. Initially the investigation was to determine if the bridge failed, where, what failed and why. He was able to access various locations and positions throughout the bridge from the south end, across the bridge to the north end. Through this observation he was able to determine that the sub and superstructure of the bridge appeared to be structurally sound with no signs of a structural failure within the pile bents, caps, beams or girder sections.

While the FRA bridge specialist was on the bridge and after his assessment to determine if any part of the bridge failed he conducted a cursory investigation into what may have caused the derailment. He took note of wheel marks on the rail head on both rail transition “miter rail shoes”, on the south end of the north approach span. Also noted was what appeared to be wheel caused damage to the southeast proximity sensor on the north approach span. The sensor was knocked off its mount. Also noted were wheel marks on the inside brace structure of the northwest swing span miter rail shoe and on the outside of the northeast miter rail shoe on the swing span. He said that from the north swing span miter rail shoes it was very evident the cars were derailed on the tie deck and over the side of the bridge.

On November 30, 2012, when the CRSH Communication and Signal (C & S) supervisor arrived at the derailment site at Paulsboro Moveable Bridge, he shut off commercial power that was being supplied to the bridge and to all C&S locations. He recorded the following error codes from the PLC prior to shutting off the electrical power.

Code 45 - Hydraulic tank Lo-Lo oil level trip.
Code 78 - Bridge failed to open.
Code 79 - Bridge failed to close.
Code 5 - Local lock out hydraulic pump motor.
Cade 10 - Limit switch fault creep / 10ls3a.
Cade 11 - Limit switch fault creep/ 10ls3b.
Code 19 - Position switch fault S- TLNK/7LS1A/B.
Code 44 – Hydraulic tank lo oil level.

Subsequent Postaccident Investigations

On January 9, 2013, the NTSB’s track and structures group chairman and the NTSB senior metallurgist and electrical engineer from Research and Engineering (RE), CRSH Party representatives, the PLC designer, two FRA representatives (the Track Inspector and the Chief Engineer-Structures) and the USACE representative collectively inspected the PLC and the bridge slide lock and miter rail assemblies.

The NTSB electrical engineer, the PLC designer, the FRA Chief Engineer-Structures and CRSH representatives concentrated their efforts on the PLC. The purpose of this effort was to gain understanding of the physical layout of the bridge control system, and to determine the status of the PLCs, which had been powered down soon after the accident. Power was restored to the bridge control room and the primary PLC in the bridge control system. The following response was observed from the front panel of PLC #1:

- The 'Ready' indicator lit.
- The 'Run' indicator lit.
- The 'Battery' indicator remained unlit, indicating that the internal backup battery within the PLC was still charged.

Using the RS-232 interface on the front of the PLC and laptop running Schneider Electric's ProWorx NXT software, it was confirmed that the program code stored in PLC #1 was identical with the program code previously downloaded into the unit by the integrator on November 8, 2012. The ProWorx NXT software was used to poll the discrete output lines corresponding to the error codes recorded by Conrail personnel on the day of the accident just prior to removing power from the bridge control system. The following states were recorded for each corresponding output line:

- Output line #5, LOCAL LOCK-OUT / HYDR. PUMP MOTOR, asserted (indicating error)
- Output line #10, LIMIT SW. FAULT / CREEP (10LS3A), not asserted
- Output line #11, LIMIT SW. FAULT / CREEP (10LS3B), not asserted
- Output line #19, POSITION SW. FAULT / S-TLNK (7LS1A/B), not asserted
- Output line #44, HYDR. TANK / LOW OIL LEVEL, asserted (indicating error)
- Output line #45, HYDR. TANK / LO-LO OIL LEVEL TRIP, asserted (indicating error)
- Output line #78, BRIDGE FAILED / TO OPEN, not asserted
- Output line #79, BRIDGE FAILED / TO CLOSE, not asserted

The process was repeated with PLC #2, and identical results were obtained. The system was not designed to retain information concerning the time or order in which the error states were changed. Therefore, these error codes are in no particular time order sequence.

The NTSB senior metallurgist, the NTSB track and structures group chairman, CRSH representatives, the FRA Track Inspector and the USACE representative rebuilt the miter rail components and conducted a very close inspection of the miter rail and slide lock assemblies. The examined bridge and mating side lock components were arranged in their approximate original bridge closed relative positions. All of the recovered bridge deck level locking components was examined including approximately 10 to 15 feet of running rail on either side of the bridge to land interface and the hydraulic cylinder. (See Figures 1 thru 11 from the metallurgist's report).

Both the north and south ends of the bridge contained slide locking mechanisms. Though of different mechanical component details, they operated on the same principle. With the bridge structure in the closed position (closed to marine traffic open to rail traffic), slide locks on the swing span were actuated through deck side operating rods by under deck mechanisms. The slide locks extend outward from the swing span and engaged slots on the bridge approach side fixed structure. Both the north and south ends had mirrored locking components associated with each of the running rails. According to CRSH representatives, with the bridge closed, the gap between the fixed running rails and the movable span running rails average from 2 ½" – 2 ¾" inches.

As previously noted the slide locking mechanisms at the north and south ends were slightly different design utilizing different components. Both designs used the running rails to form the gage sides of the locking mechanisms.

At the north end four specialty blocks (two per rail) guided the field sides of the slide locks on the swing span and a single block formed the field side of each slot on the fixed bridge approach span. The field side heads of the running rail are trimmed to accommodate the shape of the slide locks. Proximity detectors were mounted on brackets attached to the fixed side guide blocks for both rails. The centerlines of proximity detectors located 6.5 inches north of the ends of the fixed running rails. Gage side wheel flange guards were incorporated into the support structures of both the swing and fixed side mechanisms.

For the south end lock mechanisms, the bottom flanges of short stock rail sections were butted against the running rail bottom flanges on both the swing span and bridge approach span. The south sliding locks were machined so as to ride in the web area pockets formed by the running rail profile and the stock rail sections. The south end proximity detectors were located in the webs of the fixed stock rail sections. The detector centerlines were located about 5 inches south of the northern tips of the stock rail sections. Due to the near proximity of the bridge pivot to the south edge of the bridge, the southern bridge to approach span interface components were heavily angled to accommodate the short pivot radius.

Examinations of the north side lock components found the north corner of the fixed northwest flange guard overstress fractured but no fractures of major components were found. The brackets holding the proximity detectors were removed at the time of inspection. The end of the running rails (east and west) showed battering deformation for 2 to 3 inches on either side of the end gaps. Both east and west slide locks moved relatively easily in greased areas on the swing span. Displaced grease in the fixed side slots indicated a normal slide lock engagement of approximately 8 inches.

The north ends of the slide locks were undamaged as were the mating areas of the fixed side slot components. Multiple marks and dents consistent with wheel flange impacts were noted on the gage side wheel flange guard at the northeast rail and on top of the field side guide blocks of the northeast rail.

Disturbed grease lines on the south side fixed side components indicated about 5 to 6 inches of engagement of the slide locks. Minimal battering deformation was noted at the gap in the south side running rails.

The fixed southwest running rail was fractured though the web for approximately 18 inches. The CRSH representatives indicated that the rail was originally found in place but was separated during the track repair process. The separated piece reportedly fell into the waterway and was not recovered. The remainder of the southwest swing and fixed locking mechanism was intact with little apparent damage.

In contrast, the southeast slide lock assembly components showed significant damage. On the swing span, the slide lock and guide rail were separated from the swing side bed plate. The slide lock was reportedly found some distance south on the south approach span. The guide rail was not recovered. The bolts holding the guide rail were separated and 1 sheared bolt remained in the bed plate. The operating rod for the southeast rail slide lock was separated and not recovered.

The north end of the fixed southeast running rail was fractured through the web and head separating two pieces. The fractures were overstress with features indicating bending loads to the gage side of the rail. The north head fracture was located at the grease indicated south tip of the slide lock in the locked position. Dents were apparent on the web side fracture consistent with wheel impacts after fracturing. Wheel marks were also found on the north end of the guide rail and the rail support with 3 of the bolts fractured.

The NTSB electrical engineer conducted subsequent analysis the following bridge components at the Washington, D.C. facility: 2 north end swing span limit switches, 2 bridge seat motor limit switches, 1 southeast proximity sensors, 1 southwest proximity sensor and two swing span proximity sensors. A chain-of-custody was completed. It was subsequently determined that the components may need to be tested at a later date.

Bridge Records

CRSH Visual Inspection Document Record Review

CRSH conducted two semiannual Level One inspections per year. The last inspection was performed on November 5, 2012. The previous inspection was conducted on May, 8, 2012. The conditions noted on the paper report do not indicate any adverse conditions which would affect the integrity of the bridge to perform as intended.

CRSH Quarterly Inspection, Inspect the Movable Bridge Mechanism and Hardware Record Review

The last quarterly inspection performed was on June 25, 2012. No conditions noted on the inspection form indicate any adverse conditions which would affect the integrity of the bridge to perform as intended.

As a note, CRSH's Bridge Management Program (BMP) adopted September 13, 2012, as required by FRA, 49-CFR-237.31, (d), states that they will conduct a quarterly moveable bridge inspection. FRA 49-CFR-237 does not require this by statute; however, if the railroad states more frequent inspection cycles in their BMP, they shall adhere to their BMP. The last quarterly inspection conducted on the Paulsboro Movable Bridge was on June 25, 2012. The September quarterly was not conducted, and this is non-compliant with CRSH's BMP. The CRSH bridge inspector stated that the September quarterly inspection was not conducted because he was under medical care at the time and that prevented him from scheduling the inspection.

Previous Bridge Problems

Previous Bridge Failure & Underwater Inspections

The Paulsboro Movable Bridge had previously collapsed on August 23, 2009. Temporary repairs were made by August 29, 2009 to resume train operations. Underwater bridge inspections were conducted on August 26, 2009 and in September 2009. The combined inspections drove the repair plan for permanent bridge repairs. Repair plan drawings were completed October 26, 2009 and permanent repairs completed by April 5, 2010. All piles were spliced and jacketed, and the jackets were filled with epoxy grout.

Underwater inspections were necessitated due to piles failing in the north rest toe bent for the swing span. The north end, toe of swing span settled down from the pile failure resulting in an excessive rail cross-elevation and line resulting in the derailment of two rail car trucks which were dragged across the bridge deck and for a distance south of the bridge.

Previous Bridge Operation Problems

Between December 1, 2011 and November 30, 2012 there were a total of 24 reported bridge problems recorded at the dispatcher office trouble desk. Thirteen of those problems occurred between October 27 and November 30, 2012[5]. Nine of the thirteen problems involved bridge operational problems.

---

[5] The November 30, 2012 reported the train derailment.

CRSH bridge repair responders were troubleshooting the problems and making repairs as they were found, but the problems continued.

Because of the reported previous bridge problems, a total of 17 employees that had involvement with the bridge maintenance were interviewed on December 2, 4, and 5, 2012. The interviews revealed that there were no specific problems with the bridge operations. The problems included; debris fouling bridge closure, replacing proximity sensors, adjusting the hog rods so the swing span would not drag on the bridge seat, resetting error codes on the PLC and operating the bridge with no apparent problems and trying to trouble shoot bridge operation failures.

The CRSH Supervisor of Structures said that he accompanied a representative from Heidenriech Associates, Inc., Control Systems Engineers, to the Paulsboro movable bridge on two occasions, November 13, 2012 and November 20, 2012, for the purpose of troubleshooting an apparent increase in the number of operational failures. The CRSH Supervisor of Structures said he spoke to the contract engineer responsible for the development and implementation of the PLC based control system utilized for the automation of the swing bridge the day after their November 20, 2012 visit to the bridge to advise him that the programming change that had been implemented the day prior had not eliminated the problem of the bridge failing to open automatically after the passage of a train. During this telephone conversation, the representative recommended that the CRSH Supervisor of Structures speak to the owner of the marina adjacent to the bridge in order to obtain the owner's consent to stop operating the bridge prior to the December 1, 2012 statutory seasonal closing. The reason for recommending the early closure was to allow CRSH to inspect and evaluate the electrical wiring on the bridge to determine the cause of intermittent failures.

The track and structures group and the signal group interviewed the CRSH bridge repair responders. One of the responders was an electrician who said that he could not find any water damage from Hurricane Sandy when he made his electrical inspections.

The CRSH Supervisor of Structures stated that he considered the recommendation to stop bridge operations and close the bridge early, but did not act the recommendation because he believed it was for the convenience of trouble shooting repair and not the safety of the bridge operation. He did not contact the marina owner, the U.S Coast Guard, or otherwise attempt to implement the recommendation. He also indicated that he did not discuss this recommendation with his managers.

When the previous train approached the bridge the signal at the bridge was "red" stop and the bridge was open. The train crew sent a radio signal to the bridge control system receiver to close the bridge for them to proceed across the bridge. The previous train traversed over the bridge on November 29, 2012 at approximately 11:09 p.m. and passed the north end bridge clearing circuit. The following messages were broadcast for the previous train:

1. 11:08:51 to 11:09:08 Bridge operation message was triggered while train was proceeding north but still on bridge circuits. "Conrail Paulsboro New Jersey Moveable Bridge Closing, out."
2. 11:15:37 to 11:15:47 Bridge operation message was triggered after a train clears the bridge going from south to north. "Conrail Paulsboro New Jersey Moveable Bridge Failed to Operate, out."
3. 11:19:34 to 11:19:43 Bridge operation message was triggered about 5 minutes after the above message was transmitted. "Conrail Paulsboro New Jersey Moveable Bridge Closed, out."
4. 11:25:31 to 11:26:05 Bridge operation message was triggered about 6 minutes after the above message was transmitted. "Conrail Paulsboro New Jersey Moveable Bridge Failed to Operate, out."

Train crew did not report the bridge message "…failed to operate…" to the train dispatcher. The trouble desk was not informed of the situation either; so it could document and dispatch the appropriate employees to investigate and correct the problem.

When the accident train arrived at the bridge from the north, the bridge was closed[6] and the signal displayed a "red" signal aspect. The train crew sent multiple radio code requests for the bridge, but the bridge control system receiver would not accept the radio signal. After a discussion with the dispatcher, the train crew reported that the track was inspected by the conductor and then were given authority to operate their train past the red signal; shortly after the train derailed. The following messages were broadcast for the accident train on the morning of November 30, 2012:

1. 06:49:40 to 06:49:55 Bridge operation message was triggered after a train approaches the bridge from the north and attempts bridge closure using the radio keypad. "Conrail Paulsboro New Jersey Moveable Bridge Closing, out."
2. 6:54:00 – 6:54:21 Keypad beep sequence (repeat) Keypad beep sequence.
3. 6:55:08 – 6:55:16 Keypad beep sequence
4. 6:55:49 – 6:55:57 Keypad beep sequence
5. 6:56:09 – 6:57:35 Engineer: "…the bridge was closed we got a stop signal displayed the conductor walked it we hit the code prompt a few times to see if it would pop up clear but it had not." Dispatcher: "Is the bridge lined locked for your movement there?"
   Bridge: "Conrail Paulsboro New Jersey Moveable Bridge Failed to Operate, Out"
   Engineer: "Yeah, it's giving us a failed to operate but it is lined and locked, the conductor walked it, showing us a stop signal."
   Dispatcher: "Okay, CA11 CSXT 8817, permission by the stop signal at the Paulsboro moveable bridge single to single south direction."
   Engineer: "CSXT 8817 has permission by the stop signal at the Paulsboro moveable bridge single to single track Penns Grove south."
6. 6:59:59 – 7:02:02 Engineer: "CA 11 to South Jersey, Emergency, Emergency, Emergency" "…the bridge is down…" "…vapor trail behind us…"

Pertinent Federal Regulations

The following federal regulations stipulate who can inspect track or bridges:

§213.5; Responsibility for Compliance

(a) Except as provided in paragraph (b) of this section, any owner of track to which this part applies who knows or has notice that the track does not comply with requirements of this part, shall (1) bring the track into compliance; (2) halt operations over that track; or (3) operate under authority of a person designated under § 213.7(a), who has at least one year of supervisory experience in railroad track maintenance, subject to conditions set forth in this part.

§ 237.57; Designations of individuals

Each track owner shall designate those individuals qualified as railroad bridge engineers, railroad bridge inspectors and railroad bridge supervisors. Each individual designation shall include the basis for the designation in effect and shall be recorded.

Point of Derailment

The point of derailment (POD) was determined by the track and structures group to be located at MP 13.7, where the swing toe end of the bridge matched up with the stationary portion of the bridge at the north

---

[6] The normal and expected position of the bridge is open to navigable water traffic.

end bridge miter rail. Photographic evidence showed wheel strike marks on the rail support braces appearing to start at this location and trace across the bridge to where they dropped off into the water. See Figures 1A, 2A, 3A, and 4A. Also, based on video and pictorial evidence it appears the first car to derail was the lead truck of the Vinyl Chloride tank car, OCPX 80323.

Damages

$50,654.00	Track Damage
$400,000.00	Bridge
$450,654.00	Total

Inspection Notes - CONRAIL U.G. Bridge 13.70, 14-Dec-12
Cameron Chasten, P.E., USACE

Span/Location	Member	Orientation	Straighness	Condition	Notes
Span 1	West Girder	Level	good	good	Photo 1
	East Girder	Level	good	good	
	Girder bracing		good	good	
	Pile Cap	Level	good	good	Photo B1 - cap. Photo B4 - Expansion Bearings at limit. Bolt bearing at end of slot.
	Piles		good	good	
	Pile bracing		good	good	
Span 2	West Girder	Level	good	good	Photo 2
	East Girder	Level	good	good	
	Girder bracing		good	good	
	Pile Cap	Level	good	good	
	Piles		good	good	
	Pile bracing		good	good	
Span 3	West Girder	Level	good	good	
	East Girder	Level	good	good	Northwest bearing stiffener is not straight. Photo B6
	Girder bracing		good	good	
	Pile Cap	Level	good	good	
	Piles		good	good	
	Pile bracing		good	good	
Swing	West Girder	Level	good	good	Photo B14
	East Girder	Level	good	good	Photo B12 NE end stiff damaged. Dent in bottom E flange. Neither defect critical
	Girder bracing		good	good	Photo B13
Pivot Bent	Pile Cap 1	Level	good	good	
	Pile Cap 2	Level	good	good	Pivot bearing has some fractured stiffeners
	Pile Cap 3	Level	good	good	
	Bracing		good	good	Not visual on bent 1 and 2
	Toe Bent Cap	Level	good	good	Photo B10, B11
Span 4	West Girder	Level	good	good	Photo B7
	East Girder	Level	good	good	Photo B8, B9
	Girder bracing				Not observed
	Pile Cap	Level	good	good	Photo B10, B11
	Piles		good	good	
	bracing		good	good	

General Notes:

Surface freckle corrosoin - typical
Paint failure/ general surface corrosoin - typical

Photo 1. East girder bottom flange, span 1

Photo 2. East girder, span 2

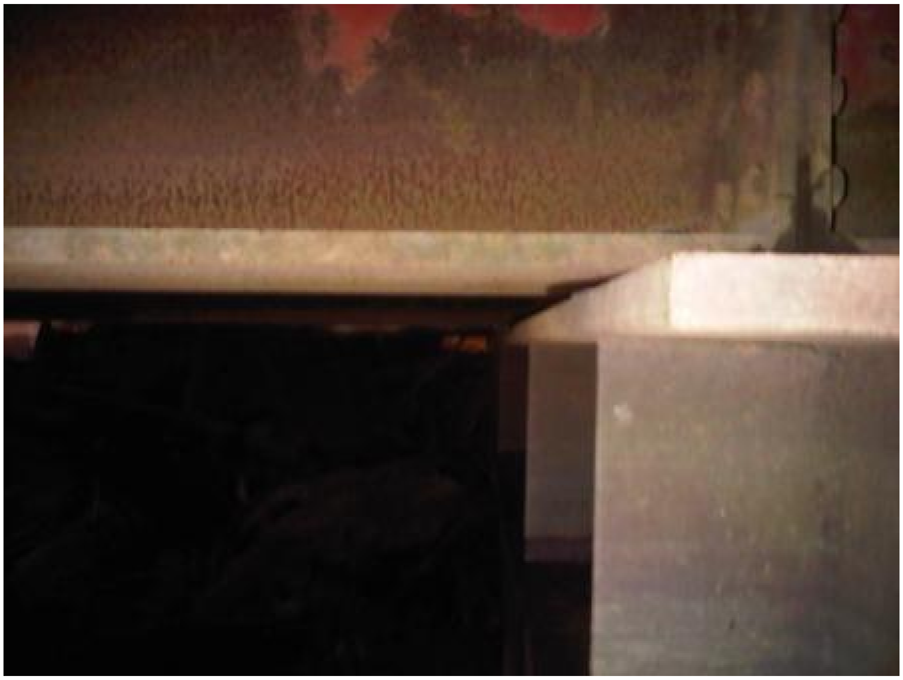

Photo B1. Bent 1 cap top flange looking east

Photo B4. West expansion bearing on Bent 1

Photo B6. NW bearing stiffener, E girder, Span 3

Photo B7. West girder bottom flange, span 4

Photo B8. West flange of east girder, span 4

Photo B9. East bottom flange of east girder, span 4

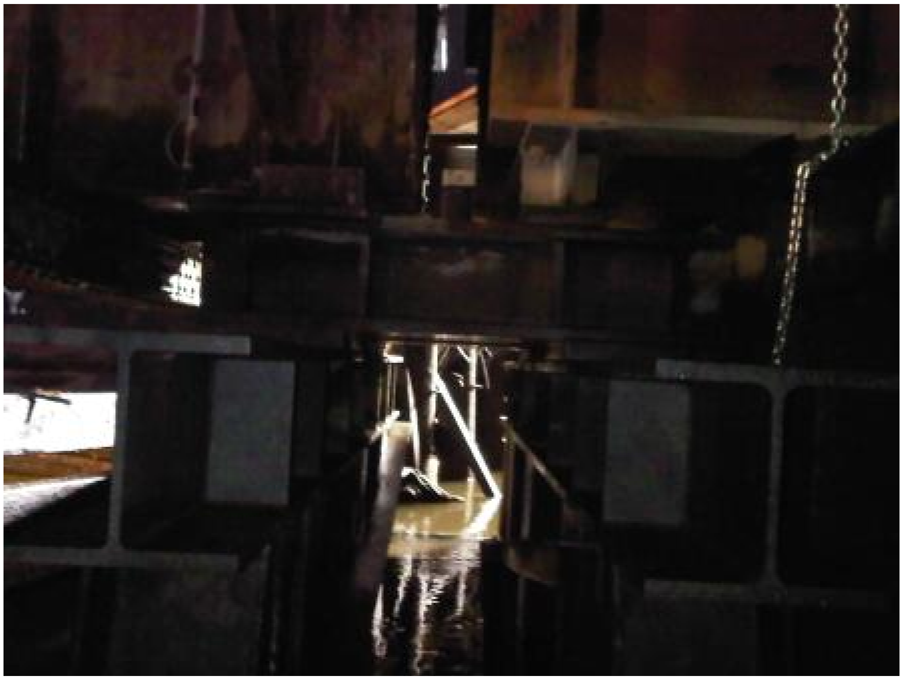

Photo B10. Double bent (toe bent and bent 4) looking west

Photo B11. Double bent (toe bent and bent 4) looking west

Photo B12. Northeast bearing bent – swing span, east girder

Photo B13. Internal bracing – swing span looking north

Photo B14. Swing span west girder bottom flange

Derailment Notes / Track Measurements (Page 1)

CONRAIL

District: South Jersey
Line / Yard Name: Pennsgrove Sec.
Track Name / No.: Single

M.P.@ Pt. Of derailment: 13.7
Train Symbol Involved: CA11
Engine No(s): 8817 / 8830 CSX

Time: 6 : 5 7 am
Date: 11/30/12
Speed: 8 MPH
Timetable Speed: 10 MPH
FRA Track class: I

Direction of travel: South
Type of Equip. 1st derailed: 1 Tank Car
Designated Elevation: 0
Alignment@ P.O.D.: Tangent x

Date of last inspection: 11/20/12
Maximum Gage: **56 ¾’’**
Location: **At 0 PD**

Name of Inspector: K. Rivell
Max. Deviation in X-level: **+1 1/8’’**
Location: **Station 10**

Max. Change in X-level: **7/8’’**
Location: **Station 5 + Joint**

Measurements Taken By:
Name: T. Mingolla
Title: Director Track

Name: L. Tomassone
Title: Supervisor Track

Date Notes Taken 12/12/12
Name: M. Diarenzo
Title: Supervisor Track

Rail used as reference rail for crosslevel readings: North ____ South ___ East ___ West x

15.5’ sections

				Elevation Light		Elev. - Under Load		
Station No.	Plus to Joints	Ordinate	Gage	Station	Joint	Station	Joint	Remarks
10			56 3/8''	**+1 1/8 ***				
9			56 1/2''	+1/4				
8			56 1/4''	+1/8				
7			56 1/4''	- 1/8				
6			56 3/8''	- 1/4				
5			56 1/4''	**+3/8 ***				
	5 1/2”		56 1/2''		**-1/2***			I-rails North & South
4			56 1/2''	+1/4				
3			56 5/8''	+1/2				
2			56 3/8''	+1/2				
	13’ 4”		56 1/2''		+1/4			I-rails North & South
1			56 5/8''	+1/4				
	3’ 5”		56 3/8''		+1/4			Joints North & South
0			**56 3/4''***	0				North End of Mitre Rail
-1	Plate Gage 54'' Rails Out of Plates							
-2	Plate Gage 54'' Rails Out of Plates							
-3								
-4								

Derailment Notes / Track Measurements (Page 2)

CONRAIL

District: South Jersey

Line / Yard Name: Pennsgrove Sec.

Track Name / No.: Single

M.P.@ Pt. Of derailment: 13.7

Train Symbol Involved: CA11

Engine No(s): 8817 / 8830 CSX

Time: 6 : 5 7 am

Date: 11/30/12

Speed: 8 MPH

Timetable Speed: 10 MPH

FRA Track class: I

Direction of travel: South

Type of Equip. 1st derailed: 1 Tank Car

Designated Elevation: 0

Alignment@ P.O.D.: Tangent x

Date of last inspection: 11/20/12

Maximum Gage:

Location:

Name of Inspector: K. Rivell

Max. Deviation in X-level:

Location:

Max. Change in X-level:

Location:

Measurements Taken By:

Name: T. Mingolla — Title: Director Track

Name: L. Tomassone — Title: Supervisor Track

Date Notes Taken

12/12/12 — Name: M. Diarenzo — Title: Supervisor Track

Rail used as reference rail for crosslevel readings: North ____ South___ East___ West x

15.5’ Sections

				Elevation Light		Elev. - Under Load		
Station No.	Plus to Joints	Ordinate	Gage	Station	Joint	Station	Joint	Remarks
20			56 3/4"	+1/4				
19			56 3/8"	+1/4				
18			56 1/2"	+1/4				I-rail East
	13’ 3’’		56 1/2’’		+1/4			I-rail West
17			56 5/8"	+1/4				
16			56 1/2’’	+1/8				
15			56 1/4’’	+1/8				
14			56 3/8’’	+1/4				
13			56 3/8’’	+1/4				
12			56 1/2’’	+1/8				
11			56 1/2’’	+1/4				
0								
-1								
-2								
-3								
-4								

Figure 1A
Northeast Slide Lock Assembly on the North Approach Span and POD

Figure 2A
Northeast Slide Lock Assembly on the North Swing Span and POD

Figure 3A
Northeast Slide Lock Assembly on the North End of the Swing Span and Initial Sign of Wheel Marks Crossing the Movable Bridge

Figure 4A
Looking from the Southwest End of the Swing Span Toward the North End Tracing Wheel Marks

Signed ________________________________ date ___________________

Cyril E. Gura, NTSB Track and Structures Groups Chairman